Observation and Numerical Study of a Winter Storm over Baffin Island

Shunli Zhang[1], John Hanesiak[2] and Dylan Jones[1]

[1]University of Toronto

[2]University of Manitoba

Outline

• Diagnosis of the significant southern Baffin Island snowfall event (17-18 November 2007).

Frontal-cyclone life cycle of the extratropical cyclone

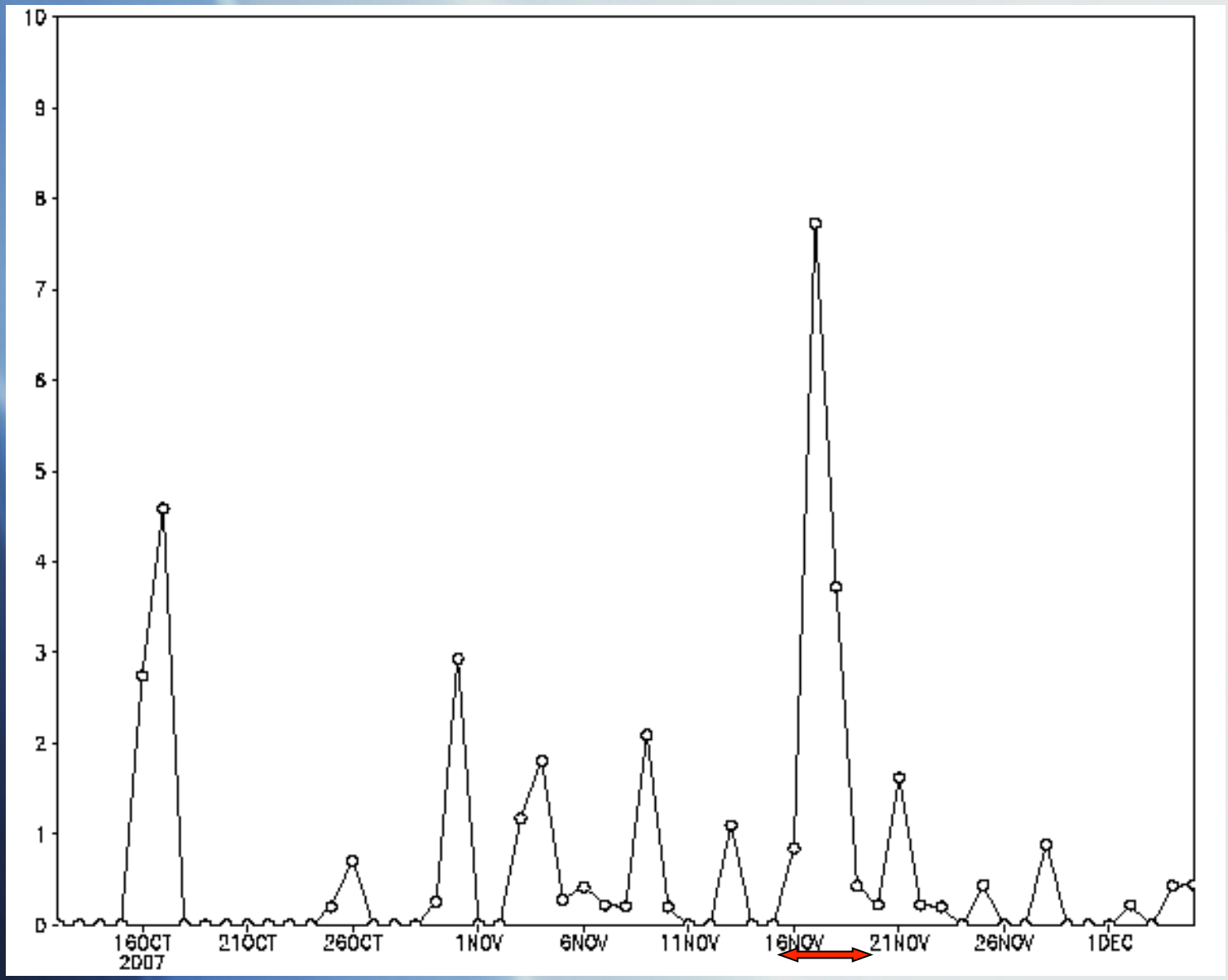
1) thermal evolution 2) cloud evolution

• STAR observations during this event.

•Weather Research and Forecasting model (WRF) simulation

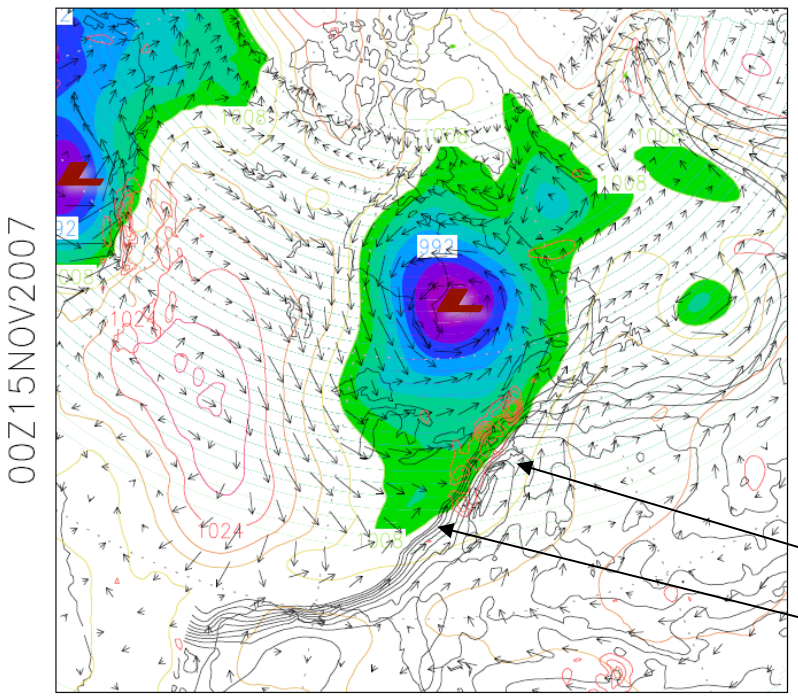
1) Model verification 2) Mesoscale characteristics of precipitation and surface wind

•Conclusions



Daily Precipitation (mm) at Iqaluit

Hourly precipitation (mm) at Iqaluit (transducer 1 and 2)



Sea level pressure

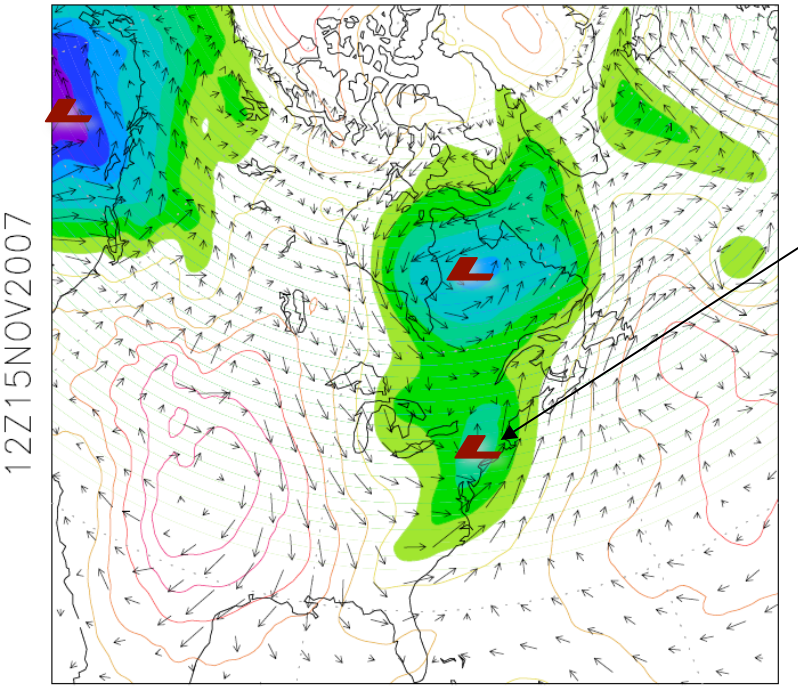
925 hPa temperature

wind vectors

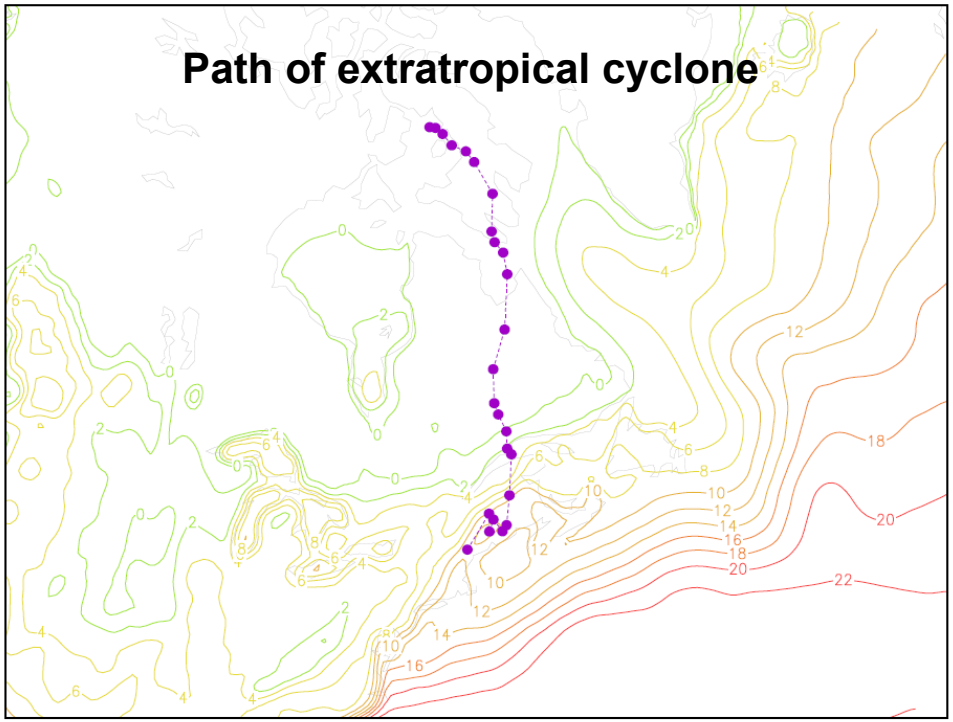
Shadings---extratropical cyclones

Low level upward motion

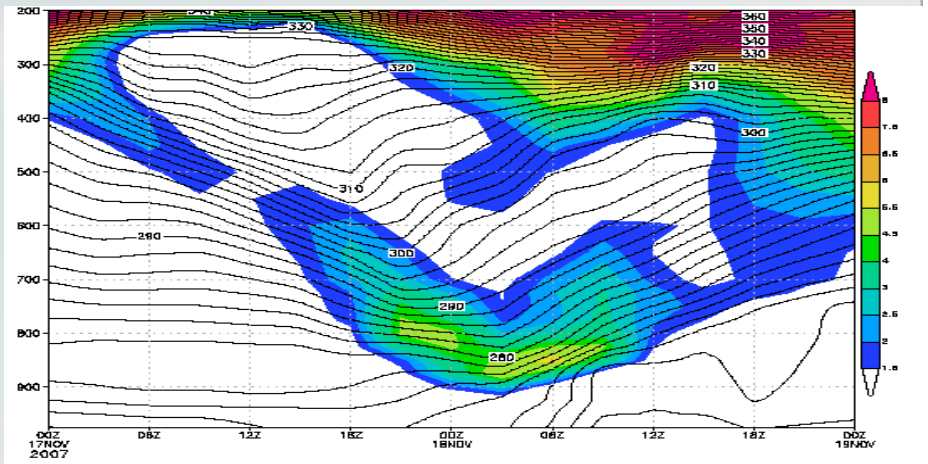
Strong baroclinic zone

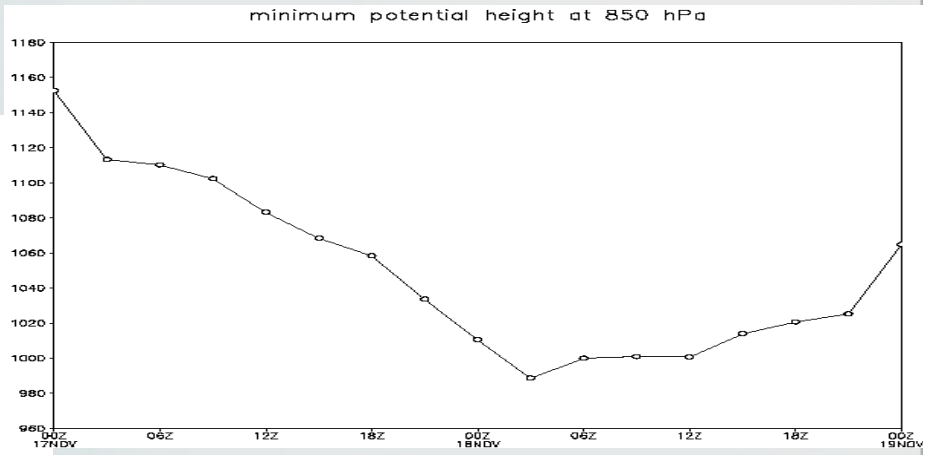


Cyclogenesis



Height-time cross section of PV (shading) and Theta (contour) along Iqaluit from 00Z 17 to 00Z 19 November 2007





