

Global Climate Change

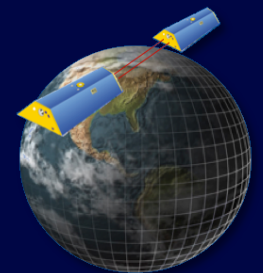
Jianli Chen

(陈剑利)

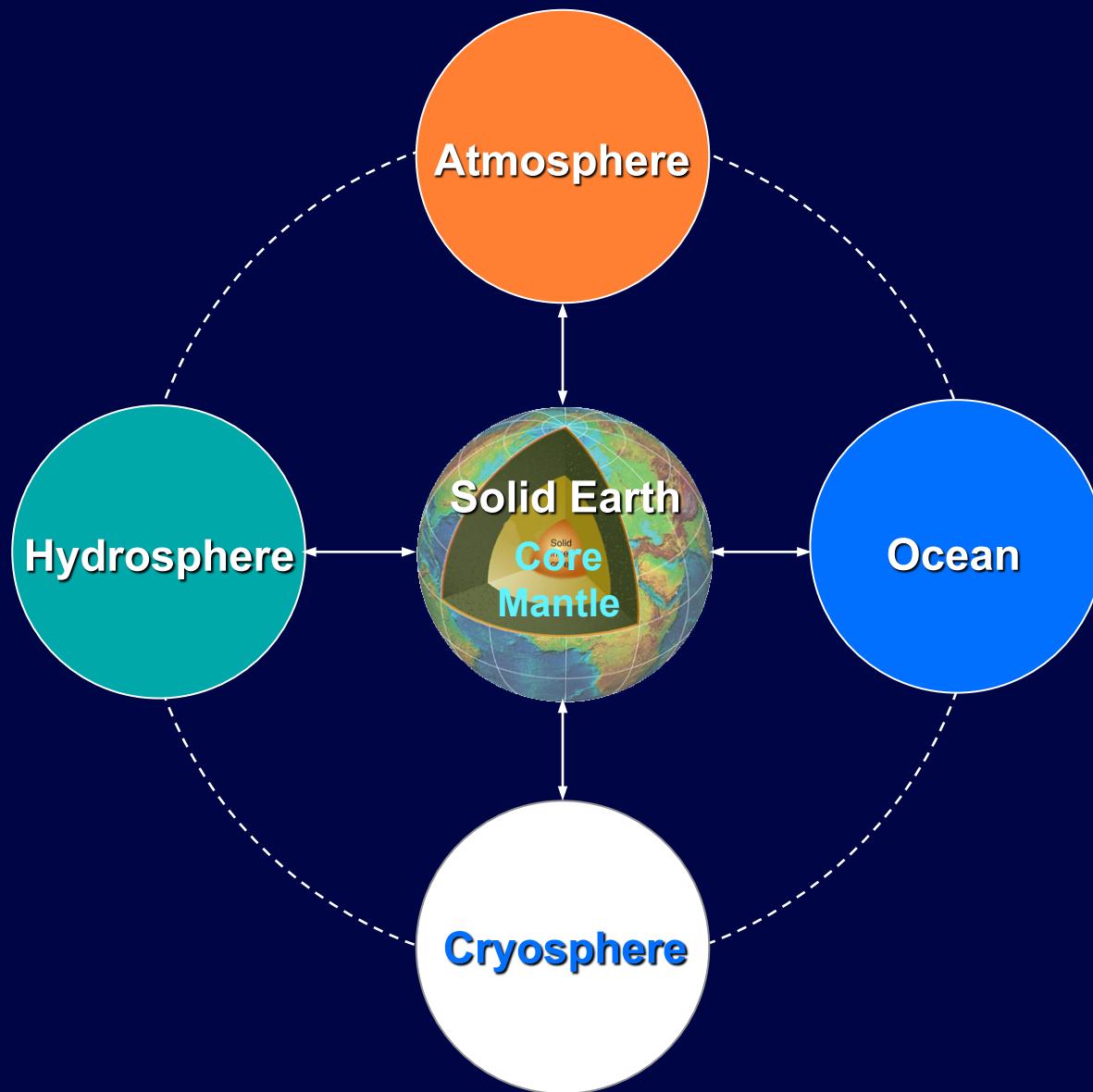
Ph.D., Senior Research Scientist

Center for Space Research, University of Texas at Austin

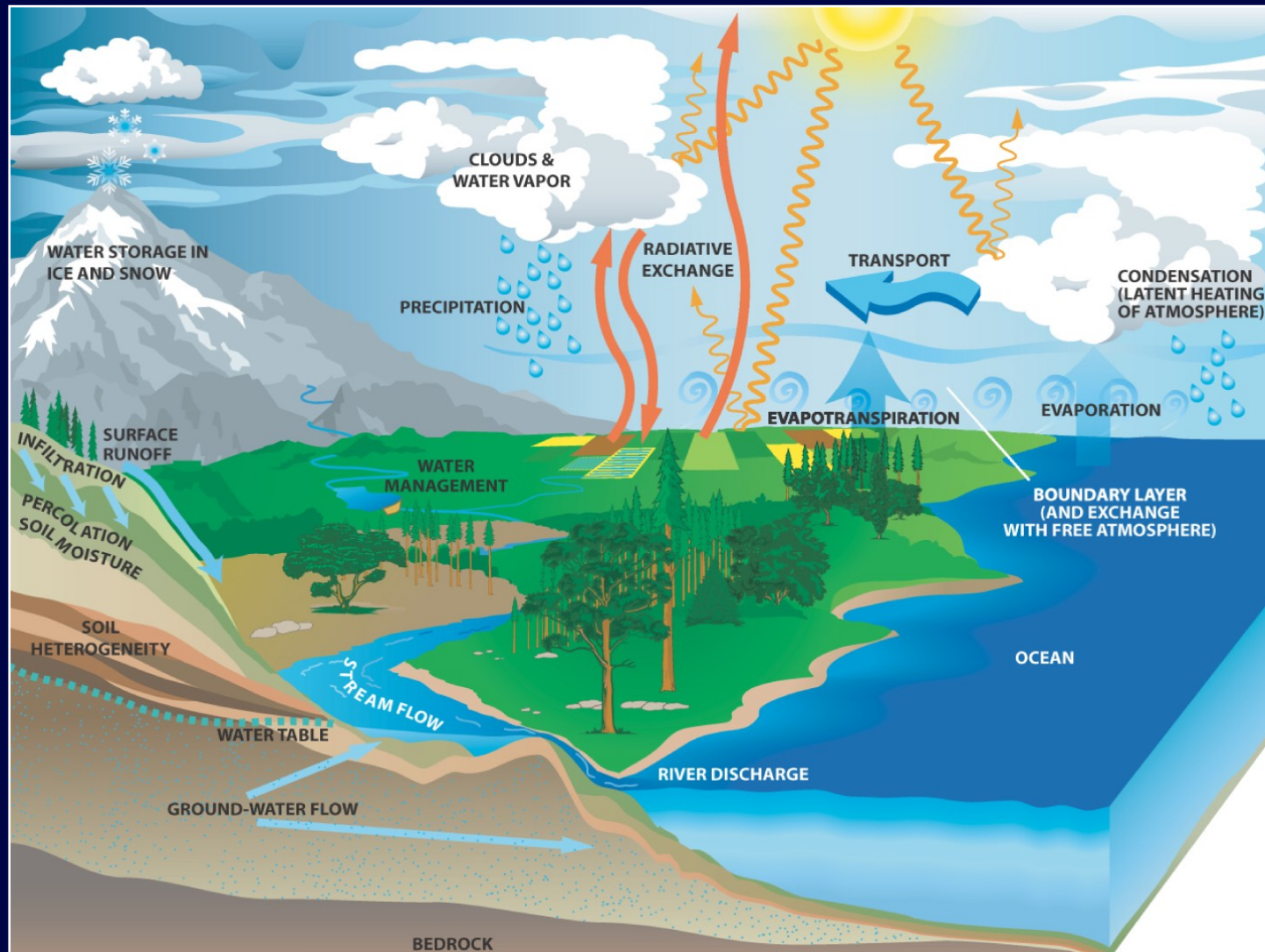
2014 SEOGC Summer School 07/14-07/19, Shanghai



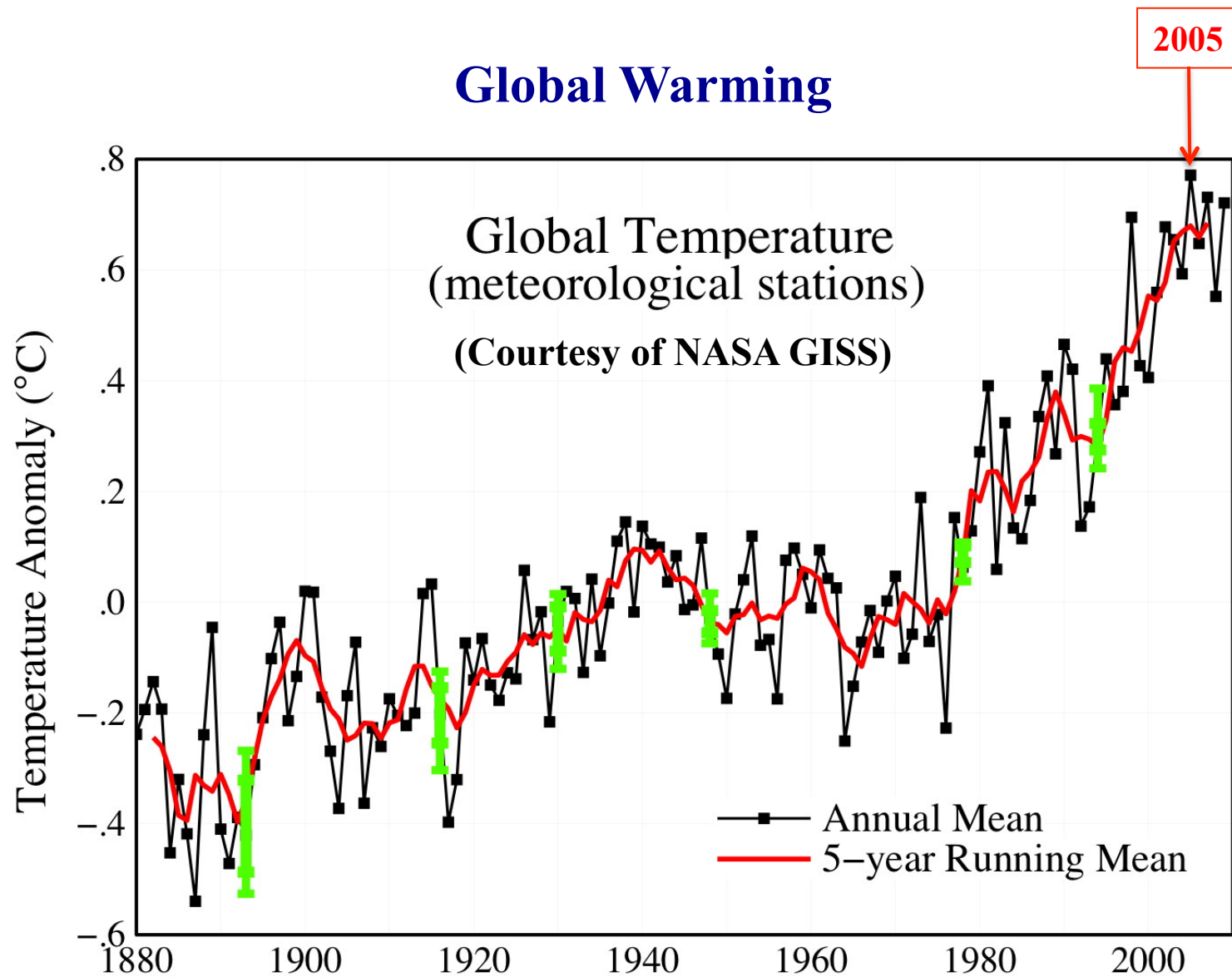
The Earth System



Climate System and Global Water Cycle



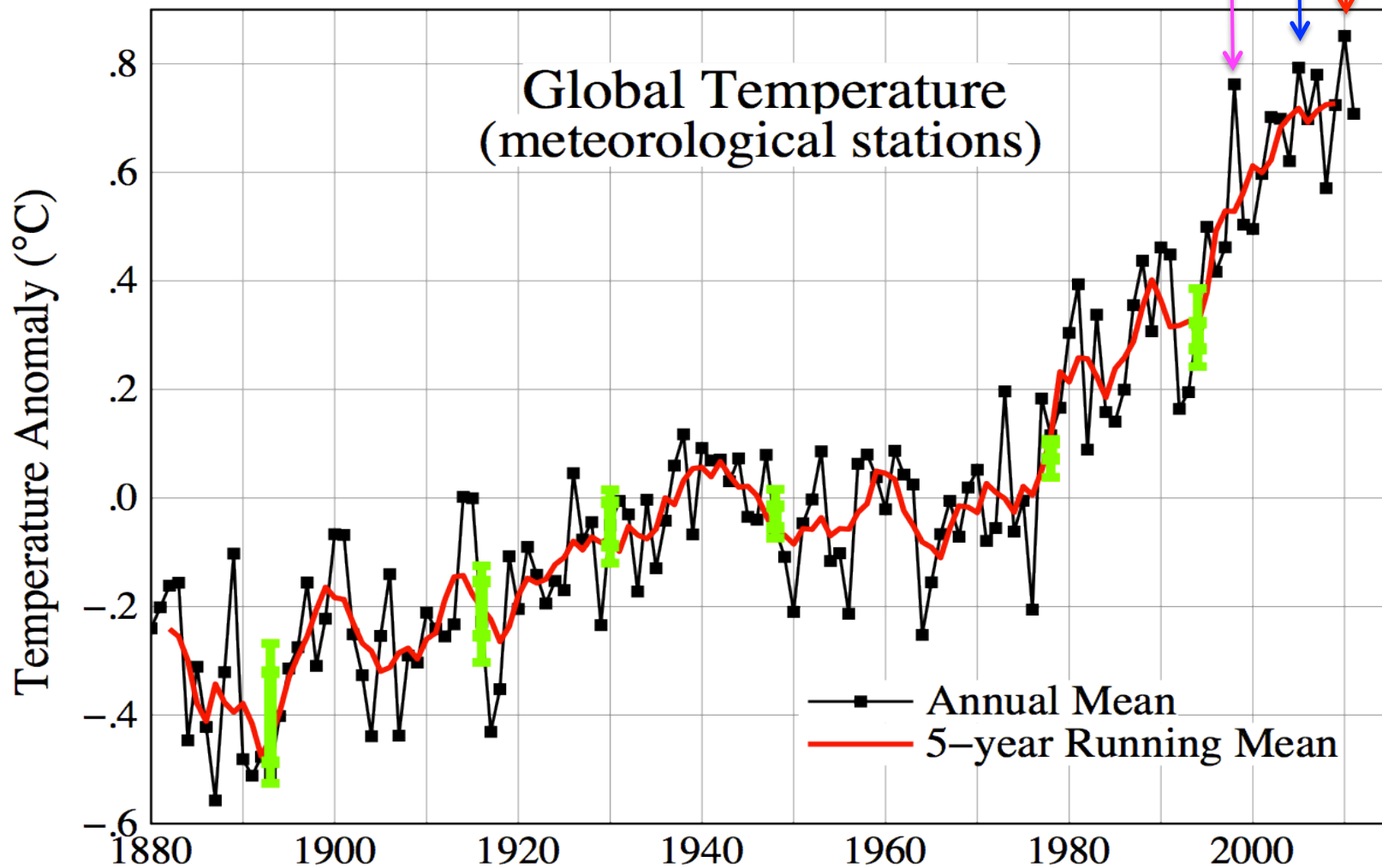
Global Warming



2005 was recorded as the warmest year in history.

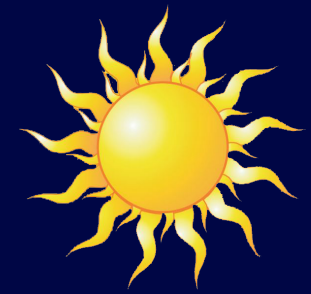
(slide used in 2010)

Global Warming



2010 was recorded as the warmest year in history.
(2005 as the 2nd warmest year in history)

(Courtesy of NASA GISS)



Many places in the world broke various records again last summer.

