WATCHING THE WEATHER TO PROTECT LIFE AND PROPERTY

CELEBRATING 50 YEARS OF WORLD WEATHER WATCH

World Meteorological Organization
Weather • Climate • Water

WMO-No. 1107

The WMO vision

To provide world leadership in expertise and international co-operation in weather, climate, hydrology and water resources, and related environmental issues, and thereby to contribute to the safety and well being of people throughout the world and to the economic benefit of all nations.

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Hurricane *Elena* over
the Gulf of Mexico and Florida

FOREWORD

Weather and climate know no national borders. The transformation of the International Meteorological Organization into the World Meteorological Organization (WMO) in 1950 was therefore an essential response to the need for strengthening global cooperation in this scientific area. WMO's aim: to reduce the loss of life and property caused by disasters and other catastrophic events related to weather, climate and water, as well as to advance the universal goal of sustainable development and safeguard the environment and the climate for present and future generations.

In 1960, the Executive Council of WMO established World Meteorological Day to build public awareness of the services provided by National Meteorological Services and WMO. These services involve the observation, collection, processing and dissemination of meteorological, hydrological and other related data and products. The 23rd of March was chosen for the commemoration as it marks the date of entry into force of the WMO Convention.

The 2013 World Meteorological Day theme is "Watching the weather to protect life and property," with the subtitle "Celebrating 50 Years of the World Weather Watch". This theme focuses attention on the crucial role of meteorological services in strengthening safety and resilience to weather events. It also pays tribute to the World Weather Watch, a foundation programme of the WMO that will mark its fiftieth anniversary in 2013.

Established in 1963, in the middle of the Cold War, the World Weather Watch is an outstanding landmark in international cooperation. It combines observing systems, telecommunication facilities, and data-processing and forecasting centres in order to disseminate essential meteorological and related environmental information and services in all countries.

The ever growing need for more and better weather and climate services has reaffirmed the World Weather Watch as a core operational infrastructure facility for all WMO Programmes as well as for many of the international programmes of other agencies.

