

Prognostic Sea-Ice Albedo Parameterization for ICON-NWP

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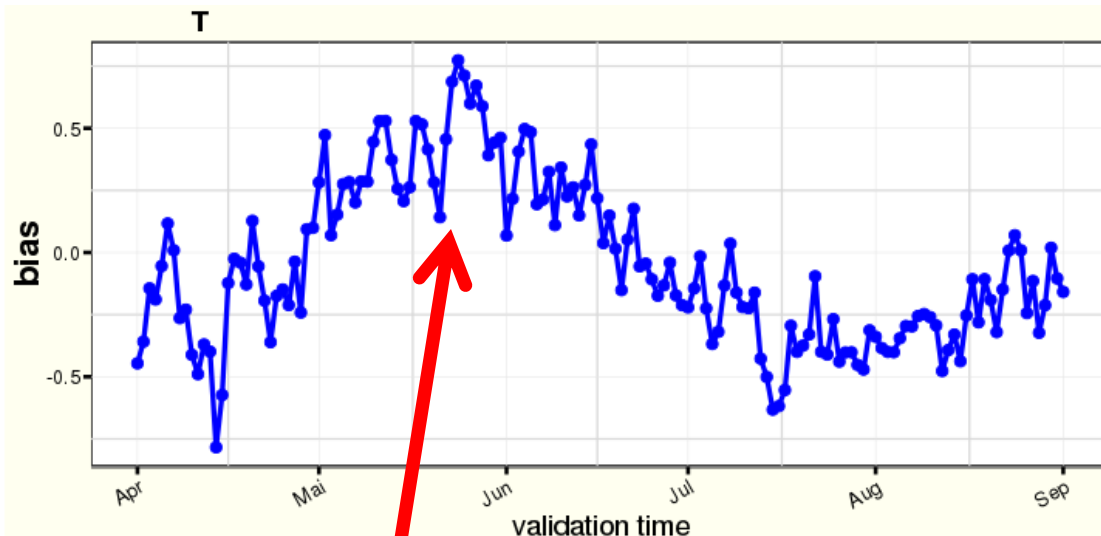


- Motivation
- Diagnostic sea-ice albedo parameterization
- Prognostic parameterization
- Results from numerical experiments
- Conclusions and outlook

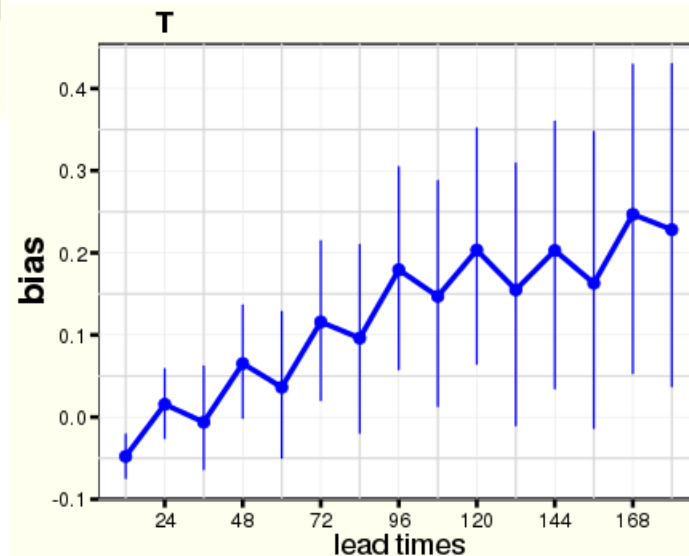
- Overestimation of the air temperature in the lower troposphere in polar regions.
- A likely reason is a too quick response of the sea-ice surface albedo with respect of solar radiation to changes in the sea-ice surface temperature (α_i immediately follows θ_i).
- A too low albedo, particularly in the beginning of the melt season, leads to an erroneous ice-surface energy balance and an overestimation of the air temperature in the lower troposphere.

Motivation (cont'd)

