

# Dr. Anthony Lupo

Soil, Environmental and Atmospheric Sciences

**Climate, Climate Change & Hurricanes**



Sponsors: MU Office of Research  
Department of Physics and Astronomy  
Division of Biochemistry  
Christopher S. Bond Life Sciences Center

# Climate, Climate Change & Hurricanes



- Climate – What is it?
- Weather → the day-to-day state of the atmosphere. Includes state variables and descriptive material such as cloud cover and precipitation, etc.
- We can get this material instantaneously

# Climate, Climate Change & Hurricanes

- Climate → Is the long-term or time mean state of the earth-atmosphere system and the state variables along with higher order statistics. Also, we must describe extremes and recurrence frequencies.
- In 'English': A long-term summary of what has happened (in the past).

# Climate, Climate Change & Hurricanes

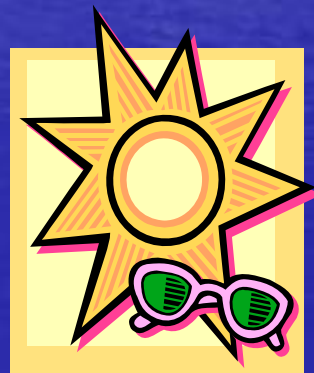
- Climatology is the study of climate in a mainly descriptive and a statistical sense. Climatologists study these issues, as well as changes in climate.
- Climatology is, of course, a popular subject today because of the concern over climate change.

# Climate, Climate Change & Hurricanes

- Long-term is defined by the World Meteorological Organization (WMO) as 30-years. Why...?
- Climate change, then, is simply any change to the 30-year statistics.

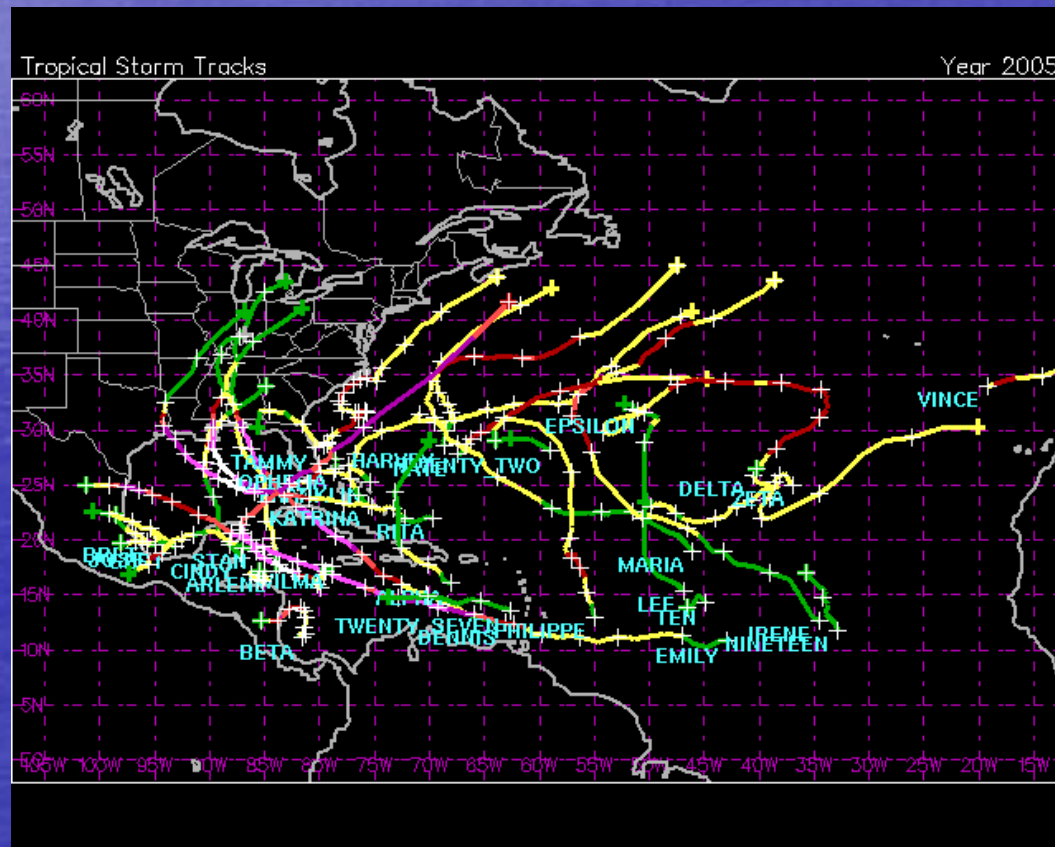
# Climate, Climate Change & Hurricanes

- Climate can, therefore, be descriptive and tell us something about, 'what is possible' in a given region.



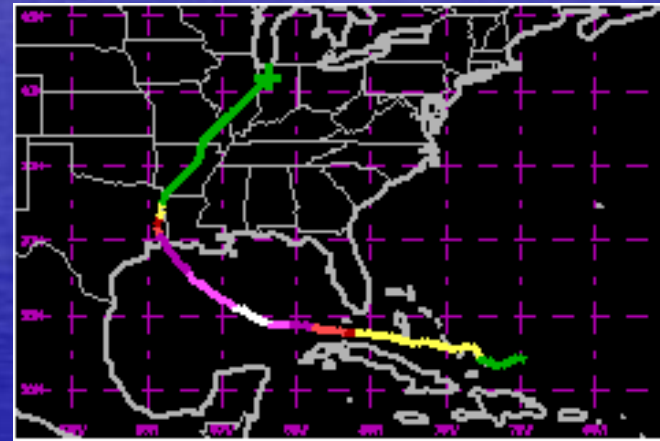
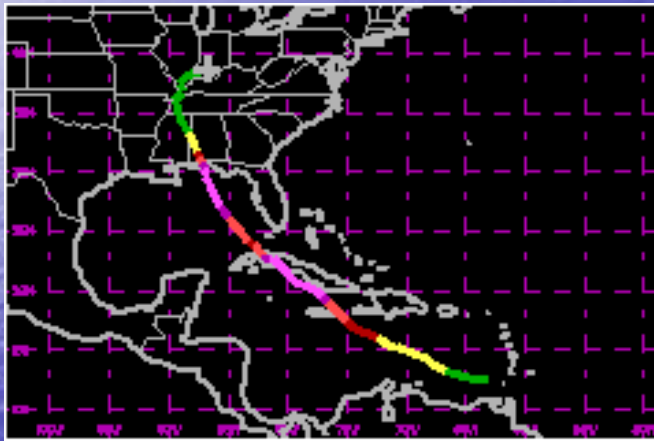
# Climate, Climate Change & Hurricanes

- Hurricane Season 2005 – 27 Named Storms!



