

# Simulating Energy, Water and Carbon Fluxes at the Shortgrass Steppe Long Term Ecological Research site

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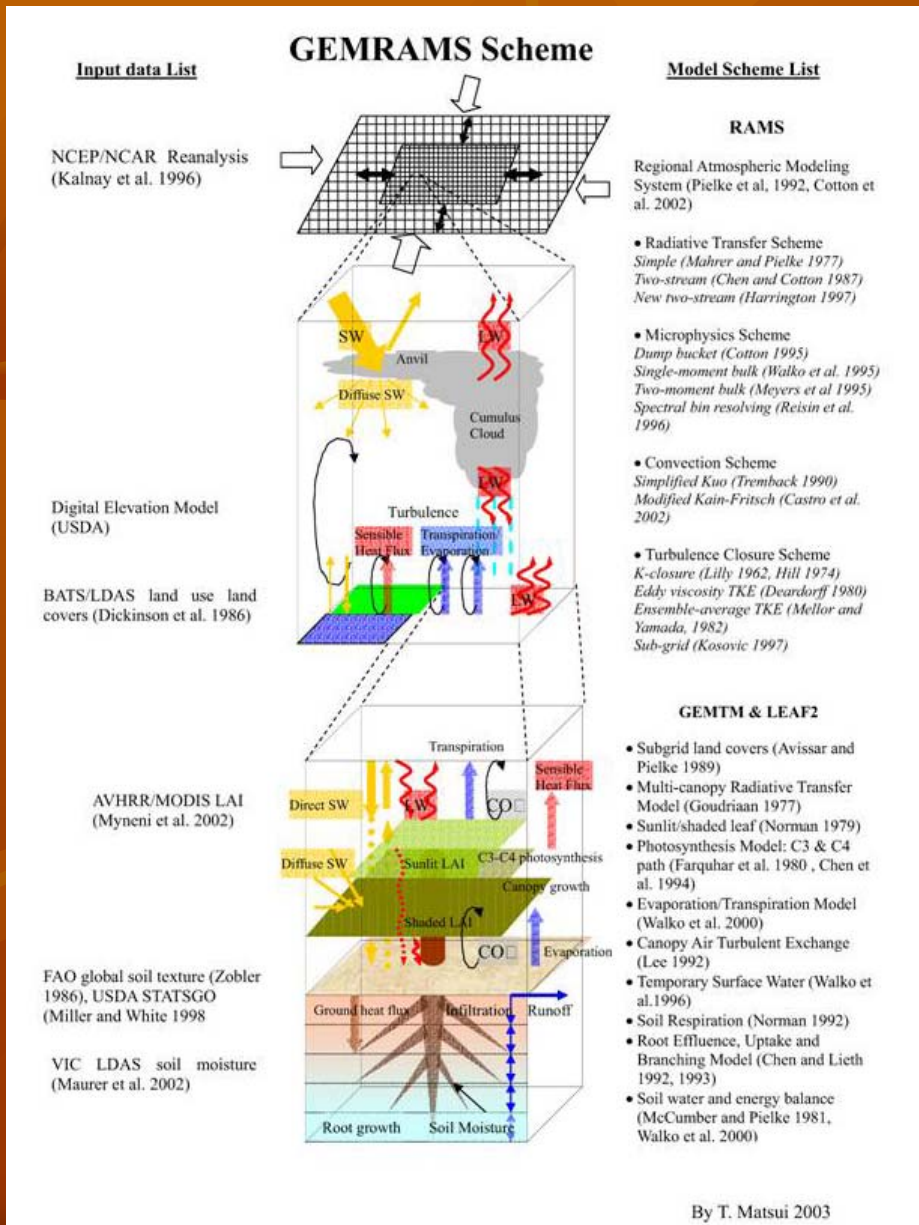
December 7, 2005



- *Land-surface changes affect surface energy fluxes, that in turn affect local and regional atmospheric conditions*