ICON routine

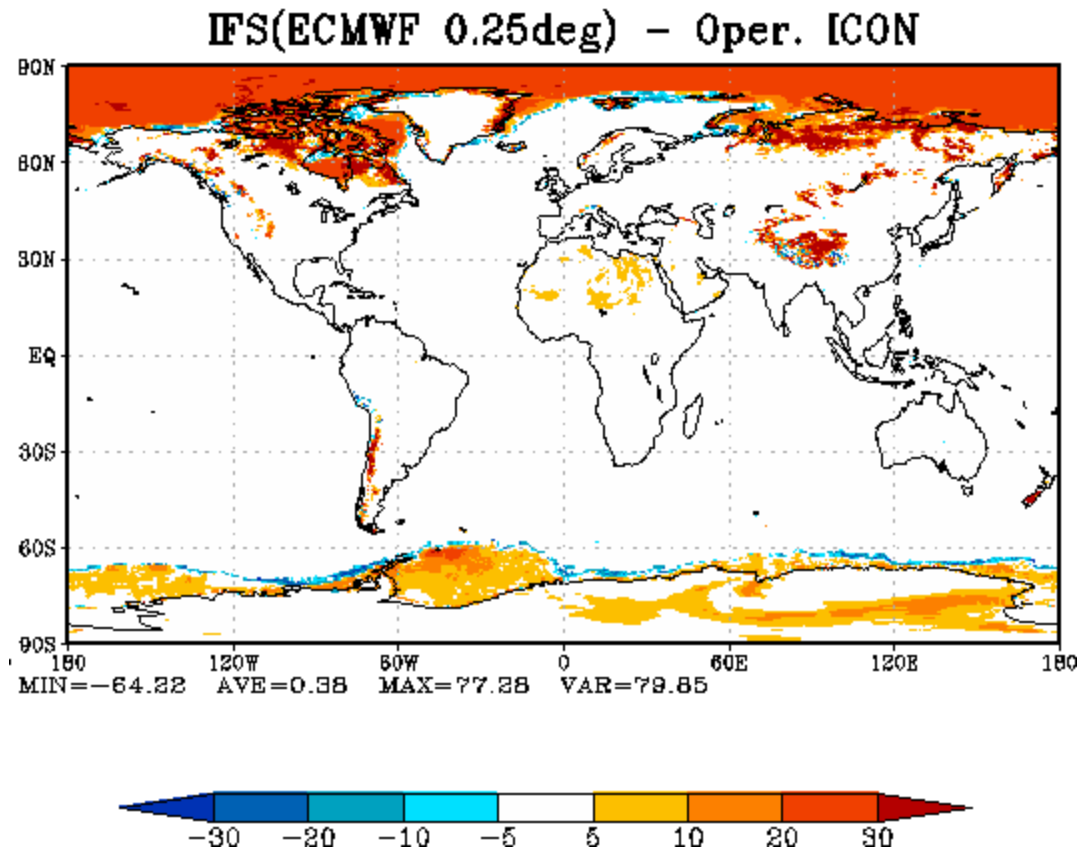


Temperature bias vs. lead time
North pole region, 925hPa
avg for 160501-160801



Motivation (cont'd)

Sea-ice albedo in the beginning of the melt season (IFS – ICON difference $\times 100$)



IFS values are interpolated from monthly means (Ebert and Curry, 1993)

Diagnostic Sea-Ice Albedo Parameterization

“Equilibrium” sea-ice albedo,
function of the ice surface temperature

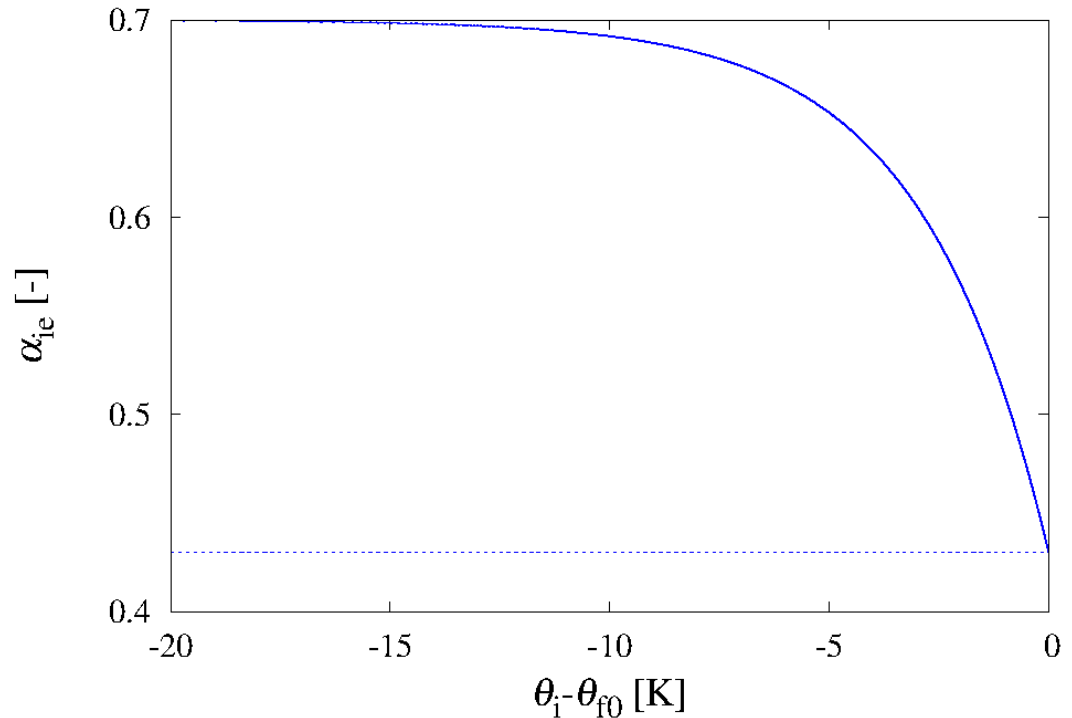
$$\alpha_i = \alpha_{ie} = \alpha_i^{max} - (\alpha_i^{max} - \alpha_i^{min}) \exp \left[-C_{\alpha i} \frac{\theta_{f0} - \theta_i}{\theta_{f0}} \right],$$

$$\theta_{f0} = 273.15 \text{ K}$$

$$C_{\alpha i} = 95.6$$

$$\alpha_i^{min} = 0.43 (0.48)$$

$$\alpha_i^{max} = 0.70$$



Prognostic Parameterization

Relaxation-type equation

$$\frac{d\alpha_i}{dt} = -\frac{\alpha_i - \alpha_{ie}}{\tau_{\alpha i}} - \frac{\alpha_i - \alpha_{sne}}{\tau_{\alpha sn}}$$

