Meteorology – Lecture 21

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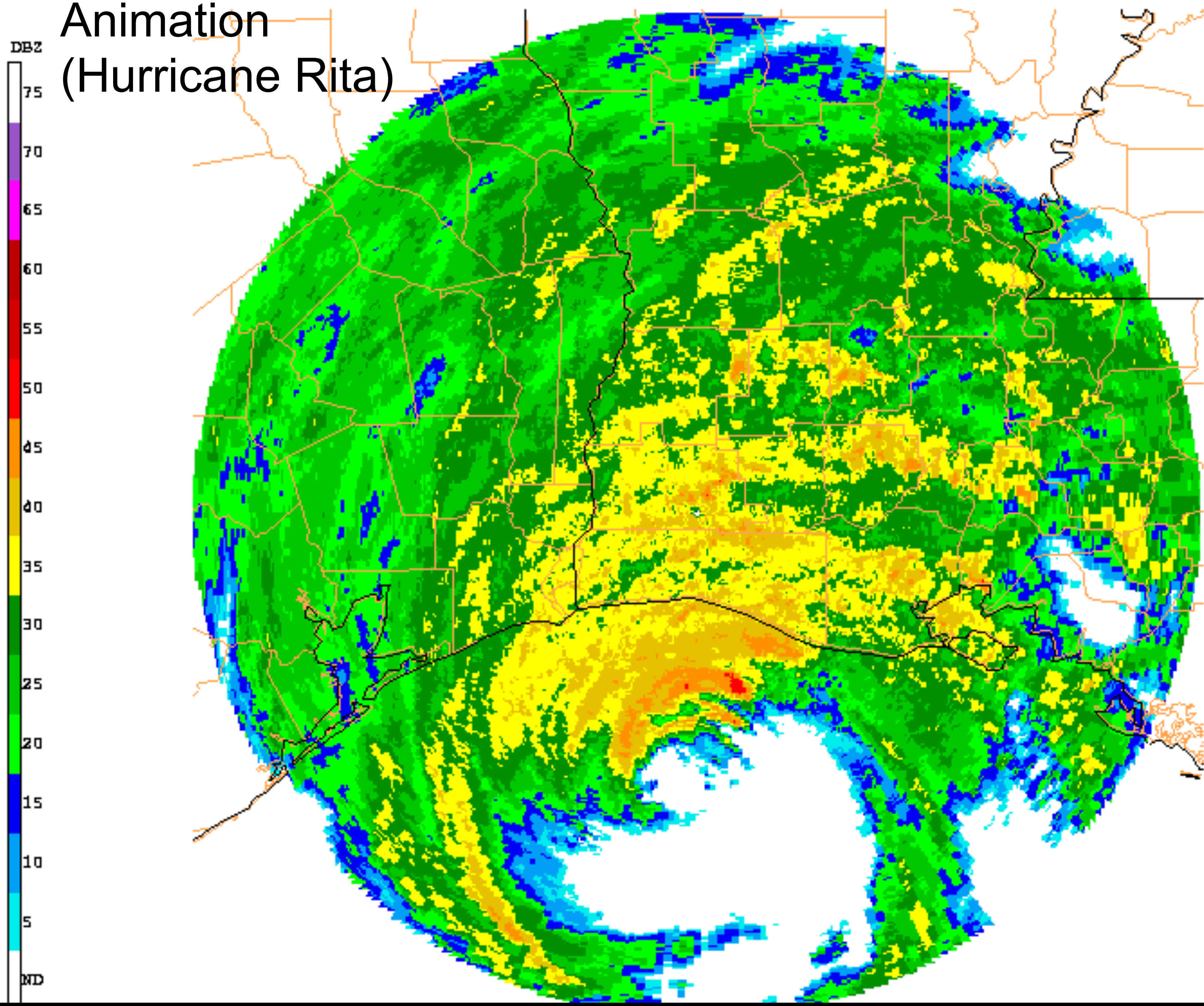
Important notes

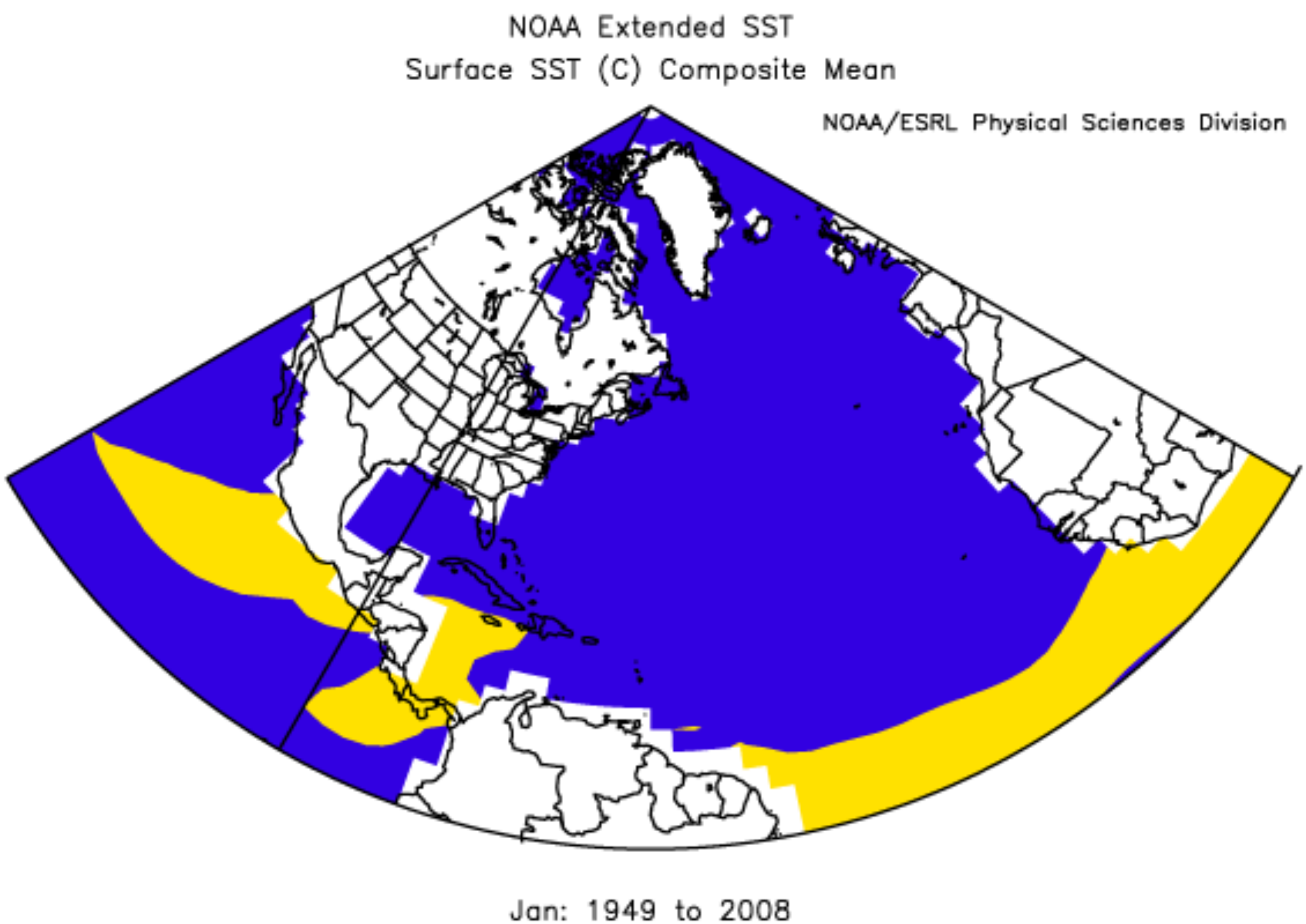
- These slides show some figures and videos prepared by Robert G. Fovell (RGF) for his "Meteorology" course, published by The Great Courses (TGC). Unless otherwise identified, they were created by RGF.
- In some cases, the figures employed in the course video are different from what I present here, but these were the figures I provided to TGC at the time the course was taped.
- These figures are intended to supplement the videos, in order to facilitate understanding of the concepts discussed in the course. *These slide shows cannot, and are not intended to, replace the course itself and are not expected to be understandable in isolation.*
- Accordingly, these presentations do not represent a summary of each lecture, and neither do they contain each lecture's full content.

