

Intermediate Marine Weather

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*Landfall Navigation
Marine Training Center (MTC)
Stamford CT
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Overview of the Course

The scales of weather systems will be studied from the largest global patterns, i.e. the Jet Stream, to the local weather phenomenon, i.e. Gulf Stream North Wall, coastal winds and squall lines. Upper air charts will be introduced and integrated with surface weather maps for forecasting and introductory routing and heavy weather avoidance. Sea and swell formation, propagation and decay will be introduced. This knowledge will be applied to the OPC and TPC wind and wave analyses and forecast charts. Tropical cyclone basics and the rules for avoidance will be introduced. Favorable boating weather (e.g. afternoon winds and sea-breezes) and potentially dangerous weather (e.g., squall lines and tropical cyclones) will be emphasized. This course, along with the MTC Basic Marine Meteorology course, provides the foundation for the MTC Advanced Marine Meteorology course.

Goal of the Course

To *weatherproof* you: recognize, understand, act!

Intermediate Marine Weather Topics

- **Scales of weather:** global weather patterns; local weather phenomena, i.e. Gulf Stream 'north wall', coastal winds, squall lines
- **Introduction to upper-air charts:** integration with surface weather maps for forecasting (*forecasting* exercise) and introductory routing to avoid heavy weather
- **Introduction to sea and swell:** formation, propagation and decay; overview of OPC and TPC wind and wave analyses and forecast charts
- **Tropical cyclone:** basics and the rules for avoidance

This presentation is at www.sci.ccny.cuny.edu/~hindman

Certification

Upon completion of the course, you will receive a
Landfall Navigation-Marine Training Center
Certificate of Completion in Intermediate Marine Weather

References

Reeds Maritime Meteorology 3rd edition, Cornish & Ives
(ISBN: 0713676353, available from Amazon.com)

Weather at Sea 4th edition, Houghton
(ISBN: 1904475167, available from Landfall Navigation)

North U Weather for Sailors 2nd edition, Biewenga
(ISBN: 097446760X, available from Landfall Navigation)

Your course expectations?

Scales of weather: Global weather patterns

•To balance the energy excess in the Equatorial regions and the energy deficit in the Polar regions, the Earth's atmosphere and oceans transport the 'excess warmth' toward the Poles and the 'excess cold' toward the Equator. The transport is accomplished by the atmospheric winds (60%) and oceanic currents (40%):

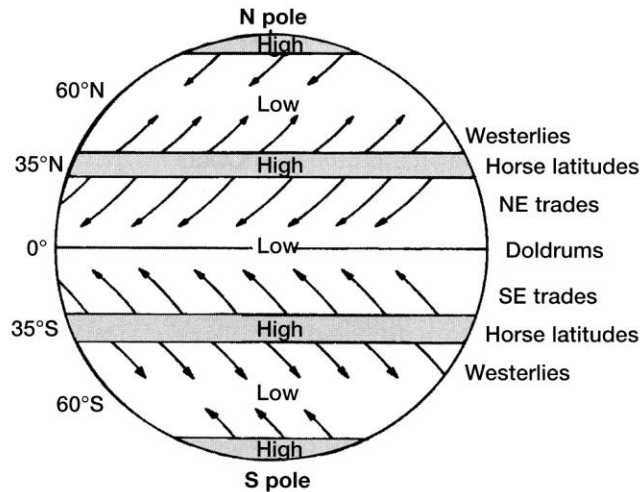
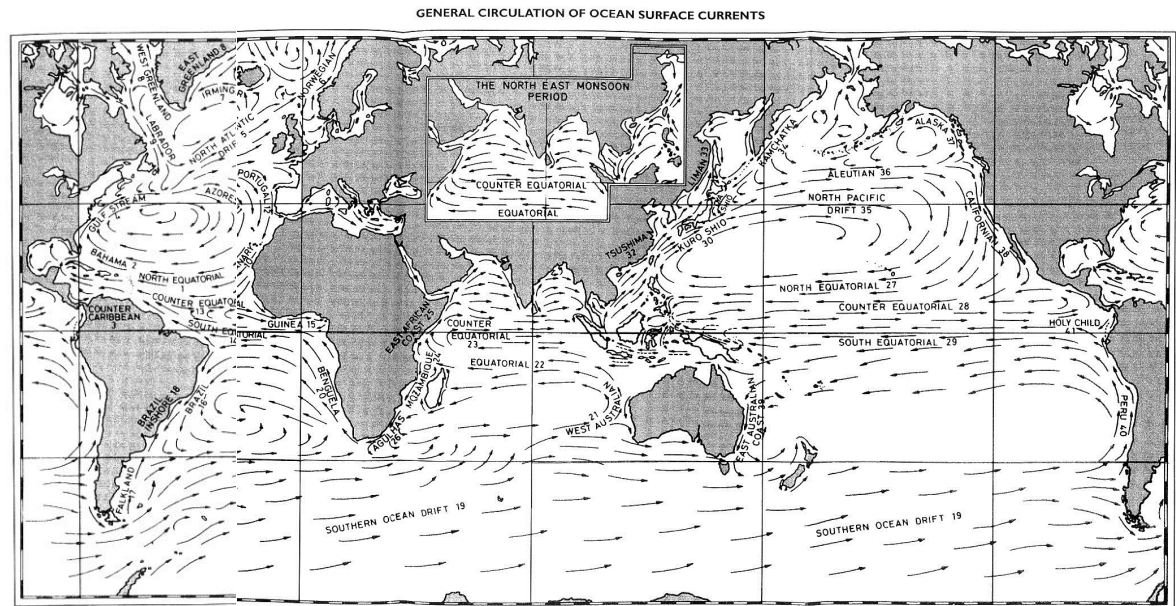
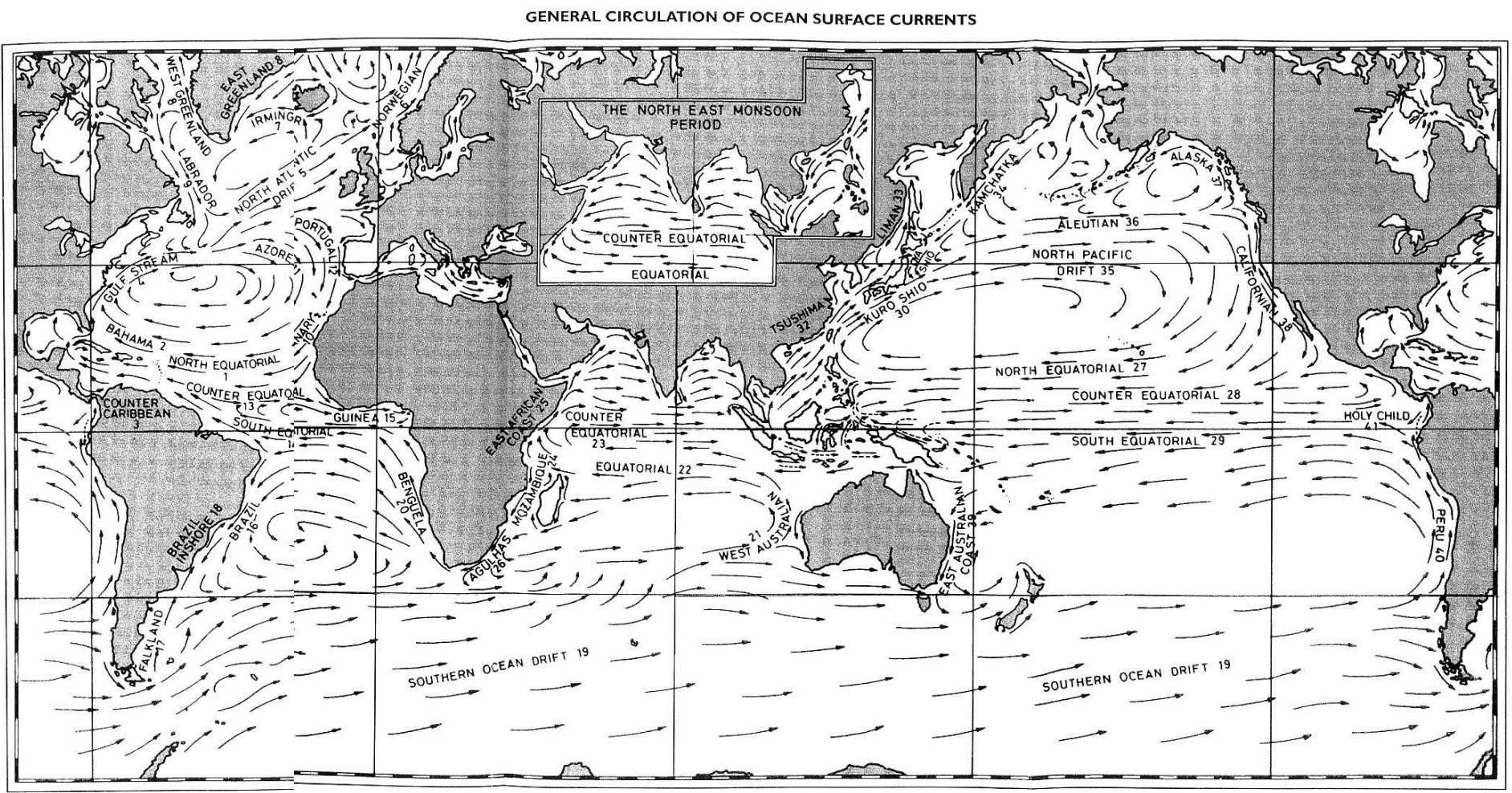


Fig 9.7



Refer to Chapter 20 for average daily drifts

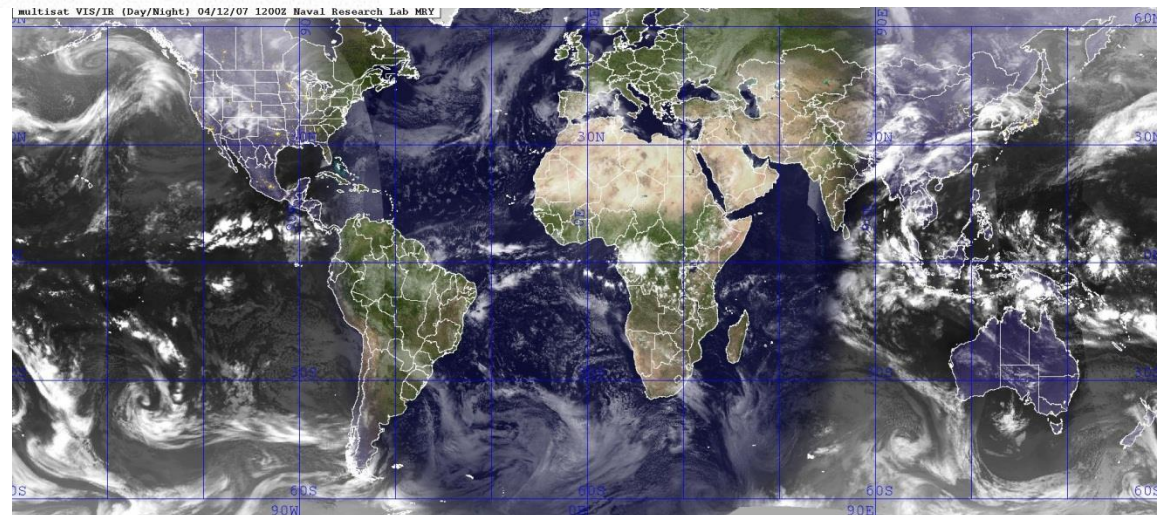
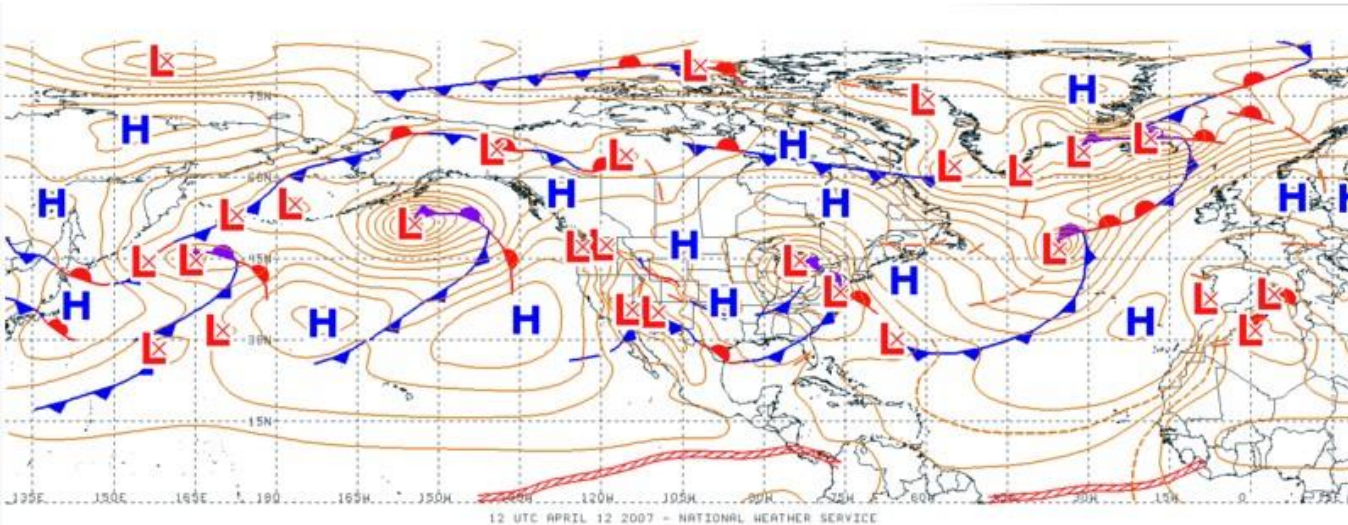
Scales of weather: Global weather patterns – the major ocean currents



Refer to Chapter 20 for average daily drifts

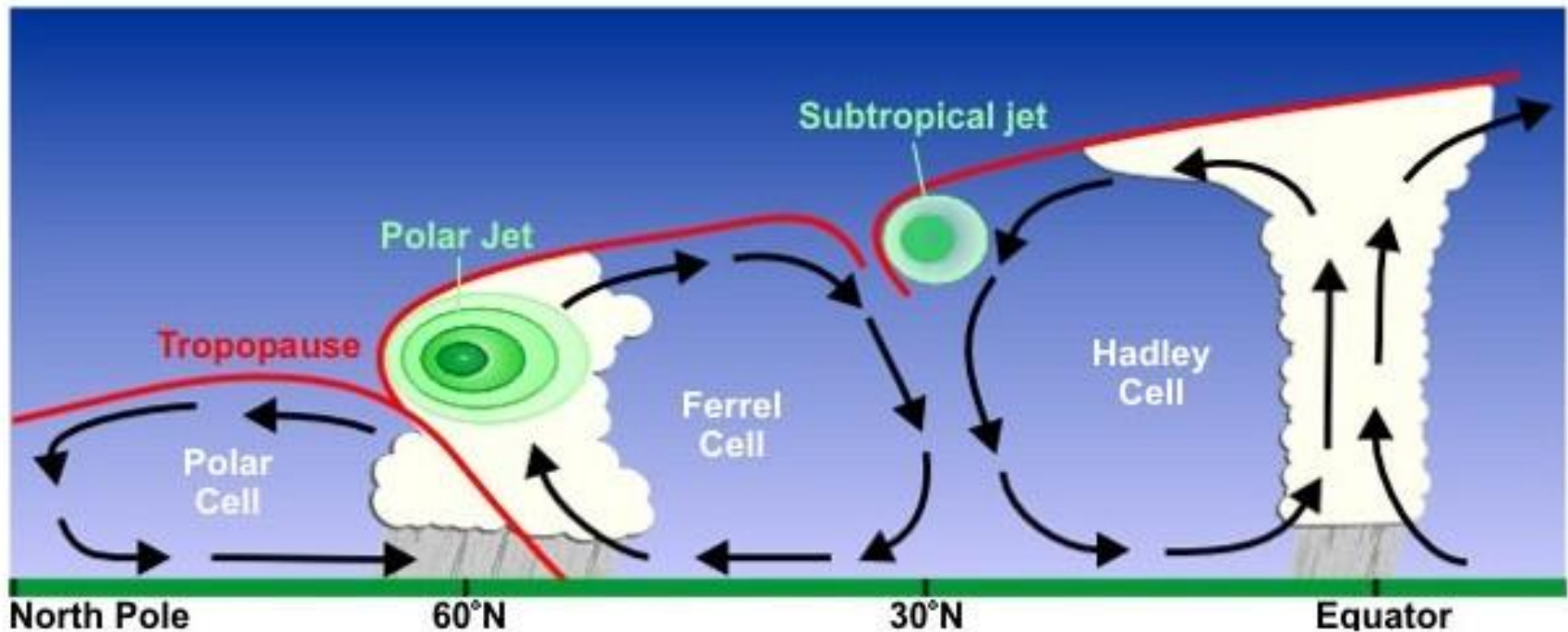
Scales of weather: Global weather patterns simultaneously from the surface and from satellites

- Surface weather map from www.opc.ncep.noaa.gov/
- Satellite image & loop from www.nrlmry.navy.mil/sat-bin/global.cgi
- Satellite loop (Global mollwiede) from www.ssec.wisc.edu/data/comp/ir/irmoll.mpg

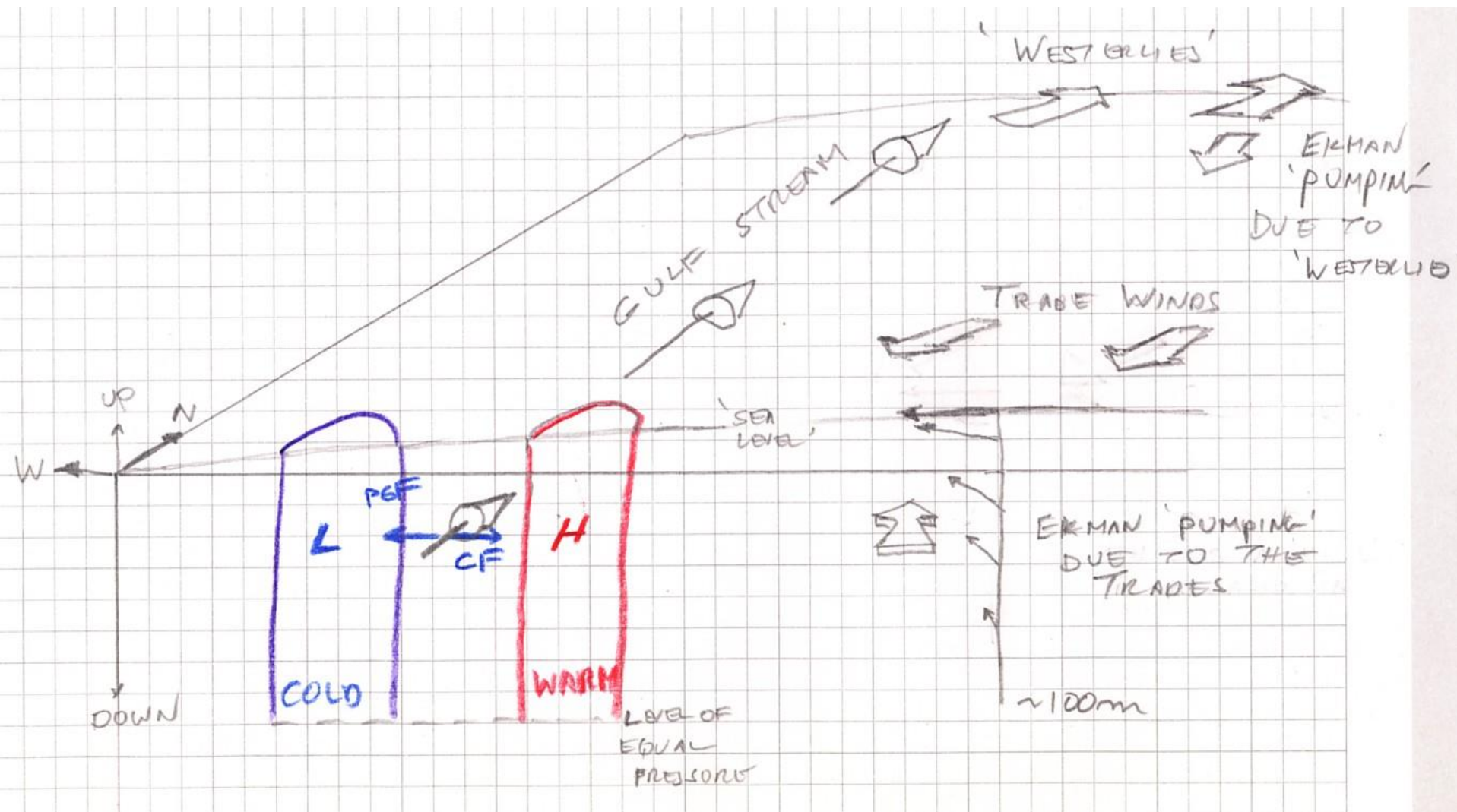


Scales of weather: Local weather phenomena – Gulf Stream

- The Gulf Stream is an oceanic ‘jet stream’.
- First, what is a ‘jet stream’? It’s a high speed river of air aloft in the Earth’s atmosphere. There are two ‘jet streams’, the subtropical and the polar. The subtropical is formed by the conservation of angular momentum and the polar is formed by temperature differences across the Polar Front.



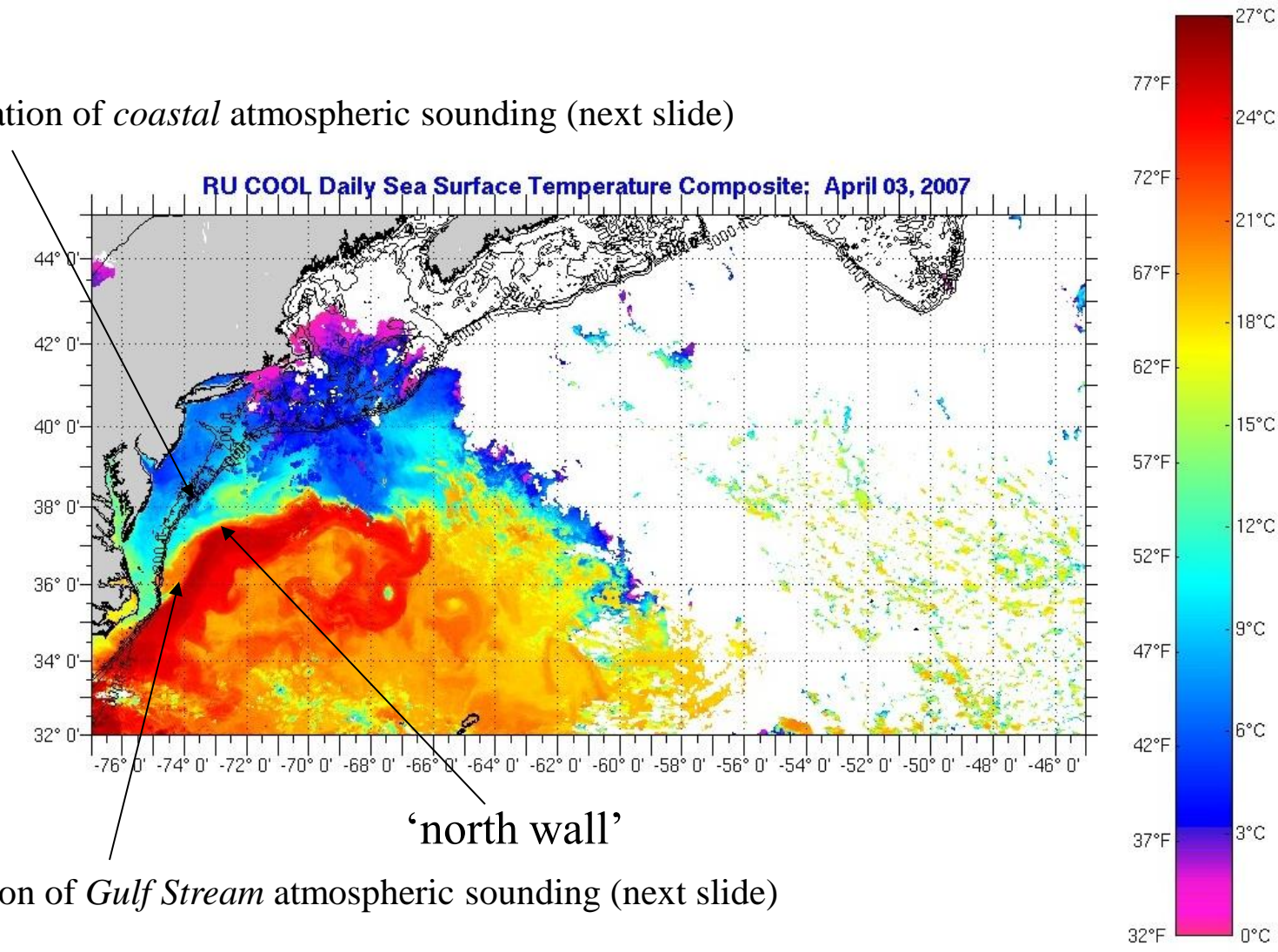
Scales of weather: Local weather phenomena – Gulf Stream formation



Scales of weather: Local weather phenomena – Gulf Stream ‘north wall’

- The ‘north wall’ refers to the extremely strong temperature gradient between the cool coastal water and the warm Sargasso Sea waters.

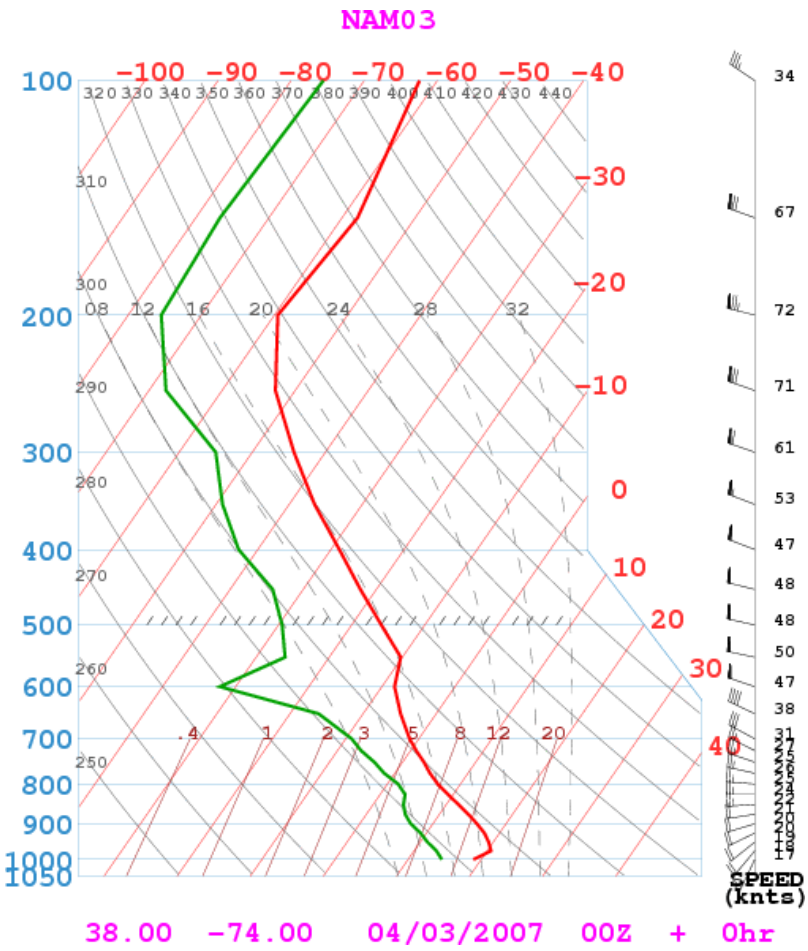
Location of *coastal* atmospheric sounding (next slide)



Scales of weather: Local weather phenomena – Gulf Stream ‘north wall’ weather

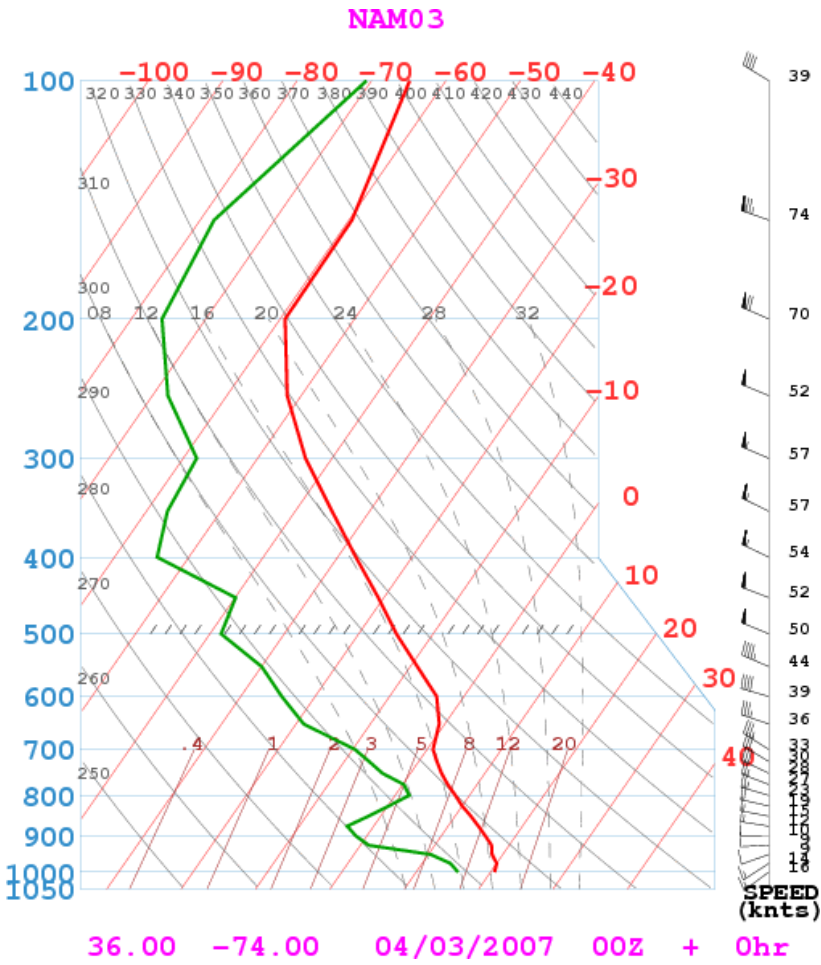
Coastal waters

Stable marine boundary layer



Gulf Stream waters

Conditionally stable marine boundary layer



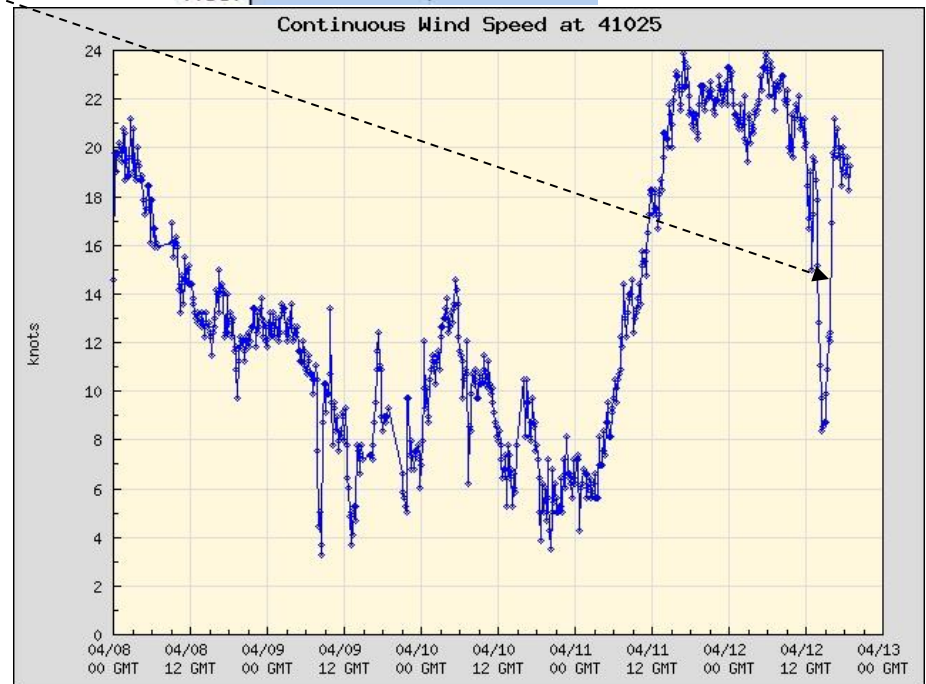
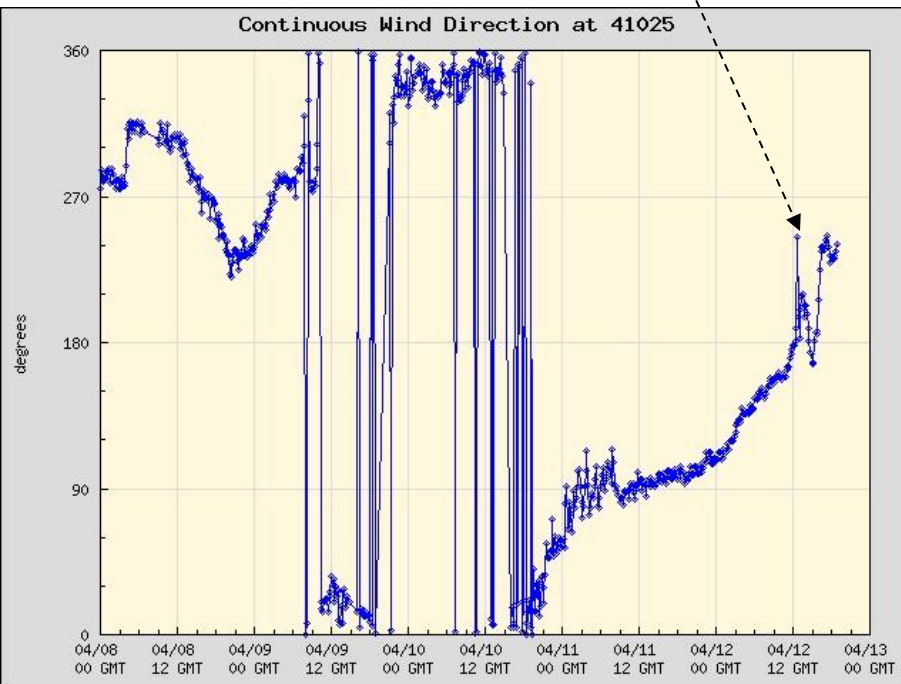
Scales of weather: Local weather phenomena – Gulf Stream ‘north wall’ weather

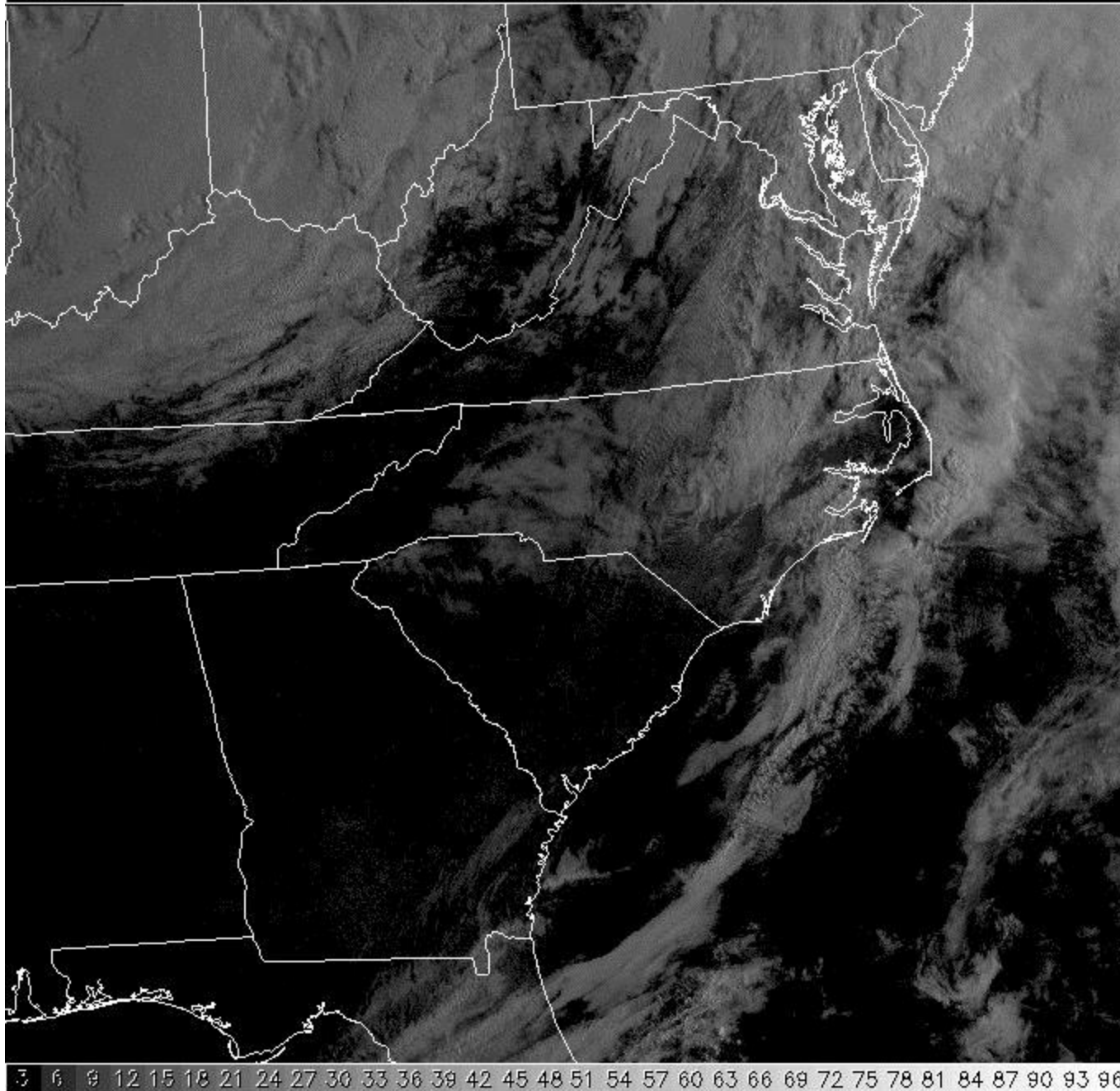
- Squall passage 11 April 2007

As measured from NOAA Buoy 41025:

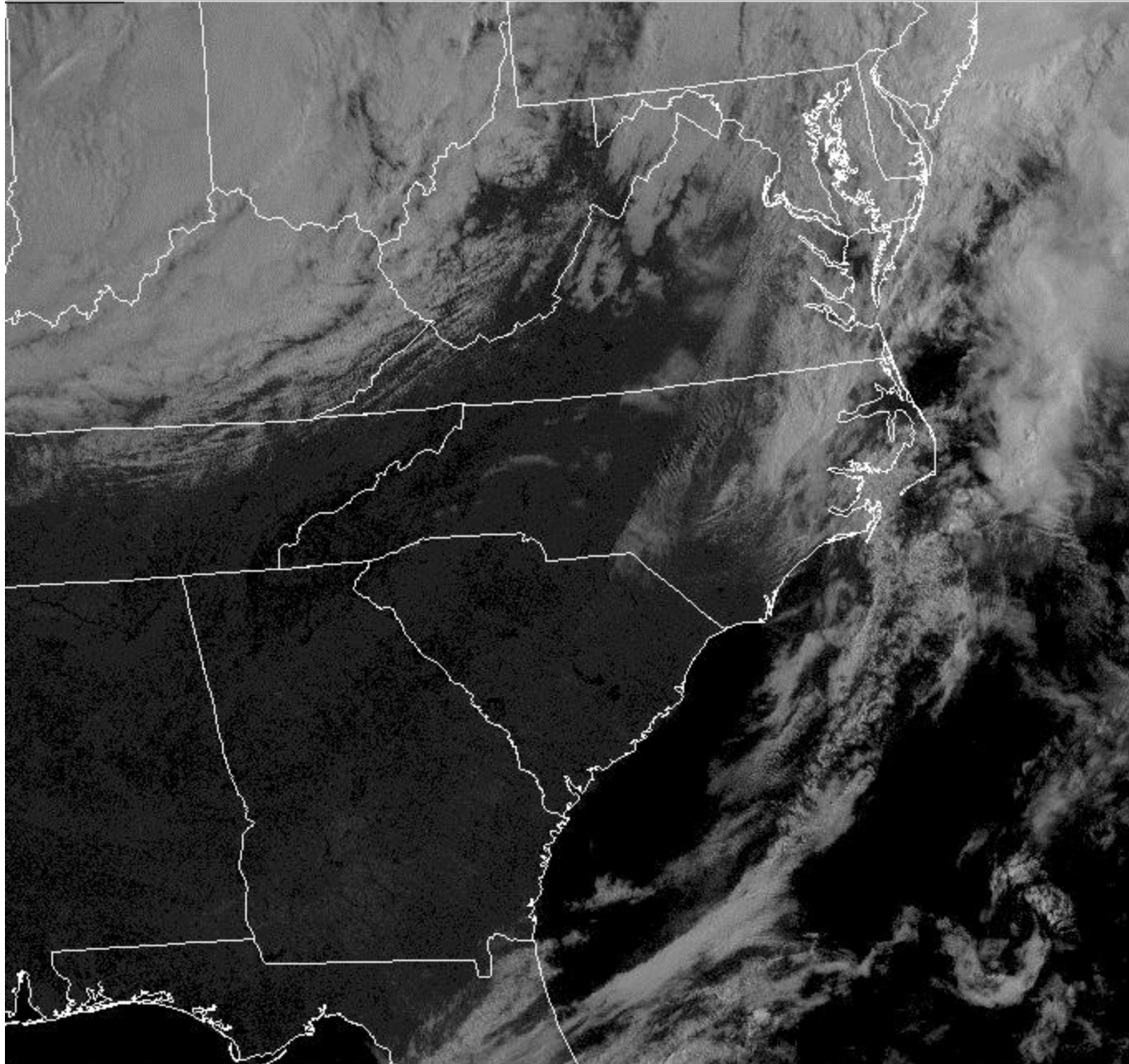


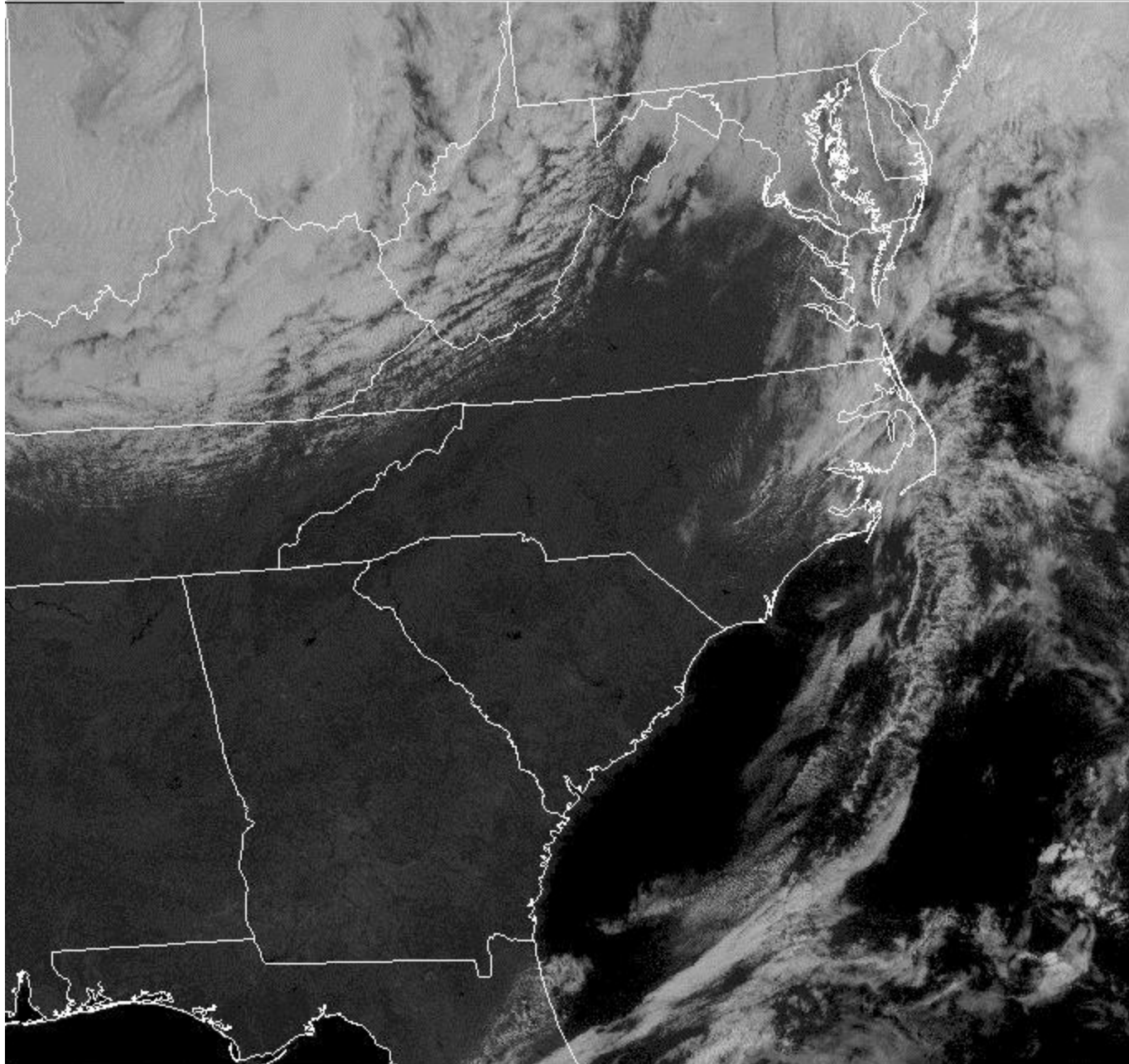
Squall passage

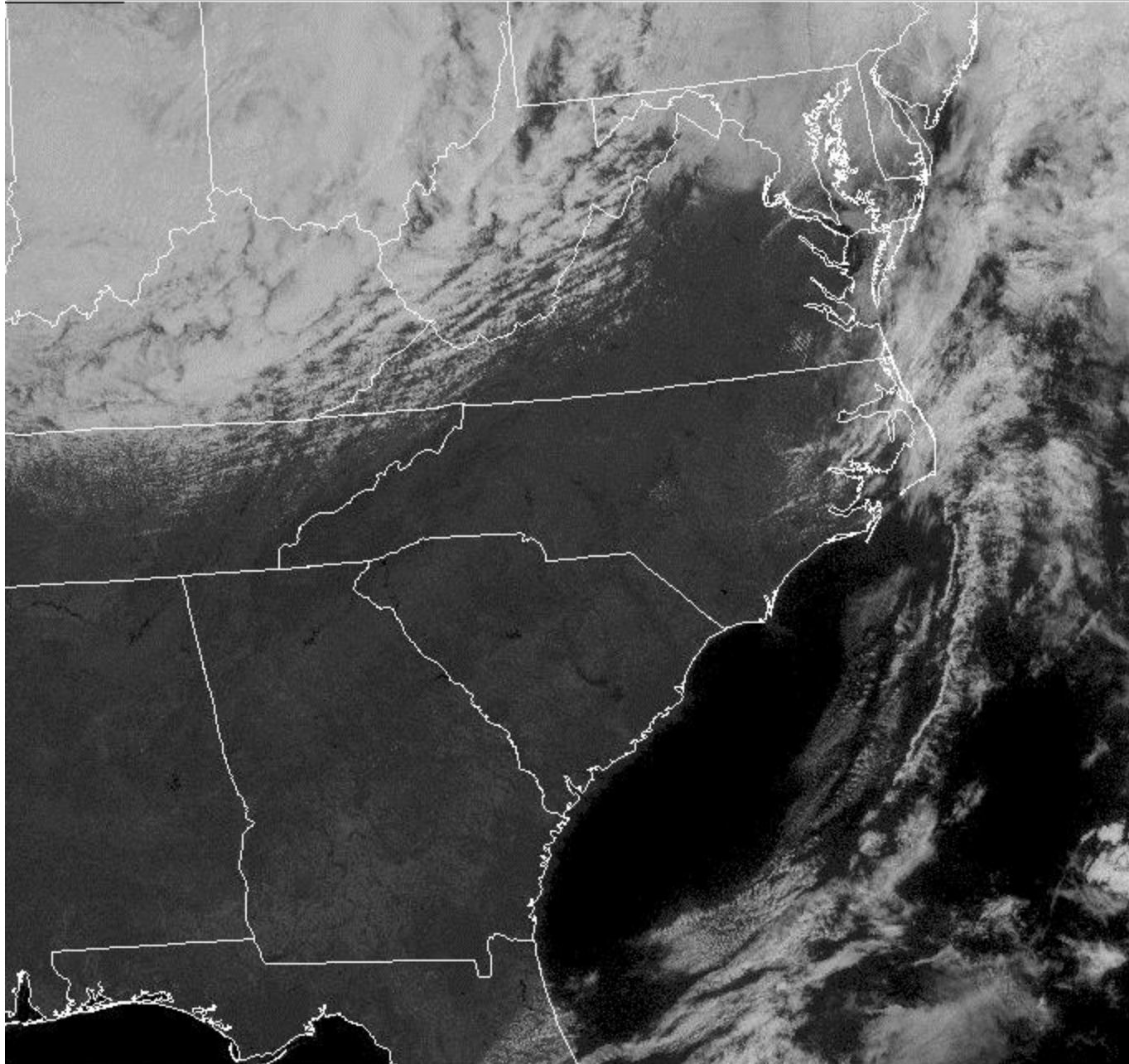




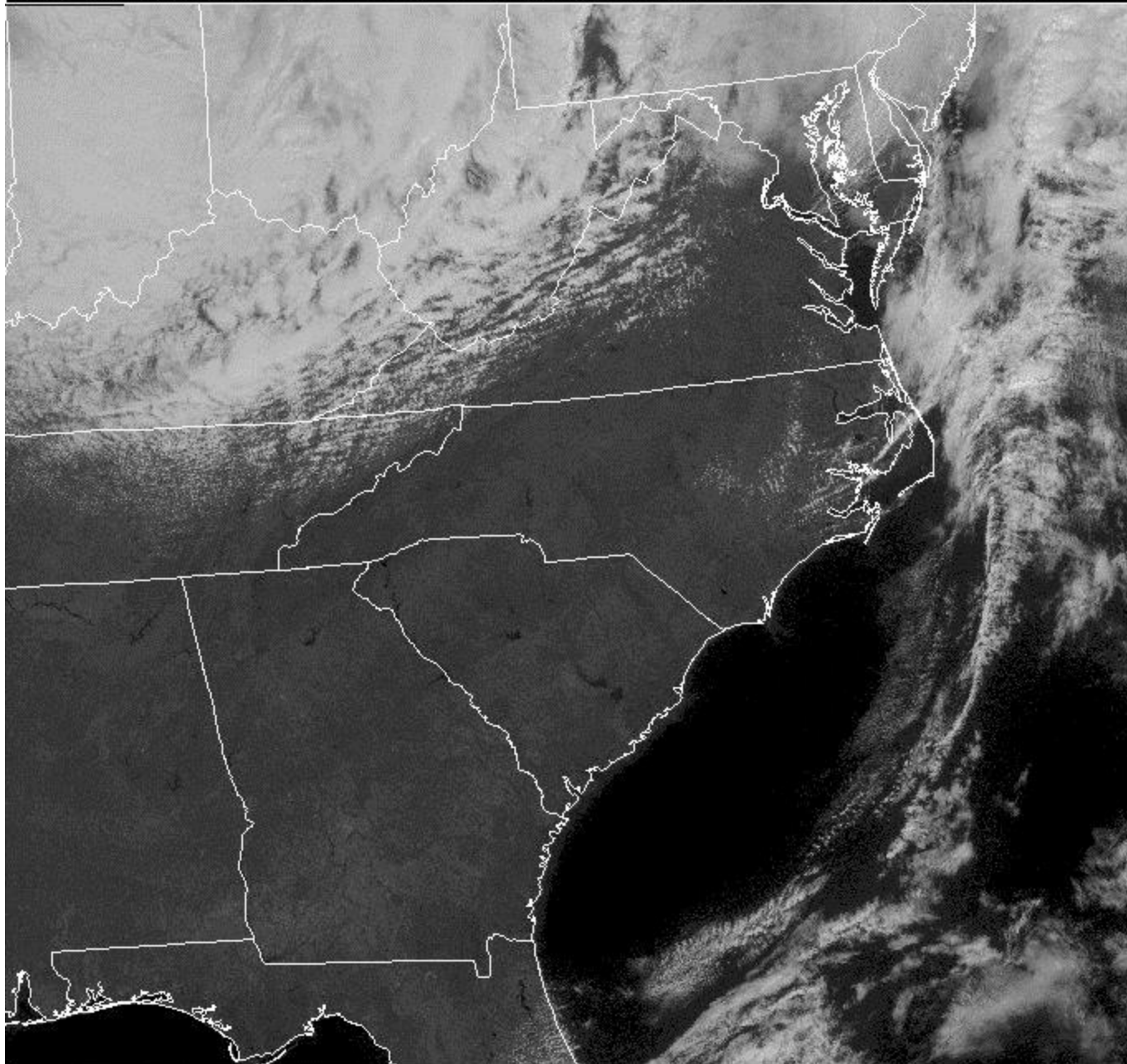
As detected
by satellite



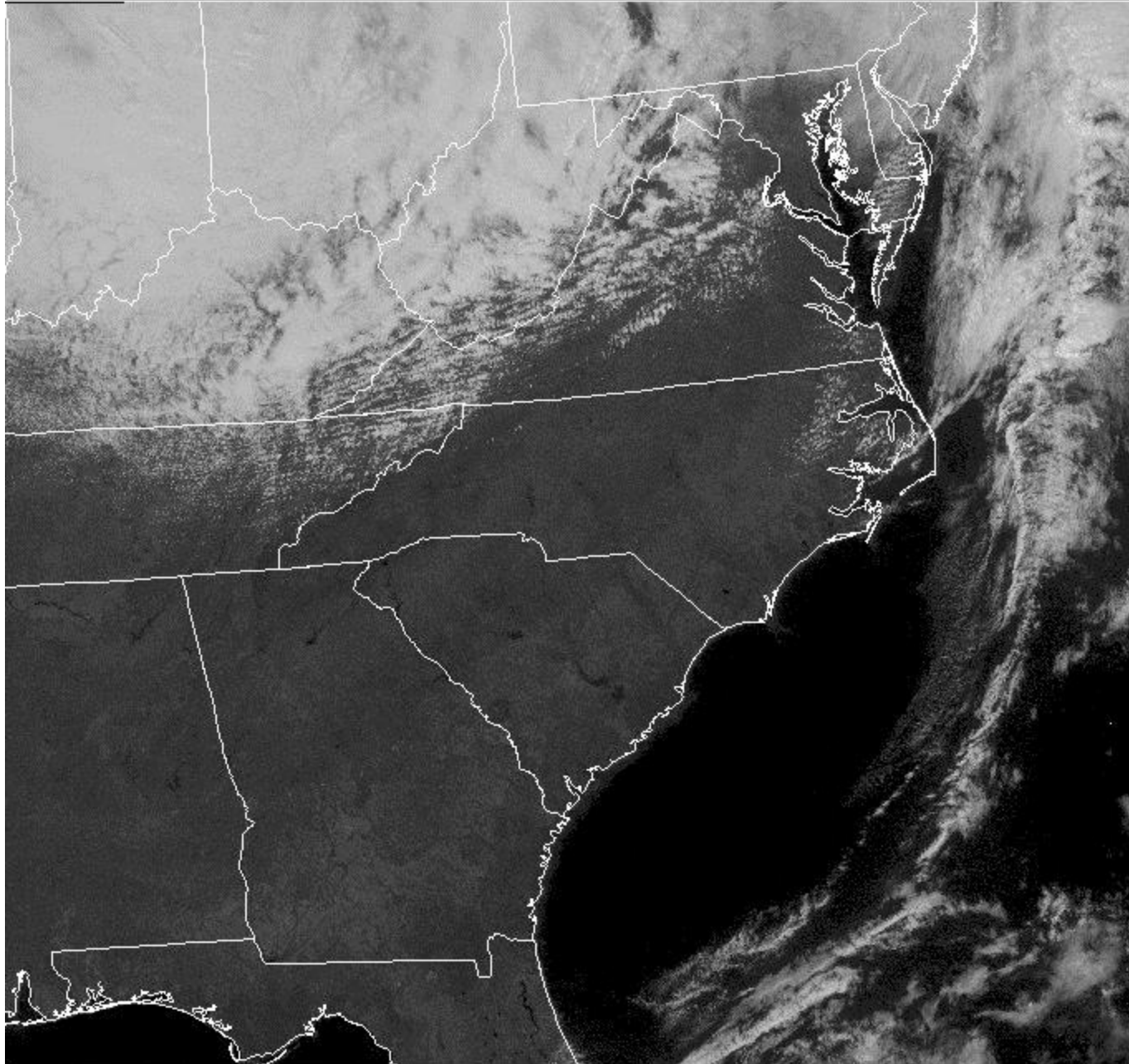




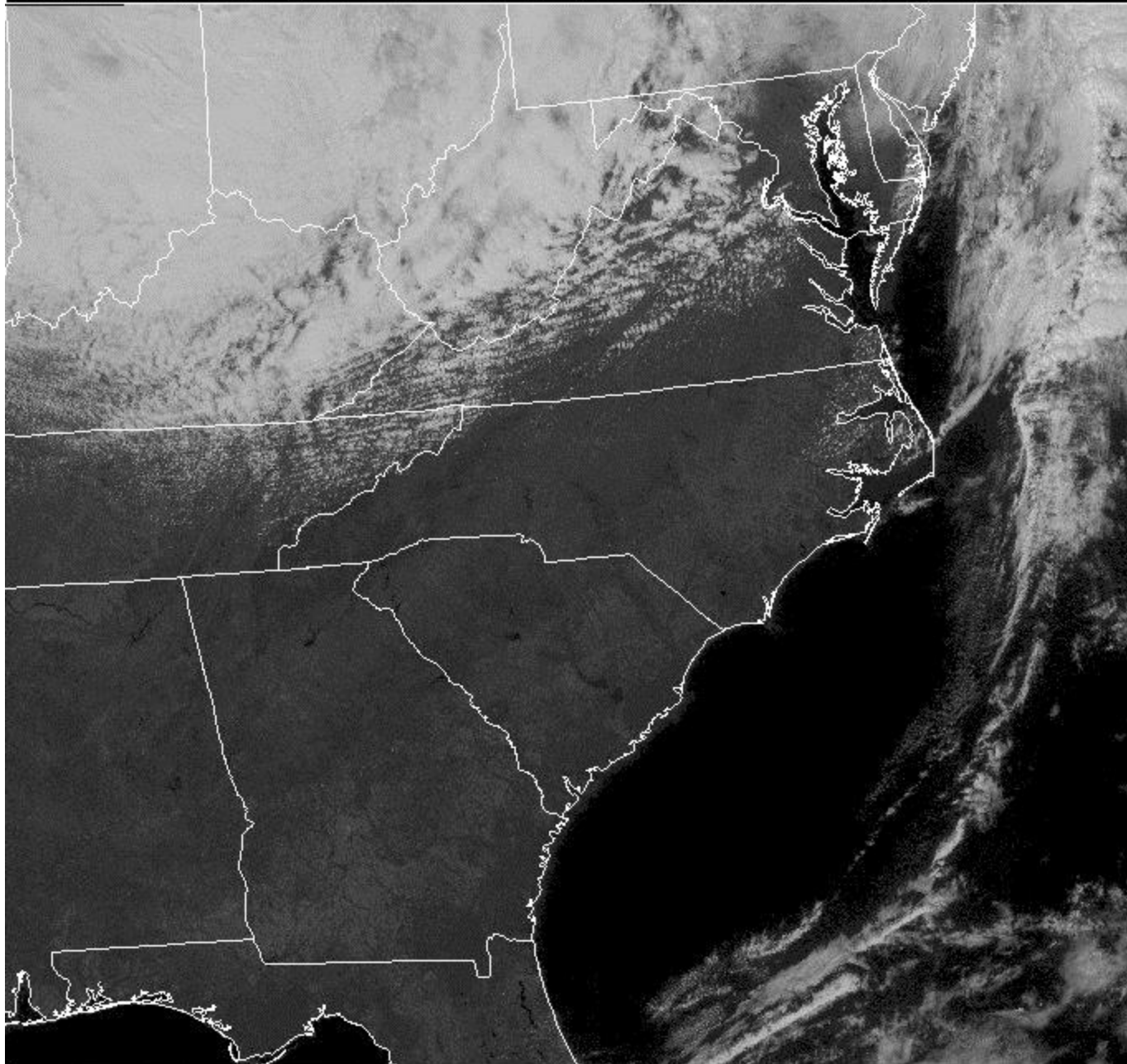
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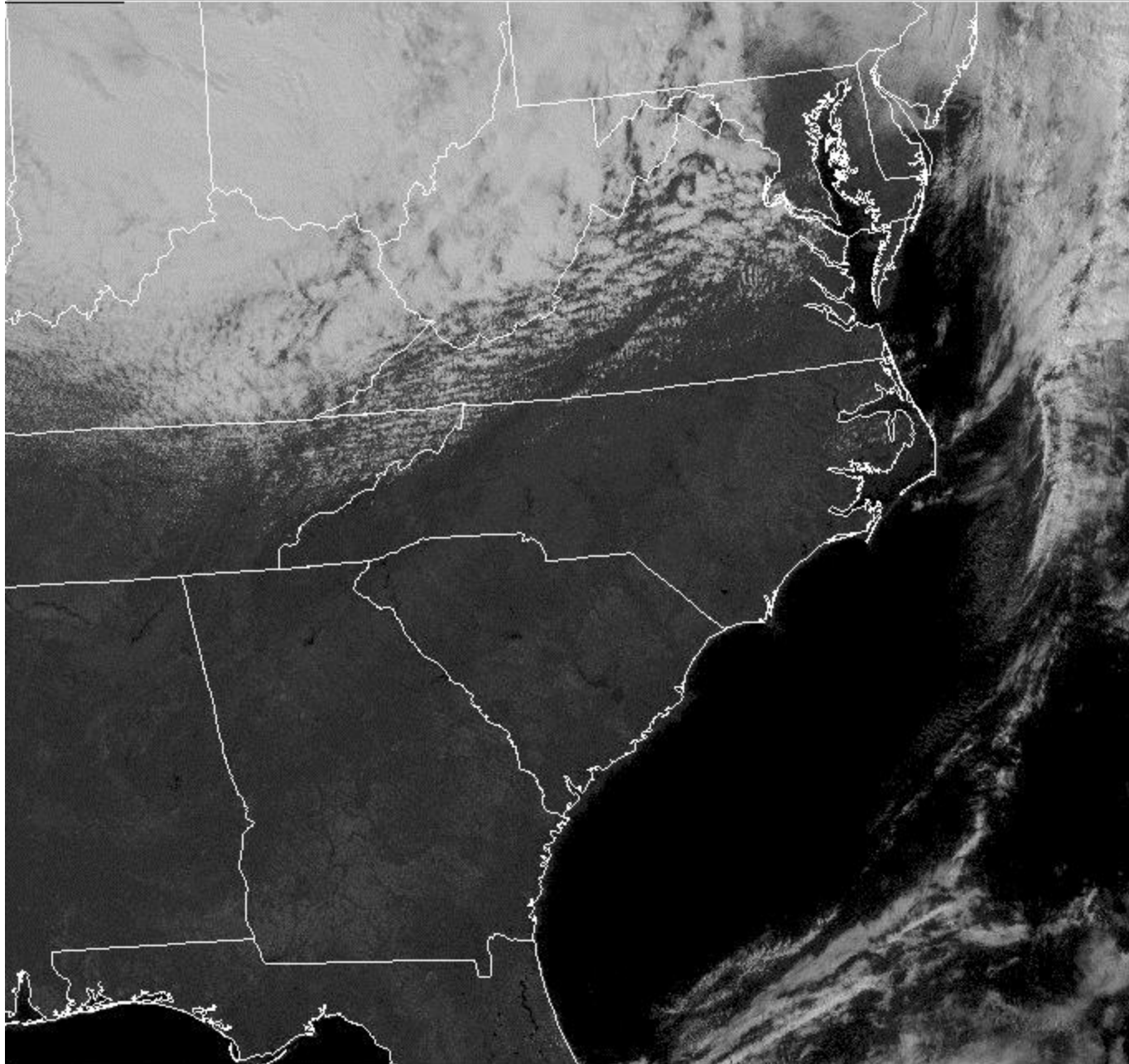


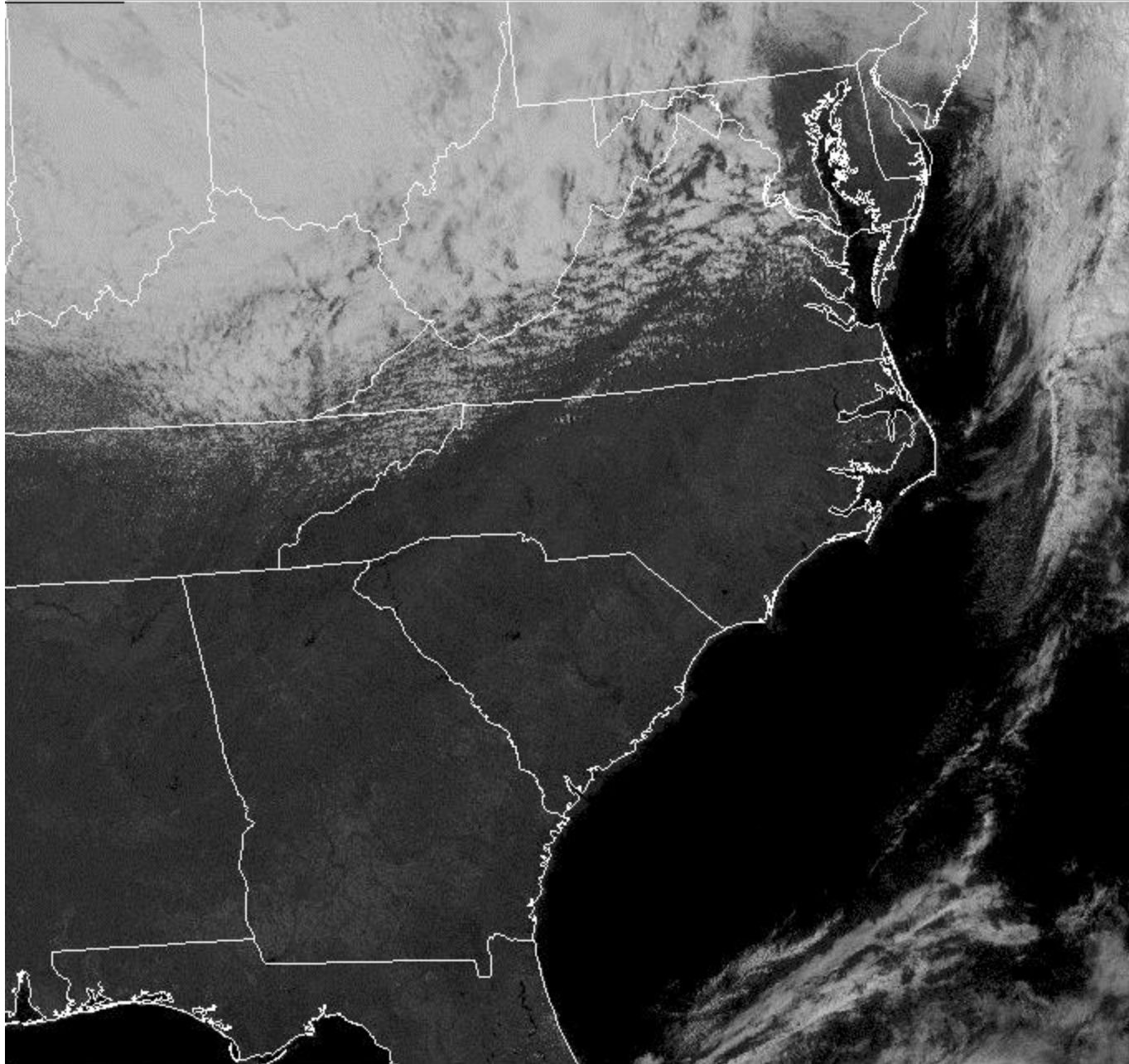
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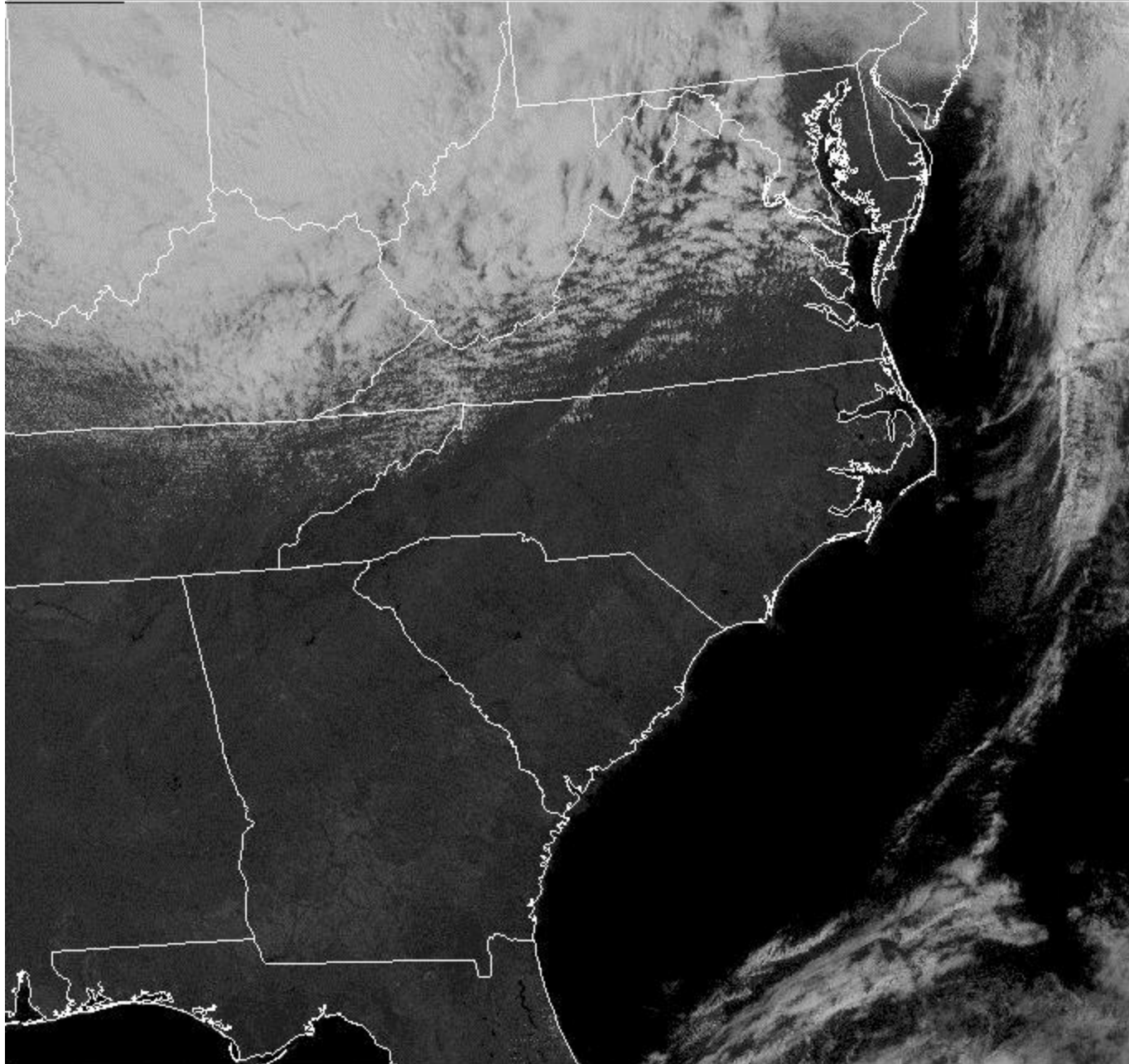
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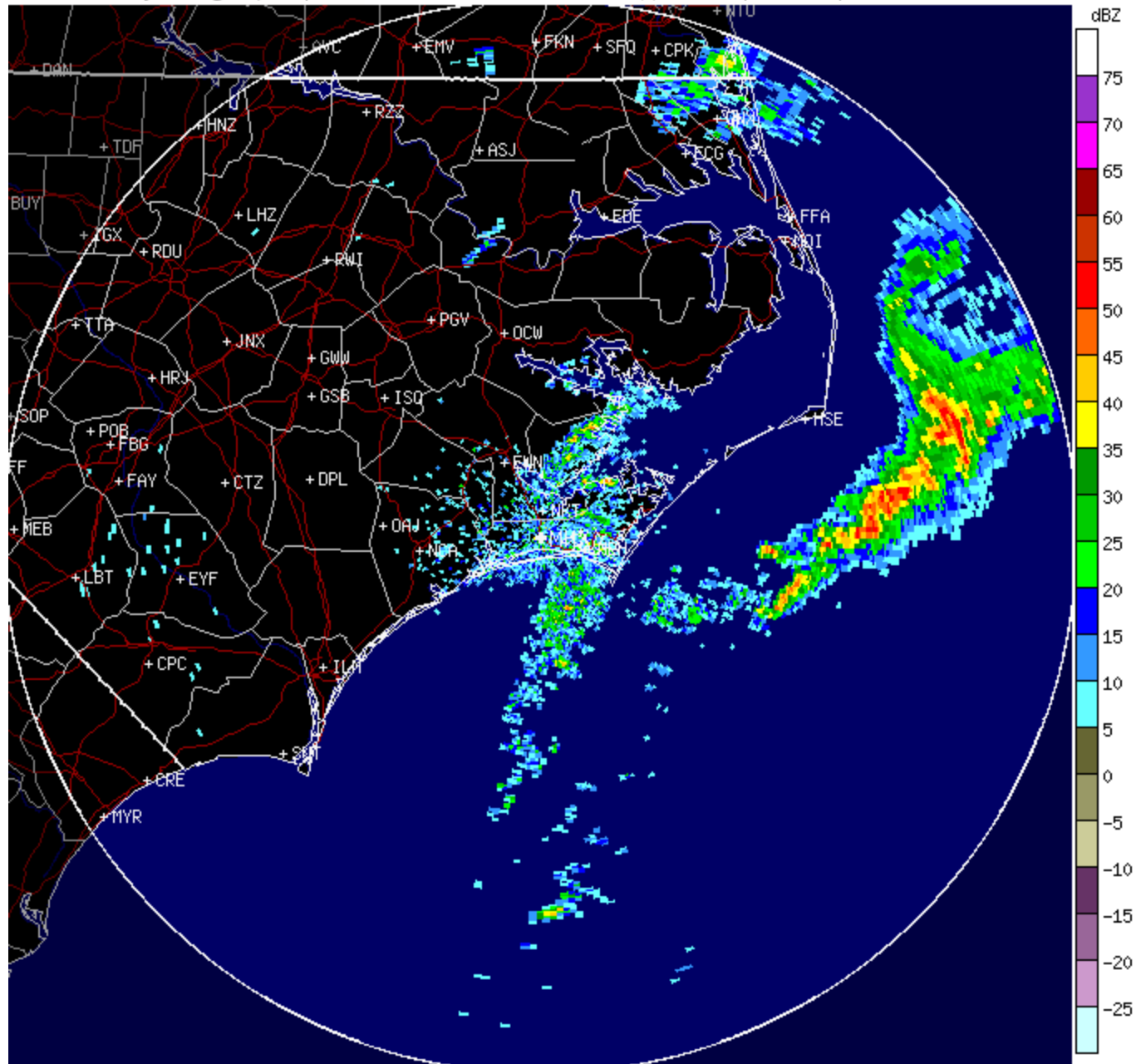




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3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84 87 90 93 96



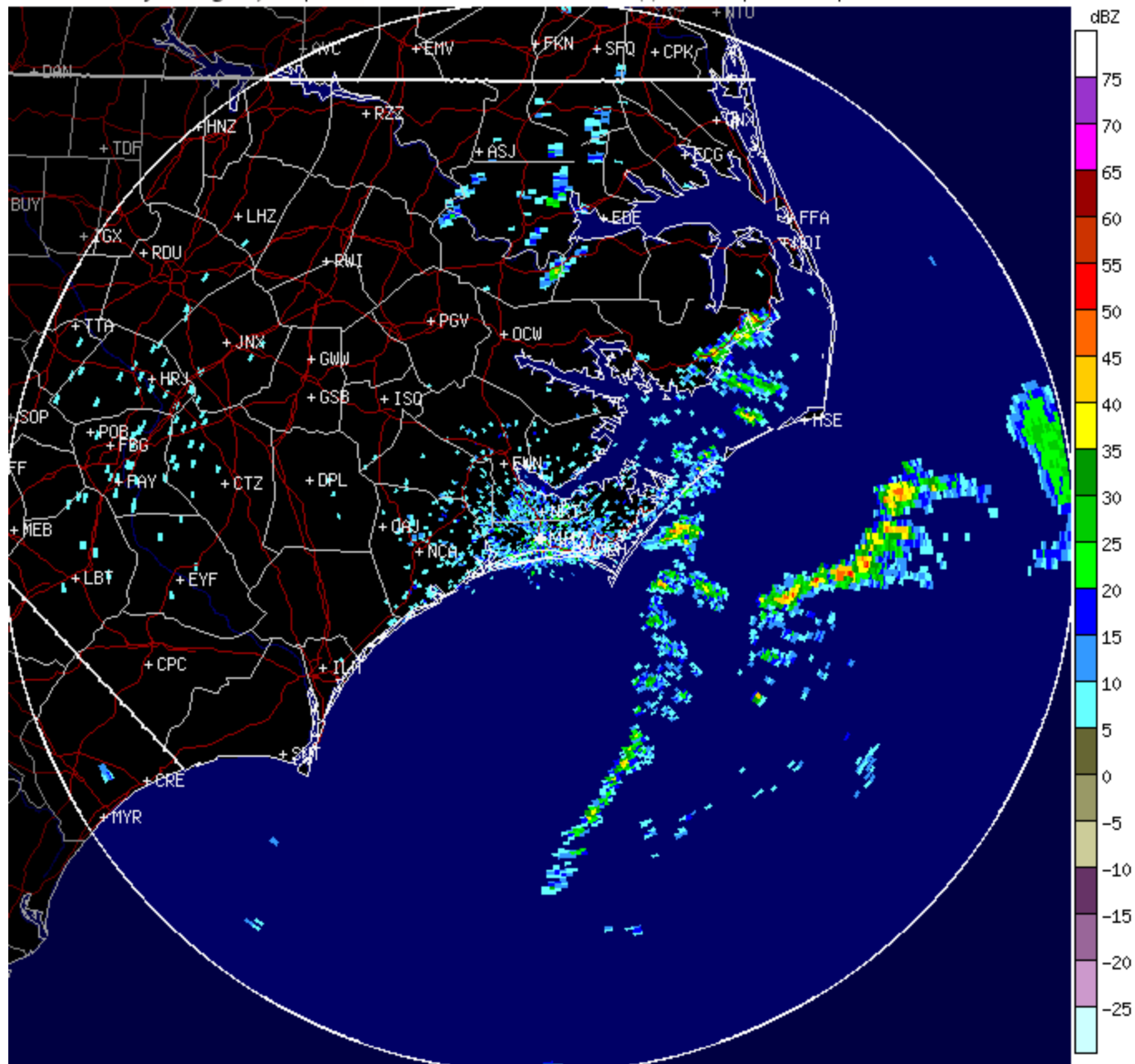
As detected
by radar

KMHX -- Morehead City, NC/Newport

13:58:37 UTC Thu 12 April 2007

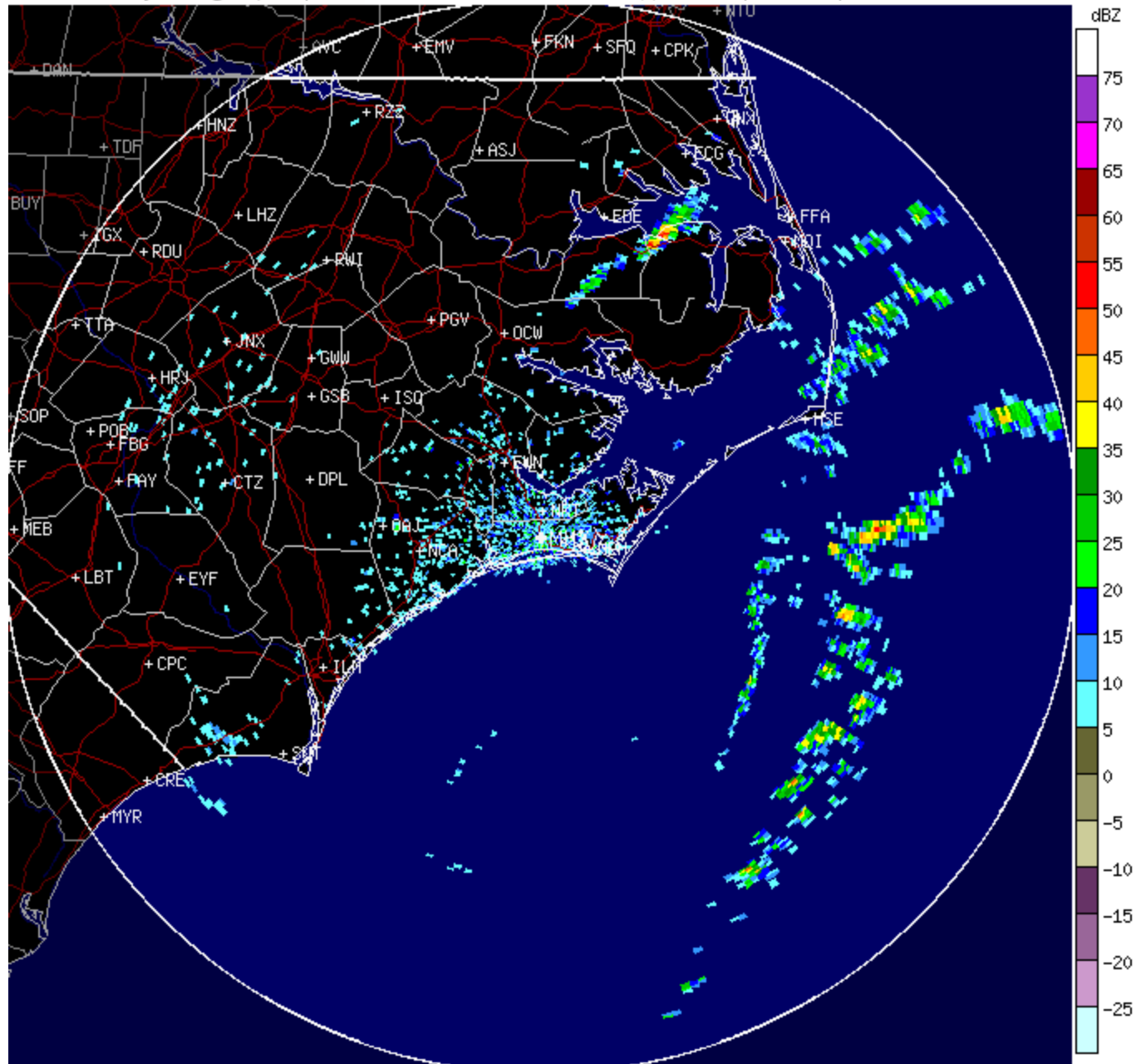
Base Reflectivity: 0.5 degrees, Precip Mode

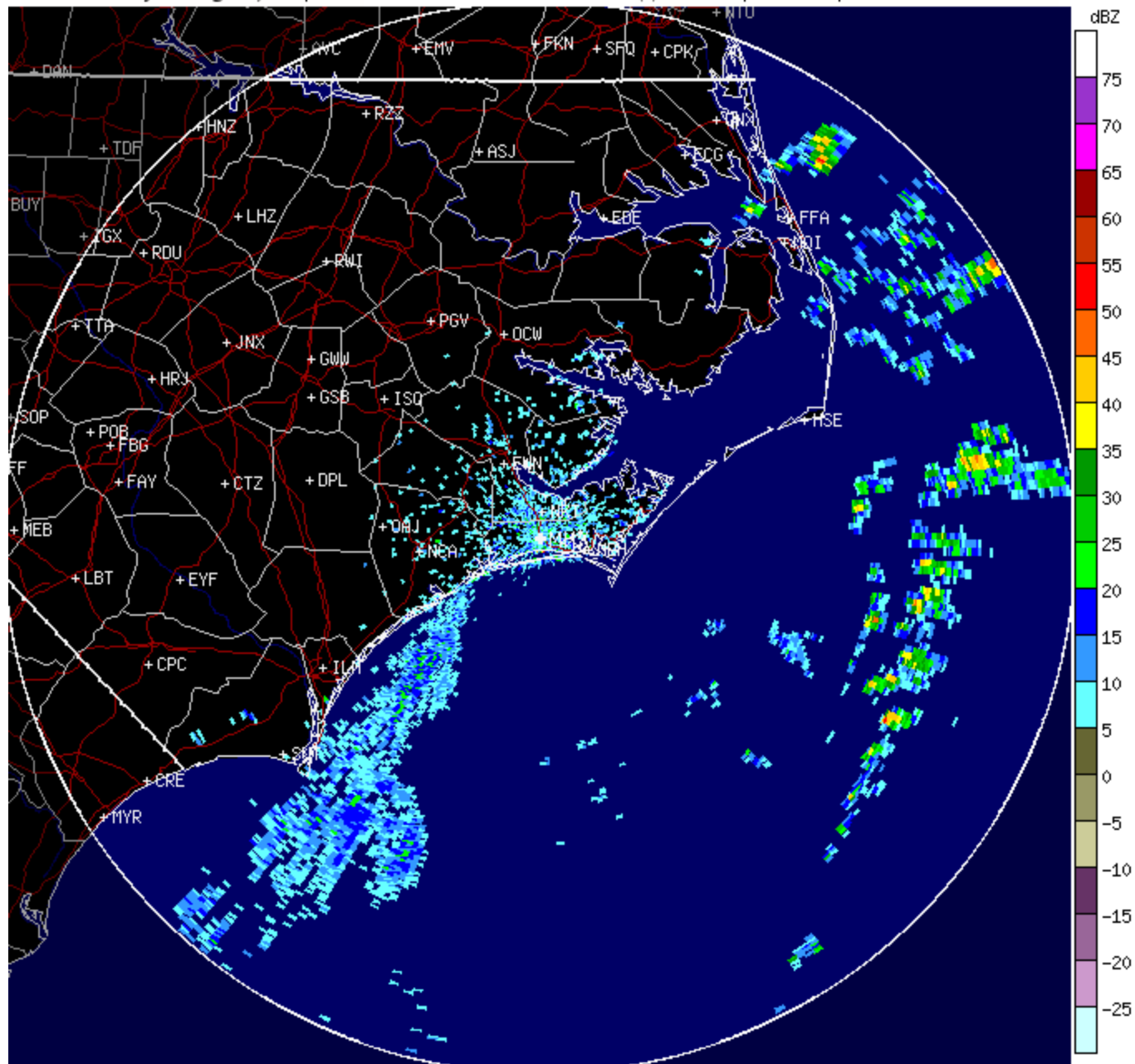
(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



