WORLD METEOROLOGICAL ORGANIZATION

UNITED NATIONS ENVIRONMENT PROGRAMME

RAPPORT DE LA DEUXIÈME RÉUNION DES DIRECTEURS DE RECHERCHES SUR L'OZONE DES PARTIES À LA CONVENTION DE VIENNE POUR LA PROTECTION DE LA COUCHE D'OZONE

GENÈVE, 10-12 MARS 1993

Projet mondial OMM de surveillance et de recherche concernant l'ozone
Rapport N° 32

1. OUVERTURE DE LA RÉUNION ET ÉLECTION DES PRÉSIDENTS

1.1 La deuxième réunion officielle des Directeurs de recherches sur l'ozone des Parties à la Convention de Vienne a été ouverte le mercredi 10 mars 1993 à 13h30 dans les locaux du siège de l'Organisation météorologique mondiale. A cette occasion, MM. A.S. Zaitsev et M. Sarma ont prononcé des allocutions au nom, respectivement, du Secrétaire général de l'OMM, M. G.O.P. Obasi, et du Directeur exécutif du PNUE, Mme Elizabeth Dowdeswell. La liste des participants figure à l'appendice A.

1.2 Dans son allocution de bienvenue, M. Zaitsev a rappelé que pour s'acquitter "de la mission de coordination internationale de l'étude de l'atmosphère et des observations systématiques à l'appui de la Convention de Vienne" que lui ont confiée les diverses Parties à la Convention, l'OMM continue d'apporter son concours énergique aux activités de recherche et de surveillance concernant l'ozone qu'elle a mises en train voilà plus de trente ans. M. Zaitsev a précisé que l'OMM se félicitait de la collaboration du PNUE pour tout ce qui concerne l'organisation de la présente réunion.

1.3 Les deux années qui se sont écoulées depuis la première réunion des Directeurs de recherches ont permis de mener à bien la publication de l'Evaluation scientifique de l'appauvrissement en ozone - 1991 (Rapport OMM sur l'ozone N° 25). Ce rapport, qui fait le point des connaissances actuelles en la matière, est le fruit des efforts concertés de centaines de scientifiques et a bénéficié de l'appui de la NASA ainsi que d'autres organismes nationaux ou internationaux tels que le PNUE. En outre, pour répondre aux demandes formulées lors de la réunion que les Parties à la Convention ont tenue à Helsinki et consignées au paragraphe 24 du rapport élaboré à cette occasion, l'OMM a continué à accorder une importance particulière aux améliorations du Système mondial d'observation de l'ozone ($SMOO_3$), lequel a produit des données essentielles pour l'étude et la détection de l'appauvrissement de la couche d'ozone.

1.4 En tant qu'institution des Nations Unies faisant autorité en matière atmosphérique, l'OMM, outre les évaluations scientifiques auxquelles elle a procédé ces trois dernières années, publie des informations en temps quasi réel sur l'état de la couche d'ozone pendant le printemps au-dessus de l'Antarctique et durant l'hiver et le printemps dans l'hémisphère Nord. M. Zaitsev a conclu son allocution prononcée au nom du Secrétaire général en soulignant que la Veille de l'atmosphère globale mise en train par l'OMM permet également d'obtenir des données complémentaires sur les paramètres météorologiques et les gaz précurseurs de l'ozone et, par voie de conséquence, de mieux comprendre les modifications de la concentration d'ozone, à la fois dans la stratosphère et dans la troposphère.

1.5 Au nom du Directeur exécutif du PNUE, Mme Elizabeth Dowdeswell, le coordonnateur du Secrétariat de l'ozone, M. Madhava Sarma, a souhaité la bienvenue aux participants à la réunion. Il a insisté sur le caractère décisif du rôle que les Directeurs de recherches sur l'ozone ont joué jusqu'ici par le biais des conseils avisés qu'ils ont dispensés aux gouvernements. Il est revenu en détail sur la façon dont ces conseils ont permis aux pouvoirs publics d'engager des actions fructueuses en vue de protéger la couche d'ozone et a fait valoir que les gouvernements auront encore besoin de conseils de ce genre pendant les années à venir, jusqu'à ce que la couche d'ozone retrouve l'équilibre qui était le sien avant 1970. Il a souhaité que les participants à la réunion parviennent à définir les principes directeurs qui guideront à l'avenir la recherche sur l'ozone.

1.6 Les participants ont élu à l'unanimité MM. Mike Kurilo, Christos Zerefos et Eugenio Sanhueza aux fonctions de coprésidents.

1.7 L'ordre du jour figurant à l'appendice B a été adopté.

2. EVALUATION DU RAPPORT DE LA PREMIÈRE RÉUNION DES DIRECTEURS DE RECHERCHES SUR L'OZONE

Les participants ont, dans l'ensemble, approuvé le contenu et, plus particulièrement, les recommandations du rapport de la première réunion (publié en tant que Rapport de projet OMM concernant l'ozone N° 23). Il est apparu que la plupart des recommandations restent toujours valables et que les Parties à la Convention de Vienne doivent s'efforcer de les mettre en application.

3. ASPECTS ACTUELS DE L'ÉTUDE DE L'OZONE ATMOSPHÉRIQUE, y compris L'ÉTAT D'AVANCEMENT DU SYSTÈME MONDIAL D'OBSERVATION DE L'OZONE ET DES RECHERCHES CONCERNANT LES MODIFICATIONS DU RAYONNEMENT ULTRAVIOLET B ET LEURS CONSÉQUENCES POSSIBLES

3.1 Pour ce qui est de ce point de l'ordre du jour, les participants ont d'abord suivi avec intérêt un exposé sur l'évolution récente des recherches et des observations systématiques relatives à l'ozone, présenté par M. Bojkov, de l'OMM (voir appendice C). Cet exposé a fait état d'une diminution statistiquement significative (plus de 10%) de l'ozone, qui s'est produite ces vingt dernières années aux latitudes boréales moyennes et polaires avec certaines particularités régionales. La raréfaction de l'ozone s'est accentuée ces deux dernières années, l'ozone total atteignant des valeurs minimales sans précédent. Cette baisse est plus marquée aux latitudes moyennes ainsi qu'en hiver et au printemps, et est moins prononcée, voire négligeable, sous les tropiques et en été. Les résultats publiés ces deux dernières années ont été étudiés en détail et confirment la diminution régulière de l'ozone total dans toutes les parties du globe, à l'exception de la ceinture intertropicale. Les données en provenance de cette zone sont cependant insuffisantes. L'examen auquel a procédé l'OMM a confirmé la validité des conclusions des trois dernières évaluations internationales, à savoir l'Evaluation de l'évolution de l'ozone réalisée en 1988 par le groupe d'experts NASA/OMM, l'Evaluation scientifique de l'ozone stratosphérique de 1989 et l'Evaluation scientifique de l'appauvrissement en ozone de 1991, publiées dans les rapports relatifs au Projet mondial OMM de surveillance et de recherche concernant l'ozone N° 18, 20 et 25 respectivement.

3.2 En 1992, le trou d'ozone printanier au-dessus de l'Antarctique a occupé une surface plus grande que jamais (jusqu'à 25 millions de km^2), est apparu quelque deux semaines plus tôt que d'habitude (à la mi-août) et a correspondu à l'appauvrissement le plus prononcé, avec des valeurs inférieures d'environ 110 m atm-cm à la moyenne de 330 m atm-cm enregistrée avant l'apparition du trou d'ozone. De plus, aux latitudes boréales moyennes, on a enregistré en janvier 1992 et en février-mars 1993, à une échelle continentale, des valeurs inférieures de plus de 20% aux valeurs normales à long terme, ce qui représente une baisse sans précédent depuis 35 ans que l'on procède à des relevés de l'ozone. Toutefois, en raison des particularités de la circulation atmosphérique dans la région arctique, la baisse de l'ozone par rapport à la normale reste modérée et l'apparition d'un "trou d'ozone" est tout à fait exclue dans les circonstances présentes.

3.3 Il a été souligné que, pour faciliter l'atteinte des objectifs de la Convention de Vienne, il convenait de renforcer le Système mondial d'observation de l'ozone en effectuant davantage de mesures de la répartition verticale de l'ozone et en implantant de nouvelles stations en Arctique, sous les tropiques et dans l'hémisphère Sud. Les instruments doivent faire périodiquement l'objet de comparaisons et d'étalonnages méticuleux auxquels les divers pays doivent apporter un appui approprié. Il faut mener de front les analyses des données recueillies au sol et par satellite afin d'en assurer la cohérence et de déceler les divergences à un stade précoce.

3.4 Les participants ont pris connaissance avec préoccupation des indices de plus en plus nombreux d'un accroissement de l'ozone troposphérique, à raison d'environ 1 à 2% par an dans l'hémisphère Nord, et il a été vivement souhaité que l'on fasse plus d'observations systématiques dans des zones qui ne sont pas directement exposées aux sources de pollution et en des endroits où il est possible d'échantillonner de l'air troposphérique non perturbé (dans des stations de haute montagne, par exemple). Il a été souligné que la plupart des études récentes fondées sur des mesures réelles des modifications de la couche d'ozone intervenues ces vingt dernières années indiquaient que les effets cumulés de ces modifications pourraient avoir une incidence positive considérable sur le forçage radiatif, comparable à celle occasionnée par les modifications de la concentration des autres gaz à effet de serre tels que CO_2, CH_4 et les CFC.

3.5 Après l'exposé du représentant de l'OMM, les participants ont écouté les rapports des représentants nationaux sur les activités scientifiques récentes et les derniers résultats des recherches concernant la modification de la couche d'ozone ainsi que sur certains travaux touchant le rayonnement ultraviolet B (voir le point 4 de l'ordre du jour et les appendices appropriés). Plusieurs recommandations ont été faites et sont indiquées au point 7 de l'ordre du jour.

4. RAPPORTS NATIONAUX SUCCINCTS SUR LES ACTIVITÉS DE RECHERCHE ET DE SURVEILLANCE EN COURS ET PRÉVUES CONCERNANT L'OZONE

Les représentants des pays signataires de la Convention de Vienne ont informé les participants de leurs activités nationales en ce qui concerne l'étude scientifique de l'ozone et les recherches en cours sur d'éventuelles conséquences de la modification de la couche d'ozone pour l'environnement. Plusieurs recommandations relatives aux recherches à réaliser à l'appui de la Convention ont aussi été faites; elles sont méthodiquement présentées au point 7 de l'ordre du jour. On trouvera les résumés des exposés nationaux, présentés dans l'ordre alphabétique, à l'appendice D.

5. EXAMEN DES MOYENS D'ASSURER UNE FORMATION SCIENTIFIQUE ET TECHNIQUE EN MATIÈRE DE SURVEILLANCE ET D'ÉTUDE DE L'OZONE PERMETTANT D'ACCROÎTRE LE POTENTIEL DES PAYS EN DÉVELOPPEMENT

5.1 Les participants ont noté que, dans les pays en développement il est nécessaire d'assurer la formation continue et l'amélioration des connaissances du personnel chargé des observations et de l'analyse des études concernant l'ozone. En conséquence, les Parties à la Convention disposant d'importants moyens d'observation et de recherche ont été priées instamment d'accorder leur aide en matière de formation et leur assistance technique aux pays en développement.

5.2 Il a été suggéré que l'OMM et le PNUE incluent dans leurs programmes en cours concernant l'ozone des activités de formation destinées à accroître la compétence des pays en développement, de sorte que ceux-ci puissent participer activement à la surveillance de l'ozone et aux travaux de recherche sur ce gaz au plan national et international. On trouvera une recommandation émise en ce sens au paragraphe 7.6.2.

6. MISE EN OEUVRE DE LA CONVENTION DE VIENNE ET DU PROTOCOLE DE MONTRÉAL (amendé)

6.1 Le Secrétariat de la Convention de Vienne et de son Protocole de Montréal a fourni un document d'information détaillant les diverses activités accomplies par les Parties, à l'occasion de leurs diverses réunions, en vue de la mise en application de la Convention et du Protocole ainsi

que par le Secrétariat lui-même en vue de la mise à exécution des décisions prises lors des réunions. Le 28 février 1993, les Parties à la Convention de Vienne, au Protocole de Montréal et à l'Amendement de Londres au Protocole étaient respectivement au nombre de 107, 102 et 46.

6.2 Depuis la dernière réunion des Directeurs de recherches sur l'ozone en mars 1991, les Parties au Protocole ont tenu deux réunions et les Parties à la Convention, une conférence.

6.3 Les participants à la troisième réunion des Parties au Protocole, qui s'est tenue en juin 1991, ont approuvé l'inclusion dans ce Protocole de l'"annexe D", une liste des produits contenant certaines des substances réglementées figurant à l'annexe A. Cette annexe D est entrée en vigueur le 27 mai 1992 et, dans l'année suivant cette date, les Parties devaient cesser de conclure des contrats d'importation de ces produits avec des pays non-Parties. Au cours de leur quatrième réunion qui s'est tenue en novembre 1992, les Parties au Protocole ont approuvé un certain nombre d'aménagements et d'amendements. Les aménagements avaient trait à la date de suppression de tous les CFC, du tétrachlorométhane et du trichloroéthane, ramenée de l'an 2000 à 1996, et à celle des halons, ramenée quant à elle de l'an 2000 à 1994, sauf en ce qui concerne leurs usages essentiels, qui doivent être approuvés lors des prochaines réunions des Parties. L'Amendement a inclus les HCFC et le bromométhane dans la liste des substances réglementées. Les HCFC doivent être éliminés progressivement d'ici l'an 2030. Quant au bromométhane, sa consommation doit être gelée en 1995, et d'autres études de cette substance pourraient conduire à réglementer plus strictement son usage.

6.4 Les participants à la quatrième réunion ont demandé aux groupes d'évaluation d'actualiser leurs rapports de 1991 d'ici la fin de l'année 1994, avec mandat précis de se pencher et de faire rapport sur le bromométhane, le transport aérien subsonique, le recyclage, etc.

6.5 Les participants à la quatrième réunion ont également décidé que le Fonds multilatéral deviendrait permanent à partir du 1er janvier 1993. Ce Fonds a recueilli 94 millions de dollars en 1991 et 1992 et devrait recueillir, selon les engagements pris, 113 millions de dollars en 1993. Des programmes nationaux sont en préparation grâce à l'ouverture d'agences du Fonds dans 42 pays, administrées conformément aux indications de l'article 5 du Protocole. Le Conseil exécutif du Fonds a jusqu'ici approuvé neuf programmes nationaux.

6.6 Un examen de la situation en matière de mise en oeuvre a montré que la plupart des Parties sont en avance sur les calendriers du Protocole.

6.7 A l'occasion de leur deuxième conférence, les Parties à la Convention de Vienne se sont intéressées, entre autres, au rapport de la première réunion des Directeurs de recherches sur l'ozone. Un appel a été lancé en faveur d'une contribution au Fonds spécial de l'OMM pour la surveillance de l'environnement, dans l'optique de renforcer le Système mondial d'observation de l'ozone ($SMOO_3$). Le Secrétariat a mentionné que les Parties à la Convention n'avaient guère réagi à cet appel. Seule la Commission des communautés européennes a souhaité obtenir plus de précisions, que l'OMM lui a d'ailleurs fournies depuis.

6.8 Le Secrétariat a mentionné que son document d'information contenait les renseignements fournis par les Parties à propos des institutions et des experts que la coopération internationale en matière de recherche sur l'ozone intéresse. Les Parties pourraient tirer profit de ces renseignements pour promouvoir la collaboration dans ce domaine. Deux corrections apportées par le Japon et le Danemark au document d'information ont été reportées dans le document en question par le Secrétariat.

7. ADOPTION DES RECOMMANDATIONS ET CLÔTURE DE LA RÉUNION

Les participants à la réunion ont examiné attentivement et adopté un certain nombre de recommandations reproduites aux paragraphes 7.1 à 7.6. Ces recommandations sont en général des versions augmentées des recommandations de base faites lors de la première réunion des Directeurs de recherches sur l'ozone.

7.1 Préambule

7.1.1 Les participants à la réunion ont souligné que les activités de recherche permettaient avant tout de mieux comprendre la physique, la chimie et les modes de transport de l'ozone atmosphérique et d'évaluer de façon plus précise les éventuelles perturbations causées tant par les activités humaines que par des phénomènes naturels. Cela suppose un programme complet d'observations systématiques, d'études des processus, d'élaboration de scénarios d'émission et de modélisation prévisionnelle. Pour toutes ces activités, et notamment les observations au sol et par satellite, la continuité est un facteur essentiel.

7.1.2 Les participants ont en outre identifié plusieurs grands objectifs scientifiques hautement prioritaires destinés à guider les travaux futurs concernant l'ozone, comme cela est recommandé dans le présent chapitre.

a) En premier lieu, il importe au plus haut point de caractériser les conditions chimiques et météorologiques qui occasionnent des modifications de l'ozone stratosphérique dans les régions polaires, aux latitudes moyennes et dans la zone tropicale des deux hémisphères. Il convient en particulier de définir quantitativement les conditions qui engendrent un appauvrissement en ozone au-dessus de l'Arctique, compte tenu de l'extension rapide du trou d'ozone printanier au-dessus de l'Antarctique dès que la charge chlorée et bromée dépasse 2 ppb.

b) Il faut aussi de toute urgence améliorer les modèles actuels, fondés sur la chimie et le transport atmosphériques, grâce à l'élaboration continue de modèles tridimensionnels combinant la chimie et le climat, de manière à disposer d'outils prévisionnels fiables en ce qui concerne l'évolution future de la couche d'ozone.

c) Compte tenu des conséquences des modifications de l'ozone **tant** stratosphérique **que** troposphérique pour le forçage radiatif, il est indispensable d'obtenir de meilleures mesures de la répartition verticale de l'ozone, afin de pouvoir déterminer l'altitude et la latitude auxquelles se produisent ces modifications et calculer plus aisément leurs effets potentiels sur le climat ainsi que l'incidence des autres gaz à effet de serre sur la production et la décomposition de l'ozone.

d) Il est nécessaire d'en apprendre plus long sur la basse stratosphère et sur sa relation chimique et dynamique avec la haute troposphère, notamment dans la perspective d'une prévision efficace des conséquences des vols supersoniques à haute altitude et du transport civil subsonique.

e) Il faut élaborer une climatologie du rayonnement ultraviolet, avec une résolution tant spatiale que temporelle, afin de disposer des bases voulues pour évaluer les effets de la raréfaction de l'ozone sur les êtres vivants et sur l'homme. Il importe en particulier de multiplier fortement les mesures du rayonnement ultraviolet B (< 1nm) à haute résolution spectrale à l'échelle du globe. La compréhension des relations entre le rayonnement UV et les autres variables atmosphériques, comme la modification de la couche d'ozone ou la présence d'autres gaz en traces, de nuages et d'aérosols, doit progresser pour que l'on puisse élaborer des algorithmes prévisionnels.

f) A la lumière des preuves de plus en plus nombreuses de l'appauvrissement de la couche d'ozone dans les deux hémisphères, il est essentiel d'en apprendre plus long sur les effets des rayonnements UVB et UVA sur les systèmes biologiques, quoique l'immense diversité de ces derniers ne permette guère de formuler une appréciation générale. Ces effets sont caractérisés en tant que "spectres d'action". La compréhension des effets du rayonnement UVB est en constante évolution, et il convient en premier lieu d'étudier l'exposition dans des conditions naturelles, parce que la majeure partie des "spectres d'action" utilisés actuellement ont été déterminés sur la base d'expériences de laboratoire.

g) Il importe de renforcer (ou de développer au besoin) et de préserver les moyens de mesure des halocarbures à l'état de traces tels que CH_3Br, les HFC ou les HCFC pendant une période de temps suffisamment longue pour que la validité de nos connaissances en ce qui concerne les sources, les puits et les temps de séjour de ces composés puisse être confirmée.

7.2 Mesures systématiques

7.2.1 Réseau ozone

Objectif

Etablir une base qui permette d'en savoir plus long sur le régime de l'ozone et son évolution.

Progrès enregistrés

Trois nouvelles stations d'observation de l'ozone total ont été mises en service pendant la période 1991-1993. Aucune amélioration des mesures de la répartition verticale de l'ozone n'a toutefois été constatée.

Approche

La mesure systématique de l'ozone total et de sa répartition verticale (tant dans la stratosphère que dans la troposphère), effectuée dans le cadre du Système mondial d'observation de l'ozone ($SMOO_3$) par divers satellites et par certaines stations équipées d'instruments perfectionnés telles que celles du NDSC, devrait se poursuivre sans interruption. Ces observations permettront de procéder à un contrôle mutuel de la qualité des systèmes et d'instaurer la confiance au sujet de leur capacité de couverture mondiale. On prêtera une attention particulière aux points suivants :

a) Il est absolument indispensable de renforcer les moyens de mesure de l'ozone total et de sa répartition verticale, notamment dans l'Arctique, en Sibérie orientale et dans la ceinture intertropicale. Parallèlement, il est toujours nécessaire de disposer de données satellitaires fiables sur l'ozone total et de mesures satellitaires améliorées de sa répartition verticale.

b) En ce qui concerne la mesure de la répartition verticale de l'ozone, il faut en particulier s'efforcer de poursuivre et de multiplier les sondages de l'ozone et les mesures Umkehr, en hyperfréquences et lidar et d'élaborer des techniques d'observation satellitaire plus sûres. Il convient en outre de s'employer à mettre en train des programmes de sondage de l'ozone dans des stations implantées sur les îles qui parsèment les vastes océans de l'hémisphère Sud, en particulier aux latitudes où l'on a observé d'importantes diminutions de l'ozone et où l'on ne dispose pas encore de mesures de ce genre.

c) Il faut accompagner les mesures Umkehr d'observations lidar concernant les aérosols, surtout les années marquées par d'importantes éruptions volcaniques (1982 et 1991, par exemple). L'emploi de facteurs de correction destinés à compenser les effets des aérosols sur les mesures Umkehr opérationnelles doit être absolument généralisé, et il importe de réévaluer avec soin l'ensemble des 40 000 profils disponibles, de manière à pouvoir en déduire le maximum d'informations sur la répartition verticale de l'ozone au cours des 35 dernières années.

d) Pour bien comprendre les modifications de la couche d'ozone, il est nécessaire de disposer de mesures de l'ozone en surface, effectuées dans des conditions de base à faible altitude et en haute montagne, de manière à obtenir des données sur les concentrations d'ozone libre dans la troposphère.

e) Les instruments de toutes sortes couramment utilisés pour mesurer l'ozone total dans le cadre du SMOO3 doivent être régulièrement étalonnés et normalisés et doivent faire l'objet de comparaisons internationales au moins tous les trois ans. L'application rétroactive des corrections nécessaires est une mesure essentielle.

f) La mesure satellitaire de la colonne d'ozone et de son profil de répartition doit se poursuivre. La combinaison de satellites et d'instruments au sol bien étalonnés permettra d'obtenir un relevé mondial des modifications de la couche d'ozone. Il faut également continuer à mesurer les spectres solaires UV et X et à évaluer la variabilité des différents domaines spectraux.

7.2.2 Observations à long terme des éléments chimiques liés à l'ozone

Objectif

Observer l'état physique et chimique de l'atmosphère en prêtant une attention particulière à la stratosphère, en vue d'en détecter et d'en comprendre les modifications.

Progrès enregistrés

Des efforts soutenus ont été consentis dans le but de renforcer la Veille de l'atmosphère globale (VAG) au sol et le Réseau de détection des changements dans la stratosphère. Alors que la VAG sert essentiellement à surveiller les teneurs en CO_2, CH_4, N_2O, CO, O_3, CFC et en composés halogénés de la troposphère, le réseau fournit des renseignements sur la concentration dans la stratosphère d'un certain nombre de composés importants (C10, NO_x, etc.).

Approche

Il faut faciliter l'exploitation du réseau, qui devrait être prochainement renforcé par un ensemble de cinq stations de télédétection au sol d'une grande qualité, permettant d'effectuer des observations de l'ozone et des principaux composés chimiques influant sur sa concentration (C10, NO_x, etc.), mais aussi de mesurer d'autres paramètres (par exemple la température). Les données stratosphériques fournies par le NDSC seront complétées par les observations satellitaires et les données fournies par les stations de la VAG, dont deux douzaines environ sont actuellement en service ou à un stade avancé d'implantation.

En outre, les programmes de surveillance mentionnés doivent inclure des mesures du tétrachlorométhane, du trichloroéthane, de tous les CFC, des halons, des HCFC, des HFC et du bromométhane, compte tenu du rôle important que jouent ces composés dans les bilans du chlore et du brome dans la stratosphère. Bien que les méthodes de mesure des HCFC et des HCF en soient encore au stade de la recherche, il faut élaborer les stratégies et les perspectives de leur emploi.

7.3 Etudes des processus

7.3.1 Modification de la couche d'ozone

Objectif

Déterminer l'ampleur et les causes de la raréfaction de l'ozone stratosphérique, en mettant l'accent sur le rôle que jouent les régions polaires dans le régime de l'ozone et sur ses conséquences aux latitudes faibles et moyennes.

Progrès enregistrés

Outre les observations réalisées de manière continue par le $SMOO_3$ et l'implantation de nombreux systèmes de mesure dans les régions polaires, un certain nombre de campagnes spéciales telles que l'Expérience européenne concernant l'ozone stratosphérique au-dessus de l'Arctique (EASOE) et les Expéditions aéroportées dans la stratosphère au-dessus de l'Arctique (AASE I et II) ont été menées et le satellite de recherche en haute atmosphère (UARS) a permis d'obtenir des données sur la répartition du C10 et d'autres composés.

Approche

Il s'agit de compléter les données de la surveillance de base (au sol et par satellite) par des mesures obtenues lors de campagnes intensives sur le terrain et d'analyser les résultats au moyen de modèles. On s'attachera en particulier à :

a) mener des campagnes périodiques de mesure intensive des substances en traces, notamment quand on prévoit des perturbations régionales de la chimie et/ou de la dynamique;

b) poursuivre l'étude de la stratosphère au-dessus des deux régions polaires, et cela à l'intérieur, au bord et à l'extérieur du tourbillon circumpolaire pendant un cycle hivernal complet;

c) mieux comprendre la chimie et le temps de séjour des sources des gaz en traces d'origine naturelle et humaine qui peuvent avoir un effet préjudiciable sur la couche d'ozone, et notamment à renforcer les moyens de surveillance des accumulations de HCFC, de HFC et de bromométhane;

d) étudier le cycle biogéochimique des halocarbures et le rôle possible des gaz réagissant avec l'ozone, tels que SO_2;

e) mettre en service et utiliser des aéronefs de grande capacité volant à haute altitude en vue des campagnes intensives sur le terrain;

f) améliorer en permanence les modèles axés sur les processus servant à planifier les observations réalisées au cours de ces campagnes et à analyser les données obtenues ainsi qu'à mieux cerner les conditions propices à la modification de la couche d'ozone.

7.3.2 Durée de séjour des halocarbures et produits de dégradation

Objectif

Définir le comportement des halocarbures artificiels dans le milieu atmosphérique.

Progrès enregistrés

Des progrès considérables ont été accomplis dans la production de données de laboratoire sur la durée de séjour atmosphérique de nombreux composés halogénés (en usage ou dont l'utilisation est envisagée).

Approche

Il s'agit d'étudier la photolyse et l'oxydation des halons, des HCFC, des HFC, du trichloroéthane et du bromométhane dans les conditions propres à la stratosphère et à la troposphère, et cela dans le cadre d'expériences en laboratoire complétées par des mesures sur le terrain. A cet effet, il faut :

a) mettre au point et installer des instruments perfectionnés pour surveiller l'accumulation de HCFC et de HFC et de leurs produits de dégradation;

b) chercher à mieux comprendre l'action oxydante de l'atmosphère, notamment grâce à une meilleure détermination de la répartition globale du radical hydroxyle, afin d'en apprendre plus long sur le devenir des produits de remplacement utilisés actuellement ou dont l'usage est envisagé ainsi que de leurs produits de dégradation;

c) élaborer, à propos des émissions, des fonctions et une méthodologie permettant de définir la teneur des sources anthropiques en bromométhane, HCFC et HFC avec une précision convenable;

d) engager des études portant sur les cycles biogéochimiques des halocarbures.

7.3.3 Flux de gaz en traces

Objectif

Comprendre les processus physiques, chimiques, géologiques, biologiques et sociaux qui gouvernent le degré d'abondance atmosphérique des composés influant sur la répartition de l'ozone, à savoir principalement le méthane, les halocarbures, le monoxyde de carbone, le dioxyde de carbone, l'oxyde nitreux et les oxydes d'azote et d'hydrogène.

