# Preliminary thoughts on the relationships between lower troposphere profile data at individual sites and various spatial scales in the horizontal

COST/Net_ FAM workshop Olso.

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# WG4 study on methods to scale up from individual profiles to distribution in the horizontal of temperature, water vapour profiles, including boundary layer height and other lids in the lower troposphere and associated winds

- What temporal resolution?
- What spatial resolution?
- Representativeness errors.

# Future Upper Air requirements? Needs further discussion with users.

| UK Regional NWP requirement | Boundary layer temperature (K) | | | Lower troposphere temperature (K) | | | Lower troposphere relative humidity (%) | | | Horizontal wind component (u,v) ($ms^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Min | Brk | Max | Min | Brk | Max | Min | Brk | Max | Min | Brk | Max |
| Accuracy | 1.5 | | 0.5 | 1.5 | | 0.5 | 10 | | 5 | 3 | | 1 |
| Vertical resolution (km) | 0.5 | .03 | .01 | 2 | 1 | 0.1 | 2 | 1 | 0.1 | 2 | 1 | 0.1 |
| Horizontal spacing of network (km) | 10 | 10 | 1 | 200 | 30 | 3 | 200 | 30 | 3 | 200 | 30 | 3 |
| Time between Observations (h) | 3 | | .16 | 12 | 3 | 0.5 | 12 | 3 | 0.5 | 12 | 3 | 0.5 |
| Delay in delivery to user (h) | 3 | | .08 | 5 | | .25 | 5 | | .25 | 5 | | .25 |

Radiosonde and wind profiler 300m

These resolution specifications are very inconsistent

# Alternate answer for vertical resolution and accuracy; Quality similar to radiosonde

For lower troposphere

- For wind, vertical resolution better than 300m in the troposphere, accuracy (2 s.d.) better than 2 $ms^{-1}$

At what range do Doppler weather radar winds no longer meet this vertical resolution? Matters if vertical wind shear is important in the lower troposphere. Does vertical shear need to be resolved?

- For temperature and relative humidity vertical resolution of initial measurement better than 20m, but may be destroyed by TEMP code processing.
- Accuracy [2 s.d.] temperature 0.5 K
- water vapour 1 g/kg [summer ]

# Some Questions to be addressed

- How much can remote sensing fall short of the better standards and still be useful and justify the extra expenditure, and which aspects are most critical? No simple answer, since it depends on quality of surrounding network observations.
- Where there are network gaps lower resolution may still be useful for interpolation whether in time or space. [ground based or satellite based remote sensing?
- Should remote sensing be collocated with radiosondes to give improved interpolation with time, or interspersed to provide bettter interpolation between best quality measurements?

# Relationship between temporal resolution at an individual site and horizontal network resolution [1]

- If a weather system is moving at between 30 and 60 km/h [ over UK this is not unusual], then a time step of 1 hour corresponds to a displacement in the horizontal of 30 to 60 km

- In the lower troposphere, the rms difference between two profile measurements at one site separated by an hour is likely to be the same as that between two simultaneous profile measurements between 20 and 30 km apart

# Relationship between temporal resolution at an individual site and horizontal network resolution [2]

- Thus if a profiling site is located in a place where the effects of local topography or surface roughness changes are small, the time series of profile observations is likely to represent the passage of the weather system.
- For the more usual weather system speeds, 30 km in the horizontal should correspond to between 30 minutes and 1 hour resolution.
- Earlier experience with wind profilers in the UK suggested it is relatively safe to use a time series to extrapolate information down wind from the site for at least 1 hour after the initial observation, and this is also probably true for temperature
- GPS water vapour measurements in summer convection indicate that it is very dangerous to extrapolate integrated water vapour downwind for more than half an hour.

# Relationship between temporal resolution at an individual site and horizontal network resolution [3]

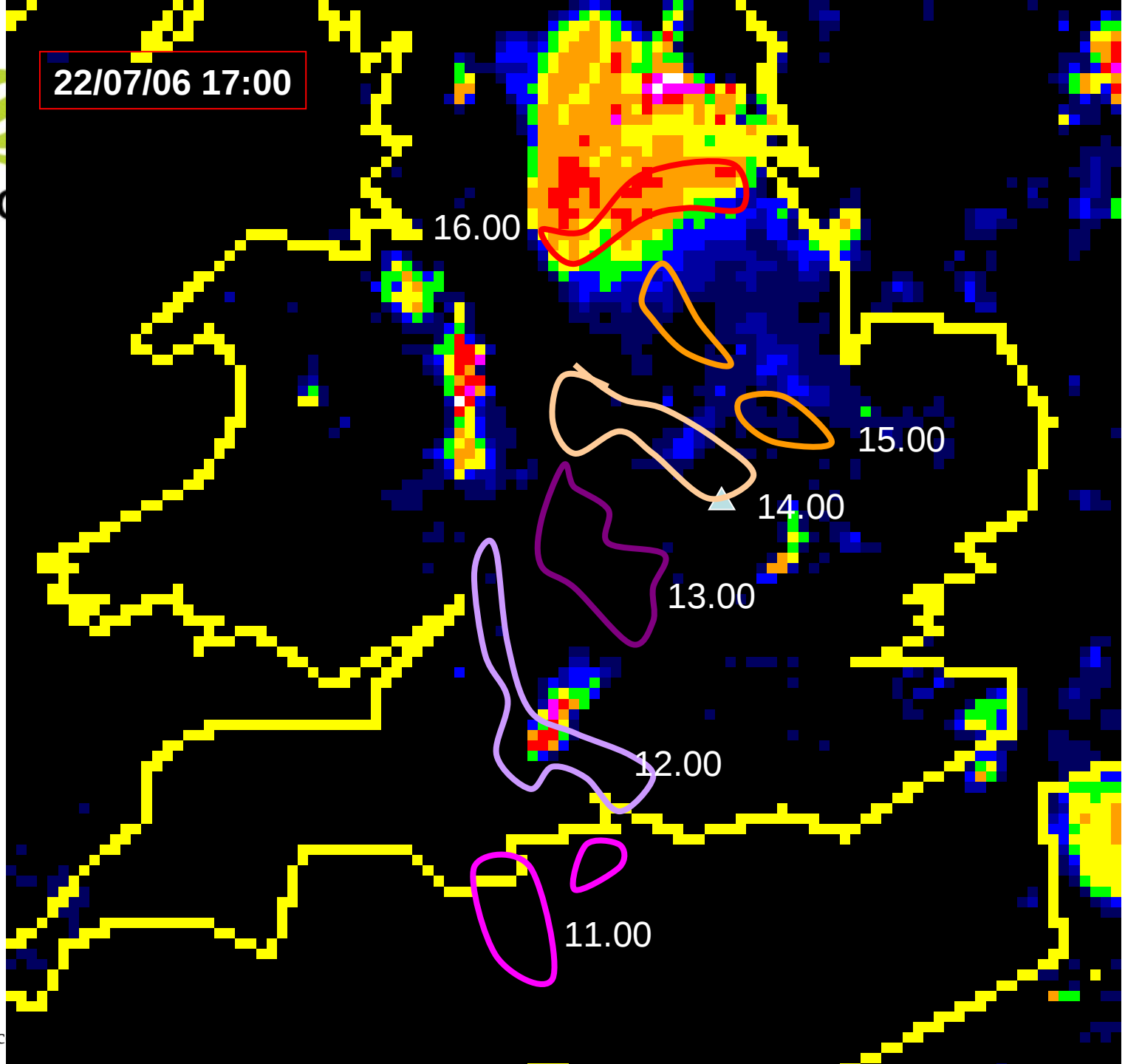
- Destructive winds in winter are quite commonly associated with weather systems with speeds in excess of 100 km/h
- Thus , in this case averaging for 30 minutes is equivalent to averaging over at least 50km in the horizontal and this is too crude to adequately resolve the strongest winds. If these are to be observed , wind profilers need to produce winds at temporal resolution of at least 15 minutes and possibly even higher resolution.
- Thus, it must be recognised that optimum temporal resolution will depend on the conditions, whether very strong winds with relatively weak convection , or strong convection but light winds.

# One example to illustrate a situation where vertical wind shear was important, on a horizontal spacing of less than 200km.

# Low level temperature gradients induced by the effects of organised convection over southern UK.

## 22.07. 2006

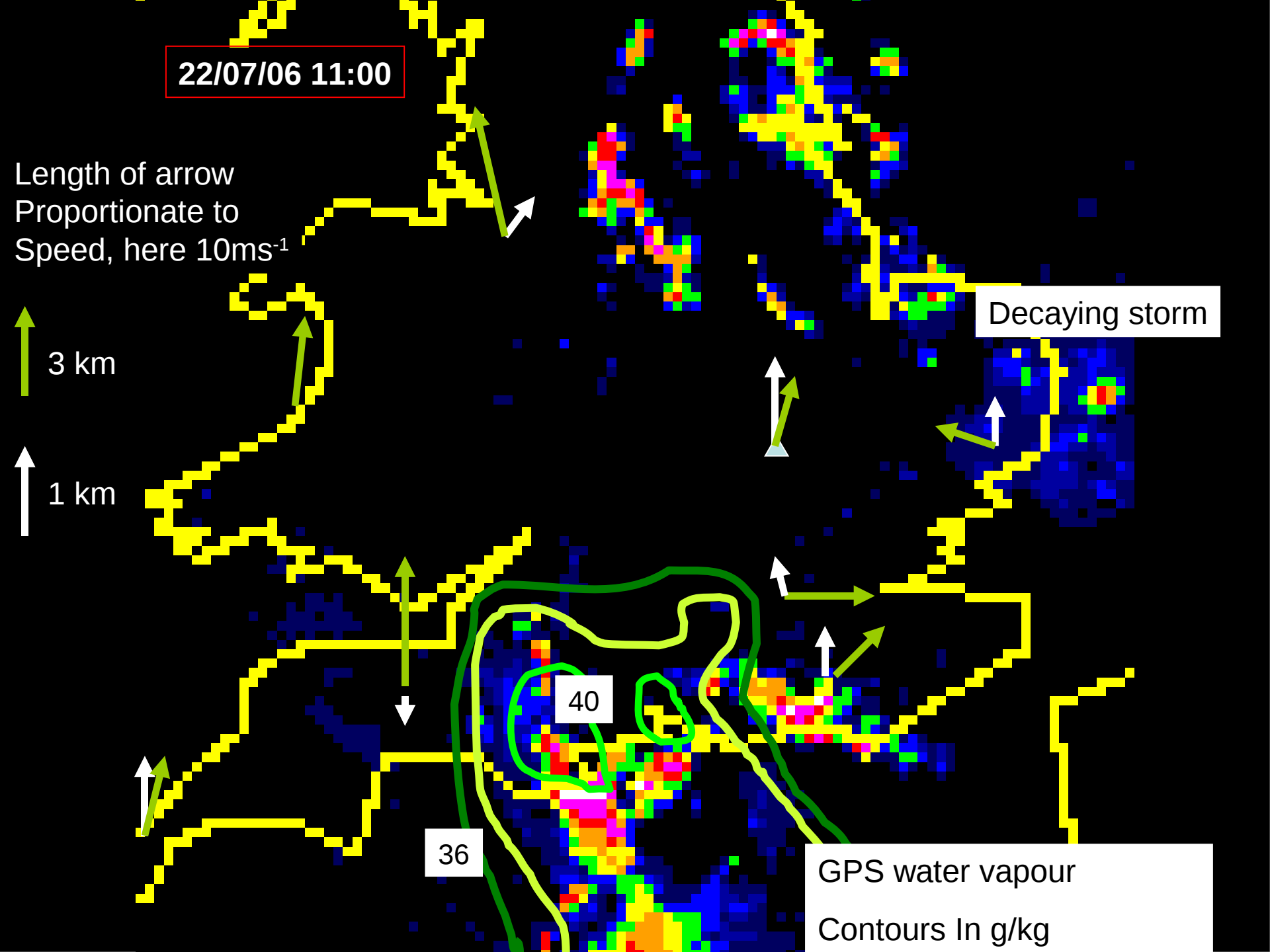
Wind fields on this day have a lot of small scale structure associated with various organised thunderstorms propagating northwards in general , but not in a straight line!, see next slide where the track of the more active cells in one thunderstorm complex, as detected by the weather radar, is shown.

