- **On surface energy budget closure**

+

- **A snapshot on LBF09**

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Closure of the surface energy budget

Radiation + Soil Flux = Turbulence exchange (heat and moisture)

$R_{n0} + G_0 = H_0 + \lambda E_0$

It should close, it does not!

From Foken (2008): imbalances above 30% over bare soil, short grass, agricultural land, down to 10% over more homogeneous surfaces like irrigated cotton fields or wheat fields.

For a particular experiment over grass, Foken attributes the errors mainly to measuring processes

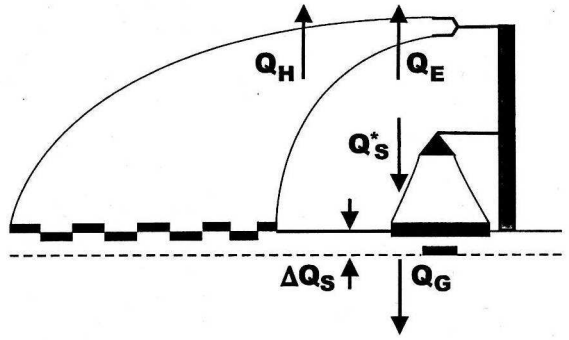


Fig. 3.34. Schematic view of the measuring area of the different terms of the energy balance equation

Latent: 5 to 20%
Sensible: 10 to 20%
Net radiation: 10 to 20%
Ground: up to 50%
Storage and others: unknown

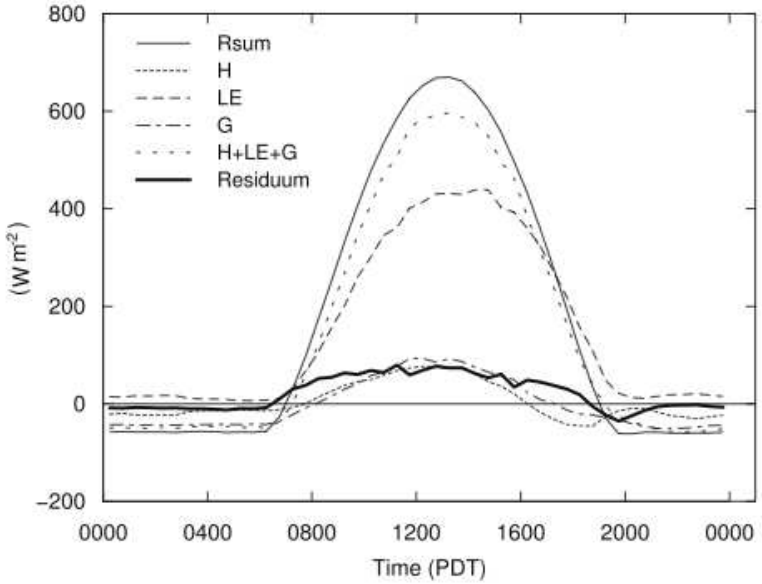


Fig. 6 The diurnal composite of the surface energy balance for EBEX from all sites over the entire measurement period. Shown are the "Major Terms" described in Sect. 5

Oncley et al (2007)

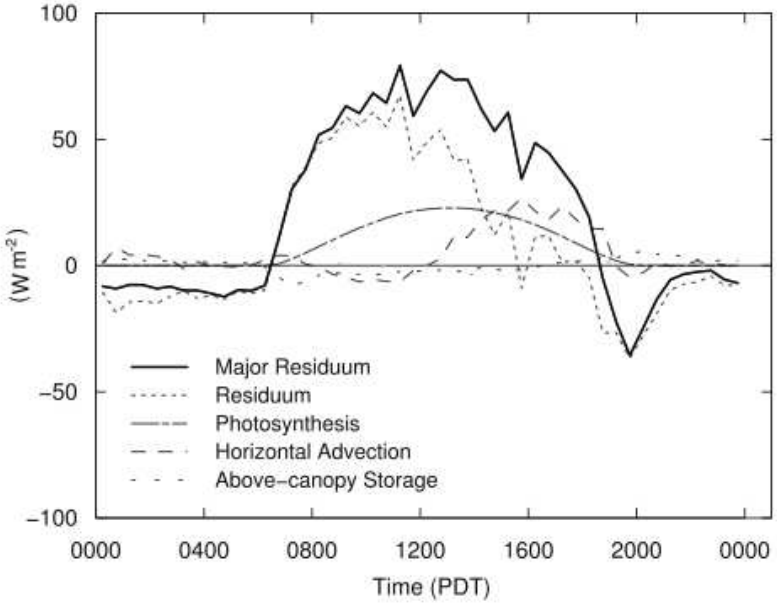


Fig. 9 The diurnal composite of the minor surface energy balance terms, along with the residuum found from the major terms for EBEX from all sites over the entire measurement period

Extremely weak turbulence: submeso motions

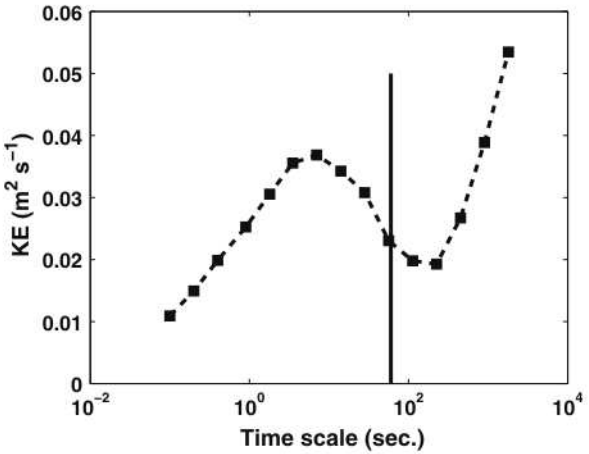
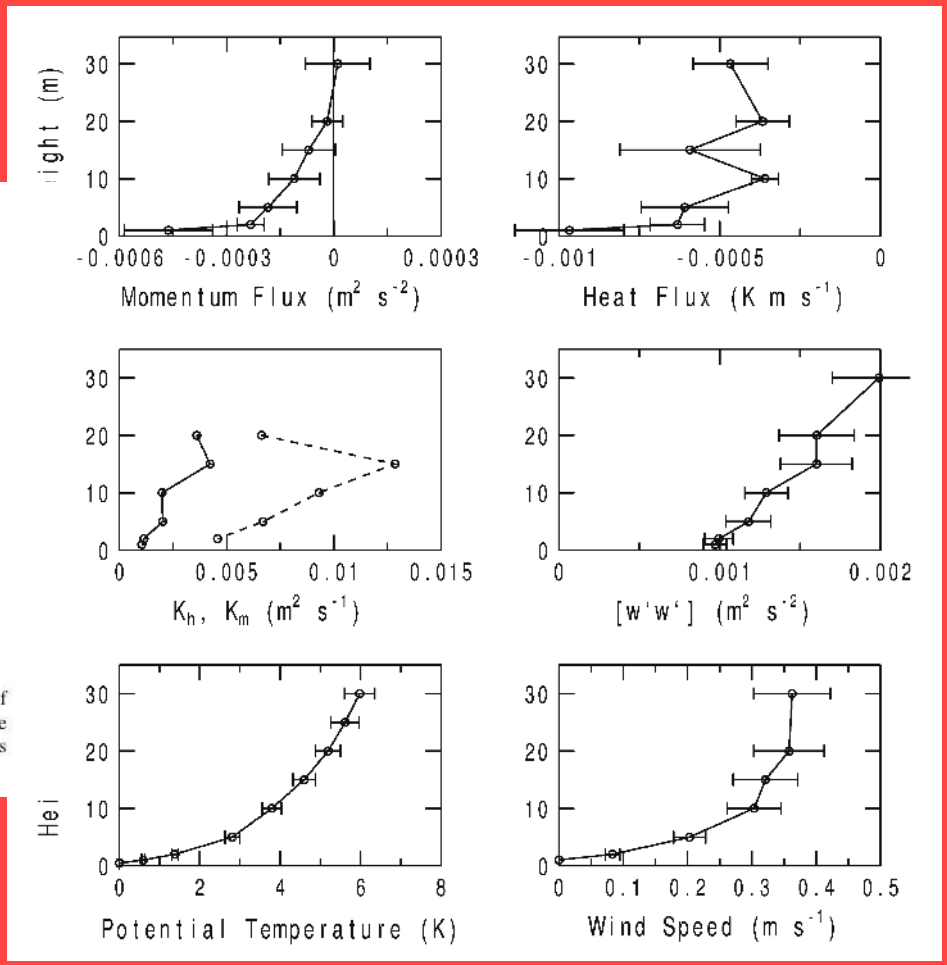