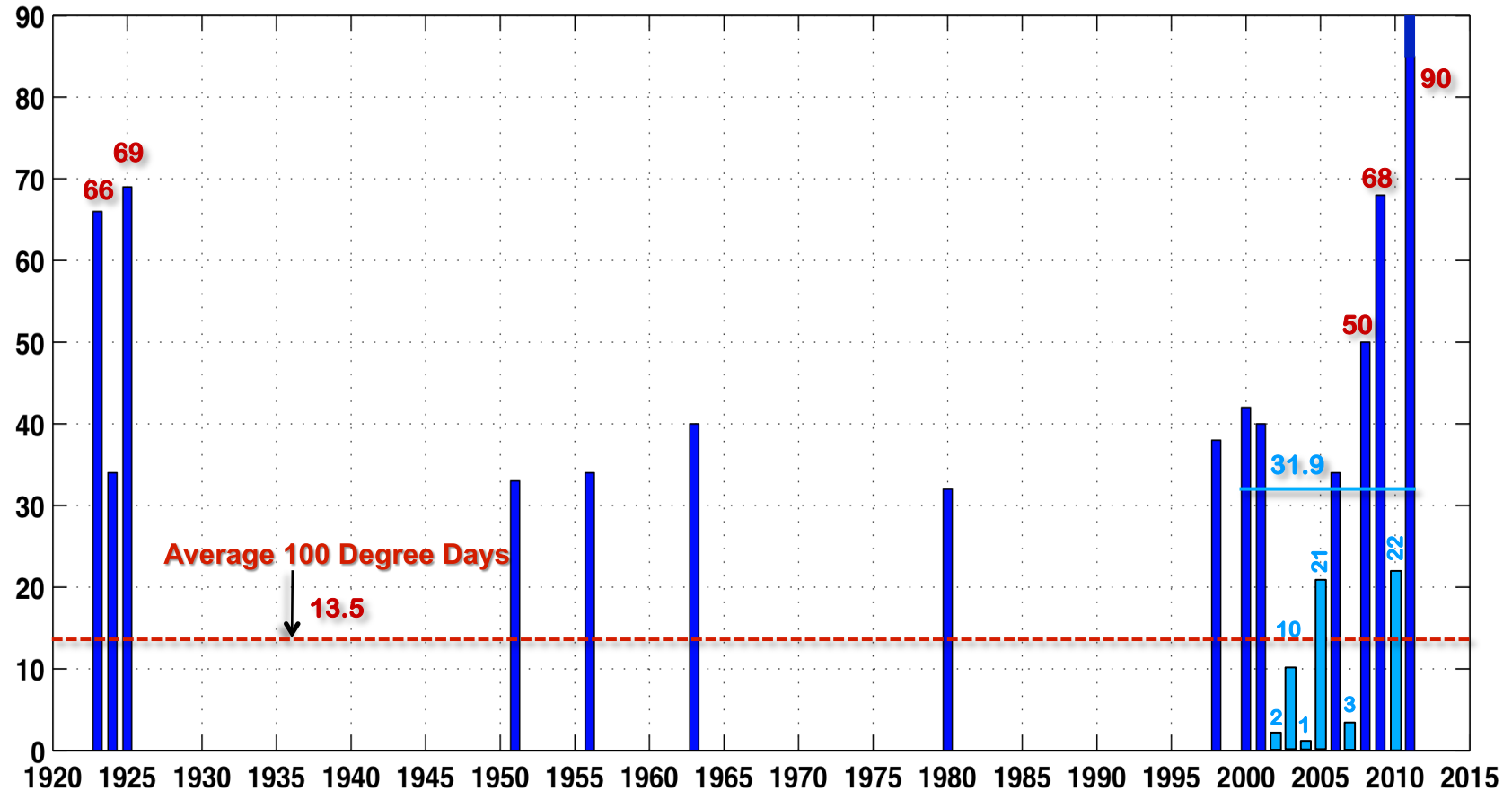
- ❖ **The month of June was the hottest recorded for Texas since 1895, according to the US National Weather Service. (CNN)**
- ❖ **Heatwave brought warmest UK April for more than 100 years. (BBC)**
- ❖ **UK Set for Record Breaking Summer - we had the hottest May in 350 years, so it looks like there is more of this hot weather to come. (wordpress.com)**
- ❖ **Spring drought brought Yangtze driest season since 1961. (CCTV)**
- ❖ **Florida experienced the driest season ever on record. (WPTV)**
- ❖ **Texas driest season ever on record**

2011 – HOT!



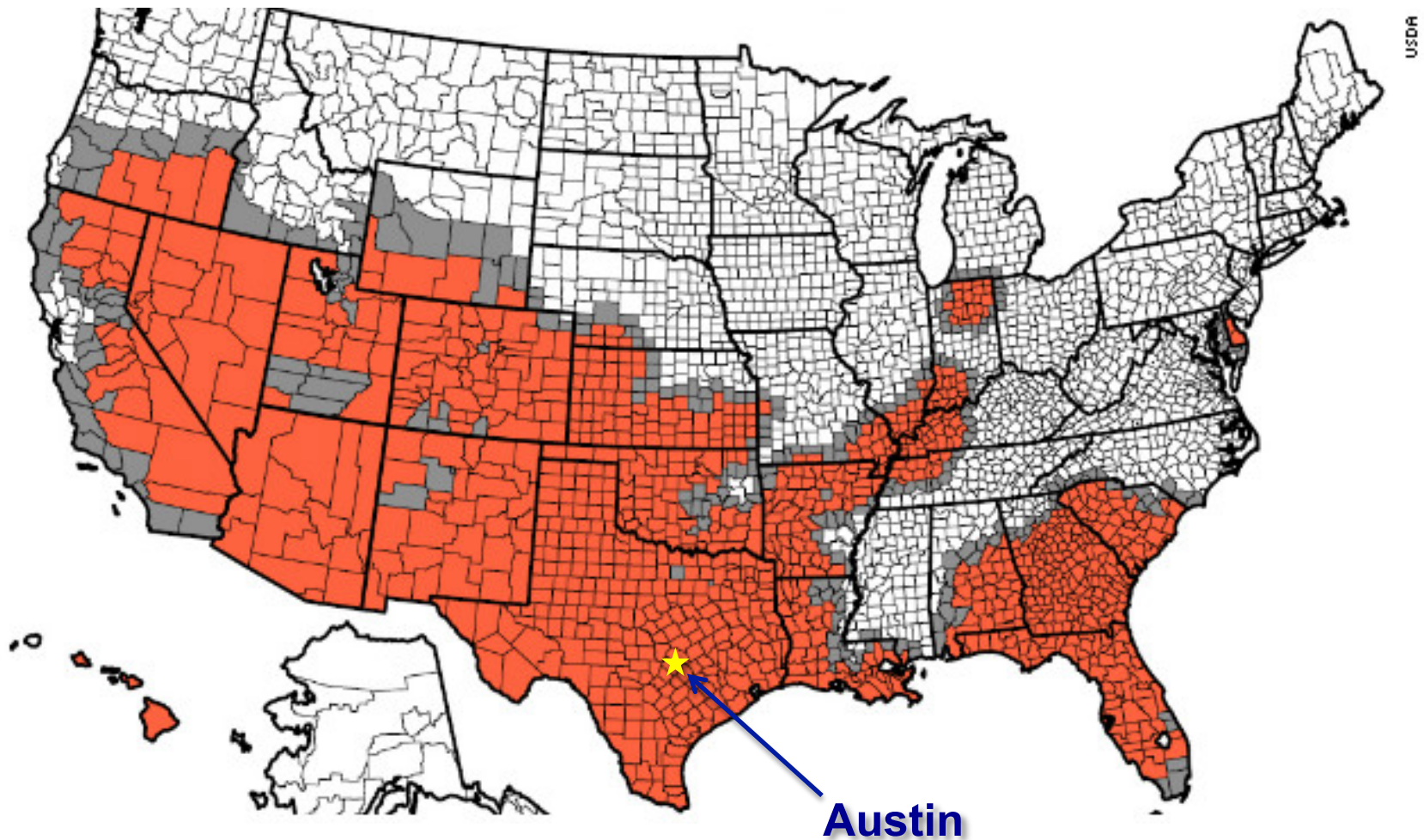
Well. How do I know global warming is real ?!

AUSTIN (CAMP MABRY) TOP 14 MOST 100 DEGREE DAYS IN A YEAR 1898 TO 2011



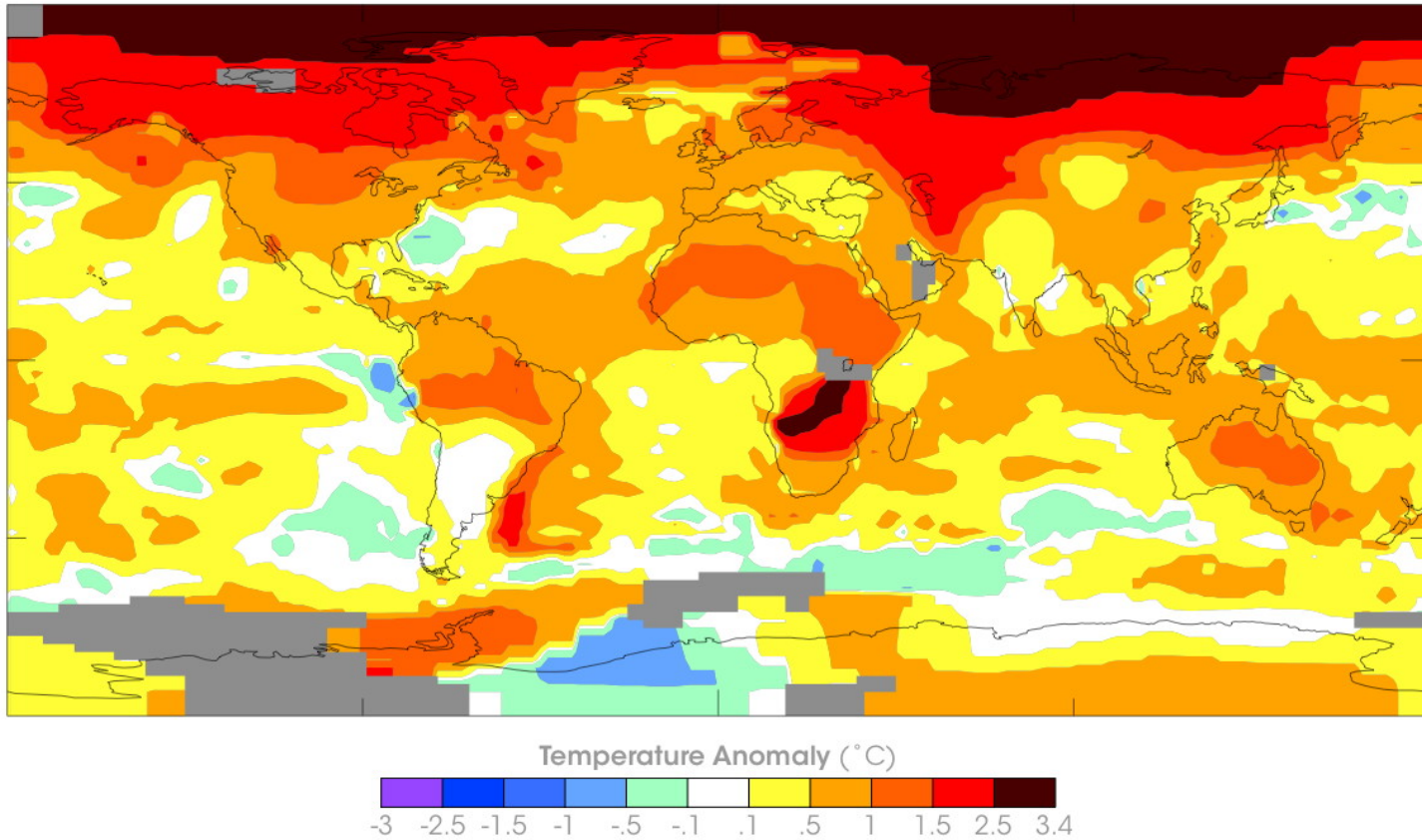
(up to 09/29/2011)

Drought now a disaster in 1,000 U.S. counties. A severe drought is causing some of the worst conditions in decades in parts of the nation (CNN Report, Fri July 13, 2012).



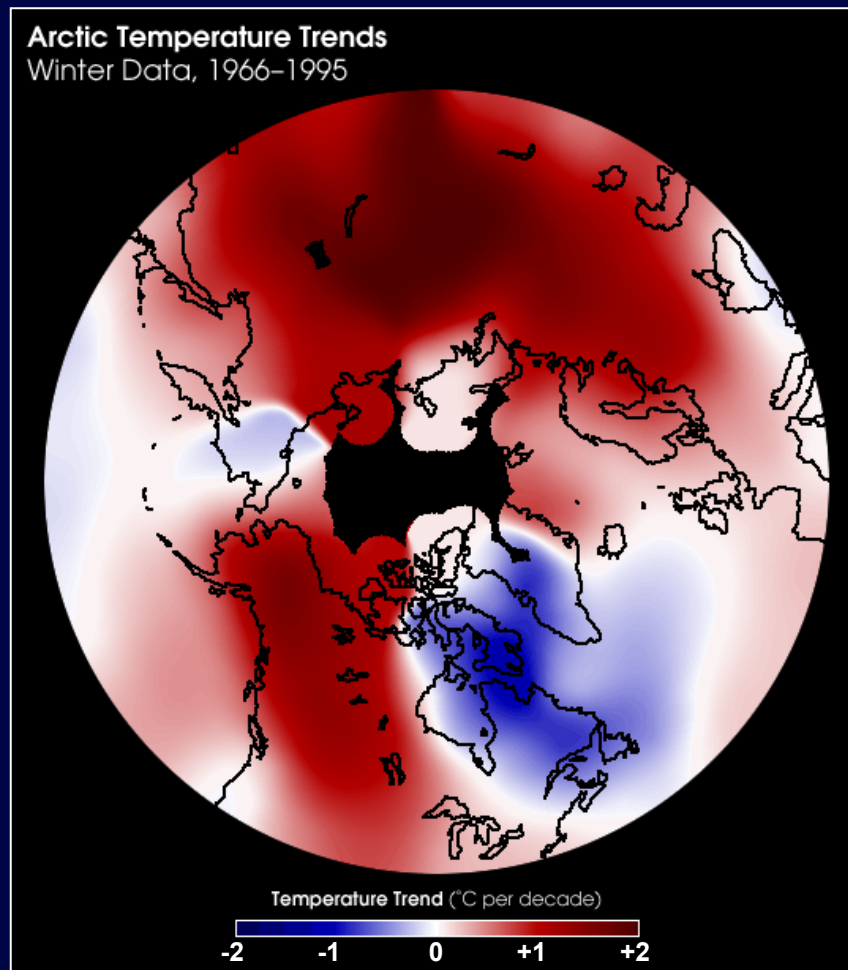
Global Temperature Anomalies in 2005

(Featured by the Arctic Warming)



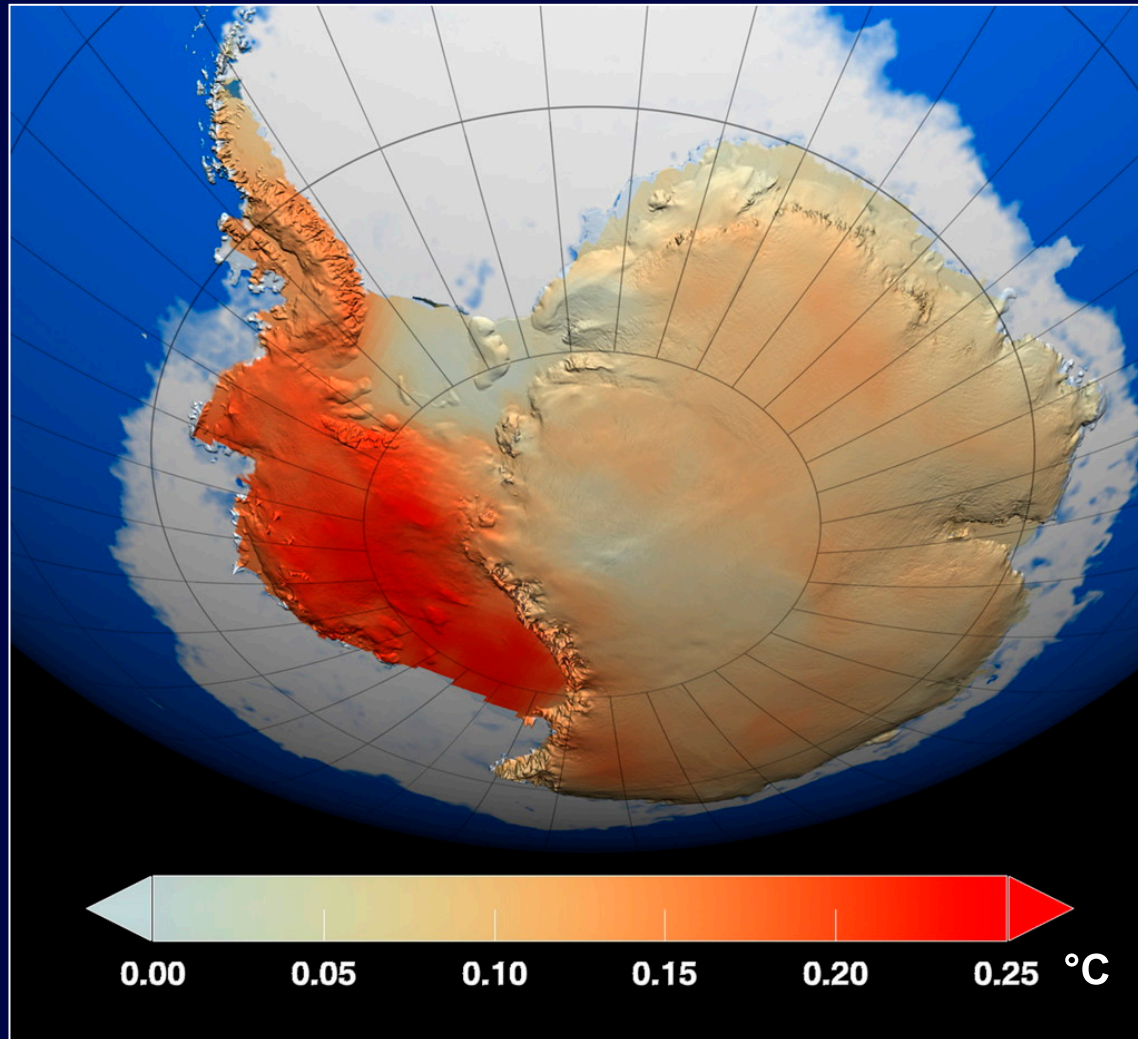
Year 2005 was **2nd** warmest on record.