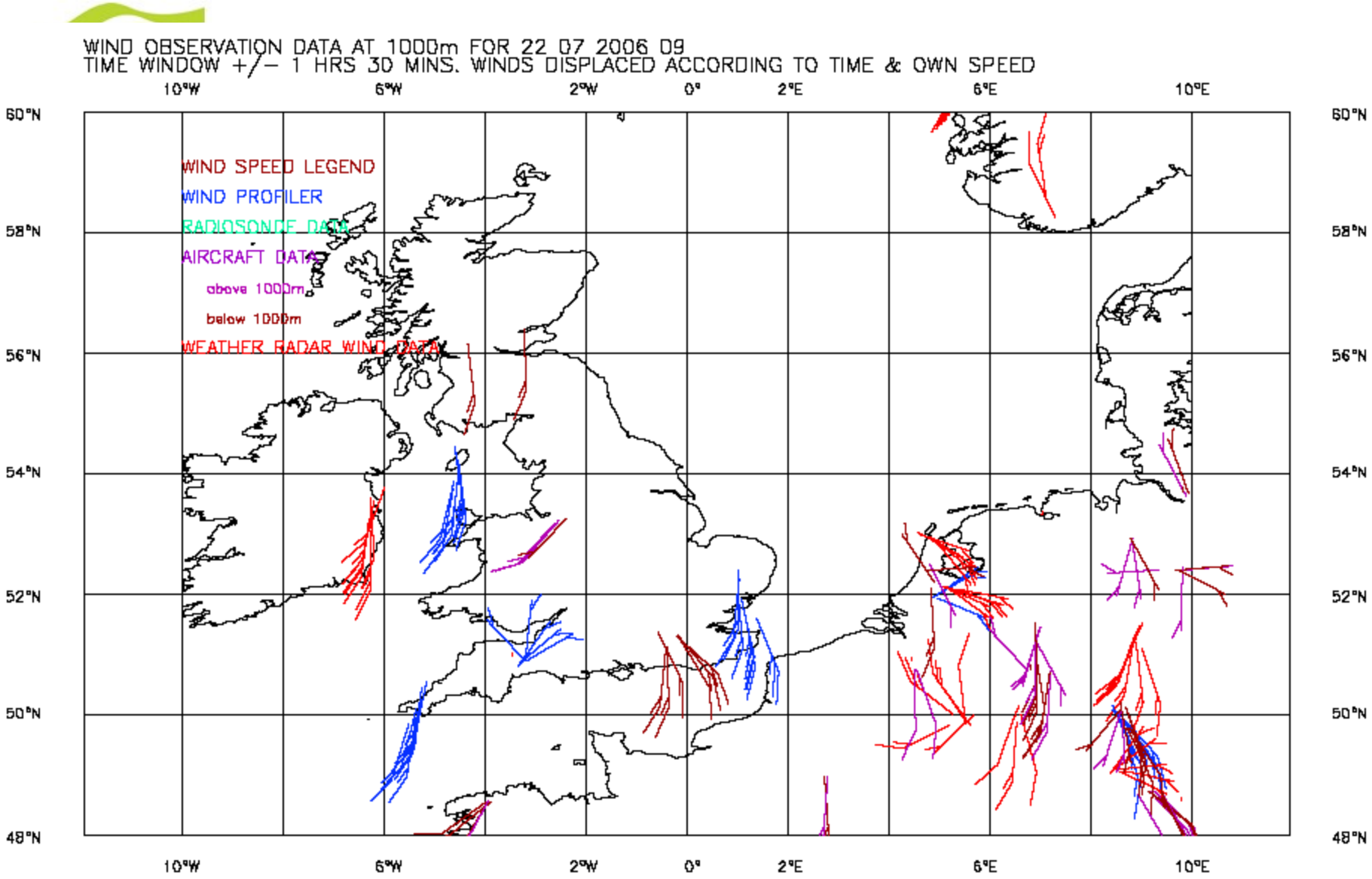


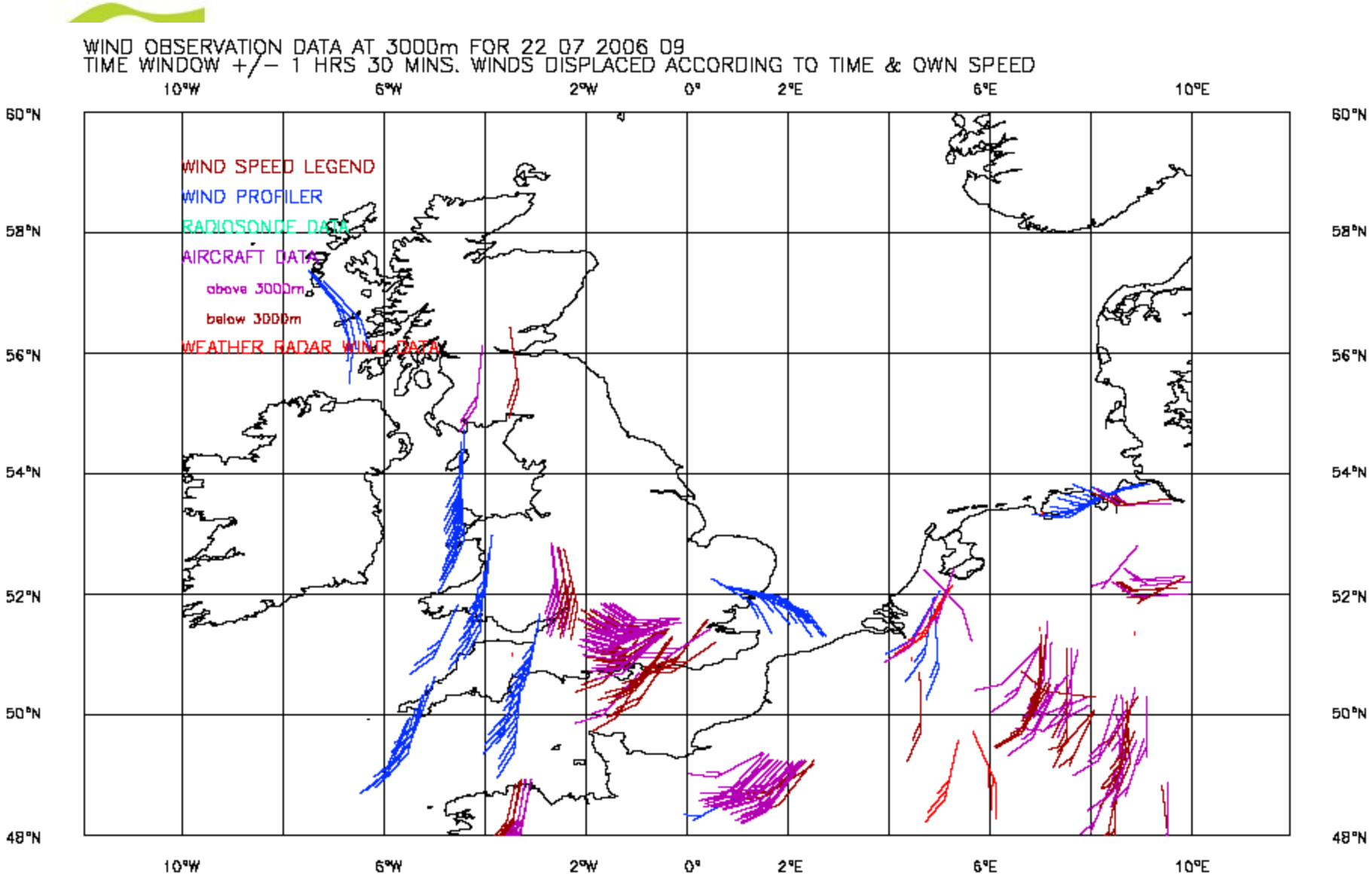
# At around 10.30

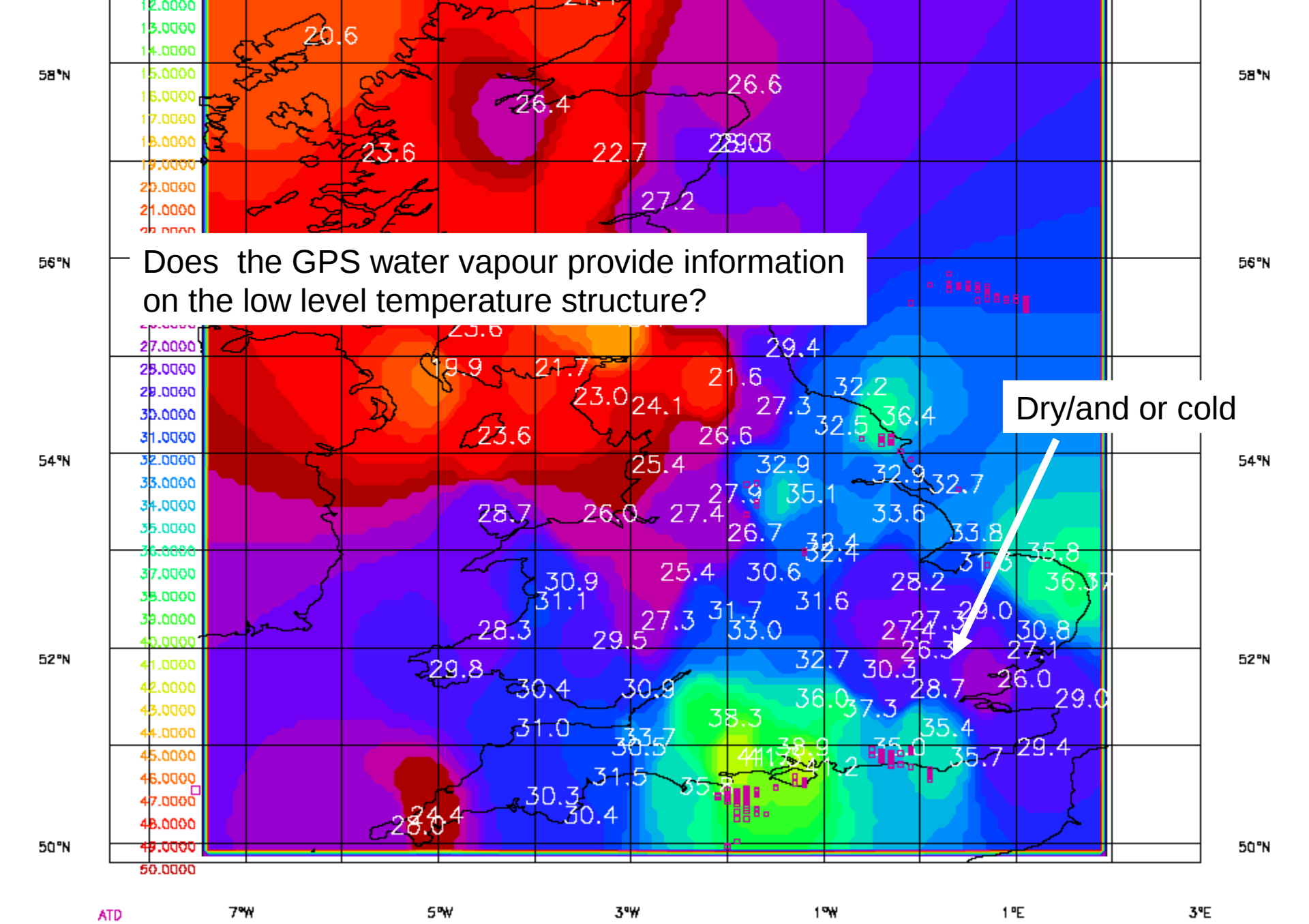
- Thermal wind [3-1 km] varies a great deal in southern England because of the low level thermal gradients associated with the approaching storm and the storm decaying further north in the east.