Fig. 1 The scale dependence of the horizontal kinetic energy for the entire turbulence and submeso range of time scales composited over all of the nocturnal records for the Iowa network. The vertical line designates the 1-min time scale used to pragmatically separate turbulence and submeso motions for all of the networks. This study concentrates on submeso scales to the right of the vertical line

Mahrt (2008)



Mahrt and Vickers (2006)

Radiation (no wind)

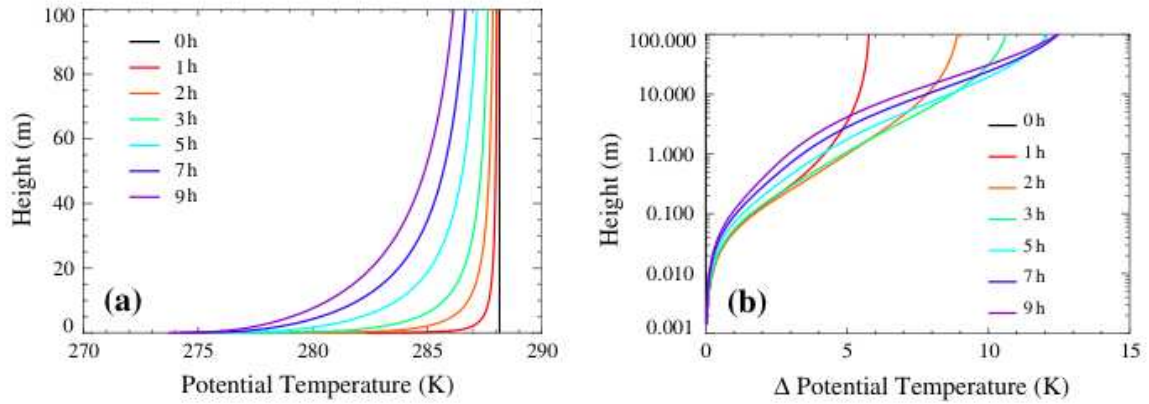


Fig. 1 Profiles of potential temperature at hourly and subsequently two-hourly intervals. **a** With a linear height scale. **b** With a logarithmic height scale, showing the difference from the surface temperature

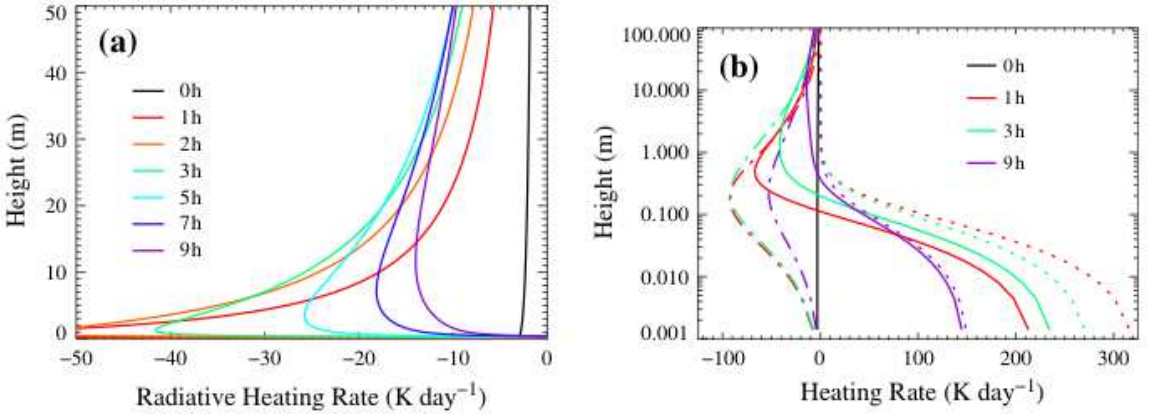


Fig. 2 Profiles of the radiative heating rates at hourly and subsequently two-hourly intervals. **a** Actual radiative heating rates on a linear height scale. **b** On a logarithmic height scale, showing actual radiative heating rates (solid), *minus* the conductive heating rates (dotted) and the portion of the radiative cooling rate due to direct cooling to the surface (dot-dashed)

Edwards (2009)

Radiation (weak and moderate wind)

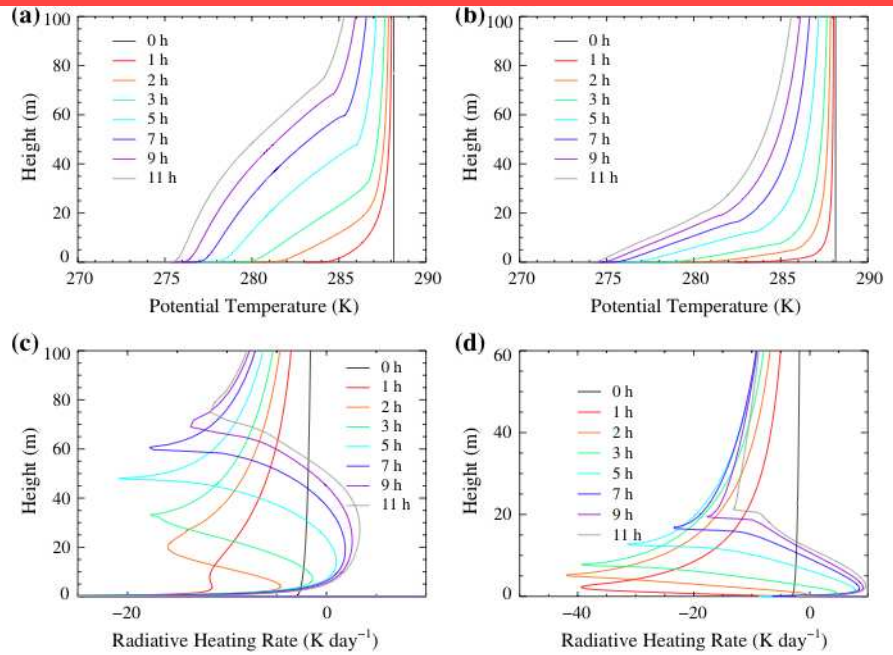
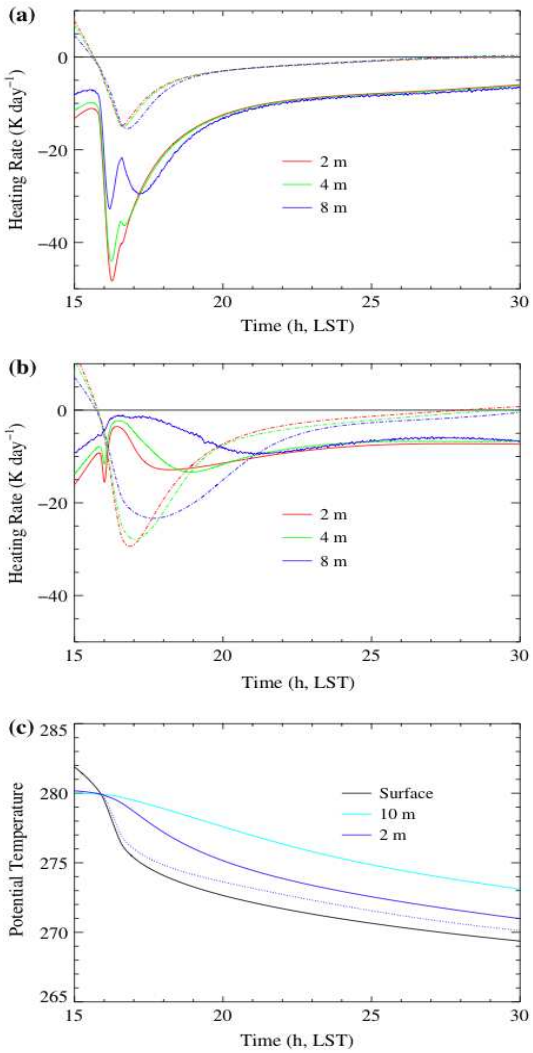


Fig. 4 Vertical profiles of potential temperature and radiative heating rates at hourly and subsequently two-hourly intervals. **a** Potential temperatures for a geostrophic wind of 7 m s^{-1}. **b** Potential temperatures for a geostrophic wind of 3 m s^{-1}. **c** Radiative heating rates for a geostrophic wind of 7 m s^{-1}. **d** Radiative heating rates for a geostrophic wind of 3 m s^{-1}

Fig. 10 **a** The radiative (*broken lines*) and turbulent (*solid lines*) heating rates at 2, 4 and 8 m for a geostrophic winds of 3 m s^{-1}. **b** As (**a**), but for a geostrophic wind of 1 m s^{-1}. **c** The surface temperature and the potential temperatures at 2 and 10 m for a geostrophic wind of 1 m s^{-1} (*solid lines*), together with the potential temperature at 2 m as inferred from conditions at the surface and at 10 m using surface similarity theory



Edwards (2009)

