

*A Climatology of the decade leading to
Cloud and Land Surface Interaction
Campaign (CLASIC)*

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Global Climate Change

- Global surface temperatures have been increasing over the last few decades

Hansen J.E, Journal of Climate

- Land use can influence cloud cover

Xingkui X. et al., Journal of

- Climate can be altered by cloud cover

Croke M.S, Journal of Climate

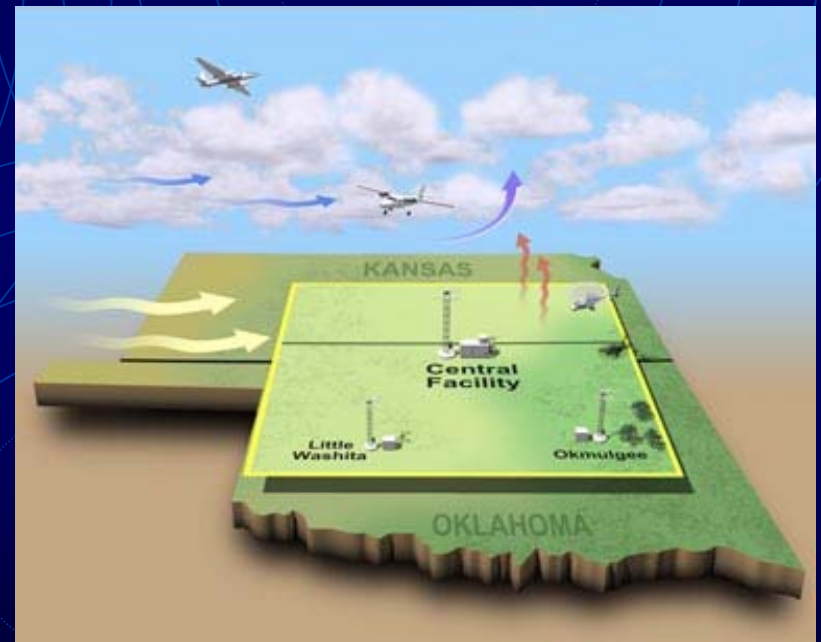
- Investigation of the physics behind cloud development and structure is necessary

Miller M., CLASIC P.I.

CLASIC

Cloud and Land Surface Interaction Campaign

- Field program to study cloud and land surface interactions
- Mid-continent location, Atmospheric Radiation Measurement Program's Southern Great Plains Site (SGP, 15+ years climate research)
- June 8th - June 30th 2007

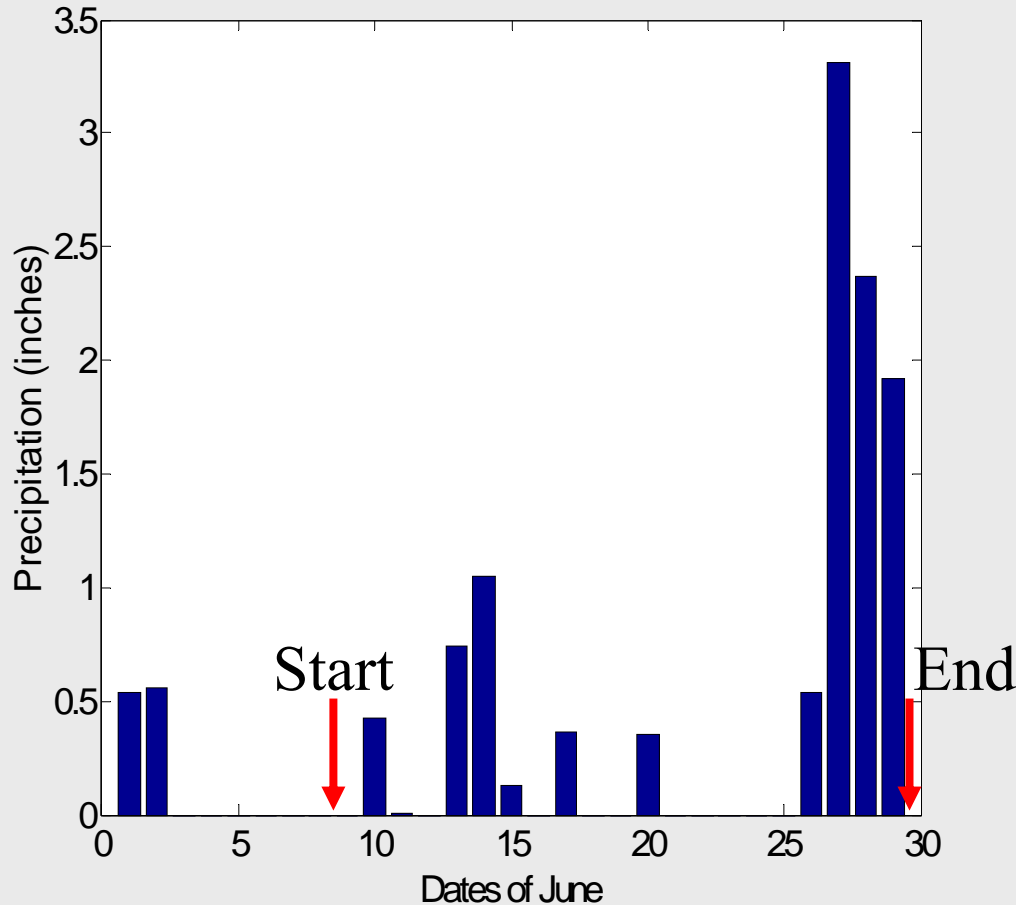


Question

- How do the conditions in the atmosphere and at the surface encountered during CLASIC compare to the previous decade?
- Are they representative, or was the experiment period anomalous?

