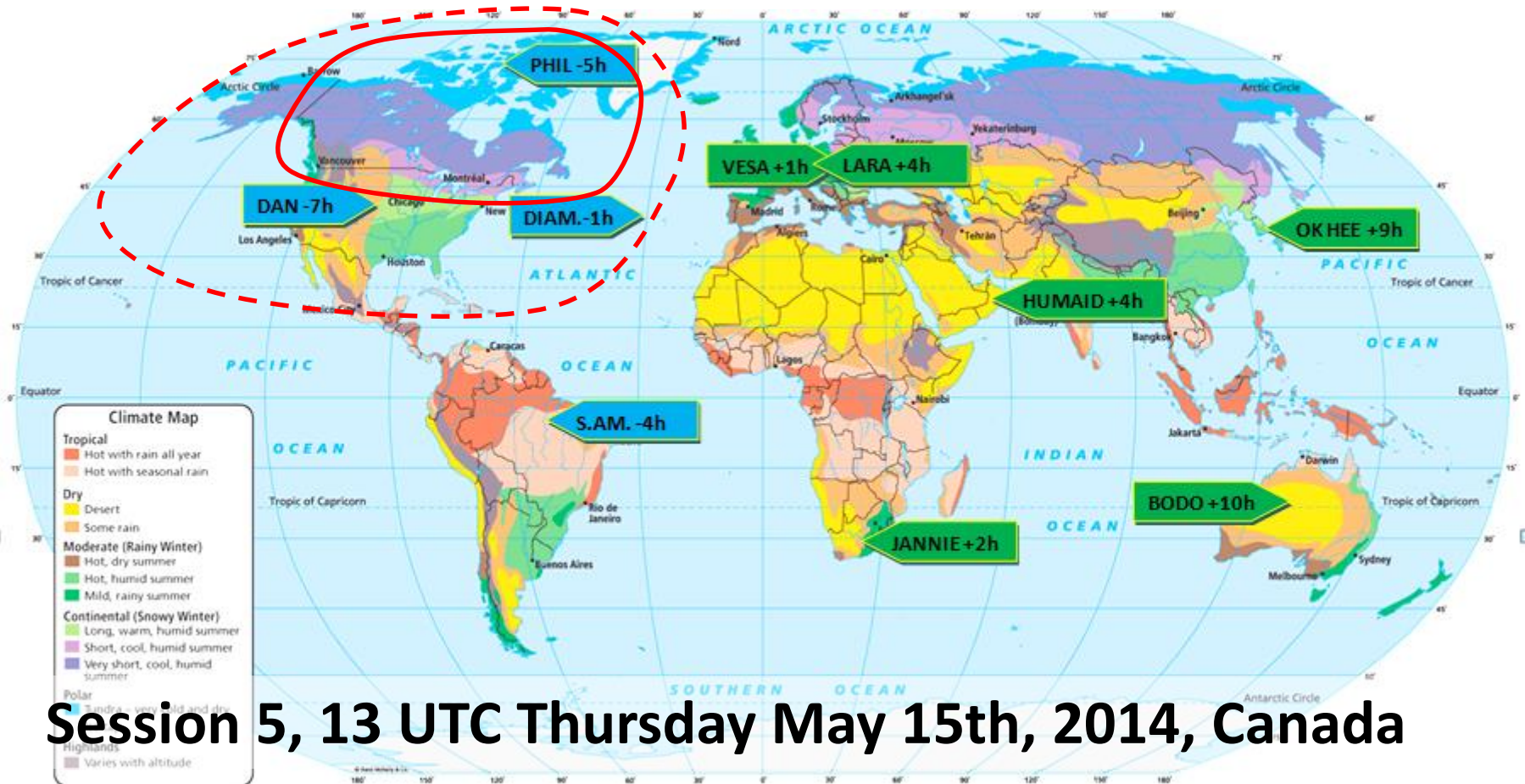


Session 5 Basic Satellite Meteorology Course - 2014



Session 5, 13 UTC Thursday May 15th, 2014, Canada

Session 5 Basic Satellite Meteorology Course - 2014

Water Vapour Imagery
with
Phil the Forecaster
Chadwick



Retired COMET meteorologist
from the Meteorological
Service of Canada

Artist
Philtheforecaster.blogspot.ca



Environmentalist





Atmosphere thickness comparable in scale to the skin of an apple



**Horizontal dimension of atmosphere
Compared to depth of atmosphere**

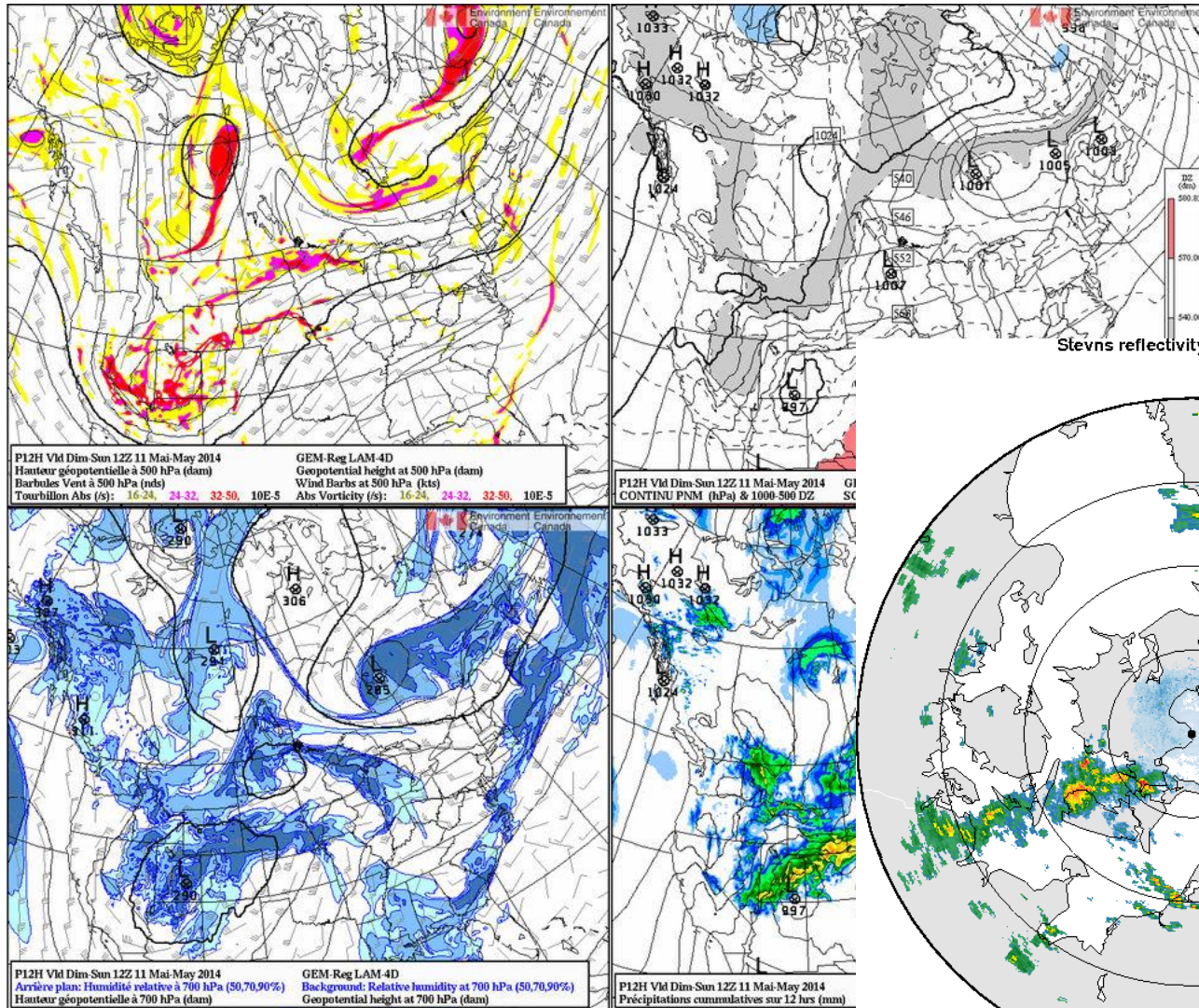
(Drop a marker on your answer)

Much greater than atmosphere depth

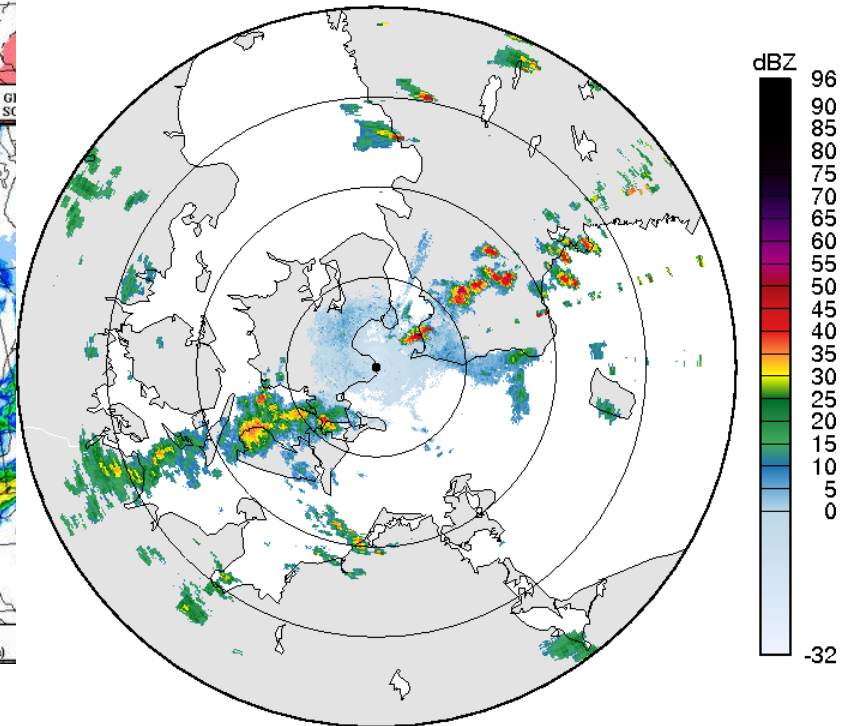
About equal to atmosphere depth

Much less than atmosphere depth

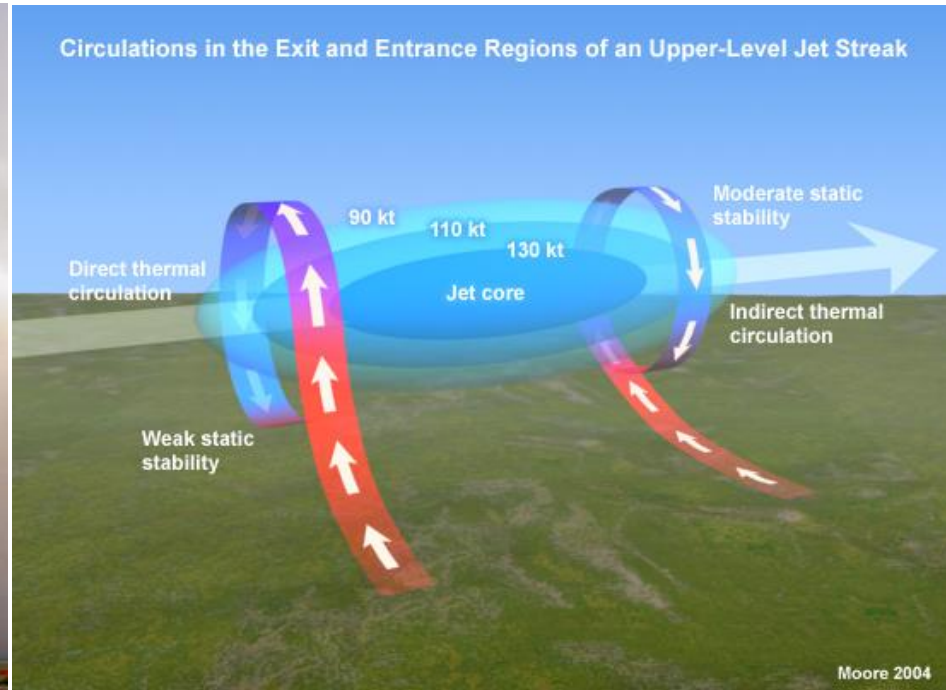
Most depictions of weather are flat! Why?



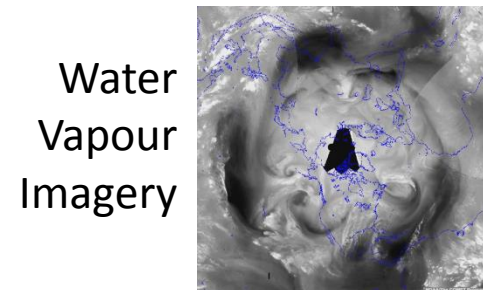
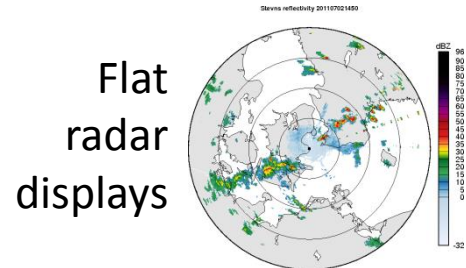
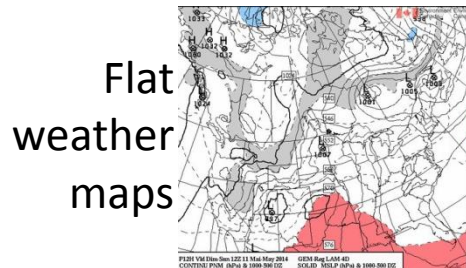
Weather maps
 Numerical Models
 Display screens
 Radar images
 Satellite images ...
 Everything is flat!



