Evaluating how ERA5 reanalysis copes with changing vegetation

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Abstract

The dynamic nature of vegetation cover has an important role in modulating land-climate interactions. The rise and fall in total leaf area following the seasonal growth of vegetation not only alters the terrestrial surface albedo, but also evapotranspiration and surface roughness. Land cover change has the similar effects but in a more abrupt fashion. Together, all these changes can alter the surface temperature, the convective cloud regime and the quantity of water available for growth, ultimately affecting the carbon capture capacity of the land sink. Earth Observation (EO) is an invaluable tool to monitor these changes in land surface properties, but what is often required in Earth System Science is an integrated approach in which the underlying processes are also linked within a deterministic modelling scheme to enable forecasting future events.

The Copernicus Climate Changes Services (C3S) aims at providing reliable access to high-quality authoritative climate data. One of the flagship products is the European Centre for Medium Range Weather Forecasting (ECMWF) climate reanalysis ERA5 dataset, which provides a large array of land surface fields based on a combination of a land surface model (HTESSEL) with a data assimilation system to 'reanalyse' archived observations. However, HTESSEL uses a limited representation of the land-atmosphere interactions regarding vegetation and land cover. Leaf area index (LAI) is prescribed in the model with a monthly climatology derived from MODIS data, while in reality LAI changes dynamically from one year to the next depending on the interannual variability of the weather and on land management practices. This means that when there is a substantial difference between real LAI from the climatological value, the land surface properties are not well represented in the model, which could lead to discrepancies in the surface energy balance and have repercussions on the quality of the reanalysis product, but also on the forecasting skills. Furthermore, the HTESSEL model also runs with a static and outdated map of land cover. Actual changes in land cover can further create discrepancies within the simulations, which can further affect the quality of the reanalysis and reduce the forecasting skills.

In this study, we dress a global diagnostic of the performance of ERA5 under these considerations. We compare ERA5 biophysical variables with equivalent variables derived from various remote sensing datasets, such as those derived in ESA's Climate Change Initiative (CCI). We focus on places and events in which there are strong deviations between observed LAI and climatological LAI, and quantify the associated discrepancies in land surface temperature (LST), albedo, soil moisture, cloud cover and evapotranspiration based on independent EO data streams. This comprehensive diagnostic should provide a clear indication of where to prioritize improvements in the ECMWF system, which should improve both climate reanalysis quality and weather forecasting skill.

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