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

• 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

- 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
Extremely Dry Year
Parcels originating from west

Extremely Wet Year
Parcels originating from west and south
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?

- 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


• 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!
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.**

\[ H + H_{LE} + H_G + Q^* = 0 \]
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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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)

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