Global Warming



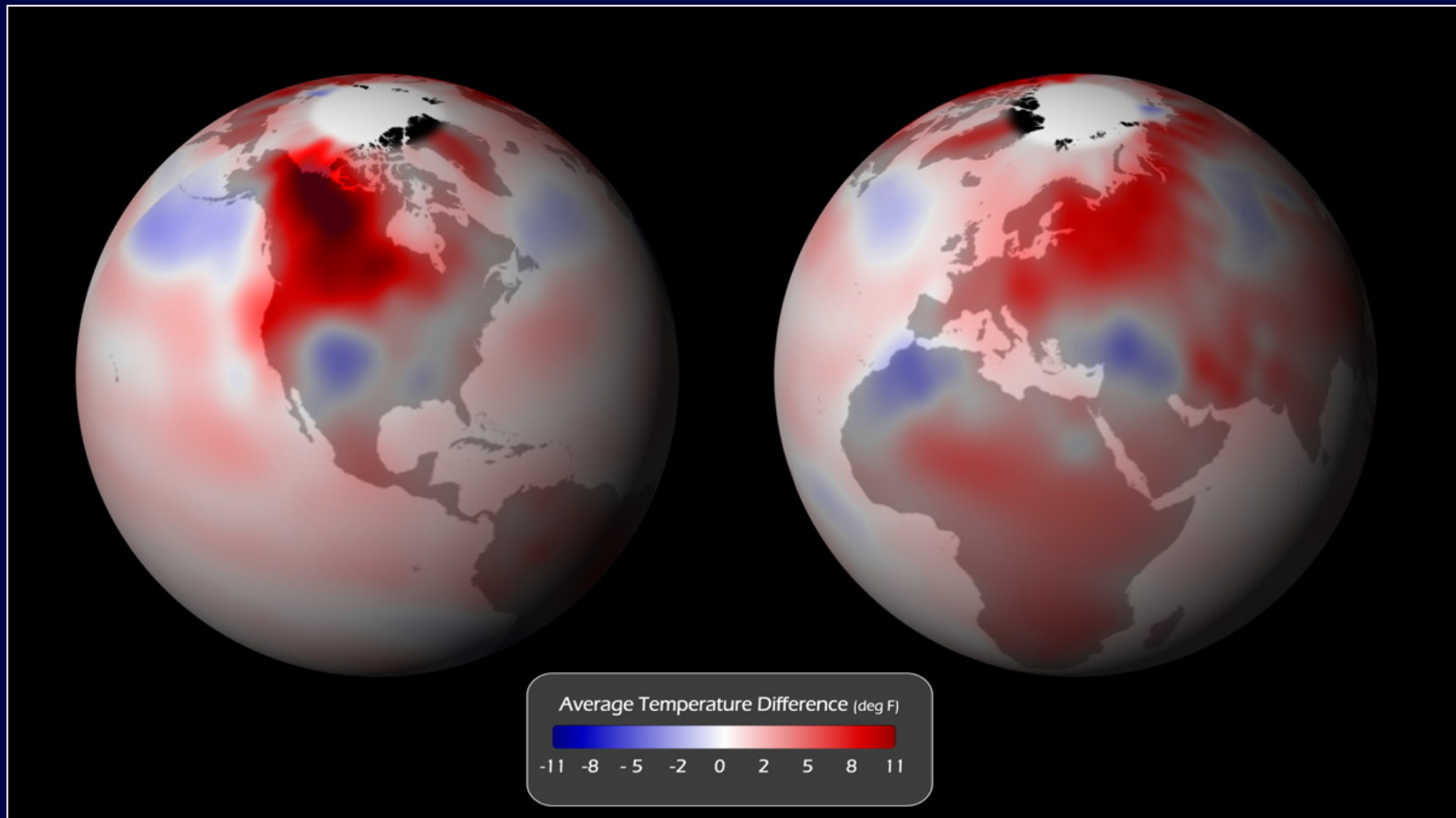
**Arctic Winter Temperature Trends
(1966-1995, °C per decade)**

Global Warming



Antarctic temperature change per decade over the past 50 years.

Global Temperature Anomalies in September, 2009 (second warmest on record, behind 2005)



2005 Melt
Extent

Ice Sheets and Glaciers Melting

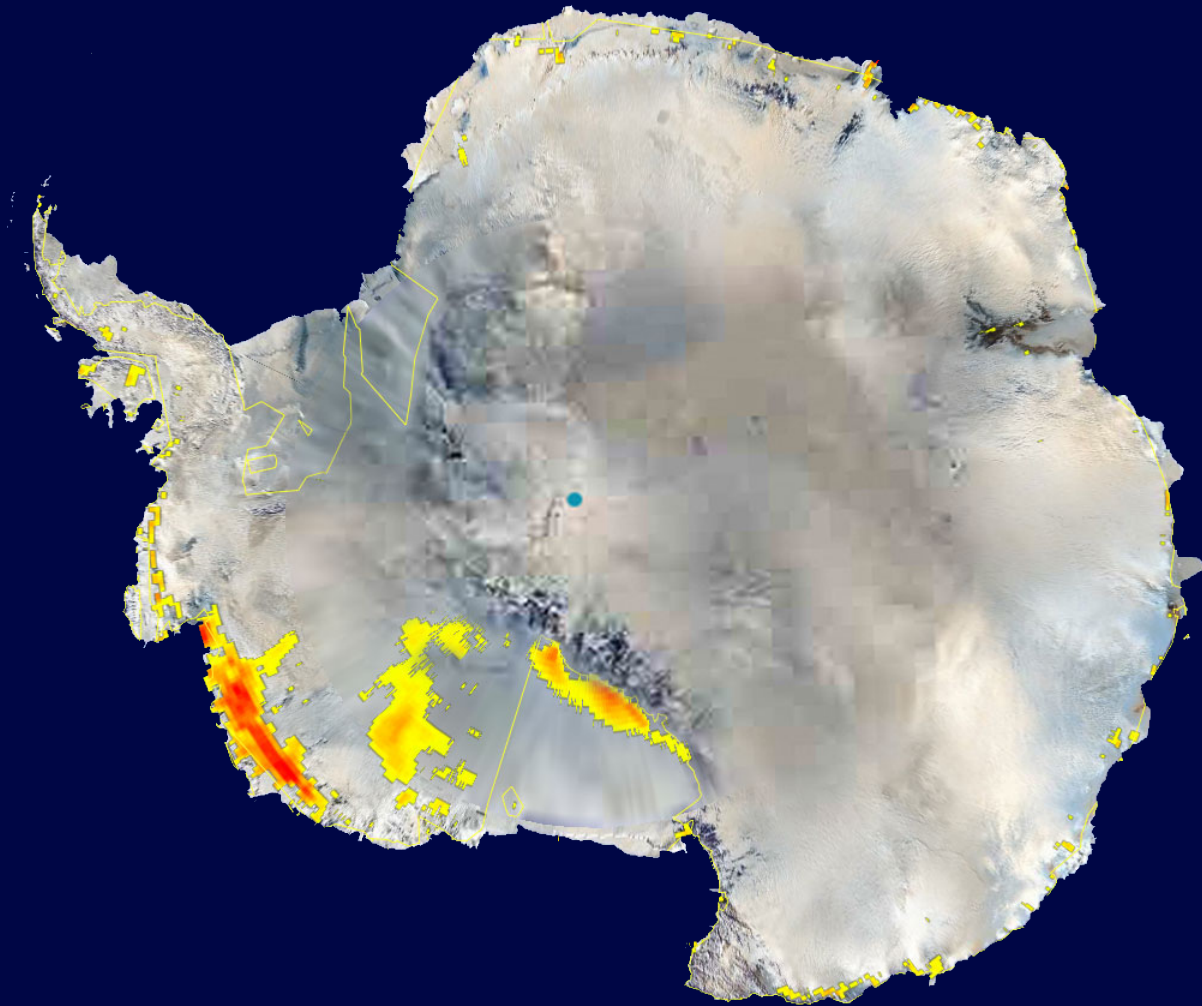
- Melted in 2005
- 1st Recorded Melt
- 2,000m Elevation

University of Colorado CIRES

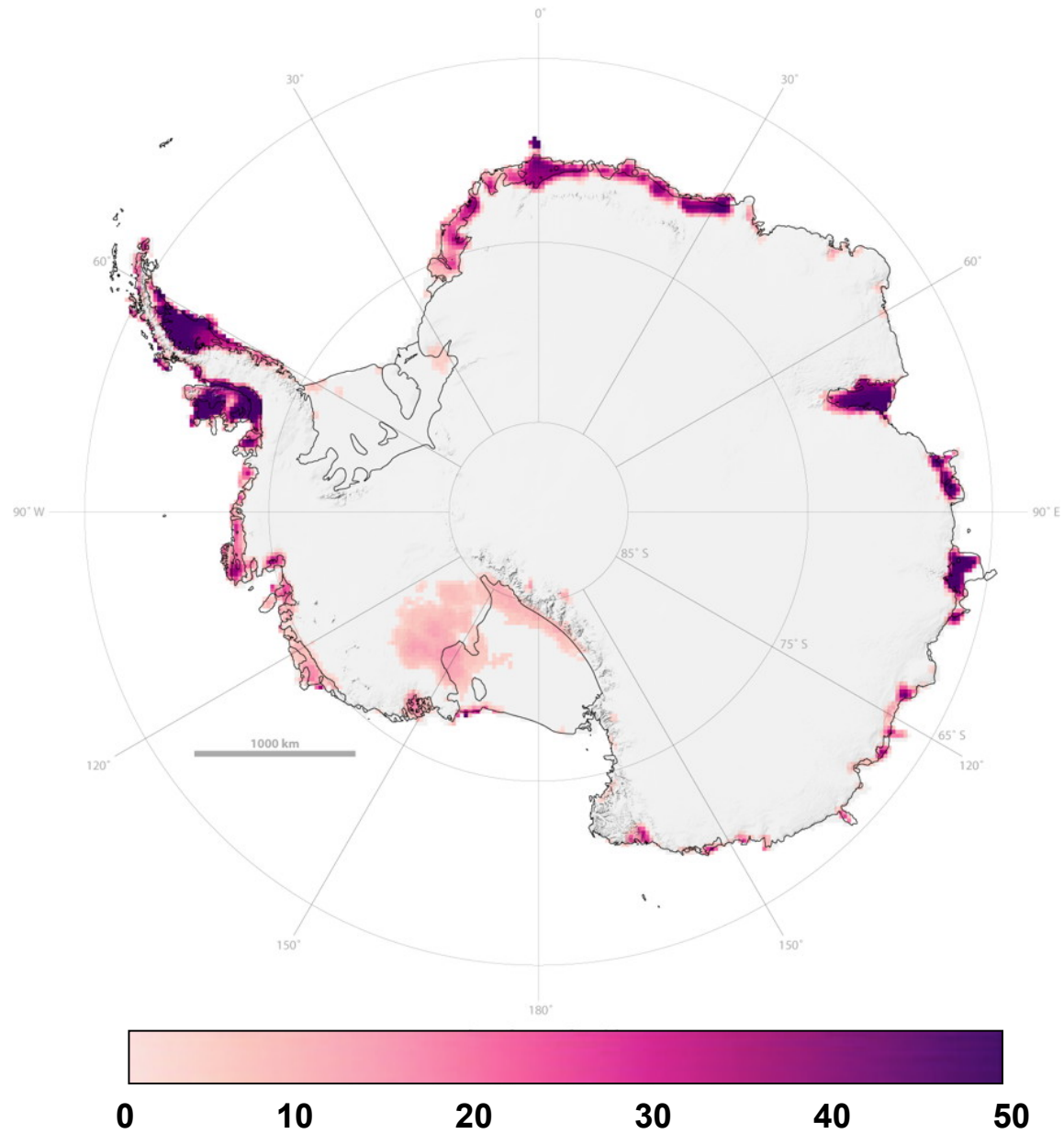
Courtesy Russell Huff and Konrad Steffen



Antarctic Ice Sheet Melting



Antarctic Melting Days in 2005



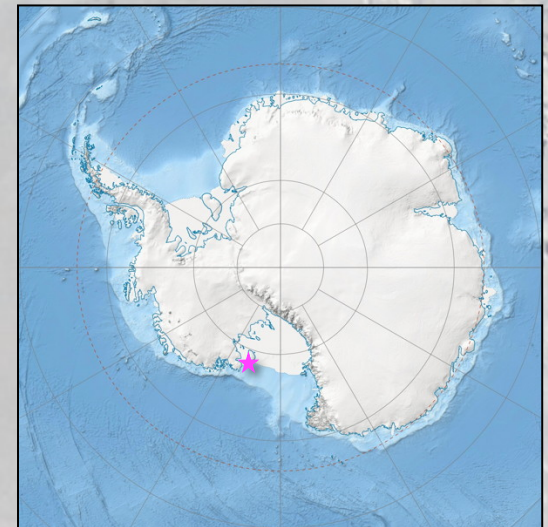
Ice Sheets and Glaciers Melting

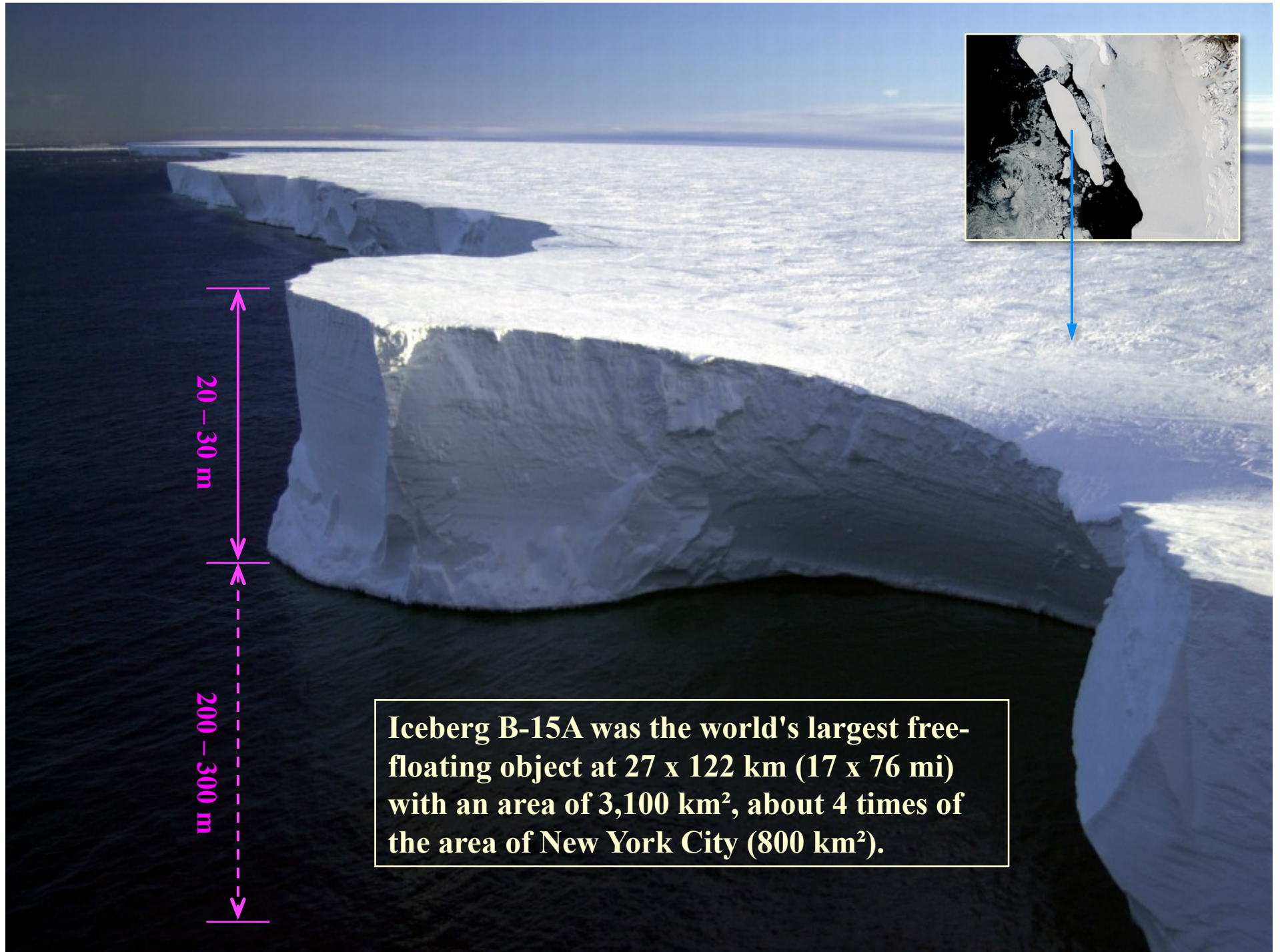


Ice Calving (Breaking Up)

Originally calved from the Ross Ice Shelf near Roosevelt Island in March 2000, Iceberg B-15A was the world's largest free-floating object at 27 x 122 km (17 x 76 mi) with an area of 3,100 km².

