**Global Data Processing System**
**Progress Report for 2001**

**HONG KONG, CHINA**

## 1. Summary of highlights

The Global Telecommunication System (GTS) link between Guangzhou and Hong Kong, China was upgraded from a 9600bps analogue circuit to a 64kbps digital link in September 2001. The GTS link between Regional Telecommunication Hub (RTH) Bangkok and Hong Kong, China was decommissioned in February 2001.

An IBM RS/6000 SP server cluster was installed in 2001 at the Hong Kong Observatory (HKO) to replace two IBM 590 servers.

HKO started the AMDAR programme in late 2000. The additional AMDAR observations were ingested to the HKO's Operational Regional Spectral Model (ORSM) and used for research on detection of wind shear and turbulence at the Hong Kong International Airport.

## 2. Equipment in use at the centre

Current systems at the HKO with their major characteristics are listed below:

| Machine | Quantity | Peak performance | No. of CPU | Memory | Year of Installation |
|---|---|---|---|---|---|
| IBM SP | 1 | 54.0 GFLOPS | 36 | 20.7 GB | 2001 |
| CRAY SV1-1A | 1 | 19.2 GFLOPS | 16 | 8 GB | 1999 |
| SGI Origin 2000 | 1 | 4.0 GFLOPS | 8 | 2.5 GB | 1998 |
| SUN E450 | 2 | 2.4 GFLOPS | 4 | 1 GB | 1998 |
| SGI O2 | 2 | 0.4 GFLOPS | 1 | 1 GB | 1998 |
| IBM RS/6000 590 | 3 | 0.3 GFLOPS | 1 | 128 MB | 1994 |

An IBM SP cluster replaced three IBM 590 servers in December 2001. The cluster is used for generating diagnostic products, plotting weather charts, producing graphics displays to support the operations of the Central Forecasting Office (CFO) and the Airport Meteorological Office (AMO) and running a database for keeping climatological records. It is also used to support climatological research and the development of the next generation of numerical weather prediction system.

The CRAY SV1-1A is used to run the analysis and forecast system of the ORSM.

The SGI Origin 2000 is deployed to support the data pre-processing and graphical product generation of the ORSM. It is also used to support the development of a non-hydrostatic model.

One of the SUN E450 is used for the provision of Numerical Weather Prediction (NWP) products to support aviation operations using ORSM and the verification of the model products. The other is for running the rainstorm nowcasting system to support CFO. Two SGI O2 are used as graphics display workstations for the visualization of nowcasting products and staging the web server for ORSM products.

## 3. Data and products from GTS in use

The approximate number of bulletins received from GTS circuits on a typical day in 2001 are given below:

| | |
|---|---|
| SYNOP/SHIP | 70500 |
| TEMP/PILOT | 2500 |
| AIREP | 5000 |
| AMDAR | 500 |
| SATEM/SATOB | 2500 |
| TOVS/ATOVS | 40000 |

About 450 GRID bulletins and 3,000 GRIB files are received each day on the GTS. On days with tropical cyclones in the region, additional GTS bulletins (e.g. RADOB) and radio facsimile charts are also received.

Hong Kong, China started the AMDAR programme in late 2000. In 2001, the HKO received about 30 additional AMDAR bulletins (totally about 300 observations) per day from US and Australian airlines landing or departing from the Hong Kong International Airport via the GTS. Research was being conducted to make use of the additional AMDAR observations for real-time monitoring and detection of low-altitude wind shear and turbulence at the Hong Kong International Airport. The additional observations were also ingested to the ORSM.

## 4. Data input system

Automated.

## 5. Quality control system

For quality control of incoming data, adherence to prescribed coding formats, internal consistency, and physical and climatological limits are checked automatically.

External consistency check against the first guess field provided by the forecast from the ORSM is also carried out automatically.

Quality control of outgoing observational data originating from Hong Kong is implemented to ensure conformity to WMO coding formats and to enforce checking against internal consistency, time consistency as well as physical and climatological limits.

## 6. Monitoring of observing system

Monitoring on the territorial level.

## 7. Forecasting system

The Observatory operates the ORSM at 20 km and 60 km resolutions to provide 24-hour forecasts and 48-hour forecasts respectively. ORSM was adapted from the Japan Meteorological Agency (JMA) and was put into operation in 1999. The 60-km model is run at a 6-hourly analysis-forecast cycle with its boundary data extracted from the JMA's Global Spectral Model forecasts. The 20-km model is run at a 3-hourly analysis-forecast cycle and is one-way nested into the 60-km model.

### 7.1 System run schedule

The outer 60-km ORSM is run four times a day with a cut-off time of 3 hours to produce 48-hour forecasts for the area 9 S – 59 N, 65-152 E based on 00, 06, 12 and 18 UTC analysis data. The inner 20-km ORSM is run 8 times a day for

24-hour forecasts for the area 10–35 N, 100-128 E based on 00, 03, 06, 09, 12, 15, 18 and 21 UTC analyses.

### 7.2 Medium-range forecasting system (4-10 days)

Not implemented.

### 7.3 Short-range forecasting system (0-72 hours)

#### 7.3.1 Data assimilation, objective analysis and initialization

Meteorological data assimilated by the analysis scheme of the ORSM are as follows:

(A) From GTS

| | |
|---|---|
| SYNOP, SHIP | surface data and ship data |
| TEMP, PILOT | radiosonde and pilot data |
| AIREP, AMDAR | aircraft data |
| SATEM | satellite thickness data |
| TOVS, ATOVS | virtual temperature profiles |
| SATOB | satellite wind data |

(B) From RSMC Data Serving System (DSS) of JMA

GMS digital data - total cloud amount, mean cloud top temperature and its standard deviation for moisture bogus

GMS cloud motion vectors during tropical cyclone situations

(C) From NCEP data server

Daily sea surface temperature analysis at 1-degree resolution

(D) Locally generated data

Tropical cyclone bogus data during tropical cyclone situations

Three-dimensional multivariate optimal interpolation is performed four times a day based on 00, 06, 12 and 18 UTC data for the 60-km outer domain. Data cut-off time is about three hours after the observation time. For the inner domain, the same objective analysis scheme is performed 8 times a day based on 00, 03, 06, 09, 12, 15, 18, and 21 UTC. Data cut-off time is about 2 hours. All analyses are applied to 36 vertical levels.

