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Multi-scale enhancement of climate prediction over land by increasing the model sensitivity to vegetation variability in EC-Earth

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The EC-Earth earth system model has been recently developed to include the dynamics of vegetation. In its original formulation, vegetation variability is simply operated by the Leaf Area Index (LAI), which affects climate basically by changing the vegetation physiological resistance to evapotranspiration. This coupling has been found to have only a weak effect on the surface climate modeled by EC-Earth. In reality, the effective sub-grid vegetation fractional coverage will vary seasonally and at interannual time-scales in response to leaf-canopy growth, phenology and senescence. Therefore it affects biophysical parameters such as the albedo, surface roughness and soil field capacity. To adequately represent this effect in EC-Earth, we included an exponential dependence of the vegetation cover on the LAI. By comparing two sets of simulations performed with and without the new variable fractional-coverage parameterization, spanning from centennial (20th Century) simulations and retrospective predictions to the decadal (5-years), seasonal and weather time-scales, we show for the first time a significant multi-scale enhancement of vegetation impacts in climate simulation and prediction over land. Particularly large effects at multiple time scales are shown over boreal winter middle-to-high latitudes over Canada, West US, Eastern Europe, Russia and eastern Siberia due to the implemented time-varying shadowing effect by tree-vegetation on snow surfaces. Over Northern Hemisphere boreal forest regions the improved representation of vegetation cover tends to correct the winter warm biases, improves the climate change sensitivity, the decadal potential predictability as well as the skill of forecasts at seasonal and weather time-scales. Significant improvements of the prediction of 2m temperature and rainfall are also shown over transitional land surface hot spots. Both the potential predictability at decadal time-scale and seasonal-forecasts skill are enhanced over Sahel, North American Great Plains, Nordeste Brazil and South East Asia, mainly related to improved performance in the surface evapotranspiration.