Extratropical Cyclone Conceptual Models

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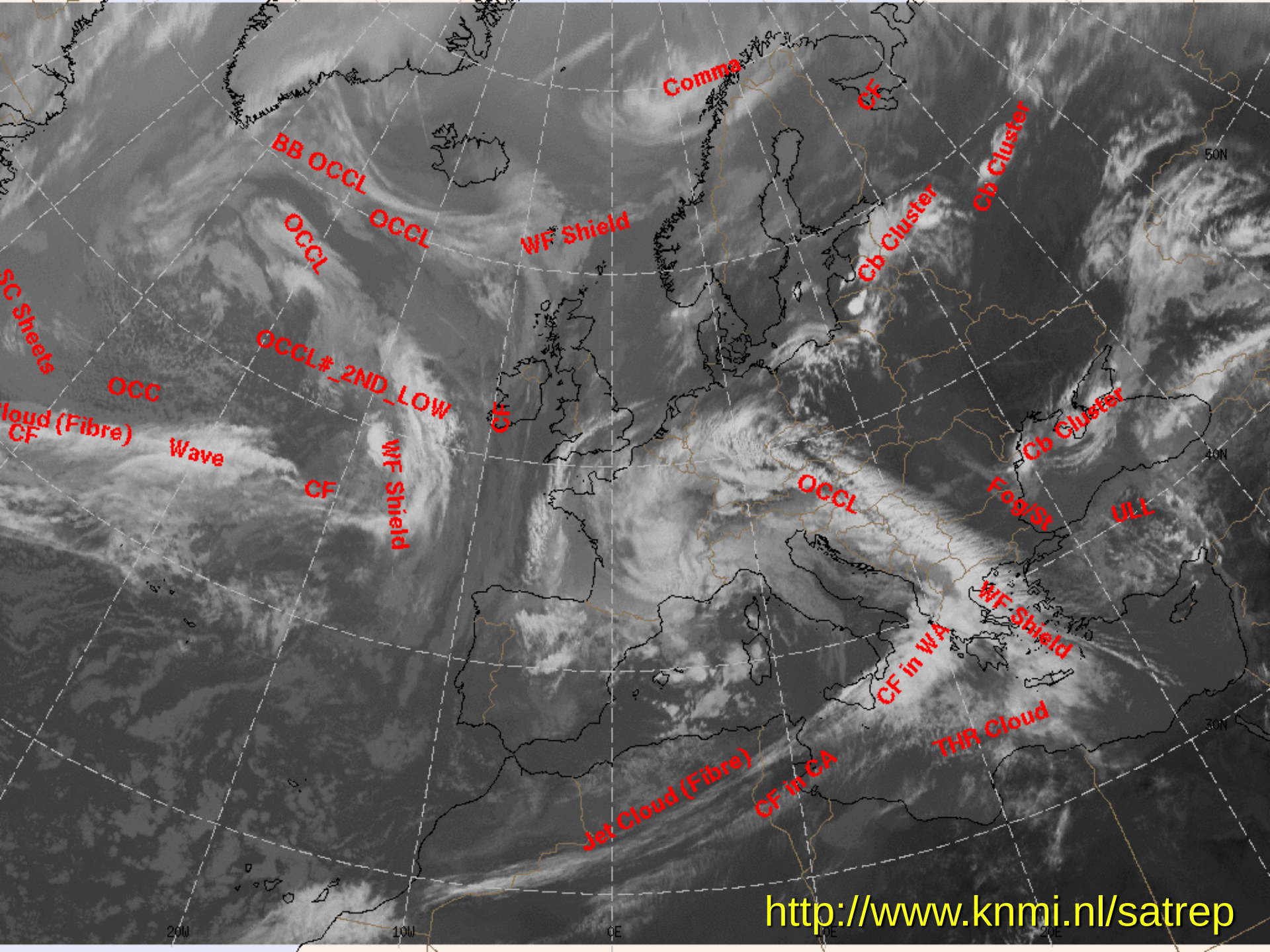
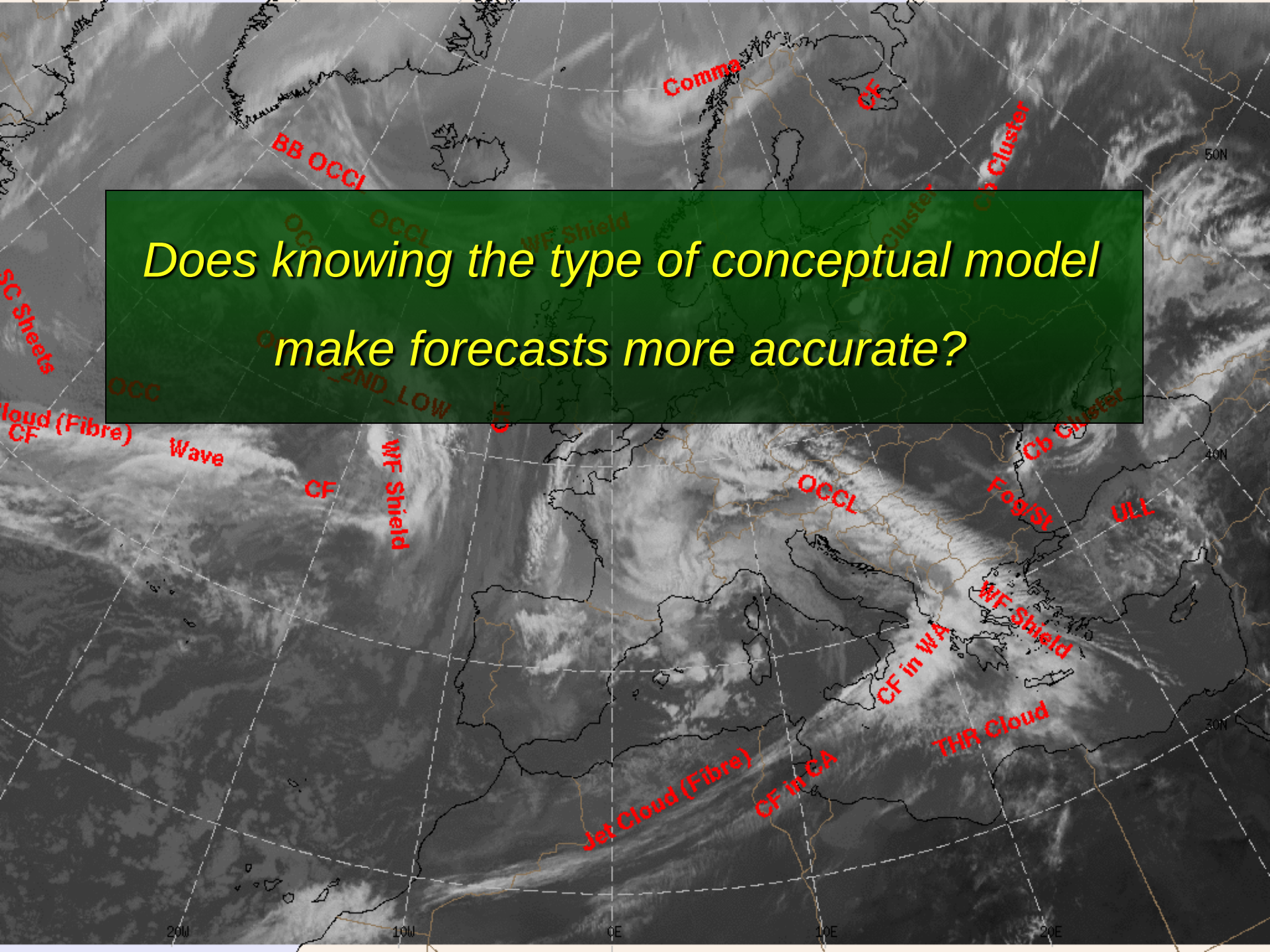
Conceptual Models

What are they *good* for?



