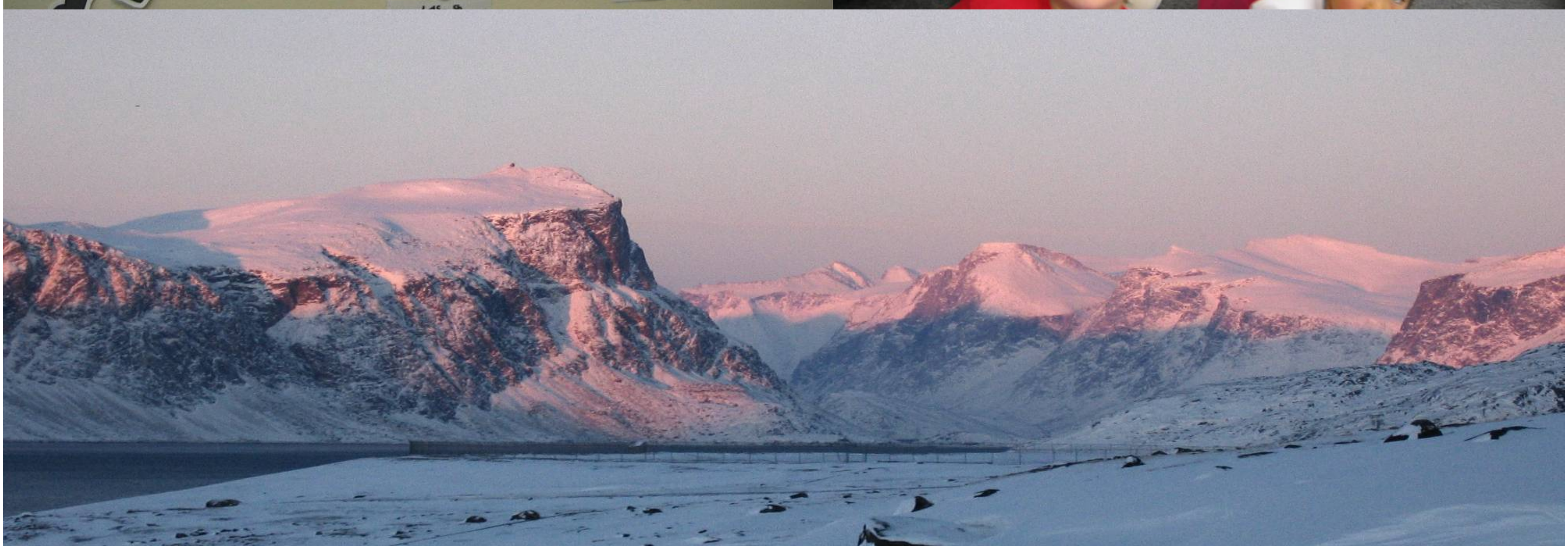
Storm Studies in the Arctic

Goodson Adventures

Will Briefly Discuss

- Visit to Pangnirtung
- STAR 3-hourly Sounding at Pangnirtung
  - recap of what was learned (previously presented STAR 2008)
  - application to a recent case
- Comparison of Surface Winds to Plateau Winds at Pangnirtung
- Examples of North East Wind Events at Iqaluit
- A GEMLAM Winter Evaluation





Pangnirtung Walk Around

- Visited Pangnirtung to learn more about typical and strong wind patterns
- Walked around Pangnirtung and surrounding area with GSP and hand-held anemometer (copying idea of Gabrielle Gascon and Robyn Dyck)
- Talked to community members
- Internal Training presentations have been created based upon results

“Typical” Non-Synoptic Pangnirtung Winds

Measurements made in Pangnirtung show drainage winds flowing down the Duval River drainage and then spreading out.

It is similar on the other side of the fiord

What Was Learned (or reinforced)

- What we, as forecasters, need to remember that “prevailing conditions” are very sensitive to local conditions – and may not even apply across a Hamlet
- We should be more aware of the representativeness of observations
- This is particularly important for Pangnirtung as the observing station is near base of steep slopes

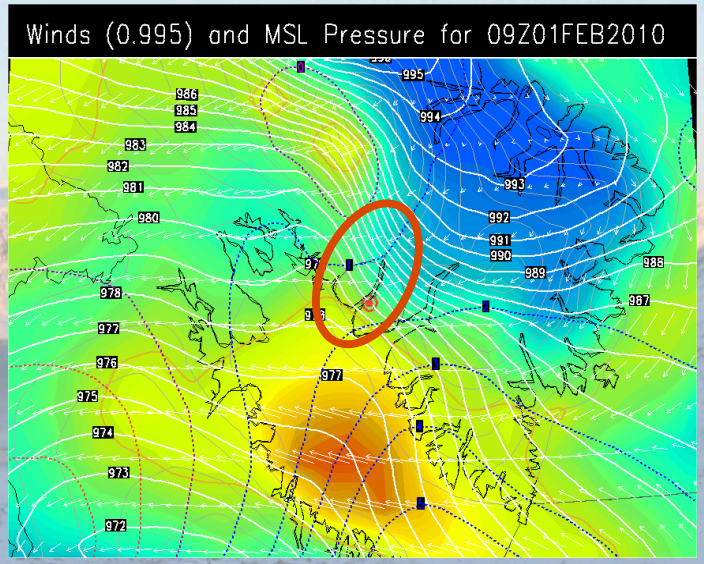
Pangnirtung Easterly Winds

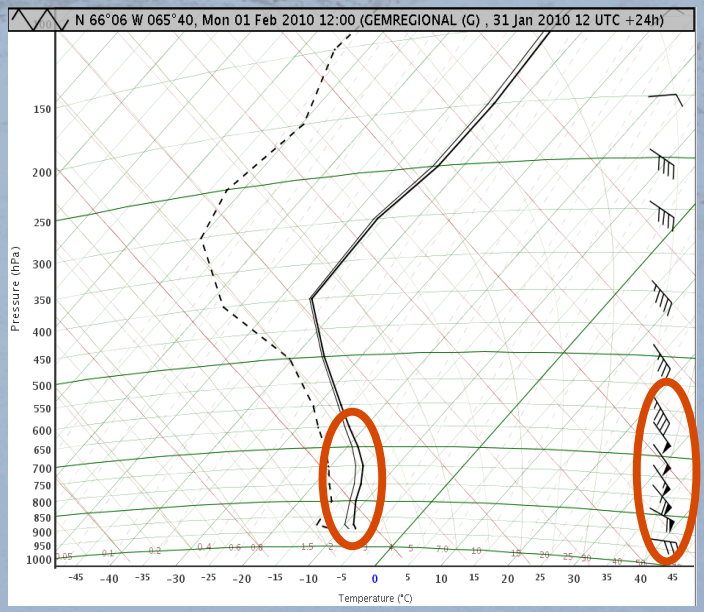
The observed “strong-wind” direction at Pangnirtung Airport is almost always easterly

The surface pressure pattern favours a gap-type flow within the Pangnirtung Fiord, which would give northeasterly winds

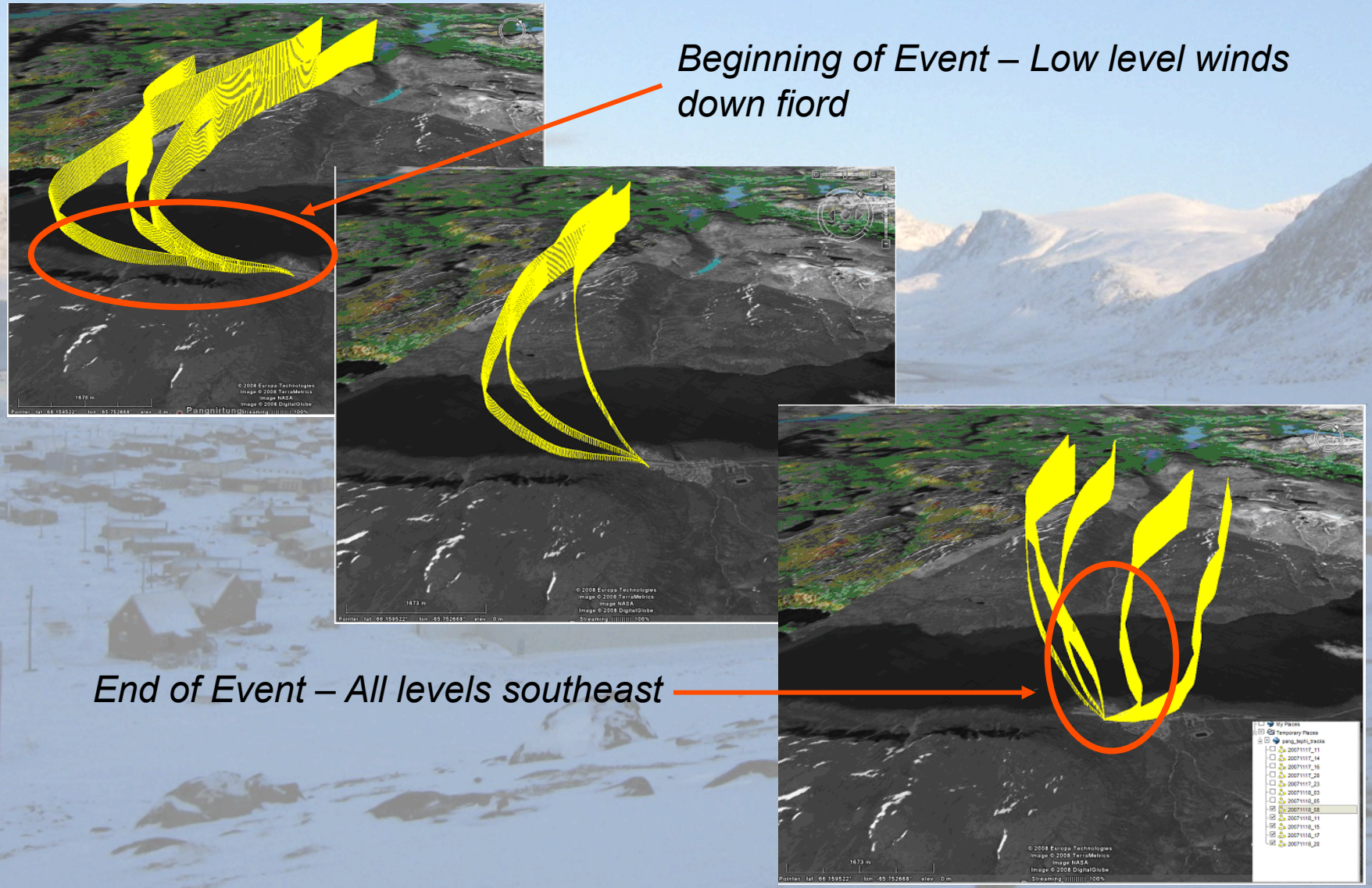
The vertical structure upstream of Pangnirtung often favours downslope winds from the slopes behind the town. These would result in southeasterly winds

So – where are the winds coming from ?





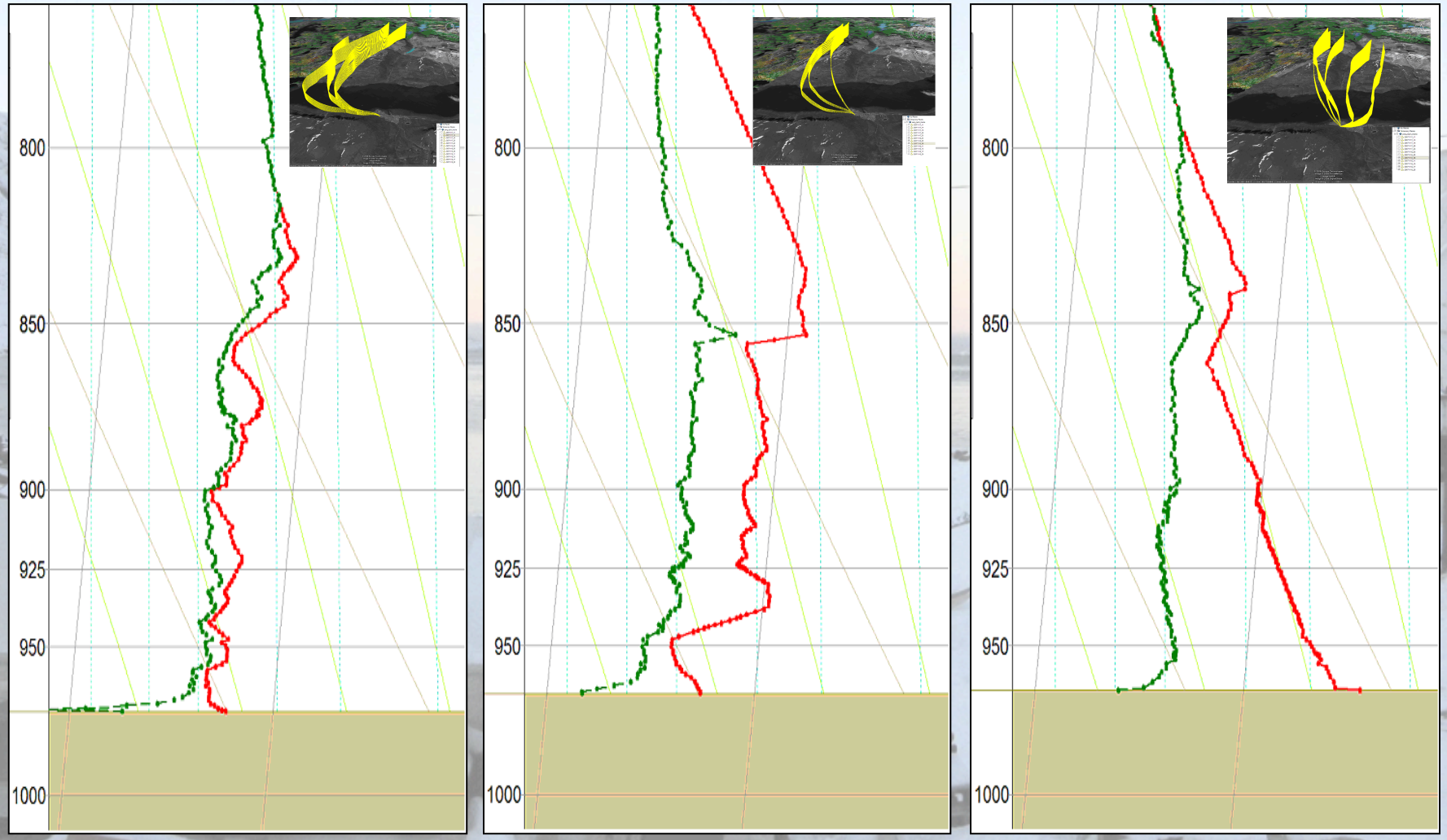
3 hourly balloon trajectories clearly show the transition from down-fiord, to down mountain flow.



