Assimilation experiments using COSMIC occultation data

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1. Introduction Radio wave transmitted from GPS satellites is bended or delayed when it penetrated the atmosphere. The bending angle and atmospheric delay have the information of atmosphere along the path from GPS satellite and Low Earth Orbit (LEO) satellite. In GPS occultation observation, vertical profile of refractivity can be obtained from the bending angle or atmospheric delay. In MRI, the assimilation method for the GPS occultation data has been developed by using the occultation data observed by LEO satellite CHMAP, and the impact of it on the rainfall forecasts has been investigated with Meso-4Dvar system of JMA. On June 2006, new LEO satellite COMIC, which is composed of 6 satellites, was launched. In this report, the impact of COSMIC data is investigated using the developed method.

2. COSMIC occultation data Figure 1a shows the horizontal distribution of the tangent point, which is the closest point to the earth on the path, from 1st to 14th September 2006. These data were provided by UCAR, which is one of the organizations that have developed the COSMIC. Because the COSMIC is composed of 6 satellites, number of the occultation data is much larger than that of CHAMP. The observed refractive index ($n=(N-1)*10^6$) that existed in the domain of meso-scale model (MSM) of JMA was compared with the first-guess index produced from the outputs of MSM (fig. 1b). Refractivity index was estimated from the lower height than the CHAMP data, and the bias of the difference between aforementioned indexes is as small as that of CHAMP data. Thus, COSMIC data is expected to be useful assimilation data.

3. Outline of assimilation methods Assimilation method that was developed with CHAMP data was used. In this method, the path data, not tangent point data, is assimilated in consideration of the vertical correlation of the observational error. When CHAMP occultation data, of which tangent point passed near the rainfall system, was assimilated, the rainfall system, which was not developed when CHAMP data was not assimilated, was well reproduced. Because the rainfall forecast was improved and the property of the occultation data (i.e. path data and vertical correlation of the observation error) was considered, this methods seems to be one of proper assimilation method.

4. Assimilation results There were 10 profiles estimated from the lower layer in the domain of MSM (fig.1c). In most of the profiles, the difference of first-guess and observed indexes at lowest height was positive. These positive differences at northern and central Japan and North Korea are expected to moisten the atmosphere when these data are assimilated. On the other hand, there was a profile whose lowest difference is negative on southeast of Japan.

Figure 2a shows the difference of water vapor between the analyses, which were estimated with and without the assimilation of path data. Water vapor was increased at the central and northern Japan and North Korea. The water vapor was decreased where the refractive index with negative difference was observed. This increment of water vapor indicates that the assimilation was performed correctly. When the forecast was performed from this analysis field, the rainfall region over the central Japan was expanded (fig. 3). The rainfall region extending from central Japan to northeast, which is marked by circles, becomes closer to the observed one. This result indicates that COSMIC data improves the rainfall forecast.

Finally, the difference of impact of the tangent point data and path data are explained. Figure_2b shows the difference of water vapor from the control run with the assimilation of path data or tangent point data. There is a large difference of the increment near North Korea. In this area, conventional data reduced the moisture near North Korea. When the tangent point was assimilated, the water vapor only around tangent point was increased. On the other hand, water vapor along the path line indicated red line was moistened by the assimilation of occultation data. This difference indicates that path data should be assimilated.

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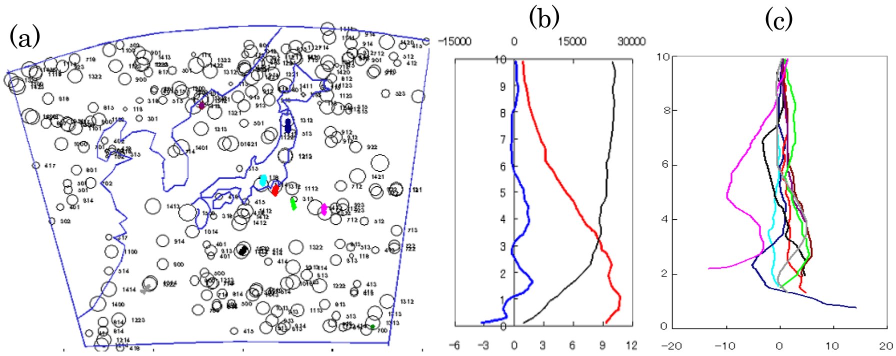

Fig. 1: (a) Distribution of tangent point observed by COSMIC from 1 to 14 September 2006. (b) Vertical distribution of bias and RMS of 'D-values'. Thin line indicates the number of the occultation data. (c) vertical distribution of D-values observed from 21JST to 24JST 13 September 2006.

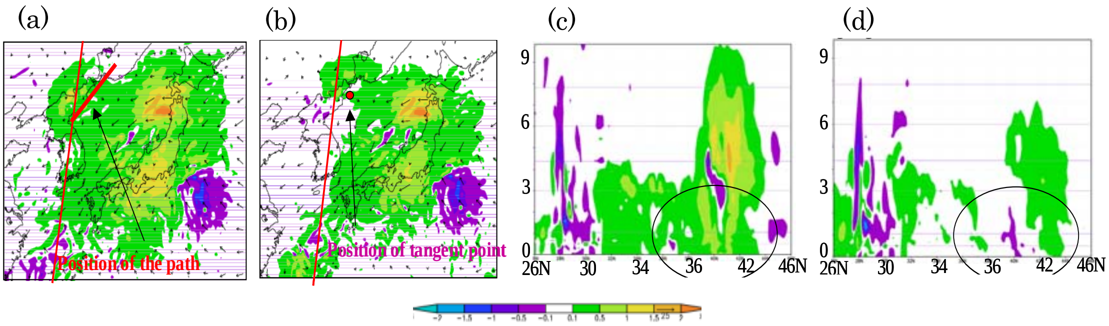

Fig. 2 Difference of water vapor of analysis fields from that of the control run. Path data (a) and tangent point data (b) were assimilated, respectively. (c) and (d) are the cross section along the red line in (a) and (b)

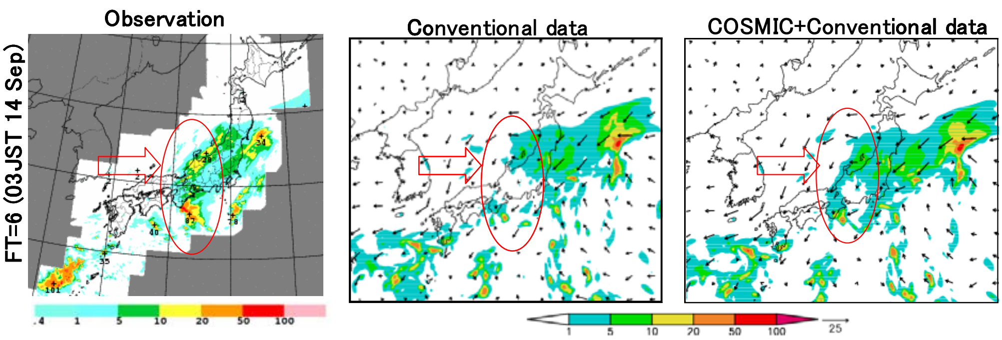

Fig. 3: (Left) Rainfall observed by conventional radar and rain gauges from 00JST to 03JST 13 September 2006. (Center) Rainfall distribution predicted from analyzed fields that were obtained by the assimilation of conventional data (CNTL). (Right) Same as except for by assimilation of conventional data and COSMIC data.