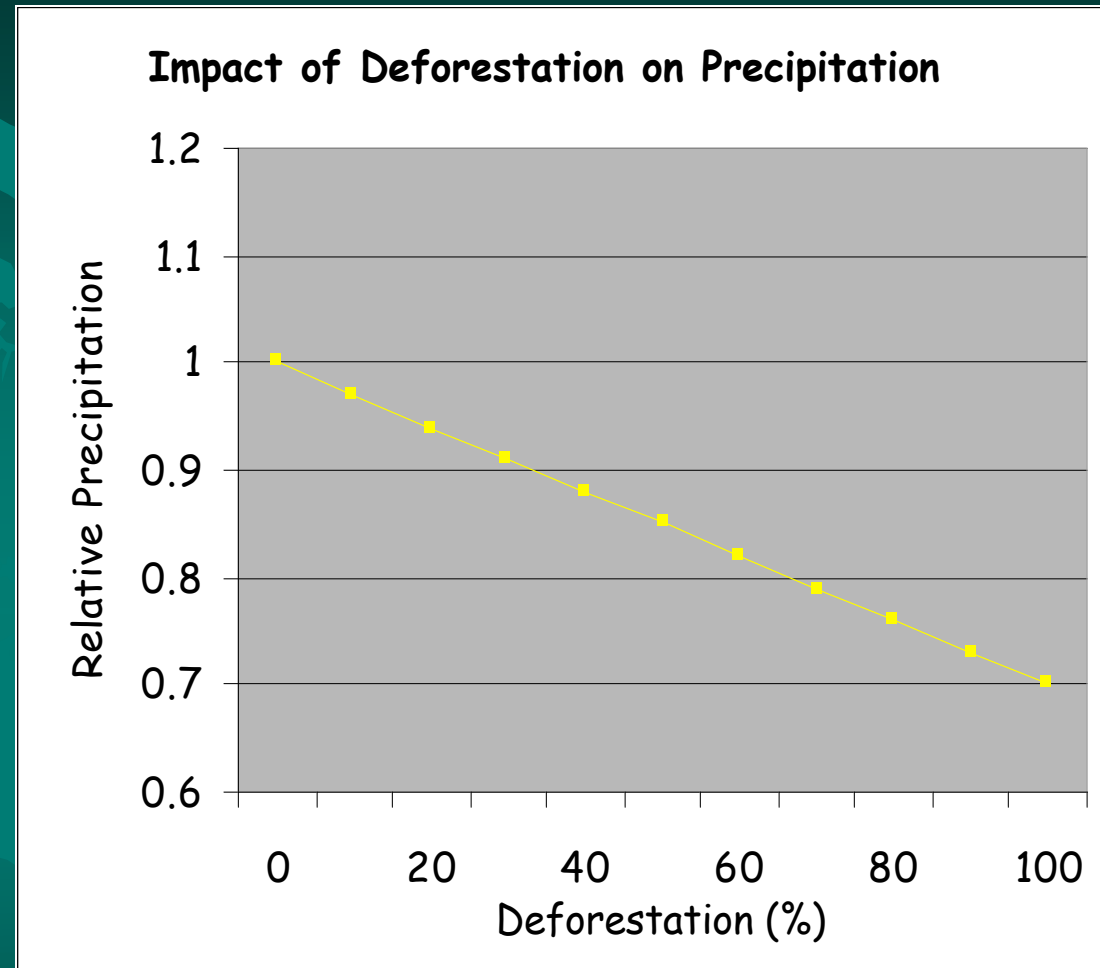
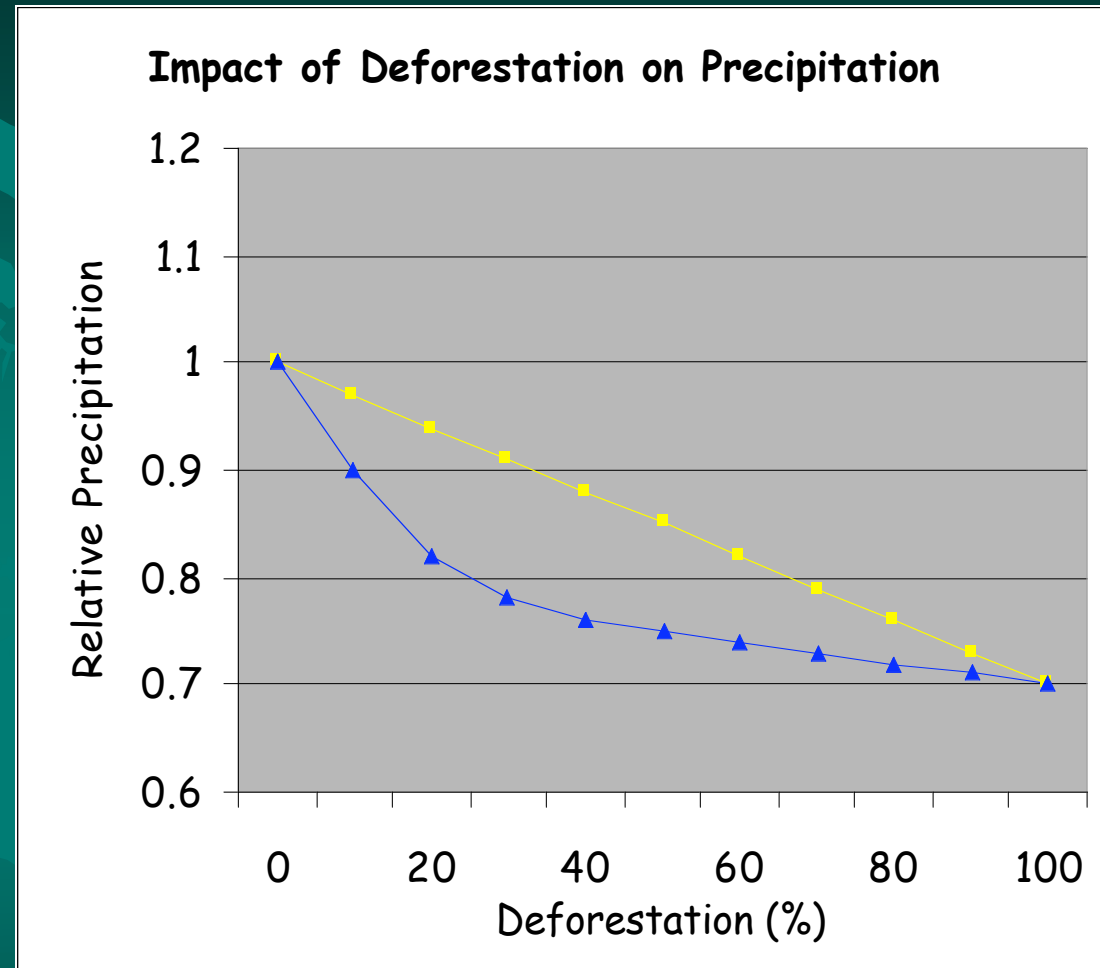


The Issue...

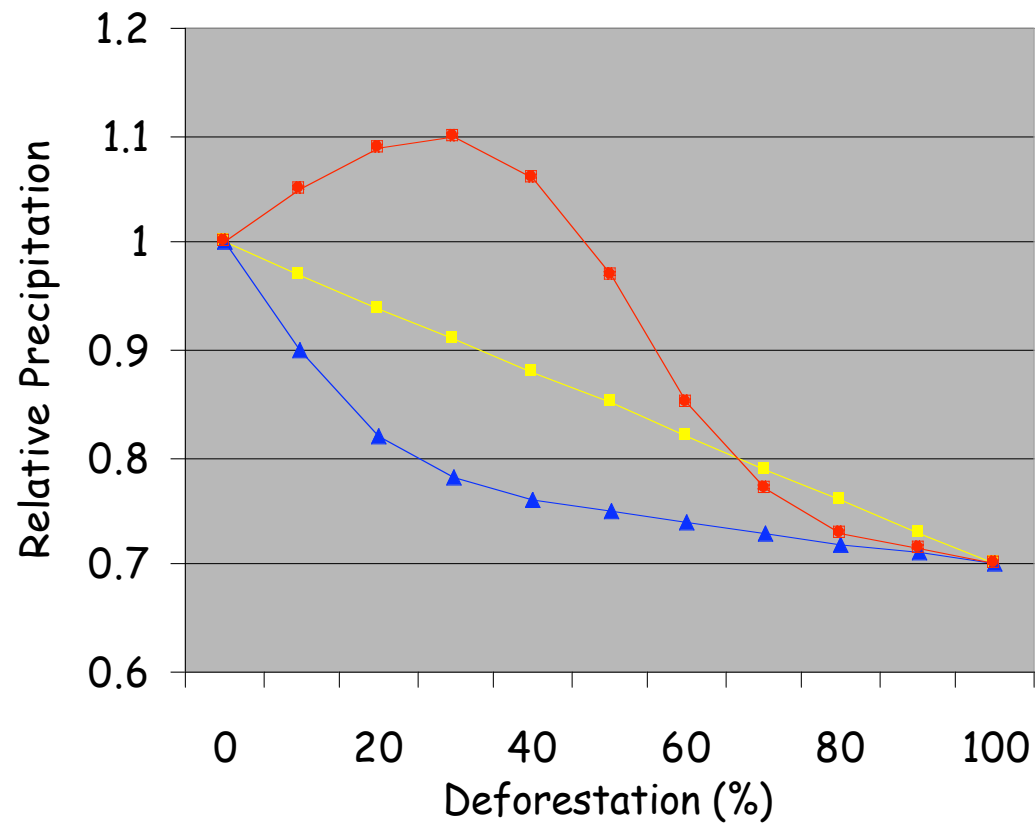


The Issue...



The Issue...

Impact of Deforestation on Precipitation



The Issue...



The Issue...

Local, Regional and Global Effects of Amazon Deforestation

Scientific Questions

Does human modification of the landscape affect the characteristics of the atmosphere, the hydrological cycle and water resources? If yes, where? What are the spatial scales of forcing and the spatial scales of response? To what extent? And when?

R. Avissar and D. Werth

Duke University

S. Daidya Roy

Princeton University

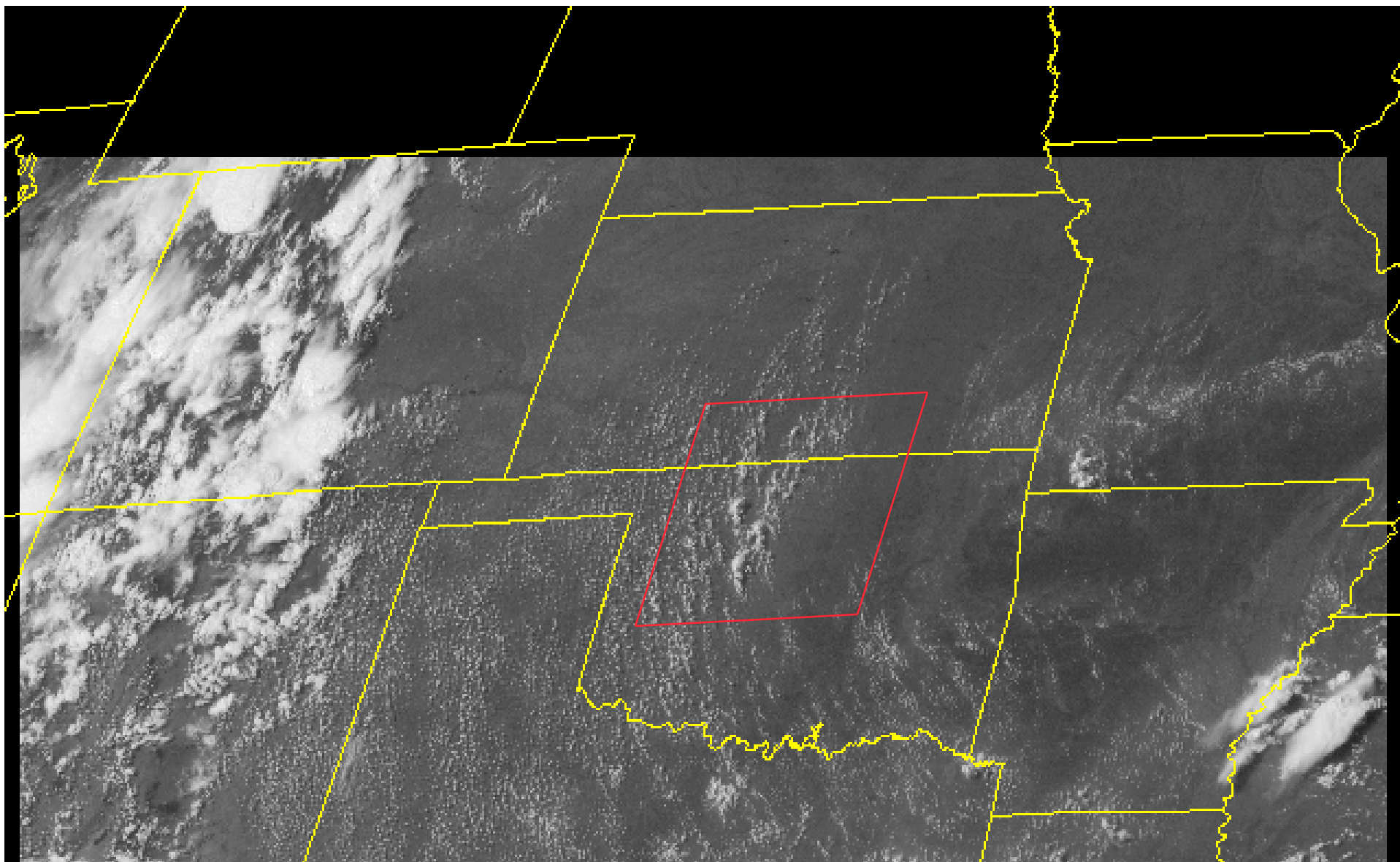
C. D. Weaver

Rutgers University

Outline

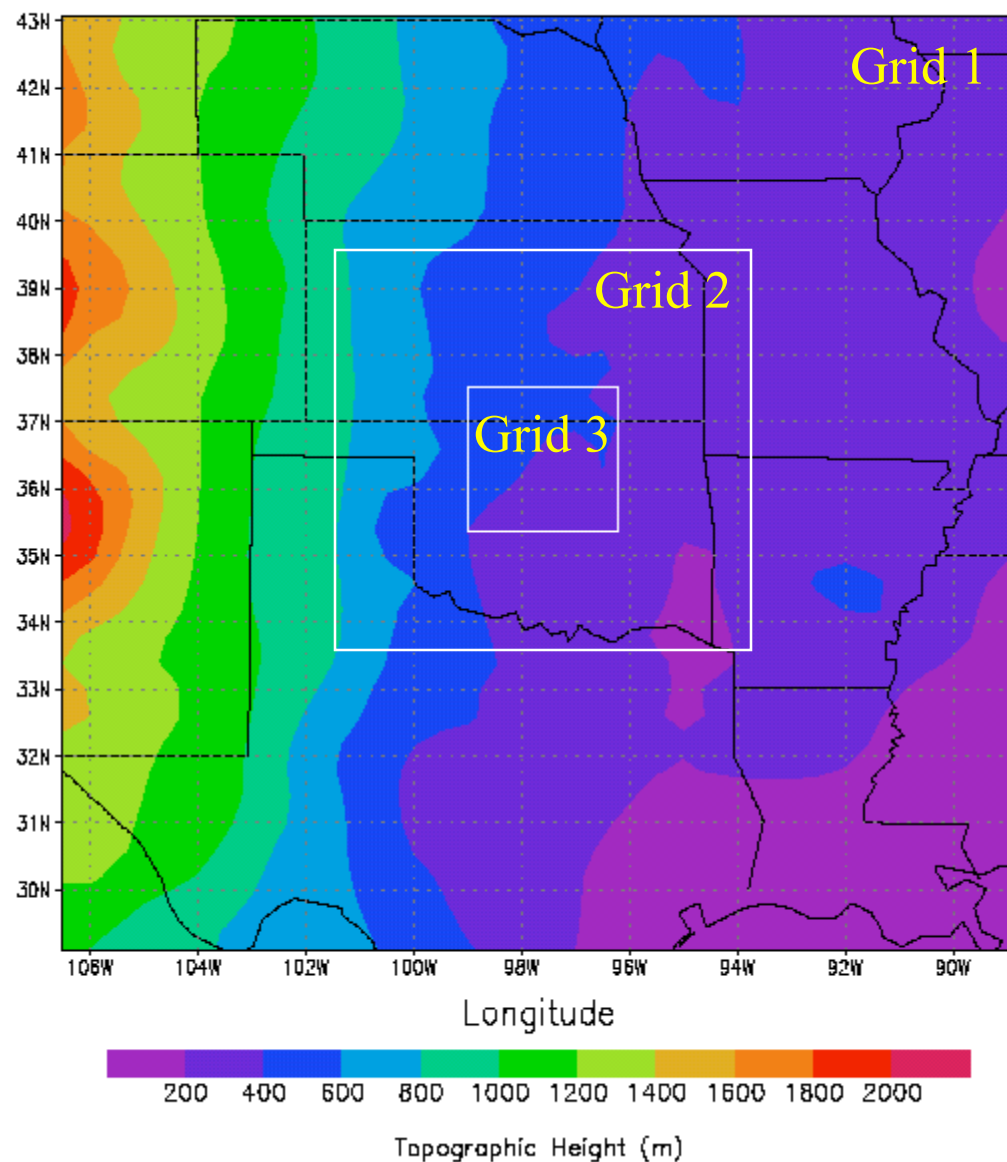
1. Regional impact of LU/LCC on convection:
GCIP and LBA studies
2. Teleconnections: A GCM analysis
3. Conclusions and research direction