Relaxation time scales

$$\tau_{\alpha sn} = R_{sn}/R_*$$

$R_* = 5 \text{ kg}\cdot\text{m}^{-2}$ is a disposable parameter (R_{sn} is a snowfall rate)

Relaxation towards equilibrium
“snow-over-sea-ice” albedo only if
 $\alpha_i < \alpha_{sne}$ (albedo tends to increase)
and
 $\theta_i < 272.95 \text{ K}$ (close to the freezing point, melt ponds do not re-freeze)

$\tau_{\alpha i} = 3$ days at (fresh-water) freezing point, and increases towards 21 days as θ_i approaches 268.15 K



Prognostic Parameterization (cont'd)

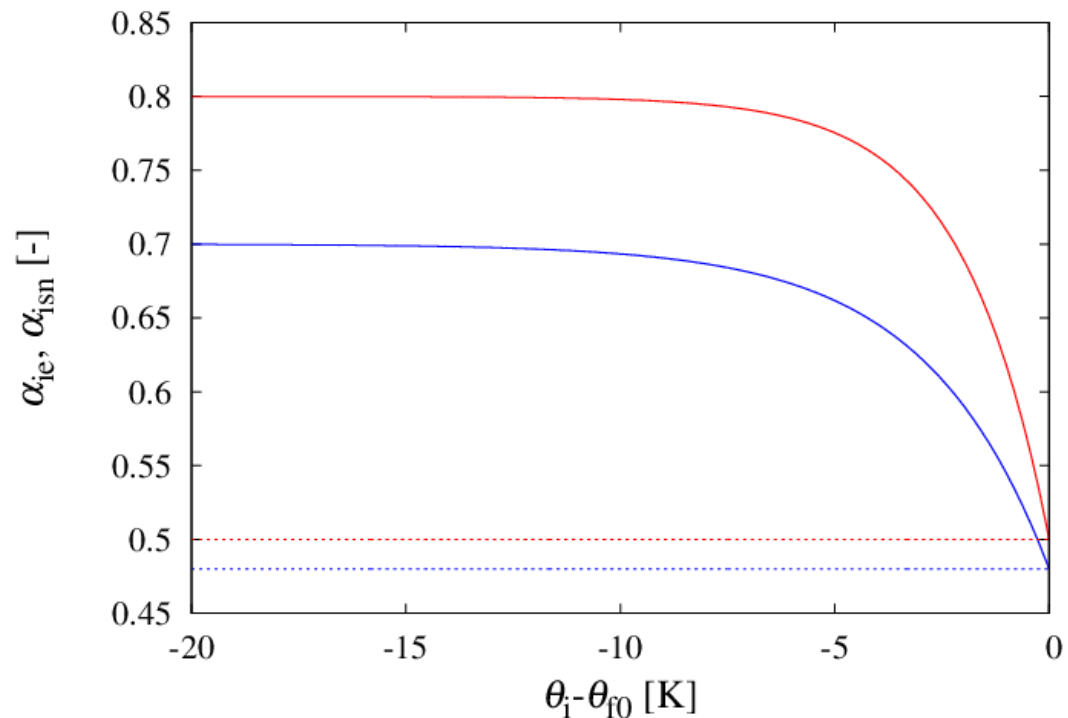
Equilibrium “snow-over-sea-ice” albedo

$$\alpha_{sne} = \alpha_{sn}^{max} - (\alpha_{sn}^{max} - \alpha_{sn}^{min}) \exp \left[-C_{\alpha sn} \frac{\theta_{fo} - \theta_i}{\theta_{fo}} \right]$$

