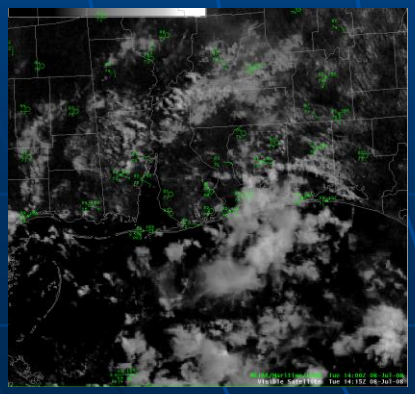
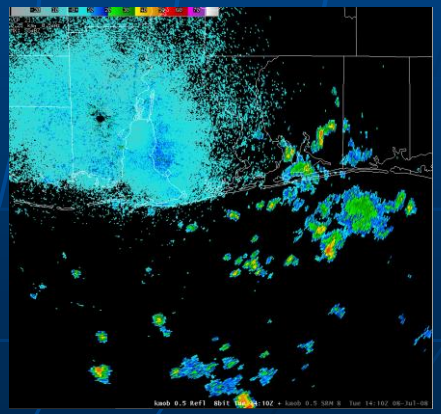
Waterspout Forecasting

A Gulf Coast Perspective and Modern Day Look



Jeffrey M. Medlin
NOAA - NWS Forecast Office
Mobile, AL

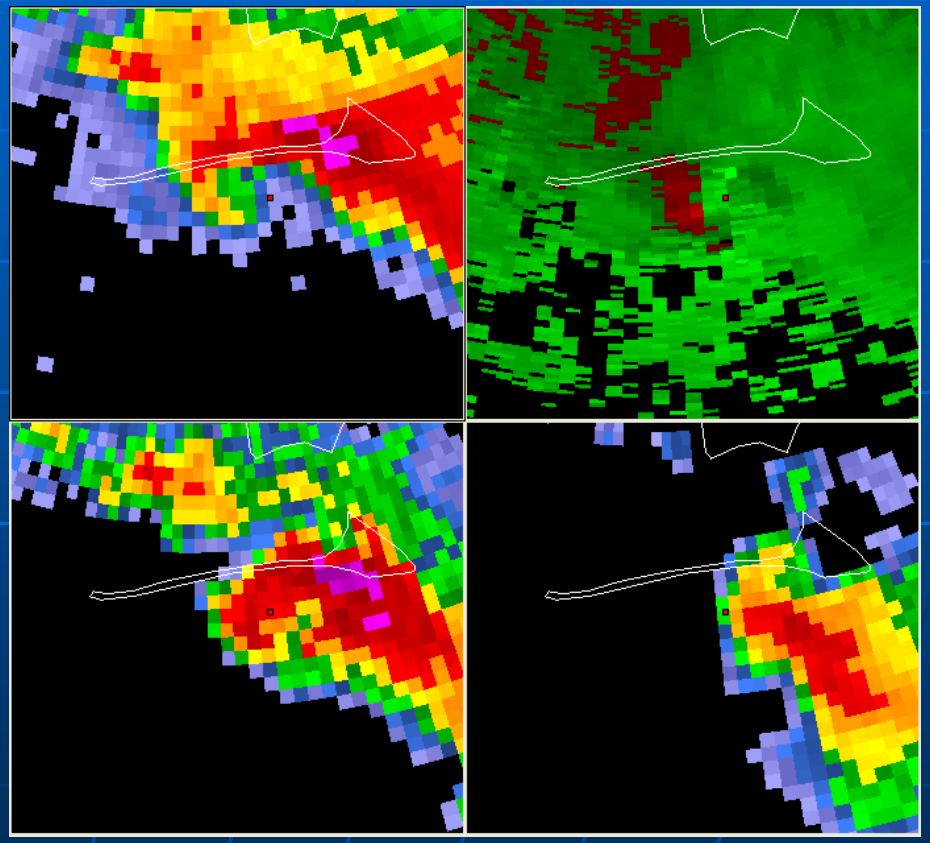
Jeffrey F. Garmon
NOAA – NWS Forecast Office
Cheyenne, WY



Tornado over the water…

Possesses a *parent mesocyclone*: a much different animal.

Image Courtesy of WKRG TV, Mobile AL



Waterspouts…

- Wind speeds are more often under 100 KT. But…even these weaker circulations can cause damage and injury. [EF0 -> 65-85 mph, EF1-> 86-100 mph – most of what I've seen in 20+ years!]
- On days of deeper instability forming over zones of stronger convergence…they can become quite strong with winds over 100 KT…posing a much greater hazard.
- Several documented cases of waterspouts producing EF1/F-1 damage.

Mesocyclone versus Misocyclone

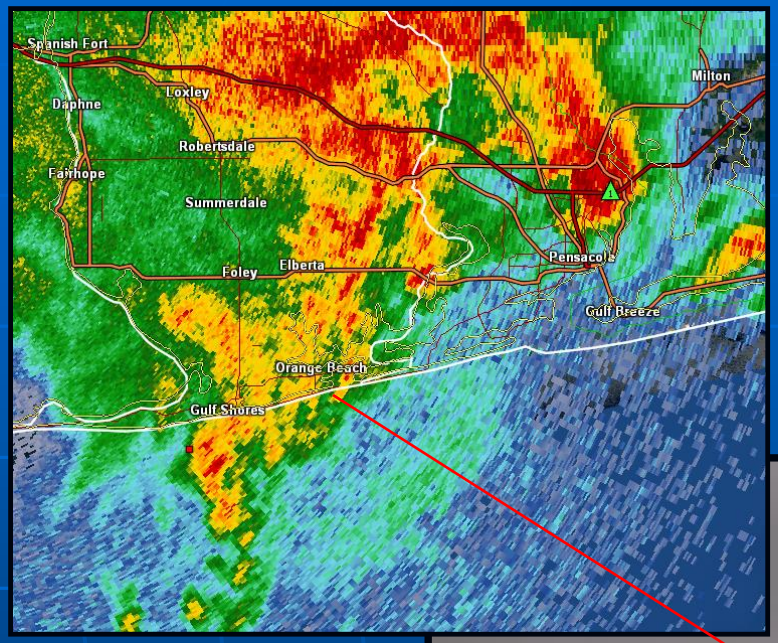
Tornadoes form under two regimes (Fujita, 1981)

- Mesocyclone (diameter >4 km) "Supercell"
- Misocyclone (diameter < 4 km) "Non-Supercell"

