Production of final dataset of GAME-HUBEX Regional 4DDA by JSM-SiBUC

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Abstract

Regional land-atmosphere coupled model (JSM-SiBUC) is applied to the GAME-HUBEX region to produce a high accuracy dataset with 30km resolution. The period of the dataset is from 1998/6/21 00Z to 1998/7/22 00Z (31days). As for the main atmospheric model, JSM (Japan Spectral Model) was provided from JMA (Japan Meteorolocal Agency) for the GAME community. As for the land surface model, latest version of SiBUC is adopted to describe presicely the land surface condition within the domain. GAME-Reanalysis Ver1.5, which was produced by JMA, is used for initial and external boundary condition. Through the comparison with upper air sounding data, lower level specific humidity of GAME-Reanalysis data was found to be smaller than observed one. Therefore, upper air sounding data in the whole GAME-HUBEX region are re-assimilated to produce more accurate initial and boundary conditions. The final dataset of this regional 4DDA includes surface fluxes (sensible heat, latent heat, etc.) and surface state variables (soil moisture, surface temperature, etc.) as well as atmospheric state variables (temperature, humidity, wind, etc.).

Keyword: GAME-HUBEX, JSM-SiBUC, GAME-Reanalysis, data assimilation, humidity

1. Introduction

Land-Atmosphere interaction and its role in the formation of meso-scale precipitation systems are one of the most important research targets of GAME-HUBEX Projects. This kind of research becomes possible due to the existence of high accuracy datasets. To perform the regional 4DDA (four dimensional data assimilation) accurately, not only the used model but also the external dataset is very important. In this study, regional 4DDA is executed for the GAME-HUBEX region by JSM-SiBUC coupled model. GAME reanalysis data and upper air sounding data is utilized to produce better initial and boundary conditions.

2. Model Description

2.1. JSM-SiBUC coupled model

Japan Spectral Model (JSM) was developed for mesoscale numerical prediction by the Japan Meteorological Agency (JMA). Model variables are represented at 129 $\times$ 129 horizontal grid points and 23 vertical σ levels. In the original JSM model, land-surface process was described very simply. To deal with land-atmosphere interaction properly, latest version of SiBUC, which can treat mixed landuse/landcover conditions, has been coupled into JSM (**Fig. 1**) [3]. Especially, irrigated farmland and paddy field should be expressed in this region[1]. The simulation domain (**Fig. 2**) covers the whole target area of GAME-HUBEX (E110-E122, N28-N40).

2.2. Surface parameter

Two datasets are utilized to make fractional areas of each land-use within JSM grid. For Japan area, KS-202 data which has about a 100m resolution and 15 landuse categories is available. For other parts

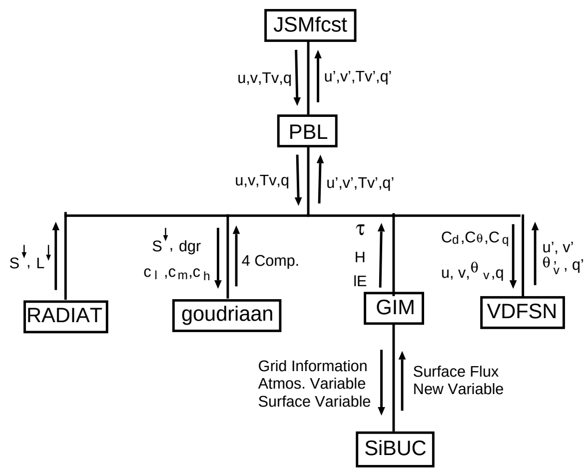


Fig. 1 : Structure of JSM-SiBUC

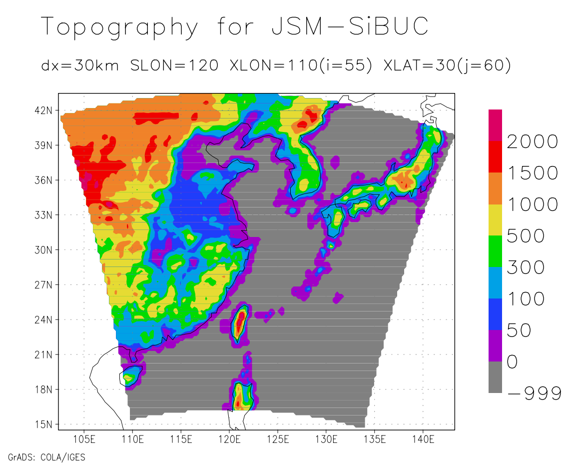
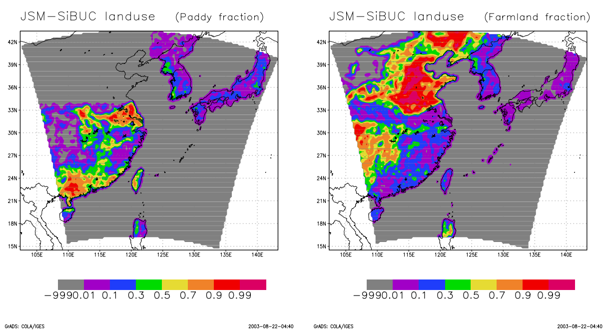


