Report on the GAME Reanalysis

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1. Introduction

GAME reanalysis project in Japan started in 1999 with a joint effort of the Meteorological Research Institute, Numerical Prediction Division/Japan Meteorological Agency (JMA), and the Earth Observation Research Center. The Object of the GAME reanalysis is to collect off-line data during the GAME IOP period and to obtain reanalysis (Yamazaki et al., 2000, Yatagai et. al. 2000) of higher quality using the most updated assimilation system and the off-line data as well as on-line data through the GTS. The target period is from April to October, 1998. Most of collected off-line data are located between 25 N and 40 N in China. The assimilation system used is almost the same as the current operational JMA system: 3 dimensional optimum interpolation scheme and forecast model with 0.5625 degree horizontal resolution, 30 vertical layers and prognostic Arakawa-Schubert convective scheme.

The GAME reanalysis version 1.1 and 1.5 were released in September 2000 and June 2002 respectively. Anyone can access and use these reanalysis data for scientific purpose. Please refer to the web page http://gain-hub.mri-jma.go.jp/GAME_reanal.html for more detailed information and data access.

The difference between ver.1.1 and 1.5 is shown in Table 1. The main differences are:

1) SCSMEX Sonde observation data are incorporated.
2) Input data of snow depth are retrieved from SSM/I and input data of soil temperature are taken from result of the six hour forecast. Both of them were climatological values in ver.1.1.
3) Total precipitable water information over sea estimated from SSM/I and OLR is incorporated.
4) Forecast time to obtain some reanalysis output as precipitation is now 12 to 18 hour forecast. It varied 18 to 24 hours or 12 to 18 hours in ver.1.1.

2. Validation

Purpose of this paper is to validate the GAME reanalysis data using independent observation data, GPCP, TRMM, station(sonde, flux) and to compare with other reanalysis. Table 2 shows data used and methods to validate.

(1) Wind validation

The Tibetan Plateau is believed to play an important role in evolution of the Asian monsoon, few sonde stations are operational, e.g., no operational rawin sonde station in west Tibet. GAME IOP(Intensive Observational Period) sonde network is specially focused in the Tibetan Pleateau. Fig. 1 shows comparison of mean square wind vector difference from sonde obsevation at Amdo, east Tibet in 1998 summer season. Reanalysis data is interpolated from 2.5 degree data. No Amdo data happen to be used at any analysis

products. The difference of the GAME reanalysis ver1.5 is comparable to ECMWF and shows good performance.

Comparison with Shiquanhe data in west Tibet is shown in Fig.2. Only GAME reanalysis uses this station data. As expected, GAME reanalysis ver.1.5 is the closest to the observation.

(2) Validation of surface energy fluxes

Surface energy fluxese are the important driving forces to control the seasonal evolution of the asian monsoon. Comparison of latent, sensible heat fluxes at Tak, Thailand for July 1998 (Fig. 3) indicates the GAME reanalyses are the closest to the observation in diurnal variation as well as in absolute magnitude.

(3) Validation of precipitation

In the Asian monsoon regions better precipitation estimate in data assimilation is essential to analyze better circulation fields associated with the monsoon because condensation heating due to precipitation is dominant to determine the circulation pattern.

Truth data for precipitation is TRMM combined 3G68 hourly precipitation. To validate precipitation and compare with other reanalyses, we first interpolate all data into 2.5 by 2.5 gridded data and calculate monthly root mean square at each grid and every 6 hourly if TRMM data are available. It is defined as

$$\text{Monthly RMSQ} = \Sigma\ \Sigma (R(\text{reanl}) - R(\text{obs}))^2$$

$$= \Sigma [(<\text{Rreanl}> - <\text{Robs}>)^2 + 2\ \text{Sreanl Sobs}\ (1-\text{CR}) + (\text{Sreanl} - \text{Sobs})^2],$$

where <Robs> is TRMM monthly precipitation and <Rreanl> is that from reanalyses, Sanal and Sobsare corresponding monthly standard deviation, and CR is temporal correlation coefficient between TRMM and reanalysis precipitation. Summation for average runs over tropical belts or over entire TRMM observation area (37.5S to 37.5N).