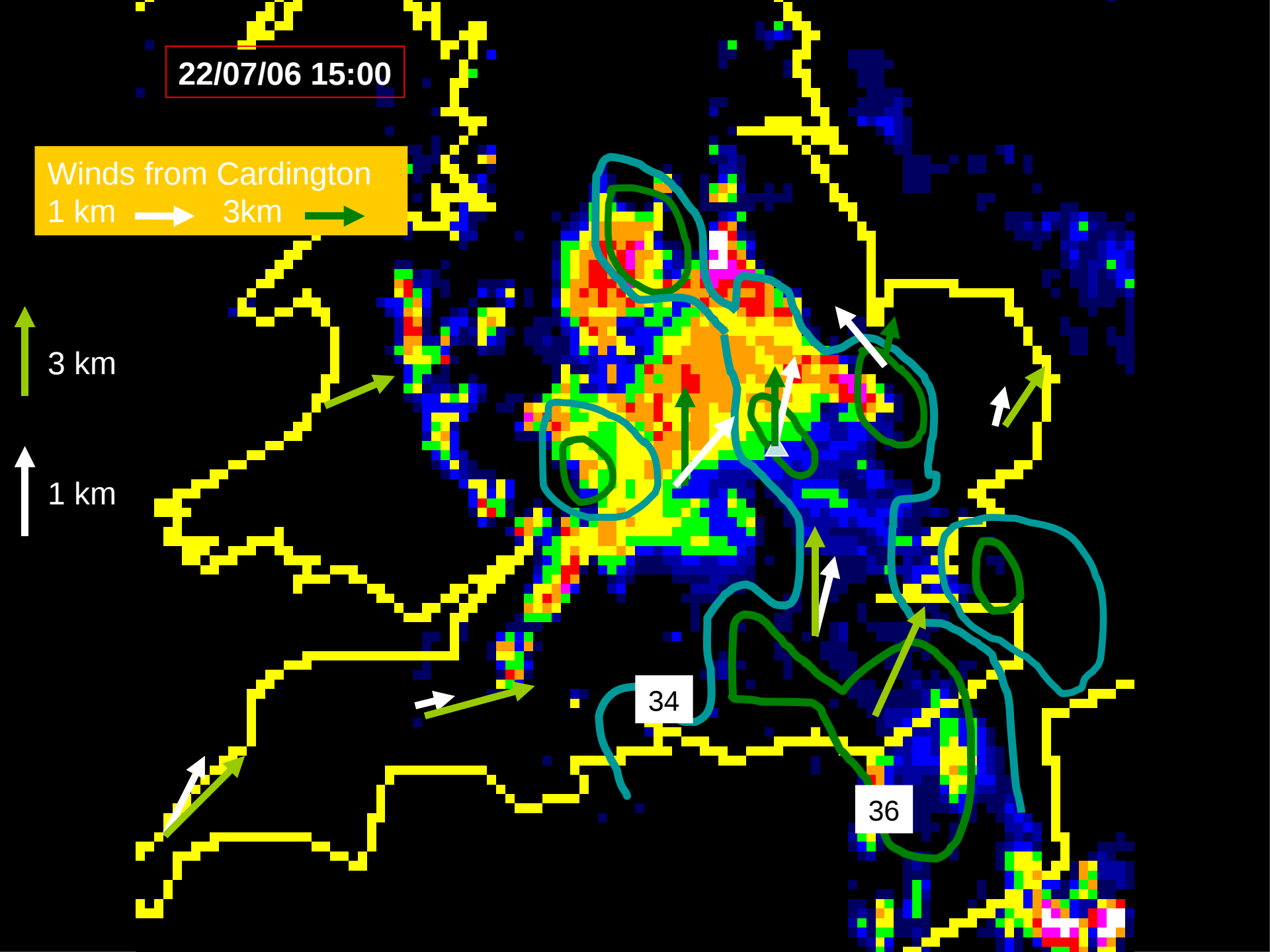
- Here a resolution of 200km in the horizontal is insufficient to define what is happening, resolution would be improved to some extent by adding Doppler weather radar winds

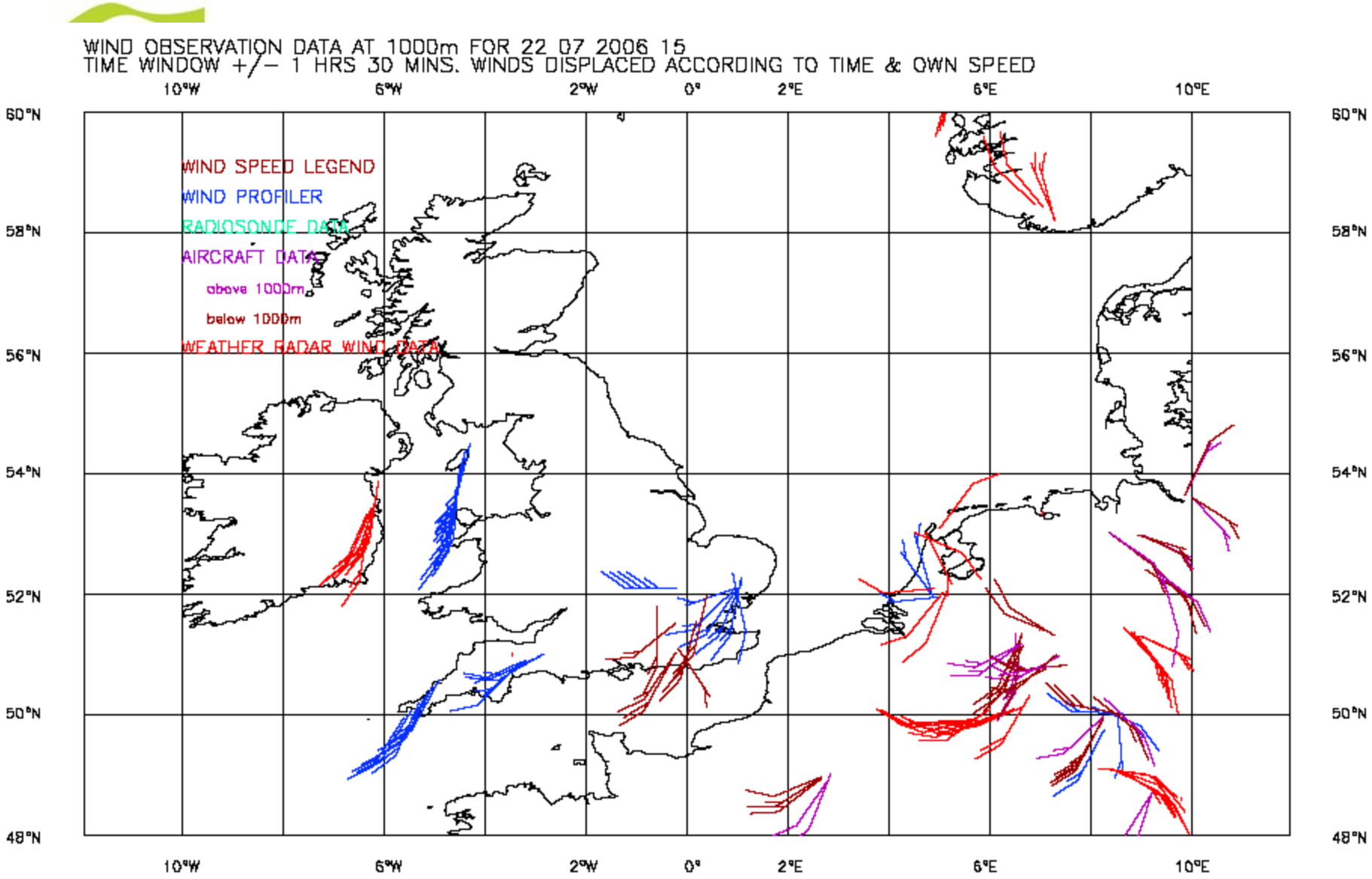

22/07/06 11:00
Length of arrow
Proportionate to
Speed, here 10ms-1
3 km
1 km
Decaying storm
40
36
GPS water vapour
Contours In g/kg

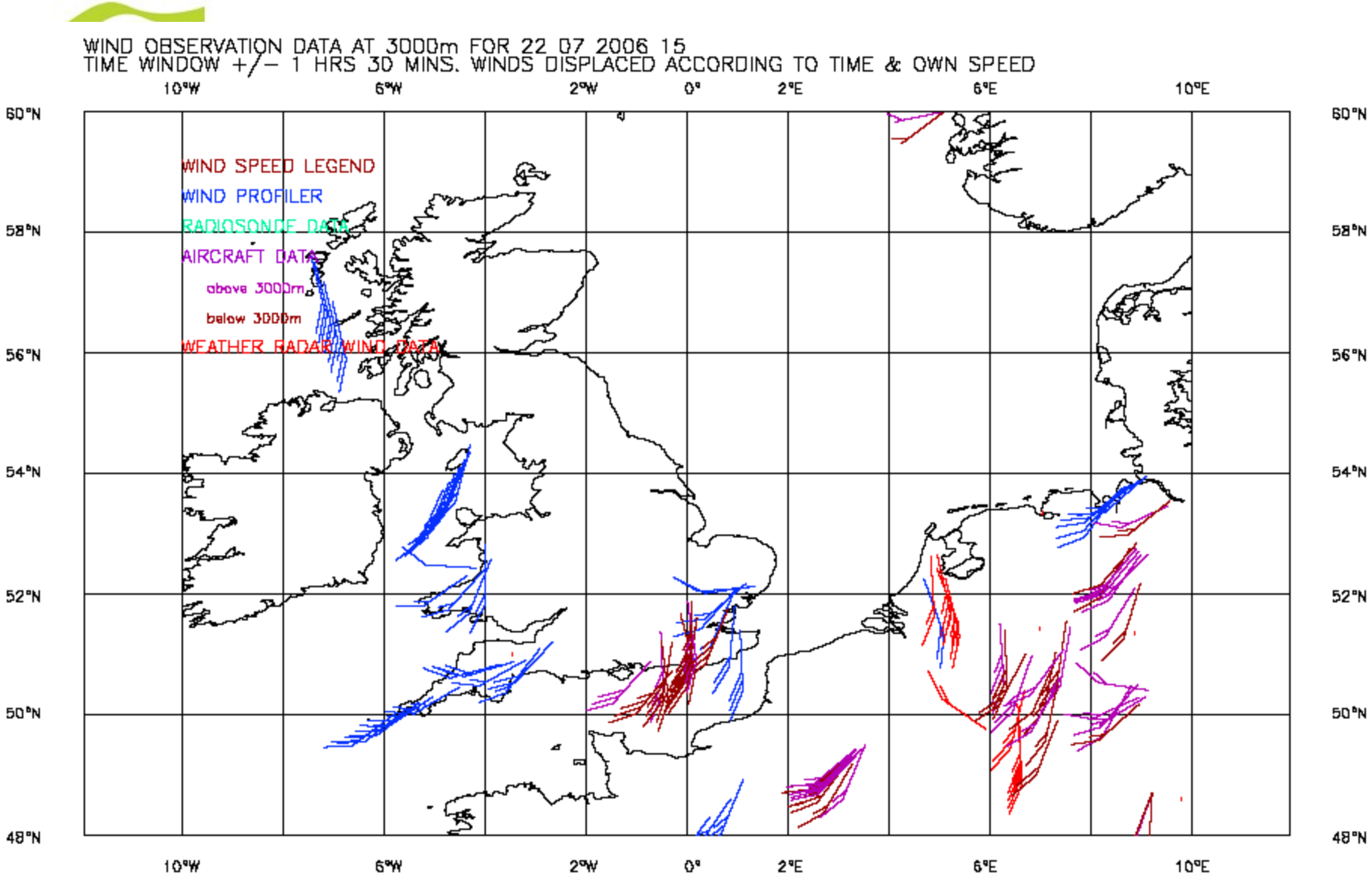





Does the GPS water vapour provide information on the low level temperature structure?
Dry/and or cold
58°N
56°N
54°N
52°N
50°N
7°W
5°W
3°W
1°W
1°E
3°E
ATD


