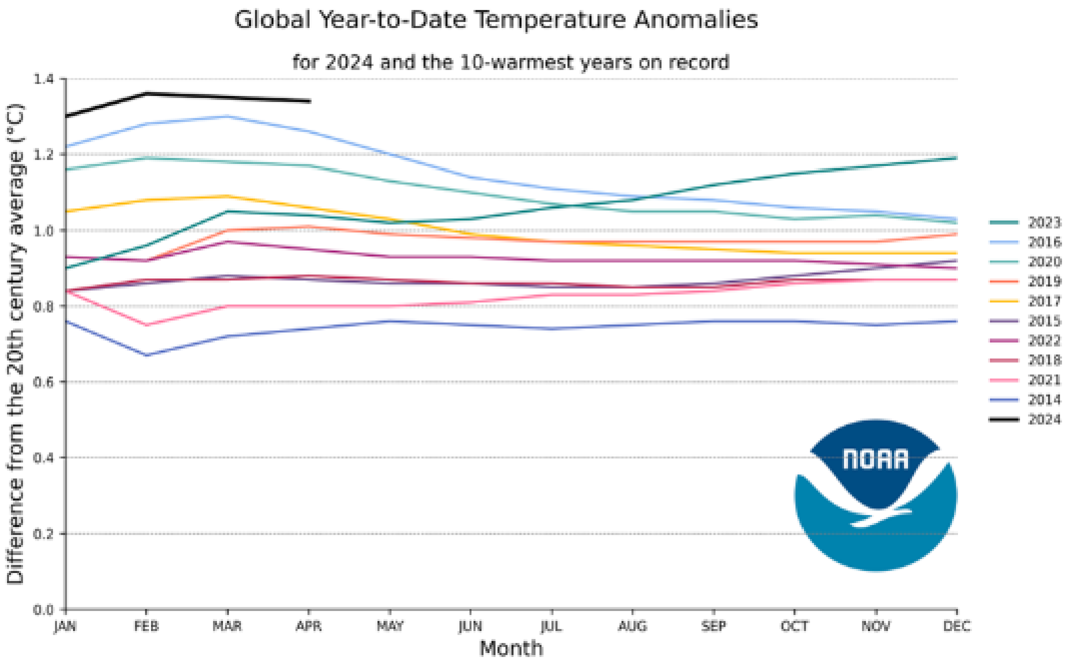
CISA Extreme Weather Outreach

ISART: Weather and Climate Focus

"The 10 warmest years in the 143-year record have all occurred since 2010" (NOAA, 2023).



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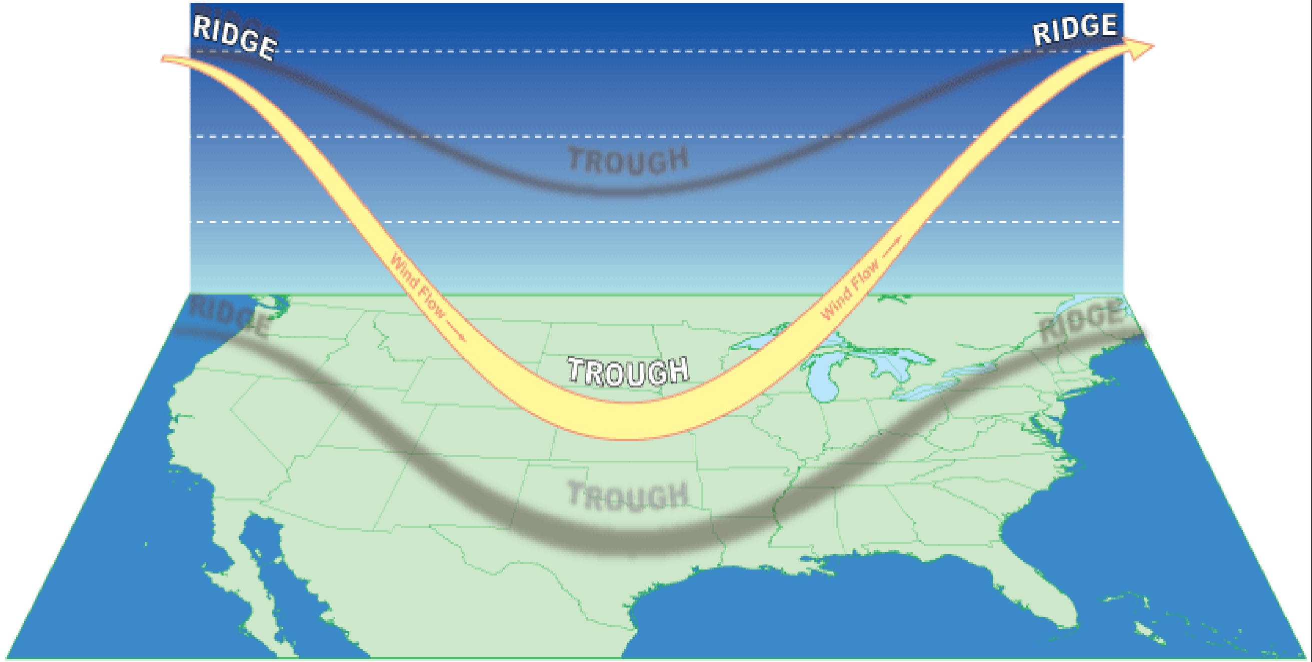
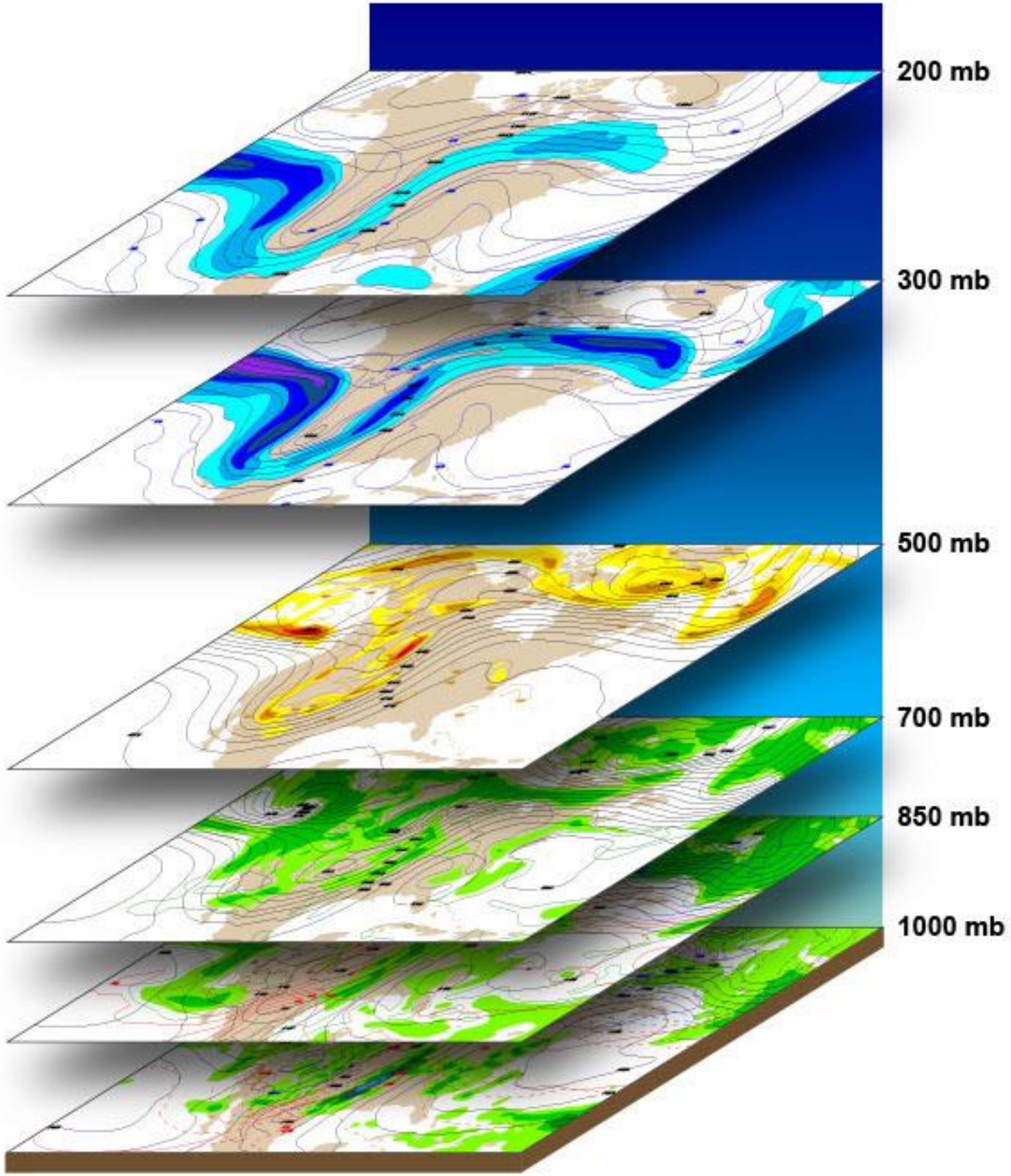
Atmospheric Pressure - Millibar 101

In essence, upper air charts show the atmosphere in three dimensions.

