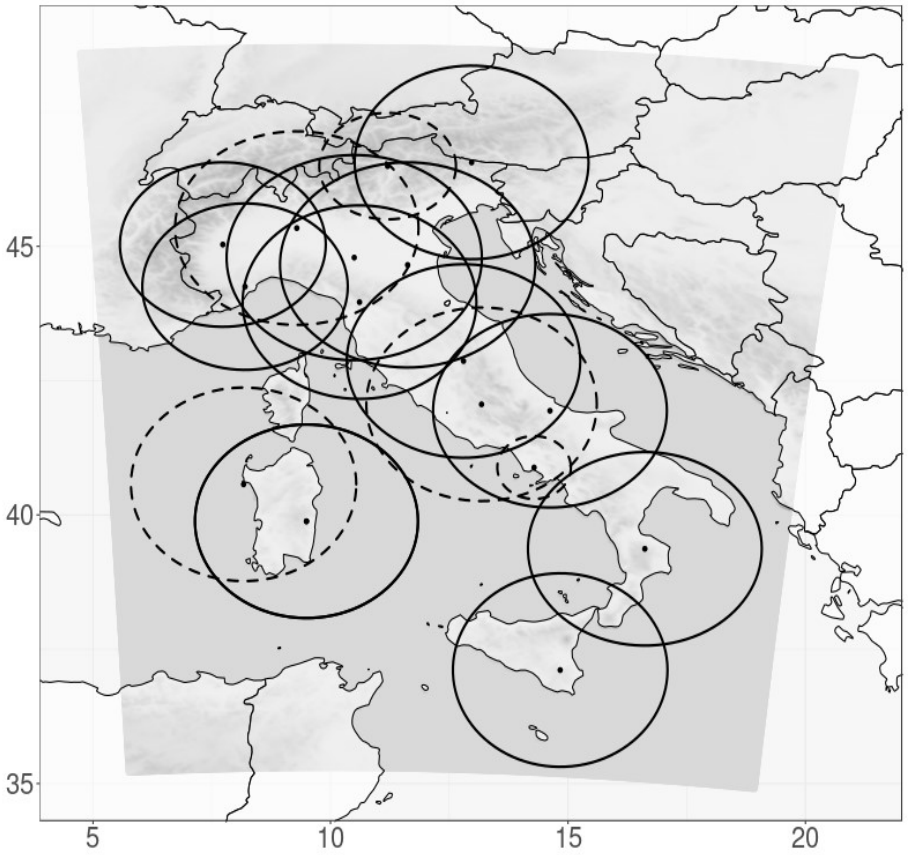
Pre-operational assimilation of radar reflectivity volumes at Arpae

Gastaldo T., Poli V., Cesari D., Alberoni P.P., Paccagnella T.

Operational set-up (*ope*)

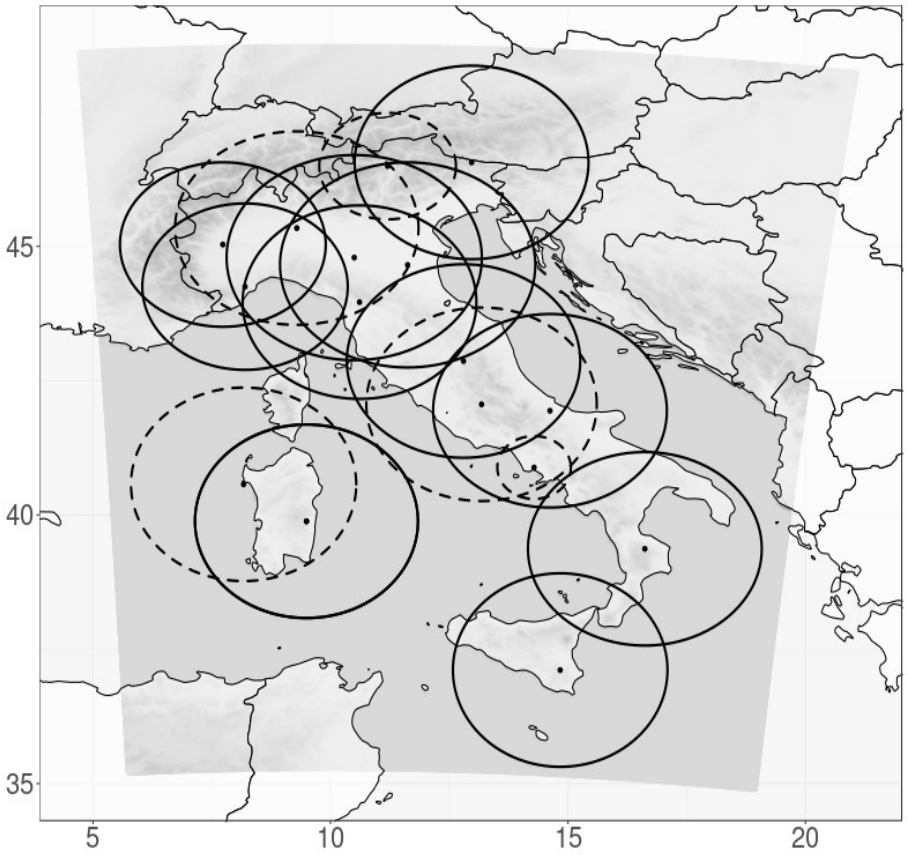
- COSMO 5.05 at 2.2 km horizontal resolution
- Ensemble consisting of 36 members + deterministic run
- 3h assimilation cycles
- assimilation of conventional data (AIREP, TEMP, SYNOP) through KENDA
- LHN performed on each member of the KENDA ensemble. Precipitation field is provided by the Department of Civil Protection and it is based on all radars in the figure (both solid and dashed circles)



Parallel suite set-up (*volrad*)

Same set-up as the operational one but replacing LHN with direct assimilation of reflectivity volumes and employing hourly cycles instead of 3-hourly. Only radars depicted with a solid circle are employed. We use:

- 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.



ope vs. *volrad*

Evaluation period

From 27/04 to 29/06. Due to a technical issue, the parallel suite has been stopped on 01/06 at 00 UTC and restarted on 02/06 to 06 UTC. Accordingly, verification is split in two periods:

- ***aprmay*:** from 27/04 at 00 UTC to 01/06 at 00 UTC
- ***june***: from 02/06 at 06 UTC to 29/06 at 21 UTC

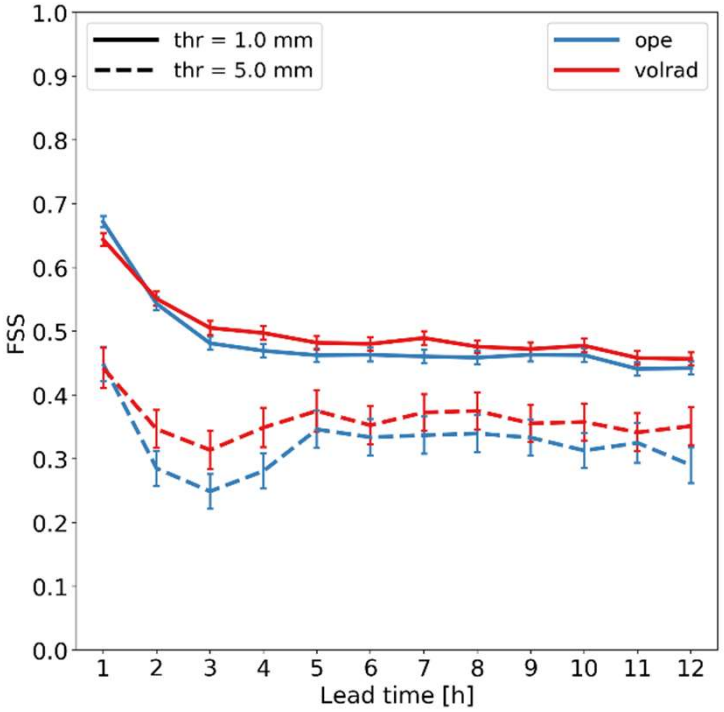
Verification

A 12h **deterministic** forecast is initialized every 3h from the deterministic analyses of both *ope* and *volrad*. Total forecasts for each period:

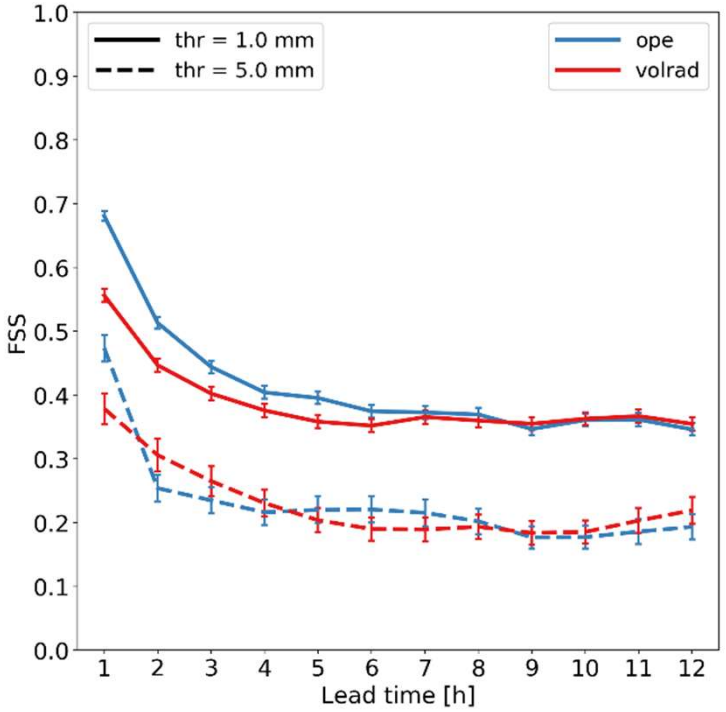
- ***aprmay*:** 224
- ***june***: 214

Forecast precipitation (FSS)

