PT SNOWE

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COSMO GM, 2015

OUTLOOK

- PT SNOWE (Goal, motivation)
- The SNOWE technology and organization of operational runs
- Tests of SNOWE
- Analysis of effects of implementation of SNOWE based on VERSUS conditional verification
- Conclusions

PT SNOWE GOAL

To develop the system of continuous calculations of snow WE on synoptic stations as block for DAS correction into COSMO-model (on COSMO-Ru).

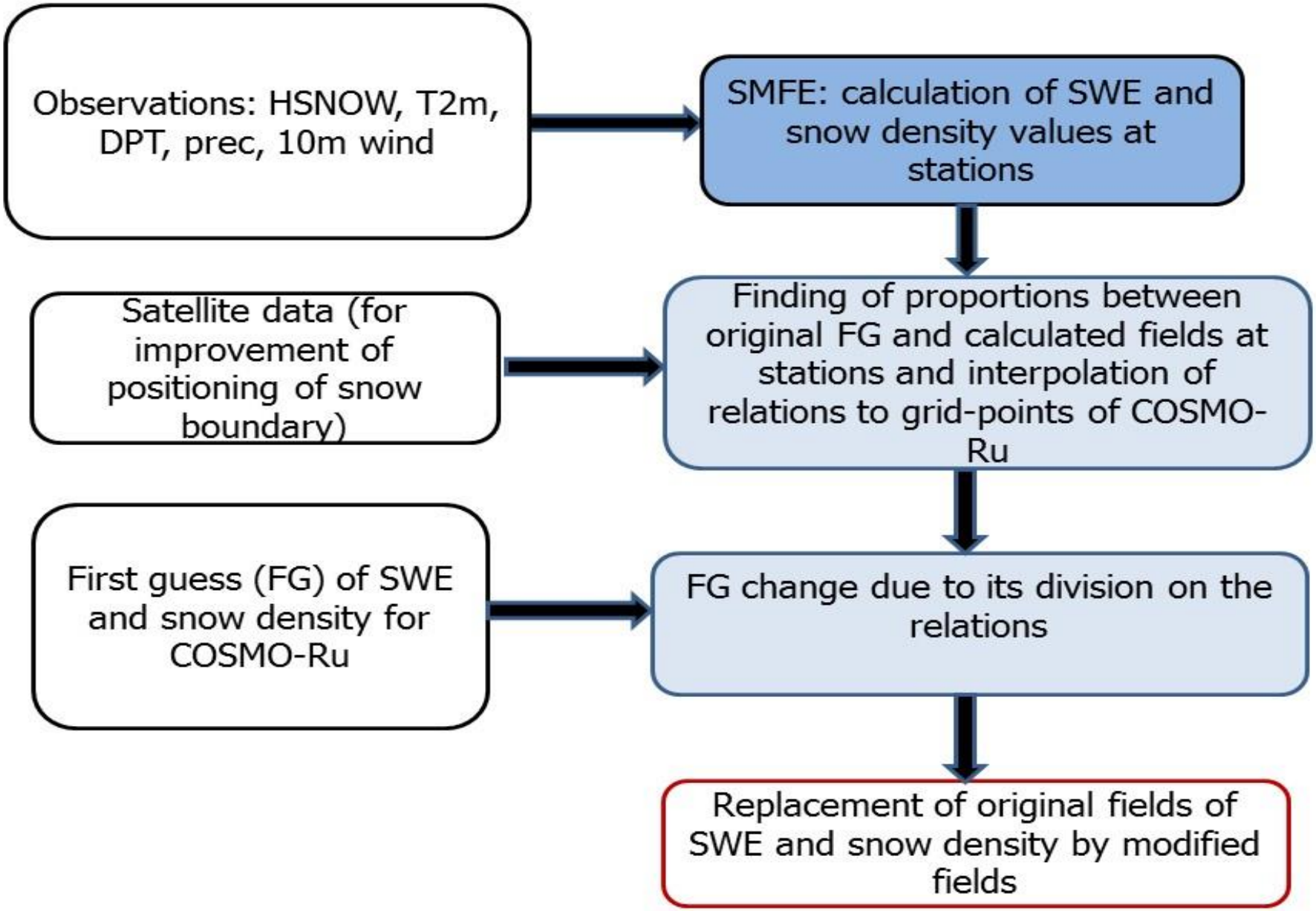
To prepare the software and its description for continuous calculations of snow WE based on regular measurements (Snow Depth, T, Td, Wind) done at synoptic stations.

To test the SNOWE technology / analyze the effects of its implementation in COSMO-modeling

SNOWE motivation

- Atmospheric models need SWE and snow density values as initial fields.
- The only regular SYNOP measurements of snow depth are operational available data about snow cover (also satellite data of snow boundary position). SWE data is held only on highly restricted number of specialized stations during snow courses which are done once in 5-10 days
- The snow density values are in dependence on thermal history of whole cold period. The values could be received through empirical relationships which allow converting snow depth into needed values or as results of SWE simulation during continuous DAS cycles with accumulation of errors. As result for the regions of long snow period the differences between calculated and measured SWE can be more 1 m (100 kg/m2!). This lead to wrong calculation of heat budget components near snow boundary and, wrong T2m forecasts (ME till 15 Degrees!) in this narrow zone (Kazakova E., Rozinkina I., COSMO Newsletter, 2011).
- The proposed technology SNOWE permits to obtain the initial fields of SWE based on the proceeding of SYNOP data (Snow Depth + Meteorological parameters) during the whole snow period in couple with correction of FG of SWE based on the model simulations

SNOWE TECHNOLOGY



Quasi-operational regime
Daily calculation of SWE and snow density at stations since 1 September 2014

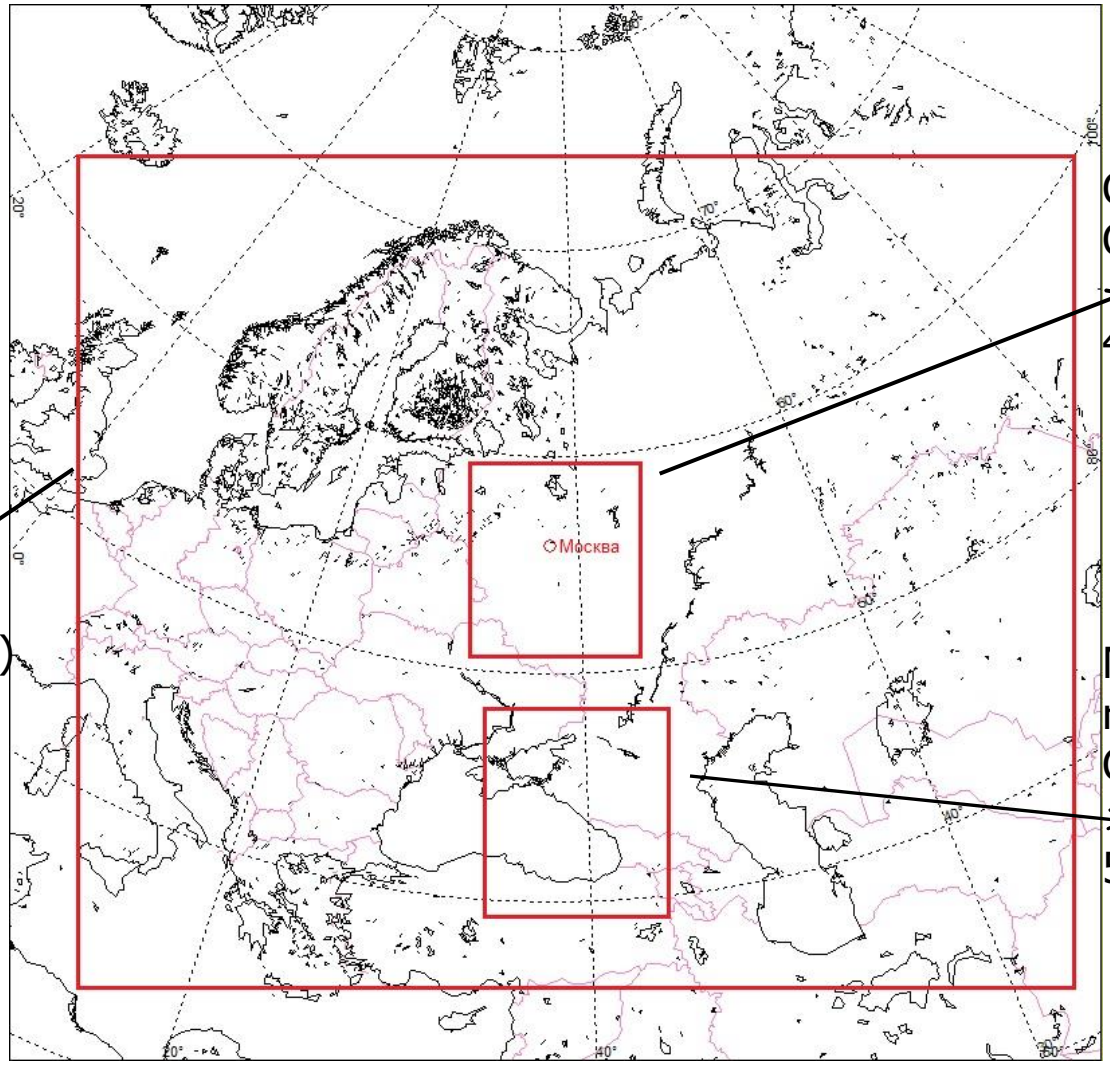
• We selected stations which have more then 4 observations per day and make snow depth measurements: 436 – for COSMO-Ru2, 2296 - for COSMO-Ru7

• Before calculation of snow fields primary data quality control was carried out (T2m, dew point temperature, snow depth)

• FG of snow fields were not modified for mountain regions (higher than 500 m) and water areas (fr_land<0.5) in COSMO-model

• If there are zones free of snow in COSMO-model initial field (and according to SMFE they are covered with snow), it is supposed to consider them snowless

COSMO-Ru domains



Central region,
COSMO-Ru2 (2,2 km)

436 stations

Europe,
COSMO-Ru7 (7 km)

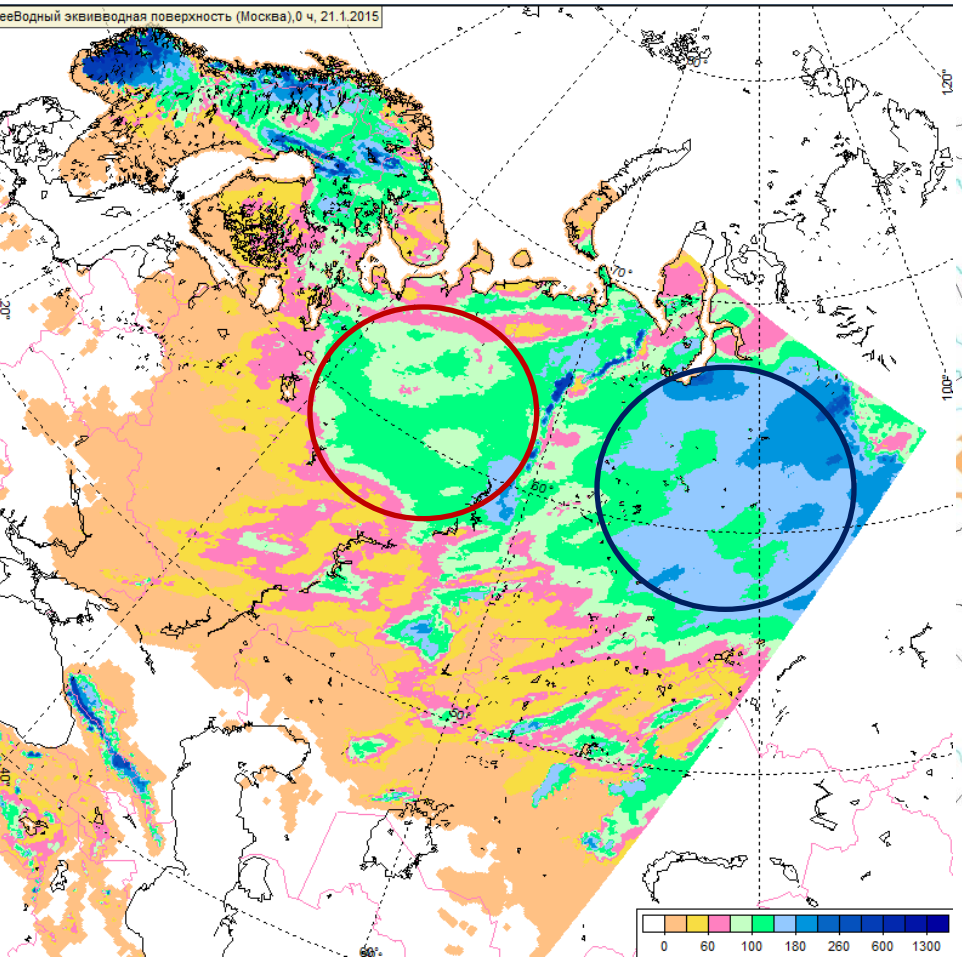
2296 stations

North-Caucasian
region,
COSMO-Ru2 (2,2 km)

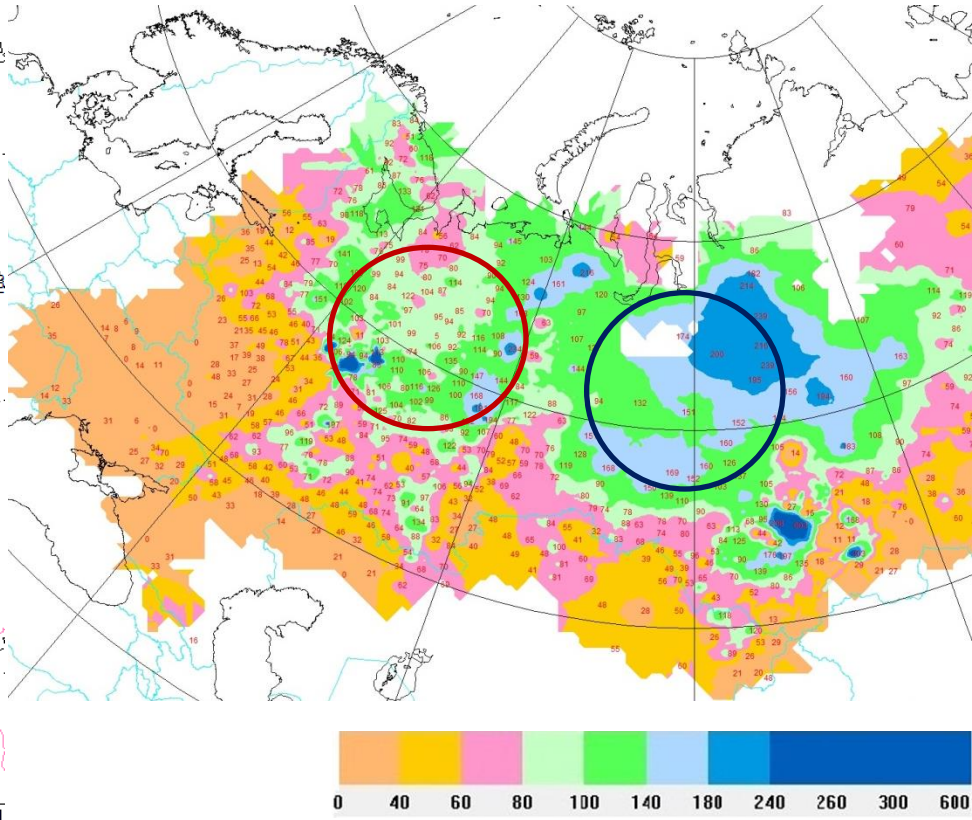
551 stations

SWE fields. 20 January 2015

COSMO-Ru7 SWE initial field (new technology)

