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Wetter und Klima aus einer Hand

ICON

Activities at DWD to reduce systematic errors of the ICON model

WGNE meeting, Tokyo, 11 Oct. 2018

Günther Zängl

Overview

- Examples for bias issues for which there has already been significant progress
- Examples for model biases/errors that are not yet understood (let alone solved)
- Establishment of a task force to better focus further development work on systematic model deficits

Bias issues for which there has already been some progress

- Moist and cold bias during evening transition phase of the PBL
- Moist and cold bias in boreal forest regions during snow melt phase
- Temperature bias dipole in tropical troposphere (too cold in lower troposphere, too warm in middle troposphere)

Diurnal cycle of T2M and RH2M

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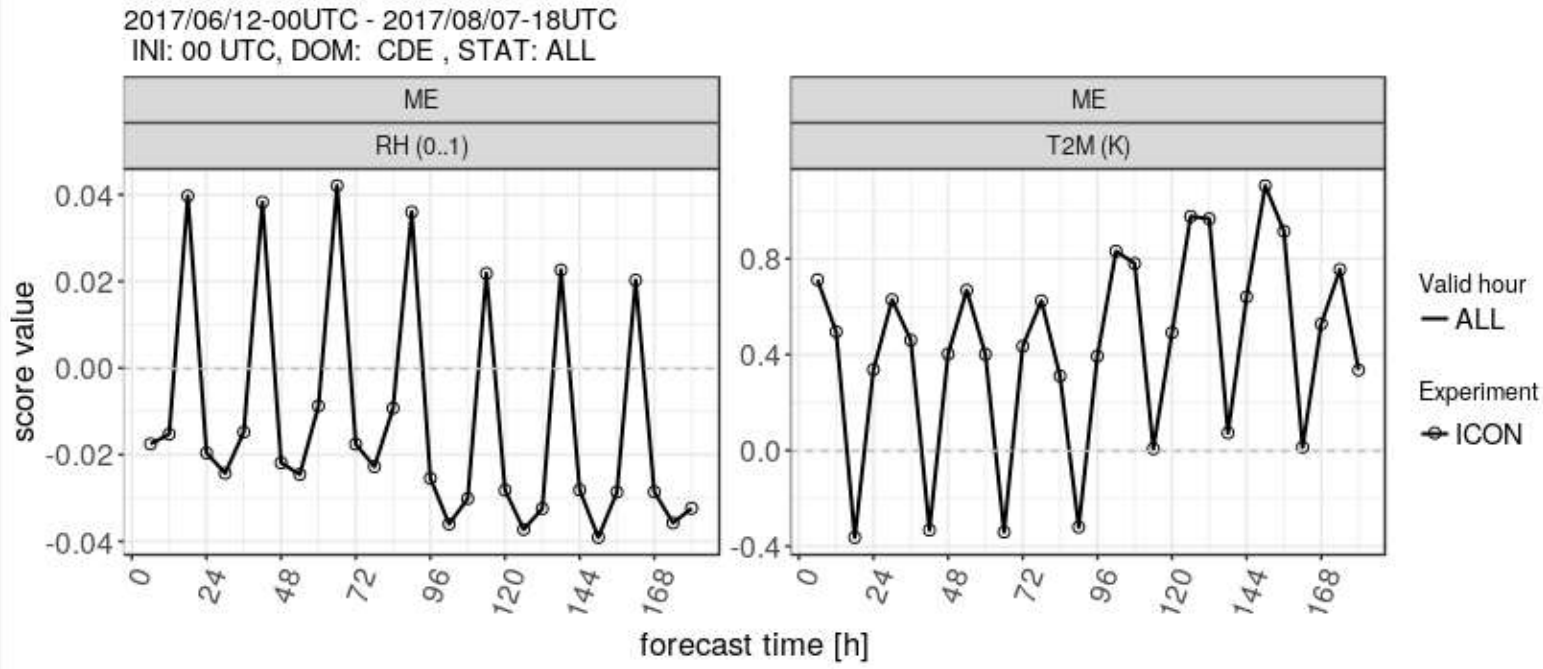
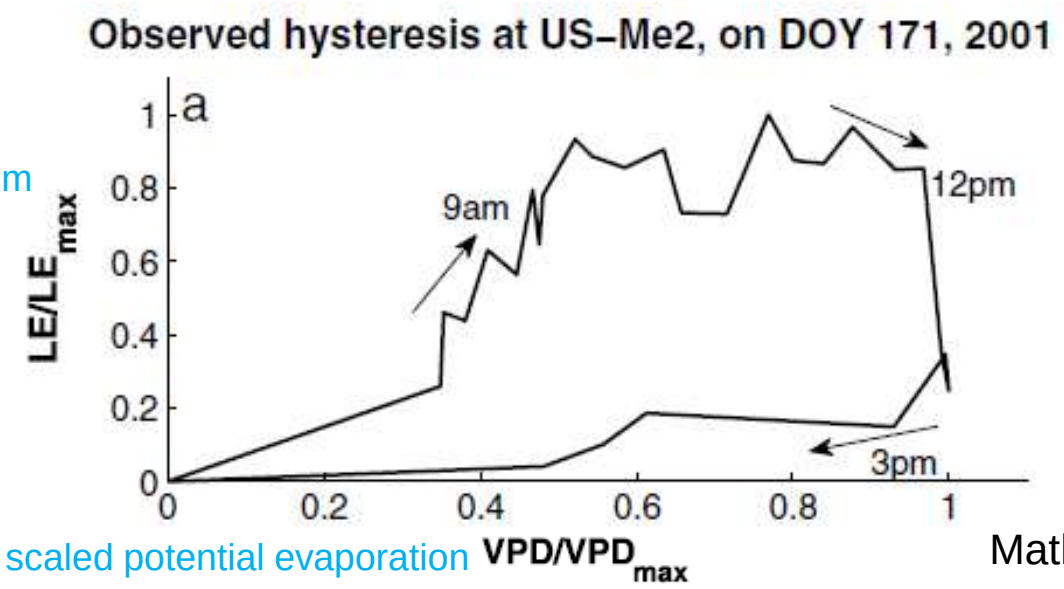
T2M and RH2M bias, central Europe, June/July 2017