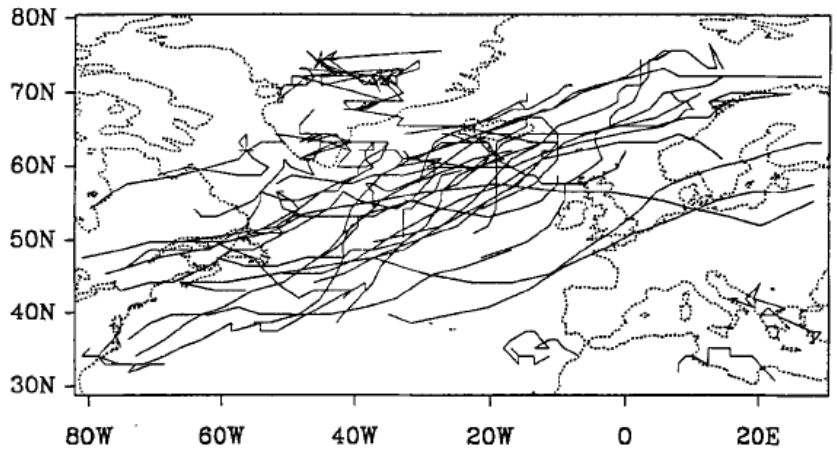
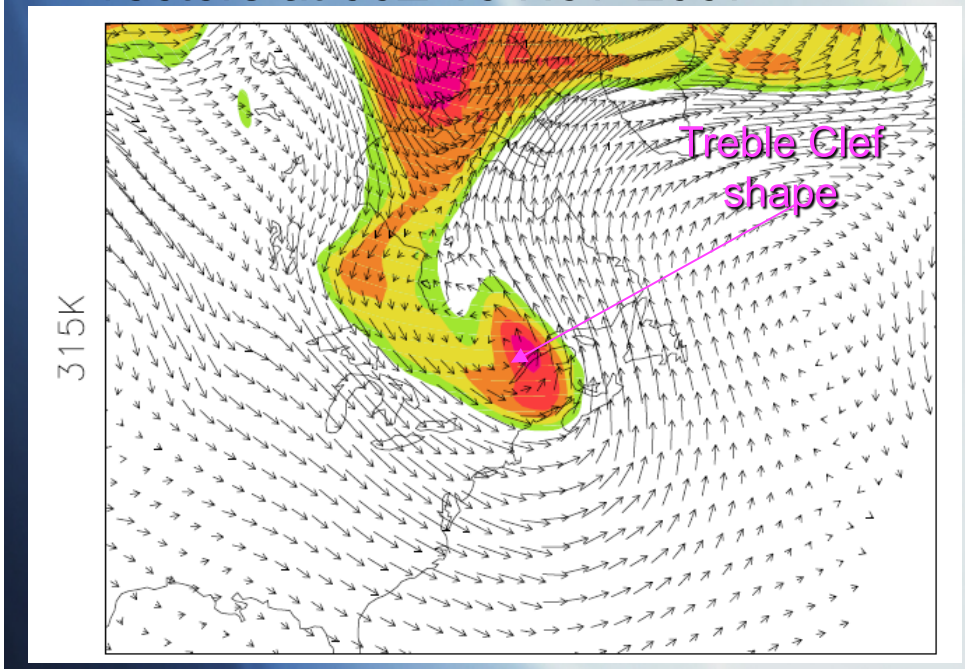


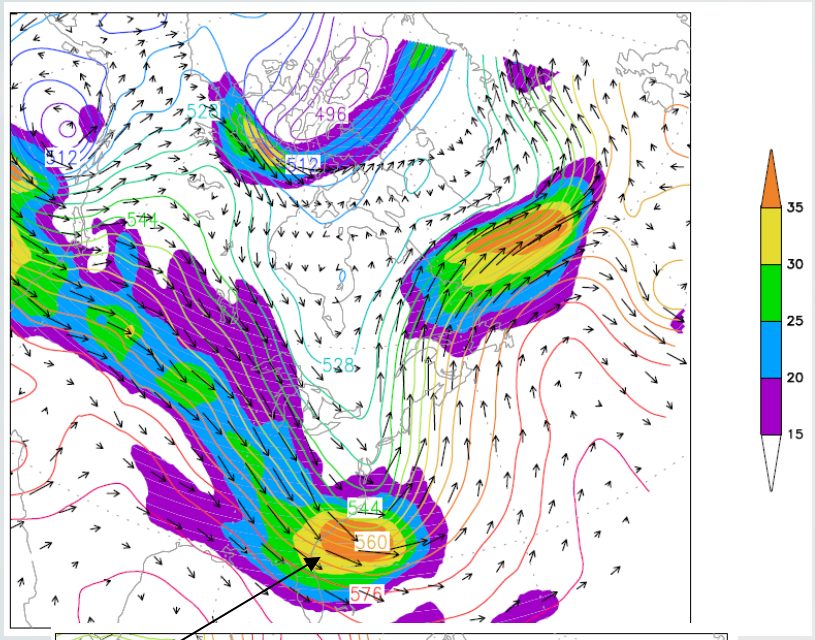
Figure 1. Paths of cyclones with a minimum lifetime of $T = 3$ days (November 1990 to March 1991)

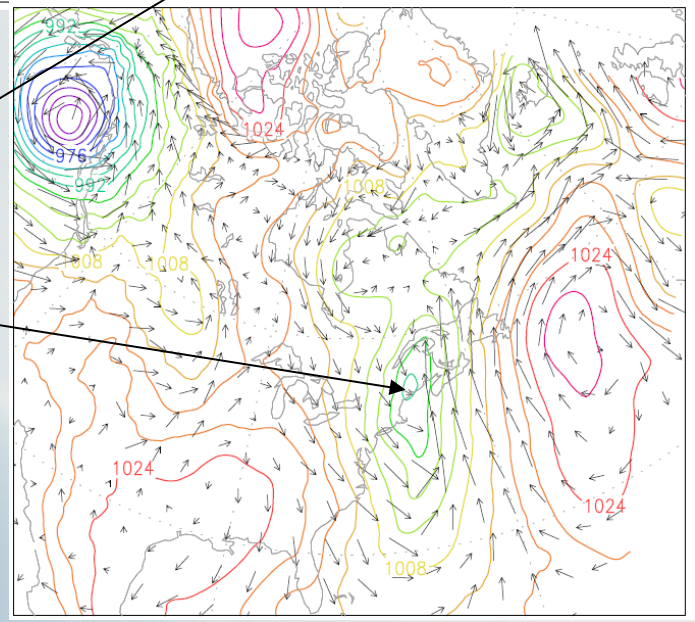
R. Blender et al, 2006, QJRMS

Potential Vorticity (PV) and wind vectors at 06Z 16 Nov. 2007



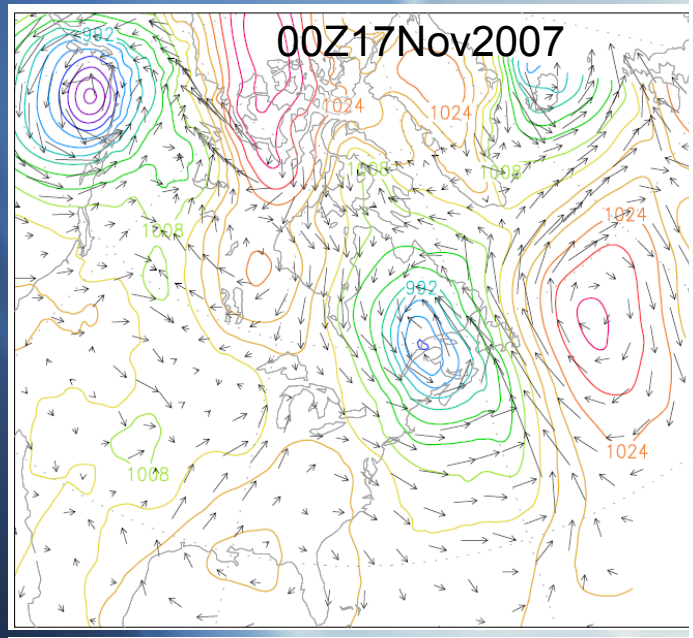
500 hPa H, zonal wind speed, wind vectors (upper) and sea level pressure (bottom) at 06Z 16 Nov. 2007

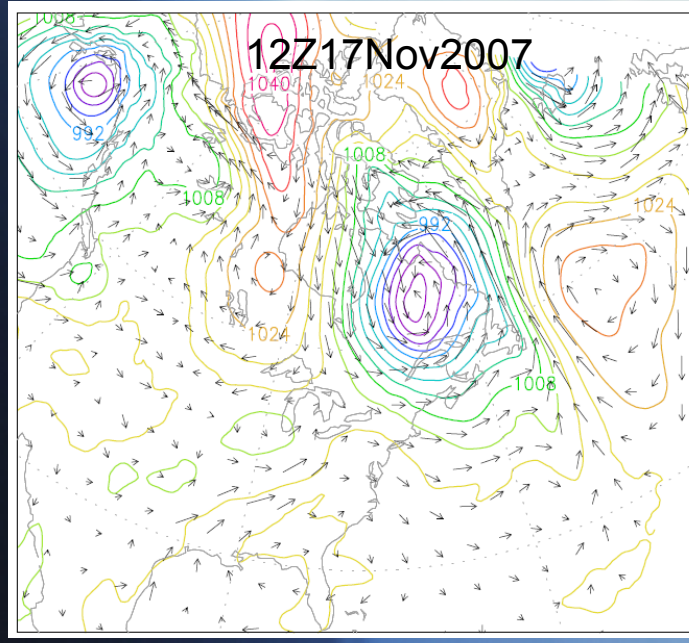




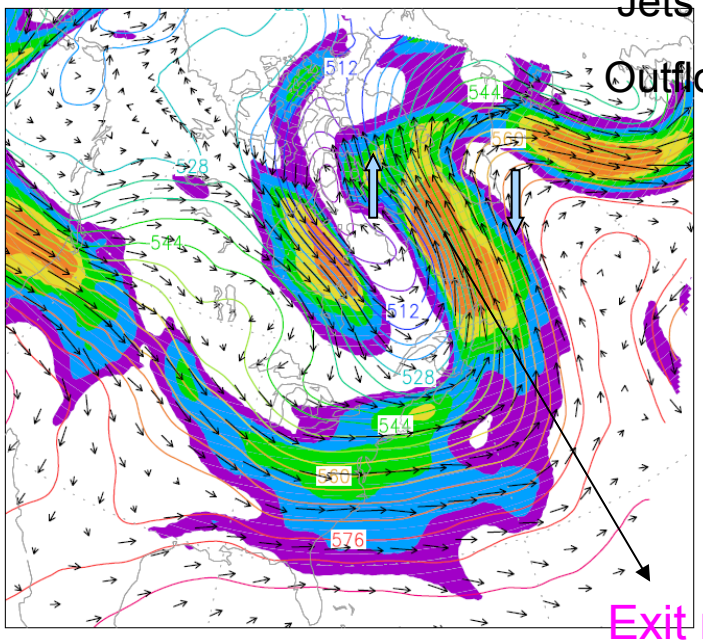
Cyclone on the cyclonic side of the jet stream

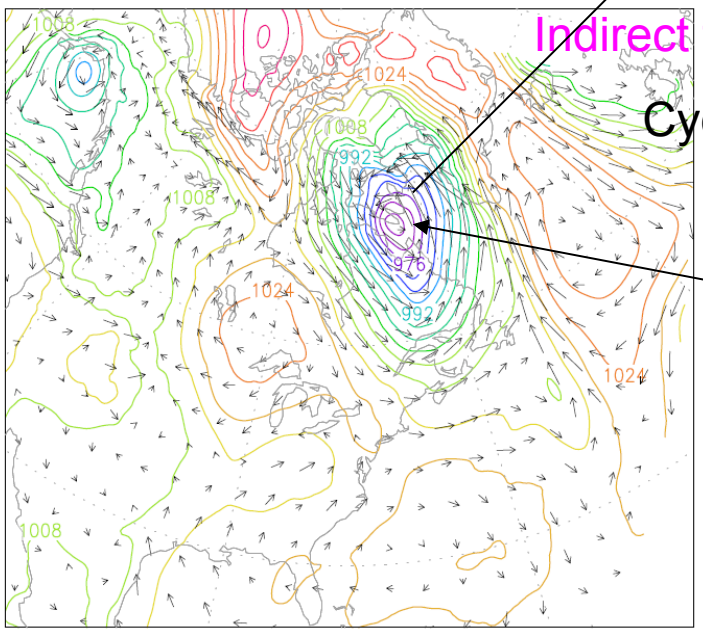
LC2 type (cyclonic behavior) Wrapping up cyclonically and poleward





