



- KENDA, based on DACE code:
 - less resources for algorithmic developments (LETKF, EnVar; 4D-EnVar (global), PF)
 - observations (screen-level, radar, satellite, ...) (DWD, MeteoSwiss, ARPAE, CNMCA)
- code redesign / re-write of analysis code for generalized states (control vector) (incl. hydrometeors, ocean, surface / soil, greenhouse gases, ...)
- AI → AI-Var (*Keller and Potthast, 2024 (arXiv:2406.00390v1)*)



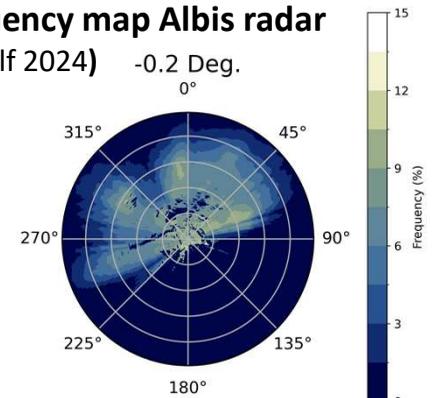


Activities Overview (ongoing)

Daniel Leuenberger, Claire Merker, Krishnamoorthy Chandramouli, Alina Yapparova, Bas Crezee

- Finalized KENDA-CH1 setup using **ICON**, **operational** since 2024-05-28 (*Daniel Leuenberger*)
- Assimilation of **Raman Lidar** humidity and temperature profiles (*Bas, Claire*)
 - impact in KENDA-1 (COSMO) positive on analysis + FG, neutral – slightly positive on forecasts
 - paper submitted, DA with ICON soon
- Assimilation of Swiss radar volume observations (*Alina, Claire*)
 - **shading** by real and simulated topography, use frequency / visibility maps
- Adaptive Parameter Tuning (*Daniel*)
- Diagnosis of KENDA-CH1 system (*Krishna*)
 - overall, T2M + RH2M obs very beneficial e.g. for forecast of fog / low stratus, but ...

frequency map Albis radar
(1st half 2024) -0.2 Deg.

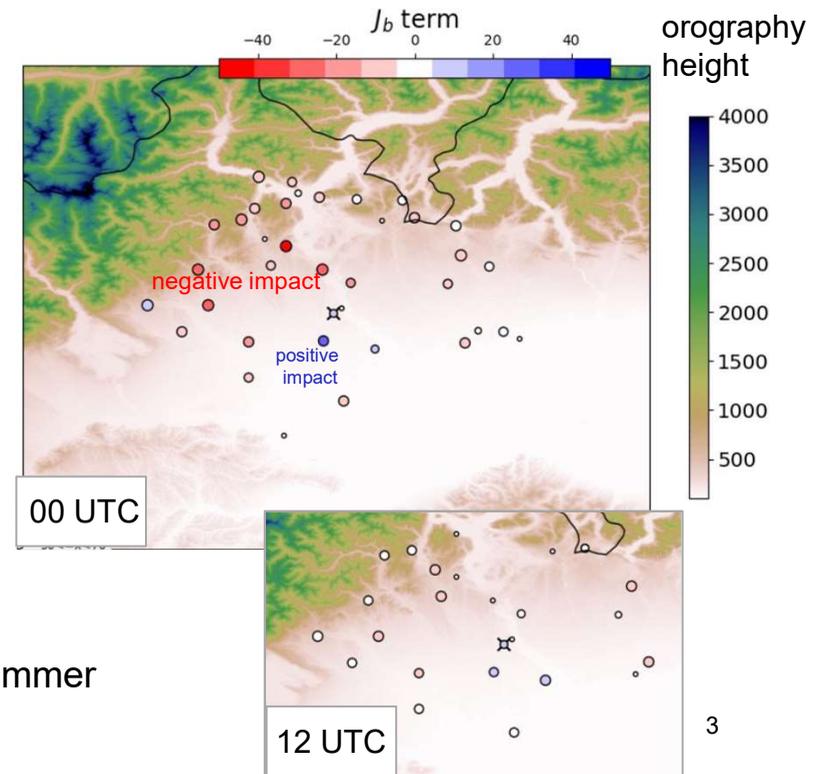




Cross validation diagnostics (Stiller, 2021)

in some cases, fit of analysis to radiosondes **degraded due to T2M assimilation**:
station-wise diagnostics of T2m assimilation w.r.t. Milan TEMP during **OND 2023**

