EMS7/ECAM8 Abstracts,
Vol. 4, EMS2007-A-00033, 2007
7th EMS Annual Meeting / 8th ECAM

Characterization of the global hydrologic cycle in the Iberian Peninsula from a back-trajectory analysis of atmospheric water vapor

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The analysis and study of the precipitation over the Iberian Peninsula is proposed here from the widest possible point of view. We intended to describe, analyze, and finally to understand in detail how water vapor and precipitation interact across different spatial and temporal scales using a Lagrangian atmospheric transport model. The acquired knowledge will be useful to improve the present meteorological and climatic models. Additionally, many recent papers have emphasized on the diagnosis of increasing trends of extreme precipitation events, probably related to changes induced in the climate system by anthropogenic activities. Thus, on the short term, a better understanding of the water cycle across its different scales will lead to an improved forecasting system for potentially disastrous events. On the long term, scenarios of future variations in precipitation due to climate change will be foreseen with more reliability if the complete water cycle across different scales is included in the forecasting model.

In recent works a robust Lagrangian method of diagnosis has been applied to determine the source of moisture in a basin [Stohl and James, 2004, 2005; Nieto et al. 2006, 2007]. This method is based on the combined use of meteorological analysis data, a particle dispersion model, and a Lagrangian analogue to the Eulerian budget method for diagnosing the surface moisture flux. Therefore, the main objective of this study is to exploit this Lagrangian method of diagnosis to identify the main sources of moisture and precipitation over the Iberian Peninsula, by means of backward tracking the air masses that ultimately reach the Iberia. Here we employ the Lagrangian particle

dispersion model FLEXPART [Stohl et al., 1998] and meteorological analysis data from the ECMWF to track atmospheric moisture along back trajectories of 1398801 particles. This was done for a five-year period (2000–2004) and using ECMWF operational analysis available every six hours (00, 06, 12 and 18 UTC) with a 1ºx1º resolution. We traced (E-P) backwards from the Iberian Peninsula region, limiting the transport times to 10 days, which is the average time that water vapour resides in the atmosphere. All the particles residing over the Iberian region were identified every six hours and tracked backwards for 10 days. We calculated (E-P) on a 1ºx1º grid and averaged over seasonal, annual and five-year periods. Moreover taking into account the large spatio-temporal variability of the water cycle over Iberia we have computed E-P for four relatively homogeneous climatological areas inside the Iberian Peninsula (North-West, North, Eastern-Mediterranean and South-Central).

As an example of our results we summarize briefly those derived from the annually (E-P) fields on the first, second, third, fifth, and tenth days of transport and averaged over all 10 days that the moisture. Considering only one day back in time, most of the air resided over the Iberian Peninsula itself and maritime surrounding areas. Values of E-P were negative over the Atlantic Ocean (the so-called “tropospheric rivers” up growing the moisture to Warm Conveyor Belts). E-P was positive over the Iberian Peninsula and the closest oceanic areas (Mediterranean Sea and Cantabric Sea), which indicates that the moisture over the Iberian Peninsula region has a strong contribution from the soil moisture. Similar source regions can be observed for E-P at two and three days back in time with a logical expansion to the west and east over the Oceans. This displacement continued in the fifth day of transport, but now with the Mexican Gulf appearing as a new source of moisture. Averaged over all 10 days of transport, there is a strong moisture uptake over the Iberian Peninsula itself (which indicates the importance of recycling), the North Atlantic coasts down to Canary Islands, the West Mediterranean area, and the tropical North Atlantic Ocean, including the Mexican Gulf. These patterns of the E-P fields were robust for the whole Iberian Peninsula, so similar structures appeared when the analysis was done on different regions inside the Peninsula. Moreover these sources appear to be independent on the analysis being done at the annual or seasonal level. The largest differences appear for summer, with more recycling and higher values of E-P over the surrounding seas. During fall and winter the Mexican Gulf source showed a displacement to the north. Finally, large differences concerning the magnitude of the recycling component appear when a regional study was done.