Studying 2006 dry and 2007 wet events using surface observations and NCEP Reanalysis

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NASA ENERGY AND WATER CYCLE STUDY

NEWS

Objectives

1. How do seasonal cycles of observed water and energy change in Dry year (10/2005-09/2006) and Wet year (10/2006-09/2007) and their severities?

2. To what extent does the large-scale dynamics play a role in controlling the WY06 dry and WY07 wet events?

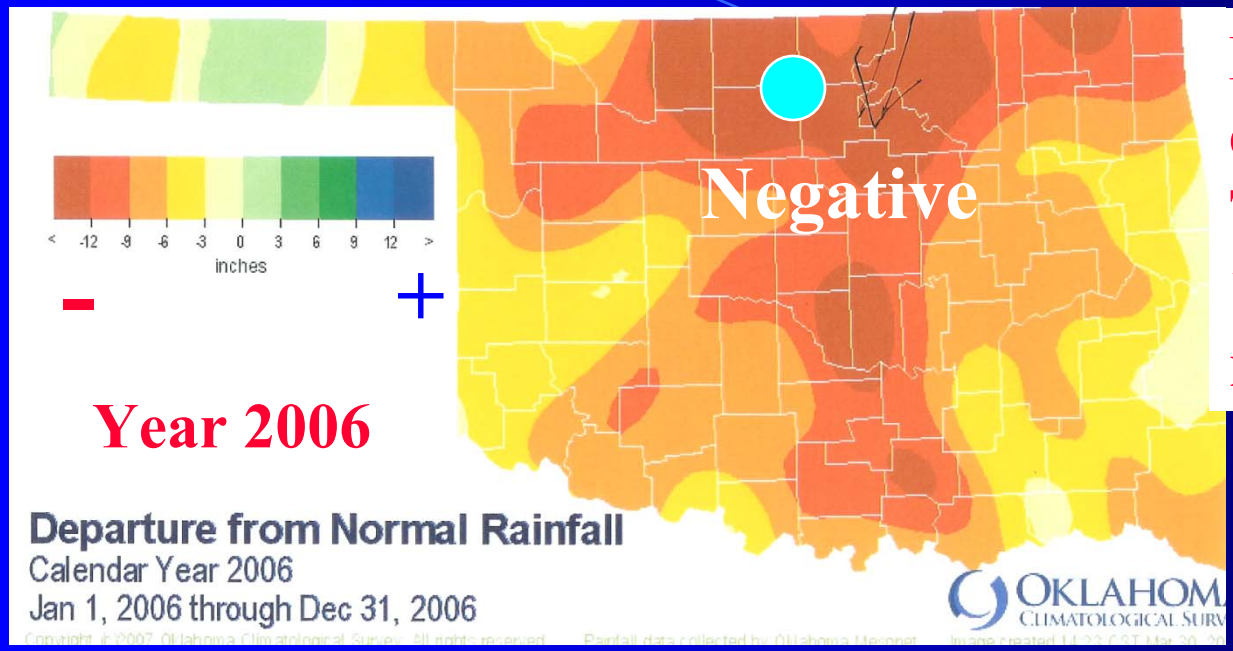
Data: ARM Surface Observations

1) Cloud Fraction→ Derived from DOE ARM radar-lidar data at the ARM SGP site during the period of 1997-2007
2) Precipitation and surface Temp→ Measured by tipping bucket rain gauge and thermometer mounted on a 10-m tower
3) Surface SW flux: Measured by up-looking PSP.

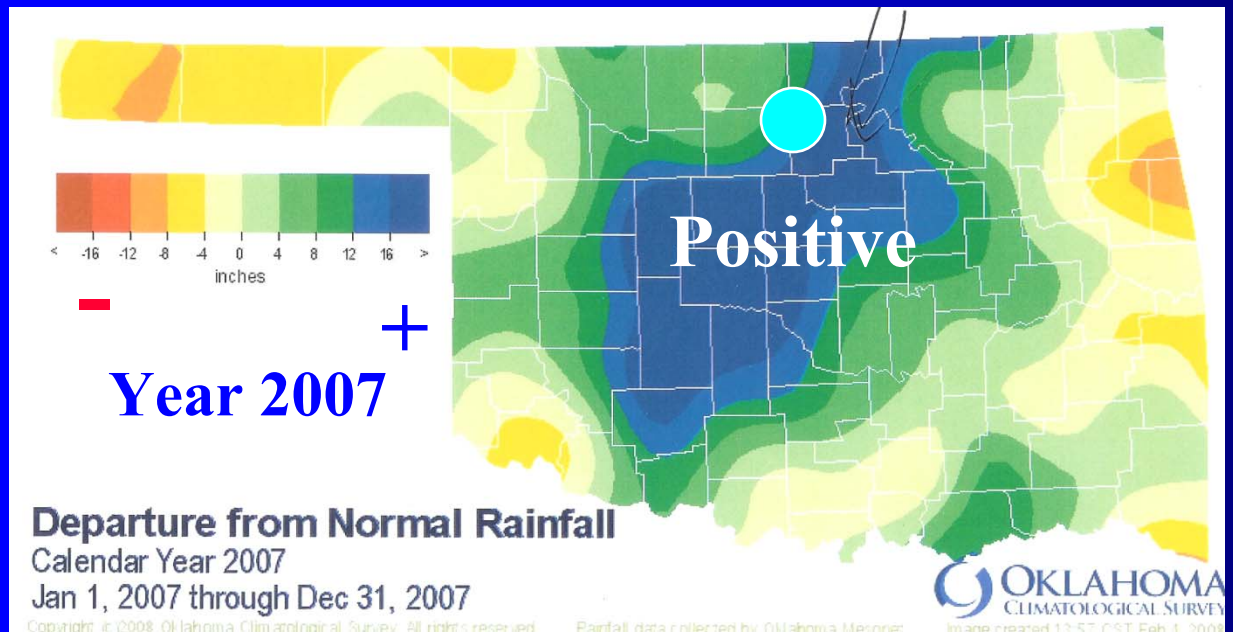
Data: NCEP reanalysis

1) 2.5° x 2.5°, 6 hourly, 17 levels
2) Ideally suited for diagnosing synoptic conditions over the ARM SGP site →To study the impact of large-scale dynamics on the WY06 dry and WY07 wet events.

Severities of the 2006 dry and 2007 wet events

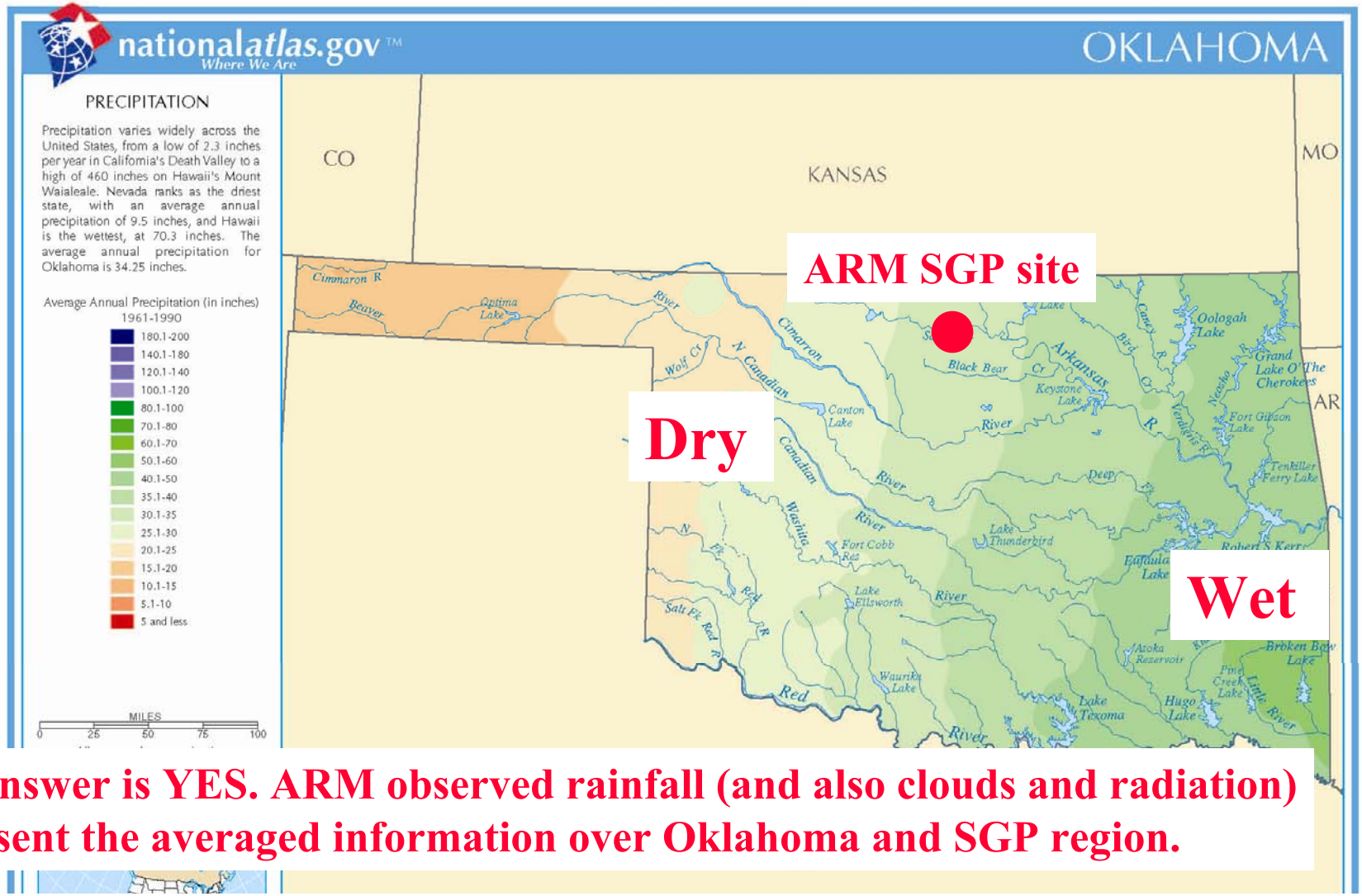


It was state-wide dry event during 2006. The annual rainfall is 18 inches lower than normal.



