BOUNDARY LAYER OVER THE SNOW: RESULTS FROM THE 2012-2013 EXPERIMENTAL FIELD AT CONCORDIA STATION, DOME C, ANTARCTICA

S. Argentini

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SUMMARY

The site

The instrumentation

Wind field

PBL thermal structure, PBL height

summer, winter

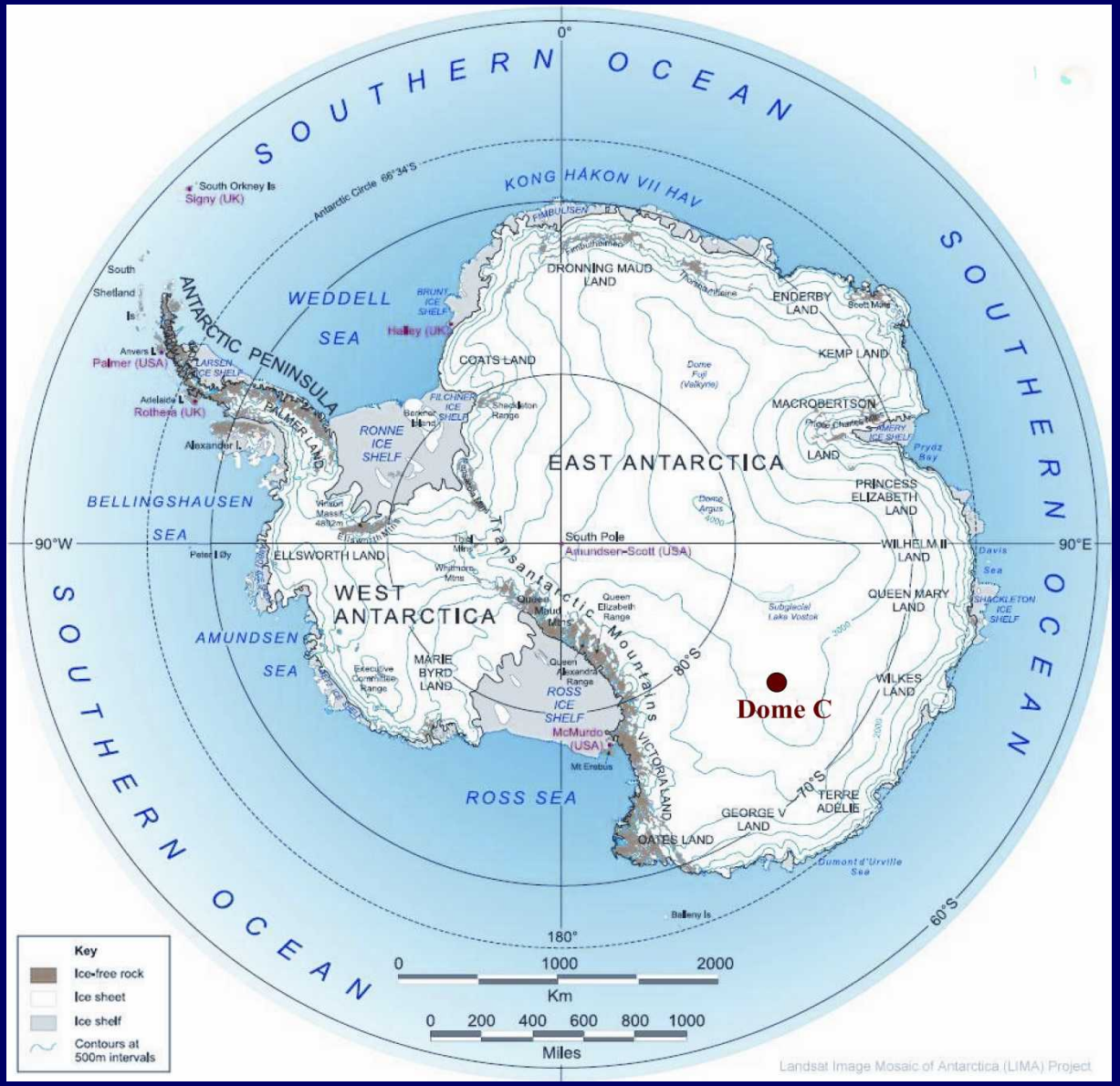
SITE : Concordia station, Dome C, East Antarctica

FIELD EXPERIMENT:

December 2011
to
January 2013

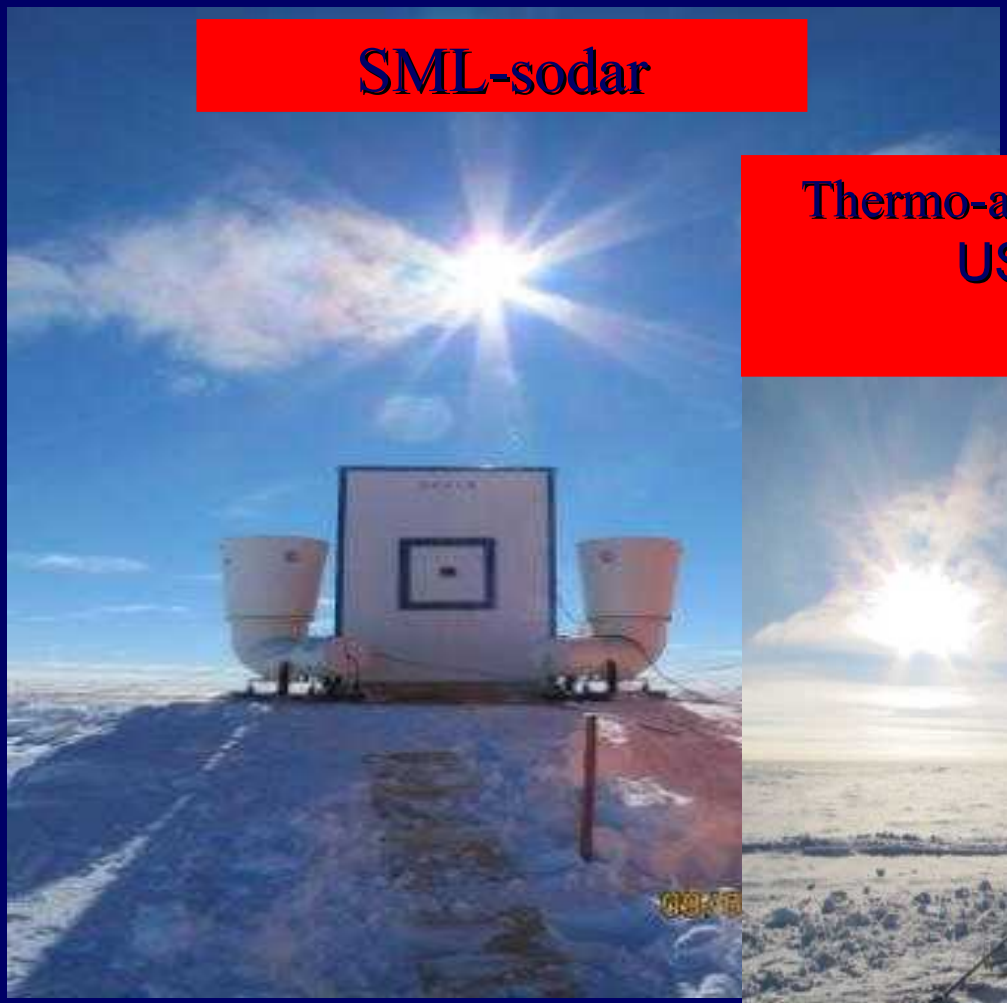
74.1 °S, 123.3 °E

Height: 3233 m a.s.l



INSTRUMENTATION

SML-sodar



Thermo-anemometer Metek
USA-1 sonic

Kipp & Zonen pyrgeometers
and pyranometers

AWS Milos520

December 2011 to January 2013

Available measurements:

Sodar: thermal structure, mixing height)

Sonic anemometer : momentum and heat fluxes, wind speed and direction, turbulence

Radiometers: short & long wave radiation up & down

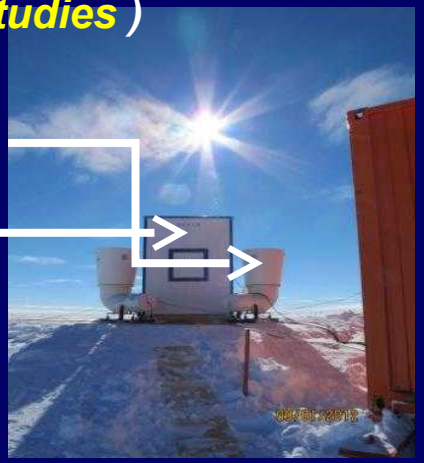
Surface Layer Mini Sodar (SLM Sodar)

SLM Sodar

high frequency (high resolution , low range, Surface Layer studies)

low frequency (low resolution, higher range, PBL studies)

3 emitting horn antennas to increase the signal intensity
(and signal-to-noise ratio)
1 larger diameter receiving antenna



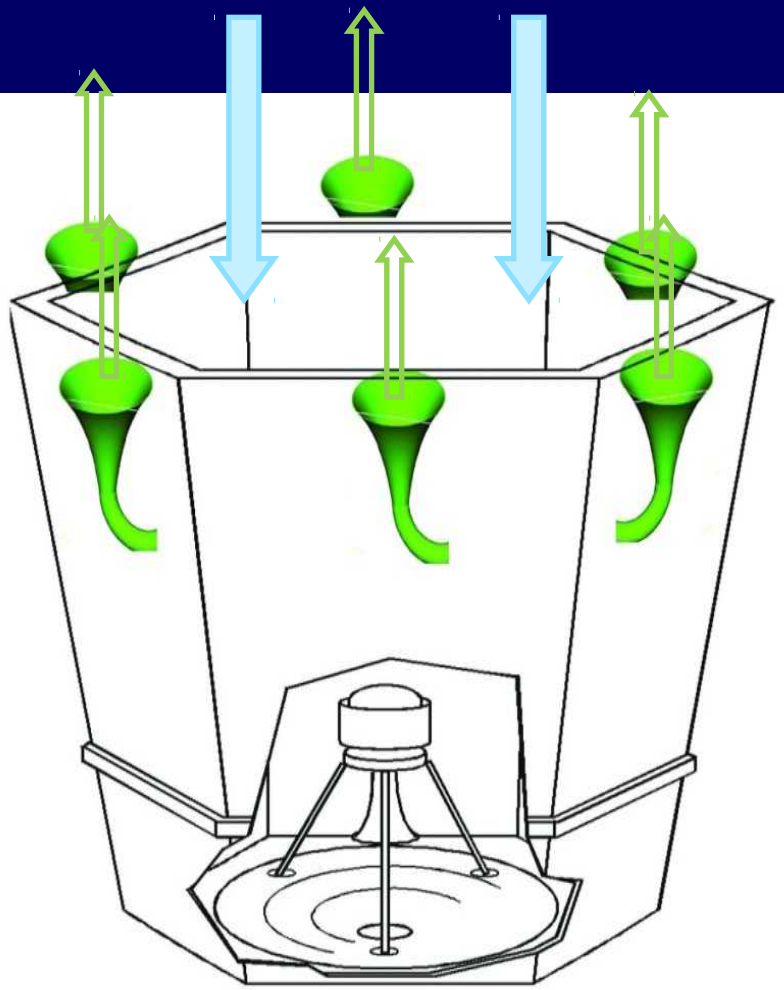
Electronic parts minimized

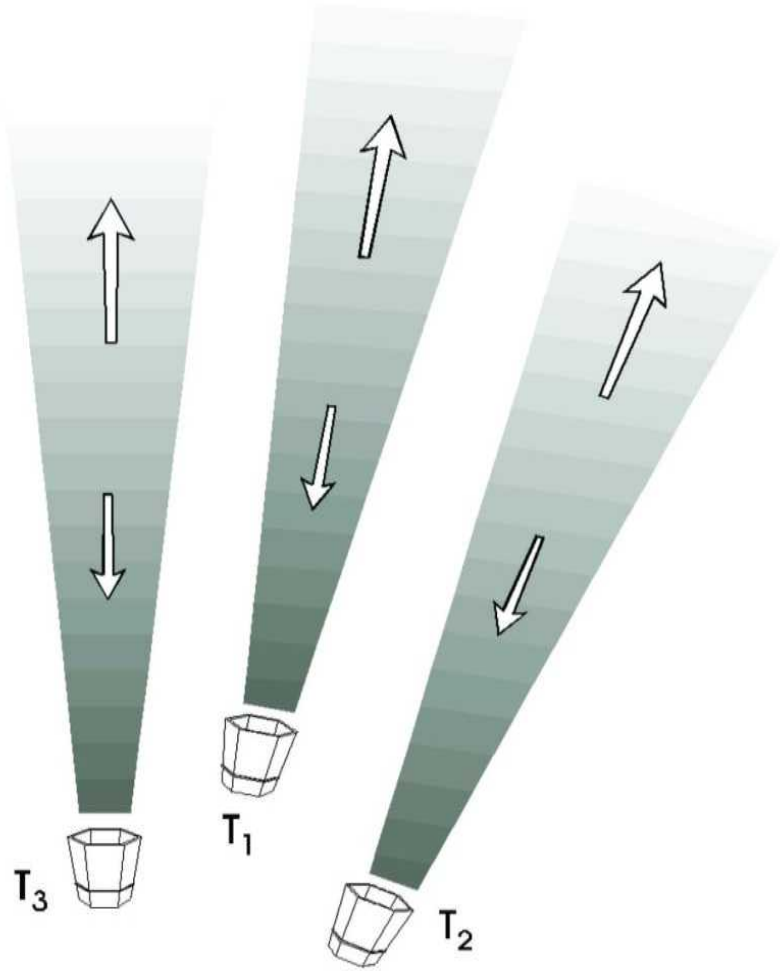
antenna preamplifier

power amplifier for the burst amplification

Parameters		
Carrier frequency	2000 Hz	4850 Hz
Pulse repetition rate	200 ms	10 ms
Maximum range	895 m	294 m
Lowest level	31 m	2 m
Vertical resolution	34 m	2 m

