Night-time evolution of a strong surface inversion in the Eastern Ebro basin

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The setup

1) Over a terrace, in a clearing among vineyards

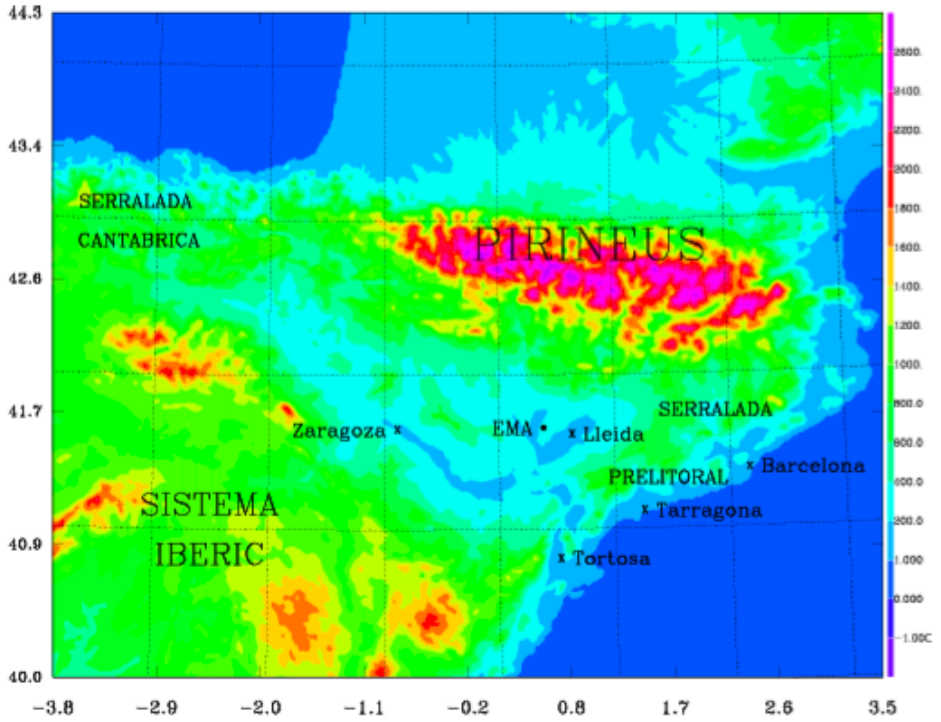
2) The vineyards surrounded by irrigated and dry areas with mountain ranges at distances of several 10's of kilometers

3) The situation corresponds to a clear winter night, under anticyclonic conditions and no well defined synoptic wind.

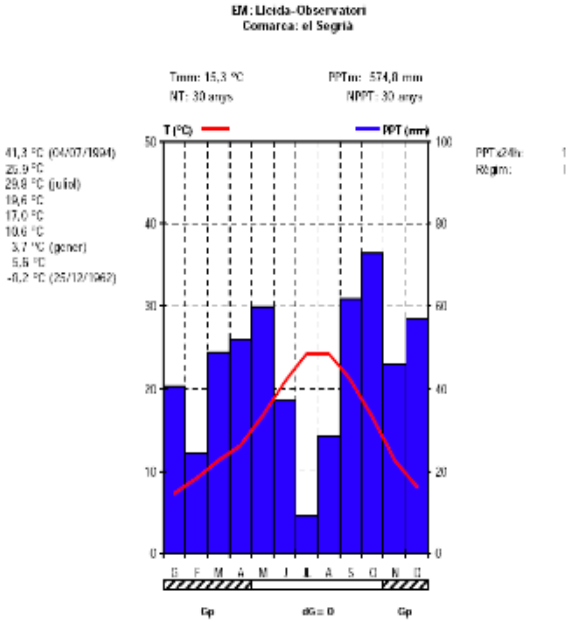
4) The night is studied using:
   * a Wind RASS (RASS-Sodar): profiles from 40 to 360 m every 10 min
   * a captive balloon, operated continuously during the experiment
   * a surface energy budget station, providing the 4 components of radiation, the latent and sensible turbulent heat fluxes and the ground flux
   * a Multicopter remotely controlled samplimg the first 80 m(data still in process)

5) The night 9 to 10 february had sunset at 17h23' UTC (=local solar time) and sunrise at 07h00'. A strong inversion was set from an hour before the sunset to short before sunrise (with first daylight). There was dew in the first part of the night and frost in the second part. Despite moisture around 100% there was no fog, contrarily to the previous night.

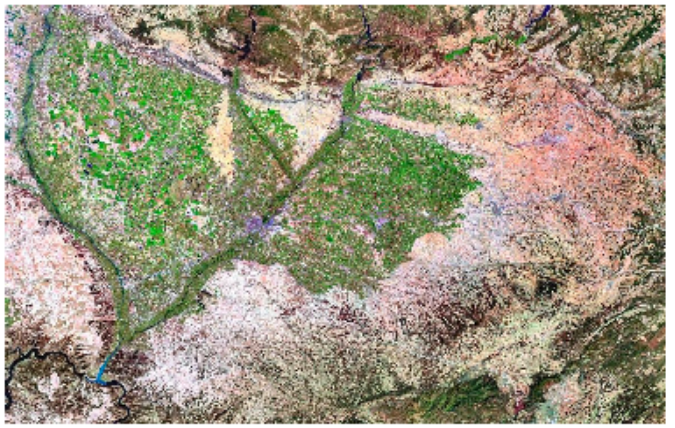
The Ebro basin and the Lleida sub-basin (eastern part)



(c)

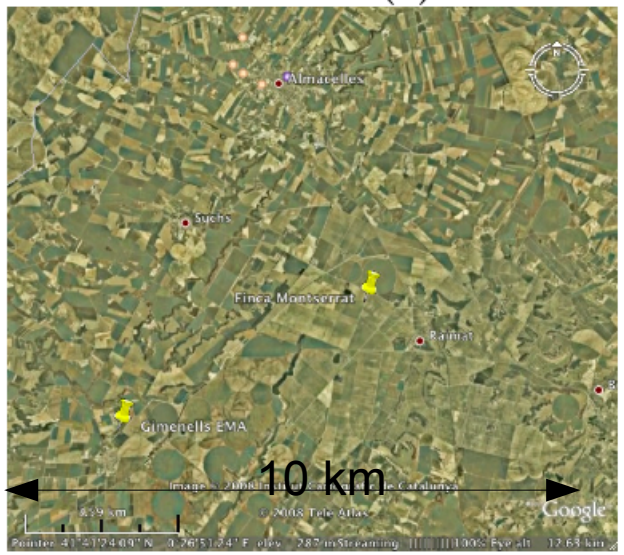


(d)