At the scale of importance to clients, weather is very three dimensional. Conceptual models of the atmosphere must be three dimensional. Vertical motions rule!

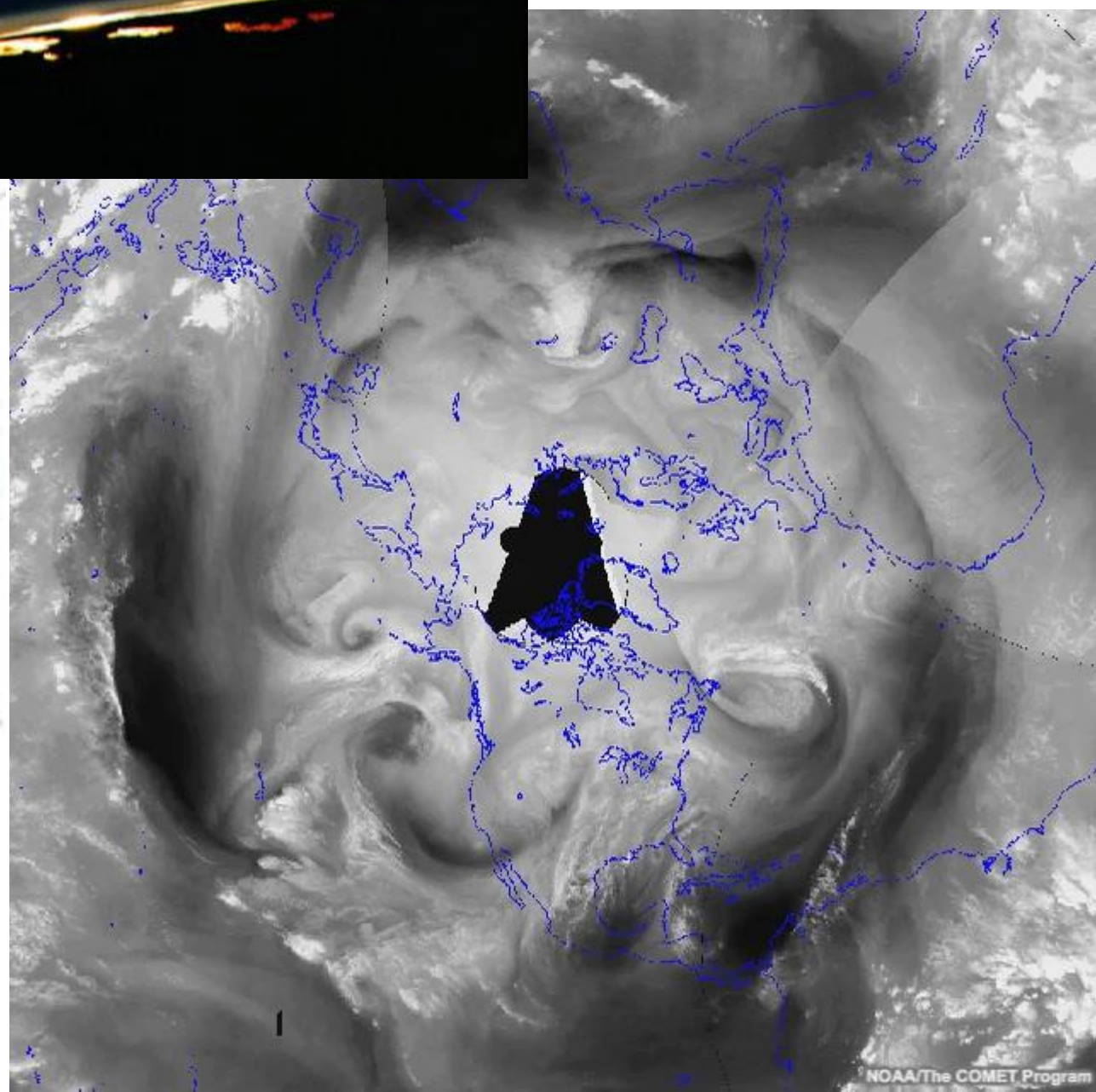


Which might be the best tool for meteorologists to apply 3D conceptual models to better understand the atmosphere? (Drop a marker on your answer)





Water Vapour
Imagery is the
solution...

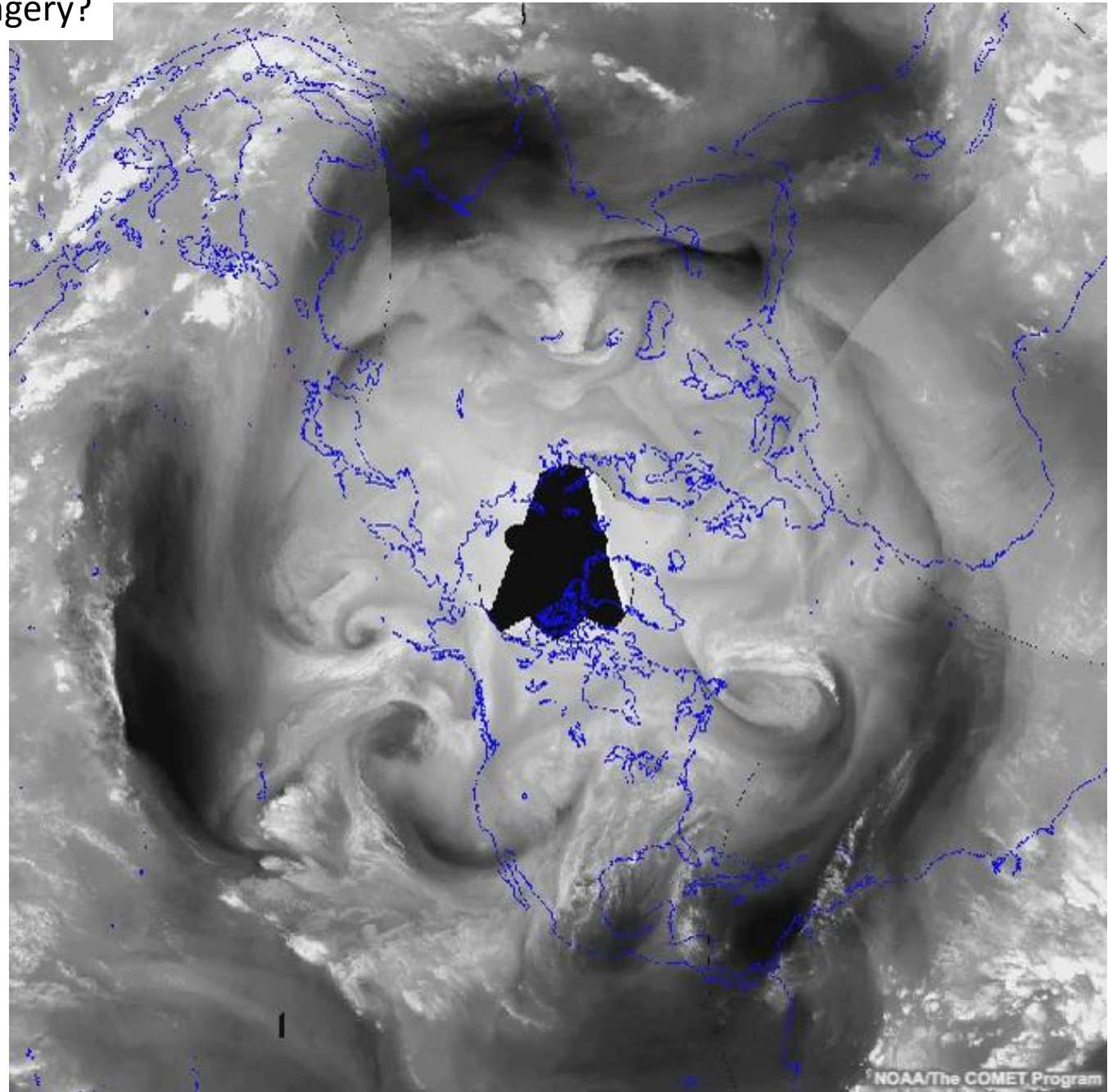


Why Water Vapour Imagery?

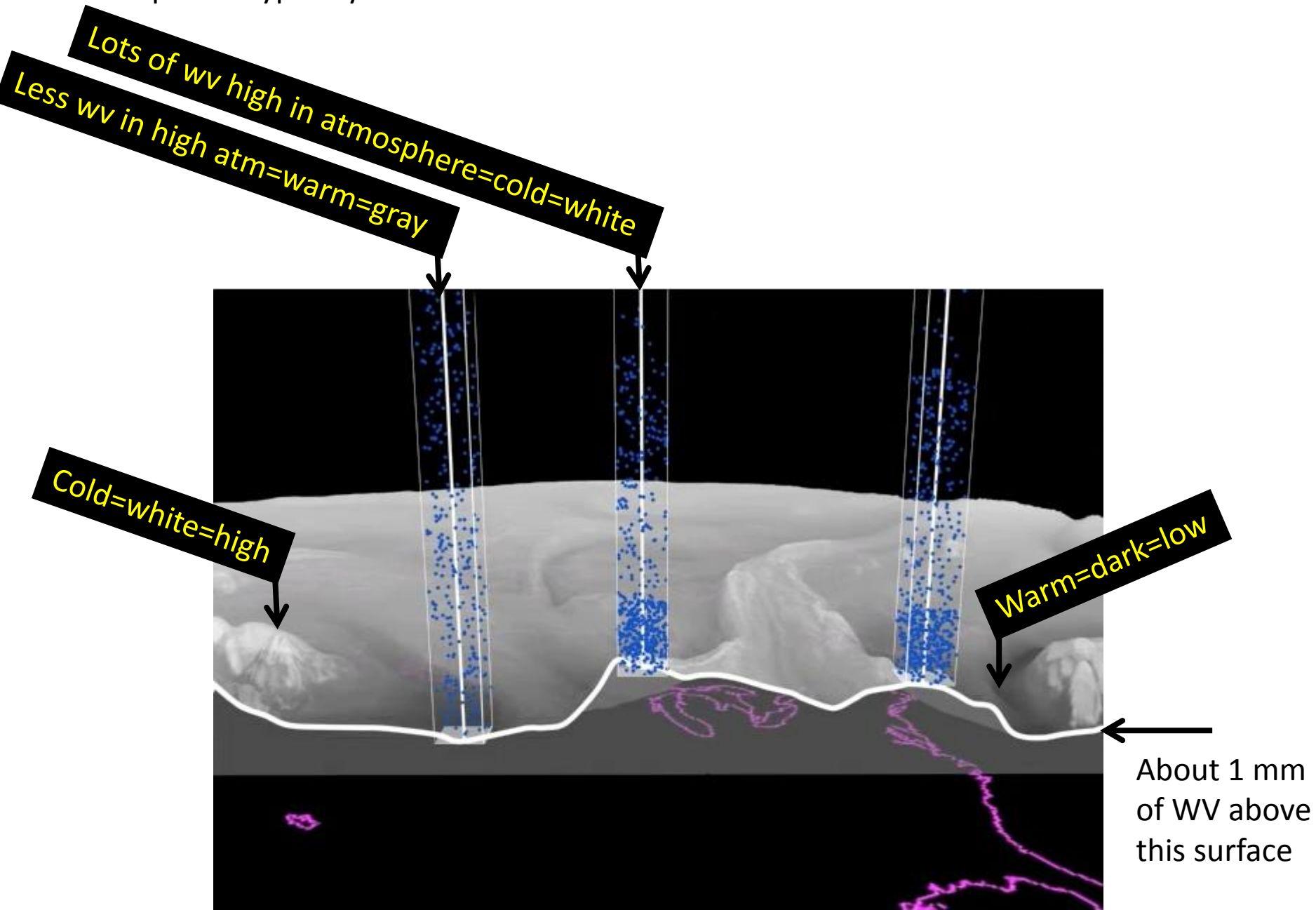
- Global
- Space resolution
- Time resolution
- Three dimensional

Animation adds the
4th dimension

Water Vapour
Imagery is tool
for the
meteorologist
who wants to
better
understand the
atmosphere



