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The NASA Energy and Water cycle Extreme (NEWSE) Integration Project

P. Houser (GMU/CREW), W. Lapenta (MSFC), R. Schiffer (UMBC/GEST)

NASA ENERGY AND WATER CYCLE STUDY
NEWS

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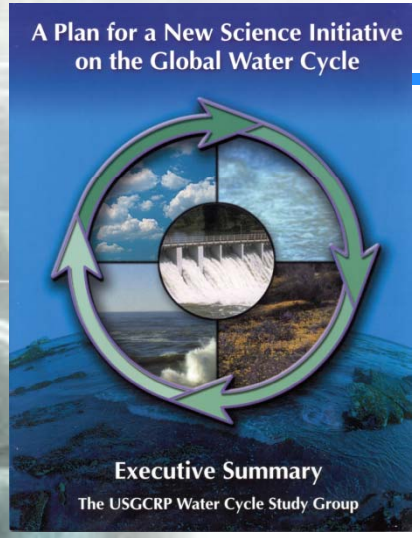


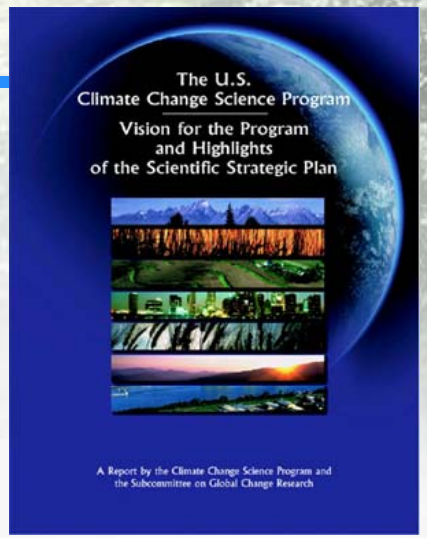
NASA ENERGY AND WATER CYCLE STUDY

NEWS

What are the causes of water cycle variations?

Are variations in the global and regional water cycle predictable?

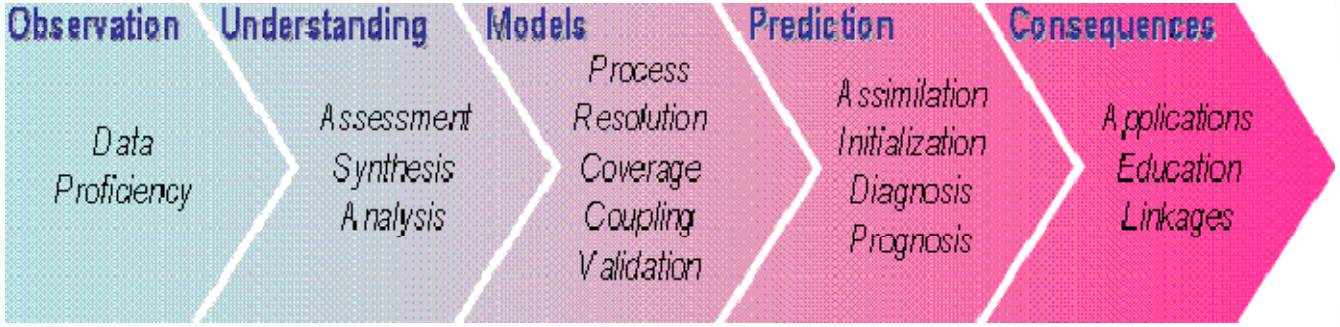
How are water and nutrient cycles linked?



NEWS Integrated Water and Energy Cycle Research Challenge:

Document and enable improved, observationally-based, predictions of water and energy cycle consequences of Earth system variability and change.

The NEWS challenge is **global** in scale and requires the integration of NASA **system components** to **make decisive progress toward the NEWS challenge** in an **end-to-end program**



NASA ENERGY AND WATER CYCLE STUDY NEWS

Water Cycle Integration – How to achieve the desired integrated products?

What is integration?

- Integrating observations to establish a more complete system description
- Integrating model components to build a earth modeling system
- Integrating research results to establish end-user solutions

Data Integration: Spatial and temporal rectification to allow intercomparison and quality evaluation of disparate model and observation data;
Data-Model Integration: Physical rectification or constraint of data and its error using four dimensional data assimilation and modeling techniques.
Model Integration: Using component models to build a system model.
Solution Integration: Integrating components (research results) to develop solutions
Interpersonal Integration: Interconnection of disparate water cycle research teams.

Science Integration:

- Data integration
- Coordinate energy and water process modeling
- Water & energy cycle trend and variability assessments
- End-user decision support & solution network connections
- Program integration?

Water & Energy Cycle Data Integration

Water Cycle Data Integration: compile, diagnose and disseminate water and related energy cycle observations and predictions.

3 NEWS Integration projects:

1: Daily Time Scale (Leads: Rossow & Njoku)

- Do models handle coupling between land/atmosphere correctly?
- Local versus global scale diagnostics, synoptic and seasonal time scales.

2: Water Cycle Extremes; Two Golden Years, SGP 2006-2007 focus (Leads: Houser, Schiffer, Lapenta)

- How does diurnal cycle of WEC variables change in wet vs dry years?
- To what extend does the large scale dynamics play in controlling extremes, and are they predictable?
- Use an integrative analysis of observed extremes to improve our models' ability to predict extremes.

3: Annual and Longer time scales (Leads: Lin & Schlosser)

- How do we build on "zero-order" assessment done by Lin & Schlosser?
- Focus on recent years (2003+ to encompass "EOS-rich" measurements)
- What does "close the W & E cycle" really mean?

Key components of the WEC data integration include:

- Provide a "one stop", streamlined access to coordinated, geolocated, and integrated water & energy cycle data and visualizations from all sources.
- Identify and acquire global water and energy cycle observations and model predictions from all relevant sources, over the longest available period.
- Establish the products in consistent formats and access protocols.
- Develop an integrated re-processing plan.
- Assess the physical consistency of products.

NEWSE Integration Project Outline

Motivation: **Skillful predictions of water and energy cycle extremes (flood and drought) are elusive.**

What: **To better understand the mechanisms responsible for water and energy extremes, and to make decisive progress in predicting these extremes, the collaborative NASA Energy and Water cycle Extremes (NEWSE) Integration Project, is studying these extremes in the U.S. Southern Great Plains (SGP) during 2006-2007, including their relationships with continental and global scale processes, and assessment of their predictability on multiple space and time scales.**

Hypothesis: **an integrative analysis** of observed extremes which reflects the current understanding of the role of SST and soil moisture variability influences on atmospheric heating and forcing of planetary waves, incorporating recently available global and regional hydro- meteorological datasets (i.e., precipitation, water vapor, clouds, etc.) in conjunction with advances in data assimilation, **can lead to new insights into the factors that lead to persistent drought and flooding.**

Goals:

- provide an improved definition, attribution and prediction on sub-seasonal to interannual time scale extremes
- improve understanding of the mechanisms of decadal drought and its predictability
- improve monitoring and attribution of extremes
- transition to applications; bridge the gap between hydrological forecasts and stakeholders.

- How does diurnal cycle of NEWS data change in wet vs dry years?
- To what extent are these extremes and processes predictable?