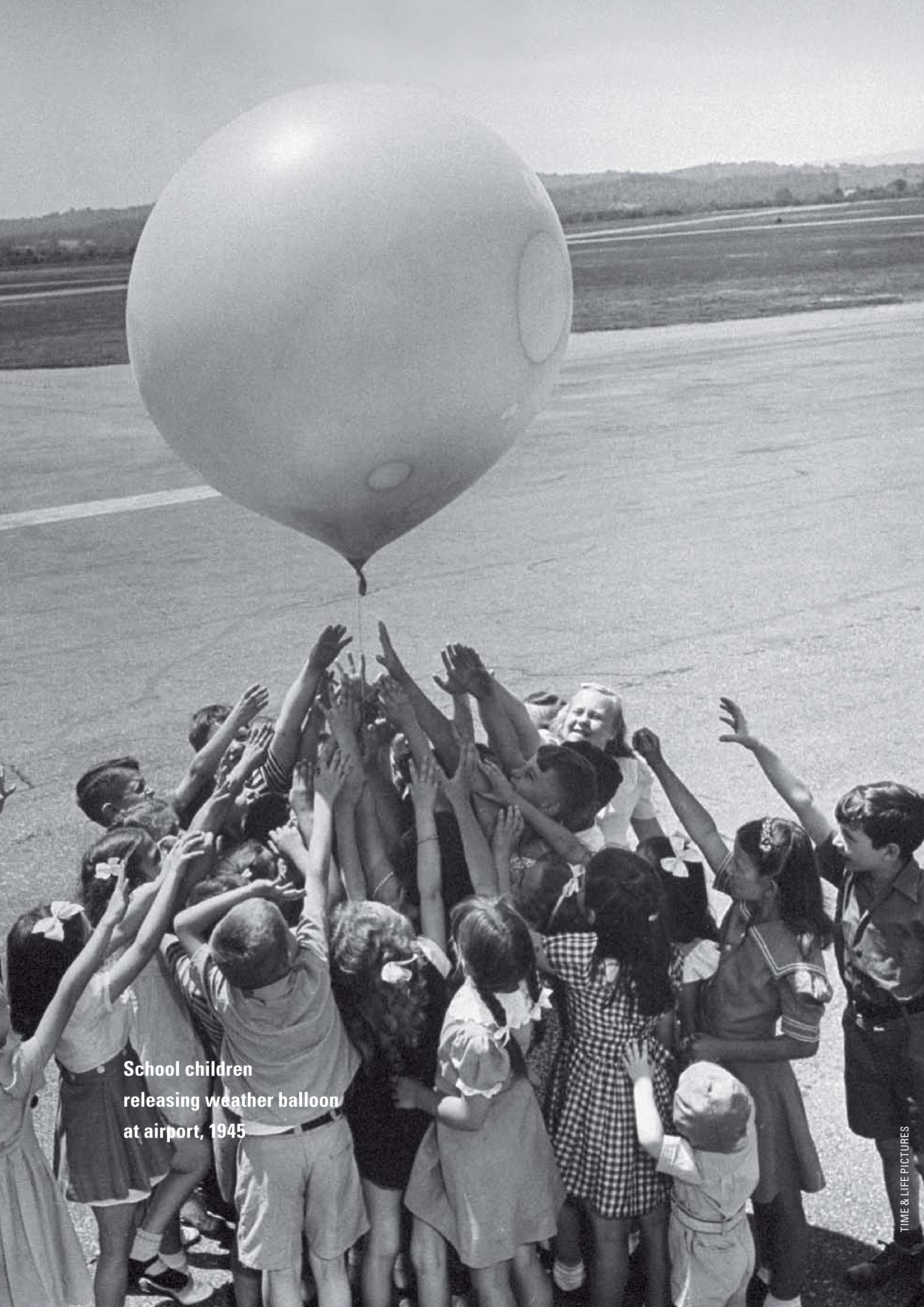
The World Weather Watch provides a fundamental contribution to WMO priority areas, from the Global Framework for Climate Services (GFCS) to disaster risk reduction, from the WMO Integrated Global Observing System to the WMO Information System, capacity building and aeronautical meteorology.

Weather extremes have a tremendous impact on our planet's 7 billion-strong population, and that impact will increase as economies develop and the global population grows to reach the 9.3 billion mark expected in around 2050. Between 1980 and 2007, nearly 7,500 natural disasters took the lives of over 2 million people and produced economic losses estimated at over US$ 1.2 trillion. More than 70 percent of the casualties and almost 80 percent of the economic losses were caused by weather-, climate- or water-related hazards such as tropical cyclones and storm surges, droughts, floods or related disease epidemics and insect infestations. Over time, there has been a significant reduction in the loss of life thanks to early warnings issued by National Meteorological and Hydrological Services. Economic losses have, however, increased.

Much more must, and can, be done to allay human suffering. The memories of the losses caused by extreme weather in 2012 are still alive: tropical cyclones, heavy rainfalls and floods, droughts and cold and heat waves have affected the entire world, alerting us to the worst implications of growing climate variability and change.

More than ever the world needs global cooperation to promote and coordinate the provision of better and longer-term weather and climate forecasts and early warnings to protect life and property. The 2013 World Meteorological Day offers an occasion to reinforce this message and to contribute to addressing the challenges of the 21st century.

(M. Jarraud)
Secretary-General



School children
releasing weather balloon
at airport, 1945

INTRODUCTION

Weather observation is almost as old as humanity itself. Early man could anticipate the weather to some extent by watching the sky and the behaviour of plants and animals. But while some people still rely on local observations of natural phenomena to predict the weather, remarkable advances in technology, science, and international cooperation have revolutionized our understanding of meteorology and our ability to provide skillful forecasts on longer and longer timescales.