- Cold+moist bias in late afternoon / early evening
- Most striking during summer months, when the bias peak occurs around 18 UTC in central Europe

Observed diurnal cycle of plant evaporation (station in USA, early summer)

plant evaporation (scaled w.r.t. maximum of diurnal cycle)



Matheny et al. (2014)

Hypothesis: taking into account the asymmetric diurnal cycle of plant evaporation could reduce the early evening bias

Asymmetric plant evaporation

- **Detailed vegetation models include a prognostic variable for water storage in the stem**
- **Simplified parameterization approach in TERRA: Introduce a prognostic variable for integrated plant evaporation since sunrise (with some offset) and vary minimum stomata resistance depending on this variable**

Result

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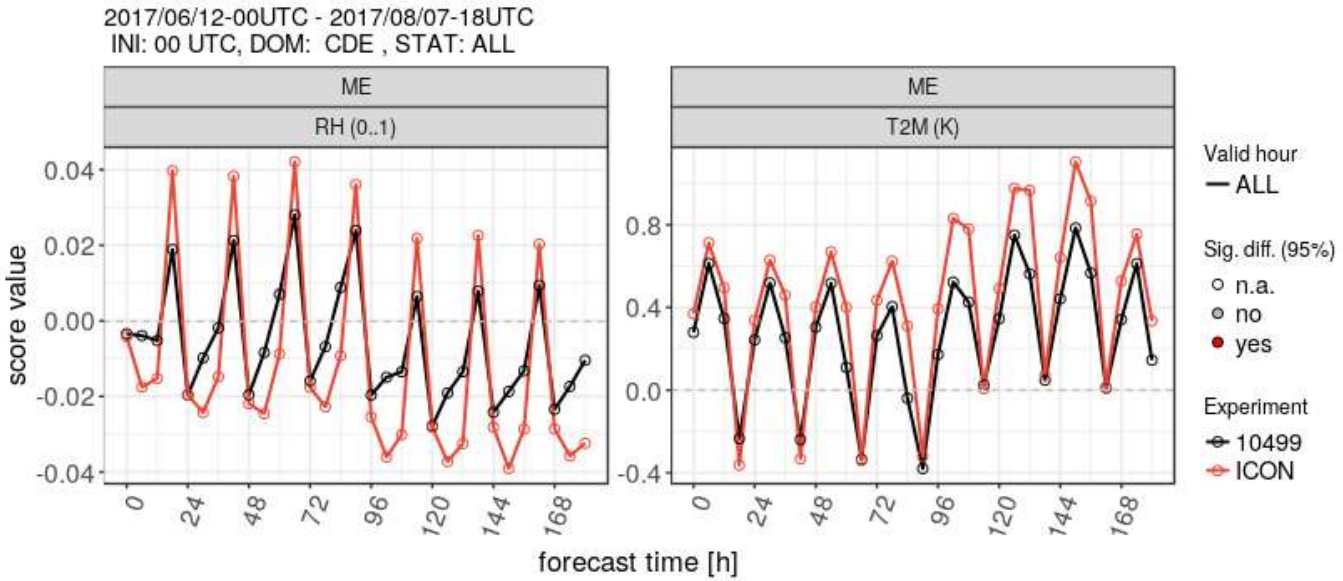
T2M and RH2M bias, central Europe, June/July 2017



- **Black line: Experiment with asymmetric plant evaporation**
- **The amplitude bias in the diurnal cycles of T2M and RH2M is clearly reduced, but still present**
- **There have to be other sources, e.g. a too large transfer coefficient during the evening transition phase**

Moist and cold bias in snow-covered regions with high vegetation

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- Verification scores used to indicate dramatic model errors in Siberia and Canada, particularly during the snow melt phase
- Fundamental problem: TERRA still lacks a canopy-layer scheme

Tuning measures adopted to reduce the bias issues:

- Artificial reduction of snow-cover fraction of melting snow, creating a snow-free tile or enhancing its fractional aera
- Reduction of snow temperature used for calculating potential evaporation depending on differential radiation absorption and saturation deficit
- Further developed variant of evaporation tuning using (in addition) snow age and maximum snow depth during snow accumulation period to parameterize the difference between the accumulation phase and the melting phase

