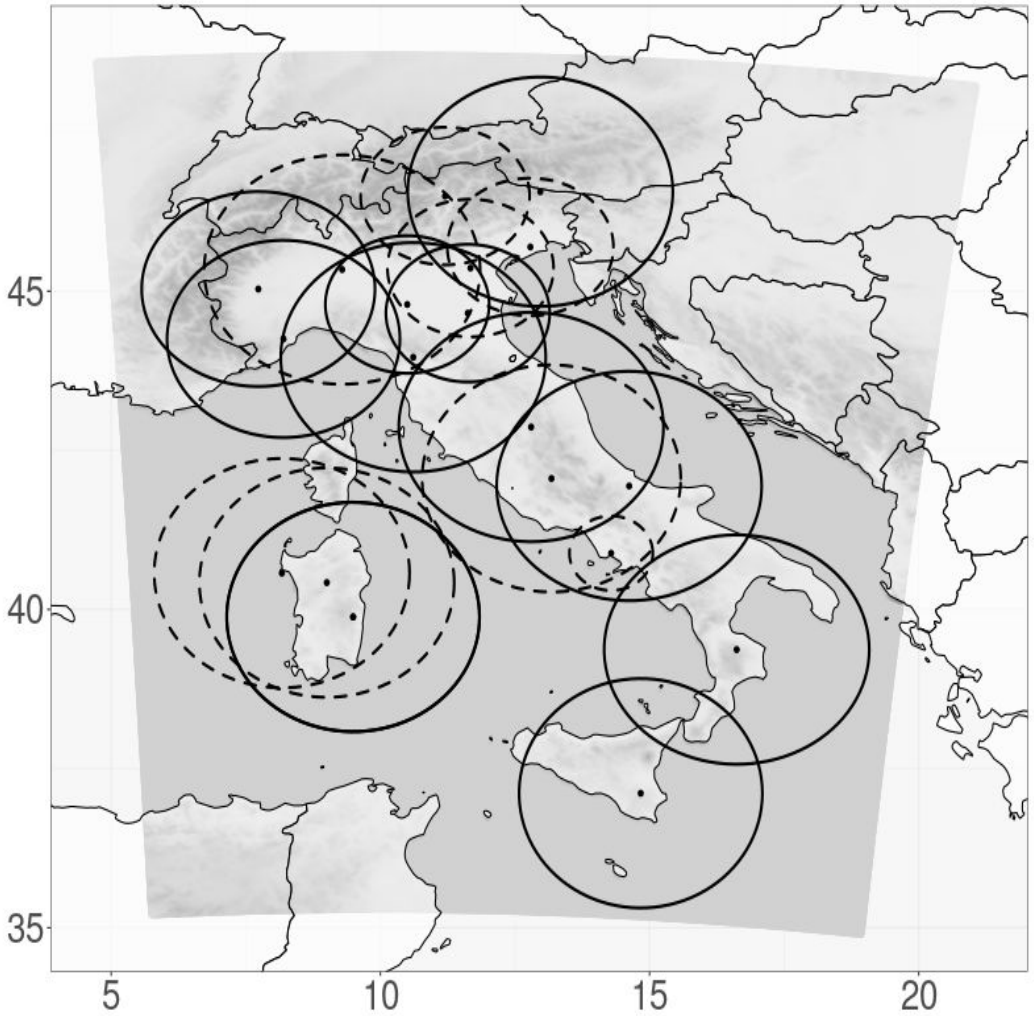
Status of the assimilation of reflectivity and radial wind observations at Arpae

Gastaldo T., Poli V., Cesari D., Marsigli C., Alberoni P.P.

Operational set-up to generate COSMO-2I analyses (*radvol_lhn*)

- COSMO 5.05 at 2.2 km hor. res.
- 36 members + deterministic run
- 1h assimilation cycles
- assimilation of AIREP, TEMP, SYNOP (wind and surface pressure) and radar reflectivity volumes (solid circles) through KENDA. Regarding radar data:
  - observation error of 10 dBZ for all data;
  - superobbing at 10 km;
  - 5 dBZ threshold on reflectivities;
  - for each radar, only the reflectivity volume closest to analysis time is assimilated.
- LHN based on all radars in the figure (both solid and dashed circles)



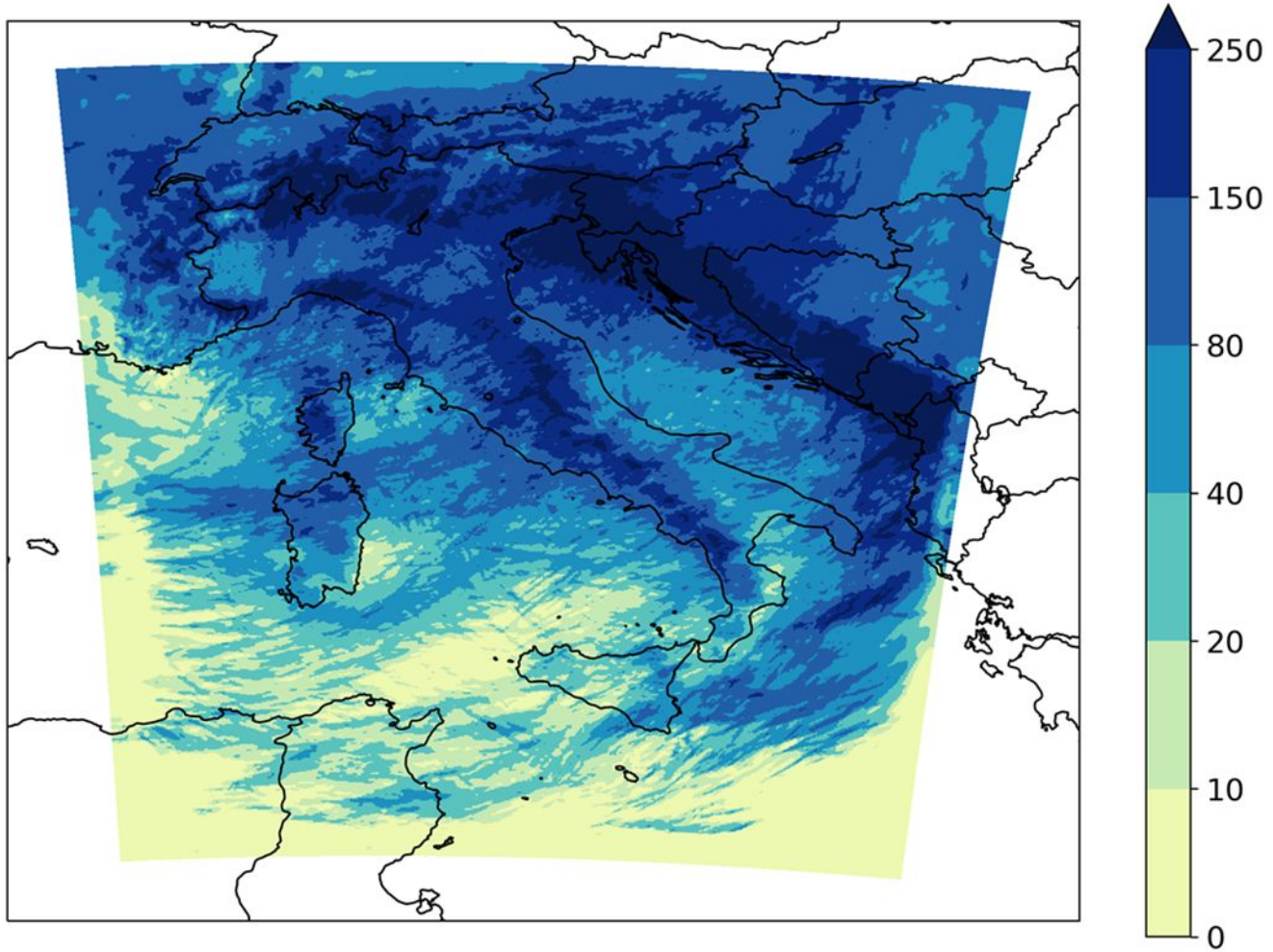
Experiments performed

- Tests to improve the assimilation of reflectivity volumes:
  - assimilation of more radars
  - removal of the lowest elevation (the most error-prone)
  - use of a “reduced” control vector (without *qr, qs, qg*)
- Assimilation of radial winds

Evaluation period

From 18/09/2020 to 19/10/2020. A 12h **deterministic** forecast is initialized every 3h from the deterministic analyses of each suite (total forecasts: 236)

Model estimated precipitation over the evaluation period

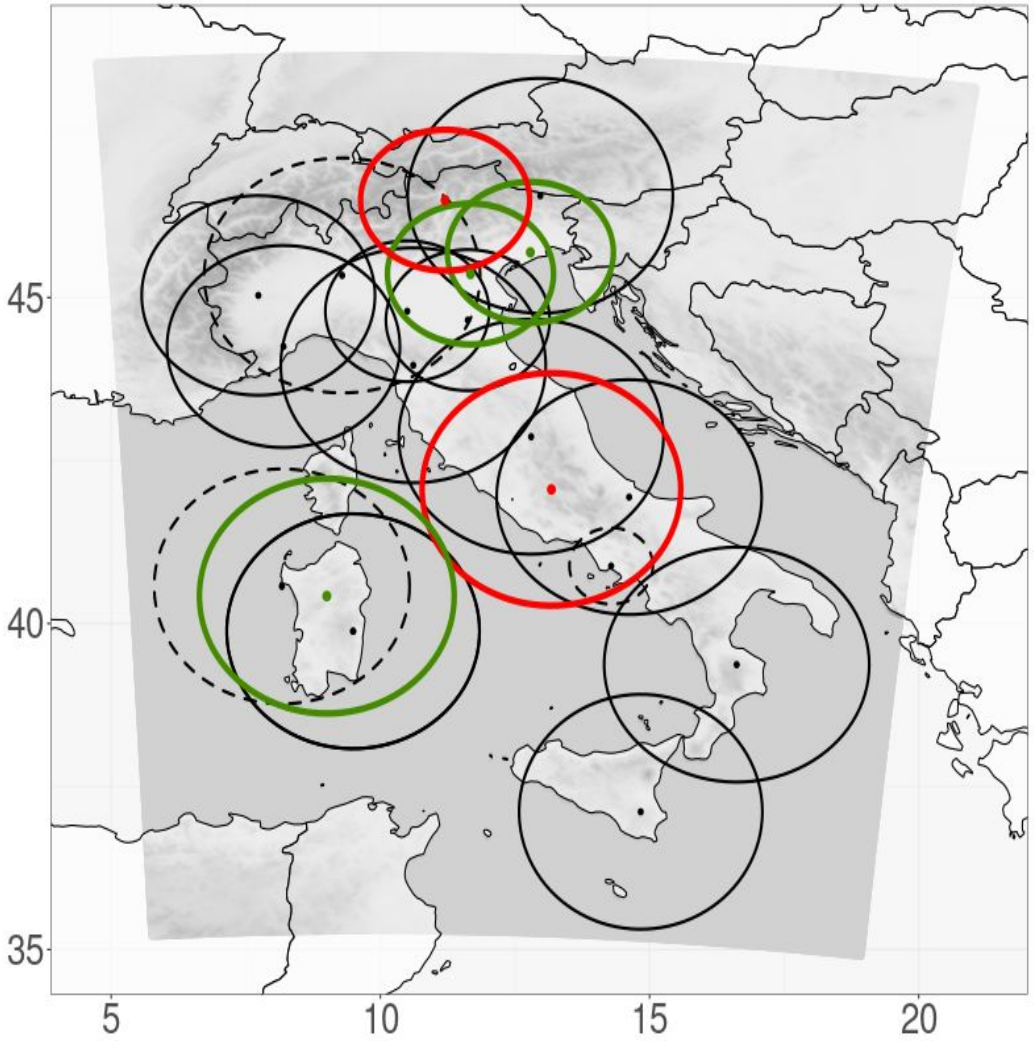


Assimilation of more radars and removal of the lowest elevation

Several experiments performed:

- Use of all new radars (green + red) or only the best quality ones (green)
- Discarding the lowest elevation for all radars.
- Tests with and without LHN

Conclusion: no impact on the accuracy of precipitation, near-surface and upper-air variables



Reduced CV: experimental set-up

Experiments:

- ***radvol***: same as our operational set-up but without LHN. The operational CV is:
  pp t q u v w qcl qci **qr qs qg**
- ***radvol_cvred***: same as *radvol* but using the "reduced" CV:
  pp t q u v w qcl qci