- Wind flowing from a ridge toward a trough is decreasing in height above the surface. Conversely, wind flowing from a trough into a ridge is increasing in height.
- Between the colder, more dense air and the warmer, less dense air is the location of the greatest change (gradient) in heights of any pressure level. (NWS Jet Stream)
- By looking at these contours we observe patterns of higher heights (called ridges) and lower heights (called troughs). These ridges and troughs drive the weather we experience at the surface.

Atmospheric Pressure is measured with an instrument called a barometer, which is why it is also referred to as barometric pressure.





High and Low Pressures: the Carousal of Weather

A **low-pressure system** has lower pressure at its center than the areas around it. Winds blow towards the low pressure, and the air rises in the atmosphere where they meet.

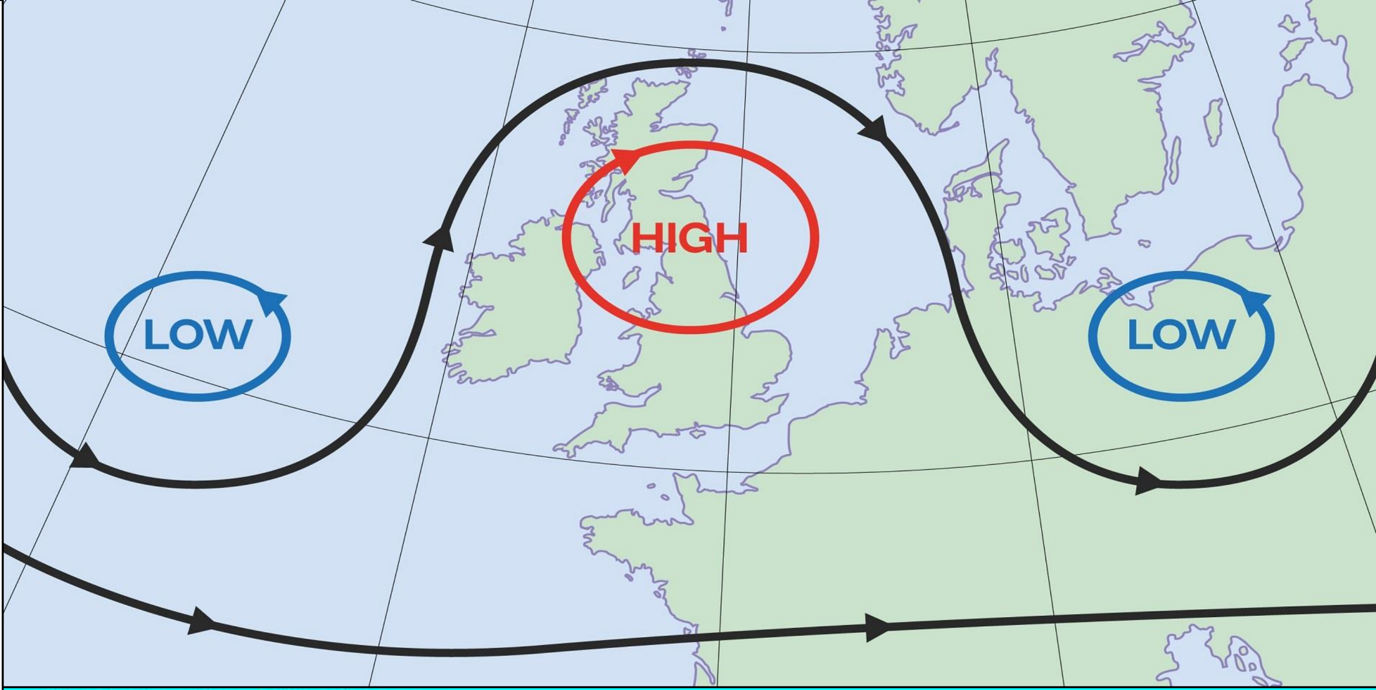
- Because of Earth's spin and the Coriolis effect, winds of a low-pressure system swirl counterclockwise north of the equator.
- As the air rises, the water vapor within it condenses, forming clouds and often precipitation.
- On weather maps, a low-pressure system is labeled with red L.

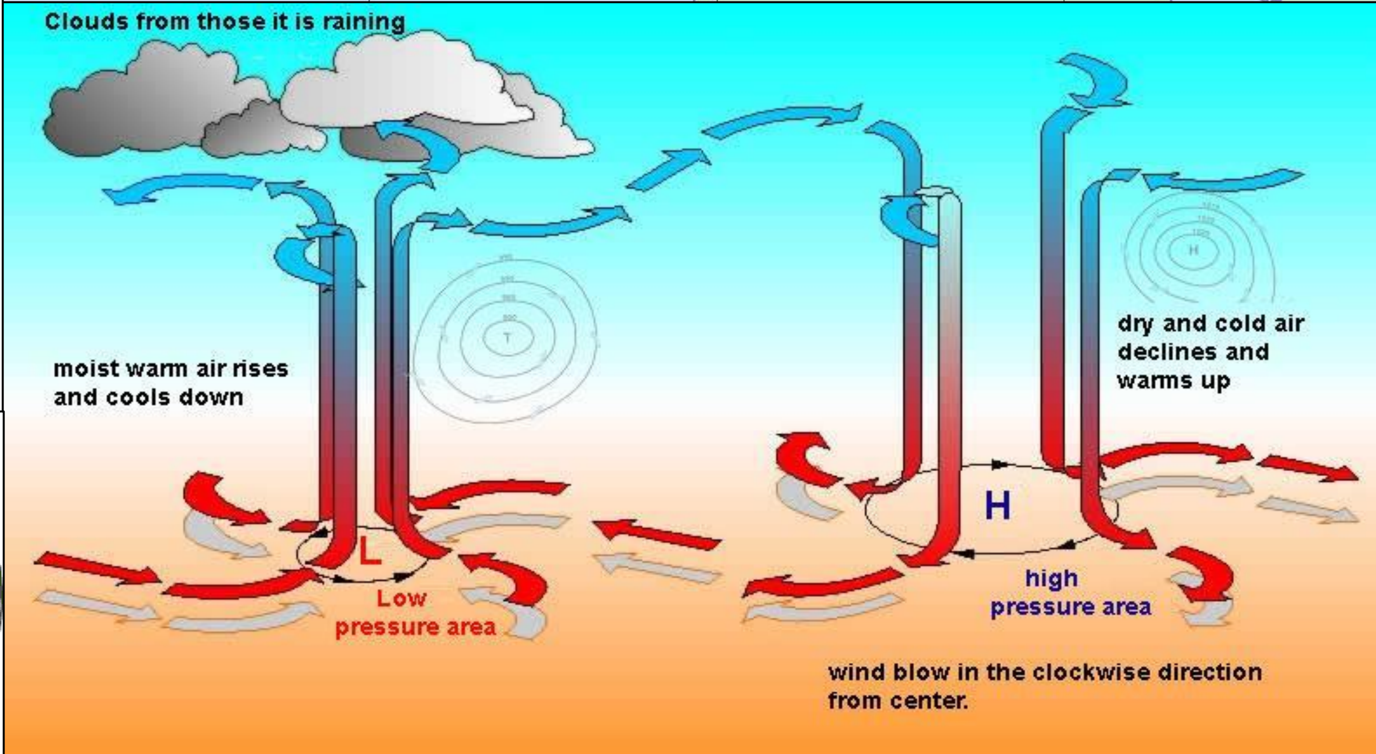
A **high-pressure system** has higher pressure at its center than the areas around it. Winds blow away from high pressure.

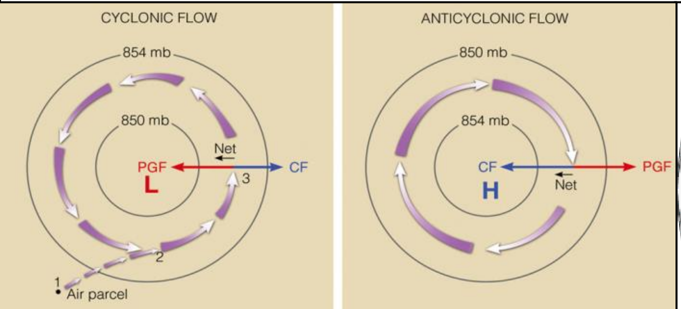
- Swirling in the opposite direction from a low-pressure system, the winds of a high-pressure system rotate clockwise north of the equator (anticyclonic flow).
- Air from higher in the atmosphere sinks down to fill the space left as air is blown outward. On a weather map, you may notice a blue H, denoting the location of a high-pressure system.

Air pressure depends on the temperature of the air and the density of the air molecules. Air masses differ based off their prevailing fields.