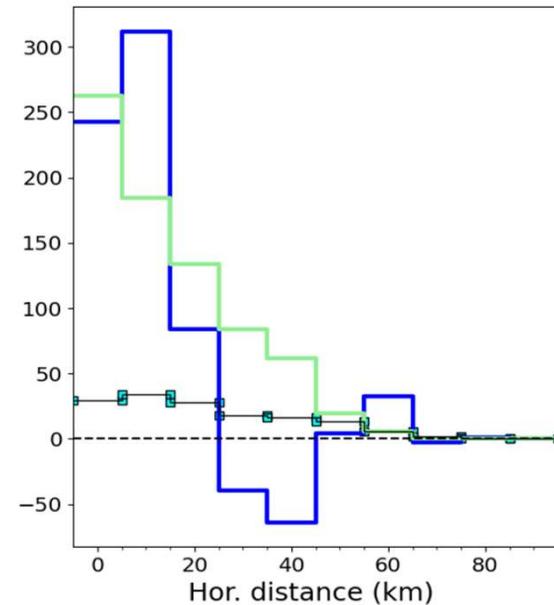
- only stations below 950 hPa considered here
- negative impact from most stations
- negative impact mostly at **night**,
particularly from very **cold T2M obs**: cold bias in O-B
(hints of limited representativity
where certain stations (in valleys / near orography)
tend to have lower T2M than other stations)
- similar effects also at Payerne radiosonde, e.g.:
large negative impact at nighttime low-level inversion in summer





Cross validation diagnostics (Stiller, 2021)

- mismatch between **observation minus model** and **ensemble** estimated covariances (near-surface temperature, OND 2023)
→ testing reduced horizontal localization scale for SYNOP
- vertical correlations → vertical localisation
- station selection



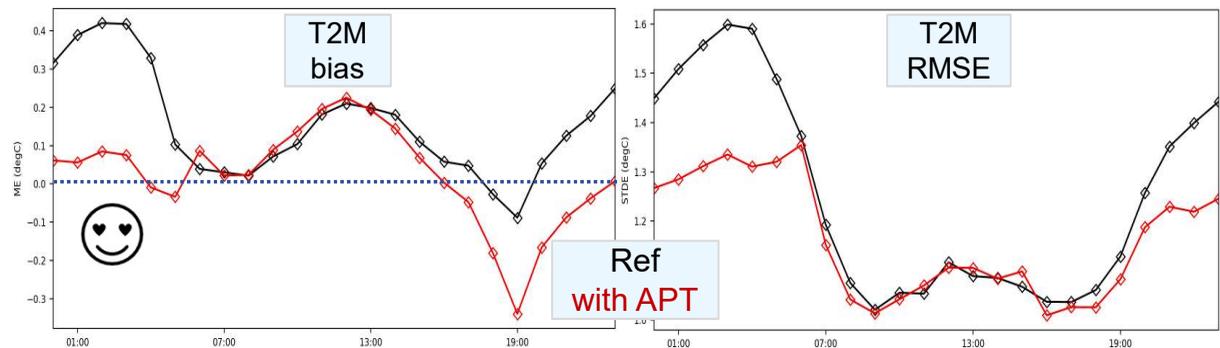
Adaptive parameter tuning by model – DA coupling

(Günther Zängl, DWD)

- uses time-filtered temperature + humidity analysis increments at lowest model level (~10m a.g.) as predictor fields, reflecting (mainly) model bias vs. T2M + RH2M obs;
adapted fields:
 - thermal conductivities of soil & skin layers
 - thermal capacity of soil
 - bare soil + vegetation evaporation (minimum evaporation resistances)
 - snow albedo



- KENDA-CH1 first guess verif. against Swiss SYNOP stations (24.05. – 14.06.2023)