Research funded by
NOAA and NASA



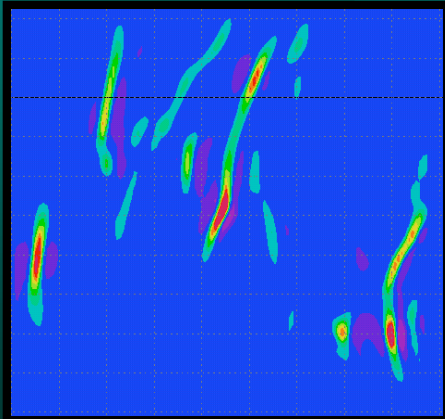
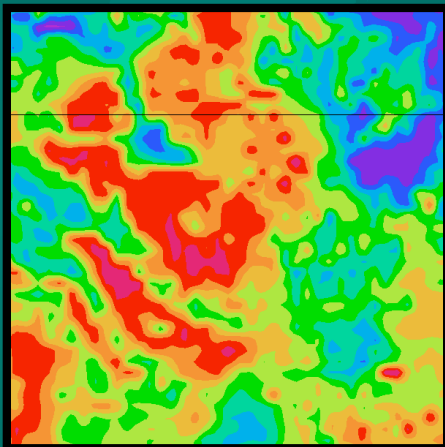
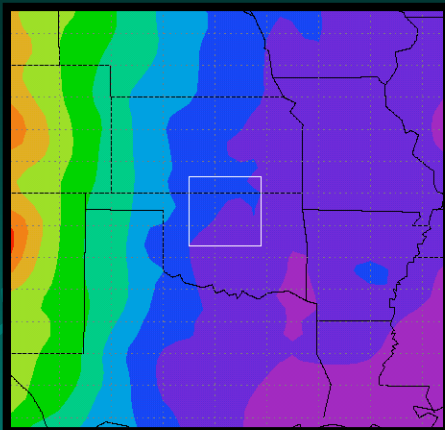
The GCIP SW-LSA 1995 Data

RAMS Grid 1 with Grid 3 Inset

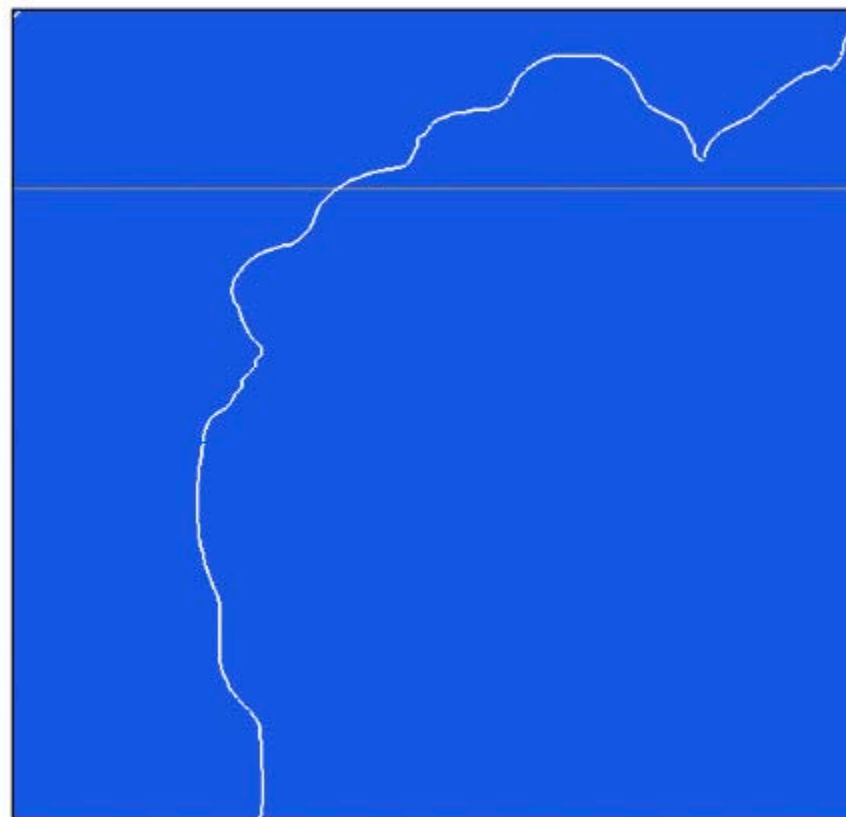
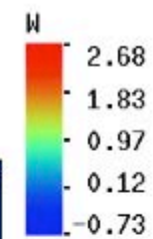


Simulation Characteristics

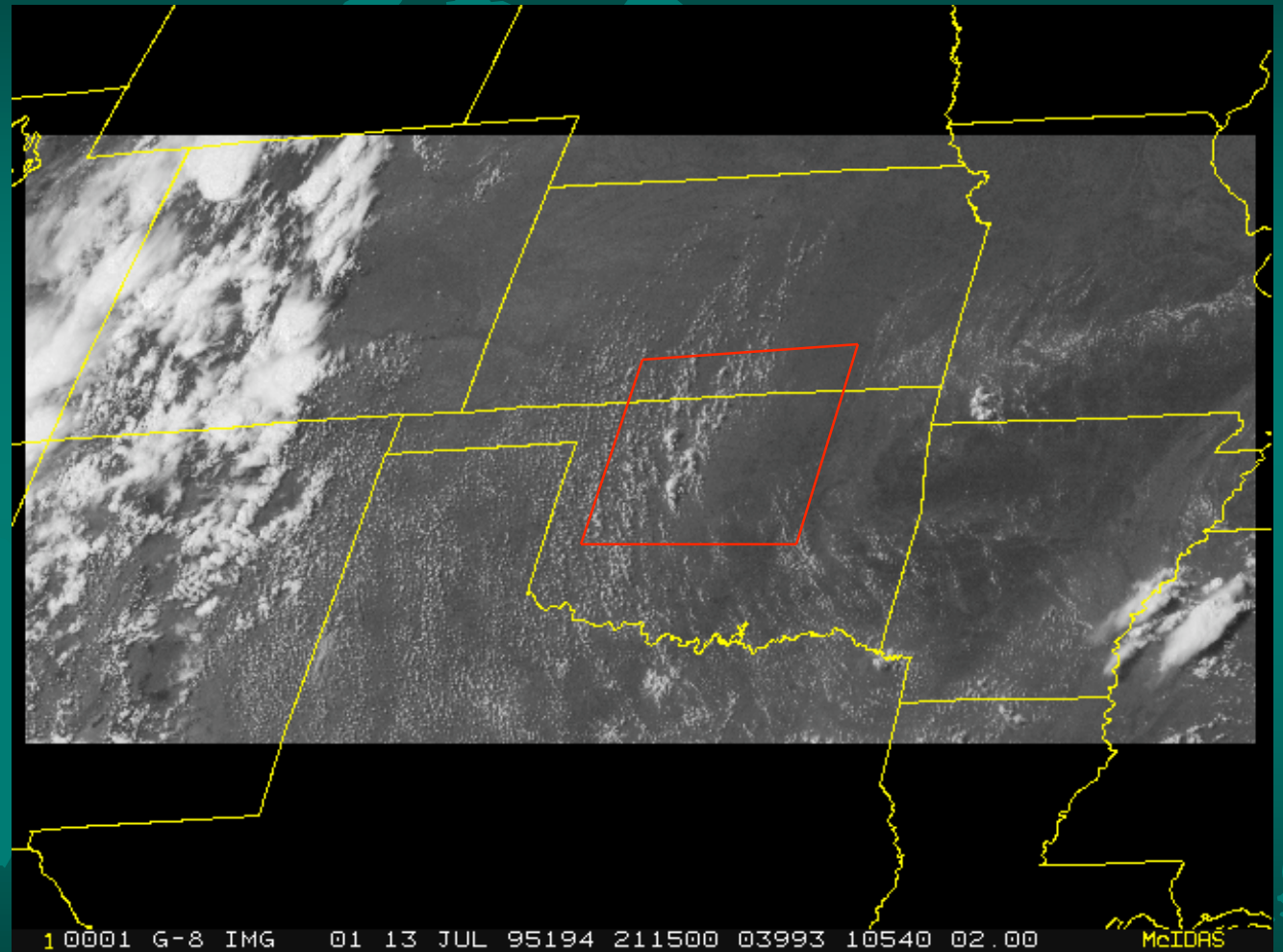
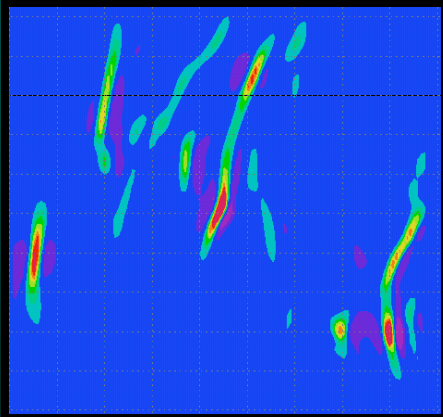
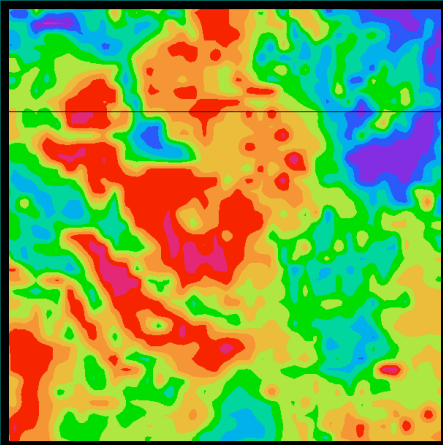
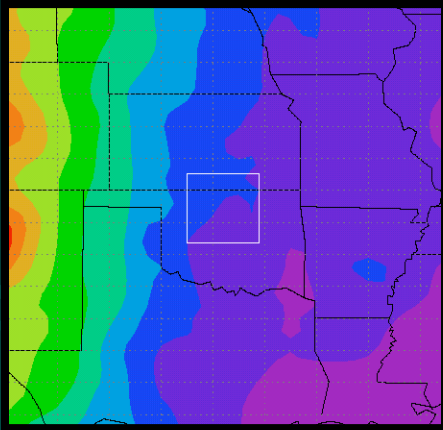
- 3 nested grids (2x2; 8x8; 32x32 km);
- 38 vertical levels up to 22 km 6 a.m. - 6 p.m.;
- 10 s time step in Grid 3;
- NCEP reanalysis assimilated in Grid 1, including wind, geopotential height, potential temperature, and relative humidity;
- Surface fluxes from Zhong and Doran derived from ARM/CART observations and RAMS surface scheme in Grids 1 & 2, with IGBP vegetation class;
- Subgrid-scale turbulence of Mellor & Yamada;
- Radiation of Chen and Cotton.



06:00:00
13 Jul 95
1 of 145
Thursday

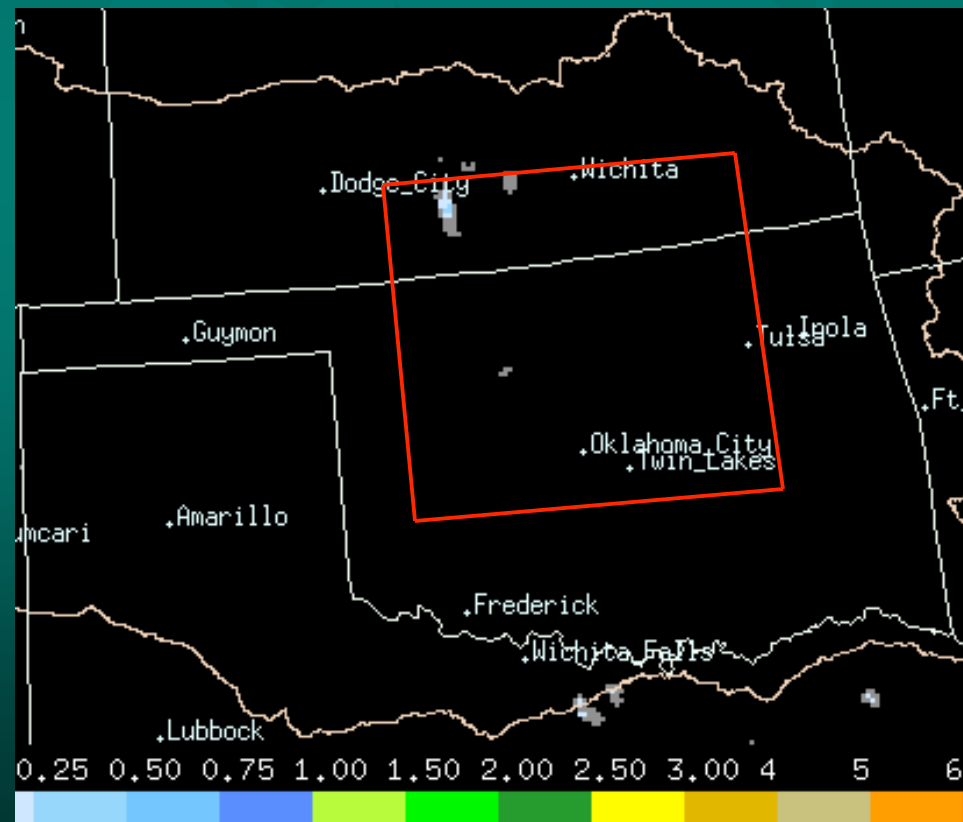
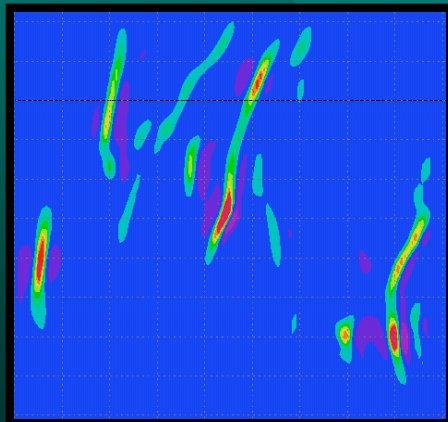
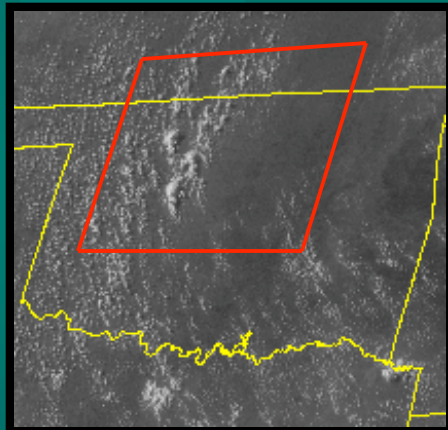
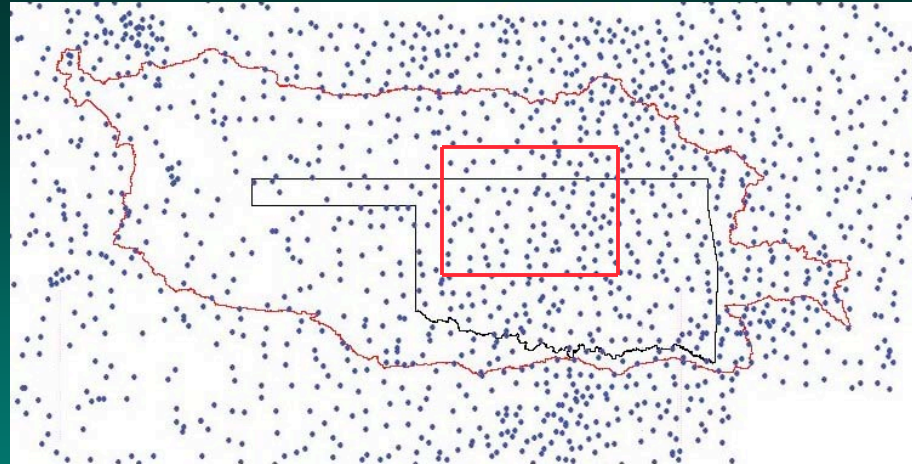