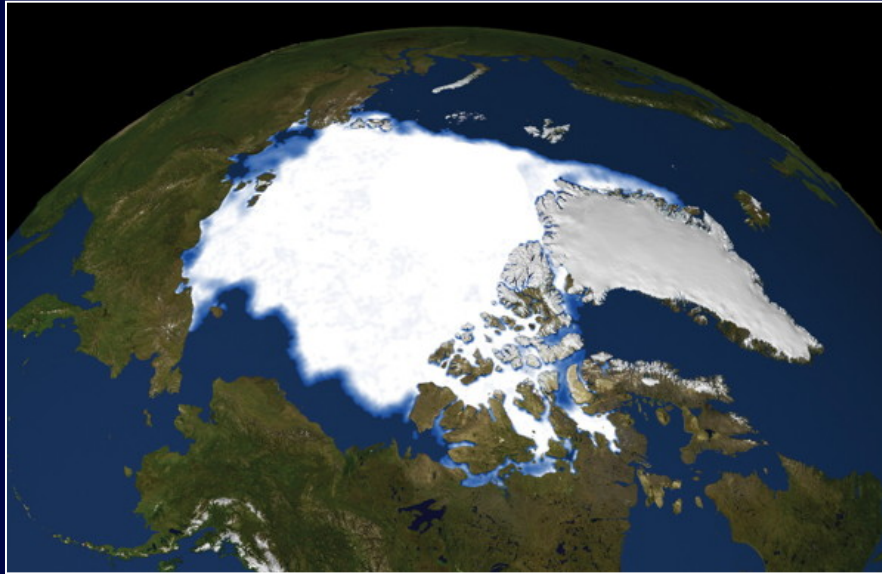
122 km



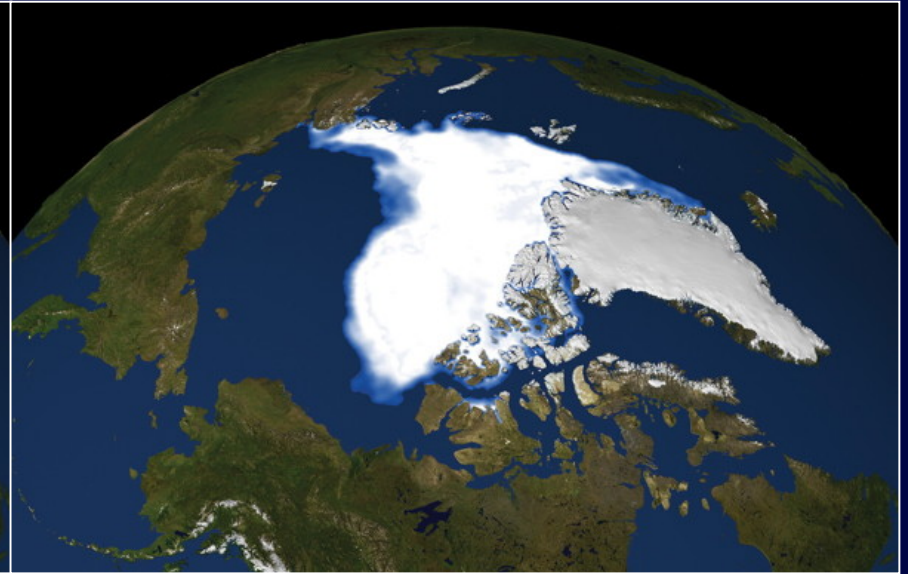


Iceberg B-15A was the world's largest free-floating object at 27 x 122 km (17 x 76 mi) with an area of 3,100 km², about 4 times of the area of New York City (800 km²).

Decreased Arctic Sea Ice Coverage

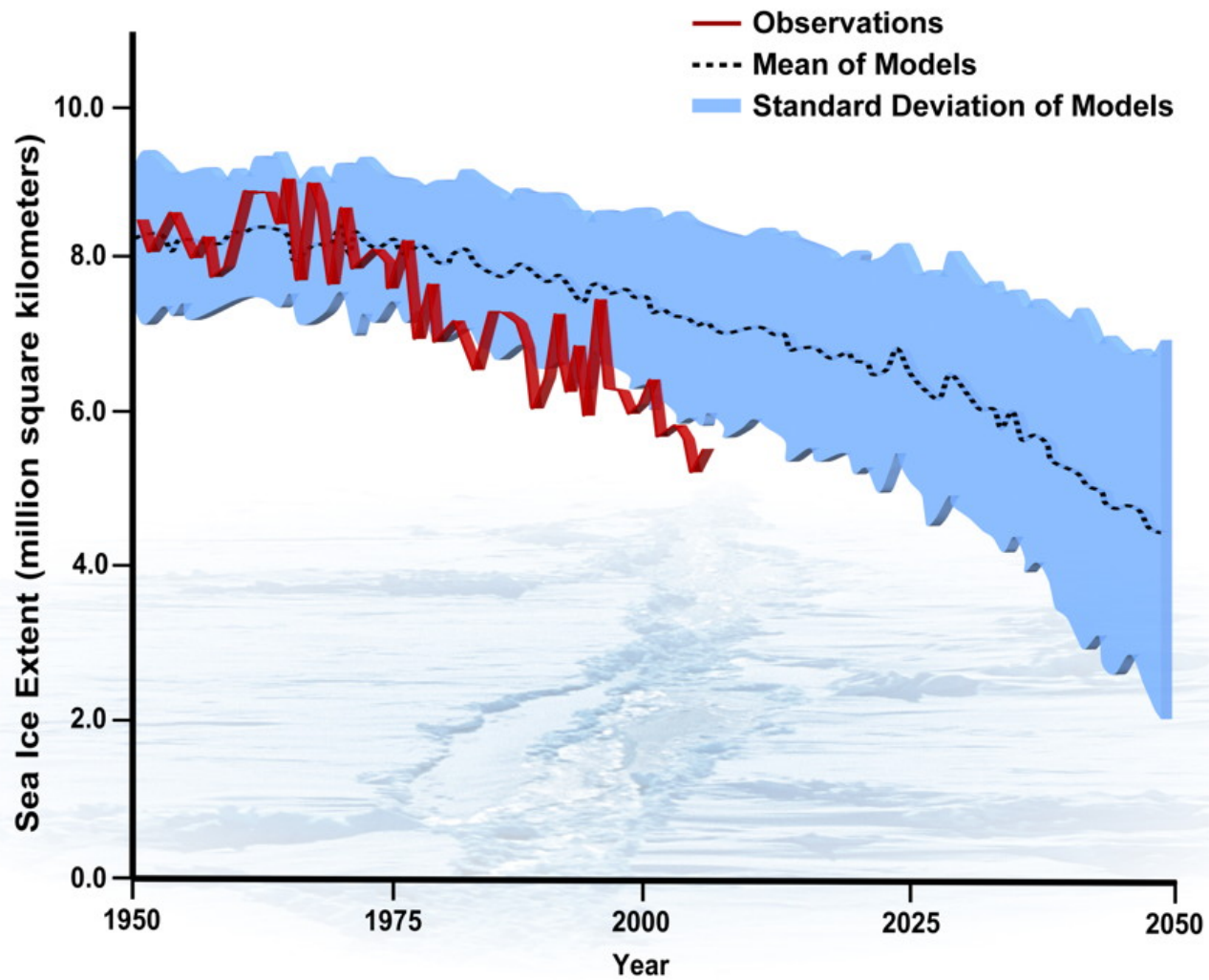


September 1979



September 2007

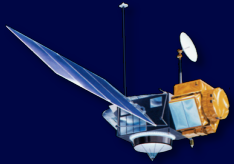
Arctic September Sea Ice Extent: Observations and Model Runs



Sea Level Rise

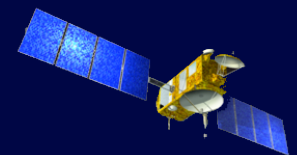
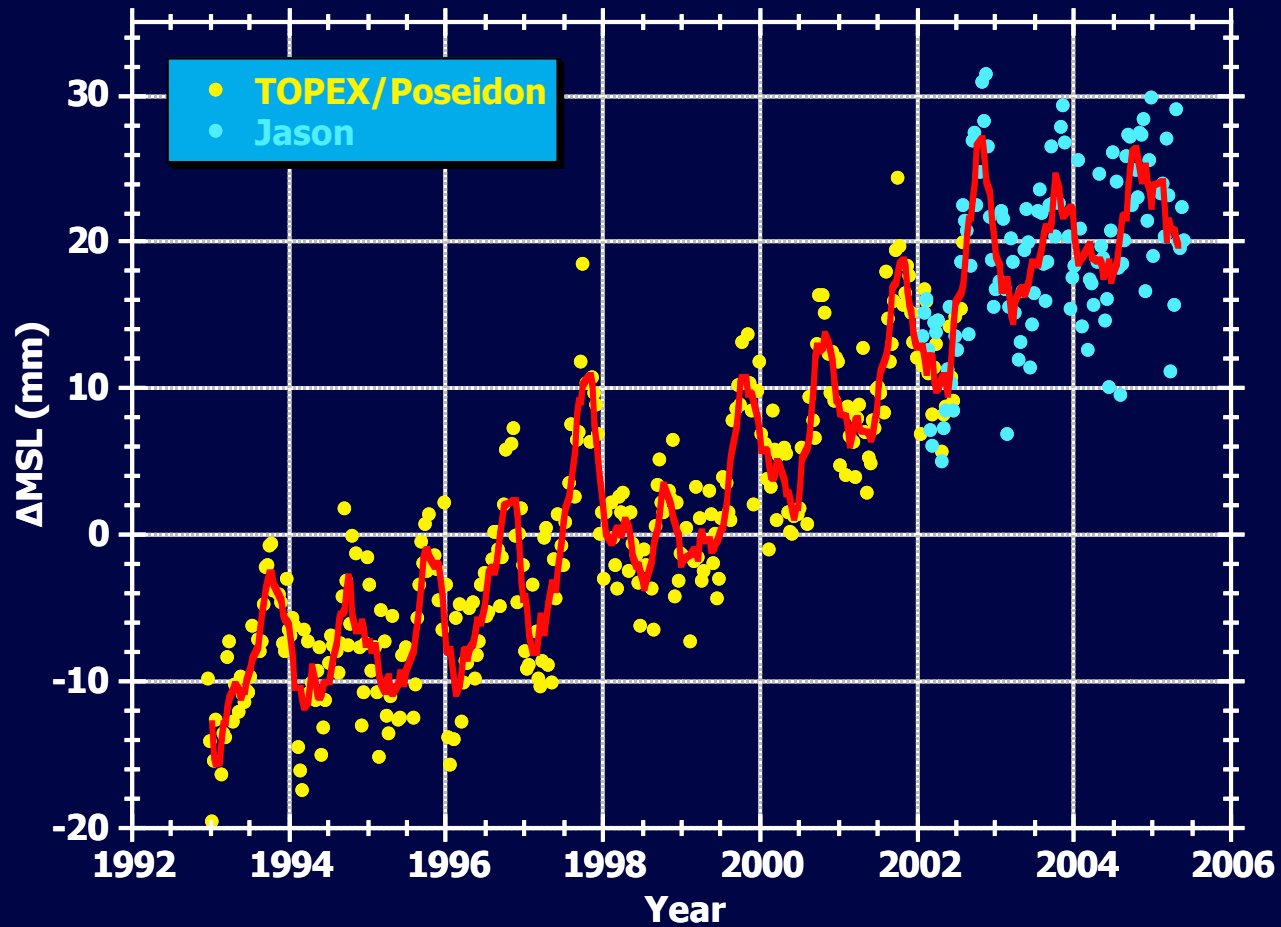
Manhattan Skyline





Global Mean Sea Level Rise

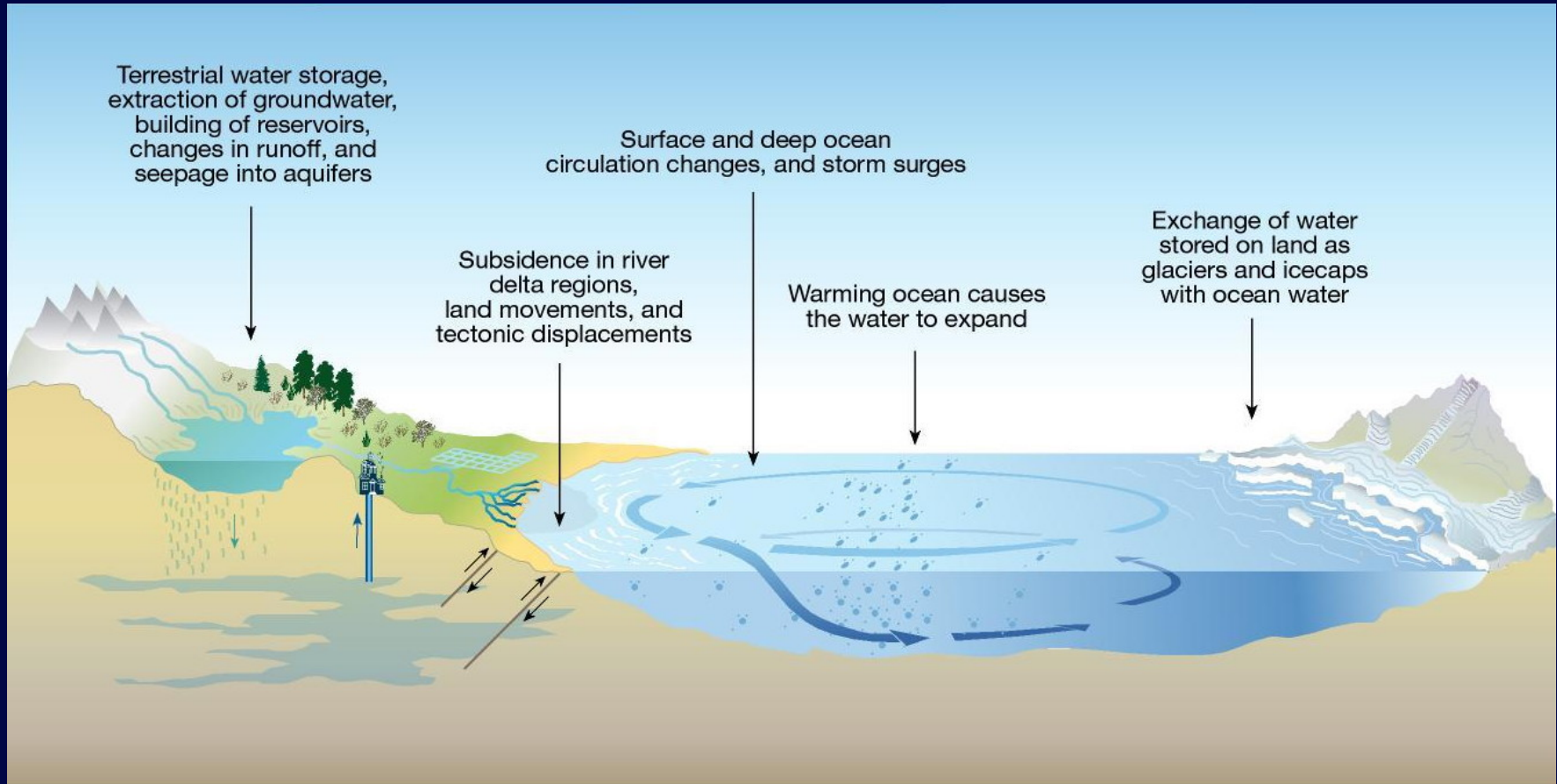
From Satellite Altimetry



Why Does Sea Level Rise?