☒ Finca Vinícola Montserrat (Raïmat, Lleida)

(a)

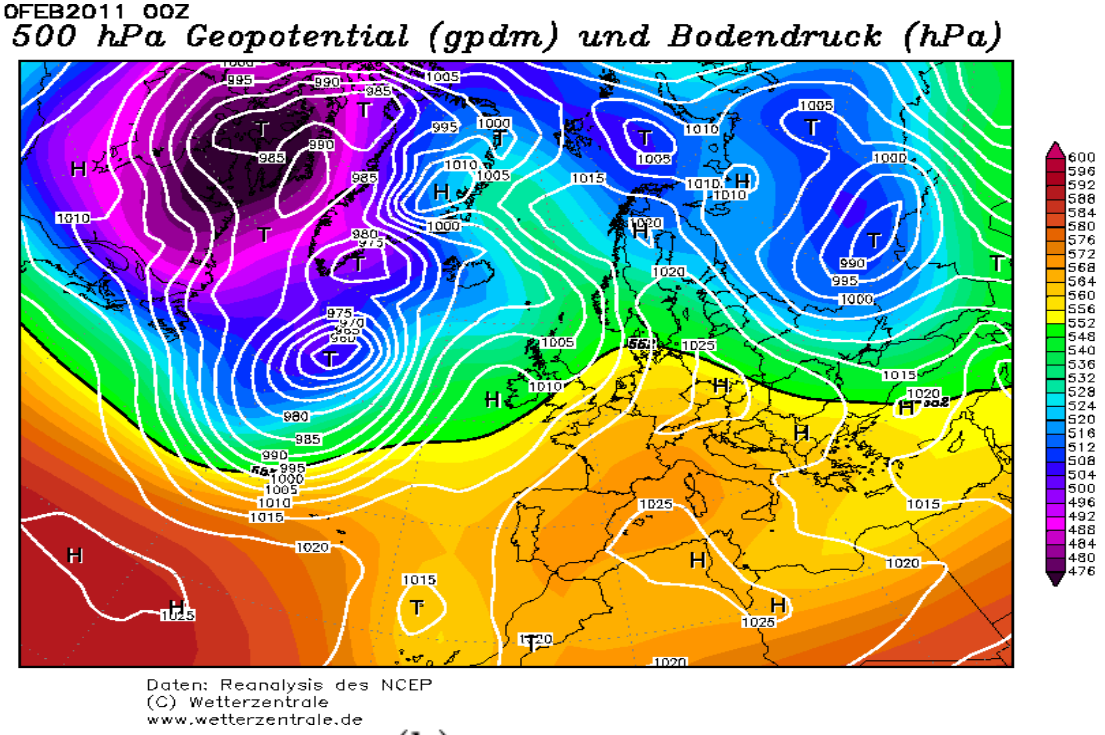


(b)

(c)

(d)