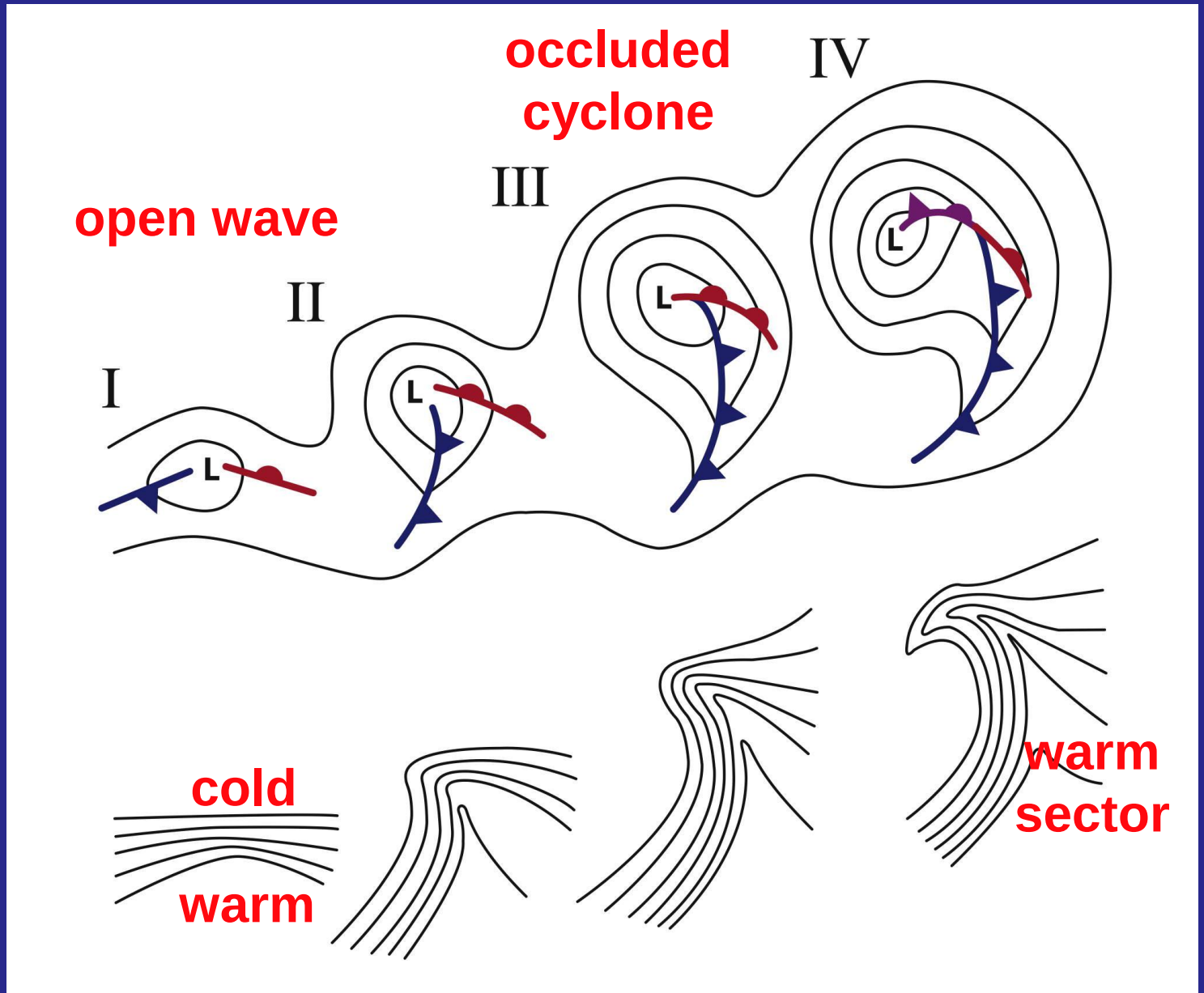
http://www.knmi.nl/satrep



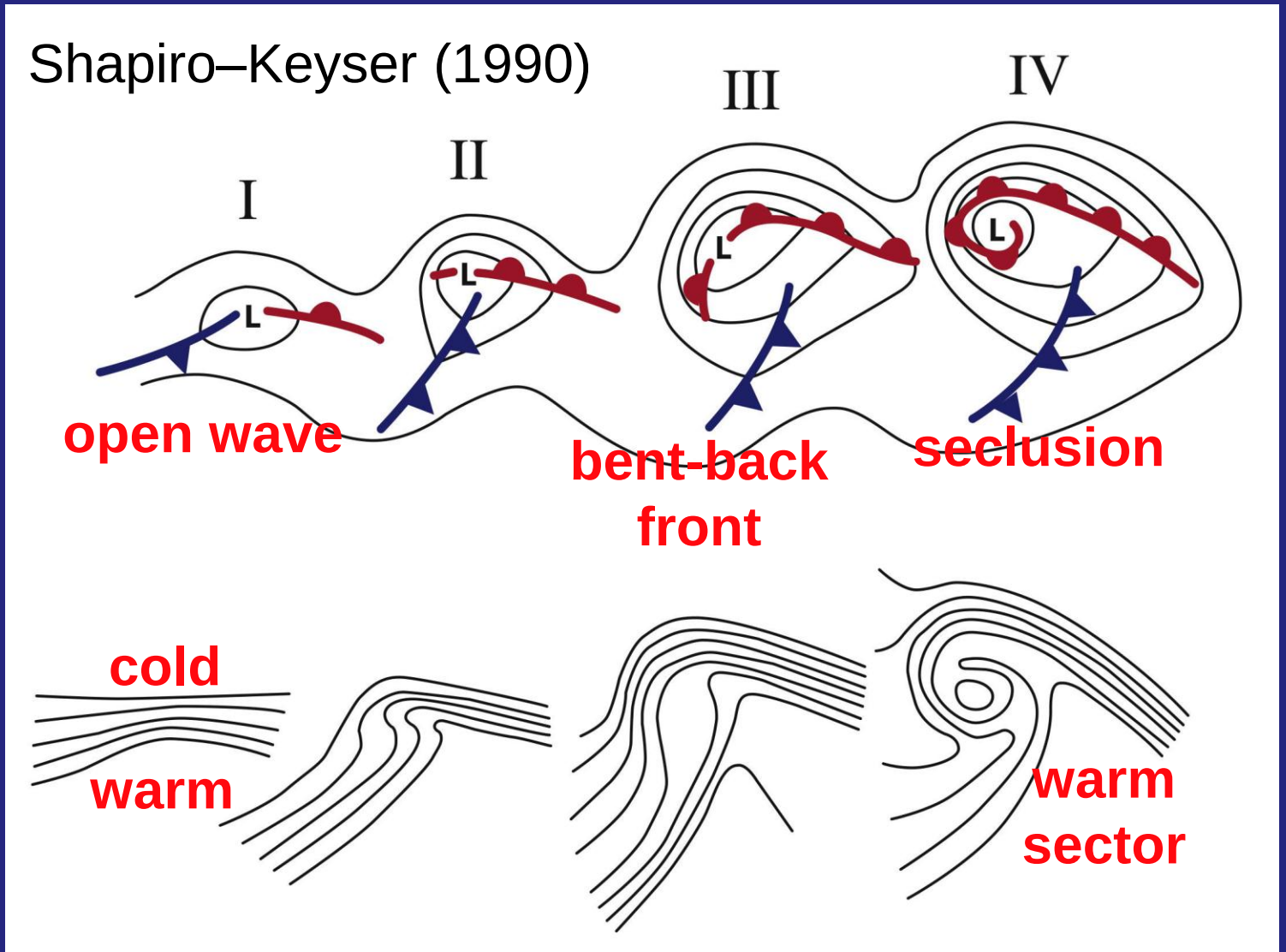
Does knowing the type of conceptual model make forecasts more accurate?

Two conceptual models of extratropical cyclone structure and evolution

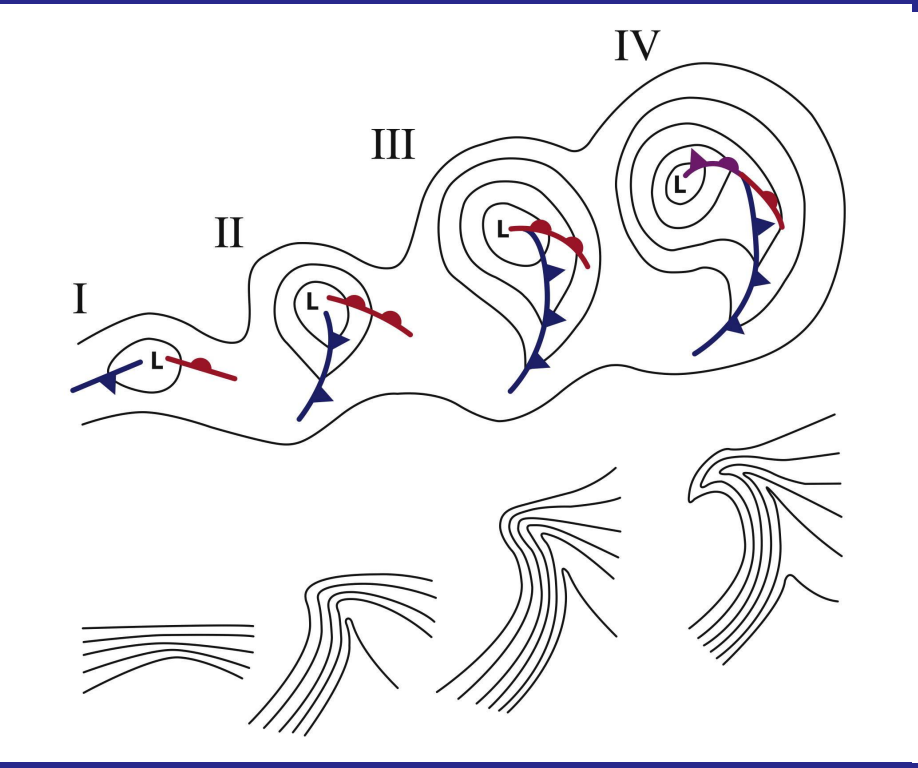
Norwegian cyclone model

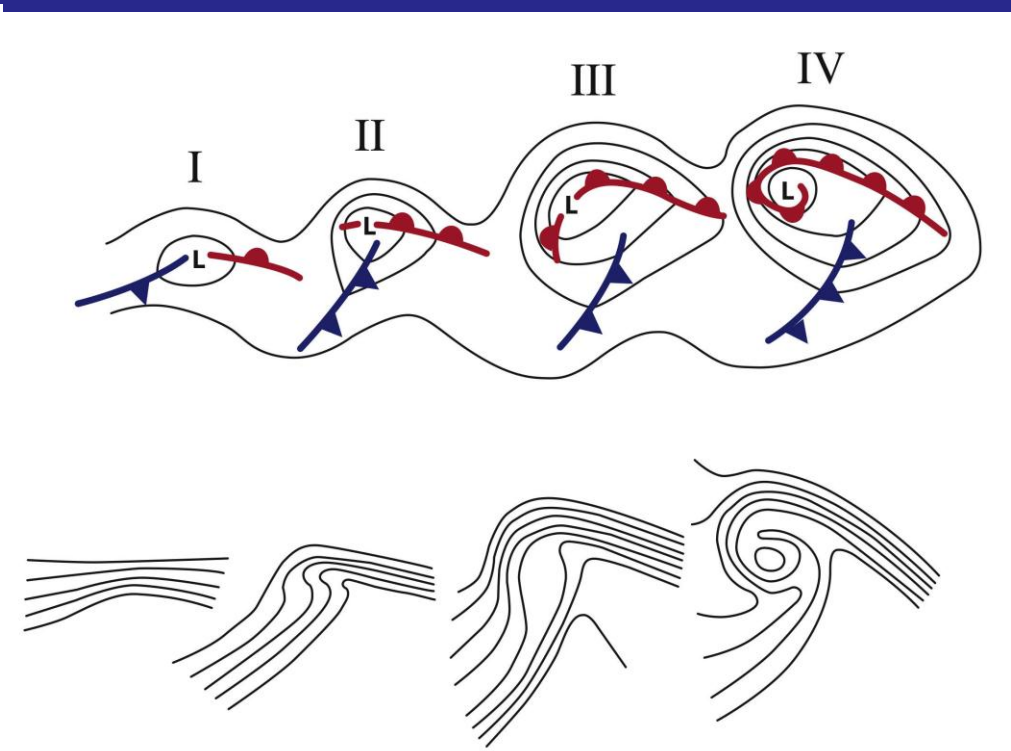


Shapiro–Keyser cyclone model



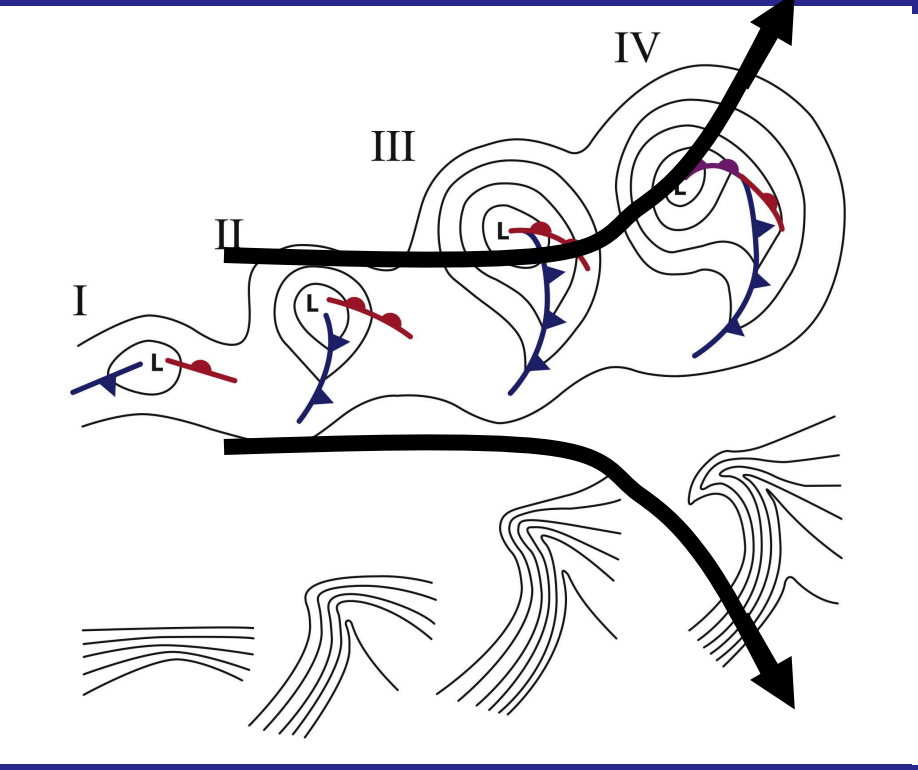
Two Conceptual Models of Lower-Level Cyclone Structure and Evolution



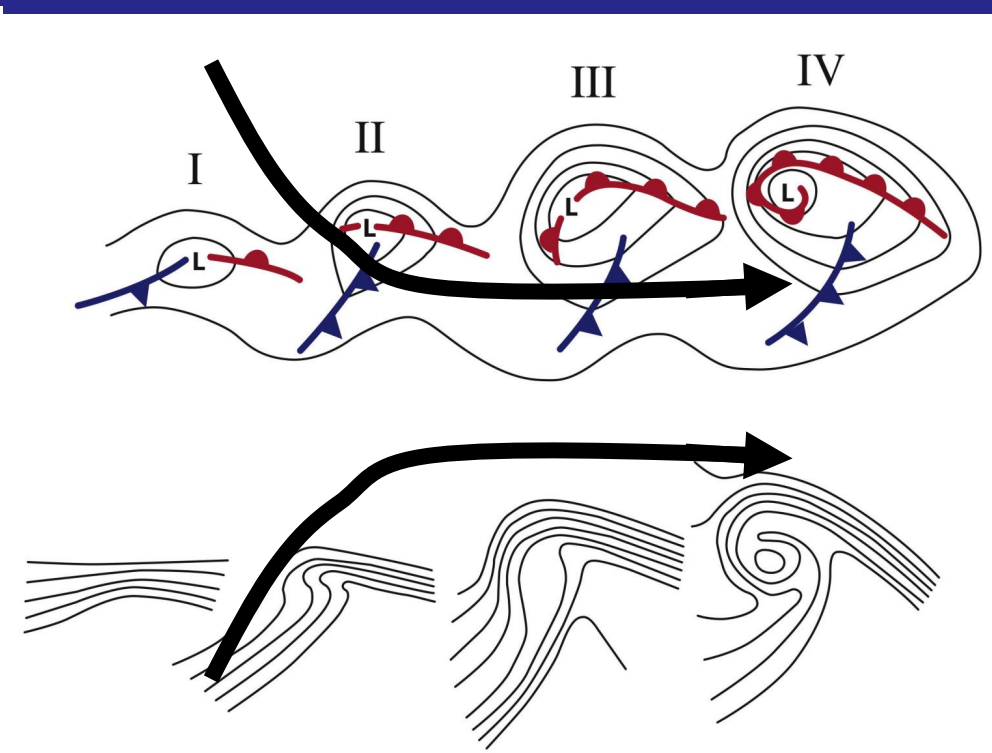


(Schultz et al. 1998)

