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Weather • Climate • Water

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WEATHER AND CLIMATE: ENGAGING YOUTH

Bulletin

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In this issue

During 2014, WMO will reach out to young people and seek to engage them in weather and climate issues. In January, the Organization launched a new web-based Youth Corner (www.wmo.int/youth/). In February, it issued a new edition of Careers in Meteorology aimed at young people who are deciding what to study or what kind of work to pursue. In March, over 100 students were invited to WMO headquarters in Geneva to celebrate World Meteorology Day with the theme "Weather and Climate: Engaging Youth."

While weather and climate issues affect the lives of young people today, they will have increasingly dramatic impacts in the future. What are some of the biggest environmental concerns that future generations will face? The health of the oceans, the impacts of desertification and the growth of megacities are three important issues that will have to be addressed. "Hot, Sour and Breathless – Oceans Under Stress," "The Future of the Aral Sea lies in Transboundary Co–operation" and "Towards Integrated Urban Weather, Environment and Climate Services" provide some insight into those issues.

Then follows a series of contributions from young people. "Junior Professional Officers" at WMO feel an urgent need to address the threats and opportunities of climate change. They share their passion with readers and urge others to consider careers in sciences. Along that career path can come some rare perks as shown in "Meteo-Volunteers for Sochi Olympic Games 2014." For those taking a different path, there are other avenues for them to act on climate issues. Landry Ndriko Mayigane provides examples in "How African Youth are Participating in Global Climate Change Politics." The final article in the series is by a student from the Ferney-Voltaire International School, reporting on the WMO-supported "Model United Nations" event on climate change, which took place in January.

WMO Members and others in the meteorology community "engage" youth as part of their mandates. Space only permits us to present a few of our community's efforts, including those of the LaMMA Consortium in Italy, the Met Office and the Royal Meteorological Society in the United Kingdom of Great Britain and Northern Ireland (UK), the American Meteorological Society (AMS), the Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG), and the Caribbean Institute for Meteorology and Hydrology in Barbados. WMO Members all over the world are implementing similar initiatives, and readers are encouraged to contact their national meteorological and hydrological services for more information. The WMO website contains links to the websites of the national meteorological and hydrometeorological services of its Members (visit www.wmo.int/pages/members/members_en.html) where more information can be obtained on local activities and young people can see how they can get involved. The new WMO Youth Corner also contains direct links to youth websites and materials created by Members.

The two final articles focus on efforts by WMO and its partners to fill the gaps in observation systems in the polar regions to respond to growing scientific understanding of the critical role these regions play in the global weather and climate system.

Hot, Sour and Breathless – Ocean Under Stress

This article has been republished with the authorization of the Plymouth Marine Laboratory[1]

How is the biggest ecosystem on Earth faring?

The ocean covers nearly three quarters of the Earth's surface, contains 96 per cent of its living space, provides around half of the oxygen we breathe and is an increasing source of protein for a rapidly growing world population. However, human activity is having an impact on this precious resource on local, regional and global scales.

Over the coming decades and centuries, ocean health will become increasingly stressed by at least three interacting factors. Rising seawater temperature, ocean acidification and ocean deoxygenation will cause substantial changes in marine physics, chemistry and biology. These changes will affect the ocean in ways that we are only beginning to understand.

It is imperative that international decision-makers understand the enormous role the ocean plays in sustaining life on Earth, and the consequences of a high CO_2 world for the ocean and society.

1 – Ocean acidification

Ocean acidification is directly caused by the increase of carbon dioxide (CO_2) levels in the atmosphere. When CO_2 enters the ocean it rapidly goes through a series of chemical reactions, which increase the acidity of the surface seawater (lowering its pH). The ocean has already removed about 30 per cent of anthropogenic CO_2 over the last 250 years, decreasing pH at a rate not seen for around 60 million years.

This effect can be considered beneficial since it has slowed the accumulation of CO_2 in the atmosphere and the rate of global warming; without this ocean sink, atmospheric CO_2 levels would already be greater than 450 ppm. However, the continuation of such a fundamental and rapid change to ocean chemistry is likely to be bad news for life in the sea; it will not only cause problems for many organisms with calcium carbonate skeletons or shells (such as oysters, mussels, corals and some planktonic species) but could also impact many other organisms, ecosystems and processes with potentially serious implications for society.

The average acidity of the upper ocean has already declined by around 0.1 pH unit (30% increase in acidity) since the industrial revolution and it is expected to further decline by about 0.3 pH units by the end of this century if CO_2 emissions continue at the current rate.

2 – Ocean warming

Over the last decades ocean warming has been a direct consequence of increasing atmospheric temperature due to the "greenhouse effect." This warming affects the exchange of gases between the ocean surface and the atmosphere, and their transport and storage in deeper waters. In a warmer ocean, there will also be less mixing between the nutrient-rich deep waters and the nutrient-poor surface ocean, particularly in tropical areas with detrimental consequences for ocean productivity, hence significantly diminishing food security from fisheries.

Ocean warming is also likely to have direct effects on the physiology of marine organisms and thereby alter the geographical distribution of species, including those of commercial importance, currently well-adapted to existing conditions; for example, temperature increase is almost certainly contributing to the decline of cod in the North Atlantic.

[1] By C. Turley, T. Keizer, P. Williamson, J.-P. Gattuso, P. Ziveri, R. Monroe,K. Boot and M. Huelsenbeck of the Plymouth Marine Laboratory, UK Ocean Acidification Research Programme, European Project on Ocean Acidification, Mediterranean Sea Acidification in a Changing Climate project, Scripps Institution of Oceanography at UC San Diego, OCEANA; 2013 6pp. ISBN: 978-0-9519618-6-5 (available at www.oceanunderstress.com).

The heat content of the ocean is immense with ~90 per cent of the energy from warming of the Earth system stored in the ocean over recent decades. There has already been a mean sea surface warming of about 0.7°C over the last 100 years, likely to increase by over 3°C in some ocean regions by the end of this century.

3 – Ocean deoxygenation

Ocean deoxygenation is the reduction of dissolved oxygen (O_2) in seawater. Climate change can influence oxygen levels in the ocean in several ways. This is certain to occur in a warmer ocean since higher temperatures reduce oxygen solubility. Warming is also likely to create a more stratified ocean, decreasing the downward oxygen supply from the surface. Ocean acidification and nutrient run-off from streams and rivers can also contribute to deoxygenation.

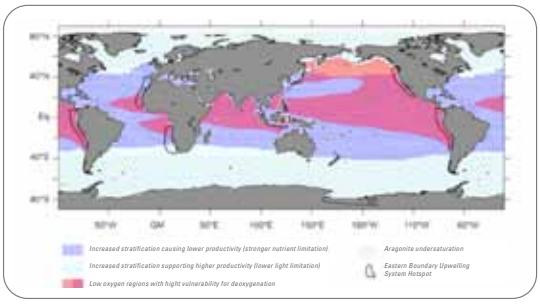
Fish and many other marine organisms depend on sufficient levels of oxygen to function, and may therefore be stressed by declining oxygen concentrations. Extended zones of low oxygen may result in the exclusion of such organisms. However, other organisms tolerant of low oxygen, particularly microbes are likely to flourish, altering the balance of communities. Low oxygen levels in the ocean may also increase the amount of greenhouse gases in the atmosphere by changing feedback mechanisms involving methane and nitrous oxide.

Current ocean models project declines of 1 to 7 per cent in the global ocean oxygen inventory over the next century. However, there are considerable uncertainties regarding the scale and location of oxygen changes, and their ecological impacts.

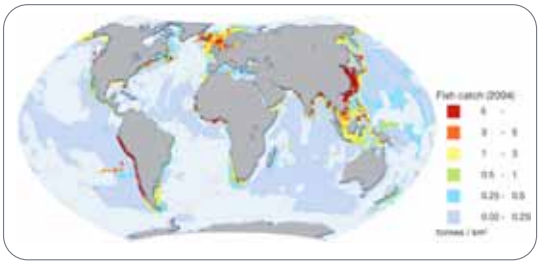
Triple trouble – multiple stressors

In the future many parts of the ocean are likely to experience more than one of these environmental stressors at the same time, since they are driven by the same underlying process – increases in atmospheric CO_2 and other greenhouse gases. These "hot spots" will not only be warmer, but are also likely to be more stratified, have increased acidity and contain less oxygen, increasing the stress on marine life in ways that may be more than the simple addition of each.

For example, ocean acidification can make species more susceptible to the impacts of warming waters, and higher CO_2 alongside lower oxygen levels can create respiratory difficulties. Acting together these stressors could more rapidly threaten biogeochemical cycles, ecosystems and the goods and services the ocean provides to society, thereby increasing the risk to human food security and industries depending on productive marine ecosystems. Furthermore, changes in the exchange of gases between the atmosphere and ocean will impact on climate change.



Nicolas Gruber, Phil. Trans. R. Soc. A (2011) 369, 1980–1996



UNEP 2010. UNEP Emerging Issues: Environmental Consequences of Ocean

Importantly and worryingly, these "hot spots" of multiple stressors are likely to coincide with areas high in ocean productivity - and currently supporting significant fisheries and subsistence fisheries in developing countries (see maps).

Steps ahead

Mitigation: As ocean acidification is mainly caused by CO_2, strong mitigation measures are required to reduce its emission. Atmospheric accumulation of other greenhouse gases should also be limited, as all of them contribute to ocean warming and hence deoxygenation.

Adaptation: Adaptation strategies need to be developed as the world is already committed to a substantial amount of additional warming, acidification and deoxygenation, even if atmospheric CO_2 could be stabilized at the current level. A key strategy is to ensure maximum potential for resilience in the system, e.g. by maintaining, or even increasing biodiversity and by conserving a diverse set of habitats. The reduction of other environmental stressors, such as coastal eutrophication and pollution by organic and inorganic substances will be helpful as well. However, given the unprecedented rate of change it is doubtful that adaptation measures alone, without mitigation, will be sufficient to avoid most of the harm.

Research: Research is required to improve our knowledge and understanding of these three connected stressors. For example, whilst ocean acidification has recently become a topic of high research priority, deoxygenation has not yet reached that level of recognition.

What is really missing is the joint perspective, where the combined effects of two or all three stressors acting at the same time are investigated. Already, detailed laboratory studies and field experiments from regional to global scale monitoring and modelling are beginning, through cross-disciplinary and international cooperative partnerships. Importantly, research capacity needs to be grown globally, particularly in vulnerable developing countries.

In order to better understand the impacts on ecosystems and the consequences for every one of us, research will increasingly need to follow a multi-disciplinary approach across the physical, life, chemical, Earth, social and economic sciences. These studies need to be policy relevant, with a rapid exchange of knowledge between researchers and decision-makers.

Ocean Stress Guide

What the ocean will experience this century without urgent and substantial reduction in greenhouse gas emissions.

Stressor	Causes	Result	Direct effects	Impacts	Feedback to climate
Warming ● A relatively mature study area in terms of physical changes and physiology but poorly studied at ecosystem and biogeochemical level	● Increasing greenhouse gas emissions to the atmosphere	● Temperature increase, particularly in near-surface waters ● Less ocean mixing due to increased stratification ● Increased run-off and sea-ice melt will also contribute to stratification in Arctic waters	● Decreased carbon dioxide solubility ● Increased speed of chemical and biological processes ● Reduced natural nutrient re-supply in more stratified waters	● Stress to organism physiology, including coral bleaching ● Extensive migration of species ● More rapid turnover of organic matter ● Nutrient stress for phytoplankton, particularly in warm waters ● **Changes to biodiversity, food webs and productivity, with potential consequences for fisheries, coastal protection and tourism**	● Reduced ocean uptake of carbon dioxide due to solubility effect ● Increased oxygen consumption, carbon dioxide production and decrease in oxygen transfer to the deep ocean ● Potential decrease in the export of carbon to the ocean's interior ● Decreasing primary production except in the Arctic where sea-ice loss may result in an increase
Acidification ● Developed as a research topic in past decade	● Increasing atmospheric carbon dioxide emissions ● Coastal nutrient enrichment, methane hydrates and acid gases from industrial emissions may also contribute locally	● Unprecedented rapid change to ocean carbonate chemistry ● Much of the ocean will become corrosive to shelled animals and corals, with effects starting in the Arctic by 2020	● Reduced calcification, growth and reproduction rates in many species ● Changes to the carbon and nitrogen composition of organic material	● Impeded shell or skeletal growth and physiological stress in many species, including juvenile stages ● Change to biodiversity and ecosystems, and the goods and services they provide ● **Cold and upwelling waters currently supporting key fisheries and aquaculture likely to be especially vulnerable**	● Reduced ocean uptake of carbon dioxide due to chemical effects ● Changes to the export of carbon to the ocean's interior ● Higher oxygen use throughout the water column due to changing composition of organic material
Deoxygenation ● Emerging issue, poorly studied	● Reduced oxygen solubility due to warming ● Decreased oxygen supply to the ocean interior due to less mixing ● Nutrient rich land run-off stimulating oxygen removal locally	● Less oxygen available for respiration especially in productive regions, and in the ocean interior ● Extended areas of low and very low oxygen	● Reduced growth and activity of zooplankton, fish and other oxygen-using organisms ● Endocrine disruption	● Stress to oxygen-using organisms ● Risk of species loss in low oxygen areas ● Impacts on reproductive success ● **Shift to low oxygen-tolerant organisms, especially microorganisms and loss of ecosystem services in these areas**	● Enhanced production of the two greenhouse gases methane and nitrous oxide
All three together ● Few studies	● Increasing greenhouse gas emissions, especially carbon dioxide, to the atmosphere	● More frequent occurrence of waters that will not only be warmer but also have higher acidity and less oxygen content	● Damage to organism physiology, energy balance, shell formation: e.g. coral reef degradation	● Ocean acidification can reduce organisms' thermal tolerance, increasing the impact of warming ● **Combined effects further increase risk to food security and industries depending on healthy and productive marine ecosystems**	● Major change to ocean physics, chemistry and ecosystems ● Risk of multiple positive feedbacks to atmosphere, increasing the rate of future climate change

The Future of the Aral Sea Lies in Transboundary Cooperation

Based on the UNEP Global Environment Alert Service (GEAS) bulletin January 2014 [1] [2]

Diversion of water sources has caused the Aral Sea in Central Asia to decline significantly over the past five decades. It has broken into several smaller seas, leaving behind a vast desert and a multitude of environmental, economic and social problems. Recent restorative action has produced a rebound in the fishing industry in what is now the North Aral Sea, possibly indicating a turn for the better, but it has come at the expense of the South Aral Sea which was starved of water flow when the Kok-Aral dam was constructed. Although the water levels of the Aral Sea may never return to pre-1960s levels, transboundary co-operation on the implementation of and compliance with conservation policies and activities provides some hope for the survival of the Aral Sea and security of livelihoods in the region.

Why is this issue important?

Once the fourth largest lake in the world, the Aral Sea now covers approximately 10 per cent of its former surface area, holds less than 10 per cent of its former volume, and receives 10 times less water than it used to. The basin supports a population of more than 60 million people – a population that has increased more than four times since 1960. The Aral Sea basin covers 1.5 million square kilometres in Central Asia and is predominantly shared by six countries: Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Meltwater from snow and glaciers on the southwestern Pamir Mountains in Tajikistan and the Tien Shan Mountains that border China and Kyrgyzstan contributes water to the Amu Darya and the Syr Darya, the two main rivers that historically have fed the Aral Sea. The sea has no outflow river. Meltwater is particularly valuable during the hot, dry summers. However, the Amu Darya and Syr Darya have been diverted to support irrigation schemes and, consequently, the flow of both rivers has been altered and the sea itself has become desiccated. Diversion of the Amu Darya and Syr Darya rivers began as early as 1938 to provide water for irrigation. Natural events such as spring floods breaching the banks of the Amu Darya have also occurred, but they have caused only insignificant changes in water levels.

Kvitlauk/ Flickr.com/ CC BY-NC 2.0

The salty shores of the Aral Sea

New irrigation schemes for cotton and rice farming in the arid region accelerated the diversion of water in the 1960s. While the use of groundwater for irrigation was explored, the focus remained on using surface water. Climate change could also influence water flows into, and around, the Aral Sea. Glacier shrinkage on surrounding mountains is already occurring, which could eventually lead to reduced runoff, and the region could experience more floods and droughts.

[1] Lead Author Lindsey Harriman, Remote Sensing Research Scientist, United Nations Environment Programme/Global Resource Information Database Project, Sioux Falls.

[2] The original, full-length version of this article with full references is available in the online version of the Bulletin and from UNEP at www.unep.org/geas

The sea itself is now made up of several water bodies: the North Aral Sea, which has essentially maintained its water levels due to the construction of a dam; and two independent sections of the South Aral Sea, the deeper, more stable western portion and a shallower eastern portion, which has recently been fluctuating in size. Maintaining water levels of the western lobe of the South Aral Sea is essential to any hope of preserving the sea as an ecological system. Additionally, some water needs to remain in the eastern portion to ensure that it does not dry up completely, leaving behind a larger area of potentially dangerous dust and salt.