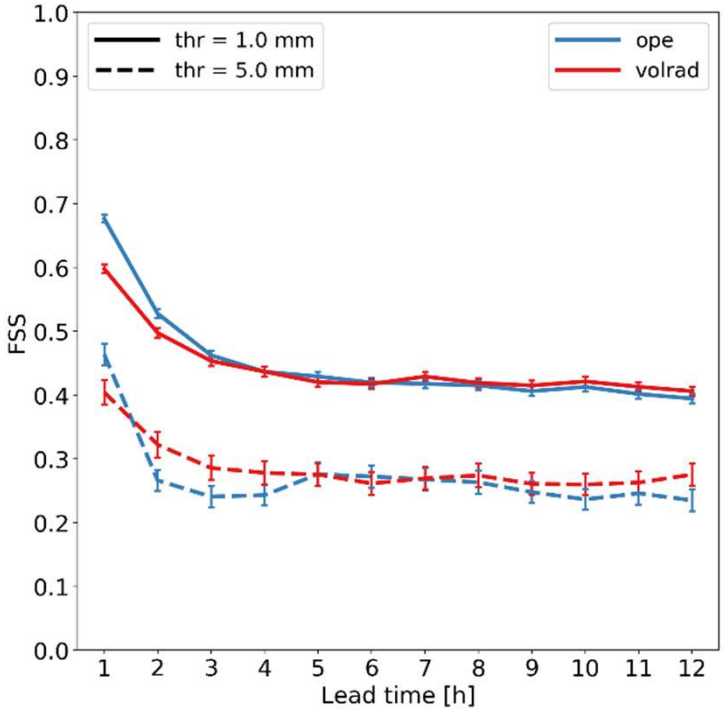
aprmay



june



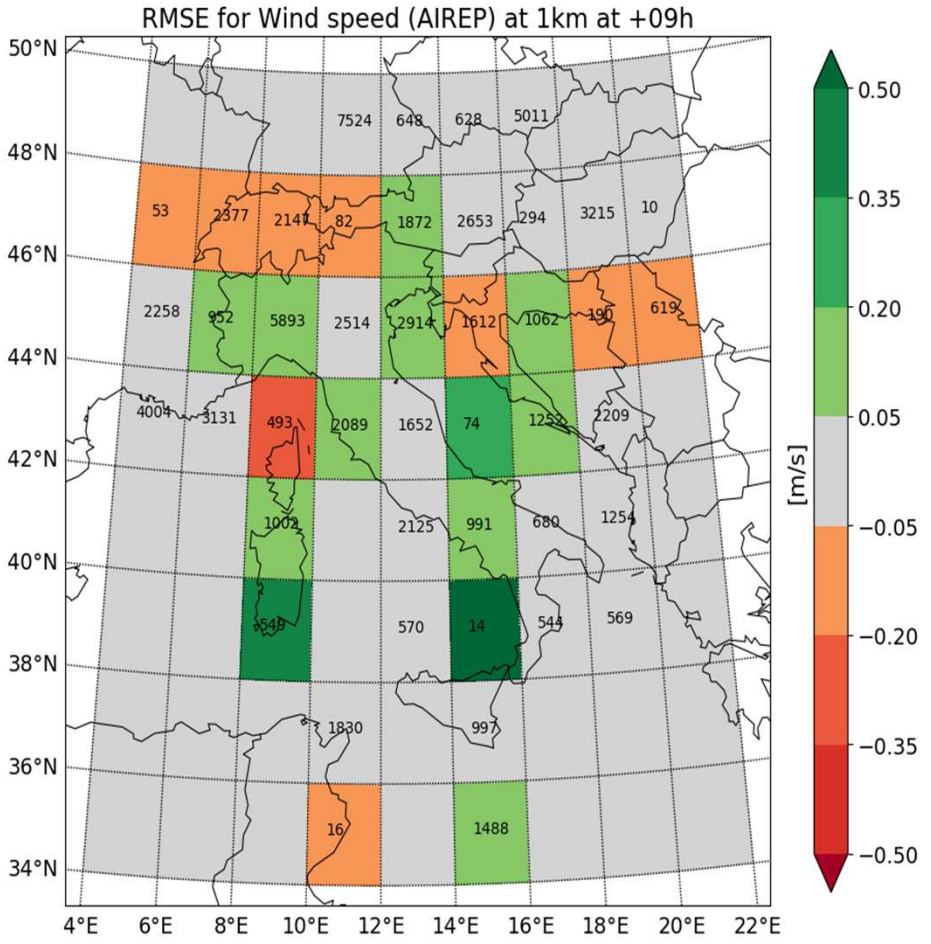
aprmay+june



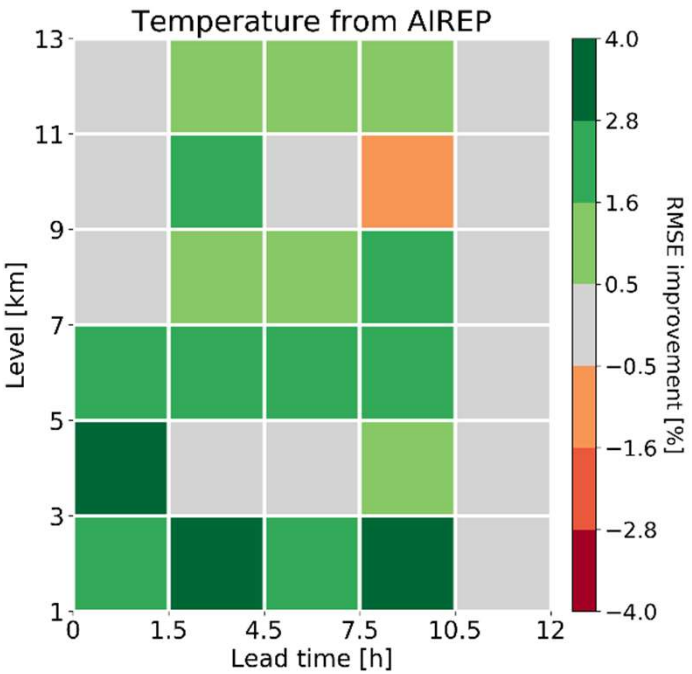
- Boxes of 0.2° X 0.2° over the Italian mainland
- Observations are hourly rainfall fields from the Italian radar composite adjusted by rain-gauges

Upper-air and surface variables

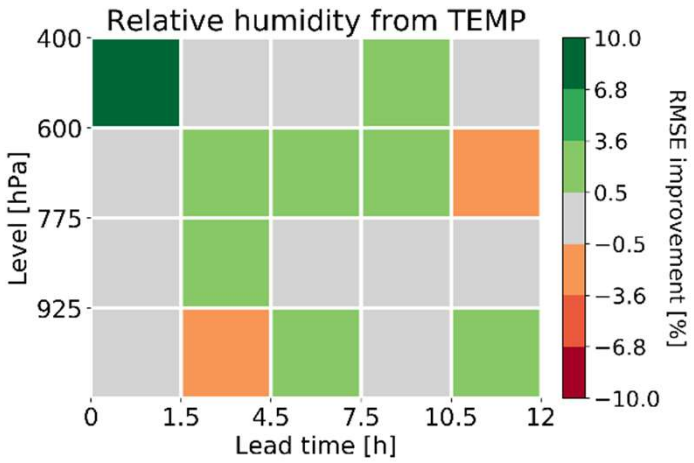
- Domain is divided into horizontal boxes of 2° x 2° and vertical layers of 2 km
- RMSE is computed for each horizontal box at each vertical layer and at a specific forecast time interval, if there are at least 60 observations
- For each forecast time interval and each vertical layer, the average of the RMSE values over all horizontal boxes is computed
- The difference between RMSE of *ope* and RMSE of *volrad* is computed



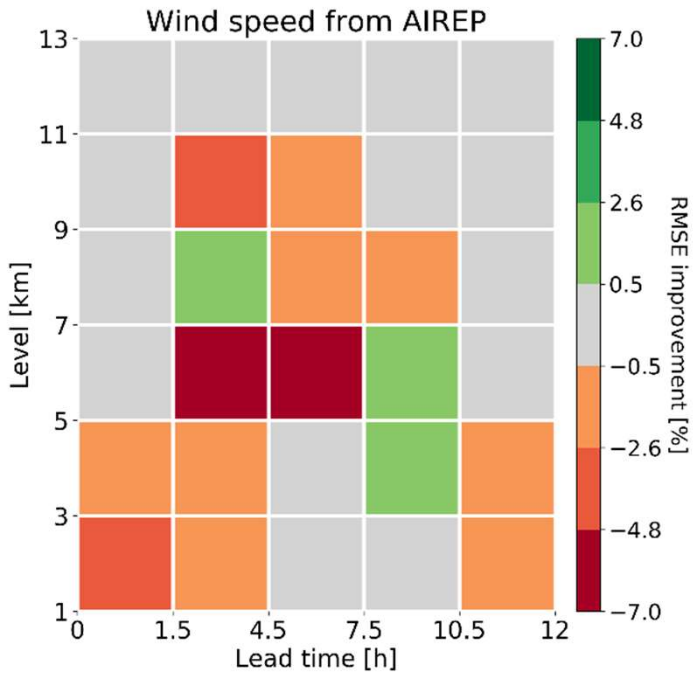
RMSE(*ope*) – RMSE(*volrad*): *aprmay*



Average number of obs.: 2197 (ranging from 905 to 7223)
Average RMSE (cntr): 0.86 K (ranging from 0.84 K to 1.43 K)

