Status of data assimilation for ICON-2I model at Arpae

Thomas Gastaldo, Virginia Poli

Arpae Emilia-Romagna
Struttura IdroMeteoClima

Pre-operational assimilation in ICON-2I model

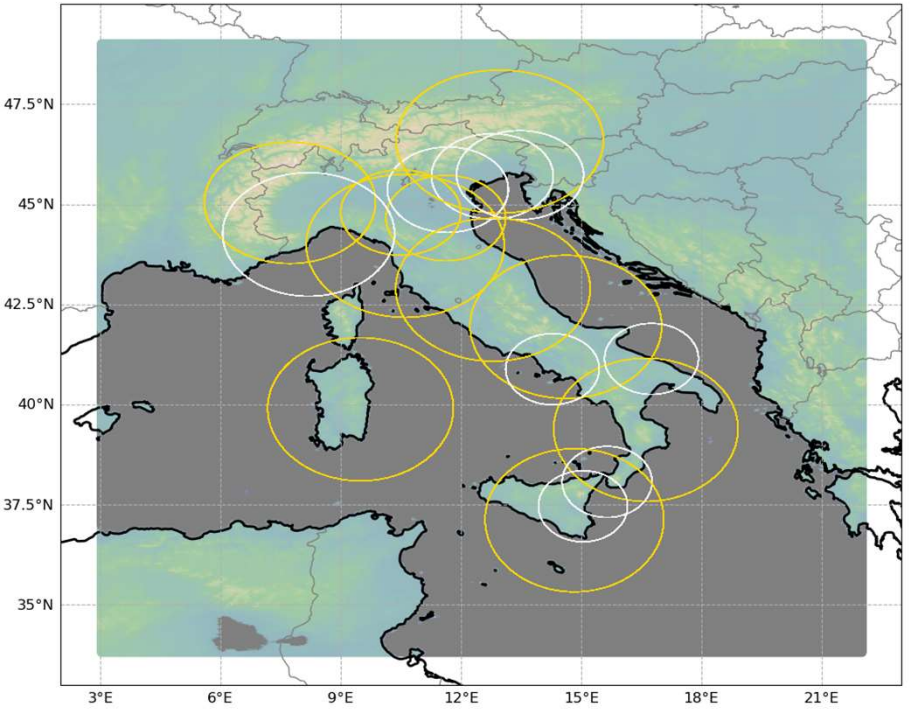
ICON-2I analysis pre-operational since 23/11.

Model:

ICON 2.6.5.1 at 2.2 km horizontal resolution

KENDA implementation:

- 24 members + deterministic run (will be 40+1)
- 1h assimilation cycles, employing IAU with a 10 minutes window
- RTPS
- Assimilation up to 200 hPa
- Control vector: `pf t q u v qcl`.



Assimilated observations:

- AIREP, TEMP, SYNOP (wind and surface pressure) through KENDA
- radar estimated precipitation via LHN using the composite of all radars

Comparison with COSMO-2I

Experiments:

- ***ICON-2I***: set-up described in the previous slide
- ***COSMO-2I***: operational configuration, employing:
  - 36 members + 1 deterministic run
  - assimilation of conventional observations, radar estimated precipitation via LHN and radar volumes of reflectivity and radial winds.

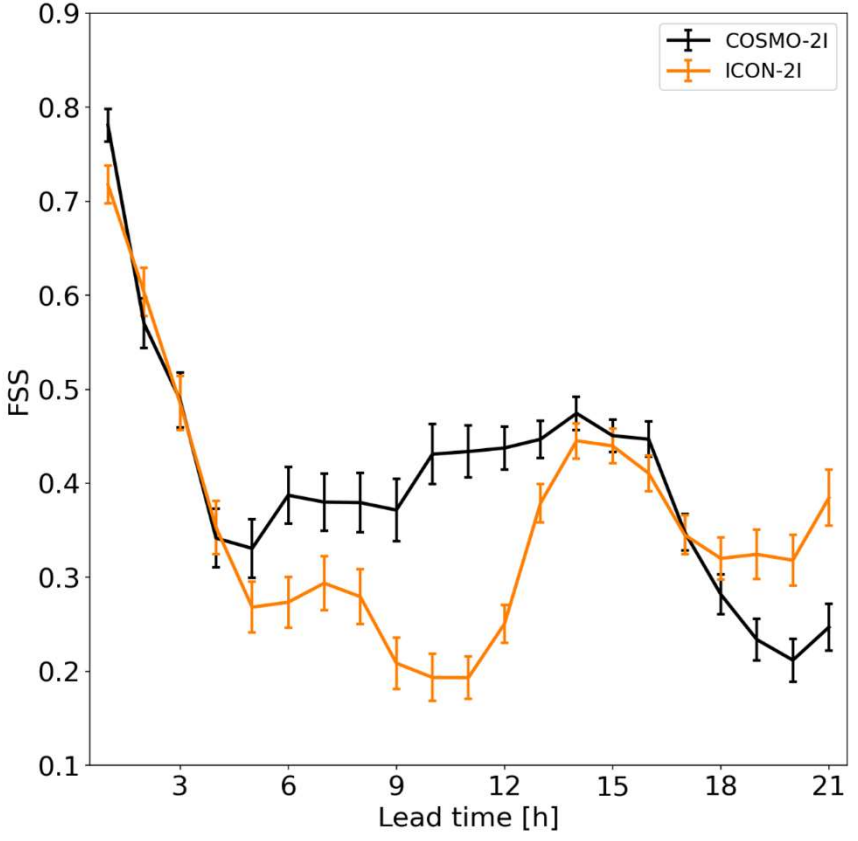
Evaluation period:

- ***aug2022***: from 01/08 to 22/08, few convective events;
- ***may2023***: from 29/04 to 18/05, several mainly stratiform events, including Emilia-Romagna floods.

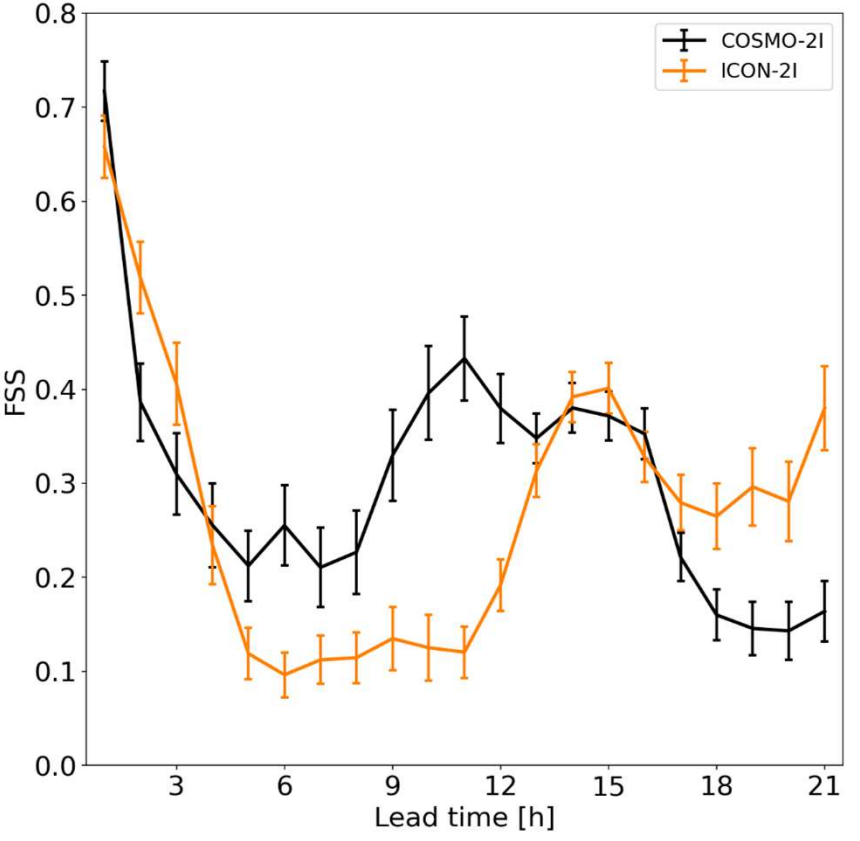
A 21h deterministic forecast is initialized from analysis at 00 UTC for each experiment (in total 21 forecasts in *aug2022*, 19 in *may2023*).