00Z18NOV2007





Jets enhanced upper-level

Outflow and low-level inflow

Exit region to the jet→

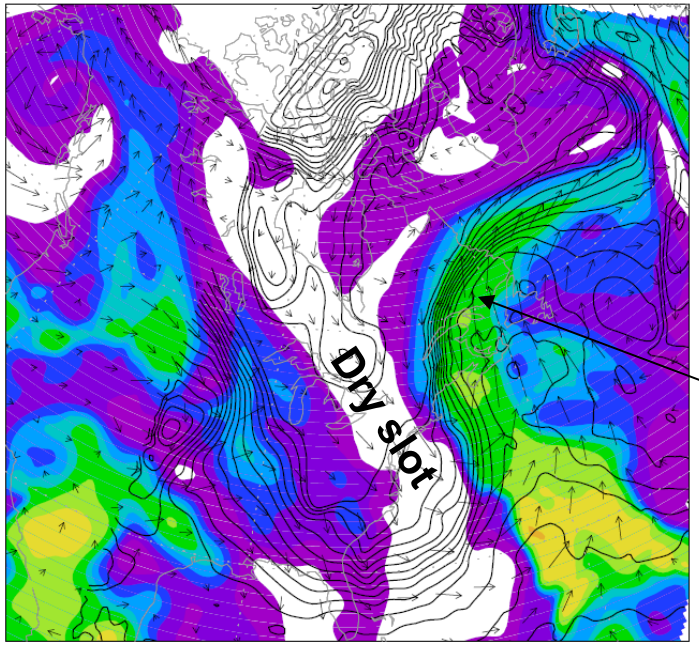
Indirect thermal circulation →

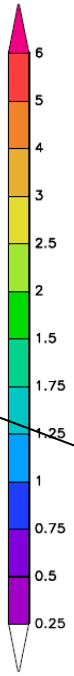
Cyclone deepened

Moved to Hudson Strait

Evolution of the thermal structure

12Z16NOV2007

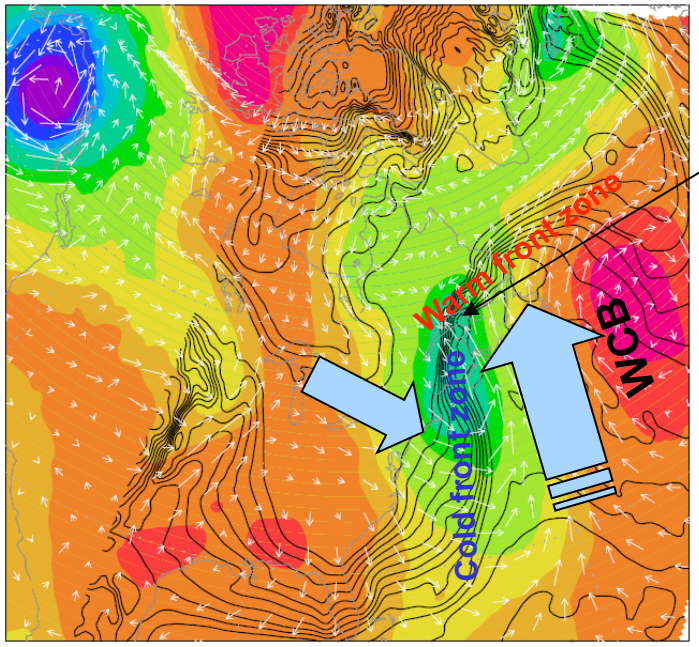


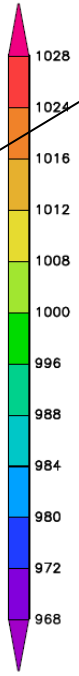


500 hPa temperature (contours)

Specific humidity(shading)

Temperature discontinuity

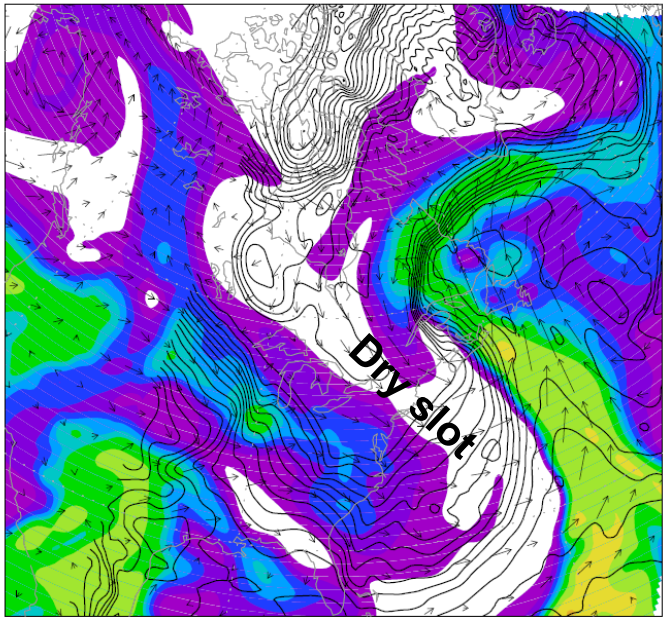


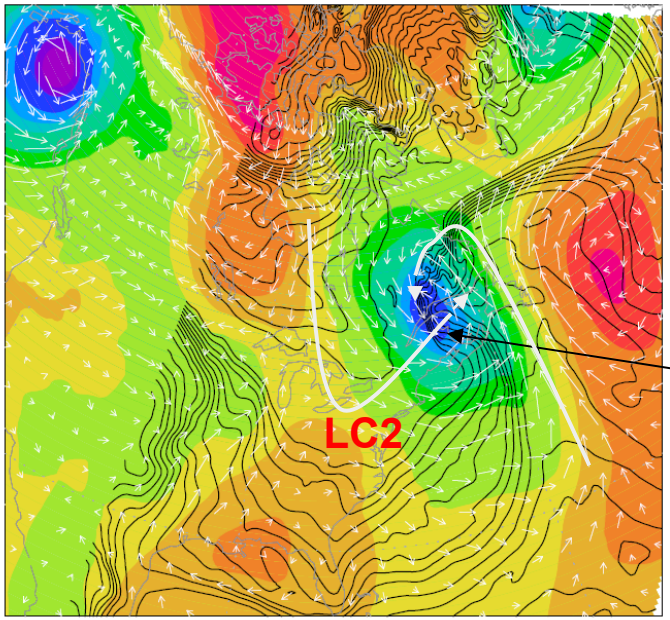


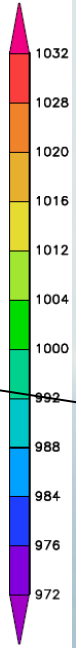
900 hPa temperature (contours)