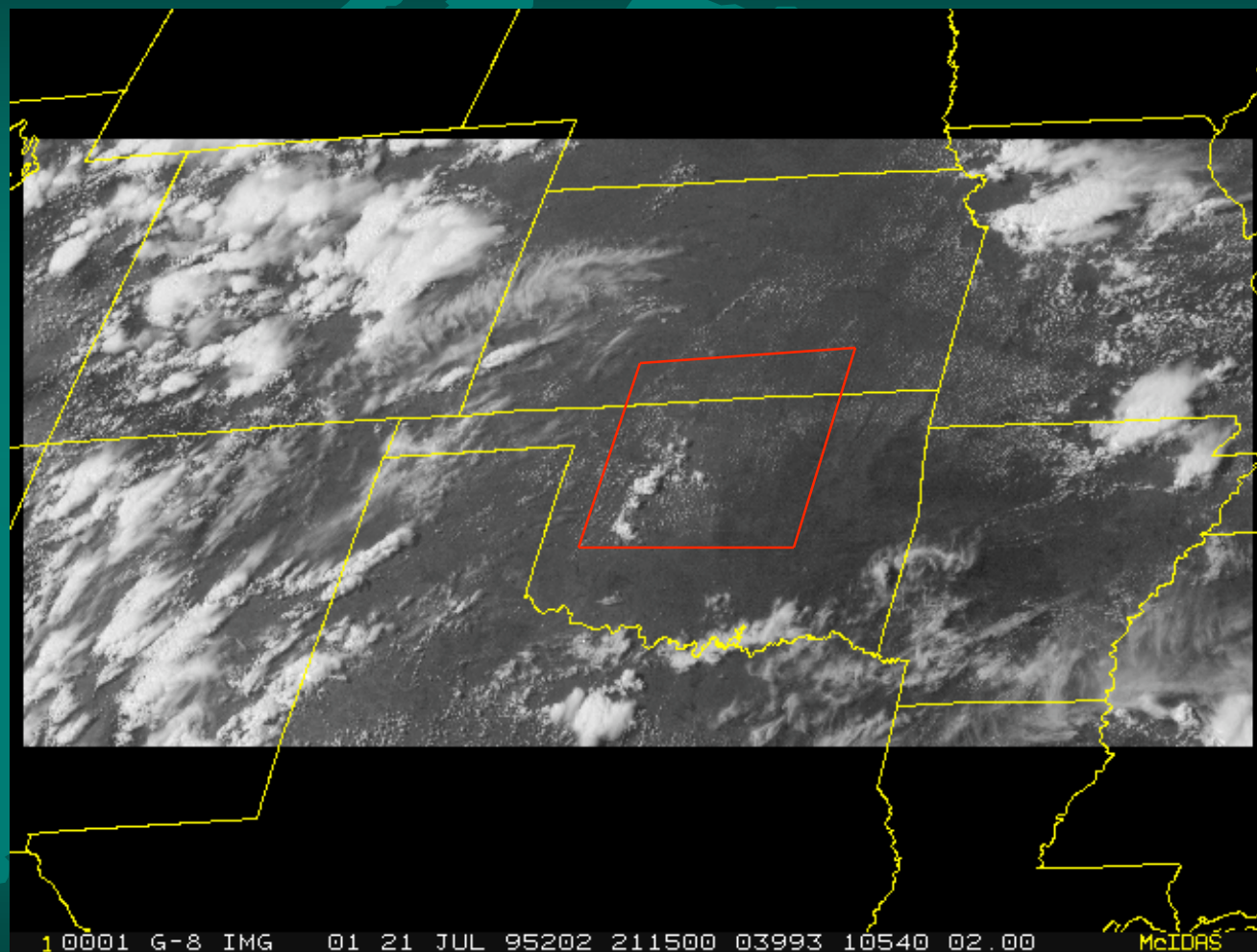
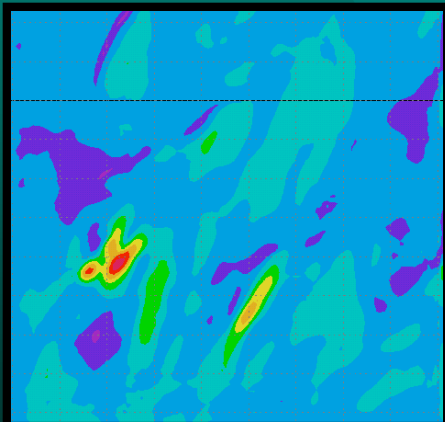
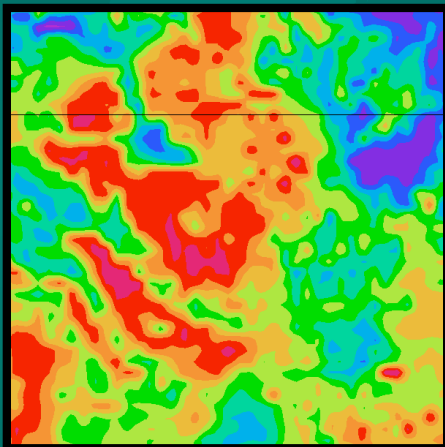
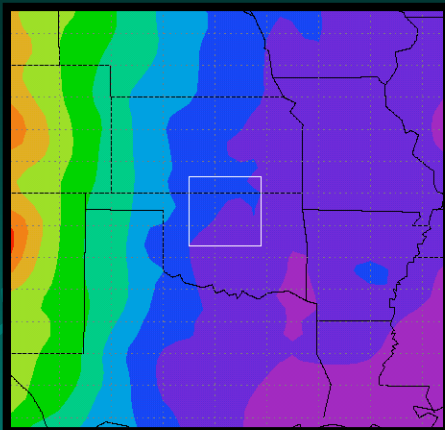
W at 1100m & WATER VAPOR MIXING RATIO at 3000m

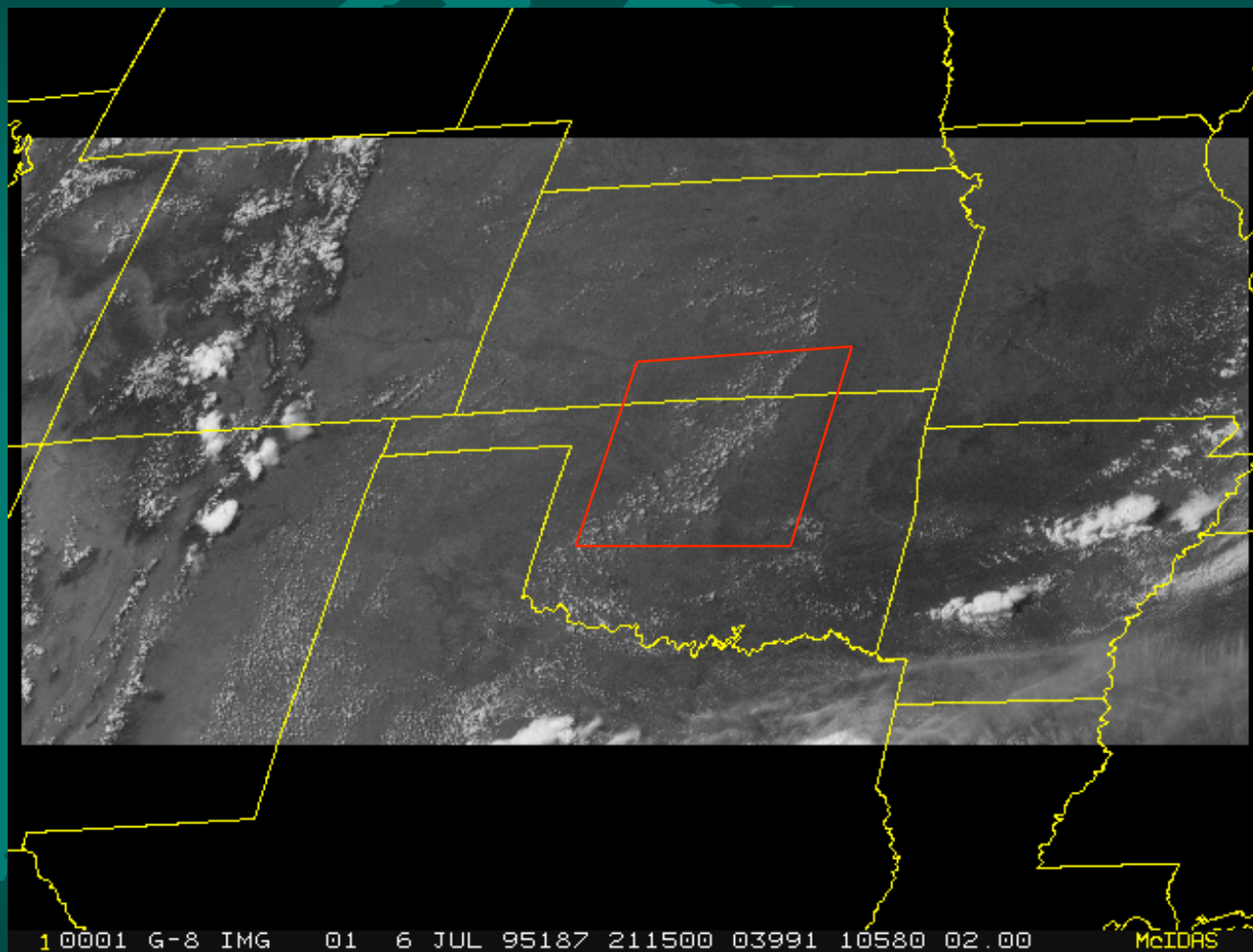
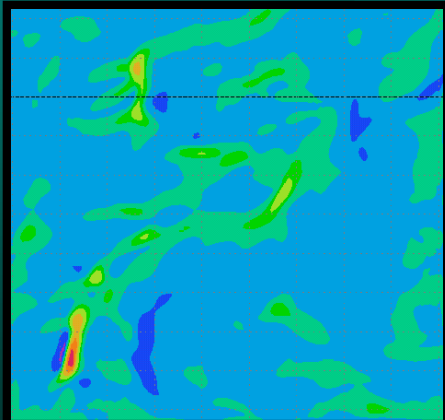
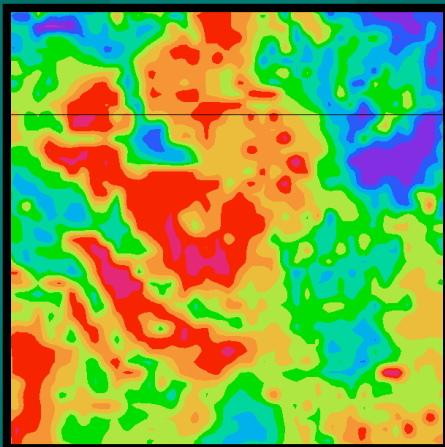
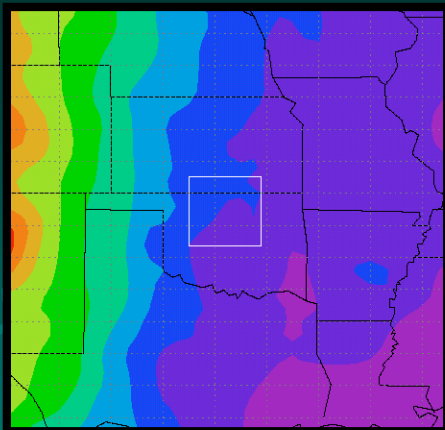


Raingauge & Weather
Surveillance Doppler Radar
(WSR-88D) Network of
Arkansas-Red Basin River
Forecast Center (ABRFC)