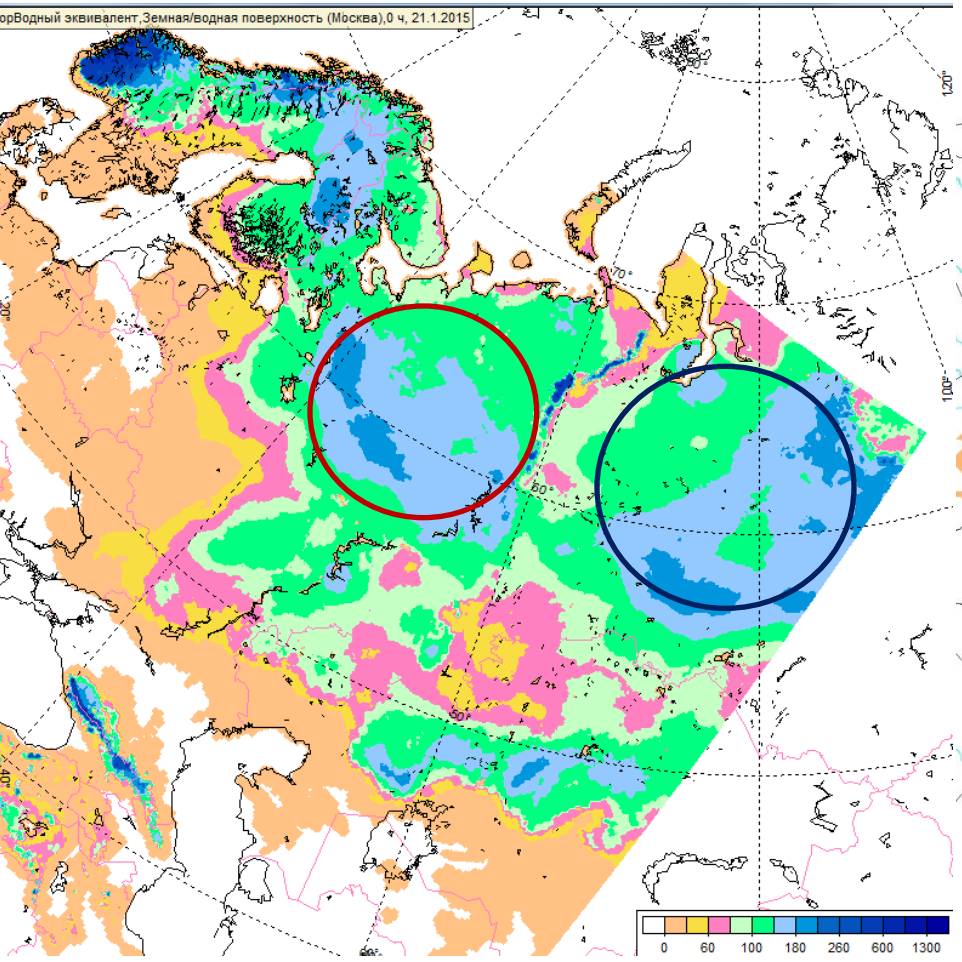


SWE measurements

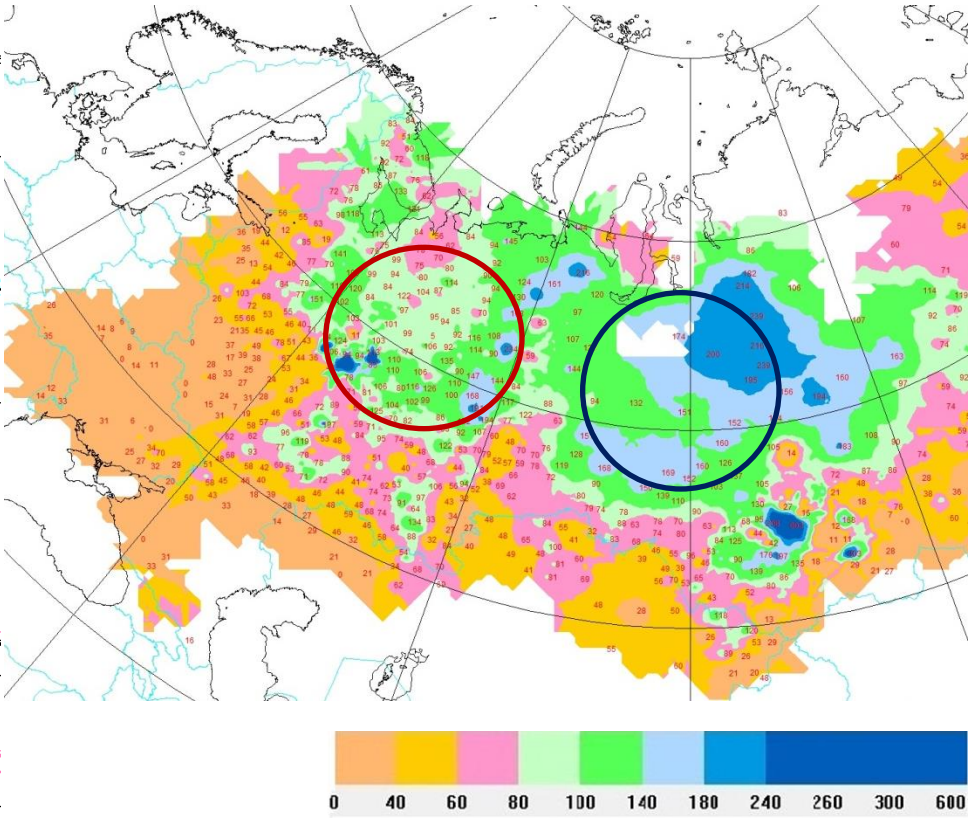


SWE fields. 20 January 2015

COSMO-Ru7 SWE initial field (reference)



SWE measurements

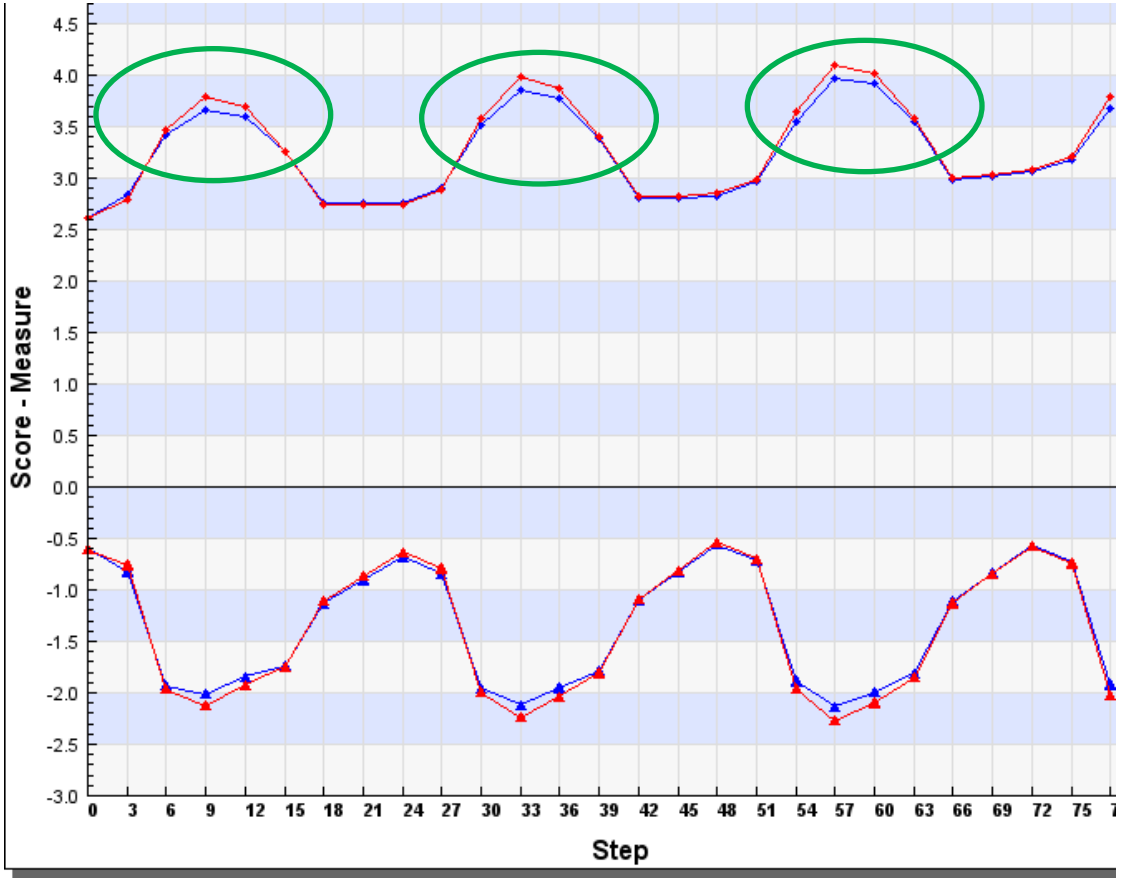


T2m forecasts

RMSE and ME for COSMO-Ru7 (European region)
24 Feb – 31 March 2015

Standard verification

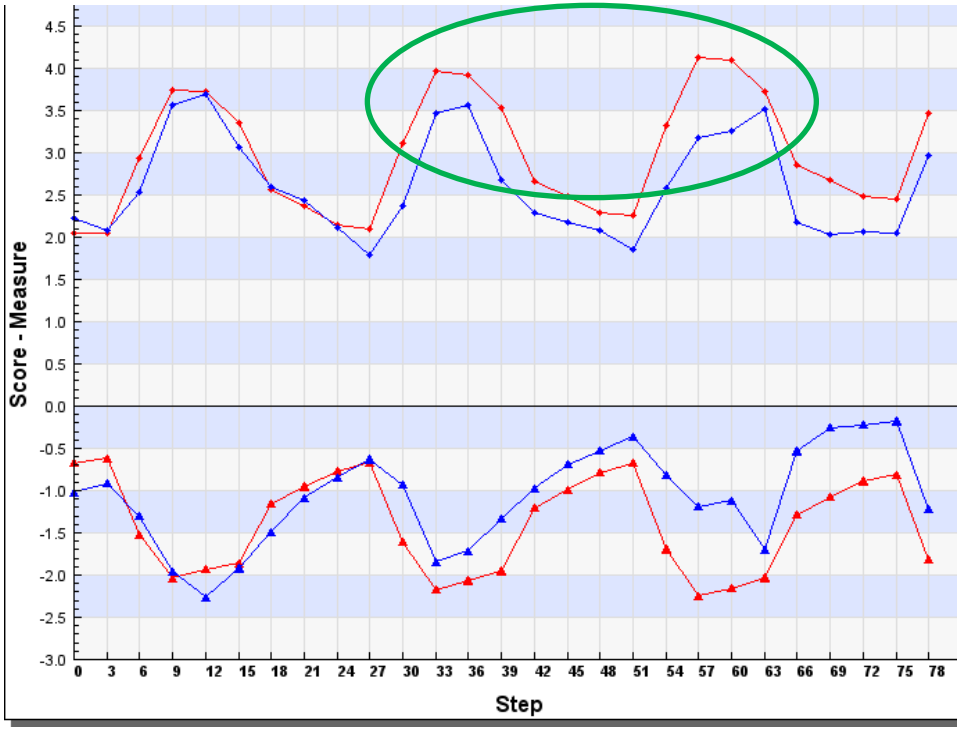
Verification for ~800 stations



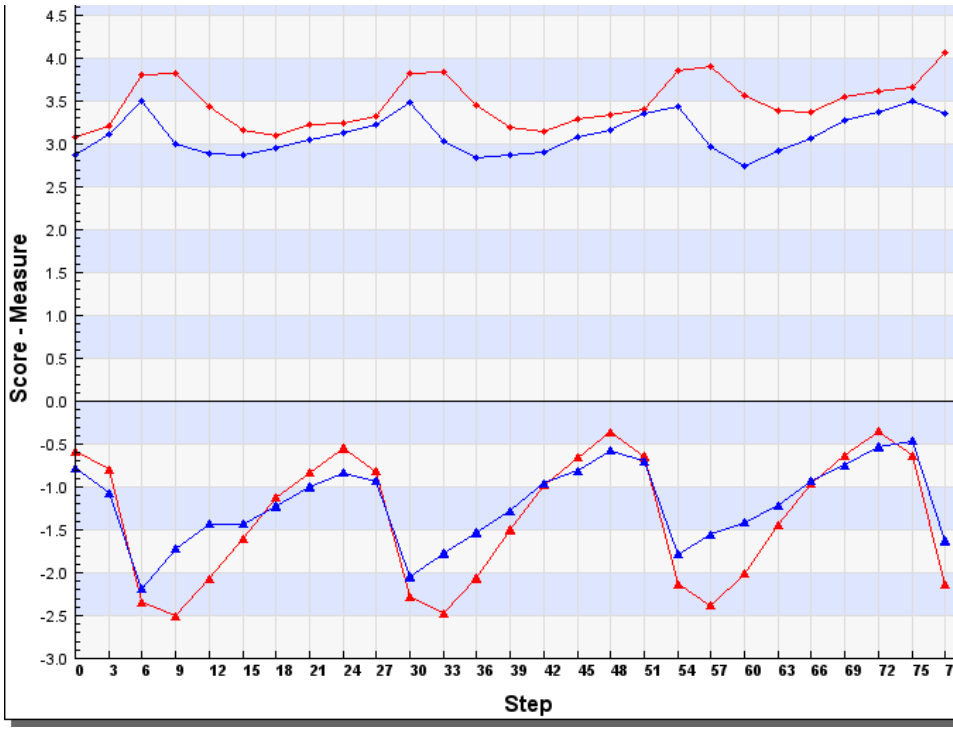
Conditional verifications are needed, as the greater effect will be observed only in a narrow zone close to the snow boundary

T2m (°C) RMSE and ME for Europe region 24 Feb – 31 March 2015

Conditional verification: *T2m > 0°C or T2m ≤ 0°C*



Condition: positive observed temperatures

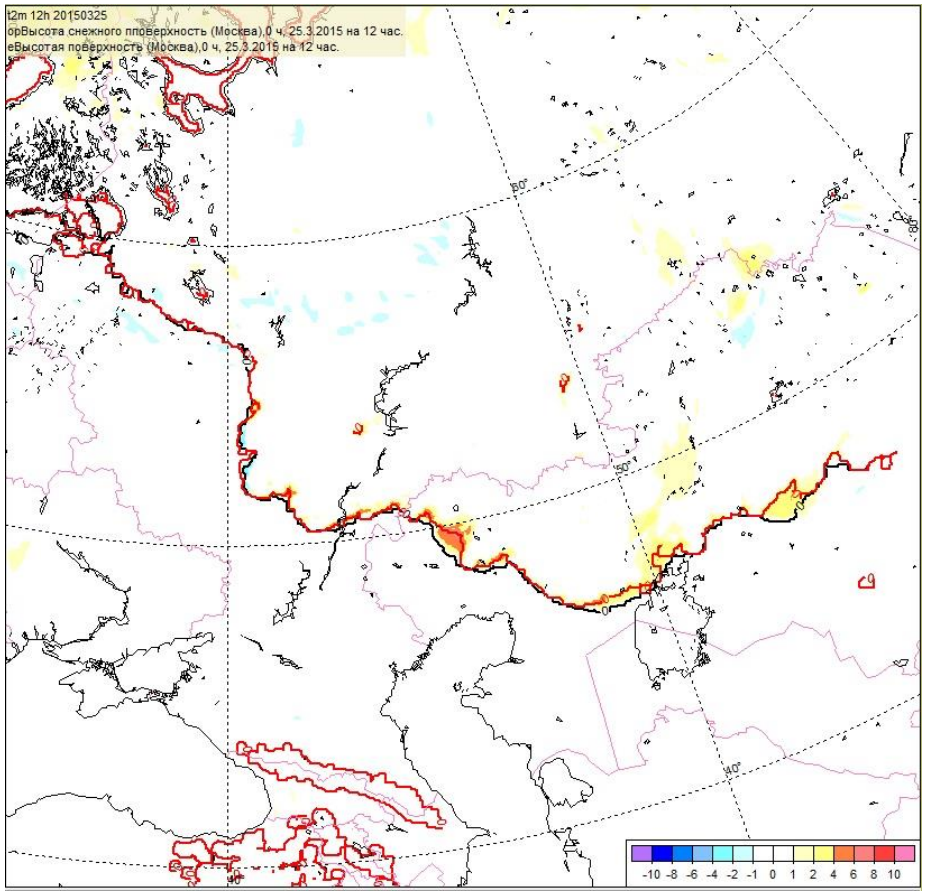


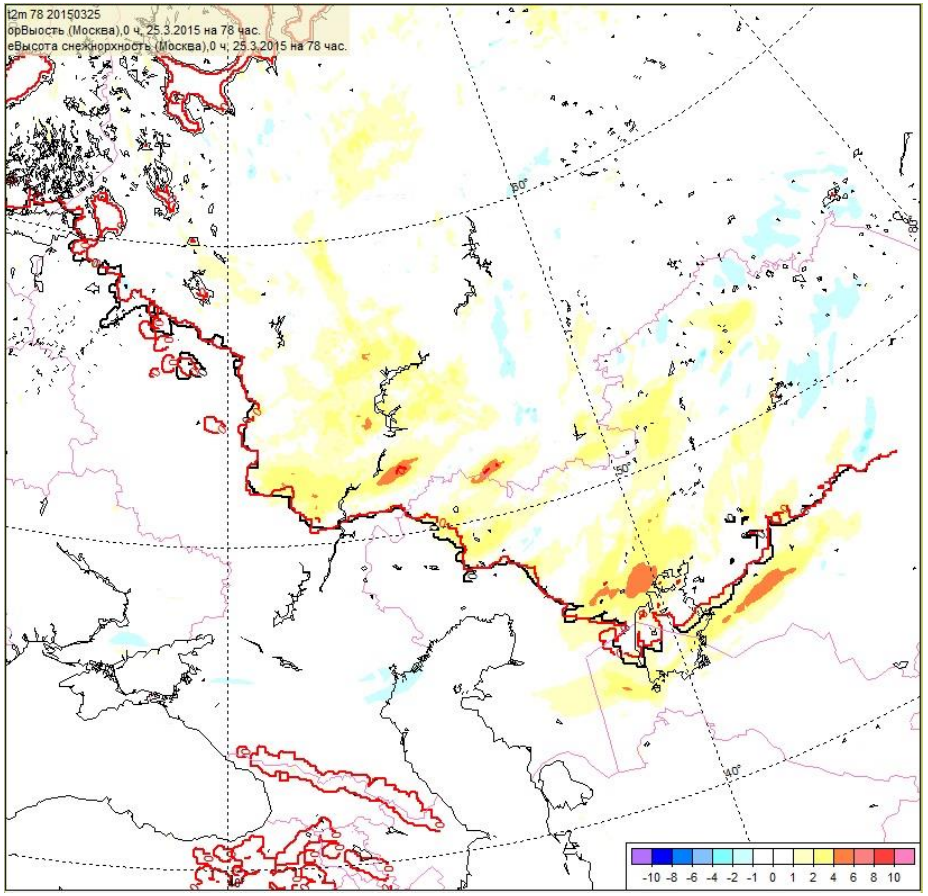
Condition: negative observed temperatures