N-Europe, April 2018

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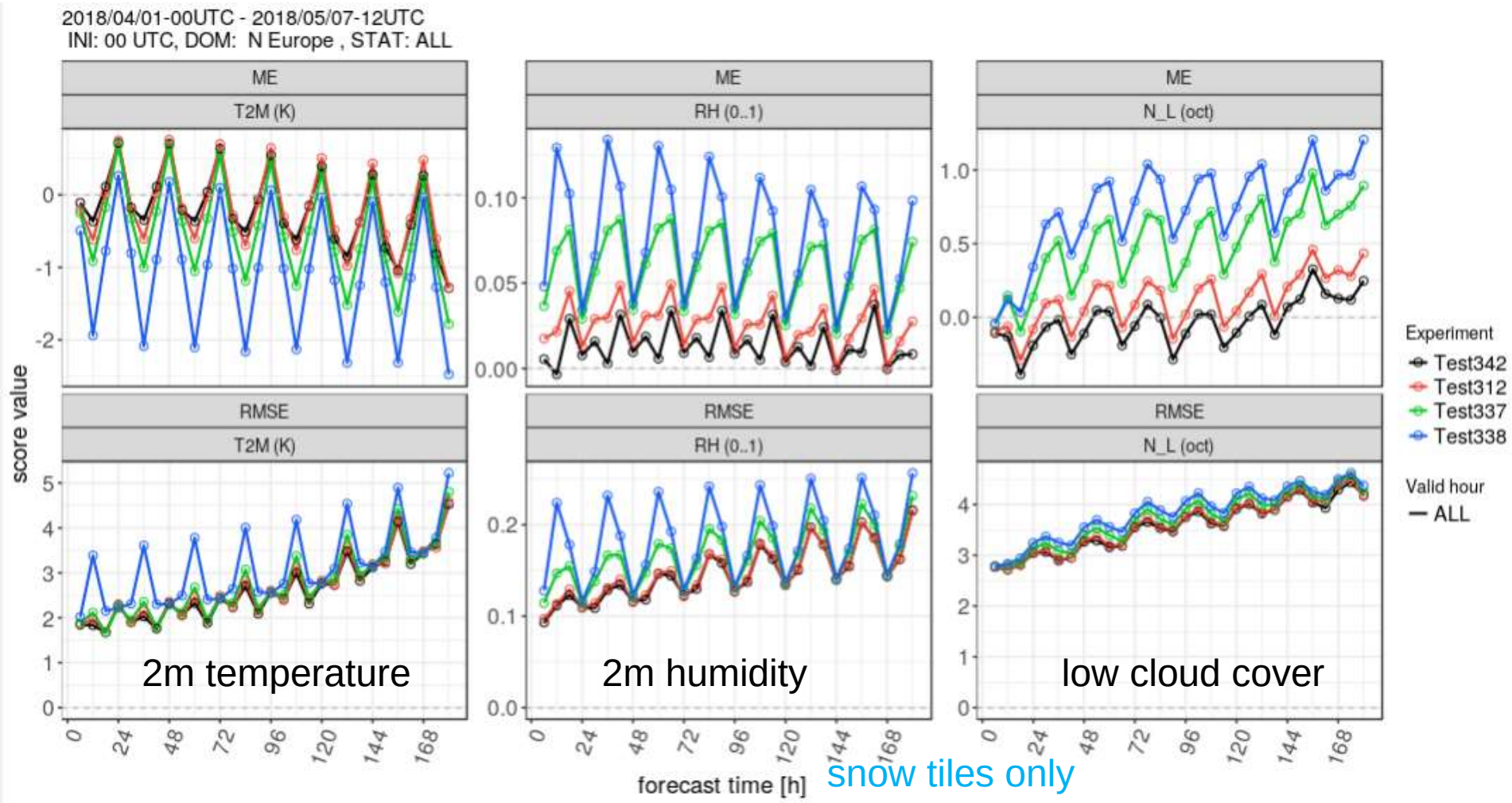