NEWSE Integration Project Methods & Tasks

Data Gathering Tasks: Need to compile required datasets

- *Identify required data & availability (Data mining)*
- *Should look more broadly at how 2006/7 fit into the longer-term perspective (e.g. 1988/1993)*
- *Local In-Situ Observational data*
- *Global Satellite Observational Data*
- *Model/forecast data , inc. standard operational seasonal forecast products*

Data Analysis Tasks:

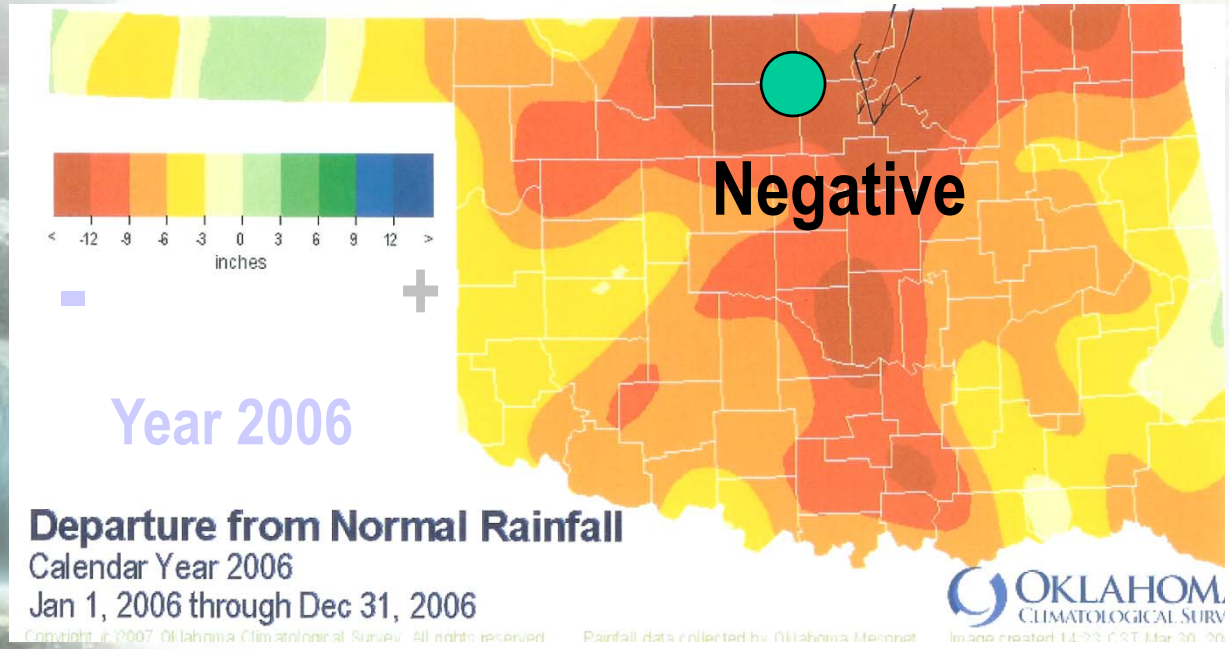
- *Characterize the drought/flood: Return period, severity, etc. - Do we need a common definition?*
- *Extreme value fits*
- *TimeScale Analysis: Diurnal Cycle Extremes*
- *Seasonal/Annual anomalous extremes: Seasonal mean budgets*
- *Where independent products exist establish error bars by checking consistency*
- *Complete reanalysis budget over the anomalies, and differences between the two years*

Modeling Tasks:

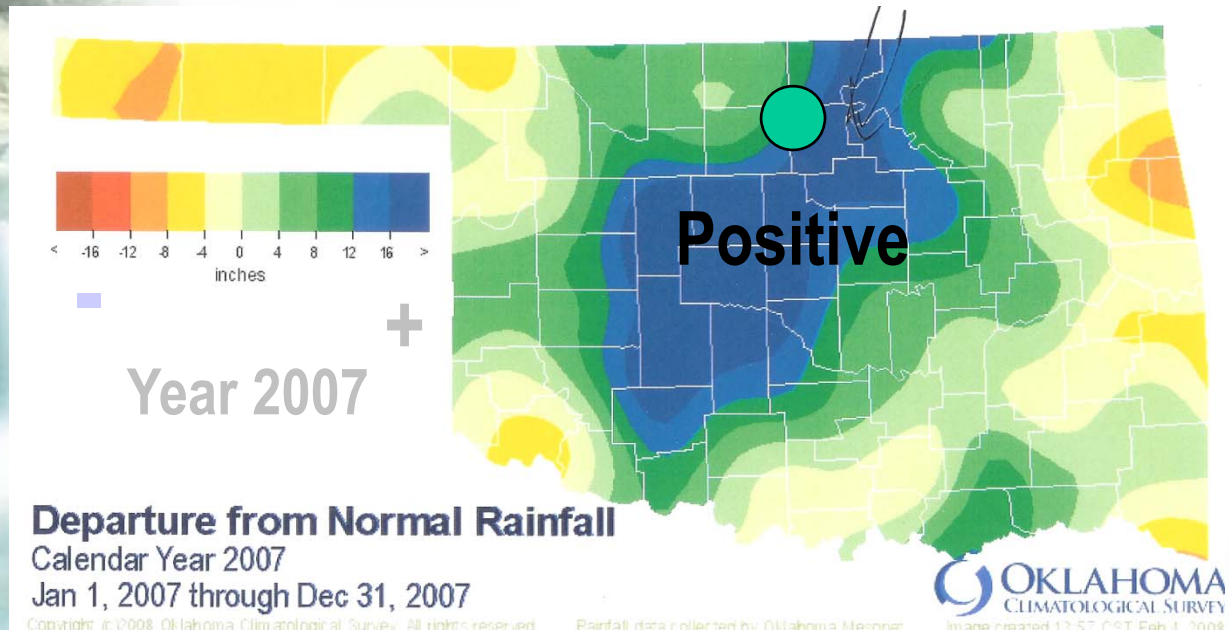
- *Numerical model experiments need to be done to test hypotheses*
- *New WRF/LIS experiments*
- *Develop common model diagnositcs for various time/space scales.*
- *Betts methodology to examine land/atm coupling can be used?*
- *Simulate land/atmo compling of composited wet/dry events + MMF*
- *Land surface sensitivity experiments*
- *Coupled century-long AMIP ensemble forecasts*
- *MERRA Reanalysis*

Dong (2008)

Severities of the 2006 dry and 2007 wet events



It was state-wide dry event during 2006. The annual rainfall is 18 inches lower than normal.



It was on central Oklahoma and 2007 summer with its wettest summer, 14 inches above normal