Forecast precipitation (FSS): aug2022

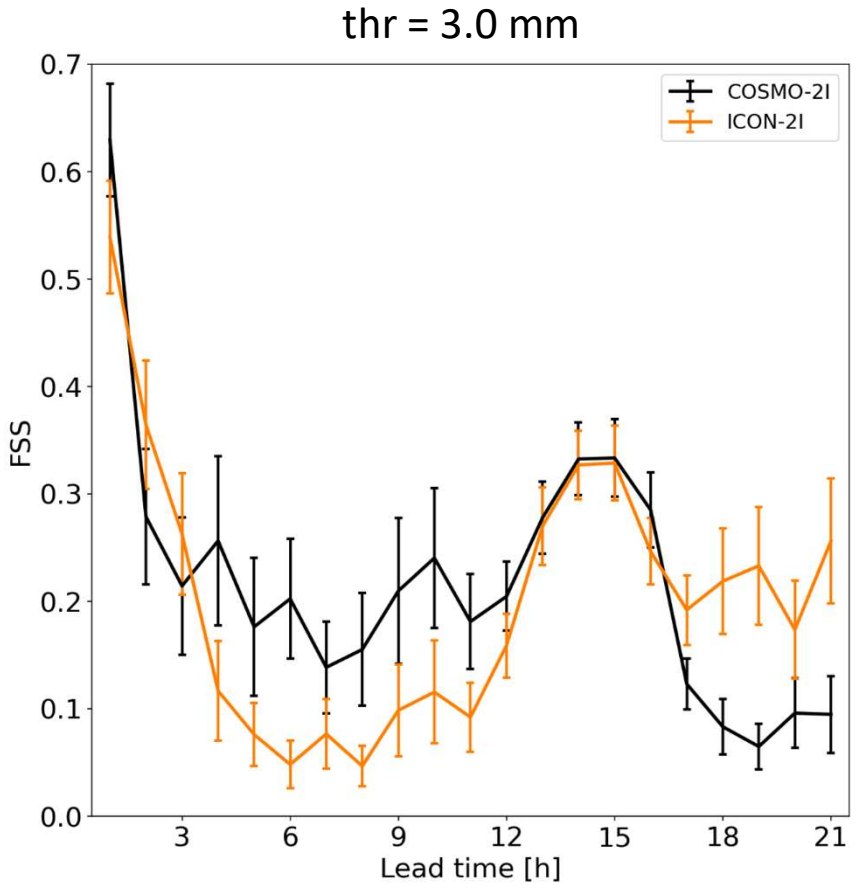
thr = 0.1 mm

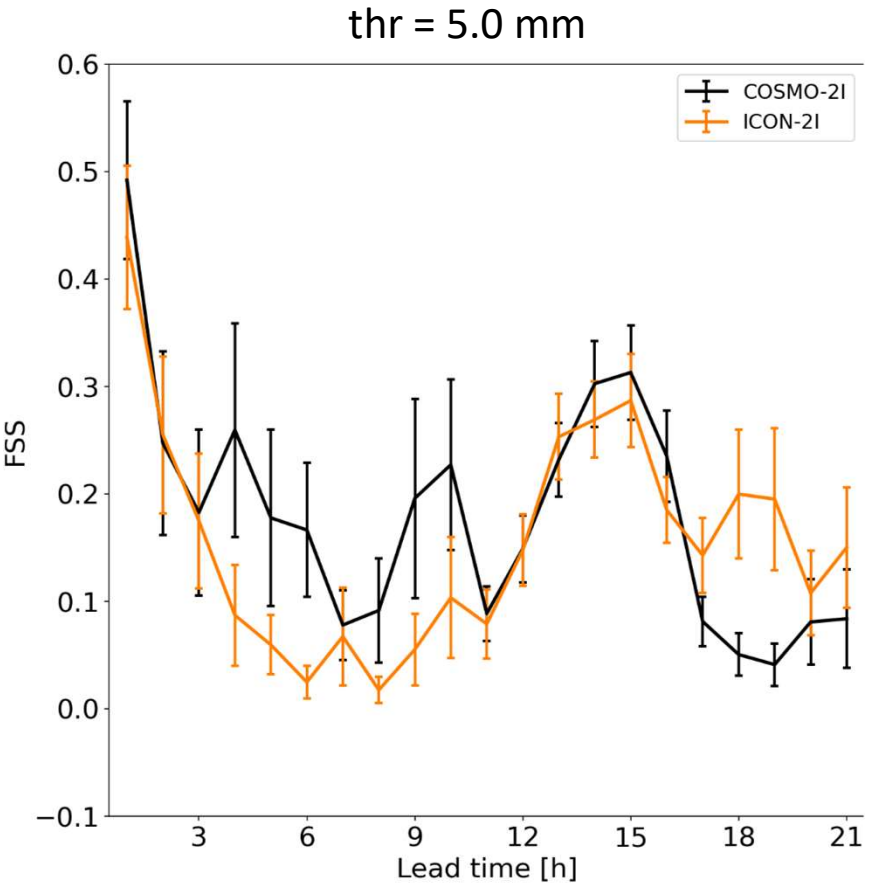


thr = 1.0 mm



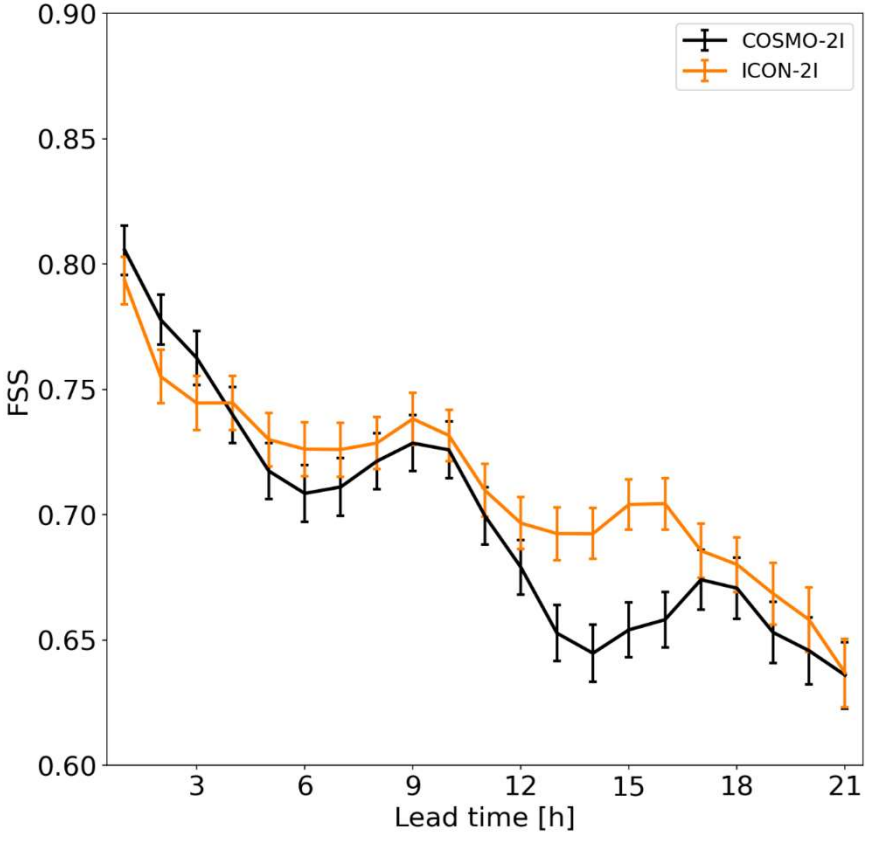
Forecast precipitation (FSS): aug2022



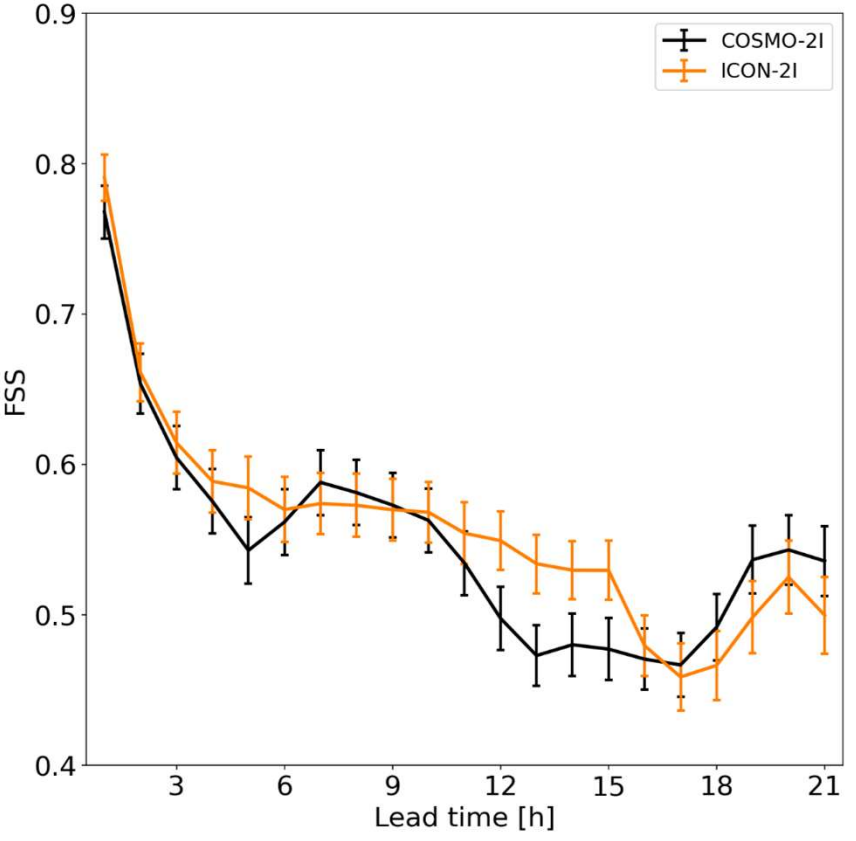


Forecast precipitation (FSS): may2023

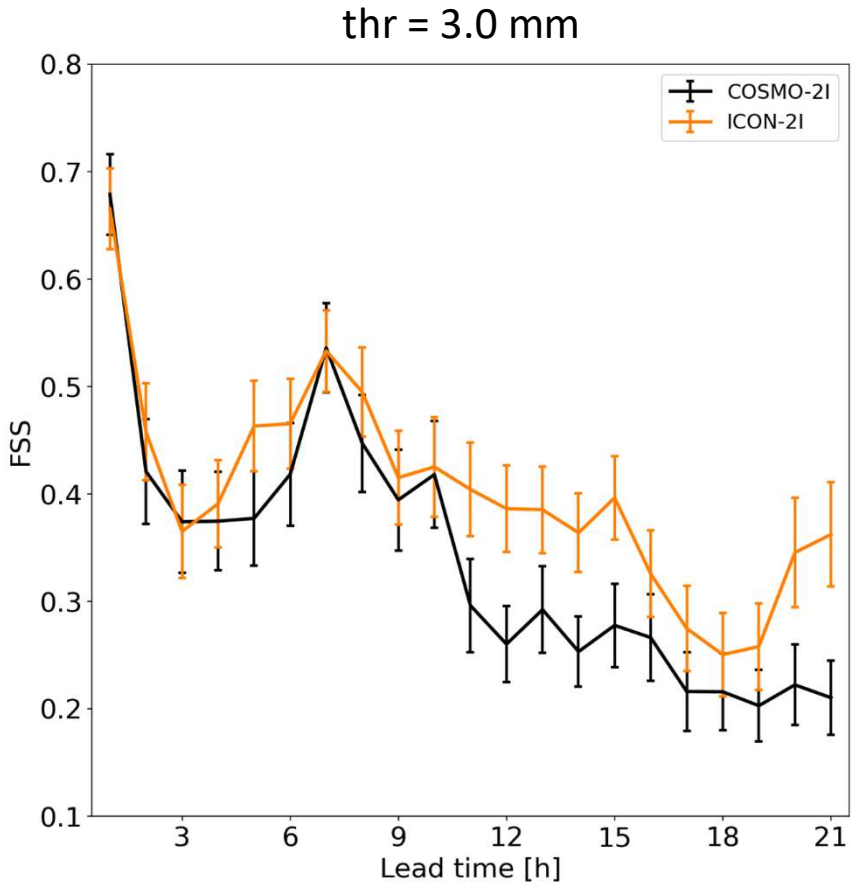
thr = 0.1 mm

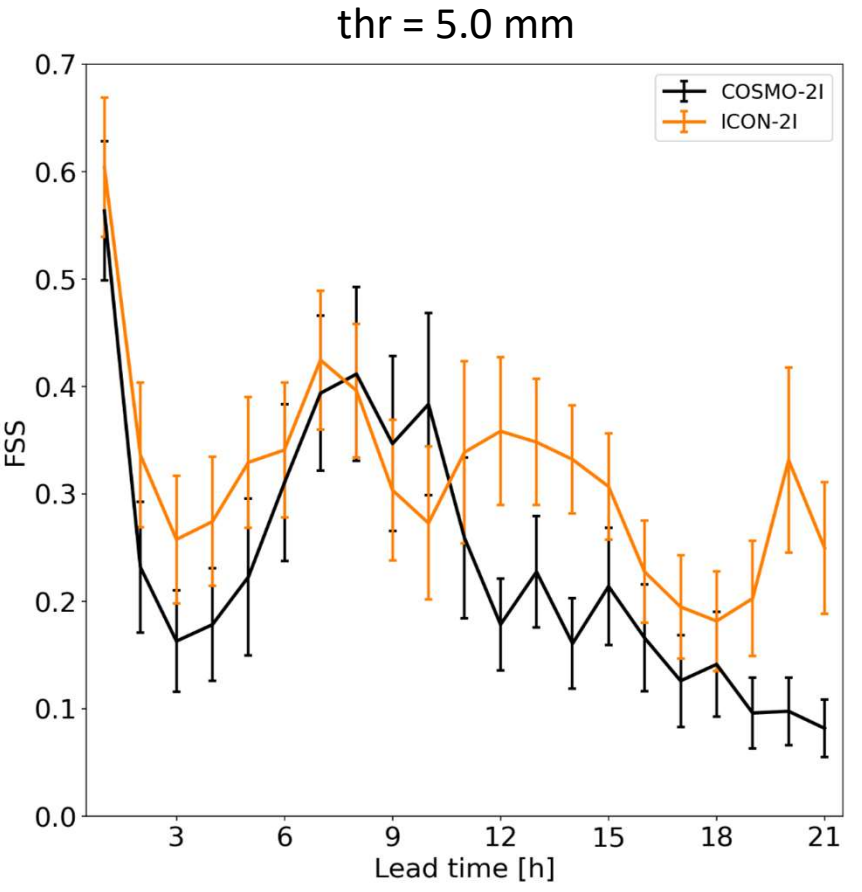


thr = 1.0 mm



Forecast precipitation (FSS): may2023



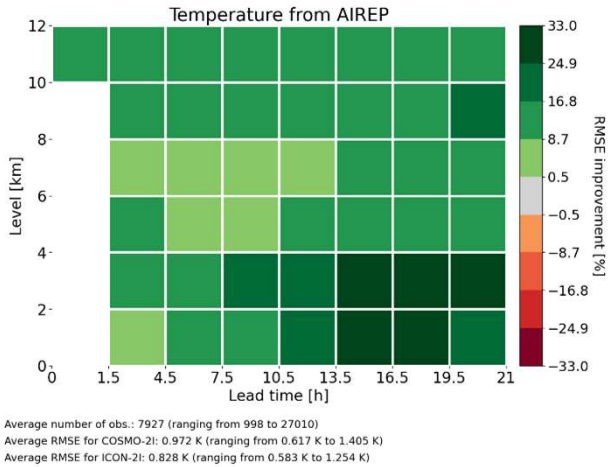


Upper-air variables: RMSE

Plot difference: RMSE(*COSMO-2I*) - RMSE(*ICON-2I*).

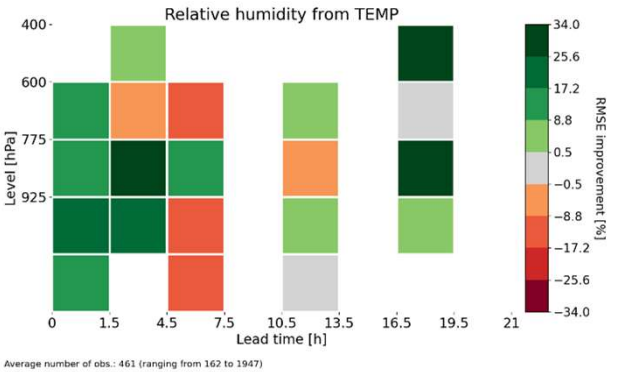
Positive values (green) → *ICON-2I* better than *COSMO-2I*

Temperature



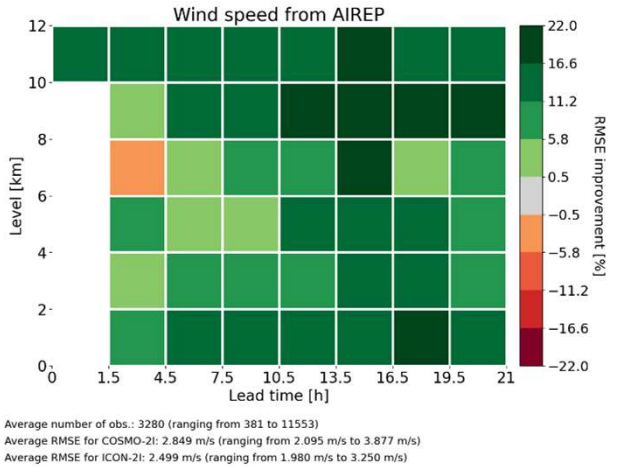
Average number of obs.: 7927 (ranging from 998 to 27010)
Average RMSE for COSMO-2I: 0.972 K (ranging from 0.617 K to 1.405 K)
Average RMSE for ICON-2I: 0.828 K (ranging from 0.583 K to 1.254 K)

Relative humidity



Average number of obs.: 461 (ranging from 162 to 1947)
Average RMSE for COSMO-2I: 0.154 kg/kg (ranging from 0.087 kg/kg to 0.215 kg/kg)
Average RMSE for ICON-2I: 0.141 kg/kg (ranging from 0.084 kg/kg to 0.216 kg/kg)