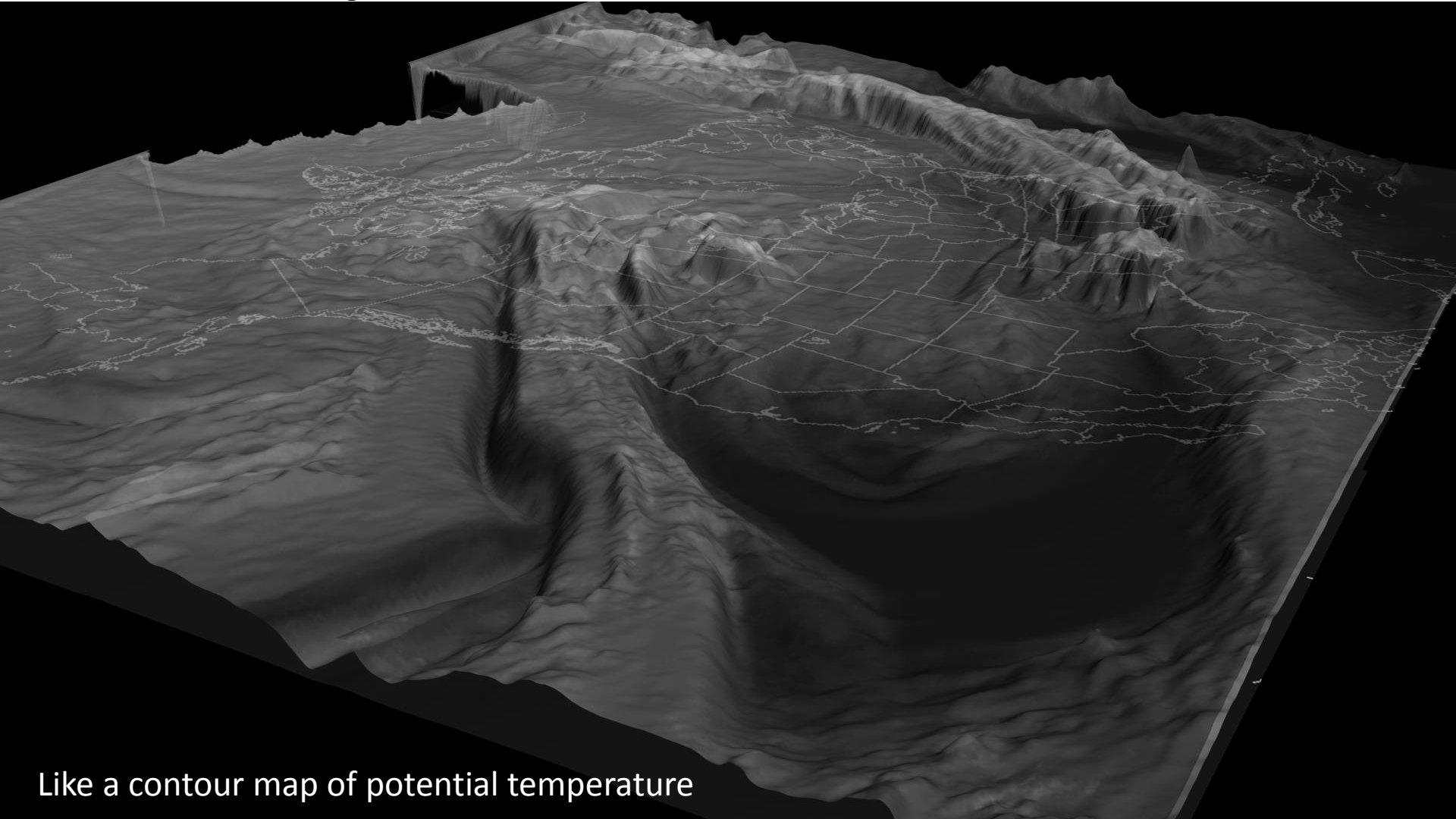
WV isosurface depicted is the temperature where the sensor accumulates about 1 mm of water vapour – typically between 250 and 700 mb.



First 3D WV Image from 2011 - Simply place temperature on the vertical axis

Cold = White = High

Warm = Dark = Low



Like a contour map of potential temperature

(Drop a marker on something high)

Do you see shapes? Patterns? Conceptual Models?

The Meaning of Life in Satellite Interpretation – How to Analyze Shapes and Patterns

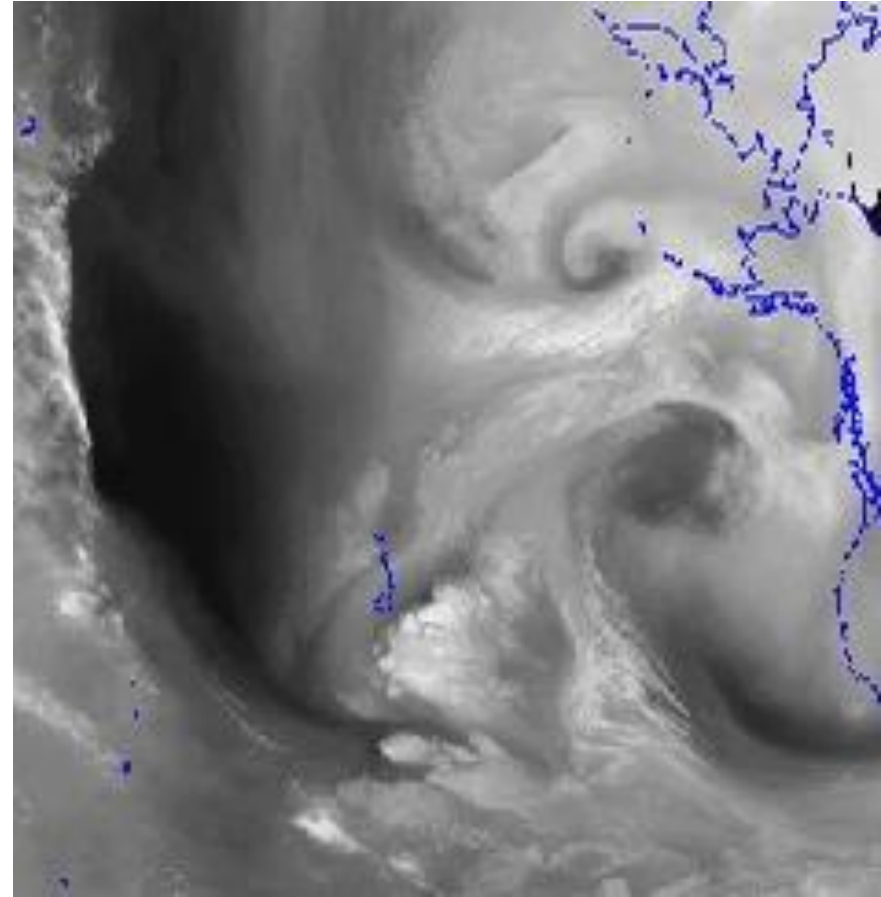
Patterns are defined by edges which are lines

Lines bordering air parcels moving in the same direction define the axis of maximum winds

All other lines are deformation zones

Follow cyclonically curved lines to vorticity maxima (part of the DZ conceptual model)

Follow anticyclonically curved lines to vorticity minima (part of the DZ conceptual model)

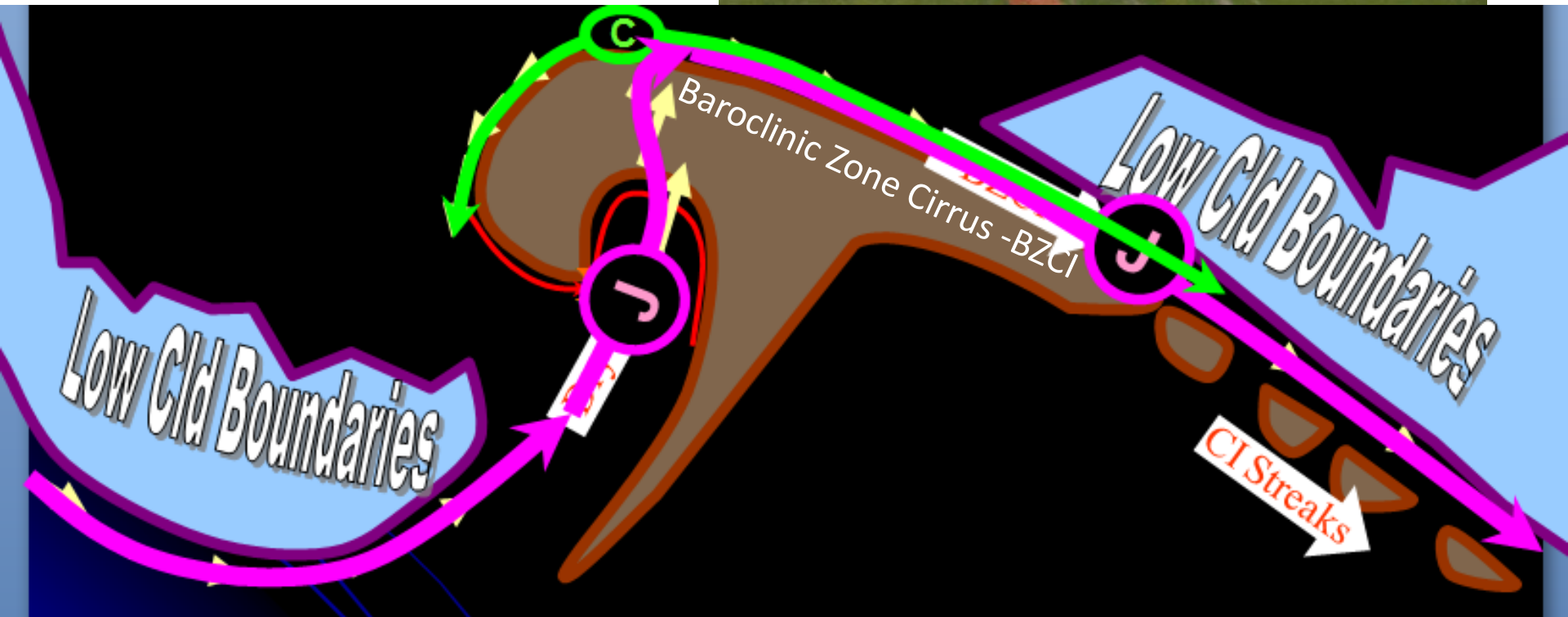
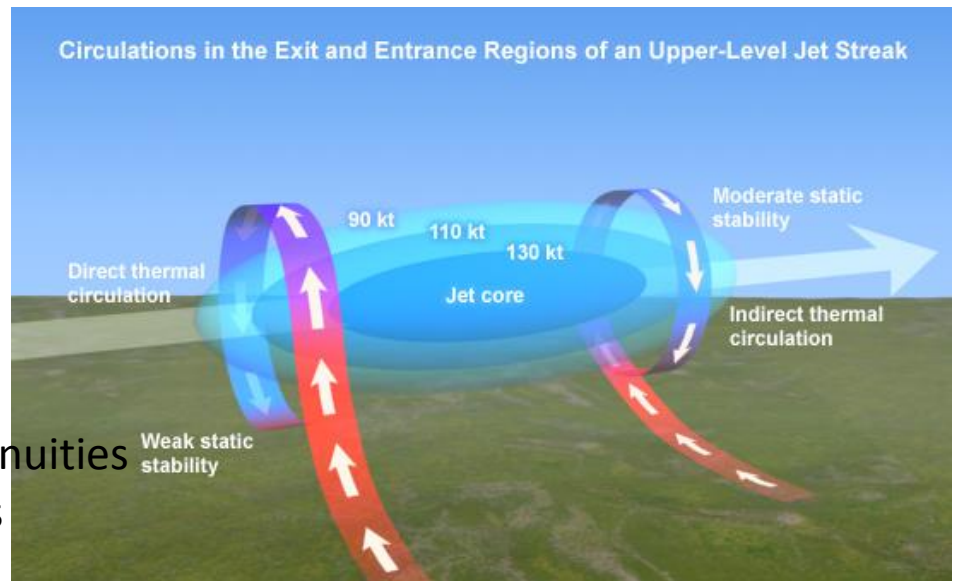


There are no other rules... the rest is learning and practice

Axis of Maximum Winds Lines Conceptual Models

Locate the axis of maximum winds

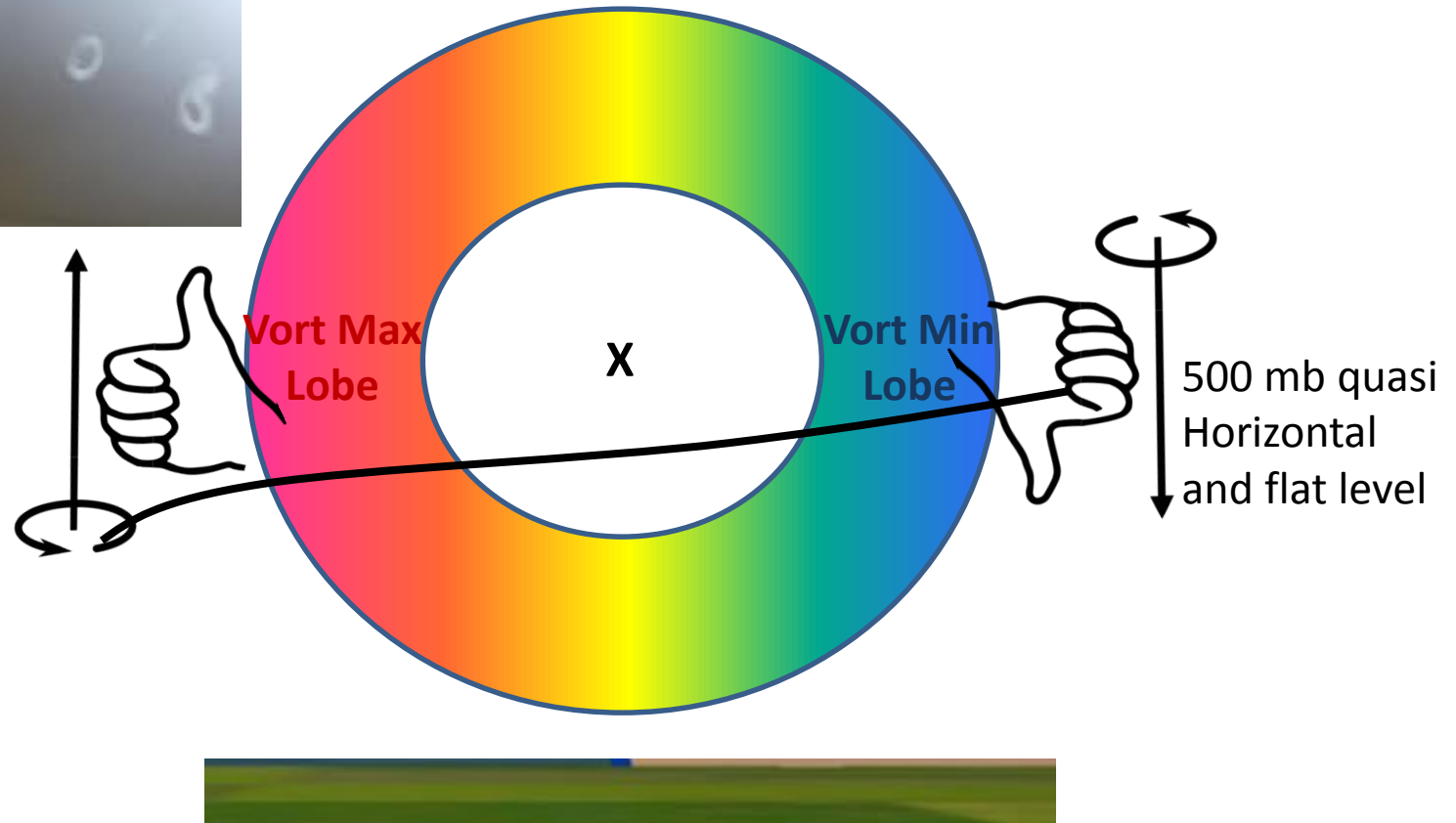
1. On the cold side of BZCI
2. On the cold side of jet streaks
3. In the dry slot of a comma
4. On the warm side of low cloud discontinuities
5. Moisture moves with axis of max winds