Fig. 2 : Topography for JSM-SiBUC

Table 1 : Analysis cycle and weight for overlapping period

date	6/20		6/21				6/22				6/23		
UTC	12 13	..	23 0 1	..	11 12 13	..	23 0 1	..	11 12 13	..	23 0 1	..	11 12
cycle 1	0 1	..	11 12 13	..	23 24 25	..	35 36						
			weight 1		**12 11**	..	**1 0**						
			weight 2		**0 1**	..	**11 12**						
cycle 2					0 1	..	11 12 13	..	23 24 25	..	35 36		
							weight 2		**12 11**	..	**1 0**		
							weight 3		**0 1**	..	**11 12**		
cycle 3									0 1	..	11 12 13	..	23 24

of the simulation domain, the NOAA-AVHRR global landuse/landcover dataset (from USGS), which has about 1km resolution and 14 categories, is used. By the way, this dataset has some problem in describing the cropland area[4],[1]. Then, new cropland information is used in JSM-SiBUC (**Fig. 3**). According to the in-situ flux measurement data[2], some model parameters are calibrated to reproduce the diurnal variation of surface energy balance components well.



(a)Paddy field (b)Farmland

Fig. 3 : Paddy field and farmland fraction

3. Experimental design

3.1. Analysis period

Initial and boundary condition is produced from GAME Reanalysis data (ver.1.5)[7]. Target period is from 1998/6/21 00Z to 1998/7/22 00Z, and this period coinsides with HUBEX-IOP. A series of 36-hour simulations initialized at 1200UTC (2000BST) everyday are executed. This means that each simulation period overlaps 12hours. As for the overlapping period, two simulation results are combined according to the hour from initial time. **Table 1** shows the analysis cycle and the weights for the each overlapping time.

3.2. Initialization of land surface variables

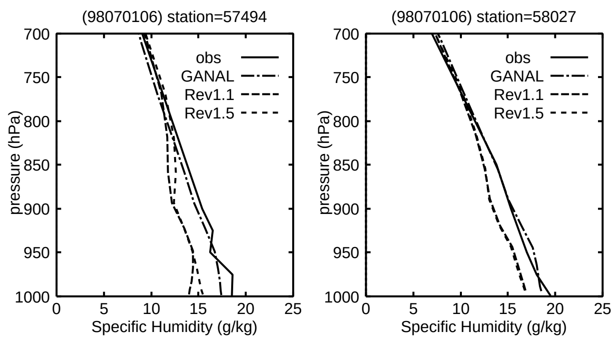
Sea surface tempersture is initialized by SST analysis data of that day. Land-surface temperature is initialized by climatological value. Soil moisture is initialized only for the first simulation (1998/6/20 1200UTC). For the sparcely vegetated area (grassland, bare soil), surface soil moisture is initialized by TRMM/TMI data [6]. For the dense vegetation area (forest, cropland), initial value is set to appropriately wet enough values. Here, vertical profile of soil moisture is given by linear profile of matric potential (This profile balances with gravity). From the second simulation, initial soil moisture is succeeded from the previous run.

4. Results

4.1. Problem in GAME reanalysis data

Analysis cycle was executed forced by GAME reanalysis data. For some events (ex. 29th June), simulated rainfall pattern and its amount was good accordance with surface measurements. But for other events (ex. 1st ∼ 2nd July), simulated rainfall was much smaller than observed one (see **Fig.6**).

Vertical profile of specific humidity at Wuhan (E114.13, N30.62) and Xuzhou (E117.15, N34.28) at 0600UTC on 1st July is shown in **Fig. 4**. Solid line is observation (upper air sounding data), dotted line is GAME reanalysis. For comparison, GANAL data is also shown by dashed line. Although all upper air sounding data were utilized to produce GAME reanalysis, lower level (1000-800hPa) specific humidity is clearly smaller than observation (GANAL is much better). The spacial resolution of GAME reanalysis is very good (0.5 degree), and wind field is known to be much better than other dataset. Here, we still use GAME reanalysis, but we try to modify the humidity field to improve the rainfall simulation.



