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Analysing vegetation phenology in response to climate change using enhanced bioclimatic indices in Iraq

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Exchanges of momentum, heat, carbon dioxide, energy, water and mass between the land's surface and the atmosphere are significantly affected by the phenological state of vegetation. Although, most phenology models have the function in analysing and predicting future trends in response to climate change, a bioclimatic index including precipitation in has not been adequately considered in the existing phenology models.
In this study a new variable is added to the common set of variables found in the literature review and it is demonstrated how these variables could be combined into an index to quantify the greenness of vegetation throughout the three different years that have been selected (2001, 2006, and 2010). These four selected variables are: Suboptimal (minimum) temperatures, evaporative demand (vapour pressure deficit), photoperiod (daylength), and precipitation.
Threshold limits (a lower threshold and an upper threshold) have been set for individual variables, within which the relative phenological performance of the vegetation is assumed to vary from inactive (0) to unconstrained (1). A combined Growing Season Index (GSI) is derived as the product of the four indices. The mean GSI values over twenty one days for the study area during the study period showed a good correlation with the MODerate-resolution Imaging Spectroradiometer (MODIS) and the derived Normalized Difference Vegetation Index (NDVI).
The model has been tested for different locations in Iraq (Sulaymaniyah in the north, Wasit in the centre and Basrah in the south) by comparing the model results for these areas with the addition of the precipitation variable and without. The correlation for this model has been improved significantly after adding precipitation as an index in the GSI model. The modified model appears suf[U+FB01]ciently robust to reconstruct historical variation as well as to forecast possible future phenological responses to changing climatic conditions. This study is of important value for understanding the Iraqi region as it considers the results of climatic and environmental changes that took place in the region in recent decades.