Progrès enregistrés

Des mesures continues ont été réalisées aux stations de la VAG établies sur le site du NOAA-CMDL et à Cape Grim ainsi que par le réseau NASA-AGAGE et quelques études ont porté sur les processus d'échange.

Approche

Il importe d'effectuer des études expérimentales et théoriques sur les cycles et la distribution des principaux composés (voir ci-dessus) influant sur la répartition de l'ozone dans l'atmosphère, les écosystèmes terrestres, les océans et les sédiments, sur les échanges gazeux entre la stratosphère et la troposphère, l'atmosphère et les océans et l'atmosphère et les écosystèmes terrestres et, enfin, sur l'incidence des activités humaines sur les cycles du carbone et de l'azote.

7.3.4 Aérosols et chimie en milieu hétérogène

Objectif

Etablir dans quelle mesure les processus où interviennent les nuages stratosphériques polaires et les aérosols d'acide sulfurique peuvent augmenter le dégagement d'espèces chlorées actives et, de ce fait, bouleverser l'ordre d'importance des divers cycles catalytiques conditionnant la recombinaison de l'ozone, mais aussi peuvent se produire dans la couche stratosphérique d'aérosols.

Progrès enregistrés

On en sait aujourd'hui plus long sur le rôle des nuages stratosphériques polaires et des aérosols soufrés dans la répartition des différentes espèces chlorées dans la stratosphère.

Approche

Il s'agit de :

a) étudier en laboratoire la chimie en milieu hétérogène où interviennent les produits de remplacement présents dans les nuages stratosphériques polaires et les précurseurs d'aérosols soufrés, et cela dans des conditions proches de celles qui règnent dans l'atmosphère réelle;

b) utiliser les mesures systématiques réalisées sur le terrain, notamment à l'aide de lidars et d'autres techniques d'établissement de profils, pour déterminer la répartition atmosphérique des aérosols et des nuages stratosphériques polaires;

c) effectuer des études de terrain en vue de déterminer par échantillonnage la composition et les caractéristiques des aérosols stratosphériques;

d) mieux comprendre la formation des aérosols dans la stratosphère.

7.3.5 Ozone troposphérique

Objectif

Définir et évaluer les processus qui régissent le bilan de l'ozone troposphérique.

Progrès enregistrés

Les mesures continues indiquent que la teneur en ozone de la troposphère a augmenté dans l'hémisphère Nord et demeure à peu près stable en zone tropicale et dans l'hémisphère Sud.

Approche

Il s'agit de :

a) mesurer simultanément l'ozone troposphérique et les gaz précurseurs de l'ozone (NO_x, CO, hydrocarbures non méthaniques, etc.) à différentes latitudes, en mettant particulièrement l'accent sur l'hémisphère Sud, où les données sont insuffisantes.

b) améliorer les modèles actuels de la photochimie troposphérique et les harmoniser avec le transport des précurseurs et de l'ozone.

7.4 Prévision

7.4.1 Elaboration de modèles

Objectif

Améliorer la capacité prévisionnelle des modèles en matière de modification de la couche d'ozone.

Progrès enregistrés

La combinaison de modèles et de données empiriques a permis d'établir de façon semi-empirique le potentiel de destruction de l'ozone (PDO) de divers composés décomposant ce gaz. La comparaison des différents modèles a permis d'élucider certaines des anomalies constatées lors de l'analyse des résultats et d'accroître la fiabilité des prévisions.

Approche

Il faut élaborer de nouveaux modèles et améliorer les modèles existants, et notamment :

a) améliorer la modélisation multidimensionnelle des processus troposphériques, y compris ceux qui déterminent la répartition de OH dans la troposphère, afin de pouvoir calculer l'incidence des HCFC sur l'évolution future de la concentration d'ozone;

b) généraliser l'emploi de modèles lagrangiens pour évaluer les études de la stratosphère réalisées sur le terrain, de manière à approfondir la connaissance des processus physiques et chimiques qui s'y produisent;

c) élaborer une paramétrisation appropriée aux processus hétérogènes qui se produisent dans la basse atmosphère et l'intégrer dans des modèles bidimensionnels;

d) mettre au point des modèles "chimie-transport-rayonnement" tridimensionnels pleinement interactifs, puisque l'on considère que la répartition de l'ozone dans la stratosphère, notamment dans la basse stratosphère, est tributaire de ces interactions.

7.4.2 Questions climatiques

Objectifs

Evaluer, au plan quantitatif, l'influence des modifications de la répartition de l'ozone sur le climat et, inversement, des changements climatiques sur cette répartition.

Concevoir les mécanismes de rétroaction entre l'ozone, le rayonnement, les nuages et la dynamique atmosphérique comme un système interactif.

Progrès enregistrés

Des calculs ont été effectués pour expliquer les effets radiatifs de l'appauvrissement en ozone de la basse stratosphère (qui entraîne un refroidissement) et de l'enrichissement en ozone de la troposphère (qui entraîne un réchauffement).

Approche

Il s'agit de :

a) élaborer un modèle climatique qui tienne compte, de manière interactive, de l'ozone et des autres gaz à effet de serre ainsi que de leurs effets sur le rayonnement et la dynamique atmosphérique;

b) poursuivre la mesure et l'analyse détaillées des variables stratosphériques et troposphériques;

c) intégrer les scénarios relatifs à l'ozone dans les modèles climatiques et utiliser les scénarios relatifs au climat pour prévoir les modifications de la répartition de l'ozone;

d) encourager les Services météorologiques à utiliser couramment des ballons-sondes susceptibles d'atteindre au moins 10 mb;

e) avoir recours à de nouvelles plates-formes telles que des aéronefs de haute altitude pour pouvoir effectuer des mesures au-dessus des altitudes habituellement échantillonnées.

7.5 Incidences

Préambule

Même dans l'hypothèse d'une suppression immédiate de tous les CFC et composés apparentés, les niveaux actuels de la charge en chlore et en brome de l'atmosphère rendent inéluctable la raréfaction de l'ozone stratosphérique bien au-delà de l'an 2000. Il est indispensable de procéder à la mesure systématique du rayonnement UVB au sol afin de faire progresser les recherches sur l'environnement et la santé et de pouvoir élaborer des stratégies d'adaptation à cette raréfaction.

7.5.1 Mesures systématiques du rayonnement ultraviolet au sol

Objectif

Réunir suffisamment de données sur le rayonnement UVB et UVA en surface et en effectuer une analyse assez détaillée pour être en mesure d'élaborer une climatologie de ce rayonnement et de prévoir son évolution future et ses effets sur la biosphère.

Progrès enregistrés

La comparaison de plus d'une douzaine d'instruments spectraux a été entreprise pendant deux étés consécutifs en Thessalonique. L'OMM a établi son Centre mondial de données sur le rayonnement UV à Toronto, la mise au point d'instruments à haute résolution est en bonne voie et l'implantation de réseaux nationaux d'observation du rayonnement UVB se poursuit.

Approche

a) Il importe avant tout que les données mesurées puissent être comparées aux résultats obtenus par modélisation. Il est de plus indispensable que les mesures du rayonnement UV soient faites en même temps et sur les mêmes sites que les mesures concernant l'état optique de l'atmosphère (nébulosité, aérosols et gaz en traces). Les données doivent avoir une résolution spectrale, temporelle et angulaire qui permette de valider les prévisions des modèles et d'évaluer les effets biologiques (résolution spectrale inférieure à 1 nm). Un projet de spécifications concernant les données sur le rayonnement UVB et les mesures connexes figure à l'appendice E. Les mesures du rayonnement UVA, quoiqu'elles obéissent à des exigences moins strictes, n'en sont pas moins importantes, car elles fournissent des informations complémentaires et autorisent un étalonnage interne permettant d'évaluer l'efficacité et la stabilité des instruments.

b) Il faut aménager des sites spéciaux voués à la surveillance rigoureuse du rayonnement UVB. De plus, les mesures de ce rayonnement doivent faire partie des activités de toutes les stations de la VAG et des observatoires du NDSC appropriés.

c) Bien que le nombre limité de données fiables sur le rayonnement UVB rende leur interprétation difficile, il convient d'élaborer des méthodes d'analyse à un stade précoce.

7.5.2 Recherche concernant les effets de la modification de la couche d'ozone sur la santé et l'environnement

Objectif

Cerner les conséquences sanitaires, biologiques et socio-économiques des modifications du rayonnement ultraviolet à la surface du globe. A ce propos, il faut prêter une attention particulière à l'incidence de ces modifications sur la production vivrière dans les pays en développement et à la mise au point de variétés végétales résistant à un rayonnement ultraviolet plus intense.

Approche

Les Directeurs de recherche présents à la réunion ont estimé qu'ils n'avaient pas les compétences requises pour se prononcer sur l'approche. Toutefois, une liste de 40 recommandations précises concernant la recherche dans des domaines où peu de progrès ont été enregistrés figure au chapitre 7 du rapport du "Groupe d'étude du PNUE pour les effets sur l'environnement" (novembre 1991). Ces recommandations reconnaissent l'importance des régions géographiques telles que les ceintures intertropicale et polaires, où les risques de dégradation sont élevés. Les domaines évoqués dans le document du PNUE incluent à la fois la santé (défaillance du système immunitaire, maladies infectieuses, troubles oculaires), les disponibilités alimentaires (plantes cultivées, chaîne alimentaire marine), la qualité de l'air troposphérique, les dommages aux matières inanimées et les besoins de surveillance.

7.6 Recommandations de caractère général

7.6.1 Le renforcement récent de la coordination de la recherche et des observations systématiques (comme l'illustrent la Veille de l'atmosphère globale de l'OMM, y compris le NDSC, ou le programme "Environnement" de la Commission des communautés européennes (CCE)) est le bienvenu et doit être amplifié à l'avenir. Le rôle primordial de l'OMM et du PNUE dans ces activités doit être reconnu et fermement appuyé.

7.6.2 Les Parties à la Convention sont incitées à apporter leur aide en matière de formation et leur assistance technique aux pays en développement par le biais :

a) d'une assistance bilatérale ou multilatérale destinée à renforcer les projets de recherche en collaboration, y compris l'implantation de stations de surveillance supplémentaires et leur maintenance (ces projets en collaboration entre pays développés et pays en développement ou à économie de transition peuvent d'ailleurs donner d'excellents résultats au plan scientifique);

b) de cours et de projets de démonstration concernant l'observation et l'étude de l'ozone.

7.6.3 L'OMM doit continuer à fournir directives et infrastructures pour la maintenance et l'étalonnage des stations du $SMOO_3$ en activité, en prêtant une attention particulière aux techniques de contrôle et d'assurance de la qualité. Les activités d'appui des laboratoires centraux d'étalonnage des spectrophotomètres Dobson (NOAA-Boulder), des sondes de Brewer-Mast (SEA-Toronto) et des instruments à filtres (MGO-Saint-Pétersbourg) doivent être amplifiées de manière à satisfaire la demande accrue d'une meilleure qualité des données.

7.6.4 Le Secrétariat de la Convention de Vienne doit continuer à recueillir, dans le cadre de la Convention, des informations sur les activités nationales de recherche et à en assurer une large diffusion.

7.6.5 Il faut s'efforcer d'améliorer les pratiques de gestion des données et le transfert des informations sur l'ozone et les gaz précurseurs. Les pays exploitant des stations de surveillance de l'ozone doivent veiller à communiquer leurs données vérifiées au Centre mondial de données sur l'ozone que l'OMM a mis en place à Toronto, et cela dans un délai de deux mois à compter de la date d'observation.

7.6.6 Les données concernant les émissions de gaz en traces d'origine anthropique doivent être compilées et mises à la disposition des chercheurs.

7.6.7 Il est possible d'assurer la planification et l'organisation à long terme que nécessite l'exploitation d'expériences de recherche complexes et multilatérales réalisées sur le terrain en faisant en sorte que les différents organismes intéressés participent au financement systématique de ces projets.

7.6.8 A la suite de l'appel lancé dans le cadre du programme Action 21 adopté par la CNUED en faveur d'une amélioration du Système mondial d'observation de l'ozone, il est préconisé que les gouvernements contribuant au Fonds mondial pour l'environnement (GEF) appuient les propositions incitant ce Fonds à allouer les montants assez restreints nécessaires au financement de cette amélioration dans les deux ou trois années à venir.

7.6.9 Les Parties à la Convention sont encouragées à élaborer et à mettre en oeuvre des programmes nationaux de sensibilisation du public, conçus de manière à satisfaire leurs exigences particulières. Ces programmes devraient permettre de :

a) disposer, quasiment en temps réel, d'informations précises et récentes sur l'état de la couche d'ozone;

b) mieux comprendre les effets potentiels de la raréfaction de l'ozone sur l'environnement et la santé;

c) mettre en évidence la nécessité d'une limitation des agents de raréfaction de l'ozone et de renforcer la volonté générale de contribuer à la mise en application des mesures de restriction.

7.6.10 Le travail considérable accompli lors de la préparation des rapports périodiques d'évaluation de l'ozone a été très apprécié, et les participants à la réunion ont souhaité que l'OMM et le PNUE veillent à l'avenir à ce que les scientifiques compétents du monde entier puissent participer de plus en plus nombreux à ces travaux de préparation, et cela dès leur phase initiale.

7.7 Clôture de la réunion

7.7.1 L'assemblée a confié l'établissement du texte final aux coprésidents et à M. Bojkov, après consultation éventuelle des participants.

7.7.2 Le Président a félicité tous les participants pour leur collaboration active et a remercié l'OMM d'avoir accueilli la réunion et assuré une excellente organisation. Il a déclaré la réunion close le 12 mars 1993, à 13 heures.

APPENDICE A

DEUXIÈME RÉUNION DES DIRECTEURS DE RECHERCHES SUR L'OZONE DES PARTIES À LA CONVENTION DE VIENNE POUR LA PROTECTION DE LA COUCHE D'OZONE

(Genève, 10-12 mars 1993)

LISTE DES PARTICIPANTS

Parties à la Convention	**Représentés par :**
Argentine	M. Gustavo Ruben Talamoni
Australie	M. Paul Lehmann
Belgique	M. D. de Muer
Brésil	M. Volker W.J.H. Kirchhoff
Canada	M. Jim Kerr
	M. Guy Fenech
Commission des communautés européennes	M. Heinrich Ott
	M. J.H. Busing
Afrique du Sud	M. C.G. Croenewald
	M. J.R. Pretorius
Allemagne	M. Rainer Stern
	M. Gerhard Hahn
	M. G.H. Klein
	M. Klaus Wege
Arabie saoudite	M. Al-Sahafi Mohammed
	M. Abdul-Mohssin Bin Fitten
	M. Bamanie Jamal
Cuba	M. Noland Empty
Danemark	M. Torben S. Jorgensen

Egypte	M. Galal K.Y. Hassan
Emirats arabes unis	M. Hizam Hamud Naji
Etats-Unis d'Amérique	M. Michael J. Kurylo
	M. Joel Levy
Fédération de Russie	M. Igor M. Nazarov
Finlande	M. Antti Kulmala
France	Mme Nicole Papineau
Grèce	M. Christos S. Zerefos
Inde	M. S.K. Srivastava
Japon	M. Hideaki Nakane
	M. Tomoyuki Ito
	M. Nobutoshi Miyoshi
Kenya	M. Leonard Njogu Njau
Koweït	M. Mane Al-Sudairawi
Malaisie	Mme Leong Chow Peng
Maroc	M. El H. Mohamed Taoufiq
Mexique	M. V. Hugo Paramo-Figueroa
Nigéria	M. I.D. Nnnodu
Norvège	M. Arne Dahlback
Nouvelle-Zélande	M. Andrew Matthews
Pakistan	M. M.A. Khattak
Pays-Bas	M. H.J. van der Woerd
	M. H. Kelder
Pérou	M. Otto Ramos Bustos
Philippines	Mme Aida M. Jose
Royaume-Uni	Mme Sandra M. Cayless

Slovénie	M. Dusan Hrcek
Sri Lanka	M. W.L. Sumathipala
Suisse	M. Niklaus Kampfer
Syrie	M. A. Razzak Safar Jalani
Thaïlande	M. Suphavit Piamphongsant
	M. Pradit Amornratanayut
Venezuela	M. E. Sanhueza

Observateurs

M. J.M. Libre

M. A. McCulloch

Secrétariat de la Convention pour la protection de la couche d'ozone

M. K.M. Sarma

M. G.M. Bankobeya

Secrétariat de l'OMM

M. Rumen D. Bojkov

Représentants du Groupe d'experts OMM/CE/Groupe de travail de la CSA sur la pollution de l'environnement et la chimie de l'atmosphère

M. I.M. Nazarov
M. E. Sanhueza
M. C.S. Zerefos

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APPENDICE B

DEUXIÈME RÉUNION DES DIRECTEURS DE RECHERCHES SUR L'OZONE DES PARTIES À LA CONVENTION DE VIENNE POUR LA PROTECTION DE LA COUCHE D'OZONE

(Genève, 10-12 mars 1993)

ORDRE DU JOUR

1. OUVERTURE DE LA RÉUNION ET ÉLECTION DU PRÉSIDENT

2. EVALUATION DU RAPPORT DE LA PREMIÈRE RÉUNION DES DIRECTEURS DE RECHERCHES SUR L'OZONE

3. ASPECTS ACTUELS DE L'ÉTUDE DE L'OZONE ATMOSPHÉRIQUE, Y COMPRIS L'ÉTAT D'AVANCEMENT DU SYSTÈME MONDIAL D'OBSERVATION DE L'OZONE ET DES RECHERCHES CONCERNANT LES MODIFICATIONS DU RAYONNEMENT ULTRAVIOLET B ET LEURS CONSÉQUENCES POSSIBLES

4. RAPPORTS NATIONAUX SUCCINCTS SUR LES ACTIVITÉS DE RECHERCHE ET DE SURVEILLANCE EN COURS ET PRÉVUES CONCERNANT L'OZONE

5. EXAMEN DES MOYENS D'ASSURER UNE FORMATION SCIENTIFIQUE ET TECHNIQUE EN MATIÈRE DE SURVEILLANCE ET D'ÉTUDE DE L'OZONE PERMETTANT D'ACCROÎTRE LE POTENTIEL DES PAYS EN DÉVELOPPEMENT

6. MISE EN OEUVRE DE LA CONVENTION DE VIENNE ET DU PROTOCOLE DE MONTRÉAL AMENDÉ

7. ADOPTION DES RECOMMANDATIONS ET CLÔTURE DE LA RÉUNION

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SITUATION DU SYSTÈME MONDIAL D'OBSERVATION DE L'OZONE ($SMOO_3$)

Par M. Rumen D. Bojkov, de l'OMM

INTRODUCTION

1. Il fait partie des attributions du Bureau de la Convention de Vienne de faciliter la mise en oeuvre du programme de recherche et d'observations systématiques et de l'évaluer en application des articles 3 et 4 (entre autres). Cette évaluation est d'ailleurs utile dans la perspective de la deuxième réunion des directeurs de recherches sur l'ozone (qui doit se tenir à Genève du 10 au 12 mars 1993). C'est pourquoi le présent document résume brièvement la situation du Système mondial d'observation de l'ozone ($SMOO_3$), compte tenu des changements intervenus depuis la deuxième conférence des Parties à la Convention de Vienne (Nairobi, 17-18 mai 1991) et évoque les développements ultérieurs indispensables.

2. Lors de leur première conférence (Helsinki, avril 1989), les Parties à la Convention de Vienne ont confirmé "qu'il incombait à l'OMM de coordonner au plan international les sciences de l'atmosphère et les observations systématiques réalisées à l'appui de la Convention". Pendant plus de 35 ans, l'OMM a été chargée de définir les normes propres aux observations de l'ozone, d'uniformiser les techniques afin de garantir la grande qualité des données et de coordonner les recherches et les évaluations connexes. A l'heure actuelle, plus de 140 stations terrestres de surveillance de l'ozone, complétées par des satellites, constituent l'ossature du Système mondial d'observation de l'ozone ($SMOO_3$). Ces stations sont exploitées par près de 60 pays Membres de l'OMM et mettent à contribution des centaines de scientifiques.

3. Il faut rappeler que l'annexe I de la Convention de Vienne appelle à une coopération étendue entre les Parties en ce qui concerne la recherche et les observations systématiques dans les domaines de la physique et de la chimie de l'atmosphère, y compris les observations systématiques concernant l'ozone. En outre au paragraphe 4 de l'article 6 de la Convention de Vienne, il est stipulé que la Conférence des Parties à la Convention ...(j) "s'assure, selon qu'il convient, les services d'organismes internationaux et de comités scientifiques compétents, et **en particulier ceux de l'Organisation météorologique mondiale**, de l'Organisation mondiale de la santé ainsi que du Comité de coordination pour la couche d'ozone, pour des recherches scientifiques, des observations systématiques et d'autres activités conformes aux objectifs de la présente Convention; elle utilise aussi, selon qu'il convient, les renseignements émanant de ces organes et comités".

4. A la suite des découvertes scientifiques effectuées pour la plupart par le $SMMO_3$, l'OMM a publié, dès 1975, un document faisant autorité qui a permis d'alerter l'opinion au sujet d'une raréfaction possible de l'ozone dans la stratosphère, imputable aux activités humaines. Depuis lors, grâce aux contributions essentielles de centaines de chercheurs de nombreux pays et à la participation d'institutions nationales de premier plan (par exemple la NASA et la NOAA aux Etats-Unis d'Amérique), l'OMM a publié, en étroite collaboration avec le PNUE, des rapports périodiques détaillés sur la situation de la couche d'ozone atmosphérique, le dernier en date étant l'Evaluation scientifique de l'appauvrissement en ozone parue en 1991 (Projet mondial OMM de surveillance et de recherche concernant l'ozone - rapport N° 25).

5. Il est bon de rappeler qu'en 1989, les gouvernements ont mis en place la **Veille de l'atmosphère globale de l'OMM**, qui constitue le principal système de surveillance du milieu atmosphérique et qui intègre de nombreuses activités de surveillance et de recherche faisant notamment intervenir la mesure de la composition de l'atmosphère. De ce fait, la VAG fait office de système **d'alerte rapide** permettant de déceler de nouveaux changements dans les concentrations atmosphériques des gaz à effet de serre, les modifications de la couche d'ozone et les fluctuations du transport à longue distance des polluants, y compris l'acidité et la toxicité des pluies ainsi que la charge atmosphérique en aérosols. Le $SMMO_3$ constitue une part essentielle de la VAG, au même titre que le tout nouveau réseau de stations à haute technologie (le NDSC, par exemple). La VAG favorisera la collaboration des pays développés et en développement en vue d'une meilleure compréhension des phénomènes atmosphériques et **permettra de prévoir** les états futurs de l'atmosphère et des systèmes terrestres connexes, l'ozone occupant une place prépondérante dans ses activités.

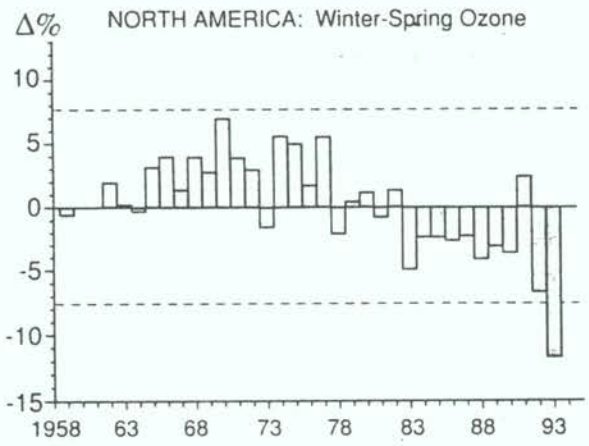
6. La CNUED (Rio de Janeiro, juin 1992), en adoptant le programme Action 21, a explicitement préconisé un renforcement du Système mondial d'observation de l'ozone ($SMMO_3$) et de la VAG. Ces réseaux seront des éléments essentiels du tout nouveau Système mondial d'observation du climat (SMOC).

SITUATION ACTUELLE DU $SMOO_3$

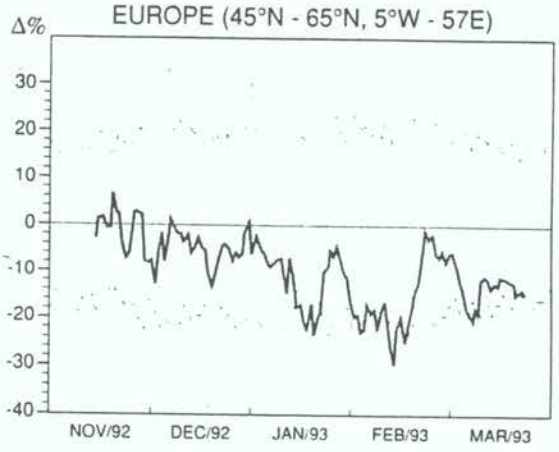
7. La confirmation définitive de la théorie de l'appauvrissement en ozone réside dans la détection de **changements à long terme** de la répartition mondiale de l'ozone, tant totale que verticale, qui à son tour exige une collecte continue et exhaustive de données fiables par le Système mondial d'observation de l'ozone de l'OMM. Les mesures au sol constituent la composante essentielle du système, à la fois du fait de leur valeur propre en tant que seuls relevés à long terme et parce qu'elles constituent la réalité de terrain pour les systèmes satellitaires. Ces derniers sont censés offrir, dans les années à venir, une meilleure couverture de l'espace et des informations complètes tant sur l'ozone total que sur sa répartition verticale. Toutefois, **les informations sur la réalité de terrain continueront d'être nécessaires.** Bien que des mesures précises de l'ozone soient difficiles à réaliser et que leur interprétation sont entachée d'**incertitudes** généralement dues à leur grande **variabilité** naturelle, la communauté scientifique mondiale est néanmoins persuadée que les informations actuellement disponibles **sont exploitées avec compétence**. Il existe toutefois de nombreuses lacunes dans la couverture du globe. Une partie des informations les plus récentes sur le comportement de l'ozone sont résumées ci-dessous.

Ozone total

8. Pendant l'hiver 1992/1993, on a observé dans l'hémisphère Nord de très faibles concentrations d'ozone, inférieures de 9 à 20 pour cent à la normale, aux latitudes moyennes et élevées. Selon les données fournies par le $SMOO_3$, cet appauvrissement s'est produit exceptionnellement pendant deux hivers d'affilée, ce qui explique que l'on ait relevé les plus basses concentrations d'ozone jamais observées entre 45 et 65° de latitude nord. Pendant la période allant de fin janvier à la mi-mars environ, les teneurs en ozone total observées au-dessus de l'Amérique du Nord, de l'Europe septentrionale, centrale et orientale et de la Sibérie étaient inférieures de plus de 20 pour cent à la normale, ce qui s'est traduit par un écart des valeurs de l'ozone total supérieur à celui enregistré durant la même période de 1992, qui correspondait pourtant déjà à une baisse sans précédent (voir figures tirées de Bojkov, Bulletin de l'OMM, 1993).



Ecarts annuels de la teneur totale en ozone par rapport à la moyenne à long terme en hiver et au printemps (de décembre à mars) en Amérique du Nord. Ce tableau indique un déficit en augmentation constante depuis le milieu des années 70. Pendant la saison 1992–1993, ce déficit a été supérieur aux deux écarts types (lignes tiretées horizontales).



Ecarts quotidiens de la teneur moyenne en ozone par rapport à la moyenne à long terme en Europe (45°N - 65°N ; 5°W - 57°E). Mi-janvier, fin janvier, première moitié de février et début mars, les écarts négatifs ont été supérieurs aux deux écarts types (ligne brisée), censés constituer la limite naturelle des fluctuations du taux d'ozone.

9. Bien que ces valeurs les plus basses jamais enregistrées représentent une diminution appréciable du niveau d'ozone total, elles descendent rarement au-dessous de 240 m atm-cm. En revanche, dans l'Antarctique, on a relevé la moyenne journalière de 105 m atm-cm, la plus basse jamais atteinte, à la station du pôle Sud pendant le printemps austral. Bien que l'air fasse l'objet de la même perturbation chimique (C10 > 1 ppbv) au-dessus des deux régions polaires, la circulation atmosphérique dans l'hémisphère Nord est marquée par de fréquents échanges méridiens de masses d'air, ce qui empêche l'atmosphère de trop se refroidir. Les conditions favorables à la destruction de l'ozone ne persistent donc pas, et il n'y a pas de trou d'ozone au-dessus de l'Arctique.