(a) Wuhan (b) Xuzhou

Fig. 4 : Vertical Profile of Specific Humidity at Wuhan and Xuzhou (1998/7/1 0600UTC) solid: observation, dashed: GANAL, dotted: GAME reanalysis v1.5

4.2. Adjustment of humidity field by PW

Precipitable water (PW) of external data (GAME-Reanalysis) is calculated for each grid (PW_{ext}). On the other hand, PW can be calculated from upper air sounding data (25 stations). These station's values (PW_s) are horizontally interpolated with influence radius of 5 degree to produce gridded values (PW_g). Then, this observation based PW_g and external data based PW_{ext} are compared. According to the ratio of PW_{ext} and PW_g, specific humidity value in the external dataset (q_{ext}) is modified.

$$q_{ext}(z)^* = q_{ext}(z) \times PW_g/PW_{ext}(z = 1, z_{max}) \quad (1)$$

This modified specific humidity (q^*_{ext}) is given to JSM-SiBUC. **Fig. 5** shows the ratio of PW between original and re-assimilated run at 0000UTC. According to **Fig. 5**, specific humidity is increased by this re-assimilation in large part of this region.

4.3. Time series of area average rainfall

To see the impact of moisture adjustment, area average rainfall is calculated for the different spacial scale.

1. AREA1 : E110-E122,N28-N40(12deg × 12deg)
2. AREA2 : E111-E122,N31-N36(11deg × 5deg)
3. AREA3 : E114-E117,N31-N34(3deg × 3deg)
4. AREA4 : upstream of Huaihe river basin

According to **Fig. 6**, the rainfall amount of the original run (green line) is much smaller than observation (blue line). While that of re-assimilated run (red line) is closely to observation (but still small). As for AREA3 and AREA4, the rainfall event in 29th June is too much enhanced. But for AREA1 and AREA2, rainfall amount of that day is almost same as observation. This means that rainfall area is slightly shifted from actual one.

4.4. Horizontal distribution of correlation

Spatial distribution of the correlation coefficient for the daily rainfall time series is shown in **Fig. 7**. The left panel is for the original simulation, and the right panel is for the re-assimilated simulation. In general, the correlation coefficient is improved in many of the 1 degree × 1 degree grid area. Then, not only the rainfall amount, but also spatial pattern of rainfall distribution is improved by re-assimilation of sounding data. As for the north-west part of the basin, correlation coefficient becomes worse. This may be a result of the too much moisture adjustment. Since the influence radius is 5 degree, precipitable water in the sea side area (moist area) affects inner dry region. If the sounding data in this dry region is available, this part will be improved.

4.5. Final product

Although there is some possibility in the improvement of model output, now is the time to finalize the GAME-HUBEX activity. The final product of HUBEX regional 4DDA is produced from this re-assimilated run. This product is provided with 30km resolution and 1 hour interval. It consists of the following items.

- Precipitation, Evapotranspiration, Runoff
- Downward short-wave and long-wave radiation, Upward short-wave and long-wave radiation
- Net radiation, Sensible heat flux, Latent heat flux, Momentum flux
- Soil Moisture (3-layer), Temperature (Canopy, soil, deep soil)
- Surface meteorology (air temperature, vapor pressure, wind speed)
- 3-D meteorology (air temperature, vapor pressure, horizontal wind)

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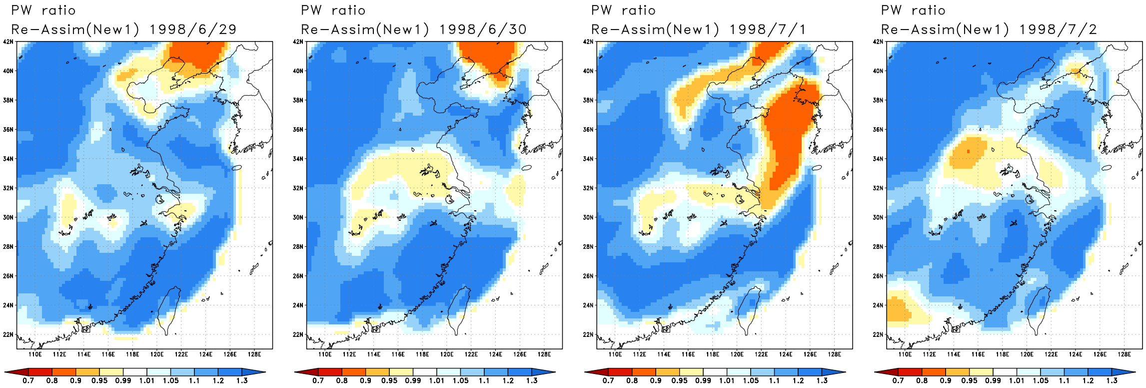


Fig. 5 : Ratio of initial Precipitable water (6/29-7/2)

