

Clouds:
stable and otherwise

Syllabus for ESS 17:

“Dinosaur paleontology is the most interesting scientific discipline. Of course, those teaching other courses might think their material is the most interesting. But the others are wrong.”

Syllabus for ESS 17 (**corrected**):

“Atmospheric convection is the most interesting scientific discipline. Of course, those teaching other courses might think their material is the most interesting. But the others are wrong.”



"As one watches them (clouds), they don't seem to change, but if you look back a minute later, it is all very different."

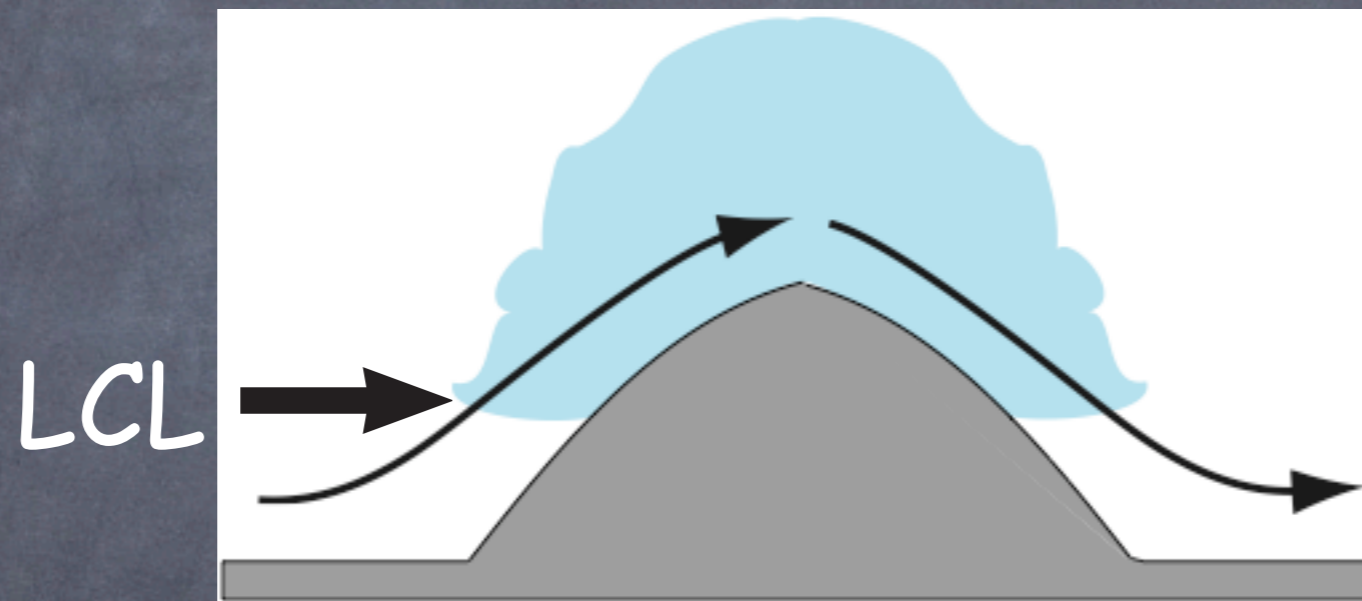
- Richard P. Feynman

Note how swiftly the clouds are moving,



...but cloud base doesn't move much and
wind in foreground is nearly calm

Air forced to rise on windward side
brought to saturation

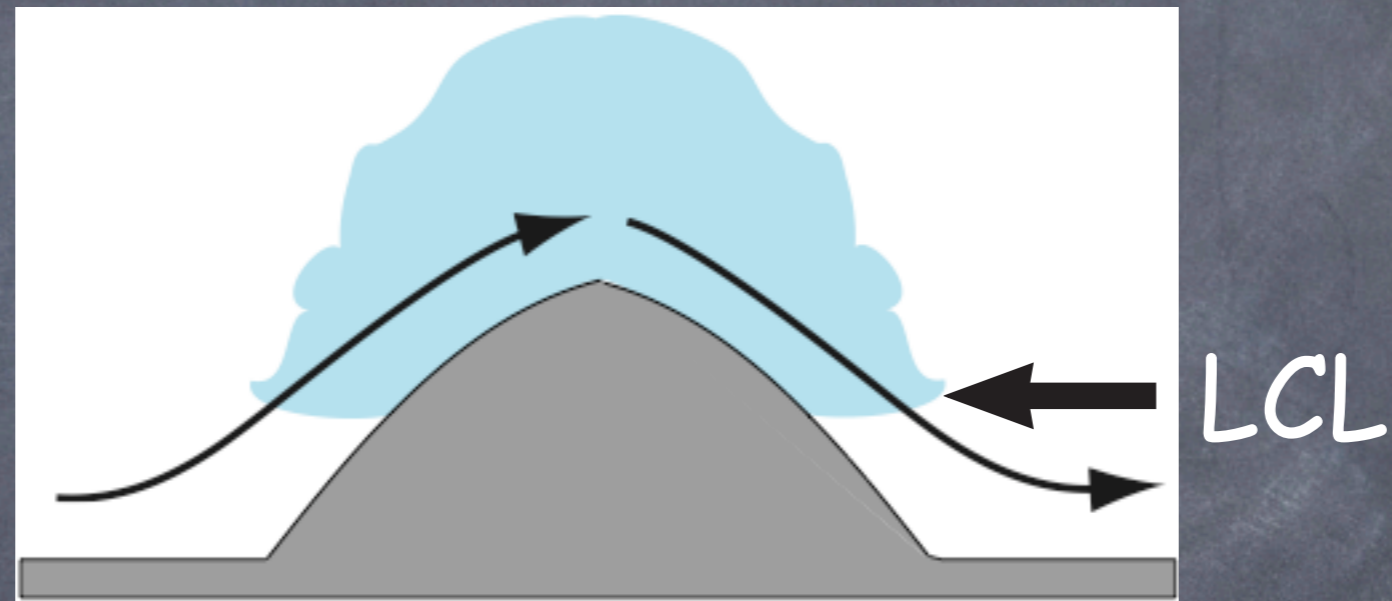


Air ascends @ DALR 'till saturation,
@MALR thereafter



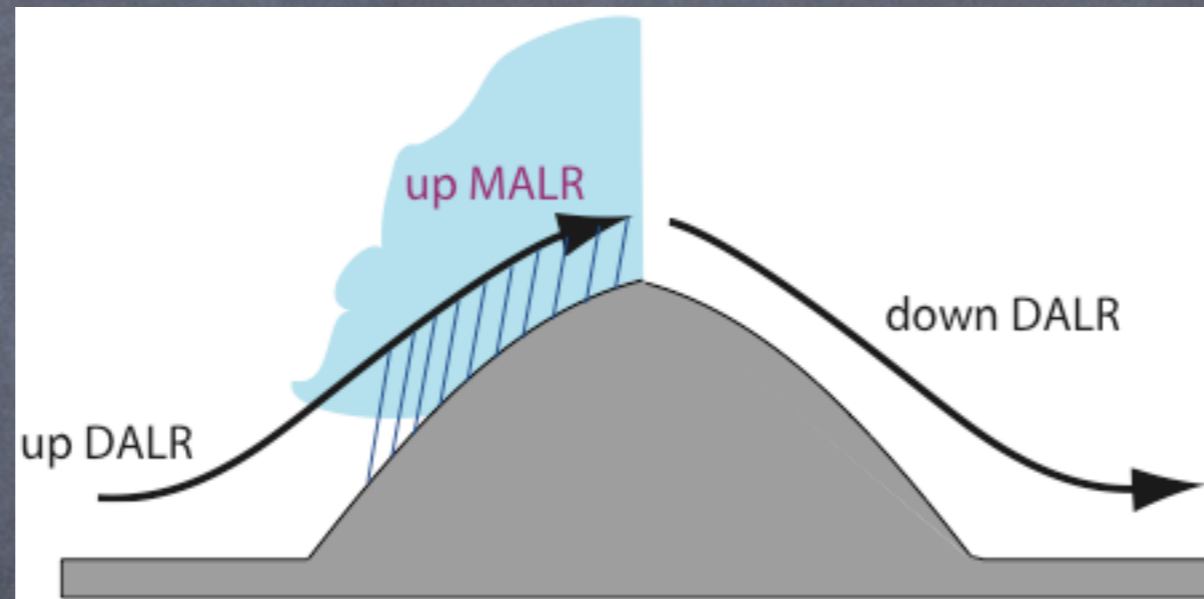
Cap cloud on Mt. Rainier

<http://cargsun2.atmos.washington.edu/sys/waveclouds.html>



If parcel doesn't lose condensed water,
process works in reverse on lee side.