Dew

Saturation can occur near the surface

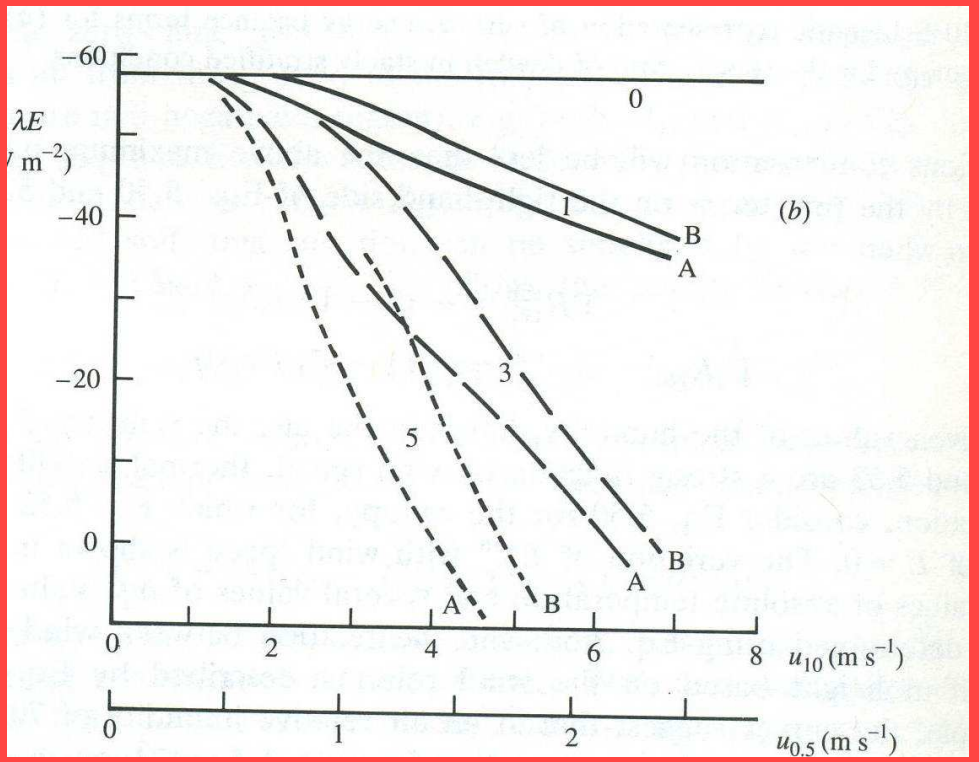
Condensation implies release of heat to environment

Up to 1 l/m^2 in one night

SEB modified

In a small closed valley in the Alps, Whiteman et al (2006) estimated that the dew reduces to 1/3 to 1/2 half the nocturnal cooling

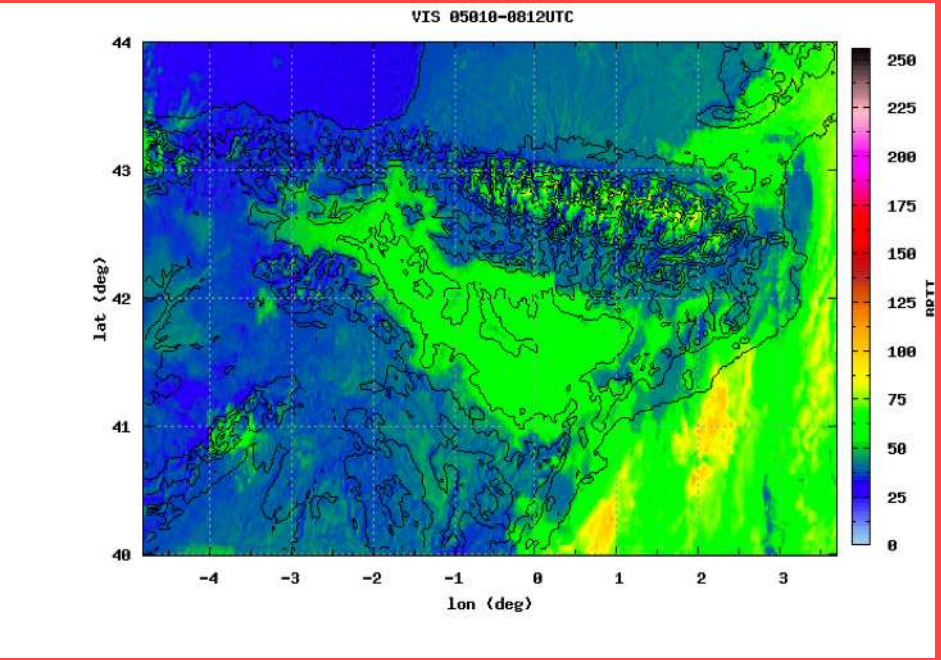
Garratt (1992)