Animations linked in the PowerPoint version of these slides may also be found here:

http://people.atmos.ucla.edu/fovell/meteo/

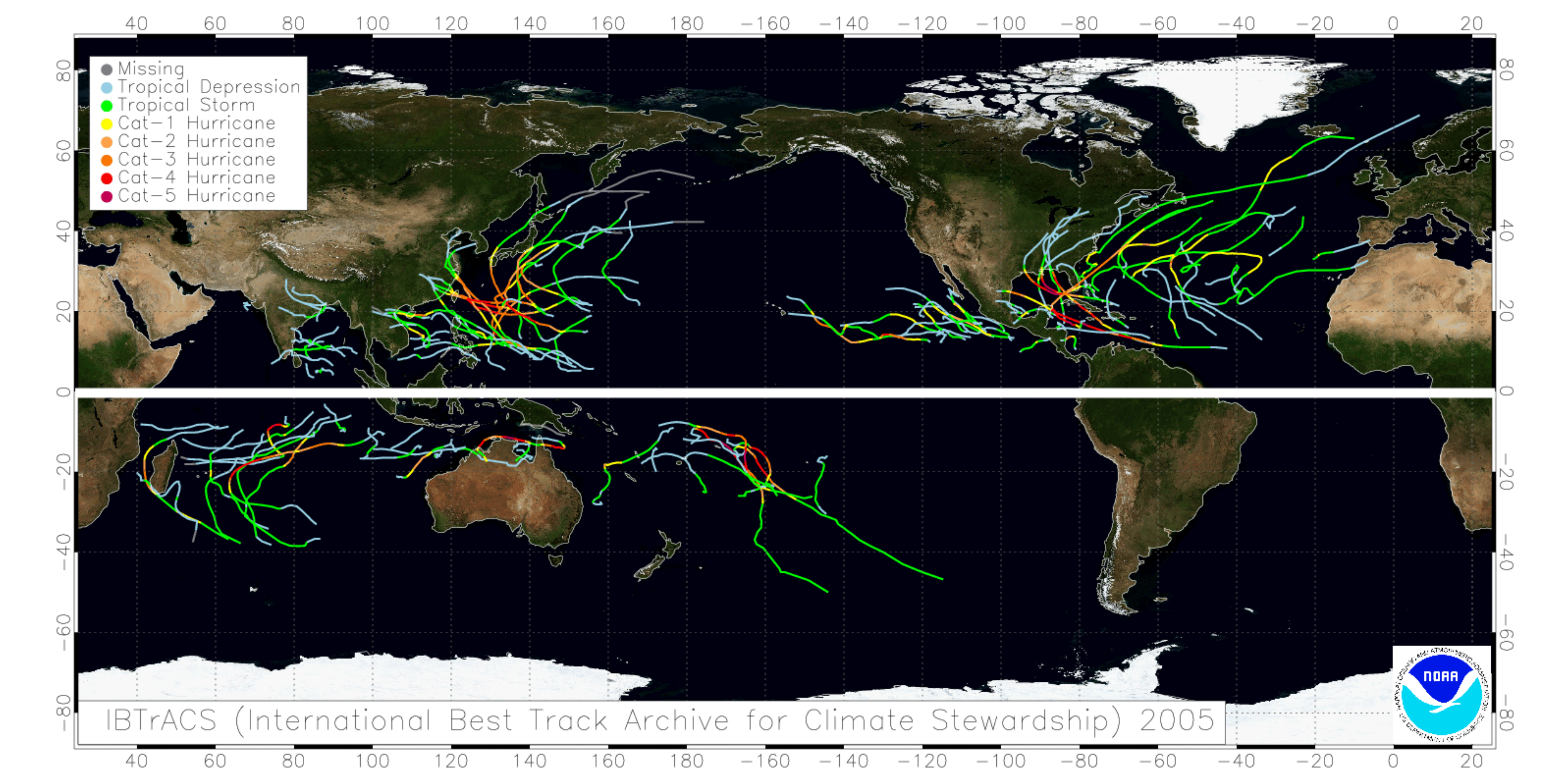
Animation
(Hurricane Rita)



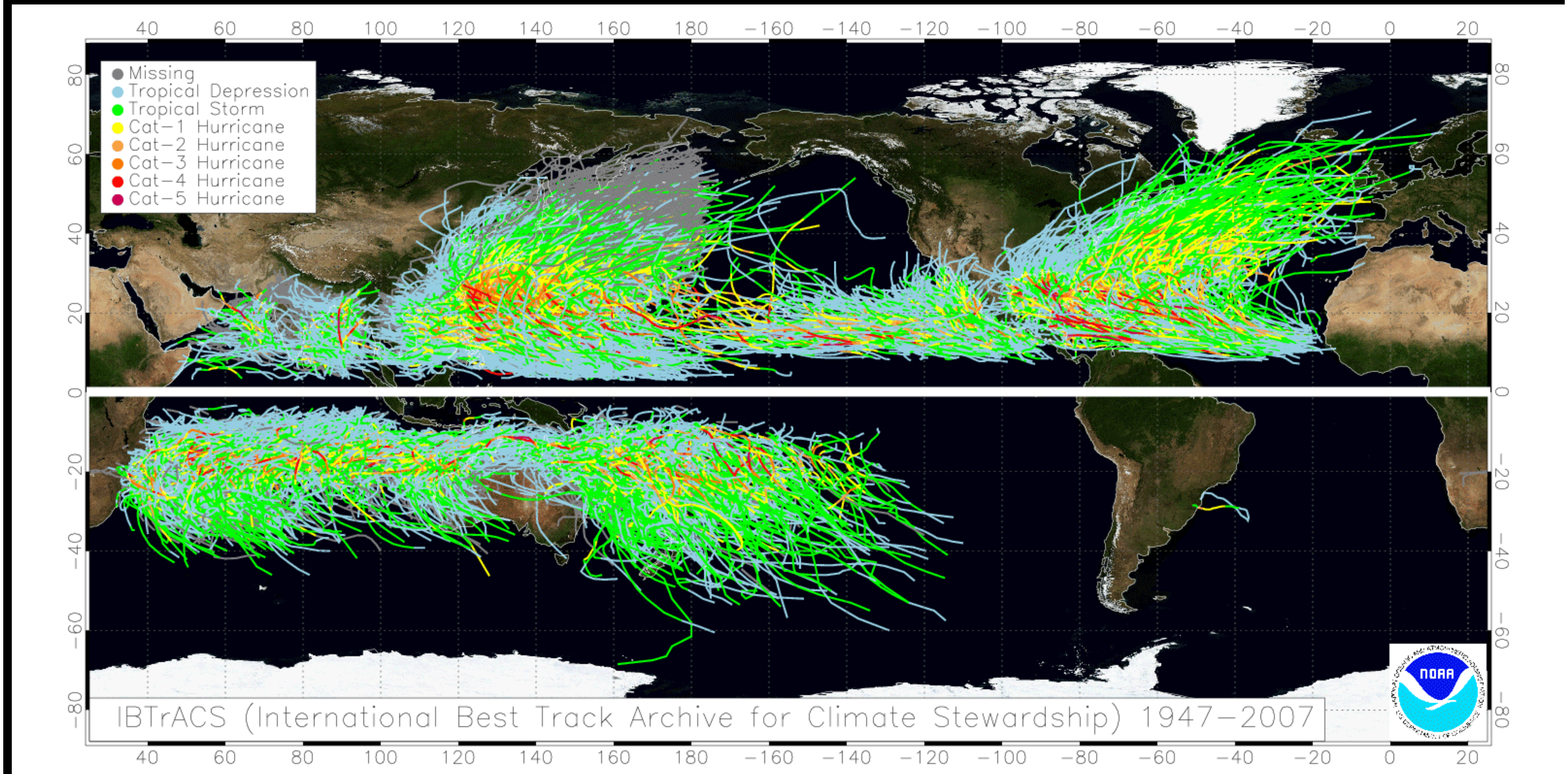


Animation
(SST exceeding 27˚C)

