A new surface scheme for HIRLAM including snow and canopy temperatures

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Outline:

- A short overview of the surface scheme
- Some results for june 2005
- Also for March 2006

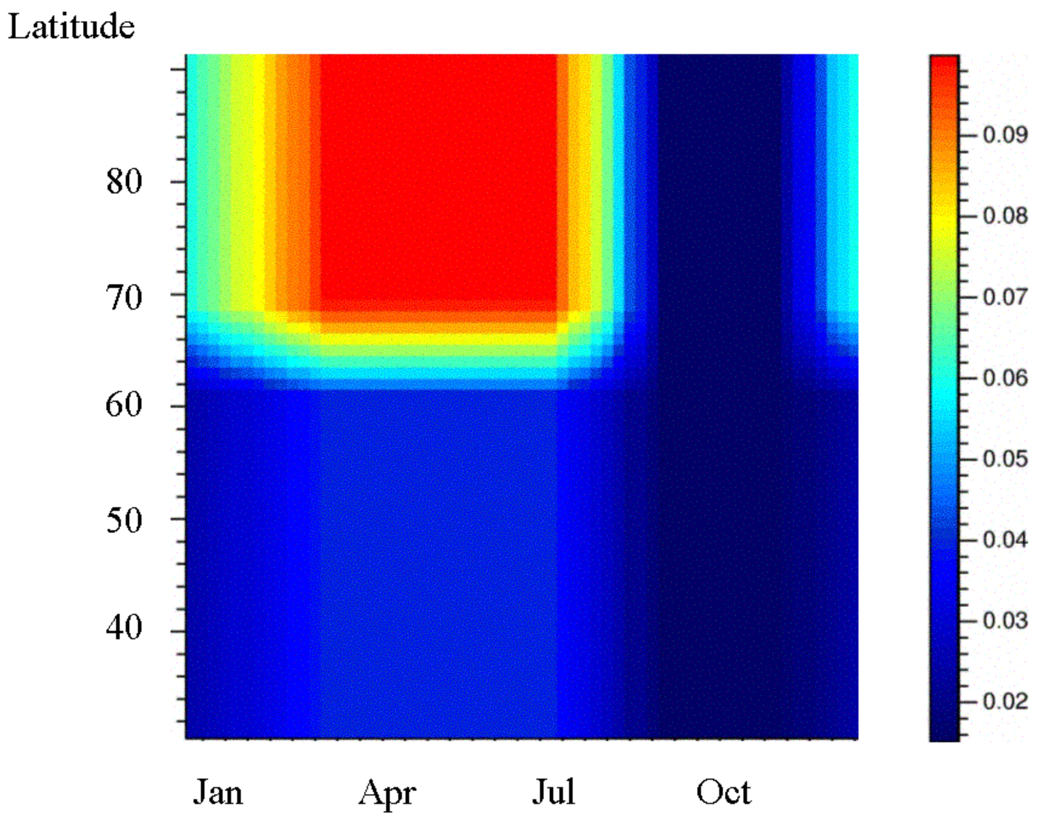
A new surface scheme for HIRLAM including snow and canopy temperature

- Totally 7 tiles: sea, ice, open land, low veg., forest, open land snow, forest snow
- For all land tiles: 3 prognostic tempereatures, soil depths of 1, 7.2 and 43.2 cm. Heat conduction dependent on soil type, soil water and (parameterized) soil ice. Climatological forcing below third layer.
- The forest tile has a common (prognostic) canopy temperature and separate temperatures for the snow free and snow covered forest floor.
- Two separate snow covers with separate evolutions of temperature, snow amount, liquid water, density and albedo
- Sea ice has 3 layers, the deepest 92 cm for oceans and 42 cm in the Baltic. Heat flux at the bottom, from the water.

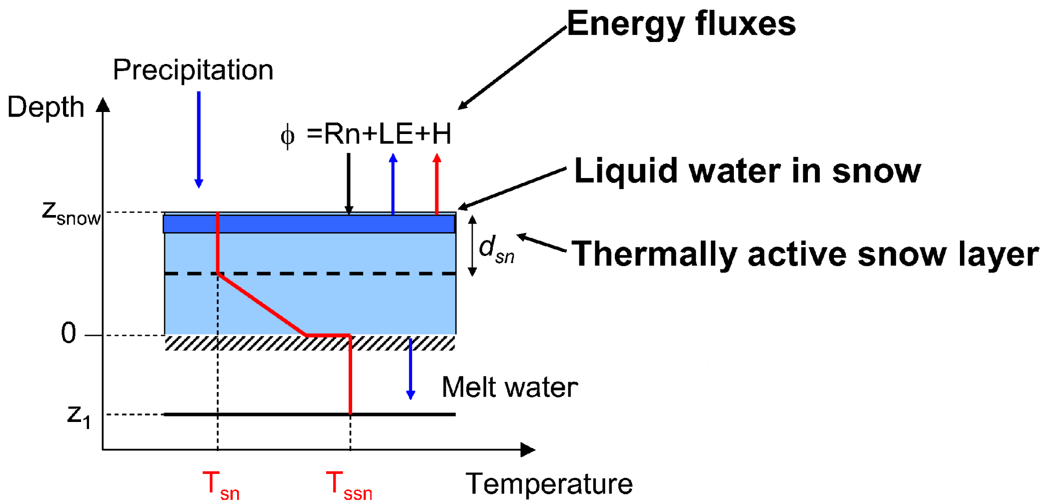
The snow fractions are simply estimated as:

$$frsn(x,y,t) = sn(x,y,t)/sncrit(x,y,t), \quad frsn \leq 1$$

At present an ad hoc *sncrit* as a function of latitude and time of the year



Here we use only one layer of snow, the depth of which is Z_{snow} [m snow]. Only the upper part is thermally active in cases of deep snow:



$$\frac{dT_{sn}}{dt} = \frac{1}{c_{snow} * MIN(Z_{snow}, d_{sn})}[\Phi - \alpha_{snow}(T_{sn} - T_{ssn})]$$

$$c_{snow} = vhice * \rho_{sn}/\rho_{ice}$$

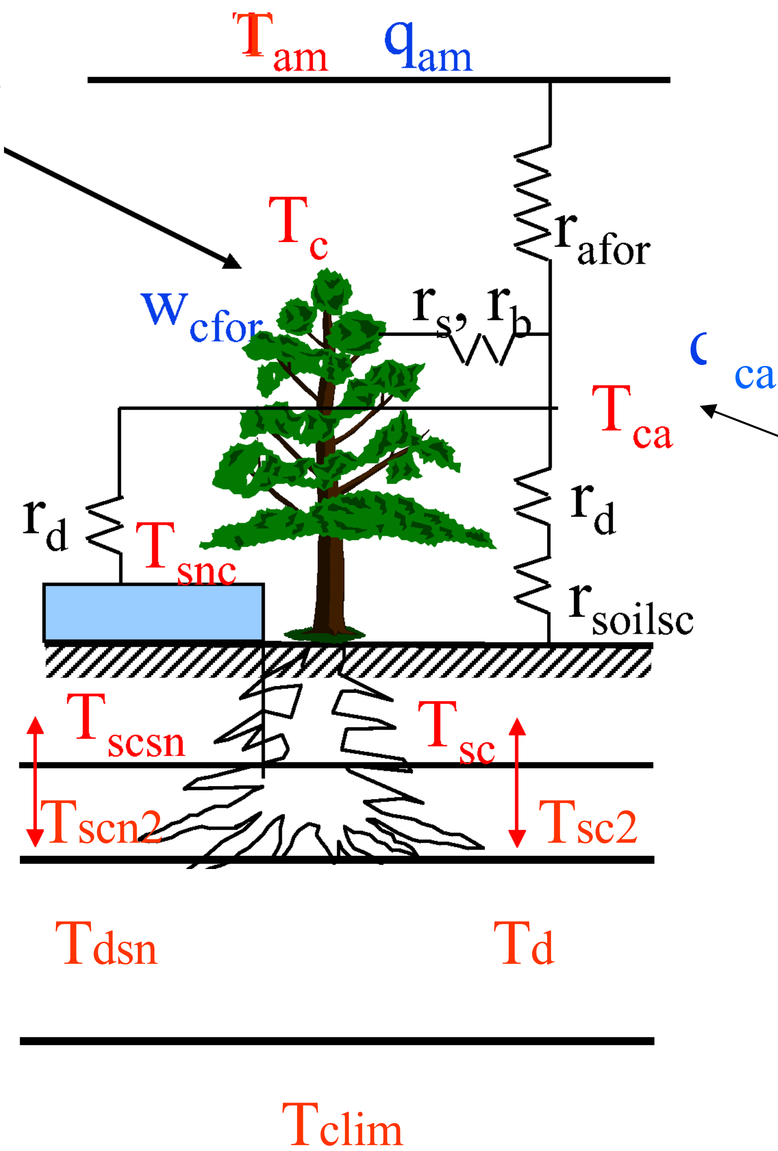
Here the coefficient α_{snow} (formulation from ERA 40) is parameterizing a "fictive" profile through the snow, since the isolation is a function of the snowdepth:

$$\alpha_{snow}^{-1} = 0.5\frac{Z_{snow}}{\lambda_{sn}} + 0.5\frac{Z_1}{\lambda_{soil}} \;; \quad \lambda_{sn} = \lambda_{ice}\left(\frac{\rho_{sn}}{\rho_{ice}}\right)^{1.88}$$

Now slightly reduced value of this resistance (tuning)