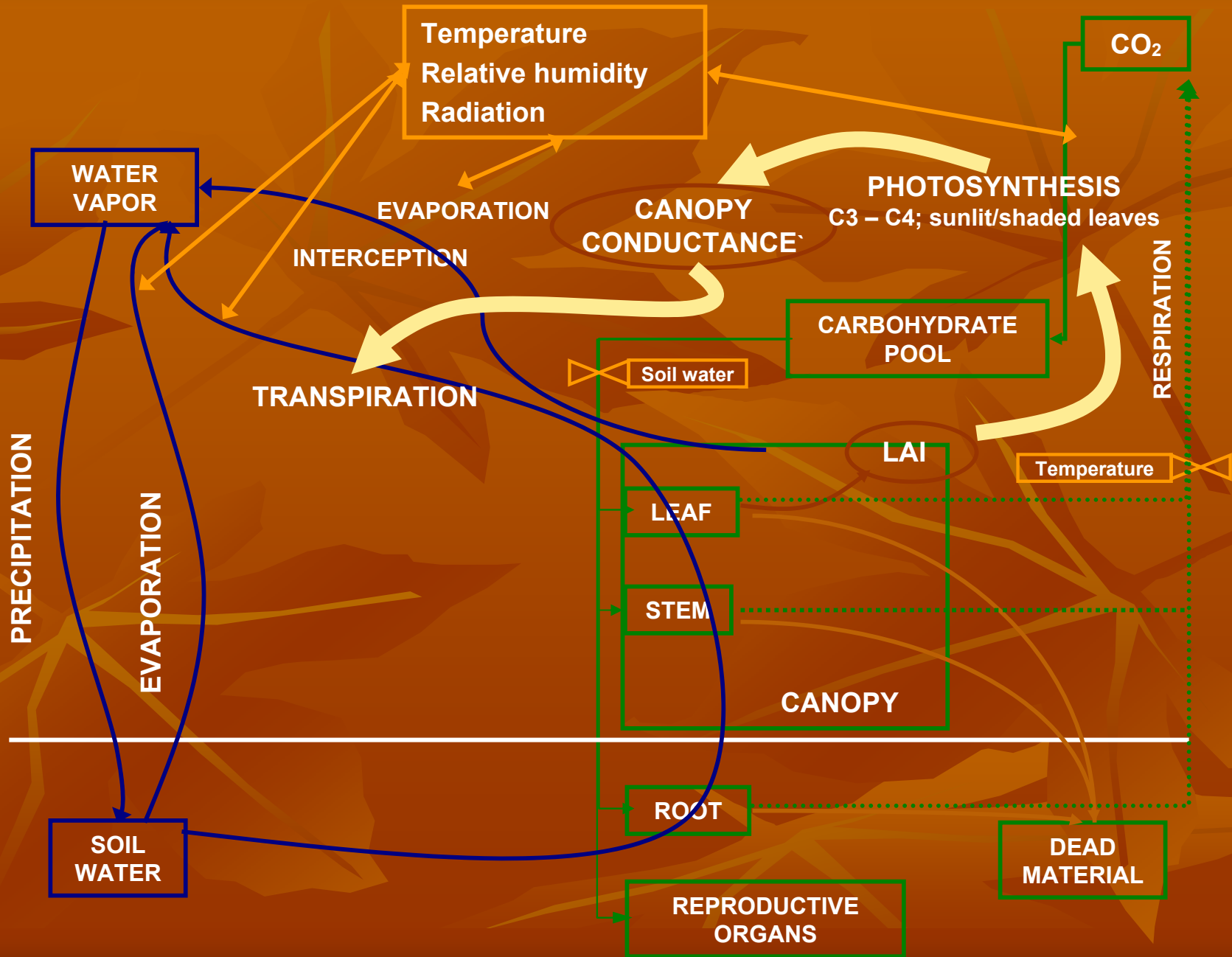
- *Coupled atmospheric-plant models can help to understand the effects of those changes.*

# ■ Tool : Regional atmospheric model – coupled to a plant model



**RAMS : Regional Atmospheric Modeling System**

**GEMTM : General Energy and Mass Transport Model**

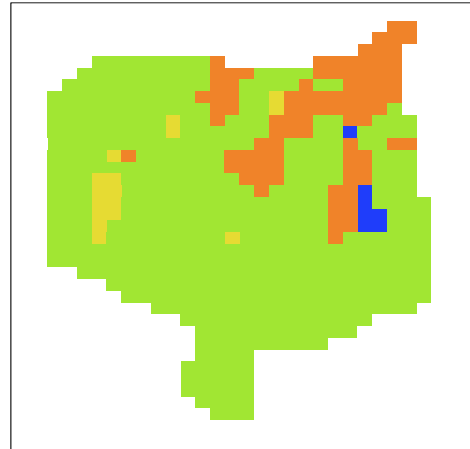


# Changes in land-cover

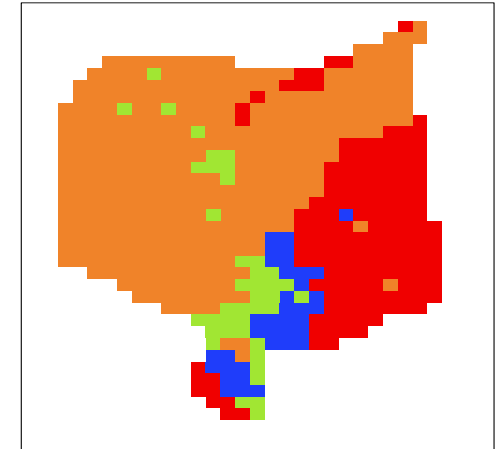
## Jornada Long Term Ecological Research site, New Mexico