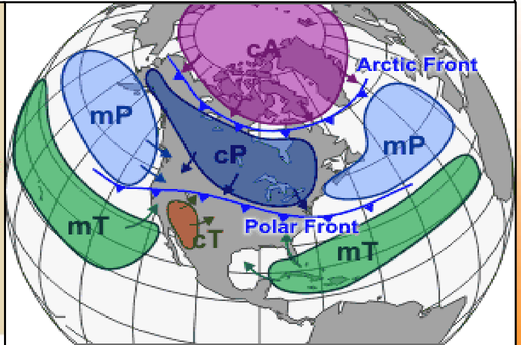
The tighter the gradient between the high and the incoming low, the stronger the winds will be as they mix down from the upper levels.







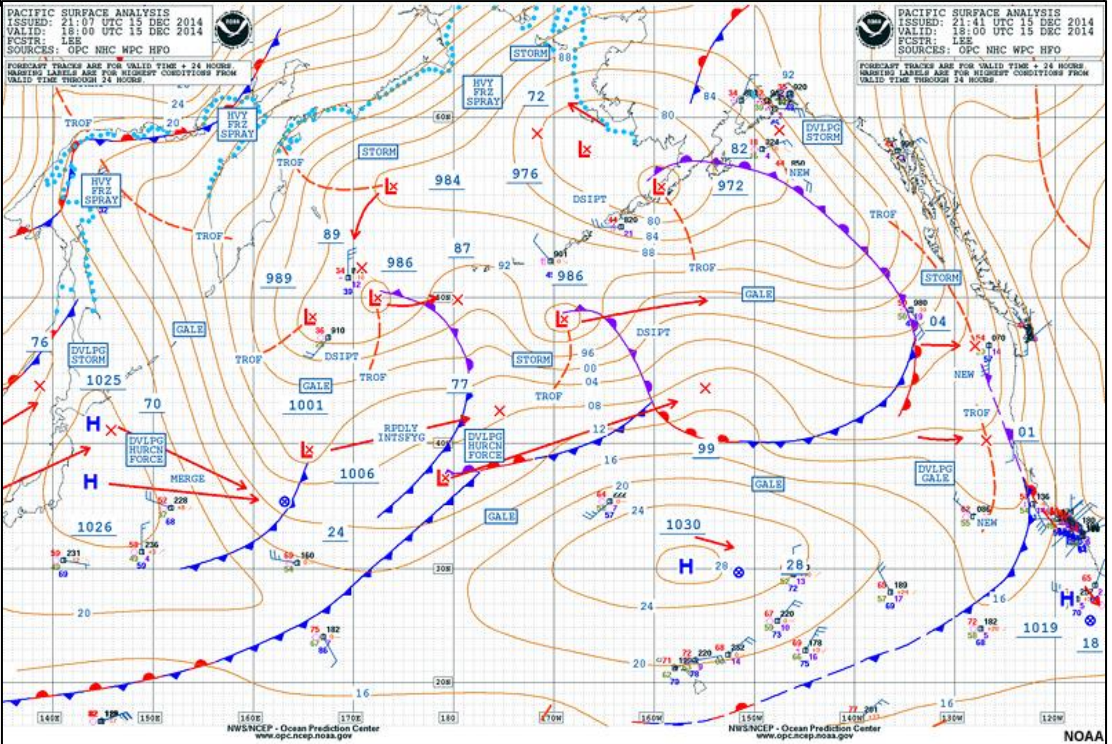
(a) Low pressure area (cyclone) aloft
(b) High pressure area (anticyclone) aloft

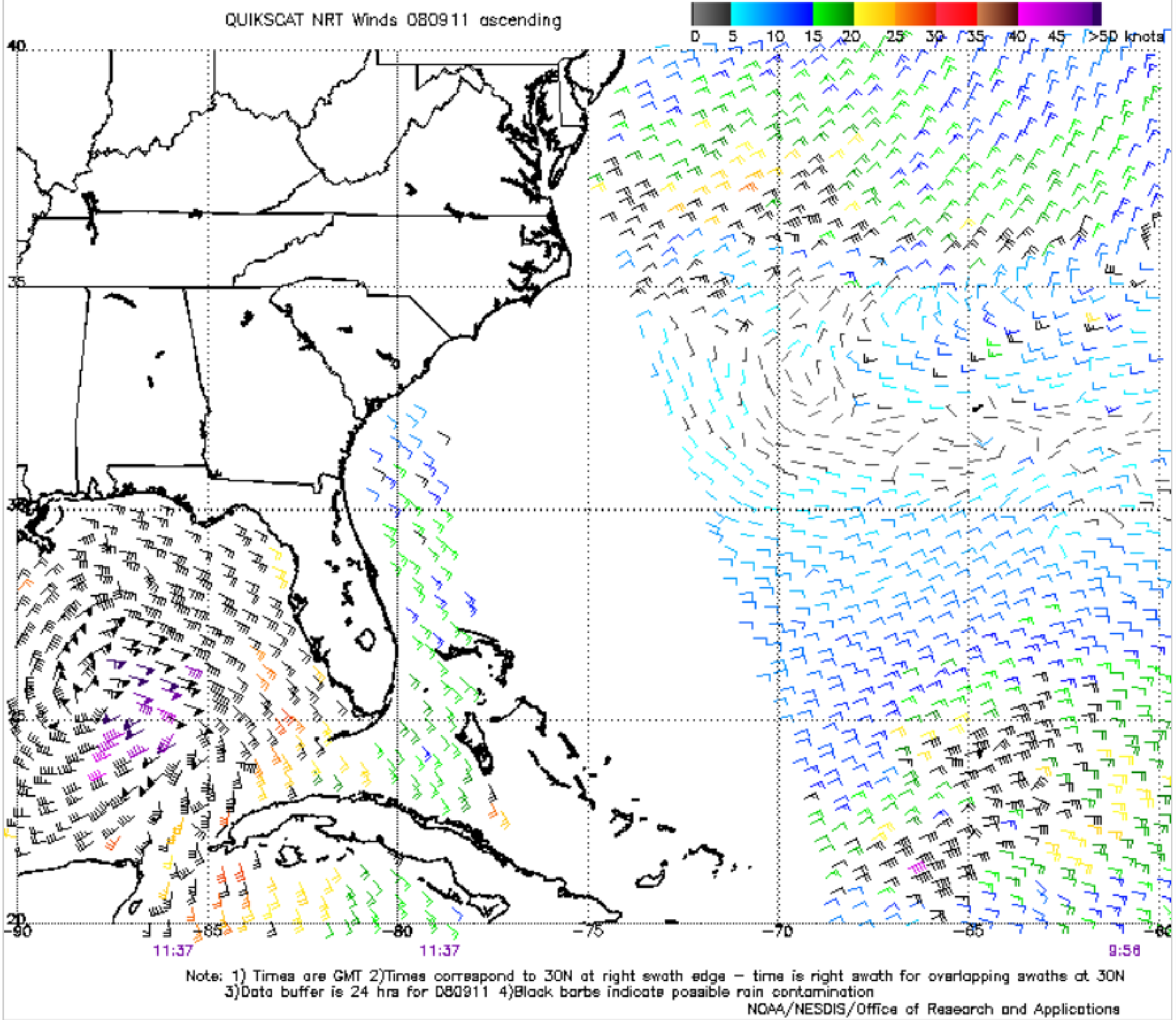


Use of Scatterometer and Surface Data

The use of various observation and forecast datasets were required for forecasting through 2020, comparing wind from various levels, buoy data, satellite images, and ship observations from nearby ports or pathways.

The frontal boundary maps with gradients and wind barbs for intensities at the levels from 500 to 700/800 to the surface would enable forecasters the understanding that systems stack forward from the upper levels, requiring monitoring hundreds of miles of data.





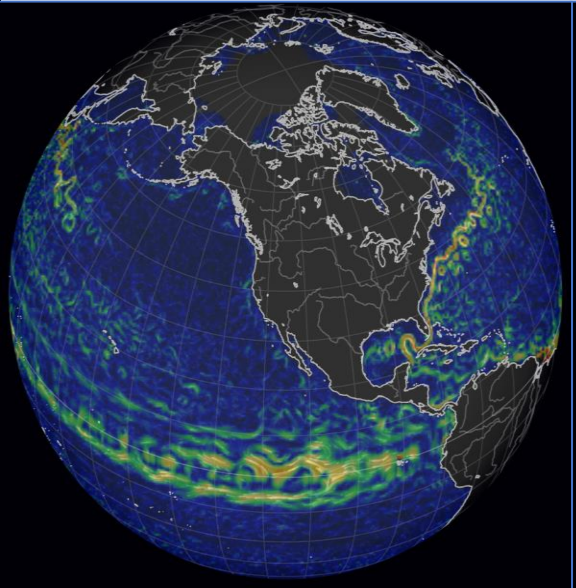
Data from the QuikSCAT scatterometer on September 11, 2008, showed the cyclonic surface circulation of Hurricane Ike in the Gulf of Mexico. Black wind barbs indicate contaminated data that are unreliable.