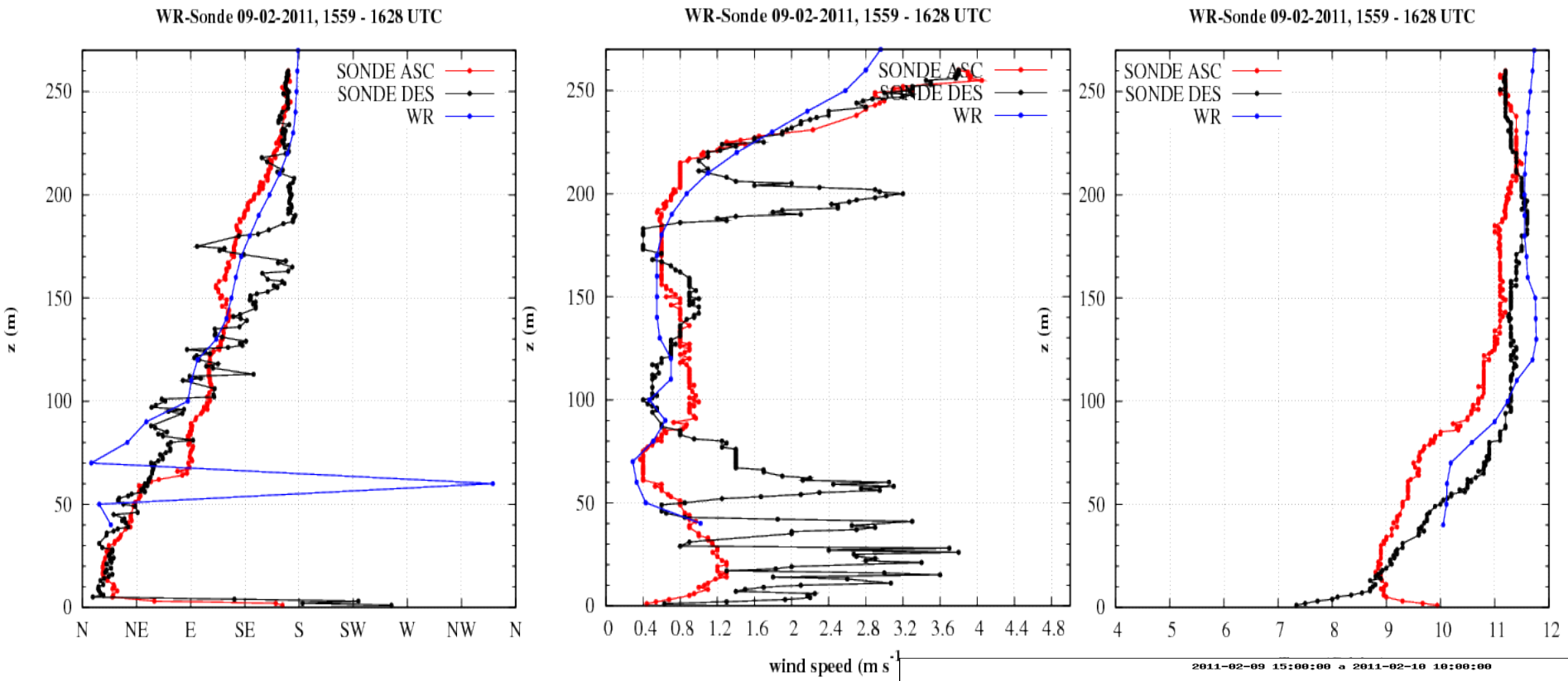
Progressive zoom over the station

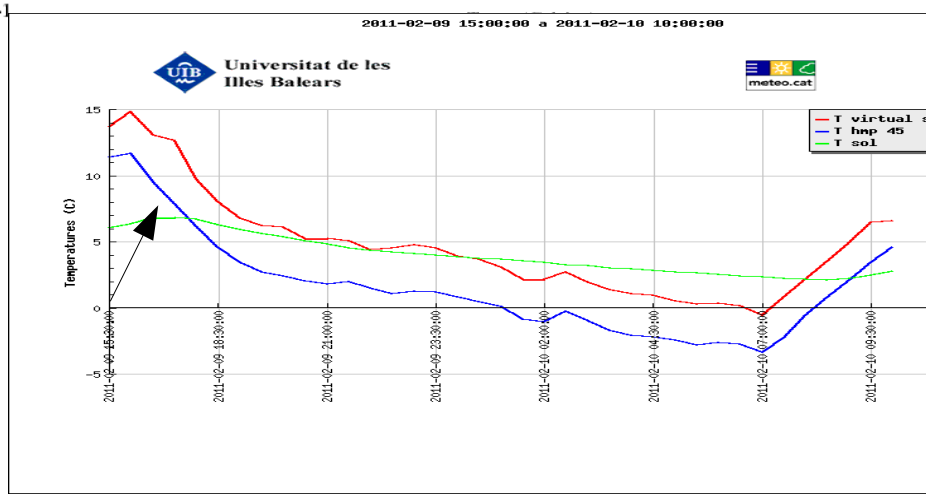


(b)

WindRASS (SMC)

Evening transition:
change to stable stratification 1/2 h before sunset, surface skinflow

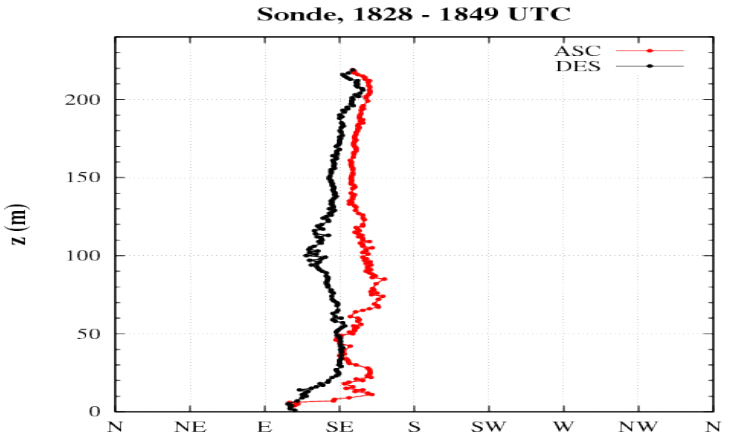


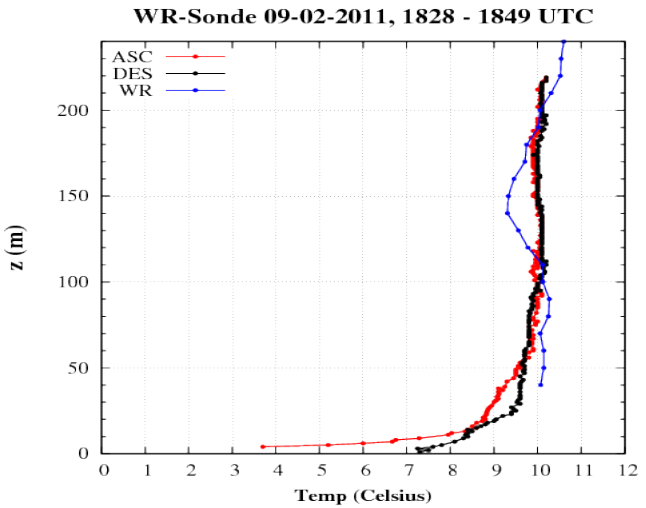


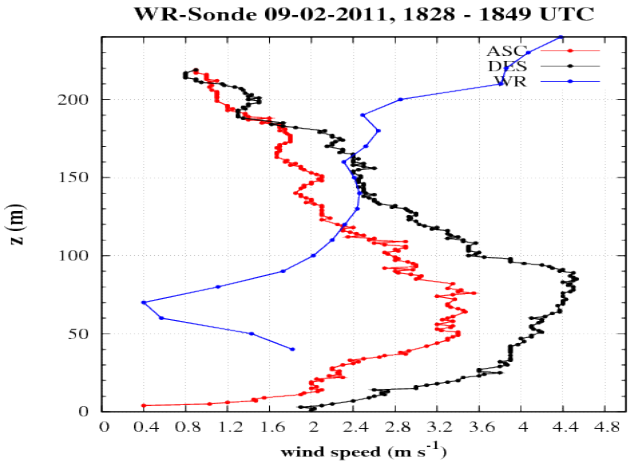
Fall of almost 3 K in 0.5 hours,
Above 50 m: wind smaller than 1 m/s from SE
Below 50 m: establishment of a NNE low-level jet
speed increasing from less than 1 m/s to 3 m/s
Temperature gradient 4K/60m

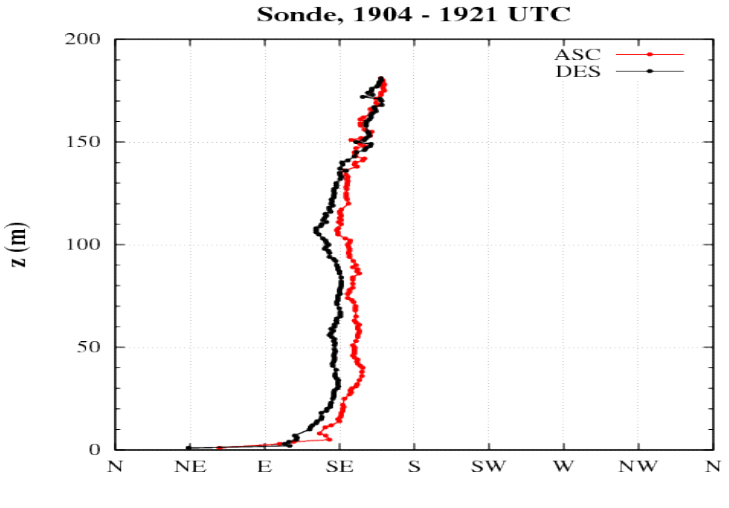
At near the time T2m < T soil,
Net radiation turns negative, even if 1h before sunset