<http://www.abrfc.noaa.gov>

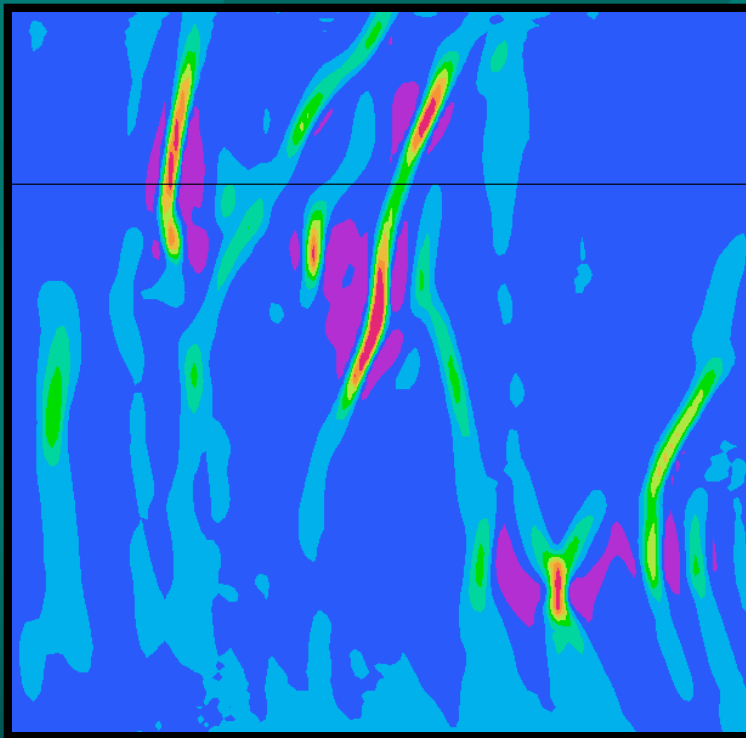




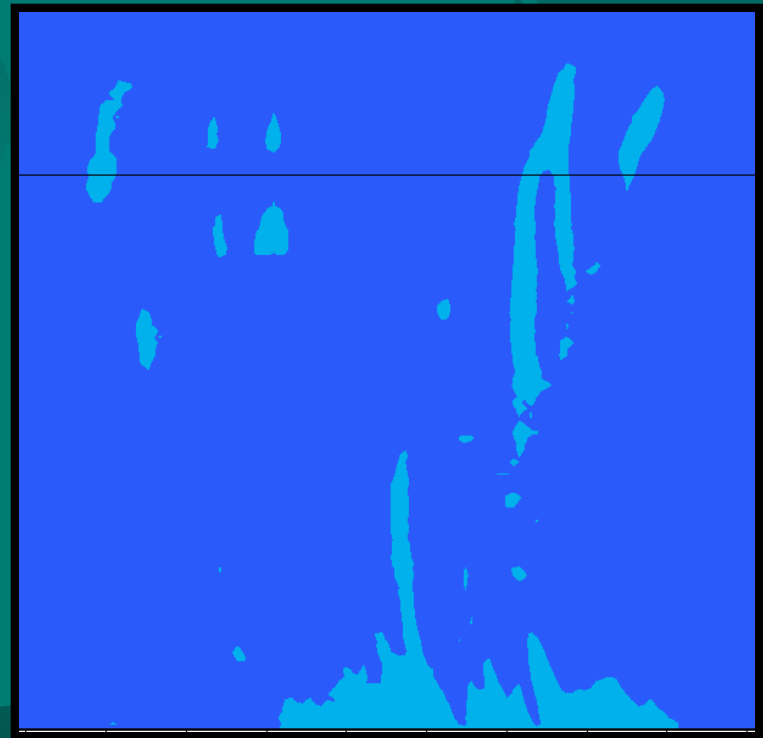


Impact of surface heat flux heterogeneity

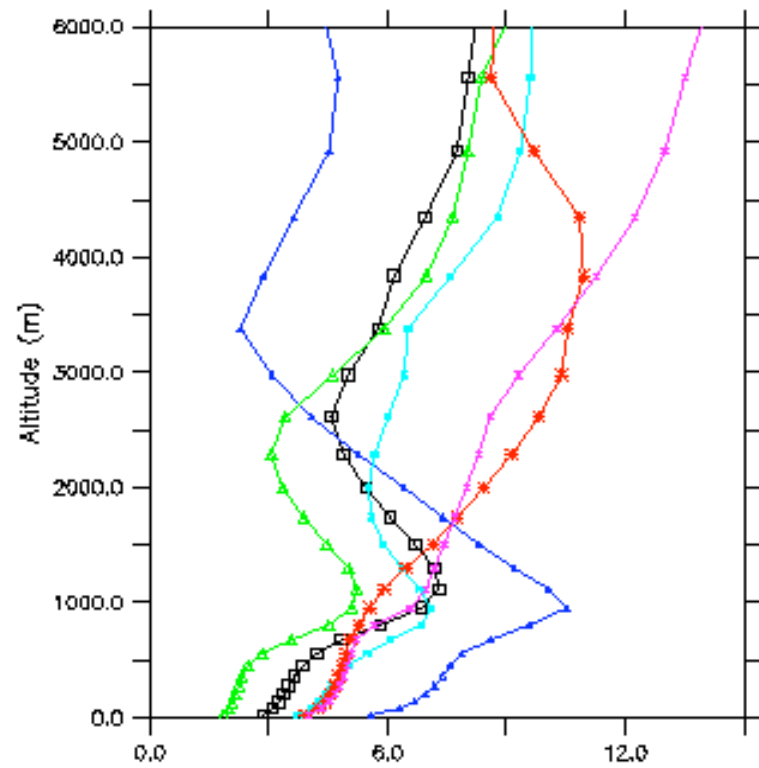
With observed fluxes



With domain-averaged fluxes

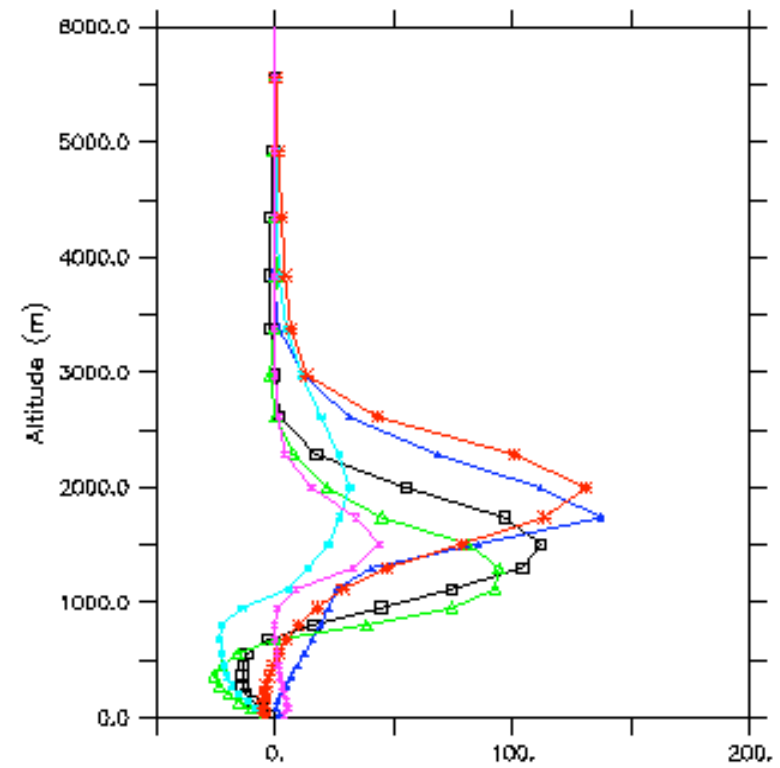


Horizontal cross-section of w (m/s), 1300 m above ground surface



Wind Speed (m/s)

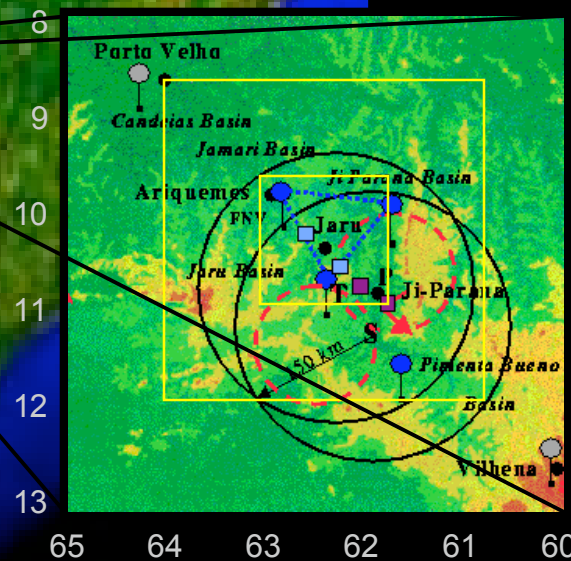
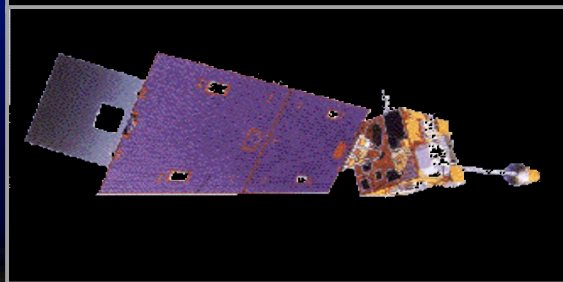
— July 13, 1995
— July 21, 1995
— July 06, 1995



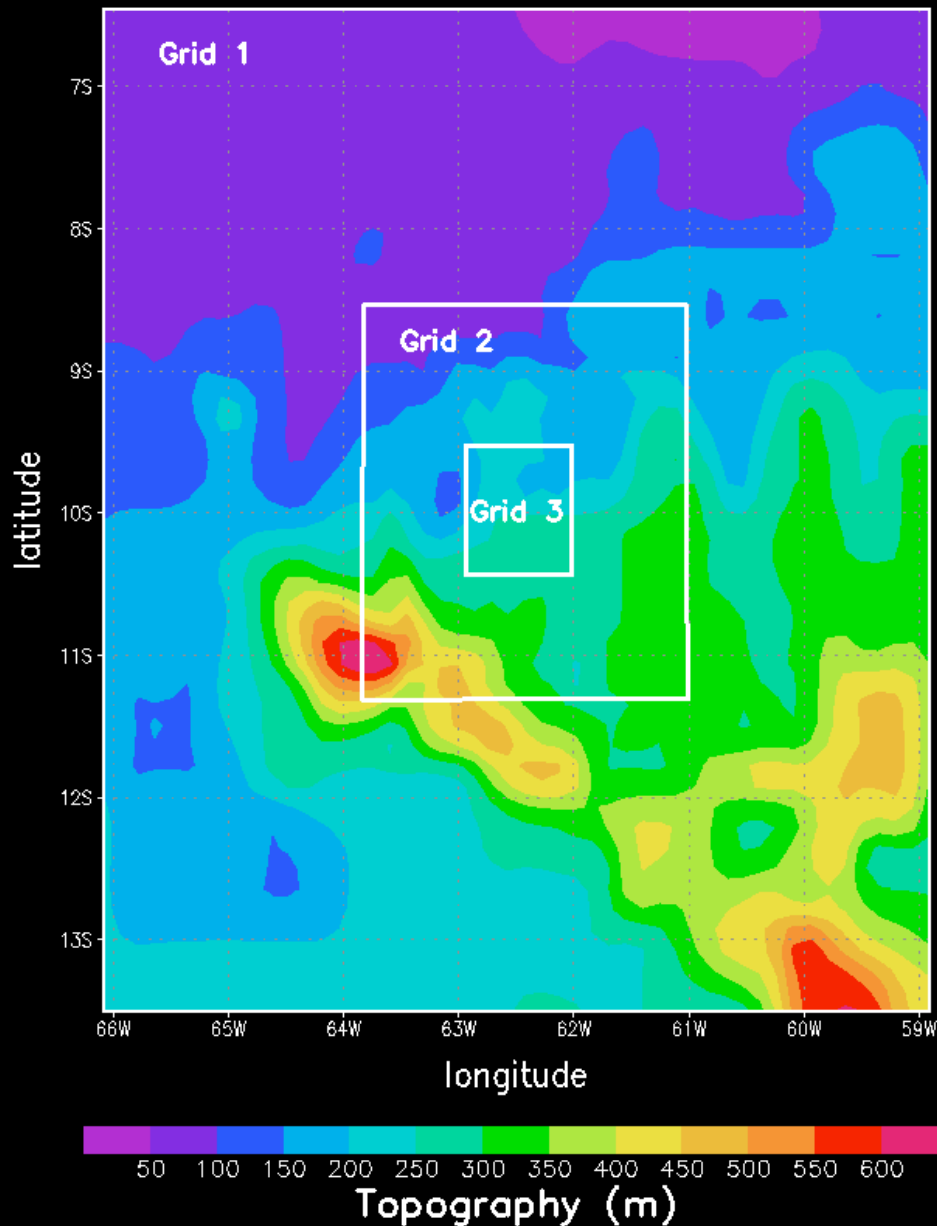
Mesoscale LH Flux (W/m²)

— July 10, 1995
— July 07, 1995
— July 12, 1995





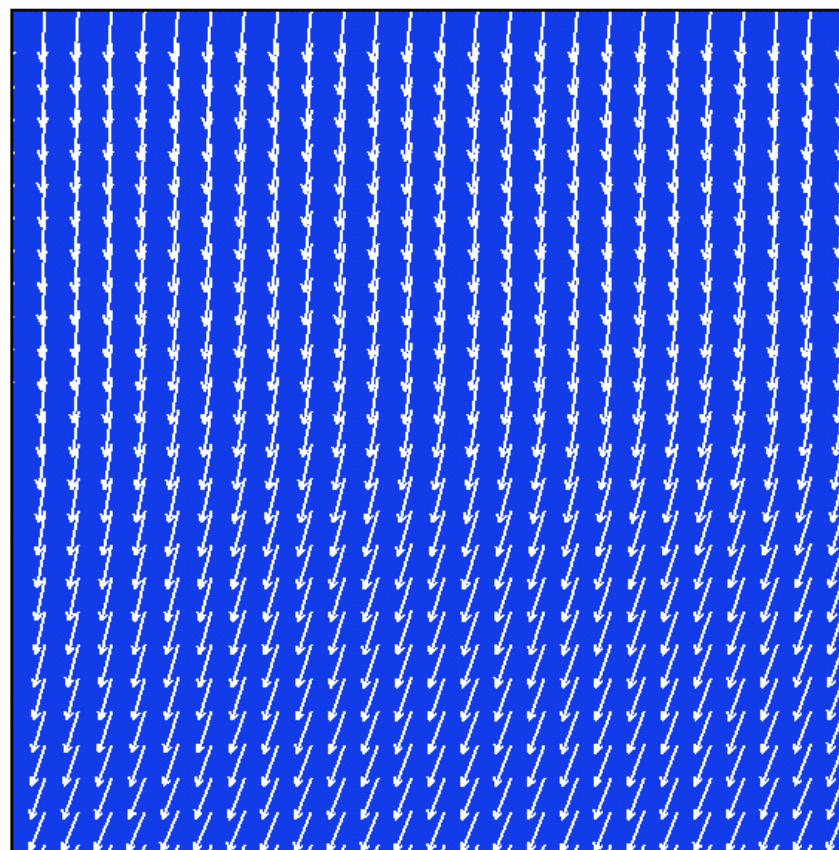
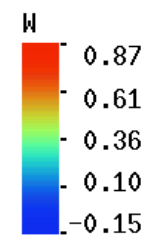
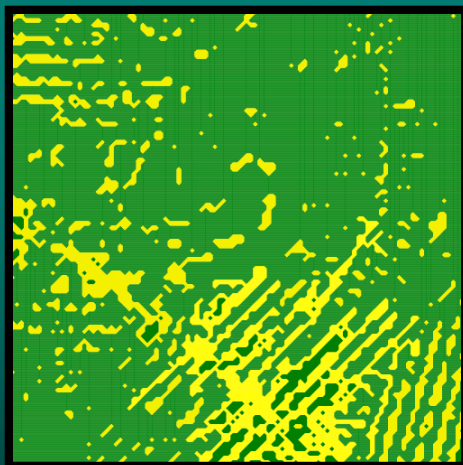
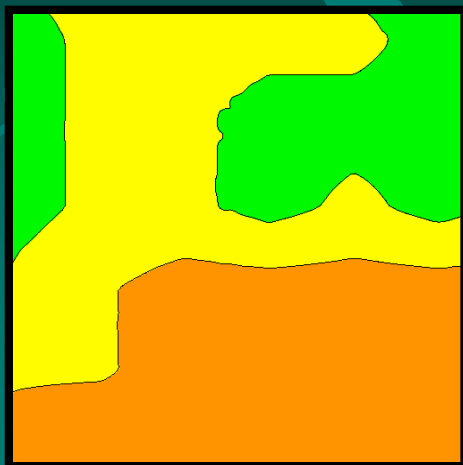
RAMS Grids



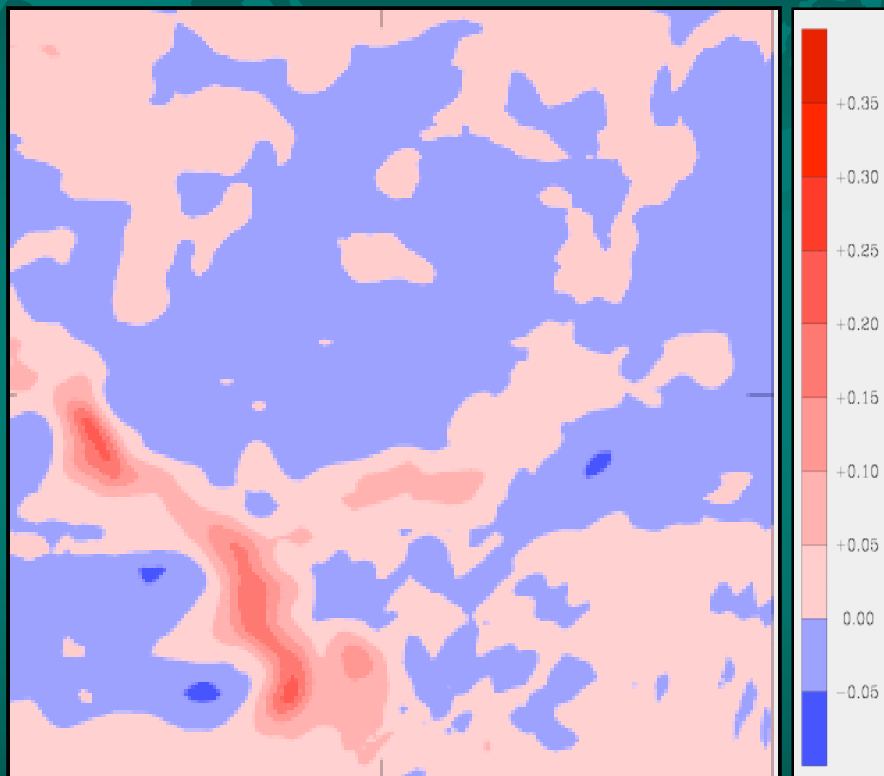
Simulation Characteristics

- 3 nested grids (1x1; 4x4; 16x16 km grid-spacing);
- 38 vertical levels up to 24 km;
- 7 a.m. - 7 p.m.;
- 5 s time step in Grid 3;
- NCEP reanalysis assimilated in Grid 1, including wind, geopotential height, potential temperature, and relative humidity;
- Surface fluxes from RBLE3 observations and RAMS soil-vegetation model in Grid 1, with IGBP vegetation class;
- Subgrid-scale turbulence of Mellor & Yamada;
- Radiation of Chen and Cotton.

