Are Atmospheric Rivers attracting Lagrangian Coherent Structures in the wind field?

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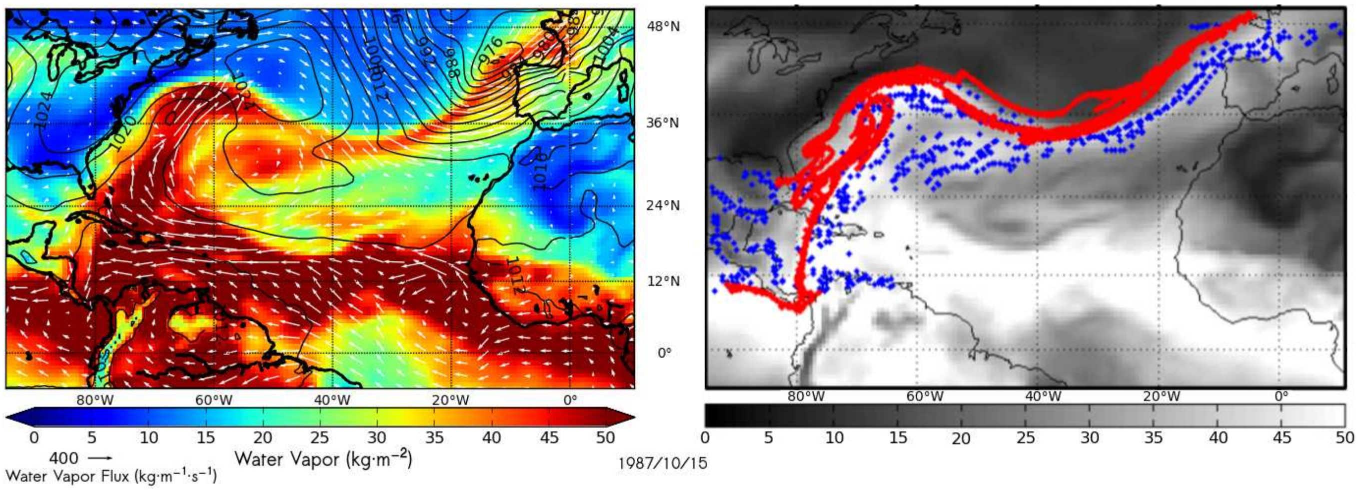

FIG. 1. Intense Atmospheric River impacting over the Iberian Peninsula (left) and the Lagrangian Coherent Structure (LCS) (ridge red points) calculated from the FTLE using the integrated column water vapor (right). Blue dots correspond to the ridge position of the Atmospheric River.

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 with very high water vapor content within the pre-cold frontal Warm Conveyor Belt (WCB) and Low Level Jet (LLJ) of extratropical cyclones[1] mostly associated to the polar front. These structures, labeled as Tropospheric or Atmospheric Rivers (ARs)[2], are defined as areas of Integrated Water Vapor (IWV) column over 2 cm and strong winds, transporting water vapor in the lower troposphere, close to 1 km above the sea level[3].

Due to their filamentous shape, these structures have been analyzed in terms of Lagrangian Coherent Structures (LCS), using the Finite-Time Lyapunov Exponents (FTLE)[4,5].

In order to develop such analysis, a 2D-velocity field from vector flux fields was extracted 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,

$$Q = \frac{1}{g}\int_0^1 q\frac{\partial p}{\partial \eta}d\eta \qquad (\Phi_\lambda, \Phi_\phi) = \frac{1}{g}\int_0^1 (u,v)q\frac{\partial p}{\partial \eta}d\eta \quad (1)$$

with η a hybrid vertical coordinate. Eastward and northward average drift velocities,

$$<\lambda> = \frac{\Phi_\lambda}{Q} \qquad <\phi> = \frac{\Phi_\phi}{Q} \quad (2)$$

were used at each grid point of the domain, so the velocity is dominated by those layers with high water vapor content.

An Atmospheric River analysis in terms of the FTLE was developed for 10 strong events 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 of water vapor variable Eq. (1). We found that repelling LCS derived from the forward FTLE do not show any connection with the ARs. However, there is a strong correlation between the AR ridges and the attracting LCS and both present similar structures, Fig. 1. This opens interesting possibilities for the understanding of the general circulation of the atmosphere.

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