Over the past 50 years, watching and predicting the weather has become a highly sophisticated scientific activity dedicated, in particular, to protecting life and property around the world. Continuously improving scientific weather forecasting has saved many lives and contributed enormously to sustainable development. Everyone, from the farmer and urban planner to the emergency responder, water manager or weekend picnic organizer to government officials, benefits from modern weather and climate services.

These benefits will multiply in the future as meteorologists provide information that is more and more accurate, long-term and user-specific. Remarkable new observation and modelling technologies continue to develop, helping scientists to advance their understanding of the Earth's complex global weather and climate system. As a result, today's five-day forecasts are as reliable as the two-day forecast of 25 years ago. Meteorologists and climate scientists are starting to make seasonal and longer term forecasts and blurring the boundaries between weather and climate prediction by developing "seamless weather and climate forecasts".

Underpinning this progress is the commitment of the world's weather, climate and water communities to cooperate through the World Meteorological Organization (WMO), which was established on 23 March 1950 (replacing the International Meteorological Organization that was set up in 1873). Soon after the launch of the first weather satellite in 1960, the UN General Assembly requested WMO to produce a report on the potential of weather satellites. A working group led by the United States, the USSR and several other countries produced a report that led WMO to launch the World Weather Watch Programme in 1963. This system for collecting, analyzing and distributing weather and other environmental information became the backbone of other WMO Programmes.

The World Weather Watch marked the start of a new era in weather observation based on the enhanced, real time exchange of meteorological information by National Meteorological and Hydrometeorological Services in 191 Members. It links together weather observation instruments, telecommunications systems for collecting and sharing data and data-processing centres that model the global atmosphere and predict its future state. The founding of WMO and the World Weather Watch, together with new scientific insights and technological advances in computing, telecommunications and satellites, form the vital ingredients for modern weather science and prediction.

MORE OBSERVATIONS …

The technological foundations of scientific weather prediction were laid down by the invention of thermometers, barometers and other measuring instruments in the 17th century. Thanks to these developments the first international network of weather stations (comprising 11 stations across Austria, France, Germany, Italy and Poland) was launched in 1654. A network with 37 stations in Europe and two in North America was established in 1780. Samuel Morse's electric telegraph made it possible to start transmitting and exchanging in near-real time the weather reports produced by such networks in 1849.

Technological progress gained pace in the 20th century. Networks of modern observing stations multiplied, so that today the world boasts tens of thousands of weather stations. Balloons, airplanes and rockets carry measuring instruments into the upper atmosphere. Some 1,000 merchant ships take atmospheric measurements as they travel the oceans, while a global fleet of Argo buoys monitors sea temperatures and currents. Wind profilers, radar systems, lightning detection networks, and many other sensors are increasing the spatial and temporal resolution of weather and climate observations. Ever-faster telecommunications systems and the Internet distribute vast amounts of data from these instruments rapidly and cheaply.

Remote-sensing weather satellites started to play a vital role in the 1960s and expanded greatly during the 1970s. Today polar-orbiting weather satellites view every part of the Earth at least twice a day, providing global measurements of cloud cover, temperature, water vapour and many other parameters. A second system of geostationary satellites, each in a fixed position above the Equator, provides a continuous view of weather systems over most of the planet. These various space, air, land and sea-based systems work together to provide a comprehensive picture of the world's atmosphere, weather and climate.

Another critical technological breakthrough has been the development of computers. National weather services, as well as regional and global data processing centres, were amongst the first organizations to operate extremely powerful supercomputers. These computers are able to analyze enormous volumes of data in order to produce forecasts of ever greater reliability. Continuing advances in computing power make it possible to run sophisticated weather and climate models and data assimilation algorithms that can take full advantage of the growing quantity of observations from satellites and other observing systems.