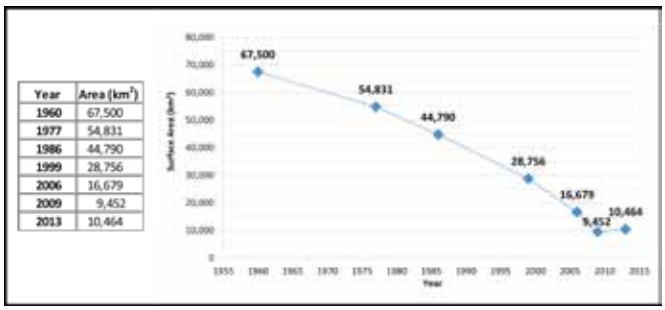
The Aral Sea Basin [3]

The significant decrease in the size and volume of the sea (see graph at right) has contributed to the collapse of its fishing industry, compromised drinking water, and caused soil salinization and the proliferation of dust storms due to the formation of a man-made desert, the Aral-kum. Transboundary co-operation between upstream and downstream countries, collaborative water management and the development of water resources are central to meeting the needs of water, energy, food and environmental security in the future. Regional projects, such as planting trees along the former sea-bed, have contributed to afforestation efforts in the Aral-kum and to the conservation of particular ecosystems. The question is, how can these efforts be sustained to increase ecosystem health and livelihoods of the surrounding populations?

Impacts and responses

The Aral Sea has gone through many changes over the past 50 years, including a significant increase in the population of the Aral Sea basin, a doubling of the area of irrigated land and an unsustainable decline in water runoff to the sea. As a result, shocking visible changes to the sea have occurred together with environmental, economic and social impacts.

At present, fluctuations between seasons, wet and dry years and the yearly flows of the Amu Darya determine the water levels of the two lobes of the South Aral Sea, as demonstrated by the satellite image time series on page 8. A general increase in surface area of the eastern lobe of the South Aral Sea can be observed from June 2009 to June 2013, as can water retention in the Amu Darya delta. The figure on page 8 shows how much the eastern lobe of the South Aral Sea can fluctuate; it almost disappeared in 2012 but then rebounded to more than 10 000 km^2 by 2013. The surface area of the North Aral Sea remained relatively stable, and some fluctuations in the Syr Darya delta are visible. The estimated total volume of the Aral Sea in 2010 was 98.1 km^3 (22.6 km^3 for the North and 75.5 km^3 for the South), and it is expected to decrease to 75.4 km^3 by 2031, based on measurements of trends in precipitation, evaporation and river runoff.[4] River runoff has decreased to 3-20 km^3/yr from the pre-1960s range of 47-70 km^3/yr. This has increased the importance of groundwater as a source of water for both the rivers and the surrounding populations.

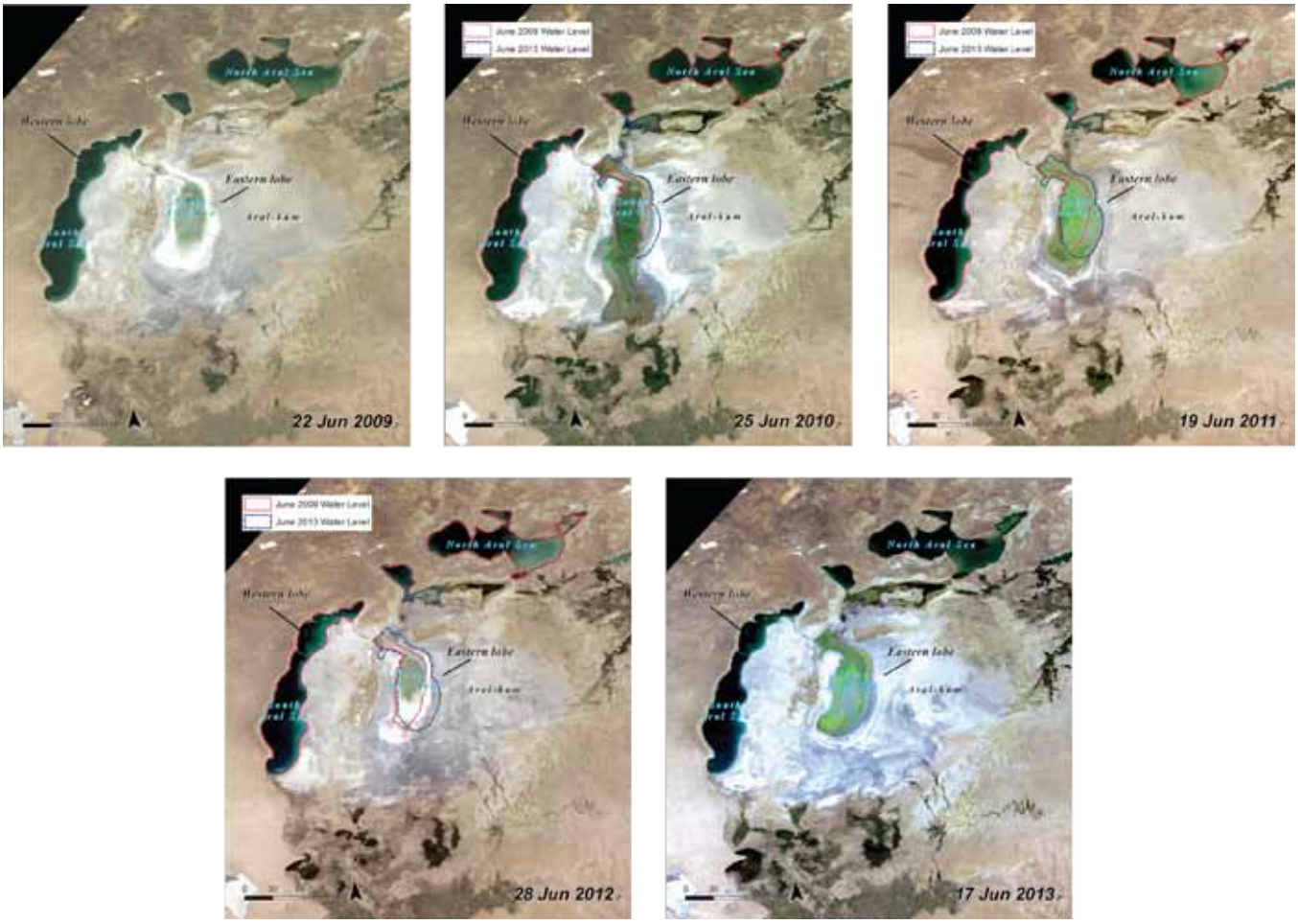


Changes in total surface area of the Aral Sea for select years from 1960 to 2013 [5]

[3] Gaybullaev, B., Chen, S-C., Gaybullaev, D., 2012. Changes in water volume of the Aral Sea after 1960. Applied Water Science 2, 285 – 291. ; Micklin, P. P., 2007. The Aral Sea Disaster. Annual Review, Earth Plan. Sci. 35(4), 47-72. ; Landsat satellite imagery from USGS/NASA; Digital Elevation Model from USGS EROS; visualization by UNEP/GRID-Sioux Falls

[4] Gaybullaev, B., Chen, S-C., Gaybullaev, D., 2012. Changes in water volume of the Aral Sea after 1960. Applied Water Science 2, 285 – 291.

[5] Sources: 1960 water level: EC-IFAS, 2013; 1977, 1986, 1999, 2006, 2013 water levels: calculated by UNEP/GRID-Sioux Falls from digitisation of similar season Landsat satellite imagery; calculations exclude land masses; line connects the data points and should not be considered a trend line.



NASA MODIS Terra satellite imagery showing changes in the Aral Sea from 2009 to 2013

The changes in the area and volume of the Aral Sea have had a serious impact on the environment, livelihoods and economies of local populations in Central Asia. The decline of the Aral Sea's fishing industry in the 1980s costs tens of thousands of people their jobs. Some of these jobs, and the resulting fish catch, have been reclaimed due to the stabilization of water levels in the North Aral Sea in the past decade and the replenishment of surrounding lakes. Fishery output in the late 2000s reached an estimated range of 2 650 to 3 000 tonnes of fish, as compared to only 52 tonnes caught in 2004. The diversion itself has proved relatively successful economically, as irrigated lands, which cover only 10 per cent of all agricultural land in Uzbekistan, now account for more than 95 per cent of gross agricultural products. Uzbekistan is a top global producer of cotton worldwide. However, any and all benefits have come at a cost to local populations and the environment.

Aridification and dust storms

The Aral-kum is nearly 60 000 km^2 of sandy, salty soil, most of which is contaminated with fertilizers from the agricultural lands, and which is now fuel for dust storms

The salty soils and bare areas surrounding the Aral Sea, which are the types of surface that generate the greatest potential for dust storms, increased surface area from 40 per cent in 2000 to 54 per cent in 2008. This increasing size has also contributed to a more arid local climate, with hotter summers and colder winters.

High winds that blow through the region carry an estimated 15 million to 75 million tonnes per year of contaminated sand and dust. Researchers have found that about 13 dust storms occurred per year between 2000 and 2009 in the Aral Sea region, carrying dust in all directions. The salt-dust clouds can be up to 400 km long, and finer particles can travel up to 1 000 km away.

The densely populated areas south of the Aral Sea in the Amu Darya delta are most vulnerable to these storms because of their location downwind from the Aral-kum source area. These dust storms have negative implications for agricultural and pastoral land. As for local populations, increased respiratory and kidney disorders have been reported, and the dust affects visibility for air and vehicle traffic. Further studies regarding the implications of land cover change and increased salt and dust

loads, including the cumulative effects of salt and dust storms on human and ecosystem health, are needed. Additionally, more regional weather observations and models would make it possible to more effectively quantify impacts.

Widespread afforestation of the Aral-kum would reduce ecological tension in the southern Aral region. Increased vegetation cover could help to reduce the number of dust storms. In the past decade or so, several international organizations have initiated afforestation projects in the Aral Sea region, creating forest plantations on the dried seabed of the Aral-kum in order to help stabilize the soil. An ongoing project conducted by the International Fund for saving the Aral Sea (IFAS) plans to increase forest cover by 10 to 14 per cent (approximately 40 000 ha) across parts of Kazakhstan, Turkmenistan and Uzbekistan. The health of the local environment could be improved through the continued facilitation of afforestation projects. Involving local populations in afforestation could also make the projects more sustainable and less expensive to implement.

Drinking water

Increased agriculture has been accompanied by a greater use of fertilizers and pesticides. This has compromised the quality of ground and surface water, contaminated seabed sediment and caused groundwater levels to rise. Reports show that groundwater levels have risen as much as 2.5 metres in some areas, including in parts of Turkmenistan, which can lead to further soil salinization. Water quality, especially for drinking, has also decreased because of higher salinity, bacterial contamination and the introduction of pesticides and heavy metals. Low-energy and low-cost desalinization techniques to increase the quality of drinking water have yet to be developed or widely adopted in Uzbekistan.

Biodiversity

Diversion of the Amu Darya and Syr Darya has not only resulted in lower water levels for the Aral Sea, but also in the disappearance of the smaller lakes and deltas that these rivers once supported, as well as of riparian habitats such as tugai forests and reed beds. The Amu Darya delta supported about 2 600 lakes in the 1960s, but the number had fallen to 400 by 1985. Tugai forests and reed beds once covered more than 500 000 ha but now only about 10 per cent of these ecosystems remain; the rest has been replaced by irrigated cropland or has disappeared because of the lack of water regeneration.

To restore the ecology of the surrounding deltas, numerous man-made lakes or reservoirs have been constructed. As a result, wetland cover has increased, and some migratory waterbirds have taken refuge. Diversity remains low, but some species of waterbirds have expanded their breeding ranges along valleys of the Amu Darya and Syr Darya. Additionally, a conservation project was completed in 2011 to establish Uzbekistan's first biosphere reserve consisting of 68 718 ha of protected area in Karakalpakstan. The reserve will support the conservation and sustainable use of biodiversity resources, including the tugai forests.

What are the implications for policy?

Transboundary co-operation is needed to address the future use of water resources between upstream (Kyrgyzstan and Tajikistan) and downstream countries (Kazakhstan, Turkmenistan and Uzbekistan) in the Aral Sea basin. However, conflicts of interest can inhibit co-operation. Efforts to strengthen transboundary co-operation for water and land management within the basin date back to the early 1970s, when the Aral Sea first showed signs of decline. Integrated Water Resources Management has been implemented in Central Asia, but the principles have not yet been fully applied. The region's critical issues need to be more deeply integrated into institutional frameworks to encourage co-operation. A lack of regional coordination to implement effective restoration and awareness projects has been cited as the reason why some attempts at cooperation have proved unsuccessful.

Several committees, organizations and institutions have been created, and third-party donors have been engaged to cope with the consequences of the loss of the Aral Sea. Most recently, the 2013 High-Level International Conference on Water Cooperation held in Tajikistan addressed the implementation of policies. It highlighted the outcome of a multi-agency project that included a tangible set of analytical policy tools related to the water, agriculture and energy sectors that have been adopted by all participating member countries.

Historically, countries across the globe have leaned toward co-operation in response to transboundary water competition. Competition for water in the Aral Sea basin has led to the desiccation of the Aral Sea and a multitude of negative consequences for people, economies and the environment. The ecosystems and livelihoods supported by the Aral Sea may never be what they were five decades ago, but they have a chance for revitalization with political will and proper attention to water resource management, ecosystem health, energy resources and human needs.

Towards Integrated Urban Weather, Environment and Climate Services

By Sue Grimmond[1] and the WMO Secretariat

Over the past few hundred years, people have increasingly clustered in large settlements, to the point where the world's urban population now exceeds its rural population. These cities of varying sizes are concentrated in 1–3 per cent of the Earth's land surface. The number of cities with more than 5 million people is growing: from 4 in the 1950s it is expected to reach 59 in 2015. Many of these cities are in developing countries, many have high levels of air pollution. In 2009, 16 per cent of the world's population was living in cities with more than 5 million inhabitants.[2] A large proportion of the movement of population into cities can be attributed to young people, less than 35 in age. Cities present a vibrant backdrop to innovation, cultural interaction and economic progress. They also attract youth due to educational and job opportunities.

Such large entities depend heavily on their underlying infrastructure, including transport systems (road, rail, pedestrian, bicycles, etc.), water and power supply, sanitation and drainage systems, and communication networks. The complexity of this infrastructure, together with its vulnerability, increases in a non-linear way with size. Doubling the size of a city may increase its complexity and, therefore, its vulnerability several times. Large, fast-growing cities are major drivers of global economic growth (80% of future growth)[3], but such growth can often be rapid and unbalanced as many new urban populations are often poor.

The dramatic demographic shifts associated with the growth of cities have wide-ranging implications. Few are felt more by residents than the deterioration of air quality. Cities in poor developing countries often do not place restrictions on emissions of the sort that are more common in North America and Europe. For example, London and Los Angeles have implemented policies and strategies to curb air pollution. Until recently, the changes in air quality resulting from increasingly dense urban centres have not been quantified in detail, and their effects on regional climates and global warming are still not systematically documented.

[1] Department of Meteorology, University of Reading

[2] UN, 2010: UN's World Urbanization Prospects: The 2009 Revision. UN, Department of Economic and Social Affairs, Population Division

[3] Göbel, B., 2004: Urbanization and Global Environmental Change. International Human Dimensions Programme on Global Environmental Change (IHDP)

[4] UN, 2012: UN's World Urbanization Prospects: The 2011 Revision. UN, Department of Economic and Social Affairs, Population Division. March 2012

[5] In this article, megacities have a threshold population of 5 million but a threshold of 10 million is often used.

Urban areas in numbers[4]

The urban transition now underway in Asia involves a population much larger in magnitude than any other region in the world and is taking place on a scale unprecedented in human history. Mexico City, São Paulo, Seoul, Mumbai, Jakarta, Teheran tripled their population between 1970 and 2000. 95% of urban population growth between 2000 and 2030 will be in less developed countries. 60% of growth between 2010 and 2040 will be in Asia (notably, China and India).

	Megacities (> 5 million[5])				Total Urban Population (millions)
Year	Number	World Population (millions)	Population in Less Developed Regions (millions)	Asia population (millions)	
1950	4	49	5	11	745
1980	28	211	115	103	1 753
2000	> 30	431	309	255	2 859
2002	39	394			
2005		515	371	305	3 198
2010		619	462	386	3 559
2015	59	732	551	454	3 927

The urban weather and climate footprint

There are two main mechanisms by which cities will further affect local, regional and global climates. Firstly, urban features such as morphology and heat emissions will continue to influence local temperatures, air circulation, precipitation and the frequency and intensity of thunderstorms. Secondly, changing chemical emissions and feedbacks resulting from atmospheric pollutants will alter weather and climate, both locally and further afield.