T2m forecasts

ΔT2m (°C, ex-oper) for forecast time 12h (left) and 78h (right) for COSMO-Ru7 (European domain)

start 00 UTC 25 March 2015

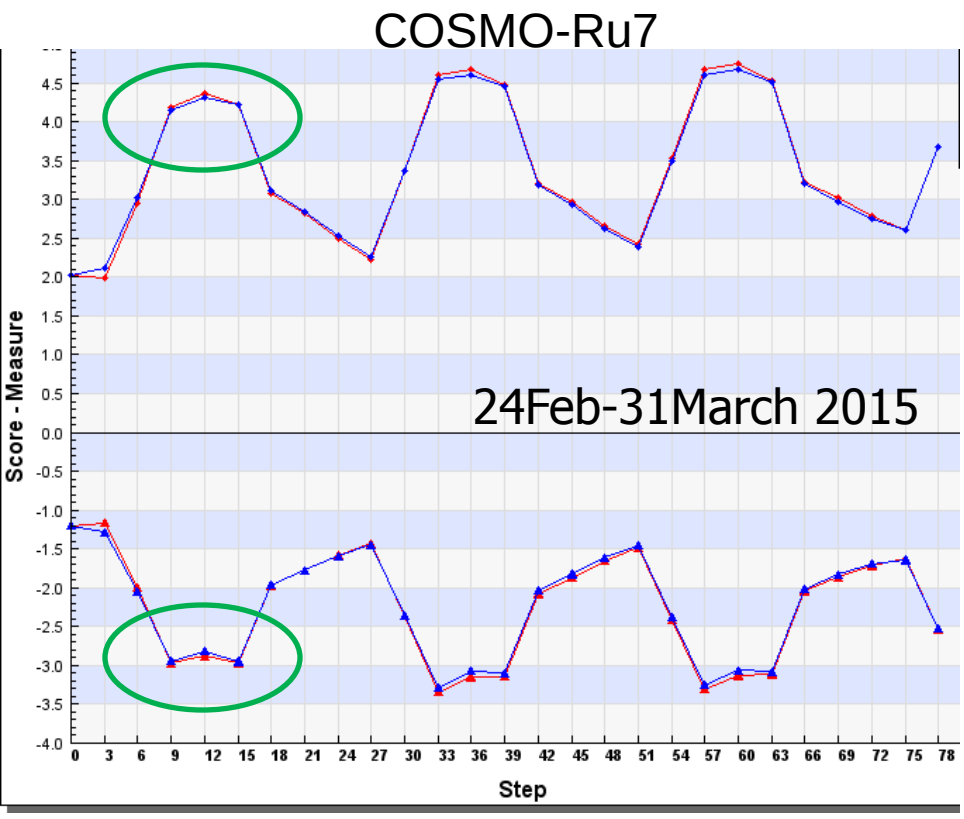


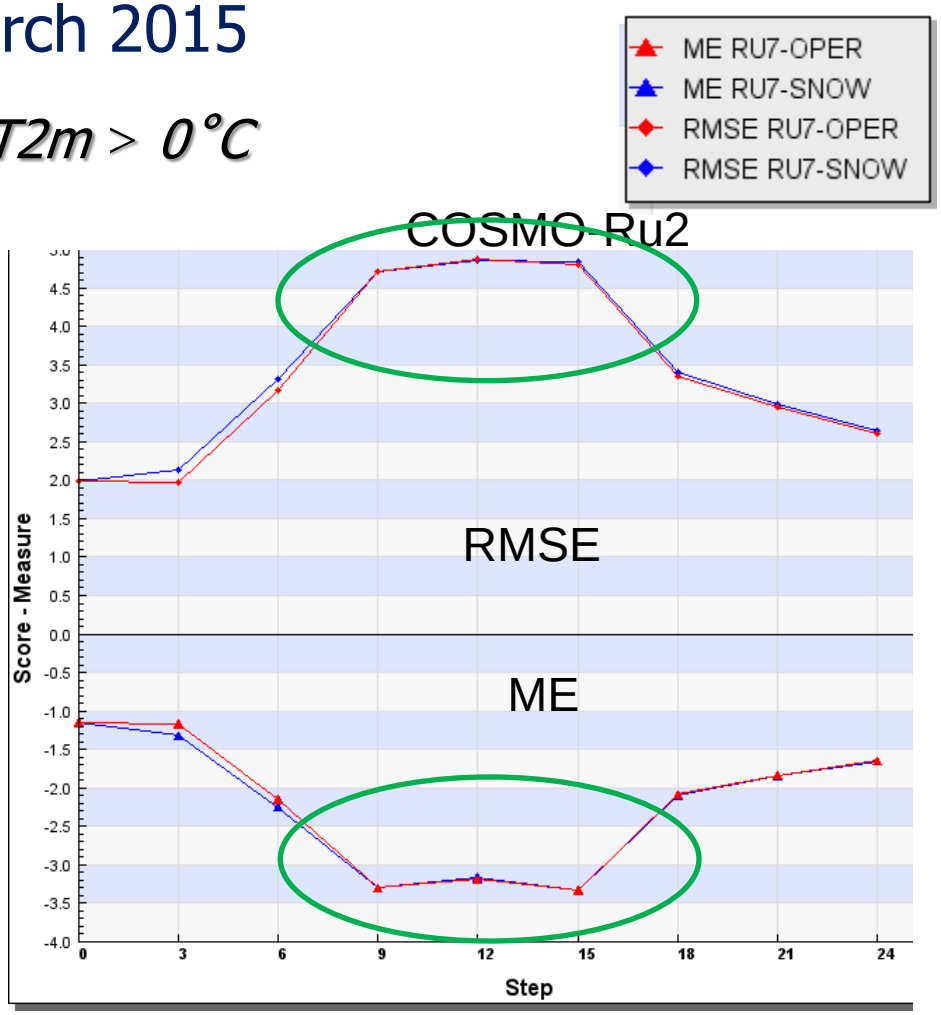


Lines show the snow boundaries: black – oper, red - ex

T2m (°C) RMSE and ME for Central region
1– 31 March 2015

Conditional verification: T2m > 0°C



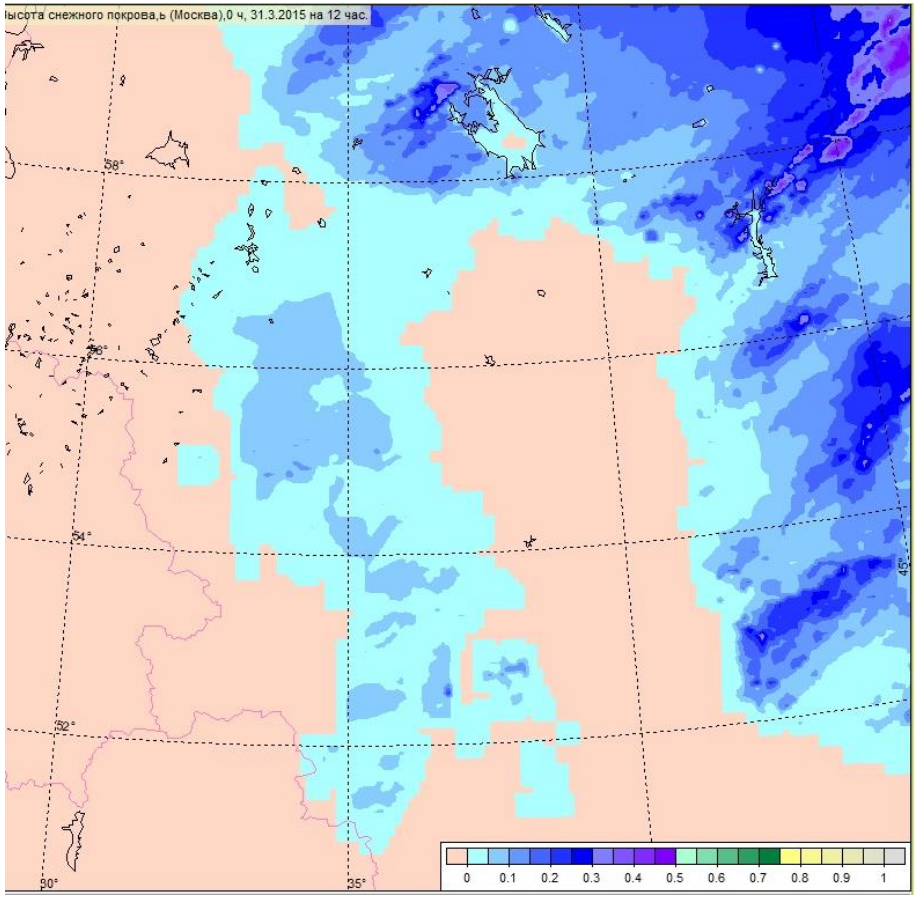


Condition: positive observed temperatures

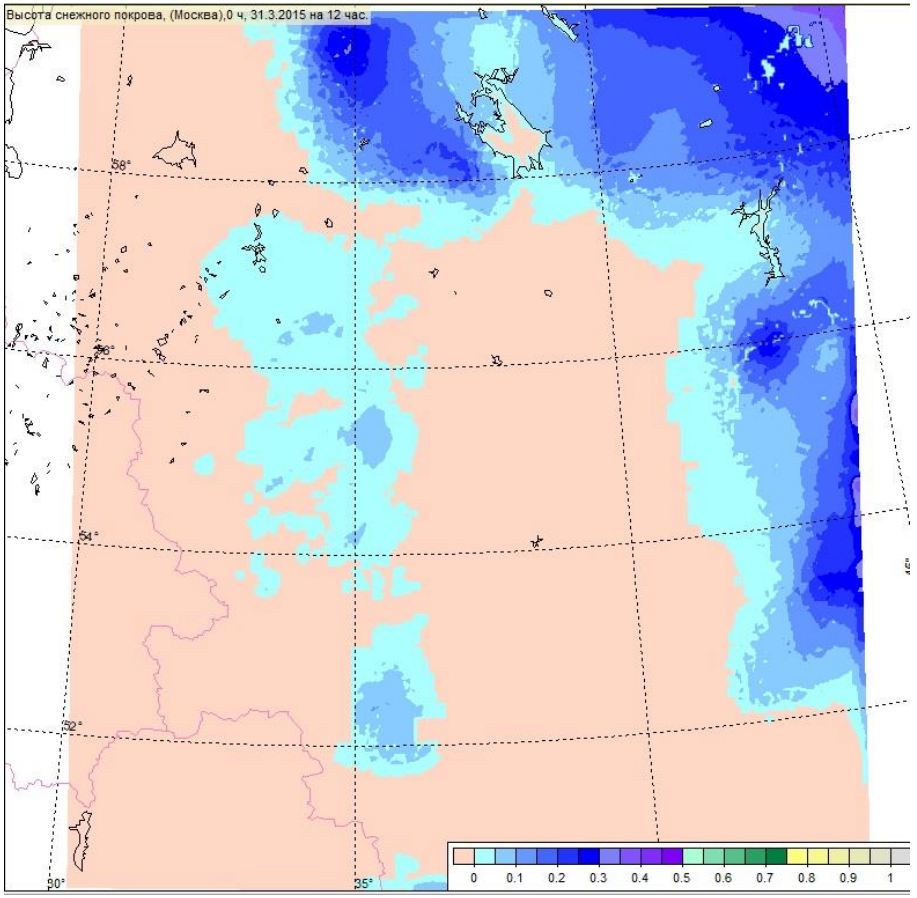
Condition: positive observed temperatures

SWE (mm) 12h forecast for Central region different interpolation approaches of initial data (31.03.2015)

COSMO-Ru7: normalized FG



COSMO-Ru2 (direct interpolation)

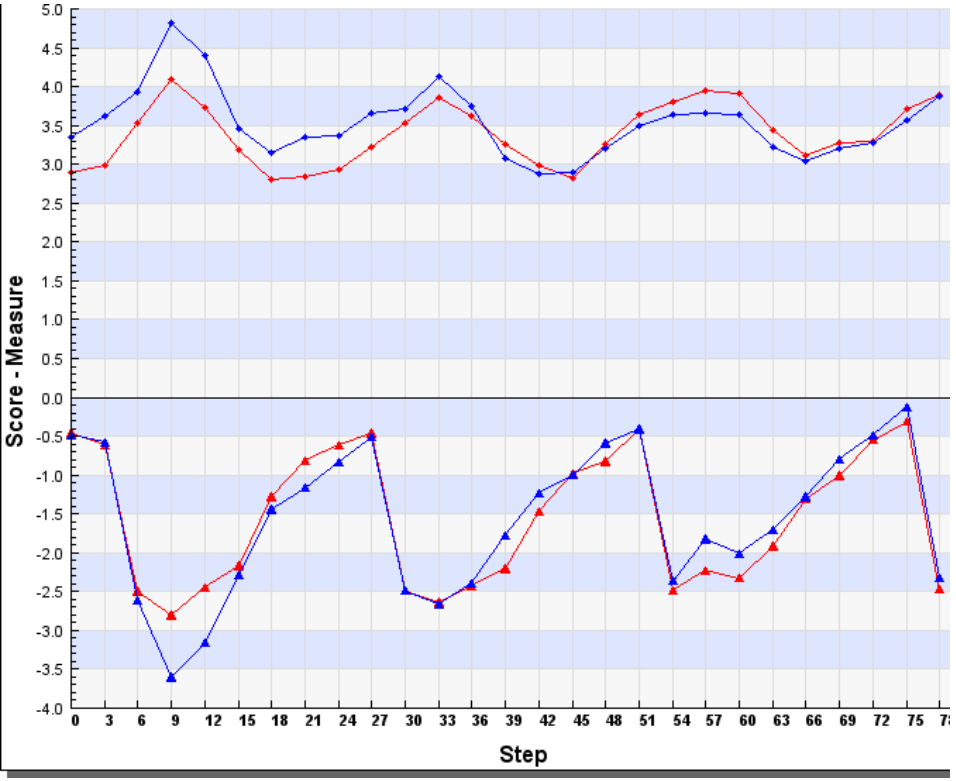


Conclusions (part1): main features

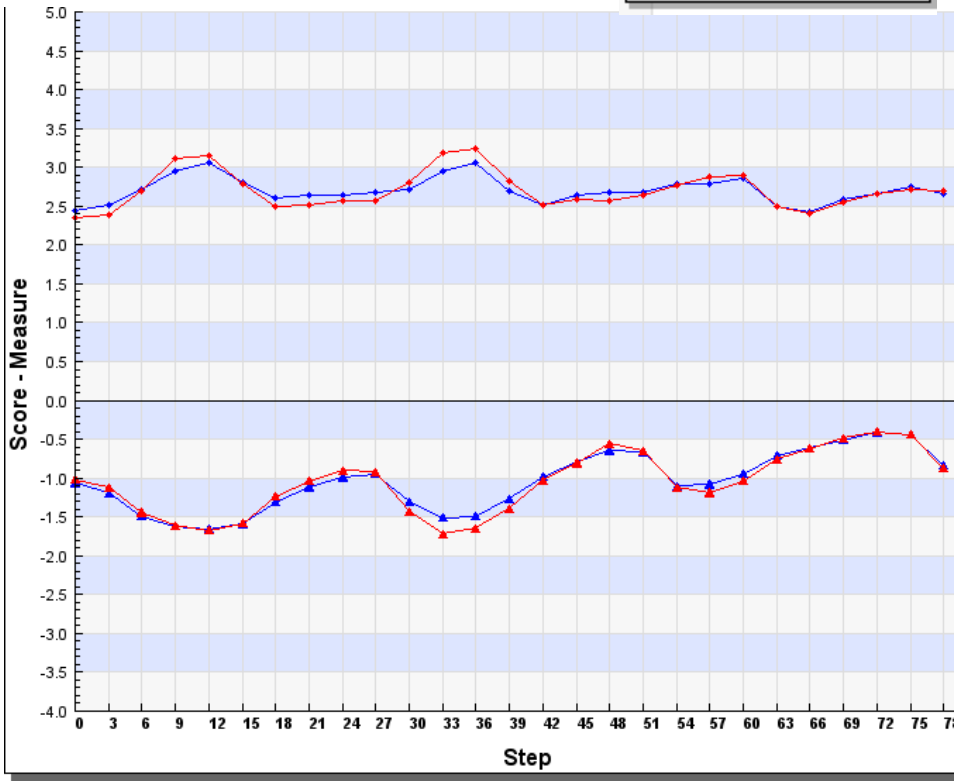
- ME and RMSE values for T2m for COSMO-Ru7 (Europe area) were reduced (RMSE decreased to 0,5-1,5°C and ME to 0,5-1,0°C);
- Maximum improvement is observed to the 3^{d} day of the forecast;
- Improvement in T2m forecasting with the use of the technology is observed both for positive and negative T2m (despite that forecasts errors in positive T2m were greater than in negative);
- The effect of T2m forecast improving was more evident for the more large region and was similar for both versions with different resolution: COSMO-Ru2 and COSMO-Ru7 for same region;
- Use of normalized based on the SMFE correction of FG from DAS permits to obtain the quite realistic estimates of SWE and snow density values