Two Conceptual Models of Lower-Level Cyclone Structure and Evolution



confluence

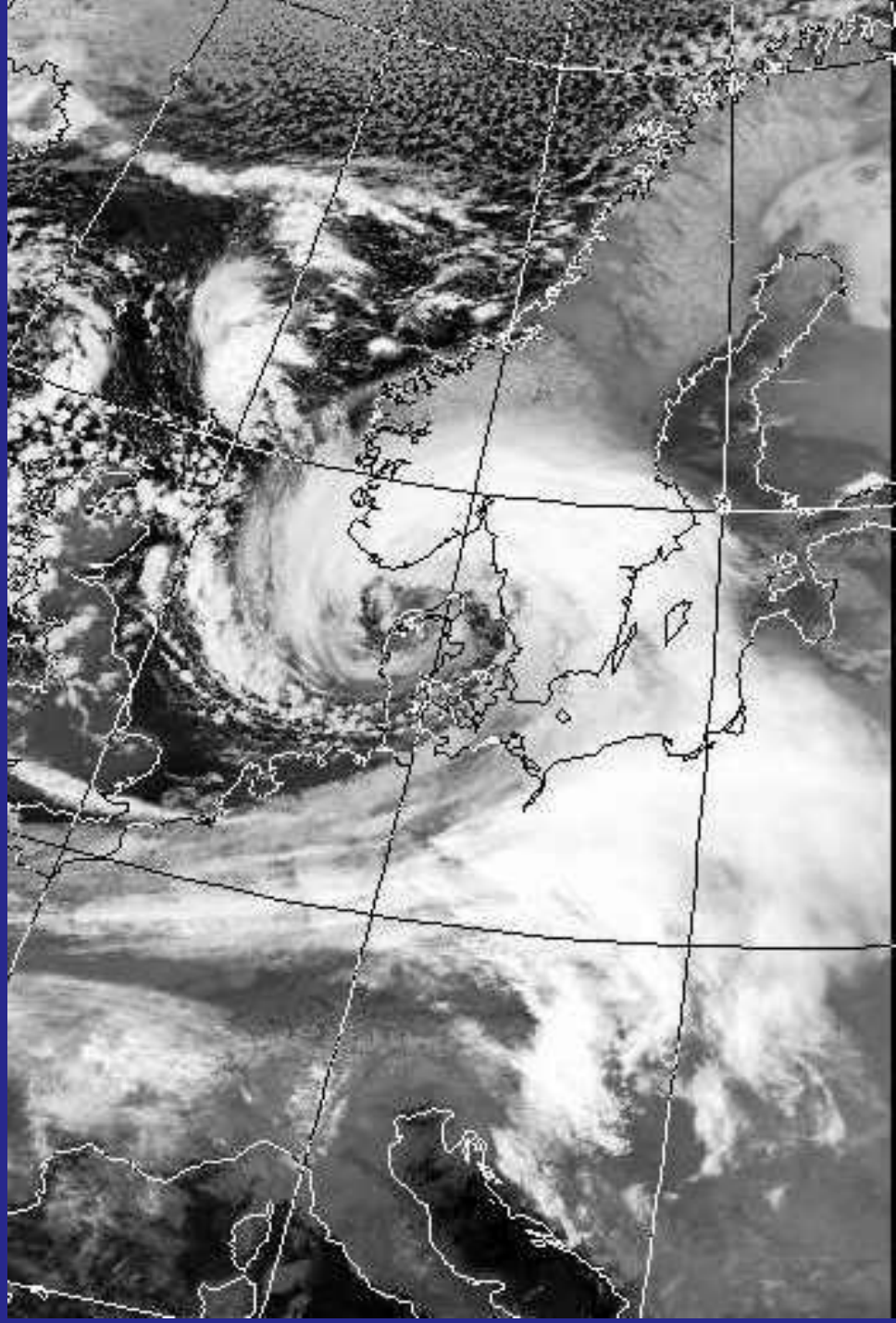


diffluence

(Schultz et al. 1998; Schultz and Zhang 2007)

These conceptual models are useful for marine wind forecasting:

Sting jets
Cold conveyor belts



Infrared satellite image of Anatol,
1625 UTC 3 December 1999 (Wikipedia)

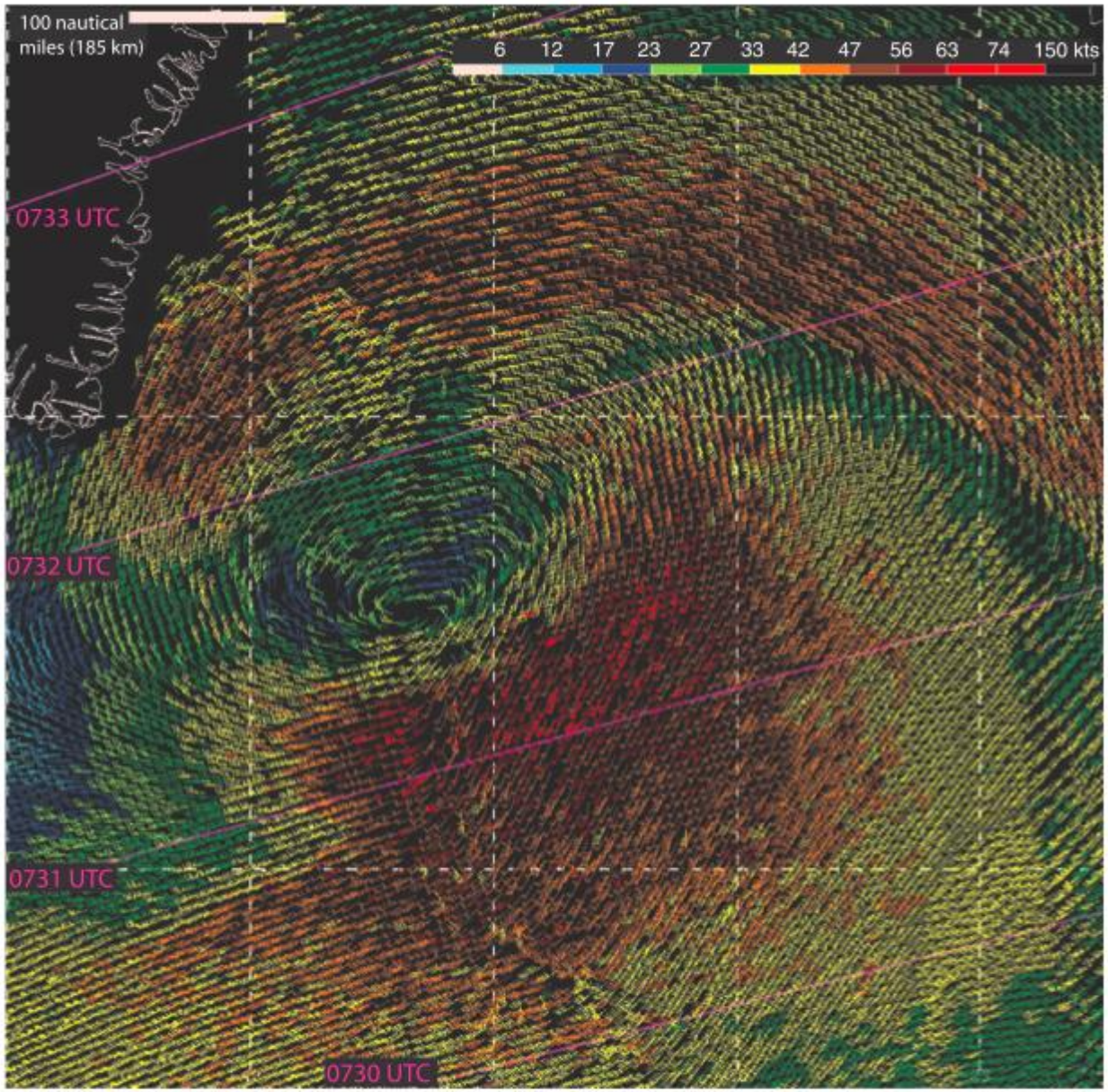
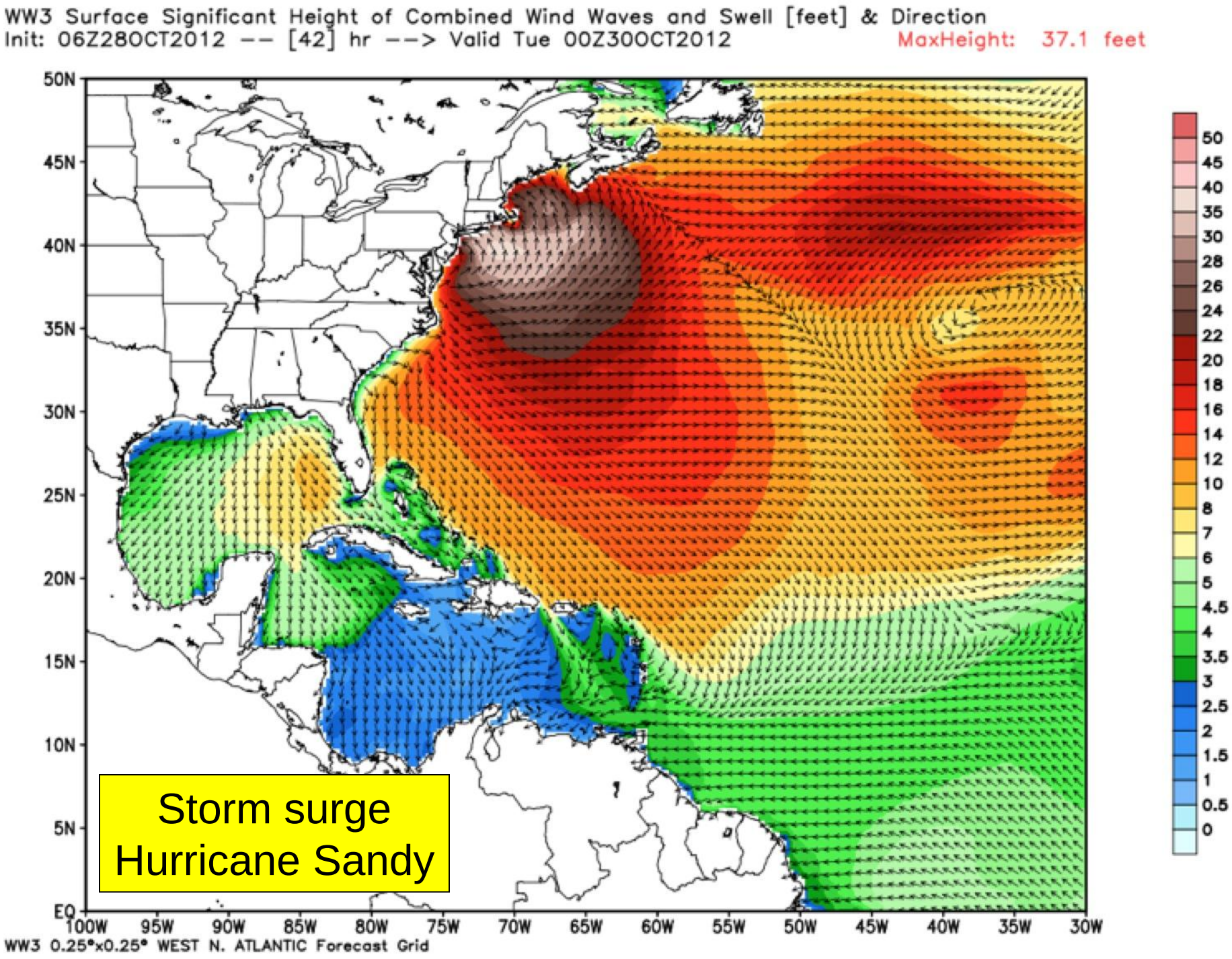
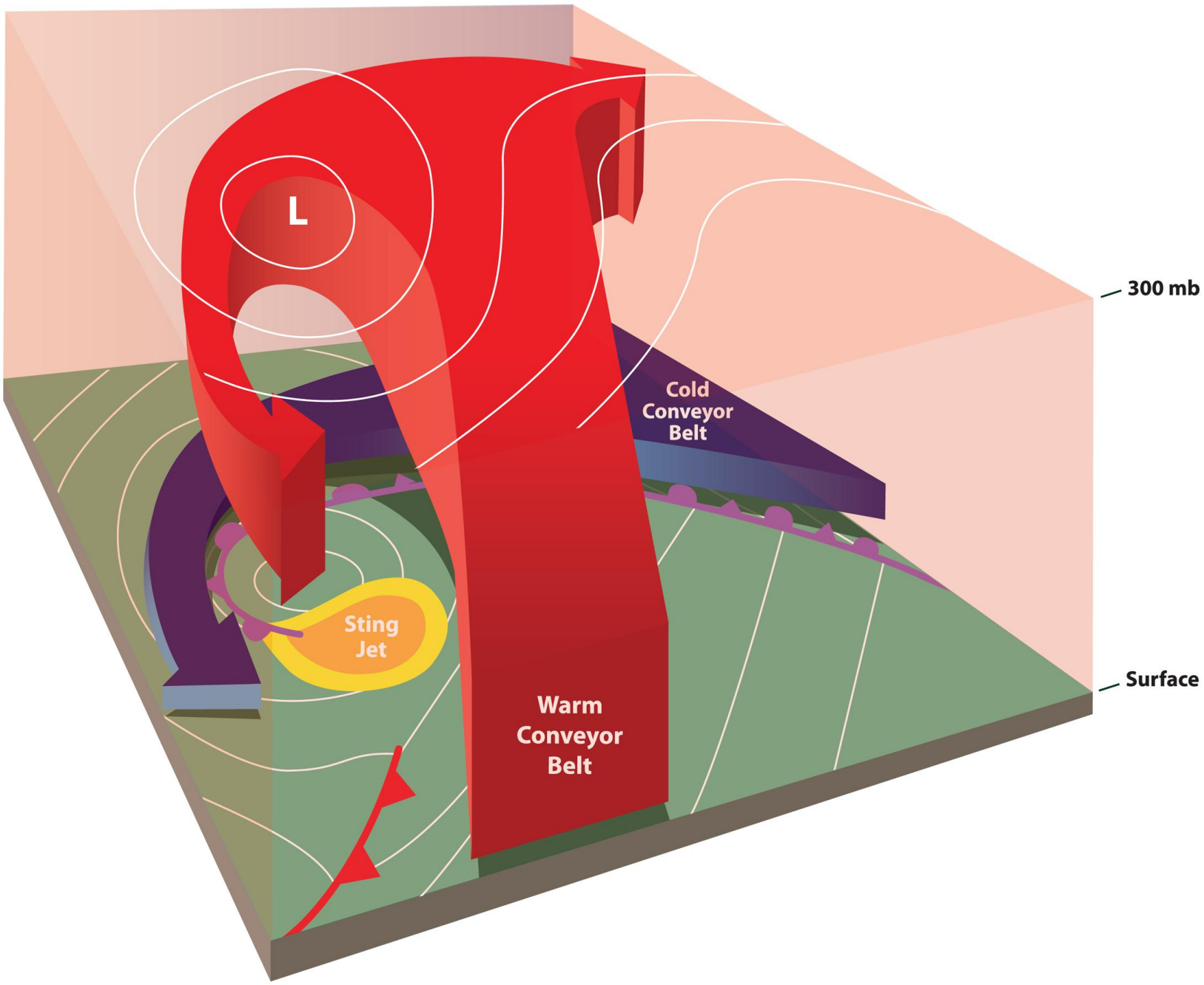