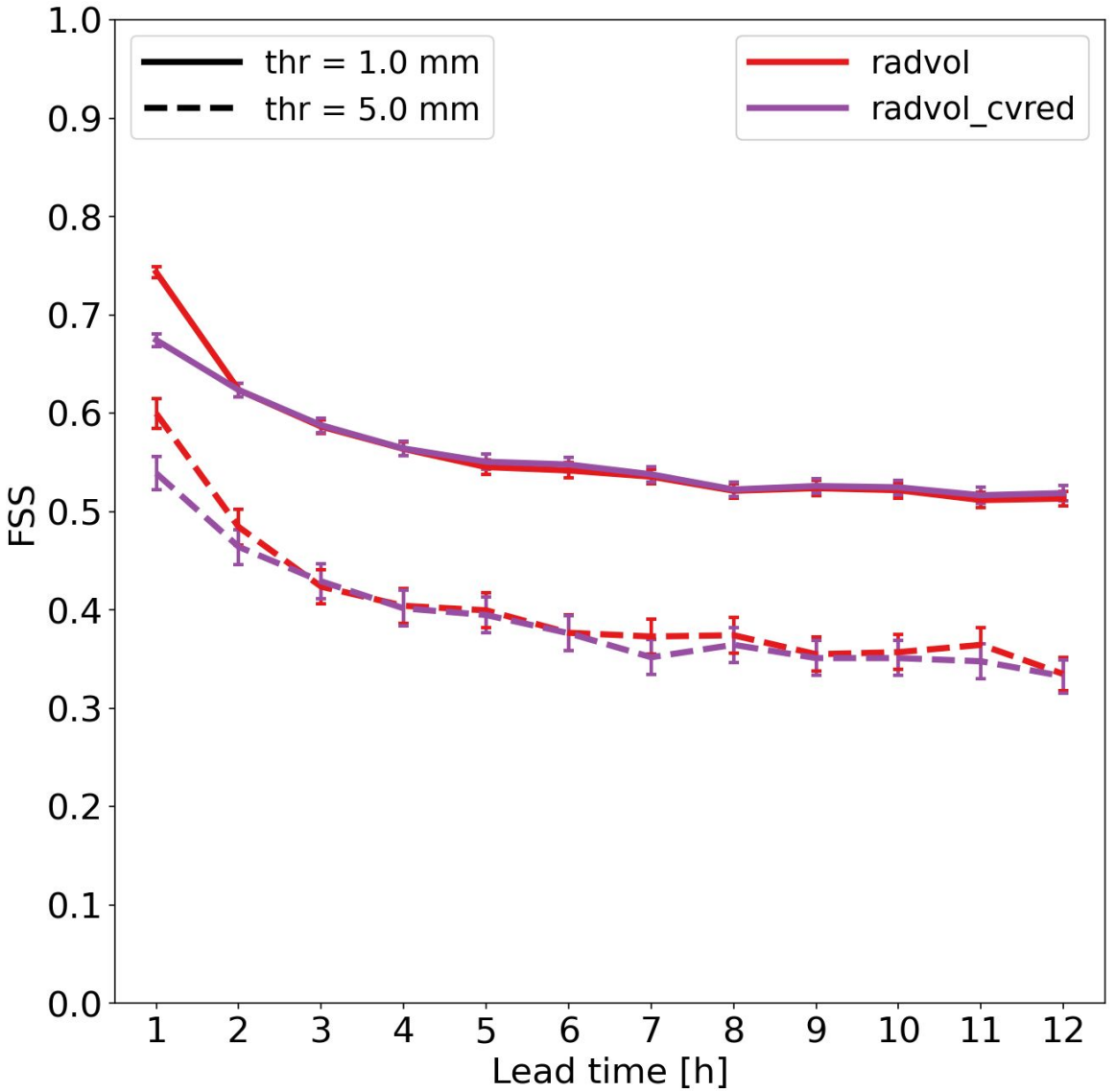
Reduced CV: forecast precipitation (FSS)

Experiments:

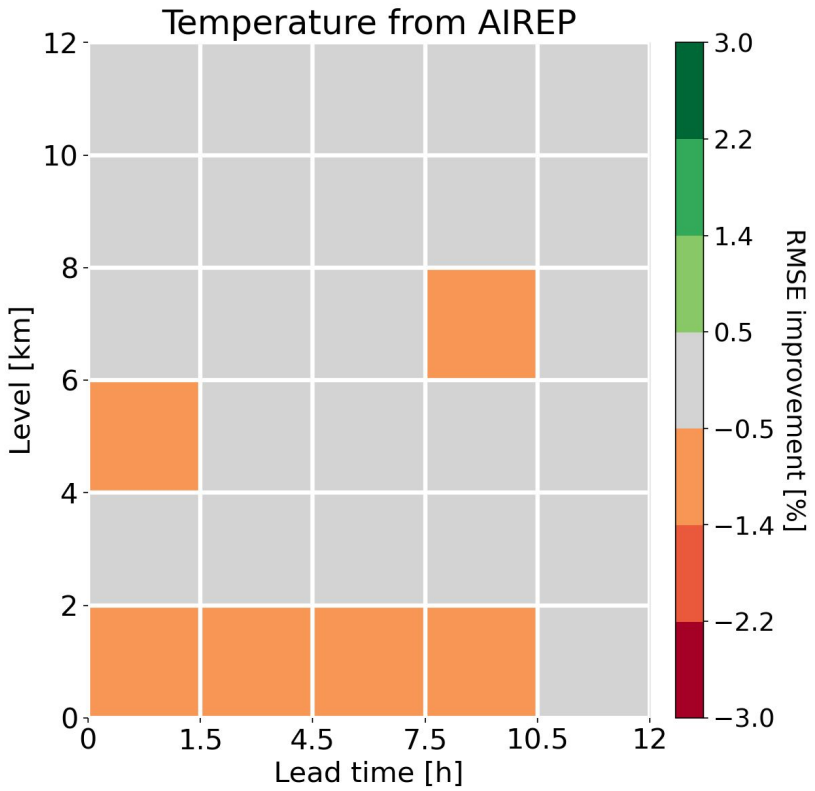
- ***radvol***: same as our operational set-up but without LHN. The operational CV is:
  pp t q u v w qcl qci **qr qs qg**
- ***radvol_cvred***: same as *radvol* but using the "reduced" CV:
  pp t q u v w qcl qci

FSS implementation:

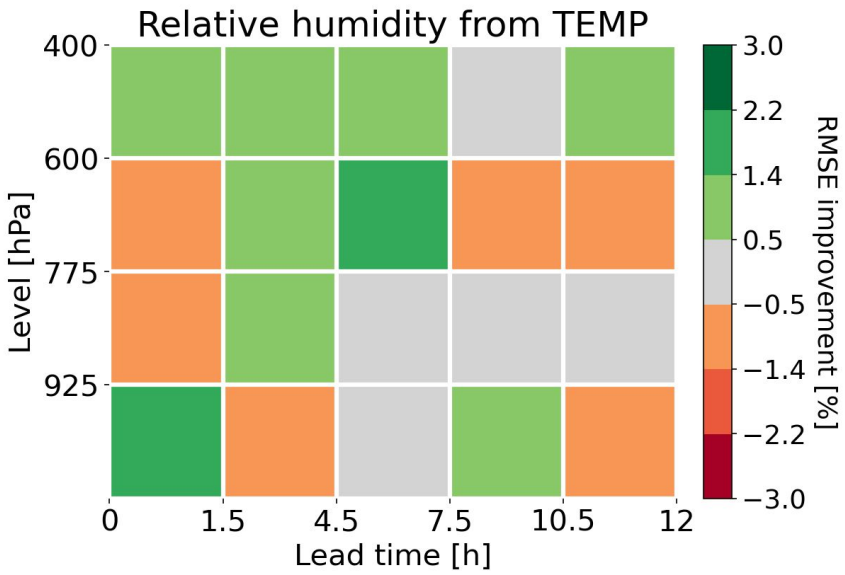
- boxes of 0.2° X 0.2° on Italian mainland
- Observations are hourly rainfall fields from the Italian radar composite adjusted by rain-gauges



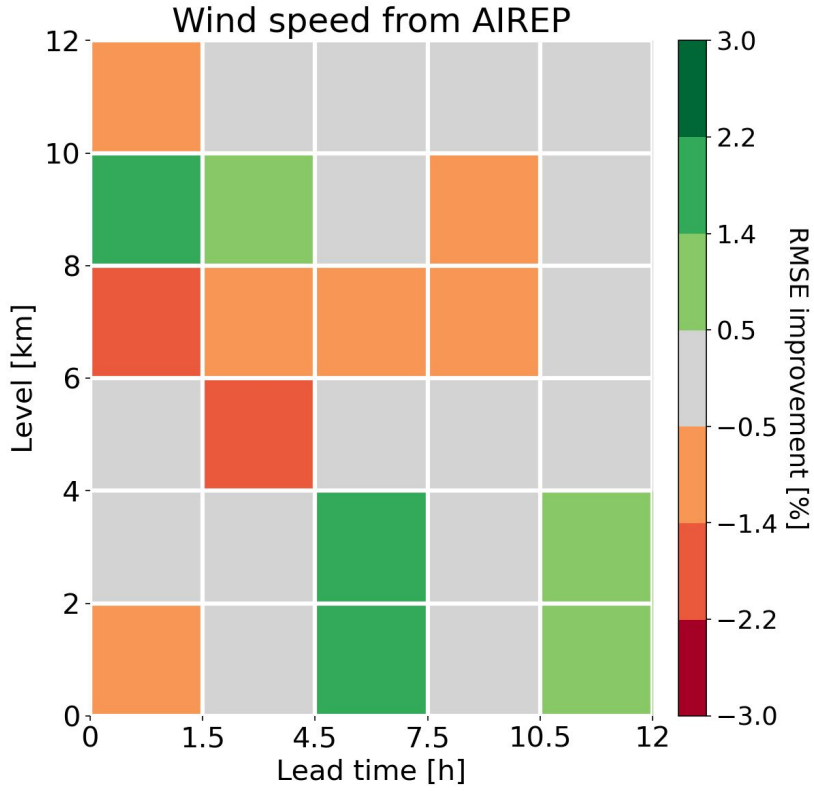
Reduced CV: RMSE(*radvol*) - RMSE(*radvol_cvred*)



Average number of obs.: 21624 (ranging from 7367 to 50254)
Average RMSE (cntr): 1.08 K (ranging from 0.81 K to 1.49 K)



Average number of obs.: 4961 (ranging from 1345 to 8259)
Average RMSE (cntr): 0.19 kg/kg (ranging from 0.13 kg/kg to 0.23 kg/kg)

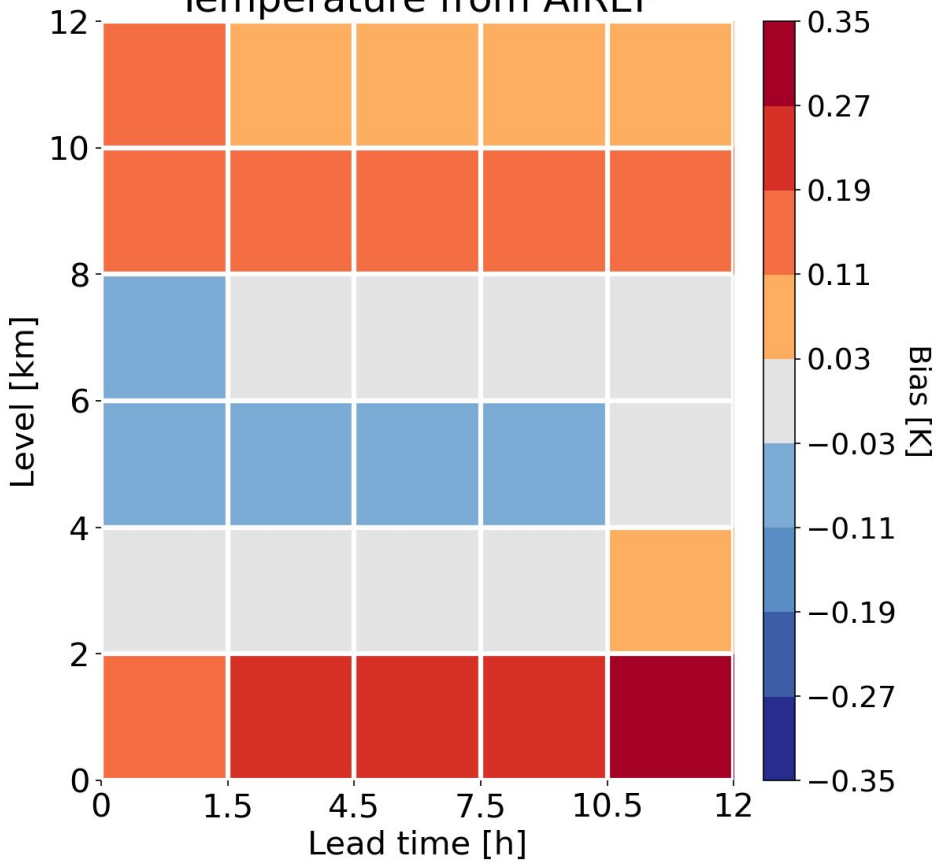


Average number of obs.: 10867 (ranging from 3352 to 27033)
Average RMSE (cntr): 3.01 m/s (ranging from 2.62 m/s to 3.55 m/s)

