Fair-Weather Clouds at the SGP: Looking to the Future

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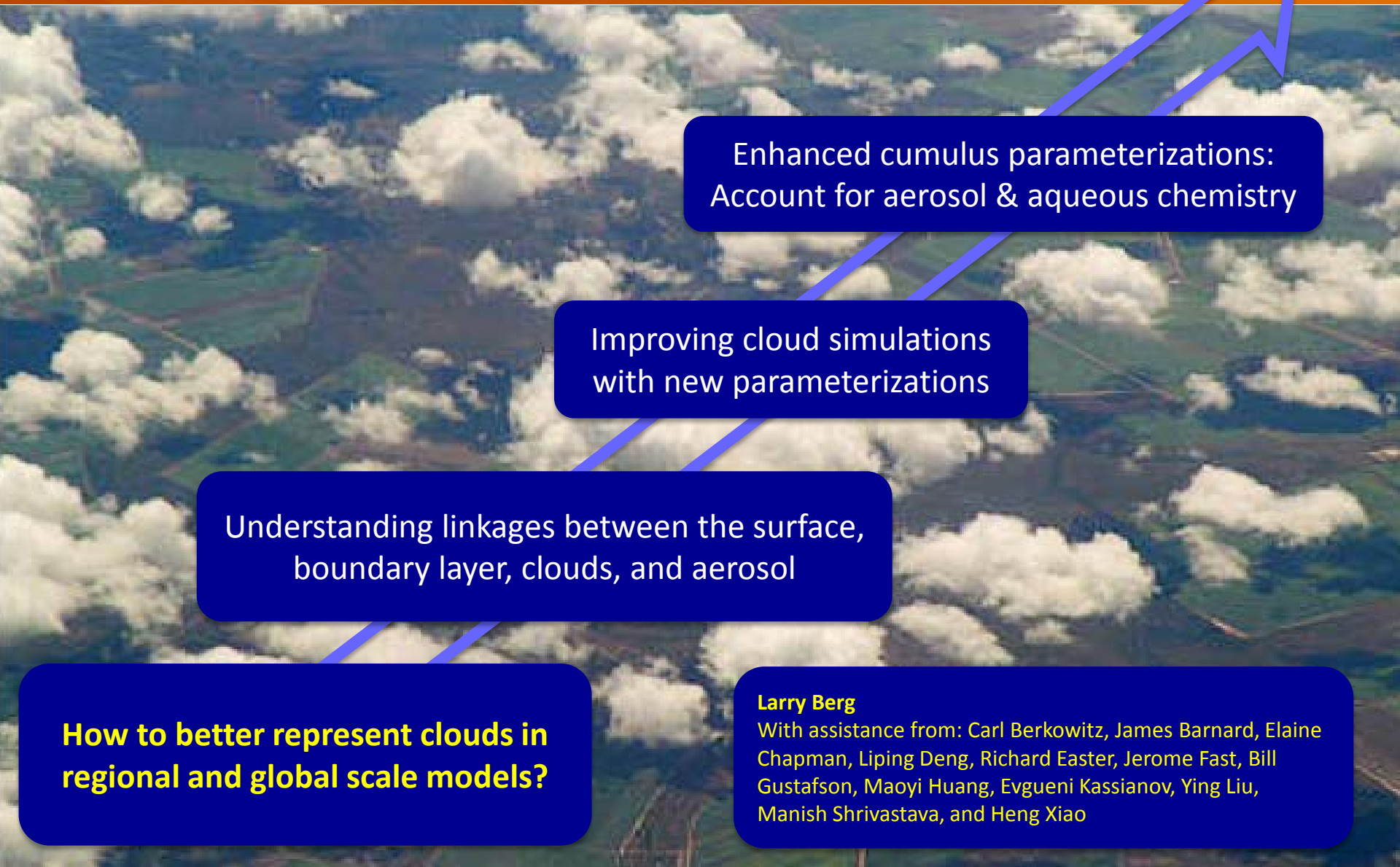