14:58:27 UTC Thu 12 April 2007

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



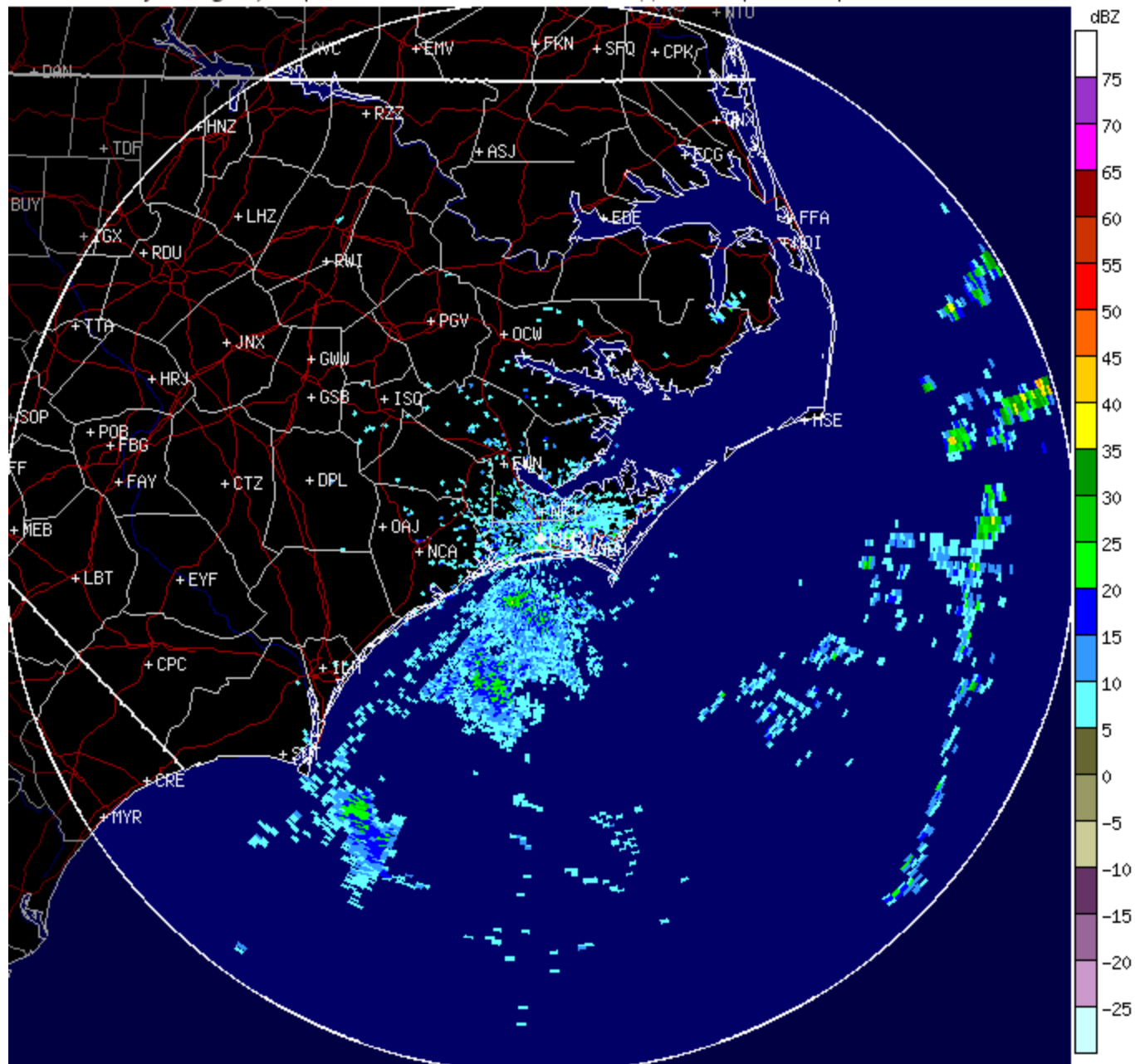


KMHX -- Morehead City, NC/Newport

16:56:31 UTC Thu 12 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

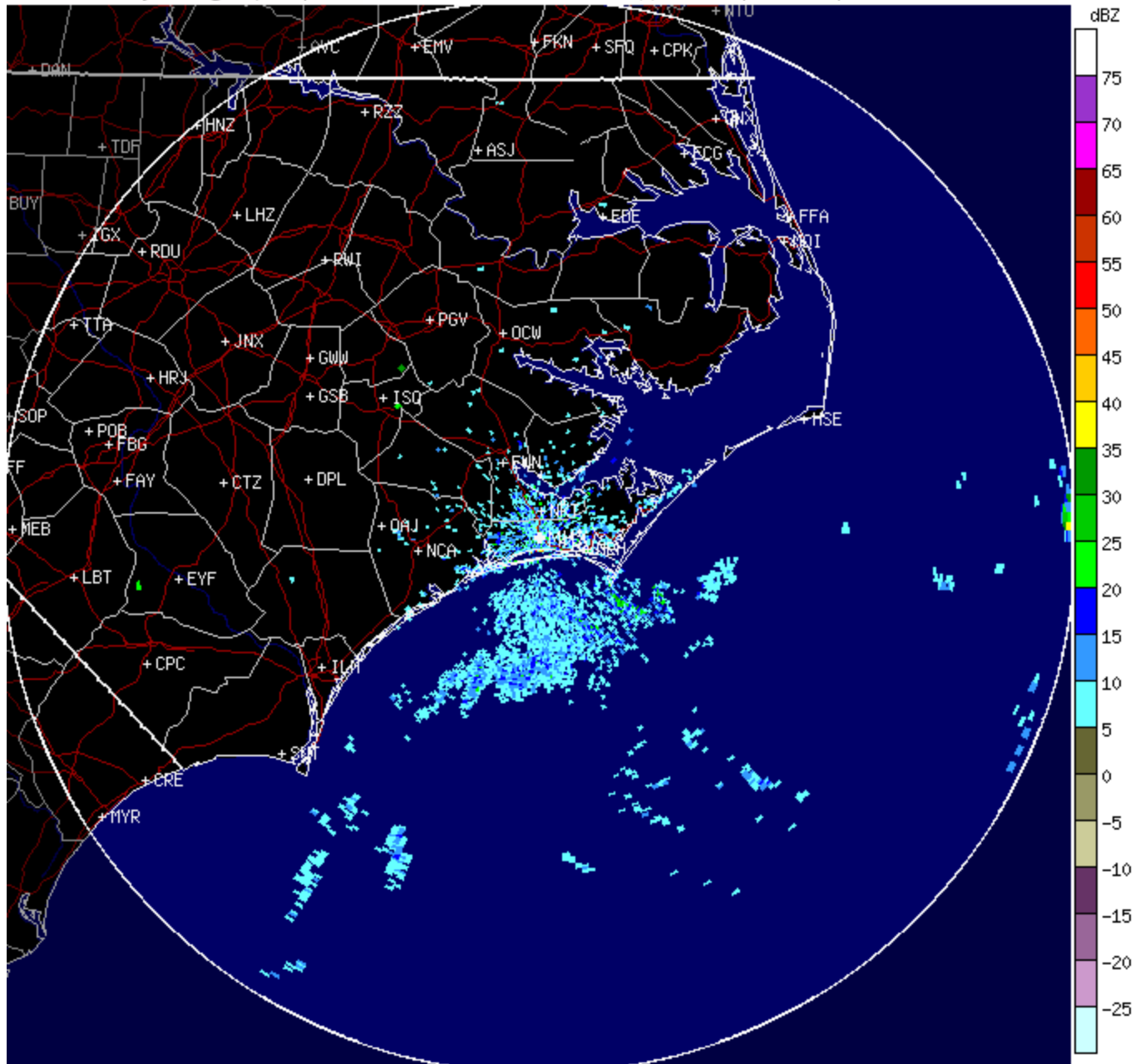


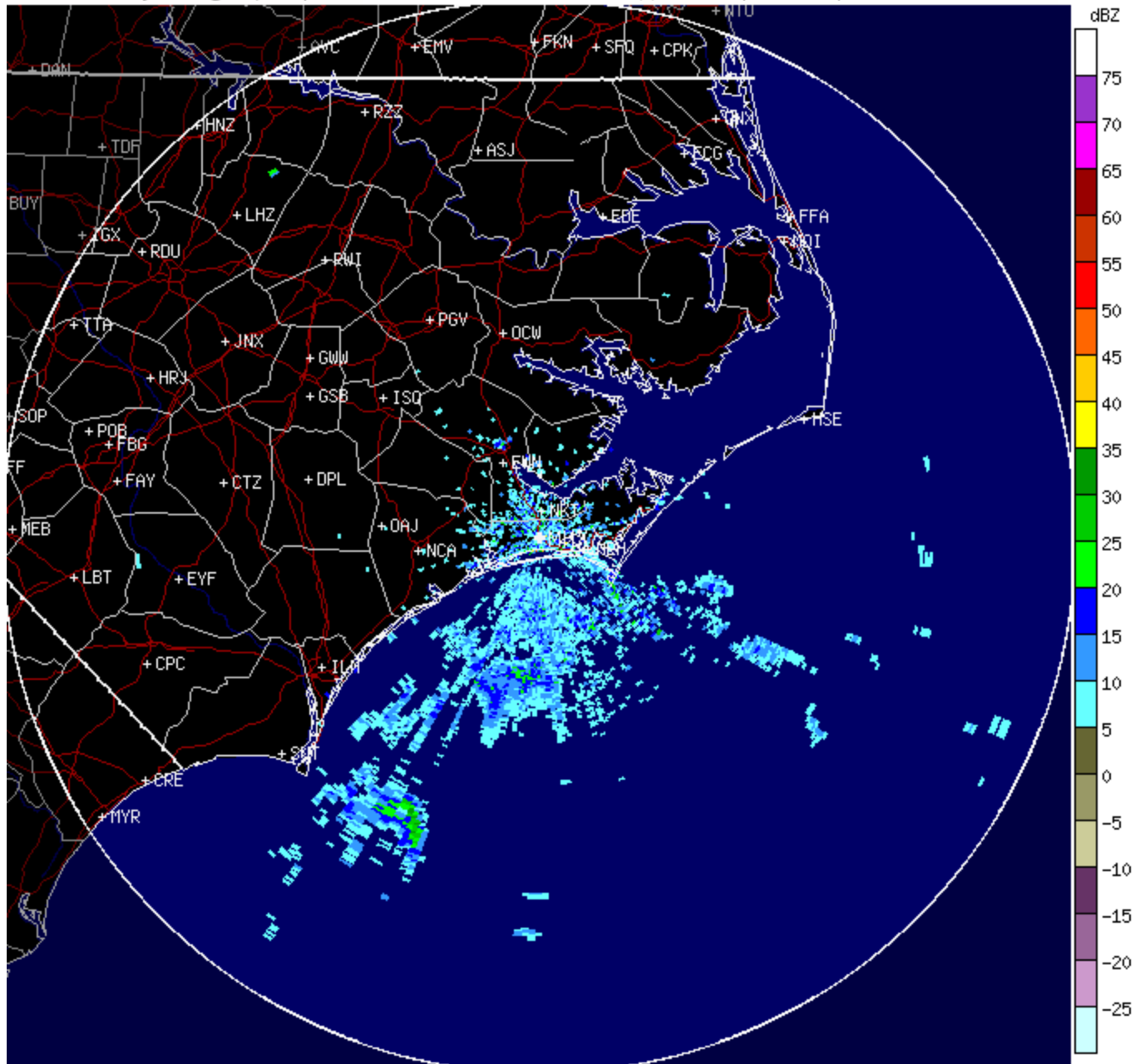
KMHX -- Morehead City, NC/Newport

17:59:49 UTC Thu 12 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



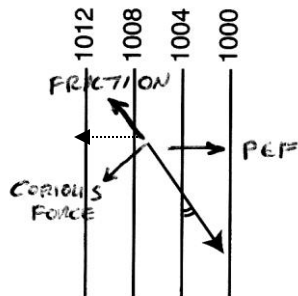


Scales of weather: Local weather phenomena – Coastal winds

(adapted from *Weather at Sea* 4th Edition)

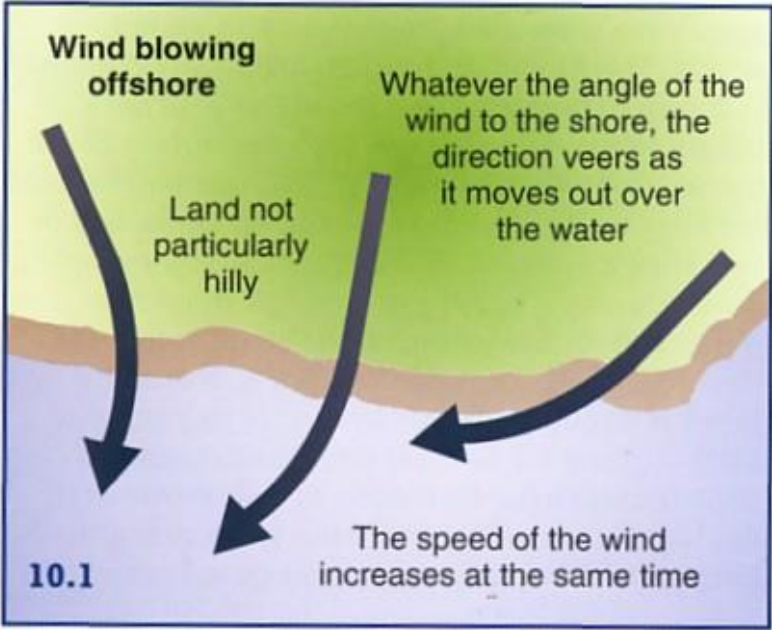
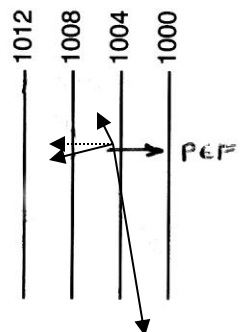
- When winds flow offshore, the direction ‘veers’ (turns to the right) and increases in speed:

Land



Coast

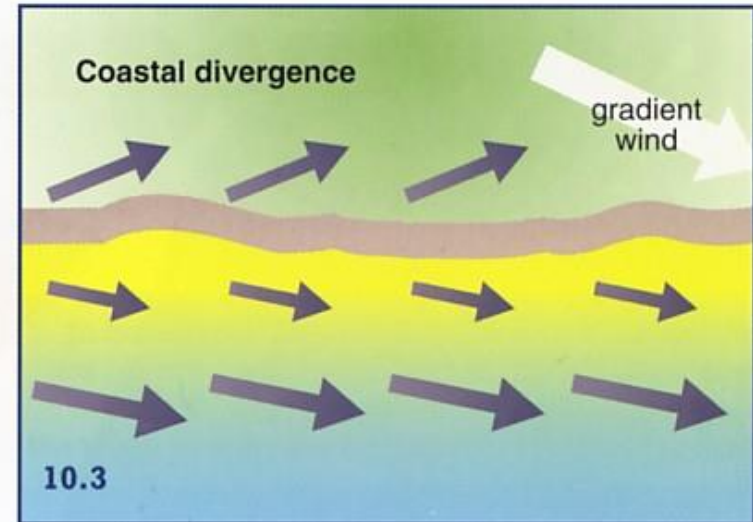
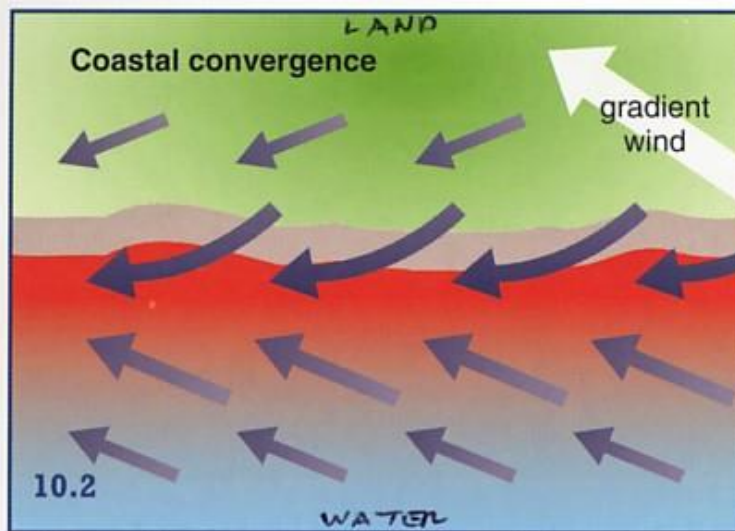
Water



(When winds flow onshore, the direction always ‘backs’ (turns to the left) and decreases in speed)

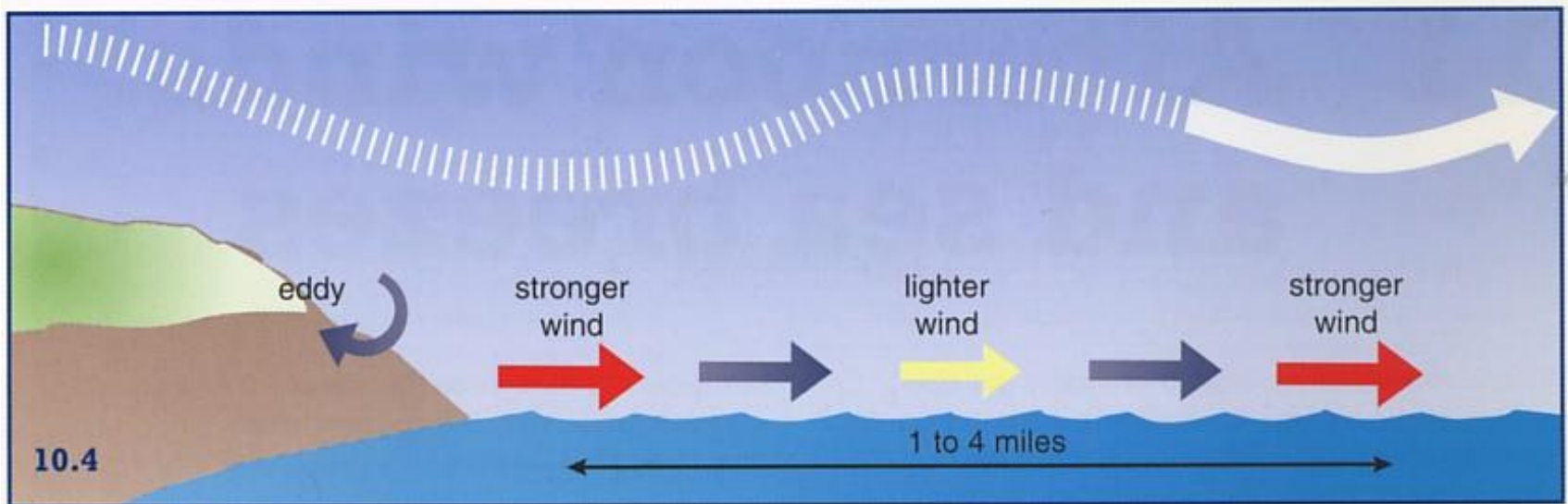
Scales of weather: Local weather phenomena – Coastal winds

- When you are aboard and the coast is to your right (left) with your back to the wind, the winds over land and water will converge (diverge) causing a region of increased (decreased) speed. Note, the gradient wind is the 'frictionless' wind.



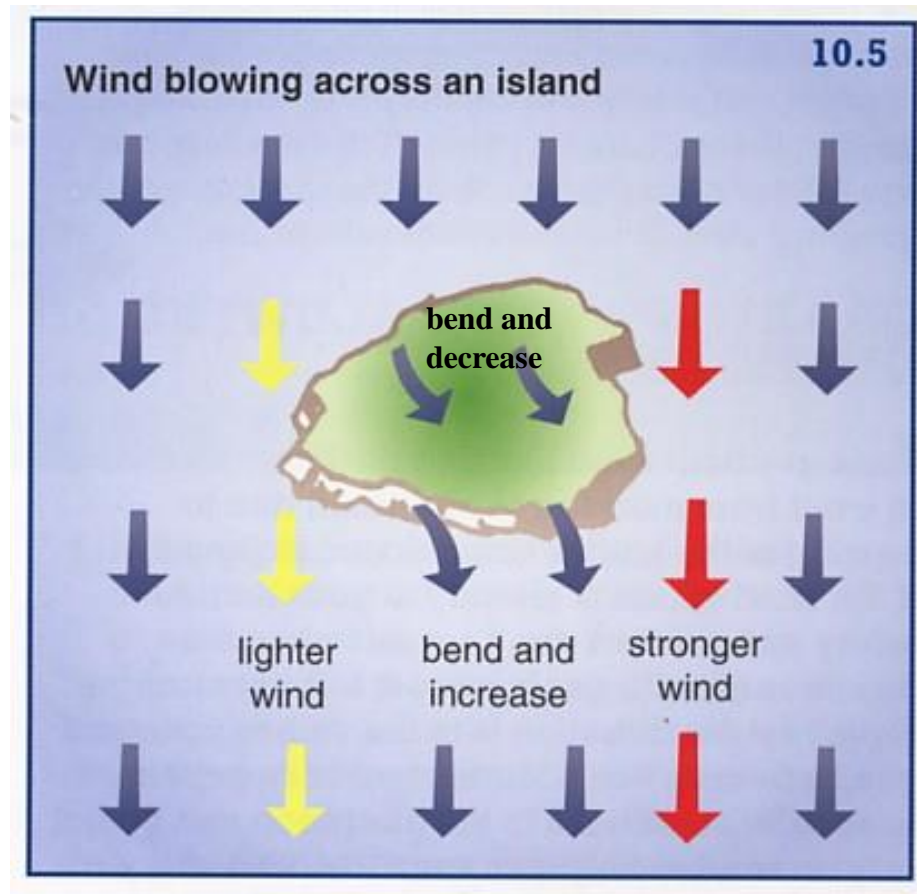
Scales of weather: Local weather phenomena – Coastal winds

- When the wind is blowing offshore, standing waves may form downwind of the coast if the air is stable. Zones of stronger and weaker winds are produced parallel to the coast:



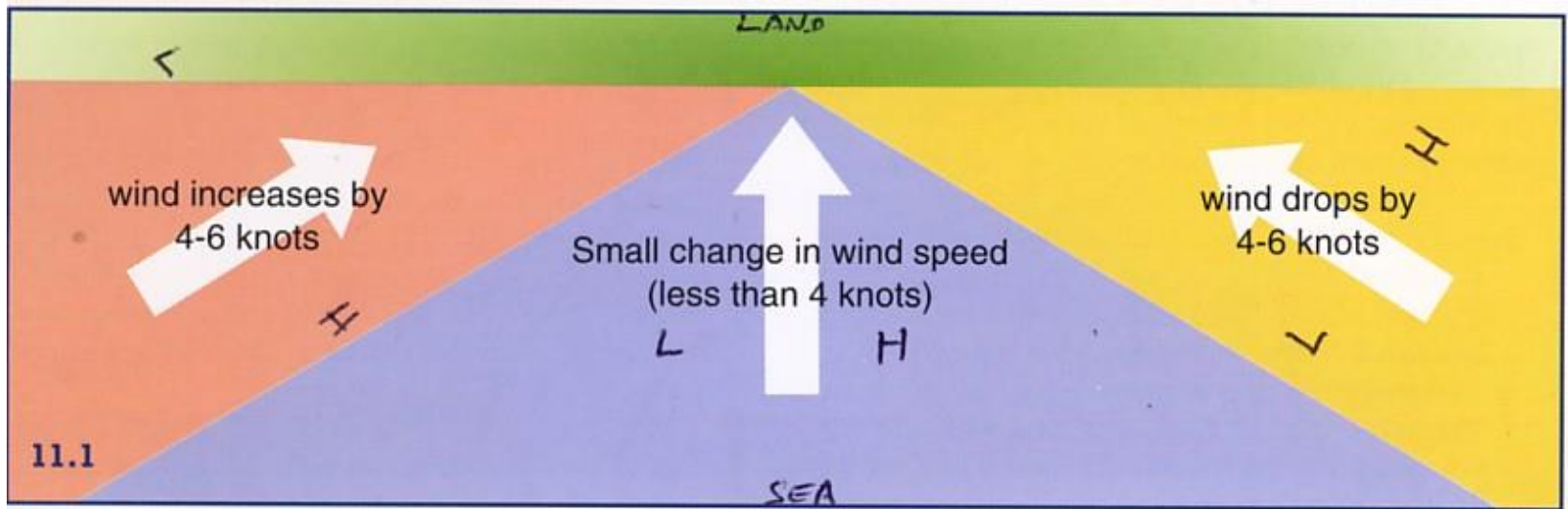
Scales of weather: Local weather phenomena – Coastal winds

- When the wind is blowing across a flat island in a stable air mass the following wind distribution will probably occur:



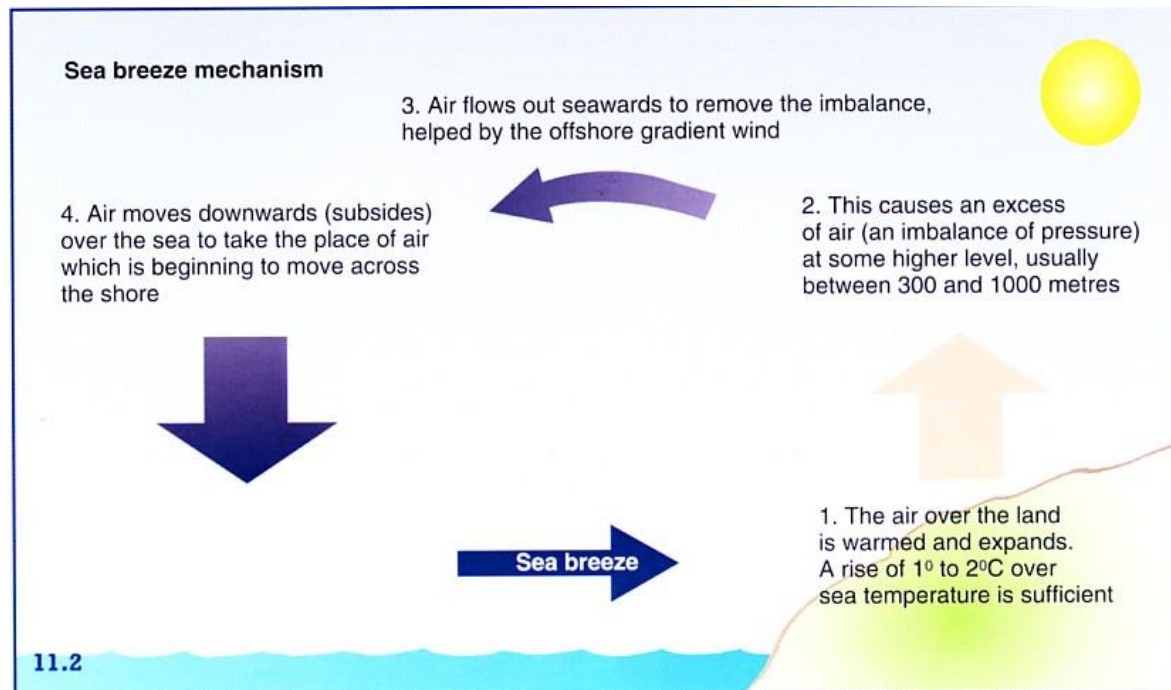
Scales of weather: Local weather phenomena – Coastal winds, afternoon winds

- For a wind blowing onshore from three different directions, the change in speed can be significant from morning to afternoon due to heating of the land reducing surface pressure:

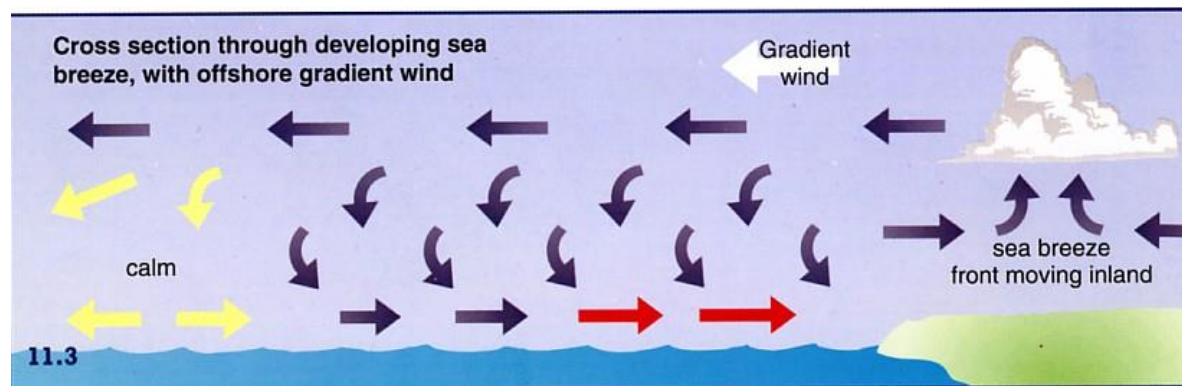


Scales of weather: Local weather phenomena – Coastal winds, the sea breeze

- The sea-breeze mechanism (the sea-breeze requires an off-shore gradient wind of less than 20 knots and no major storms in the vicinity):

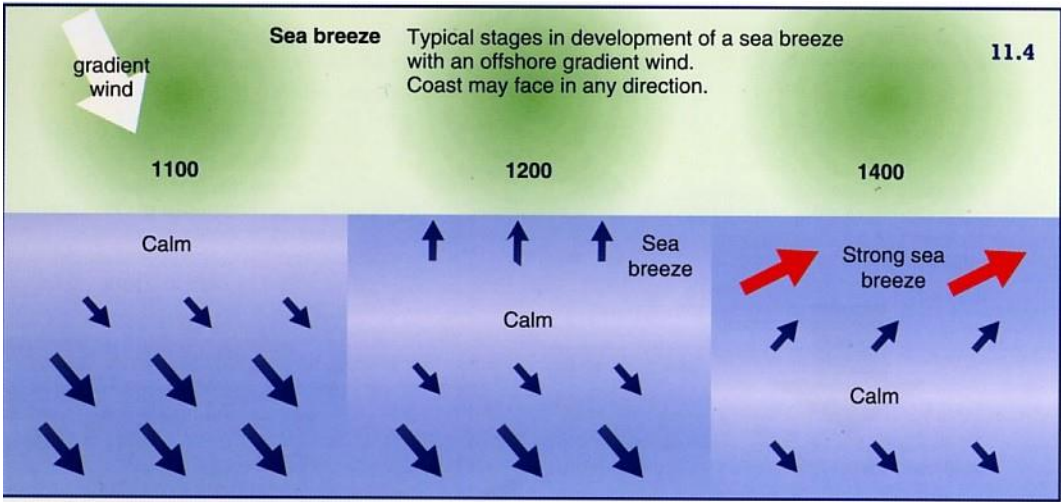


- The breeze is always strongest near the shore:

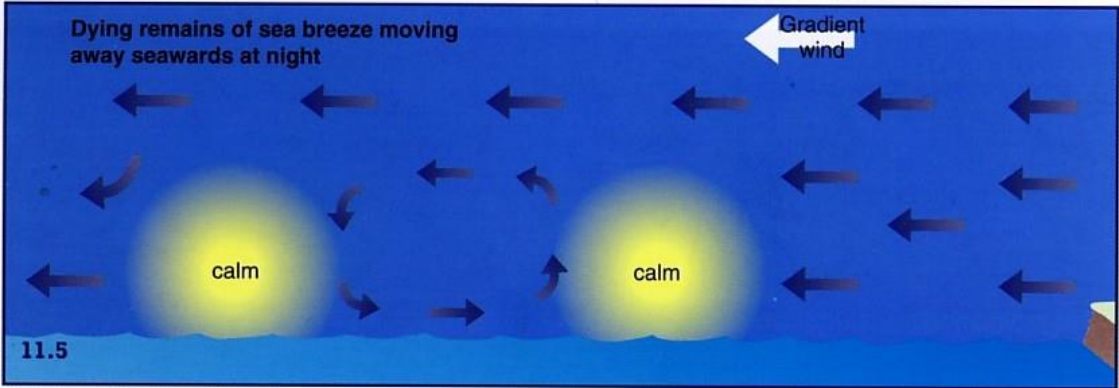


Scales of weather: Local weather phenomena – Coastal winds, the sea breeze

- The sea-breeze is deflected to the right of the flow by the Coriolis effect:



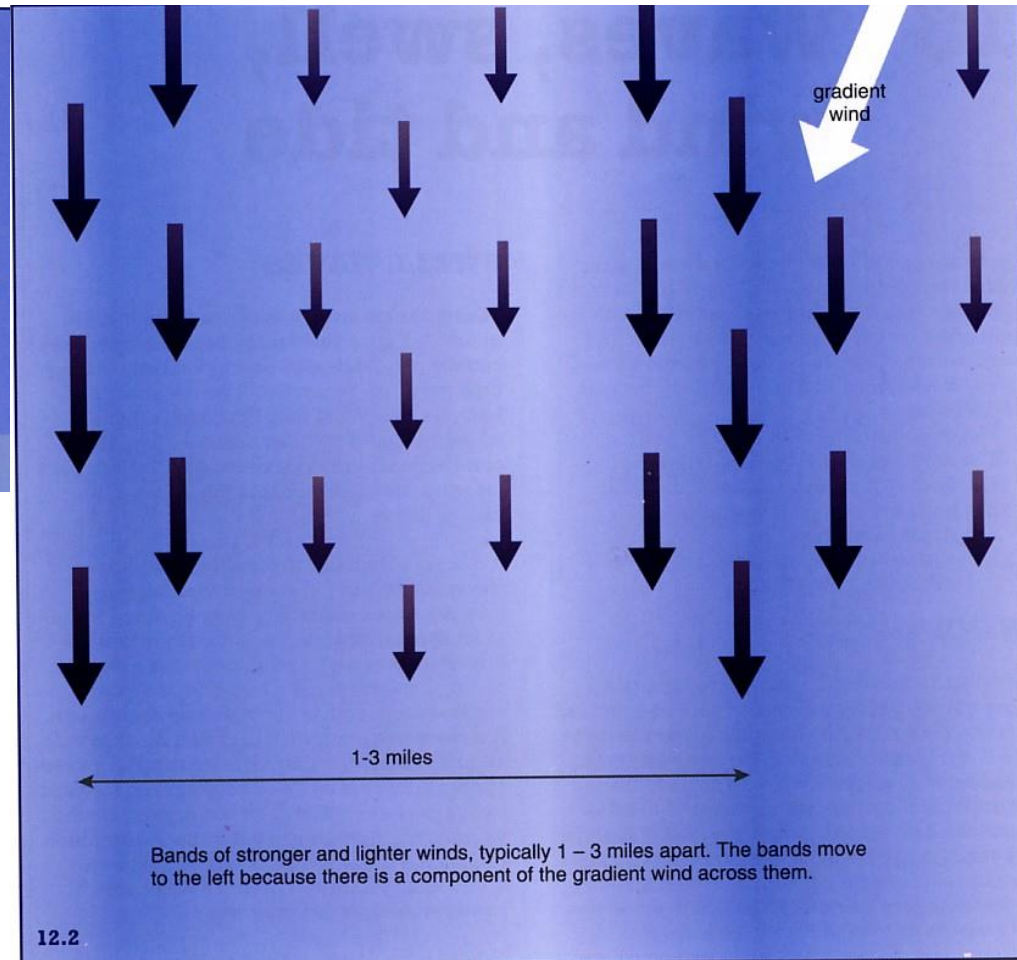
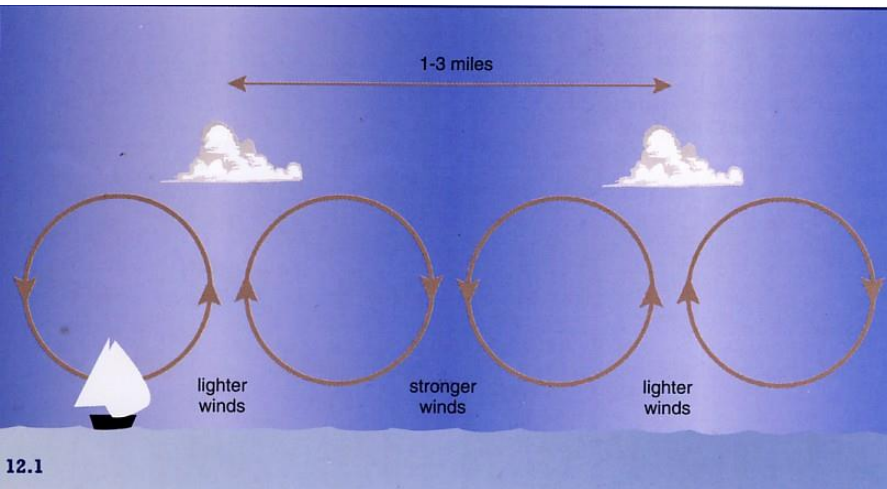
- The breeze drifts offshore in the evening in the gradient flow:



Sea breeze cumulus forming ashore

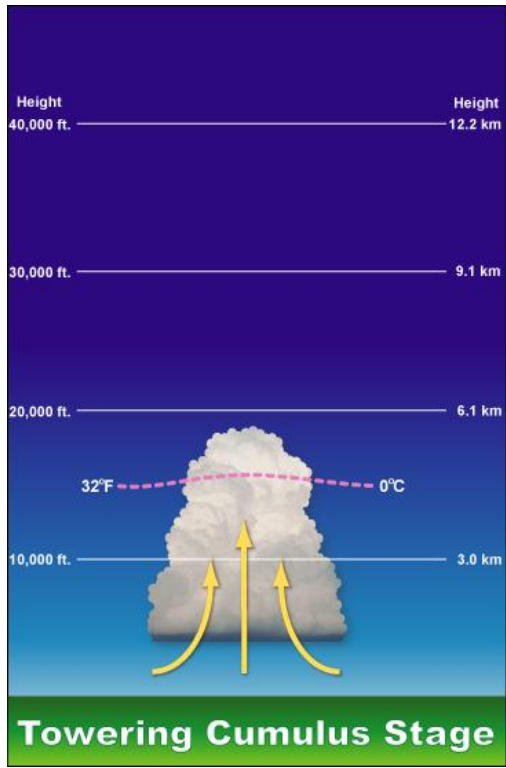
Scales of weather: Local weather phenomena – Winds over the open ocean

- In a stable marine boundary layer, a steady wind will develop horizontal roll vortices that will produce regions of suppressed and enhanced wind speed:

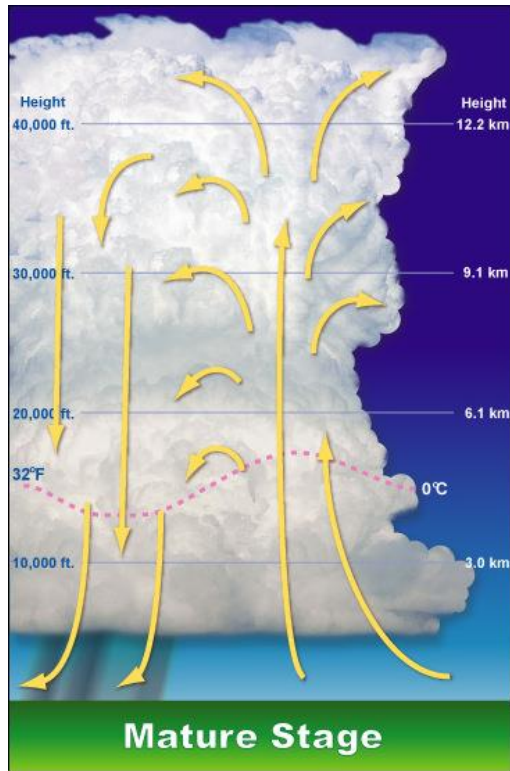


Scales of weather: Squall lines

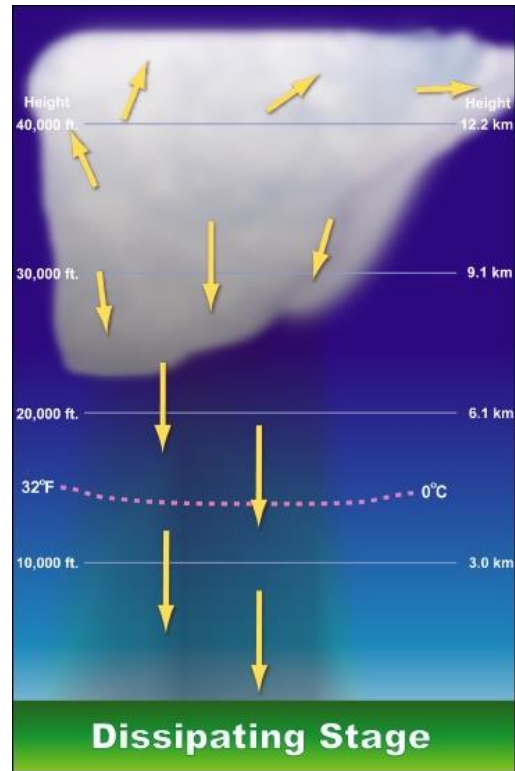
- A squall line is a propagating, organized line of thunderstorms, each storm has a life cycle that leads to new cell formation:



~30 min



~30 min

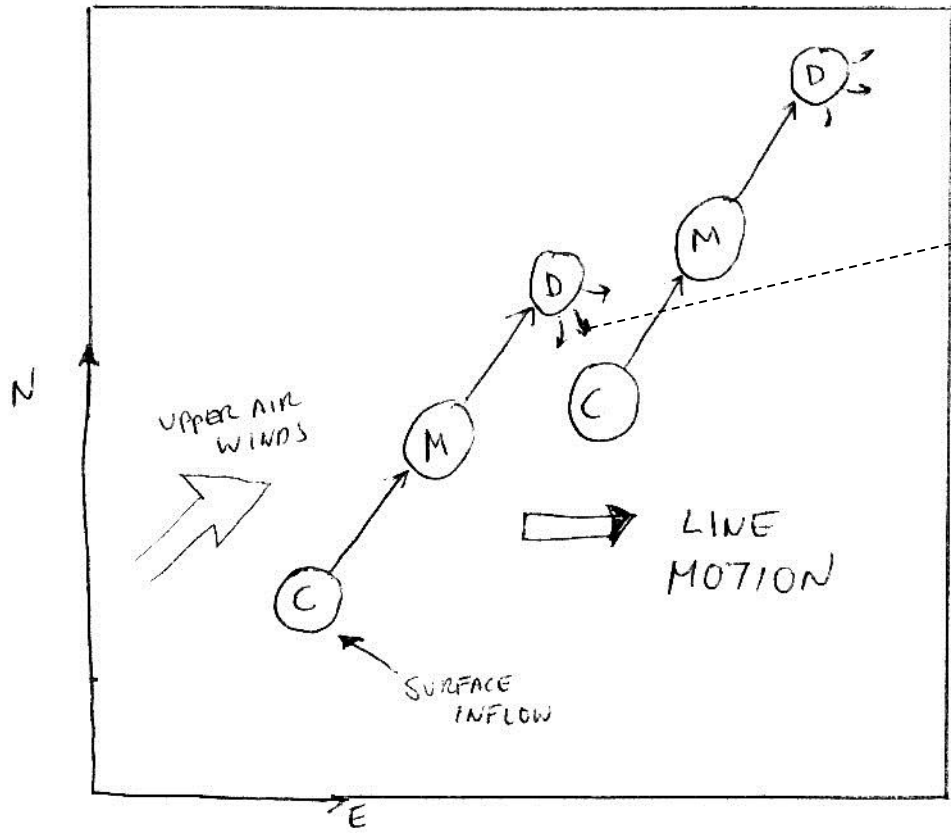


~30 min

The sudden storm lasts not three hours; the sharper the blast, the sooner 'tis past.

Scales of weather: Squall lines

- A squall line is a propagating, organized line of thunderstorms, each storm has a life cycle that leads to new cell formation:



*Beware the bolts from north or west;
in south or east the bolts be best.*

*Rainbow to windward, foul fall the day;
rainbow to leeward, rain runs away.*

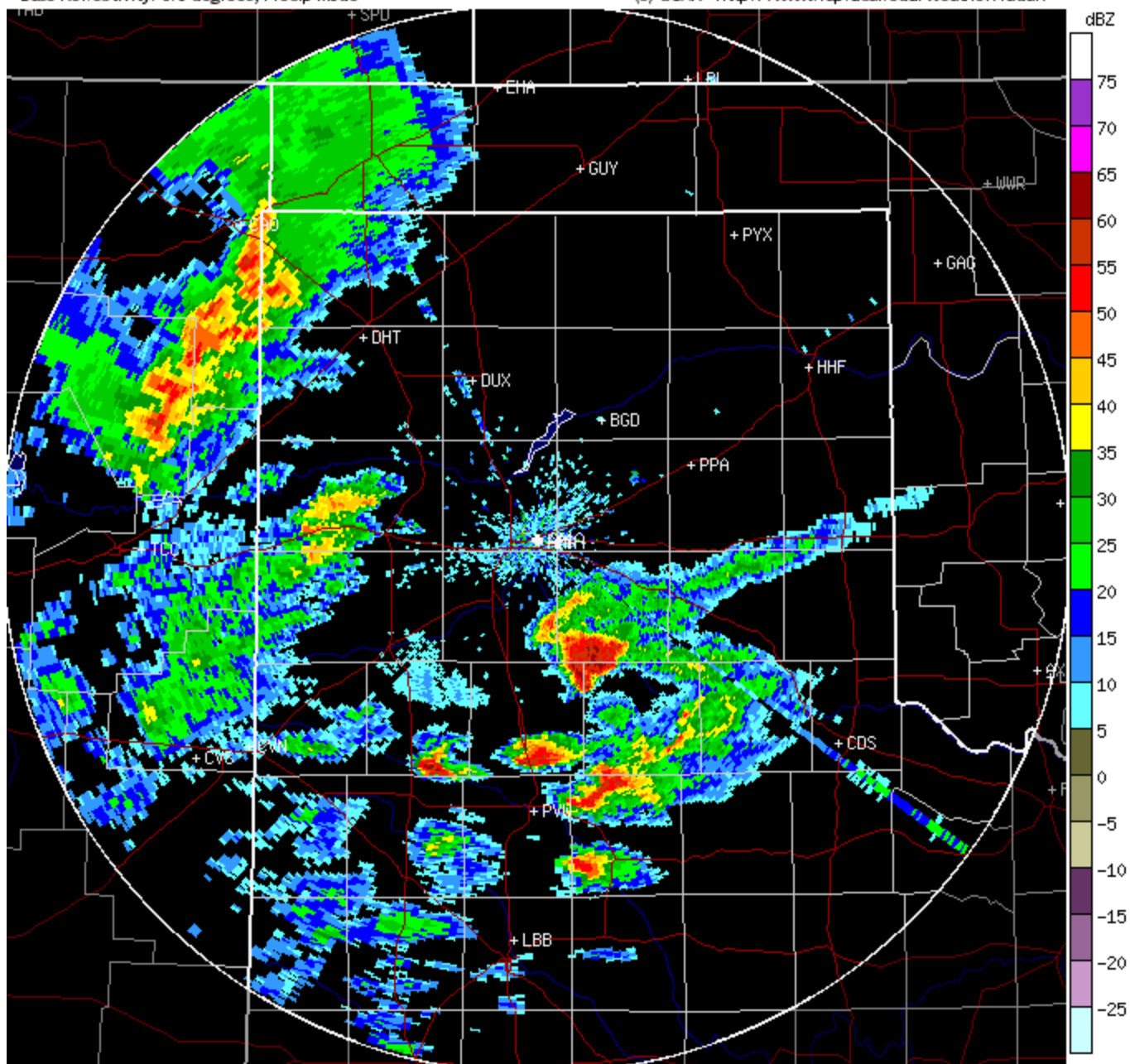
Observe squall line motion for 12 April 2007 evening storms in west Texas in the following sequences: radar, satellite and surface.