snow tiles only

artificially reduced snow-cover fraction

evaporation tuning level 1

evaporation tuning level 2

NW-Siberia, April 2018

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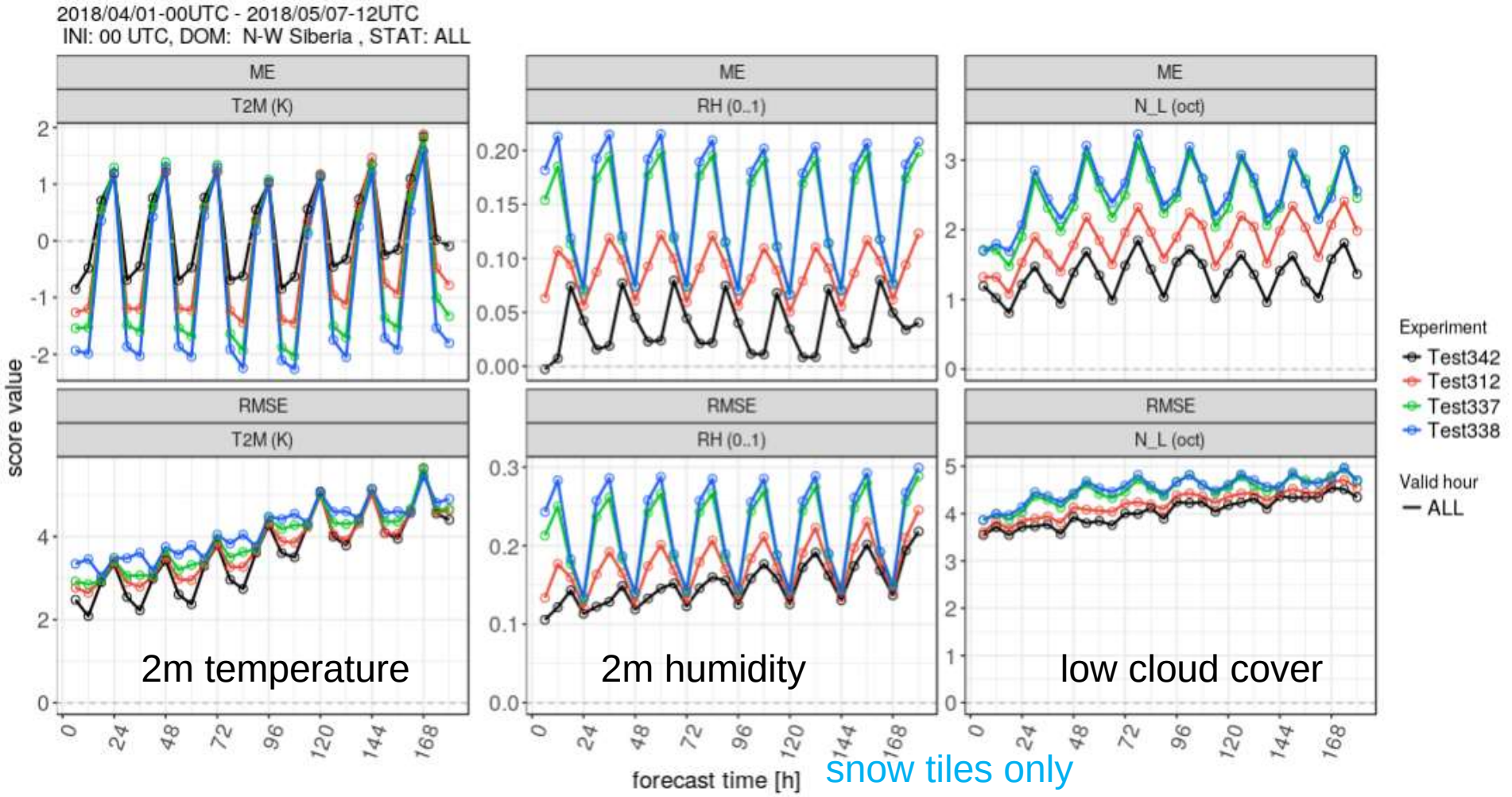

snow tiles only

artificially reduced snow-cover fraction

evaporation tuning level 1

evaporation tuning level 2

SW-Siberia, April 2018

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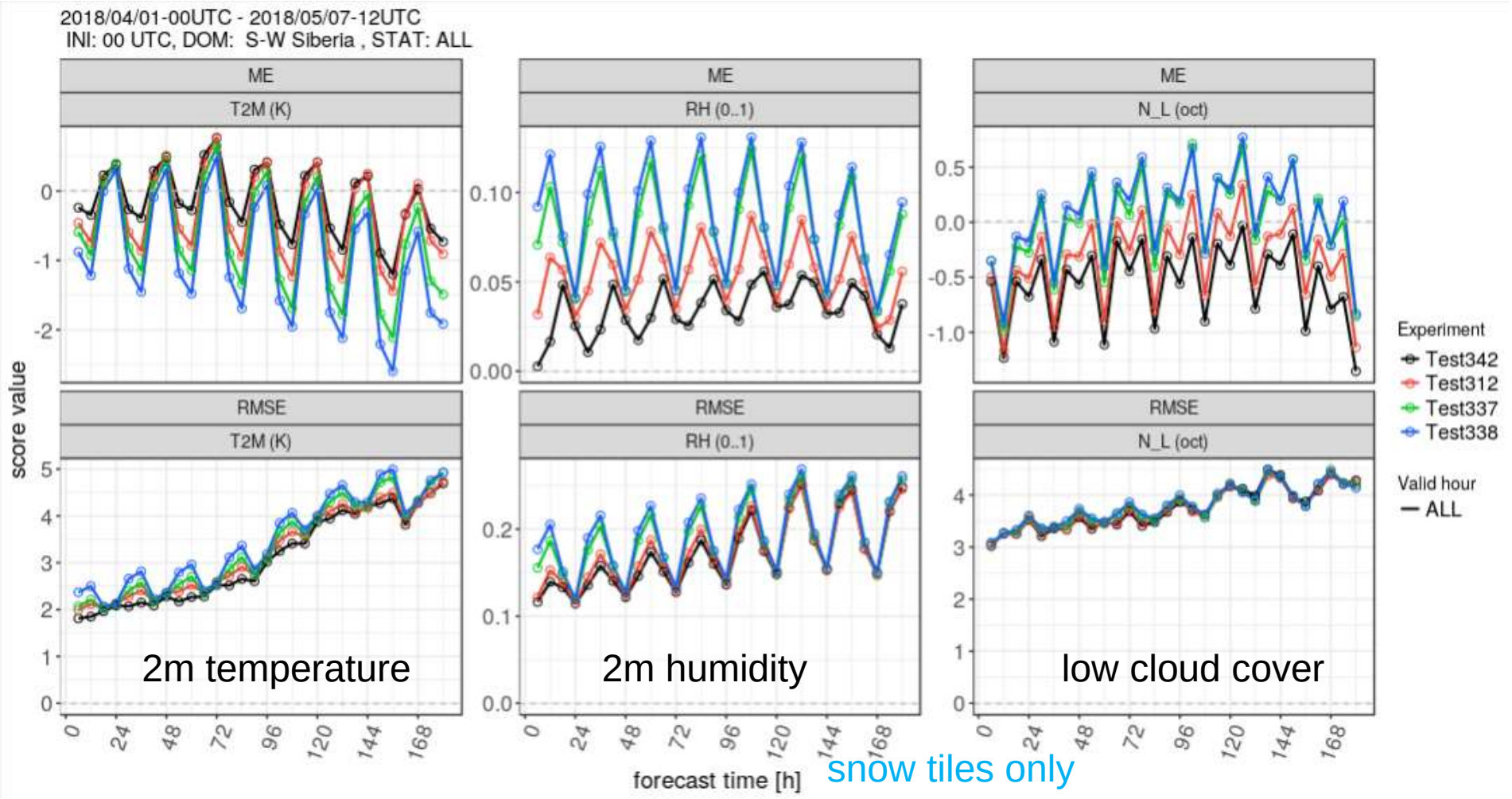

