DWD center report

Günther Zängl

WGNE 39, Toulouse, Nov. 5, 2024

Overview

- Operationalization of SINFONY-RUC
- High-resolution activities: TEAMx forecasts, ICON-D05
- Major improvements in our operational system

Operationalization of SINFONY-RUC

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DWD

- SINFONY: Seamless INtegrated FOrecastiNg sYstem; project led by Uli Blahak
- SINFONY-RUC: Rapid-Update-Cycle variant of ICON-D2
- Same model domain as ICON-D2, but full two-moment cloud microphysics including hail, and pure shallow convection scheme instead of deep convection with grayzone tuning
- Hourly analyses and forecasts with 14 h lead time, much shorter data cutoff than standard ICON-D2 (~ 15 min), forecasts are completed 35-40 min after analysis time
- Assimilation cycle branches off from ICON-D2 each day at 03 UTC, followed by 4 hours of spinup, in order to avoid disadvantages due to short cutoff time
- Focus on nowcasting of (heavy) precipitation and seamless blending between nowcasting products and NWP output
- Two-moment microphysics provides much better radar reflectivities than one-moment scheme, which is particularly important for combined nowcasting products
- RUC became operational on July 10, 2024, after ~ 6 years of intensive development work

What does „seamless“ mean in the context of nowcasting?
One example for SINFONY products

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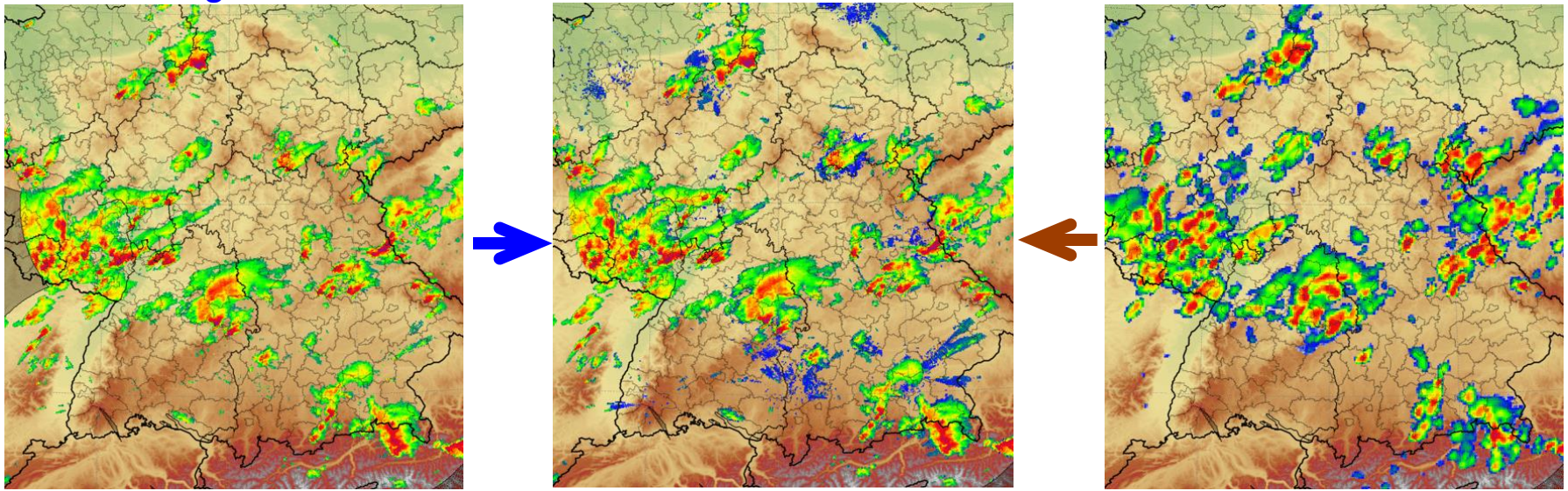
Nowcasting STEPS-DWD | **Combination INTENSE** | **NWV ICON-RUC-EPS**



Nowcasting-ENS (5‘ updates)

SINFONY - combined products „Best of both worlds“

NWV-ENS (hourly updated forecasts)

t_0 → Fcst lead time

INTENSE (comb. ENS)
Nerini et al. 2019
Only 1 member shown

Uli Blahak

Verification of reflectivity STEPS-Nowcasting and SINFONY-RUC vs. Radar in 07/2023