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

Do the ARM (point) observations represent a large region (SGP)?

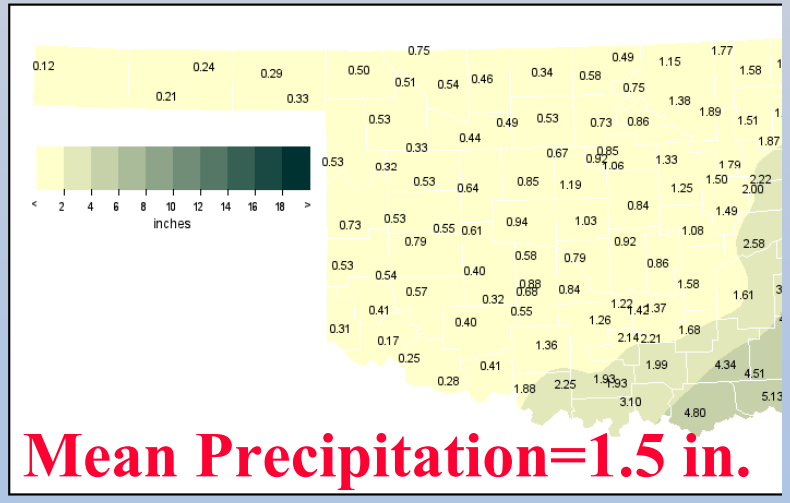


The answer is YES. ARM observed rainfall (and also clouds and radiation) represent the averaged information over Oklahoma and SGP region.

WINTER 2005-2006 SUMMARY

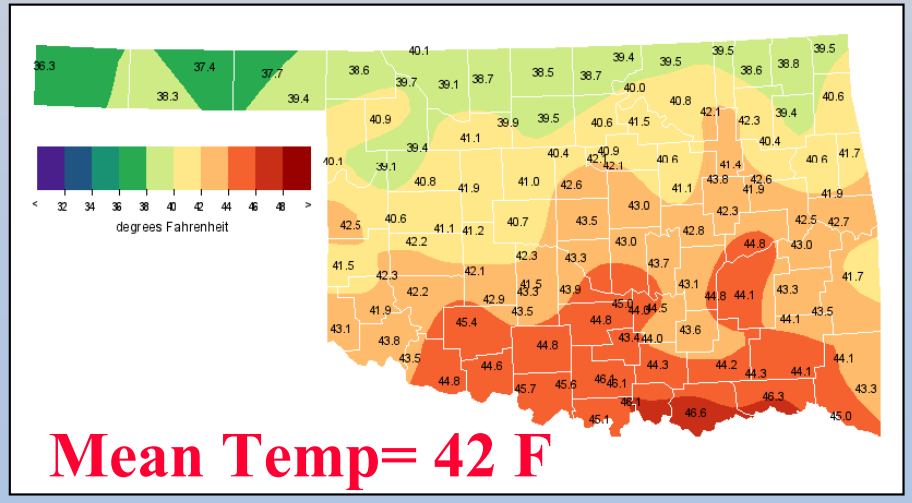
05-06 Winter: extreme Dry

Observed Rainfall



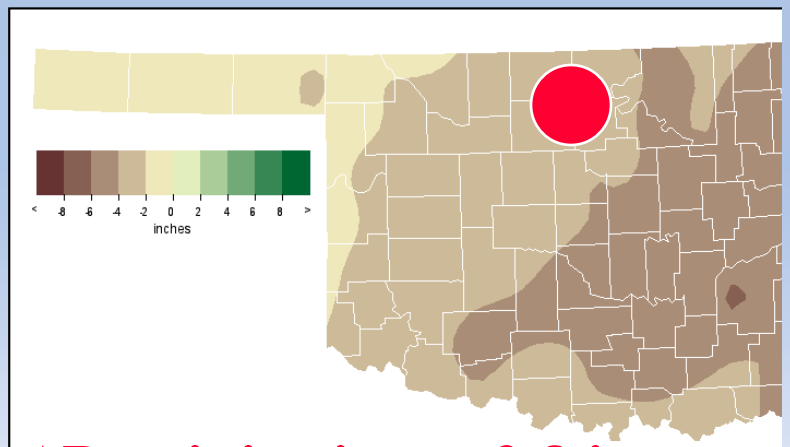
Mean Precipitation=1.5 in.

Average Temperature



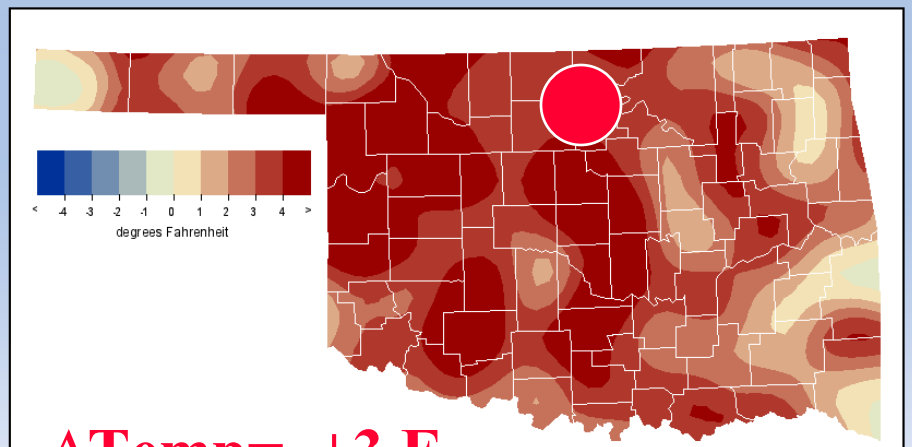
Mean Temp= 42 F

Rainfall Departure from Normal



ΔPrecipitation= -3.8 in.

Temperature Departure from Normal

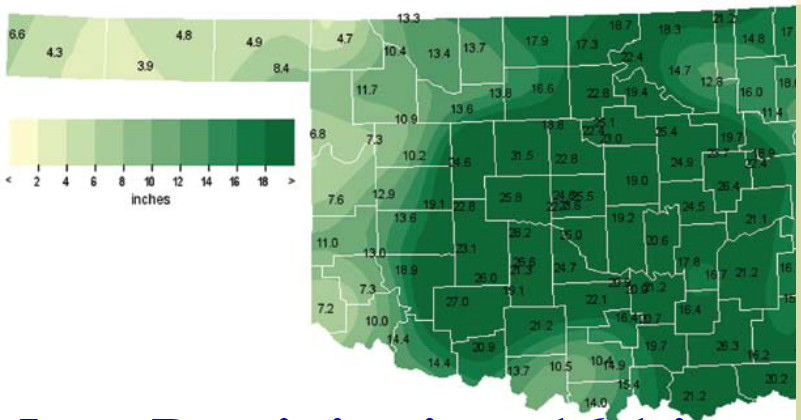


ΔTemp= +3 F .

SUMMER SUMMARY 2007

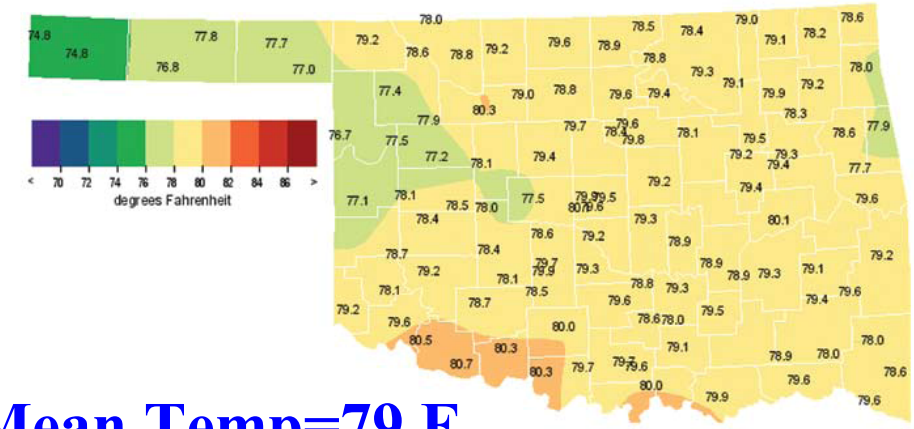
Summer 2007: extreme Wet

Observed Precipitation



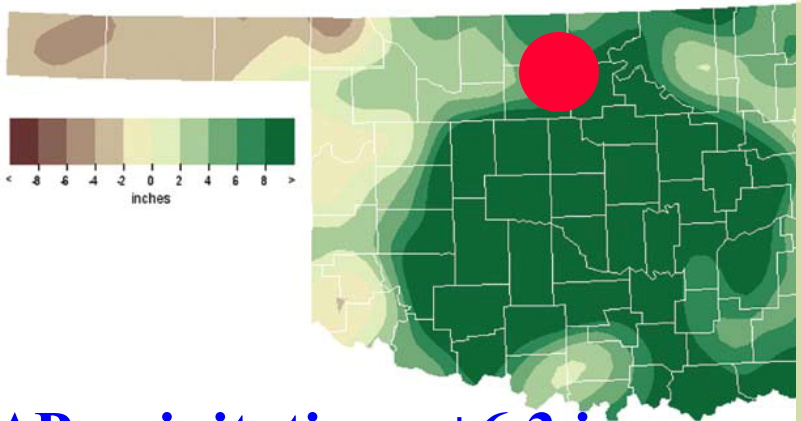
Mean Precipitation=16.1 in.

