Update on AROME-RUC (ZAMG)

Florian Meier

LACE
nwp central europe

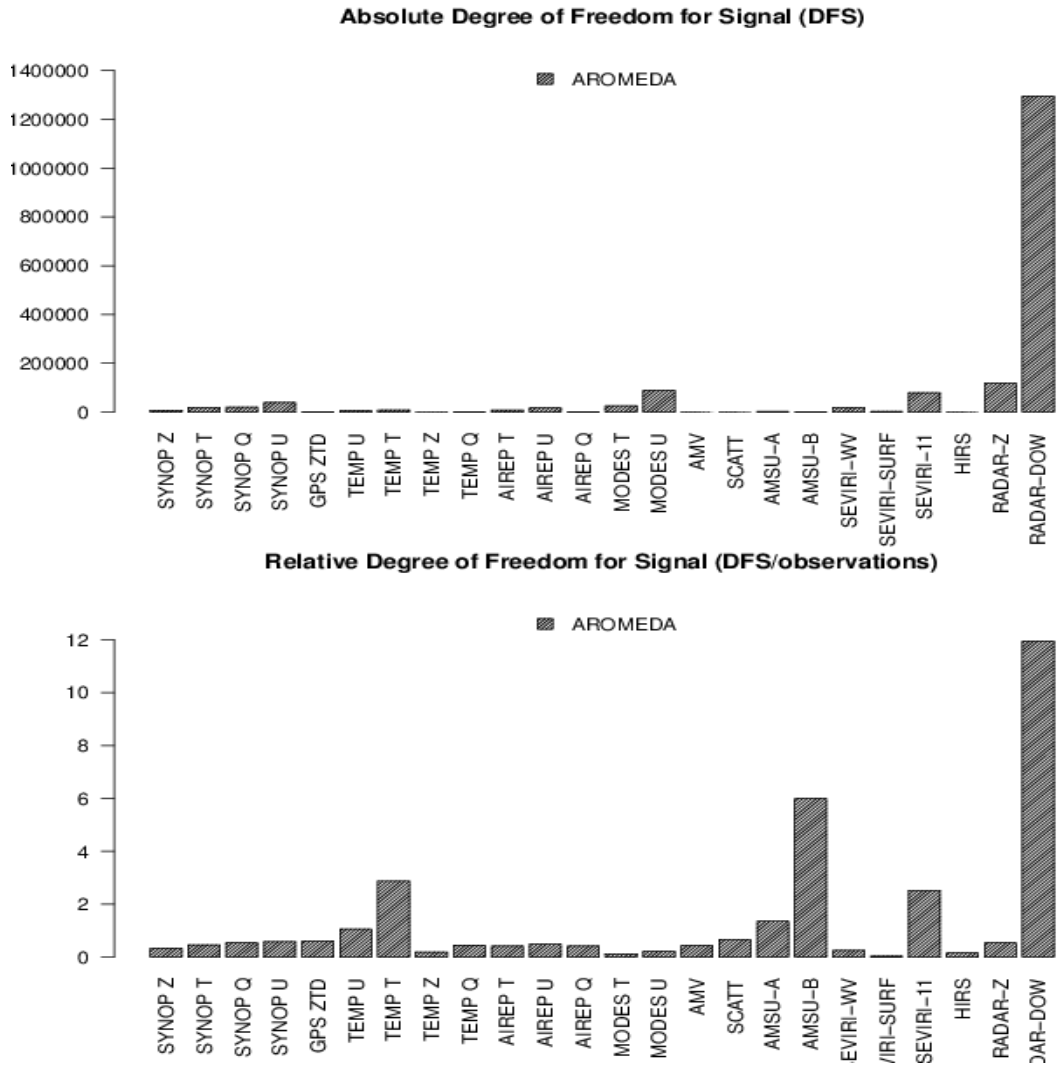
ZAMG
Zentralanstalt für
Meteorologie und
Geodynamik

Outline

- Observation impact
- Spin_up
- wind profiler
- radar + bator cy40t1->cy43t2
- Assimilation of private weather stations

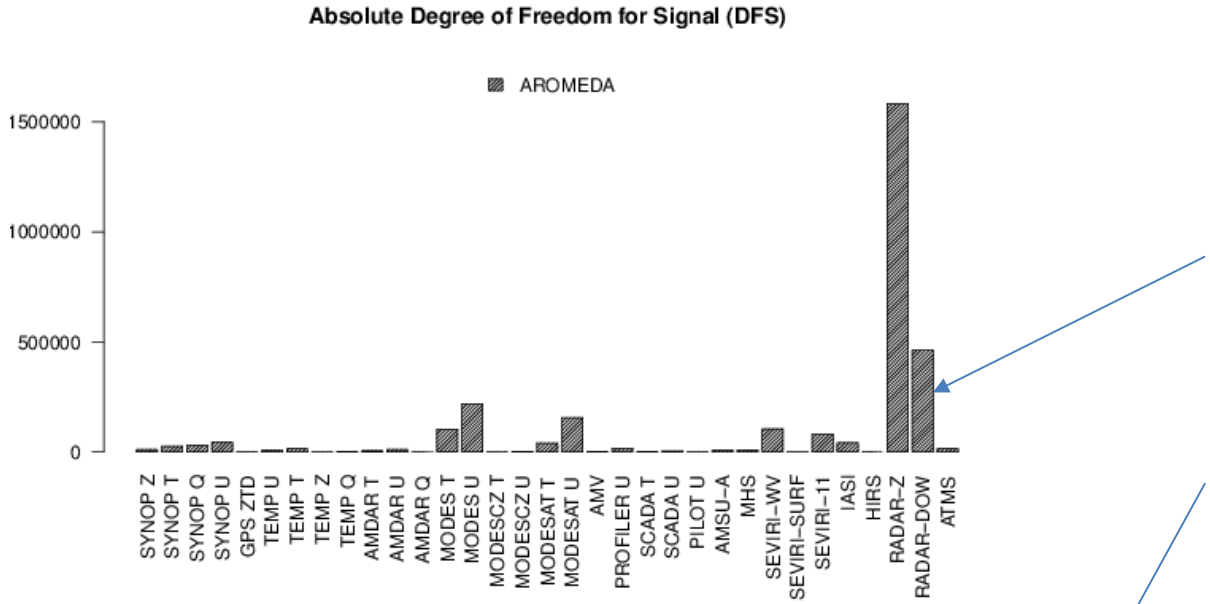
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

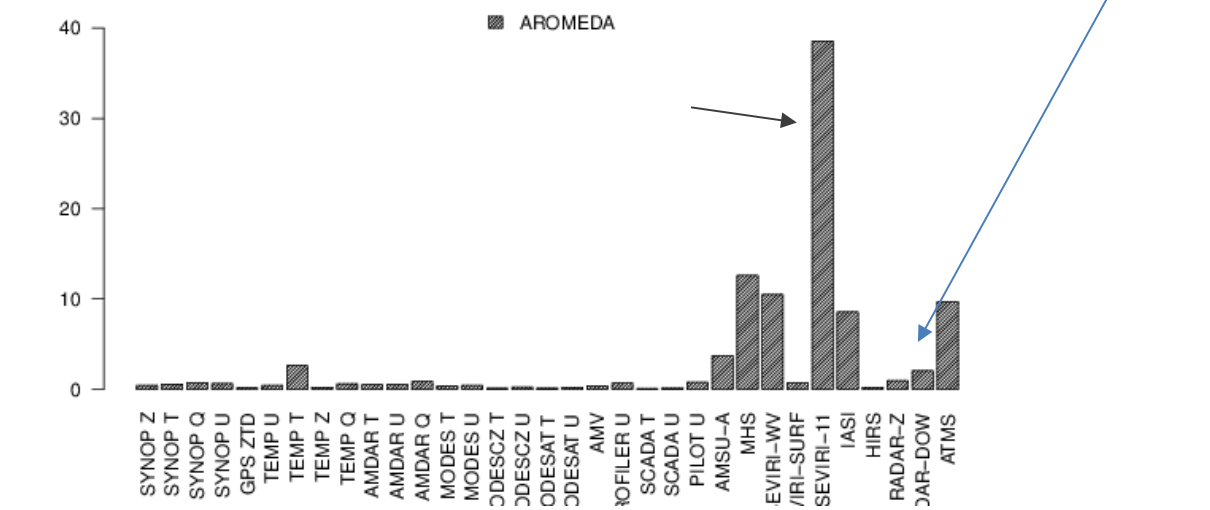
DFS in AROME-RUC (old setting noVARQC, larger rejection limit for DOW):