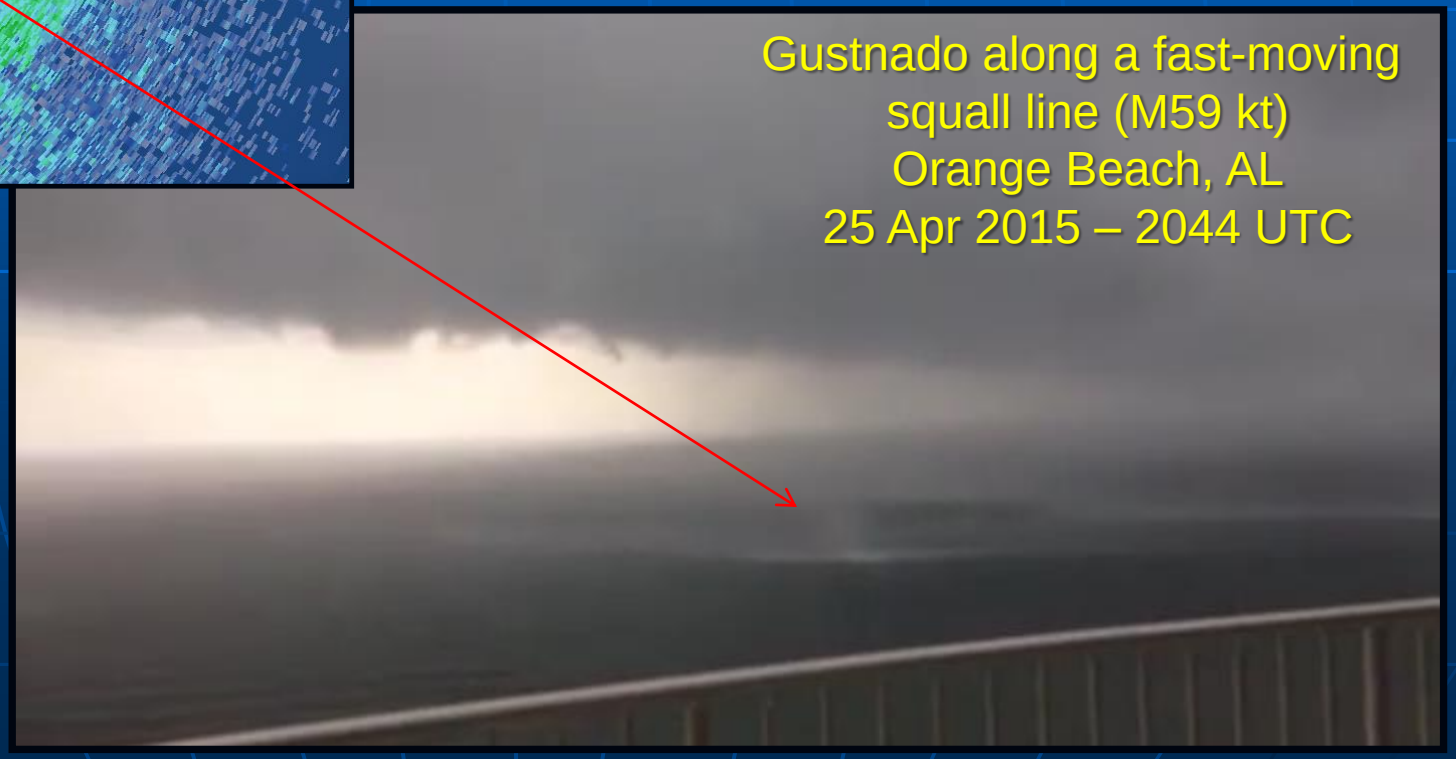
Misocyclone circulations are the most probable mode of formation for:

- "landspouts" (Bluestein, 1985) and
- **"waterspouts"** (Wakimoto and Wilson, 1988).

Not a gustnado either! . . .



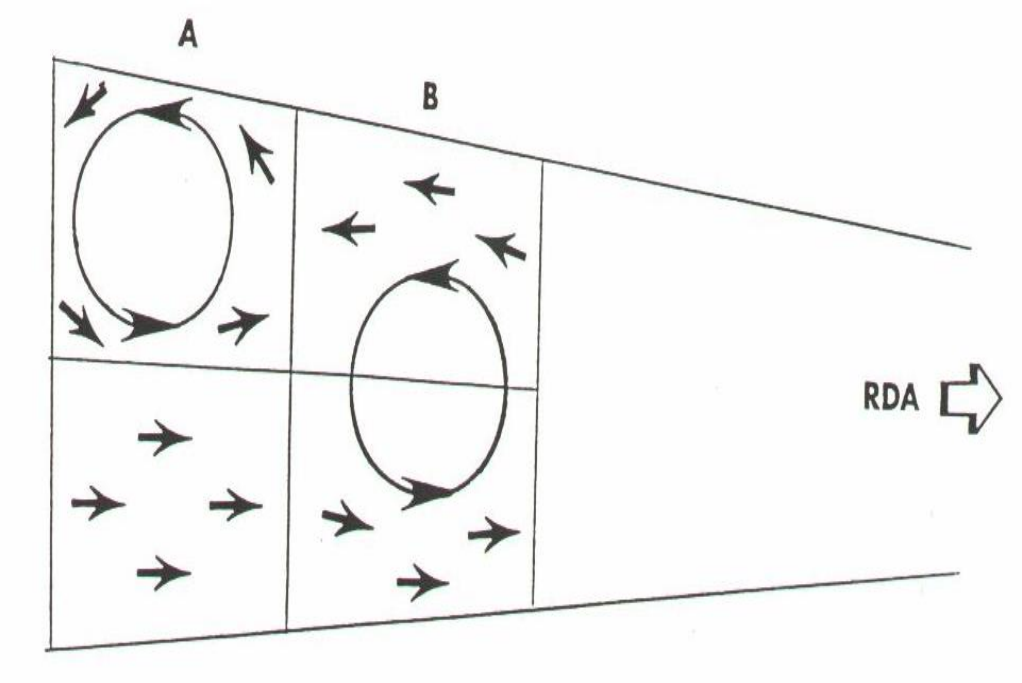
Although some similarities!



