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Relating trends in land surface-air temperature difference to soil moisture and evapotranspiration

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Soil water is central to both physical and biogeochemical processes within the Earth System. Drying of soils leads to evapotranspiration (ET) becoming limited or "water-stressed" and is accompanied by rises in land surface temperature (LST), land surface-air temperature difference (delta T), and sensible heat flux. Climate models predict sizable changes to the global water cycle but there is variation between models in the time scale of ET decay during dry spells. The e-stress project is developing novel satellite-derived diagnostics to assess the ability of Earth System Models (ESMs) to capture behaviour that is due to soil moisture controls on ET.

Satellite records of LST now extend 15 years or more. MODIS Terra LST is available from 2000 to the present and the Along-Track Scanning Radiometer (ATSR) LST record runs from 1995 to 2012. This paper presents results from an investigation into the variability and trends in delta T during the MODIS Terra mission. We use MODIS Terra and MODIS Aqua LST and ESA GlobTemperature ATSR LST with 2m air temperatures from reanalyses to calculate trends in delta T and "water-stressed" area. We investigate the variability of delta T in relation to soil moisture (ESA CCI Passive Daily Soil Moisture), vegetation (MODIS Monthly Normalized Difference Vegetation Index) and precipitation (TRMM Multi-satellite Monthly Precipitation) and compare the temporal and spatial variability of delta T with model evaporation data (GLEAM).

Delta T anomalies show significant negative correlations with soil moisture, in different seasons, in several regions across the planet. Global mean delta T anomaly is small (magnitude mostly less than 0.2 K) between July 2002 and July 2008 and decreases to a minimum in early 2010. The reduction in delta T anomaly coincides with an increase in soil moisture anomaly and NDVI anomaly suggesting an increase in evapotranspiration and latent heat flux with reduced sensible heat flux.

In conclusion there have been distinct signals in delta T during recent decades and these provide an independent assessment of hydrologically-forced changes in the land surface energy balance which can be used as a metric for the assessment of Earth System Model and global surface flux products.