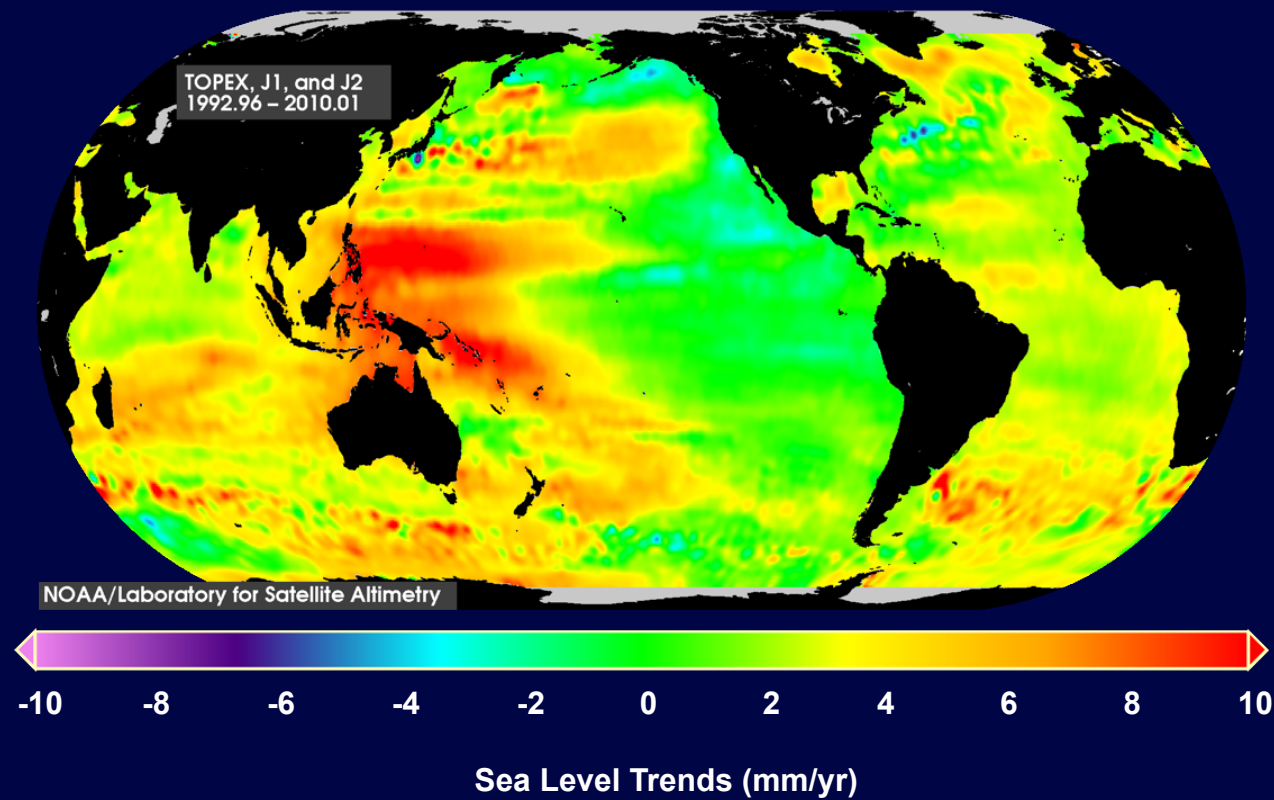


Why Does Sea Level Rise?



Global Mean Sea Level Rise

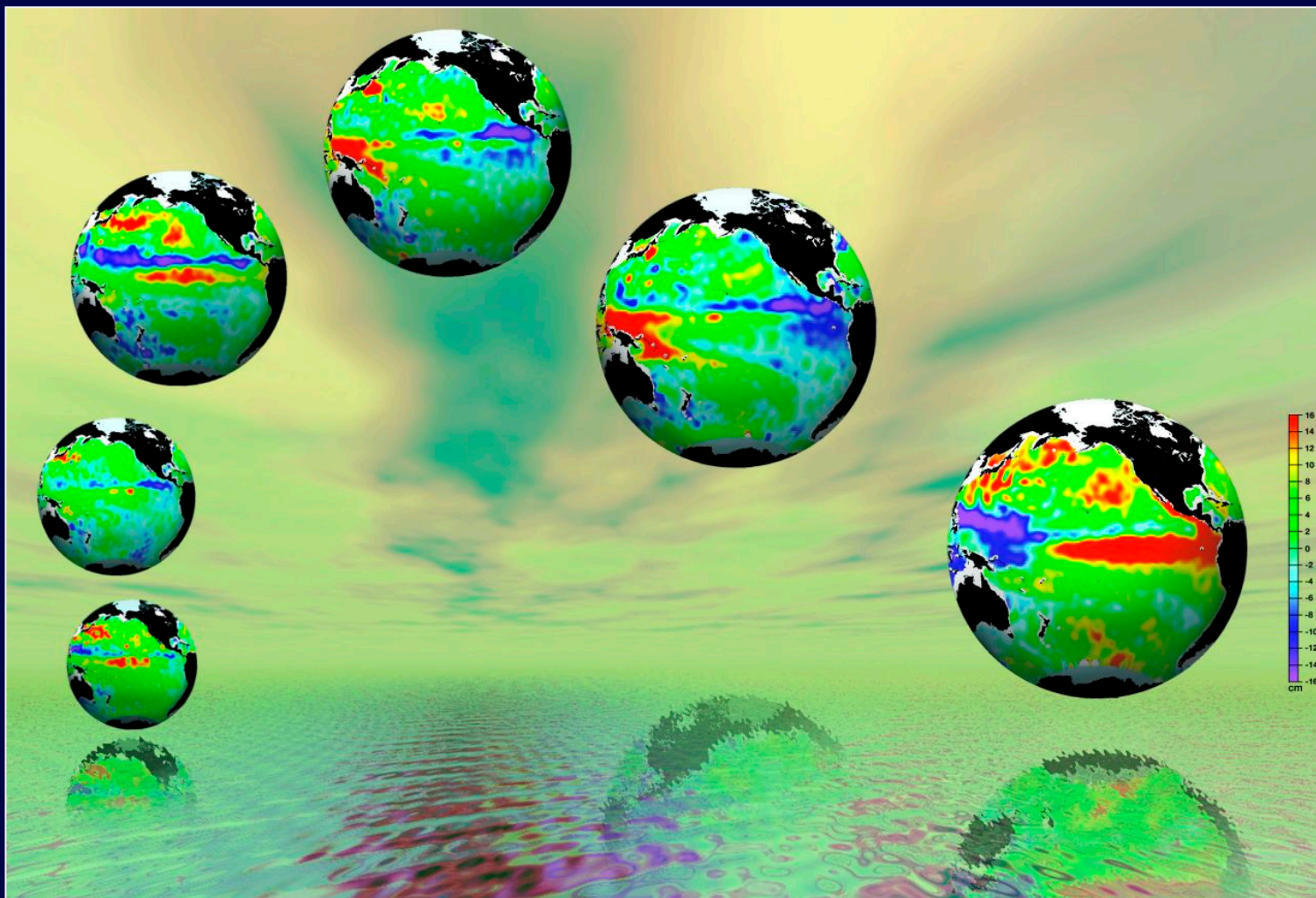
From Satellite Altimetry



Impacts of Global Warming & Climate Change

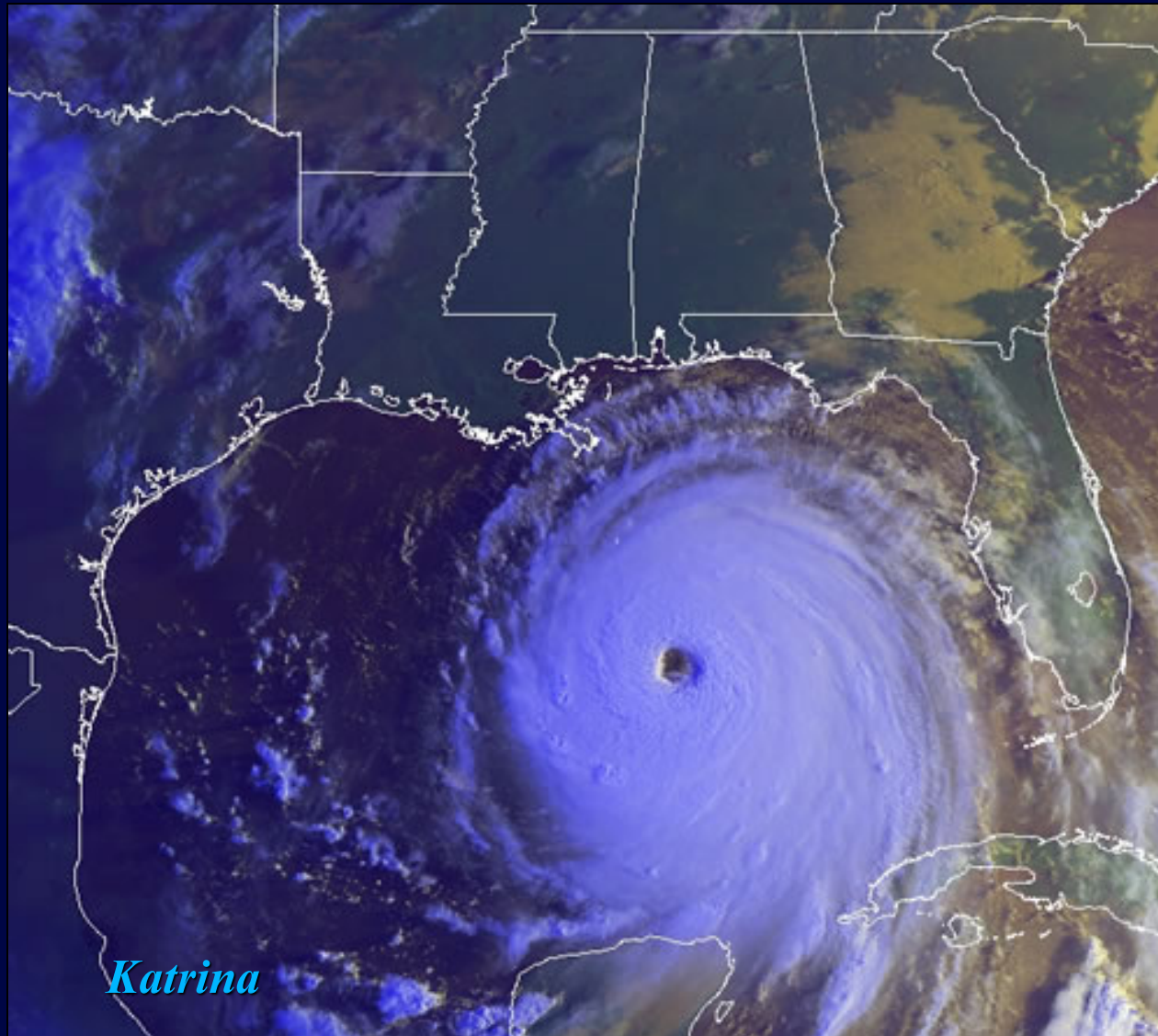


El Niño/La Niña



By courtesy of NASA

Increasing Number and Strength of Hurricanes



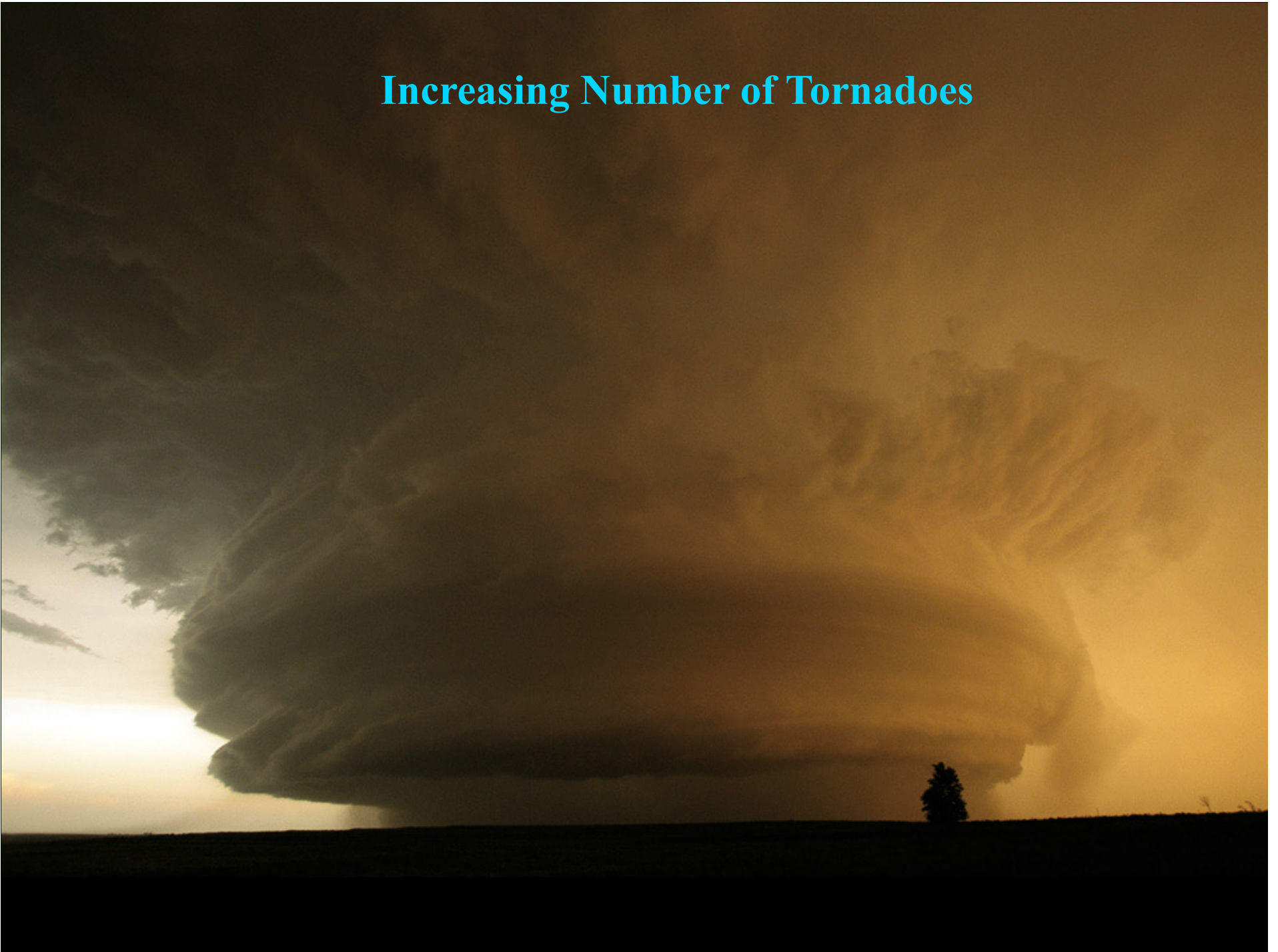
By courtesy of NOAA

Table 1. Change in the number and percentage of hurricanes in categories 4 and 5 for the two 15-year periods 1975–1989 and 1990–2004 for the different ocean basins.