Vegetation 1858

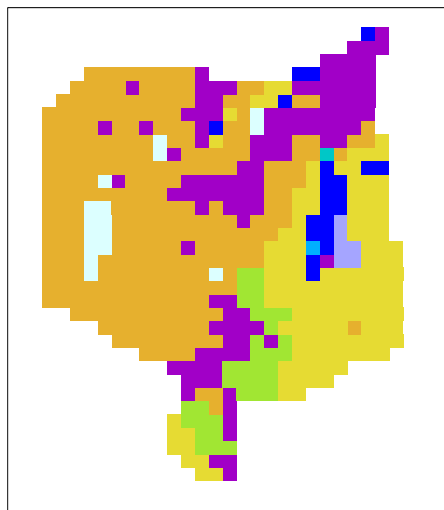


Vegetation 1998



■ Grass   
 ■ Mesquite   
 ■ Creosote   
 ■ Tarbush   
 ■ Poor grass

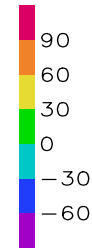
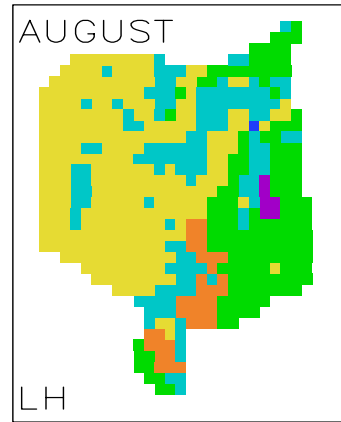
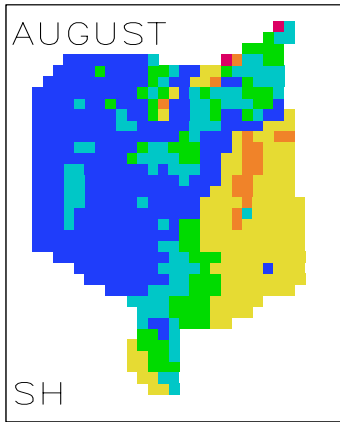
Vegetation changes from 1858 to 1998



<span style="color: green;">■</span> Grass to tarbush	6%
<span style="color: yellow;">■</span> Grass to creosotebush	22%
<span style="color: orange;">■</span> Grass to mesquite	} 48%
<span style="color: cyan;">■</span> Poor grass to mesquite	
<span style="color: purple;">■</span> Tarbush to creosotebush	} 1%
<span style="color: teal;">■</span> Tarbush to mesquite	
<span style="color: blue;">■</span> Mesquite to tarbush	
<span style="color: darkblue;">■</span> Mesquite to creosotebush	4%
<span style="color: purple;">■</span> No changes	19%

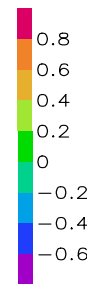
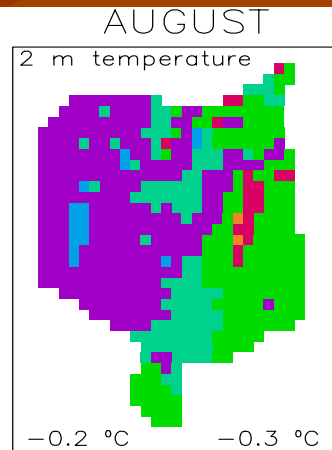
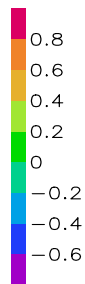
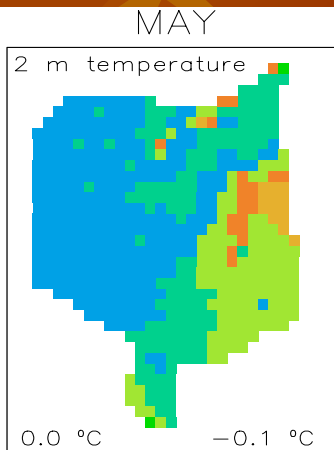


