The Process of Occlusion

Atmos 5110/6110
Synoptic-Dynamic Meteorology I
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Supplemental Reading: Schultz and Mass (1993), Schultz and Vaughan (2011)
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Objections to the NCM Occlusion

• Structures resembling an occlusion can be present without a pre-existing warm sector

• The so-called “occluded front” is often drawn from the peak of the warm sector to the low center without evidence that the process of occlusion occurred
  • “The occlusion is added as an accretion”

• There is often little or no temperature gradient across an occlusion at the surface
  • The largest gradients are often aloft

Source: Schultz and Mass (1993)

Outstanding Questions

• Do cyclones ever occlude in a classical manner in which the cold front catches up to the warm front?
  • A: Yes!

• Can occlude structures form from non-classical mechanisms
  • A: Yes!

• Might there be a better way to conceptualize the occlusion process
  • A: Probably!

Source: Schultz and Mass (1993)

Evolution of Ideal Occlusion

Pre-existing warm & cold fronts
Warm sector narrows as cold front overtakes warm front
Occlusion lengthens as warm & cold fronts “zipper”
**Vertical Structure**

- **HR 18**
  - Distinct warm and cold fronts
  - Intervening warm sector
  - Cold & upper level fronts somewhat distinct

- **HR 24**
  - Warm sector narrows
  - Cold & upper-level fronts merge

**Source:** Schultz and Mass (1993)

- **HR 30**
  - Cold & warm fronts meet, forming warm-type occlusion

- **HR 33**
  - Upper-level cold front continues to move downstream, forming elevated cold front of the occlusion

**Source:** Schultz and Mass (1993)

**Vertical Structure**

- **Key points**
  - Surface-based cold front catches warm front in classical manner
  - Cold front does not "ride up" over warm front
  - Upper-level frontal zone provides elevated cold-front of the occlusion

**Source:** Schultz and Mass (1993)

**Airflow**

- **Sfc trajectories** show confluence of air across occlusion
- **Air within warm tongue aloft originates in warm sector (40, 42, 47, 56)**
- **Warm sector air removed from SFC**

**Source:** Schultz and Mass (1993)

**Non-Classical Occlusion**

- **Deeply occluded system with warm-core seduction**
- **Front forms from “occludogenesis” rather than catch up**
- **Wind fields generate the warm tongue & seduction**

**Source:** Kuo et al. (1992)

**Non-Classical Occlusion**

- **Confluence of trajectories along occlusion**
- **“Crossing” of post-occlusion trajectories**
  - #5 starts in south in warmer air than 13. #5 ends in seclusion.
- **Seduction forms from the “wrapping” of cold air originating in warm/occluded frontal zone**

**Source:** Kuo et al. (1992)
Conventional Wisdom

- The occluded front forms and lengthens as the cold front overtakes the warm front.
- The occlusion may be warm or cold type depending on the temperatures behind the cold front and ahead of the warm front.
- The formation of an occlusion signifies an end to the cyclone deepening phase.
- The occluded front features the pre-frontal weather of a warm front (widespread clouds and precipitation) and the post-frontal weather of a cold front (clear skies and drying).

Catch-Up Process

- Question
  - Is the catch-up process an explanation of occlusion formation or a consequence of the underlying physical process?
- Alternative Answer
  - Lengthening and narrowing of warm tongue, and catch-up of cold and warm fronts better explained by deformation and rotation around low center.

Warm and Cold Type Occlusion

- Temperature “rule” for occlusion formation doesn’t work because fronts are not zero order discontinuities in temperature.
- Static stability is a better discriminator for occlusion type (low static stability goes over high)
  - Explains why warm-type is more common
    - Cold front is usually less stable
  - Suggests that cold-type occlusions may be more common in areas where warm fronts tend to be weak (e.g., California).
Occlusion Ends Cyclone Deepening

- Norwegian Model
  - Occlusion indicates end of deepening phase because cyclone no longer has access to potential energy stored in warm sector
    - “After the occlusion, the cyclone soon begins to fill up” (Bjerknes and Solberg 1922)
  - Reality
    - Cyclones often deepen after occlusion formation
    - Cyclogenesis better viewed from QG or PV perspective

Source: Schultz and Vaughan (2011)

Occlusion Weather and Precip

- Norwegian Model/CW
  - Occlusions are associated with widespread clouds/precip followed by clearing after surface frontal passage
  - Reality
    - Occlusions are associated with a variety of cloud/precip patterns, including dry slots and banded precipitation

Source: Schultz and Vaughan (2011)

Occlusion Weather and Precip

The Dry Air Stream

Gradients in "weather" not necessarily collocated with surface front
Don’t use back edge of cirrostratus to locate surface front!

Source: Schultz and Vaughan (2011)

Occlusion Weather and Precip

Source: Mass and Schultz (1993), Schultz and Vaughan (2011)

Summary

- Occlusions form as described by Norwegian Cyclone Model (i.e., Catch up)
  - The also form through non-classical processes
  - Formation and lengthening of warm tongue and catch-up process better explained by the wrap-up of the baroclinic zone by deformation and rotation
  - Move into the 21st century
    - Warm/cold type determined by static stability
    - Think QG/PV to understand cyclone development
    - Recognize cloud/precip patterns with occlusions are varied

Source: Schultz and Vaughan (2011)