$$C_{\alpha sn} = 136.6$$

$$\alpha_{sn}^{min} = 0.50$$

$$\alpha_{sn}^{max} = 0.80$$

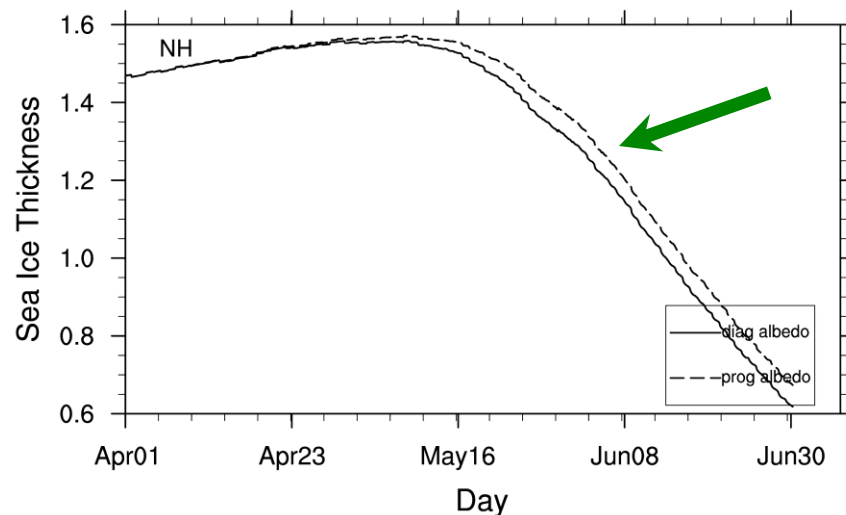
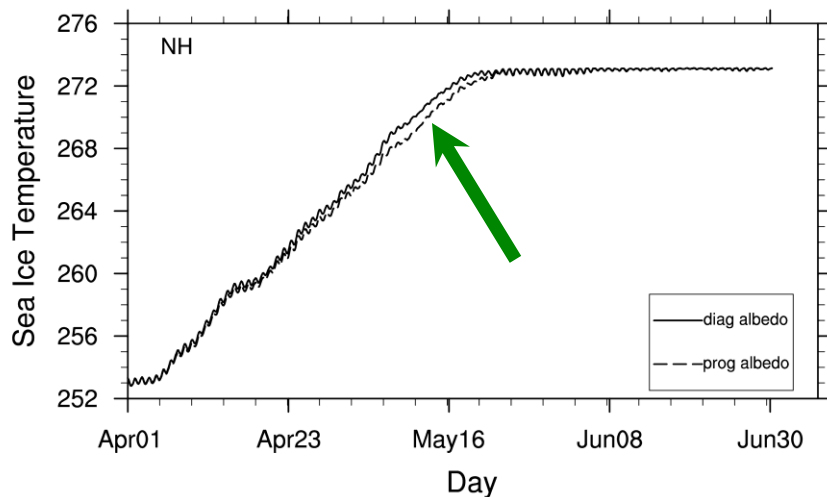
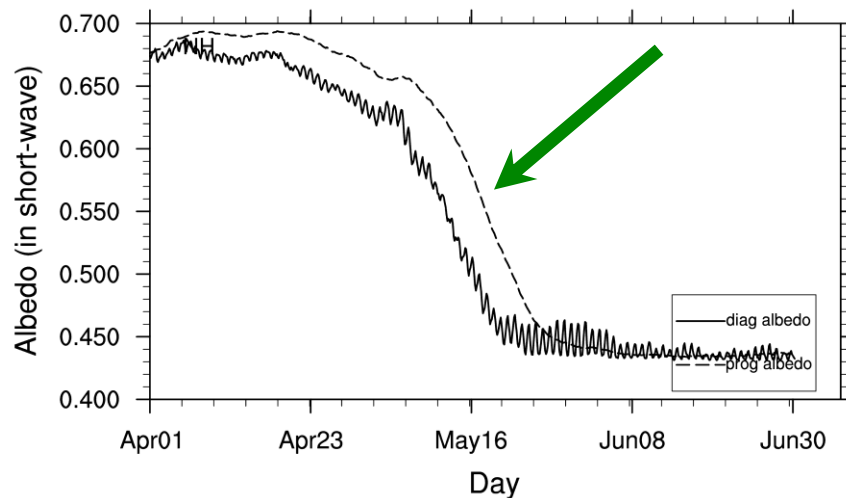