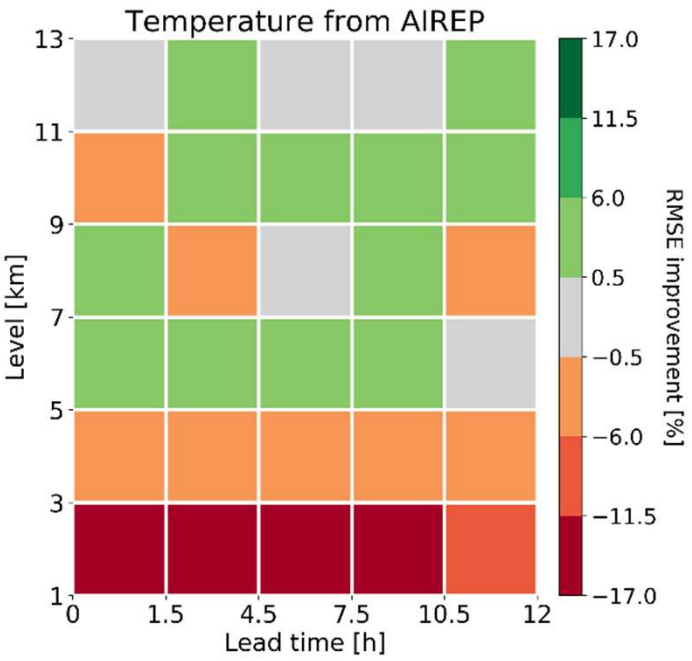


Average number of obs.: 3793 (ranging from 1926 to 6570)
Average RMSE (cntr): 0.16 kg/kg (ranging from 0.11 kg/kg to 0.23 kg/kg)

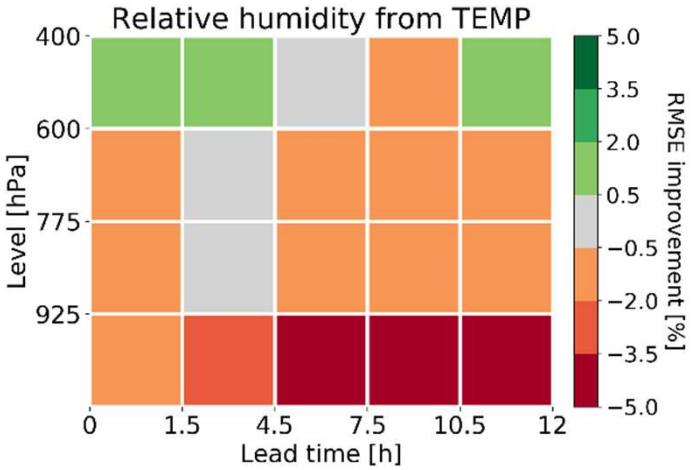


Average number of obs.: 1888 (ranging from 814 to 6090)
Average RMSE (cntr): 2.18 m/s (ranging from 2.35 m/s to 3.71 m/s)

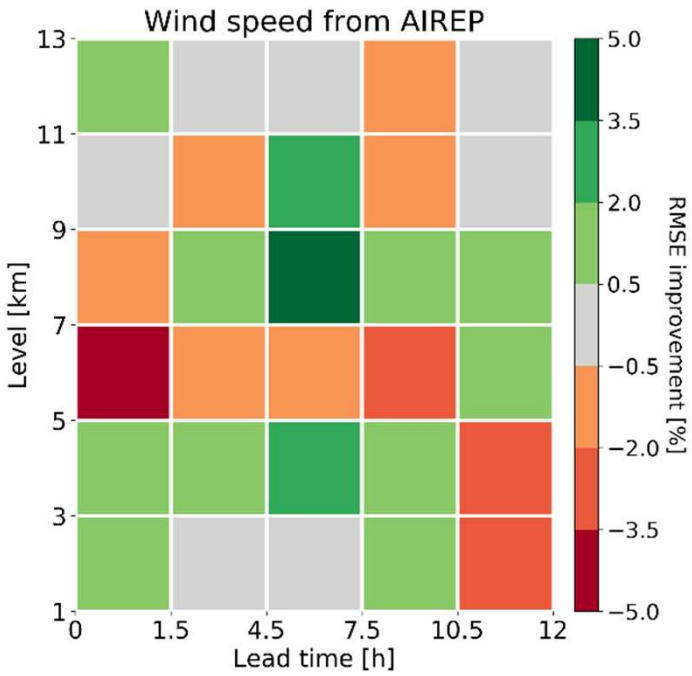
RMSE(*ope*) – RMSE(*volrad*): *june*



Average number of obs.: 7371 (ranging from 1393 to 19229)
Average RMSE (cntr): 1.06 K (ranging from 0.75 K to 1.53 K)

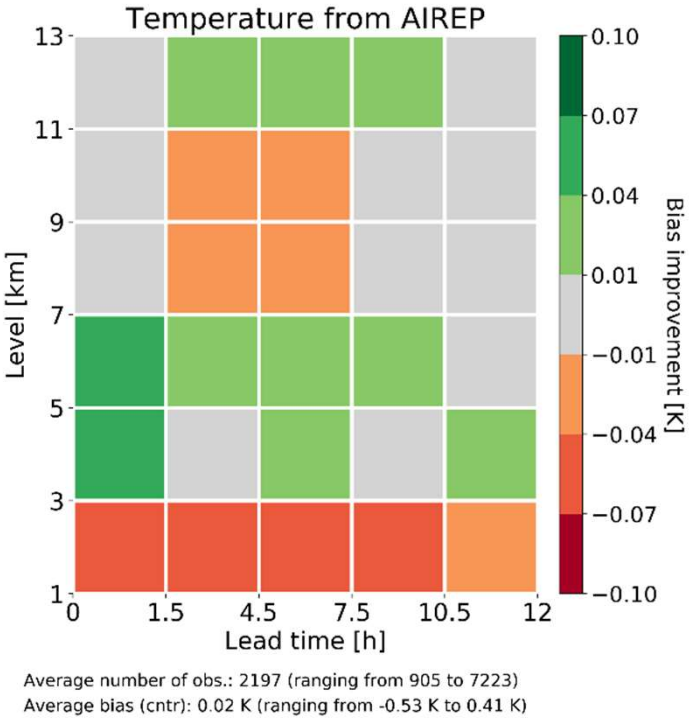


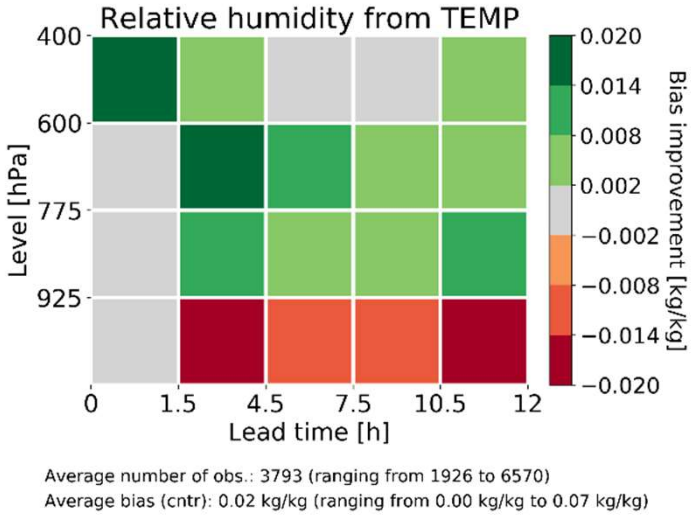
Average number of obs.: 4332 (ranging from 1418 to 6724)
Average RMSE (cntr): 0.19 kg/kg (ranging from 0.12 kg/kg to 0.23 kg/kg)

