The Importance of Observing Weather and Climate

Each year, since 1961, World Meteorological Day has been celebrated, on 23 March, to commemorate the entry into force of the World Meteorological Convention on that day in 1950. The International Meteorological Organization, which had existed since 1873, was accordingly transformed into the intergovernmental World Meteorological Organization (WMO). The WMO Executive Council selects a specific theme to provide a focus for the celebration each year. For 1994, the theme was 'observing the Weather and Climate'. This was partly motivated by the emphasis, placed by world leaders at the UN Conference on Environment and Development held in Rio de Janeiro in June 1992, on the need for a reliable national and global observing system for monitoring, understanding, and predicting, the behaviour of the global environment. The theme also provides an opportunity to highlight the key role of national Meteorological and Hydrometeorological Services in sustainable development.

From earliest times, Mankind has been dependent upon his natural environment, and particularly on weather and climate. It is often said that 'if you do not measure or quantify it, you cannot understand it'. And without understanding, it is not possible to predict weather and climate or *limit human interference with it*. Systematic observations of the global environment, the atmosphere, and water, are thus fundamental to understanding their behaviour and enormous impact on our lives.

Advances in Meteorology

Organized international collaboration in meteorology began in 1853 when, at a meeting of seafaring nations, a programme for obtaining weather observations over the oceans was developed to increase the safety of life at sea. At about this time, countries also began to establish national Meteorological Services. With observations available over both land and sea, there was need for a more formal collaboration for their collection on a wider scale than had hitherto been practised. This led to the creation of the International Meteorological Organization in 1873.

As a result of these institutional developments and the progress made in various scientific fields, meteorology advanced rapidly. Improved methods of observing the atmosphere evolved, numerous networks of observing stations on land appeared, and merchant ships made regular observations from the sea. The upper atmosphere was explored by balloons and kites and later by aeroplanes, radiosondes, and rockets. Arrangements were made for the inter-service exchange of observational data, which became quicker and more reliable as telecommunication technology improved.

Thus in 1963, these activities and developments in satellite and computer technologies were brought together with the creation by WMO of an integrated world-wide operational system called the World Weather Watch (WWW), comprising a Global Observing System, a Global Telecommunications System, and a Global Data Processing System, to which virtually every country in the world contributes every day of every year for the common good.

Today, there are some 9,000 observing stations on land and 7,000 voluntary observing ships which make observations over the world's oceans. Most of these provide basic weather measurements every three hours. About one in ten of the land stations, and a few of the ships, make upper-air soundings once or twice a day to obtain data on pressure, temperature, humidity, and winds, up to heights of 30 km. These are complemented by observations from commercial aircraft currently producing some 10,000 reports per day, some 350 automated or partially automated land-based weather stations, 300 moored buoys or fixed platforms serving as automatic marine stations, and some 600 buoys drifting with the ocean currents.

Great advances in meteorological satellites and automated observing systems in the past three decades have ensured that nowadays, at any given time, four highly instrumented polar-orbiting satellites, carrying automatic picture-transmitting equipment, orbit the Earth and provide meteorological surveillance of every involved point on its surface twice daily. They provide global observations of the Earth's cloud-cover, vertical temperature and humidity profiles, sea-surface and land temperatures, and snow- and ice-cover. A second system of geostationary or Earth-synchronous satellites over the Equator, revolving at the same speed as the Earth and thus 'stationary' relative to it, provide meteorological information of the same areas on a near-continuous basis.

The observation and analysis of daily weather is the first step towards understanding climate and its variations. These can be applied towards the myriad of economic and social decisions that have to be taken daily. Examples of these include preparedness against the growing effects of natural disasters such as floods, tropical cyclones, and droughts, as well as environmental emergencies. However, in order to achieve a better understanding of climate and its possible changes, other parameters need to be observed.

Water Widely Fundamental

Fresh water, a very important component of the environment, appears very obviously in rivers, lakes, and reservoirs, and also as snow and ice. It is less obvious when stored in the soil, vegetation, and in aquifers.