Many features in cities can influence atmospheric flow, its turbulence regime, and the microclimate. These features can modify the transport, dispersion, and deposition of atmospheric pollutants, both within and downstream of urban areas (one form of which is acid rain). Key examples include:

- The distribution of buildings and other obstacles (or more generally of all roughness elements) affects the turbulence regime, speed and direction of the flow.
- The extensive use of impermeable materials and the frequent reduction in vegetation in urban areas affects the hydro-meteorological regime and pollutant deposition.
- The release of anthropogenic heat by human activities (such as transportation and the heating and cooling of buildings) affects the thermal regime.
- The release of pollutants (including aerosols) affects the transfer of radiation, the formation of clouds, and precipitation.
- Street geometry ('street canyons') affects the flow regime and heat exchange between different surfaces (such as roads and walls).

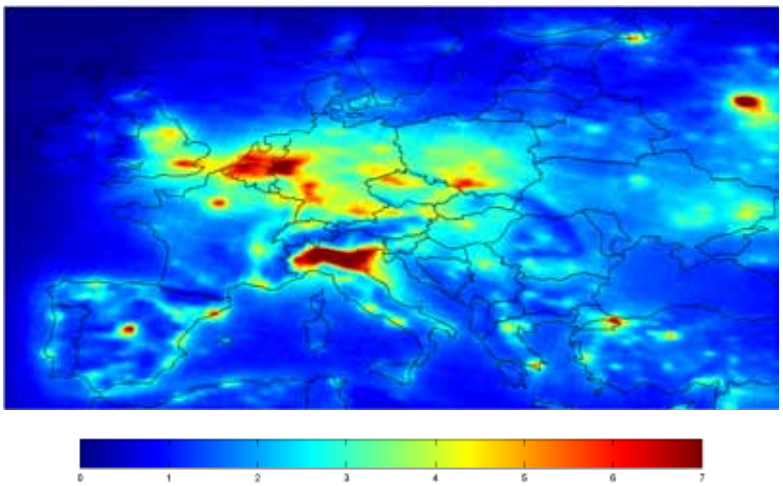
The net result may be strong urban heat islands – areas of warmer temperatures – which can lead to cities with air temperatures several degrees warmer than nearby rural areas. Such temperature differences can disturb regional air circulation. Wind patterns may be disrupted even further because of ever more numerous high-rise buildings. The disturbances can in turn lead to altered levels of precipitation, air pollution and thunderstorm frequencies.

In addition, the contribution of cities to global warming through greenhouse gas (GHG) emissions is substantial, mostly due to plumes of carbon dioxide (CO_2) emissions from urban or nearby supporting areas, although on a per capita basis their emissions intensity may be slightly lower than rural areas.

Megacity air quality and climate change

A number of recent international studies have been initiated to explore these issues.[6] These studies aim to assess the impacts of megacities and large air-pollution hotspots on local, regional and global air quality; to quantify feedback mechanisms linking megacity air quality, local and regional climates, and global climate change; and to develop improved tools for predicting air pollution levels in megacities.

[6] See MILAGRO (http://www.mce2.org/), MEGAPOLI (http://megapoli.info), CityZen (https://wiki.met.no/cityzen/start), ClearfLo (www.clearflo.ac.uk), WISE (Seoul), and SUIMON (Shanghai). A comprehensive worldwide overview of impacts of megacities on air pollution and climate and corresponding projects is available at WMO/IGAC, 2012



MEGAPOLI partner Steffen Beirle, MPI Mainz, Germany

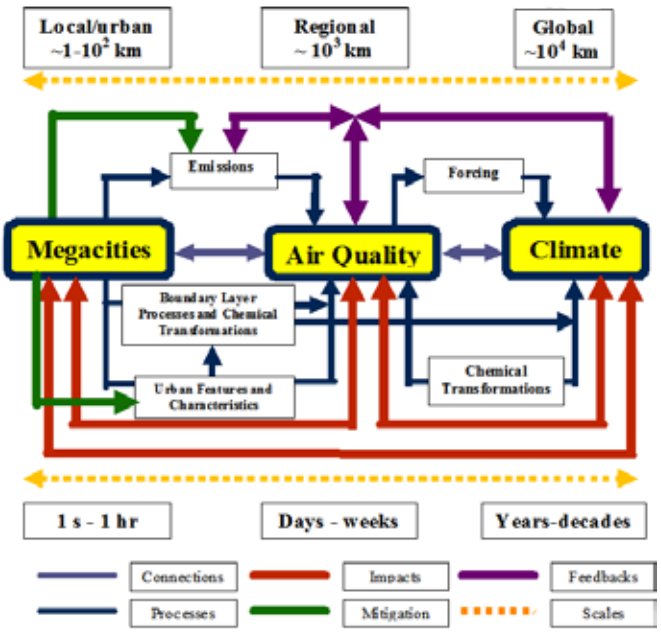
Mean tropospheric NO2 column density (1015 molec/cm2) from measurements of the SCIAMACHY instrument on board the ESA satellite ENVISAT, for the years 2003-2007.

While important advances have been made, new interdisciplinary research studies are needed to increase our understanding of the interactions between emissions, air quality, and regional and global climates. Studies need to address both basic and applied research and bridge the spatial and temporal scales connecting local emissions, air quality and weather with climate and global atmospheric chemistry. WMO has established the Global Atmosphere Watch (GAW) Urban Research Meteorology and Environment (GURME) project[7] to help enhance the capabilities of national meteorological services to handle meteorological and related aspects of urban pollution.

Megacities and other densely populated regions emit significant amounts of pollution into the atmosphere. The local effects are especially evident within the boundaries of well-known polluted megacities, such as Beijing and Delhi. The pollutants are usually derived from urban transport, energy production and other types of industry, and they have effects on the environment that are harmful to health. However, this pollution is not confined within the boundaries of the megacities themselves but can be transported over large distances, so that it contributes to the overall hemispheric background pollution.

The sources and processes leading to high concentrations of the main pollutants, such as ozone, nitrogen dioxide and particulate matter, in complex urban and surrounding areas are not fully understood. This limits our ability to forecast air quality accurately. Three major global emissions inventories, alongside two city-level inventories, were compared in the MEGAPOLI study.[8] This showed that the sources and degrees of emissions vary hugely between megacities, in particular, by geographical region. For example, much of the megacity emissions in Europe and the Americas are associated with road use, whereas in Asia and Africa the output largely stems from residential energy.

Predicting how global climate change will impact cities requires studies to understand the large-scale and long-term processes such as ocean temperature and current, changes in land cover and slow-changing atmospheric variables. Ocean and land surface changes can produce climate fluctuations that potentially are predictable at seasonal and inter-annual time scales. To provide targeted climate-prediction products, prediction models for temperature, rainfall and high-impact events such as heat waves and floods need to be developed. To meet the special needs of cities, refined climate change products can be produced through the regional downscaling of integrated climate-chemistry or Earth-system models.



Main linkages between megacities, air quality and climate, with the main feedbacks, ecosystem, health and weather impact pathways, and mitigation routes.[9] The relevant temporal and spatial scales are also included.

Alexander Mahura, DMI, Copnhagen, Denmark

Urban flooding in August 2010 in Copenhagen

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[7] http://mce2.org/wmogurme/

[8] Denier van der Gon, et al., 2011: Discrepancies Between Top-Down and Bottom-Up Emission Inventories of Megacities: The Causes and Relevance for Modeling Concentrations and Exposure. In D. G. Steyn& S. T. Castelli (Eds.), Air Pollution Modeling and its Application XXI, NATO Science for Peace and Security Series C: Environmental Security (Vol. 4, pp. 194-204).

[9] Baklanov, A., et al., 2010: MEGAPOLI: concept of multi-scale modelling of megacity impact on air quality and climate, Adv. Sci. Res., 4, 115-120, doi:10.5194/asr-4-115-2010.

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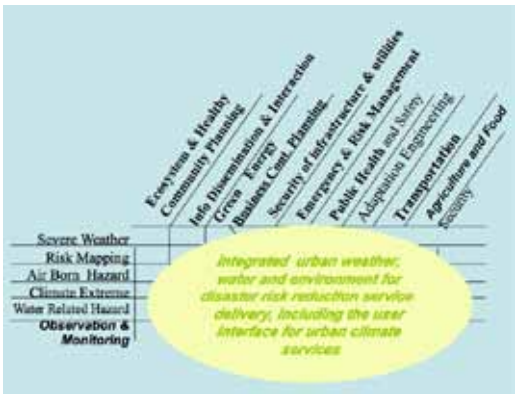
Research needs and a strategy for the future

The needs and requirements of each city should be informed by a holistic identification of impacts and hazards in order to map the city's specific vulnerabilities and identify the services that would be most beneficial. Coastal cities have different concerns to land-locked cities; similarly, the requirements of an urban area in the tropics are different to those of cities affected by severe winter weather. Data sharing arrangements between city institutions are a fundamental building block for authorities when they identify priority services and also when they design and establish urban observational networks that capture the phenomena of interest at the spatial and temporal resolution required.

City services are heavily reliant on high-resolution, coupled environmental-prediction models that include realistic city-specific processes, boundary conditions and fluxes of energy and physical properties. New urban-focused observational systems are needed to drive these models and provide the high-quality forecasts to be used in these new services. The use of new, targeted and customized means of communicating with users is required to ensure that services, advice and warnings lead to appropriate action and to feedback that improves the services. New skills and capacities will be required to make the best use of new technologies to produce and deliver new services in a challenging and evolving city environment.



Supporting platform for building climate resilient societies

National meteorological services are encouraged to establish sound working relationships with municipal authorities. They should then jointly identify and agree on the priorities for joint services and the resources required for sustained service delivery and improvement. Considering the global importance of urbanization and the growing number of megacities and large urban complexes, WMO Members would do well to include this phenomenon as a high-level priority. They should consider how best to include the unique climate service requirements of the urban environment in the Global Framework for Climate Services (GFCS). WMO Members may also wish to showcase and share their urban experiences and establish best practices for how to serve the urban dweller, who is now rapidly becoming a majority stakeholder in urban weather, climate, water and related environmental services.

Integrated Urban Weather, Environment and Climate Service

A broad set of concepts defines the development of Integrated Urban Weather, Environment and Climate Service. These concepts relate to the conditions faced by urban populations, the impacts of environmental conditions on megacity and urban societies, the need for a legal framework and clearly defined government agency interactions to enable the creation and maintenance of such services, and the scientific and technological advances required to develop and implement them.

The delivery of urban weather and climate information also needs to be considered. For example, youth are keen on using new methods of communication, thus social media will need to play an increasing role in developing and providing weather and related environmental services.

The numerical models most suitable for integrated urban weather, air quality and climate forecasting operational systems are the new generation of limited-area models with coupled dynamic and chemistry modules (so called Integrated Meteorology-Chemistry Models (IMCM). These models have benefited from rapid advances in computing resources plus extensive basic science research.[10]

Current state-of-the-art IMCMs encompass interactive chemical and physical processes, such as aerosols-clouds-radiation, coupled to a non-hydrostatic and fully compressible dynamic core that includes monotonic transport for scalars, allowing feedbacks between the chemical composition and physical properties of the atmosphere. However, simulations using fine resolutions, large domains and detailed chemistry over long time durations for the aerosol and gas/aqueous phase are still too computationally demanding due to the models' huge complexity. Therefore, IMCM weather and climate

Examples of Collaboration: Shanghai[14]

The Shanghai Meteorological Service (SMS) aims to move from traditional weather forecasts to weather disaster risk forecasts, using multi-hazard risk analysis and a reduction-support approach. To realize this, SMS is focusing on the risk from high-impact weather to site-specific areas, based on the nature of the weather or weather-related hazard, as well as on the vulnerability and exposure of the sites. This will enhance the resilience of the city's infrastructure as well as its capacity for risk management.

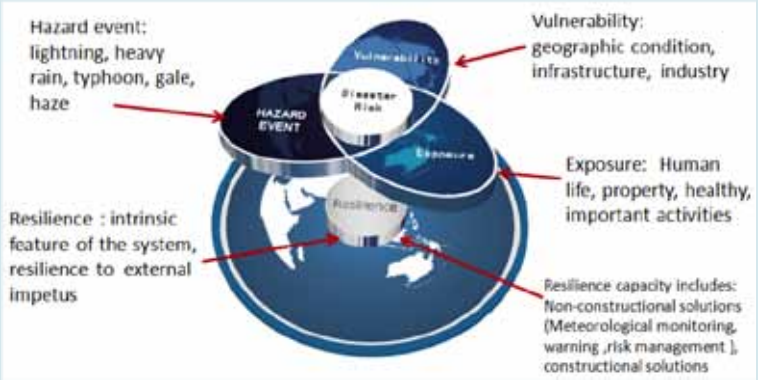


Figure: Linkages between exposure and vulnerability to weather and climate events influence the impacts and probability of disasters (disaster risk).

Source: SMS modified from IPCC 2012

applications must still make compromises between the spatial resolution, domain size, simulation length and degree of complexity for the chemical and aerosol mechanisms.

A typical model run at the weather scale for an urban domain uses a reduced number of chemical species and reactions because of its fine horizontal and vertical resolutions, while climate runs generally use coarse horizontal and vertical resolutions with reasonably detailed chemical mechanisms.[11] There are initiatives to expand the related services of large forecast centres. For example the MACC-II – Monitoring Atmospheric Composition and Climate - Interim Implementation – project[12] currently serves as the pre-operational atmosphere service on the global and European scale; it could be extended and downscaled to megacities and urban agglomerations.

Representation of the urban land surface and urban sub-layer has undergone extensive development, but no scheme is capable of dealing with all of the surface exchanges.[13] To complicate this further, the increasing resolution of models, combined with the large size of urban buildings in many cities, challenges the limits of current understanding. Key questions include: Should buildings be directly resolved? What can be simplified to make the computations tractable in realistic modelling time? At what scale can the current land surface schemes and model physics be applied?

Other research needs relate to secondary organic aerosols and their interactions with clouds and radiation, data assimilation that includes chemical and aerosol species, dynamic cores with multi-tracer transport efficiency capability, and the general effects of aerosols on the evolution of weather and climate. All of these areas are concerned with an efficient use of models on massively parallel computer systems.

Operational centres that base their products and services on IMCMs need to closely follow the evolution of the research and development of these coupled models, but they also need to interact with these activities. Research on basic physical and chemical processes and the development of numerical models and tools are integral and central components of reliable and accurate forecast products and services. Nevertheless, because operational personnel will not be fully responsible for these research and development activities, strong and long-term partnerships should be established between researchers and internal and external operational groups. These partnerships should promote the development of methods for measuring improvements in forecast skills and benefits.

WMO Secretariat contributors

- Tang Xu, Director, Weather and Disaster Risk Reduction Services Department
- Alexander Baklanov, Atmospheric Research & Environment Branch, Research Department

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[12] http://www.gmes-atmosphere.eu/

[13] Grimmond CSB, et al. 2010b: The International Urban Energy Balance Models Comparison Project: First results from Phase 1 J. of Applied Meteorology & Climatology, 49, 1268-92, doi: 10.1175/2010JAMC2354.1, and Grimmond CSB, et al. 2011: Initial Results from Phase 2 of the International Urban Energy Balance Comparison Project, International J. of Climatology 31, 244-272 doi: 10.1002/joc.222

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Junior Professional Officers

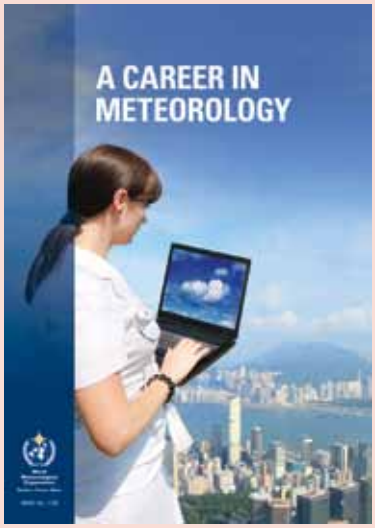
By WMO Secretariat

Junior Professional Officers (JPOs) contribute to all areas of WMO's work while gaining hands-on experience in the international arena working with experts from around the world. The United Nations has hundreds of JPOs working in its offices around the world. These young professional have high academic qualifications but only a few years' professional experience. The conditions of employment are stipulated in agreements signed between the UN agency in question and the donor countries concerned. The cost of employing a JPO is entirely covered by the donor country.

At WMO, the Director of the department wishing to recruit a JPO must seek the prior authorization of the Secretary-General. If it is agreed that the services of a JPO are needed, the Department prepares a job description for Human Resources to transmit to interested donor countries. Each donor country defines its own rigorous selection process for candidates. The Donor countries then submit the curriculum vitae of successful candidates to WMO for consideration. Where several candidates are presented for the same position by the different donor countries, the Staff Selection Board screens the candidatures and makes a recommendation to the Secretary-General who decides on the appointment.

Currently, WMO has six JPOs at its headquarters in Geneva. In this issue of the Bulletin, dedicated to youth, the WMO JPOs tell their stories in order to encourage others to follow their path.