Average Temperature



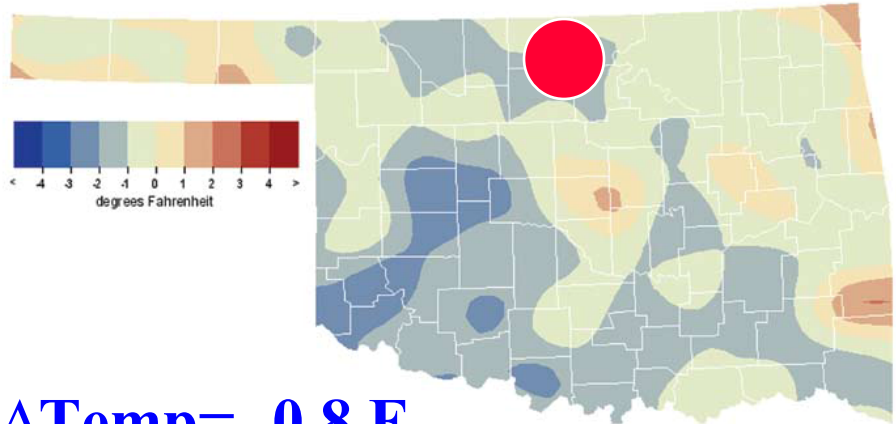
Mean Temp=79 F

Precipitation Departure from Normal



ΔPrecipitation= +6.3 in.

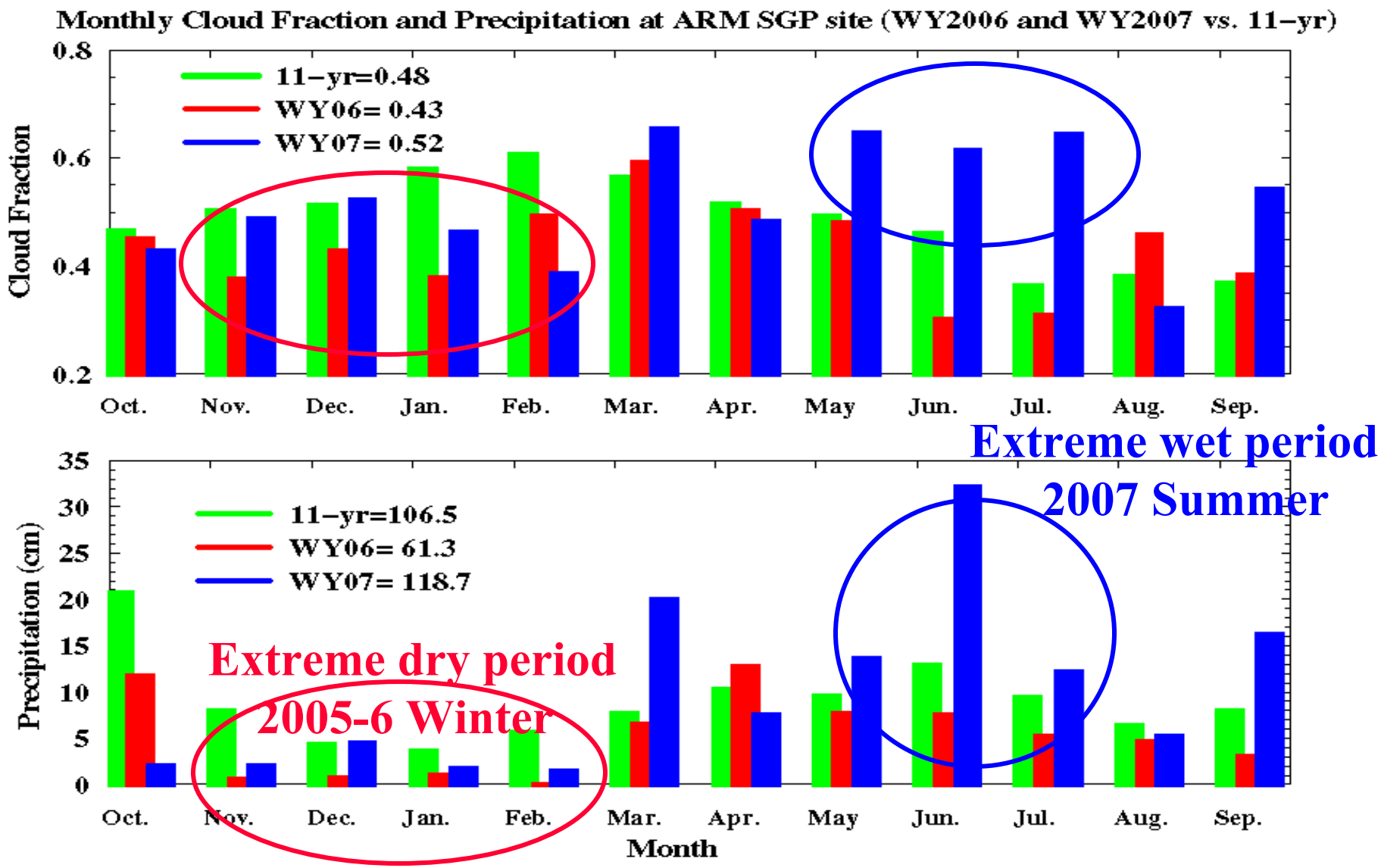
Temperature Departure from Normal



ΔTemp= -0.8 F

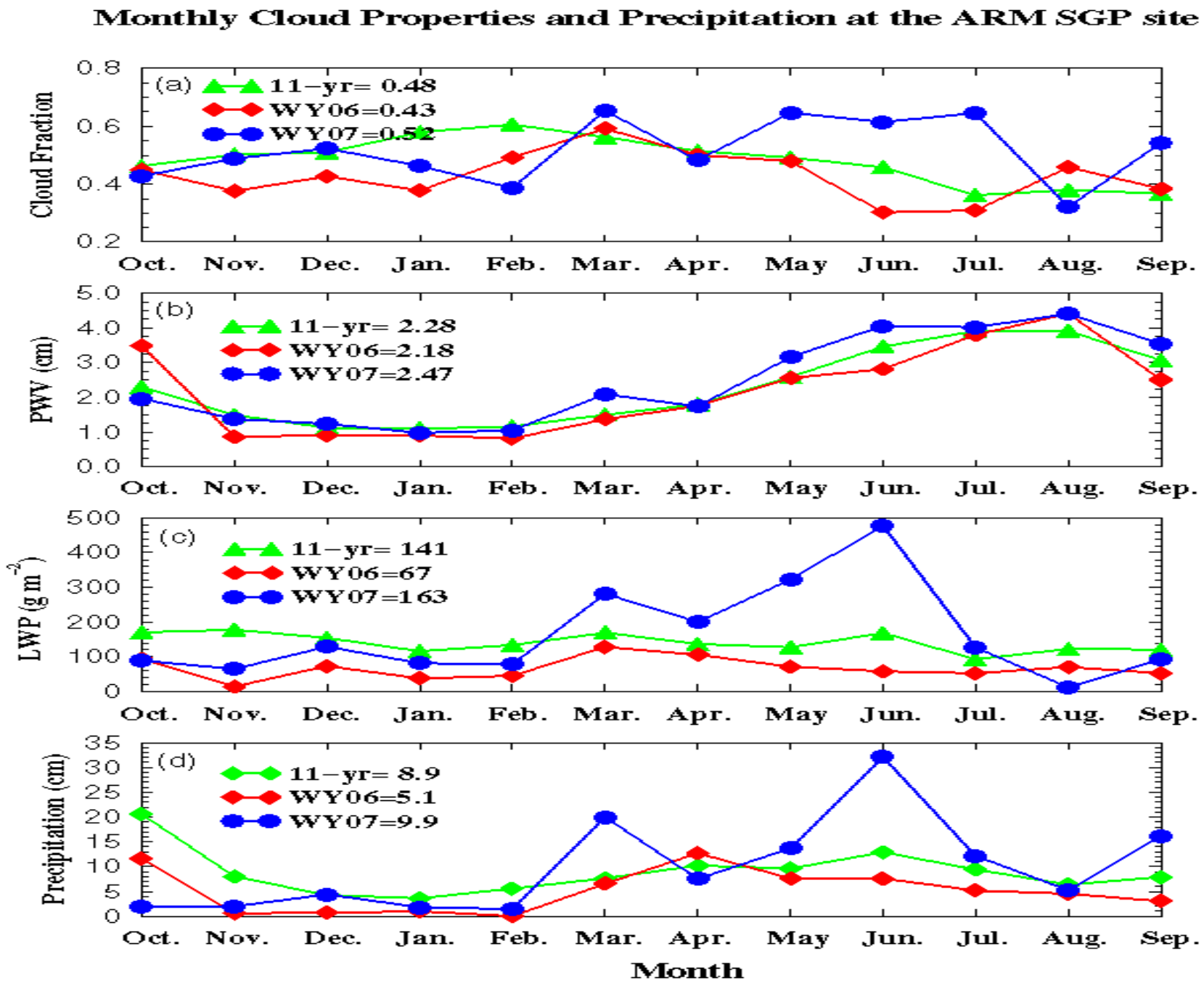
Objective 1

- **How do seasonal cycles of observed water and energy change in Dry year (10/2005-09/2006) and Wet year (10/2006-09/2007) and their severities?**

