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Analysis of the transport of the plumes from coal power plants under typical circulation types over the Iberian Peninsula

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An important reduction of emissions has been registered in Spain in the 2004-2012 period, from 1400 Gg to 900 Gg for NO_x and from 1300 to 400 Gg for SO_2. However, coal power plants were the second contributor in electricity generation in Spain in 2012 (19.3% of total production). The associated annual emissions were 115 Gg of NO_x and 132 Gg of SOx (14% and 52% of total Spanish emissions). Air pollution has an impact on human health, close to and far from the sources, as well as for chronic and acute episodes. The main objective is to analyse the influence of typical circulation types (CTs) over NO_2 and SO_2 surface concentration and transport dynamics for a selection of nine Spanish power plants.

In order to obtain an automatic synoptic classification for the present climate (1983-2012) over the Iberian Peninsula for air quality purposes, a comprehensive sensitivity analysis is performed including tests of 12 classification techniques (correlation, cluster, principal component analysis), varying number of CTs, high to low temporal and spatial resolutions, and different domain sizes. The explained variation is used as metric to evaluate the separability and within-type variability of each resulting classification.

The best classification set-up uses a k-means clustering on daily sea level pressure and identifies six CTs that consistently represent different advective patterns towards the Iberian Peninsula. The two most common CTs occur in summertime, replacing one another. NWadv (23.9% of climatic frequency) is a NW advective pattern characterized by the arrival of polar maritime air masses towards the Iberian Peninsula. IBtl (22.4%) is compatible with the development of the Iberian thermal low with net advection from North African air masses at 500 hPa geopotential height. ENEadv (21%), especially frequent in spring, is the result of a blocking anticyclone over central Europe that leads to E-NE advection towards the Iberian Peninsula. AtlHi (12%) is a winter anticyclonic situation that enables the arrival of Atlantic air masses towards the Iberian Peninsula, whereas ZonWadv (10%) is characterised by zonal Atlantic maritime advection. WNWadv (10%) is typical of transitional seasons and it presents unstable conditions over the Iberian Peninsula with W-NW advection.

The analysis of the transport dynamics of the NO_2 and SO_2 concentrations for each CT does not show a common behaviour for the nine studied power plants. There is a superposition of synoptic, mesoscale and local circulations that explain the plume dynamics. However, synoptic patterns control the transport of pollutants from facilities located in continental and Atlantic areas and places with flat topography. The contribution of coal power plants on surface concentration at medium range distance (30-90 km) is higher for CTs with strong advection (NWadv & ZonWAdv) than for CTs characterised by local recirculations (IBtl) and unstable conditions (WNWadv). At short range distance (< 30 km), the plume dynamics depend more on the meso and local circulations, especially at power plants along the Mediterranean coast and in complex topographic regions.