T2m (°C) RMSE and ME for COSMO-Ru7 (European domain)
24 Feb – 31 March 2015

Conditional verification: clear sky of cloudy weather



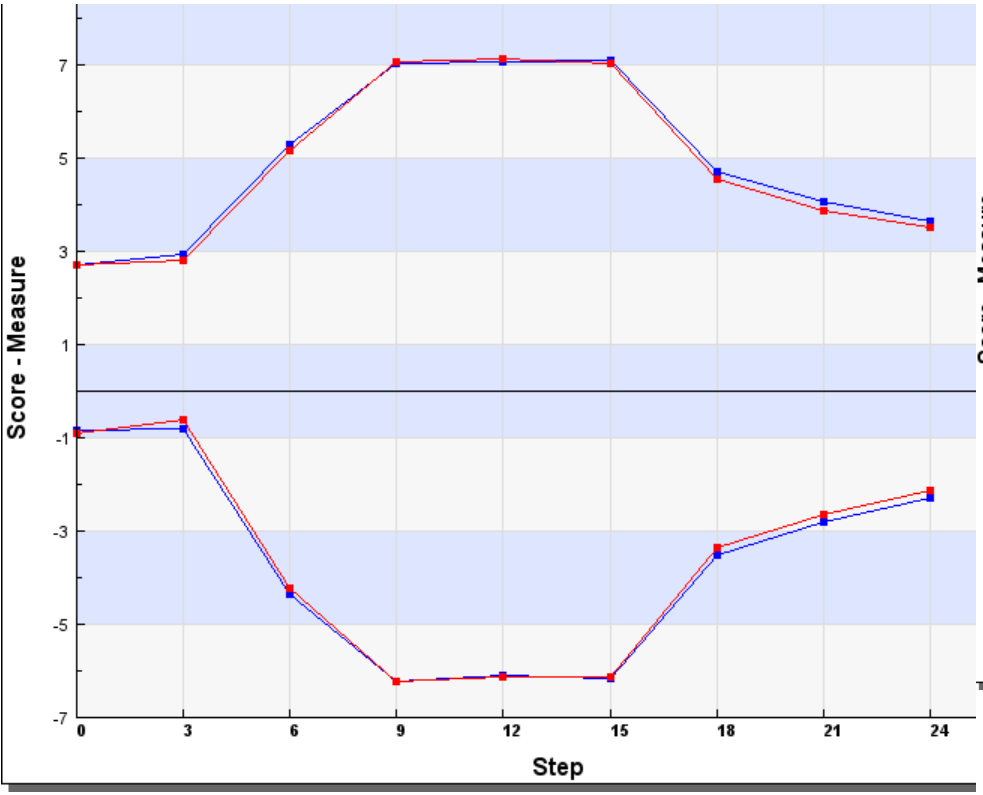
Condition: prognostic total cloud ≤ 25%



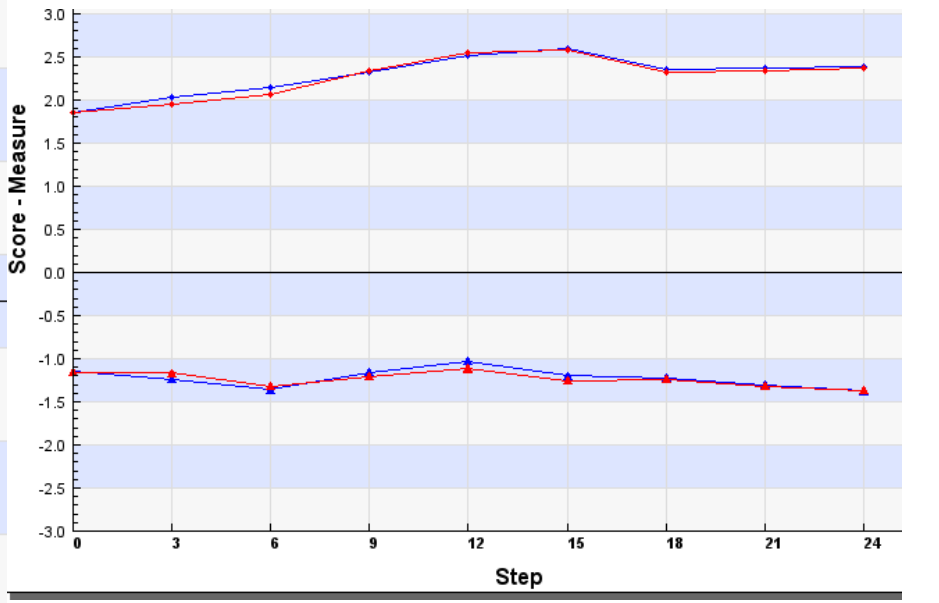
Condition: prognostic total cloud ≥ 75%

T2m (°C) RMSE and ME for Central region 1– 31 March 2015

Conditional verification: clear sky of cloudy weather



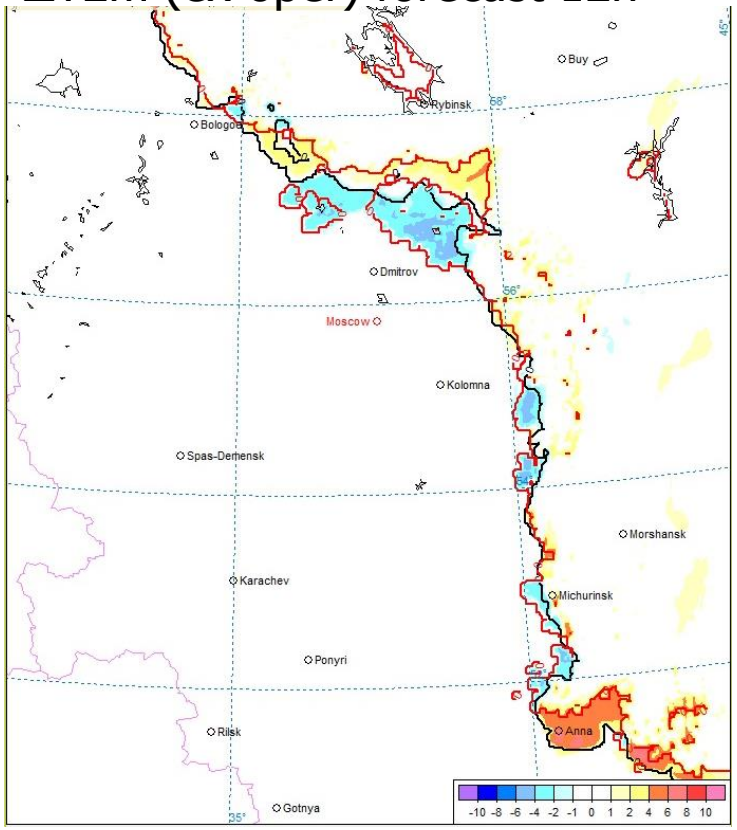
Condition: prognostic total cloud ≤ 25%



Condition: prognostic total cloud ≥ 75%

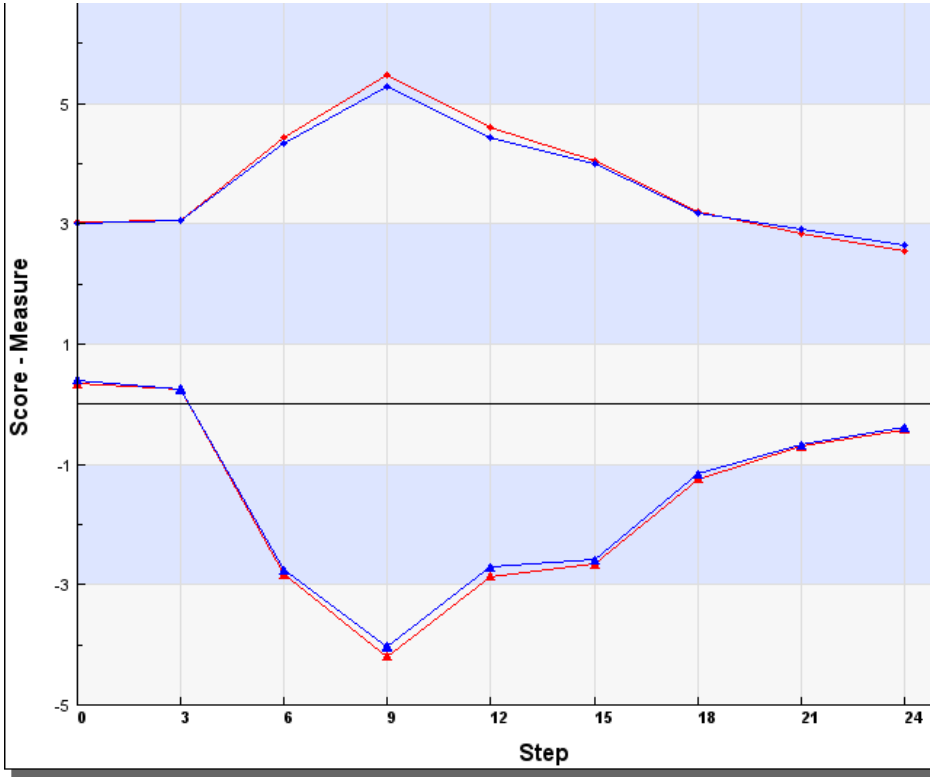
T2m (°C) RMSE and ME for Central region
20 March 2015

ΔT2m (ex-oper) forecast 12h



Forecast of snow boundary: red line – experiment, black line – operational run

Standard verification

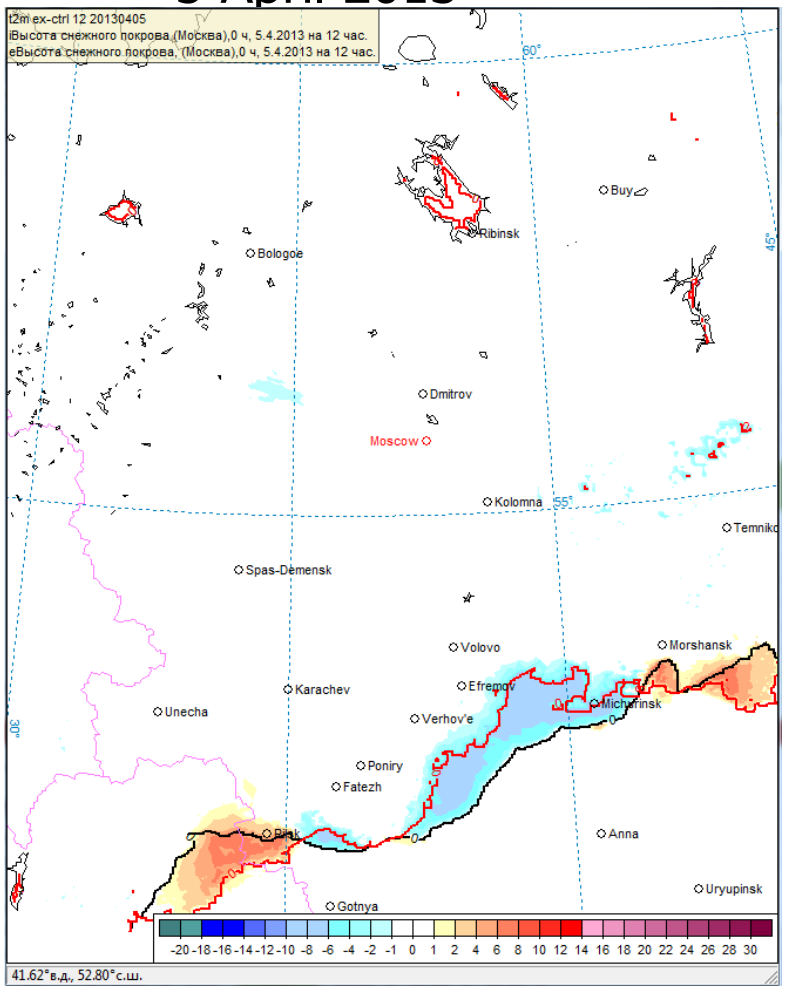


Impact of snow initial fields replacement

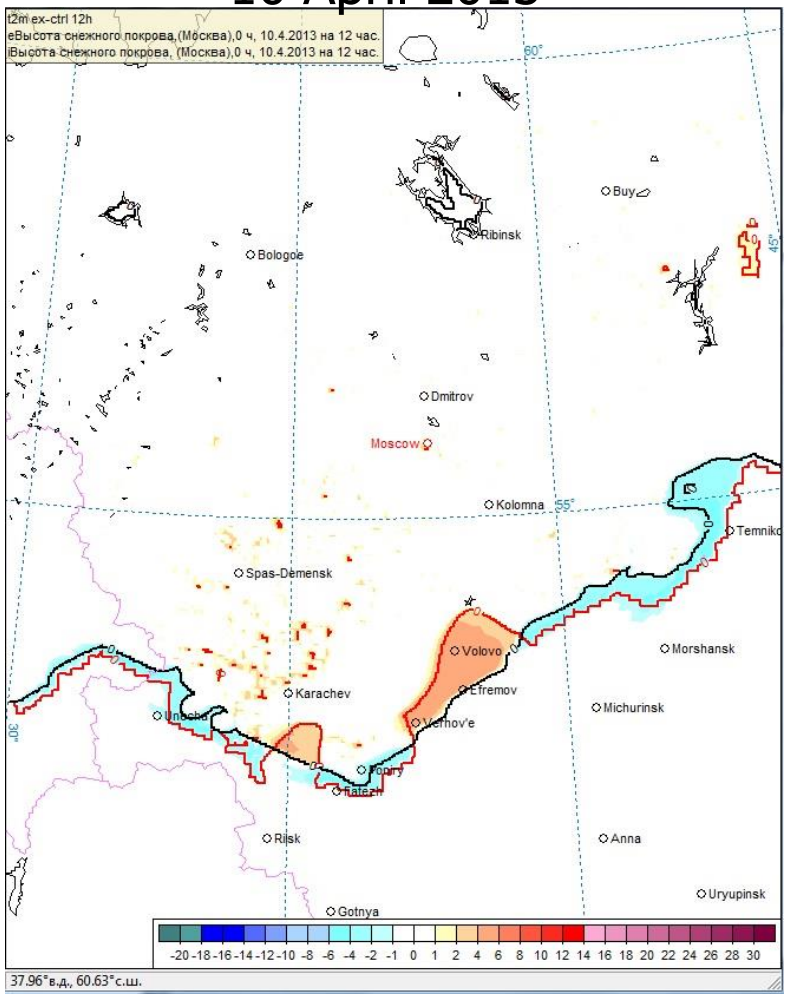
ΔT2m (ex – oper) forecast at 12 UTC. Start – 00 UTC

Lines – snow boundary forecast at 12 UTC: black– operational version, red– experiment

