Impacts of updated green vegetation fraction data on WRF simulations of the 2006 European heat wave

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Climate change studies suggest an increase in heat wave occurrences over Europe in the coming decades. Extreme events with excessive heat and associated drought will inevitable impact the seasonal course of the vegetation and lead to alterations in the partitioning of the surface energy. In this study, the atmospheric conditions during the heat wave year 2006 over Europe were simulated using the Weather Research and Forecasting (WRF) model. To account for the drought effects on the vegetation, new high resolution representations of green vegetation fraction (GVF) were developed for the domain. These GVF products are based on NDVI data from MODIS satellite images. To minimize impacts from low-quality satellite retrievals in the NDVI series, as well as for comparison with the default GVF climatology applied in WRF, a new background climatology using 10 recent years of images was also developed. The relationship between NDVI and GVF is under debate and both a linear and a quadratic formulation for the year of 2006 were evaluated. The grid size of the new GVF products is 1 km^2 and the temporal resolution is 8 days.

The seasonal course of the new GVFs was compared to the default GVF data in WRF at 18 km^2 grid resolution for the most common land use classes in the domain. The new climatology generally has higher GVF levels throughout the year, where autumnal extended growth season is the most marked feature. A clear indication of vegetation stresses related to heat and drought was found in the explicit 2006 GVF representations as expected. The GVF product based on a quadratic NDVI relationship shows the best agreement with the levels and seasonal range of the default input data, in addition to including updated information of the seasonal course for various land use classes.

The application of the new GVF products in WRF was tested and found to work well for the spring of 2006 where the difference between the default and new GVF products was small. The WRF 2006 heat wave simulations were verified by comparison with daily gridded data of mean, minimum and maximum temperature and daily precipitation. The simulation using the new GVF product with a quadratic relationship to NDVI resulted in a consistent improvement of modeled temperatures during the heat wave period, where the mean temperature cold bias of the model was reduced by 10% for the whole domain and by 30-50% in areas severely affected by the heat wave. The improvement of the minimum temperature was generally higher, whereas maximum temperature was less improved and the impact on precipitation was not significantly altered. The results show that model simulations during heat waves require updated land cover description in order to obtain reliable results.