NCEP Hurricane Forecast System Requirements Document
March 2007

This document sets requirements between the NCEP's Environmental Modeling Center (EMC) and NCEP's Tropical Prediction Center (TPC) for the testing and evaluation (T&E) of a new candidate hurricane model to replace an existing hurricane system in NCEP operations and for annual or periodic upgrades to an existing operational hurricane model for transition to NCEP operations.   Although the IT requirements are comparable for both perspective implementations and must adhere to NCEP concept of operations, the T&E requirements differ.   The latter must display five day forecast skill that is representative of the storms across a singular season that often encompasses at least a six-week to two month record of daily model forecasts run four times a day although the T&E period may vary with seasonal activity.   The former is far more stringent in the T&E requirements in that in addition to the requirements for upgrades to an existing model, a proposed new model must also establish a long term record of performance skill across multiple seasons to capture seasonal variability. Both these standards must be met for five day forecast skill for both the Atlantic and East Pacific basins for which numerical guidance is provided to TPC to meet operational forecast requirements. Additionally, close collaboration with EMC is required for both types of implementations to ensure consistency with EMC's overall hurricane data assimilation and model development plans, changes to TPC requirements, and changes involving NCEP's Central Operations (NCO).

General Requirements

IT Compatibility
- General system configuration and functionality criteria
    - Must work properly on NCEP operational and research computers.
    - Produces all operationally required output fields in NCEP standard formats (GRIB2, BUFR), including standard meteorological variables, ozone and potentially other tracers as required
    - Inputs all operationally required input fields and data in NCEP standard formats
    - Uses standard NCEP utility routines and software packages wherever possible
    - Run-time (scripting) environment consistent with NCEP Central Operations (NCO) best practices
    - Code structure and usage conforms to current operational codes whenever possible
    - Impacts of any proposed changes to operational formats, codes and systems must be considered across all of NCEP's numerical forecast systems; changes must be negotiated with NCEP staff and changes must be propagated and tested across NCEP's system as needed
    - Produces all necessary diagnostic information consistent with NCEP file formats and visualization requirements

Efficiency

- Computation performance
    - Computational performance applies to all major components of the NCEP Production Suite, including
        - Global Data Assimilation System (GDAS)
        - Global Forecast System (GFS)
        - Regional Data Assimilation System (RDAS)
        - North American Model (NAM)
        - Rapid Refresh (RR)
        - Coupled Hurricane System (HUR)
        - Climate Forecast System (CFS), including the Global Ocean Data Assimilation System (GODAS)
        - Air Quality Forecast System (AQFS)
        - Real-Time Ocean Forecast System (RTOFS)
        - Global and Regional ensemble systems
    - Fits into NCEP Production Suite resource window for each of the following computer resources
        - Processors
        - Memory
        - Timing
    - Efficient use of computing resources through message-passing, threading and other standard High Performance Computing protocols
    - Scales well with anticipated future NCEP computing hardware
- In cases where additional computing resources are required to execute the upgrade operationally, the value-added by the upgrade will be weighed against the increased computing resources. In the event additional resources are not available on the NCEP operational computer, the upgrade has sufficient value-added to warrant implementation and other criteria are met, the upgrade will be scheduled for implementation when a new operational computer is available.

Sustainability

- Software Management and Capabilities
    - Meets (negotiated) requirements for response to emergencies (e.g. system failures)
    - Capable of progressive future upgrades by NCEP/EMC and partners
    - Written in standard languages (Fortran, C, C++ and other languages with mutual arrangement)
    - Uses minimum code structure complexity to meet operational mission and anticipated future requirements
    - Code is sustainable by NCEP staff and can be fully understood, navigated and modified without excessive difficulty
    - Contains inline documentation in NCEP standard format (e.g. docblock)
    - Adaptable to NCEP's changing computing environment and portable to major computing architectures
    - Conforms to the NCEP code management system (e.g. "Subversion")