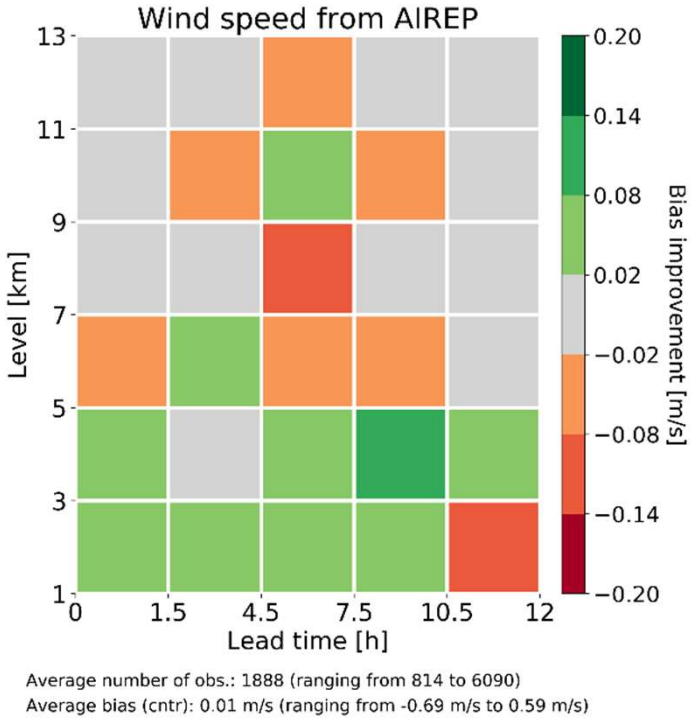


Average number of obs.: 6444 (ranging from 1176 to 16379)
Average RMSE (cntr): 2.89 m/s (ranging from 2.43 m/s to 3.64 m/s)

|bias(*ope*)| – |bias(*volrad*)|: *aprmay*



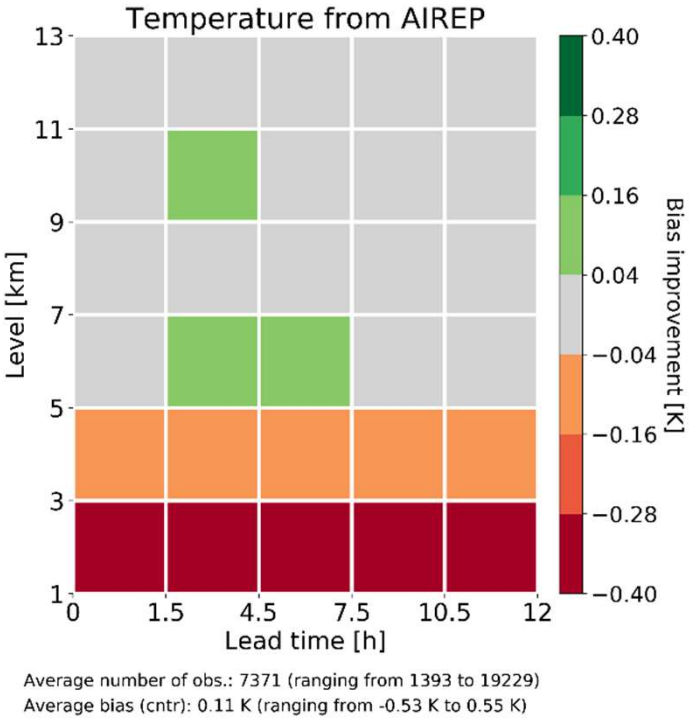


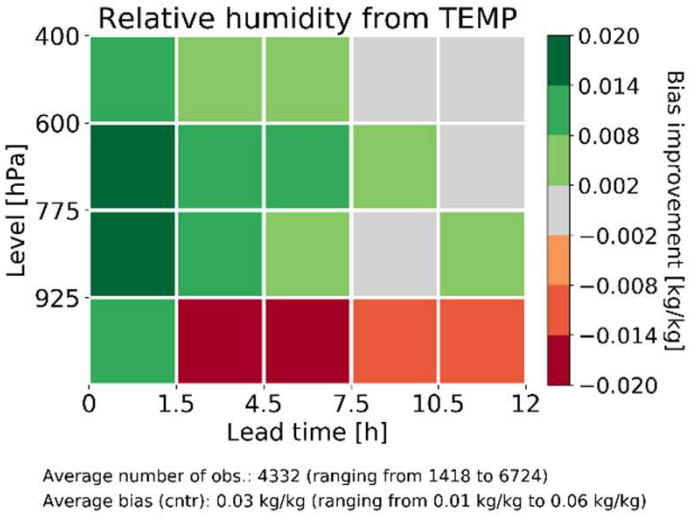


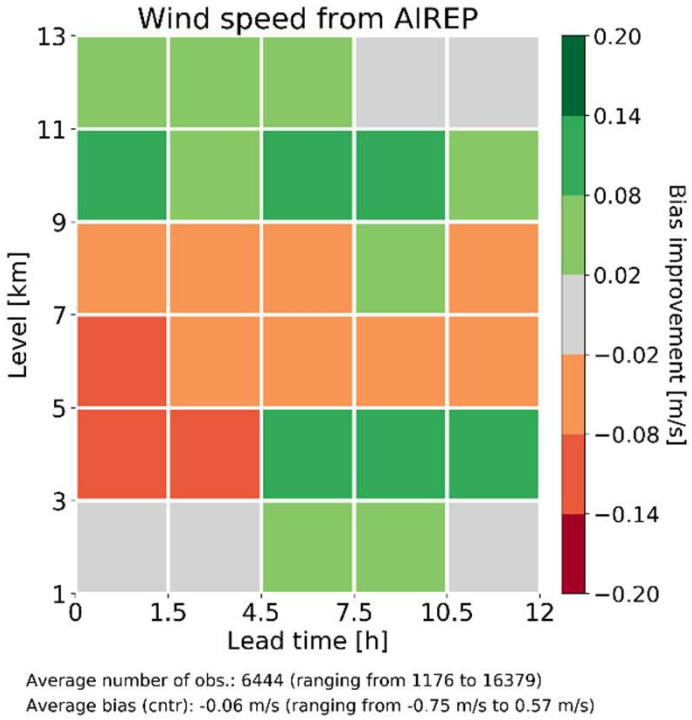
Close to the surface, *ope* has a positive bias; *volrad* is even warmer

