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On strong large-scale ocean evaporation and its relevance for deuterium excess in evaporation and precipitation

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The relevance of strong large-scale ocean evaporation (SLOE) for deuterium excess in evaporation (de) and precipitation (dp) is discussed here using the 36-year reanalysis dataset ERA-Interim from the European Centre for Medium Range Weather Forecast (ECMWF) and data from several stations of the Global network of isotopes in Precipitation (GNIP) in the North Atlantic and the Southern Ocean. SLOE is identified using an "evaporation-efficiency" diagnostic delimiting large-scale areas of ocean evaporation, in which the surface evaporation flux is large compared to the near surface precipitable water in the atmosphere. This ensures that the identified evaporation events have a large impact on the locally available near-surface humidity. SLOE is particularly frequent along the warm ocean western boundary currents and their extensions, downstream of large continental areas and at the sea-ice edges. An analysis of the past history and fate of air parcels involved in cold season SLOE in the North Atlantic and the Southern Indian Ocean shows that cold-air advection over warm ocean surfaces is the main dynamical mechanism that induces these events. Extratropical cyclones thereby play a central role as a driver in setting the necessary equatorward synoptic flow pattern. The isotope signature associated with the evaporation flux during SLOE thus sets the isotope signature of the low-level moisture, justifying the approximation that the system follows the closure assumption. Distinct positive anomalies of de during SLOE with global mean values of 12-23‰ result from the strong near-surface air-sea humidity gradients characterizing these events. The sensitivity of SLOE de to its climate controls involved in the widely used isotope evaporation parametrisation, the Craig-Gordon Equation, is analysed for different formulations of the non-equilibrium fractionation factor. The Eulerian hotspots of strong atmospheric moisture uptake identified in this study may play an important role in shaping the stable water isotope signature of mid- to high latitude precipitation. An analysis of the relation between the interannual variations in dp at different GNIP stations and the occurrence frequencies of SLOE at the moisture source confirms this hypothesis.