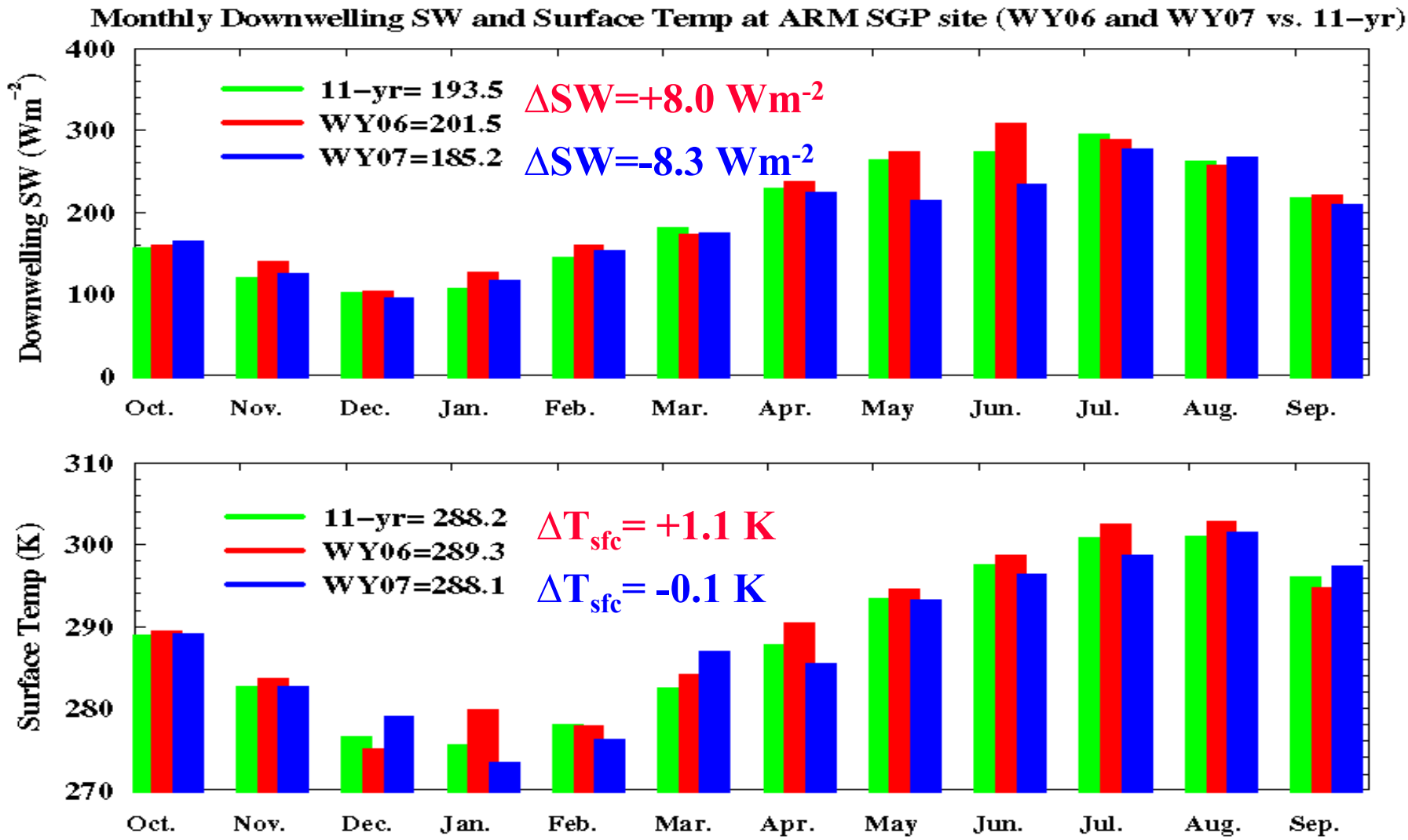


Compared to the 11-yr averages,

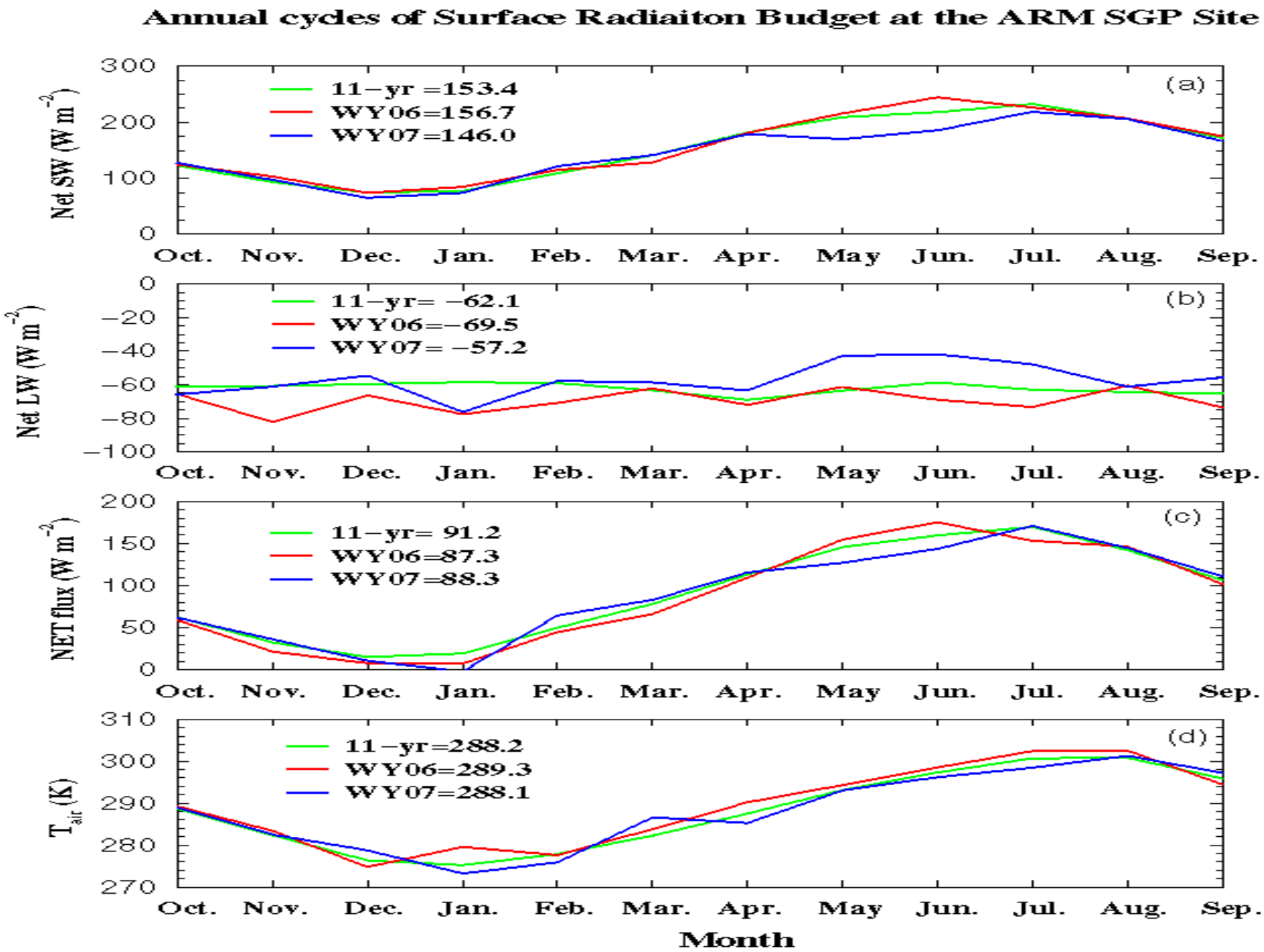
1) **the WY06 dry year cloud fraction is 5% less, and precipitation is 42% less**
2) **the WY07 wet year cloud fraction is 4% more, and precipitation is 12% more**


Monthly Cloud Properties and Precipitation at the ARM SGP site
(a)
11−yr= 0.48
WY06=0.43
WY07=0.52
Cloud Fraction
0.8
0.6
0.4
0.2
(b)
11−yr= 2.28
WY06=2.18
WY07=2.47
PWV (cm)
5.0
4.0
3.0
2.0
1.0
0.0
(c)
11−yr= 141
WY06=67
WY07=163
LWP (g m^{-2})
500
400
300
200
100
0
(d)
11−yr= 8.9
WY06=5.1
WY07=9.9
Precipitation (cm)
35
30
25
20
15
10
5
0
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep.
Month

Feedbacks of Dry Year



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

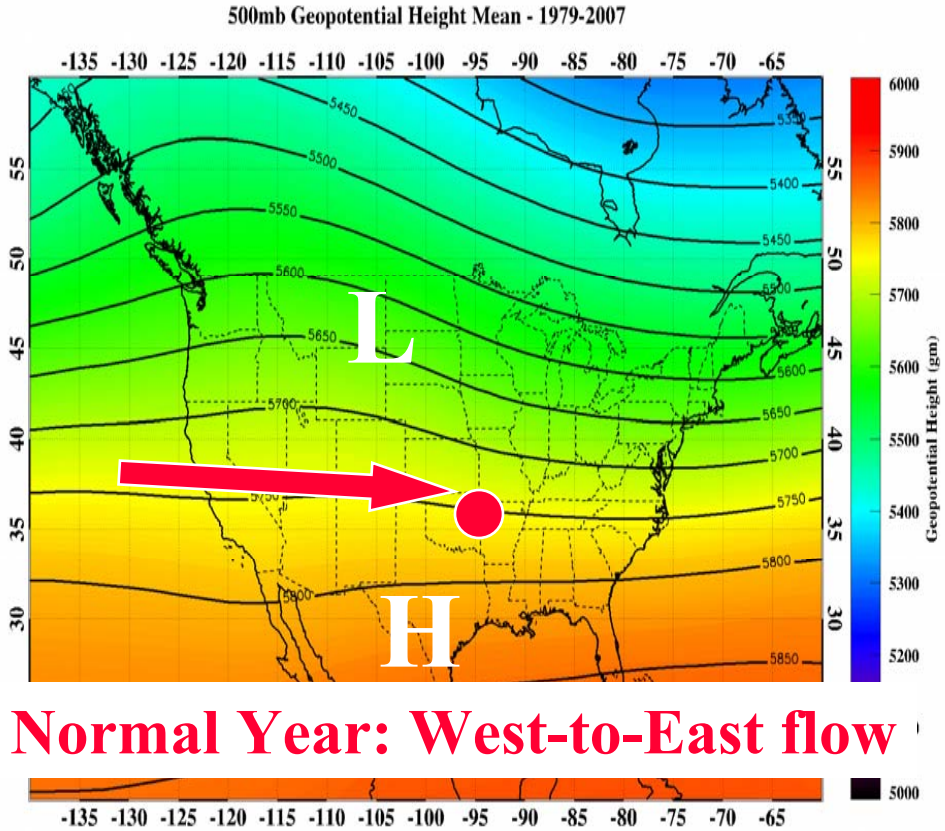

Annual cycles of Surface Radiaiton Budget at the ARM SGP Site
Net SW (W m^{-2})
11−yr =153.4
WY06=156.7
WY07=146.0
(a)
Net LW (W m^{-2})
11−yr= −62.1
WY06=−69.5
WY07= −57.2
(b)
NET flux (W m^{-2})
11−yr= 91.2
WY06=87.3
WY07=88.3
(c)
T_{air} (K)
11−yr=288.2
WY06=289.3
WY07=288.1
(d)
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep.
Month