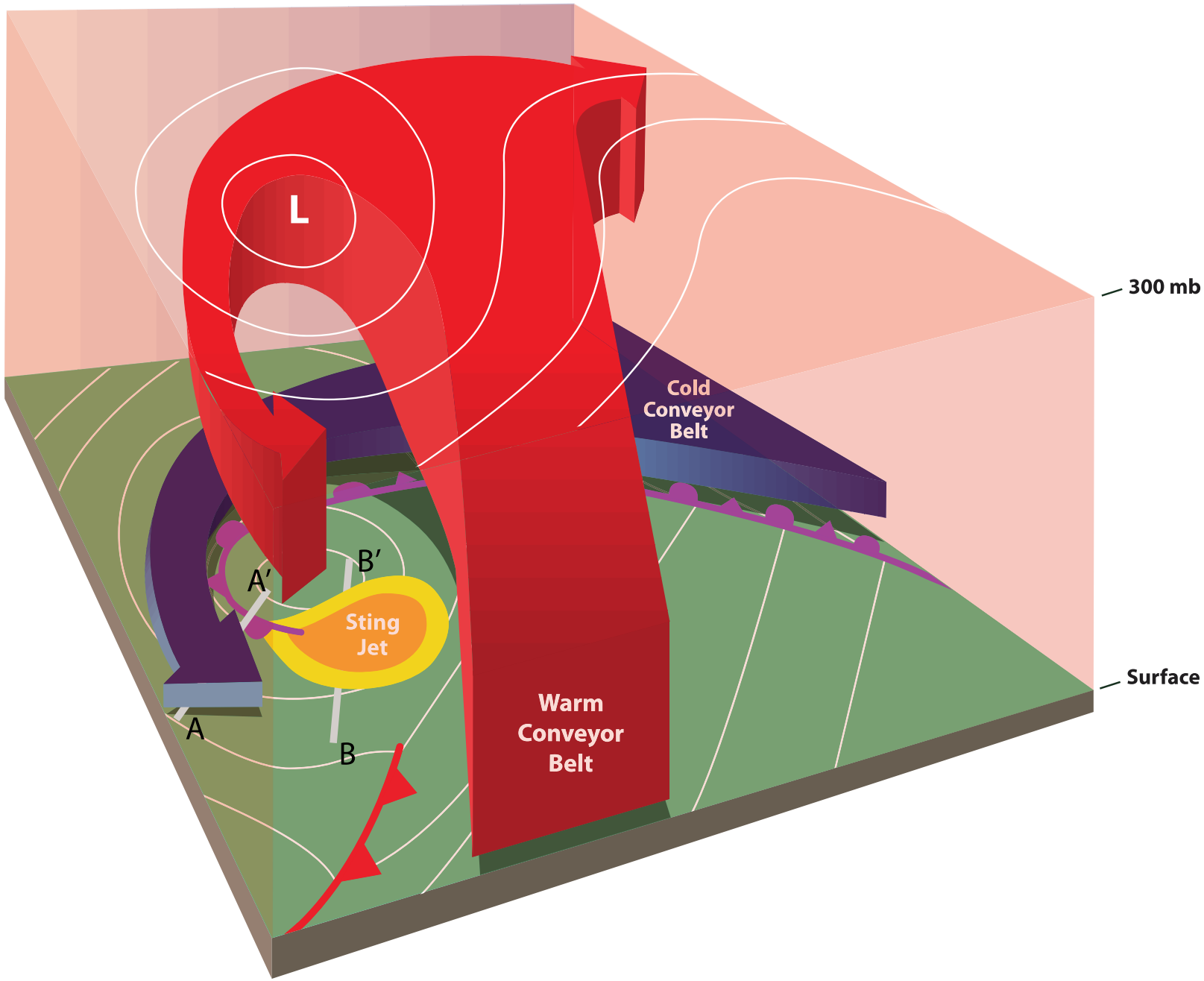
FIG. 1. QuikSCAT imagery of horizontal wind speed and direction at 0730–0733 UTC 8 Dec 2005 (pennant, full barb, and half-barb denote 50, 10, and 5 kt, respectively, where 1 kt = 0.514 m s^{-1}; separation between displayed wind vectors is 12.5 km). The colored wind barbs represent wind speed (kt) according to the scale in the top-right corner, the pink lines represent satellite overpass times, and the scale bar in the top-left corner represents 100 nautical miles (n mi, or 185 km).

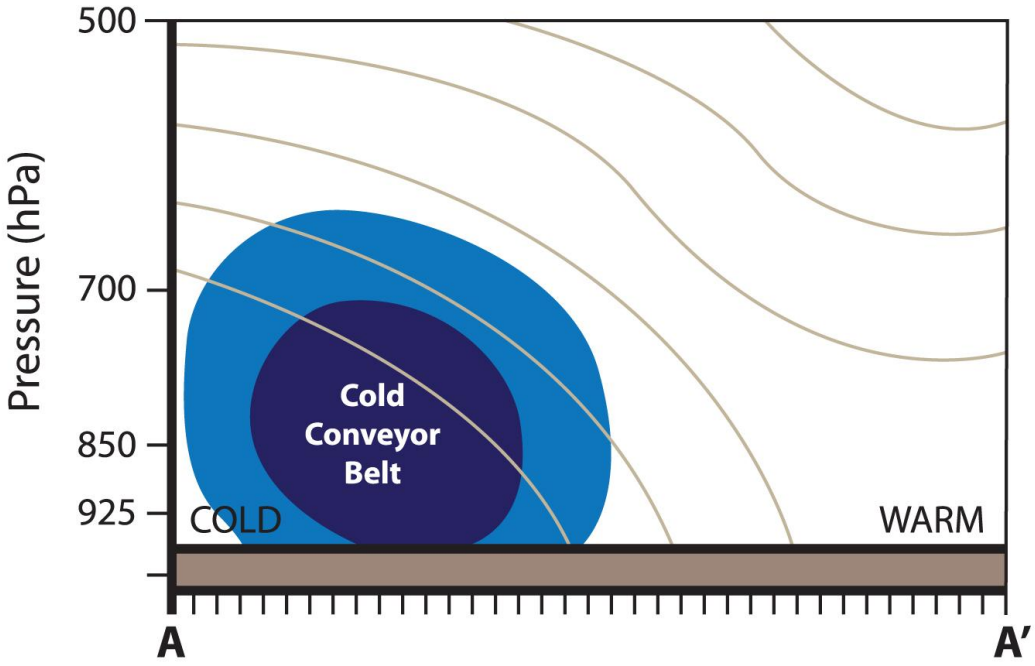
QuikSCAT 8 Dec 2005

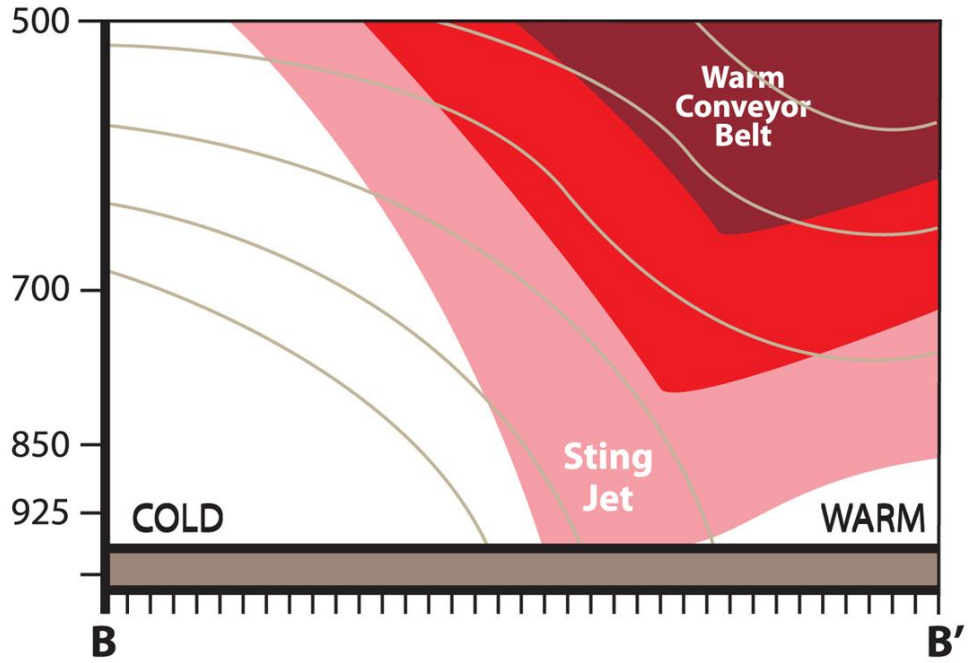
Schultz and Sienkiewicz (2013, *Weather and Forecasting*)

