Discrepancy of surface wind system between GAME reanalysis and in-situ observations in the central Tibetan Plateau during 1998 monsoon season

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Introduction

The GAME-Tibet project was carried out during the summer monsoon season in 1998 (Yasunari, 2001) and GAME (GEWEX Asia Monsoon Experiments) reanalysis data was made by using the project data. GAME-reanalysis data have been widely used to diagnose the water and energy cycle system around the Tibetan Plateau (TP) in 1998. In the same period, 4 months successive sonde observation was conducted at the central TP, Amdo station under the flame work of GAME-Tibet intensive observation, but the data was not assimilated in the re-analysis data. The stationary precipitation was observed after the trough passed over central TP at 500 hPa. And there were the discrepancies between the GAME-Reanalysis (Yamazaki et al., 2003) and in situ data (GAME-Tibet project, Yasunari, 2001). However, the disturbance was not analysed clearly in the GAME reanalysis data. In this study, we revealed atmospheric fields of these cases and structure of the small scale vortex in the lower troposphere.

Data and methods

Analysis period was set from July to August in 1998. Especially, 1-2 August, 10-11 August (CASE 1) and 18-20 August (CASE 2) when the trough passed over the TP were chosen for the case studies. The GAME-Tibet reanalysis data ver. 1.5 (Yamazaki et al., 2003) was used to understand the atmospheric fields in the TP. Observed data in situ that were NASDA-Radar data (Fig.1c), Amdo sonde data (Fig.1c) and METEOSAT5-IR data were used to understand the atmospheric fields in the TP. The Weather Research and Forecasting (WRF) model (Skamarock et al., 2005) was used to diagnose synoptic-scale atmospheric condition. Numerical simulation by the WRF model was performed in the domain of Figure 1b with 15km horizontal grid interval and 24 vertical layers. GAME-reanalysis data consisted of 6 hours interval with 0.5 degree grids was used for atmospheric initial and boundary data, and NCEP-NCAR reanalysis data (Kalnay et al., 1996) was used for surface initial condition. The convective parameterization was Kain-Fritsch scheme (Kain and Fritsch, 1993) and the surface parameterization was Noah land-surface model (Chen and Mitchell, 1997). Topography of the WRF model was made by GTOPO30 data. Model version was 2.1.2.

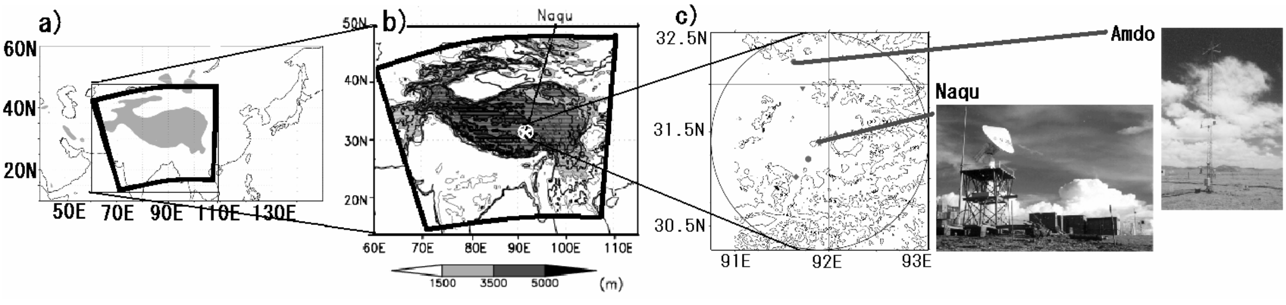

Figure 1 Tibetan Plateau with analysis domains and observation points, a) Location of TP, b) Analysis domain,

and c) Radar area and observation points Amdo (http://monsoon.t.u-tokyo.ac.jp/tibet/misc/photo/index.html), Naqu (http://monsoon.t.data/iop/precipitation/photo/pbl.htrml).

Results

Comparison of GAME-reanalysis and observation data

Figure 2 showed that there were some cases that the surface wind system of the GAME-reanalysis data differed from its sonde data observed at the Amdo. These cases were tended to observed precipitation.