The forest tile

Low tree heat capacity



$$H_{for} = \rho c_p \frac{T_{ca} - T_{am}}{r_{afor}} =$$

$$= H_c + frsn * H_{snc} + (1 - frsn) H_{sc}$$

Canopy air temperature and humidity

Calculations of rb and rd follows Choudbury and Monteith, 1988

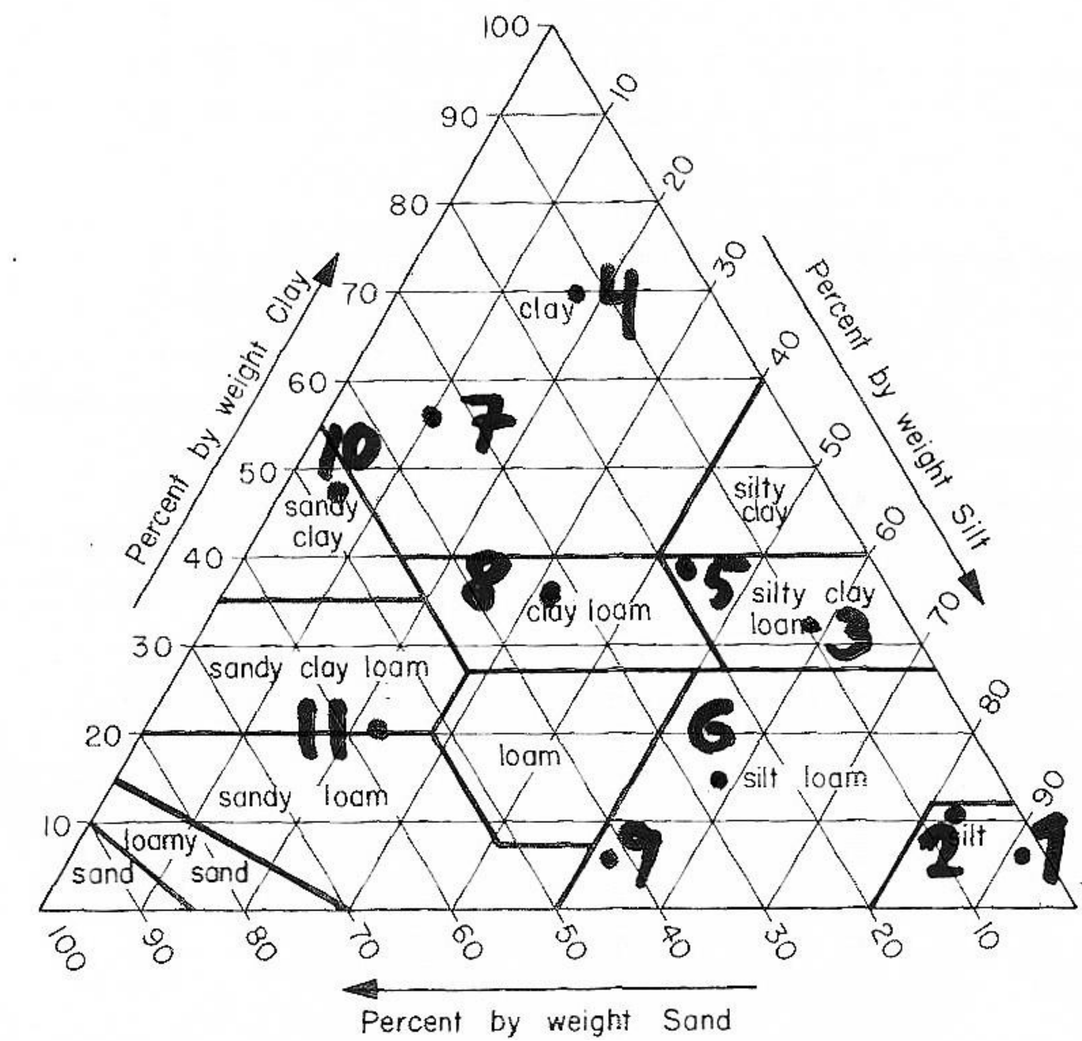
Radiation in the forest

We define a "view factor" *viewfs* , defined as how much of the incoming SW radiation is passing the canopy and reaching the forest floor. This parameter is a function of LAI, solar angle and total cloudcover. The corresponding factor for long wave radiation, *viewfl*, is only a function of LAI.

Then we calculate the radiation as usual between soil and atmosphere, but also between the canopy and the forest floor, both for snow covered and snow free parts, separately.

Heat conduction in the soil.

Dependent on the fractions of clay, silt and sand the soil is classified in 11 classes:

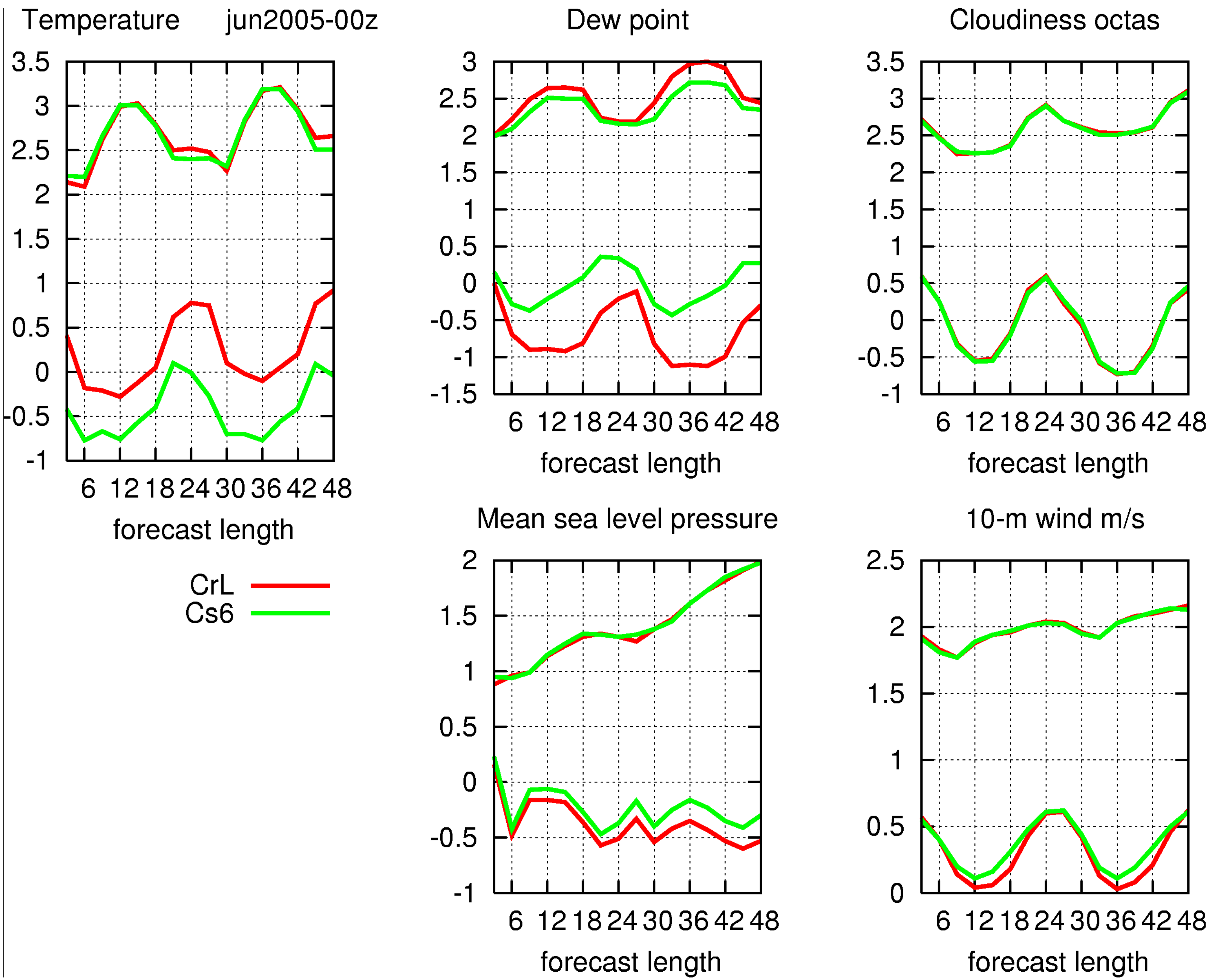


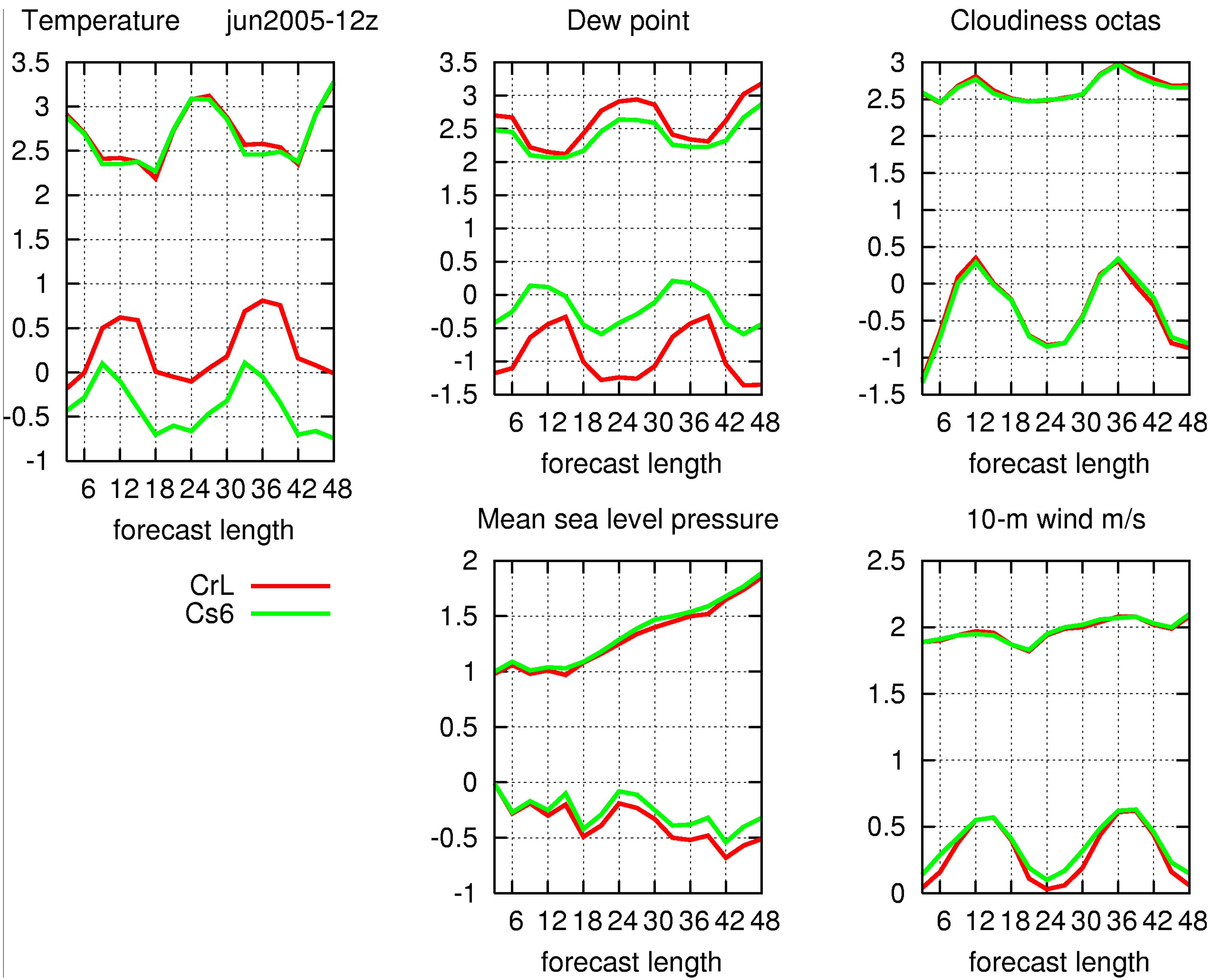
Dependent on the class, the porosity and amount of quartz is estimated, and the heat conductivity is calculated, taking into account the amount of soil water and the soil ice, at present estimated as a function of temperature (Viterbo). This parameterization follows Peters-Lidard et.al., 1998

Results for June 2005.

