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Are Atmospheric Rivers Lagrangian Coherent Structures?

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Most of the advective moisture transport from the tropics (main planetary precipitable water source) to mid-latitudes is not smooth and uniform. More than 90% of poleward water vapor transport is accomplished by narrow and elongated (longer than 2000 km and narrower than 1000 km) structures within the pre-cold frontal Warm Conveyor Belt (WCB) and Low Level Jet (LLJ) of extratropical cyclones, mostly associated to the polar front. These structures, labeled as Tropospheric or Atmospheric Rivers (ARs), are defined as areas of Integrated Water Vapor (IWV) column over 2 cm and strong winds, transporting water vapor whitin the lower troposphere (close to 1 km above the sea level).

Due to their nature, we analyzed these structures in terms of Lagrangian Coherent Structures (LCS), using the Finite-Time Lyapunov Exponents (FTLE).

In order to develop such analysis, we extract 2D-velocity field from vector flux fields over the North Atlantic Ocean, using vertical integrals of water vapor (Q) and eastward/northward water vapor flux (Φ_λ, Φ_ϕ), retrieved from the ECMWF Reanalysis (ERA-Interim) at a $0.7^\circ \times 0.7^\circ$ horizontal resolution. Such 2D-velocity fields are dominated by those layers with high water vapor flux content.

We carry out an Atmospheric River analysis in terms of the FTLE for a set of 10 strong events whit different shape (7 of them have a clear water transport filament shape and the rest have a scattered one) over the North Atlantic Ocean. To that end, we compare the LCS extracted from the FTLE fields computed backward and forward for 5 days with the ridge extracted from the vertical integral Q. We find that repelling LCS derived from the forward FTLE do not show any connection with the ARs. However, for the well defined AR there is a strong correlation between AR ridges and the attracting LCS and both present similar structures, whereas for the other ARs with scattered shape we do not find a principal LCS derived from the AR event.