5 April 2013

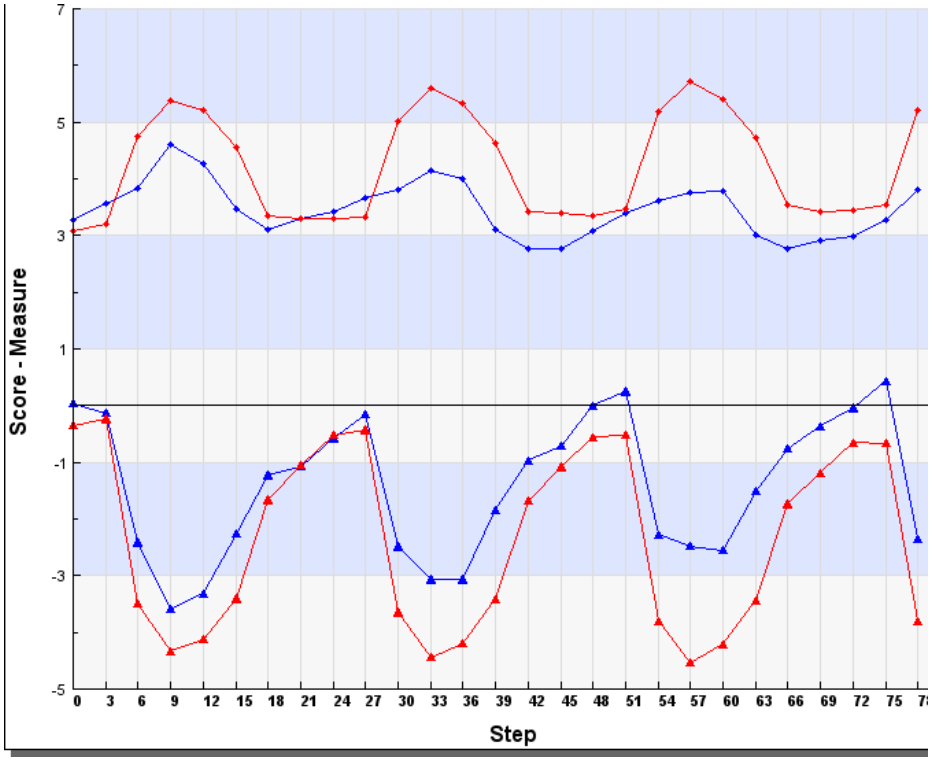


10 April 2013

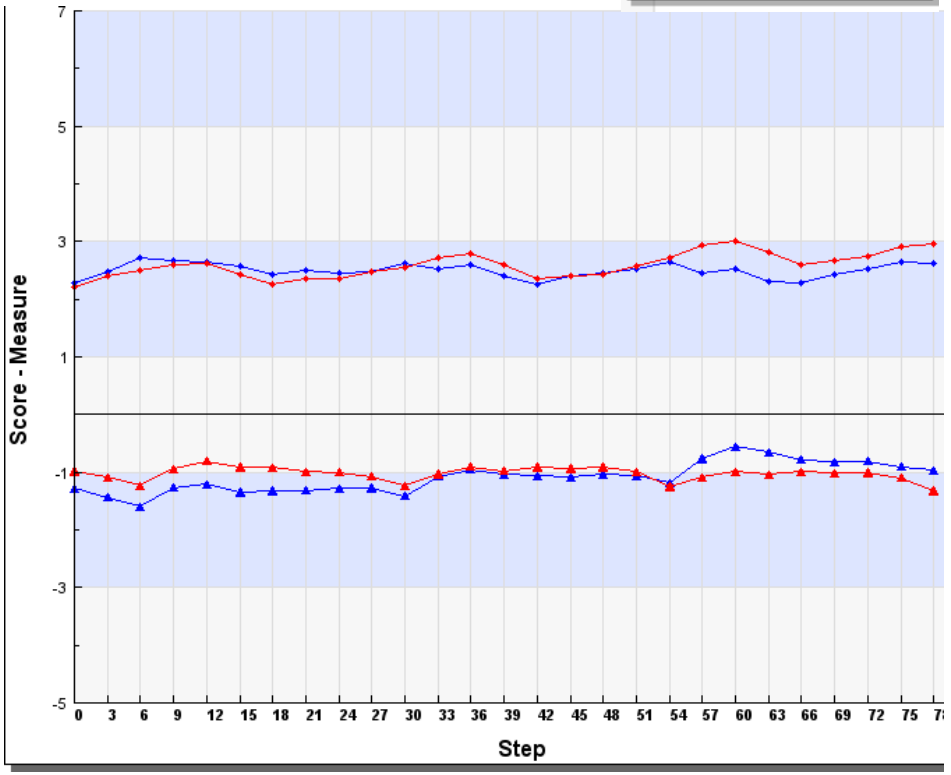


T2m (°C) RMSE and ME for COSMO-Ru7 (European domain) 24 Feb – 31 March 2015

Conditional verification: clear sky of cloudy weather



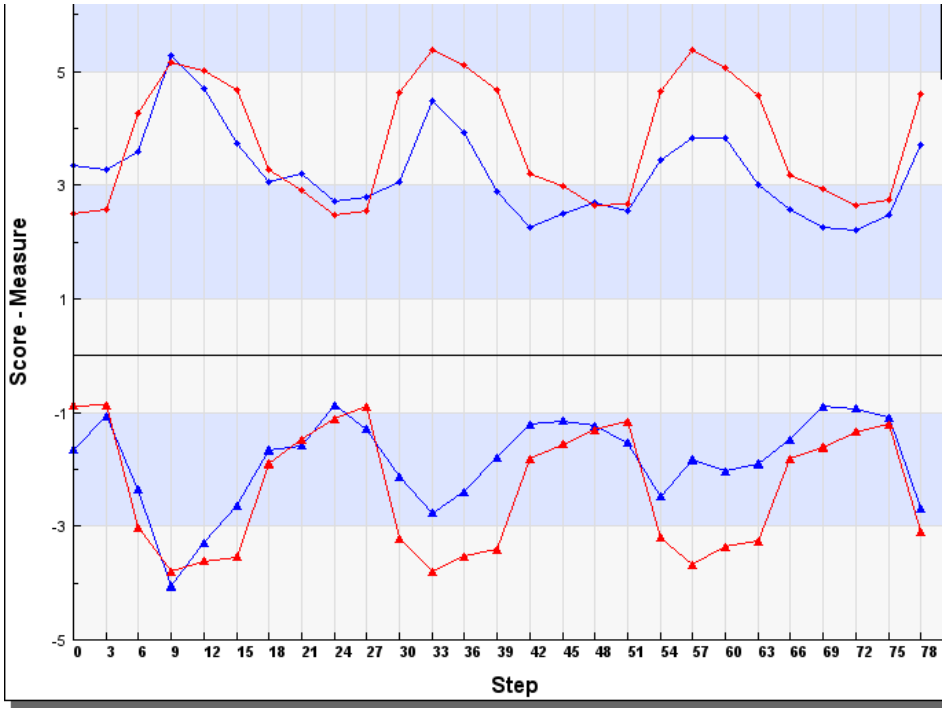
Condition: prognostic and observed total cloud ≤ 25%



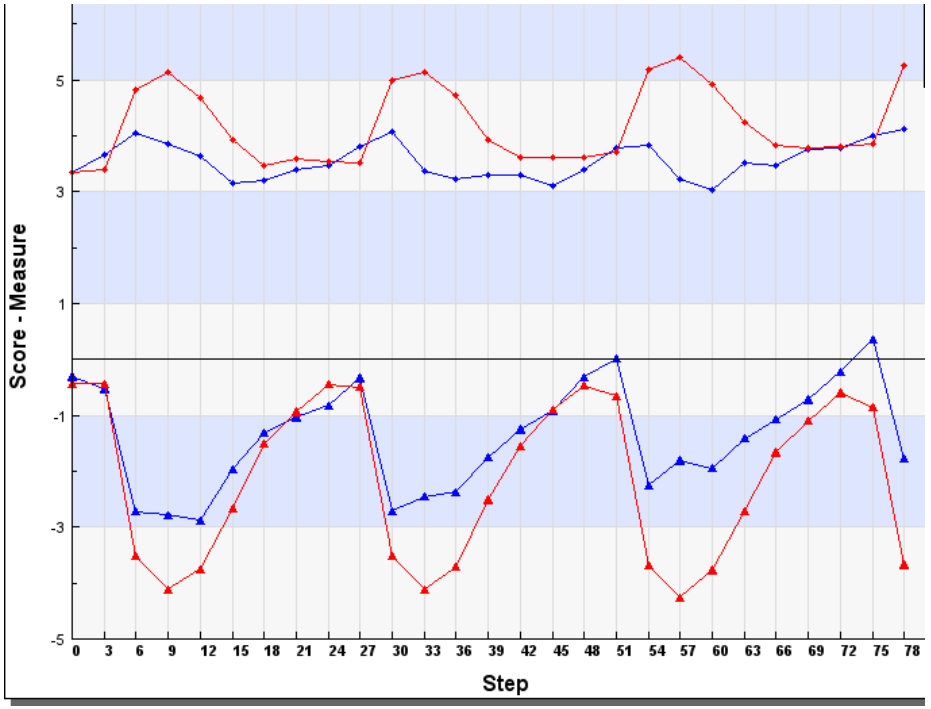
Condition: prognostic and observed total cloud ≥ 75%

T2m (°C) RMSE and ME for COSMO-Ru7 (European domain)
24 Feb – 31 March 2015

Conditional verification: clear sky



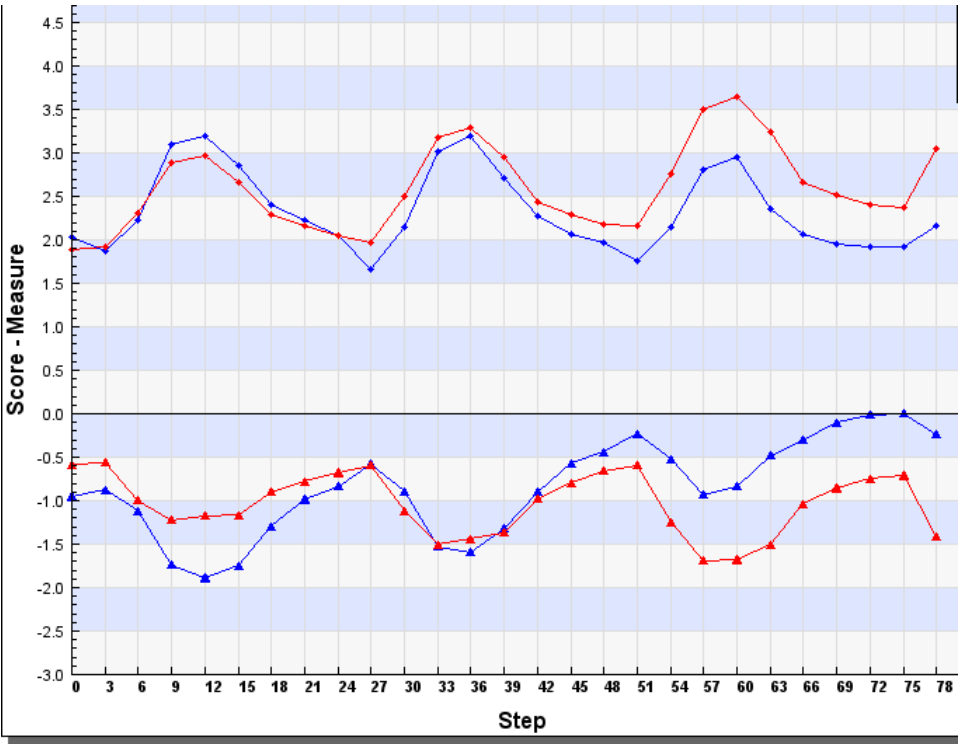
Condition: prognostic total cloud ≤ 25%+
positive observed temperature



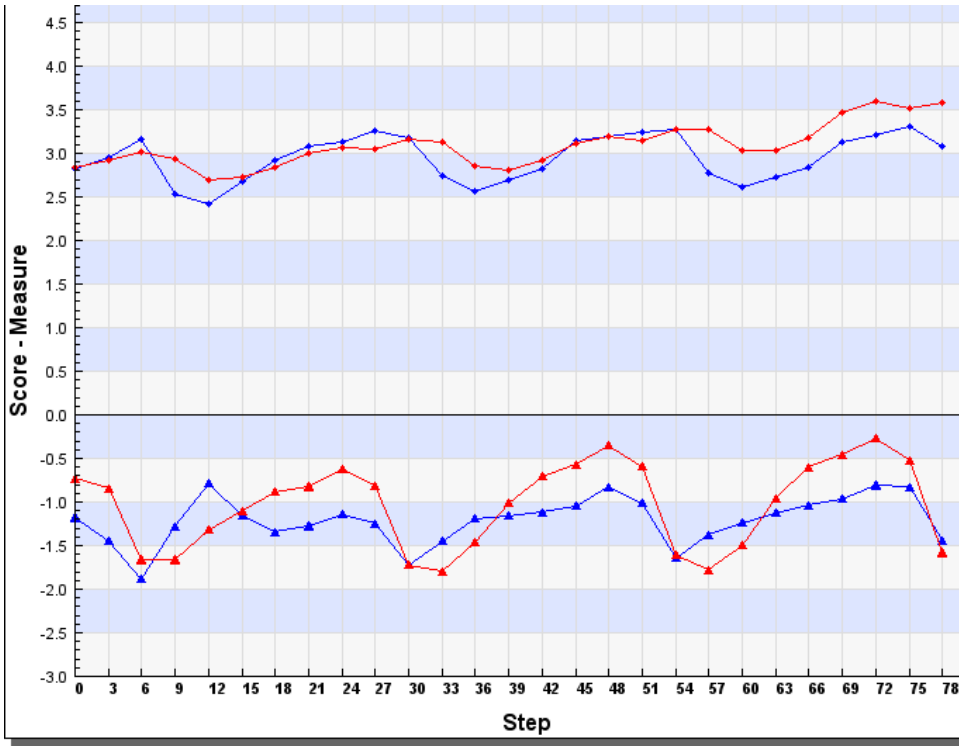
Condition: prognostic total cloud ≤ 25%+
negative observed temperature

T2m (°C) RMSE and ME for COSMO-Ru7 (European domain) 24 Feb – 31 March 2015

Conditional verification: cloudy weather



Condition: prognostic total cloud ≥ 75%+
positive observed temperature



Condition: prognostic total cloud ≥ 75%+
negative observed temperature

Conclusions (part2). Cloudiness influence

- In case of TCC prognostic values the SNOWE technology gives some deterioration for clear sky (TCC≤25%) for the first day of the forecast → maybe local TCC changes in the COSMO-model.*

- Then if we take into account prognostic and observed values of TCC, significant improvement of RMSE and ME is observed for clear sky, in cases of both for positive (RMSE decrease up to 2°C) and negative (RMSE decrease up to 0,5°C) observed T2m;

- For overcast (TCC≥75%) improvement of RMSE for positive temperatures is for 2-3 forecast day, for negative – it is not so indicative (RMSE is decreasing, ME is increasing);

- So, the proposed technology improved mostly positive T2m during clear sky conditions.

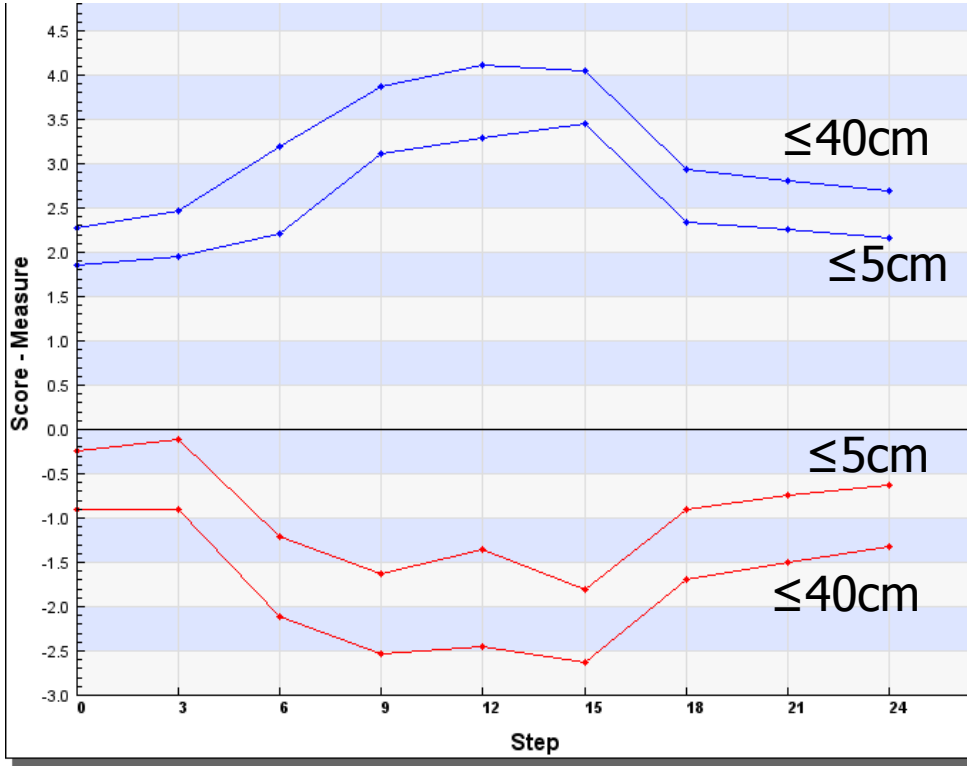
* Model and observed total cloud cover (TCC) are not equal. Total cloud means the whole amount of clouds, without dividing between layers.

