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The Impact of Observational Data on Numerical Weather Prediction

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Summary and Purpose of Document

Large amounts of observational data are assimilated in the operational NWP system at JMA. In recent years, the volume of remote sensing data such as satellite radiance has been increasing, and now accounts for about 80% of all observational data. The data remaining 20% come from conventional observation such as SYNOP and Radiosonde, however, still play an important role in the NWP system. JMA perform quality control (QC) for observational data, and this is an essential part of improving the initial value and forecast field. In some cases, observational data are found to include anomalous values. Here, we show the importance of maintenance for the observation network through examples. Finally, we introduce the Report on the Quality of Land Surface Observations in RA-II published by JMA as the lead center, and also outline the Monthly Global Data Monitoring Report.

1. Introduction

The Japan Meteorological Agency (JMA) continues to work on the development of its Numerical Weather Prediction (NWP) system. As one of the world's most advanced NWP centers, JMA now provides a variety of NWP products that play a vital role in weather services both nationally and on an international level.

Currently, JMA operates the following NWP models:

1) The Global Spectral Model (GSM) for the short- and medium-range forecast up to nine days ahead to cover the entire globe,
2) The Mesoscale Model (MSM) for warnings and the very short-range forecast of precipitation to cover Japan and its surrounding areas,
3) A low-resolution version of the GSM for ensemble prediction in one-week forecasting and long-range forecasting up to six months ahead, and
4) Others for specific targets such as ocean waves, sea ice extent and El Niño.

The specifications of the deterministic NWP models are shown in Table.1

Table.1 Specifications of JMA's NWP models (deterministic only)

	Global Model (GSM)	Mesoscale Model (MSM)
Purposes	Short- and medium-range forecast	Very short-range forecast
Forecast domain	Globe	Japan and its surrounding areas
Grid size and/or number of grids	0.1875 deg. (TL959)	5 km / 721 x 577
Vertical levels / Top	60 / 0.1 hPa	50 / 21,800 m
Forecast hours (Initial time)	84 hours (00,06,18UTC) 216 hours (12UTC)	15 hours (00,06,12,18UTC) 33 hours (03,09,15,21UTC)
Initial condition	4D-Var analysis	4D-Var analysis

2. Data use of NWP system

Large amount of observational data are assimilated in the operational NWP system at JMA. High-performance telecommunications and data processing are needed to enable this system to operate on an everyday basis. As one of the Regional Telecommunication Hubs (RTHs) in RA II of the GTS, JMA is connected to two World Meteorological Centers (Washington and Melbourne), four RTHs (Beijing, New Delhi, Bangkok and Khabarovsk), and three National Meteorological Centers (Seoul, Hong Kong and Manila).

Figure 1 shows data use of NWP models. The daily number of observational report reaches about 650,000 for the GSM and about 820,000 for the MSM. In recent years, the volume of remote sensing data such as satellite radiance has increased and now accounts for about 80% of all assimilated data. The remaining 20% come from conventional observation such as SYNOP. Although the percentage of conventional data among assimilated observational data is relatively small, it still plays an important role in the NWP system.

Observation type	Instrument	Global Analysis	Mesoscale Analysis
Conventional	SYNOP	Pressure	Pressure
	AMeDAS*		Rain (Analyzed Rain)
	Ship, Buoy	Pressure	Pressure
	RAOB	Pressure, Wind, Temperature, Relative Humidity	Pressure, Wind, Temperature, Relative Humidity
	Aircraft	Wind, Temperature	Wind, Temperature
Ground based remote sensing	Wind profiler	Wind	Wind
	Radar		Radar reflectivity (Analyzed Rain), Doppler velocity
	GPS		Total precipitable water
Satellite	VIS IR radiometer	AMV, Radiance (clear sky)	AMV
	IR MW sounder	Radiance (clear sky)	Radiance (Temperature)
	MW imager	Radiance (clear sky)	Radiance (TPW, Rain rate)
	Scattrometer	Surface wind	Surface wind
	GPS-RO**	Refractivity	

Figure 1. Data use of NWP models.