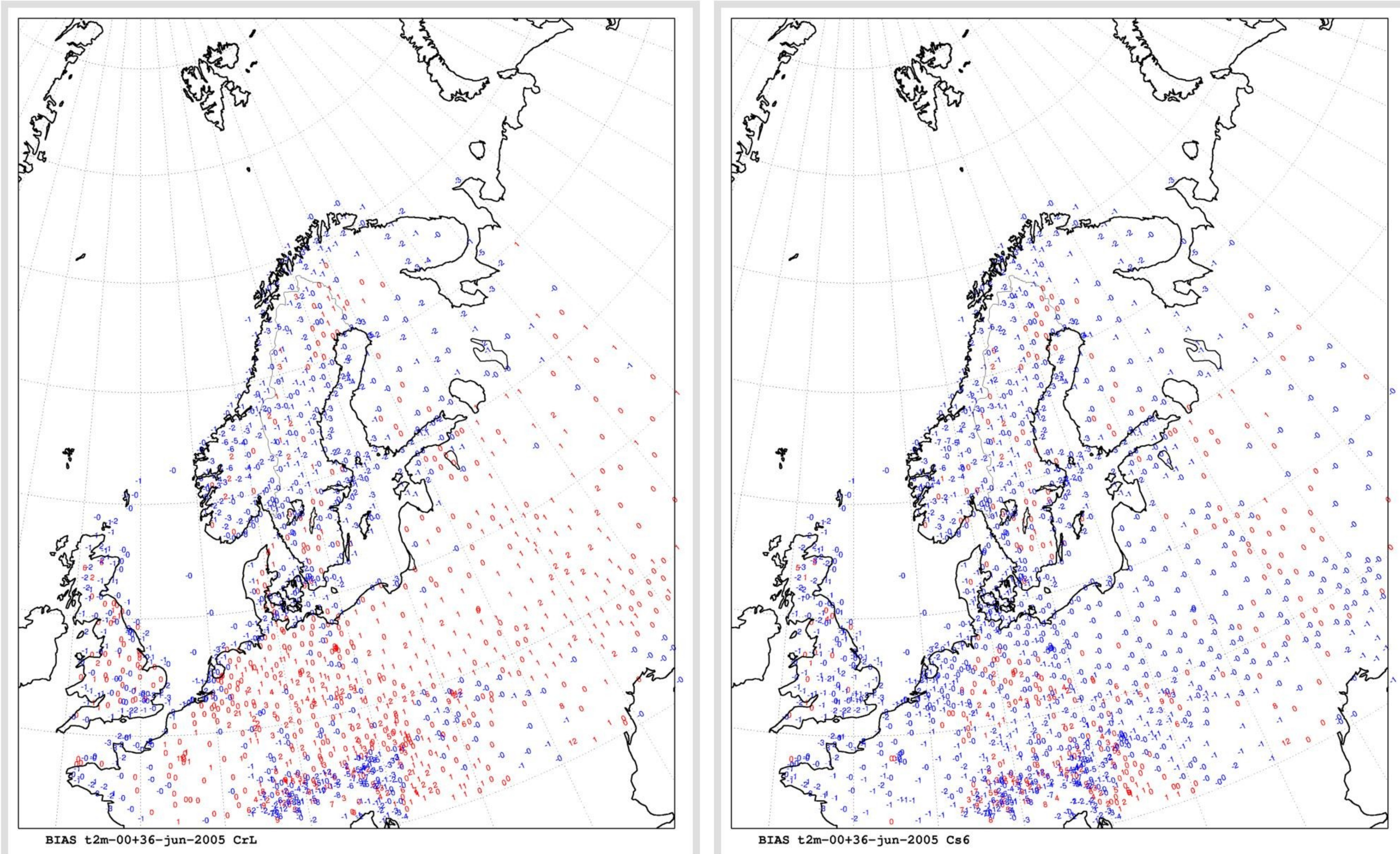
CrL=Reference Hirlam 6.4.0 but with
Kain-Fritch instead of Straco condensation scheme

Cs6=The same but with the new surface scheme, and a small modification in RADIA (background LW-down increased by 7 W/m2)

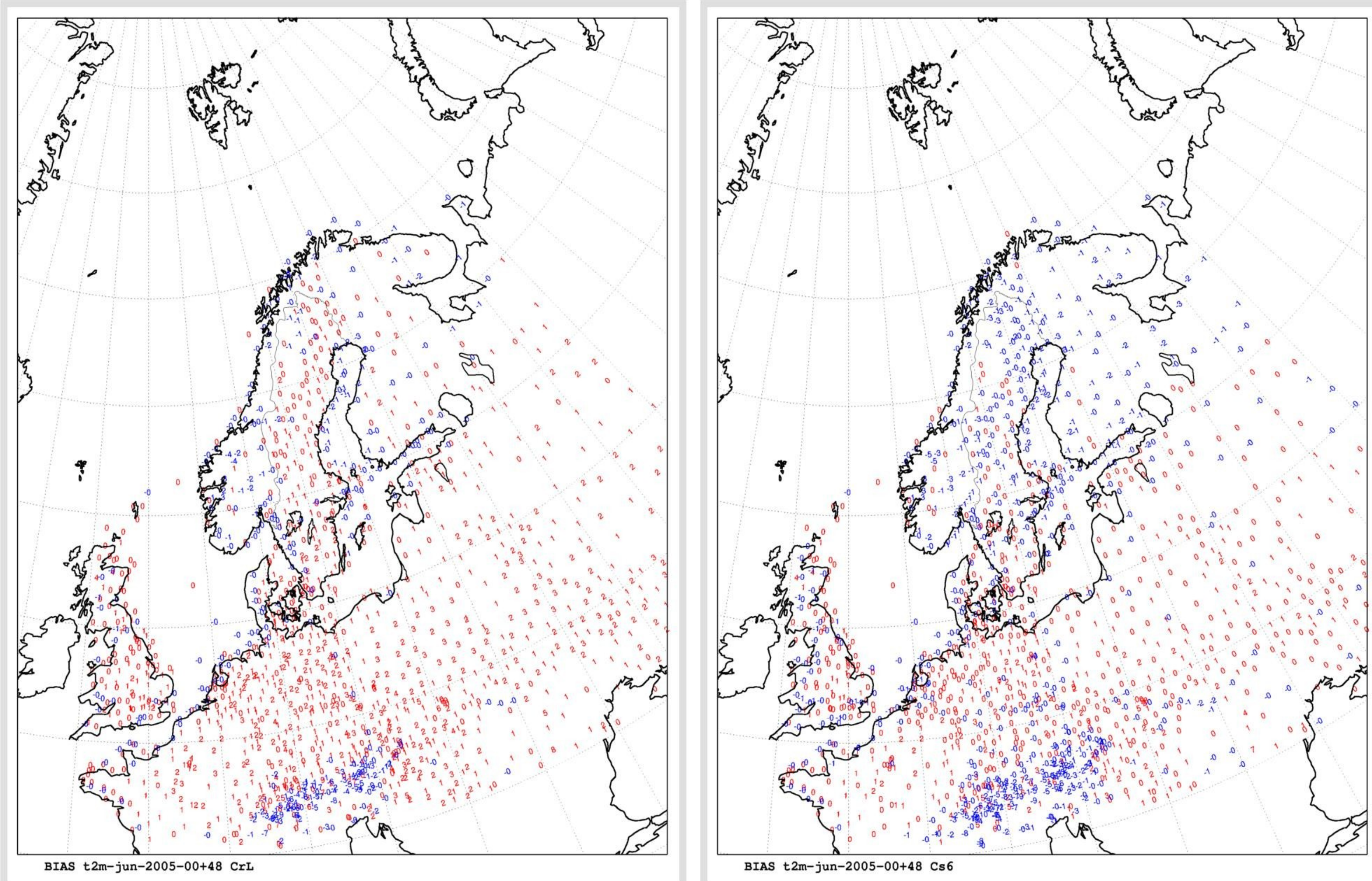

Temperature
jun2005-00z
Dew point
Cloudiness octas
Mean sea level pressure
10-m wind m/s
forecast length
6 12 18 24 30 36 42 48
CrL
Cs6



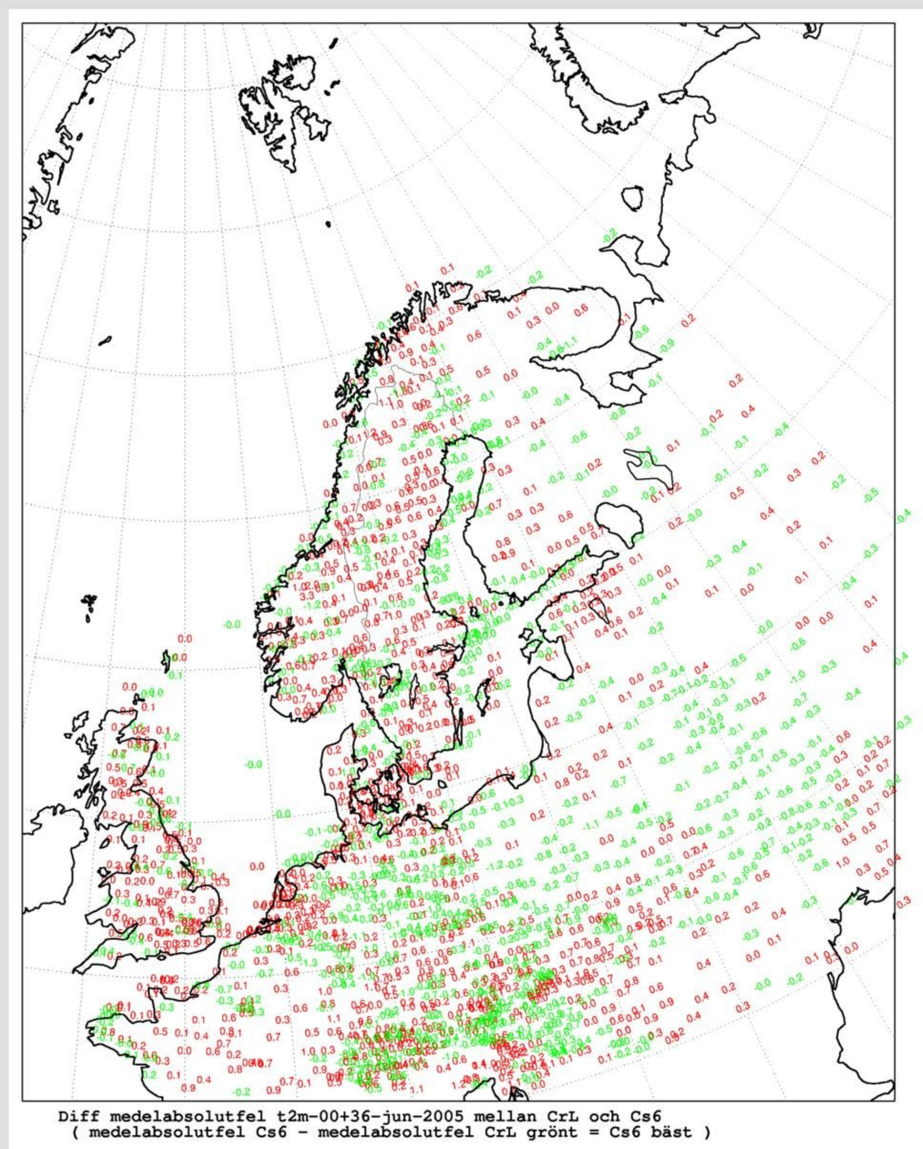
Temperature
jun2005-12z
Dew point
Cloudiness octas
Mean sea level pressure
10-m wind m/s
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
-1
-1.5
6 12 18 24 30 36 42 48
forecast length
CrL
Cs6