# Climate, Climate Change & Hurricanes

- Even in Missouri.....



- Dennis

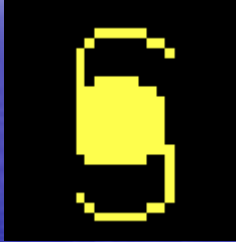
Rita



# Climate, Climate Change & Hurricanes

- Hurricanes: are the most destructive phenomena on the planet.
- The word "hurricane" is a Caribbean, Spanish, and French word for "evil wind".
- They live about 9 days in the Atlantic, which averages 10 storms per year.

# Climate, Climate Change & Hurricanes

- What makes a hurricane? 
- A low – level cluster of thunderstorms
- Warm waters,  $\geq 80^{\circ}$  F
- Low wind shear (High pressure aloft)

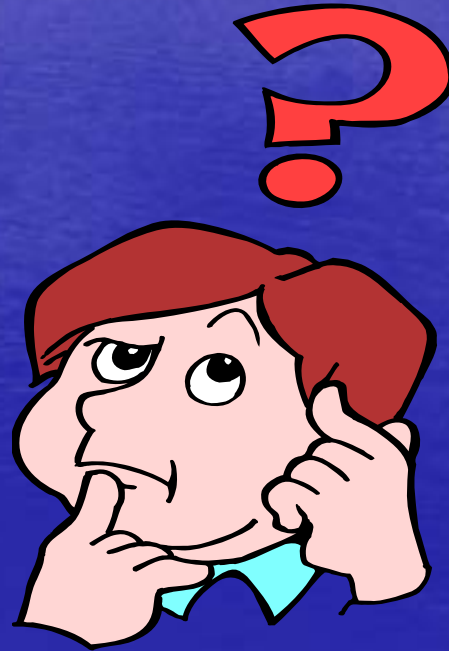
# Climate, Climate Change & Hurricanes

- The warm waters are critical for storm intensification. This provides the fuel for the storm via large amounts of water vapor.

This water vapor condenses and all this latent heat energy is released, some of which becomes wind energy.

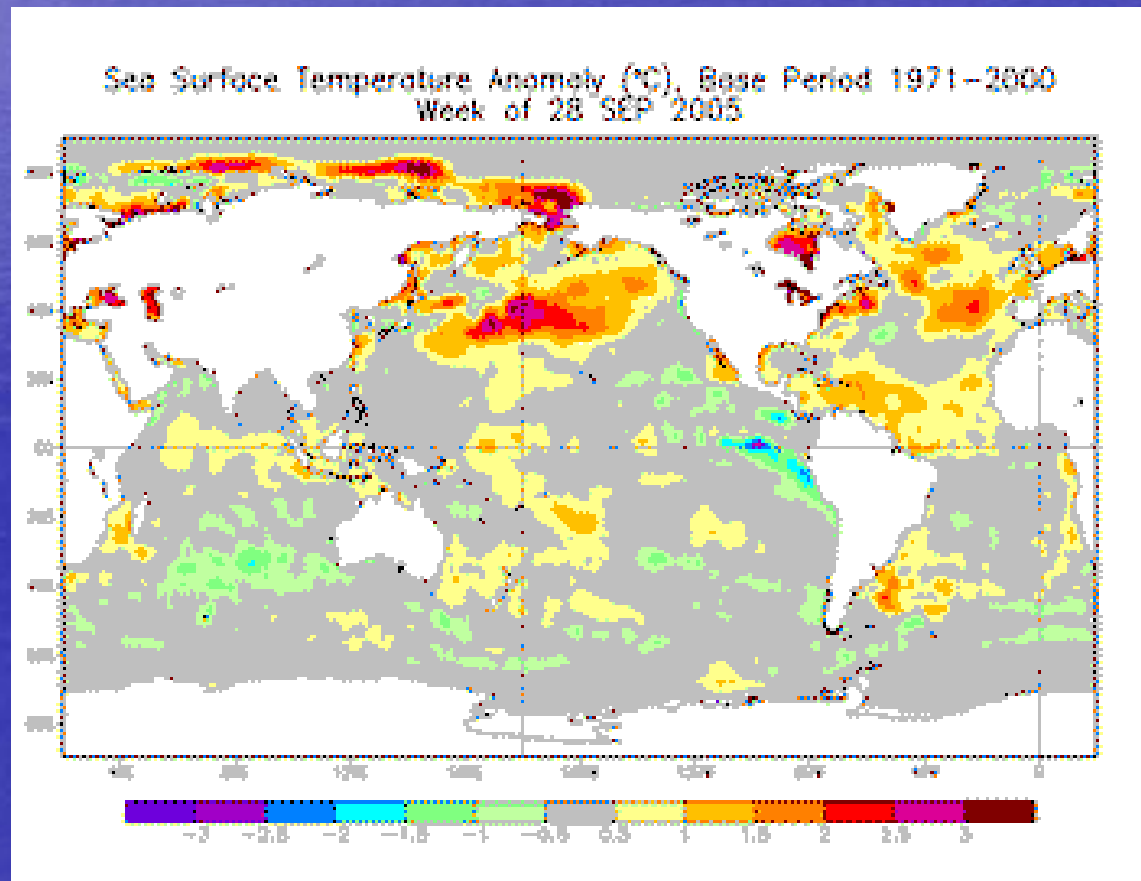
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- What were the immediate causes of the busy 2005 season?