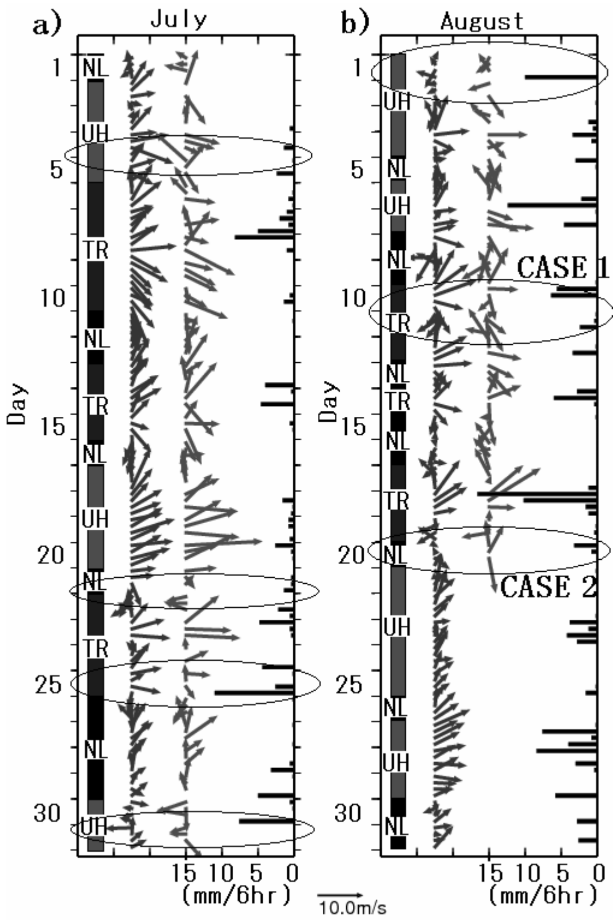

Figure 2 Time sequences of wind vectors by the Amdo sonde at 500hPa data (right) and GAME-reanalysis data (left) at the corresponding location. Synoptic conditions defined by Yamada and Uyeda (2006) were labeled in the left. The right bar chart showed the observed precipitation at the Amdo. Obvious discrepancy cases were circled. a) July, b) August.

Disturbances observed by the METEOSAT and Radar data.

To understand the atmospheric condition of the discrepancy cases, we compared the GAME-reanalysis and METEOSAT data (Radar echo data at the Naqu) for the synoptic scale condition (the meso scale condition). The cyclonic flow was not analysed clearly at the central TP in the GAME-reanalysis data (Fig.3 left). However, cumulus cloud and precipitation echo were observed by METEOSAT5-IR (Fig.3 center) and radar observation (Fig.3 right). According to Fig3c, the precipitation was observed and it caused the convergence wind at the low level in both cases. The disturbances caused discrepancy of surface wind system between GAME-reanalysis and in-situ observations in the central TP at low level.

