Comparison of Zonal-mean Temperature and Precipitation Trends in Multi-reanalysis and Analysis Sources

Xingang Dai
RCE-TEA, Institute of Atmospheric Physics, CAS, Beijing 100029, China

Ping Wang
Chinese Academy of Meteorological Sciences, CMA, Beijing 100081, China

The trends of zonal-mean temperature and precipitation are estimated using multi-reanalysis and multi-analysis datasets for assessing the validation of several reanalysis datasets in study of global climate change. The analysis include CRU, UDel, GPCC and CMAP datasets, and the reanalysis refers to NCEP-DOE AMIP-II and NCEP/NCAR Reanalysis, ERA-40 and JRA25 As expected, the warming trends in the analysis data assume a globally universal mode and an inhomogeneous mode along meridian, i.e., the warming is intensifying towards the North or South Pole. And the warming in Northern Hemisphere is stronger than that in Southern Hemisphere over the past 50 years. Surprisingly, a significant cooling is located at about 45ºS connecting a sharp warming at a further south latitude over the Antarctic Peninsula for 1958-2001. The warming rate over land is intensified northward from 45ºS to north high latitudes and reached its extreme at about 65ºN.

On the other hand, the reanalysis datasets show a similar distribution of the temperature trend with the analysis data over the land, but it is a little weak in norm. The uncertainties in the reanalysis data mainly appear in high latitudes of both hemispheres. The ERA-40 exhibits a good estimate on Arctic warming with extreme warming rate of 2.9º-3.5ºC/century, and so does the NCEP/NCAR over the Antarctica with a extreme rate of 3.2º-4.7ºC/century for 1958-2001. In addition, both analysis and reanalysis datasets reveal that the warming rates become increased in Northern Hemisphere during the past three decades, with an extreme warming rate of 8.5ºC-8.9ºC/century in Arctic region, but there is no significant changes over the southern latitudes out of Antarctica. Moreover, a very rapid arctic warming has appeared since the beginning of the twenty first century resulting from one of CRU's datasets similar to the estimates in the four reanalysis datasets. Nevertheless, a cooling appears over the southern latitudes and the Antarctic continent in JRA 25, different from others. As a result, the unbalance warming between two hemispheres would enhance the thermal contrast of the hemispheres further and would cause much exchange in water vapor and energy across the Equator. In addition the inhomogeneous warming would weaken the equator-pole thermal contrast and lead to a declining in boreal westerly in Northern Hemisphere and, in turn, it would intensify the thermal contrast over the other hemisphere. The reanalysis data also shows that the cooling latitudes in southern mid-latitude have shifted southward and intensified during the past thirty years, and accordingly the Antarctic Circumpolar Westerly is southward-shifted too since the beginning of the new century.

Besides, zonal-mean precipitation trends estimated by the analysis datasets are also inhomogeneous on meridian, and two significant peaks on the Equator and high latitudes, respectively, while decrease in precipitation appears in subtropics in association with the extension of the subtropical highs over two hemispheres with global warming. Nevertheless, the precipitation trends estimated from the reanalysis datasets are not good as the analysis datasets do. Finally the possible mechanism for the variation of precipitation is discussed basing on the changes of thermal structure and dynamics of atmosphere accompanying global warming. Our investigation demonstrates the potential of the reanalysis data in studying the features of global climate change, especially in temperature despite of large uncertainties existed. The uncertainty could be reduced if combing analysis and reanalysis data in estimating the characteristics of global climate change.

Corresponding Author:

Name: Xingang Dai
Organization: RCE-TEA, Institute of Atmospheric Physics
Address: CAS, Beijing 100029
China