## Sensible (SH) and Latent (LH) heat fluxes



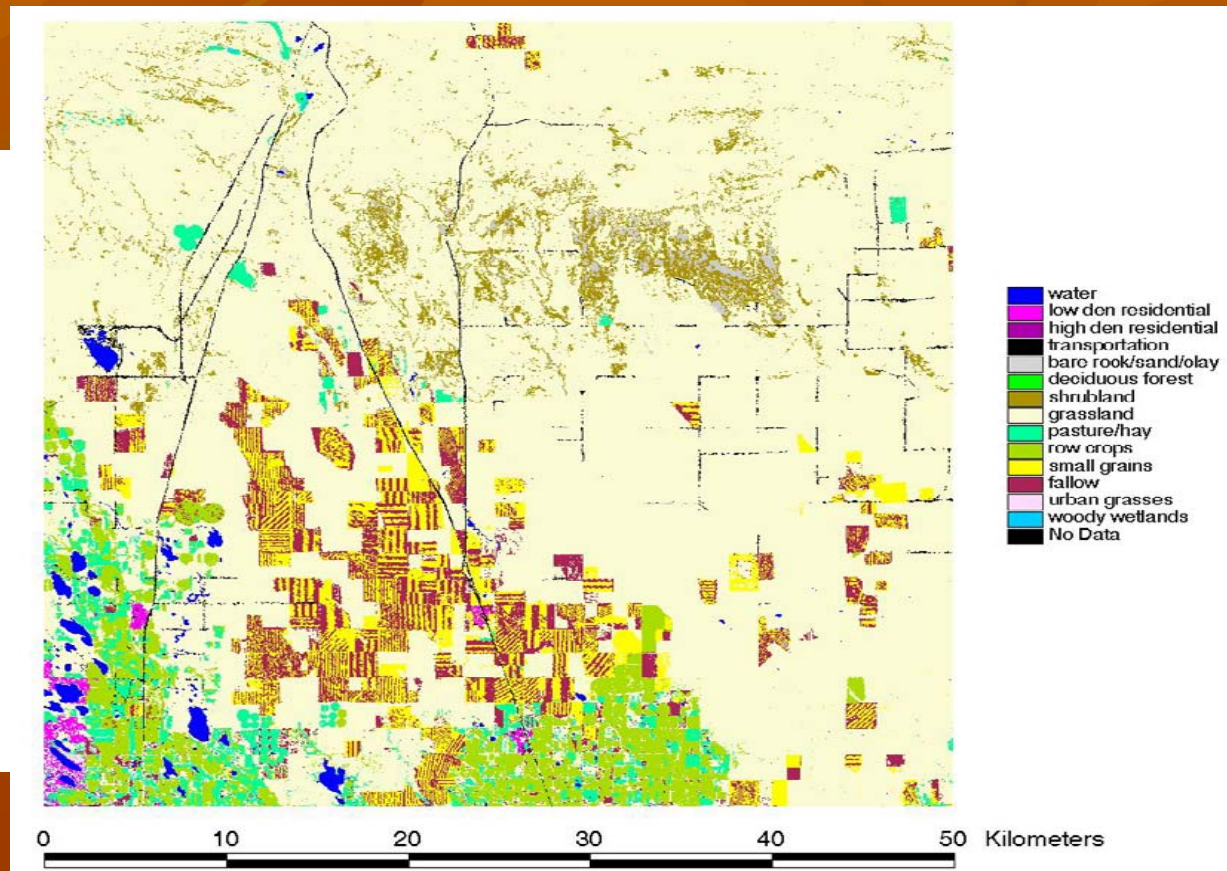
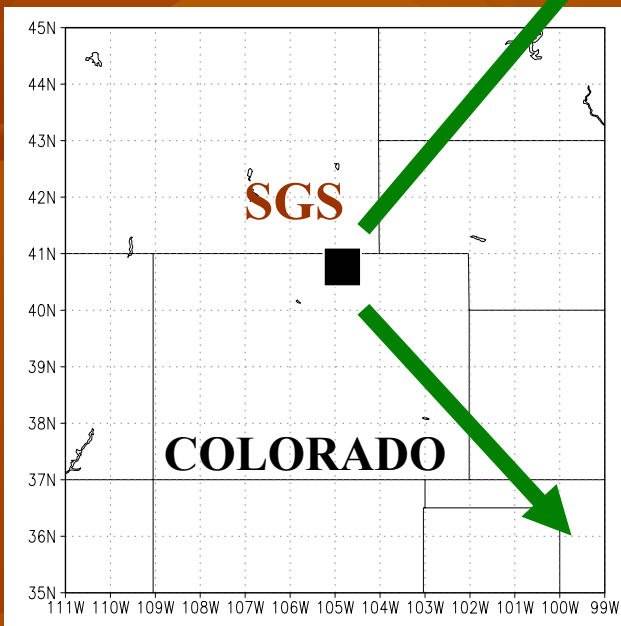
	SH	LH
Grass to mesquite	↓	↑
Grass to creosotebush	↑	↓

## 2 m temperature (°C)



- Conversion from grass to mesquite cools the near surface atmosphere and from grass to creosotebush warms it
- Available energy was dissipated mainly as LH due to the deeper root system in mesquite.

# Study area



Vegetation types for a 50x50km grid (30x30m grid space) centered at SGS, from National Land Cover Data (NLCD). (Courtesy Chris Hiemstra).

## Energy, and CO fluxes are being monitoring with BREB towers



**Wheat-fallow system**



**Grassland**



**Irrigated corn**

Open-top chamber measurements of photosynthesis and leaf conductance are used to obtain parameters associated with C3-C4 grasses (and with CO<sub>2</sub> enrichment).

Other parameters are obtained from previous measurements, while others are being measured in situ (i.e. albedo).

Measurements of above and belowground biomass, LAI and soil moisture are being used to evaluate the performance of the coupled modeling system GEMRAMS.