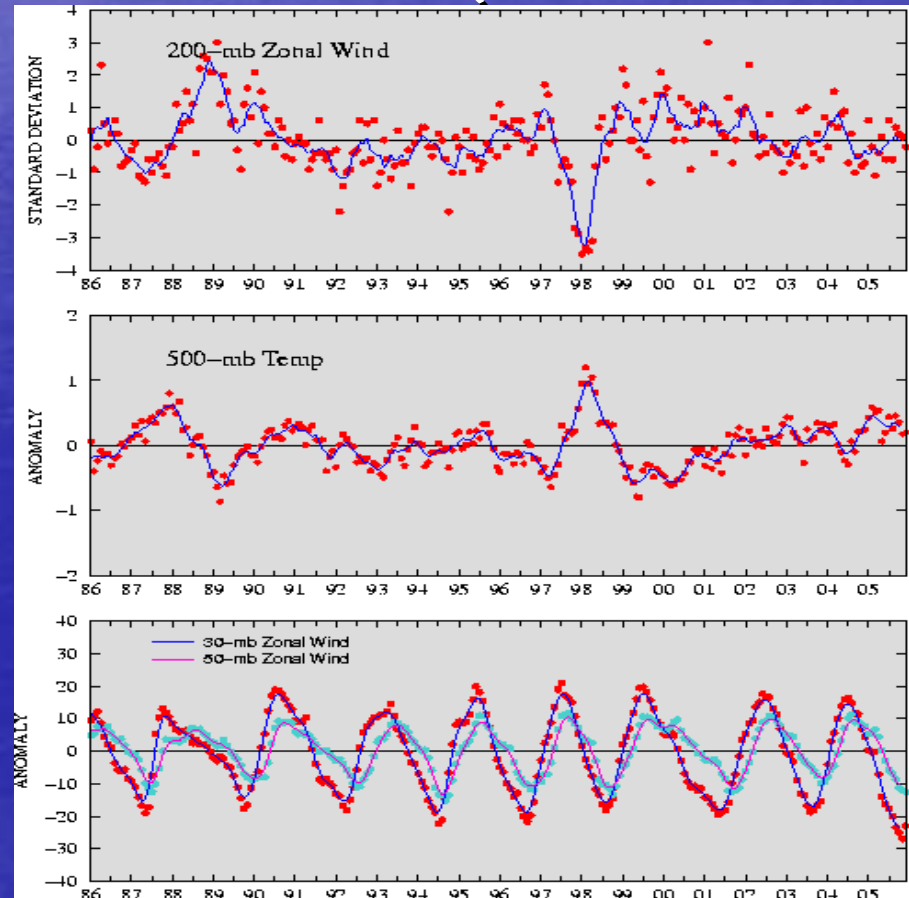
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- Very warm Atlantic Basin waters (intensity)



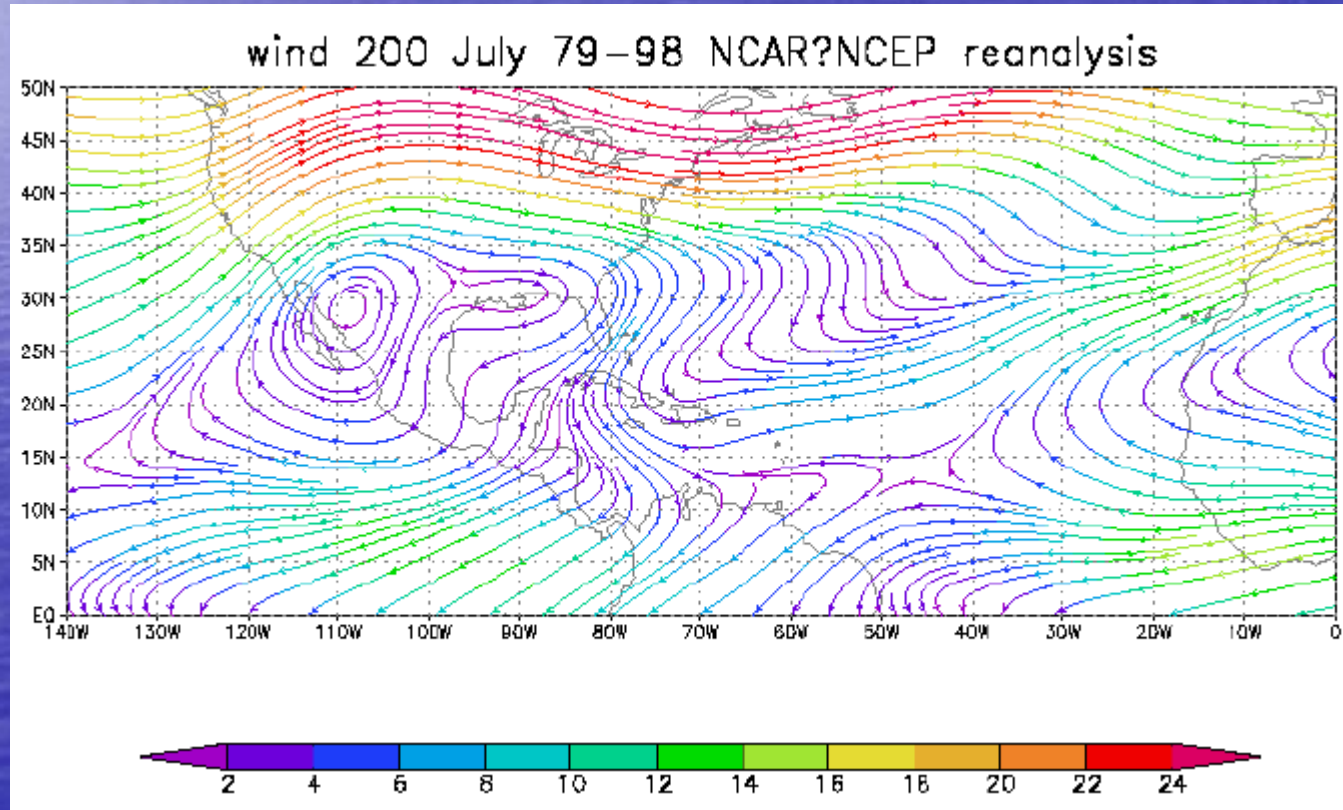
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- Strong Easterly winds aloft (numbers and intensity)



# Climate, Climate Change & Hurricanes

- No trough aloft in the Atlantic (numbers)



# Climate, Climate Change & Hurricanes

- Why no trough aloft? Blame El Niño (or lack of one!)
- What is El Niño?



# Climate, Climate Change & Hurricanes

- El Niño –means literally “the child”, in this case, THE Child as El Niño typically sets in around Christmas!