Enhanced cumulus parameterizations: Account for aerosol & aqueous chemistry

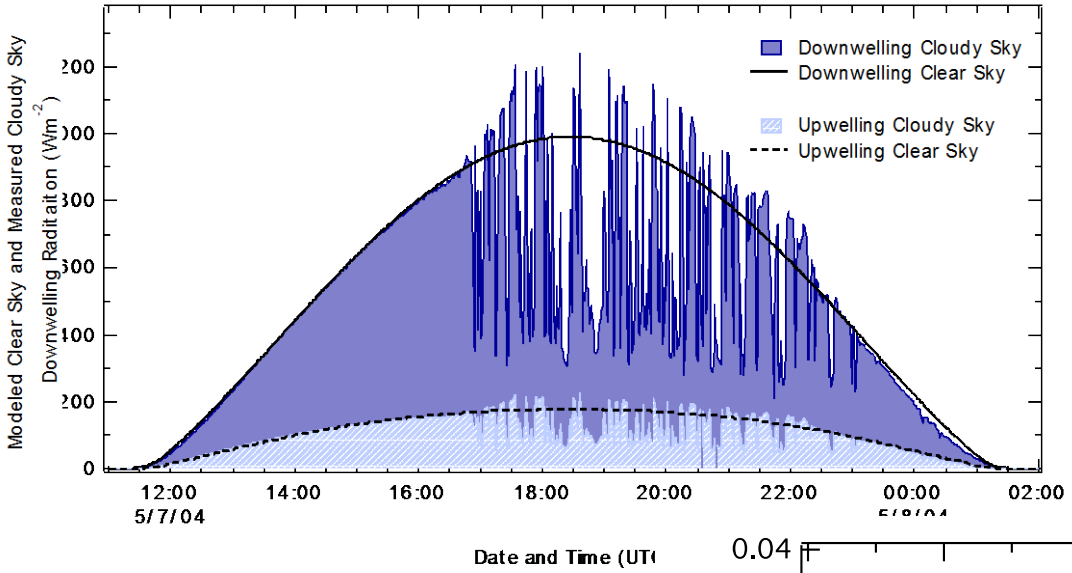
Improving cloud simulations with new parameterizations

Understanding linkages between the surface, boundary layer, clouds, and aerosol

How to better represent clouds in regional and global scale models?

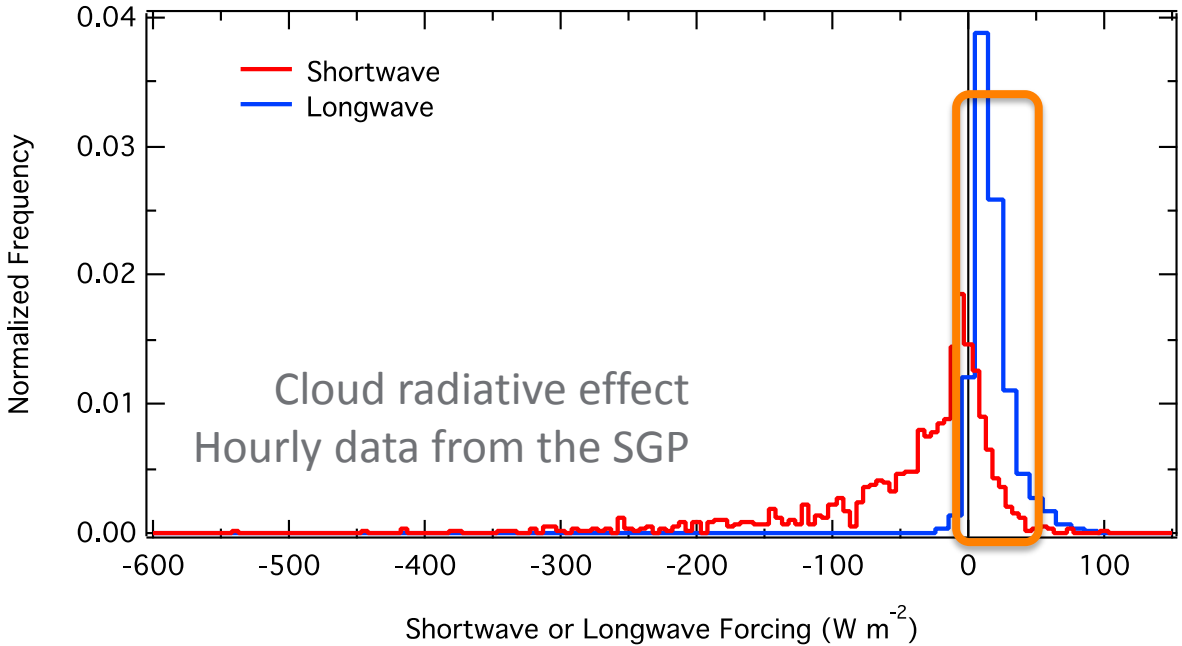
Larry Berg
With assistance from: Carl Berkowitz, James Barnard, Elaine Chapman, Liping Deng, Richard Easter, Jerome Fast, Bill Gustafson, Maoyi Huang, Evgueni Kassianov, Ying Liu, Manish Shrivastava, and Heng Xiao