# Overall objective

**“To evaluate the interactions of land use, biotic responses and atmospheric processes at scales from local to regional.”**

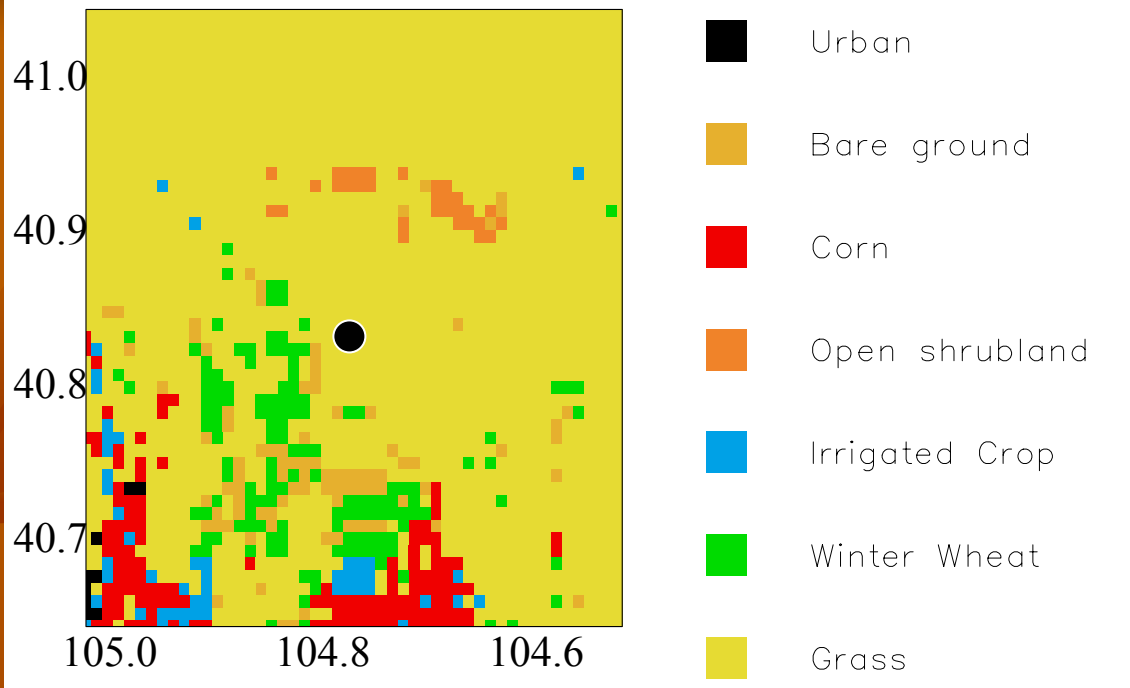
SGS LTER 2002-2008 Proposal

**To evaluate the performance of a plant-scale model with measurements carried out in the region.**

**To examine the effects of historical land cover changes, C3/C4 dominance, soil moisture and increase of CO<sub>2</sub> on the surface fluxes and near surface temperature and humidity using a fully coupled atmospheric model.**

## Experimental set-up and design

- 50x50 km domain
- Grid-cell size 1x1km
- 2 vegetation patches
- 60 levels (top 23 km)
- 8 soil levels (bottom 3 m)
- Homogeneous boundary atmospheric conditions



Predominant vegetation types for a 50x50km grid (current scenario).

## Control runs

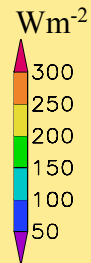
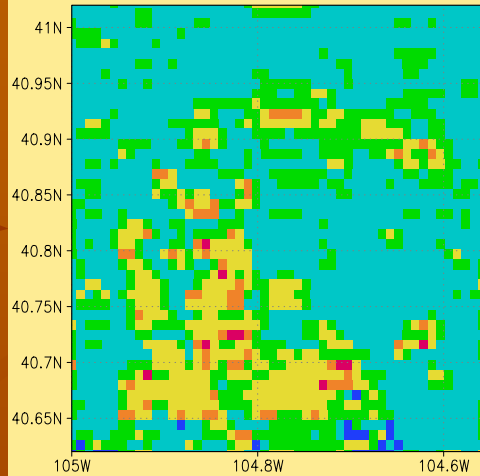
Two experiments, using GEMRAMS, were performed using two land cover scenarios, with identical initial meteorological conditions (2 clear days in June and October 2000)

- **Additional sensitivity experiments to Different initial soil moisture conditions, for both land cover scenarios**
  - **Wet case:** soil profile is 20% wetter than the control case.