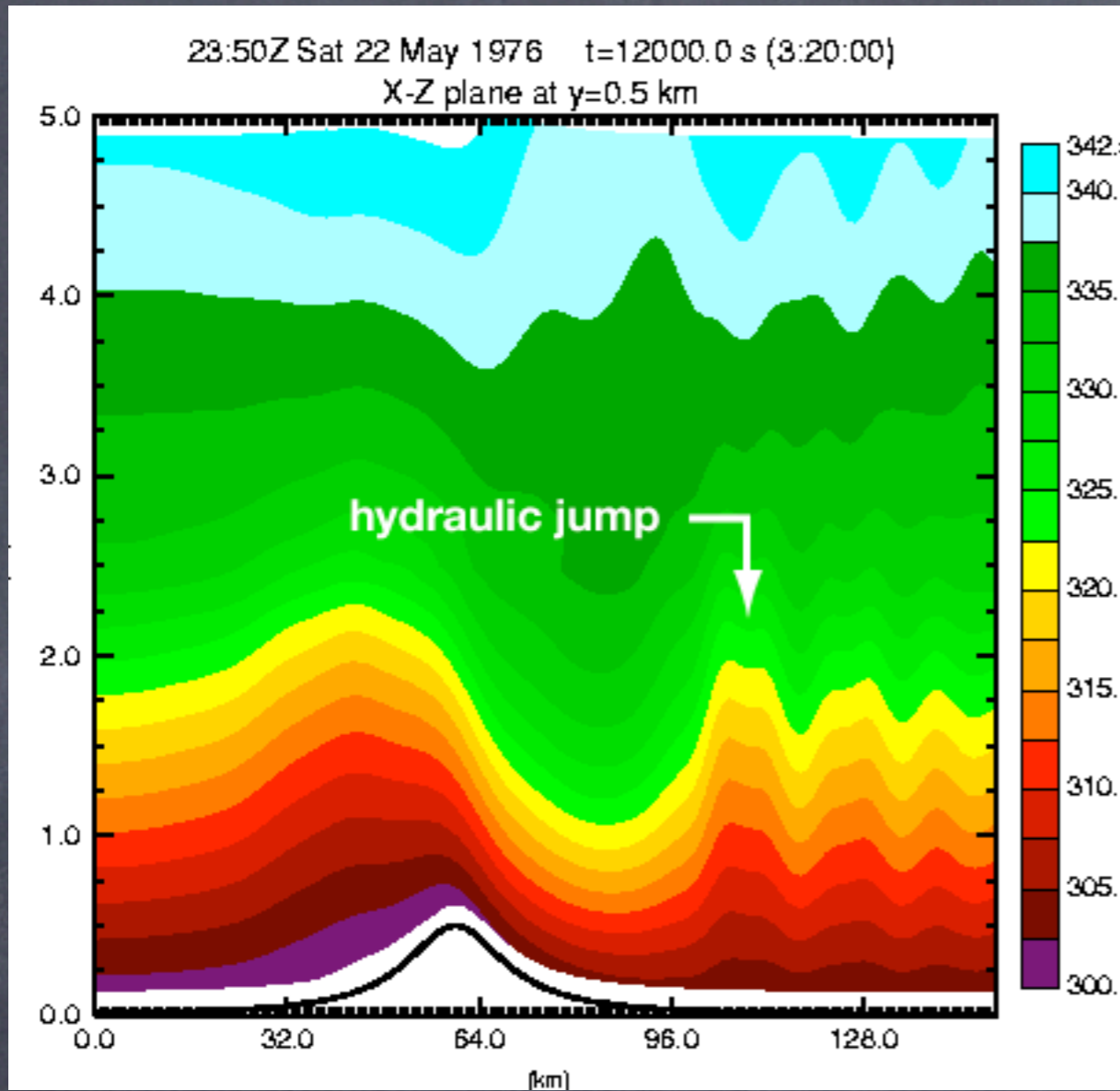
Parcel recovers same T , VS .



If the parcel loses its condensed water, it goes down the lee slope dry adiabatically, winding up **warmer** and **drier** than it started



relatively calm a few miles from foothills...



Owens Valley, CA



Hydraulic jump topped by clouds
(wind blowing to left)

<http://www.atmos.washington.edu/atlas/Houze.1.23.gif>



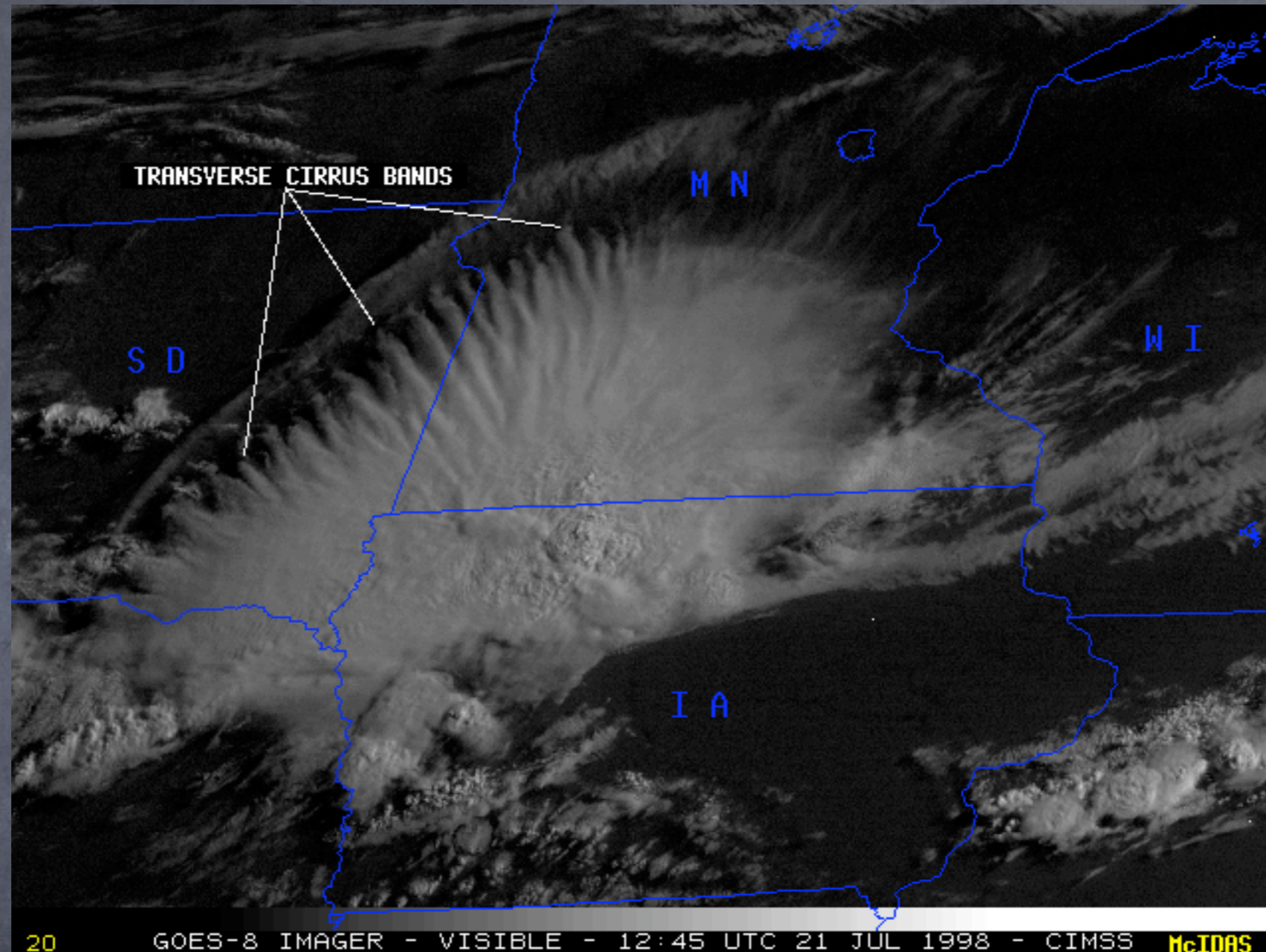
Buoyancy oscillations made visible
by clouds