Fig.4 shows comparison of validation with other analyses. The two left (right) hand figures are the monthly RMSQ and correlation coeffients, respectively. The first and the third figures (the second and the fourth) from the left are those averaged over the glove

Table 1 Main difference between Game Reanalysis ver.1.1 and 1.5

Version	Ver.1.1	Ver.1.5
Release	September 2000	June 2002
Model	T213L30	
Sonde data	+GTS(GAME-T) +TIPEX & JEXAM +HUBEX	+SCSMEX +North INDIA:Wind
Assimilation	3D-Optimal Interpolation	
Snow	Climatological	Retrieved from SSM/I
Soil temperature	Climatological	6 hour forecast
Water Vapor bogus	Not used	Derived from SSM/I TPW and OLR only over the ocean
Physical monitor	18 & 24 hour forecast at 00 & 12UTC initial	18 hour forecast at 00,06,12,18UT

and over the Asian Pacific regions, respectively. Irrespective of the averaging regions, the GAME reanalysis precipitation shows the least RMSQ and large correlation with TRMM precipitation.

3. Summary

We made validation of the GAME reanalysis output with observation. The key variables as wind field and surface energy fluxes over the Asian Continents and precipitation over the entire tropical regions are validated and compared with other reanalysis output.

1) Wind fields in the GAME reanalysis have better quality than others in the vicinity of GAME intensive observation regions. The GAME IOP sonde observations, which were not reported to operational numerical prediction centers via GTS, contribute to improvement of the GAME reanalyses products.
2) Precipitation from the GAME reanalysis shows better agreement with observation than others. The version 1.5 is better than the version 1.1. This due to inclusion of the moisture data over sea retrieved from
3) We also made validation of geopotential height and surface energy flux over the Tibetan Plateau, precipitable water over sea. These results also show good correspondence of the GAME reanalysis output with observation.

Yatagai et. al.(2001, 2002,2003) extensively comapred surface fluxes from the GAME reanalysis and AAN observations. These studies also shows the GAME reanalysis are reasonably close to the AAN observational.

We believe the GAME reanalysis product is comprehensive and usefull data to study water and energy budget over the Asian monsoon region and hope many people use these

Table 2 Data used and methods

Analysis products	Analysis	Physical monitor	
			Precipitation
GAME reanalysis Ver.1.1	2.5 deg.	2.5 deg.	0-6h
GAME reanalysis Ver.1.5	2.5 deg.	2.5 deg.	0-6h,12-18h
JMA routine analysis (GANAL)	1.25 deg.	2.5 deg.	0-6h
NCEP1 reanalysis	2.5 deg.	1.875 deg.	0-6h
ECMWF routine analysis	2.5 deg.	2.5 deg.	Not used

Global precipitation	TRMM 3G68	GPCP 1x1 daily

Interpolated into 2.5 deg. for precipitation analysis

Station data	location
Sonde	Amdo,TIPEX
Flux (LE,H)	EGAT(Tak)

All data were compared with values estimated by interpolation at the location of the station.

data for their study.

