Experiments with single- and multi-layer snow models

Ekaterina Machulskaya

German Weather Service, Offenbach am Main, Germany

(ekaterina.machulskaya@dwd.de)

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Outline

- Experiment with a new formulation for snow fraction (dependence on snow height)
- Multi-layer snow model: status
- Distribution of the incoming solar radiation between snow-covered and snow-free parts
- Experiments with the tile approach (snow-covered and snow-free tiles)
- Conclusions and outlook

Snow fraction: dependence on snow height (with J. Helmert)

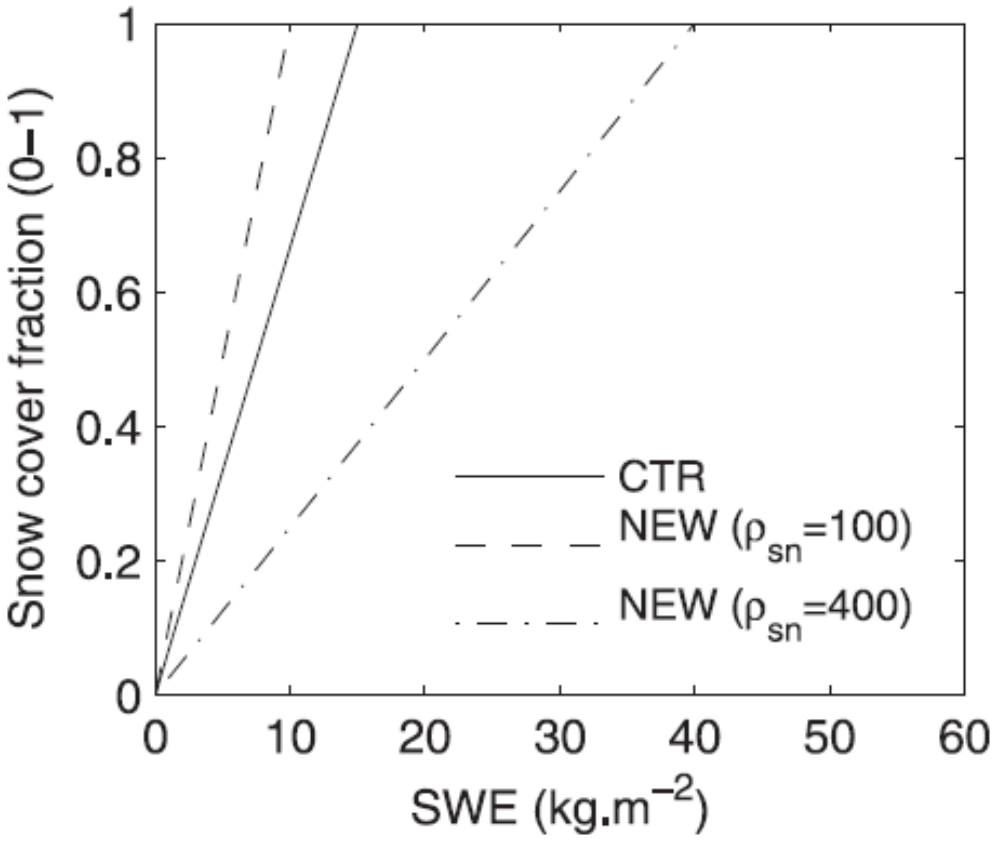


FIG. 2. Snow cover fraction as function of SWE as in the original HTESSEL snow scheme [solid line, Eq. (A2)], and new [Eq. (8)] for snow densities of 100 (dashed line) and 400 (dashed dotted line) kg m^{-3}.

Dutra et al. (2010)