Red solid curve shows “snow-over-ice” equilibrium albedo



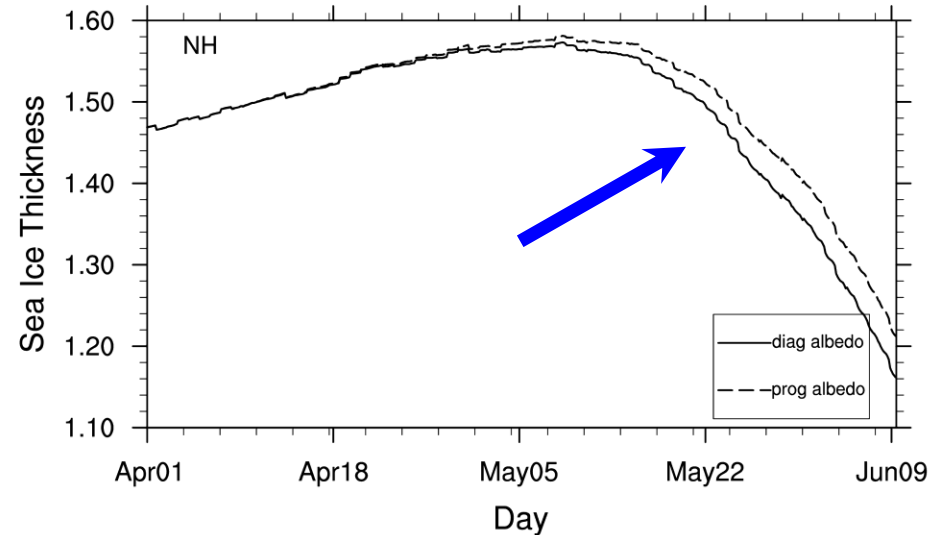
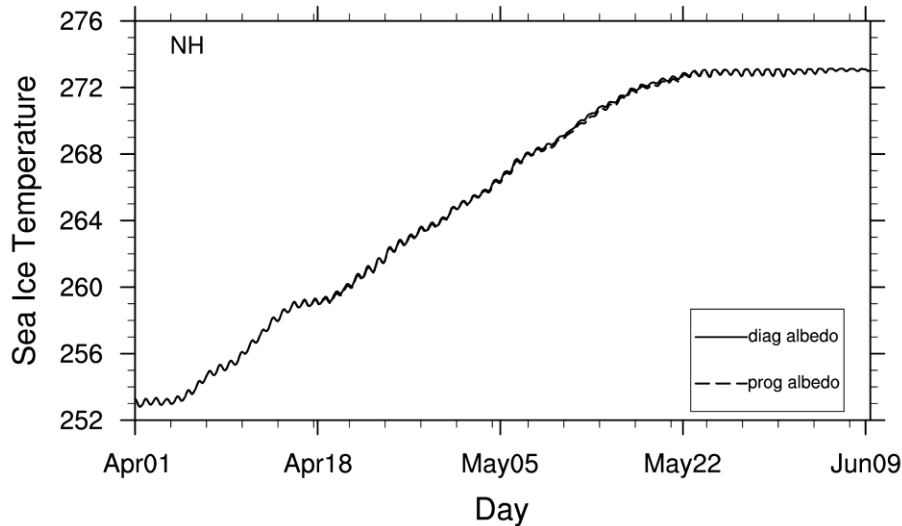
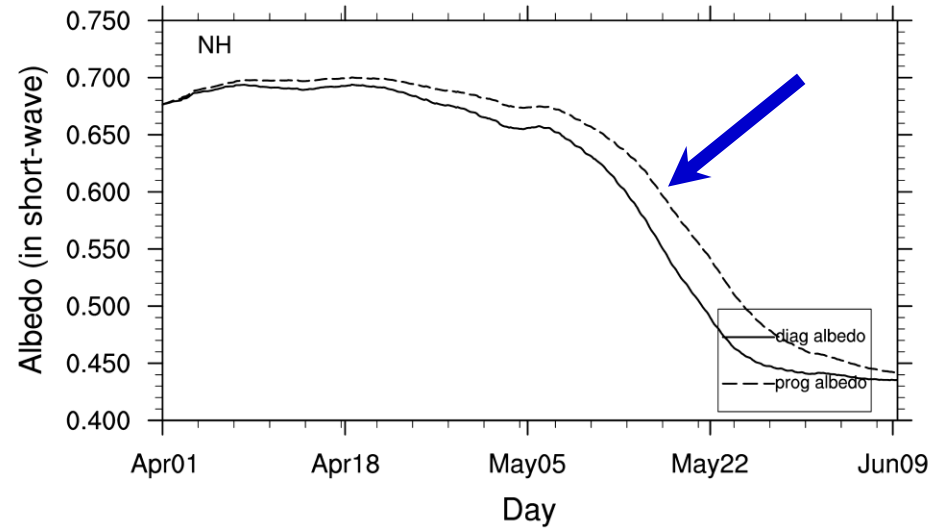
Results from Numerical Experiments

BaCy experiments (01.04-30.06.2016), data from assimilation cycle „analysis“.
Solid curves – reference experiment (similar to operational ICON),
dashed curves – experiment with prognostic albedo parameterization.



Results from Numerical Experiments (cont'd)

BaCy experiments (01.04-30.06.2016), data from assimilation cycle „analysis“.
Tuning of prognostic parameterization: solid curves – experiment with “baseline” values of disposable parameters, dashed curves – experiment with “tuned” relaxation time scale.



Higher albedo, thicker ice, marginal decrease of ice temperature.