T2m (°C) RMSE and ME for Central region
1– 31 March 2015
The SNOWE technology

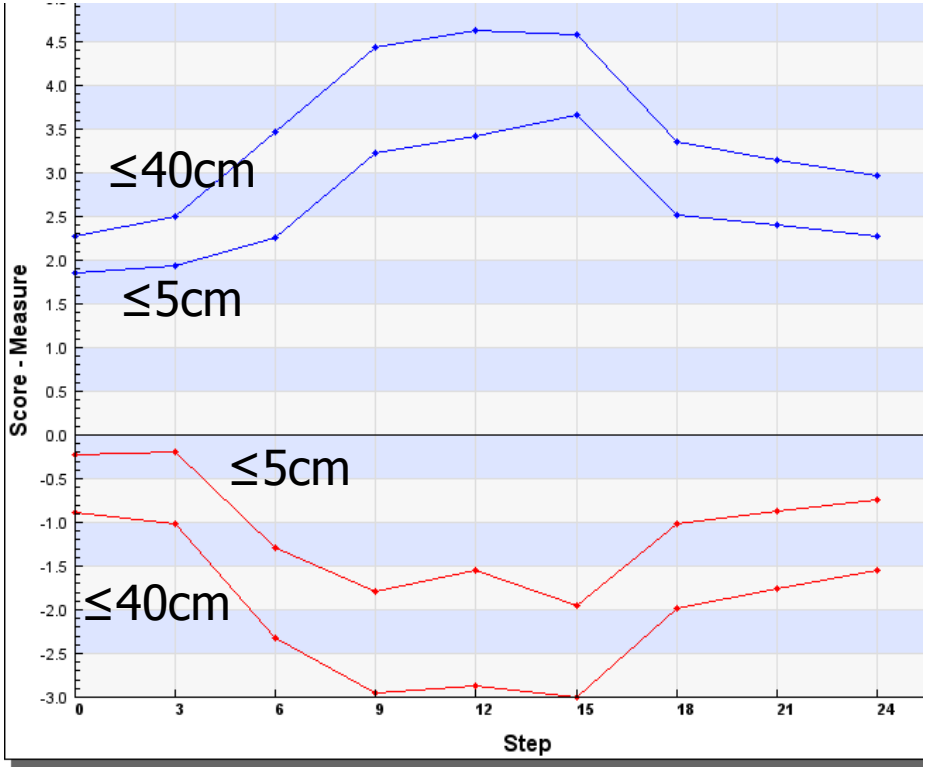
Conditional verification

ME
RMSE

COSMO-Ru7



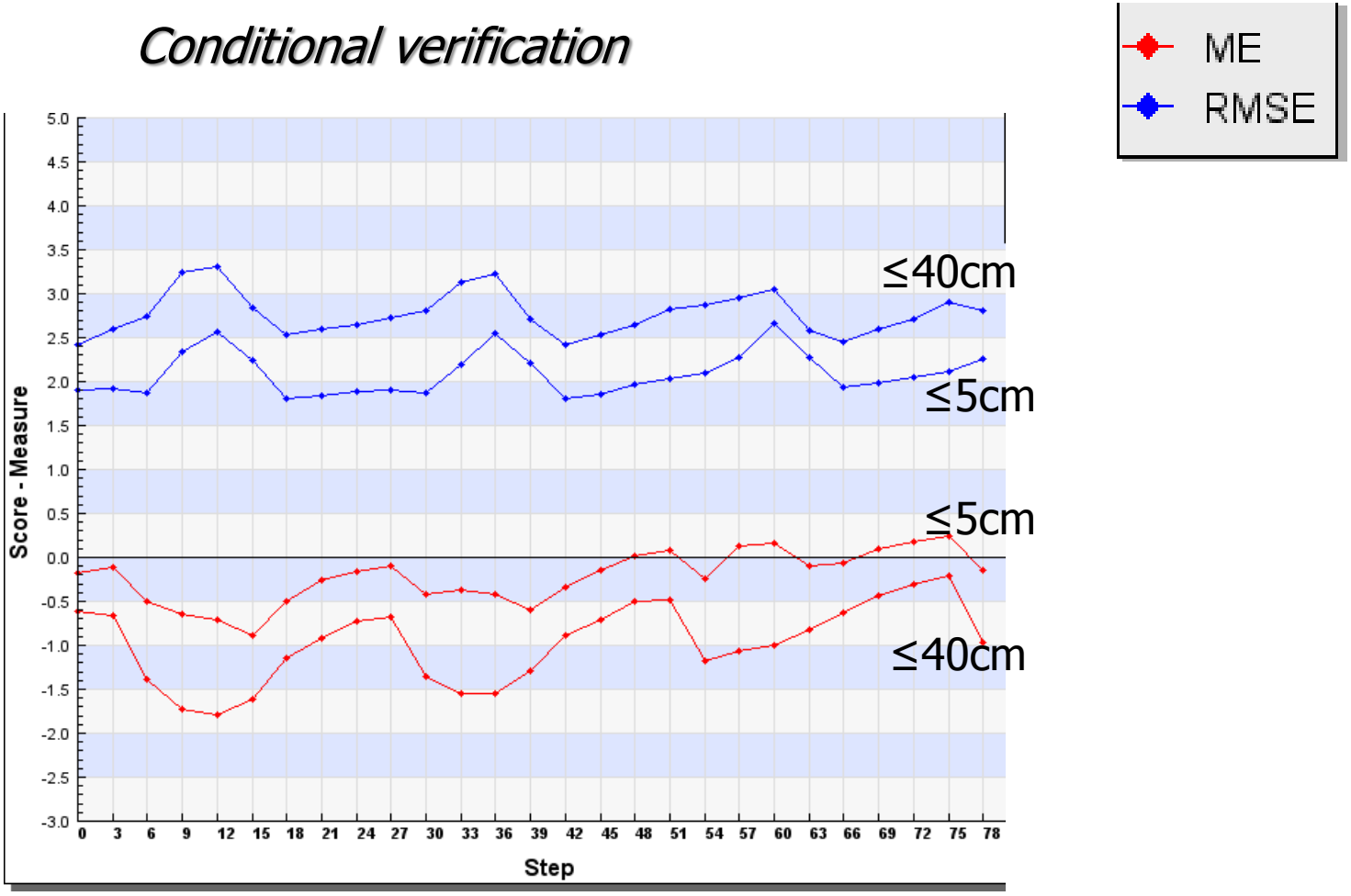
COSMO-Ru2



Condition: prognostic snow depth ≤ 5cm or prognostic snow depth ≤ 40cm

T2m (°C) RMSE and ME for COSMO-Ru7 (European domain) 24 Feb – 31 March 2015

Conditional verification



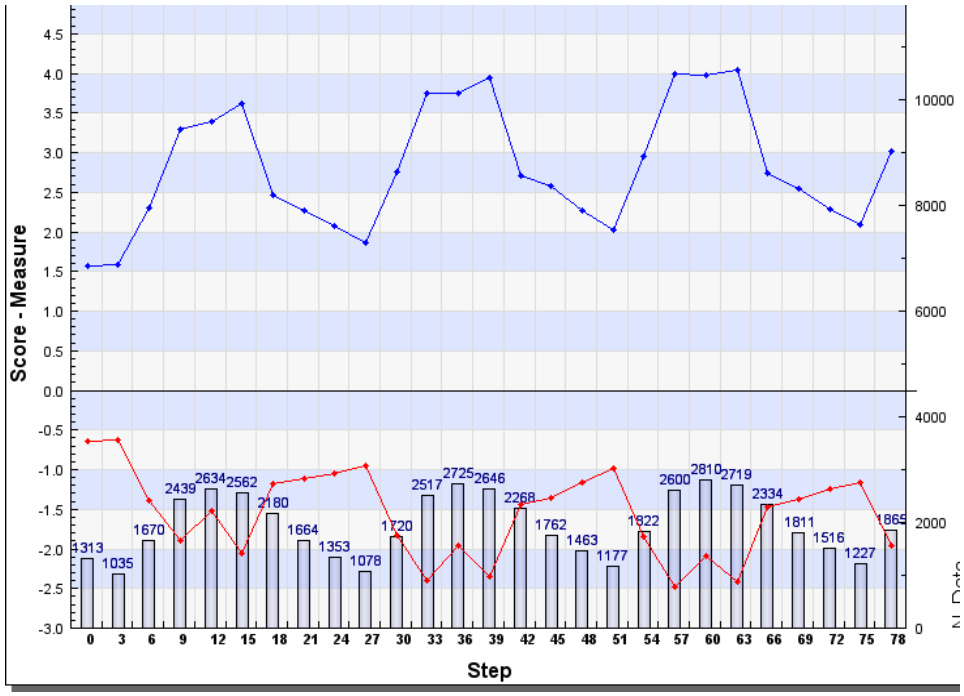
Condition: prognostic snow depth ≤ 5cm or prognostic snow depth ≤ 40cm

T2m (°C) RMSE and ME for Central region
1– 31 March 2015
The SNOWE technology

Conditional verification

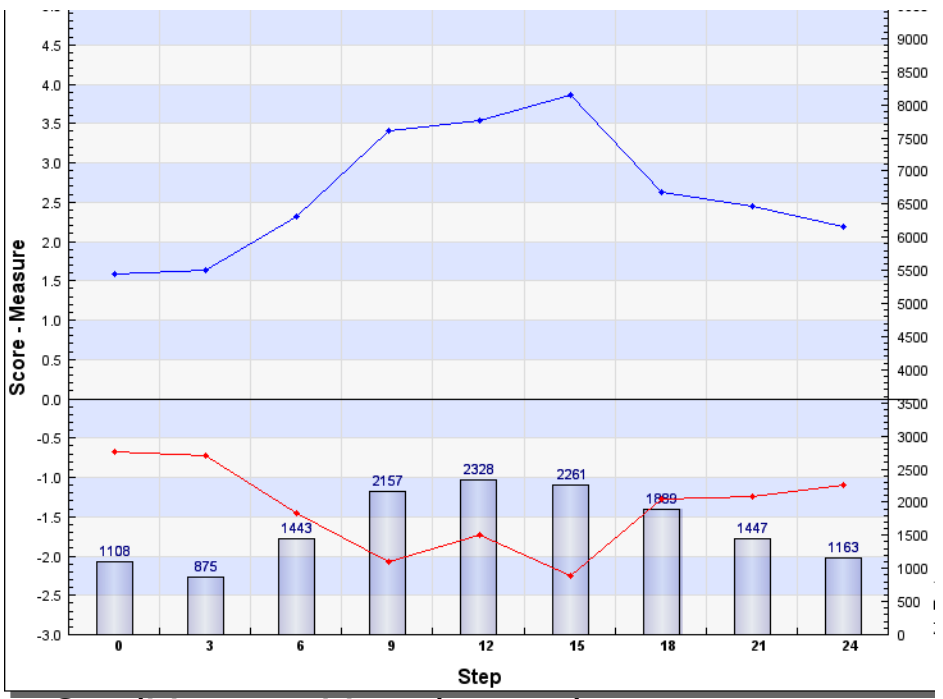
ME
RMSE

COSMO-Ru7



Condition: positive observed temperatures+ prognostic snow depth ≤ 5cm

COSMO-Ru2

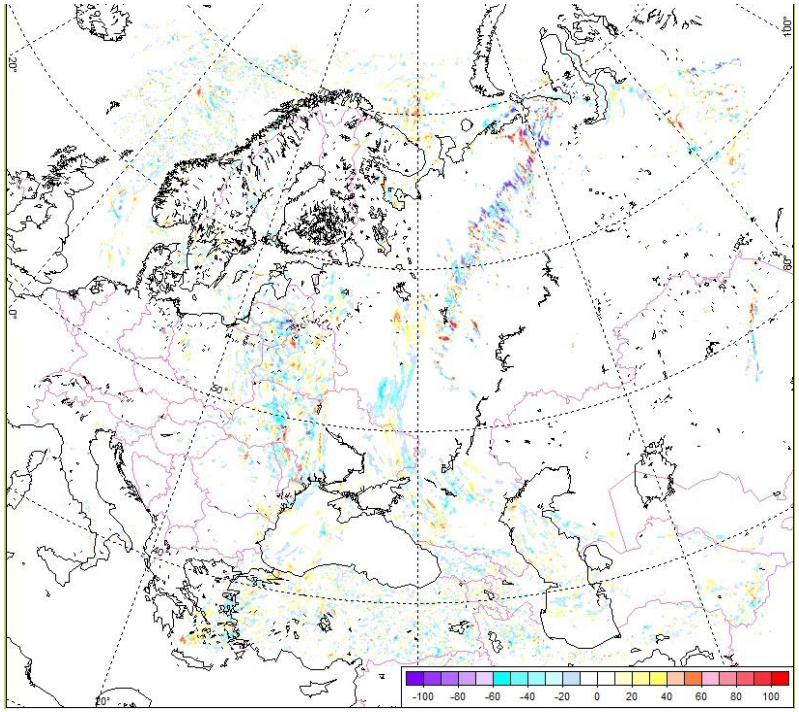


Condition: positive observed temperatures+ prognostic snow depth≤ 5cm

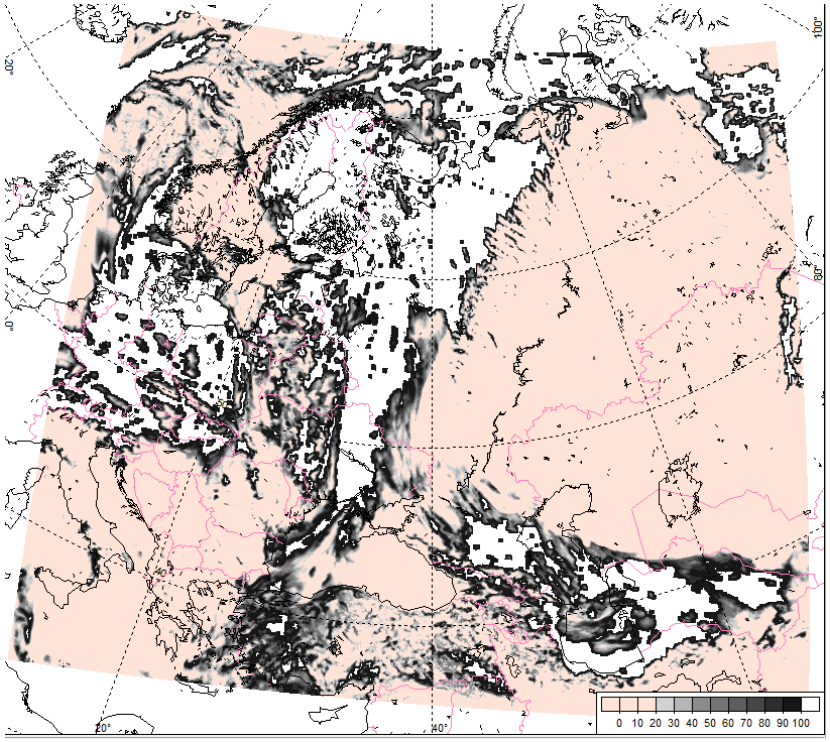
Conclusions (part3). Snow depth influence

- Changes in improvement T2m forecasts are observed both for COSMO-Ru2 and COSMO-Ru7 for the snow cases;
- For COSMO-Ru7 region (Europe area) improvements for the monthly means are a little bit better than for Central Russia for same period;
- The thin snow cover is (snow depth ≤5 cm), the more probability we have that it will melt during the forecast time (decreasing of RMSE and ME in time scale).