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… AND BETTER SCIENCE

The sun heats the Equator more than it warms the poles. The atmosphere and the ocean respond to this imbalance by redistributing the captured energy over the Earth. The resulting patterns of wind are shaped by the Earth's rotation around its tilted axis, the basic laws of thermodynamics and physics, and the non-linear nature of complex systems. We experience these patterns as weather.

By the 1980s, scientists had achieved an increasingly sophisticated understanding of how the weather is influenced by the oceans and the stratosphere (the layer of the atmosphere above the weather-producing troposphere). The oceans store much more heat, and for longer periods, than does the atmosphere, and they transfer this heat together with moisture into the atmosphere. Stratospheric processes, including those related to the ozone layer, affect the circulation in the stratosphere and interact with the winds below in the troposphere.

In addition to relying on observations, scientists study the weather by creating mathematical models that simulate the behavior of the atmosphere over time. These numerical weather prediction models process weather observations over the entire globe through sets of mathematical equations that describe how clouds, precipitation, wind, temperature, pressure and other weather variables evolve and interact with one another. As scientific understanding of the Earth system advances, scientists steadily improve these models. Forecasters then draw on their expertise and experience to interpret what the models mean for their regional or local areas of responsibility and inform the public.

Meanwhile, the science of climate variability and climate change has also progressed by leaps and bounds over the past several decades. Climate is often defined as the average weather over a long period of time (typically 30 years). Climate scientists try to predict changes in climate by studying general changes in temperature, precipitation and storms over seasons, years, decades, centuries or millennia. Climate is shaped by natural and human-made changes and variations in the Earth's land surface, oceans, rivers, lakes, glaciers, ice caps, and forests and other ecosystems. It is also influenced by changing levels of carbon dioxide and other greenhouse gases – by absorbing the infrared radiation reflected back out to space by the Earth after it is heated by the sun, these gases control the way natural energy flows through the climate system.

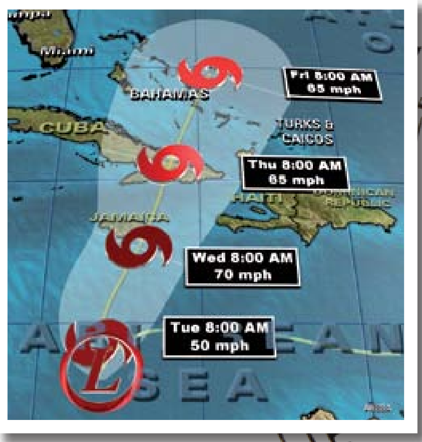
A better understanding of climate contributes to a better understanding of weather, and vice versa. For example, new insights into how climate change will alter the patterns and frequencies of storms and other extreme events will enable better weather analyses and predictions. Improved observations of, and research into, weather events and trends will help to fine tune climate models and forecasts.