At each level, v*olrad* is drier than *ope*

|bias(*ope*)| – |bias(*volrad*)|: *june*



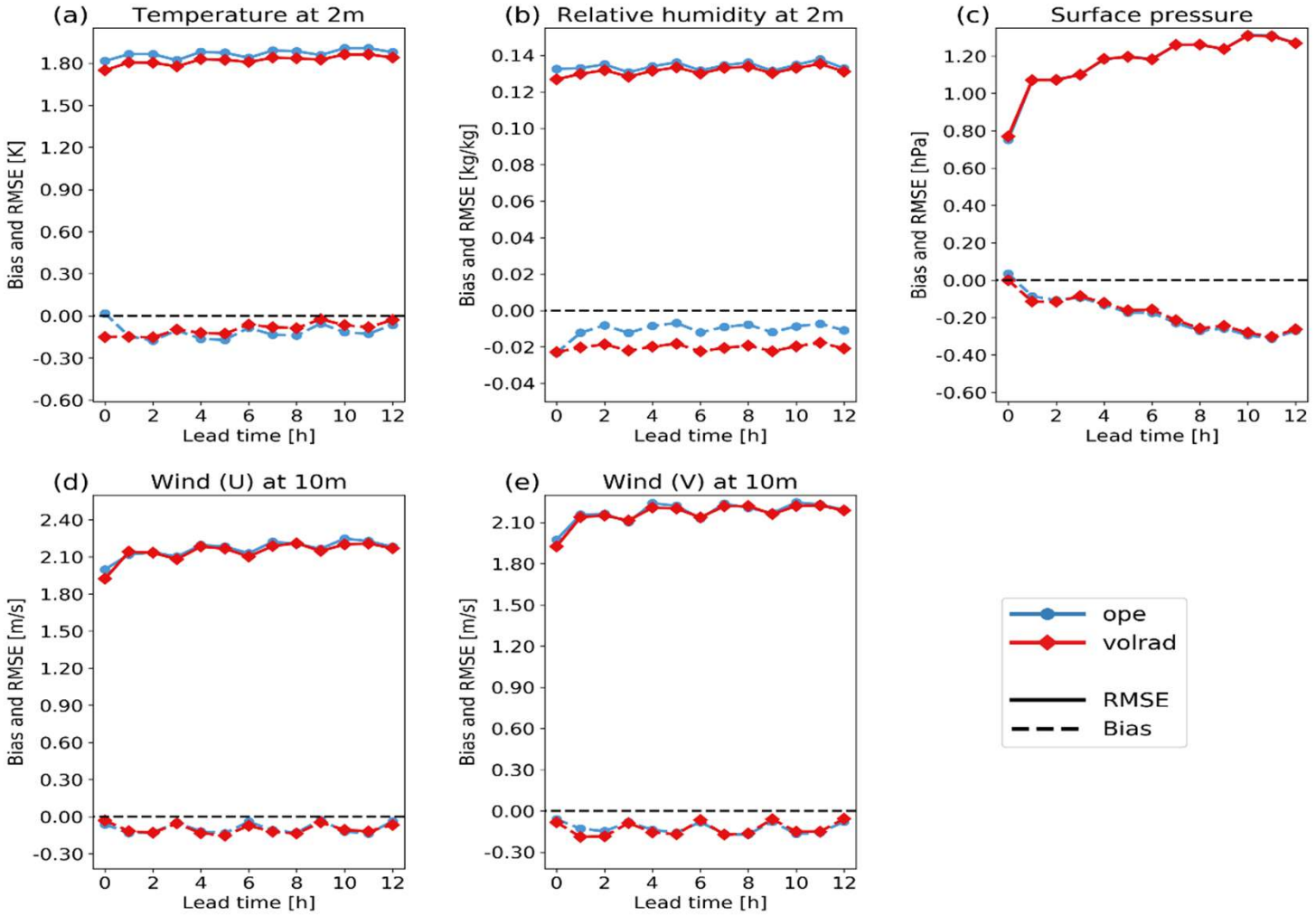




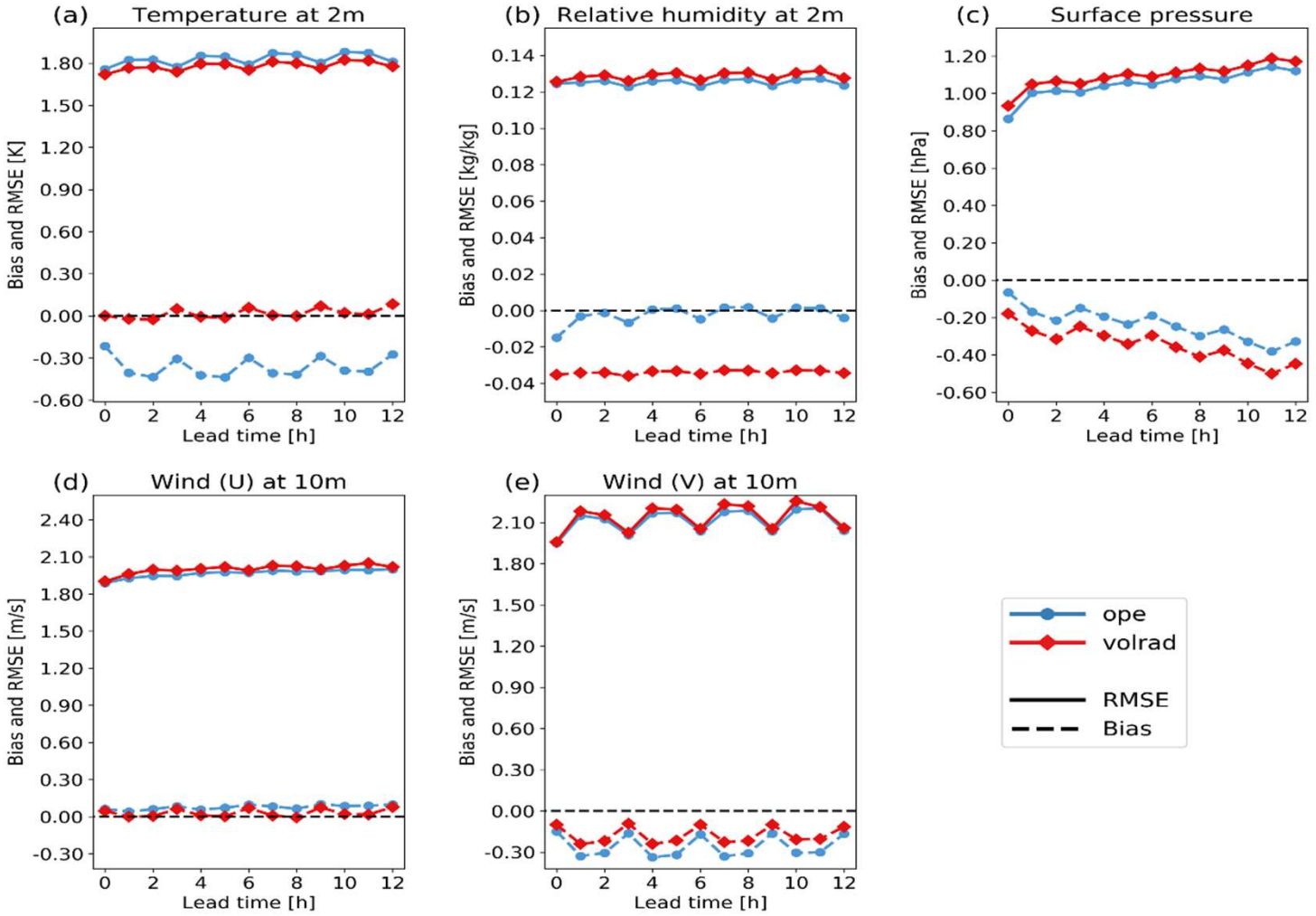
Close to the surface, *ope* has a positive bias; *volrad* is even warmer

At each level, v*olrad* is drier than *ope*

Surface variables: *aprmay*

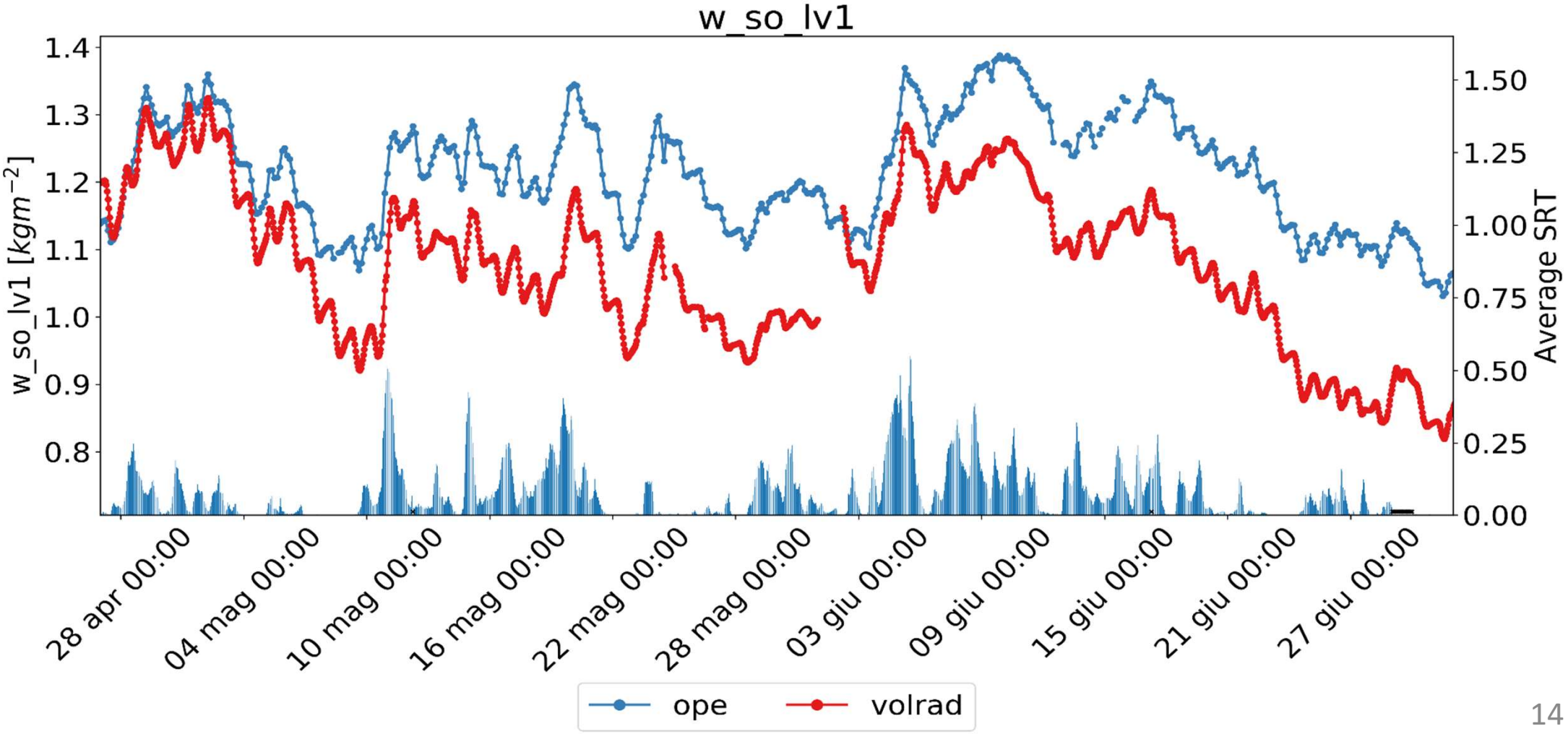


Surface variables: *june*



Why?

Soil humidity at first level (domain average)



Why?