Positive values (green) -- > *radvol_cvred* better than *radvol*

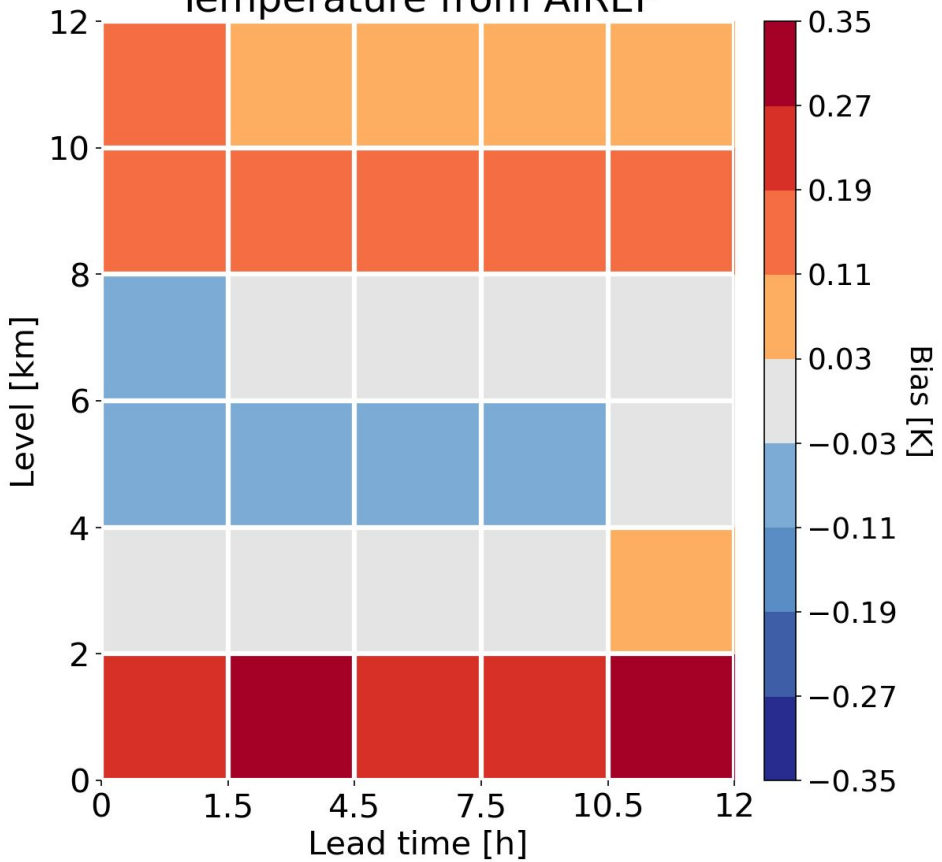
Reduced CV: bias of temperature

radvol



Average number of obs.: 21624 (ranging from 7367 to 50254)
Average bias: 0.071 K (ranging from -0.040 K to 0.289 K)

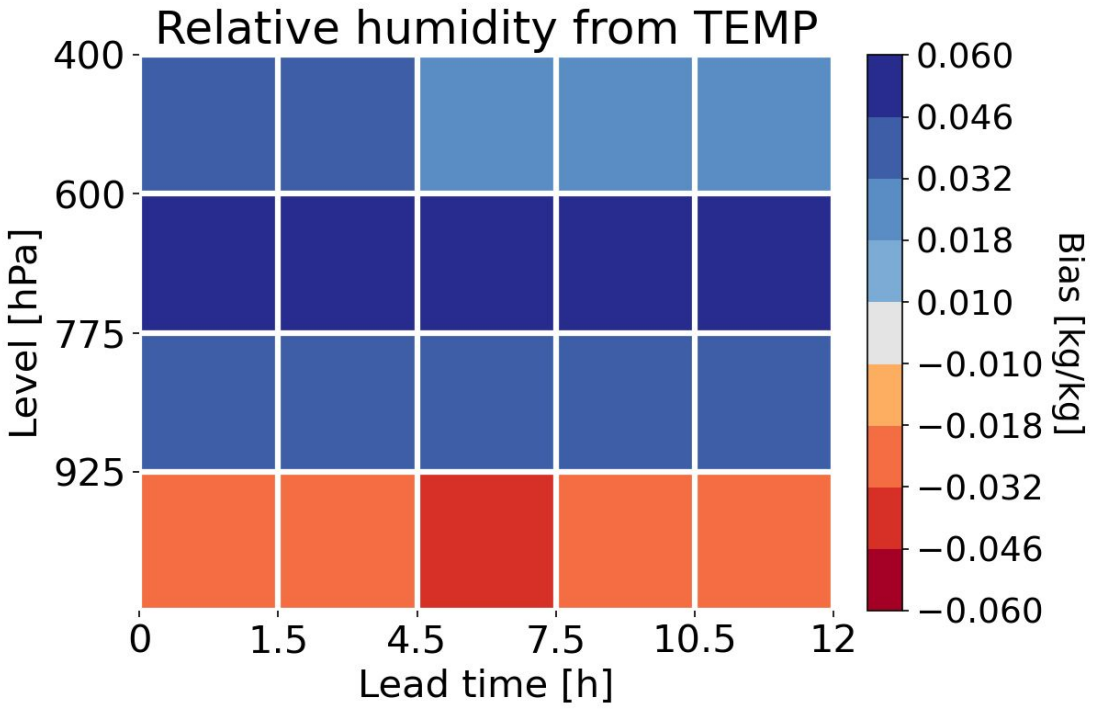
radvol_cvred



Average number of obs.: 21627 (ranging from 7366 to 50297)
Average bias: 0.075 K (ranging from -0.046 K to 0.301 K)

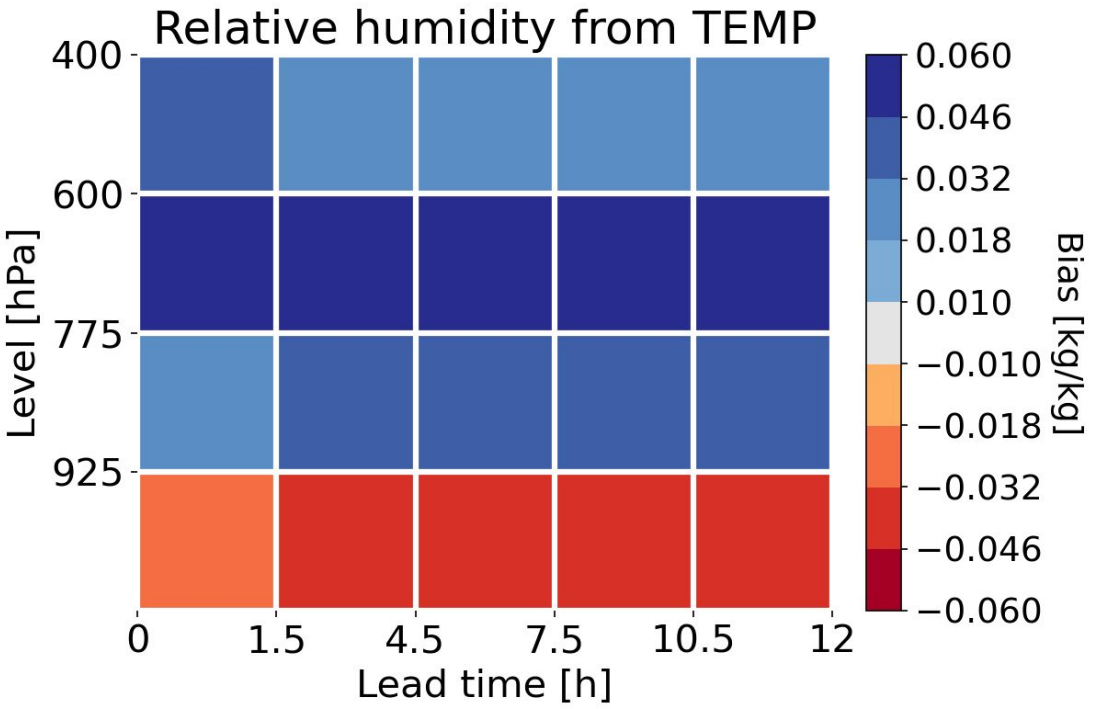
Reduced CV: bias of relative humidity

radvol



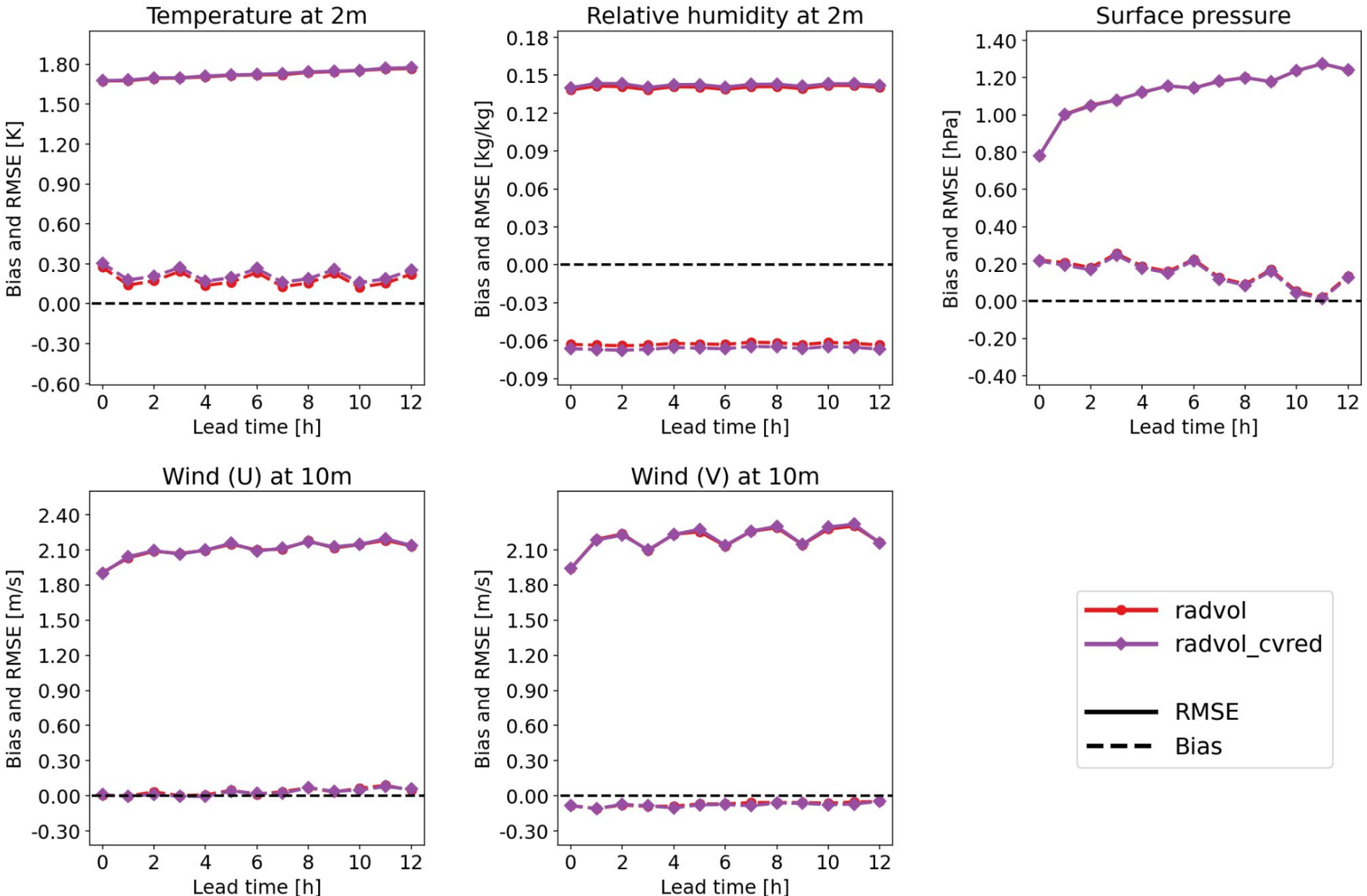
Average number of obs.: 4961 (ranging from 1345 to 8259)
Average bias: 0.023 kg/kg (ranging from -0.032 kg/kg to 0.053 kg/kg)