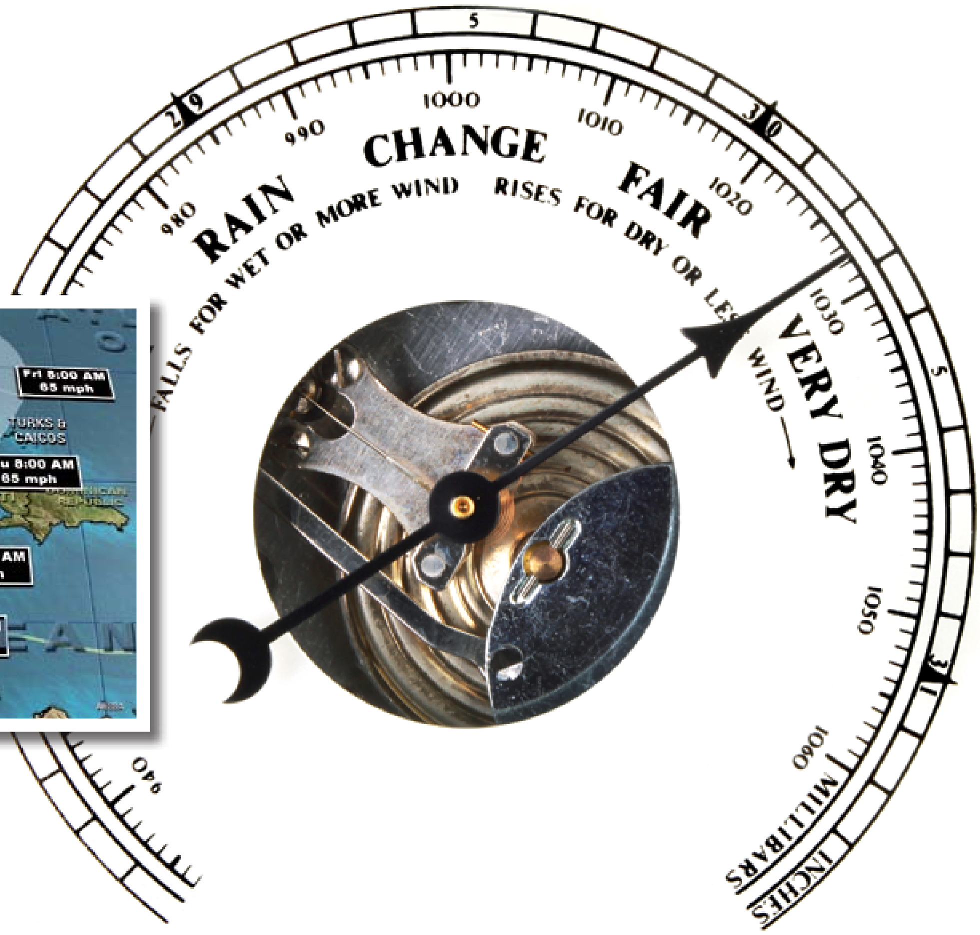
EXTENDING THE FORECAST

Until the 1980s, meteorologists usually provided forecasts for up to two or three days ahead. Today's forecasts extend out to five or even ten days, and they are much more reliable than the shorter term forecasts of earlier decades. Further improvements are in the pipeline.

For example, scientists working together on a project called THe Observing system Research and Predictability EXperiment (THORPEX) seek to extend forecasts of high-impact weather events out to two weeks and to test the next-generation forecast products. Ten forecast centres are supporting THORPEX by contributing ensemble forecasts consisting of as many as 20 or more simulations of a storm's potential path. This makes it possible to assign probabilities to the various possible paths. Forecasters, in turn, will use these probabilities to verify that the resulting products and services are beneficial. As a next step, they will provide improved early warnings of high-impact weather events.

The weather and climate communities are increasingly working together to improve their predictions. They aim to extend the reliability and usefulness of their forecasts to levels beyond what is currently thought possible. This effort includes exploring seamless weather and climate prediction based on an integrated view of the weather-climate continuum. Weather forecasting and climate prediction have usually been treated as separate scientific disciplines. Conceptually, however, the traditional boundaries between weather and climate are increasingly viewed as artificial.





CNN WEATHER CENTER | RICHARD GRIFFIN (SHUTTERSTOCK.COM) | NOAA | NEW JERSEY GOVERNOR'S OFFICE

OSCILLATIONS AND TELECONNECTIONS

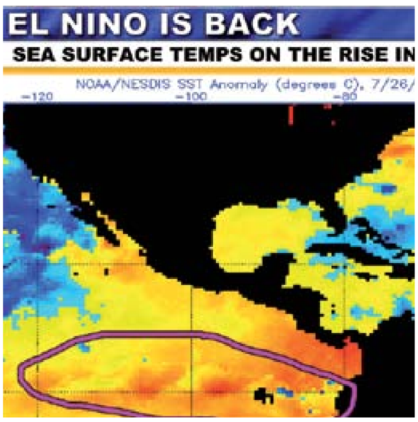
Aided by improved observations and computing power, scientists have made considerable progress in detecting and understanding broader patterns and cycles in the weather and climate system. In the 1980s and 90s major international efforts to improve observations and understanding of how the oceans and atmosphere interact led to significant progress in our ability to predict seasonal patterns, particularly in the tropics.