Motivation: Impact on Radiation



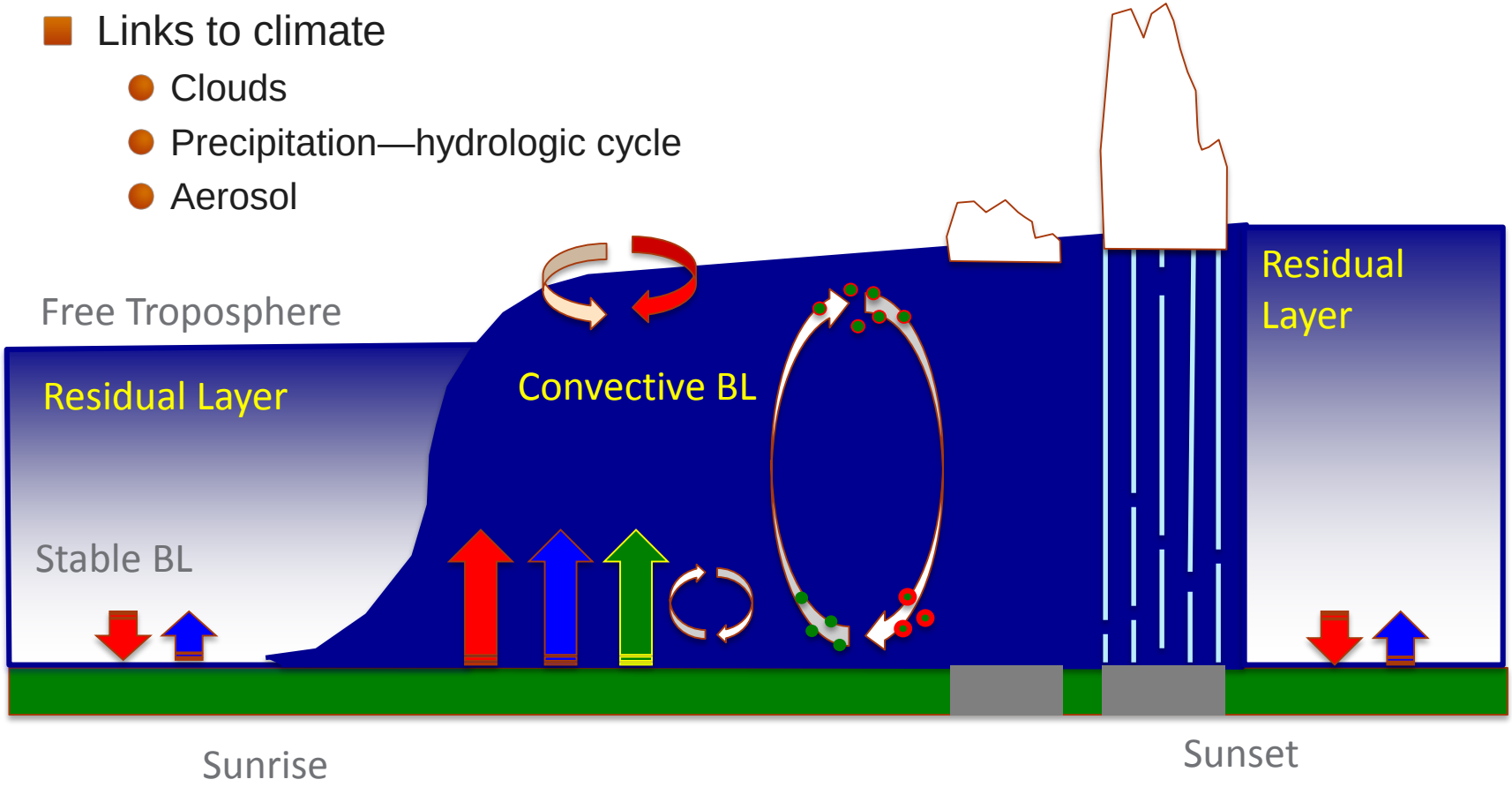
Berg et al. 2011

- Impact on the radiation budget
  - **CRF_{SW} = -45.5 W m^{-2}** (out of 612 W m^{-2})
  - **CRF_{LW} = +15.9 W m^{-2}** (out of-105.2 W m^{-2})
  - Median cloud fraction at SGP ~**37%**