KAMA -- Amarillo, TX

00:03:36 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

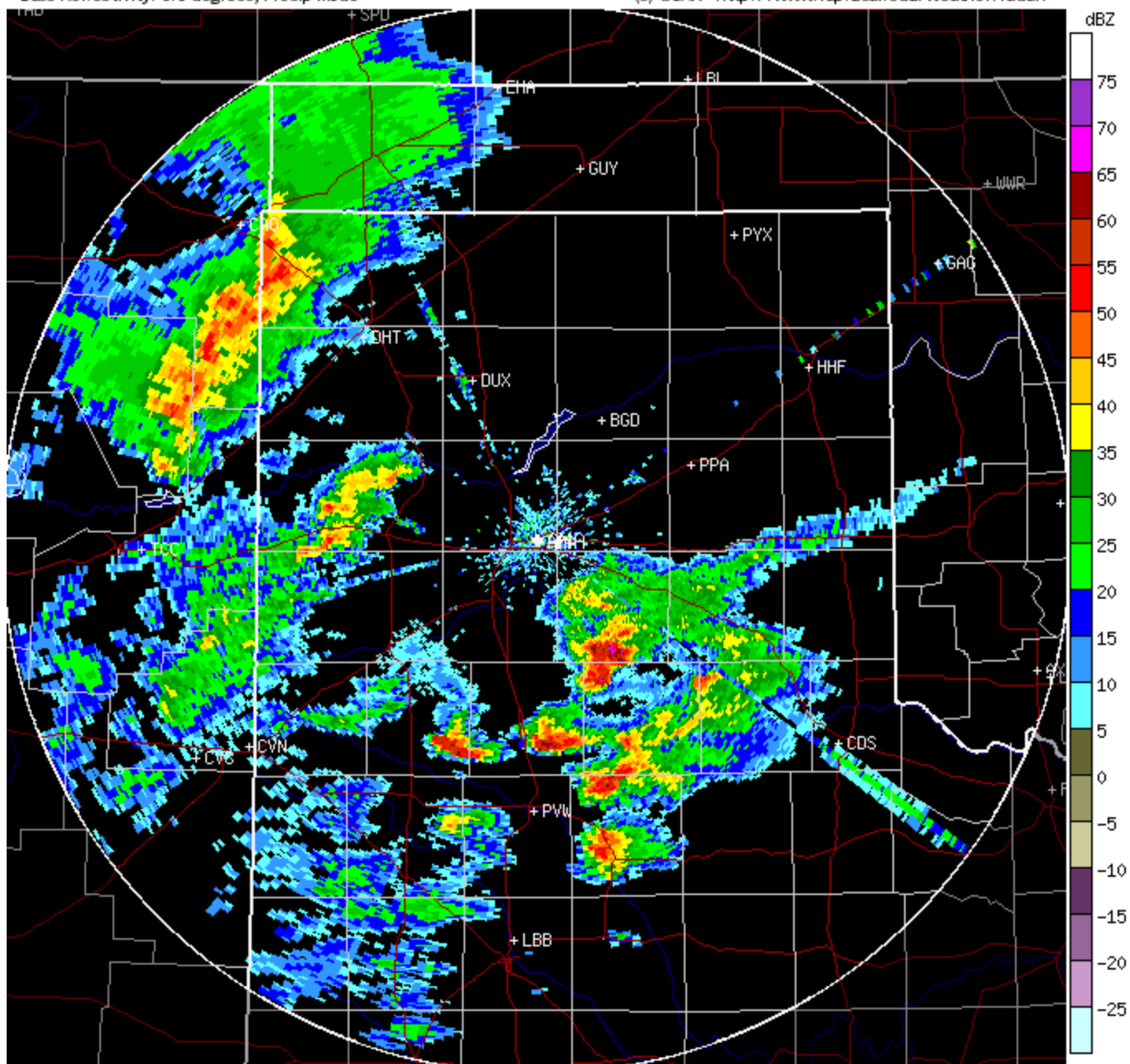


KAMA -- Amarillo, TX

00:13:23 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

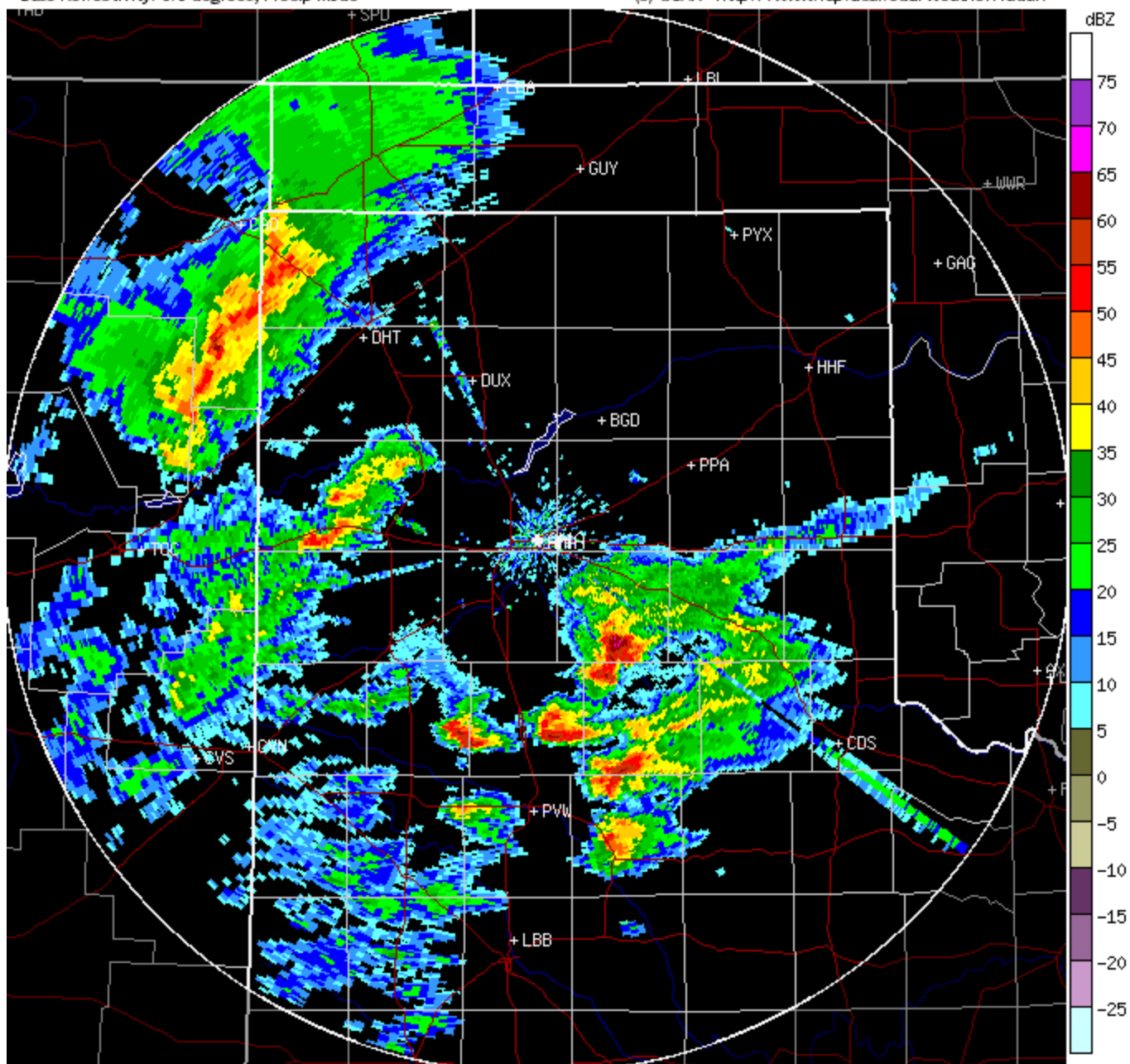


KAMA -- Amarillo, TX

00:18:16 UTC Fri 13 April 2007

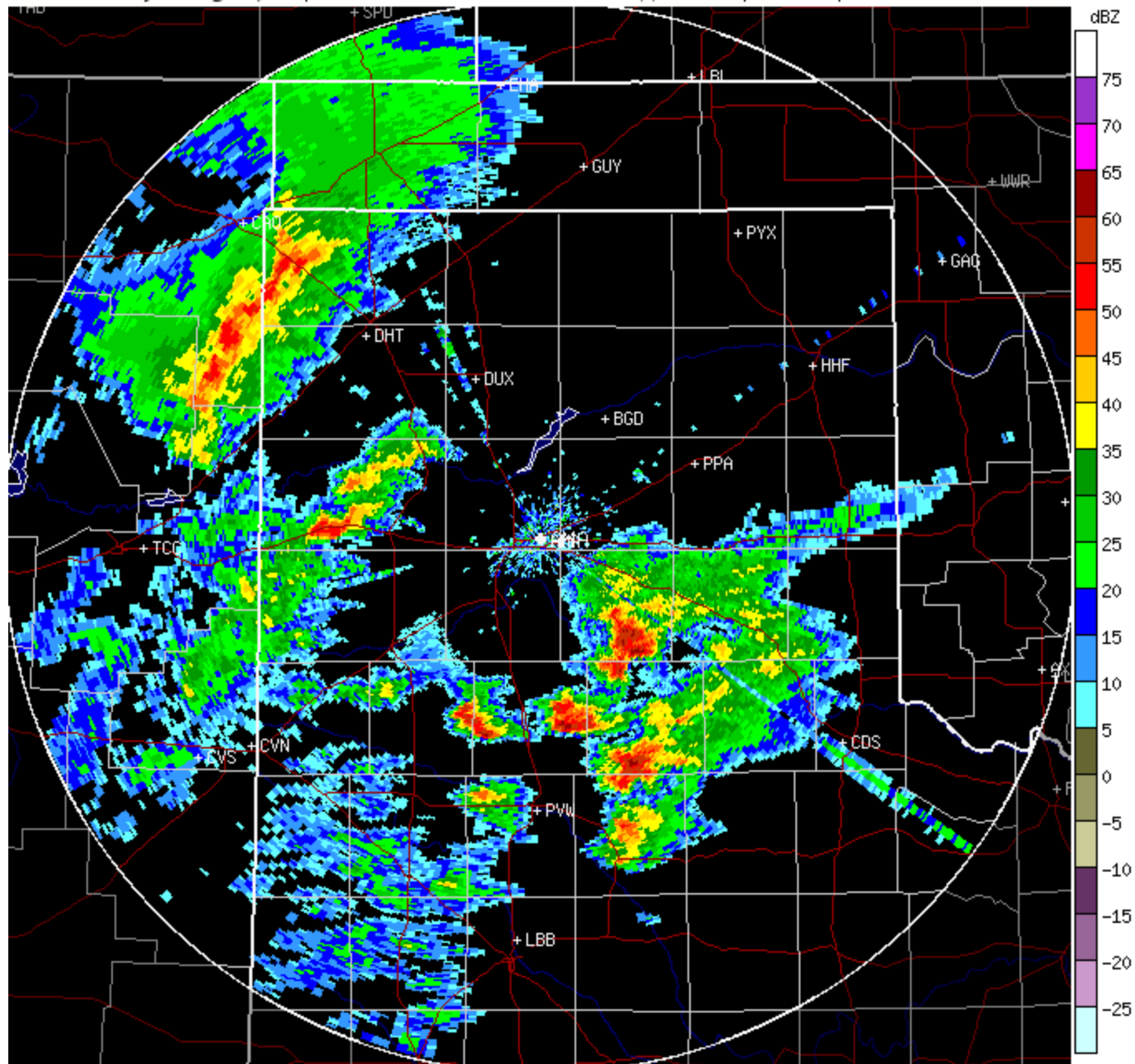
Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

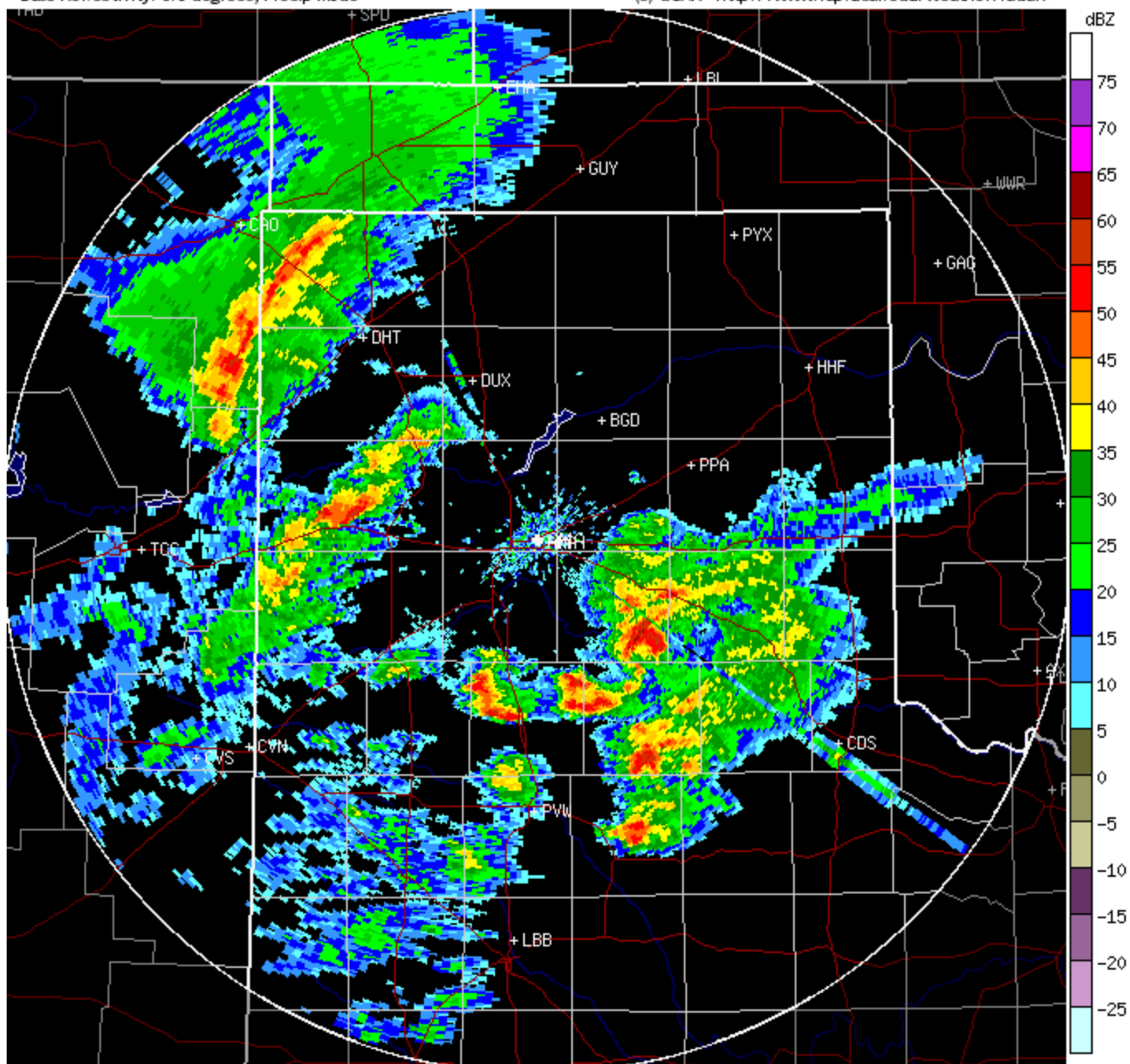


KAMA -- Amarillo, TX

00:32:58 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

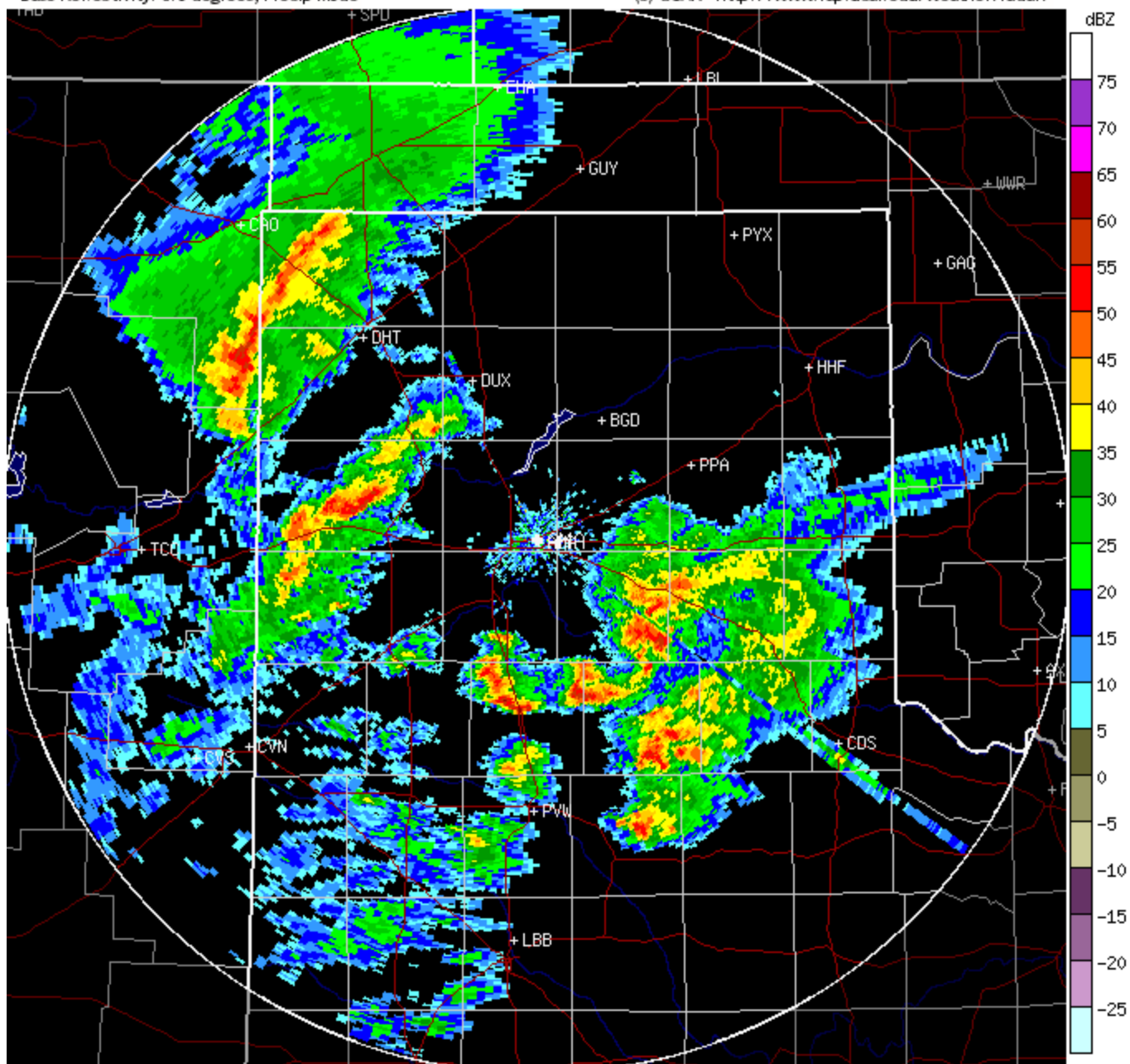


KAMA -- Amarillo, TX

00:37:51 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

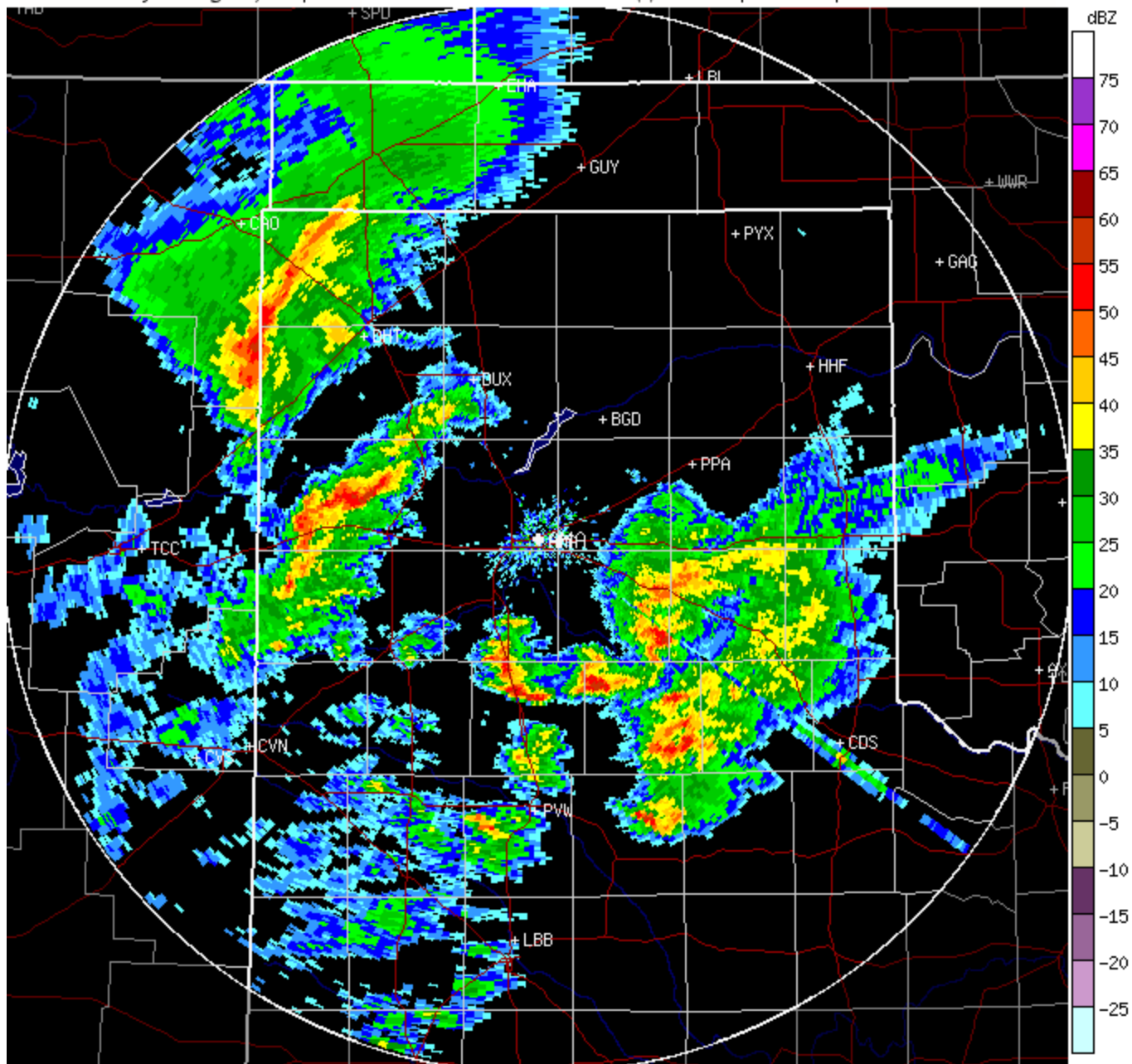


KAMA -- Amarillo, TX

00:42:44 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

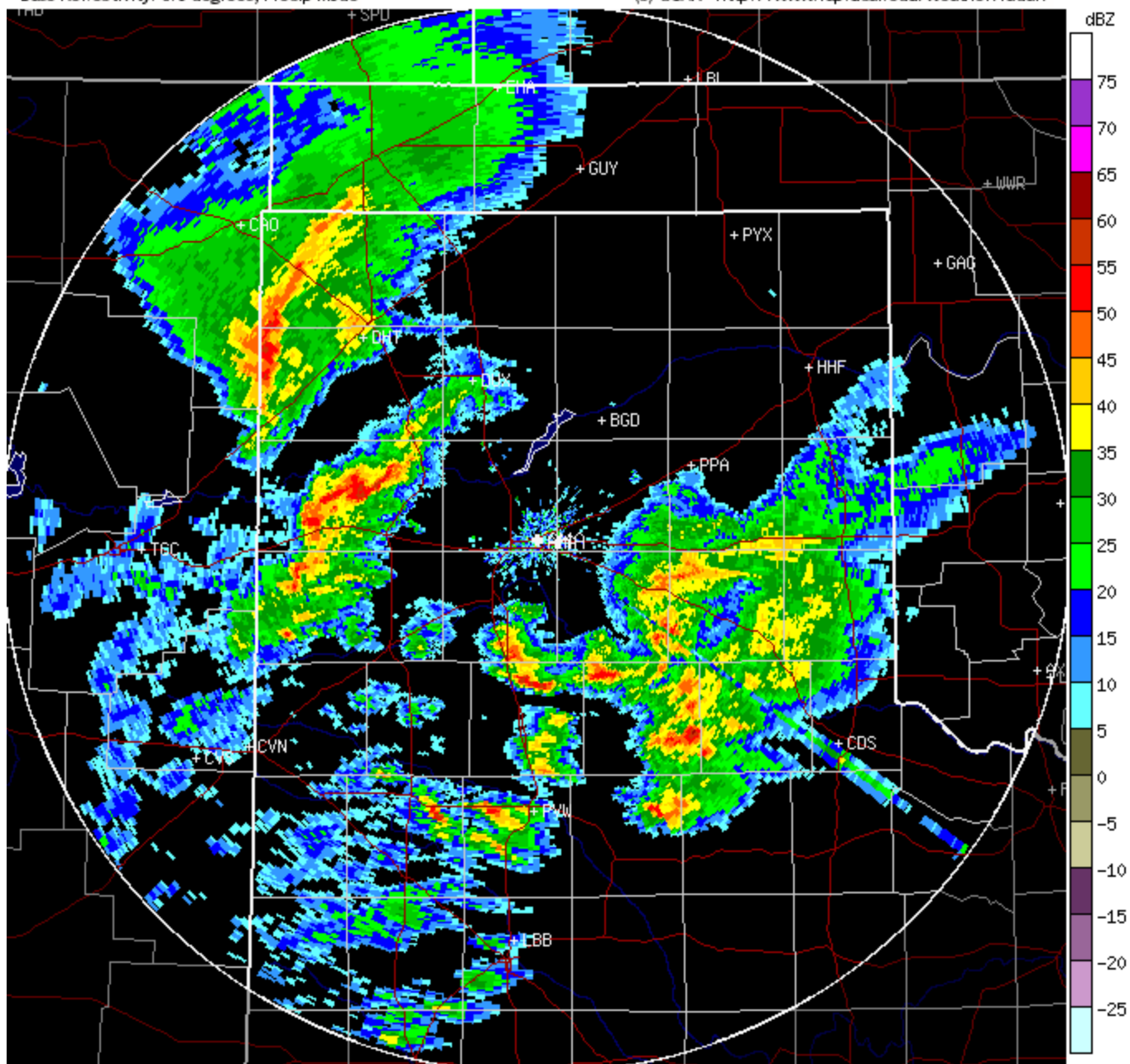


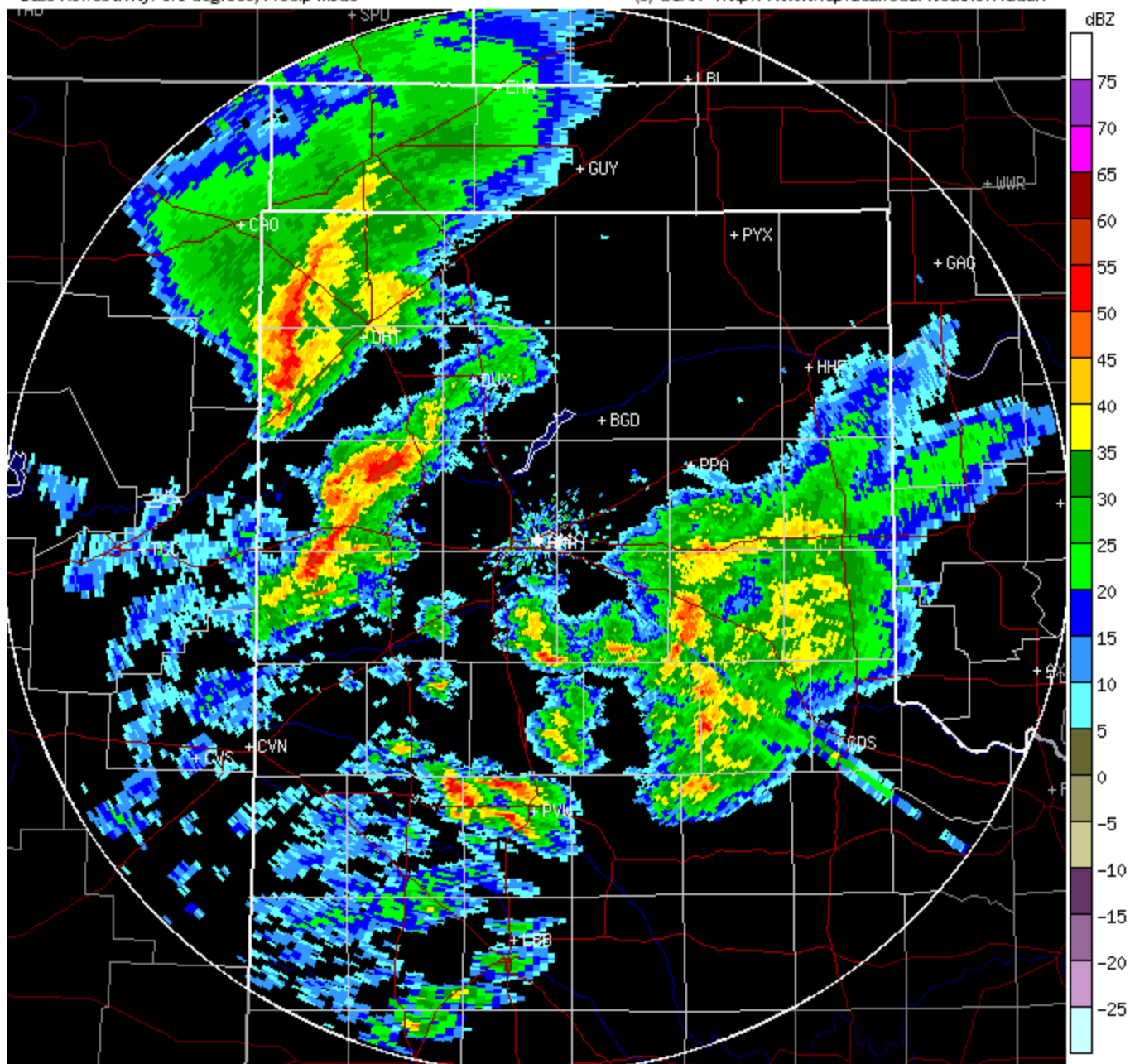
KAMA -- Amarillo, TX

00:47:37 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



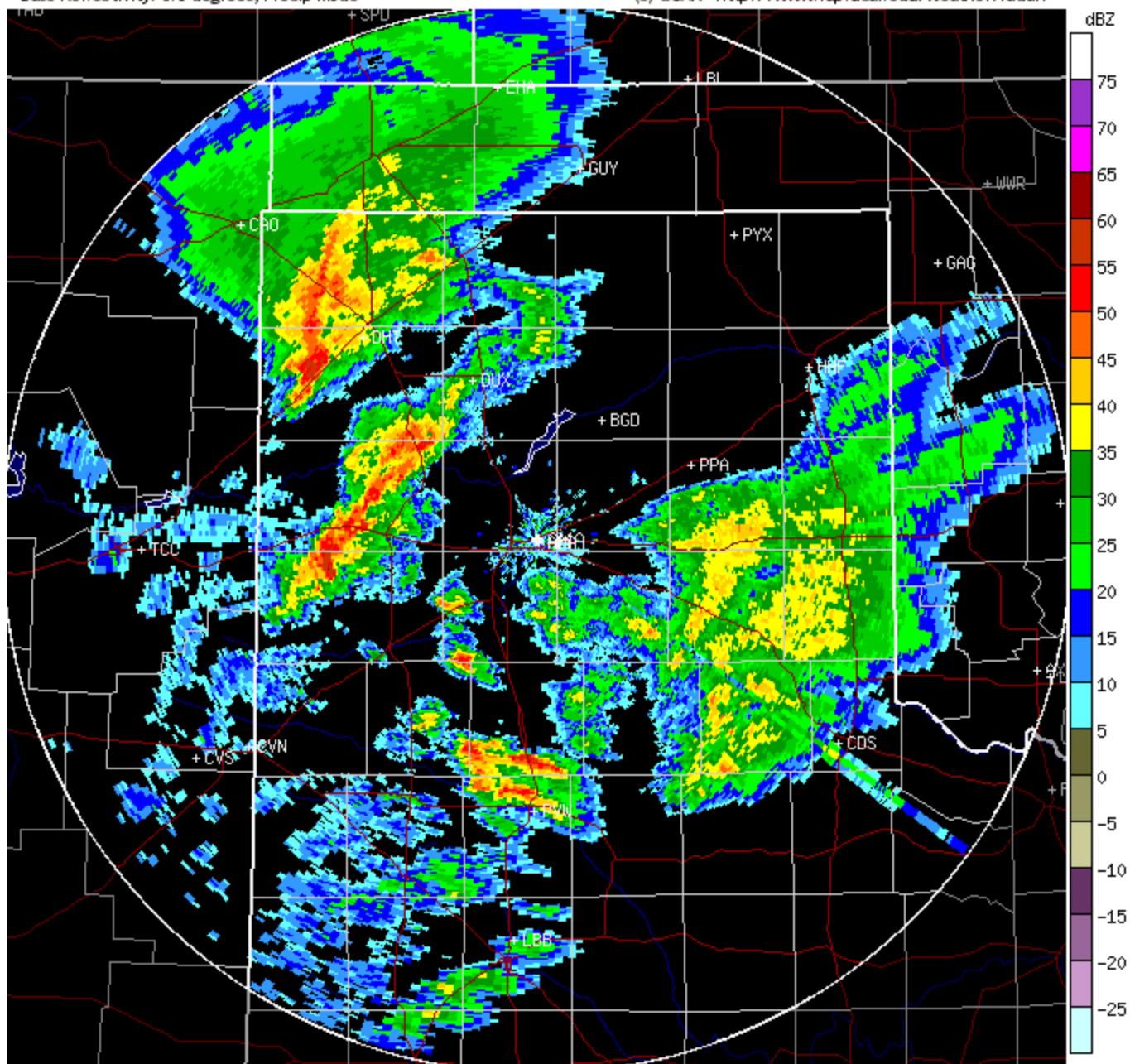


KAMA -- Amarillo, TX

01:07:10 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

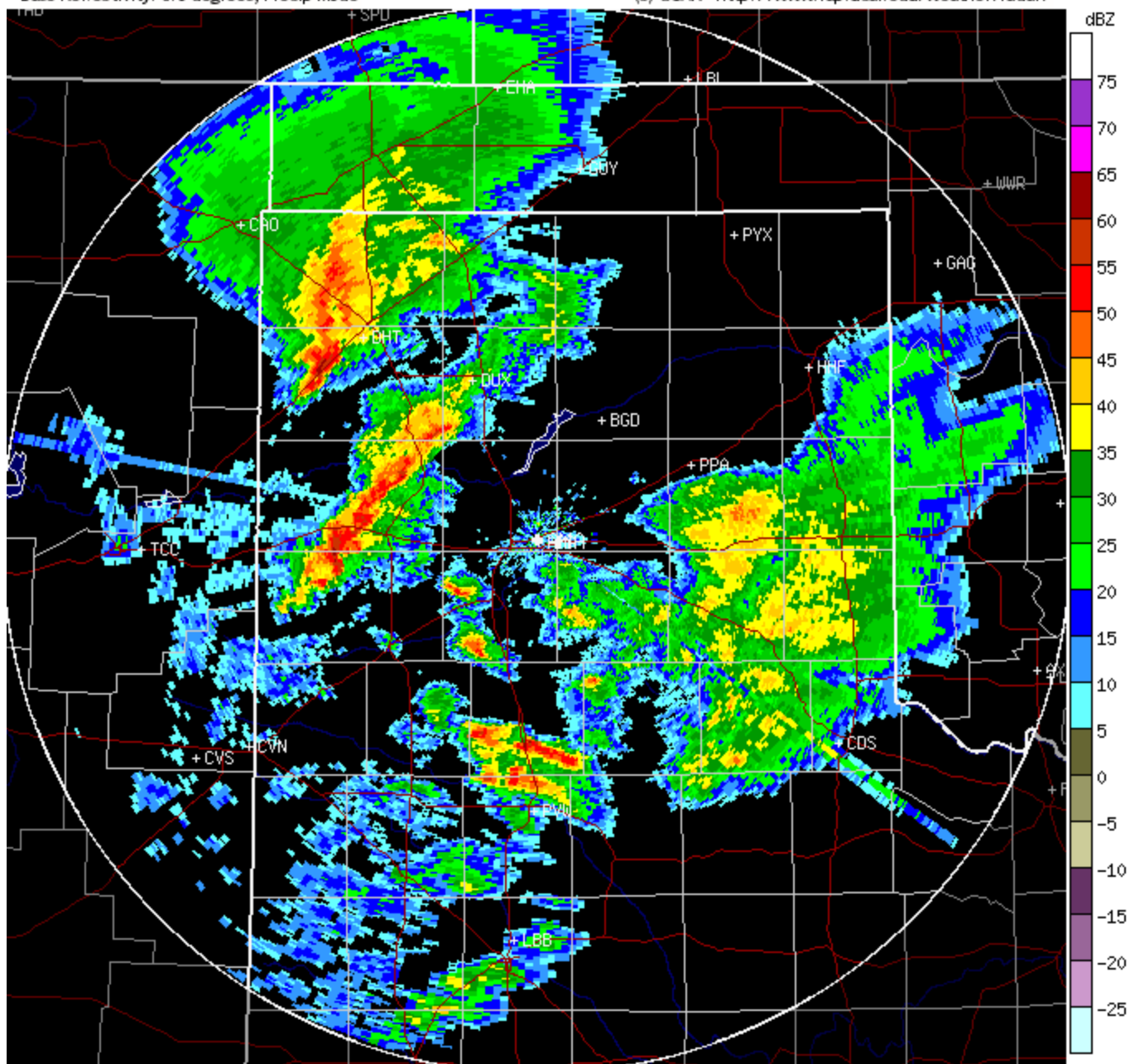


KAMA -- Amarillo, TX

01:12:03 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

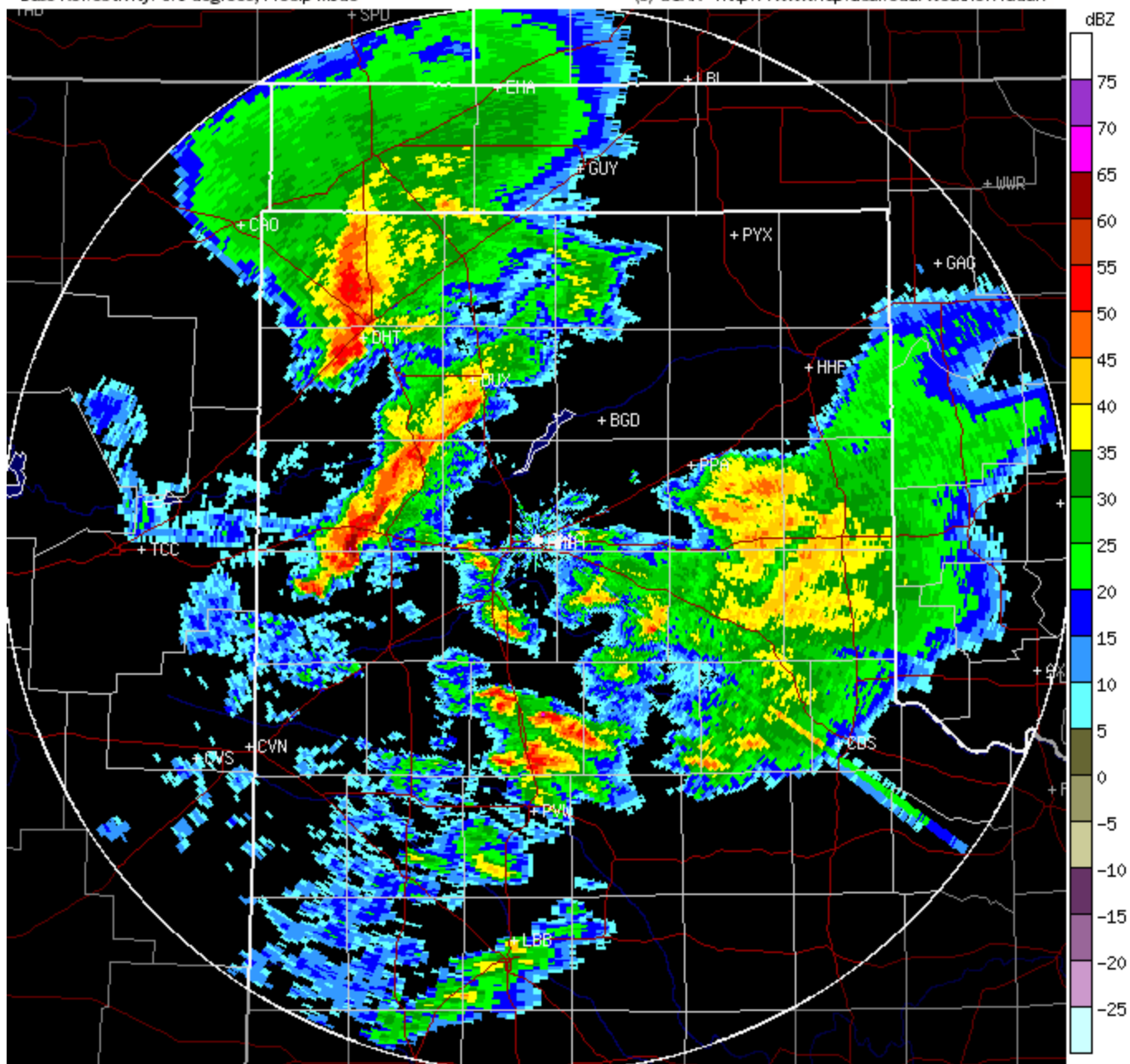


KAMA -- Amarillo, TX

01:21:49 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

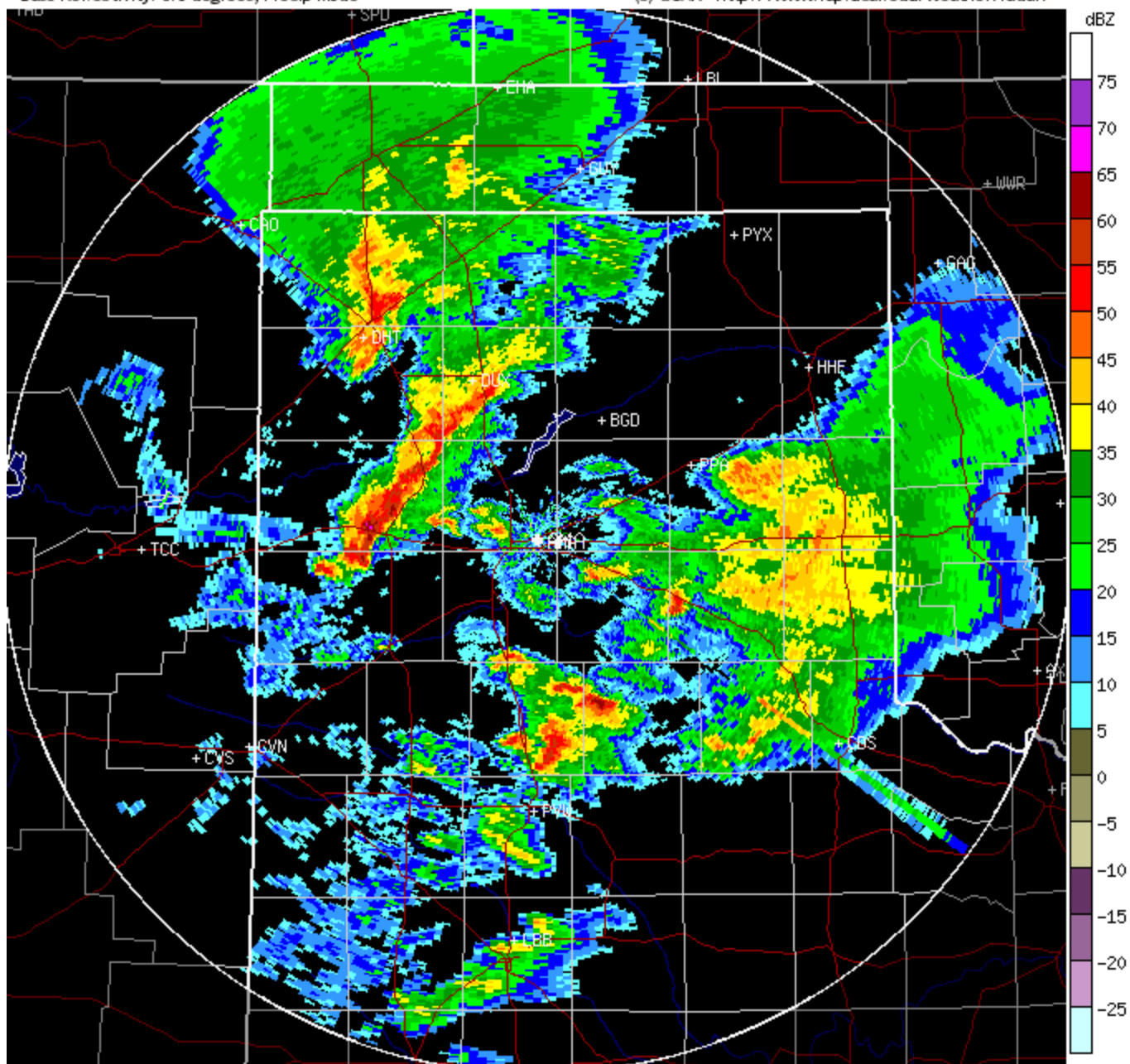


KAMA -- Amarillo, TX

01:31:35 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

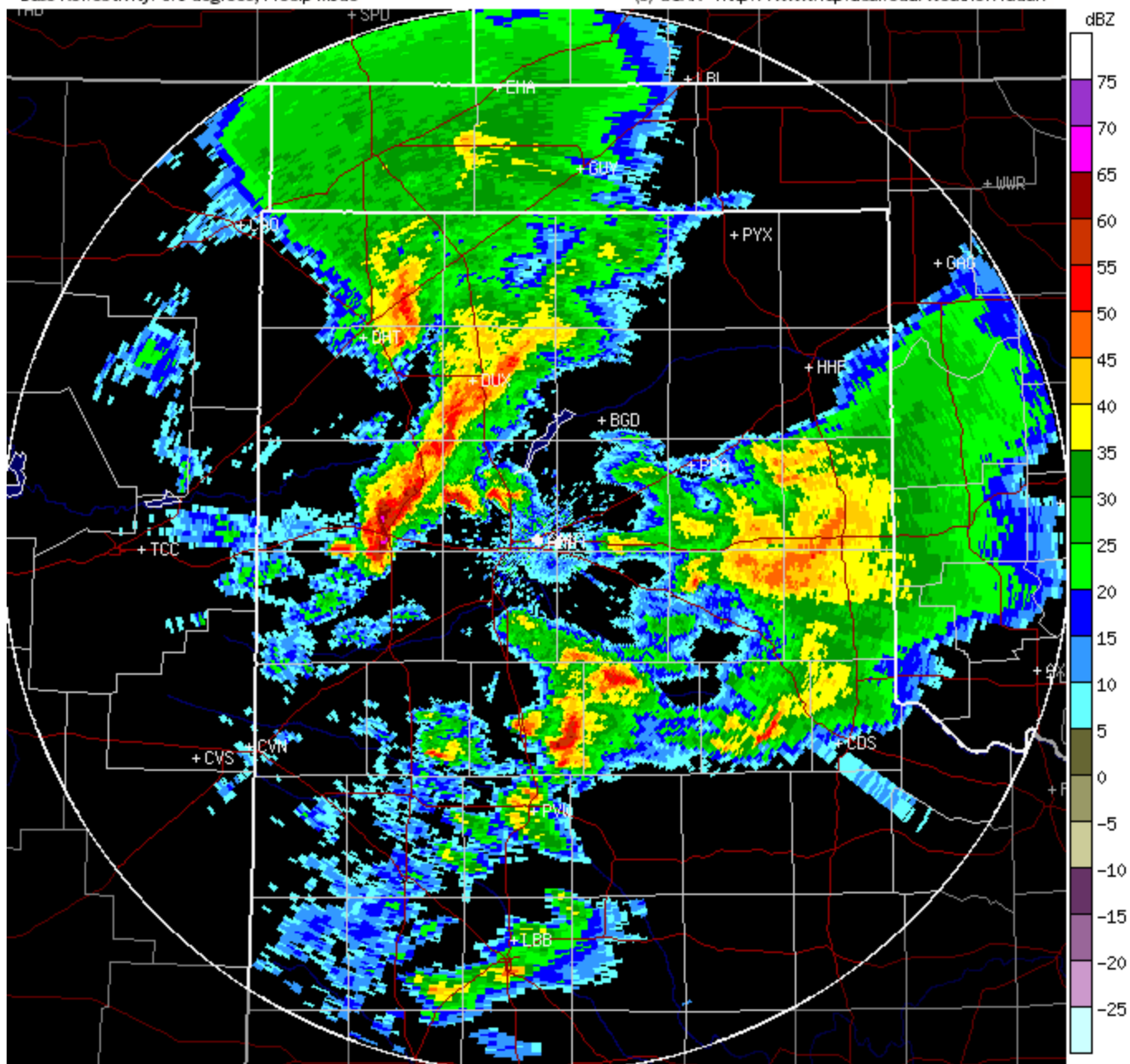


KAMA -- Amarillo, TX

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Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