The most important such pattern is known as the El Niño/Southern Oscillation (ENSO). ENSO results from interactions between the atmosphere and the ocean in the tropical Pacific Ocean. During the El Niño phase, sea-surface temperatures off the South American coast near Peru become higher than normal. During the La Niña phase, these temperatures become lower than normal.

ENSO is linked via "teleconnections" to major climate fluctuations around the world. For example, during El Niño events, parts of North America tend to have warmer winters, while other parts become cooler and wetter; eastern Africa usually sees wetter than normal conditions, while south-central Africa, southeast Asia and northern Australia usually become drier than normal. La Niña events often cause drought in the coastal regions of Peru and Chile and wetter than normal weather in north Brazil from December to February.

Scientists have identified other large-scale oscillations that affect climate. The North Atlantic Oscillation is a fluctuation of pressure between the high-pressure system centered over the middle of the Atlantic and the low-pressure system centered near the Arctic. It controls the strength and direction of westerly winds and storm tracks across the North Atlantic. A large difference in pressure between the two systems tends to strengthen the moist westerly winds blowing across the Atlantic, giving Europe cool summers, mild winters and more frequent rain. When the pressure gradient is low and the winds are weak or suppressed, more weather comes from the continental east; summers tend to be hotter and winters colder, with reduced precipitation. The weather of Northern Africa and eastern North America can also be affected by the North Atlantic Oscillation.

This growing understanding of how the atmosphere, oceans and land surface interact to produce oscillations and teleconnections can be used to improve weather and climate forecasting. As scientists continue to study the climate system, they will gain greater confidence in their understanding of such large-scale climate patterns and their impacts. This in turn will provide more lead time for taking effective measures to protect life and property from extreme weather and climate events.



SEASONAL AND CLIMATE FORECASTING

The improved understanding of ENSO and its links to climate variations around the world opened the door to seasonal and longer term climate forecasting. Today forecasters can provide useful climate information, particularly about the coming season in certain regions, and their climate forecasting skills continue to improve.

Knowing there is a high probability that the coming monsoon season will have low, average or high rainfall can help farmers and energy and water suppliers plan their activities. Even if individual hurricanes, typhoons and other tropical disturbances cannot be accurately predicted beyond a few days in advance, by providing probabilities for the future tracks, numbers and intensity of such storms, forecasters can support planning decisions and help to save lives.

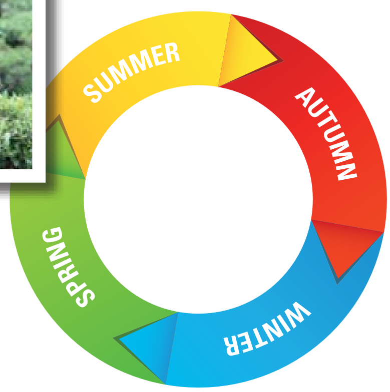
Seasonal to multiyear climate forecasts are increasingly being used to generate actionable information for making decisions on disaster risk management, health, agriculture, fisheries, water resources, tourism, transport, and other weather-sensitive sectors. A growing number of governments, organizations and companies are building on their experience with general weather and climate information to go one step further: providing weather and climate products and services that have been customized and targeted to specific needs.

These services incorporate science-based climate information and prediction into planning, policy and practice to achieve real benefits for society. Recognizing that the challenges facing humanity are increasingly complex, interconnected and related to climate variability and climate change, governments are collaborating through the Global Framework for Climate Services (GFCS) to build greater capacity for using climate services.

