The correction of initial values of temperature based on T2m measurements

Russian Hydrometeocentre

Denis Blinov
Anastasia Revokatova
Inna Rozinkina
Gdaly Rivin

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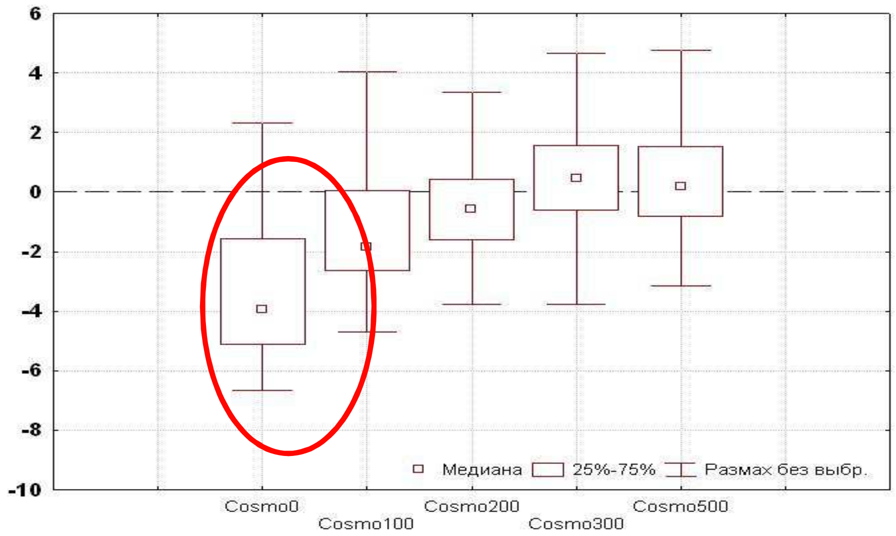
Motivation

Errors temperature at low levels exist in initial fields from GME/ICON and DAS for domain Cosmo-Ru7

The nudging assimilation system with does not help, because
- DA does not use observations of temperature at 2 m
- It does not change the temperature of surface and soil



Summer, August, 2013

Severe <u>underestimation</u> of temperature at low model levels (winter) → **Low quality of forecast**

Errors in the initial fields can occur for unknown reasons (for RHM). Therefore, we need to have a tool to change this situation - **Module correction.**

The idea

To correct initial values of temperature at low model levels by using observations (temperature at 2 meters)

Algorithm

1. Find increment of temperature at 2m ($\Delta t2m$) in point of station
2. Horizontal extrapolation of $\Delta t2m$ to the model grid
3. Vertical extrapolation $\Delta t2m$ to low model levels and surface and soil temperature
4. Result increments in soil and atmosphere levels to add to first guest

Algorithm (1/4)

Find increment of temperature at 2m (Δt2m) in point of station:

1. Find temperature at 2m (T_2M_{fg}) from first guest using logarithmic profile between temperature surface (T_S) and lowest model levels (T_10M)
2. Bilinear interpolation T_2M_{fg} to points of stations $T\_2M_{fg\_st}$
3. Find temperature increments from model and observation temperature at 2m - **Δt2m**
4. Filter values with large values **Δt2m** (15°C)**, ΔHeight** (200m)

Algorithm (2/4)

Horizontal extrapolation

Interpolation of Δt2m to the model grid

Based on Rivin G., Heise E. «Operational DWD numerical forecasts as input to flood forecasting models», Computational Science and High Performance Computing, Spinger Berlin / Heidelberg, p. 83-97, 2006.

Cressman scheme:

For each grid point 3 point neighborhood with different effective radiuses have been chosen (10, 40, 70 and 110 km)

For each station *k*, in the point neighborhood horizontal distance from the grid (ρh) and ρv difference in height therebetween were calculated. Then *factor (coefficient)* by which the temperature at the station *k* taken into account during the interpolation was determined.

$$w_k^m = h_k^m v_k^m,$$

$$h_k^m = 0.5\ [a\ 1 + \cos\ (\pi\, \rho_h^{k,m}/R_{scan})],$$

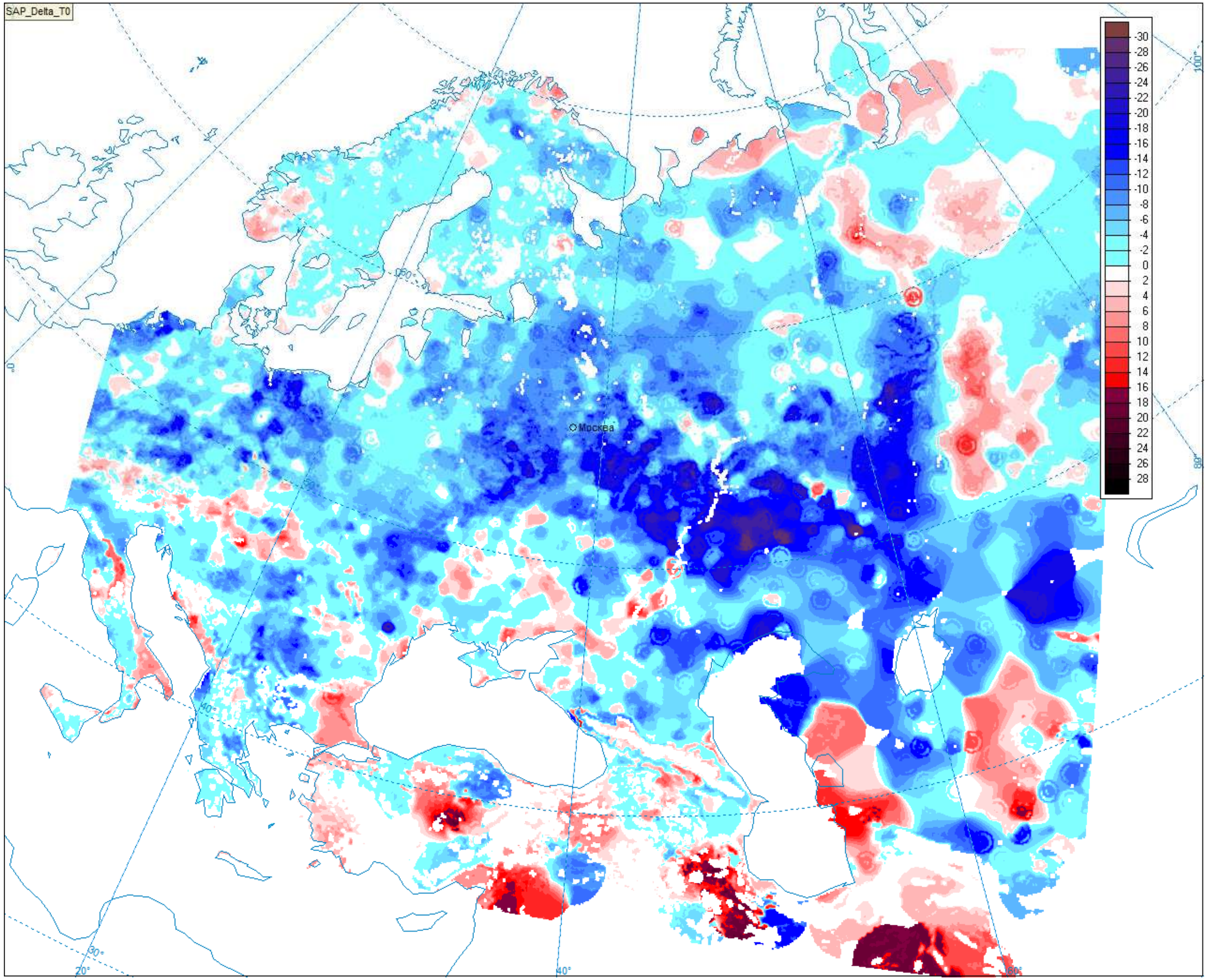
$$v_k^m = 0.5\ [a\ 1 + \cos\ (\pi\, \rho_v^{k,m}/H_{max})\ /\ (1+0.8\, \rho_v^{k,m}/H_{max})],\quad H_{max} = \max(\rho_v^{k,m},\ Z_{max}).$$

If sum of Σw > *threshold values*, than $P_m = \Sigma k(w_k^m P_{obs,k})/\Sigma_k w_k^m$