following… Surface Layer Sodar – 3D

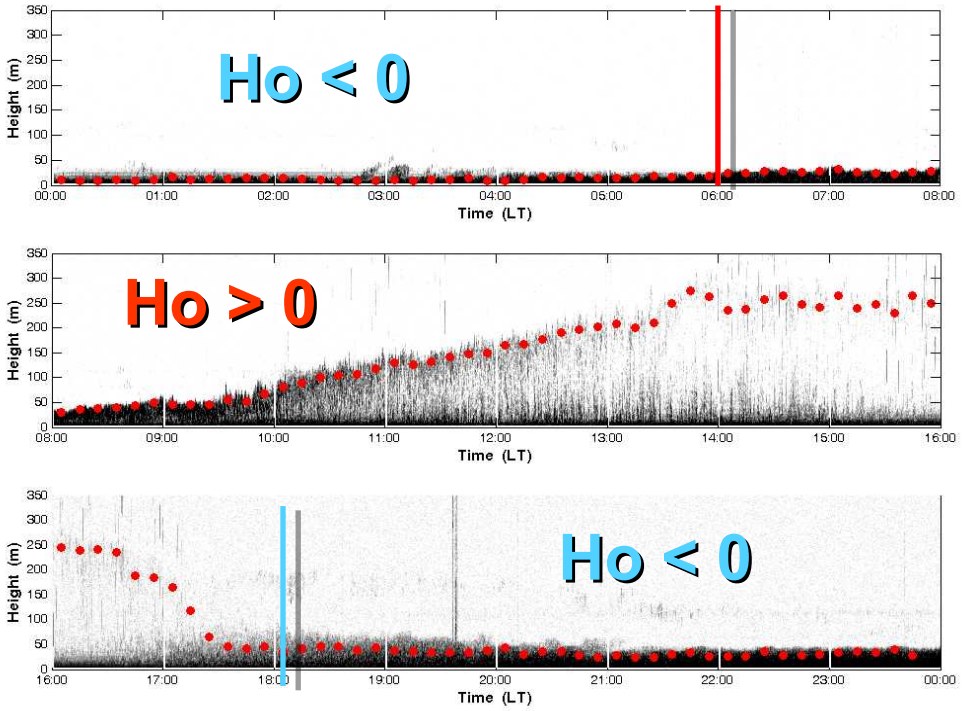


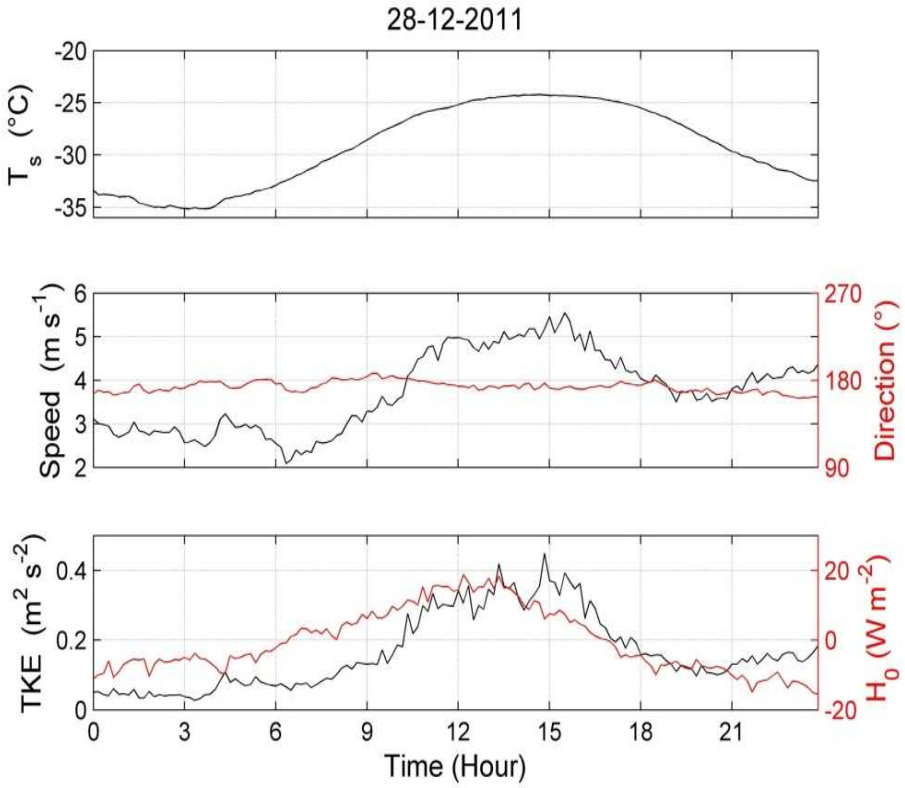


PBL THERMAL STRUCTURE

SUMMER

PBL behaviour (28 December, 2011





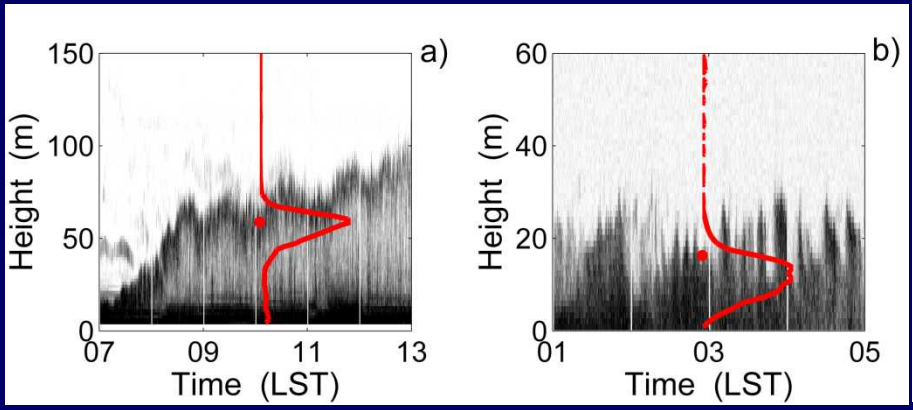
Transition from stable (Ho < 0) to unstable (Ho > 0)

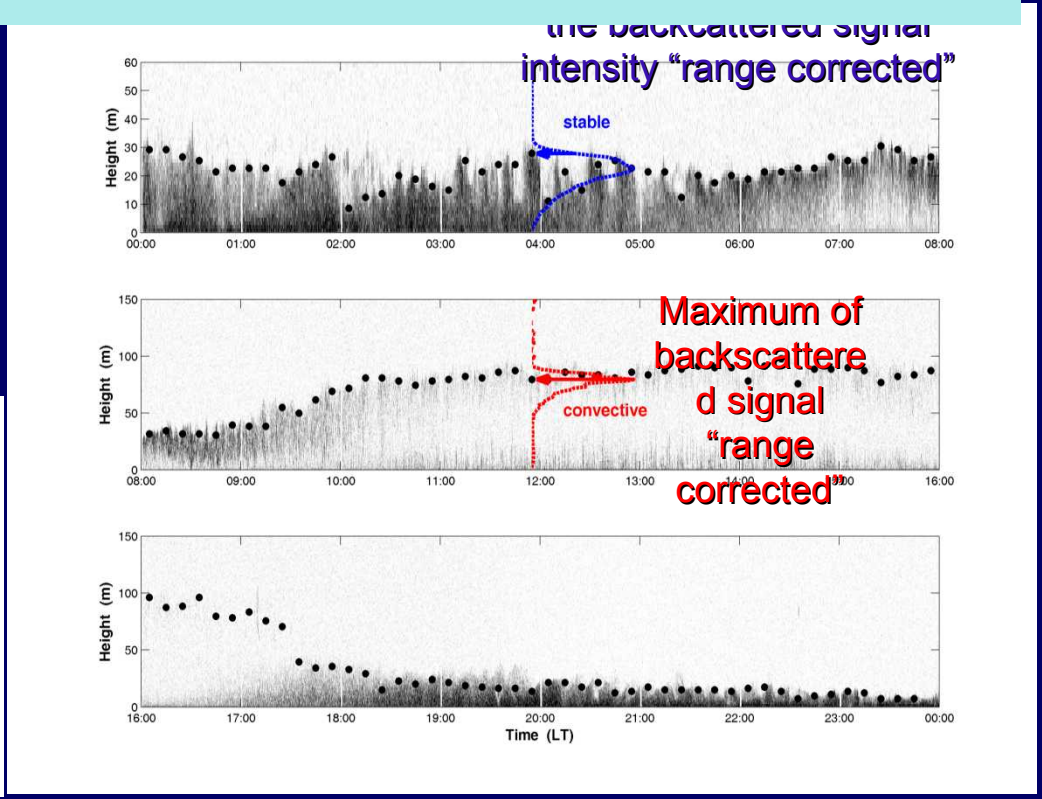
Maximum of temperature, wind speed, Ho,TKE 1200 -1800 LST

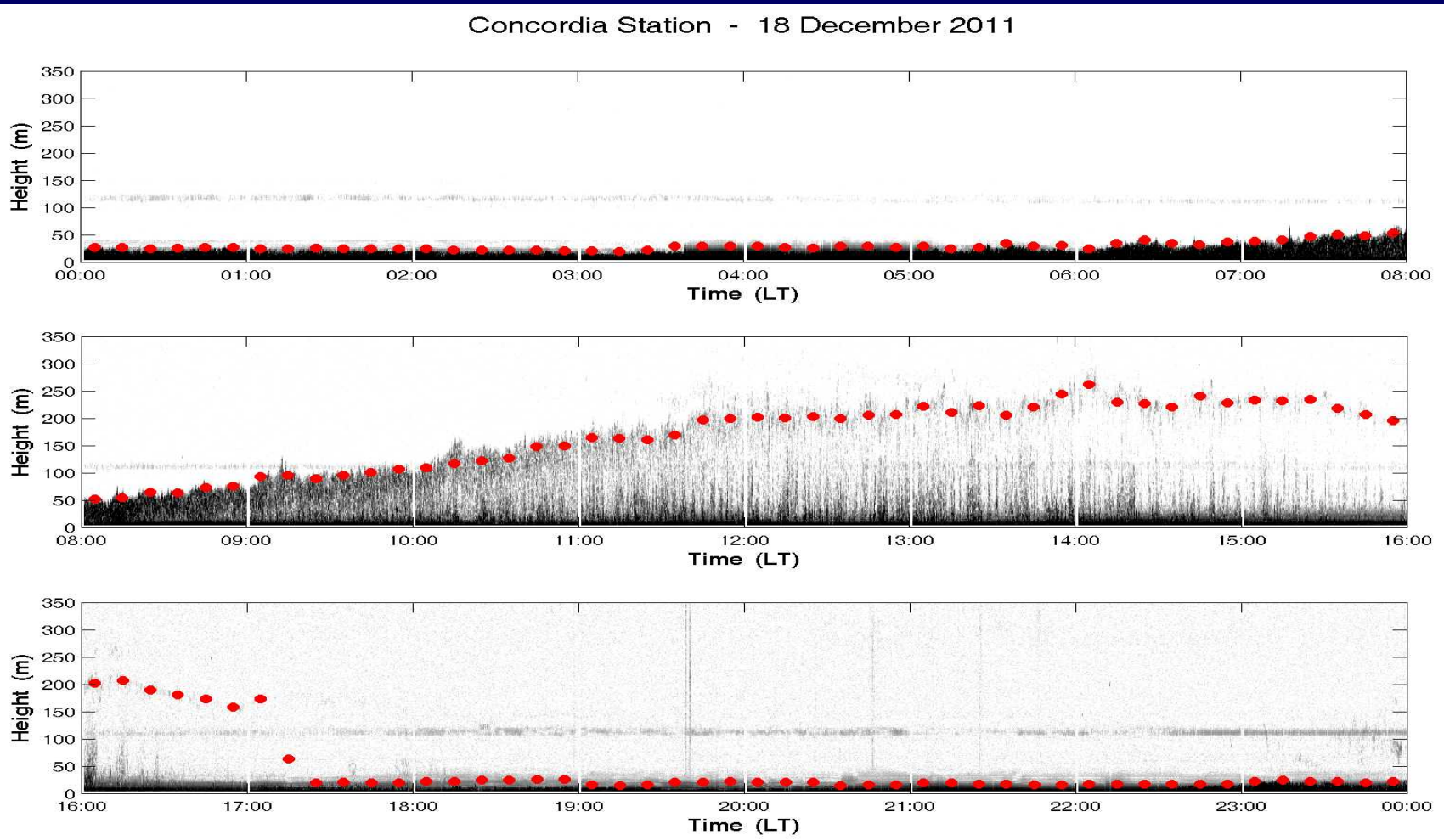
PBL height estimate

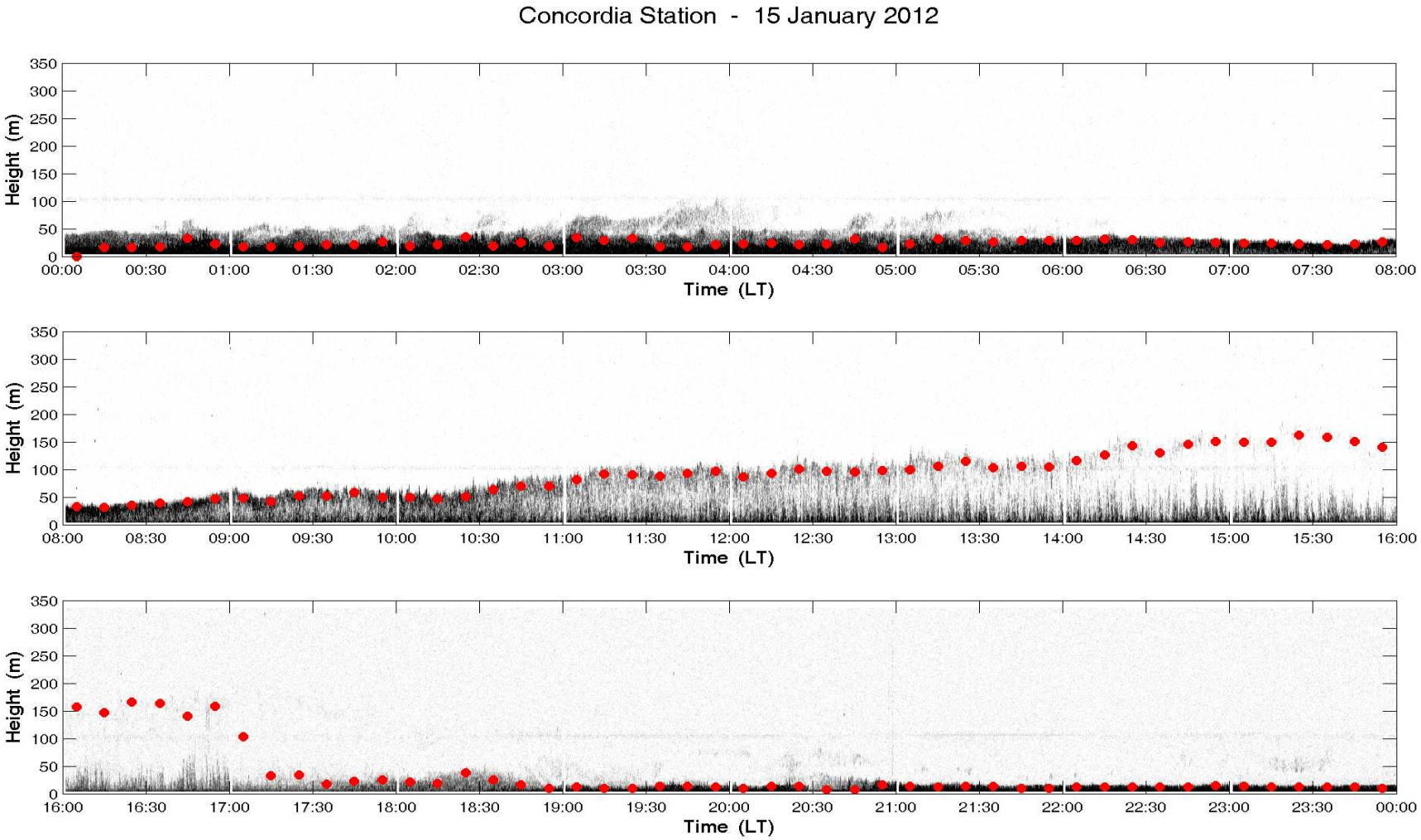
ABL regime	Shape of the RCS	Applied method
Stable ABL	Continuous decrease with height	Maximum RCS curvature
	Elevated maximum in RCS	RCS first derivative minimum
Convective ABL	Elevated maximum in RCS	Height of the maximum

RCS = Range Corrected Signal






Concordia Station - 18 December 2011
Height (m)
350
300
250
200
150
100
50
0
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
Time (LT)
Height (m)
350
300
250
200
150
100
50
0
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
Time (LT)
Height (m)
350
300
250
200
150
100
50
0
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
00:00
Time (LT)