A Career in Meteorology



This book offers a brief introduction to a career in meteorology. This second edition has been published to mark the 2014 World Meteorological Day, whose theme is "Weather and climate: Engaging youth". Since the first edition was published in 2006, weather and the related concerns of climate and hydrology have gained an increasingly high profile. In 2007, the Intergovernmental Panel on Climate Change (IPCC), established by the United Nations Environment Programme and WMO, won the Nobel Peace Prize. Today, weather and climate are featuring prominently in the development of the United Nations post-2015 Sustainable Development Goals and of the post-2015 phase of the Hyogo Framework for Action on disaster risk reduction.

Meteorology – A passion, but not at first sight

By Karolin Eichler

When I was still in high school, I liked geography, physics and math, but wasn't passionate about any specific field. I chose to study meteorology because it combines the three subjects I liked at a level I thought I could manage – pure math or physics would have been too tough for me.

My core course started nicely with lessons on the formation of clouds, hail, etc. – it was easy to understand, we had already learnt it in school. But I soon realized that meteorology could be extremely theoretic. Nevertheless, there are a lot of options, such as synoptics (forecasting the weather) and climate, so one does not need to excell in all areas. I wrote my diploma thesis in collaboration with the German Research Centre for Geosciences in the field of GPS-Meteorology.

Afterwards, I decided to take a position at the German Weather Service, which gave me the chance to do research without doing a PhD. I enjoyed the challenge of research, solving problems and bugs in the numerical model. Sometimes it took minutes, sometimes days. I introduced new variables into the numerical weather prediction model and discussed the results with colleagues and at conferences. I learnt a lot during that time and the exchange with my colleagues boosted my motivation. The job was a great experience for me. Weather is a chaotic system, I was always surprised that small elements could completely modify a forecast.

Data assimilation became a passion for me. There was a lot of programming, which was not what I had in mind when I chose to study meteorology – I thought a meteorologist was someone who spent the day outside measuring wind and temperature. Field work was one of the reasons I chose meteorology. You do need to be outside from time to time (during field studies, etc), but most of the time you're inside in front of your computer.

After two years, I decided to change my area of expertize completely. From research I went to WMO, from weather forecasting (looking into the future) to climate change (looking into the past). The learning curve was steep: climate, climate change, data rescues and the communication of critical climate change issues to the public. I also organize meetings and coordinate publications. I especially like traveling and attending international conferences and meetings. Working in the UN family and collaborating with experts from all over the world is an extraordinary privilege.

It is hard to say what will be next for me. My work experiences have given me the passion that I did not initially have for meteorology, especially for climate and data assimilation. There are a lot of job openings around the world for scientists but I do worry that most contracts are only for two to three years. Since I began studying, I have moved eight times and I hope that there will be a chance to settle somewhere in a job I like and about which I can be enthusiastic.

The Flores Creek Project

By Tamara Avellan

Christian and Letitia, 7 and 9 at the time this photograph was taken (see page 17), live in rural Uruguay. They were privileged in that they enjoyed clean running tap water, a flush toilet and an effective sewage treatment system. But that did not promise to be the case for much longer. In 2003/2004, as part of my Masters degree in biology, I had researched the water quality of Flores Creek, their local water source, its impact on the area's aquatic and riverine ecosystems, and the interplay between agriculture and biodiversity. The quality of the children's fresh water was jeopardized by the use of pesticides and fertilizers, and the water level in their region was dropping due to irrigation.

Uruguay is my mother's homeland, so I resolved to return after conducting further research on ecosystem responses to pollutants and climate change in the United States of America. I wanted to find viable solutions for controlling the agricultural pollution of Flores Creek. When I went back with support from local and national government and international institutions, we – the farmers, villagers and I – created Uruguay's first constructed wetland as a sewage treatment facility for waste water from dairies.

During several participatory meetings, we explained the water cycle and the importance of aquatic and riverine ecosystems to water quality and quantity. Christian and Laetitia were shown how to take measurements of river height and flow velocity on their way to and from school,

which they did daily for roughly a year. Their father was trained to manage the endogenous low-growing trees of the flood plains so that cattle could pass through without the need to clear-cut and burn the area, as had traditionally been done. Maintaining water quality and quantity is a challenge in this watershed as well as in many other creeks in Uruguay, but this project opened up avenues for change. I managed the Flores Creek project for three years while working on a PhD at the University of Munich on the current and future state of agricultural land use.

I was then offered a Junior Professional Officer position at the WMO to work on the implementation of the Global Framework for Climate Services (GFCS). I was interested in global policies and intergovernmental negotiation processes and how they are steered to make things happen on the ground. It was a great opportunity.

My work in both the local and global arenas of water, climate and agriculture has raised my consciousness of the challenges of raising awareness of environmental issues in everyday surroundings and of the slow changes that take place almost unnoticed. It has taught me to respect the knowledge that people have acquired through experience and how to explain the unseen impacts that their activities can have on parts of the environment. I have also learned to sound out options and to improvise, and to make the best of everyone's capabilities, from the Minister of Agriculture to the local NGOs or the everyday person.

As for Christian and Laetitia, he has finished school and now goes wood chopping with his father, and she is now in high school. She wants to become a veterinarian. They have learned that they live in a world in transition that is in need of further protection.

Tasting soil

By Moritz Krüger

I brooded for weeks before I finally decided what to do after high school. Geography sparked my interest the most – specifically the study of how people move, settle and behave in urban environments and how, as a result, cities grow and develop over time. This was surprising, as I had failed high school geography. When I started geography studies, I quickly realized it involved much more than what I had thought: geography bridges analyses of human and natural phenomena and explores the interaction between them. So I took courses on urban development, hydrology, development research and climatology. I studied in Germany and Iceland and focused on physical geography, mainly on landscape evolution and hydrology.

An essential – and most enthralling – part of these subjects consisted of the field trips that put theory into practice. On such trips, students and researchers would take soil and water samples, map landscape features, and conduct topographical surveys and runoff measurements. For example, in order to quickly determine a soil's grain size, we would taste it – a crunchy soil contained a considerable amount of sand. It sounds trivial, but for me it was fascinating. What started with tasting soil would lead to highly sophisticated computations such as real-time simulations of past floods in large river basins or the reconstruction of the climate over the past 12 000 years.

I broadened my knowledge of the topics that interested me most. I took an internship at a German State Office, working in the field of soil monitoring and mapping, followed by a stint at the Alfred Wegener Institute for Polar and Marine Research, assisting in a project on past environmental and climatic conditions on the Tibetan Plateau. After completing my Masters, I worked as a

consultant for the University of Berlin on research and e-learning projects and as a lecturer.

In parallel, I started looking into related fields, such as geology and informatics. I focused mainly on water resources, flood management and modeling to investigate how mankind interacts with, and changes, the environment. Hydrology is both a challenging and an evolving field. Scholarships, field trips and workshops provided opportunities to study and work in Asia, Europe and South America. Each rewarded me with a new environment and new challenges – both personally and professionally.

Working at WMO in the Associated Programme on Flood Management is providing me another perspective on the diversity of water management. Everyday work is focused on project planning and management. I do miss field trips, surveys and technical issues to resolve. Nevertheless, I appreciate applying what I have learned: our team supports countries worldwide in their flood management initiatives. We help answer questions like: how do we establish a flood forecasting system? What is an integrated approach to flood management? How can flood management be integrated with economic and environmental issues? How can communities develop a flood warning system with very limited resources?

When organizing workshops for hydrological services, we cooperate with other UN agencies, private companies, universities and research centres. On such occasions, it is inspiring to learn from professionals who have been engaged in flood management for years. The people, regions, climates and political and cultural settings with which I work provide an environment that poses new challenges and clearly shows that there is no single "right" solution.

Development cooperation

By Lina Sjaavik

As a social scientist, I was originally interested in development and security policy. I started working on livelihood and environmental issues at a Norwegian nongovernmental organization (NGO) after I graduated with a Masters degree in Global Studies and a Bachelors degree in Latin American studies. At first my work addressed the social and environmental impacts of the mining industry, and then I moved to climate change adaptation. Upon discovering how weather events and climate change affect people who are already marginalized, I became passionate about climate change issues.

I got to know WMO only a few months before I applied for the position I now hold, when the WMO Secretary General gave a presentation on the Global Framework for Climate Services (GFCS) at a climate change seminar in Oslo. I found the Framework interesting and decided to read and learn more about it. When the Norwegian Ministry of Foreign Affairs announced the availability of a JPO position at WMO, I knew I had to apply. I was really looking forward to learning more about the technical side of weather, climate, and water.

I am currently working on two projects, the Norway-funded "GFCS – Adaptation and Disaster Risk Reduction in Africa" and the Swiss-funded "CLIMANDES – Andes-Based Climate Services for Decision-Makers" in Peru. I also coordinate the Voluntary Cooperation Programme focused on meeting the needs of WMO Members through direct financing or transfer of expertize and technology between Members.

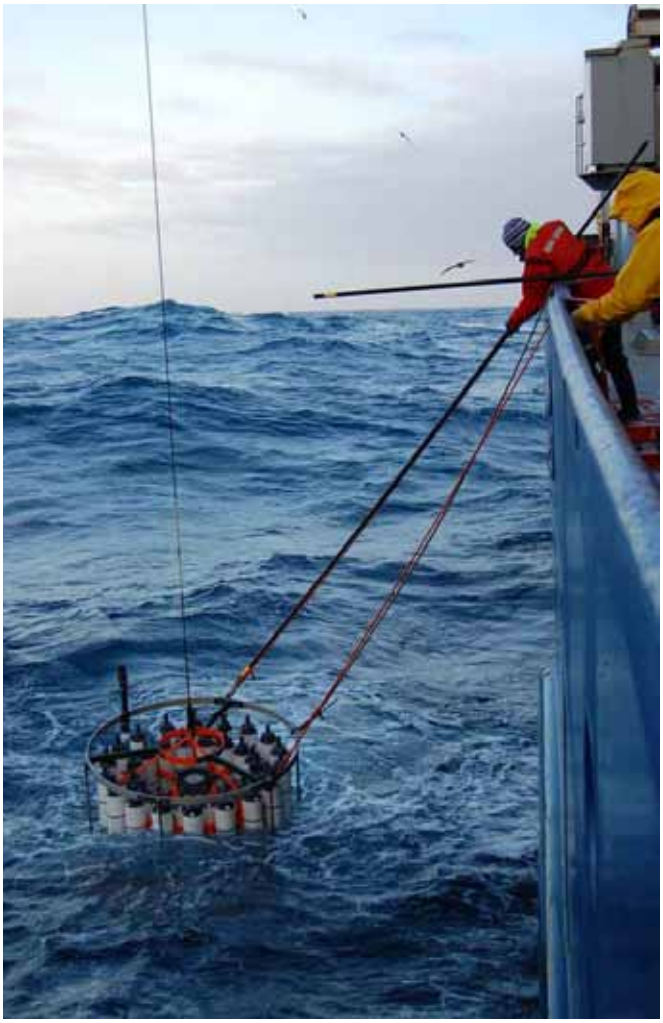
As a social scientist, my future career path is open, but I definitely want to work in climate-related areas, either in the UN system, an NGO or the Norwegian public administration. It is interesting to be a social scientist working with colleagues who have strong technical backgrounds from the natural sciences. Were I to remake the choice of what to study today, I would add natural sciences to the composition. However, I believe that a lot of interesting work happens at the crossroad.

Protecting the oceans

By Jessica Holterhof

I have always been fascinated by oceans and marine ecosystems, which cover more than 70 per cent of the Earth's surface and make up 95 per cent of all the space available to life, and by how they affect people's lives every day. Climate variability, human-induced global changes and a range of other drivers are causing the degradation or loss of marine ecosystems. The oceans are facing threats from many sides: marine pollution, ocean acidification, marine habitat destruction, rising sea

levels and temperatures, and overfishing. These forces are driving the need for improved monitoring of, and research into, marine physical, biological and chemical variables, as there is still considerable uncertainty about the details of how climate variability is affecting the oceans.



Since the beginning of my geo-scientific studies, I have been passionate about the environment and sustainable development, linked to marine environmental protection and adaptation to climate change. This is increasingly becoming a key part of international climate policy. Therefore, I mainly focused my academic and professional attention on the monitoring of physical and biogeochemical processes in the oceans. These processes are integrated into a fascinating framework of oceanography, which includes the study of ocean currents and how they interact with the atmosphere, the weather and the climate.

My Masters studies in marine geosciences, followed by my post-graduate work for several international organizations and research institutes, have not only allowed me to collaborate with great scientific minds, but also to visit parts of the world that I never imagined I would see. I love working in the sector of marine geosciences, and it has provided many opportunities for me. For example, I was able to conduct a rapid response study on ecosystem behaviour after the oil spill in the Gulf of Mexico, carry out research on particular opportunities for oil and gas exploration companies and their potential effects on the marine ecosystem, and draft recommendations on features of the list of threatened species and habitats in the North East Atlantic that were presented to the European Union. This summer, I will join a team of scientific experts on board a research vessel to undertake a study on maritime meteorological and biogeochemical processes in the waters around Southern Africa and the Indian Ocean.

Working at WMO has given me the opportunity to make use of and further develop my scientific understanding of oceanographic and climate dynamics, while allowing me to engage with a broad range of experts from different cultures and backgrounds. I learned to collaborate with several partners, including other UN organizations, governments and civil society, and it has shown me that there is a pressing need for more informed environmental decision-making that is supported by effective monitoring of the climate system, and its variability and change. I can only recommend working in the field of marine geosciences, as it is a compelling subject. It is considered one of the most all-encompassing fields of geosciences, including aspects of geology, chemistry, biology, physical oceanography and engineering.

Environmental preservation, travel and history

By Jochen Luther

Since childhood, I have had a strong interest in biology, geology and, more generally, in spending time outdoors satisfying my curiosity about the Earth's natural and human history. These interests developed into environmental and cultural awareness, a will for preservation, and a desire to travel the world. The latter seemed impossible growing up in East Germany, where travel opportunities were limited. In view of my interest, science and international relations/cooperation studies provided some hope to overcome this situation, which fortunately changed when the Wall came down.

In 2004, I obtained my Diploma in Geography (this was just before the system changed to Bachelors and Masters) from the Philipps-Universität Marburg in Germany. My thesis dealt with historic landscape changes along the Greek coast, involving mainly geomorphologic and sedimentologic field and laboratory work. My studies had already taken me to Houston, USA, Quebec, Canada, and to Greece.

In 2002 and 2005, large river floods occurred in Germany and Central Europe, which led to the launch of a number of research projects on innovative flood risk management approaches. I accepted a job offer from the Leibniz Institute of Ecological Urban and Regional Development (IOER) in Dresden to work in projects dealing with the analysis of future flood risks along the Elbe River. After four years, I moved to the Helmholtz Centre for Environmental Research (UFZ) in Leipzig. There I worked in particular on hazard and risk mapping and social capacity development. My last project focused on capacity development for disaster risk reduction and climate change adaptation in Africa cities.

While on those projects, I worked with, or came across, various UN organizations. I decided to widen the scope of my job applications to the public and intergovernmental sector, which brought me to the WMO Disaster Risk Reduction Programme. The Programme's aim is to strengthen the institutional capacities of Members with respect to the provision of meteorological, hydrological and climate services and to cooperation in disaster risk management for the protection of lives and property. The activities include establishing and fostering partnerships and developing standards, guidelines and service delivery in areas such as risk analysis, multi-hazard early warning systems, sectoral risk management and disaster risk financing/transfer. These activities are based on the WMO Service Delivery and Capacity Development Strategies and consistent with its Quality Management System principles.

The projects I work on are not explicitly scientific, although they demand a good understanding of both natural and social sciences. However, should I return to academia, I am convinced that this work will be an asset for understanding the applications and the practitioners' views of scientific projects, their findings, and the bases for their decisions – hazard (and damage/risk) data. In addition, I am learning how to work in an international environment that addresses problems on different scales, and I am improving my writing and project management skills. From hydrology to urban planning or health and logistics – disaster risk reduction and management is a cross-cutting area of practice and research, ideal for geographers like me. Through this work, I hope to contribute to the implementation of integrated and holistic disaster risk management concepts in which national meteorological and hydrological services have a prominent role and are well connected within and beyond various countries and regions. Another inestimable benefit of this experience is the unique access WMO provides to a wide range of experts in very different fields and sectors.

For students and graduates wanting to go into disaster studies, I believe it is important to have a thorough understanding of the basic natural processes underlying weather, climate and hydrologic phenomena. However, disaster risk management requires knowledge and experience in the social sciences – quantitative and qualitative social research methods, political and sociological theories and processes, etc. – augmented by good writing and language skills, experience with Geographic Information Systems and maybe even with modelling and programming. Vocational training on these topics must continue after graduation in order to keep up with new developments.

Meteo-Volunteers for Sochi Olympic Games 2014

By Maria Mamaeva[1] and Anna Kanukhina[2]

Students from Russian State Hydrometeorological University (RSHU) were given a unique opportunity to volunteer, starting in 2012, to be part of the meteorological team that would support the XXII Winter Olympic Games and XI Paralympic Games to be held in the city of Sochi (herein after referred to as Games) in 2014. The success of RSHU in the fields of meteorology and hydrology, as well as in scientific research, earned it this privilege.

