Technology transferred to operations/application and an assessment of their significance/impact on operations (1b)

GFDL has delivered a number of products to NOAA for operational use.

Modular Ocean Model (MOM)

The Modular Ocean Model (MOM) is *the* canonical ocean climate model use by many researchers around the world. The model origins date back to the community code first developed by Kirk Bryan and Mike Cox in the 1960's-1980's, and to which many other ocean climate models can trace their origins. The third version of MOM (MOM3) is a z-coordinate model released in 1999 and has been the ocean component of National Centers for Environmental Prediction's (NCEP's) coupled Climate Forecast System (CFS) and Global Ocean Data Assimilation System (GODAS) since that time. The CFS became operational in 2004.

NCEP's Environmental Modeling Center (EMC) has developed and is testing a new version of CFS (CFS-v2) for the prediction of short-term climate out to one year. The CFS-v2 upgrades MOM3 to MOM4.1, together with the NCEP atmospheric Global Forecast System (GFS), and a Global Ocean Data Assimilation System (GODAS) that includes MOM4. The CFS-v2 is expected to replace the current operational CFS-v1 in 2010.

GFDL's Coupled Model Output for Seasonal-to-Interannual Research

GFDL delivers coupled model output to NCEP/EMC in a collaborative effort to develop a multi-model ensemble for operational seasonal-interannual prediction. The model used is CM2.1, one of the GFDL models used in the Intergovernmental Panel on Climate Change's (IPCCs) Fourth Assessment Report (AR4). The output is in the form of one-year hindcasts starting each month from 1982 to the present.

Towards a similar purpose, in 2004 GFDL began collaborating with the International Research Institute (IRI) for Climate and Society to produce real-time seasonal forecasts as part of their monthly Multi-model ensemble (MME) seasonal prediction system. The predictions of the individual atmospheric models are objectively combined into a multi-model ensemble probability forecast, where weights assigned to the individual models are based on historical hindcast performance using prescribed, observed SST for the season and location. Results are posted at the IRI website (http://portal.iri.columbia.edu/portal/server.pt?open=512&objID=584&PageID=7923&cached=true&mode=2&userID=2). The IRI MME provides guidance for the Climate Prediction Center (CPC) operational long lead forecasts.

Real-time seasonal forecasts over North America are also available at GFDL's website (http://gfdl.noaa.gov/seasonal-to-interannual-experimental-predictions).

GFDL's Hurricane Forecast System

The dynamical model used in the prediction system is an outgrowth of a research model, the construction of which began in 1970 at GFDL. The research model was used in a number of idealized numerical experiments and produced results that demonstrated a high degree of simulation capability. The performance of the research model suggested a substantial potential benefit from application of the model to forecasting real tropical cyclones.

The work to convert the research model to a comprehensive prediction system started in the mid-1980s. The prediction capability of the GFDL hurricane model was first investigated using global analysis data of the National Centers for Environmental Prediction (NCEP) for cases of Hurricane Gloria 1985. The results were quite promising and indicated that a prediction system had to include a model initialization process, in addition to a process to link the model with the database. During the early 1990s, the model showed substantial improvement over the available operational track guidance, notably by successfully forecasting the sharp recurving of Hurricane Emily near the North Carolina Outer Banks. The model was transferred to NCEP in 1994 for a parallel mode test. Intensive effort was made in this step to improve throughput efficiency so that the system would meet a demand that the entire procedure for making a 72-h prediction be completed in less than 20 min. Prompted by the skill demonstrated by the system in the 1994 season, NOAA's National Weather Service (NWS) officially adopted the GFDL system in 1995 for use as a guidance tool for hurricane prediction.

Since that time, continuous improvements have included coupling the atmospheric component with the Princeton Ocean Model, which became operational in 2001, major physics upgrades implemented in 2003 and 2006, and increases in both the vertical resolution in 2003 and the horizontal resolution in 2002 and 2005. During the 2003-2006 seasons, GFDL track errors were the lowest of all the dynamical model guidance available to the NWS Tropical Prediction Center in both the Atlantic and eastern Pacific basins. It will also be shown that the GFDL model has exhibited a steady reduction in its intensity errors during the past five years, and can now provide skillful intensity forecasts. The introduction of a cloud microphysics package and an improved air-sea momentum flux parameterization in 2006 led to a significant improvement in the model's reliability and skill for forecasting intensity that occurred in 2006.

Most recently, upgrades to the GFDL prediction system have centered on the version used by the United States Navy and will support this through its end-of-life. GFDL continues to conduct research into the structure and prediction of hurricanes through NOAA's Hurricane Forecast Improvement Project.