22/07/06 15:00
Winds from Cardington
1 km
3km
3 km
1 km
34
36

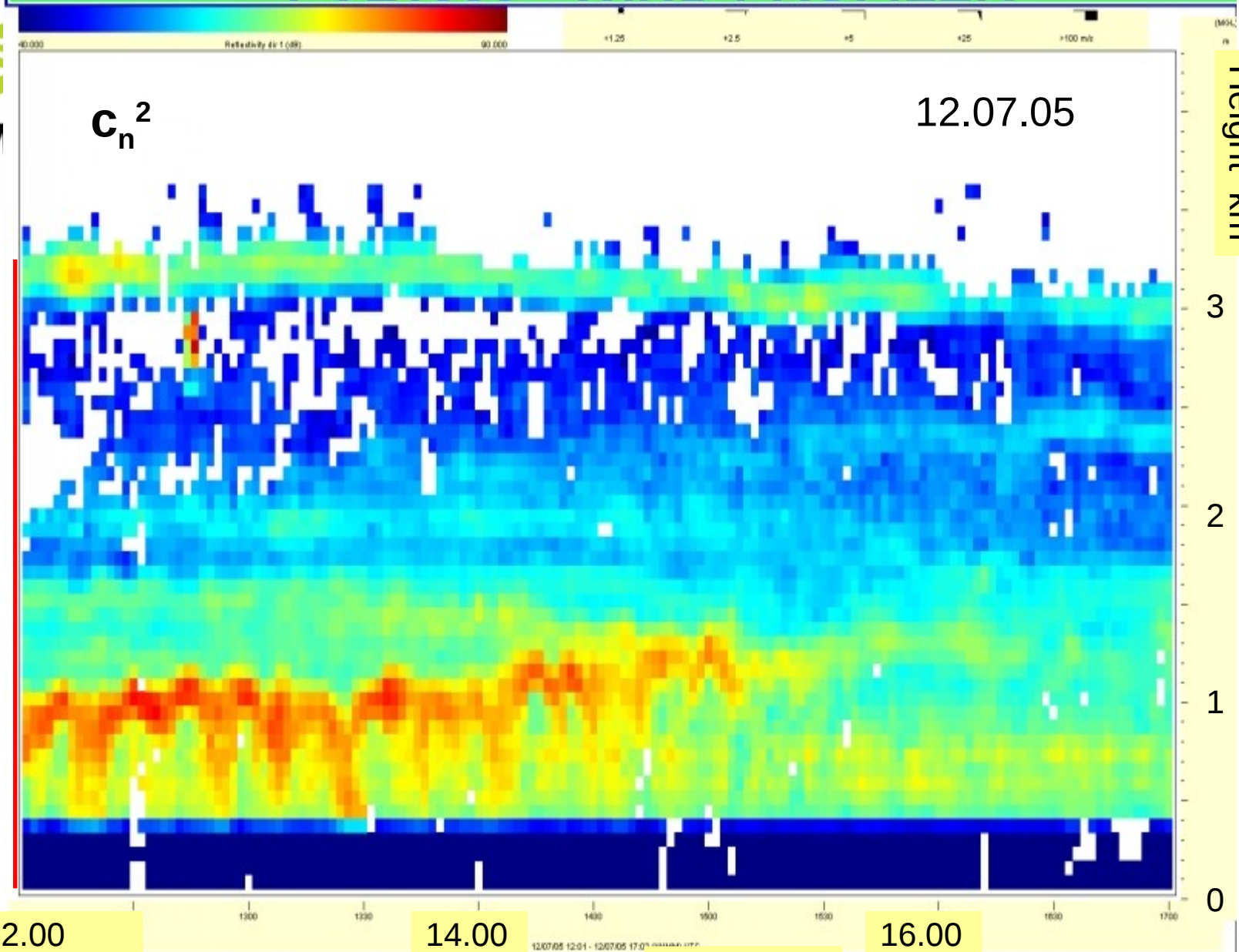




# Representativeness in boundary layer height?

- How do you represent variability to potential users … forecasters? Or NWP

# PCL1300 - WIND PROFILER



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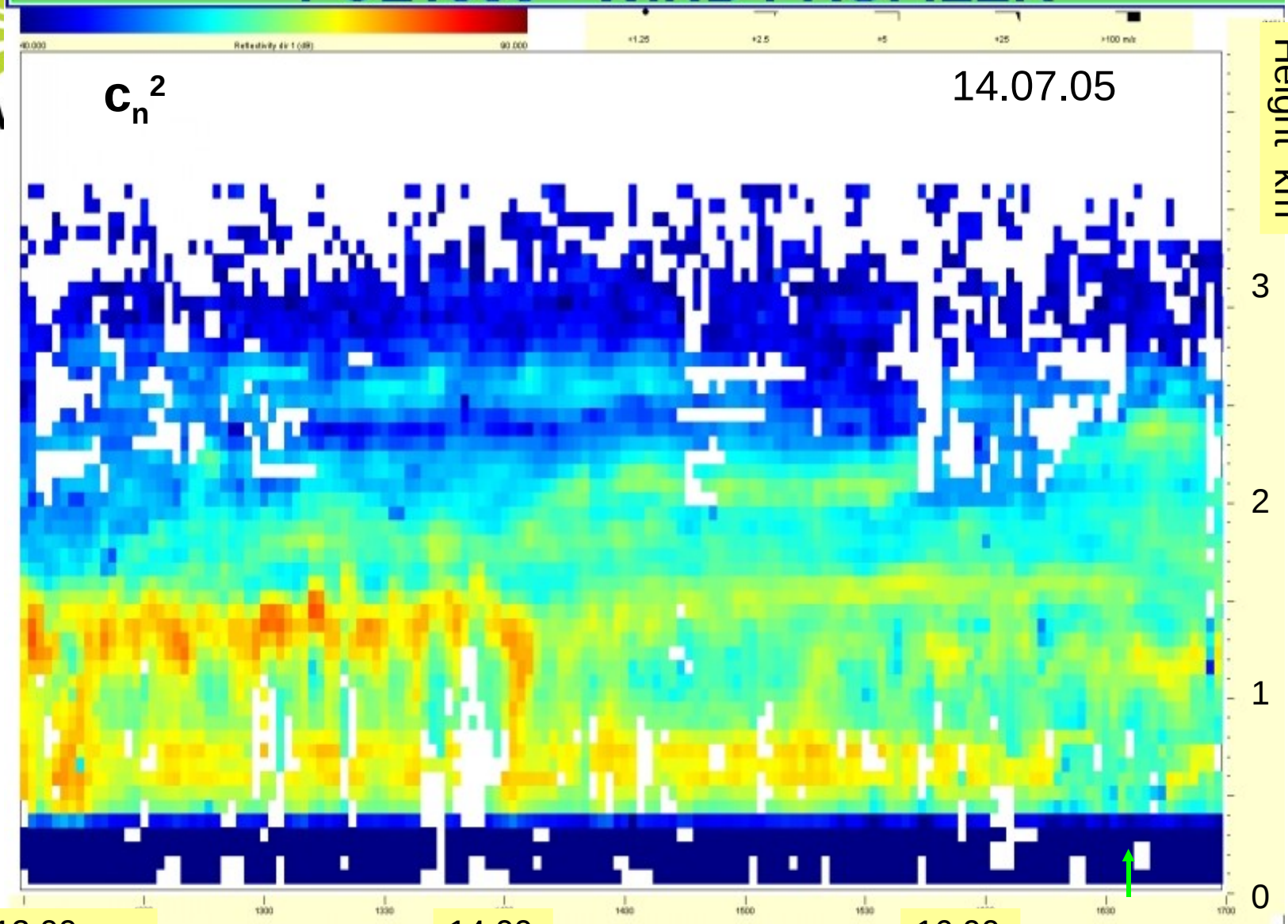
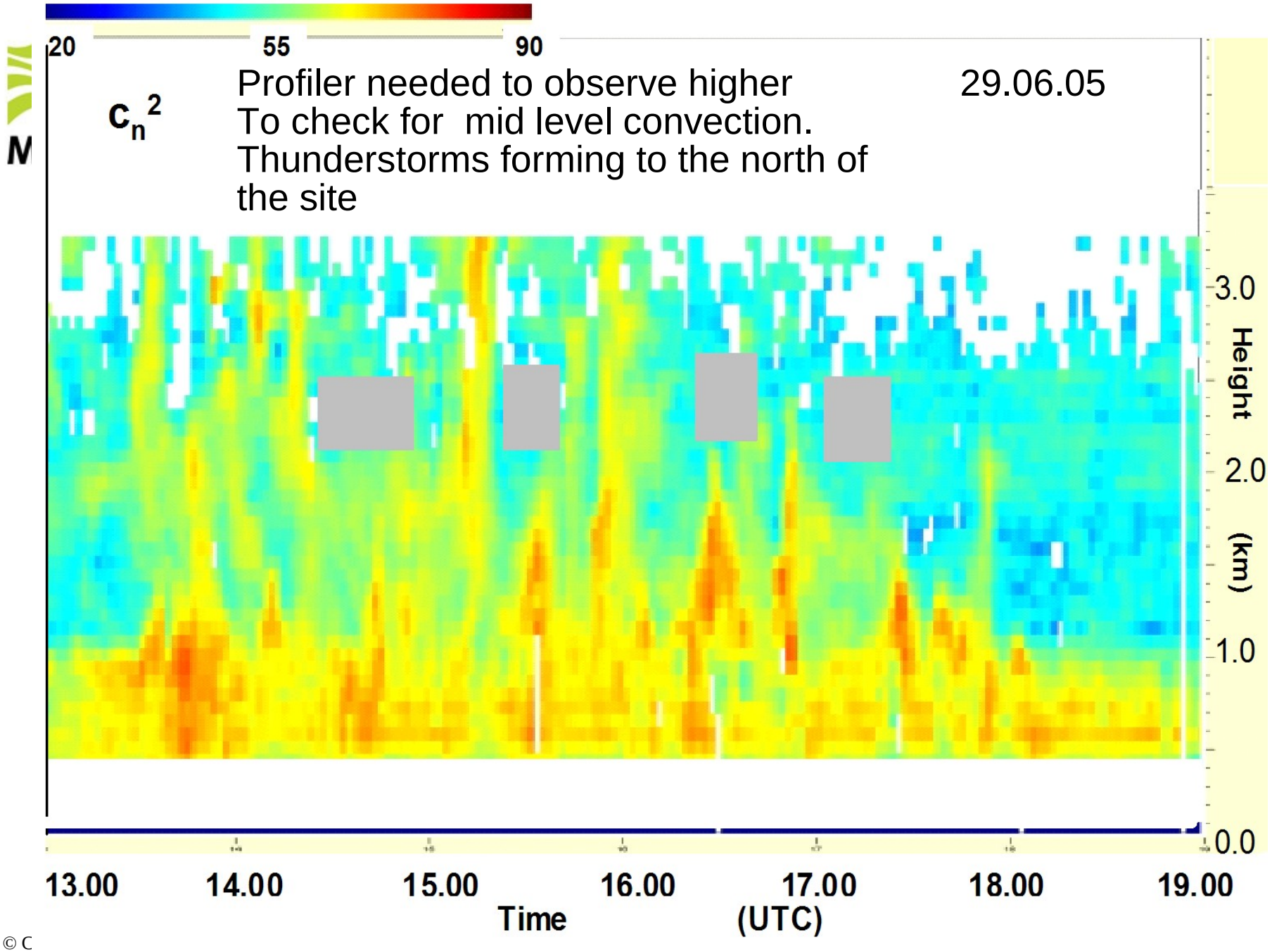
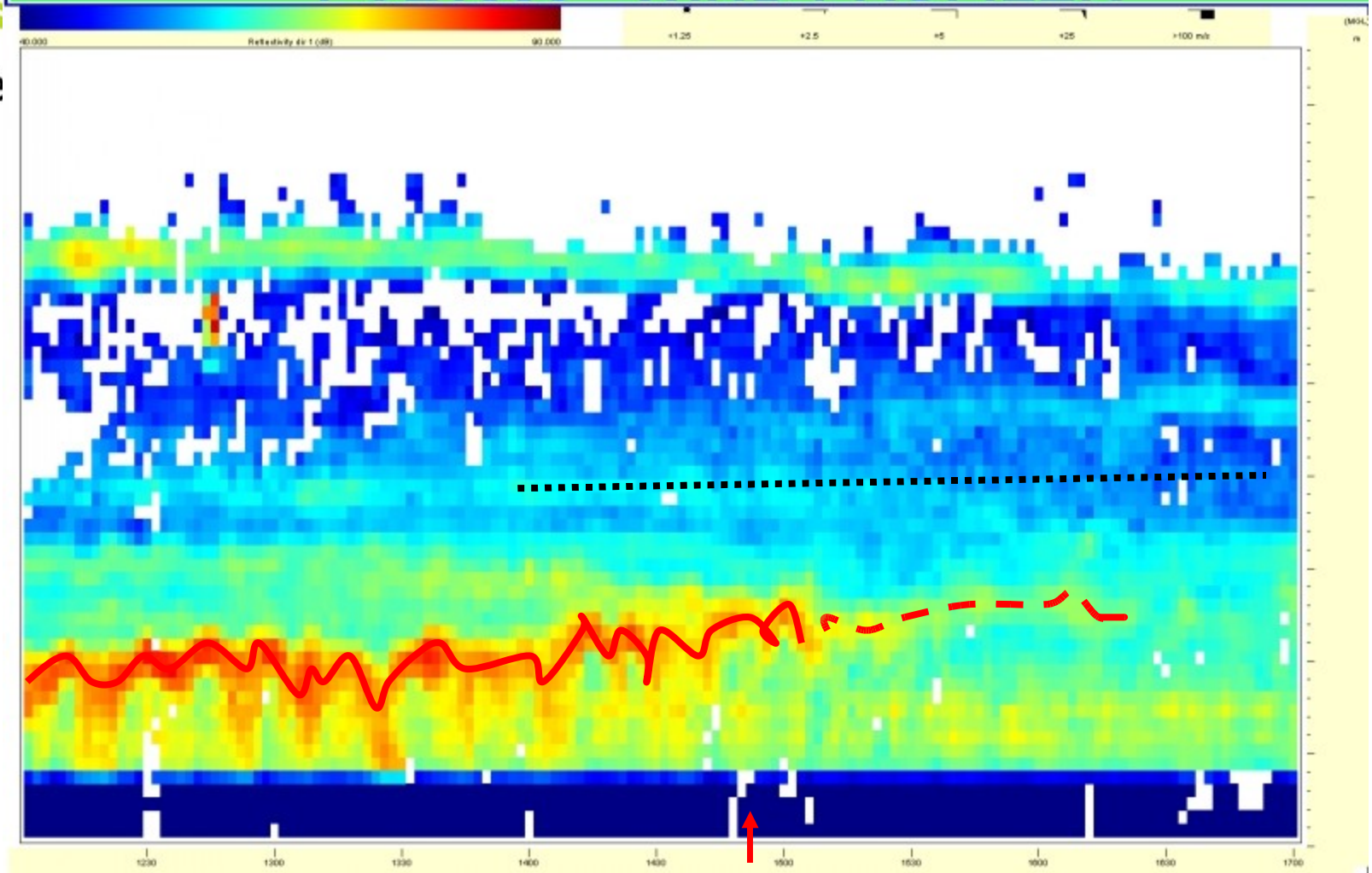