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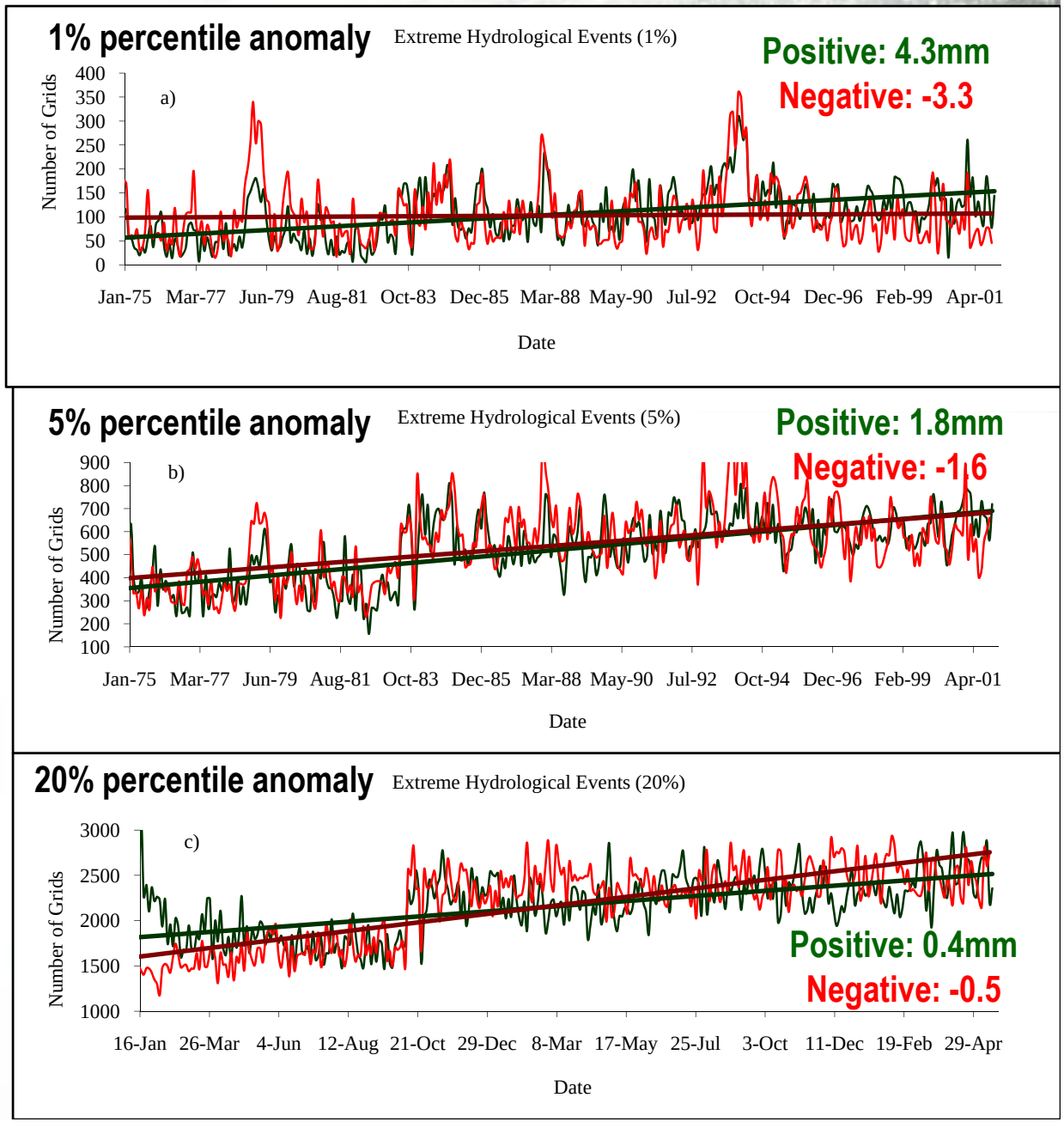
Global GPCP Extreme Change

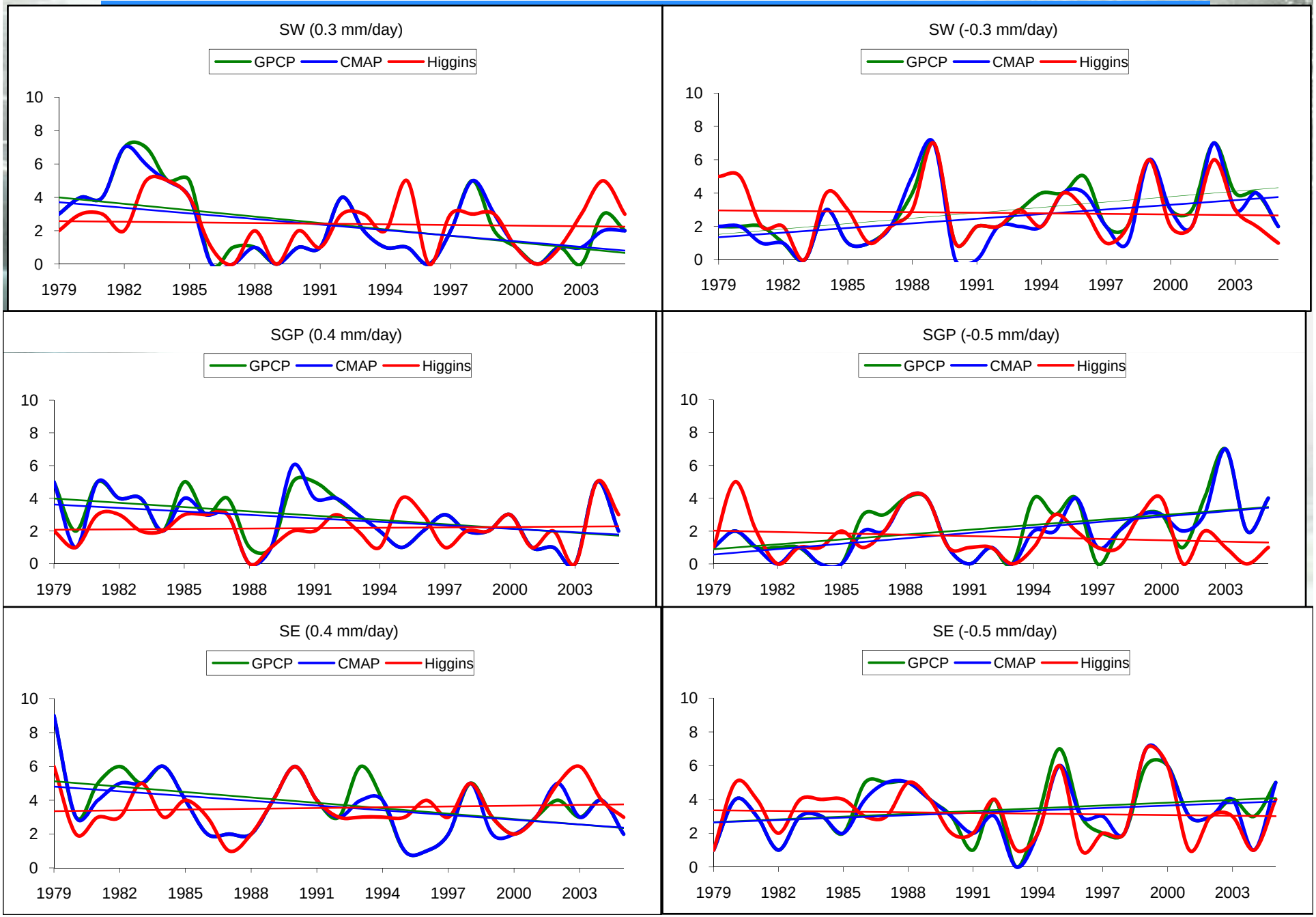
Feng (2008)

Annual variation of number of grids for a)1, b)5 and c) 20 percentile of global precipiation anomaly from GPCP.



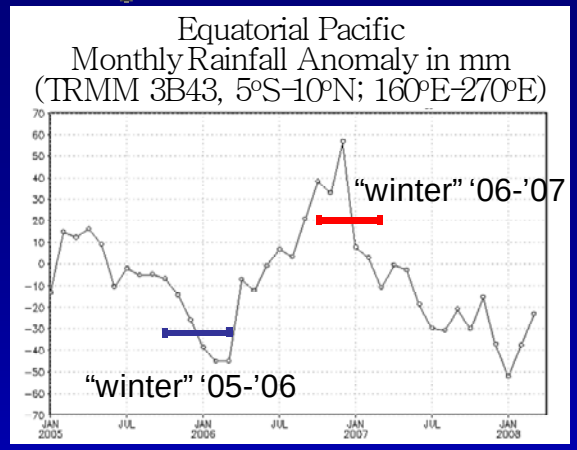
Annual variations of number of months with 20 percentile precipitation anomaly

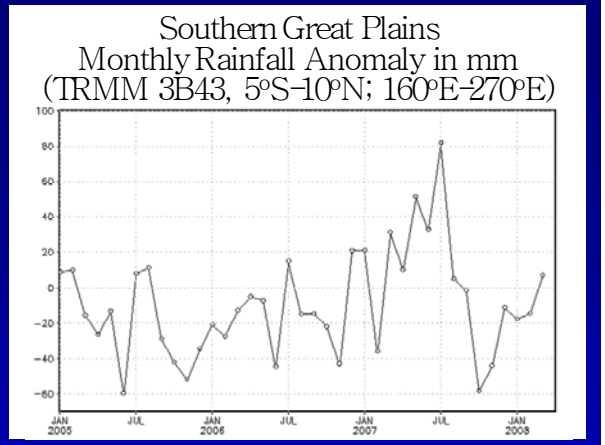
Feng (2008)