Weather Conditions

Precipitation for June 2007



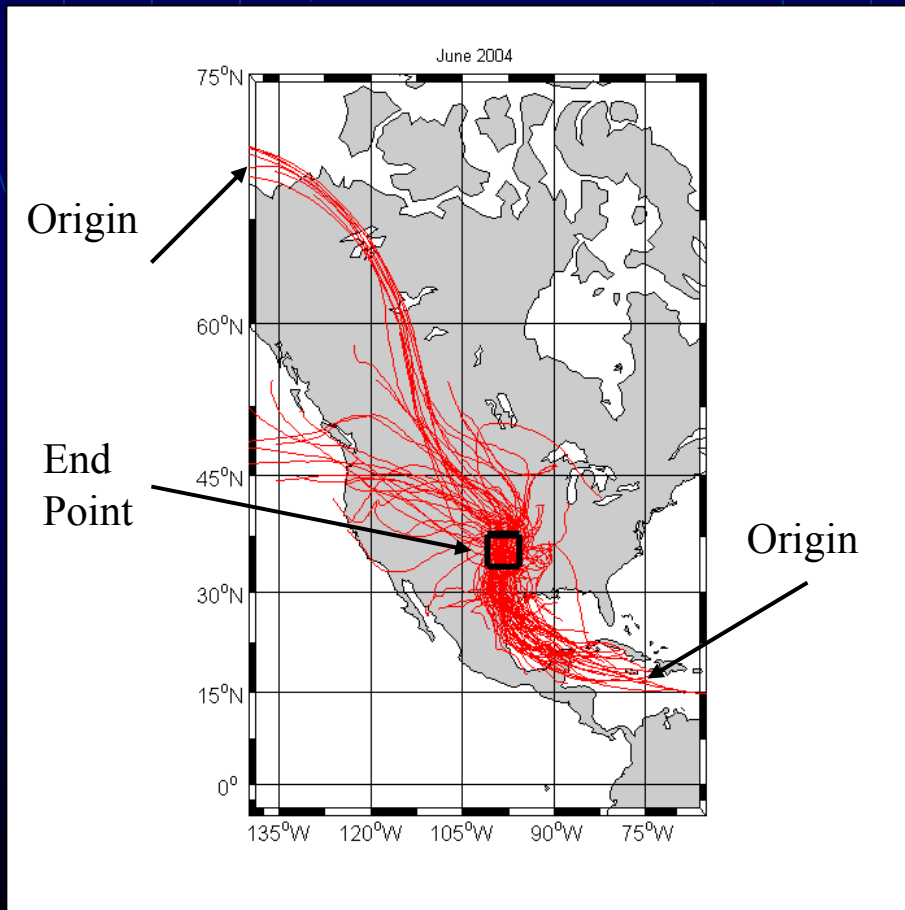
- Broke rainfall records in both Oklahoma and Kansas
- Precipitation for Lamont, Ok (central facility)
- Dry interval from June 3rd - 10th
- Substantial rainfall at the end of June (8" +)

Question: Why was June 2007 such an extreme year?

Climatological Survey

Atmospheric Low Level Flow
1997-2007

June 2004



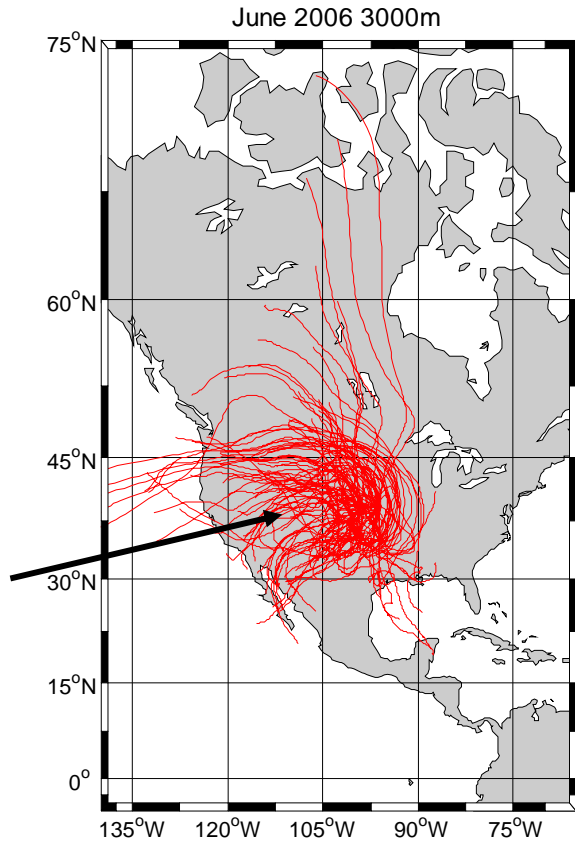
Back Trajectories of Parcels

Question: What are Back Trajectories really telling us?