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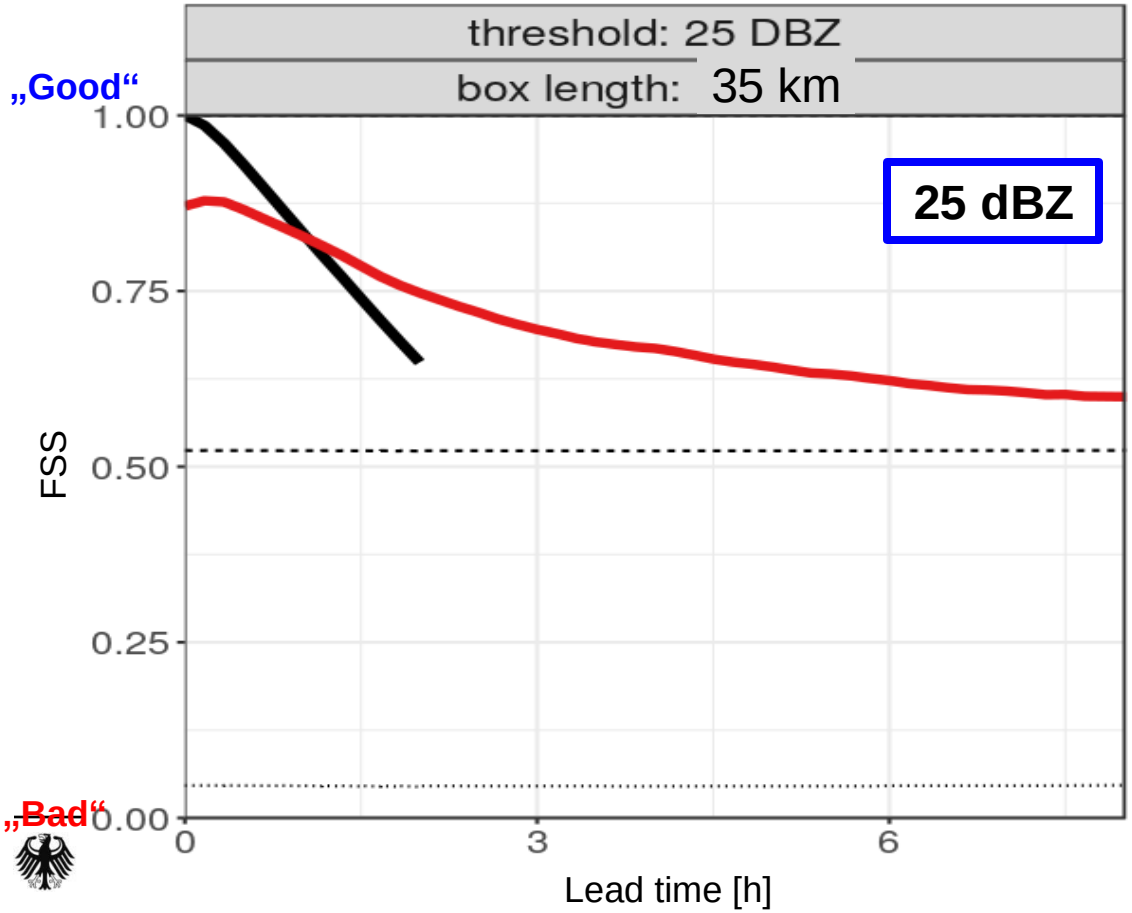

Period: 01.07. – 31.07.2023

Forecasts: 12, 13, 14, … ,18 UTC (deterministic)

Parameter: **Radar reflectivity (dBZ)**

Score: **fraction skill score (FSS)**

STEPS-DWD Nowcasting (det)

ICON-D2-RUC det, 2 km, LHN + 3D-rad

Uli Blahak

SINFONY

Verification of reflectivity STEPS-Nowcasting and SINFONY-RUC vs. Radar in 07/2023