Environmental Conservation, Vol. 21, Nr 4, Winter 1994 — © 1994 The Foundation for Environmental Conservation — Printed in Switzerland

Measuring the storage and movement of water on the surface of the Earth is the task of the world's Hydrological Services. River-flow measurements were first made on a regular basis at the start of the 19th century. Now, there are approximately 60,000 river-gauging stations in operation around the world, but many important rivers are still not measured. Measurements of the materials that are being carried by the river water in solution, in suspension, and by saltation, were not started until the 20th century, and even today, there are few stations where the water quality of rivers, wells, and boreholes, is observed. These measurements of surface- and ground-water, together with those made of the meteorological parameters, have contributed to improved understanding of the environment and of the weather and climate that characterize it.

However surface observations, upper-air soundings, and systematic global satellite measurements, do not provide all the information required to investigate the mechanisms that are at the root of past natural climate variations, much less predict them in the future. The dynamics of climate involve a vast range of interactive processes, from the formation of clouds and their effect on radiative transfer, to oceanic circulations that respond to minute changes in surface air–sea fluxes. For these reasons a scientifically adequate climate observation programme, calling for numerous additions to the basic operational Global Observing System of the WWW, is required — to understand, in quantitative terms, the interplay between the global atmospheric circulation, water and energy transfers, the world ocean circulation and sea-ice, the land-surface moisture, vegetation, and hydrology.

Ongoing Projects and Researches

Much innovative research is thus being undertaken to address these critical issues about the climate. It is essential to know if the climate is undergoing change, what are the consequences of climatic change, and what is the role of human activities in affecting this change. In 1984, WMO established a Climate Monitoring System — a project to provide synthesized information on the state of the climate system and diagnostic insights into climatic events of regional and global consequence, such as those associated with El Niño periods. Through the massive array of special oceanographic and atmospheric measurements under the Tropical Oceans Global Atmosphere (TOGA) project, scientists have recently had some success in predicting El Niño/Southern Oscillation (ENSO) events and the related climate anomalies such as droughts and floods in tropical regions around the globe. For such phenomena, observations of selected parameters will be required on a more permanent basis when once the TOGA research project is over in 1995.

The World Ocean Circulation Experiment (WOCE) — in the manner of TOGA, required for the understanding of the long-term responses of the coupled atmosphere–ocean system and others — are all components of the World Climate Research Programme (WCRP), a global research undertaking jointly implemented by WMO with other agencies. WCRP is itself one of the components of the World Climate Programme (WCP), created in 1979 to address the full gamut of climate and climate-change issues. WCP is the major international programme supporting the work of the Intergovernmental Panel on Climate Change (IPCC), the Intergovernmental Negotiating Committee for a Framework Convention on Climate Change (INC/FCCC), that on Desertification (INC/D), and other activities undertaken by Members of WMO in the context of UNCED and its *Agenda 21*.

In order to meet such long-term observational requirements for a more enhanced description of the Earth climate system, as envisaged under *Agenda 21*, WMO and three other international organizations established the Global Climate Observing System (GCOS) in 1992. Currently in its early planning phase, GCOS is taking a comprehensive view towards these requirements, and will of necessity include observations from the ocean, in concert with the Global Ocean Observing System (GOOS) and the Global Terrestrial Observing System (GTOS) in addition to the current observational programme on the atmosphere.

Man-engendered Threats

Increasing threats to the marine environment through human activities have put an even greater emphasis than formerly on the need for extensive, rapid, and accurate, ocean data to be made available to governments and the public. GOOS will also provide long-term, operational monitoring of physical, chemical, and biological, variables of the world's oceans which cover 70% of the surface of the globe and play a major role in the global climate system. Though a huge undertaking, GOOS is being built on firm foundations, through the hundreds of ocean observations that are now being made and exchanged every day under the umbrella of the World Weather Watch and the global ocean research programmes.