TCC (%) RMSE and ME for Europe region
31 March 2015



Δlow cloudiness (ex-oper) (%)
12h COSMO-Ru7 forecasts

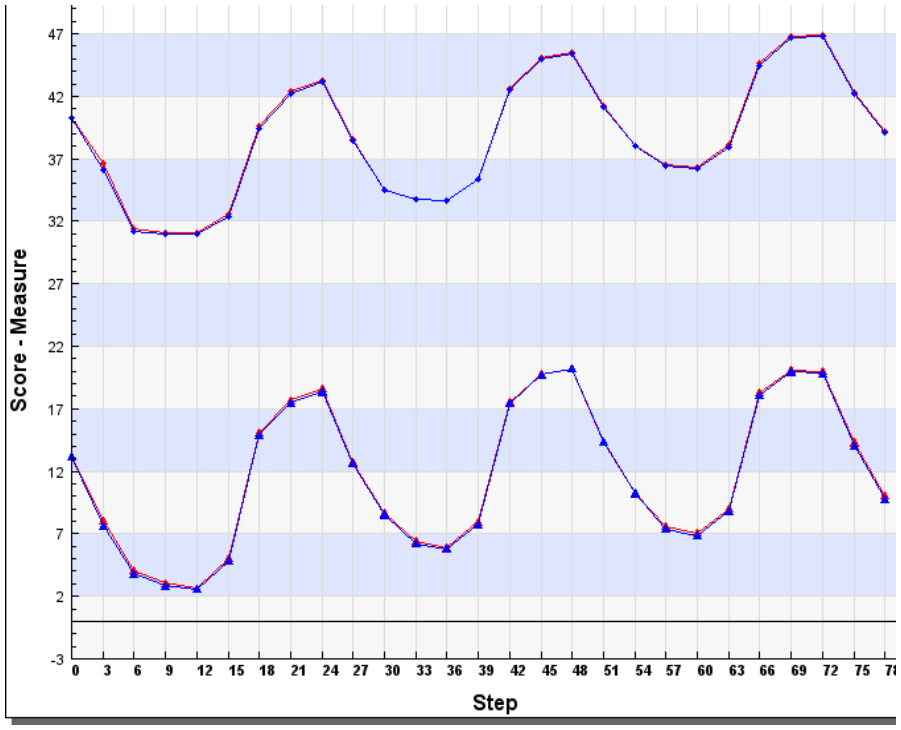


low cloudiness (ex) (%) 12h
COSMO-Ru7 forecast

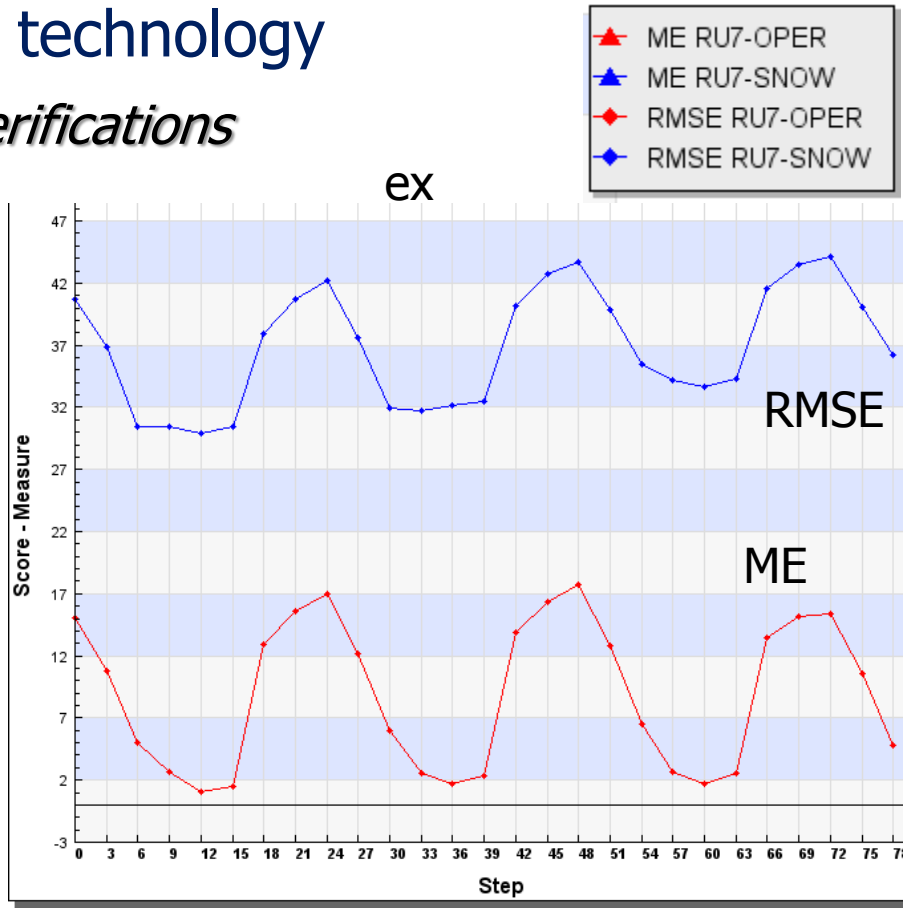
Differences are mostly observed on cloud edges and in zones of rare cloudiness

TCC (%) RMSE and ME for Europe region
24 Feb – 31 March 2015
The proposed technology

Standard and conditional verifications



ex

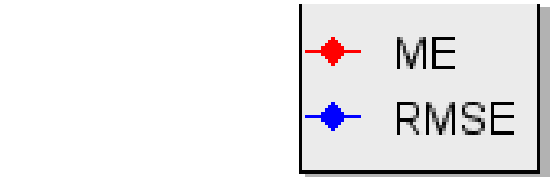


Condition: prognostic snow depth ≤ 5cm

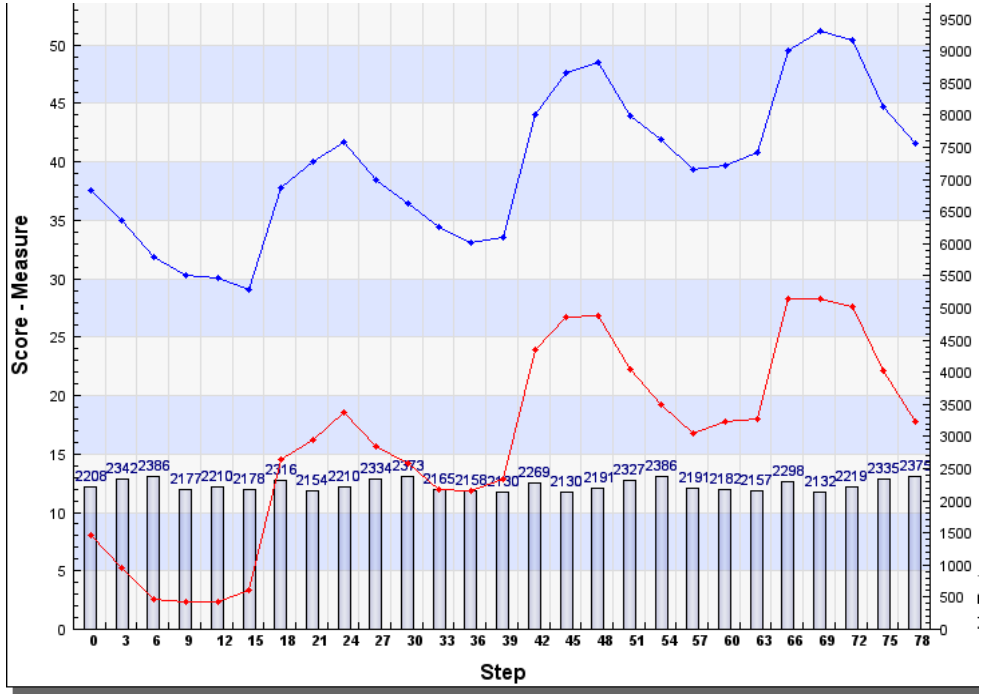
Errors don't grow up during forecast time the same way as for standard verification

TCC (%) RMSE and ME for Central region 1– 31 March 2015 The proposed technology

Conditional verification

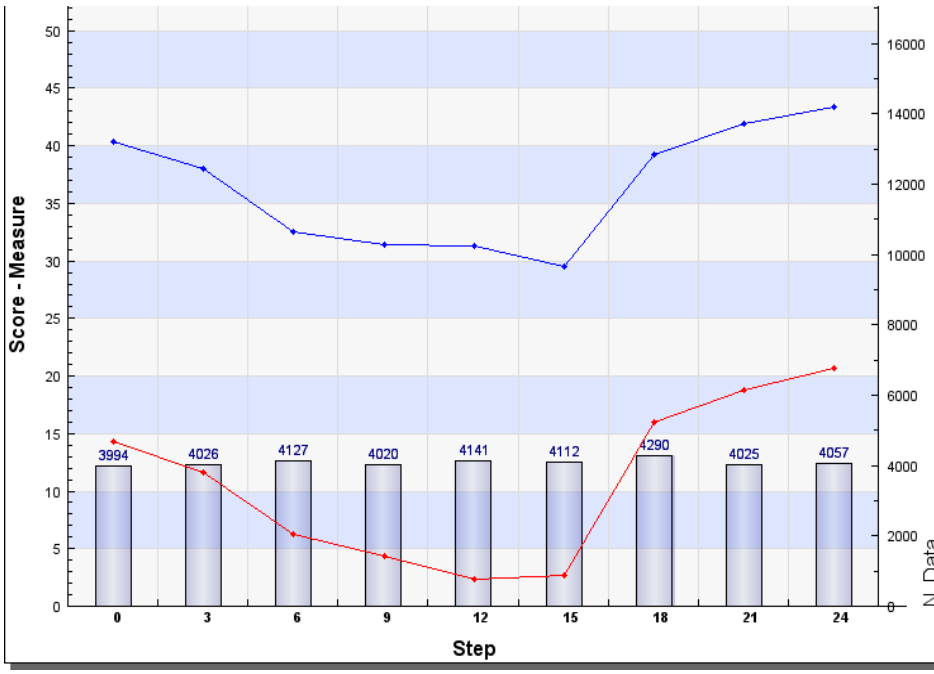


COSMO7



Condition: prognostic snow depth ≤ 40cm

COSMO2

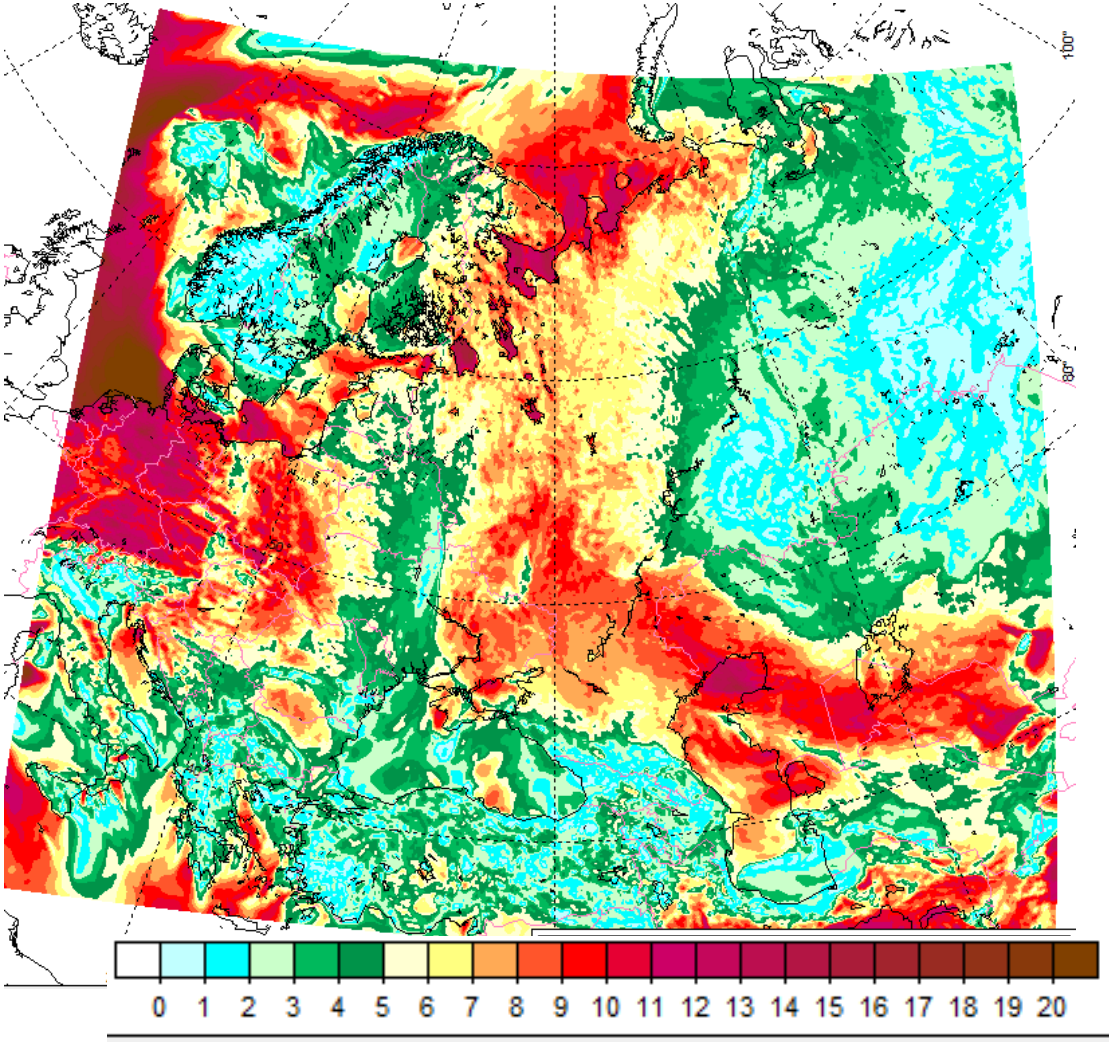


Condition: prognostic snow depth≤ 40cm

The effect of more or less stable errors is observed only for thin snow cover

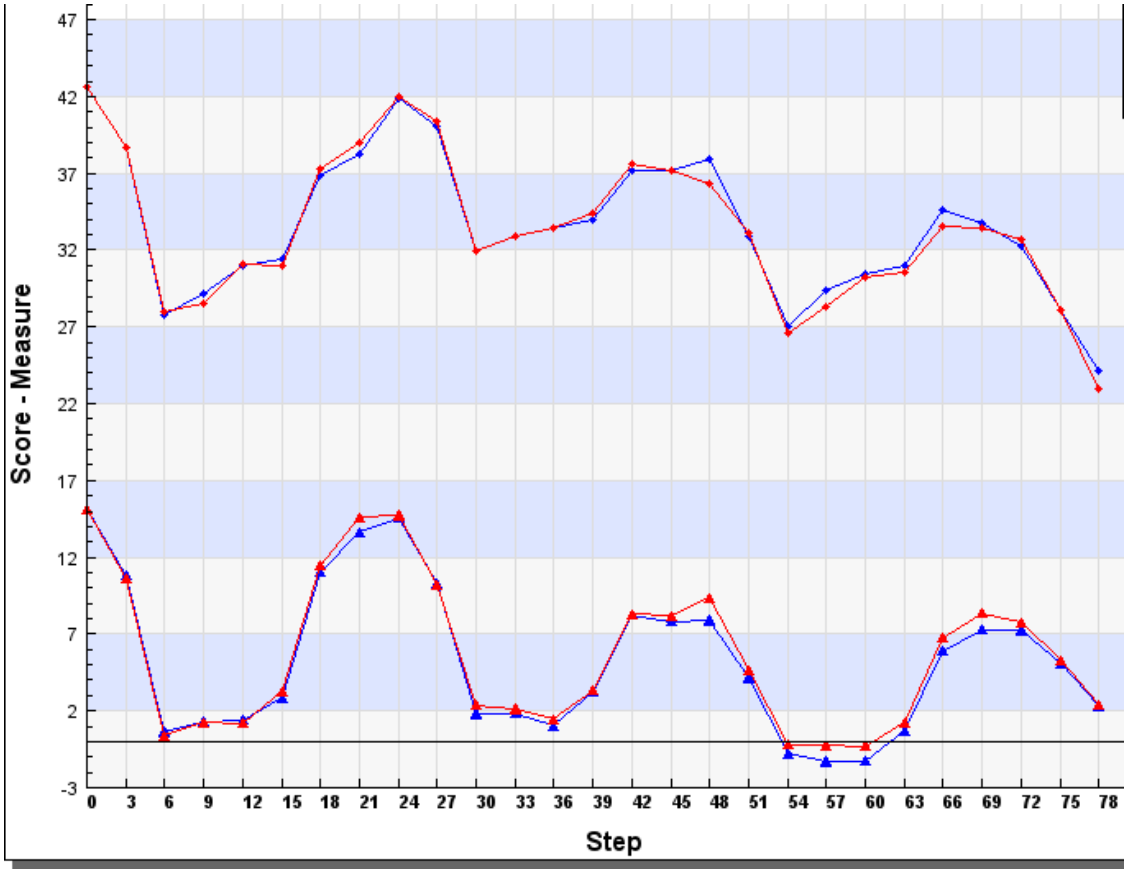
10m wind speed (m/s) 12h forecast for Europe region
31 March 2015

ex



TCC (%) RMSE and ME for Europe region 24 Feb – 31 March 2015 The proposed technology

Conditional verification



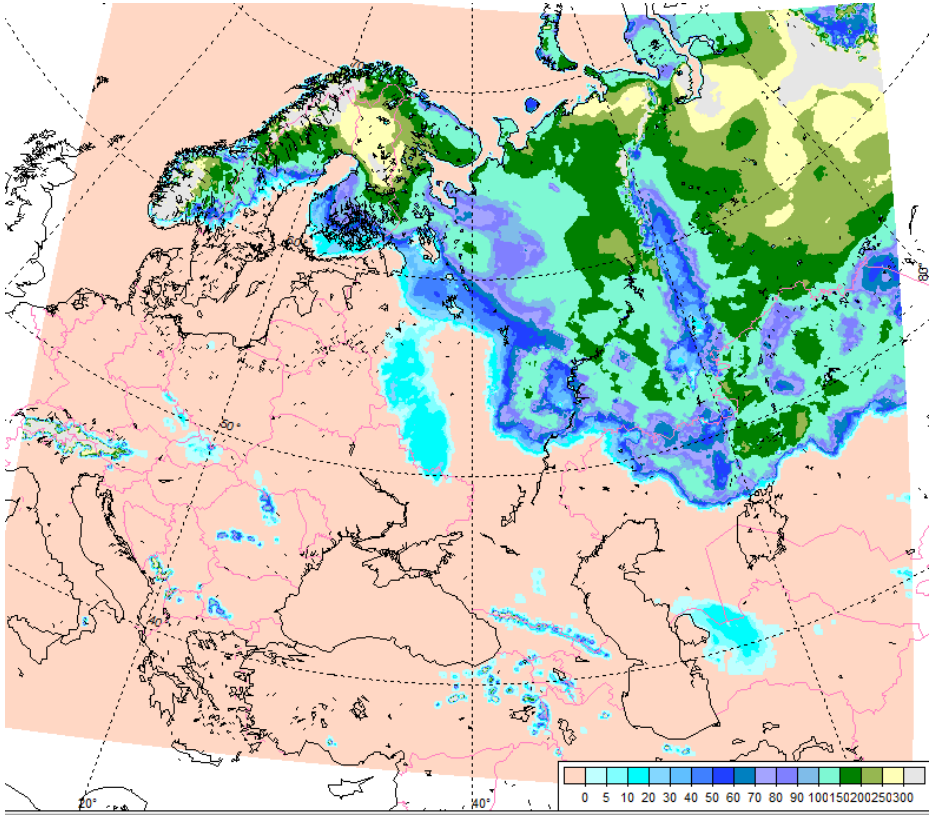
Condition: prognostic 10m wind speed > 3m/s (frontal sitiations)