Wind speed

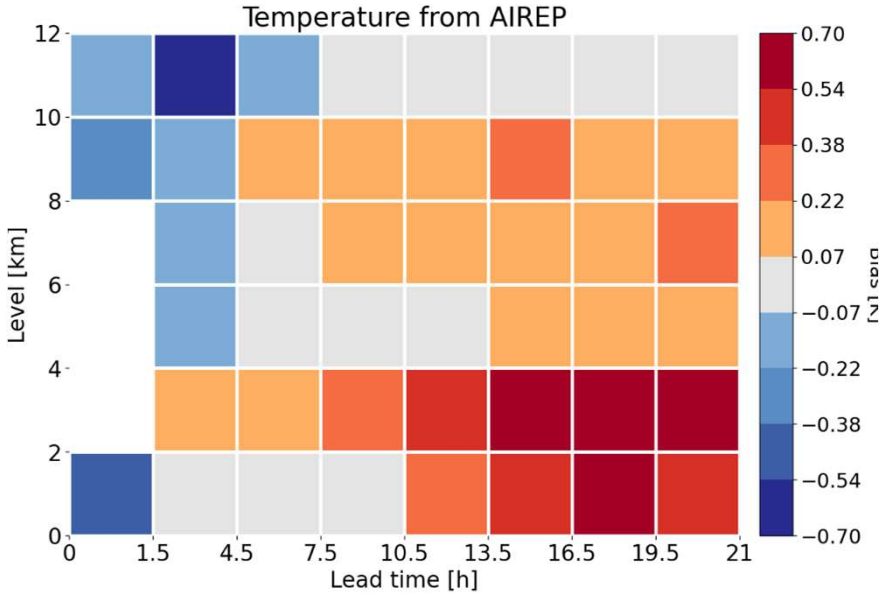


Average number of obs.: 3280 (ranging from 381 to 11553)
Average RMSE for COSMO-2I: 2.849 m/s (ranging from 2.095 m/s to 3.877 m/s)
Average RMSE for ICON-2I: 2.499 m/s (ranging from 1.980 m/s to 3.250 m/s)

Scores calculated using forecast of both *aug2022* and *may2023*

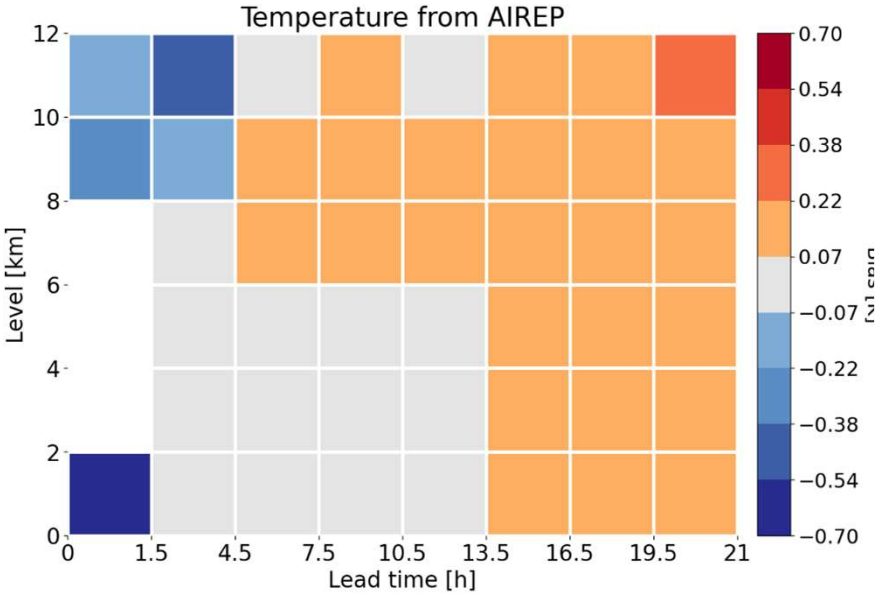
Upper-air variables: bias of temperature

COSMO-2I



verage number of obs.: 7106 (ranging from 102 to 27010)
verage bias: 0.118 K (ranging from -0.618 K to 0.667 K)

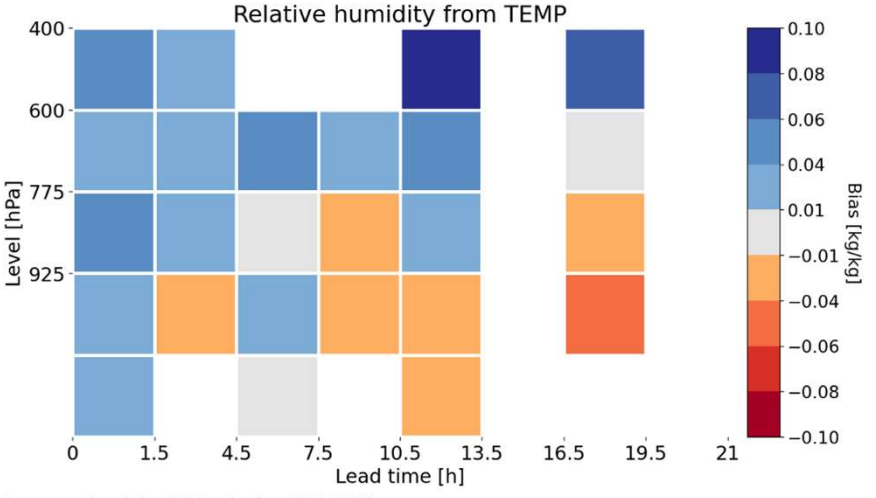
ICON-2I



verage number of obs.: 7106 (ranging from 102 to 27010)
verage bias: 0.045 K (ranging from -0.619 K to 0.222 K)

Upper-air variables: bias of relative humidity

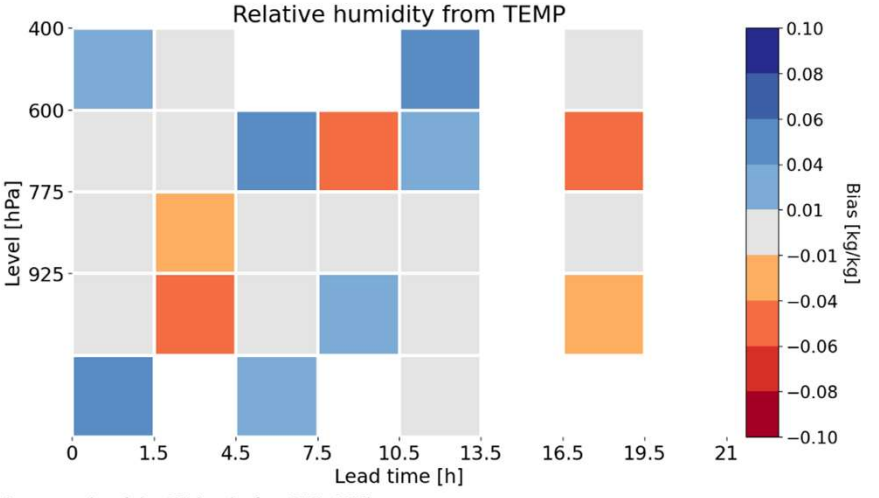
COSMO-2I



Average number of obs.: 350 (ranging from 109 to 1947)

Average bias: 0.016 kg/kg (ranging from -0.044 kg/kg to 0.088 kg/kg)

ICON-2I

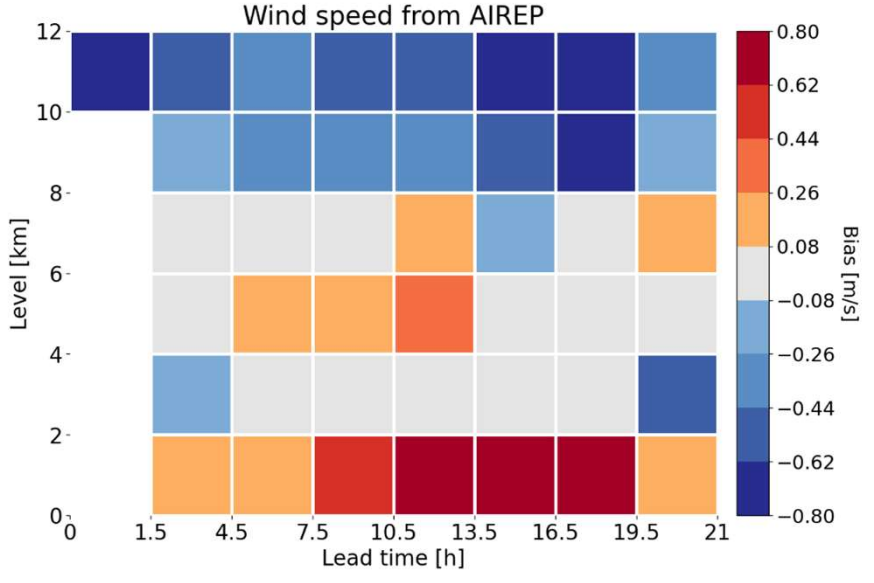


Average number of obs.: 350 (ranging from 109 to 1947)

Average bias: 0.003 kg/kg (ranging from -0.048 kg/kg to 0.051 kg/kg)

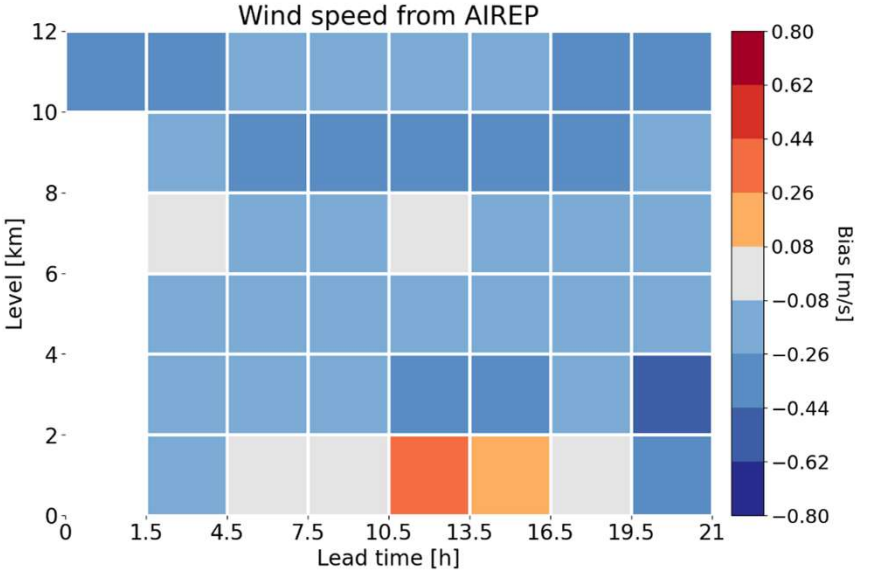
Upper-air variables: bias of wind speed

COSMO-2I



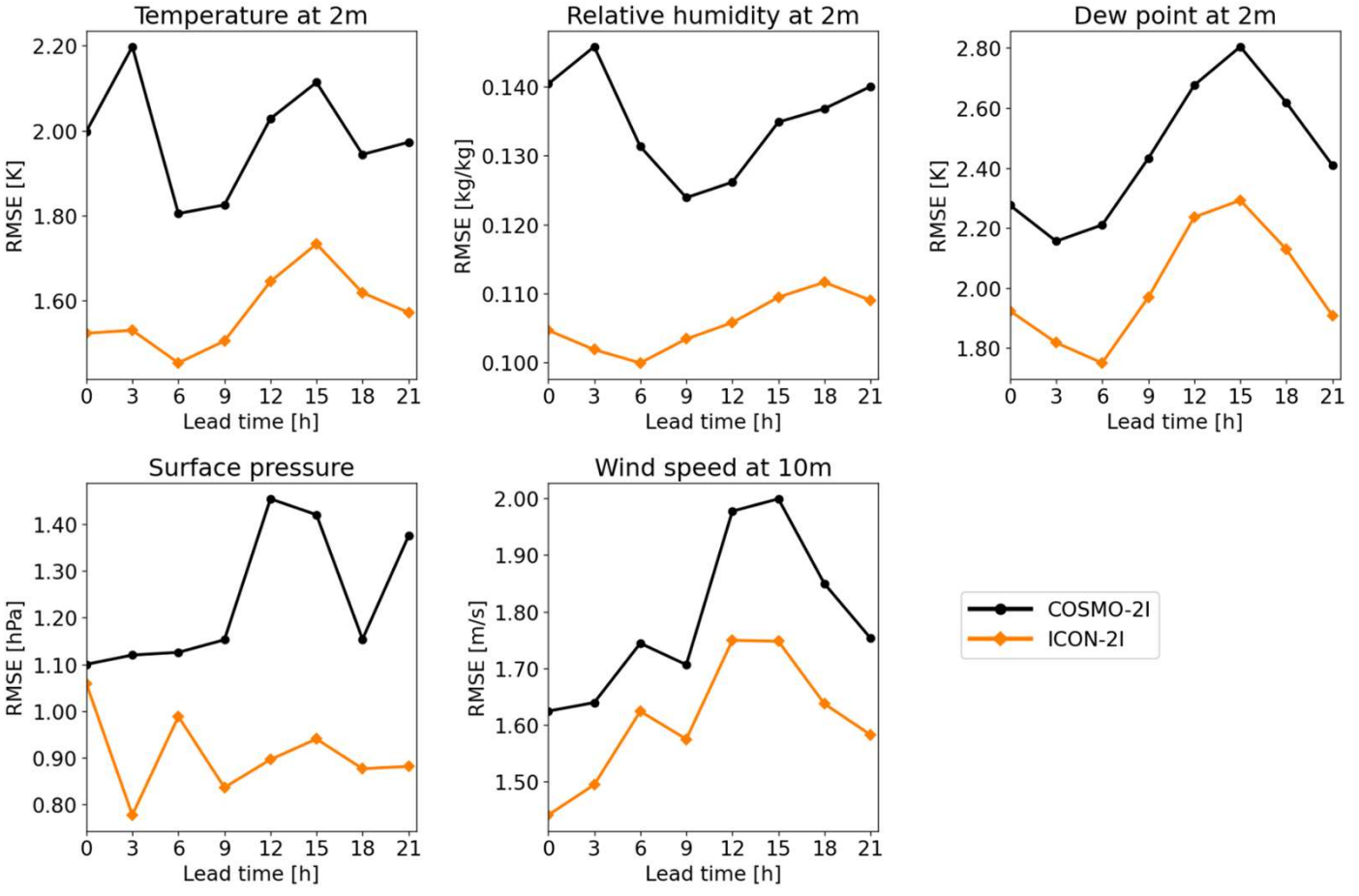
Average number of obs.: 2939 (ranging from 381 to 11553)
Average bias: -0.085 m/s (ranging from -0.660 m/s to 0.717 m/s)