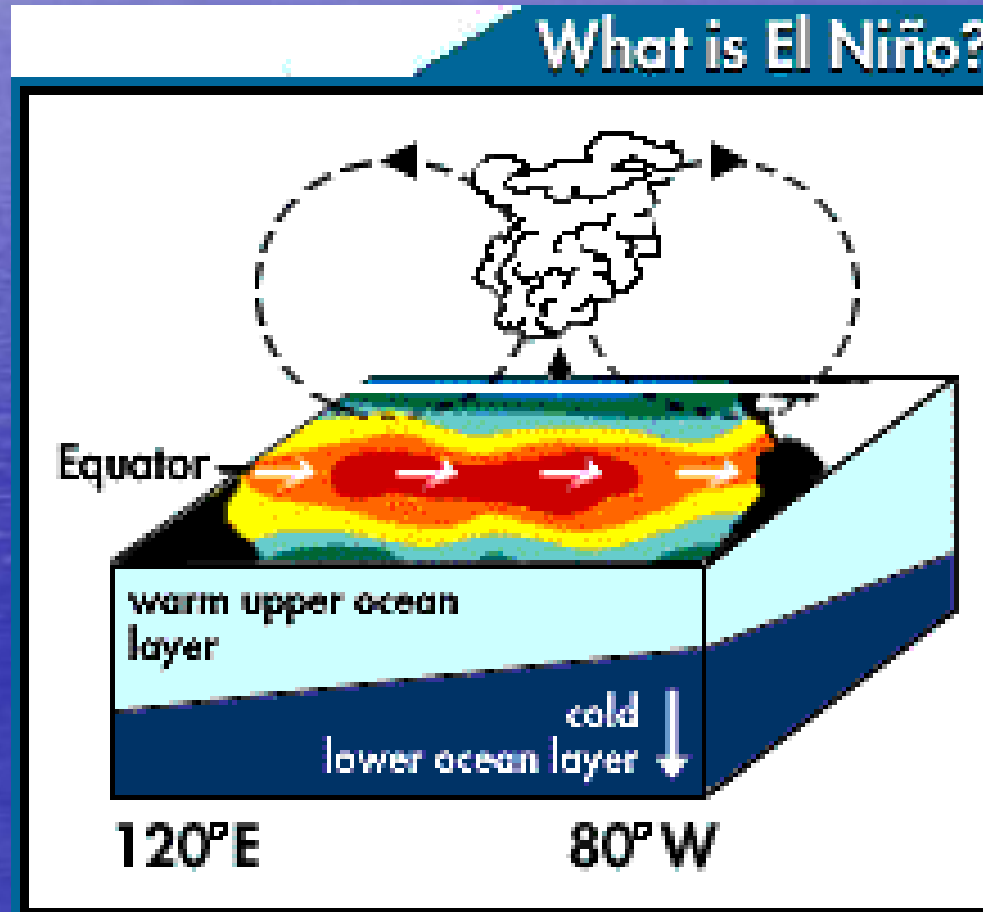


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- El Niño refers to the see-saw of warm and cold sea surface temperature patterns in the Tropical Pacific
- This occurs every 2 – 7 years!

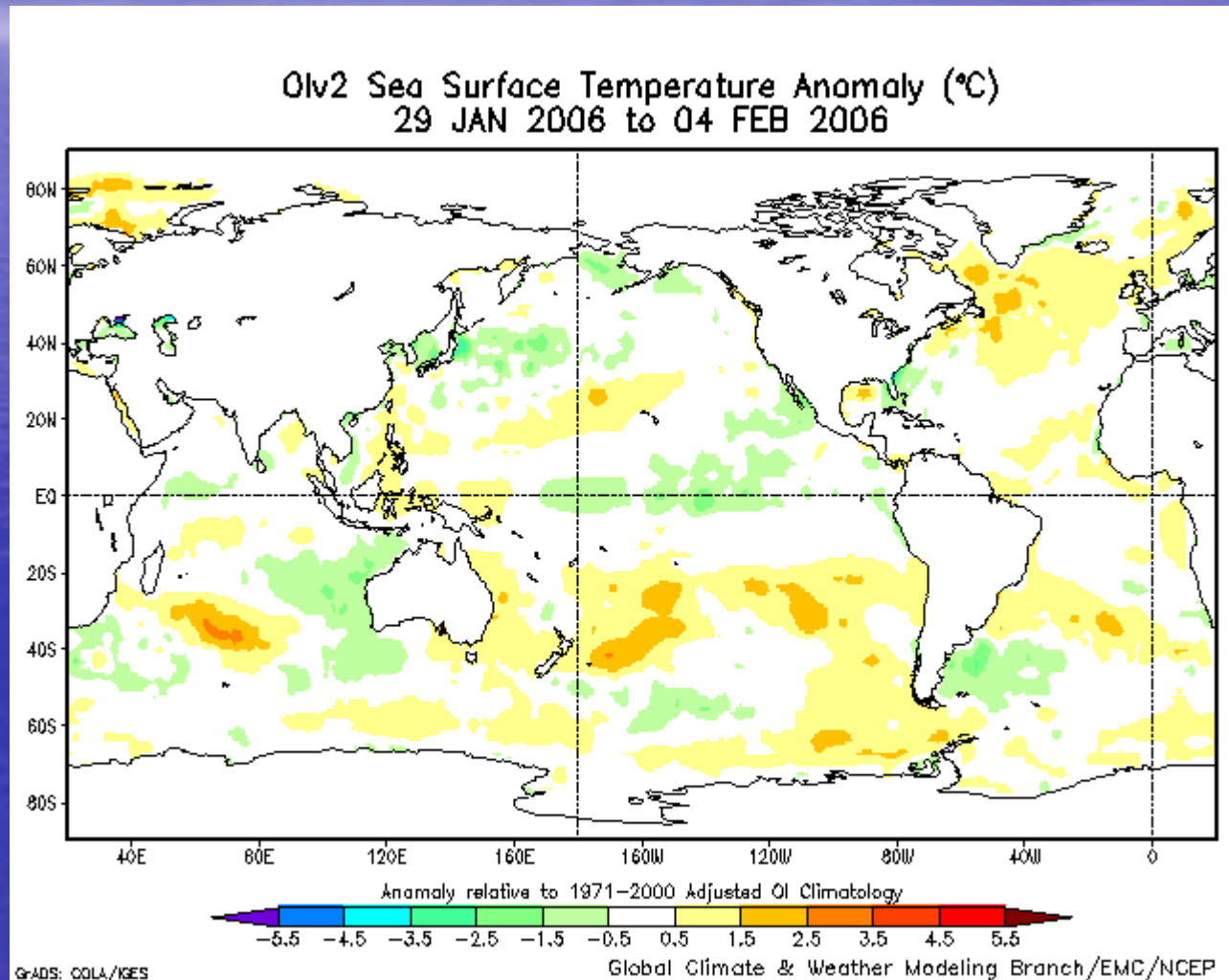
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- El Niño:



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- Currently:



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- To summarize:

Conditions in the Atlantic were very favorable for a busy season, due to warm waters, weak wind shear, no El Niño.

The season was forecast to be busy ahead of time.