Concordia Station - 15 January 2012
Height (m)
Time (LT)
0
50
100
150
200
250
300
350
00:00
00:30
01:00
01:30
02:00
02:30
03:00
03:30
04:00
04:30
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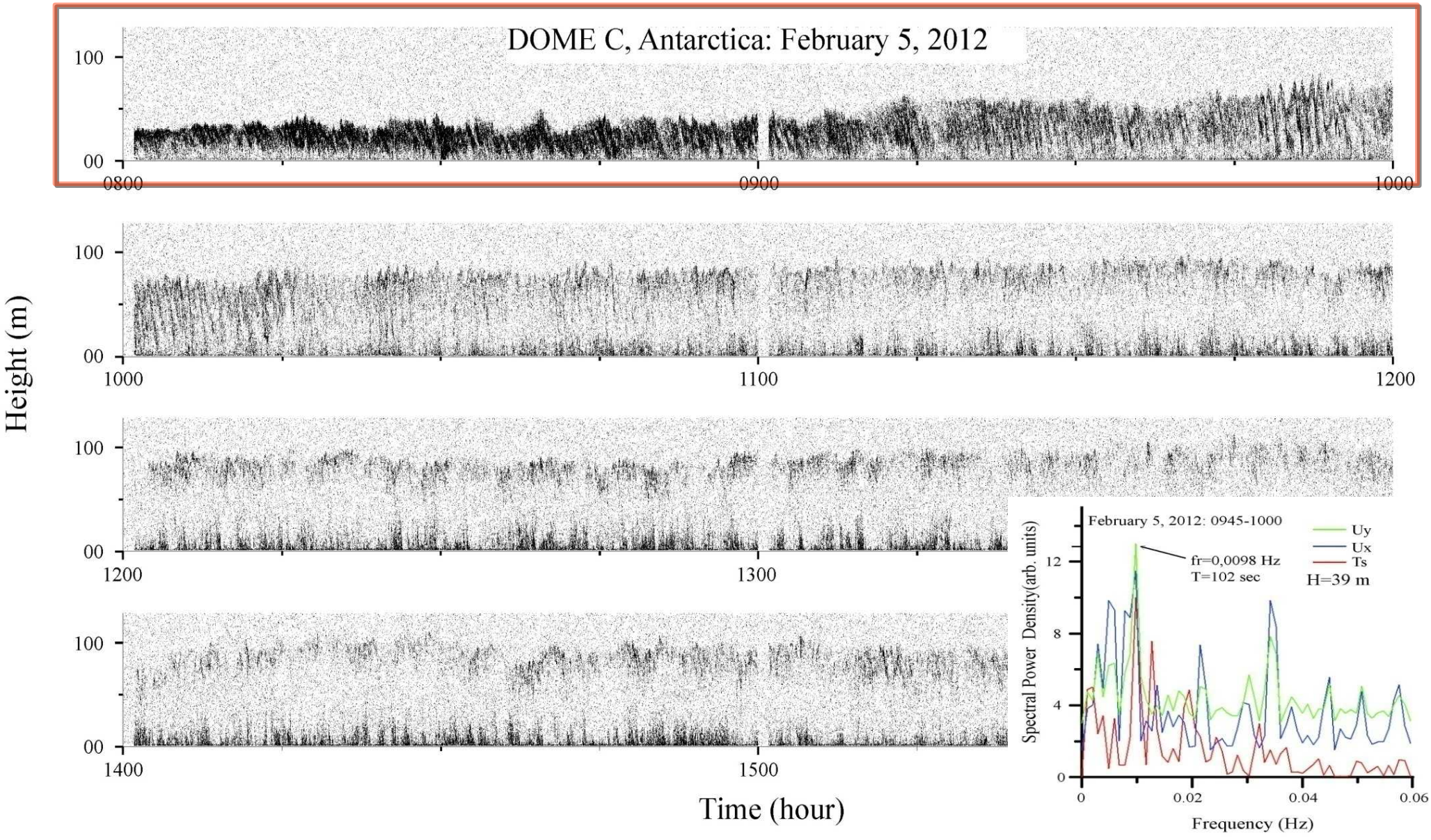
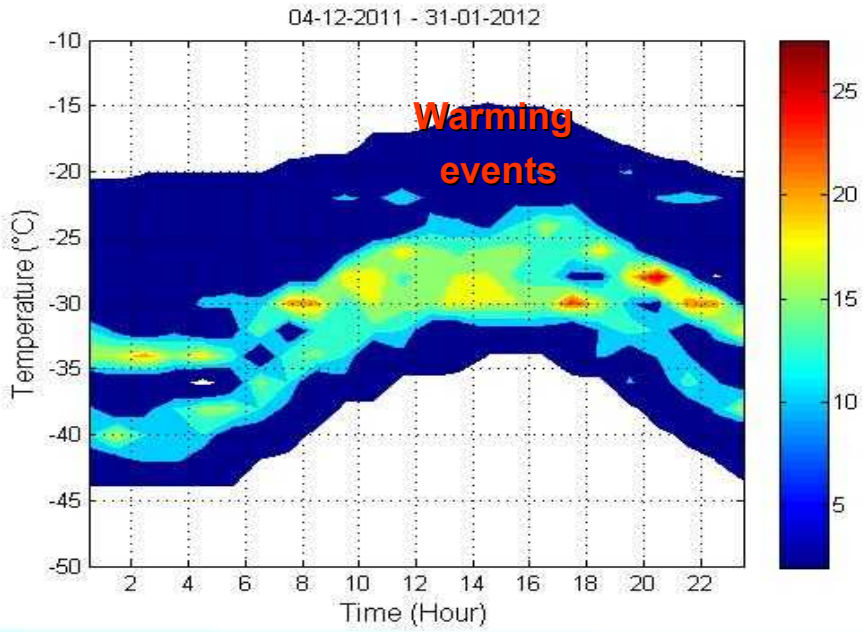
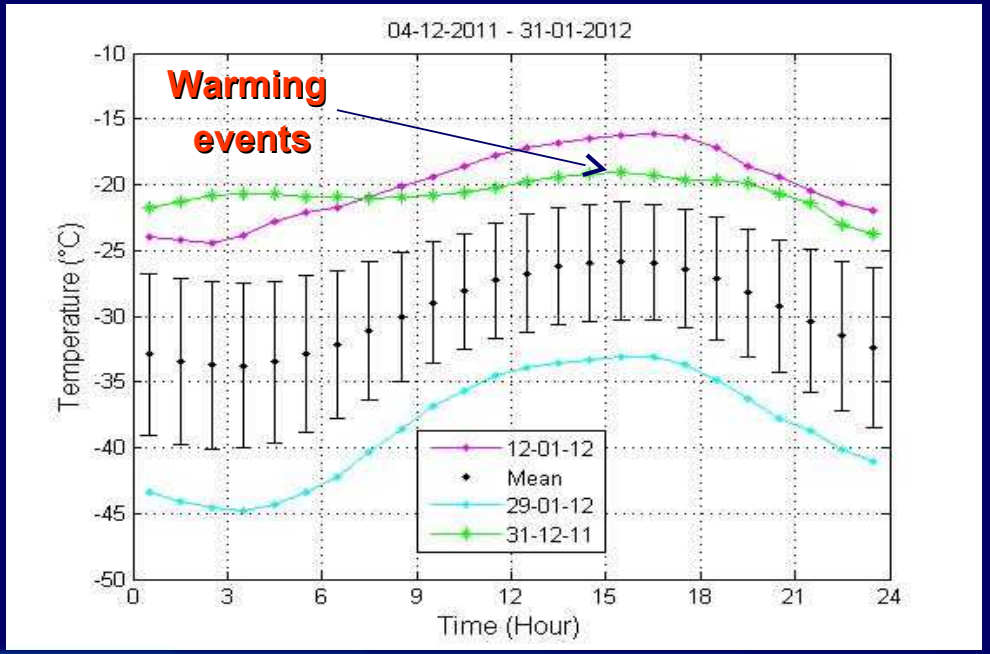
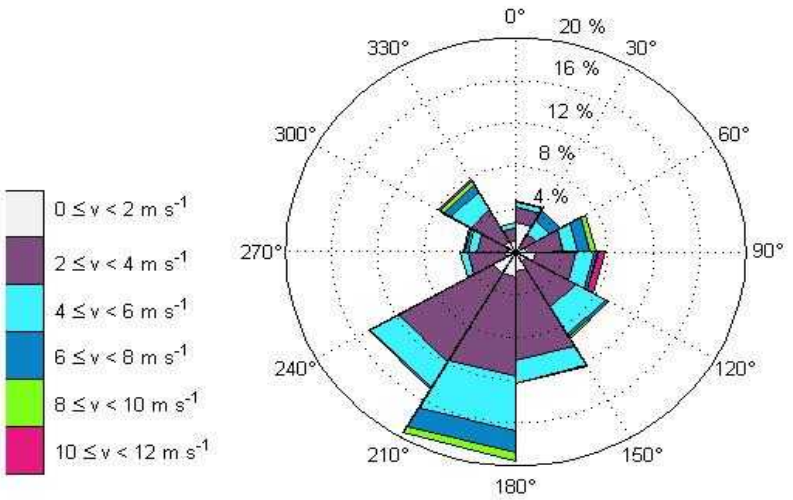
The spectral analysis showed that most frequent are high frequency waves (period 90 - 120 s)