Example horizontal extrapolation **Δt2m,** domain CM-Ru7

Δt2m from

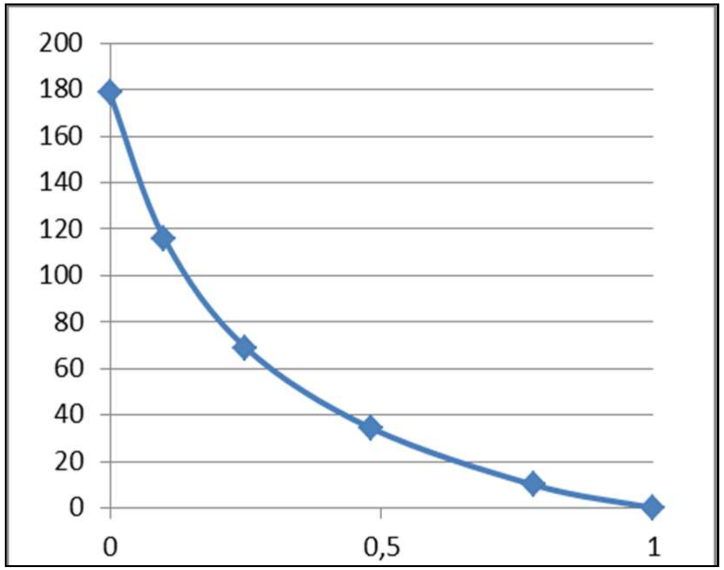
-10°C
to
+10°C



Algorithm (3/4)

Correction of temperature al low model levels:

- Assume that at GME analysis field temperature (T) at 925 hPa (~550 m) is pretty exactly (due-to using of atmospheric sounding data)
- Thus we need to correct T from the surface to 550 m. Correction increment decrease from surface to 550 m (Influence of t2m decreases with H)
- Monin-Obukhov theory (logarithmic temperature profile)



Dependence of coefficient for T correction from log H

$$K_l = \ln\left(\frac{H_{top}}{H_l}\right) \Big/ \ln\left(\frac{H_{top}}{H_1}\right)$$

During the experiments the optimal amount of corrected levels was determed.

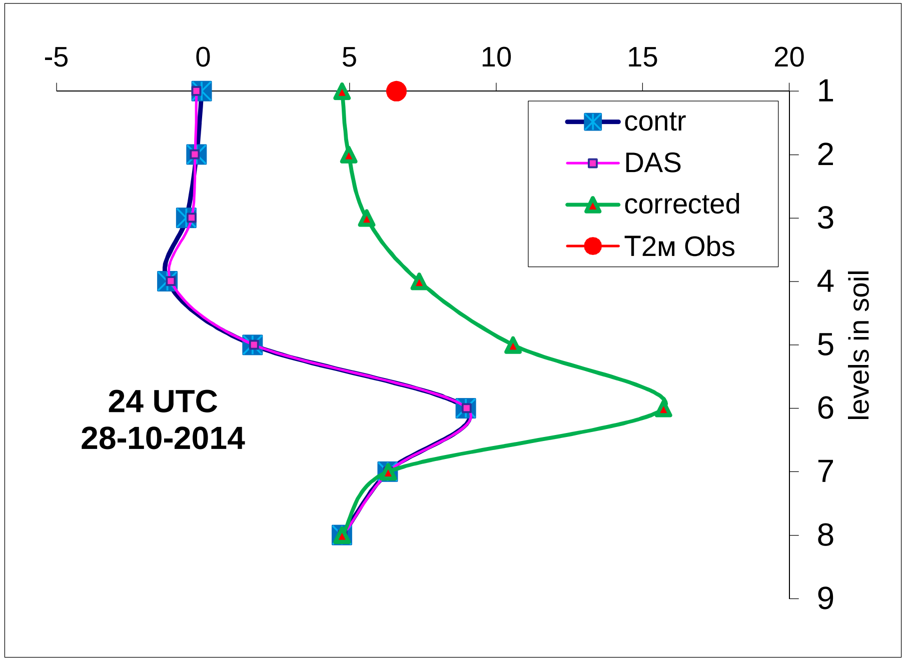
5 levels from surface ~ 120-150 m

Algorithm (3/4)

Soil layers

Vertical coefficients in the soil are calculated via the Fourier coefficients

$$K_l = \frac{z_{bottom} - z_{l+1}}{z_{bottom} - z_1}, \ \text{l=1,…,7 (bottom=7)}$$



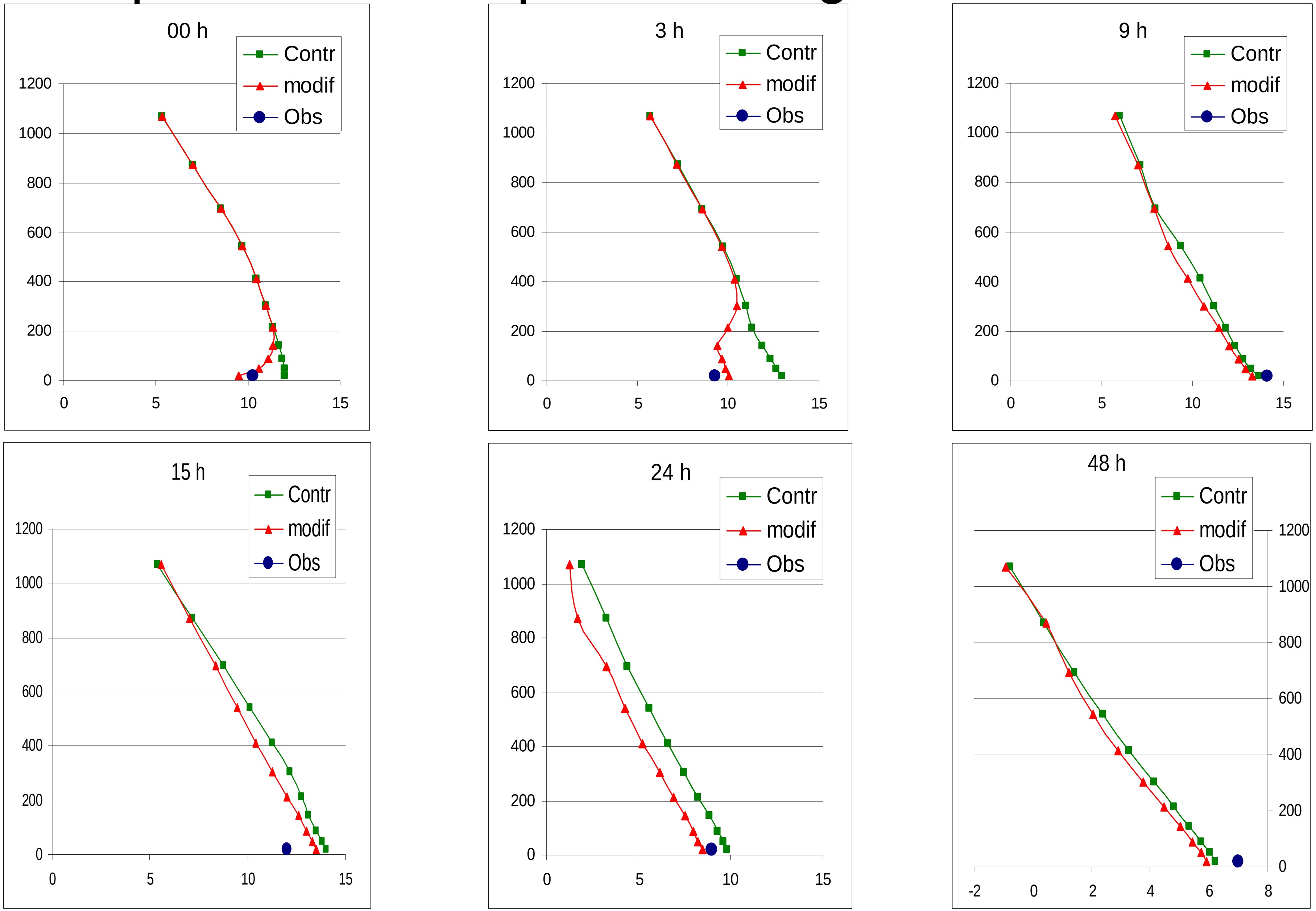
Algorithm (4/4)

Initial conditions are corrected:

- atmosphere temperature T_{lev} (level =1-5 from surface)
- surface temperature T_S, T_SNOW
- soil temperature T_SO_{lev} (level=1-6)

external parameters

Dependence of T profile changes on forecast time



List of experiments

1. **Contr** – control experiment without observation (initial data from GME)
2. **DAS** – initial data from DAS
3. **Corr** – initial data from GME + module correction
4. **Corr_DAS**: Experiments with couple system module correction and DAS (3) corr + (2) DAS
    1. Full correction: atmosphere and soil
    2. Only soil temperature correction

For verification we selected cases with large error of initial field of temperature