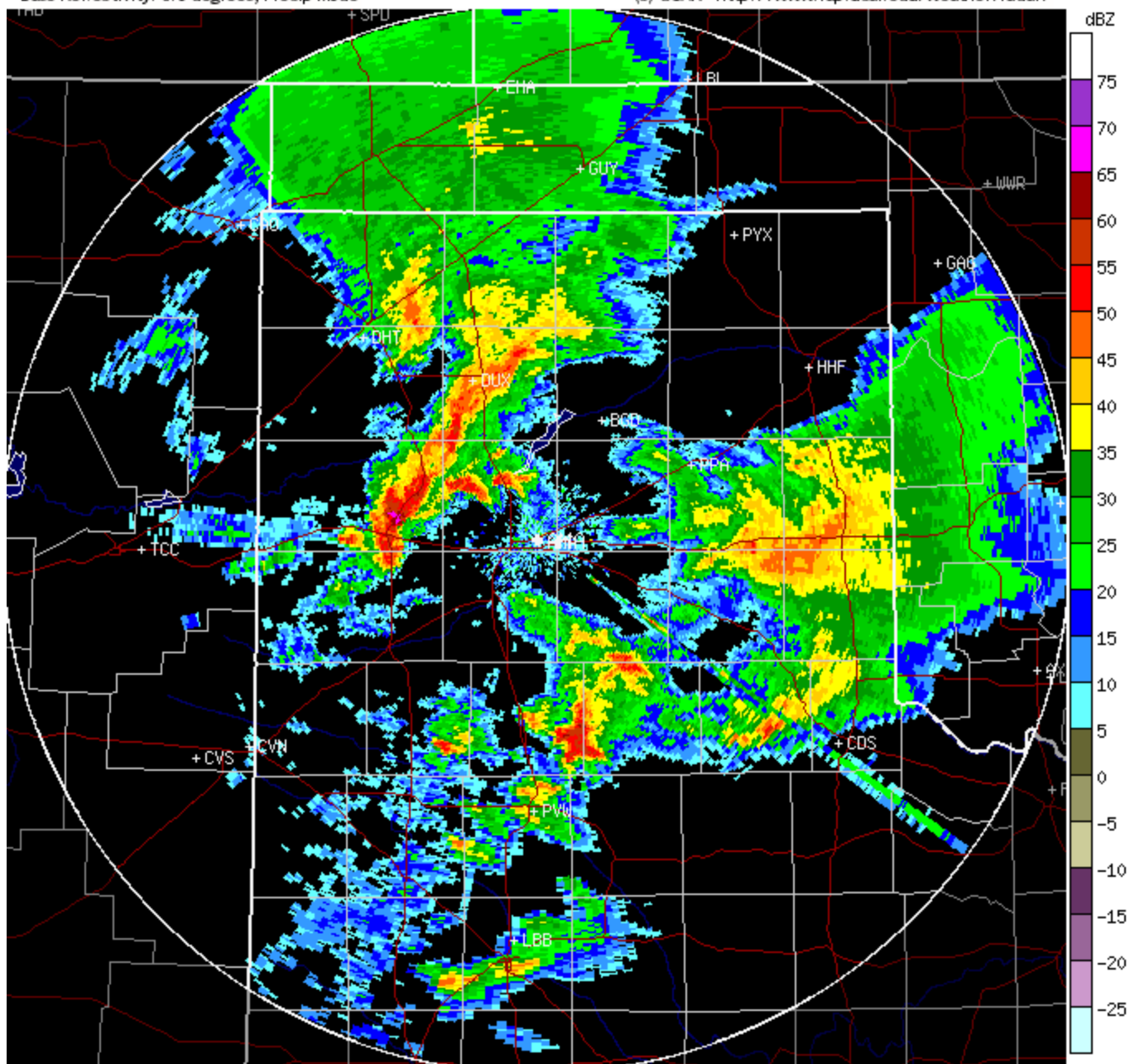


KAMA -- Amarillo, TX

01:46:15 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

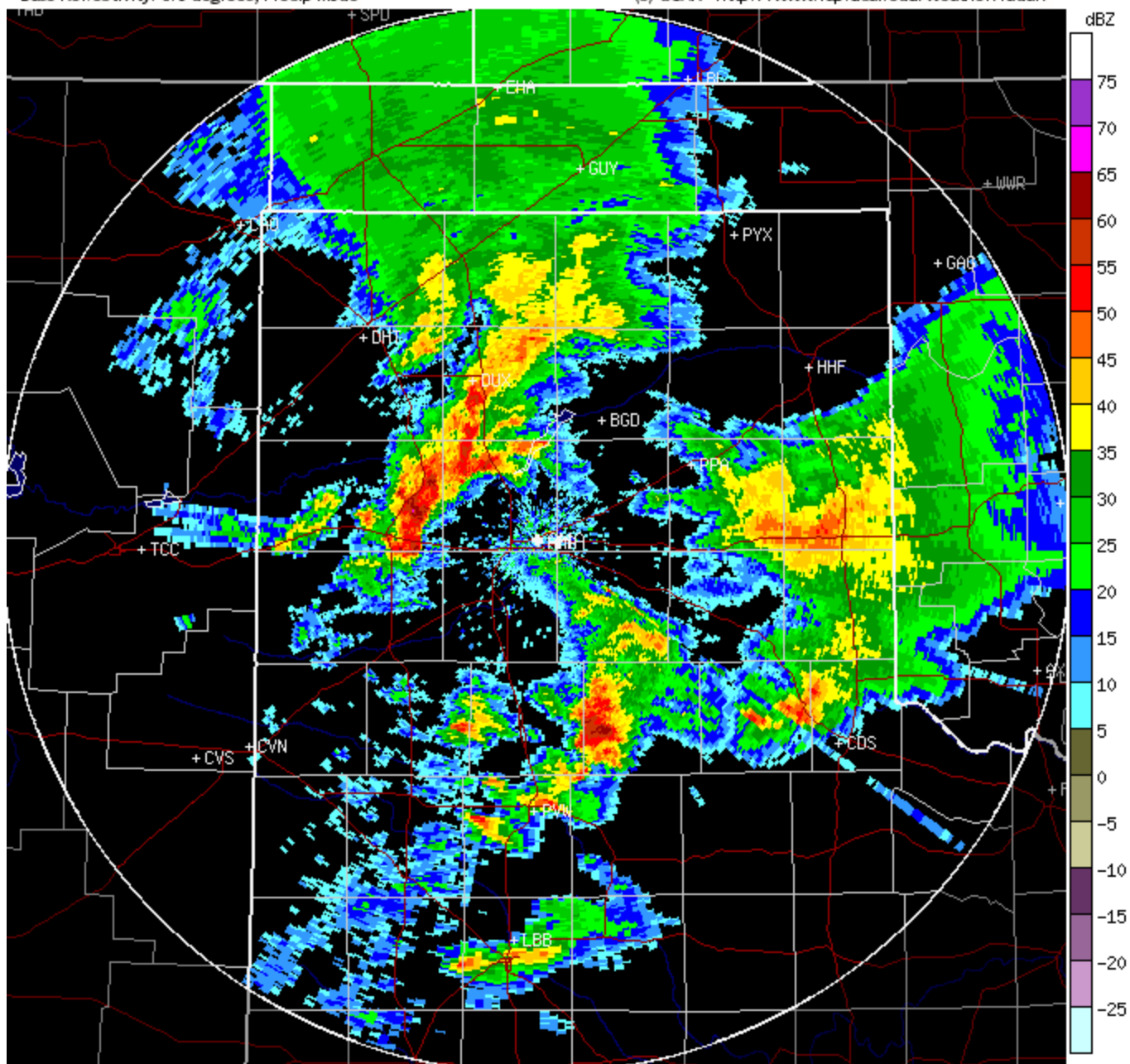


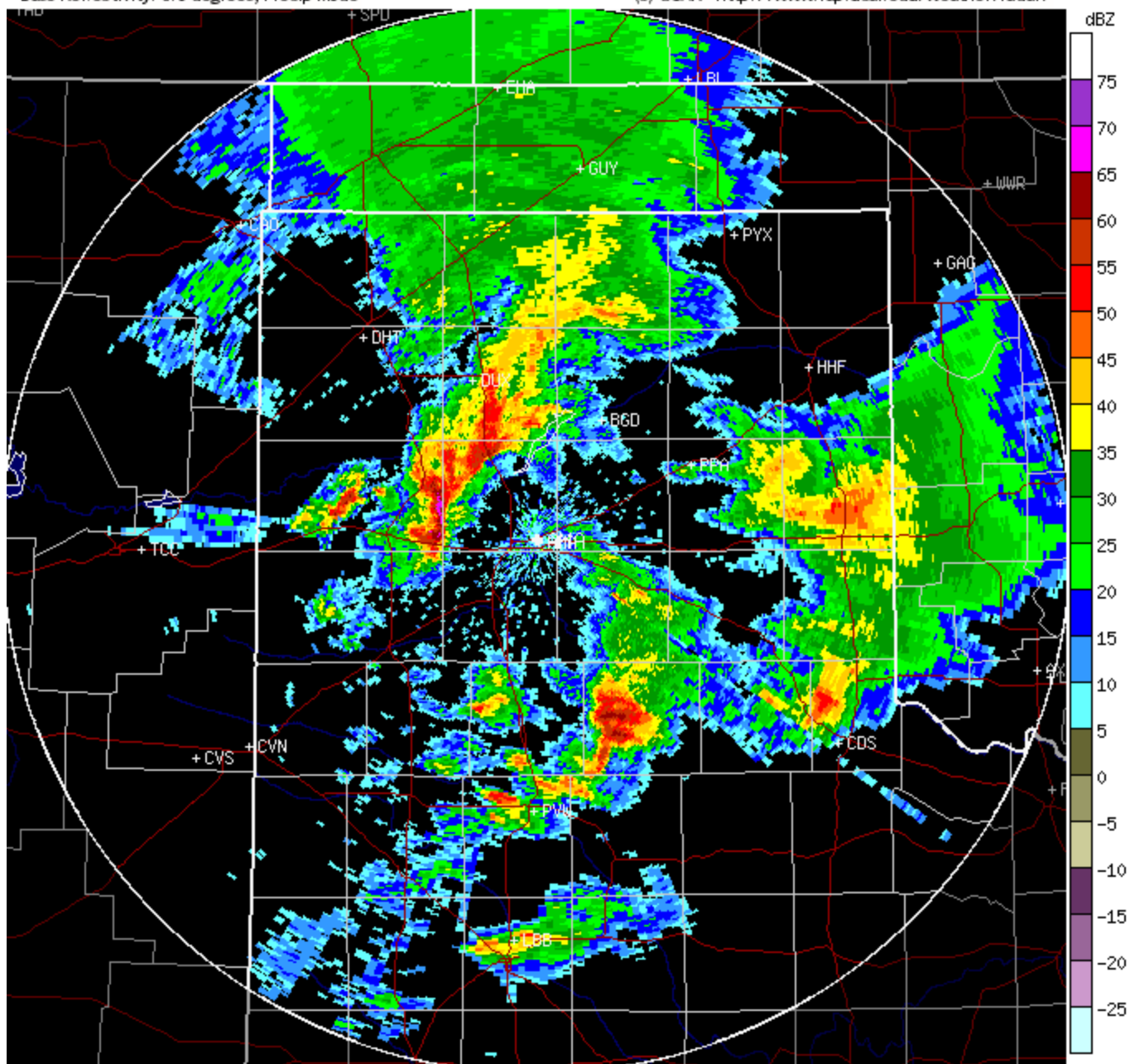
KAMA -- Amarillo, TX

01:56:01 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



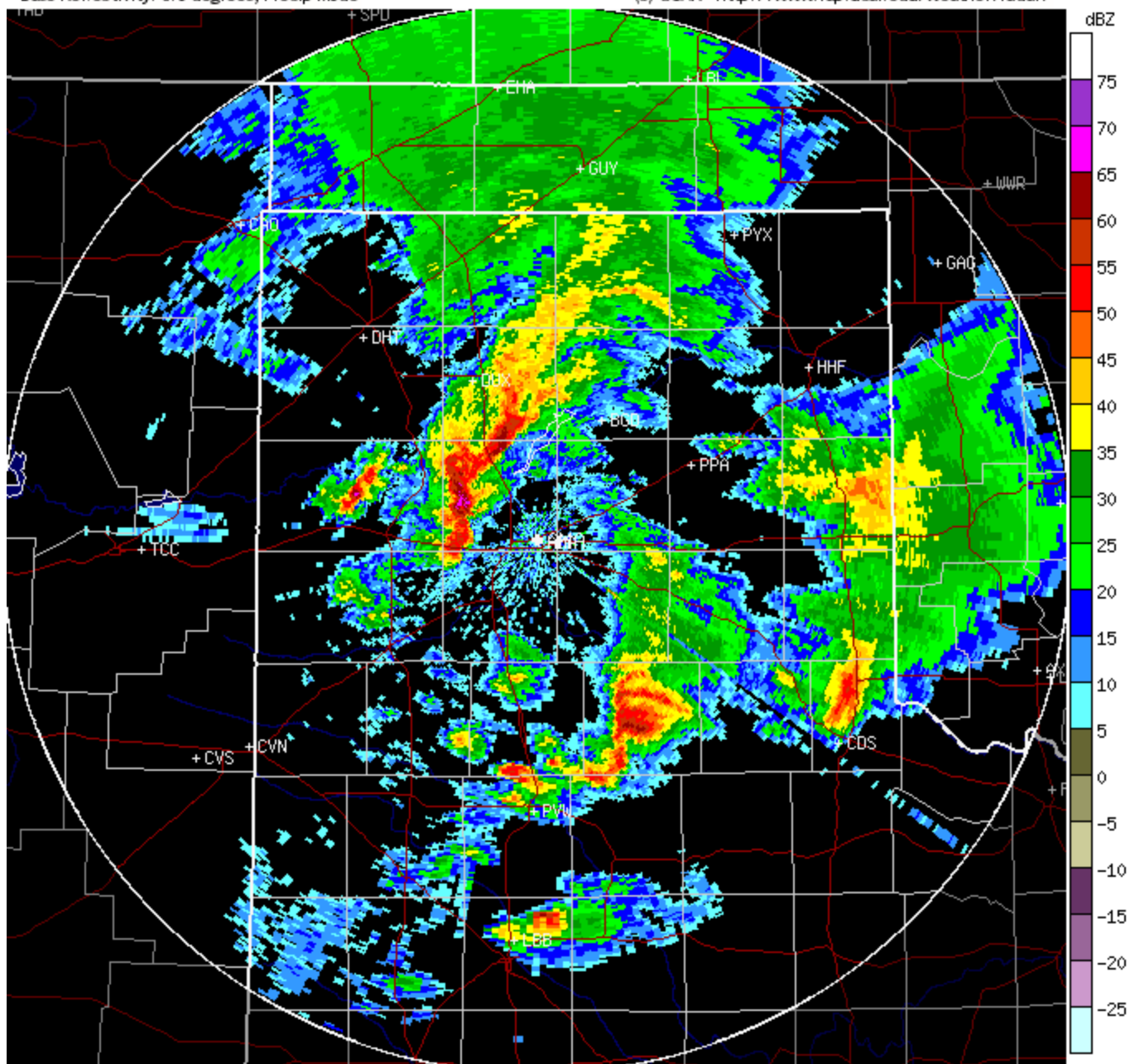


KAMA -- Amarillo, TX

02:15:33 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

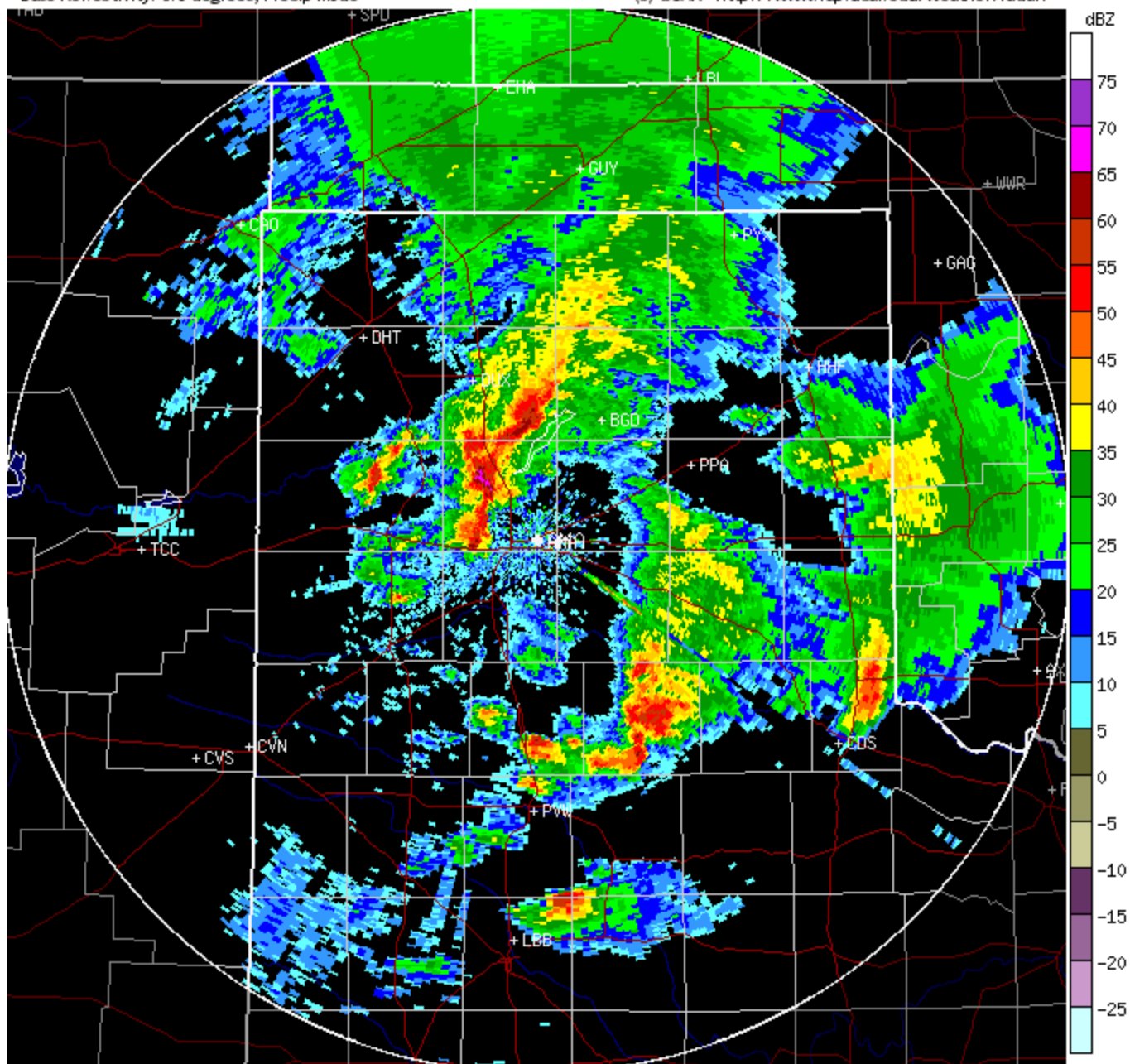


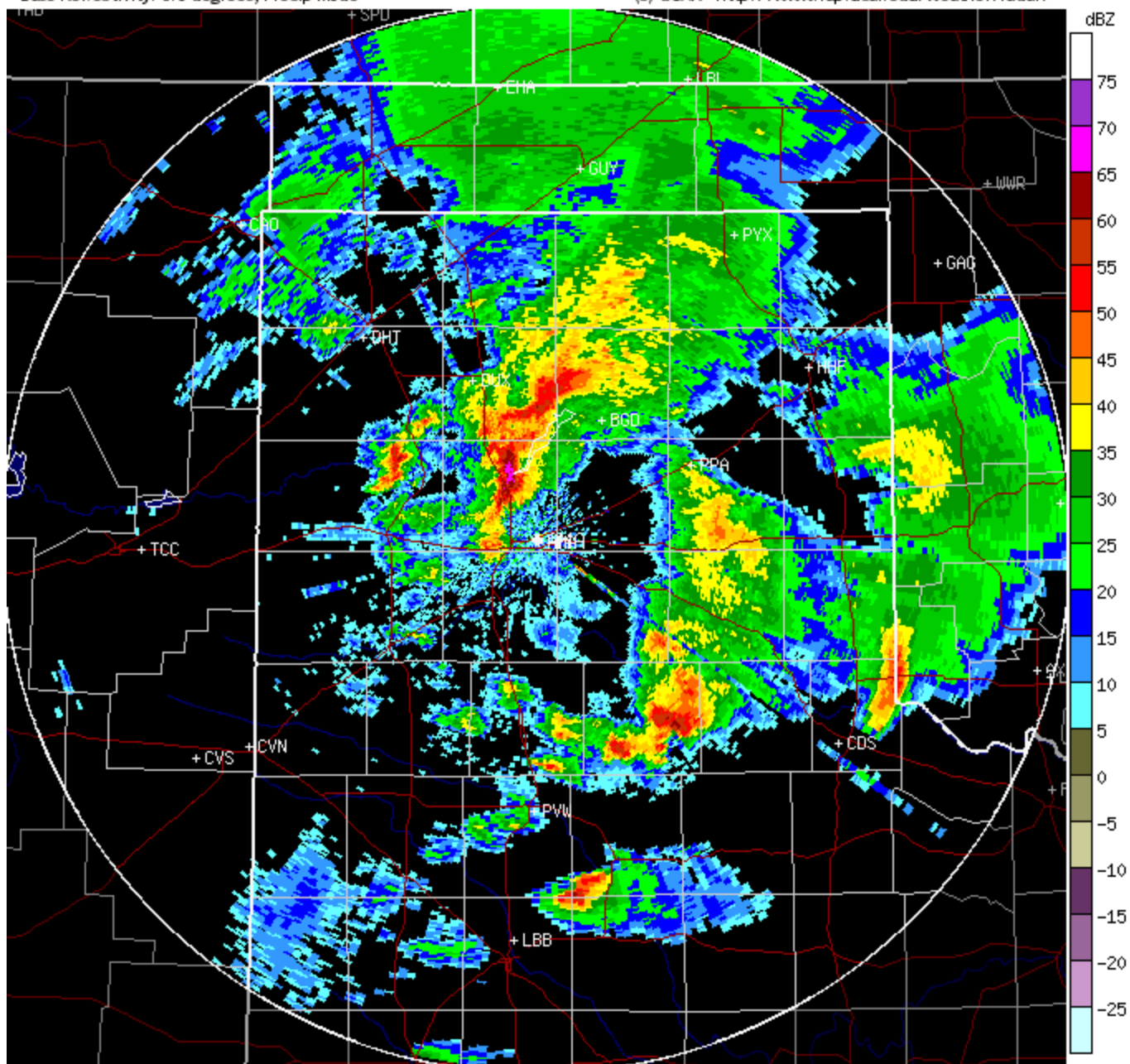
KAMA -- Amarillo, TX

02:25:19 UTC Fri 13 April 2007

Base Reflectivity: 0.5 degrees, Precip Mode

(c) UCAR <http://www.rap.ucar.edu/weather/radar/>



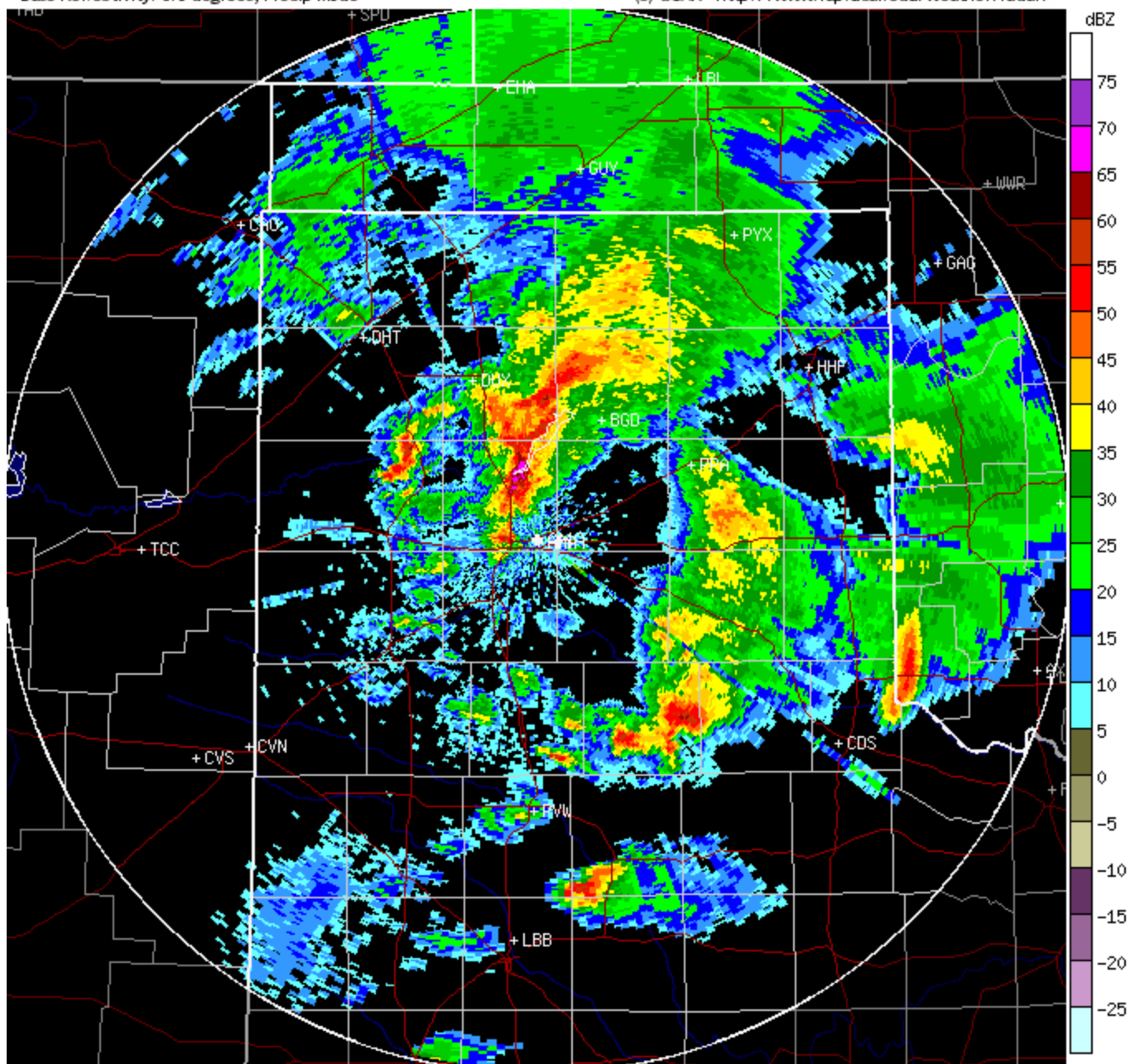


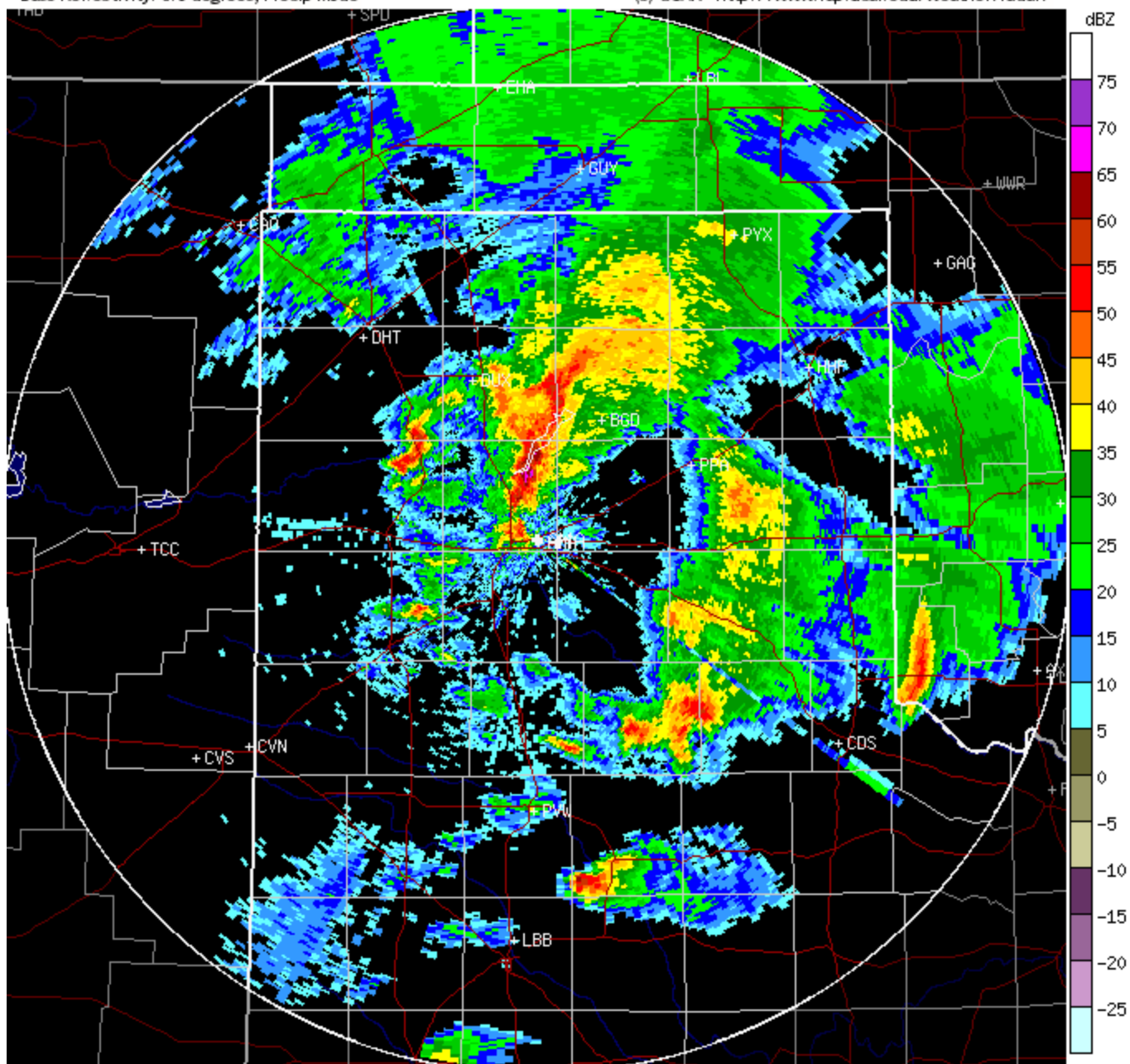
KAMA -- Amarillo, TX

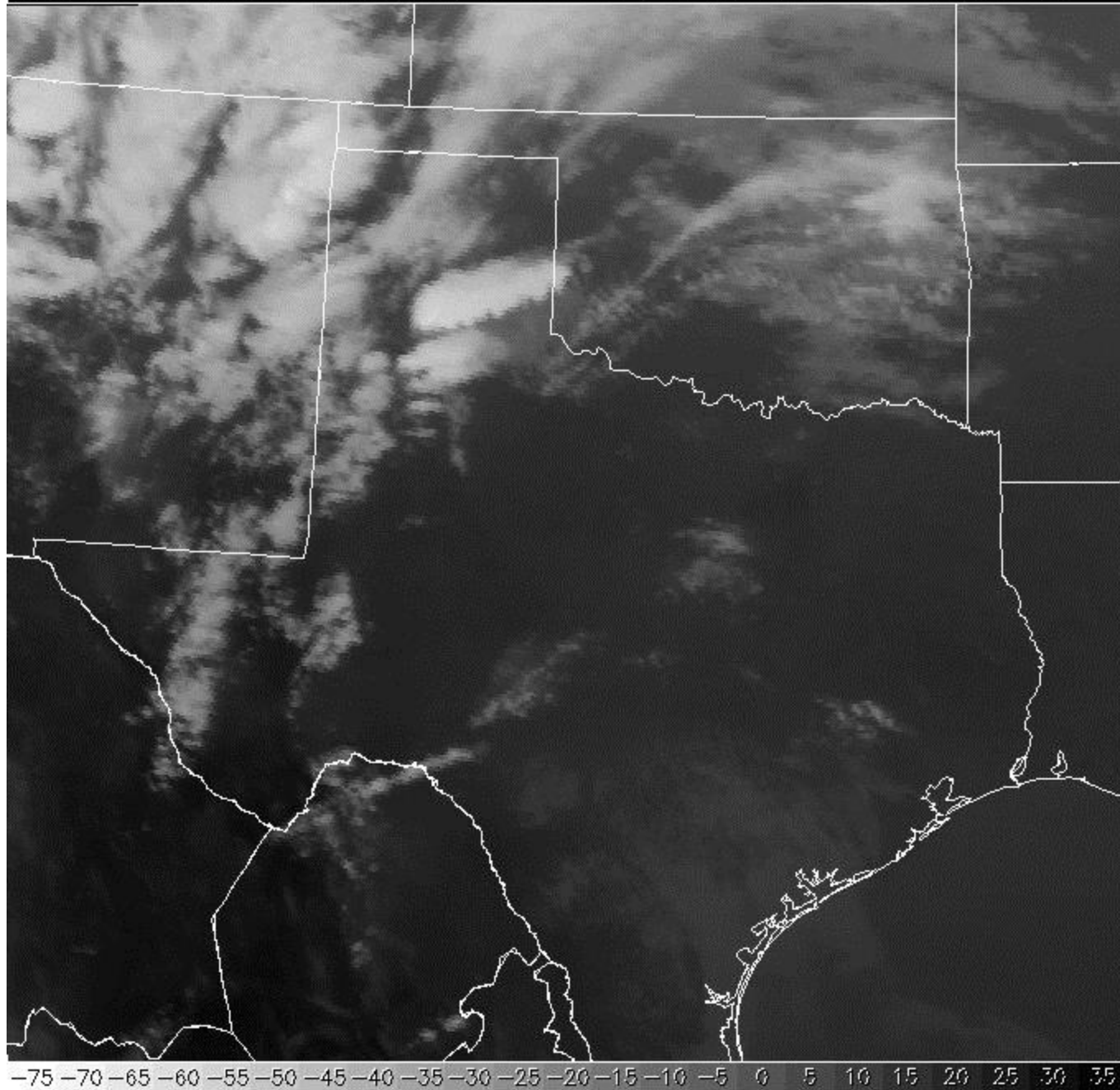
02:39:58 UTC Fri 13 April 2007

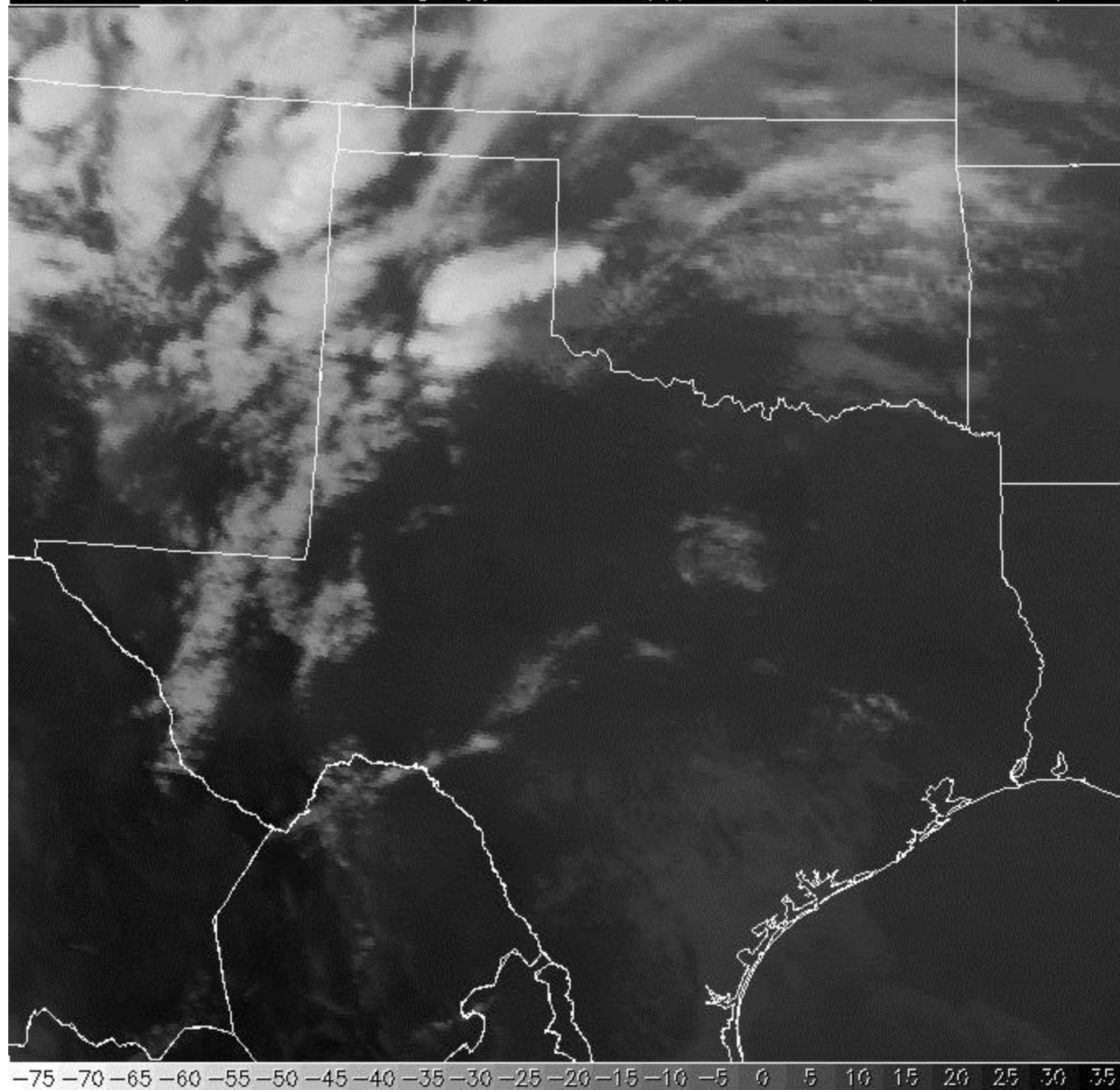
Base Reflectivity: 0.5 degrees, Precip Mode

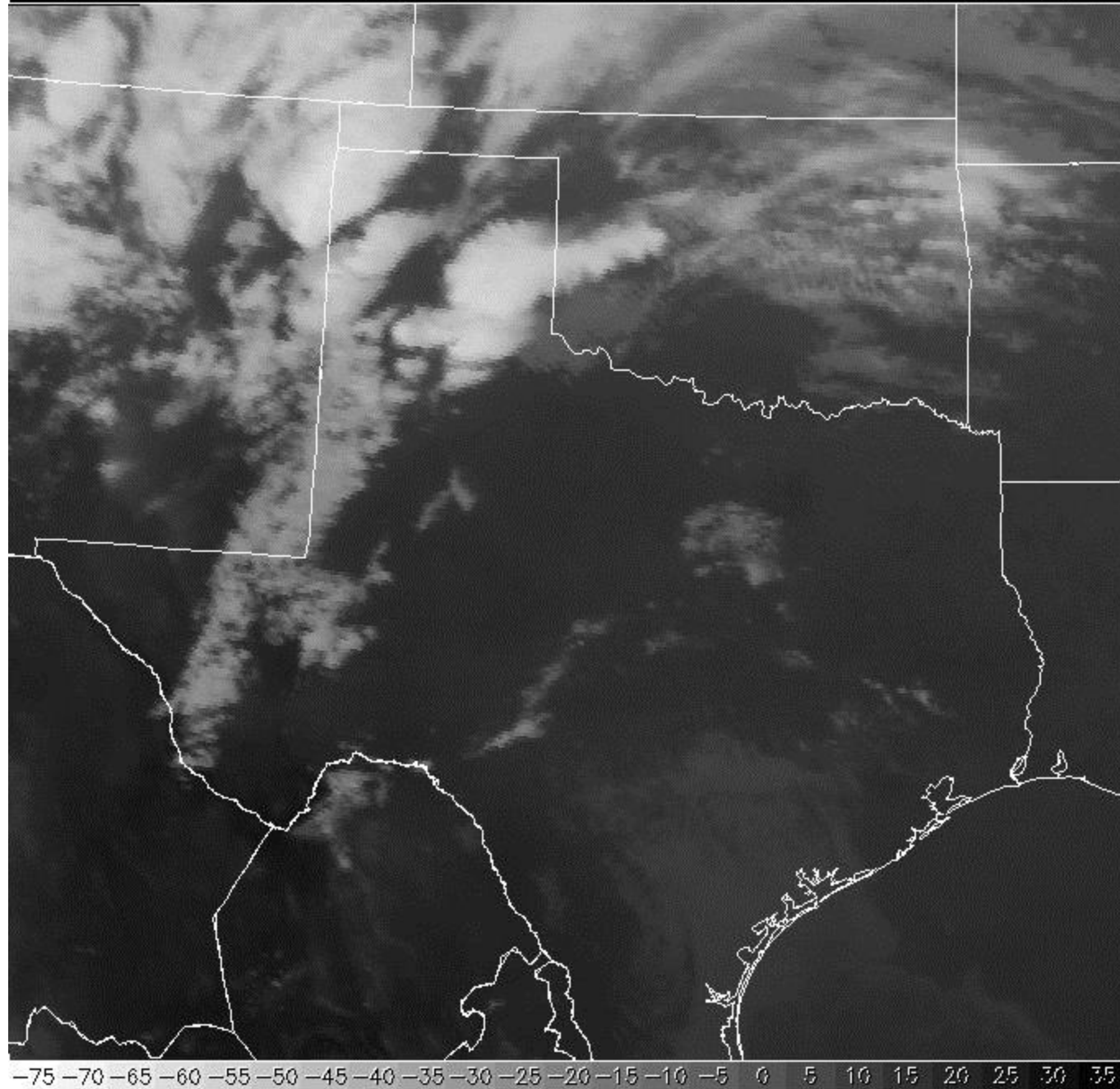
(c) UCAR <http://www.rap.ucar.edu/weather/radar/>