10. Lorsque les calculs relatifs à l'évolution de l'ozone sont poursuivis de manière à inclure les deux dernières saisons hivernales, il apparaît que, depuis 1969-1970, l'ozone s'est régulièrement raréfié, la baisse cumulée atteignant plus de 14 pour cent au-dessus de la partie continentale de la ceinture zonale comprise entre 45 et 65° de latitude nord. Cette baisse régulière doit être distinguée des épisodes d'appauvrissement beaucoup plus marqué de la couche d'ozone d'une durée d'une semaine ou deux qui se sont produits en janvier, février et mars 1993.

11. Dans l'hémisphère Nord, la diminution de l'ozone stratosphérique et l'augmentation substantielle de l'ozone troposphérique modifient le forçage radiatif attribuable à l'absorption de l'ozone. De nouveaux calculs (voir tableau) semblent indiquer que les modifications effectives de la répartition verticale de l'ozone au cours des vingt dernières années peuvent occasionner un forçage radiatif positif (un réchauffement) d'une ampleur comparable à celle du forçage engendré par l'augmentation de tous les autres gaz à effet de serre pendant la même période.

Tableau

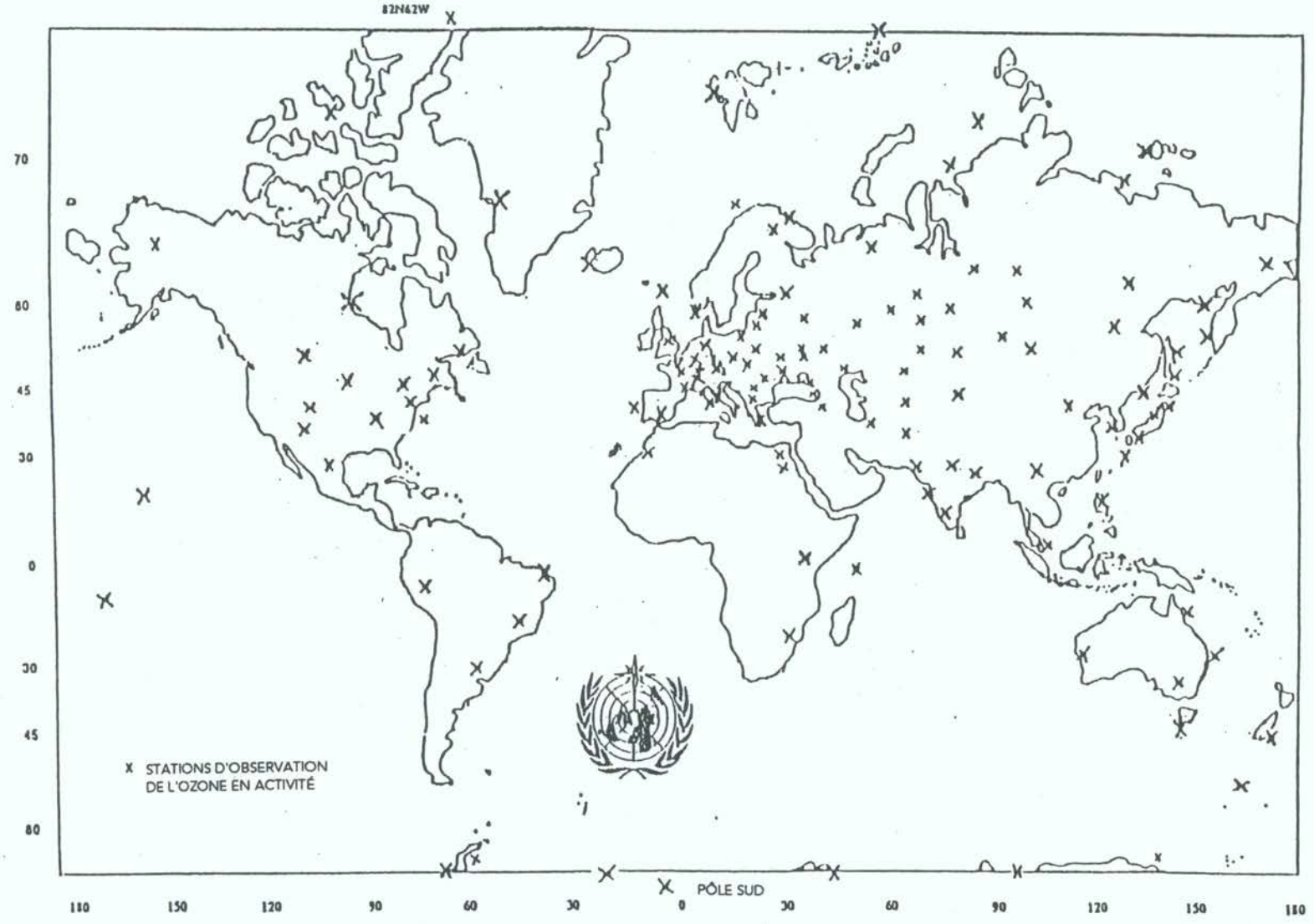
Comparaison des modifications du forçage radiatif (W/m^2) résultant des modifications de O_3 (ozone total et ozone troposphérique) et des modifications de O_3 auxquelles s'ajoutent les changements dus à l'augmentation des concentrations de gaz à effet de serre (CO_2, CH_4, CFC-1, CFC-12 et N_2O) pour les périodes 1971-1980 à 1981-1990, avec des valeurs déterminées de température (T) et de réchauffement dynamique (D) (d'après Wang, Zhuang et Bojkov, GRL, 1993)

	Modifications de 0_3				Combiné avec les autres gaz à effet de serre	
	Ozone total		Ozone troposphérique			
	T	D	T	D	T	D
Hohenpeissenberg						
Janvier	.410	.327	.222	.136	.794	.710
Juillet	.570	.548	.490	.467	1050	1027
Payerne						
Janvier	.356	.190	.242	. 074	.797	.630
Juillet	.397	.136	.097	-.167	.879	.617
Resolute						
Hiver	-.038	-.085	012	-.036	.230	.183
Eté	.194	-.009	.052	-.153	.620	.415
Goose Bay						
Hiver	.025	-.066	.013	.012	.379	.288
Eté	.043	-.218	-.153	-.415	.497	.235

12. Le spectrophotomètre Dobson est l'instrument clé du $SMOO_3$, et c'est sur lui que se fondent toutes les évaluations de l'état de la couche d'ozone. Au cours des vingt dernières années, l'OMM a pris des dispositions pour que les **deux tiers** environ des spectrophotomètres Dobson régulièrement utilisés soient améliorés et/ou étalonnés, soit avec l'instrument étalon primaire mondial conservé par la NOAA à Boulder, au Colorado, soit avec un instrument étalon régional (secondaire). La majeure partie des données Dobson sur l'ozone communiquées au Centre mondial des données sur l'ozone (CMDO) de l'OMM, exploité en collaboration avec le Service de l'environnement atmosphérique du Canada, sont obtenues avec ces instruments. A l'heure actuelle, quelque 80 stations en sont équipées et transmettent régulièrement leurs données.

13. Il faut noter que les spectromètres d'ozone Brewer sont utilisés opérationnellement depuis 5 à 6 ans dans le cadre du $SMOO_3$ et que le CMDO dispose des premières données issues des mesures systématiques effectuées à l'aide de ces instruments (depuis janvier 1993, 28 stations au total communiquent des données de ce type). En juin 1992, l'OMM a organisé à Charlottesville, en Caroline du Nord, le deuxième débat technique sur l'exploitation, l'étalonnage et le traitement des données des instruments Brewer, conjointement avec le deuxième atelier international sur la réévaluation des données Dobson relatives à l'ozone. Les échanges d'expérience technique entre les opérateurs des deux sortes d'instruments se sont révélés fort fructueux.

VEILLE DE L'ATMOSPHÈRE GLOBALE – Système mondial d'observation de l'ozone ($SMOO_3$)



14. La réalisation d'étalonnages et de comparaisons périodiques (la comparaison des divers instruments des stations avec le spectrophotomètre Dobson étalon mondial conservé par la NOAA à Boulder ou les inspections effectuées avec l'instrument Brewer itinérant de l'OMM) joue un rôle **essentiel** dans la préservation de la haute qualité des données sur l'ozone. Actuellement, plus des deux tiers de tous les instruments présentent des écarts inférieurs à $\pm$ 1,5% par rapport aux étalons. Il s'agit là d'une excellente performance d'ensemble du $SMOO_3$. Toutefois, les incitations à une amélioration encore plus prononcée nécessitent davantage de fonds internationaux, dont le rassemblement devra mobiliser toutes les Parties à la Convention.

15. Même lorsque la qualité est excellente, la couverture du globe assurée par les stations au sol est loin d'être satisfaisante, notamment en raison du **manque de données** dans la ceinture intertropicale, en Amérique du Sud et, jusqu'à un certain point, dans l'Arctique (voir la carte jointe). Lors de la deuxième conférence des Parties à la Convention de Vienne, le Bureau a fortement recommandé l'implantation de 12 à 15 stations dans ces régions. Les Parties à la Convention ont adopté la décision II/9 appelant à une extension du $SMOO_3$ et à la contribution dans ce dessein au Fonds spécial de l'OMM pour la surveillance de l'environnement. Toutefois, aucun crédit n'a été jusqu'ici alloué à cet effet.

16. L'OMM est quant à elle parvenue à obtenir, à une seule reprise, une contribution du Fonds mondial pour l'environnement (GEF) en vue de l'implantation de quelques stations de la VAG dans des pays en développement, dont trois stations du $SMOO_3$ (Argentine, Algérie et Chine), en 1993. L'OMM est par ailleurs sur le point d'installer une autre station Dobson au Nigeria, et le GEF devrait débloquer des fonds afin d'intensifier la surveillance de l'ozone et du rayonnement UVB dans la partie méridionale de l'Amérique du Sud et de pallier ainsi le manque de données dans cette région.

Répartition verticale de l'ozone

17. La diminution de la concentration d'ozone dans les couches supérieures de la stratosphère (aux environs de **40 à 45 km**), prévue par modèle et imputable aux émissions de CFC, est théoriquement plusieurs fois supérieure à l'appauvrissement prévu en ozone total correspondant. La progression de la teneur à CO_2, responsable du refroidissement de la haute stratosphère, pourrait y accroître la concentration d'ozone, mais toutefois pas au point de compenser l'appauvrissement prévu dû aux CFC. Le fait est que l'on observe une raréfaction effective et importante **dans la basse stratosphère** (probablement attribuable aux réactions hétérogènes qui s'y produisent). En conséquence, **les données correspondant à ces couches** devraient fournir les informations **les plus sensibles** sur les perturbations de l'ozone. De plus, les indices d'un accroissement progressif de l'ozone troposphérique susceptible d'avoir une incidence marquée sur le climat doivent être **étayés** par des observations supplémentaires de la répartition verticale de l'ozone. Quoique l'importance de ces mesures soit généralement reconnue, les progrès enregistrés dans ce domaine **sont lents** et les pays devraient mettre davantage l'accent sur une observation régulière de la répartition verticale de l'ozone, **à la fois par ozonosondes et par le procédé Umkehr.**

18. L'OMM a mis en train un projet international d'examen minutieux et de réévaluation de l'ensemble des 40 000 profils Umkehr dont dispose le CMDO et qui couvrent les 35 dernières années. Un nouvel algorithme avec des profils de température plus précis, de nouveaux coefficients d'absorption de Bass et Paur et, surtout, la prise en considération rigoureuse des corrections relatives aux aérosols devraient fournir des informations inestimables dans l'optique de l'évaluation des modifications de la couche d'ozone dans le plan vertical et de l'étalonnage à partir d'une source indépendante des profils de l'ozone transmis par certains satellites.

Rayonnement UVB

19. Depuis que des propositions détaillées en matière de surveillance mondiale ont été formulées en 1977 par l'OMM (Projet mondial OMM de surveillance et de recherche concernant l'ozone - rapport N° 3), on note un intérêt de plus en plus vif pour les informations sur les **doses réelles de rayons UVB** atteignant le sol. Cet intérêt s'est d'ailleurs aiguisé depuis que l'appauvrissement en ozone est devenu un fait avéré. Au début d'octobre 1992, le fait que les régions très récemment peuplées de l'extrémité sud du continent sud-américain ont subi les conséquences, pendant quelques jours, d'un appauvrissement de plus de 30% de la couche d'ozone lorsque le trou d'ozone de l'Antarctique s'est étendu jusqu'à elles, a encore accentué l'intérêt porté aux données relatives au rayonnement UVB.

20. Conformément aux conclusions de nombreuses études scientifiques et réunions internationales, il est indispensable d'effectuer une surveillance mondiale fiable du rayonnement UVB, de manière à pouvoir se pencher objectivement, tant au plan physique que biologique, sur ses fluctuations et ses effets. On estime généralement que cette tâche nécessite quelques douzaines d'instruments **spectraux** à haute résolution (0,5 nm), complétés par quelques centaines de radiomètres à filtres à large bande, fréquemment et convenablement étalonnés. En complément nécessaire de cette surveillance, il faut continuer à mesurer les diverses autres caractéristiques du rayonnement solaire, l'ozone total et en surface, la nébulosité, la température, l'humidité, etc., de manière à faciliter l'analyse des modifications du rayonnement UVB. L'OMM encourage d'ailleurs ses stations VAG d'importance mondiale (11 actuellement, et qui devraient être au nombre de 25 à 35 avant la fin de la présente décennie) ainsi que les stations VAG-SMOO$_3$ d'importance régionale à procéder à ces mesures. Il faut néanmoins rappeler qu'**il n'existe pas** actuellement de système de surveillance fiable du rayonnement UVB.

21. Pour faciliter l'accès initial à des données de qualité contrôlée sur la rayonnement UVB, l'organe directeur de l'OMM, le Conseil exécutif, a approuvé en 1992 la création du **Centre mondial de données sur le rayonnement ultraviolet**, qui doit être établi au même endroit que le Centre mondial de données sur l'ozone de l'OMM, exploité en collaboration avec le Service canadien de l'environnement atmosphérique, situé à Toronto. Toutes les stations sont invitées à suivre les procédures de contrôle de la qualité définies et à communiquer régulièrement leurs données à ce centre mondial de collecte, qui entrera en service à l'automne 1993.

RECOMMANDATIONS DIVERSES

22. Le bref exposé ci-dessus montre clairement que la surveillance de l'ozone se poursuit au même rythme que pendant la décennie **précédente.** Il y a largement place pour des améliorations au plan quantitatif (meilleure couverture géographique) et qualitatif (données convenablement étalonnées et d'une qualité parfaitement contrôlée). Les précédentes interventions en faveur de l'élargissement et de l'amélioration du Système mondial d'observation de l'ozone faites par les groupes d'experts chargés des évaluations scientifiques dans le cadre du Protocole de Montréal, par l'OMM et le PNUE et, plus récemment, par la CNUED (Rio de Janeiro, 1992) ne peuvent être mise en application qu'à condition que des fonds suffisants soient débloqués. Les données sur l'ozone et les informations connexes sont des éléments essentiels de la réalisation des objectifs de la Convention et de la vérification de l'efficacité et de la mise en application du Protocole. Cela a été bien compris, et un appui financier a été sollicité par le truchement des recommandations émises par le Bureau lors de sa réunion de mars 1991; par ailleurs, la décision II/9) des Parties invite les pays développés à contribuer au Fonds spécial de l'OMM pour le SMOO$_3$. Toutefois, cela n'a guère été suivi d'effets jusqu'ici.

23. Il faut bien reconnaître que les activités du $SMOO_3$, dans sa forme actuelle, ne satisfont pas aux exigences de la Convention. Moyennant des dépenses **non renouvelables** de quelque 6 millions de dollars, étalées sur deux ans, on pourra développer le $SMOO_3$ dans les régions tropicales et en Amérique du Sud et effectuer des comparaisons et des étalonnages réguliers dans de bonnes conditions. L'OMM a dressé une liste précise des propositions de financement destiné à ces activités.

24. Une autre recommandation importance se rapporte au fait que certaines stations (essentiellement les stations européennes de sondage de l'ozone) omettent de communiquer leurs données au CMDO établi à Toronto et limitent ainsi les quantités de données exploitables dont pourrait tirer parti la Convention. Cela doit être porté à l'attention des pays concernés, de sorte qu'ils puissent remédier à ces anomalies.

25. L'OMM continuera à prodiguer ses conseils et à fournir l'infrastructure en vue de la maintenance et de l'étalonnage des stations du $SMOO_3$ dans sa forme actuelle ou élargie. Ce système constitue la seule source continue de données sur l'ozone dont a besoin la communauté internationale pour analyser de manière objective les modifications de la couche d'ozone. En conséquence, il est essentiel que les Parties à la Convention s'engagent de façon ferme à accentuer leur appui.

APPENDIX D
(reference item 4)

BRIEF NATIONAL REPORTS OF ON-GOING AND PLANNED OZONE RESEARCH AND MONITORING

ARGENTINA

OBSERVATION ACTIVITIES :

Through the National Weather Service, Argentina has been carrying out systematic measurements of the total ozone content, by means of Dobson spectrophotometers, at :

a) Obs.Villa Ortúzar (34º35'S, 58º29'W) since 1966

b) Centro Met.Antártico Vcom.Marambio (64º14'S, 56º43'W) since 1986.

At the said stations , additional measurements are also performed by means of sunphotometers and pirheliometers,and a 1st Class Solar Radiation Station also functions at Villa Ortúzar.

Since early 1991 , a Brewer espectrophotometer has been operating at Base Belgrano (72º52'S, 34º34'W), as part of a joint project with the National Antarctic Direction and the "Programa Nationale de Richerche in Antartide" (Italia).

Since 1990, the Marambio Antarctic Meteorological Center operates an ozone sounding system, jointly with the Finnish Met. Institute . This is based on an agreement of cooperation that concluded at the end of the past year . Ozone soundings are performed twice monthly , from December through July , and twice weekly on the remaining months, which are the ones that coincide with the "Ozone Hole".

All the information that was obtained with the said equipment, is channeled to the GOOS via the GTS ; and it is also concentrated and distibuted at the Buenos Aires Ozone and Radiation Data Concentration and Distribution Regional Centre to users that may require it at the regional level.

At the CADIC (Austral Scientific Research Centre), which depends on the National Scientific and Technological Research Council, measurements are performed with a spectroradiometer , as part of the NSF Polar UV Network.

Between the months of February and August 1992, observations at Marambio were suspended , while this equipment was transfered for comparisson and maintenance. This task was carried out at the NOAA - CMDL laboratories in Boulder (USA) , with the partial support of WMO (The cost of the return shipment).

ACTIVITIES PLANNED FOR THE SHORT-TERM

The Project for the installation of a GAW Observatory of global importance in Tierra del Fuego, is in development, as part of a network planned by WMO. To date , the work to achieve the neccesary structure during the present year,has begun. A planning meeting has been convened by WMO,(Buenos Aires, March 1993).

At the regional level, the Monitoing of Greenhouse Gases Including Ozone Regional Network is to be installed in the Southern Cone countries (Argentina,Brasil,Chile,Paraguay,Uruguay) To date , we are waiting for the resolutions by the international organizations, of the approval of financial assistance. while Argentina already has the required basic infraestructure. At the said meeting, it was suggested that Argentina act as a Center for concentration and distribution for ozone and radiation data , and Center for training in ozone and UV-B measurements . These responsabilities have already begun to be assumed , following the widespread reports on th 1992 Antarctic Ozone Episode.

RESEARCH ACTIVITIES :

The Argentine Antarctic Institute, in colaboration with the Nationat Institute of Aerospace Technology of Spain , have planned the installation of spectrometers in the UV-B limit , at Bases Belgrano y San Martin.

There is a research proposal within the German-Argentine cooperation for the study of veretical profiles of tropospheric ozone in the Southern Hemisphere,submitted by the Max Planck Institute for Meteorology of Hamburg (Germany), and some Institutes of Argentina (NWS,INQUIMAE,CITEFA).

The CIBIOM (Biometeorological Research Center), that depends of the CONICET , has a research line of physic radiometry and UV biological aspects. There are results of studies on photoadaptation of the subantarctic plancton with subletal dosis of UV

The University of Mendoza participates in the MAS (Milimeterwave Atmospheric Sounder),in colaboration with the MPAE (Max-Planck Institute for Aeronomie (Germany) . This project is to obtain global ozone, water vapor,CLO, Pressure and Temperature data , at 20 to 90 km of altitude , between 60ºN and 60ºS, using sensors to be instaled in the Space Shuttle of NASA , and the 2nd mission (ATLAS2) will take place in March 1992 . Other projects as TROPWA, trends to measure the tropospheric and mesospheric water vapor using microwave radiometry - spectrometry . For the short term, these measurements will be complemented with others of ozone in 142 GHZ.

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AUSTRALIA

The Australian programme in research and monitoring of stratospheric ozone has maintained the activities outlined in Appendix D of the report of the previous Meeting of Ozone Research Managers. Activities not previously reported, and which also relate to ozone research, are included here.

- Research into the causes of winter mid-latitude ozone loss in the southern Australasian region has been completed and published in two GRL papers, and results were presented at the 1992 Quadrennial Ozone Symposium (Va, U.S.A.). This work was carried out in collaboration with NASA/GSFC and NIWAR (NZ). Further analysis on winter ozone losses is also being carried out on SAGE II and SBUV ozone profile data for the southern Australasian region.

- The RA V standard Dobson spectrophotometer (instrument #105, Ozone Unit, BoM) waws calibrated against the world standard (NOAA, instrument #63) at Boulder, Co., U.S.A., June 1992. Zenith corrections for Melbourne Dobson measurements were re-derived based on the extensive record of sun versus zenith observations since 1984.

- Preliminary ozone sonde launches were carried out at Macquarie Island in December 1991 to examine capability of supporting a permanent ozone sonde program. Installation of a hydrogen electrolyser at Macquarie Island in 1992 upgraded balloon launching facilities. The funding for an ozone sonde program at Macquarie Island has not yet been realised.

- The Australian Bureau of Meteorology Research Centre GASP model analysis has been improved and has demonstrated a five day prediction capability of the break-up of 1992 Antarctic ozone hole. It seems likely that the prediction capability can be extended to approximately ten days.

- An ozone research program between the Australian Bureau of Meteorology, CSIRO Division of Atmospheric Research, CSIRO Division of Applied Physics, Cray Research, and Monash University (Melbourne) under the Australian **Cooperative Research Centre** (CRC) for Southern Hemispheric Meteorology is to be established in July 1993. This will create a major resource of expertise in the science of atmospheric ozone, bringing together expertise in stratospheric dynamics and transport, stratospheric modelling, stratospheric chemistry and modelling, and tropospheric chemistry.

- Relevant Australian Bureau of Meteorology areas, including ozone research and monitoring, solar radiation, Cape Grim , and all GAW matters, have been combined into an "**Atmosphere Watch**" section. Ozone research activities in this section will interact with other research under the CRC.

- The CSIRO Division of Applied Physics in Sydney has a project designed to provide assessment of long-term ozone trends in the stratosphere. This involves laboratory investigations of chemical processes believed to affect the distribution of ozone in the stratosphere, and the development of 2-D stratospheric models that include photochemistry and dynamics.

- The Cape Grim Baseline Air Pollution Station (NW Tasmania) has been involved in precision monitoring of surface atmospheric constituents (including CFC concentrations) since 1976. The data records of some of these constitents are the longest in existence. UVA and UVB spectral monitoring is also carried out on a regular basis.

- UV spectral measurements are being carried out by the Australian Radiation Laboratories at Melbourne and Davis Base, as well as broad-band UVA and UVB measurements at several locations across Australia. UV measurements (non-spectral) and biological impacts research are also being carried out at Flinders University (SA) and the Australian Antarctic Division.

- The University of Adelaide has a project involved in the study of troposphere/stratosphere atmospheric constituent exchange processes using VHF radar wind field measurements.

- Observations and modelling work on UVB interaction with tropospheric ozone and hydrogen peroxide is being carried out in a collaborative study between the CSIRO Div. of Atmospheric Research, the University of East Anglia and the Australian Bureau of Meteorology. A paper on the work has been published in Nature.

Publications:

Lehmann, P., D.J. Karoly, P.A. Newman, T.S. Clarkson, W.A. Matthews, *Long-term winter total ozone changes at Macquarie Island*, Geophys. Res. Lett., 19, 1459-1462, 1992.

Lehmann, P., D.J. Karoly, P.A. Newman, T.S. Clarkson, W.A. Matthews, *An investigation into the causes of stratospheric ozone loss in the southern Australasian region*, Geophys. Res. Lett., 19, 1463-1466, 1992.

Lehmann, P., *A statistical seasonal analysis of winter decreases in ozone at Macquarie Island*, submitted Geophys. Res. Lett., 1993.

Ayers et al., *Photochemical production of hydrogen peroxide and co-destruction of ozone in marine air over the southern ocean*, Nature, 360, 446-448, 1992.

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BELGIUM

Ozone research in Belgium is primarily spread across national scientific institutes, namely the Belgian Institute of Space Aeronomy (BISA), the Royal Meteorological Institute (RMI) and the Institute of Hygiene and Epidemiology (IHE).

1. Ground-based observations

- A Daily monitoring of the total ozone amount is performed at Uccle (50°48'N, 4°21'E) using a Dobson and a Brewer spectrophotometer, within the framework of the Global Ozone Observing System (GO_3OS). The Brewer spectrophotometer is completely automated and allows a monitoring of UV-B radiation. The complete data record of both instruments was back-corrected and was used for a trend analysis (RMI).

- Systematic measurements of the amount of ozone and NO_2 in the stratosphere are performed at the Jungfraujoch using a UV-visible spectrometer (SAOZ), in connection with the ESMOS project. The impact on the data of the injection within the stratosphere of large quantities of aerosols from the eruption of Mount Pinatubo was studied (BISA).

- During the winter months and in connection with the European EASOE campaign: measurement of the total amount of ozone and NO_2 at Keflavik (64°N, 23°W) using a spectrograph that covers the spectral region from 300 to 600 nm (BISA).

- Participation in a STEP program "Determination of standards for an UV monitoring network" (BISA).

- The near surface concentration of ozone and other minor constituents is measured at the campus of the Free University of Brussels, using the DOAS method. Part of these measurements is done within the framework of EUROTRAC (BISA).

- The ozone concentration at the surface is measured continuously at 5 locations, within the framework of the Belgian automatic air pollution monitoring network (IHE).

2. Balloon-borne observations (RMI)

- The vertical ozone distribution is measured 3 times per week at Uccle by means of Brewer-Mast sondes. The data record of 24 years is back-corrected to allow an ozone trend analysis as a function of altitude. Some studies using these measurements are done in connection with the TOR/EUROTRAC project and the EASOE campaigns. Other studies are done in cooperation with RIVM and KNMI (Netherlands).

- The daily variation of profiles of ozone and meteorological parameters in the boundary layer is studied during episodes of photochemical ozone formation, utilizing a tethered balloon.

3. Space experiments (BISA)

- Within the framework of a project to measure the solar spectrum from UV to the near IR, Belgium participated in two space missions.
  - The SOLSPEC experiment aboard the ATLAS-1 mission (NASA) was launched on 24 March 1992 and had a duration of 9 days.
  - The SOSP experiment aboard the EURECA 1 mission (ESA) was put in orbit on 1 August 1992 and has a nominal duration of 6 months.

- With the Grille spectrometer aboard ATLAS-1 absorption spectra of ozone, HCl and a number of other species were measured during more than 65 occultations.

- Preparation of the MIRAS experiment. MIRAS is a limb-sounding infrared high resolution spectrometer designed as a payload of the MIR station.

4. Laboratory studies (BISA)

- Measurement of UV absorption cross sections of species which result from photochemical degradation of alternate halocarbons.

5. Modelling studies

- A zonal 2-D model was mainly used to study budgets of chlorine and fluorine (BISA).

- A model is developed to forecast the photochemical production of ozone near the surface during the summer months (RMI).