$$f_{sn} = MIN\left(\frac{W_{sn}}{W_{cr}}, 1\right)$$

$$W_{cr} = 15mm$$

$$f_{sn} = MIN\left(\frac{W_{sn}/\rho_{sn}}{0.1}, 1\right)$$

$$\Updownarrow$$

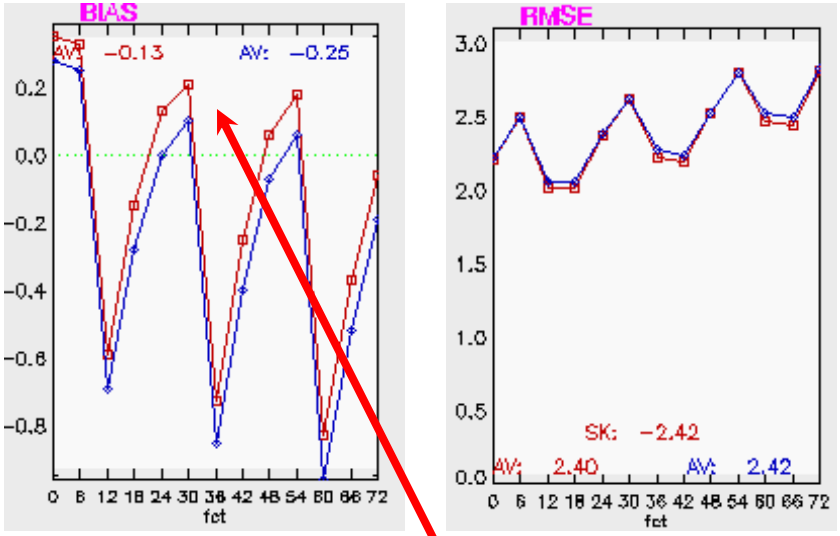
$$f_{sn} = MIN\left(\frac{H_{sn}}{H_{cr}}, 1\right)$$

$$H_{cr} = 0.1m$$

Dependence of snow fraction on snow height: verification

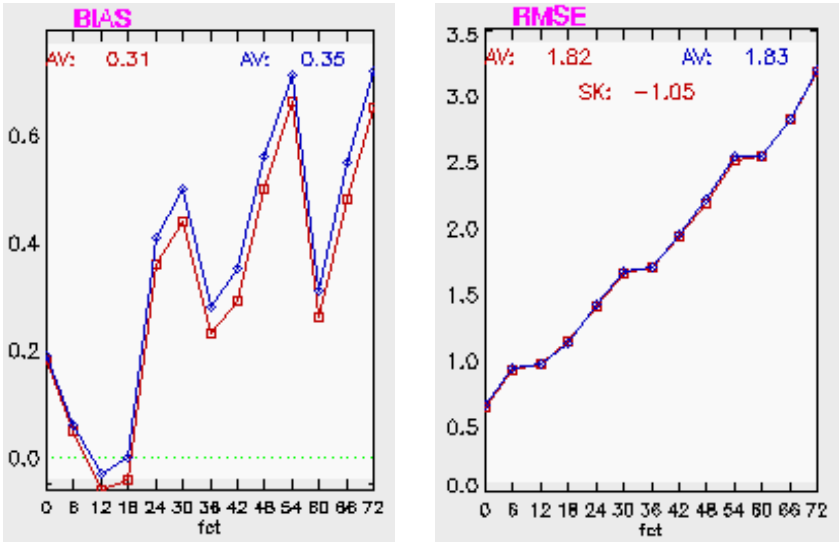
COSMO-EU domain, January-February 2012

2m temperature



cold bias slightly reduced!

Surface pressure



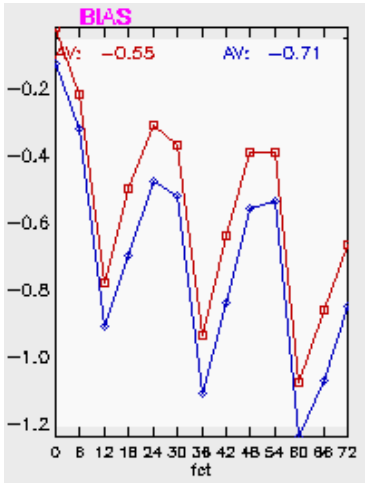
positive bias in pressure slightly reduced

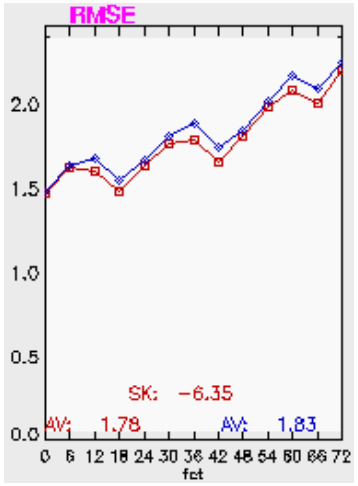
2m specific humidity and wind, cloud cover, precipitation are not affected

