3.2 Observational Data

3.2.1 Data used in the analysis

Data	Short description	Parameters to be used for analysis
SYNOP	Surface observations at fixed stations over land	P, u, v, T, Rh
SHIP	Surface observations by ships, oil rigs and moored buoys	P, u, v, T, Rh
BUOY	Surface observations by drifting buoys	P, u, v, T, Rh
TEMP	Upper-air observations by rawinsondes	P, u, v, T, Rh
PILOT	Upper-air wind observations by rawins or pilot balloons	u, v
Aircraft	Observations by aircraft	u, v, T
Wind Profiler	Wind profiler data in Japan, USA and Europe	u, v
PAOB	Australian manual bogus data	P
SATEM	Thickness profile retrievals from ATOVS sounders	T
ATOVS	Virtual temperature and mixing ratio profile retrievals from ATOVS sounders	T, Rh
AMV	Atmospheric Motion Vectors retrieved by tracking cloud and water vapor imagery from geostationary satellites and polar orbit satellites	u, v
Scatterometer	Surface wind data from scatterometers	u, v
ATOVS level-1B radiance	Raw radiances from ATOVS sounders.	radiance
MWR	Radiances from microwave radiometers (MWR) such as SSM/I, TMI, and AMSR-E.	radiance, TCWV, precipitation
Doppler Radar	Wind data of doppler radars in Japan.	radial velocity
Radar-Raingauge Analyzed Precipitation	Precipitation amount from radars and automatic surface weather stations.	precipitation amount

3.2.2 Treatment of data

(a) TEMP

Bias correction on geopotential heights and temperatures is performed for observations mainly above middle troposphere by a simple statistical correction method. The correction table is calculated based on the statistics of the previous month. The bias correction is conducted to the data reported without correction of radiation effects and data with systematic biases.

(b) Aircraft

AIREP and the data automatically reported by AMDAR and ACARS are used. The aircraft data are sometimes very dense. The data are thinned so that distance between each data is at least 100 km in global and regional analysis, 28km in mesoscale analysis.

(c) Wind Profiler

Wind profiler data observed in Japan, USA and Europe are used in the analysis.

(d) SATEM and ATOVS

The thickness of SATEM and virtual temperature of ATOVS are converted into temperature and used in the mesoscale analysis and regional analysis. The mixing ratio of ATOVS is converted into relative humidity and used in the regional analysis.

(e) AMV

Atmospheric Motion Vectors (AMVs) from cloud tracking observation with visible and infrared cloud imagery and with water vapor channel imagery are used. AMV data from geostationary satellites covers 60N-60S while those from polar orbit satellites cover polar regions. After a thinning procedure, they are assimilated when their quality indicator (QI) exceeds predefined criteria.

(f) Scattrometer

Sea surface wind data from scattrometer instruments onboard polar orbit satellites are used. A specialized quality control named 'Group QC' is performed for the wind data. In order to remove wind direction uncertainty inherent in scatterometers, spatial consistency among the wind data is checked in terms of smooth change in wind direction and wind speed.

(g) ATOVS level-1B radiance

Full-resolution, raw radiance data from ATOVS are calibrated and undergo simple quality check with AAPP package (Whyte, 2003) at the beginning of the analysis process. Less cloud/rain-affected radiances from microwave sounders in ATOVS are assimilated using a fast radiative transfer model RTTOV7 (Saunders et al. 2002) in the global analysis. They are thinned at each time slot of the assimilation window (approximately one hour) and quality-controlled, including channel selection, gross-error check, cloud/rain identification. Observation related biases are corrected by subtracting pre-calculated averaged observation-minus-simulation at each scan position in the pre-processing, followed by the variational bias correction (VarBC) to remove air-mass dependent biases in the 4DVar main analysis. VarBC is an adaptive bias correction scheme where a linear regression formula to represent biases is embedded in the observation operator and the regression coefficients are obtained as analysis variables (Derber and Wu 1998; Dee 2004).

(h) MWR

In the global analysis, less cloud/rain-affected radiances of vertically polarized channels are assimilated over the ice-free ocean using RTTOV7. Quality control procedures, including geometrical check, gross-error check and channel consistency check, are applied before thinning procedure at each time slot. VarBC is used to remove air-mass dependent biases. In the mesoscale analysis, total column water vapor (TCWV) and precipitation retrievals are assimilated over the sea around Japan. The TCWV retrievals are thinned for each time slot. The precipitation retrieval is converted into the grid data of inner model and smoothed spatially. It is assumed to be 1-hour amount and the treatment is the same as radar precipitation except for larger observation errors assigned to MWR (see Subsection 3.7.4).