New Hurricane model T&E and NCEP Concept of Operations

- Performance testing
    - Case load
        - At least 3 full seasons for new model
        - Critical cases from historical archive as requested by TPC
        - Approved by TPC
    - General criteria for track, intensity
        - At least as skillful as mean track and intensity error for all forecast cases in each year using standard verification software for both Atlantic and East Pacific basins
        - Assessment primarily with the existing model, .e.g the GFDL or the HWRF after 2007, as the benchmark for track and intensity
        - Homogeneous case comparisons with other models used operationally for track and intensity and official forecast
        - Subjective judgment for individual, critical cases as specified by TPC
    - Subjective evaluation for structure by TPC using model output fields

- System functionality for testing and transition to operations
    - Initialized same as current operational system
        - Operational location, structure and intensity information from TPC
        - GFS fields
        Additionally, the new system:
        - Uses the NCEP GSI for cycled initial guess field and operational observations
        - Be coupled with
            - Ocean model
            - Wave model
    - Produces all operational products consistent with NCEP file formats and visualization requirements
    - Run-time (scripting) environment consistent with NCEP Central Operations (NCO) standards

In addition to the above, any external candidate hurricane modeling system(s) considered for operational implementation at NCEP in 2007 and beyond, must present a forward looking plan to accommodate the planned hurricane modeling upgrades for coupling with NOAA's National Ocean Service (NOS) modeling activities for high resolution coastal and storm surge forecasts and EMC's coupled hurricane land surface modeling efforts for improved rainfall forecasts to address the inland flooding problem for coupling with hydrology and inundation models to address the inland flooding problem.

Annual or periodic modeling upgrades to existing hurricane model/NCEP Concept of Operations :

Many of the standards for implementation of annual upgrades to an existing operational system are comparable with a new hurricane modeling system with the exception of the T&E requirements. This assumes that all upgrades are closely coordinated in the planning stages with EMC's hurricane modeling development efforts.

- Performance testing
    - Case load
        - Previous season (or subset TBD)
        - Critical cases from historical archive
        - Approved by TPC
    - General criteria for track, intensity
        - At least as good mean track and intensity error for all forecast cases in each year using standard verification software for both Atlantic and East Pacific basins
        - Homogeneous case comparisons with other models used operationally for track and intensity and official forecast
        - Subjective judgment for individual, critical cases as specified by TPC
    - Subjective evaluation for structure by TPC using model output fields

- System functionality for testing and transition to operations

    - Operational products consistent with NCEP file formats and visualization requirements
    - Run-time (scripting) environment consistent with NCEP Central Operations (NCO) standards
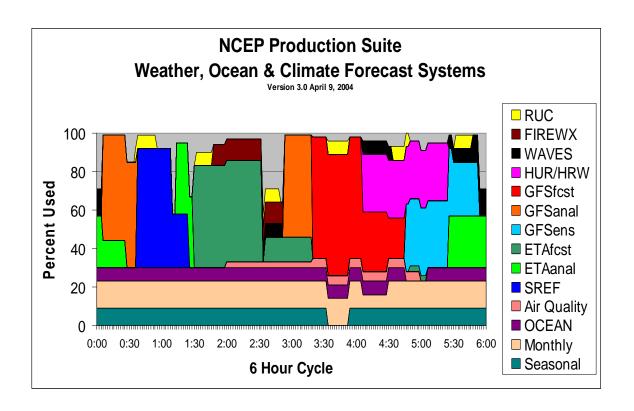
Fig. 1   The NCEP Production Suite

For all hurricanes, the five day runs must not exceed **40% of computer resources on NCEP's operational computer. Therefore, each storm must not exceed 10% of computer nodes for a maximum of four storms. This includes jobs for the preparation of the lateral boundary conditions from the 126hr GFS forecast, a data assimilation capability for the airborne Doppler radar data for the hurricane core initialization**, **the post processing of model gridded data and product generation.**