Vorticity lobes parallel a channeled axis of maximum winds

Axis of Max Winds into the page – Think 3D

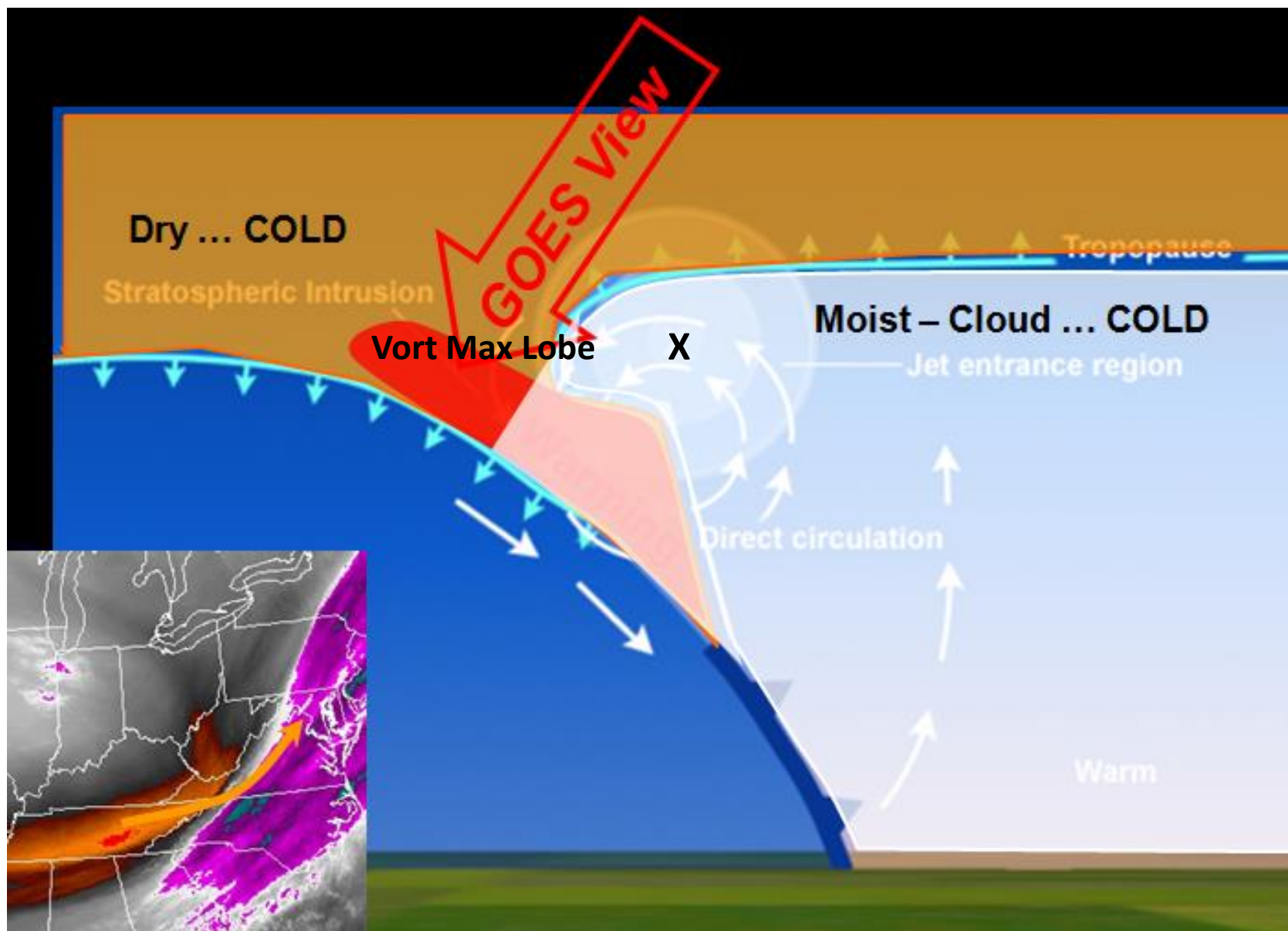
Vorticity is like smoke rings along the axis of maximum winds



Follow the vorticity ring applying the right hand rule and see how vorticity, the vertical component of the local rotation of the fluid changes.

These swirls create important and largely misunderstood patterns in the atmosphere.

Lines in the GOES Projection – Think 3D

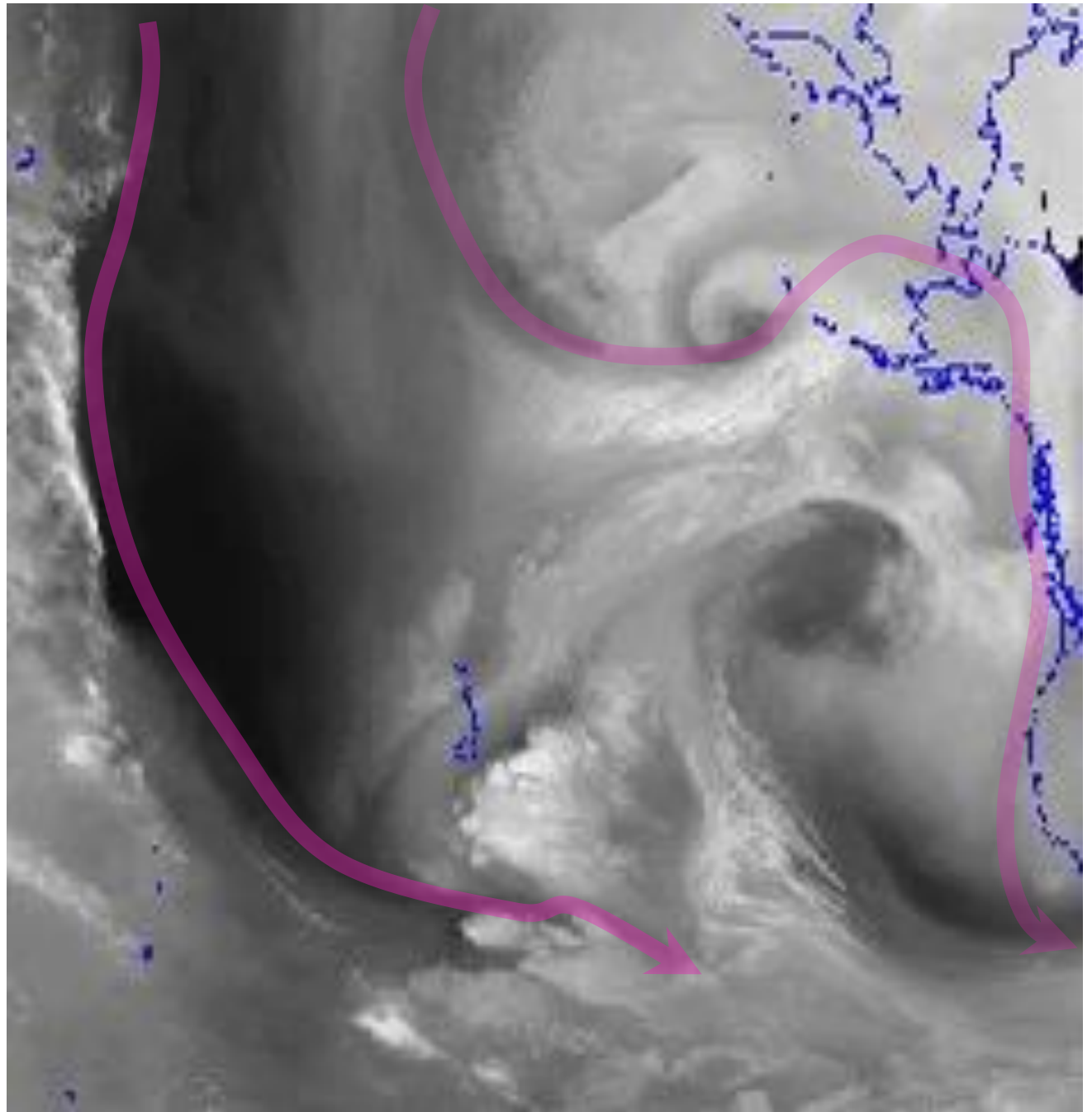


Vort Lobe Practice

Draw a red line along where you would expect a lobe of vorticity maxima.

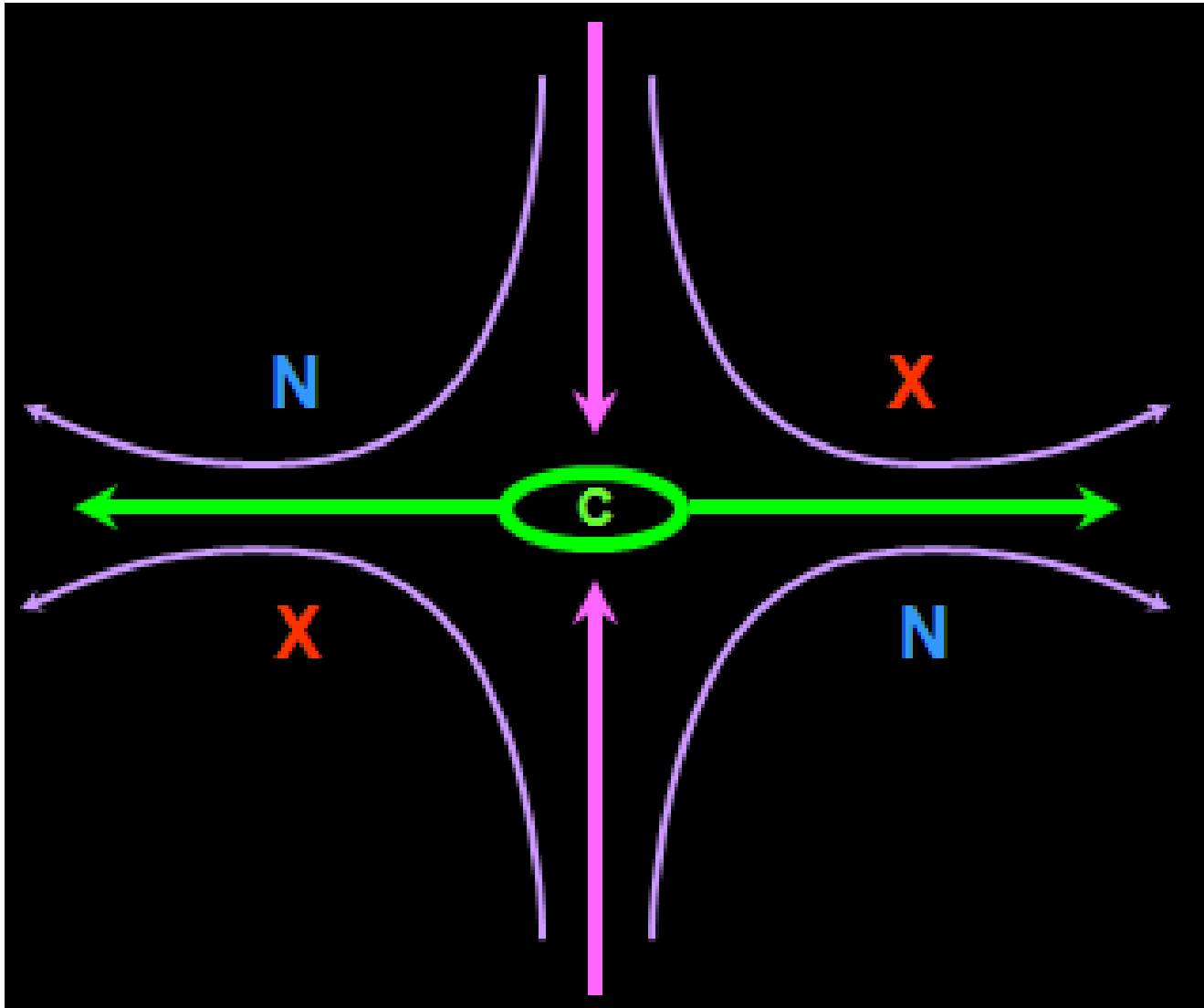
Draw a blue line along where you would expect a lobe of vorticity maxima.