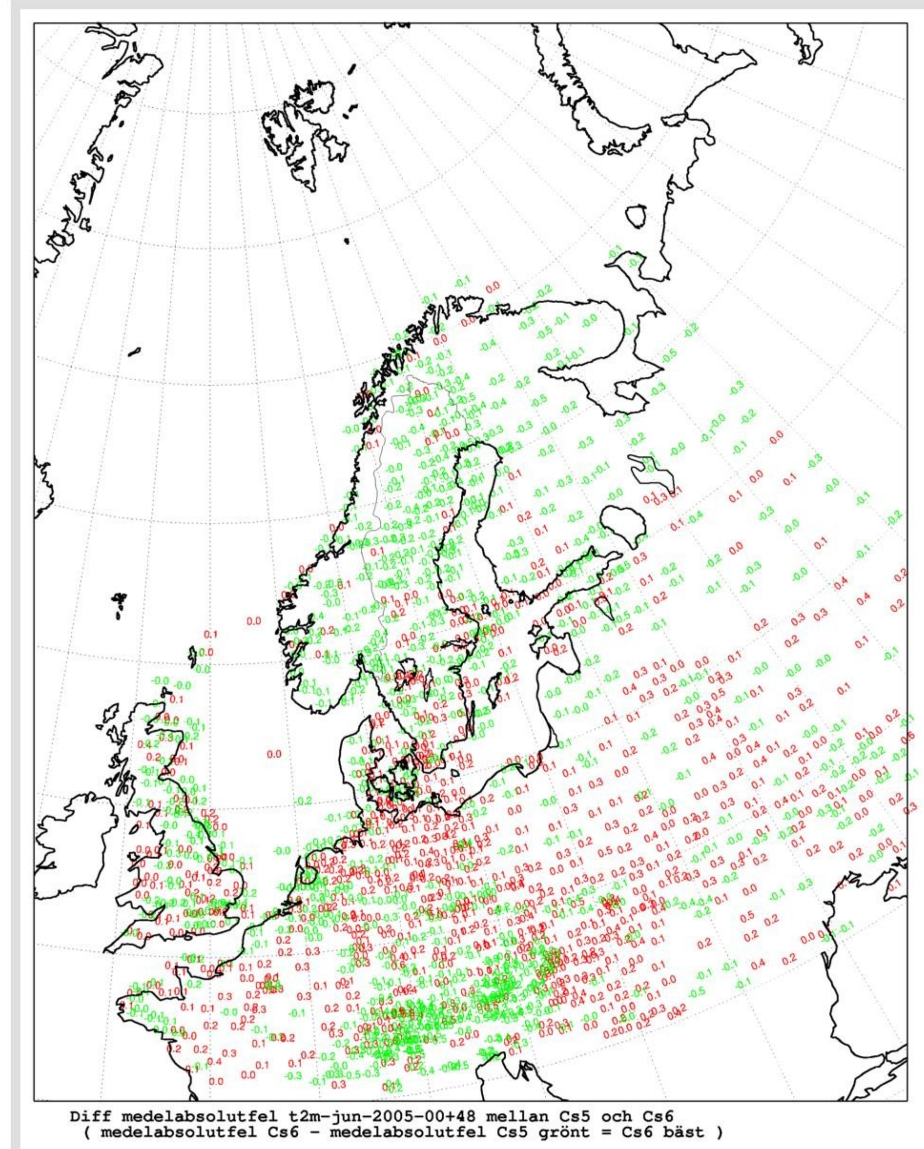


T2m bias at noon +36H   Left CrL   Right Cs6

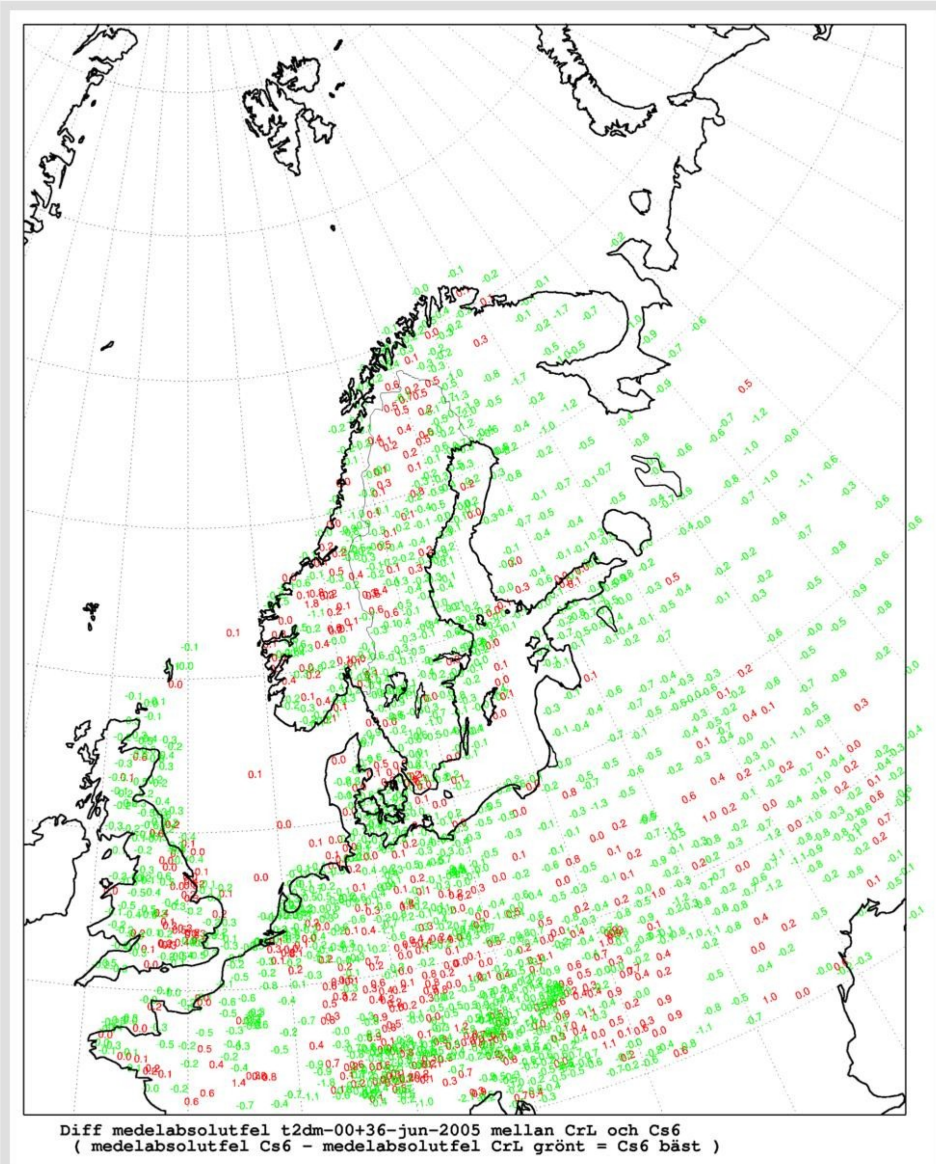


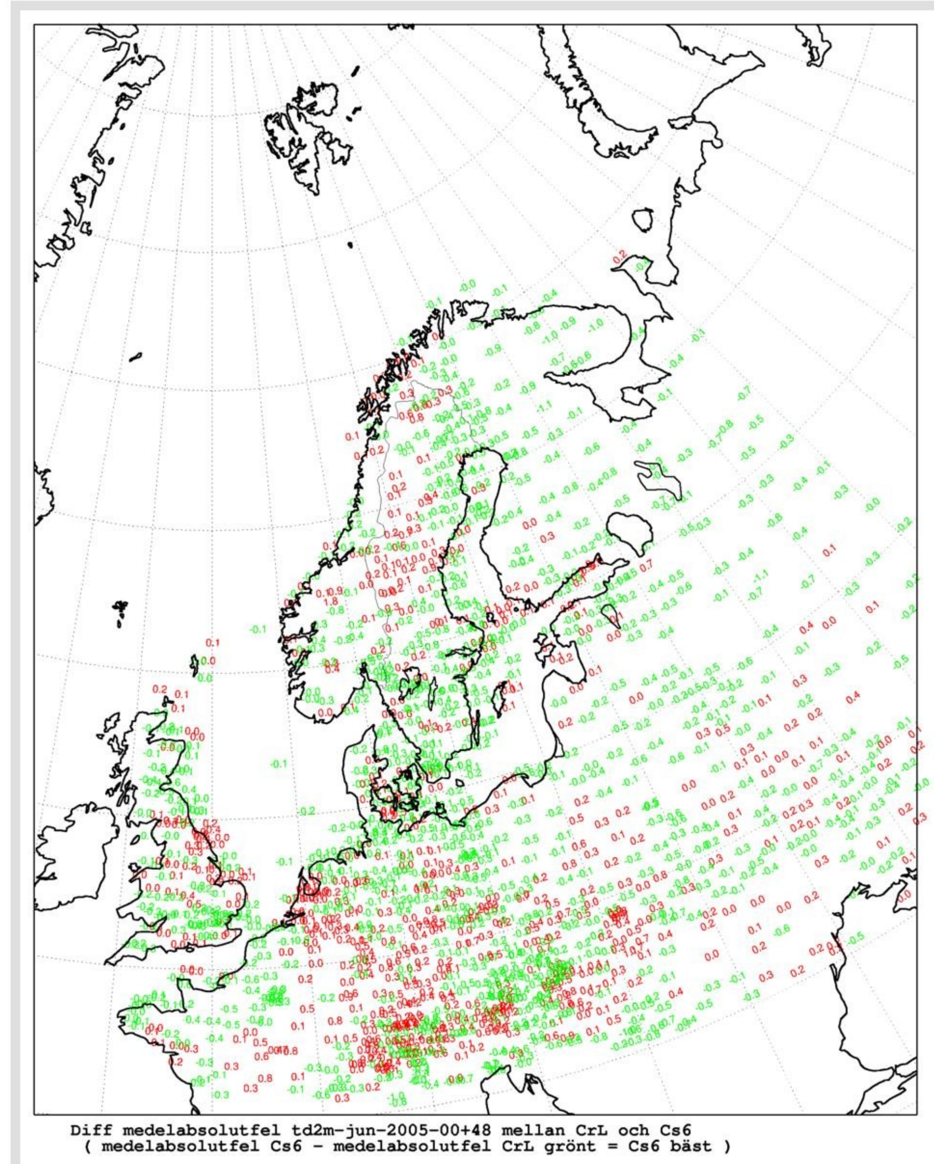
T2m bias at midnight +48H Left CrL Right Cs6





T2m meanabs differences, left at noon (+36H), right at midnight (+48H)
Green=Cs6 is better than CrL, Red= the other way around