20
55
90
$C_n^2$
Profiler needed to observe higher
To check for mid level convection.
Thunderstorms forming to the north of
the site
29.06.05
3.0
2.0
1.0
0.0
Height
(km)
13.00
14.00
15.00
16.00
17.00
18.00
19.00
Time
(UTC)

# PCL1300 - WIND PROFILER



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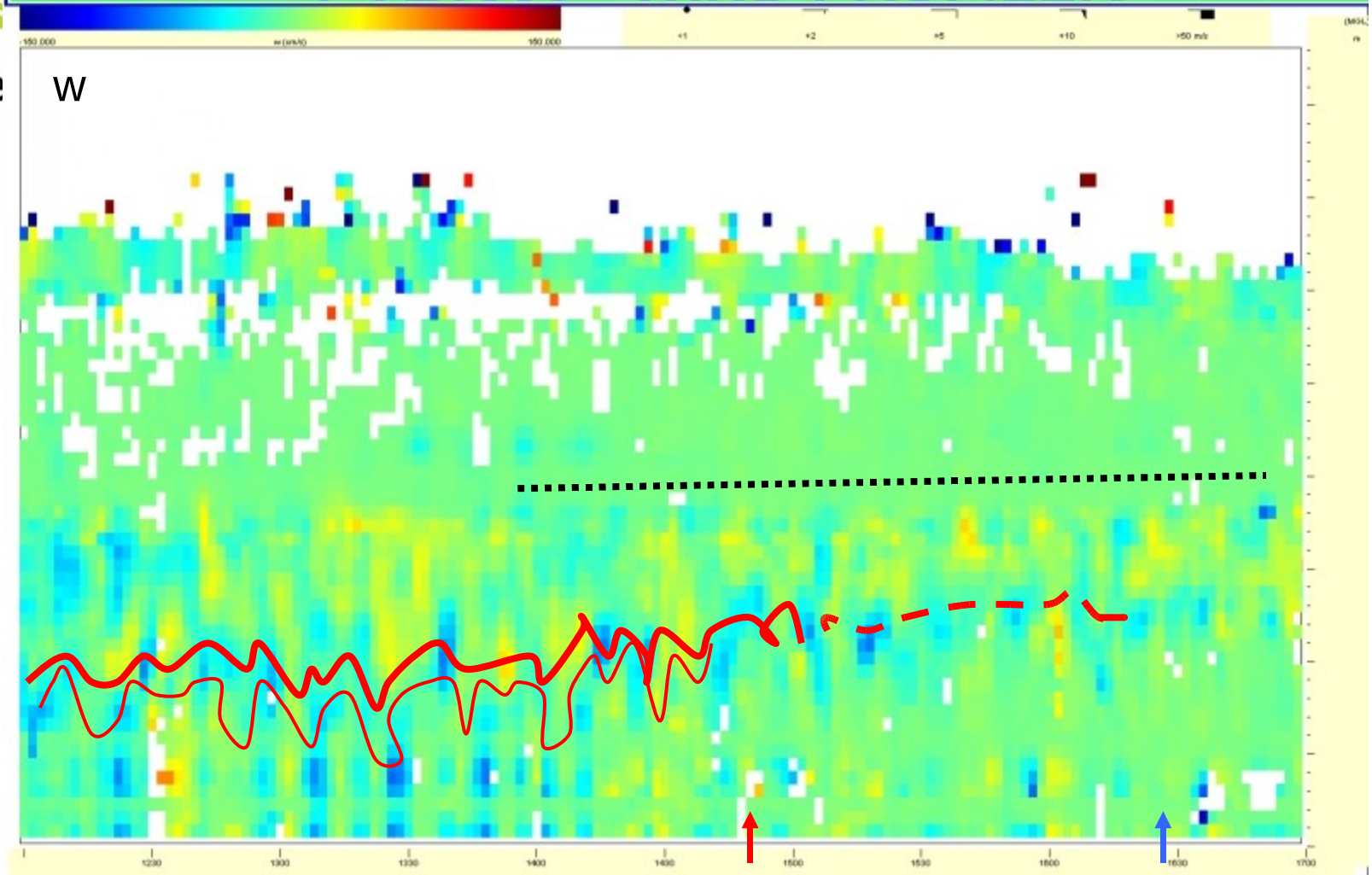

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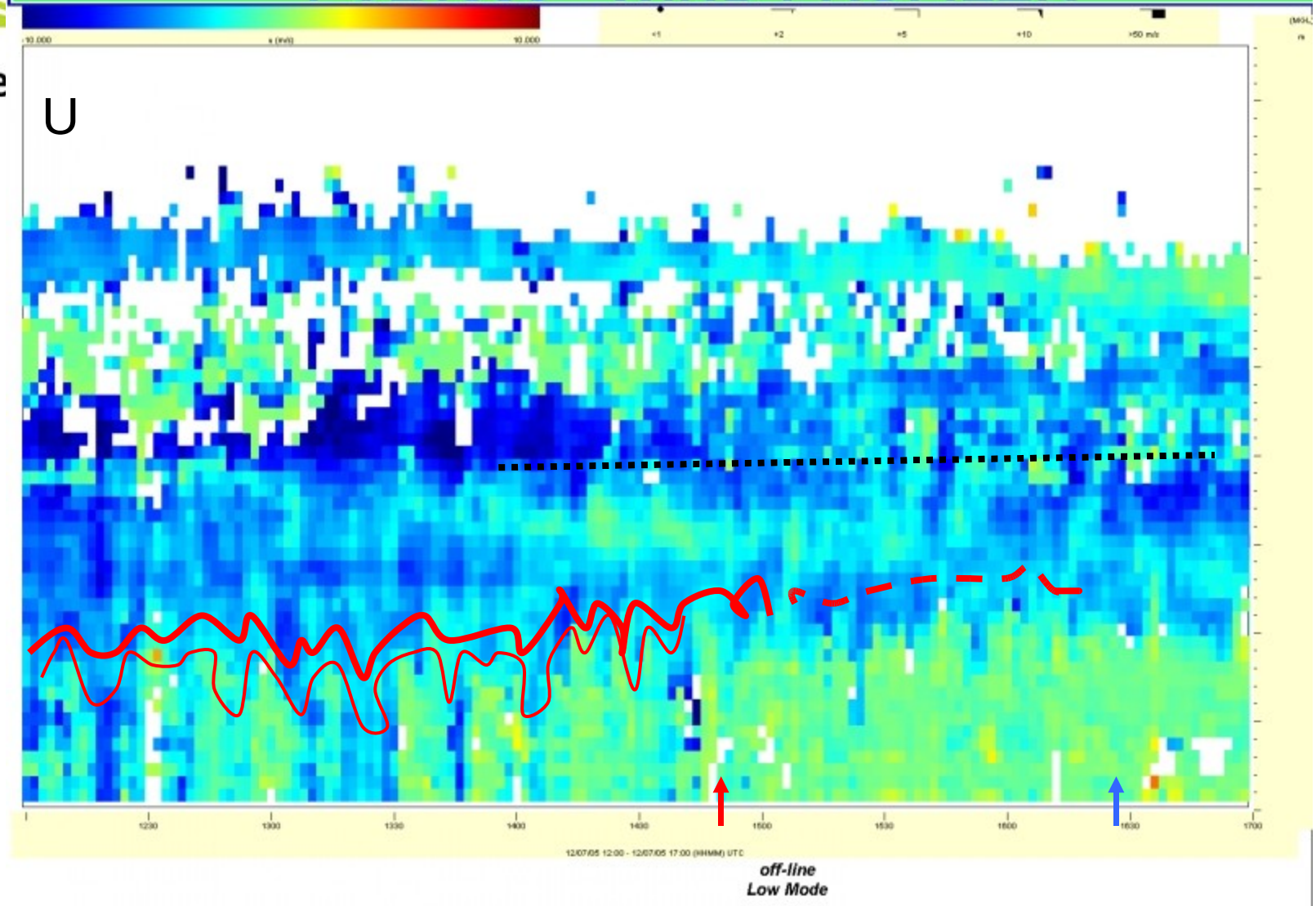

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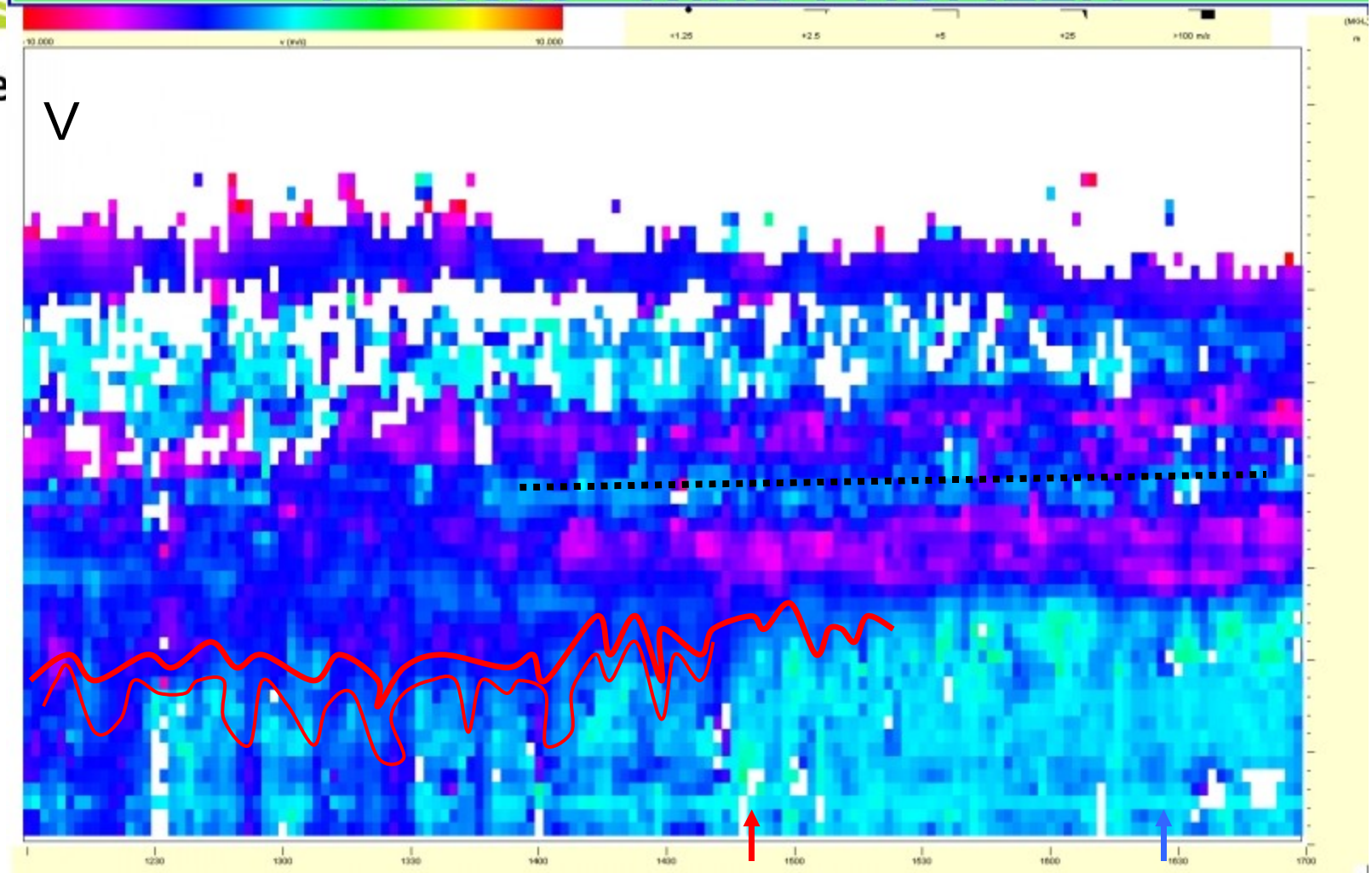