TC tracks for 2005



TC tracks for 1947-2007

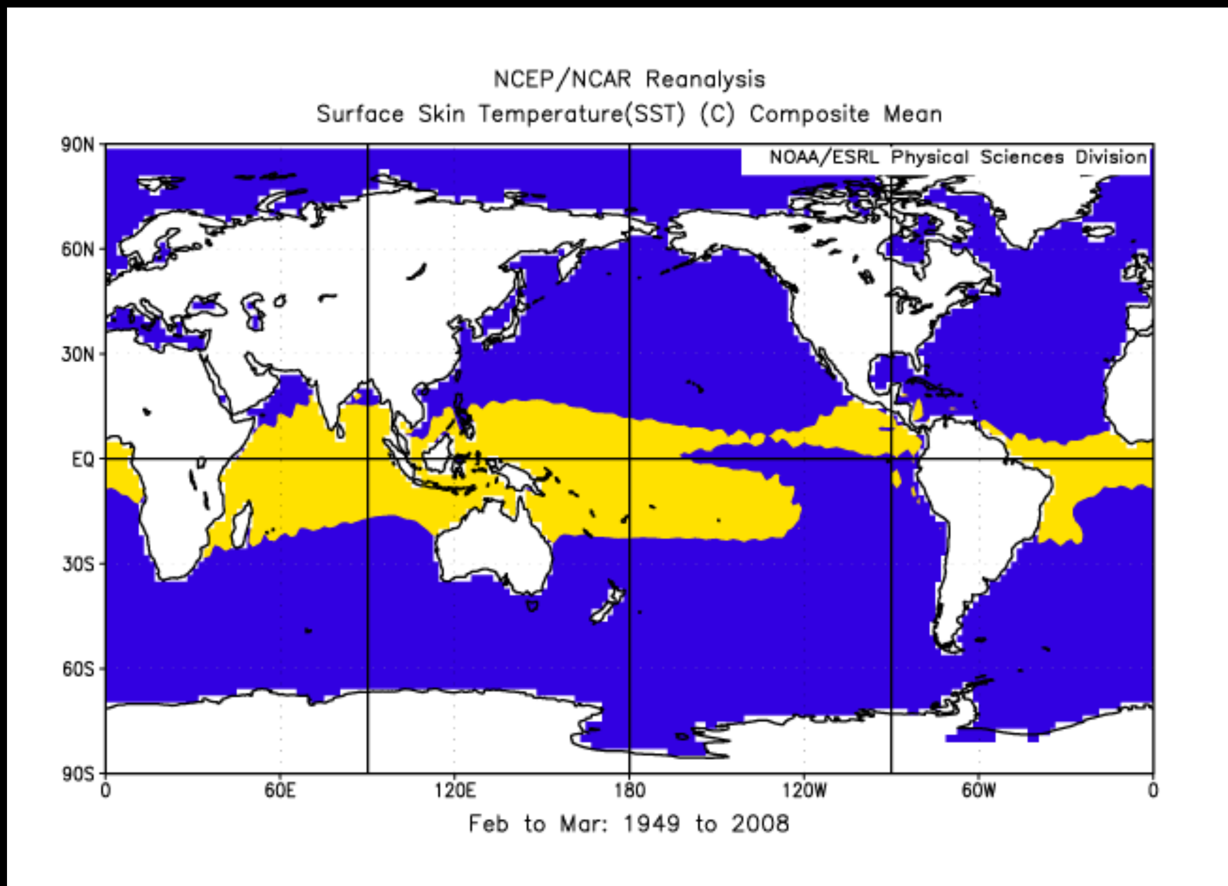


Saffir-Simpson scale

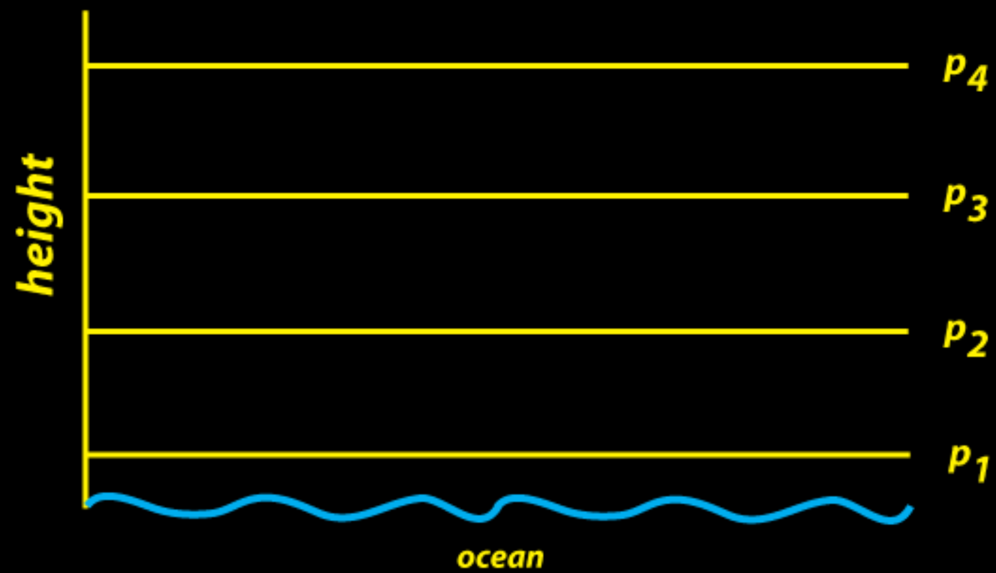
Category	mph	knots	km/h	m/s
Tropical storm	39	34	63	17.5
Cat 1	74	64	119	33
Cat 2	96	83	154	43
Cat 3	111	96	178	50
Cat 4	130	113	209	59
Cat 5	≥157	≥137	≥252	≥70