Beginning of Event – Low level winds down fiord

End of Event – All levels southeast

3 hourly soundings reveal change from cool low-level fiord flow to warmer, drier subsidence flow



What Has Been Learned

Strong consistent easterly wind events at Pangnirtung airport may actually be a evolution from flow down the fiord, to downslope flow from the mountains behind the town-site

This is not meteorologically astounding (as it potentially happens in many locations), but is the first time it has was measured at Pangnirtung

CYXP 180000Z AUTO 09019G31KT M02/M03 A2876=

CYXP 180100Z AUTO 08016G26KT M03/M03 A2874=

CYXP 180200Z AUTO 07024G34KT M02/M03 A2867=

CYXP 180300Z AUTO 10022G35KT M02/M04 A2864=

CYXP 180400Z AUTO 07022G32KT 03/M03 A2862=

CYXP 180500Z AUTO 08028G39KT 04/M02 A2860=
CYXP 180600Z AUTO 09025G32KT 03/M02 A2862=

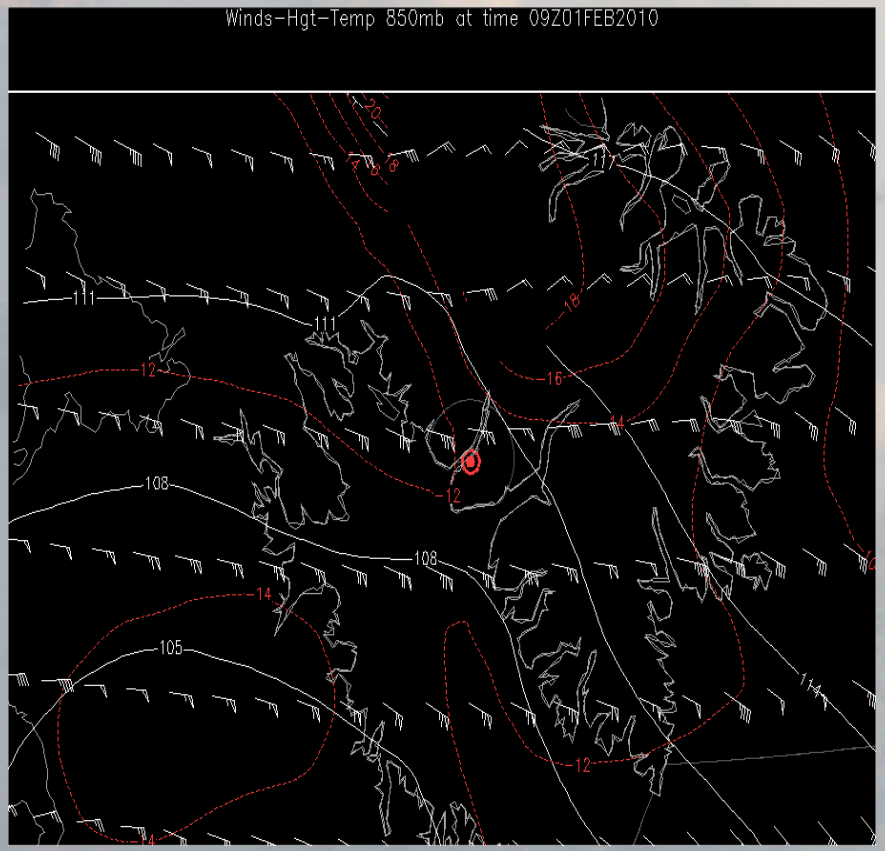
CYXP 180700Z AUTO 10033G38KT 02/M01 A2864=

CYXP 180800Z AUTO 10038G44KT 02/M01 A2867=

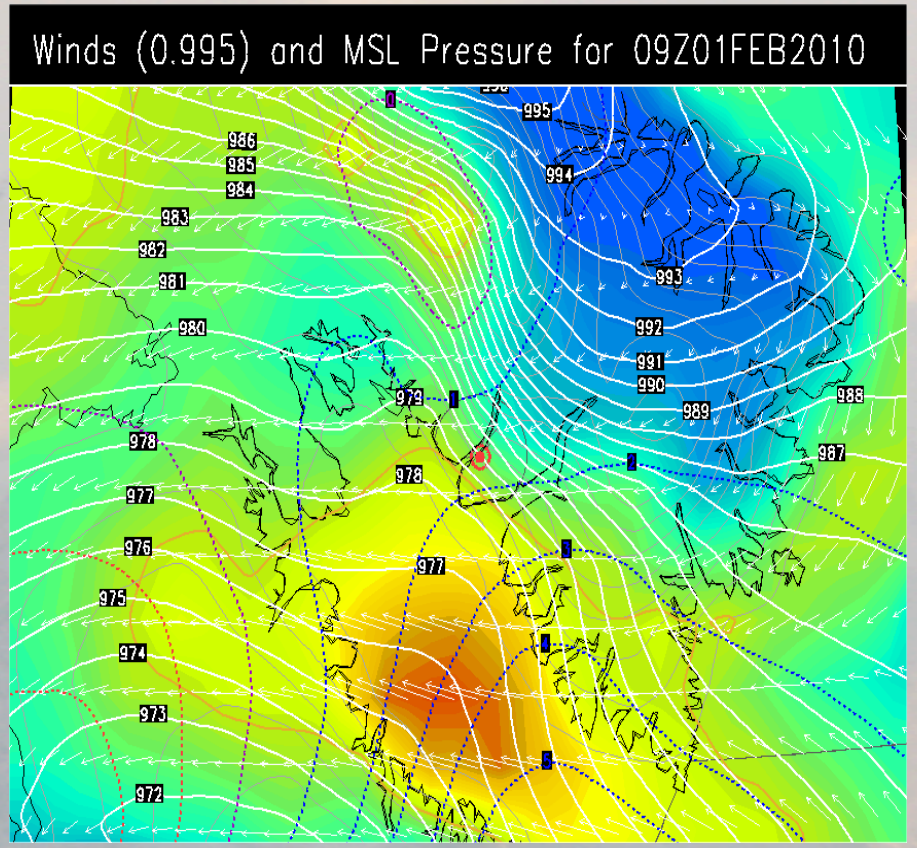
In the observations, the transition can be seen in the 5 deg C rise in temperature between 03 GMT and 04 GMT. However, to a busy meteorologist, this can easily be missed

The transition is not well shown in the observations, and the consistent easterly winds do not well-reflect the likely low-level conditions over the fiord. Lack of representativeness negatively impacts both understanding and forecasting

New Super Case
but no 3-hourly balloons !!

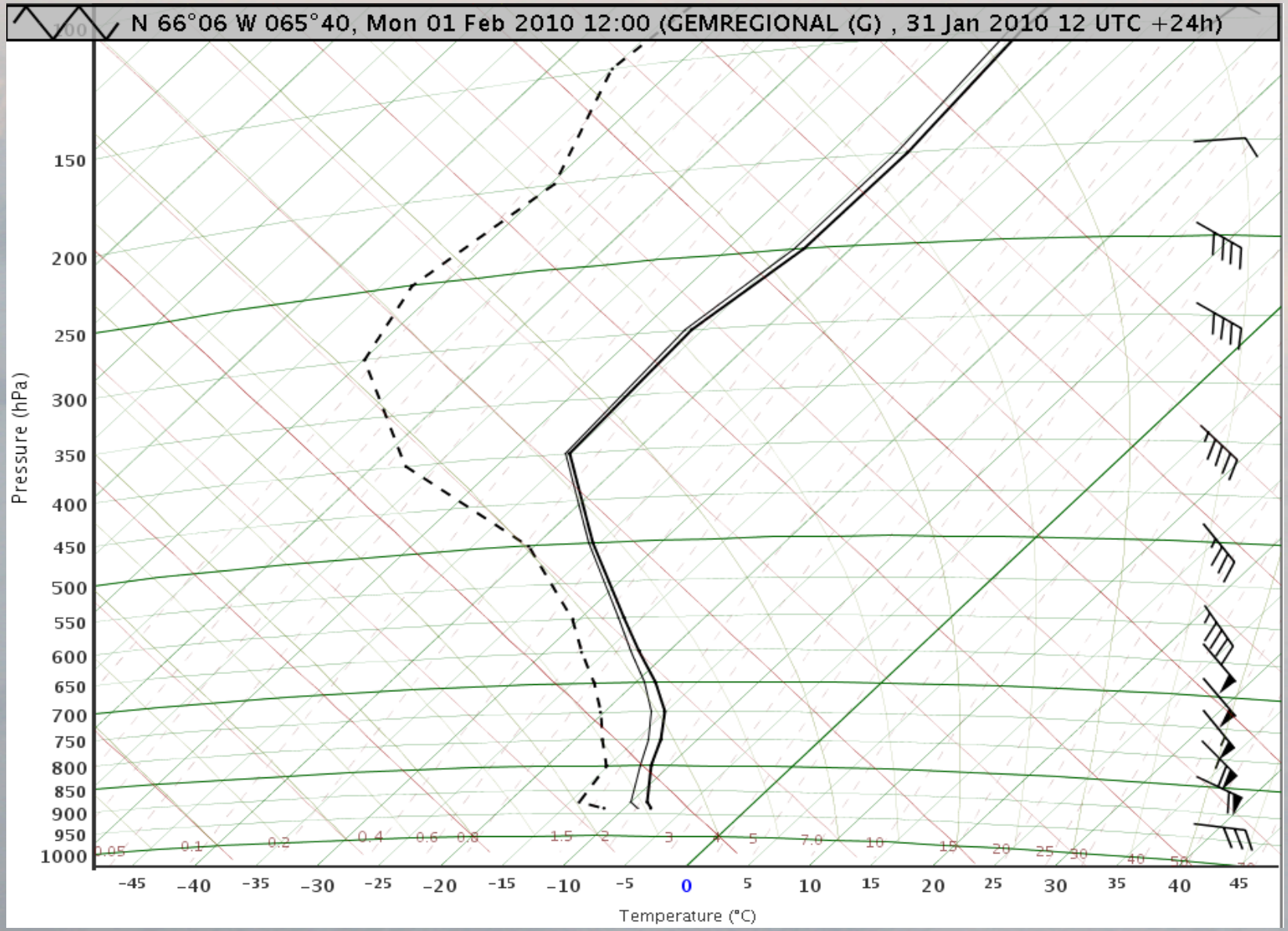


850mb Winds and Temperature



0.995 winds and Sfc Pressure (1mb)

Sounding


N 66°06 W 065°40, Mon 01 Feb 2010 12:00 (GEMREGIONAL (G) , 31 Jan 2010 12 UTC +24h)
Pressure (hPa)
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
-45 -40 -35 -30 -25 -20 -15 -10 -5 0 5 10 15 20 25 30 35 40 45
Temperature (°C)

Apply The Mental-Model and Dissect the Observations

WXP 010000Z AUTO 08044G67KMH -9.9/-13.0 RMK PK WND 0736 2347Z SOG 15 ALTM MISG SLP773 58012=

à Warning issued here

WXP 010100Z AUTO 08046G69KMH -9.7/-13.3 RMK PK WND 0737 0053Z ALTM MISG SLP775 55009=

WXP 010200Z AUTO 08044G67KMH -9.1/-12.9 RMK PK WND 0836 0153Z ALTM MISG SLP772 58003=

WXP 010300Z AUTO 07043G65KMH -8.6/-13.0 RMK PK WND 0835 0217Z ALTM MISG SLP767 58006=

WXP 010400Z AUTO 07050G67KMH **-8.8**/-12.5 RMK PK WND 0736 0352Z ALTM MISG SLP762 58013=

WXP 010500Z AUTO 08048G69KMH **-4.0**/-8.7 RMK PK WND 0837 0452Z ALTM MISG SLP762 56010=

WXP 010600Z AUTO 09050G65KMH -4.7/-9.0 RMK PK WND 0941 0524Z SOG 14 ALTM MISG SLP766 55001=

WXP 010700Z AUTO 09065G102KMH -4.5/-9.2 RMK PK WND 1155 0657Z ALTM MISG SLP767 53005=

WXP 010800Z AUTO 08065G87KMH -4.6/-9.0 RMK PK WND 1055 0700Z ALTM MISG SLP774 53012=

WXP 010900Z AUTO 09069G111KMH -4.2/-9.7 RMK PK WND 0860 0858Z ALTM MISG SLP777 53011=

WXP 011000Z AUTO 09076G119KMH -4.3/-9.2 RMK PK WND 0963 0952Z ALTM MISG SLP775 50008=

WXP 011100Z AUTO 08076G106KMH -4.2/-9.8 RMK PK WND *1071* 1012Z ALTM MISG SLP783 53009=

WXP 011200Z AUTO 08043G80KMH -3.6/-12.5 RMK PK WND 1159 1103Z SOG 03 PRESRRPRECIP PAST 15MIN 0.2MM ALTM MISG SLP826 53049=