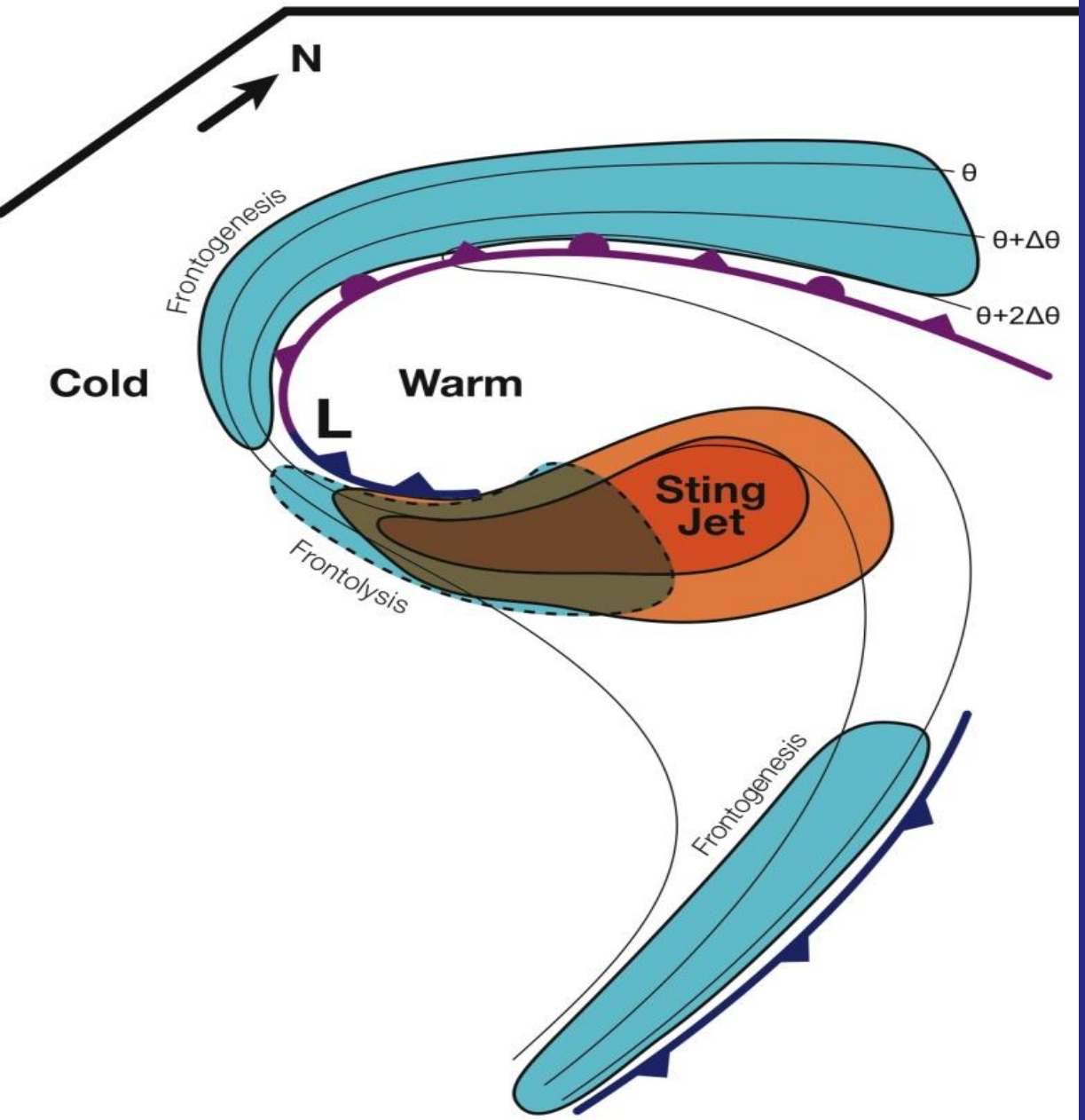

WW3 Surface Significant Height of Combined Wind Waves and Swell [feet] & Direction
Init: 06Z28OCT2012 -- [42] hr --> Valid Tue 00Z30OCT2012
MaxHeight: 37.1 feet
50N
45N
40N
35N
30N
25N
20N
15N
10N
5N
EQ
100W
95W
90W
85W
80W
75W
70W
65W
60W
55W
50W
45W
40W
35W
30W
50
45
40
35
30
28
26
24
22
20
18
16
14
12
10
8
7
6
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Storm surge
Hurricane Sandy
WW3 0.25°x0.25° WEST N. ATLANTIC Forecast Grid


(a)
L
300 mb
Cold
Conveyor
Belt
Sting
Jet
Surface
Warm
Conveyor
Belt


(a)
L
300 mb
Cold
Conveyor
Belt
A′
B′
Sting
Jet
A
B
Warm
Conveyor
Belt
Surface


500
700
850
925
Pressure (hPa)
Cold
Conveyor
Belt
COLD
WARM
A
A′


500
700
850
925
Warm
Conveyor
Belt
Sting
Jet
COLD
WARM
B
B′



Schultz and Sienkiewicz (2013, *Weather and Forecasting*)

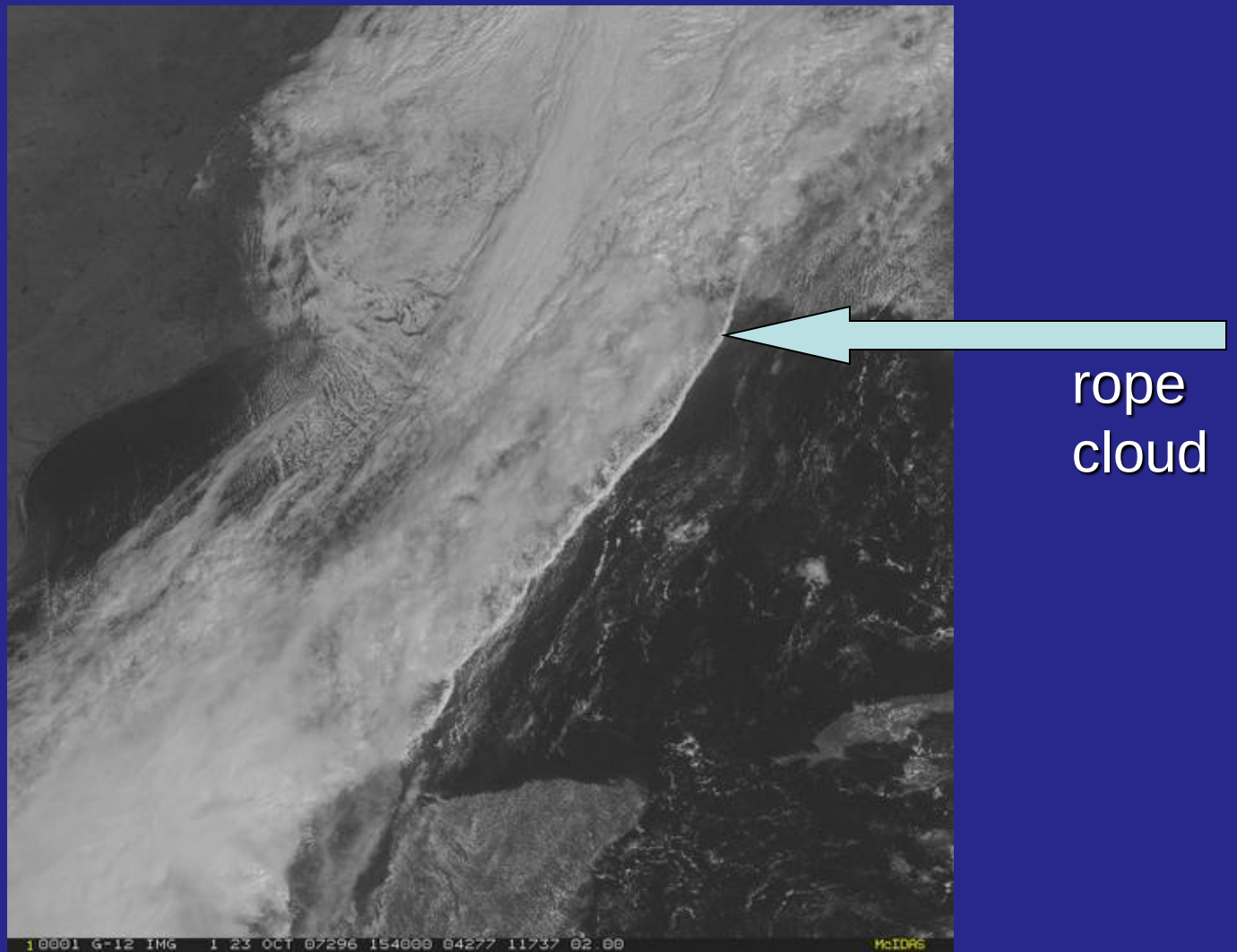
New ideas in conceptual models:

Cold fronts

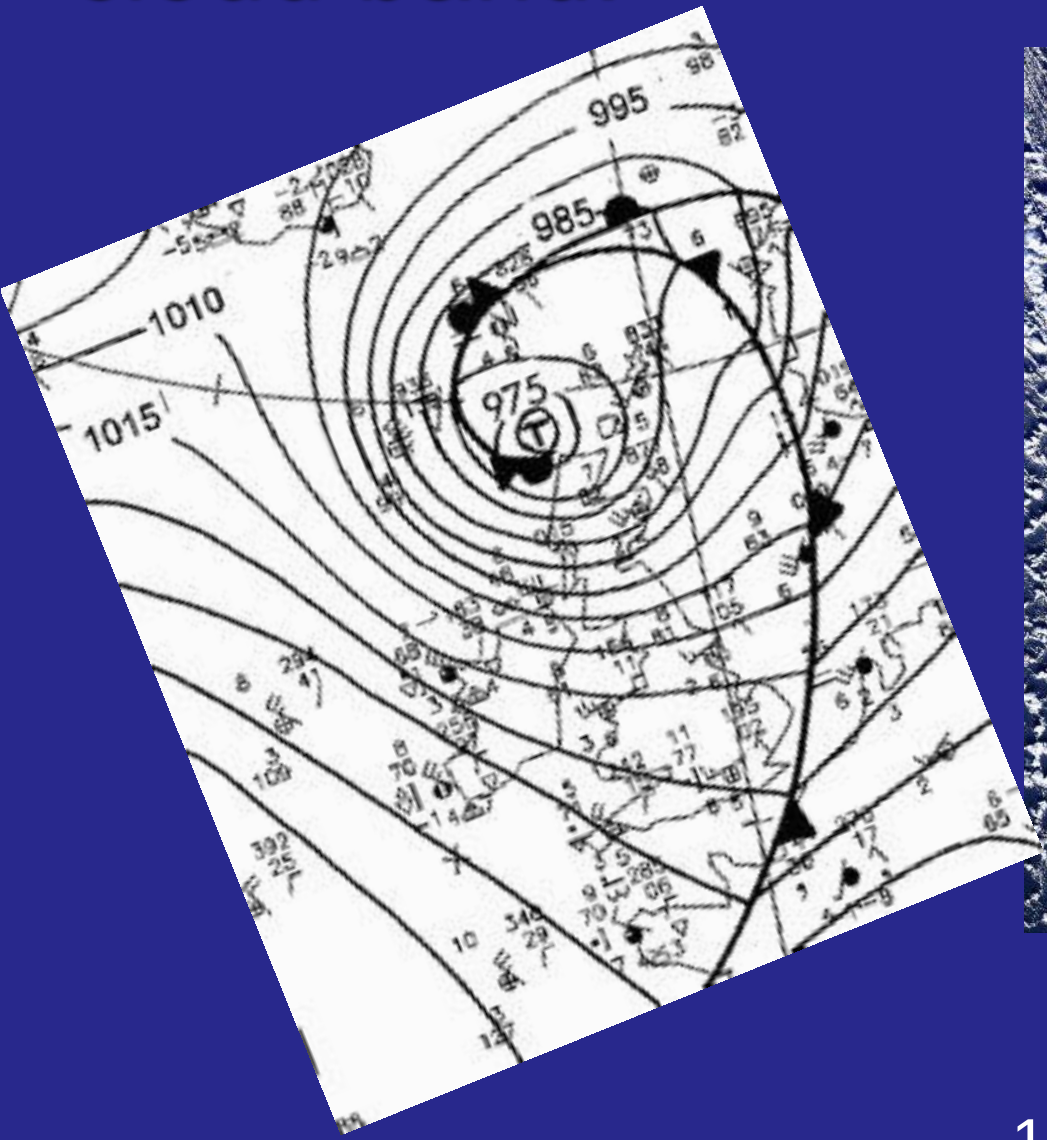
Occluded fronts

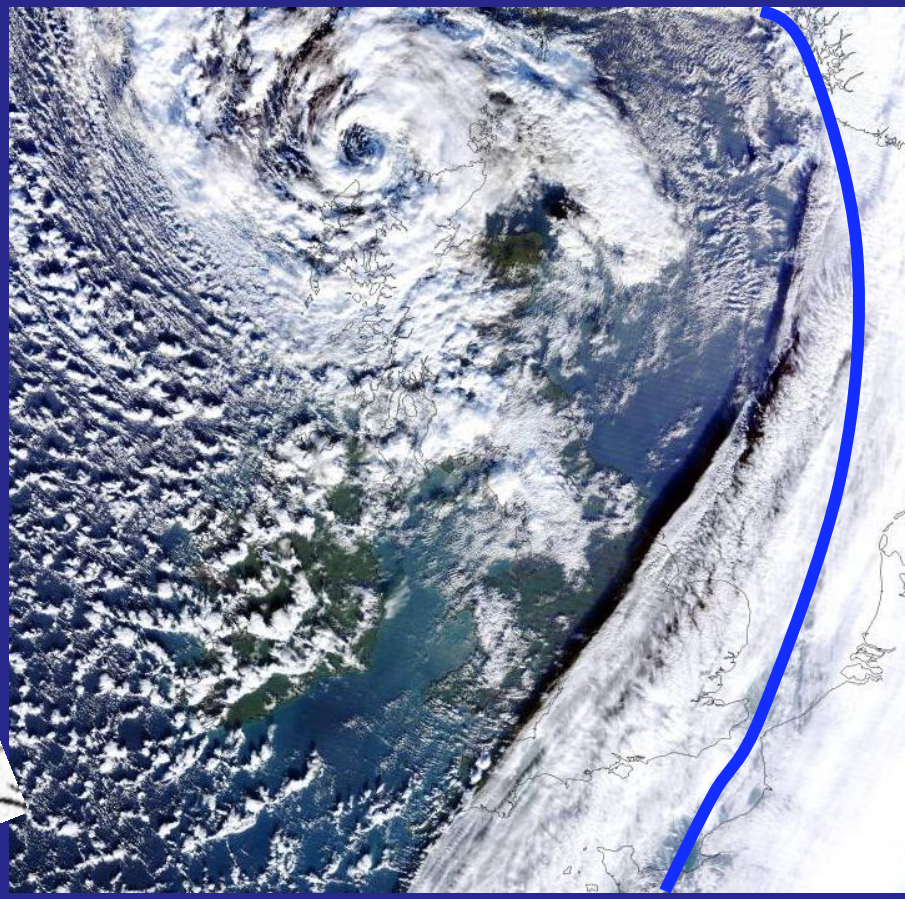
Conventional Wisdom:

The cloud band depicts the location of the surface cold front.



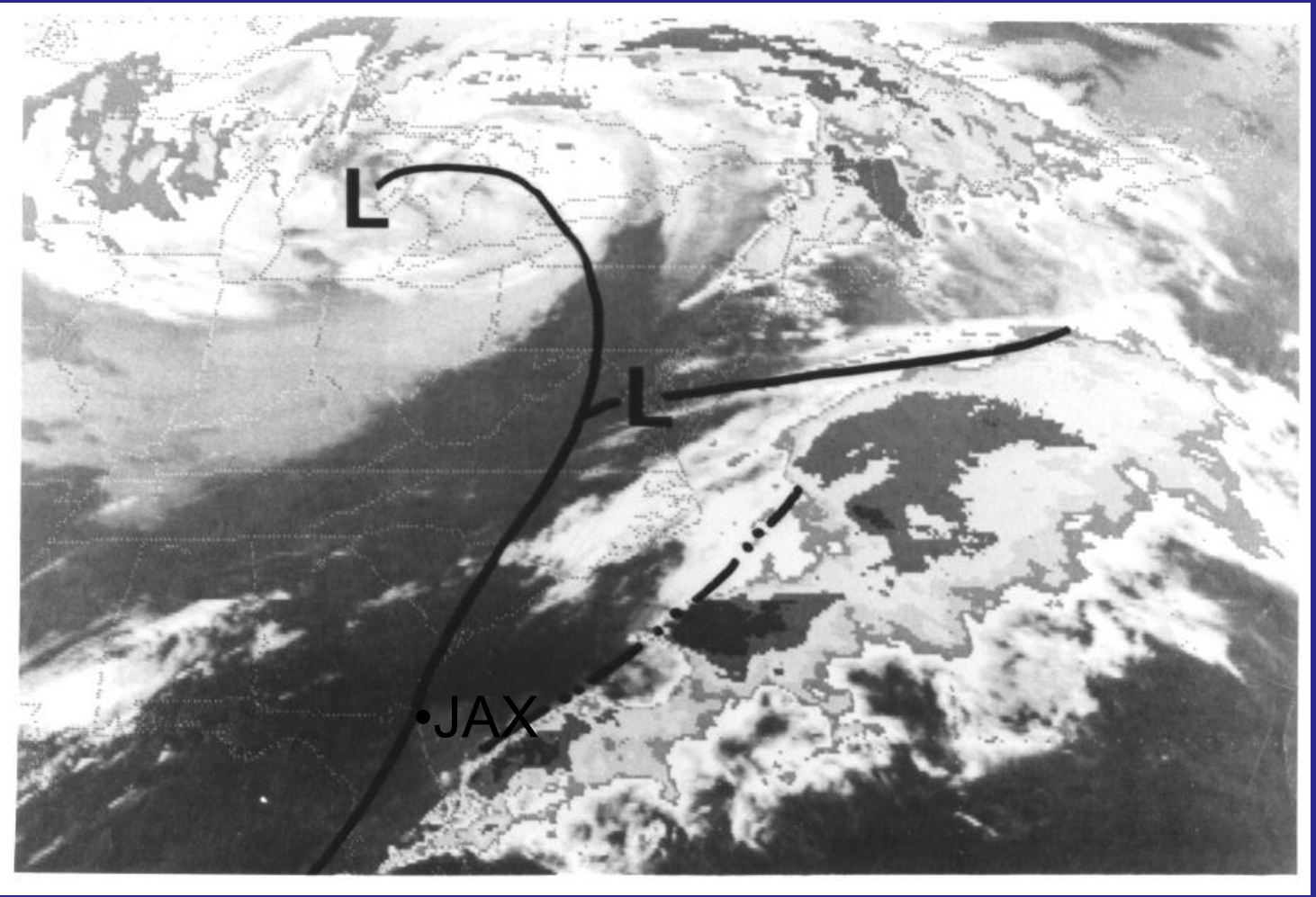
This cold front is not associated with a cloud band.





1200 UTC 28 December 2011

This cold front is not associated with any cloud band.



2301 UTC 15 December 1987

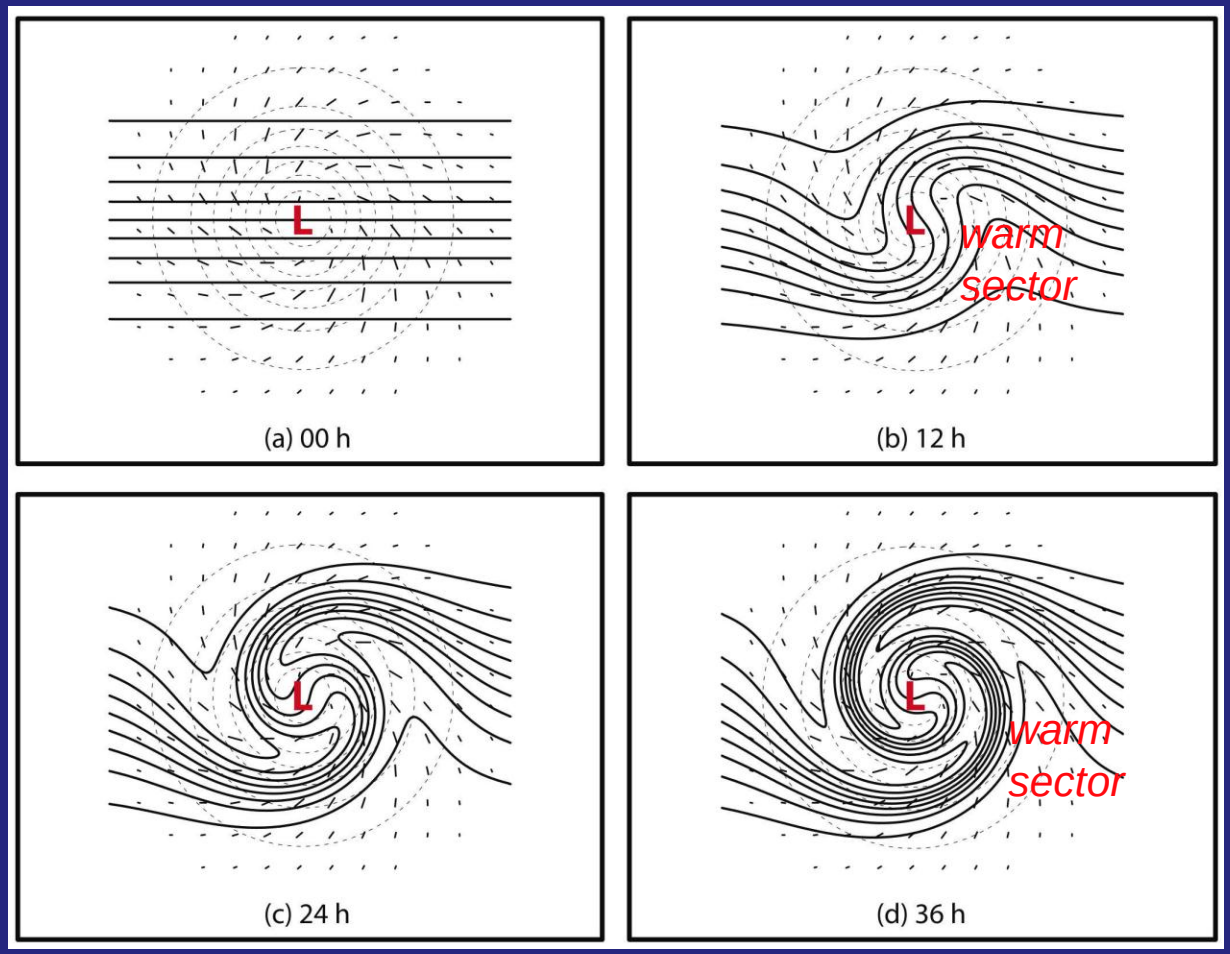
JAX frontal passage after 0000 UTC (Schultz and Vaughan 2011)

What about occluded fronts?

Conventional Wisdom

Occluded fronts form when cold fronts catch up to warm fronts.

Rotation and deformation around a nondivergent vortex will produce a narrowing warm sector.



isentropes

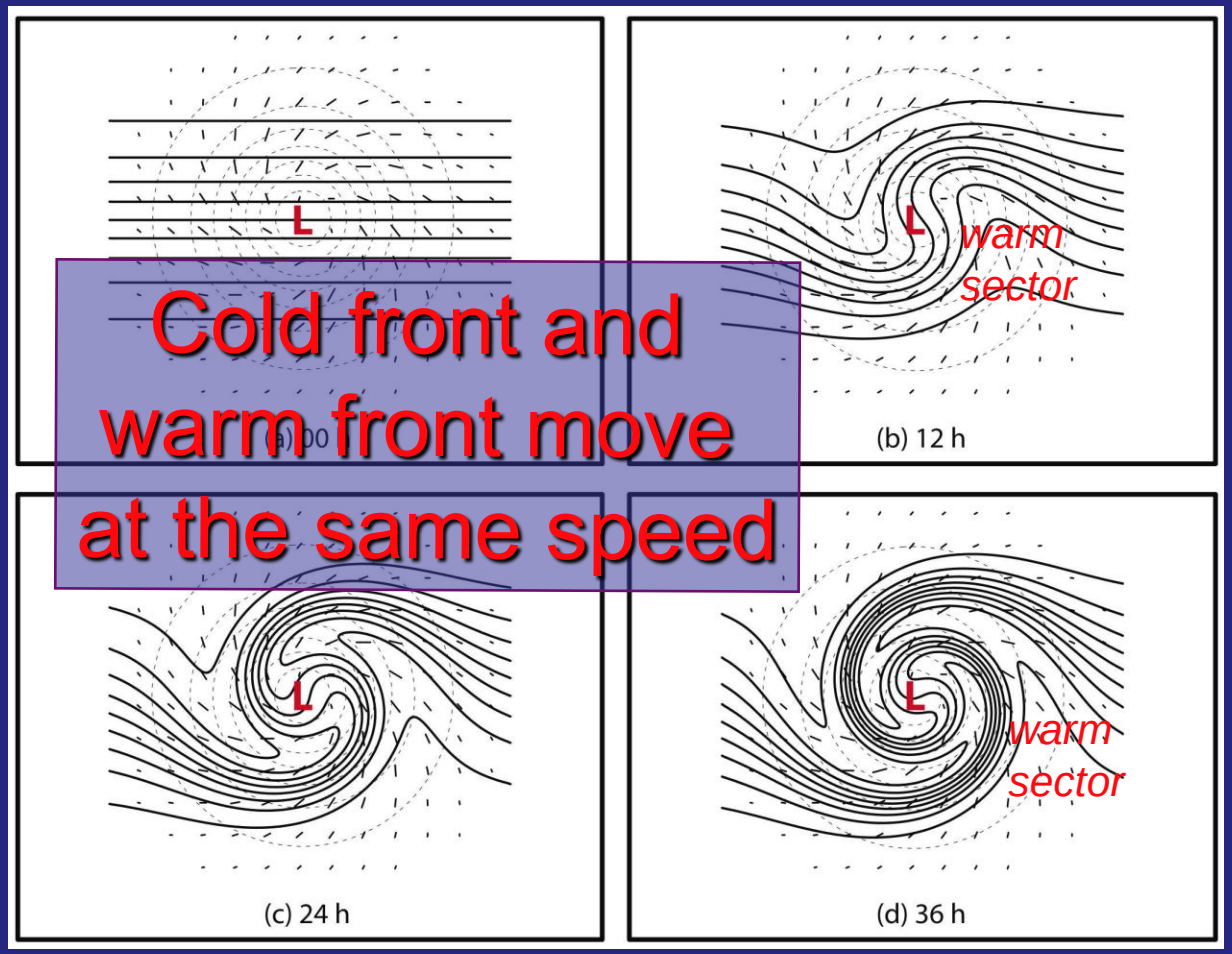
streamlines

axes of dilatation

barotropic model with passively advected isentropes

(Doswell 1984, 1985; Davies-Jones 1985; Schultz et al. 1998)

Rotation and deformation around a nondivergent vortex will produce a narrowing warm sector.