snow tiles only

artificially reduced snow-cover fraction

evaporation tuning level 1

evaporation tuning level 2

Canada/Alaska, April 2018

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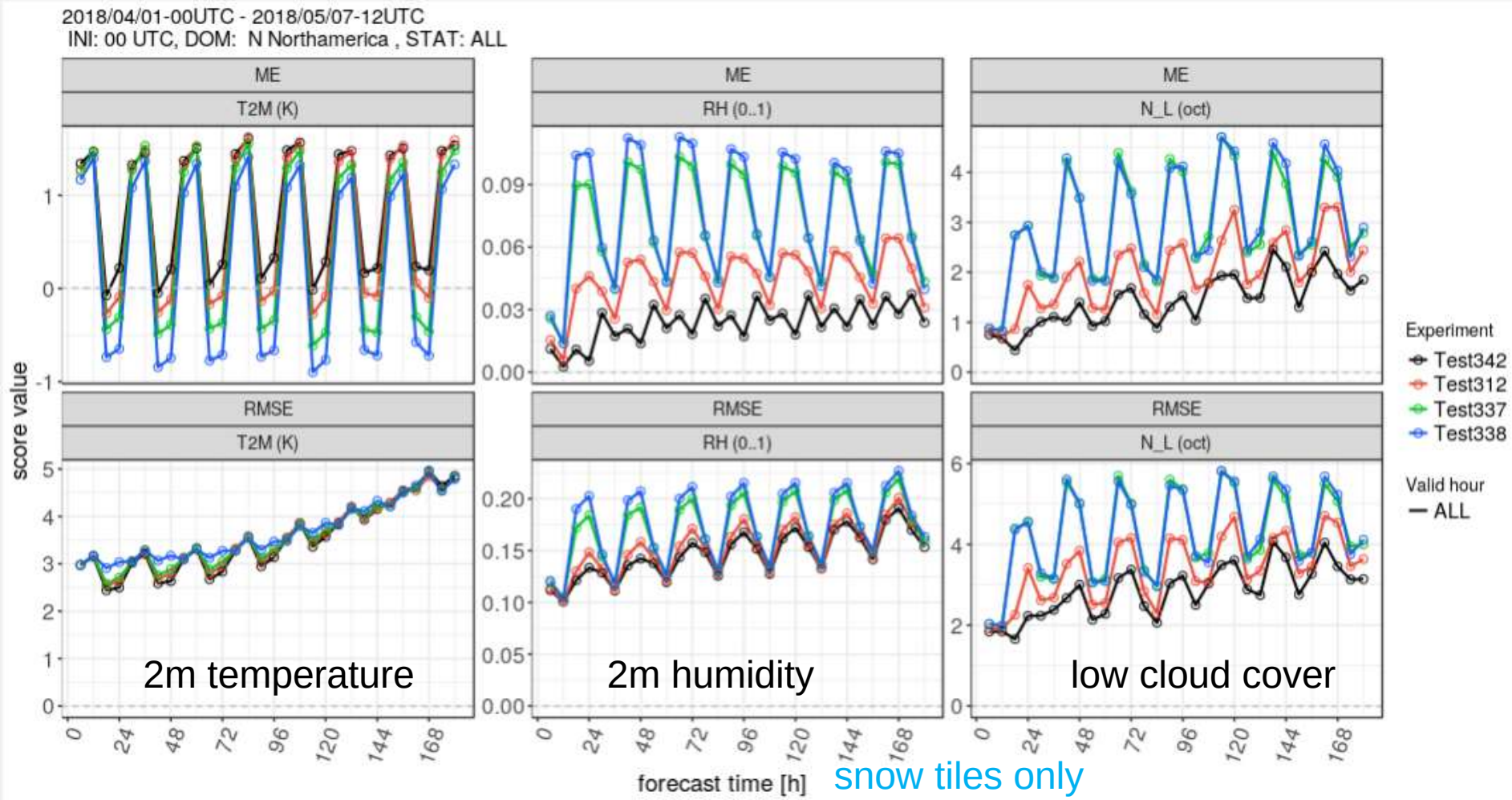

snow tiles only

artificially reduced snow-cover fraction

evaporation tuning level 1

evaporation tuning level 2

Temperature bias dipole in the tropical troposphere

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DWD

- ICON tends to be too cold in the lower troposphere and too warm in the middle troposphere
- This causes adverse feedback effects in the data assimilation cycle because the temperature/humidity increments destabilize the atmosphere and reinforce excessive convection