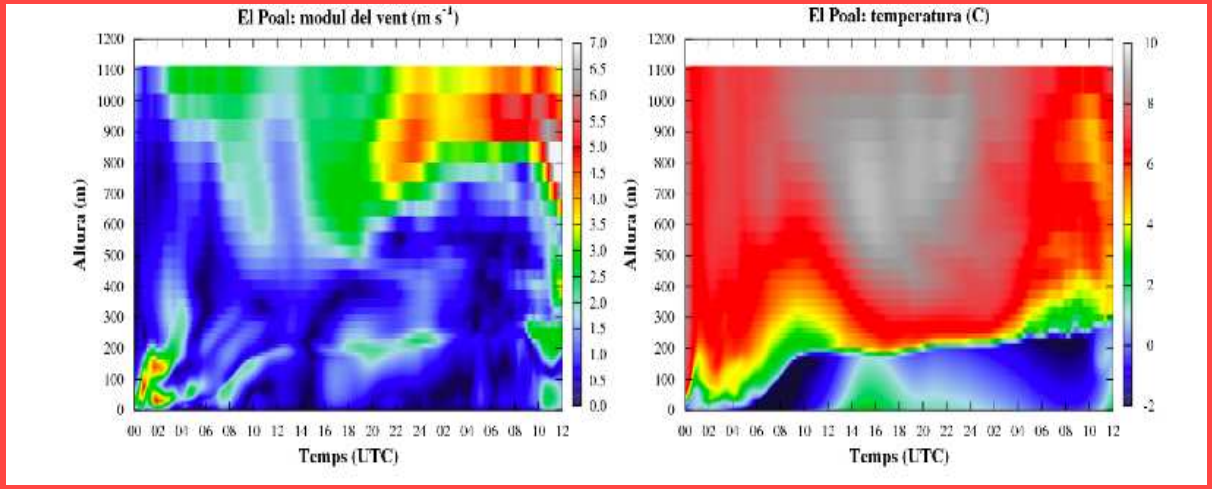


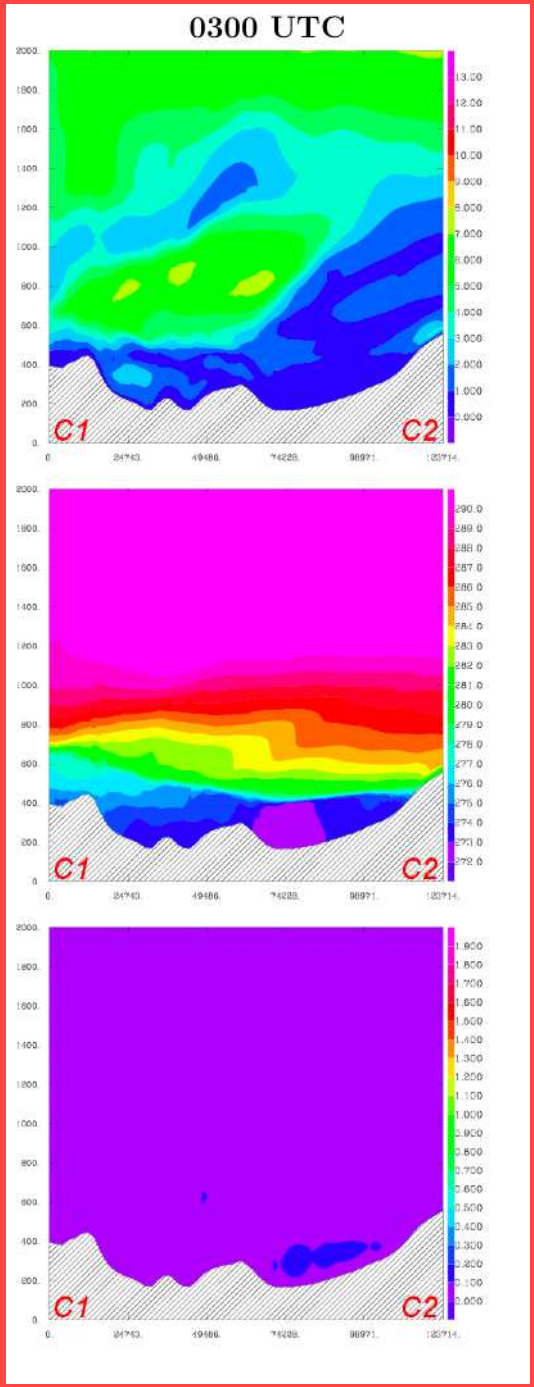
T=293K, A:ΔT=0.6K, B: ΔT=2.5K

100%, 79%, 66%

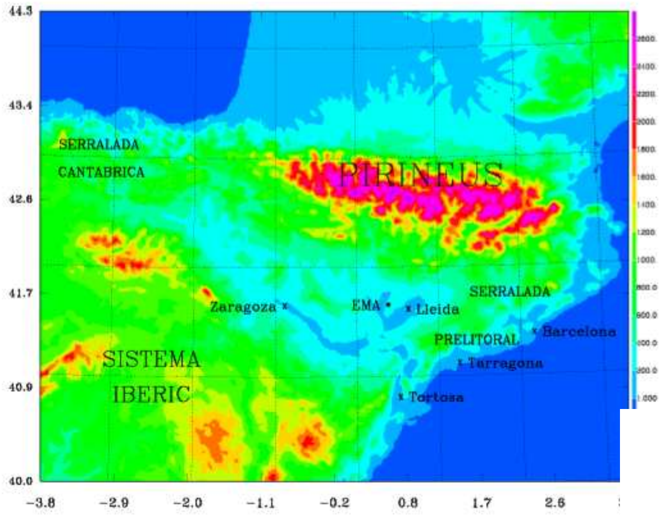
Fog







(Cuxart et al 10)

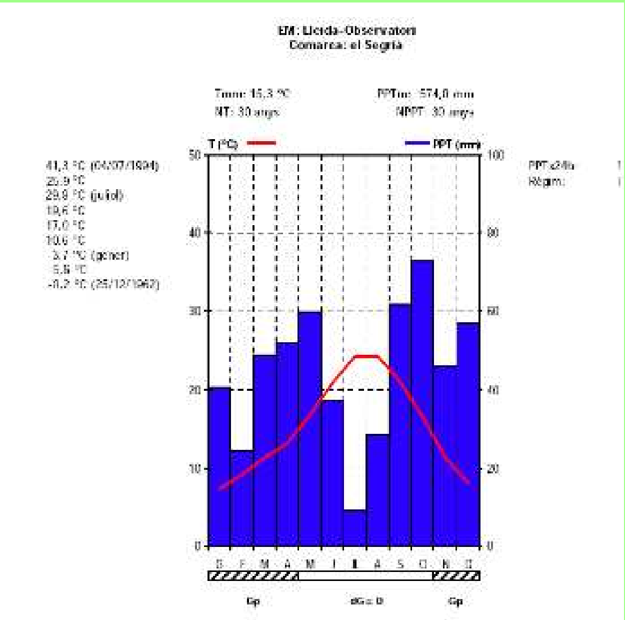


SERRALADA CANTABRICA
PIRINEUS
Zaragoza
EMA
Lleida
SERRALADA PRELITORAL
Barcelona
Tarragona
SISTEMA IBERIC
Tortosa

(c)

REGADÍOS
JUNTAS DE EXPLOTACION

(d)



EM: Lleida-Observatori
Comarca: el Segrià
T (°C)
Gp
Gp

(a)

Almacelles
Finca Montserrat
Raimat
Gimenells EMA
Google

(b)

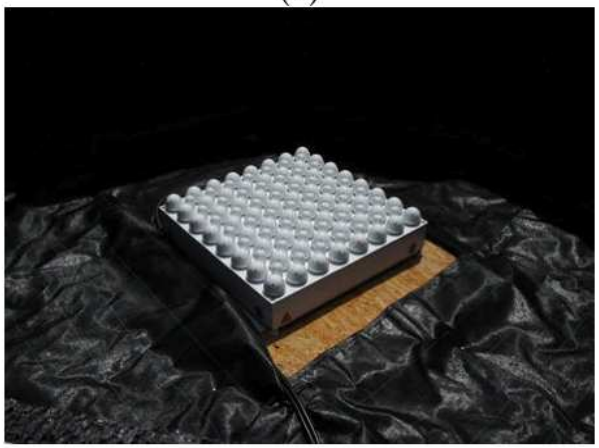
Raimat-EM
Google

(c)

Raimat-EM
Google

(d)

(a)



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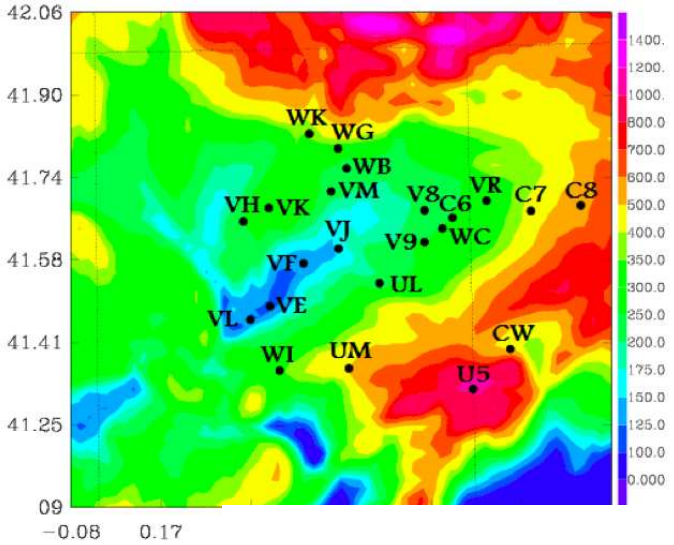
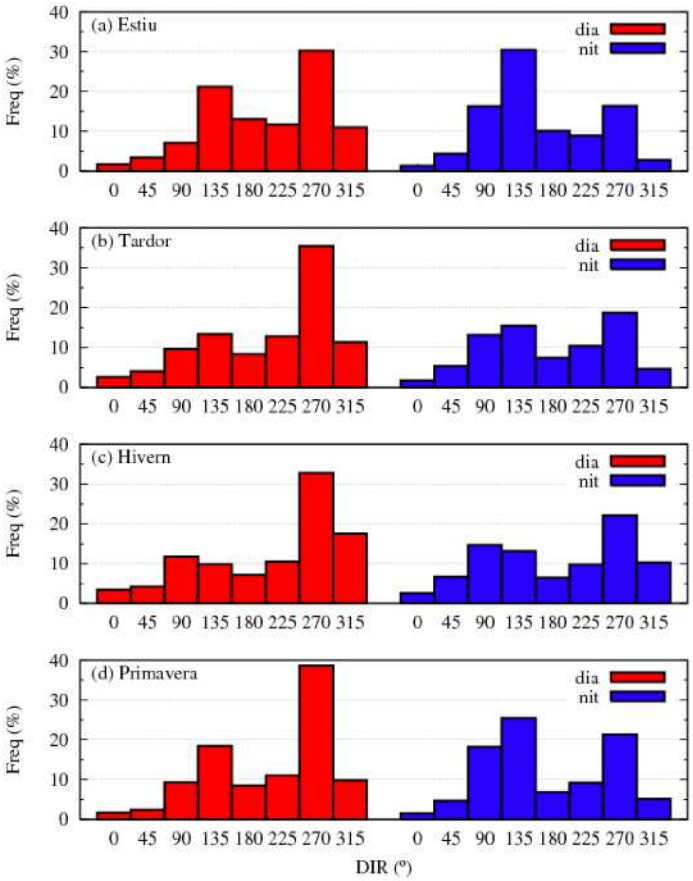
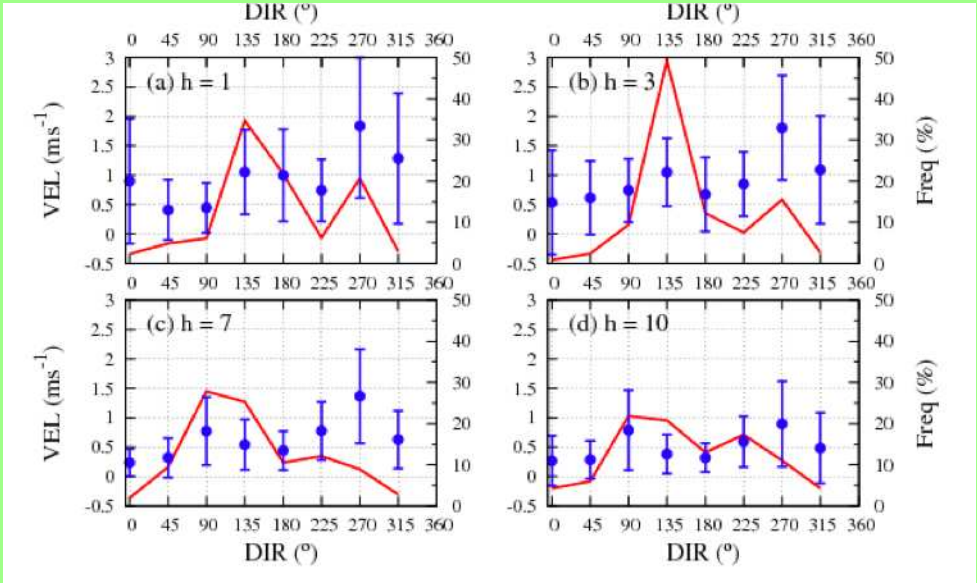