Basin	Period			
	1975–1989		1990–2004	
	Number	Percentage	Number	Percentage
East Pacific Ocean	36	25	49	35
West Pacific Ocean	85	25	116	41
North Atlantic	16	20	25	25
Southwestern Pacific	10	12	22	28
North Indian	1	8	7	25
South Indian	23	18	50	34

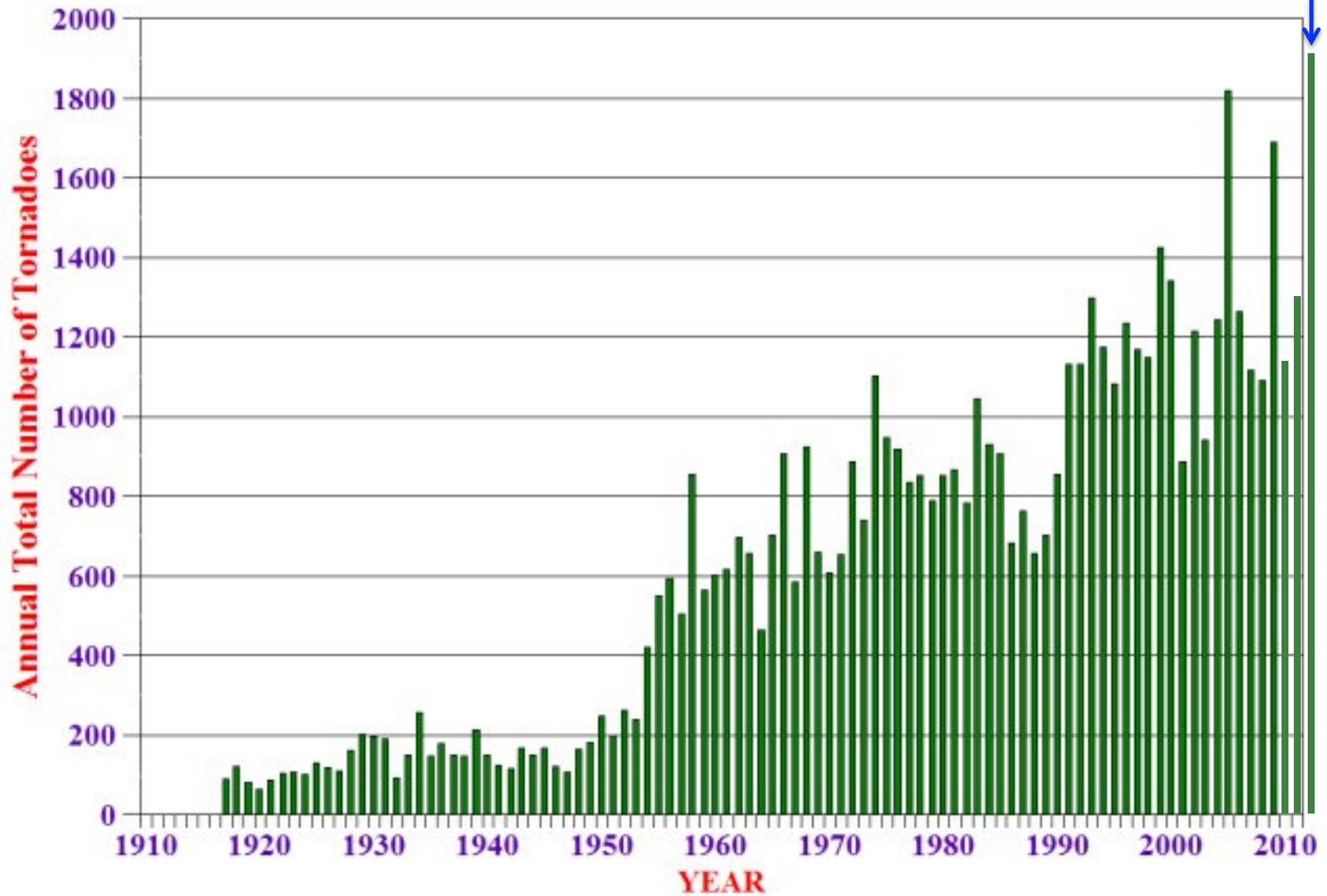
Webster et al., 2005

Increasing Number of Tornadoes



UNITED STATES TORNADOES 1916-2008

(2011)
1897



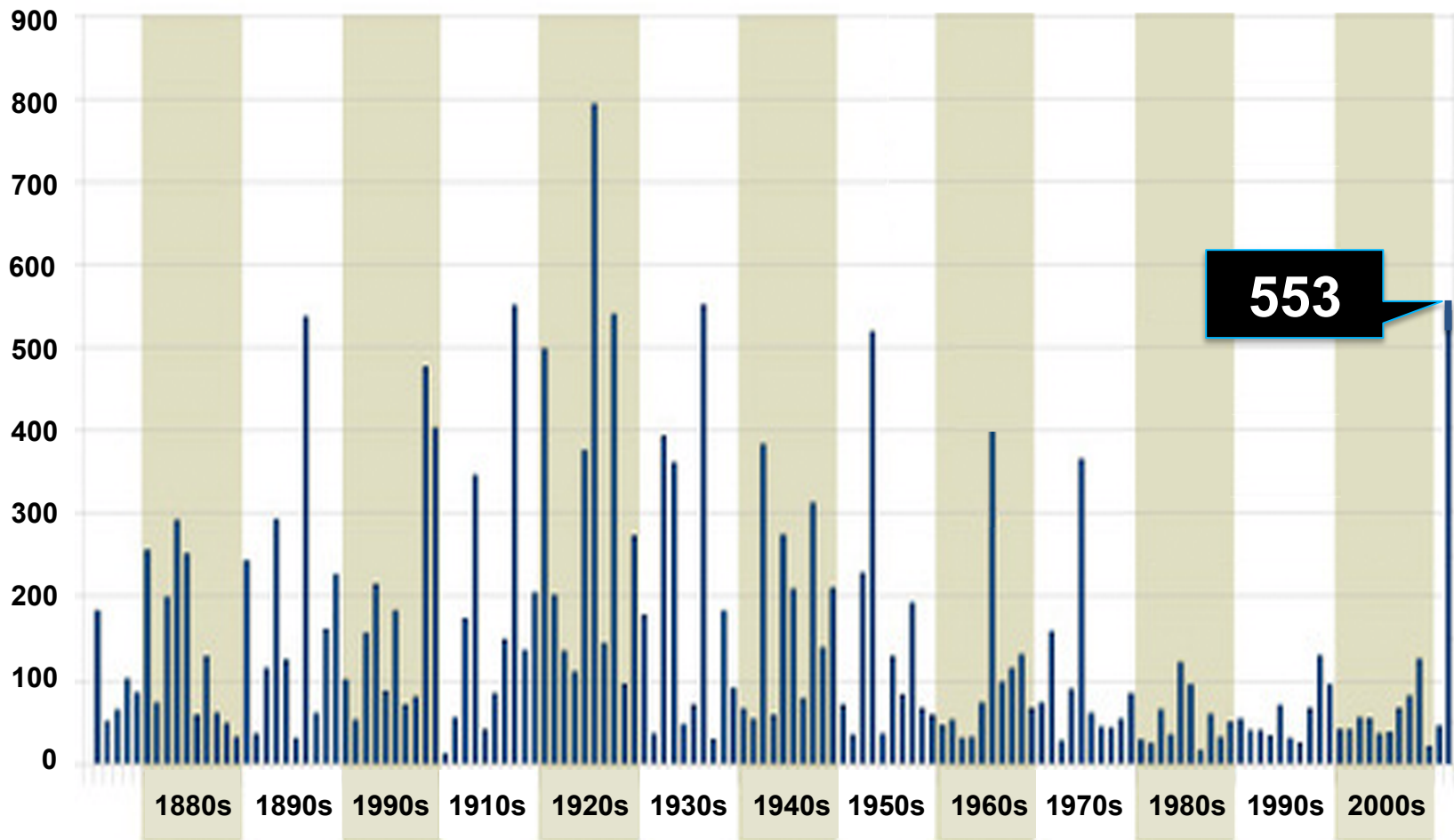
2011 Tornadoes Outbreaks in the US

There were 1,897 tornadoes reported in the US in 2011 (of which 1,704 were confirmed). 2011 had been an exceptionally destructive and deadly year for tornadoes; worldwide, at least 577 people perished due to tornadoes: 12 in Bangladesh, one in New Zealand, one in the Philippines, one in Russia, one in Canada, and an estimated 553 in the United States (compared to 564 US deaths in the 10 years prior).

Due in large part to several extremely large tornado outbreaks in the middle and end of April and in late May, It wss also the deadliest year for tornadoes in the United States since 1936, due mostly to the 324 tornadic deaths that occurred during the April 27 outbreak across the Southeastern United States and the 158 tornadic deaths in the 2011 Joplin Tornado.

(http://en.wikipedia.org/wiki/Tornadoes_of_2011)

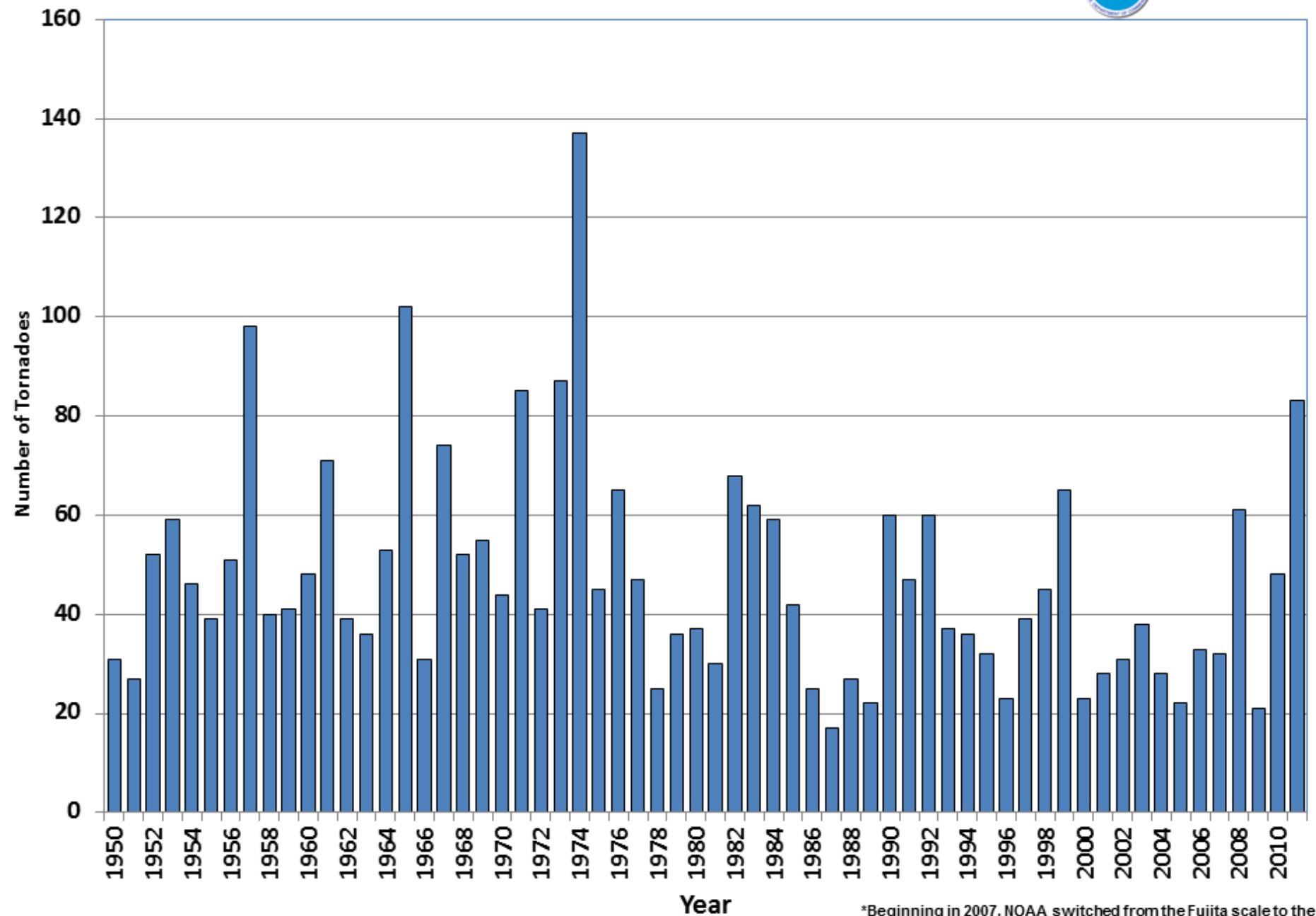
Tornado Deaths in the United States, 1875 to present



Number of Strong to Violent (EF3-EF5*) Tornadoes

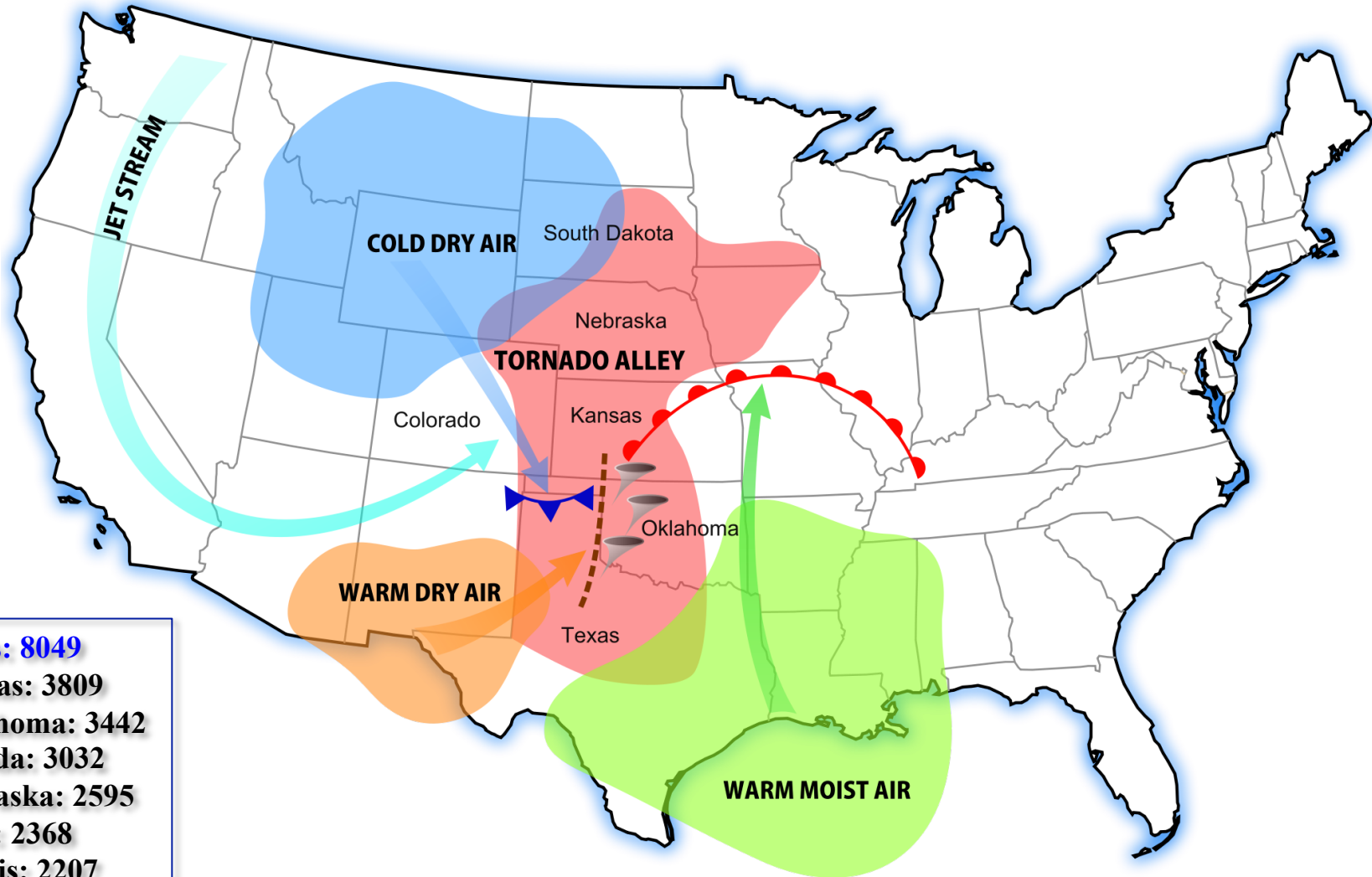


NOAA's
National Climatic Data Center



*Beginning in 2007, NOAA switched from the Fujita scale to the Enhanced Fujita scale for rating tornado strength.