Land-Atmosphere-Cloud Interations (LACI): Connecting the Surface and Clouds

- Why are we interested in boundary-layer (BL) processes?
  - Connects the surface and free atmosphere
  - Links to climate
    - Clouds
    - Precipitation—hydrologic cycle
    - Aerosol



Influence of Land Surface on Clouds

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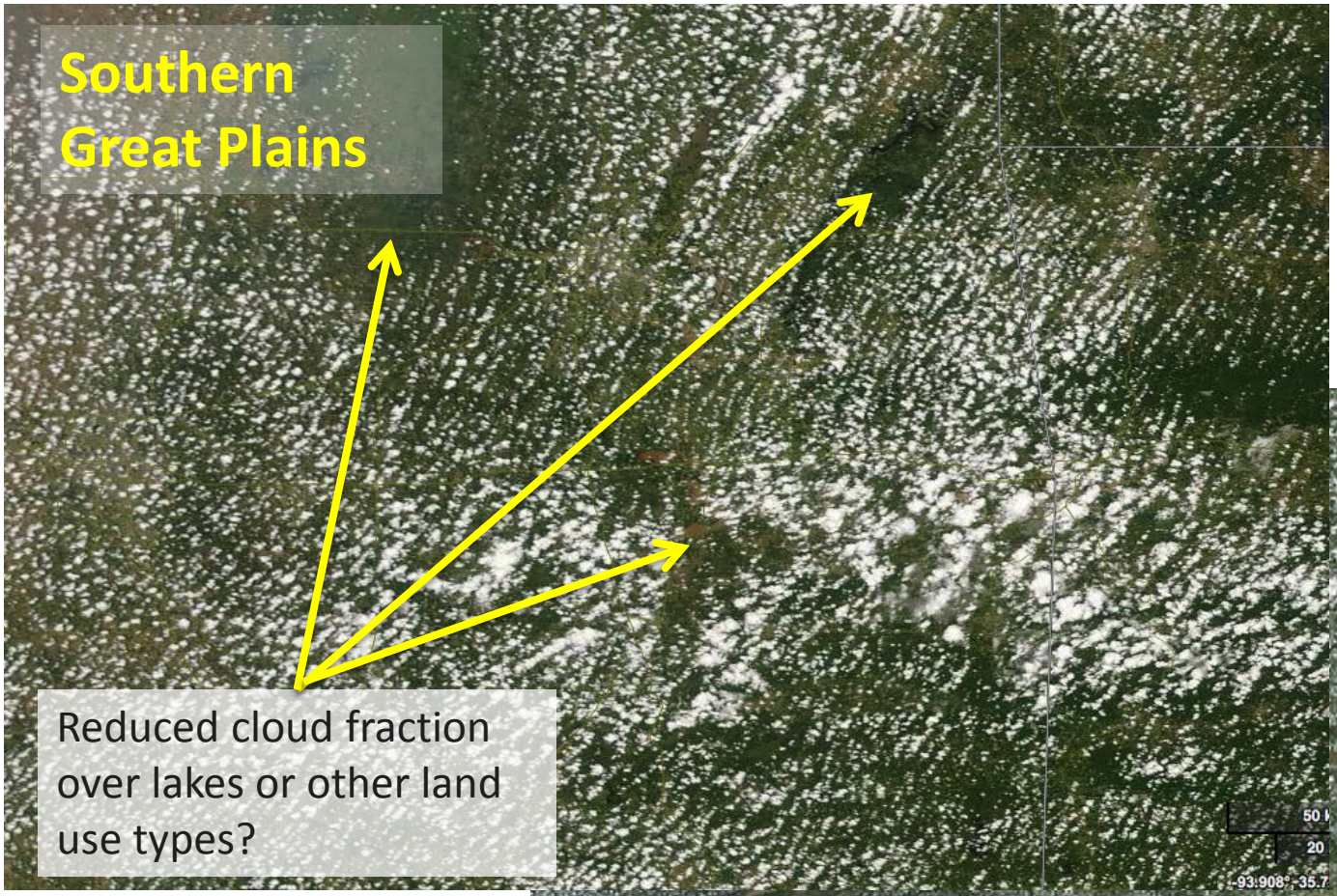
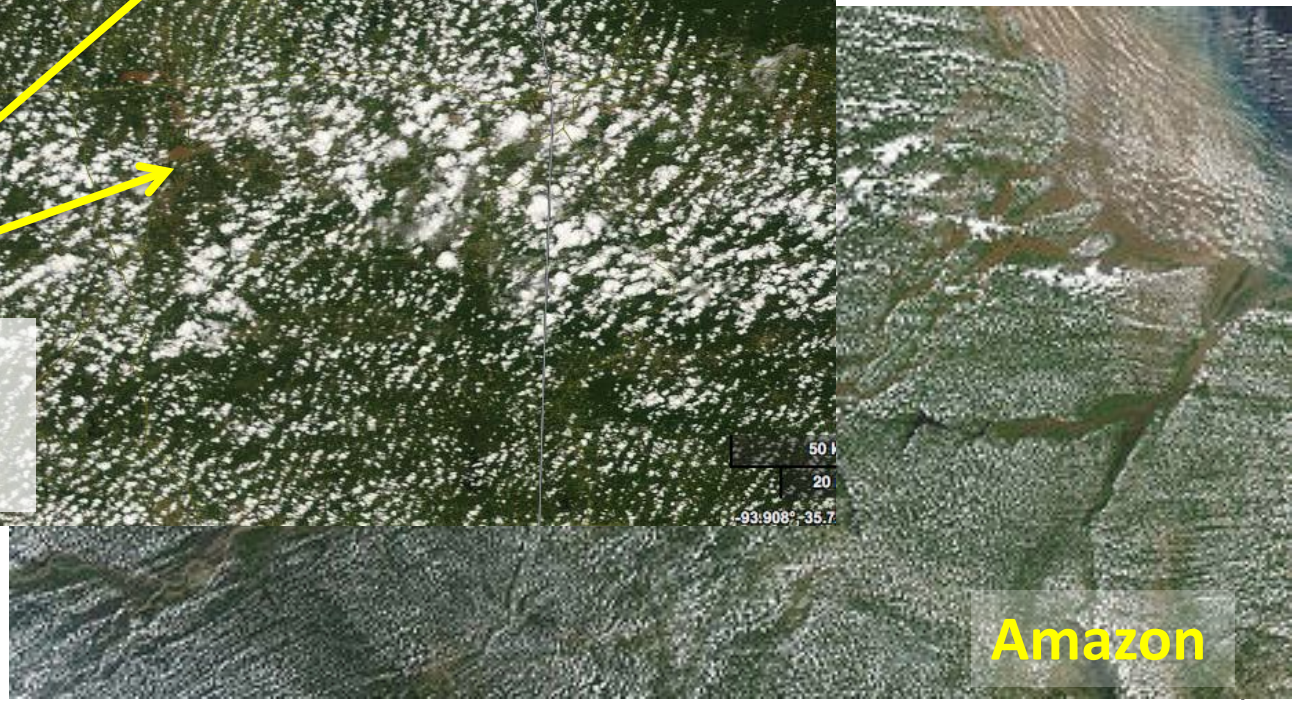