Gustnado along a fast-moving squall line (M59 kt)
Orange Beach, AL
25 Apr 2015 – 2044 UTC

Radar Observation of the Circulation

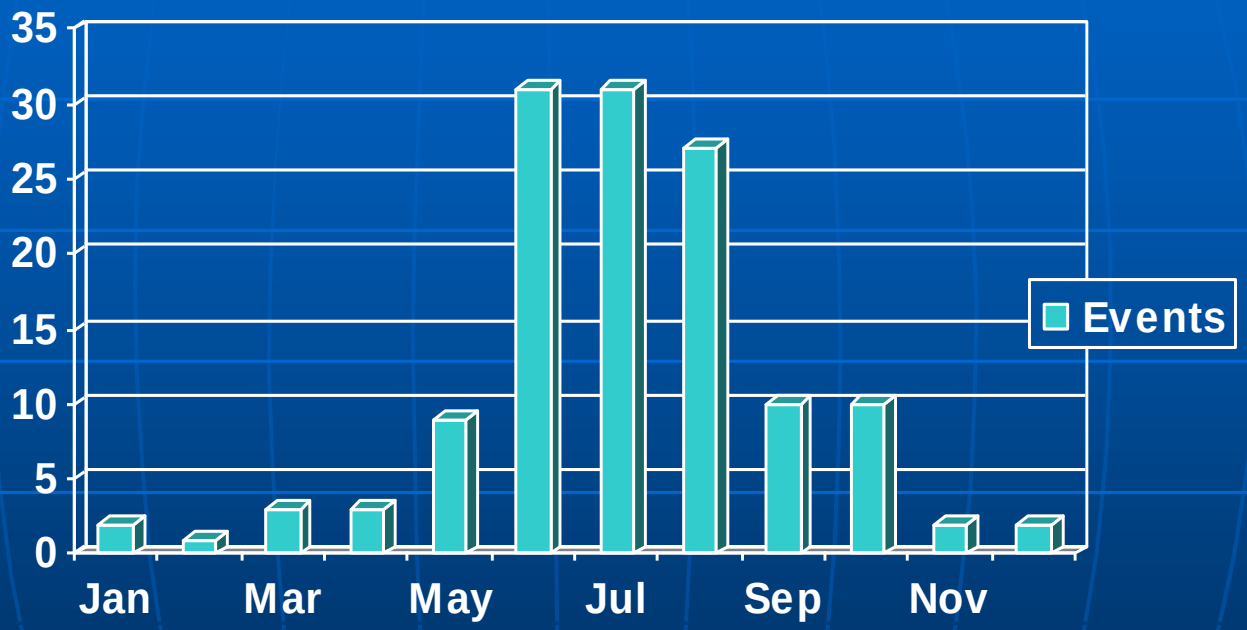
Aspect Ratio (core dia. / beam width) prevents sampling of the phenomena much beyond 40 km



In sample "A"…SW values would likely be high…a tip off!

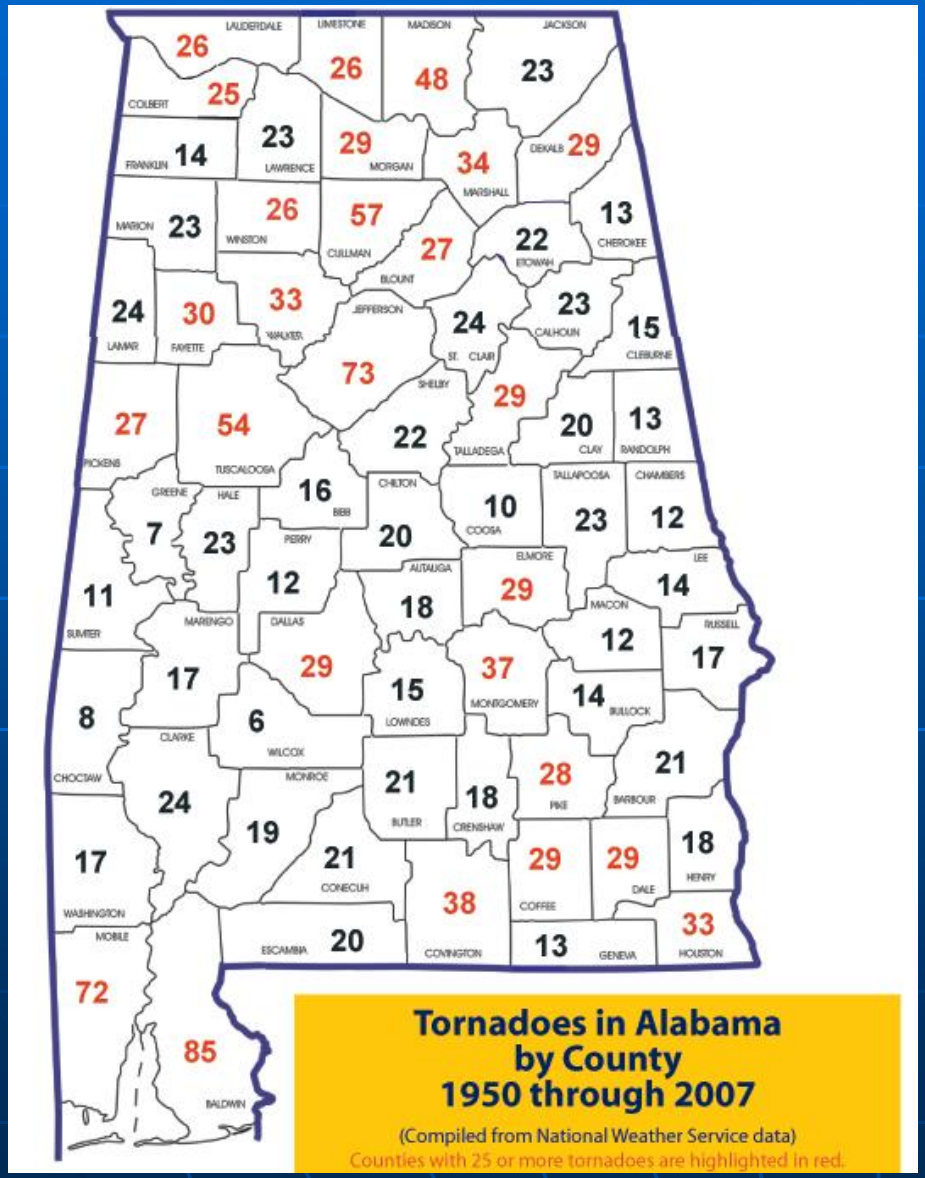
Waterspout circulation is much more ***shallow*** and is ***smaller***…therefore it will involve significant sampling issues due to beam elevation and beam width with range.