RSHU has provided high-level meteorological and hydrological education and training since 1930 and, today, counts some 5 000 students from over 40 countries. As a WMO Regional Training Centre, RSHU also offers training to the staff of national hydrological and meteorological offices (NHMS) of WMO Members around the world.

In 1996, the RSHU Meteorological Faculty started teaching its undergraduate degree program in Applied Meteorology in English. RSHU adopted this approach to bring graduates closer to the international meteorological community and to enable them to communicate with fellow scientists around the world as they pursue further studies and develop their careers. Experts in education and training, as well as representatives of NMHS and the WMO Education and Training Office, are invited to participate in the state examination committee for the English group every year. So far some 150 students have graduated from the program, receiving Honored Diplomas recognized by all WMO Members.

Sochi volunteers

The RSHU volunteers for the Games completed an online application, provided recommendation letters and passed a face-to-face interview. The success candidates received full financial support from RSHU as of the autumn of 2012 to take part in the "Specialized hydrometeorological support of test events and the Sochi Olympic Games" workshops and training sessions organized by Roshydromet. During the training, the students got acquainted with the meteorological team with whom they would work during the competitions in 2013 and the 2014 Games. They students became familiar with the meteorological equipment that would be used during the Games and learnt various ways of using meteorological data, including radar data, numerical forecasts, observational data and nowcasting. They also discovered the FROST (Forecast and Research in Sochi Olympic Testbed) project. They gained practical understanding from exchanges with Canadian meteorologists on challenges and achievements during the 2010 Olympic Games in Vancouver and with Korea meteorologists planning for the next Winter Olympic Games in 2018.

The Russian HydrometCentre Sochi 2014 Organizational Committee scheduled a specialized sports-related training course "My work, Meteorology" which was held in RSHU in October 2013. In the two-day course, 20 students – from RSHU, Moscow State University and St. Petersburg State University – learned how to support different user groups during the Games by improving their communication skills.

Off to the games

The meteorological support team for the Games, made up of 15 student-volunteers and 2 RSHU graduates, went off to Sochi at the beginning of February where they will remain for the Olympic and Paralympic Games (February and March). Most of the students are from the RSHU Applied Meteorology program in English. All of the meteo-volunteers view their participation as

[1] Head of RSHU International Relations Office (IRO)
[2] Academic Mobility Coordinator, RSHU IRO, Associated Professor

a once-in-lifetime opportunity – a chance to touch the history of the country and the world.

One of the student volunteers, Alena Andonova, wrote RSHU expressing her enthusiasm, "I would like to thank the University, especially RSHU's International Relations Office for this opportunity to work as a meteo-office assistant at the Olympic Games in Sochi. Now, I am a part of a great team of people who have been meteorologists and forecasters all of theirs lives, so I am very lucky! We want the Sochi Olympics to be spectacular and memorable event for everyone. I have a unique chance not only to watch the Games on TV or sitting in the stands but to 'touch' it myself, to help the Games happen. I am very glad that I am here in Sochi right now."

"We have a fantastic opportunity to see meteorology in practice and to understand how to apply the knowledge we received in RSHU," said Svetlana Chernysheva. "We've learnt modern methods of weather forecasting and understand which is best in each different regions (mountainous areas, for example). And what an opportunity to observe interesting mountain weather phenomena."

"I'm working with the best meteorologist in the beautiful biathlon centre. I love the biathlon, my stadium and of course my job!" said Evgeniya Durneva.

The theoretical and practical knowledge and skills acquired will be a valuable asset at the Games and as they further their university education. They will also be able to share experiences and knowledge with others in preparation of further sport events and relevant activities both in Russia and abroad.

How African Youth are Participating in Global Climate Change Politics

By Landry Ndriko Mayigane[1]

WMO and its Members have pledged to promote the active participation of global youth in issues related to weather and climate change by dedicating 2014 to "Weather and Climate: Engaging Youth." In this context, I would like to share my experience of engaging youth in Africa and around the world, especially in the area of "climate justice mobilization."

Many African youth became involved with climate change issues in 2006 when the African Youth Initiative on Climate (AYICC) was launched. This took place during the 12th Session of the Conference of the Parties (COP 12) of the United Nations Framework Convention on Climate Change (UNFCCC) in Nairobi, Kenya. Since then, the network has grown and gained momentum. It is now the leading youth movement on climate change and sustainable development in Africa, with well over 10 000 members in 42 countries.

AYICC is recognized as a strong constituency for youth in Africa by many international organizations, including the African Union Commission, the African Climate Policy Centre (ACPC), the UN Economic Commission for Africa and the UN Environment Programme (UNEP). It works closely with the UNFCCC Youth Constituency (YOUNGO) to promote the effective participation of African youth in the UNFCCC process. Over the last four years, more than 300 African youth leaders have participated in the annual climate change international conferences. We take the Latin saying Nihil de nobis, sine nobis (Nothing about us without us) to heart. As African youth, we resolve to engage more actively in international debates and initiatives on climate change and to raise our voices and concerns in the processes that affect our future.

AYICC members create climate change awareness in their communities and work on adapting to climate change impacts. They use AYICC as a hub to share best practices. Together they build a conscientious and resilient generation of African youths who will act as change makers and global citizens.

African Youth Climate Justice Caravan

One of the greatest youth mobilizations for climate justice in Africa has been the African Youth Climate Justice Caravan, dubbed "We Have Faith – Act Now for Climate Justice." Some 160 youth from 18 countries embarked on a caravan trip from Nairobi, Kenya, across six countries – Kenya, Tanzania, Malawi, Zambia, Botswana and South Africa. They performed in 10 climate justice concerts and numerous street shows through rain and shine all the way to Durban in December 2011 to demand climate justice at COP 17.

Caravan Media Team

African Youth Caravan at COY 7, University of Kwa Zulu Natal, Durban.

[1] President /Founder, Rwanda #YACA (Youth Alliance for Climate Actions)

The over 200 000 petitions that they collected during the road trip were handed over to UNFCCC Executive Secretary Christiana Figueres by Archbishop Desmond Tutu who had acted as the patron of the 'We Have Faith' campaign. The caravan was an initiative of AYICC and the Kenyan Youth Climate Network (KYCN). Coordinated by AYICC members Winnie Asiti, Reuel Waithaka and David Wainaina, and supported by the Norwegian Church Aid, the campaign drew in faith-based organizations, youth groups, NGO's and other civil society groups.

The campaign's greatest success is in the awareness left in its wake in remote villages and the big cities, amongst youth, adults and elderly, everyday citizens and policymakers. It still remains Africa's biggest ever climate justice campaign. Active groups have since emerged in many of these places. They are working to resolve the effects of climate change that already bedevil their communities.

Connected Voices

The Connected Voices (CV) project started in 2012 during COP18 in Doha, Qatar. CV provides a platform for youth from all countries and backgrounds to articulate their demands in international climate arenas through peer representation. CV collects messages from youth across the globe and channels them to negotiators directly involved in the COP sessions.

Some 1.5 billion young people in more than 150 countries have no direct representation at the UN climate change conferences. These young people live mainly in developing countries and are often highly vulnerable to the negative effects of climate change. They are the most important stakeholders – their futures are at stake – yet their voices are not heard. CV aims to change this. Last year during COP 19, Claire Anterea from the Republic of Kiribati, a climate-vulnerable small island state in the central tropical Pacific Ocean, sent the message "We don't want to be wiped away from the map of the world."

My goal in CV is to increase youth participation and to assure that voices and messages from under-represented youth in Africa are heard by those directly involved in the negotiations. I have taken to heart the words of the seventh Secretary-General of the United Nations, Mr Kofi Annan, who said, "Young people should be at the forefront of global change and innovation. Empowered, they can be key agents for development and peace. If, however, they are left on society's margins, all of us will be impoverished. Let us ensure that all young people have every opportunity to participate fully in the lives of their societies."

I am convinced that we – the youth – can be part of the solutions to global issues. We should be given a chance to show what we are capable of. I encourage more young people to join our movements, to make our voice more audible in order to build an ever-greater momentum for positive change.

Landry during the UNFCCC climate Change Negotiations held in December 2009 in Copenhagen, Denmark

Useful links:

African Youth Caravan: http://www.sacc.org.za/content/SACC%202012%20DOCS/NOV%202012/We%20have%20faith.pdf

Caravan video: https://www.youtube.com/watch?v=MxFMAypNpc8

www.ayicc.net

http://connected-voices.org/

Connected voices pictures: http://www.flickr.com/photos/connected-voices

My other local involvement: https://www.facebook.com/pages/Rwanda-YACA-Youth-Alliance-for-Climate-Actions/360658207283160

My AYICC Profile: http://www.ayicc.net/dr-landry-ndriko-mayigane/

www.rwanda-yaca.org

Addressing Climate Change at the International Model United Nations 2014

By Leila Hassan[1]

On 8 January of this year, the Ferney-Voltaire International Model United Nations (FerMUN) held its fourth annual conference at the Geneva-based International Telecommunication Union (ITU) in collaboration with WMO. This year's conference included a special focus on climate change. Months of preparation led up to this three-day event – one of an estimated 400 Model UN conferences held annually worldwide – and some 550 students and 50 teachers from 30 schools and 12 countries participated.

Managing all of these well-groomed student delegates proved complicated, but despite the chaos the first day was a time for intense lobbying and the forming of alliances. Model UN conferences can follow different formats, but they all focus on diplomatic role-playing to give students an opportunity to explore how intergovernmental negotiations work. For this year's FerMUN event, the students were assigned to nine committees:

Committee GA 1 on Climate and Water debated:

- How to secure coastal areas from severe storms and tsunamis and organize an efficient emergency communication system to inform threatened populations.
- The issue of the melting of the ice sheets in the Arctic Ocean and rising sea levels: consequences on ecosystems and on local human communities.
- Assessment of global water resources. The lack of a comprehensive assessment of global water supply and demand, the development of water redistribution systems for human consumption and irrigation.

Committee GA 2 on Climate and Health debated:

- The issue of the rise of waterborne diseases due to climate change.
- The effects of global warming on human health.
- The issues of water and ozone depletion leading to human health problems.

Committee GA 3 on Climate Change and Agriculture debated:

- New agricultural regions such as Greenland and Siberia: development of new crops in areas affected by climate change.
- The proposition to use run-off water by collecting rain water in cities.
- Increase of desertification with the loss of arable land.

Committee GA 4 on the Disarmament Committee debated:

- The impact of weapon development and war on the environment.
- Land claims in the Arctic: states and aboriginal people.
- National claims to the North West and North East Passages/International waterways.

[1] Class 1ère Economics and Social sciences (12th Grade), International Lycée of Ferney-Voltaire

The Special Committee for Politics and Decolonization debated:

- The threat of rogue nations or terrorist groups in possession of nuclear weapons.
- Climate change awareness raising and knowledge amongst young people.

The Human Rights Council debated:

- Whether climate refugees should be considered as a new category by the UNHRC?
- CCTV surveillance in cities.
- Surveillance of the global flow of information.

The Security Council debated:

- Conflict over water control in the Middle-East.
- The resolution of the conflict in Syria.

The G20 Economic Committee debated:

- The negative economic impacts of global warming.
- The development of efficient desalination technologies as a source of fresh water.
- The relocation of telecommunication infrastructures vulnerable to weather disasters.

The FerMUN 2014 Forum on Child Online Protection debated:

- The impact of developing standard processes for handling user generated content (social networks, mobile phones and interactive media policies).
- The impact of the development of e-financial transactions on youth online safety.
- The impact of online behavior on good digital citizens (gaming, hacking, illegal downloading).
- Issues pertaining to grooming and online bullying.

The United Nations Office in Geneva hosted the FerMUN 2014 opening ceremony. Conference Secretary-General Juliana Rademaker reminded the audience that "global warming is our issue: this challenge concerns us all, particularly the younger generation which builds tomorrow's world." She stated that the conference would be an eye-opener and would "make us think about concrete solutions to change our way of life."

Each committee had an average of six resolutions on which to vote by the last day, when the General Assembly would meet! On the final day, controlling the length of debates on each resolution in the General Assembly proved challenging, but by 3:30 pm everyone was preparing for the closing ceremony. ITU Director General Hamadoun Touré joined the ceremony by Skype from his home in Mali, and the UN Secretary-General's Envoy on Youth, Ahmad Alhendawi, sent a video message. Mr. Alhendawi told the audience, "We always have a Plan B, but we don't have a Planet B." FerMUN delegates were excited and thrilled to hear that selected resolutions from their debates would be presented to UN Secretary-General Ban Ki-moon by Dr Touré.

Today's youths are tomorrow's leaders. We have to start taking issues into our own hands and, as Dr Touré said, "just go and do it."

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Engaging Youth on Global Climate Issues – Model UN Conference hosted by ITU, 8 - 10 January 2014.

Who Wants to be a Weather Forecaster?

Engaging students in meteorology

By Valentina Grasso, CNR IBIMET – Consorzio LaMMA

The theme "Weather and Climate: Engaging Youth" of the 2014 Meteorological Day addresses the relation between today's Met services and the next generations. The next generation is the ultimate stakeholders of the weather and climate services provided by governmental assets. Education on meteorology is essential to enable youth to take advantage of the information provided by the public services. To that respect, in Italy there are several initiatives carried on by relevant state and regional entities in academia and the education sector in accordance to the guidelines given by WMO. In addition to those structured, high-level education initiatives, it is important to have initiatives targetting very young students such as the Air Force National Meteorological Service has put in place for this World Meteorological Day (www.meteoam.it/?q=giornata_meteorologica_mondiale_2014). The initiatives of LaMMA described in the article are in the sector of primary schools and are valuable in raising awareness of meteorology at an early age.

- Col. GArn Luigi De Leonibus, Permanent Representative to WMO for Italy

The LaMMA Consortium is in charge of the weather forecasting service in Tuscany, Italy. It combines the scientific research skills of the Italian National Research Council (CNR) and the public service commitment of the Region of Tuscany, its two parent organizations, to monitor atmospheric conditions and produce daily weather bulletins and reports as well as customized weather services. The coordination of environmental education and informative scientific activities for primary and secondary schools in Tuscany is a priority for LaMMA.

Scientific institutions can play an important role in education by fostering opportunities for students and teachers to learn. Laboratory visits and "learning by doing" activities offer the most effective means of doing this. The research sectors involved in meteorology, climatology, remote sensing, oceanography, the carbon cycle, biometeorology, energy efficiency and environmental sustainability all participate in LaMMA's education and outreach activities.

LaMMA collaborates with CNR's Institute of Biometeorology (IBIMET) to offer opportunities for researchers to get involved in responding to requests from schools. There are training seminars for teachers, such as the 2012/2013 project "A Pact for Water," which provided learning modules on climate change and water resources to more than 600 teachers in Tuscany; visits to the Meteorology Room, where students can meet meteorologists and see how forecasts are generated; and outreach activities such as open days and science festivals.

Meteorology for schools

When LaMMA was launched, teachers immediately started asking if forecasters could participate in educational activities. A small group of individuals dedicated to

scientific education and meteorology took the initiative to respond. Educational activities, mainly lessons in classrooms, contributed to spread the LaMMA "brand" within Tuscany over the ten years that followed. This pushed researchers to produce educational materials for classrooms, and thus an informal network of passionate individuals became institutionalized.

In 2010, LaMMA developed a new communication strategy and website. This led to the decision to play a more active role in structuring educational modules for students at different grade levels. The new website includes an education section that presents opportunities for schools to visit LaMMA. It offers electronic booklets and publications by IBIMET colleagues on climate, climate change and sustainability. Education and outreach activities have always been an important aspect of IBIMET's work, they have produced class materials for different grade levels on topics in meteorology, climate change and the carbon cycle. IBIMET is also a WMO Regional Meteorological Training Centre for Region VI and is responsible for organizing international training courses for developing countries.

Learning about weather at LaMMA

Any school in Tuscany can attend a lesson on meteorology at LaMMA, which includes a visit to a fully functional weather operating room. They can select any of four 2-hour modules.

Weather for kids - This lesson for children aged 4–6 years old is playful and humorous. Children learn to recognize the main weather conditions and to connect them to icons on the weather bulletin. Each student then receives a set of sketched weather icons to colour, cut out and paste on big maps of the Tuscany region to produce there own weather bulletins that they can take home to their parents.

Basic weather lesson - This module is for students from kindergarten to middle school (14 years old). It presents the basic meteorological concepts – atmospheric composition, altitude and temperature, the water cycle, cloud composition and rain, thermal conditions and winds, wind patterns. Tuscany's main weather conditions are described. The lesson concludes with a presentation on how LaMMA meteorologists produce forecasts using observations and atmosphere-sea models. Much focus is placed on the issuing of weather alerts. Students get to see LaMMA meteorologists broadcast the morning weather forecast.