Objective 2

- **To what extent does the large-scale dynamics play a role in controlling the WY06 dry and WY07 wet events?**

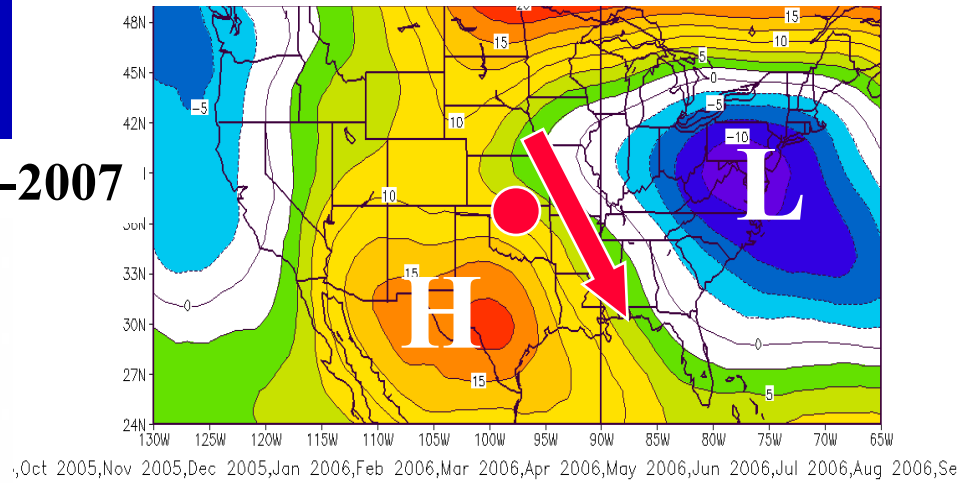
Synoptic patterns dominate WY06 dry event

