Spatial and Interannual Variability of Agricultural Evapotranspiration in Nebraska using Two-source energy balance model ALEXI and VIIRS Satellite

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Accurate quantification of crop evapotranspiration (ET) is essential for irrigation water management, water allocation, and assessment of agricultural water productivity across the U.S. Great Plains. In this study, we present an eleven-year assessment from 2014 to 2024 of seasonal evapotranspiration across the state of Nebraska using the Atmosphere Land Exchange Inverse ALEXI two source energy balance model. ALEXI estimates surface fluxes by solving the coupled energy budgets of the soil and vegetation canopy separately, thereby accounting for heterogeneous surface conditions and partial canopy cover typical of row crop systems.

The ALEXI framework programmed at the supercomputer at University of Nebraska-Lincoln (Glodet.nebraska.edu), uses two land surface temperature observations from day and night overpasses by the Visible Infrared Imaging Radiometer Suite VIIRS sensor, a polar orbiting satellite instrument, to partition latent and sensible heat flux during the morning hours through an atmospheric boundary layer growth model. Net radiation is partitioned into soil and canopy components, and latent heat flux (LE) is retrieved as the residual of the energy balance after estimating sensible and soil heat fluxes. The two-source approach enables improved representation of crop phenology, canopy structure, and soil evaporation dynamics compared to single source models. Crop specific seasonal ET was derived by integrating annual land use classifications from the USDA National Agricultural Statistics Service CropScape program, which enabled consistent identification of major crops across the state of Nebraska.

Evapotranspiration maps show spatial and interannual variability in seasonal ET that is strongly linked to Nebraska's marked east to west precipitation gradient. Mean annual precipitation decreases substantially from the humid eastern portion of the state to the semiarid western High Plains, creating distinct hydroclimatic regimes. Consequently, rainfed crops in eastern Nebraska exhibit higher and more stable seasonal ET, while western regions show greater dependence on irrigation to sustain crop water use. Over the eleven years period, seasonal evapotranspiration dynamics for the major crops grown across Nebraska, including corn, soybean, winter wheat, and alfalfa, will be presented and analyzed, with emphasis on interannual variability and differences across the state's precipitation gradient.

The spatially distributed ALEXI derived ET maps, combined with CropScape land use information, provide consistent field to regional scale estimates suitable for long term water resource assessment. This 11-year dataset highlights the interaction between precipitation variability, irrigation practices and crop variety change across Nebraska's climatic gradient and supports improved irrigation scheduling, drought monitoring, and sustainable groundwater management.