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

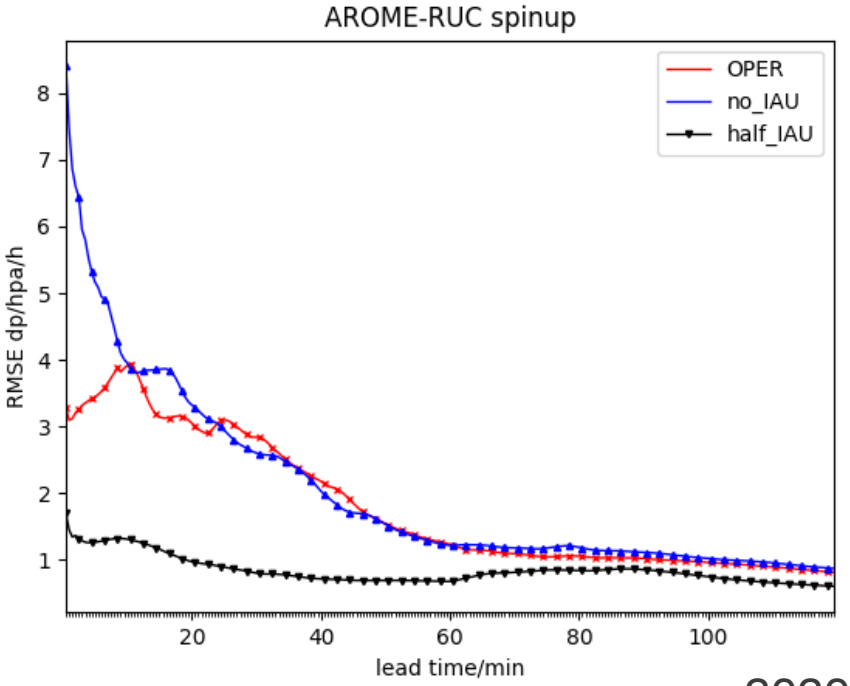
DFS in AROME-RUC current setting:

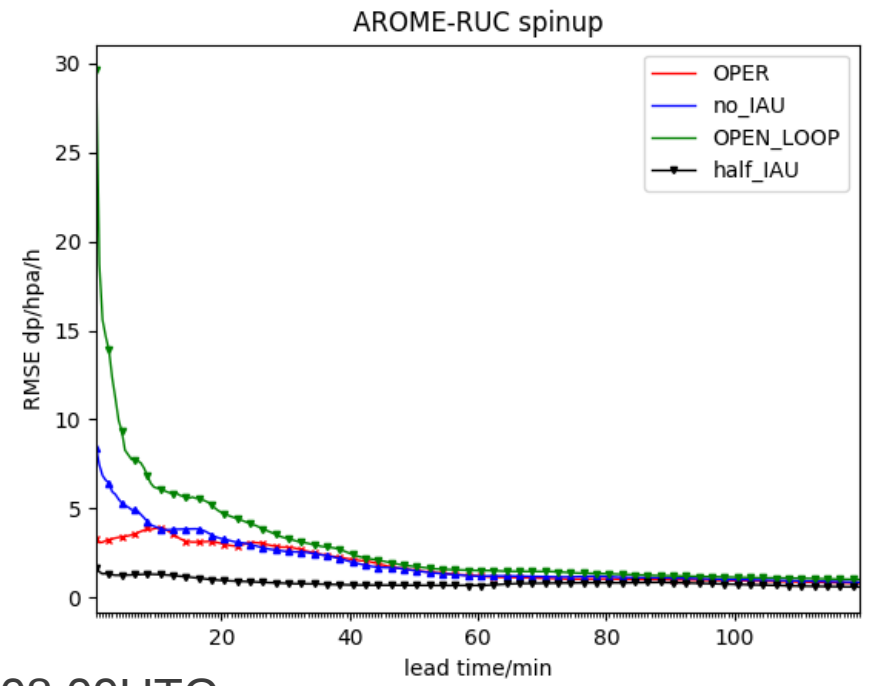




ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Spin-Up





20200908 09UTC

- -45min to 0 min IAU is very efficient in filtering (black); accuracy?
- no_IAU: directly started from Minimization output
- 2x IAU (OPER) still better than without IAU especially till +20min,
  but not so much at +1h
- Open loop has most spin-up issues as there is interpolation of FG 2.5 -> 1.2km
- Most of the spin up until +60min gone

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Assimilation of wind profilers / wind turbines/ SODAR

- KNMI reported problem with height attribution (Videomeeting, no details)

- Observation is function of height, but model needs pressure
  ->BATOR ecriture: „conversion altitude en pression si necessaire“
  assumes standard atmosphere, which can be far from reality especially in PBL
  error of 20m and more

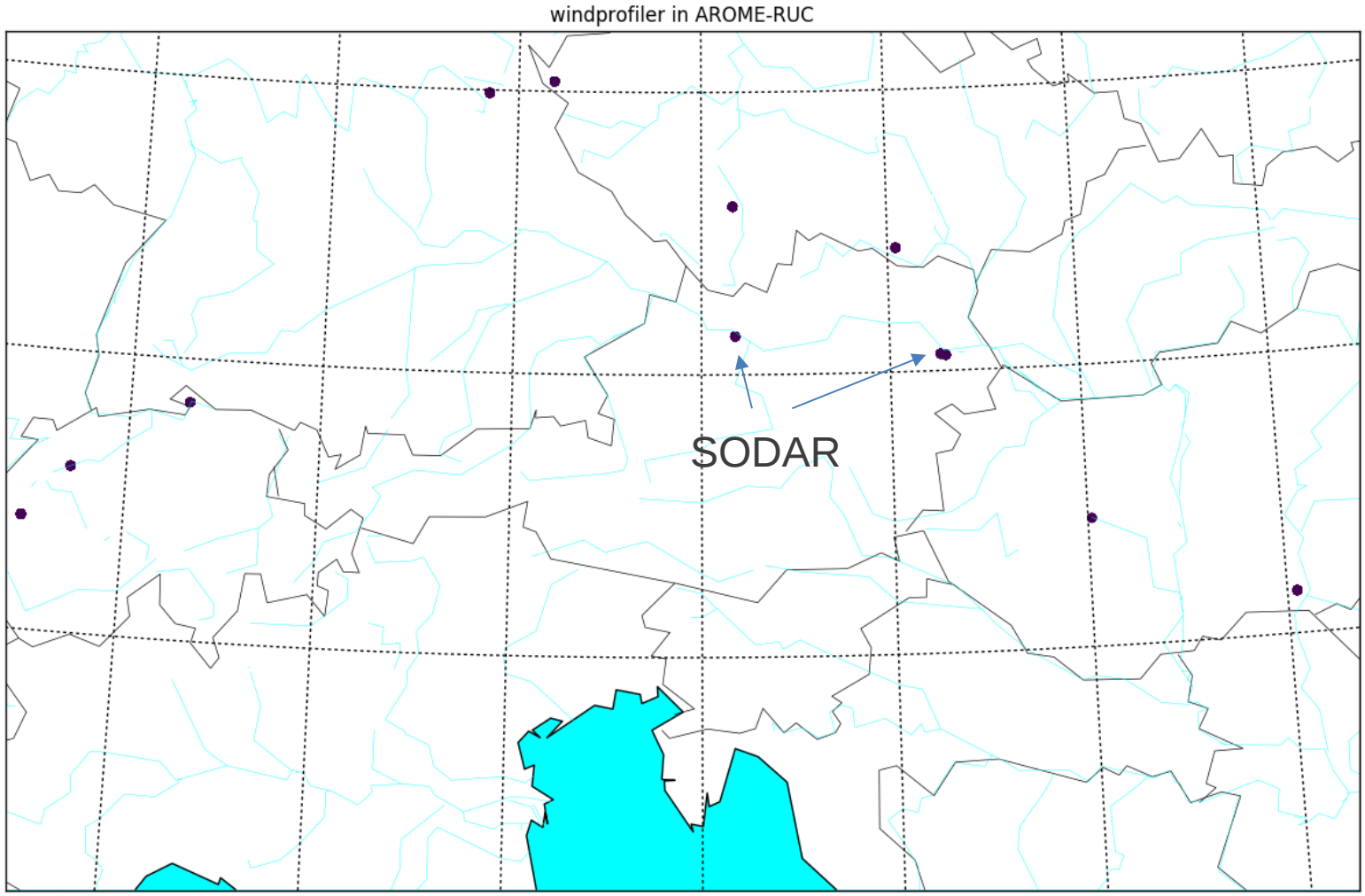
- Take pressure/temperature/height relation from FG instead (barometric equation)
  -> coded in hretr.F90/hretr_conv.F90 (cy43t2) (see LACE forum)
  -> KNMI has different solution in hop.F90
- Depending on FG, which is not so nice, if FG is incorrect, but assumption of standard atmosphere can deviate even more (T inversion etc.)