Sea level pressure

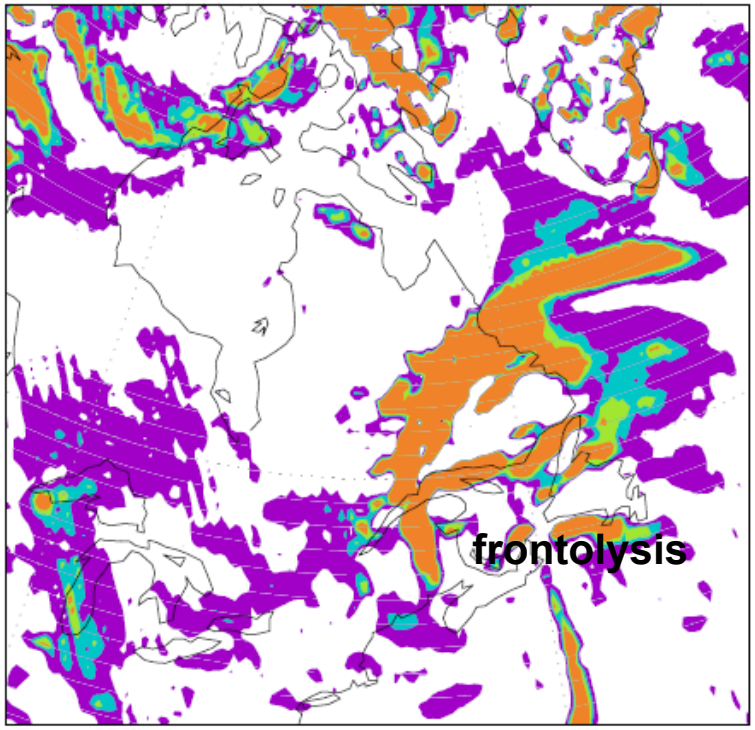
00Z17NOV2007





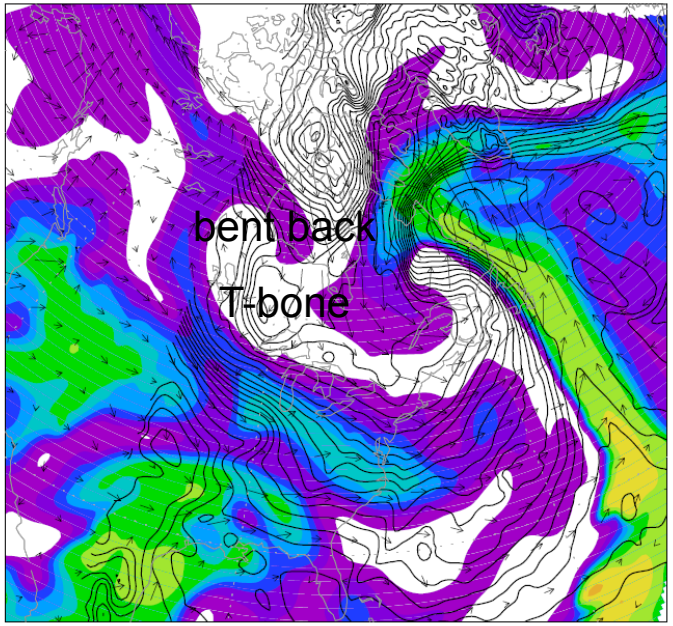


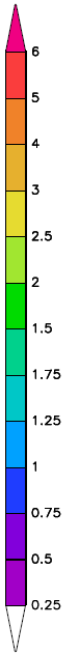
Frontgenesis function

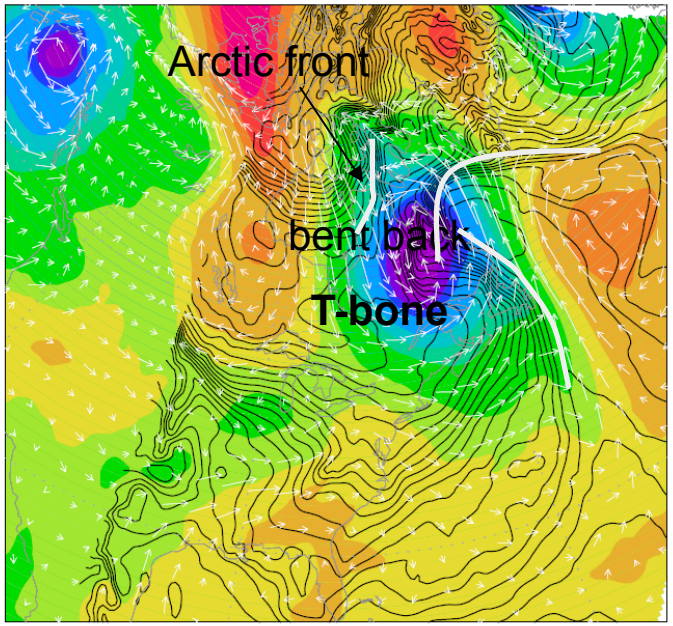


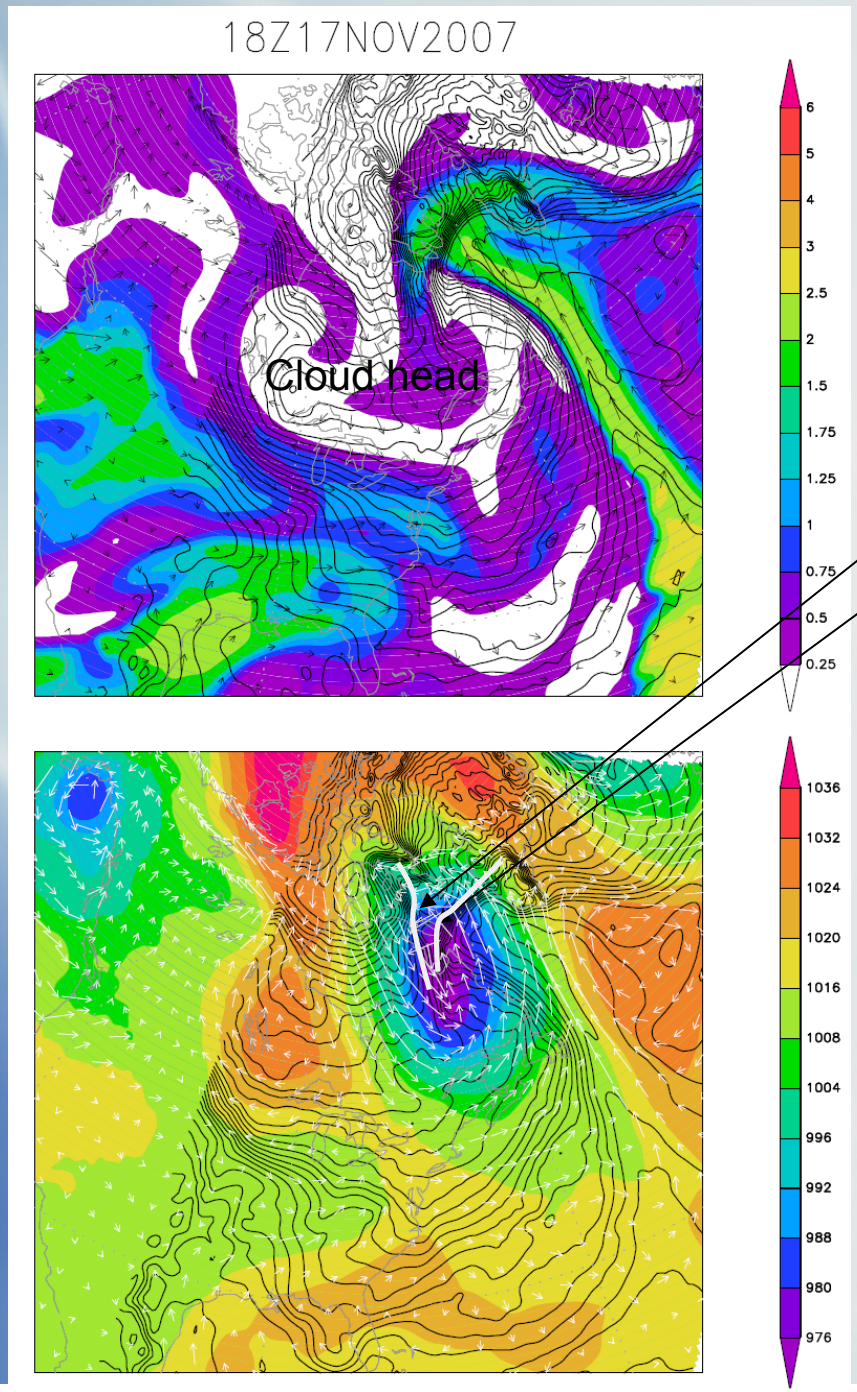
Front fracture

12Z17NOV2007

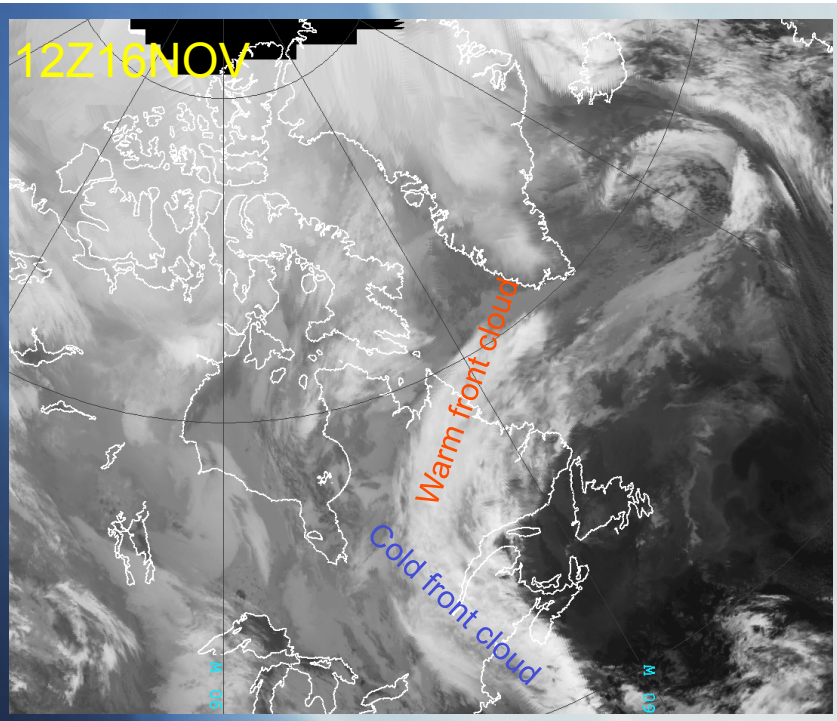


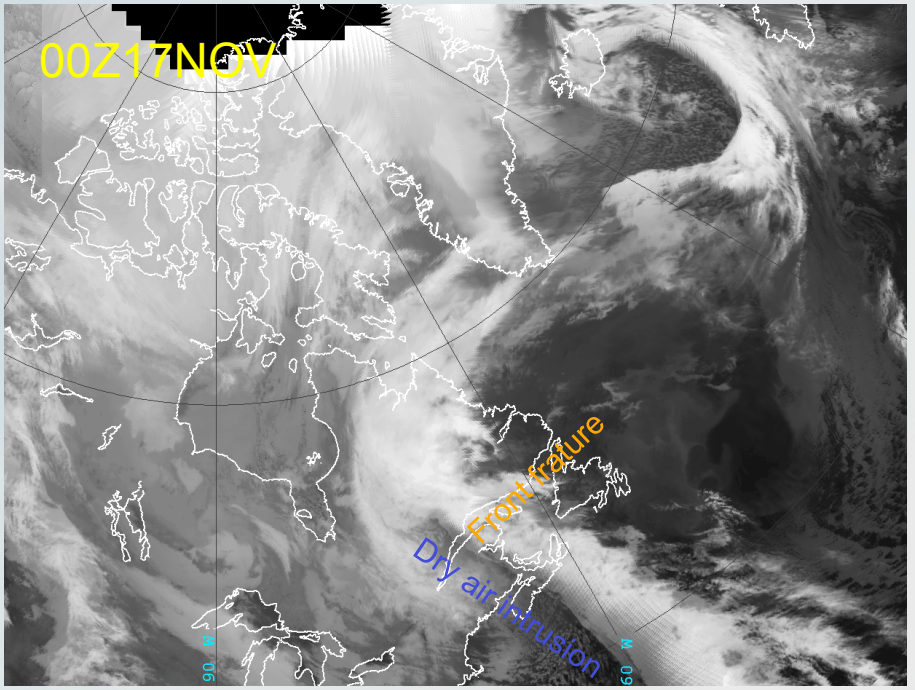


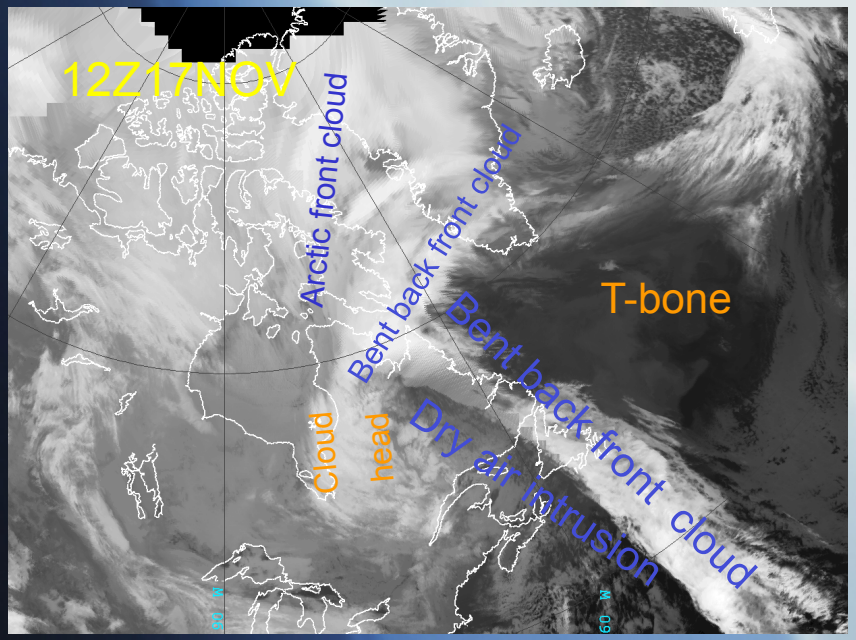


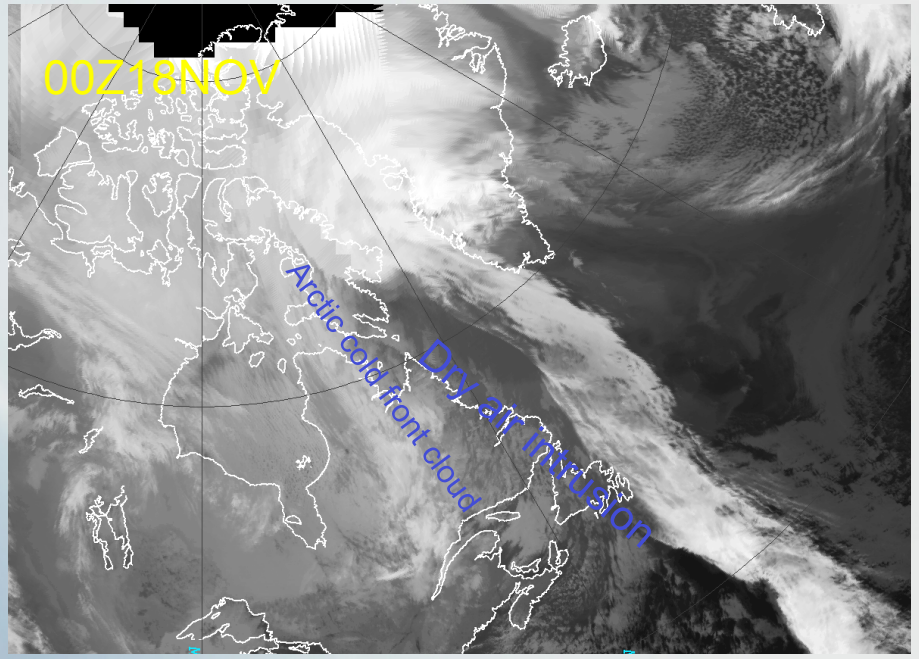

18Z17NOV2007
Cloud head
6
5
4
3
2.5
2
1.5
1.75
1.25
1
0.75
0.5
0.25
1036
1032
1024
1020
1016
1008
1004
996
992
988
980
976
Arctic front and bent back front tend to merge