Don't worry.... Have fun!



The Fundamental Deformation Zone (DZ) Conceptual Model

It is a ***Dynamic*** Conceptual Model – change one thing and something else ***must*** change

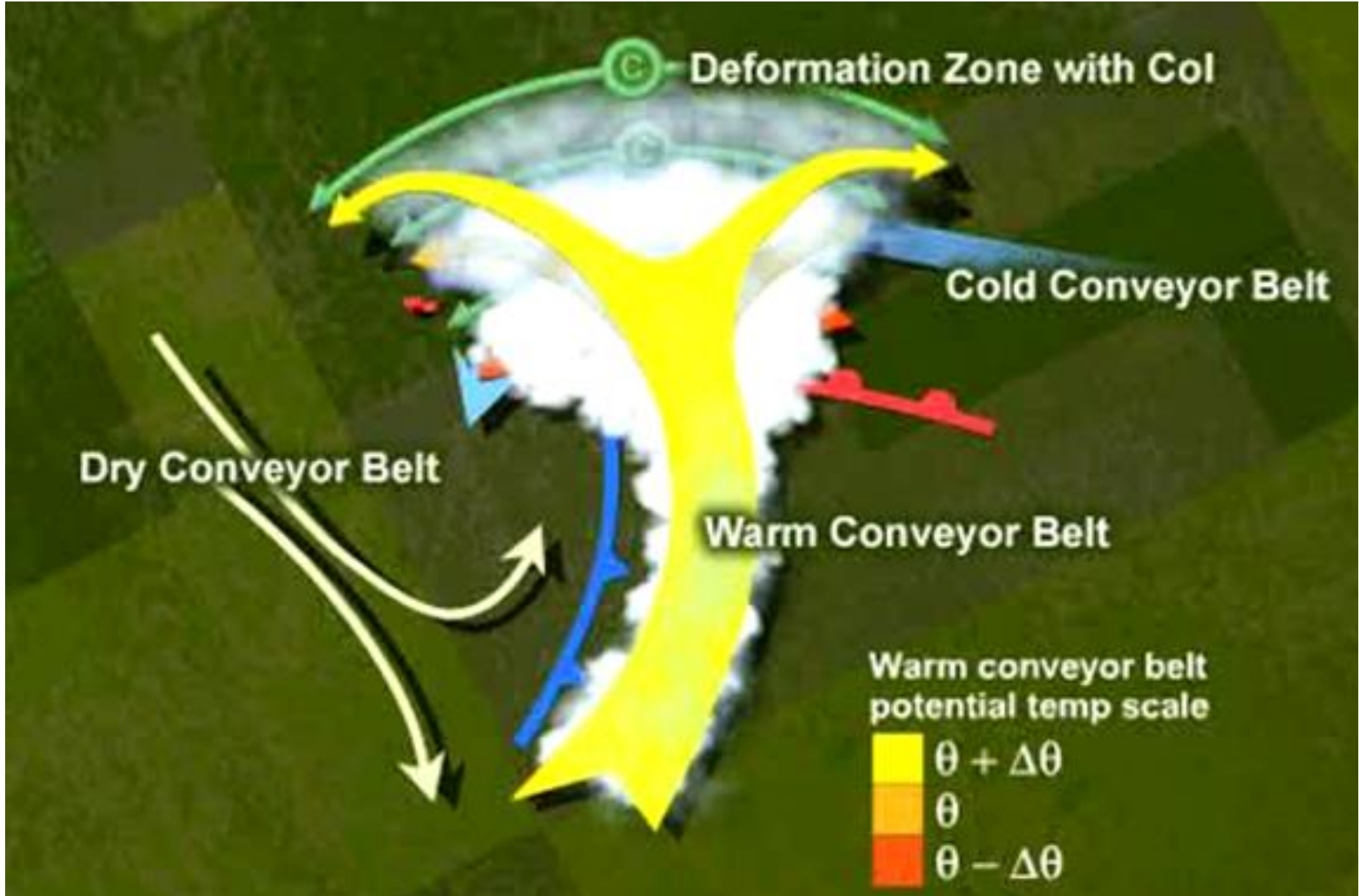


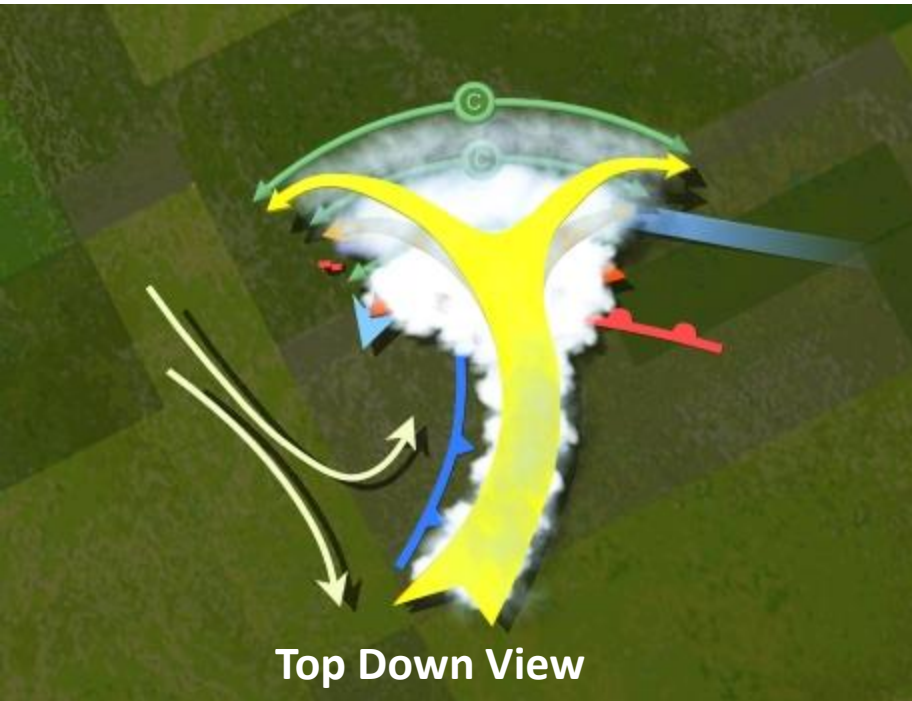
Vorticity centres define the deformation zone conceptual model.

The shape of a DZ reveals the character of these associated vorticity centres.

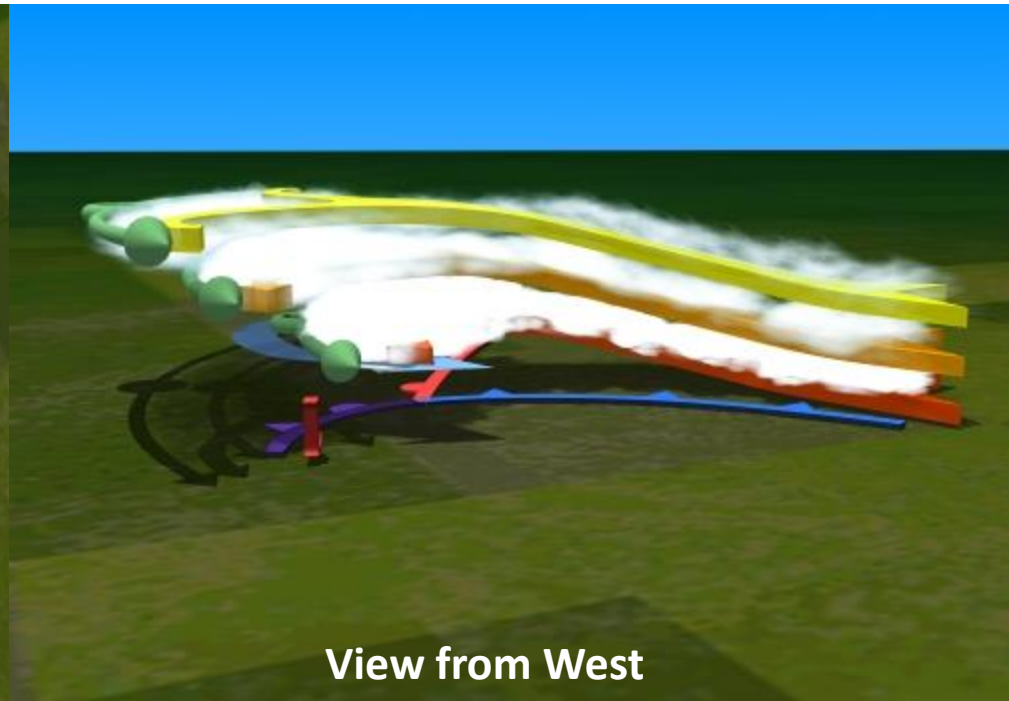
The DZ is actually a 3D Skin

DZ Lines are only intersections with the DZ Skin





Top Down View



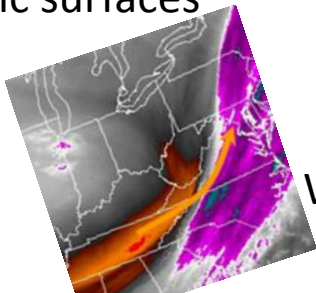
View from West

Southward moving conveyor belts

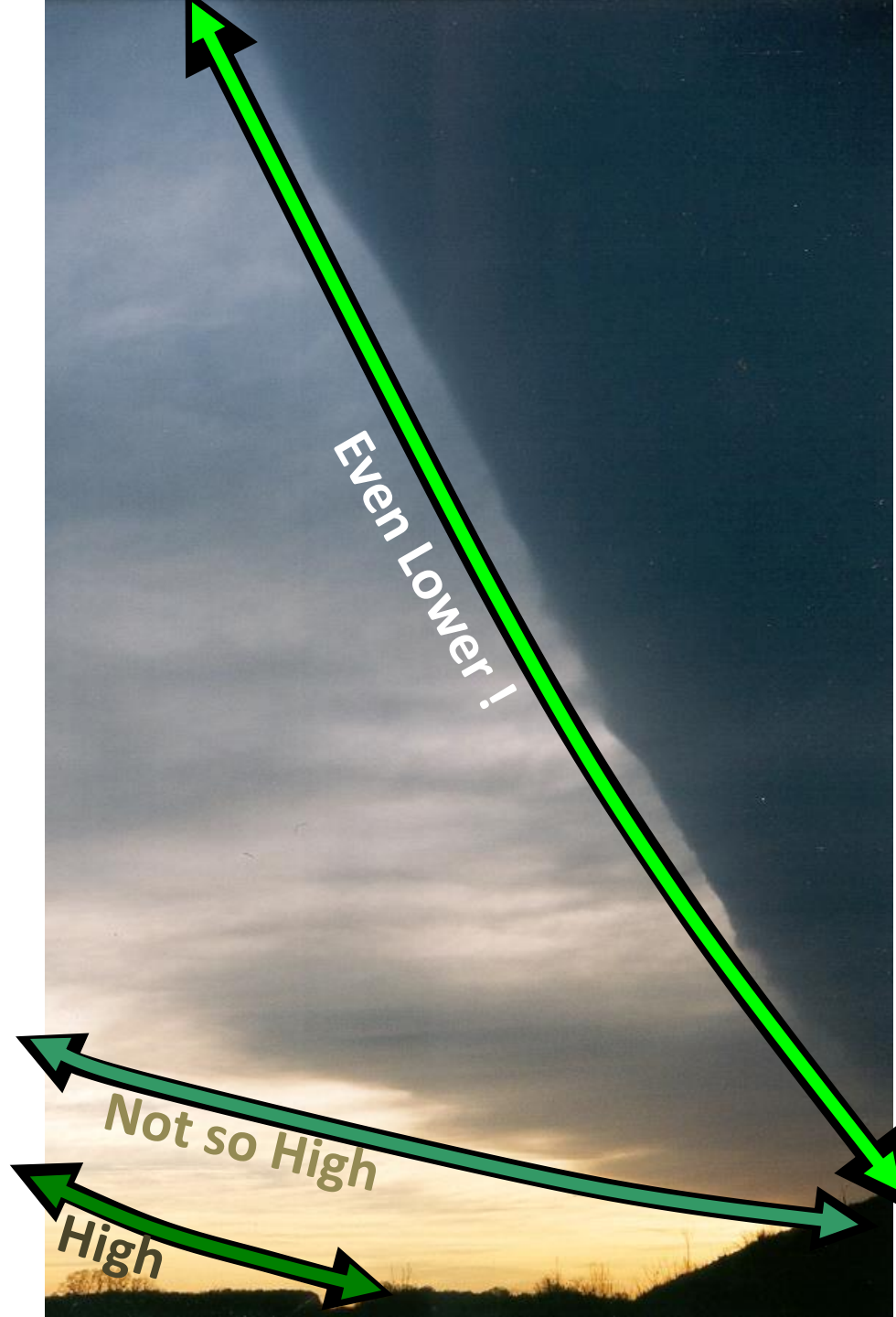
- Sink along isentropic surfaces
- Become warmer
- Become darker on WV imagery
- Discourage convection and parcels stay on isentropic surfaces
- DCB

Northward moving conveyor belts

- Rise along isentropic surfaces
- Become colder
- Become whiter on WV imagery
- Encourage convection and parcels leaving isentropic surfaces
- WCB



Where is the Dry Conveyor Belt?