<http://www.atmos.washington.edu/atlas/17.301.150.gif>



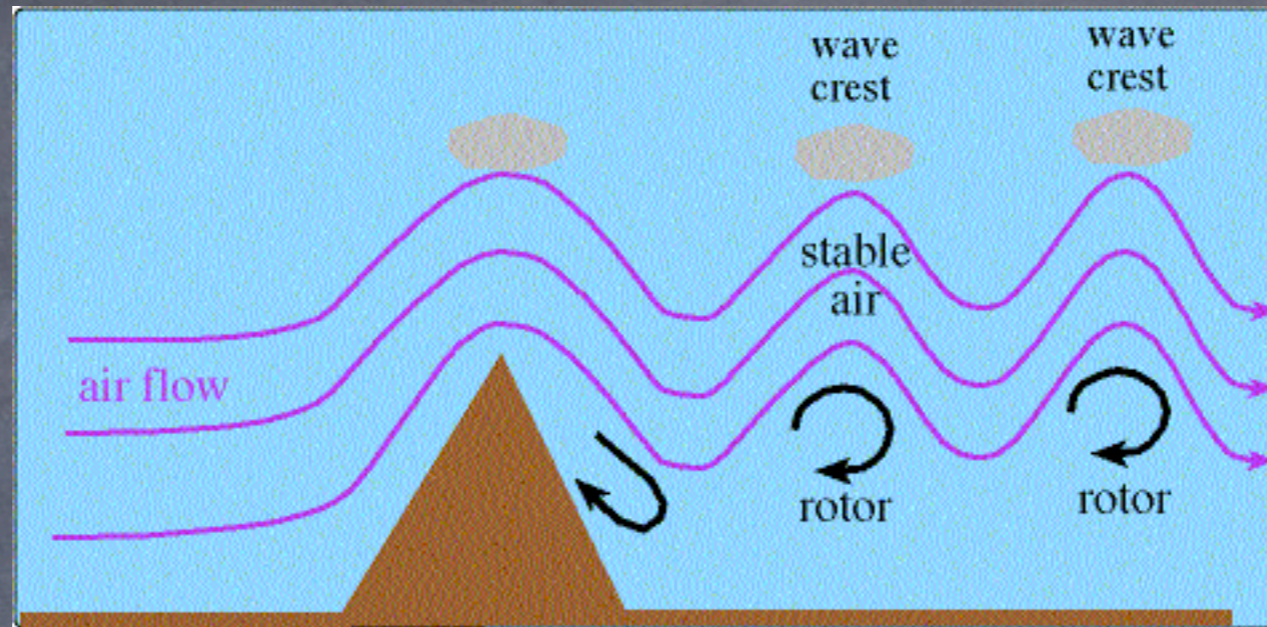
More buoyancy oscillations

<http://www.photolib.noaa.gov/historic/nws/wea00039.htm>

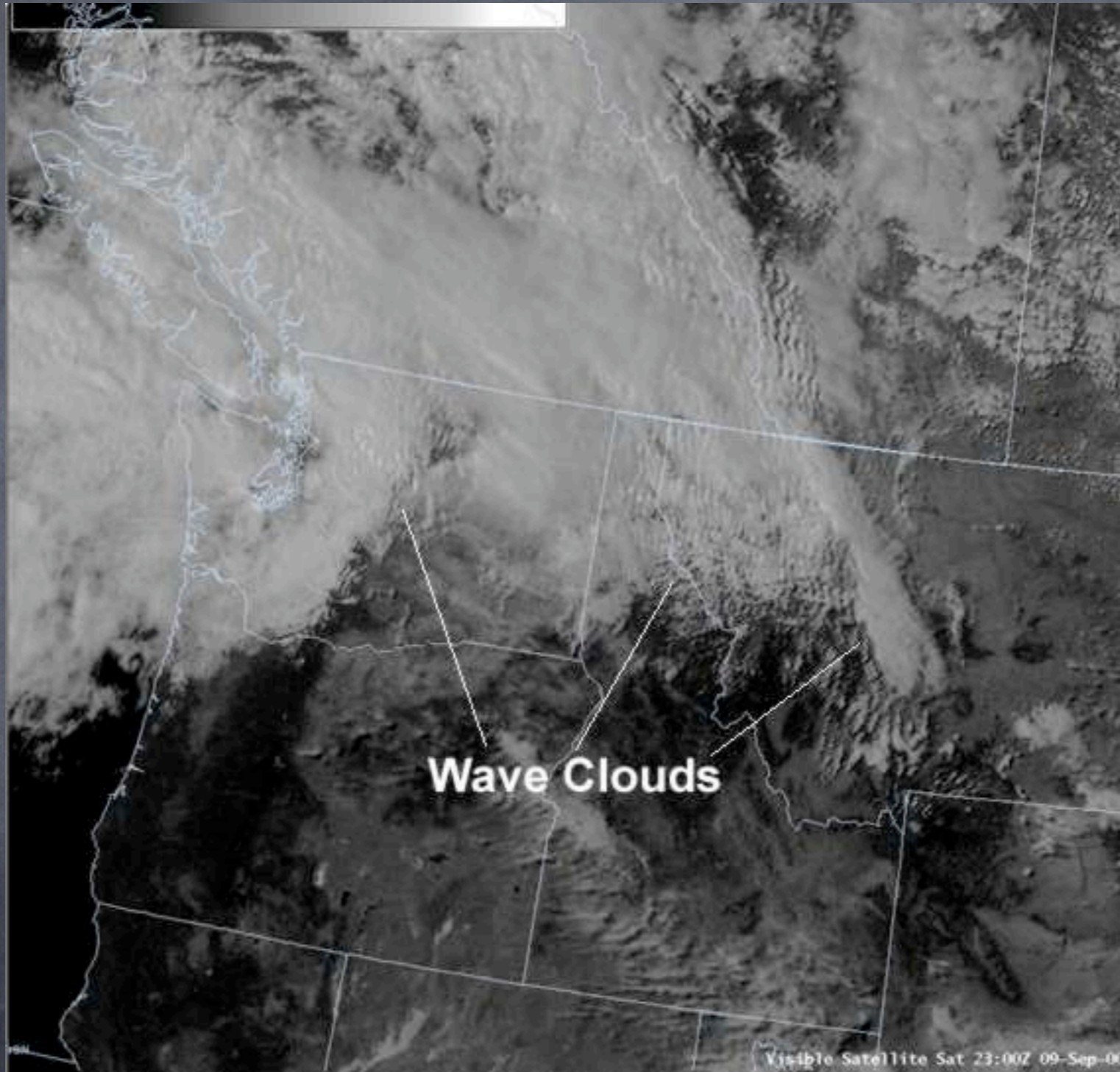


Buoyancy oscillations near storms

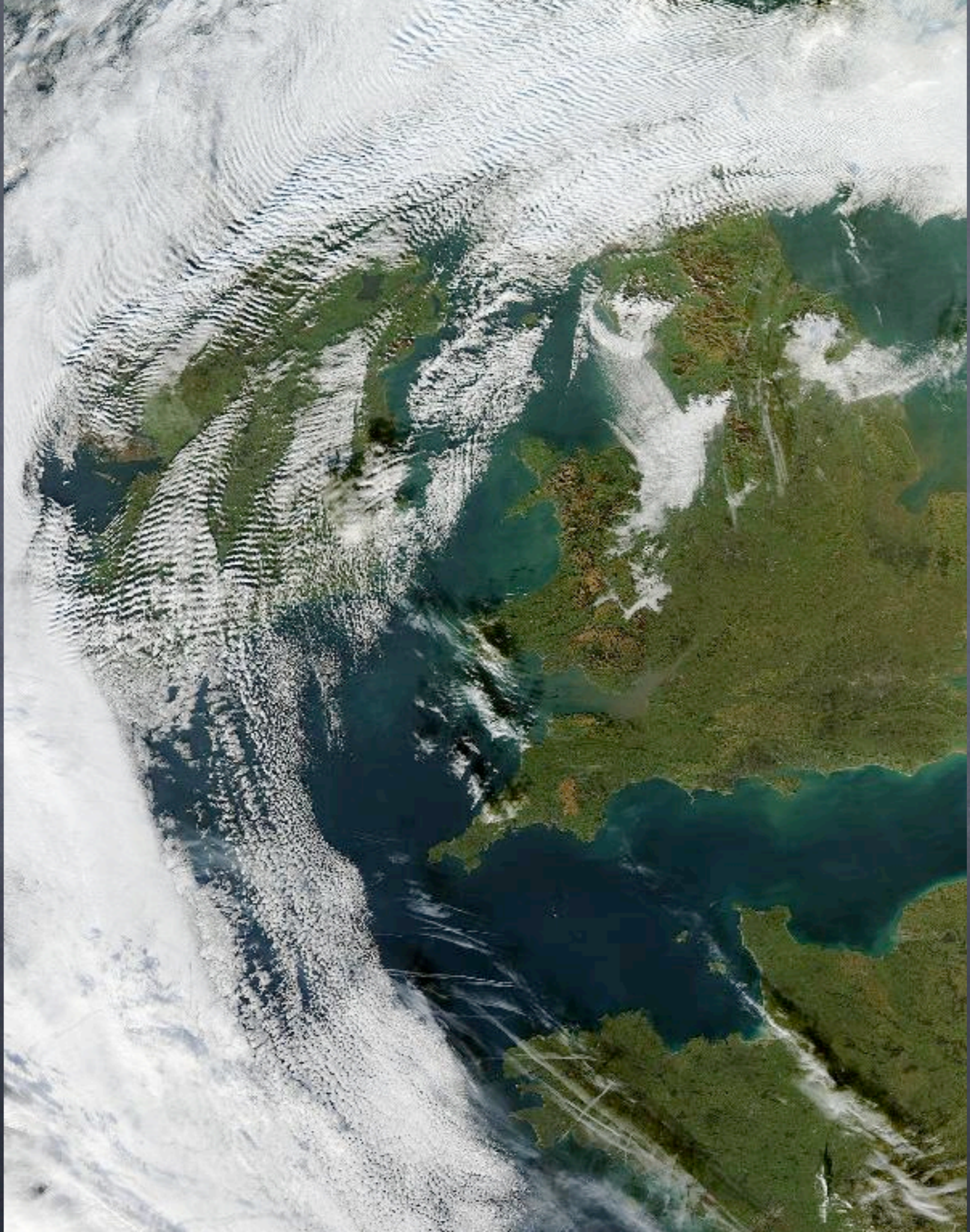
http://cimss.ssec.wisc.edu/goes/misc/980721_1245_vis.GIF



Mountain wave clouds,
buoyancy oscillations forced by orographic lifting



http://www.wrh.noaa.gov/spokane/pix_month/waves.htm





More mountain wave clouds

<http://www.photolib.noaa.gov/historic/nws/wea00108.htm>



Roswell, NM ????????