500 - mb Geopotential height mean: 1979-2007



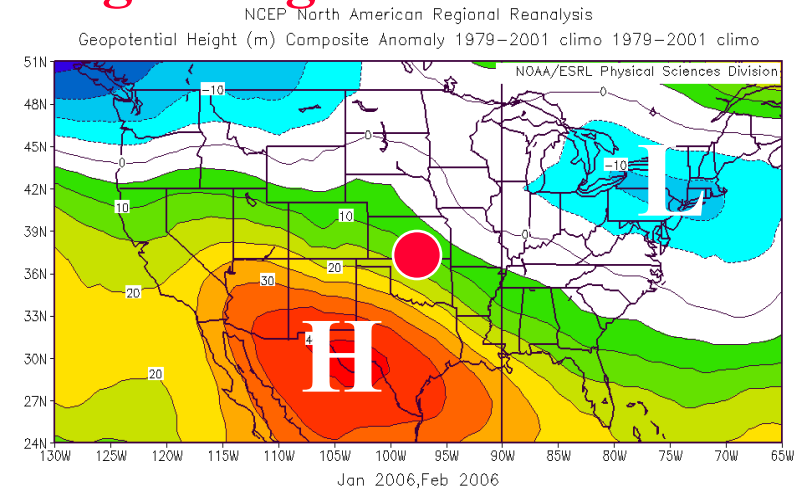
Normal Year: West-to-East flow

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

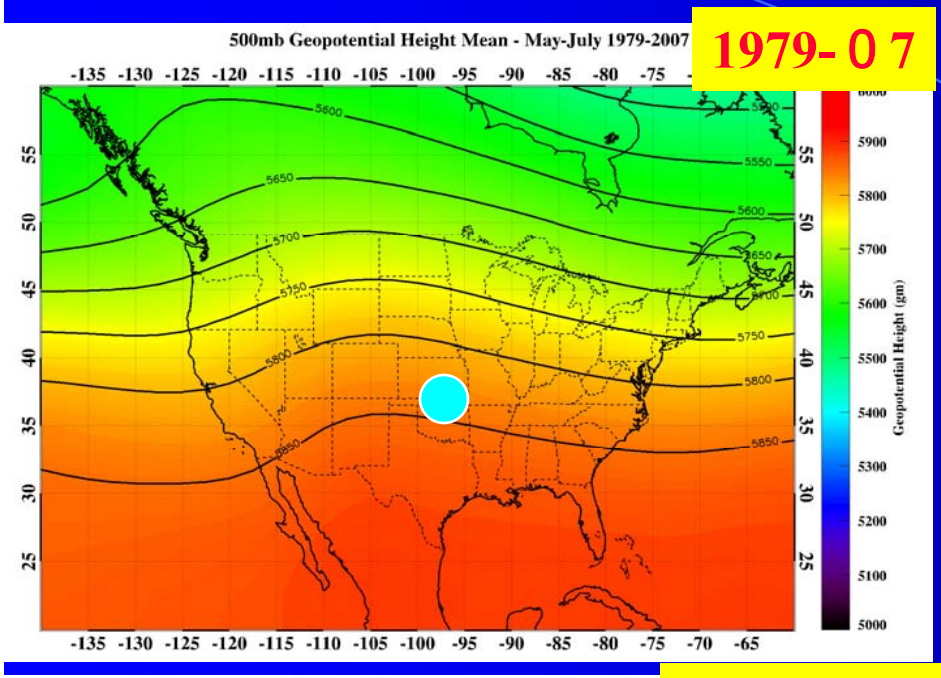


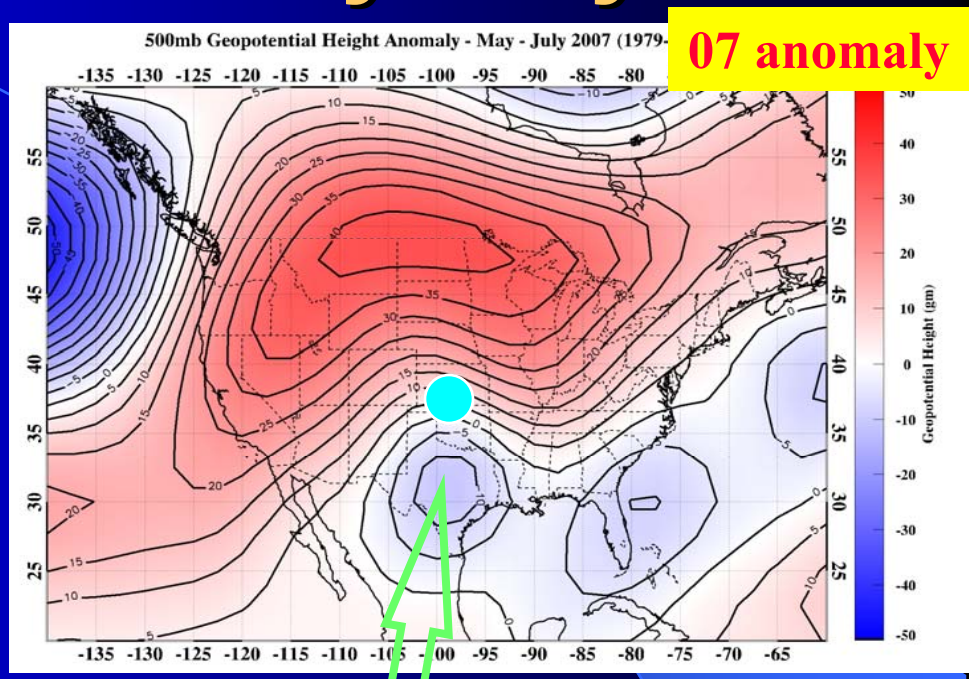
2005-06 Winter: extreme dry

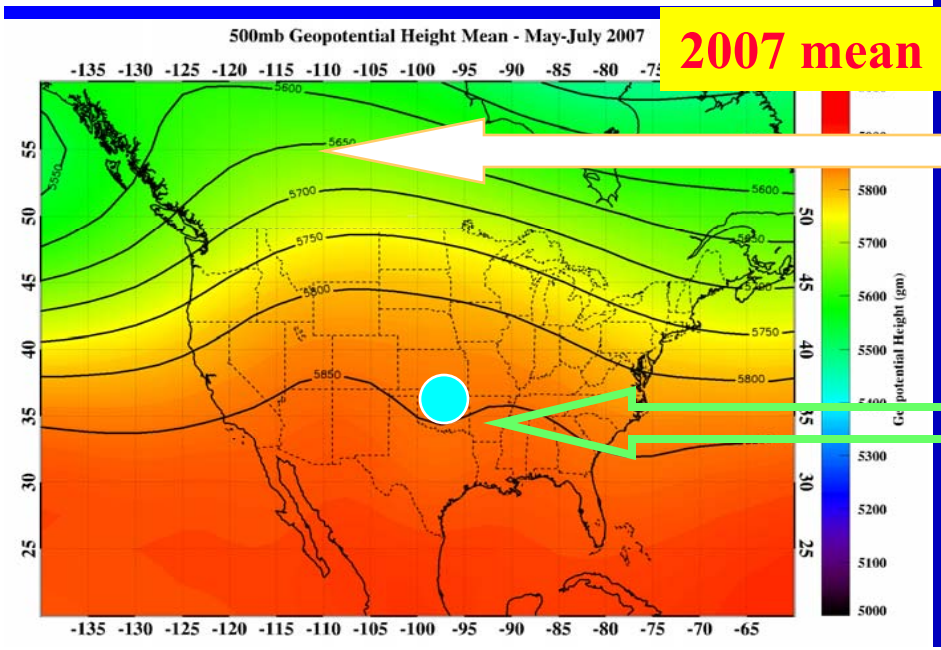
Stronger large-scale subsidence



Extreme Wet Period: May-July 2007

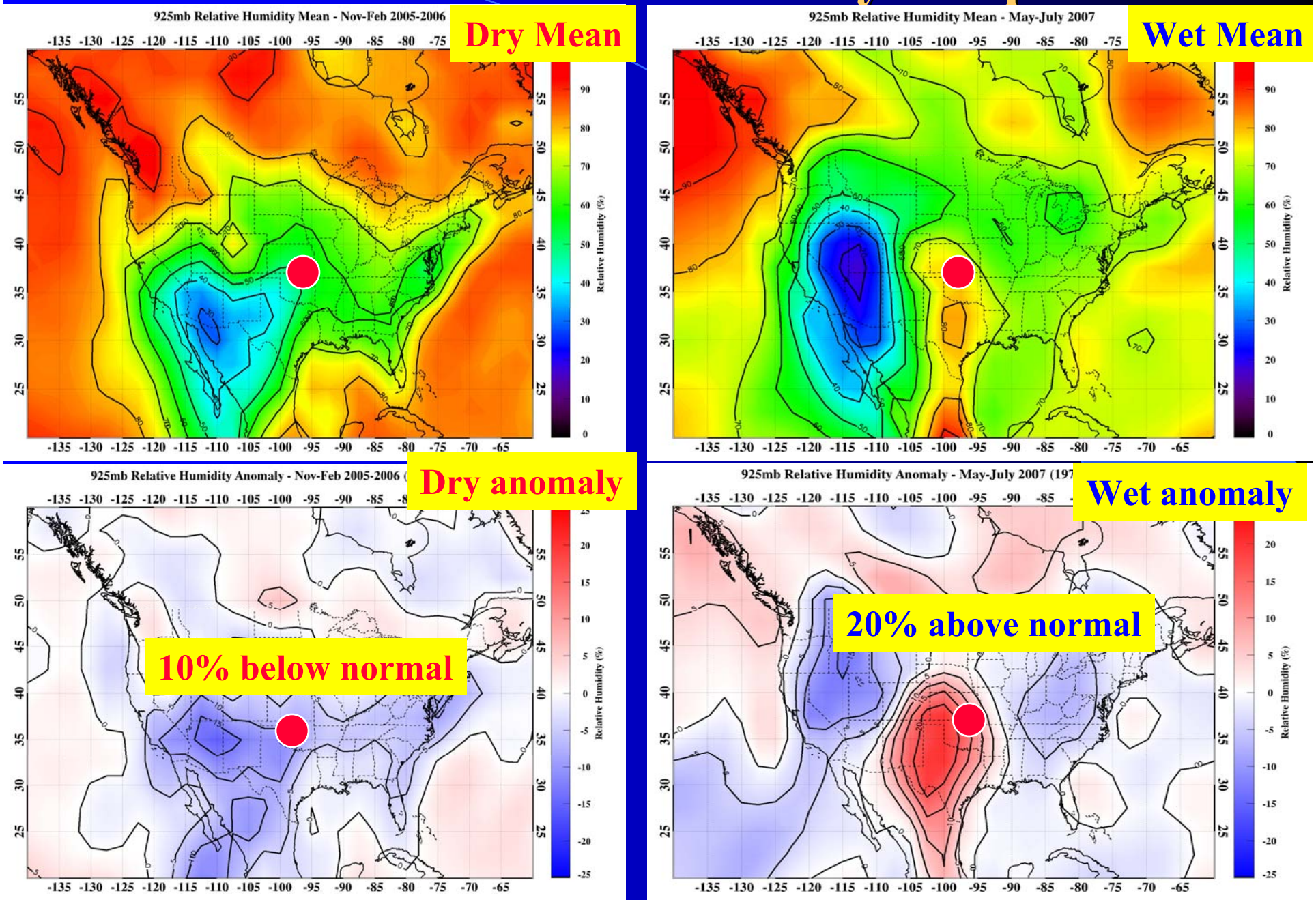




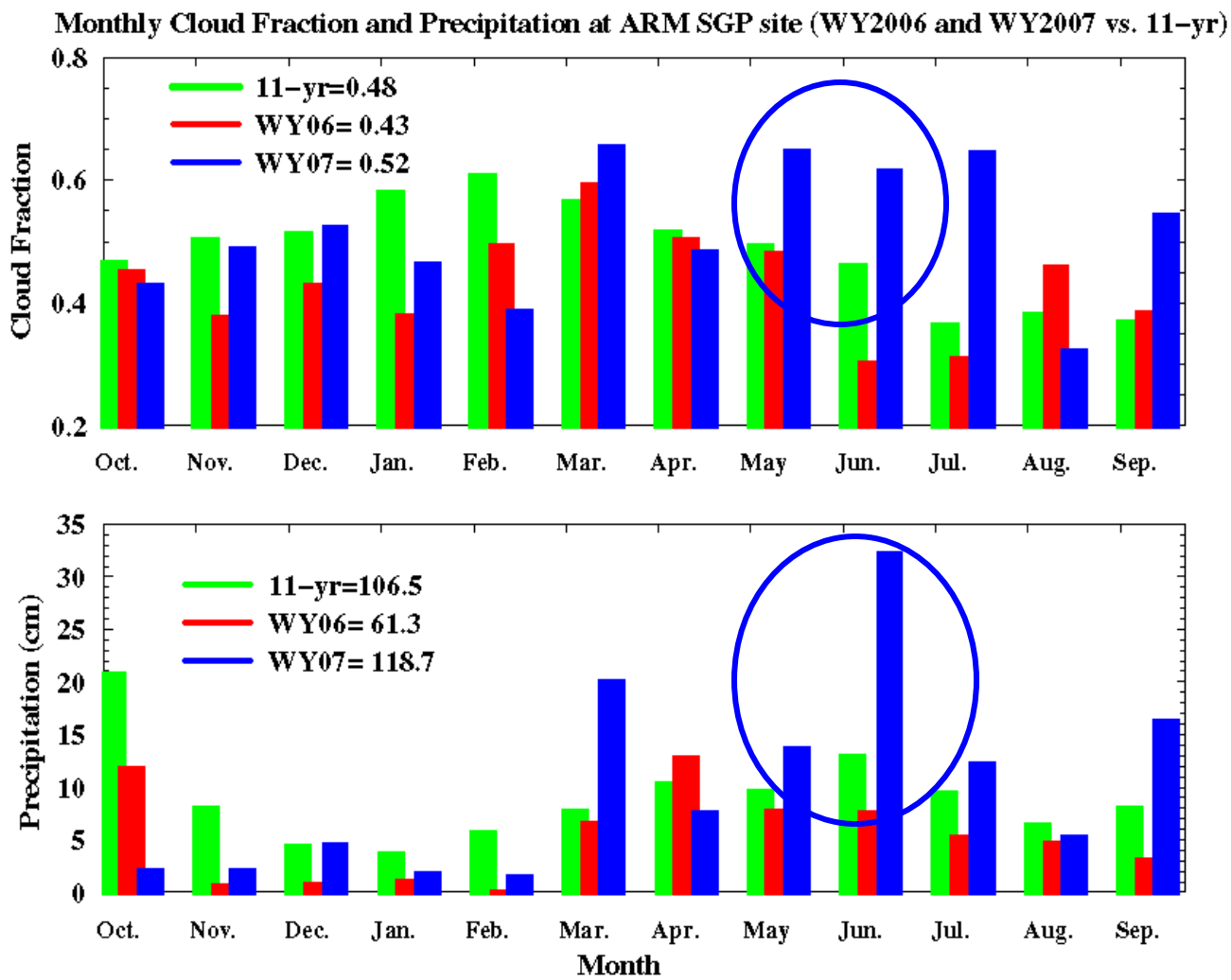


Stronger heights (ridge) over most of the US, however, there is a negative anomaly centered over the OK/TX region which can be seen as a long-term shortwave trough during these three months.

RH anomalies for extreme dry/wet periods



The 2007 Summer wet event is associated with both synoptic and mesoscale patterns



Why their CFs are the same, but the Precipitation in June is much higher?

During May, more stratiform clouds are associated with large-scale dynamics.

During June, clouds are associated with both large-scale dynamics and mesoscale thunderstorms (late afternoon)

Conclusions

1) Compared to the 11-yr averages,

The WY06 dry year cloud fraction is 5% less, and precipitation is 42% below

The WY07 wet year cloud fraction is 4% more, and precipitation is 12% above

2) With less clouds and precipitation during the WY06, the downwelling SW flux increased 8 Wm^{-2} and surface temperature rose 1.1 K. This additional warming can strengthen an existing drought.

