Outstanding Accomplishments in Research

Weather Modeling

Research is at the center of all National Oceanic and Atmospheric Administration services. NOAA's Office of Oceanic & Atmospheric Research (OAR) conducts research, develops products, and provides scientific understanding and leadership to support NOAA's mission to meet our nation's economic, social and environmental needs.

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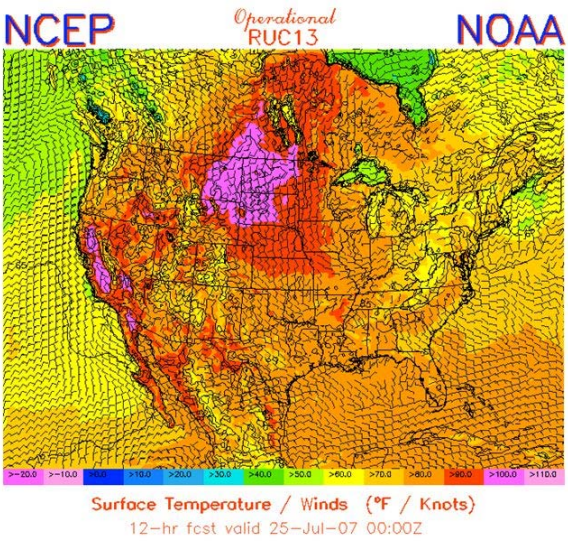
NOAA Research is a leader in developing, evaluating, and improving weather models that forecast future conditions with increasing accuracy. So how do scientists model the weather? The behavior of the Earth's weather is governed by physical laws that can be expressed as mathematical equations. These equations represent how atmospheric and oceanic features, such as temperature, currents, wind speed and direction, and humidity, will change over time. Scientists model the weather by sub-dividing the atmosphere and oceans into a 3-D grid and solving these equations at each point repeatedly over small time periods.

Rapid Update Cycle

The primary client for weather models developed by NOAA Research is the National Weather Service (NWS); in addition, many other federal agencies utilize these models in support of their missions – including NASA, the Federal Aviation Administration, Federal Highway Administration, the National Renewable Energy Laboratory, and the U.S. Air Force.

A good weather model takes in and organizes a lot of data, applies a comprehensive simulation of the physics governing the Earth system, and spins out a forecast quickly – before the weather hits. NOAA researchers at the Earth System Research Laboratory developed the Rapid Update Cycle (RUC) model, so-named because it provides updated numerical analyses and forecasts more frequently than any other models that are used by NWS forecasters.

The RUC provides high-frequency, hourly analyses of conventional and new data sources over the contiguous United States, and short-range numerical forecasts. Its ability to keep up with quickly changing local weather systems makes it valuable to aviation weather and storm prediction forecasters. A 13-kilometer resolution model now runs out to 72 hours, with updates every three hours. The RUC is revised yearly to continually improve forecasts of severe weather, precipitation, winds, and aviation hazards like turbulence and icing.



Recent RUC model showing 12-hour forecast for temperature and winds over the lower 48 states.

Weather Research and Forecast Model

One of the best-known weather models is the Weather Research and Forecast Model (WRF). A collaboration among NOAA's computer- and model-centric laboratories – including the Earth System Research Laboratory (ESRL) and the National Severe Storms Laboratory (NSSL) – and other partners including NOAA's National Centers for Environmental Prediction (NCEP), and the National Center for Atmospheric Research (NCAR) WRF project has developed and refined a next-generation forecast model that advances understanding and prediction of weather systems.

Now, weather model scientists from NOAA are developing a new operational version of the NCAR WRF model in an hourly-updated RUC successor model/assimilation system called Rapid Refresh. The Rapid Refresh, like the RUC, is designed for aviation and severe weather applications in one- to 12-hour forecasts. NOAA scientists are combining expertise on physical processes, modeling, and data assimilation that will enhance the new model.