Dependence of snow fraction on snow height: verification

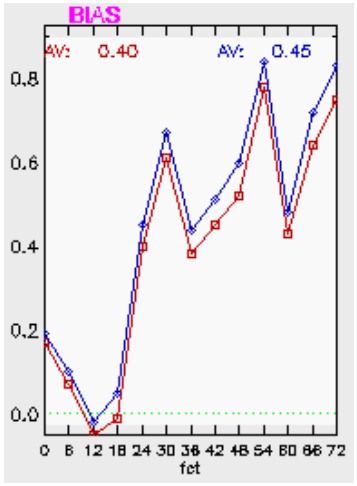
COSMO-EU verified over DE domain, January-February 2012

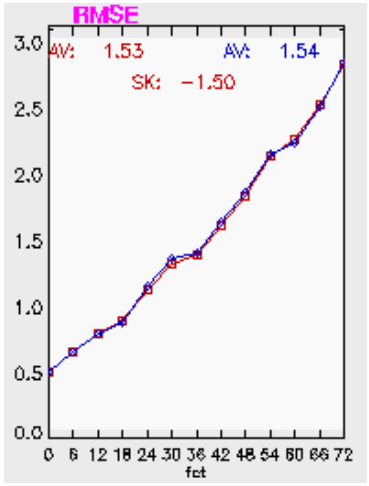
2m temperature



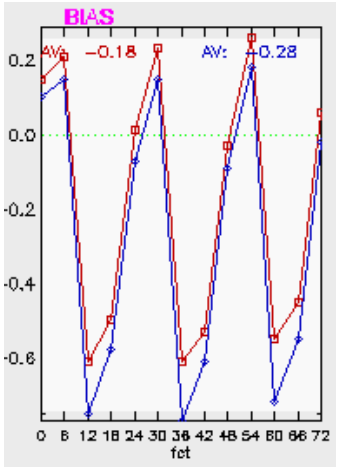


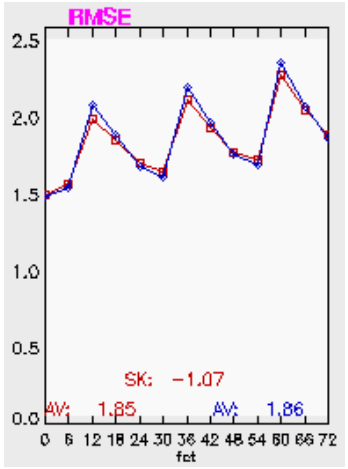
Surface pressure