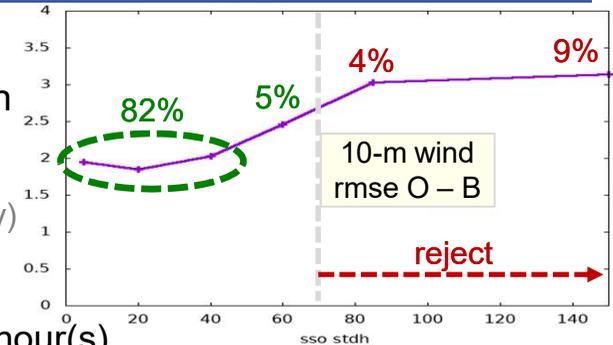


→ after reduction of biases by APT, will redo cross validation of T2M obs

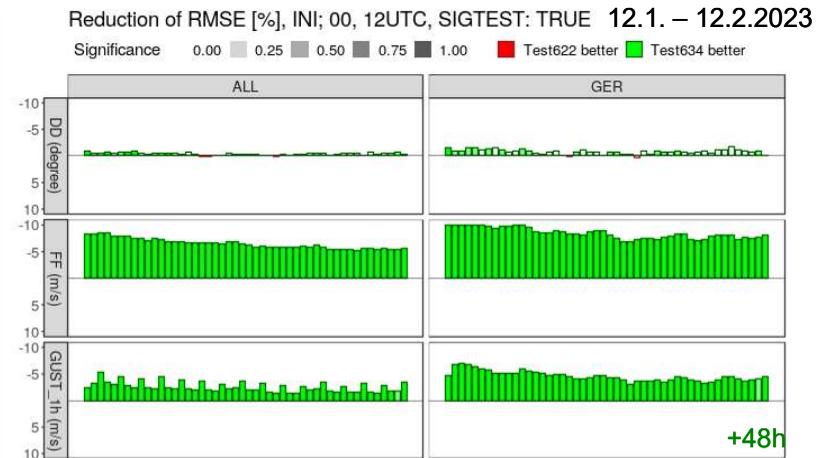


Screen-level obs: 10-m wind

- revised criteria for station selection for 10-m wind assimilation allows to use 86% of stations over distributed over whole model domain
 - SSO standard deviation ≤ 70 m (as in global ICON setup)
 - distance station height to model orography ≤ 100 m (rejects 1% additionally)
- reduced obs errors : 3.6 m/s \rightarrow 2.0 m/s (\cong rmse O – B)
 - \rightarrow neutral impact for upper-air wind, slightly positive for 10-m wind in first hour(s)



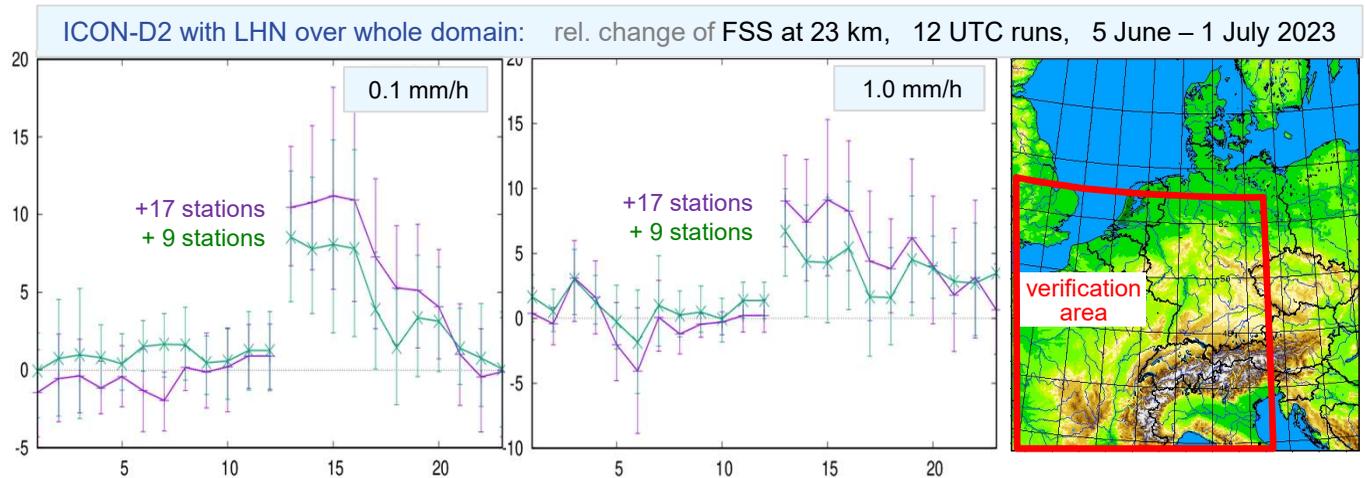
- allows for introduction of adaptive surface friction using wind analysis increments at lowest model level (~ 10 m a.g.) as predictor field, as in global ICON, Günther Zängl):
 - adaptive adjustment of vegetation roughness length
 - adaptive SSO blocking tendency at lowest model level
- \rightarrow major improvement of 10-m wind speeds + gusts (winter + summer)
- operational since Jan. 2024



3-D radar reflectivity + radial velocity

- ICON-D2: foreign radars (Klaus Stephan, DWD)
 - very heterogeneous data / scan strategies → evaluate country-wise

- start with (17) French C-band radars (Z + Vr):
 - positive impact on precip
 - (use only 9 radars: 20% less data, 50% cost reduction)