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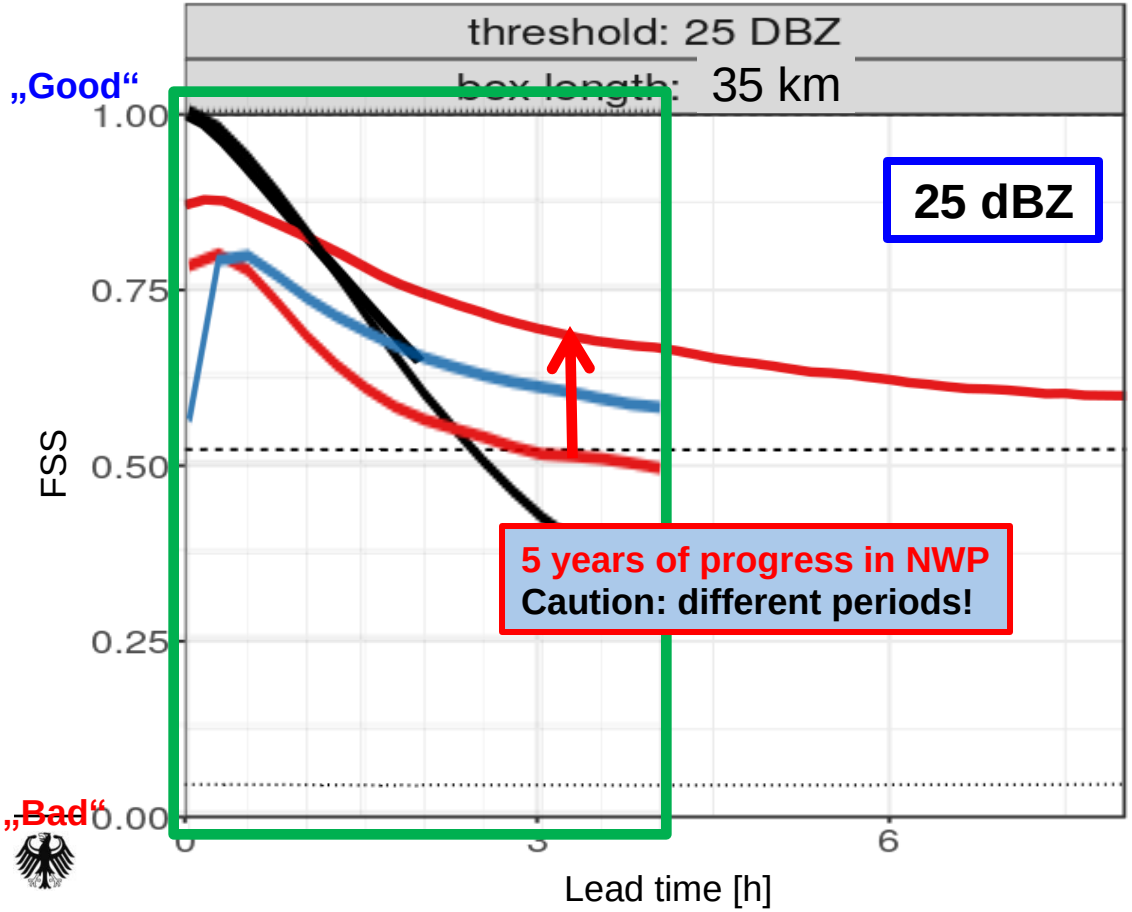

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Forecasts: 12, 13, 14, … ,18 UTC (deterministic)

Parameter: **Radar reflectivity (dBZ)**

Score: **fraction skill score (FSS)**

- **STEPS-DWD Nowcasting (det)**
- **ICON-D2-RUC det, 2 km, LHN + 3D-rad**

Overlay: Same comparison 5 years ago

Period: 26.05. – 25.06.2016 !!!

- **Previous version of STEPS (det)**
- **COSMO det, 2.8 km, 1-mom, LHN**
- **COSMO det, 2.8 km, 2-mom, 3D-rad**

Uli Blahak

SINFONY

ICON @ 500 m for the Alps / Germany

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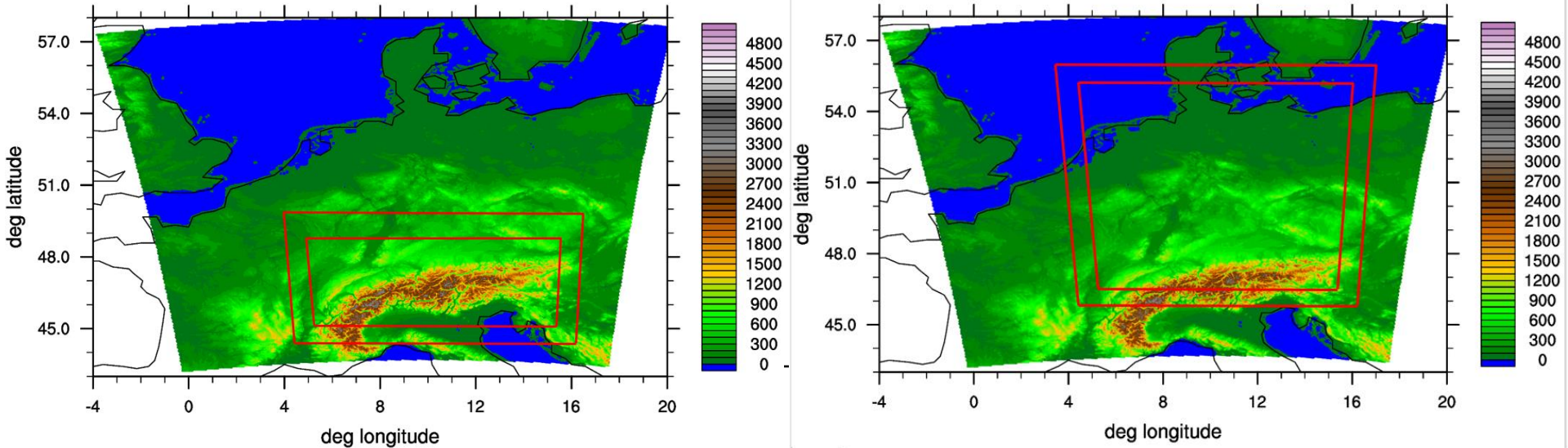
- First suite of experiments motivated by the plan to prepare dedicated high-resolution forecasts for the TEAMx observational campaign that started in mid-September
- Envisaged configuration: start from operational D2 analysis and spawn two nested domains (1 km, 500 m) after the end of the latent-heat-nudging phase
- A few months later, the idea came up to investigate an analogous configuration for Germany