2006/2007 Drought/Flood Episodes in the Southern Great Plains

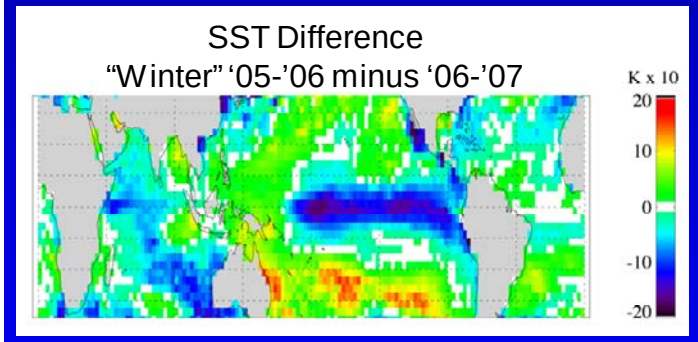
- here, we're looking for signatures of the tropical "large-scale" forcing of the SGP 2006/07 drought/flood episodes based upon satellite estimates of sea surface temperature, precipitation, and latent heating.
- at right, the equatorial Pacific time series of rain rate anomalies shows a drought signature in "winter" '05-'06 relative to "winter" '06-'07. The SGP flood signature lags the tropical signature by ~7 months.

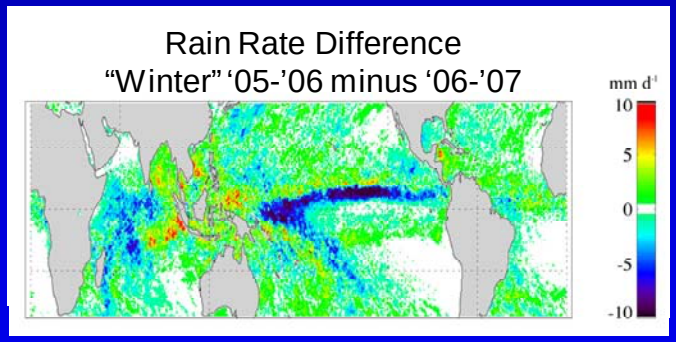


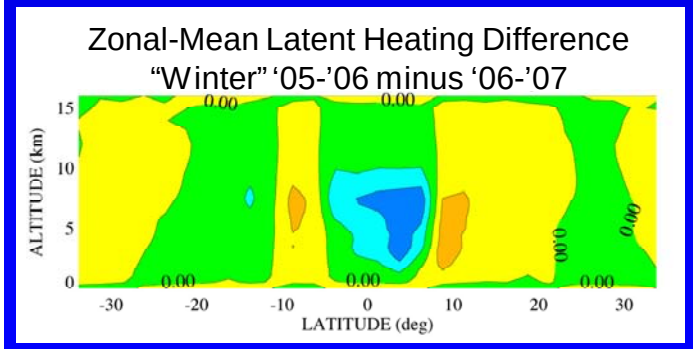


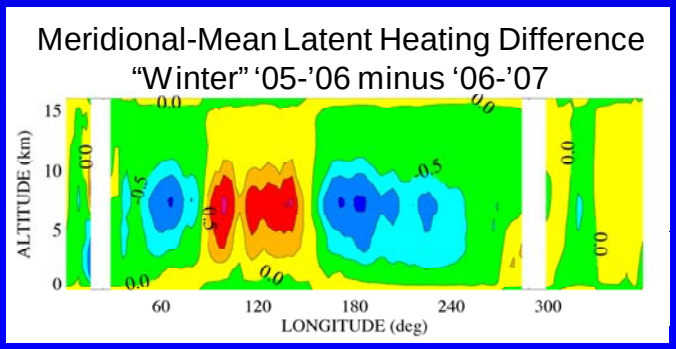
above, TRMM 3B43 courtesy G. Huffman (NEWS).

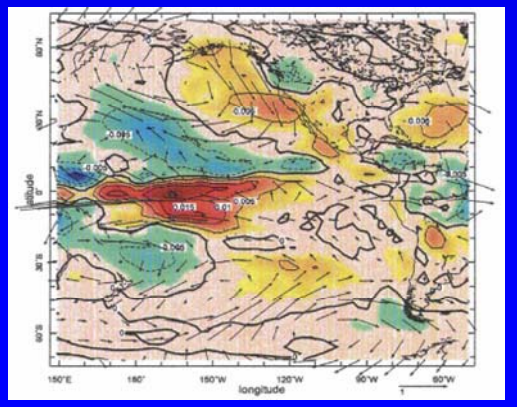
- at left, "winter" difference maps of SST and rain rate show "La Nina-like" signatures, with negative departures in the eastern equatorial Pacific.
- below, left, "winter" latent heating differences reveal negative departures in the eastern equatorial Pacific; correlate with "Dust Bowl" vertical motion distributions from a GCM study, below.