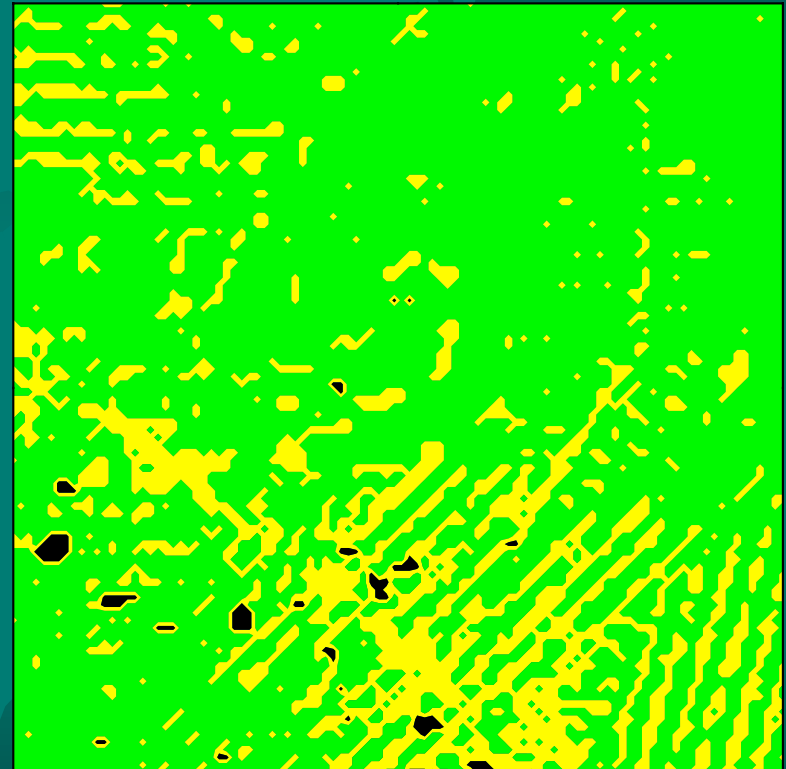
07:00:00
17 Aug 94
1 of 145
Wednesday



VERTICAL WIND AT 500M & NEAR-SURFACE HORIZONTAL WIND

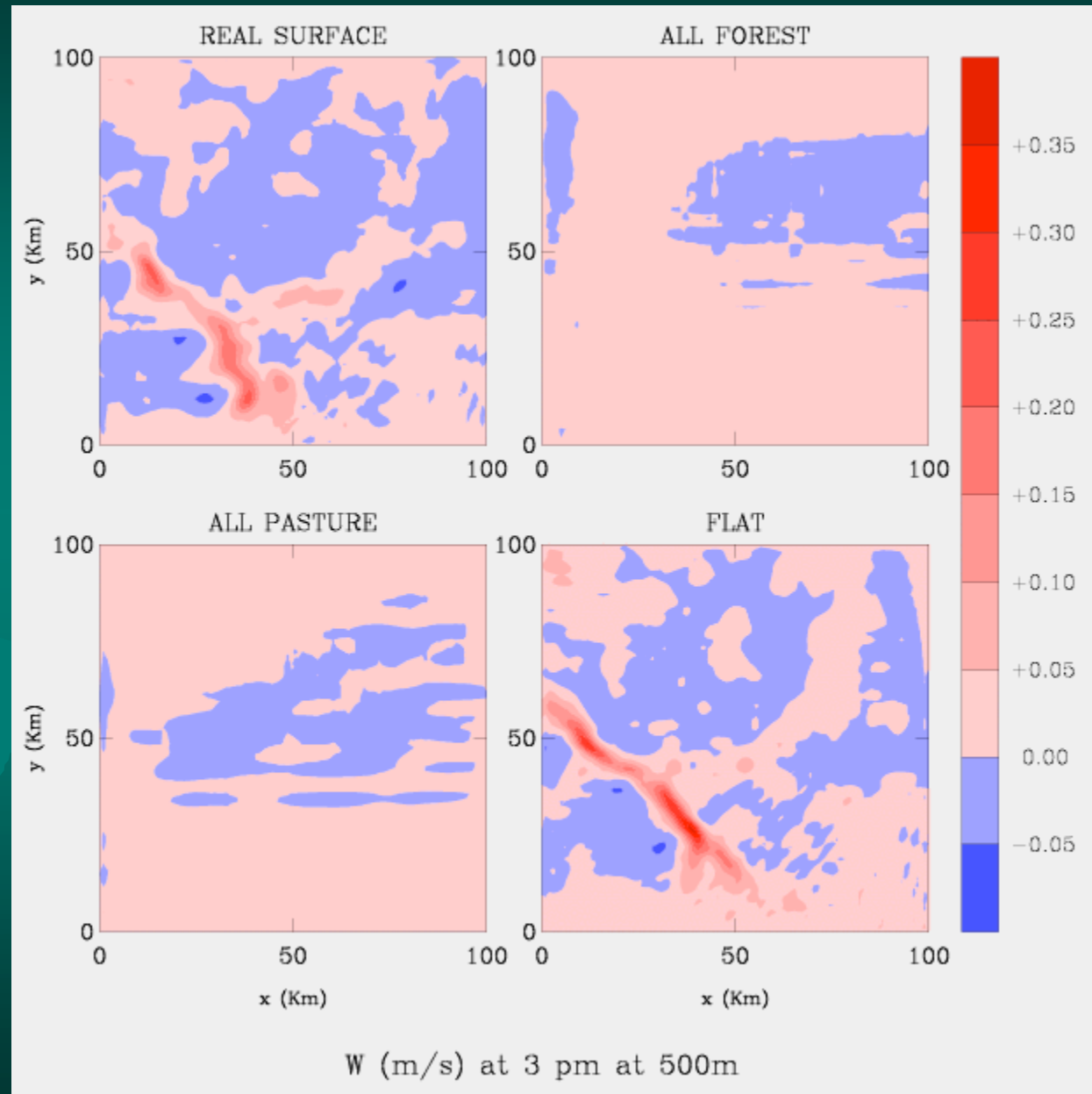
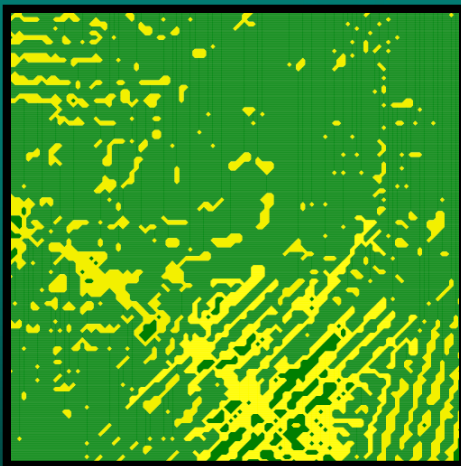
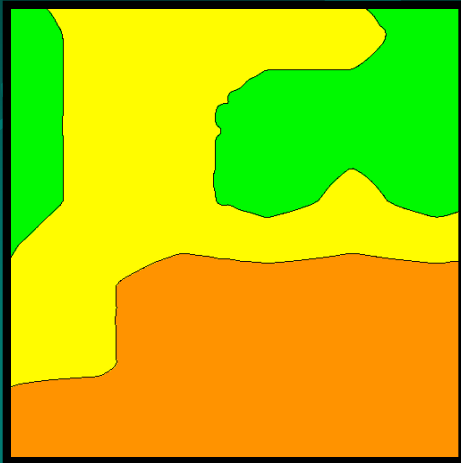


w (m/s) at 3 p.m., 500 m



Clouds at 3 p.m. (from GOES)

Impact of surface heat flux heterogeneity

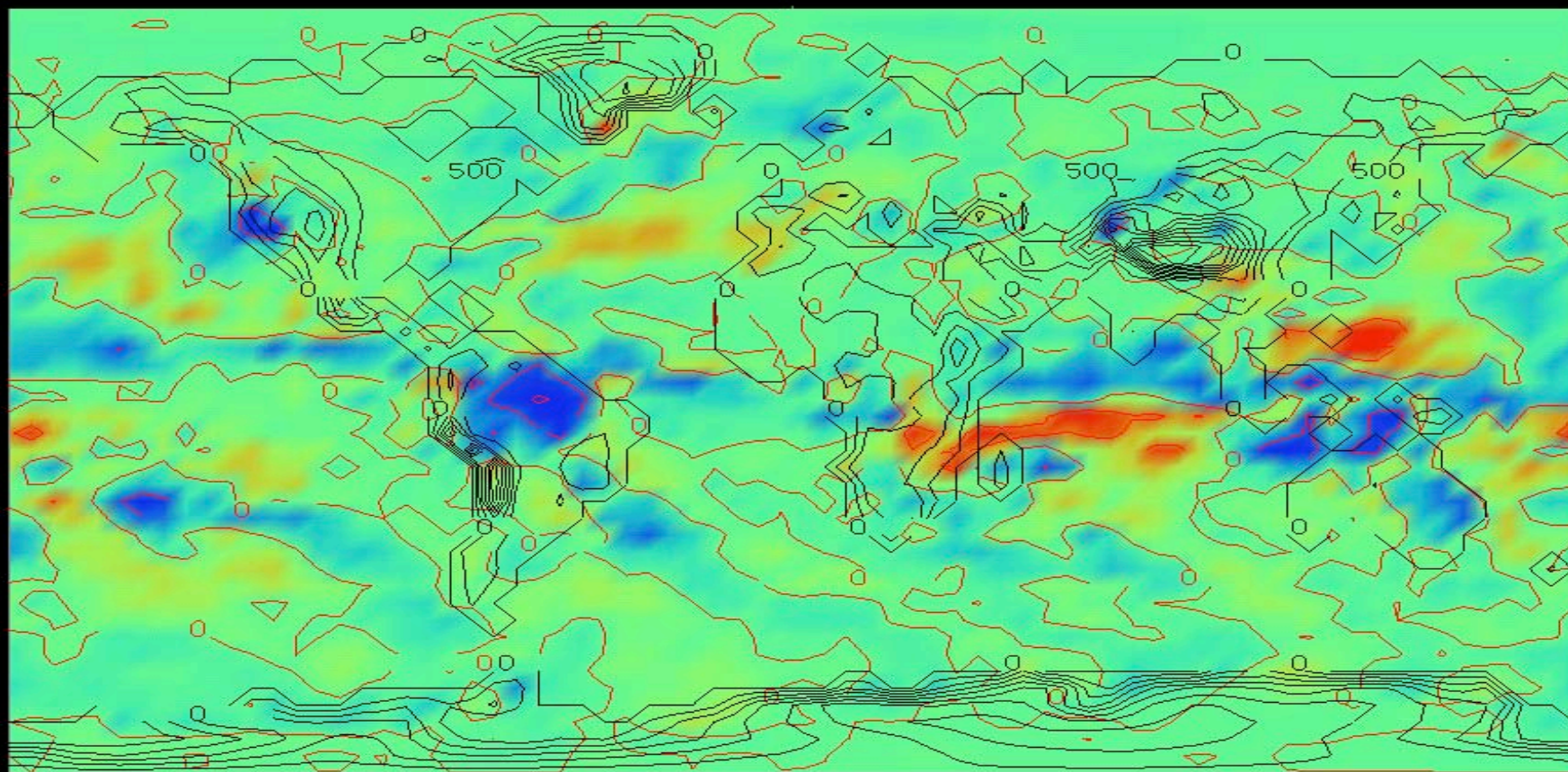


A faint world map is visible in the background of the slide, showing the continents in a light blue color against a darker blue background.