CONSORTIUM FOR SMALL SCALE MODELING COSMO

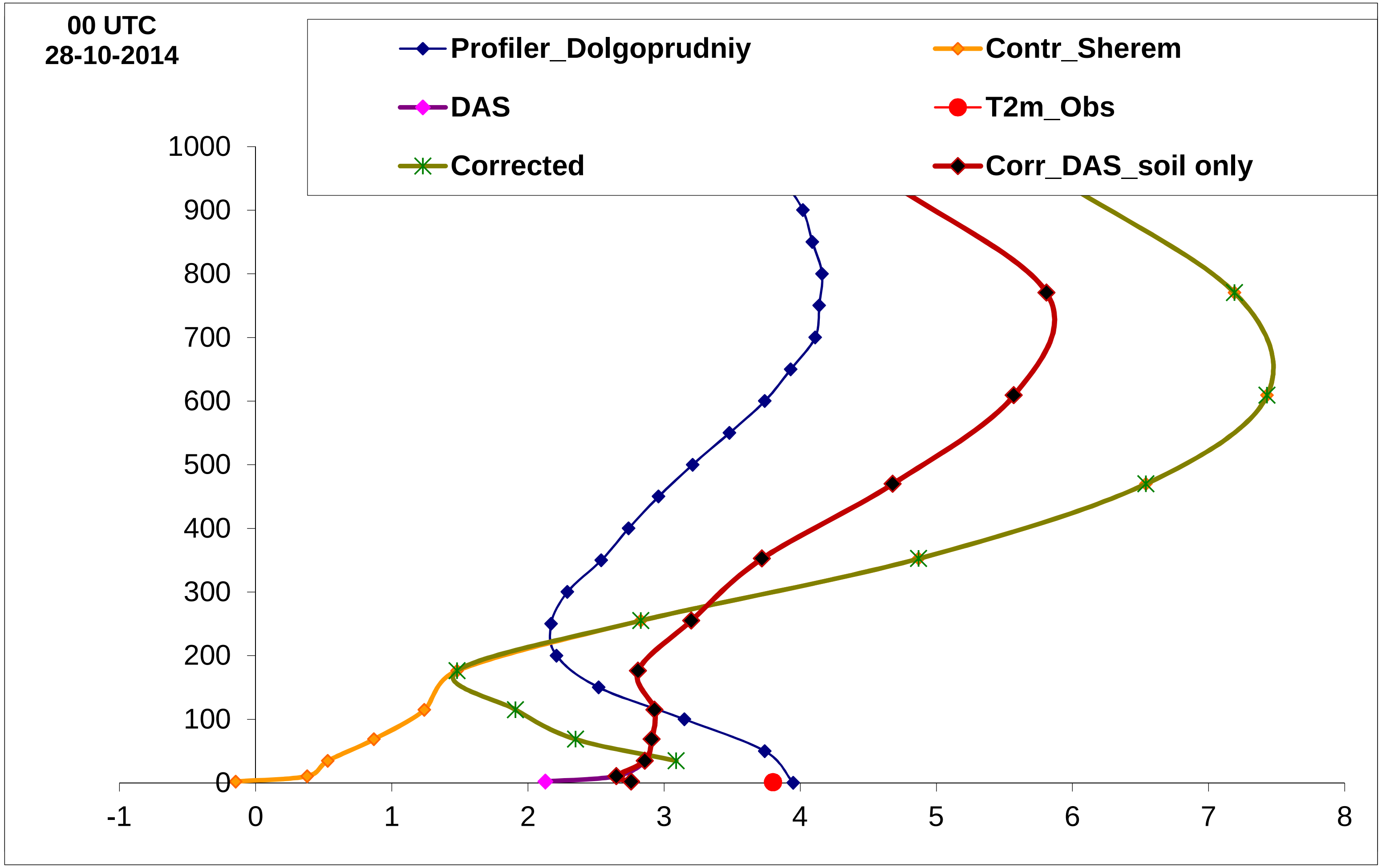
Scheme of assimilation system based on nudging

Namelist variable	DA-M 07	RU 07 km
data_ini	GME — 3 h	DA-M 07
data_bd	GME — 3 h	GME + 0 h
hstop	3	78
number of runs	8	4
cut-off time	02:35:00	02:50:00
hnudgend	7	4
	DA	nudgcast

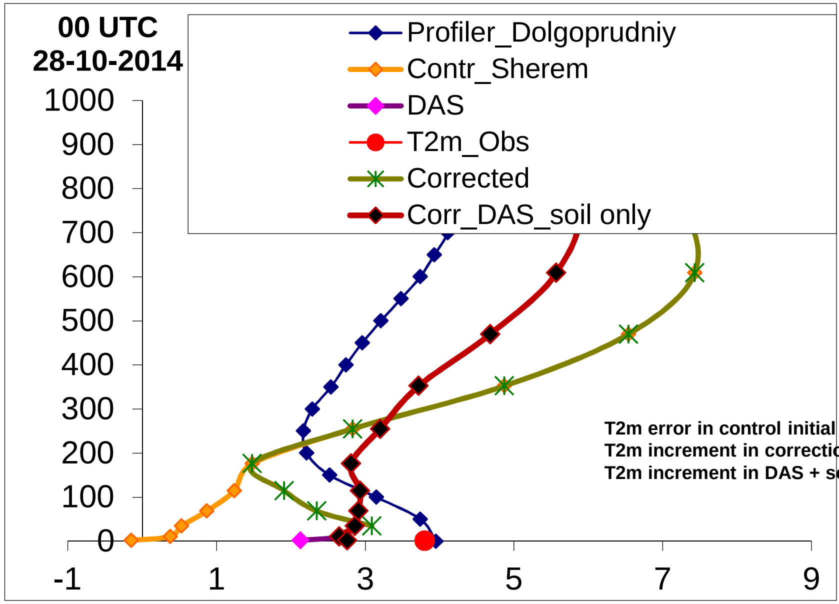
domain	grid model	OBSERVATIONS T_2m (TEMP)	wind_10m, pmsl, Td_2m (TEMP, SYNOP)
ETR07	434.000	119	2700
CFO02	197.400	10	190
SFO02	197.400	6	170
VFO02	211.500	9	161
ENA13	500.000	295	4368
SIB13	90.000	78	1006