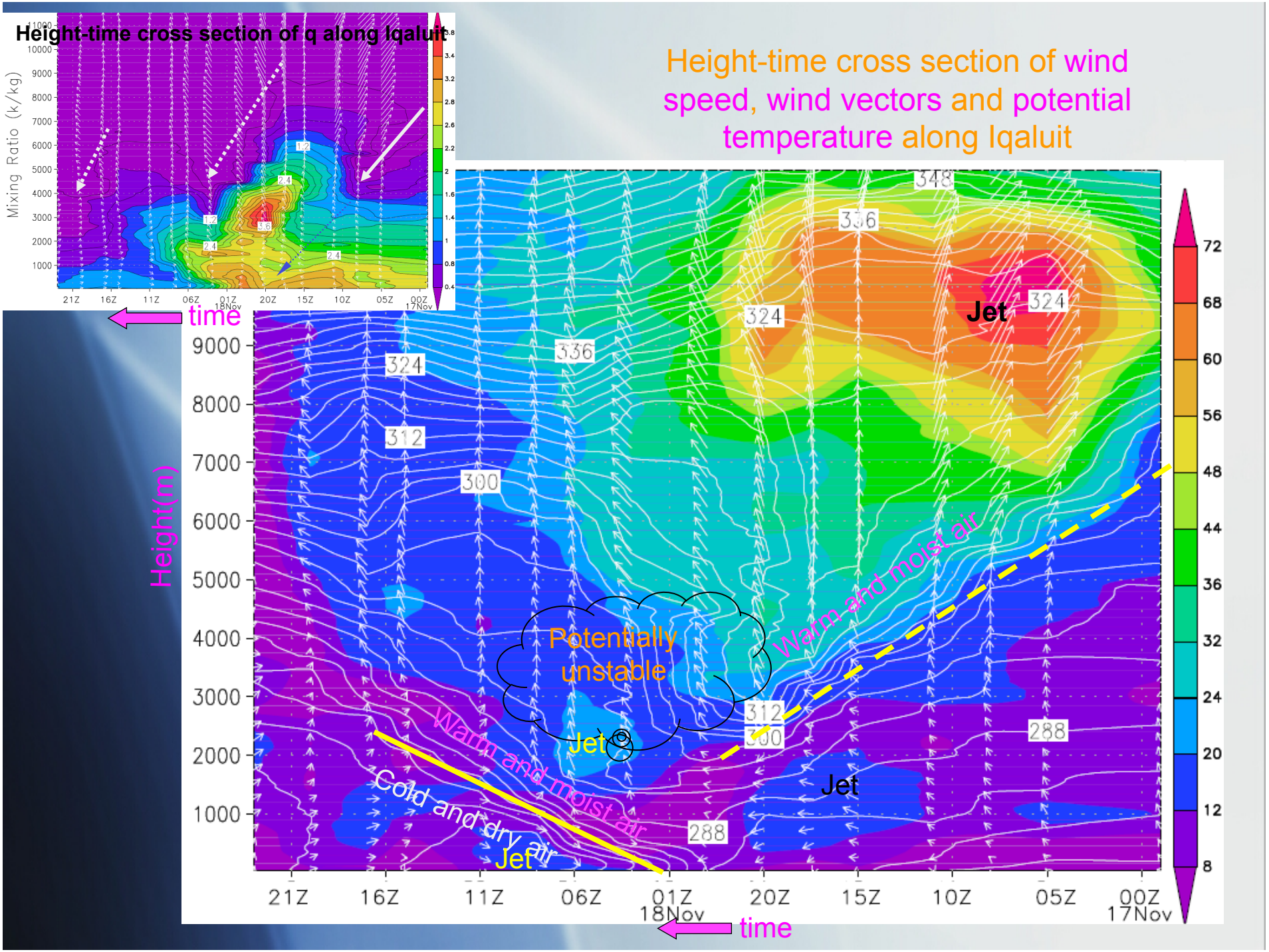
Evolution of the cloud system


12Z16NOV
Warm front cloud
Cold front cloud


00Z17NOV
Front fracture
Dry air intrusion

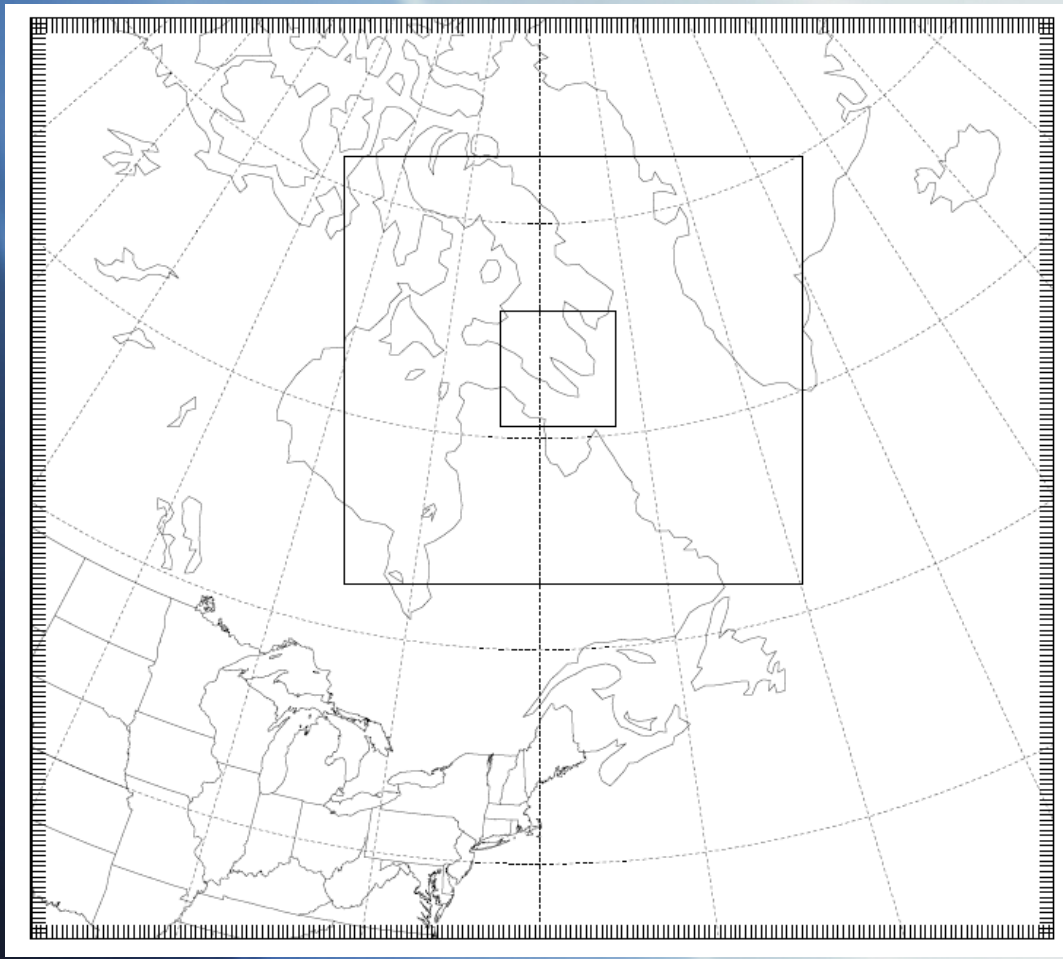

12Z17NOV
Arctic front cloud
Bent back front cloud
T-bone
Bent back front cloud
Cloud head
Dry air intrusion


00Z18NOV
Arctic cold front cloud
Dry air intrusion


Height-time cross section of q along Iqaluit
Mixing Ratio (k/kg)
time
Height-time cross section of wind speed, wind vectors and potential temperature along Iqaluit
Height(m)
Jet
Potentially unstable
Warm and moist air
Cold and dry air
Jet
Warm and moist air
Jet
Jet
time
21Z
16Z
11Z
06Z
01Z
18Nov
20Z
15Z
10Z
05Z
00Z
17Nov

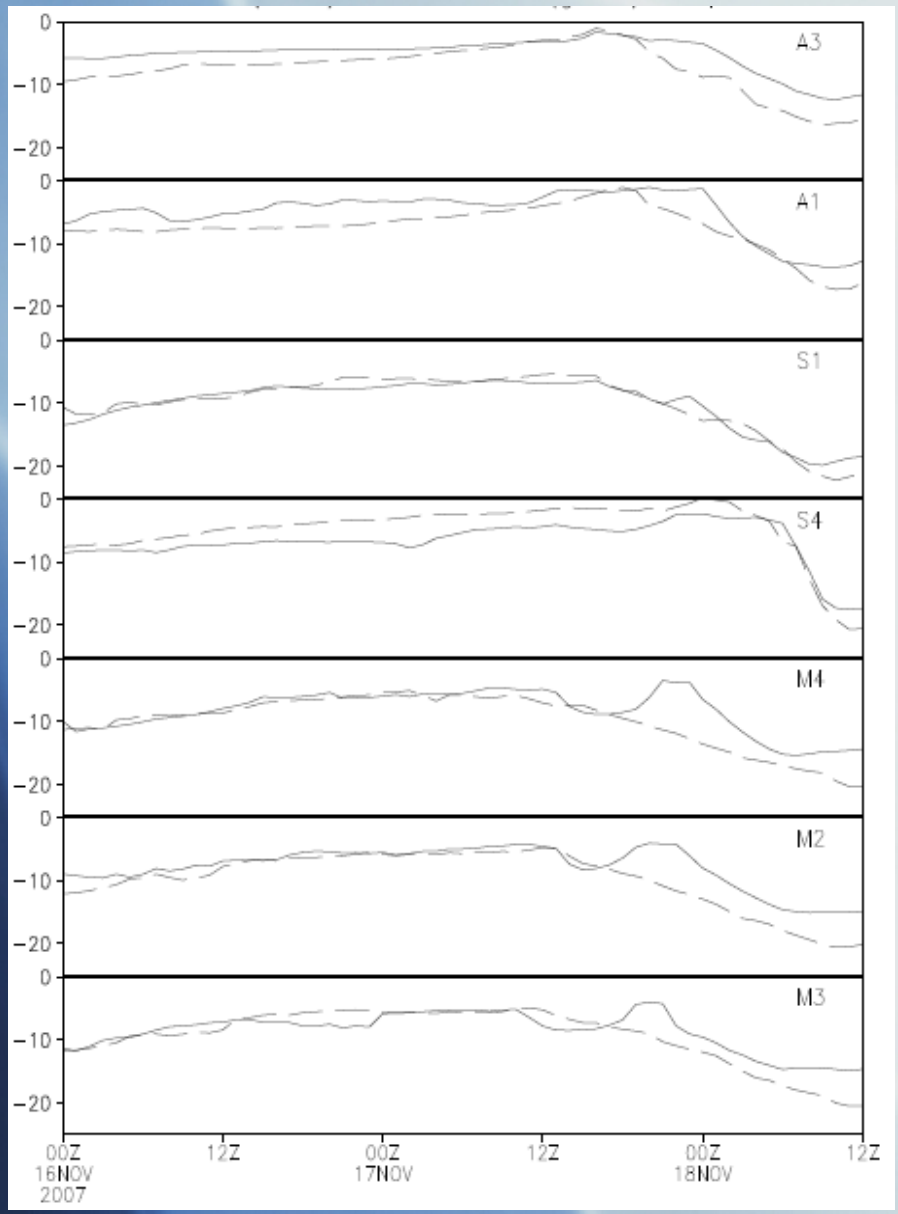
WRF simulations

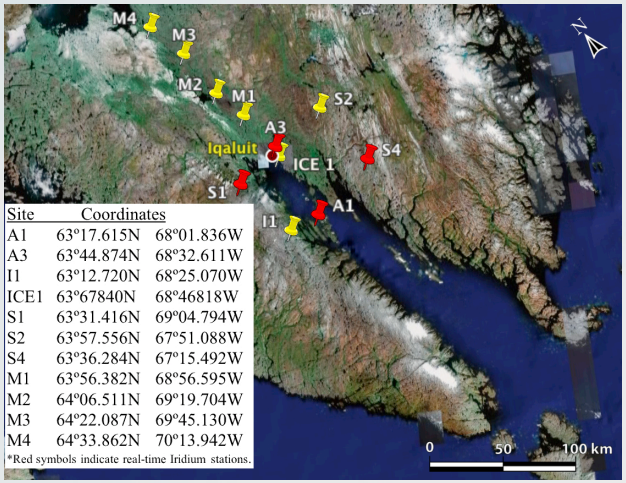
WRF configuration and verification



- 3 two-way nested domains (27km, 9km and 3km resolutions)
- 35 vertical layers
- Initial and boundary conditions: 6-hourly FNL
- YSU PBL scheme
- New Kain-Fritsch cloud scheme

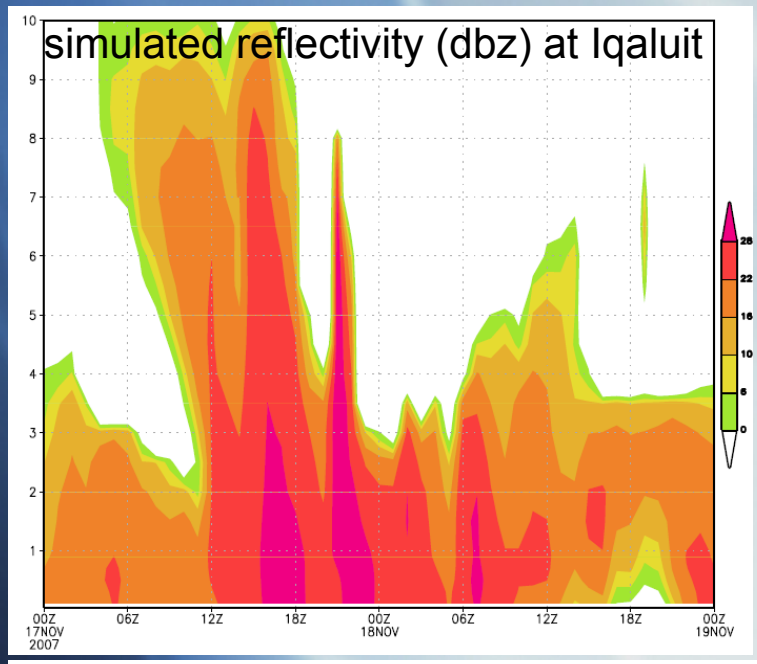
Simulated (dash) and observed (solid) temperature (°C)