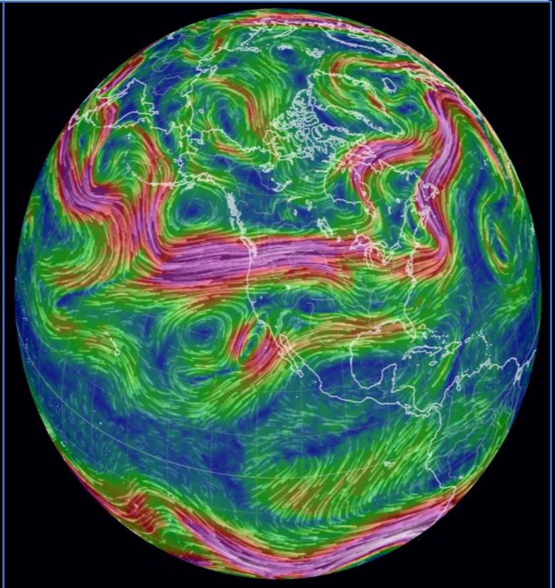
Credit: NESDIS Center for Satellite Application and Research

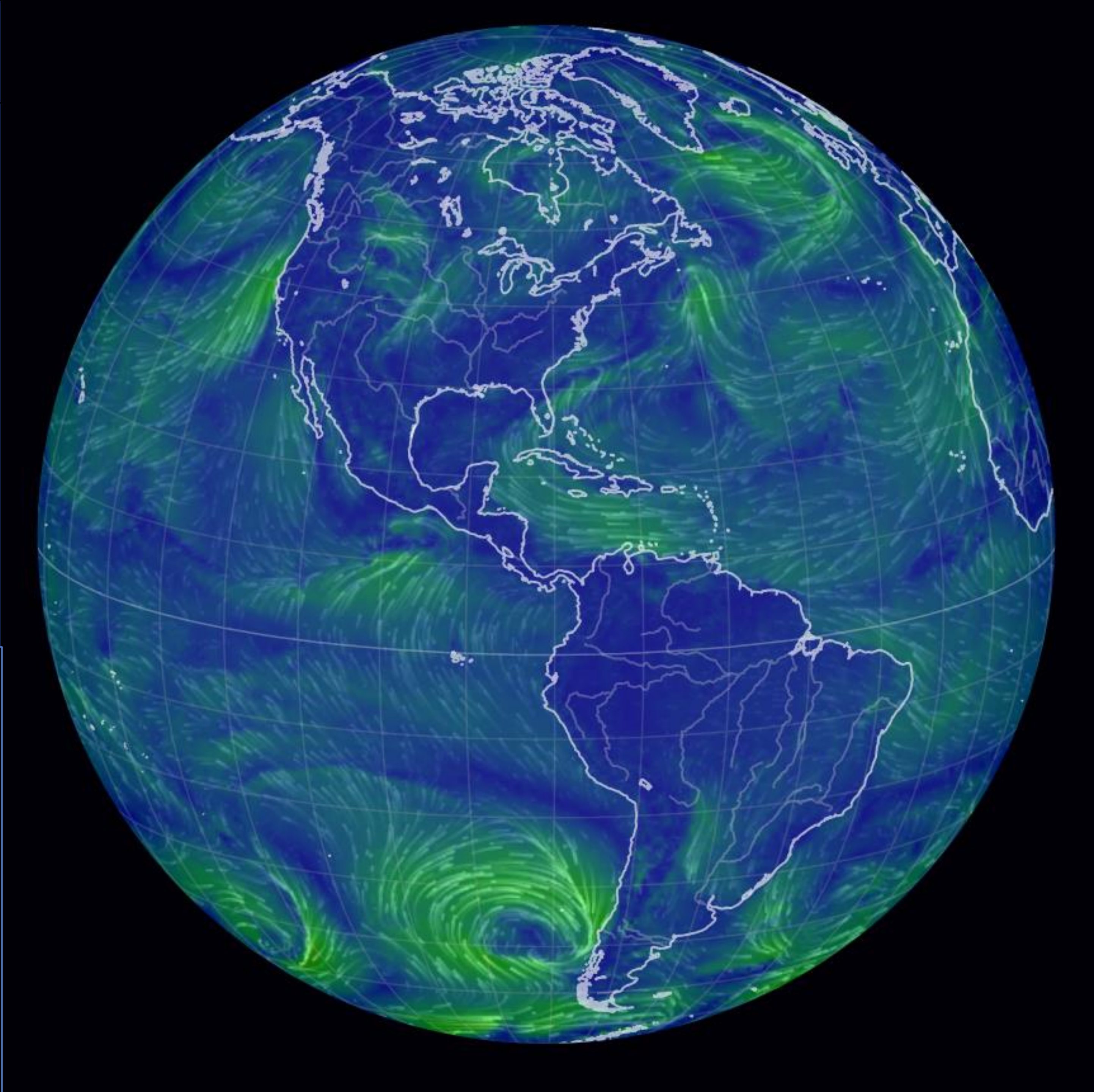
Supercomputer Data

Needing access to supercomputer models of weather from all levels of the atmosphere which stores the past decade of data for comparison of systems and upper-level setups for considering major shifts in weather conditions on the horizon provides forecasters with a global overview of the mesoscale of impacts; what happens in one country can absolutely have impacts on other countries ‘downstream’ along the shared jet.

- In the US our main frontal boundary movement is triggered by the Polar Front Jet, visualized below at the 250mb winds.
- Being able to reference the tidal data, the currents, and ocean content aids tropical and coastal forecasts.







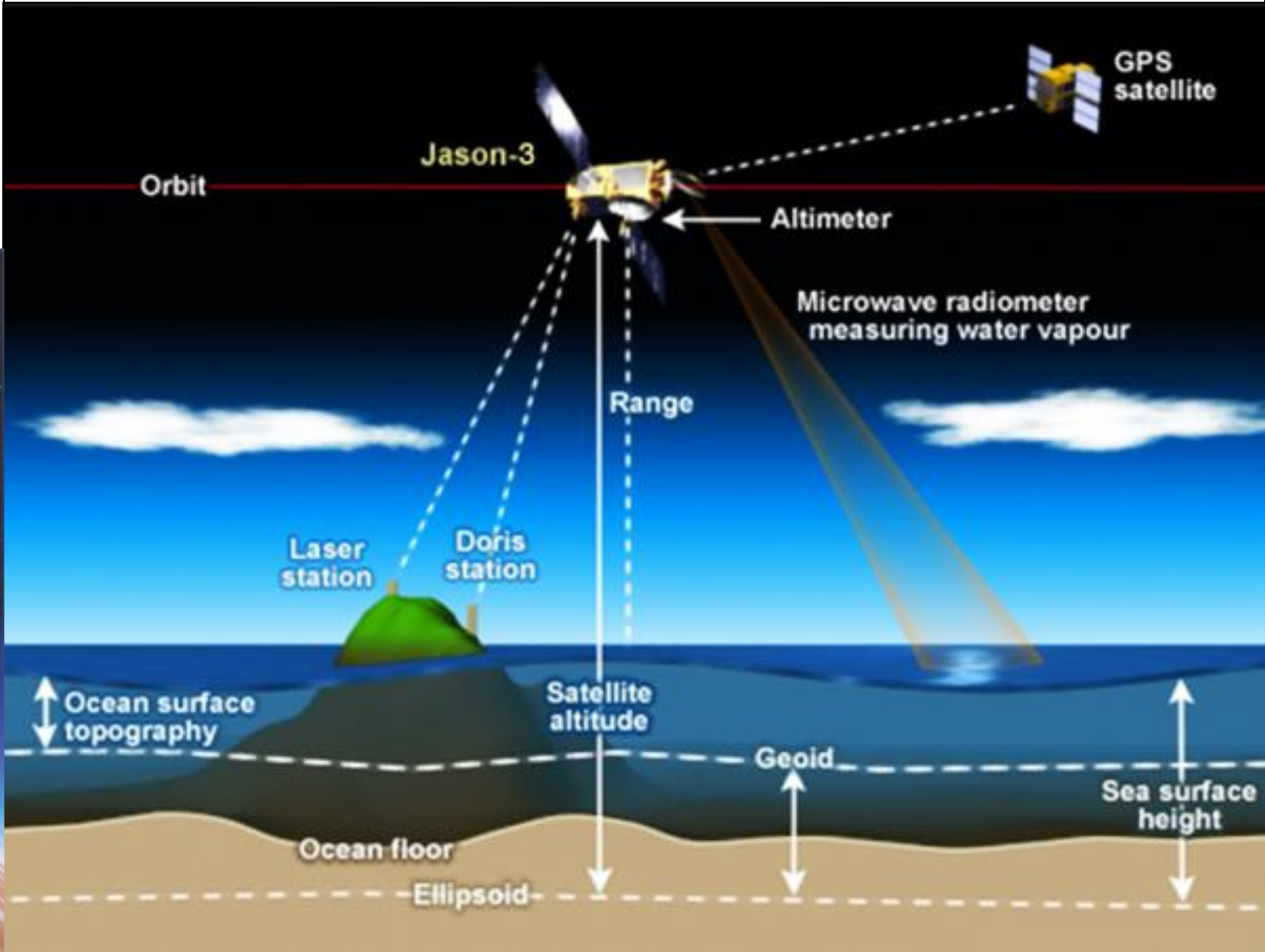
Satellite Needs

Satellite imagery and radar are necessary for the whole-of-atmosphere overview required in forecasting larger areas for longer periods of time.