2m dew point

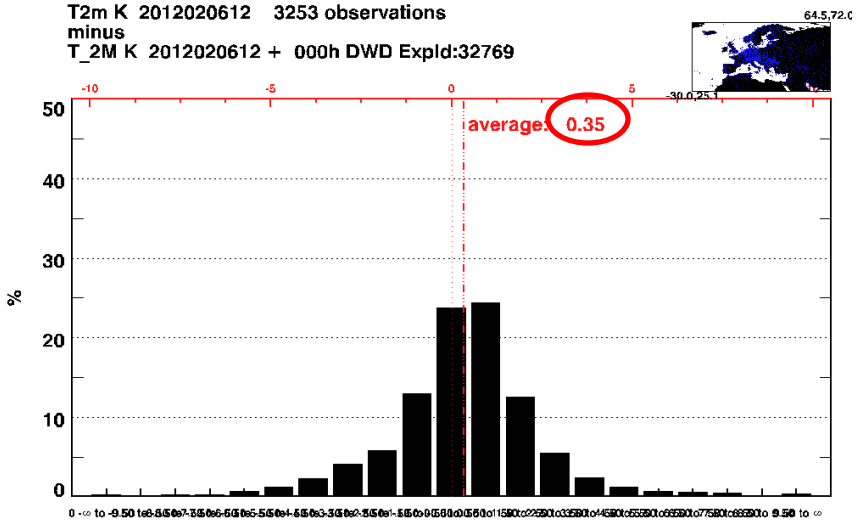


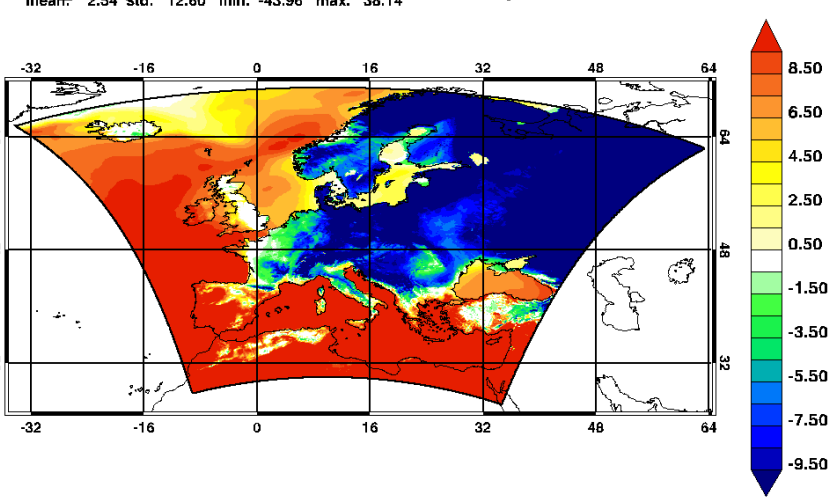


dry bias
slightly reduced

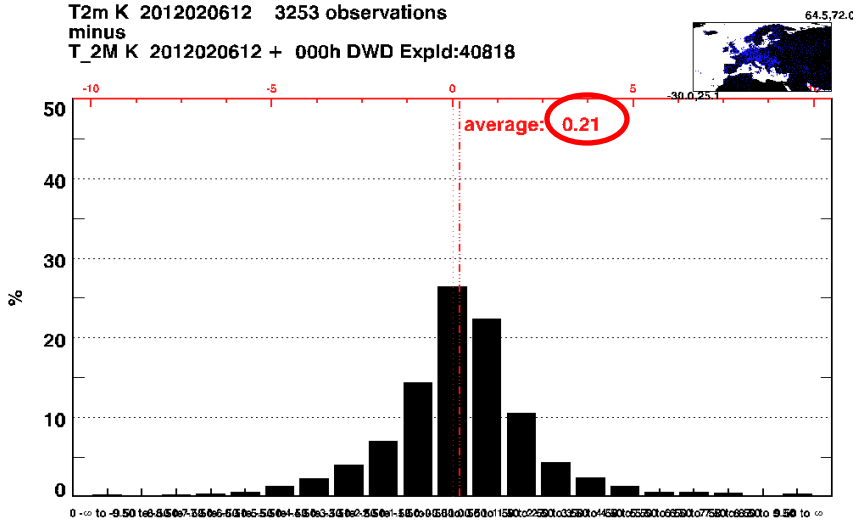
Dependence of snow fraction on snow height: an example

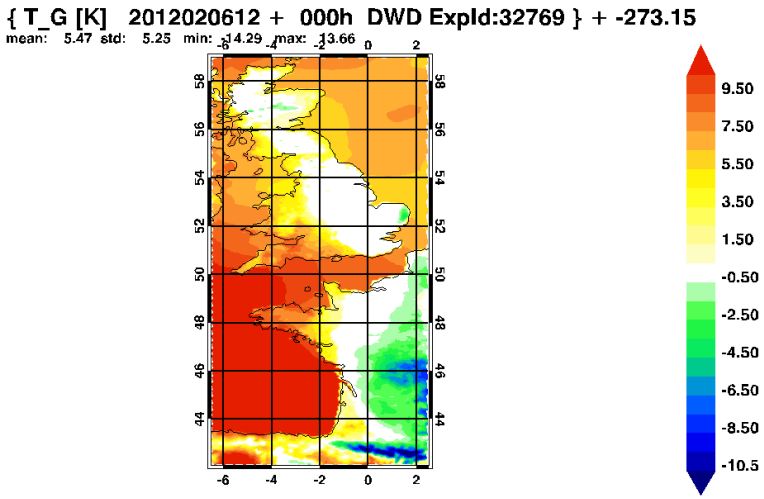
2m temperature error (Routine)