approximate domain configurations



ICON-LAM with 500 m

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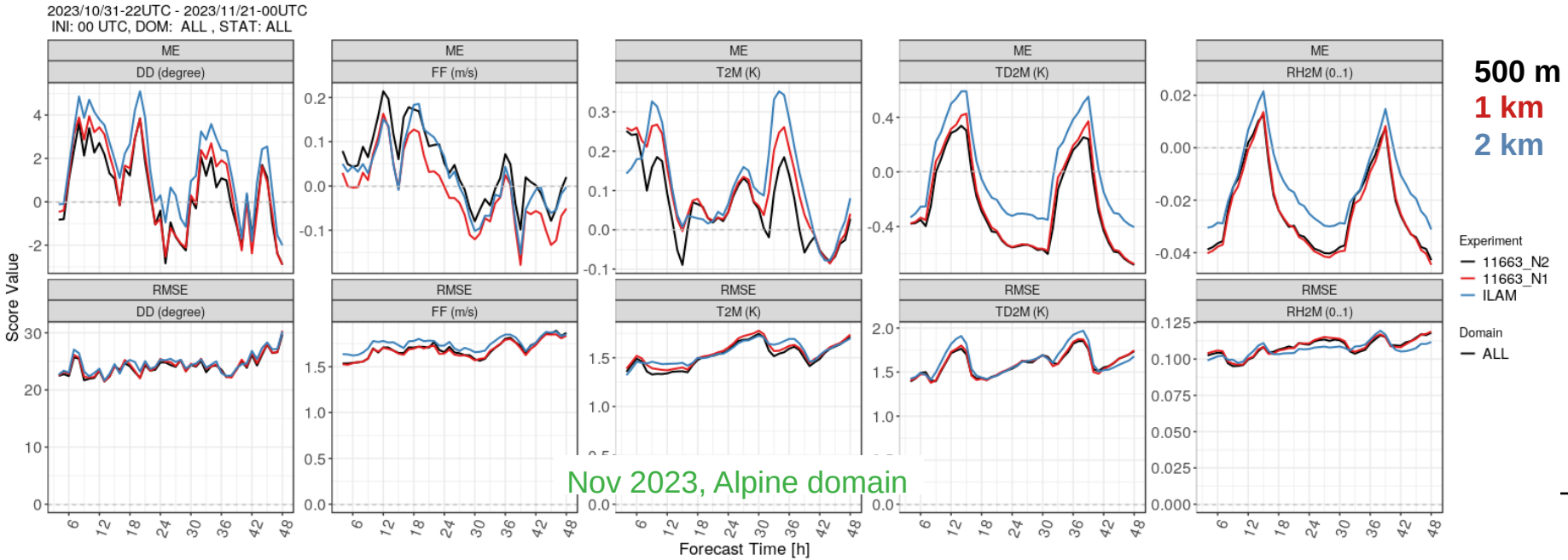
- **Refining the mesh size from 2 km to 500 m tends to improve the model skill in various aspects**
  - **Improved 10-m winds in mountainous regions under stable conditions, for T2M this depends on the time period, and results for TD2M (dew point) and RH2M are contradicting**