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BRAZIL

Ozone research in Brazil is conducted by the National Institute for Space Research, INPE, located in the city of S. José dos Campos, near S. Paulo (23 S, 45 W). The ozone group of INPE is a relatively new one, having been created around 1985, with the implementation of laboratory space and official support. Actually, however, the work on ozone research has started much earlier, with the operation of a Dobson spectrophotometer in Cachoeira Paulista (a city near S. José dos Campos) since 1974. With the official creation of this group, not just ozone measurements have been made, from several sites in Brazil, but a serious effort was started to begin work in Atmospheric Chemistry, in a much more comprehensive way. Today work is carried out with a number of modern sensors, at a number of different sites in Brazil, with interest in tropospheric and stratospheric chemistry. As reference publications we cite for tropospheric work: Excess ozone production in Amazonia from large scale burnings, Kirchhoff et al.,J.Atmosph.Terr.Phys.,54, 583-588, 1992; Enhancements of CO and O3 from burnings in sugar cane fields, Kirchhoff et al.,J.Atmosph. Chem., 12, 87-102, 1991; Surface carbon monoxide measurements in Amazonia, Kirchhoff and Marinho, J.Geophys. Res., 95, 16933-16943, 1990. For stratospheric work we cite our recent Natal paper Ozone climatology at Natal, Brazil, from in situ ozonesonde data, J.Geophys. Res., 96, 10899-10909, 1991.

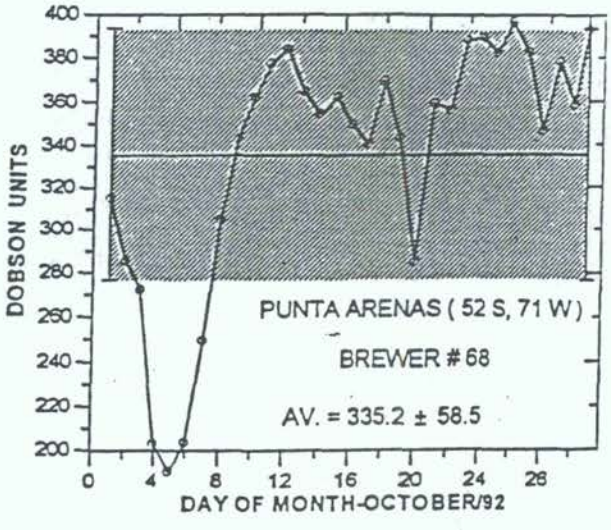
In an effort to create local specialists the Institute has invested heavily in the last few years, as is demonstrated by the number of sophisticated equipments that were acquired to form our stratospheric ozone network, which we present below:

THE BRAZILIAN STRATOSPHERIC OZONE NETWORK

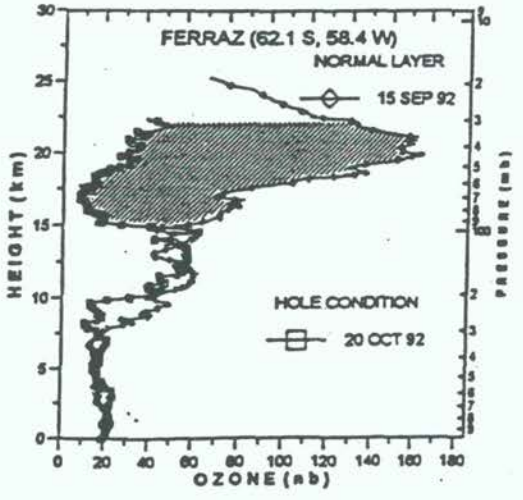
MONITOR	SITE	OBSERVES	START DATE
BREWER*	CUIABÁ 16S,56W	O3,SO2,UV	OCT 90
BREWER	STA MARIA 29S,54W	O3,SO2,NO2,UV	MAY 92
BREWER	RIO BRANCO 09S,67W	O3,SO2,NO2,UV	OCT 91
BREWER	PUNTA ARENAS 52S,71W	O3,SO2,NO2,UV	AUG 92
DOBSON**	CACHOEIRA 23S,45W	O3	1974
DOBSON	NATAL 06S,35W	O3	1978
SONDES	COM. FERRAZ 62S,58W	O3	APR-OCT 92

*BREWER SPECTROPHOTOMETER **DOBSON SPECTROPHOTOMETER

The year 1992 was a very active one for the Brazilian ozone group. Data was collected at all the sites shown in the Table above, except at Rio Branco where a lightning discharge has kept the instrument inoperable. The Antarctic stratospheric ozone hole has been observed for the first time by the Punta Arenas Brewer, during a short period in October, as shown by the figure below



The group has also made a number of ozonesoundings at the Brazilian Antarctic station Commander Ferraz, where the stratospheric ozone hole was observed by several soundings. An example is shown below:



For more information contact V.W.J.H.Kirchhoff - INPE, C.P. 515 - 12201 S.José dos Campos, S. Paulo, Brazil. Fax. 55 123 218743 Phone - 55 123 229887

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CANADA

There have been several recent developments in the area of ozone research and monitoring in Canada under the co-ordination of the Atmospheric Environment Service (AES). Many of these advances have come as a result of Canada's Green Plan which is a national agenda of research, regulation, provision of public information and other activities aimed at protecting the environment. The following report summarizes advances related to ozone research and monitoring.

Monitoring Network

Within the past year the ozone monitoring network in Canada has been expanded. Brewer spectrophotometers were installed for ground-based monitoring at Halifax and Winnipeg in July, 1992 and at Montreal in February, 1993. Ground-based monitoring is also scheduled to commence at the Arctic Ozone Observatory in Eureka this Spring. In May, 1992 all Brewer network instruments were upgraded and calibrated to enable the routine monitoring of spectral UV-B radiation. A network of broad-band UV-B instruments was established in May, 1992. Routine balloon ozonesonde measurements commenced at Eureka in early 1993.

An automatic data reporting system was made operational in March, 1993 for the AES ground-based ozone monitoring network. The Brewer instrument has been programmed to report automatically (usually over telephone lines) to the Canadian wide area network (WAN) which is used to receive and distribute regular meteorological data on a real time basis. Summaries of preliminary ozone values are reported from each station to the WAN about once an hour. These data are available immediately throughout the country for real time operational applications.

Public Awareness Programs in Canada

In response to the increasing concerns expressed by the Canadian public regarding the

state of the ozone layer and possible increased levels of UV-B radiation which may result from ozone depletion, the AES has initiated two public awareness programs: Ozone Watch and the UV index program. Ozone Watch reports on the current state of the ozone layer and the UV index provides quantitative information and forecasts on UV-B radiation levels.

The Ozone Watch program reports the most recent ozone values averaged over a two week period and compares them with the corresponding historical seasonal values which were measured prior to 1980. These values are reported to the public on a weekly basis. At present the historical comparisons are made at the five sites which have records since about 1960. The comparisons are accompanied by a statement which summarizes the results and outlines possible links with other factors such as weather patterns or volcanic effects.

The UV index program provides to the public a quantitative daily forecast of UV-B radiation levels and, in close co-operation with the medical community, provides advice for appropriate precautionary action. Index values are proportional to erythemally weighted UV-B fluxes through a horizontal surface and are valid at local noon under clear sky conditions. Prediction of the UV index is a two stage process. The first step is the prediction of a total ozone field. At present this is achieved by using the most recent measurements of total ozone to correct a predicted ozone field made from the forecast meteorological field and past meteorological-ozone relationships. The second stage is to use the total ozone field to establish a clear sky UV-B radiation field at local noon. This is done through an empirical relationship between clears sky UV-B flux and total ozone values established from four years of simultaneous measurements made at Toronto. Surveys have indicated that the public is generally aware of the UV index program and that the product is beneficial.

World Ozone Data Centre

The AES hosts the World Ozone Data Centre (WODC) in Toronto on behalf of the WMO. With the recent increased interest and requirements for ozone data, the AES is planning to upgrade the data archiving and distribution operations. Recently, it has become possible to request and receive data through electronic mail. Plans for allowing users to review and retrieve data interactively over telephone lines are presently being considered.

In 1992, the AES volunteered to expand the WODC to include the archiving of UV-B data. Workshops are being held to assist in the planning of the operation of the UV-B data centre through the assessment of measurement capabilities and user requirements for data.

Arctic Research and Monitoring

Construction of the Arctic Ozone Observatory in Eureka (80N) was completed in late 1992. This observatory will play a key role in the Arctic component of the international Network for the Detection of Stratospheric Change (NDSC). Installation of two Lidar systems (one DIAL ozone and one aerosol) and a solar absorption infrared interferometer commenced in early 1993. The aerosol Lidar and the interferometer are both joint Japanese-Canadian experiments. Preliminary Lidar results have been obtained.

The wintertime Arctic balloon campaign which started at Alert in 1987 was carried out in January-March, 1993. Measurements of ozone, HNO3,aerosols and NO2 are made with some co-operation with scientists from USA. Ground-based sampling of ozone depleting substances continued at Alert.

Research on UV-B Effects

Concern is emerging about the possible effects that stratospheric ozone depletion could have on Canada's ecosystems during the next two or three decades. Canada has a very large

Arctic and sub Arctic land mass, with innumerable lakes and the longest coastline of all countries. Therefore, concerns are focused primarily on aquatic and terrestrial ecosystems. A preliminary review of existing Canadian research on UV effects on biological systems indicates that, while some expertise exists, it is scattered and not integrated.

Canada gives high priority to the development of a nationally coordinated research and monitoring program to investigate potential effects of ozone depletion. The program will include, among others, the development of a UV climatology and investigation, through field and laboratory studies, of the effects of change in the UV regime to aquatic and terrestrial ecosystems. The first workshop to recommend a general direction for the program will be held in Toronto on April 22-23.

Other Research and Monitoring Activities

Modelling studies of stratospheric photochemistry have been carried out at York University. The AES is working with York University to incorporate photochemistry in a dynamic model.

Ozone trend analyses are being carried out using ground-based and ozonesonde data. Relationships between meteorological variables and total ozone are being studied to improve trend detection capabilities and ozone forecasting.

The AES developed a compact UV-Visible CCD array spectrometer which measures in the 300nm to 900nm wavelength range. This instrument was used by a Canadian Mission Specialist from the Space Shuttle to take solar occultation measurements in October, 1992. The instrument is also included as part of the NASA SPADE measurement program from on board the ER-2 aircraft.

In co-operation with scientists from Russia, the AES has participated in the installation of a Brewer instrument on a commercial Aeroflot aircraft which will make routine trans-polar flights between Moscow and Montreal. Total ozone above the aircraft will be measured. Results of this routine measurement set made from a platform above the troposphere will be useful for monitoring stratospheric polar ozone and for comparison with satellite data.

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COMMISSION FOR THE EUROPEAN COMMUNITIES

The EC Environment R&D Programme (1991 - 1994)*) is aimed at contributing to the scientific and technical basis for the implementation of EC environmental policy. The specific objectives for the topic "Stratospheric Ozone" within the Programme are as follows:

a) to understand and forecast processes which lead to the depletion of the ozone layer and

b) to estimate the health risk of exposed population groups and to quantify effects on the natural environment.

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*) The Programme is open to a project-by-project participation of institutes and organizations from non-Member States; a full participation of the EFTA States (except Switzerland) is foreseen in the framework of the EEA agreement.

Furthermore, the Programme supports the development of techniques and instrumentation to study stratospheric and tropospheric chemistry.
The Environment Programme (1991 - 1994) constitutes an extension and expansion of the former STEP Programme (1989 - 1992)**). It supports, in line with the recommendations adopted at the First Meeting of the Ozone Research Programme Managers, systematic measurements, process studies, prediction and impact related issues by means of long-term strategic research as well as campaign-type field experiments.

In particular, emphasis has been put on the following topics:

a) Stratospheric chemistry and ozone depletion

Detection and spatial extent of perturbed chemistry and associated ozone loss.

Effects of transport of chemically perturbed air.

Homogeneous and heterogeneous processes influencing the partitioning and distribution of active halogen, nitrogen and hydrogen radicals.

Dynamics and composition of lower stratospheric air.

Distribution and trends of solar UV flux in Europe.

b) Health risks and risks to the natural environment

Identification of groups at risk and estimation/prediction of exposure by direct/indirect methods.

Understanding mechanisms of UV radiation effects, primarily on human skin, and on the immune system.

Accurate field exposure levels of UV-B radiation.

Biological action spectra of UV-B for sensitive components of the foodweb.

Direct effects of UV-B radiation on sensitive organisms in aquatic and terrestrial ecosystems.

<u>Implementation</u>:

Co-ordinated research projects funded through:

- EC R&D Programme "Environment"
- National R&D Programmes

European-wide co-ordination in the field of stratospheric chemistry and ozone depletion is promoted by a Task Group, consisting of:

- The <u>Co-ordinating Unit</u> hosted by the British Antarctic Survey, Cambridge, jointly funded by the UK and the CEC; head: J. Pyle.

**) Austria, Finland, Iceland, Norway and Sweden are associated to the STEP Programme.

- The "Science Panel" composed of 15 senior scientists from EC and EFTA countries; chairman: G. Mégie.

Research into the properties of CFCs and potential substitutes, into clean technologies and recycling technologies is dealt with in other research areas of the Environment R&D Programme.

Prospects for the future:

Understanding the dynamics and chemistry of ozone in middle latitudes in the lower stratosphere remains the highest scientific priority. In this connection, ground-based monitoring of stratospheric ozone-related species continues to be a key component for future stratospheric research on a global and macro-regional scale.
As regards modelling activities, the strategy aims at increasing the detailed understanding of the relevant atmospheric processes in order to carry out long-term predictions of possible ozone change.
Field experiments and modelling will be supported by laboratory studies with emphasis on a better understanding of the role of the chemistry of atmospheric bromine compounds, new chain carriers and catalytic cycles, liquid stratospheric particles, key chemical components of the stratosphere (HOCl, ClONO2, N2O5, etc.), and low temperature homogeneous and heterogeneous chemistry. Research aimed at the improvement of data on uptake coefficients on PSC materials, on the degradation of HFCs, HCFCs, and similar compounds is required as well as laboratory spectroscopic studies in support of remote sensing measurements.
In relation to estimating and predicting the impact of changes in UV-B radiation on health and the natural environment, it is intended to further develop research on the themes described above. A comprehensive assessment will be made of European efforts in this area and a long-term European strategic research plan will be formulated at a workshop in Munich on 27-29 October 1993. The workshop, organized by the Commission of the European Communities and hosted by the Forschungszentrum für Umwelt und Gesundheit (GSF), will be open to European scientists working in this field.

A call for proposals covering the second phase (1993/94) of the EC R&D Programme "Environment" will be launched in April 1993 with a deadline of 11 June 1993 (tentative).

Besides the above described research topics, the call will also invite the submission of proposals in the framework of the Second European Stratospheric Arctic and Middle Latitude Experiment (SESAME). A planning document is available on request to all scientists interested to participate in SESAME.

SESAME will build on the experience of the extremely successful European Arctic Stratospheric Ozone Experiment (EASOE) which covered the entire winter period from November 1991 to March 1992 and which brought together over 300 scientists from 18 countries.

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CUBA

On 12 October 1992, Cuba became Party of the Vienna Convention for the Protection of the Ozone Layer (1985), and its Montreal Protocol on substances that deplete the Ozone Layer (1987).

Actually we are presenting to the Executive Committee of the Multinational Fund our National Country Programme. This programme has been prepared by the National Commission for Environmental Protection of Cuba (COMARNA) and has received technical assistance for its preparation by two UNDP advisors.

In the near future, three resolutions will enter into force:

- Resolution of the Academy of Sciences that create the National Group for the Montreal Protocol Implementation.
- Resolution of the Academy of Sciences that create the National Commission of Climate Changes.
- Resolution of the COMARNA for regulation of refrigeration and climatization technologies, importation and consumption of ODS.

We are making particular efforts for the elaboration of the second national country programme of technological reconversion.

In relation to stratospheric and tropospheric ozone monitoring, Cuba has a strong Meteorological Institute that belongs to the Academy of Sciences. This institution has developed a wide monitoring programme but it has difficulties concerning the quality or capacity and calibration of monitoring equipment and instruments.

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DENMARK

Danish Meteorological Institute (DMI)

Division of Middle Atmosphere Research:

The DMI participates in the following research and monitoring projects, relevant to stratospheric ozone depletion. These projects are externally supported by the Commission of the European Community (CEC), the Nordic Council of Ministers (NCM), or the Danish Environmental Protection Agency (DEPA):

- *Stratospheric climatology using UV-visible spectroscopy* (CEC). DMI performs investigations of stratospheric dynamics and trajectory analysis, and makes observations of ozone and other trace gases, using UV-vis spectroscopy.
- *Modelling of changes in stratospheric ozone and other trace gases due to emission changes* (CEC). DMI is engaged in microphysical modelling of polar stratospheric clouds (PSC) and aerosols.
- *Investigations of ozone, aerosols, and clouds in the Arctic stratosphere* (CEC). DMI performs ozone and aerosol/PSC backscatter soundings from Thule, Greenland.
- *Ozone as a climate gas* (NCM). DMI performs ozone soundings from Scoresbysund, Greenland, and is engaged in GCM modelling of climate effects due to changes in tropospheric and stratospheric ozone.
- *Groundbased monitoring of ozone and UV-B radiation* (DEPA). DMI performs ozone monitoring from Copenhagen, Denmark, and Thule and Søndre Strømfjord, Greenland, using Brewer, SAOZ, Dobson spectrometers, and spectroradiometer for UV-B measurements from Thule.

The DMI is engaged in investigations of *gravity waves and PSC formation*, using the 3-D wind profiler and lidar, installed by Stanford Research Institute International in Søndre Strømfjord, Greenland.

The DMI hosts an Arctic station in Thule, Greenland, within the *Network for Detection of Stratospheric Change* (NDSC). Presently, groundbased monitoring of ozone and other trace gases are performed, together with Danish/US (balloonborne) and Italian (lidar) aerosol/PSC backscatter measurements, and US measurements of active chlorine.

Copenhagen University

The University is engaged in the following projects, relevant to the ozone depletion:

Niels Bohr Institute for Astronomy, Physics and Geophysics,
Department of Geophysics, together with DMI:
- *The role of ozone in the climate system* (DEPA).

Institute for Ecological Botany:
- *Investigation of increased UV-B radiation on lichens* (DEPA).

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EGYPT

1-Research

There are some research work that have been carried out in the Meteorological Authority such as:

- Constructing an empirical zenith blue sky charts and tables by multiple linear regression technique.
- Annual and semi-annual oscillation of the vertical distribution of ozone over Egypt.
- Total Ozone Trend over Cairo.
- Some aspect of ozone layer over Egypt.
- The relation between total ozone and Tropopause height.

There are some research under investigation such as:

- Estimation of aerosol scattering from total ozone observations.
- Photochemical and Dynamical effects on the annual variations of ozone layer in the Northern Hemisphere.
- The recomputation of the back ground ozone observations on the basis of the new absorption coefficients for both Cairo and Aswan stations.
- The Meteorological Authority and the National Atomic Safety by cooperation of Germany still work in the field of measuring surface ozone over greater Cairo and to study the effect of dust and other pollutants on the surface ozone.

The Academic Research of Science cooperate with the National Research Institute, the Meteorological Authority and the National Atomic Safety, to put a project to study the atmospheric ozone and related compounds by the Cooperation of the Federal Republic of Germany.

The aims of the project are the following:

A- development of the National Strategy to protect the ozone layer.

b- Better understanding of atmospheric reactions and chemistry of aerosols.

c- Systematic observations of the ozone and related compounds.

d- To identifying the sources of the compounds that directly and indirectly interact with the ozone layer and to quantify the emission from each source to the atmosphere.
e- To study the effect of UV-B on crops
f- Reduction of CFCs emissions in Egypt.

2-Observations:

-Total ozone and the vertical distribution of ozone are usually carried out on routine basis at both Cairo and Aswan stations,by using Dobson Ozone Spectrophotometer No 96 and 69 respectively.

-UV wide range are continuous observing over Cairo and Aswan from five years ago up till now by using Epply Photometer.

-Turbidity measurements are carried out in routine basis at Cairo and Aswan using the Link pyrheliometer.

-The surface ozone, dust and carbon mono-oxide will be measuring side by side over Cairo and South-West part of Egypt (New- Valley) at the 21 of march 1993 for three weeks,through the shared project of the cooperation between Egypt and Germany.

- Ozone-Sonde:

There are some difficult to start the project of ozone sonde over Egypt up till now because of to the problem of interfacing between radiosonde and ozone sonde . In this manner we are looking for International help from the European Observatories through WMO.

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FINLAND

Global ozone

Measurements

Ozone sonding in Sodankylä (67° 22'N, 26° 30'E), and joint measurements with Argentinian Weather Service in Marambio, Antarctica, since 1988.

Supporting instruments in Sodankylä, winter 1991/92 ; ozone-lidar (France) and aerosol-lidar (Germany/Italy).

UV-measurements in three locations in Finland.

Research activities

Statistical treatment of stratospheric ozone observations, modelling of radiation, development of satellite instruments, ESA/ENVISAT-1(1998)/GOMOS-instrument.

Ozone depletion in the Arctic was for the first time observed in Finland during winter 1992. Systematic negative deviations of the order of 10 - 20 per cent were obsereved through January to April. The most intense negative deviations occured over Southern Scandinavia in January 1992.

Tropospheric ozone

Measurements

8 measurement stations (4 EMEP, 4 special research stations), and a joint EMEP-station together with Russia, Jäniskoski, Kola Peninsula.

Research activities

Statistical treatment of tropospheric ozone observations, EUROTRAC/TOR project, joint evluation of the effects of ozone episodes together with biologists.

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FRANCE

Research activities

Ozone Research is coordinated in France by the Middle Atmosphere Programme jointly funded by CNRS, CNES and the SRETIE (Ministry of Environment). The main scientific objectives of the programme are to:

- understand the physical, chemical and dynamical processes, in order to improve their parameterization in numerical models,

- study variability, trends and budgets at regional and global scales, and their relation to man-induced pertubations.

Accordingly, the research activities conducted under the programme by scientists from CNRS and Universities are split into four main streams :

- polar ozone studies,

- UARS correlative measurements programme,

- troposphere-stratosphere exchange processes,

- trend studies.

The programme also supports modelling and other fundamental research activities including spectroscopy and investigations of heteregeneous chemical processes.

The French observation capabilities include ground-based, aircraft, balloon and space-borne systems and the associated data processing facilities. Space systems proposed by the national community are developed under the responsibility of CNES by Research laboratories or industry, in the framework of various international cooperations.

Space-related activities

The current activities are focussed on:

- the calibration and analysis of data collected by the Canadian-French WINDII experiment on UARS aimed at measuring wind and temperature patterns in the upper atmosphere,

- the analysis of stratospheric and mesospheric absorption spectra obtained by the French-Belgian GRILLE spectrometer flown on the ATLAS1 mission in 1992 on board the Shuttle, the main objective being to document the latitudinal variations of species like CH4, H2O, HCL,HF... and to compare the results with those obtained by the HALOE and CLAES experiments on UARS,

- a UARS validation programme including seven NASA-selected French correlative measurement experiments aimed at collecting high quality observations of Ozone, NO2, NO3, T, HCl...

- the monitoring of the seasonal and interannual variability of the solar UV spectrum in relation with the solar cycle, based on the consistent data series collected by the SOLSPEC spectrometer during the ATLAS's and the EURECA missions.

The French community is also preparing for the use of atmospheric data to be collected by the ENVISAT-1 mission developed by ESA for launch in 1998. In particular, significant efforts are dedicated to the development of methods, algorithms and software for interpreting and processing the high vertical resolution, self-calibrated profiles of ozone, aerosols, water vapour, NO3, temperature profiles to be measured on global scale by the French-proposed GOMOS spectrometer. This instrument is dedicated to the long-term monitoring of trends. French contributions to several international precursor experiments using occultation and other techniques (POAM-2 on SPOT-3, GOME on ERS-2, ILAS on ADEOS, MIRAS on MIR) are also part of this long-term effort.

The importance of tropospheric chemistry is also being increasingly recognized as reflected in the mission objectives assigned to the IASI advanced infrared sounder currently under joint French-Italian phase B study and proposed for flight on the ESA/EUMETSAT METOP mission, scheduled for launch in 2000.

Field campaigns

France contributed directly or on behalf of the CEC to the European Artic Stratospheric Ozone Experiment (EASOE 1991-1992), aimed at documenting the conditions for a potential "ozone hole" to form in the Arctic region. In particular, France:

- contributed a number of ground-based, balloon-borne and aircraft elements of the observing system,

- managing the overall balloon launch campaign and coordinating of recovery over the Russian territory,

- participated in the overall coordination task.

The data analysis, assessment and modelling phase is now underway. A cooperative effort with US scientists has been initiated as an attempt to take advantage of the combination of EASOE and UARS observations to understand polar processes. Preparatory work is also going on in the prospect of the follow-up European campaign, SESAME, focused on specific aspects of the mecanisms of ozone chemistry both in Artic and in middle latitudes.

An equatorial, long duration balloon campaign is planned at the end of 1993, to study the troposphere-stratosphere water vapour exchanges over convective areas. The observing system is composed of a set of long-duration Infrared Mongolfiere carrying dedicated low weight hygrometers.

Another concept for a wide-scale balloon campaign, called STRATEOLE, is under definition with the international community and considered for implementation by the end of the century. The objective is to study the polar vortex from a dynamical point of view, and the mechanisms which contribute to the dilution of the ozone hole to mid-latitudes, using up to 200 pressurized balloons launched from sites located at the boundary of the polar vortex.

Network for the Detection of Stratospheric Change(NDSC)

The French contribution to the NDSC includes already the OHP operational site. New capabilities are under development or considered at La REUNION and DOME-C, Antarctica.

Modelling

A hierarchy of one dimensional, two dimensional and three-dimensional numerical models is being developed and upgraded primarily by METEO-FRANCE, LPCE Orléans, SA Verrières le Buisson and ONERA.

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GERMANY

1. Research

1.1 Ozone Research Programme (ORP)

In 1989 the German Federal Ministry of Research and Technology (BMFT) has launched the Ozone Research Programme (ORP) which has the following goals:
- determination the status and changes of stratospheric ozone
- investigation of the causes
- development of tools for prognosis of future development

Concentrating on the Northern hemisphere, the ORP comprises field measurements, modelling, and laboratory research. UV-B research is planned as an extension.

1.1.1 Field measurements (20 running projects)

The ORP comprises ground-based, balloon-borne, aircraft-borne, and rocket-borne field experiments, based on a broad variety of in situ and remote sensing instruments. Most of these instruments have been developed in preparation for participation in co-ordinated international activities.

In winter 1991/92, all field measurement groups of the ORP have participated in the EASOE campaign of the Commission of the European Communities (CEC). Participation of several ORP groups in the SESAME campaigns of CEC is to be expected.

1.1.2 Modelling (7 running projects)

Modules are being developed for homogeneous and heterogeneous stratospheric chemistry, photochemistry, radiation transfer, and atmospheric dynamics. Future work in this area will be focussed on integrated modelling.

The EASOE campaign has been supported by ORP modelling groups (meteorological diagnosis; computation of backward trajectories, chemical model runs).

1.1.3 Laboratory research (6 running projects)

Laboratory research groups are working on ozone-relevant stratospheric gas phase chemistry and on heterogenous chemistry at aerosol surfaces. Research on aerosol microphysics is planned.

1.1.4 UV-B research

The BMFT plans to integrate UV-B research as an additional area into the ORP. The planned activities comprise correlative measurement of UV-B spectral intensities, ozone vertical profiles, aerosol vertical profiles, cloud cover, surface albedo, etc.

Research aspects of UV-B trend monitoring will also be supported by BMFT. BMFT will sponsor the development of advanced-quality calibration sources, the upgrading of an existing reference instrument, and the development of high-quality UV-B spectral radiometers which in a later stage may replace the UV-B trend monitoring instruments that are currently in use (see below).

Development of advanced numerical methods (deconvolution) for the upgrading of UV-B spectra as well as of 3-dimensional models of radiation transfer through the atmosphere will also be sponsored by BMFT.

1.2 Strato-2C

BMFT sponsors the development of a high-flying, manned civil aircraft for stratospheric (and other) research. This aircraft, Strato-2C, should be available by 1996 and has the following design features:
- up to 24 kilometres altitude
- up to 18,000 kilometres range
- up to 800 kilogrammes of payload.
- pressurized cabin with room for two pilots and two scientists

These features will reduce the need for automatization and miniaturization and will thus reduce the time needed for mission planning. Strato-2C is designed for use by the international scientific community as a versatile tool for intensive measurement campaigns in the stratosphere.

1.3 Other research programmes

Several German Bundesländer are sponsoring independent research activities. The Bavarian Climate Research Programme, for example, comprises projects on stratospheric ozone, solar UV-B transfer through the atmosphere, and UV-B impacts on the biosphere.

1,.4 Institutional research

Project-independent long-term research on the ozone issue is performed by several German research centers (such as KFA, KfK, AWI), by several institutes of the Max-Planck-Society, and by several German universities.