http://www.nhc.noaa.gov/aboutsshws.php

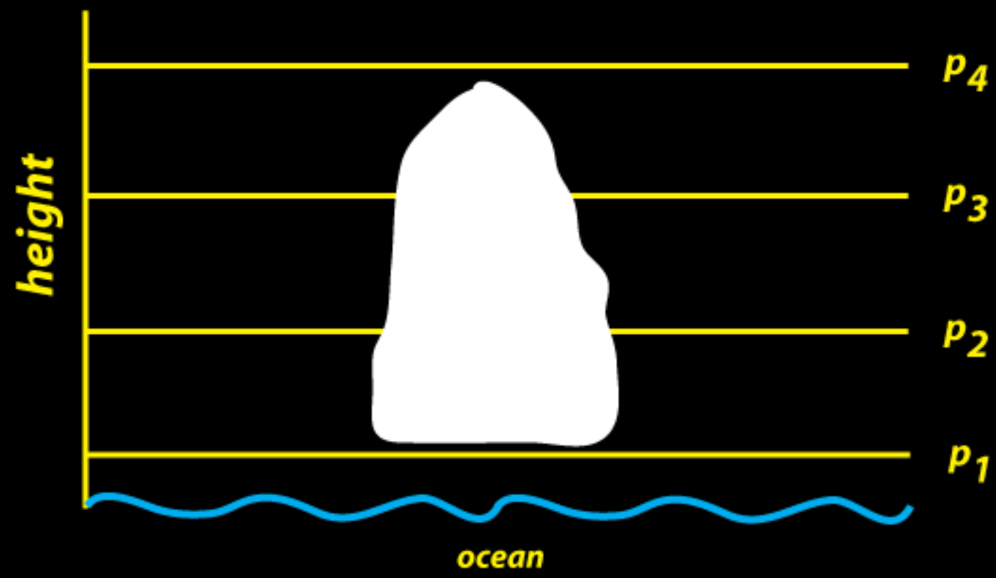
Mean SST for February-March



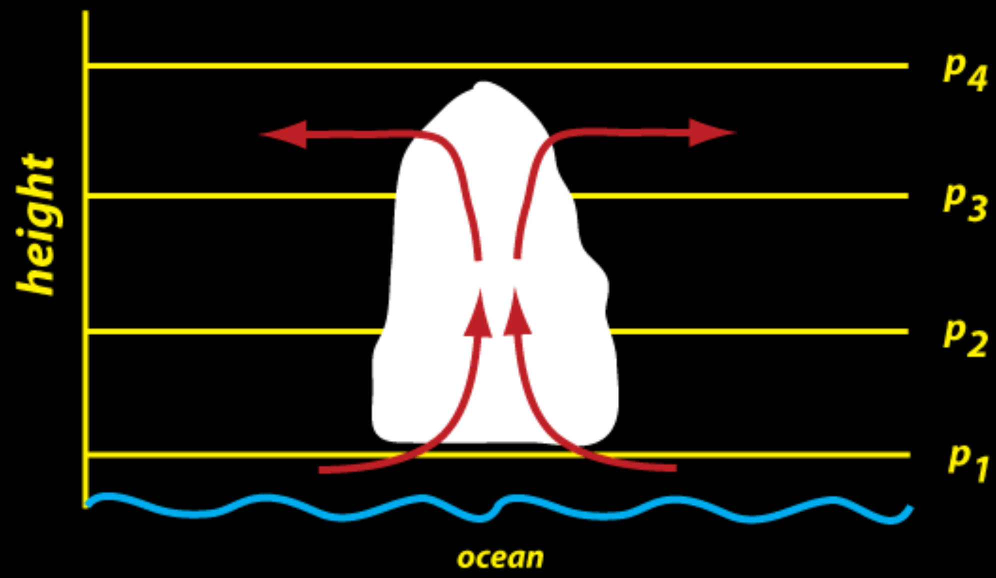
Why vertical wind shear is harmful to hurricanes



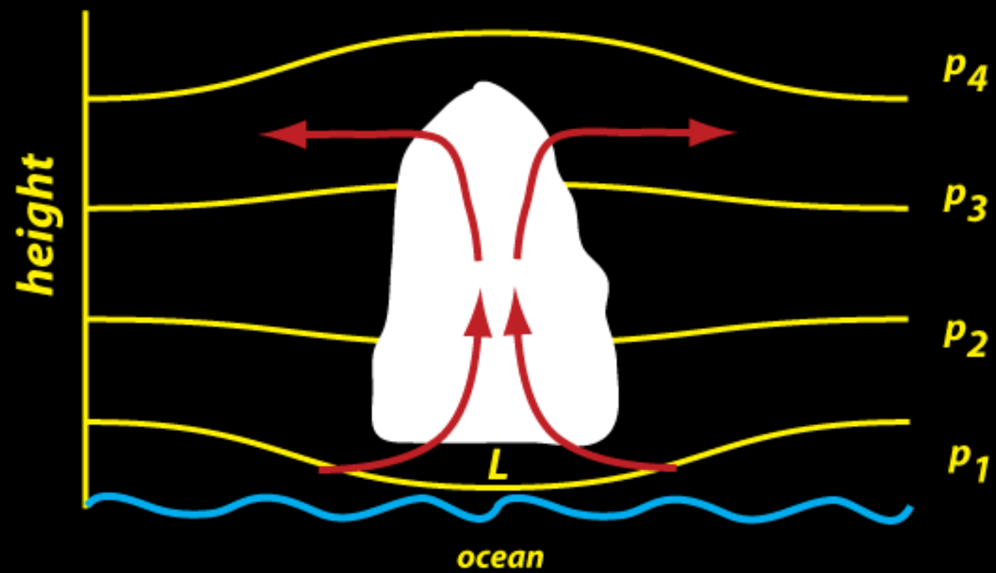
Isobars in a vertical plane.
Pressure decreases with height, as usual, so p1 > p2.
There are no initial pressure gradients, at least in this plane.



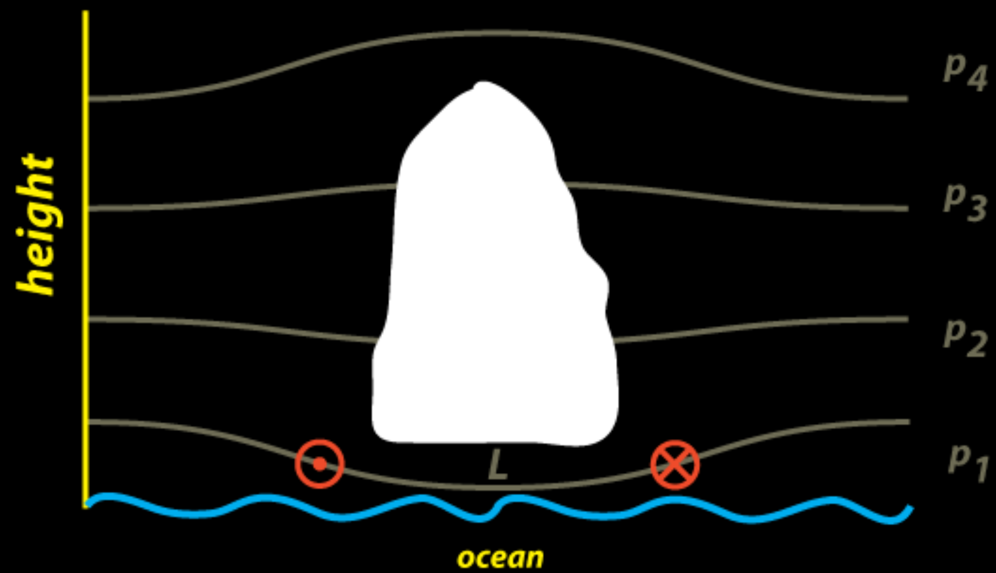
Thunderstorms start growing in this initially calm environment. What will they do to their surroundings?



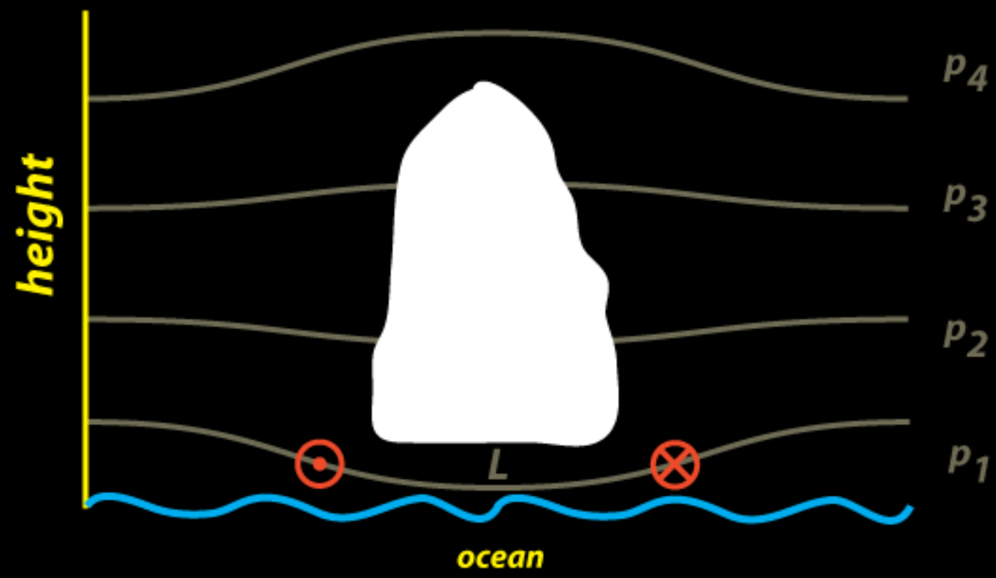
The storm complex is pushing air upward, fueled by latent heat release. The combination of latent heating and upper level divergence causes the pressure beneath the cloud to start decreasing.