ICON-LAM with 500 m

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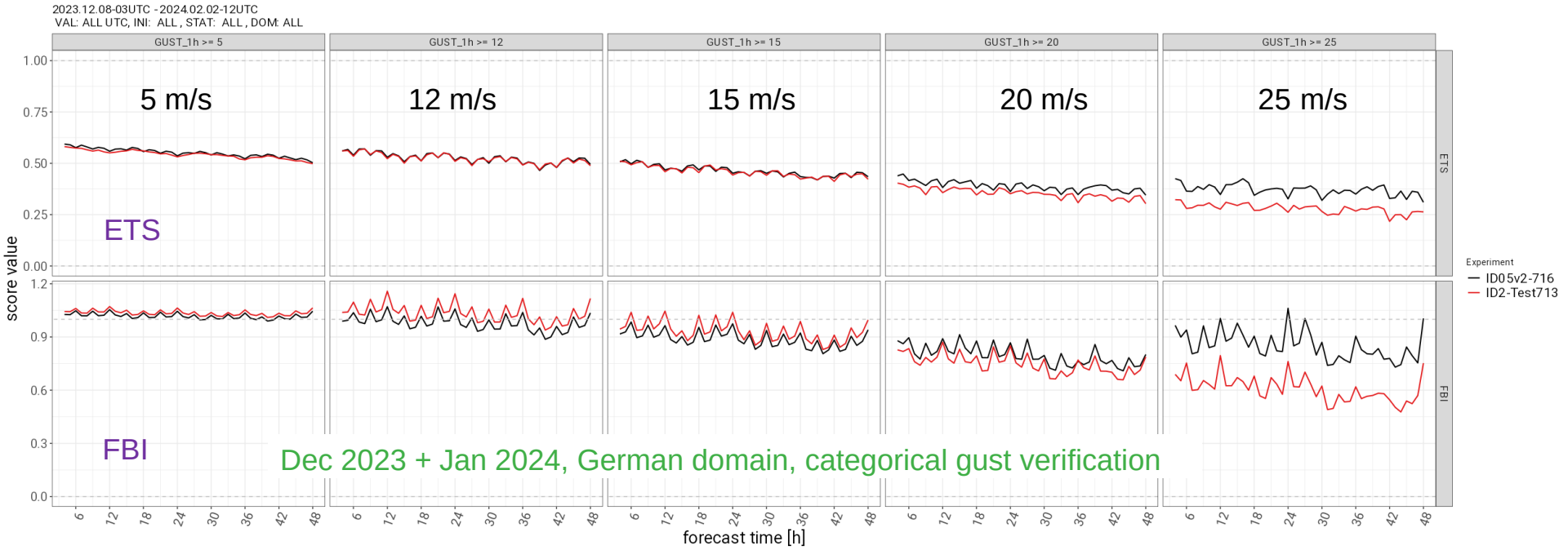
- Refining the mesh size from 2 km to 500 m tends to improve the model skill in various aspects
  - **Better representation of wind maxima / gust at mountain crests**



ICON-LAM with 500 m

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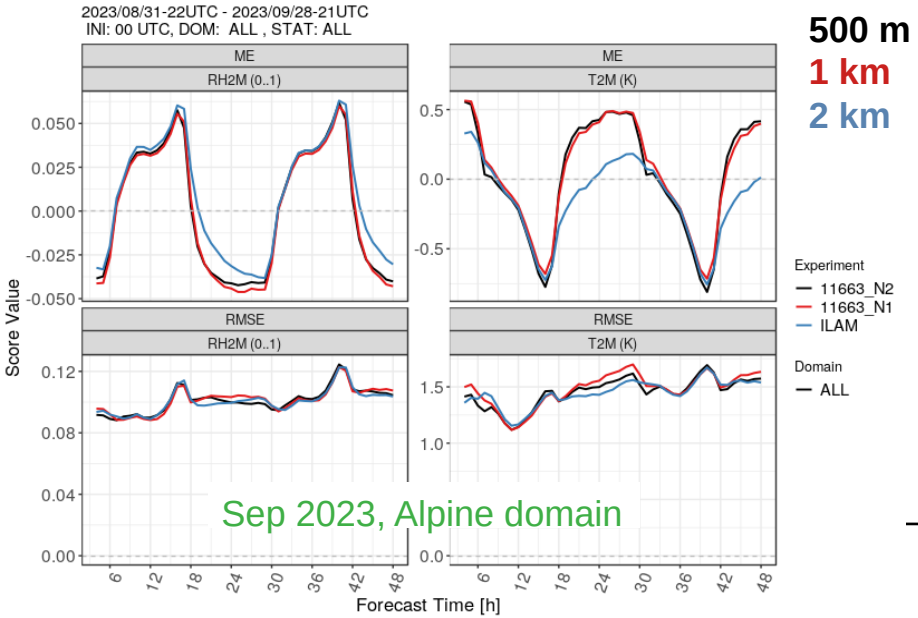
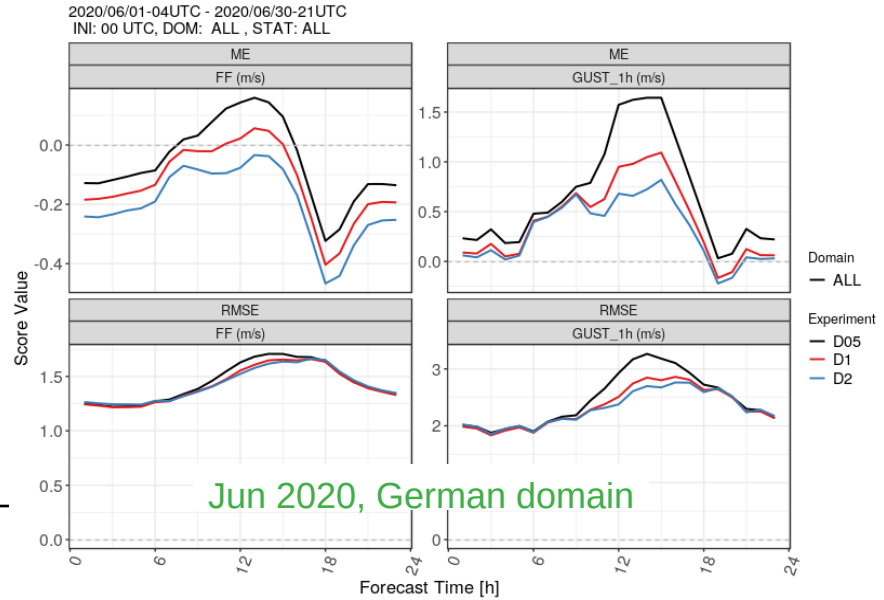
- **However, there were also several issues that required further model development**
  - **Increased nocturnal warm bias in valleys during the summer months**
  - **Large overestimation of diagnosed wind gusts in summertime conditions with a deep daytime PBL due to double-counting issues with ‘permitted large eddies’**