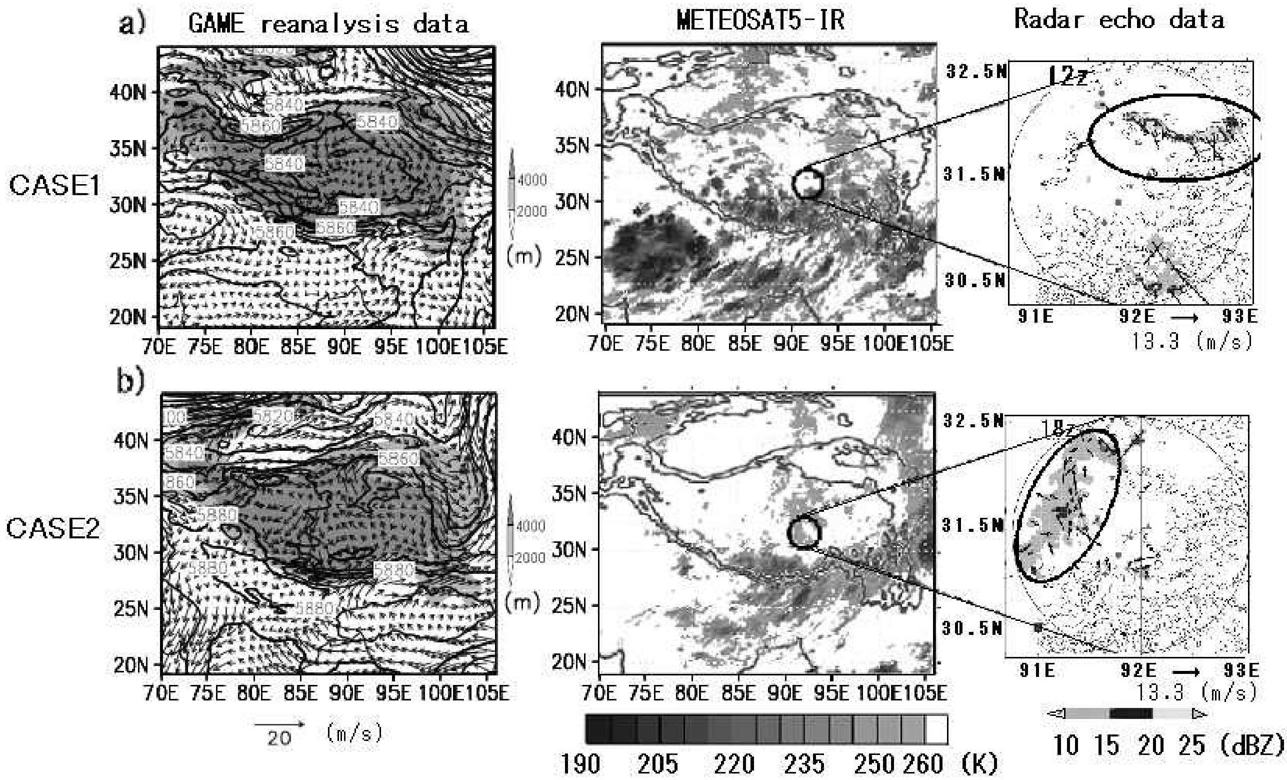

Figure 3 The atmospheric condition of synoptic scale and the Naqu basin. The left is synoptic scale atmospheric condition of GAME reanalysis data at 500 hPa wind (arrows) and geopotential height (contours, m). The center is brightness temperature of METEOSAT5-IR. The right is radar echo data at the Amdo. a)12UTC 11 August, b)18UTC 19 August.

Numerical simulations in three cases of discrepancy

According to the numerical simulations, the small scale cyclone was generated at southern central TP in CASE 1 and CASE 2 (Fig.4b,c,thick arrow). And the large scale cyclone was generated (Fig.4a thick arrow). However, the disturbance was not analysed clearly in the GAME reanalysis data (Fig.4 upper panel).

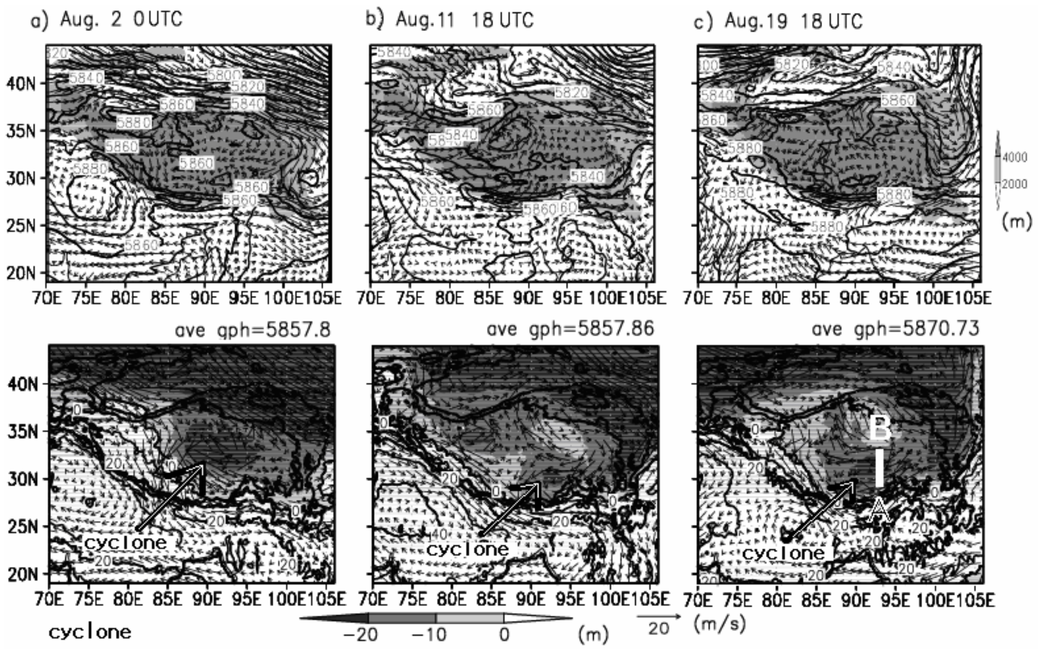

Figure 4 Comparison of synoptic scale atmospheric condition of GAME reanalysis data (upper panel) and WRF model results (lower panel) at 500hPa. Upper panel same as Fig.3 left except for the time. The shade (contour) means negative (positive) geopotential height anomaly in the lower panel and the arrows means wind. a)0 UTC 2 August, b)18UTC 11 August, c)18UTC 19 August.

