JP4.3 REGIONAL SCALE ENERGY AND WATER FLUX CLIMATOLOGIES AS DERIVED FROM REMOTE SENSING INPUTS AND A LAND-EXCHANGE MODEL

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1. INTRODUCTION

Anderson et al. (1997) and Mecikalski et al. (1999) detail a method for evaluating fluxes of sensible and latent heat at the land surface using an Atmospheric Land-surface Exchange Inverse (ALEXI) model. As described in these papers, the ALEXI model is primarily driven by data that can be obtained from remote sensing instruments. These data include the AVHRR-derived fraction vegetation cover, 10.7-11.0 µm brightness temperatures and solar insolation from the GOES satellites, as well as satellite derived cloud amount information. Details of the GOES data stream can be found in Diak et al. (2003).

ALEXI is a so-called "two-source" model, the two sources being soil and vegetated components of a scene. Each of these scene subcomponents contributes to the radiometric temperature of the scene, taking into account the view angle of the GOES observation and, thus, the relative amounts of soil and vegetation being viewed.

The ALEXI model is used to generate high-resolution (5-10 km) maps of sensible (*H*), latent (*LE*) and ground (*G*) heat fluxes, along with net radiation (*NR*). In addition to these daily surface energy fluxes, evapotranspiration (*ET*) and soil moisture (*Aw*) are also produced. Figure 1 shows an example of instantaneous sensible heat flux at 1.5 hours before local noon produced by ALEXI at 10 km resolution while Fig. 2 demonstrates the production of daily-integrated fluxes from ALEXI.

Recent efforts have validated this modeling procedure to within 10-12% of surface- and tower-based instruments (Norman et al. 2002). In Norman et al., the ALEXI model was used with a Disaggregation ALEXI technique (DisALEXI) to compare the ALEXI flux fields to tower and aircraft

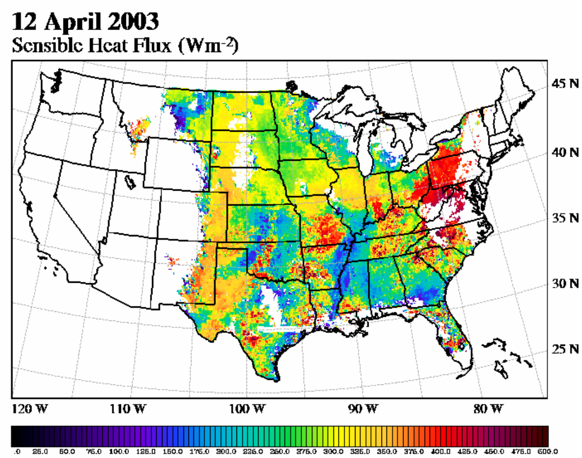

Figure 1: ALEXI sensible heat flux for 12 April 2003. Exceptionally clear-sky conditions over the eastern two-thirds of the US allowed retrieval of this field by ALEXI.

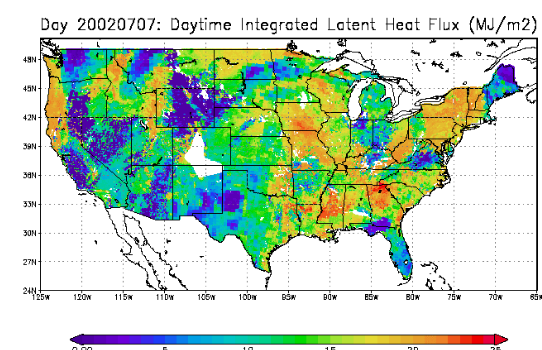

Figure 2: ALEXI daily-integrated latent heat flux for 7 July 2002. Through the use of hourly weather information and the assumption of a constant "evaporative fraction", daily fluxes can be estimated by ALEXI regardless of cloud cover.

flux measurements. Other recent work has involved the use of LandSat-ETM+ data within DisALEXI to estimate fluxes at 30 and 60 m resolution for comparison with ground-based measurements from the Oklahoma Mesonet. Mecikalski et al. (2003) overview an ongoing effort to validate 5 km ALEXI estimates against the 10

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Oklahoma Mesonet "SuperSites" for several mostly-clear sky days in 2001 and 2002. From this flux comparison effort, it was shown that ALEXI 5 km fluxes compare to within 30% of ground-based sensors, allowing us to have confidence in the regional-scale maps that ALEXI produces. Each of these studies demonstrates that ALEXI is a robust remote-sensing based method for estimating fluxes on micro- to regional scales. Current validation of ALEXI soil water and energy is being done through the analysis of data collected during the Soil Moisture Atmospheric Coupling EXperiment (SMACEX) field campaign in 2002 within the state of Iowa. Accurate tower and surface flux measurements, vegetation information and soil moisture measurements are available from SMACEX to assist in developing and testing the ALEXI scheme. Readers are encouraged to overview the above references in regards to the use of the ALEXI scheme.