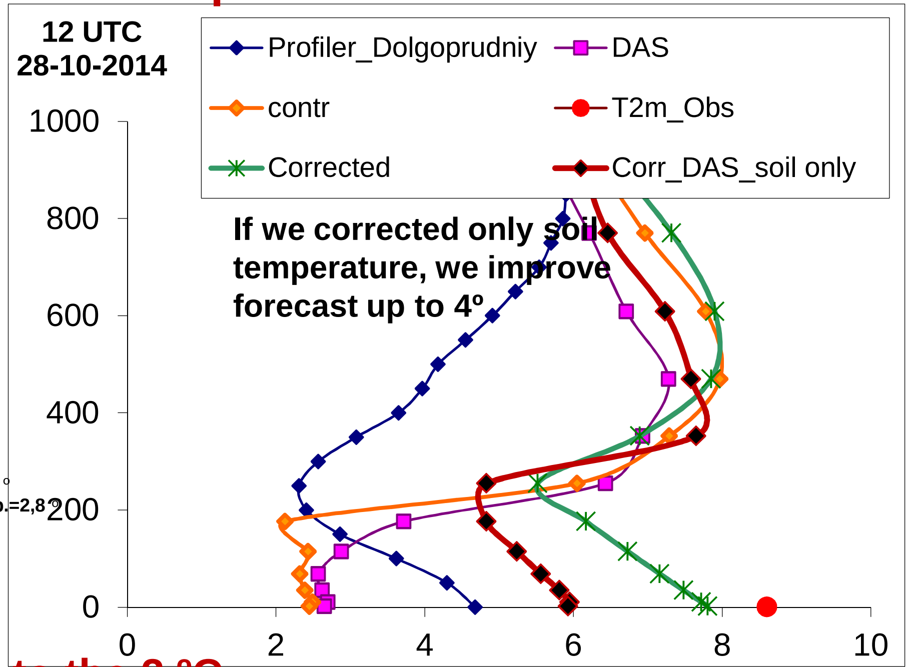
Model grids and used observations

Correction error temperature

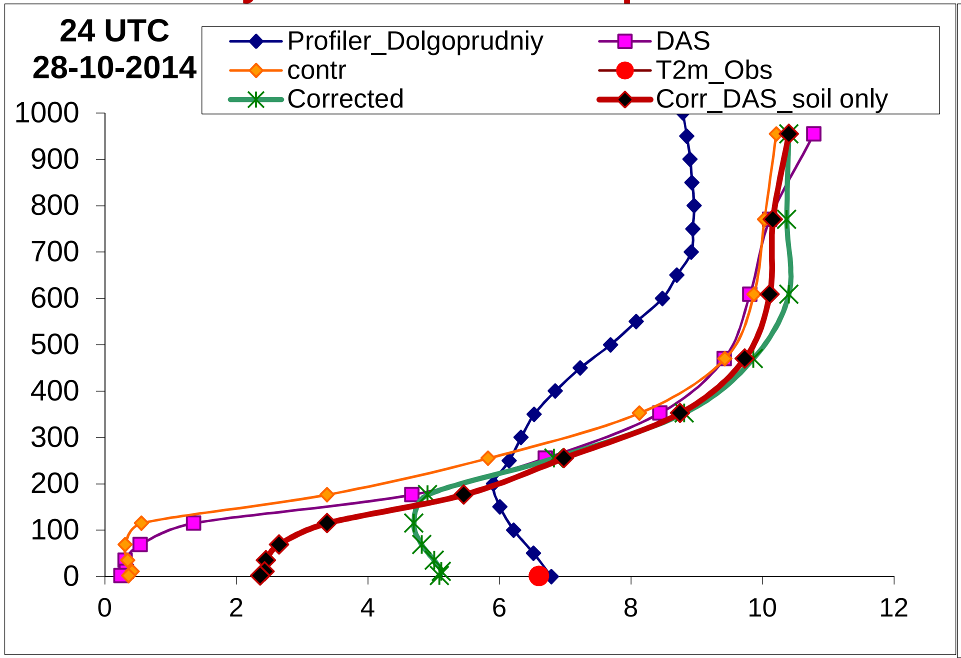


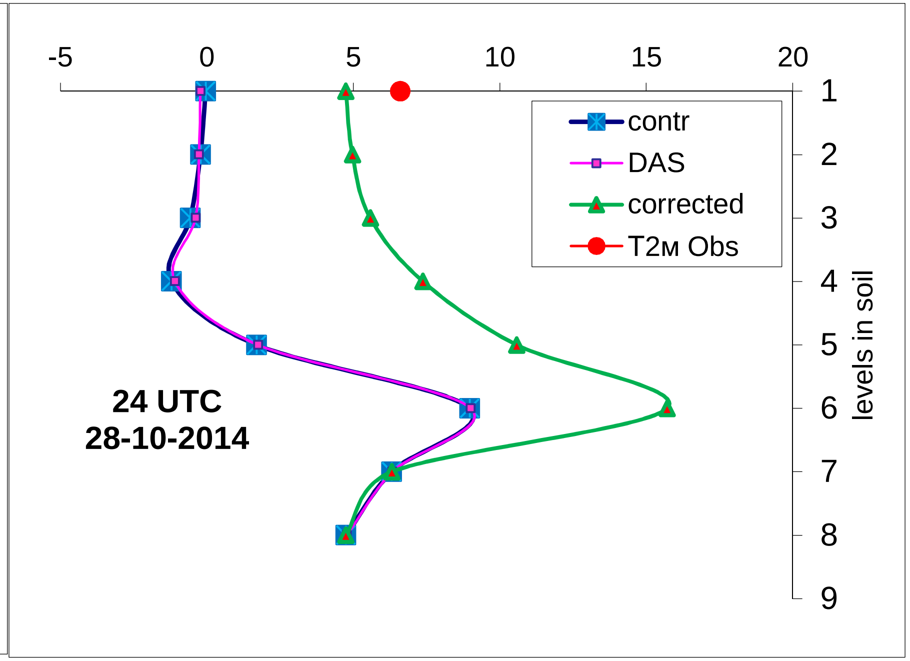
Soil memory and influence of soil temperature to the T2m



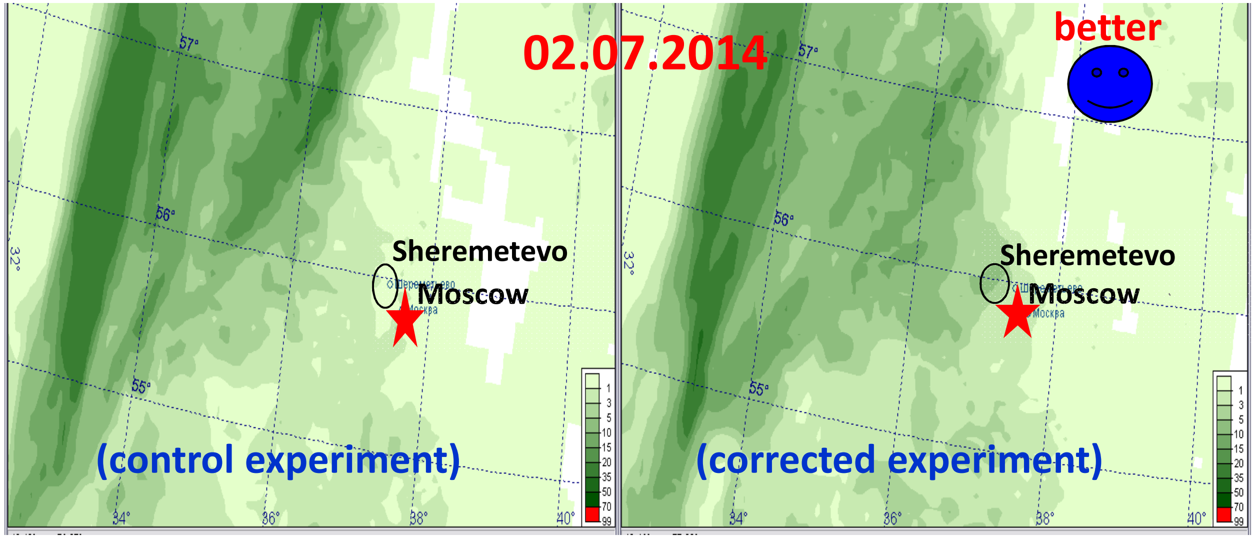


Soil memory after 24 hours improves forecast to the 2 ºC

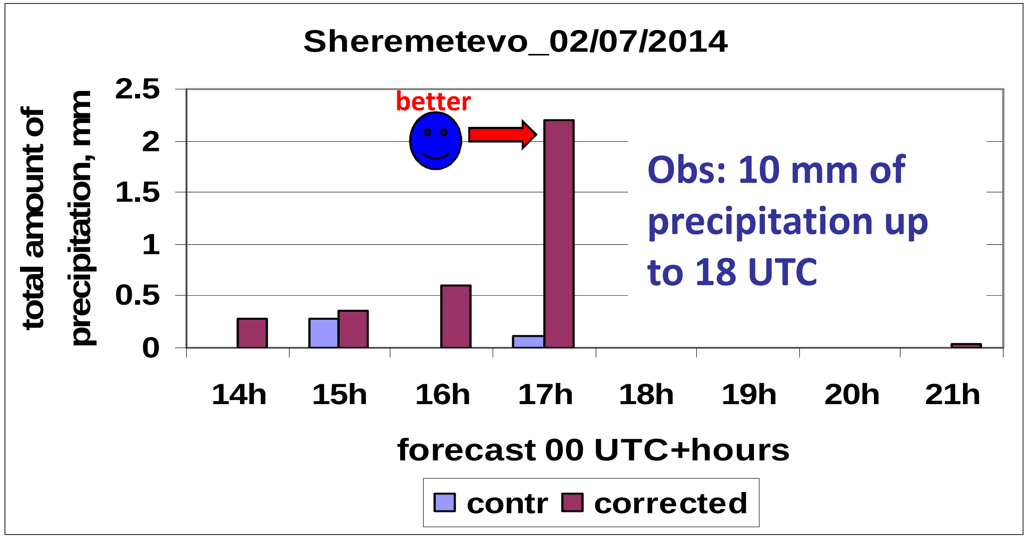




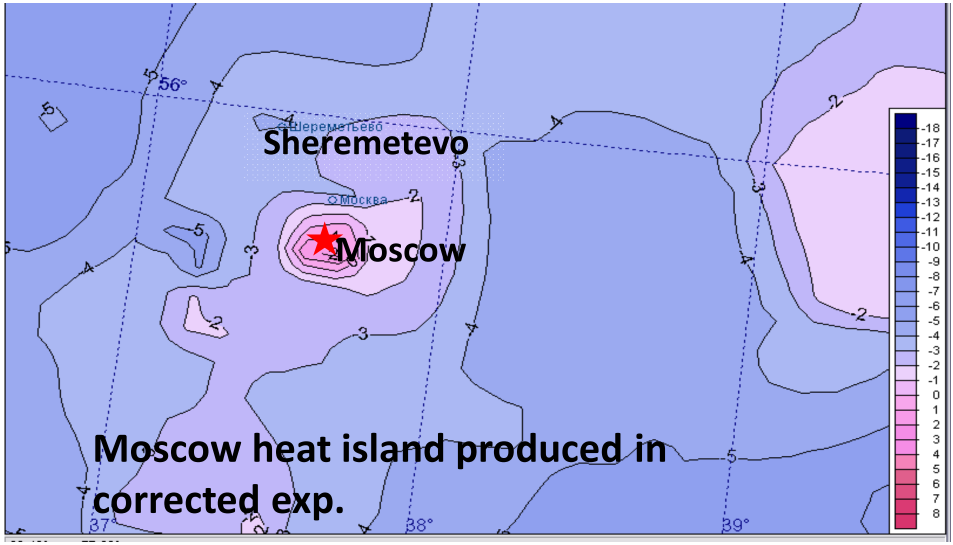
Influence of temperature correction on convective precipitation