What's up there - This module is for students aged 9 to 15. Two researchers use basic physics experiments to explain the main concepts of meteorology while students observe. The researchers introduce new knowledge and concepts after each experiment concludes, and the students form possible hypotheses to define a scientific basis for further experimentation. The experiments are very effective from the didactic point of view, especially for younger people, as they stimulate their natural curiosity and help them to formulate appropriate questions and verify possible answers. This module aims to spark the students' interest and make them passionate about science.

Who wants to be a forecaster? - This module is highly participative and interactive to stimulate a passion for meteorology within its participants – students, aged 12 and up. The exercises demand creativity and originality. First forecasters explain the "ingredients" needed to prepare a weather bulletin. Special attention is paid to the communication of weather forecasts. Videos of weather bulletins – old and new, Italian and foreign – are shown to the students. The goal is to make students aware of the communication process behind the weather bulletin: the daily challenge that forecasters have to be precise and use plain and clear language. The students then work in groups of four or five to "cook-up" their own weather forecasts, for their own recorded weather bulletins. The videos are edited with proper covers, titles and credits, and uploaded to the LaMMA website (www.lamma.rete.toscana.it/didattica/video-ragazzi), Vimeo channel and Facebook page, where the students can watch them and share them with friends.

Over the past three years, LaMMA has provided about 150 hours of lessons and taped more than 320 minutes of student videos.

Evaluating the impact

During the 2011/2012 school year, more than 2 000 students participated in LaMMA events. LaMMA researchers used a survey to evaluate the educational impact of their activities on the students. Of the 730 respondents more than 90 per cent rated their overall experience as "good" or "very good." The most popular module being "Who wants to be a weather forecaster" rated "good" or "very good" by 97 per cent of the 182 surveyed. The open-ended questions in the survey received responses such as :

"LaMMA is very interesting, and after this visit I'm very keen to understand everything about meteorology."

"The best thing for me was the recording of the weather forecast – it was very funny!"

"I think it was very interesting, because we learned how the weather service works."

"It was very interesting because it made me understand that familiar things like weather forecasts that are seen every day by people are the fruit of hard work."

Educating the public remains a priority

Easy access to weather information, mostly due to the proliferation of mobile and handheld devices, has increased public interest in weather – but that does not necessary translate into interest in understanding weather. However, investment in educating the public on weather and climate variability and change is more relevant than ever if society is to benefit from the opportunities and mitigate the risks of climate change.

In recent years, LaMMA has invested time and effort to set up outreach and education activities on meteorology and climate issues in order to increase awareness and resilience in face of more frequently occurring severe weather events. LaMMA aims to prepare all communities in Tuscany for weather related emergencies.

Acknowledgements

The educational activities carried out by LaMMA are possible thanks to the commitment of many people working directly and indirectly with LaMMA, namely: Giorgio Bartolini, Riccardo Benedetti, Giulio Betti, Valerio Capecchi, Elena Cristofori, Lorenzo Giannelli, Bernardo Gozzini (LaMMA's Director), Valentina Grasso, Susanna Lotti, Ramona Magno, Simone Montagnani, Andrea Orlandi, Francesco Piani, Francesco Sabatini, Claudio Tei, Tommaso Torrigiani, Federica Zabini.

For more information visit the Education section at www.lamma.rete.toscana.it/en/

Working with Youth on Weather and Climate

The mission of the Agency for Meteorology, Climatology and Geophysics of the Republic of Indonesia (BMKG) is to be reliable, responsive and capable in supporting public safety and national development. As such, the Agency is committed to building public awareness of weather, climate and geophysics in order to reduce the risks related to these natural occurrences. Its campaigns engage youth through "fun" activities and encourage young adults to pursue careers in weather, climate and geophysics.

It is essential to promote weather and climate issues in the younger generation. Improving their understanding will improve their future as it will help them to deal with weather and climate phenomena and may push them to take action to protect the natural environment.

Students visit program

Visits to BMKG offices – headquarters as well as regional weather stations – offer great opportunities to reach out to youth. The students are divided into groups to visit the meteorological and geophysical stations and see how the observation equipment operates. They learn weather and climate basics and observe forecasters as they make analyses using satellite, radar and other data. They then see how these predictions are disseminated to stakeholders and those dealing with extreme events. These activities are conducted in the Operational Unit for the Meteorological-Climatological Early Warning System (MCEWS). The climate and weather part of the visit ends in the air quality laboratory where they learn how greenhouse gas concentrations are measured and about climate change.

In the geophysical part of the visit, students learn how an earthquake signal is processed to provide early warnings for tsunamis. The Operational Unit for the Indonesian Tsunami Early Warning System (InaTEWS) staff explain what to do before, during and after an earthquake. Posters on the wall describe actions to take and the Mercalli Modified Intensity (MMI) scale for measuring seismic activity. But students' favourite part of the visit is always the simulator. The simulator room has two chairs, a kitchen cabinet, a hanging lamp and decorations. It is connected to a computer that shakes the room to a level corresponding to that of any earthquake signal. Students can sit in the chairs and experience an earthquake mainshock such as the destructive 2006 Jogjakarta earthquake. The students get very excited. When the shaking starts, they often experience momentary dizziness and the swinging lamp and falling flower vase help them imagine the disastrous effects. They are full of enthusiasm when they describe their experience.

The visit ends in a museum of old observation and data analysis equipment, which includes an old Wiechert seismograph. Students are encouraged to ask questions and cheerful discussions often arise.

Engaging youth beyond BMKG

BMKG developed the Indonesian Academy for Meteorology, Climatology and Geophysics, which grants students full scholarships, even providing a living allowance. Staff from the Agency teach and share their knowledge and experiences with the students at the Academy. Included in the curriculum are BMKG scientific seminars in English. The cadets – students – in this class must also present their papers in English. This prepares the cadets to follow in the footsteps of their seniors working in the international arena such as the BMKG Director General, Ms Sri Woro B. Harijono, who is President of WMO Regional Association V.

In addition, BMKG publishes posters, booklets and comic books on weather, climate and earthquake issues for youth, and provides related source material for magazine publishers and TV programs for young people. BMKG also participates in school evacuation simulations in collaboration with local government authorities in earthquake vulnerable area such as in Buleleng, West Bali.

What's to come

BMKG is now planning the launch of a Bahasa language website on weather, climate and earthquake topics for youth. The site will contain kids posters, comics and booklets. Young people will be able to email their question to experts in order to get further explanation on weather climate and earthquake phenomenon.

BMKG does not have a budget allocated for these activities, but it is committed to the promotion of weather and climate issue to its community, especially to reaching out to the young generation. The future of our planet is in their hands.

Weather and Water Go Hand in

By Andrea Sealy, Kathy-Ann Caesar and David Farrell, Caribbean Institute for Meteorology and Hydrology, Barbados

Youth activities at the Caribbean Institute for Meteorology and Hydrology (CIMH) in Barbados centre on its annual summer school camps and on encouraging students to pursue hydrology, meteorology and related atmospheric sciences as a career.

The annual summer school that was launched in 2007 focused solely on hydrology. In 2008 and 2009, the camp offered concurrent meteorology and hydrology activities. Participants had to choose between the two, but they came together for lectures on common topics and for off-site field trips. In 2010, the coordinators organized a combined meteorology and hydrology programme and adopted the name "Weather and Water Camp." The camp took a haitus in 2011 but has continued under that name since then.

The Weather and Water Camp is based on a four-week Hydrological and Meteorological Observer's course. The course is practical and focuses on the fundamental aspects of both fields. It targets secondary school students aged 14 years and older and is also open to teachers and trainers at secondary and tertiary level institutions. Participants learn about the instruments used for weather observation, the hydrological cycle, global and tropical weather systems, electronics in Earth sciences, water quality testing, agrometeorology, seasonal and daily rainfall and temperatures in the Caribbean, measuring and estimating evapotranspiration, scalar analysis, satellite and radar imagery, features on weather charts, forecasting techniques, disaster management and climate change.

Numerous activities are organized. On arrival students are shown how to make and log daily observations and given observation booklets to maintain their own daily logs. They go on field trips to institutions involved in meteorology, hydrology and related sciences such as the Barbados Meteorological Services at the Grantley Adams International Airport, the Barbados Water Authority's groundwater pumping stations and the Ionics Freshwater Limited's desalination plant. The Coastal Zone Management Unit takes them on a full-day trip to study the coastal features on the south, east and north of the island. They are shown documentary videos on extreme weather events. And lots more…

At the end of each course, the students are divided into groups to make presentations on what they learned. Most students put a lot of effort into these presentations. Some of the more recent ones highlighted:

- The effect of climate change on water resources;
- The effect of the climate on vectors in Barbados;
- Global warming and its effect on weather in the Caribbean; and
- Sea surface temperatures and their impact on marine life.

The camps, as well as all CIMH outreach and educational activities for youth, aim to stimulate interest in pursuing a career in hydrology, meteorology and other related fields. In addition, CIMH participates in the annual Barbados Association of Guidance Counselors (BAGC) National Career Showcase and makes presentations on request at various high schools across the island.

These efforts are bearing fruit. Of the 26 Barbadian students currently enrolled as meteorology majors at the University of the West Indies, Cave Hill Campus, six participated in the CIMH Weather and Water Summer Camp and four benefited from a career showcase or other CIMH outreach activity. That is approximately 40 per cent of Barbadian meteorology majors.

CIMH will continue to fulfill its mandate by raising awareness of meteorology, hydrology and climatology in schools and general public. The demand for persons with such expertize is increasing as the region implements climate change adaptation strategies.

CIMH Acting Chief Meteorologist, Kathy-Ann Caesar, speaking to students at the National Career Showcase.

Science, Technology, Engineering and Maths (STEM) at the Met Office

By Felicity Liggins and Huw Lewis of the Met Office

Science, technology, engineering and mathematics (STEM) are at the heart of what the Met Office does. Without continued expertize in these fields, the Met Office would not be able to maintain its position as the national weather service of the United Kingdom of Great Britain and Northern Ireland (UK), and a leading centre for climate research. The Met Office needs to attract the brightest people and to enable employees to develop their professional skills during their careers. The UK's prosperity and technological development depends on having an available pool of motivated and highly-trained scientists, technologists, engineers and mathematicians.

Met Office STEM outreach activities aim to interest youth in its work.

What is STEM outreach?

STEM outreach enables learners of all backgrounds and abilities to meet inspiring role models, gain an understanding of real-world applications of STEM subjects and experience motivating hands-on STEM activities that bring learning and career opportunities to life.

Organizations across the UK engage in STEM outreach activities. A leading coordinator of this outreach is STEMNET – the Science, Technology, Engineering and Mathematics Network. It runs three core national programmes, including the national STEM Ambassador scheme, which has over 26 000 volunteers who give their time to inspire young people. Offering outreach in creative, practical and engaging ways, STEM Ambassadors come from a wide range of careers and professions. They demonstrate how vital STEM is in everyday life, provide free curriculum resources for teachers and promote careers in STEM.

Met Office STEM Ambassadors

From 10 active STEM Ambassadors just four years ago, the Met Office now has more than 120. The STEM outreach programme is embedded into Met Office culture, bringing benefits to both the Met Office and its wider communities.

Community engagement – For the Met Office, STEM outreach is about community engagement. But this means much more than the local communities surrounding its Headquarters in Exeter. It includes people around all of its offices in the UK and abroad. Community engagement also refers to the wider UK population, particularly with reference to the Met Office's public weather service work, and to the broader global community through its work with WMO, international forecasts and climate research.

To help measure whether they were successful, three years ago the Met Office included a number of STEM Ambassador activities as a metric within its Business Performance Measures.

Enhancing staff motivation and enthusiasm – Participation in STEM Ambassador events, particularly home-grown activities such as Met Office Science Camp, has given staff volunteers huge satisfaction and pride, an effect that lasts beyond a given event. Staff members view the activities as an opportunity to get involved in something different to "the day job."

New and different opportunities for staff learning and development – Preparing for and delivering STEM activities give staff the opportunity to learn more about the Met Office, to develop planning and organizational skills and to test communication skills in presenting to audiences that are often non-specialist and challenging. STEM activities also provide opportunities for staff to meet other colleagues with whom they would not normally interact and to learn about the wider science of the Met Office.

Enhanced reputation – The feedback shows that the youth-oriented activities are extremely well received by the participating children and their supervisors. The Met Office has forged stronger links with its local communities and developed skilled ambassadors to promote its work. Word-of-mouth is spreading about Met Office STEM activities, and more schools are approaching the Met Office about getting involved in future events.

Providing new STEM activities for young people – The more Ambassadors, the more ideas generated for fun and inspiring activities to engage young people in STEM subjects. Events such as the Met Office Science Camps, new in 2013, have led to the development of activities which allow participants a more immersive view of the Met Office's work. They also provided a focus for developing new content, which is already being applied in other school activities and visits by STEM Ambassadors.

Met Office Science Camp

In the summer of 2013, the Met Office ran a series of pilot events, providing an educational science night for young people aged 11–12 at the Met Office headquarters in Exeter. These Met Office Science Camps were a great success. Over the four events, 176 children from local schools and scout/guide groups got hands-on with STEM at the Met Office and camped overnight in its conference rooms, helped along by a team of over 100 staff volunteers.

The event engendered cross-office support and engagement. The volunteers had different levels of experience – from months to decades spent in the organization – and represented almost all areas of the Met Office's work.

All the students who submitted evaluation forms said that they would recommend Met Office Science Camps to a friend. The feedback from staff was equally positive, saying that they would recommend volunteering to colleagues and would take part again. A significant proportion said they would be happy to help organize future events.

Building on the success of Met Office Science Camp 2013, the Met Office will again run four events over the summer of 2014, endeavouring to make each one bigger, louder and more fun.

What's it like being a Met Office STEM Ambassador?

The work of Met Office STEM Ambassadors varies hugely. Activities include visits to local schools to talk about science or careers; weather balloon launches; and code clubs. Ambassadors also take part in national events such as The Big Bang – an annual science fair that hosts over 65 000 young people. There are active Met Office STEM ambassadors across the UK.

The Met Office also gets involved with other organizations' STEM-related activities. For example, over the last three years, it has been collaborating with EDF Energy to educate young people on climate science. EDF Energy has created The Pod (www.jointhepod.org) – a website where registered schools and community groups can access free teaching resources, download activities, blog and share ideas on sustainability. The Met Office is explaining the science behind phrases like "the greenhouse effect" and "climate adaptation" – helping to ensure that children using The Pod have a good understanding of the climate science underpinning the other sustainability topics they study.

On the site, teachers are able to download hands-on activities, designed by the Met Office, which help young people get to grips with climate science, covering topics such as natural variability or the carbon cycle. To date, over 17 700 schools are registered on the site with more than 26 000 users. Collaborations such as this enable Met Office science to reach as wide an audience as possible, build on its wider educational offerings, strengthen its collaborations and enhance its reputation.

The Royal Meteorological Society – Engaging the Next Generation

Since its foundation over 150 years ago, the Royal Meteorological Society[1] has grown and diversified, but its focus on advancing the science of meteorology has remained. The Society is the custodian of both the science and the profession of meteorology in the UK. With over 3 000 members around the globe, it is also one of the world's largest meteorological societies.

The Society, thanks to its heritage and reputation, is able to get the ear of policymakers on weather and climate matters at home and internationally. Its dynamic website and social networking channels deliver news and information to people every day of the year, while its portfolio of journals and online newsletters caters to a broad audience – from the specialist scientist through to the general public, including youth.

TheWeather Club

The public outreach arm of the Society – theWeather Club – was launched in 2010 to inform and educate while encouraging people to participate and pursue their interest in meteorology. On its website (www.theWeatherClub.org.uk) and quarterly newsletter, theWeather Club publishes news items, features on weather and climate and stunning photography. It works closely with media partners to provide clear advice and comments on current weather situations and scientific reports. In addition, the website provides opportunities for members to participate in weather debates and discussions, join forums, post views, propose ideas, submit images and share weather observations. Access to "Ask the expert" provides a two-way educational process.

TheWeather Club promotes training courses, educational activities and relevant events linked to weather and climate. It reaches out to young people with information on careers in meteorology and on national weather experiments that encourage school and public participation in the collection of weather observations, such as the Great British Weather Experiment.

TheWeather Club on tour promoting the Great British Weather Experiment

The Society established a Climate Science Communications Group in 2011 to disseminate more effective scientific communication on climate change. It draws together climate science expertize and experienced media professionals. The Group has given to the Society's climate communications a direction and focus as one single coherent programme, identified potential collaborators and partners, and defined when new initiatives should be launched to meet specific needs.

The next generation

Encouraging the next generation of meteorologists is particularly important to the Society. Its Education Committee aims to improve the teaching of weather and climate in schools by raising the level of weather literacy amongst all students and promoting careers in meteorology. The Society supports the teaching of weather and climate in a number of ways, with the focus on assisting teachers of students aged 5–18.

The Society's education website, www.metlink.org, is a platform for curriculum-linked resources, instrument loans, useful information and access to trained Meteorology Ambassadors for school visits. The Meteorology Ambassadors, mostly early career meteorologists, give up their time to go into schools to give talks and run activities.