In the remainder of this document, we will briefly describe the ongoing work related to the ALEXI model. This work includes: a) the development of a 2-year climatology of land-surface energy, evaporation and soil moisture (root zone, 6 cm-1.5 m, and surface layer, 0-6 cm) estimates over the continental United States and b) using the surface and root zone soil moisture estimates from ALEXI in a data assimilation system. This component being developed at the University of Alabama-Huntsville will strive to determine the quality of the ALEXI soil moisture estimates, as well as to gauge their impact on mesoscale weather prediction.

2. NEW COMPONENTS OF THE ALEXI MODEL

2.1 *Flux Climatology Work*

As of autumn 2003, the ALEXI model is run daily over the continental United States, the International H_20 Project (IHOP_2002) domain over the south-central Great Plains, the Soil Moisture EXperiment (SMEX) region centered on Iowa, and over a mesoscale region of the Tennessee River valley in northern Alabama and southern Tennessee (UAH). ALEXI-estimated sensible, latent, and ground heat fluxes and net radiation, as well as surface and root zone soil moistures are output for these domains. For the IHOP_2002, SMEX and UAH regions, field-experiment-specific 0.05 x 0.05-degree resolution (~5 x 5 km) fluxes are generated; for the U.S. domain, fluxes on a 0.1 x 0.1-degree grid (~10 x 10 km) are generated. These fluxes are computed at the end of a given day once GOES-10 and GOES-12 observations of surface radiometric temperature are available. The ALEXI flux estimates, along with all input variables, are displayed daily on the web at:

http://kang.ssec.wisc.edu/~alexi/USAlexi_home.html.

Daily flux estimates for the US domain will be used to develop a climatology of energy (*H*, *LE*, *G* and *RN*), *ET*, and the two *Aw* components (surface and root zone). Specific components of this climatology work will be to examine seasonal, regional, and specific land surface and water components of the surface energy system. Figure 3 illustrates a preliminary example of some simple 5- and 10-day latent heat flux averages.

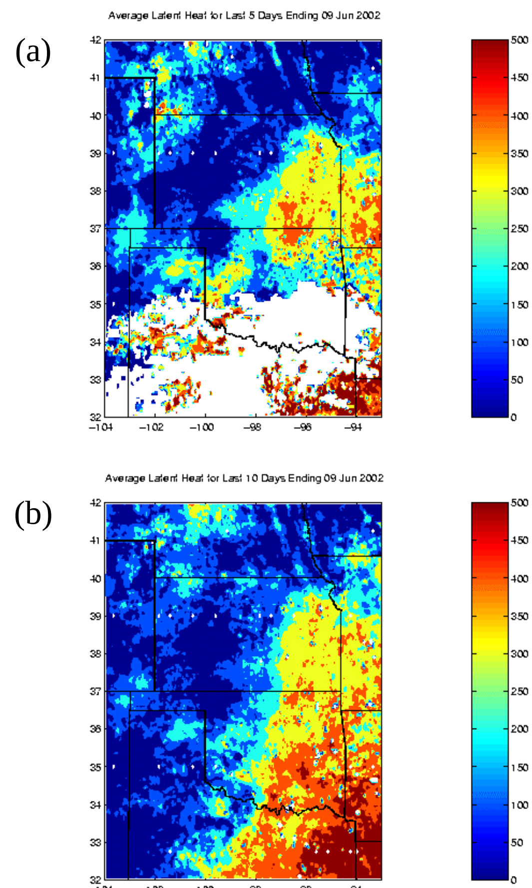

Figure 3: (a) ALEXI-derived average latent heat flux over the IHOP_2002 domain for the 5-day period ending on 9 June 2002. White areas represent regions that were never clear during this 5-day period. (b) Same as Fig. 3a but for the 10-day period ending on 9 June 2002.

2.2 *ALEXI Soil Moisture Assimilation*

ALEXI-derived soil water and ET estimates provide us an exciting opportunity to assess the value of this satellite-derived information on regional numerical weather prediction (NWP). This is, in essence, an excellent example of the assimilation of satellite-derived information that is particularly important to NWP, namely soil moisture and surface evaporation.

For this effort, the ALEXI soil moisture information will be infused into the Local Area Prediction System (LAPS) to create initialization data sets for regional forecasts. Model simulations will initially use the Penn State/ NCAR MM5, but will transition to the Weather Research and Forecast (WRF) model with time. The goal of this component of the work will be to assess the sensitivity of soil moisture information to various aspects of mesoscale weather, in particular, boundary layer growth and development, cloud development, and deep convection and convective initiation. This is expected to be a 2-3 year project that will evaluate via several case study days (and eventually real-time processing) the importance of correctly initializing soil moisture within a model. Using ALEXI ET estimates will also allow us to assess the influence of the land surface on regional/mesoscale NWP.