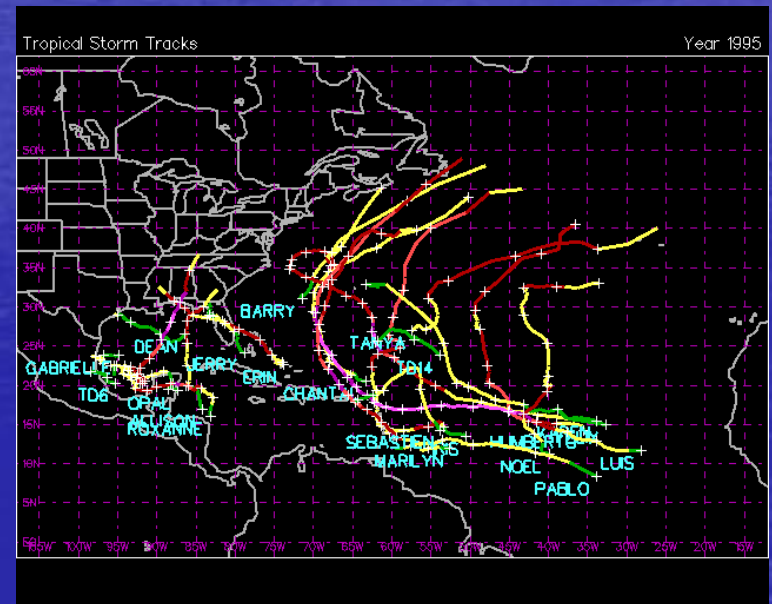
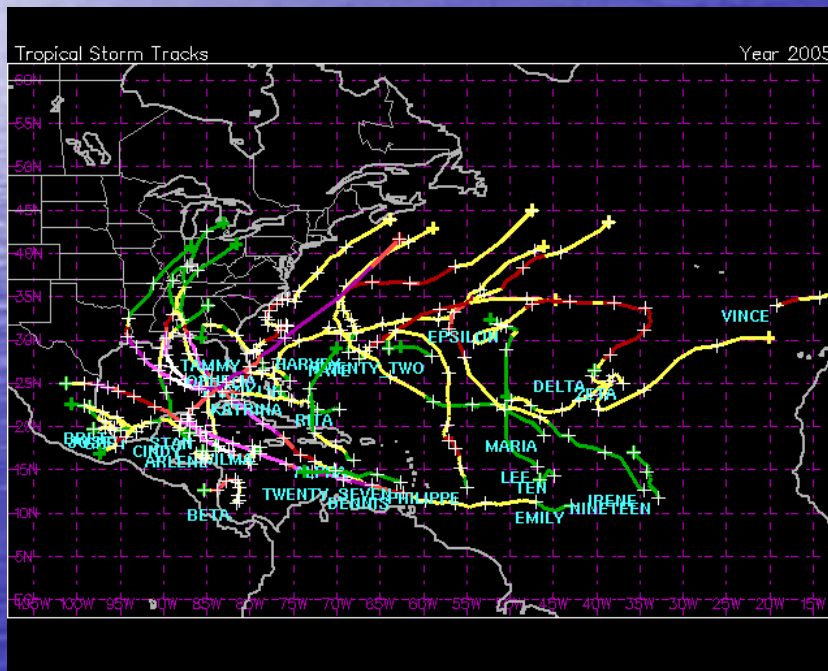
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- Historical perspective (Courtesy of Lupo and Johnston, 2000; Latham, Lupo, and Clark 2006)

Cat	1940-69	1970-89	1990-99	2000-2005	All
Cat 1,2	3.1	3.5	3.9	4.0	3.6
Cat 3-5	2.9	1.7	2.5	4.2	2.8
Cat 4-5	1.4	0.9	1.4	2.7	1.6
All	6.0	5.2	6.4	8.2	6.4

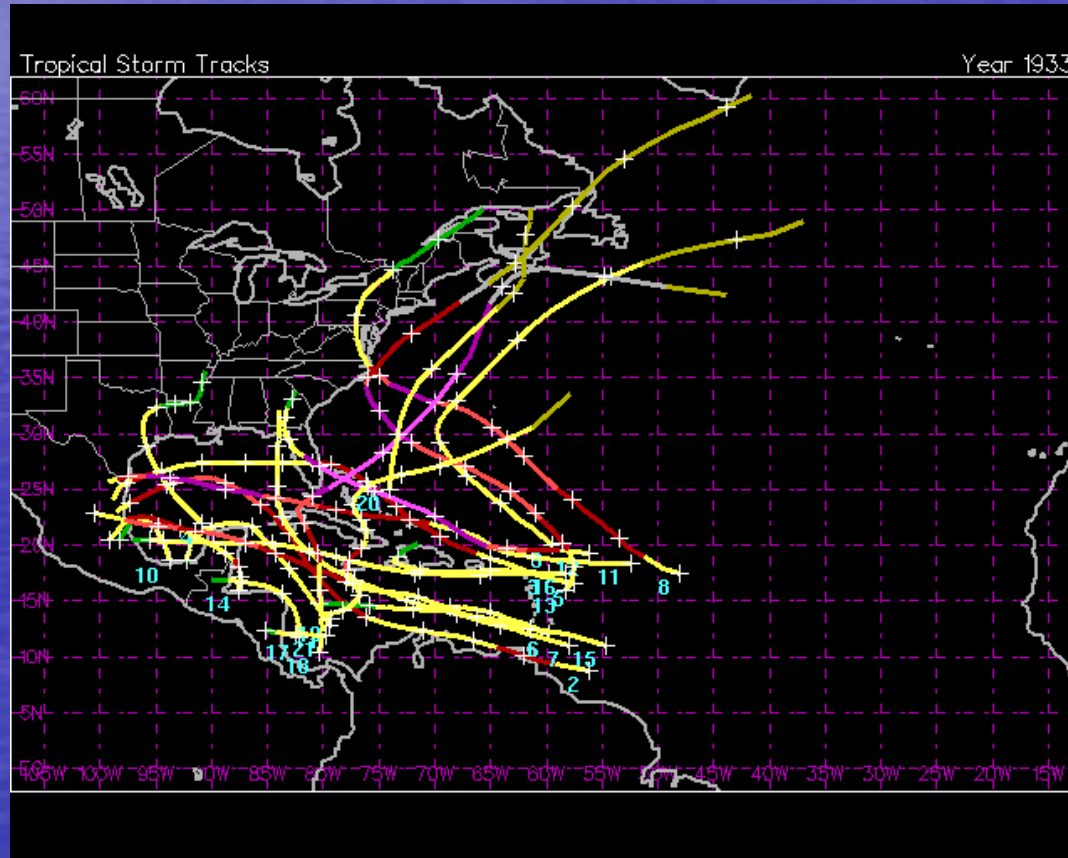
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- 2005 (27) versus 1995 (19)



