The correction of initial values of temperature based on T2m measurements

Russian Hydrometeocentre

Denis Blinov
Anastasia Revokatova
Inna Rozinkina
Gdaly Rivin

COSMO GM2015, Wroclaw, 7-10 September
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 underestimation 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 ($\Delta t_{2m}$) in point of station
2. Horizontal extrapolation of $\Delta t_{2m}$ to the model grid
3. Vertical extrapolation $\Delta t_{2m}$ 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 ($\Delta t_{2m}$) 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 - $\Delta t_{2m}$
4. Filter values with large values $\Delta t_{2m}$ (15°C), $\Delta$Height (200m)
Algorithm (2/4)

Horizontal extrapolation

Interpolation of ∆t2m to the model grid


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 \( \rho_h \) and \( \rho_v \) difference in height therebetweeen were calculated. Then factor (coefficient) by which the temperature at the station \( k \) taken into account during the interpolation was determined.

\[
w_k^m = h_k^m v_k^m, \\
h_k^m = 0.5 \left[ a \ 1 + \cos \left( \pi \ 0.5 \ \rho_v^m H_{\max} \right) \right], \\
v_k^m = 0.5 \left[ a \ 1 + \cos \left( \pi \ 0.5 \ \rho_v^m H_{\max} \right) \right], \quad H_{\max} = \max(\rho_v^m, Z_{\max}).
\]

If sum of \( \Sigma w \) > threshold values, than

\[
P_m = \frac{\Sigma k (w_k^m P_{obs,k})}{\Sigma k w_k^m}
\]
Example horizontal extrapolation $\Delta t_{2m}$, domain CM-Ru7

$\Delta t_{2m}$ from $-10^\circ C$ to $+10^\circ C$
Correction of temperature at 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

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

During the experiments the optimal amount of corrected levels was determined. 5 levels from surface ~ 120-150 m
Algorithm (3/4)

Soil layers

Vertical coefficients in the soil are calculated via the Fourier coefficients

\[ K_l = \frac{z_{bottom} - z_{l+1}}{z_{bottom} - z_1}, \quad l=1,...,7 \ (\text{bottom}=7) \]
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)
Dependence of T profile changes on forecast time

00 h

3 h

9 h

15 h

24 h

48 h
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
Scheme of assimilation system based on nudging

<table>
<thead>
<tr>
<th>Namelist variable</th>
<th>DA-M 07</th>
<th>RU 07 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>data_ini</td>
<td>GME — 3 h</td>
<td>DA-M 07</td>
</tr>
<tr>
<td>data_bd</td>
<td>GME — 3 h</td>
<td>GME + 0 h</td>
</tr>
<tr>
<td>hstop</td>
<td>3</td>
<td>78</td>
</tr>
<tr>
<td>number of runs</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>cut-off time</td>
<td>02:35:00</td>
<td>02:50:00</td>
</tr>
<tr>
<td>hnudgend</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>grid</th>
<th>OBSERVATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>wind_10m, pmsl, Td_2m (TEMP, SYNOP)</td>
</tr>
<tr>
<td>domain</td>
<td>model</td>
<td>T_2m (TEMP)</td>
</tr>
<tr>
<td>-------</td>
<td>-------</td>
<td>-------------</td>
</tr>
<tr>
<td>ETR07</td>
<td>434.000</td>
<td>119</td>
</tr>
<tr>
<td>CFO02</td>
<td>197.400</td>
<td>10</td>
</tr>
<tr>
<td>SFO02</td>
<td>197.400</td>
<td>6</td>
</tr>
<tr>
<td>VFO02</td>
<td>211.500</td>
<td>9</td>
</tr>
<tr>
<td>ENA13</td>
<td>500.000</td>
<td>295</td>
</tr>
<tr>
<td>SIB13</td>
<td>90.000</td>
<td>78</td>
</tr>
</tbody>
</table>

Model grids and used observations
Correction error temperature

00 UTC
28-10-2014

Profiler_Dolgoprudniy
Contr_Sherem
DAS
T2m_Obs
Corrected
Corr_DAS_soil only
Soil memory and influence of soil temperature to the T2m

If we corrected only soil temperature, we improve forecast up to 4º.

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

Obs: 10 mm of precipitation up to 18 UTC
Temperature increment for 10.07.2014 corr_T_40 - GME_T_40

Moscow heat island produced in corrected exp.

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.
Obs.: 18.07.2014 was NO precipitation

Total amount of precipitation 18.07.2014 00UTC+5hh
Verification temperature at 2m, July 2014

Mean error T_2m for CFO July 2014

- contr
- DAS
- corr
- corrDAS

ME_t_2m [degree] vs Lead time, h
Verification temperature at 2m. July 2014

RMSE of T_2m for CFO July 2014
Verification July 2014. CFO
Dew point at 2m

Mean error $T_d_{2m}$ for CFO July 2014
Verification July 2014. CFO
Dew point at 2m

RMSE of Td_2m for CFO July 2014

Lead time, h
RMSE td_2m [degree]

contr  DAS  corr  corrDAS
Verification July 2014. CFO wind speed at 10m

Mean error ws10m for CFO July 2014

- contr
- DAS
- corr
- corrDAS

Lead time, h

ME \( t_{2m} \) [degree]
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!