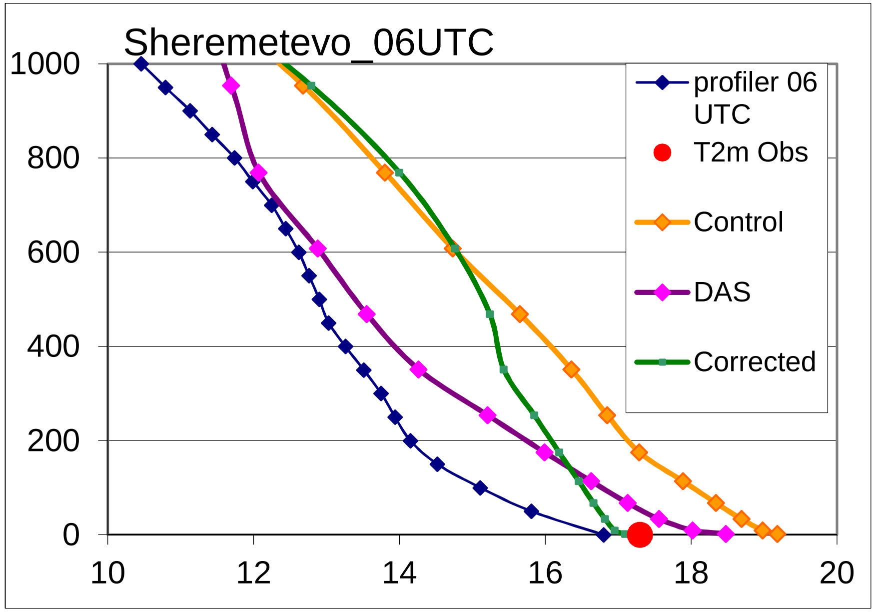
Total amount of precipitation 02.07.2014 00UTC+16hh