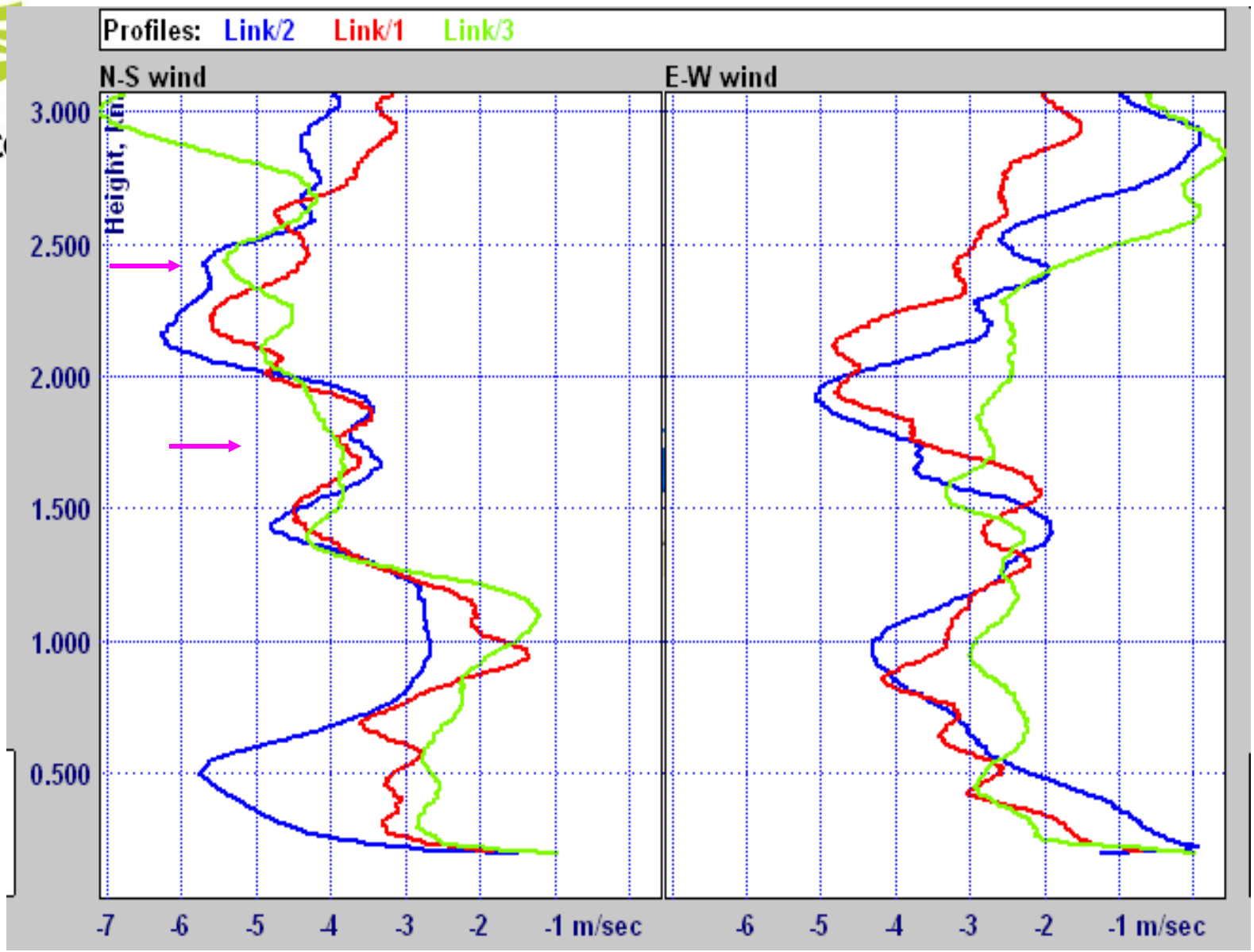

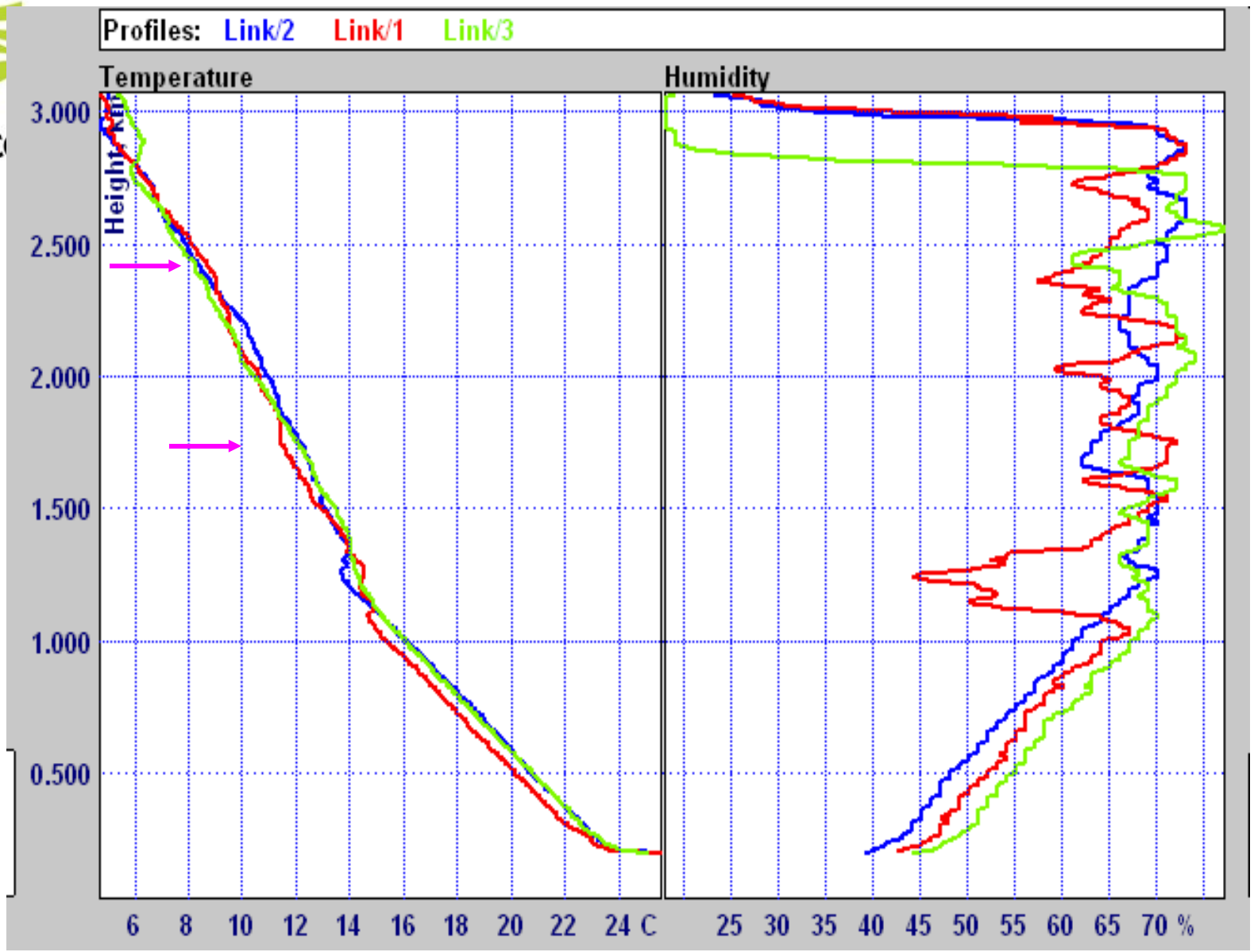

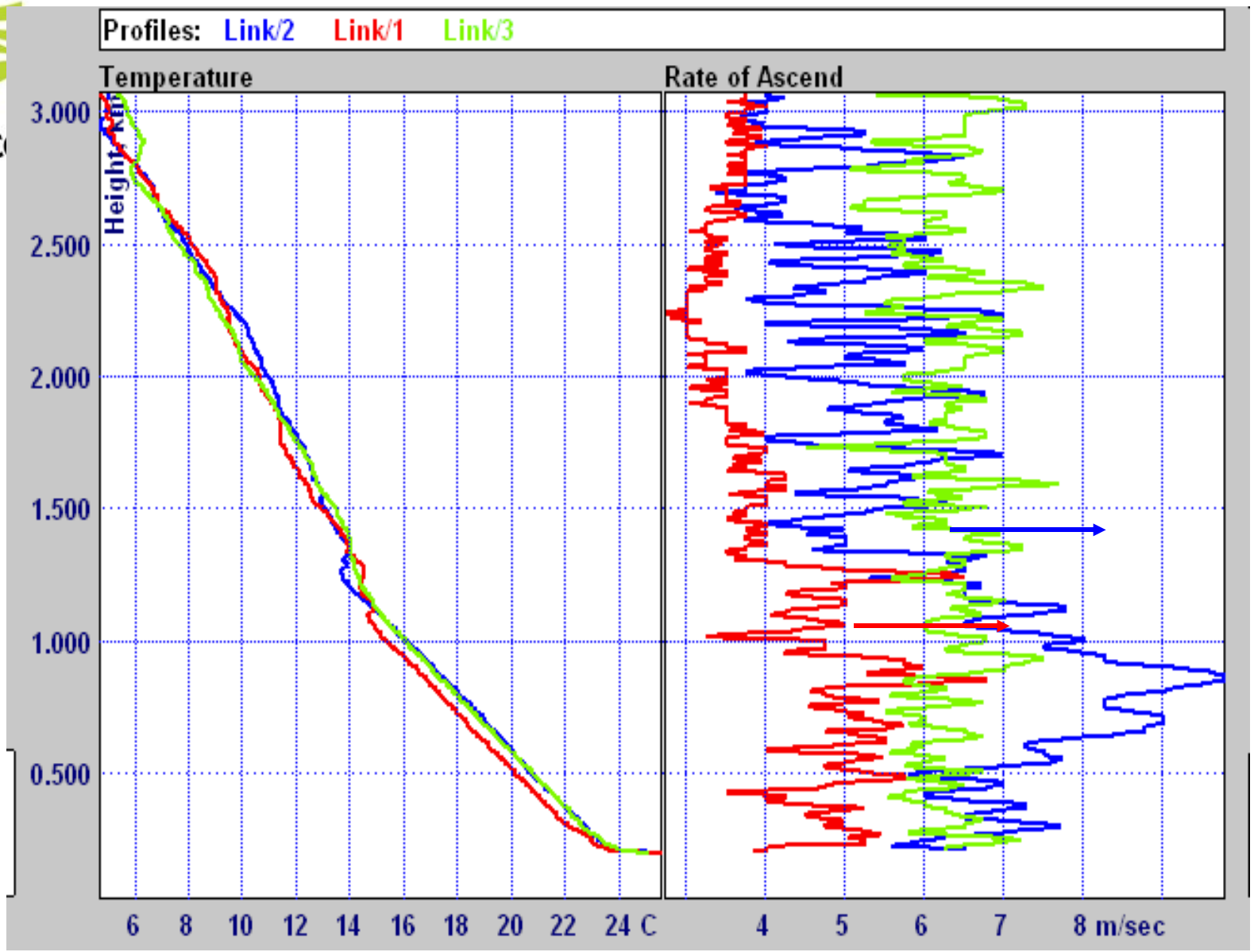

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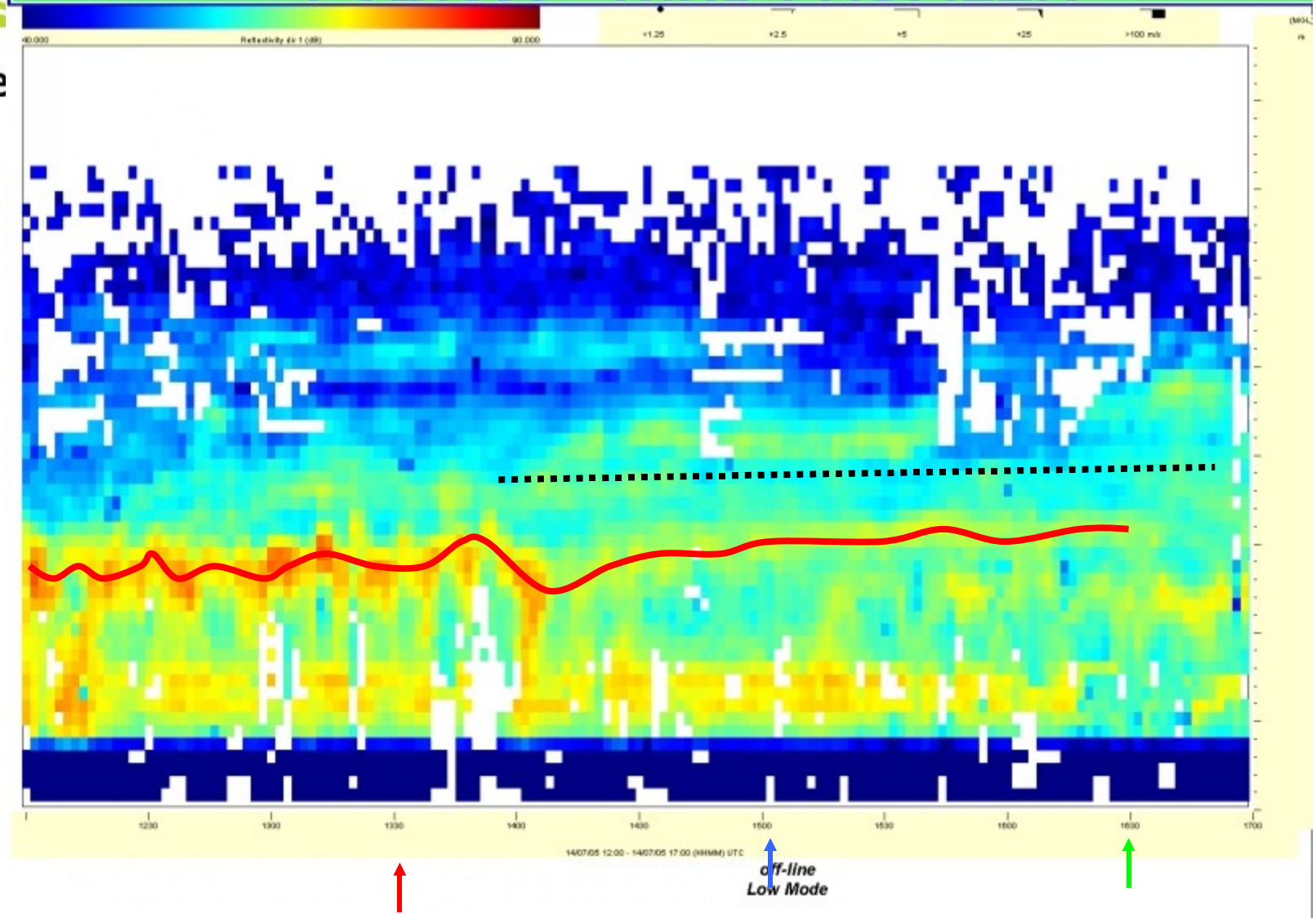

