Verification of the Japanese 55-year Reanalysis "JRA-55" Quality Focused on the Various Time Scale Variability of the Stratospheric Temperature and the Atmospheric Flow on the Isentropic Surface in the Troposphere

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The Japan Meteorological Agency (JMA) started the second Japanese global atmospheric reanalysis project named the Japanese 55-year Reanalysis (JRA-55). It covers 55 years, extending back to 1958, when the global radiosonde observing system was established. In this study, we compare and verify the quality of products with special focus on the variability of the stratospheric temperature and the atmospheric flow on the isentropic surface in the upper troposphere.

We compared the stratospheric temperature in JRA-55 with the radiosonde observation, processed microwave sounder measurements, and other re-analyses. As a result of the comparison, we found that a large temperature bias in the lower stratosphere was significantly reduced comparing to those in the Japanese 25-year Reanalysis (JRA-25). Moreover, it is also found that temperature bias in the lower stratosphere is small during not only the period of the stream B (1980 -) but also the stream A (1958 -), and monthly scale variability in global mean temperature is stable. In addition, it is noteworthy that the quasi-biennial oscillation (QBO) and sub-monthly scale phenomena, such as the stratospheric sudden warming (SSW) are well reproduced even during 1960s of the stream A.

Next, we attempted to verify and visualize the improvement of atmospheric flow in the upper troposphere. Previous studies have shown that Ertel's potential vorticity conserves for adiabatic, frictionless motion, and acts as a tracer of the atmospheric flow on an isentropic surface. Therefore, it is reasonable to verify the representation of the atmospheric flow and circulation in reanalyses using products on the isentropic surface. In addition, it has been pointed out that potential vorticity on the isentropic surface is changed by the diabatic heating processes, for example, convective heating and radiation processes. Therefore, we compare and verify the quality of products on the isentropic surface and the diabatic heating processes in JRA-55 with those in JRA-25. In order to confirm the quality on the isentropic surface, we calculate potential vorticity using the forecast model fields during the period from June to July in 1983 and the period from December 1984 to January 1985.

Firstly, distributions of potential vorticity on the isentropic surface (Q-maps) in JRA-55 are compared with those in JRA-25. Q-maps in the upper troposphere (i.e. 340 – 360 K) show that the atmospheric flow in JRA-55 is much smoother than that in JRA-25. In particular, the atmospheric flow is improved extraordinarily in the region where blocking and Rossby wave breaking occur, e.g. around Greenland, on the North Pacific Ocean. In addition, the distribution of isentropic potential vorticity increments exhibits the whole decrease of potential vorticity increments in JRA-55. In particular, it is remarkable in the Asian summer monsoon region. We also estimated the consistent rate of the isentropic potential vorticity tendency term to the advection term. This reveals that the consistency in the region from sub-tropics to mid-latitudes is relatively higher than that in high-latitudes. Moreover, in the region from sub-tropics to mid-latitudes, we also found that quite higher consistency in JRA-55 than that in JRA-25.

Secondly, we calculated the monthly time scale isentropic potential vorticity tendency by potential vorticity advection in the adiabatic process, and the tendency by the diabatic heating processes. These tendencies are compared with the actual monthly time scale isentropic potential vorticity

tendency. In the case of boreal summer, we found that the tendency by the diabatic heating processes in JRA-55 is more reasonable not only in the tropics but also in the extra-tropics than that in JRA-25. We found that the tendency by the diabatic heating processes related to precipitation, however, is excessive in comparison with the actual isentropic potential vorticity tendency both in summer and winter in the boreal region.

These results indicate the representation of the variability of the lower stratospheric temperature and the atmospheric flow on the isentropic surface are improved evidently in JRA-55. It is suggested that these improvements are brought by some major updates in the JMA operational numerical weather prediction system, for example, increase of resolution, introduction of a new radiation scheme to the forecast model, four-dimensional variational data assimilation with variational bias collection.

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