Climatology…



NWS Storm Data – NCDC database period 1995-2007
Mobile, Baldwin, Escambia, Santa Rosa, and Okaloosa Counties

Landfalling waterspouts reported as tornadoes…

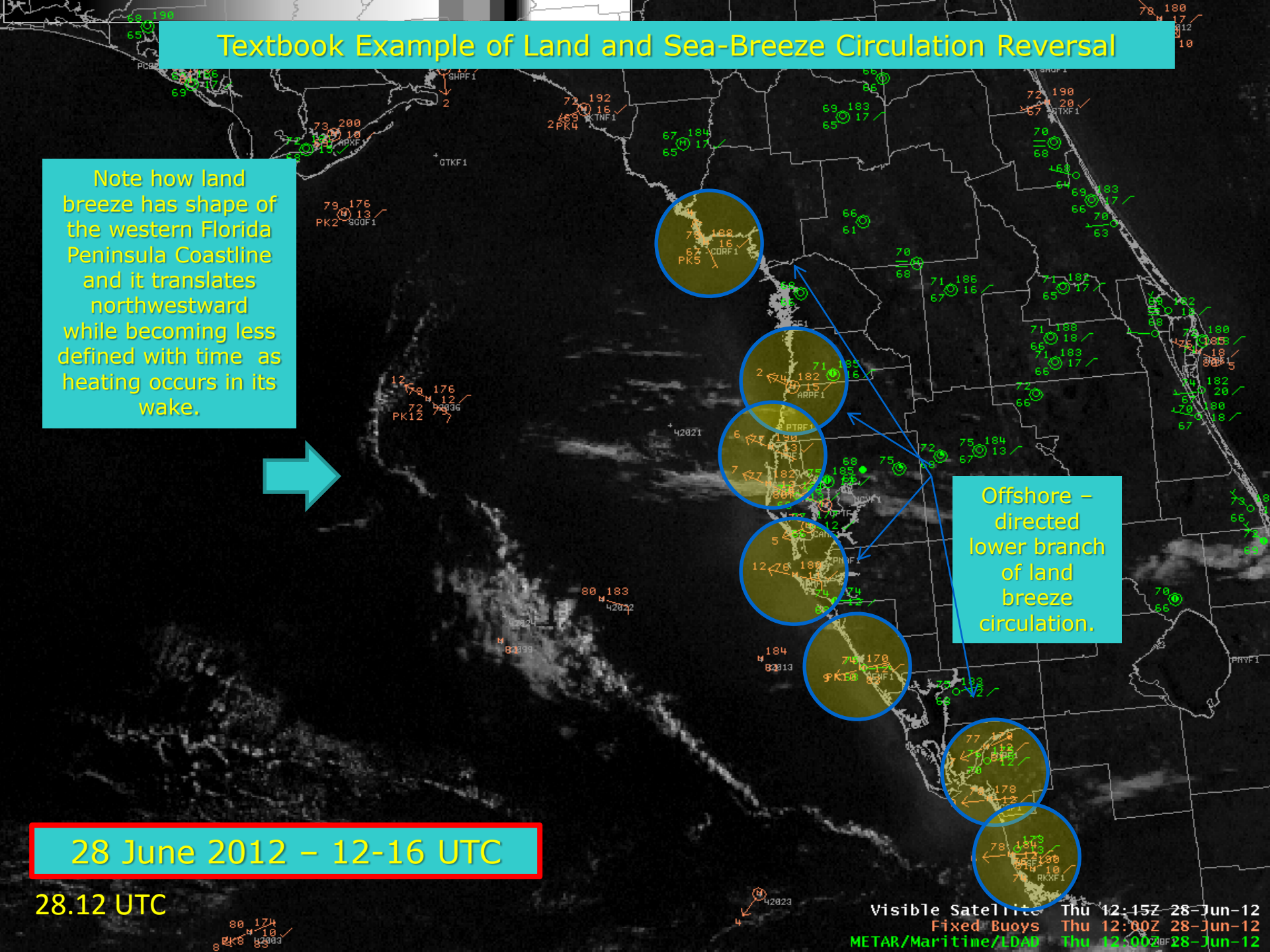


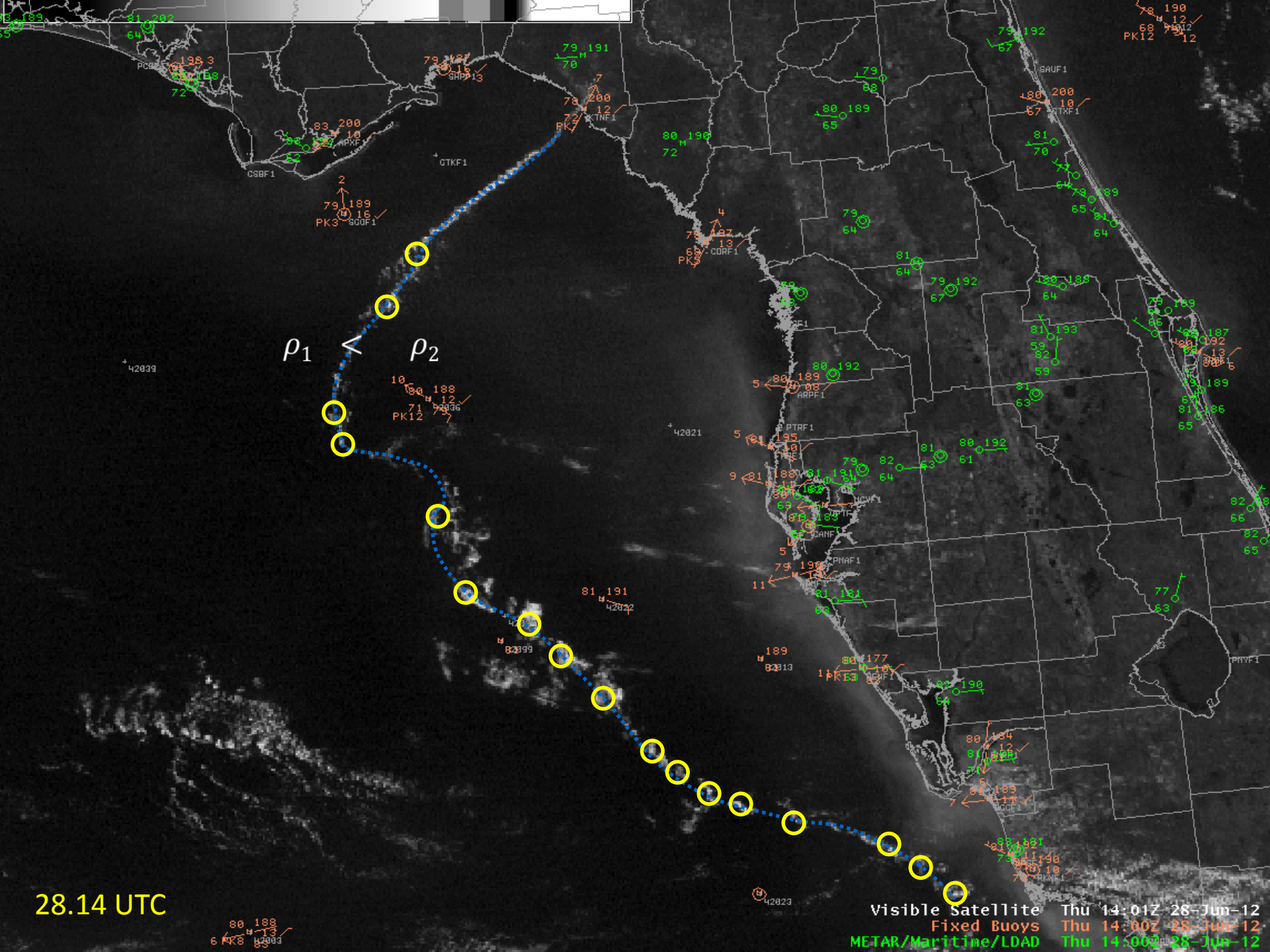
A significant number of the warm season coastal “tornadoes” in the historical database are in fact land-falling “fair weather” waterspouts.