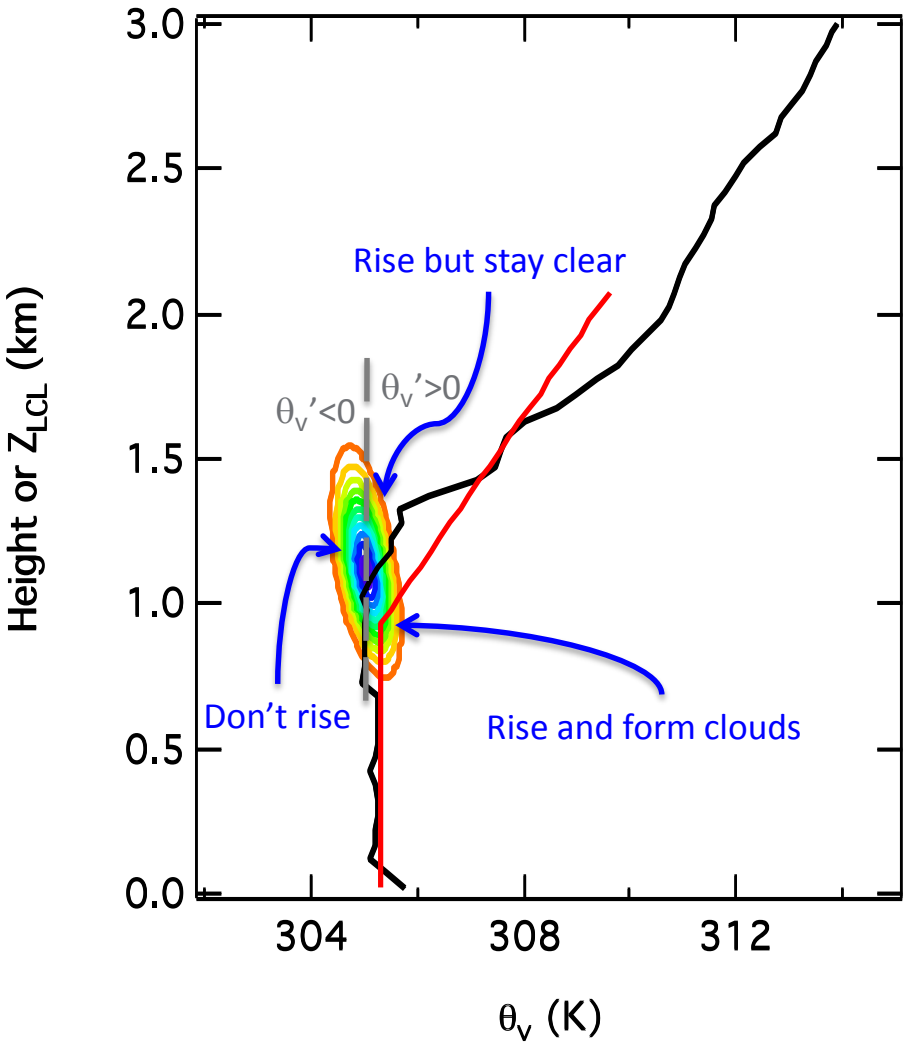
Triggering Convective Clouds: The Good, the Bad, and the Complicated