2. Monitoring

2.1 German Weather Service

The German Weather Service is regularly monitoring ozone and UV at several locations in Germany:

	Hohen-peißen-berg	Linden-berg	Potsdam	Hamburg	Arkona
ozone sondes, up to 35 km, winter 2-3 per week, summer 2 per week	X	X			
ozone lidar, 15 to 50 km, during clear nights; backscatter ratio Mie /Rayleigh available	X				
total ozone, Dobson and Brewer (dependent on weather conditions)	X	X	X		
UV-B, Brewer, spectral, twice per hour	X	planned	planned		
UVerythem, Dehne, integral, continously	X			X	
UV, own development, integral for certain spectral intervals, continously			X		
surface ozone, continously	X	X	X	X	X

Recent results (concerning ozone losses in the lower stratosphere) from the Hohenpeißenberg observations have been presented during the meeting.

2.2 Federal Environmental Office / Federal Office of Radiation Protection

In 1993, regular monitoring of spectral UV-B radiation will be started at five sites in Germany. Bentham DM 150 spectral radiometers will be used.

2.3. Other monitoring activities

Independent UV-V monitoring activities are being performed or planned by several German Bundesländer.

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GREECE

During the past two years, since the previous convention of the ozone programme managers, Greek undertook important steps towards understanding and monitoring ozone and the harmful solar ultraviolet-B radiation. Several Greek institutions participated in national and international programmes related to the ozone issue. Analytically the actions which took place in Greece relating to the ozone issue can be summarized as follows:

1. As from the winter 1991/92, the laboratory of Atmospheric Physics, University of Thessaloniki, in collaboration with the Central Aerological Observatory, Moscow, is operating as the provisional WMO/GO$_3$OS synoptic ozone mapping centre. The activity for the first year of operation was funded by the Commission of the European Communities (CEC) and for the second year partly from CEC, WMO and the University of Thessaloniki.

2. In the frame of the European Arctic Stratospheric Ozone Experiment (EASOΣ) organized by CEC, 3 Greek institutions participated in the campaign. The University of Thessaloniki by operating daily analysis of the ozone field, i.e. operating the provisional WMO/GO$_3$OS World Centre and at the same time by operating UV-B measurements at Reykjavik in collaboration with Iceland's Meteorological Service and at Thessaloniki. The second institution involved was the Laboratory of Meteorology, University of Athens, which participated in the ozone soundings programme of EASOE and the Academy of Athens, Research Centre for Atmospheric Physics and Climatology, which participated in the complicated calculations involved in the total ozone field during EASOE.

3. Greece participated through the Universities of Thessaloniki, Athens and other institutions in various European and other international programmes related to ozone.

4. In early 1993 Greece has established the National Network for ozone and solar UV radiation and decided that it will be hosted at the Laboratory of Atmospheric Physics, University of Thessaloniki. The network at the moment comprises 9 UV-B monitoring stations and several stations monitoring background ozone. It has a cone station equipped with single and double monochromotors, long-path measuring systems, LIDAR for tropospheric aerosols, a UV-B calibration and several other facilities.

5. Greece is collaborating with DG-XII of CEC, is participating in a significant European/international UV-B programme and hosted international precision UV-B intercomparison campaigns held in the summers of 1991 and 1992 in Panorama, Thessaloniki.

6. Greece thinks highly on the priority for the protection of the ozone layer and the Minister for the Environment, Public Works and House Planning has signed all international agreements in this direction.

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INDIA

1. *INTRODUCTION*

The Indian involvement in monitoring atmospheric ozone dates back to 1928 when Dr. Royds made total ozone measurements from Kodaikanal with Dobson Photoelectric Ozone Spectrograph as part of the first worldwide ozone measurements organised by Prof. G.M.B. Dobson. The first Dobson Spectrophotometer was acquired by India Meteorological Department (IMD) in 1940.

The Indian ozone observational and research programmes are as follows:

1.1 **Observational Programme:**

(a) Total ozone - the integrated amount of ozone over any vertical column using Dobson Spectrophotometer.

(b) Vertical distribution of ozone - measured by ozonesondes and by umkehr method.

(c) Ozone near the surface - using Brewer technique.

1.2 **Research Programme:**

Important areas in ozone research currently pursued are:

i. Ozone production; distribution and destruction mechanisms
ii. Global ozone trends
iii. Effect of ozone on global climate
iv. Ozone and the ecosystem
v. Ozone instrumentation

2. INDIAN ACTIVITIES

2.1 **Total Ozone:**

With the first Dobson Spectrophotometer acquired in 1940, measurements were carried out from Pune, Bombay and Kodaikanal. Subsequently, IMD acquired five more Dobson Spectrophotometers. The present network of Dobson Spectrophotometer consists of the following:

S.	Name of Station	Lat.	Long.	Instrument Type & S.No.	Frequency of obsn.	Since when
1.	Srinagar	34°05'N	74°50'E	Dobson 10	5-6/day	Nov 1955
2.	New Delhi	28°35'N	77°12'E	Dobson 36	6/day	Jan 1955
3.	Varanasi	25°18'N	83°01'E	Dobson 55	6/day	Dec 1963
4.	Pune	18°32'N	73°51'E	Dobson 39	6/day	Mar 1973
5.	Kodaikanal	10°14'N	77°28'E	Dobson 45	6/day	Jul 1957
6.	New Delhi	STANDARD		Dobson 112		Apr 1969

The Spectrophotometer No.112 serves as a National STandard. There is one more Dobson Spectrophotometer in India belonging to the Physical Research Laboratory, Ahmedabad. This has been operating from Ahmedabad or Mount Abu.

Routine measurements of total ozone are made a number of times a day (upto a maximum of six) by trained personnel from all the above stations. Whenever sky conditions permit, umkehr observations are also made from these stations to compute the vertical distribution of ozone.

2.1.1 Standardization:

The network instruments are standardized against the National STandard at regular intervals. The National STandard, in turn, is intercompared with world standard in international intercomparisons. India participated in such comparisons held at Belsk (1974), Boulder (1977) and Melbourne (1984).

New Delhi is the National Ozone Centre for India and the Regional Ozone Centre for the Regional Association-II (Asia) of the World Meteorological Organization (WMO).

2.1.2 Publication of data:

The total ozone and Umkehr data collected from the network are published regularly in the "Ozone Data of the World" brought out from Toronto by the WMO through the Canadian Meteorological Service.

2.2. Vertical distribution of ozone:

The development of an Indian ozonesonde was taken up in 1963. The first successful sounding was carried out in September 1964. The sonde was subsequently intercompared in 1970 in West Germany and went into network use in 1971. Since then fortnightly soundings are attempted from the following stations:

S.	Name of Station	Lat.	Long.	Frequency of Observation	Since when
1.	New Delhi	28°35'N	77°12'E	Fortnightly	1971
2.	Pune	18°32N	73°51'E	Fortnightly	1971
3.	Thiruvananthapuram	8°29'N	76°57'E	Fortnightly	1971
4.	Dakshin Gangotri	70°03'S	12°E	Fortnightly,	1986-89
5.	Maitri	70°48'S	11°42'E	but more than one in a week during ozone hole period	1990

Ozone sounding were successfully carried out from Antarctica during the second Indian Scientific Expedition in 1982-83. Since the seventh expedition to Antarctica in 1986 end, ozone soundings have become a major programme of the Indian Scientific Expedition to Antarctica.

2.2.1 Standardization:

The Indian ozonesonde was intercompared in West Germany in 1970 and later in 1980, and in Saskatoon, Canada in May 1991.

2.2.2 Allied Programme:

In addition, the Indian ozonesonde has participated in a number of joint Indo-USSR ozone campaigns from Thumba. Regular ozone soundings were also made from the three stations, viz. New Delhi, Pune, and Thiruvananthapuram, during Indian Middle Atmosphere Programme (IMAP) campaigns.

2.3 Surface ozone measurements:

During the 70s, the electrochemical surface ozone measurement system was successfully developed. The system is fairly simple and operates practically unattended for 10-15 days at a time and gives a continuous record of ozone at the level of the sensor intake tube. The system is successfully operating from the following stations:

S.No.	Name of Station	Lat.	Long.	Since when
1.	New Delhi	28°35'N	77°12'E	1972
2.	Pune	18°32'N	73°51'E	1971
3.	Kodaikanal	10°14'N	77°28'E	1976
4.	Thiruvananthapuram	8°20'N	76°57'E	1973
5.	Nagpur	21°04'N	79°02'E	1978
6.	Srinagar	34°05'N	74°50'E	1981
7.	Dakshin Gangotri	70°03'S	12°E	1986-89
8.	Maitri	70°48'S	11°42'E	1990

2.4 UV-B Measurements:

The network of solar ultra violet-B (UV-B) radiation is as follows:

S.No.	Name of Station	Lat.	Long.	Since when
1.	New Delhi	28°35'N	77°12'E	1978
2.	Waltair	17°25'N	78°27'E	1986
3.	Jodhpur	26°18'N	73°01'E	1986
4.	Mysore	12°18'N	76°42'E	1986
5.	Pune	18°32'N	73°51'E	1986

One unit was sent to Indian Station at Maitri in 1990. These UV-B photometers are operating at 290, 300 and 310 nm. A laser heterodyning system using CO_2 waveguide laser is being used at National Physical Laboratory, New Delhi for ozone profiling between 15-40 km.

2.5 Measurement of minor constituents:

The status of Indian observations of various greenhouse molecules are as follows:

1.	CO_2	*Not measured in routine but flux from biomass burning by portable gas chromatograph (PCG)*
2.	CH_4	*PGC(NPL) Profile, Balloons (Hyderabad)*
3.	O_3	*Extensive: Groundbased, Balloons, Rockets*
4.	NO_x	*NO in mesosphere (Rockets)* *N_2O in Tropo/Strat (Balloons)* *NO_2 in Tropo/Strat (Laser Heterodyning system)*

3. PUBLICATION OF RESULTS

A large number of papers have been published in various journals.

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ITALY

In what follows the research activities related to the ozone problem, carried out by Italian groups in the period 1990-1992 are briefly described. Financial support came mainly from the following programs and institutions:

Agenzia Spaziale Italiana (ASI),
Programma Nazionale di Ricerche in Antartide (PNRA),
Ministero per l'Università e la Ricerca Scientifica e Tecnologica (MURST),
Consiglio Nazionale delle Ricerche (CNR),
Commission of the European Communities (CEC).

Large part of the research carried out recently was in connection with EASOE (European Arctic Stratospheric Ozone Experiment): analyses are still in progress.

The groups involved are listed below.

Dipartimento di Fisica, Università di Roma "La Sapienza", Atmospheric Physics Group. p.le Aldo Moro, 2, 00185 Roma

G. Fiocco, D. Fuà, M. Cacciani, G. di Sarra, A. Amoruso, E. Zuccheretti, G. Panegrossi.

The group carries out research on several aspects of the atmospheric sciences; in particular it maintains lidar systems at a few sites, which essential constitute a minimal, but global, lidar network. Locations and measurement techniques implemented are as follows.

Amundsen-Scott South Pole Station: in collaboration with NOAA and NSF, since 1987 (Nd YAG SHG laser, 0.5 m diameter telescope: aerosol, PSCs).

Thule: in collaboration with DMI, since 1990. (Nd YAG SHG laser, 0.8 m diameter telescope: aerosol, PSCs, temperature).

Rome: (0.5 and 0.8 m diameter telescopes) aerosol, temperature (NdYAG SHG laser), DIAL (NdYAG THG + XeCl + Ti:Sa lasers), Doppler (Argon + seeded NdYAG SHG lasers), Raman.

Long series of observations related to PSCs and stratospheric aerosol have been obtained. Seasonal evolution of the phenomena, and the sensitivity of PSC formation to temperature are being studied. Volcanic aerosols due to the eruptions of Mt. Pinatubo and Mt Hudson have been extensively observed.
Realistic models for the evolution of polar stratospheric clouds have been developed and used to simulate polar stratospheric conditions.

Measurements of the absorption cross sections of various gases at low temperatures are being conducted or prepared with different systems, located at the University of Rome and at the Gran Sasso National Laboratory in Assergi.

Dipartimento di Fisica, Università "La Sapienza", Meteorology Group;
p.le Aldo Moro, 2, 00185 Roma.

S. Palmieri, Anna Maria Siani, J.Nzioka Muthama.

The activity of the group is mainly devoted to field measurements of solar spectrophotometry, data analysis, modelling of atmospheric processes. The current research lines are:

-monitoring of total ozone, SO_2 and NO_2;
-investigations on possible trends and "change points" of meteorological long time series and total ozone time series;
-study of UVB data and urban environment (with special reference to the urban canopy radiation budget);
-interactions between troposphere and stratosphere and ozone;
-severe storms and orographic rainfall monitoring;
-climate fluctuations and trends in the instrumental period.

Istituto di Fisica dell'Atmosfera (IFA)/CNR, Frascati (Elettrofisica Atmosferica);
via Galilei, 00044 Frascati.

Two research projects relevant to the global ozone depletion are being carried out:

a) G.P. Gobbi, F. Congeduti
Work concerning the Antarctic ozone depletion started in 1988. During that year a collaboration with the Harvard group of Prof. M.B. McElroy led to the definition of a growth model of polar stratospheric clouds (PSC), the thin clouds believed to cause denitrification of the polar stratosphere. The activity carried out in Frascati is mainly based on the lidar observations of the stratospheric aerosol load. Since 1988, lidar observations of density and temperature in the middle atmosphere (35-100 km) are also carried out.

b) A. Adriani
Experiments at Mc Murdo to observe PSCs have been carried out. One experiment is based on a balloon-borne sonde for observing PSC particles by means of an impactor, a microscope, and CCD detector. The other experiment is based on the simultaneous deployment of a lidar and stratospheric sondes launched by the University of Wyoming (Prof. T. Deshler).

Istituto di Fisica dell'Atmosfera (IFA)/CNR, ROMA;
p.le L. Sturzo, 31, 00144, Roma

L. Ciattaglia, A. Anav, A. Guerrini, R. Valenti.

In February '89 the group installed a BREWER spectrophotometer at Scott Base (lat = 77.8 S, long = 166.7 E), by agreement with NZMS (New Zealand Meteorological Service). Data coming weekly from Scott Base by E-mail are analyzed in Rome. Another Brewer was installed in January 1992 at the Argentine antarctic base Belgrano II (lat=77.9 S, long=34.63).

Dipartimento di Fisica, Università de L'Aquila;
via Vetoio, Coppito, 67010 L'Aquila.

G. Visconti, A. D'Altorio, E. Mancini, G. Pitari, V. Rizi, F. Sassi, M. Verdecchia.

spectroscopic measurements. The group operates a lidar station at Preturo, L'Aquila.
The focus of the modelling has been to quantify the influence of the heterogenoeus chemistry on mid latitude and polar ozone. A simple parameterization for the PSC (Polar Stratospheric Clouds) formation has been developed for the 2D model. Application has been directed to study the effects of the QBO on the polar ozone; the dehydration of the winter polar stratosphere; the long term ozone trend in the northern hemisphere; the effects of large volcanic eruptions on ozone. The general circulation model (3D) has been used to study the interaction between the increasing carbon dioxide concentration and polar ozone.

Collaboration between:
Istituto Ricerca Onde Elettromagnetiche (IROE)/CNR, Firenze;
Università di Firenze, Dipartimento di Astronomia e Scienza dello Spazio;
Università di Bologna, Dipartimento di Chimica Fisica e Spettroscopia.

B. Carli, A. Bonetti, M. Carlotti, F. Mencaraglia.

Purpose of this activity is the measurement of stratospheric composition with passive remote sensing techniques based on high resolution Fourier transform spectroscopy in the far infrared spectral region for the study of ozone chemistry and depletion. Measurement are carried out from high altitude balloon (IBEX/FIREX Project), but studies have also been made for exploiting the same technique from satellite (SAFIRE Project) and high altitude aircraft (Geophysica Project).

The main results are:
- preparation of a spectroscopic atlas of the observed atmospheric lines in the submillimeter and far infrared spectral regions;
- laboratory spectroscopic measurements for the improvement of the data base;
- development of retrieval techniques;
- measurement of the vertical distribution of important stratospheric minor constituents (O_3 and isotopes, H_2O and isotopes, ClO, HOCl, HO_2 , H_2O_2 , CO, and HCN);
- measurement of the diurnal variability of critical species (OH);
- measurement of trends in the concentration of anthropogenic species (HF, HCl);
- validation of satellite measurements.

Istituto Ricerca Onde Elettromagnetiche (IROE)/CNR, Lidar Group;
via Panciatichi, 64, 50127 Firenze

L. Stefanutti, M. Del Guasta, M. Morandi, F. Castagnoli, V.M. Sacco, L. Zuccagnoli, V. Venturi

This group has been variously connected with the ozone research mainly by operating lidars in the polar regions. During the austral summer 1987/88 the group installed and operated a Lidar at the Italian base in Terra Nova Bay. In the following year, in a cooperative project with CNRS (G. Megie), the lidar was installed at the French base Dumont d'Urville measuring background stratospheric aerosols, and during the Antarctic winter, also polar stratospheric clouds. From 1991 a complex multispectral lidar was implemented in Dumont d'Urville, for the observation of ozone, aerosol and polar stratospheric cloud profiles.
For the EASOE campaign the IROE group, in collaboration with a group from the Freie Universitaet Berlin implemented a multispectral depolarization lidar using a Nd:YAG and a Ti:Sa laser in Sodankyla. The multispectral lidar signature was utilized for particle size determination of the stratospheric aerosol.

Istituto per la Fisica della Bassa ed Alta Atmosfera (FISBAT)/CNR, Bologna;
via dei Castagnoli,1, 40126 Bologna

G. Giovanelli

This group is engaged in studies and observations of the ozone balance in the stratosphere, with emphasis on the Mediterranean area. Objectives can be summarized as follows:

1. Development of differential spectrophotometers (GASCOD), in the ultraviolet and visible spectrum regions for the measurement of trace-gas total columns.
2. Modelling of atmospheric radiation transfer.
3. Systematic ozone-soundings and Dobson measurements at the San Pietro Capofiume Station near Bologna (Sta. 297 of ODW-WMO).
4. Systematic measurements of column amount and vertical profiles of ozone, NO_2, OClO and BrO by GASCOD at the Mt Cimone a station in the northern Apennines (2165 m asl).

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JAPAN

The Japan Environment Agency (JEA) and the Japan Meteorological Agency (JMA) play essential roles in promoting, coordinating, and implementing monitoring of the ozone and related constituents and research on the ozone layer and the effects of UV-B. JEA and JMA have strengthened their functions in recent years. In 1990, JEA started the "Global Environment Research Programme" (GERP) to promote coordination and cooperation among national institutes and universities and has provided financial assistance. In the same year the Center for Global Environmental Research (CGER) was established in the Nationsl Institute for Environmental Studies (NIES). This center's function is to monitor global environment changes on a long-term basis. In 1989, JMA established the "Ozone Layer Monitoring Office" at is headquarters for further coordinated observation, monitoring, and data processing of the ozone in the atmosphere.

The ongoing and planned monitoring, atmospheric research, and effects research activities are as follows.

1. Monitoring

1.1 Global Ozone Observing System (GO_3OS)

JMA carries out daily total ozone and Umkehr observation with Dobson Ozone Spectrometers and weekly observation of vertical ozone distributions with ozone-sondes at four sites in Japan (Sapporo, Tsukuba (Tateno), Kagoshima and Naha) and, at the Syowa Station, Antarctica. In late 1993, the observation of total ozone and Umkehr is to begin on Minami-Torishima Island (24° 17' N, 153° 58' E) with a Brewer ozone spectrometer, in order to extend the GO_3OS to the tropical region which was recommended at this first meeting. In Minami-Torishima, various kind of source gases are also to be measured as a Global Atmospheric Watch (GAW) station. In 1992, JMA issued "Atmospheric Ozone Data in Japan, 30-year period averages (1961-1990)" based on re-evaluated past JMA data for total ozone, Umkehr layer ozone, and vertical distribution of ozone partial pressure.

1.2 Lidar monitoring of the ozone layer

Since October 1990, CGER in NIES has been measuring the vertical profiles of the stratospheric ozone above Tsukuba with a laser radar (lidar). CGER will make this

data available to interested parties though the publication of their data reports.

1.3 Monitoring of related chemical constituents

JEA carries out observation of CFCs, CCl_4, CH_3CCl_3, halons, etc. at remote sites (Wakkanai and Nemuro) and at an urban site. CGER in NIES plans to observe chemical constituents related to ozone depletion at a remote site (Hateruma). JMA observes surface ozone, CFCs, CCl_4, CH_3CCl_3, CO_2, N_2O, CH_4 and CO at Ryori (one of WMO's Extended Regional Air Pollution Station for BAPMoN). JMA also periodically observes CFCs, CO_2, CO, N_2O and CH_4 in both the atmosphere and in sea water in the western North Pacific on board the meteorological observation vessel "Ryofu Maru".

1.4 UV-B monitoring

JMA observes UV-B with Brewer spectrometers at the GO_3OS stations in Japan. CGER in NIES also plans to observe UV-B with a Brewer spectrometer in Tokyo from fiscal year 1993.

2. Research

2.1 Atmospheric Research

(a) Research related to Network for the Detection of Stratospheric Change (NDSC)

NIES, Meteorological Research Institute (MRI), Communication Research Laboratory (CRL) and some universities have developed NDSC instruments including lidars (O_3, aerosols, temperature), millimeter wave radiometers (O_3, ClO), visible spectrometers (O_3, NO_2), an ultra-violet spectrometer (OH), and infra-red spectrometers. Some of activities conducted by these organizations that make use of these instruments are expected to be incorporated into the NDSC complementary measurements in Japan, which should have special benefits to the NDSC through geographical location.

Meteorological Research Institute, Communication Research Laboratory, and the Solar-Terrestrial Environment Laboratory (STEL) of Nagoya University are developing instruments for some NDSC primary stations such Eureka (Canadian Arctic) and Lauder (New Zealand).

(b) Satellite observations

JEA is developing satellite sensors to observe profiles of the ozone and related substances. The "Advanced Earth Observing Satellite" (ADEOS) on which the planned sensors will be placed, is being developed by the Nationsl Space Development Agency of Japan and is going to be launched in early 1996. One of the sensors is called "Improved Limb Atmospheric Spectrometer" (ILAS) which detects solar

infra-red radiation absorption through the atmospheric layer on the limb of the earth's atmosphere. Another sensor is a kind of mirror called "Retroreflector in Space" (RIS), which reflects laser light emitted from the ground station to the satellite installed on ADEOS.

(c) Observation and data analysis

Temporal and spatial variations of the ozone, aerosols and ozone related chemical constituents are studied by NIES, MRI and universities under GERP. This project also includes research on volcanic effects on the ozone layer. In 1992, MRI started a three year programme, with the cooperation of national and foreign institutes, named "Effect of the Pinatubo Eruption on Climate" (EPIC), which includes the study on th effects on the ozone layer. Japanese researchers from MRI and CRL participate in the Canadian project in the Arctic region under the Canada-Japan Science and Technology Agreement. The ozone layer in the polar region is being studied by the National Institute of Polar Research and by universities. In the winter of 1991-1992, STEL participated in the European Arctic Stratospheric Ozone Experiment (EASOE) campaign. Data analyses are also carried out by MRI and by universities.

(d) Modelling and experimental studies

A two-dimensional model was developed at MRI, results of which are included in the "Scientific Assessment of Stratospheric Ozone, 1991". The model has now heterogeneous processes incorporated in it. One-dimensional models were developed by NIES and Tokyo University. Studies on chemical processes and measurements of rate constants of chemical reactions related to ozone depletion are being carried out at NIES. Experimental and theoretical studies on the physical processes of stratospheric aerosols are being carried out by Mechanical Engineering Laboratory and STEL.

2.2 Effects Research

The following studies are being carried out under GERP.

(a) UV-B effects on human health

The effects of UV-B radiation on the development of skin cancer are being studied by the National Cancer Center Research Institute, universities and NIES. Research on the UV-B effects on microorganism infections and photoallergy are being carried out by the National Institute of Health and the National Institute of Industrial Health respectively.

(b) UV-B effects on plants

The effects of UV-B on crop production, the marine phytoplankton community, and marine algae are being studied by the National Institute of Agro-Environmental Sciences,

Hokkaido National Fisheries Research Institute, and the Marien Ecology Research Institute. Research on the mechanisms of leaf injury and growth inhibition by enhanced UV-B are being carried out by NIES.

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KENYA

1.0 INTRODUCTION

The increasingly critical state of the ozone layer has been a subject of numerous discussions in several international fora. A decrease of atmospheric ozone and a change of its vertical distribution will have many adverse effects on life in this planet. Ozone is also a major atmospheric driving force of climate systems. Significant changes in ozone concentrations will have adverse ecological impacts which may consequently alter the climate. Ozone is highly vulnerable to destruction by chlorine-based gases introduced into the stratosphere both by man and natural processes. Measurements of atmospheric ozone and theoretical attempts to explain the observations are fundamental to understanding the ozone state and cycle in the atmosphere.

2.0 MONITORING

In Kenya, there is only one total ozone observing station located at Chiromo Campus, University of Nairobi. The observatory has been making total ozone measurements since March, 1984 when the Dobson Ozone Spectrophotometer was installed there. This important Dobson Spectrophotometer was generously donated to Kenya by the Canadian Atmospheric Environment Service within the framework of the WMO Global Ozone Research and Monitoring Project. The installation of the Dobson Spectrophotometer in Nairobi has extended both meridional and zonal span of the global ozone observing network. The observed data are regularly disseminated to the World Ozone Data Centre(WODC)

3.0 RESEARCH

Only very limited studies on ozone have been carried out in Kenya. The studies covered the following:-

(1) Ozone Fluctuations: The East Africa situations
(2) Equatorial Total Ozone linked to Tropospheric Temperature Anomalies and ENSO.

Important findings emerged from the forementioned studies. Among the findings we have are:-

(i) The marked seasonal total ozone veriations associated with variations in the Tropopause height.

(ii) The effect of upper troposphere temperature on the total ozone over the equatorial region. Temperature variation highly correlated to the total ozone and linked to the El Nino and Southern Oscillation (ENSO).

CONCLUSION

The following could be accorded priority:-

(1) Express need and further support to developing countries in the equatorial - tropical latitudes to undertake measurements and research on the surface, vertical, total, ozone and ultraviolet radiation including atmospheric chemical constituents expeditiously,

(II) Encourage and support a wider participation of parties

to Vienna convention in the ozone research, conferences, workshops, and training towards enhancing improved scientific capability and institutional strengthening and exchange of information,

(III) Initiate research Project support to scientists pursuing advanced research in ozone and ozone-related problems,

(IV) The WMO to continue regular checks of Dobson Spectrophotometer for gross calibration errors.

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MALAYSIA

1. Introduction

The International Conference on Tropical Ozone and Atmospheric Change held in Penang in February 1990 underscored the lack of tropospheric and stratospheric ozone measurements and research in the equatorial tropical region. Realizing the importance of developing countries in the tropics to play a more prominent role in the global initiatives to achieve a better understanding of the inadvertent atmospheric changes linked to ozone depletion, Malaysia has initiated its active involvement in the WMO Global Ozone Observing System (GO3OS) with the launching of its ozone monitoring programme at the Headquarters of the Malaysian Meteorological Service (MMS) on 30 October 1992.

2. Monitoring Activities

The MMS ozone monitoring programme involves monitoring of ozone concentrations at the surface, the vertical distribution of ozone throughout the atmosphere and finally total column ozone in the atmosphere.

Ozone concentrations at the surface are measured at MMS Headquarters, Petaling Jaya as well as four other sites in the Klang Valley as part of a two-year project for air pollution control carried out by the Department of Environment assisted by various government agencies. Funding is provided by the Government of Japan under the technical cooperation programme through JICA. The instrument used is an automatic ozone analyzer from Kimoto Electric Co. Ltd. consisting of a detector unit, an air sampler unit, a data processing unit and a display unit. The final report will include data on diurnal patterns of ozone concentrations from February 1992 to January 1993. Attempts are also made to investigate the causes of high ozone concentrations by correlation analysis with meteorological factors and other pollutants. The project is expected to be completed by June 1993, after which the Department of Environment will continue with the monitoring. MMS will have access to this data set which should be useful for tropospheric ozone studies.