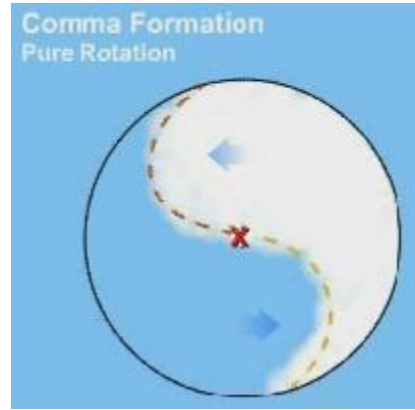
Looking
Upward at the
deformation
zone skin of a
WCB

Typical
northeastward
slope of the
atmosphere
with *three*
discrete layers
of moisture

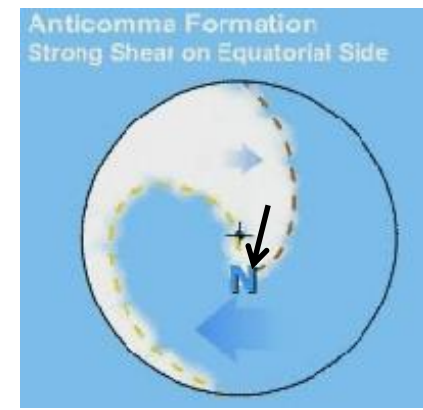
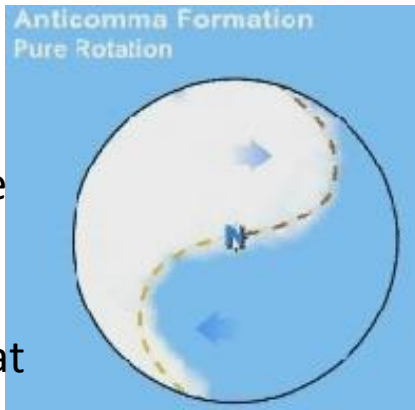
The Secret Behind Atmospheric Swirls

- Cusps require wind shear
- Sharper cusps are older or stronger shear
- The swirls of vorticity maxima and vorticity minima are **identical**. The pattern only appears different because of the side the moisture fills
- Follow lines inward to determine sign of the vorticity

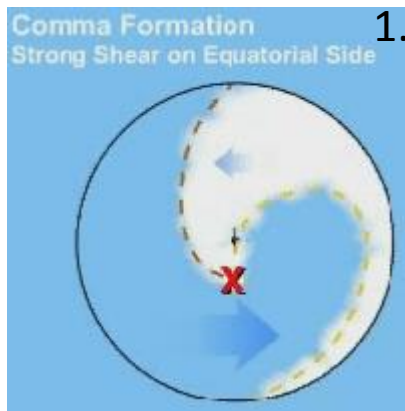
- Rotating a pattern does not change the sense of rotation
- Reflecting a pattern/ reversing the moisture side changes the sense of rotation
- An observer looking down at a rotation will see the opposite of an observer looking UP at the same rotation



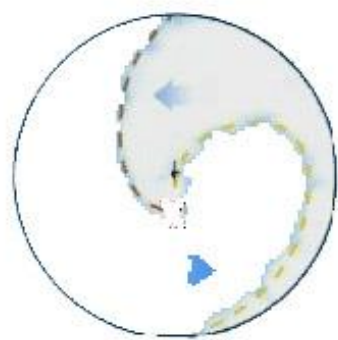
1.



4.



1. 2. Removed the Blue and X



3. Horizontal reflection



4. Labeled the "N"

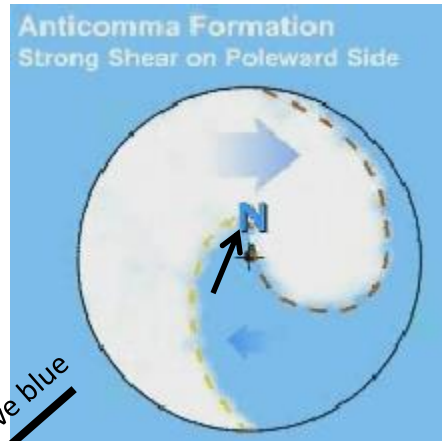
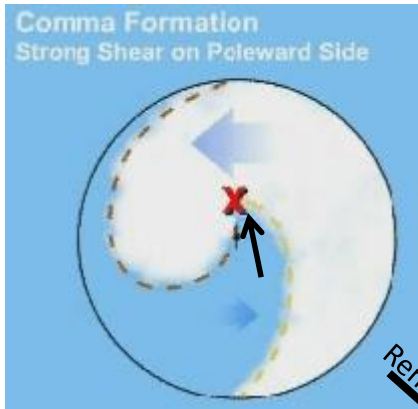


The Yin and Yang of Atmospheric Circulations

Vorticity generated by poleward shear has
INWARD Cusps

- Reflection reverses sense of rotation
- Reversing the colour or side of moisture fill preserves the sense of rotation

Vorticity generated by equatorward shear has
OUTWARD Cusps



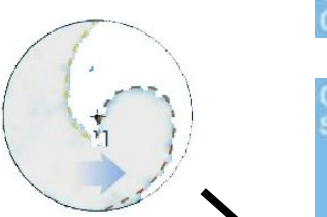
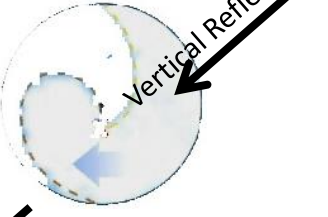
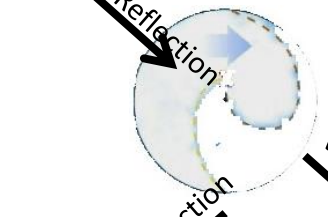
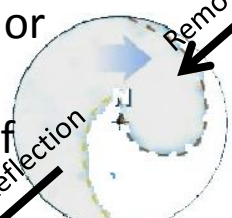
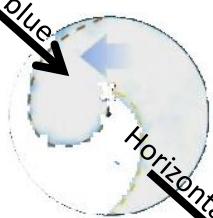
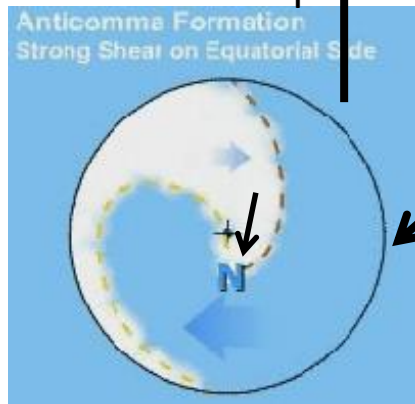
Remove blue