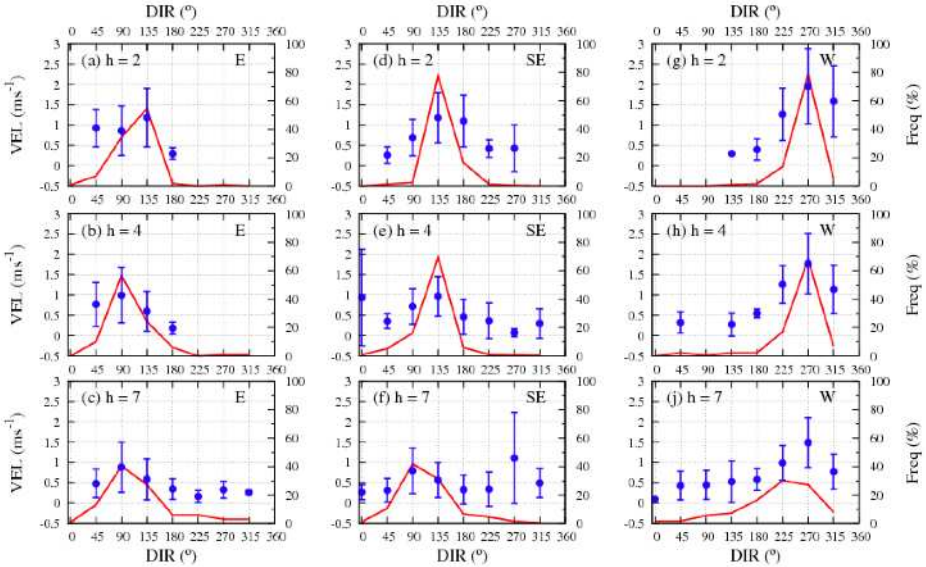
(a)

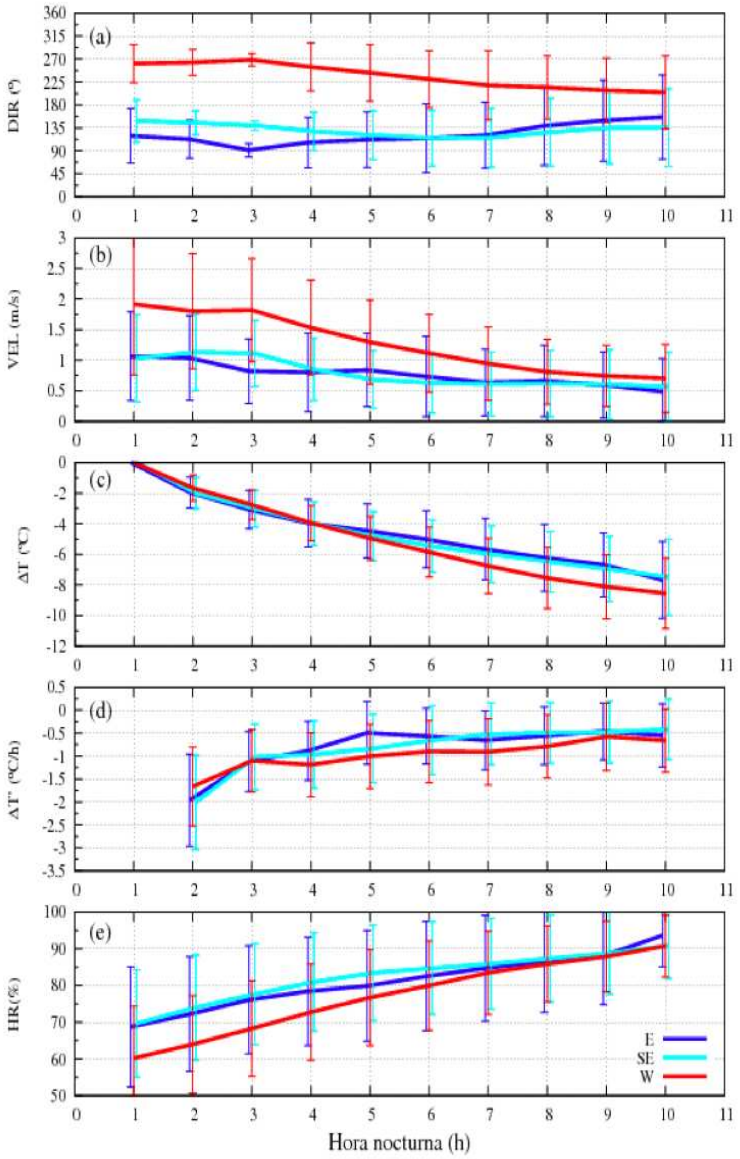
ra 4.14: Localitz

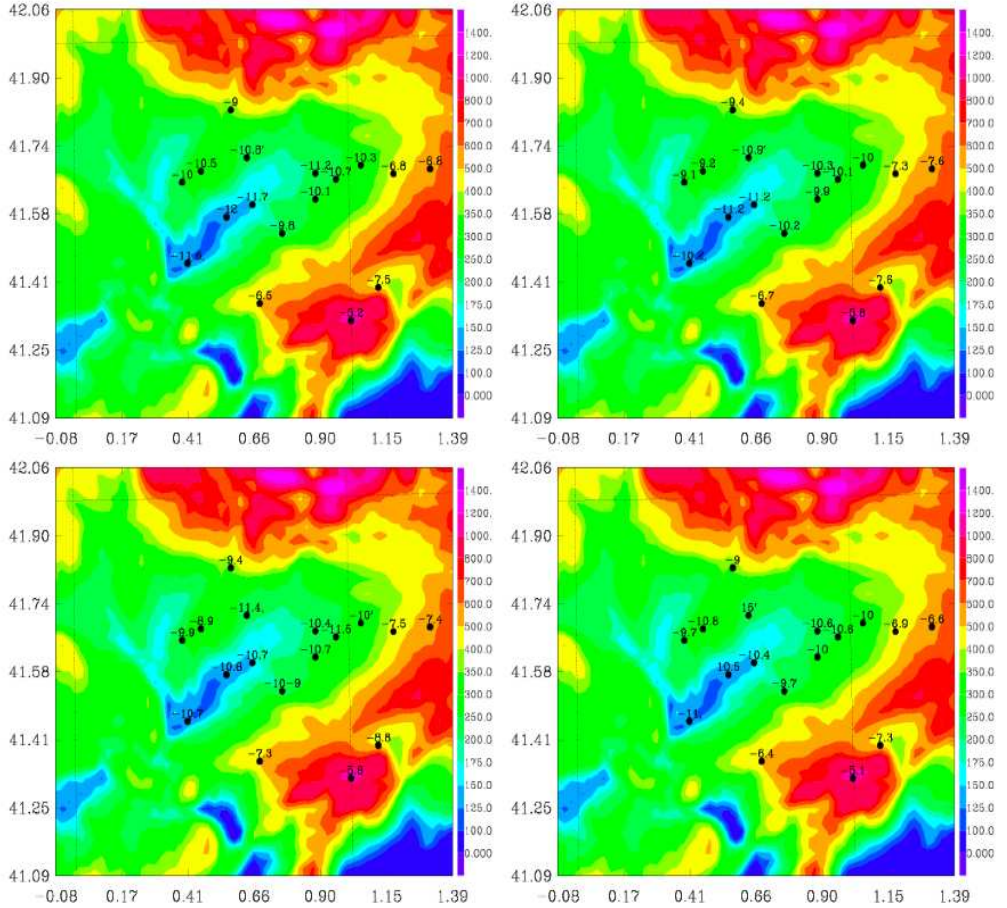
(b)


(a) Estiu
(b) Tardor
(c) Hivern
(d) Primavera
dia
nit
Freq (%)
DIR (º)


(a) h = 1
(b) h = 3
(c) h = 7
(d) h = 10
VEL (ms-1)
Freq (%)
DIR (º)


(a) h = 2 E
(b) h = 4 E
(c) h = 7 E
(d) h = 2 SE
(e) h = 4 SE
(f) h = 7 SE
(g) h = 2 W
(h) h = 4 W
(j) h = 7 W
VEL (ms-1)
Freq (%)
DIR (º)