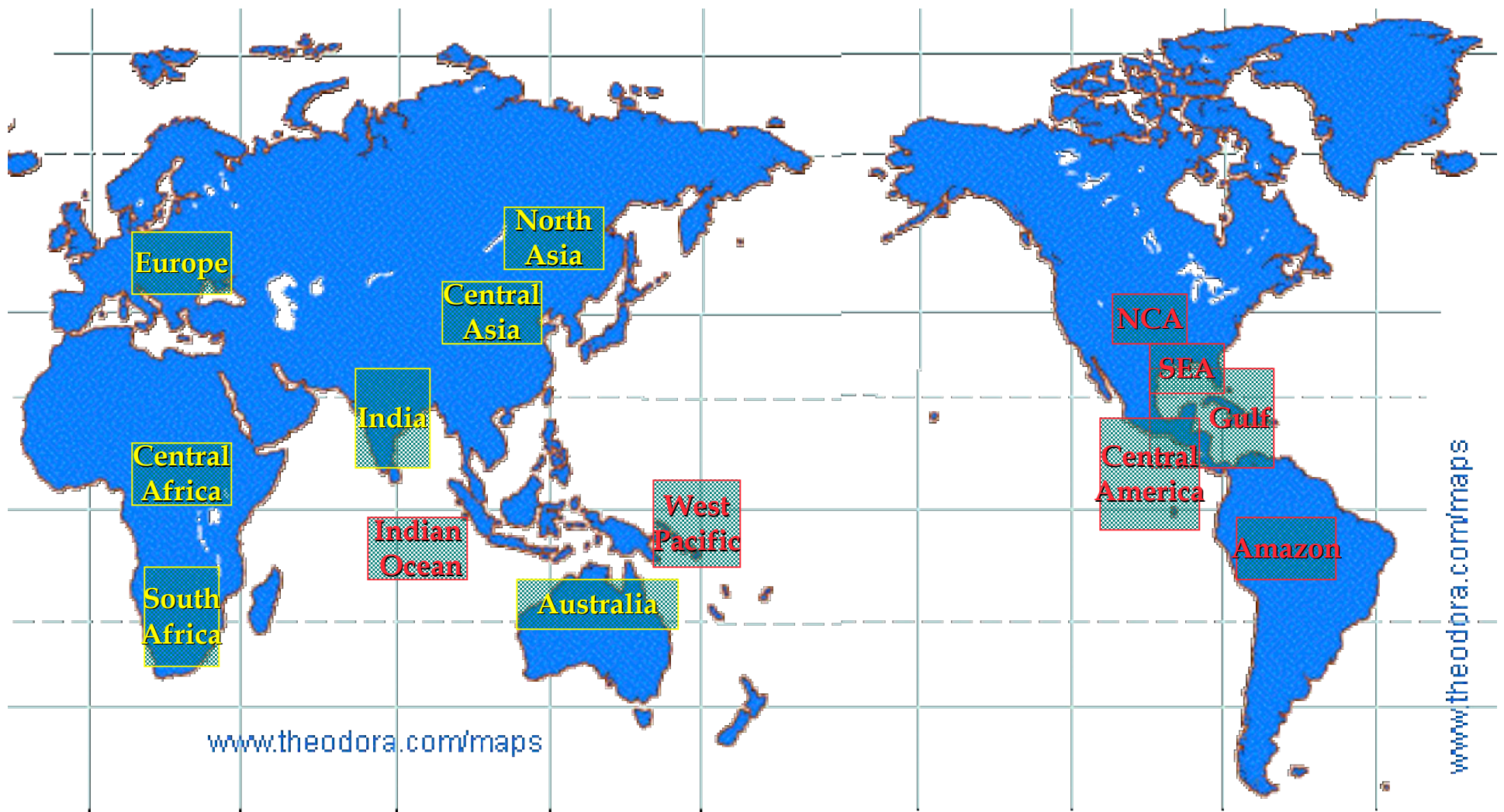
Teleconnection Experiment

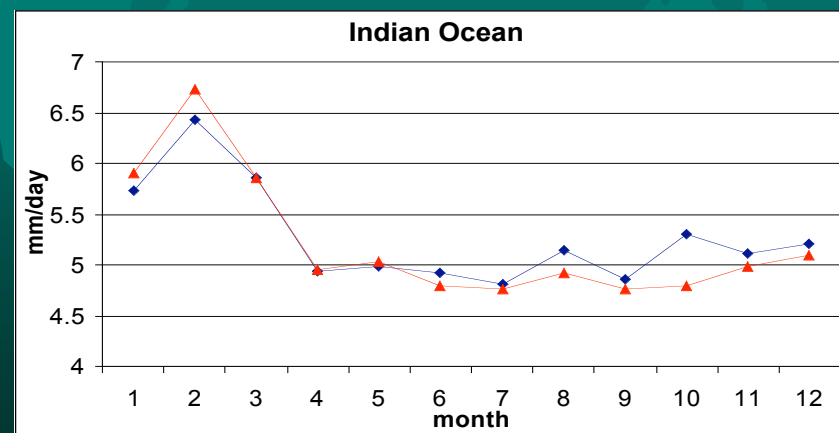
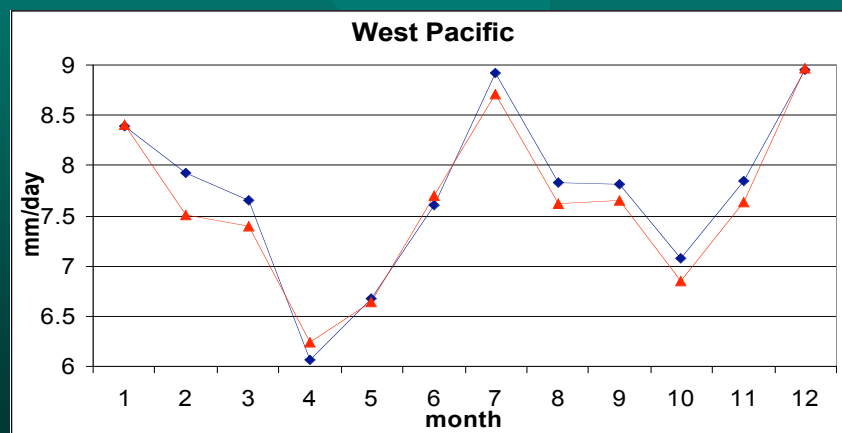
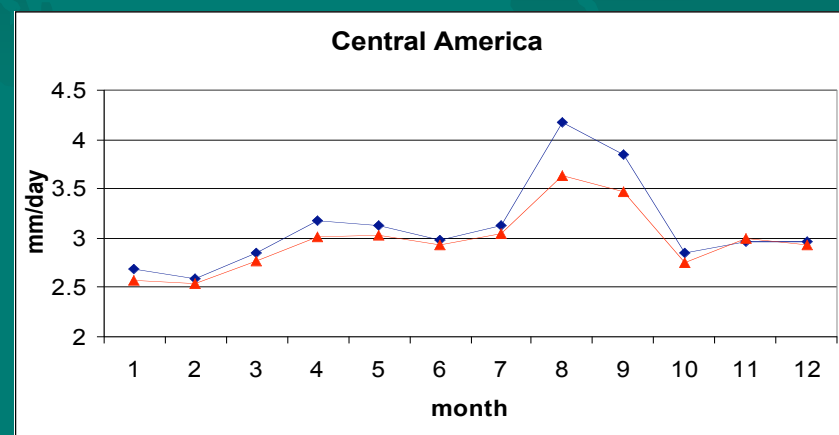
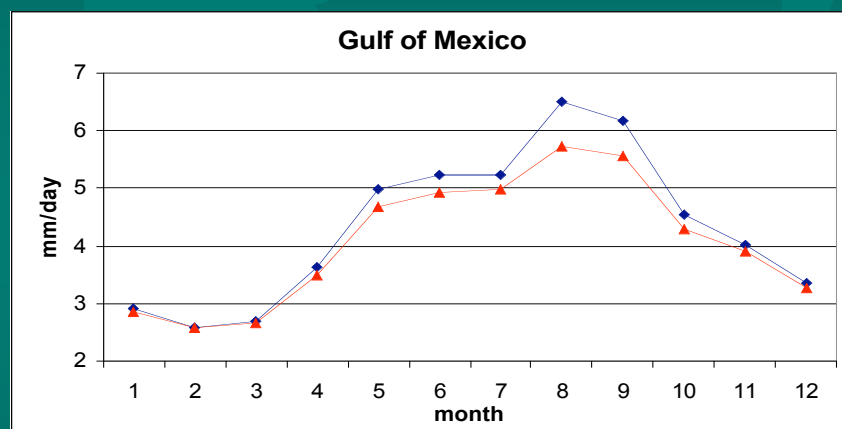
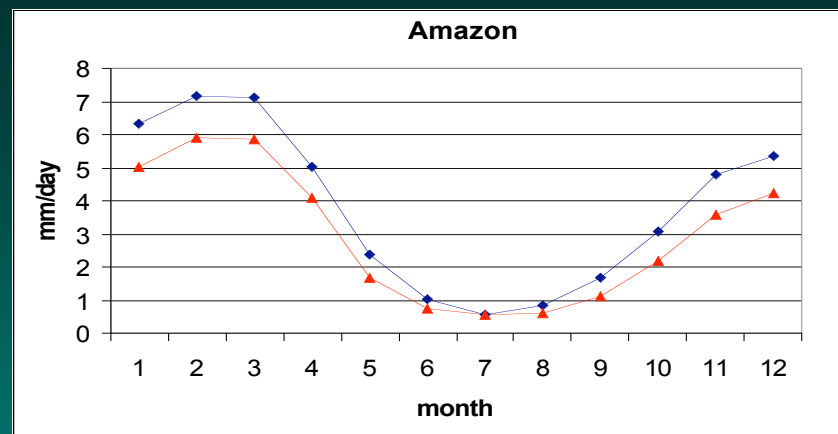
- Use of the GISS Model II GCM to study regional and global effects of the Amazon deforestation;
- “Control” has mix of forests and grassland (current vegetation);
- “Deforestation” assumes that the Amazon rainforest is converted into a mix of shrub and grassland;
- Six 12-year realizations for each case.
- 4x5 degree resolution;
- Heat and humidity advected with quadratic upstream scheme;
- Momentum advected with 2nd order scheme;
- Second order closure PBL;
- 6 soil layers, hydrology;
- Climatological SSTs.

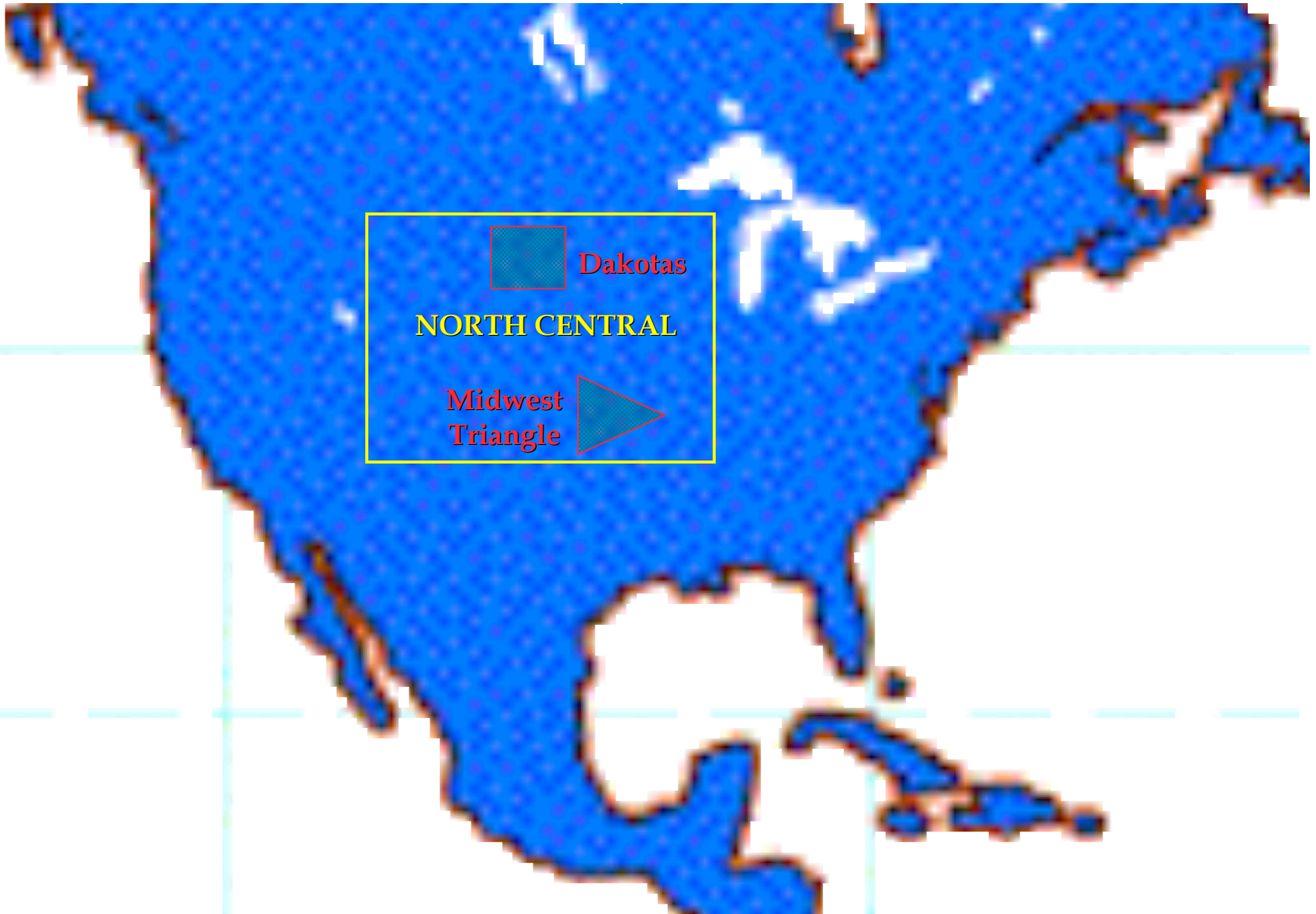
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1 of 12