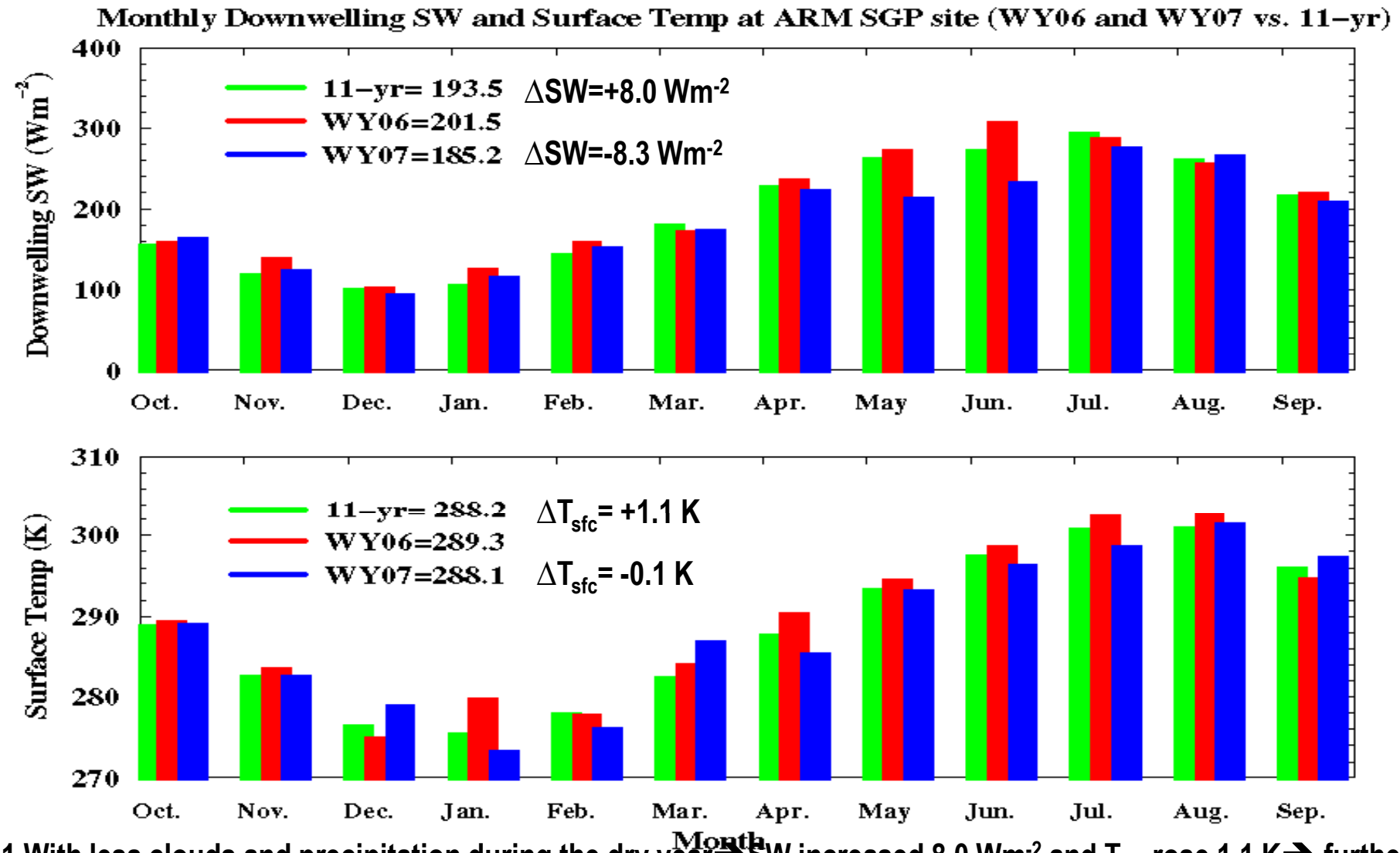


above, SST from Wentz TRMM archive; others from Olson, Grecu, Shie (NEWS); right, from Seager et al. (J. Clim. 2005).

Olson (2008)

Feedbacks of Dry Year

Dong (2008)



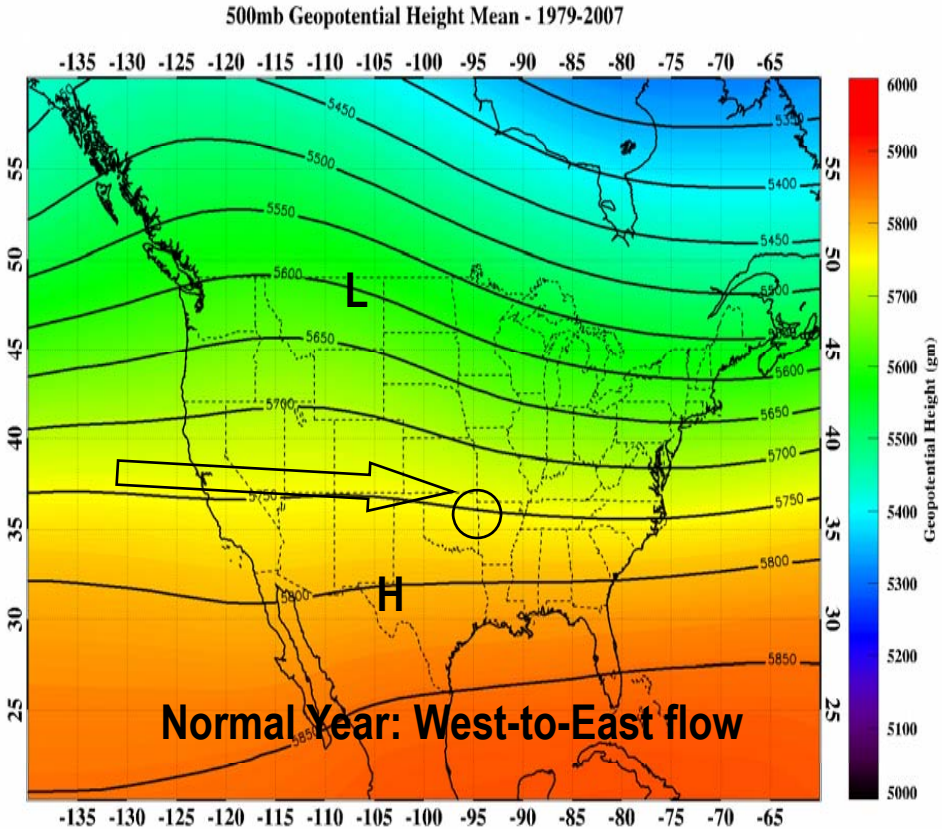
1.With less clouds and precipitation during the dry year➔SW increased 8.0 Wm^{-2} and T_{sfc} rose 1.1 K➔ further strengthen an existing drought.

2. Both net radiation budget +non radiation (LH and SH)➔ ΔTsfc = + 1.1 K

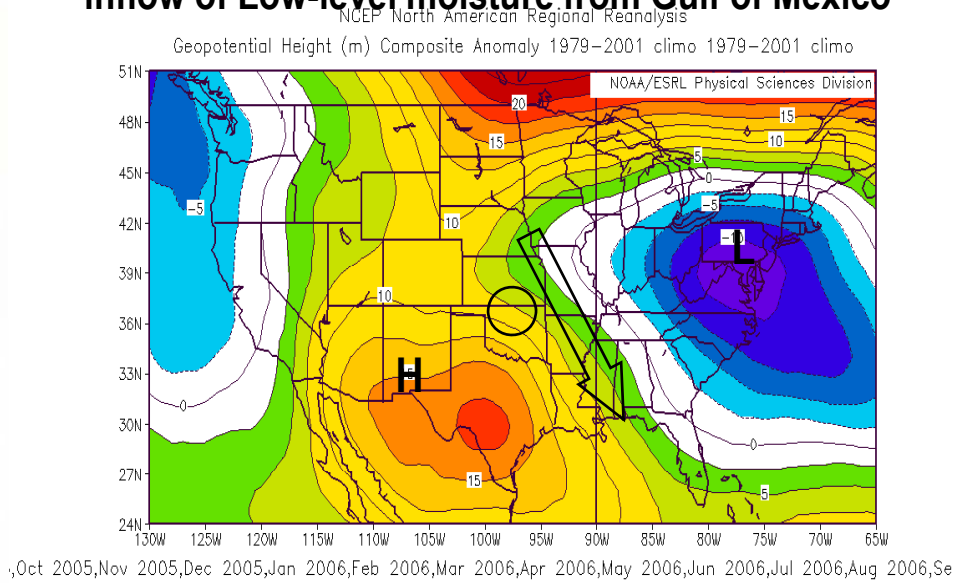
Synoptic patterns dominate WY06 dry event

Dong (2008)

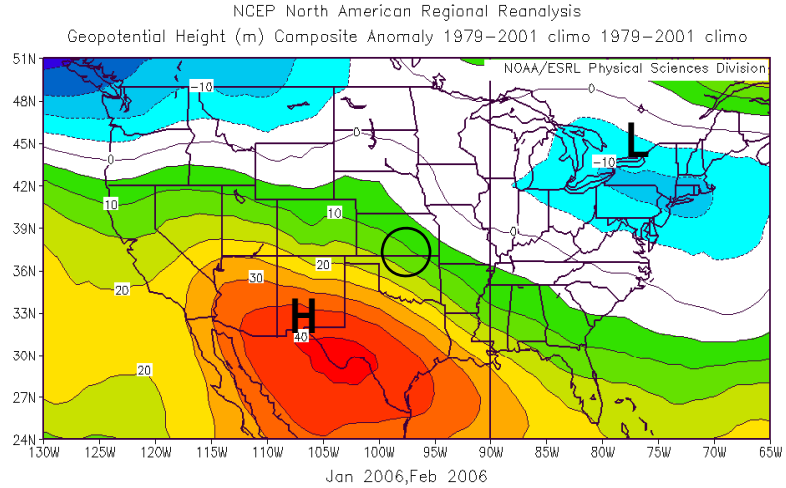
500 mb Geopotential height mean: 1979-2007