(a)
DIR (°)
(b)
VEL (m/s)
(c)
ΔT (°C)
(d)
ΔT' (°C/h)
(e)
HR(%)
E
SE
W
Hora nocturna (h)



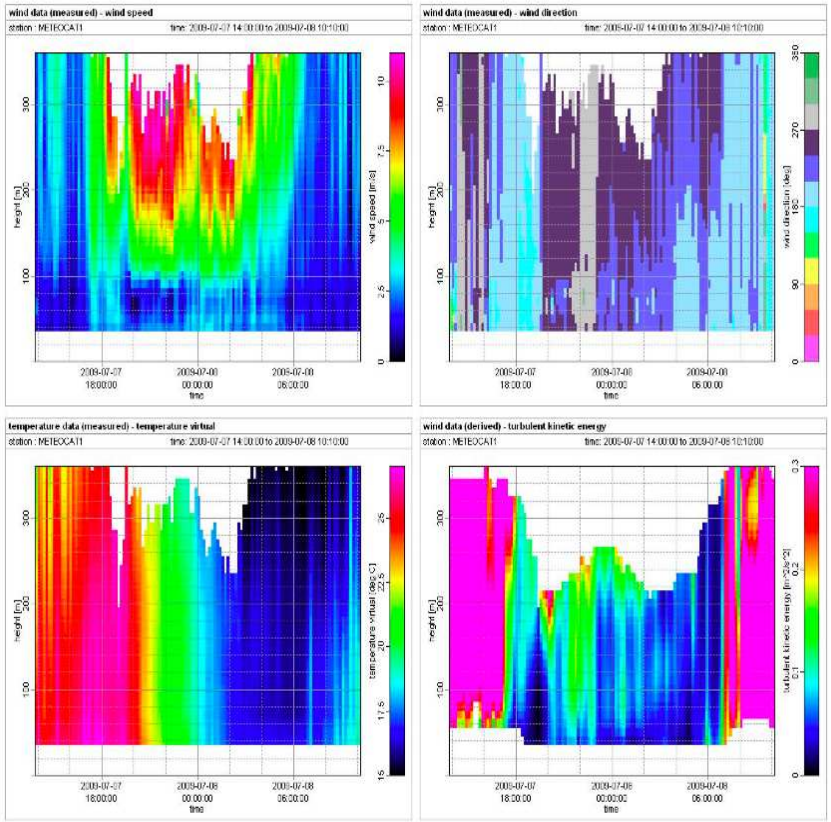


Figura 5.1: Mesures del perfilador de les 14 UTC del 7 a les 10 UTC del 8 de juliol d 2009: dalt-esquerra: velocitat, dalt-dreta: direcció. baix-esquerra: temperatura virtua baix-dreta: energia cinètica turbulenta estimada.

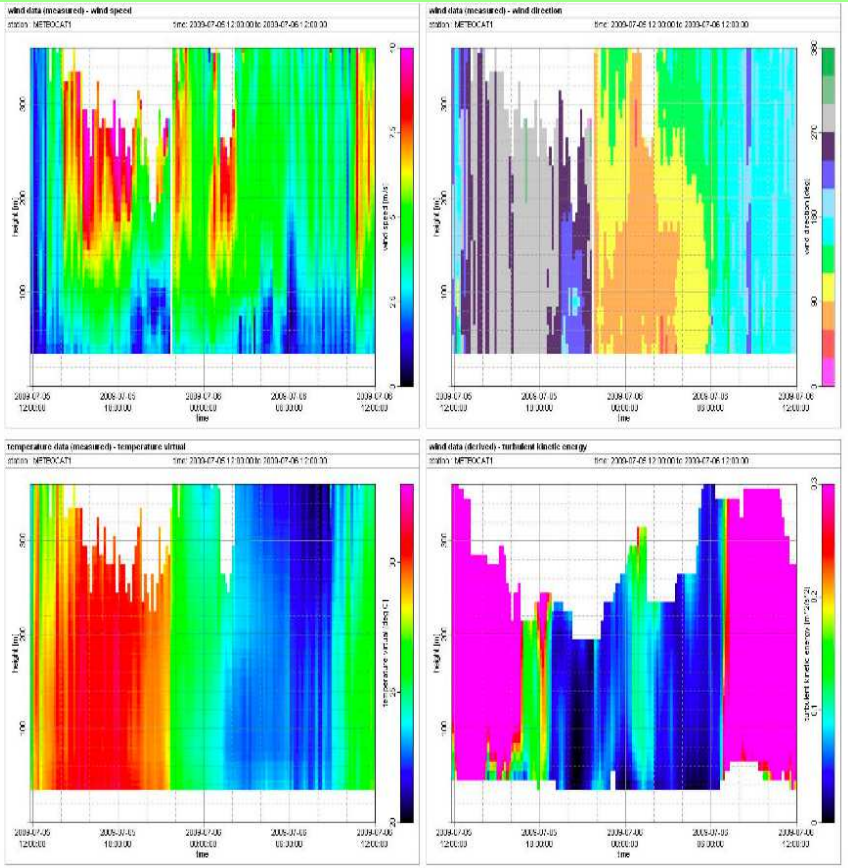
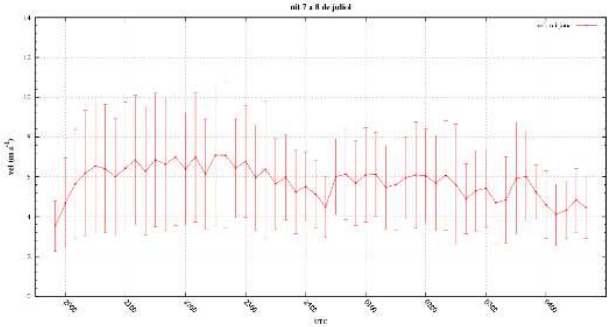
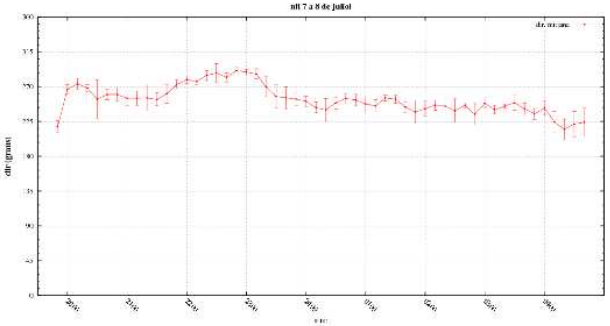
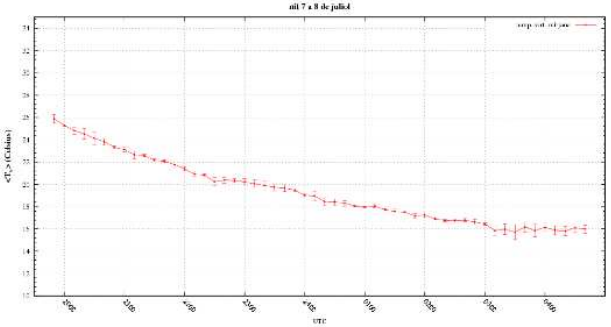


Figura 6.1: Mesures del perfilador des de les 1200 UTC de dia 5 a les 1200 UTC de dia 6 de juliol de 2009.