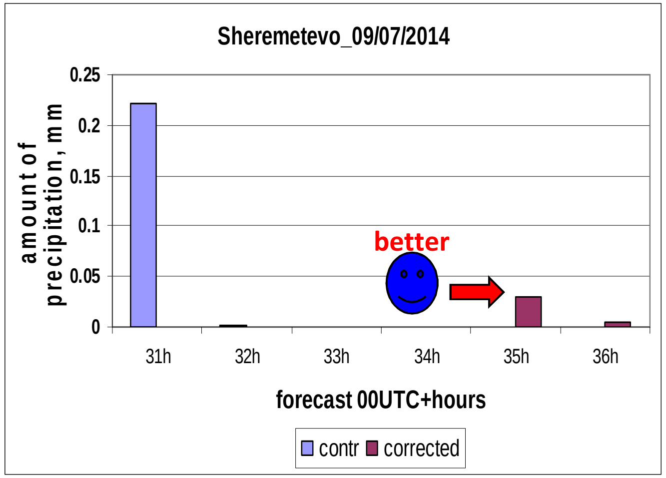


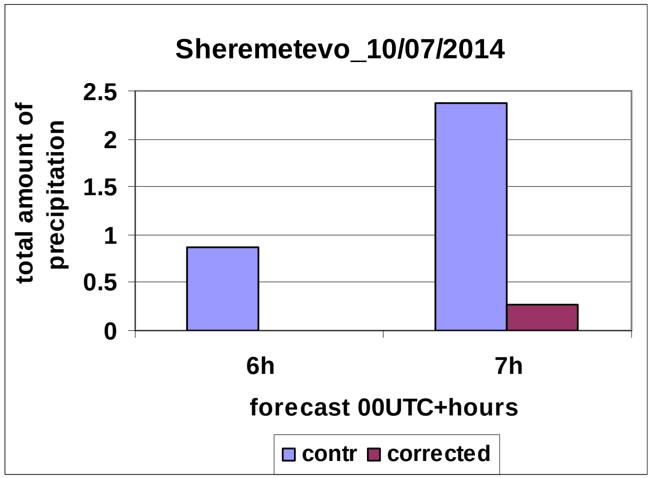
10.07.2014



Temperature increment for 10.07.2014 corr_T_40 - GME_T_40

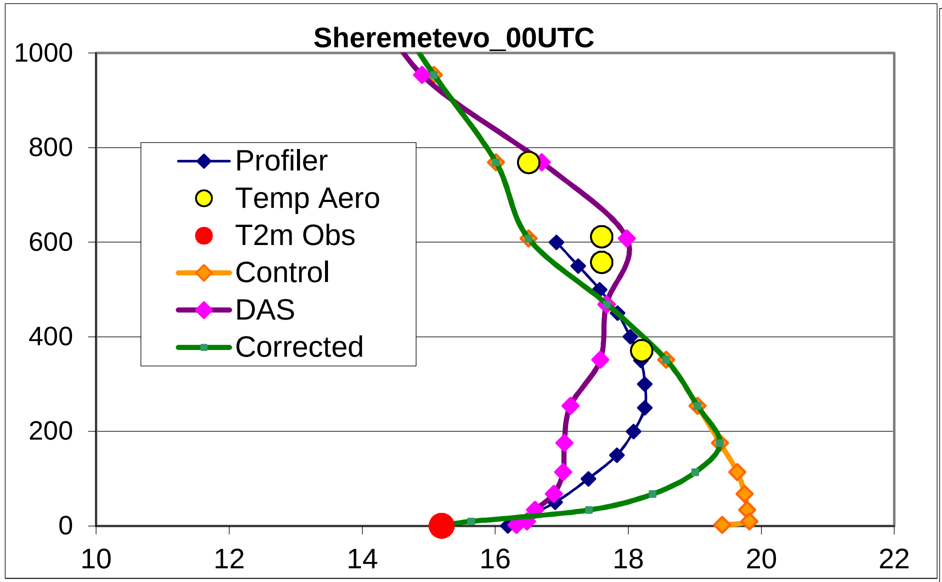


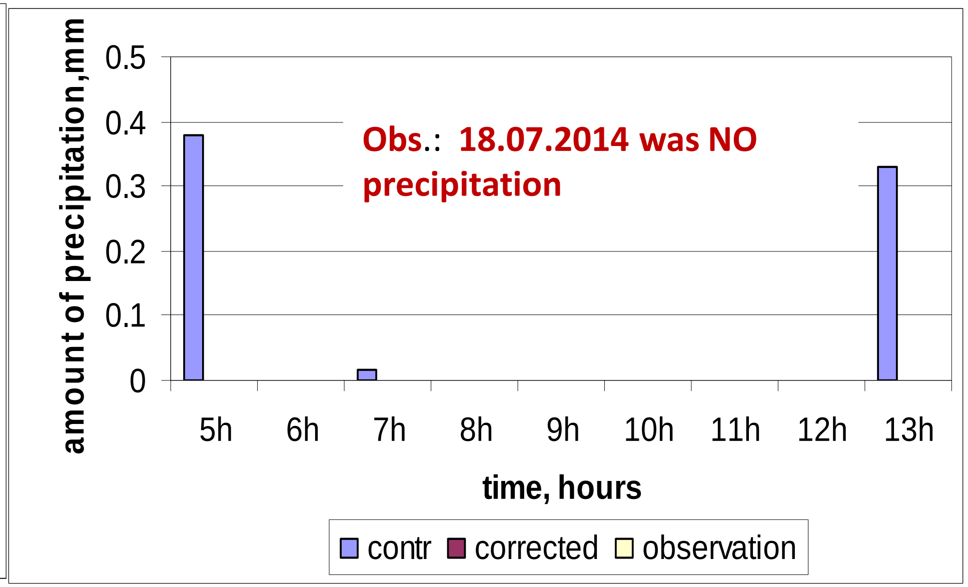


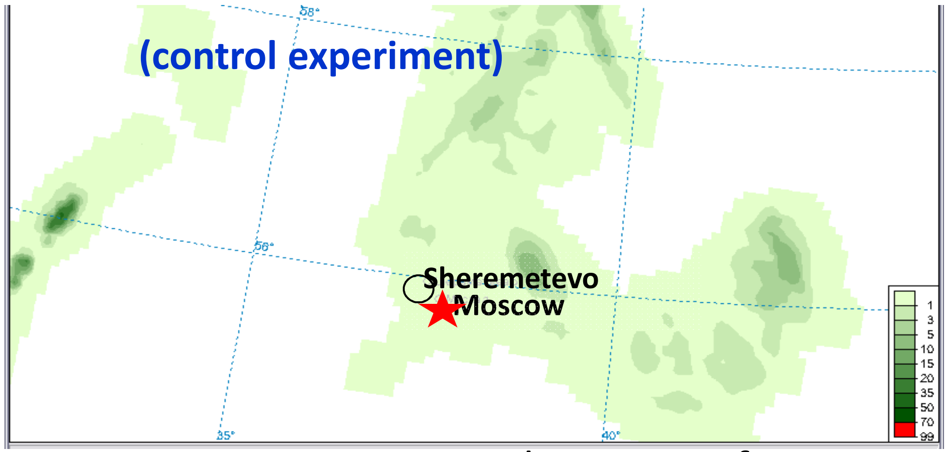


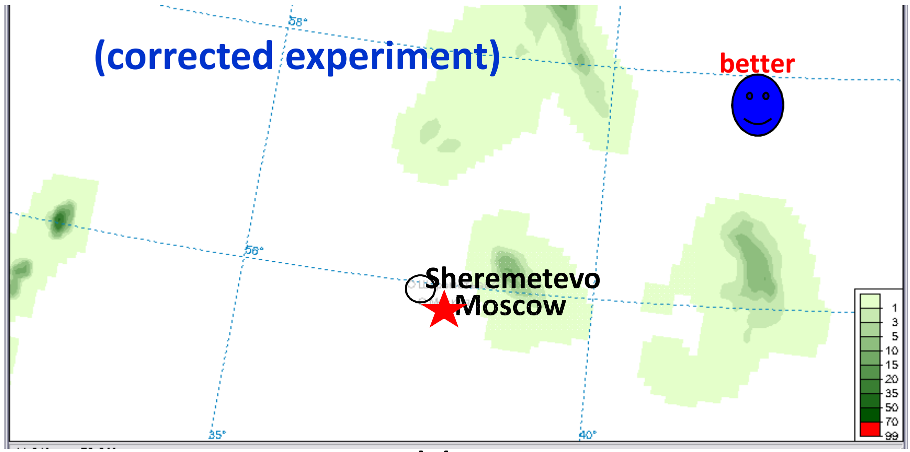
Obs.: **18UTC 10.07.2014 precipitation = 0.1 mm**, thus in control exp., started from 09.07 00UTC+31…36 hh and control exp., started from 10.07 .2014 00UTC+ 6,7 hh precipitation were overestimated. **In corrected exp. – better.**