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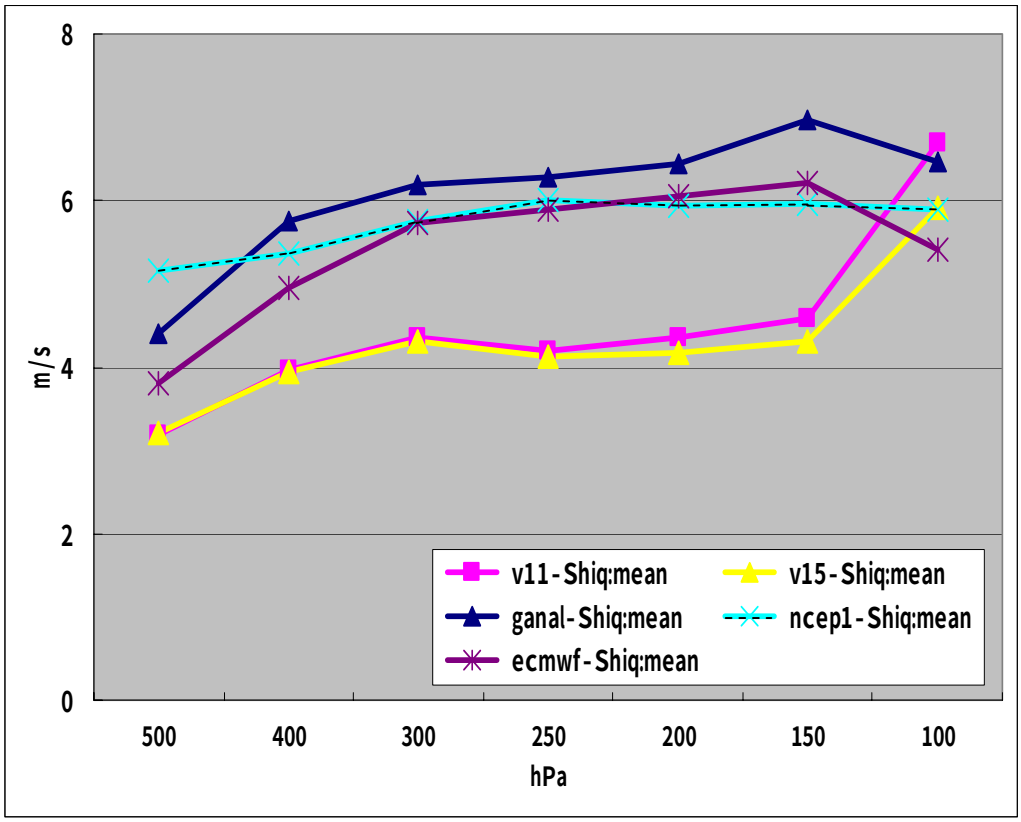