Three groups of points

- Some parcels sink (the bad)
- Some parcels rise (the good)
  - Some reach their Z_{LCL}, some don't
  - Those that reach their Z_{LCL} form clouds
  - Details of clouds are also related to convective available potential energy (CAPE) and convective inhibition (CIN) (the complicated)

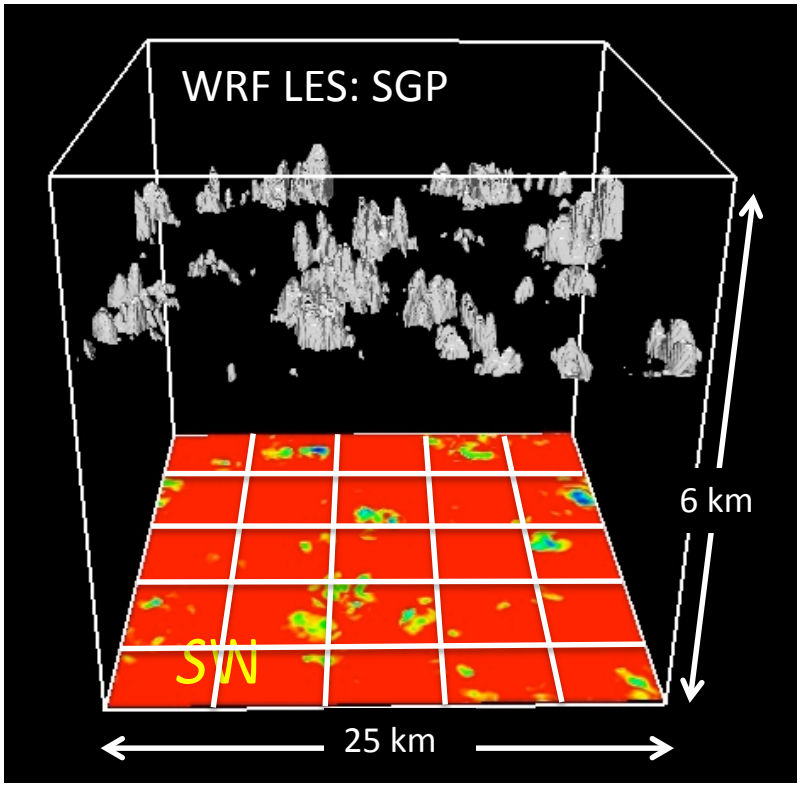
The tails of the distribution are important!