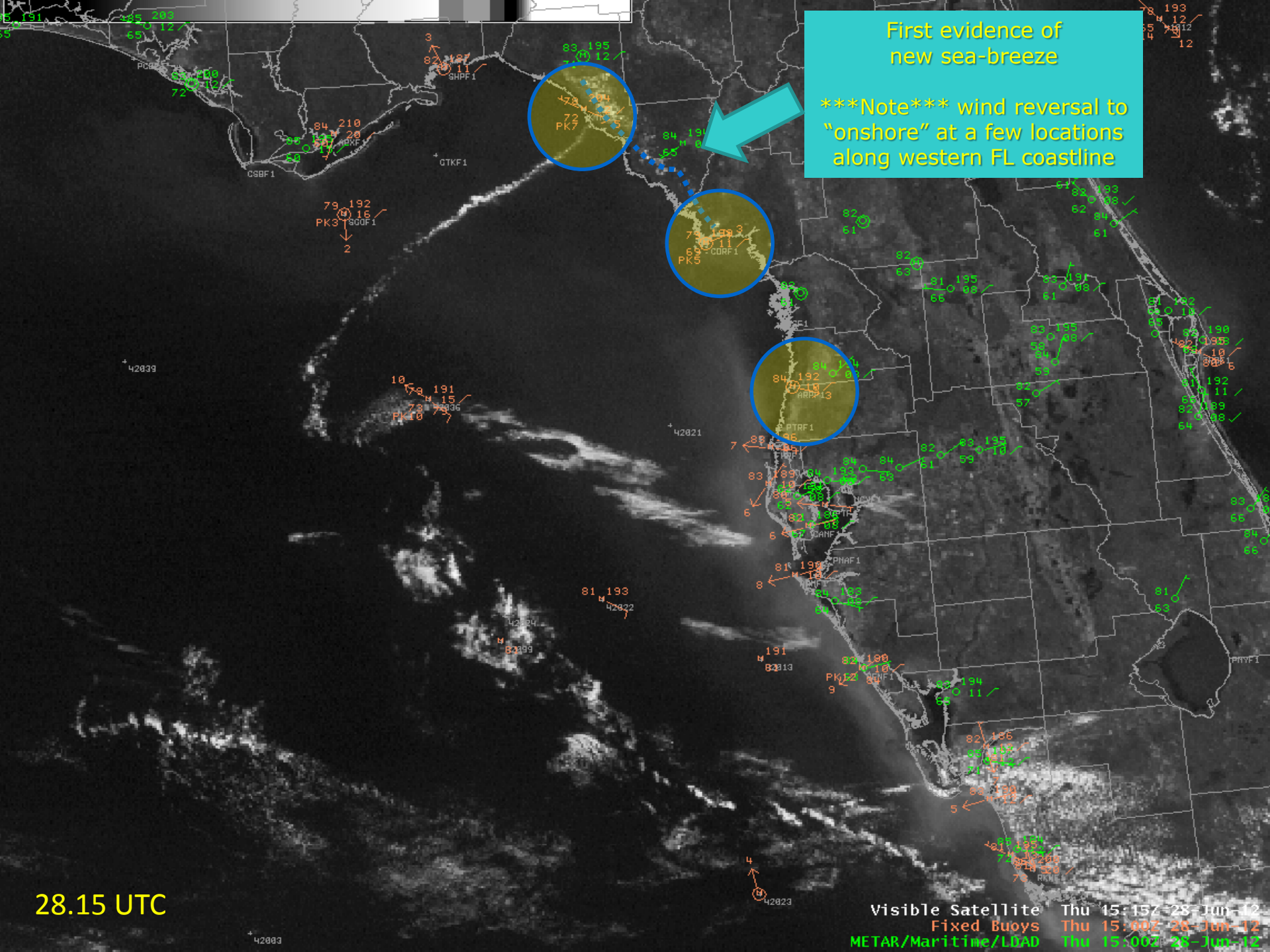
Landfalling waterspouts reported as tornadoes…