18.07.2014



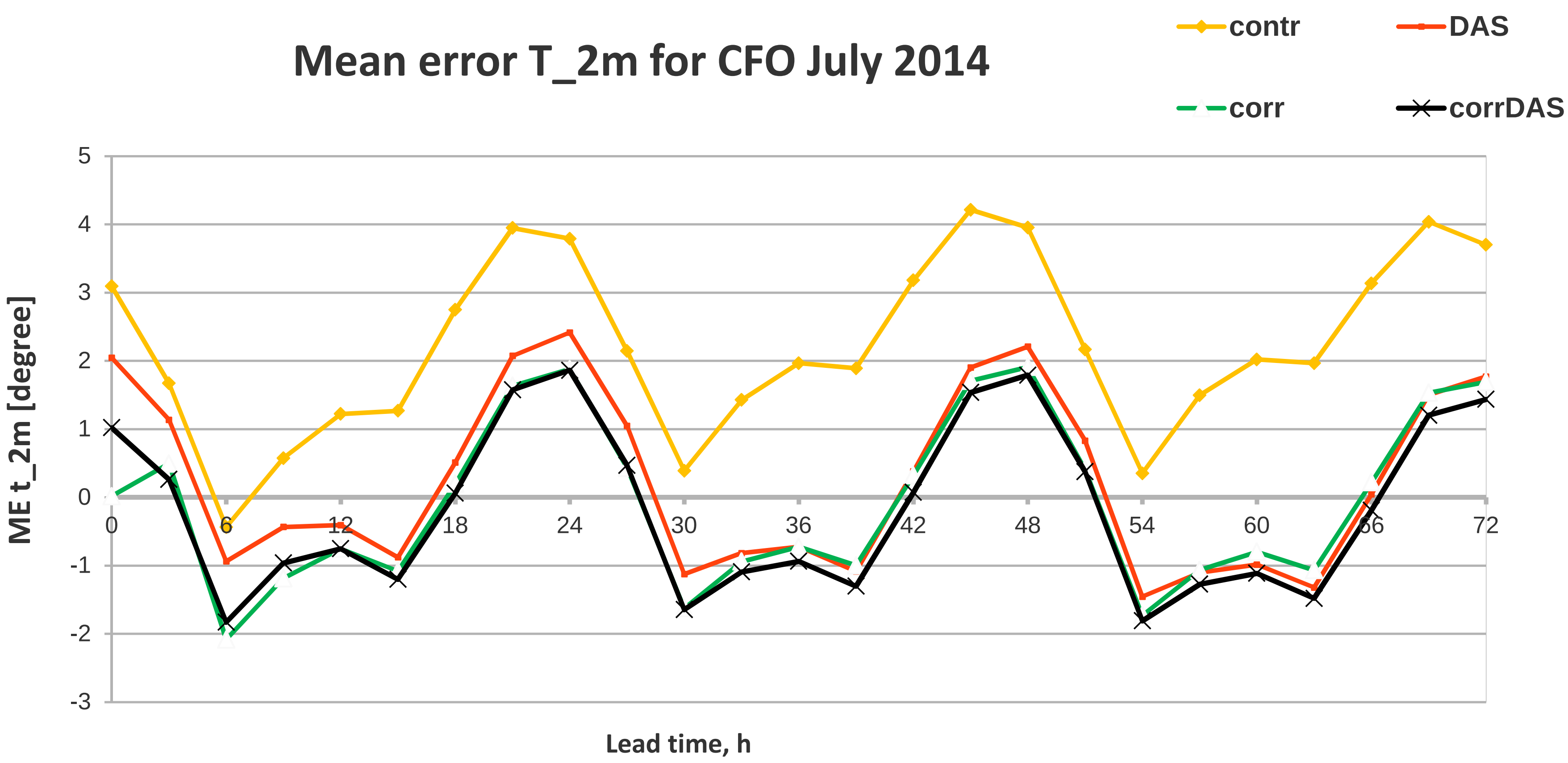






Total amount of precipitation 18.07.2014 00UTC+5hh

Verification temperature at 2m, July 2014



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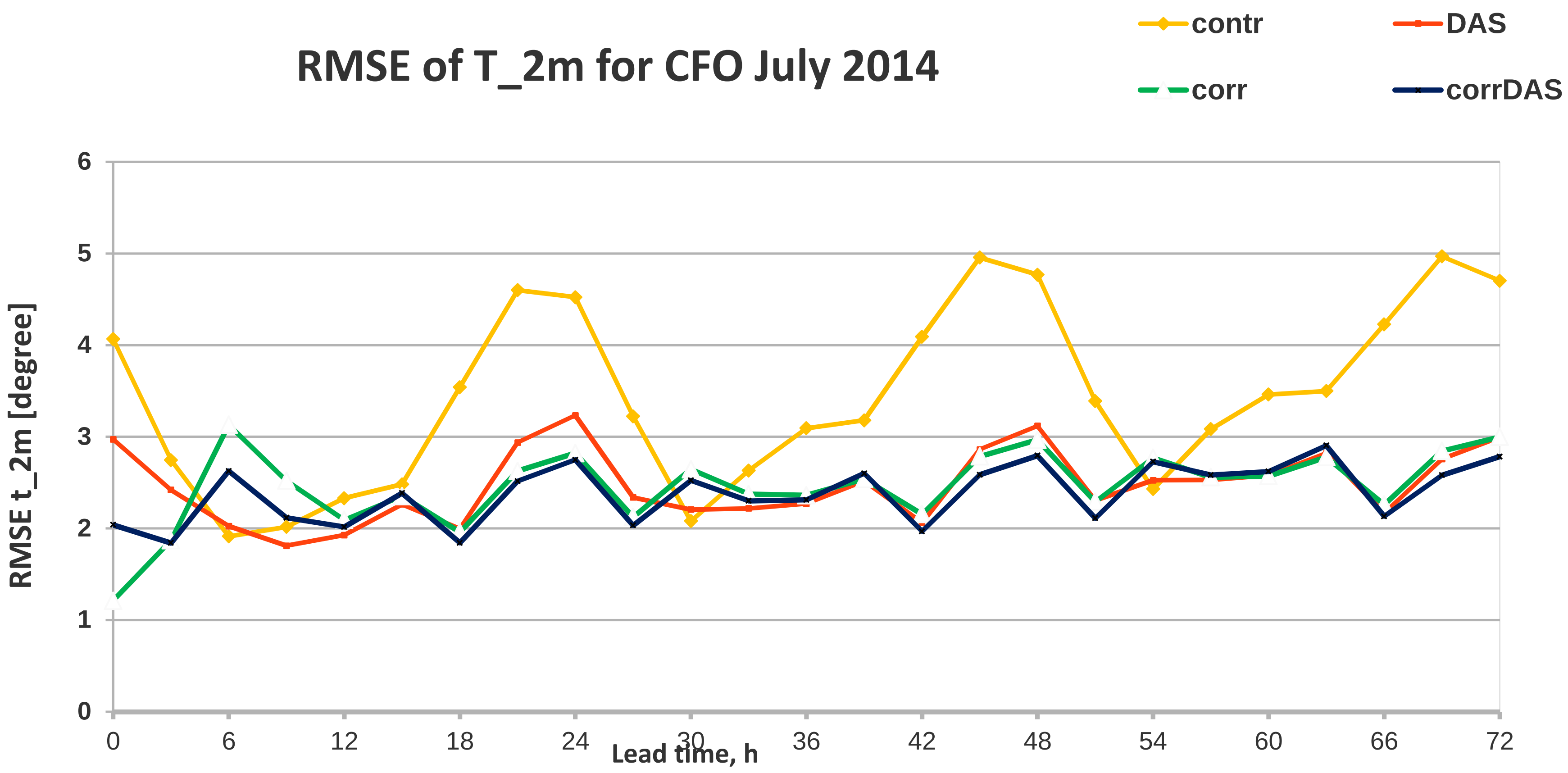
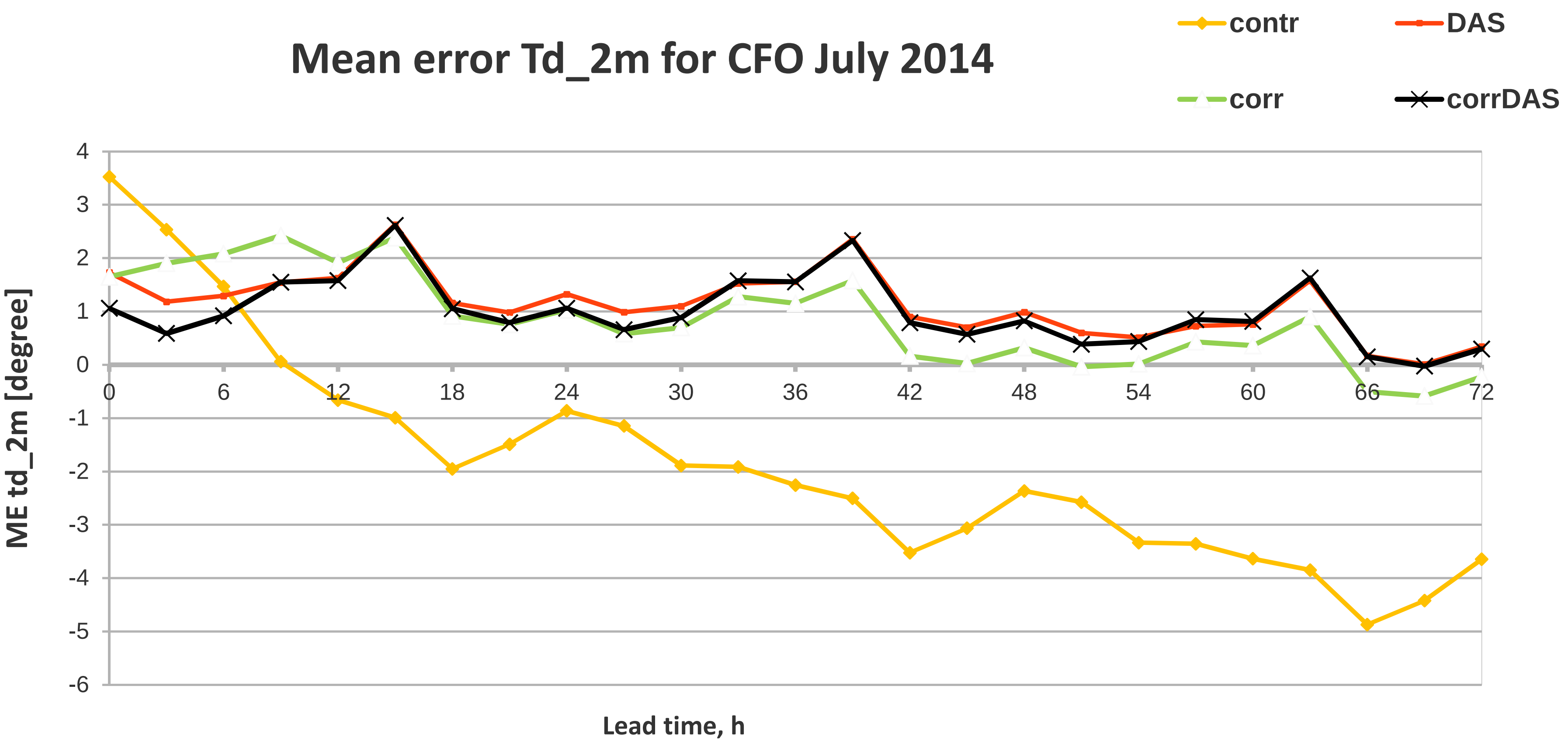
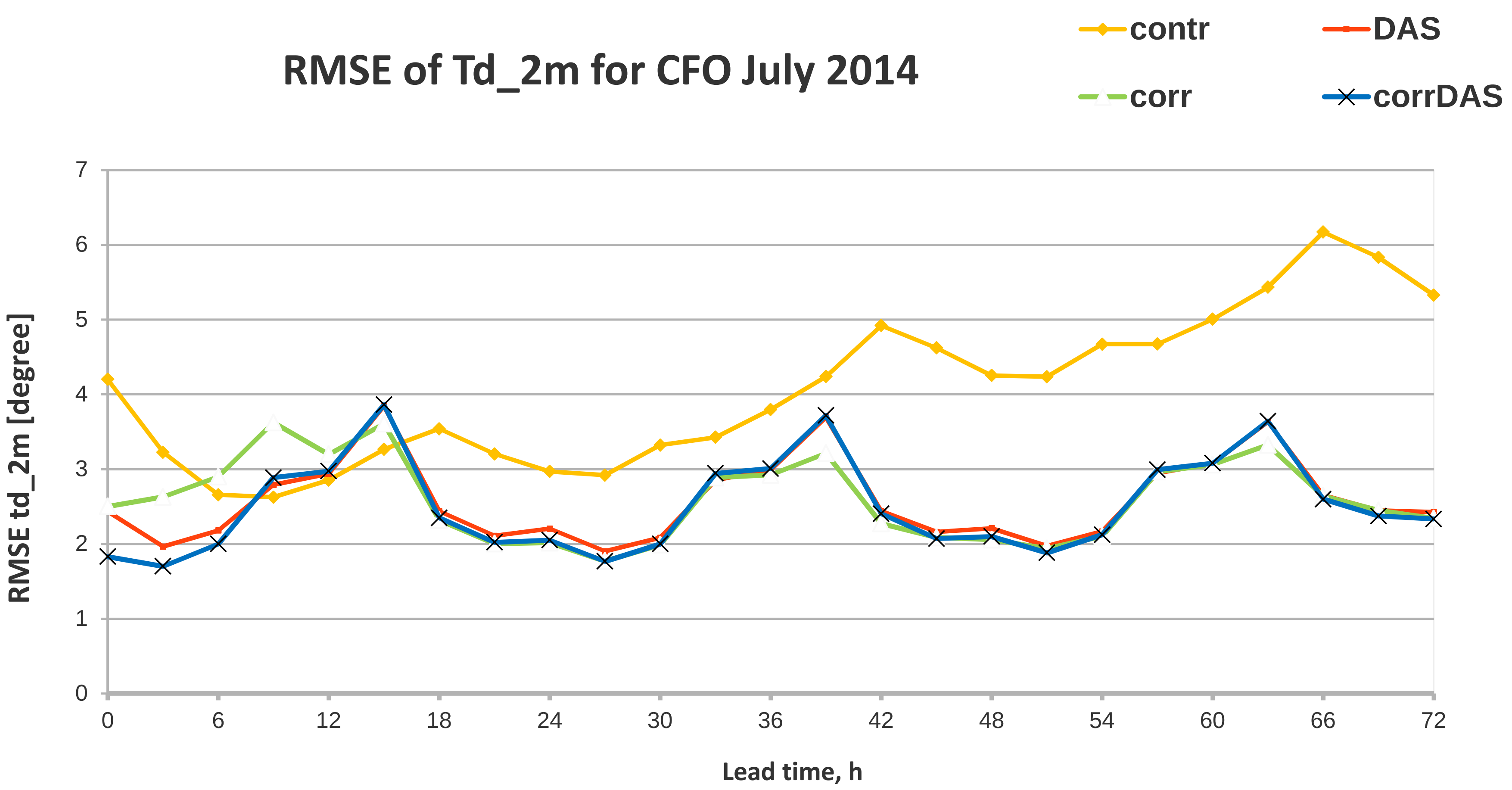