# Climate, Climate Change & Hurricanes

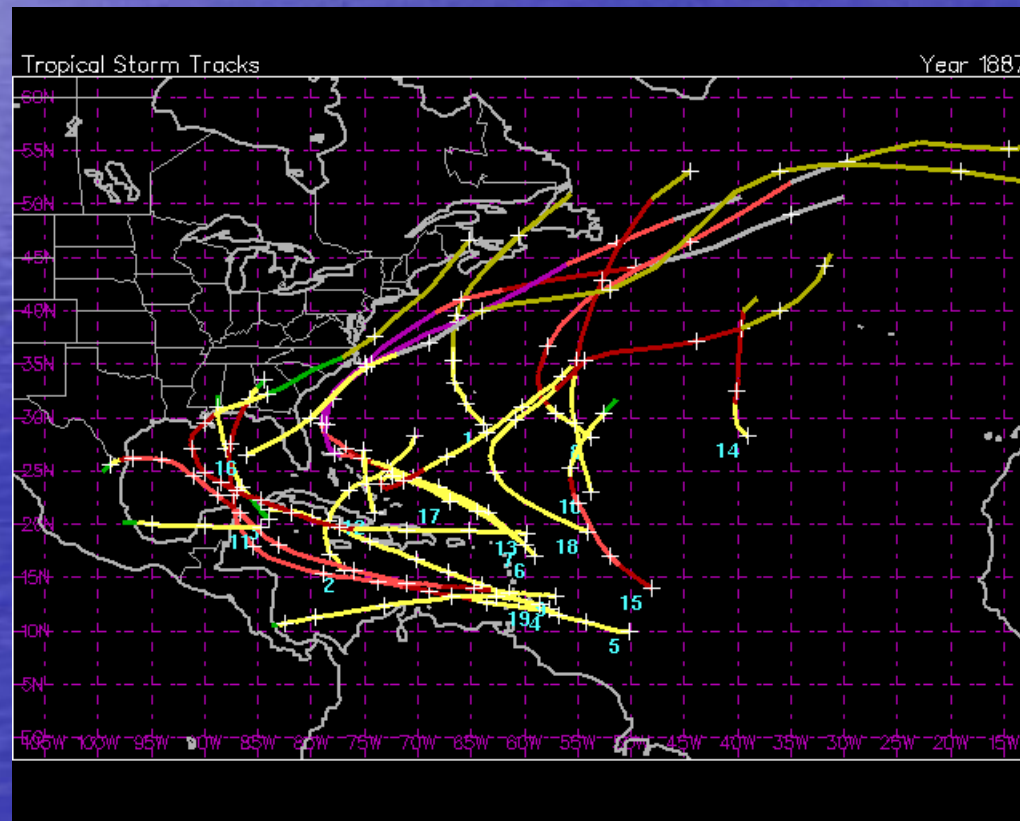
- 2005 versus 1933 (21)





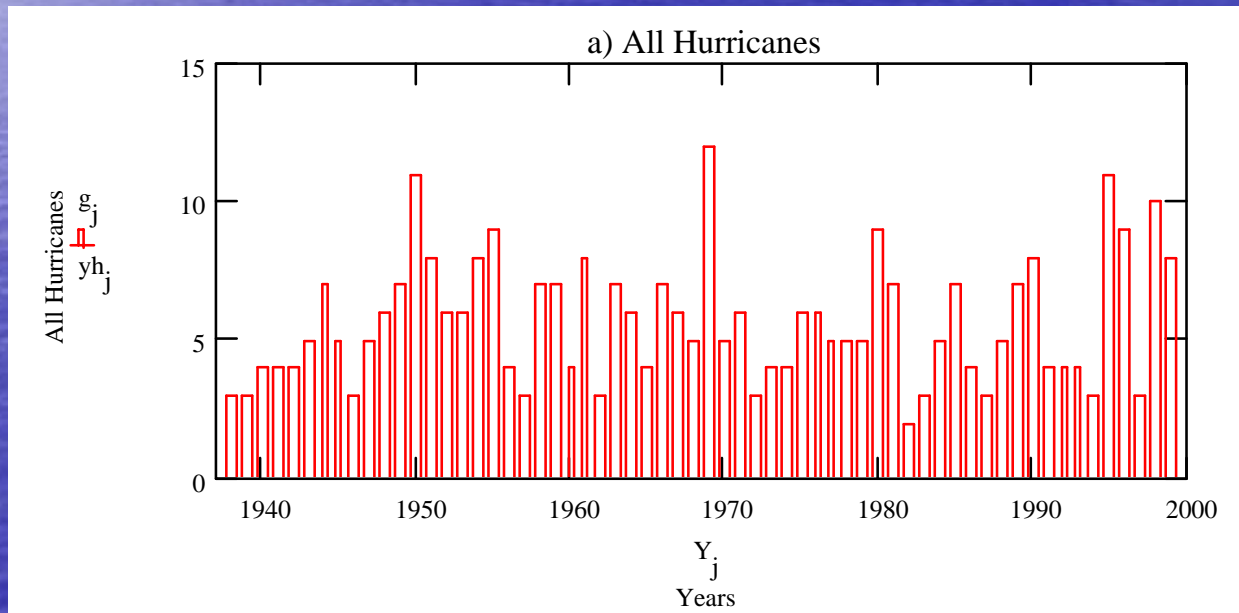
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- 2005 versus 1887 (19)



# Climate, Climate Change & Hurricanes

- Is global warming increasing the hurricane numbers?



# Climate, Climate Change & Hurricanes

- Hurricanes / Are warm waters alone enough (Zuki and Lupo, 2005)?

Year	Total Storms	ENSO	SST (°C)	Wind shear m/s	Div.	Vorticity
1987	0	El Nino	29	0.77	2.07	-6.58
2002	0	El Nino	28.8	-0.57	1.31	-9.14
1966	0	Neutral	28.4	-2.47	0.86	-7.66
1963	0	El Nino	28.4	0.20	0.68	-8.11
1986	0	El Nino	28.3	-0.70	2.48	-8.83
Avg	0		28.6	-0.55	1.48	-8.06



# Climate, Climate Change & Hurricanes

- Hurricanes / Are warm waters alone enough (Zuki and Lupo, 2005)?