While these systems range 20-45 minutes in delay for updated data, the average forecaster can be trained to estimate movement potential, growth and overshooting tops of storms, and impacts to local weather from various cloud types depending on the clarity of the satellite imagery.

The loss of satellite systems would remove the ability to gauge storm growth as the low-level clouds would be harder to identify outside of upstream observation stations such as airports or spotter networks.

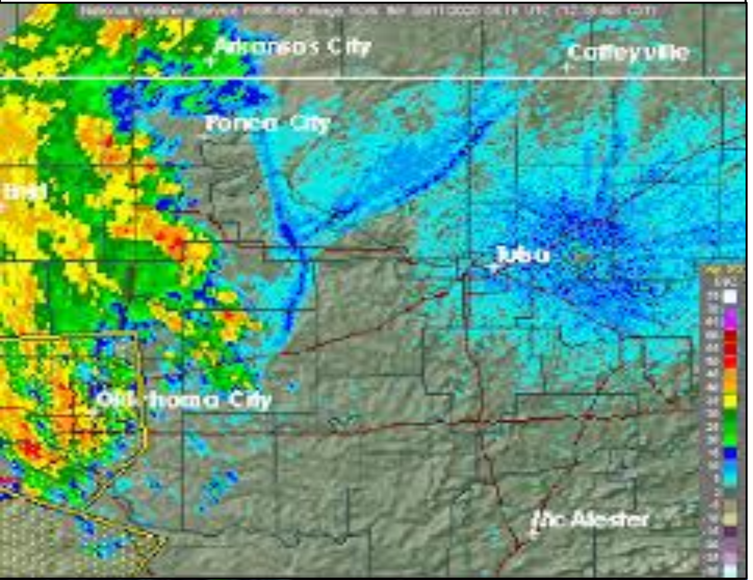
Using satellite historic data has enabled researchers the ability to compare year-over-year trends of heating, wave height intensities, and cloud coverage from ship trails or cirrus clouds which work to warm the area.

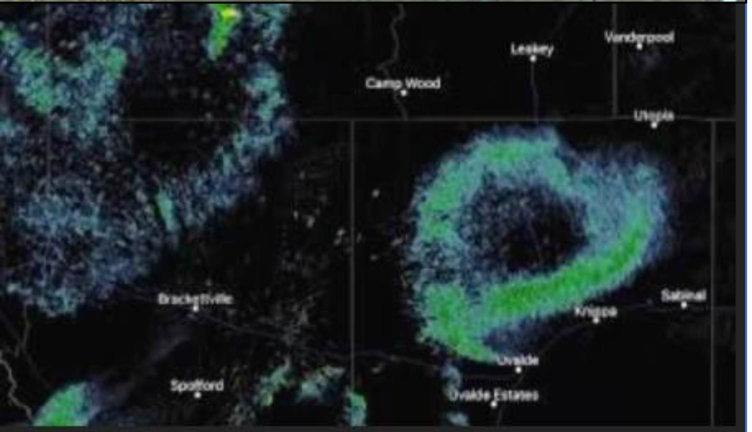


Radar Use

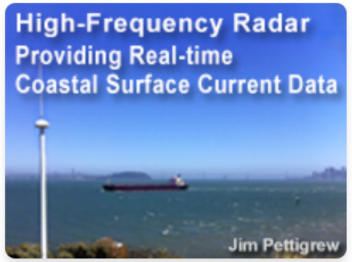
Various training programs exist for understanding radar application.

Comparing weather events against continuous noise in the radar system requires training on imagery.





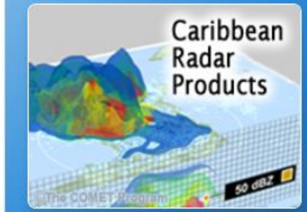
High-Frequency Radar: Supporting Critical Coastal Operations with Real-time Surface Current Data



Produced in collaboration between NOAA's National Ocean Service (NOS) US Integrated Ocean Observing System (IOOS) Program Office and The COMET Program, this video explains how high-frequency radar (known as HF radar) is used to provide detailed information in real-time on coastal ocean surface currents. It describes the important role that HF radar products play in critical coastal operations such as hazardous spill response. Finally, it covers basic capabilities and strengths of HF radar as well as how to access coastal current data.

Coastal decision-makers and managers across all levels of government, users of navigation products, as well as coastal environmental resource managers will find this 5 minute video helpful for better understanding and making use of real-time coastal current information obtained from HF radar. Fisheries management, scientific users as well as the members of the general public may also find it useful.

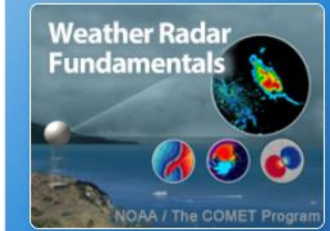
For more information on high-frequency radar, visit https://ioos.noaa.gov/project/hf-radar/.



Caribbean Radar Products

★★★★☆

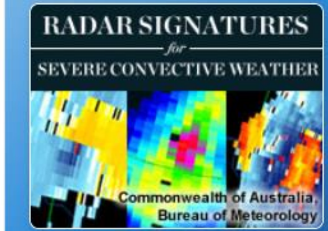
Skill level : 1 - Basic
Publish Date: 12/30/2013



Weather Radar Fundamentals

★★★★☆

Skill level : 1 - Basic
Publish Date: 3/20/2012



Radar Signatures for Severe Convective Weather

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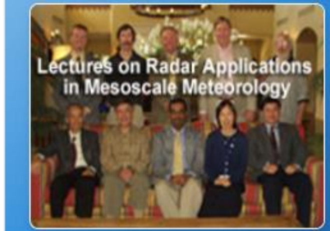
Skill level : 3 - Advanced
Publish Date: 12/21/2010



Lectures on Radar Applications in Mesoscale Meteorology

★★★★☆

Skill level : 3 - Advanced
Publish Date: 2/6/2006

Animator Start >

Please select model

MODEL BLEND NEW	ECMWF	ECMWF (3H) INCL. 06Z/18Z	ECMWF (1H) INCL. 06Z/18Z	EPS	EPS CYCLONES	EPS MEMBERS	EPS 46-DAYS
GFS FREE!	GFS WAVES	GFS WAVES (1H)	GFS (3H)	GFS HOURLY	GEFS	GEFS 31 MEMBERS	ACCESS-G
ICON	ICONEU	ICON-D2	RAPV5	UKMET	HREF ENSEMBLE	HIRLAM	CMC UPDATED
KOREA KMA	HRRR	RRFS-A	NAM-CONUS	NAVGEM	NWS NDFD	NCAR AMPS	NCEP WPC
NCEP NAM	NCEP HIRES-FV3	NCEP HIRESW-ARW	NCEP HIRESW-NSSL	RGEM	CAMS (DUST)	NASA-DUST GLOBAL	CPTWRF
ARPEGE	AROME	NCEP HMON	NCEP HWRF				

In forecasting it is encouraged that a ‘favorite’ model not exist.