* Automated Meteorological Data Acquisition system

** GPS radio occultation

3. The impact of assimilated observations

An observation system experiment was conducted in regard to ground-based observation with the JMA global data assimilation (DA) system. An analysis-forecast cycle experiment was carried out in which ground-based conventional observation (SYNOP, RAOB) were not assimilated. The MSLP departure of observation and background (O-B) values increased in comparison with those of the operational analysis-forecast cycle. This result shows that continuous observation and dense network is important for initial value improvement.

We also investigated which type of data had the greater influence. Langland and Baker (2004) suggested a method to estimate the observation impact. The global observation impact can be expressed as the sum of contributions from all individual observations by considering sensitivity gradients. The quantities for which the system uses the observations to pull the signal from the background are called DFS (degrees of freedom for signal; see for example Wahba, 1995). DFS values according to the type investigated by JMA shows that conventional data still exert a significant influence in the DA system.

It is very important to continue and maintain the conventional observation for NWP system even though the ratio of conventional data has become smaller overall.

4. Quality control in NWP system

JMA operationally performs quality control (QC) for all observational data. QC plays an essential part in maintaining the quality of the initial value and forecast field. The QC system is composed of an automatic component called real-time QC and a manual component called non real-time QC.

The DA system performs real-time QC. If data are climatologically unrealistic, appear as duplicates, show a large difference from the first-guess field (background) of the model or significantly disagree with neighboring values, they are rejected in real-time QC.

In some cases, however, data are found to include anomalous values that are difficult to reject in real-time QC. A blacklist is kept for non real-time QC to deal with such data. Platforms (stations, airplanes, ships, etc) found to report biased or erratic observations placed on the blacklist for careful monitoring, and blacklisted observations are rejected before real-time QC procedures. The blacklist is updated manually whenever sudden deterioration occurs, and blacklisting status is lifted when the careful monitoring shows that the quality has returned to an accepted standard.

Typical causes of blacklisting include the following:

- Problems with instrumentation
- Erroneous reporting formats
- Change of tendency from new correction methods
- Data with low observation density

Some correct observation, however, deviates from the background because the NWP model is not perfect. It is difficult to discriminate wheather errors are related to observation or to the NWP model itself.

5. Data monitoring report

JMA publishes the following two reports:

1) Monthly Global Data Monitoring Report

The JMA Global Data Monitoring Report is a monthly publication intended to give an overview of the quality of observation. It should be recognised that the statistics given in this report refer to data as received by JMA in time for appropriate analysis. The information presented on data quality is based on differences between observations and the values of the most recent JMA forecast (known as first guess) of the same parameters.

2) Report on the Quality of Land Surface Observation in Region II (Asia)

As stipulated in Paragraph 22 of Attachment II.7, of the Manual on the Global Data Processing and Forecasting System (WMO No.485), the Regional Specialized Meteorological Center (RSMC) Tokyo was designated by the President of the Commission for Basic Systems (CBS) as a lead center for monitoring the quality of land surface observations (i.e. SYNOP) for Region II in March 1991. The lead center is responsible for monitoring the quality of land surface observations and composing lists of suspected low-quality observations together with adequate evidence. These lists are passed on to the WMO Secretariat and centers participating in this monitoring activity as well as to members of the Regional Association (RA) II for their reference.

6. References

Langland, R. and N. Baker, 2004: Estimation of observation impact using the NRL atmospheric variational data assimilation adjoint system. Tellus, 56A, 189-201.

Wahba, G. D. R. Johnson, F. Gao and J. Gong, 1995: Adaptive tuning of numerical weather prediction models: Randomized GCV in three and four dimensional data assimilation, *Mon. Wea. Rev.*, 123, 3358-3369.