Tornado Alley in the United States



Texas: 8049
Kansas: 3809
Oklahoma: 3442
Florida: 3032
Nebraska: 2595
Iowa: 2368
Illinois: 2207
Missouri: 2119
Mississippi: 1972
Alabama: 1844

U.S. tornadoes per state: 1950-2009

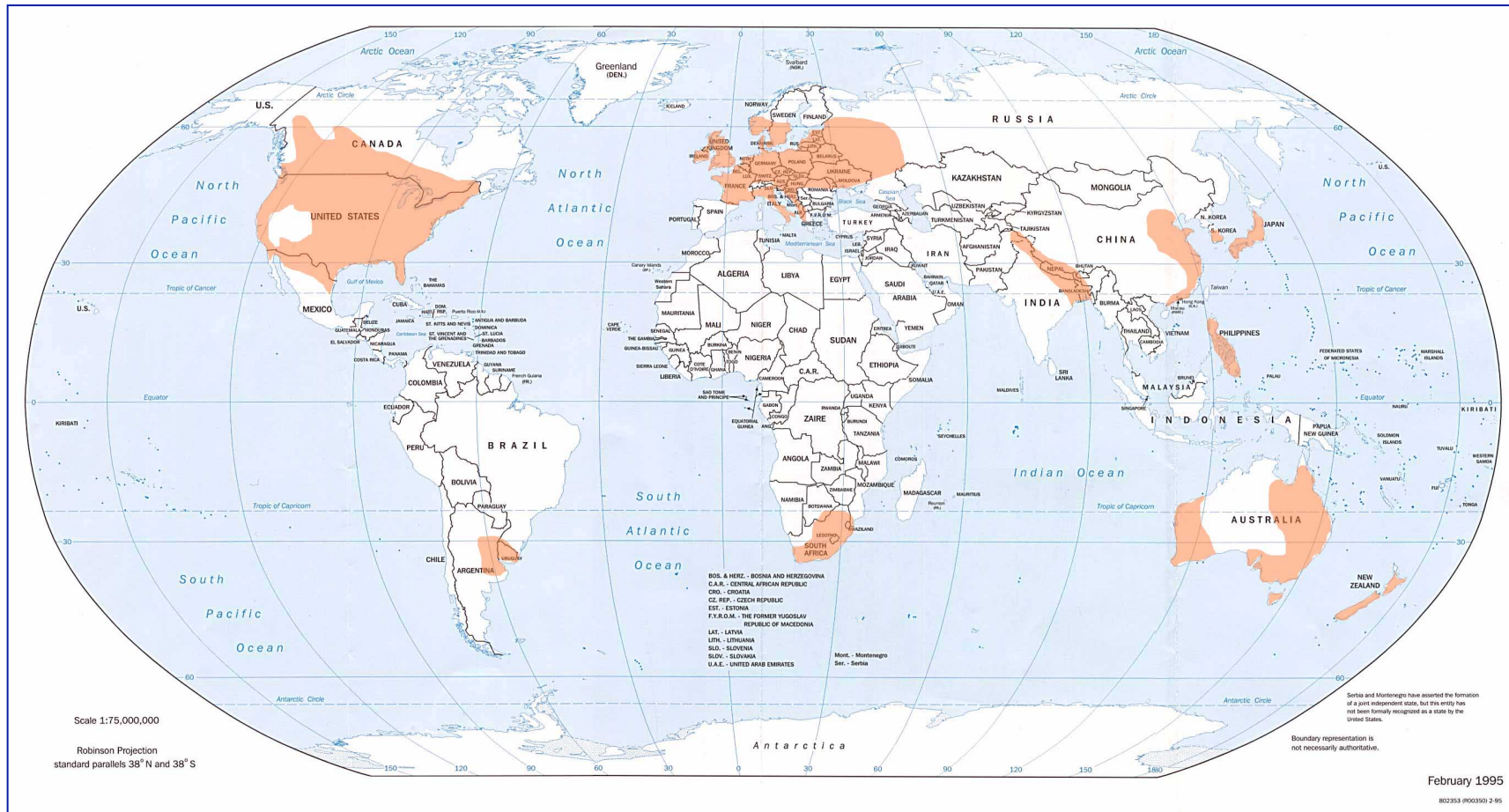
By courtesy of NOAA

Why is the United States so “special”?



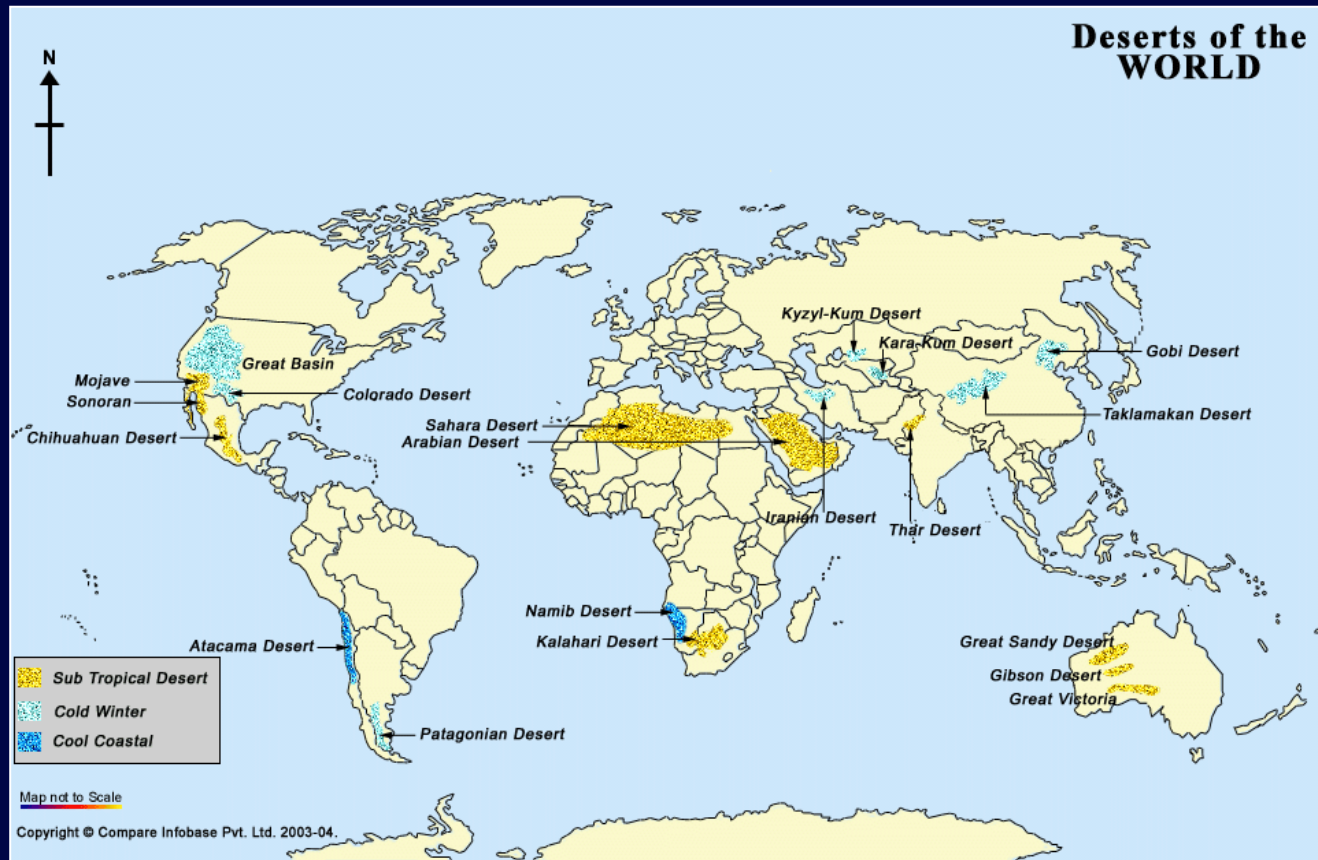
The United States has the most tornadoes of any country, nearly four times more than estimated in all of Europe, excluding waterspouts. This is mostly due to the unique geography of the continent. North America is a large continent that extends from the tropics north into arctic areas, and has no major east-west mountain range to block air flow between these two areas. In the middle latitudes, where most tornadoes of the world occur, the Rocky Mountains block moisture and buckle the atmospheric flow, forcing drier air at mid-levels of the troposphere due to downsloped winds, and causing the formation of a low pressure area downwind to the east of the mountains. Increased westerly flow off the Rockies force the formation of a dry line when the flow aloft is strong, while the Gulf of Mexico fuels abundant low-level moisture in the southerly flow to its east. This unique topography allows for frequent collisions of warm and cold air, the conditions that breed strong, long-lived storms throughout the year.

Regions of the world with increased likelihood of experiencing tornadoes



By courtesy of NOAA

Desert & Desertization



Desert can be beautiful.

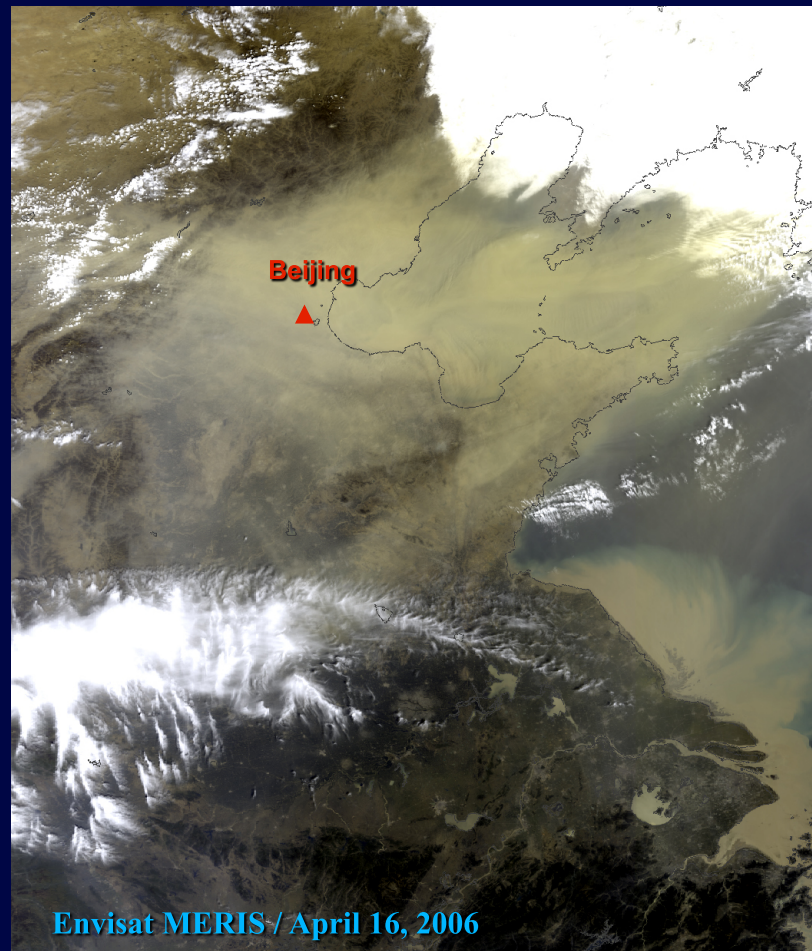


Desert can be ugly as well.



The Infamous Sand Storm

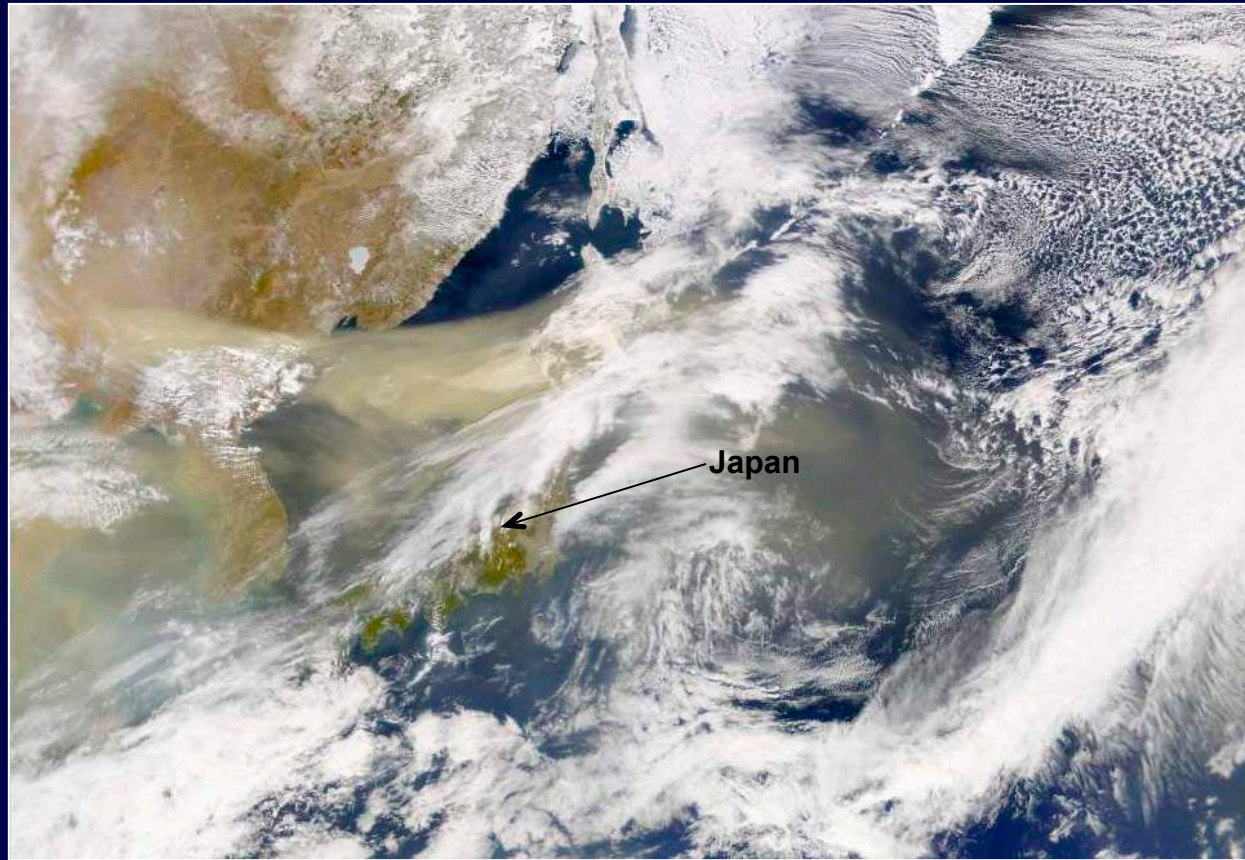
Desert & Sand Storm



Envisat MERIS / April 16, 2006

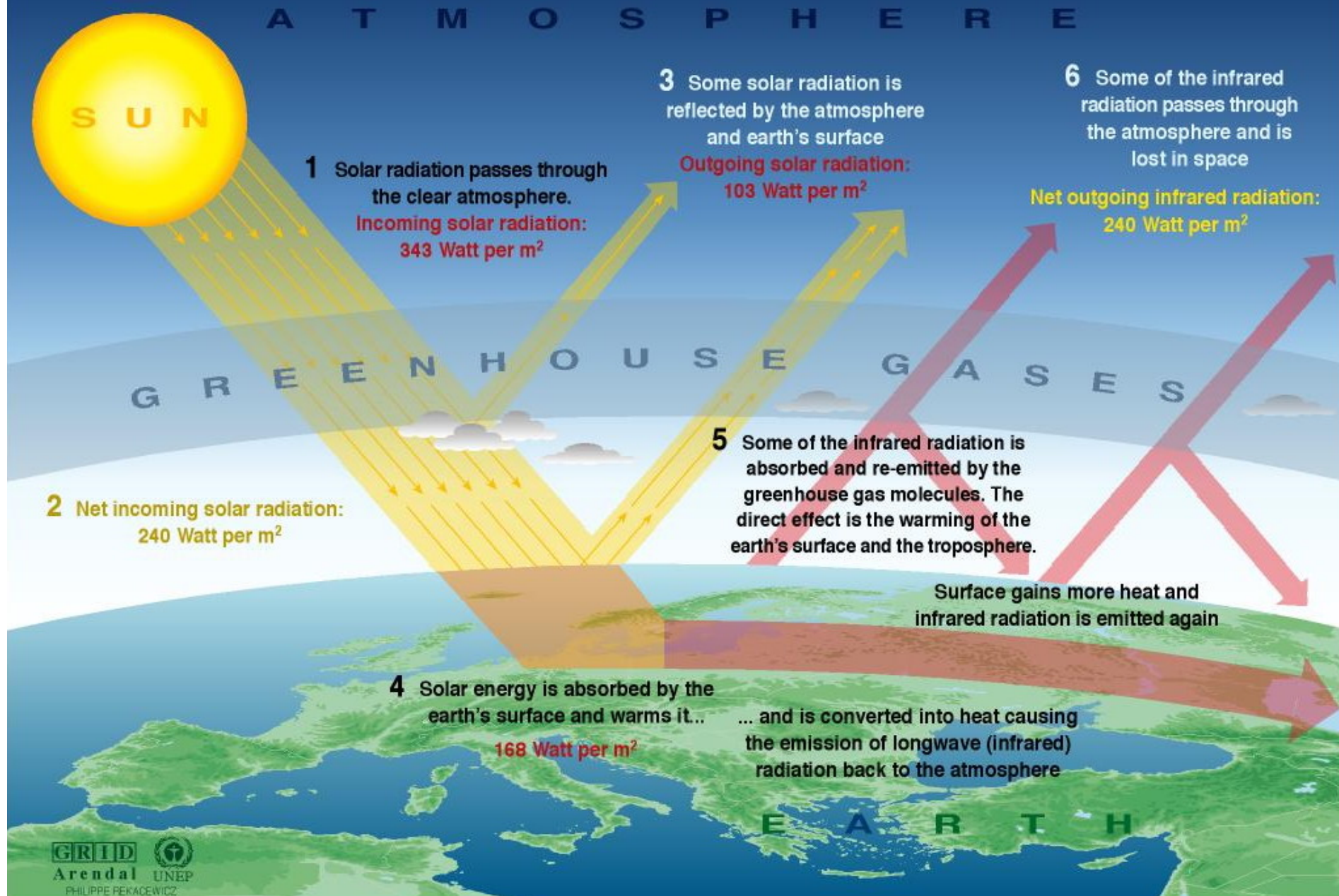
By courtesy of ESA

Sand Storm into the Ocean



Who is to Blame for Global Warming and Climate Change ?