ICON-2I

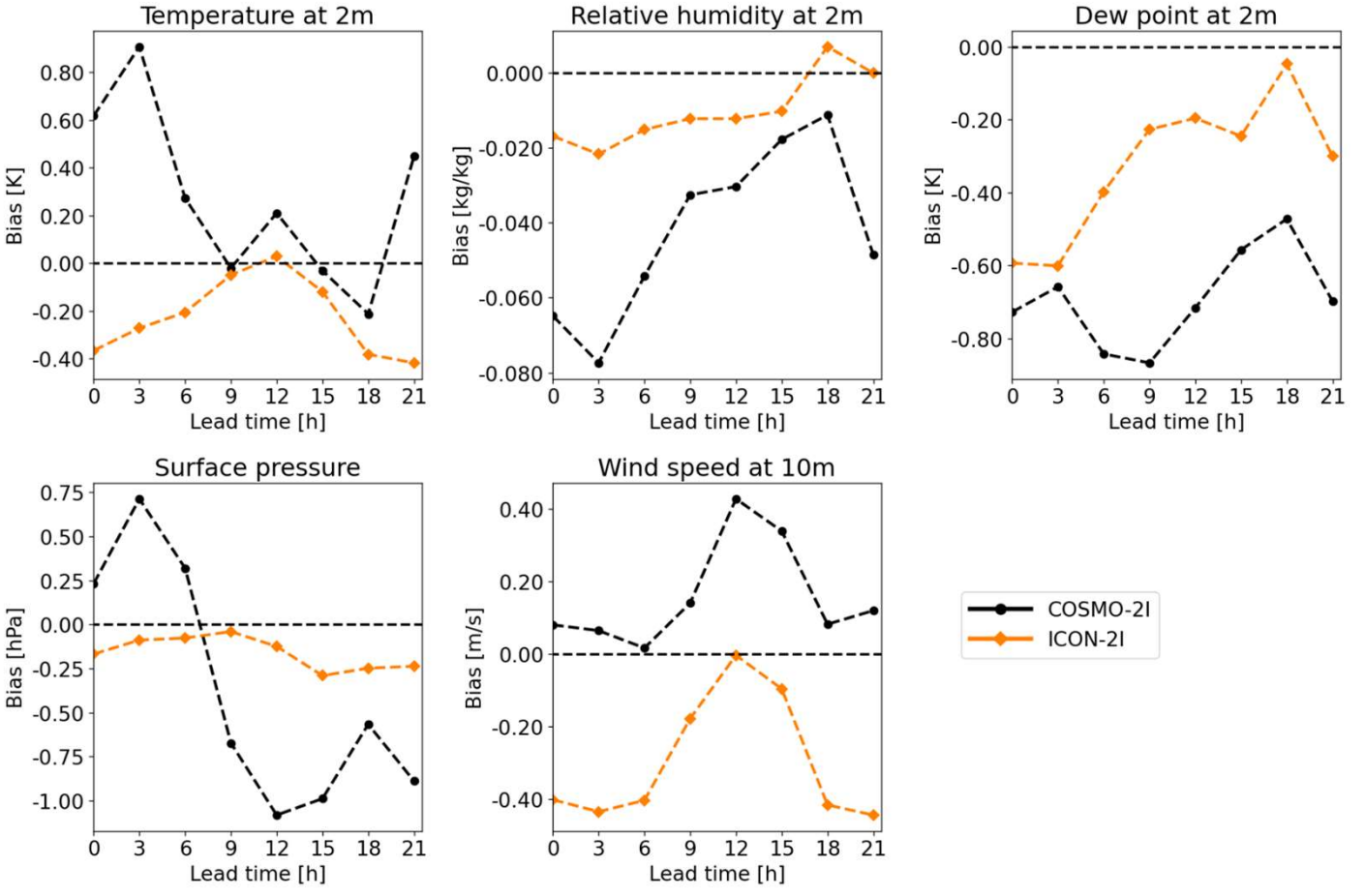


Average number of obs.: 2939 (ranging from 381 to 11553)
Average bias: -0.187 m/s (ranging from -0.615 m/s to 0.270 m/s)

Near-surface variables: RMSE



Near-surface variables: bias



Assimilation of radar volumes

Experiments:

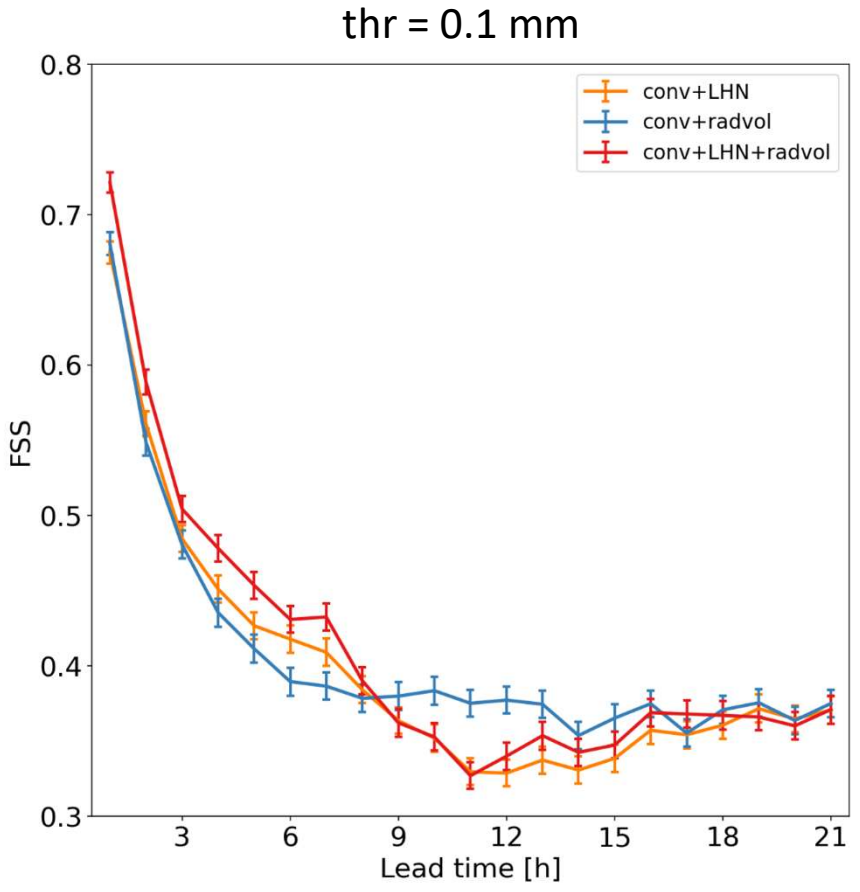
- ***conv+LHN***: current pre-operational set-up
- ***conv+LHN+radvol***: as *conv+LHN* but assimilating also radar volumes of riflectivity and radial winds. For radar volumes, same set-up of COSMO-2I
  - For each radar: superobbing at 10 km and only the volume closest to analysis time is assimilated.
  - For reflectivities: observation error of 10 dBZ for all data and a 5 dBZ threshold on reflectivities;
  - For radial winds: observation error decreasing from 25 m/s for reflectivities lower than 0 dBZ to 2.5 m/s for reflectivities greater than 10 dBZ
  - Control vector: `pf t q u v qcl qci qr qs qg`
- ***conv+radvol***: as *conv+LHN+radvol* but without LHN.

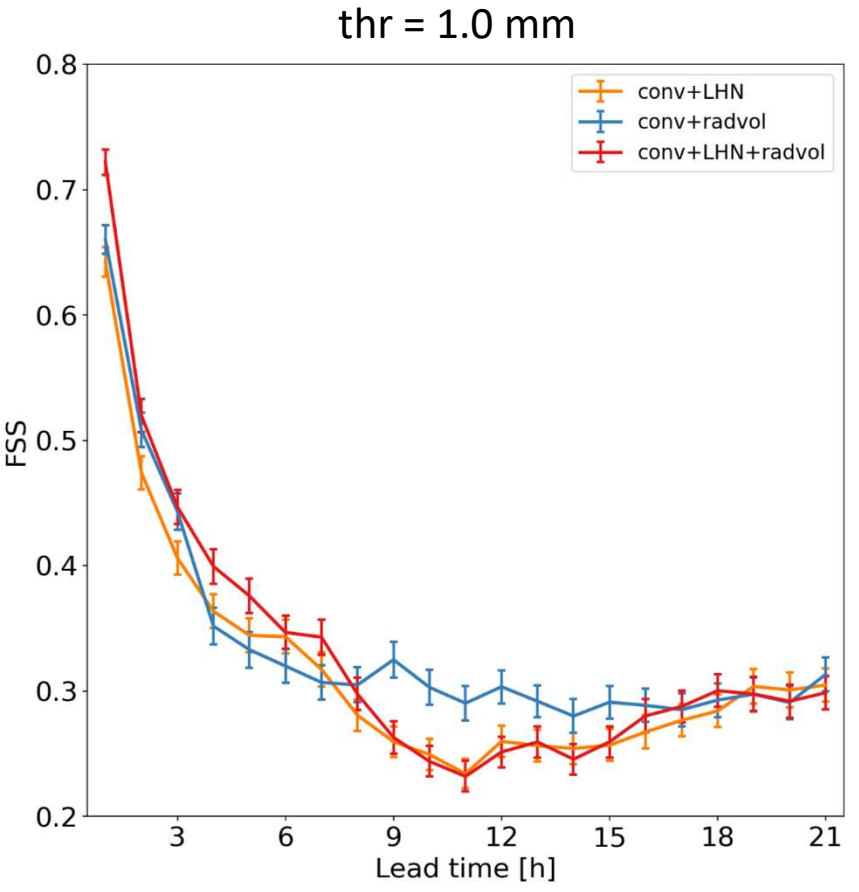
Evaluation period:

- ***aug2022***: from 01/08 to 22/08;
- ***may2023***: from 29/04 to 18/05.

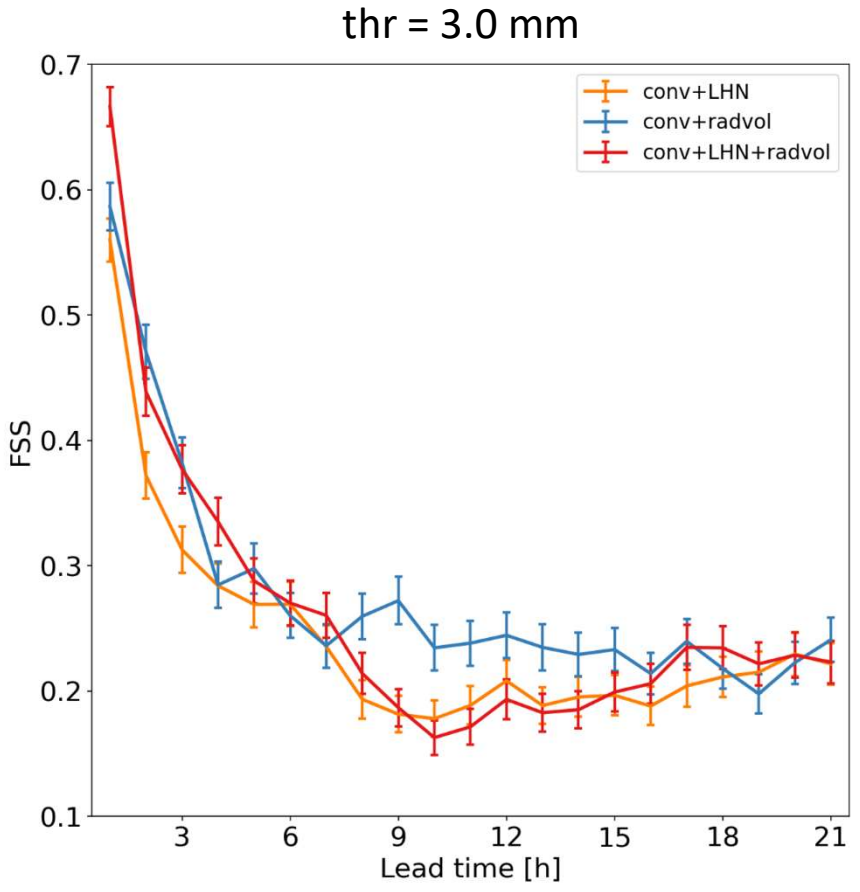
A 21h deterministic forecast is initialized from analysis and first guess of the deterministic member every 3h (in total 160 forecasts for *aug2022* and 153 for *may2023*).