[1] The British Meteorological Society was formed in 1850 and became the Royal Meteorological Society in 1883 when Her Majesty Queen Victoria granted the privilege of adding 'Royal' to the title.

In partnership with the Royal Geographical Society and British Council, the Society developed the Climate-4Classrooms website (www.climate4classrooms.org). This free resource is for schools in the UK and around the world. It contains up-to-date scientific data about the Earth's climate system and projections that explore the potential impact of climate change at the national scale. Climate4Classrooms is the first website to use national level climate projections tailored to individual countries. It allows teachers and students to see how their nations and others around the world might be affected by climate change and how they might adapt to or mitigate these changes.

The Society provides weather-training days to trainee geography teachers. Most of them are geography graduates, but not having studied UK weather since they were 14 years old, they feel unprepared to teach it in the classroom. During 2013, students from 20 different universities learned about mid-latitude depressions and other aspects of meteorology through lectures, fieldwork and practical activities. This increases both their subject knowledge and confidence, leading to improved teaching of weather and climate in secondary schools.

Every year the Society lends weather instruments to schools, free of charge, for classroom activities and to allow them to conduct fieldwork. The Society's higher-specification instruments accompany young people on expeditions to remote locations worldwide. The Society also supports the OPAL (Open Air Laboratories) weather roadshow, which tours the UK allowing young people and the general public to learn about observations, weather forecasting and extreme weather.

The Society regularly writes articles for science and geography magazines aimed at young people and their teachers – recent topics have included launching weather balloons from schools, weather fieldwork and teaching tornadoes. There has been a flurry of publicity relating to weather balloon launches from schools, as they are rightly seen as being an exciting application of Science, Technology, Engineering and Mathematics (STEM) as well as geography skills. The Society, with support from scientists from Manchester University, had its own balloon launch from a school in the northwest of England. It has also written guidelines for other schools planning launches. A balloon, carrying a camera, tracker radiosonde and small parachute, can reach an altitude of around 21 km before its parachute opens, returning it safely to the ground, where it can be recovered using the tracking system. The radiosonde collects atmospheric data.

Social media

The Society has also set up an annual meteorological conference for students and young scientists as a platform to show their work, network and meet potential employers. The student conference has its own Facebook account to organize meetings, recruit members, coordinate the conference, and much more. Younger members of the Society also set up Facebook accounts to coordinate group activities and meetings.

Many members of the Society, including the student community, have Twitter accounts and tweet regularly. The real time Twitter platform is a powerful medium for communicating weather events, its immediate broadcast of tweets makes it ideal for conversations and catching up on news. It is invaluable for students who tweet about their work, ideas and courses. It is easy to gain a sense of comradeship through Twitter, and it is an ideal tool for networking.

On 20 March, the Society will host a Twitter chat on careers arranged in conjunction with World Meteorological Day. The Society will collaborate with the Institute of Physics and a number of weather service providers to offer careers advice and answer questions online.

Other activities

As the science of meteorology involves pooling knowledge from a wide range of fields, the Society works with specialists from a growing range of disciplines. By bringing experts together, it encourages collaboration and the dissemination of knowledge on weather and climate. Working together with the Met Office and the Department for Education, it developed the Weather Observations Website (WOW). A hub for UK weather observations, the site helps to educate people about weather and to stimulate amateur interest in weather observing. The site hit 100 million observations in the spring of 2013.

Scientific publishing is the core activity of the Society, which has a portfolio of six journals as well as a book-publishing programme with a growing number of titles. The Society also maintains a programme of local, national and international meetings for members and non-members. In addition, it delivers a wide range of charitable benefits with schools, the public and the meteorological profession. The time volunteered by its membership increases the Society's impact in advancing the understanding of weather and climate, and the science and its applications, for the benefit of all.

Serving the Next Generation: AMS Initiatives to Foster Scientific Literacy and Engage Today's Youth

By James A. Brey[1] and Elizabeth W. Mills[2]

The mission of the American Meteorological Society (AMS) is to advance atmospheric and related sciences, technologies, applications and services for the benefit of society. Founded in 1919, AMS has a membership of more than 14 000 scientific professionals; students at the pre-college, college and graduate levels; and weather enthusiasts. AMS publishes 11 atmospheric and related climatic, oceanic and hydrologic journals, sponsors more than 12 conferences annually, and offers numerous programs and services.

AMS engages the next generation of youth through two general types of programs: (1) those that serve current or future Society members; and (2) those that aim to increase the scientific literacy of youth on behalf of AMS membership. AMS guides pre-college students interested in future science careers; college students majoring in the atmospheric, oceanic, hydrologic or related sciences; and graduates seeking internships or full professional employment. The Education Program increases the scientific literacy and engagement of students nationwide through substantive teacher professional development programs and by bringing weather, ocean and climate courses into undergraduate institutions that do not traditionally have extensive coursework in AMS disciplines. All AMS youth educational initiatives have a component directed towards increasing the participation of underrepresented minority students.

Bringing the youngest members into the society

Student resources page – The AMS Student Resources webpage has a wealth of information for youth from kindergarten through to graduate college levels. Resources are grouped by grade levels (i.e. K-6, 7-12, undergraduate students and graduate students). The K-6 webpage links to online pictures, games, science fair project ideas and other resources in order to engage the youngest students with a keen interest in weather, water and climate. The 7-12 webpage informs those considering their future career, with links to summer opportunities, colleges and universities offering degree programs, and career guides and information on local AMS chapters, including those serving the pre-college audience. The undergraduate and graduate student pages support those within a degree program and contain information on scholarships, internships, fellowships and the AMS Career Center. The pages for the three oldest student groups link to the AMS Bookstore. AMS has many publications appropriate for college-level courses and a comprehensive, general-interest weather book, The AMS Weather Book: The Ultimate Guide to America's Weather.

Student membership – AMS membership has several categories. Those serving youth include pre-college student membership and college student membership, with an early career transitional period. Youth membership is offered at reduced rates, and the pre-college category includes a subscription to Weatherwise or the Bulletin of the American Meteorological Society (BAMS). Weatherwise, written for a general audience, offers a colorful and non-technical look at the latest discoveries in meteorology and climatology. BAMS, the Society's membership magazine, informs members of activities, services, and benefits. Membership also includes discounts on the Society's journals, AMS publications, meetings and access to other resources. AMS student members are increasingly using its social media platforms – Facebook and Twitter.

Student Conference – AMS junior, senior and graduate level student members may attend the Student Conference and Career Fair at the AMS Annual Meeting. Now

[1] Director, Education Program, American Meteorological Society
[2] Associate Director, Education Program, American Meteorological Society

in its 13th year, the Student Conference focuses on interdisciplinary topics and wide-ranging opportunities in the atmospheric and related sciences. It features presentations and group discussions by noted professionals and fellow students, a student poster session, and a career fair and networking evening for students to personally interact with professionals who represent potential employers and graduate institutions.

AMS pre-college local chapters – Local AMS chapters help to increase the awareness of atmospheric science among the general public and provide a mechanism for local gatherings of professionals and weather enthusiasts. AMS has approximately 125 active local chapters, including over 40 student chapters. Of these, several are organized by high schools to engage students interested in science at the grass roots level. Local chapters convene regular meetings with a local speaker.

Scholarships and fellowships – AMS administers an array of graduate fellowships and undergraduate scholarships with the support of its members and of corporations and government agencies nationwide. AMS fellowships and scholarships help further the education of outstanding graduate and undergraduate students pursuing a career in the atmospheric and related oceanic or hydrologic sciences. Minority scholarships are directed towards increasing opportunities for underrepresented youth.

AMS career center and job board – This website gives students a broad overview of exciting careers in the atmospheric and related sciences. It provides links to the US Department of Labor outlook for jobs in meteorology and features a job board used by both job seekers and employers/recruiters. Students can securely post their resumes to be viewed by potential employers.

A DataStreme course leader conducts a weather experiment with a group of youth at WeatherFest.

WeatherFest – Held at the AMS Annual Meeting, WeatherFest is an interactive, four-hour science and weather fair designed to instill a love for math and science in children of all ages. It is formatted to spark their interest so that they will consider a career in these and other sciences. This event provides a unique opportunity for many different types of organizations to reach a targeted audience of weather enthusiasts and to support education and outreach for the atmospheric and related sciences.

Serving educators and youth

The AMS Education Program promotes the teaching of weather, water and climate topics through the professional development of teachers and the elaboration of instructional resource material at the kindergarten through introductory college levels.

Highly trained teachers are the cornerstone for increasing the scientific literacy of youth and building a competitive and diverse science, technology, engineering and mathematics (STEM) workforce. With support from the US National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA) and the National Science Foundation (NSF), the Education Program has offered various professional development courses such as DataStreme Atmosphere (1996-present), Water in the Earth System (2001-2008), Ocean (2003-present), and Earth's Climate System (2009-present). The courses are held during the fall and spring semesters for in-service, pre-college teachers.

AMS designed the DataStreme Program to create a large community of master educators who enhance classroom teaching with current environmental data and peer-train their colleagues to do the same.

The AMS Education Program works with a network of Local Implementation Teams (LITs) to administer the DataStreme courses. LIT leaders receive training at AMS summer workshops, including Project Atmosphere at NOAA's NWS Training Center, and the Maury Project on the physical foundations of oceanography held at the U.S. Naval Academy. DataStreme courses and summer workshops are free to teachers, who receive three tuition-waived graduate credits per course completed. Teachers then enhance STEM education and engage youth within their schools and communities. As a whole, DataStreme has directly impacted 18 500 teachers, who have peer-trained more than 100 000 additional teachers and impacted millions of K-12 students.

AMS undergraduate courses

The established and self-supporting AMS Undergraduate College Courses for Weather, Ocean and Climate feature science content and pedagogical underpinnings that are derivatives of the DataStreme courses. Since 1998, 780 master licenses for AMS courses have been signed by US colleges and universities, including 325 from minority-serving institutions (MSIs).

AMS focuses on getting the courses into undergraduate institutions that lack a full degree program in the atmospheric and related sciences, including smaller liberal arts schools, community colleges and MSIs.

Nearly 100 000 students, including 24 000 MSI students, have taken the courses. AMS writes and administers the courses, which are offered locally in settings ranging from face-to-face lectures and laboratories to online classes. Student use a textbook, an investigations manual, and a course website similar to those designed for DataStreme . The Education Program supports course instructors by providing a faculty CD and website with answer keys, test banks and files compatible with course management systems.

It is noteworthy that these courses have likely impacted thousands of pre-service teachers in the general education environment. In addition, some colleges use the courses exclusively in teacher training programs, broadening AMS initiatives to increase scientific literacy and youth engagement.

Special initiatives to enhance participation of underrepresented students

For its teacher professional development programs, AMS proactively recruits teachers who are members of groups traditionally underrepresented in the sciences or teach in schools with high minority-student enrollment. With National Science Foundation support, AMS Diversity Projects have trained MSI faculty in weather, ocean, and climate through five-day course-implementation workshops and follow-up workshops at the AMS Annual Meeting[4]. Participating MSIs commit to offering a given course for at least one semester, and many have offered one or more courses for several years. As a result of this program, some colleges have developed Earth science course concentrations and there is anecdotal evidence of MSI students pursuing career paths in the geosciences, the ultimate goal of the Diversity Project.

AMS Policy Program

The Policy Program's mission is to strengthen the connection between public policy and the Earth system science and services by building policy research and by creating opportunities for policymakers and scientists to engage and exchange perspectives to foster better-informed decisions. The annual AMS Summer Policy Colloquium, which has received the National Science Foundation, NOAA and NASA support, contributes to youth engagement by bringing a select group of graduate students – and occasionally top undergraduate students – and professionals to Washington, D.C. for an intense, ten-day immersion in atmospheric policy.

The Colloquium surveys current atmospheric policy issues, provides opportunities for participants to meet with the federal officials and Congressional staffers, and helps participants build skills, experience, and contacts. Through the Colloquium and many other efforts, the Policy Program objectively analyzes issues and educates others, including the next generation of scientists, without engaging in direct advocacy.

Future directions

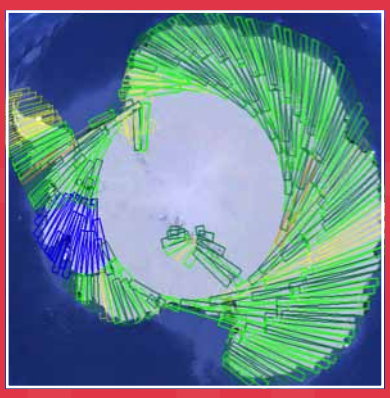
AMS programs support the very youngest students interested in sciences, those pursuing degrees in the atmospheric and related sciences, and graduates preparing to enter the scientific workforce, thereby providing a clear pathway from initial scientific interest through to involvement as an AMS professional member. Through its educational initiatives, AMS serves on behalf of its membership by expanding scientific literacy via substantive development programs for teachers, and supporting faculty offering its undergraduate courses in weather, ocean and climate. All aforementioned programs have experienced marked growth in recent years, and AMS will continue to find ways to foster a more scientifically literate and engaged populace and broaden its membership.

Acknowledgements

AMS has received significant support from National Science Foundation, NOAA, NASA, and the U.S. Navy to conduct its youth education programs, as well as contributions from industry and AMS members. For more information on AMS programs, please visit www.ametsoc.org.

For more information visit the AMS Student Resources website at http://ametsoc.org/amsstudentinfo/.

Ice Sheet Observations from Space



By WMO Secretariat

Ice Sheet Observations from Space

WMO and the United Nations Framework Convention on Climate Change (UNFCCC) both recognize ice sheets as an essential climate variable within the Global Climate Observing System. Observing and monitoring the vast, remote Arctic and Antarctic ice sheets, however, is a challenge, and only feasible globally from space. To better understand and help predict changes in ice sheet size and volume, and implications for example on sea level, significant progress is needed in generating continuous, global datasets. This can only be achieved through global cooperation, and by bringing together all space agencies that operate satellite instruments relevant for observing ice sheets and other variables of the cryosphere, the WMO Polar Space Task Group (herein referred to as the Task Group) started this task in 2011. The Task Group prioritizes user requirements for observations, engages in dialogue with polar science authorities and supports the development of satellite sensor-derived products for cryospheric research and applications. The Task Group builds on the legacy of successful satellite data collection efforts during the International Polar Year.

Over the last two years, the ice sheet science community collected and consolidated user needs for observing ice sheets in order to inform the Task Group of satellite operators. Surveys on ice sheet science and climate change impacts summarized the requirements of more than 60 experts worldwide.

Users emphasized the need for continuous records of low-resolution satellite data in the interior areas of ice sheets and high-resolution data in the margin areas for measuring both ice velocity and grounding lines (where the glacier loses contact with the ground and becomes a floating ice shelf), particularly for modelling major fast-flowing ice streams and glacier systems.

Polar-orbiting satellites with Synthetic Aperture Radar (SAR) instruments provide an all-weather, day/night sensing capability which is suitable for measuring ice sheet topography and variability. SAR instruments use active radar signals (in L, C, or X-bands) and typically offer a range of observation modes that determine the spatio-temporal coverage of the generated datasets. SAR-related Science Requirements for Ice Sheets were analyzed, consolidated and documented for consideration by the Task Group.[1] The document suggests a phased implementation of SAR data acquisition campaigns for Arctic and Antarctic ice sheets monitoring and outlines areas of priority. To address these requirements, the Task Group is using the SAR assets of several space agencies (see inset Box on the right), a "virtual constellation" of coordinated satellite SAR missions.

CSA, MDA, BPRC

During its 17-year mission, the Canadian RADARSAT-1 provided a wealth of SAR data over polar regions, including the Antarctic Mapping Mission in 1997 and concluding with InSAR coverage of Greenland in 2013.

[1] An SAR Coordination Working Group (SAR CWG) was formed by the Task Group to assist with the collection and use of spaceborne synthetic aperture radar (SAR) data sets.

Phase I

A critical issue during Phase 1, carried out in 2013, was the availability of SAR sensor systems and imaging capacity, given the recent demise of the important ASAR (ESA, Europe) and PALSAR (JAXA, Japan) sensors and the planned launch of new sensors in the near future. However, available RADARSAT (CSA and MDA, Canada), TerraSAR-X (DLR, Germany) and COSMO-SkyMed (ASI, Italy) systems could be tasked with data acquisitions over the Arctic, with a focus on Greenland, Svalbard and Canadian ice caps. Interferometric C-band SAR coverage of Greenland was acquired by the Canadian RADARSAT-1 in fine imaging mode between January and March (just before that mission also came to an end) with data reception at Norway's Tromsø Station. Concurrently, X-band data were acquired over fast flowing glaciers of the western and eastern coasts of Greenland.

Throughout most of 2013, RADARSAT-2 acquired, in right-looking SAR mode, repeated interferometric coverage of the coastal regions of Antarctica from 80 degrees south to the coast, while the German and Italian X-band missions acquired detailed data sets over selected fast-flowing outlet glaciers in Antarctica.

