A physically-based drought product using thermal remote sensing of evapotranspiration

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Thermal infrared (TIR) remote sensing of land-surface temperature (LST) provides valuable information about the sub-surface moisture status. While empirical indices measuring anomalies in LST and vegetation amount (e.g., as quantified by the Normalized Difference Vegetation Index; NDVI) have demonstrated utility in monitoring drought conditions over large areas, they may provide ambiguous results when other factors (radiation, advection, air temperature) are affecting plant stress. A more physically based interpretation of LST and NDVI and their relationship to sub-surface moisture conditions can be obtained with a surface energy balance model driven by TIR remote sensing. This approach, the Atmosphere-Land Exchange Inverse (ALEXI) model, couples a two-source (soil+canopy) land-surface model with an atmospheric boundary layer model in time-differencing mode to routinely and robustly map fluxes across the U.S. continent at 5-10km resolution using thermal band imagery from the Geostationary Operational Environmental Satellites (GOES). The moisture stress is quantified in terms of the reduction of evapotranspiration (ET) from the potential rate (PET) expected under non-moisture limiting conditions. A derived Evaporative Stress Index (ESI), given by 1-ET/PET, shows good correspondence with standard drought metrics and with patterns of antecedent precipitation, but at significantly higher spatial resolution due to limited reliance on ground observations. Higher resolution drought assessments can be generated through spatial disaggregation using TIR data from polar orbiting instruments such as Landsat (60-120m) and MODIS (1km).

The ALEXI ESI algorithm is diagnostic and does not require precipitation or soil texture information, unlike most other drought models. In addition, ALEXI has potential of global applications once properly integrated with other geostationary meteorological satellite systems, such as the European METEOSAT and the Chinese FY-2B. With ESI being an independent means for assessing drought conditions, it has significant potential for enhancing the existing suite of drought monitoring products. Work is underway to further evaluate multi-scale ESI implementations over the U.S. and other continents with geostationary satellite coverage.

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