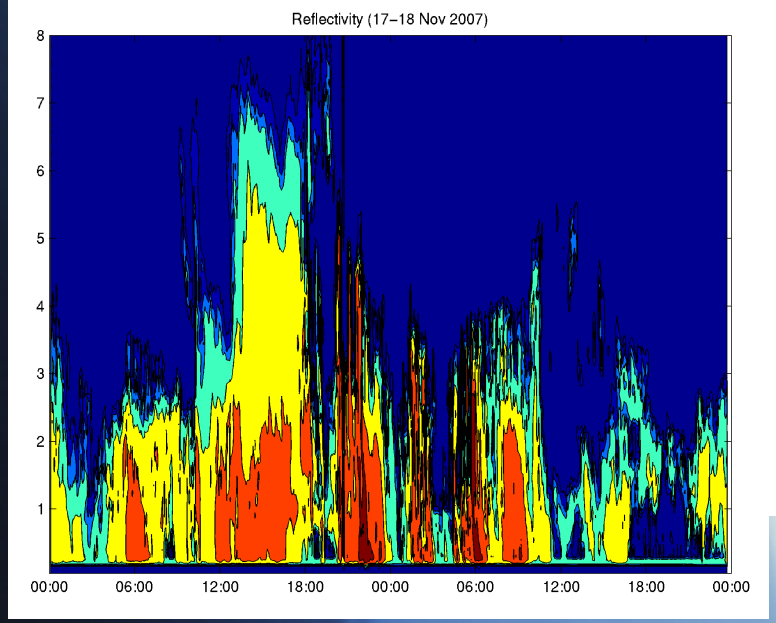




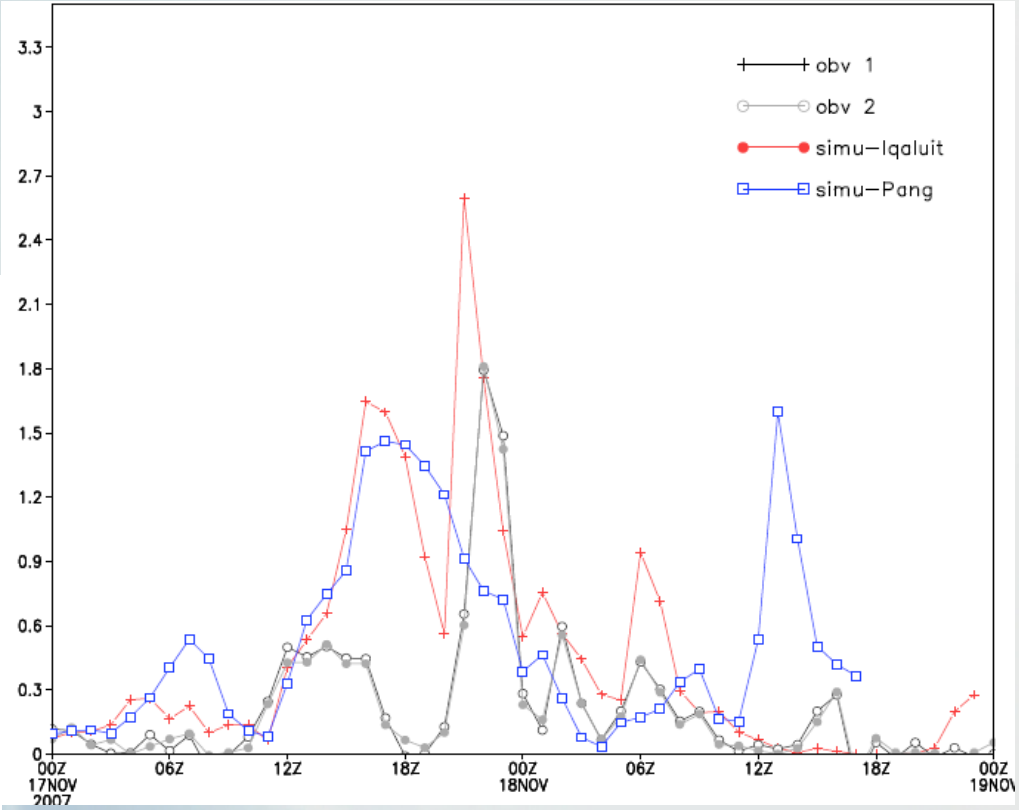
Site	Coordinates	
A1	63°17.615N	68°01.836W
A3	63°44.874N	68°32.611W
I1	63°12.720N	68°25.070W
ICE1	63°67840N	68°46818W
S1	63°31.416N	69°04.794W
S2	63°57.556N	67°51.088W
S4	63°36.284N	67°15.492W
M1	63°56.382N	68°56.595W
M2	64°06.511N	69°19.704W
M3	64°22.087N	69°45.130W
M4	64°33.862N	70°13.942W

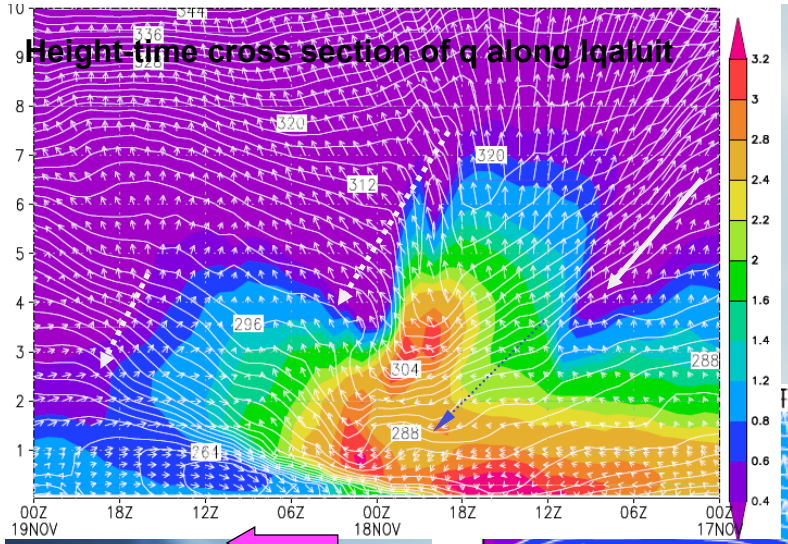
*Red symbols indicate real-time Iridium stations.



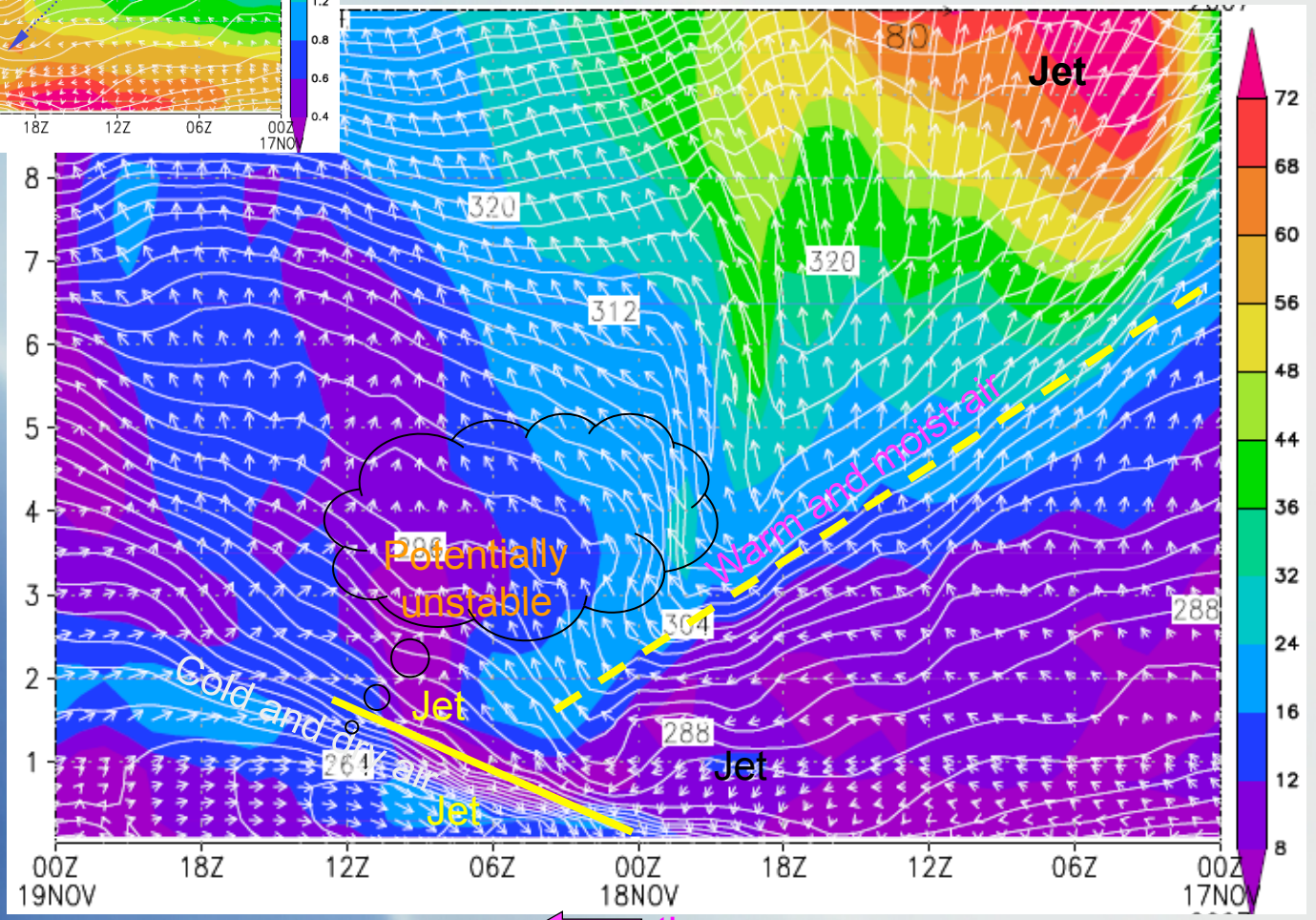


Observed and simulated precipitation at Iqaluit

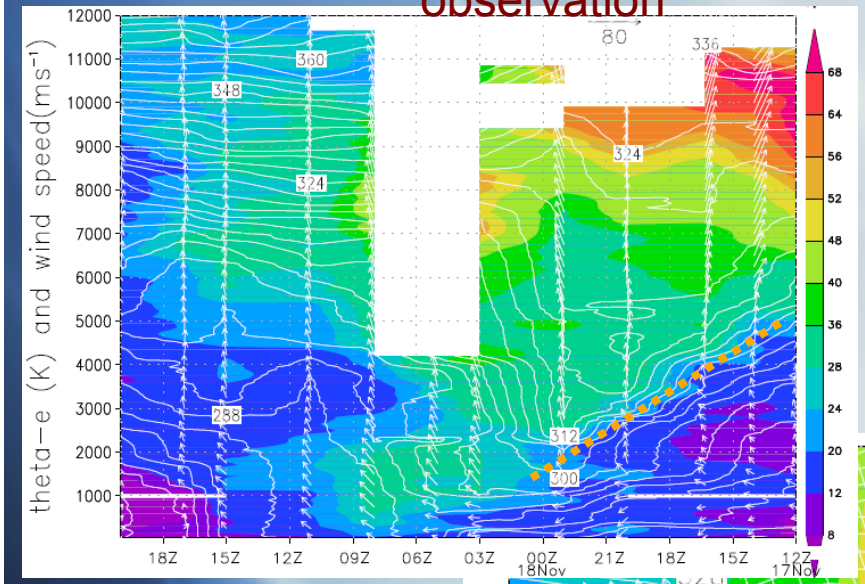




Height-time cross section of wind speed, wind vectors and potential temperature along Iqaluit