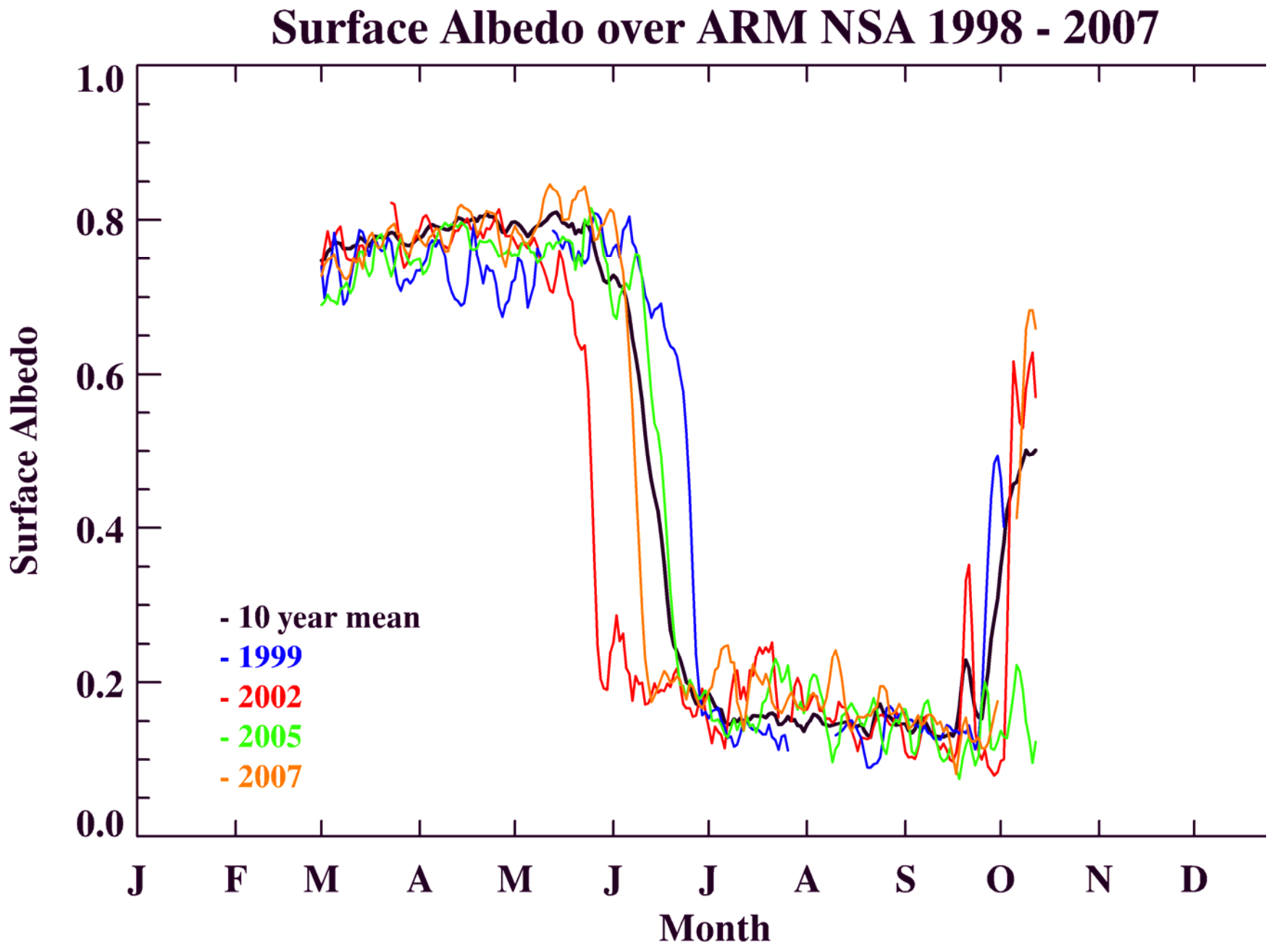
3) The large-scale dynamics has a significant impact:

WY06 Dry Year: Dominated by synoptic patterns

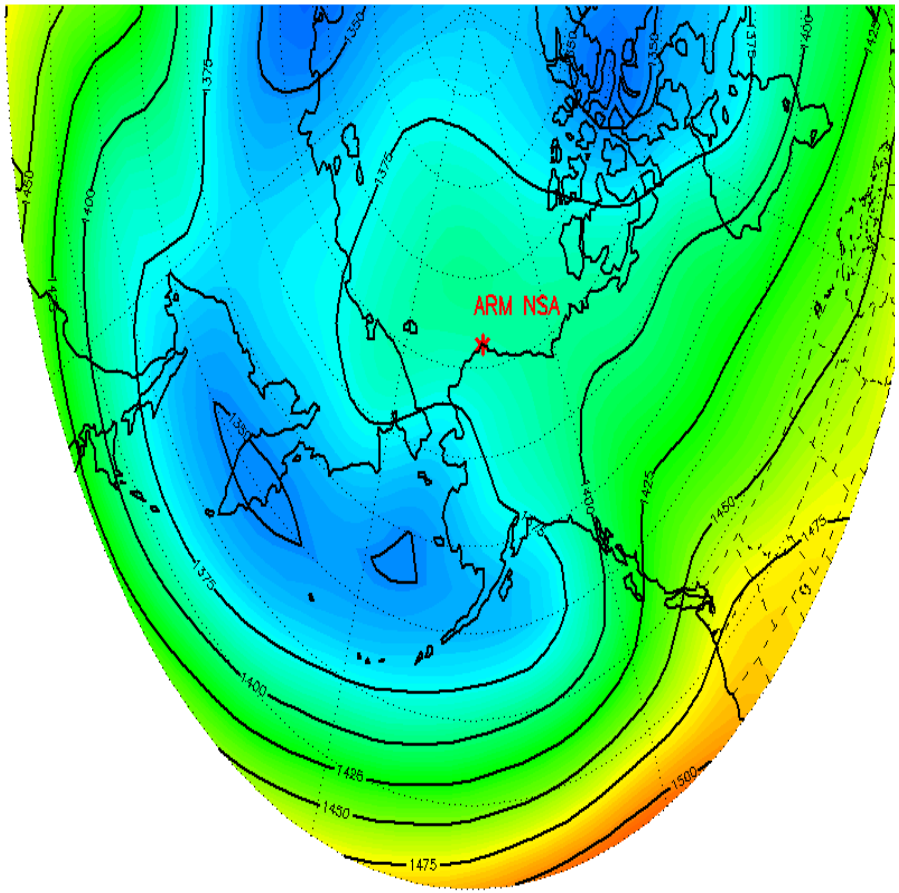
WY07 Wet Year: Associated with both synoptic and mesoscale patterns

What is next after we have done the two extreme events at the SGP site

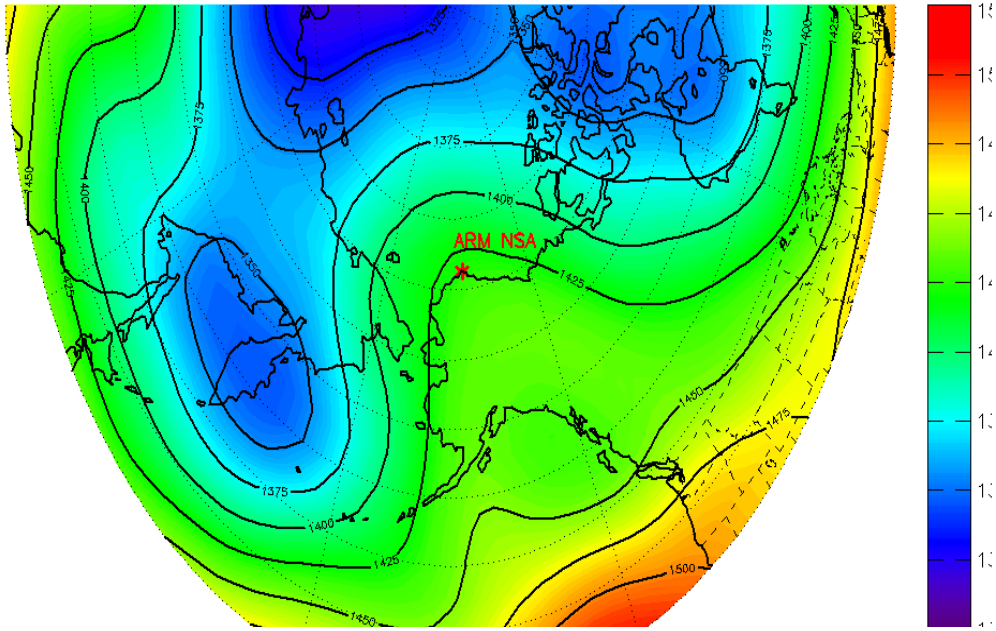
1) The 2007 snow/ice coverage (min) is hot topic now.
2) Impact of large-scale dynamics and seasonal snow accumulation on early and late snowmelt events


Surface Albedo over ARM NSA 1998 - 2007
Surface Albedo
1.0
0.8
0.6
0.4
0.2
0.0
- 10 year mean
- 1999
- 2002
- 2005
- 2007
J
F
M
A
M
J
J
A
S
O
N
D
Month