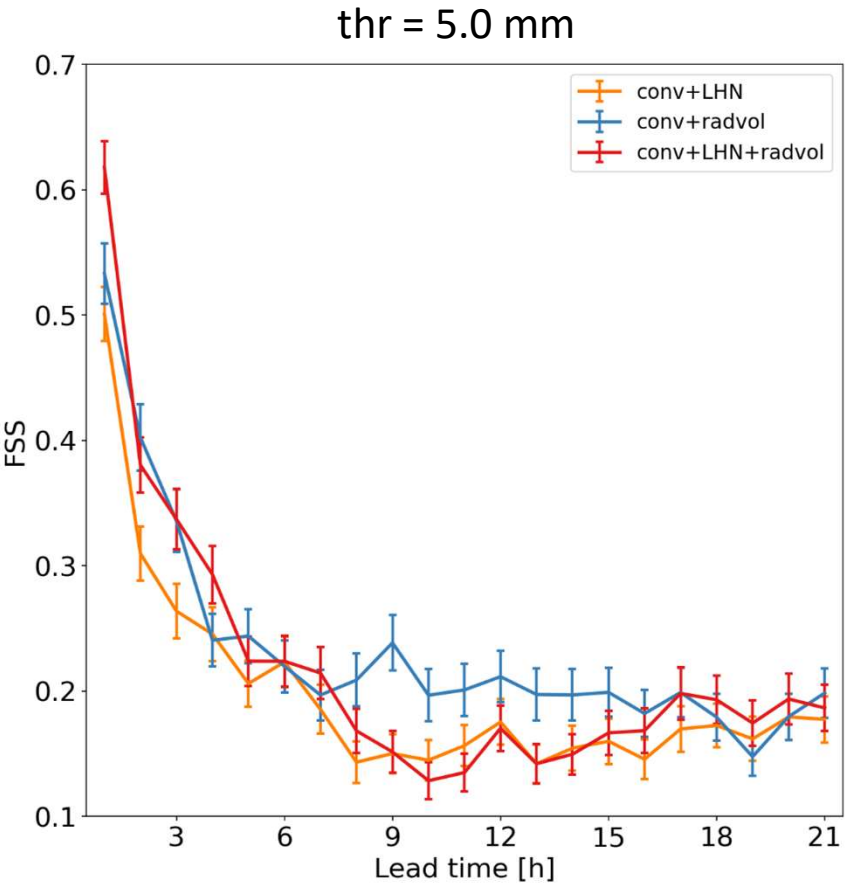
Forecast precipitation (FSS): aug2022



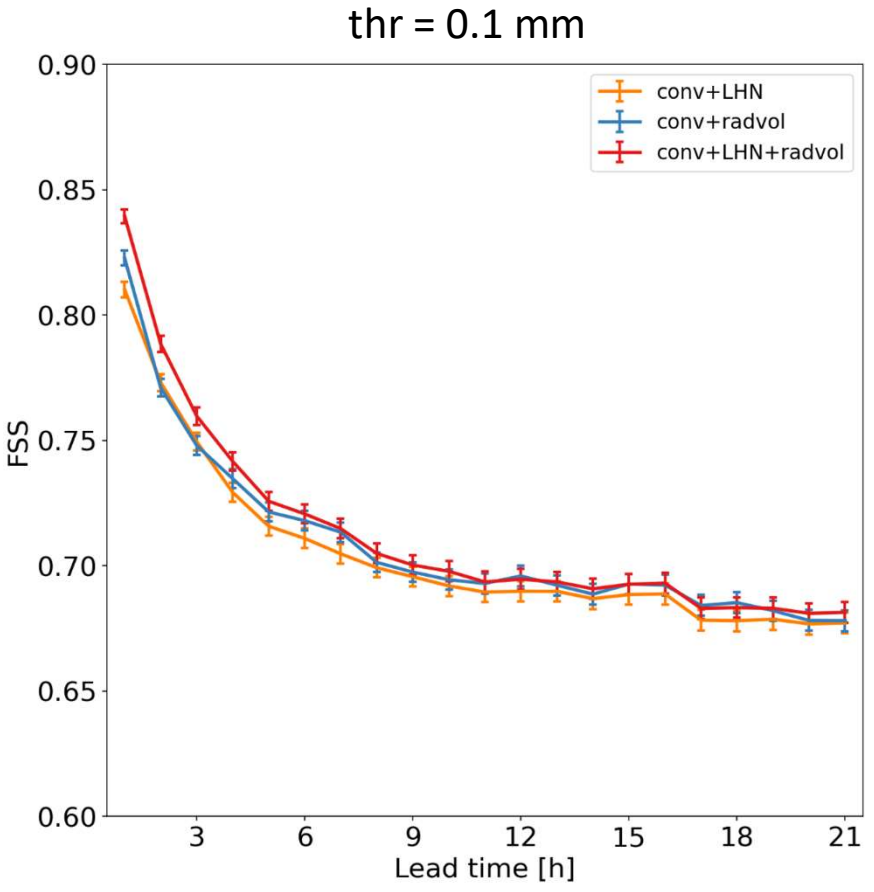


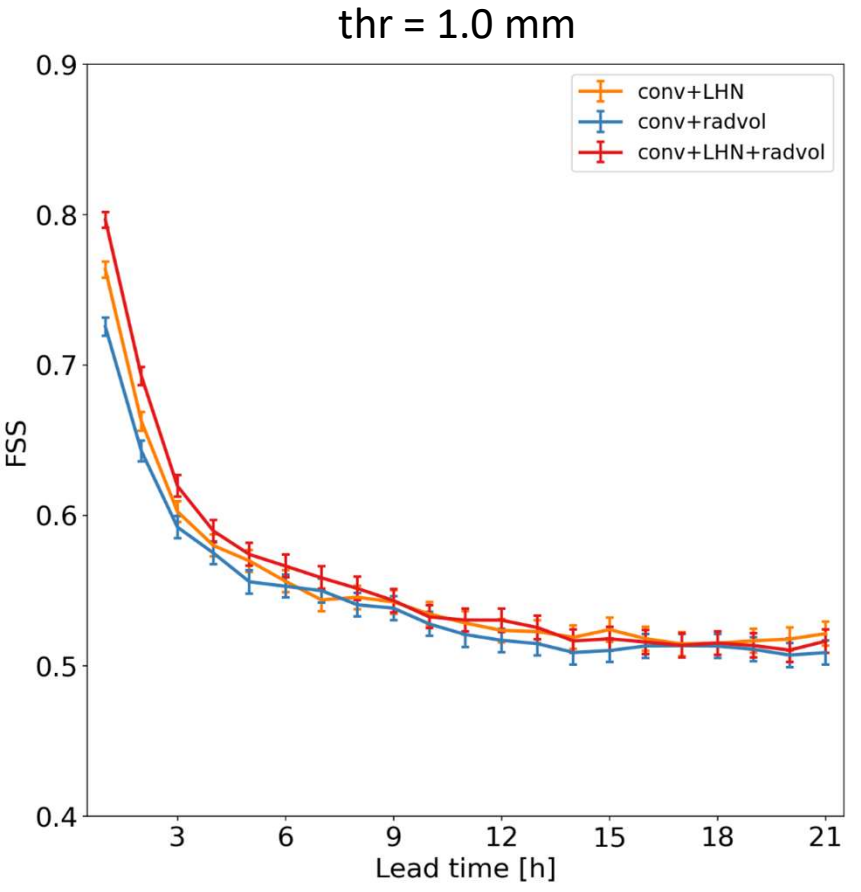
Forecast precipitation (FSS): aug2022





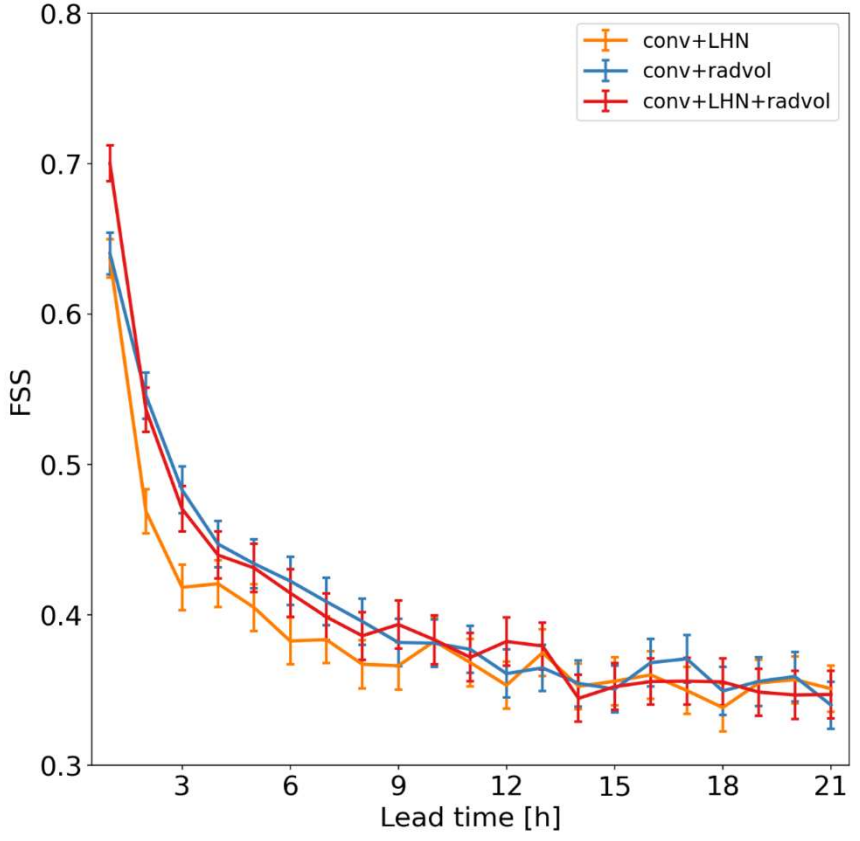
Forecast precipitation (FSS): may2023



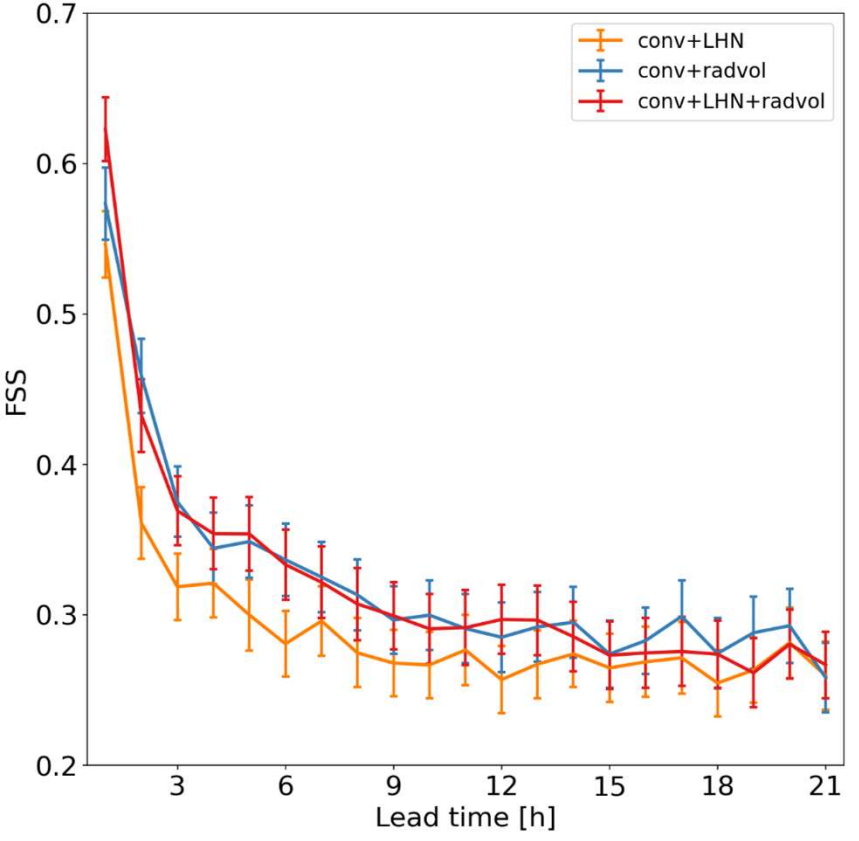


Forecast precipitation (FSS): may2023

thr = 3.0 mm

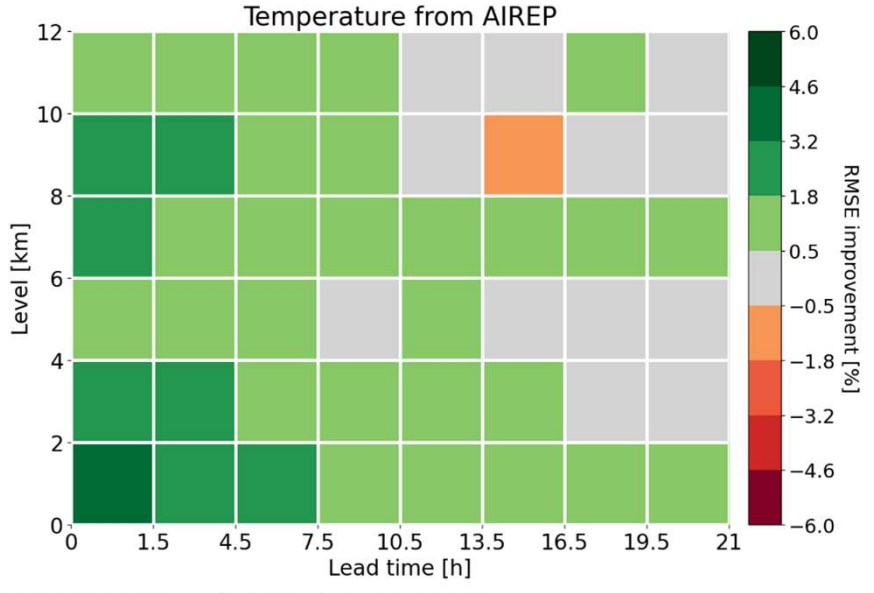


thr = 5.0 mm



Upper-air temperature: RMSE

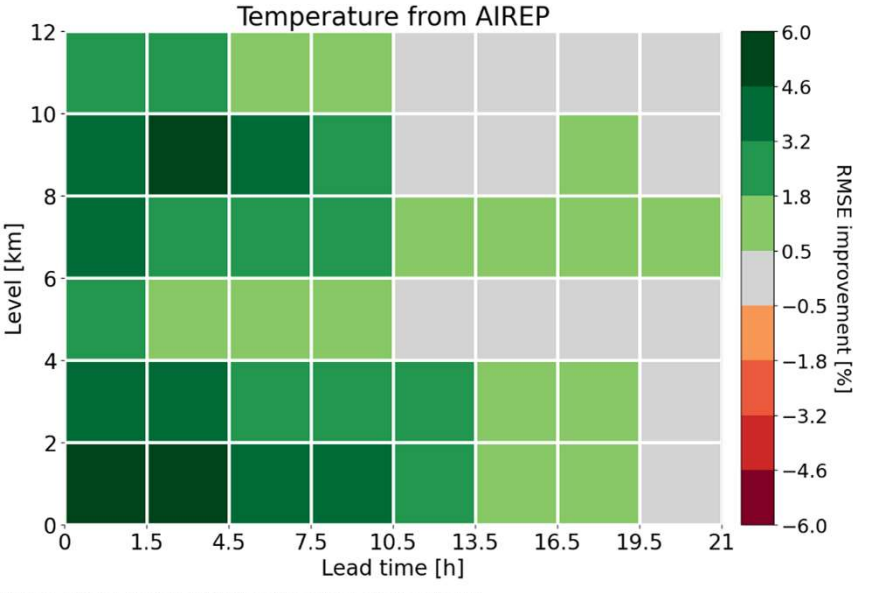
RMSE(*conv+LHN*) - RMSE(*conv+LHN+radvol*)