- Profiler data from OPLACE -> adaptation of param.cfg „WARNING - template inconnu“
  in BATOR many different bufr templates

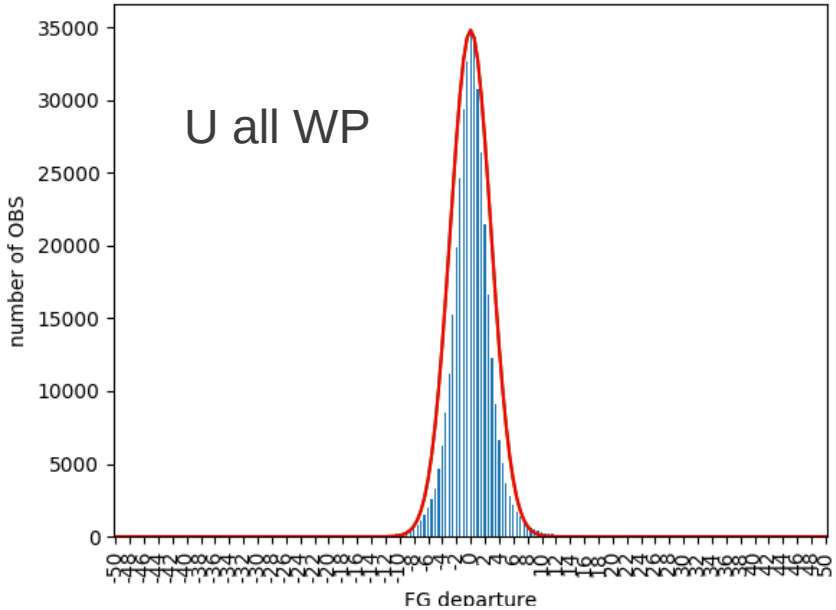
- blacklist VAD profiles in LISTE_NOIR_DIAP
- SODAR to obsoul

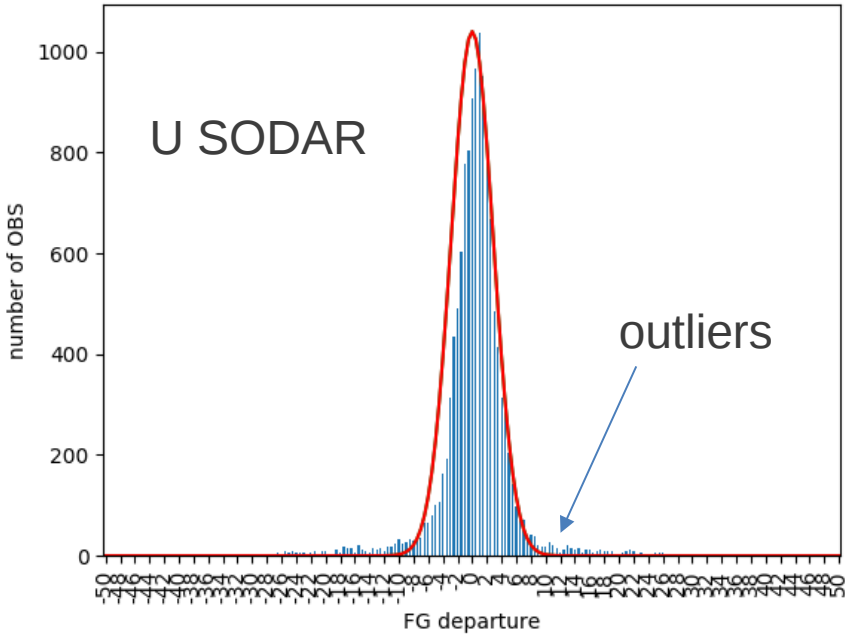
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Assimilation of wind profilers / SODAR

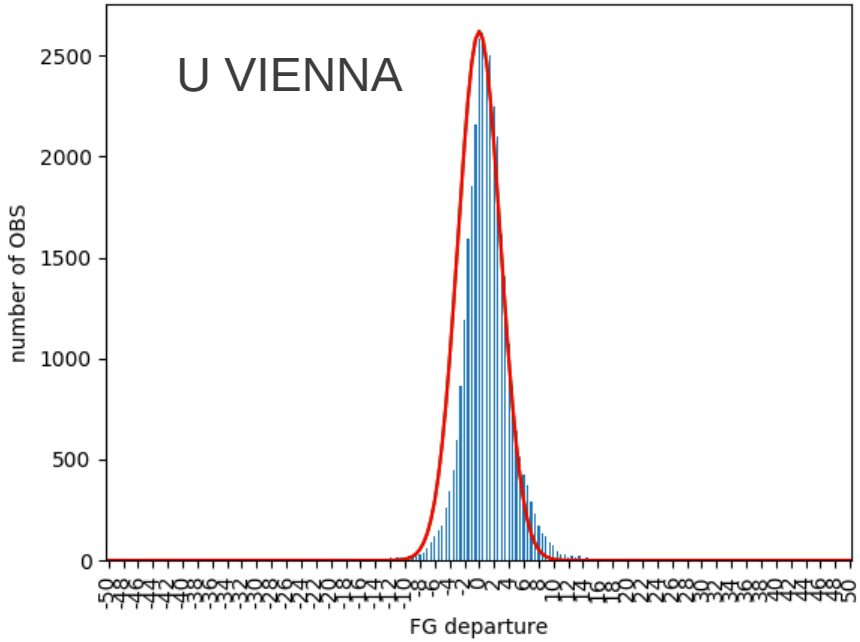


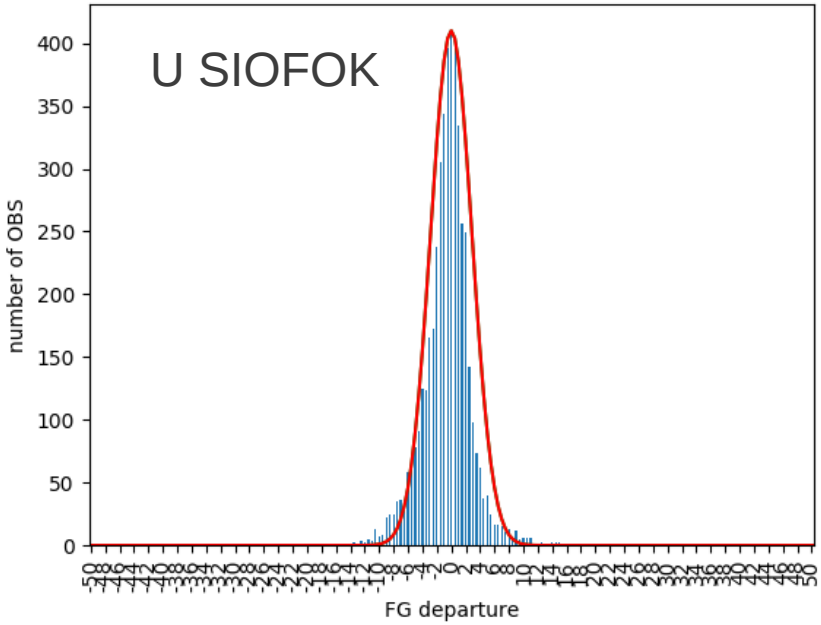
ZAMG
Zentralanstalt für Meteorologie und Geodynamik



