Geophysical Research Abstracts
Vol. 21, EGU2019-14116, 2019
EGU General Assembly 2019

Satellite- based drought assessment in Spain: trends from a process- based Evapotranspiration model

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Droughts are one of the major threats to ecosystems worldwide. Meteorological droughts are caused by a deficit in precipitation or high temperatures over an extended period with severe consequences for environment, agriculture and society. Water-limited regions such as the Iberian Peninsula are predicted to be among the most affected areas by severe and recurrent droughts by the end of the 21st century. Mapping tools based on Earth Observation (EO) data to better understand drought development, extent and ecosystem recovery are highly needed. During drought events soil moisture decreases, vegetation gets stressed and as a consequence evapotranspiration (ET) is reduced from potential levels (PET). Land feedbacks to the atmosphere induced by changes in ET and energy balance can further amplify drought intensity and persistence. Therefore, ET is a key variable for understanding and mapping droughts. EO datasets can be used to model potential and actual evapotranspiration and drought indices can be developed based on the relationship between PET and ET. This way the availability of long EO datasets time series makes it possible to assess drought event dynamics in time and space.

The objective of this research is to assess drought dynamics in Spain from daily to inter-annual time scales in relation to changes in ET. We identified the periods and areas with higher drought occurrence (hotspots) using drought indices derived from MODIS satellite data. To assess drought, we used relationship between PET and ET at a high spatial resolution of 1.1 km for 17 years. Two drought metrics were used: the ratio between ET and PET and the difference between PET and ET. They were calculated using a modified version of the two source PT-JPL (Priestley Taylor –Jet Propulsion Laboratory) model at daily time scale. Inputs included products from both MODIS Terra and Aqua sensors to ensure better temporal coverage at 1.1 km (land surface temperature, emissivity, albedo, NDVI, Leaf area index and fraction of absorbed PAR). We also used a climatic dataset interpolated to a high spatial resolution of 1.1 km from meteorological stations for air temperature, shortwave incoming radiation and precipitation. A key part of the study is the matching in the spatial resolution of satellite and climatic datasets instead of using typical coarse climatic reanalysis datasets to avoid obscuring relevant climatic spatial patterns.

Using Empirical Orthogonal Function analysis, we found significant differences in drought impacts over space and time and significant temporal trends in the metrics derived from ET. In addition, some of the drought impacts were only observable at high temporal resolution. We also generated maps showing the hotspots where more depth analysis can be performed and mitigation actions could be targeted.