radvol_cvred

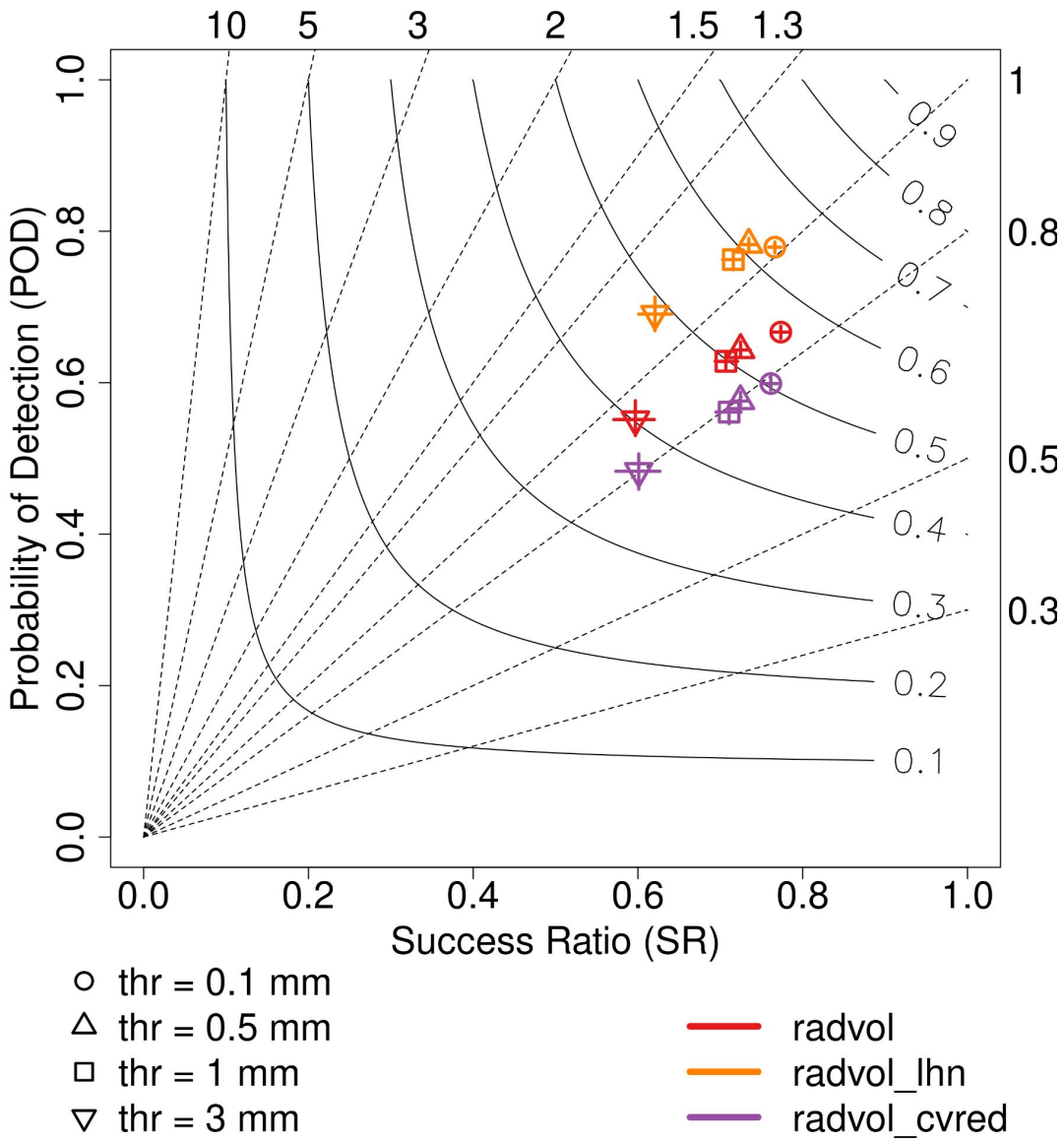


Average number of obs.: 4952 (ranging from 1345 to 8261)
Average bias: 0.022 kg/kg (ranging from -0.036 kg/kg to 0.052 kg/kg)

Reduced CV: near-surface variables



Reduced CV: precipitation during assimilation cycles



Verification implementation:

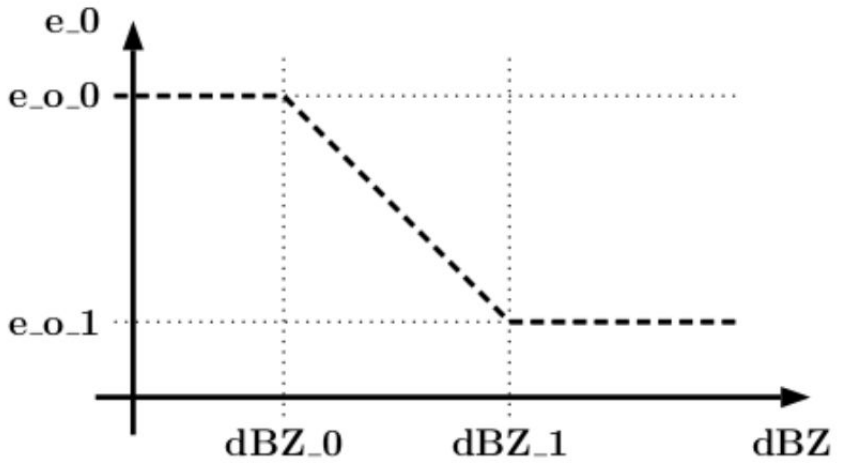
- Dichotomous scores computed on alerting areas defined by the Civil Protection Department

- Rain gauges as observations (~3000)

Radial winds: implementation

- COSMO updated from version 5.05 to 5.08
- KENDA updated from version 1.53 to 2.06
- Modifications to the EMVORADO operator:
  - for each radar and elevation, Nyquist velocity is set as the maximum (in absolute value) of the read data;
  - the same sign convention for radial winds is imposed for all radars
- Localization as reflectivity observations:
  - h_loc =16
  - v_loc = 0.3
- Observation error: reflectivity dependent, same as DWD (?)
  - itype_obserr_vr = 2
  - e_0_1 = baseval_obserr_vr = 2.5
  - e_o_0 = maxval_obserr_vr = 25.0
  - dBZ_0 = ramp_lowdbz_obserr_vr = 0
  - dBZ_1 = ramp_highdbz_obserr_vr = 10.0
  - supob_vrw = 10

Multiplied by 1.0 in KENDA



Radial winds: experimental set-up

Experiments:

- ***radvol_lhn_newbins***: same as our operational set-up but using COSMO 5.08 and KENDA 2.6 (no significant differences with radvol_lhn)
- ***radvol_lhn_wind*** same as above but assimilating also radial winds

Evaluation period:

From 18/09/2020 to 06/10/2020 (129 forecasts for verification)

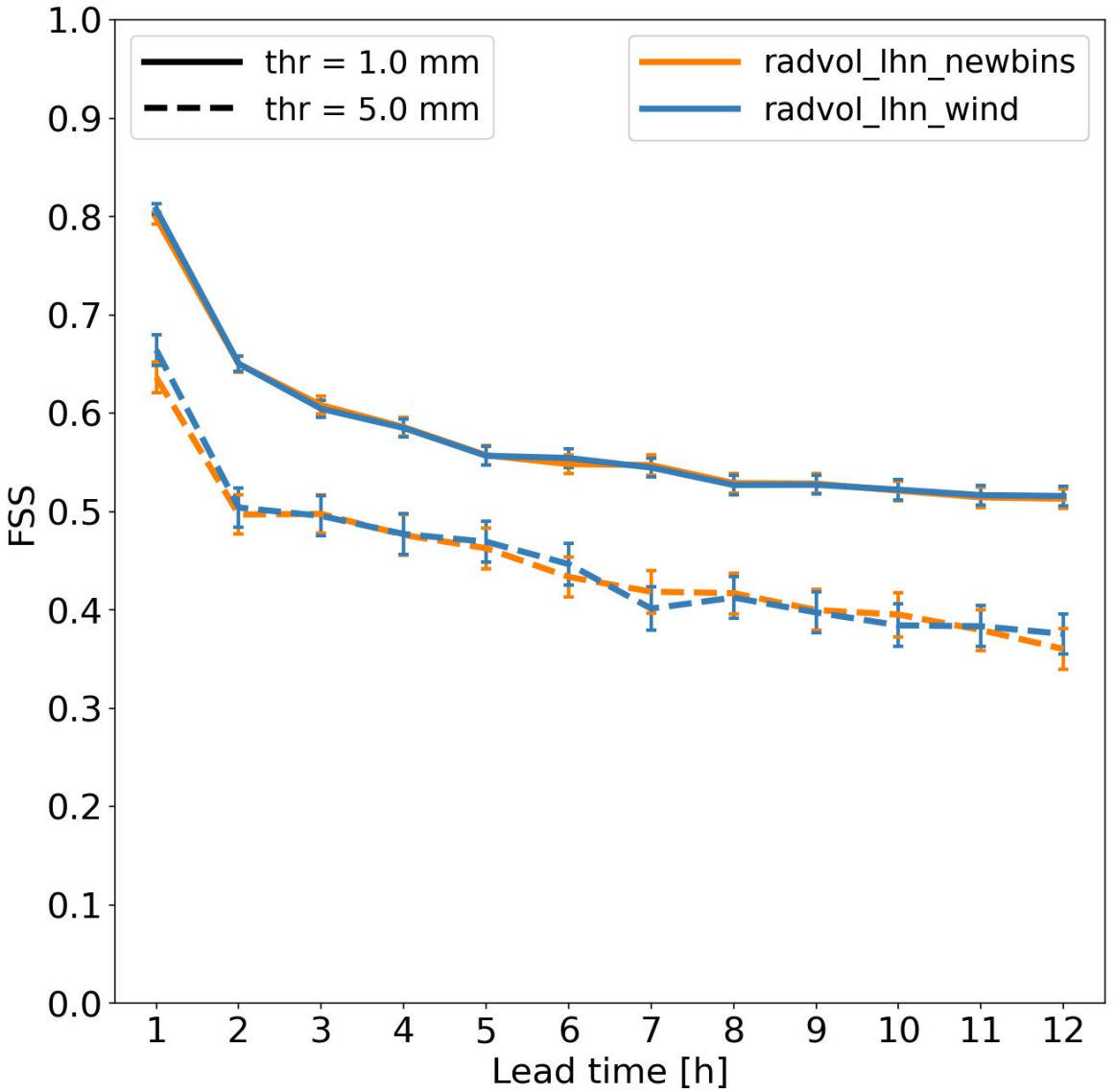
Radial winds: forecast precipitation (FSS)

Experiments:

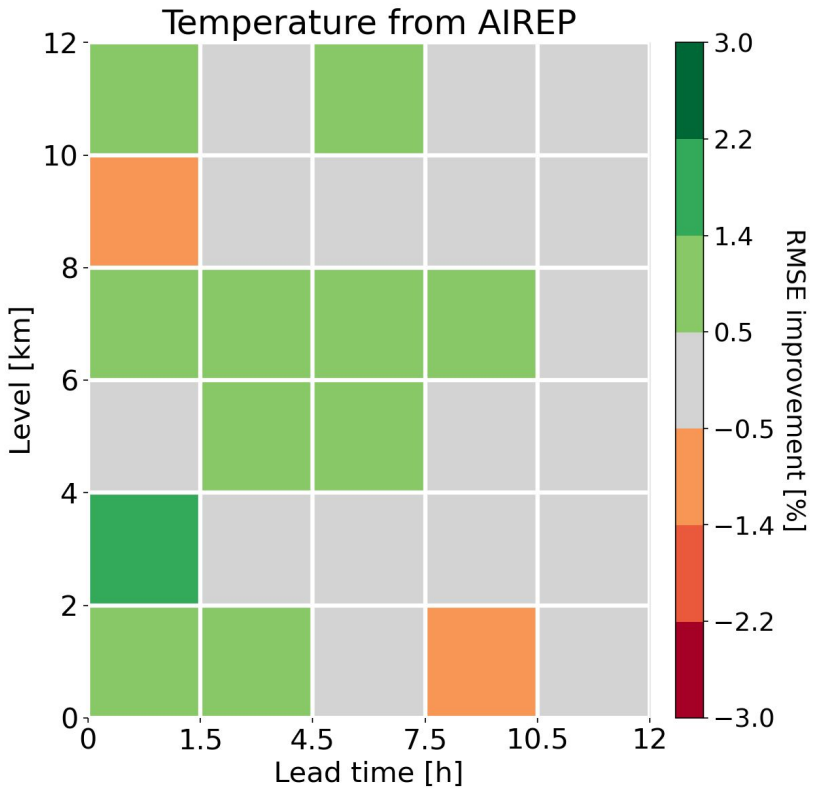
- ***radvol_lhn_newbins***: same as our operational set-up but using COSMO 5.08 and KENDA 2.6 (no significant differences with radvol_lhn)
- ***radvol_lhn_wind*** same as above but assimilating also radial winds

Evaluation period:

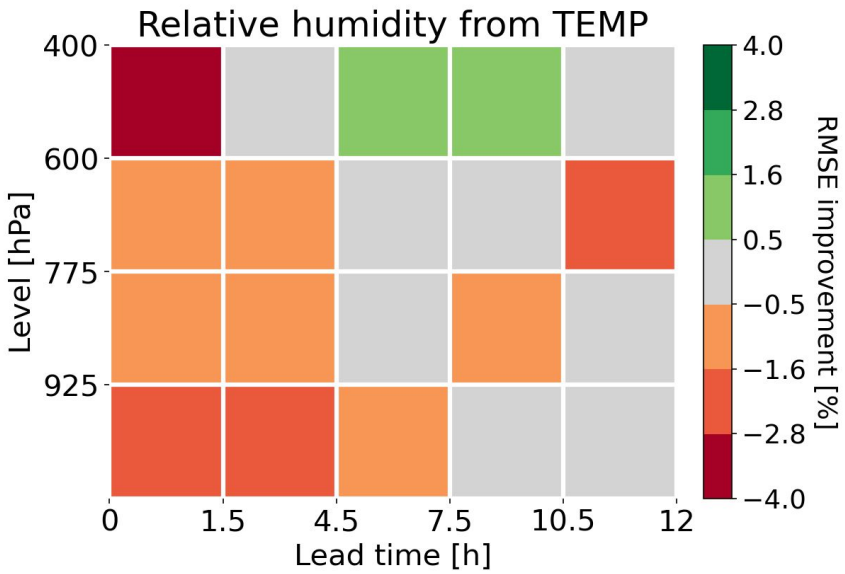
From 18/09/2020 to 06/10/2020 (129 forecasts for verification)



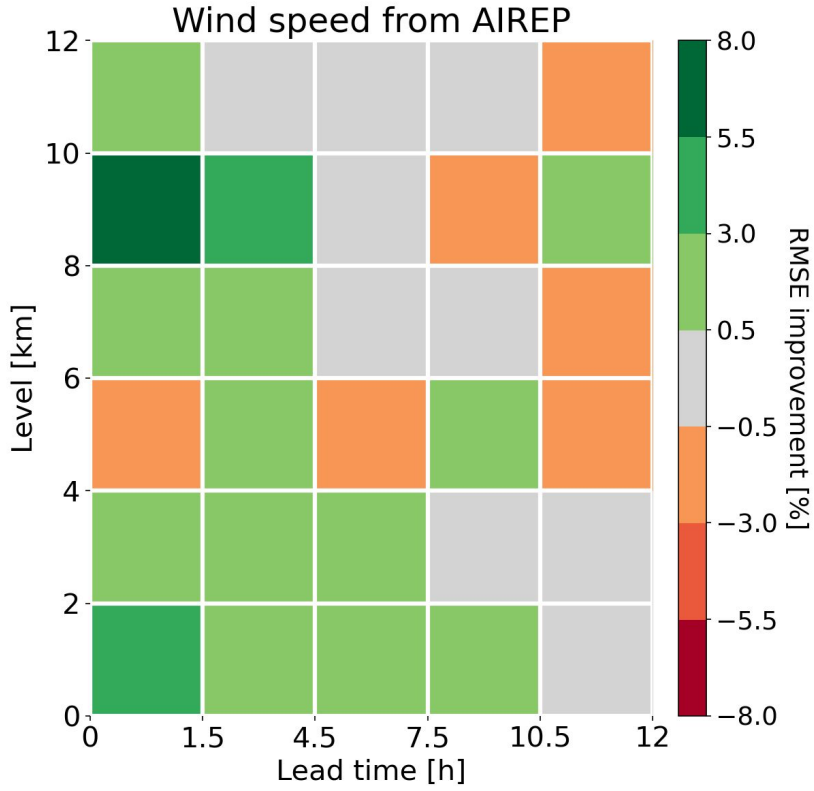
Radial winds: RMSE(*radvol_lhn_newbins*) - RMSE(*radvol_lhn_wind*)



Average number of obs.: 12698 (ranging from 4055 to 28981)
Average RMSE (cntr): 1.12 K (ranging from 0.85 K to 1.62 K)



Average number of obs.: 2733 (ranging from 630 to 4737)
Average RMSE (cntr): 0.19 kg/kg (ranging from 0.12 kg/kg to 0.23 kg/kg)

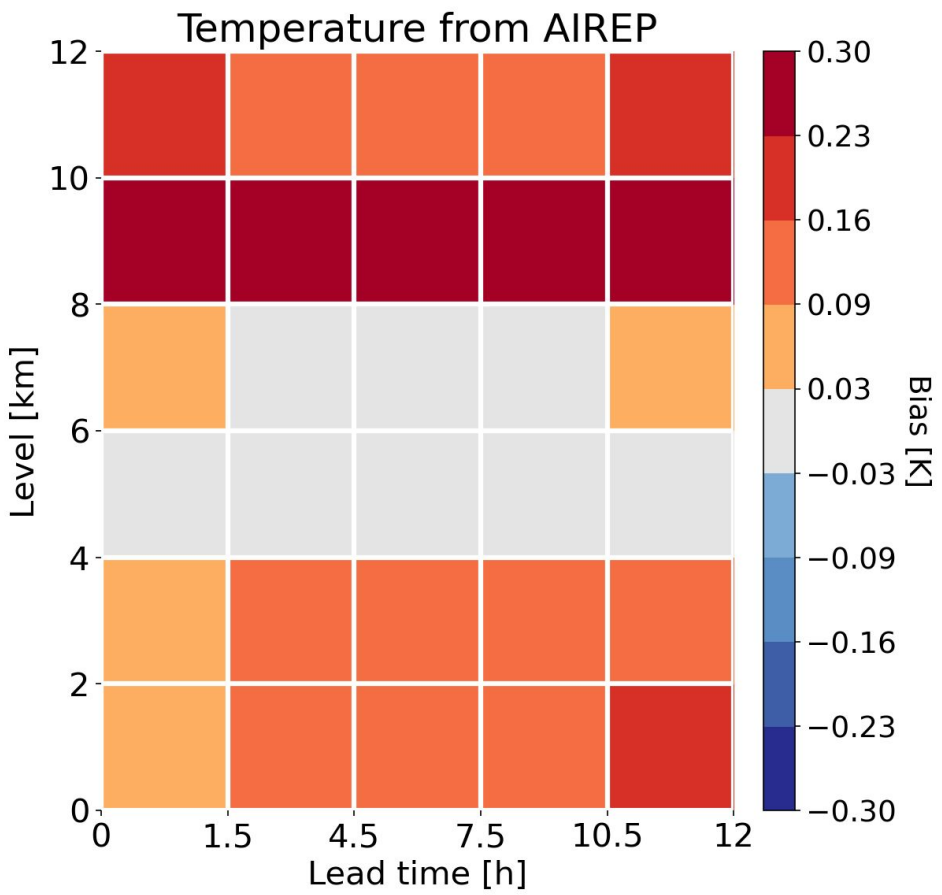


Average number of obs.: 5770 (ranging from 1317 to 14599)
Average RMSE (cntr): 3.22 m/s (ranging from 2.79 m/s to 3.89 m/s)

Positive values (green) -- > *radvol_lhn_wind* better than *radvol_lhn_newbins*

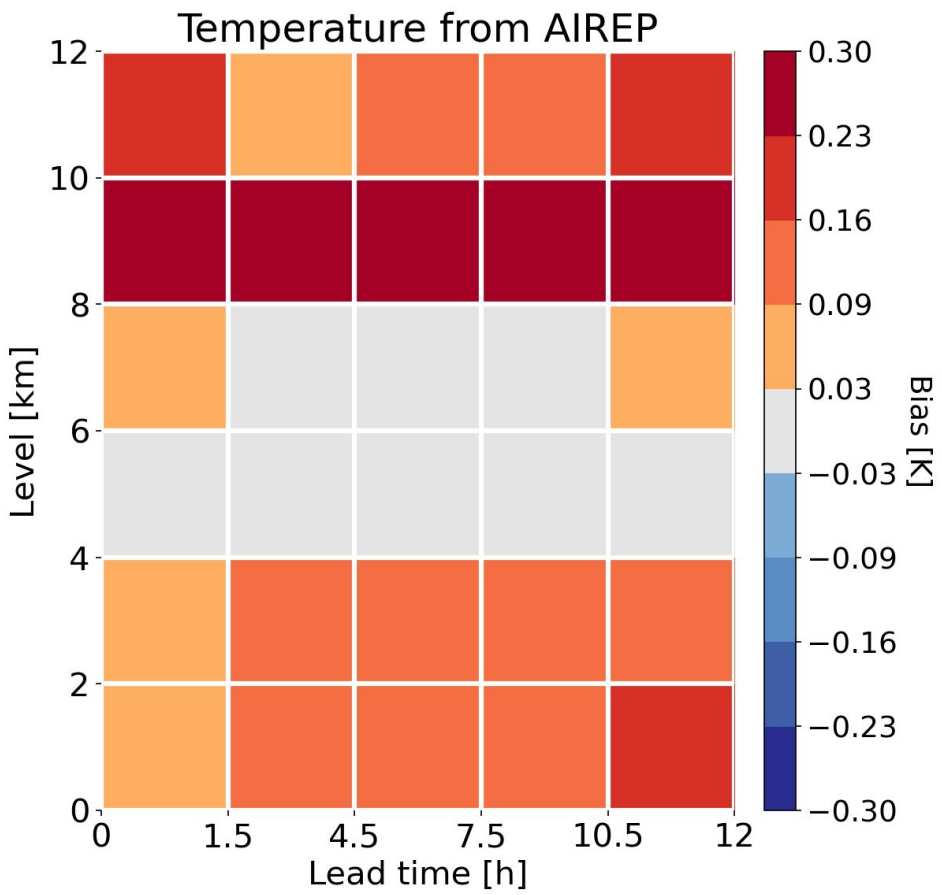
Radial winds: bias of temperature

radvol_lhn_newbins



Average number of obs.: 12698 (ranging from 4055 to 28981)
Average bias: 0.092 K (ranging from -0.014 K to 0.271 K)

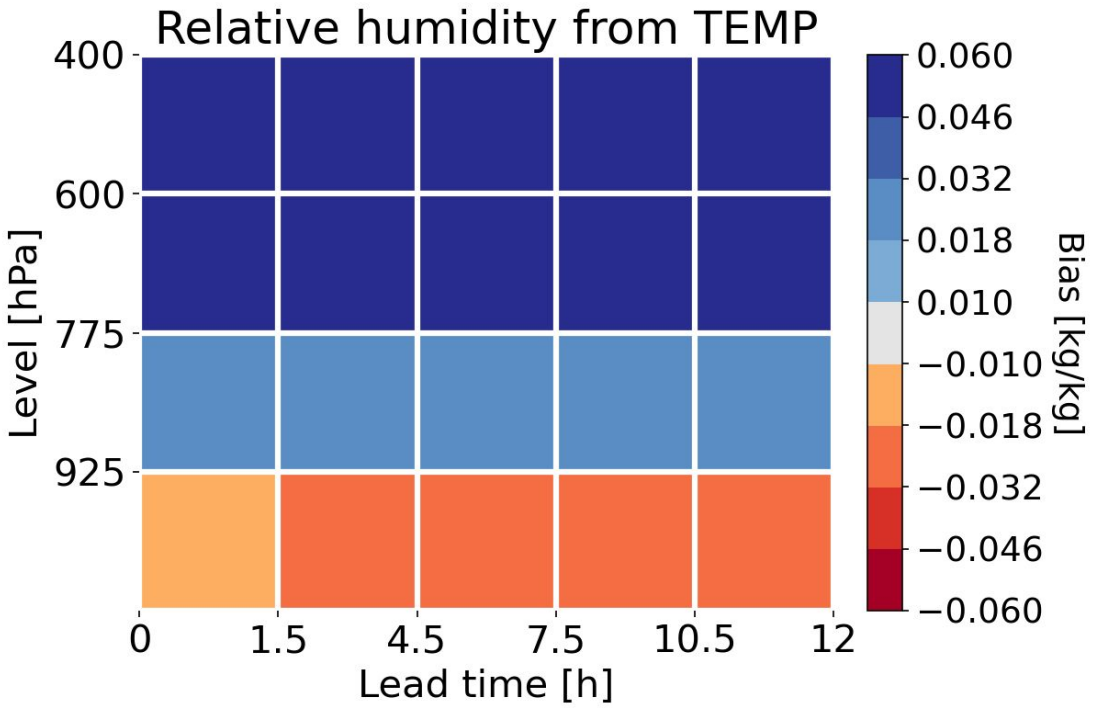
radvol_lhn_wind



Average number of obs.: 12708 (ranging from 4059 to 29009)
Average bias: 0.092 K (ranging from -0.015 K to 0.273 K)