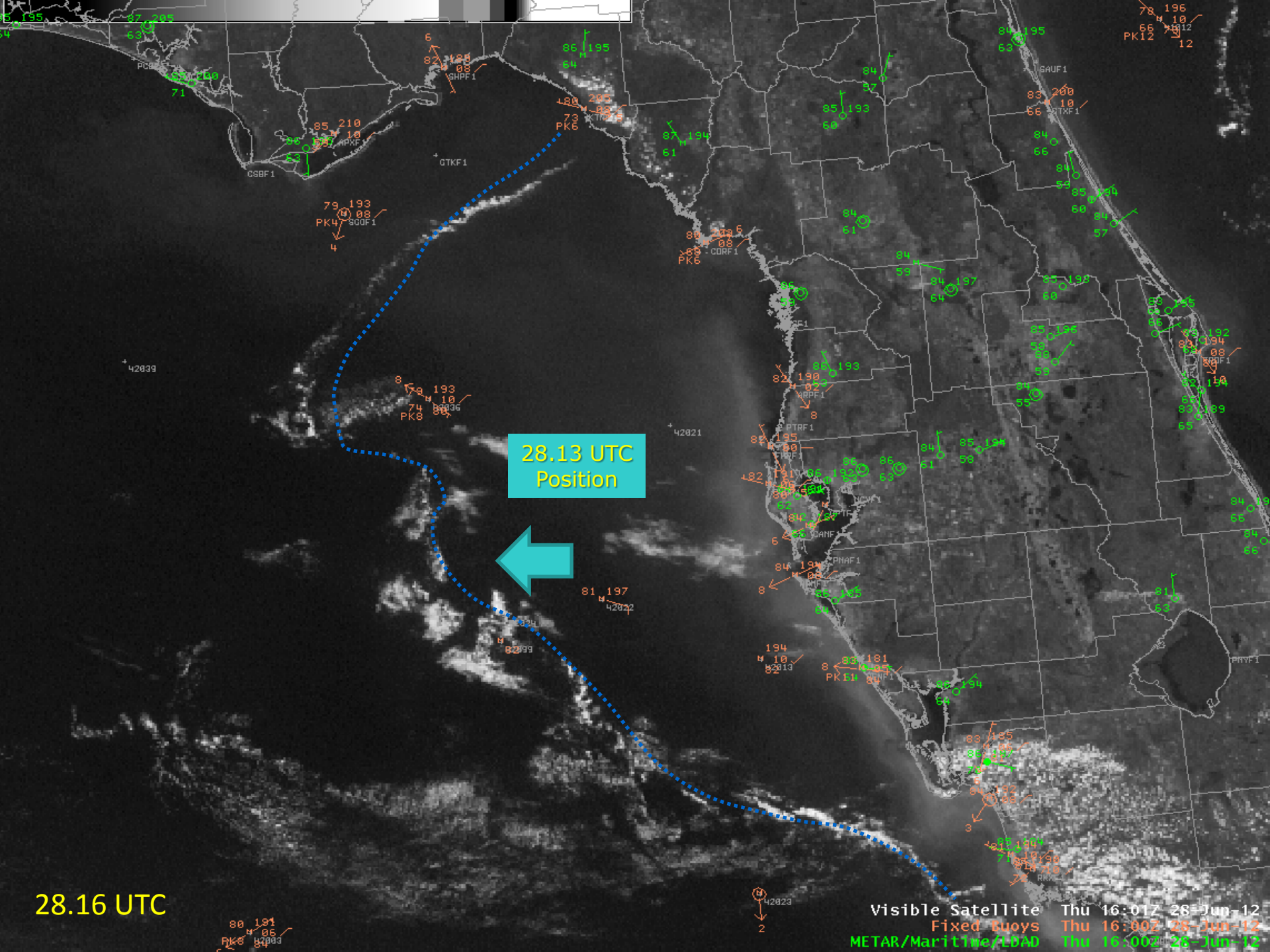
- A preliminary study conducted back in the 2003-2007 time frame revealed over half the time, when one waterspout was reported there were two or more (unpublished, Medlin and Caceres).
- There is a reason for this!

Textbook Example of Land and Sea-Breeze Circulation Reversal




$\rho_1 < \rho_2$
28.14 UTC
Visible Satellite Thu 14:01Z 28-Jun-12
Fixed Buoys Thu 14:00Z 28-Jun-12
METAR/Maritime/LDAD Thu 14:00Z 28-Jun-12


First evidence of
new sea-breeze
Note wind reversal to
"onshore" at a few locations
along western FL coastline
28.15 UTC
Visible Satellite Thu 15:15Z 28-Jun-12
Fixed Buoys Thu 15:00Z 28-Jun-12
METAR/Maritime/LDAD Thu 15:00Z 28-Jun-12


28.13 UTC
Position
28.16 UTC
Visible Satellite Thu 16:01Z 28-Jun-12
Fixed Buoys Thu 16:00Z 28-Jun-12
METAR/Maritime/LDAD Thu 16:00Z 28-Jun-12

Waterspouts…

- Formation aided by…
  - pre-existing vertical vorticity maxima (e.g., existing along a nocturnal land breeze boundary) which become coincident with…
  - low-level updrafts with TCu forming along the boundary.

- Waterspouts have been observed to occur along thunderstorm outflow boundaries and are formed by a similar process.

- Another requirement for their occurrence is unstable airmass which enhances boundary layer updrafts, resulting in vortex stretching.

Misocyclone formation…

Wakimoto and Wilson, 1989

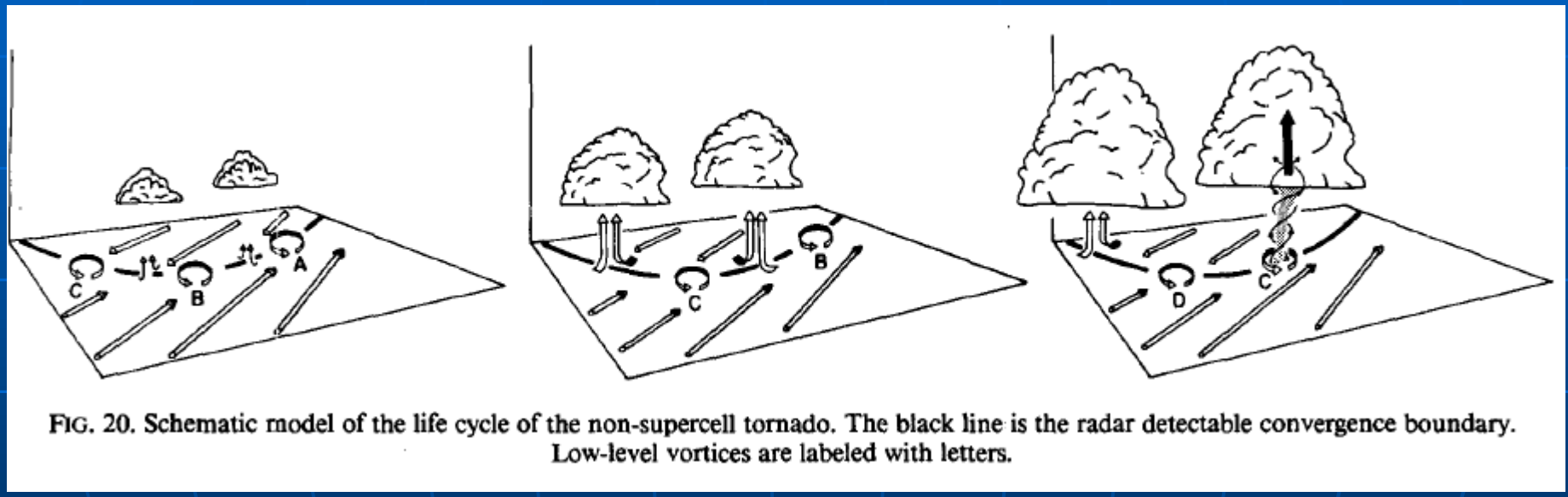


FIG. 20. Schematic model of the life cycle of the non-supercell tornado. The black line is the radar detectable convergence boundary. Low-level vortices are labeled with letters.

In the case of most waterspouts…these boundaries can be an attendant land-breeze, seabreeze, or outflows from nearby convection.