Features for forecasting TCC (%) by COSMO-model according to two technologies

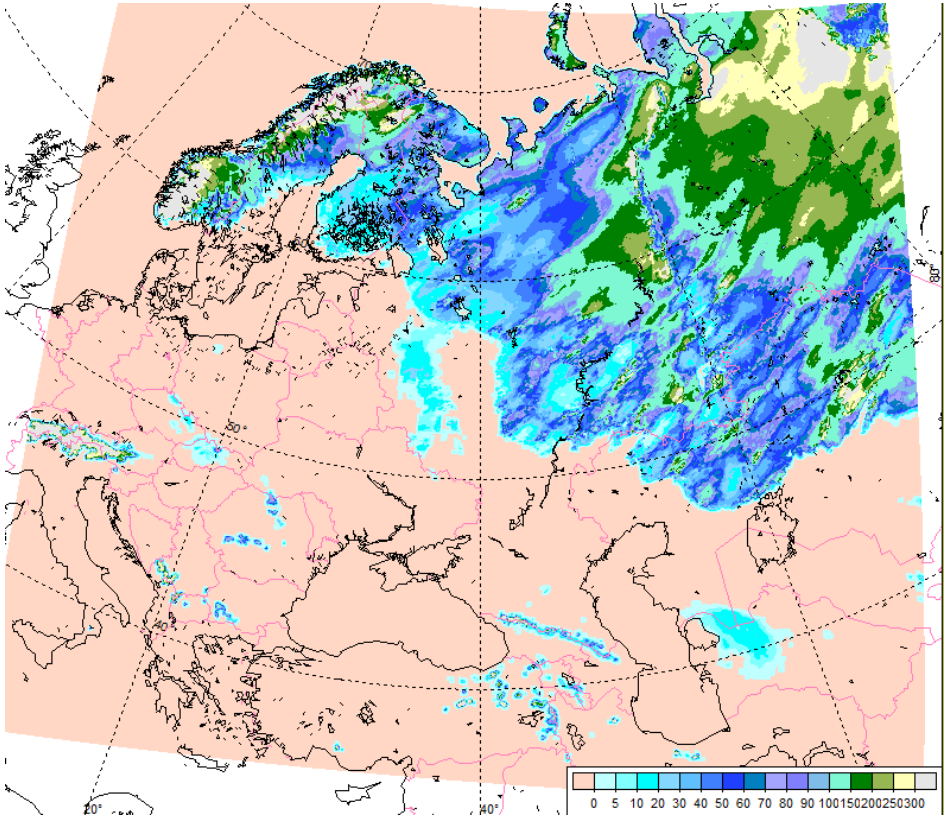
- One should take in mind that prognostic and observed values of TCC are two different kinds of information;
- Differences between two technologies are mostly observed on cloud edges and in zones of rare cloudiness. But standard verifications didn't reveal this peculiarity (due to lack of stations and small areas with TCC distinctions);
- COSMO-model TCC RMSE tends to grow through forecast time. In case of thin snow cover the error is more or less stable;
- COSMO-model errors are smaller for cases of thick cloudiness (which were diagnosed as cases with wind speed more than 3 m/s). There is a little improvement of ME TCC forecasts with the use of the proposed technology during evening time (18-24 UTC). Model errors are decreasing though forecast time. The fact that COSMO-model errors are smaller for cases of thick cloudiness can also be explained by a better correspondence between model values and observations than in case of thin cloudiness.

SWE (mm) 12h forecast for Europe region
31 March 2015

COSMO7 oper

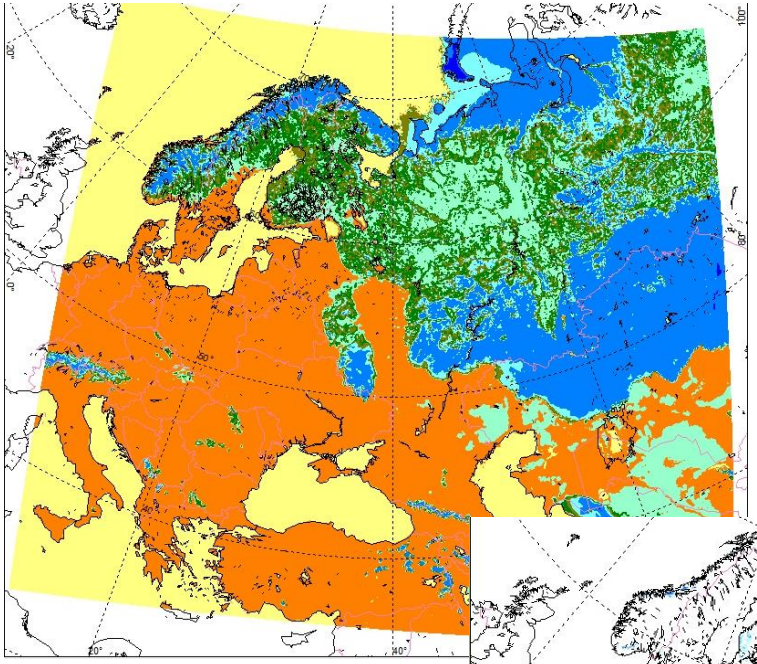


COSMO7 ex

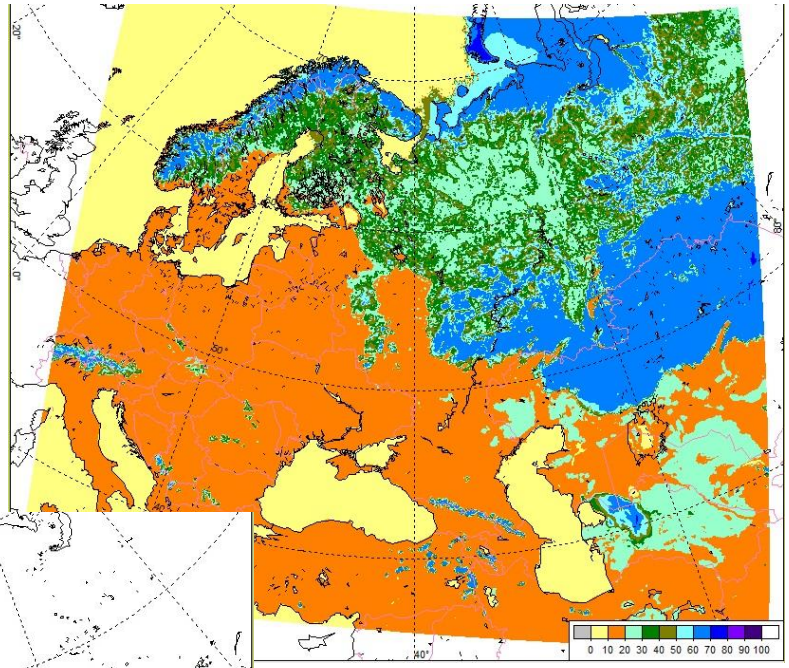


Surface albedo (%) 12h forecast for Europe region 31 March 2015

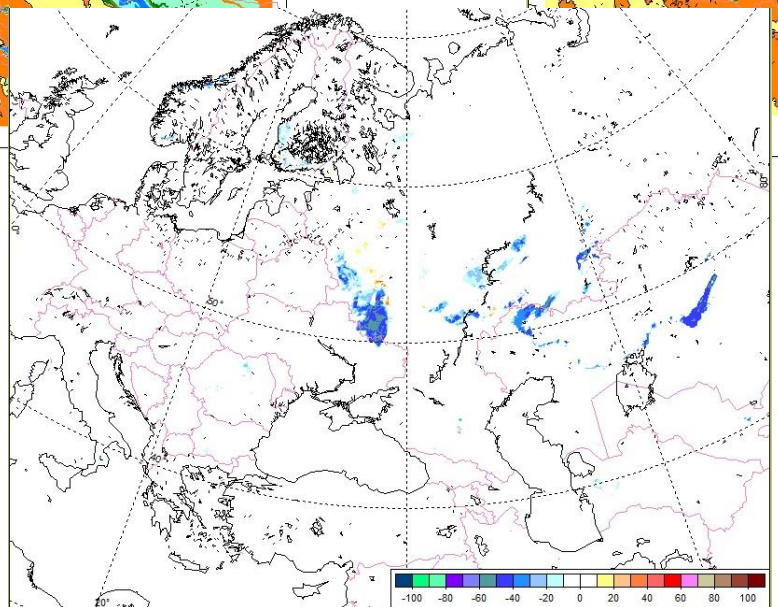
COSMO7 oper



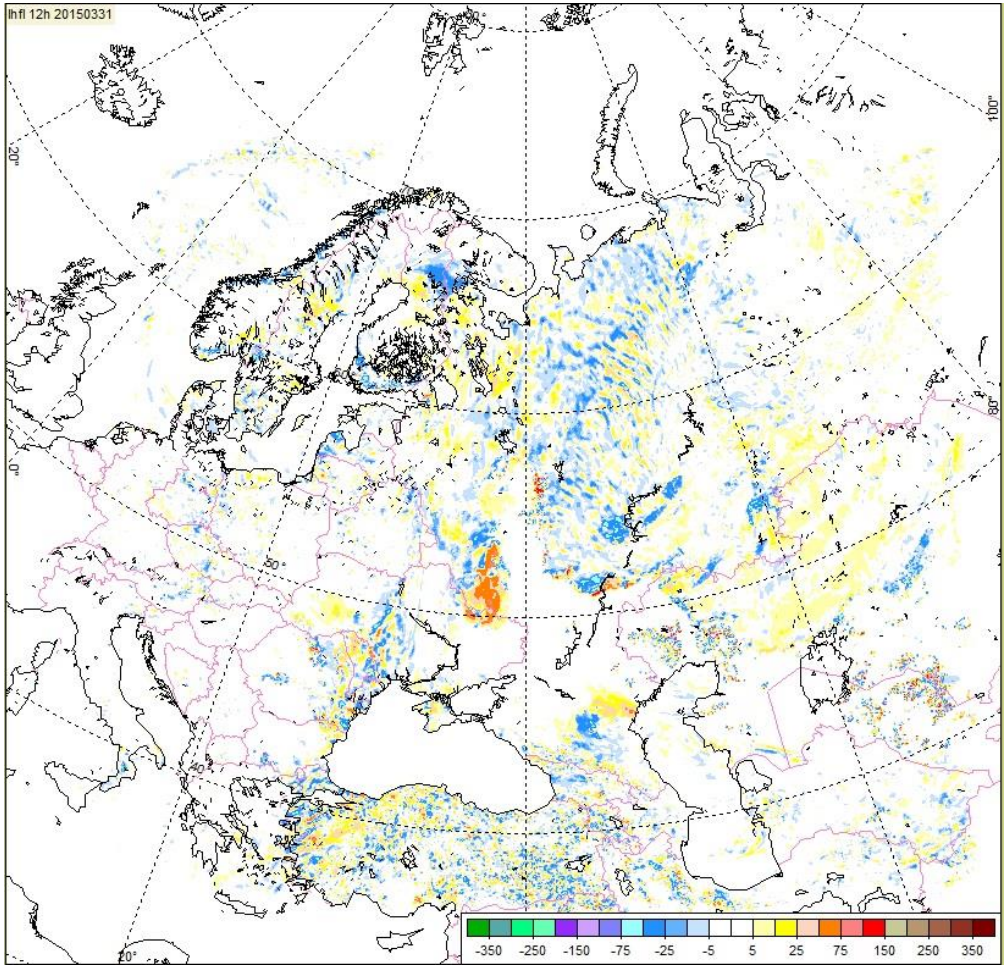
COSMO7 ex



Δalbedo



ΔLH flux (W/m2, ex-oper) forecasts to 12 UTC for Europe region from 00 UTC 31 March 2015

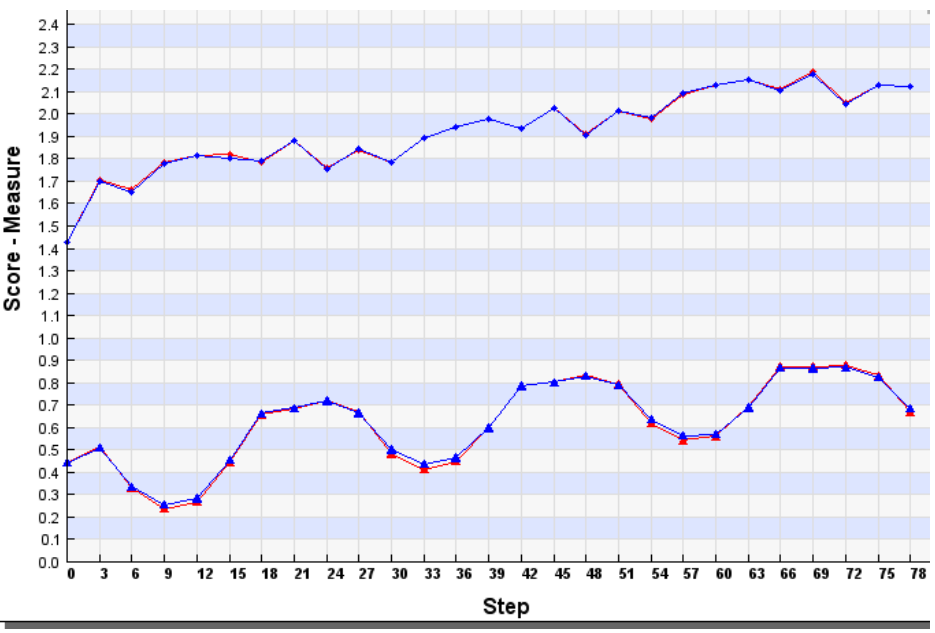


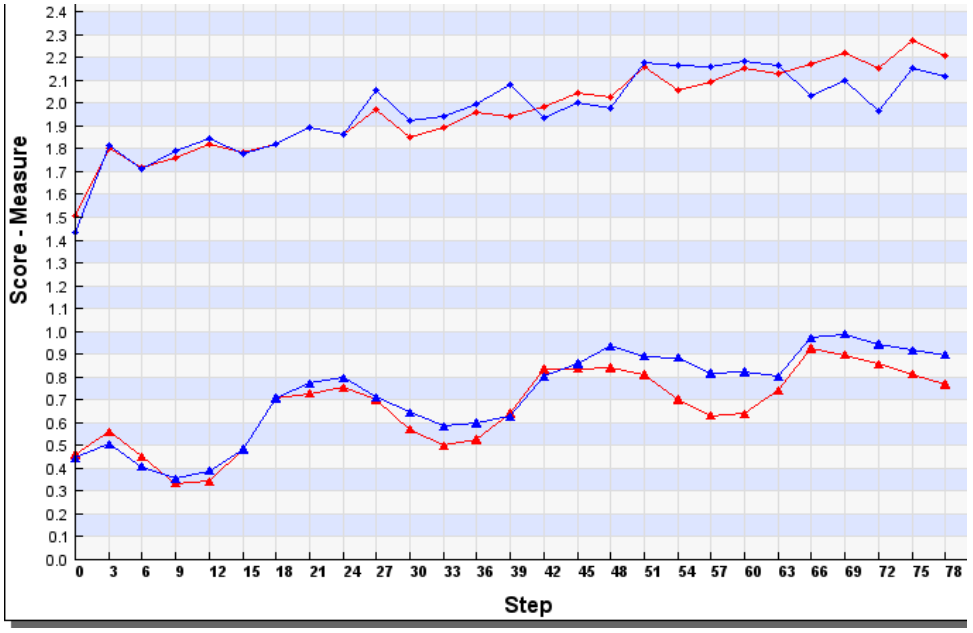
Features for forecasting some parameters by COSMO-model according to two technologies

- Changes in albedo are registered in places where snow cover was removed according to the proposed technology (snow→surface), close to snow boundary;
- SWE values are needed to calculate snow albedo;
- Changes in albedo and TCC lead to changes in heat fluxes (especially close to snow boundary)

10m wind speed (m/s) RMSE and ME for Europe region 24 Feb– 10 April 2015 The proposed technology

Standard and conditional verifications





Condition: no

Condition: positive observed temperatures

Changes in 10m wind speed forecasts are observed by using the proposed technology. But the positions of patterns of their occurrence were not diagnosed.

Conclusions

- The SNOWE technology was realized in operational technologies COSMO-Ru at run at 2014-2015 winter
- The implementation of SNOWE technology showed the positive impact for the SWE forecasts also for the T2m forecasts near the snow boundary
- The more realistic forecast of SWE based on the SNOWE corrected initial data provides more realistic speed of movements of snow boundary during the forecast time
- The largest improvement (2-3 ºC after averaging and till 7 ºC for particular cases) is observed for T2m forecasts in the cases clear sky conditions and for cases of thin snow cover
- Some influence is indicated for TCC and 10m wind speed

Thank you for your attention!