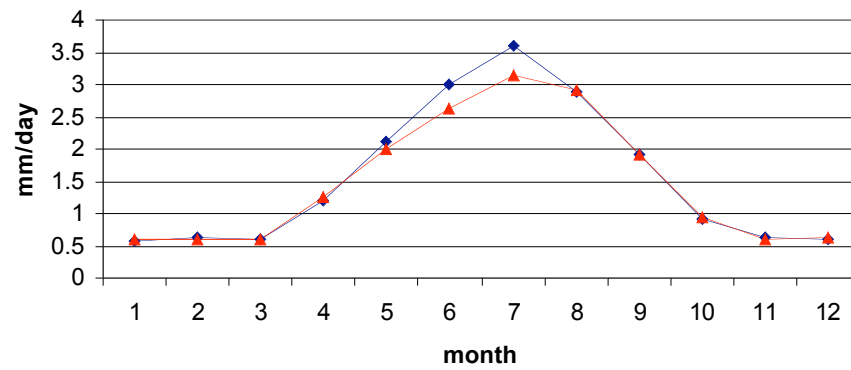
Vis5D



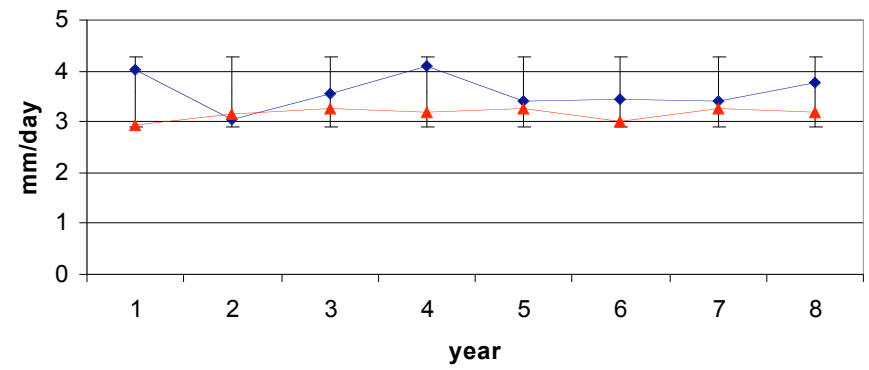




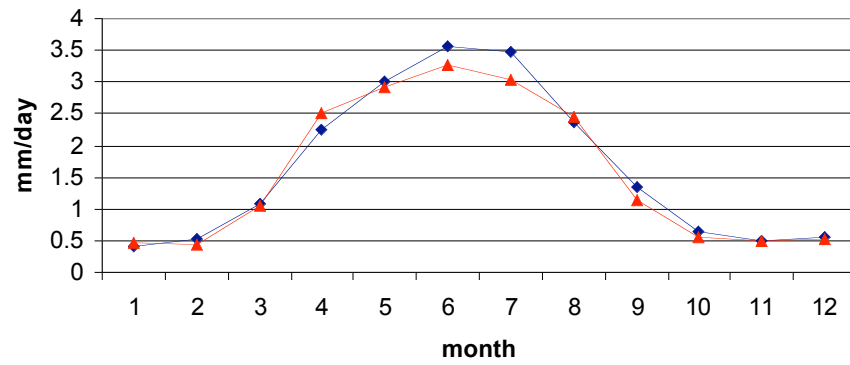
Dakotas



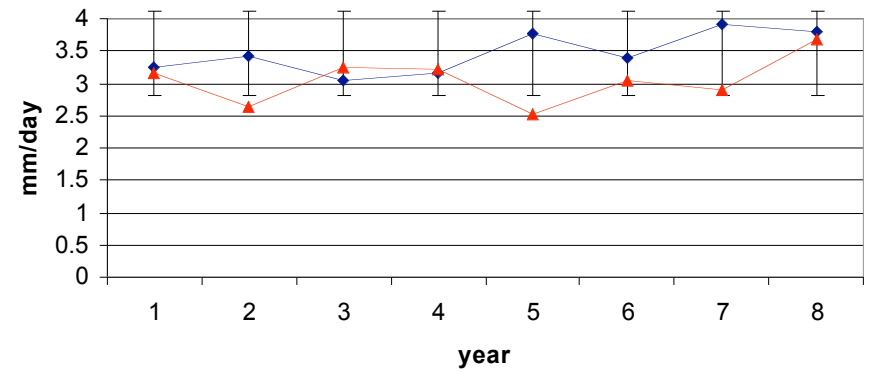
Dakotas

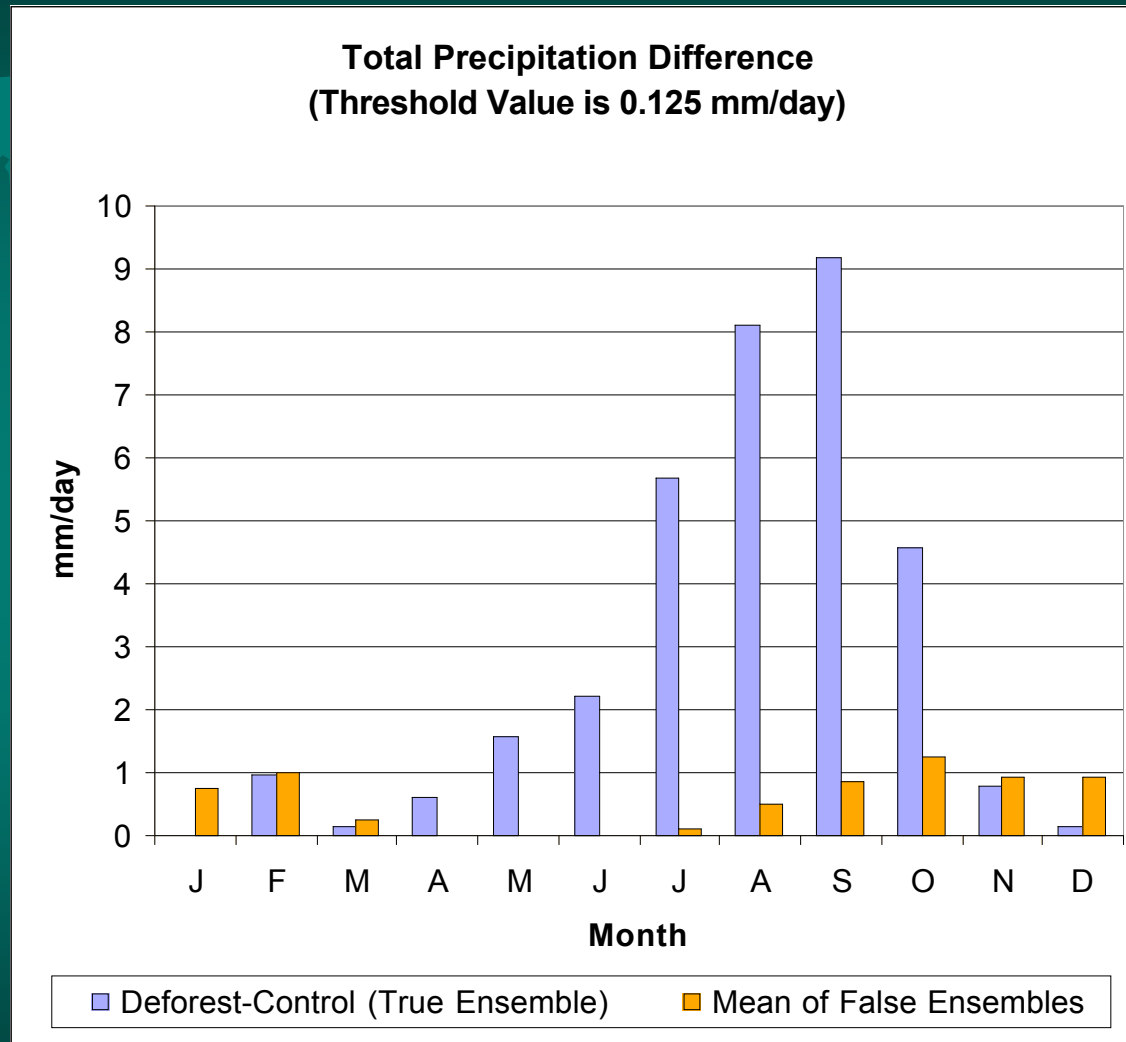


Midwest Triangle



Midwest Triangle





"True" ensemble

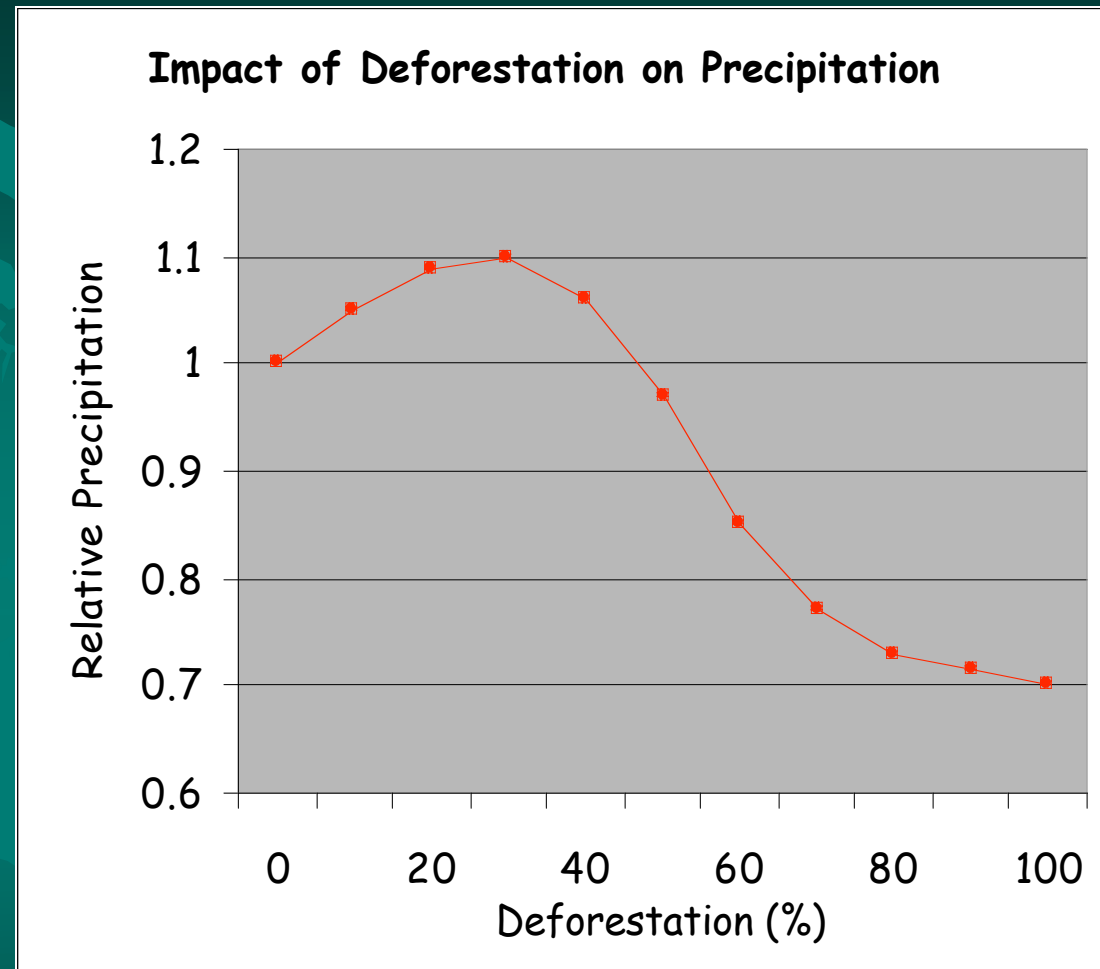
$$\begin{pmatrix} C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \end{pmatrix} - \begin{pmatrix} D_1 \\ D_2 \\ D_3 \\ D_4 \\ D_5 \\ D_6 \end{pmatrix}$$

"False" ensembles

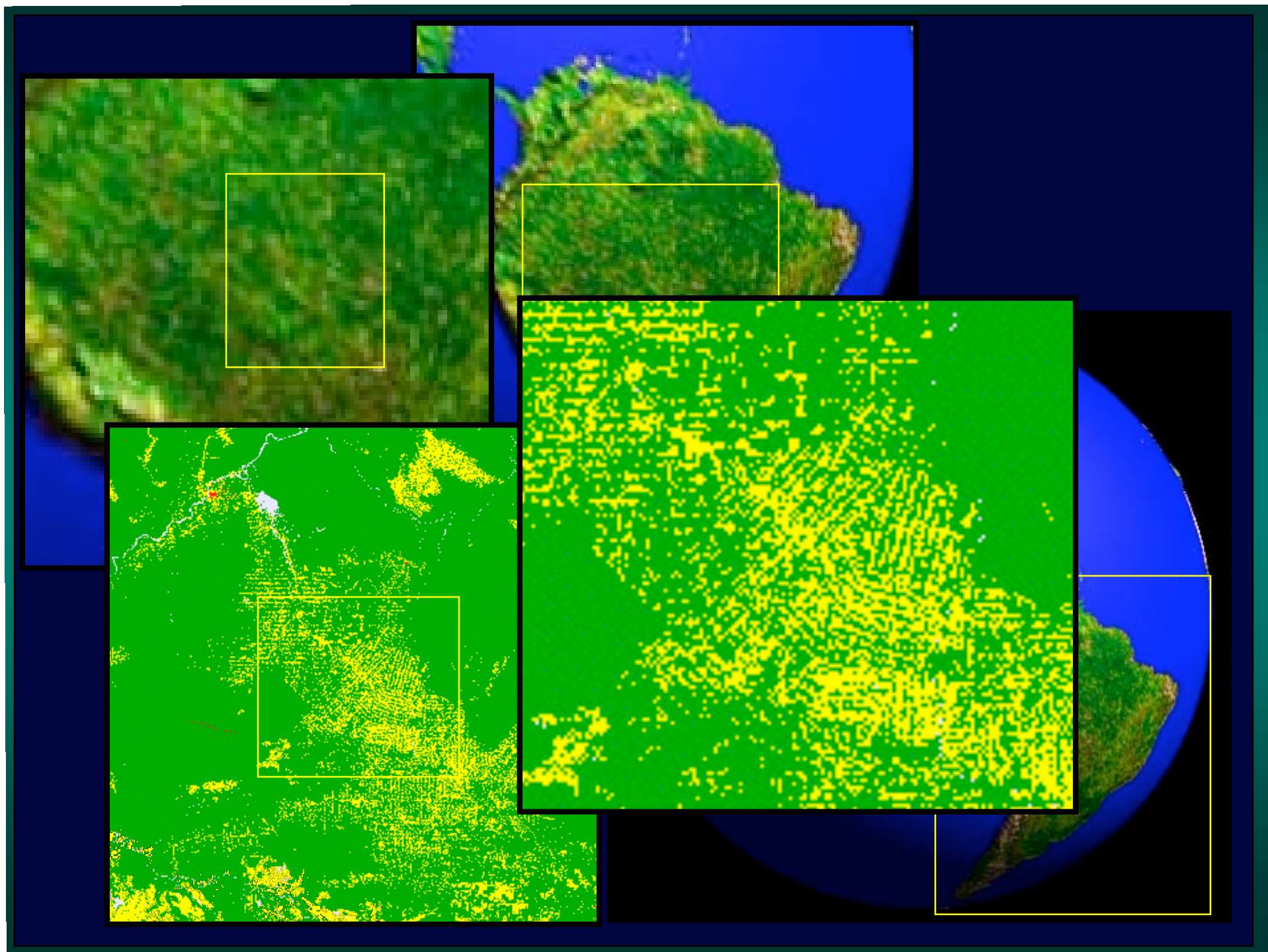
$$\begin{pmatrix} C_1 - C_2 & C_1 - C_3 \\ C_3 - C_4 & C_2 - C_4 \\ C_5 - C_6 & C_3 - C_5 \\ C_1 - C_2 & C_1 - C_5 \\ C_3 - C_5 & C_2 - C_6 \\ C_4 - C_6 & C_3 - C_4 \\ D_1 - D_2 & D_1 - D_3 \\ D_3 - D_4 & D_2 - D_4 \\ D_5 - D_6 & D_3 - D_5 \\ D_1 - D_2 & D_1 - D_5 \\ D_3 - D_5 & D_2 - D_6 \\ D_4 - D_6 & D_3 - D_4 \end{pmatrix}$$

Conclusions

- Both in the Amazon and the Central US regions, the atmospheric boundary layer is significantly affected by land use / land cover change (LU/LCC);
- LU/LCC in the Amazon significantly affects the regional hydroclimatology of South America and other tropical regions, and to a lesser but still significant degree, the hydroclimatology of North America. Convective activity is one of the key factors that trigger teleconnections between tropical regions and mid latitudes;
- Frequently, the landscape heterogeneity created by LU/LCC generates horizontal pressure gradients strong enough to generate and sustain organized mesoscale circulations (synoptic flow determine the orientation of these circulations);
- These circulations affect convective activity, clouds and precipitation. These circulations are neither resolved by, nor parameterized in, GCMs. Clearly, this limits our capability to estimate the real magnitude of teleconnections between the Amazon and the rest of the world.



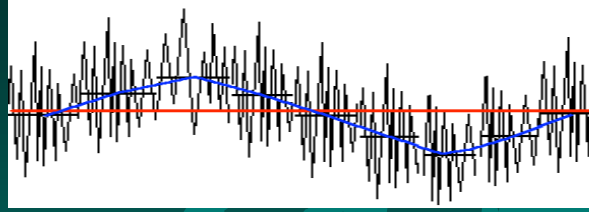
so what's next...



$$\phi = \bar{\phi} + \phi''$$

$$\bar{\phi} = \langle \phi \rangle + \phi'$$

$$\phi = \langle \phi \rangle + \phi' + \phi''$$



$$\frac{\partial \langle u_i \rangle}{\partial t} + \langle u_j \rangle \frac{\partial \langle u_i \rangle}{\partial x_j} = -\delta_{i3} g - 2\varepsilon_{ijk} \Omega_j \langle u_k \rangle - \frac{1}{\langle \rho \rangle} \frac{\partial \langle p \rangle}{\partial x_i} + v \frac{\partial^2 \langle u_i \rangle}{\partial x_j^2} - \frac{\partial \langle u_i'' u_j'' \rangle}{\partial x_j} - \frac{\partial \langle u_i' u_j' \rangle}{\partial x_j}$$

