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Global and regional cooling in a warming climate from CMIP5 models

Iselin Medhaug (1) and Helge Drange (2,3)

(1) IAC, ETH Zürich, Zürich, Switzerland (iselin.medhaug@env.ethz.ch), (2) Geophysical Institute, University of Bergen, Bergen, Norway, (3) Bjerknes Centre for Climate Research, Bergen, Norway

Instrumental temperature records show that the global climate may experience decadal-scale (hiatus) periods without warming despite an indisputable long-term warming trend. A large range of factors have been proposed to explain these non-warming decades, like volcanic cooling, reduced solar energy input, low stratospheric water vapor content, elevated tropospheric aerosols, internal variability of the climate system, or a combination thereof.

We have analysed 17 global climate models participating in phase 5 of the Coupled Model Intercomparison Project (CMIP5), identifying the likelihood and duration of periods without warming in the four Representative Concentration Pathway (RCP) scenarios RCP2.6, RCP4.5, RCP6.0 and RCP8.5, together with the preindustrial control and historical simulations. We find that non-warming periods, when the effect of volcanic eruptions and variations in the solar cycle are neglected, may last for up to 10, 15 and 30 years for RCP8.5, RCP6.0 and RCP 4.5, respectively.

Regionally, the likelihood of a decadal-scale hiatus periods decrease first in the tropical Atlantic, Indian Ocean and western Pacific with increasing global temperatures in the RCP scenarios. The North Atlantic and the Southern Ocean are the regions with largest variability relative to the regional warming signal.

As a response to the global temperature increase, the radiative imbalance at top of the atmosphere increases and the global oceans warm. This holds for both the upper and the deep ocean in all scenarios. In the CMIP5 simulations, anomalous uptake and storage of ocean heat are the main factors explaining the decadal-scale surface temperature hiatus periods. The tropical East Pacific is a key region for these variations, acting in tandem with basin-scale anomalies in the sea level pressure. On sub-decadal time scales, ocean storage of heat is largest and comparable in magnitude in the Pacific and Southern Oceans, followed by the Atlantic Ocean. We find no relation between the decadal-scale hiatus periods and the decadal net top of atmosphere radiation variability.