The Greenhouse Effect



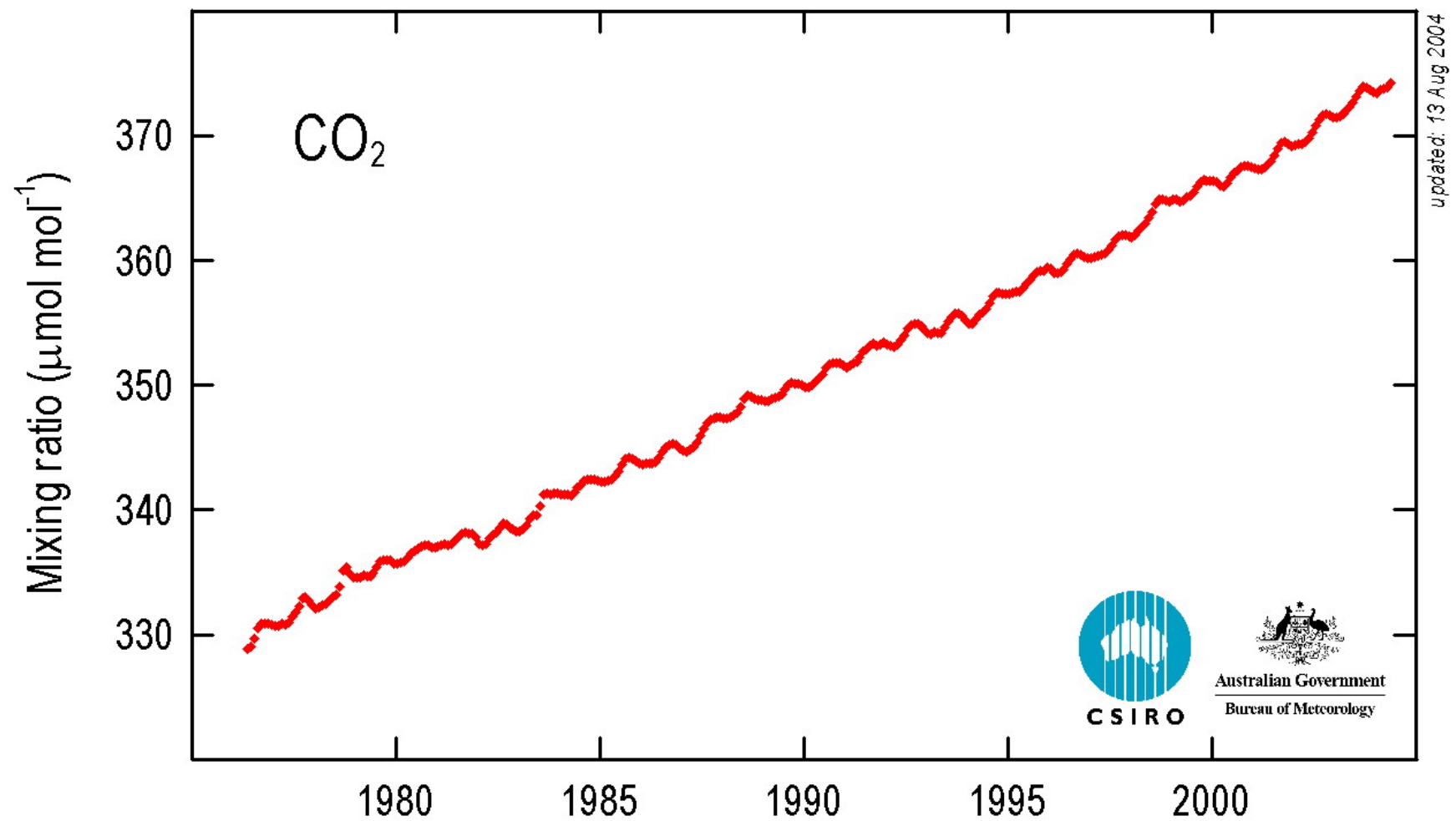
温室效应 – Greenhouse Effect



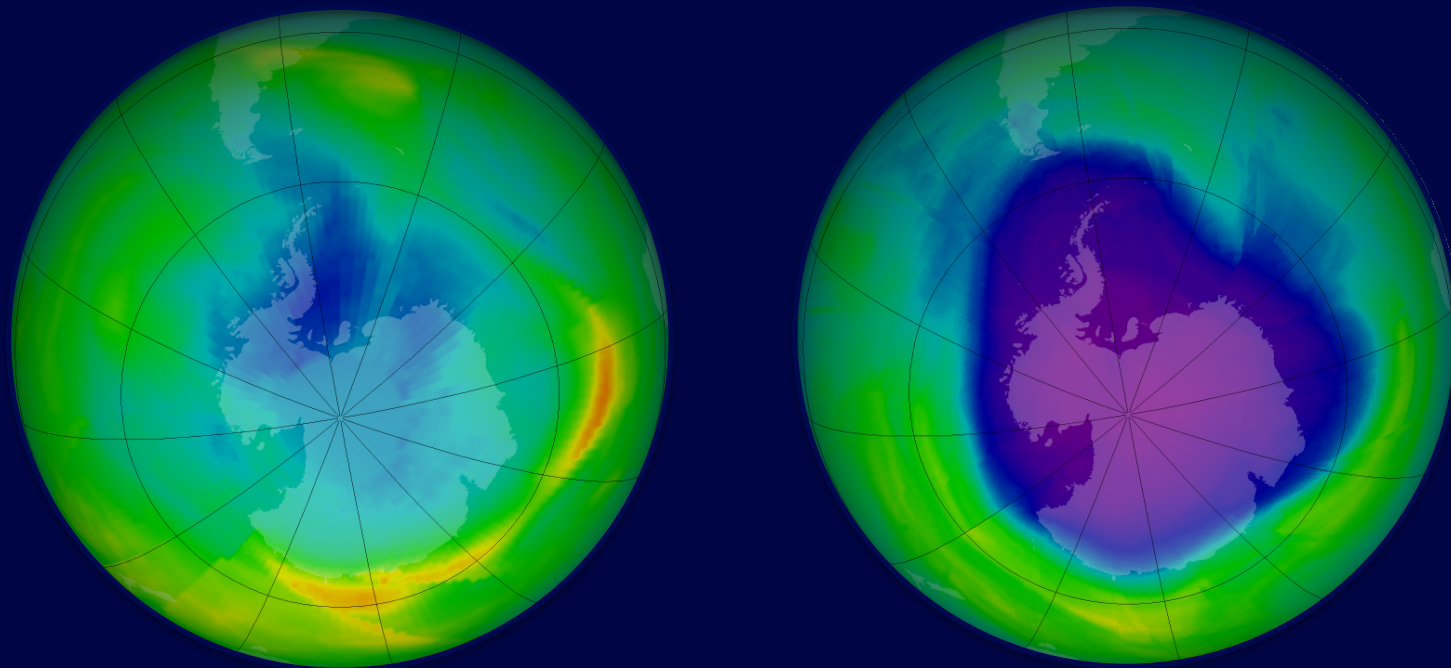
Carbon Dioxide (CO₂)



Carbon dioxide at Cape Grim, Tasmania



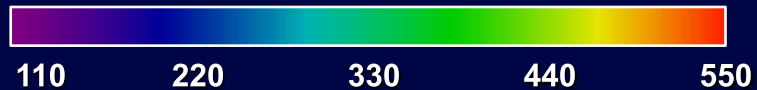
Ozone Hole Over the Antarctic Continent



(1979)

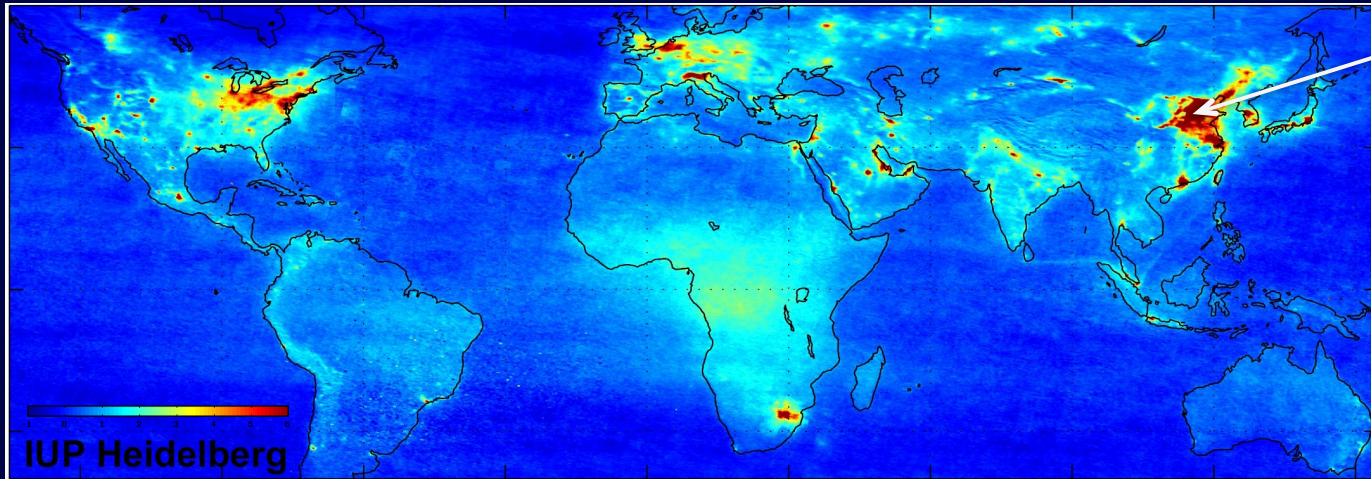
(2008)

Ozone (Dobson Units)



The ozone (O_3) layer, 15 - 50 km above the Earth, protects us from harmful ultraviolet rays.

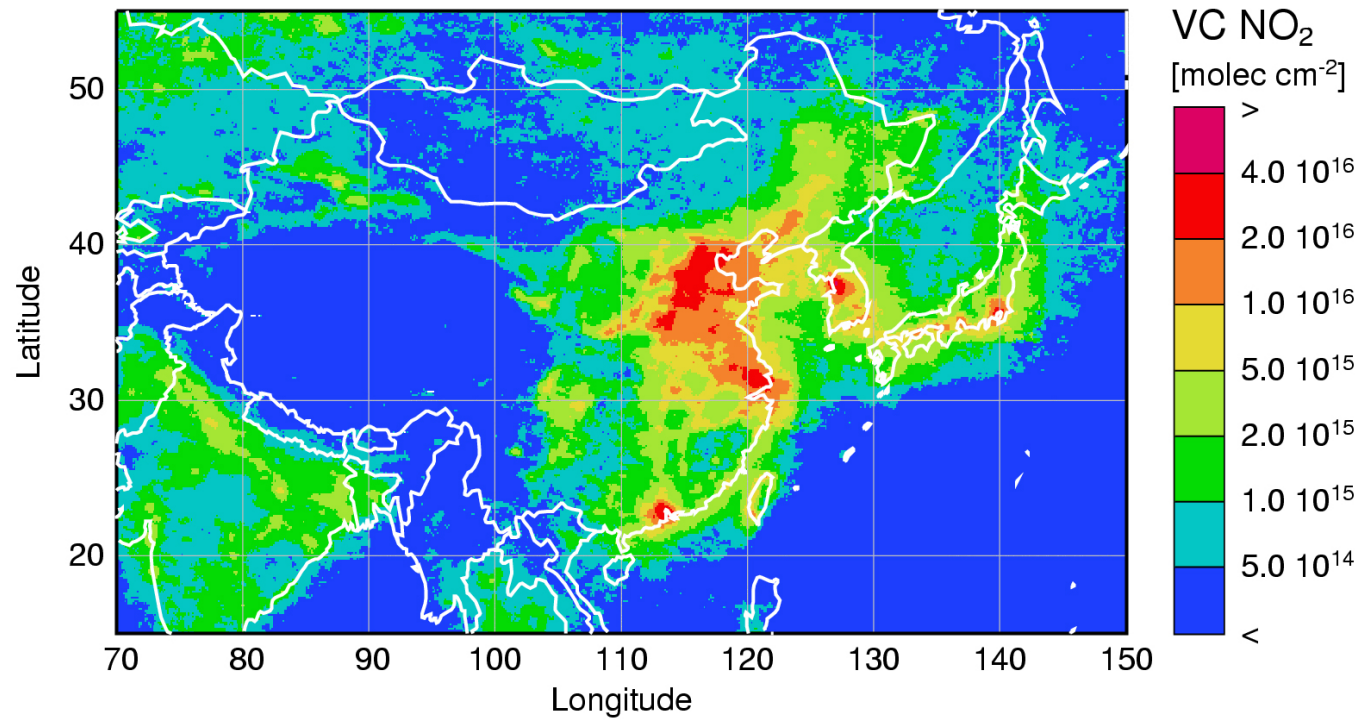
Global Air Pollution Map Produced by Envisat's SCIAMACHY



By courtesy of ESA

Nitrogen dioxide (NO₂) is a mainly man-made gas, excess exposure to which causes lung damage and respiratory problems. It also plays an important role in atmospheric chemistry, because it leads to the production of ozone in the troposphere – which is the lowest part of the atmosphere, extending up to between 8 and 16 kilometers high.

Air Pollution Map Over China & East Asia



Natural challenges:

- ✓ Global warming
- ✓ Polar ice sheet and glacial melting
- ✓ Global sea level rise
- ✓ El Niño/La Niña
- ✓ Hurricane/tornado/flooding
- ✓ Earthquake & tsunami
- ✓ Desert/desertization/sand storm
- ✓ & many others ...

Enough or not?!

Man-made Environmental Hazards:

- ❑ Green house effect & global warming**
- ❑ Water pollution**
- ❑ Air pollution**
- ❑ Soil pollution**
- ❑ Marine pollution**
- ❑ Groundwater Scarcity**
- ❑ Desertization**
- ❑ Deforest**
- ❑ Ozone hole**
- ❑ Many others**

We are feeling about these everyday.

The image features a central view of Earth from space, showing the Americas. Three satellites are positioned around the globe: two in the upper left quadrant and one in the upper right. The background is a deep black space filled with numerous white stars. Overlaid on the image are three text elements: 'Save Our Home!' in bold orange, 'Thank You!' in a light blue script, and 'The Magic Blue Marble' in a dark blue box at the bottom.

Save Our Home!

Thank You!

The Magic Blue Marble