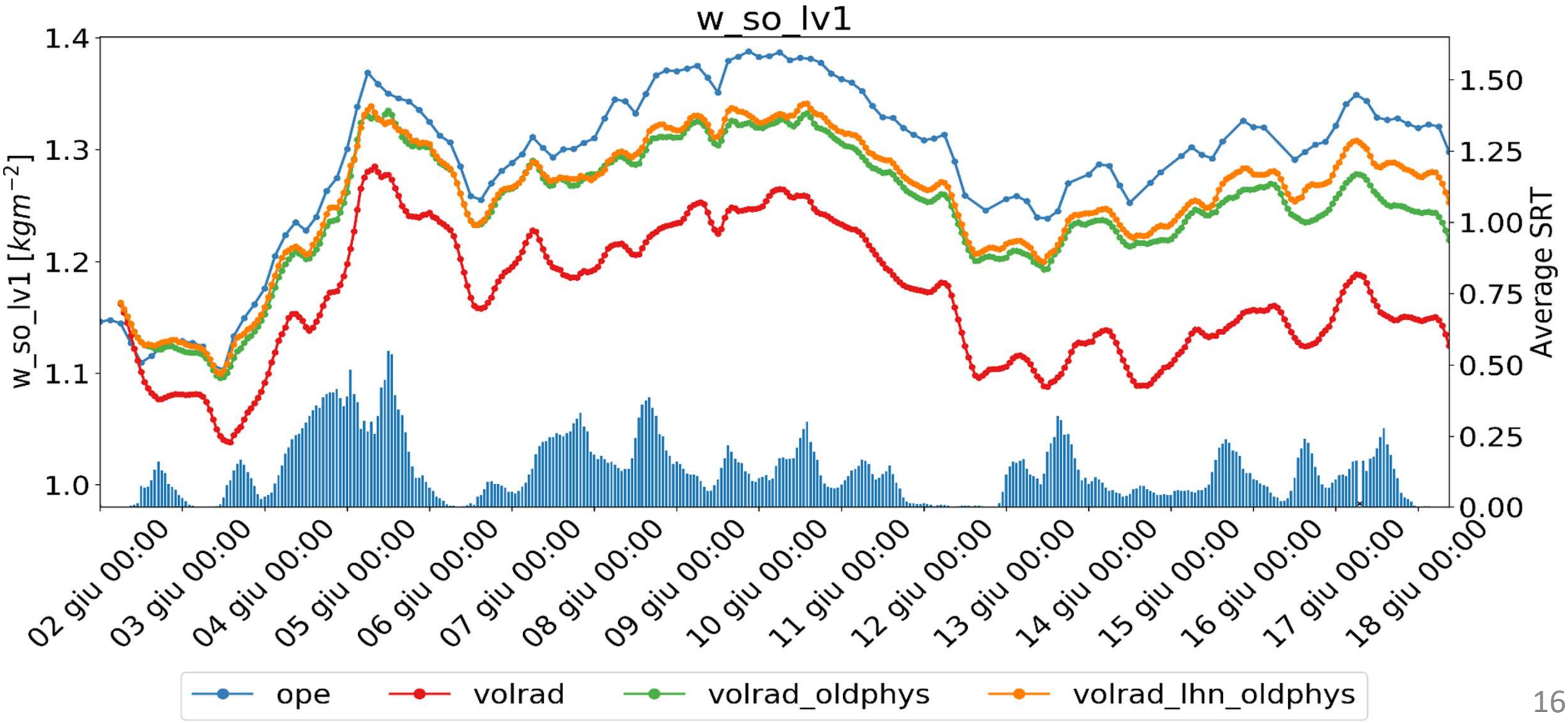
volrad uses the **new** physics (loldtur=.FALSE.) while *ope* uses the **old** one.

Two new experiments are run:

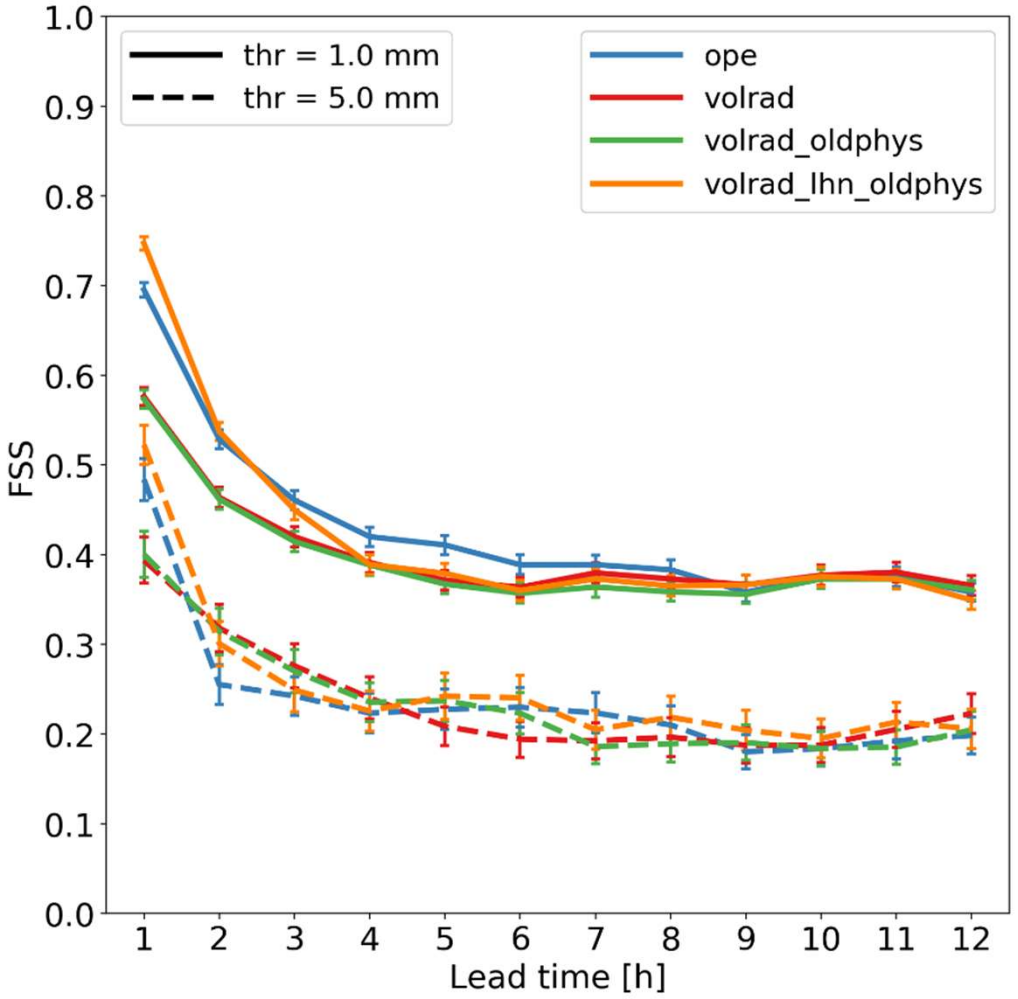
- ***volrad_oldphys***: same as *volrad* but using the same namelist of *ope* (old physics)
- ***volrad_lhn_oldphys***: same as *volrad_old_phys* but using LHN in combination with the direct assimilation of reflectivity volumes.

Evaluation period: from 02/06 at 06 UTC to 18/06 at 06 UTC. The verification is based on 121 deterministic forecasts.

Soil humidity at first level (domain average)

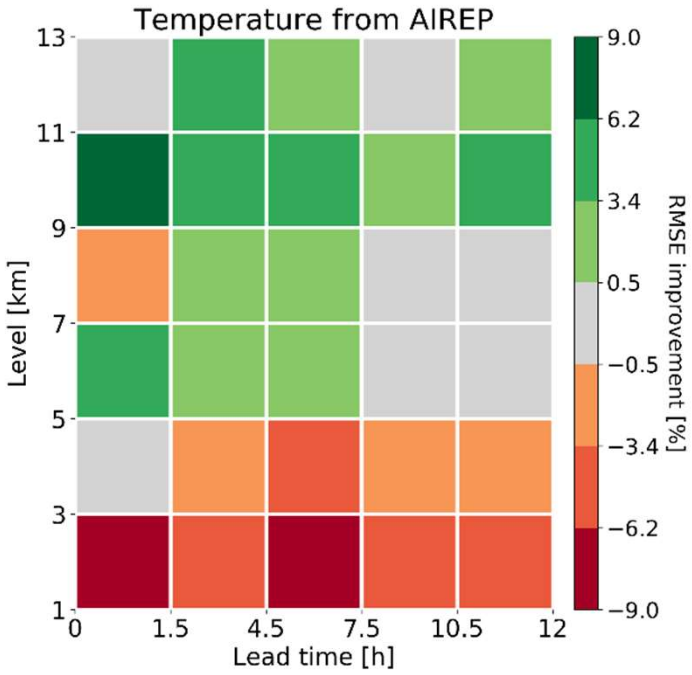


Forecast precipitation (FSS)