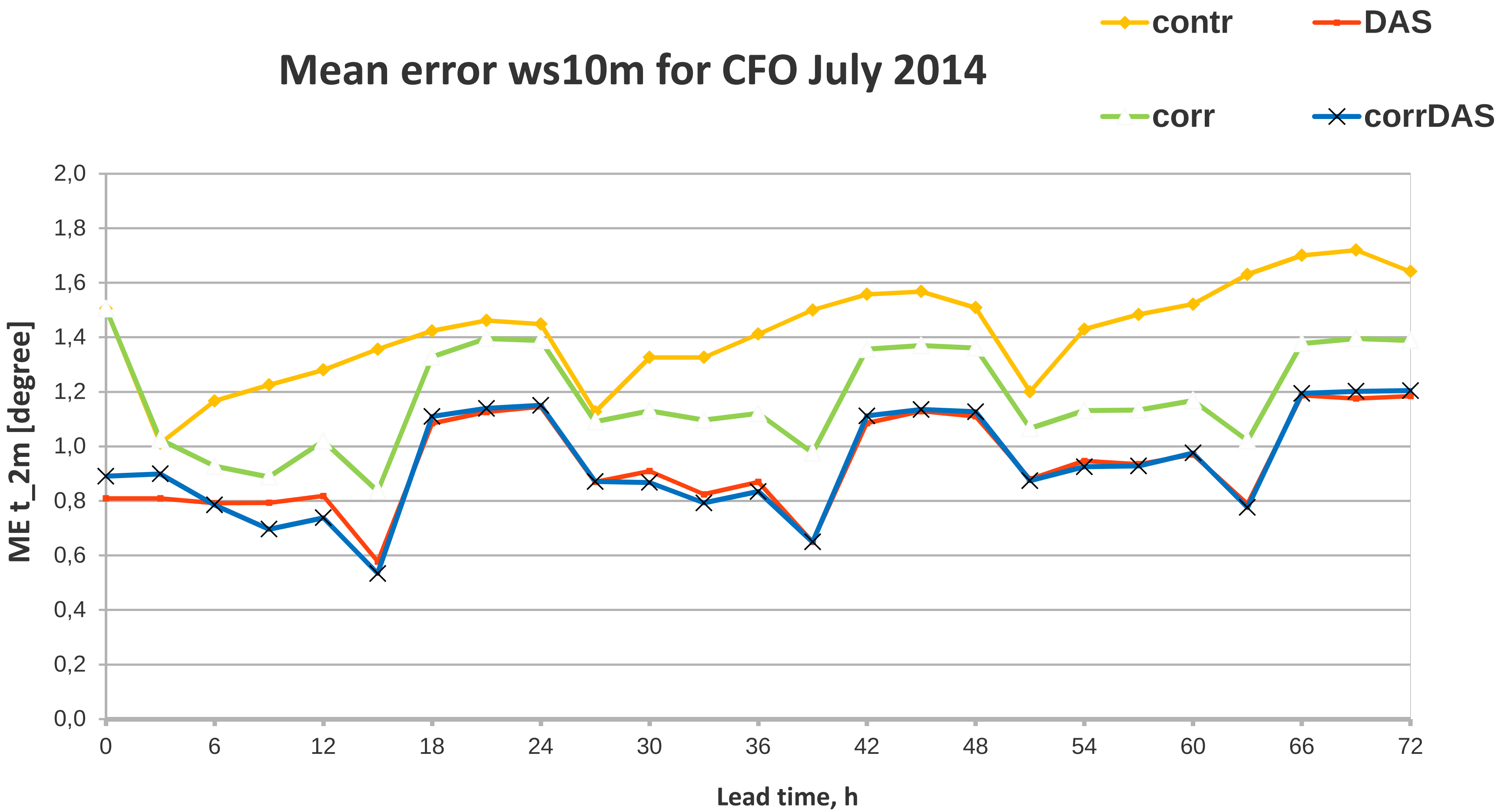
Verification July 2014. CFO
Dew point at 2m



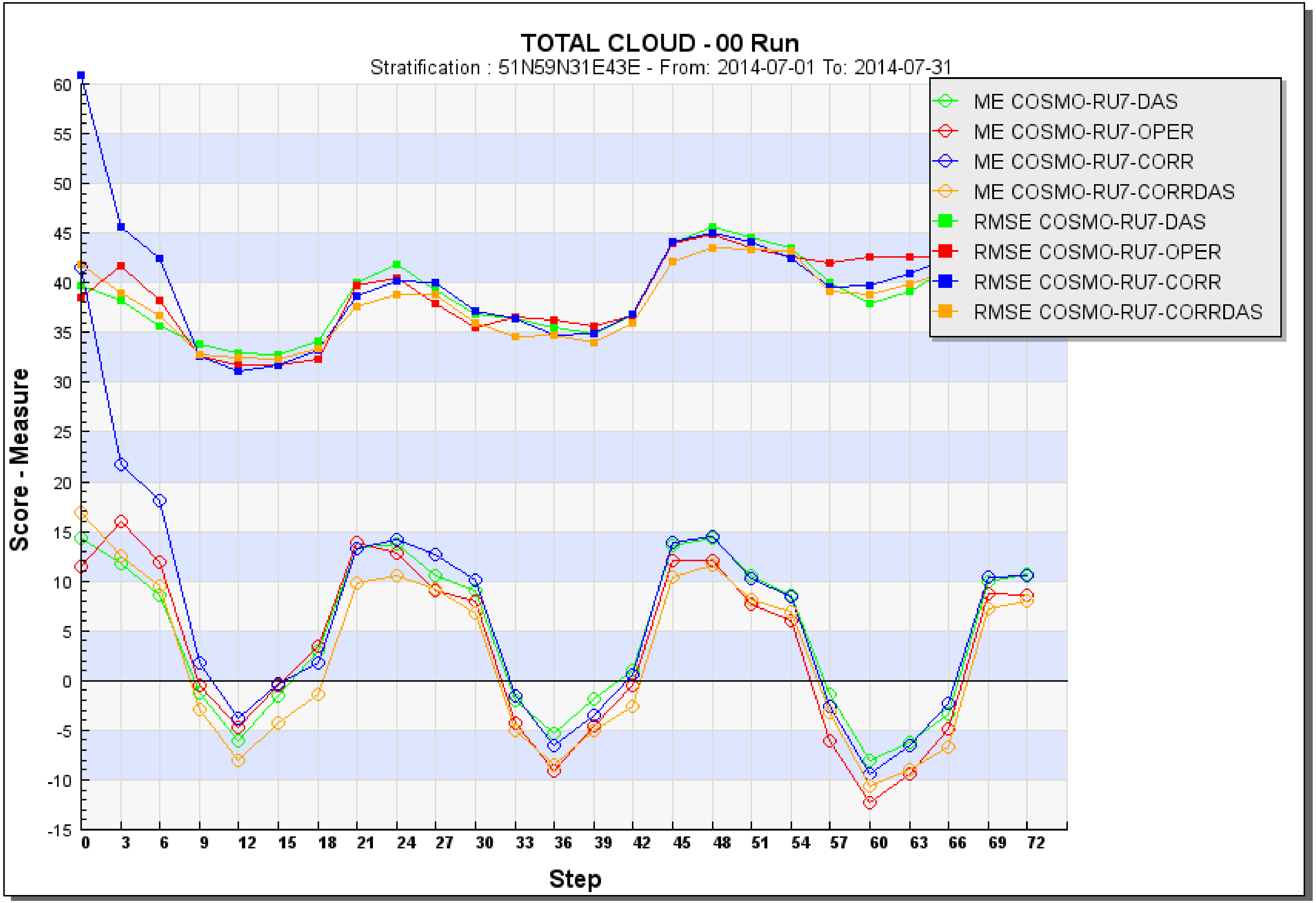
Verification July 2014. CFO
Dew point at 2m



Verification July 2014. CFO
wind speed at 10m



Verification July 2014. CFO
Total cloud cover



Conclusions

- The “module correction” was tested and show good results: initial field of temperature can be improved, and quality of t2m forecast increases.
- The combination with the system of assimilation leads to improved temperature and dew point at the initial time.
- Estimates of the other fields (wind, pressure, cloud cover) are the same as that with field from data assimilation.
- In some cases convective precipitation can decreased or increased due to changes in temperature profiles. Large-scale precipitation configuration almost does not change.

Outlook

- Verification of precipitation (convective) for long period
- Experiments for winter season with snow cover
- Tuning coefficients, weights, number levels of correction
- Adjustment of dew point.

Thank you for your attention!