One of the next frontiers in forecasting is seasonal prediction. Forecasting the weather out to 10 days involves obtaining today's atmospheric pressure, temperature, wind direction and humidity, as well as land and ocean surface conditions. Models use these "initial conditions" to compute their future values. Forecasting for the next season, however, requires modelling the dynamic interactions between all parts of the Earth system, such as how the temperatures of the ocean and the land influence the temperature of the air above. Sub-seasonal forecasting addresses the gap between these two time frames, the period between 10 days and three months. Neither initial nor surface conditions alone are sufficient for sub-seasonal forecasting. Filling the sub-seasonal gap is essential for providing truly seamless weather and climate forecasts.

The reality of climate change will also increasingly shape weather prediction and the risks that weather poses to life and property. Climate change research reveals that average temperatures and precipitation are already changing all over the globe. Researchers are making rapid progress in understanding climate change, and, because of their work's powerful political, social and economic implications, the state of scientific knowledge is assessed every few years by the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC).

Based on this collective research, the IPCC's most recent estimate (in 2007) is that global average temperatures will increase by 1.8-4.0°C by 2100 in response to rising atmospheric levels of carbon dioxide and other greenhouse gases. Continued improvements in climate change science will help to clarify the kinds of weather and weather-related risks that will confront future generations. Of particular value will be regional scenarios of increasingly high resolution and credibility made possible by more sophisticated models running on ever more powerful supercomputers.



MATEJ HUDOVERNIK, ANDREY TIYK, YGANKO (SHUTTERSTOCK.COM) | NASA

THE FUTURE OF FORECASTING

Weather observation and forecasting have made remarkable progress over the past 50 years. This represents one of the most impressive achievements in all of science. The next 50 years promise to be equally exciting – if not more so. Meteorologists will continue to improve information products and make them more narrowly targeted to specific users in fields such as agriculture, water resources, public health and urban management. These future advances will be driven by the growing demands for greater safety and security. The impacts of climate change will also drive the search for increased weather and climate resilience.

A greater understanding of climate and weather will support policies for sustainable development. It will contribute to humanity's efforts to interact sustainably with the natural environment despite growing economies and populations. For example, improved forecasts will support efforts to maximize the efficiency of water use, rationalize energy consumption through the optimal timing of renewables production, and allocate resources more precisely in the agriculture, construction and transport sectors.

More targeted and reliable forecasts will empower resource managers and decision makers of all kinds to craft better short-term decisions and long-term strategies. Improved weather forecasts will enable farmers to adapt more quickly to the arrival of too much or too little rain, while better climate forecasts will guide them in planting the best crops for the next season's conditions. Disaster managers will more precisely fine tune how they position their resources in advance of likely floods or storms. Public health teams will roll out more timely and effective vaccination campaigns for weather- and climate-related diseases.

The expansion of megacities over the coming years will be a particularly important factor in guiding forecasters' efforts. To help urban centres manage their particular vulnerability to extreme events, many weather services will build denser urban weather monitoring networks. They will seek to increase the resilience of cities by developing customized forecasting products that integrate weather and climate data with socio-economic data. These products will be used to manage complex evacuation procedures and weather-affected systems such as water supply, sewage, underground transport and energy.

Empowering people to use tomorrow's more sophisticated forecasts will require building the skill sets of a wide range of individuals. To use the improved information and forecasts effectively, decision makers as well as the public at large will need training and capacity development. They will need to gain a good understanding of how to interpret probabilistic forecasts – for example, that there is a 70 per cent probability the spring will be hotter and drier than normal. Evaluating statistics and uncertainty is not always intuitive, but without this skill the most sophisticated weather and climate models may add little value.

For all of these remarkable capabilities to become a reality, the world's governments and researchers will need to collaborate ever more closely on weather, climate and water-related issues and systems. They will need to invest in new instruments for improving observations of currently monitored variables as well as for detecting variables that are not yet being measured, such as carbon fluxes from oceans and forests. In this way, the international community will realize the truly exciting vision of applying science and technology to solve some of humanity's greatest challenges.

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