ICON-LAM with 500 m

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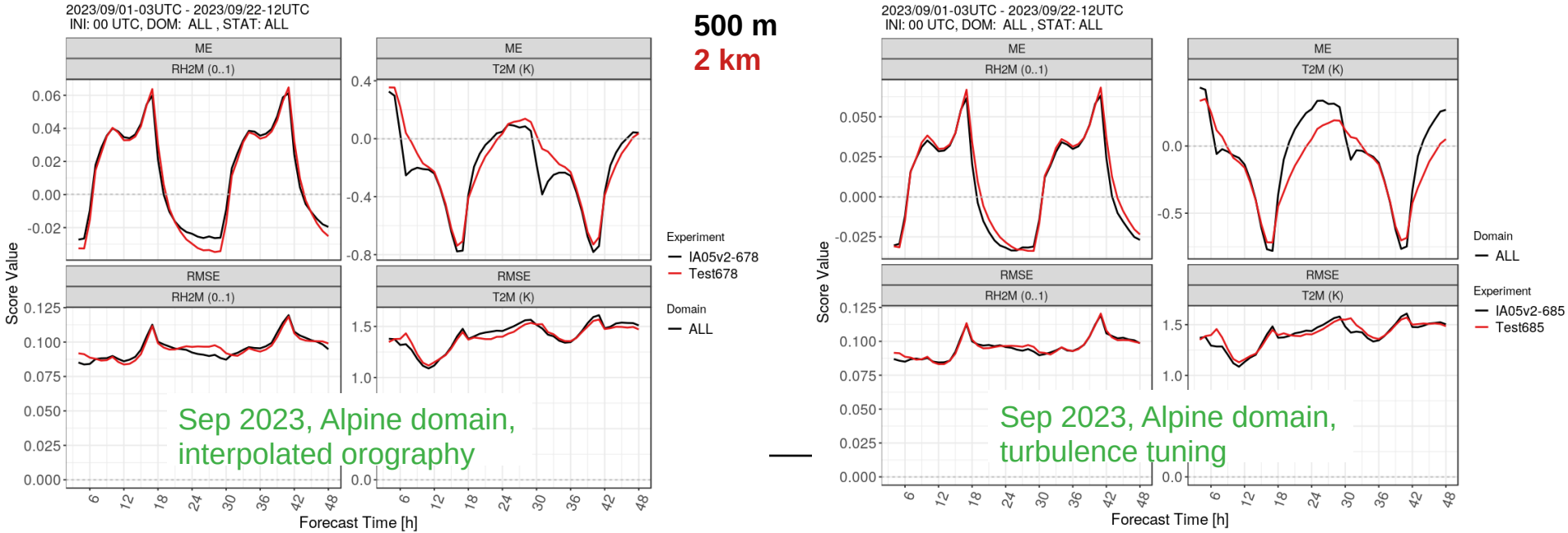
- **Subsequent findings related to the nocturnal temperature bias difference**
  - **Interpolating the model orography from 2 km to 500 m removes the bias difference (left)**
  - **Reducing parameterized turbulent mixing over sloping terrain reduces the bias difference (right)**