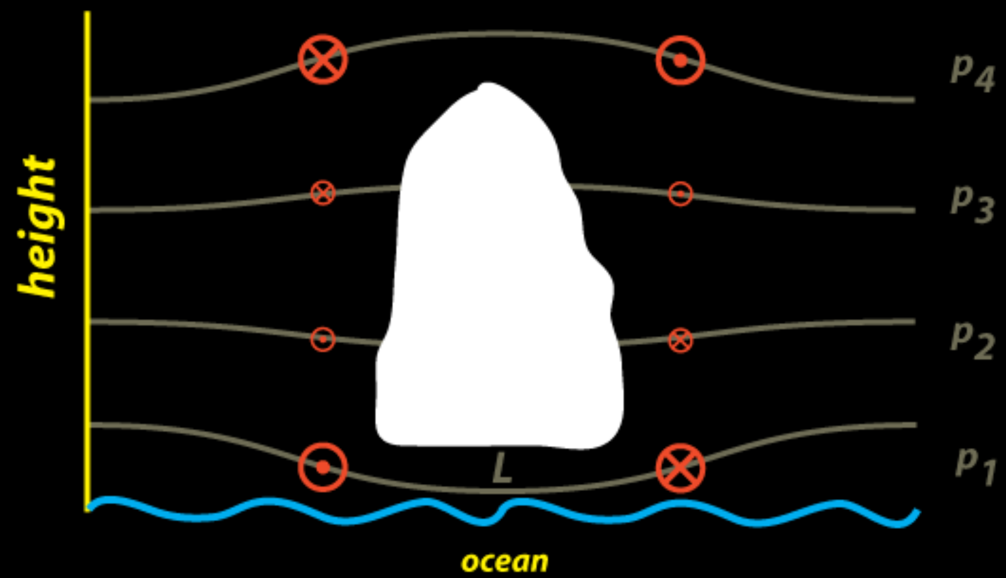
That low pressure is helping draw warm, moist air into the cloud from below. This is OK for short-lived clouds, but we know as lifetimes get **longer**, Earth's rotation via the Coriolis force becomes more important, even in the tropics where Coriolis is relatively small.



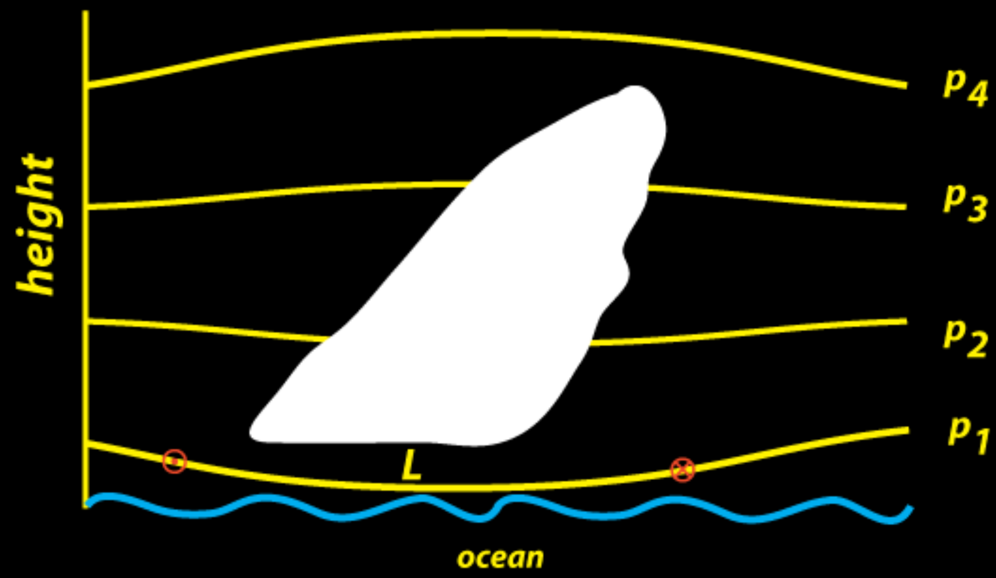
In the NH, the large-scale wind blows with lower pressure towards the left. That means on the right side of our cloud, the air will start blowing INTO the page. It will come out of the screen on the other side.
Do you see we have a cyclonic surface circulation?



Note the winds are calm in the center of the circulation. Note also that isobar p2 is less curved than p1, so the horizontal pressure gradient (and wind speed) at that level is smaller.

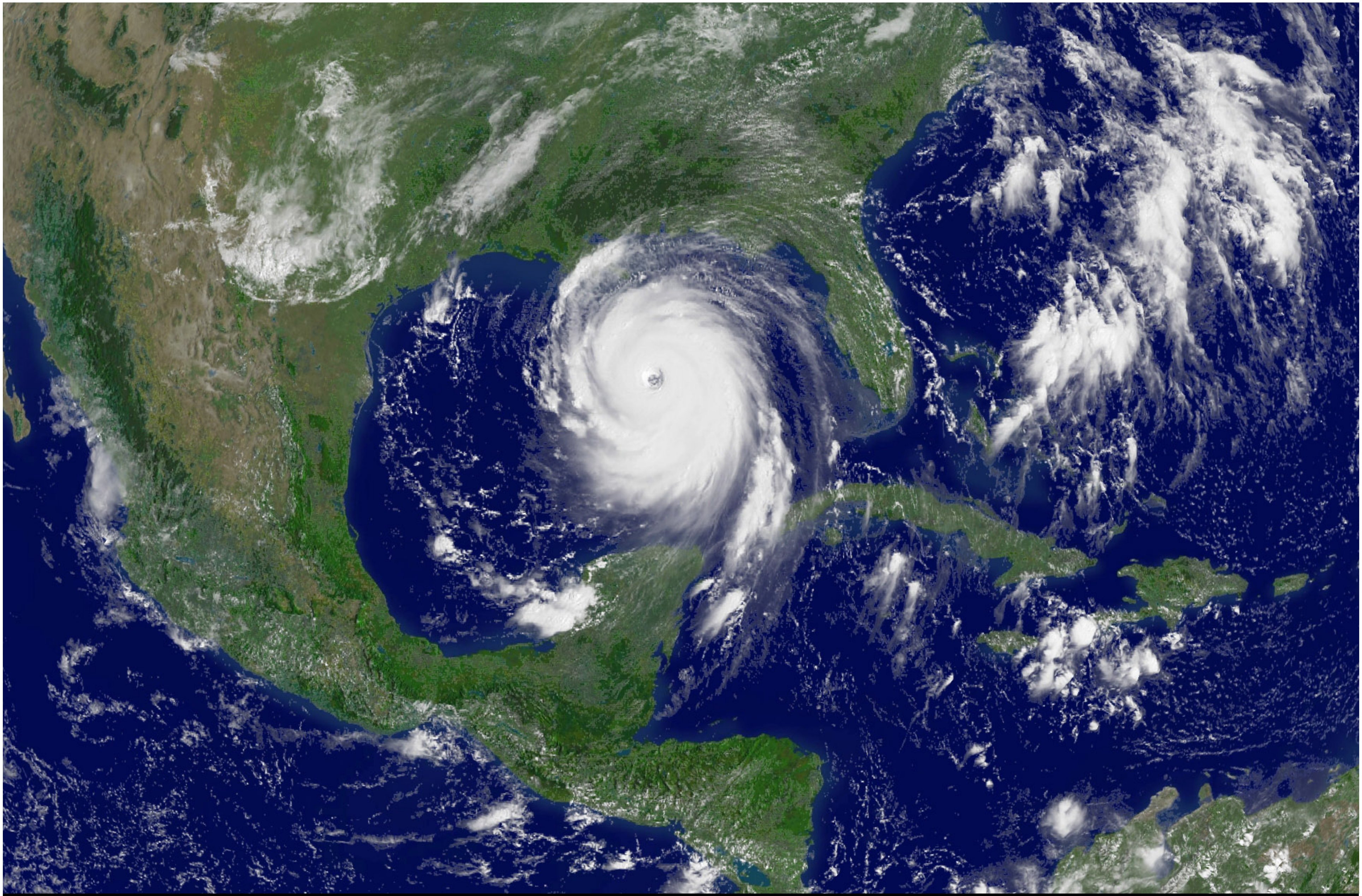


Now note the isobars at upper levels are bowing upward. The pressure gradient and wind direction is reversed there (anticyclonic). (The vertical symmetry is exaggerated.)