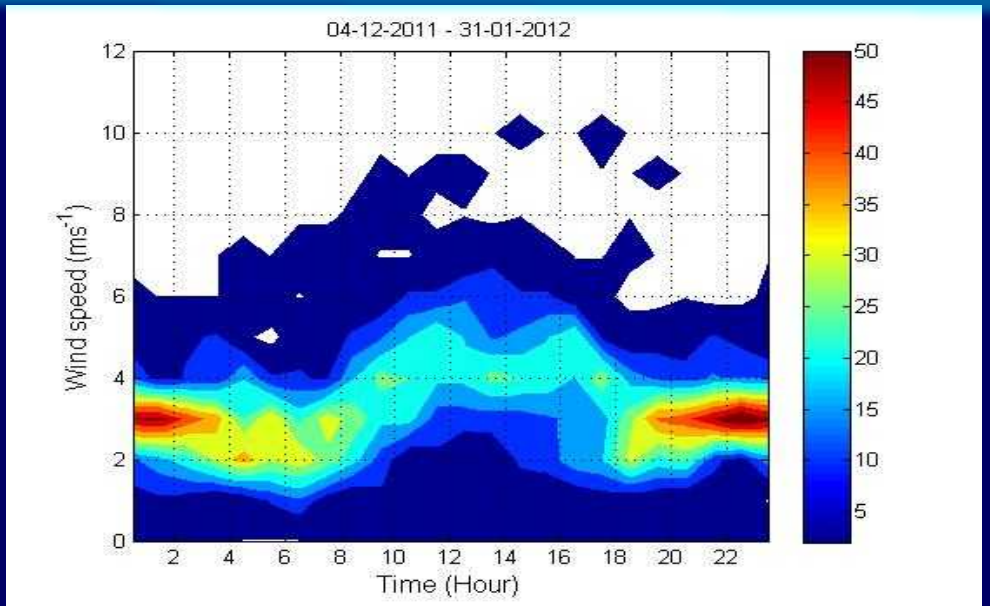


Meteorological parameters during the summer

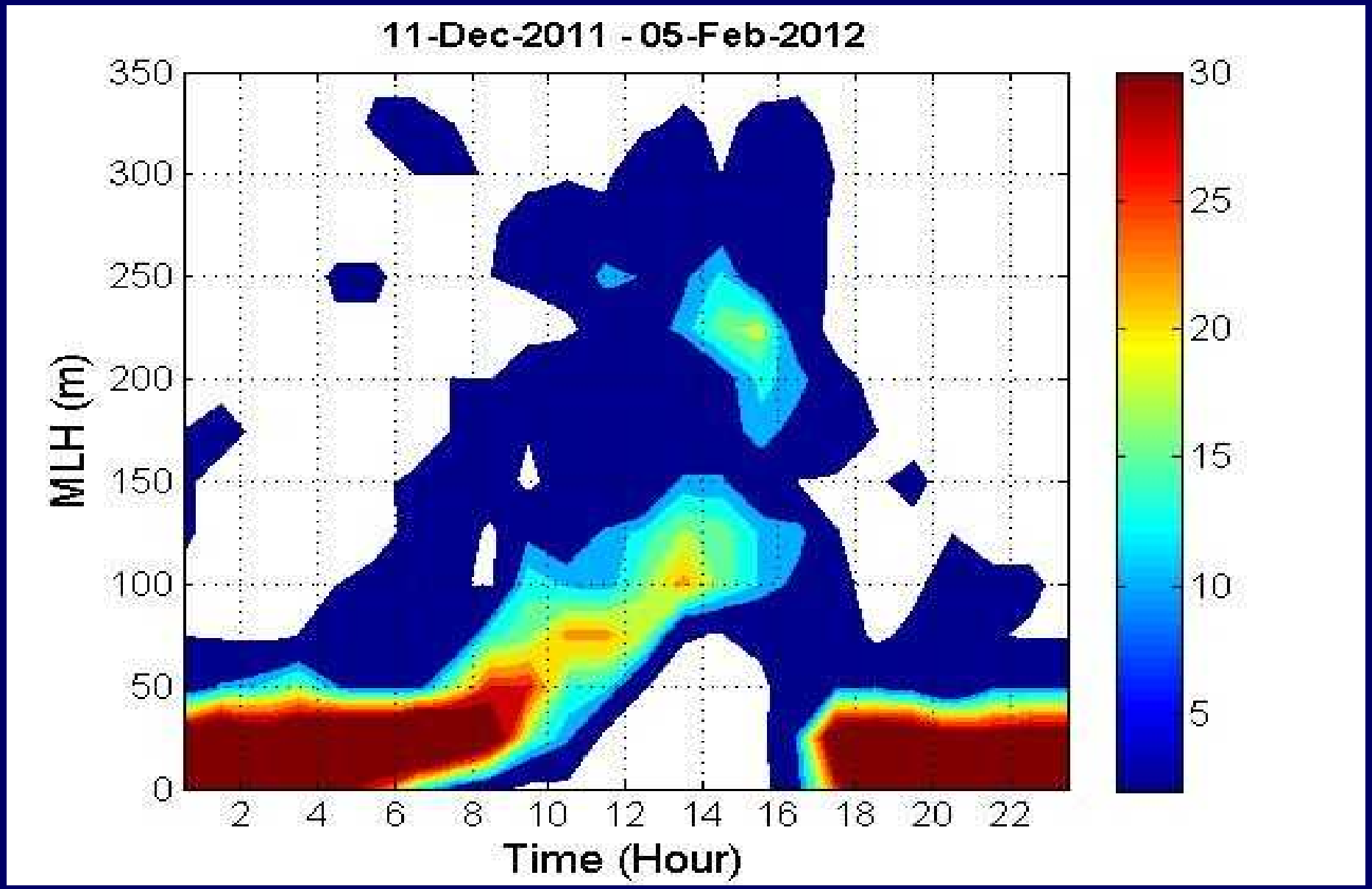




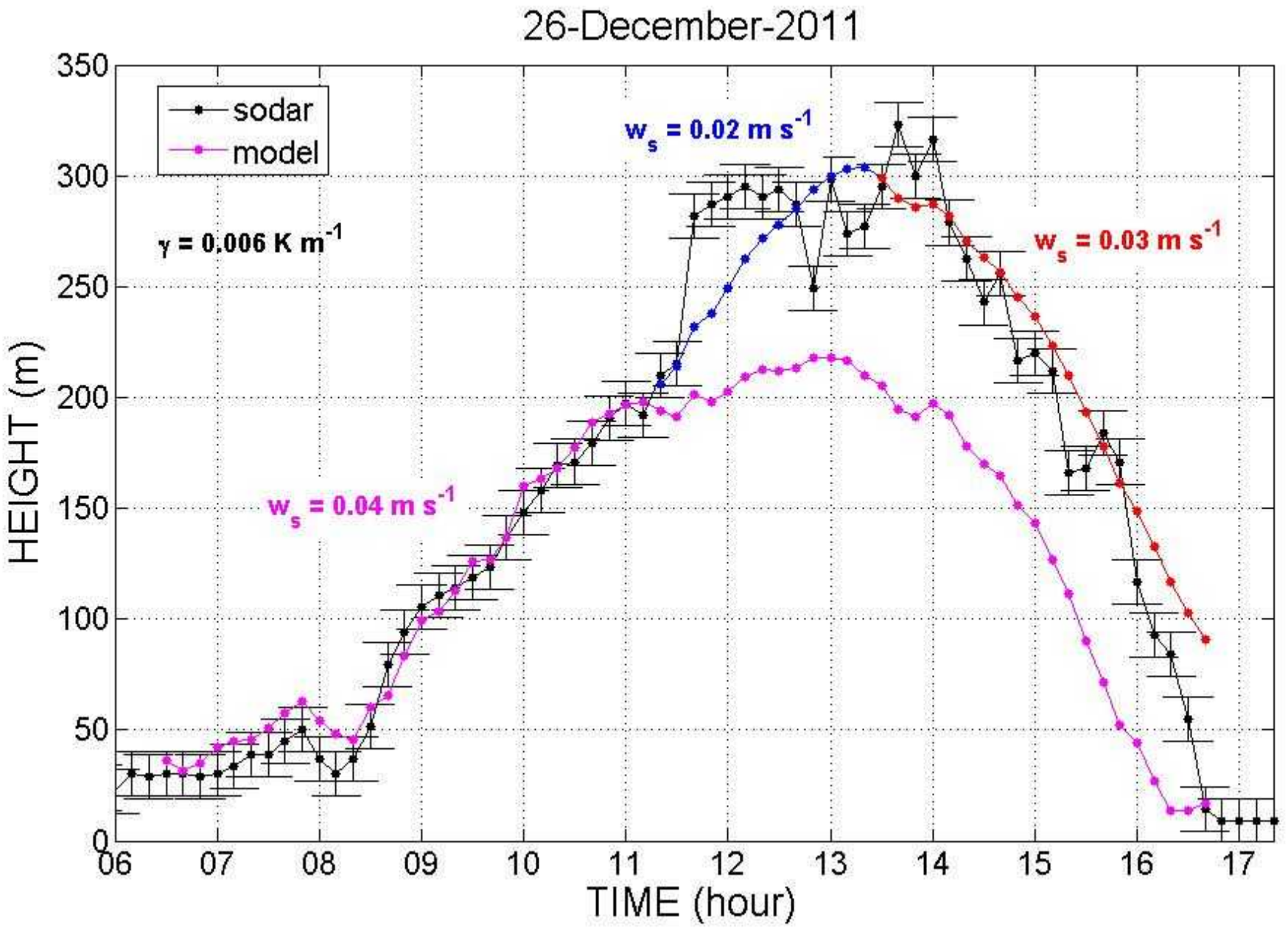




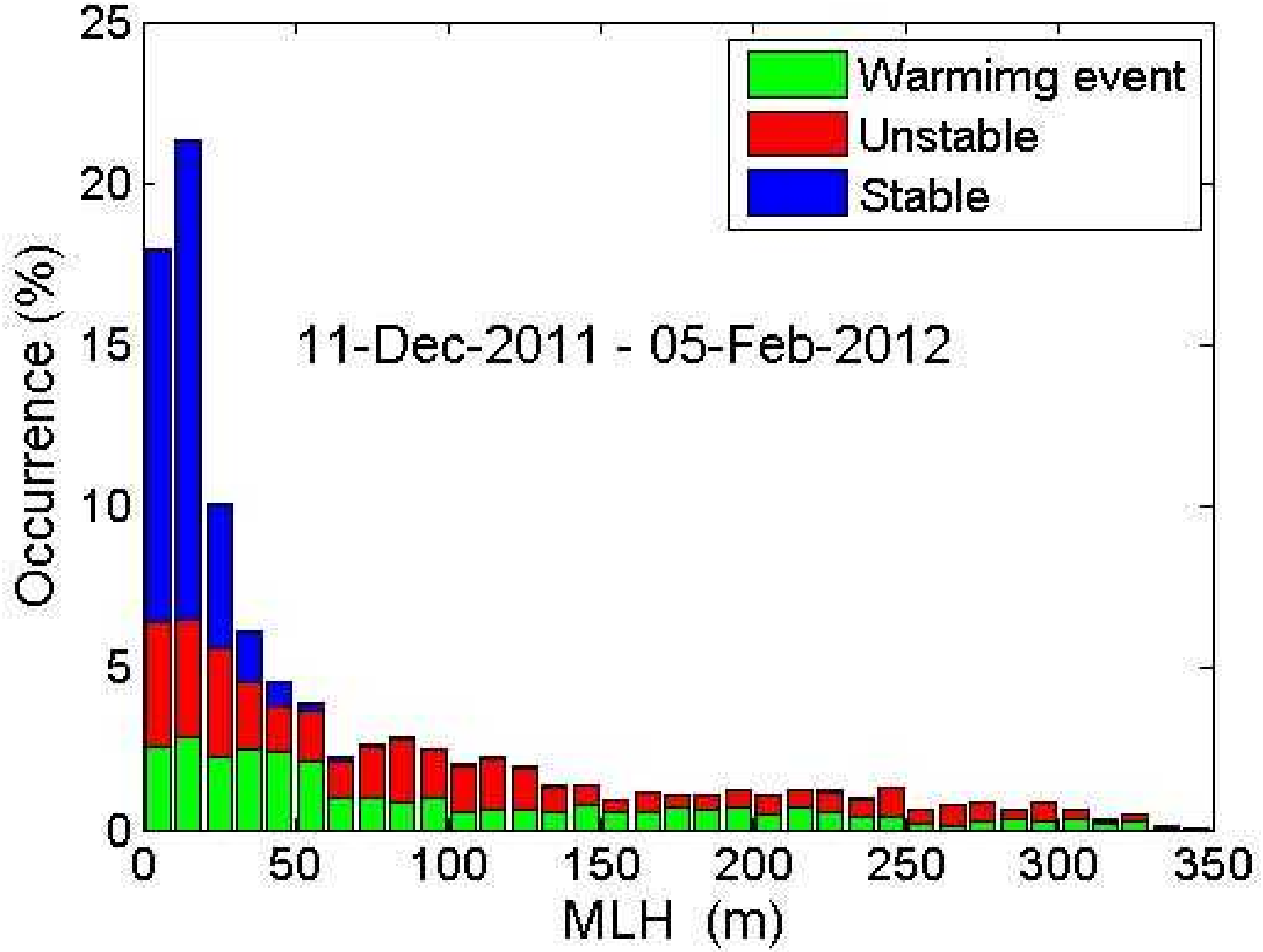
SUMMER : PBL height daily behaviour



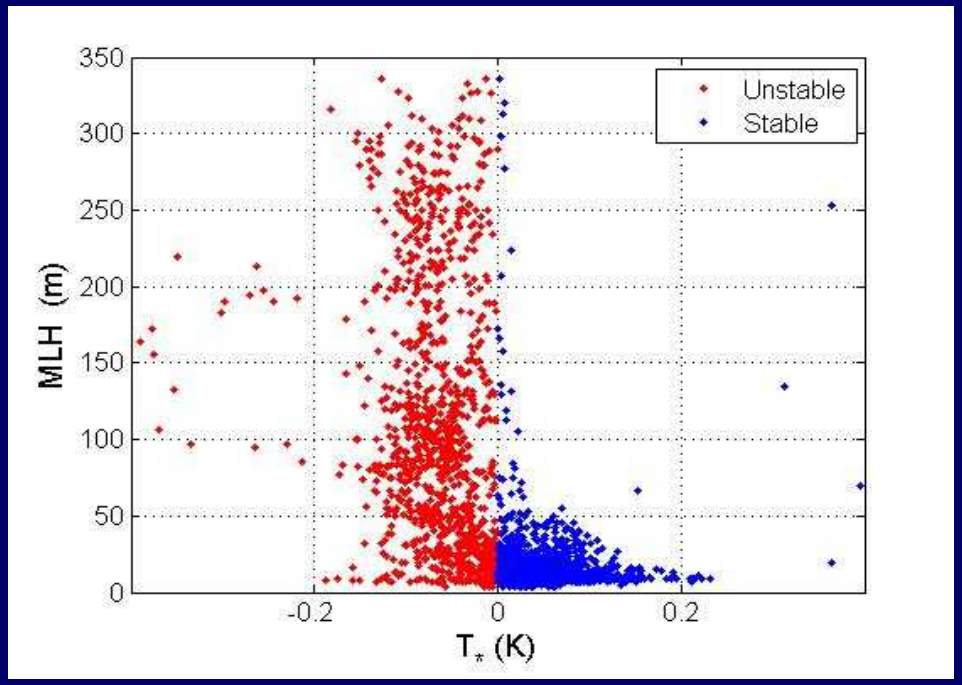
GB model for convective PBL VS SLM-Sodar

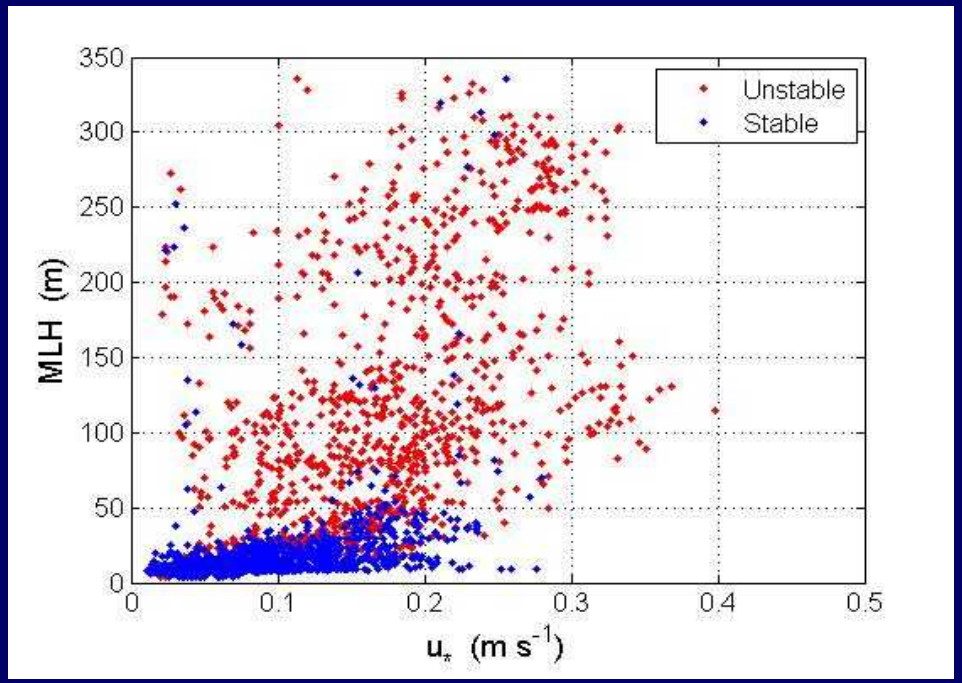


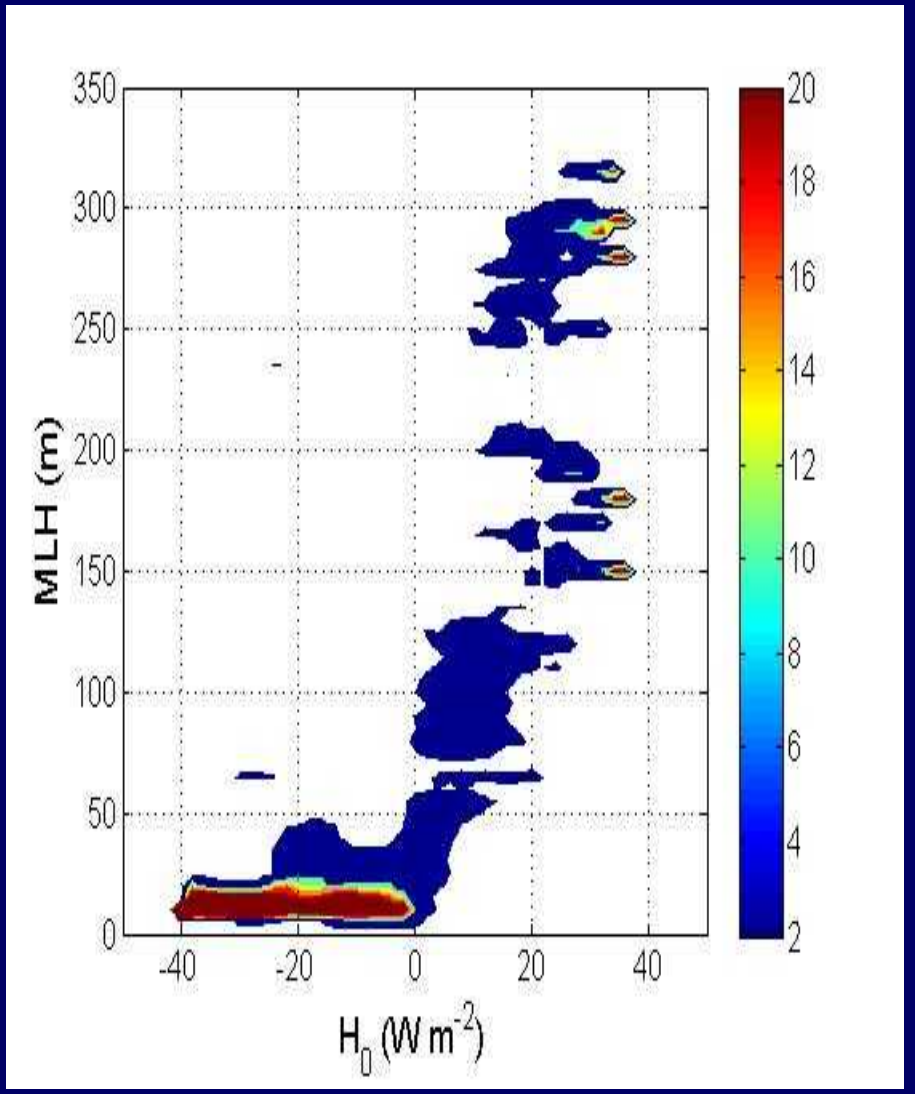
SUMMER : PBL height distribution



MLH *vs* T*,u*,Ho


Unstable
Stable
MLH (m)
T* (K)

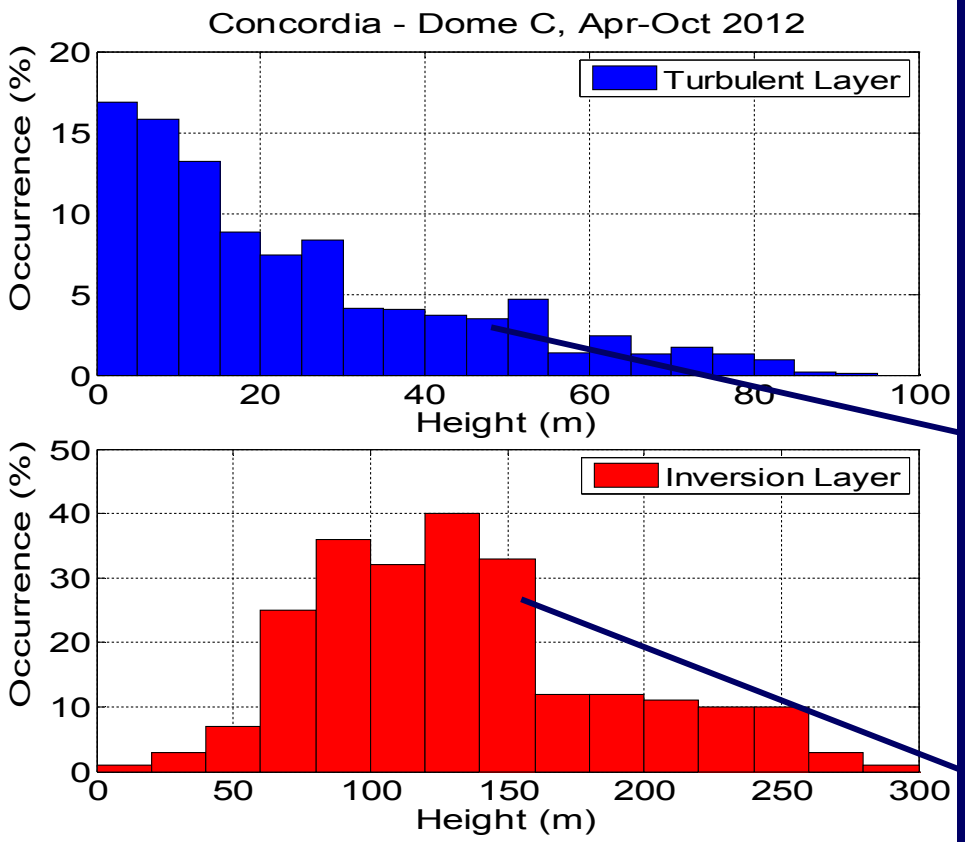

Unstable
Stable
MLH (m)
u* (m s-1)

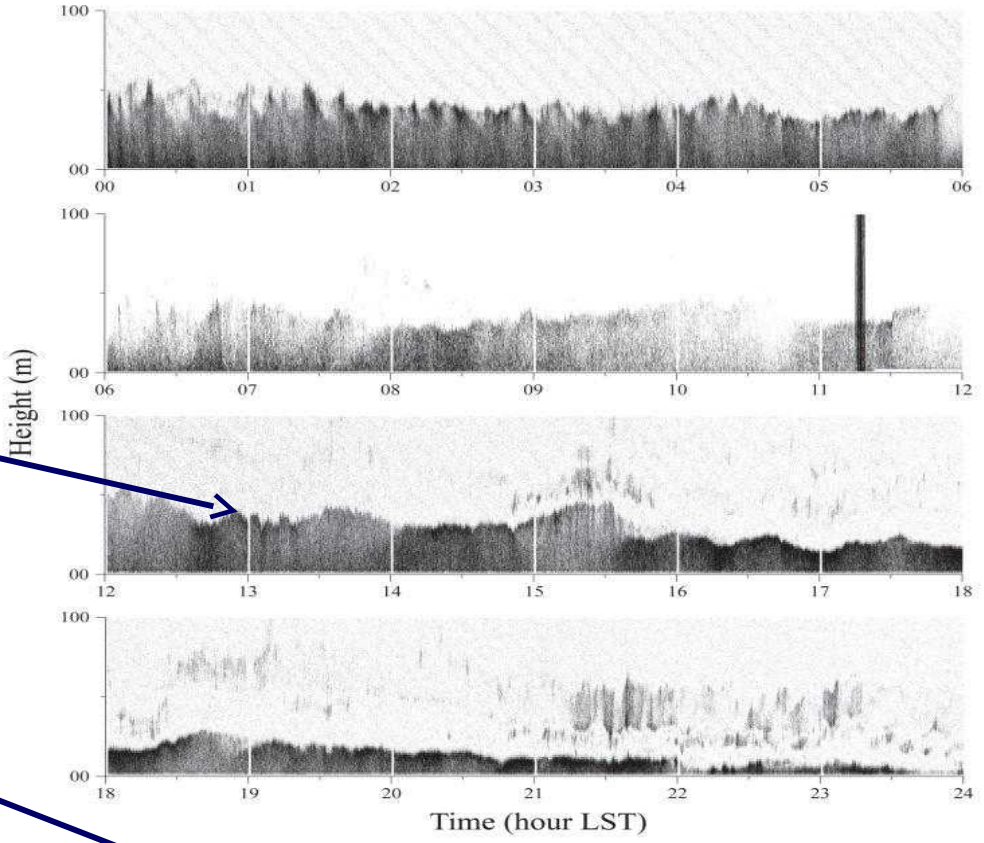

MLH (m)
H0 (W m-2)