WXP 011300Z AUTO 10032G57KMH -4.7/-12.6 RMK PK WND 1046 1219Z ALTM MISG SLP843 53068=

WXP 011400Z AUTO 09035G44KMH -6.3/-14.4 RMK PK WND 1026 1346Z ALTM MISG SLP855 51072=

Temperature rises 5 degrees in one hour between 04 and 05 GMT

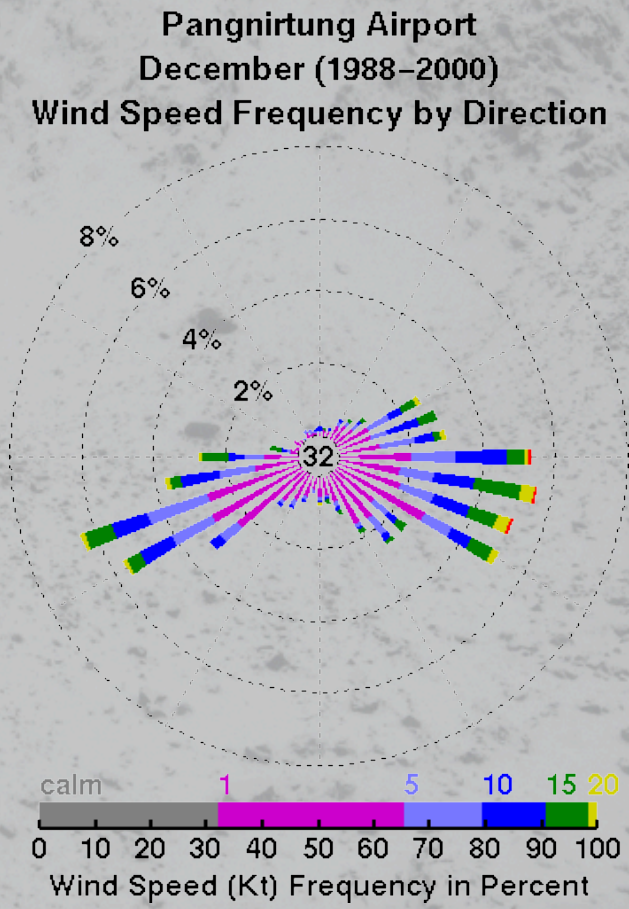
Not much change in wind direction, but no 070 after 05 GMT

Transition from down fiord flow to downslope flow probably occurred near 05 GMT

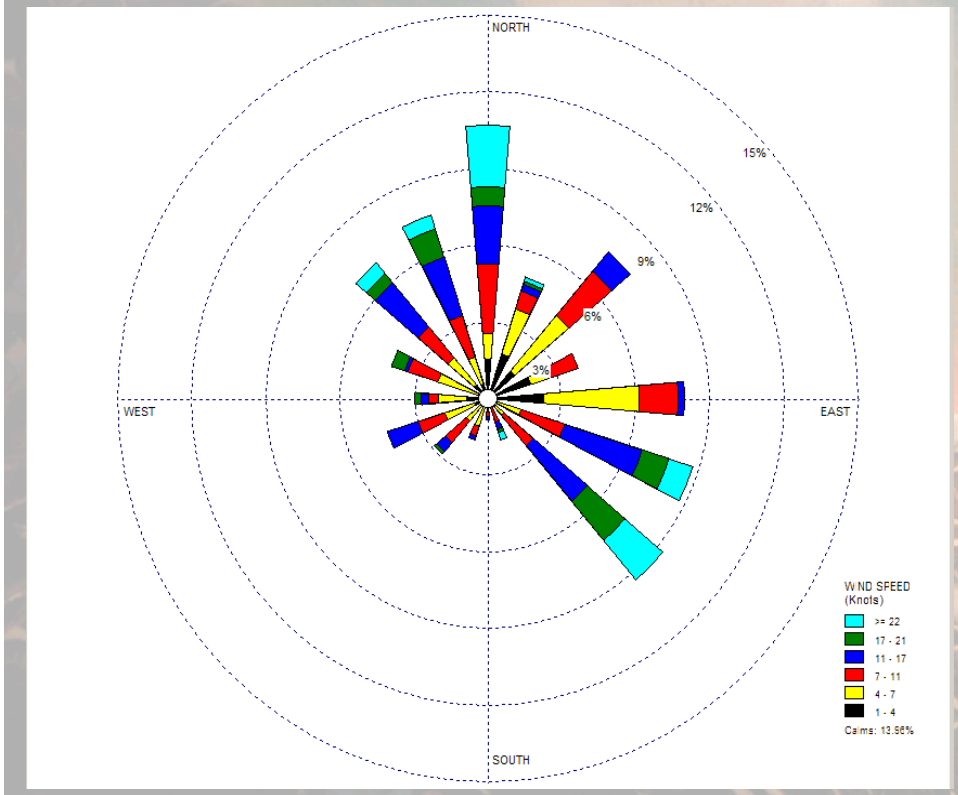
Perfectly fits the “conceptual model” suggested by the STAR observations – even if the transition not easily seen in wind observations at airport

North Winds at Pangnirtung

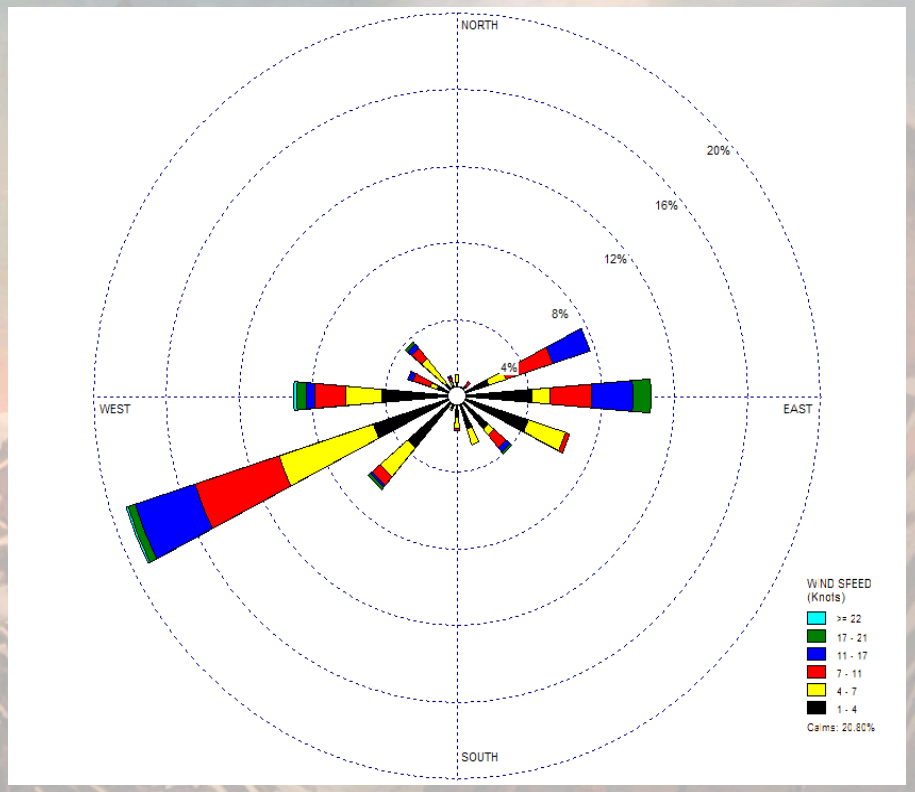
- North winds do occur at Pangnirtung, but they are uncommon and generally light
- It is very common to have a strong northerly(ish) gradient over the region
- A weather station installed on the plateau above Pangnirtung gives some insight to conditions above the fiord
- Data was made available for October – December 2008



Large Differences Between Surface and Plateau

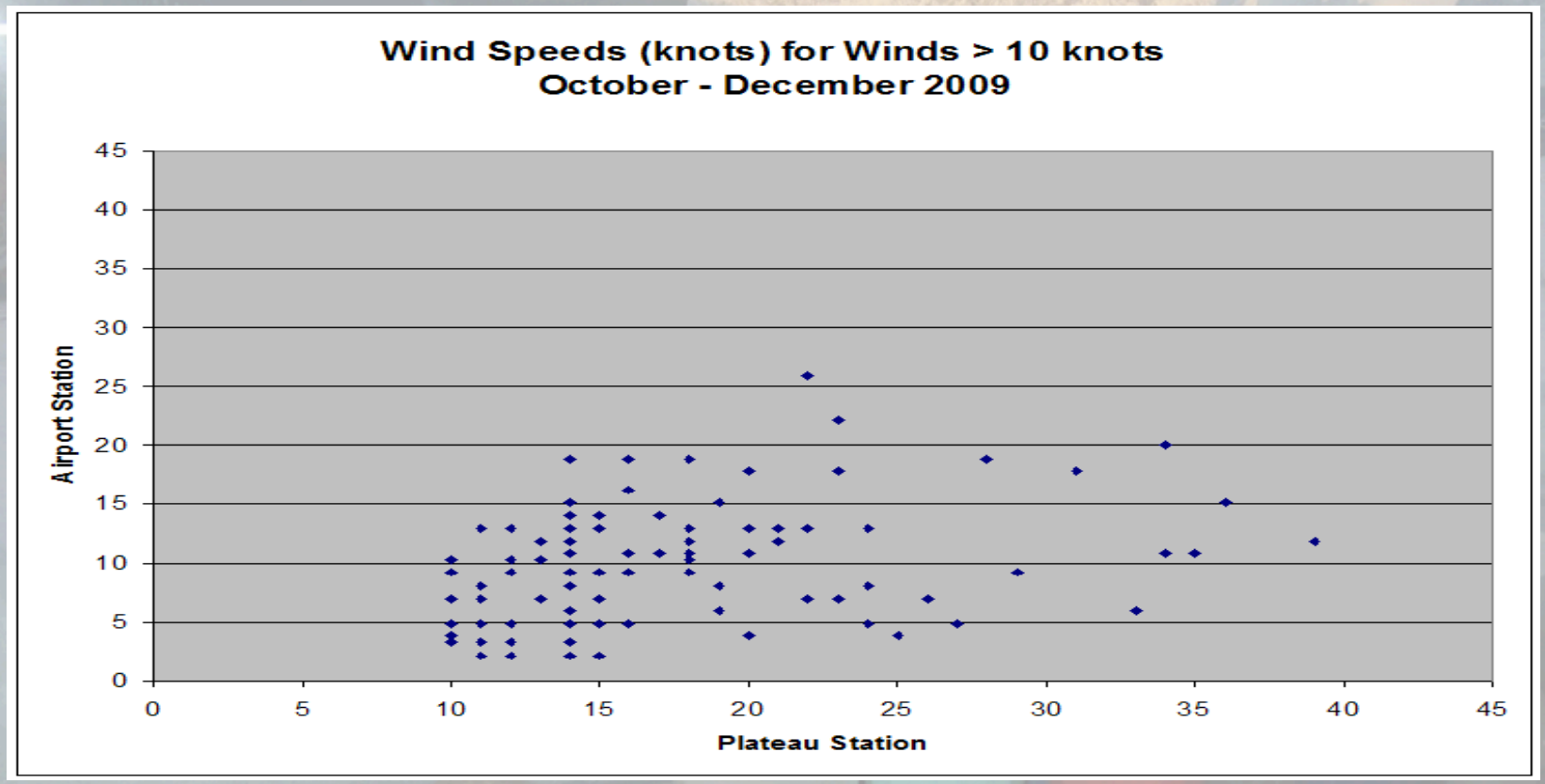


Pangnirtung Plateau wind rose for Oct - Dec 2008



Pangnirtung Autostation wind rose for Oct – Dec 2008

Wind Speed Comparison



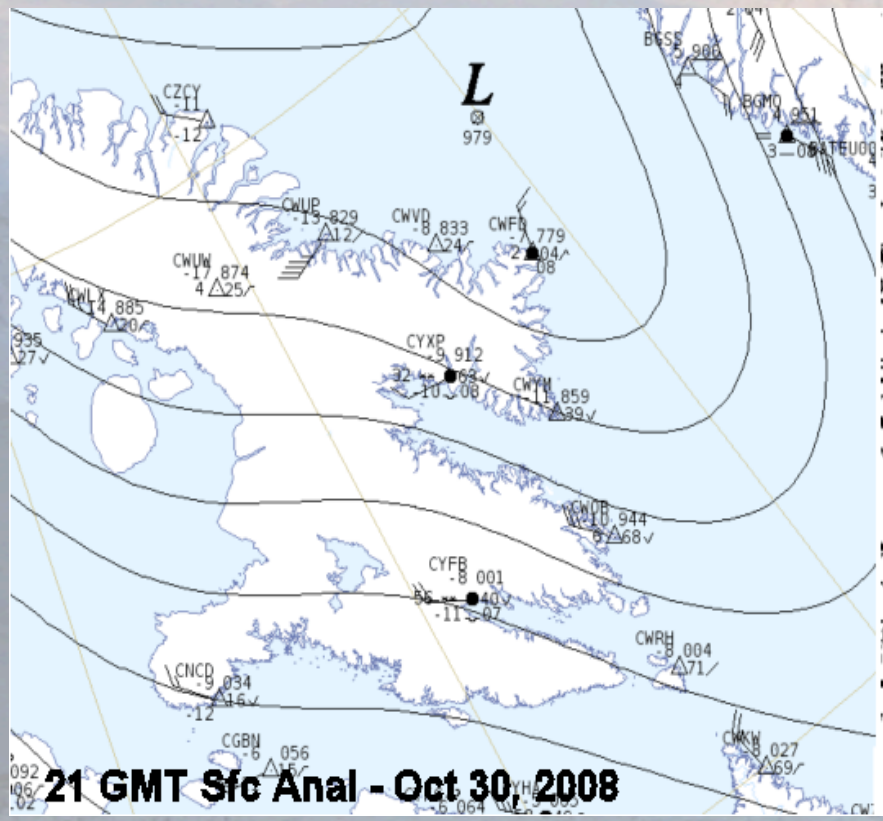
Airport winds of only 10 knot could be > 30 knots on the plateau.