- Parcels Origin (air mass)
- Direction to SGP

Using...**Hysplit4**

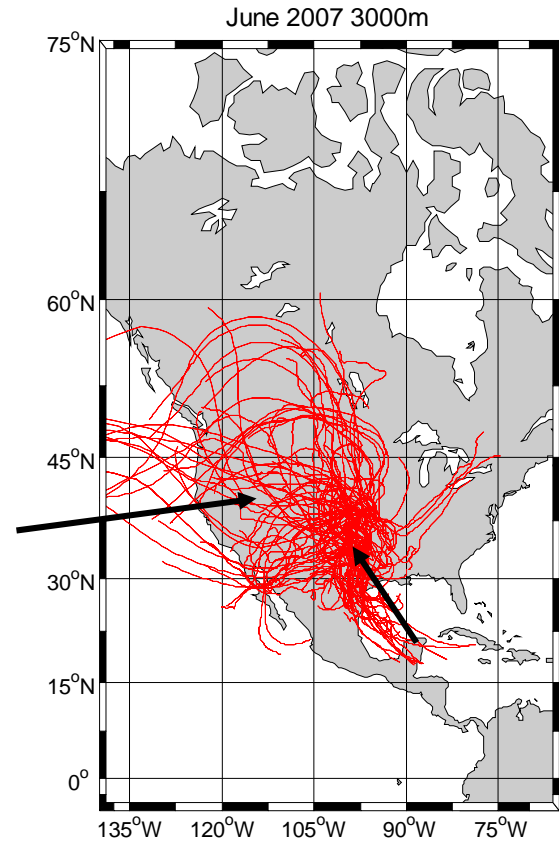
June 2006 3000m



Extremely Dry Year

Parcels originating from west

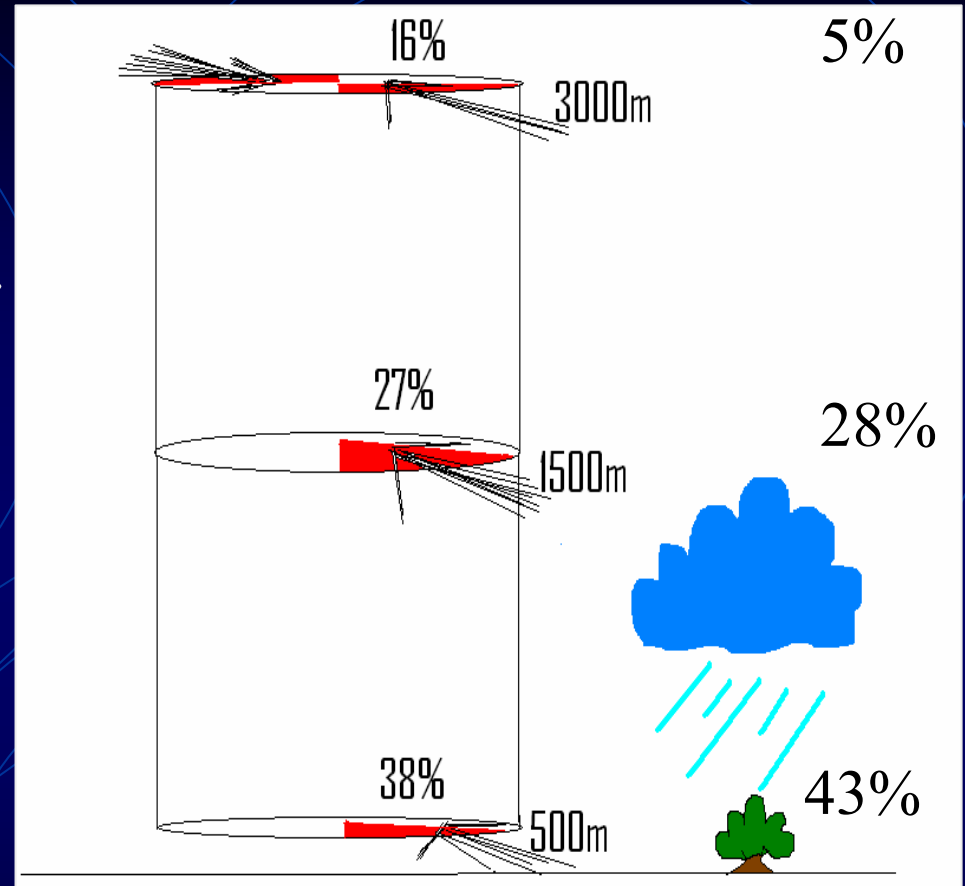
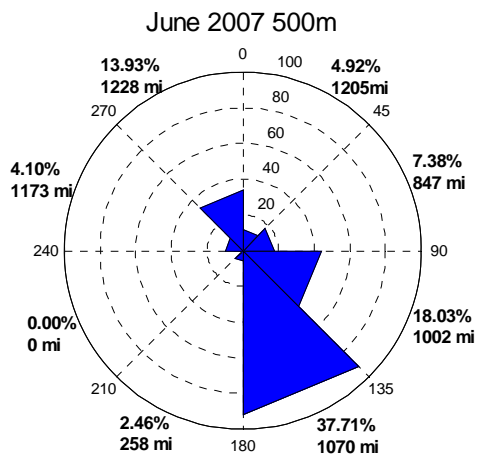
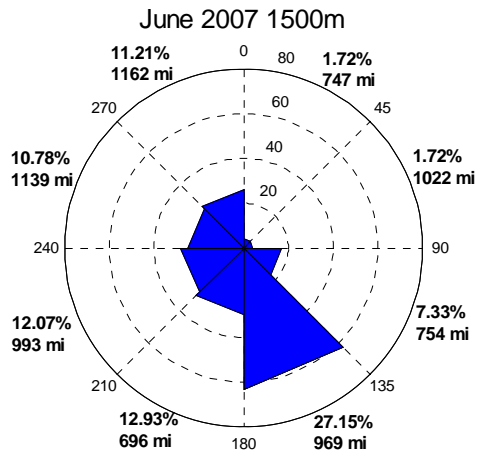
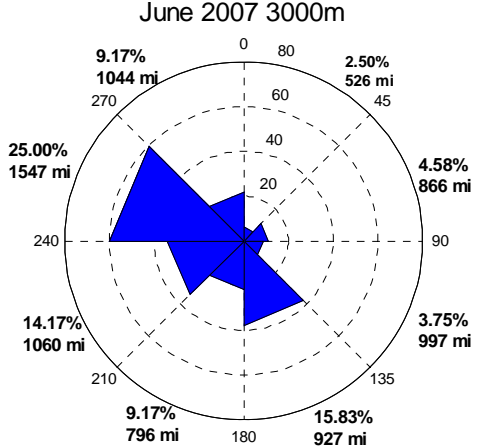
June 2007 3000m