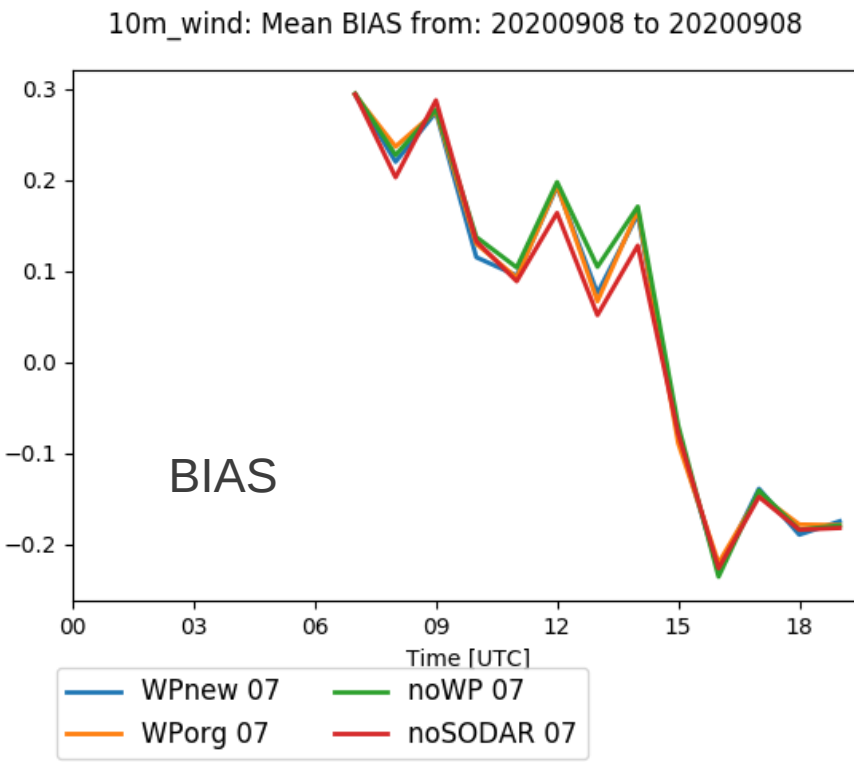


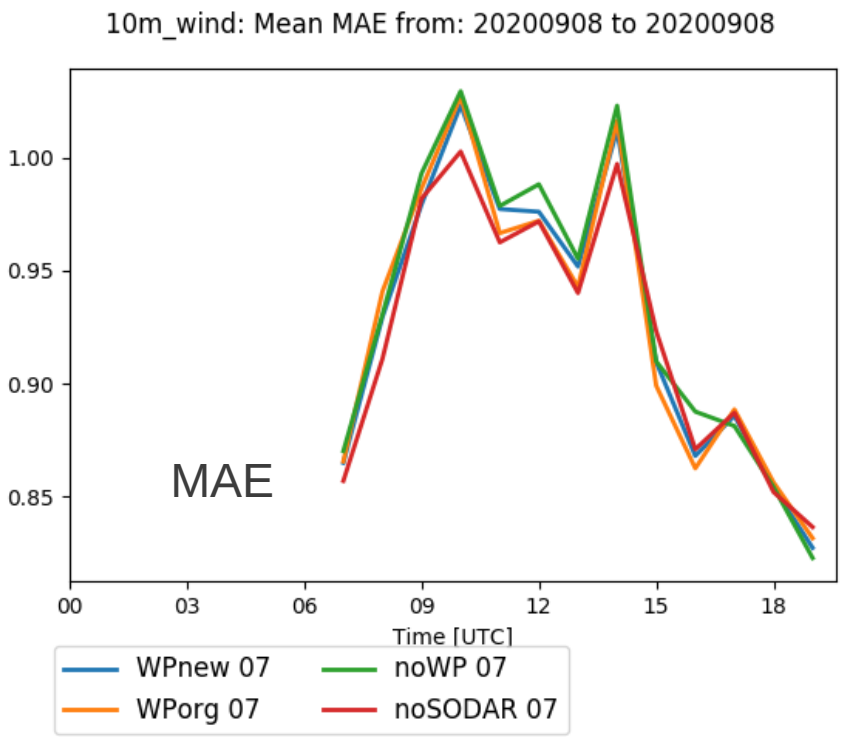
FG-departures 20200819-20200831





Assimilation of wind profilers / SODAR case study





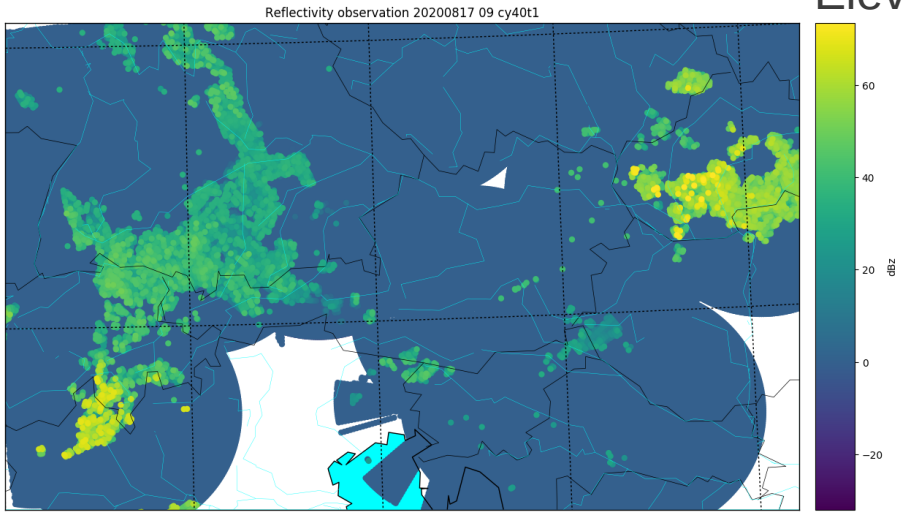
- Yellow WP+SODAR with height attribution from standard atmosphere
- Blue as yellow, but height attribution from First Guess
- Red as blue, but without SODAR only WP assimilated
- Green: reference without WP and SODAR

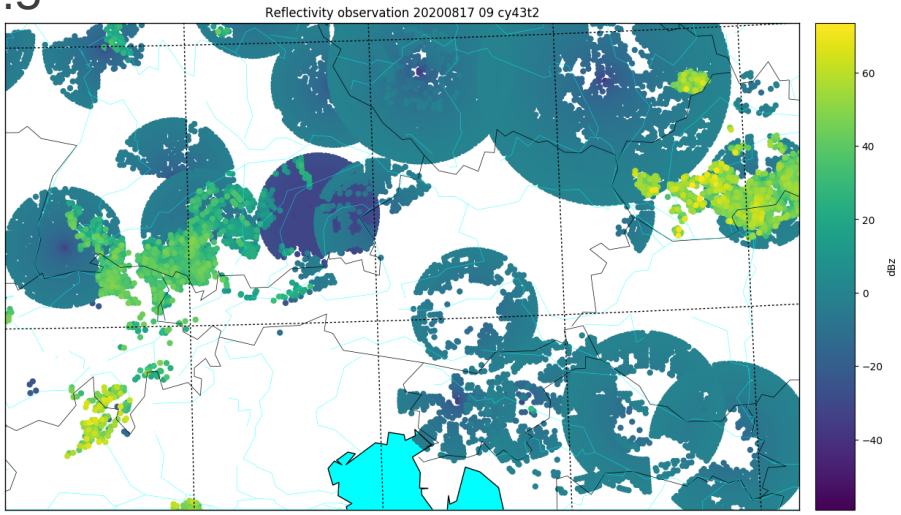
-> in principle nice impact, but SODAR needs better quality checks

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Reflectivity in BATOR cy40t1 (HIRLAM modified) vs cy43t2 MF