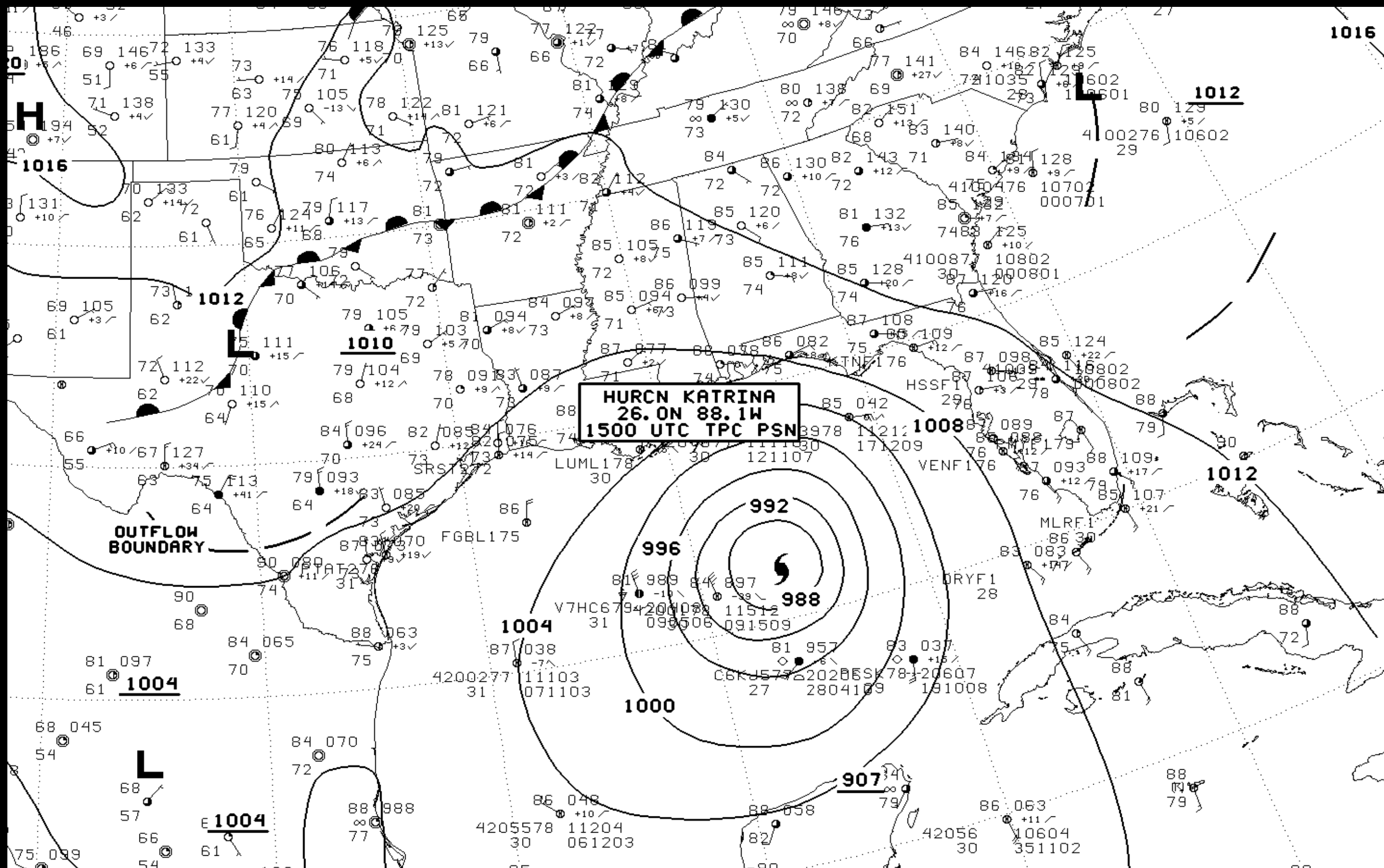


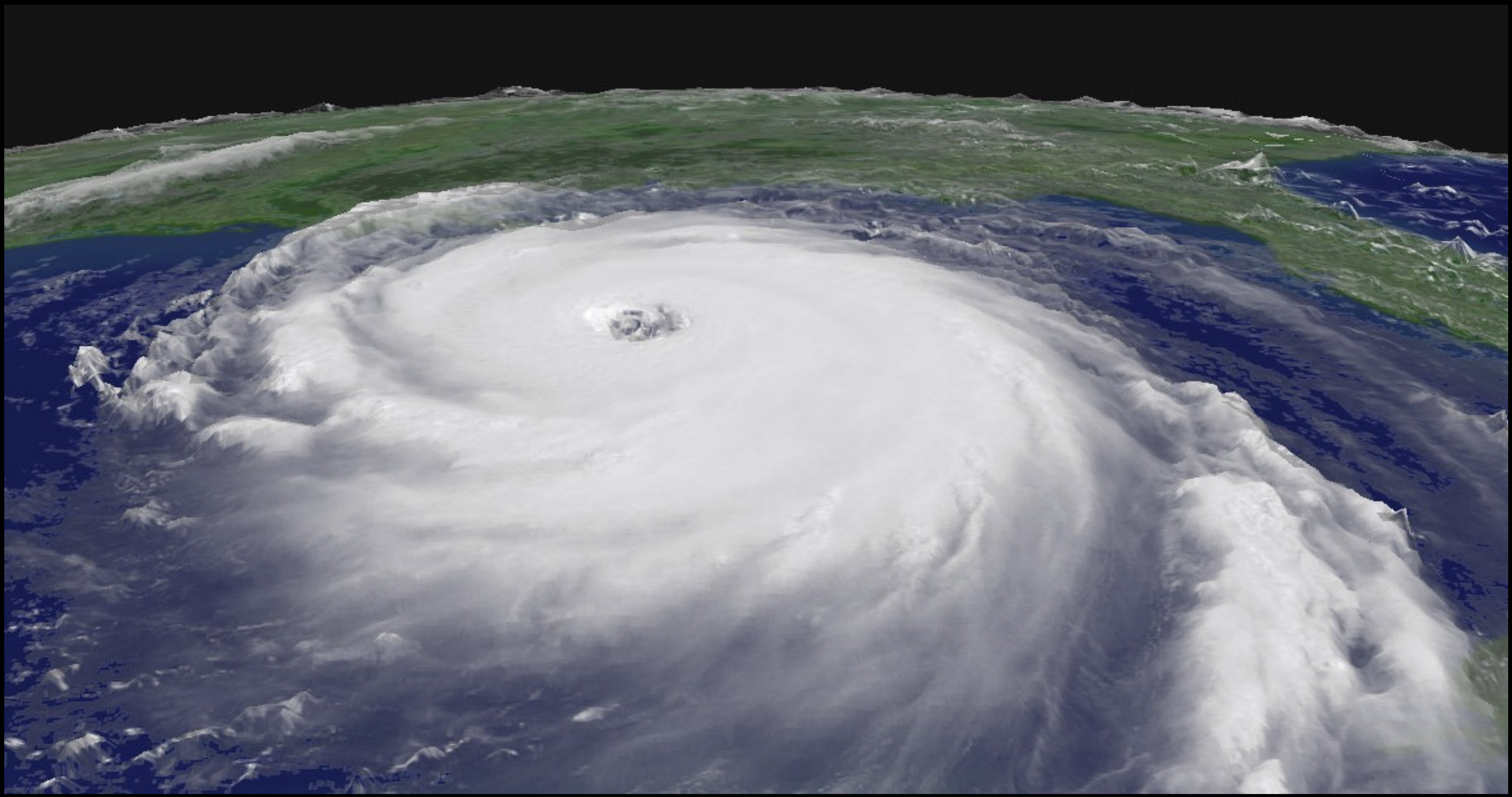
Vertical wind shear **distorts** this process. Suppose we impose a shear directed from left to right on our cloud. By itself, vertical shear makes the cloud want to tilt **downshear**. This horizontally stretches the heating and reduces the pressure gradients and winds.