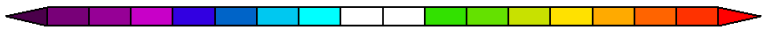


Abnormal high located over southwest of U.S. with subsidence of dry and cold air, which blocks the inflow of Low-level moisture from Gulf of Mexico



2005-06 Winter: extreme dry
Stronger large-scale subsidence

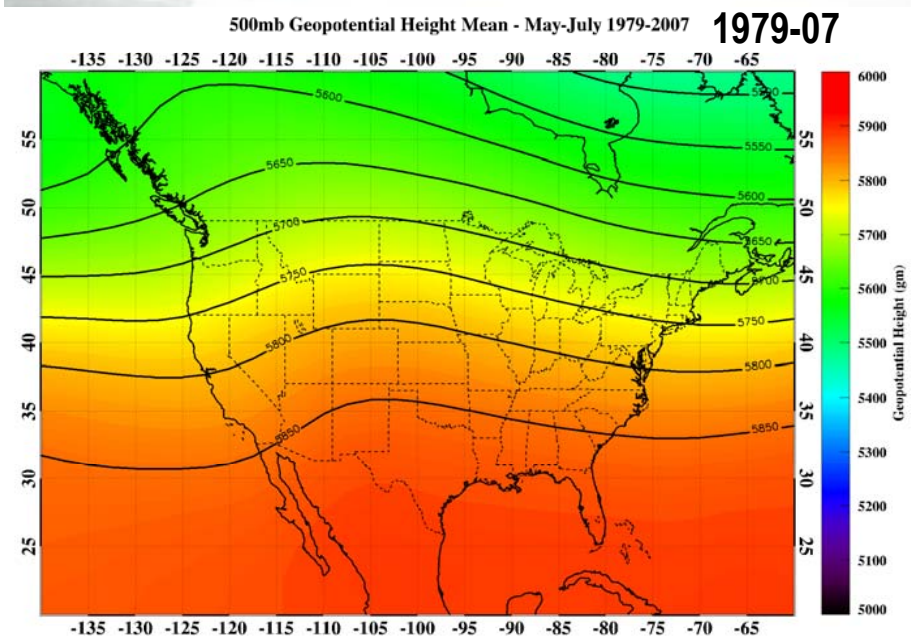


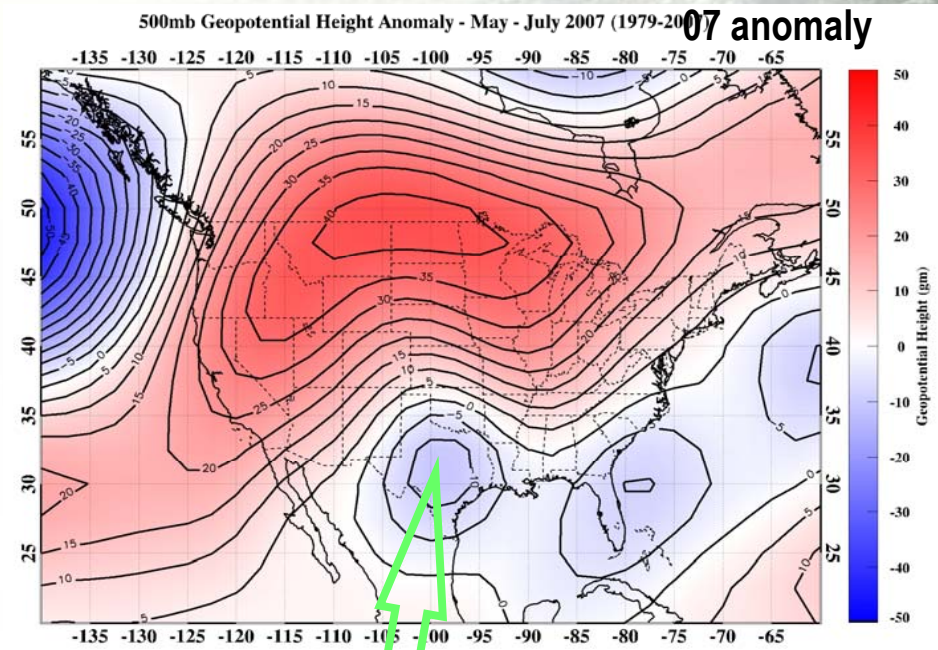


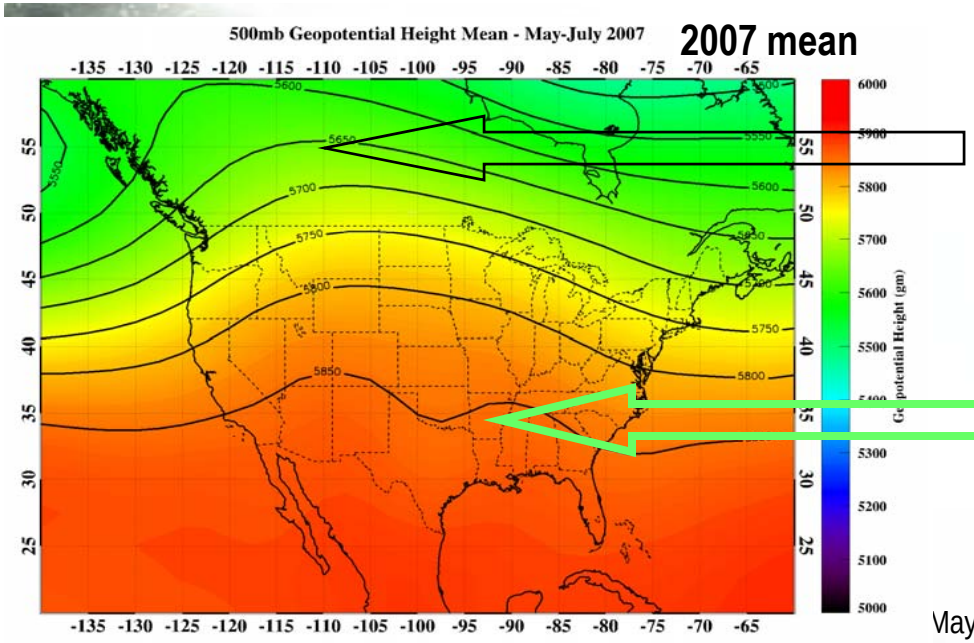
Paul R. Houser, May

Extreme Wet Period: May-July 2007

Dong (2008)







Stronger heights (ridge) over most of the US, however, there is a negative anomaly centered over the OK/TX region which can be seen as a long-term shortwave trough during these three months.

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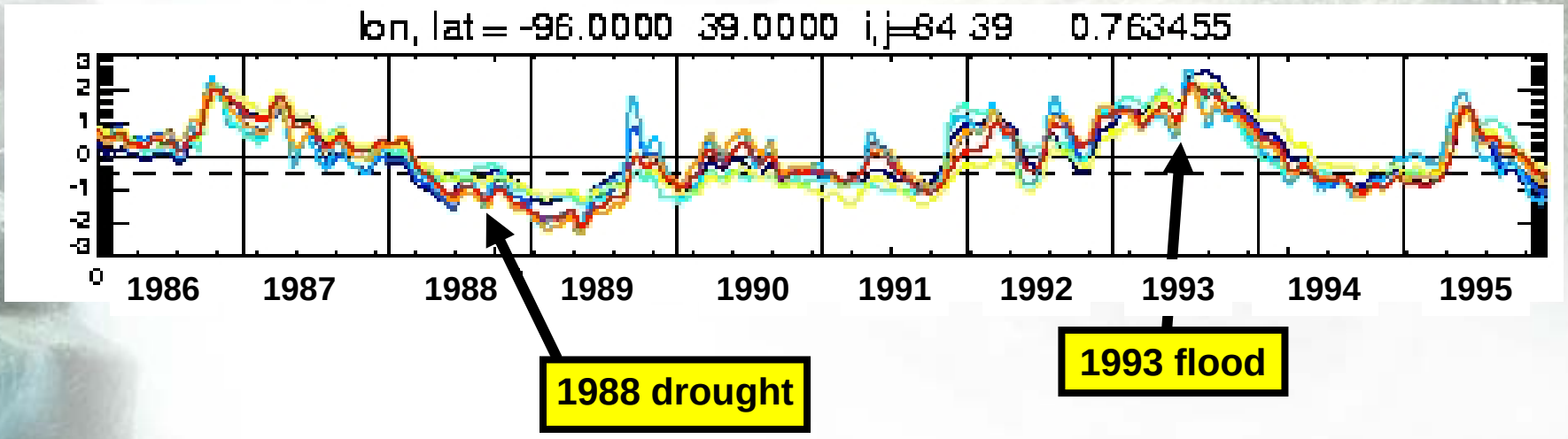
Schubert (2008)