Average number of obs.: 76503 (ranging from 21322 to 216555)
Average RMSE for conv+LHN: 0.842 K (ranging from 0.662 K to 1.161 K)
Average RMSE for conv+LHN+radvol: 0.834 K (ranging from 0.645 K to 1.156 K)

Positive values (green): *conv+LHN+radvol* better than *conv+LHN*

RMSE(*conv+LHN*) - RMSE(*conv+radvol*)

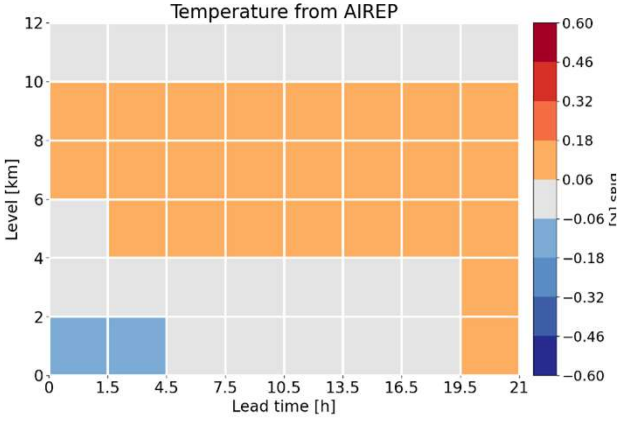


Average number of obs.: 76503 (ranging from 21322 to 216555)
Average RMSE for conv+LHN: 0.842 K (ranging from 0.662 K to 1.161 K)
Average RMSE for conv+radvol: 0.827 K (ranging from 0.637 K to 1.156 K)

Positive values (green): *conv+radvol* better than *conv+LHN*

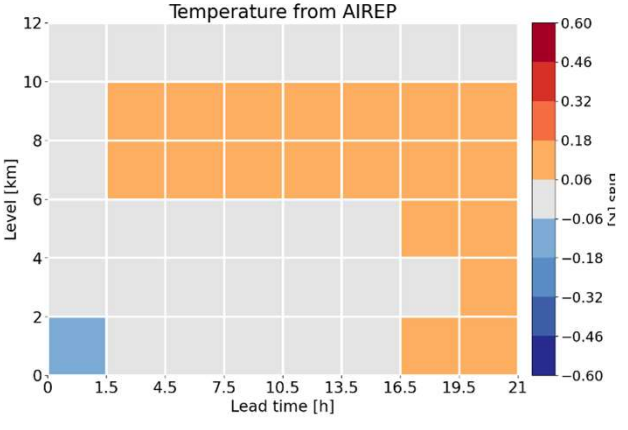
Upper-air temperature: bias

conv+LHN



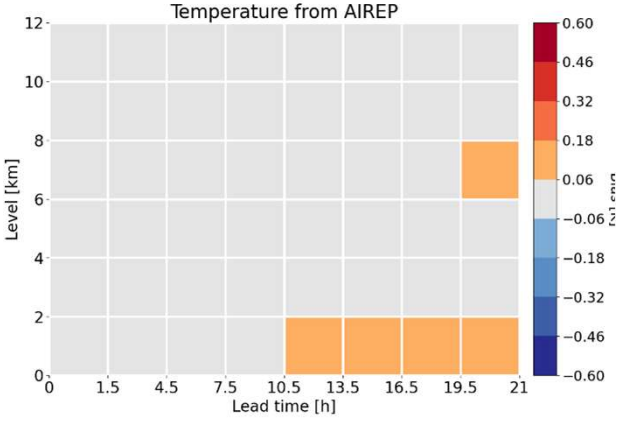
verage number of obs.: 76503 (ranging from 21322 to 216555)
verage bias: 0.042 K (ranging from -0.111 K to 0.097 K)

conv+LHN+radvol



verage number of obs.: 76277 (ranging from 21229 to 216023)
verage bias: 0.038 K (ranging from -0.069 K to 0.103 K)

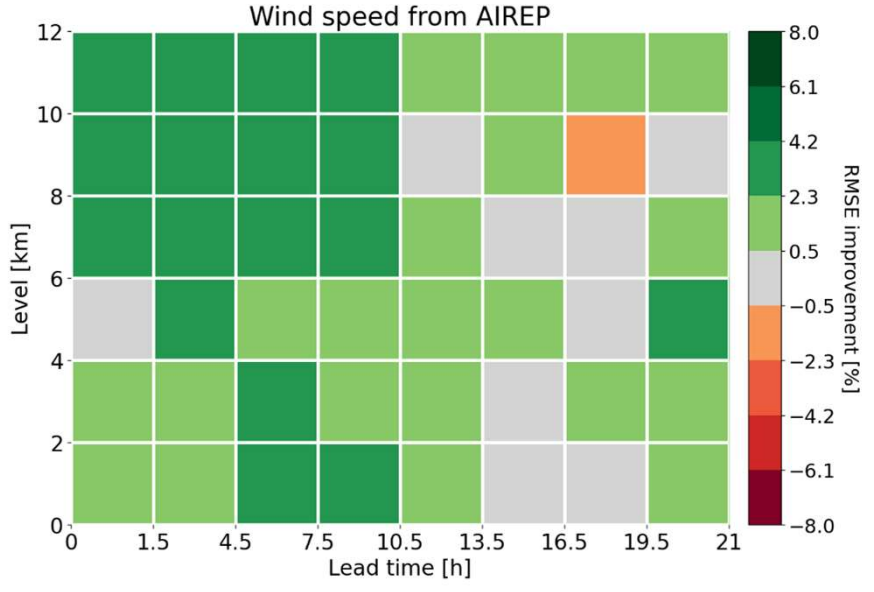
conv+radvol



verage number of obs.: 76504 (ranging from 21322 to 216555)
verage bias: 0.030 K (ranging from -0.047 K to 0.145 K)

Upper-air wind speed: RMSE

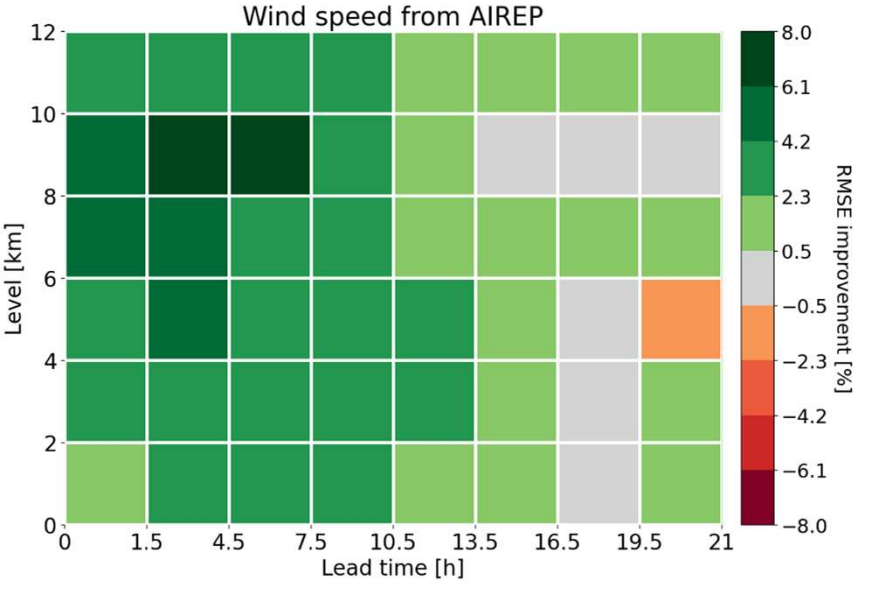
RMSE(*conv+LHN*) - RMSE(*conv+LHN+radvol*)



Average number of obs.: 33320 (ranging from 11445 to 91239)
Average RMSE for conv+LHN: 2.569 m/s (ranging from 2.137 m/s to 3.421 m/s)
Average RMSE for conv+LHN+radvol: 2.531 m/s (ranging from 2.136 m/s to 3.408 m/s)

Positive values (green): *conv+LHN+radvol* better than *conv+LHN*

RMSE(*conv+LHN*) - RMSE(*conv+radvol*)

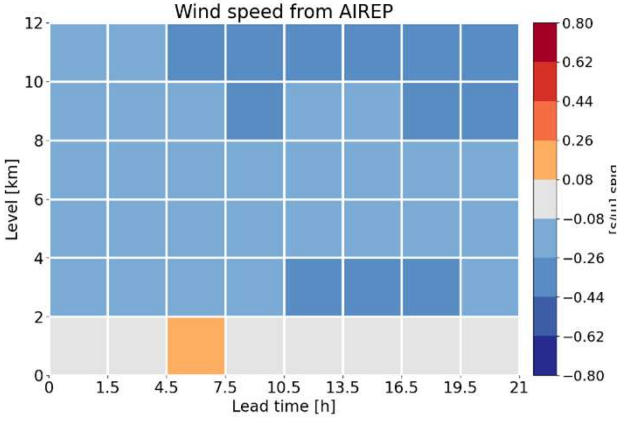


Average number of obs.: 33320 (ranging from 11445 to 91239)
Average RMSE for conv+LHN: 2.569 m/s (ranging from 2.137 m/s to 3.421 m/s)
Average RMSE for conv+radvol: 2.508 m/s (ranging from 2.061 m/s to 3.408 m/s)

Positive values (green): *conv+radvol* better than *conv+LHN*

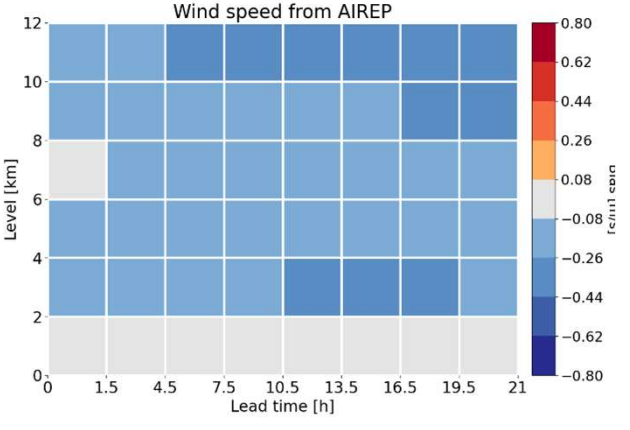
Upper-air wind speed: bias

conv+LHN



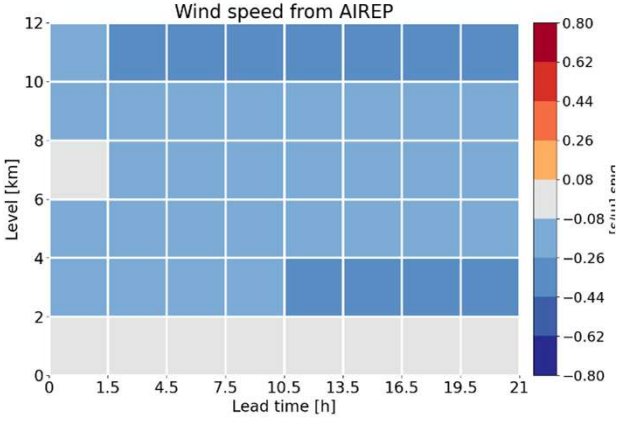
verage number of obs.: 33320 (ranging from 11445 to 91239)
verage bias: -0.177 m/s (ranging from -0.358 m/s to 0.090 m/s)

conv+LHN+radvol



verage number of obs.: 33224 (ranging from 11398 to 91056)
verage bias: -0.179 m/s (ranging from -0.337 m/s to 0.055 m/s)

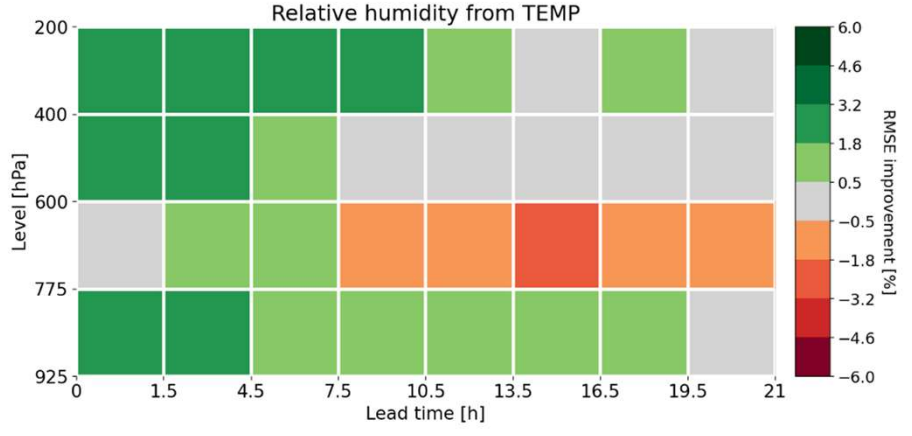
conv+radvol



verage number of obs.: 33320 (ranging from 11445 to 91239)
verage bias: -0.174 m/s (ranging from -0.325 m/s to 0.023 m/s)