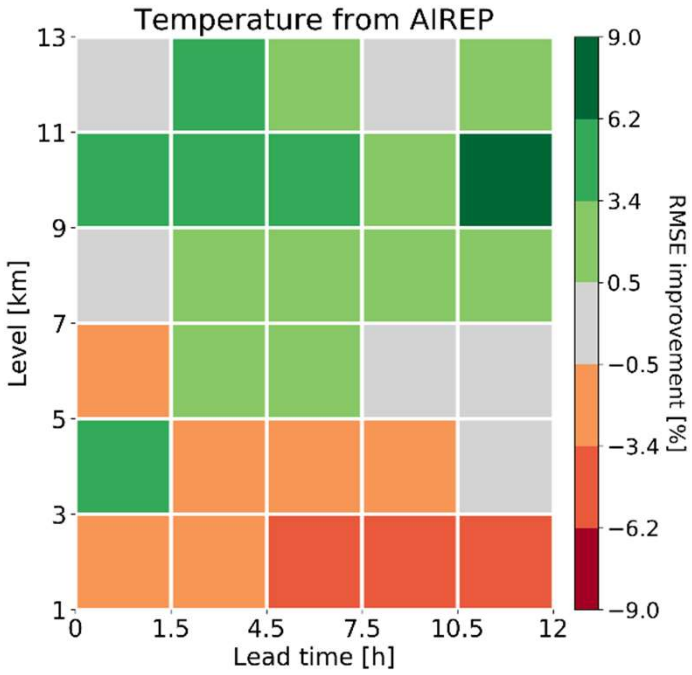
Temperature: RMSE(*ope*) – RMSE(exp)

exp = *volrad*



Average number of obs.: 3137 (ranging from 576 to 9031)
Average RMSE (cntr): 1.05 K (ranging from 0.81 K to 1.47 K)

exp = *volrad_oldphys*



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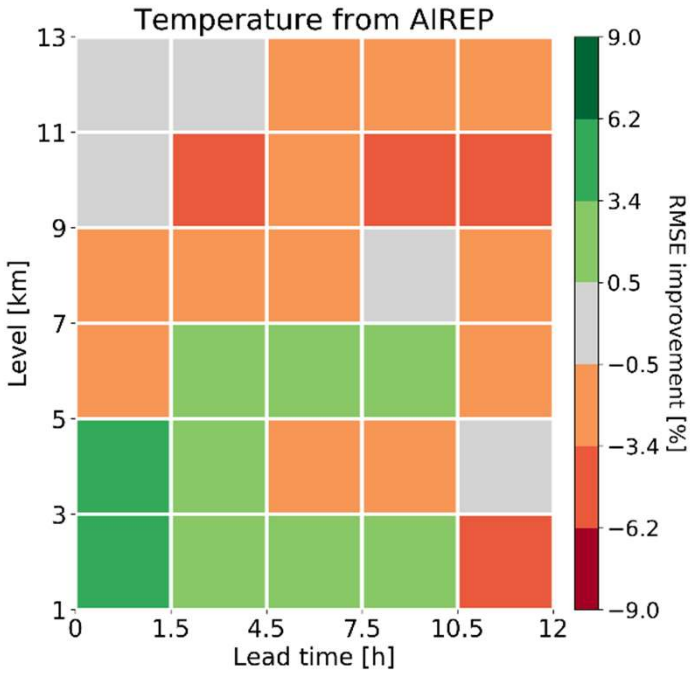

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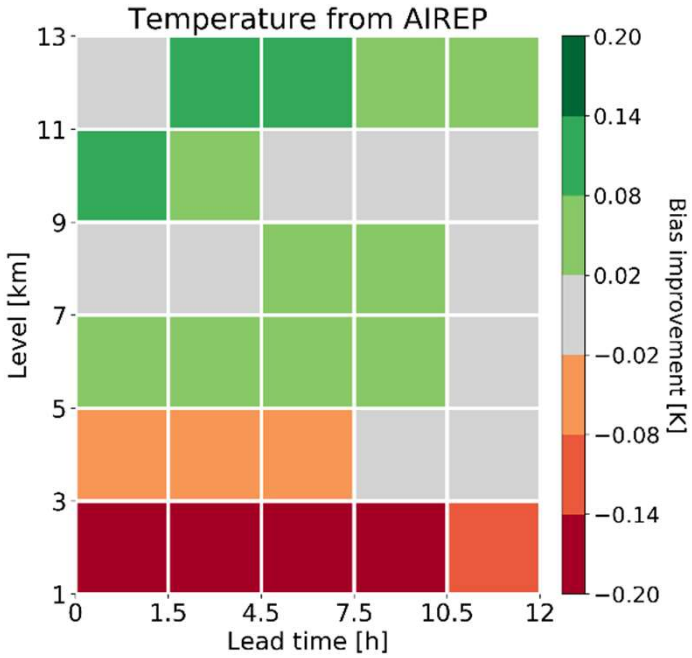
Temperature: |bias(*ope*)| – |bias(exp)|

exp = *volrad*



Average number of obs.: 3137 (ranging from 576 to 9031)
Average bias (cntr): 0.16 K (ranging from -0.49 K to 0.60 K)

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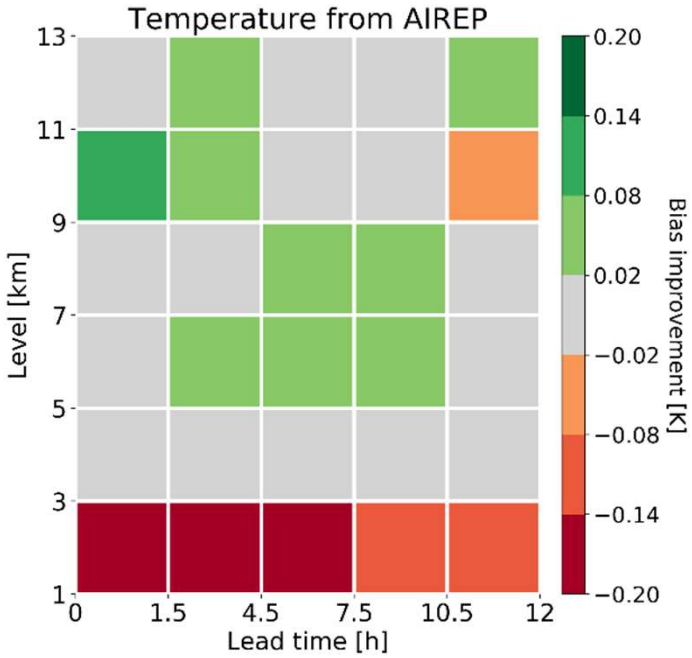

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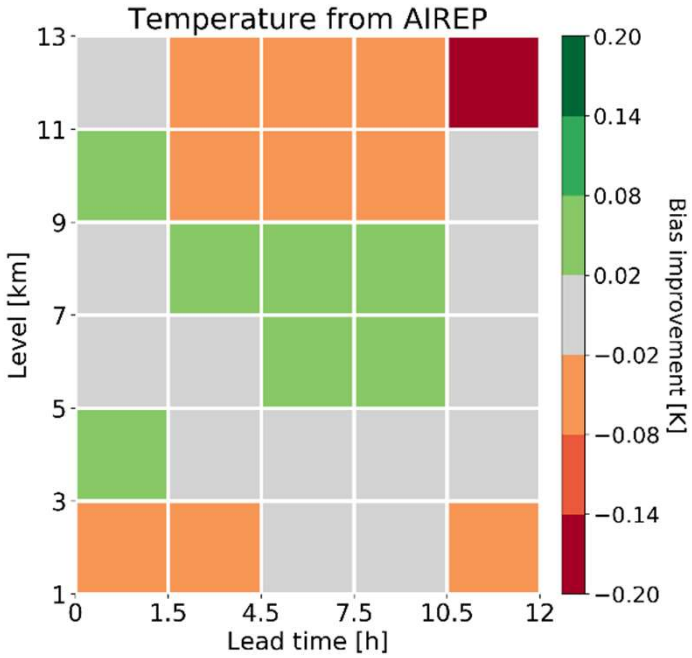
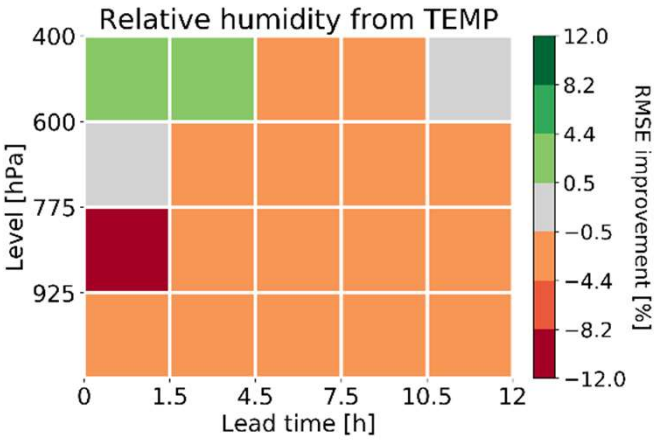


Average number of obs.: 3137 (ranging from 576 to 9031)
Average bias (cntr): 0.16 K (ranging from -0.49 K to 0.60 K)

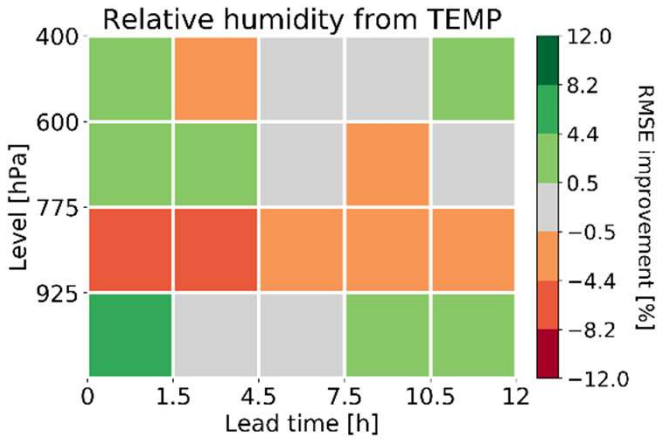
Relative humidity: |bias(*ope*)| – |bias(exp)|

exp = *volrad*



Average number of obs.: 2397 (ranging from 696 to 3932)
Average RMSE (cntr): 0.18 kg/kg (ranging from 0.11 kg/kg to 0.23 kg/kg)

exp = *volrad_oldphys*



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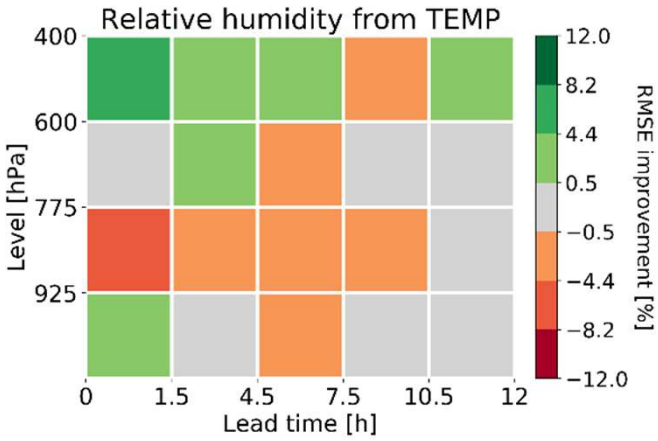