nit 7 a 8 de julio
vel (m s-1)
UTC


nit 7 a 8 de julio
dir (grau)
UTC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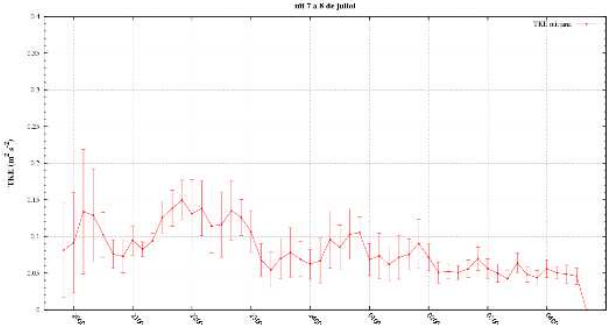
<T> (Celsius)
UTC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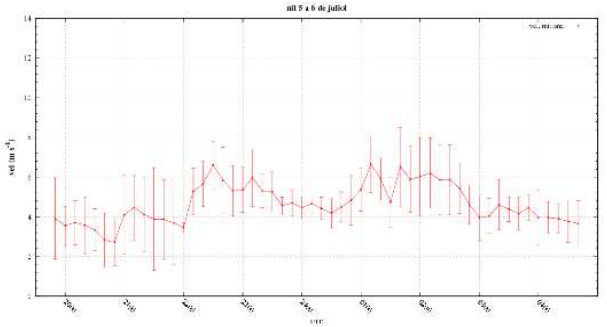
TKE (m2 s-2)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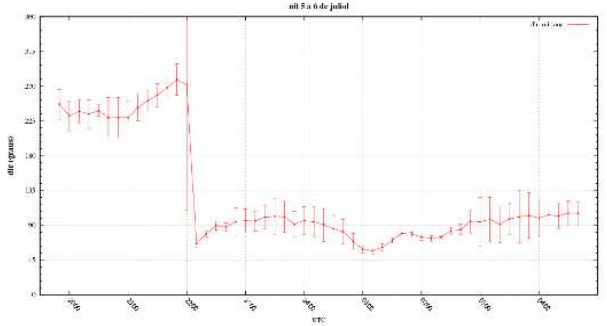
vel (m s-1)
UTC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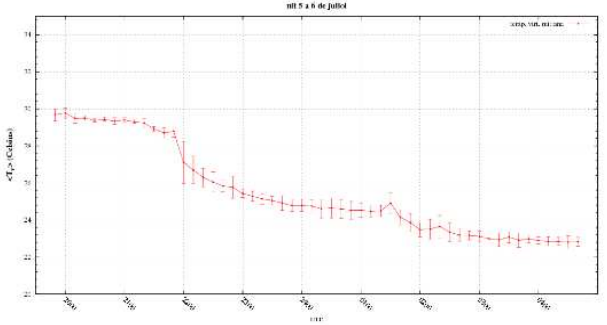
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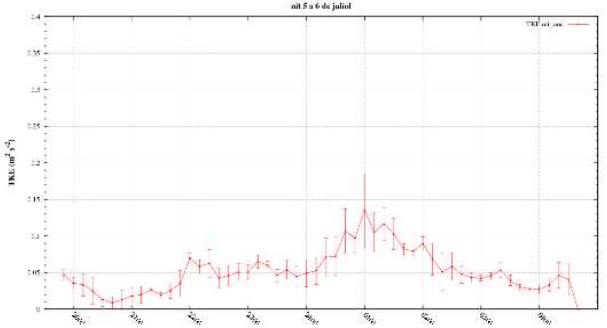
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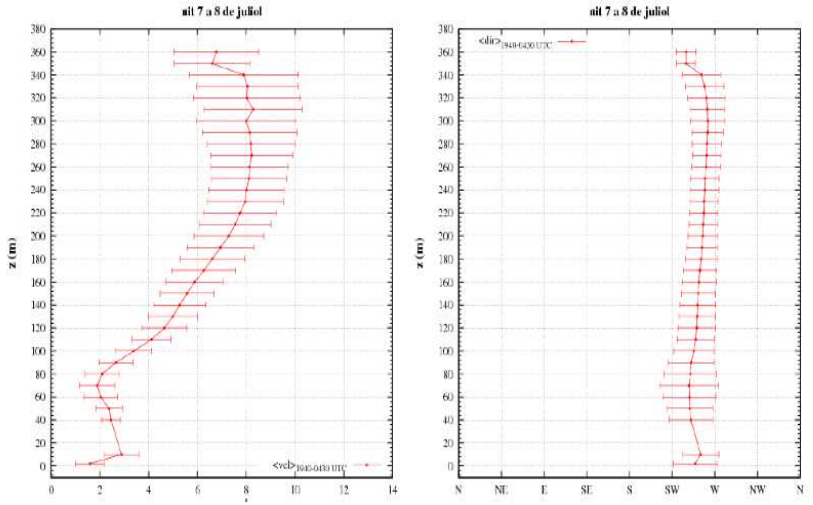
nit 7 a 8 de juliol
z (m)
<vel>1940-0430 UTC</vel>
nit 7 a 8 de juliol
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NE
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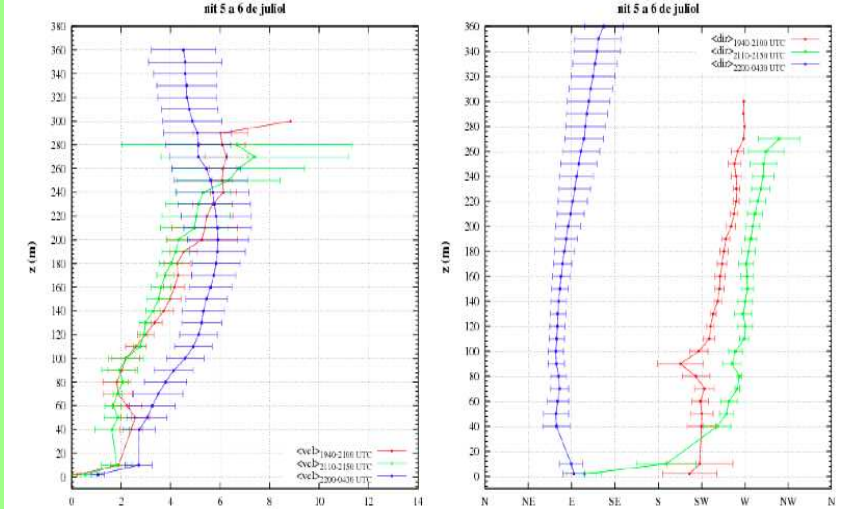
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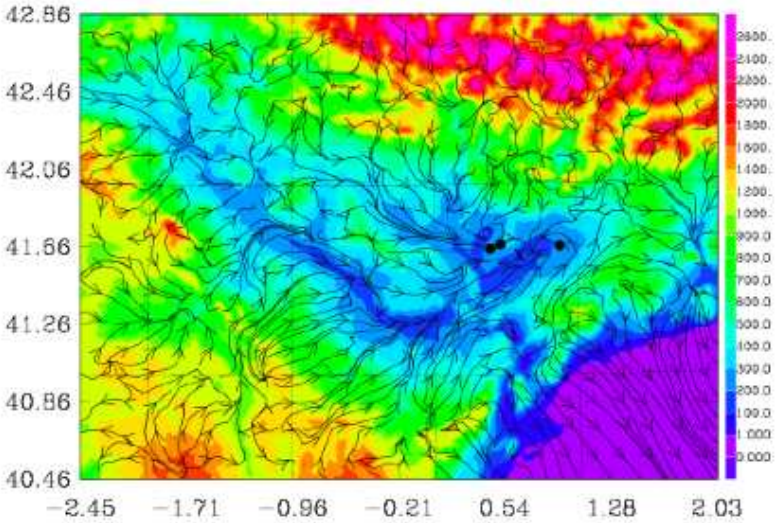
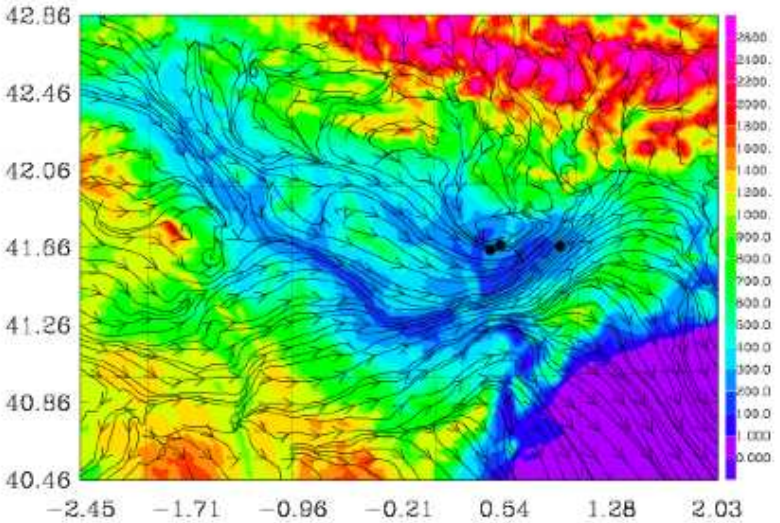
0300 UTC