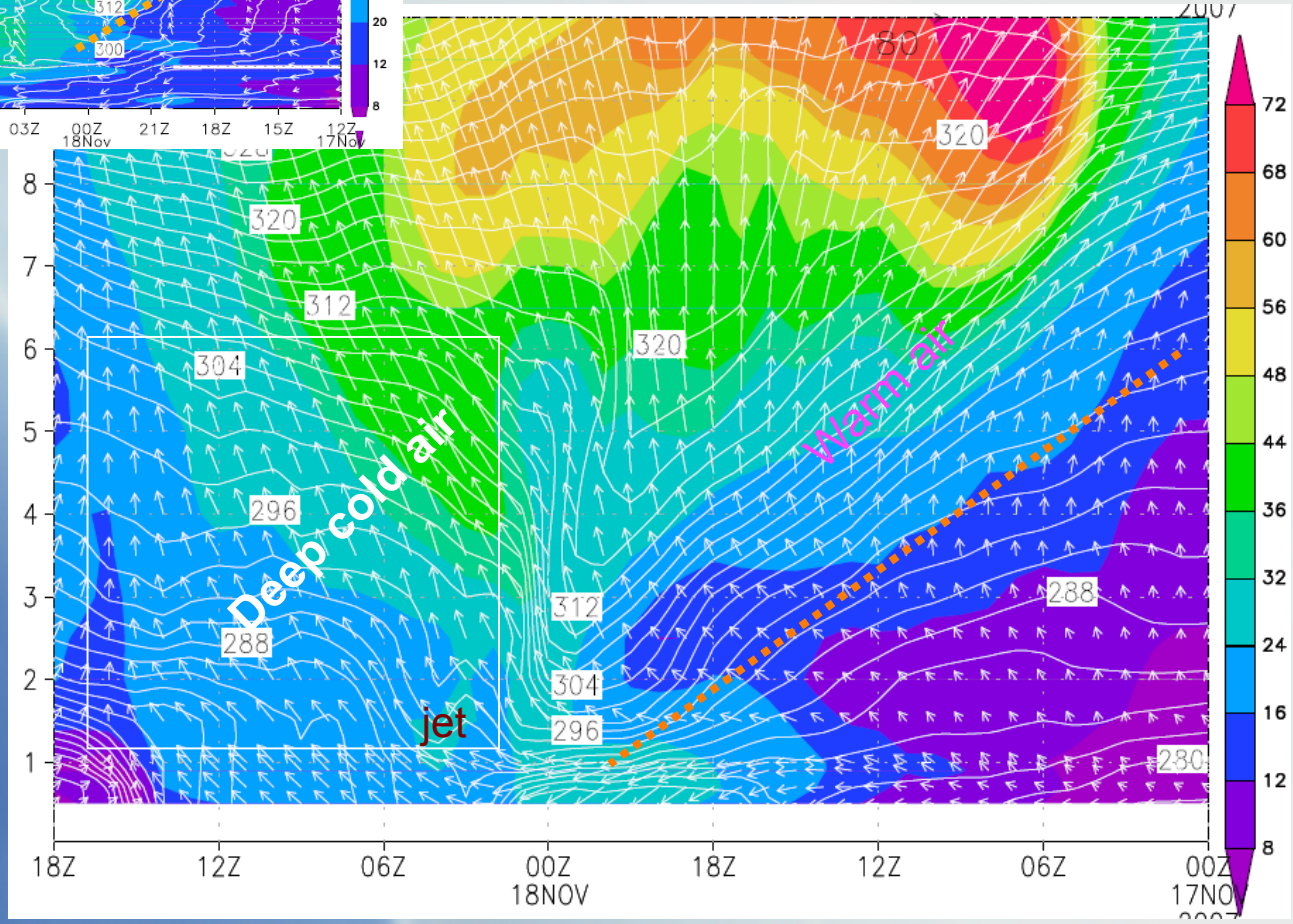


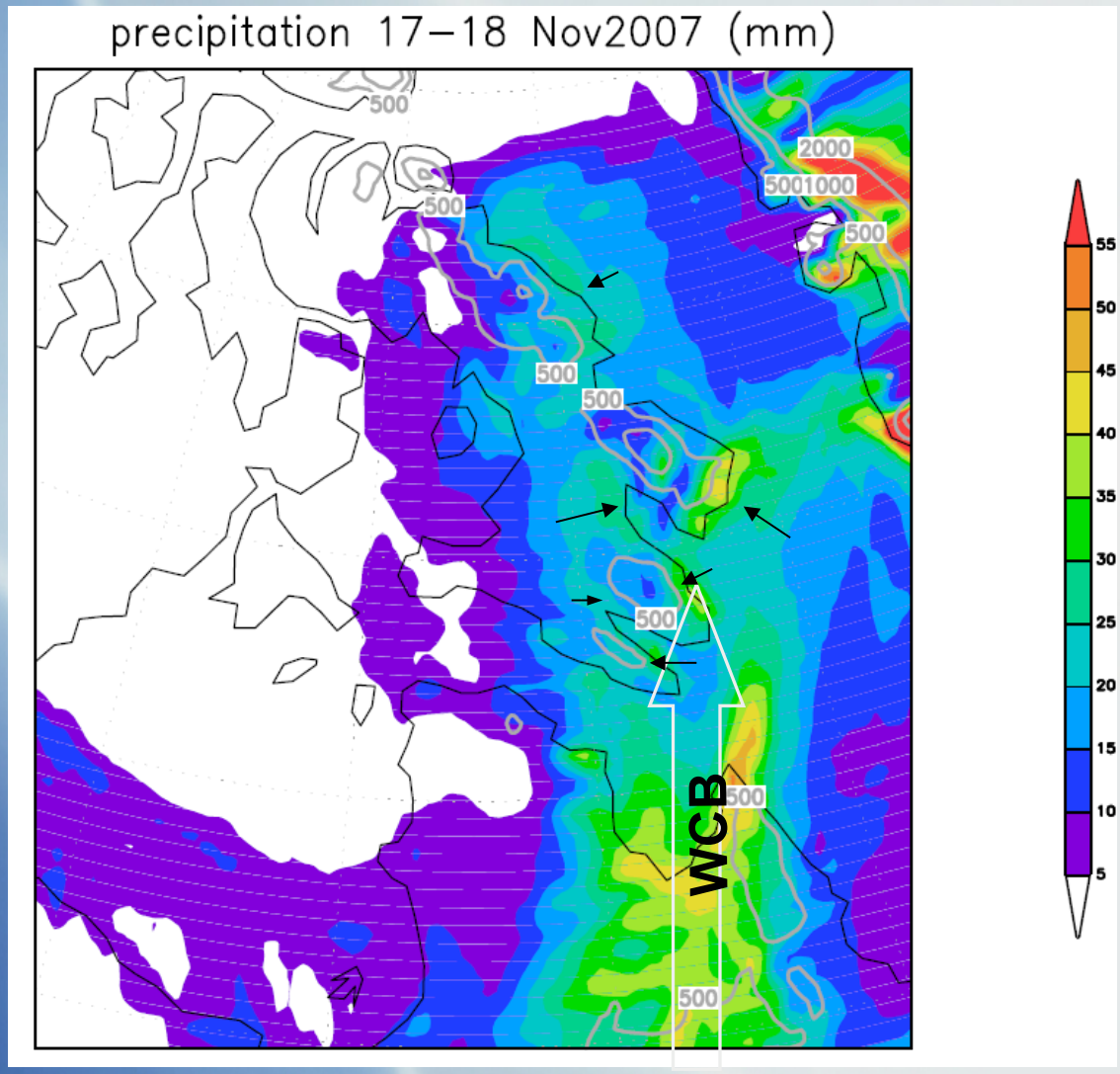
observation



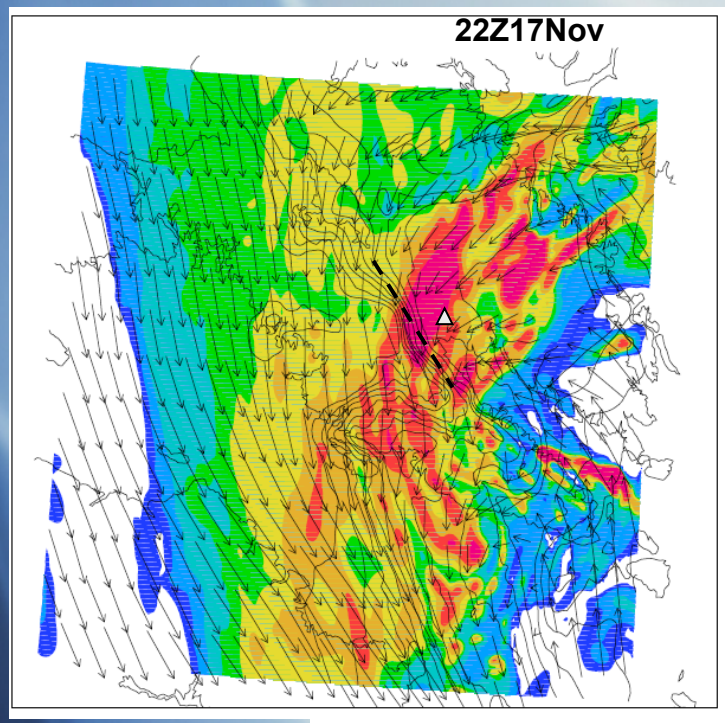
Height-time cross section of wind speed, wind vectors and potential temperature along Pang

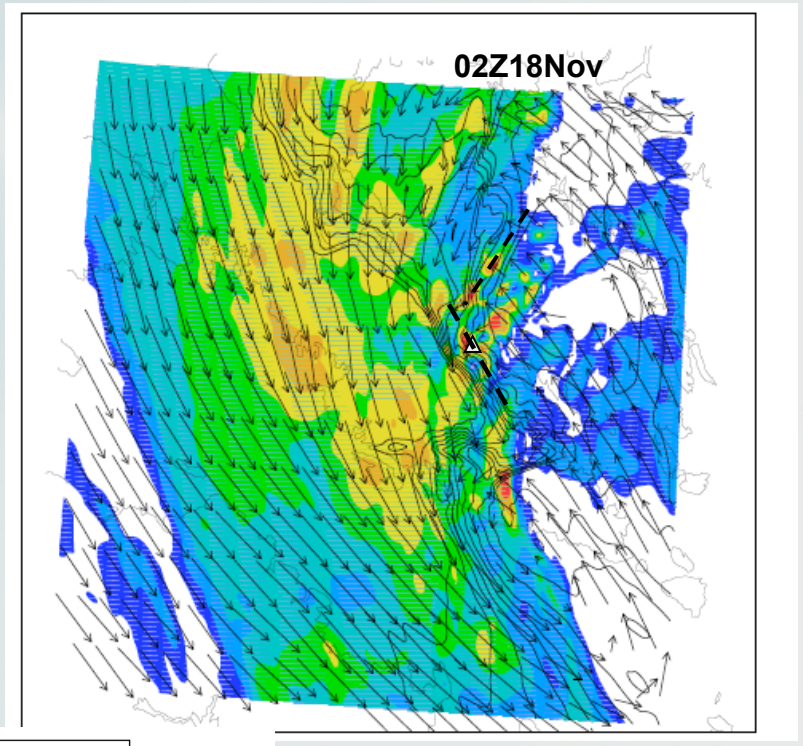
simulation

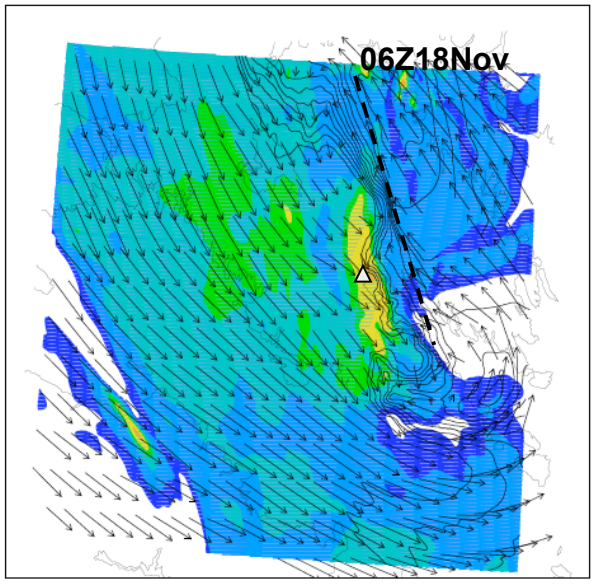


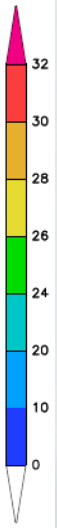

precipitation 17–18 Nov2007 (mm)
500
2000
5001000
WCB
55
50
45
40
35
30
25
20
15
10
5