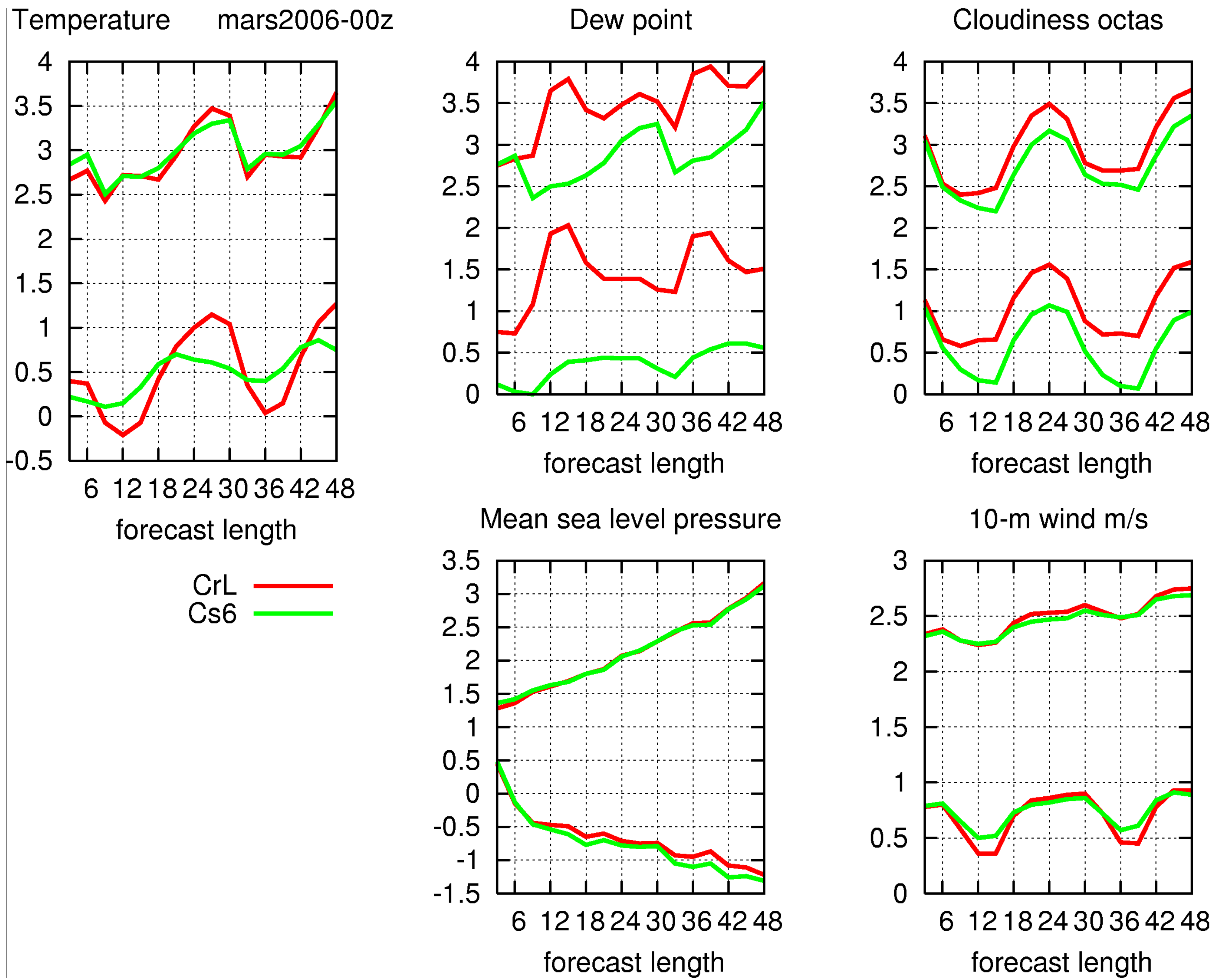


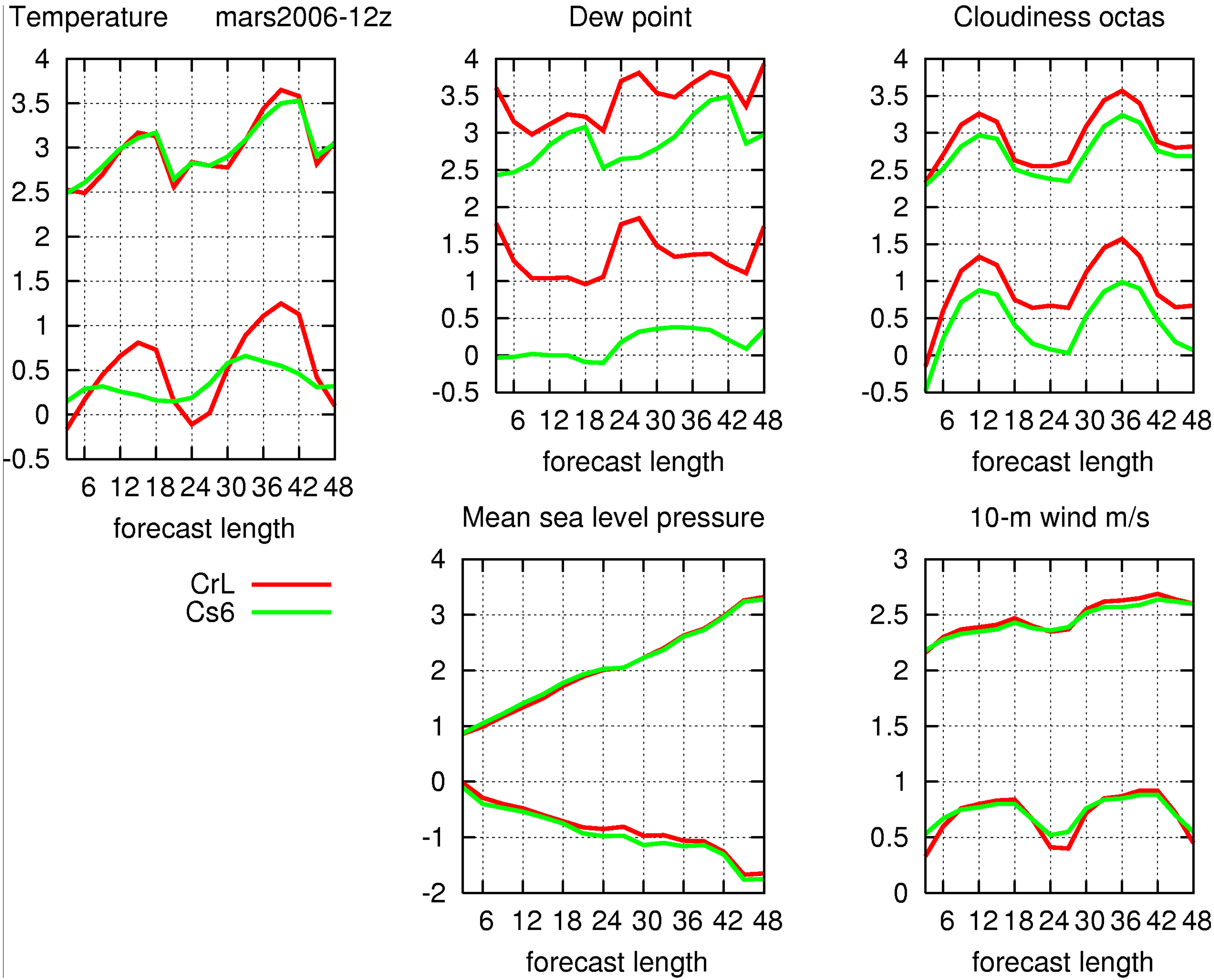
The same as previous, but for Td2m

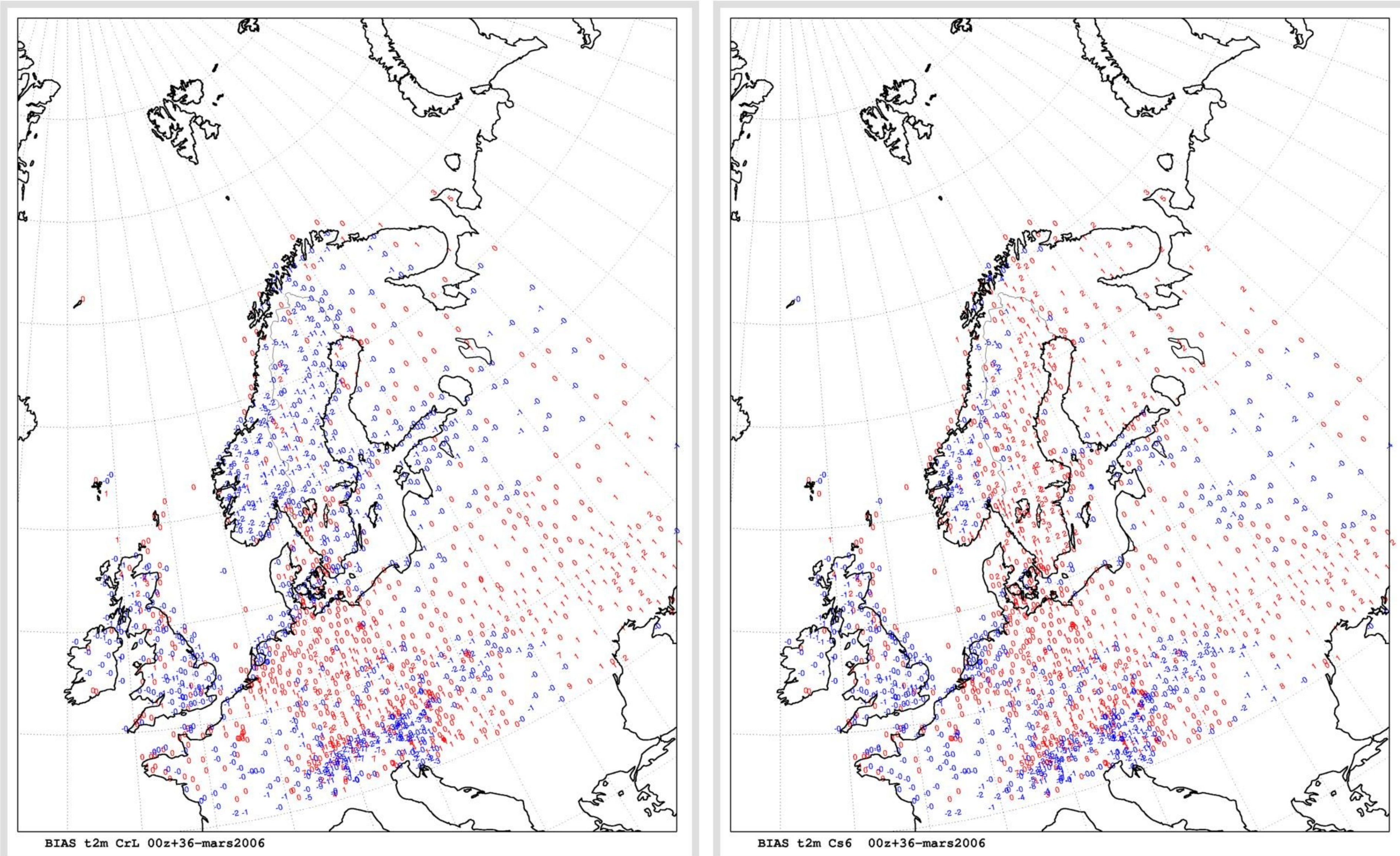
Conclusions for June 2005:

- Neutral impact or slightly worse than the reference for T2m.
- Neutral for clouds, surface pressure and 10m winds
- Clearly better for Td2m