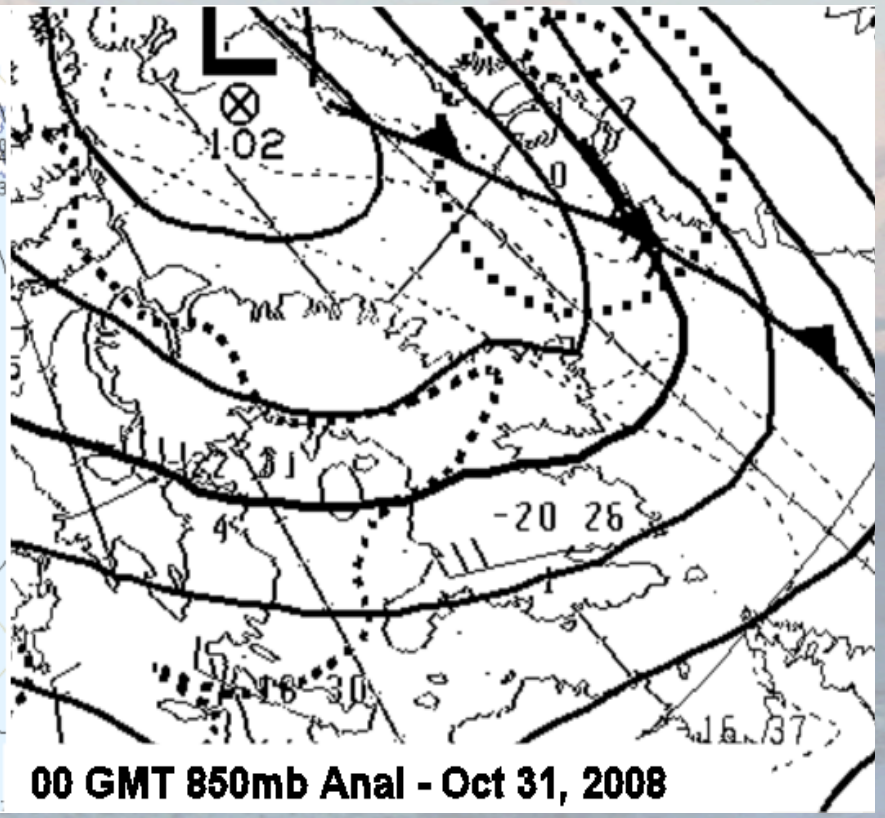
Not incredibly surprising, but these are the first and only observations

The strong north – northwesterly wind events aloft are seen at the surface as southwest winds

Important information for aircraft operations

For a flight into Pangnirtung up the fiord – there would be a considerable push from the side (toward cliff walls) – changing to a light tailwind upon descent





Iqaluit North East Wind

GEMLAM Results

The Issues

The strongest, most damaging winds are often from the North East

The winds descend the terrain upstream of Iqaluit

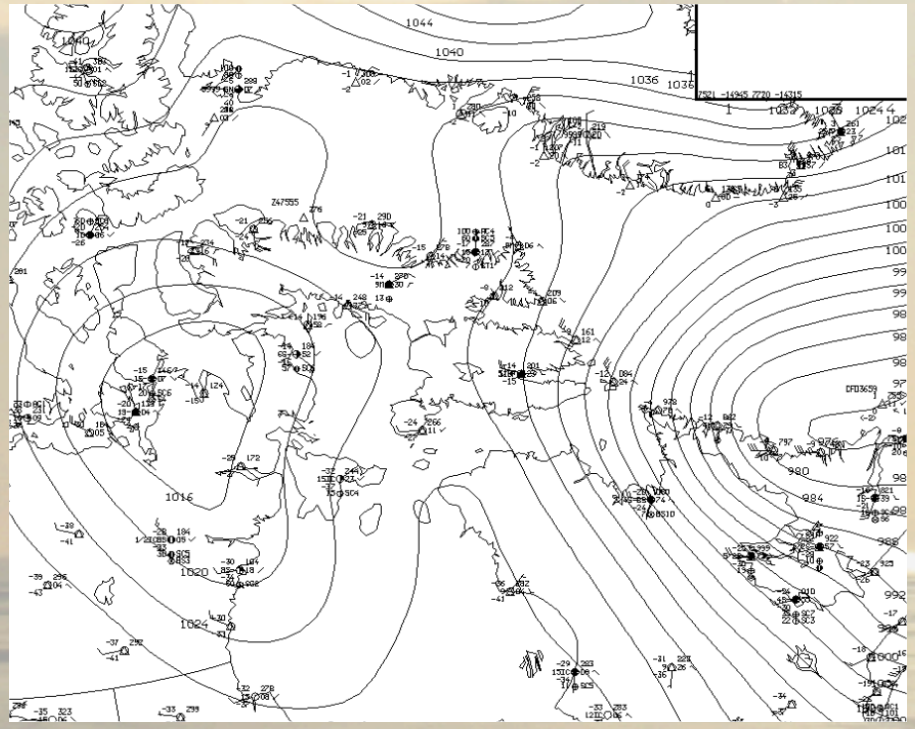
Their onset is very difficult to predict as often a underlying cold layer of northwesterly winds must first be displaced

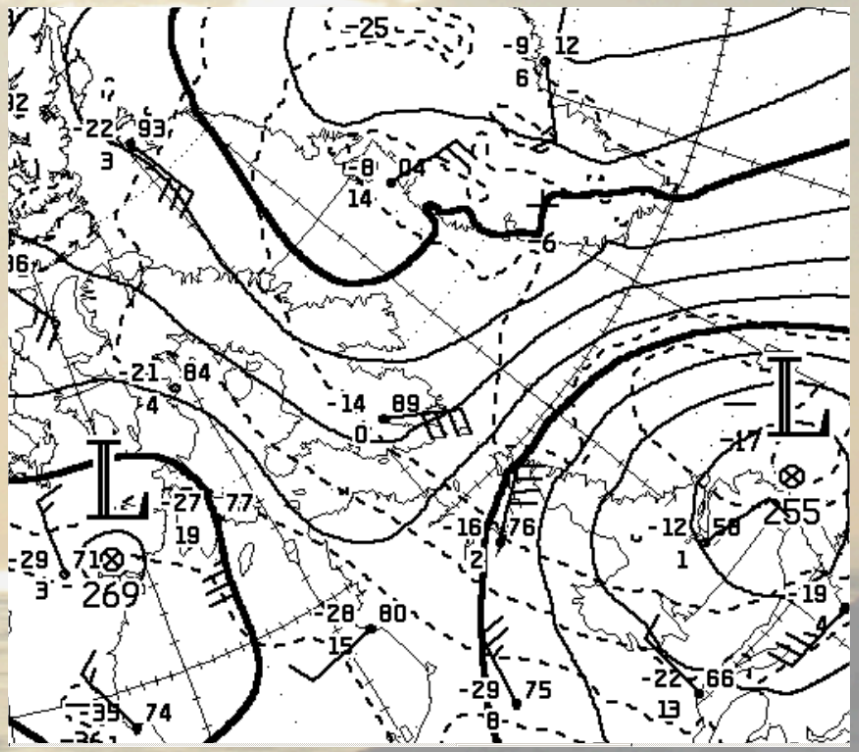
The depth and “strength” of the cold air is not known.

For a description of the “conceptual model” see:

Daniel Deacu, Ayrton Zadra and John Hanesiak Simulating Wind Channelling over Frobisher Bay and its Interaction with Downslope Winds during the 7-8 November 2006 Wind Event – Atmosphere Ocean 48-2

Stronger Than Average But Typical Evolution
February 26, 2006





Surface analysis at 12GMT. In early stage, the large pressure gradient at the surface support moderate to strong northwesterly winds

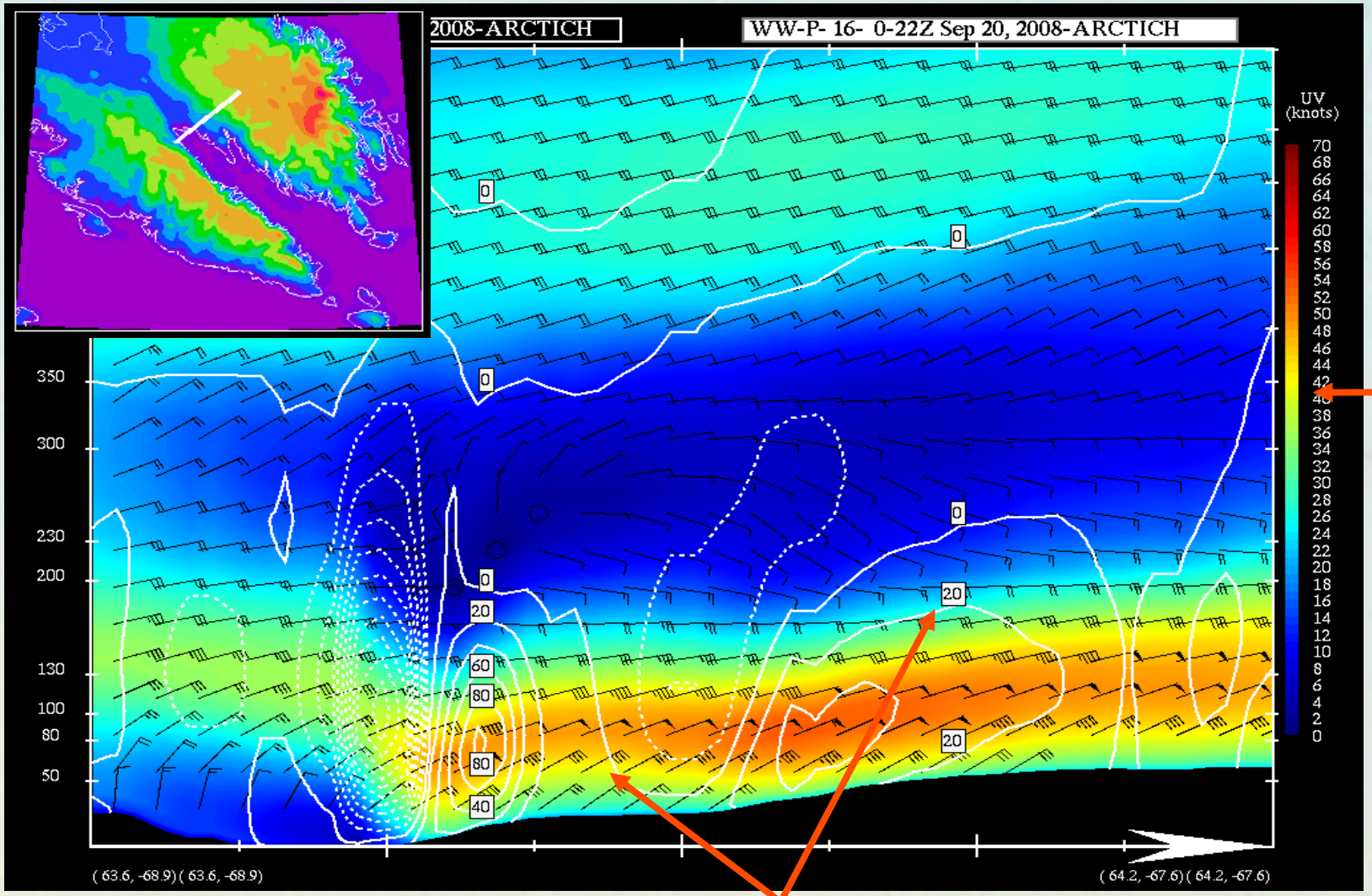
But the 700mb shows that a deep layer of northeasterly flow is a-coming