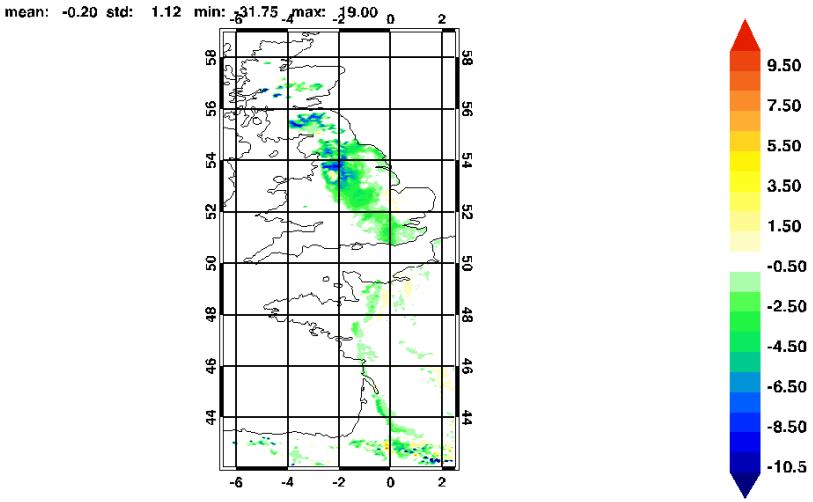
2m temperature error (Exp)



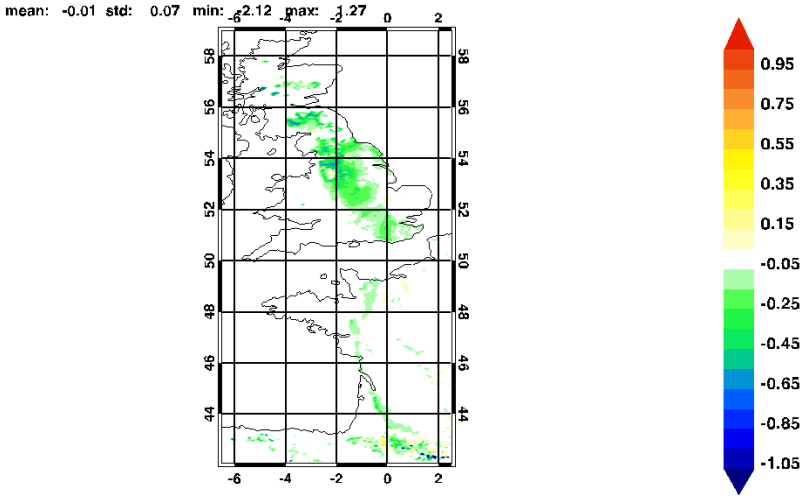


Dependence of snow fraction on snow height: an example

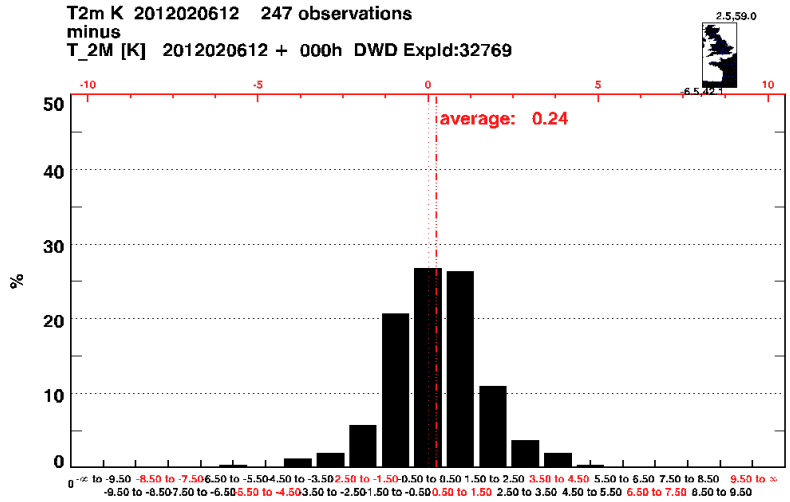
SWE, Exp – Rou



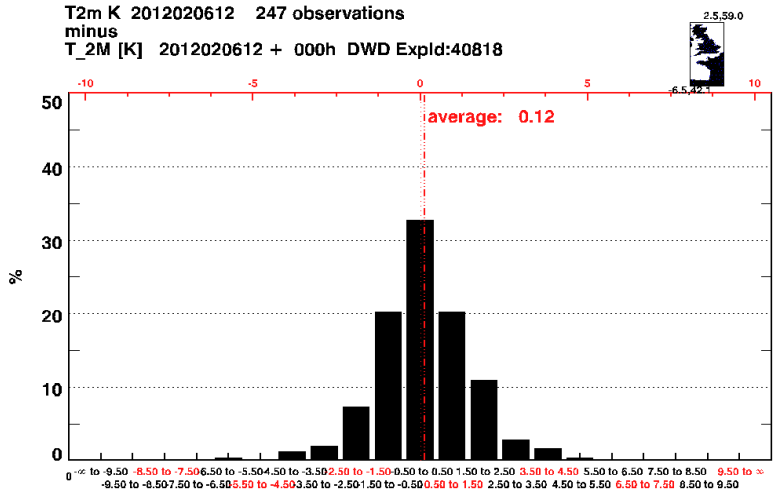
Snow fraction, Exp – Rou



T2m error (Routine)