The horizontal scale of the cyclone was about 500km and the thickness was about 325hPa (Fig.5b) in the case 2. The center of the cyclone was colder (warmer) in the lower (upper) layer than its surrounding air (Fig.5) and the cumulus cloud existed over the cyclone.

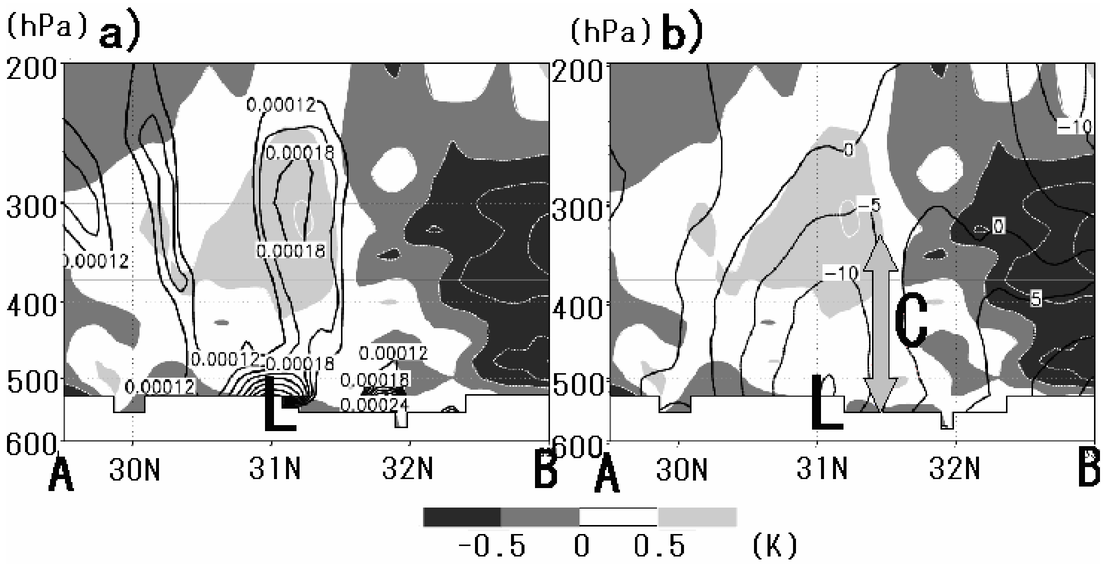

Figure 5 The vertical cross section for 92.8°E between A and B in Fig.4c lower. The shade showed temperature anomaly and the contour showed the amount of cloud water and ice (a) and geopotential height anomaly (b) on 18 UTC 19 August. L means center of the cyclon and (b)C means thickness of the cyclone.

Water vapor that was transported from south of the TP was supplied to the cyclone (Fig.6 A). The edge of the trough extended to the southern central TP on 23 UTC 19 August (Fig.7a upper) and remained the positive vorticity on 18 UTC 19 August (Fig.7b lower). The cyclone about CASE 1 had similar characteristics to the CASE 2 (not shown).

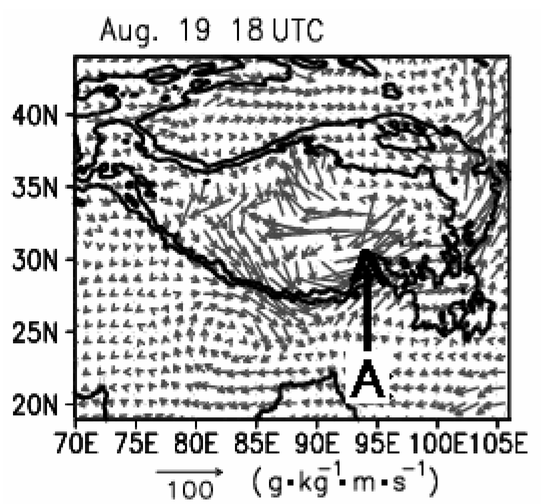

Figure 6 Distribution of water vapor flux (arrows) at 500hPa on 18UTC 19 August.