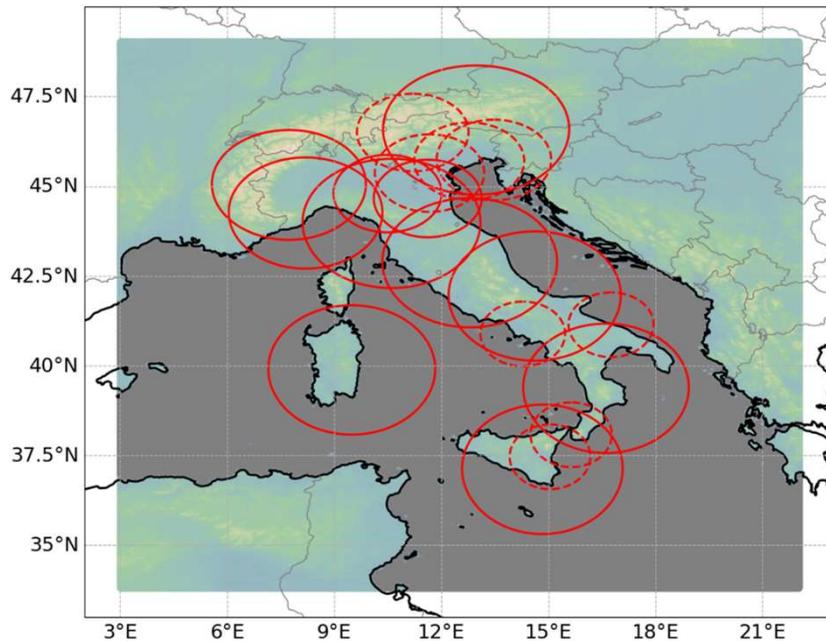
- ✓ in **ICON-D2** operational since 22 May 2024
- ✓ in **Sinfony-RUC** suite (operational)



DA for ICON-I2 at Arpae and ItaliaMeteo

*Thomas Gastaldo, Virginia Poli, Chiara Marsigli, Enrico Minguzzi,
Marcello Grenzi, Alfonso Ferrone, Davide Cesari, Pier Paolo Alberoni*

ICON-2I model fully operational since 18/06/2024



KENDA implementation:

- 40 + 1 members, 1-hrly cycle, IAU, RTPS
- Control vector: pf, t, q, u, v, qcl, qci, qr, qs, qg

Assimilated observations:

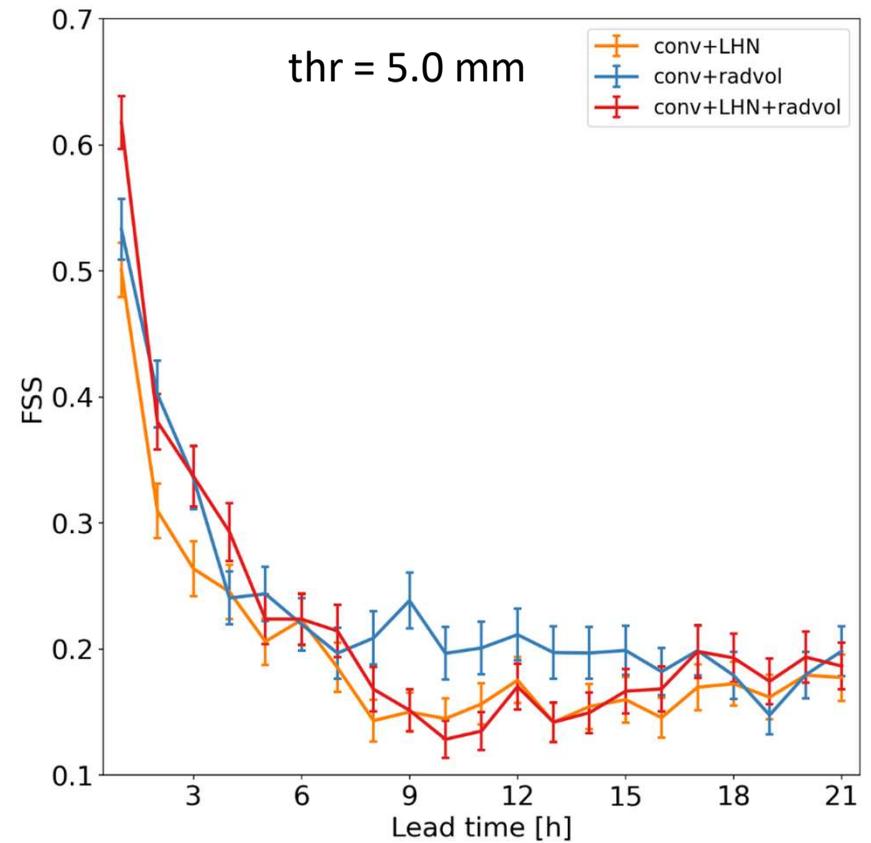
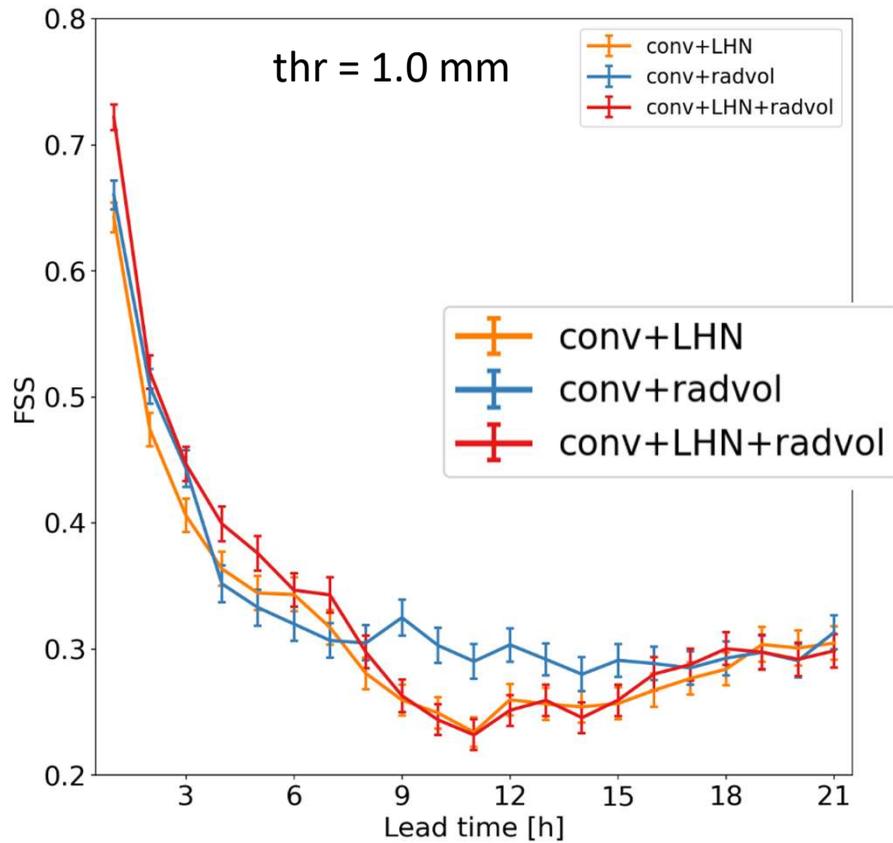
- AIREP, TEMP, SYNOP (wind, surface pressure), 3-D reflectivity + radial wind (radars: solid lines)
- LHN: radar estimated precipitation rates from composite of all radars (solid + dashed lines)