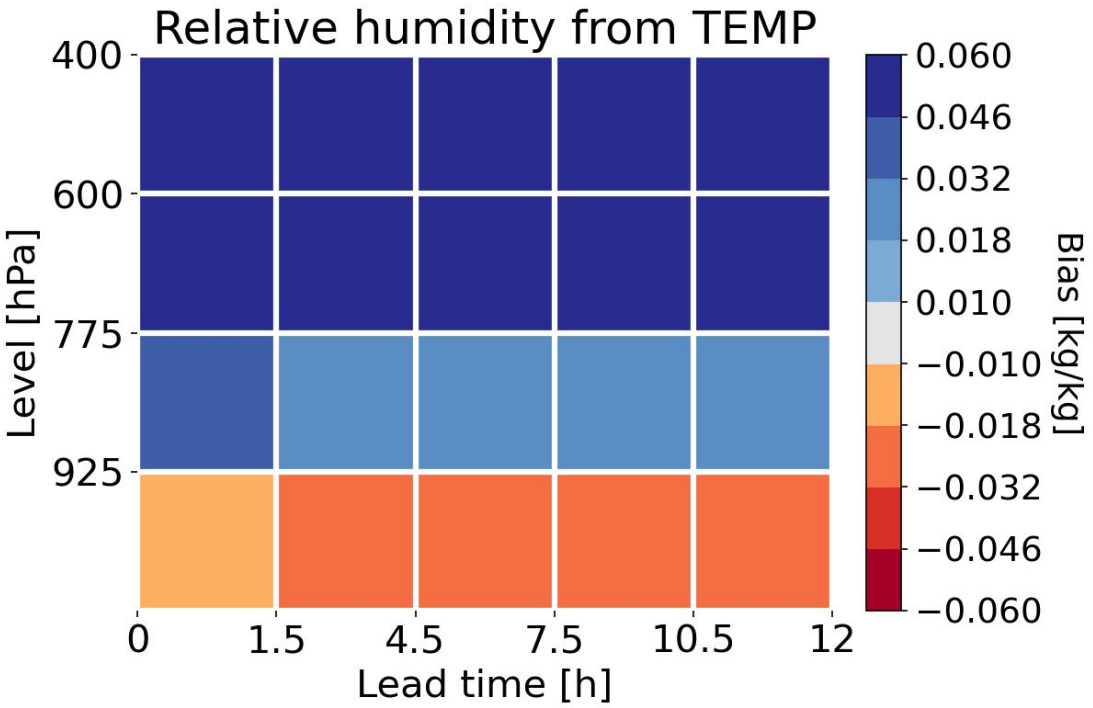
Radial winds: bias of relative humidity

radvol_lhn_newbins



Average number of obs.: 2733 (ranging from 630 to 4737)
Average bias: 0.026 kg/kg (ranging from -0.027 kg/kg to 0.055 kg/kg)

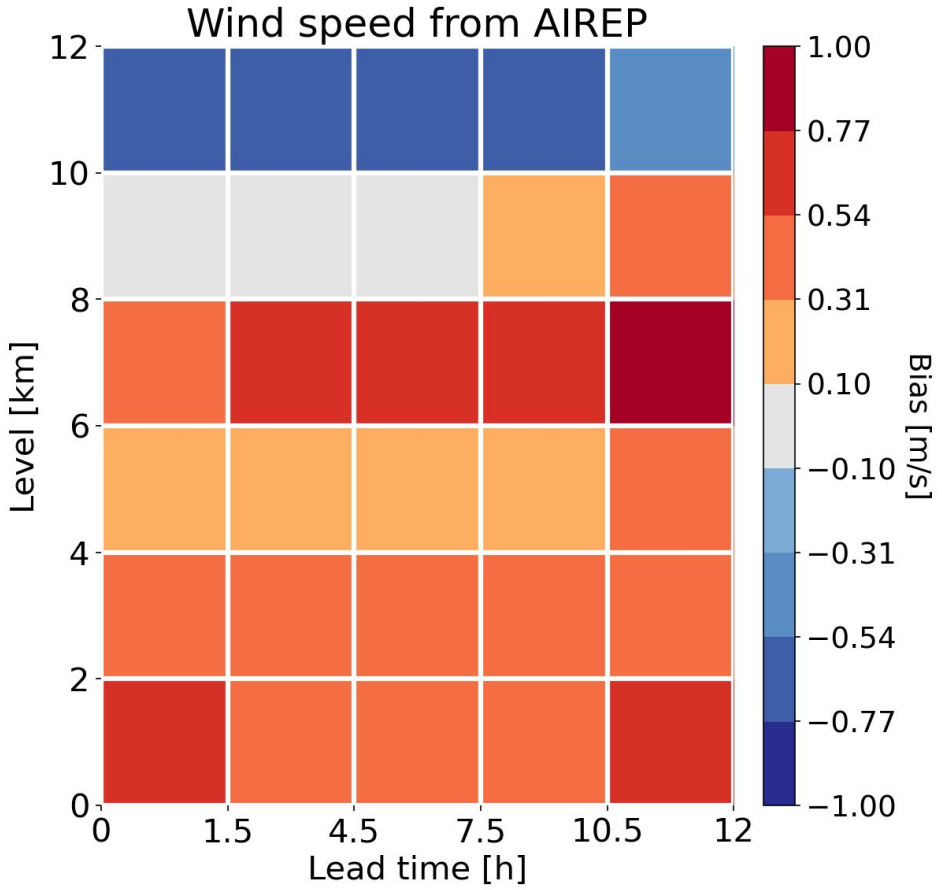
radvol_lhn_wind



Average number of obs.: 2732 (ranging from 630 to 4767)
Average bias: 0.027 kg/kg (ranging from -0.027 kg/kg to 0.058 kg/kg)

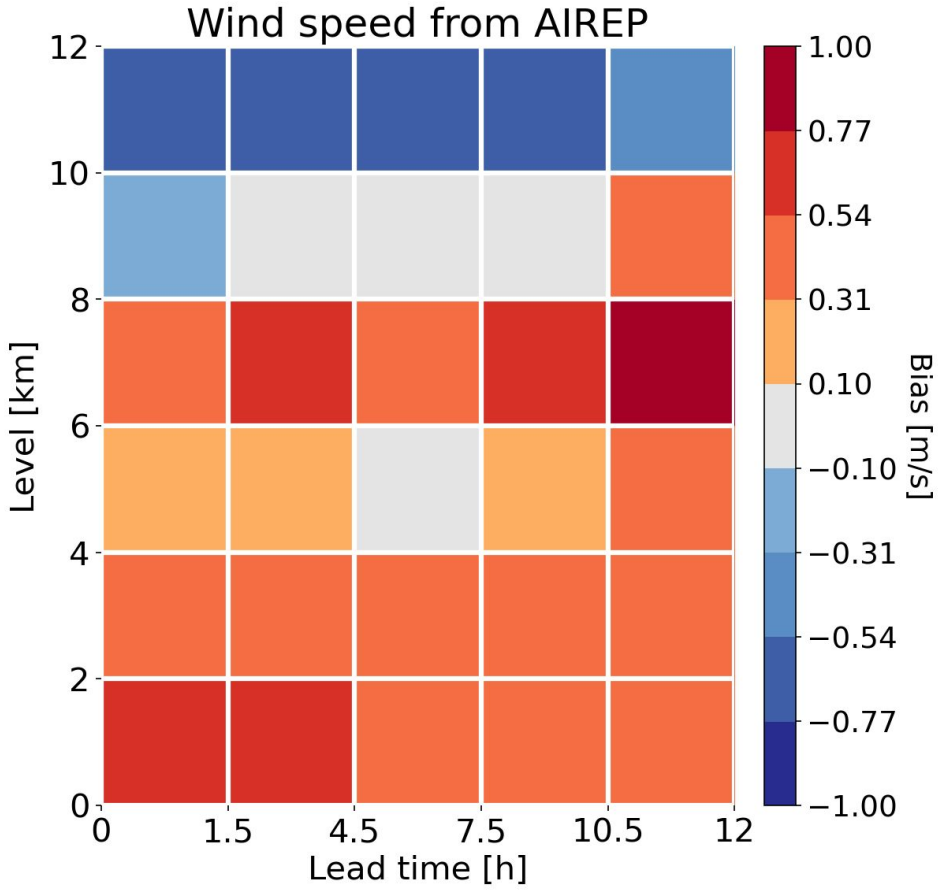
Radial winds: bias of wind speed

radvol_lhn_newbins



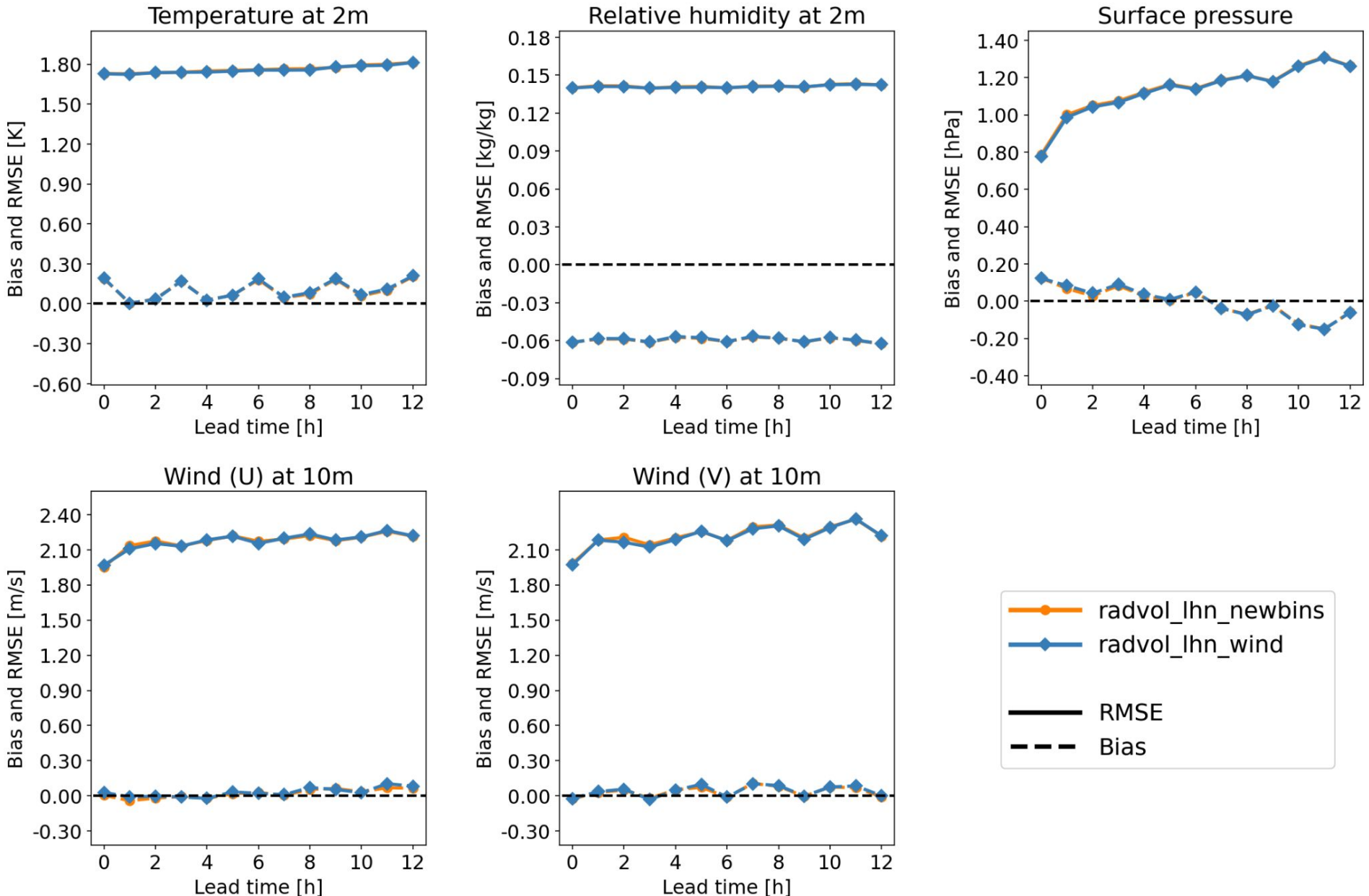
Average number of obs.: 5770 (ranging from 1317 to 14599)
Average bias: 0.185 m/s (ranging from -0.593 m/s to 0.780 m/s)

radvol_lhn_wind



Average number of obs.: 5770 (ranging from 1315 to 14609)
Average bias: 0.168 m/s (ranging from -0.624 m/s to 0.831 m/s)