Sometimes they look like flying saucers

<http://www.photolib.noaa.gov/historic/nws/wea00010.htm>



Mt. Rainier, WA

...or a stack of saucers

http://www.phototripusa.com/Images/rwarfield/rw_3843_12.html



...other times like rolls or tubes

<http://www.photolib.noaa.gov/historic/nws/wea00013.htm>



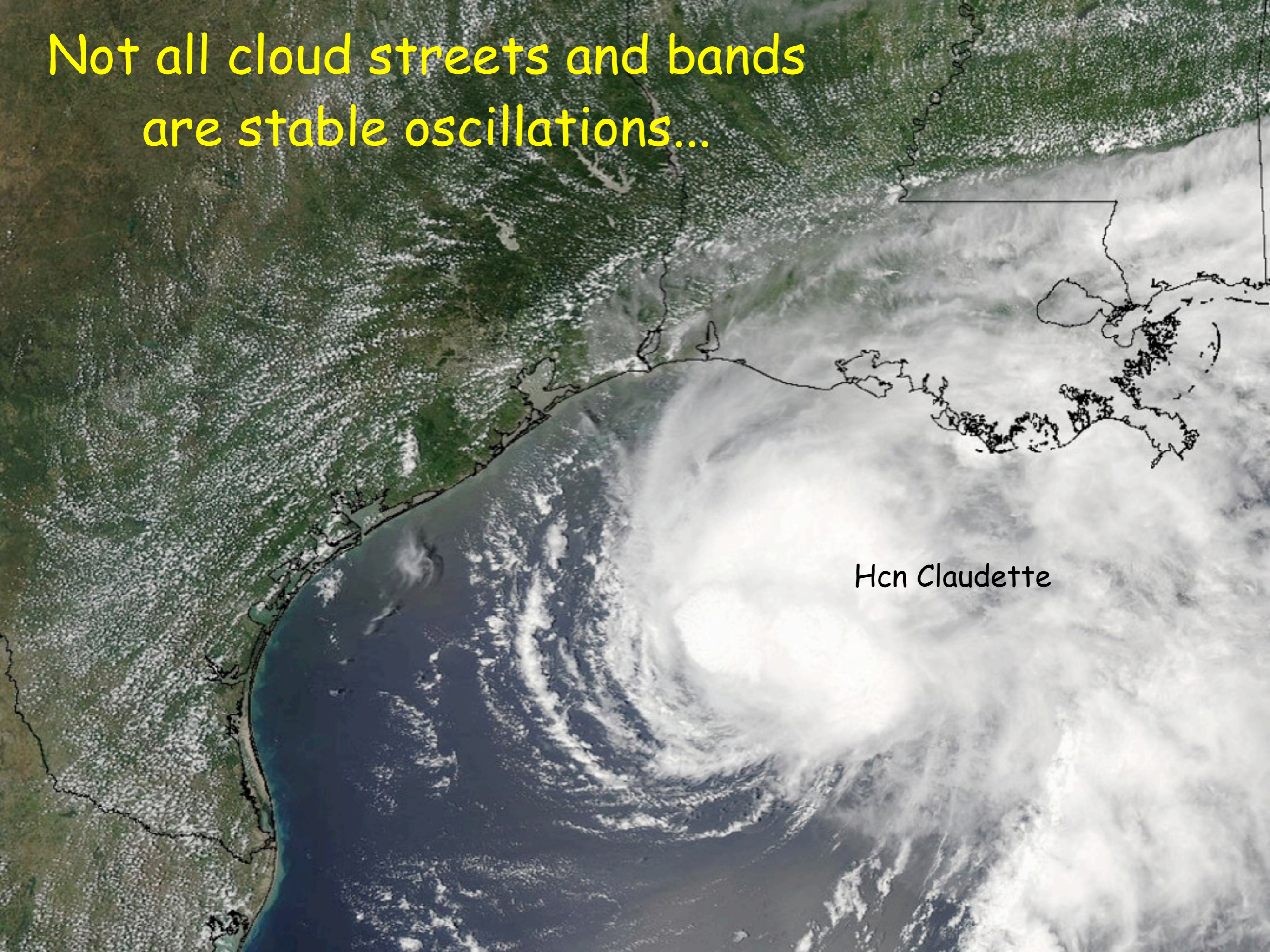
...or something in between

<http://www.photolib.noaa.gov/historic/nws/wea00011.htm>

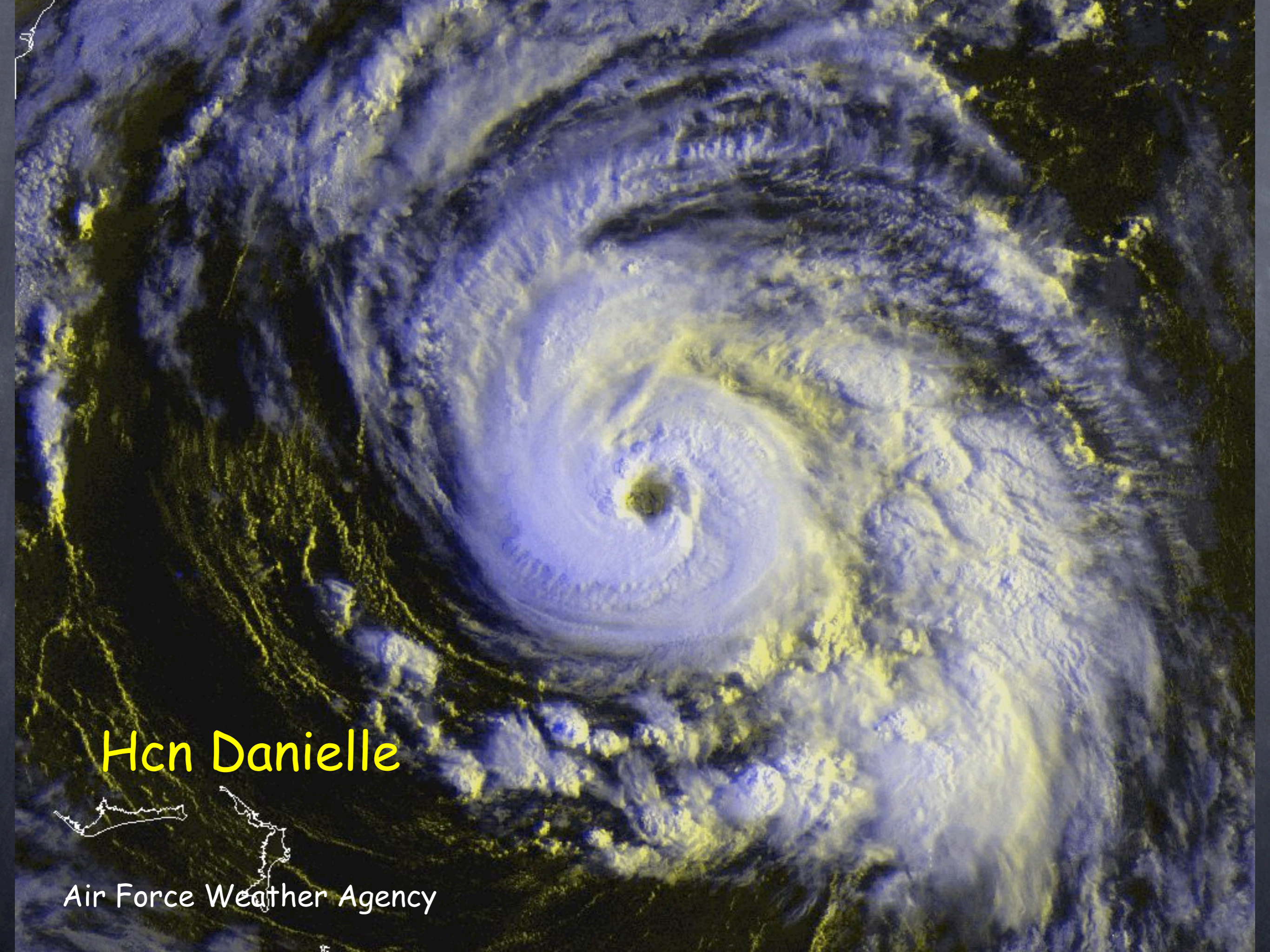
Enough of clouds in stable atmospheres.

Time for some **instability**

Not all cloud streets and bands
are stable oscillations...