Extremely Wet Year

Parcels originating from west and south

Air Column June 2007



June 2007 was atmospherically different than the decadal trend leading up to CLASIC

Land Surface and Energy Balance Fluctuations



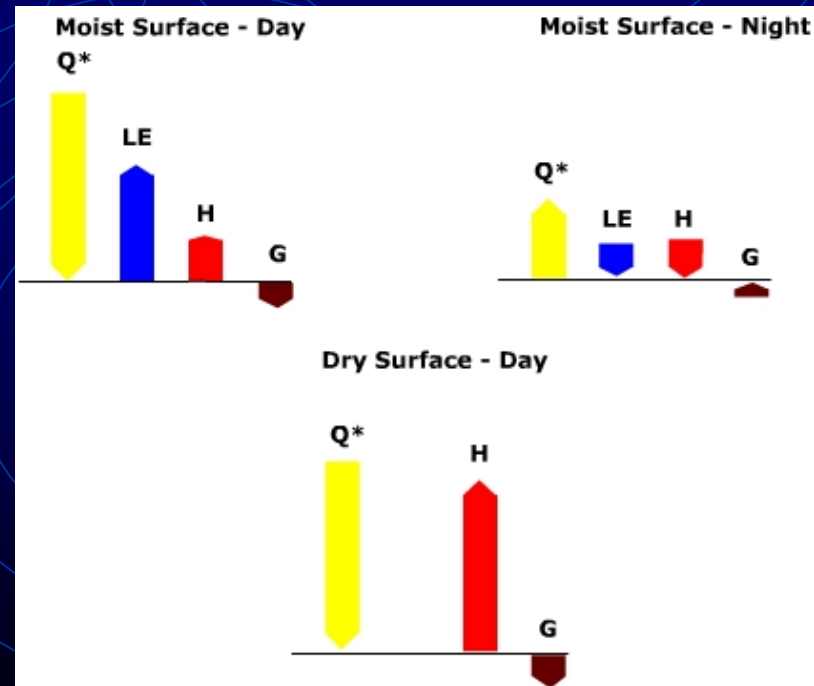
Land Surface

- Cause: plowing, crop rotation and irrigation
- Immediate Effects: Energy Balance, albedo, etc.
- Implications: cloud formation and climate models

Energy Balance Equation

$$H + H_{LE} + H_G + Q^* = 0$$

- Sensible Heat (H)
- Latent Heat (LE)
- Ground Heat (G)
- Radiative Heat (Q*)



Climatological Survey

Land Surface Processes

1997-2007

Lamont, Ok (Central/Extended Facility)

Compile Data Series:

- Energy Balance
 - Sensible Heat Flux
 - Latent Heat Flux
 - Evaporation Rate
 - Radiative Heat Flux
 - Ground Heat Flux
- Bowen Ratio