PBL THERMAL STRUCTURE

WINTER

stable stratifications with waves
warming events



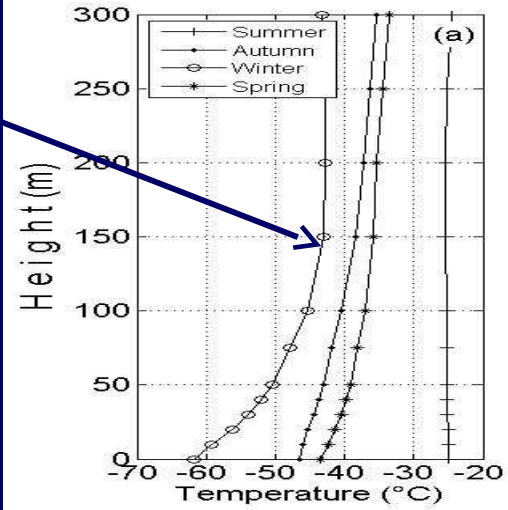


Heights of Surface Turbulent Layer and Inversion Layer

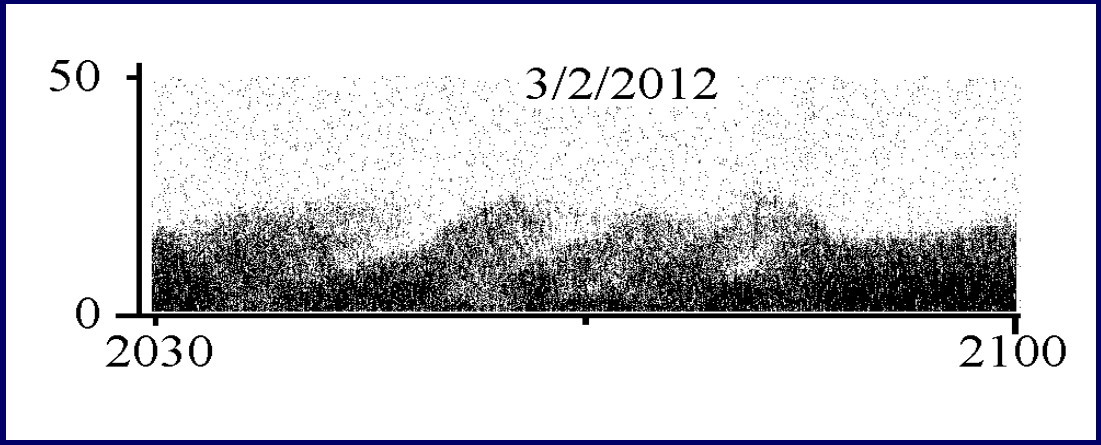
Apr-Oct 2012

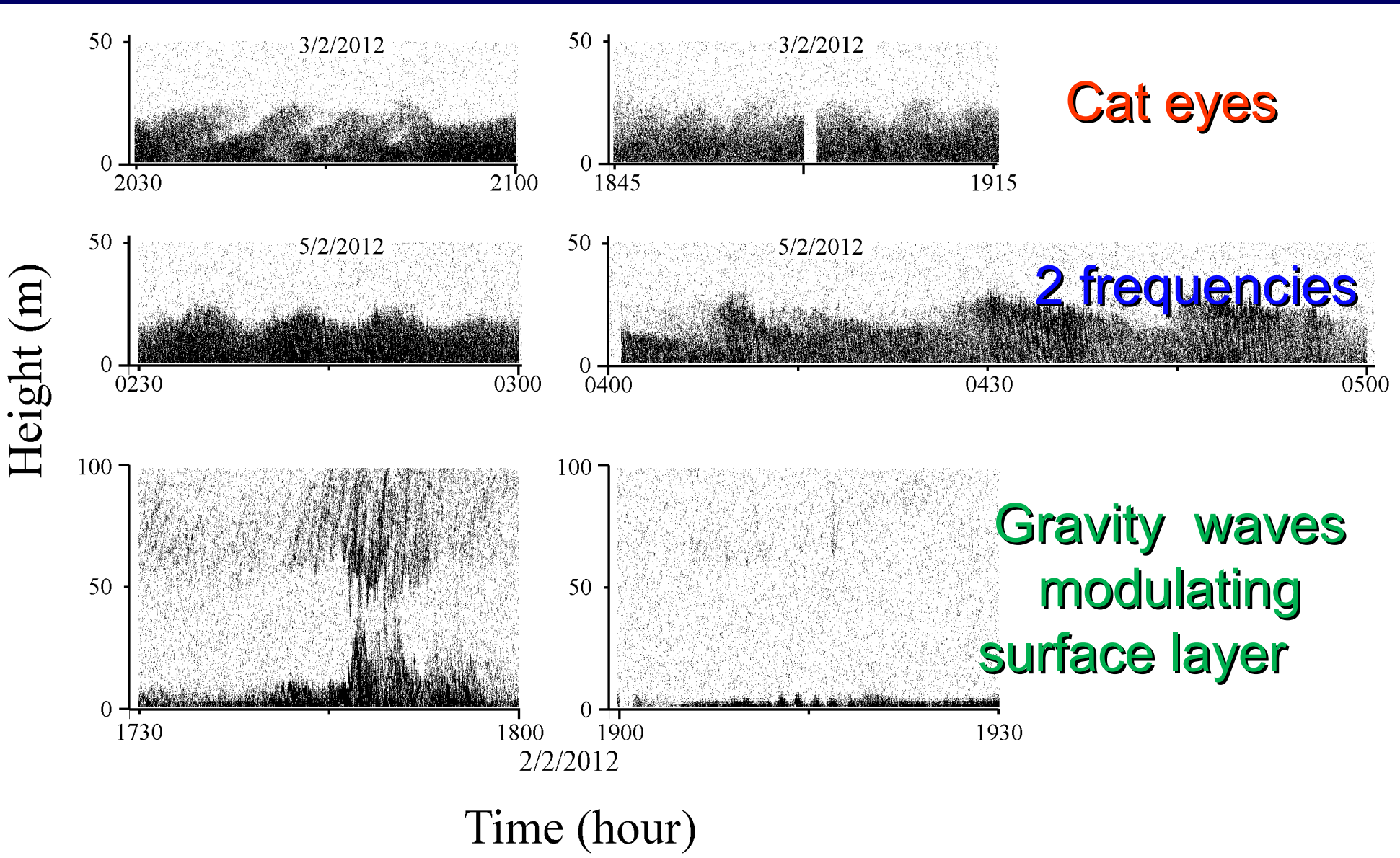
Height (m)	Mean (m)	Median (m)	Std (m)
Turbulent Layer	23	16	20
Inversion Layer	133	125	63

Surface-based Turbulent Layer occupies only the lowest 10-30% of the whole inversion layer



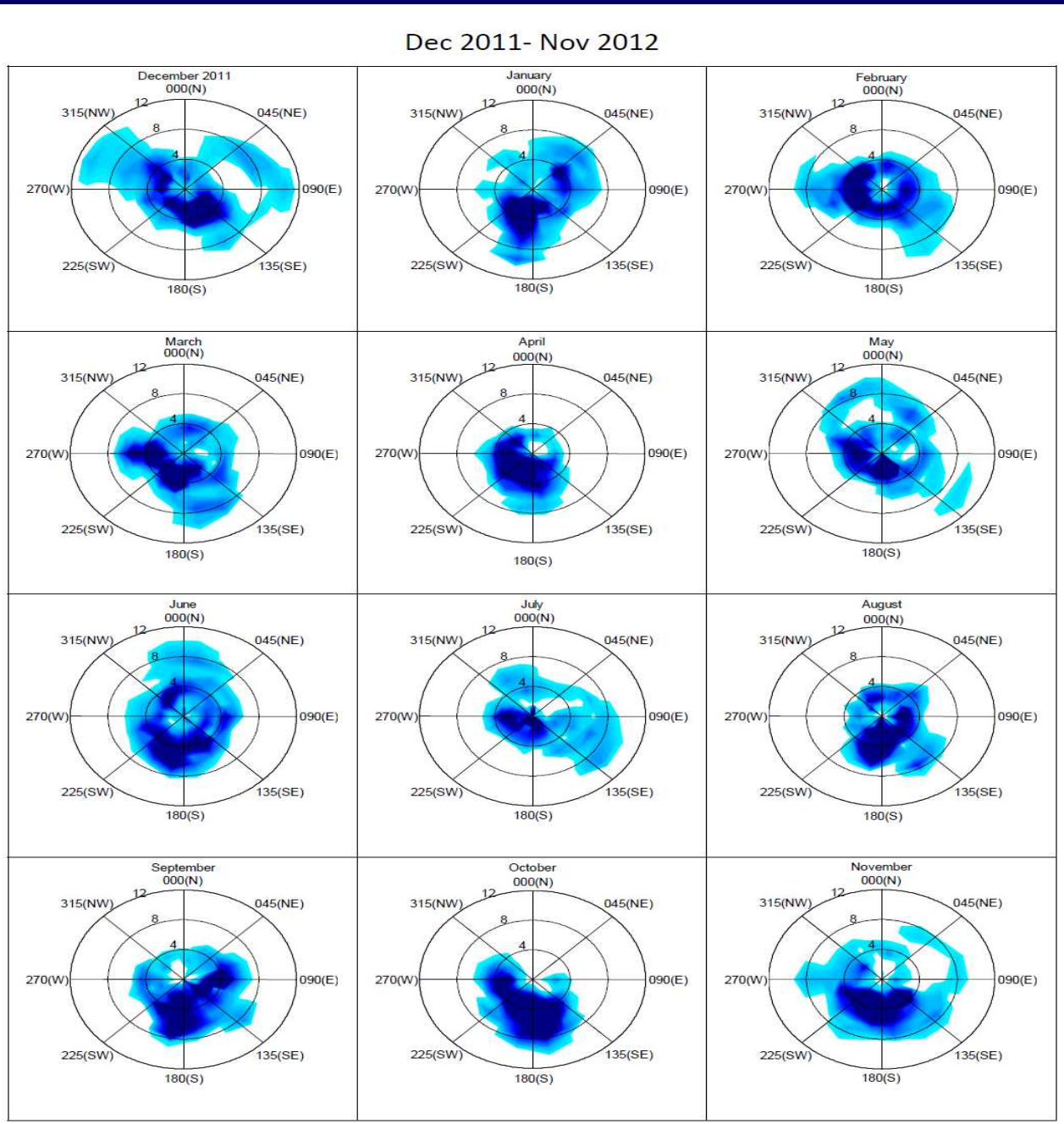
WAVES

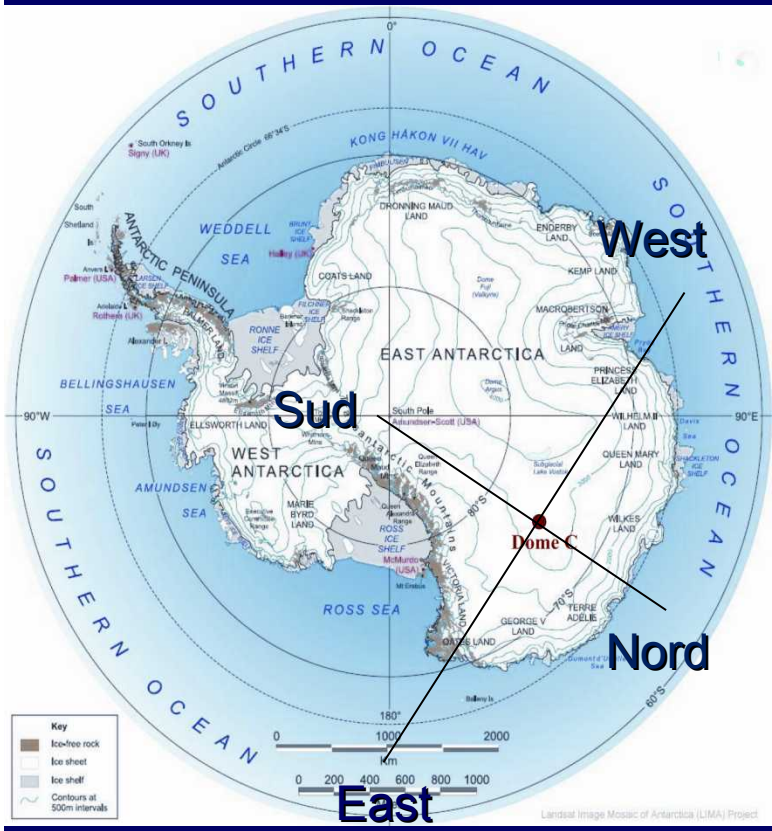




4 4 DAYS WAVES MORE THAN 35 % OF THE TIME

WIND DISTRIBUTION



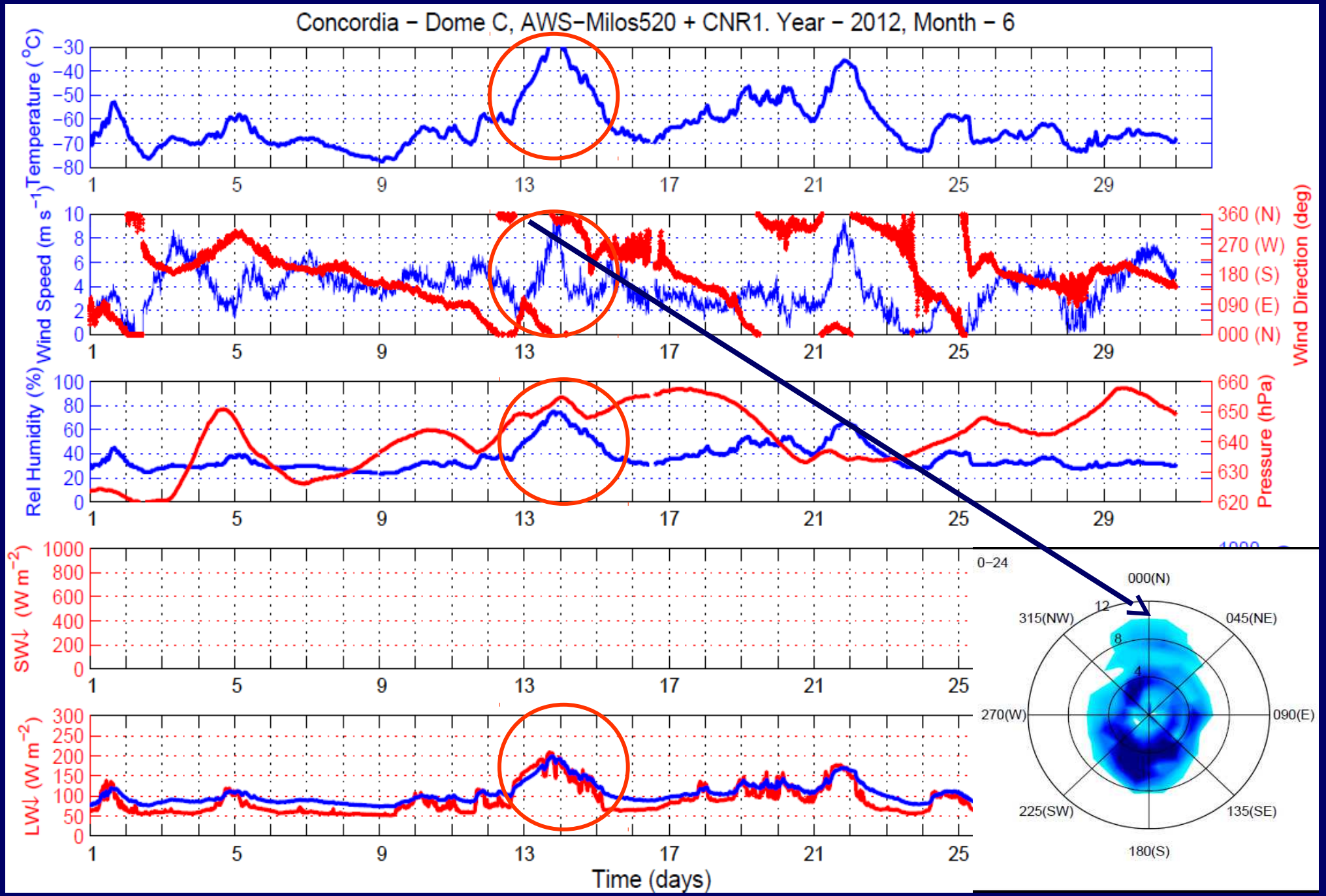


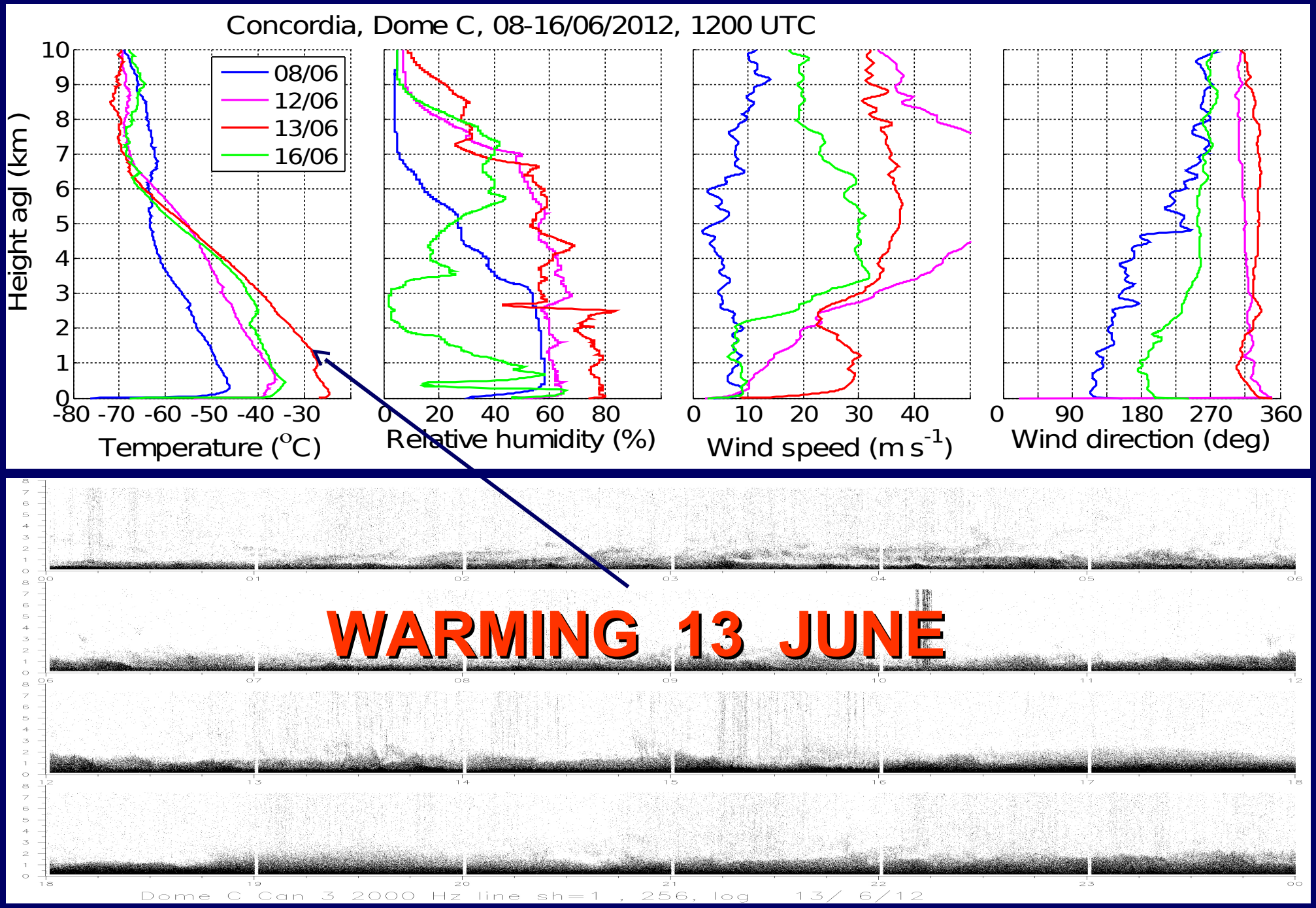
WARMING EVENTS

Cyclones approach to the Antarctic continent from the lower latitudes, these cyclones advect warm air and clouds over the Antarctic Continent which 'modify' the usual surface inversion.