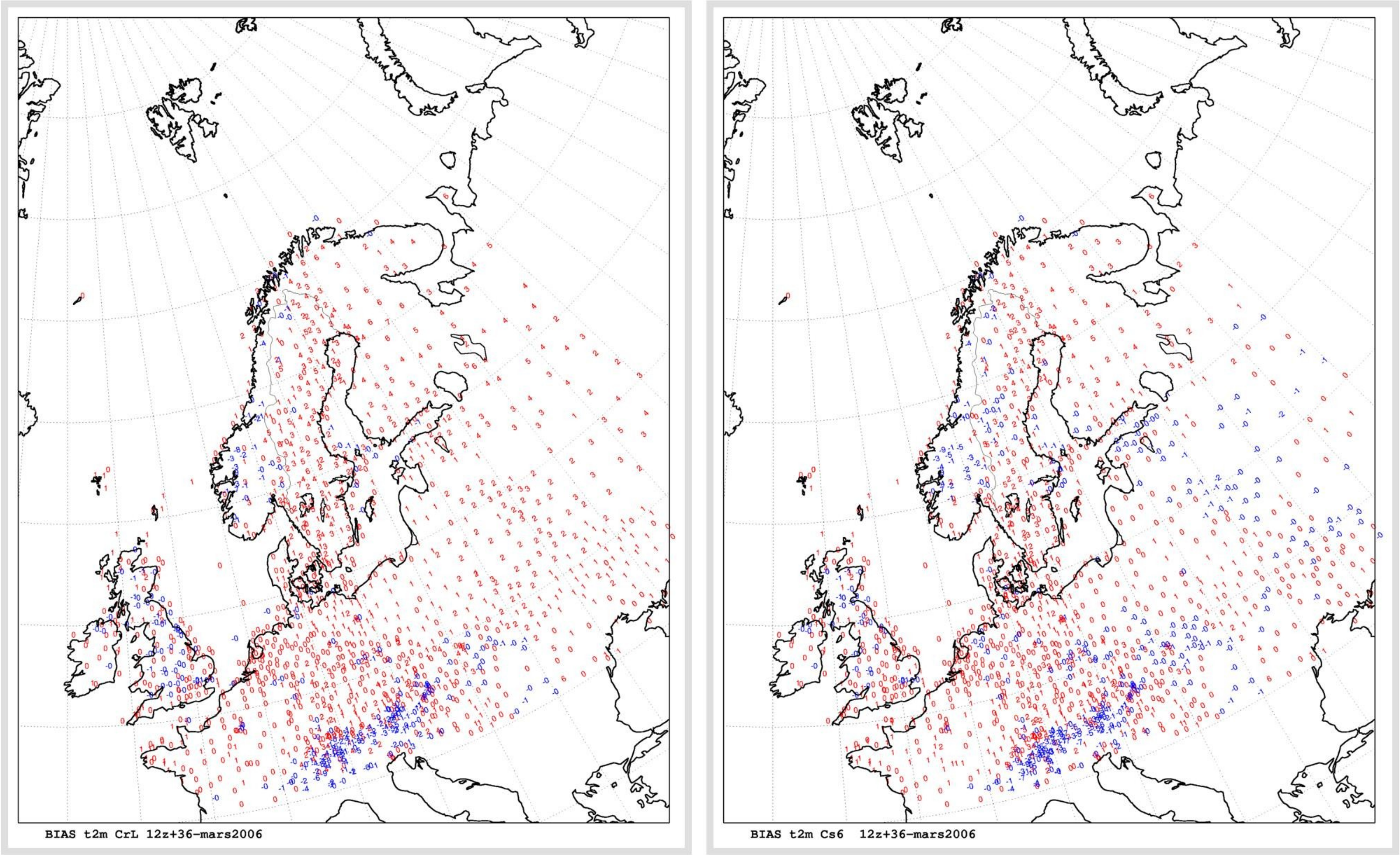
Now results for the relatively cold month March 2006:


Temperature
mars2006-00z
Dew point
Cloudiness octas
Mean sea level pressure
10-m wind m/s
forecast length
6 12 18 24 30 36 42 48
CrL
Cs6

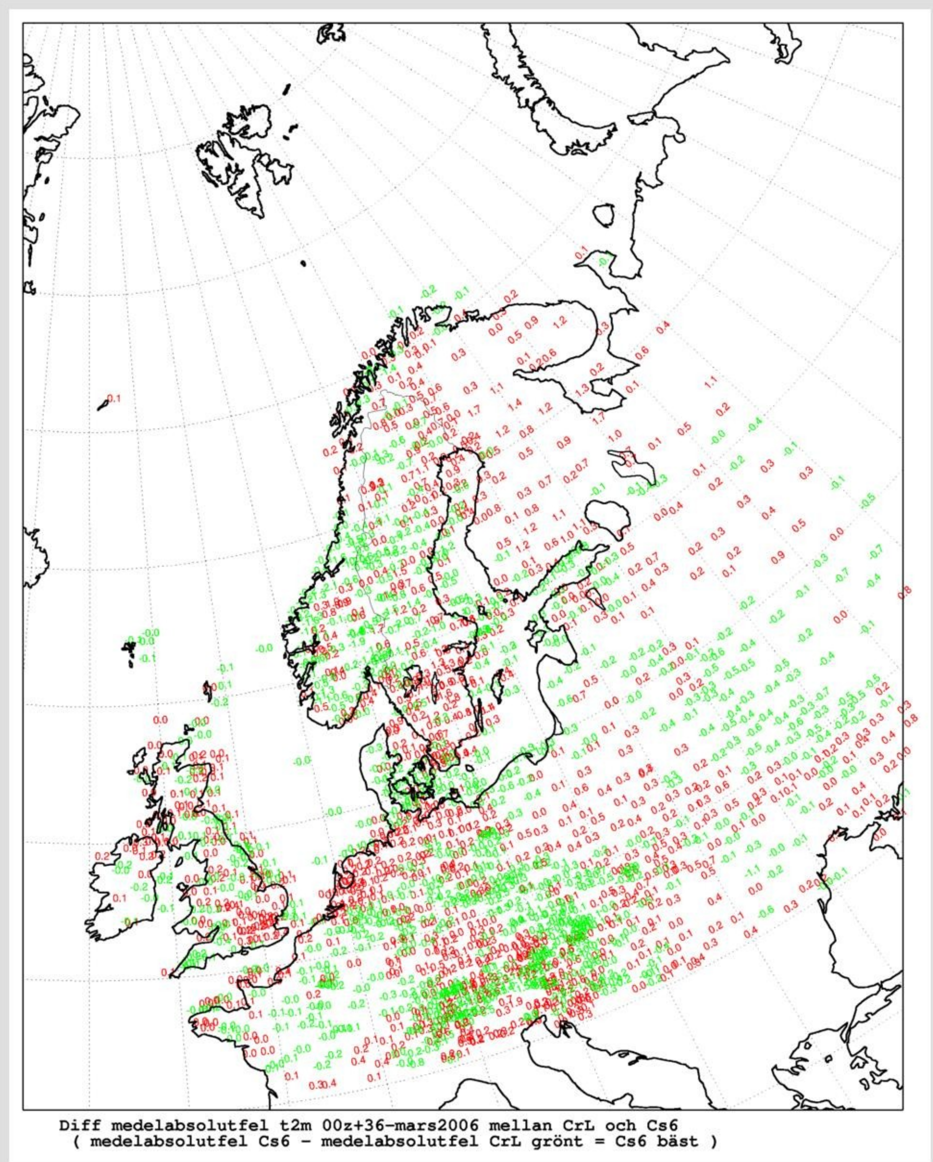

Temperature
mars2006-12z
Dew point
Cloudiness octas
Mean sea level pressure
10-m wind m/s
forecast length
CrL
Cs6