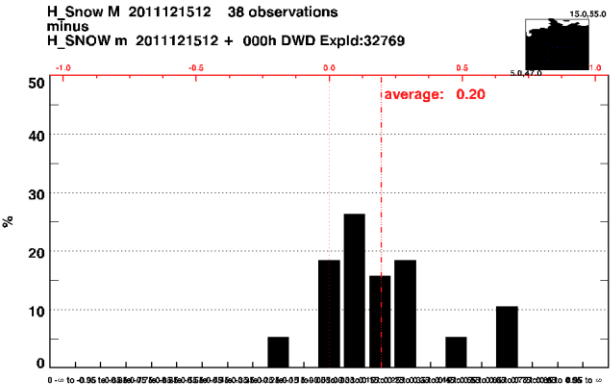
T2m error (Exp)

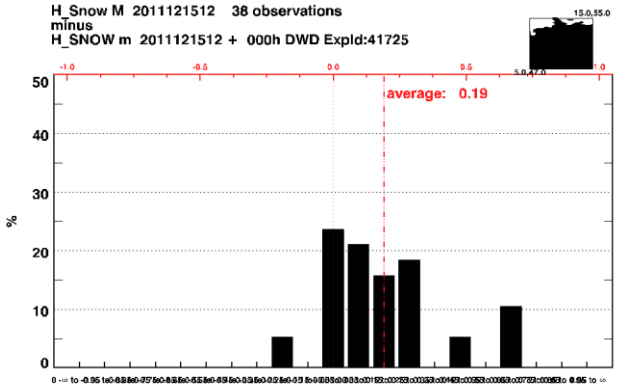


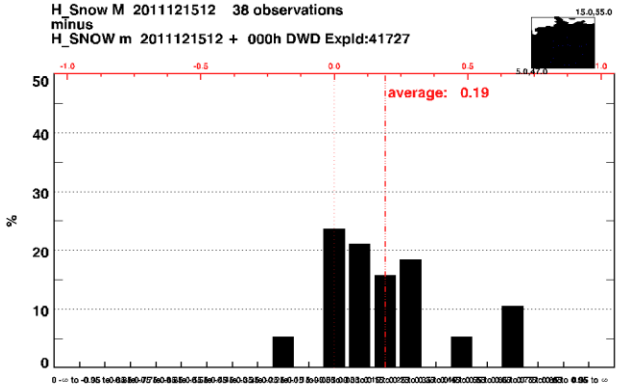
Multi-layer snow model

Routine | ML snow model | ML+snow fraction

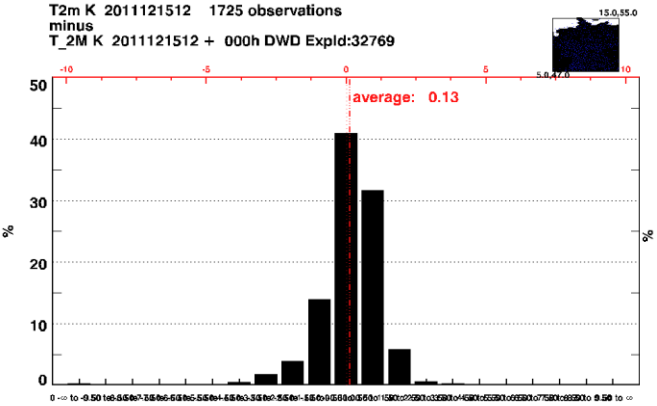
snow height error

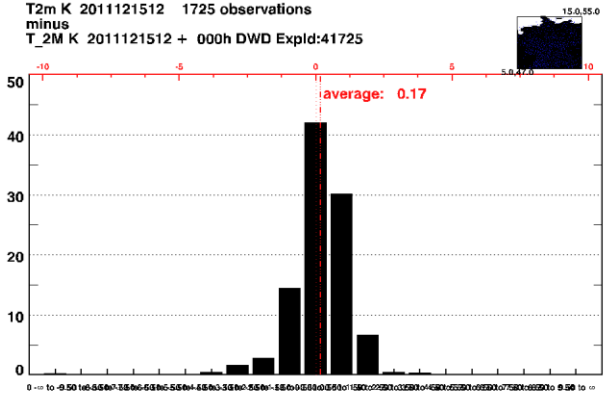


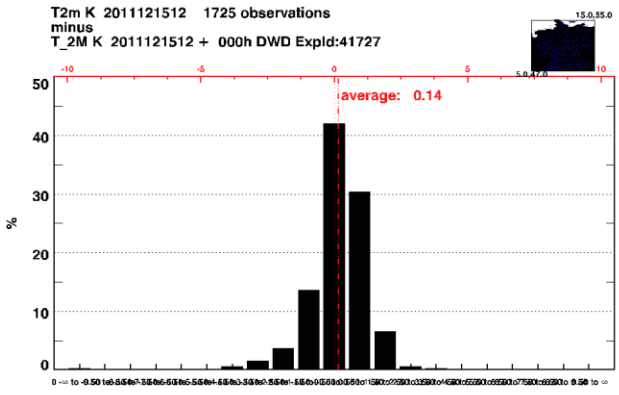




2m temperature error







Distribution of the solar radiation

