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Transitions and irreversibility of weather regimes

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Weather regimes are usually defined as large typical clusters of atmospheric flows that are observed in an specific region. The methodology is based on dynamical systems theory and statiscal mechanics analysis of atmospheric variability. Weather regimes appear as sticky regions of the phase-space where the trajectories slow down, possible due to the vicinity of stationary solutions or quasi-stationary solutions. Numerous studies have characterized weather regimes using cluster analysis finding four stable clusters over the North Atlantic sector for sea-level pressure or geopotential height. However there are less information about their transitions.

Here, we have analysed the transitions between weather regimes and the irreversibility in the North Atlantic sea-level-pressure fields using NCEP/NCAR reanalysis and in an experimental turbulent flow, the von Karman flow, using the velocity orthogonal to the central plane. This flow is highly turbulent and features spontaneous transitions among metastable states and can be therefore considered as a proxy for atmospheric circulation

The results show that the states that do respect the symmetries of the flow are the one with the least irreversibility. They correspond to the zonal and antizonal regimes typical of the North Atlantic Oscillation (NAO + and NAO-). . The most irreversible transitions are between zonal flows and meridional flows as they break the time symmetry of the flow. There is a strong seasonal dependence. Winter is more irreversible than summer.

The results are confirmed in the von Karman flow.