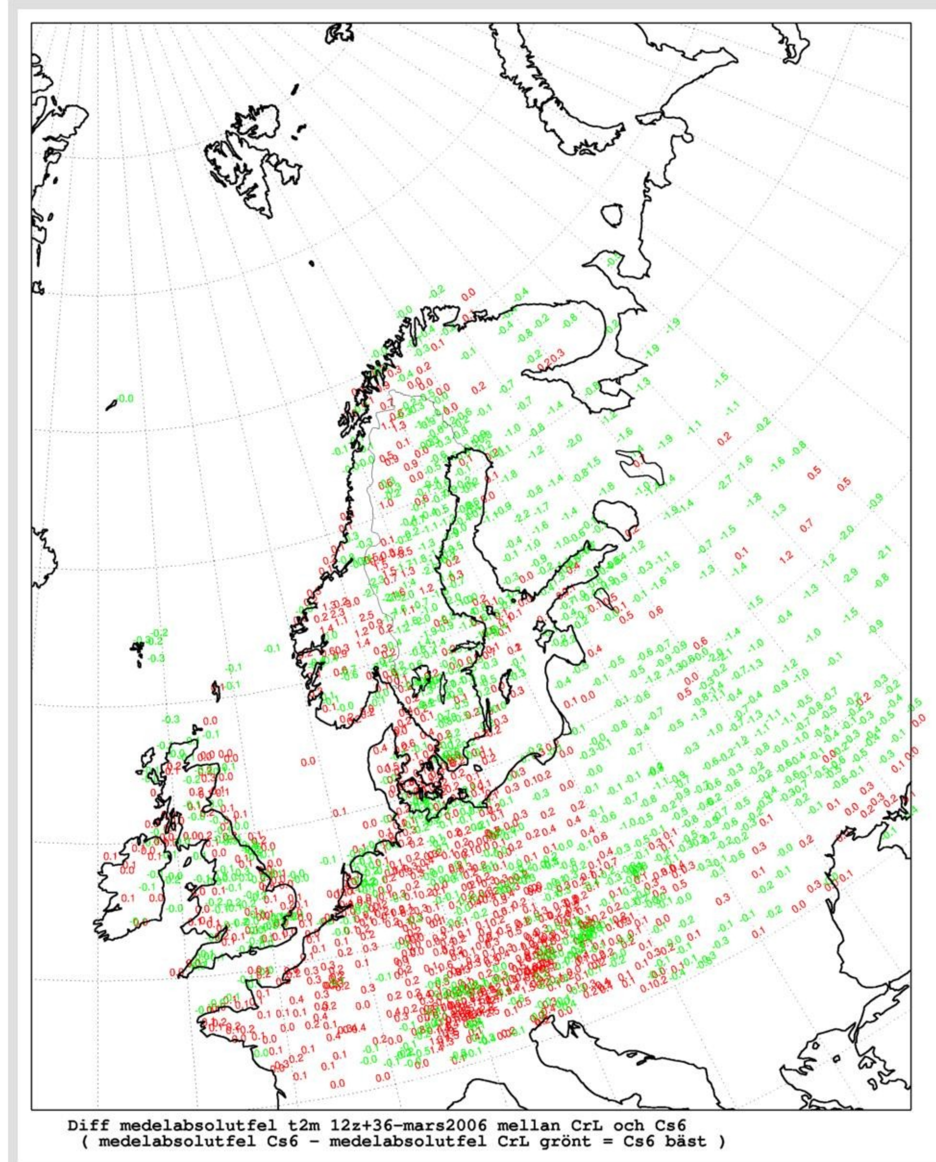


T2m bias at noon +36H   Left CrL   Right Cs6

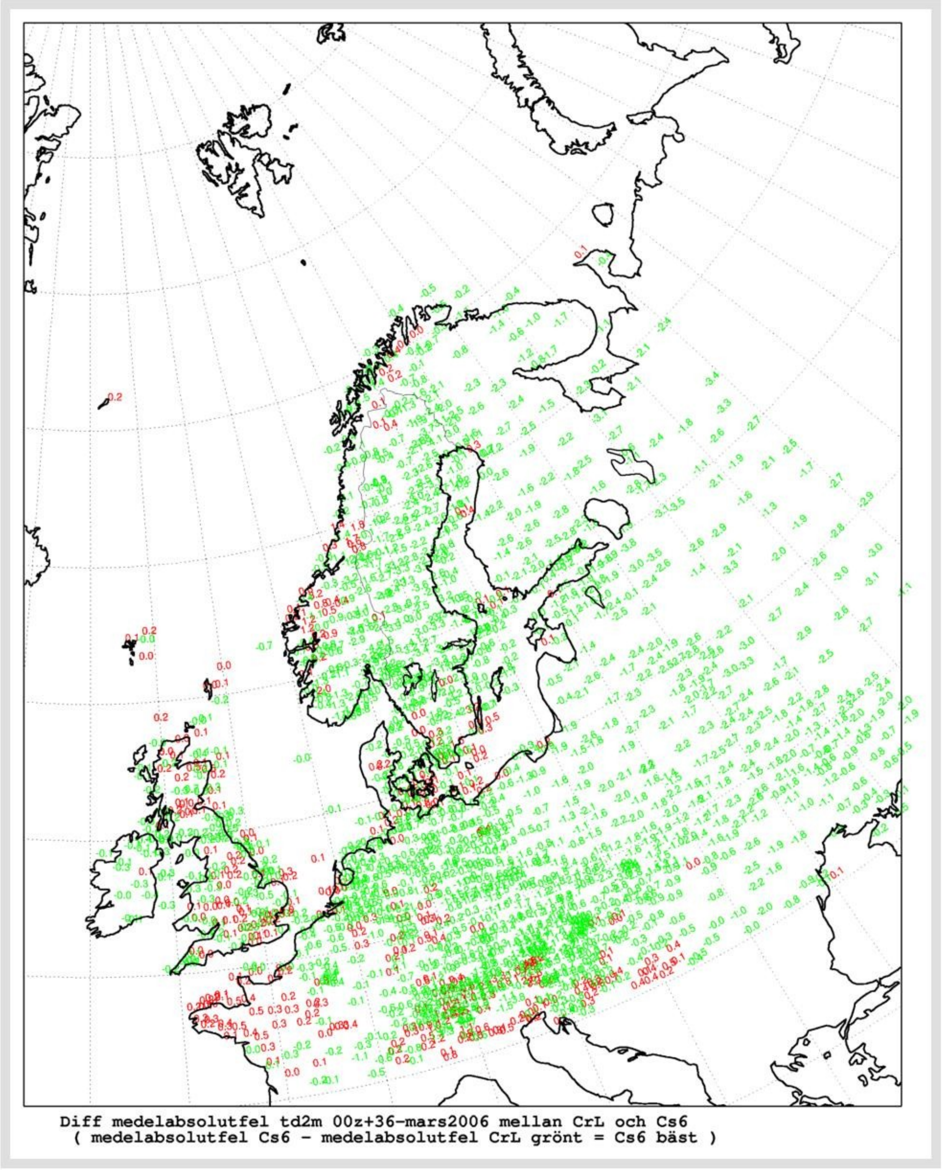


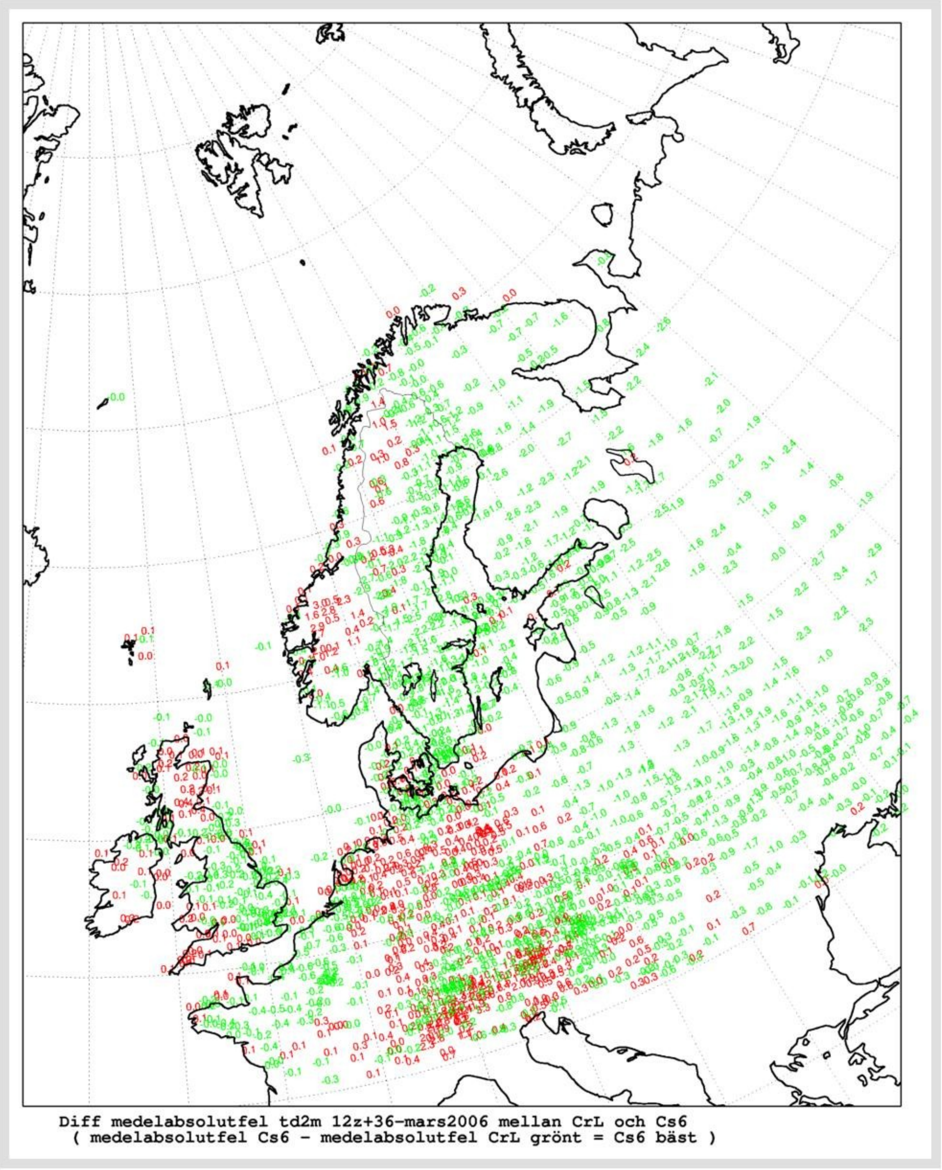
T2m bias at midnight 12Z+36H Left CrL Right Cs6