Work in 2024:

- Transition to ICON
- 3-D radar DA, LHN
- MW WV channels from polar satellites (→ all-sky)

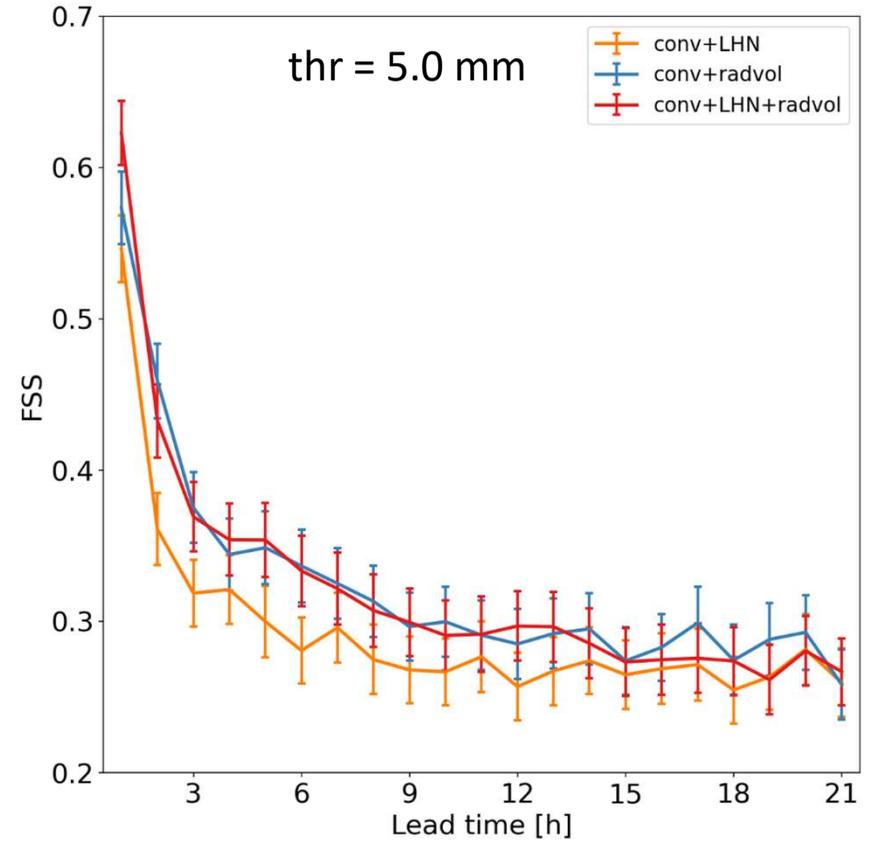
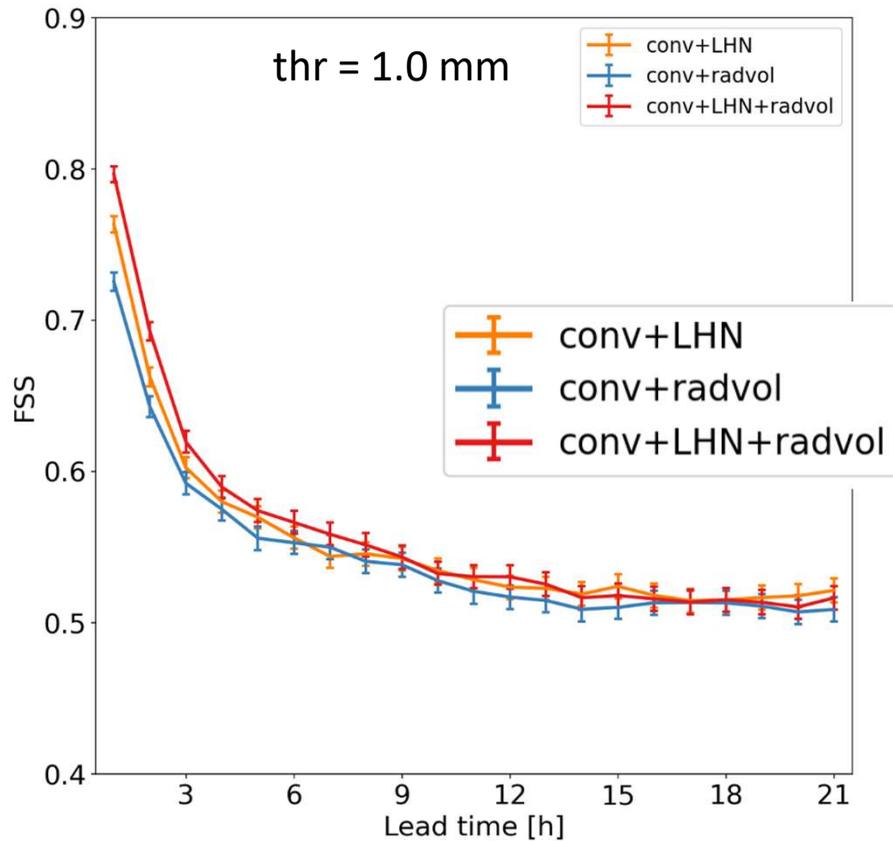
Assimilation of radar volumes

precipitation FSS: Aug. 2022 (1 – 22 Aug., forecasts every 3 h)



Assimilation of radar volumes

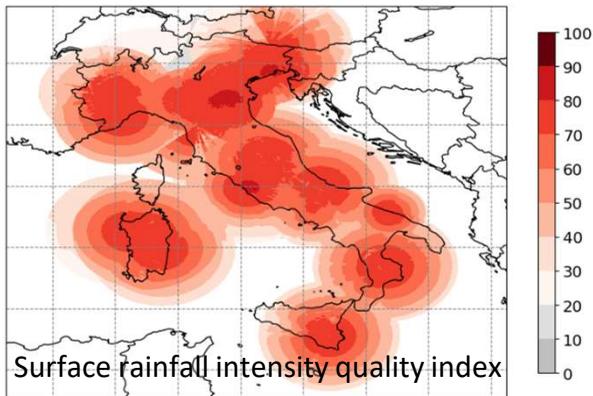
precipitation FSS: May 2023 (29 April – 18 May, forecasts every 3 h)