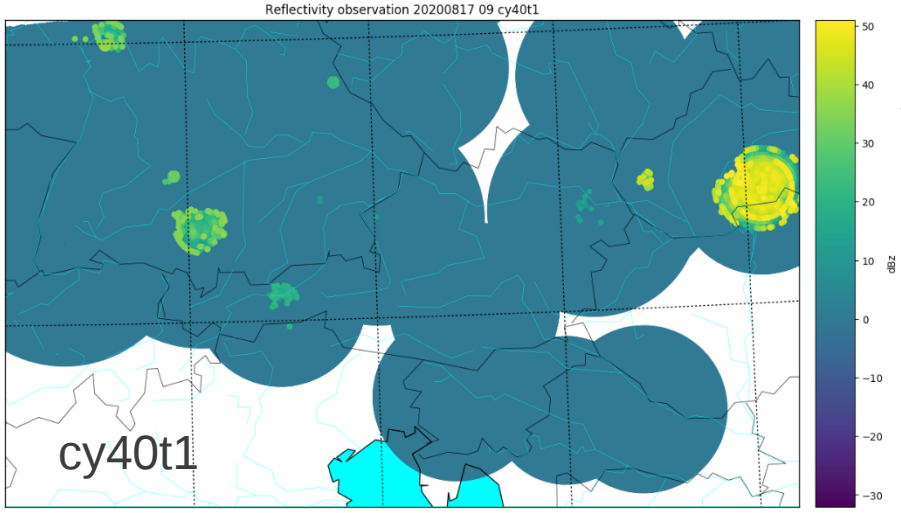
Elev=0.5

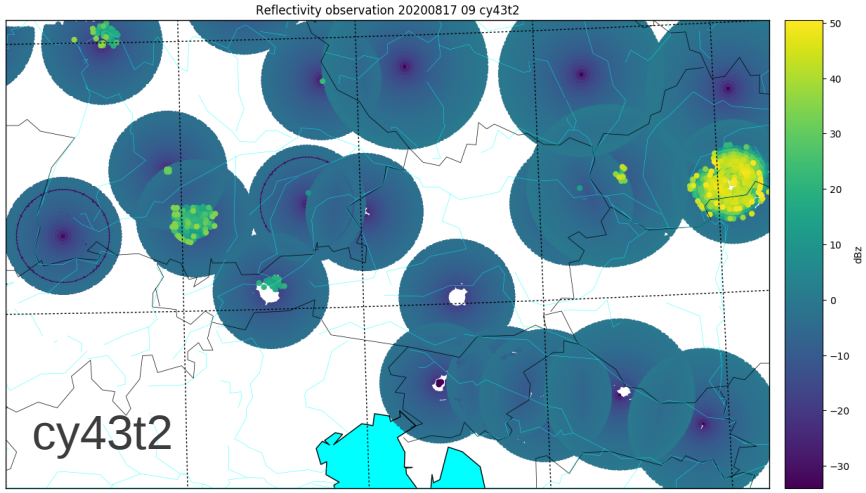




cy40t1 17th August 09UTC cy43t2

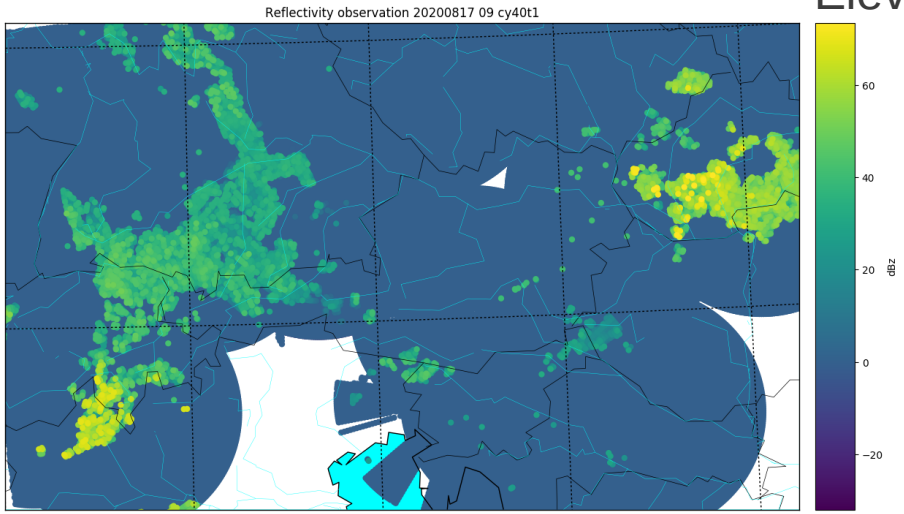
Elev=33.0

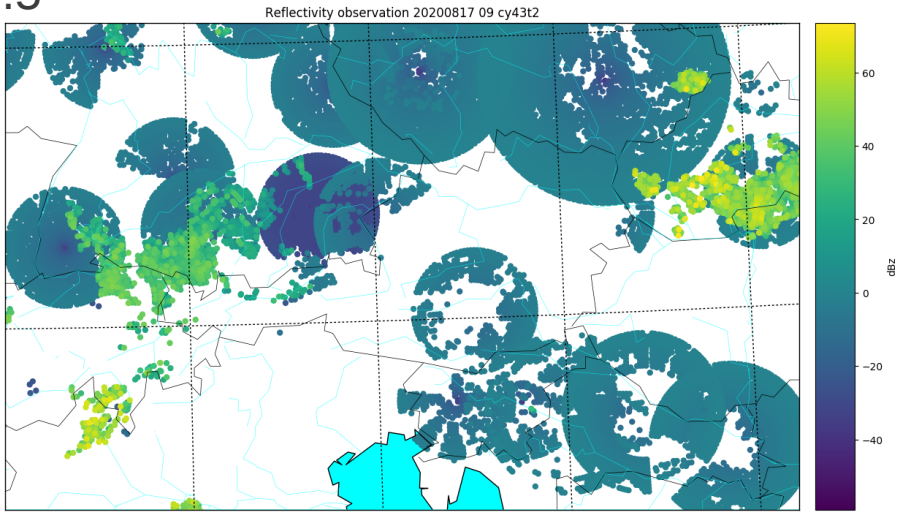




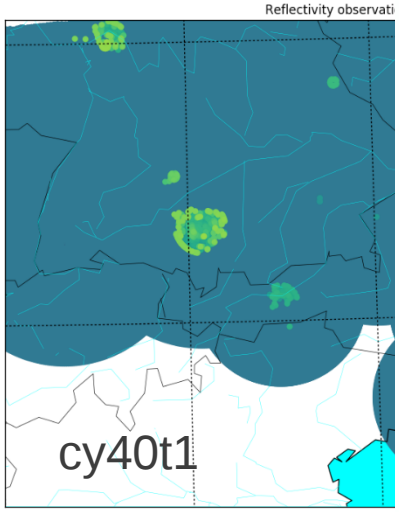
Reflectivity in BATOR cy40t1 (HIRLAM modified) vs cy43t2 MF