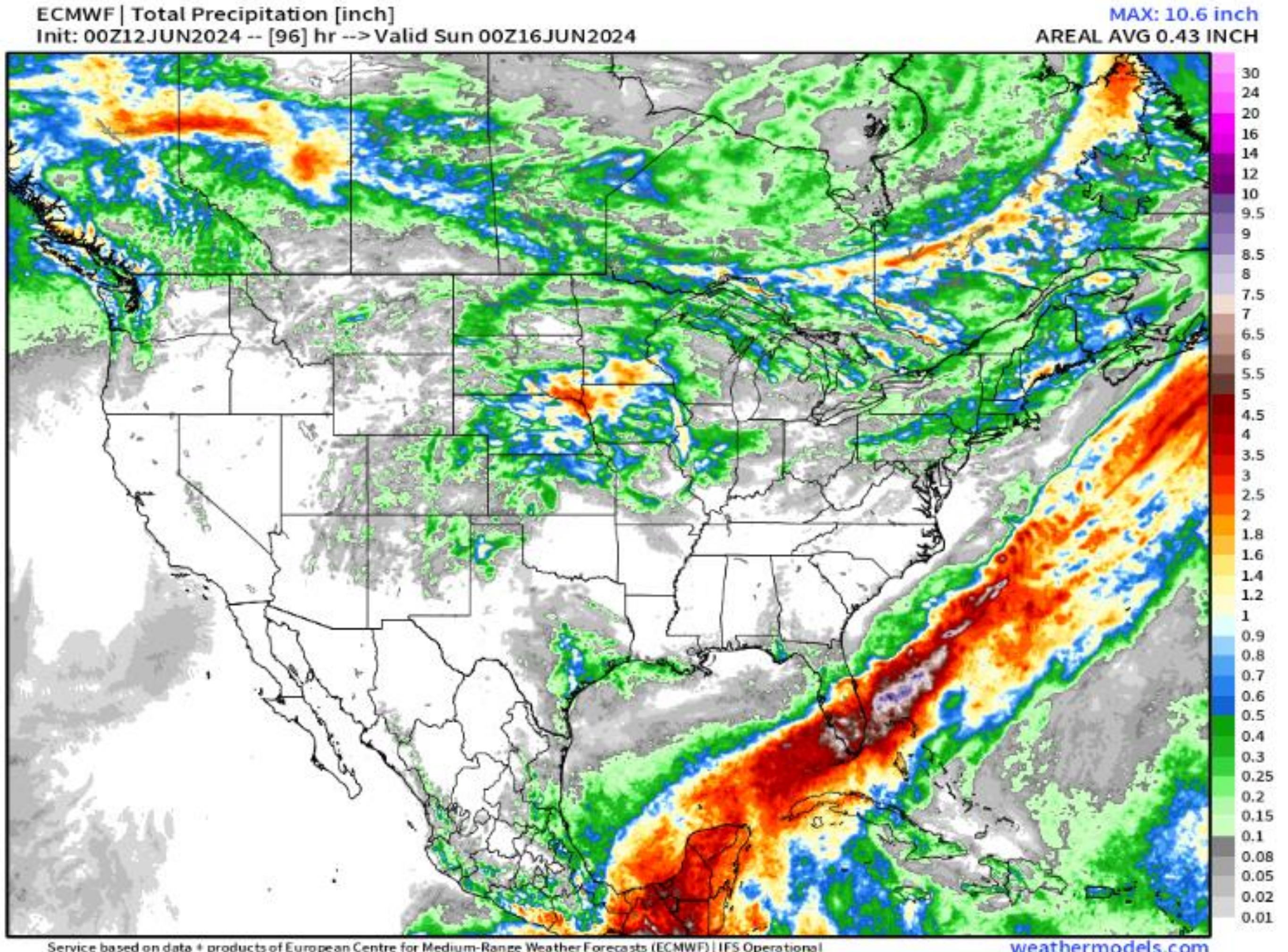
Instead, the forecasters work to compare multiple models, the most popular of which are the GFS, ECMWF, NAM, HRRR, and GEFS.

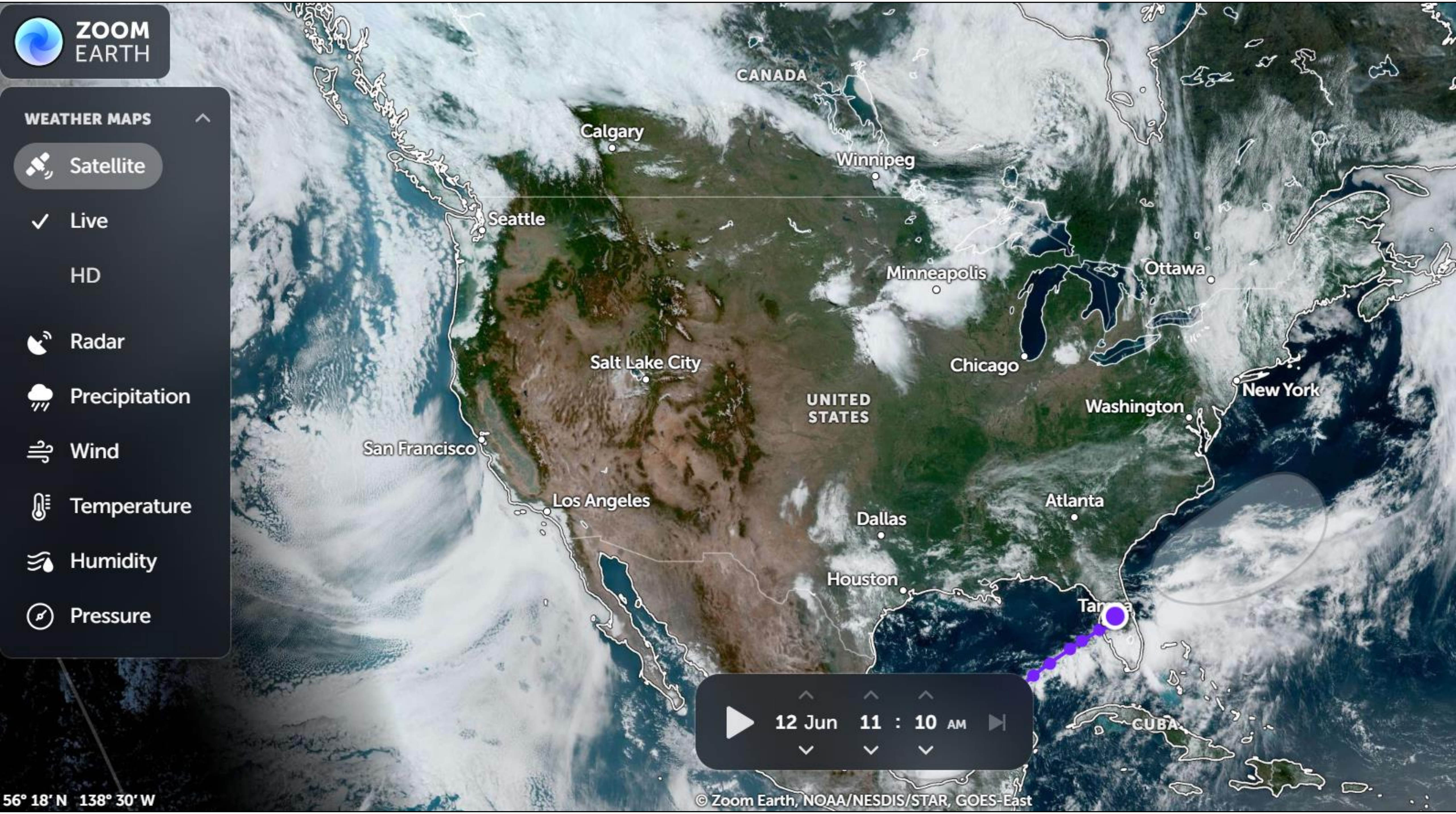
Forecasters need to understand the strengths between each model set, how the model weighs different conditions or considers other data such as topography, upper atmospherics, leading temperature anomalies against intensities, and changes at the surface over time like developments.

Here we compare the forecast models GFS and ECMWF for total precipitation expected over the coming 4 days to highlight areas of concern.

Obvious threats are noted to Florida from a boundary draped across the state.

Other areas of concern would be the Nebraska- South Dakota- Minnesota region from what is likely a passing storm system.




ZOOM EARTH
WEATHER MAPS
Satellite
Live
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Radar
Precipitation
Wind
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Salt Lake City
UNITED STATES
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San Francisco
Los Angeles
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11 : 10 AM
56° 18′ N 138° 30′ W
© Zoom Earth, NOAA/NESDIS/STAR, GOES-East

Radar Systems - Propagation

Starting in military weather forecasting, our radar stations were alongside our quad-screen desks where we drafted the forecast booklets. Inside the booklets would be the statistics from various models, observations, and references to satellite or radar systems.

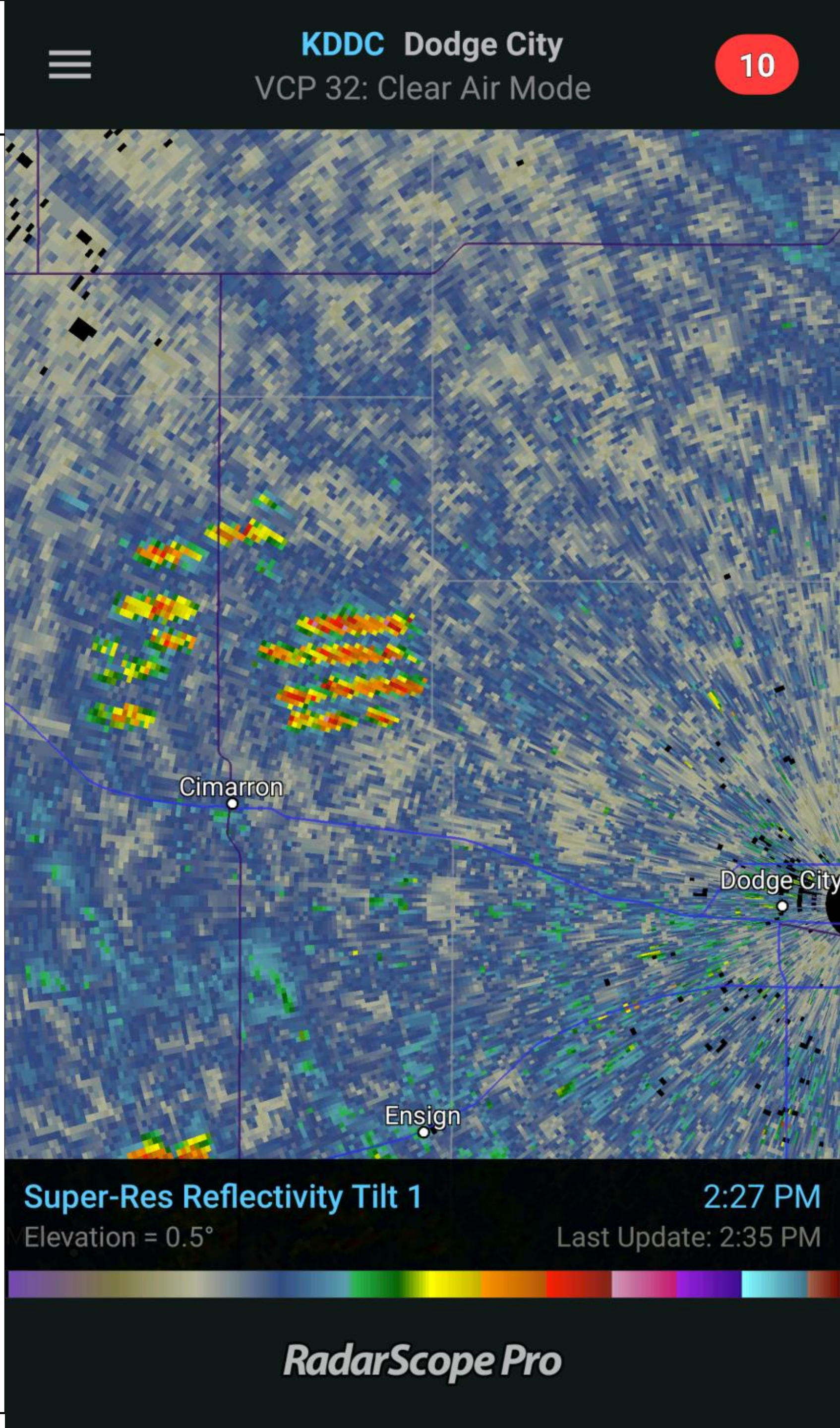
Training was provided every few months on radar cases where forecasters had lessons learned to share, such as identifying bats or butterflies against outflow boundaries from thunderstorms.