The present world-wide concern about climate has its roots in the changing chemical composition of the atmosphere. These changes are occurring quite rapidly under the impact of human activities, with consequent environmental problems of 'acid rain', airborne toxic chemicals, severe ozone-layer depletion, and 'greenhouse' gas-induced global warming. These are the danger signals that Mankind is seriously contaminating the atmosphere and is thus threatening some life-forms, human health, water supplies, and food production. Measurements of the changes which are taking place are essential to diagnose these trends, their likely impacts, the sources of the polluting substances, and so be able to reduce the human burden on the atmosphere.

[Concluded on page 353]

has been largely ignored by waterfowl policymakers and managers. An economic analysis of 'crippling losses' for prairie Canada and the USA was conducted, based on 1992 harvest statistics. The analysis is based on current levels of spending on habitat programmes designed to bolster declining North American duck populations, with reference to the North American Waterfowl Management Plan.

In 1992, continental 'crippling losses' were 1.6-4.4 million ducks, a figure which contrasts sharply with the 750,000 ducks which the North American Waterfowl Management Plan proposed to add to the continental breeding populations in the same period. The implicit value of continental 'crippling losses' was 20 to 560 million US dollars. For Mallard (*Anas platyrhynchos*) alone, between 57,000 and 152,000 ha of wetland breeding habitat would have been required to compensate for Canadian prairie Mallard 'crippling losses' in 1992.

These analyses suggest that the scope of waterfowl management should be broadened to include policies and regulations inducing improvements in hunter behaviour and hunting competency. Lowering the 'crippling loss' rate would complement waterfowl habitat improvement initiatives, and would enable continental waterfowl population goals to be realized sooner.

References

Anderson, D.R. & Burnham, K.P. (1976). *Population Ecology of the Mallard: VI, The Effect of Exploitation on Survival.* US Bureau of Sport Fisheries and Wildlife Service Resource Publication 128, Laurel, Maryland, USA: 66 pp.

Anon. (1986). *North American Waterfowl Management Plan.* Canadian Wildlife Service and US Fish and Wildlife Service, Environment Canada, Ottawa, Ontario, Canada: 19 pp.

Anon. (1987). *The Canadian Prairie Habitat Joint Venture: Prospectus.* Canadian Wildlife Service and US Fish and Wildlife Service, Environment Canada, Ottawa, Ontario, Canada: 11 pp.

Anon. (1992). *Ducks Unlimited Canada 1992 Annual Report.* Ducks Unlimited Canada, Winnipeg, Manitoba, Canada: 27 pp., illustr.

Bellrose, F.C. (1953). A preliminary evaluation of cripple losses in waterfowl. *Transactions of the North American Wildlife and Natural Resources Conference*, **18**, pp. 337–60.

Bethke, R.W. & Nudds, T.D. (in press). Partitioning the effects of changes in climate and land use on breeding duck abundance in the prairie-parklands of Canada. *Ecological Applications.*

Bishop, R.A. & Wagner, W.C. II (1992). The U.S. cooperative lead poisoning control information program. Pp. 42–5 in *Lead Poisoning in Waterfowl* (Ed. D.J. Pain). (Proceedings of the IWRB Workshop, Brussels, Belgium, 1991.) IWRB Special Publication 16, Slimbridge, England, UK: 105 pp.

Boyd, H. (1971). *Observations on Duck Hunting in Eastern Canada in 1968 and 1969.* (Canadian Wildlife Service Occasional Paper Nr 12.) Environment Canada, Ottawa, Ontario, Canada: 22 pp.

Evrard, J.O. (1970). Assessing and improving the ability of hunters to identify flying waterfowl. *Journal of Wildlife Management*, **34**, pp. 114–6.

Gray, B.T. & Kaminski, R.M. (1989). Illegal harvest of waterfowl: what do we know? *Transactions of the North American Wildlife and Natural Resources Conference*, **54**, pp. 333–40.

Hochbaum, G.S. & Walters, C.J. (1984). *Components of Hunting Mortality in Ducks.* (Canadian Wildlife Service Occasional Paper Nr 52.) Environment Canada, Ottawa, Ontario, Canada: 29 pp.