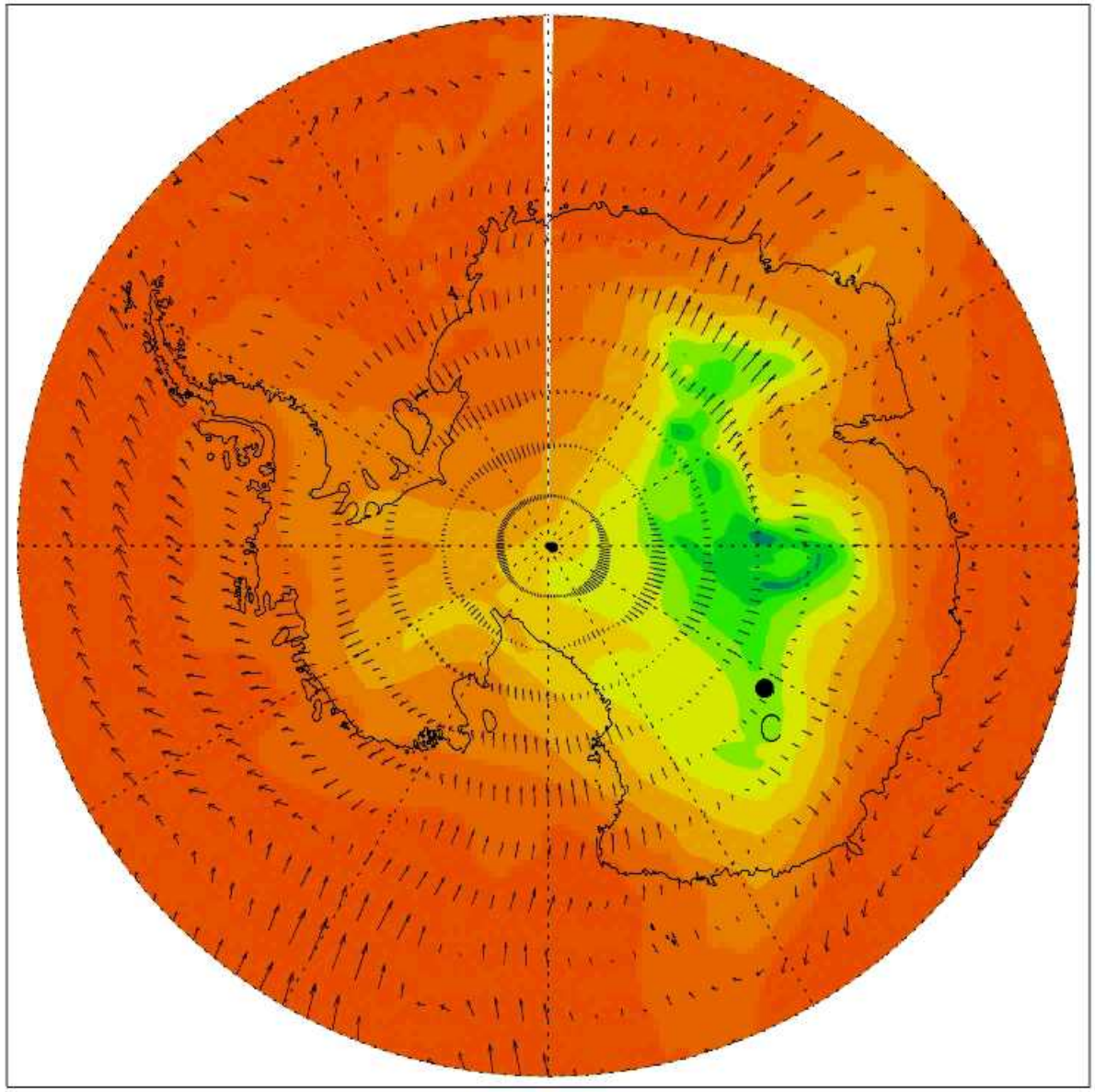
The intrusion of marine air masses

a) contribute to the ice sheet's surface mass balance through precipitation;
b) Contribution to climate change because it is a very important source of energy and moisture for the interior of Antarctica.

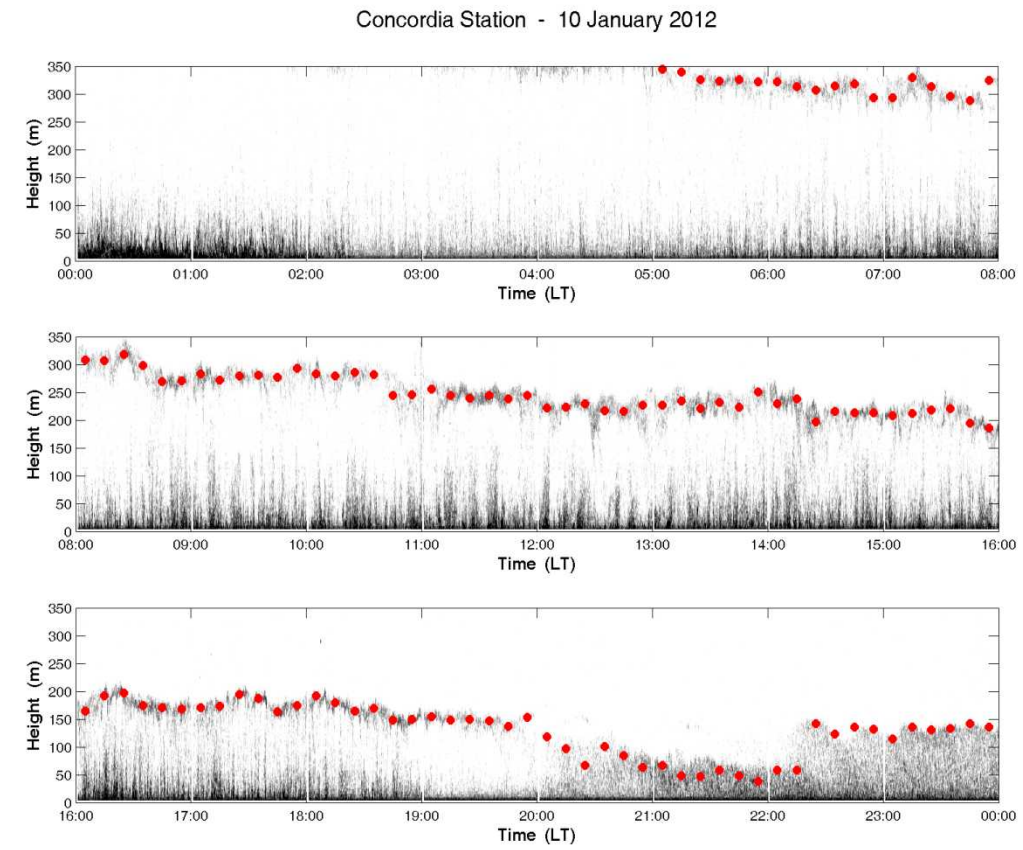

Concordia − Dome C, AWS−Milos520 + CNR1. Year − 2012, Month − 6
Temperature (°C)
Wind Speed (m s⁻¹)
Wind Direction (deg)
360 (N)
270 (W)
180 (S)
090 (E)
000 (N)
Rel Humidity (%)
Pressure (hPa)
SW↓ (W m⁻²)
LW↓ (W m⁻²)
Time (days)
0−24
000(N)
045(NE)
090(E)
135(SE)
180(S)
225(SW)
270(W)
315(NW)

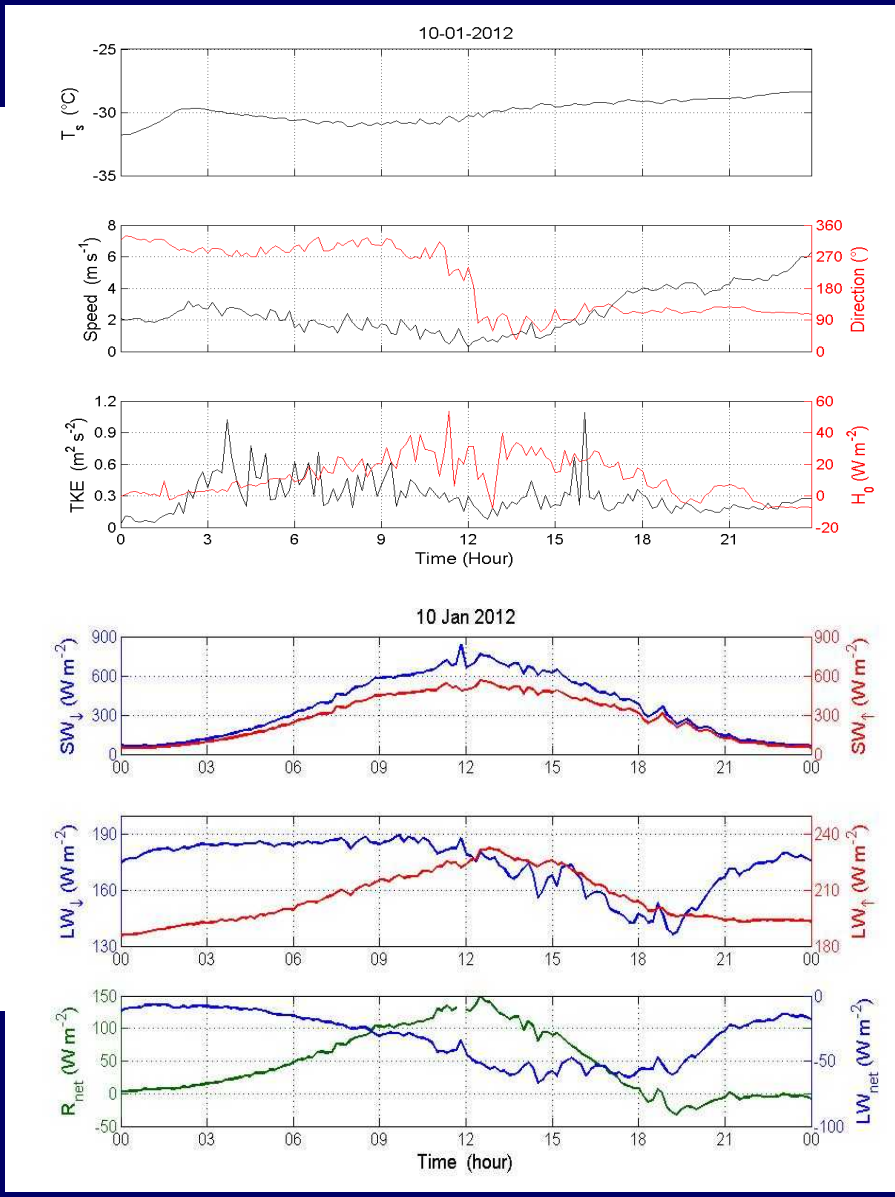

Concordia, Dome C, 08-16/06/2012, 1200 UTC
08/06
12/06
13/06
16/06
Height agl (km)
Temperature (°C)
Relative humidity (%)
Wind speed (m s-1)
Wind direction (deg)
WARMING 13 JUNE
Dome C Can 3 2000 Hz line sh=1 , 256, log 13/ 6/12