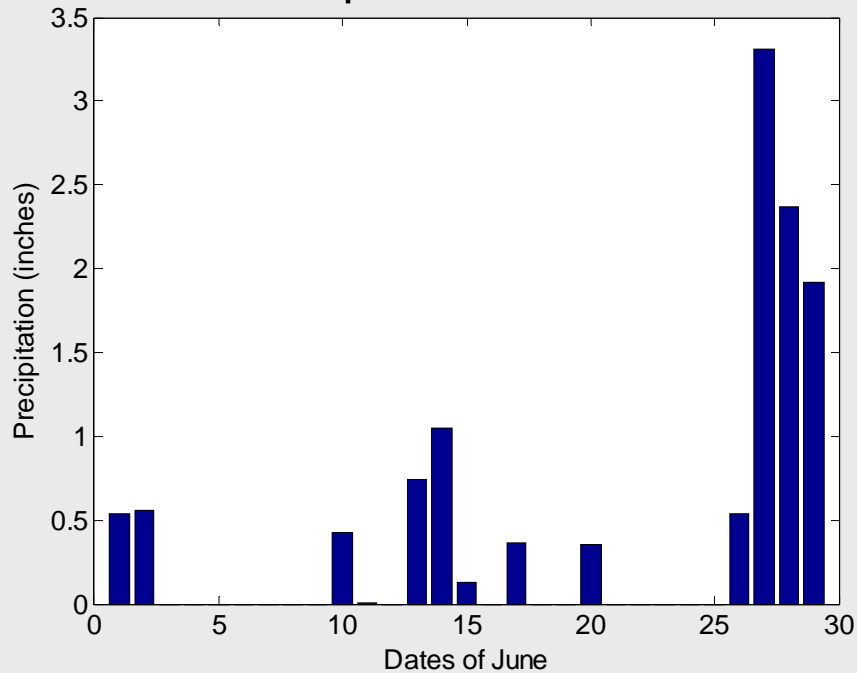


All data from www.arm.gov achieve.

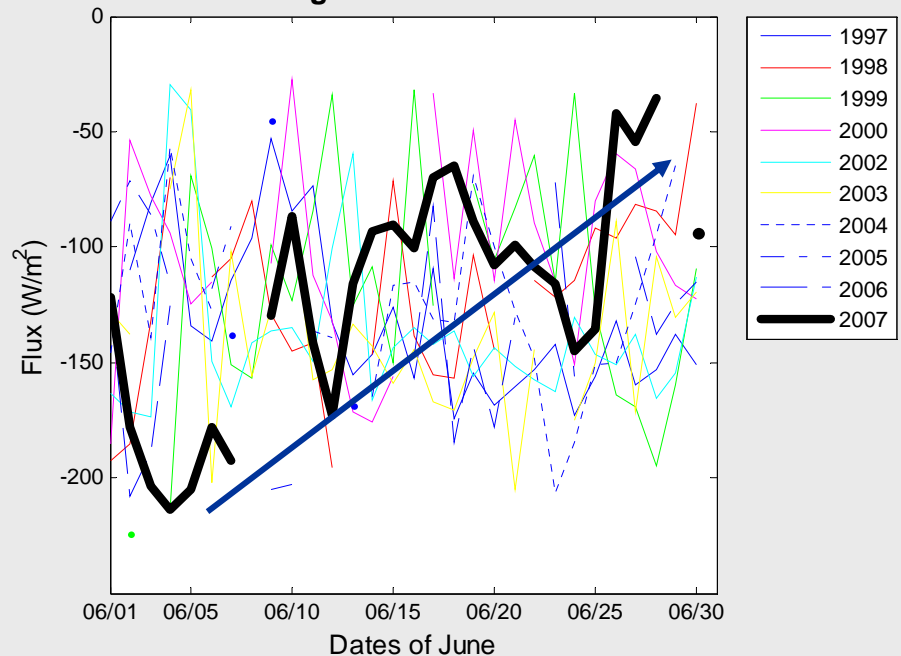
Relationship between Precipitation and Land Flux

Question: How does precipitation influence the surface fluxes?

Precipitation for June 2007



Average Latent Heat Flux



- Climatological Survey of Latent Heat
- Latent heat peaks after a rain event
- Latent heat diminishes during precipitation events
- An upward trend → more analysis...

Key Findings

Atmosphere

- June 2007 low level flow was somewhat anomalous relative to past years
- A deep southeasterly flow toward the SGP site seems integrally related to higher than normal rainfall rates
- Strong and persistent flow from the northwest brings in dry stable air that diminishes convection from taking place
- More analysis on the convergence zone is warranted at this site

Land Surface

- Surface fluxes in June 2007 fall within decadal envelope (not exclusive)
- Correlation between precipitation and latent heat signals may promote further precipitation and may retard drying (recycling)
- Precipitation likely influences fluxes
- More analysis is needed to explain the influences of these fluxes on the atmosphere

These data are the door way to a better understanding of land-atmosphere interactions!

Acknowledgments

Thank You Jeff and Milton!

Thank you Mark Miller, Mary Jane, and the rest of the ARM Faculty at BNL!

Thank you to all participants of SURE/GREF!



References

- Croke, M.S. et al. 1999. *Regional Cloud Cover changes associated with global climate change: Case studies for three regions of the U.S.*; Journal of Climate. **12**. 7. 2128-2134
- Hansen, J.E. et al. 2006. *Global Temperature Change*; PNAS. **103**
- Sud, Y.C. et al. 1999. *Influences of Land Surface fluxes on precipitation: Influences from simulations forced with four ARM-CART SCM datasets*; Journal of Climate. **14**. 17. 3666-3691
- Xingkui, E. et al. 2007. *The Influence of Land Surface changes on regional Climate in Northwest China*; Advances in Atmospheric Sciences. **24**. 3. 527-537