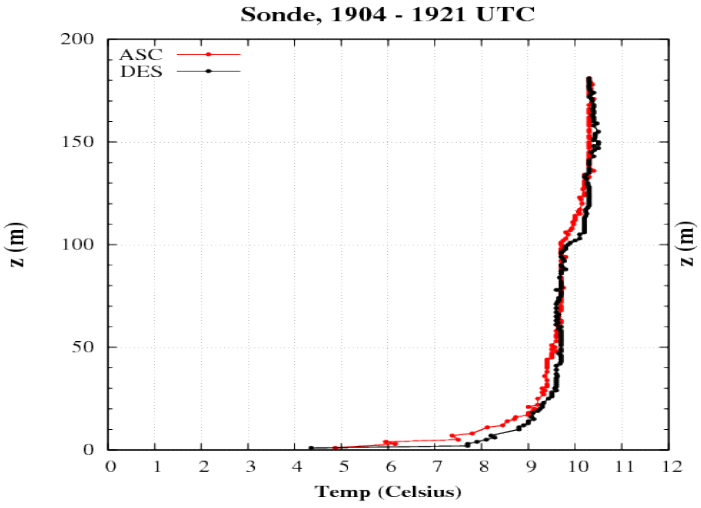
A mixing episode related to enhanced LLJ raises near surface-T 4 K and changes wind direction in the surface layer . After 20 min, the inversion recovers the previous shape with northern skinflow