Measurement of ozone profile was first started by MMS on 22 November 1991. The ozone sounding facilities consist of :

i) Ozonesonde - Electrochemical Concentration Cell (ECC) Model 5A manufactured by Science Pump Corporation
ii) Radiosonde - RS80-15E manufactured by Vaisala Oy
iii) Conditioning Equipment - Ozoniser/Test Unit Model TSC-1
iv) Receiving Equipment - Digicora MW11
IBM Compatible PC

Every attempt was made to carry out two soundings per month. The data is being assessed by a small group of meteorologists to study seasonal characteristics of atmospheric ozone over Malaysia in particular the role of the East Asian Hadley circulation in controlling tropospheric and stratospheric ozone.

To obtain a comprehensive set of ozone, UV-B and sulphur dioxide data for research purposes, the MMS has purchased a Brewers Ozone Spectrophotometer from SCI-TEC Instruments Inc. in October 1992. The instrument is functioning well after initial teething problems.

Besides the MMS, another researcher in ozone and UV radiation is Dr. Mohd. Ilyas from the University of Science Malaysia. Dr. Ilyas has acquired similar equipment to the MMS to measure vertical ozone profile. There are plans to conduct intensive weekly soundings for two months within this year. An officer from MMS who is pursuing a Masters degree under Dr. Ilyas will be working on the data. The observations will be carried out at the Astronomical Research Centre at Pantai Acheh in the western side of Penang Island. Dr. Ilyas who is coordinating a national program to study atmospheric changes in the tropics, plans to install instruments to measure tropospheric ozone and UV on a high platform at the same site.

3. Research Plans

As long-term monitoring of ozone has just begun in Malaysia, ozone research is very much in its infancy in the country. Nevertheless, when sufficient data is collected for meaningful assessment, MMS hopes to draw upon the wealth of experience, knowhow and technologies available in the developed countries to assess the data for the study of ozone variations and its impacts in the tropics.

In order that the monitoring activities initiated so far function smoothly, and in response to future demands, the MMS feels the need to work closer with the international community particularly to upgrade and strengthen the capabilities of local scientists. Malaysia therefore would appreciate assistance in the following areas:

i) Access to TOMS measurements over the tropics for comparison with the ground-based Brewer measurements
ii) Training for technical or operation personnel in the operation and maintenance of instruments
iii) Regular intercalibration of the Brewers with the travelling standard
iv) Postgraduate training overseas for scientists in atmospheric chemistry and physics
v) Consultations or joint collaboration studies with scientists from the advanced countries to investigate possible climatic impacts on greenhouse warming etc.

As MMS is currently involved in ozone monitoring and research, it sees a need to attend the various fora including conferences, seminars which are orgnized by UNEP or WMO so as to provide an opportunity for exchange of experiences and knowledge in this area. Accordingly MMS would appreciate if UNEP would inform us regarding the holding of such relevant international activities.

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MEXICO

Stratospheric ozone research in Mexico is been made by the Universidad Nacional Autonoma de Mexico (UNAM). There exist two principal research laboratories that have ongoing projects on this subject, these are:

(a) The Instituto de Geofisica, in which Dr. Jose Luis Bravo has been performing measurements on the ozone layer since 1965 with a Dobson spectrophotometer. Due to technical problems, absence of data exist for some periods of time. This Institute also is measuring radiation (total and diffuse) and meteorological parameters (humidity, temperature). Reports from 1988 through 1991 have been publisned

(b) The Laboratorio de Radiacion y Fisico-Quimica de la Atmosfera which belongs to the Atmospheric Sciences Centre and managed by Dr. Carlos Gay, who performs and develops theoretical aspects on ozone research. Dr. Roberto Acosta, Researcher of this laboratory is conducting a collaborative project with the Atmospheric Physics Laboratory of the University of Trent, Ontario, Canada. This research is focussed on studies about UV-B and UV-A Radiation and measurements are being made in Mexico City and Ontario.

Addresses of these institutions are as follows:

Instituto de Geofisica/UNAM
Ciudad Universitaria
Delegacion Coyoacan
CP. 04510, MEXICO D.F.
Tel: (5) 6224140

- Centro de Ciencias de la Atmosfera
Circuito de Investigacion Cientifica
Ciudad Universitaria
Apdo. Postal 70-487
C.P. 04510, Mexico D.F.
Tel: (5) 6224063

These activities should be intensified in the aspect of involving other Mexican research institutions and by collaboration agreements with other countries. Principally, support for local infrastructure to support ozone research is needed.

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MOROCCO

The stratospheric ozone measurements have started in Morocco (Casablanca) since 1969. They began with the Dobson Spectrophotometer, but by the mid 80s some difficulties started to appear due to a lack of technical support and spare parts. So, we opted for the Brewer spectrophotometer which has been installed in 1989. However, we continued to face some monitoring problems , lack of documentation and technical support. This situation led us to interruptions in the measurements. Finally the device was fixed again, but only partly since we could not fix the chronological regulating system. Therefore, the measurements of stratospheric ozone are now made on a daily basis only, and not on the continuous mode. Also, in cloudy days the values are rejected by the data automatic control, a problem which we could not solve up to now. Despite this situation we still try to keep the measurements as well as possible in fact we have never received any reclamation on the subject. The data is always trasmitted routinely to the Atmospheric Environment Service of Ontario (Canada). We are also planning to install

another station in Ifrane (Middle Atlas Mountains) once the Casablanca station is fixed. To conclude, we would greatly appreciate if some support could be directed to our people in the field, particularly in assisting the development of an improved scientific capability in Morocco in the following areas:

1) Instrument training for Brewer Spectrophotometer.

2) Periodic intercalibration of instruments with the standard network.

3) Training workshops and consultations between scientists working on ozone data and ozone experts from developed countries.

4) Providing documentation and publications related to the ozone issue (in French).

We are convinced in Morocco of the importance of the protection of the ozone layer and our Minister of Public Works is himself very sensibilized to the issue. Therefore, we do not neglect any effort to carry out our part of the task.

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NETHERLANDS

Research Programmes

Ozone research in The Netherlands is traditionally focussed on the boundary layer and the free troposphere. Recent developments at the national meteorological institute (KNMI), environmental protection institute (RIVM) and the university of Utrecht (IMAU) show a growing research effort in the monitoring and modelling of ozone in the upper troposphere/ lower stratosphere and stratosphere.

There are two programmes related to the Vienna Convention:

- National Research Programme "Global Air Pollution and Climate Change"
  research area: Causes and effects of climate change
  Systems analysis and scenarios
  Sustainable development
  It includes research on UV-B effects (immune systems, plants and algae)
  Contact: dr. T. Schneider, coordinator, RIVM.

- National programme on Earth observation
  research area: stimulation of permanent use of remote sensing data
  high priority for atmospheric research
  Contact: dr. F. Baede, working group Earth Observation, KNMI

Research Institutes

Ozone related atmospheric research is concentrated in the following institutes:

RIVM: National Institute of Public Health and Environmental Protection,
PO Box 1, 3720 BA Bilthoven, tel: +31 30 742002, fax: +31 30 287531

KNMI: Royal Netherlands Meteorological Institute,
PO Box 201, 3730 AE De Bilt, tel: +31 30 206911, fax: +31 30 210407

IMAU: Institute for Marine and Atmospheric Research Utrecht,
PO Box 80005, 3508 TA Utrecht, tel: +31 30 533275, fax: +31 30 543163

TNO: Netherlands Organization for Applied Scientific Research,
PO Box 6011, 2600 JA Delft, tel: +31 15 696900, fax: +31 30 616812

ONGOING ACTIVITIES

Monitoring

a. ozone and other tracegases

- Stratosphere
  LIDAR system; O_3 profile 15-45 km; NDSC site in Lauder (New Zealand)
  operational summer 1993
  contact: dr. D. Swart, RIVM, +31 30 742677

- Troposphere
  LIDAR system; O_3 profile 1-12 km; TOR site in Kollummerwaard (NL)
  operational since 1992
  contact: dr. D. Swart, RIVM, +31 30 742677

- TOR ground station Kollummerwaard
  O_3, NO_x, CO, PAN, ...
  operational since 1992
  contact: ir. J. Beck, RIVM, +31 30 742362

- TOR database
  Eurotrac - Tropospheric Ozone Research database
  operational since 1992
  contact: ir. J. Beck, RIVM, +31 30 742362

- O_3 balloon sondes
  ozone distribution and transport near cyclones
  operational end 1992
  contact: dr. H. Kelder, KNMI

- O_3 TOVS satellite ozone data
  operational since 1992,
  contact: dr. H. Kelder, KNMI

b. UV measurements

- high spectral resolution UV-VIS
  site at RIVM, operational since 1992
  contact: dr. H. Reinen, RIVM

- UV-B narrow band and spectral measurements
  site at KNMI, operational since 1992
  contact: dr. H. Kelder, KNMI

Research

a. Modelling

- RIVM: (ir. J. Beck, dr. H. van der Woerd)
  integral source-effect chain model for CFC ==> UV-B cancer incidence
  risc assessments for amendments Montreal Protocol

  troposphere 3D-modelling (Moguntia in GLOMAC, EUROTRAC)
  role of CH4 in the troposphere,
  role of traditional Aircraft (AERONOX-EC)

  stratosphere 2D-modelling (Cambridge model)
  study of HCFC's

- KNMI: (dr. H. Kelder, dr. L. Heijboer, dr. P. van Velthoven)
  troposphere 3D-modelling (Tracer model in GLOMAC, EUROTRAC):
  troposphere/ stratosphere exchange (ESTIME, F-NL)
  atmospheric effects of traditional aircraft (AERONOX-EC)
  atmospheric chemistry
  climate effects of trace gases (SINDICATE - EC)
  stratosphere O_3 budget and meteorological aspects
  reanalysis of early ozone data (EC-STEP)

- TNO: (drs. M. Roemer)
  troposphere; 2D-modelling (Isaksen/TNO model)
  NMHC's, connection O_3 <==> climate radiative forcing

- IMAU: (dr. H. van Dop)
  troposphere: 3D-modelling (Moguntia in GLOMAC, EUROTRAC)

b. Observations

- O_3 column observations NOAA - TOVS;
  correlation with meteorology (KNMI and IMAU)

- aircraft observations STREAM
  multi-component measurements up to 13 km (IMAU)
  first flight Kiruna feb. 1993

PLANNED ACTIVITIES

The national institutes participate in European space research related to atmospheric (chemistry) research: instrument development, characterisation, calibration validation and interpretation.

- GOME (ERS-2) end of 1994

- SCIAMACHY (ENVISAT in 1998) is partly funded by The Netherlands

- Stratosphere / troposphere exchange (KNMI)
  O_3 -sonde network, satellite and meteorological observations

- STRATEOLE (USA, F, NL) project on vortex dynamics (KNMI)

RECOMMENDATIONS

1 - HCFC's measurements: test on Protocol **and** atmospheric chemistry

2 - HFC's investigations: not covered by the Protocol

3 - O_3 - climate interactions (assessments <=> IPCC)

4 - high resolution UV-B measurements and **Networking**

5 - high altitude and traditional aircraft, research on environmental and climate effects.

6 - closer involvement of The Netherlands in assessment reports

7 - more effort into modelling, in the range of boxmodel to fully coupled 3D- climate chemistry models.

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NEW ZEALAND

The goal of New Zealand's stratospheric research programme is to quantify the concentration and temporal variability of ozone and a number of related trace species so that meaningful predictions about future atmospheric change and changes in ground level UV flux can be made.

The programme is coordinated through the National Institute of Water and Atmospheric Research (NIWAR) with support from the Foundation for Research Science and Technology.

The programme has 2 major thrusts: (1) the study of ozone and related trace gases both in NZ and overseas and (2), UV radiation studies.

The selection of the NIWAR Laboratory at Lauder as the charter site for the International Network for the Detection of Stratospheric Change has resulted in the implementation of a number of joint experiments to complement National experiments. A list of experiments to measure the relationship between ozone and a number of trace gases is presented in Table 1.

A list of New Zealand experiments being performed outside New Zealand is given in Table 2.

New Zealand has taken a very active role in attempting to establish quality control methodologies, particularly with regard to UV visible spectroscopy.

It hosted in May 1992 an international intercomparison campaign where 9 groups deployed instrument systems at Lauder for in "blind/blind" NO_2 intercomparison campaign. The results of this intensive intercomparison will appear in the open literature in the near future.

In February 1993, ultraviolet spectrometer systems from Germany and Australia were brought to New Zealand and run side by side for a 2 week period. The aim of this intercomparison was to relate European UV intercomparison measurements from Thessaloniki with UV spectral radiation measurements being made in the Australasian region.

National Institute of Water and Atmospheric Research
Atmospheric Division

Table 1

Operational — Lauder, New Zealand (45°).

INSTRUMENT	PARAMETER	COMMENT	COOPERATING INSTITUTIONS
Dobson	Direct sun obs Automated umkehrs	UV	NOAA/CMDL, Boulder, USA
Balloon sonde (ECC type)	Ozone, T, P	Weekly through year & twice per week in Spring - early Summer	NOAA/CMDL, Boulder, USA
UV - Vis spectrometer	Column ozone Column NO_2	Chappuis band 430 - 450nm	
IR interferometer (FTIR)	Column HCl, HNO_3, OCS, CFC'S etc	3μ window & 7-12μ window	University of Denver, Denver, USA University of Wollongong Australia
OH Interferometer (Pepsios)	OH Column	308nm	Florida/Atlantic University, Boca Raton, USA
Aerosol lidar	Aerosol profile 6-36 km	Frequency doubled Nd-YAG at 532nm	Meteorological Research Institute, Tsukuba, Japan
Backscatter sonde	Aerosol profile 0-34 km	1 flight per month	University of Wyoming, Wyoming, USA
Ozone μ-wave radiometer	20-75 km profiles	110 GH_z and 30 min integration times	NASA Langley Hampton, USA
Water vapour μ-wave radiometer	20-60 km profiles	22 GH_z and 30 min integration times	NRL, Washington D.C., USA
UV Spectrum	Global + scattered	290 - 450nm at 1nm res.	
UV-B Monitors	Erythemal	Variety of filter radiometers	

End 1993

Ozone lidar	Ozone profiles 15-50 km	Excimer laser plus raman cells	RIVM, Bilthoven Netherlands
Aerosol/temperature lidar	Aerosol profiles 5-35 km Temp profiles 5-70 km	Nd YAG laser	IROE, Florence Italy University of Lyon, Lyon, France

Table 2

Operational Outside New Zealand

INSTRUMENT	PARAMETER	COMMENT	COOPERATING INSTITUTIONS
UV-Vis spectrometers	Ozone and NO_2 Column	Antarctica: Arrival Hghts (78°S) Halley Bay (76°S) Showa (66°S)	BAS, Cambridge, UK University of Nagoya, Nagoya, Japan
Dobson Brewer spectrometer	Direct sun and moon	Arrival Hghts (78°S)	CNR, Rome, Italy
IR Interferometer (FTIR)	HNO_3 Column	Arrival Hghts (78°S)	University of Denver, Denver, USA
UV Vis spectrometer	Ozone and NO_2 Columns	Campbell Is (53°S)	
UV Vis spectrometer	Ozone and NO_2 Columns	Tarawa (2°N)	
UV Vis spectrometer	Ozone and NO_2 Columns	Kiruna (68°N)	

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NIGERIA

There are two Universities currently actively involved in the monitoring and Research of Ozone in Nigeria - namely

(a) Obafemi Awolowo University (O.A.U.), Ile-Ife
(b) University of Lagos, Lagos.

There are other projects planned by other Institutions but the actual monitoring is yet to take off.

The Nigerian Meteorological Services has received the GAW station (Dobson Ozone Spectrophotometer and Mainz Sunphotometer included) donated by the Canadian government through the WMO/VCP and the station will take off in April 1993. There is also an advanced collaborative effort with NOAA to establish an environmental monitoring station in the Northern part of Nigeria an a Dobson Ozone Spectrophotometer will be one of the equipment.

1. O.A.U. Ile-Ife Project (Physics Department)

The project is sponsored by European Economic Community under Lome III agreement and it is in its first year extension having lasted its full span of 3 years by December 1992.

The station is presently located at Oshodi Complex of Meteorological Department (Long 03^0 26'E; LAT 06^0 36'N; HEIGHT 19.20M). It is proposed that the station will be relocated after the Meteorological GAW Station referred to above is established at the Oshodi Meteorological Complex.

The station measures the surface Ozone using the monochromatic light source and UV absorption technique. The analysis is in-situ and data is logged automatically to the computer. The monitoring has been on for 6 months.
Typical values are:

Night Ozone values 0 - 10 ppbv
Afternoon Ozone values 10 - 35 ppbv

The group is also developing an atmospheric Ozone model which will use inventory of gaseous emission (e.g. NOx) to predict Ozone concentrations in the atmosphere. The group has also a portable equipment to monitor gaseous emissions from industries and factories. There is plan for 1 or 2 stations within the next 2 years.

Other gases monitored in the station: SO_2 NO_x (NO, NO_2), CO, CO_2, CmHn (Total)
Other parameters Dust, Solar Radiation, Conventional Meteorological parameters.

2. University of Lagos (Physics Department)

This is a research project undertaken by a Ph.D degree student of the Physics Department. The research is based on optical method with radiation technique within the infrared region of the spectrum (absorption due to aerosol~1).

The method uses a polychromatic source (Sun) and modified Lambert - Beer Law and Planck's radiation Law to estimate the total Ozone concentration. The input data is the direct normal solar radiation (measured with pyrheliometer) and precipitable water (measured with Volz Sunphotometer). Data is manually processed.
Typical values:
Daily average 0.2236 atm - cm.

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NORWAY

A. MEASUREMENTS

1. DOBSON: O_3

Site	*Responsible institution*
Oslo (60 N)	Univ. of Oslo, Dept. of Physics
Tromso (70 N)	Univ. of Tromso, Auroral Obs.
Longyearbyen (78 N)	Univ. of Oslo, Dept. of Physics

2. BREWER: O_3, NO_2; UV-B

Site	*Responsible institution*
Oslo	Univ. of Oslo, Dept. of Physics

3. SAOZ: O_3, NO_2, O_4, H_2O, OClO

Site	*Responsible institution*
Ny-Alesund (79 N)	NILU

4. Ozonesondes: O_3 + PTU profiles

Site	*Responsible institution*	*Freq.*
Bear Island (74.5 N)	NILU / DNMI	weekly
Gardermoen (60 N)	NILU / DNMI	weekly
Weathership (66 N)	NILU / DNMI	monthly

5. UV-B, MED-meter, integrated UV-B

Site	*Responsible institution*
Oslo	The Norwegian Radium Hospital
Ny-Alesund	The Norwegian Polar Research Institute

6. UV-Vis spectroradiometer

Site	*Responsible institution*
Tromso	University of Tromso, Auroral Obs.
Trondheim	Universities in Norway

7. Measurement of background air

Site	*Responsible institution*
Birkenes (59 N) Meas. of CFCs + CH_4 + N_2O	NILU
Ny-Alesund (79 N) Meas. of CFCs + CH_4 + N_2O	NILU

B. THEORY / MODELLING

Activity	*Responsible institution*
2-D chemical modelling	University of Oslo + NILU
Trajectory modelling	NILU + University of Oslo
Trend analyses	NILU + University of Oslo
Effects of PSCs	NILU + University of Oslo
Effects of stratospheric aircraft	NILU + University of Oslo
Radiative transfer modelling	NILU + University of Tromso

C. EFFECTS OF UV-RADIATION

Activity	*Responsible institution*
Effects on human skin	The Norwegian Radium Hospital, University of Oslo

UV dose calc. by rad. transf. mod.	NILU
Effects on marine micro-organisms	University of Trondheim

D. LABORATORY EXPERIMENTS

Activity	*Responsible institution*
Study of PSC chemistry by FT-IR & mass spectrometry	Univ. of Oslo, Dept. of Chemistry

E. INTERNATIONAL COOPERATION

Activity	*Responsible institution*
1. STEP project on inter-pretation & intercomparison of UV-vis data. (Pommerau coord.)	NILU
2. SCUVS. CEC project on inter-pretation & intercomparison of UV-vis data. (T. Jorgensen coord.)	NILU
3. STEP project on UV monitoring (A. Webb coord.)	University of Tromso, Auroral obs.
4. CEC Environment project on 2D-models with heterogenous chemistry (G. Visconti coord.)	University of Oslo, Dept. of Geophysics + NILU
5. Participation in EASOE	
(i) Groundbased	University of Oslo + University of Tromso + NILU
(ii) Ozonesondes	NILU
(iii) Theory / modelling	University of Oslo + NILU
(iv) EASOE data & coordination center	NILU
(v) Ozonesonde coordination	NILU
6. CEC Environment project AERONOX (U. Schumann. coord.)	Univ. of Oslo + Univ. of Bergen + NILU
7. Nordic Council of Ministers: Ozone as a climat gas (I. Isaksen, project coord.)	Univ. of Oslo + NILU + NERSC

8. UARS Intercomparison Comparison of UARS with SAOZ data	NILU
9. UV monitoring network in Chile (Funded by the Government)	NILU

F. COORDINATION AND DATA HANDLING

Activity	*Responsible institution*
1. Coordination of national monitoring programme (Funded by the government)	NILU
2. National database for ozone and related data.	NILU

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PAKISTAN

INTRODUCTION:

The stratospheric ozone layer protects the earth from the excessive incidence of ultraviolet radiation. Destruction of the ozone layer will lead to increases in incidence of skin cancer and cataracts of the eye, suppression of the human immune system, damage and reduction in crop yields, and damage to aquatic organisms and natural ecosystems. The destruction of the ozone layer is being caused by man-made gases such as chlorofluorocarbons (CSFs) and halons. These chemicals are used as refrigerants in all types of refrigeration applications, as foam blowing agents for the production of flexible and rigid foams, as propellants in aerosol applications, as solvents for cleaning metal manufactured parts in precision, metal working and for cleaning metal electronic components and also as fire extinguishing agents.

Since Pakistan is a signatory of the Montreal Protocol, hence it is imperative for Pakistan to join the program of phase out of CFCs, Carbon tetrachloecle and halons by the years 2000 and also to plan for the phase out of methyl chloroform. Developing countries like Pakistan are however allowed a 10 year grace period to comply with the protocol. Not withstanding this grace period, several developing countries including Pakistan have expressed their interest in accelerating their phase out schedules and might take actions to reduce their use of controlled substances.

Pakistan does not produce CFCs which are mainly responsible for depletion of ozone layer. Also energy consumption is 1/8th of its proportional share in global consumption. Average Pakistani vehicle emits 20 times as much HC, 25 times as much Co and 3.6 times as much (NO)x in gm/km as an average vehicle in U.S.

Recent scientific data on ozone depletion over the past decade suggests that depletion has been occurring at a rate twice as fast as originally observed. For example, at latitudes where 2 percent depletion had been observed over the last decade, new data shows that actual depletion is 4 to 5 percent. This information may be considered by the parties to the Protocol in 1993, and will most probably lead to accelerated phase out dates for CFCs and halons, as well as more stringent interim reduction deadlines for all controlled substances.

Pakistan does not produce any of the controlled substances. Domestic needs for these chemicals is met via importation. With the implementation of the Protocol the supply of these chemicals will dwindle. This will have a major impact on industries using these chemicals, as well as on durable goods such as refrigerators/freezers and other refrigeration equipment that are currently in use. These pieces of equipment might have to be discarded or retired early due to the unavailability of refrigerants to service the equipment. This will result in high costs to the consumer and producer sectors in Pakistan.

II. CONSUMPTION OF CONTROLLED SUBSTANCES IN PAKISTAN.

No study has been done to quantify the use of ozone-depleting substances in Pakistan. Pakistan does not produce any of the controlled substances and demand is met via importation. Based on preliminary data obtained from ICI Chemicals and Polymers, United Kingdom the market (i.e., consumption) for CFC-11 and CFC-12 is about 1000 MT, for methyl chloroform is about 700 MT, and for CFC-113 about 50MT. This source could not provide any information on the use of other controlled substances(i.e., CFC-114, CFC-115, carbon tetrachloride, and halons).

These estimates compares well with estimates for other developing countries. Using other developing countries as model it is possible to estimate total consumption of controlled substances in Pakistan. One methodology is to base consumption on per capita consumption estimates for developing countries that have similar economic conditions(e.g. CNP per capita). Using Kenya and India as model countries, it is estimated that Pakistan's total consumption of controlled substances could be between 1300 and 1730 Metric Tons or per capita consumption of 0.016 kilograms.

III AGENCIES/ DEPARTMENT:

The following agencies and Ministries in Pakistan have initiated plans for study on Ozone Depleting Substances of ozone layer.

1. Ministry of Science and Technology.
2. Ministry of Environment and Urban Affairs.
3. Pakistan Council of Scientific and Industrial Research (P.C.S.I.R).
4. Pakistan Metereological Department.

The Metereological Department in Pakistan have observatories all over the country and a Centre at Quetta has initiated a plan for the study of the Ozone Layer Depletion. The centre is in the initial stage of its development and needs to be further strengthened with the assistance from W.H.O, U.N.E.P. and U.N.D.P. However no published data is available. Another such centre is being planned at Islamabad.

Dr. M.A Khattak
Chief Scientific Officer
PCSIR Laboratories,
Peshawar. Pakistan.

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PERU

Peru is participating in the ozone research and monitoring programme since February, 1964. A Dobson spectrophotometer donated by NOAA - Boulder was installed at Huayao Observatory (Long: 75°19'22"W; Lat:12°02'18"S; Alt:3,313 m.a.s l.), in the high central region.

After the subscription of an agreement with WMO, the Geophysical Institute and the National Meteorological Service have been carrying out Umkehr ozone measurements. Measurements have been performed almost daily, depending on climatological conditions. So, from 8.00 to 10.30h, in the mornings; from 11.00 to 13.30h at midday; and from 14.30 to 15.00h in the afternoon. An average of 70 to 75 monthly measurements are made, which are increased during the periods of May, June and July. This information is collected and sent to Boulder (Colorado, USA) and to the World Ozone Centre (Toronto, Canada).

Highly qualified professionals of the Geophysical Institute operate the spectrophotometer. The date of last calibration of the equipment is 10 October 1989.

At Huayao Observatory also operated part of the BAPMoN baseline station equipment. Ozone monitoring is also complemented with meteorological observations. So, atmospheric turbidity measurements were made with Sunphotometer EKO, which last calibration dated of 1983 by intercomparison with a standard instrument. At the same time, solar radiation measurements are being made through a national solar radiation network using Kipp and Zonnen pyranometers, which are periodically calibrated at the National Solar Radiation Centre of Huayao Observatory. All this information is being sent to the National Climatic Data Centre - Asheville.

No other public or private institution participate in ozone monitoring. It would be necessary to install other ozone equipment in the Southern Andes, where there are very favourable climatic conditions above 4.000 meters, and also at the Antarctic Peruvian Observatory of "Machupicchu" where lately, on last January 1993, a radar for research climatic changes has been installed by a scientific Peruvian expedition. So, Peru could participate more actively in the ozone programme.

The news of an increased depleted stratospheric ozone layer have seriously impacted on Peruvian people. So there is now a great interest in the national scientific community for participating on research studies on this field.

The strategic geographic situation of the country and the high altitudes of the Andean region could greatly contribute to research ozone progammes through technical and financial assistance.

Taking into consideration that on October, 1988, the Cosmos baseline BAPMoN station was exploded by terrorist actions, an international support is required for locating a new place in the Andean region for building a new observatory for both BAPMoN and ozone monitoring, as recommended in item 4.5.2. by the Report of the First Meeting of the Ozone Research Managers of the Parties to the Vienna Convention. That is to say, it is recommended that at the same time and at the same place, optic state of atmosphere measurements must be made.

This is also very important because of 1985 Vienna Convention for the Protection of the Ozone Layer has been ratified by Peru on 4th July, 1989.

Meanwhile, universities and public or private institutions are frequently engaged, through seminaries, symposiums or conferences, to prevent the community, developing educational programmes in the country.

The National Meteorological and Hydrological Service - SENAMHI, is also developing important activities for preventing the community of the threat of the depleted stratosphere ozone and the atmospheric pollution, which is one of its main objectives. So, through the performances of regional seminaries and conferences in Lima, with the important support of WMO, a great activity is being carried out in this field.

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PHILIPPINES

1. PAST AND PRESENT OZONE-RELATED ACTIVITIES

1.1 On Ozone Monitoring

1.1.1 Use of Dobson's Spectrophotometer

In cooperation with the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) established an ozone monitoring station using Dobson's Ozone Spectrophotometer and has made it operational since 1978. The primary purpose of this monitoring station is to generate reliable ozone data and trends. Data are sent regularly to the World Ozone Data Center in Colorado and form part of the Global Ozone Observing Station network of WMO.