Upper-air relative humidity: RMSE

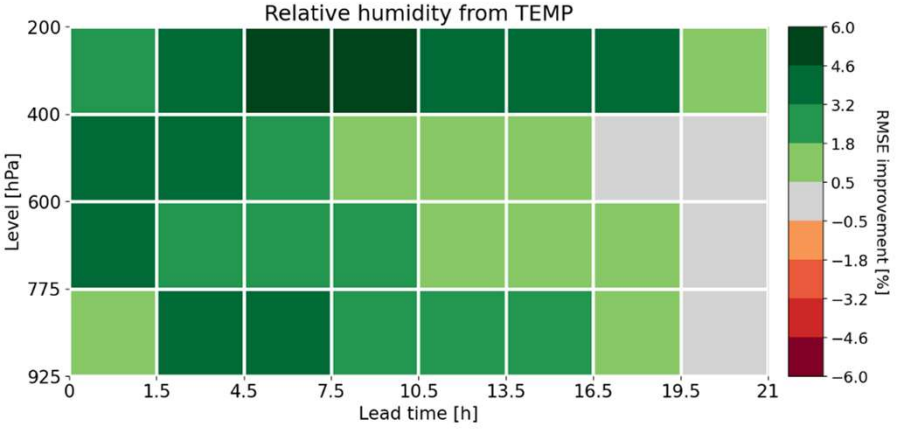
RMSE(*conv+LHN*) - RMSE(*conv+LHN+radvol*)



Average number of obs.: 21597 (ranging from 2583 to 27363)
Average RMSE for conv+LHN: 0.143 kg/kg (ranging from 0.097 kg/kg to 0.181 kg/kg)
Average RMSE for conv+LHN+radvol: 0.142 kg/kg (ranging from 0.095 kg/kg to 0.182 kg/kg)

Positive values (green): *conv+LHN+radvol* better than *conv+LHN*

RMSE(*conv+LHN*) - RMSE(*conv+radvol*)

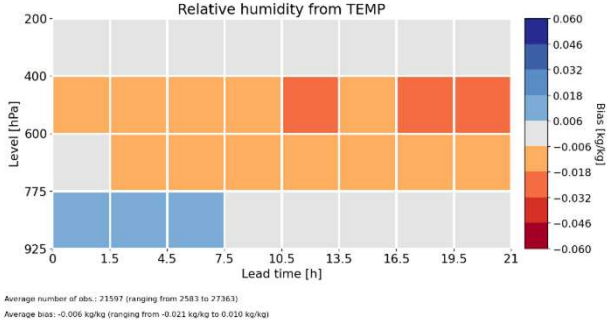


Average number of obs.: 21597 (ranging from 2583 to 27363)
Average RMSE for conv+LHN: 0.143 kg/kg (ranging from 0.097 kg/kg to 0.181 kg/kg)
Average RMSE for conv+radvol: 0.140 kg/kg (ranging from 0.096 kg/kg to 0.182 kg/kg)

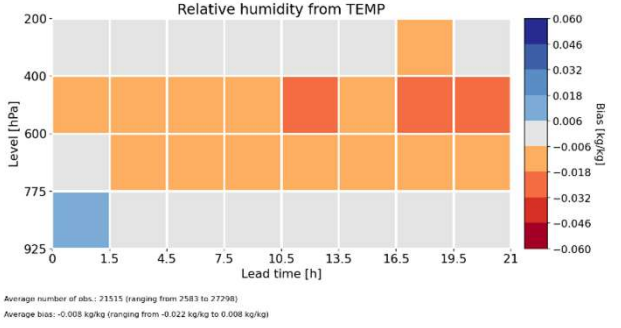
Positive values (green): *conv+radvol* better than *conv+LHN*

Upper-air wind speed: bias

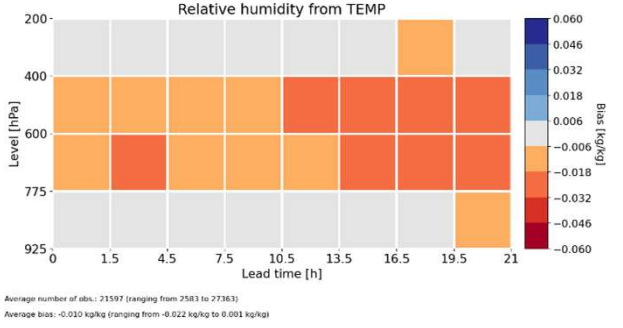
conv+LHN



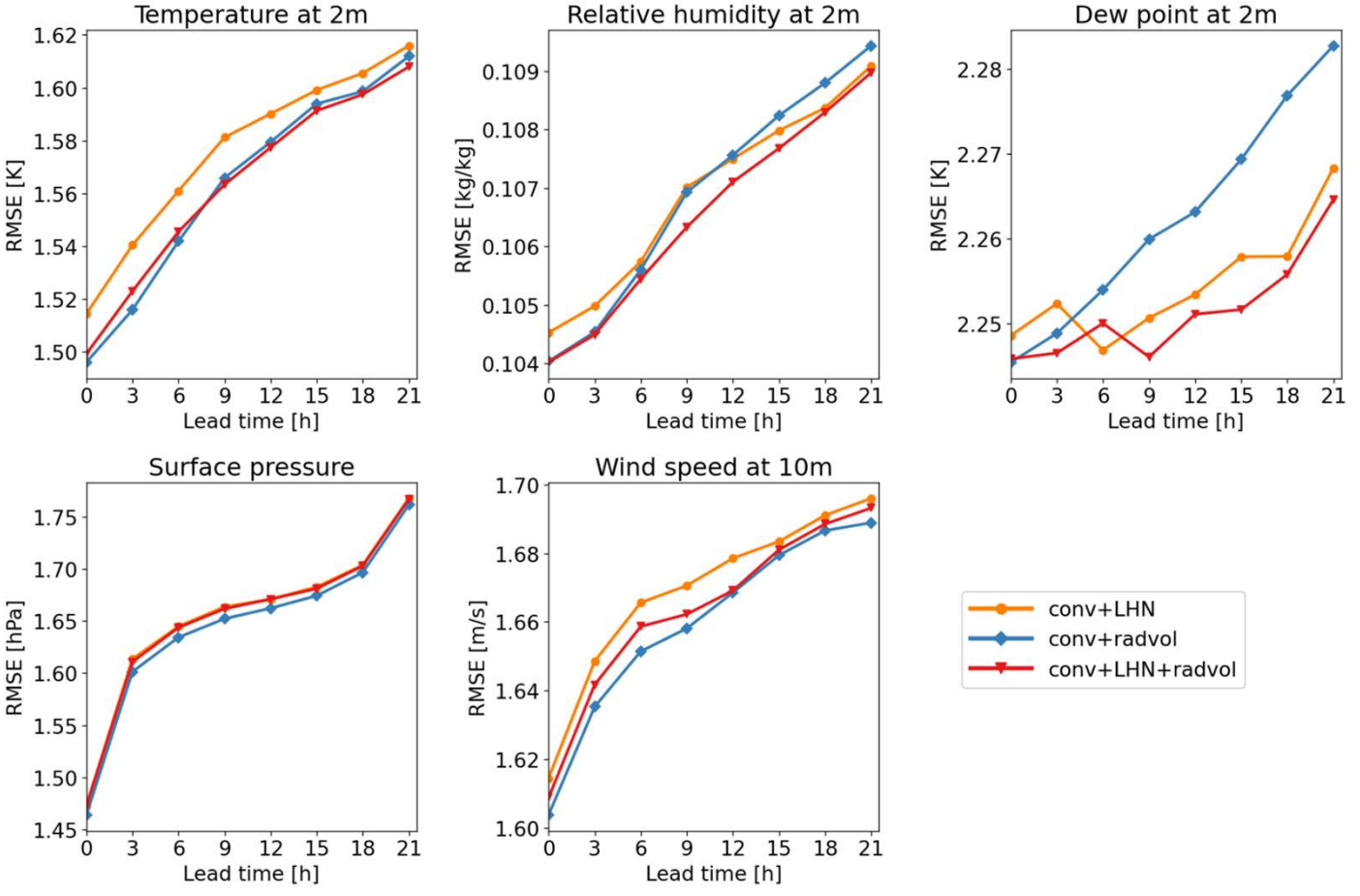
conv+LHN+radvol



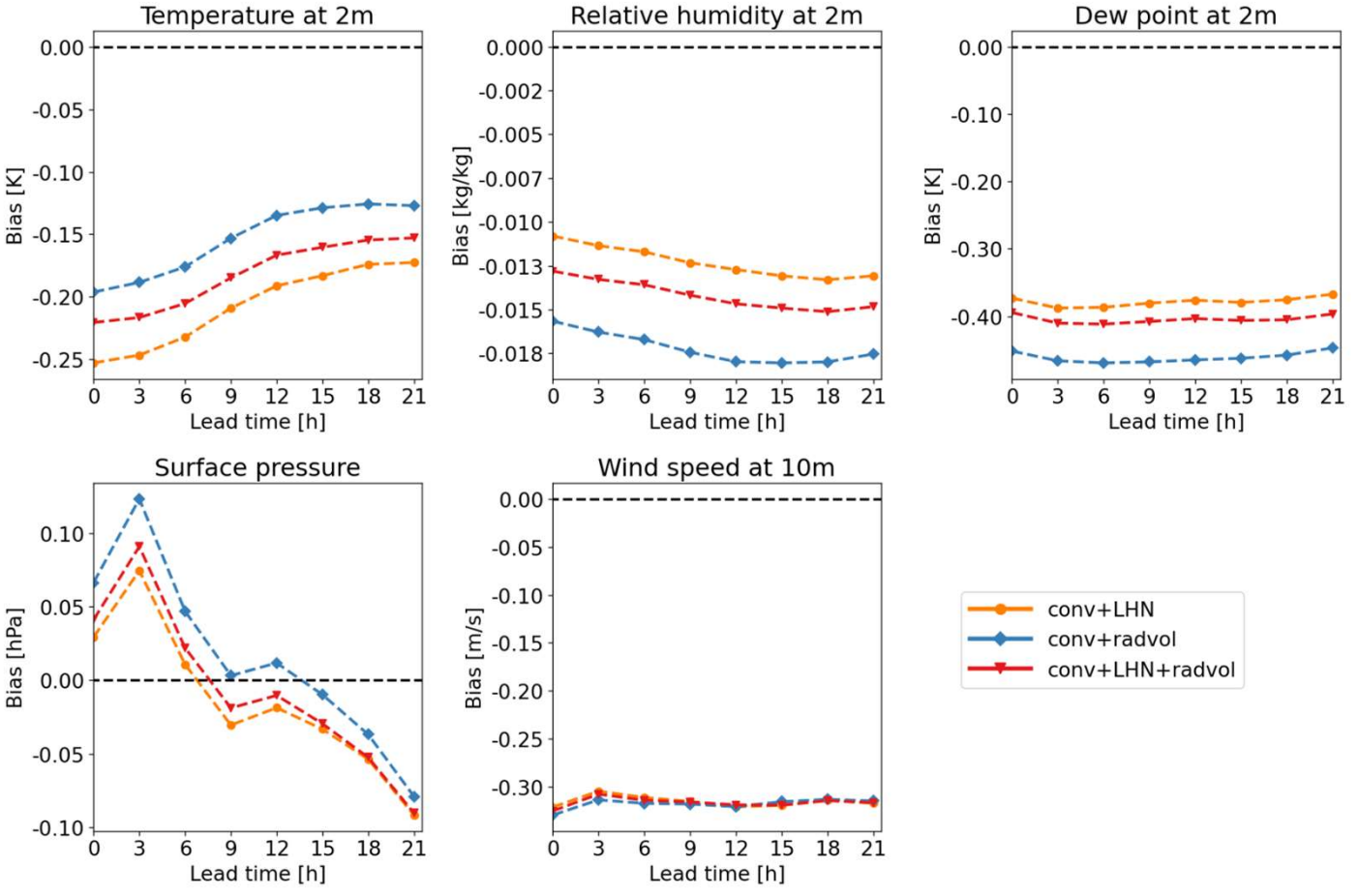
conv+radvol



Near-surface variables: RMSE



Near-surface variables: bias



Conclusions

ICON-2I is pre-operational since November 2023. Its scores are much better than those of COSMO-2I for upper-air and near-surface variables, similar or slightly better in terms of precipitation.