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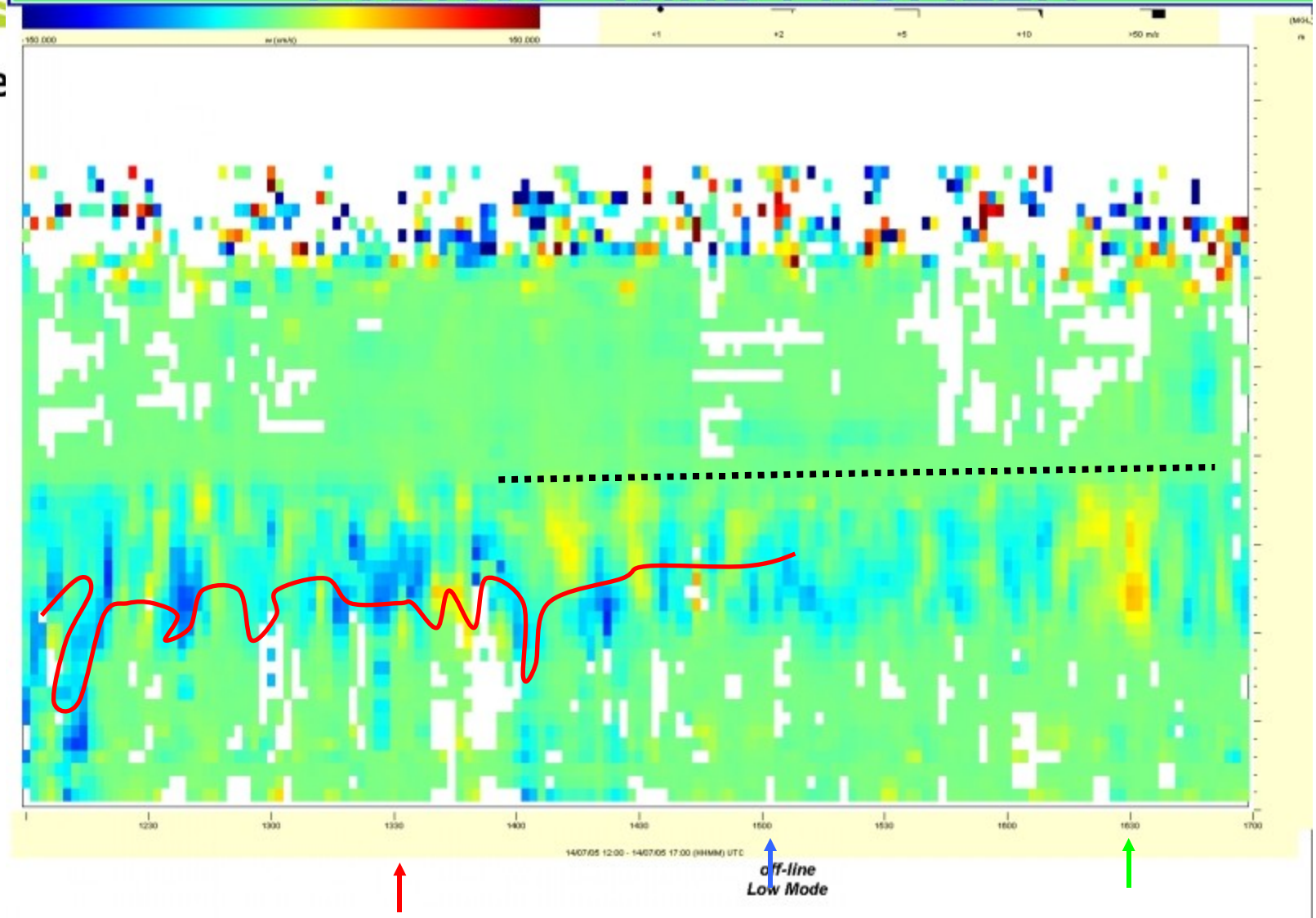
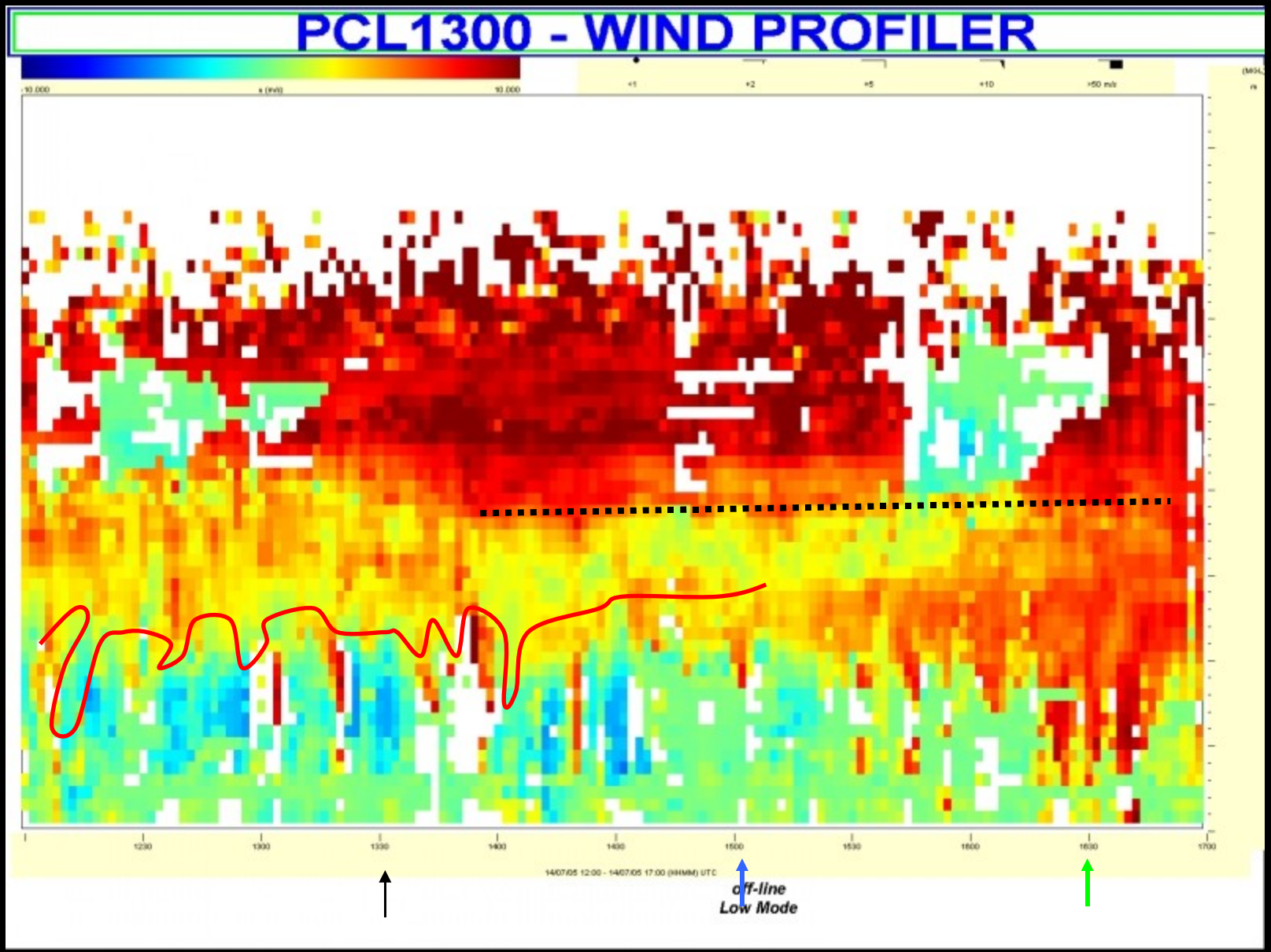
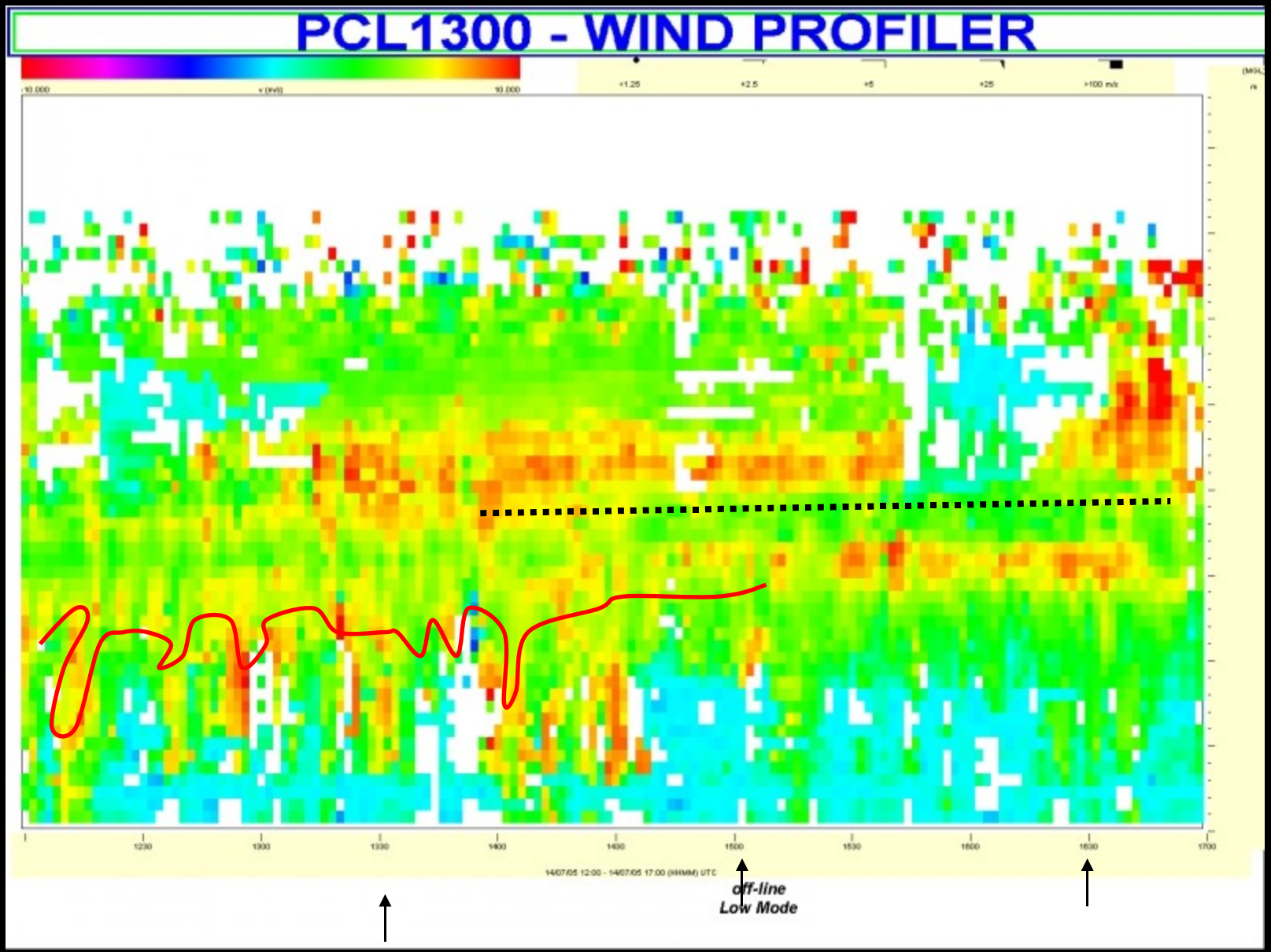
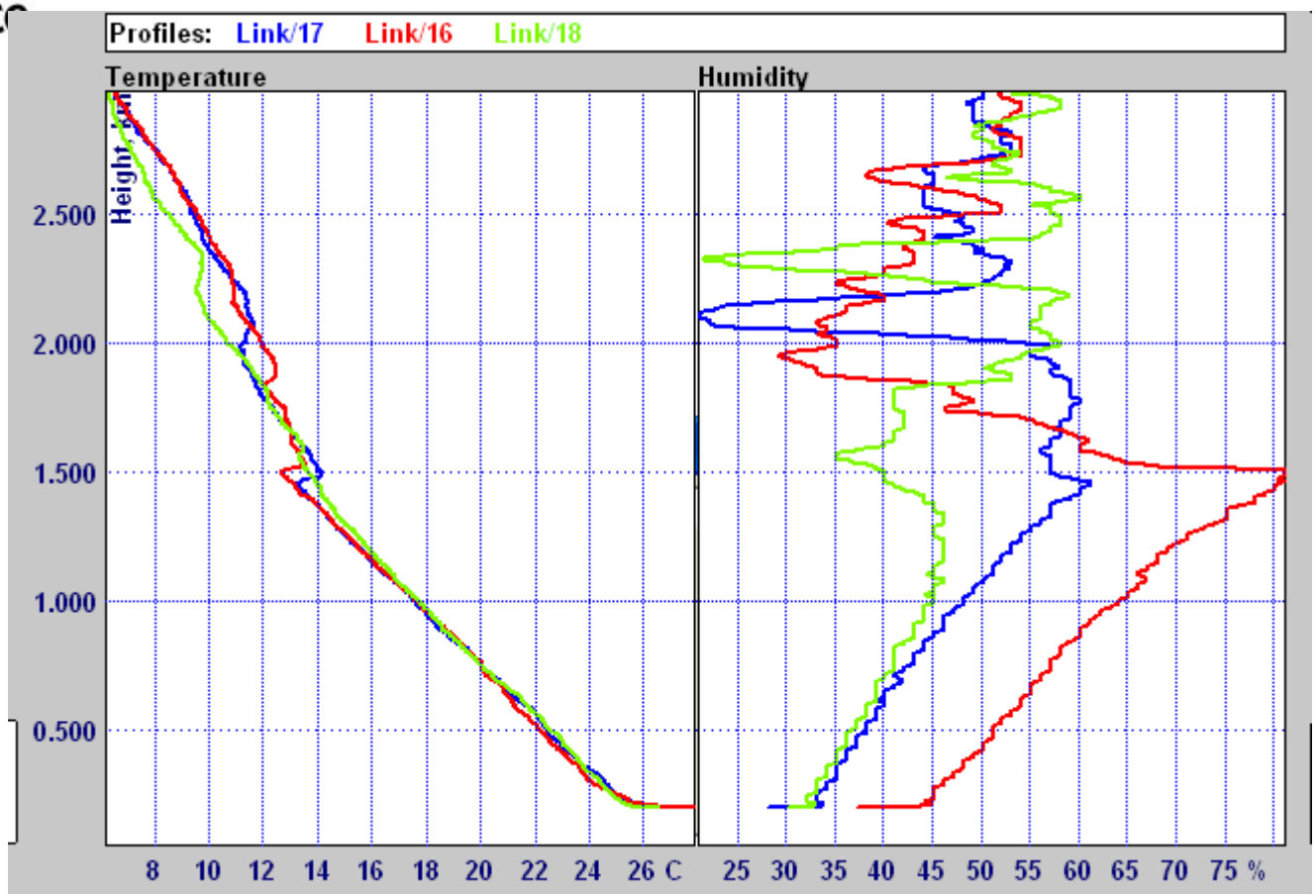