1.1.2 The Use of Satellite Technology

PAGASA through the assistance of the Australian Government has been tracking and processing data from all the operational TIROS-N/NOAA Series satellite since August 1991. In particular, it receives and processes TIROS operational vertical sounder(TOVS) data obtained in real time received in Manila Station. This provides among others, total ozone concentration.

However, measurement of ozone from space is still in its infancy stage. The present method which has been developed in Australia has to be calibrated to suit local conditions. Furthermore, the technique also has to be refined using Dobson spectrophotometer data from Manila station.

1.2 On Climatological and Ozone Trend Studies

Based on the preliminary analysis done using Philippine ozone data covering the period 1979-1990, it has been noted that there is no definite trend in the yearly data. An earlier study also carried out by PAGASA using 1979-1981 data from the same station compared with ozone data from Bangkok, Japan and Samoa, USA found out that the mean monthly data has a very pronounced bimodal distribution. Its seasonal variation behaves similarly with the data from Bangkok and Japan, but opposite that of Samoa.

Studies of possible relationships in the variations of total ozone in the Philippines with other meteorological parameters such as Quasi- Biennial Oscillation (QBO) exhibited by the 30-mb zonal winds at Singapore and the Philippine rainfall data and also with the amount of UV radiation are being undertaken.

1.3 On Ozone Depleting Substances (ODS)

Study on pattern of consumption of ODS showed that the country consumed 3,000 metric tons(MT) of CFCs and 50 MT of halons in 1989. This corresponds to a calculated consumption (weighted ozone depleting potential) of 0.05 kg per capital income, which is well below the 0.3 kg per capita level; thus allowing for a 10-year delay in compliance with the Montreal Protocol.

1.4 Other Related Studies/Activities

1.4.1 Effects of UV-B and Global Climate Change on Rice Production (EPA/IRRI Cooperative Research Plan)

In the tropical region where the Philippines is located, the ozone layer is already thin so that we receive 5 to 9 times more sunlight making us more vulnerable if there is a continuous depletion of ozone. Adaptation to, or mitigation of the effects of UV radiation and global climate change requires initiation of forward looking research programs. Thus, the U.S. environment Protection Agency (EPA) in cooperation with the International Rice Research Institute (IRRI) has initiated a major program of research into the effects of global warming, global climatic changes, increases in atmospheric CO_2, and increases in UV-B on rice production. The EPA/IRRI Cooperation Research Program has made an announcement of holding an International Symposium on Climate Change and Rice on 15-17 March 1994 at IRRI, Los Banos, Laguna, Philippines, wherein among others, results of the various studies under the program will be presented[2].

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1.4.2 Effect of UV-B on Human Health

Studies on the effect of UV-B radiation on human health particularly on the skin is also one of the concerns in the country. The belief that most Filipinos because of their tan skin are protected from the effect of the UV radiation is not entirely correct. Recent studies show that a certain percentage of the populace are sensitive to sunlight. Dermatologists have also noted that there are more incidences of younger people(as young as 20 yrs. old) with skin carcinoma, which is a very rare occurrence in the past.

1.4.3 Actions taken by the government in response to the Montreal Protocol

As a result of the country study on ODSs, two feasibility studies funded by the World Bank are being carried out by DENR, namely recycling of CFC, and the use of non-ODS technology in solvents and tobacco applications.

A DENR Montreal Protocol Secretariat was formally created to provide overall coordination for the DENR's activities/projects geared towards the fulfillment of the country's obligation to the Protocol to establish an ODS databank and to serve as the clearing house of Montreal Protocol related information.

To accelerate the phaseout of CFCs and halons, the government is designing a policy which will consist of two major components: reduction of imports according to the proposed ODS phaseout schedule; and provision of incentives to promote appropriate technologies, specifically ODS-free technologies.

2. FUTURE ACTIVITIES/RECOMMENDATIONS

2.1 The use of satellite technology is a promising activity in filling up gaps of ground-based observations using Dobson's Spectrophotometer. The Dobson's spectrophotometer data however, can be used in calibrating space-based observations. In relation to this, the Philippines plans to utilize the other space-based ozone measurements which will be available in the future such as Global Ozone Monitoring Radiometer of NOAA-M including that of the TOMS of Nimbus-7 series satellite.

2.2 Presently, there are very few personnel with training in the processing and interpretation of satellite data related to ozone and various applications on climate change issues. Hence, collaboration and support from more advanced countries on these aspects are highly recommended.

2.3 On a national level, collaborative efforts of the different sectors in promoting awareness on the harmful effects of ozone depletion are urgently needed. These can be done through massive information campaign and through holding of conference/symposia on ozone depletion and the impacts of UV-B on ecosystems, health, climate, etc.

2.4 The total amount of UV radiation increase due to ozone depletion is as great in the tropics as in the higher latitudes. Strategy for enhanced global monitoring of the solar UV-B radiation, especially in the tropics is recommended taking into consideration standard procedures of measurement and instrumentation.

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POLAND

Essential role in promoting the ozone and UV-B monitoring and research activities play the State Inspectorate for Environmental Protection and the Ministry of Environmental Protection, Natural Resources and Forestry.

There are two main groups carrying on the ozone and UV-B monitoring and research activities.

INSTITUTE of METEOROLOGY and WATER MANAGEMENT - CENTRE of AEROLOGY

Monitoring

- Regular ozone soundings are performed once a week since 1979 at Legionowo upper-air station (52.24N, 20.58E)with OSE-4 electrochemical ozone sonde (Brewer-Mast type) and MARZ radiosonde. In April/May 1993 we will start to use the ECC-5A ozone sonde and RS80 radiosonde.
- Since January 1993 on a regular basis the TOVS satellite total ozone maps are performed.
- In May/June we will start to measure regularly the UV-B ra- diation by means of 501 UV-B Robertson-Berger meters at three stations: Leba - Baltic coast, Legionowo - Centre of Poland, Kasprowy Wierch - Tatra Mountains.

Research

- Backcorrection of ozone sonde data since 1979 (after backcorrection of Dobson data by BP coefficient).
- Re-calculation of statistical characteristics of ozone profiles, re-analysis of trends and dynamical analysis of strong ozone depletion cases.

We plan to join the EASOE programme and the european UV-B network.

POLISH ACADEMY of SCIENCES - INSTITUTE of GEOPHYSICS

Monitoring

- Measurements are carried out at the Belsk Observatory (51.50N, 20.47E). Since 1963 total ozone measurements and Umkehr series have been performed by means of the Dobson spectrophotometer. In 1991 the Brewer spectrophotometer and the surface ozone meter (Monitor Labs. ML8810) were installed. The NOx measurements with Monitor Labs. (ML8841) meter started in 1992.
- Systematic measurements of ground-level ultraviolet solar radiation (UV-B) with the Robertson-Berger meter have been carried out since 1975. UV-B radiation has been also monitored with the co-located Brewer spectrophotometer.
- Total ozone and Umkehr profile series have been re-evaluated in 1983 and 1987, respectively. Re-evaluation of total ozone data taken after the major re-evaluation is on-going.

Research

- Research activities mainly focus on statistical analyses (trends) on local and global scale. Impact of the total ozone and its vertical distribution changes on UV-B solar radiation level has been also investigated and is to be continued. It is planned to develop research on total ozone measurements errors due to stray light.

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RUSSIA

The Russian programme further investigation of the ozonosphere and the effects of its changes comprises two basic sections: - assessment of changes in the atmosphere, caused by man-induced and natural processes; - assessment of the effects of enhanced UV-radiation on the biosphere, including its human inhabitants.

Research teams from many scientific institutions take part in these investigations, such as the Central Aerological Observatory, the Main Geophysical Observatory, the Institute of Applied Geophysics and Experimental Meteorology of the Federal Agency for Hydrometeorology and Monitoring of the Environment, the Institute of the Atmosphere Physics of the Russian Academy of Sciences, Universities of Moscow, St.Petersburg and Novosibirsk, as well as science research institutes of the Ministry of Public Health Protection.

These activities are being carried out in close cooperation both with the states of the former Soviet Union and countries of Europe and America. Tight links are maintained with the Ukraine, Byelorussia, Baltic states, and Central Asia in metrological support of network total ozone measurements and data exchange. Joint projects are being successfully implemented with institutions and agencies of the United States (Meteor-3 / TOMS project), Canada (Atmospheric Environment Service, Brewer spectrophotometer operation at the Russian polar station Heiss Island, Frantz Josef Land), France (Zhigansk station which has begun functioning within the network NDSC - Network for Detection of Stratospheric Changes).

An institutional basis for these activities is provided by the State Programme "Ozone-Safe Substancies ", directed at investigation of man-induced impacts on the atmosphere and diminishing damage caused to the ozone layer.

I. OZONE LAYER INVESTIGATION

Primary attention was given to the first area - investigation of the ozonosphere response to man-induced impacts.

1.1 Satellite Measurements

Since September 1991, operational work has been done to analyze daily sets of total ozone data obtained from Meteor-3 / TOMS orbital complex. In 1992, special attention was given to observing the ozone hole dynamics in the Antarctic from August through December. The data obtained indicate a dramatically low ozone amount in the region concerned and the largest area associated with this minimum. Fig. 1 gives minimum daily values of total ozone in the period from 1 September to 30 November 1992. Figure 2 intercompares ozone hole areas, with 200 D.U. over the contour, in the periods from September through December for 1987, 1991, and 1992. The data for 1987 and 1991 were borrowed form WMO report (Scientific Assessment of Ozone Depletion: 1991, WMO, Global Ozone Research and Monitoring Project - Report No. 25), while those for 1992 were obtained at CAO based on Meteor-3 / TOMS data. As is seen from the diagram, the 1992 spring-time normally in the Antarctic is characterized by an earlier period of ozone hole formation and its longer persistence. Ozone layer observations at Molodezhnaya and Mirny in the Antarctic have continued, on a regular bases. Depending of the ozone hole over the Antarctic was detected in winter and spring, its dimensions reaching record-high values since the moment of its discovery.

Total ozone distribution over the Northern Hemisphere has been mapped in an operational regime, the ozone layer state in this region receiving broad attention. Fig. 3 shows total ozone distribution over the Northern Hemisphere for 5 December 1995. Note here 240-D.U. contour embracing the south-east part of the Black Sea and northern part of the Caspian Sea. Within this contour, total ozone values go down to 220 D.U.

Besides TOMS instrument, an absorption spectrometer, SFM-1 type (CAO), to retrieve the vertical ozone profile and BUVS-2 instruments to measure total ozone are mounted on board Meteor-3 spacecraft.

A special place in ozone layer monitoring is occupied by the intercomparison and analysis of satellite and ground-based ozono- metric network data. This makes it possible to integrate ozonometric network in a single global system and eliminate possible errors caused by the recalibration of instruments, violation of the measurement technique and operator's errors. as an example, Fig. 4 presents the results of the measurements made in the period from 1 September to 25 October 1992 at the Russian ground-based station Mirny, the Antarctic, using M-124 instrument and Meteor-3 / TOMS orbital complex.

1.2. Ground-Based Network

Besides satellite-borne observations, operational work continues to be done to control the state of total ozone field over the territory of the former USSR. Such work was initiated in 1986 on the basis of ground ozonometric network. Total ozone is mapped and anomalies are analyzed daily.

In 1992, this work developed into a joint project between the Central Aerological Observatory and the Laboratory of Atmospheric Physics, University of Thessaloniki, Greece, as part of the European Arctic Stratospheric Ozone Experiment. Based on ground ozonometric observations on the networks of Europe, Canada and the former USSR, daily synoptical total ozone maps were plotted. Figure 5 presents one such map where graphically shows an area of sharp total ozone decrease over Central Europe, to 228 D.U. In winter 1992-1993, the joint work has continued within the frame- work of the WMO Global System for Atmospheric Total Ozone Monitoring.

Ozone layer studies were conducted by CAO and the State Optical Institute, under the European Arctic Stratospheric Ozone Experiment (EASOE). Under EASOE project, regular balloon-borne observations using electrochemicl ozonesondes were conducted at two Russian Arctic stations (Heiss Island and Dikson); total ozone was measured using Brewer spectrophotometers. In the eastern Arctic sector total ozone was measured in Yakutsk (Brewer spectrophotometer) and Zhigansk (French spectrophotometer SAOZ). At middle latitudes, routine measurements using Brewer spectrophotometer are being made at

the scientific research station of the Institute of Atmosphere Physics, the Russian Academy of Sciences. Regular mapping of total ozone fields was done using data from Russian ozonometric network in order to reveal anomalies of its distribution.

Network data from all the stations of the former Soviet Union are transferred to the World Center of Ozone Data in Toronto, Canada.

1.3. Research Programs

Measurements of water vapour and aerosol concentrations in the stratosphere were conducted by CAO's specialists in Sweden, at the space range ESRANGE, in balloon-borne experiments under EASOE project. Aerosol measurements using similar instrumentation (balloon-borne backscattersondes) were also conducted at Heiss Island and Dikson, under a coordinated programme jointly with European scientists and specialists from the University of Wyoming, USA. At Apatity, Kola Peninsula, jointly with CNES (France), a balloon-flight control center was set up, with telemetry data acquisition station and remote control to support balloon flights from Sweden over the Russian border and landing of gondola with scientific instrumentation on the territory of Kola Peninsula. Five balloon experiments were conducted, with the recovery of scientific instrumentation and its delivery to the site of the start - ESRANGE. Balloon-borne experiments were conducted under an agreement between CNES and ROSHYDROMET. The field programme of experiments and participation of Russian researchers was supported by the European Community under EASOE project. A unique data array on the ozone layer state for winter- and spring-time in the Arctic have been obtained. It has been pointed out that after Pinatubo eruption the stratosphere is strongly affected by aerosol whose impact extends to polar latitudes. Lowered total ozone values were observed over the European part of Russia and the eastern Arctic sector in late February to early March. The deviation of total ozone values from the climatic model was twice the standard one, which may be the manifestation of man-induced effects on the ozone layer.

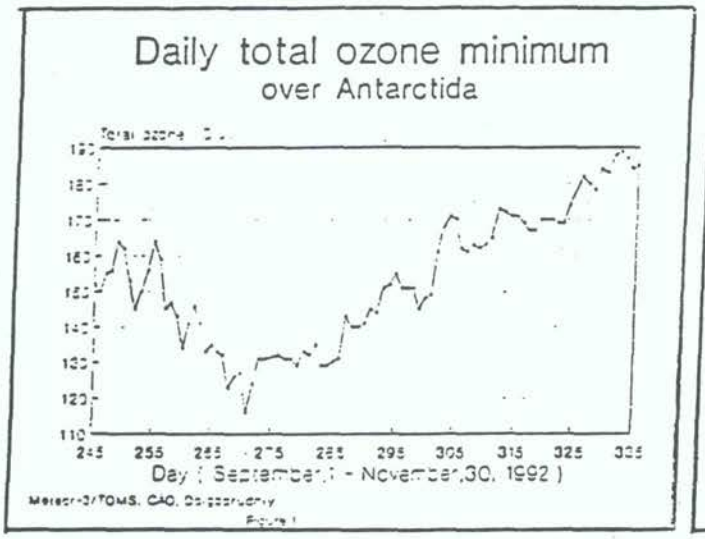
1.4. New instruments for monitoring of total ozone and UV-B radiation

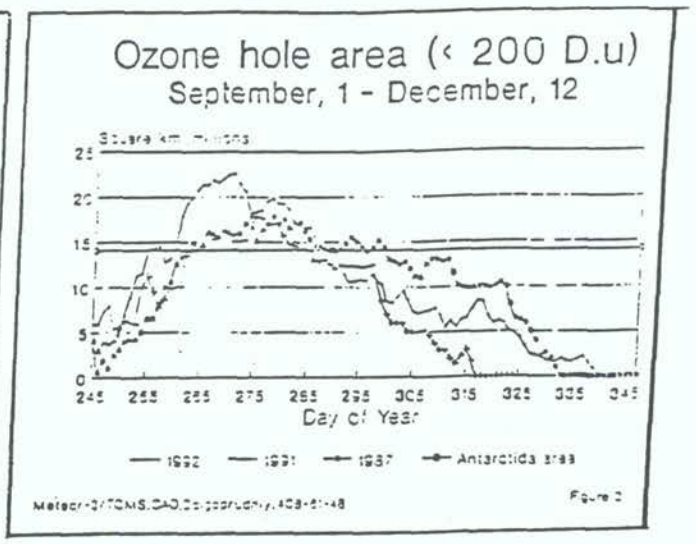
Significant attention has been given to the modification of equipment and instruments. At the Main Geophysical Observatory, a new automated filter instrument has been modernized and tested for the network monitoring of total ozone and natural UV-radiation in nine, rather narrow spectrum intervals (5-10 -nm half-width) in a 300-340 -nm range.

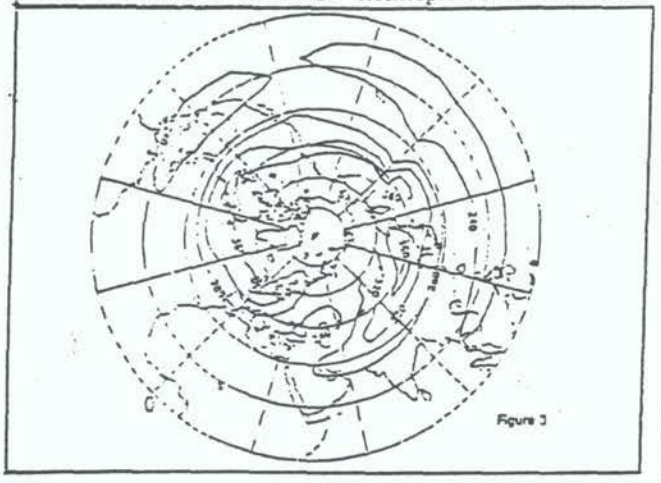
At CAO, an UV-spectrometer , SUVS-M, to measure absolute spectral irradiances of natural UV-radiation has been put in operation and a test series of observations were conducted at CAO's ozonometric station, Dolgoprudny, Moscow Region. Simultaneously, high-precision, total ozone observations using Dobson spectrophotometer and SUVS-M instrument were conducted. A second SUVS instrument was installed at a near-polar station in Murmansk region. Multi-layer numerical model has been developed and calculations were made to estimate the variability of natural UV-radiation spectral irradiance, depending on total ozone variations, vertical distribution and aerosol turbidity. For the conditions of the spectral irradiance observations using SUVS-M at CAO, intercomparisons of experimental and calculated results were made revealing considerable discrepancies in the wavelength range below 300 nm.

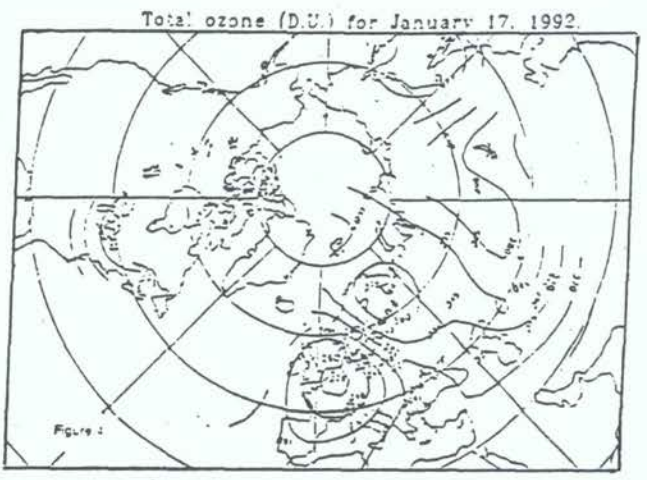
1.5 Chemical Kinetics and Photochemical data for use in Stratospheric modeling.

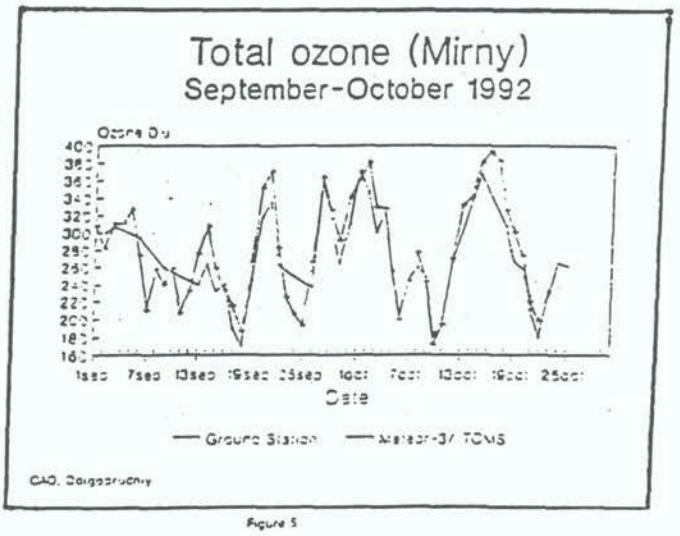
At the Institute of Chemical Physics Energy Problems, the Russian Academy of Sciences, a scientific-methodical basis for calculating the characteristics of chemical reactions in the atmosphere, involving ozone-destruction substances, is being developed. A complex of kinetic and photochemical instruments has been created to measure chemical reaction rates and radiation absorption cross-sections (in UV- and IR-spectrum ranges) of these molecules in the atmosphere. Based on these data, life-times of ozone-modifying substances in the atmosphere, their ozone- destruction and potential greenhouse effects are determined. Organizational and financial support of these activities is provided by Roshydromet and chemical industry enterprises.











II. ASSESSMENT OF THE EFFECTS OF OZONE LAYER CHANGES

Activities devoted to the second basic area - estimation of the effects of enhanced biosphere exposure to UV-radiation - have been primarily carried out by scientific workers from institutions of the Ministries of Public Health Protection and Agriculture of Russia.

At the Institute of Medico-Biological Problems of the Ministry of Public Health Protection of Russia, laboratory and field experiments to study the effects of prolonged exposure to enhances UV-radiation on the productivity of a number of crops (wheat, barley, potato, beetroot), on soil and aquatic microorganisms, the skin

and eyes of experimental model animals (mice and rabbits). Besides, work has ben initiated in two new, promising directions:

1. Studying the reflection spectra of human skin in different ethnic groups (it is necessary for obtaining more precise estimates of UV-radiation effects on human health, based on experimental data for model animals).

2. Creating a simulation, numerical, photobiological model to study and predict the likely loss in grain yield for different regions, the crops and soil bacteria being exposed to enhanced UV-radiation doses under the actual variability of basic agrochemical and weather factors.

Another scope of issues related with man-made ozonosphere changes encompasses economic and social aspects of the problem concerned. To date, a simulation model is being developed, making it possible to estimate, in single economic indices, different types of loss and gain connected with ozone layer protection activities. The ultimate aim of simulation must be the choice of the optimum version, taking into consideration such miscellaneous factors as the biosphere changing, the reconstruction of industrial production and use of ozone-modifying substances.

III. OBJECTIVES FOR THE NEXT YEARS

1. Satellite-borne monitoring - "SAGE" instrument installation on board a Russian spacecraft to study the vertical distribution of the concentrations of ozone, water vapour and nitrogen dioxide, (CAO Roshydromet, Langley, GSFC, NASA) in 1995.

2. Development of ground based network for UV-B monitoring.

3. Ground-based, aircraft and balloon-borne experiments: within SESAME project (Second European Stratospheric Arctic and Mid-Latitude Experiment, 1993-1995) is planned (CAO, IFA, CNES).

4. Further development of a complex of simulation models describing the ozonosphere and biosphere response to man-induced impacts, as well as feedback links in the system 'man - environment'.

5. Assessment of socioeconomic consequences of ozone layer changes.

6. Assessment of the biological effects of ozone layer changes.

This report is prepared at the Central Aerological Observatory, Roshydromet.

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SLOVENIA

Introduction

The monitoring and research activities on ozone in Slovenia are limited to the tropospheric and surface layer. Surface ozone is measured at ground sites elevated from 400 to 1700 m a.s.l.

With the aim to observe the effect of the stratospheric ozone changes, however, UV B solar radiation monitors are planned to be installed in the near future at three locations.

History of ozone measurements

First measurements of surface ozone started in 1984 with one monitoring station. Since then, ozone has been measured occasionally at several locations: in biggest towns in the

country, in the influence area of the thermal power plants, in forest areas, and on an elevated mountain site, close to the free troposphere.

Present state of ozone measurements

In 1992 ozone was monitored at nine locations. Three of the permanent stations belong to the National Basic Network run by the Hydrometeorologial Institute and financed by the government. Another four stations, one of them being mobile, are financed however by thermal power plants and they belong to the National Complementary Network.

One ozone monitor is owned also by the Department of Analytical Chemistry at the University of Ljubljana and is being used for the research purposes.

Measurement methods, equipment and QA

Ozone measurements are performed by continuous UV absorption monitors (ML Ozone Analyzer, Model 8810). They are calibrated automatically once a day and all measurements are recorded on the automatic monitoring station as half-hour values. Data are transferred on-line to the central computer.

Quality assurance is provided through the occasional comparison of our monitors with the ozone analyzer calibrated against the ozone standard at the Umweltbundesamt Wien. In May 1991, the Hydrometeorological Institute participated at the ozone intercomparison measurements on the LIS, Germany, organized for the Alpine countries.

International data exchange

One of our measuring sites, Krvavec, is included in the EUROTRAC TOR measurement network and upon agreement with the CCC-EMEP it is going to be the EMEP site, too. The information on elevated ozone concentrations are being interexchanged instantly within the participating European countries in the ARGE-ALPS and ALPS-ADRIATIC cooperation.

Future plans

National ozone monitoring network is planned to be expanded to some more sites during the next years. Background surface ozone is going to be measured at one EMEP site and the same station is planned to be comprised in the WMO GAW monitoring network. Some research measurements for TOR are planned in 1993, including also ozone profile measurements in the boundary layer.

Solar radiation monitors for UV B will be installed in 1993 at the following locations: near the Adriatic coast, in Ljubljana town and in the Alps at 2500 m above sea level.

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SOUTH AFRICA

Routine Monitoring

SA Weather Bureau
Stratospheric ozone was measured using a Dobson Spectrophotometer in Pretoria between 1964 and 1972. These measurements were resumed during 1989. Total ozone and Umkehr measurements are done on a daily basis.
Since 1989 a program of weekly ozone zonde measurements is maintained at Pretoria.

University of Natal, Durban (UND)
A SAOZ Spectrophotometer is operated at the Durban campus of UND. A Bentham spectroradiometer is used for ground based measurements of incident UV radiation.
A TOMS database is kept up to date routinely.

Earth, Marine and Atmospheric Science and Technology (EMATEC)

A background trace gas monitoring station at Cape Point is operated since 1978. Since the world-wide implementation of the Montreal Protocol a significant decrease in the growth-rate of CFC13 has been recorded.

Research

The following topics are being investigated:

.Interannual trends in ozone (ENSO)
.Ozone trends above SA and influence of the ozone hole
.Natural ozone depletion
.Chemical reactions - Sunscreen components-DNA-UV
.Relationships - Ozone, doses of UV and skin burn times

Special Projects

SAFARI (Southern African Fire Atmosphere Research Initiative)

in collaboration with:

STARE
TRACE-A

International involvement;

Southern African
German
French
Belgian
British
Canadian
American

The SAFARI project was designed to cover the scientific objectives of assessing the relationships between fires and savanna ecology in southern Africa, determining the emissions from savanna fires (particularly ozone and aerosols) in the region and studying the transport of biomass fire emissions across the subcontinent and adjacent oceanic areas.

Future plans

- Planing to initiate a South African National Ozone Research Program in connection with the various interested parties .
- Routine UVB measurements and public awareness programs.
- Increase the number of stratospheric ozone monitoring stations to fill in gaps in the national and international observational network.

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SRI LANKA

Sri Lanka is situated in the tropics very close to the equator between 6-10°N. Global studies in ozone have shown that the amount of ozone in an atmospheric column in the tropics is very small as compared to polar regions and mid-latitudes. Due to this reason the amount of solar radiation with harmful UV rays received in Sri Lanka is very large. Even a small change of the amount of ozone in the atmosphere will adversely affect Sri Lanka. In this respect, monitoring and taking steps to protect the ozone layer is very important.

UNDP funded survey on ozone depleting substances (ODS) is being conducted

and a country programme for phasing out ODS will be in place in the near future.

Apart from this, at present there are no institutes or individuals monitoring, assessing or conducting research on atmospheric ozone in Sri Lanka. Well funded and properly organized research and monitoring of ozone in Sri Lanka will be of immense use for the regional as well as global studies.