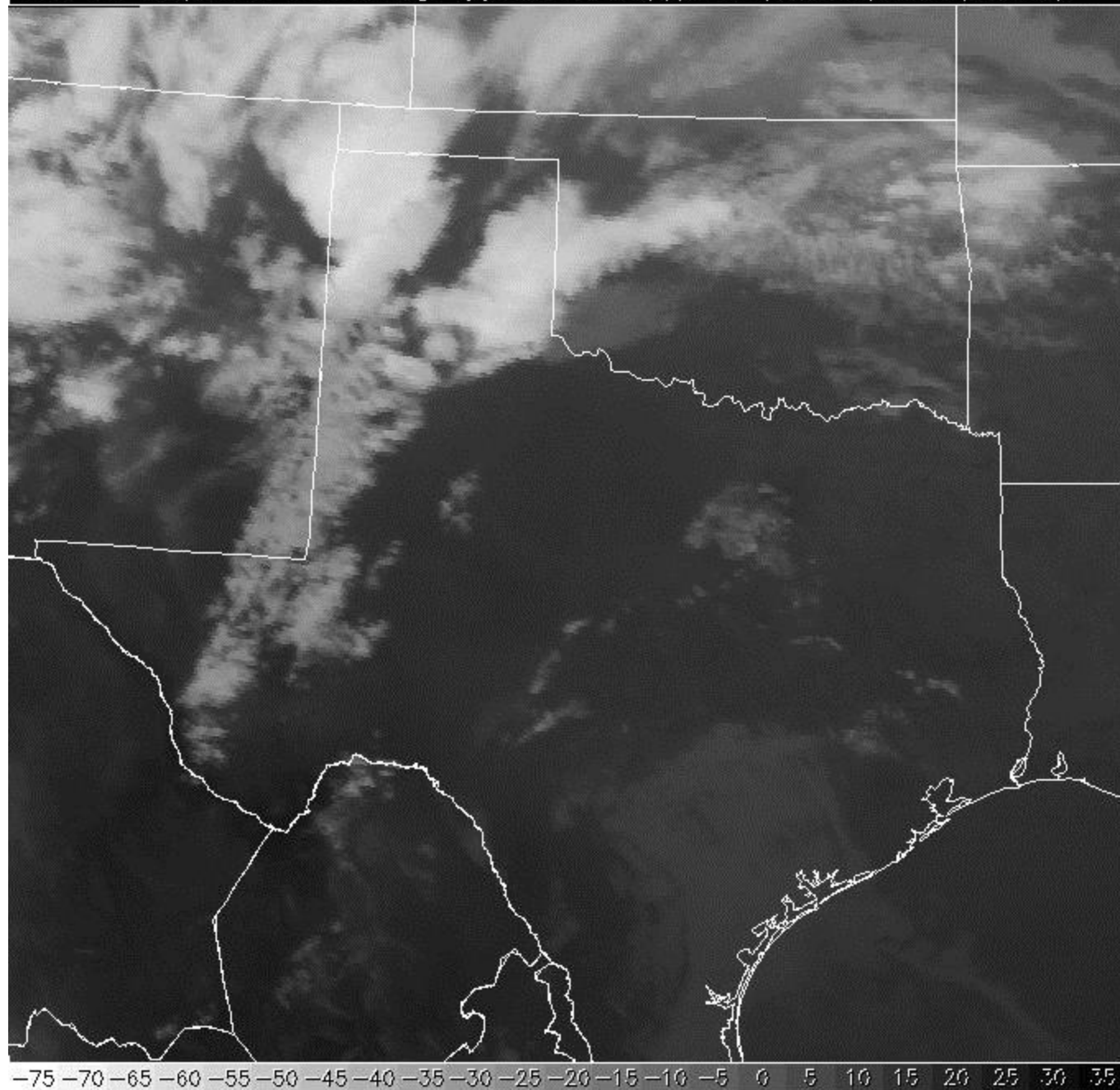


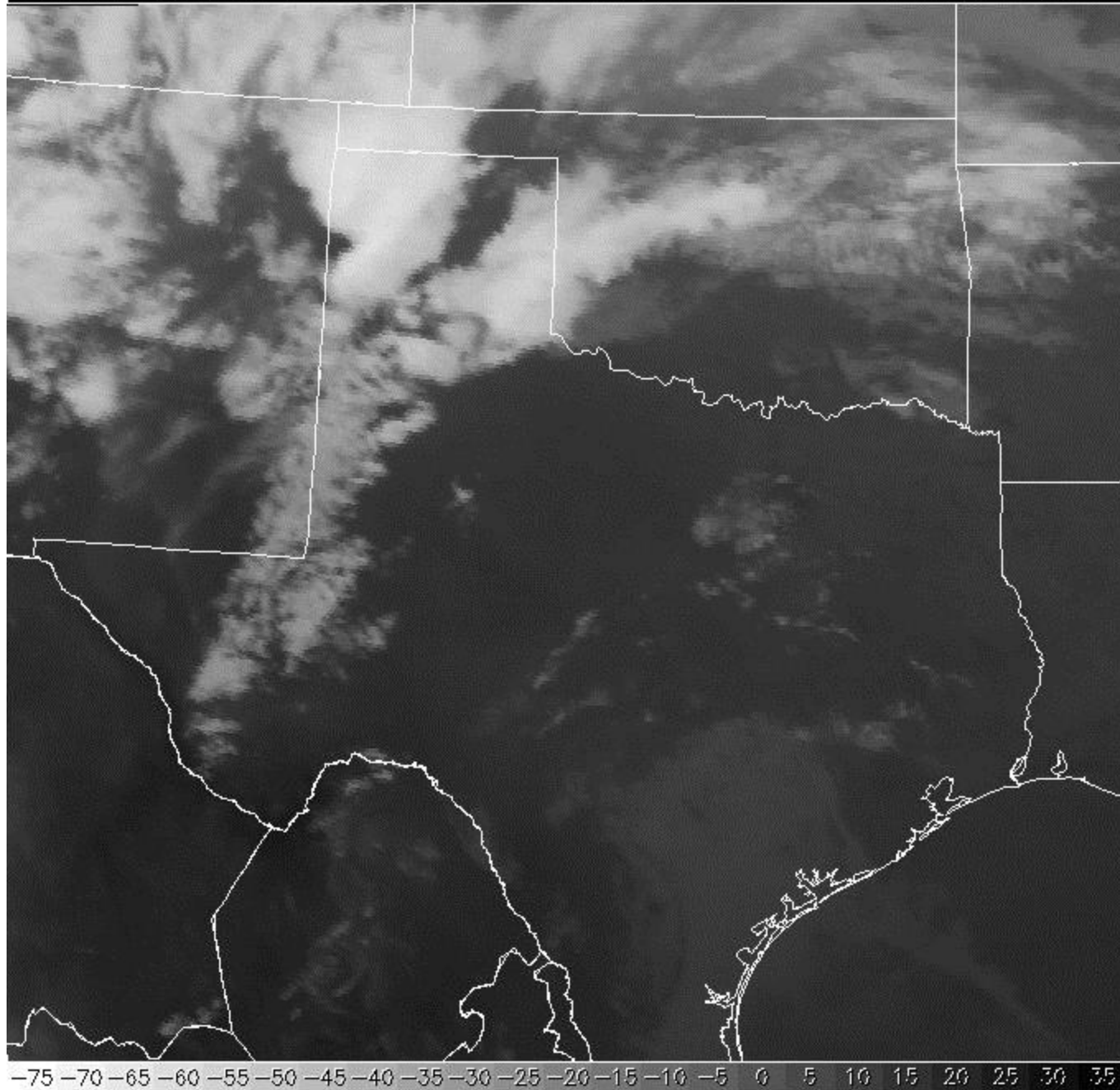


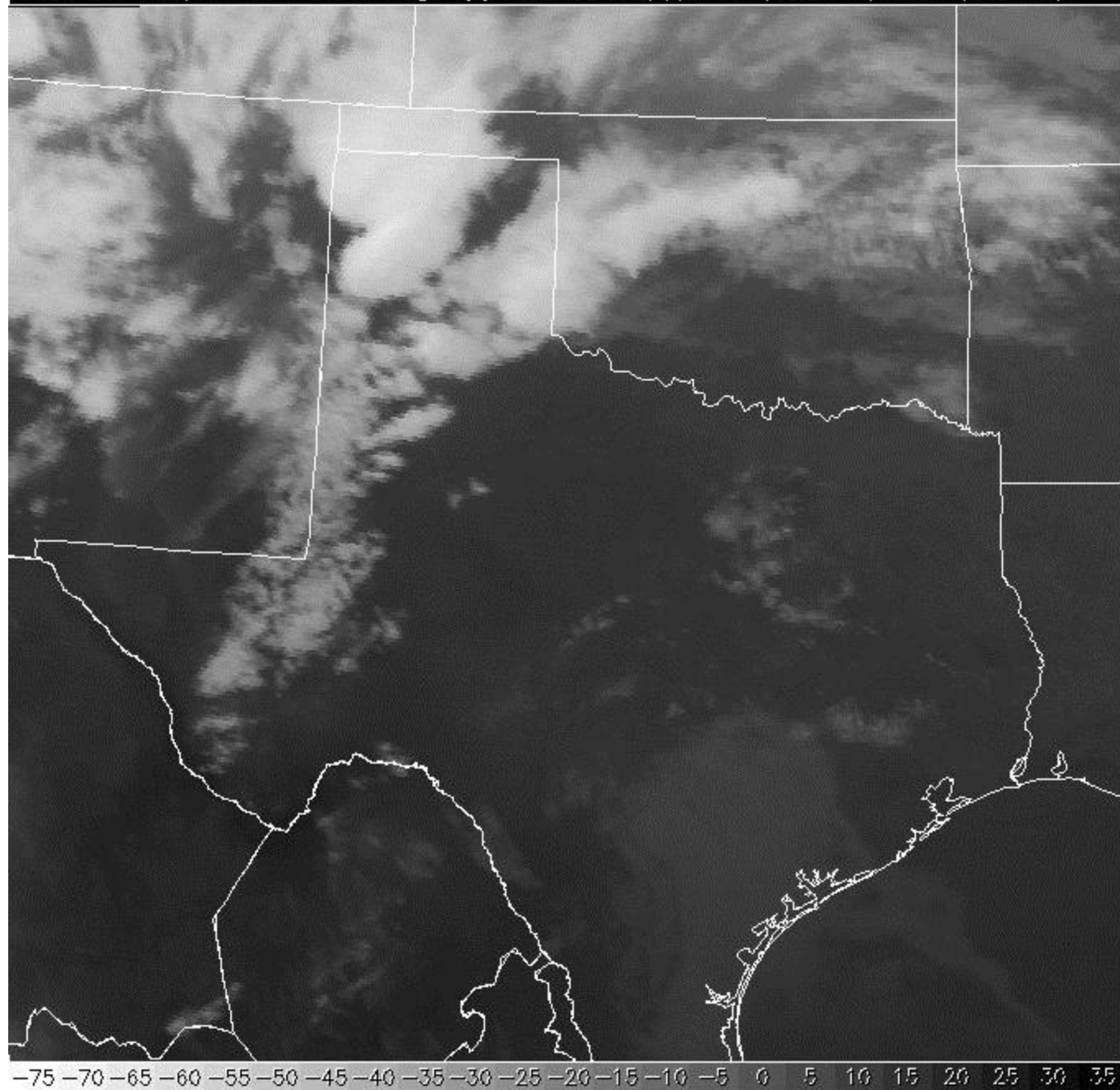


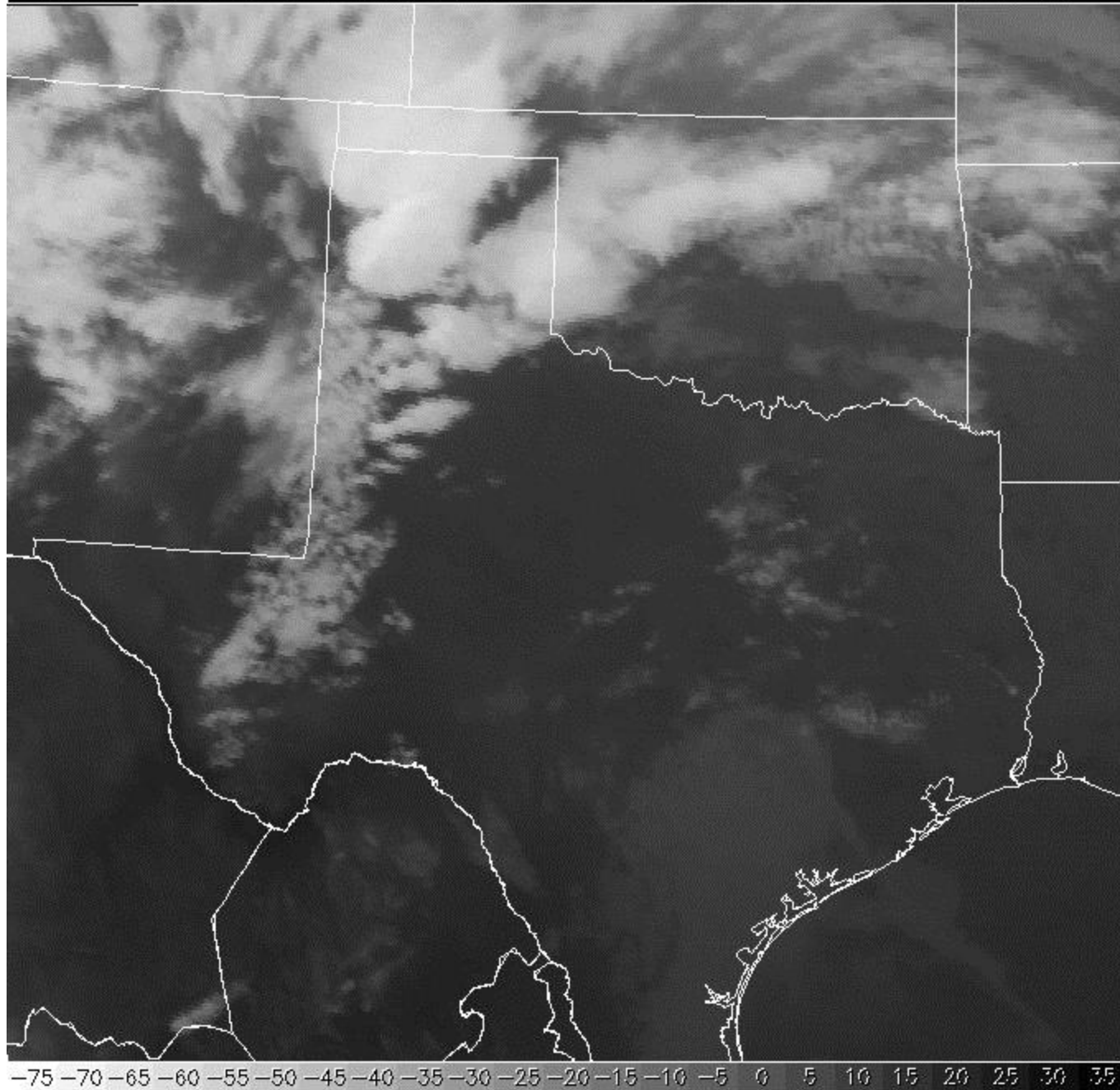


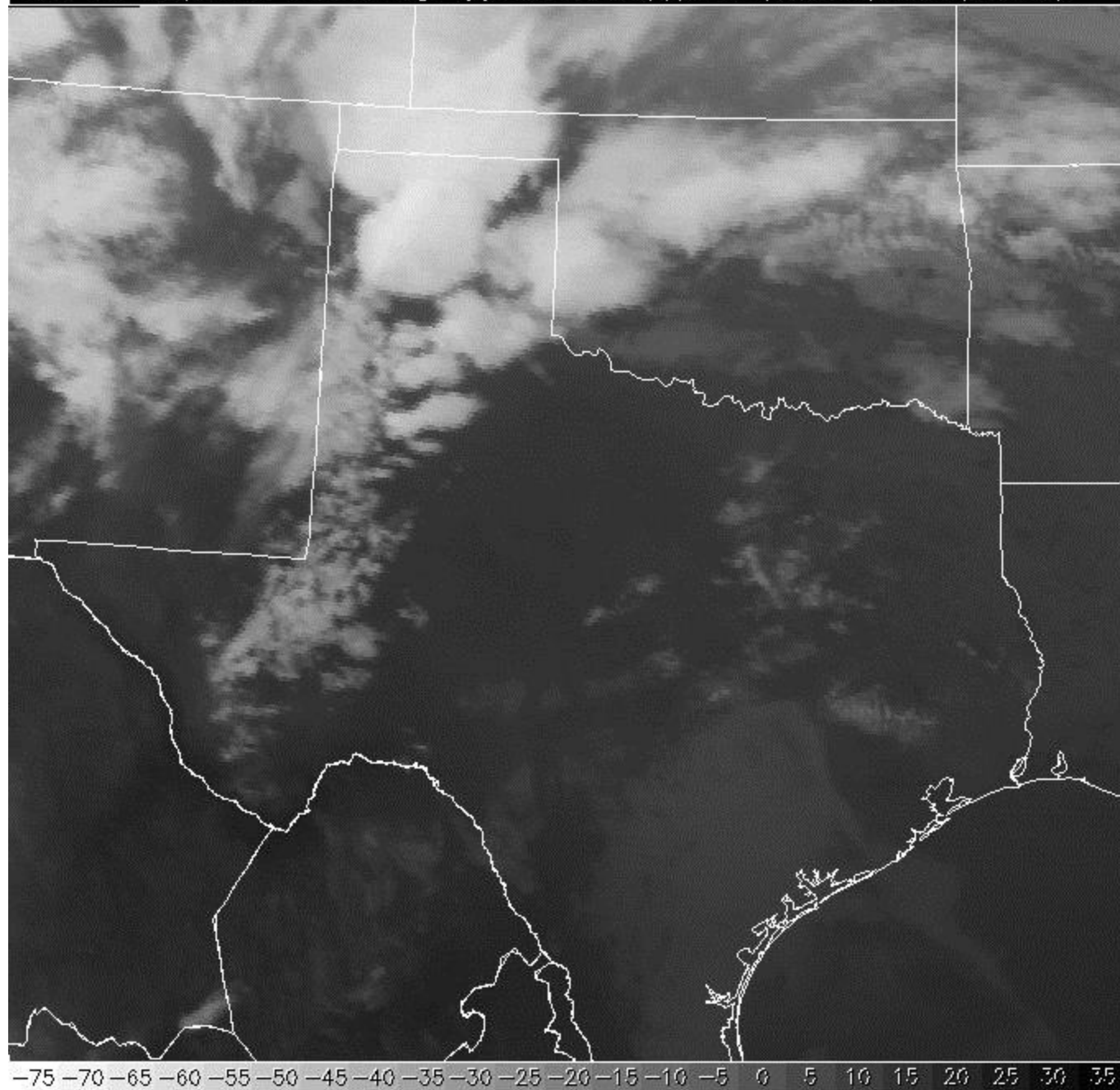


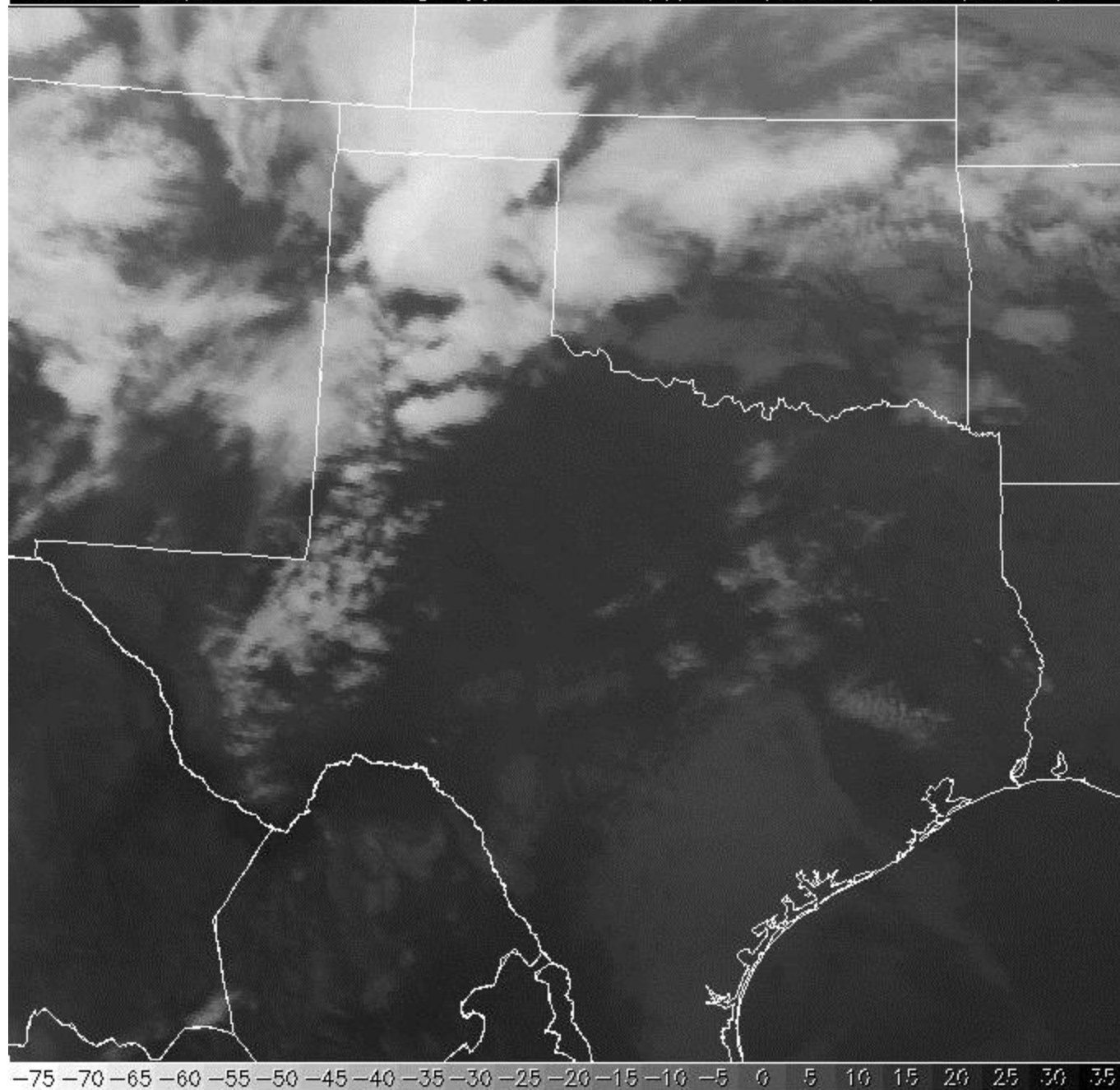


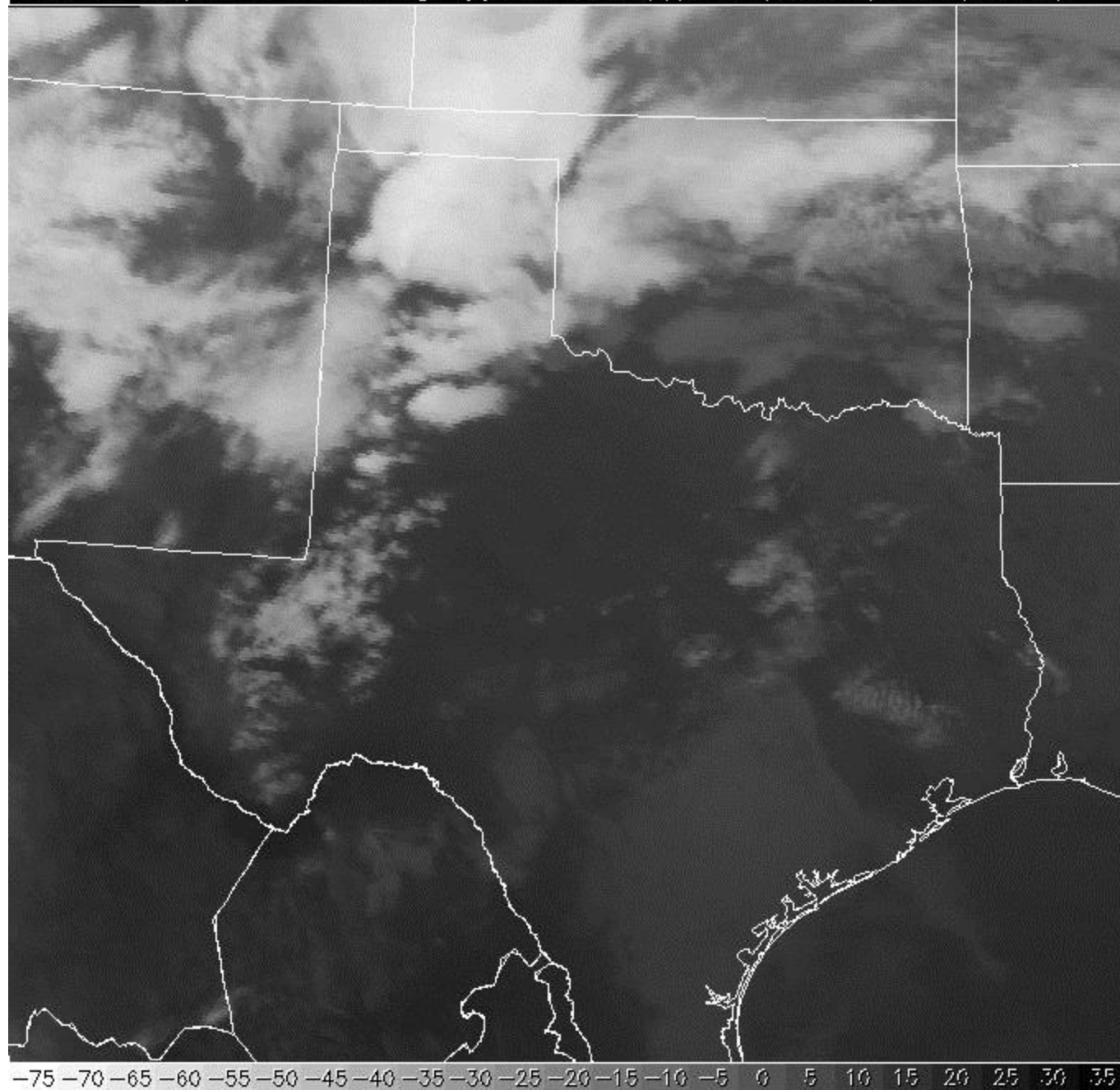


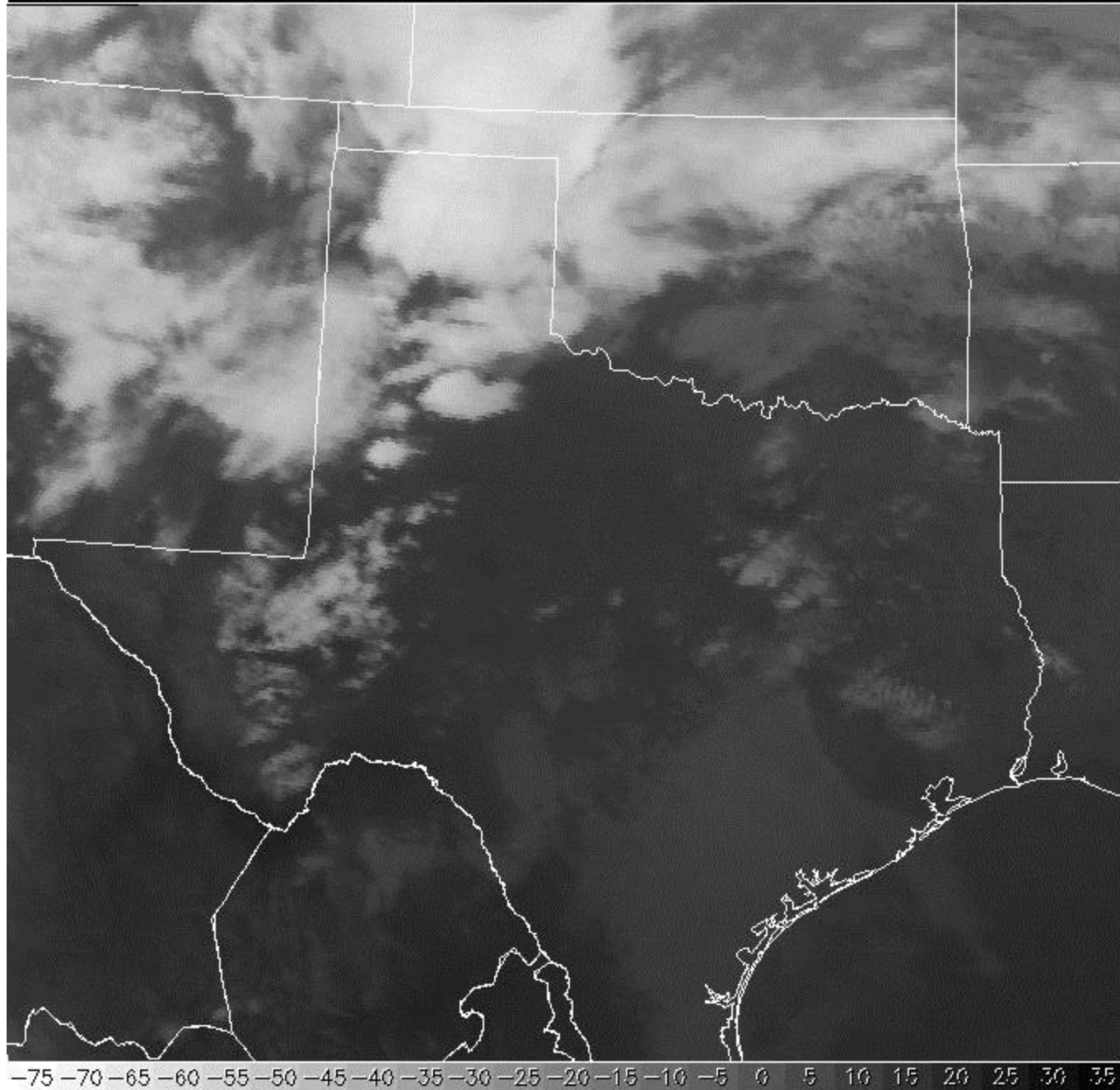


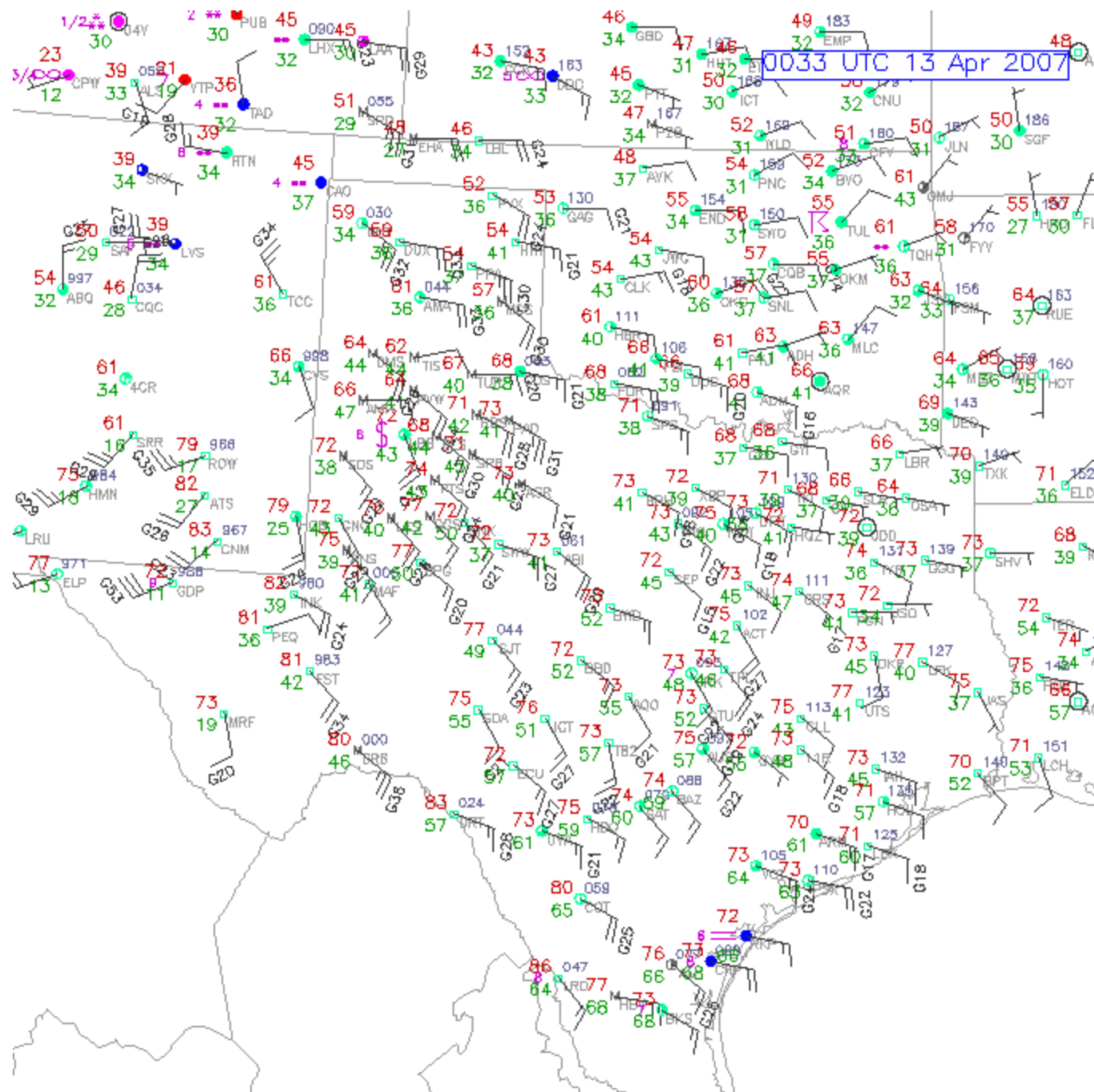


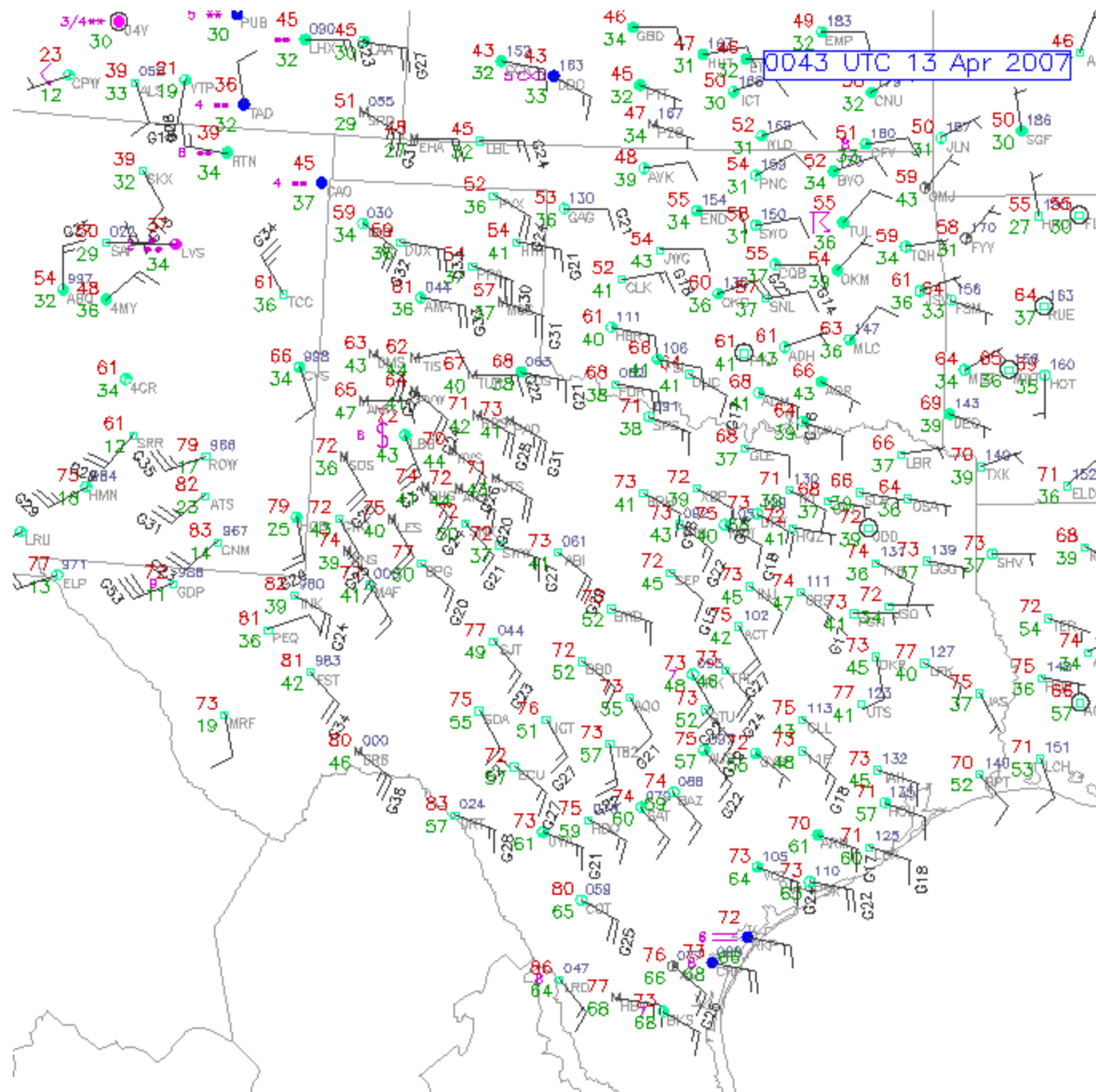


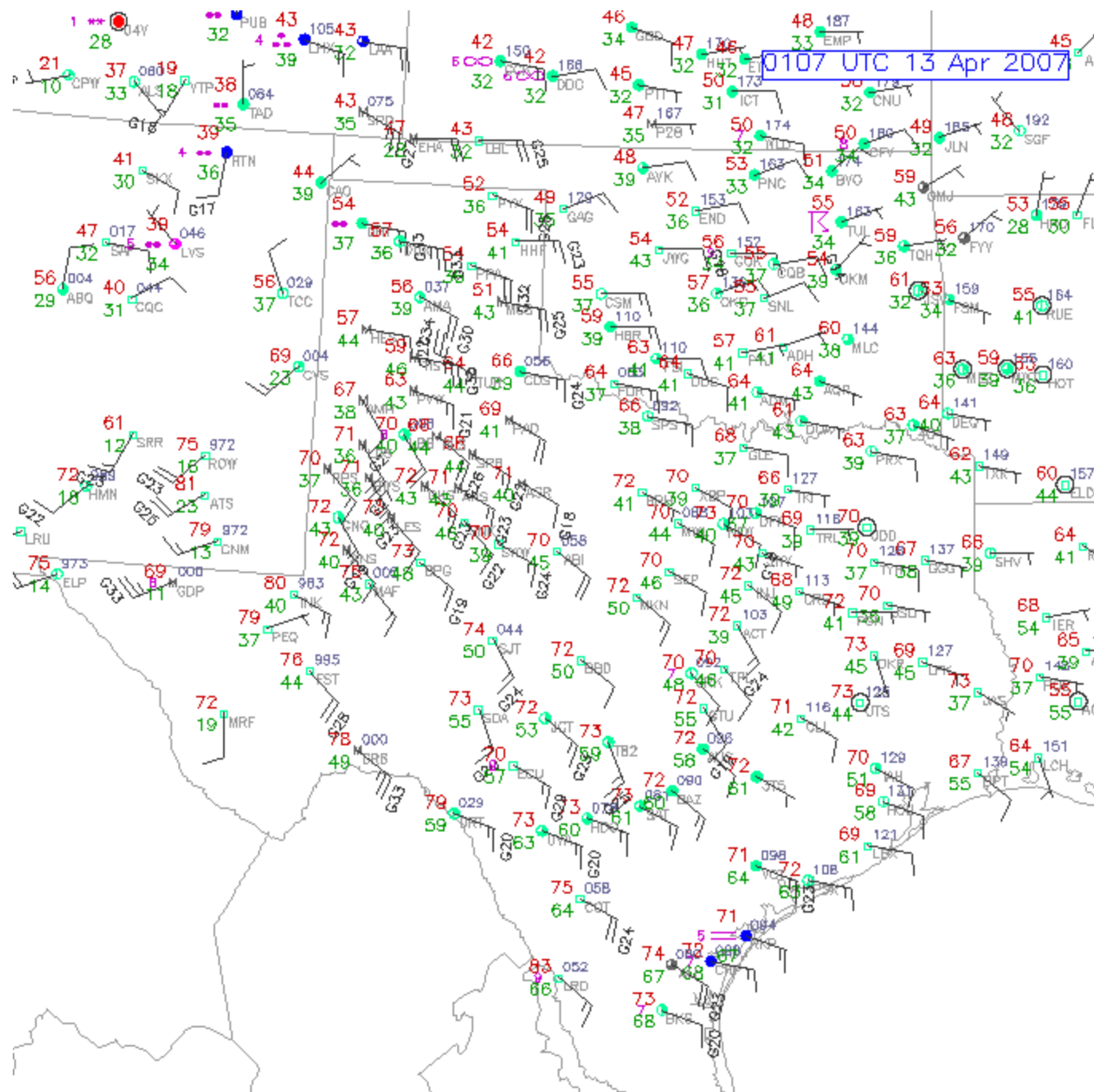


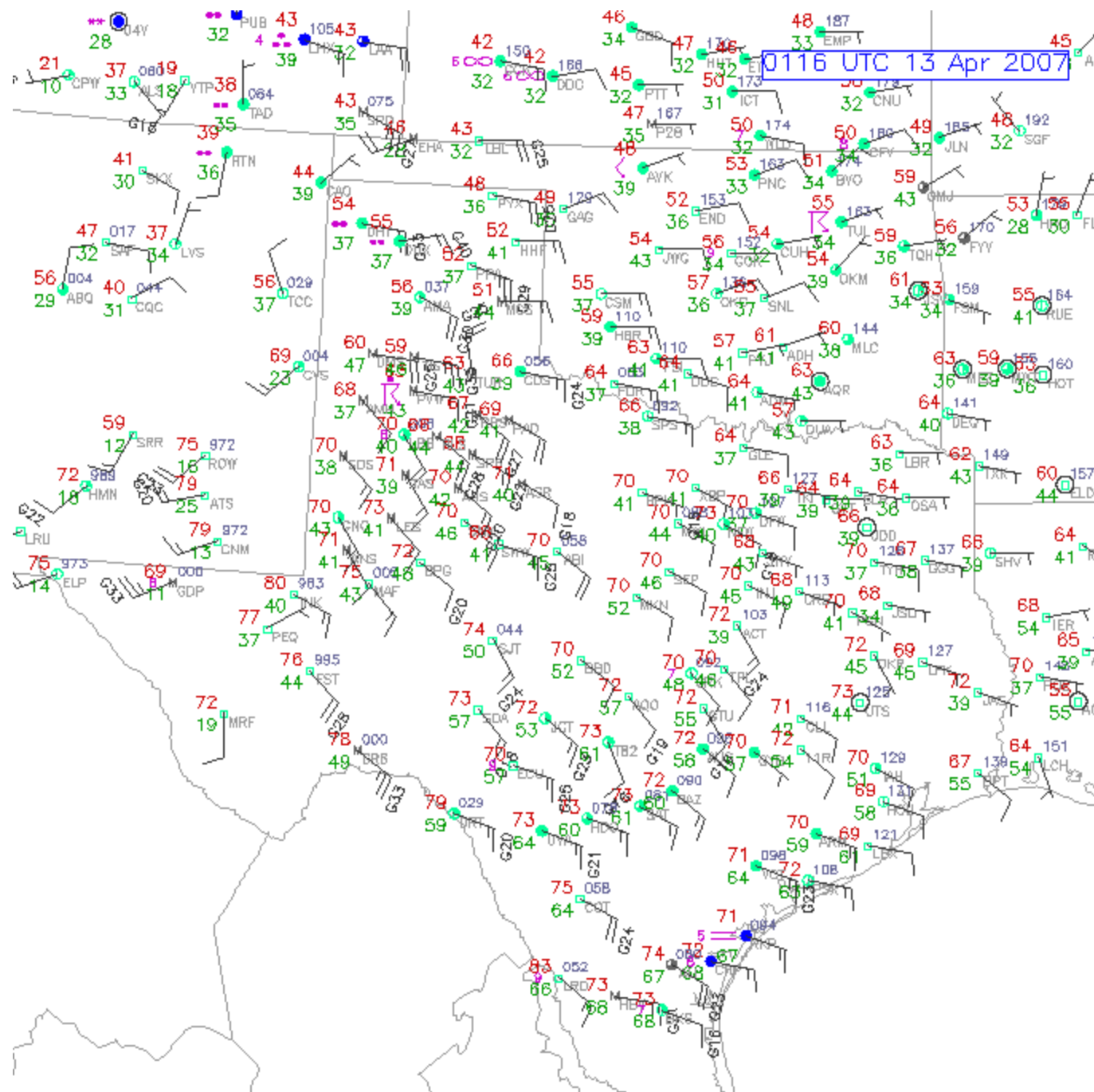


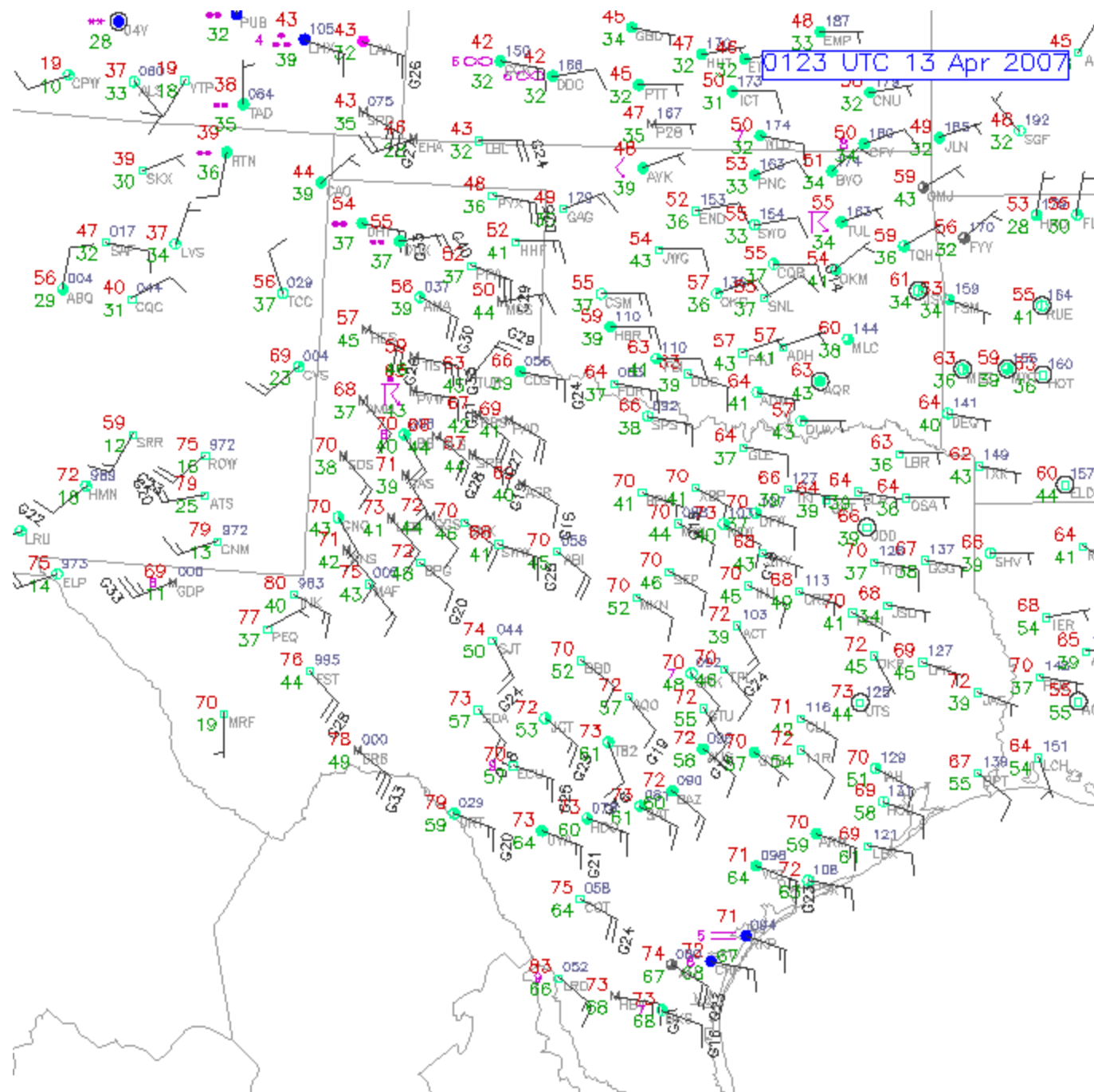


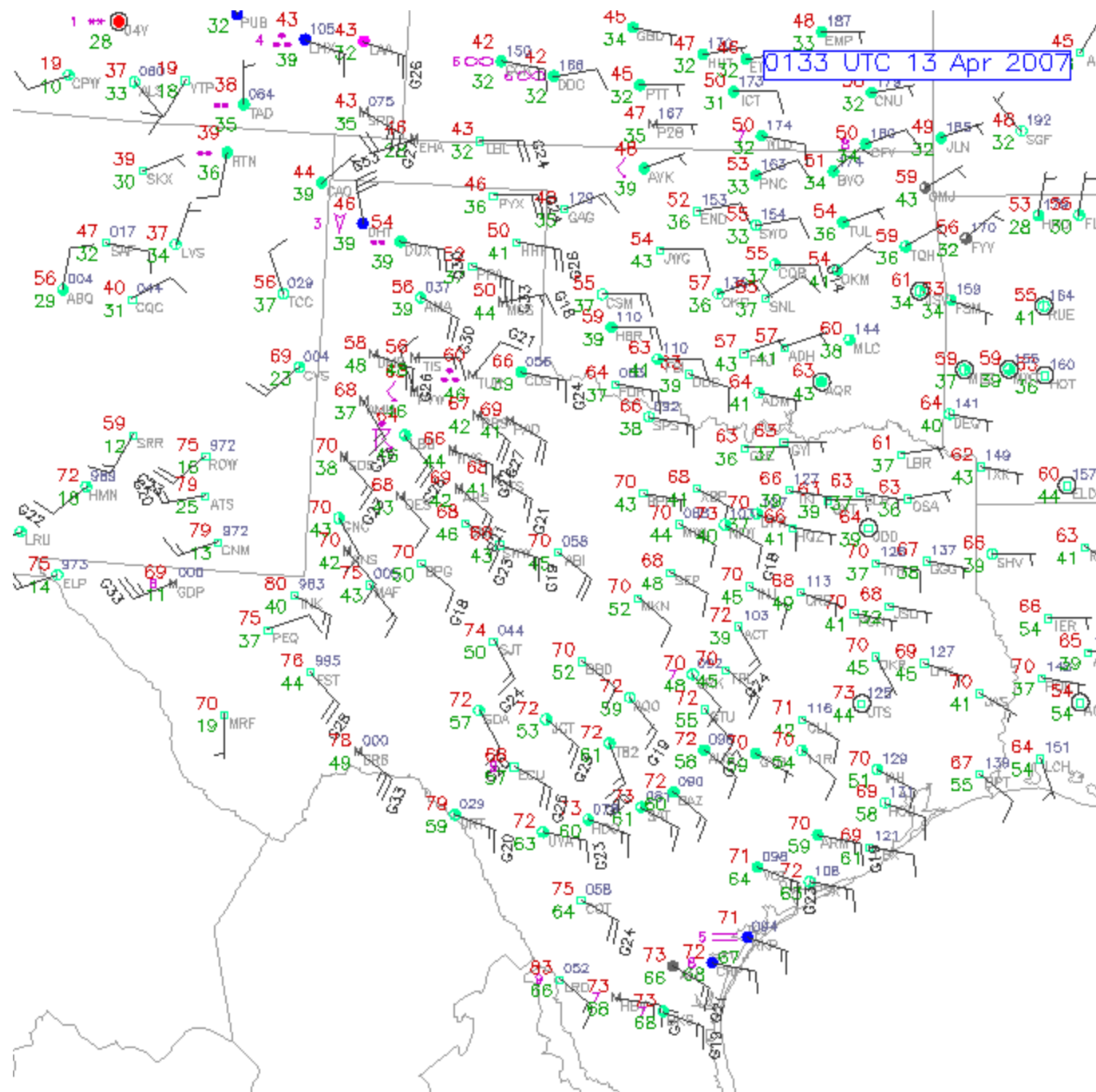


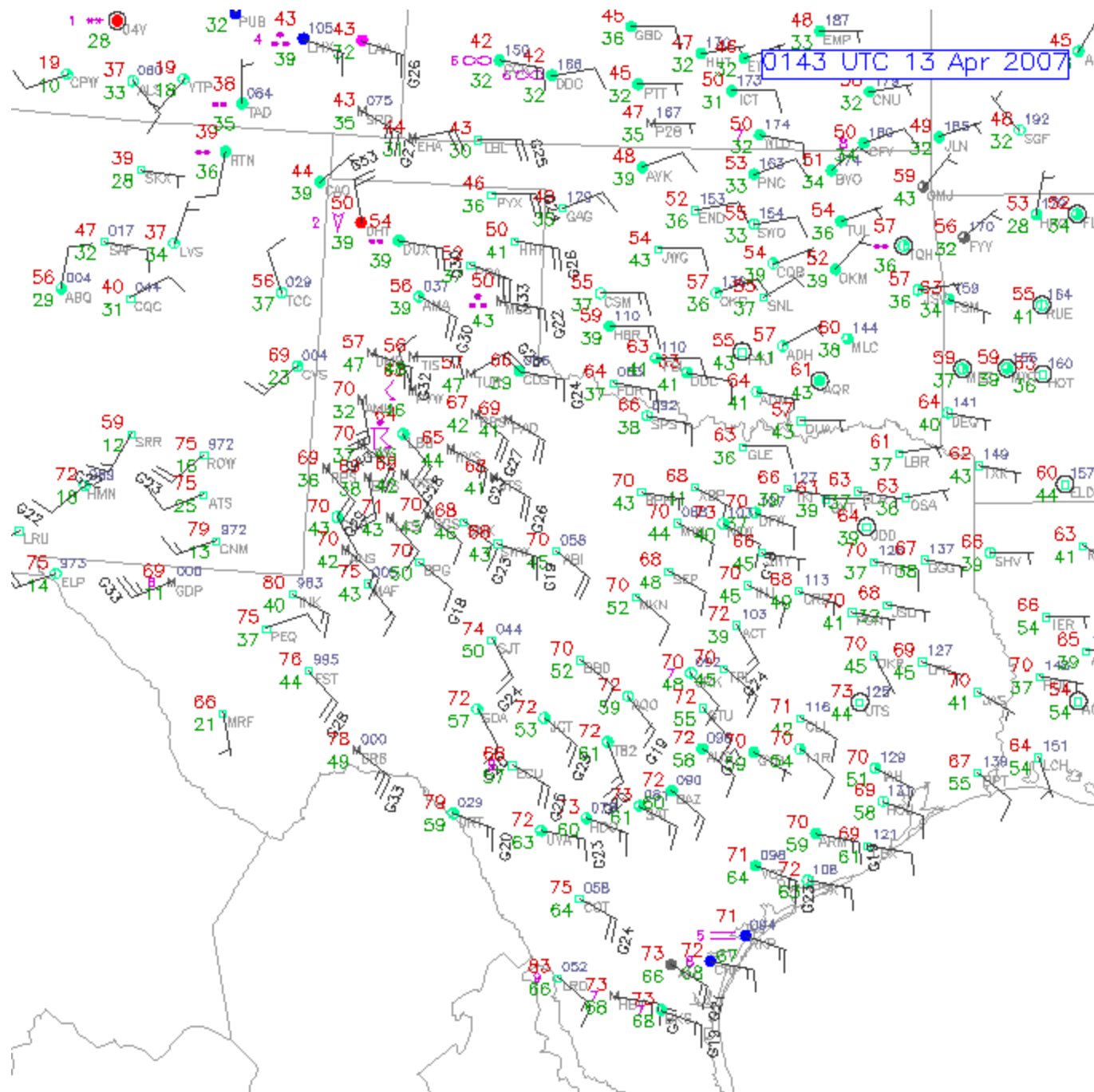


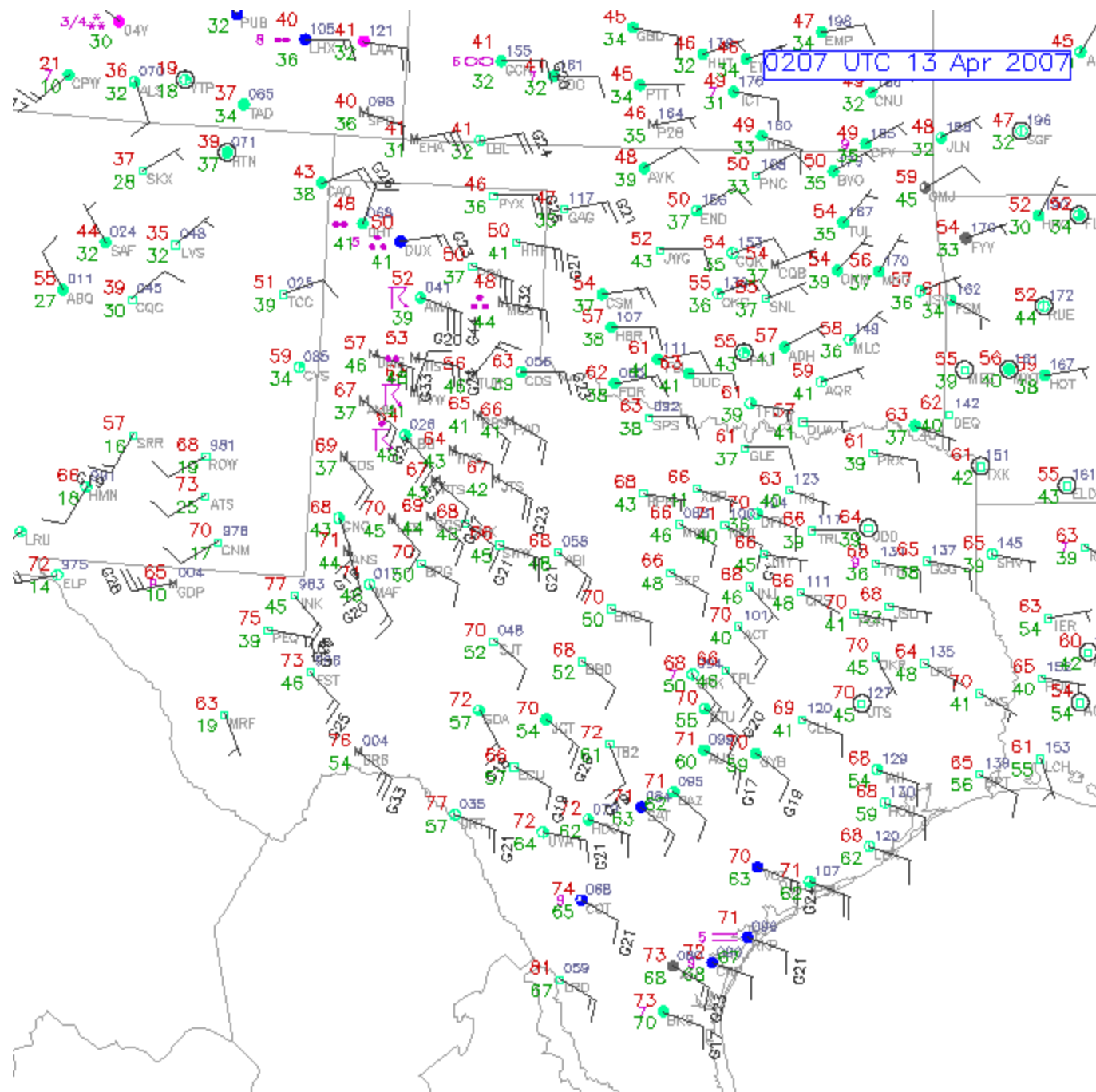


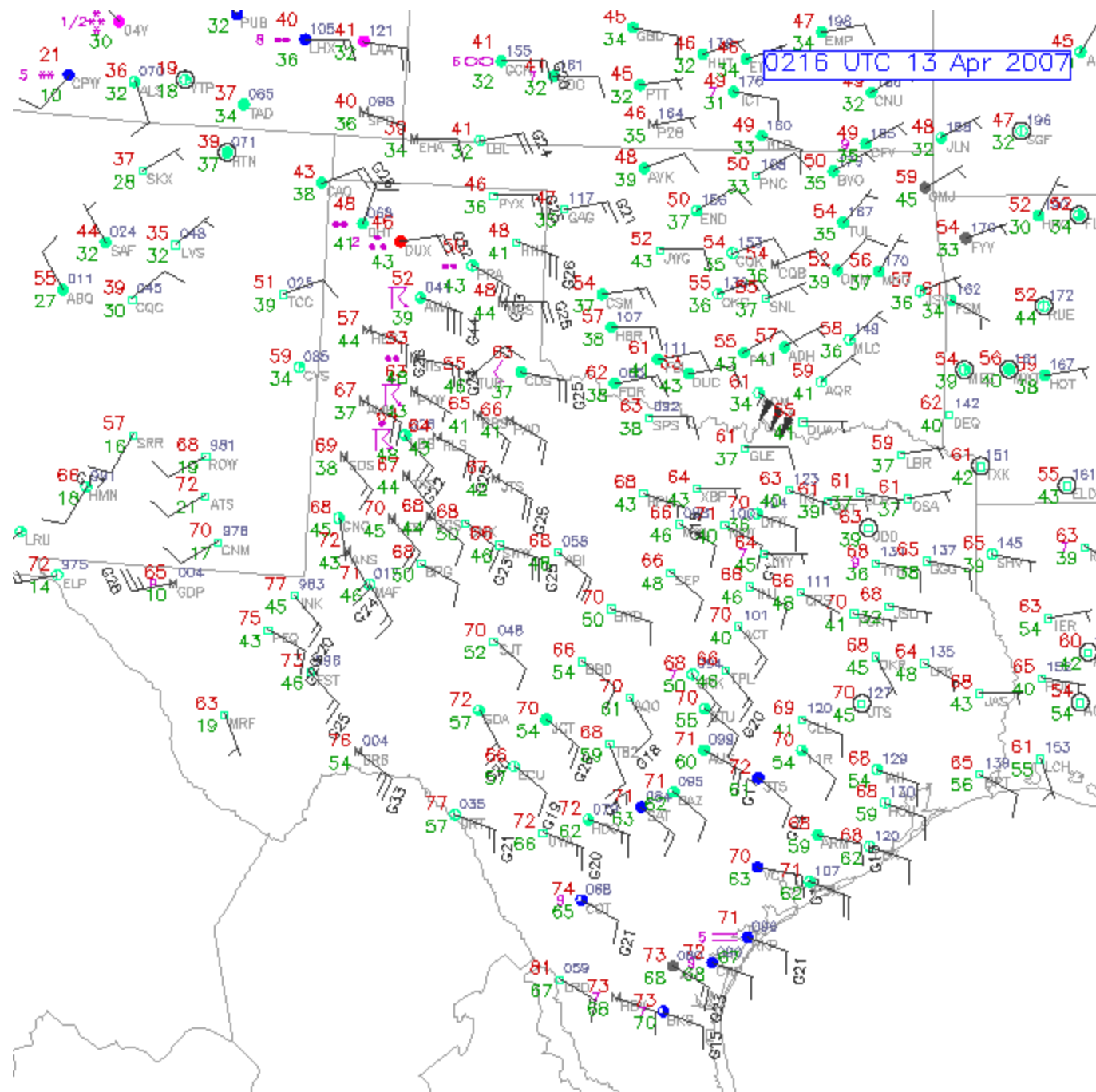


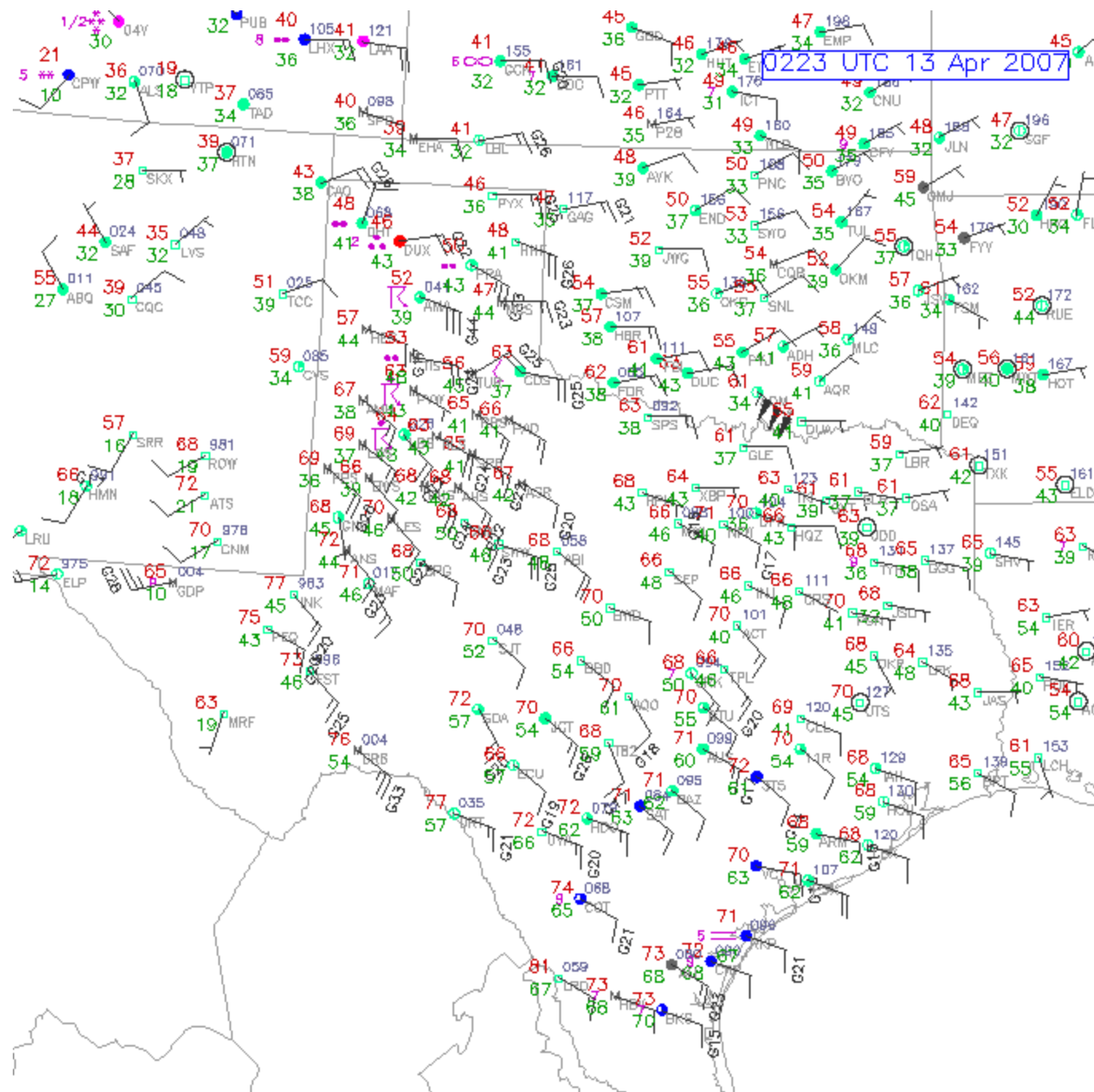


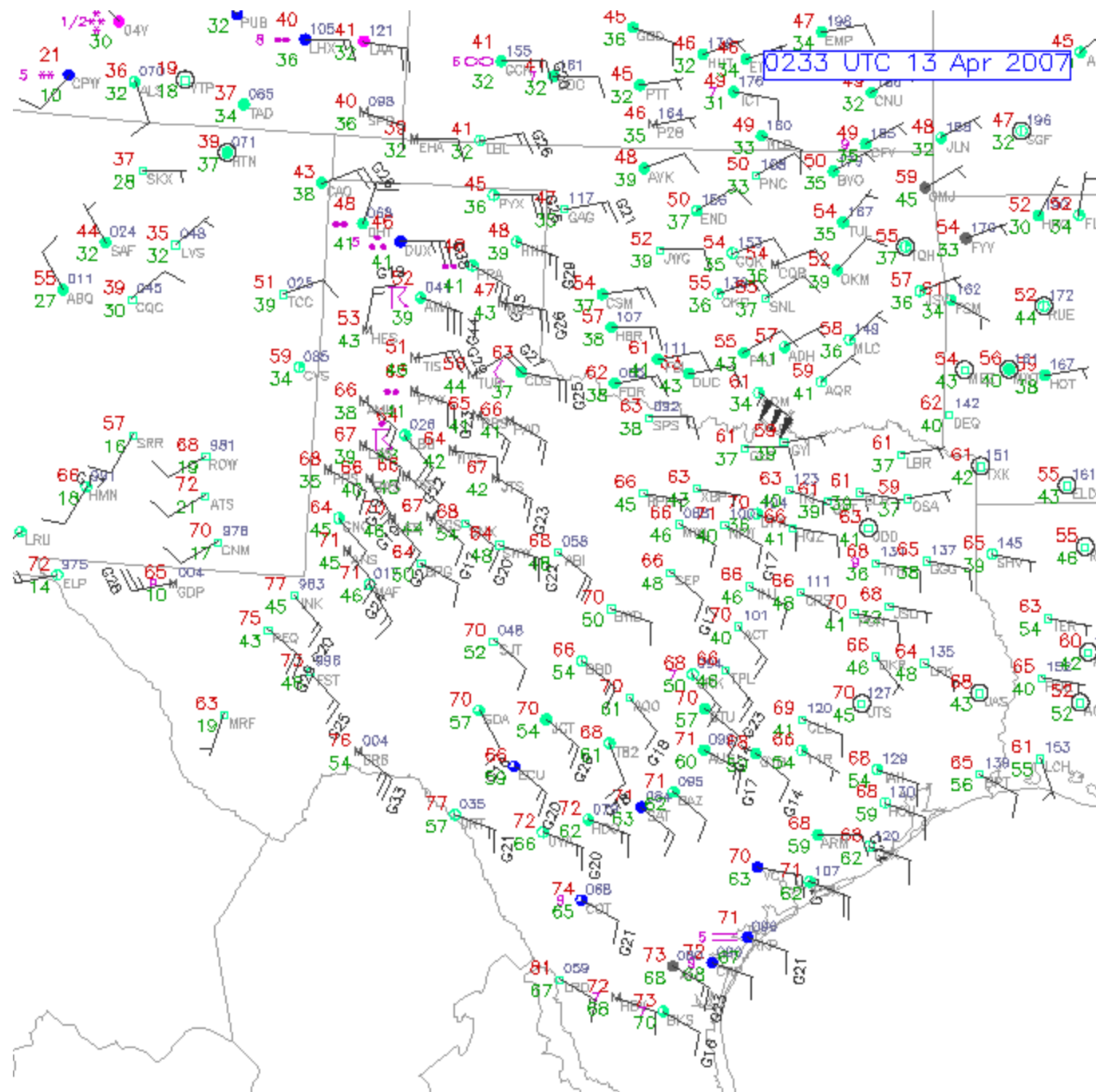












Introduction to upper-air charts

(adapted from *Reeds Maritime Meteorology* 3rd Edition)

- Pressure gradient force develops aloft due to significant temperature gradient in the region of the Polar Front:

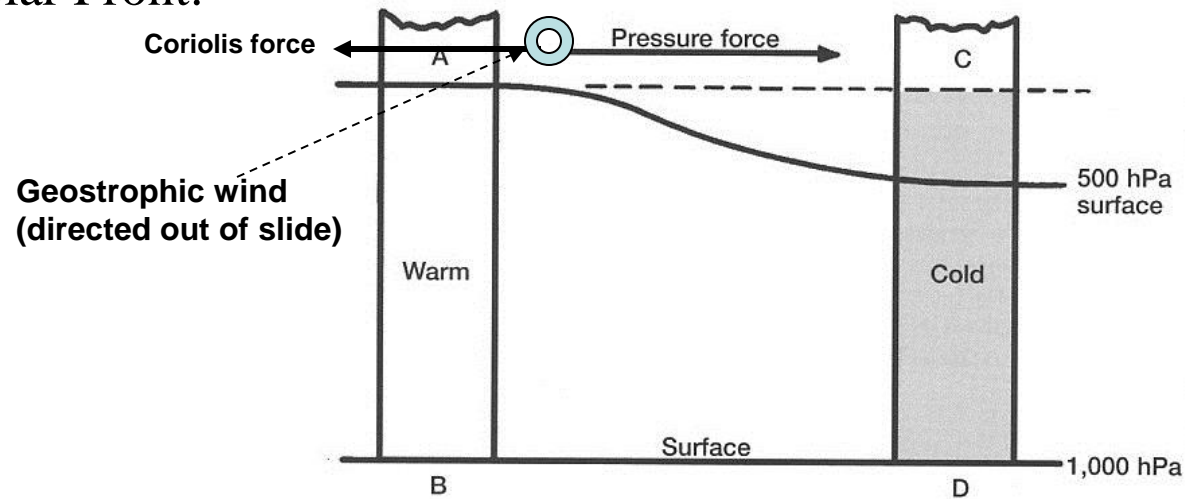


Fig 19.3

- Knowing the change in wind direction with height, you can determine if cold air is invading the region (destabilizes the atmosphere) or if warm air is invading (stabilizes the atmosphere):

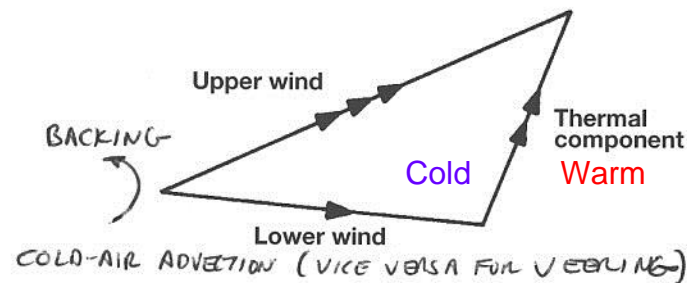
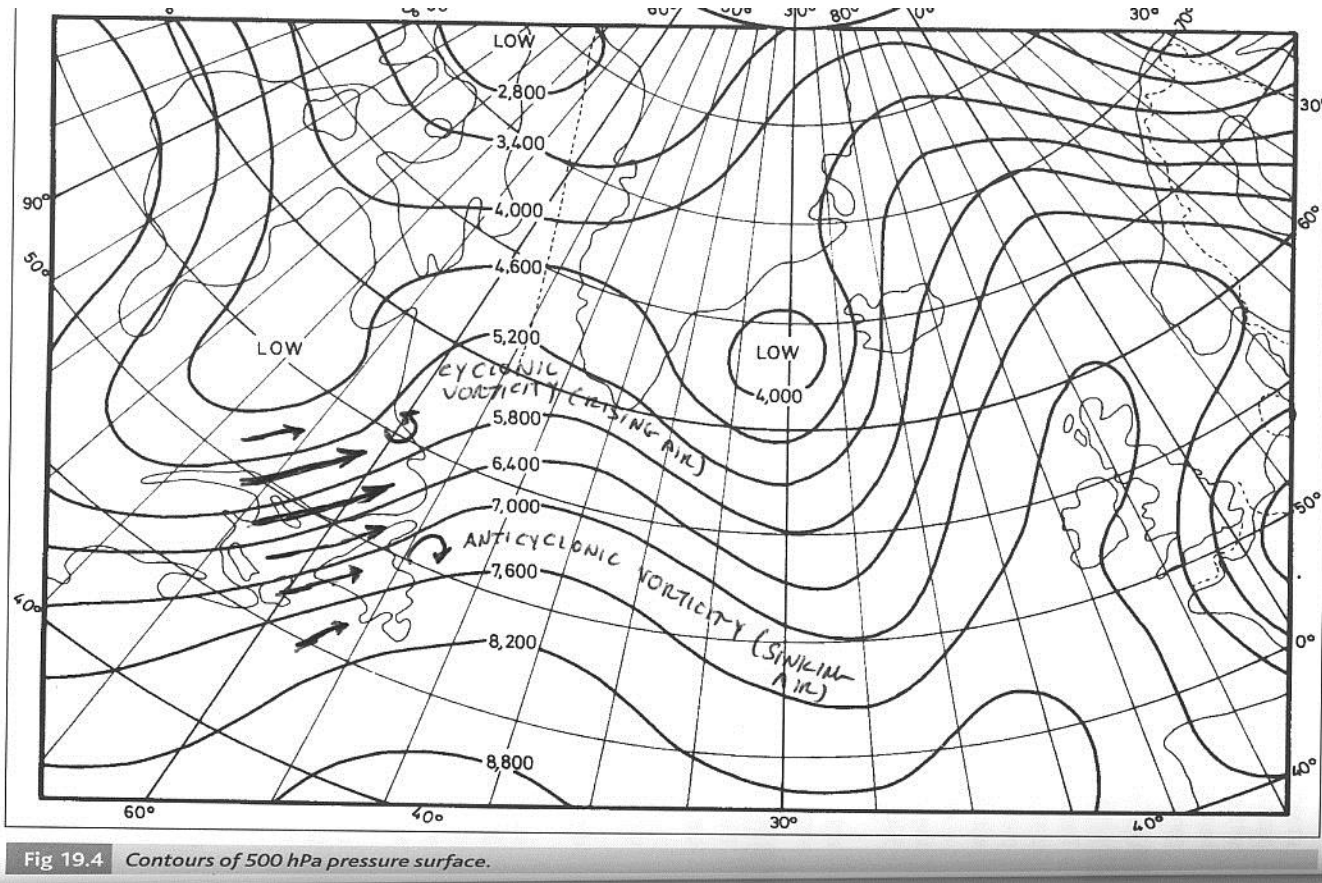


Fig 19.2 Vector diagram illustrating thermal wind.

Introduction to upper-air charts

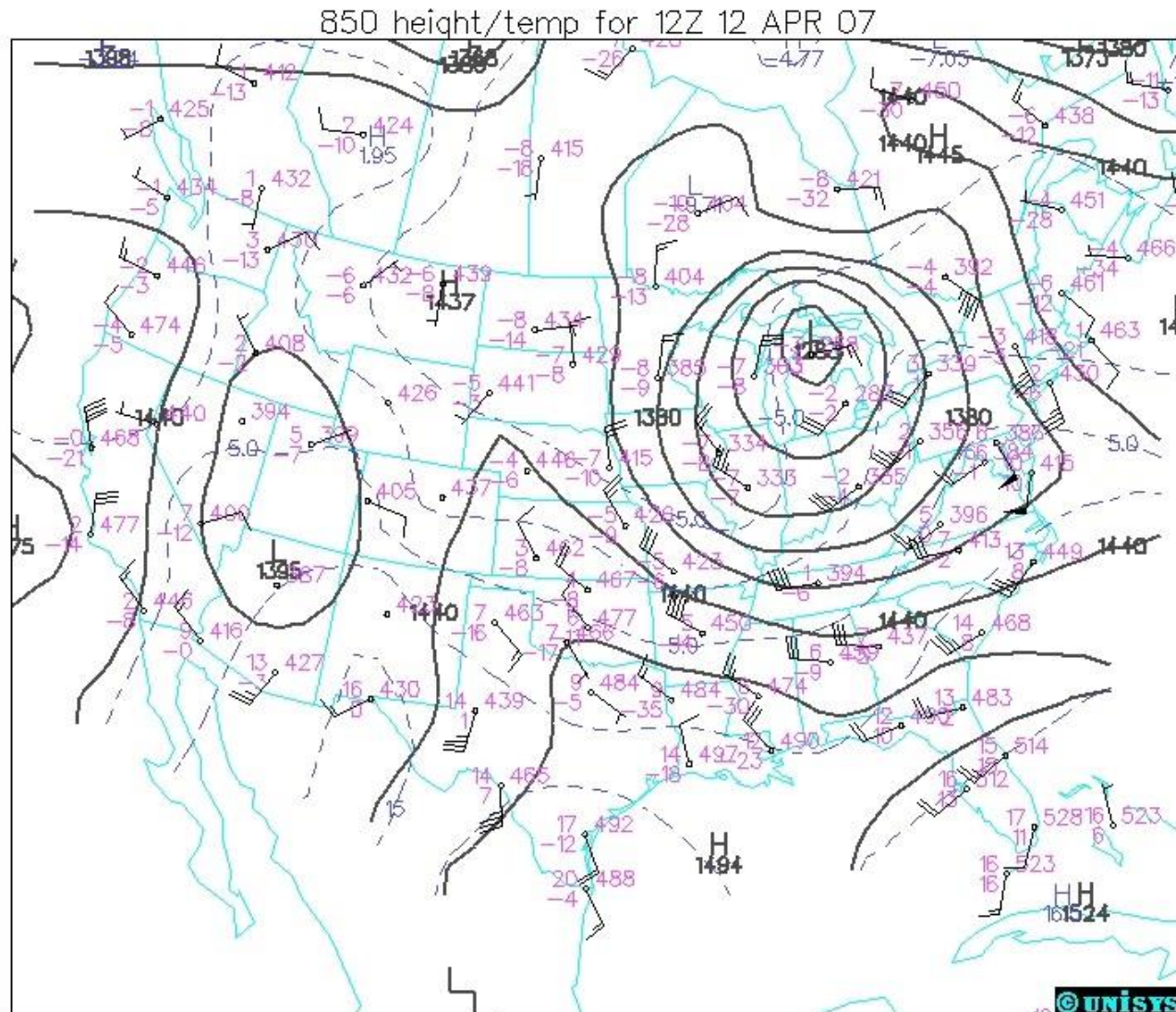
- The 500 hPa (mb) constant-pressure surface is half way up in the Troposphere:



- Identifying the wind-speed shear will define regions with cyclonic vorticity (rising air) and regions of anticyclonic vorticity (sinking air).

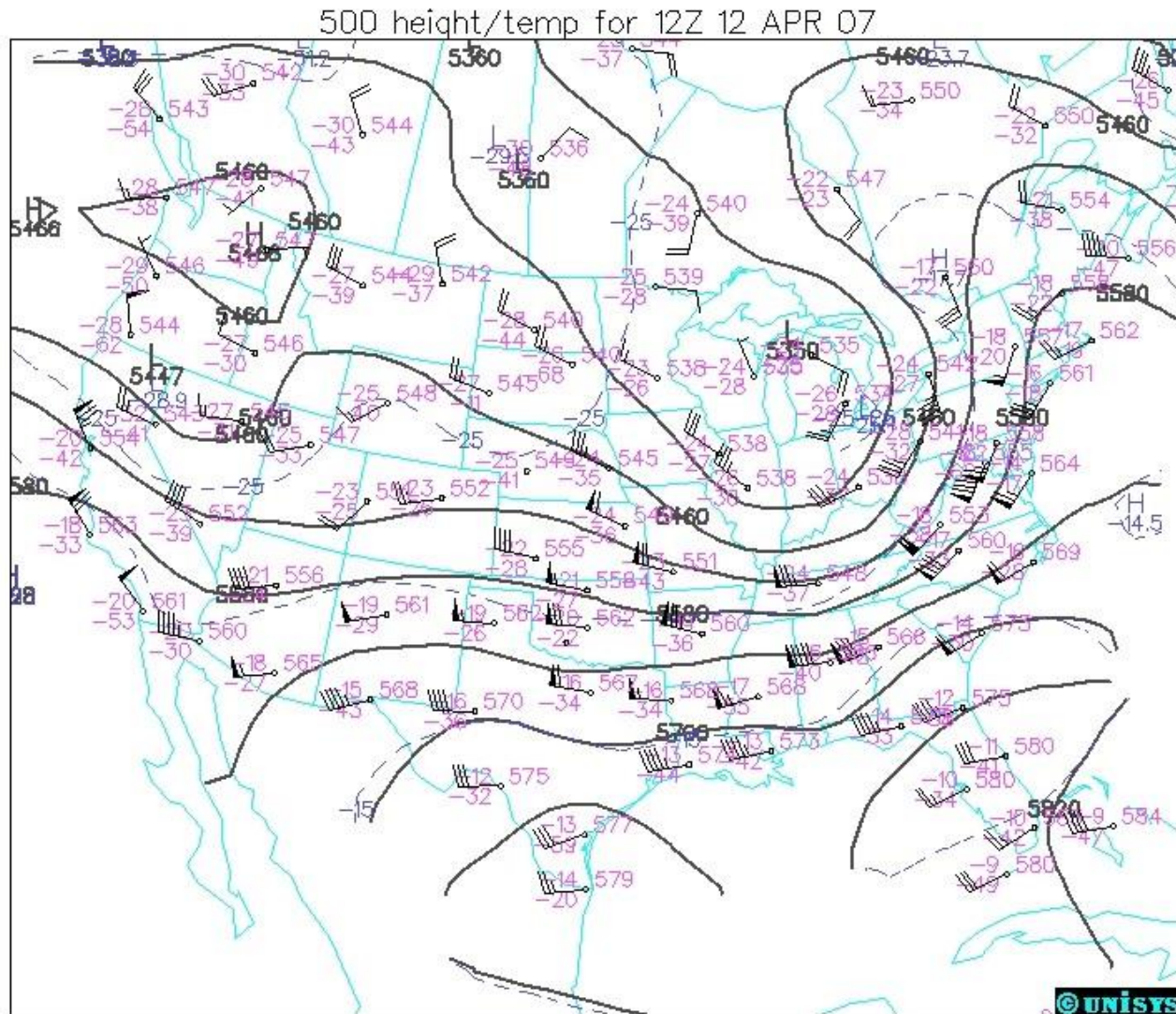
Introduction to upper-air charts

- A 'stack' of charts, each of a decreasing constant-pressure surface, reveals 'backing' and 'veering' regions, the Polar Front Jet Stream, anticyclonic vorticity and cyclonic vorticity, long-waves and short waves:



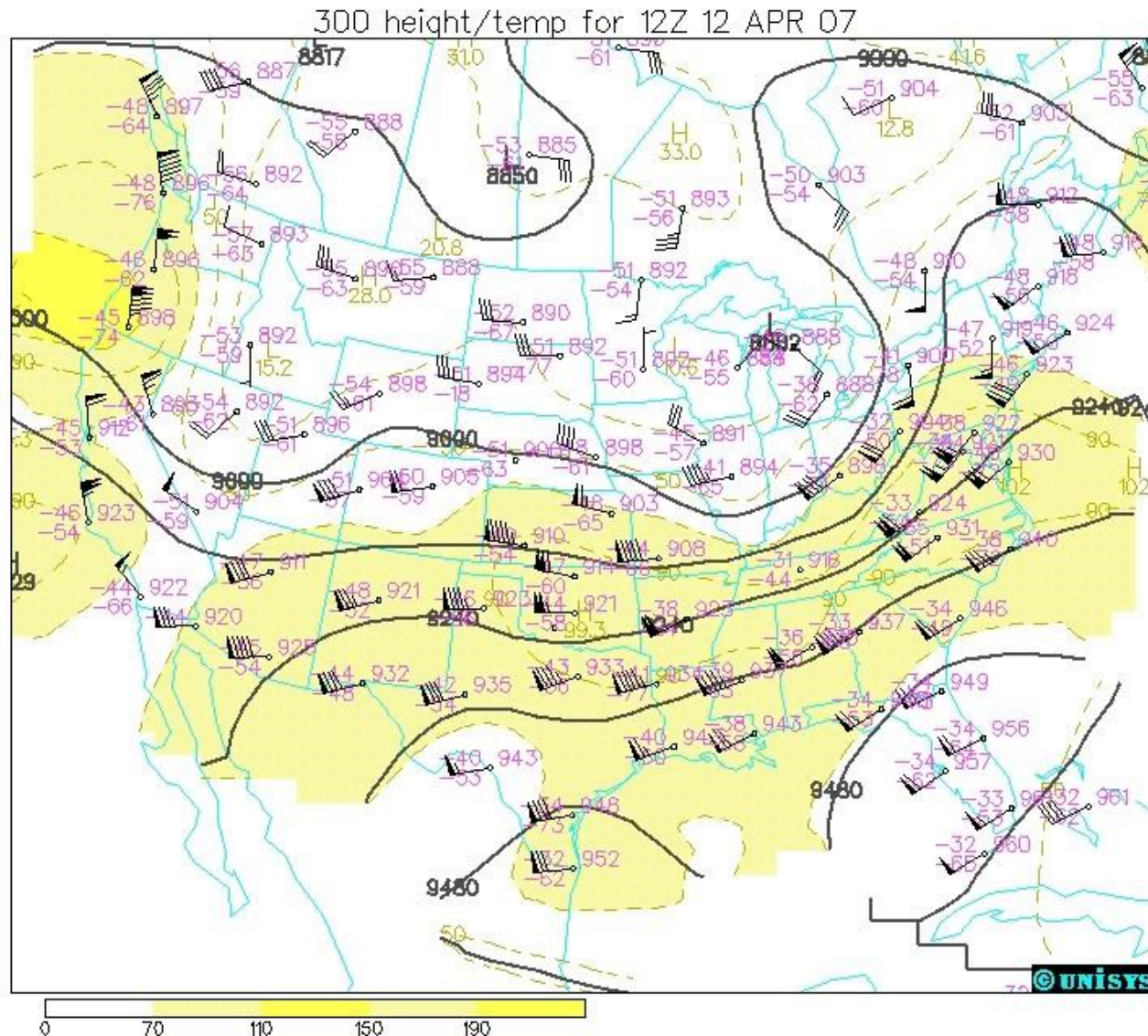
Introduction to upper-air charts

- A ‘stack’ of charts, each of a decreasing constant-pressure surface, ‘backing’ and ‘veering’ regions, the Polar Front Jet Stream, anticyclonic vorticity and cyclonic vorticity, long-waves and short waves:



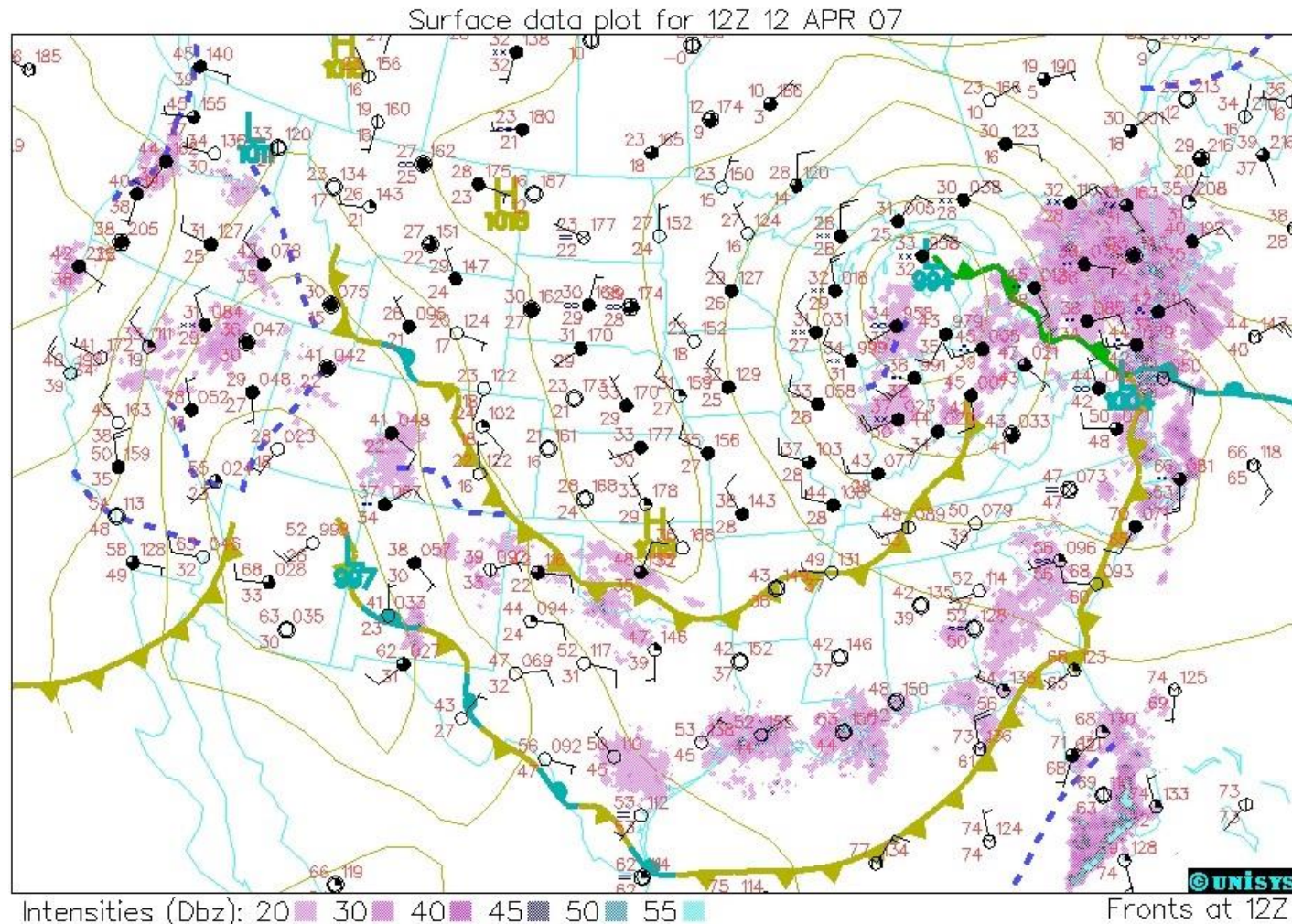
Introduction to upper-air charts

- A 'stack' of charts, each of a decreasing constant-pressure surface, reveals 'backing' and 'veering' regions, the Polar Front Jet Stream, anticyclonic vorticity and cyclonic vorticity, long-waves and short waves:



Introduction to upper-air charts: integration with surface weather maps for forecasting

- A sea-level pressure chart (negative image) and the corresponding 500 hPa constant-pressure chart (next slide) illustrate the connections between the surface and upper-air:

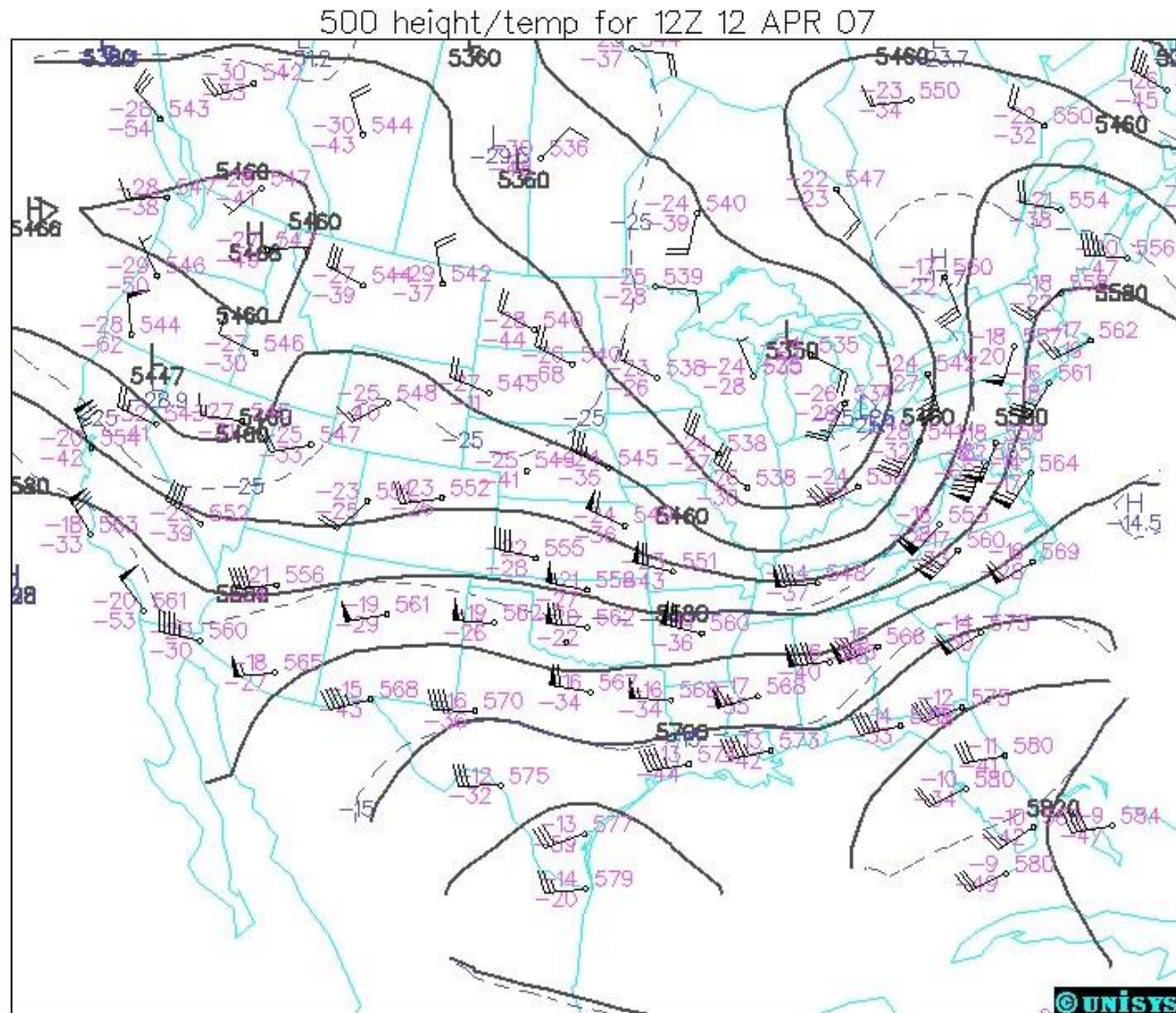


The wind maximum in the Jet Stream is above the occluding cold and warm fronts indicating additional development toward the NE. And, indeed I heard a clap of thunder at about noontime on 12 April 07.

