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The rate of information transfer as a measure of ocean-atmosphere interactions

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Exchanges of momentum, energy and mass between the ocean and atmosphere are of large importance in regulating the climate system. Here we apply the Liang-Kleeman rate of information transfer to quantify interactions between the upper ocean and lower atmosphere over the period 1988-2017 at monthly time scale in two different case studies. In the first case study, we investigate dynamical dependencies between sea-surface temperature (SST), SST tendency and turbulent heat flux in satellite observations. We find a strong two-way influence between SST or SST tendency and turbulent heat flux in many regions of the world, with largest values in eastern tropical Pacific and Atlantic oceans, as well as in western boundary currents. The total number of regions with a significant influence of turbulent heat flux on SST and SST tendency is reduced when considering the three variables, suggesting an overall stronger ocean influence compared to the atmosphere. In the second case study, we focus on the influence of ocean heat transport convergence (dynamical influence) and net surface heat flux (thermodynamical influence) on upper ocean heat content tendency in three global climate models with at least two different ocean resolutions. We find that low-resolution model configurations (1° in the ocean) show a much larger number of regions with a significant dynamical influence compared to high-resolution model configurations. The reason for the large difference in dynamical influence between low and high resolutions partly comes from the spatial distribution of ocean velocity field, which displays a larger spatial variability at high resolution.