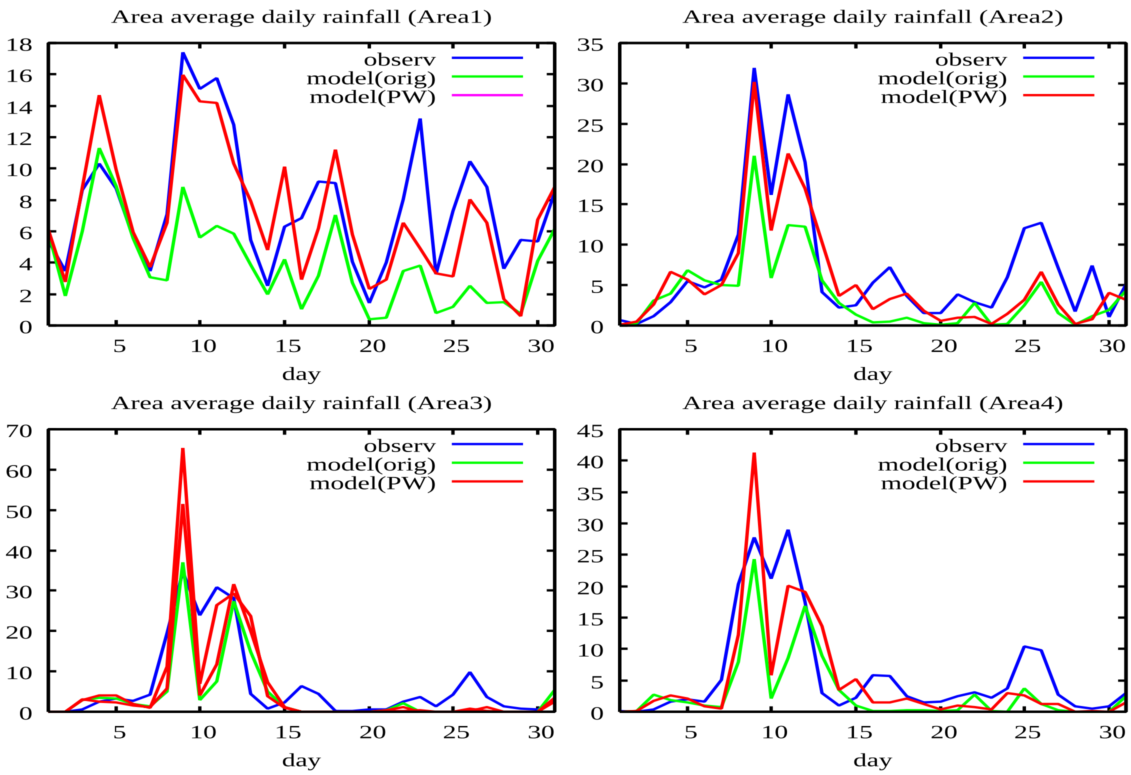
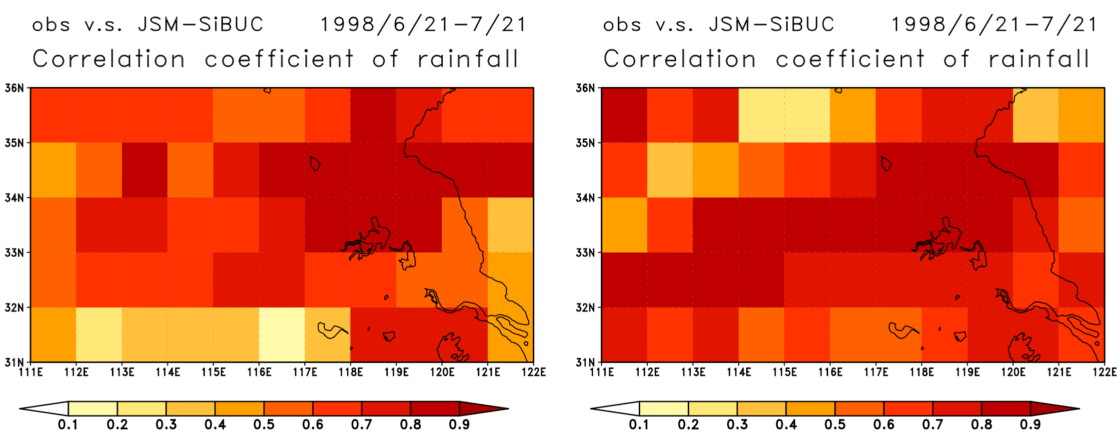


Fig. 6 : Time series of daily rainfall of four different area



(a)Original run (b)Re-Assimilated run

Fig. 7 : Correlation coefficient of daily rainfall