Remove blue



Vertical Flip

Vertical Flip



Horizontal Reflection

Horizontal Reflection

Vertical Reflection

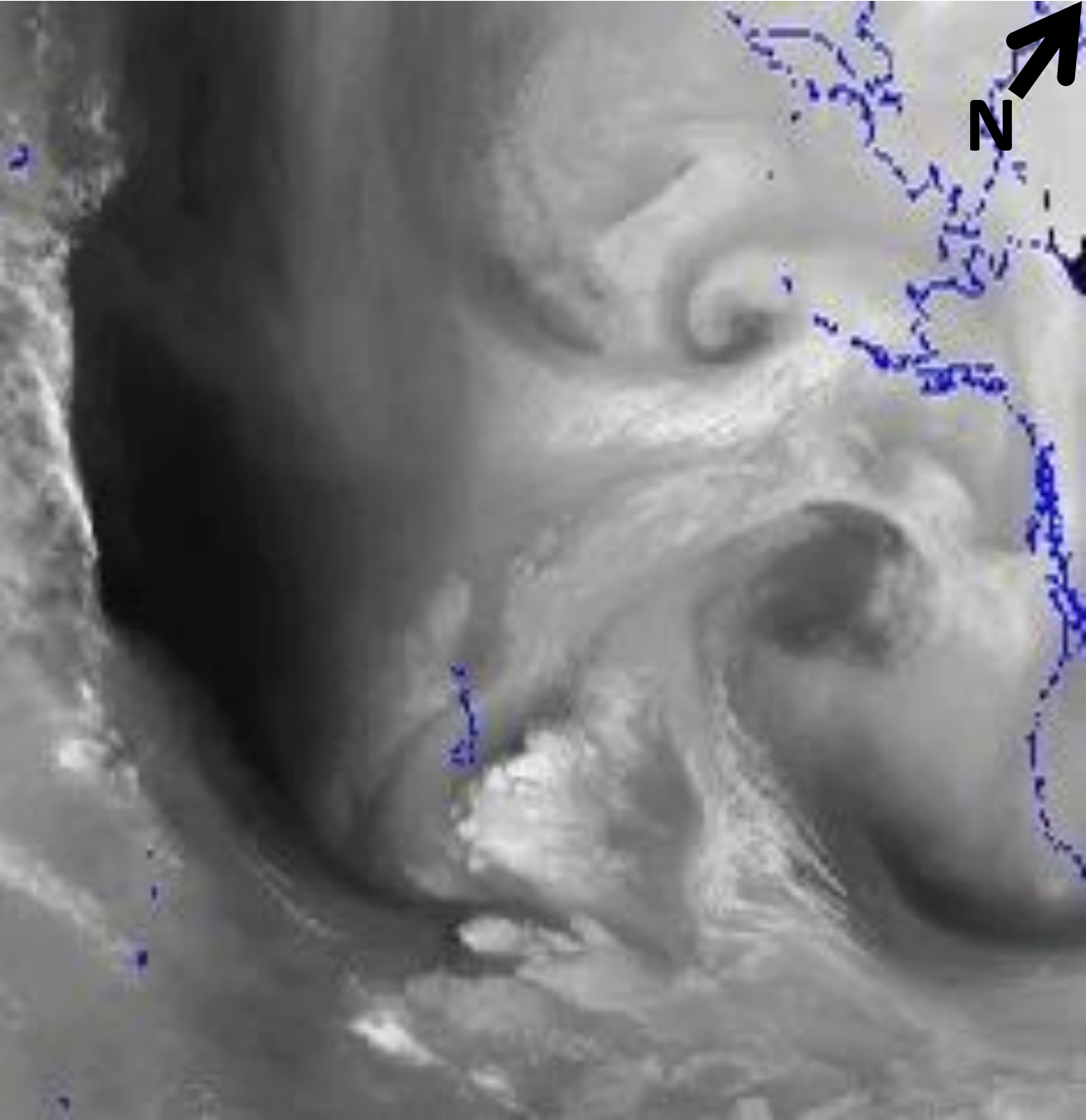
Vertical Reflection

Max and Min Practice

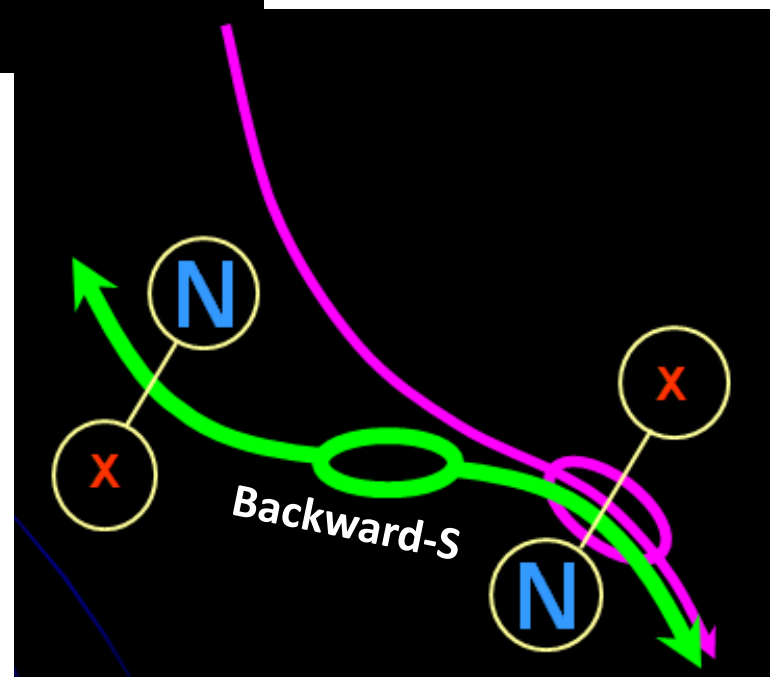
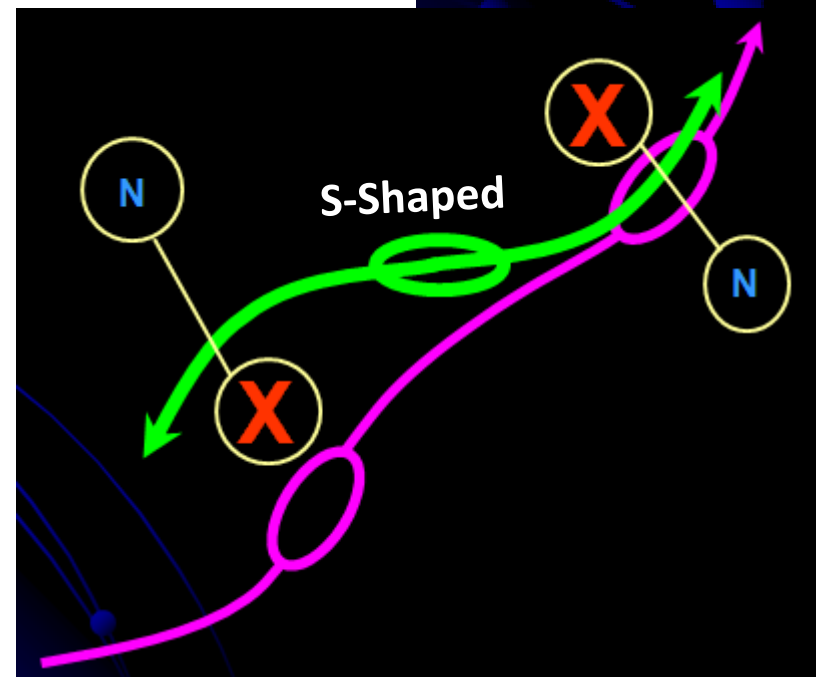
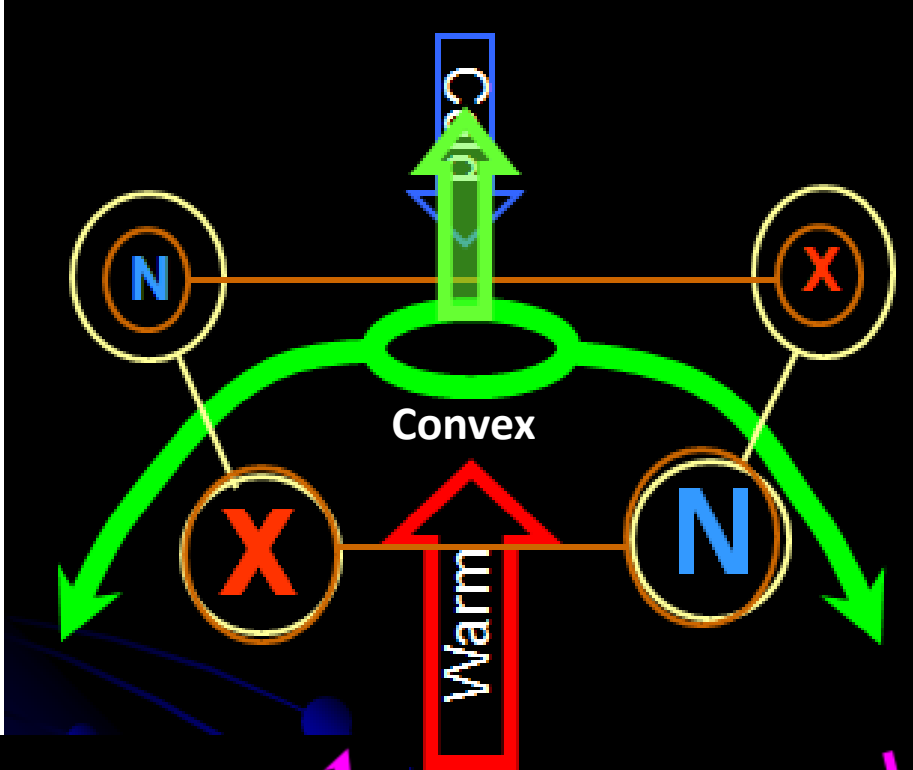
Drop a red X for a vorticity maximum.

Drop a blue N for a vorticity minimum.

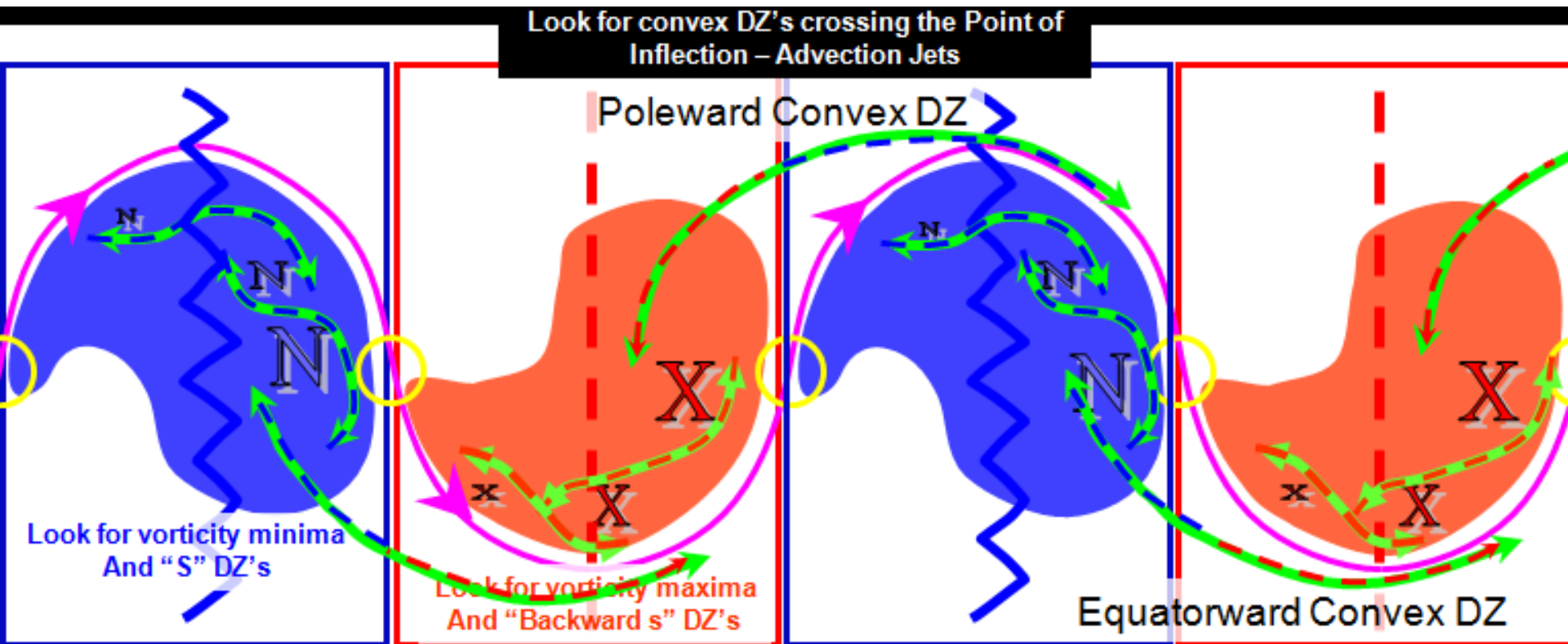
Don't worry.... Have fun!



The Relative Intensity of the Vorticity Centres Control the Shape of the DZ



Where to look for these Deformation Zones?



Anticyclonic
Curvature

Cyclonic
Curvature

Anticyclonic
Curvature

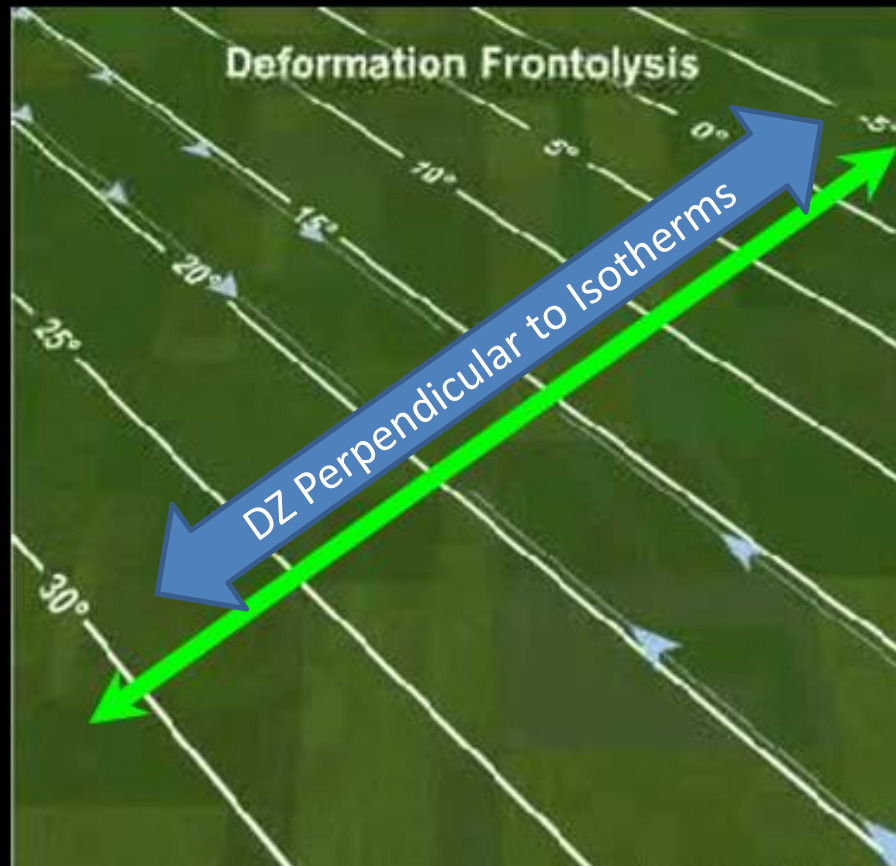
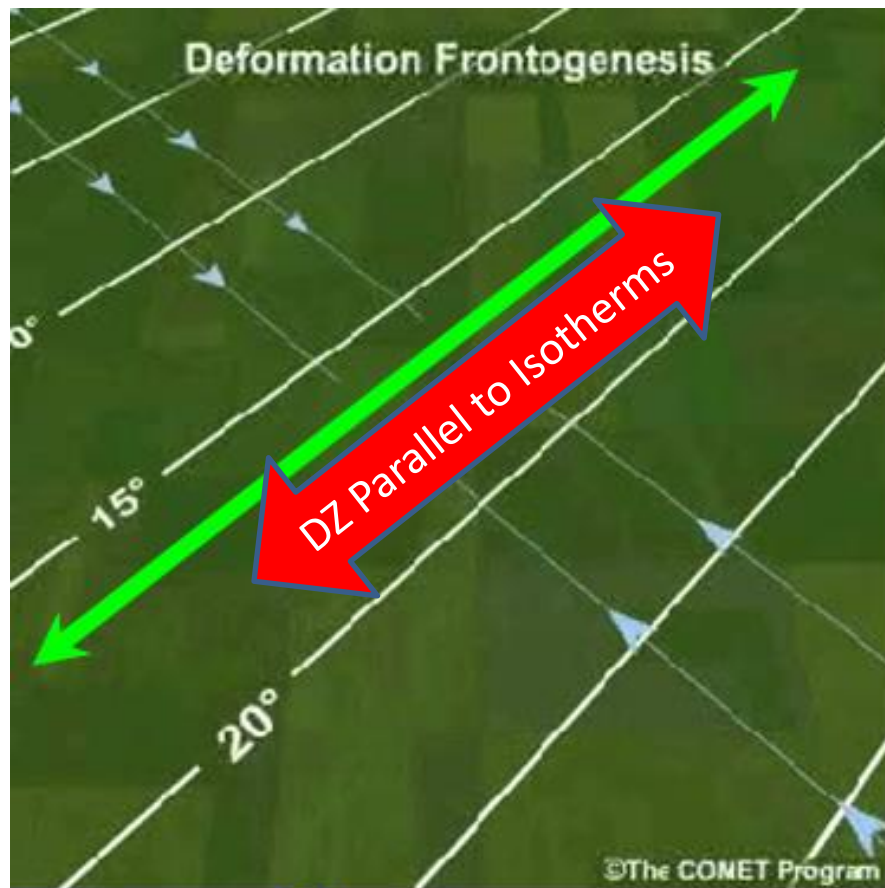
Cyclonic
Curvature

Cyclonic Shear/Curvature

Anticyclonic Shear/Curvature

White areas - Areas where *curvature* and *shear* vorticity contributions are in competition or negligible

Deformation Zones and Fronts?