$$a = fa_{snow} + (1-f)a_{soil}$$

$R_{sol}=I(1-a)$

R_{sol} R_{sol}

f $1-f$

$R_{sol}=I(1-a)$

$R_{sol-snow}= I(1-a_{snow})= R_{sol}(1-a_{snow})/(1-a)$

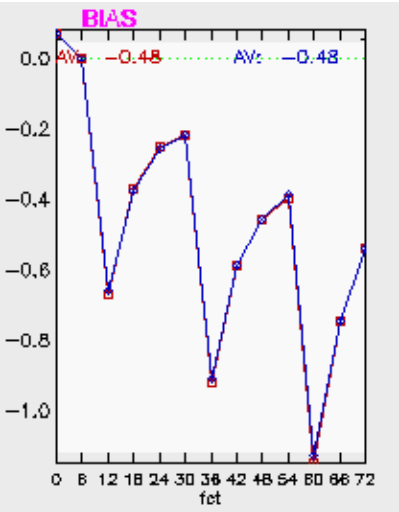
$R_{sol-soil}= I(1-a_{soil})= R_{sol}(1-a_{soil})/(1-a)$

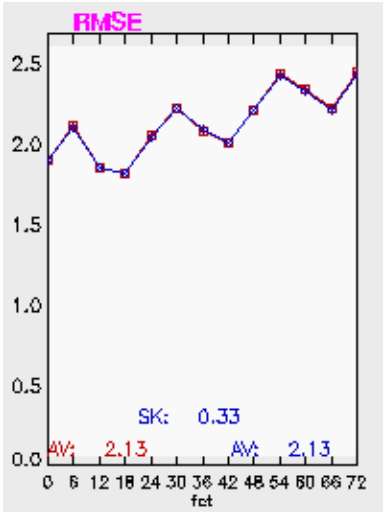
f $1-f$

Distribution of the solar radiation: verification

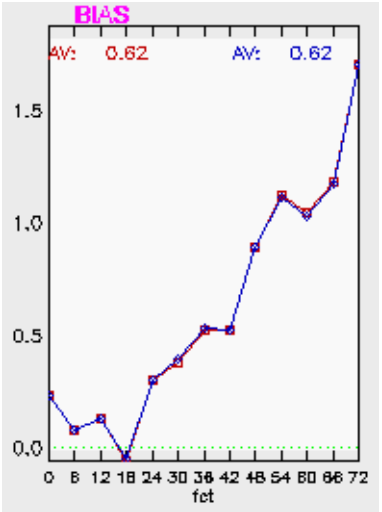
COSMO-EU domain, December 2011 - January 2012