On rare occasions – get to see winds varying strongly in speed and direction

February 05, 2007

Date/Time	MSLP	TEMP	WND DIR	WND SPD (kt)	GUST (kt)
07/02/05-02:00	993.1	-8.8	80	19	25
07/02/05-03:00	991.9	-8.4	340	14	20
07/02/05-03:15			10	16	26
07/02/05-03:38			40	21	42
07/02/05-04:00	988.3	-8.1	60	38	59
07/02/05-05:00	987.8	-8.1	60	41	54
07/02/05-06:00	989.6	-7.8	70	28	40
07/02/05-06:44			290	4	28
07/02/05-07:00	990.5	-7.6	260	13	
07/02/05-07:32			310	6	16
07/02/05-08:00	989.7	-7	60	11	21
07/02/05-08:44			220	3	18
07/02/05-09:00	988.8	-7.1	70	23	32
07/02/05-09:33			60	30	45
07/02/05-10:00	987.9	-7	60	30	45
07/02/05-11:00	987.8	-7.6	60	33	50

Does The GEMLAM Capture Northeast Wind Events



Wind Scale for Coloured Background (knots)

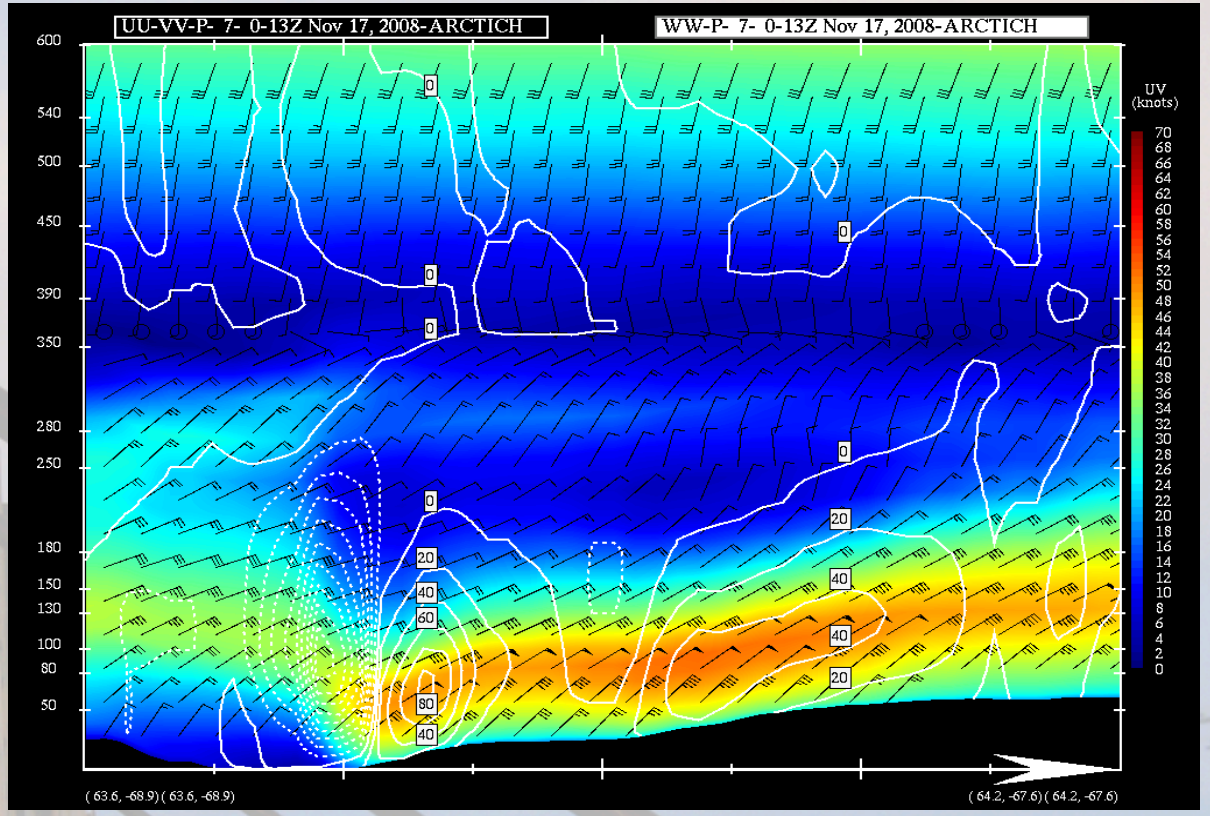
Vertical Motion with 20 pa/sec contour interval (50 pa/sec = 1 knot)

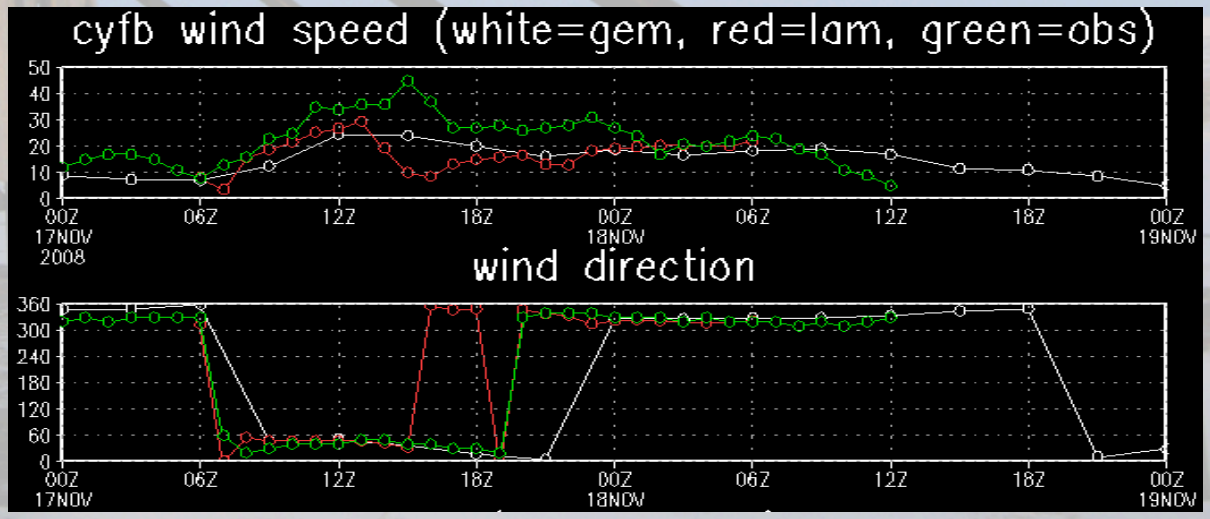
positive -> downward negative -> upwards

Nov 17, 2008

GEM winds too light and too slow to end northeast winds

GEMLAM better at start of event but winds detach from surface too early giving poor results during worst of NE wind event



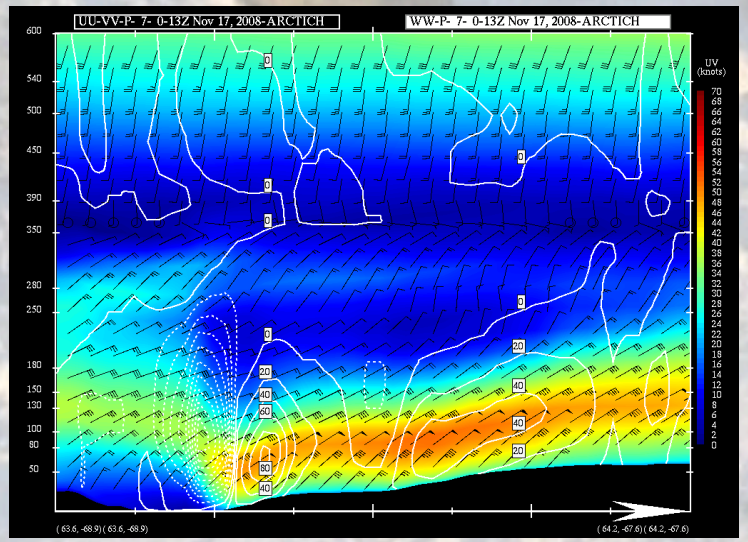


Are GEMLAM Iqaluit Winds Better Than GEM

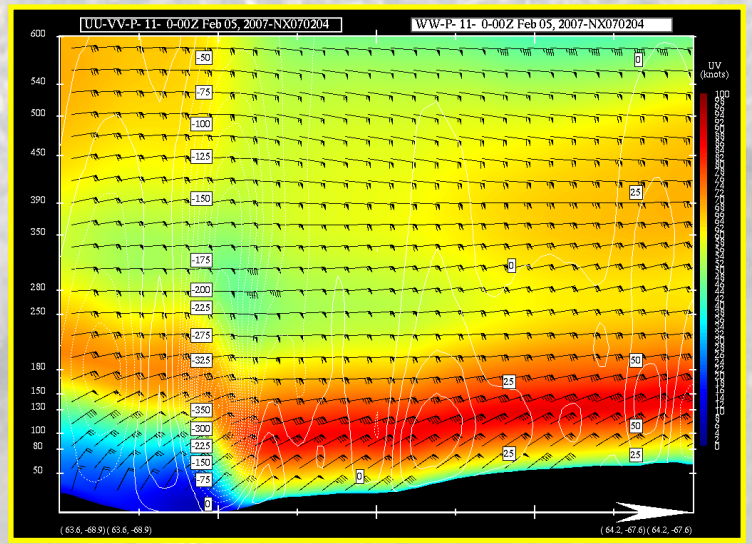
- Meteograms shown indicate that GEM and GEMLAM winds at Iqaluit are not that different
- Sometimes, GEMLAM lighter than GEM, such as when “jump” region retreats upstream
- Statistics confirm the above.

NE Wind Cases

total cases	99
average observed speed	12.3
average GEM speed	7.9
average GEMLAM speed	8.1
GEM RMSE speed	7.2
GEMLAM RMSE speed	7.6
GEM standard deviation speed	5.8
GEMLAM standard deviation speed	6.4



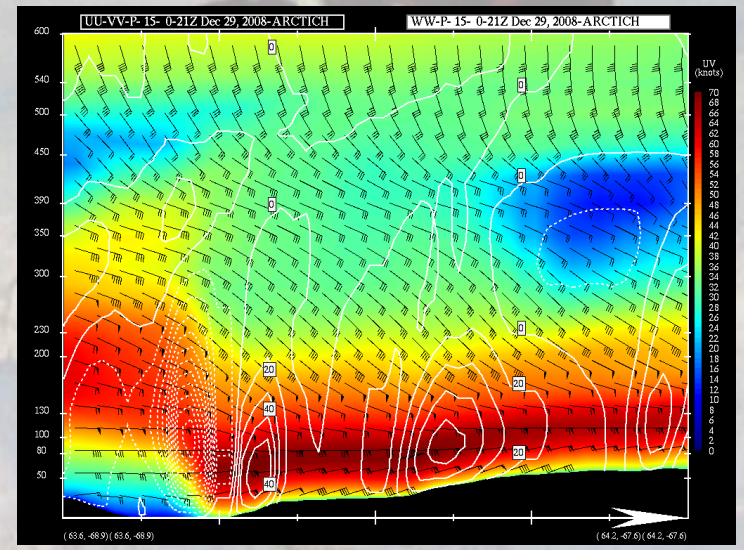
in General



GEMLAM images with a significant jump region and a well-defined area of upwards vertical motion near Iqaluit are highly indicative of a moderate-strong observed Northeast Wind Event

CYFB 300000Z 12007G17KT
CYFB 300100Z 13015G26KT
CYFB 300200Z 10016G28KT
CYFB 300300Z 12015G26KT
CYFB 300400Z 10017G24KT
CYFB 300416Z 11015G29KT
CYFB 300500Z 09025KT
CYFB 300514Z 10020G28KT
CYFB 300600Z 09023G29KT
CYFB 300621Z 08024G30KT
CYFB 300700Z 09024G31KT

but it doesn't always work



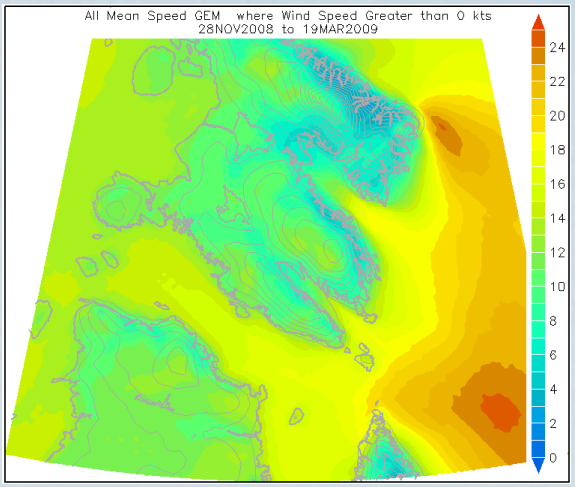
Lessons Learned

- Even with strong forcing mechanisms, a mesoscale model will not necessarily perform better than a regional model
- Quality of physical schemes and surface fields are very important for Arctic winter with strong low-level stability
- Forecasters need to have a conceptual model for the weather, and know the strength & weaknesses of a NWP model *but* also consider model sensitivity with respect to important features of the conceptual model

