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Comparision of the evolution of the Hadley Circulation between ECMWF ERA-20C centennial reanalysis and the atmospheric model ensemble ERA-20CM

Roberta D'Agostino and Piero Lionello
University of Salento and CMCC, DiSTeBA, Lecce, Italy

This study compares the evolution of the Hadley Circulation (HC) during the 20th Century in two recent datasets: ERA-20CM and ERA-20C. ERA-20CM is an ensemble of Atmospheric Model simulations forced by 10 different realizations of prescribed SSTs and by radiative forcing that follow CMIP5 protocol. ERA-20C is a single simulation that is similarly forced by the analyzed SST, but it additionally assimilates surface pressure and marine winds. This comparison allows to highlight the effect of the data assimilation on magnitude of the HC trends, and helps to identify differences in the HC structure between reanalysis and AMIP-simulation. The assimilation introduces relevant differences between ERA-20CM and ERA-20C in characteristics and trends of the HCs. In ERA-20C HCs are weaker and the whole Northern Hemisphere HC is shifted southward than in ERA-20CM. Furthermore, the magnitude of trends is larger and more statistically significant in ERA-20C than in ERA-20CM, and only ERA-20C supports a change of the HC strength. Both datasets show large multidecadal variability across 20th Century, which raises doubts on the interpretation of all recent behaviors as the onset of sustained long term trends. However, while the strengthening of the ERA-20C Southern Hemisphere HC is possibly an artifact introduced by data assimilation, the southward shift of the Southern Edge and widening of the Southern Hemisphere HC are robust features in both datasets. The widening of the whole tropical circulation is primary linked to the expansion of the Southern Hemisphere HC and it has accelerated in the last three decades. width of the Southern Hemisphere HCs throughout the 20th Century is mainly correlated to the mean global temperature, but changes in the meridional temperature gradient and planetary wave activity have a role, as well. Furthermore, we integrated the analysis in a long-term perspective with CMIP5 experiments, to analyze HC sensitivity to surface temperature from Last Glacial Maximum to future projections.