Interdecadal Variability and Trends in Global Precipitation During the Satellite Era

Guojun Gu and Robert Adler

During the satellite (post-1979) era, surface temperature has been increasing on the global scale due to the increase in anthropogenic greenhouse-gases (GHG); The two volcanic eruptions (El Chichon, March 1982 and Pinatubo, June 1991) and decadal-scale internal modes including the Pacific Decadal Oscillation (PDO) and Atlantic Multidecadal Variability (AMV) have affected global climate as well. Thus, our focus here is on examining how precipitation might have changed and how these factors may have contributed to global precipitation change. The satellite-based GPCP precipitation analysis V2 and V3 are primarily applied. Comparison with the precipitation outputs from CMIP6 and AMIP6 will further be made in terms of global mean precipitation change and regional features of precipitation change. The comparison will hence provide not only an essential means of assessing the skills of current climate models, an improved understanding of the effects of these factors, and also clues for diagnosing possible limitations in the observations.

The trend in global mean (land+ocean) precipitation is relatively weak in GPCP, roughly 0.27% per decade. However, it is interesting to note that the CMIP6 historical full-forcings and AMIP6 runs can generate a similar number, especially when the percentage change rates with surface temperature change (or sensitivity) are compared [GPCP (1.41%/C) vs CMIP6 (1.52%/C) vs AMIP (1.1%/C)]. With the lengthening of GPCP record, GPCP and CMIP6 tend to have a roughly same sensitivity, providing more confidence in both observations and model outputs, and also our understanding of the responses of global precipitation to a combination of distinct forcings.

Although the global mean precipitation trend is weak, regional trends can readily be found in GPCP. Precipitation increases along the Pacific ITCZ and SPCZ, while decreases south of the ITCZ in the central-eastern Pacific. Precipitation increase also occurs in the other regions including Indian Ocean, southwest of tropical Atlantic, etc. Subtropical drying can be observed in the Pacific and Atlantic. These rich spatial features agree with the notion of “wet-gets-wetter, dry-gets-drier”. AMIP6 shows similar results with GPCP in terms of the large-scale spatial structures of precipitation change. Further comparisons with CMIP6 suggest the combined effects from GHG, PDO, and AMV in observed precipitation. Removing the PDO/AMV effect from GPCP trends makes the residuals more similar to those in CMIP6. This suggests that in spite of the effect from internal modes, the GHG effect can already be discernible in observed precipitation. Other factors especially the two volcanic eruptions may have played an important role as well. Volcanoes significantly cooled the globe after their eruptions and further reduced precipitation.