(i) Doppler Radar

Operational doppler-radars are installed in eight airports in Japan. Though the main purpose of the radars is aviational use, the radial velocity data are provided to the NWP system with resolution of 5 km (radial distance) and 5.625 degree (azimuth angle). And Tokyo radar also provides the radial velocity data to the NWP system with resolution of 0.5km (radial distance) and 0.703 degree (azimuth angle).

(j) Radar-Raingauge Analyzed Precipitation

JMA has 20 operational C-band radars and about 1,300 automatic surface weather stations called AMeDAS. Using those observations, a multi-sensor precipitation nowcasting product is made as follows: First, radar echo intensity is converted to precipitation rate using the relationship $Z = 200R^{1.6}$. Then, the estimated precipitation rate is averaged over eight observations during one hour to produce an estimate of one-hour precipitation amount. Finally, the estimated amounts are calibrated using ground-based rain-gauges to provide one-hour precipitation amount distribution all over Japan and surrounding area with 1 km resolution. This nowcasting product is called "Radar-Raingauge Analyzed precipitation", whose grid point values are up-scaled to inner-model grids (40,20km) to be assimilated by regional and mesoscale analysis.

References

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3.3 Quality Control Procedures

Since erroneous data sometimes extremely degrade the quality of analysis, the quality control of observational data is a vital component of the analysis system. The following is a description of the quality control procedures applied in the JMA analysis system.

3.3.1 SYNOP, SHIP, BUOY, TEMP, PILOT, Aircraft, Wind Profiler, PAOB, SATEM, ATOVS and AMV

(a) Internal consistency check (internal QC)

Checks of climatological reasonability are performed. The data enlisted as problematic data in a black list are rejected. Contents of the black list are occasionally revised based on the results of non-real time quality control.

Consistency of consecutive positions is checked for reports from moving stations such as SHIP, BUOY and aircraft. Consistency of consecutive reports and consistency among elements within a report are also checked for every surface station. The vertical consistency checks are performed for TEMP and PILOT data. The check items are (1) icing of instruments, (2) temperature lapse rate, (3) hydrostatic relationship, (4) consistency among data at standard pressure levels and those at significant levels and (5) vertical wind shear. Bias correction is also applied to TEMP data if the data is reported without radiation correction or with apparent systematic biases.

(b) Quality control comparing with first guess (external QC)

Gross error and spatial consistency are checked in order to remove erroneous observations. A departure (D) of the observed value from the first guess is calculated for every observation. The absolute value of D is compared with the tolerance limits C1 and C2 which are determined by the standard deviation of the first guess error. The datum with $|D|<=C1$ is accepted for use in objective analysis. The datum with $|D|>C2$ is rejected. The datum with $C1<|D|<=C2$ is further checked by an OI method by interpolating the values of departures of the neighboring stations to the position of the datum. The difference between the departure of the datum and the interpolated departure is compared with the reasonable third limit C3 for the final judgement.

These three tolerance limits are changed according to the local atmospheric conditions which can be estimated by the first guess fields. The limits are made small if the time tendency and horizontal gradient are small in the fields, and vice versa. The scheme is called "Dynamic QC" (Onogi, 1998). The notable benefit of the Dynamic QC is to change the limits automatically by considering the local situation even at the same latitudes.

Duplicate observation reports are frequently received through different communication lines. The most appropriate single report is chosen after the gross error check of these duplicate reports considering results from quality control of these reports.

3.3.2 Scattrometer, ATOVS level-1B radiances and MWR

See 3.2.2.

3.3.3 CDA: Feedback data base

All information concerning the quality of observational data obtained during the quality control procedure is archived in the Comprehensive Database for Assimilation (CDA). CDA is extensively used for both real-time and non real-time data monitoring activities. All information contained in CDA is managed by the form of integer 2 byte. The format of CDA is quite simple and is designed for flexible use so that any information concerning observation can be archived easily. CDA is so user-friendly that any information can be extracted easily. The CDA file size tends to become large but it can be remarkably compressed by using utilities in UNIX.

Reference

Onogi, K. 1998: A Data Quality Control Method Using Forecasted Horizontal Gradient and Tendency in a NWP System: Dynamic QC. *J. Meteor. Soc. Japan.*, **76**, 497–516.