Berg and Stull 2004

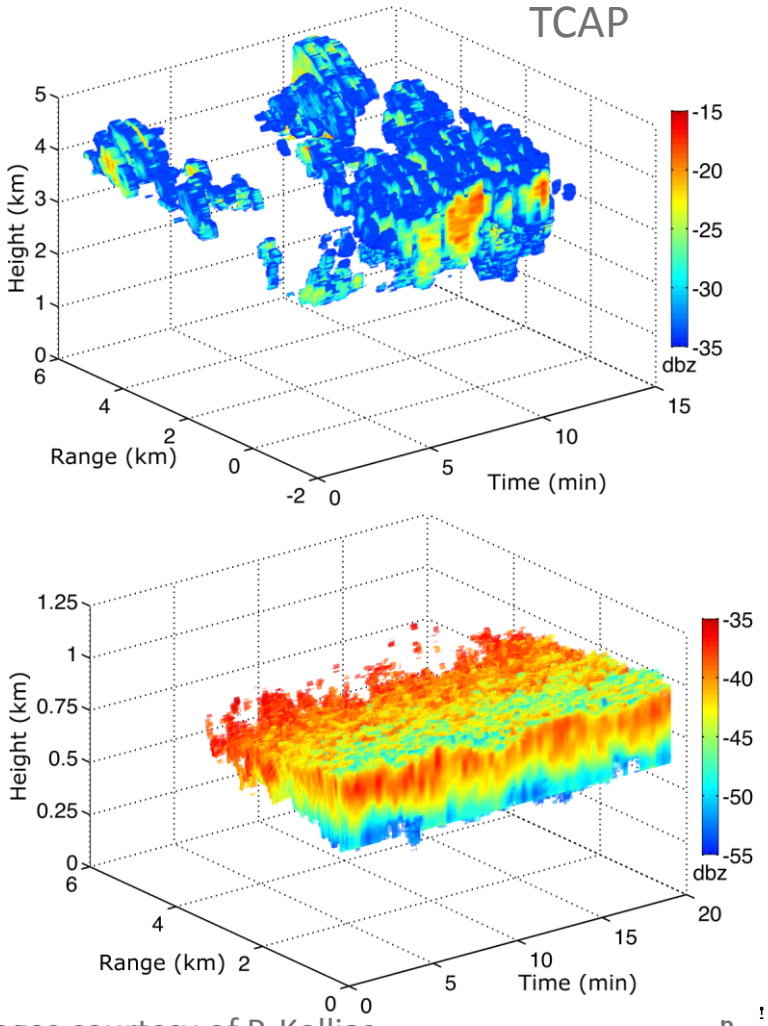


Improved Understanding of Cloud Macroscale Properties

- Unprecedented information from the scanning cloud radars and other remote sensing techniques
  - 3-D cloud properties
  - How does it inform parameterization development?



