Technical Progress Report on Numerical Weather Forecasting System and Research Activities 2006

Malaysian Meteorological Department

1. Summary of Highlights

The numerical weather model system at the Malaysian Meteorological Department mainly consists of two operational models. Both use the limited area non-hydrostatic Fifth-Generation NCAR/Penn State Mesoscale Model (MM5). One of them is run without data assimilation and the other with data assimilation. Both are run with two domains, that is 36km and 12km resolutions. 23 vertical levels are used. Mesh sizes are 154 x154 grid points for the coarse domain and 220x130 grid points for the fine domain. Both are short-range forecasting systems run twice daily at 00UTC and 12UTC.

2. Equipment in use at the Center

The High Performance Computing cluster consist of the following main components:

- Two units of Dual Processor Head Management
- Nine units of Quad Processor Compute Nodes
- Two units of High-Capacity Storage
- One unit of Gigabit Ethernet Switch
- One KVM (Keyboard, Video and Mouse) Switch

The two head management nodes are Transport GX28 servers and the nine Compute nodes are Transport TX48 servers. Processors used in the Head Management and Compute nodes are 2.2GHz AMD Opteron. 5 compute nodes are attached to one of the head management nodes while 4 compute nodes are attached to the remaining head management node. The 20CPU peak performance available is 90GFlops.

3. Data and Products from GTS in use

Numerical Weather Prediction boundary and initial conditions (GRIB format) used are the Global Forecast System (GFS) 1.0-degree resolution data from the National Center for Environmental Prediction. Observational data used are SYNOP, SHIP, TEMP, METAR, SATOB and SOUND, which are obtained from the GTS.

4. Forecasting System

4.1 System run schedule and forecast ranges

Run schedule consists of twice a day model runs at a 00UTC and 12UTC. Forecast runs have a data cut-off of hourly, 3 hourly, 6 hourly, 12hourly and 24hourly up to 72hrs forecast.

4.2 Medium-range forecasting system (4-10 days)

Medium and extended range forecasting are mainly done using available global models combined with climatological resources.

4.3 Short-range forecasting system (0-72 hrs)

4.3.1 Data Assimilation and objective analysis

- Method of Analysis: 3D-VAR
- Analyzed Variables: wind, temperature, relative humidity and pressure
- Vertical levels: 1000hPa, 850hPa, 700hPa, 500hPa, 400hPa, 300hPa, 250hPa, 200hPa, 150hPa 100hPa.

4.3.2 Model

4.3.2.1 In Operation

- Basic equations: Primitive Equation System
- Independent Variables: Horizontal Wind, Pressure, Temperature, Relative Humidity and Geopotential Height
- Numerical Technique: Non Hydrostatic, finite difference second order horizontal and vertical discretization, second order leapfrog time-step scheme though some terms like the sound-wave terms and planetary boundary layer tendencies are handled using a time splitting scheme.
- Horizontal Resolution: Larger domain is 36 km and smaller domain is 12 km. Larger domain consists of 154 x 154 grid points and smaller domain consists of 220 x 130 grid points. 23 vertical levels.
- Time Step: 108 seconds
- Shallow Convection
- Radiation: Accounts for longwave and shortwave interactions with explicit cloud and clear air.
- Atmospheric Moisture: Predicts cloud and rainwater fields explicitly. Ice phase processes also considered.

4.3.2.2 Research Performed

- Testing of different cumulus parameterization schemes, different time steps and different moisture schemes have been conducted.

4.3.3 Operationally available Numerical Weather Prediction Products

- Temperature: 2m, 1000hPa, 850hPa, 700hPa, 500hPa, 200hPa
- Wind: 10m, 1000hPa, 850hPa, 700hPa, 500hPa, 200hPa
- Mean Sea Level Pressure
- Vorticity: 1000hPa, 850hPa, 700hPa, 500hPa, 200hPa
- Relative Vorticity: 1000hPa, 850hPa, 700hPa, 500hPa, 200hPa
- Geopotential Height
- Rainfall

4.3.4 Operational techniques for application of NWP products

Short-range forecasts from Main Forecast office and Regional forecast office are based upon direct operational model output together with output of other global models.

5. Verification of prognostic products

The RMS wind vector error and predictability skill score for the 850hPa, 500hPa and 200ha levels are done four times a year corresponding to different weather seasons in the region of South East Asia.

6. Plans for the future (next 4 years)

6.1 Development of GDPFS

6.1.1 Major changes in data processing and forecasting system within the next year

- Improving the hardware technology to reduce the latency limits and also to increase the number of processors from the present 40 to 128. Processors to be used are dual core compared to the presently used single core processors.
- Given higher technological ability, the resolution of the operational MM5 model is to be increased to 4 km compared to the present 12km.

6.1.2 Major changes in data processing and forecasting system within the next 4 years

- Making the WRF model operational with a resolution of at least 4km.
- Using the higher resolution global forecast system lateral boundary data that is presently available from NCEP. The 0.5-degree resolution global forecast system lateral boundary data is to be used in place of the presently used 1.0 degree resolution data.
- Running both the high resolution MM5 and WRF with more than one source of lateral boundary data. In addition to the presently used NCEP global forecast system lateral boundary data, the lateral boundary data from the Japanese Meteorological Service and the Australian Bureau of Meteorology. With all this in place, it will be possible to proceed in the direction of short-range ensemble forecasting.
- Migration in data assimilation from 3DVAR to 4DVAR.

6.2 Planned Research Activities in NWP, Nowcasting and Long-range Forecasting

6.2.1 Planned Research Activities in NWP

- Testing out the various physics packages available within MM5 to determine the most suitable schemes to be used at the 4km resolution.
- Testing out the WRF model with an idea to make it part of the operational Numerical Weather Prediction System at the Malaysian Meteorological Department.
- Testing of the 0.5 degree resolution NCEP global forecast system lateral boundary data with an intention to replace the currently used 1 degree lateral boundary data.
- Testing the usage of lateral boundary data from the Japanese Meteorological Service and the Australian Bureau of Meteorology
- To conduct data assimilation with 4DVAR

6.2.2 Planned Research Activities in Nowcasting

- Given the higher technological advantage in the next two years, that is with a system that may have a peak performance of 1 Terra flops using an interface with latency time of around 1.4μs, research is to conducted to enable nowcasting using NWP for a period of 18 hours at least.

6.2.3 Planned Research Activities in Long-range forecasting

- Given the technological ability to conduct a few numerical weather simulations simultaneously within the next three years and using different sources of lateral boundary data and improved data assimilation processes, the combination of these outputs can be used to propel the Malaysian Meteorological Department into the field of ensemble forecasting which is imminent for long- range forecasting.