Hcn Claudette

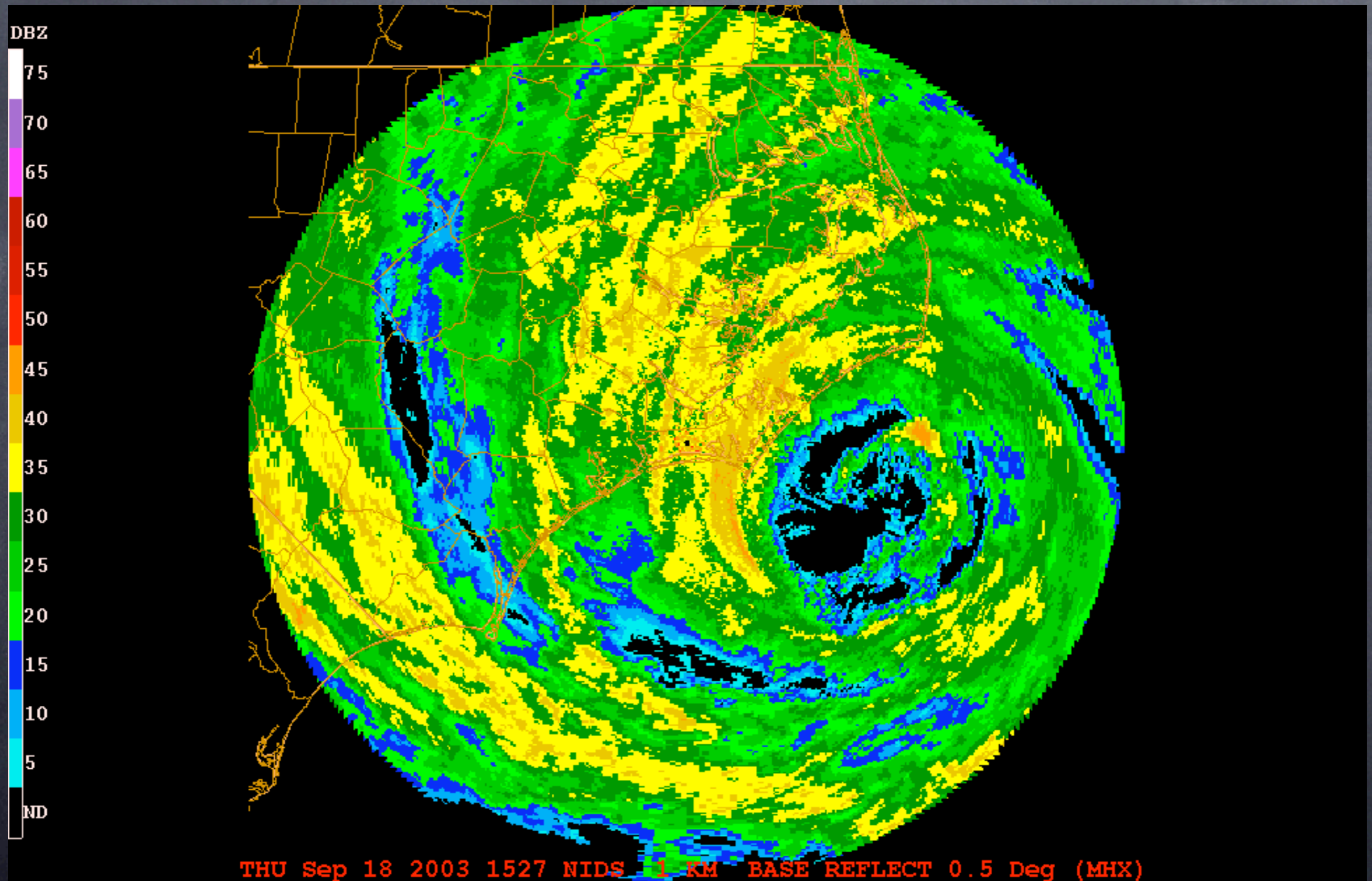


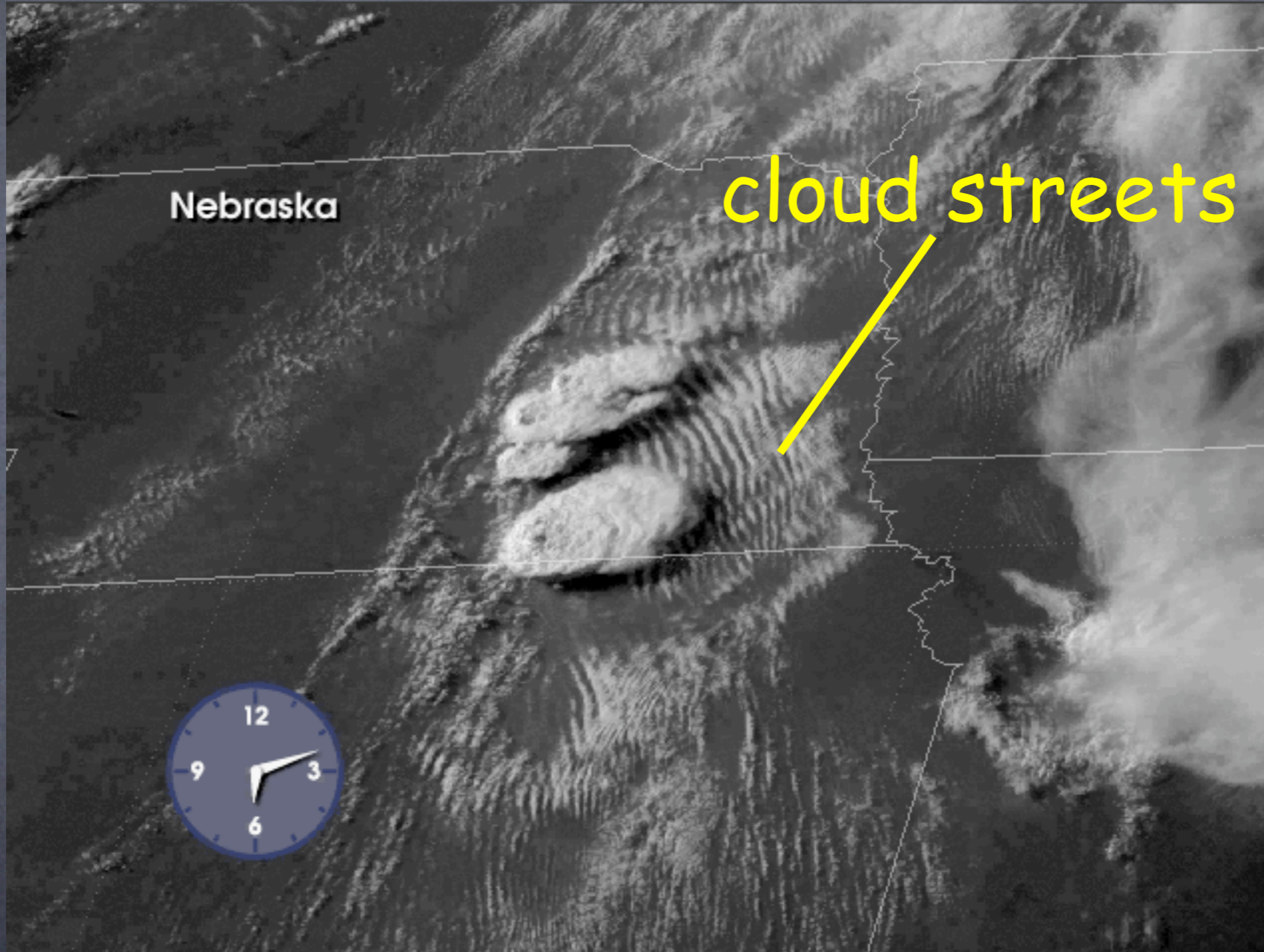
Hcn Danielle



Air Force Weather Agency

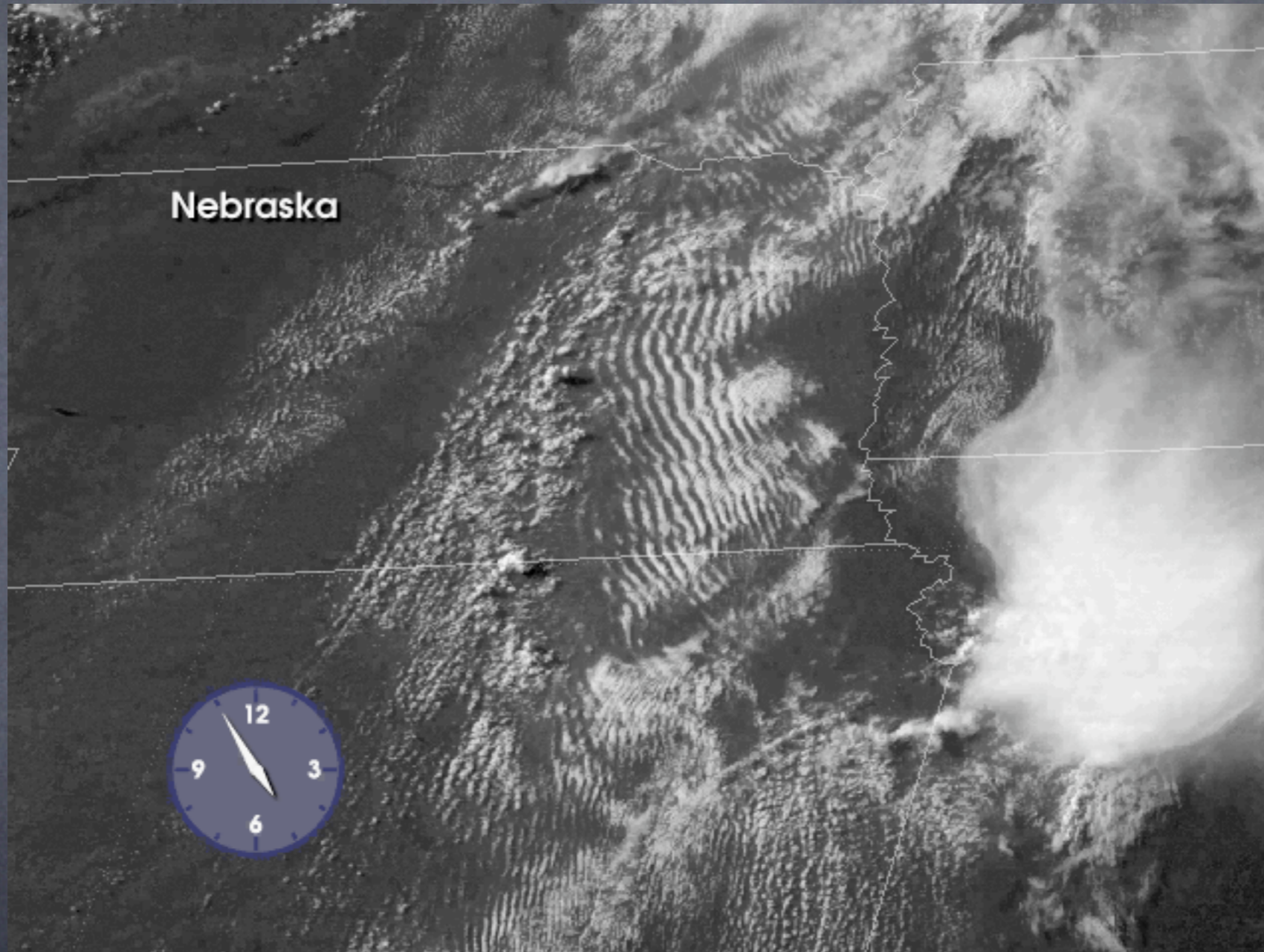
Hurricane Isabel on radar: note spiral bands





Thunderstorms build over Nebraska

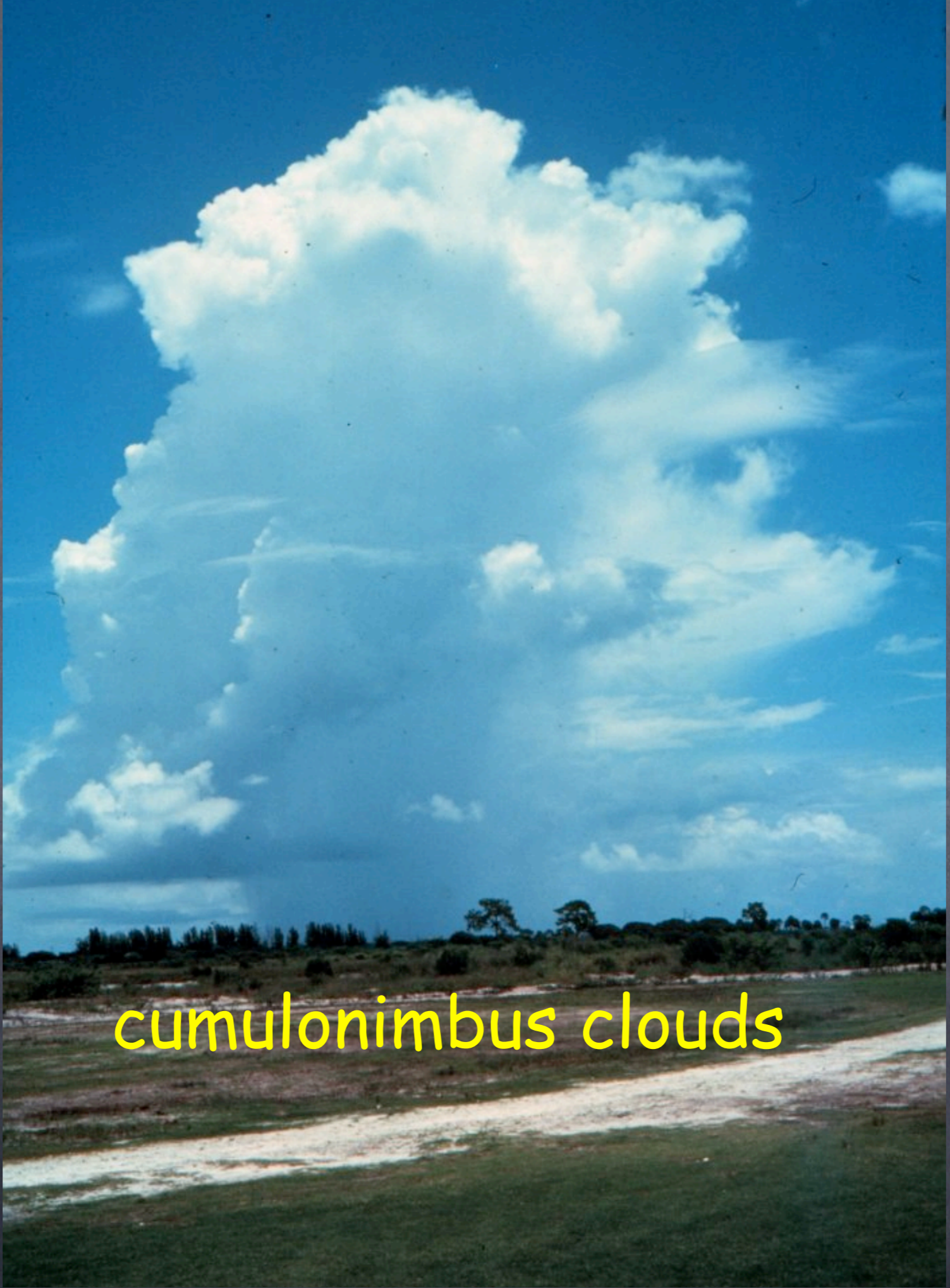
Courtesy of Jim Doyle, Naval Research Lab



Courtesy of Jim Doyle, Naval Research Lab

“Anyone who has been in a thunderstorm has enjoyed it, or has been frightened by it, or at least has had some emotion. And in those places in nature where we get an emotion, we find there is generally a corresponding complexity and mystery about it.”