Radial winds: near-surface variables



Conclusions

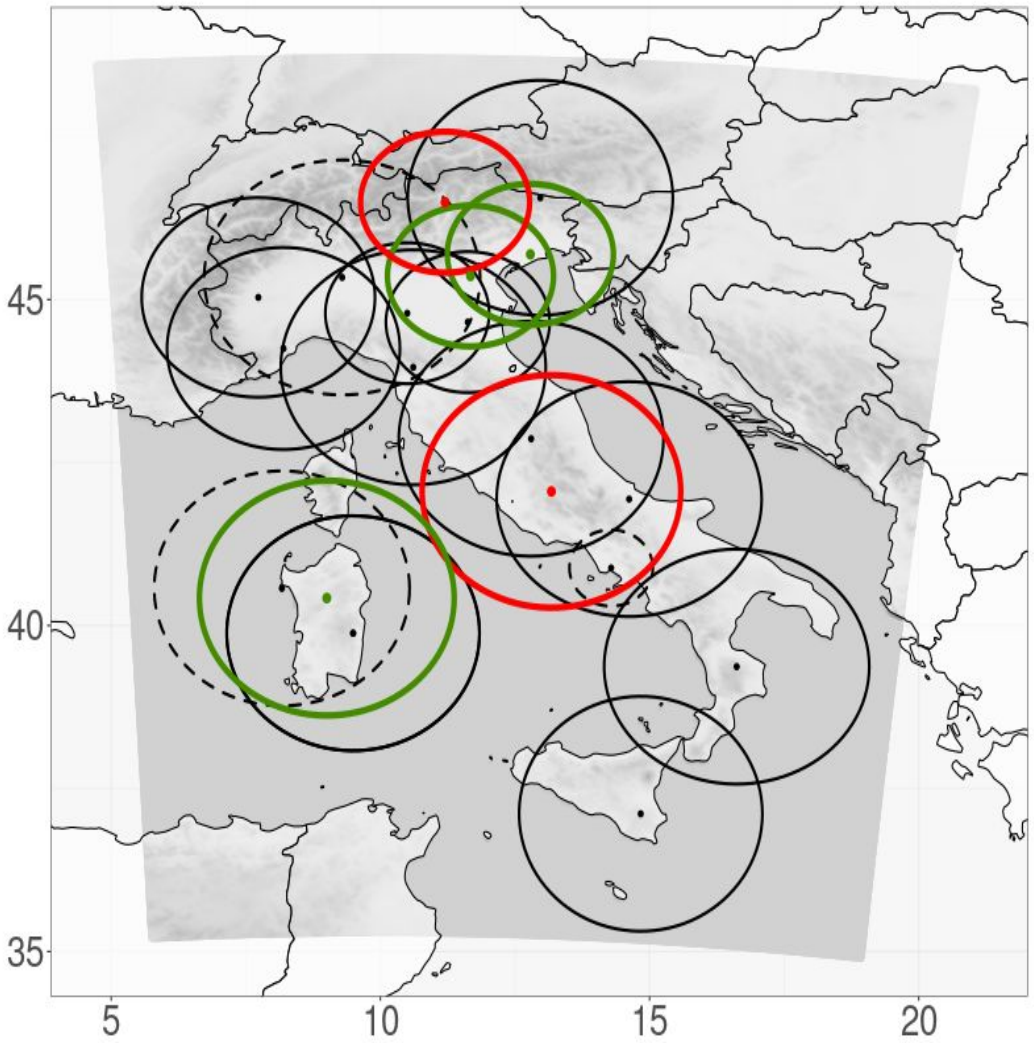
- Assimilation of more radars and removal of the lowest elevation: no impact
- Use of a “reduced” control vector (without qr, qs, qg):
  - Deterioration of precipitation during assimilation cycles and at lead times +1h/+2h during forecast
  - Precipitation is underestimated
  - Low atmosphere warmer and drier
- Assimilation of radial winds:
  - slight improvement in QPF accuracy at lead time +1h
  - Improvements in RMSE of temperature and wind speed but deterioration in relative humidity
  - Further tests and deeper investigation are needed!

Thank you!

Assimilation of regional radars and removal of the lowest elevation

Experimental set-up

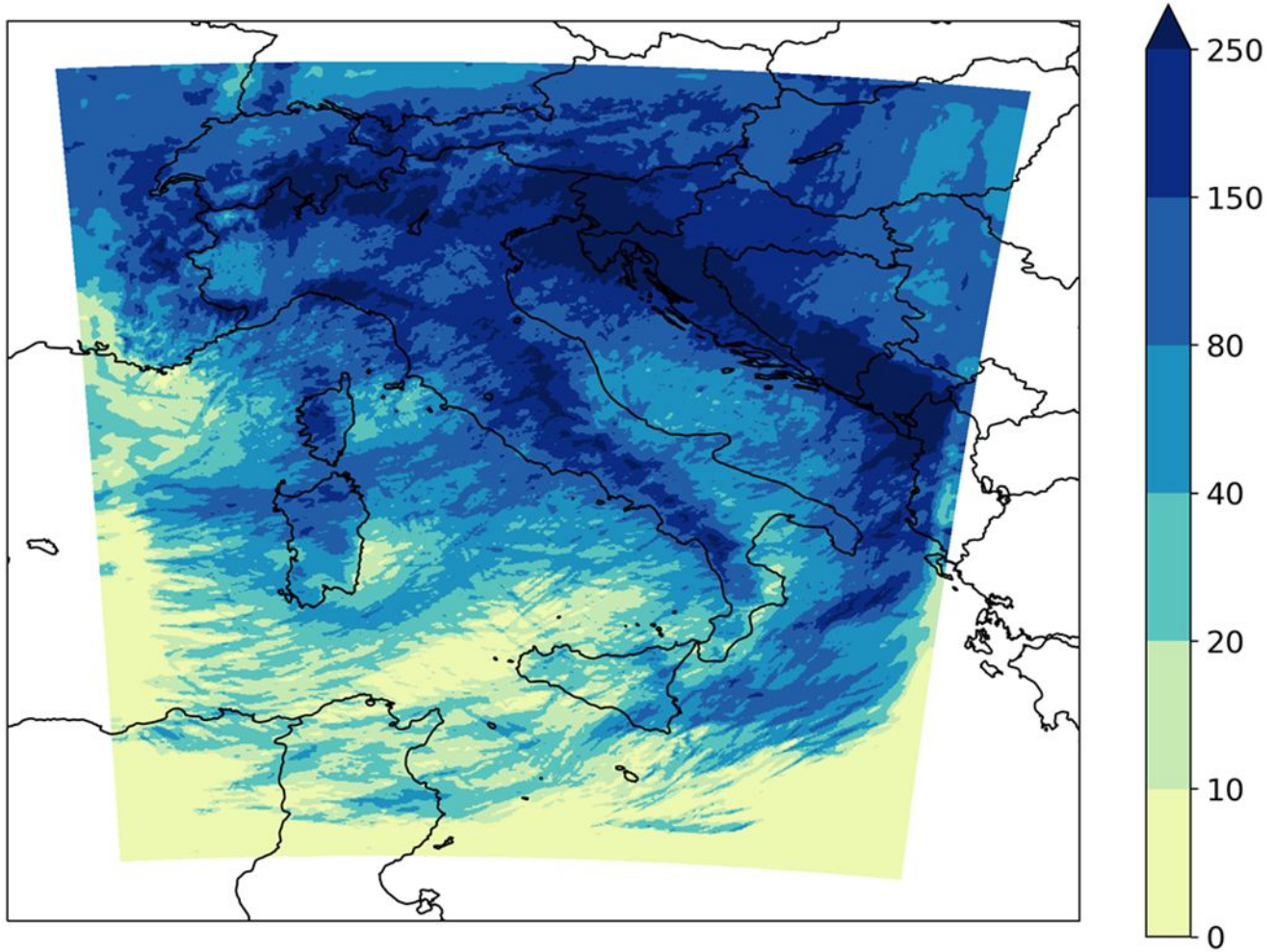
- ***radvol_lhn_reg_light***: same as *radvol_lhn* but assimilating also "red" and "green" radars;
- ***radvol_lhn_reg_hard***: same as *radvol_lhn* but assimilating also "green" radars and discarding the lowest elevation (the most error-prone) for ALL radars.
- ***radvol_reg_hard***: same as *radvol_lhn_reg_hard* but without LHN.
- ***radvol***: same as *radvol_lhn* but without LHN.