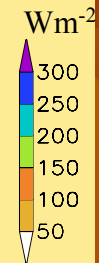
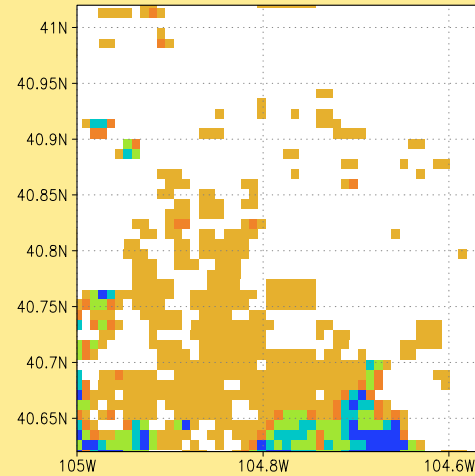
# Diurnal-averaged simulated fluxes

**SH :**  
lower values in grass  
higher in crops

June SH CTRL MIXED

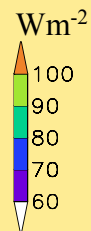
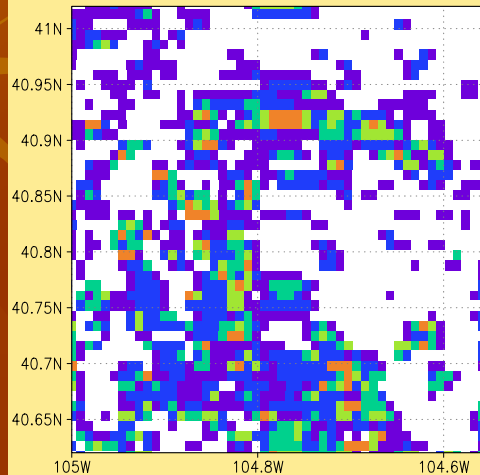


LH CTRL MIXED

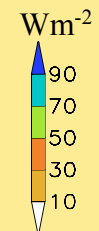
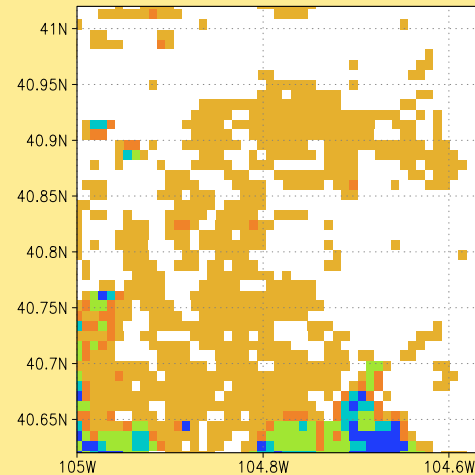


**LH :**  
lower values in grass  
higher in corn

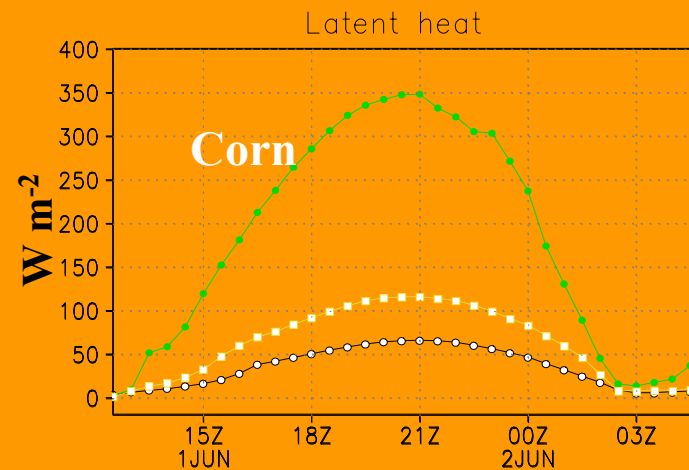
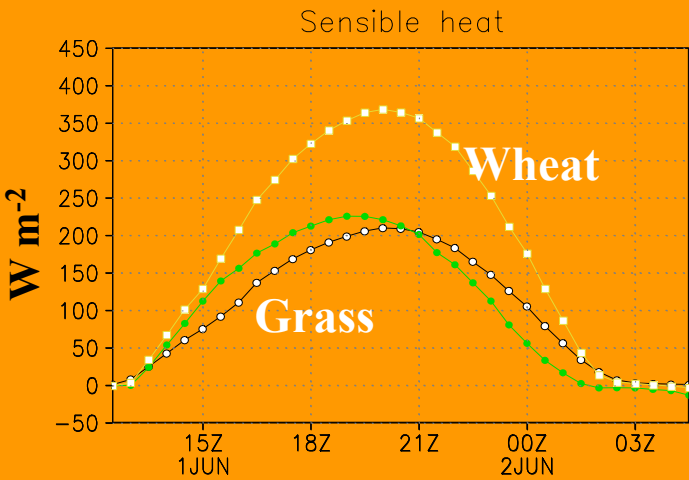
October SH CTRL MIXED