Hurricane Katrina (2005)



28 August 28 2005, 1545Z (1045 AM CDT)

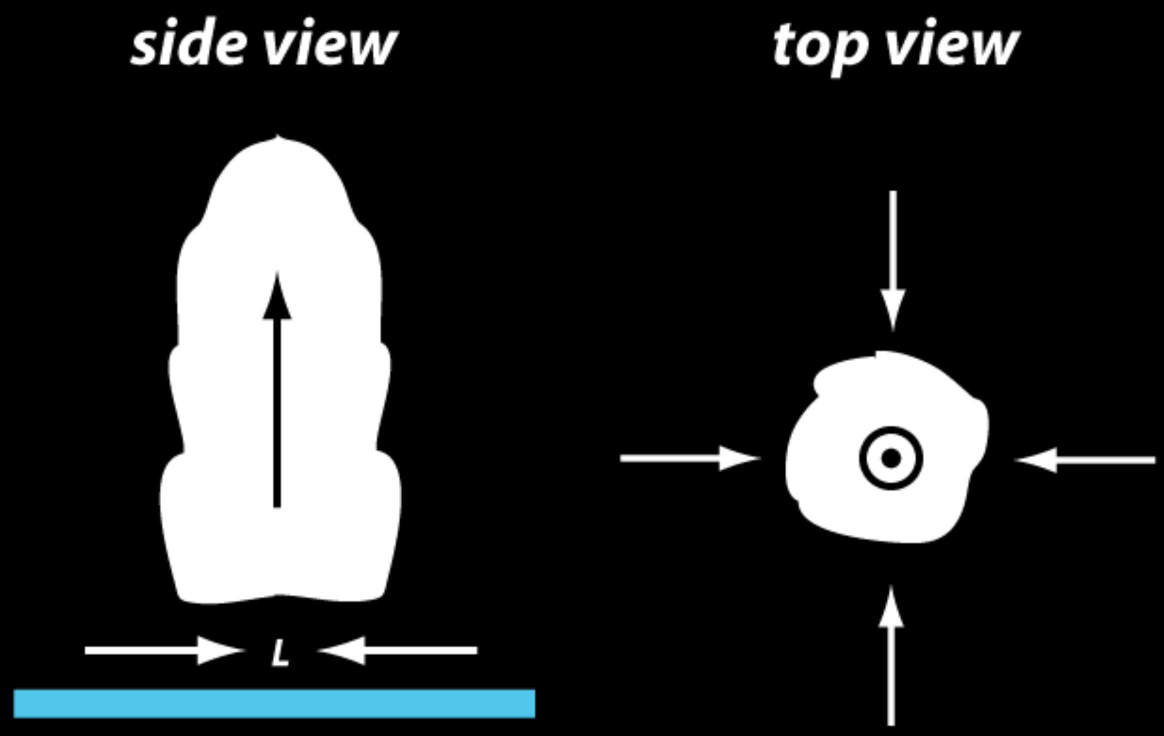

HURCN KATRINA
26.0N 88.1W
1500 UTC TPC PSN
OUTFLOW
BOUNDARY
1016
1012
1010
1008
1004
1000
996
992
988
H
L




http://www.katrina.noaa.gov

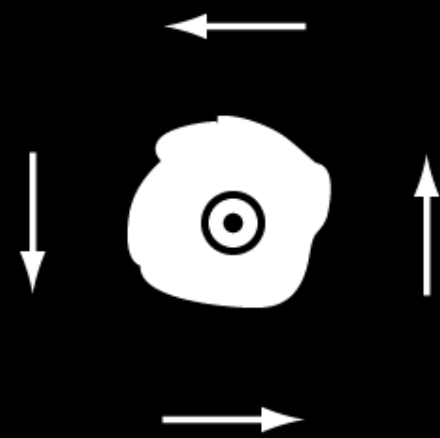
29 August 28 2005, 1915Z (215 PM CDT)

Hurricane eye formation and eyewall slant



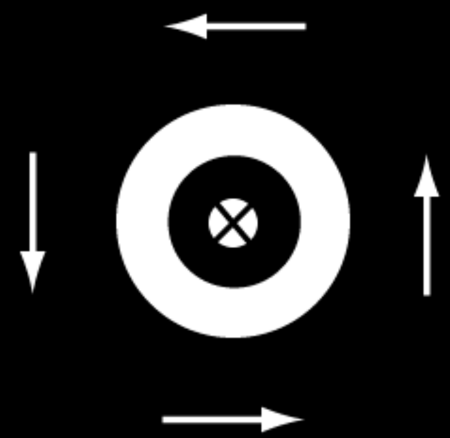
Deep convective cloud complex, side and top views.

top view

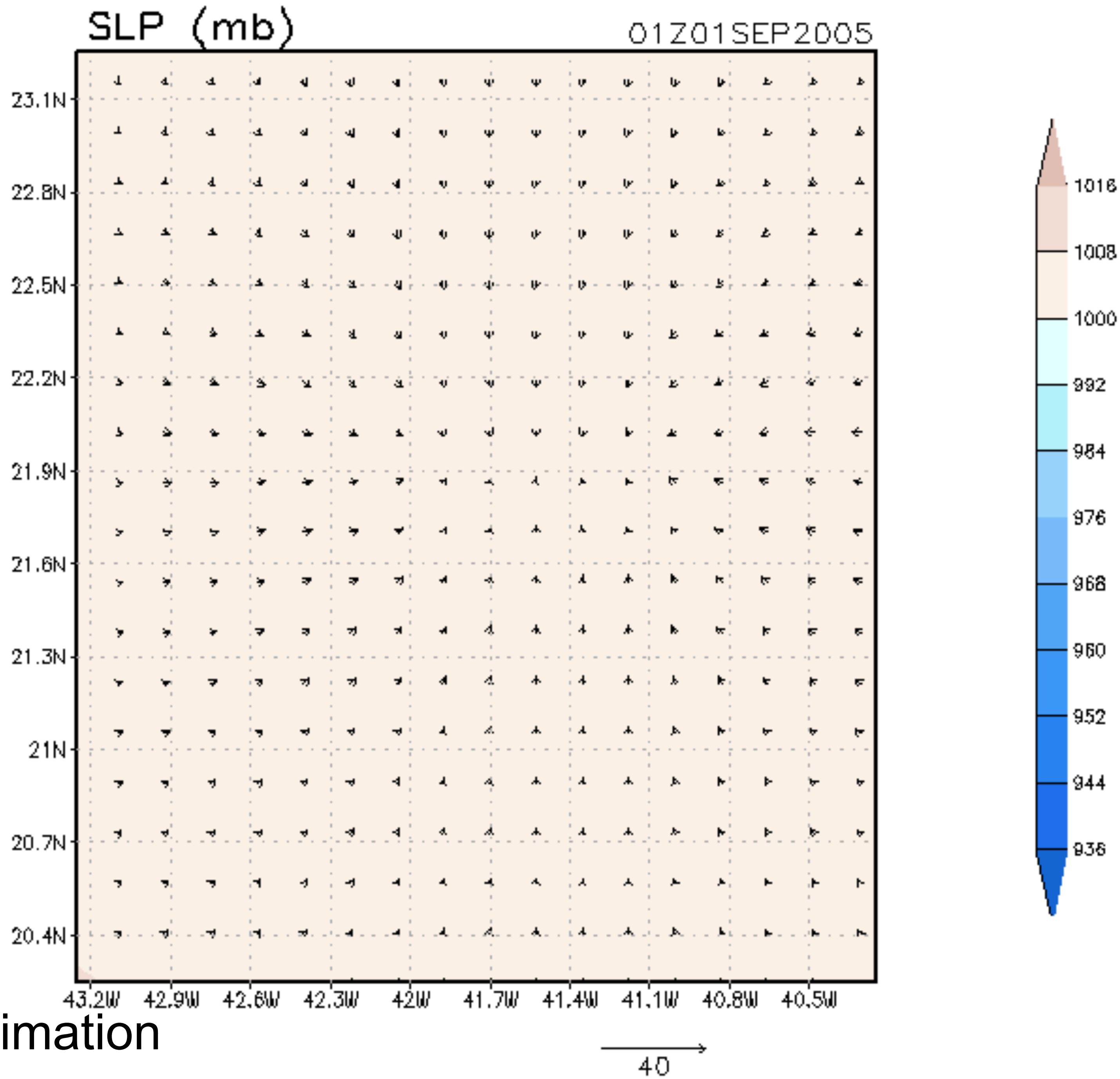


Over time, the Coriolis force will guide the winds into gradient wind balance, with CCW flow around the complex.