ICON-LAM with 500 m

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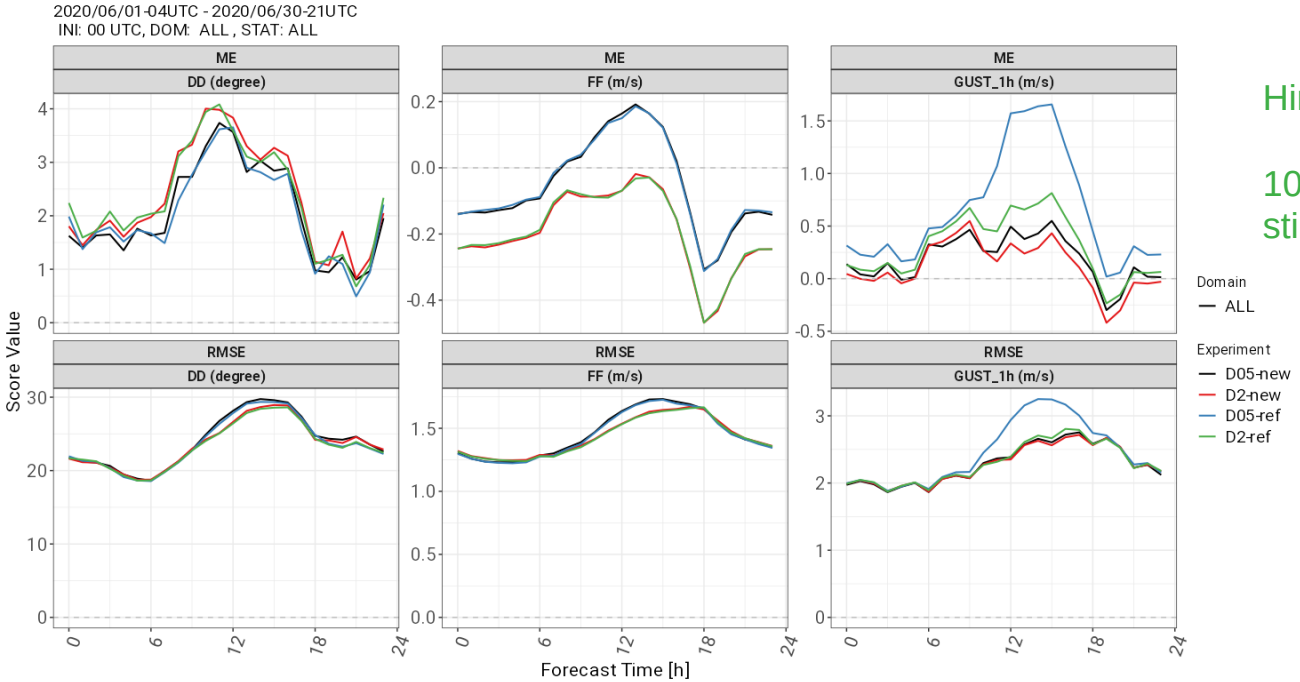
- **Adapted gust parameterization**
  - **Based upon 10-min averaged 10-m winds rather than instantaneous values in order to reduce impact of ‚permitted turbulence‘**
  - **Limitation of gust excess speed to resolved PBL wind maximum (times tuning factor)**



Hindcast for June 2020

10-m winds used for verification are still instantaneous values

ICON-LAM with 500 m

➔ Summary of tuning changes / model improvements developed and implemented so far

- Slightly increased orography filtering
- Reduced parameterized turbulent mixing over sloping terrain, combined with reduced transfer resistance for surface fluxes
- Reduced SSO source term for TKE
- Turn off sub-grid-scale condensation heating at 500 m
- Revision of resolution-dependence of tuning parameters in convection scheme (shallow convection is still active at 500 m)
- Modified gust parameterization based upon 10-min averaged 10-m winds with additional PBL limitation

Under investigation

- Reduced snow albedo over steep slopes

Adaptive surface friction in ICON-D2

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- **Builds upon time-filtered assimilation increments of wind speed at the lowest model level (10 m AGL)**
- **Provided that 10-m winds are assimilated, these can be used as a proxy for the model bias at this level**
- **Along with the revision of the 10-m wind assimilation, the assumed observation error was reduced significantly because this further improved the results (Hendrik Reich, Klaus Stephan, Christoph Schraff)**
- **Additional minor improvements could be achieved by retuning the SSO scheme**
- **Operational in ICON-D2 since February 2024 (global since November 2022)**

Synop scores for winter test period (bias/RMSE)