Changes implemented to reduce the problem:

- Various tuning changes in the convection scheme, most importantly affecting downdrafts (reduced initial downdraft mass flux, increased entrainment)
- Correction in physics-dynamics coupling

T and RH in the tropics (EPS)

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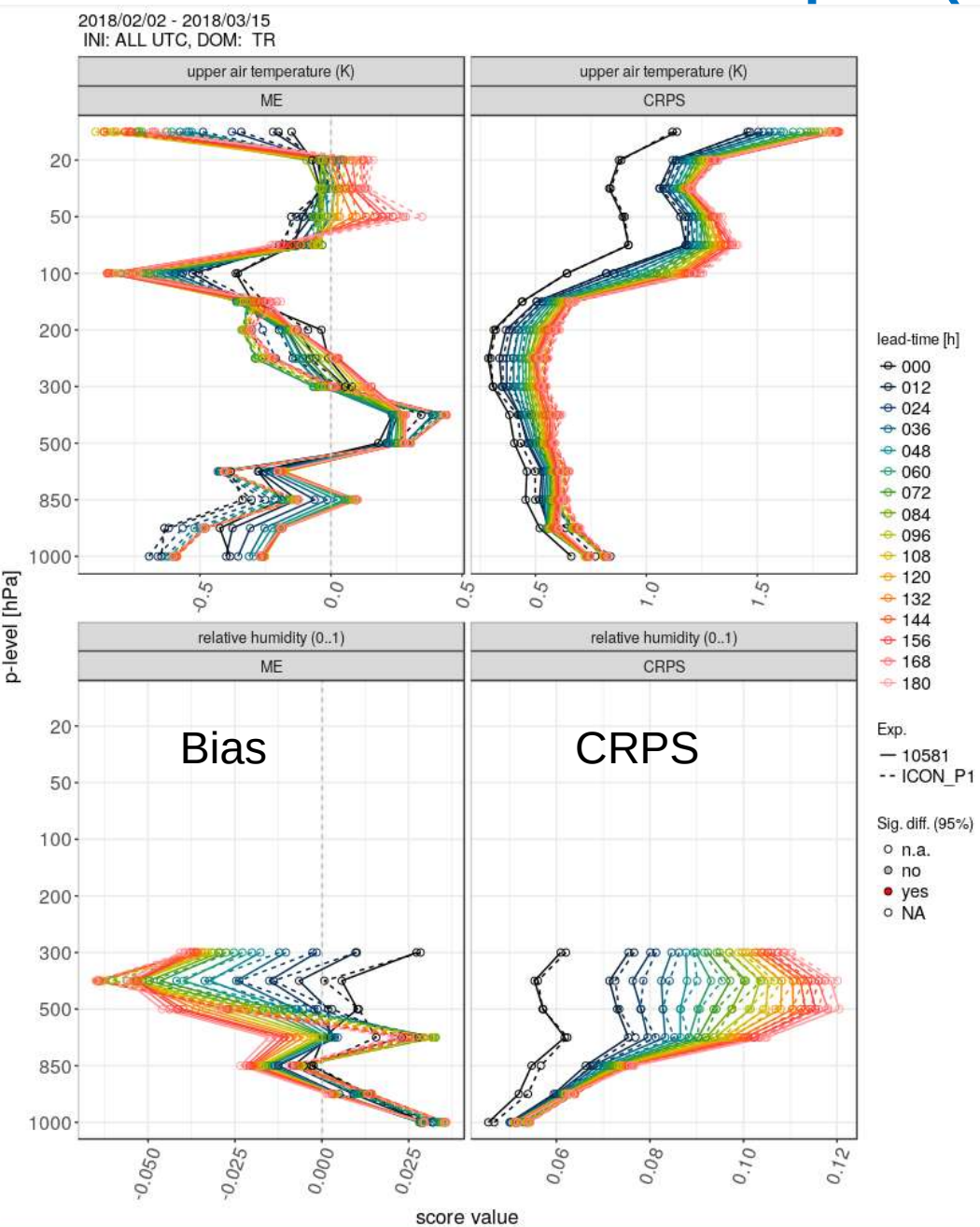
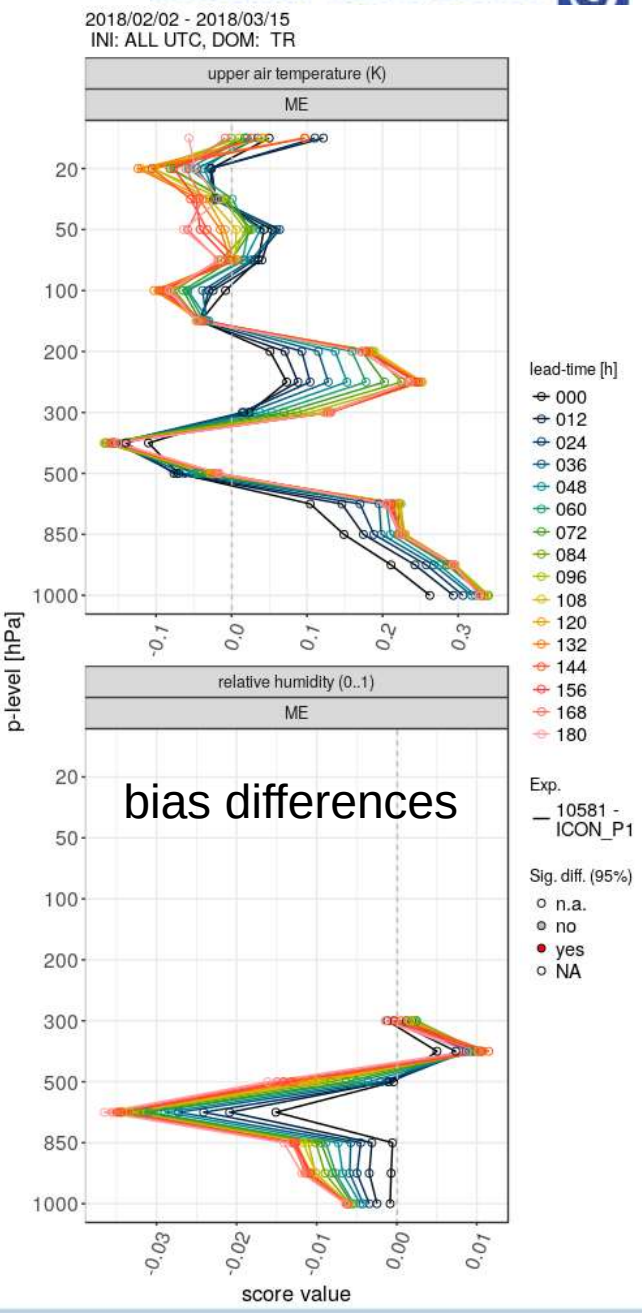
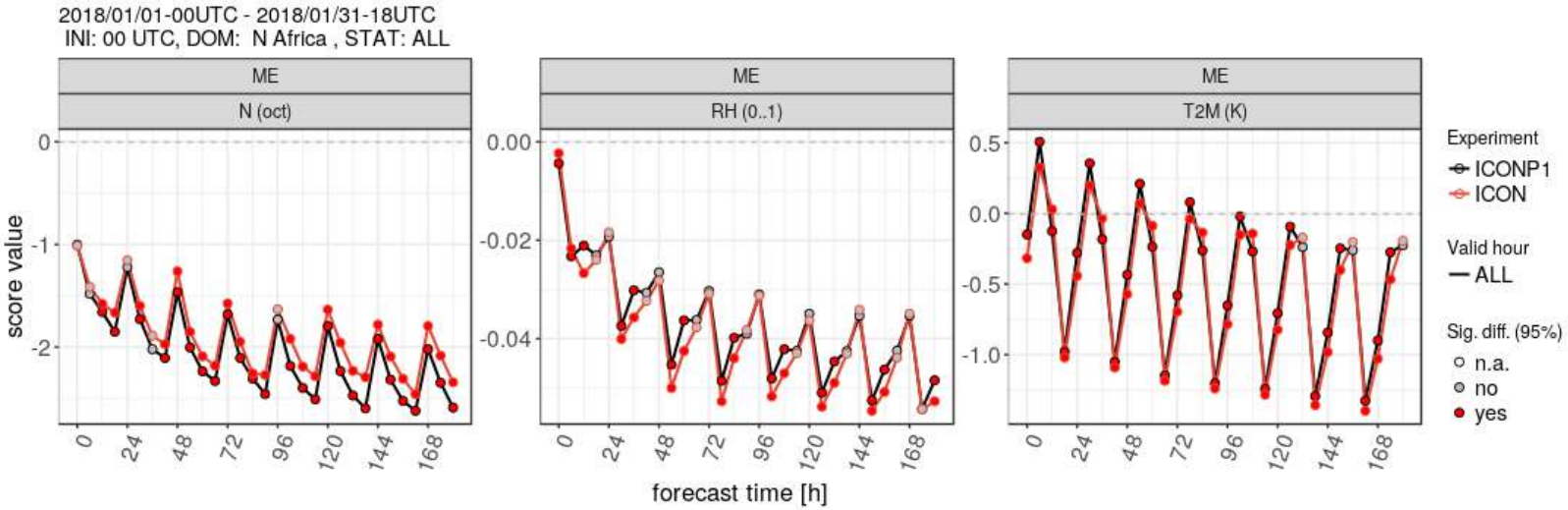




