Use of NWP and EPS Products in support of
Location-specific Forecasts

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With NWP models now firmly established as a major forecasting tool, and the increasing use of EPS-based probabilistic information in support of decision-making by forecasters as well as other special users, the challenges in downscaling the model forecasts, normally applicable for a grid area commensurable with the model resolution, to a meaningful location-specific product are by no means trivial. As global models continue to develop along the trend of increasingly high resolution, the ability to optimize the use of the large volume of numerical data and to extract the critical information most wanted by users will ultimately determine how much value can be added to the forecasting and warning services. Through a review of the post-processing techniques used currently at the Hong Kong Observatory (HKO), the importance of transferring such knowledge and skill to other parts of the world where NWP capacity remains limited will be discussed.

The HKO Operational Regional Spectral Model (ORSM), adapted from JMA, has been in operation since 1999. It is configured with a 20-km resolution inner domain and a 60-km resolution outer domain to provide 42-hour and 72-hour forecasts respectively. The 20-km model, one-way nested within the 60-km model, is run in a 3-hour analysis-forecast cycle. The 60-km model has a 6-hour analysis-forecast cycle with boundary data provided by JMA's Global Spectral Model forecasts. In support of location-specific temperature forecasts, the ORSM grid point outputs are calibrated against observation data at specific sites through Kalman filter or linear regression processes. Such calibration is able to reduce the model biases due to factors such as topographical influences and other localized effects. For instance, it has been found that calibration of temperature forecasts at 3-hourly interval can adequately correct biases observed in the diurnal trends. A time-lagged ensemble approach is also applied to the ORSM output to estimate the spread and distribution of temperature and precipitation forecasts, and a composite display in the form of meteograms updated every 3 hours is generated for reference by forecasters. Alerts on the potential threat of heavy rain and thunderstorms are visually displayed through the use of a Combined Rainstorm Warning Panel.

For the meteorological community, ORSM tropical cyclone (TC) forecast guidance has been disseminated to WMO Members through the Global Telecommunication System since 2005. The guidance is issued and updated twice a day based on 00 and 12 UTC model runs whenever a TC is
located within the HKO area of responsibility (10-30°N, 105-125°E). Under a RAII pilot project, ORSM also generates city-specific NWP products in the form of forecast time series of selected weather parameters for specified cities. With JMA and KMA also playing the role of NWP product provider, websites have been set up for participating Members to access the respective products through the Internet. As at February 2008, forecast time series for a total of 160 cities are routinely generated at the HKO website for reference and use by the project’s participants. To facilitate the recipients to adapt the model outputs for their own specific applications, a software program in the form of a spreadsheet has been developed for users to carry out post-processing and verification of the numerical forecasts.

It has been shown that super-ensemble of global models run at major NWP centres such as ECMWF, JMA, UKMO and NCEP can also provide useful objective forecast guidance. TC consensus track forecasts, based on the equally-weighted average of TC forecast positions derived from global model output routinely received at HKO, have been computed for forecasters’ reference on an operational basis in the past few years. Verification statistics indicate that the multi-model consensus tracks generally out-perform the individual models. The super-ensemble technique can be similarly applied to combine the surface temperature forecasts from various models by assigning appropriate weighting to each model member. Again, the technique is found to be superior as the forecasts so derived are found to be in general more accurate than the direct model output (DMO) from individual models.

More recently, Ensemble Prediction Systems (EPS) run at major NWP centres such as ECMWF and JMA have injected probabilistic information into the formulation of location-specific forecasts. For example, a method based on logistic regression has been developed to calibrate the probability of precipitation derived from the EPS. The method has proved to be particularly effective for improving the reliability of the probability forecasts and reducing the over-forecast bias as evident in the DMO point forecasts. An index-based approach has also been studied to detect extreme events such as heavy rain by comparing the EPS forecast probability distribution against the model climate. Time series of accumulated TC strike probability at specific points, as derived from the JMA EPS TC data, allow decision makers to critically assess the timing of TC passage with respect to the location of interest.