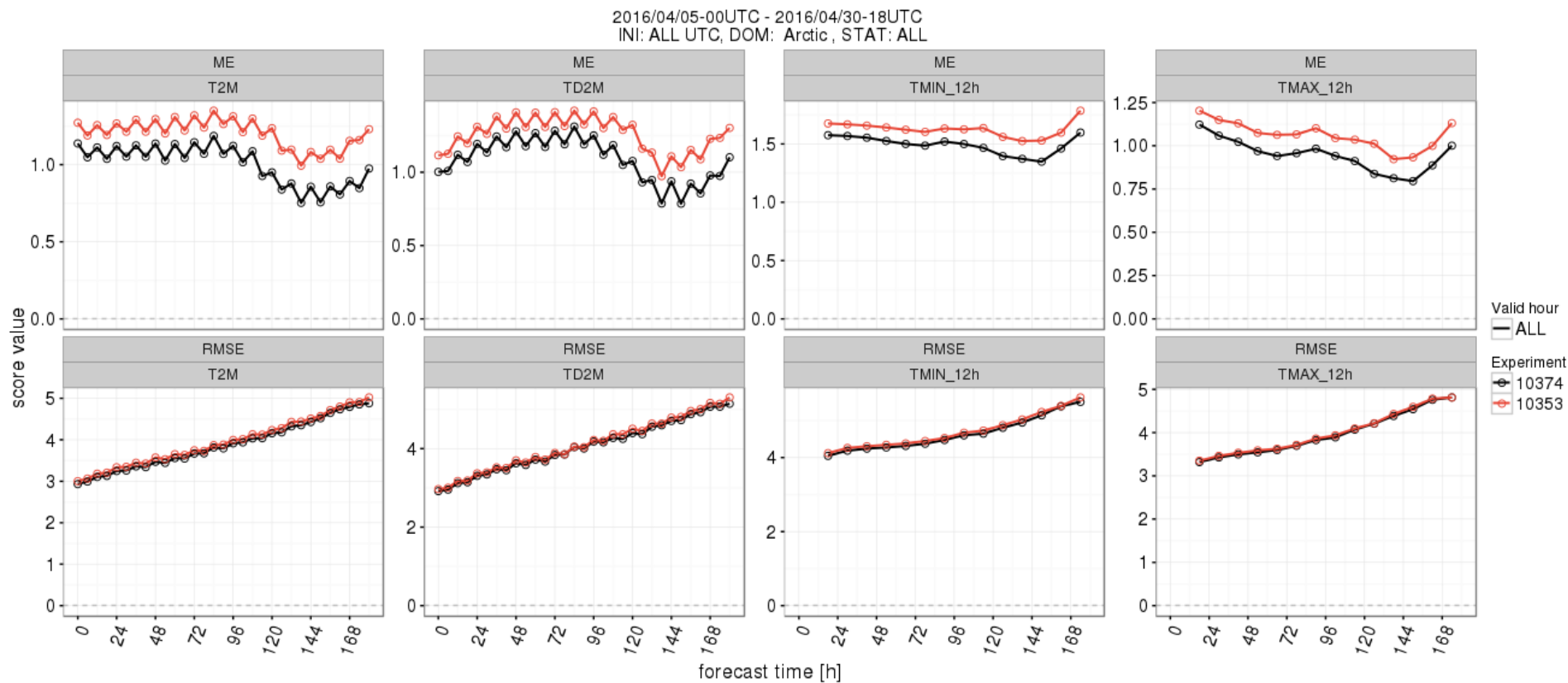


Results from Numerical Experiments (cont'd)

Bias and RMSE of T2m TD2m, TMAX_12h and TMIN_12h over North Polar region 05.04-30.04.2016.

Red curves – reference experiment (similar to operational ICON),

Black curves – experiment with prognostic sea-ice albedo parameterization.