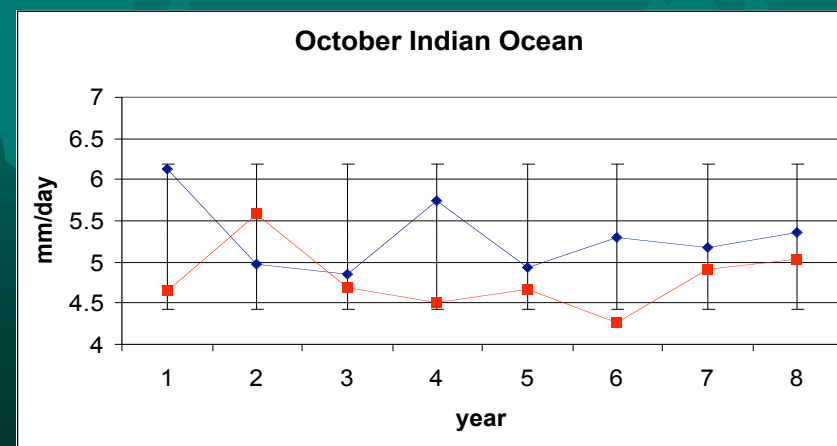
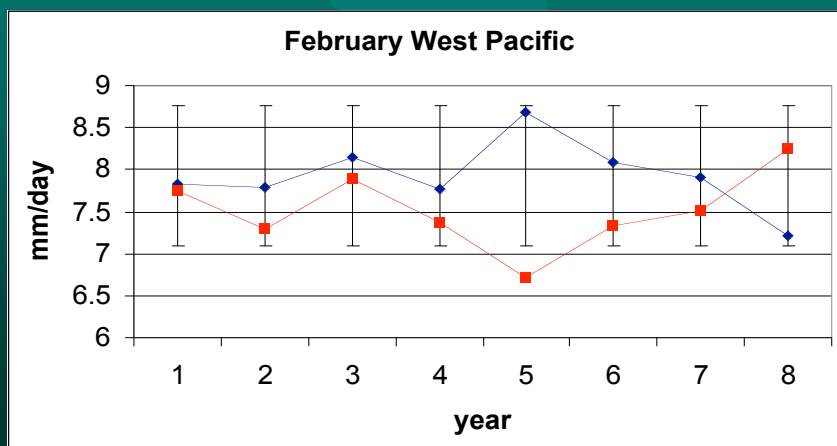
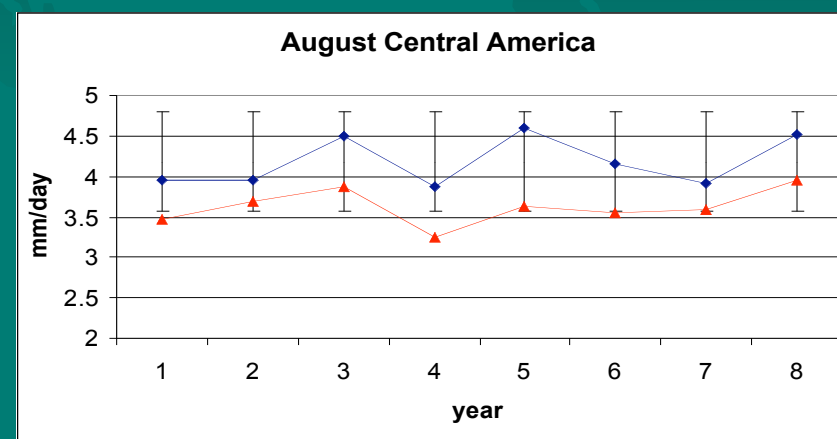
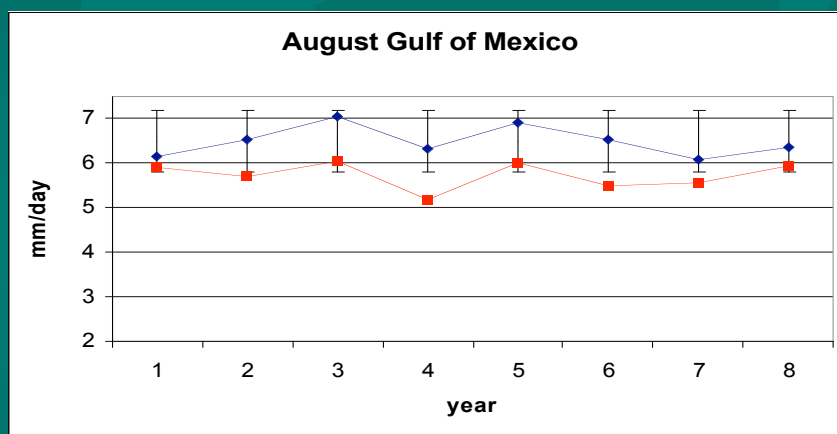
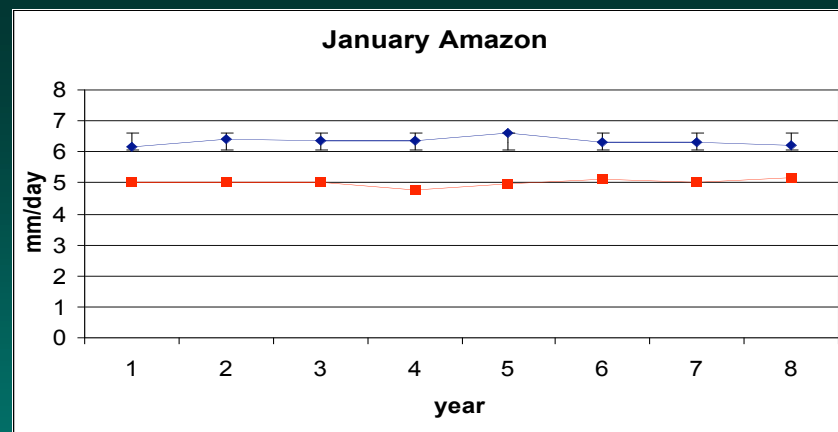
$$\begin{aligned} \frac{\partial u_i'}{\partial t} + \langle u_j \rangle \frac{\partial u_i'}{\partial x_j} + u_j' \frac{\partial \langle u_i \rangle}{\partial x_j} + u_j' \frac{\partial u_i'}{\partial x_j} = \\ -\delta_{i3} \frac{\theta_v'}{\langle \theta_v \rangle} g - 2\varepsilon_{ijk} \Omega_j u_k' - \frac{1}{\langle \rho \rangle} \frac{\partial p'}{\partial x_i} + v \frac{\partial^2 u_i'}{\partial x_j^2} - \frac{\partial \langle u_j'' u_i'' \rangle}{\partial x_j} + \frac{\partial \langle u_j' u_i' \rangle}{\partial x_j} \end{aligned}$$

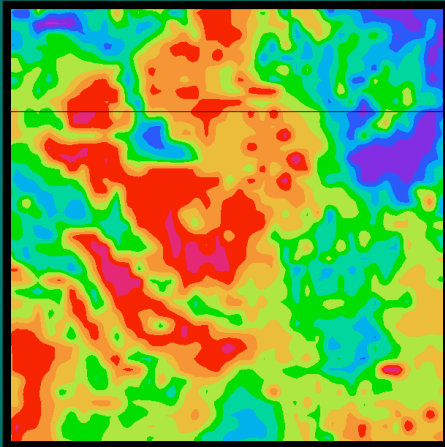
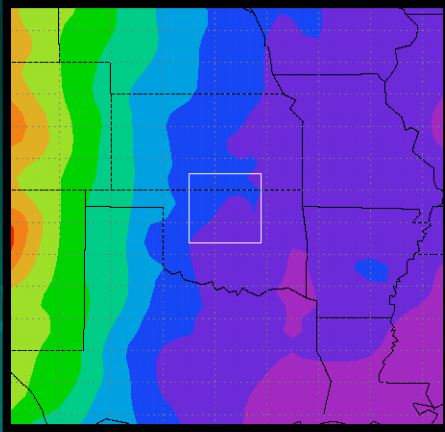
$$\frac{\partial \theta'}{\partial t} + \langle u_j \rangle \frac{\partial \theta'}{\partial x_j} + u_j' \frac{\partial \langle \theta \rangle}{\partial x_j} + u_j' \frac{\partial \theta'}{\partial x_j} = v \frac{\partial^2 \theta'}{\partial x_j^2} + \psi_\theta' - \frac{\partial \langle u_j'' \theta'' \rangle}{\partial x_j} + \frac{\partial \langle u_j' \theta' \rangle}{\partial x_j}$$

$$\begin{aligned} \frac{\partial \langle u_i' \theta' \rangle}{\partial t} + \langle u_j \rangle \frac{\partial \langle u_i' \theta' \rangle}{\partial x_j} + \langle u_j' \theta' \rangle \frac{\partial \langle u_i \rangle}{\partial x_j} + \langle u_i' u_j' \rangle \frac{\partial \langle \theta \rangle}{\partial x_j} + \frac{\partial \langle u_i' u_j' \theta' \rangle}{\partial x_j} = \\ \delta_{i3} \frac{g}{\langle \theta_v \rangle} \langle \theta' \theta_v' \rangle + 2\varepsilon_{ijk} \Omega_j \langle u_k' \theta' \rangle - \left\langle \frac{1}{\rho} \right\rangle \left\langle \theta' \frac{\partial p'}{\partial x_i} \right\rangle + \langle u_i' \psi_\theta' \rangle + \\ \left\langle \theta' v \frac{\partial^2 u_i'}{\partial x_j^2} \right\rangle + \left\langle u_i' v \frac{\partial^2 \theta'}{\partial x_j^2} \right\rangle - \left\langle \theta' \frac{\partial u_i'' u_j''}{\partial x_j} \right\rangle - \left\langle u_i' \frac{\partial u_j'' \theta''}{\partial x_j} \right\rangle \end{aligned}$$

Publications

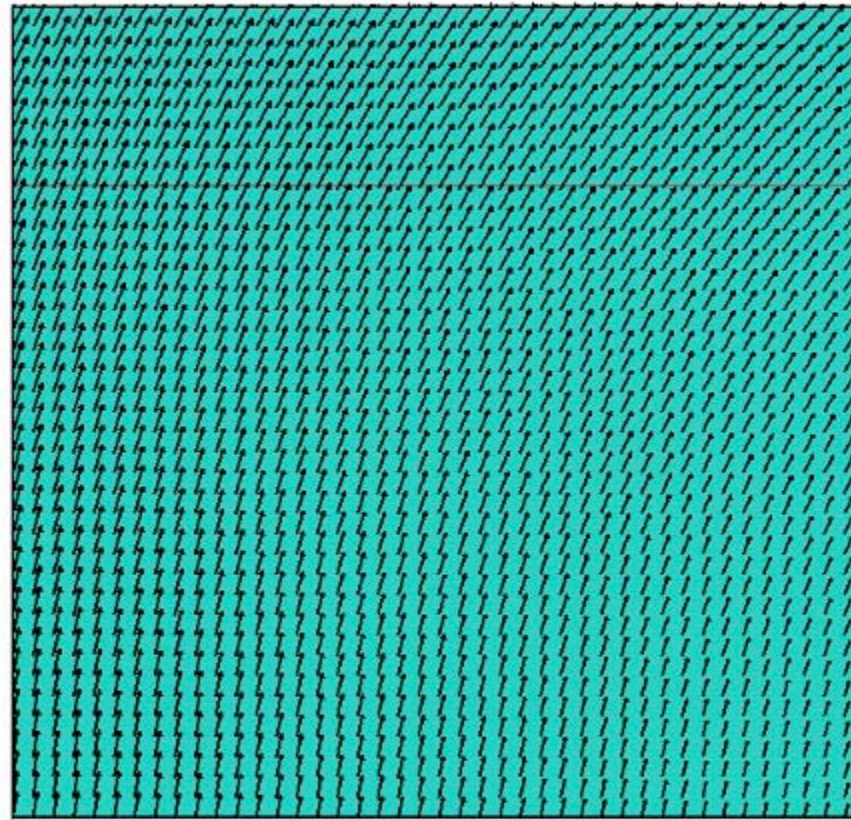
- Liu, Y., C.P. Weaver, and R. Avissar, 1999. Towards the parameterization of convection induced by landscape heterogeneity in GCMs. *J. Geophys. Res.*, **104**:19515-19533.
- Weaver, C.P. and R. Avissar, 2001. Atmospheric Disturbances Caused by Human Modification of the Landscape. *Bull. Amer. Met. Soc.*, **82**:269-281.
- Baidya Roy, S. and R. Avissar. The impacts of land use / land cover change in the Amazon on its regional hydroclimatology. *J. Geophys. Res. (LBA Special Issue)*, accepted for publication.
- Weaver, C.P., S. Baidya Roy, and R. Avissar. A sensitivity analysis of large-scale boundary-layer characteristics to initialization and forcing under realistic meteorological and surface conditions. *J. Geophys. Res. (LBA Special Issue)*, in revision.
- Werth, D. and R. Avissar. Regional and global impacts of Amazon deforestation. *J. Geophys. Res. (LBA Special Issue)*, accepted for publication.
- Werth, D. and R. Avissar. Amazon evaporation, clouds, and radiation. *J. Geophys. Res. (LBA Special Issue)*, in revision.

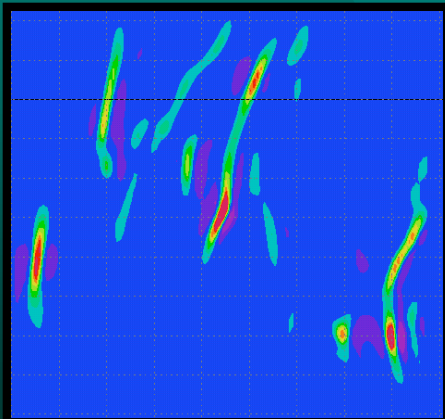
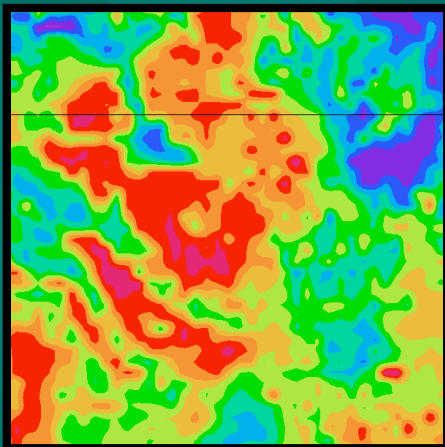
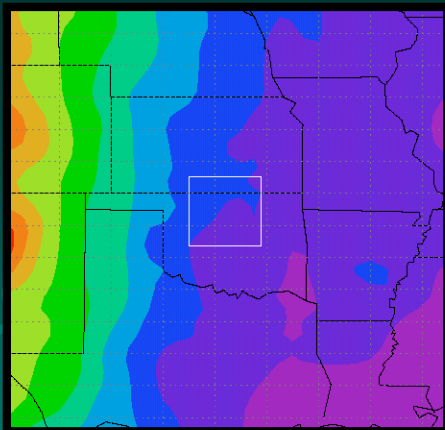




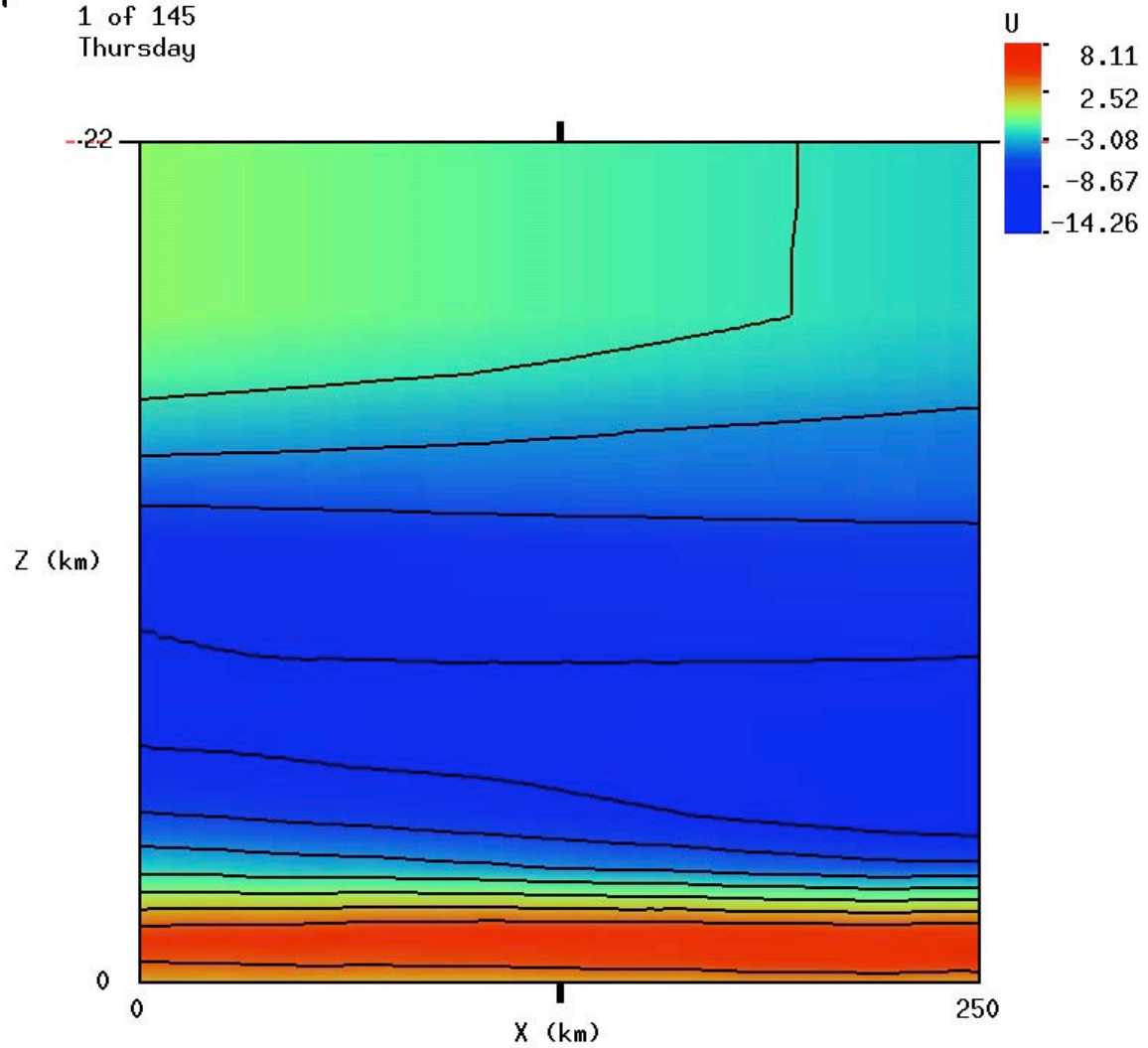
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13 Jul 95
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Thursday

SSH
629.11
371.80
114.48
-142.83
-400.15





06:00:00
13 Jul 95
1 of 145
Thursday



VERTICAL CROSS-SECTION OF U (m/s)