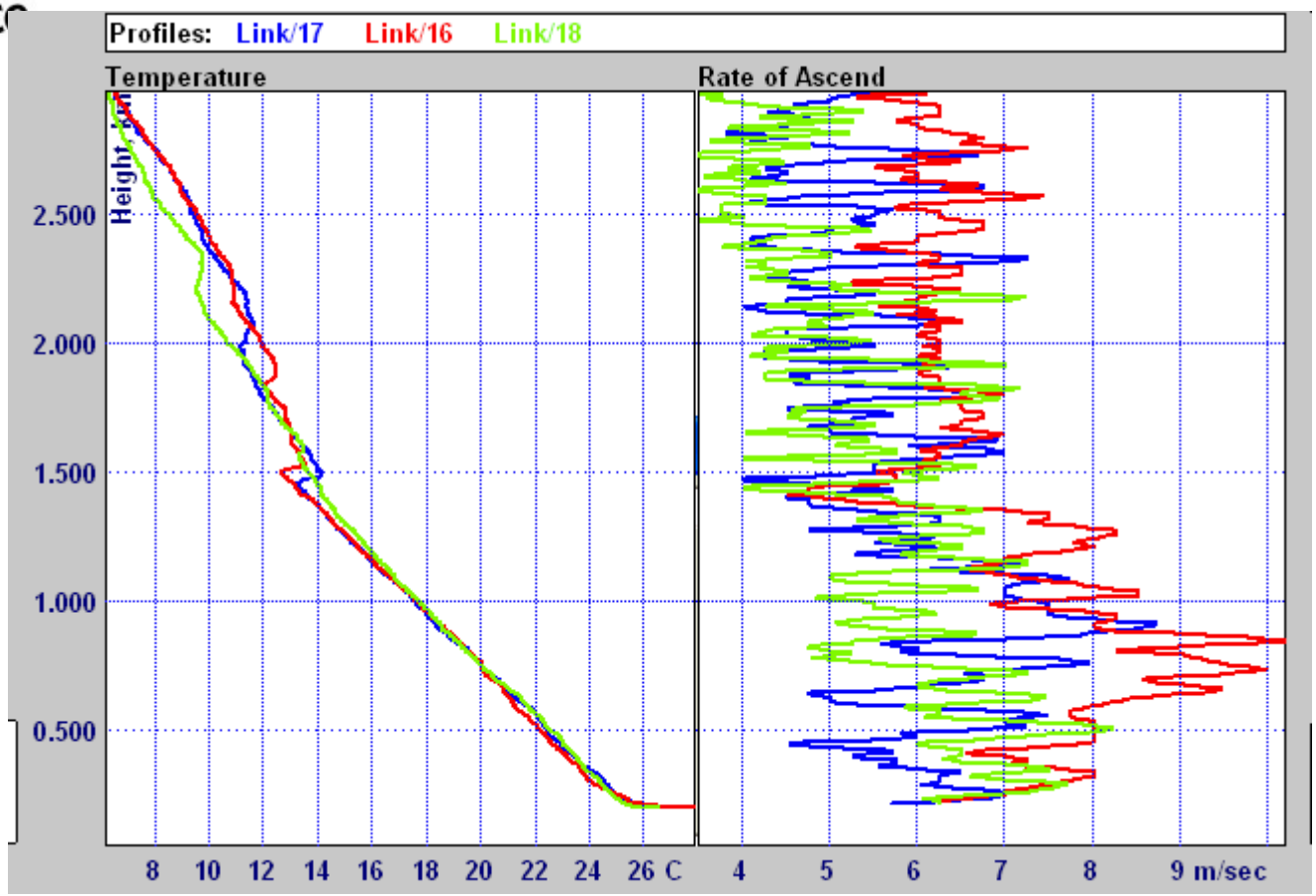

PCL1300 - WIND PROFILER
off-line
Low Mode

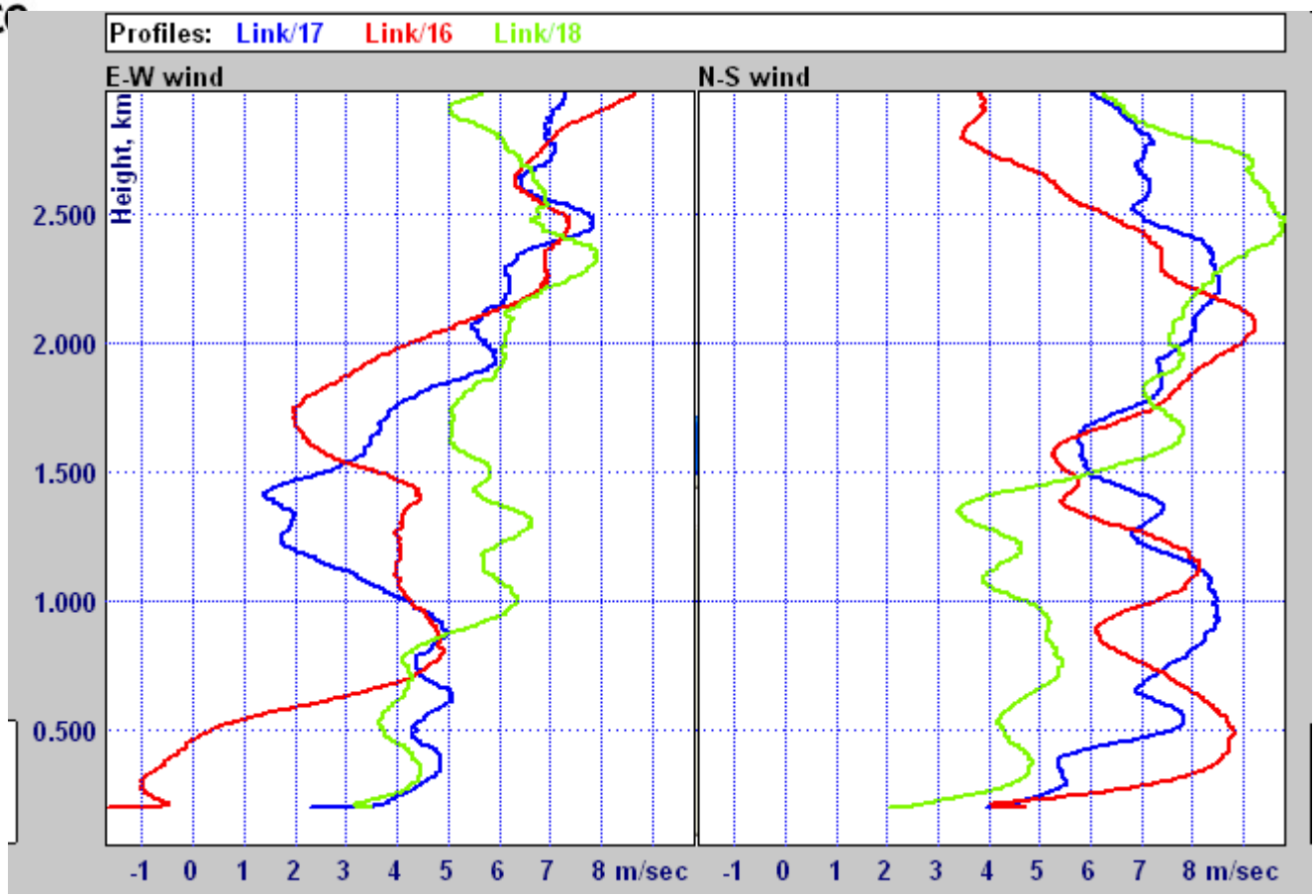
# PCL1300 - WIND PROFILER




V







# Lesson learned

- Think about your profiler set up. This profiler was not optimised for dealing with relatively light winds.
- Test it thoroughly before you start the testbed
- Minimise ground clutter– don’t relay on specialised software to rescue measurements with less than optimum sidelobe suppression.

# Questions and answers