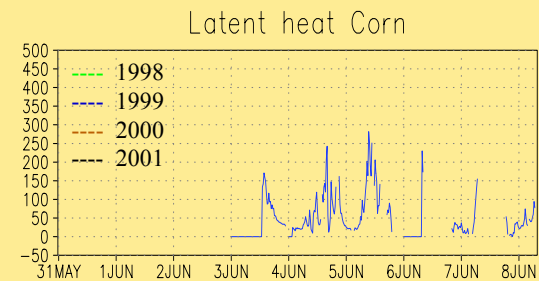
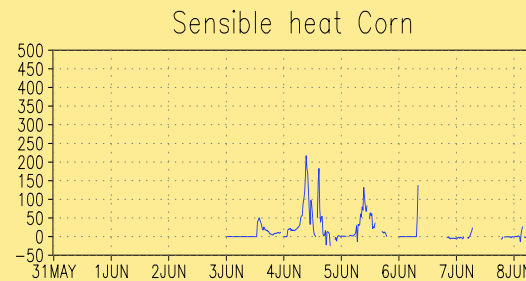
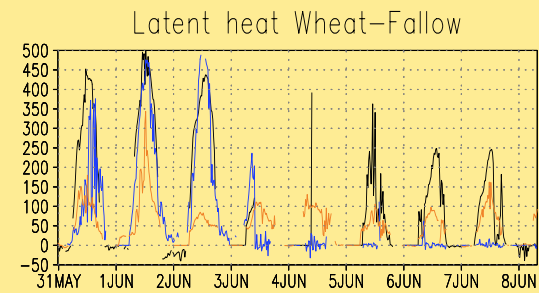
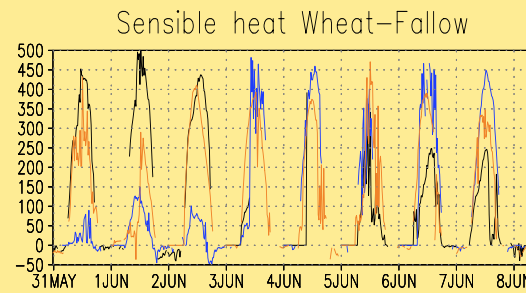
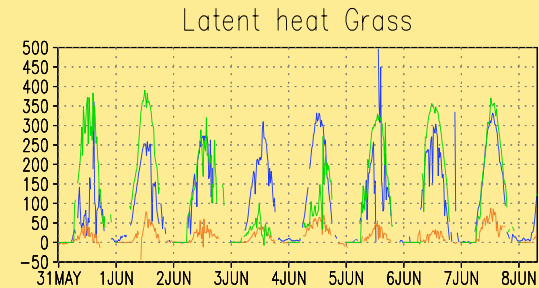
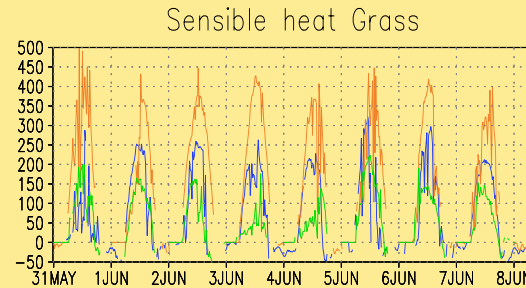
LH CTRL MIXED



# Area-averaged simulated fluxes



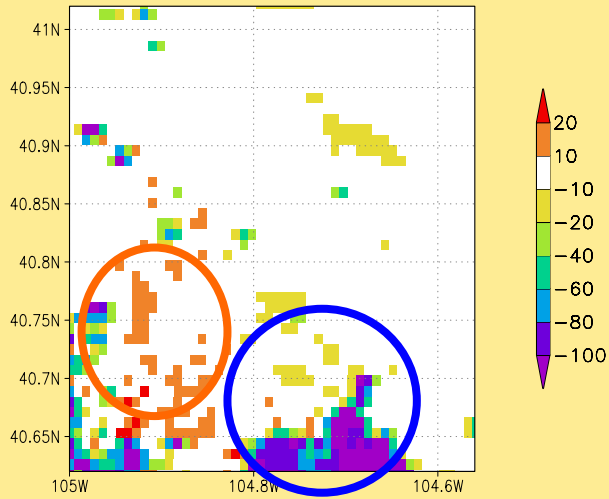
# Observed fluxes (Bowen ratio towers)