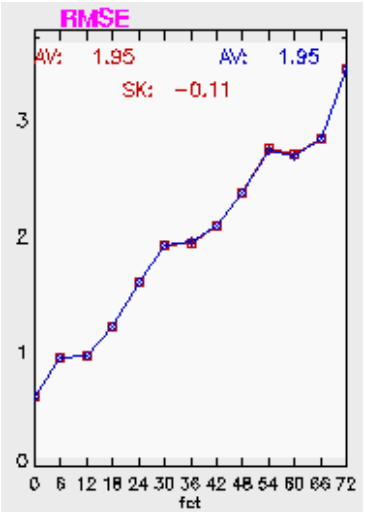
2m temperature





Surface pressure



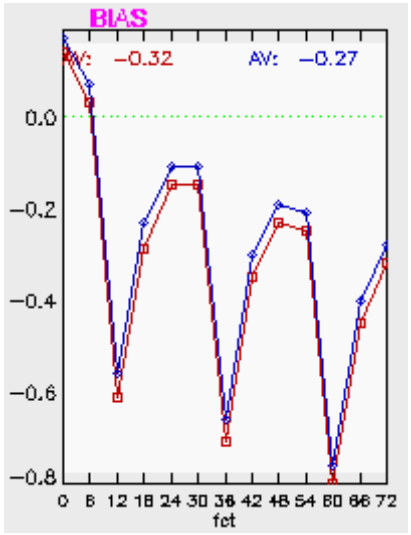


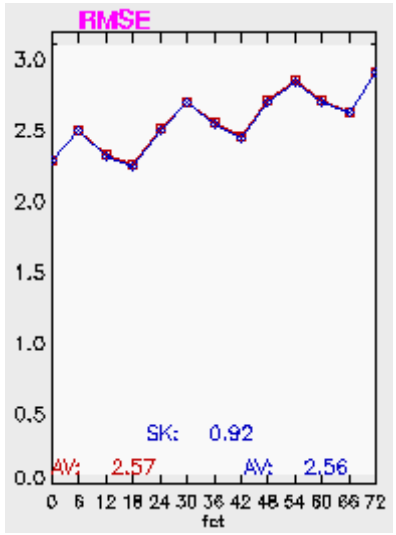
Neutral scores, although local discrepancies are noticeable:
up to several degrees in 2m temperature

Tile approach: verification

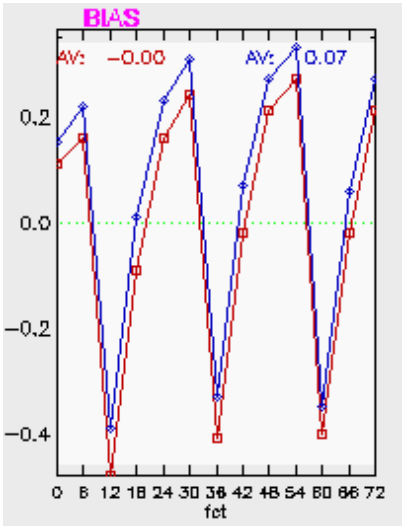
COSMO-EU domain, December 2010 - January 2011

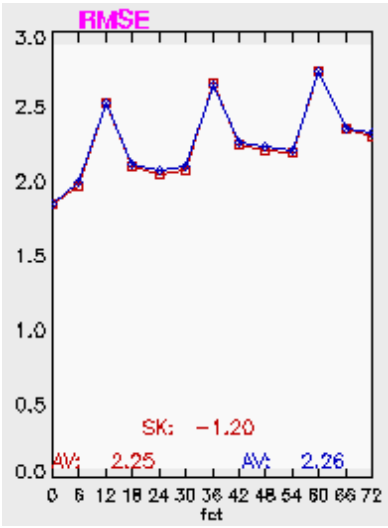
2m temperature





Surface pressure





Work in progress (full-scale tile approach
is being implemented into ICON),
no conclusive statement can be made at the moment

Conclusions

- The dependence of snow fraction on snow height looks physically based; verification scores for COSMO-EU are positive; the new formulation can be suggested to use
- Experiments with multi-layer snow model are being performed, the results look satisfactory
- Distribution of the incoming solar radiation between snow-covered and snow-free parts can be introduced; verification scores are neutral as compared to the routine; further analysis (1d) is being carried out
- Tile approach (snow-covered and snow-free tiles) is implemented into COSMO, the results of the experiments are being analysed

Thank you for your attention!

Thanks to Ulrich Damrath, Jochen Förstner, Thomas Hanisch, Jürgen Helmert, Dmitrii Mironov, Bodo Ritter, and Harald Ruppert!