Misocyclonic formation…

Wakimoto and Wilson, 1989

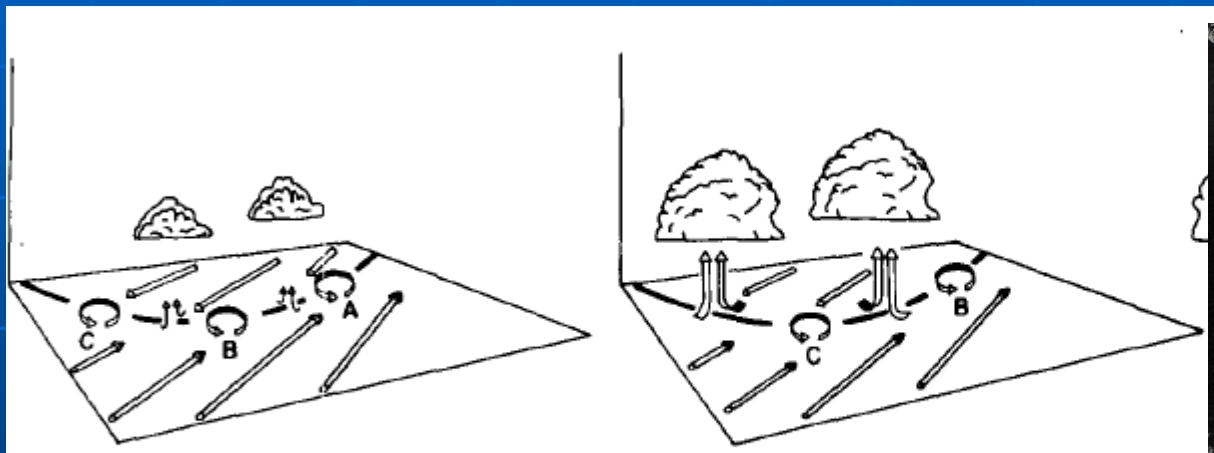
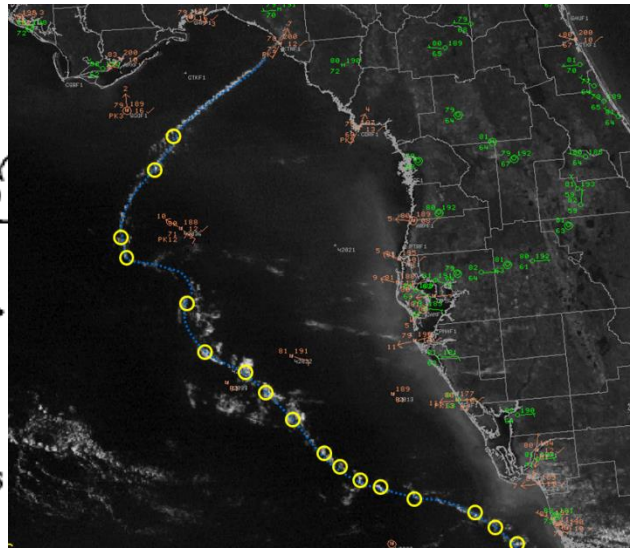


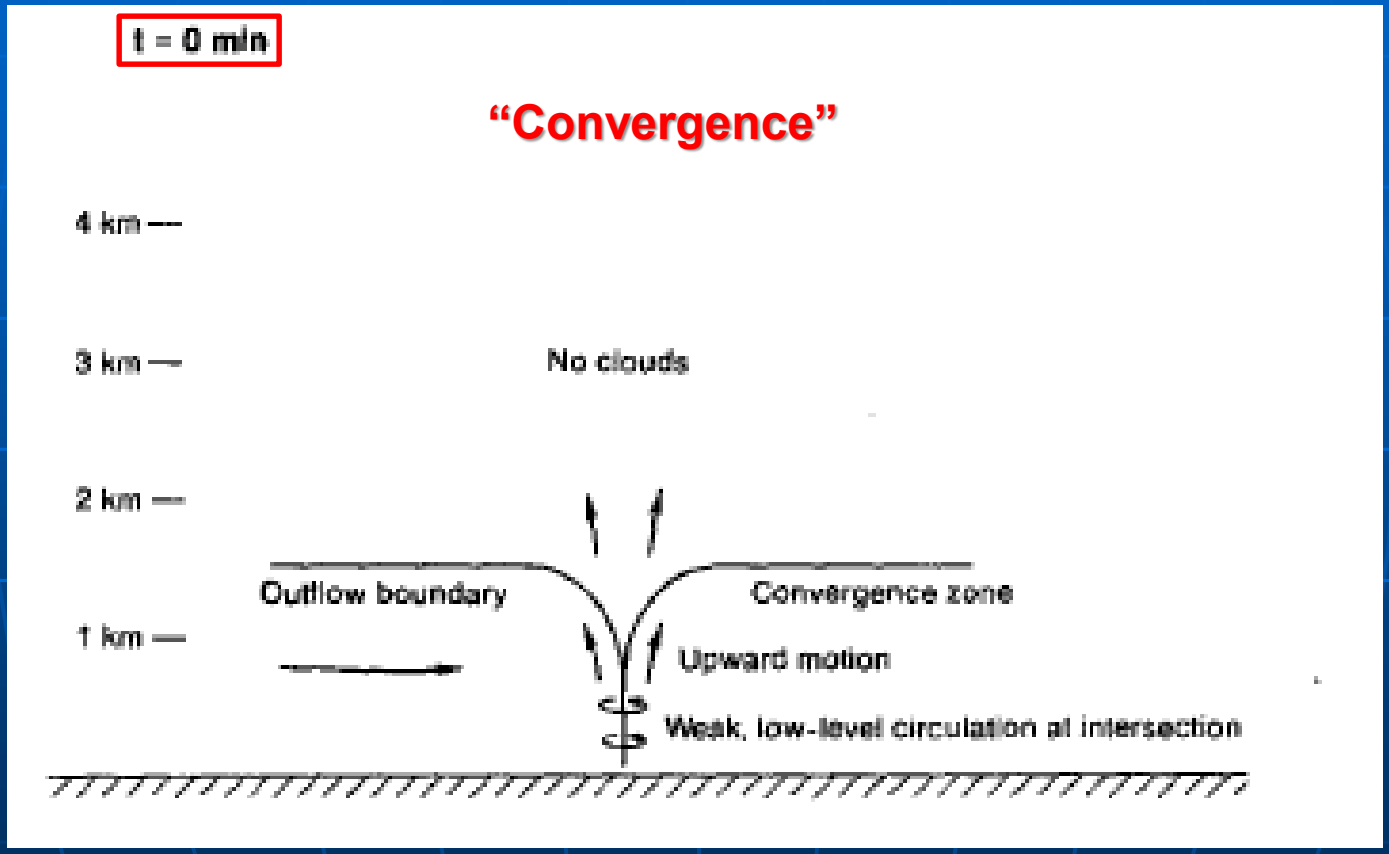
FIG. 20. Schematic model of the life cycle of the non-supercell tornado. The black line is
Low-level vortices are labeled with letters.