simulated reflectivity (dbz), 900 hPa temperature and wind vectors

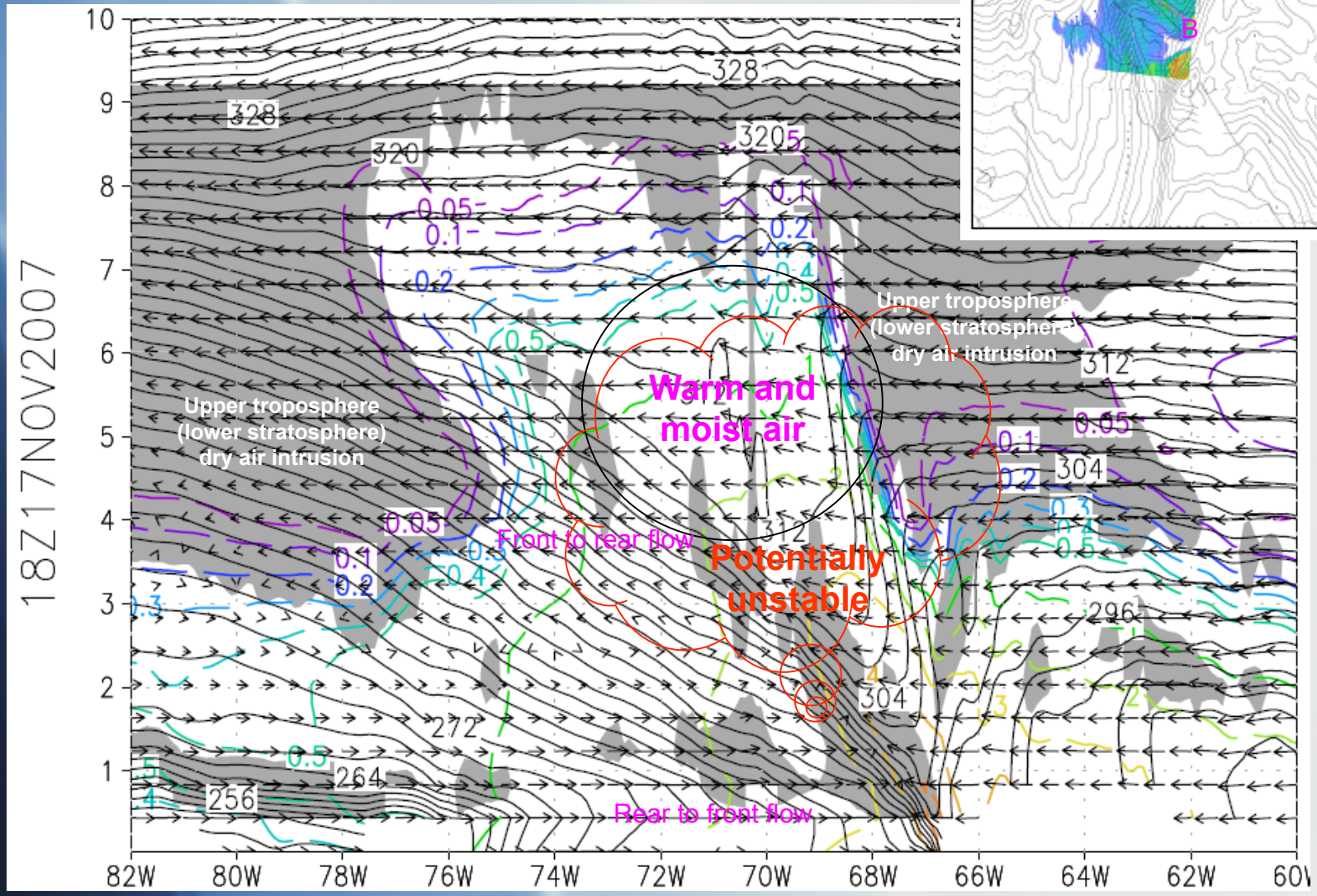


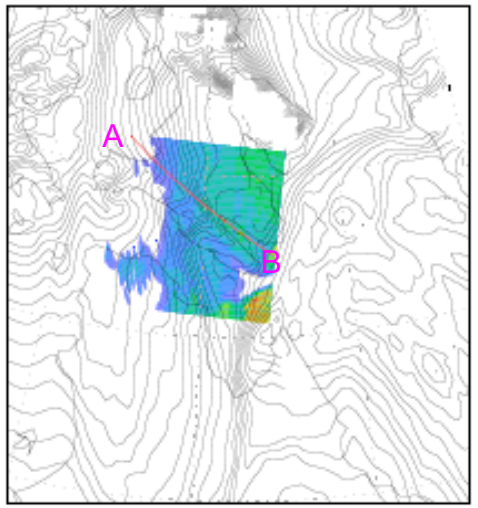


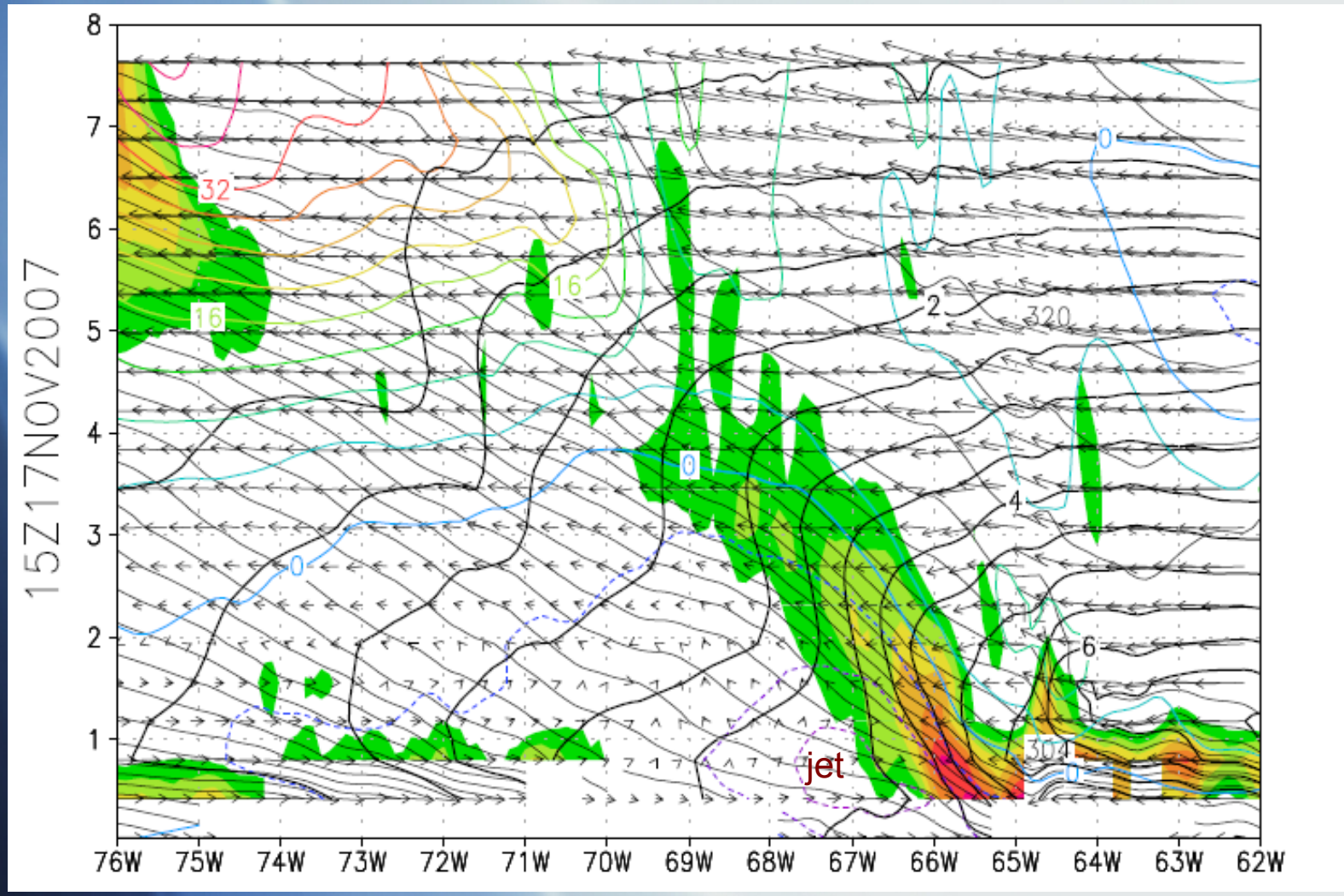




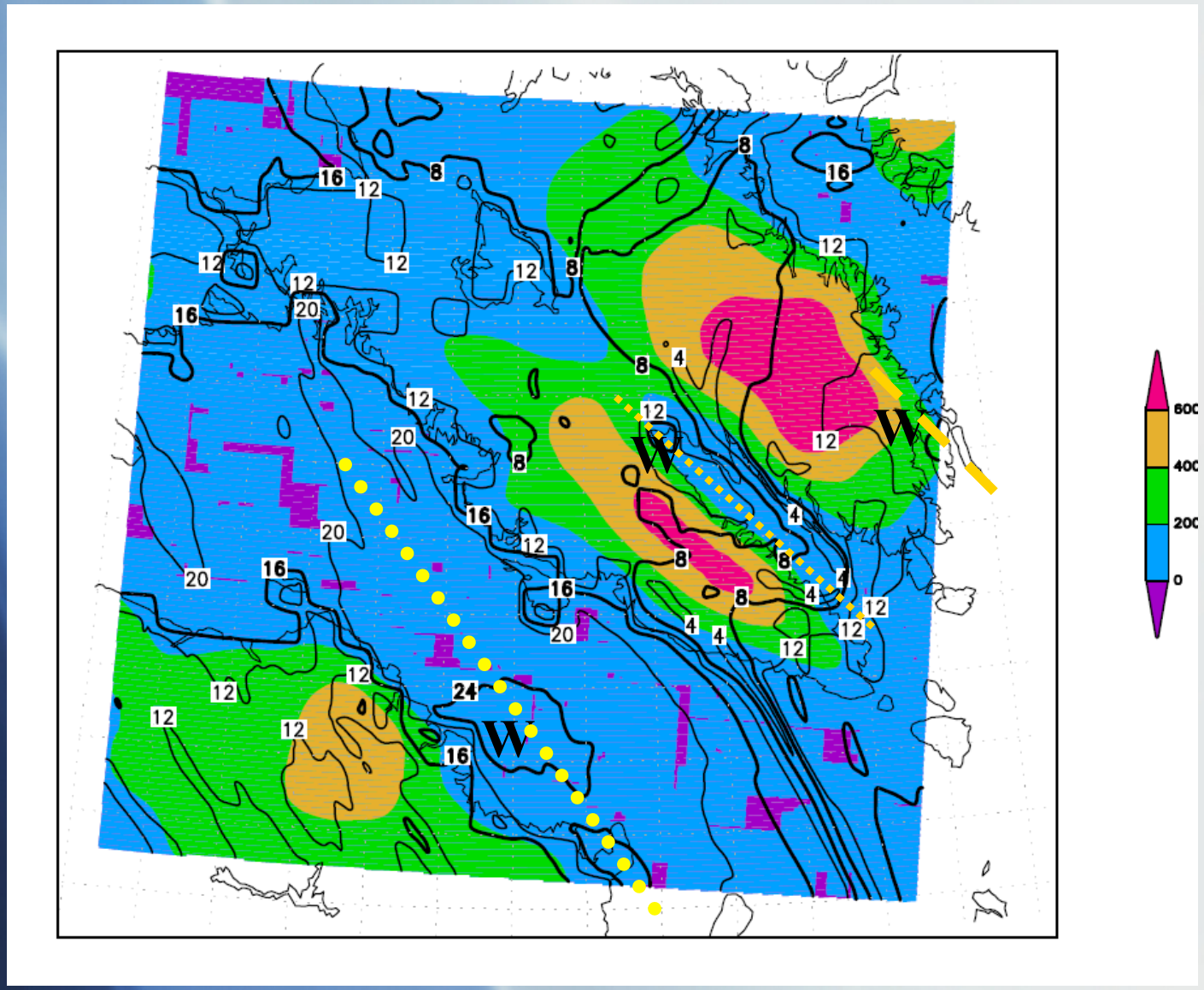
Cross section of PV(>1.5 PVU shading), Theta(solid lines), wind vectors and q (dash color lines) along AB at 15Z17Nov2007






15Z17NOV2007
8
7
6
5
4
3
2
1
76W
75W
74W
73W
72W
71W
70W
69W
68W
67W
66W
65W
64W
63W
62W
32
16
16
0
0
2
320
4
6
304
0
jet

simulated 10-m wind speed (contours, m/s) and terrain height (shading, m)



Conclusions

• The evolution of the extratropical cyclone associated with significant snowfall over southern Baffin Island was characterized by Shapiro-Keyser frontal-cyclone model with front fracture, bent-back front.

•The synoptic-scale disturbance illustrated LC2 (cyclonic) behaviours in the baroclinic wave life-cycle.

•The two-day snowfall was associated with the activities of fronts. Warm front gave rise to the significant snowfall at Iqaluit on 17 November 2007.

Conclusions (Cont'd)

•On 18 November 2007, bent-back front nearly pinched off by dry air intrusion and emerged with Arctic front, which produced strong convection and snowfall over Baffin Island.

•The passage of the Arctic clod front led to the significant decrease in surface temperature and humidity and wind direction shift over southern Baffin Island.

•WRF model reproduced the variation of surface temperature in southern Baffin Island and the dropsonde observations over Iqaluit and Pang.

Conclusions (Cont'd)

- The high Theta-e air associated with the bent back front was advected to Arctic cold front region. The mesoscale convective systems associated with the passage of Arctic front are responsible for the significant snowfall.

- Baffin Island complex topography has significant influence on the precipitation and surface wind. The upslope precipitation is obvious. Strong wind occurs along the valley and downslope regions.

Thank you!