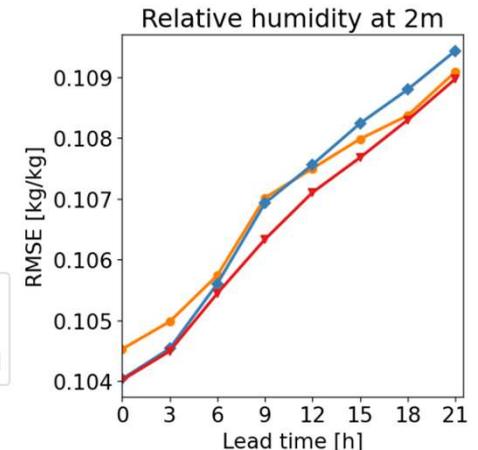
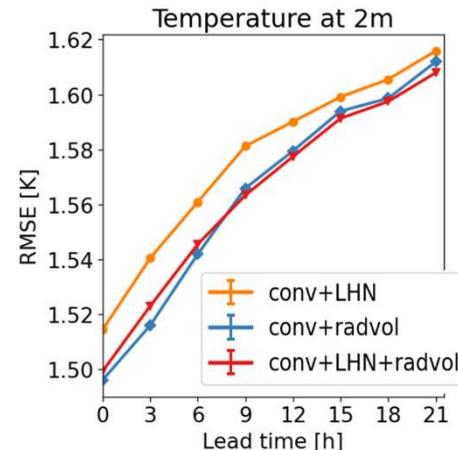
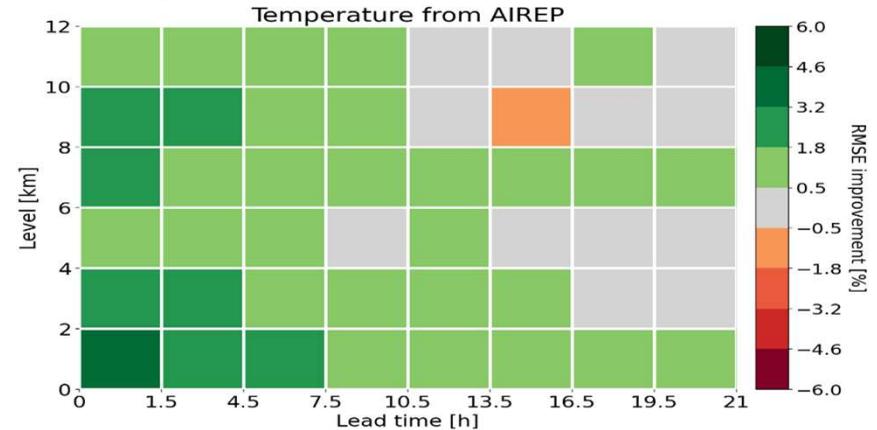
Assimilation of radar volumes

- assimilation of 3-D radar Z + Vr improves precip, upper-air, T2M, RH2M, 10-m wind ...
- impact of LHN (if in addition to 3-D radar data)
 - mixed on forecasts
 - positive on precip in DA cycle → soil moisture
 (note: qr, qs, qg in LETKF update as in Sinfony RUC)

→ ongoing work on LHN: parameter tuning, QC, SRI quality index by Civil Protection ...

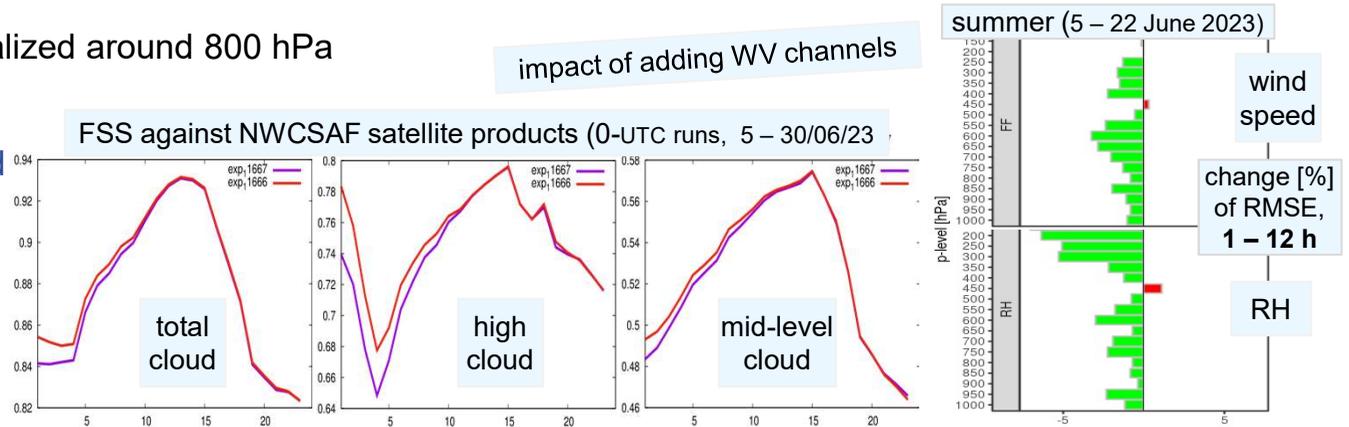


average (21h, 12km) RMSE reduction by radvol: 1%



Satellite DA: all-sky (cloudy) SEVIRI IR WV radiances

- VIS reflectance operational since March 2023 w/o vertical localization
- to combine with WV: VIS localized around 800 hPa
 - VIS: low clouds, radiation
 - WV: mid-level + high cloud
- parallel suite successful