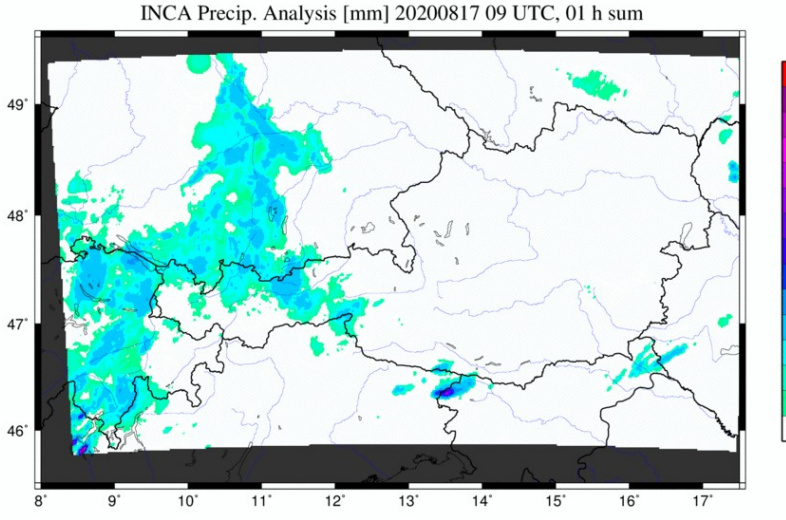
Elev=0.5

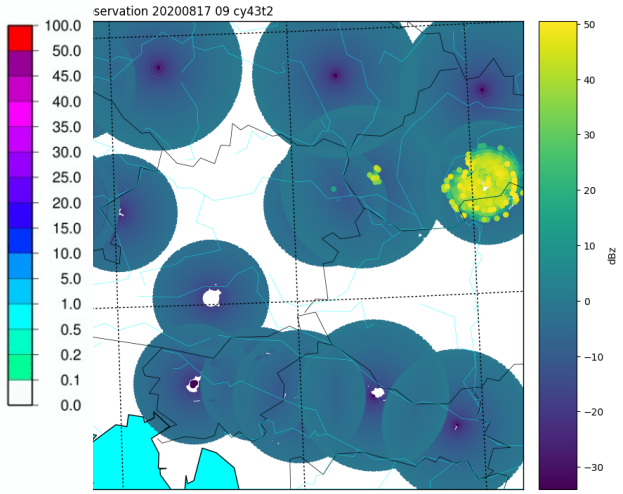




cy40t1 17th

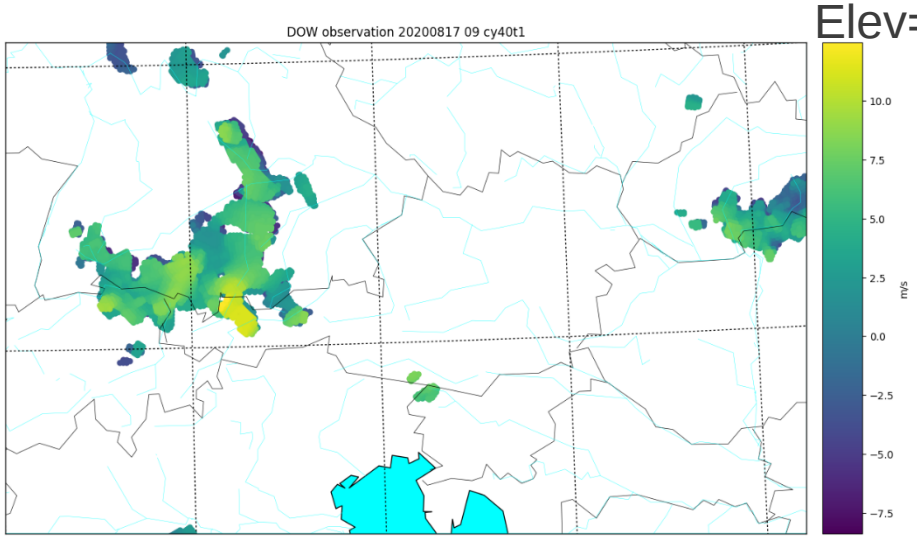


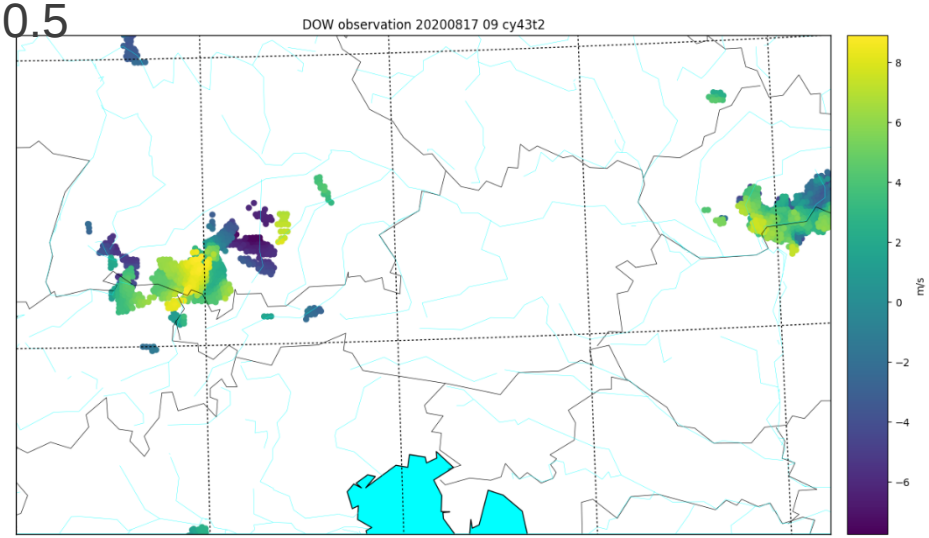




Doppler wind in BATOR cy40t1 (HIRLAM modified) vs cy43t2 MF

Elev=0.5



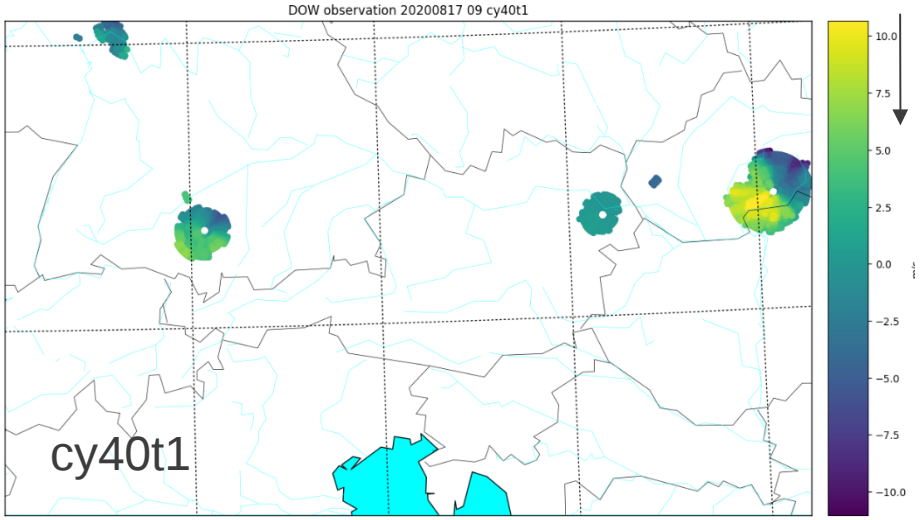


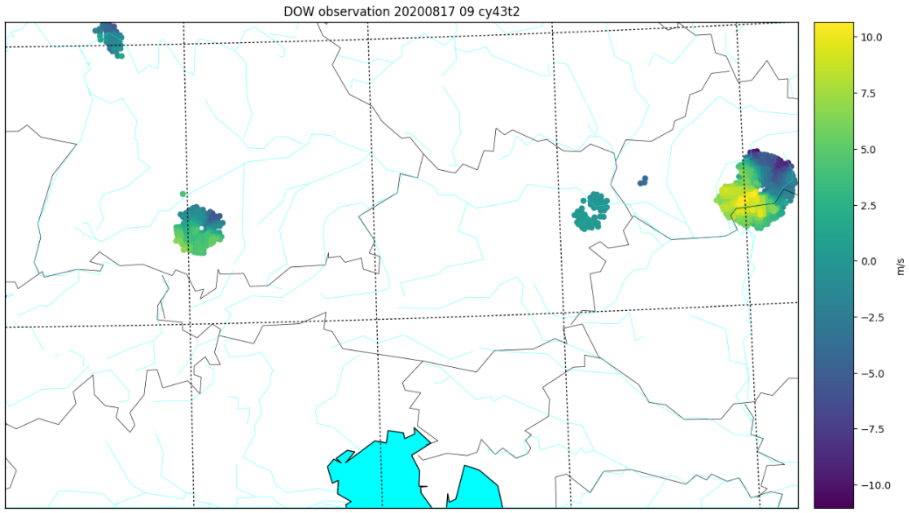
cy40t1

17th August 09UTC

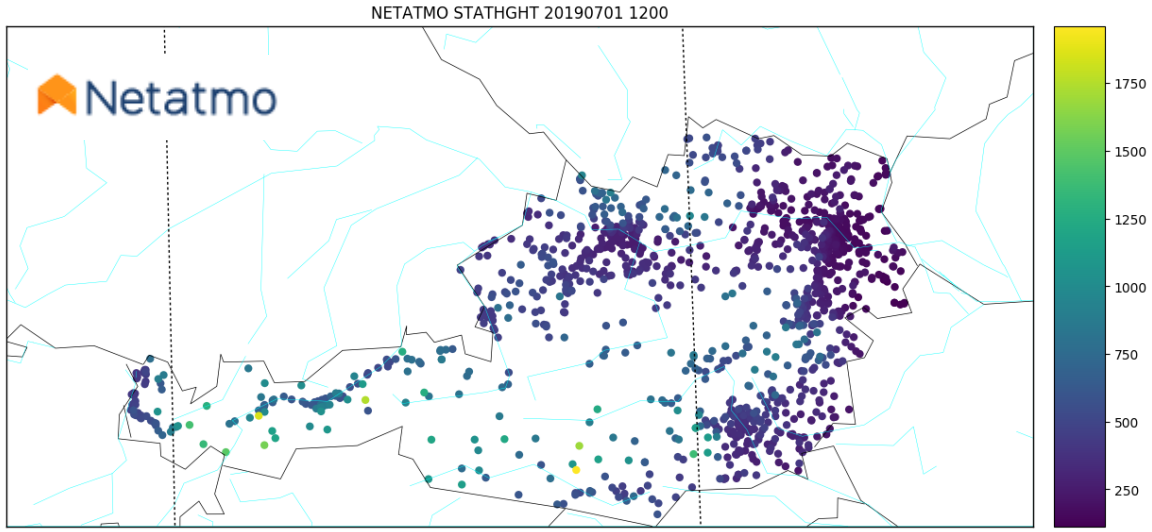
cy43t2

Elev=22.0

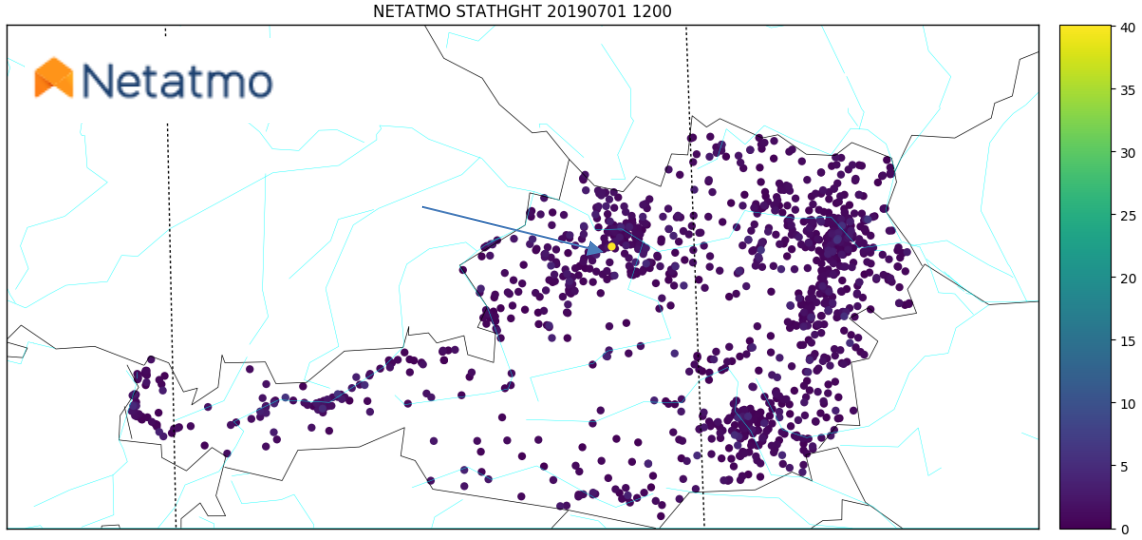




Private weather stations about 8000 stations



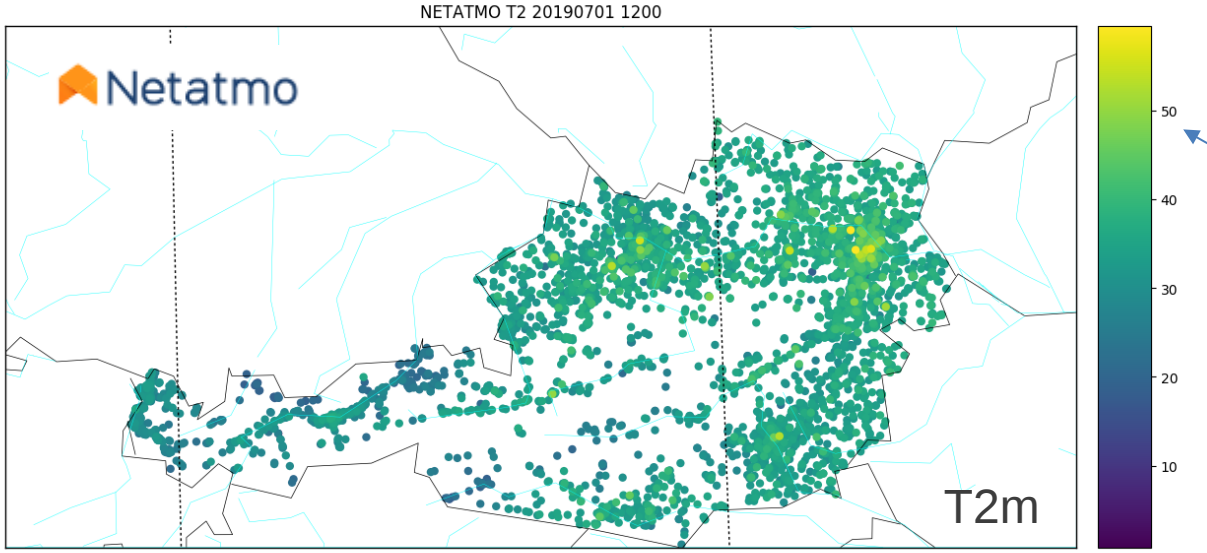
Stationheight



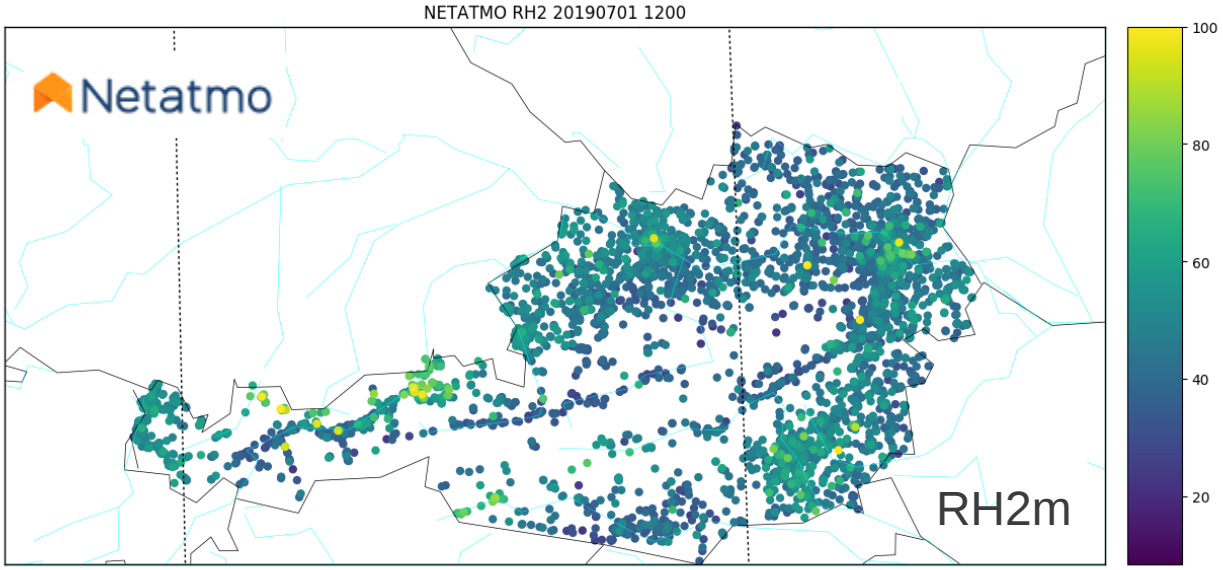
10m wind