From www.weather.unisys.com/archive/sfc_map/

Introduction to upper-air charts: integration with surface weather maps for forecasting

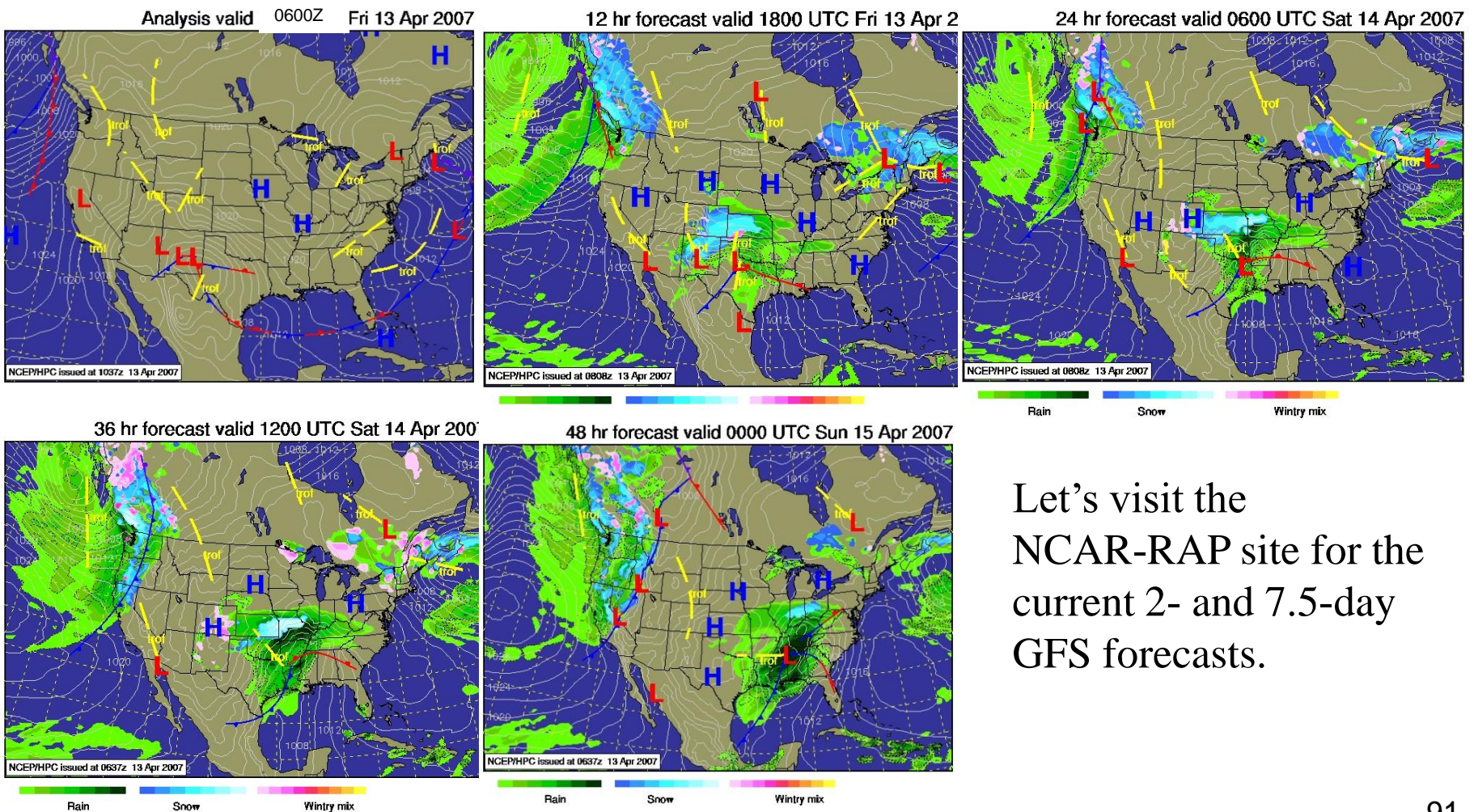
- A sea-level pressure chart (previous slide and the corresponding 500 hPa constant-pressure chart illustrate the connections between the surface and upper-air:



Weather forecasting-large scale

- Given current weather conditions and the governing physical relationships, detailed calculations are performed to produce future conditions. Meteorologists, then, interpret the conditions to produce forecasts. The NCAR-RAP site is one of the best:

weather.rap.ucar.edu/model/

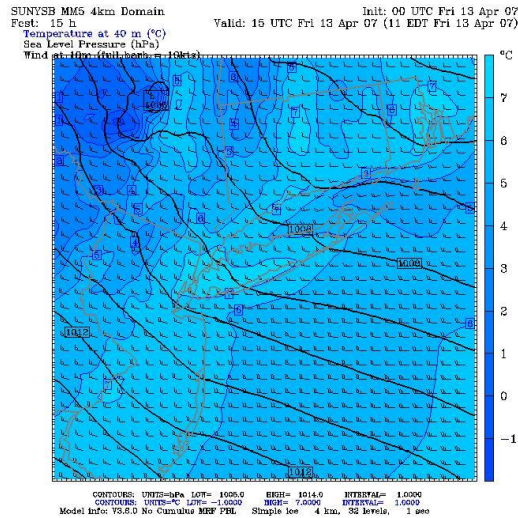


Let's visit the NCAR-RAP site for the current 2- and 7.5-day GFS forecasts.

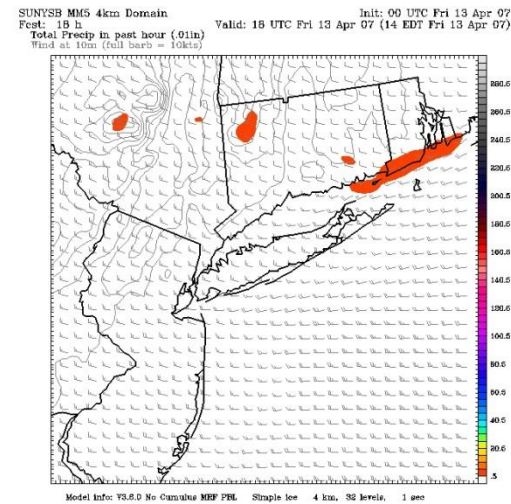
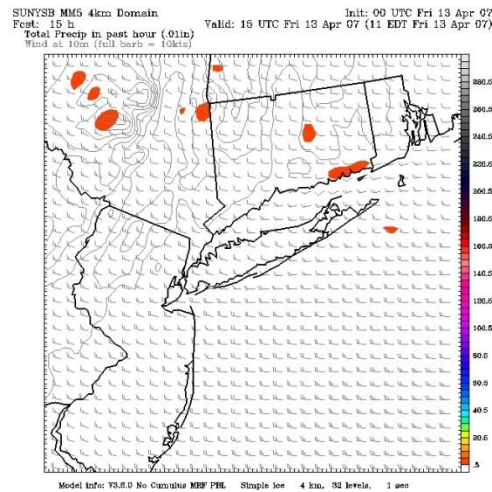
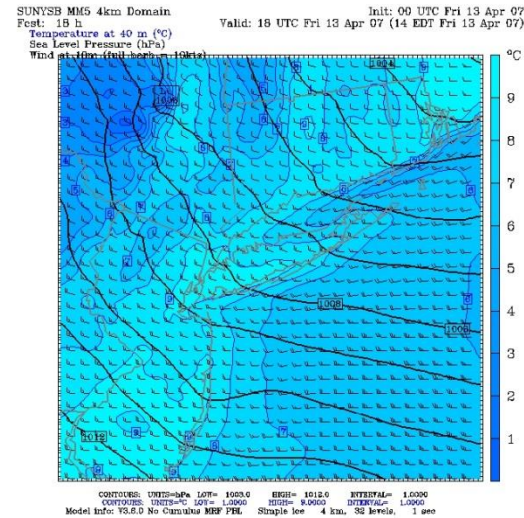
Weather forecasting-local scale

- The numerical simulations can be made on extremely fine scales (4km) producing local forecasts at 1-hour intervals for 24h or more. The SUNY-Stony Brook is one of the best sites (cheget.msrc.sunysb.edu/html/alt_mm5.cgi):

Valid 11EDT, 13 April 2007



Valid 14EDT, 13 April 2007

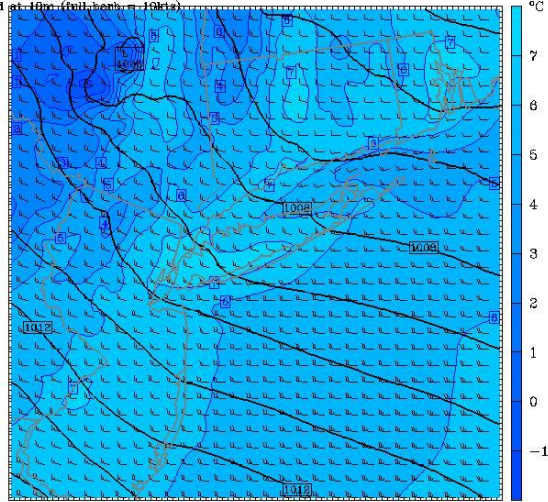


Weather forecasting-local scale

- Validation of the numerical simulations made at 20EDT (00UTC) 12 April 07:

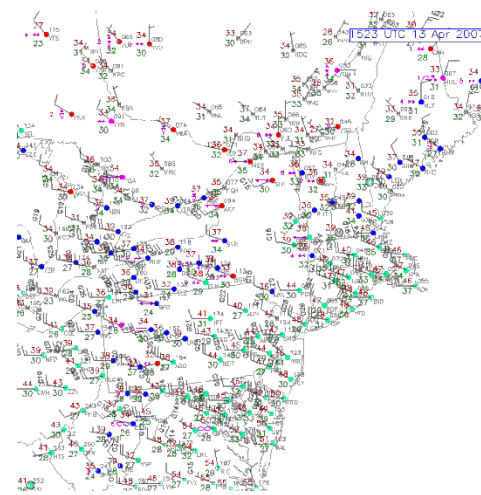
Predicted 11EDT, 13 April 2007

SUNYSB MM5 4km Domain Init: 00 UTC Fri 13 Apr 07
Fcst: 15 h Valid: 15 UTC Fri 13 Apr 07 (11 EDT Fri 13 Apr 07)
Temperature at 40 m (°C)
Sea Level Pressure (hPa)
Wind at 10m (full barb = 10kts)

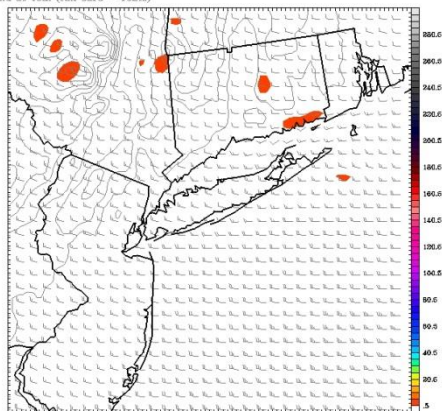


CONTOURS: UNITS=hPa LOW= 1005.0 HIGH= 1014.0 INTERVAL= 1.0000
CONTOURS: UNITS=°C LOW= -1.0000 HIGH= 7.0000 INTERVAL= 1.0000
Model Info: V3.5.0 No Cumulus MPF PBL Simple Ice 4 km 92 levels 1 sec

Actual 11EDT, 13 April 2007

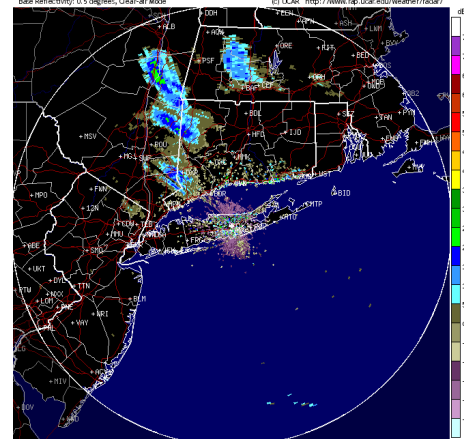


SUNYSB MM5 4km Domain Init: 00 UTC Fri 13 Apr 07
Fcst: 15 h Valid: 15 UTC Fri 13 Apr 07 (11 EDT Fri 13 Apr 07)
Total Precip in past hour (0.1in)
Wind at 10m (full barb = 10kts)



Model Info: V3.5.0 No Cumulus MPF PBL Simple Ice 4 km 92 levels 1 sec

KOKX -- New York City, NY/Upton
Base Reflectivity: 0.5 degrees, Clear-air Mode
15:17:28 UTC Fri 13 April 2007
E0 LCAR <http://www.nas.gov/ncar/ncar/ncar/>



Let's visit the Stony Brook site for the current forecasts.

Forecasts at sea available in GRIB (G**R**aphics In B**i**nary), see Biewenga Chapter 6 and www.sailwx.com/PUBLIC/index.html

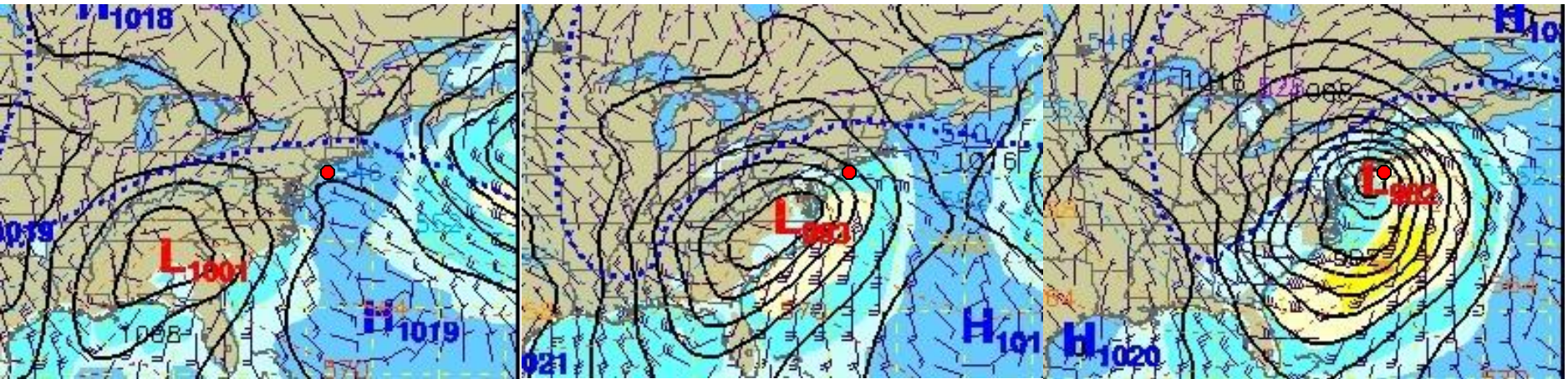
Weather forecasting – exercise (data from the UCAR-RAP site)

- Here is a sequence of Global Forecast System (GFS) forecasts:

VT 20EDT 14Apr07

VT 08EDT 15Apr07

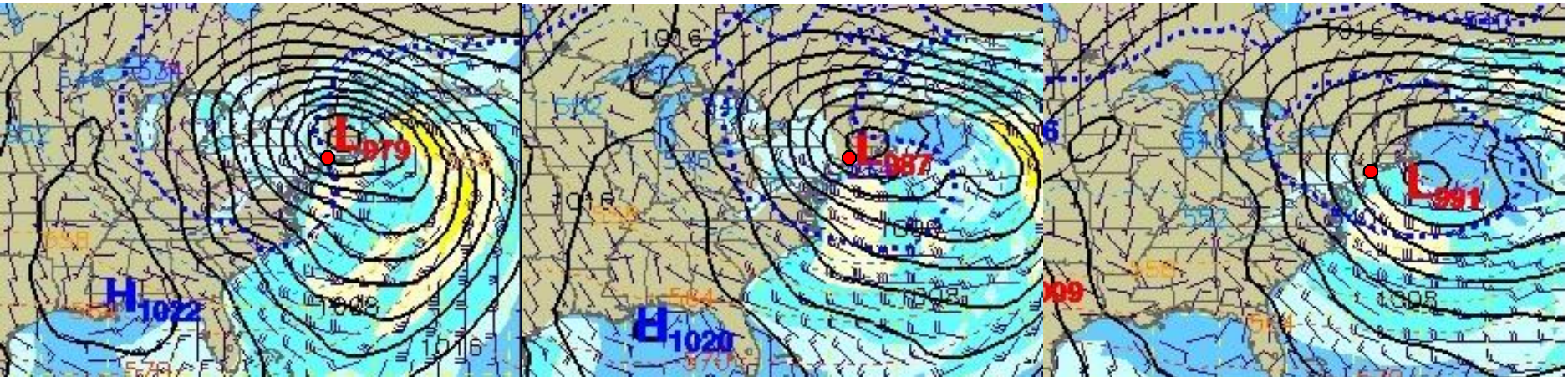
VT 20EDT 15Apr07



VT 08EDT 16Apr07

VT 20EDT 16Apr07

VT 08EDT 17Apr07



Sfc Wind (knots) / MSLP (mb) / 500-1000 mb Thickness (dm) 15 20 30 40 50 60 80 100 knots

- Write down the expected wind speed and direction for NY Harbor (RED dot) at 94 each time. What 4-hour period would you put your sailboat back in the water?

Introductory routing - climatology

- Routing using climatology - utilize the seasonal ocean currents and winds to determine the direction to sail.

For example, the Arabians used the SW and NE Monsoons to, respectively, sail to and from India.

Another example is the early mariners utilizing the Gulf Stream and Westerlies to sail from W to E across the N. Atlantic and the Atlantic Drift and NE Trades to sail from E to W across the sub-tropical Atlantic.

A final example. When I sailed from Annapolis MD to-and-from Ft. Lauderdale FL with the USNA in early June 1987, we motored the Inter-coastal Waterway to avoid the Gulf Stream off Cape Hatteras and used the Gulf Stream to speed back to Annapolis.

Introductory routing – synoptic weather reports

- “The shortest route is not necessarily the quickest”
- Routing using synoptic weather reports and forecasts is the current method to avoid regions of strong winds and large seas:

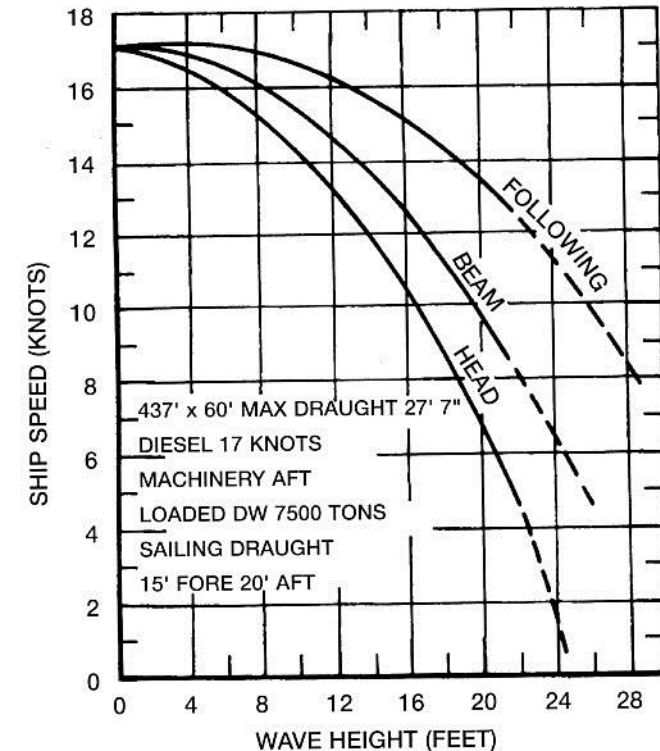


Fig 22.1

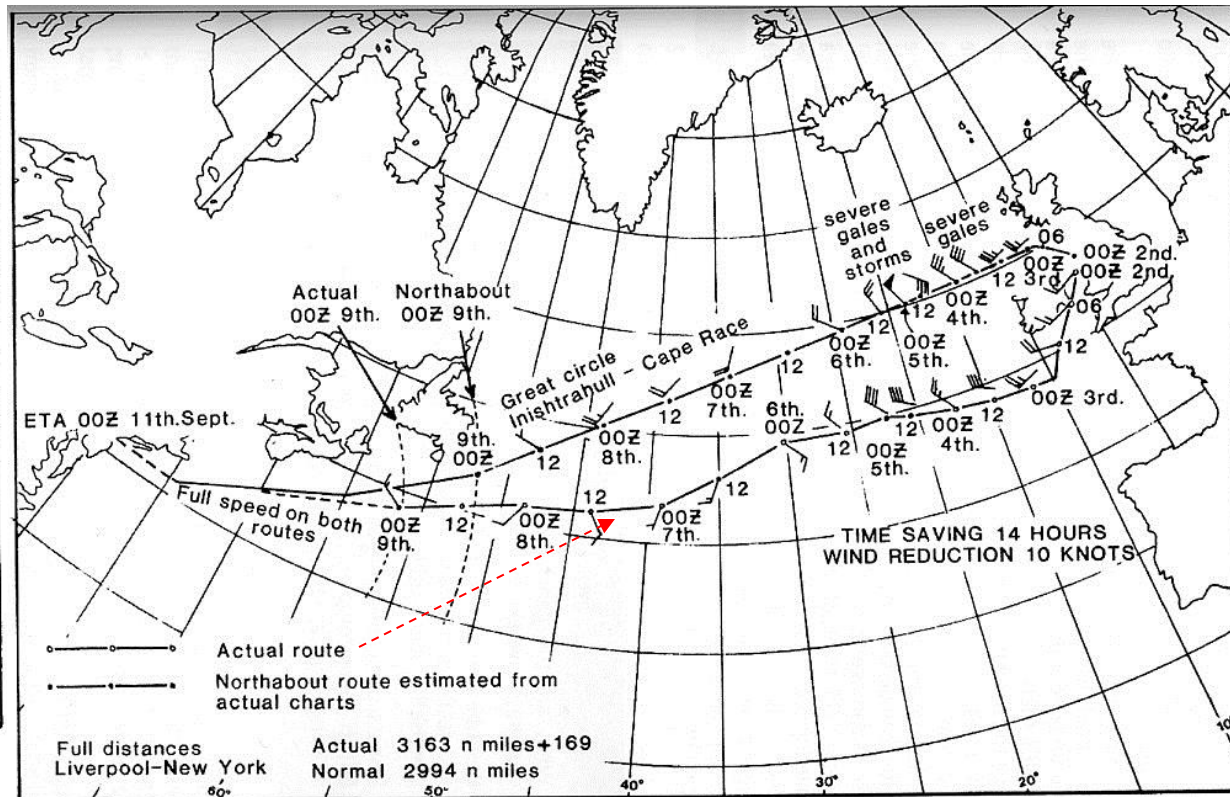
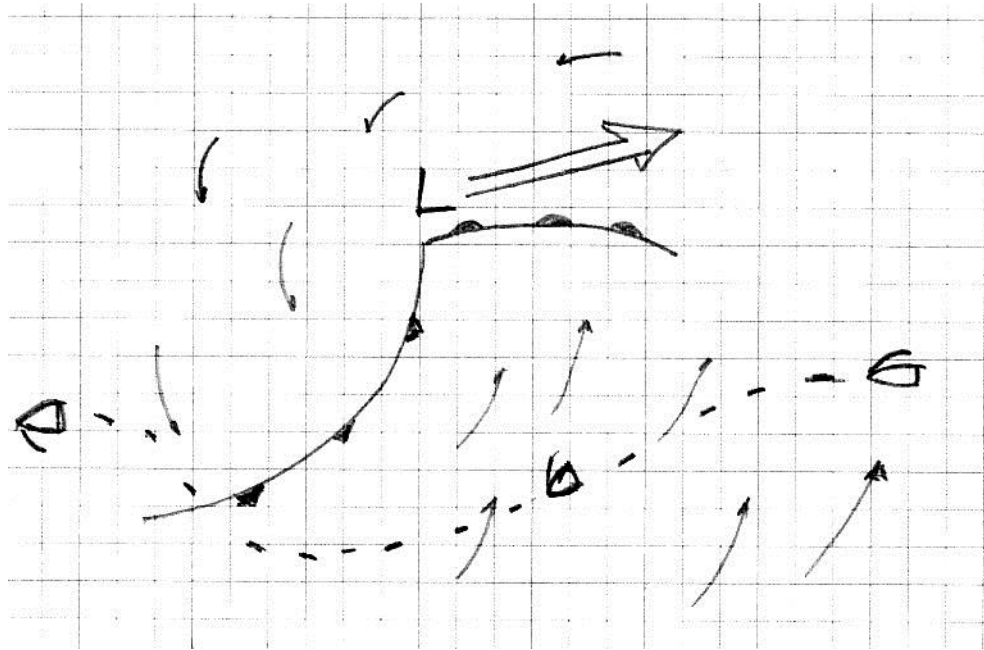


Fig 22.3

Note: 00Z indicates 0000 hrs GMT (UTC).

300 miles were added to this 3000 mile passage but, reducing time, fuel and cargo damage.

Introductory routing – cold front avoidance



- Squall line avoidance: They move too fast to avoid. Reef, point into the wind and motor to keep headway.
- “Quick to come, quick to pass. Slow to come, slow to pass”, Hindman
- Tropical cyclone avoidance discussed later

Introduction to sea and swell waves:

- A wave primer

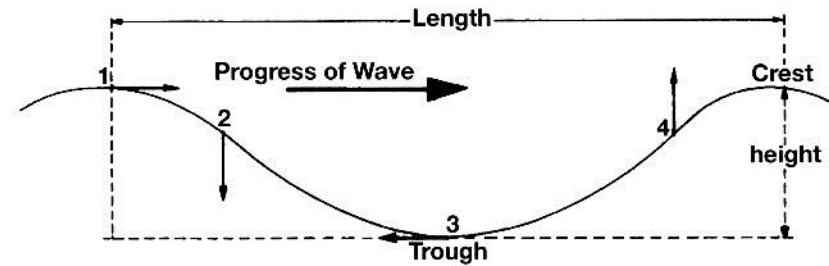


Fig 10.1(a) A simple wave form.

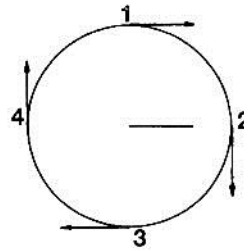


Fig 10.1(b) Resulting motion of a cork on the surface of the wave.

Period – time it takes for two crests to pass a point

Deep water waves do not ‘feel’ the bottom and shallow water waves ‘feel’ the bottom, slow down and increase in height.

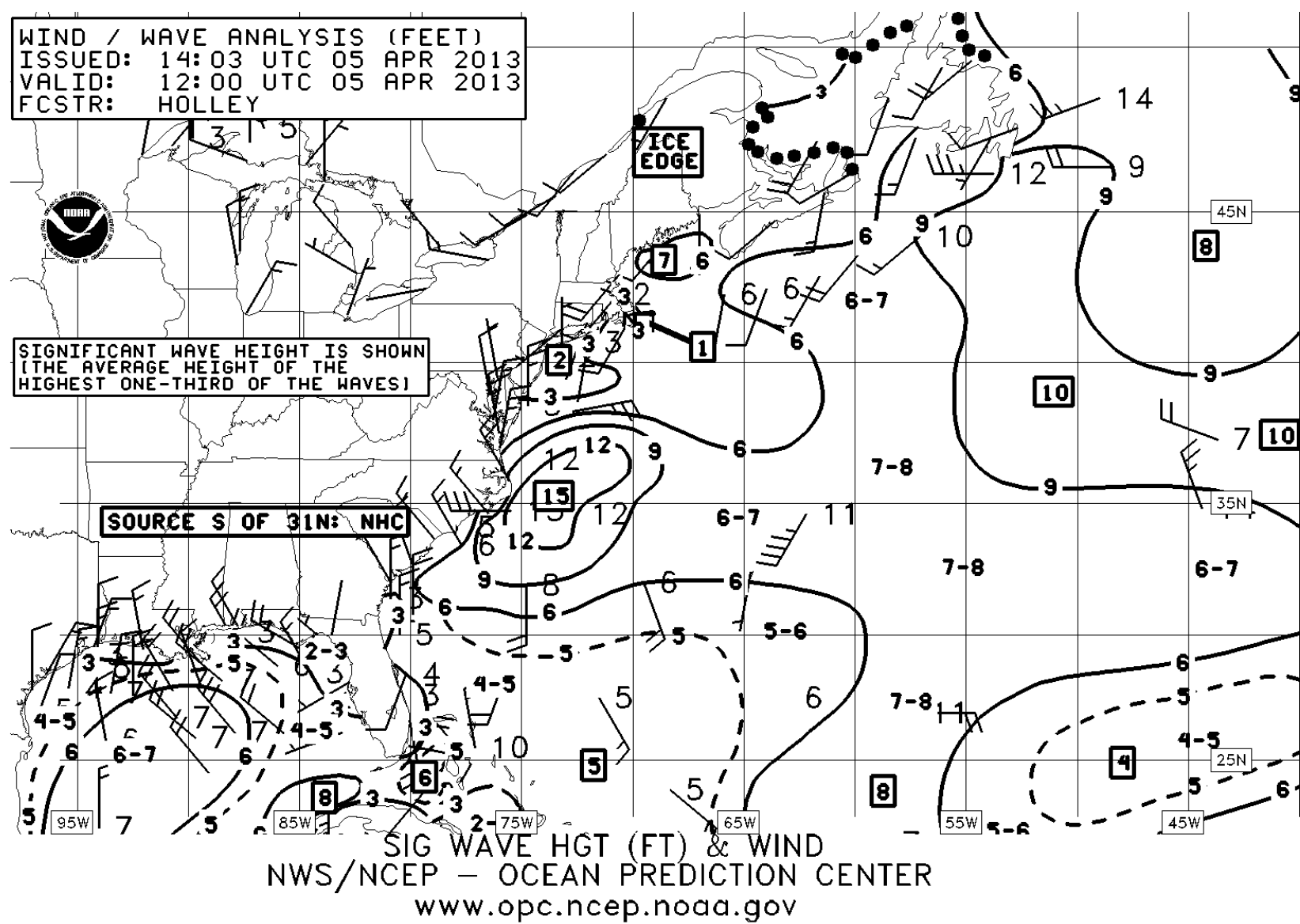
Introduction to sea and swell waves: formation

- Wave formation depends on the speed of the wind, duration of the wind and the 'fetch'. High speed winds of long duration over the longest fetch produce the largest waves and vice versa.
- The height of a wave may be either speed, duration or fetch limited (or limited by all). For example a north wind blowing across the Long Island Sound may be fetch limited.
- Sea waves are those generated in the region of the storm. They are chaotic in nature because of the continuously varying speed, duration and fetch in the region of the storm.
- Swell waves are the uniform, high speed waves that escape the storm regions and move far ahead of the storm.
- It's a challenge for the mariner to identify the swell waves transiting the locally generated sea waves or, in the case of Long Island Sound on a Sunday afternoon in August, the swell waves from the motor boat wakes!

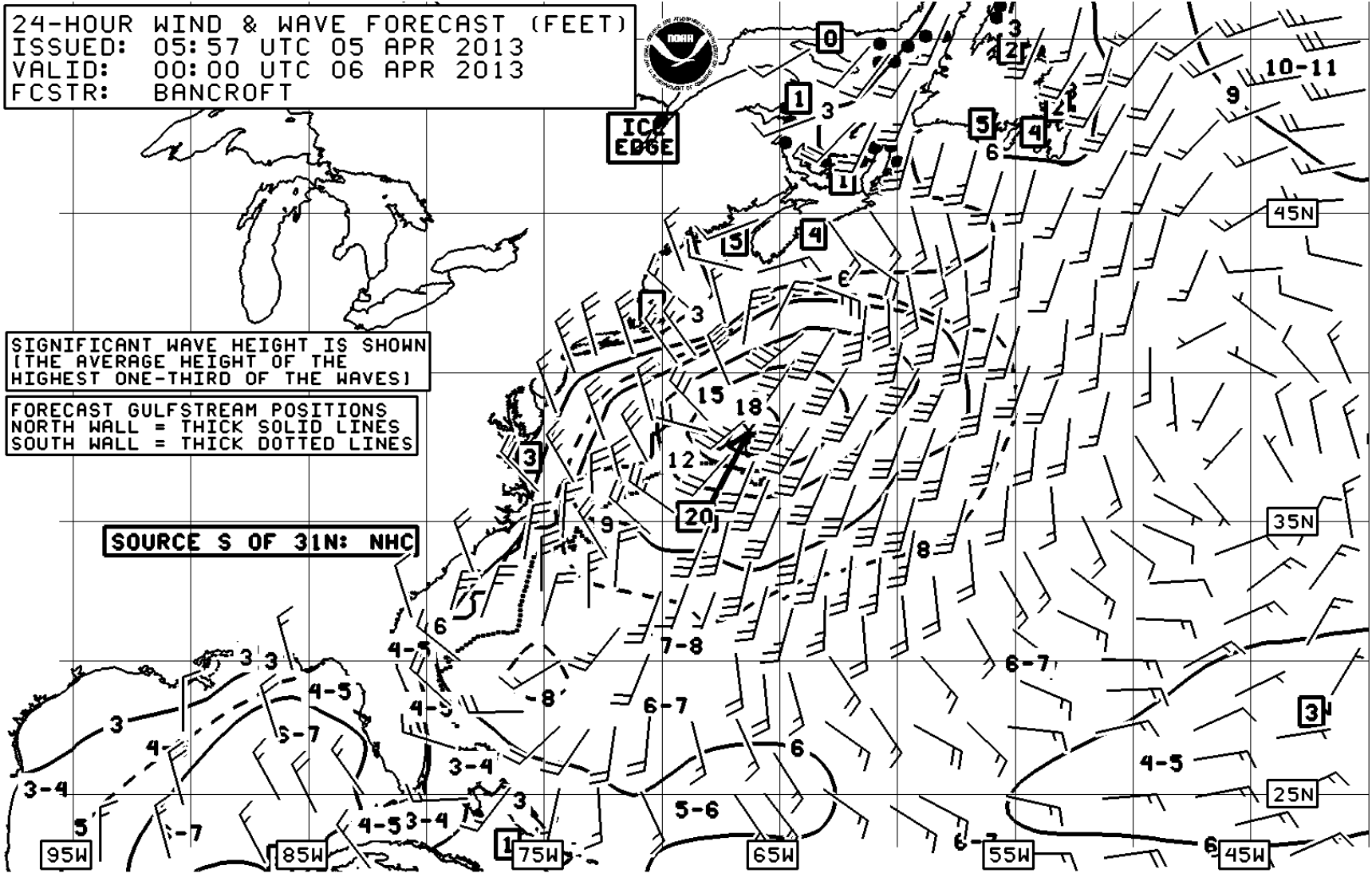
Introduction to sea and swell waves: propagation and decay

- Sea waves do not propagate significant distances because they are ‘anchored’ to the storm. The storm is injecting energy into the sea which radiates from the storm in the form of the swell waves.
- Sea waves decay (dissipate) as soon as the storm dissipates.
- Swell wave propagate great distances but loose height as they move from the storm. For example, swell generated in the Southern Ocean has been detected moving northward across the Pacific and dissipating as centimeter high waves on the Alaskan shores.
- Swell waves dissipate as the surf of the world’s beaches.

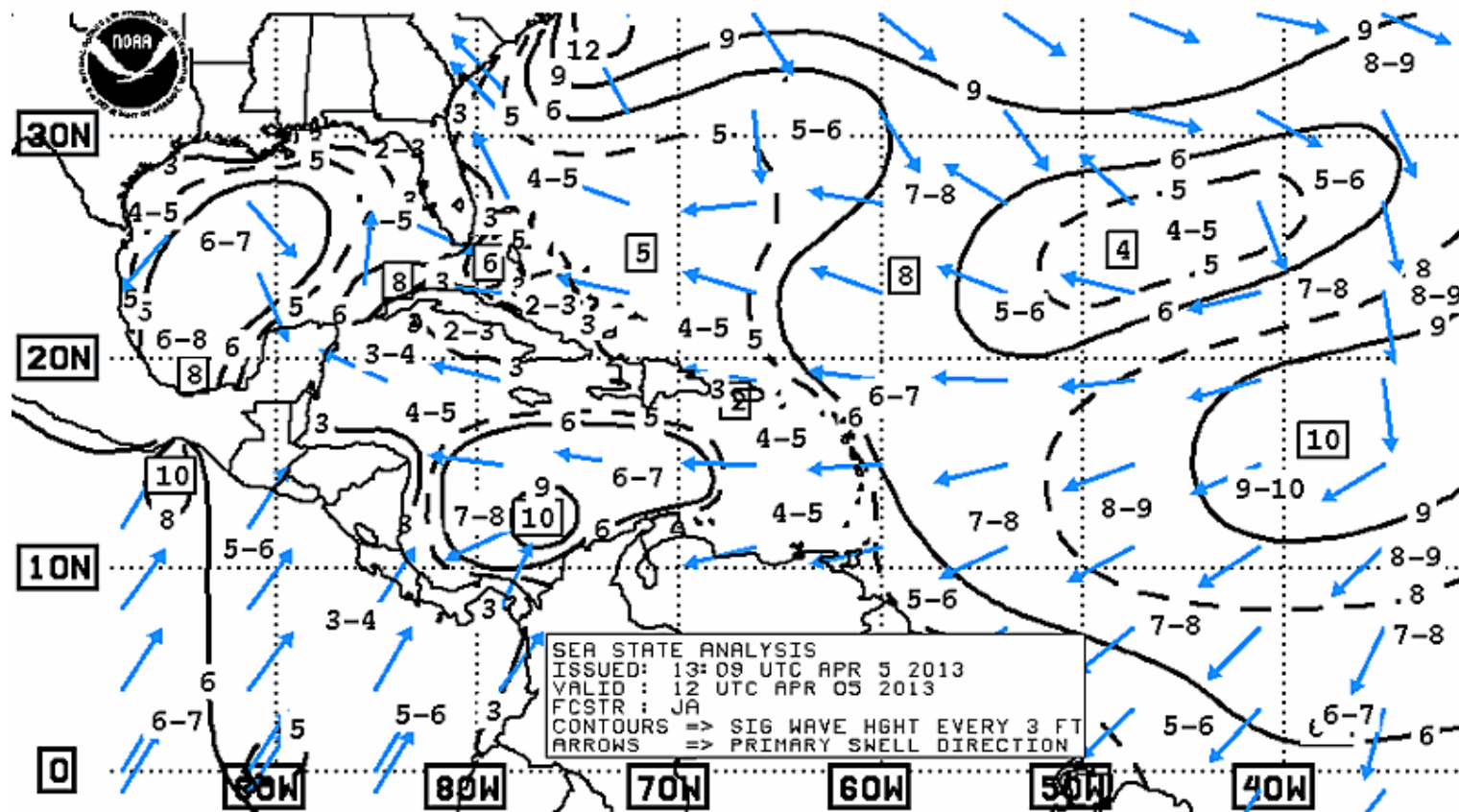
Overview of OPC wind and wave analyses charts: wind/wave analyses
(weather.noaa.gov/fax/marsh.shtml#WIND, scroll to appropriate ‘gif’ chart)



Overview of OPC wind and wave forecast charts: wind/wave forecast
(weather.noaa.gov/fax/marsh.shtml#WIND, scroll to appropriate ‘gif’ chart)

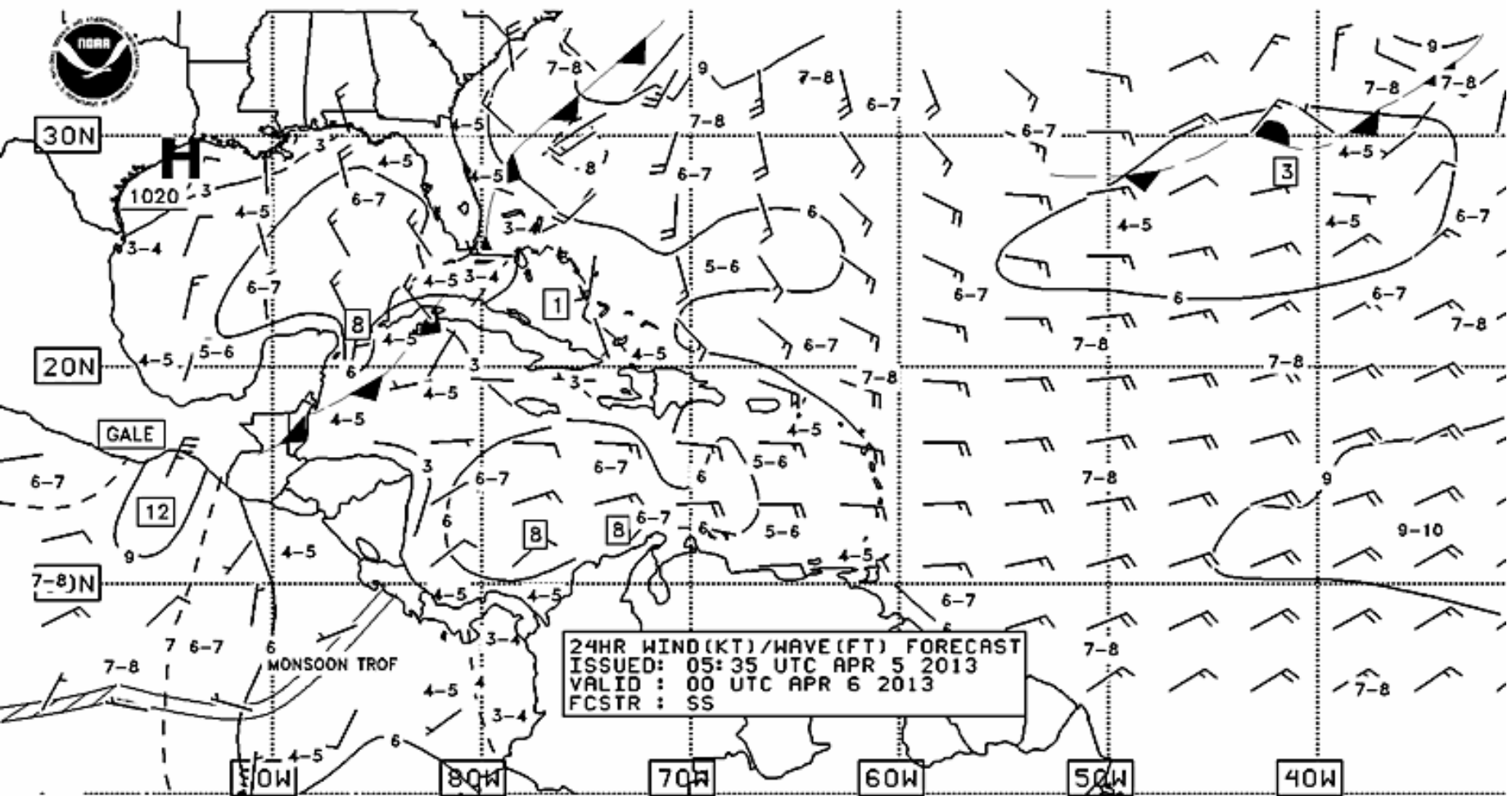


Overview of TPC wind and wave analysis charts: sea state analysis
 (www.nhc.noaa.gov/marine/), scroll down to ‘Graphical Products,
 Atlantic’ and, then, to ‘Significant Wave Height Analysis’)



NWS/NHC/TROPICAL ANALYSIS AND FORECAST BRANCH
SIG WAVE HT IS SHOWN (THE AVG HT OF THE HIGHEST 1/3 OF THE WAVES)

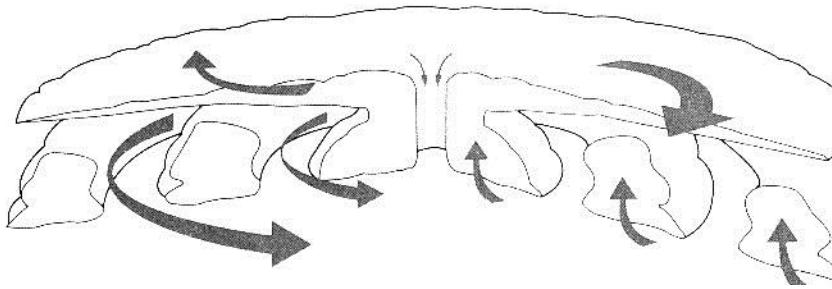
Overview of TPC wind and wave forecast charts: wind / wave
(www.nhc.noaa.gov/marine/), scroll down to ‘Graphical Products,
Atlantic’ and, then, to ‘Wind/Wave Forecasts’)



NWS/NHC/TROPICAL ANALYSIS AND FORECAST BRANCH
SIG WAVE HT IS SHOWN (THE AVG HT OF THE HIGHEST 1/3 OF THE WAVES)

Tropical cyclone: Basics and the rules for avoidance:

Because of the geostationary satellites that ring the World, there are no more undetected tropical cyclones. Therefore, you should have ample warning to either not set out or avoid if underway. If, however, you goof, here are some strategies:



Characteristics of the mature tropical cyclone (hurricane in west Atlantic and eastern Pacific) from Biewenga reference.

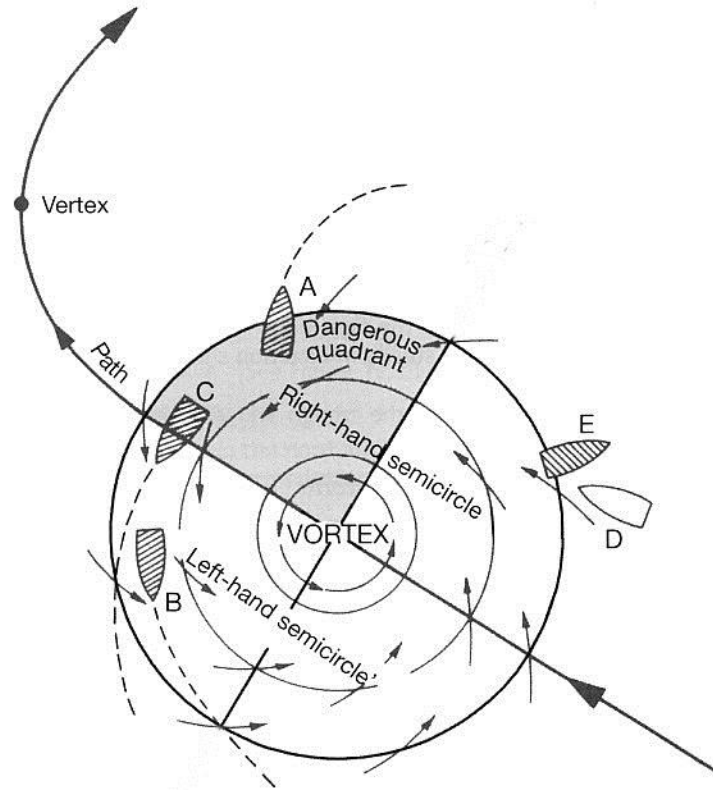


Fig 17.2

Where to access weather information

Summary of sites visited in “Intermediate Marine Weather”:

- Global satellite image from www.nrlmry.navy.mil/sat-bin/global.cgi
- Global satellite loop from www.ssec.wisc.edu/data/comp/ir/irmoll.mpg
- Weather schematics at www.srh.weather.gov/srh/jetstream/global/jet.htm
- Gulf Stream sea-surface temperatures from marine.rutgers.edu/mrs/sat_data/
- Atmospheric soundings above the Gulf Stream from ready.arl.noaa.gov/READYamet.php
- Current coastal buoy data from www.ndbc.noaa.gov
- Upper air charts from www.weather.unisys.com/upper_air/
- Archived surface weather maps from www.weather.unisys.com/archive/sfc_map/
- Large-scale weather forecasts from weather.rap.ucar.edu/model/
- Local weather forecasts from cheget.msrb.sunysb.edu/html/alt_mm5.cgi (free) and www.sailwx.com/PUBLIC/index.html (charge)
- Ocean wind and wave analyses and forecast maps for the east coast from weather.noaa.gov/fax/marsh.shtml#WIND
- Ocean wind and wave forecast maps for the sub-tropical regions from www.nhc.noaa.gov/marine/

End of ‘Intermediate Marine Weather’

**Now you are ‘weatherproofed’:
recognize, understand, act!**