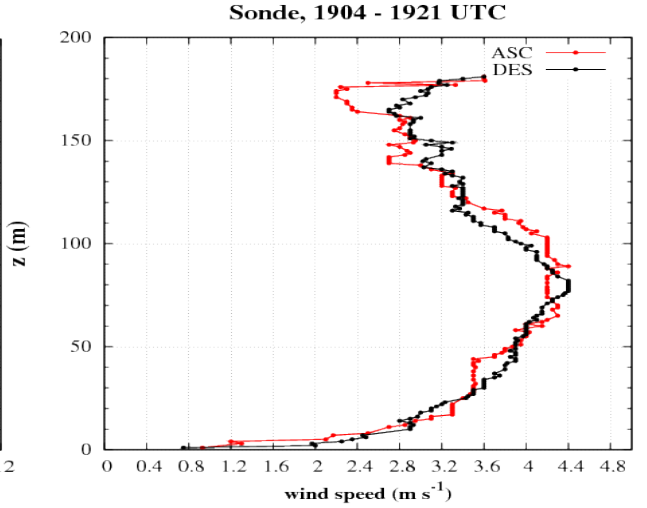




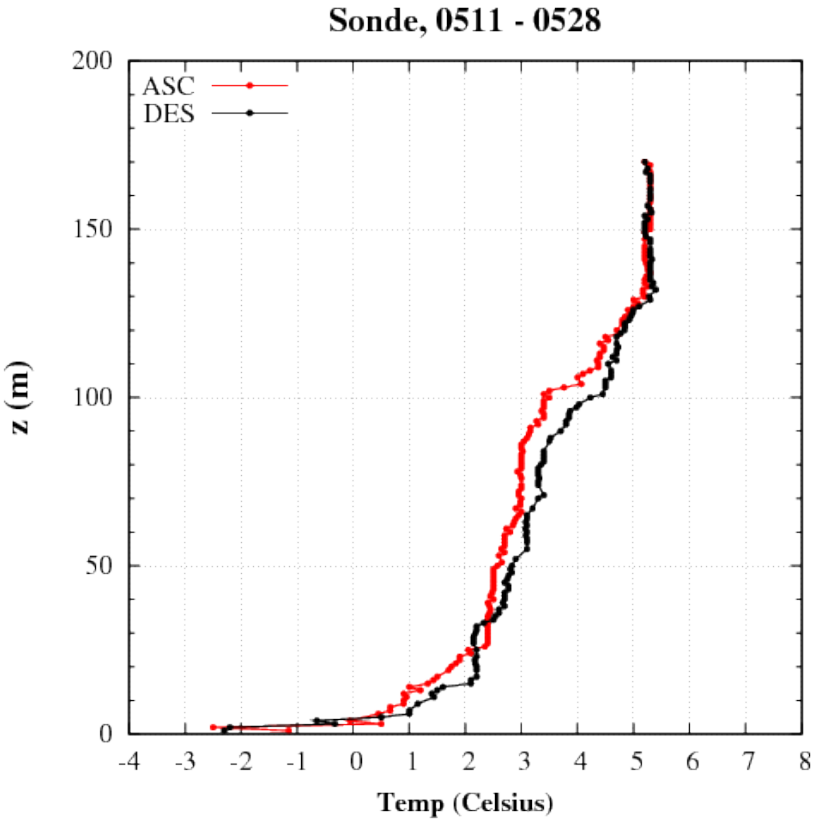


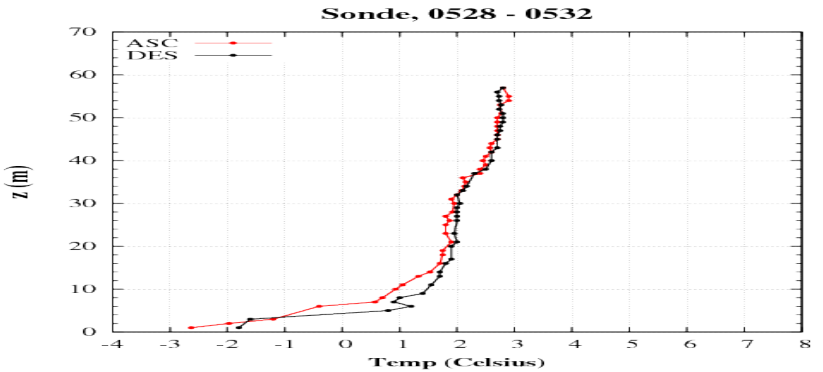


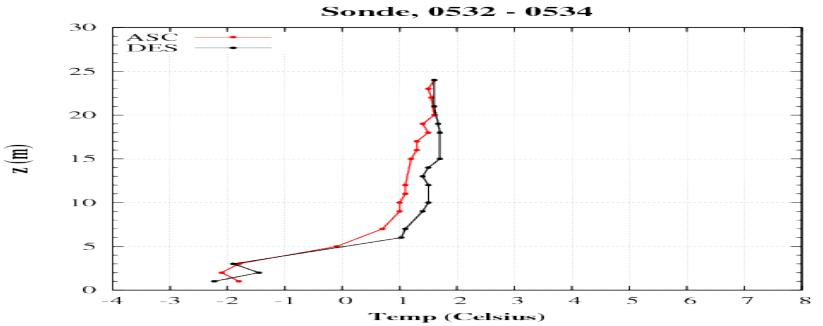


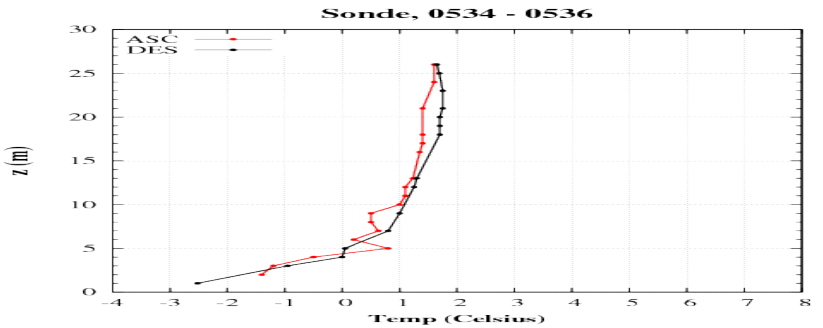


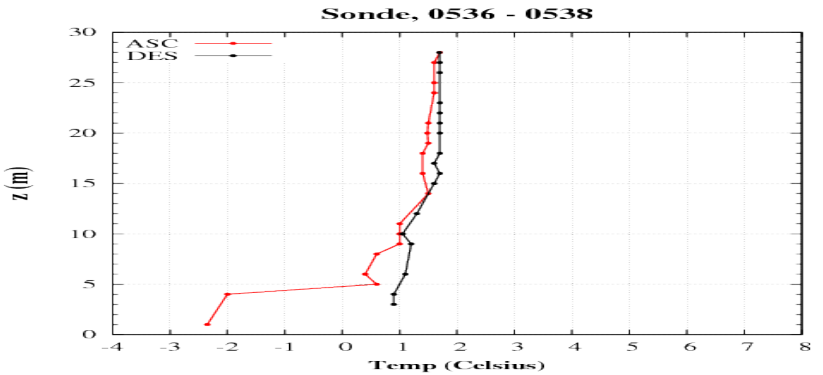
Morning Transition











Fast erosion of the surface inversion with daylight but before sunrise

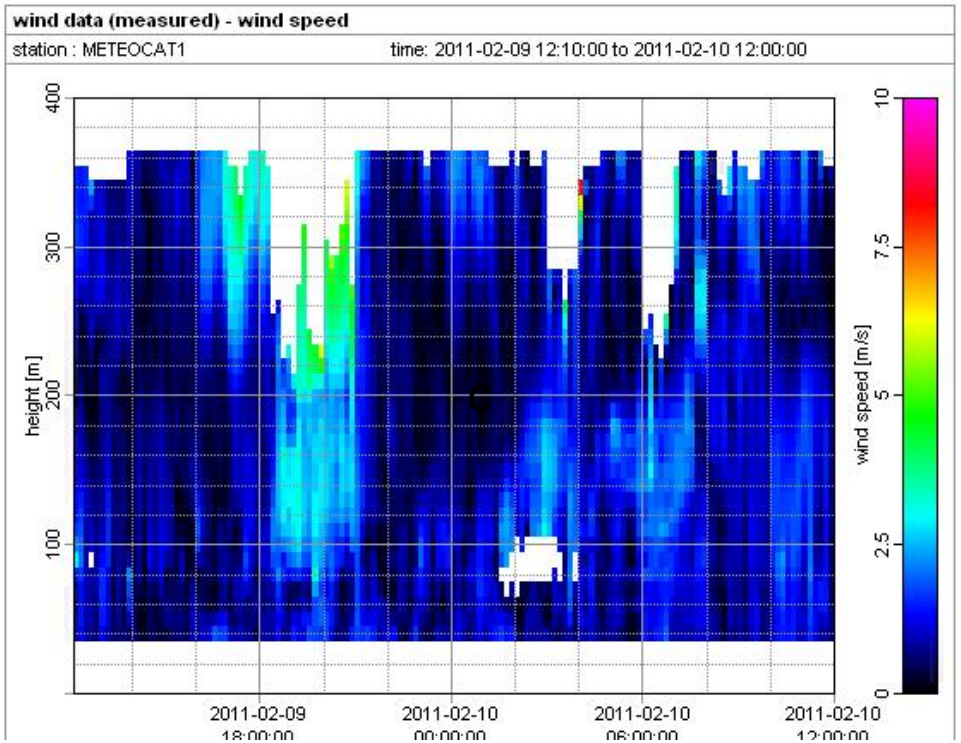
At this time at the surface net radiation loss becomes smaller than soil flux input (turbulent fluxes negligible): sudden change.

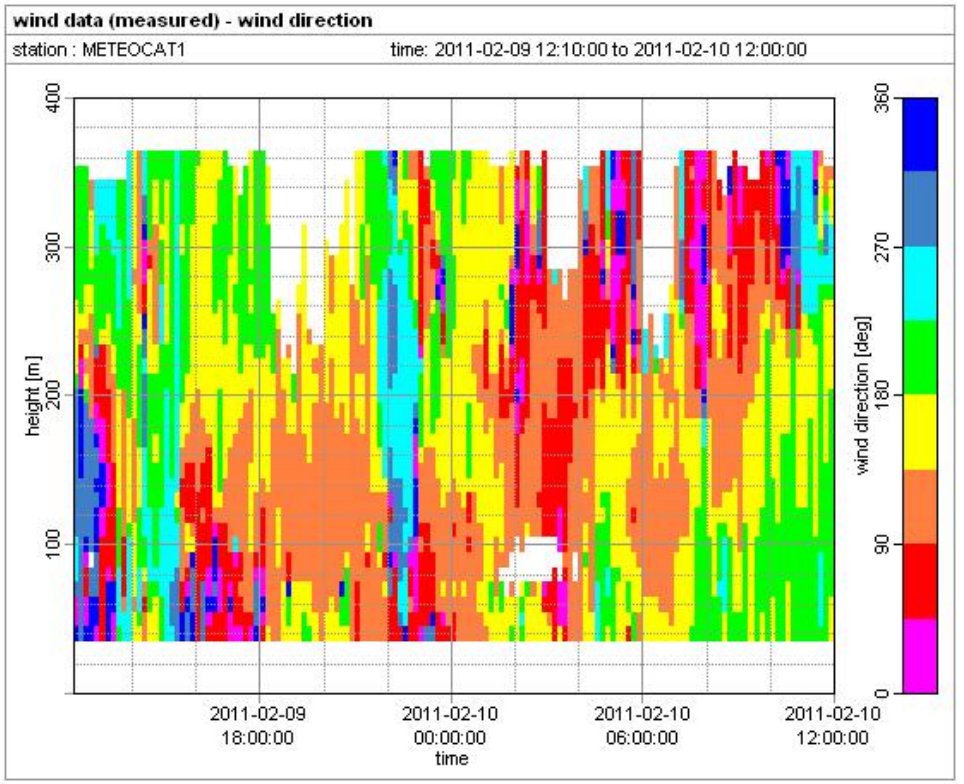
The inversion story:

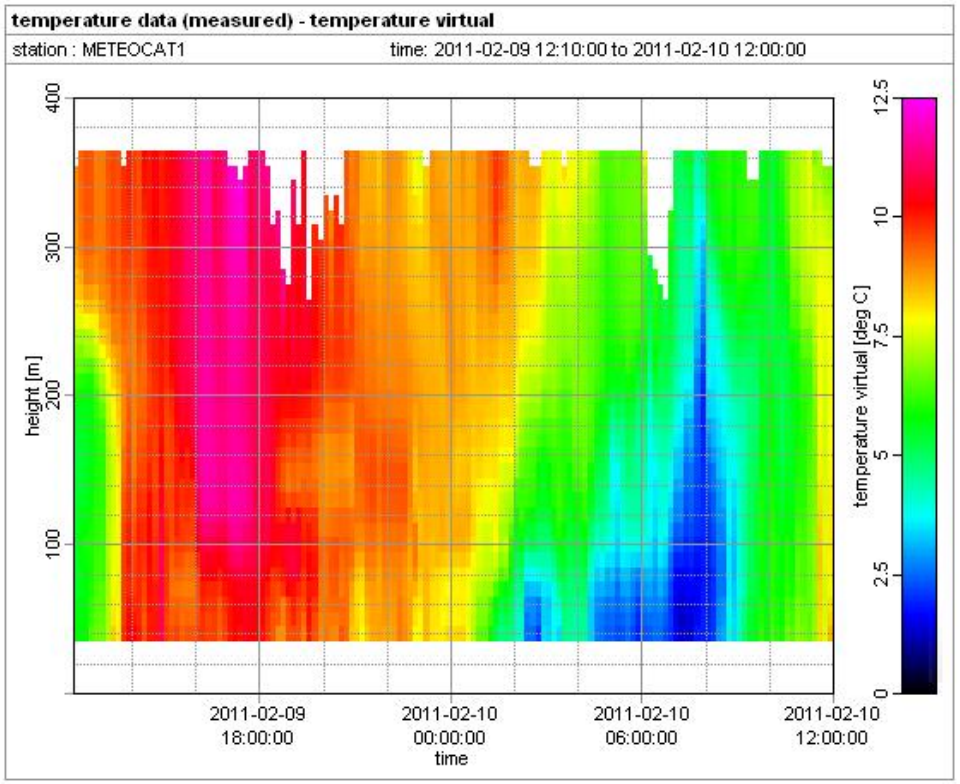
1) the stratification turns to stable before sunset, coinciding with air temperature smaller than soil temperature and with the establishment of negative net radiation and negative surface energy budget (even if the sensible heat flux is still positive)

2) Very soon a gradient of about 7 K in the first 30 m is set and stays in place all night. The whole column cools 10 degrees and the surface inversion can intermittently weaken due to mixing events related to wind shear of the low-level jet below 50 m.

3) The morning transition starts when the net radiation, even if still negative, becomes smaller than the soil heat flux, turning the air above the surface very weakly unstable before the sunrise.





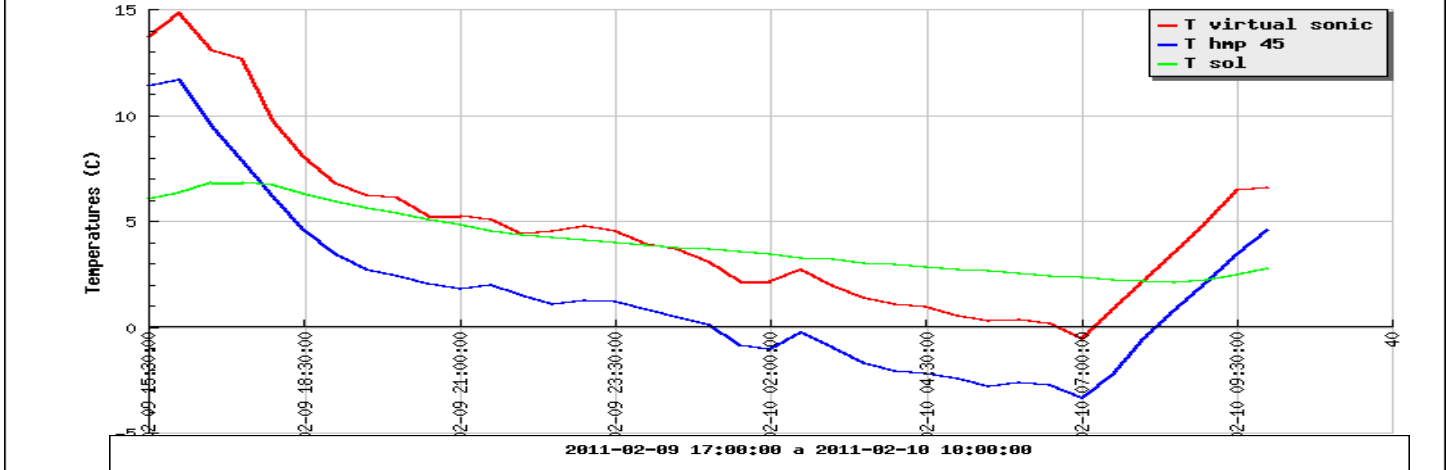


The windrass does not capture the near-the-surface events (inversion and jets below 40m).

