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Identification of homogeneous phenological patterns for the characterization of vegetation recovery times on climatic scales

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The estimation of spatial and temporal dynamics of vegetation covers is critical for both regional and global change researches. A key parameter to evaluate the status of vegetation is its resilience, which is a measure the recovery rate of vegetation from environmental shock. In particular, it is expected to be reduced in areas affected by prolonged stress of anthropic or climatic origin. In this framework, satellite observations are the main source of information for characterizing vegetation cover. They provide not only vegetation cover maps to be directly assimilated into the models, but also precious information on vegetation dynamics at different spatial and temporal scales to be used for improving the models themselves. In order to evaluate the vegetation resilience on climatic scales for the whole Italian territory, we analyzed a time series (1982-2003) of NDVI maps derived form the Global Inventory Modeling and Mapping Studies (GIMMS) dataset. Firstly, to obtain homogeneous areas from a phenological point of view, we performed a temporal clustering on monthly NDVI data averaged from the entire time series. Results were compared with land cover and climatic region classifications. With a low number of clusters, phenological patterns roughly correspond to the principal land covers (e.g., forests, maquis, cultivations); by increasing the number, the identified patterns take also into account the different climatic conditions for a given land cover. The optimal number of clusters was evalu-

ated as a trade-off between the efficacy of ecosystem representation and the dimension of clusters (pixels number) suitable for the subsequent analysis. The second step was the estimation of the persistence probability of NDVI trends for each cluster. It measures the probability that the vegetation activity level of a given stand deviates from a reference level for a time interval before returning back to it. Finally, by fitting the obtained probability functions with an exponential decay law, we estimated the mean recovery times from negative and positive NDVI trends and compared them since the presence of negative trends with persistence longer than the positive ones can be a sign of reduced vegetation resilience. The analysis of the characteristic recovery times highlighted signs of reduced resilience in some areas of the Italian territory in accordance with results obtained from independent studies, such as the identification of areas vulnerable to desertification processes or the detection of signs of forest deterioration linked directly or indirectly to climate change as prolonged drought or the consequent increase in parasite and fungi attacks. On the whole, the integrated analysis on phenological clustering and satellite-derived vegetation resilience have proved to be a suitable approach for evaluating the response of vegetation to climate change and for improving models in the context of hydrological and climate studies.