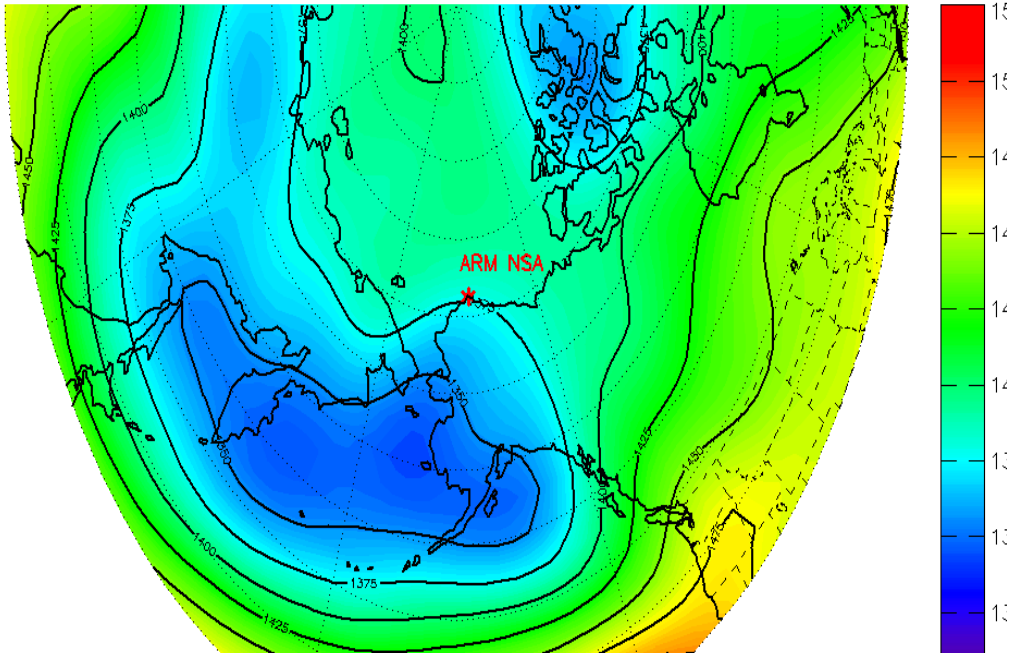
850 mb Climatology March– May (1998–2007)

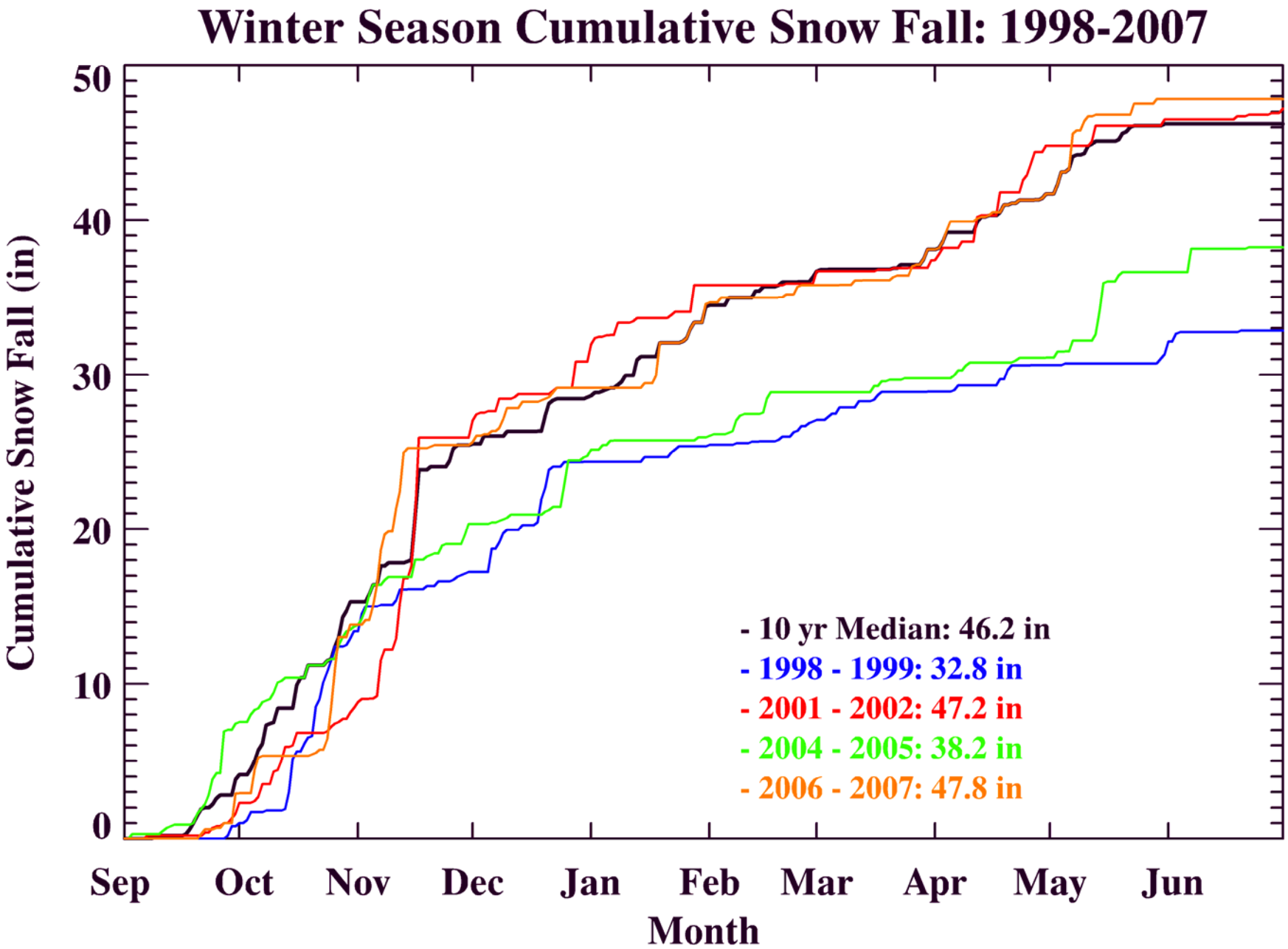
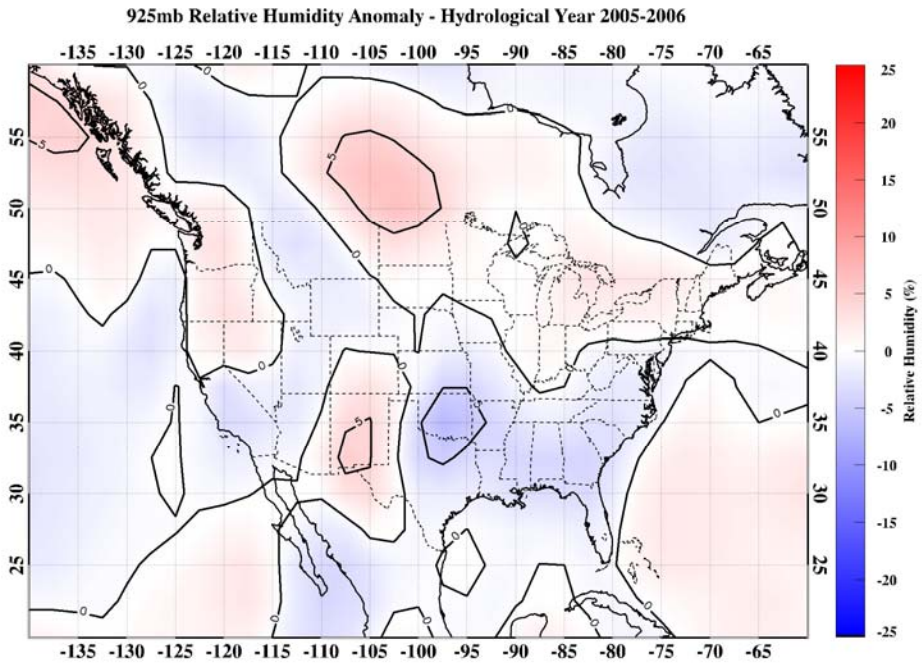
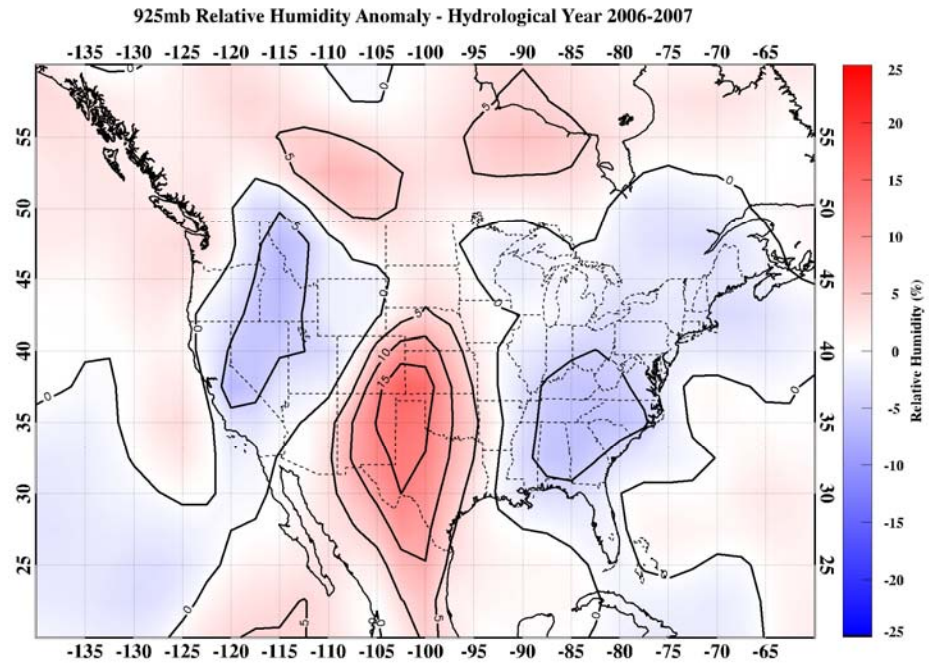


850 mb Climatology March– May 2002



850 mb Climatology March– May 1999




Winter Season Cumulative Snow Fall: 1998-2007
Cumulative Snow Fall (in)
50
40
30
20
10
0
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Month
- 10 yr Median: 46.2 in
- 1998 - 1999: 32.8 in
- 2001 - 2002: 47.2 in
- 2004 - 2005: 38.2 in
- 2006 - 2007: 47.8 in

Dry Year – Wet Year RH Anomaly