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Regional changes in precipitation regimes between 850 A.D. and 2100: the role of the Integrated Water Vapor Transport

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A key contributor to extreme winter precipitation and flooding in Western Europe is the vertically integrated horizontal water vapor transport (IVT), particularly in the form of an Atmospheric River (AR) associated with an extratropical cyclone. There is a strong link between high values of the IVT and extreme precipitation over Western Europe (e.g. Iberian Peninsula and the UK). We use a long-term climatic simulation spanning between 850-2100 A.D. to analyze long-term variability in precipitation regimes in Western Europe and their links to the IVT activity. This simulation was performed with the Community Earth System Model (CESM 1.0.1), using a modified reconstruction of total solar irradiance, volcanic forcing and the RCP8.5 forcing scenario for the 21st century.

IVT fluxes along the Iberian and UK coastlines (defined as in Ramos et al., 2016) were compared against: a) precipitation series (large scale, convective and total) in those regions; and b) mean surface temperature in oceanic boxes west of those coastlines. Results show a steady increase in the mean IVT (superimposed to the inter-annual and inter-decadal variabilities) after the Industrial Period. This rise in moisture transport towards Western Europe is in line with the concurrent rise in surface temperatures. Nevertheless, while in the UK recent and projected rainfall changes follow this positive trend, the situation is different for Iberia. Here, the overall steady correlation between the IVT and precipitation (0.75) in the Pre-Industrial period is lost afterwards, particularly during the last 100 years of the simulation (21st century). Consequently, recent notable decreases in precipitation in this region are projected to exacerbate, in a magnitude much larger than those found during wetter/drier periods occurring within inter-annual and inter-decadal scales of the long-simulation. This reduction is substantial in autumn and spring months, and occurs in spite of the simultaneous expected rises in evaporative processes, moisture availability and AR frequency in a warming climate.

Finally, a Weather Type Classification (WTs) approach was used to explore changes in dynamical features. This analysis shows a significant increase (decrease) in the frequency of anticyclonic (cyclonic and/or westerly flow) days over Iberia, and an opposite response in the UK. As so, and despite gains in oceanic moisture availability and transport, recent and projected rainfall decreases in Southern Europe can be attributed to dynamical changes towards more frequent anticyclonic conditions, with a magnitude unprecedented at the time-scales of the long-simulation period. Results also suggest a shortening of the rainy season, as typical summer-like WTs extend towards November by the end of the 21st century.

Ramos AM, Nieto R, Tomé R, Gimeno L, Trigo RM, Liberato MLR, Lavers DA (2016) Atmospheric rivers moisture sources from a Lagrangian perspective. Earth Syst. Dynam., 7, 371–384, 2016. doi:10.5194/esd-7-371-2016

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