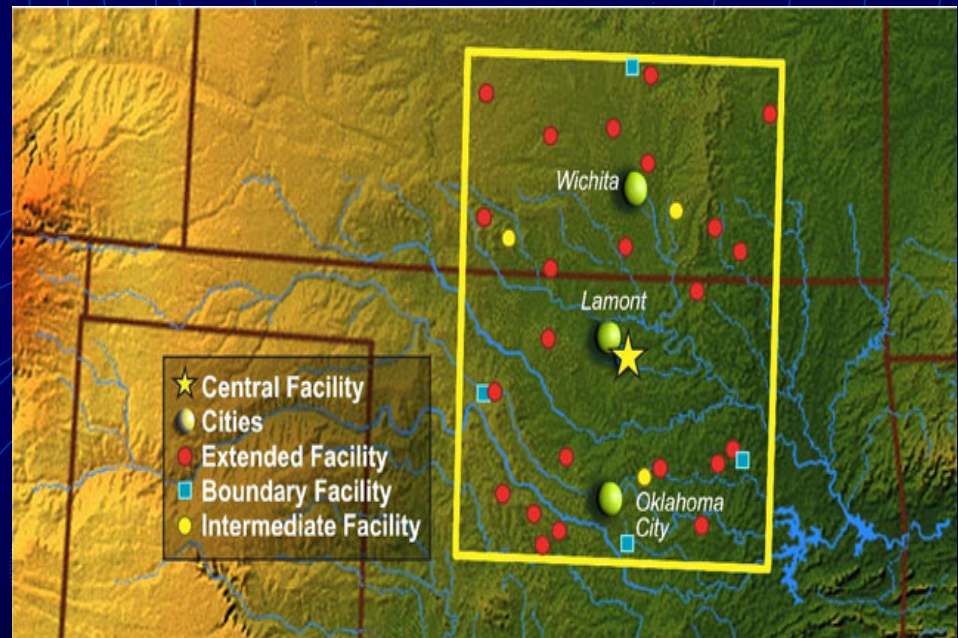
Goals Going In...

- Gain research experience at another Facility
- Increase my knowledge about Radiative Processes
- Broaden my scope of Meteorology
- Learn MATLAB
- Make Connections
- Have FUN!

Oklahoma/Kansas Surface Structure

So...Why 'Okansas'?

- **Mid-Continental**
Take advantage of climate research infrastructure
- **Diverse Land Structure**
Harvested wheat extends from southwest Oklahoma to north central Oklahoma to southern Kansas.
Late Spring/Early Summer growers harvest the wheat and dormant grassland grow



My Investigation

Climatological Survey

Land Surface Processes

- June Precipitation
- June Energy Fluxes

Atmospheric Dynamics

- Back Trajectory of Parcels
- Analysis of Wind Direction



Land Surface Fluctuations

Human Induced

Cause: Plowing, Crop Rotation, and Irrigation

Immediate Effect: Surface Heat Flux, Latent Heat Flux, Albedo, Carbon Dioxide, and **Energy Budget**

Possible Future Effect: Cloud Processes and Climate Models



Gained Coming Out...

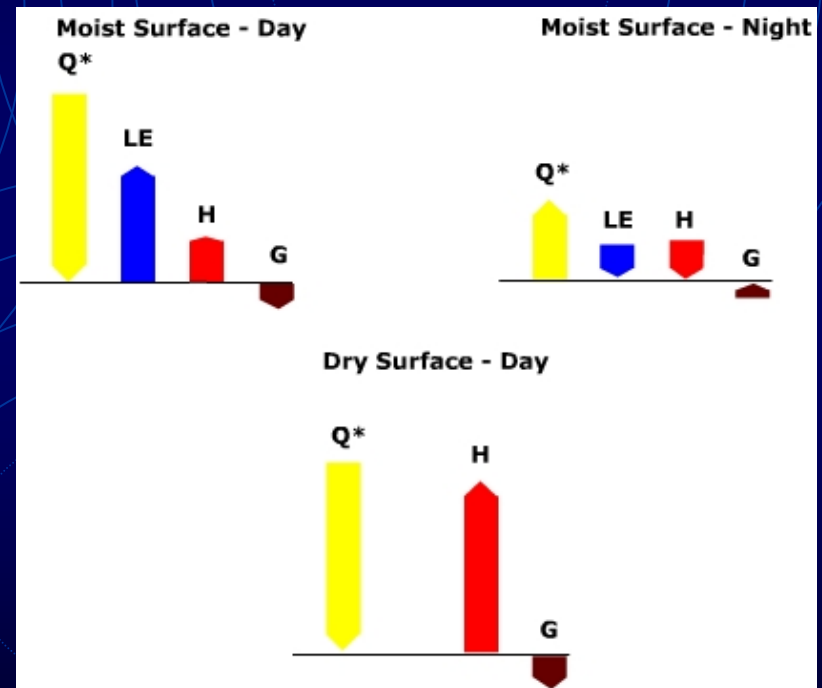
- Research experience at a National Lab
- Better understand Radiative Processes and their connection with the atmosphere
- More knowledgeable about Back Trajectory
- To think on your feet and be creative
- Seeing a different side to Meteorology
- Expert at MATLAB (well... not exactly)
- Had a blast while doing it!
- **CONFIDENCE!**

Energy Balance Fluctuations

- **Sensible Heat (H)**- heat energy transferred between the surface and air above
- **Latent Heat (H_{LE})**- heat energy transferred between the surface and air above by evaporation or condensation
- **Ground Heat (H_G)**- heat energy transferred to and from the subsurface
- **Radiation Flux (Q^*)**- heat transferred from the sun to the earth's surface

Energy Balance Eq.

