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Climatic drivers of vegetation based on wavelet analysis

Jeroen Claessen (1), Brecht Martens (1), Niko E.C. Verhoest (1), Annalisa Molini (2), and Diego Miralles (1)

(1) Laboratory of Hydrology and Water Management, Ghent University, Ghent, Belgium, (2) Institute Center for Water and Environment (iWATER), Masdar Institute of Science and Technology, P.O. Box 54224, Abu Dhabi, United Arab Emirates

Vegetation dynamics are driven by climate, and at the same time they play a key role in forcing the different bio-geochemical cycles. As climate change leads to an increase in frequency and intensity of hydro-meteorological extremes, vegetation is expected to respond to these changes, and subsequently feed back on their occurrence. This response can be analysed using time series of different vegetation diagnostics observed from space, in the optical (e.g. Normalised Difference Vegetation Index (NDVI), Solar Induced Fluorescence (SIF)) and microwave (Vegetation Optical Depth (VOD)) domains. In this contribution, we compare the climatic drivers of different vegetation diagnostics, based on a monthly global data-cube of 24 years at a 0.25° resolution. To do so, we calculate the wavelet coherence between each vegetation-related observation and observations of air temperature, precipitation and incoming radiation. The use of wavelet coherence allows unveiling the scale-by-scale response and sensitivity of the diverse vegetation indices to their climatic drivers.

Our preliminary results show that the wavelet-based statistics prove to be a suitable tool for extracting information from different vegetation indices. Going beyond traditional methods based on linear correlations, the application of wavelet coherence provides information about: (a) the specific periods at which the correspondence between climate and vegetation dynamics is larger, (b) the frequencies at which this correspondence occurs (e.g. monthly or seasonal scales), and (c) the time lag in the response of vegetation to their climate drivers, and vice versa. As expected, areas of high rainfall volumes are characterised by a strong control of radiation and temperature over vegetation. Furthermore, precipitation is the most important driver of vegetation variability over short terms in most regions of the world – which can be explained by the rapid response of leaf development towards available water content – while at seasonal scales the vegetative response is dominated by solar radiation in most regions. At the higher latitudes, the trends in all vegetation diagnostics agree with the hypothesis of a greening pattern explained by the increase in temperature. At the same time, substantial differences can be observed between the responses of the different vegetation indices as well. As an example, the VOD – thought to be a close proxy for vegetation water content – shows a larger sensitivity to precipitation than traditional optical indices like the NDVI. Our findings help to further understand the physical attributes of vegetation that each remotely-sensed vegetation index is responding to in order to optimize their use in global bio-geoscience research.