Since 2004, HKO has been operating on a trial basis a Non-hydrostatic Model (NHM) adapted from JMA. The HKO NHM is run at a 5-km horizontal resolution, with 45 levels in the vertical, and over a domain measuring about 600 x 600 km². It is updated on an hourly basis to provide 12-hour numerical guidance in support of operational forecasting and warning of fast-developing high-impact weather phenomena such as rainstorms. Initial and boundary conditions are obtained from the ORSM, while the cloud-hydrometeor amounts as analyzed by LAPS (Local Analysis and
Prediction System first developed by GSD/NOAA) are also utilized for initializing the NHM. Positive impacts are seen in the quantitative precipitation forecasts (QPF), likely to be attributable to the more advanced treatments of cloud and moisture processes in the NHM. NHM QPF guidance is also blended with the HKO nowcasting system QPF output to provide very-short-range guidance on the chance of precipitation in the next six hours.

Yet despite the significant advances seen in the development of NWP models and related technology, the notion of all meteorological centres running their own NWP models remains a distant target. Even if it is achievable, it is doubtful whether it makes any economical sense for all countries to invest heavily in computing resources for such purposes when equally good, if not better, location-specific forecast information can be derived from global models through the use of well set-out post-processing techniques. This in turns means that if major NWP centres can provide numerical data at the full resolution from their sophisticated models for subscribed users, smaller centres can then feed off those data in setting up their own specific applications. The problem then becomes a matter of capacity-building in the cultivation and use of post-processing skills, likely to be a more surmountable challenge for meteorological services in the developing and least-developed countries.

Already, we are seeing movement in that direction through the RA II pilot project on NWP city-specific forecasts. Further extension of the project in both scope and depth would certainly lead to more wide-ranging and far-reaching benefits for NMHSs lacking the essential computational resources to benefit from the ever-improving NWP technology. There are several possibilities in taking the project forward to the next phase. Firstly, we can explore the feasibility of issuing objective guidance messages to alert NMHSs of potential hazardous weather conditions based on pre-determined criteria and NWP outputs, using colour highlights, visual icons or other forms of graphical display. These can be generated through the adoption of warning thresholds for different weather elements, specified by participating Members and pre-set with respect to local climatology and other risk assessment considerations relating to specific weather hazards. Secondly, the merits of developing some kind of multi-model or time-lagged super-ensemble based on the output generated by the contributing NWP product providers can also be examined. The objectives here are to establish a more robust consensus forecast methodology for deterministic applications, as well as to inject probabilistic information into the forecasts for more effective decision-making processes. The deliverable can be in the form of a portable and easy-to-use software that ingests the relevant numerical data in a readily digestible format and carries out the computation to generate the ensemble output. Finally, especially to facilitate a user-friendly implementation of the aforementioned possibilities, the creation of a centralized portal for easy access and navigation among the products originating from various NWP sources may also become necessary.
For NMHSs with some NWP capacity to operate or experiment with limited area models in support of their own short-range forecasting systems or other specialized applications, consideration should be given to the provision of quality analyzed fields from global models run by the major NWP centres. As the data assimilation systems become increasingly complex and computationally intensive, this will help to ensure that the initial conditions are adequately represented in the simulation process. As such, a short-cut in this direction is likely to bring benefits in promoting a wider use of NWP techniques. The initiative can be implemented as a bilateral collaborative effort between major NWP centres and participating NMHSs, with the latter in return committing to the provision of local observations to ensure and enhance the quality of the analyzed fields. A positive feedback will create a win-win situation in which the major NWP centres have the assurance of ready access to reliable sources of local observations to complement the synoptic observations and remote sensing information such as satellite data; whereas the NMHSs, through the active use and innovative application of NWP techniques, will actually have visible forecast deliverables to justify the input of resources into the development and maintenance of local observation networks.