Figure 4 demonstrates the ability of ALEXI to estimate soil water. The 6-day composite of ALEXI system (soil+canopy) potential ET fraction (Fig. 4a) shows low "system stress" in areas with recent rainfall (Fig. 4b). The system potential ET fraction is used to estimate the canopy potential ET fraction, which is then used to estimate the root zone Aw. The soil potential ET fraction (surface layer Aw) is also determined at this time. These fields indicate that the recent rainfall over the Mississippi River valley has resulted in increased surface moisture (Fig. 4d) while only having a minimal impact on the amount of available water in the root zone (Fig. 4c). Key new work in the data assimilation arena will be to examine the ability of ALEXI to accurately estimate soil water content and to assess the value of such information.

The conference poster presentation will highlight the work accomplished to date, the specific plans of this research, as well as the important components of the project.

3. ACKNOWLEDGEMENTS

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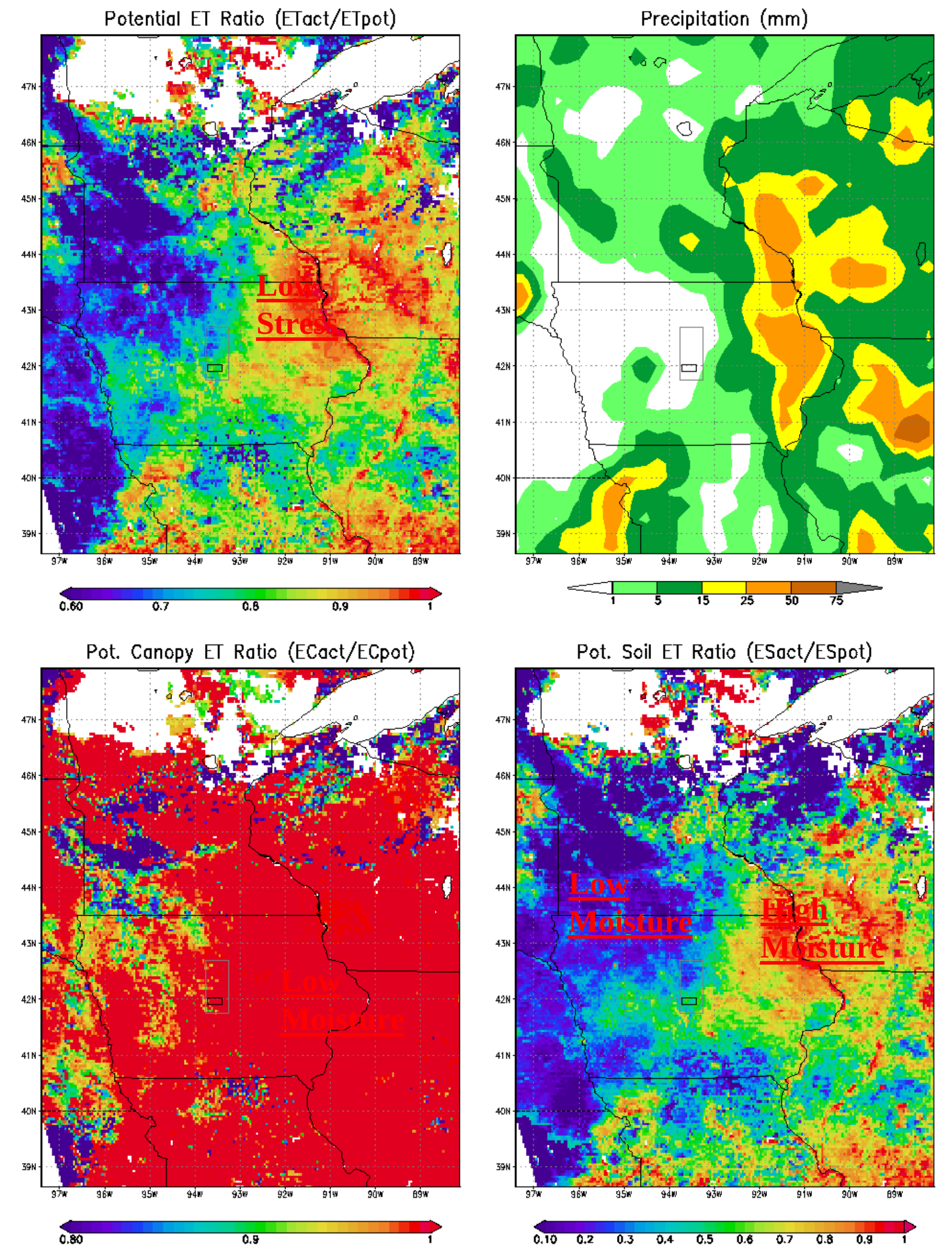

Figure 4: 6-day composite of (a) ALEXI system (soil+canopy) potential ET fraction, b) accumulated precipitation, c) canopy potential ET fraction (root zone available water), and d) soil potential ET fraction (surface layer available water) ending at 1 July 2002.