Cold front and warm front move at the same speed

isentropes

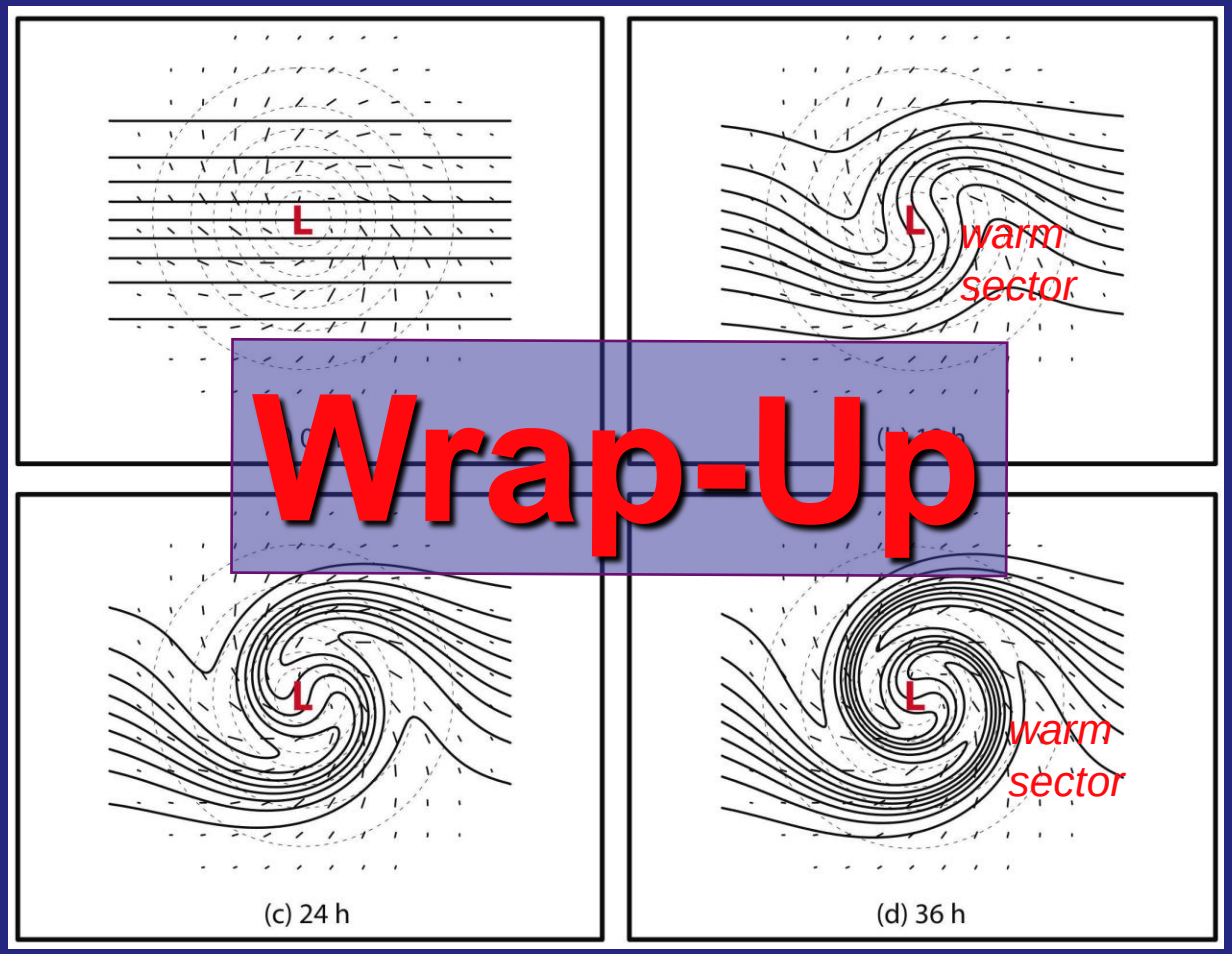
streamlines

axes of dilatation

barotropic model with passively advected isentropes

(Doswell 1984, 1985; Davies-Jones 1985; Schultz et al. 1998)

Rotation and deformation around a nondivergent vortex will produce a narrowing warm sector.



Wrap-Up

isentropes

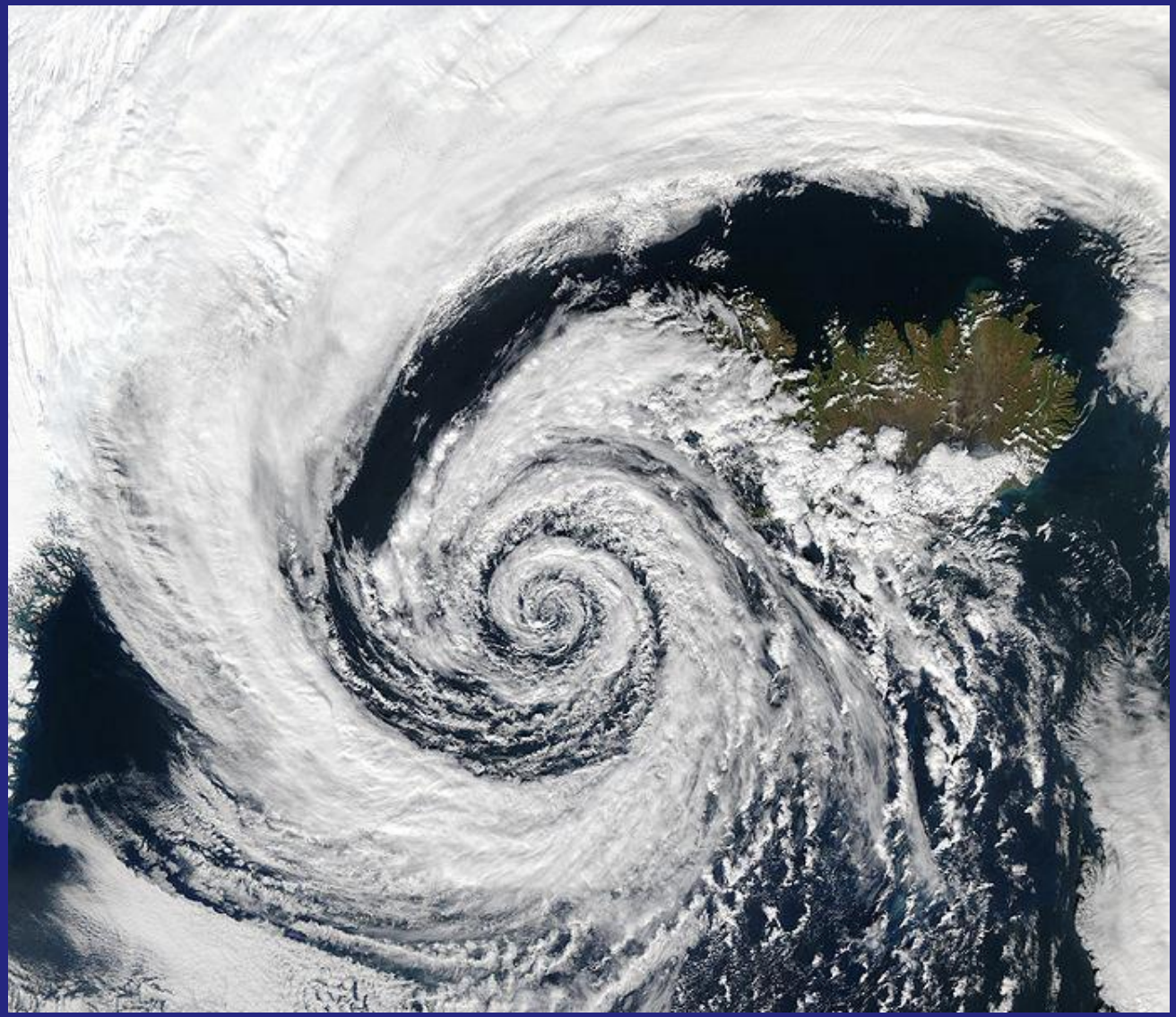
streamlines

axes of dilatation

barotropic model with passively advected isentropes

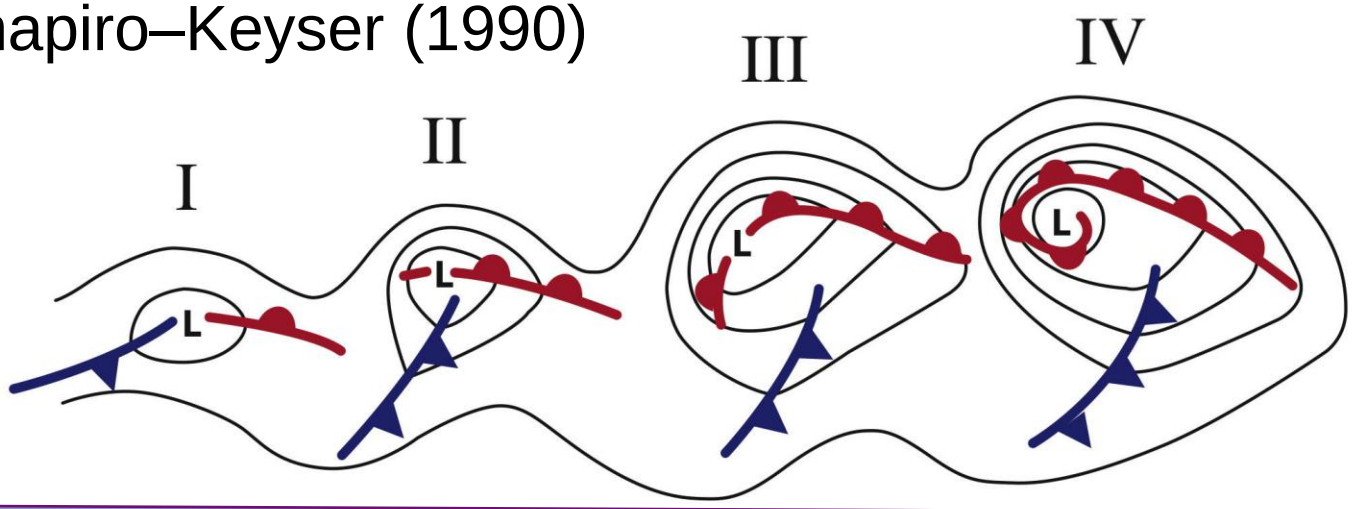
(Doswell 1984, 1985; Davies-Jones 1985; Schultz et al. 1998)

Wrap-up explains long spiral occluded fronts.