– Richard P. Feynman



cumulonimbus clouds

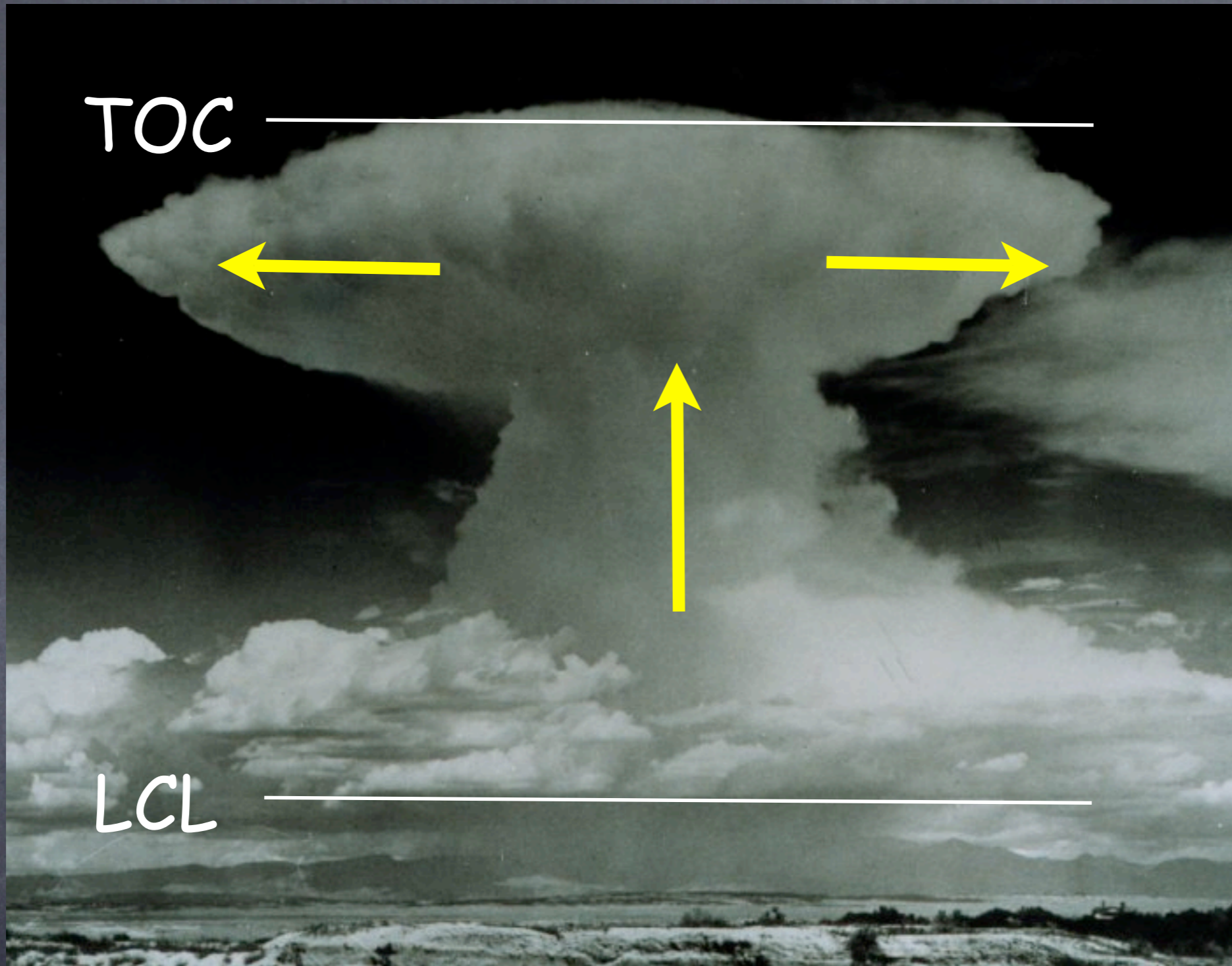


<http://www.photolib.noaa.gov>



sometimes isolated...

<http://www.photolib.noaa.gov/historic/nws/wea00031.htm>



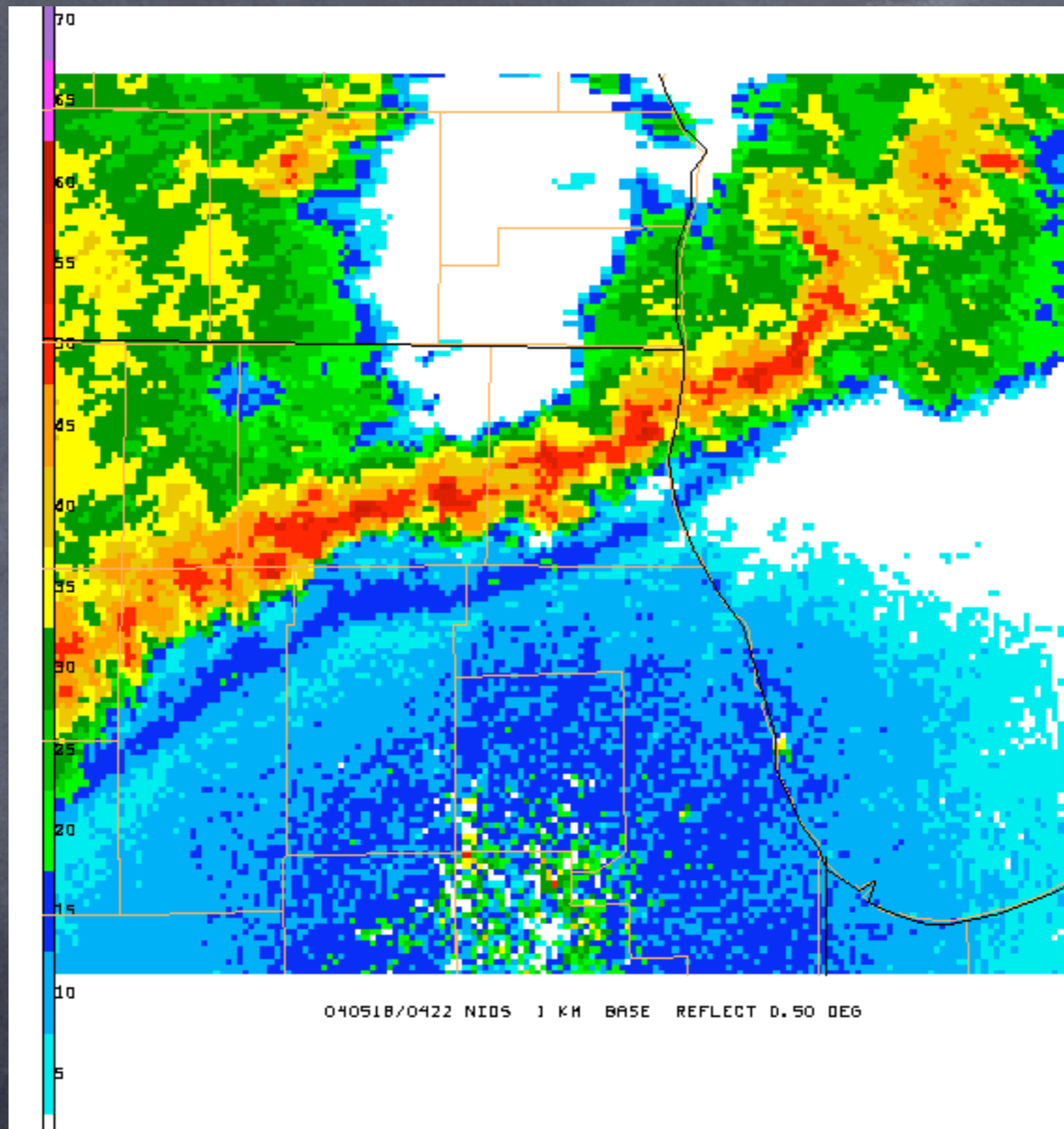
sometimes isolated...