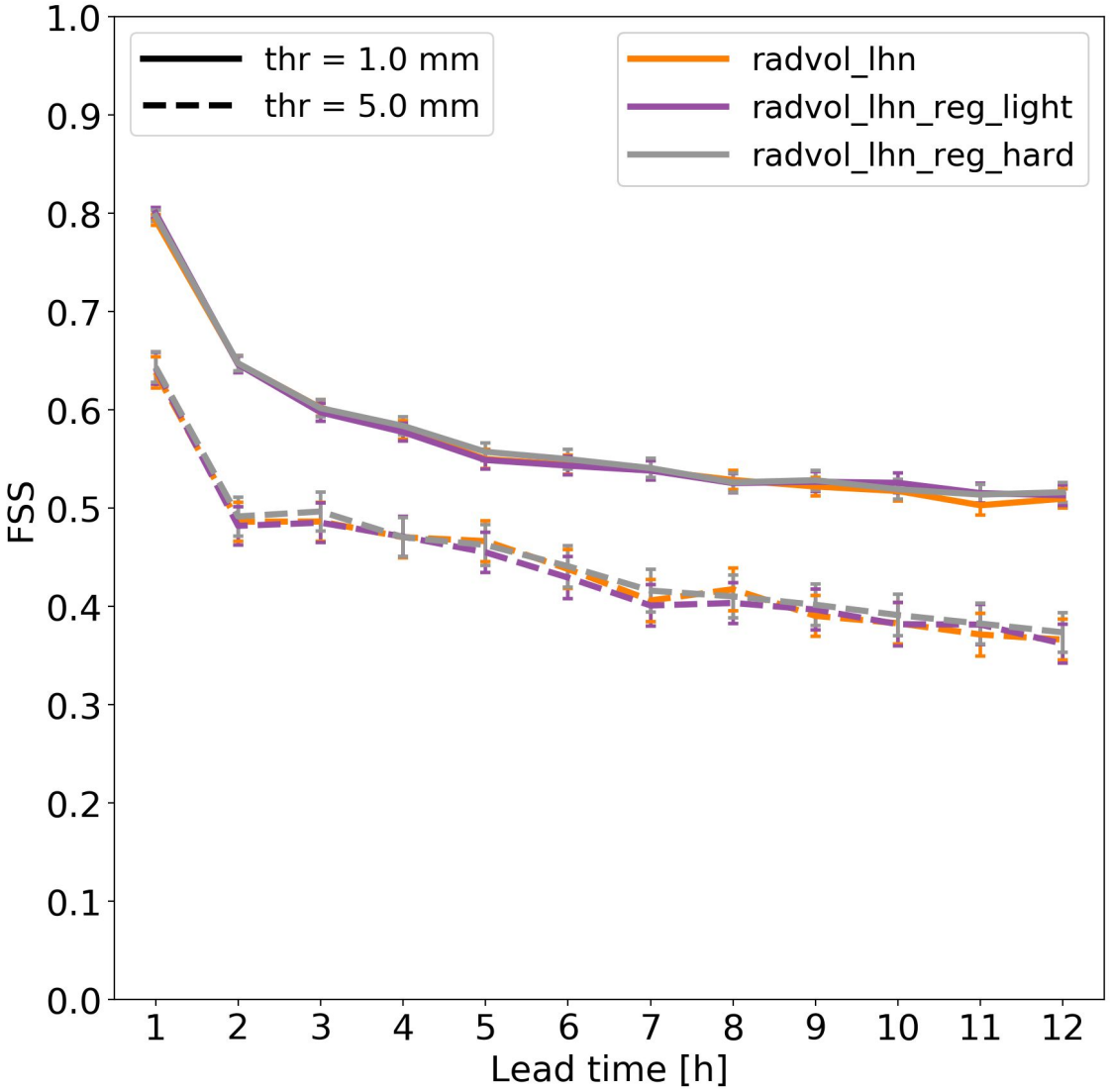
Evaluation period

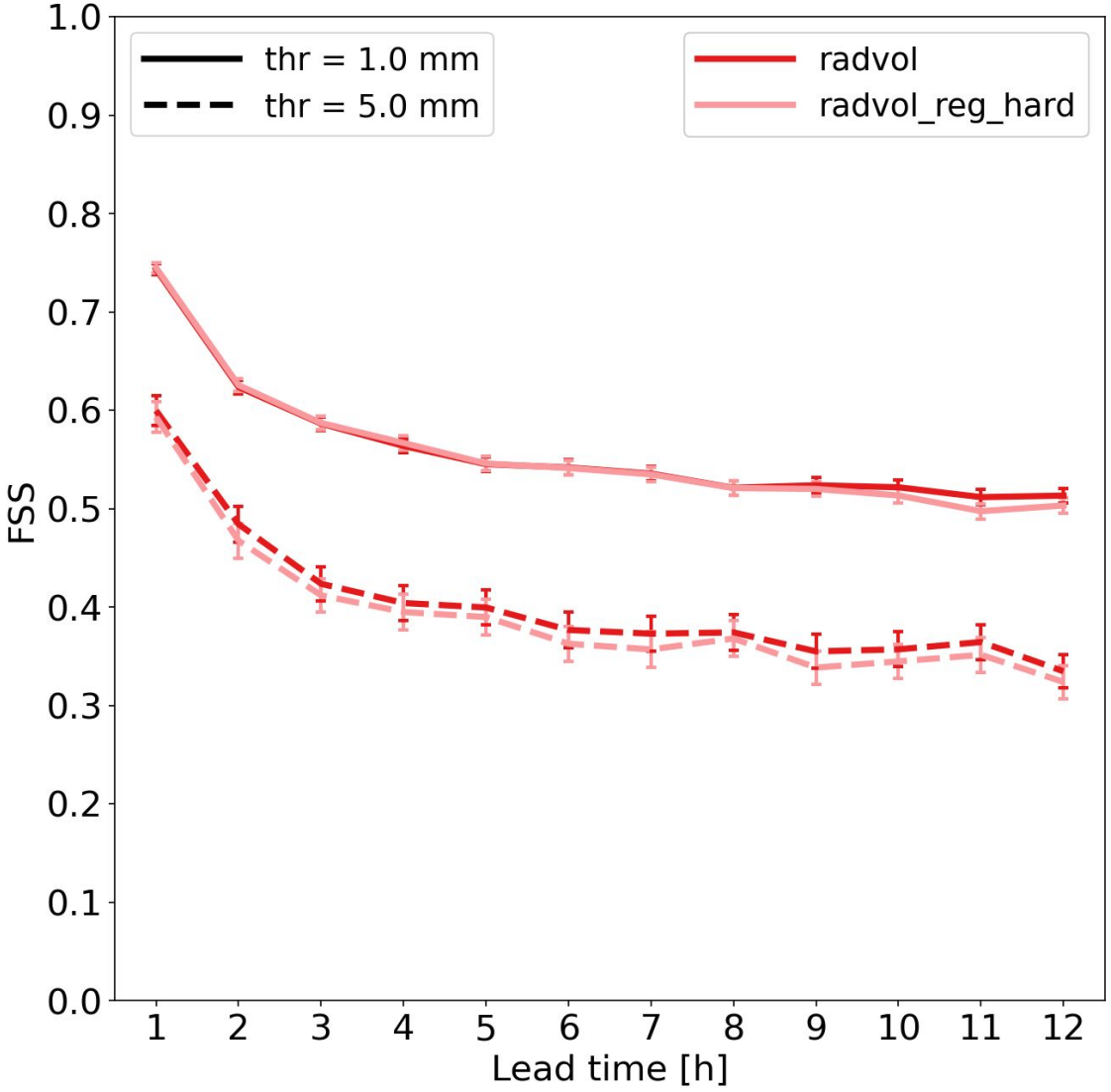
From 18/09/2020 to 19/10/2020. A 12h **deterministic** forecast is initialized every 3h from the deterministic analyses of each suite (total forecasts: 236)

Model estimated precipitation over the evaluation period



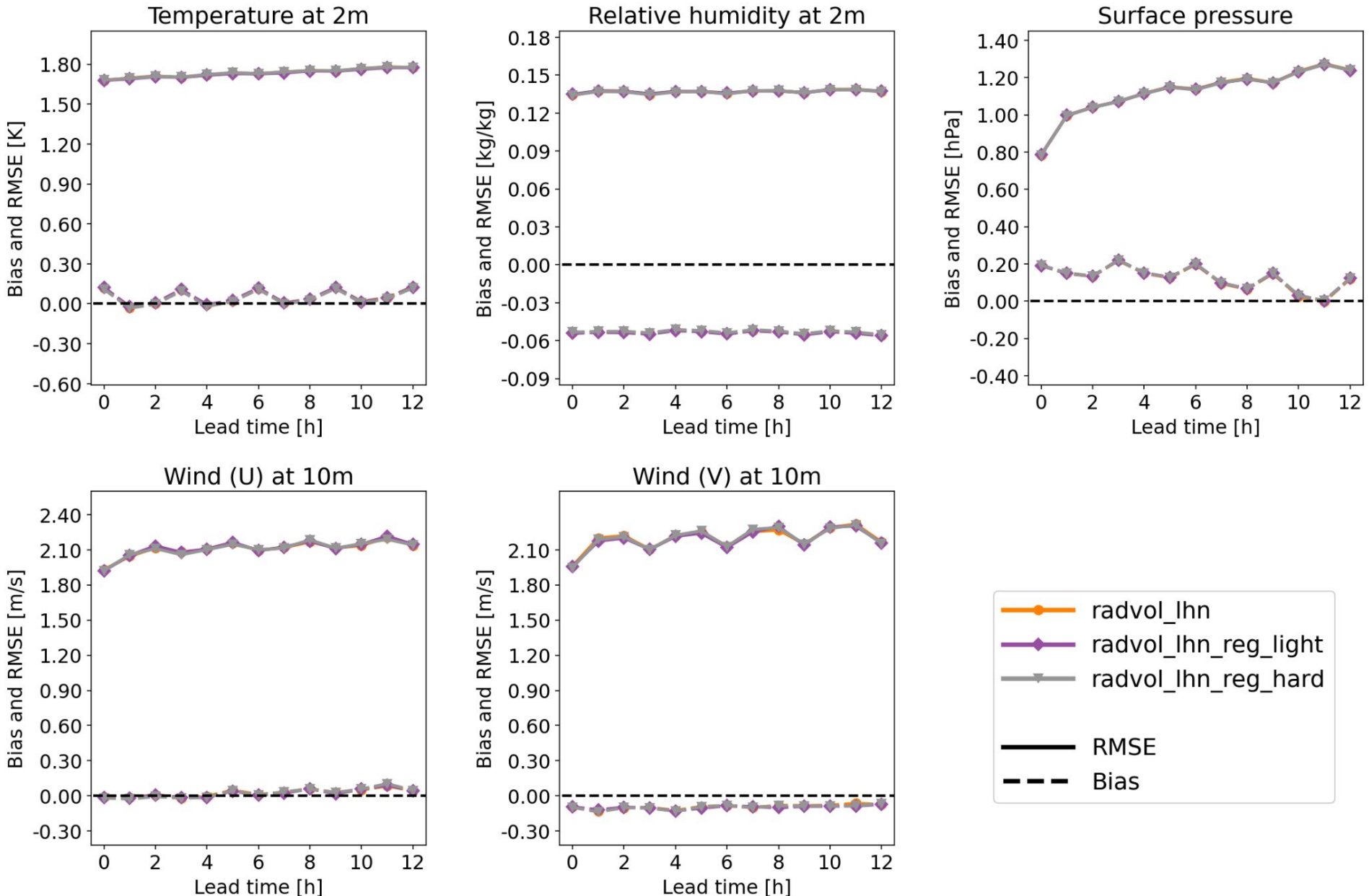
Forecast precipitation (FSS)



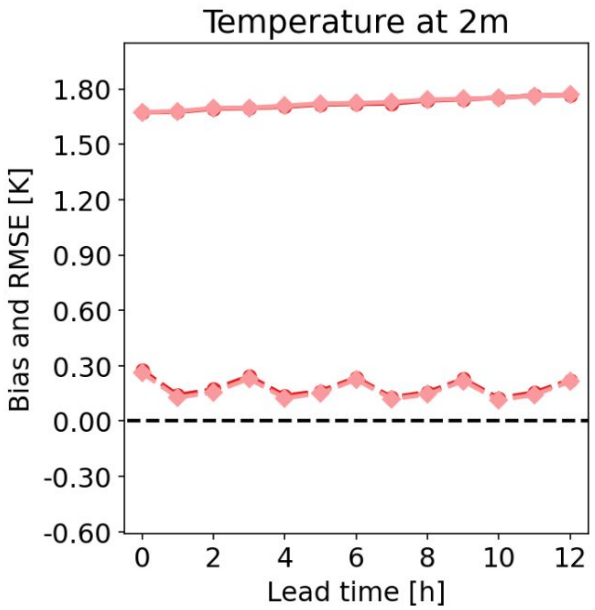


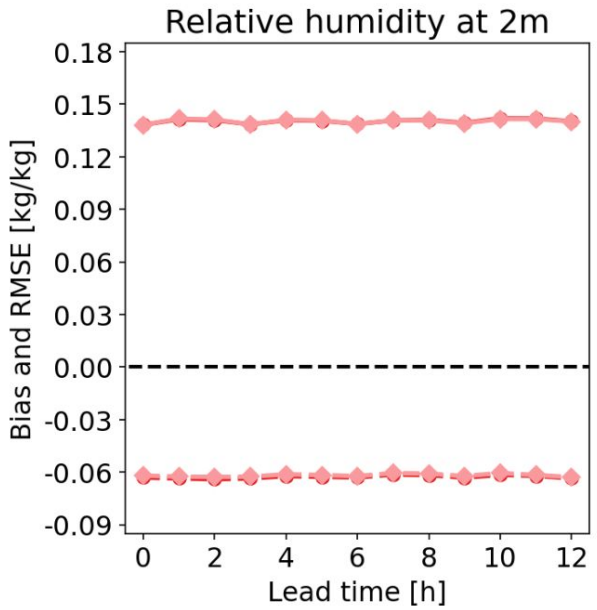
Boxes of 0.2° X 0.2° over the Italian mainland; observations are hourly rainfall fields from the Italian radar composite adjusted by rain-gauges

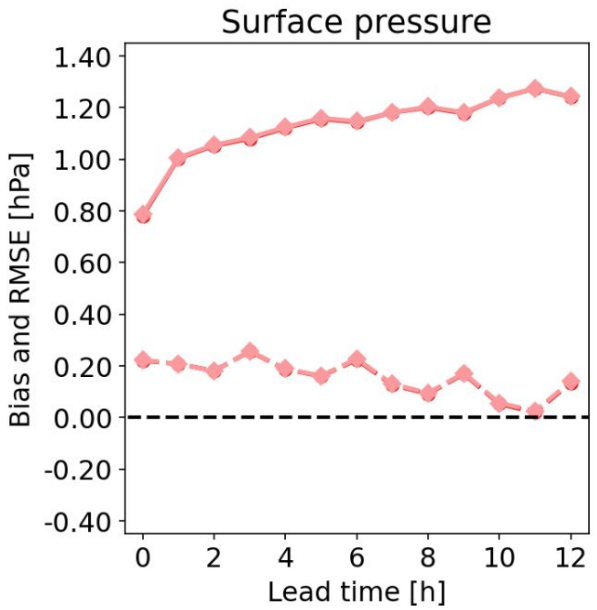
Surface variables

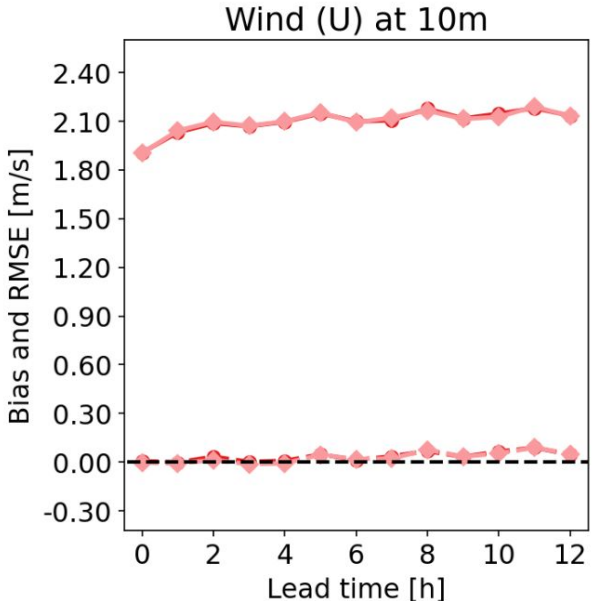


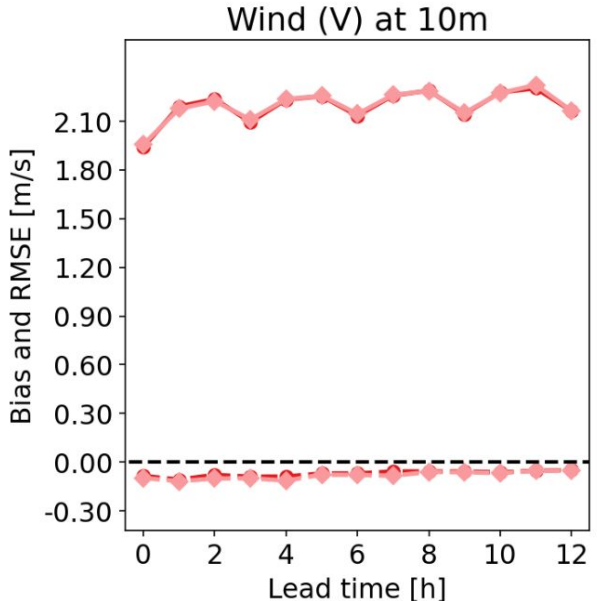
Surface variables

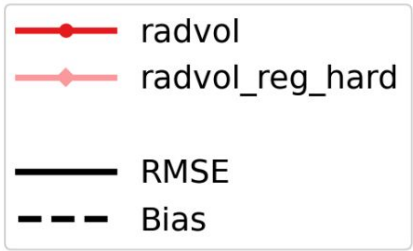












Precipitation suring assimilation cycles

Deterministic vs ensemble members

Hourly assimilation cycles from 29/09/2020 to 16/10/2021