- Non-standard atmospheric temperature or moisture gradients will cause all or part of the radar beam to propagate along a non-normal path. When non-standard index-of-refraction distributions prevail, "abnormal" or "anomalous" propagation occurs." NOAA

Clutter in the weather world can be from insects, wildlife, aircraft, industry, and even built infrastructure like wind farms.

- Wind farms are distinguished on radar data as small regions of very high reflectivity that don't move. It has unrealistically large reflectivity gradients along the edges (goes from nothing to 60+ dBZ in one or two pixels) and noisy values in the interior (a 40 next to a 50, next to a 70, next to a 30, etc.).

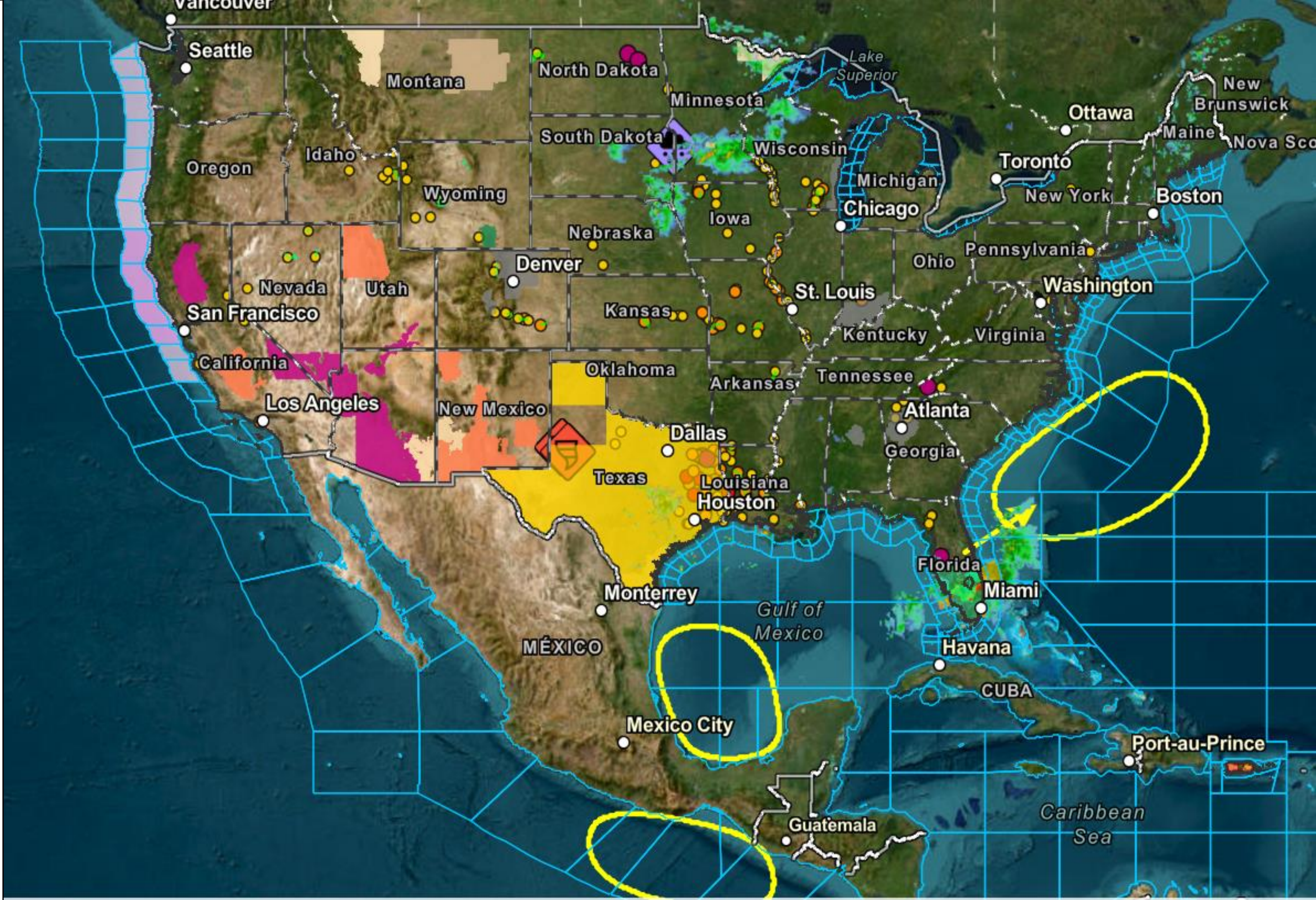
Additional ground clutter beyond what is always visible for a given radar site sometimes appears as a result of "anomalous propagation" or AP. This type of clutter occurs when the vertical temperature and moisture profile is such that the radar beam is bent back toward the ground more than usual. Its time near the ground is then prolonged, and it can encounter biological scatterers and in some cases contact with ground-based targets such as hills, trees, etc.



The use of geospatial platforms to incorporate forecast data with live observation combines hydrology, surface observation, forecast observation, forecast models, watches, warnings and advisories, and seismic activity.

Essentially the platforms can reduce the need to visit various sites to get a whole-country outlook on impacts and hazards expected.

The dashboards created using these platforms can face significant latency issues due to the amount of data being accessed and displayed in the non-visible layers.



Shifts in Future Storms

Destructive winds that flow out of thunderstorms in the central United States are becoming more widespread with warming temperatures, according to research by the US National Science Foundation and National Center for Atmospheric Research (NCAR).

- These increases are supported with research from the UAF in Alaska (here).
- The new study, published in Nature Climate Change, shows that the central U.S. experienced a fivefold increase in the geographic area affected by damaging thunderstorm straight line winds in the past 40 years.