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Private weather stations about 8000 stations



QC is crucial



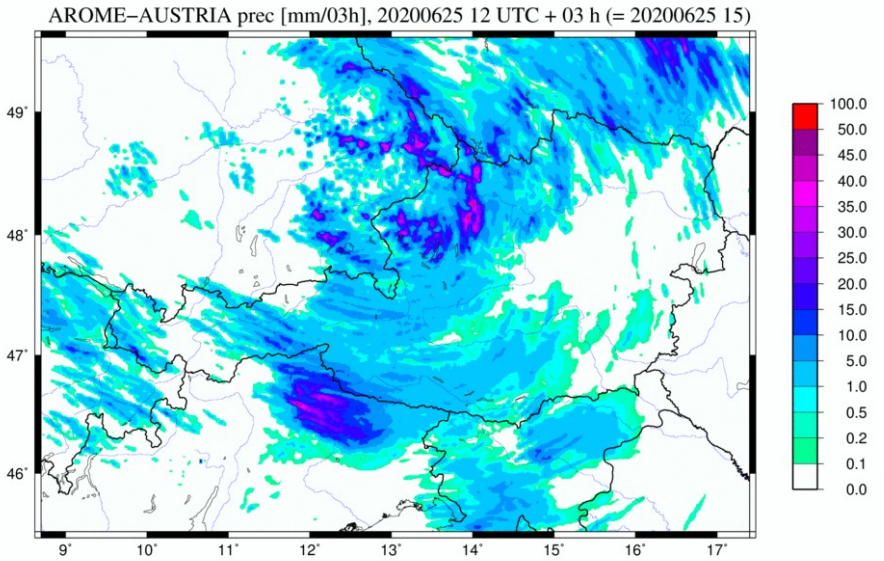
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Further plans

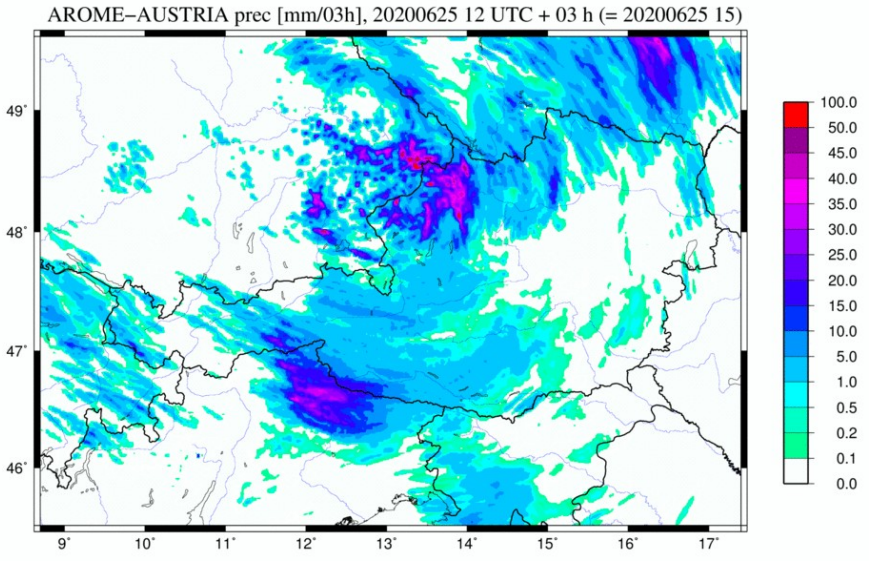
- Assimilation tests with private weather stations
- Poor man‘s ensemble
- Optimise quality control
- GNSS on trains
- Switch to cy43t2 -> include more radar stations
- Test of lead time /domain size extension
- Initialisation of Hydrometeors

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

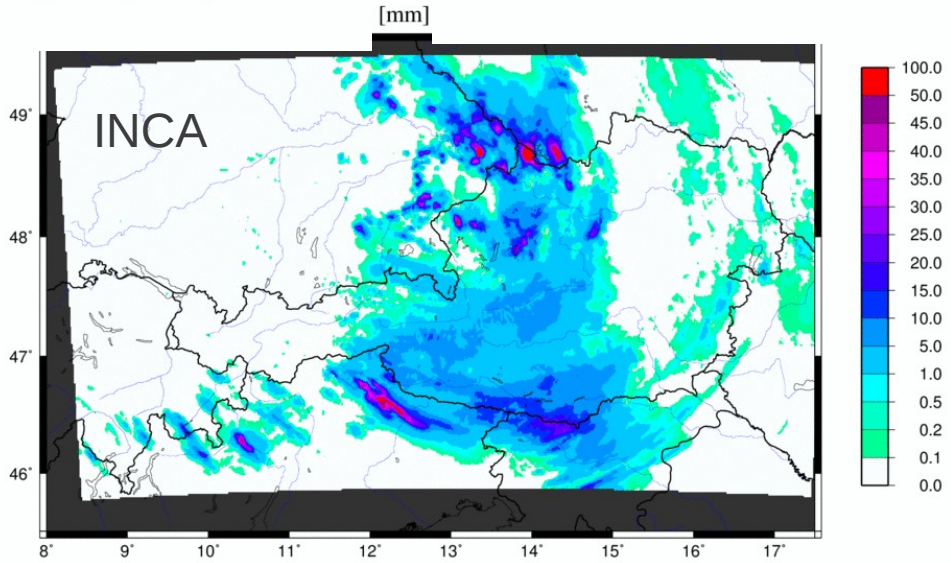
Case study effect of LHN 25th june 2020 12-15UTC