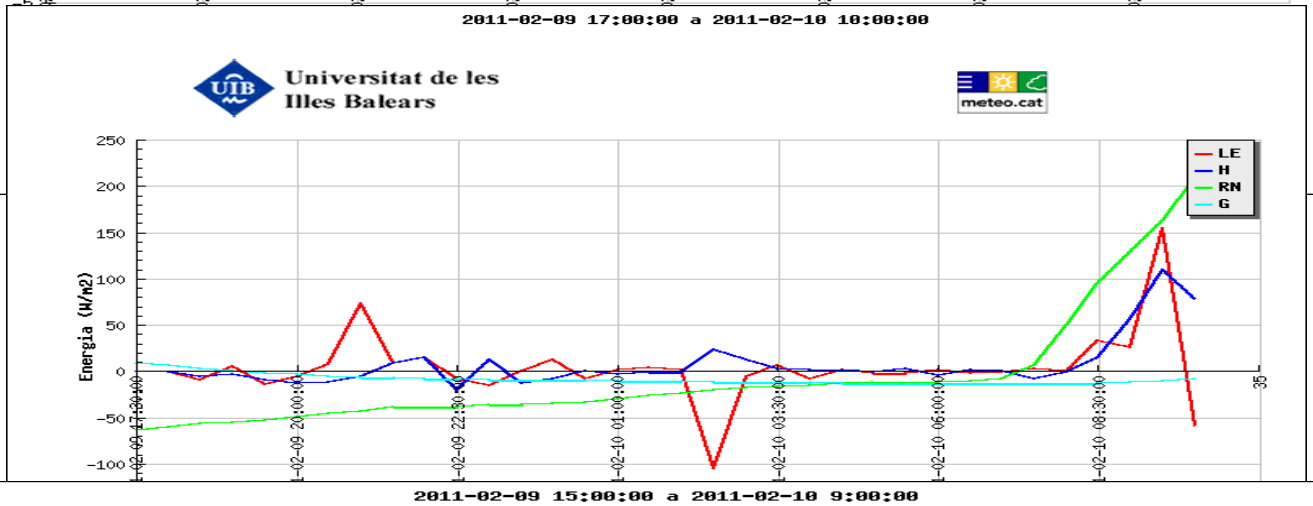
According to this source there are two weak jet events (after sunset above 200m, after midnight above 50m) from SE with speeds between 3-5 m/s

The cooling proceeds progressively with similar strength at all sampled levels

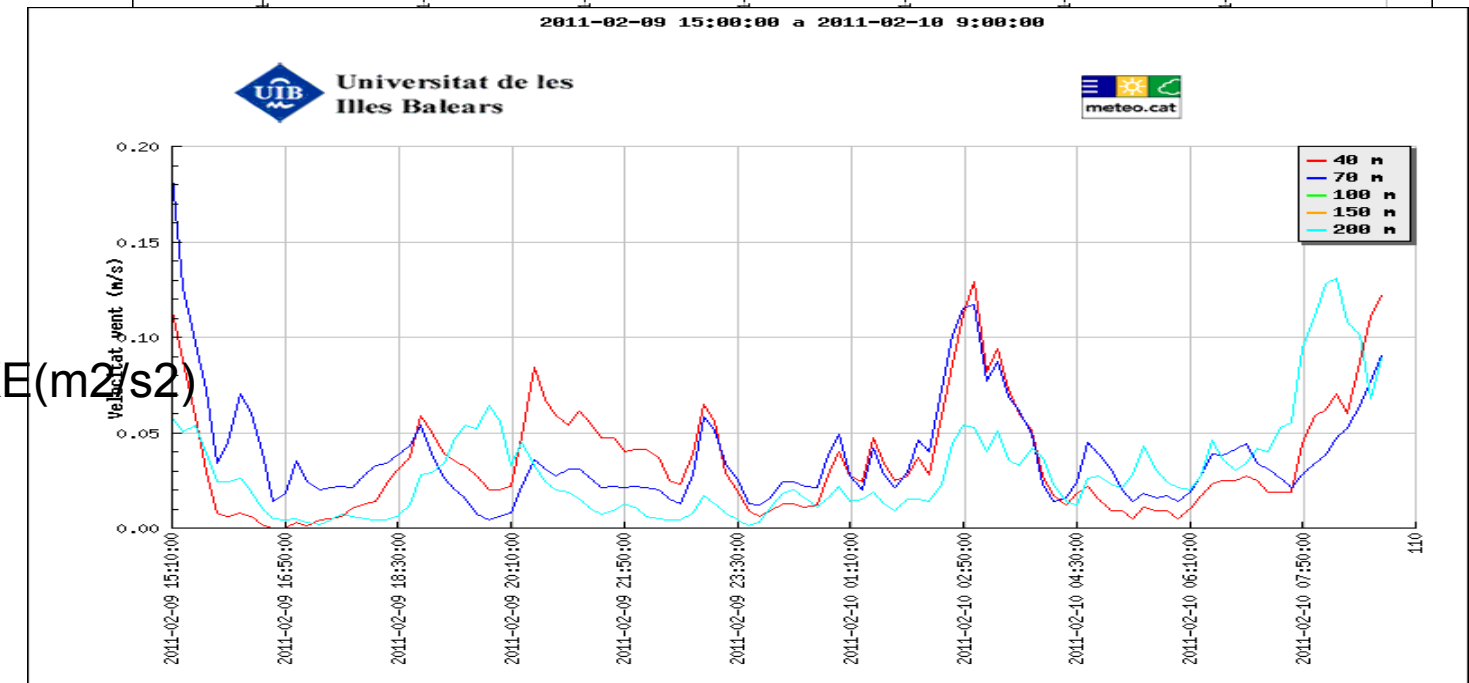
Signal on T series of:
(a) phase changes
(b) turbulence events



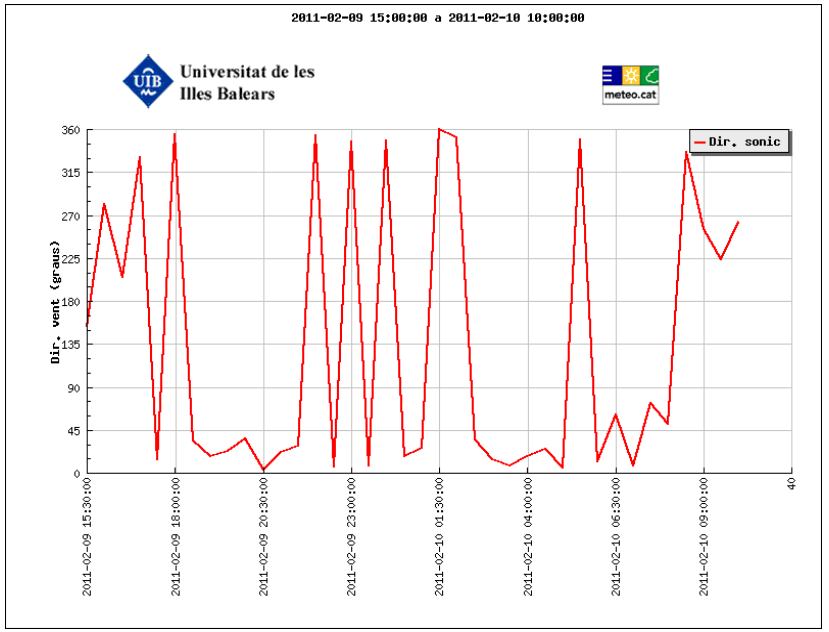
(a)