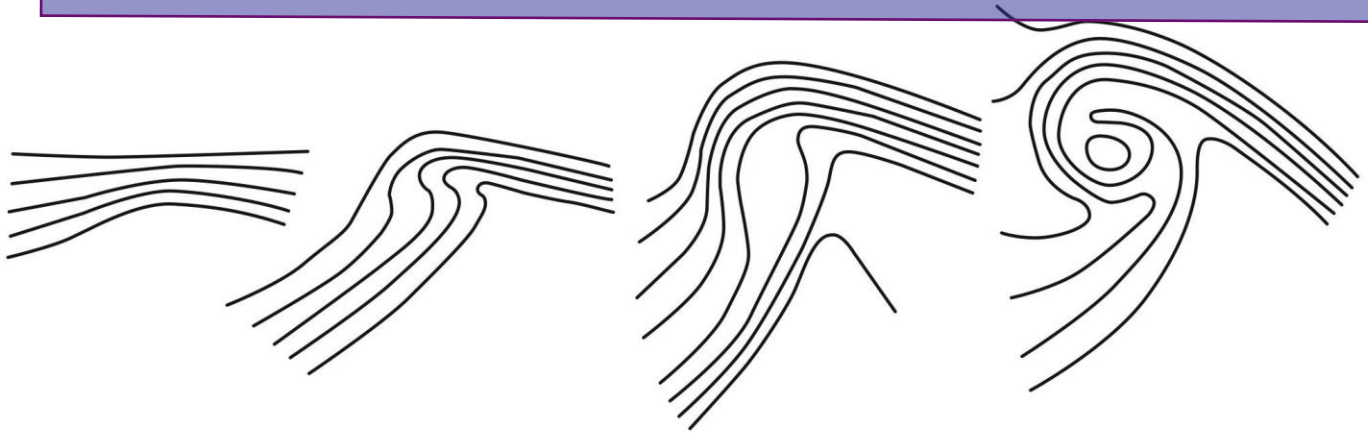
Wrap-up allows the occlusion process to be incorporated in other cyclone models.

Shapiro–Keyser (1990)



isobars

90° between cold and warm fronts



isotherms

Wrap-up is a better description of the occlusion process than catch-up.

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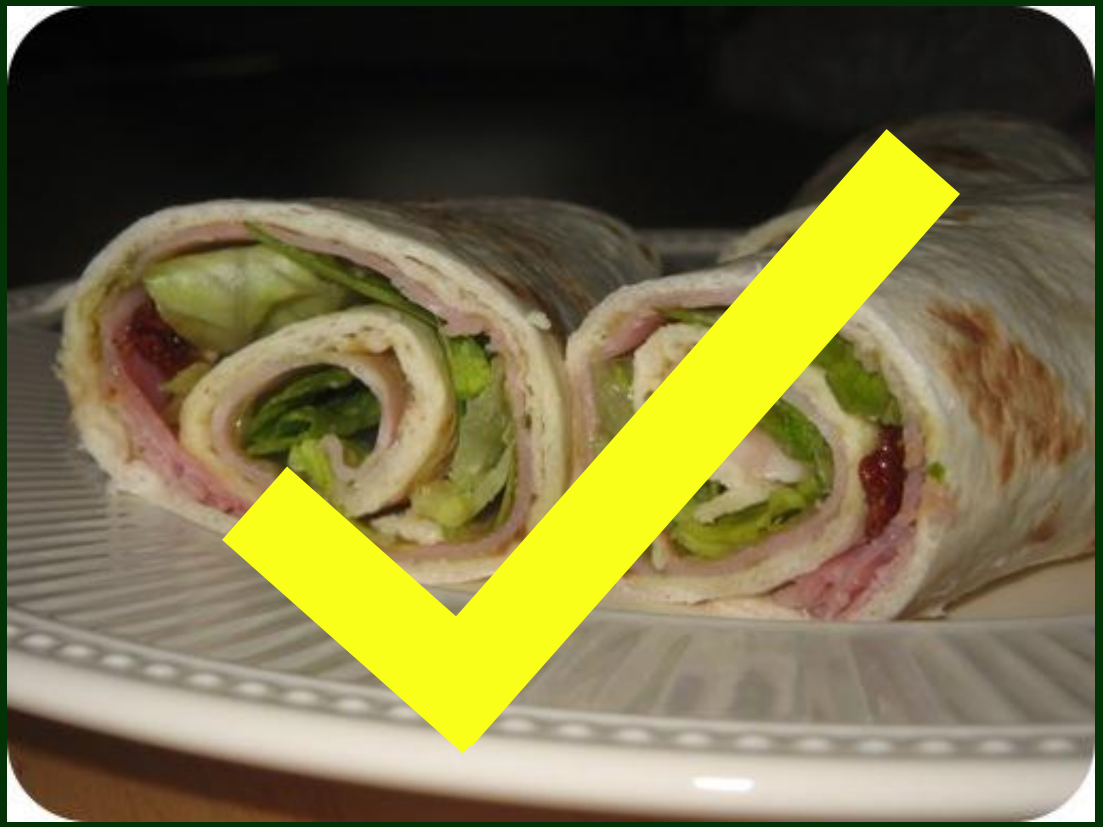


Why is so much conventional wisdom wrong?

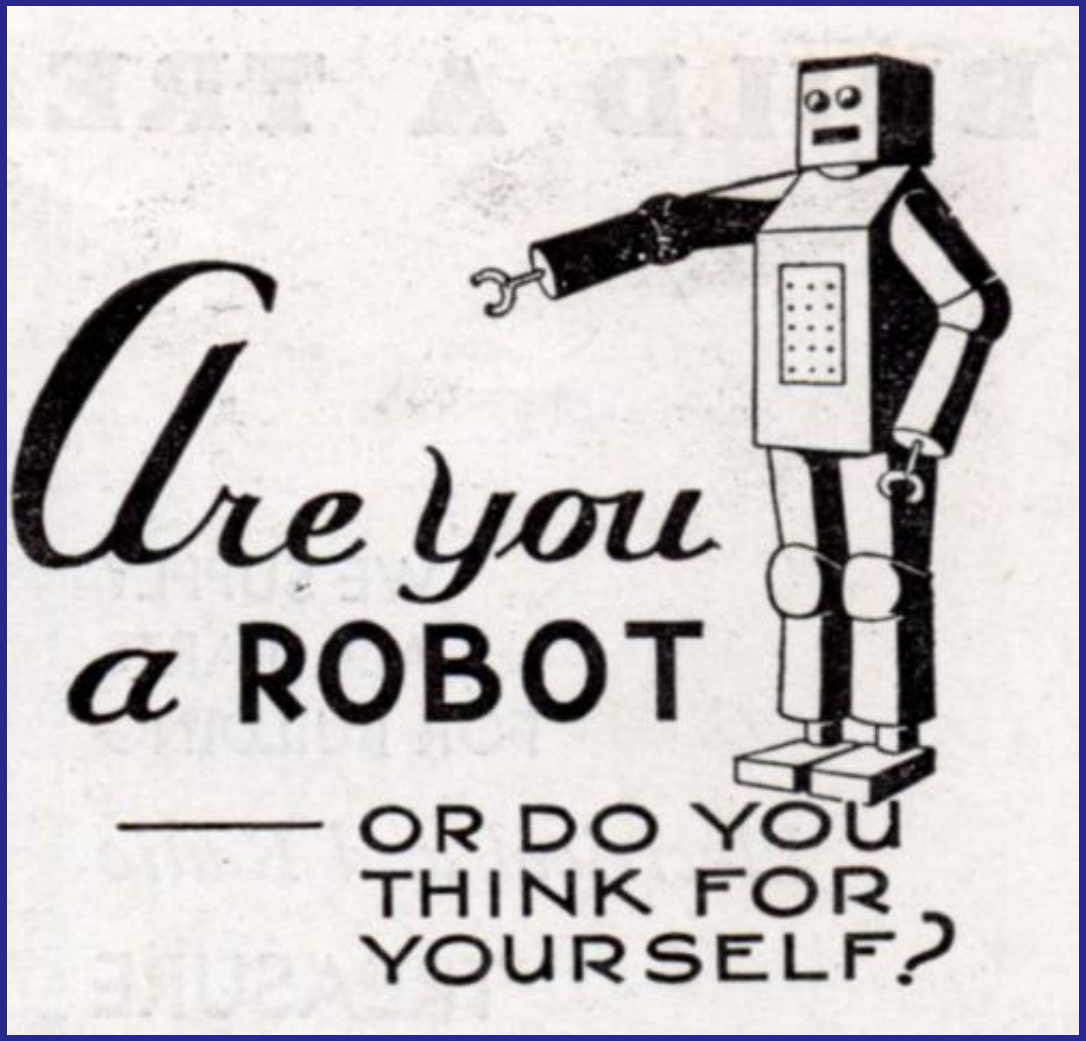
1. Interesting research questions are just laying around waiting to be discovered.

   All the good research has NOT been done.

2. A wide variety of frontal structures and evolutions are possible.

Don’t pigeonhole your data into outdated or irrelevant conceptual models.

3. Think for yourself. Question textbooks and the previous literature.



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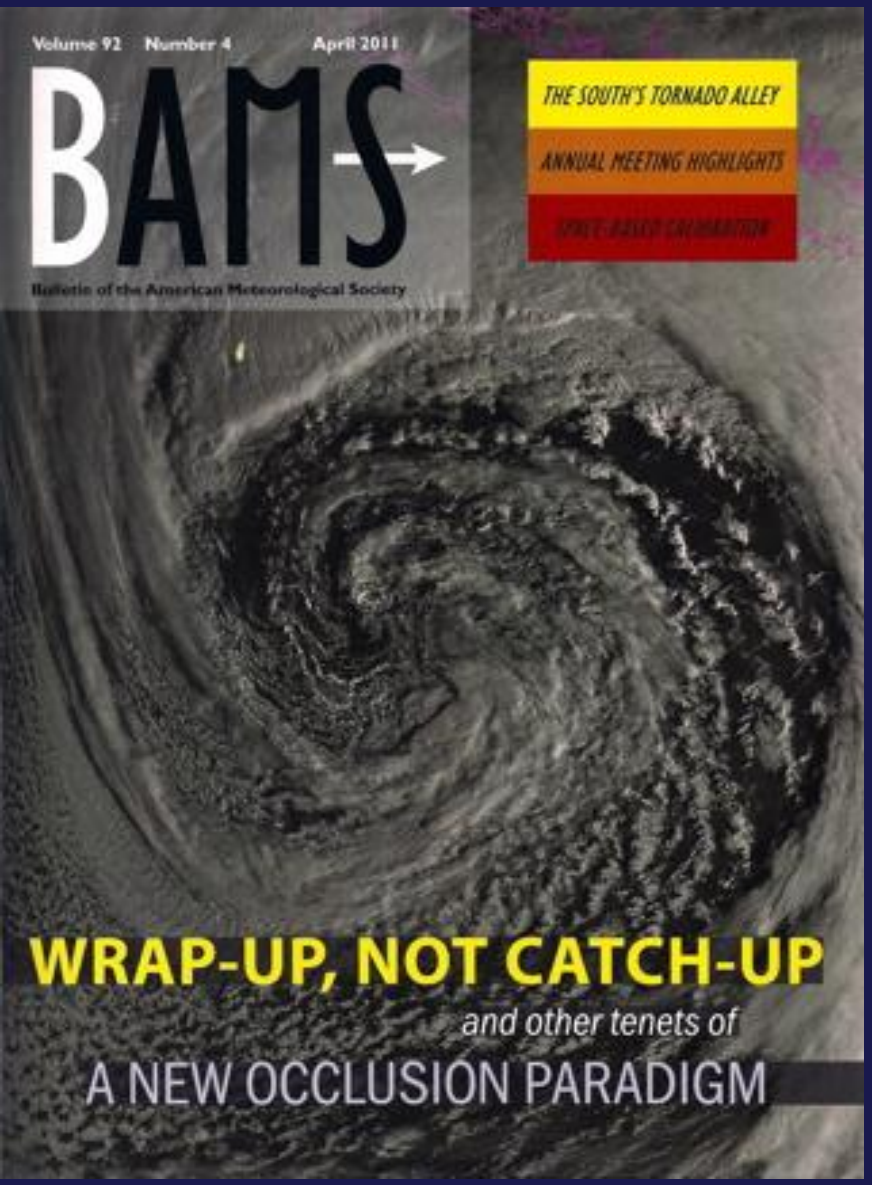

Occluded Fronts: A Fresh Look at Conventional Wisdom

David Schultz

Universities of Manchester and Helsinki, Finnish Meteorological Institute

Geraint Vaughan

National Centre for Atmospheric Science, University of Manchester

April 2011,

Bulletin of the American Meteorological Society

Conceptual models are abstractions of weather phenomena used for teaching and research.

- Give scientists and forecasters a common language
- Synthesize lots of data and analysis into a visual schematic.
- Distill important processes and structures
- Omit unimportant details and variability among individual cases

Conceptual models are susceptible to misinterpretation and over-interpretation.

- Weak link to physical understanding
- Omission of important details and case-to-case variability
- Focus on classification rather than physical processes

  Example: What is a front?

- Unusual cases forced into an inappropriate model