LES courtesy of H. Xiao, PNNL



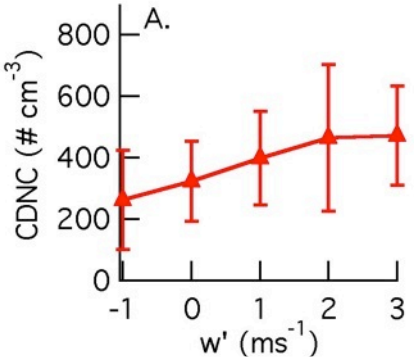
Images courtesy of P. Kollias

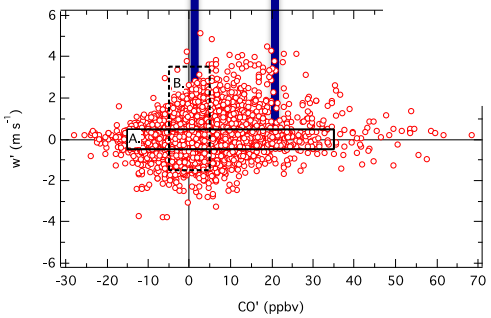
Shallow Cu Related Field Studies

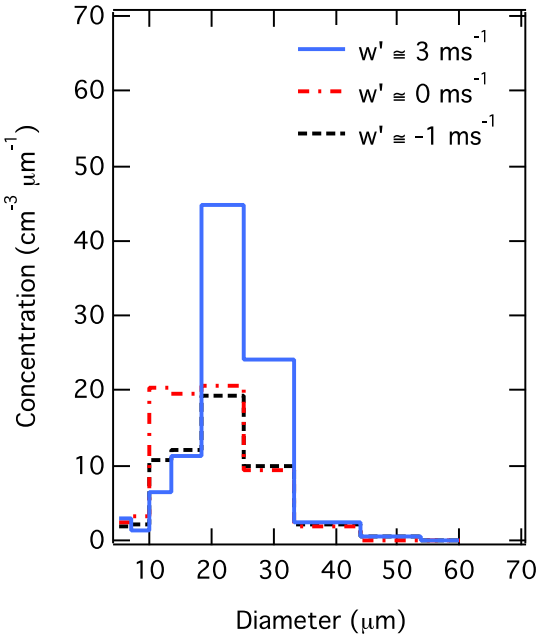
- Two studies in 2007 focused on clouds based at the SGP
  - CHAPS (Cumulus Humilis Aerosol Processing Study)—ASP
  - CLASIC (Cloud LAnd Surface Interaction Campaign)—ARM
- Long-term study January-June 2009
  - RACORO (Vogelmann et al. 2012)—ARM
- HI-SCALE (Holistic Interactions of Shallow Clouds, Aerosol, and Land-Ecosystem)
  - Two IOPS: May and August/Sept 2016
  - Aircraft observations and enhanced measurements at the ARM SGP
  - More in the HI-SCALE breakout
- ESLCS (Enhanced Soundings for Local Coupling Studies)
  - Additional radiosonde launches at the SGP
- New studies
  - New Studies-extra sondes and soil moisture at the SGP
  - ATBIS (Atmosphere-Biosphere Interaction Study), March – September 2017
  - LAFE (Land-Atmosphere Feedback Experiment), August 2017
  - Fiber optic measurements of soil temperature and moisture

CHAPS: Changes in Cloud Microphysics

- Systemic changes in cloud microphysical properties as a function of both w' and CO'







Berg et al. 2011

768 Total Cloud Penetrations

Regional Scale Impact: Changes in Aerosol Loading

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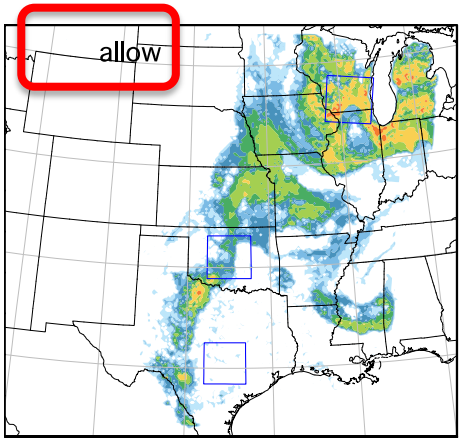
June 25, 2007



Change in column mass loading

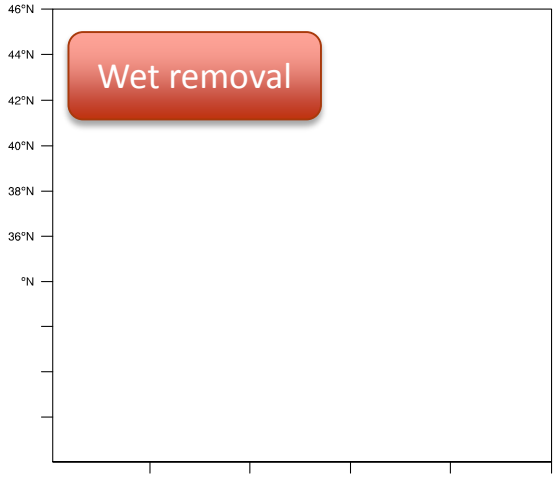
Black Carbon

Wet removal

Sulfate

Sulfate production

Organic Aerosol



Wet removal

Fractional Difference in Column Integrated mass Loading

Berg et al. 2015

Where are we going?

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Overarching Science Questions*

- How important is the influence of the land surface on boundary-layer turbulence and structure, cloud life cycle, and precipitation?
- What boundary layer and land surface processes contribute to the diversity of soil moisture-precipitation feedbacks observed in nature and simulated in models (with scales from LES to GCM)?
- How do feedbacks between biogenic emissions, SOA, boundary layer, and clouds influence the cloud lifecycle?

What data sets are needed*

- Soil moisture across the domain of interest
- Land-use/land cover (tied to surface energy, momentum, and trace gas fluxes)
- Spatial variability of winds, and thermodynamics
- Macoscale and microscale properties of the clouds

*Based on discussions with groups active in the ARM and ASR programs