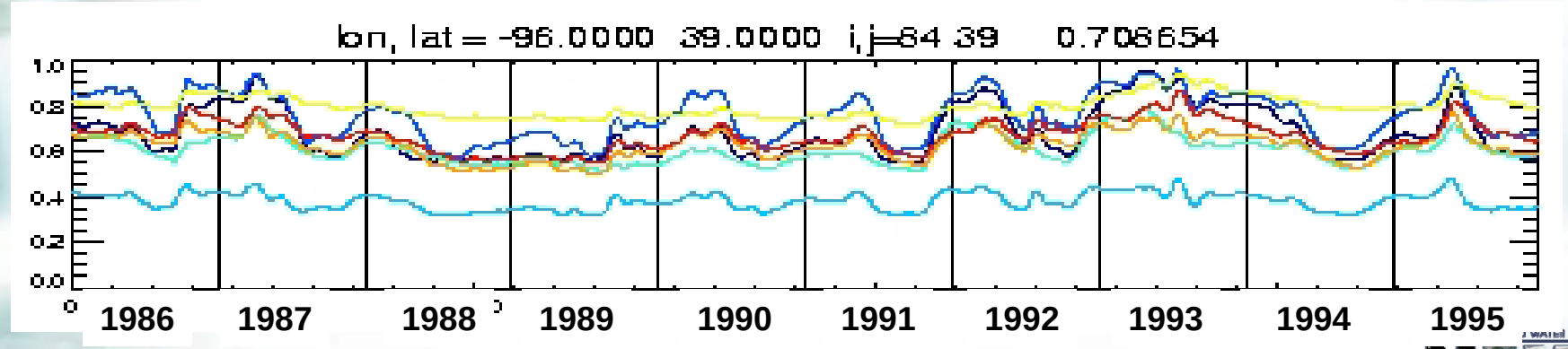
WI values for 7 different GSWP-2 models over a point in the U.S. Great Plains.



$$WI(j,n) = \frac{w(j,n) - m_w(j)}{s_w(j)}$$

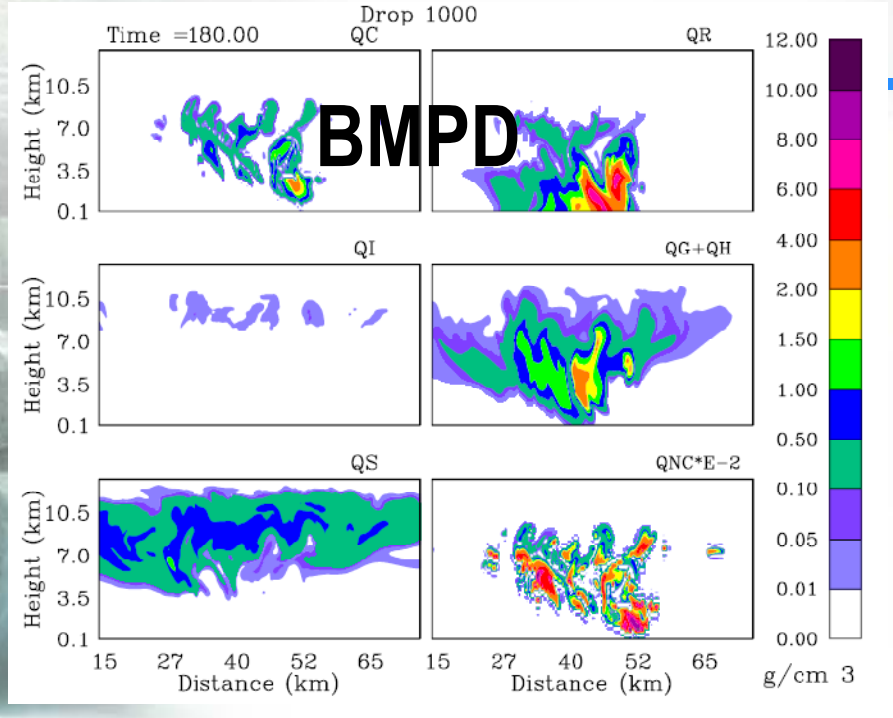
$m_w(j)$ = Mean (over many years) of w on day j.
$s_w(j)$ = Standard deviation of w on day j.
w(j,n) = model's total soil moisture for day j of year n.

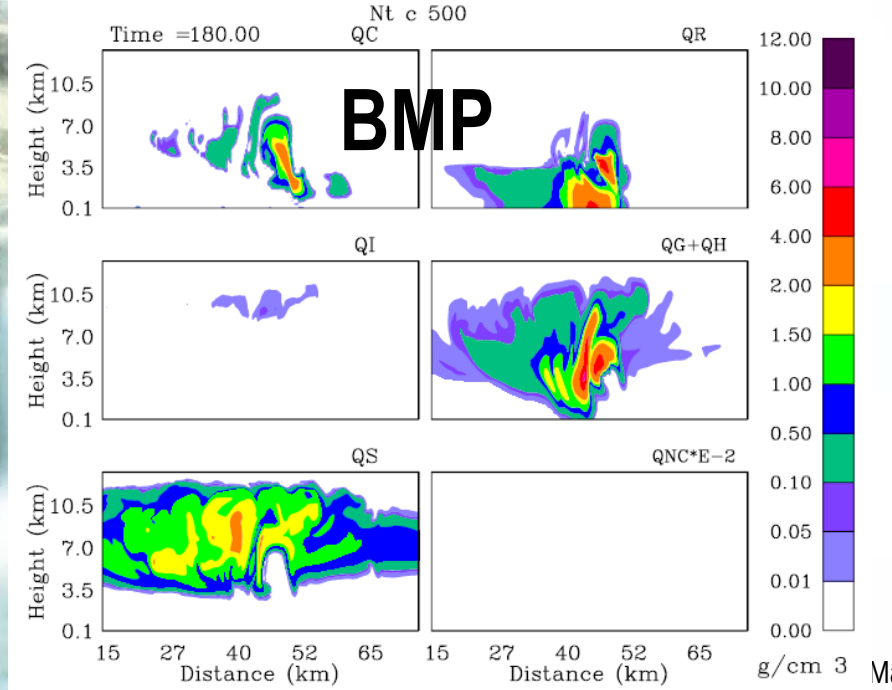
The unprocessed soil water diagnostics (shown here as degree of saturation) are not nearly as model-independent.