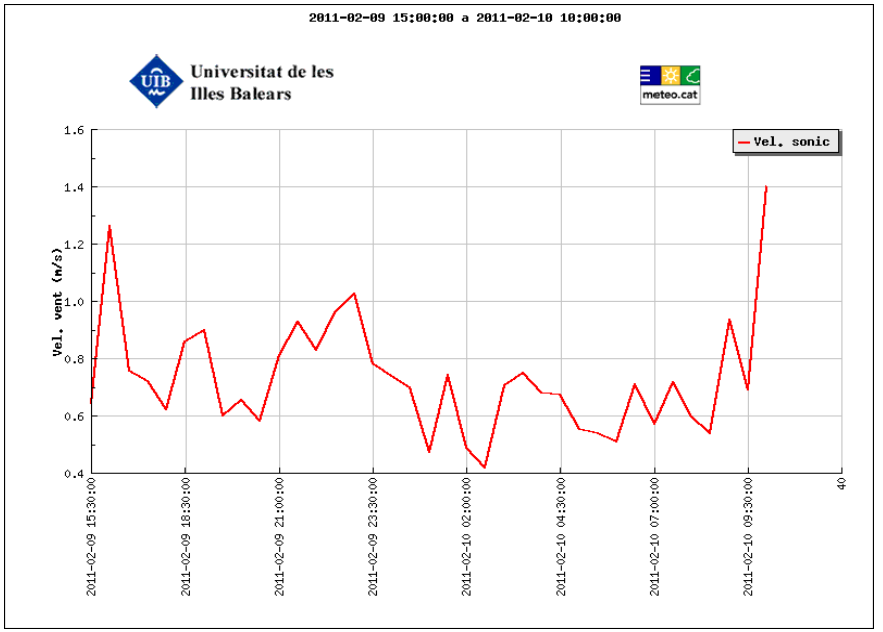


(b) TKE(m2/s2)

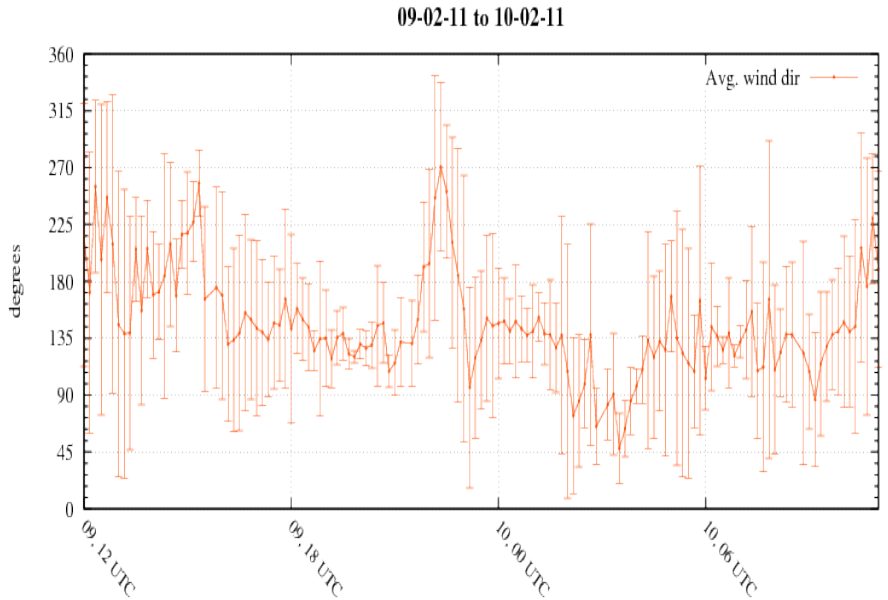


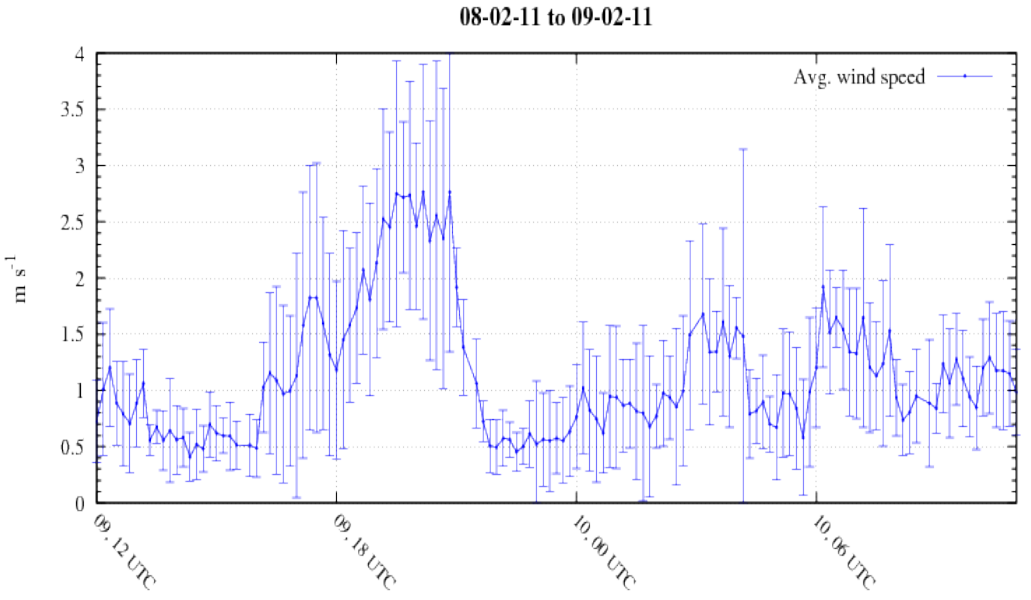
Wind at 2 m: NNW to NNE, speed below 1 m/s





WindRASS column (40-360m) averaged wind: SE, speed 2 m/s after sunset, 1 m/s after midnight





Conclusions

1) Strong inversions may develop in the first tens of meters in the beginning of the night and keep their shape and strength for all night while the whole column cools

2) The evening and morning transition are not driven by the net radiation, the Sunset or sunrise or the sensible heat flux sign, but for the complete energy budget

3) Remote sensing devices like the windRASS with range above 30 m above ground Level are not suited for the study of these events, but they complement well the Information of the events taking place above

4) The wind inside the inversion is fully decoupled from the air above with sustained angles of more than 90º. The surface layer wind has the direction of the local slope, the air above the one of the within-basin mesoscale gradient.

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