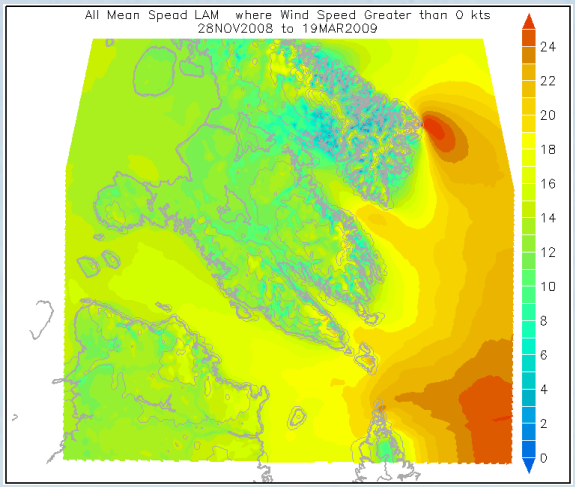
Model Comparison – GEM and GEMLAM over Srn Baff Island

- Comparison of GEM vs GEMLAM based on winter 2008/09 over southern Baffin Island
- Elements studied include: wind, cloud, precipitation
- Comparison made of GEMLAM to GEM to observations
- A few examples are shown

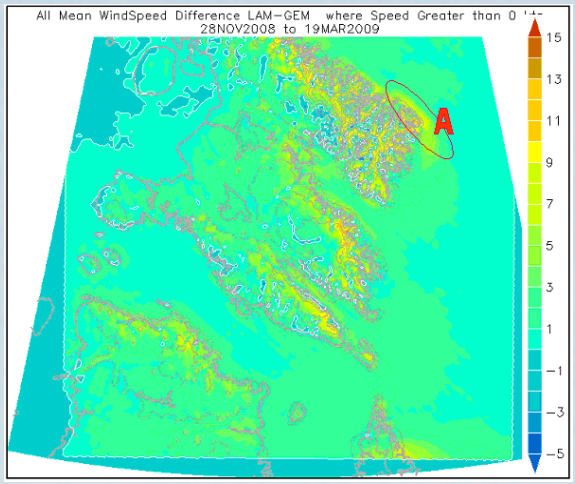
Charts



GEM



LAM



GEM - LAM

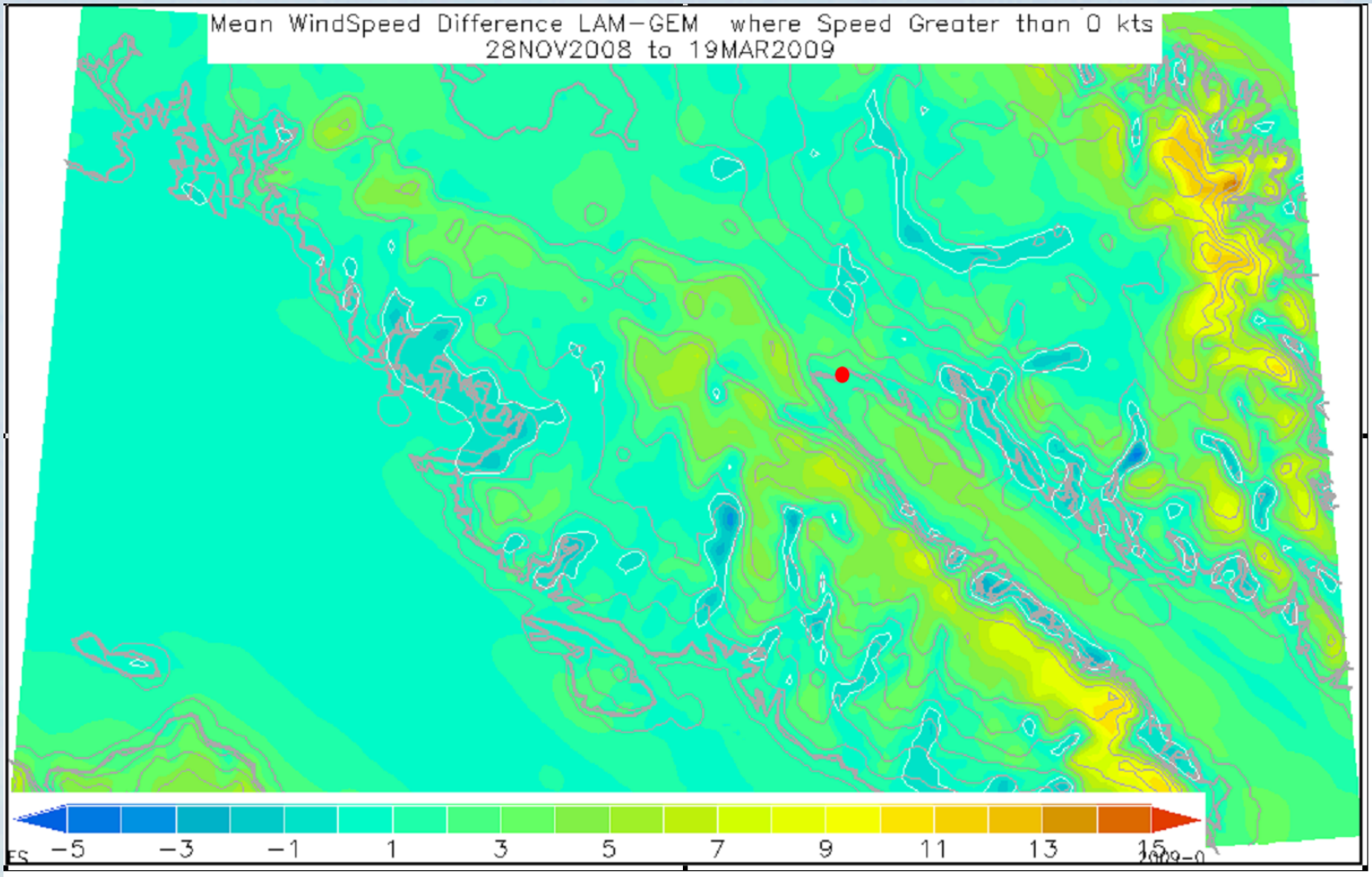
Available are charts of wind speed and direction, cloud and precipitation for the entire domain, all time periods

Charts are also stratified, such as wind speed by wind direction

Separate charts for GEM, LAM and a GEM/LAM comparison

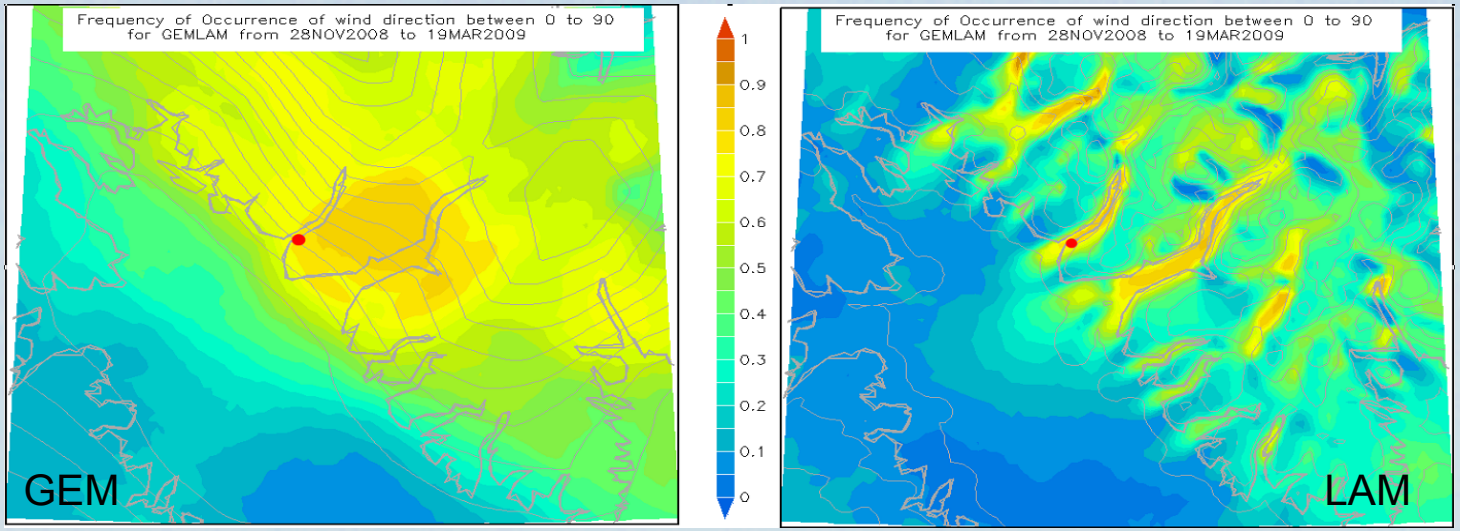
Above charts are samples for wind speed

GEM – LAM Wind Speed

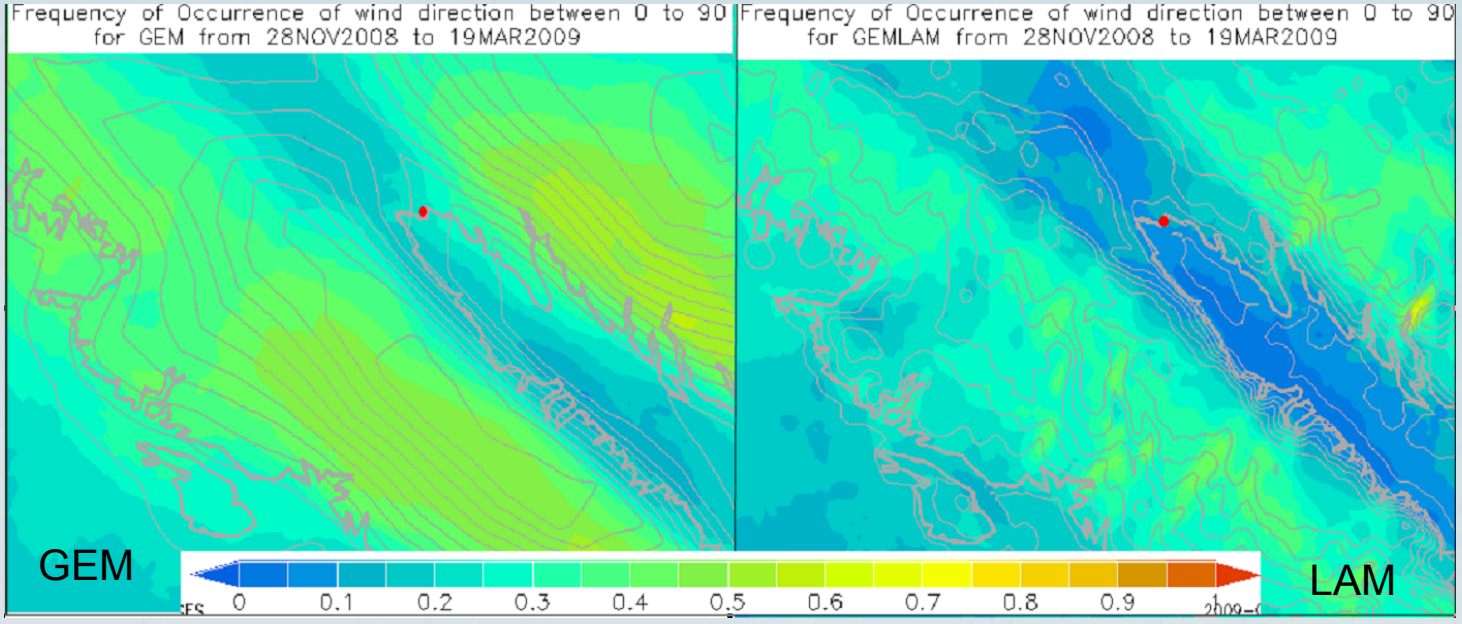


Around Iqaluit – Models are similar with slightly faster LAM winds over the water.