Short-range Ensemble Forecasting

As everyone knows, weather forecasts are not perfect. Part of this imperfection is due to our inability to observe the atmosphere accurately over the entire Earth, and part is due to imperfect weather models. These imperfections have led to the use of ensembles, or groups of weather model forecasts. Using ensembles, NOAA scientists and forecasters can better determine the odds of severe weather events, or the chance of heavy snowfall, more accurately and further into the future. This type of information is crucial to making good decisions about how private industry and government prepare for weather events that threaten public health and safety. NOAA's National Severe Storms Laboratory, in partnership with NCEP, has been at the forefront of developing and evaluating short-range ensemble systems.

Hurricane Tracking and Intensity Models

The Hurricane Prediction System developed at NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton is known as one of the best in the world and has provided operational guidance for forecasters at the National Hurricane Center (NHC) in both the Atlantic and East Pacific basins for more than 10 years. The model has shown increasingly great skill in accurately predicting a hurricane's track, while forecasting a hurricane's intensity at landfall has been more challenging.

To help reduce intensity errors in the GFDL prediction system, an improved version of the GFDL model has been developed in which the forecast model has been coupled with a high-resolution version of the Princeton Ocean Model (POM). This new model was run in parallel with the operational GFDL model during the three recent hurricane seasons, and demonstrated substantial improvements in the prediction of storm intensity, with a reduction of nearly 26% in the mean error.

Hurricane WRF

NOAA ESRL is also involved in another important application of the WRF model, as NCEP develops the Hurricane WRF (H-WRF) model. This coupled high-resolution atmospheric, ocean, and wave model is to be maintained and supported by the Developmental Testbed Center (DTC) and made available to the research community. The DTC is a joint effort of ESRL and NCAR; the DTC mission is to accelerate the infusion of new numerical weather prediction capabilities into operations and to make operational WRF models available for use by the research community.

PREEMINENT RESEARCH

High-performance computing in support of modeling is central to NOAA's efforts to understand and predict the Earth system – from forecasting hurricane landfall tomorrow, to predicting climate change 100 years from now.

NOAA scientists conduct research to improve the accuracy of weather and climate models by boosting their efficiency and ability to run on NOAA's computing facilities. They've made improvements to how computers bring in and digest data, developed ways computers can talk to each other more efficiently, and improved ways to prepare, run and verify models, so forecasters can put more information into, and extract more accurate results out of, the models.

To advance forecast science, NOAA also is working to develop scalable, affordable, efficient data management systems. Computer scientists at NOAA Research are engaged in an effort to integrate NOAA's data systems under a common infrastructure. A Data Management Integration Team has proposed that "Service Oriented Architecture" be used to integrate diverse, distributed data systems and that web services be used to enable data providers and users to communicate. In the interest of a more integrated computing and modeling program, NOAA also is consolidating what has been separately managed computational systems into a single NOAA High-Performance Computing System that will be integrated across the agency, from research to operational computer uses and needs.

VALUE TO SOCIETY

Faster computing, more thorough and standardized data assimilation, development of better model simulations of the dynamic Earth system, and the use of model ensembles to quantify uncertainties all add up to improved forecasts and more informed decisions. Whether it is safely routing airplanes around severe weather, issuing tornado warnings, or knowing when to operate snow plows, better forecasts help protect economic interests, as well as lives and property. For example, accurate hurricane forecasts can save $1 million for each mile of coastal territory that does not have to be evacuated.

To Learn More, Visit These Sites:

NOAA Research (OAR): http://www.oar.noaa.gov/
NOAA High-performance computing: http://www.cio.noaa.gov/hpcc/
NOAA Earth System Research Laboratory: http://www.esrl.noaa.gov/
NOAA Geophysical Fluid Dynamics Laboratory: http://www.gfdl.noaa.gov/
NOAA National Severe Storms Laboratory: http://www.nssl.noaa.gov/

To Work or Study at OAR, Visit These Sites:

NOAA Careers: http://www.careers.noaa.gov
Hollings Scholarships: http://www.orau.gov/noaa/HollingsScholarship/
Knauss Fellowships: http://www.seagrant.noaa.gov/knauss/

OAR's mission is to conduct research, develop products, provide scientific understanding and leadership and to conduct outreach towards fostering NOAA's evolving environmental and economic mission. In 2007, NOAA celebrates 200 years of science and service to the nation, starting with the establishment of the U.S. Coast and Geodetic Survey in 1807 by Thomas Jefferson.