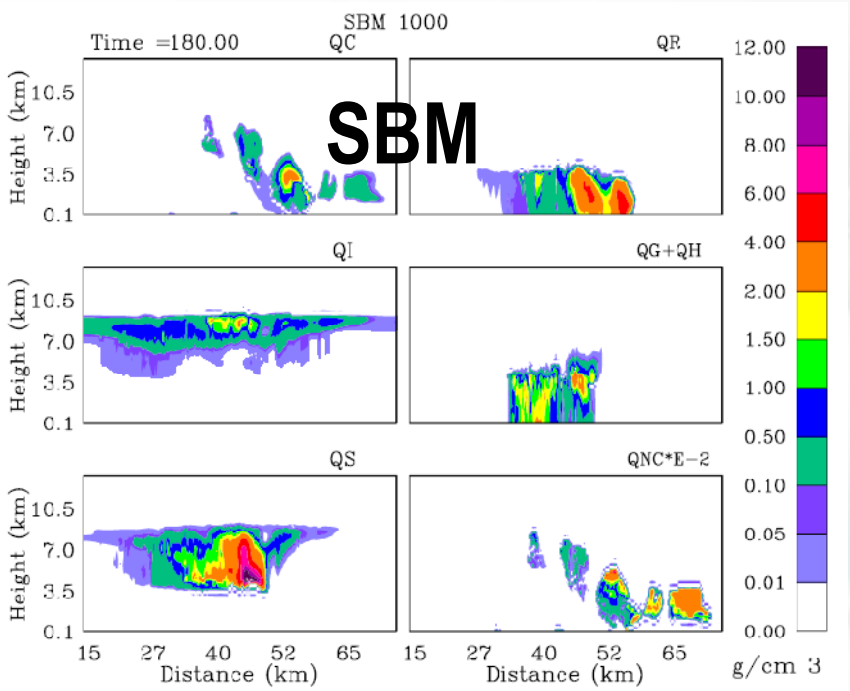


Leung (2008)

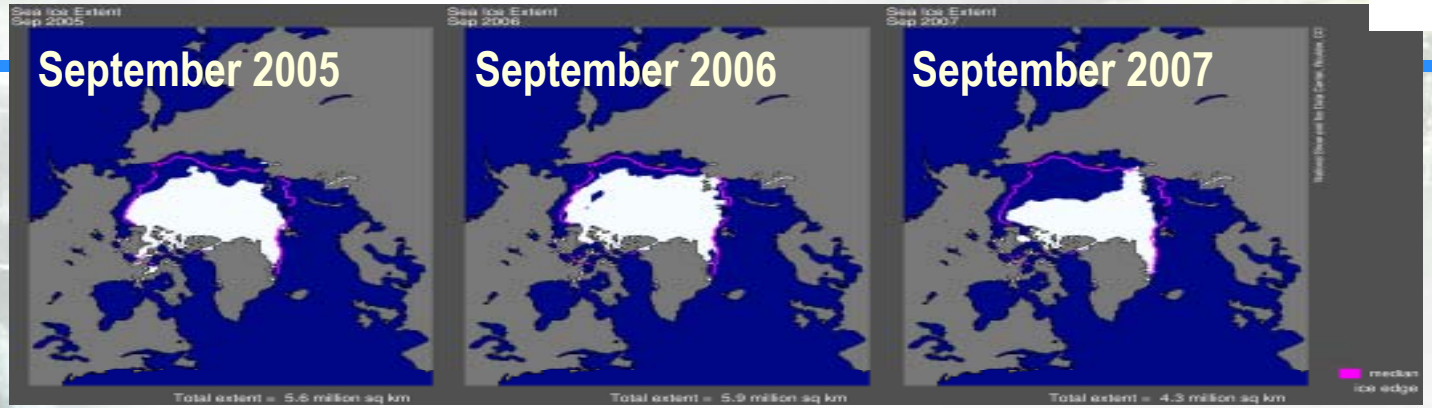
A Comparison of Three Different Cloud Microphysical Representations Implemented in WRF: Note the relatively large differences in the cloud structures simulated by the three methods

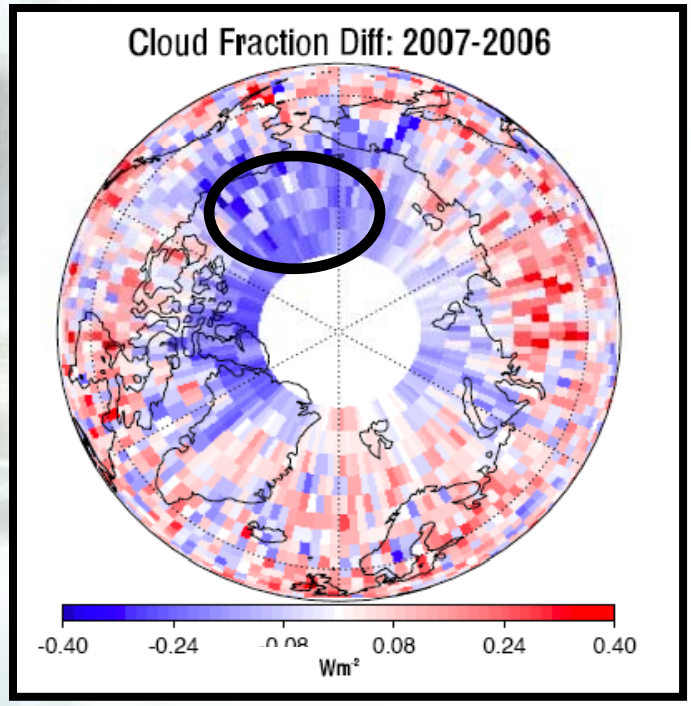


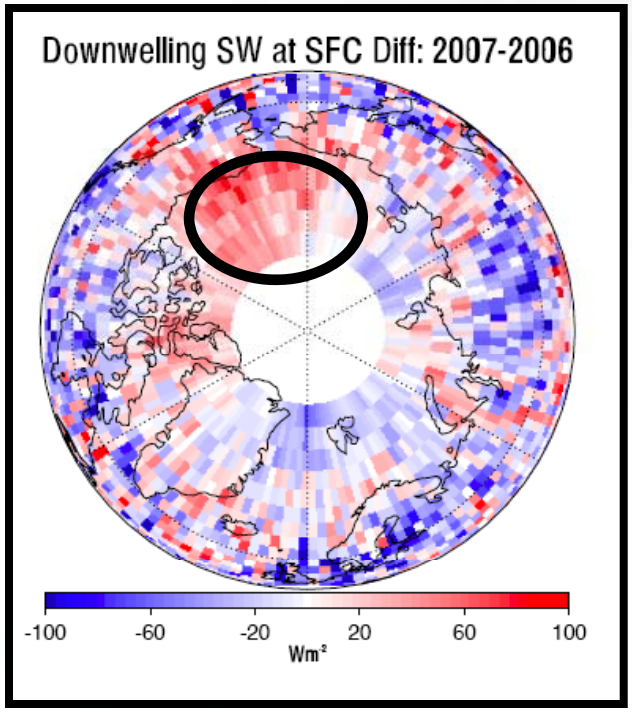




Lecuyer (2008)







The observed (A-Train) 32 Wm^{-2} surface SW radiation anomaly during this 3 month period constitutes enough energy to warm a 20 m ocean mixed layer by more than 2 K or melt a 0.3 m layer of sea ice (Kay et al, 2008).

Summary

- "Two Golden Years" Exploring WEC variability and extremes.
- The NEWSE Integration project has been defined and progress is being made.
- You too can be part of the NEWS team – it is an open process, and we need all the help we can get. You get to be part of a larger vision, and get access to NEWS ideas, interaction and data.

- NEWS Integration Workshop:
  - Friday May 30: 8am-3pm
  - Bahia Mar Beach Resort (RSVP with Debbie Belvedere – debbie@iges.org)

- NEWS Resources:
  - Web site: http://www.nasa-news.org
    - Implementation Plan, Quad Charts, Google Discussion Groups, Educational Materials, calendar of events
  - Data: ftp://crew.iges.org or http://crewi.ges.org:9090 (GDS server)