$$H + H_{LE} + H_G + Q^* = 0$$



June 2006

Dry

3000m

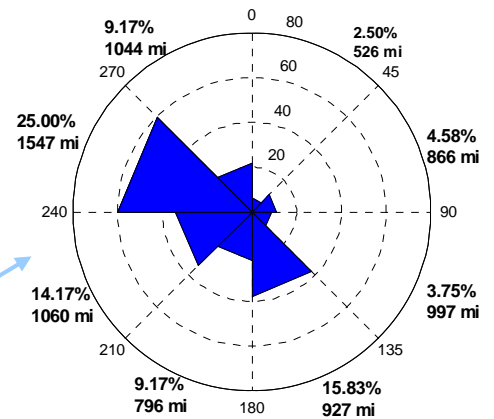
1500m

500m

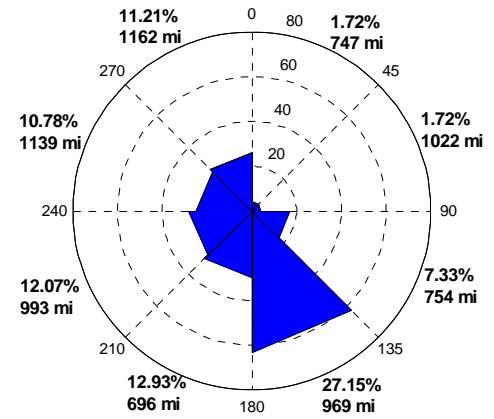
June 2007

Wet

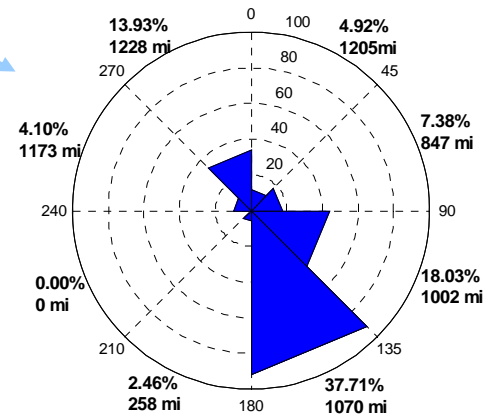
June 2007 3000m



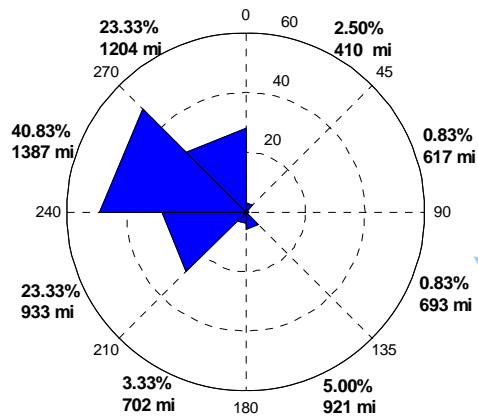
June 2007 1500m



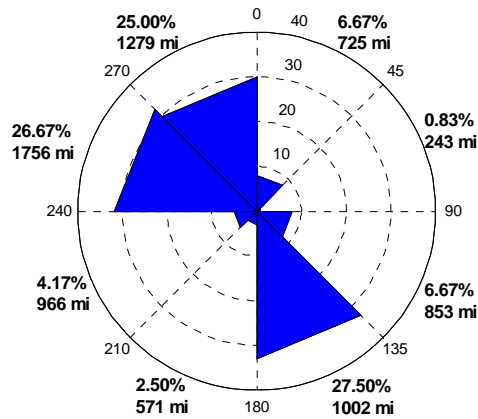
June 2007 500m



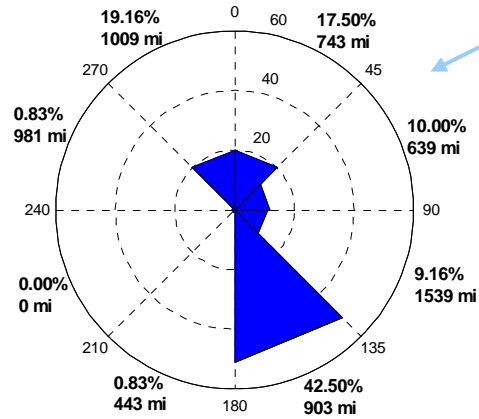
June 2006 3000m



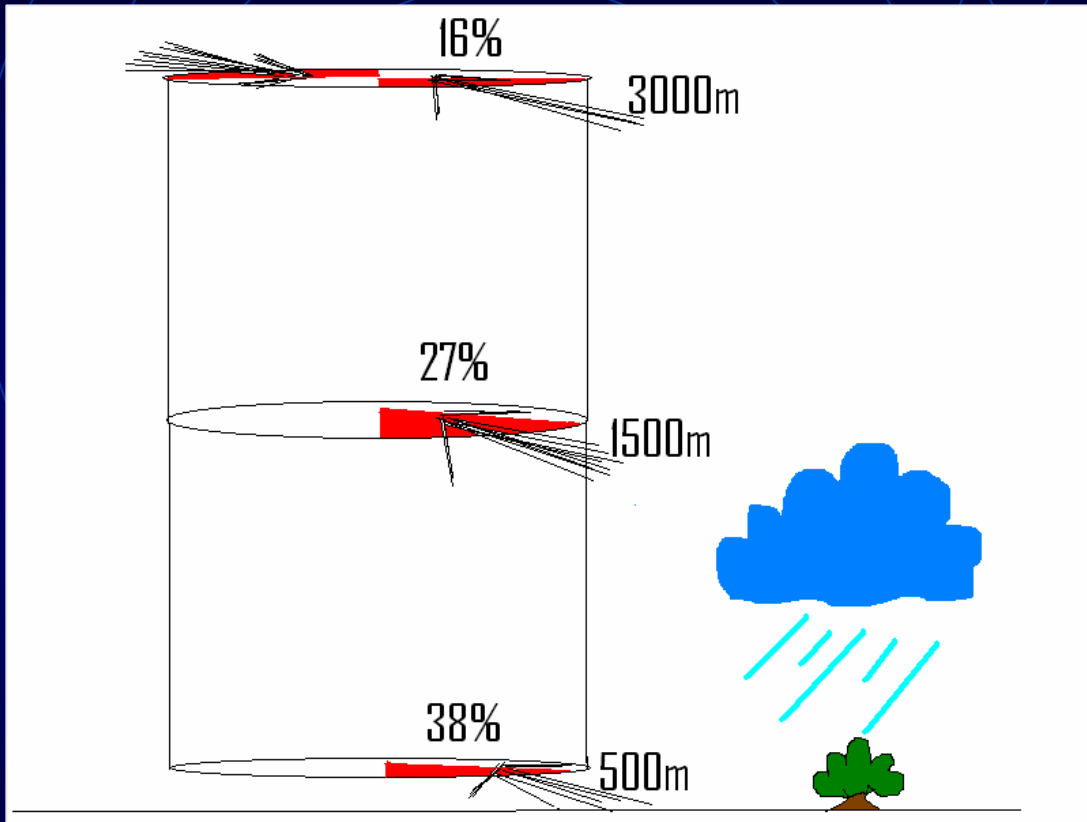
June 2006 1500m



June 2006 500m



Air Column June 2007



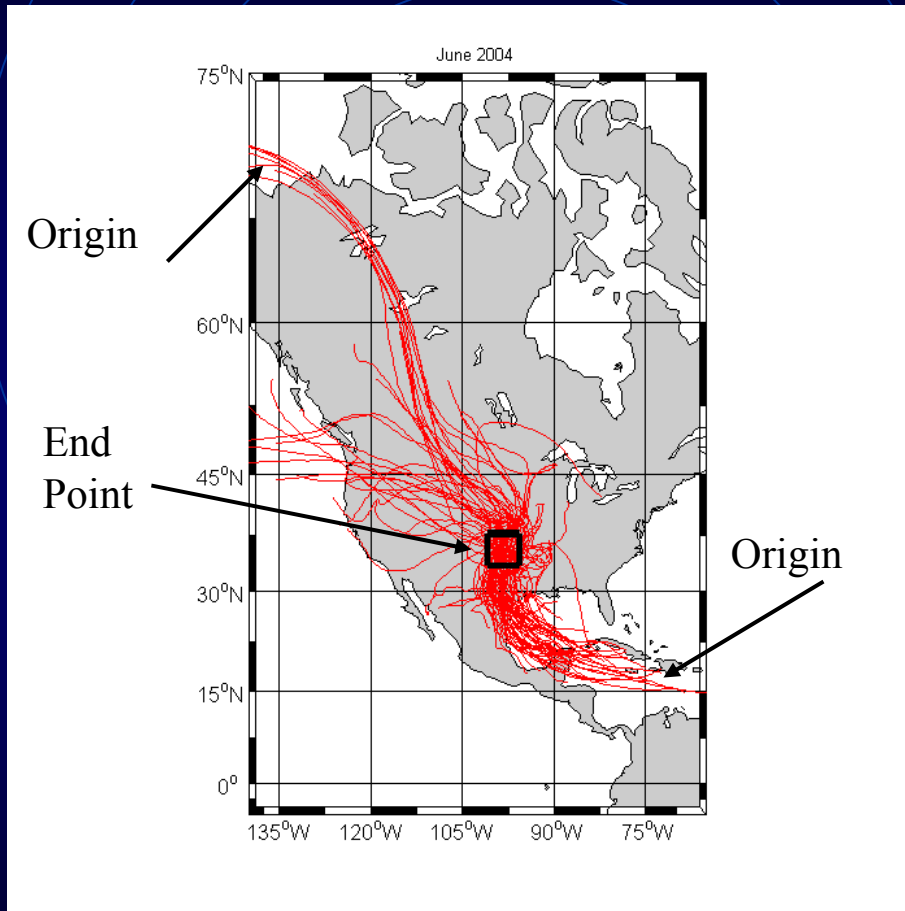
- 38% of Parcels originated from SE at 500m
- 27% of parcels originated from SE at 1500m
- 16% of parcels originated from SE at 3000m
- Trend was similar in extreme moist years

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Climatological Survey

Low Level Flow
1997-2007



Back Trajectory for June 04' at 4 locals at a height of 1500m. This amounts to 120 trajectories in one month for a single altitude

Back Trajectories of Parcels

- Parcels Origin
- Direction to SGP
- Distance (speed)
- Shows trends and outliers

HySplit4

Back Trajectory Model

Domain: 36°-39°N and 96°-99°W (SGP)

Origin: The starting point of the parcel 100 hours prior to a given day in June

Receptor: The end point for the parcel for a given day in June (SGP)