The acquisition, reception and processing of the data was made possible by the participation of the SAR mission operating agencies and the dedicated support of other space agencies (ESA, NASA and the Norwegian Space Centre) and related national partners (Alaska Satellite Facility, Kongsberg Satellite Services AS, and MacDonald Dettwiler and Associates).

Achievements so far in the first phase include coordinated ice sheet planning response and SAR data acquisitions, as follows:

- documentation of ice sheet science and observation requirements;
- coordinated satellite SAR data acquisition plans for ice sheet monitoring of Greenland and Antarctica;
- acquisition of RADARSAT-1 InSAR data sets over Greenland) and RADARSAT-2 coverage of Antarctica;
- acquisition of detailed TerraSAR-X InSAR data sets over select coastal areas of Greenland and Antarctica; and
- initial SAR data processing and product generation.

Contributing space agencies

National Aeronautics and Space Administration (NASA)
www.nasa.gov

European Space Agency (ESA)
www.esa.int

German Aerospace Center (DLR)
www.dlr.de/terrasar-x

Japan Aerospace Exploration Agency (JAXA)
www.eorc.jaxa.jp

Italian Space Agency (ASI)
www.asi.it

Norwegian Space Centre (NSC)
www.spacecentre.no/eng

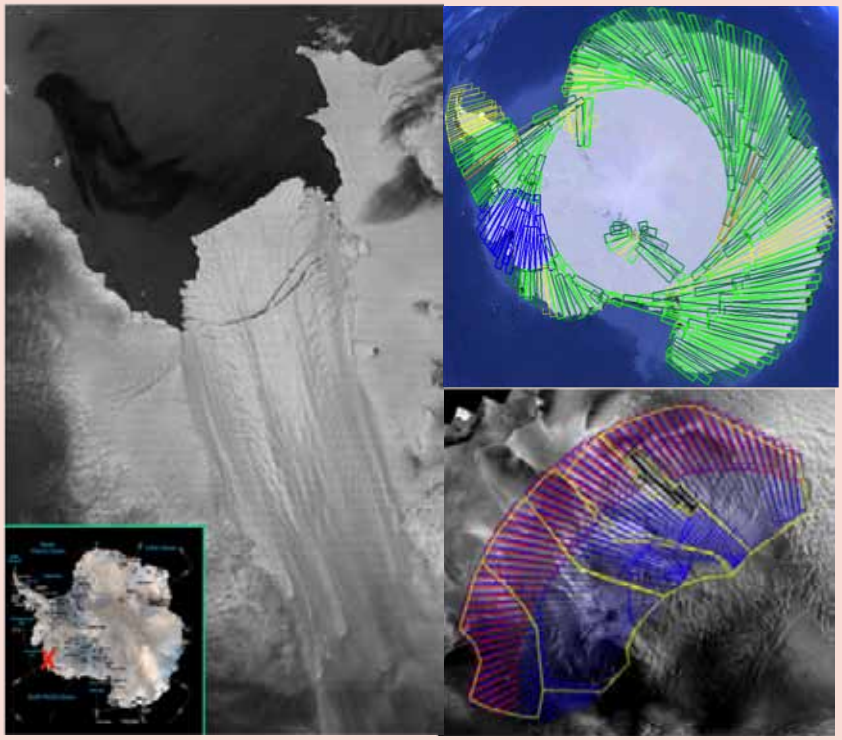
Canadian Space Agency (CSA)
www.asc-csa.gc.ca

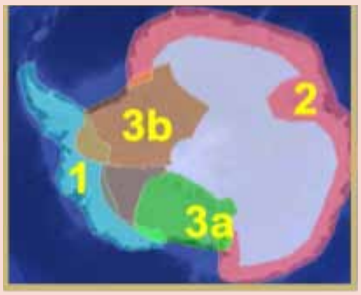
Plans for Phase II

With the launches of the Japanese ALOS-2 and the European Sentinel-1A approaching in 2014, the Task Group will be able to coordinate acquisitions among a larger fleet of SAR satellites. Repeated coverage of ice sheets in the north and south polar regions is planned during Phase II for two to three consecutive years with an increasing number of missions.

RADARSAT-2, TerraSAR-X, COSMO-SkyMed, ALOS-2, and Sentinel-1 SAR data acquisitions are planned for 2014 to 2016. For both Greenland and Antarctica, the Japanese ALOS-2 coverage is defined in the Basic Observation Strategy and the European Sentinel-1A SAR coverage is included in the Copernicus strategy in relation to ice sheet and climate applications. Canada

Highlight from the ice sheet data acquisition started in 2013





TerraSAR-X ScanSAR satellite image of Pine Island Glacier rift, Antarctica, 27 April 2013 (left, courtesy DLR).

Coverage maps of 2013 RADARSAT-2 Phase I data acquisitions (centre top, courtesy of MDA) and TerraSAR-X data acquisitions, collected for the Recovery Glacier system (centre bottom, courtesy of DLR, and B. Scheuchl / Task Group).

Priority areas for data acquisition (below) are marked from high (1) to relatively low (3), as identified in the SAR Science Requirements for Ice Sheets (see footnote 2.)

is planning left-looking RADARSAT-2 SAR data acquisitions for 2014 to cover the centre of Antarctica south of 78 degrees. The German and Italian X-band mission plans include timed series of fast flowing glaciers in both Greenland and Antarctica. A detailed coordinated inter-agency observation strategy for Phase II will be developed and adopted in 2014.

Outlook

The Task Group provides the opportunity to coordinate acquisitions from the array of different SAR missions, to best achieve ice sheet observations in fulfillment of science objectives set by the global science community. The satellite assets of member agencies will continue to monitor ice sheets and contribute to the legacy of archived Earth observation satellite products of the Arctic and Antarctica. Through this exercise, the space agencies are demonstrating their continued commitment to the critical imaging requirements articulated in response to key science issues.

The ice sheet requirement document is the first in a set to be produced by the Task Group, which is currently working with the science community to document consolidated sets of observation requirements for permafrost, snow, and sea ice. Future communications will specifically address advancement on the ice sheet response but also provide an update on the future responses to other sets of requirements.

Acknowledgments

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WMO Secretariat contributor

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[2] Prepared by B. Scheuchl in 2013 and accessible at www.wmo.int/pages/prog/sat/meetings/documents/Task Group-3_Doc_08-02-02_SAR-Req-IS.pdf

The Polar Prediction Project

By Neil D. Gordon[1] , Thomas Jung[2] and Stefanie Klebe[3]

Scientific and public awareness of the importance of the polar regions in the global weather and climate system is increasing. The popular use of the term "polar vortex" in the United States of America earlier this year is just one example of increased interest in rapid climate changes at high latitudes. The WMO annual reports on summer Arctic ice cover catch worldwide media attention every year. There is a high level of public interest – especially amongst youth – about how these factors might affect the weather and climate in the rest of the world. The expansion of human activities into the polar regions is also increasing the demand for more information and better predictions.

Recognition of the important role that polar regions occupy within global environmental systems, including the climate, has placed increasing demands for scientific investigation, semi- and permanent research stations, and various forms of in situ and remote environmental monitoring, with corresponding needs for weather and environmental information in support of tactical decision-making. For example, the forecasting of fog, low clouds and poor visibility is a concern for aircraft flights into Antarctica. These flights support a range of research activities in the Antarctic; unpredicted poor weather can be very costly if flights, unable to reach their planned destination, have to turn around.

However, the remoteness and prevalence of harsh weather and climate conditions contribute to making the polar regions the poorest observed in the world.

There are many gaps in our knowledge and understanding of key processes in polar regions, of how best to improve computer models and prediction systems, how to optimize the observing system, and what services should be provided. Polar research is an extremely resource-demanding endeavour requiring large-scale infrastructure. Coordination of research activities at an international level is therefore especially important for generating the knowledge required to improve prediction capabilities for the polar regions and beyond.

The international Polar Prediction Project was established to provide the observational database required to optimize the polar observing system. It will improve the quality of data on initial conditions in a cost-effective manner. It will also provide the ground-truthing of data needed to improve satellite retrieval algorithms, and the understanding of key polar processes, which is urgently needed to advance numerical modelling capabilities.

The Project was established under the World Weather Research Programme to address these research challenges on time scales from hourly to seasonal. It will collaborate closely with the World Climate Research Programme's Polar Climate Predictability Initiative, which deals with time scales from seasonal to multi-decadal. Together, they will provide the research that will underpin the Global Integrated Polar Prediction System (GIPPS).

The Project's International Steering Group includes academics and representatives from the operational weather and climate prediction communities. The Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, in Bremerhaven, Germany will host the Project.[4]

[1] Consultant, Polar Prediction Project, New Zealand
[2] Chair, Polar Prediction Project; Expert member, WMO Executive Council Panel of Experts on Polar Observations, Research and Services; and Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Germany
[3] Assistant, Polar Prediction Project; Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Germany
[4] Further information is available at http://polarprediction.net

Service, forecasting and underpinning research

The research goals of the Polar Prediction Project can be broadly classified into:

- Service-oriented research, tackling issues of direct relevance to users of environmental forecasts – This includes the analysis of historic and current uses of polar prediction products; the communication of risk, opportunity and uncertainty to disparate users; and the comprehensive verification of user-relevant products such as sea ice forecasts.

- Forecasting system research, encapsulating more "traditional" issues such as observations, modelling, data assimilation and ensemble forecasting – Here the emphasis will be polar-specific issues such as the lack of observations, the proper representation of the cryosphere in forecast models, data assimilation schemes, and ensemble prediction systems.

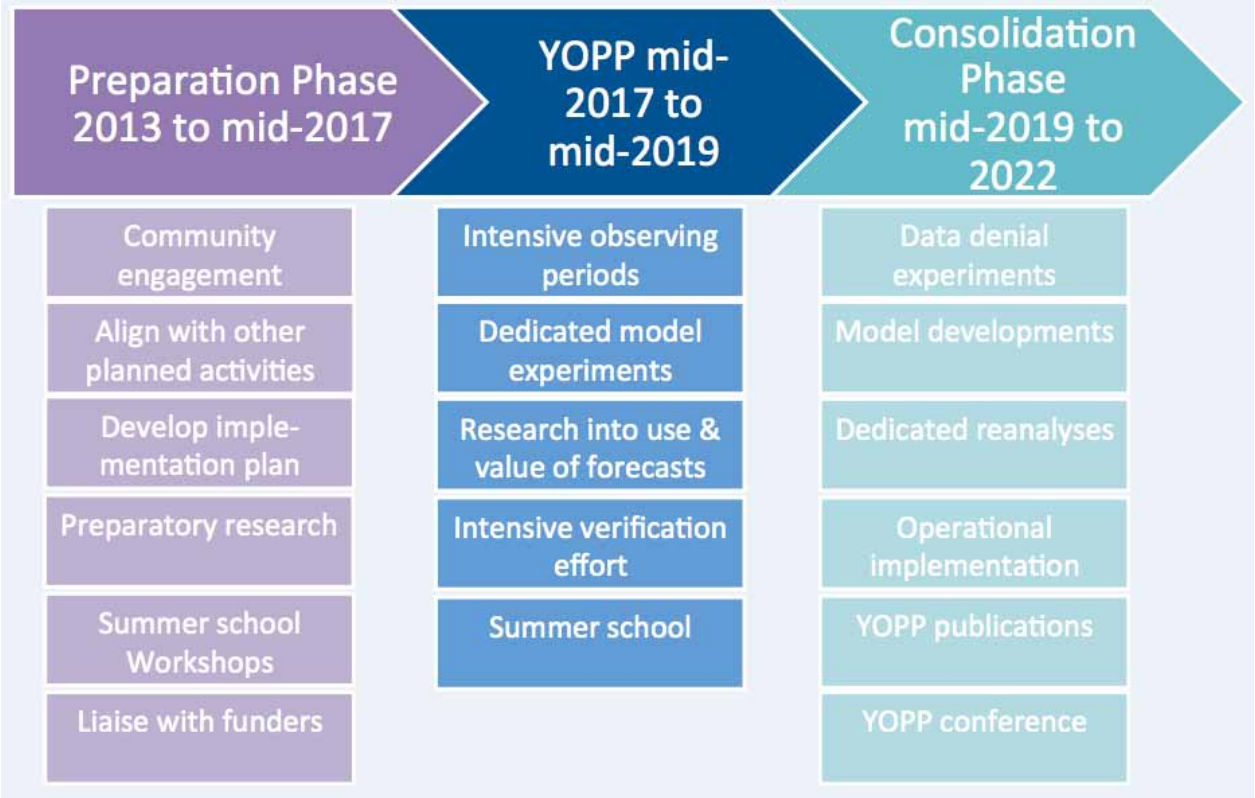
- Underpinning research, dealing with the more fundamental aspects such as predictability of the polar climate system, forecast error diagnosis, and weather/climate linkages between polar and non-polar regions.

The development of sea ice prediction capabilities has a central role in the Project. On shorter time scales it will be important to provide users with reliable information on sea ice characteristics such as leads and zones of strong sea ice convergence (important for safe shipping and sea ice management). On longer, monthly to seasonal, time scales, the focus will be on larger-scale aspects, such as the prediction of sea ice conditions in the Northern Sea Route and in the Southern Ocean around Antarctica. In line with the central role that sea ice prediction takes in the polar regions, the development of forecasting systems based on coupled atmosphere-sea ice-ocean modelling systems will be pivotal.

Year of Polar Prediction (YOPP)

The major initiative in the ten-year (2012–2022) Polar Projection Project will be the Year of Polar Prediction (YOPP), planned for mid-2017 to mid-2019. YOPP will enable significant improvement in environmental prediction capabilities for the polar regions and beyond by coordinating a period of intensive observing, modelling, verification, user-engagement and education activities.

Timeline of the three different stages of the Year of Polar Prediction (YOPP) – one of the flagship initiatives of the Polar Prediction Project – together with a number of selected key activities.



Benefits

As a result of the Project, many who live in, or visit, the polar regions, where activities related to transportation, tourism and resource development are on the rise, will benefit from improved predictions. However, the expected benefits will go beyond the provision of more accurate predictions on various time scales (hourly to seasonal) in the two regions (Arctic and Antarctic), which is the focus of the Project. Improvements anticipated in the representation of polar processes in coupled numerical weather models will help to narrow uncertainties in regional climate change projections. Furthermore, improved environmental predictions in the polar regions will result in more accurate predictions for non-polar regions, especially in the middle latitudes, through atmospheric linkages.

Contributions and support

The Polar Projection Project is an international effort that aims to provide advanced prediction capabilities in two regions that are becoming increasingly important, but which, thus far, have attracted relatively little attention from the forecasting community. The International Steering Group has developed plans and strategies in collaboration with partners from the research community and operational centres. The Polar Prediction Project may become a crucial WMO contribution into an emerging International Polar Partnership Initiative, which will unite efforts of many agencies and organizations in achieving socially important objectives in the polar and alpine regions, including the Third Pole (Tibet and Himalayas).

Ultimately, the success of the Polar Projection Project will depend on support from WMO Members through contributions to the Polar Prediction Trust Fund to ensure proper international coordination, on in-kind support from operational centres, research institutions and universities, and on an enhanced level of interest in polar prediction by national and international funding agencies.

Further reading

WMO, 2013: WWRP Polar Prediction Project Science Plan, WWRP/PPP No. 1 – 2013, 69pp. – available via http://polarprediction.net

WMO, 2013: WWRP Polar Prediction Project Implementation Plan, WWRP/PPP No. 2 – 2013, 59pp. – available via http://polarprediction.net

Andrew Peacock/ www.footloosefotography.com

The Russian ship MV Akademik Shokalskiy is trapped in thick Antarctic ice 1,500 nautical miles south of Hobart, Australia Friday, Dec. 27, 2013

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The weather: what's the outlook?

The overarching theme of WWOSC2014 is " Seamless Prediction of the Earth System: from minutes to months". The conference is structured around two programs:

- The science program will cover basic weather research that extends our knowledge of processes and systems as well as the applied research needed to put prediction systems together and assess the impacts of weather and climate events.
- The user, application & social science program will consider the goods and services economy and the role of government in disaster risk reduction and management and the communication of weather information.

Abstract Submission Now Open!

- Deadline for submission: 24 February 2014
- Limit of one submission per first author; up to ten co-authors permitted.
- Notifications of accepted abstracts will be emailed the week of 21 April, after which the presenting (or poster) speaker must confirm acceptance by 22 May.
- Note: travel support applications can be made during the abstract submission process.

Science plenary speakers to include:

- **Mel Shapiro** on the future scientific challenges of Earth-system prediction aligned with the 2010 BAMS compendium of vision papers
- **Al Kellie** on the past, present and future of High Performance Computing and its applications in weather prediction
- **Philippe Bougeault** on state-of-the-art mesoscale NWP and regional applications with some background on PPP and HIW projects and other WWRP RDPs
- **Julia Slingo** on the seamless prediction problem, including bridging global NWP and climate prediction through sub-seasonal to seasonal prediction
- **Jean-Noël Thépault** on the actual status and future challenges of data assimilation and observing systems (global and regional)
- **Alan Thorpe** on global NWP with an historical perspective and future directions

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WWOSC 2014
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