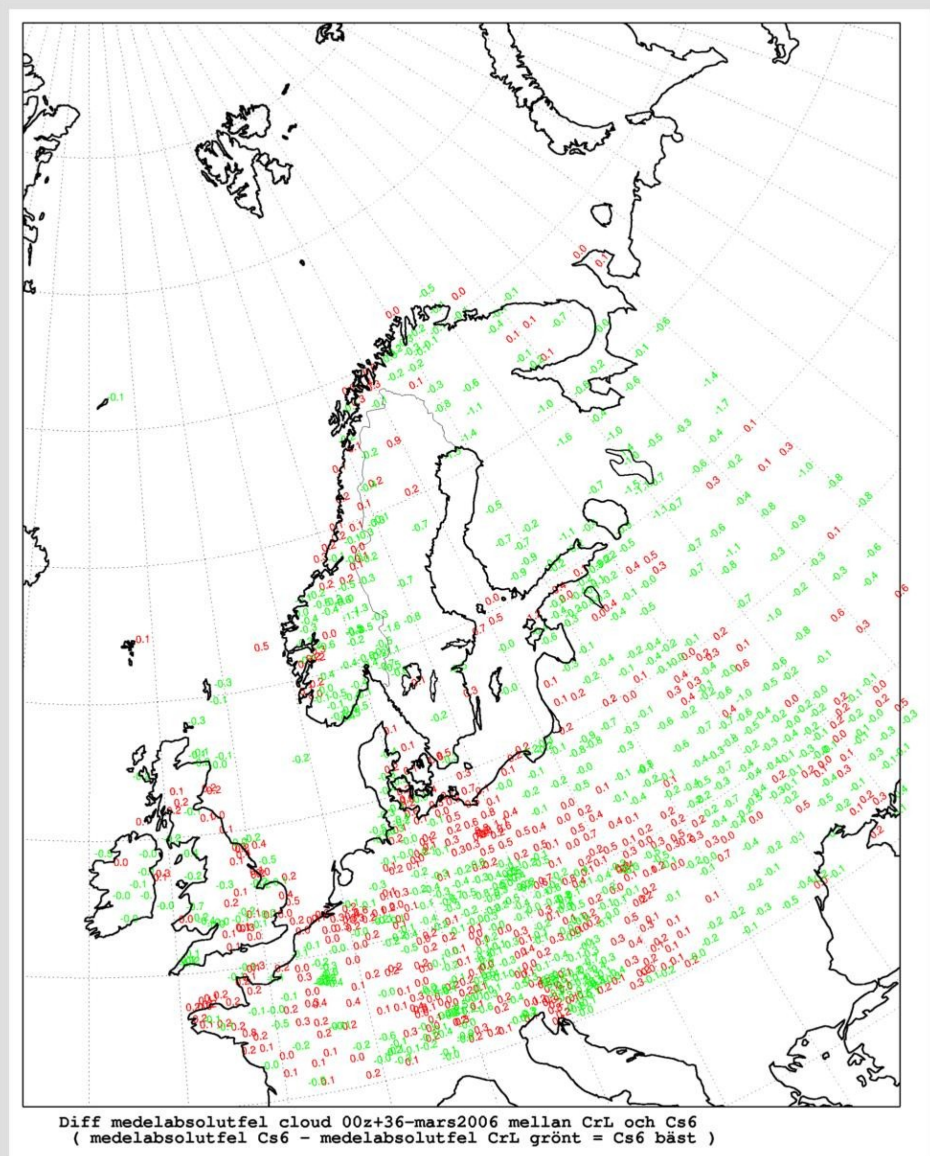


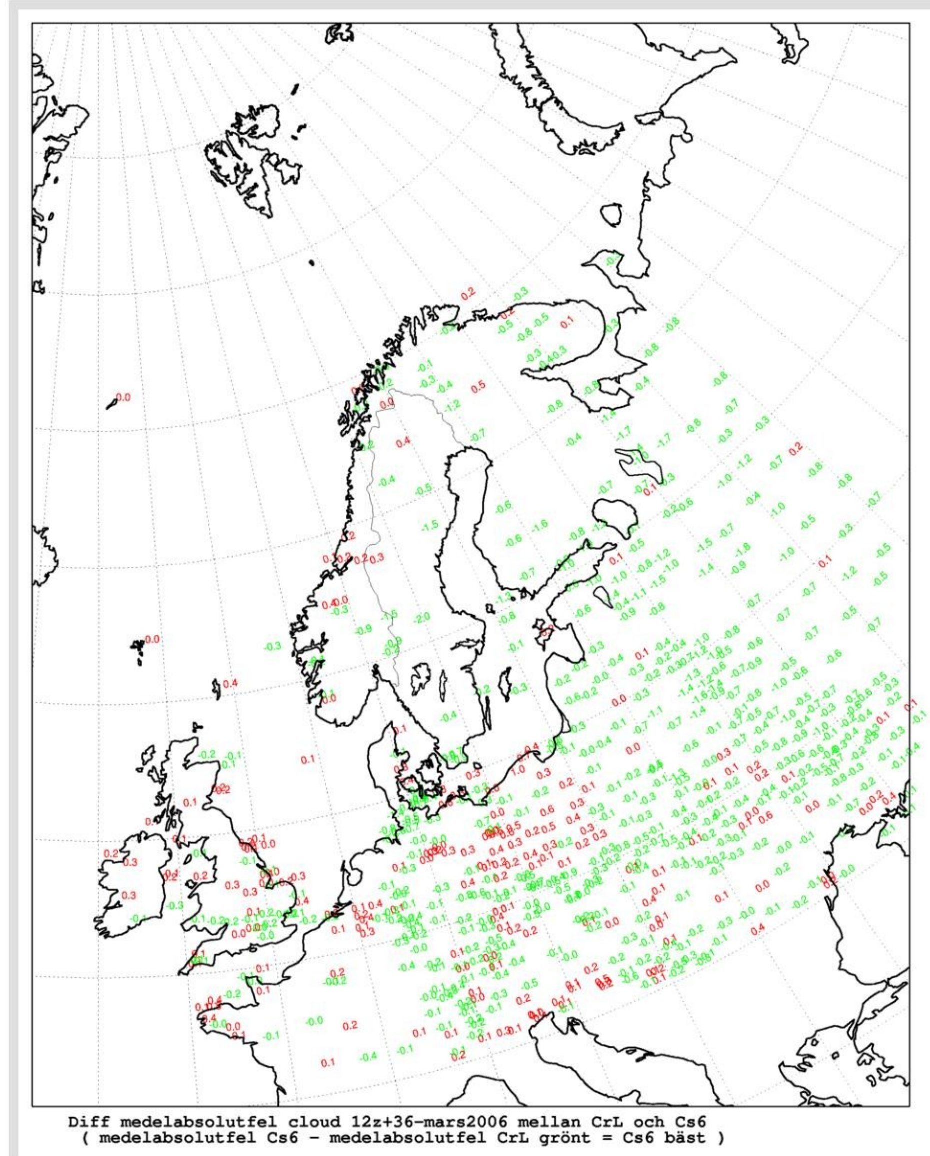
T2m meanabs differences, left at noon (00+36H), right at midnight (12+36H)





The same as previous but for Td2m



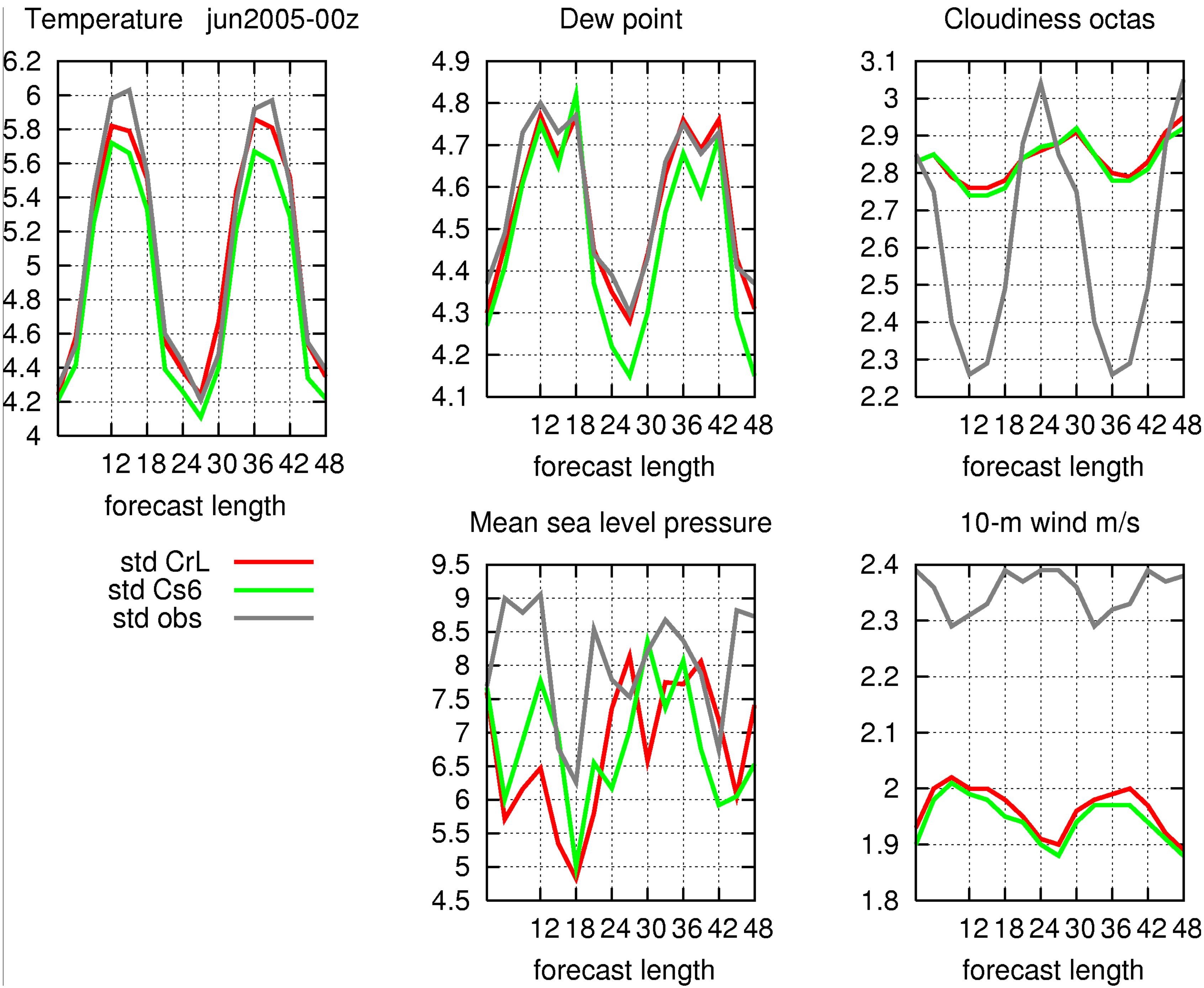


The same but for clouds

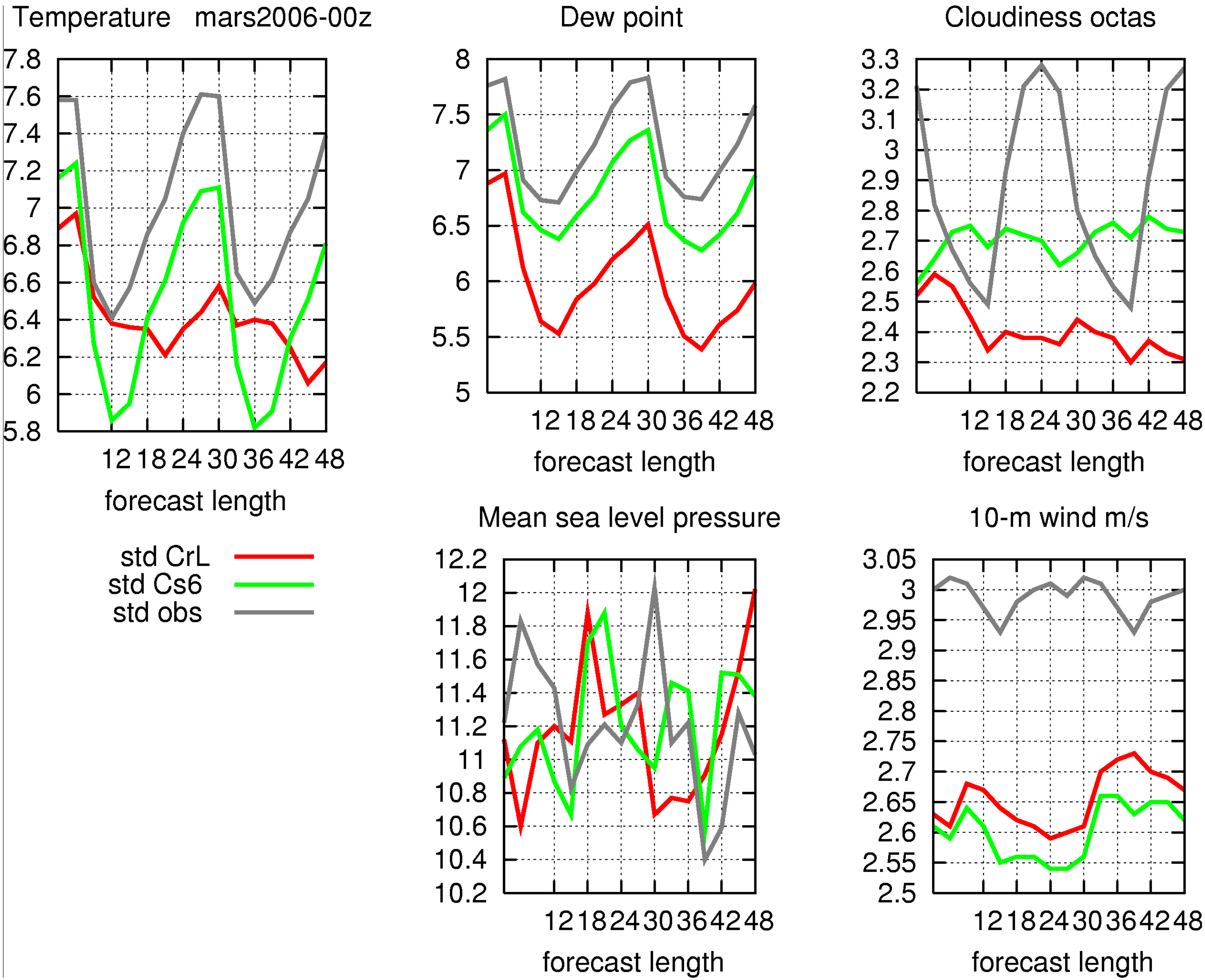
Conclusions for March 2006:

- Better T2m, better diurnal cycle
- Much better for clouds
- Much better for Td2m
- Neutral impact for surface pressure and winds

Comment: A slight cold bias in June and a slight warm bias in March
Could indicate that the change in RADIA is doubtful ??



Temperature jun2005-00z
Dew point
Cloudiness octas
Mean sea level pressure
10-m wind m/s
forecast length
12 18 24 30 36 42 48
std CrL
std Cs6
std obs


Temperature mars2006-00z
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
6.2
6
5.8
12 18 24 30 36 42 48
forecast length
std CrL
std Cs6
std obs
Dew point
8
7.5
7
6.5
6
5.5
5
12 18 24 30 36 42 48
forecast length
Cloudiness octas
3.3
3.2
3.1
3
2.9
2.8
2.7
2.6
2.5
2.4
2.3
2.2
12 18 24 30 36 42 48
forecast length
Mean sea level pressure
12.2
12
11.8
11.6
11.4
11.2
11
10.8
10.6
10.4
10.2
12 18 24 30 36 42 48
forecast length
10-m wind m/s
3.05
3
2.95
2.9
2.85
2.8
2.75
2.7
2.65
2.6
2.55
2.5
12 18 24 30 36 42 48
forecast length