Fig. 1 Mean wind vector difference at Amdo

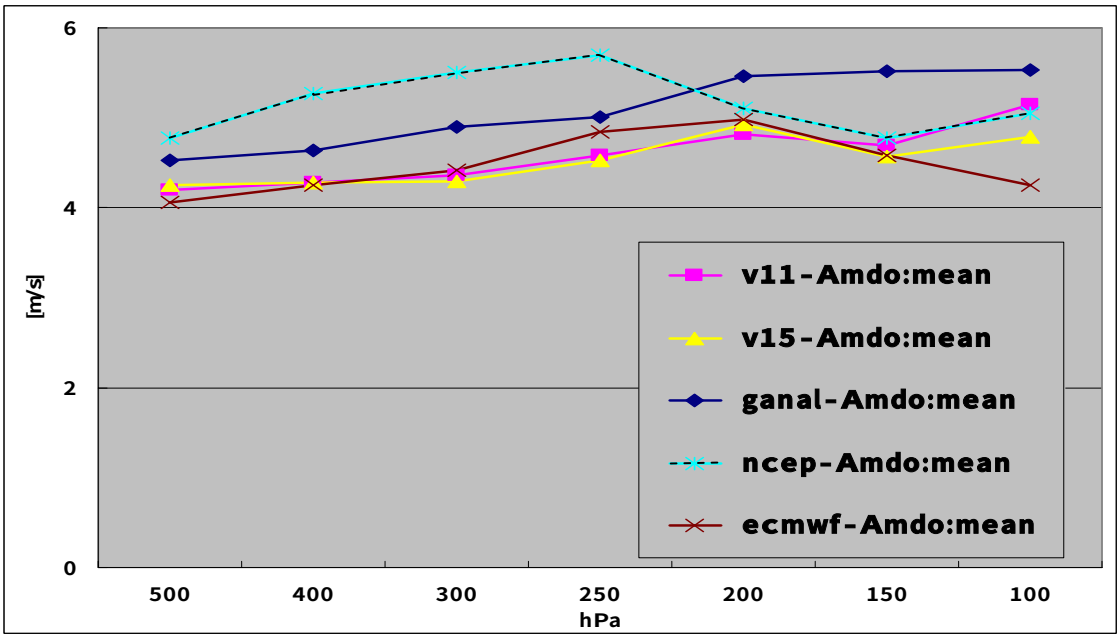

Fig. 2 Mean wind vector difference at Shiquanhe

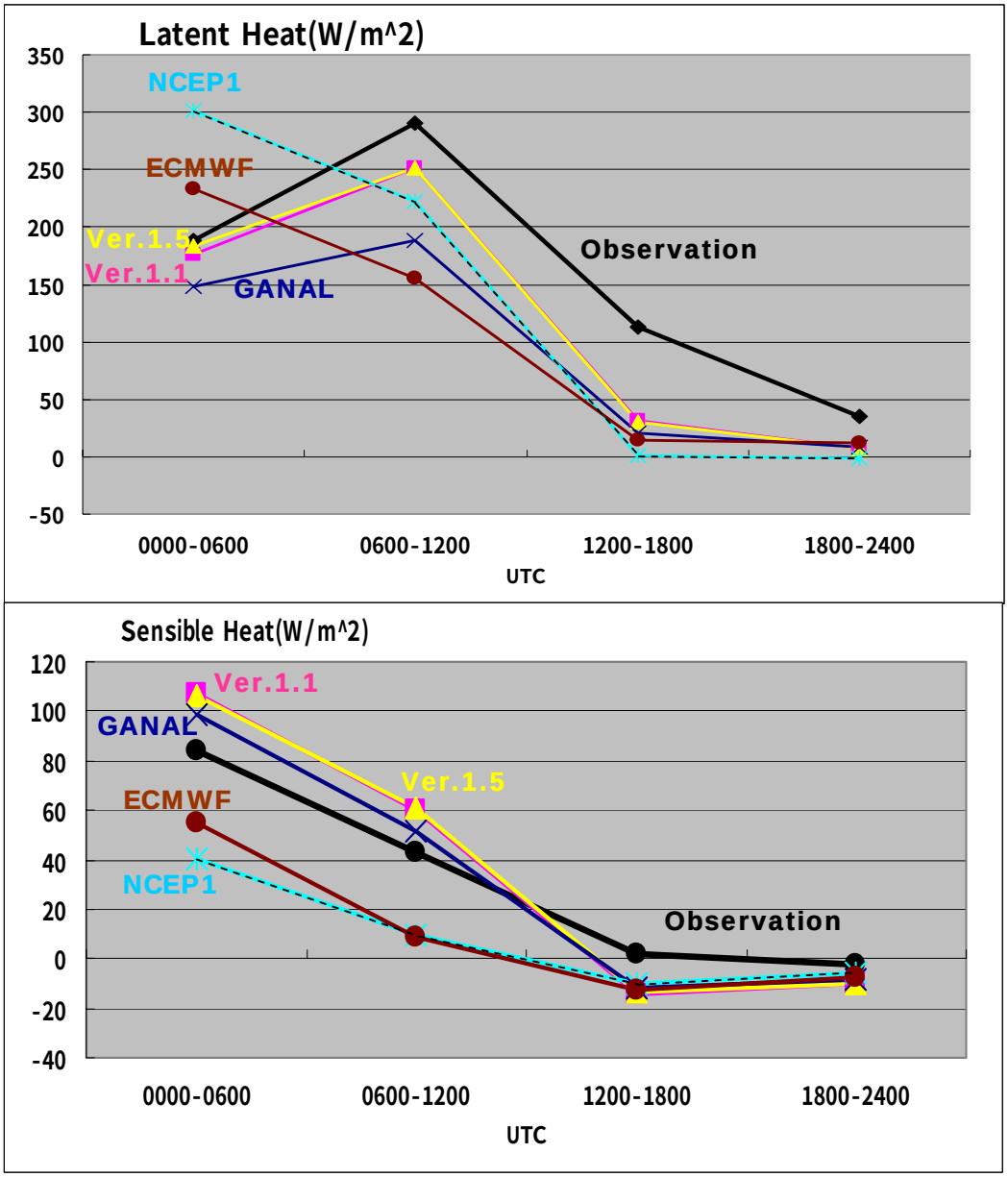