See the link!

How most waterspouts form…

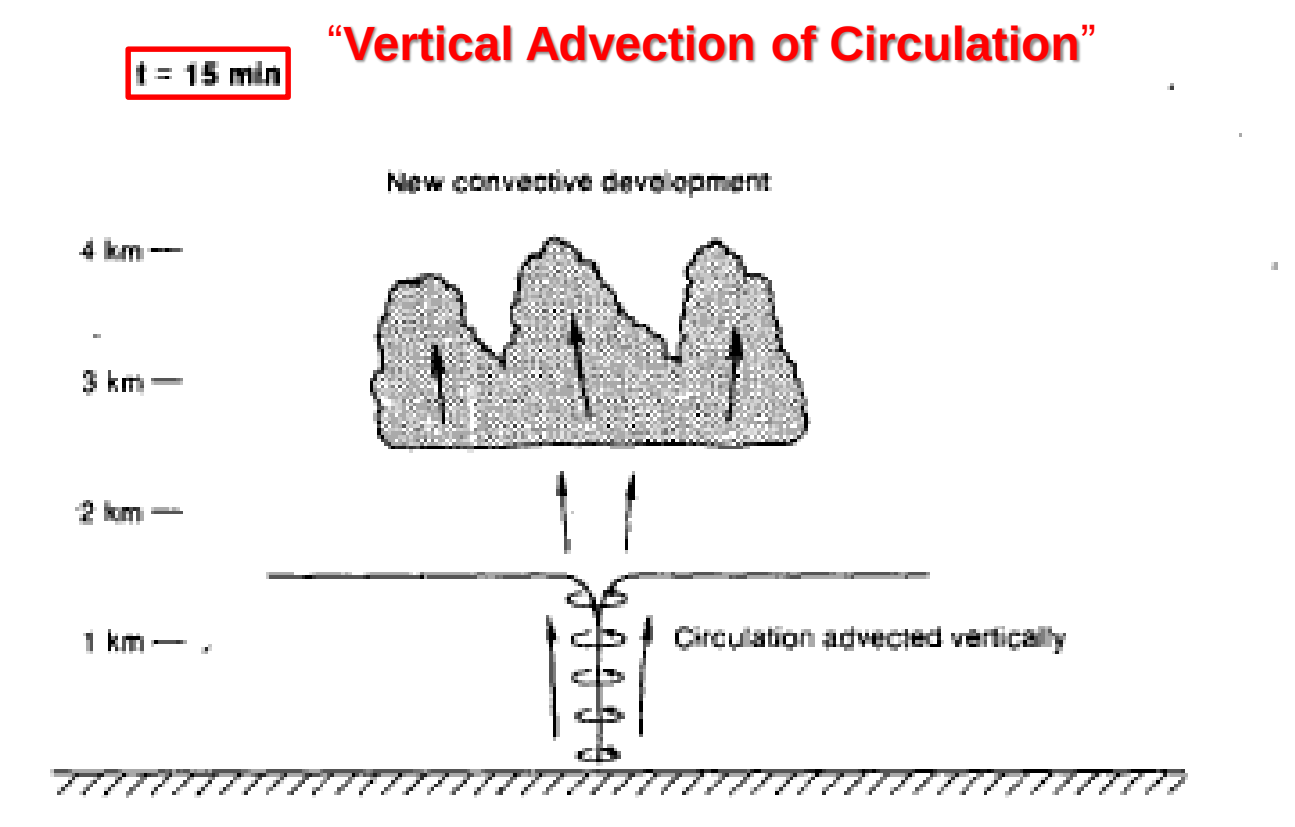
Brady and Szoke, 1989



Land-breeze or intersecting outflow boundaries establish zone of weak low level horizontal circulation

How most waterspouts form…

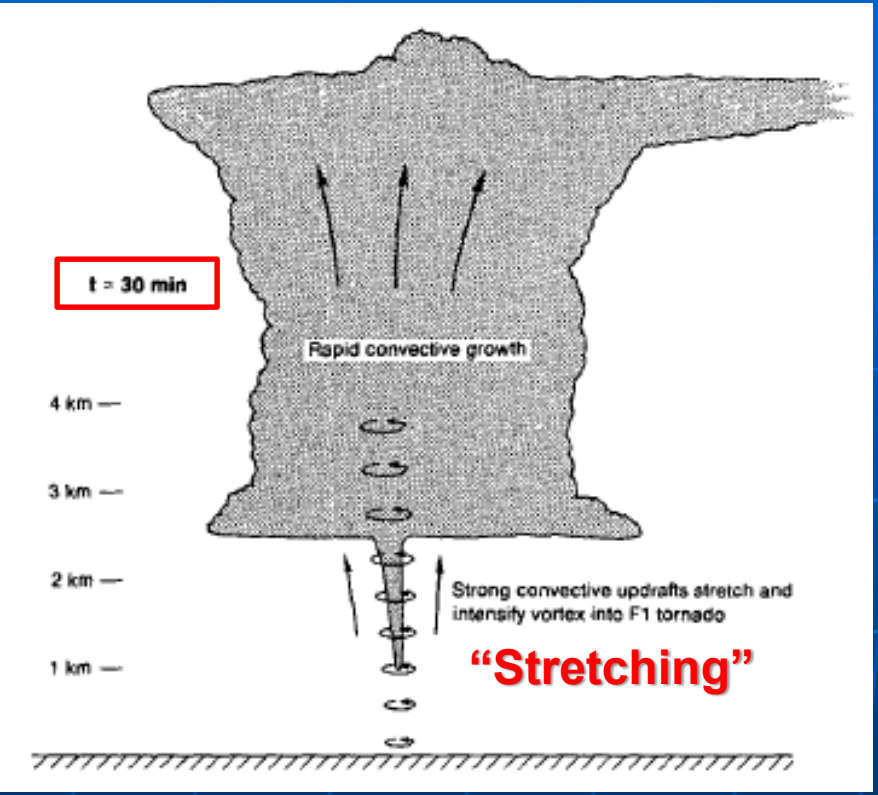
Brady and Szoke, 1989



TCu forms along the convergent line…and updrafts with the TCu lift and stretch the horizontal circulation into the vertical.

How most waterspouts form…

Brady and Szoke, 1989



As the updraft increases, it stretches, tightens and strengthens the vortex.
As the vortex velocity increases the condensation funnel forms.