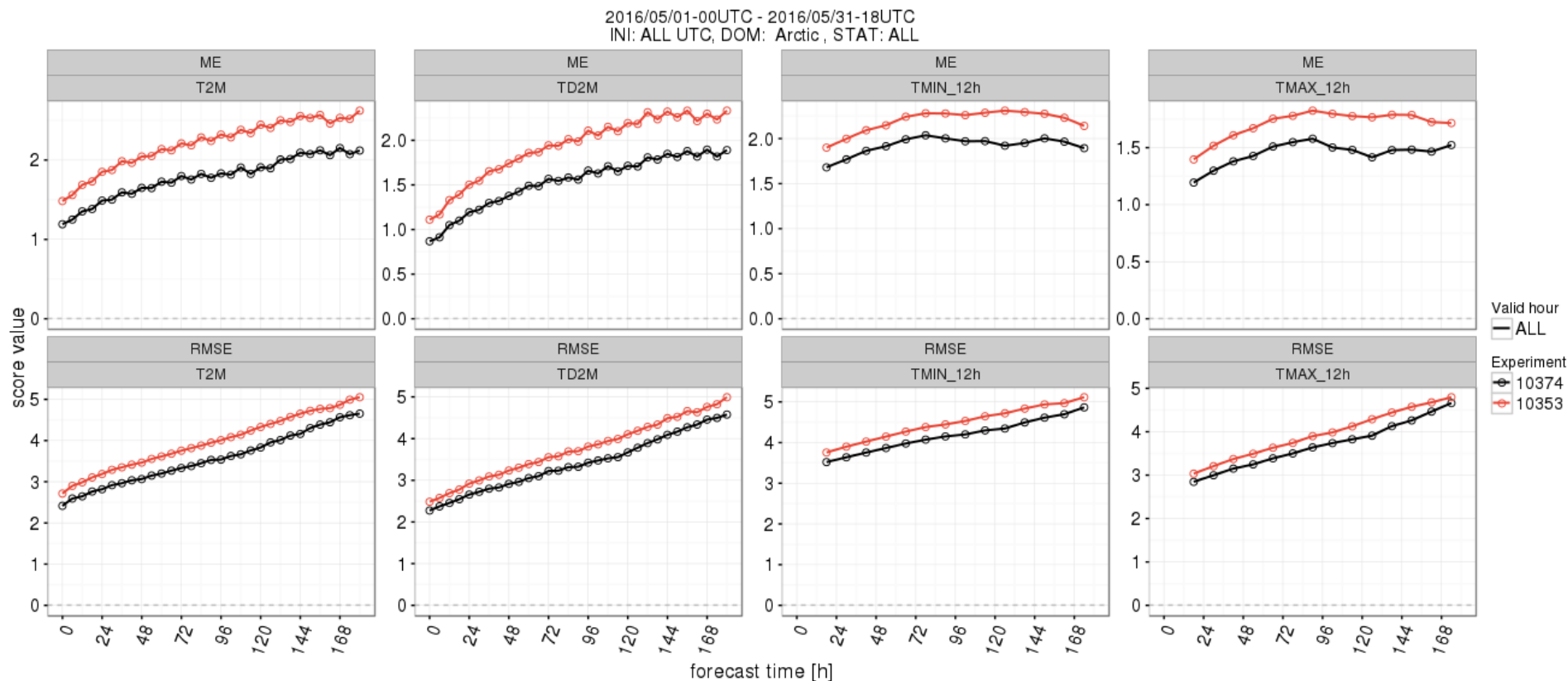


Results from Numerical Experiments (cont'd)

Bias and RMSE of T2m, TD2m, TMIN_12h and TMAX_12h over North Polar region 01.05-31.05.2016.

Red curves – reference experiment (similar to operational ICON),

Black curves – experiment with prognostic sea-ice albedo parameterization.

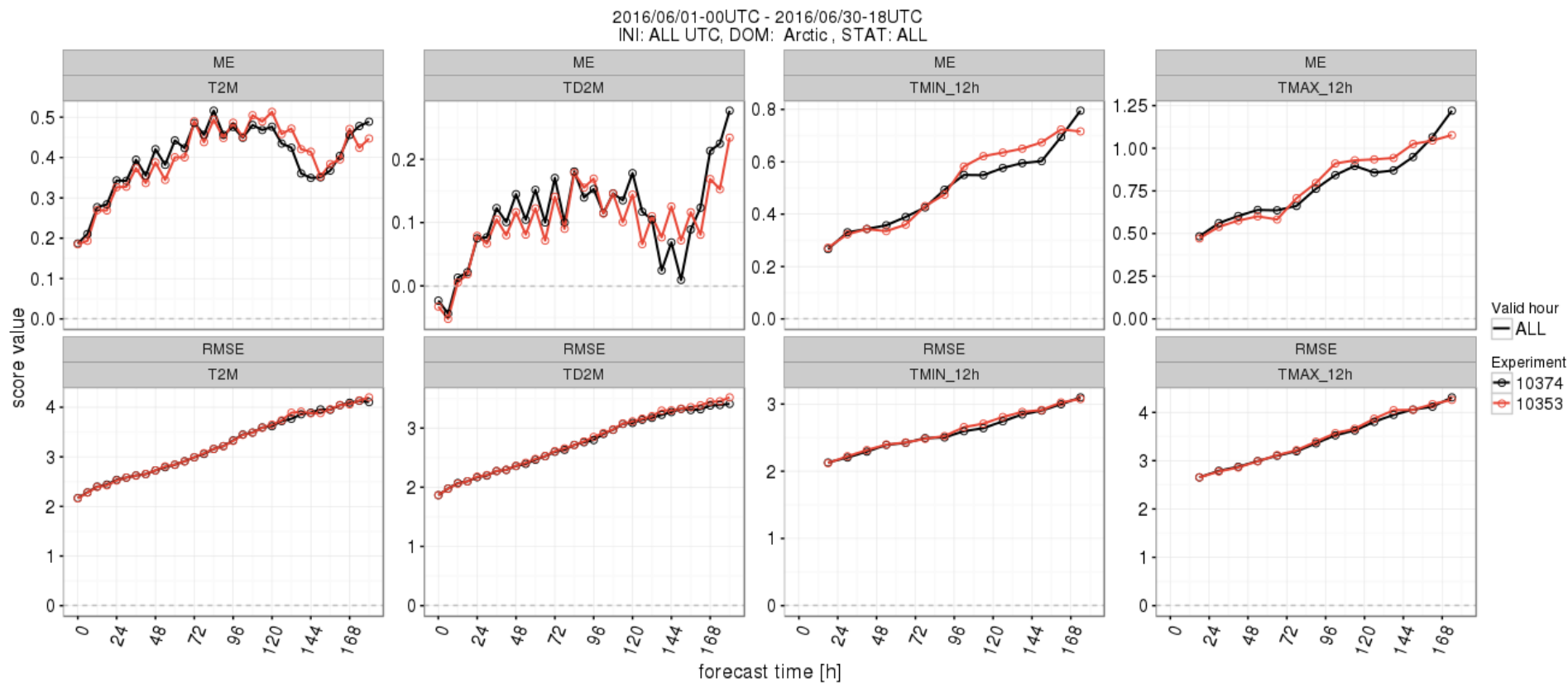


Results from Numerical Experiments (cont'd)

Bias and RMSE of T2m, TD2m, TMIN_12h and TMAX_12h over North Polar region 01.06-30.06.2016.