Fig. 3 Comparison of latent, sensible heat flux at Tak for July 1998

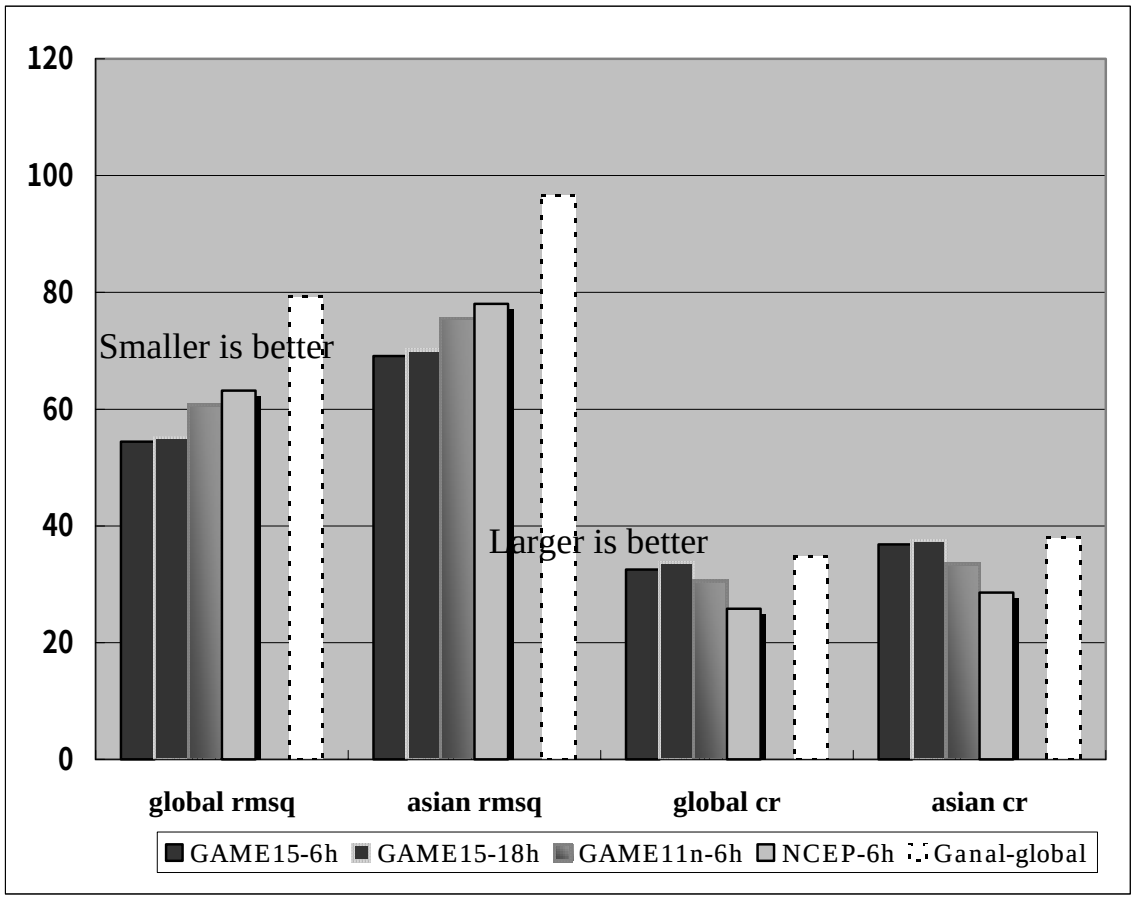

Fig.4 Comparison of TRMM TMI+PR vs Reanal Precipitation