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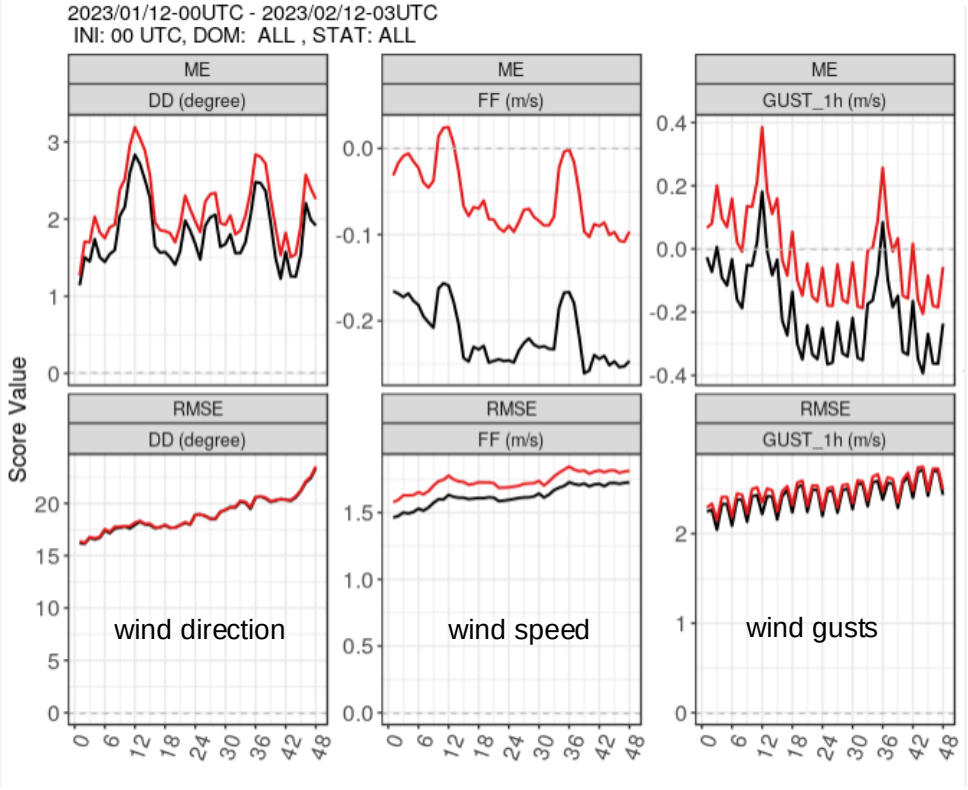
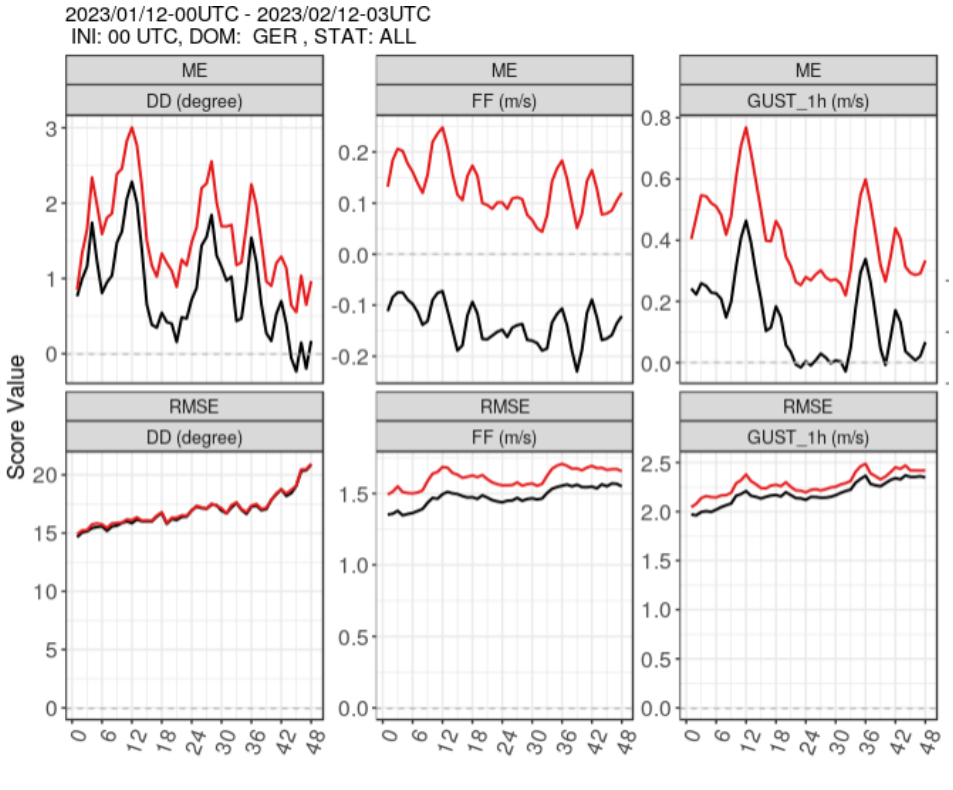
Full domain



German stations only



Summary of further model improvements

- Modifications in convection and cloud-cover schemes to reduce cloudiness and radiation biases in stable PBLs (Maike Ahlgrimm)
- Improved sea-ice scheme, accounting for bottom heat flux (Dmitrii Mironov)
- Revision of SSO tuning (along with minor formulation changes in the scheme) in order to reduce wind speed errors over the Tibetan plateau in winter
- Enhanced EPS perturbations for deep convection scheme in global system, going along with a reduction of the SST perturbations
- Consideration of moisture dependence of atmospheric heat capacities (Bjorn Stevens)
- Update of greenhouse gas concentrations (2012 → 2023)
- Activation of EPS perturbations (including LHN tuning parameters) in ICON-D2 assimilation cycle (Klaus Stephan, Hendrik Reich)