Year	Total Storms	ENSO	SST (°C)	Wind shear m/s	Div.	Vorticity
1987	0	El Nino	27.9	0.37	2.03	-12.57
2002	0	Neutral	27.9	-0.33	0.90	-10.81
1966	0	Neutral	27.9	1.57	0.50	-15.09
1963	0	Neutral	27.5	1.73	1.76	-11.94
1986	0	Neutral	27.3	1.37	1.35	-10.99
Avg	0		27.7	0.94	1.31	-12.28



# Climate, Climate Change & Hurricanes

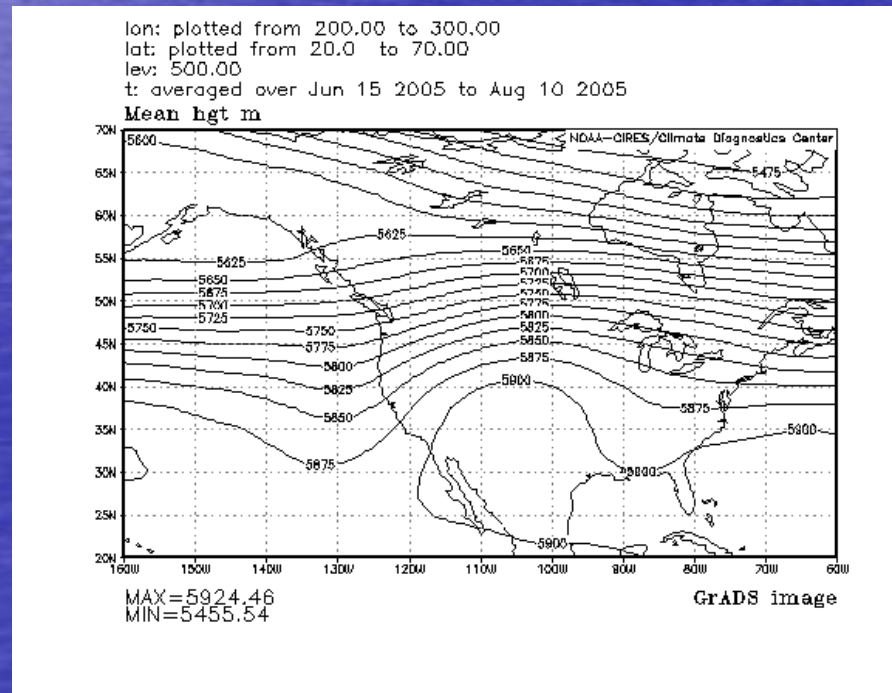
- Let's look at the drought of 2005 and discern the causes
- Spring season (March – May) Avg = 11.6 inches
- Actual rain = 7.3 inches, 63% of normal

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- Not particularly warm during the spring, the lack of precipitation still leaves the ground water supplies low! (dryness began in Dec. 2004)
- In early June, the rains stopped coming (less frequently – which is normal), the ground dried out, the temperatures rose, etc... (“drought begets drought”)

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- Classic Large-scale ridge over the central USA (map 15 June – 10 August average)



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- Summer 2005 - a year to confound those in the future!



- What me worry? (precip actually above normal)

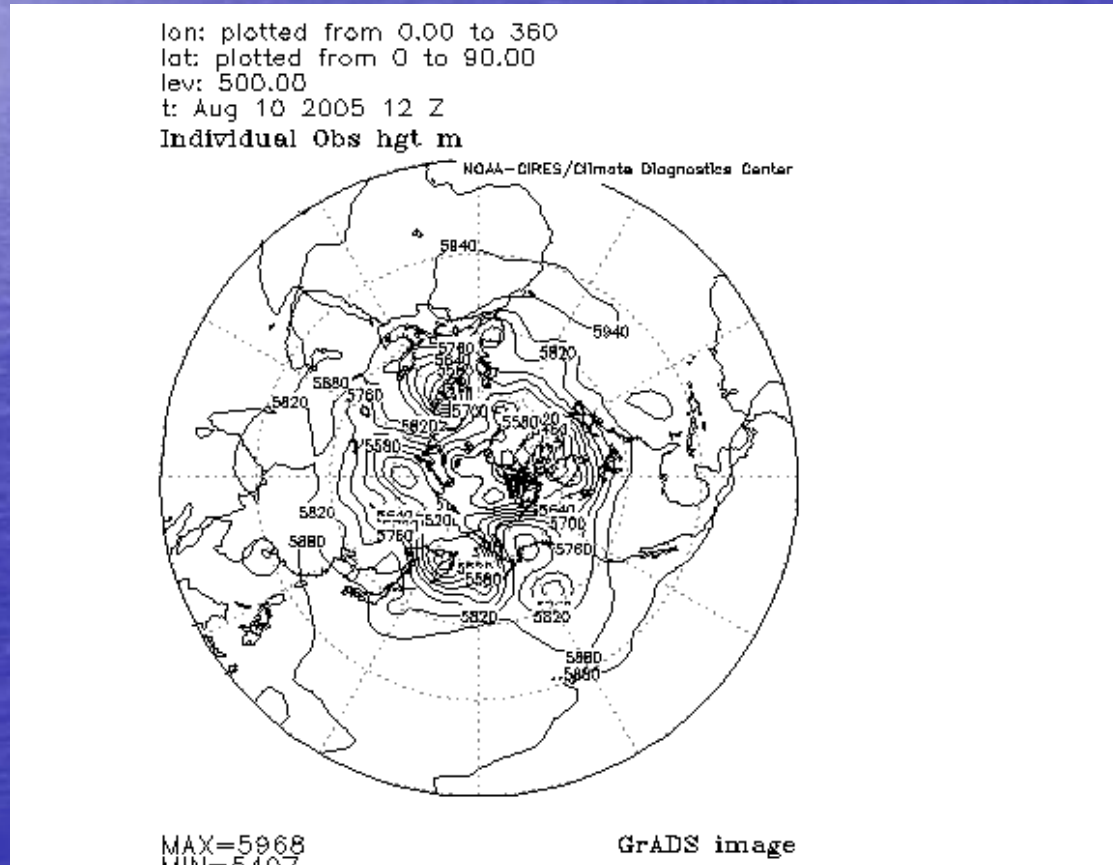


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- Summer precipitation at 15.3", normal is 11.7 inches. But 10" occurred during 14 days in August!
- A rare case of summer blocking!