The horizontal domains of both inner and outer models compose of 151 x 145 model grids in Mercator projection. The first guess fields of the model analyses are provided by their respective latest forecasts.

Hourly rainfall information derived from real-time calibration of radar reflectivity with rain gauge data as well as from the GMS digital cloud data, are incorporated into the model through a physical initialization process. In this process, the moisture of the initial field (between the lifting condensation level and the cloud top inferred from the cloud top temperature) at the point where rain is observed is adjusted to allow precipitation process to be switched on. The heating rate of the precipitation process is also adjusted to correspond to the rainfall amount observed. The rainfall information in the hour preceding analysis time is used in the outer model. For the inner model, pre-runs for 3 hours preceding analysis time are performed to incorporate the rainfall information.

Non-linear normal mode initialization is performed before the forecast model is run.

### 7.3.2 Model

Characteristics of the ORSM is shown as follows :

| | |
|---|---|
| Basic equation | Primitive hydrostatic equations |
| Vertical | Sigma-P hybrid coordinate, model top at 10 hPa. |
| Forecast parameters | Ln (surface pressure), horizontal wind components, virtual temperature, specific humidity. |
| Initialization | Non-linear normal mode initialization |
| Physical processes | |
| Radiation scheme | Sugi et al.(1990) |
| Short wave | Calculated every hour |
| Long wave | Calculated every hour |
| Moisture processes | |
| Cumulus convection | Arakawa-Schubert (1974) |
| Mid-level convection | Moist convective adjustment proposed by Benwell and Bushby (1970) and Gadd and Keers (1970) |
| Large-scale condensation | Included |

| | |
|---|---|
| Grid-scale evaporation and Condensation | Included |
| Planetary boundary layer | Scheme proposed by Troen and Mahrt (1986) in which non-local specification of turbulent diffusion and counter-gradient transport in unstable boundary layer are considered. |
| Surface | 4-layer soil model |
| | Daily sea-surface temperature analysis (fixed in forecast) |
| | Climatological snow and sea ice distribution |
| | Climatological evaporation rate, roughness length and albedo |
| umerical methods | |
| Horizontal | Double Fourier |
| Vertical | Finite difference |
| Time | Euler semi-implicit time integration |
| Topography | Envelope topography, derived from 30-second latitude/longitude resolution grid point topography data |
| Horizontal diffusion | Linear, second-order Laplacian |
| Boundary conditions | For the outer model, 6-hourly boundary data including mean sea level pressure, wind components, temperature and dew point depression at 15 pressure levels (1000, 925, 850, 700, 500, 400, 300, 250, 200, 100, 70, 50, 30, 20, 10 hPa ) and the surface, are provided by the Global Spectral Model of JMA.<br>For the inner model, hourly boundary data are provided by the outer 60km model. |

Further details on the formulation of the ORSM are given in JMA(1997).

### 7.3.3 Numerical weather prediction products

For the outer 60-km domain, the ORSM produces primarily 3-hourly numerical products including pressure/ geopotential heights, wind, temperature, dew point depression at 15 pressure levels (1000, 925, 850, 700, 500, 400, 300, 250, 200, 100, 70, 50, 30, 20, 10 hPa) and the surface. Accumulated rainfall at the surface is also produced. For the inner 20-km domain, the same forecast elements as the above are produced but at hourly intervals.

### 7.3.4 Operational techniques for application of NWP products

Graphical products from both 60-km and 20-km ORSM are generated for each model run and made available to the forecasters for reference through a web-based display. These products include forecast time cross-section and tephigrams as well as forecast rainfall distribution charts for Hong Kong. Local text forecasts based on ORSM prognostic data with warnings of thunderstorms and rainstorms, are generated automatically. Pre-defined 3-D products of forecast temperature, cloud cover and wind distribution using VIS5D are also produced.

Post-processing of the model prognostic data such as application of Kalman Filtering technique and regression method are employed to generate daily minimum and maximum temperature forecasts in Hong Kong. Regional temperature forecasts based on 20-km ORSM prognostic data are also generated for forecasters' reference.

A weather map algorithm is employed in the ORSM to produce hourly weather map (fine and cloudy areas, accumulated rainfall contours) based on ORSM prognostic data. Rainstorm risk maps based on model-forecast rainfall rates are compiled from the latest five 20-km model runs, akin to the ensemble approach. Near real-time verification of rainstorm locations as forecast by ORSM is provided.

Tropical cyclone (TC) track forecasts from consecutive 6-hourly runs of 60-km ORSM are generated to facilitate forecaster's interpretation of model forecasts. Ensemble forecast of TC track derived from global model outputs is also compiled. Forecasters can modify the weightings for different members and generate the ensemble forecast interactively.

## 8. Plan for the future

A frequently updated high-resolution local analysis system making use of the densely spaced mesoscale observations in the vicinity of Hong Kong will be developed for nowcasting purpose. Incorporating very short-range NWP-based forecasts into the nowcasting system will be explored. Variational techniques for assimilating asynoptic data and remote-sensing data in the development of non-hydrostatic models as well as ensemble methods using multi-analyses, multi-models and multi-model runs will also be explored in the context of mesoscale weather prediction.

## 9. References

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