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SWITZERLAND

Switzerland is active in many areas of stratospheric ozone research. Monitoring is primarily performed at national institutions, e.g. the Swiss Meteorological Institute, whereas research is mostly carried out at University level. A proper national Ozone-programme for the coordination of the activities does not exist.

Monitoring and research is carried out by different groups at various locations in Switzerland. Each group uses a different remote sensing or in situ technique in order to determine the distribution of ozone and other trace gases which are important for the ozone chemistry. The techniques make use of the electromagnetic spectrum from UV over visible, infrared to the microwave region as well as mass spectroscopy. Measurements are taken with experiments from the ground, balloons, rockets, aircraft and from space. Most of the groups collaborate internationally and take part in international field campaigns.

While monitoring and research of trace gases show a very high scientific standard, UV-B measurements are still modest so far.

Current and planned activities

Monitoring: Total ozone and Umkehr observations with Dobson Spectrometers and Brewer instruments are performed on a regular basis at Arosa. Three times a week an ozone-sonde is launched with a weather-balloon from Payerne. The Swiss Meteorological Institute is in charge of these activities.
Based on these measurements, multiple regression analysis has been used to deduce ozone trends (Atmospheric Physics, ETH-Z). Results are included in WMO-Report No. 25, p. 2.24/25.

Future research will also focus on the aspect of natural ozone variability and ozone trends.

UV-B: At Arosa, UV-B is measured with a Robertson Berger and a Brewer instrument in collaboration with Innsbruck University.

Microwave Radiometry: Microwave Radiometers are developed and operated by the Institute of Applied Physics of the University of Bern.
O_3 (142 GHz) operating from Bern
ClO (204 GHz) operating from Jungfraujoch
H_2O (22/31 GHz) for total water vapour and liquid water content with high temporal resolution operating from Bern or Jungfraujoch.

These measurements contribute to the EC-project ESMOS (European Stratospheric Monitoring Stations) and during winter 1991/92 to EASOE, (the European Arctic Stratospheric Ozone Experiment).
The Millimetre-wave Atmospheric Sounder (MAS) was operated during the Shuttle ATLAS-1 mission in spring 1992. Measurements of O_3, H_2O and ClO were performed.
Activities for 1993/94: Improving sensitivity of ClO-receiver and building a new CO-receiver.
Second flight of MAS on ATLAS-2: April 1993.

Mass spectrometry: A new mass spectrometer has been developed within the project SIDAMS (Simultaneous Ion Detection in Atmospheric Mass Spectrometry) and successfully tested. Objectives of this new balloon-borne instrument is the in situ measurement of the ion composition in the stratosphere, focusing on negative ions and with the final goal of inferring trace gas concentration profiles, mainly HNO_3 and N_2O_5.
The responsibility for the ion mass spectrometer lies with the Physics Institute of the University of Bern. Further rocket and balloon-borne flights of SIDAMS are foreseen in the future.

UV-Spectroscopy: A UV-visible spectrophotometer using the tangent ray technique in occultation has been developed for flights in stratospheric balloons with international collaboration by the Observatory of Geneva. A new LN_2 cooled CCD-spectrometer was built.
Further balloon flights are planned.

Lidar: New analytical and numerical methods for the characterisation of atmospheric particles such as cloud elements and aerosols and their optical properties have been investigated at the Observatory of Neuchâtel. In collaboration with CNR-IROE, Florence, and the Service d'Aeronomie, Paris, this group participated in Lidar-measurements during the EASOE-campaign.

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SYRIA

Syria acceded to the Vienna Convention for the Protection of the Ozone Layer on 12 December 1989 and Entry into force on 12 March 1990 and its Montreal Protocol.

The Government of Syria assigned the responsibility of implementation of the Vienna Convention and the Montreal Protocol to the General Commission for Environmental Affairs. The Commission is also the focal pooint to (UNEP) on the issues of ozone layer protection.

Syria has participated with interest in the various meetings convened under the Vienna Convention of the Montreal Protocol.

General Commission for Environmental Affairs organized several programmes on the environment, sometimes focussing on the problem of ozone layer depletion and international efforts being made to protect the ozone layer.

*The Country Programme:

The Country Programme reflects the commitment of the Government of Syria to comply with the obligations of the Montreal Protocol on substances that deplete the ozone layer. It provides the framework for activities to be undertaken by Syria to achieve the required phase-out of controlled substances.

*The objectives of this Country Programme are:

- To record the situation with regard to consumption and use pattern of the controlled substances for the years 1986, 1989, 1990 and 1991.

- To record the existing institutional framework in Syria for dealing with the issues of ozone layer protection and ozone depletion.

- To analyse the possible future demands for controlled substances if no measures are taken to control the consumption.

- To outline the action plan including strengthening of the institutional capacity and capability in Syria for the phase-out of the consumption of the substances controlled under the Montreal Protocol.

- To record the scheme for implementing the action plan and for monitoriong the consumption of the controlled substances to ensure that the action plan is implemented and ensure compliance with the reporting requirements of the Protocol.

The Government of Syria is committed to phasing out the consumption of controlled substances in Syria as soon as possible but not later than the year 2000. The Government has already taken actions to pursue this goal. Although Syria, as a developing country operating under paragraph (1) of Article (5), is entitled to delay the phase-out by 10 years. (The equivalent of CFCs to 0,015 kg. per capita). It will not await the elapse of the grace period before embarking on action to phase out its consumption of the controlled substances. With timely and efficient provision of the necessary financial and technical support from the Multilateral Fund under the Montreal Protocol and effective technology transfer and implementation of the Country Programme Syria could meet its goal to phase out the consumption of the controlled substances earlier than the Protocol requires for Article 5 countries.

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THAILAND

I. Introduction

Since the early 1990s the scientific community and the general public in Thailand have become aware of the threat to the ozone layer, thanks to the information materials disseminated by UNEP and WMO. Now, even music programme organizers or otherwise known as music DJs, remind the radio audience intermittently of the seriousness of the ozone depletion problem in their talks. Numerous seminars have been conducted by the authorities concerned, whereby scientists and lecturers did have a chance to participate in such seminars.

Recently, a Sub-Committee on Global Change under the ICSU-National Committee under the auspices of the National Research Council (NRC) was established. One of the functions of this Sub-Committee is to initiate research projects to be conducted by scientists and researchers within the country, whereby collaboration research with scientific institutions of developed countries is to be promoted. Ozone research is one of the possible research areas that can be funded by NRC.

II. The state of ozone research in Thailand

Up til now, ozone research has not received priority attention by policy-makers, neither at the ministries concerned nor at the universities. The lack of interest for ozone research may be due to several factors, such as,

i) Thailand has a very limited number of highly qualified atmospheric scientists, especially climatologists, who have been educated abroad;

ii) Thai dermatologists do not perceive that skin cancer arising from increased ultraviolet radiation would occur in large numbers in the Thai population. It is a well-known fact among dermatologists that the Thai hardly contract skin cancer from exposure to sunlight, owing to different physiological structures between the Thai and other nationalities such as the white populations;

iii) In the past not enough funds have been allocated to research areas that do not have direct applications. Ozone research belongs to this category. Allocation of funds was rather piecemeal;

iv) Scientists and researchers did not consider stratospheric ozone depletion a serious problem that deserved research efforts.

But things begin to change gradually. Now at least one of the largest universities in Thailand, Chulalongkorn University, has shown willingness to support ozone-related research. At least funds are available for such a research, if there are worth y applications, according to the personal communication with the Vice-Rector for Research. The question remains, however, how to formulate sound research proposals and, how to stimulate qualified scientific and research to become interested in ozone-related research. Stimulus for ozone research could be initiated by the above-mentioned Sub-Committee on Global Change as well. Moreover, the Office of Environmental Policy and Planning could also grant ozone research funds to scientific institutions, provided that research themes are approved by the Budget Bureau. In this regard, the budget approval procedure is about one year.

III. The state of ozone monitoring in Thailand

Regular monitoring of total atmospheric ozone is being conducted at Bangkok station by the Department of Meteorology since 1984, using Dobson Ozone Spectrophotometer. No significants change has been detected so far. Recently, the Department established within the Atmospheric Observation Division, a radiation and ozone unit, that is responsible, among others, for measurements of the total amount of ozone in the atmosphere. Up til now, measurements have been carried out with the help of the Observer's Handbook for the Ozone Spectrophotometer as well as the 1982 User's Manual for the Dobson Spectrophotometer prepared by the responsible Thai scientists. The unit intends to conduct more ozone measurements than that is being done at present. It is felt that more sophisticated equipment would be of great value to the ozone research in general. However, government funding for such equipment may not be forthcoming in the near future. That is the serious problem that Thai scientists/researchers are now facing.

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UNITED KINGDOM

The United Kingdom is active in most areas of stratospheric research and work on UVB impacts is also undertaken. Research is spread across government departments (primarily the Department of Environment (DoE), the Ministry of Agriculture, Fisheries and Food and the Ministry of Defence: Met Office) and the research councils (primarily the Natural Environment and Science and Engineering Research Councils, NERC and SERC). Some of the work involves European Commission support with additional support from industry including AFEAS.

Current and planned activities are as follows:

(1) Monitoring and Measurements

(a) Ozone. Measurements are currently made by the Meteorological Office using Dobson spectrophotometers at Camborne (S.W. England), Lerwick (Shetland Is) and Mahe (Seychelles). The British Antarctic Survey (BAS) monitors total ozone at Halley Bay and Faraday. The DoE is measuring ozone profiles at Lerwick using sondes.

(b) UV Spectroscopy. The NERC have initiated a programme of ground based remote sensing of the stratosphere using UV multi-channel array spectroscopy. An automated instrument was installed at the BAS base at Faraday in 1990. A second instrument was procured by University College, Wales. This instrument was successfully deployed at Lerwick during EASOE, and is now being used for measurements of O_3 and NO_2 at Aberystwyth. A third instrument with extended sensitivity and a star tracker (UVISTAR) has been assembled jointly by BAS and the University of Cambridge and was also deployed in EASOE at Abisco, North Sweden. A second version

of the UVISTAR instrument will be deployed at Halley Bay from January 1994.

(c) UVB. High resolution spectral measurements have been made since 1989 at Reading for the DoE. The instrument used took part in a first intercomparison exercise to aid the determination of standards for a UV monitoring network and will continue to be coordinated with international programmes. The National Radiological Protection Board (NRPB) carries out broadband measurements at three sites in the UK and will introduce spectral measurements to 2 of the sites this year. The broadband network will be extended to include 3 further UK sites in the next year or so.

(d) CFCs and substitutes. CFCs are monitored for the Department of the Environment at Mace Head in Southern Ireland as part of the ALE/GAGE network. Further measurements of CFCs, HFCs and HCFCs are also carried out at a site in East Anglia.

(2) The Second European Stratospheric Arctic and Mid-latitude Experiment (SESAME)

The UK will be strongly involved in the coordination of the proposed SESAME programme through the EC/EFTA Coordination Unit at Cambridge. UK scientists will be involved in measurements and theoretical studies during the campaign. The priority for SESAME is to understand the observed long term trends in mid-latitude ozone; this will require chemistry and dynamical studies in conjunction with detailed meteorological studies.

(3) Instrument Development

(a) UARS. The SERC carries out a significant programme of satellite instrument development. In particular they have provided the Improved Stratospheric and Mesospheric Sounder (ISAMS) and a sub-system for the Microwave Limb Sounder (MLS), flown on the NASA UARS satellite which was launched in the late summer of 1991. ISAMS is not now functioning but much information was gathered befored it failed. The UARS data will be used to cross-validate data gathered during EASOE. UARS will also be used to provide three dimensional assimilated fields for tropospheric/ stratospheric GCMs with photochemistry developed at the Meteorological Office.

(b) EOS. The SERC have plans to develop, in collaboration with the US and various UK groups, the High Resolution Dynamic Limb Sounder (HIRDLS) and contributions to the Extended Microwave Limb Sounder (EMLS), to be flown on the NASA-CHEM platform (launch: 2002).

(c) Ground Based and Airborne Instruments. A number of instruments will be developed by SERC, the National Physical Laboratory (NPL) and UK University groups in response to a recent NERC/SERC initiative in this area. A laser heterodyne spectrophotometer for measurement of trace species in the stratosphere has been developed by NPL for the DoE, and will form, along with a transportable fourier transform (FT) interferometer, the UK contribution to the ESMOS (European Stratospheric Monitoring Stations) project. The FT interferometer will be used as a transfer standard to compare with other infrared instruments. Measurements made by these instruments will also form part of SESAME. A methodology will be developed by NPL for the DoE to correct DIAL (advanced differential absorption lidar) measurements of ozone for systematic effects to provide accurate ozone profiles and measurements of aerosol density.

(d) The NERC and SERC have recently announced a call for proposals for a new joint initiative in development and deployment of instruments for field measurements in atmospheric science (IFAS), with particular emphasis on the lower stratosphere and the upper troposphere.

(4) Laboratory Studies

(a) Atmospheric chemistry kinetics are studied by several groups in the UK. research includes gas phase and heterogeneous reactions related to ozone depletion and HCFC degradation in the troposphere.

(b) The "Initiative in Atmospheric Chemistry", which was launched in 1991 by the SERC, is strengthening activities in this area.

(5) Modelling

(a) A variety of atmospheric modelling activities related to ozone are ongoing at the Meteorological Office, Rutherford Appleton Laboratory, Harwell Laboratory and the Universities of Cambridge, Oxford, Reading, Edinburgh, East Anglia and Imperial College. Dynamical and chemical studies are underway using a variety of models ranging from three dimensional GCMs to simple lagrangian box models.

(b) The NERC has recently expanded activity in numerical modelling of atmospheric ozone through two Special Topic Initiatives within the framework of the Universities Global Atmospheric Modelling Community Research Project (UGAMP), Numerical Modelling of

Stratospheric Ozone and Modelling of the Natural Variability of the Atmosphere Relevant to Climate and Stratospheric ozone. the NERC has established a Centre for Global Atmospheric Modelling at Reading University in order to provide infrastructure support for UGAMP.

(6) Data Archives

(a) The SERC-funded Geophysical Data Facility (GDF) is an on-line data facility for atmospheric sciences to enable research scientists user-friendly access to relevant data. Data-holdings include satellite, aircraft, ground-based and model-generated data of the atmosphere, including data from NIMBUS 7 (SAMS, LIMS, TOMS, SAGE) and more recently from the UARS platform.

(b) Stratospheric Soundings. The Meteorological Office carries out long term monitoring of the performance of the Stratospheric Sounding Units on the NOAA operational satellites. A fifteen year archive of daily fields of geopotential height, temperature and geostrophic winds has been produced and will continue to be developed at least until 1994. This data is available on the GDF.

(7) Impacts

(a) Skin. Various studies consider the impact of UVB on skin and the register of Cutaneous Melanoma cases in Scotland has been maintained for the last 15 years. The UK Department of Health is committed to halt the year-on-year increase in the incidence of skin cancer by the year 2005 and with NRPB are planning to develop a detailed action spectra for human skin *in vivo*.

(b) Ecosystems. Several studies are underway on the examination of the impact of UVB on vegetation under controlled conditions and in the field (DoE), the effects of increased UVB on competitive and other interactions in plant communities, analytical studies of UVB damage in plants and protective mechanisms, and plant phenology.

(c) Agriculture and Forestry. Studies currently include a MAFF project on the impact of increasing UVB on a range of vegetable crops and cultivars under field conditions; and a collaborative study of the responses of crop and tree species to enhanced UVB.

(d) Fish. A study supported by MAFF is investigating the effects of UVB on eggs and larvae of commercially important fish species.

(e) The recently launched AFRC/NERC UVB Initiative will strengthen activities in this area.

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UNITED STATES OF AMERICA

Atmospheric Research

The long-term objectives of the USA program are to perform research to:

(a) understand the physics, chemistry, and transport processes of the upper atmosphere, and

(b) accurately assess possible perturbations of the upper atmosphere caused by human activities as well as by natural phenomena.

The USA program supports a variety of research tasks by scientists from the university, government, and industrial communities. The program activities fall into three major categories:

(1) Field Measurements and Monitoring Research, where measurements employ in-situ and remote sensing techniques from ground-based, aircraft, balloon, rocket, shuttle, and satellite platforms, and where monitoring includes analysis of large satellite data sets;
(2) Laboratory Studies, including gas phase and heterogeneous kinetics, photochemistry, spectroscopy, and calibration standards development; and
(3) Theoretical Studies, including development of 1-D, 2-D, and 3-D models of photochemistry and dynamics; and

Current research funding supports specific investigations including those listed below.

(1) Field Measurements and Monitoring:

(a) Observations of the global distribution of ozone, its vertical profile, and temporal variations. Key components of the observational network include the TOMS instruments aboard US, Russian and Japanese satellites; the SBUV/2 and SAGE satellite-borne instruments; and the ground-based Dobson network.
(b) Determination of the distribution of trace gases in the upper atmosphere, with emphasis on those species that influence the ozone balance. Key components of the observational network include the Upper Atmosphere Research Satellite (UARS) and instrumentation associated with the Network for the Detection of Stratospheric Change (NDSC).
(c) Multi-site, ground-level measurements of the concentrations of ozone depleting substances, including CFCs, HCFCs, halons, and methyl chloroform, as well as of N_2O, CH_4, and CO_2.
(d) Field campaigns designed to better quantify the atmospheric lifetimes, and, hence, ozone depletion potentials, of ozone depleting substances. Measurements include oceanic uptake of CFCs, HCFCs, methyl chloroform, and methyl bromide, and spectroscopic determination of tropospheric OH.
(e) Integrated polar and mid-latitudinal ozone campaigns using ground, aircraft, balloon, and satellite instrumentation. These include the second Airborne

Arctic Stratospheric Expedition (AASE-II) (1992); the Stratospheric Photochemistry, Aerosols, and Dynamics Expedition (SPADE) (1993); and the joint Airborne Southern Hemisphere Ozone Experiment/Measurements for Assessing the Effects of Stratospheric Aircraft (ASHOE/MAESA) campaigns (1994).

(f) Ongoing analyses of ground-based (Dobson, NDSC) and satellite (TOMS, SBUV, SAGE) data for determination and interpretation of ozone trends, and calculation of surface UV radiation using global data sets (TOMS, ERBE).

(g) Establishment of a ground-based network for monitoring UV-B levels.

(2) Laboratory Studies:

(a) Laboratories studies in spectroscopy, photochemistry, and chemical kinetics relevant to the interpretation of atmospheric measurements and to theoretical simulations of the atmosphere. Areas of particular significance include (1) lifetimes and degradation mechanisms of CFC substitutes; (2) heterogeneous processes occurring on polar stratospheric clouds and on sulfate aerosols; and (3) mechanisms and rates of key chlorine and bromine reactions.

(b) Development of new chemicals and technologies for replacing the use of ozone depleting substances. Key investigations include evaluation of the properties and performance of new chemicals proposed for use in refrigeration, space cooling, insulation, and fire protection.

(3) Theoretical Studies:

(a) Development of improved multi-dimensional models of the atmosphere, with emphases on (1) combined chemistry-transport models; (2) dynamical and chemical coupling of the troposphere and stratosphere; and (3) chemical and radiative effects of stratospheric clouds and atmospheric aerosols.

(b) Application of trajectory studies and of 2-D and 3-D models to assess the cause of lower stratospheric mid-latitude ozone depletion, with emphases placed on the effects of aerosols and the possibility of polar preprocessing.

(c) Application of 3-D models to assess the climatic implications of stratospheric ozone depletion, including the effects on dynamics and radiative forcing.

(d) Application of 2-D and 3-D stratospheric models to assess the impacts of changing atmospheric composition. Specific emphasis is being placed on assessing the impact of high speed aircraft on stratospheric ozone.

(e) Development of improved methodologies for determination of ozone depletion potentials (ODPs), and computation of ODPs for newly proposed CFC substitutes.

Effects Research

To assess the consequences of ozone depletion, information is needed on the nature and magnitude of the ecological and human health effects of UV-B radiation. This information is critical to establishing responsible regulations, mitigation options, and adaptive strategies. Since domestic regulation currently calls for a phaseout of CFCs and halons by 1995, suitable alternatives must be found to take their places. In addition, alternative chemicals and technologies must be made available to other nations to facilitate worldwide solutions. Finally, adaptive biological strategies must be developed to cope with the unavoidable and inevitable decrease in stratospheric ozone.

The USA program supports a variety of research tasks by scientists from the university, government, and industrial communities. Current research funding supports specific

investigations including those listed below.

(a) UV-B Monitoring. Increased depletion of stratospheric ozone is expected to result in enhanced ground-level UV-B radiation. Consequently, a national UV-B monitoring network will be established to (1) develop data on UV-B trends; (2) improve algorithms used to predict UV-B exposure; and (3) provide high-quality, spectrally-resolved UV radiation measurements to support health and ecological risk assessments.

(b) Human Health effects. Increased UV-B is known to lead to increased incidence of skin cancer and cataracts. Additional investigations, however, will (1) determine the effect of UV-B radiation on the human immune system; and (2) evaluate how UV-B induced immunosuppression will affect human susceptibility to infectious diseases and vaccine effectiveness.

(c) Aquatic Effects. Studies will be performed to (1) determine the extent to which UV-B radiation adversely impacts phytoplankton species; and (2) determine indirect impacts on fisheries and ecosystems resulting from phytoplankton effects.

(d) Plant Life. Studies will be performed to (1) determine the extent to which UV-B radiation adversely impacts plant life; and (2) determine the mechanisms of plant response to enhanced UV-B.

(e) Replacement Chemicals. CFC substitutes may not be completely environmentally benign. In order to assess the substitutes, investigations will (1) evaluate the properties (e.g., toxicity, flammability, etc.) of proposed substitutes; (2) determine the atmospheric and oceanic fates of the proposed substitutes and their degradation products; and (3) determine the environmental risks associated with the replacement compounds and their degradation products.

(f) Disposal of Ozone Depleting Substances. Investigations will quantify the adverse emissions associated with the destruction of these substances.

(g) Technology Alternatives. Investigations will assess the economic and technical viability of technology alternatives which do not require replacement chemicals.

A key challenge for research in the United States regarding depletion of stratospheric ozone has been to target the available resources on those areas of scientific and engineering uncertainty that are most useful to policymakers in addressing this issue. This work will contribute to the success of the Montreal Protocol. For the conditions of the protocol to be successful on a global scale, it is essential that the research be focussed on areas that are relevant not only to the United States and other industrialized nations, but also to developing and newly industrialized countries. Research in the United States is designed to play a significant role in generating scientific information that is credible and persuasive to these important audiences.

As a consequence, a key component of US research related to depletion of stratospheric ozone includes:

(1) Development of alternative technologies to help reduce stratospheric ozone depletion, and assistance with technology and information transfer; and

(2) Providing policy-relevant information for developing assessment of the human health and ecological effects of ozone depleting substances, in cooperation with appropriate international organizations.

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APPENDICE E
(en référence au paragraphe 7.5.1)

EXIGENCES PROPRES AUX MESURES DU RAYONNEMENT UVB

A. UV-B

1. Résolution relative à la longueur d'onde : 1,0 nm ou mieux
2. Résolution temporelle : 10 minutes ou mieux
3. Résolution directionnelle (ou angulaire) : séparation en éléments directs et diffus, ou mieux
4. Stratégie d'étalonnage méticuleuse

B. DONNÉES AUXILIAIRES – ABSOLUMENT NÉCESSAIRES

1. Colonne totale d'ozone (sur 100 km)
2. Profondeur optique d'aérosol
3. Albédo au sol
4. Nébulosité

FORTEMENT RECOMMANDÉES

5. Profils lidar des aérosols
6. Répartition verticale de l'ozone
7. Eclairement énergétique de courtes longueurs d'onde (c'est-à-dire rayonnement solaire global)
8. Polarisation de la luminance énergétique zénithale
9. Teneur en vapeur d'eau

WMO GLOBAL OZONE RESEARCH AND MONITORING PROJECT

Rapport N°	*Titre*	*Situation*
No. 1	Atmospheric Ozone - A Survey of the Current State (by R.D. Bojkov to the UNEP Meeting of Experts on the Ozone Layer, Washington, D.C. March 1977)	non disponible
No. 2	Report of the Meeting of Experts on Ozone Modelling and Stratospheric/Tropospheric Exchange Processes (Geneva, April 1977)	non disponible
No. 3	Report of the Meeting of Experts on UV-B Monitoring and Research (Geneva, May 1977)	non disponible
No. 4	Report of the Meeting of Experts on Measurements of Rare Species Relevant to the Ozone Budget (Seattle, May 1977)	
No. 5	Report of the Meeting of Experts on Stratospheric Circulation Analysis and Ozone (Washington, D.C., July 1979)	
No. 6	Operations Handbook - Ozone Observations with a Dobsons Spectrophotometer (by W.D. Komhyr)	non disponible
No. 7	Report of the WMO Meeting of Experts on 2-D Ozone Models (Toronto, November 1979)	non disponible
No. 8	Report of the WMO Meeting of Experts on Rare Atmospheric Constituents of Importance to the Ozone Layer, (Washington, D.C., February 1980)	non disponible
No. 9	Report of the Meeting of Experts on Assessment of Performance Characteristics of Various Ozone Observing Systems (Boulder, July 1980)	non disponible
No. 10	Contribution of Ozone and Other Minor Gases to Atmospheric Radiation Regime and their Possible Effect on Global Climate Change (by E.L. Aleksandrov, I.L. Karol, A. Ch. Khrgian, L.R. Rakipova, Yu. S. Sedunov)	non disponible
No. 11	The Stratospheric 1981 Theory and Measurements (A Meeting of Experts on the State of the Stratosphere, Hampton, Virginia, May 1981)	
No. 12	Report of the Meeting of Experts on Sources of Errors in Detection of Ozone Trends (Toronto, April 1982)	
No. 13	Review of the Dobson Spectrophotometer and its Accuracy (by Reid E. Basher)	
No. 14	Report of the Meeting of Experts on Potential Climatic Effects of Ozone and Other Minor Trace Gases (Boulder, September 1982)	
No. 15	Report of the Meeting of Experts on Tropospheric Ozone, its Changes and Possible Radiative Effects (Shanghai, October 1984)	
No. 16	Atmospheric Ozone 1985 Assessment of our Understanding of the Processes Controlling its Present Distribution and Change (3 volumes)	non disponible
No. 17	Measurement of Atmospheric Ozone Profiles Using the Brewer/Mast Sonde - Preparation, Procedure, Evaluation (by H. Claude, R. Hartmannsgruber and H. Kohler)	non disponible
No. 18	WMO/NASA International Ozone Trends Panel Report - 1988 (2 volumes)	non disponible
No. 19	Summary Results from Dobson Intercomparisons (Reid E. Basher)	
No. 20	Scientific Assessment of Stratospheric Ozone - 1989 (2 volumes)	
No. 21	Report of the Preparatory Meeting of the Ozone Research Managers of the Parties to the Vienna Convention for the Protection of the Ozone Layer (Geneva, February 1990)	
No. 22	WMO Consultation on Brewer Ozone Spectrophotometer Operation, Calibration and Data Reporting (Arosa, Switzerland, August 1990)	
No. 23	"Rapport de la première réunion des Directeurs de recherches sur l'ozone des Parties à la Convention de Vienne pour la protection de la couche d'ozone (Genève, mars 1991)"	
No. 24	Report of the International Workshop on Dobson Ozone Data Re-evaluation (Greenbelt, MD, September 1991)	
No. 25	Scientific Assessment of Ozone Depletion - 1991	
No. 26	Report of the Meeting of Experts on Surface Ozone Data, their Analysis and Related Issues (Geneva, November 1991)	
No. 27	Third WMO Intercomparison of the Ozonesondes used in the GO$_3$OS (Vanscoy, Canada, 13-24 May 1991)	
No. 28	Intercomparison of ground-based visible-light NO_2 measuring devices (Mt. Kobau, Canada, August 1991)	en préparation
No. 29	Handbook on Dobson Data Re-evaluation	en préparation
No. 30	Meeting of Experts on Ozone Measurements by Brewer Instruments (Charlottesville, Virginia, June 1992)	en préparation
No. 31	Atlas of Total Ozone GO$_3$OS Maps for the European Arctic Stratospheric Ozone Experiment (November 1991 - March 1992)	
No. 32	"Rapport de la deuxième réunion des Directeurs de recherches sur l'ozone des Parties à la Convention de Vienne pour la protection de la couche d'ozone (Genève, 10-12mars1993)"	