Unresolved bias issues

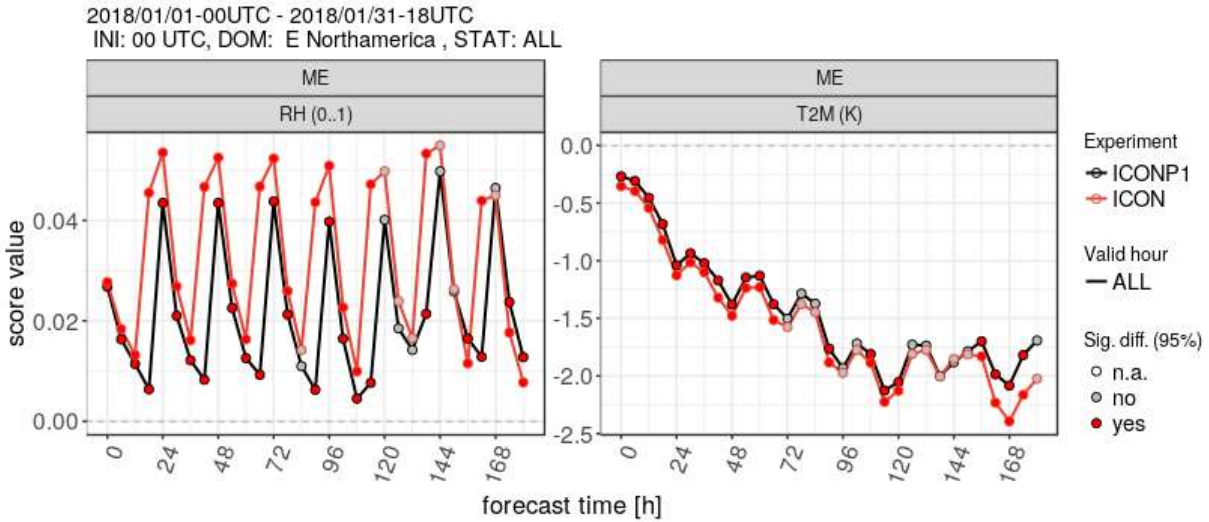
- **North African bias: too little cloud cover, too dry and too cold …**



- **… despite tuning measures like reduced albedo over the Saharan desert, increased LW absorption of mineral dust and tuned heat conductivity of sand**
- **This is clearly opposite to what we expect in a region with a positive radiation balance**

Unresolved bias issues

- **North American bias: much too cold in winter**



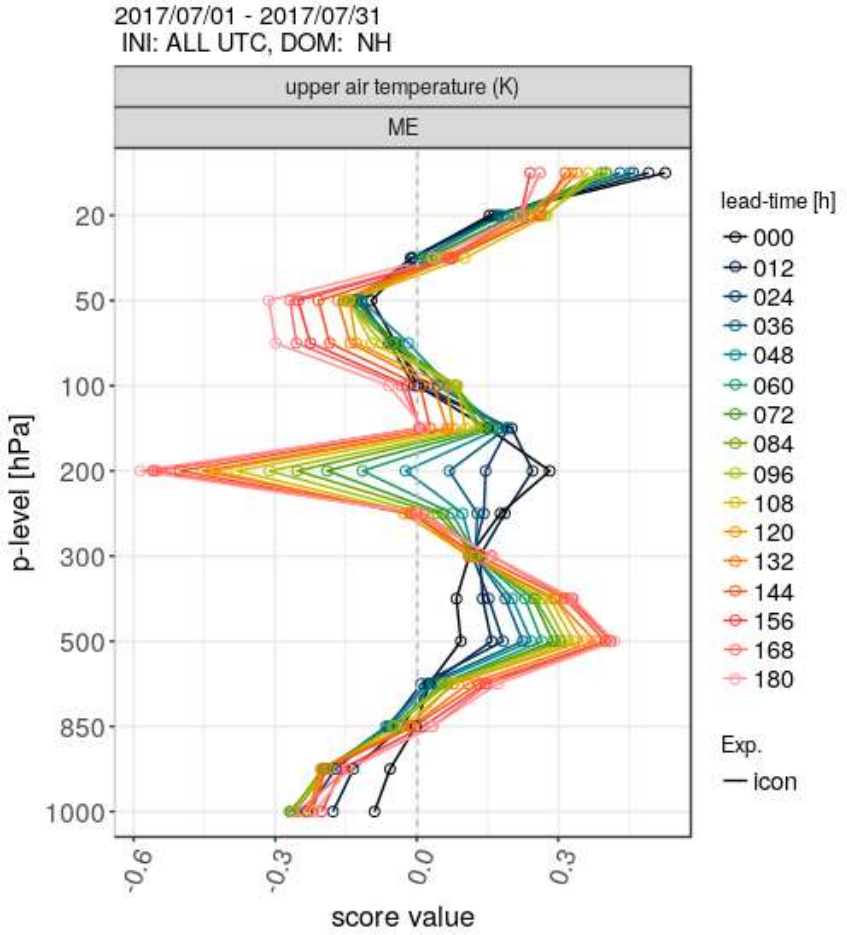
- **Bias growth is more rapid during daytime than at night, indicating too low surface heat fluxes**
- **But reducing snow evaporation (black line) or soil heat capacity has almost no impact, and a further reduction of snow albedo would not be justifiable**

Unresolved bias issues

- **Cold bias in 200 hPa in NH summer**
- **Annually recurring in July/August**

Possible causes

- **Too high tropopause?**
- **Too weak tropopause inversion?**
- **Too deep convection?**
- **Too high moisture above tropopause?**



Task Force 'ReSQME'
(Reduction of systematic quantitative model errors)

- Established in April 2018 to better focus development work related to model physics on systematic bias issues
- Formation of several small working groups to investigate selected bias problems
- Team members: V. Bachmann, J. Förstner, T. Göcke, J. Helmert, M. Köhler, D. Mironov, M. Raschendorfer, J.-P. Schulz, A. Seifert, A. Steiner, G. Zängl
- Regular discussion/interaction within task teams
- Meetings with presentations for model development division every 2-3 months