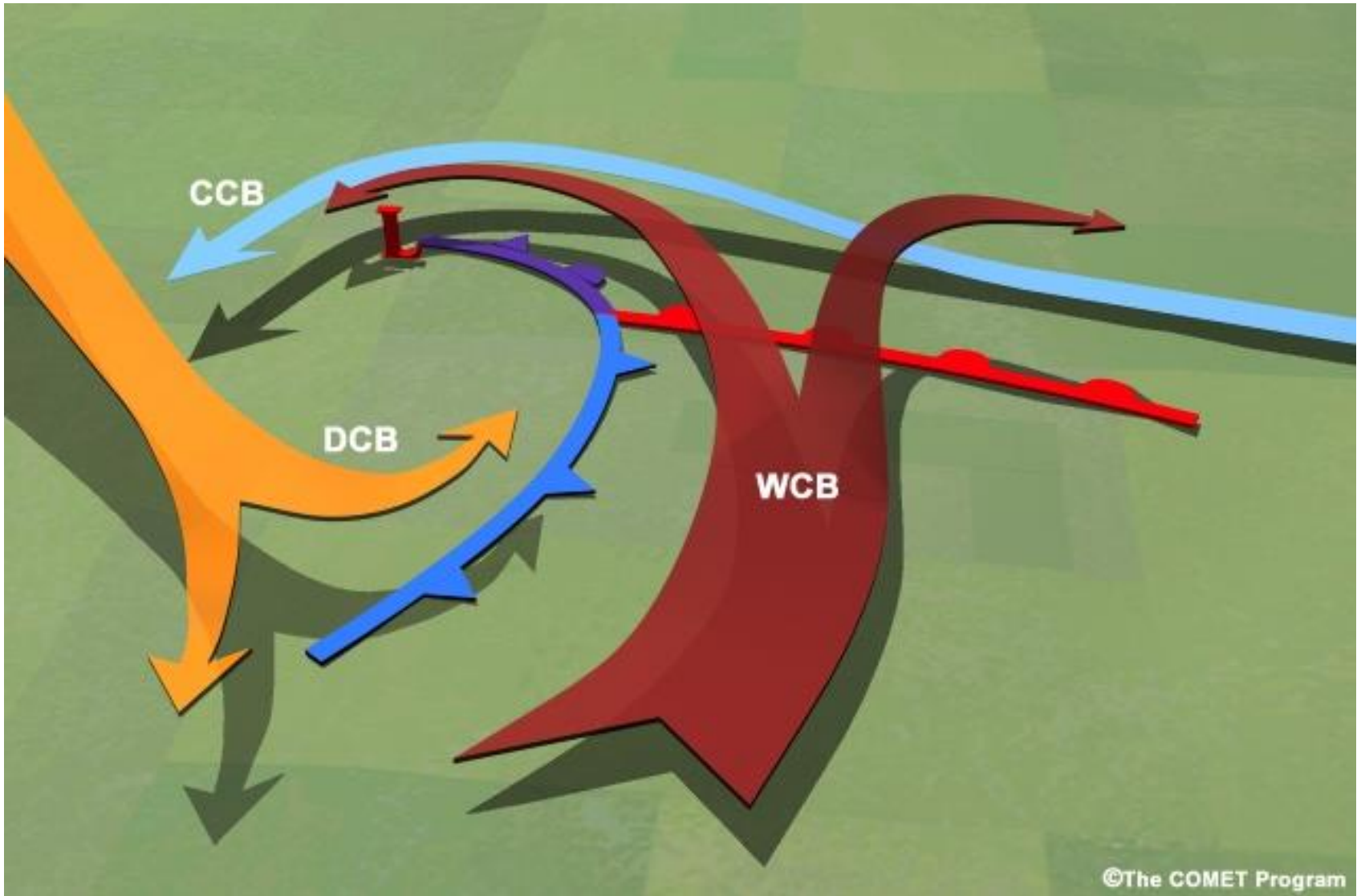
Deformation Zones and Vertical Motion?

Ageostrophic Wind Frontogenesis



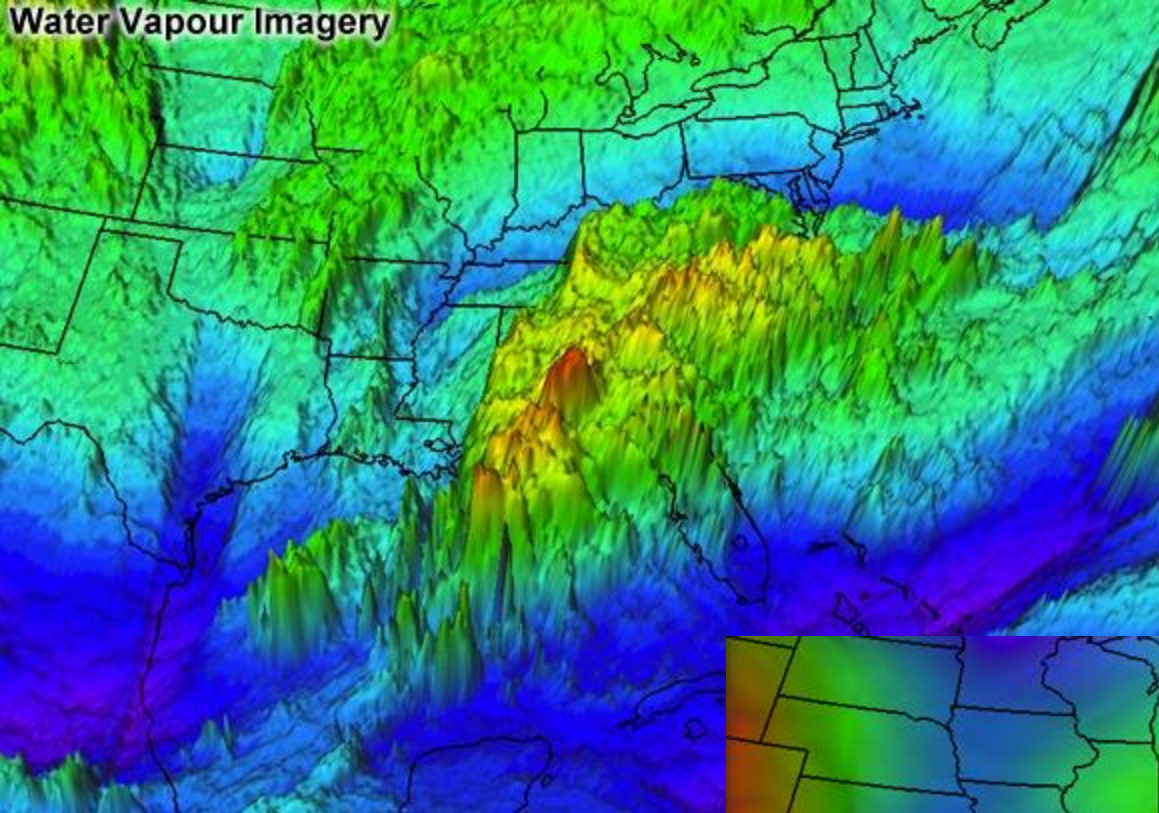
PGF = Pressure Gradient Force

Axis of Maximum Winds, Deformation Zones and Vorticity Centres
The Conveyor Belt Conceptual Model Bring them All Together



https://www.meted.ucar.edu/norlat/sat_features/conveyor_belts/

Water Vapour Imagery

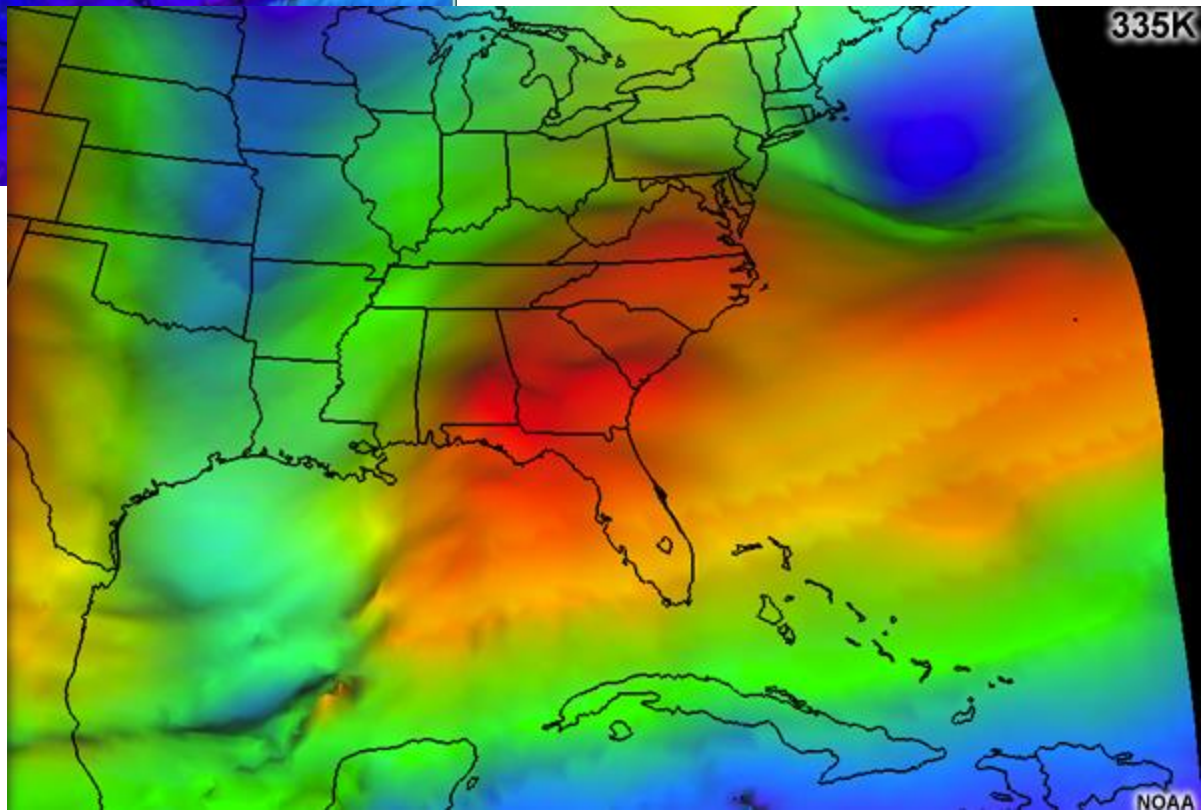


Which image would you rather look at for real time information?

Drop a symbol on the image to indicate your preference.

For more information, please visit my Satellite Palette Modules on COMET at ...

<https://www.meted.ucar.edu/norl>
at/sat_features/



335K

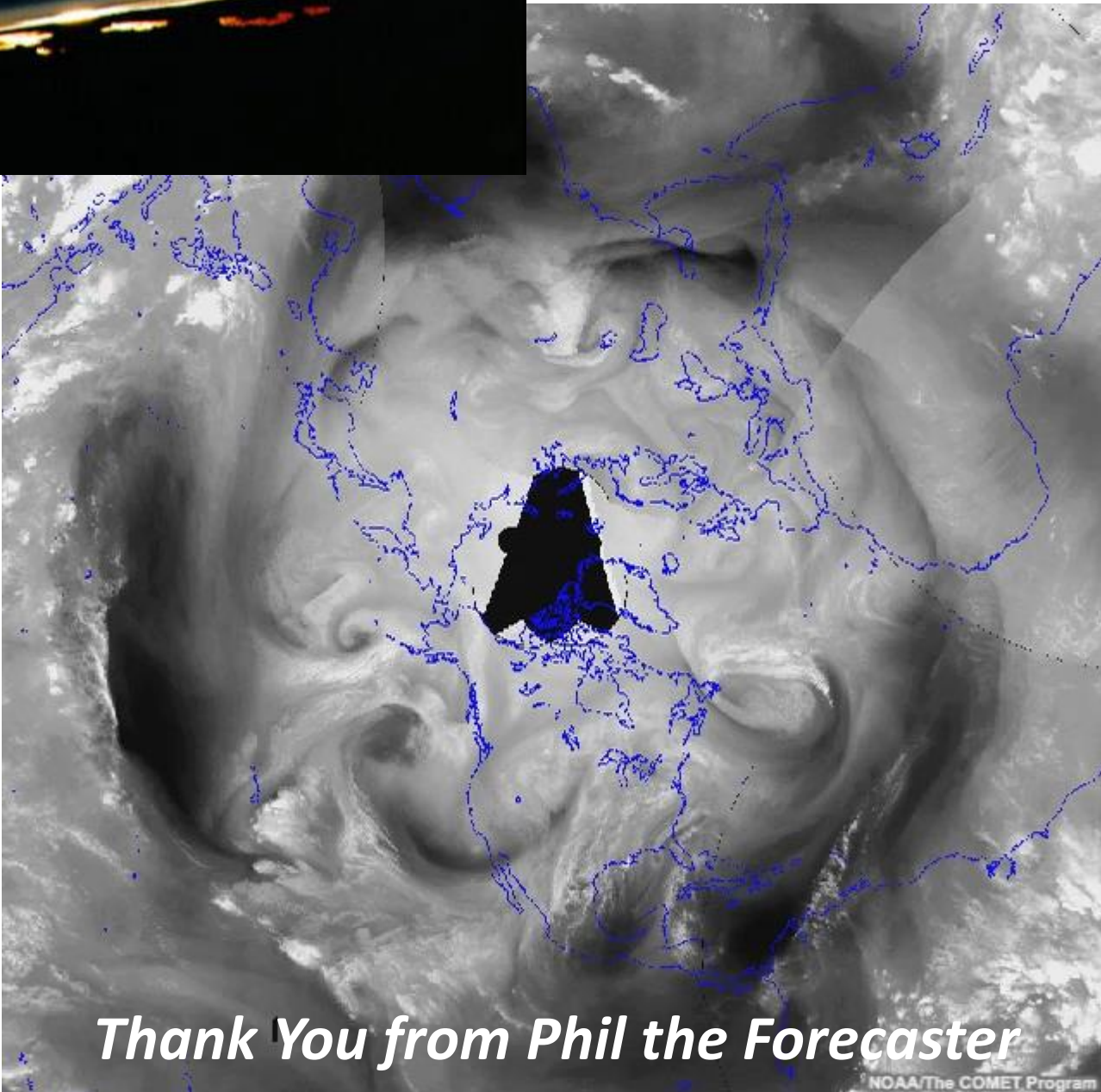
NOAA

Water Vapour Imagery - Summary

- Horizontal scale of the atmosphere far outweighs the vertical but the three dimensional motions define the weather – time is the fourth dimension
- WV Imagery like potential temperature contour map
- All atmospheric shapes can be analyzed in terms of lines or vorticity centres
- Line must be either axis of maximum winds or deformation zone
- Vorticity centres define deformation zones
- Analysis of satellite patterns in these terms allow independent NWP assessment
- Humans are ideally talented to perform this analysis



The simple concepts of lines and swirls apply at all scales of the atmosphere. The air is just another fluid!
WV Imagery is the key to understanding.



Thank You from Phil the Forecaster