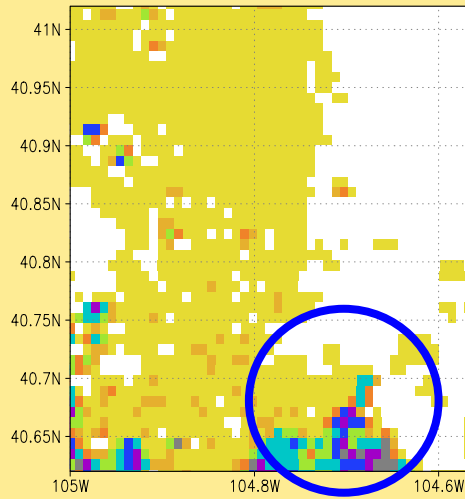
Provided by David Smith

# Differences in fluxes between CTRL and NAT simulations

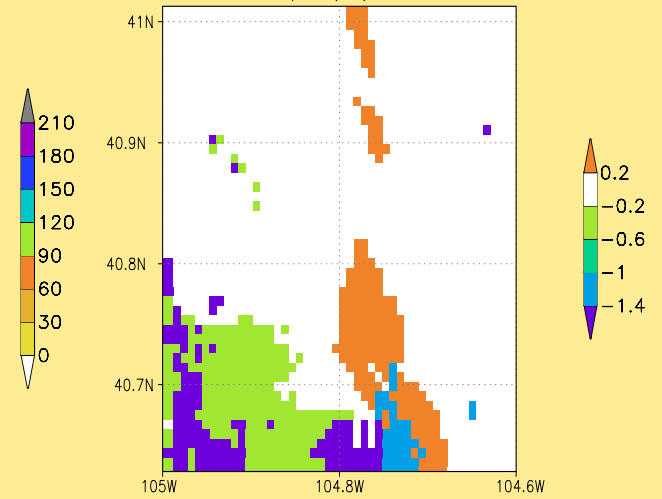
June SH CTRL-NAT MIXED



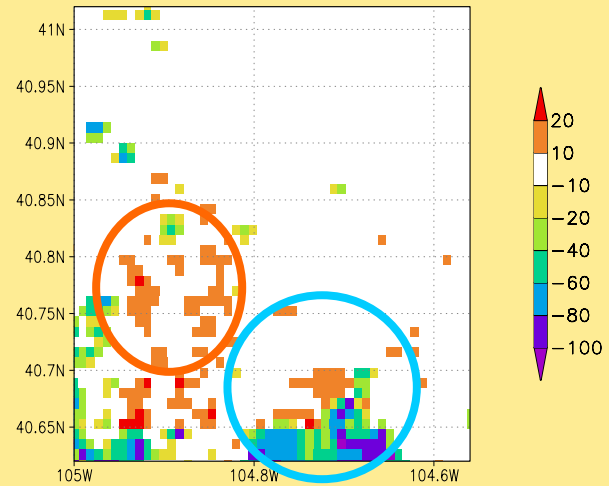
LH CTRL-NAT MIXED



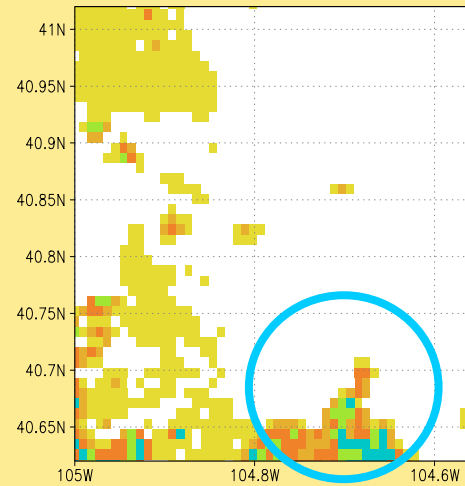
June Temp (C) CTRL-NAT MIXED



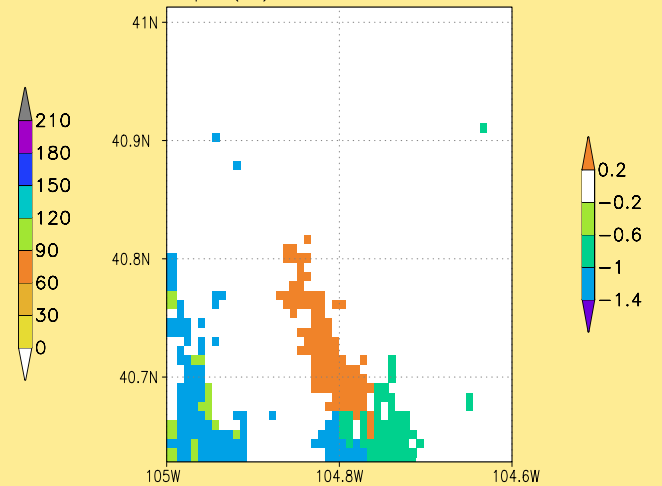
SH WET CTRL-NAT MIXED



LH WET CTRL-NAT MIXED



Temp (C) WET CTRL-NAT MIXED



Sensitivity to soil moisture initial conditions

# Concluding remarks

- GEMRAMS (offline and fully coupled) realistically simulate diurnal and seasonal sensible and latent heat fluxes, being an adequate tool to study the effects of land-cover changes.
- Cooler temperatures are found under current land-cover scenario, consistent with the results from other simulation studies for the region (Stohlgren et al. 1998; Chase et al. 1999). Soil moisture initial condition may affect the differences between the Current and Natural scenarios (key driving variable for SGS ecosystems).
- Ongoing work:
  - explore the effects of elevated CO<sub>2</sub>, changes in C3/C4 dominance, grazing practices and winter wheat/fall cropping system on the seasonal dynamics of energy, CO<sub>2</sub>, and water fluxes.