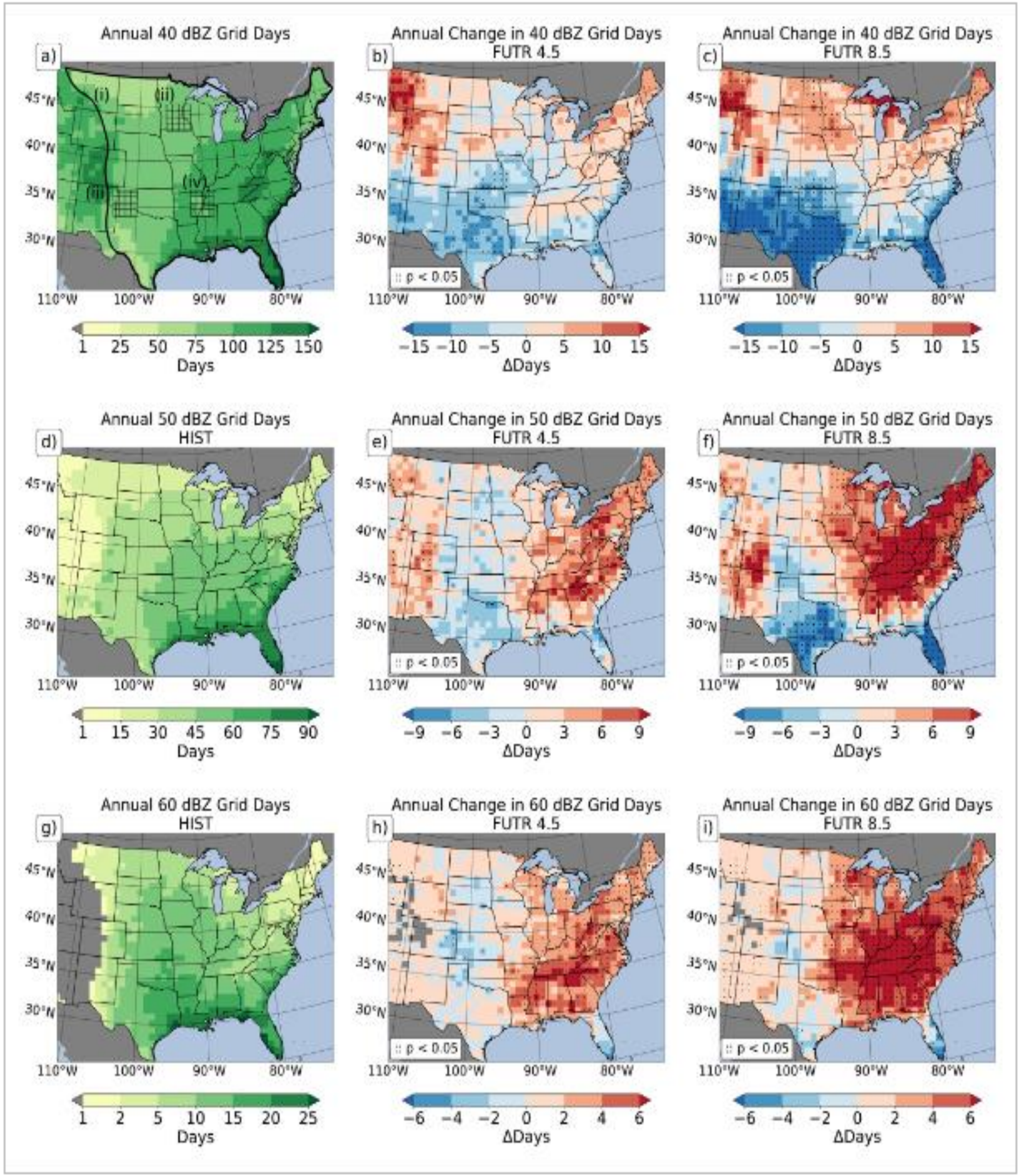
Straight line winds are caused by powerful downdrafts that flow from the base of thunderstorms.

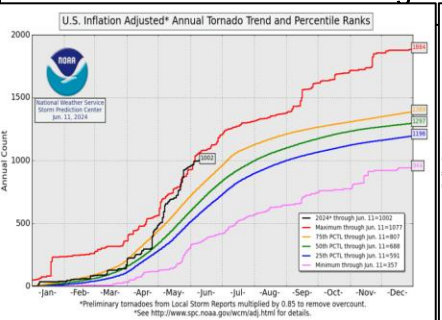
- The National Weather Service classifies such winds as damaging if they exceed 50 knots, or about 57 miles per hour.
- The winds likely cause about $2.5 billion in damage annually in the U.S., based on insurance industry estimates.

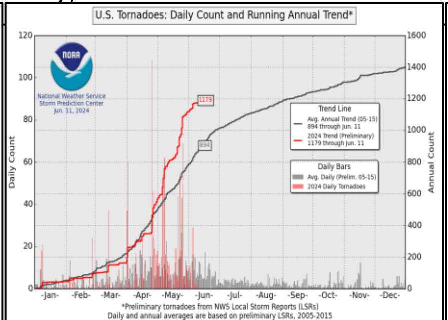
Thunderstorms also fuel the warming world. The rainfall produces friction at the surface as it strikes and the heat content from mid-levels being pushed downwards as a storm collapses can contribute to abnormal heating across the region.

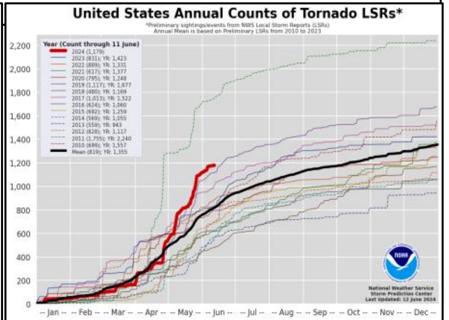
- Longer term the thunderstorms and lightning activity accounts for over 70% of the changes in the quantity of cirrus clouds in the world, per a new study from Tel Aviv.
- Cirrus clouds act as a blanket for radiation leaving Earth, causing a re-radiation event between thunderstorms thereby trapping surface and solar heat.

As heat content increases globally, so will the effects of severe thunderstorms.



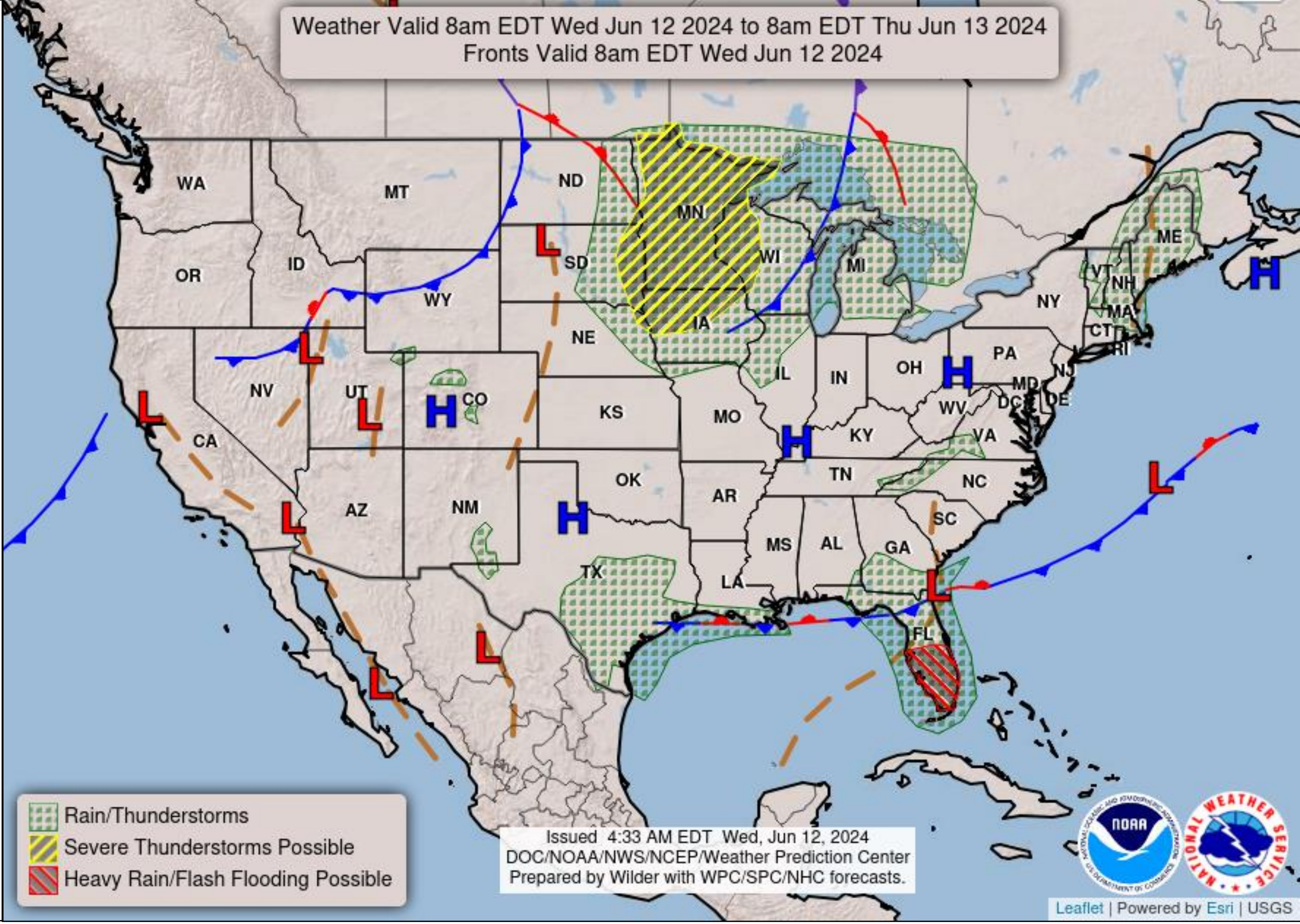






End forecast products range from visuals in the way of national or local graphics as static images, loops, or progression charts as well as geospatial layers able to be pulled by industry members and overlaid to their own mapping products for review of impacts to industry, sites, and supply chain.

Various forecast offices exist from the federal side to the private sector at all levels with international forecasting capabilities being expanded in the past decade thanks to interconnected mapping and data.



Weekly National-International Climate Summary:

Abnormal Weather Events, Climate Headlines, Forecasted Threats, Global Impacts, Wildfires, Tropical Cyclone Updates, and Graphics/Studies.

Bi-Weekly CISA Extreme Weather Working Group:

Regional Data Sharing, Upcoming Product Developments, Climate Education, Sector Impacts, Resiliency Best Practices, and National Coordination-Collaboration.

For Questions Contact:

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