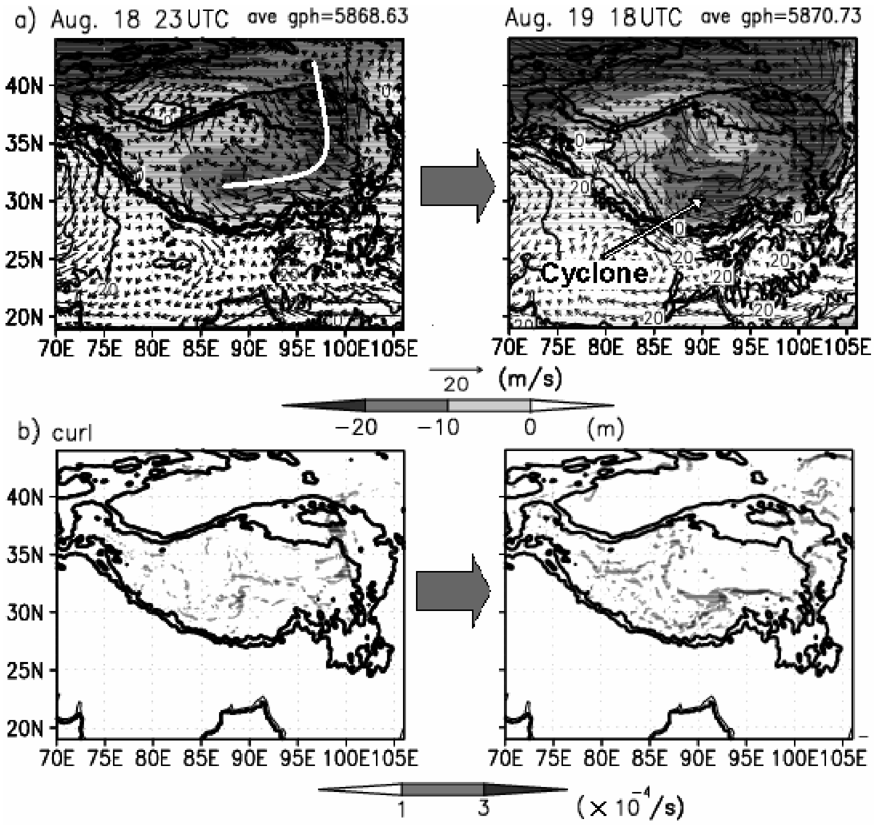

Figure 7 Time variation of a) geopotential anomaly and wind at 500 hPa and b) positive potential vorticity distribution (shade) at 500 hPa. a) same as Fig. 4 lower except for time and the white line means the trough.

Cause of developing a small scale cyclone in the southern TP

To investigate the generation of the small scale cyclone, the sensitivity experiment was performed. The experiment results without latent heat release from cumulus convection showed that the cyclone was not generated on 18 UTC 19 August (Fig.8 right). Because, the trough was not developed (Fig.8 left). Namely, the remaining positive vorticity at the central TP was needed by the generation of the small scale cyclone.

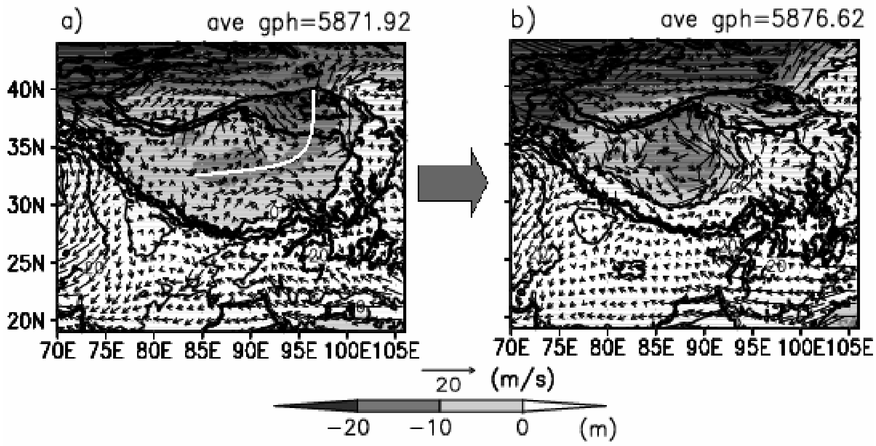

Figure 8 Same as Fig.7a except for numerical simulation without latent heat release from cumulus convection. The white line means the trough (left).

Summery

The discrepancies of surface wind system between GAME-reanalysis data and in-situ observations in the central TP were associated with transition of synoptic scale circulations, such as passing large scale trough in the north of TP, associated with meso-α scale disturbances in the TP. The numerical simulation showed that the cases of discrepancies where small scale cyclones were detected in the south of TP. Occurrence of the cyclone was associated with vorticity remained by the trough, and latent heat release in the lower atmosphere with moisture intrusion from the south of TP affected the developments.

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