T(°C) + wind – 201206080000 – Lev = 600 hPa



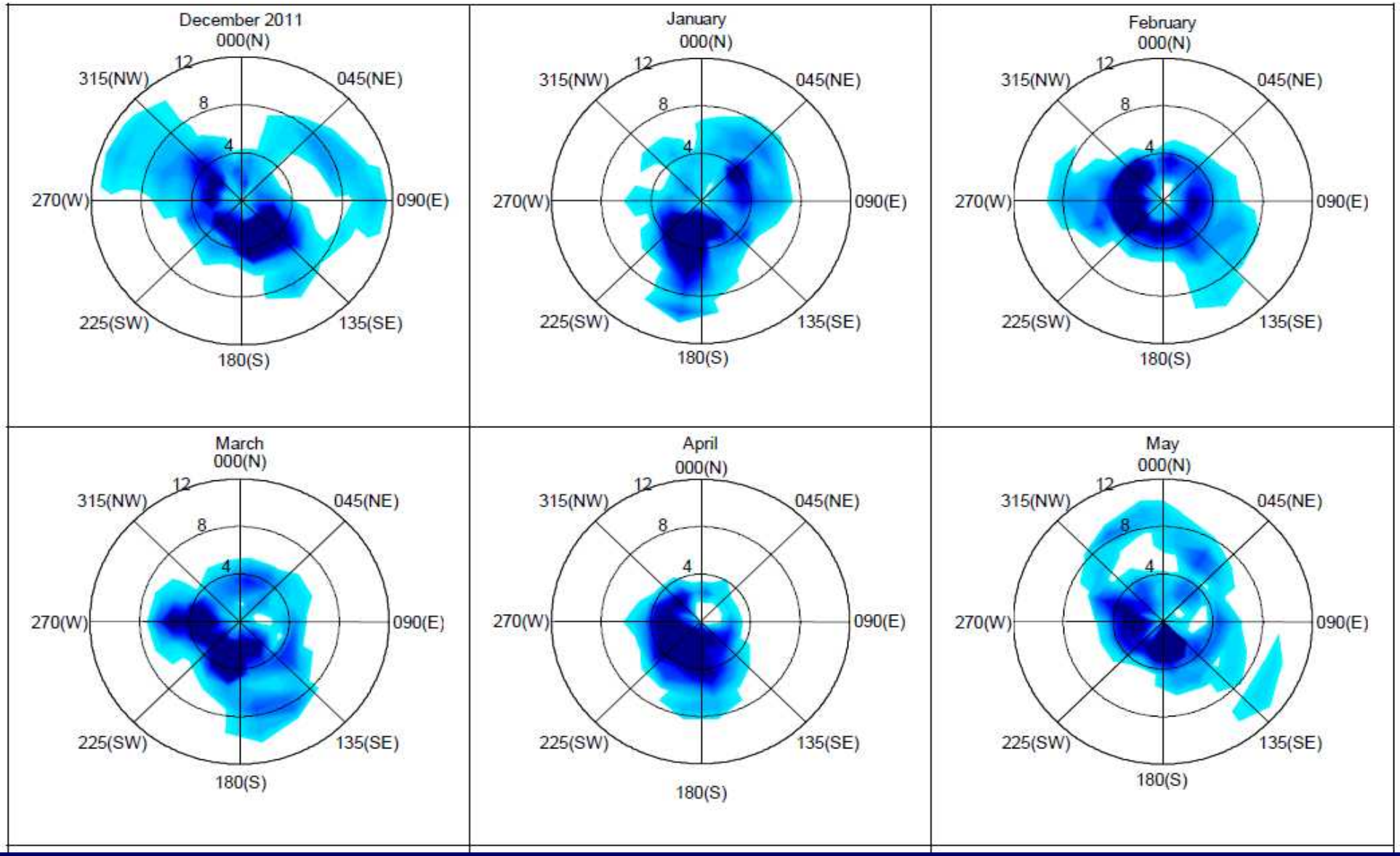
Warming event summer: 10 January, 2012



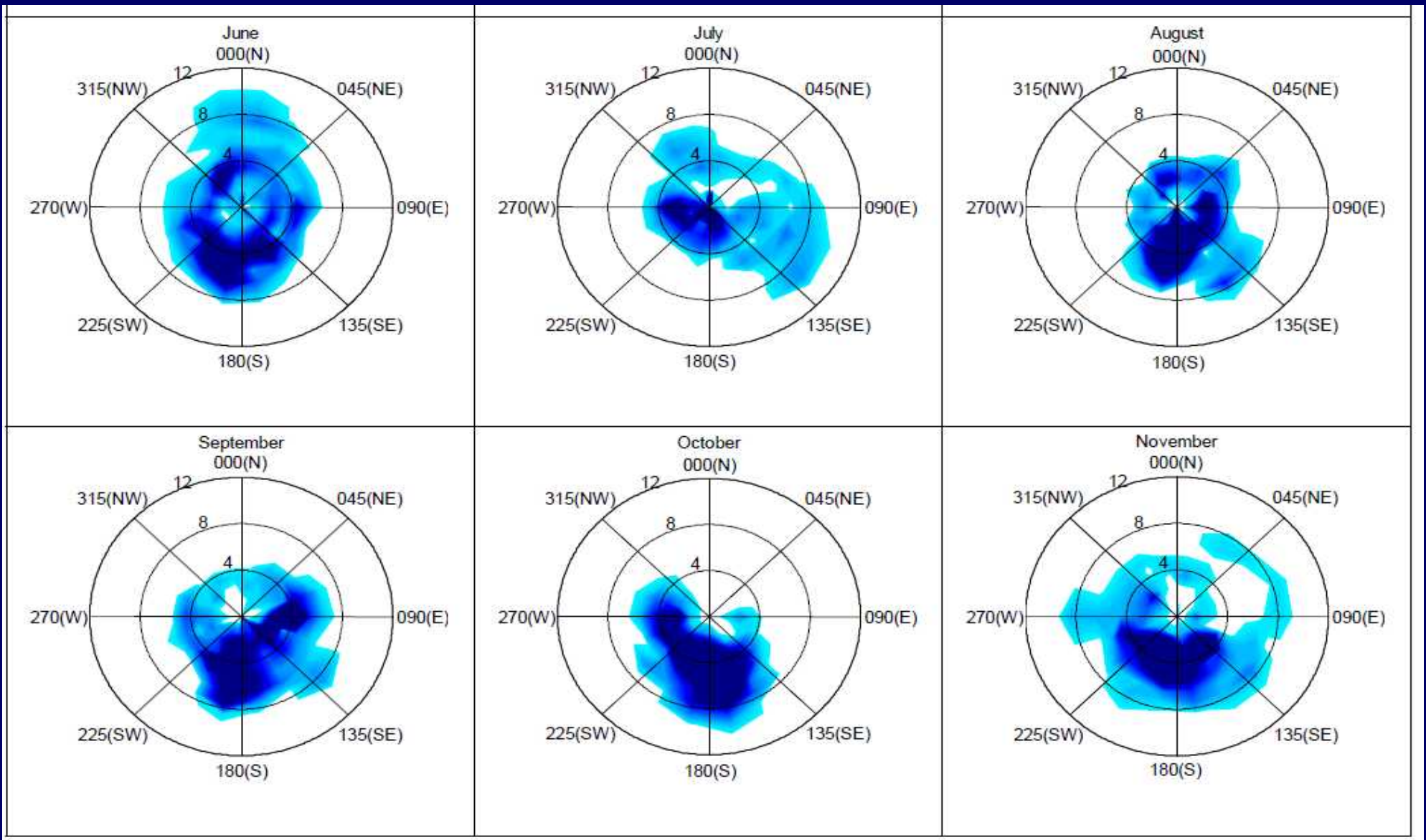


MERCI

December 2011 – May 2012



June 2012 – November 2012



WAVES

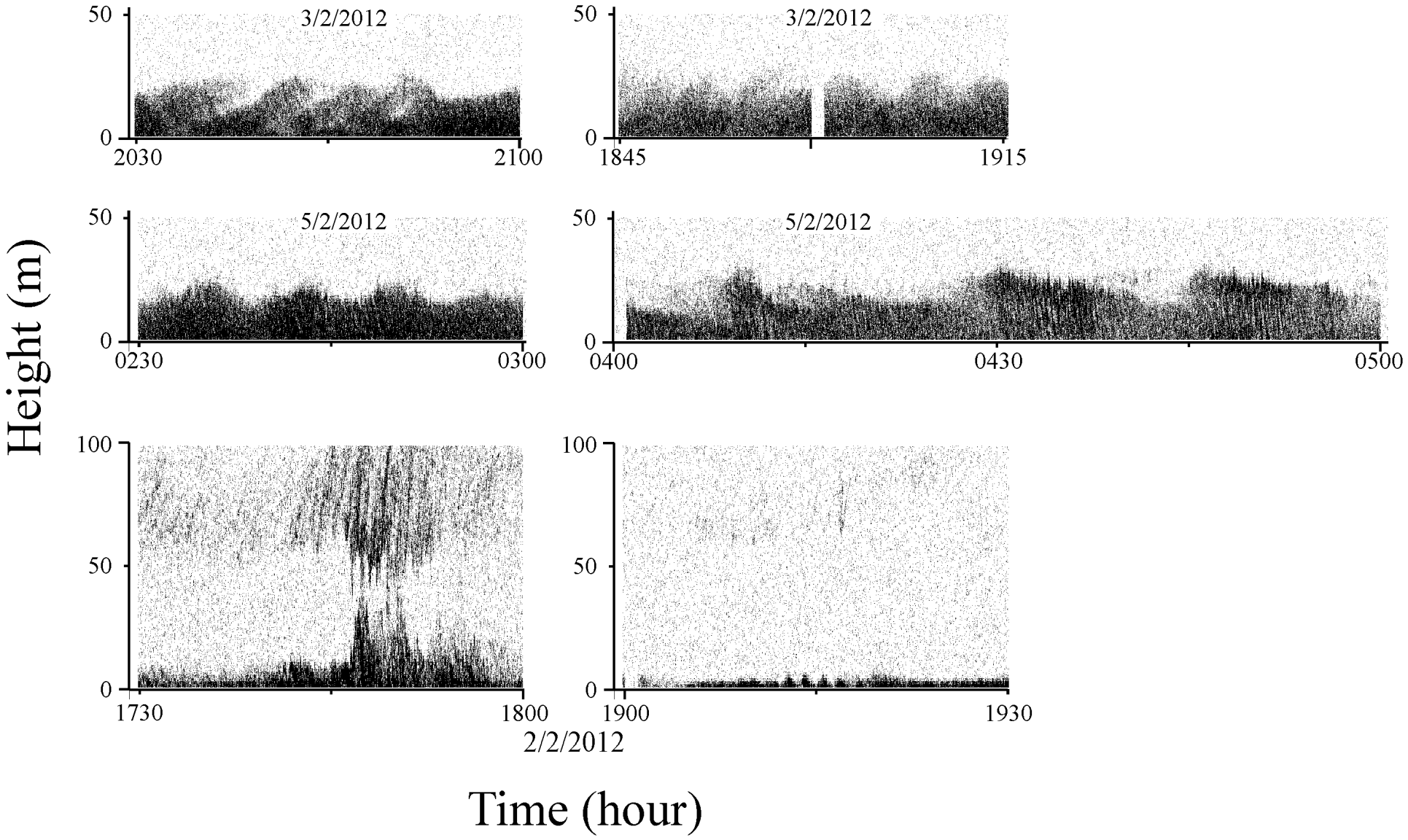
The existence of gravity waves in the atmosphere requires stable conditions otherwise a wave pattern cannot be created

Gravity waves carry momentum and energy between different points in the atmosphere, produce turbulence, trigger convection, affect the mean flow

WE WANT TO STUDY

- Generation mechanisms of the gravity waves
- The role of gravity waves in mesoscale and PBL phenomena (microscale phenomena)
- Interaction of gravity waves with turbulence

Sodar is a remote sensing device useful in revealing and measuring such waves



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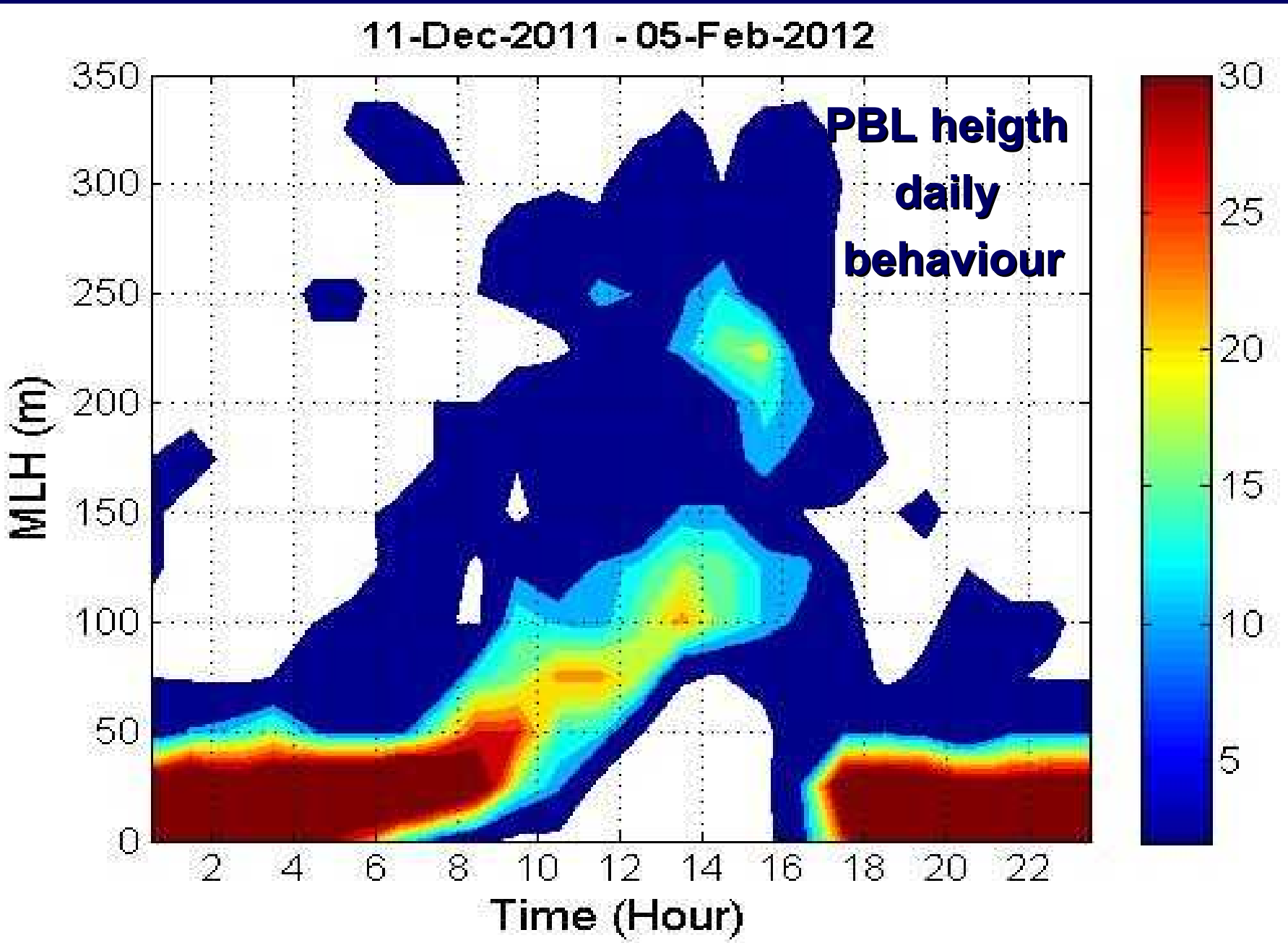
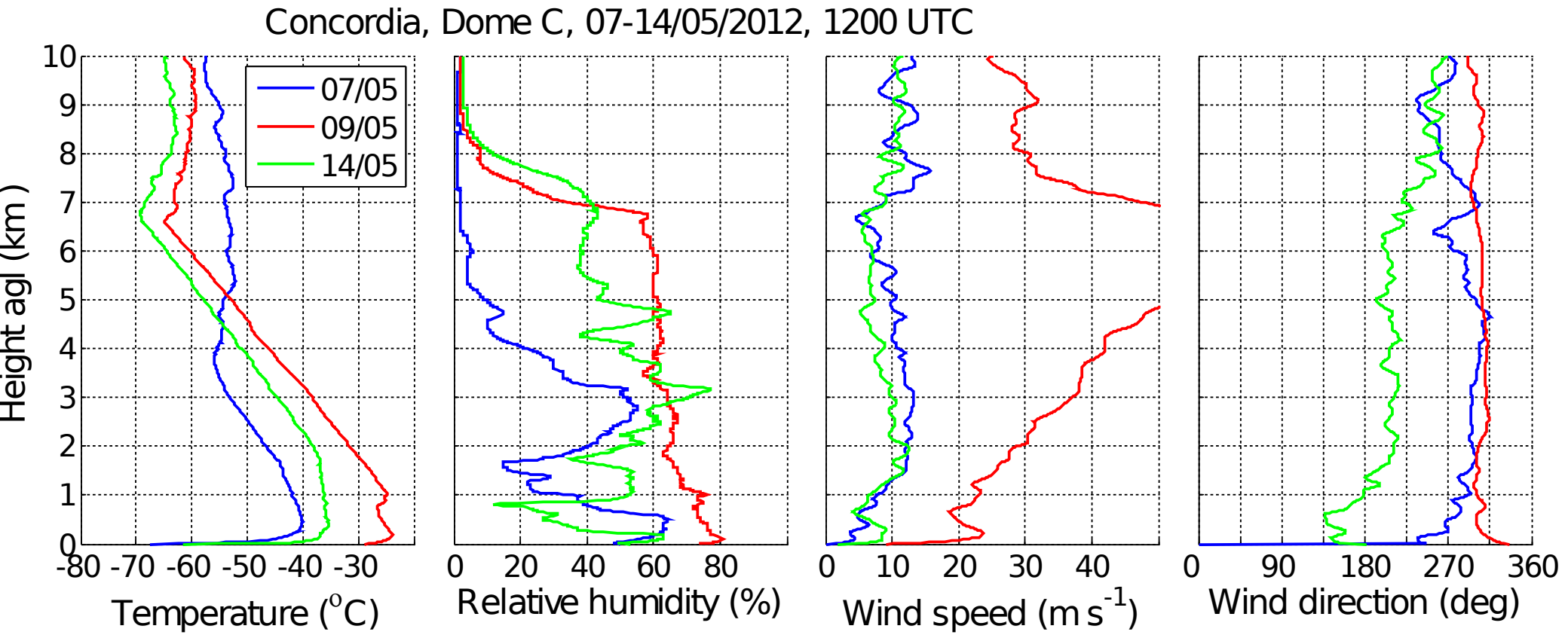
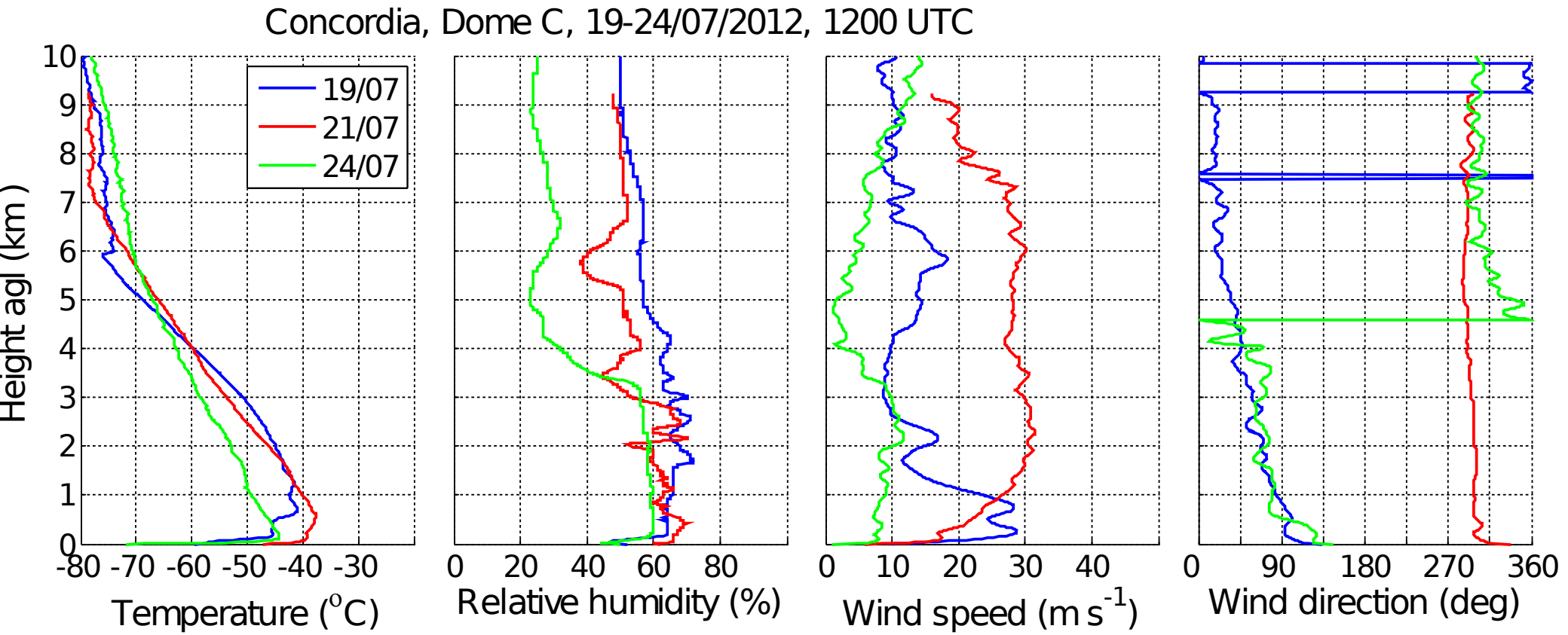

11-Dec-2011 - 05-Feb-2012
PBL heigth
daily
behaviour
MLH (m)
350
300
250
200
150
100
50
0
2
4
6
8
10
12
14
16
18
20
22
Time (Hour)
30
25
20
15
10
5