Red curves – reference experiment (similar to operational ICON),

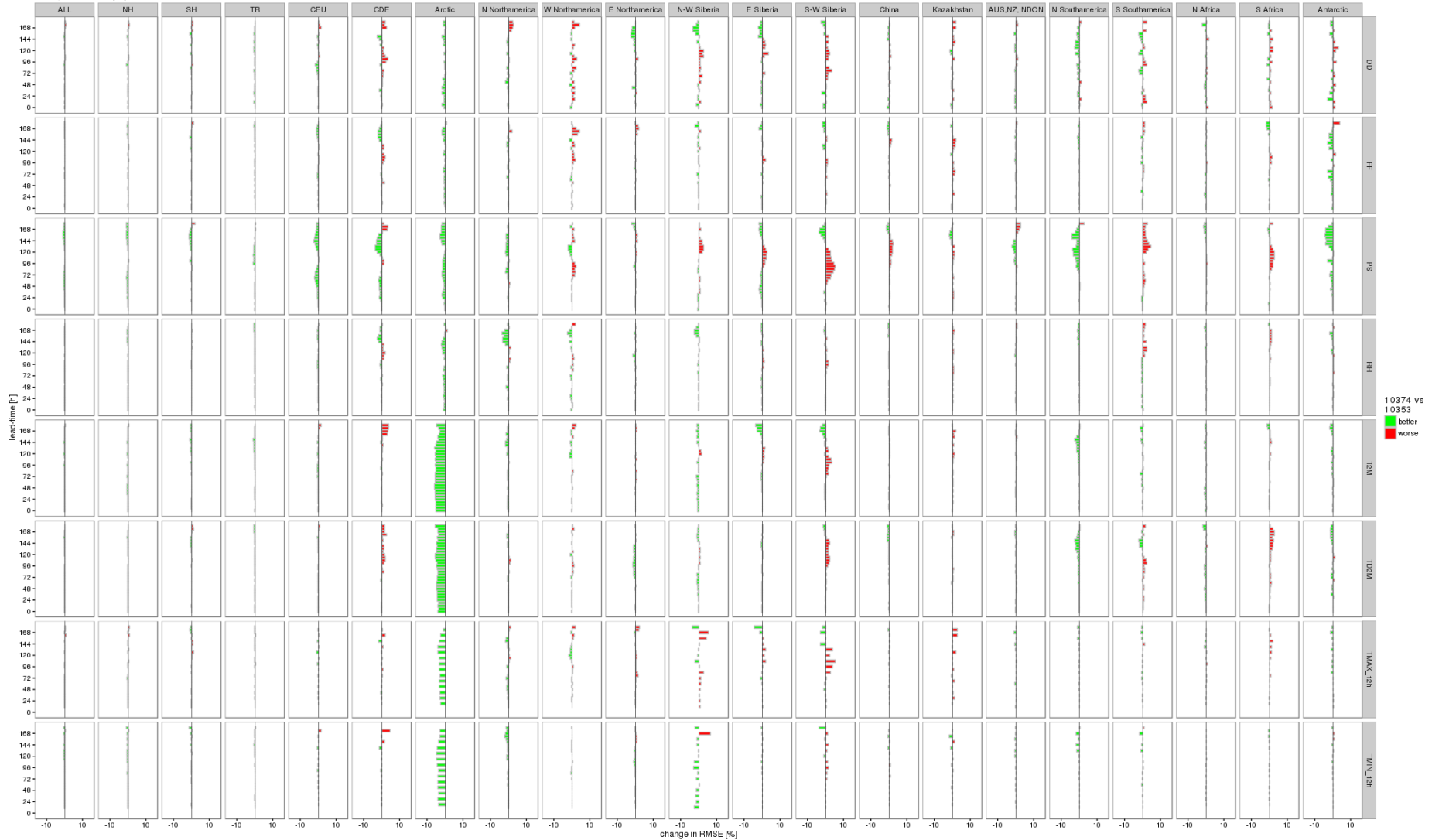
Black curves – experiment with prognostic sea-ice albedo parameterization.



Results from Numerical Experiments (cont'd)

Summary of scores for North Polar region 05.04-30.06.2016.

Verification period: 2016/04/05 - 2016/06/30
Data selection by initial-date
change in RMSE [%]



- Prognostic parameterization of the sea-ice surface albedo with respect to solar radiation is formulated
- New parameterizations is implemented into ICON-NWP
- Results from numerical experiments look promising
- Operational use of prognostic parameterization

**Thank you
for your kind attention!**

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