<http://www.photolib.noaa.gov/historic/nws/wea00031.htm>



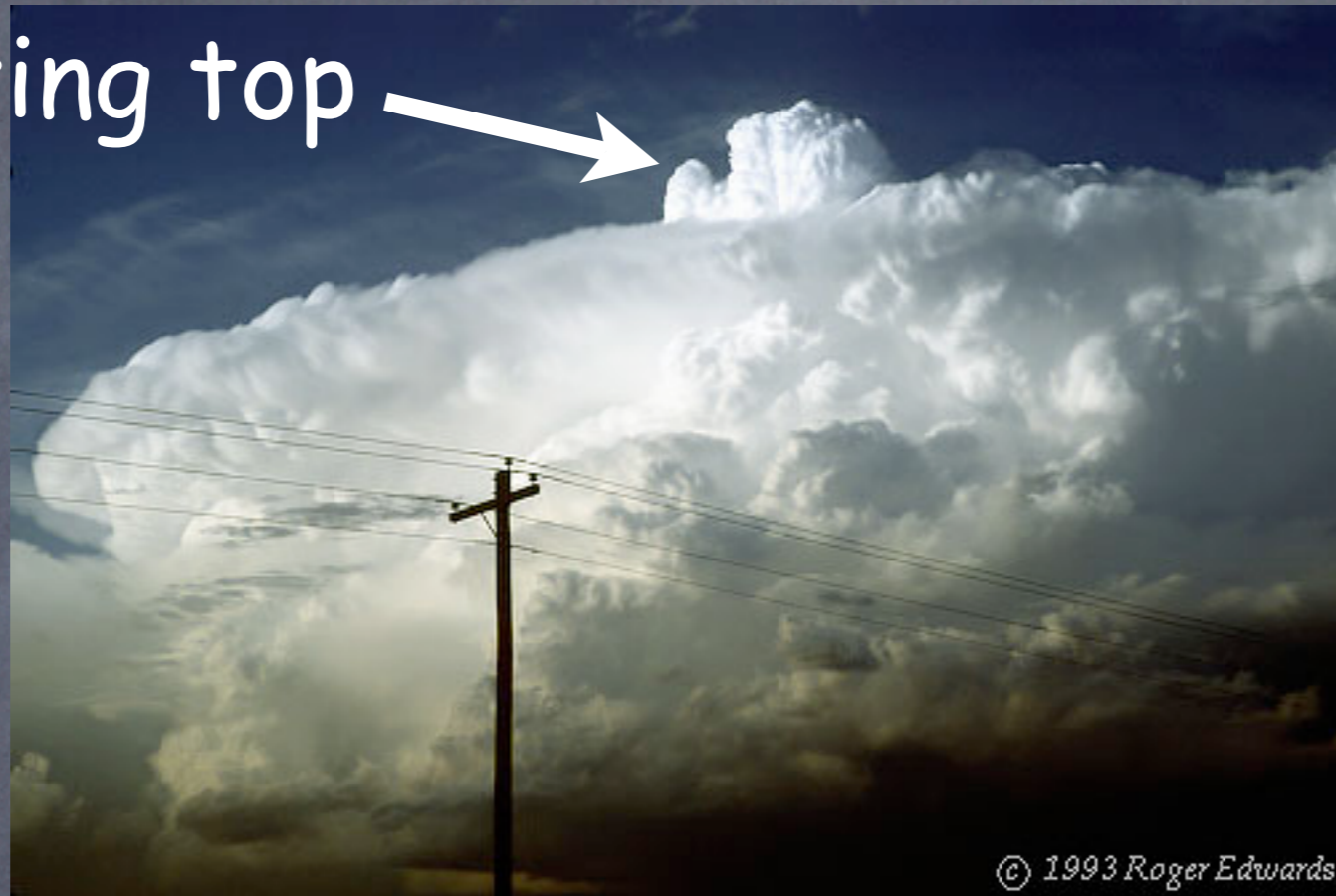
...sometimes in lines...

<http://www.photolib.noaa.gov>



A line of storm cells on radar (note gust front)

overshooting top →



The "supercell" thunderstorm

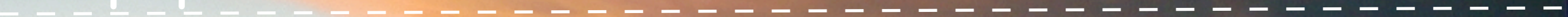
<http://www.stormeyes.org>



overshooting top



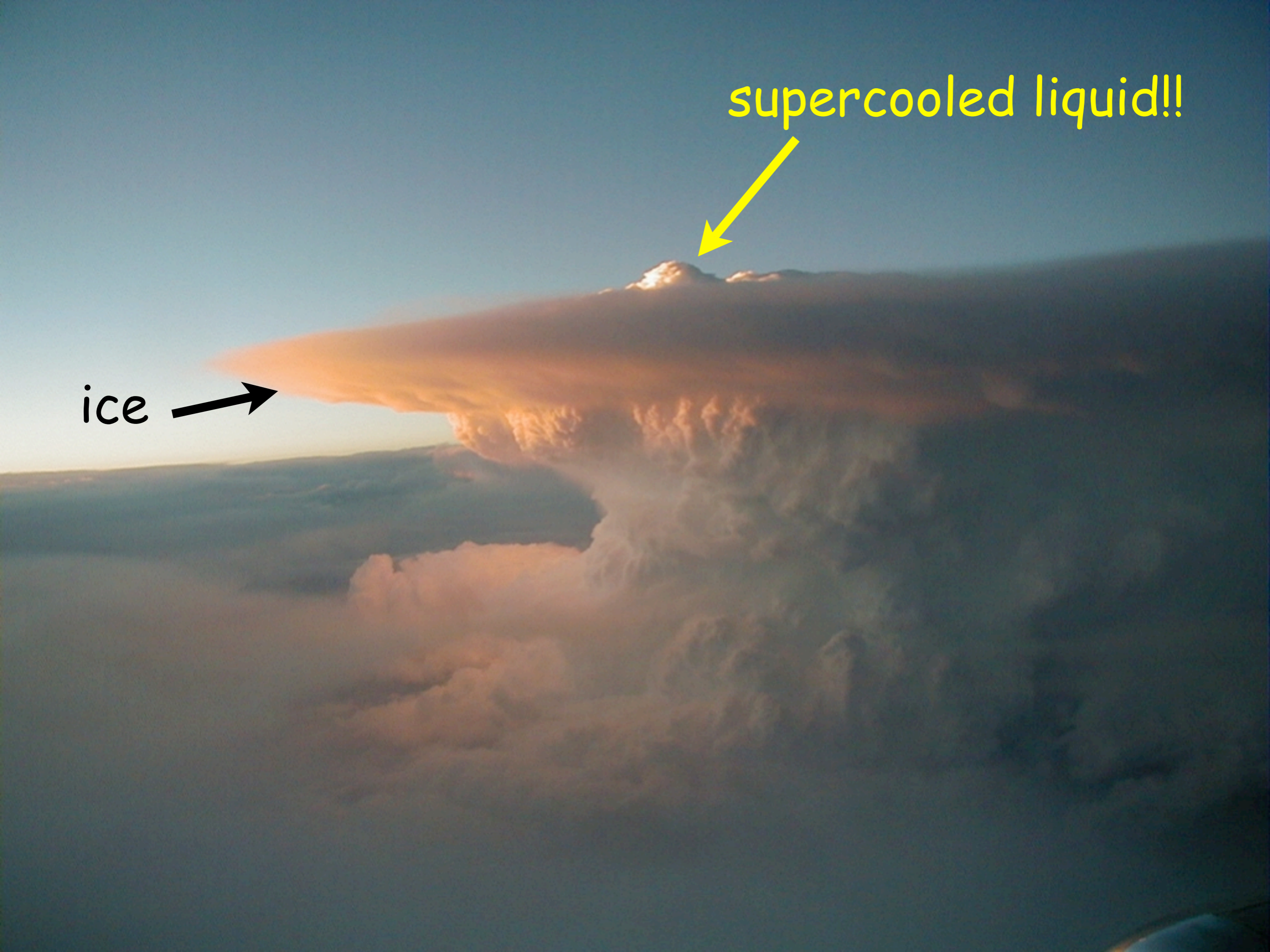
tropopause



supercooled liquid!!



ice →



© 2002 Roger Edwards



Heavy precip beneath a supercell

<http://www.stormeyes.org>



Sometimes a portion of the cloud base lowers...
forming the "wall cloud"

<http://www.ajfroggie.com/wxpics/cb/>



The supercell actually rotates, and the portion
with the wall cloud rotates **faster**

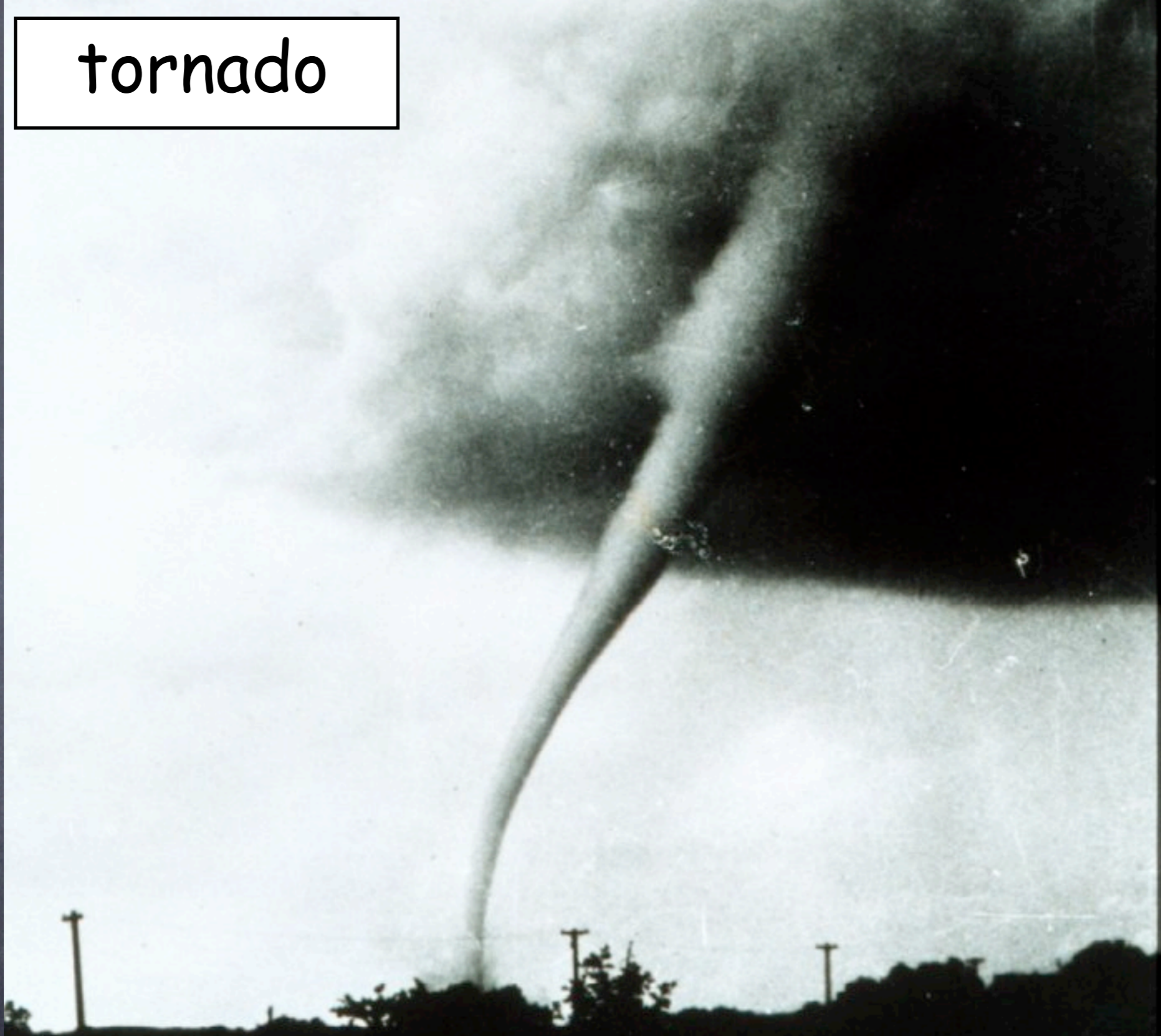
<http://www.stormeyes.org>



And part of the wall cloud develops
faster rotation still...