Radiosoundings



Radiosoundings



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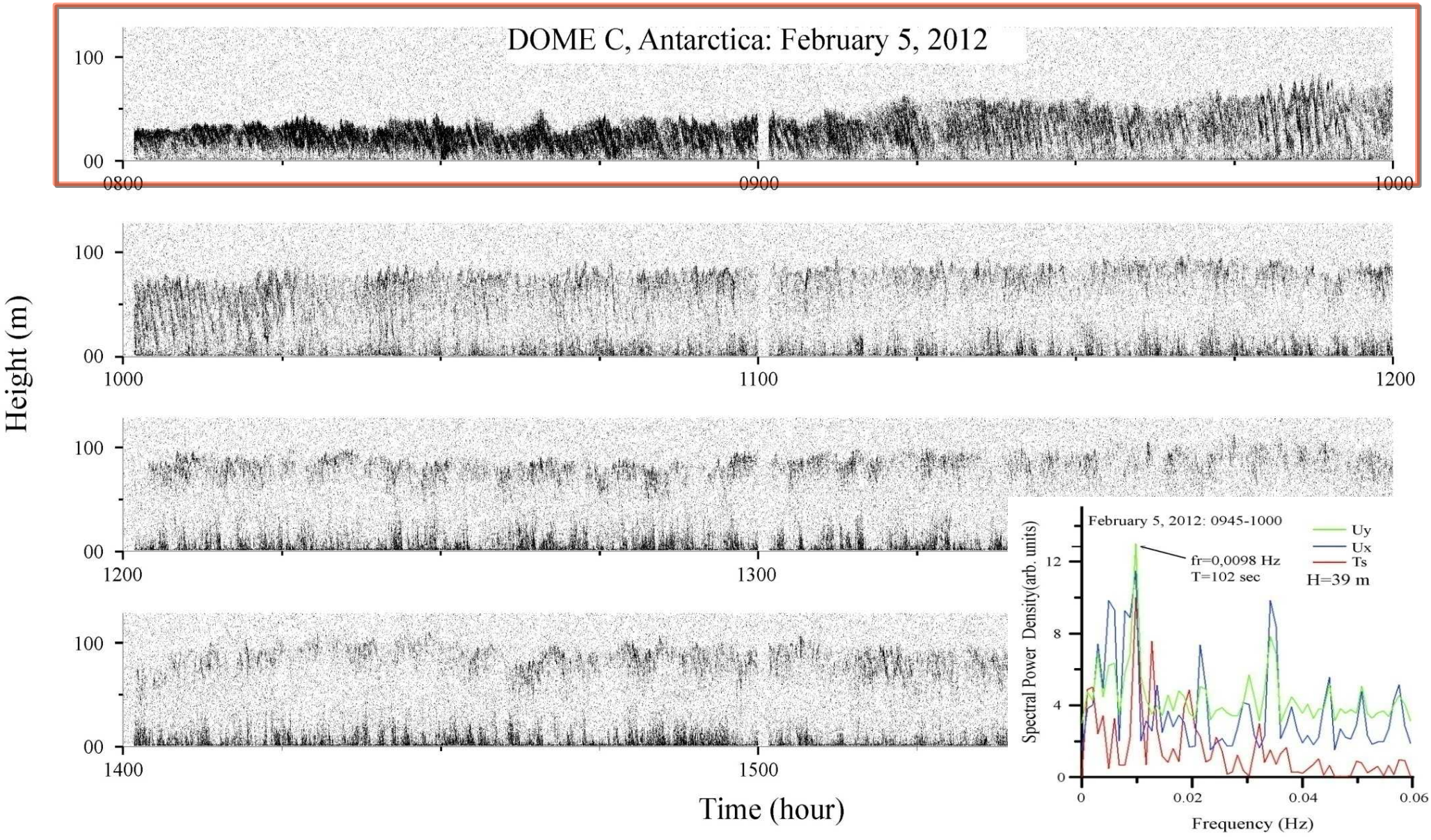
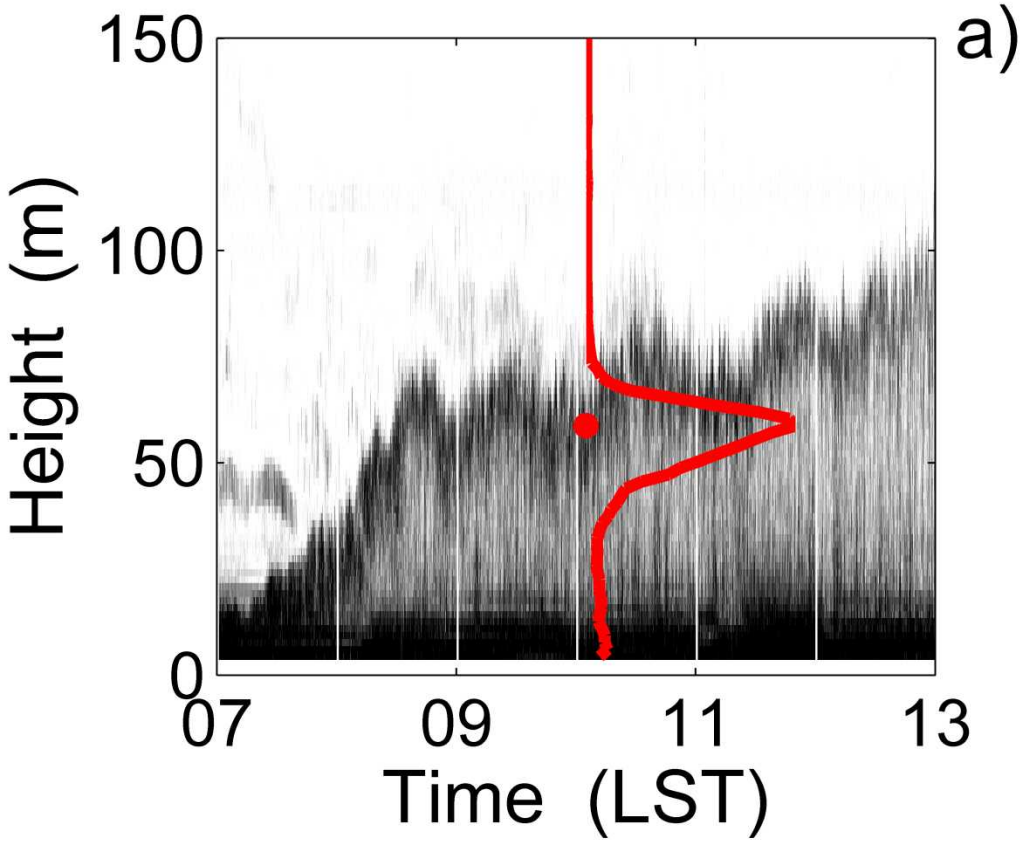
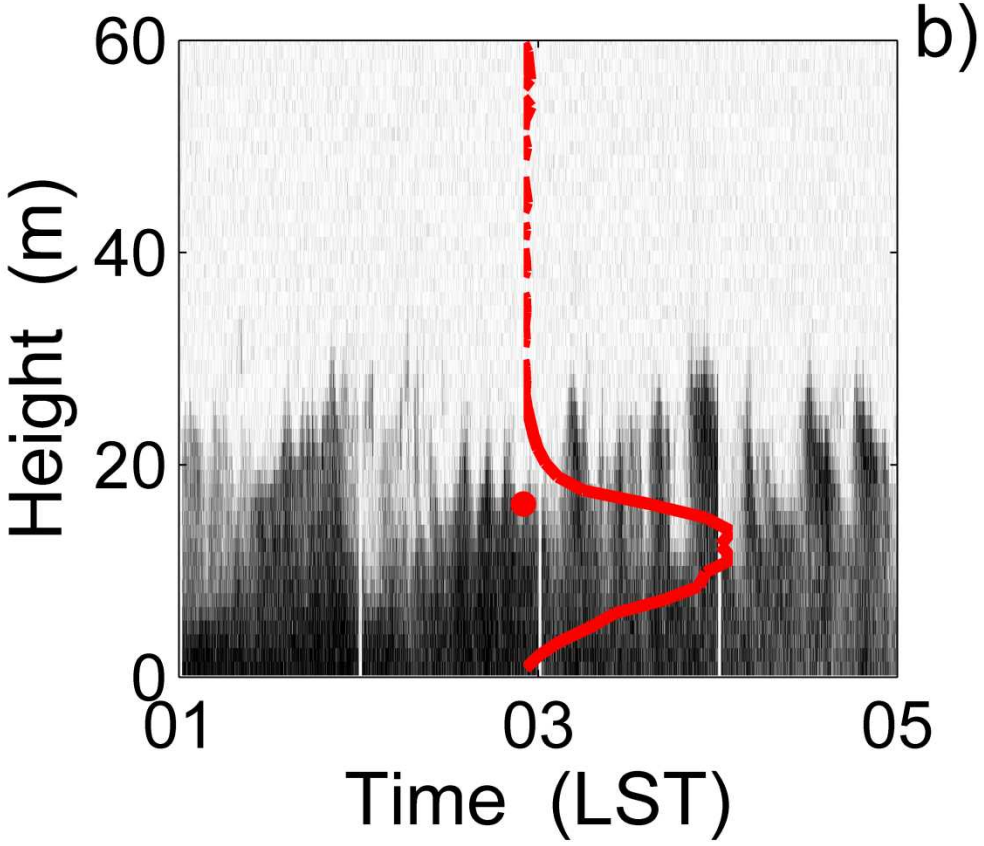
The spectral analysis showed that most frequent are high frequency waves (period 90 - 120 s)

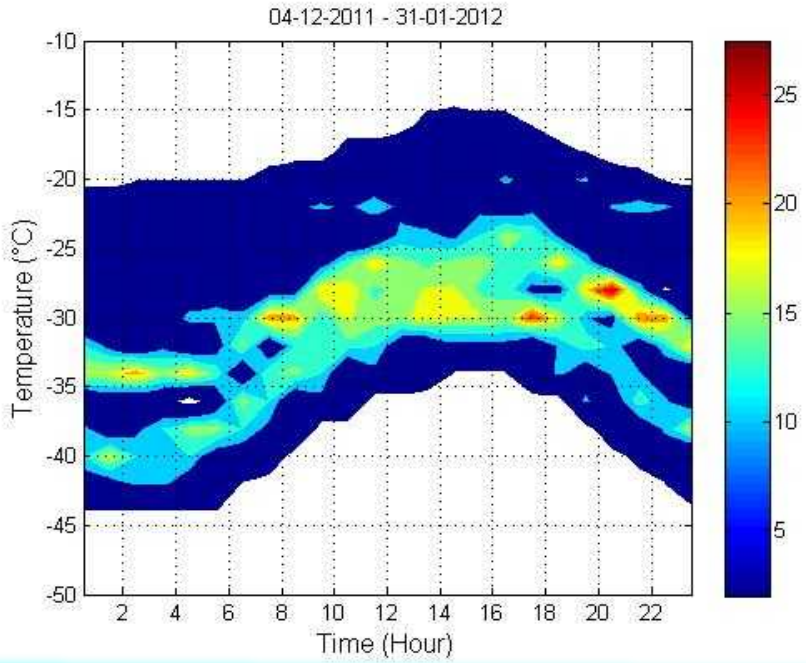


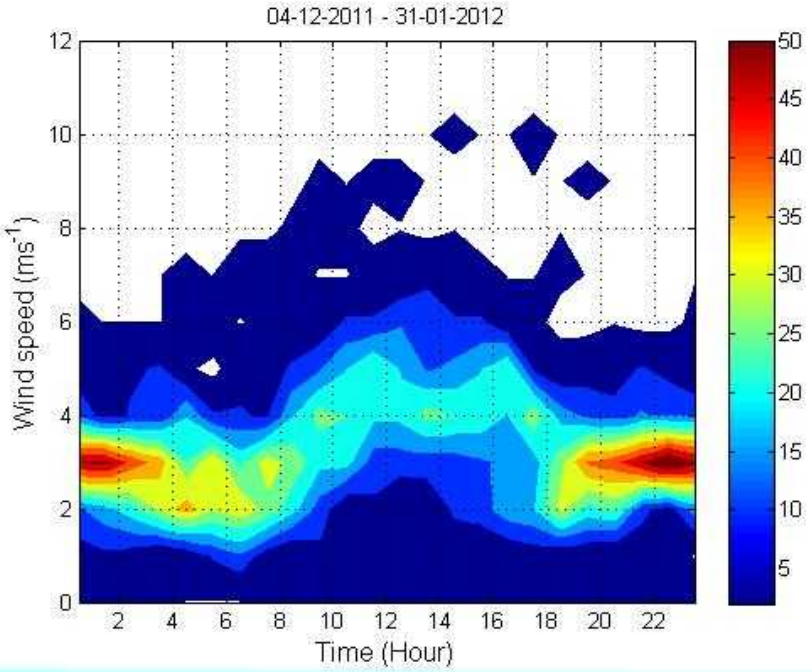
Proposal: Arctic and Antartica: influence of the Atmospheric Boundary Layer on CLIMATe (ABLCLIMAT)

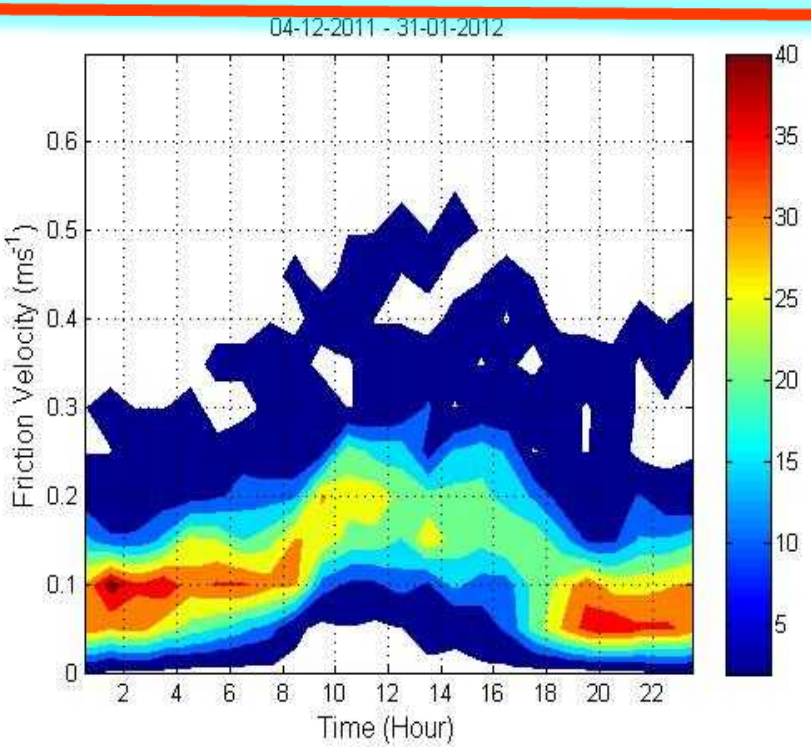
- Monitor the PBL structure to evidence major atmospheric processes
- Investigate the origin, and impact of the Antarctic warming events on PBL
- Study the origin, and characteristics of the waves in the stable PBL
- Estimate the PBL height and verify/improve parameterization for the stable/unstable PBLs

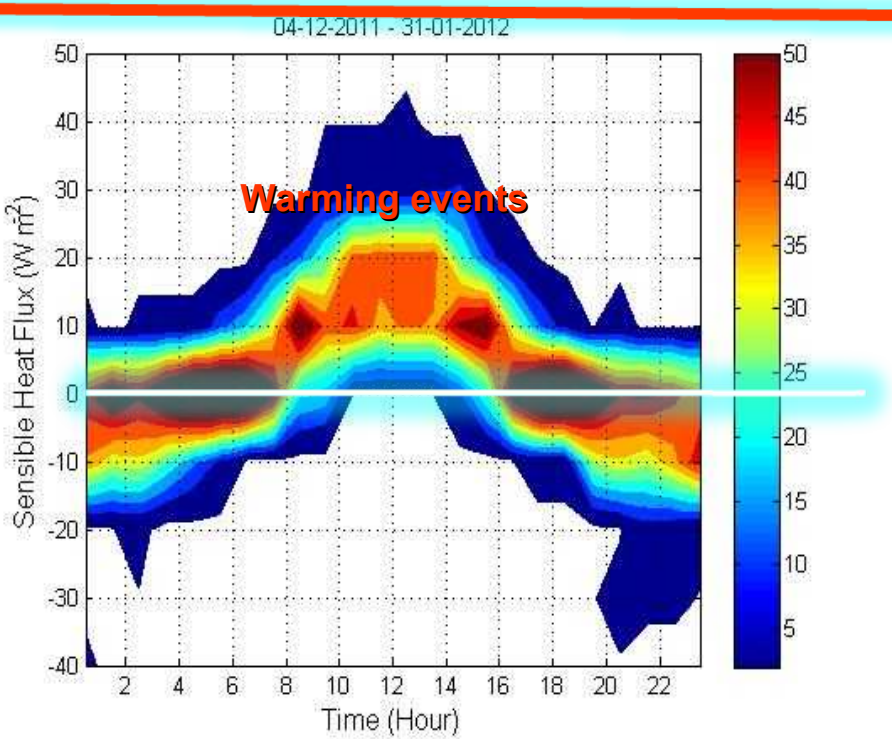

a)
150
100
50
0
Height (m)
07
09
11
13
Time (LST)


b)
60
40
20
0
Height (m)
01
03
05
Time (LST)


04-12-2011 - 31-01-2012
Temperature (°C)
-10
-15
-20
-25
-30
-35
-40
-45
-50
2 4 6 8 10 12 14 16 18 20 22
Time (Hour)
25
20
15
10
5


04-12-2011 - 31-01-2012
Wind speed (ms-1)
12
10
8
6
4
2
0
2 4 6 8 10 12 14 16 18 20 22
Time (Hour)
50
45
40
35
30
25
20
15
10
5


04-12-2011 - 31-01-2012
Friction Velocity (ms-1)
0.6
0.5
0.4
0.3
0.2
0.1
0
2 4 6 8 10 12 14 16 18 20 22
Time (Hour)
40
35
30
25
20
15
10
5


04-12-2011 - 31-01-2012
Sensible Heat Flux (W m2)
50
40
30
20
10
0
-10
-20
-30
-40
2 4 6 8 10 12 14 16 18 20 22
Time (Hour)
50
45
40
35
30
25
20
15
10
5
Warming events