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Climate Feedbacks in Europe: MODIS evidence of a water vapour accumulation mode in the Mediterranean, and implications for drought in Southern Europe

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Around the Mediterranean sea, deserts and desert-like conditions can be found in close proximity to a very warm sea and thus to a marine airmass with a high moisture content, e.g., the coasts of Morocco, Algiers, Tunisia, Libya, and Almeria in Southeastern Spain. These regions were covered with vegetation in historical times, e.g., during the Roman Empire, and in the case of Almeria, just 150 years ago, before the forests were used to fuel lead mines. The question is: did forest removal cause them to run a feedback cycle towards desertification? The reanalysis of results from seventeen EC research projects suggests that this could be the case.

This work shows that the hydrological system in this region is very sensitive to land-use changes and, more recently, to air pollution effects as well. Both of these can combine to exceed critical threshold levels, e.g, the height of the cloud condensation levels with respect to the height of the coastal mountain ranges. This results in the loss of summer storms and tips the regional climate towards desertification and drought. The non-precipitated water vapour returns and accumulates over the Western Mediterranean Basin to heights reaching over 5000 m, for periods lasting from 3 to 10 days in summer.

Moreover, changes and perturbations to the hydrological cycle in any part of the basin can propagate to the whole basin and adjacent regions, and ultimately to the global climate system, through other mechanisms. These involve: (1) an increase in Mediterranean cyclogenesis in autumn-winter through cumulative (greenhouse) heating of the sea surface by the water vapour and the pollutants (ozone) accumulated over the sea, (2) the export of the accumulated water vapour and pollutants to other regions at the end of each 3-10 day accumulation-recirculation period, which can contribute to summer floods in Central-Eastern Europe and, in turn, (3) changes in the evaporation-self-precipitation balance over the Mediterranean, which increases its salinity and drives the Atlantic-Mediterranean salinity valve.

Both the available data and the modelling results at regional scale indicate that these processes are already operating, and suggest that fundamental changes, and long-term perturbations to the water-cycle, are taking place right now. This information and the questions it raises are thus crucial for the water policies in the whole Mediterranean Region and in other European areas. Of particular importance is the question of their long term effects, since feedback processes on the hydrological cycle cannot be simulated properly in the Global Climate models used to assess future water scenarios in these regions.