<http://www.stormeyes.org>

tornado



1949 Manhattan, KS

<http://www.photolib.noaa.gov/historic/nws/wea00214.htm>



wall cloud

condensation funnel



1949 Manhattan, KS

<http://www.photolib.noaa.gov/historic/nws/wea00214.htm>



Tornado and wall cloud

<http://www.stormeyes.org>



<http://www.photolib.noaa.gov>

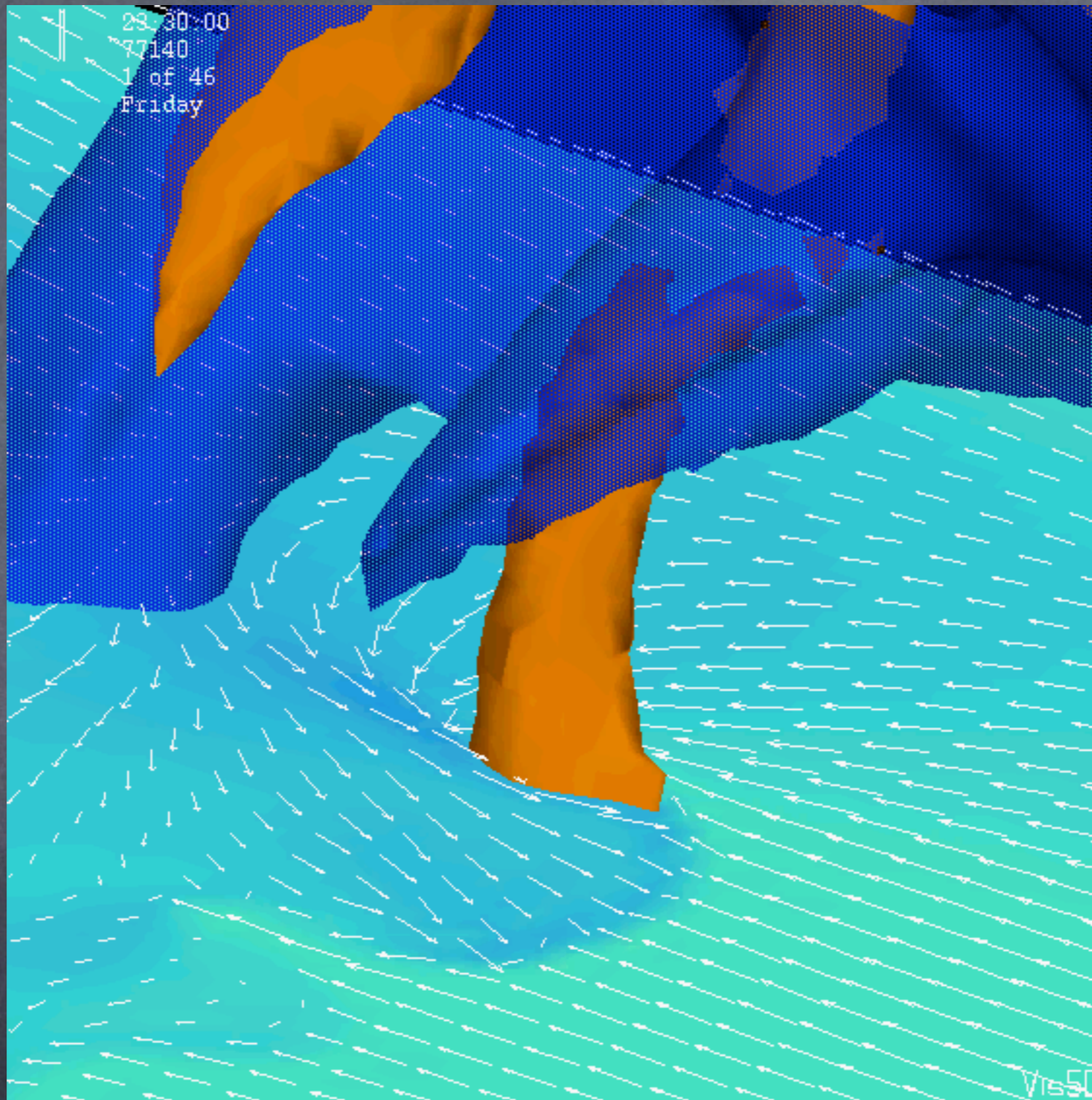


Miami, FL tornado

<http://hpccsun.unl.edu/nebraska/tornadoes-NDS99photos.html>



Movie: Brian Jewett,
University of Illinois



Simulation:
Robert Fovell, UCLA



Tornado damage

<http://www.photolib.noaa.gov>

21 April 1967

The day I became a meteorologist...



Joe Martin

THE 1967 OAK LAWN
TORNADO

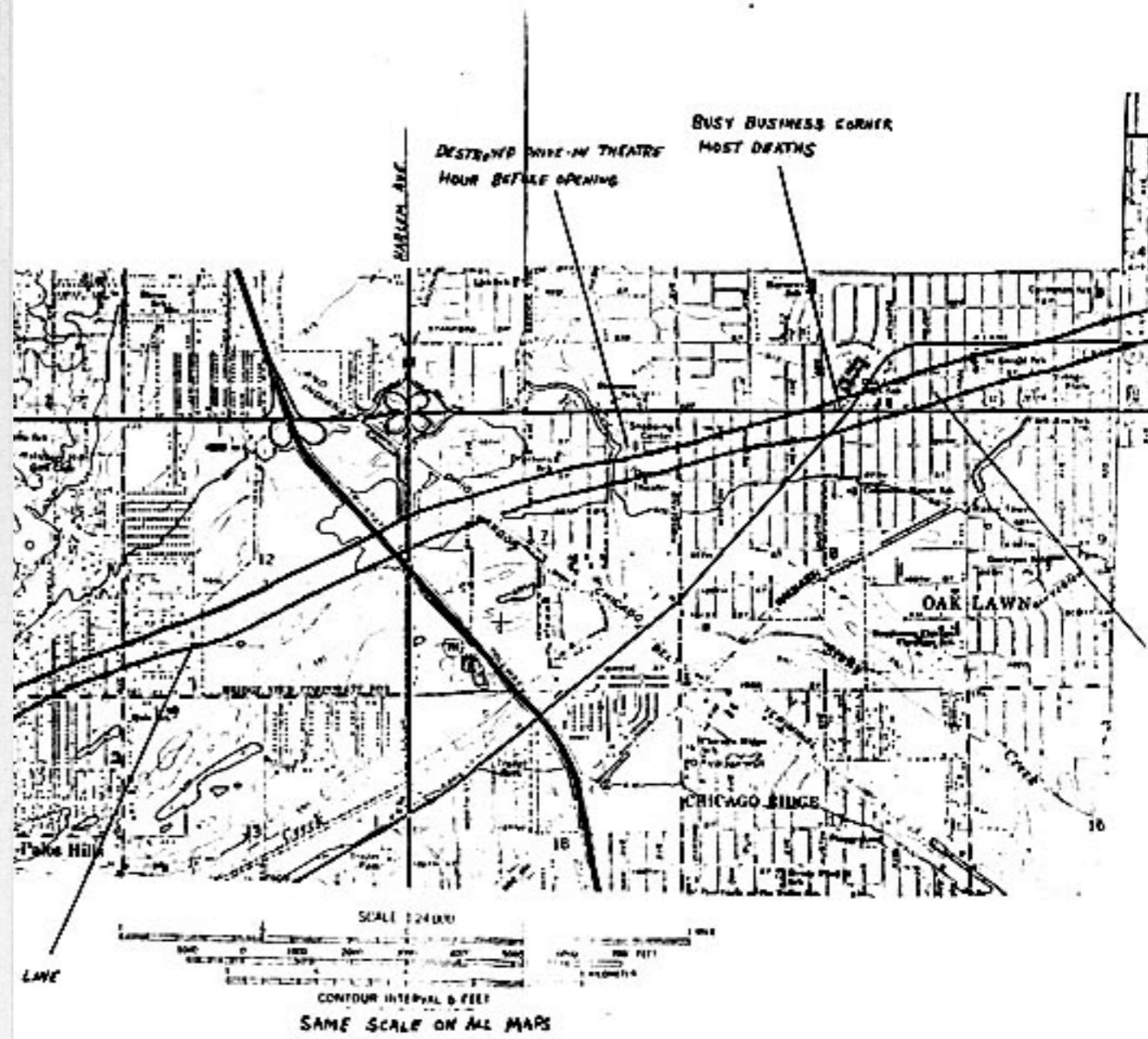
The tornado that ripped through the Fairway Supermarket, Marshall's Hotel, the Sherwood Forest Restaurant, Stein's Lakewood Lounge and collapsed the roof and tore a large section out of the high school's new swimming pool. While estimated to be as much as 600 mph, it tore into the Sherman Gas Station and the nearby Sherman Bus Company depot where they tossed buses and cars like small toys, smashing three buses and one other. A total of 18 deaths occurred in this area alone. Many occurred among persons whose cars, after having been



<http://www.lib.oak-lawn.il.us/documents>

OAK LAWN TORNADO

MAP # 1



21 April 1967
Oak Lawn, Illinois
(my hometown)

Lightning



<http://www.chaseday.com/lightning.htm>

<http://www.stormeyes.org>



<http://www.photolib.noaa.gov>



Lightning bolt temperature: 50,000°F

<http://www.photolib.noaa.gov>



<http://www.chaseday.com/lightning.htm>



Hail

<http://www.tornadoexpress.com/pictures/hail>



Los Angeles hailstorm (12 Nov 2003)

LA Times



6" diameter hailstone -- fallspeed 125 MPH

<http://www.photolib.noaa.gov>



<http://www.chaseday.com/punching.htm>



Waterspouts

<http://www.photolib.noaa.gov/historic/nws/wea00307.htm>

Music:

"The Right Stuff" by Bill Conti

AS3downloads/cloud_slides.pdf

[warning: 5.1 MB]