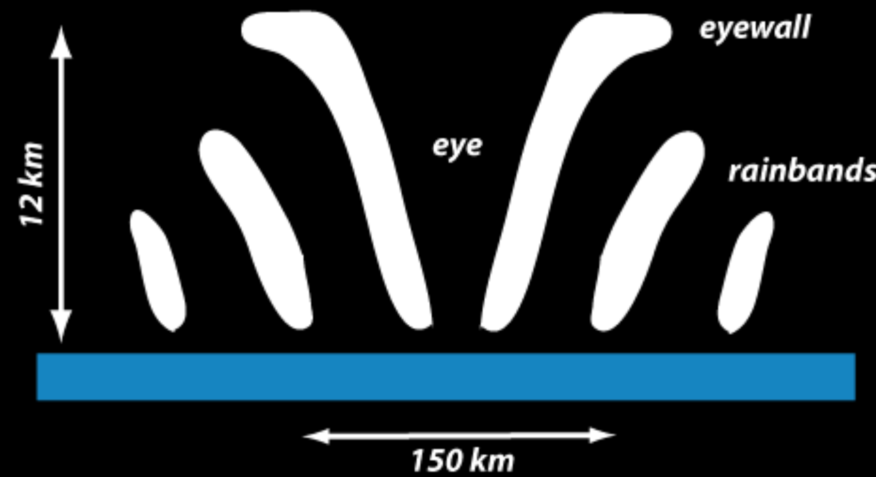
top view



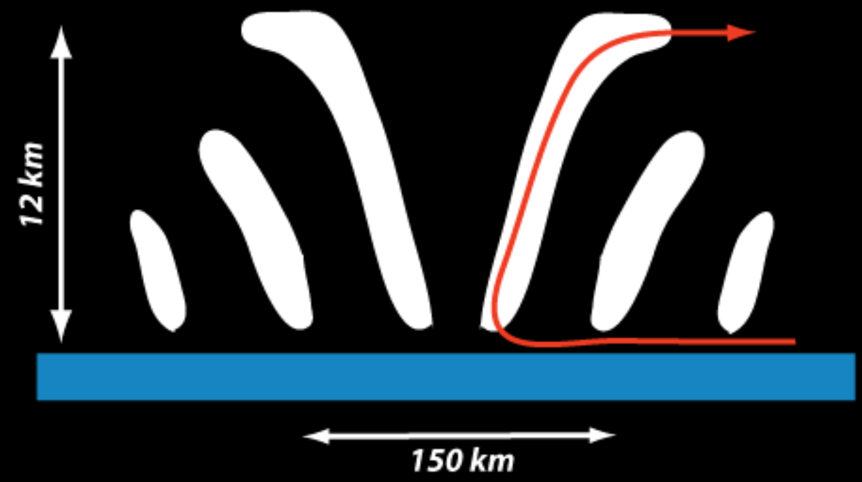
As the spin increases, the **eye** forms. At this time, there's no single accepted theory for why this happens.


SLP (mb)
01Z01SEP2005
23.1N
22.8N
22.5N
22.2N
21.9N
21.6N
21.3N
21N
20.7N
20.4N
43.2W
42.9W
42.6W
42.3W
42W
41.7W
41.4W
41.1W
40.8W
40.5W
1016
1008
1000
992
984
976
968
960
952
944
936
40

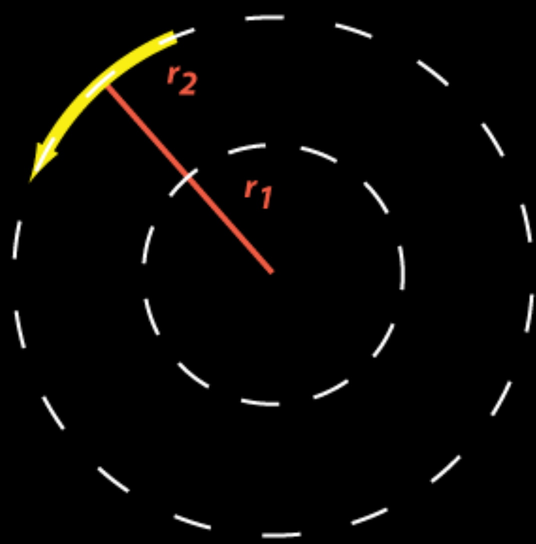
Animation



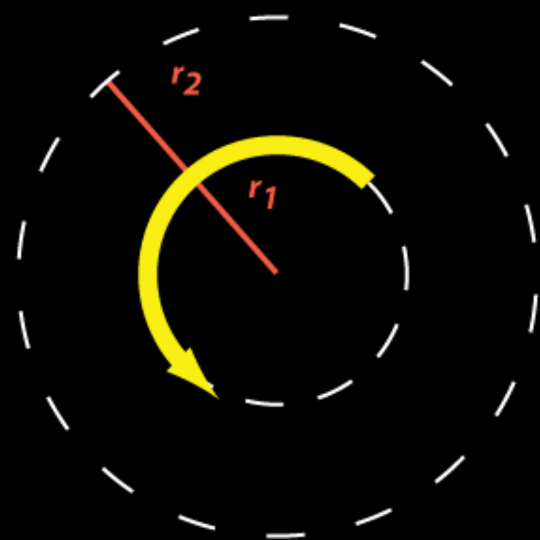
Vertical cross-section through a mature hurricane. The eye is depicted here as a completely cloud-free zone though that's not always true. This eye is about 50 km in diameter, which is close to average.



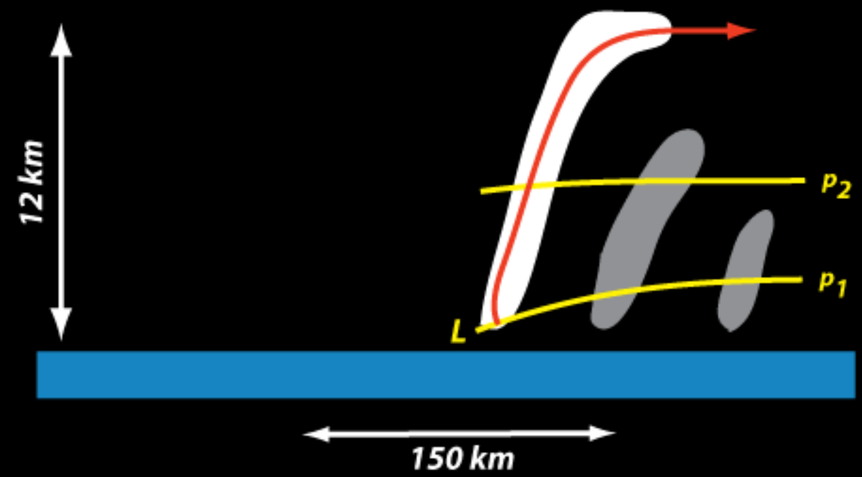
Although most of the flow is circulating cyclonically in the lower troposphere, some air able to enter the storm at low levels, in what we call the radial inflow. This is another “secondary circulation” that is more than secondarily important. Combining this radial inflow with the CCW circulation, the air is spiraling into the hurricane at low levels.



Picture an air parcel circling around the hurricane eye at some radius r2 from the center. It has a radius and a spin velocity. It has angular momentum (AM).



The radial inflow brings the parcel inward, to the eyewall at smaller radius r1. Say its original radius has been cut in half. Its spin velocity has DOUBLED. It has to double, so AM is conserved. The wind speed has increased a lot.



Now this parcel is rising in the eyewall cloud updraft. AM should still be conserved. We’ve even left the surface, and its friction, behind. BUT.. its spin velocity has to **decrease**, so it has to move **outward**, to increase its radius. This makes the eyewall tilted.

[end]