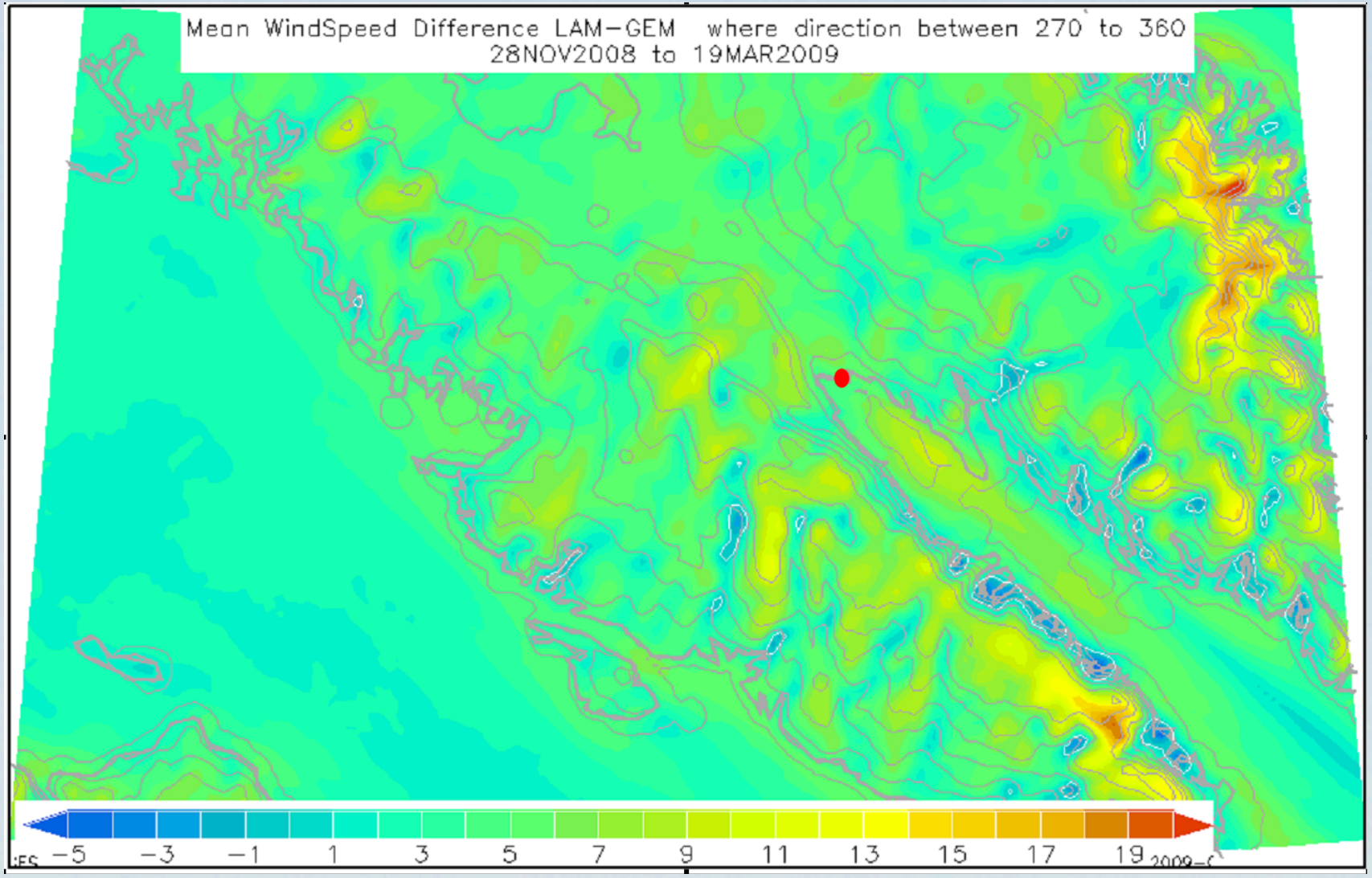
GEM- LAM Wind Direction 0 - 90



Frequency of Occurrence



GEM- LAM Wind Direction 270 - 360



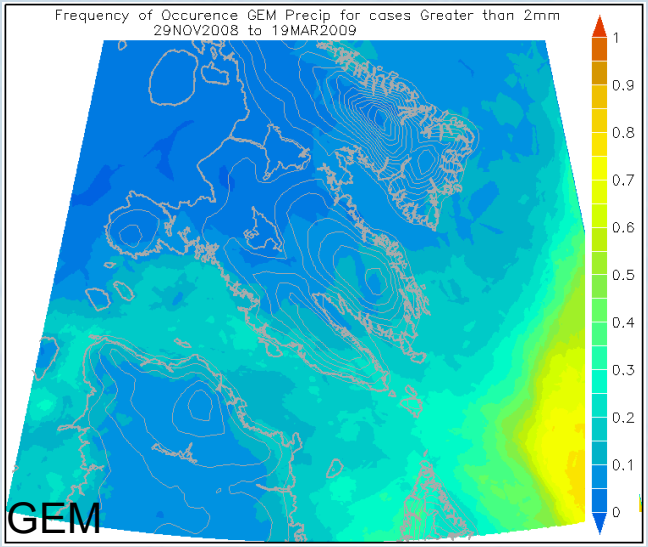
LAM winds speeds over Frobisher Bay up to 10 knots stronger than GEM

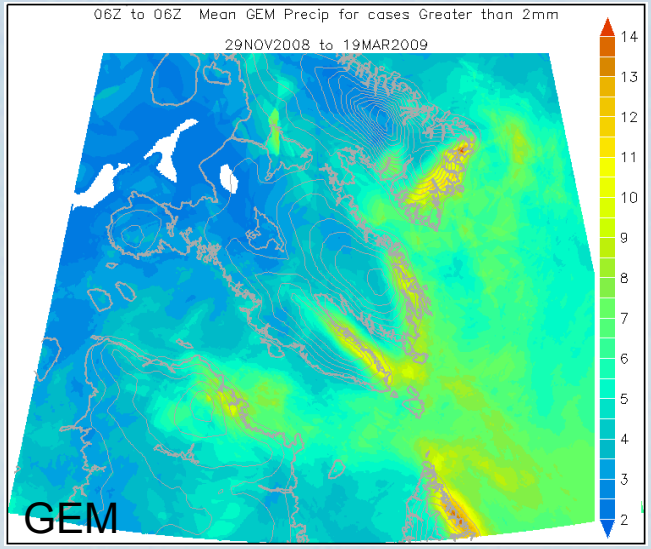
Precipitation > 2mm in 24 hours

Neither GEM or LAM have many cases of >2mm of precipitation

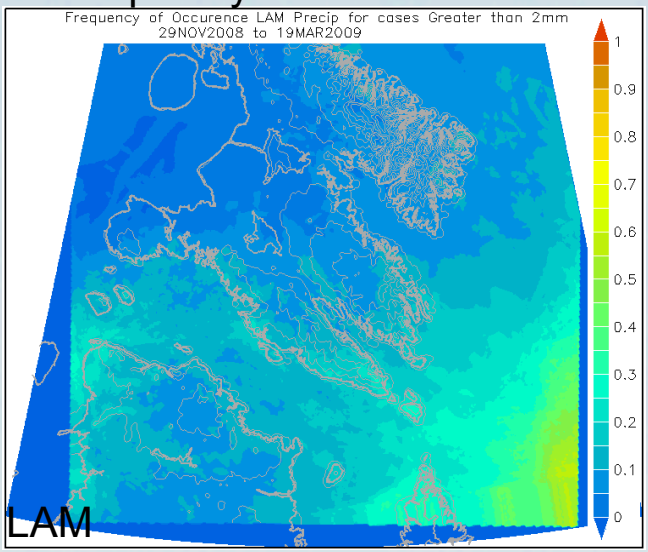
When they do, LAM precipitation exceeds GEM, mostly along upslope areas

Hint – Don't move to south coast of Frobisher Bay – Its windy and wet

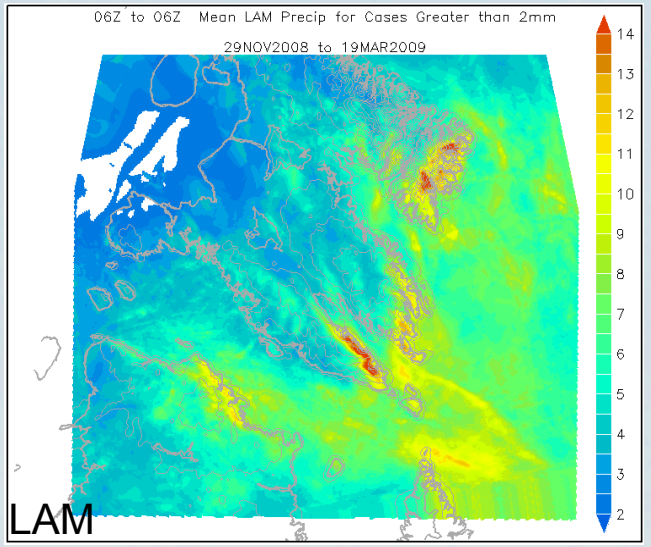




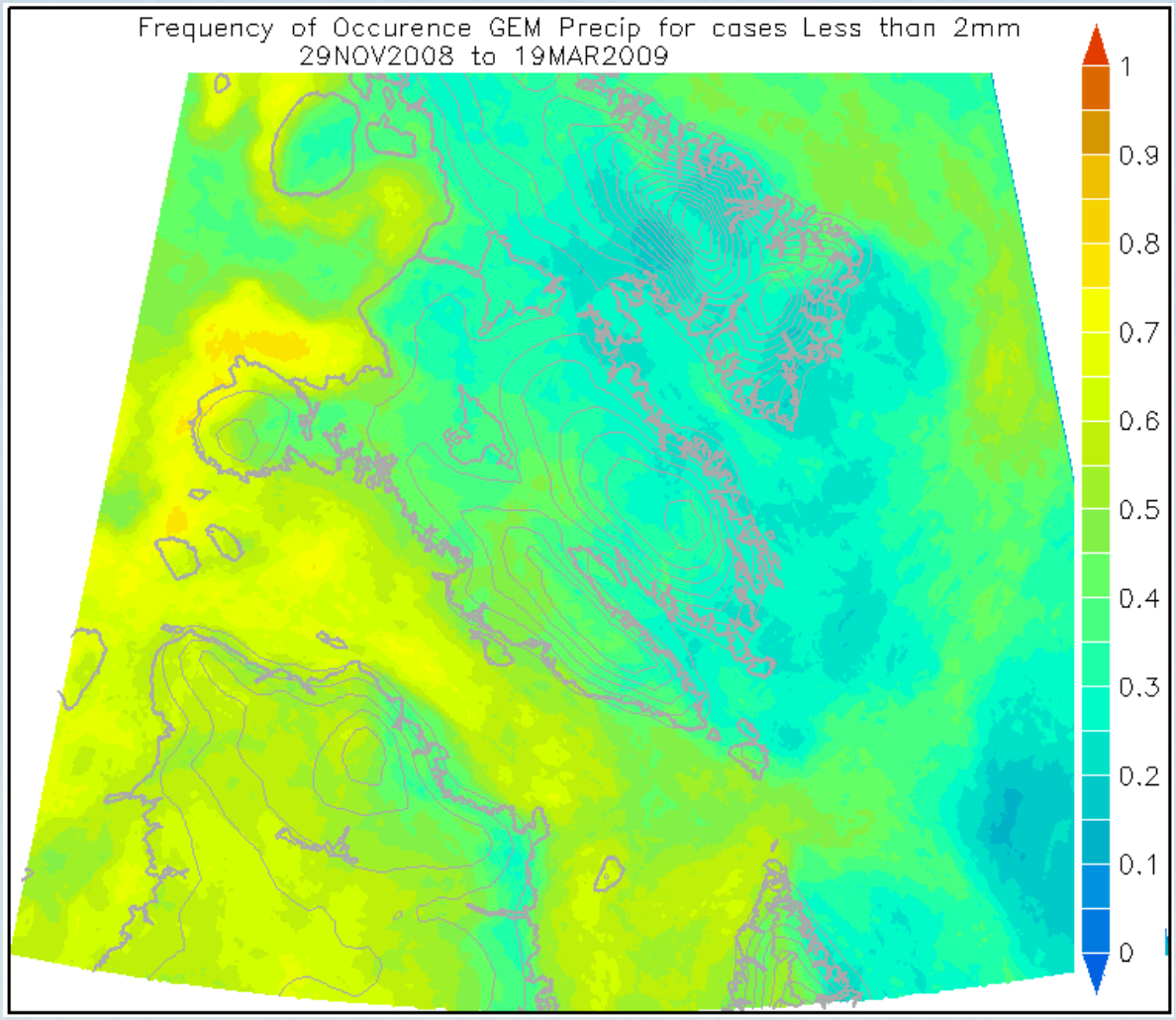
Frequency of Occurrence



Mean Amount



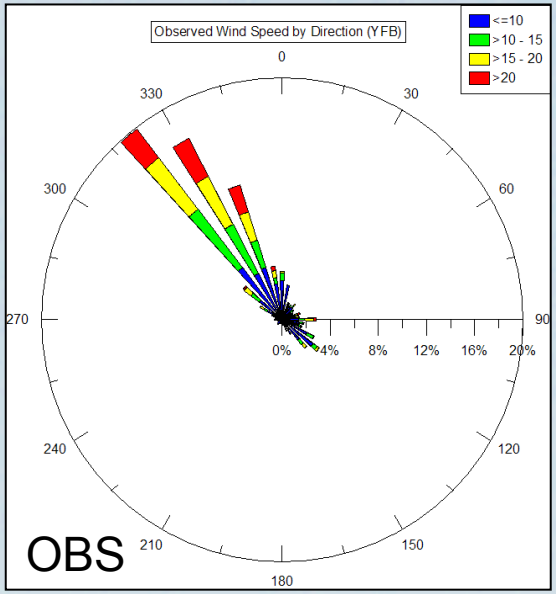
GEM Precipitation < 2mm in 24 hours

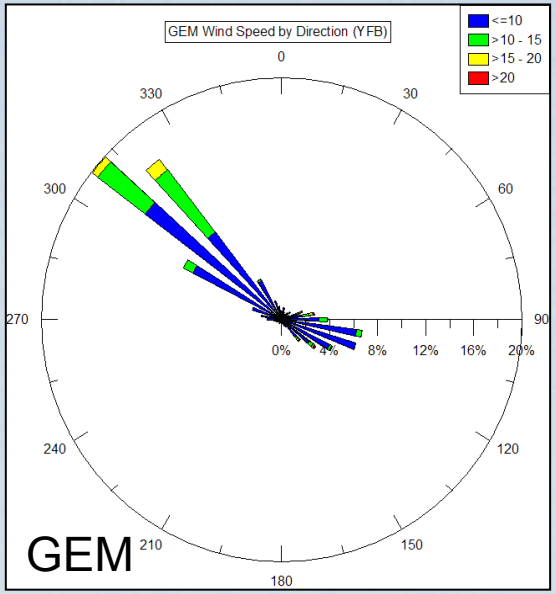


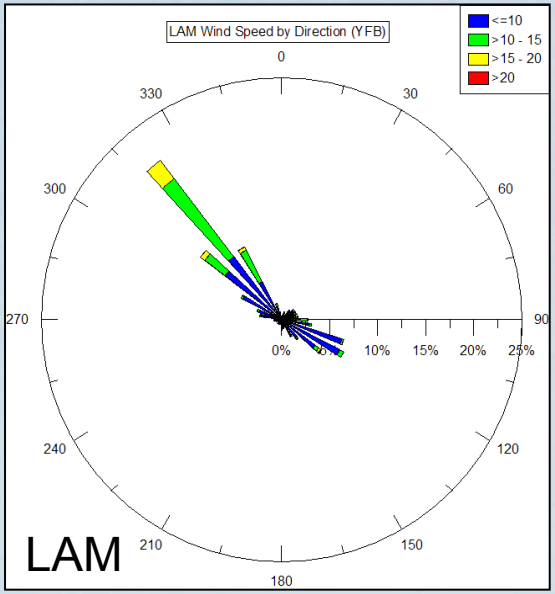
There is almost always light precipitation over the western portion of the domain.


