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Changes in the global atmospheric energy transport separated by spatial scales in a warming world

Patrick Stoll[1], Rune Grand Graversen[1], Tuomas Ilkka Henrikki Heiskanen[1], and Richard Bintanja[2]
[1]University of Tromsø, Department of Physics and Technology, Tromsø, Norway (pst019@post.uit.no)
[2]Royal Netherlands Meteorological Institute (KNMI), RDWK Netherlands

The global atmospheric circulation determines the local weather and climate. To better understand this circulation and how it may change in a warming world, we separate the atmospheric energy transport by the spatial scale, the quasi-stationary and transient nature, and the latent and dry-static component in the ERA-5 reanalysis and climate-model simulations with EC-Earth. Different to previous studies that distinguish the scale by wave-numbers, here the meso, synoptic and planetary scales are separated at wavelengths below 2000km, between 2-8000km, and above the latter, respectively. The scale (wavelength) of most transient energy transport is around 5000km for all latitudes and is associated with baroclinic, synoptic-scale cyclones. Transient, synoptic-scale waves are the largest contributor to the energy transport at all latitudes outside the tropics, where the meridional overturning circulation is dominant. Planetary-scale waves are both of quasi-stationary and transient character, strongest at latitudes with much orography, and responsible for most of the inter-annual variability of the energy transport. The energy transport associated with mesoscale waves is negligible.

In a warming world, the moisture transport increases everywhere and in all components, however strongest for planetary waves, making dry areas dryer and moist areas moister, and supporting large and long-lasting events that favour floods and droughts. The total energy transport increases at latitudes smaller than 60 degrees, with the main contribution from quasi-stationary, planetary-scale waves, indicating that weather patterns become more persistent. The changing energy transport can be associated both with changing zonal gradients in temperature and with an atmospheric circulation that becomes more effective in transporting energy.