Assimilation of radar volumes:

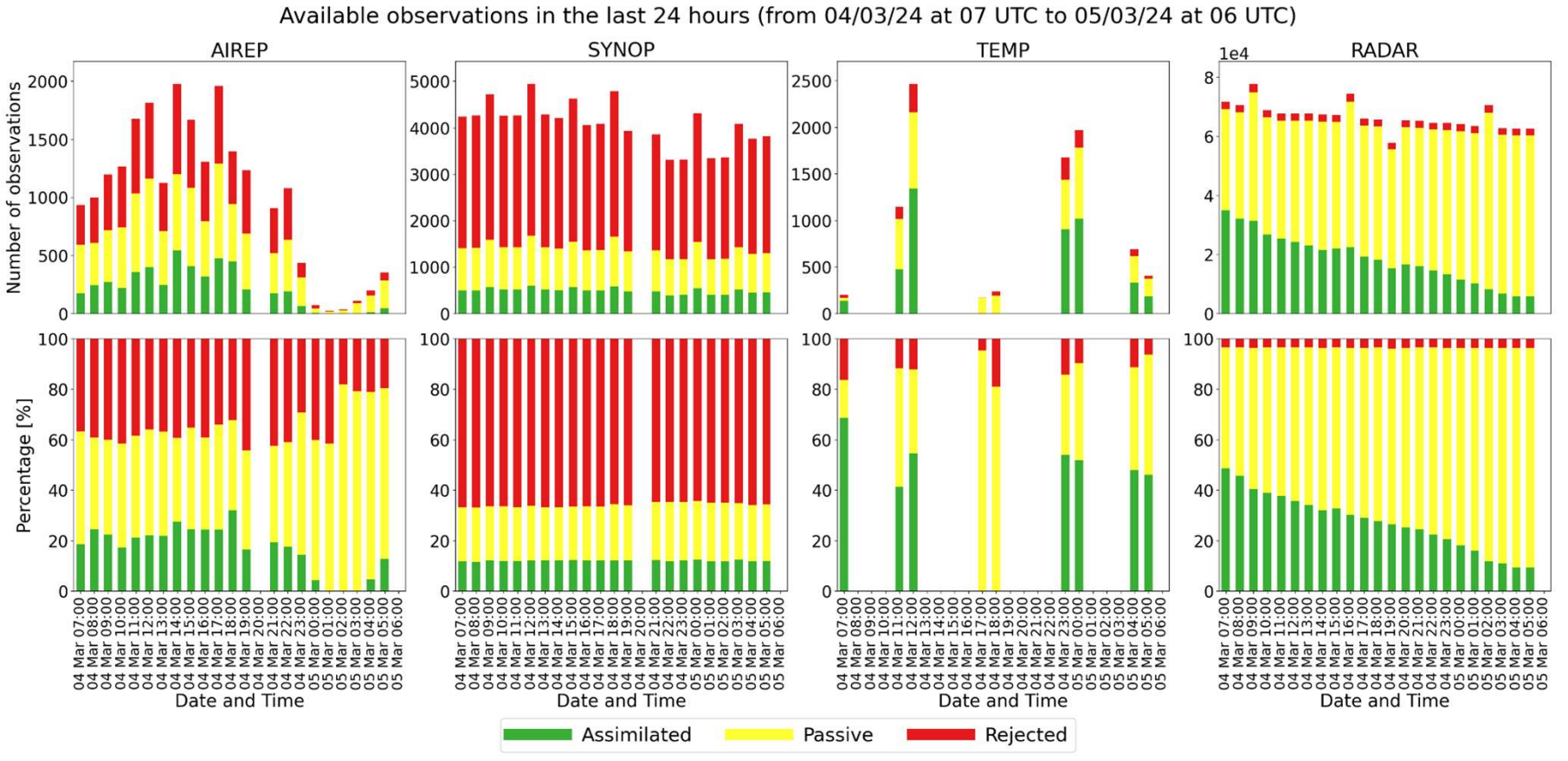
- Overall, it improves forecast accuracy.
- Best results in terms of precipitation are obtained for *conv+LHN+radvol* while *conv+radvol* has the best scores for upper-air variables

The configuration *conv+LHN+radvol* will be operational in April.

Provocative question: is the LHN still so necessary? Or, are we exploiting all the potential of LHN?

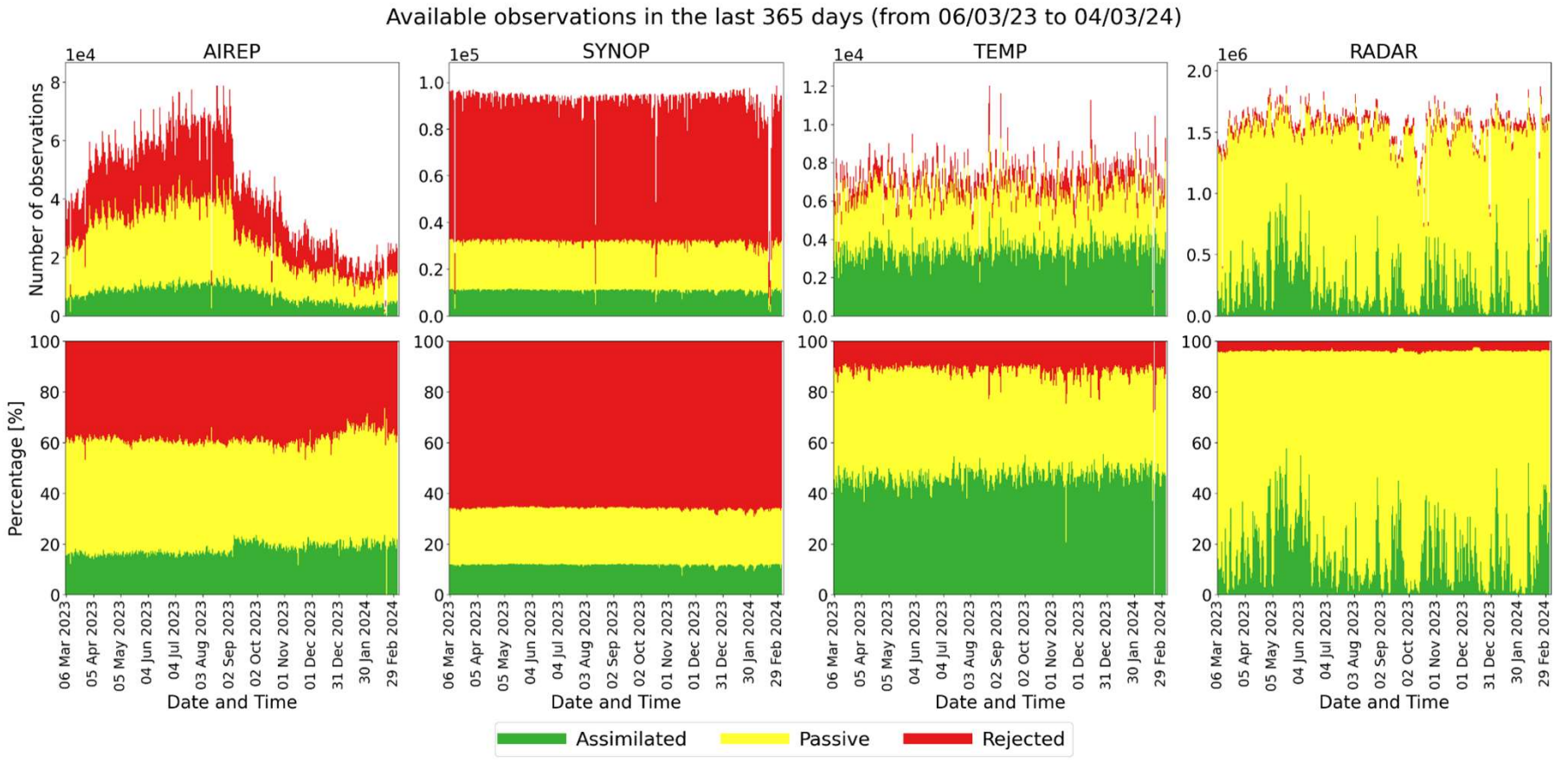
Thank you for your attention!

Monitoring of operational KENDA system

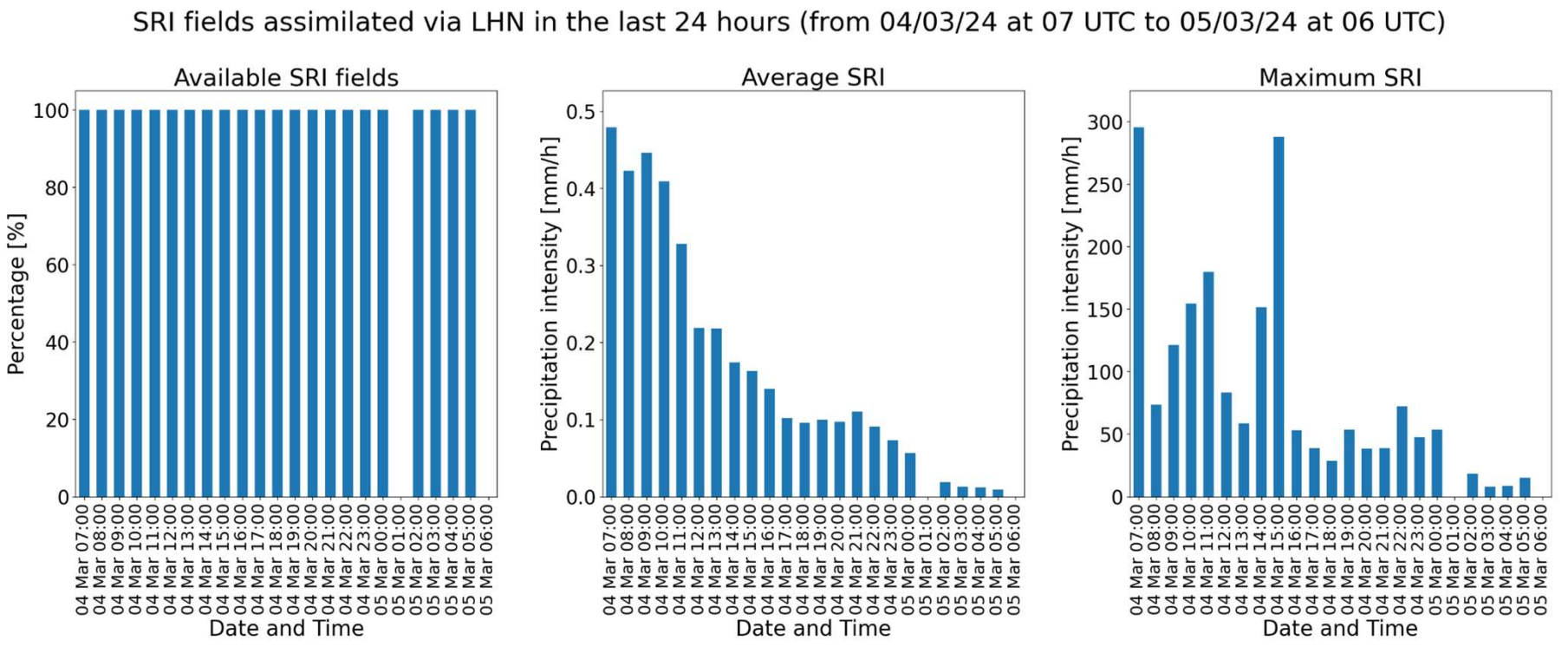


Monitoring of operational KENDA system

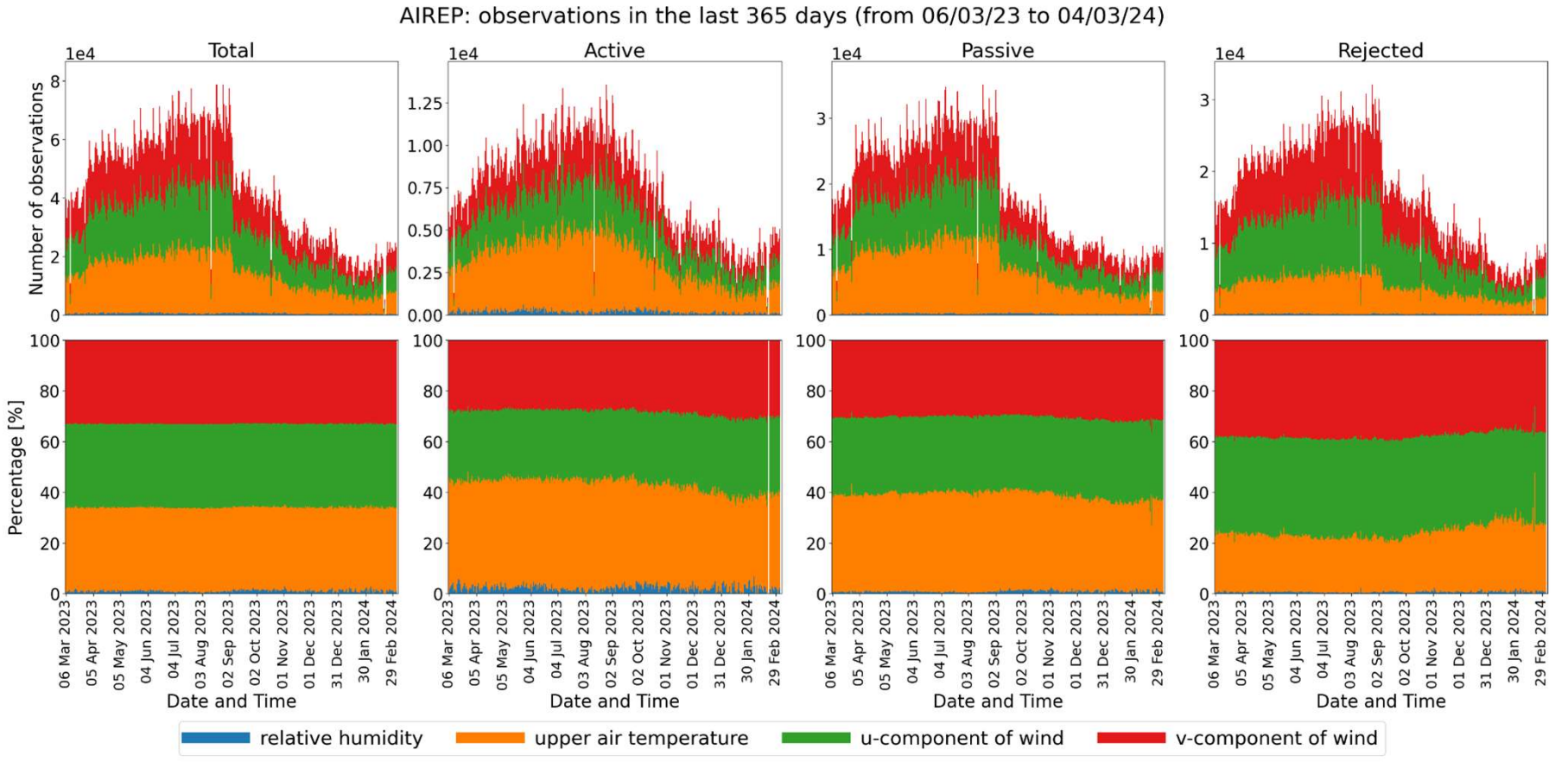
Monitoring of operational KENDA system



Monitoring of operational KENDA system



Monitoring of operational KENDA system



Monitoring of operational KENDA system