Comparisons To Observations

Wind Rose Comparison - YFB







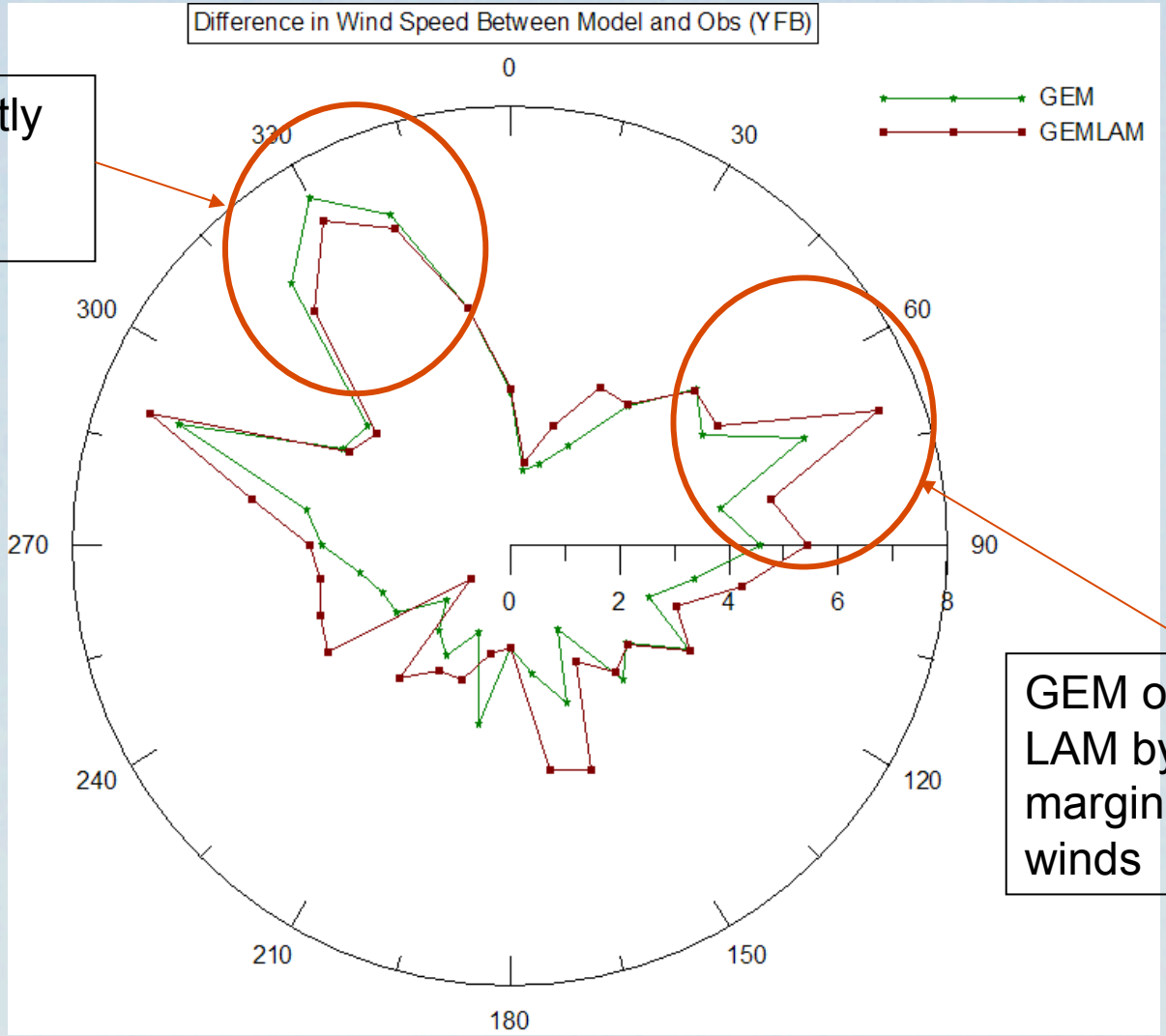
Charts such as these are available for most observations stations within the GEMLAM Domain

These provide a quick and easy method to compare model to observations such as:

- Neither model is has strong-enough NW winds – but LAM slightly better
- Neither model has enough winds in the North-East quadrant
- Both models over-predict frequency of SE, but both are too weak

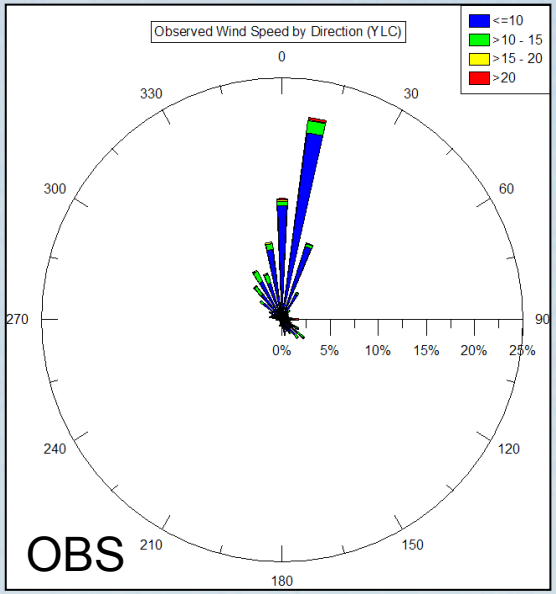
Wind Comparison By Direction - YFB

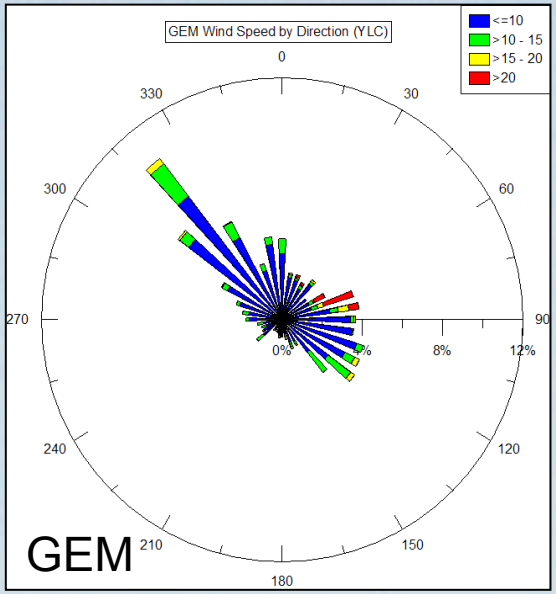
LAM has slightly lower error for NW winds

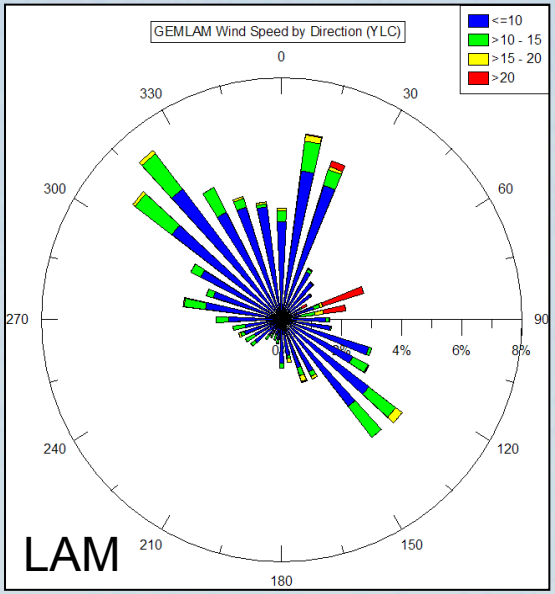


GEM outperforms LAM by a wide margin for NE winds

Wind Comparison - YLC







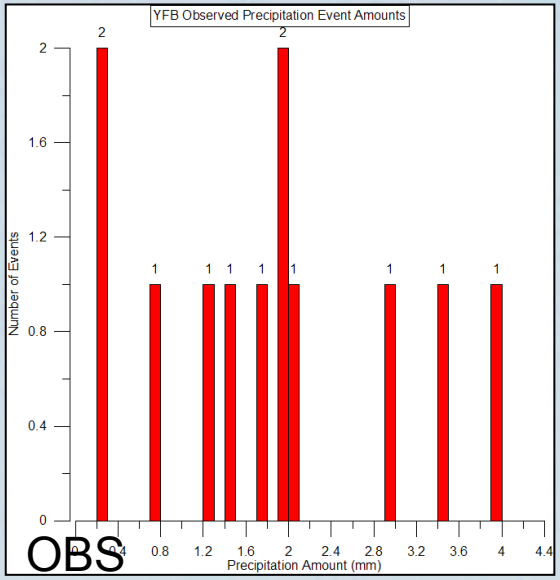
Oooops – obviously - small-scale wind-channeling that neither model handles

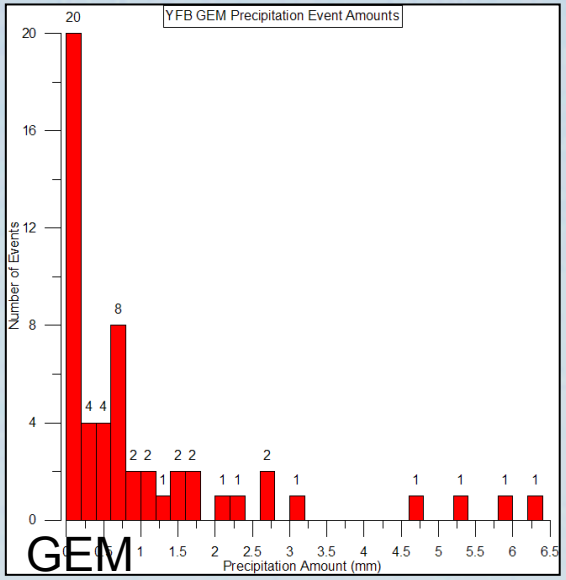
Both models horrible in predicting strong easterly winds that rarely occurred

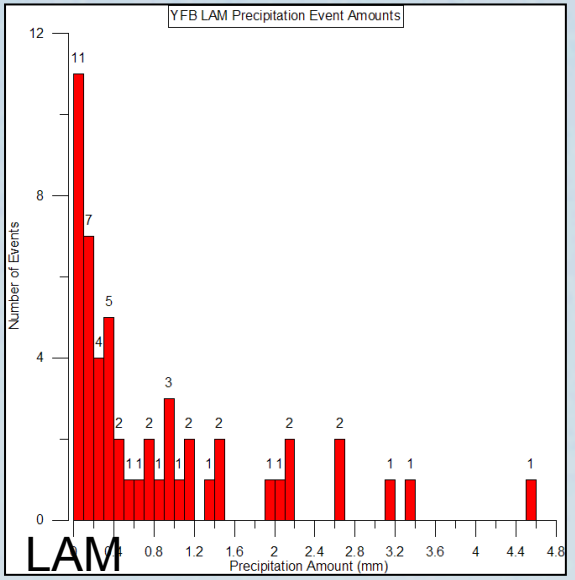
Other graphs show that model winds are east – northeast when observed winds north

But, is the airport representative of surrounding conditions?

Precipitation Comparison - YFB

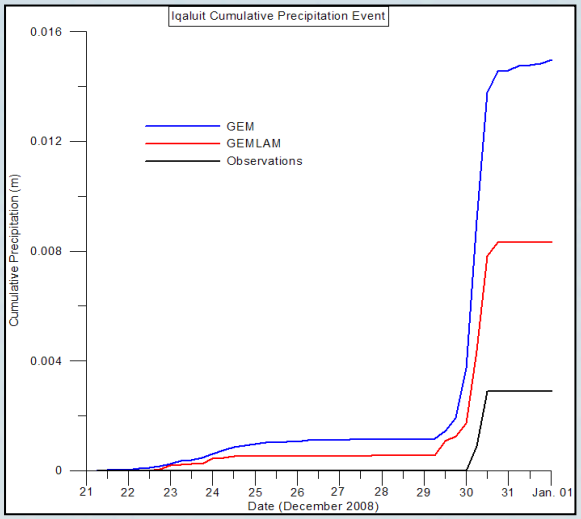






Both models have reasonable number of larger precipitation events (> 2mm) but both over-predict amounts – LAM is better than GEM

Both models hugely over-predict the number of small precipitation events – LAM much better than GEM



.. almost done

Insider Scoop

How Important STAR Decisions Were Made


WINNER !!!
LOSER


STOP
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