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- Blocking, August 2005



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- Blocking usual in August, but in the Alaska region, forces cool air into North America.
- This event was unusual because blocking usually CAUSES drought, e.g., Europe 2003!
- Blocking is key to understanding seasonal weather, both observed and for prediction.

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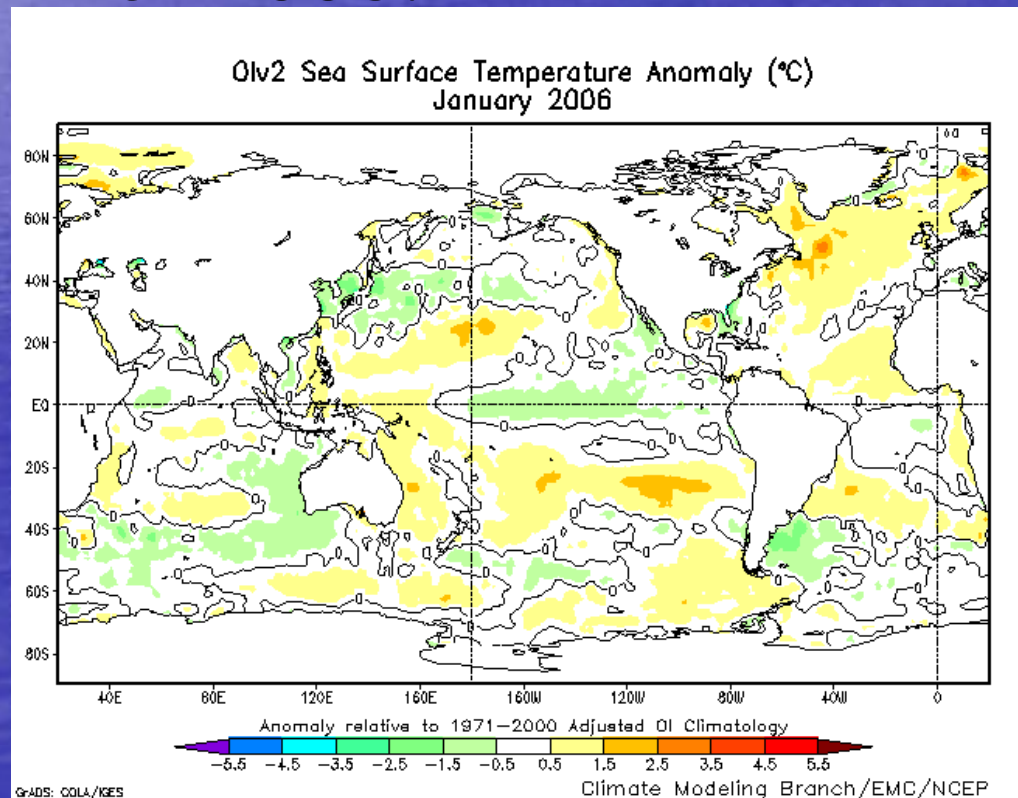
- Historical Perspective: The El Niño!  
(Everyone blames El Niño!)
- Prolonged periods of La Niña conditions lead to drier summers in Missouri.  
Examples: 1954 – 1956, 1999 – 2000.

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- Evidence of La Niña conditions could be found as far back as April 2005, and evolved toward La Niña (officially into La Niña in Dec 2005 – Jan 2006).
- La Niña typically leads to ridging over the continent during summer.

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- This could spell big trouble for Missouri in the Summer 2006!

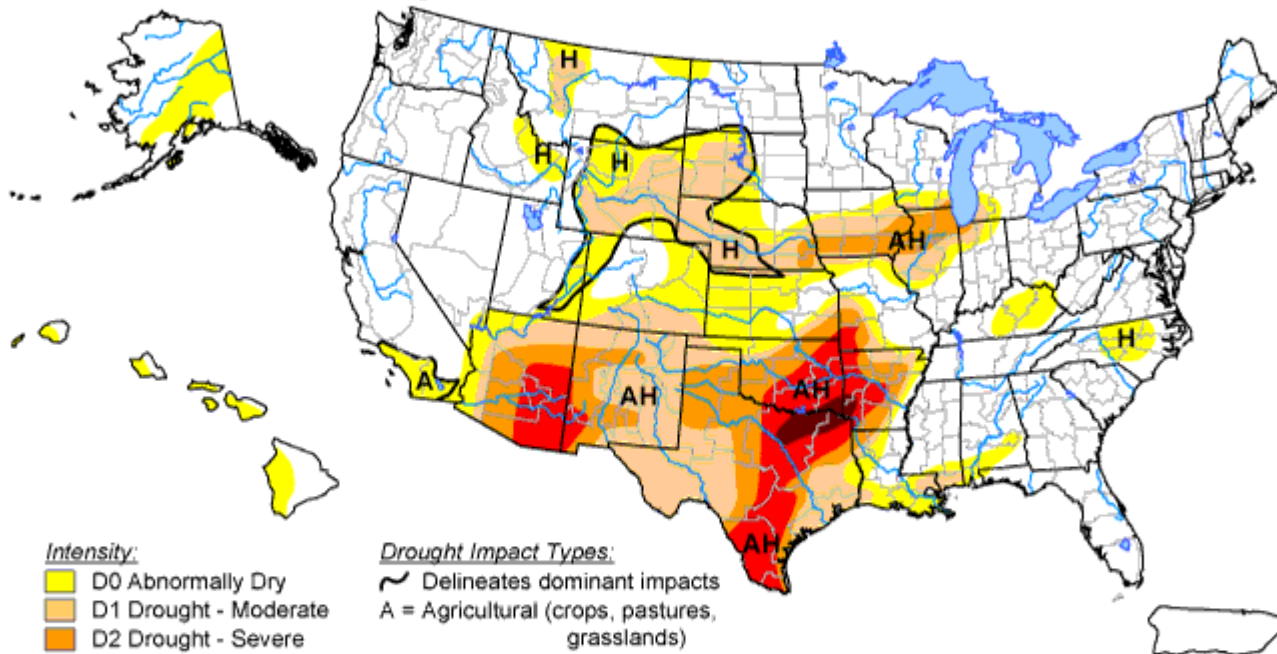


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## U.S. Drought Monitor

February 7, 2006  
Valid 7 a.m. EST



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

Drought Impact Types:

- Delineates dominant impacts
- A = Agricultural (crops, pastures, grasslands)
- H = Hydrological (water)

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

<http://drought.unl.edu/dm>



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- Questions?
- Comments?
- Criticisms?
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