0 m

0300 UTC



10 m

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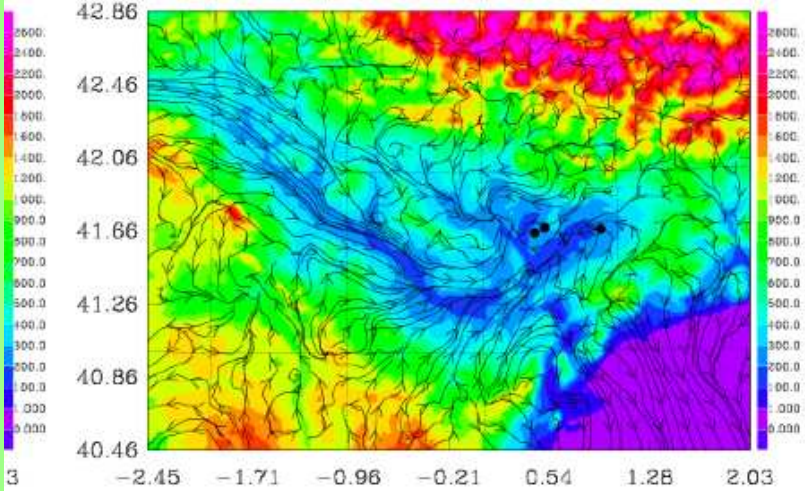
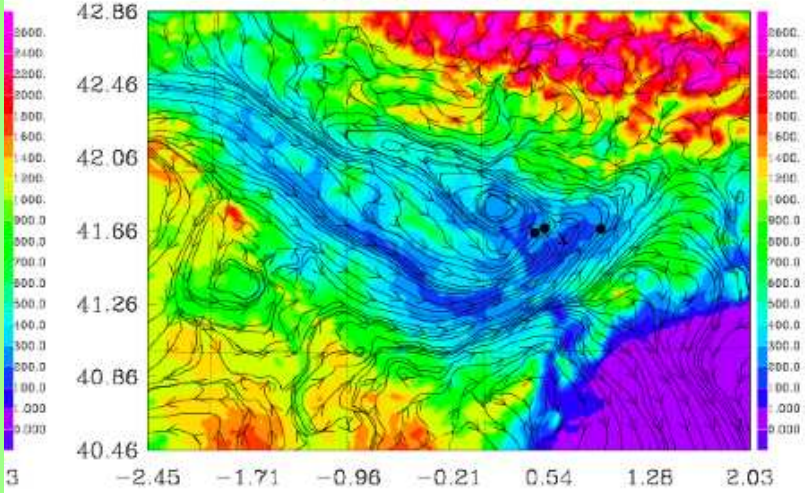
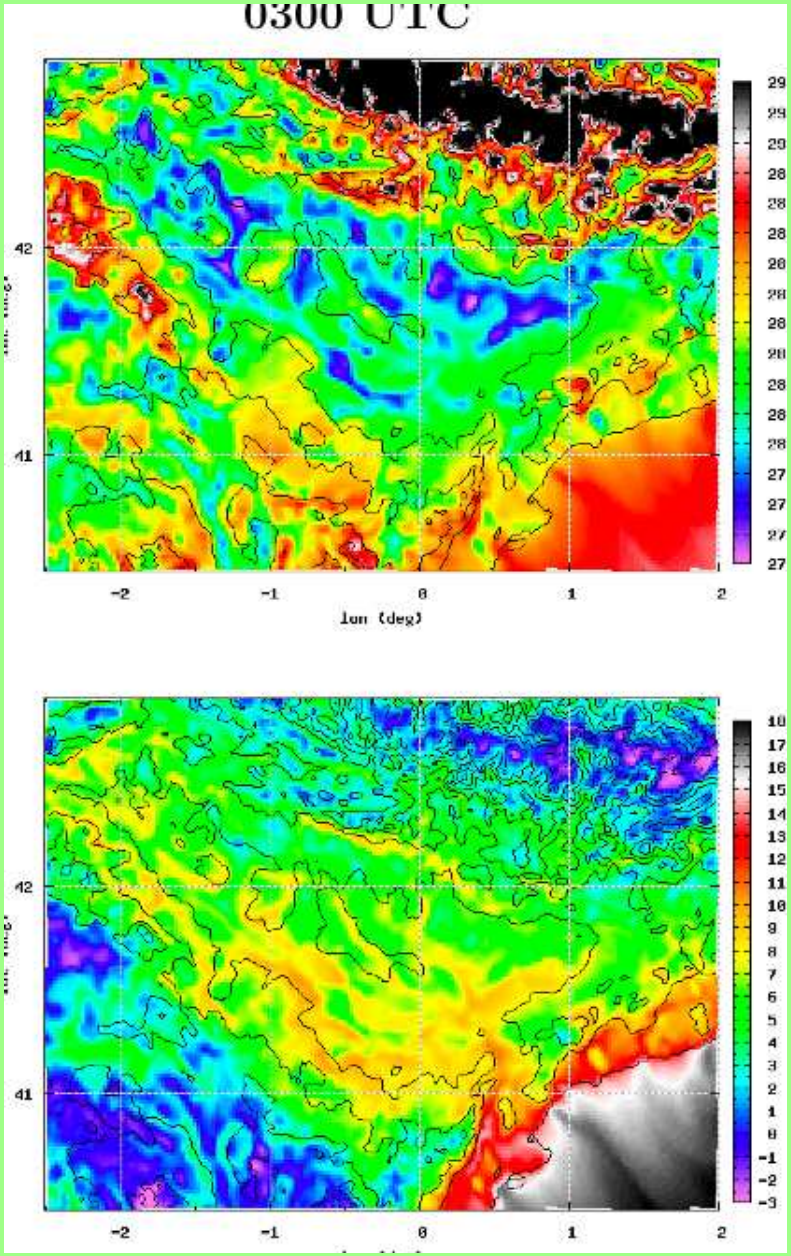
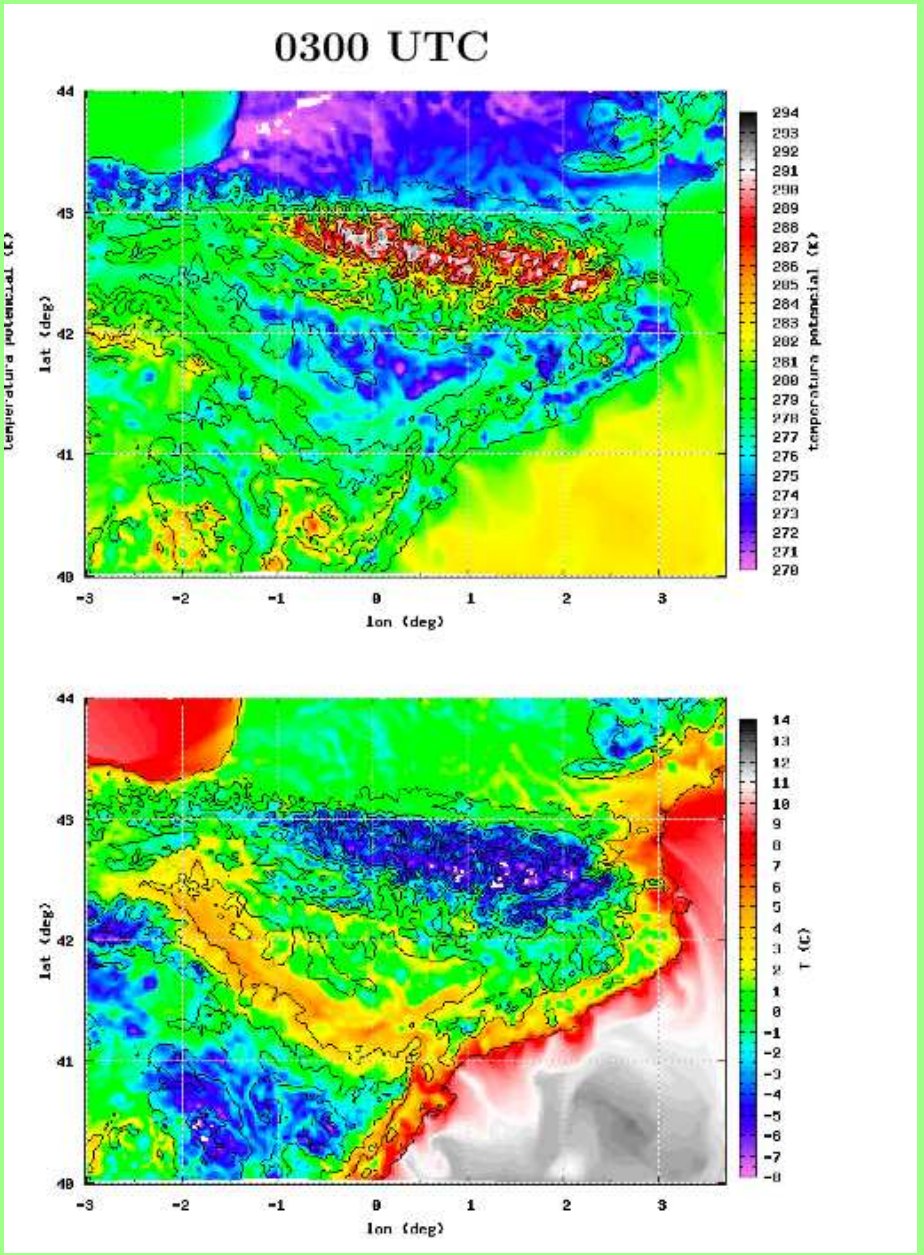


100 m

0300 UTC




0300 UTC
lon (deg)
lon (deg)


0300 UTC
lat (deg)
lon (deg)
temperatura potencial (K)
lat (deg)
lon (deg)
T (C)