Locke, L.N. & Friend, M. (1992). Lead poisoning of avian species other than waterfowl. Pp. 19–22 in *Lead Poisoning in Waterfowl* (Ed. D.J. Pain). (Proceedings of the IWRB Workshop, Brussels, Belgium, 1991.) IWRB Special Publication 16, Slimbridge, England, UK: 105 pp.

Lokemoen, J.T. (1984). Examining economic efficiency of management practices that enhance waterfowl production. *Transactions of the North American Wildlife and Natural Resources Conference*, **49**, pp. 584–607.

Martin, E.M. & Carney, S.M. (1977). *Population Ecology of the Mallard: IV, A Review of Duck Hunting Regulations, Activity and Success, with Special Reference to the Mallard.* US Bureau of Sport Fisheries and Wildlife Service Resource Publication 130, Laurel, Maryland, USA: 137 pp.

Martin, E.M. & Padding, P.I. (1993). *Preliminary Estimates of Waterfowl Harvest and Hunter Activity in the United States During the 1992 Hunting Season.* Administrative Report, US Fish and Wildlife Service, Laurel, Maryland, USA: 30 pp.

Nichols, J.D., Conroy, M.J., Anderson, D.R. & Burnham, K.P. (1984). Compensatory mortality in waterfowl populations: a review of the evidence and implications for research and management. *Transactions of the North American Wildlife and Natural Resources Conference*, **49**, pp. 535–54.

Nieman, D.J., Hochbaum, G.S., Caswell, F.D. & Turner, B.C. (1987). Monitoring hunter performance in prairie Canada. *Transactions of the North American Wildlife and Natural Resources Conference*, **52**, pp. 233–45, illustr.

Pospahala, R.S., Anderson, D.R. & Henny, C.J. (1974). *Population Ecology of the Mallard: II, Breeding Habitat Conditions, Size of the Breeding Populations and Production Indices.* US Bureau of Sport Fisheries and Wildlife Service Resource Publication 115, Laurel, Maryland, USA: 73 pp.

Reynolds, R.E. (1987). Breeding duck population, production and habitat surveys, 1979–85. *Transactions of the North American Wildlife and Natural Resources Conference*, **52**, pp. 186–205.

Smith, A.G. (1971). *Ecological Factors Affecting Waterfowl Production in the Alberta Parklands.* US Bureau of Sport Fisheries and Wildlife Service Resource Publication 98, Laurel, Maryland, USA: 49 pp.

Stoudt, J.H. (1971). *Ecological Factors Affecting Waterfowl Production in the Saskatchewan Parklands.* US Bureau of Sport Fisheries and Wildlife Service Resource Publication 99, Laurel, Maryland, USA: 58 pp.

Thomas, V.G. & Pokras, M.A. (in press). International analysis of non-toxic shot adoption for waterfowling. In *Proceedings of the 21st International Union of Game Biologists Congress.* Environment Canada, Halifax, Nova Scotia, Canada.

[Concluded from page 295]

The basic world-wide network for these observations is the Global Atmosphere Watch of WMO, initiated in 1989 to coordinate two long-standing measurements programmes: the Global Ozone Observing System (GOOS) and the Background Air Pollution Monitoring Network (BAPMoN). These activities are providing vital information on the chemical and physical constituents and properties of the global atmosphere — including their dispersion and transport, and the chemical transformation and deposition of atmospheric pollutants over land and sea, among other things. Complementary data on air pollution within cities are coordinated through the World Health Organization (WHO) and UNEP.

From all the foregoing it is clear that, as providers of meteorological, hydrological, oceanographic, and other environmental data and services, national meteorological and hydrological services are the indisputable pillars in the world-wide efforts to monitor, understand, and predict, weather and climate *inter alia* towards the planning and implementation of reliable sustainable development programmes in order to ensure increased effectiveness and efficiency in monitoring weather and climate for a safe and equable future for all Mankind.

Godwin O.P. Obasi, *Secretary-General*
World Meteorological Organization
41 Avenue Giuseppe-Motta
1211 Geneva
Switzerland.