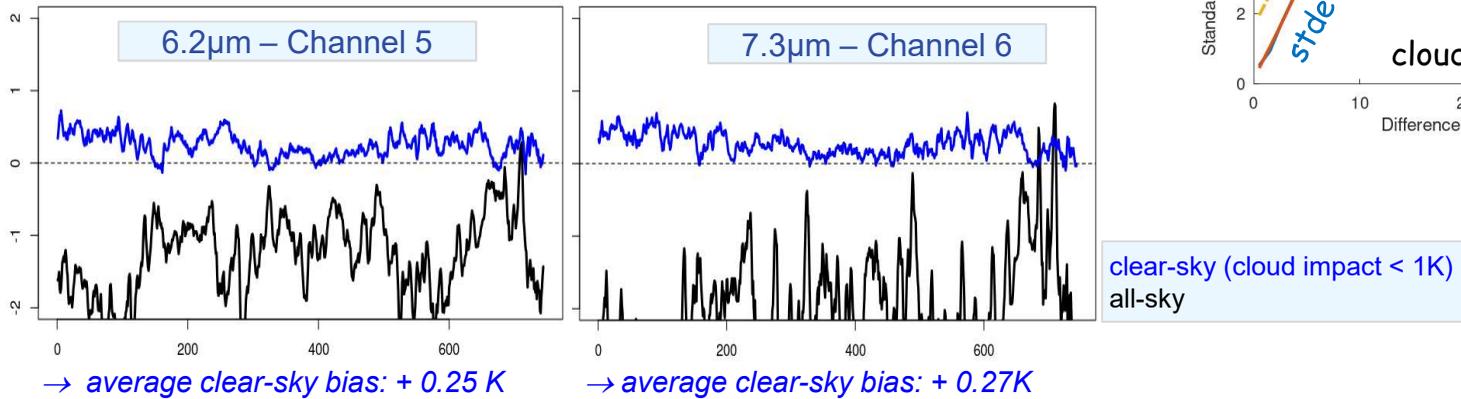
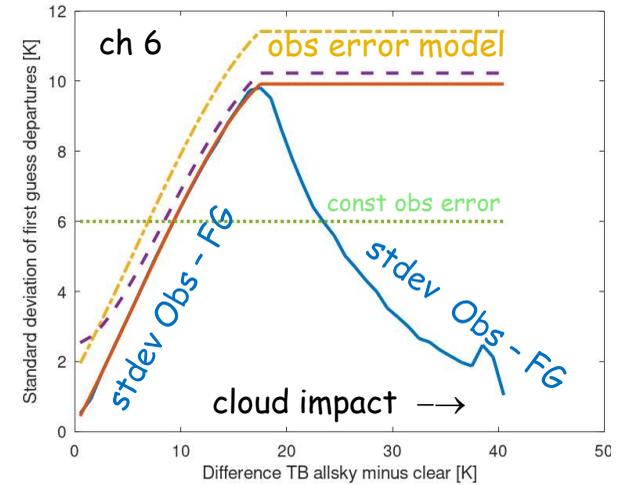
- ✓ SEVIRI WV operational in ICON-D2 & in SINFONY RUC since Nov 2023
- ✓ first time internationally: use of operational all-sky IR data assimilation

- paper in preparation



Satellite DA: all-sky (cloudy) SEVIRI IR WV radiances

- so far
 - no bias correction for SEVIRI ...
 - obs error of 2 K assigned to clear-sky obs = 2 K >> stdev(O - FG)
 - low weight given to clear-sky data (→ water vapour) (while cloud info is used well)
- for clear-sky, need bias correction
idea: derive BC from clear-sky ... (SEVIRI data passive, 4 weeks August 2022)



... and apply all-sky (first experiment with constant bias correction: mixed results vs. radiosondes)



- FCI @ MTG (*Annika Schomburg, Leonhard Scheck, a.o., DWD*)
 - preparations started for use of analogous VIS + WV channels
 - later: further visible + near IR channels of FCI
- preparation of MTG IRS data (clear sky, above clouds) (*Mahdiyeh Mousavi a.o. DWD*)
 - over land: skin temperature T_s retrieval from very low peaking channels; IR emissivity atlas
 - cloud detection + adaptive bias correction (adapted from global VAR to LAM KENDA)
 - ongoing: implementation of non-diagonal R (interchannel correlations) in LETKF
 - to do: revisit channel selection, code optimization, tuning of LETKF DA (thinning, localization...)
- microwave (MW) water-vapor channels from polar satellites, clear-sky + all-sky (*Marcello Grenzi a.o., ARPAE*)