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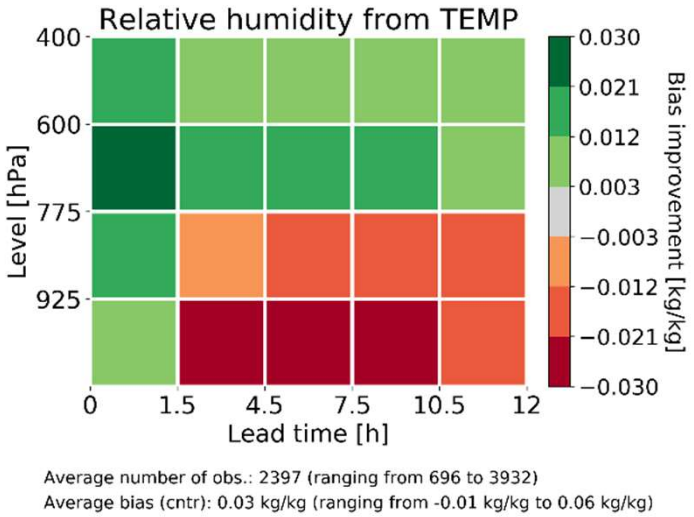
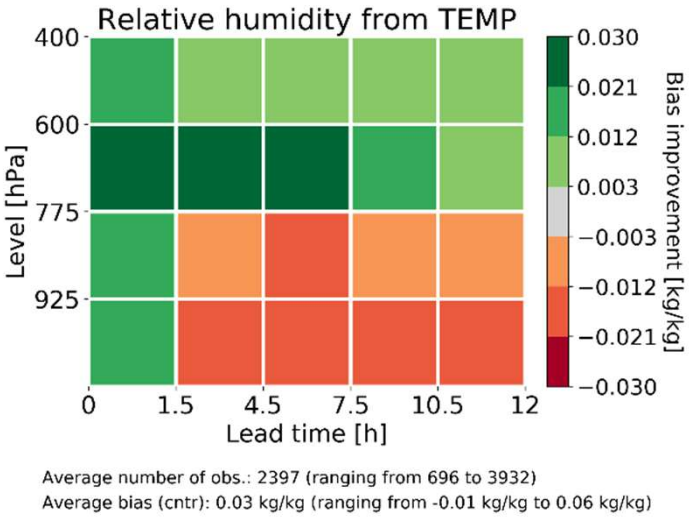
Relative humidity: RMSE(*ope*) – RMSE(exp)

exp = *volrad*



Average number of obs.: 2397 (ranging from 696 to 3932)
Average bias (cntr): 0.03 kg/kg (ranging from -0.01 kg/kg to 0.06 kg/kg)

exp = *volrad_oldphys*



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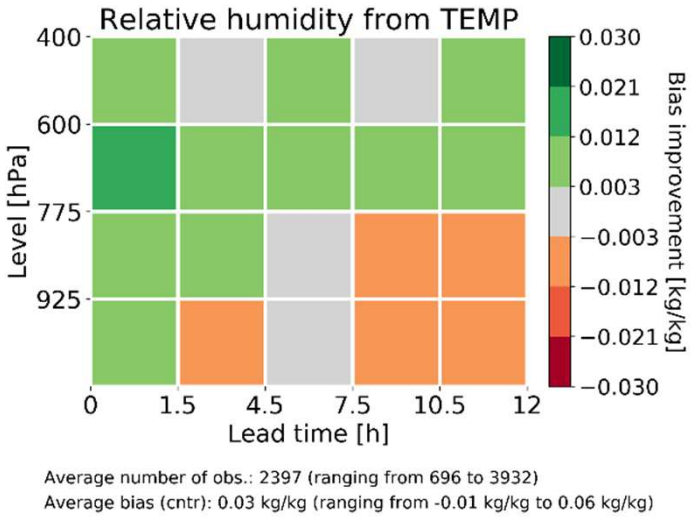

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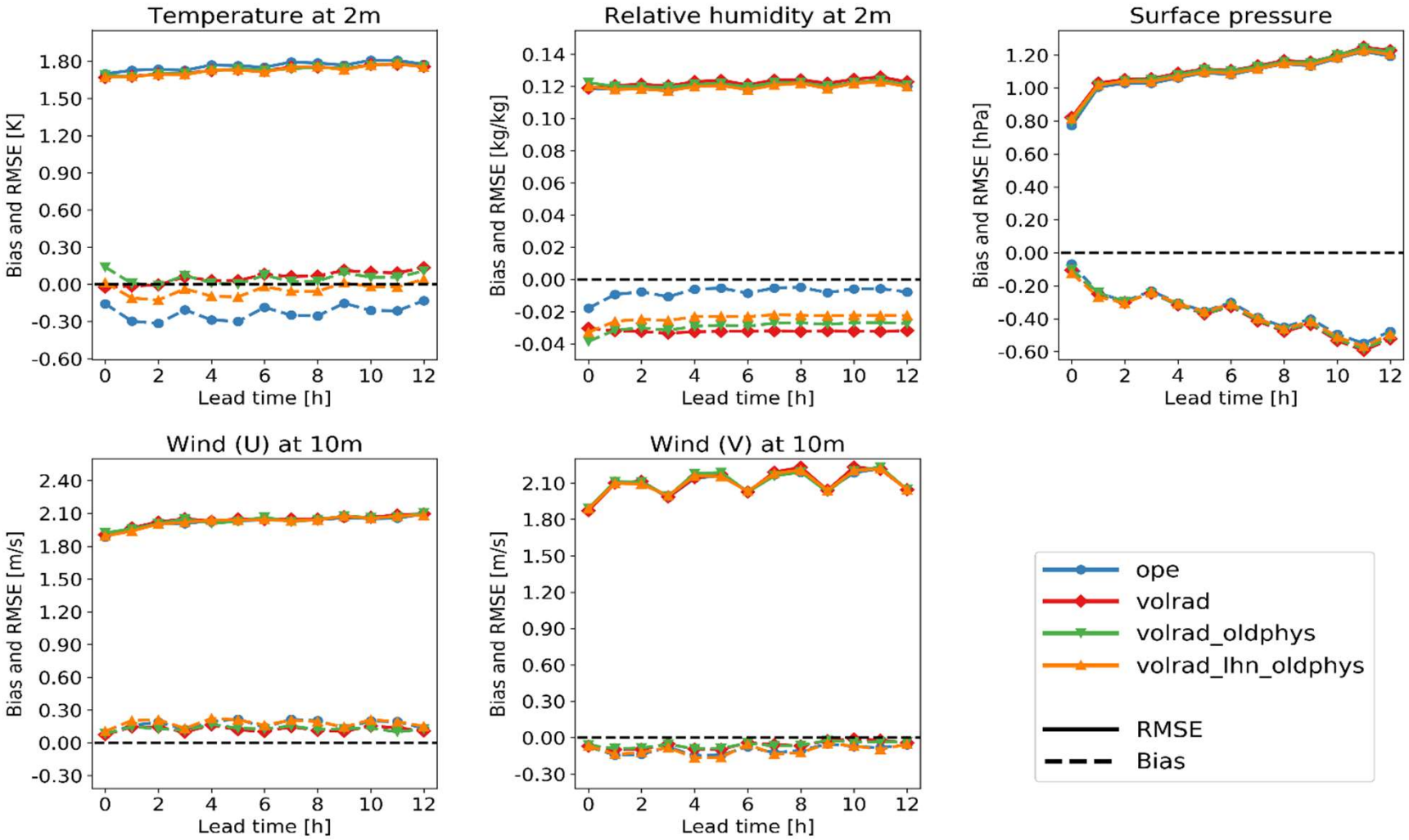
Surface variables



Conclusions

- At the end of April and May, the assimilation of reflectivity volumes outperforms LHN, as observed in the previous experiments.
- In June, LHN outperforms the assimilation of reflectivity volumes; the combination of both method is slight worse than LHN.
- The use of the new physics dries the soil, but this has no impact on QPF!
- The assimilation of reflectivity volumes dries the soil compare to LHN. Accordingly, 2-meter temperature is higher and relative humidity is lower. This effect was already observed in the previous experiments but the effect was milder.

Future plans

- Parallel suite has been restarted in August 28.
- When assimilation of reflectivity volumes will be operational (hopefully in Autumn) we will start to investigate the impact of radial winds and the use of more radars which are now available.
- We are planning to study the assimilation of other observations, in particular from satellites.

Thank you!