RUC+LHN



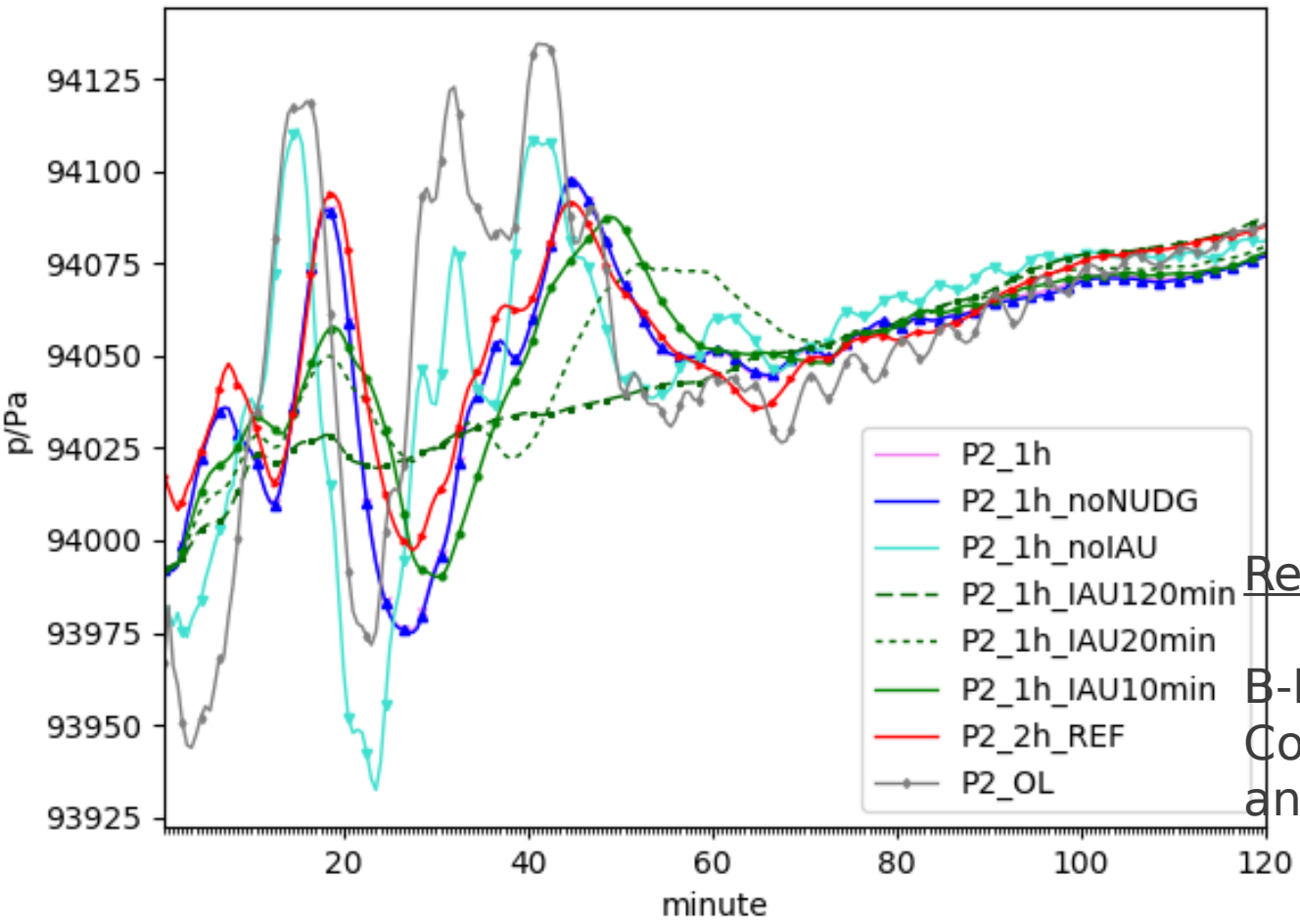
RUC noLHN



ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Spin-up and cycling startegy

ECHKEVO spin-up diagnostics



Lead time ⟶

- Spin-up >1h
- 2 hourly slightly better than 1 hourly
- Nudging/LHN has no significant impact here
- IAU filtering works
- „Open loop“ is especially problematic 2.5km >1.2km

Reasons:

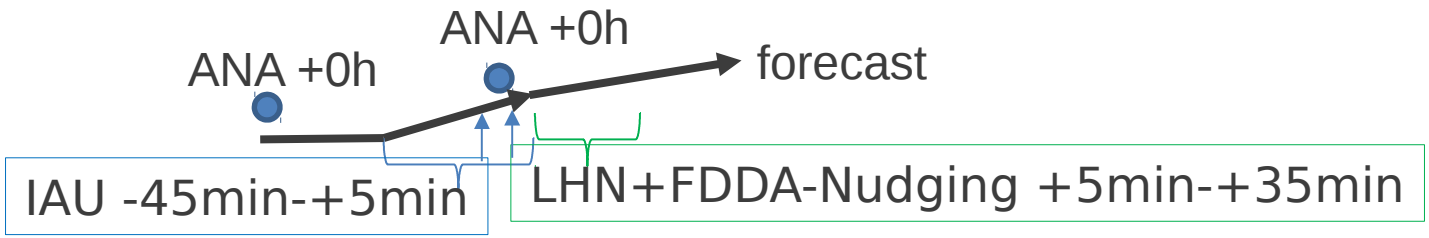
B-Matrix not well defined?
Complex orography and domain not optimal?

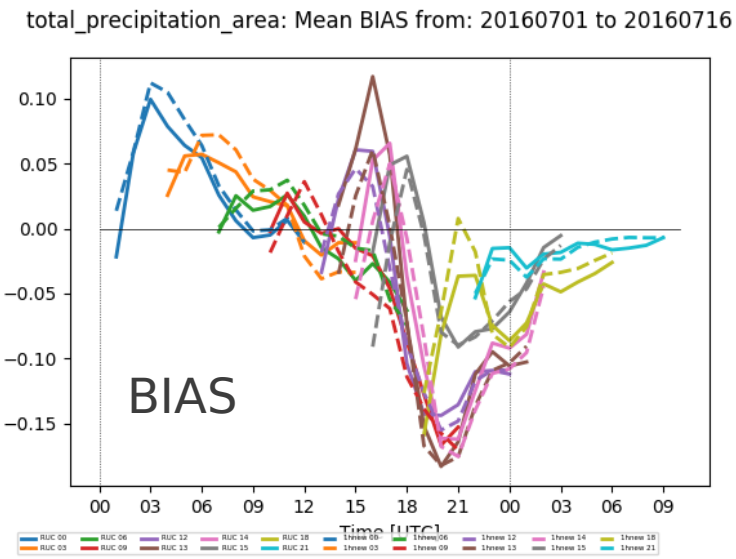
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

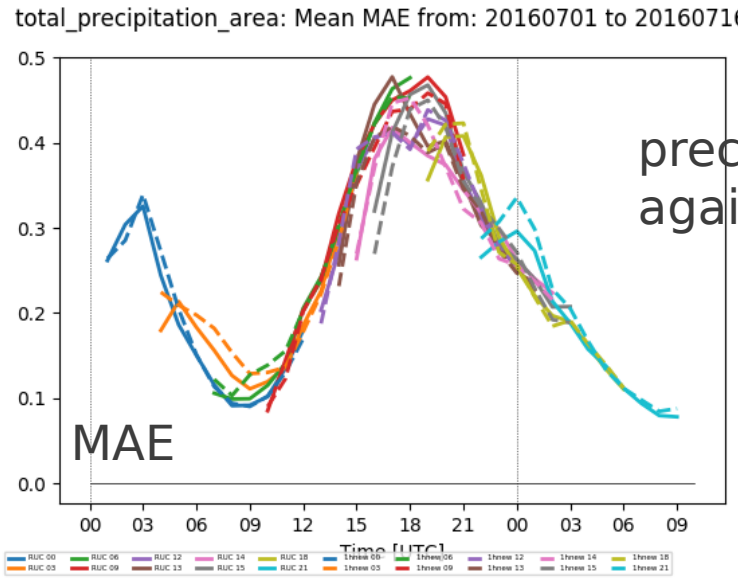
Hourly or 2 hourly cycling?

ard hourly cycling performed extremly bad compared to two hourly (Bias+RMSE)

one hour in advance and push forecast towards analysis to reduce spin-up time
competition of IAU and Nudging





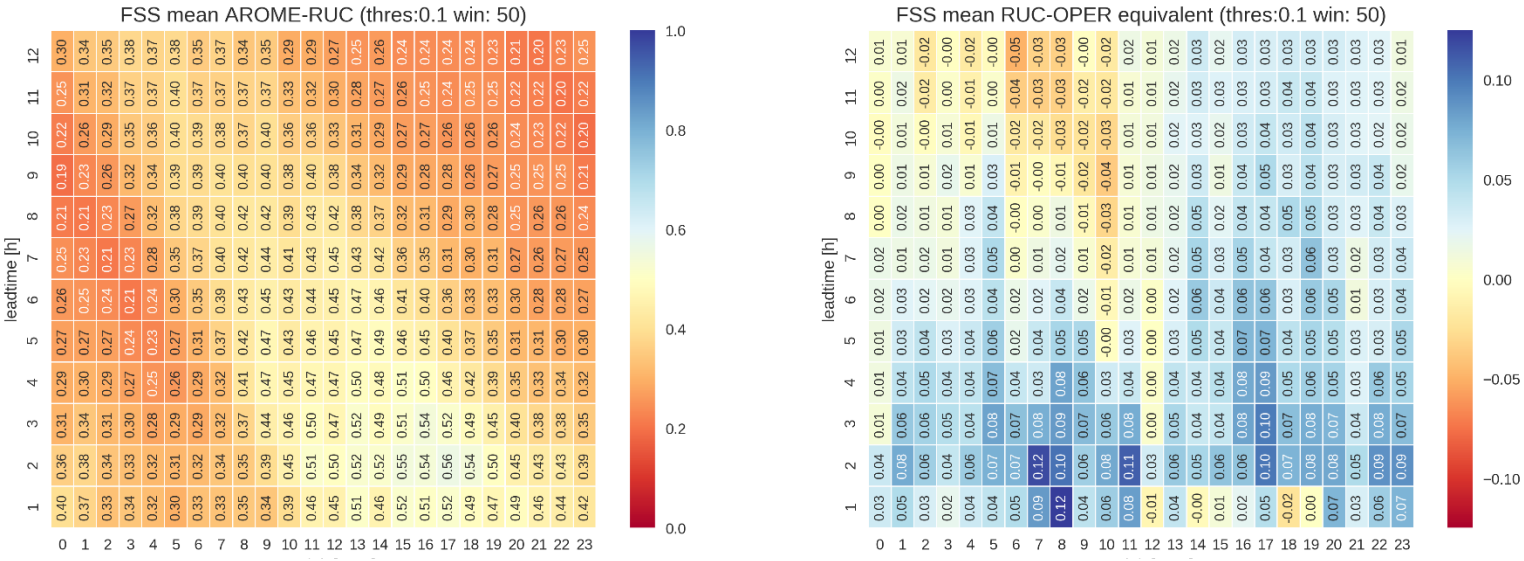


precip.
against INCA

1 Hourly with extended IAU dashed vs 2 hourly solid

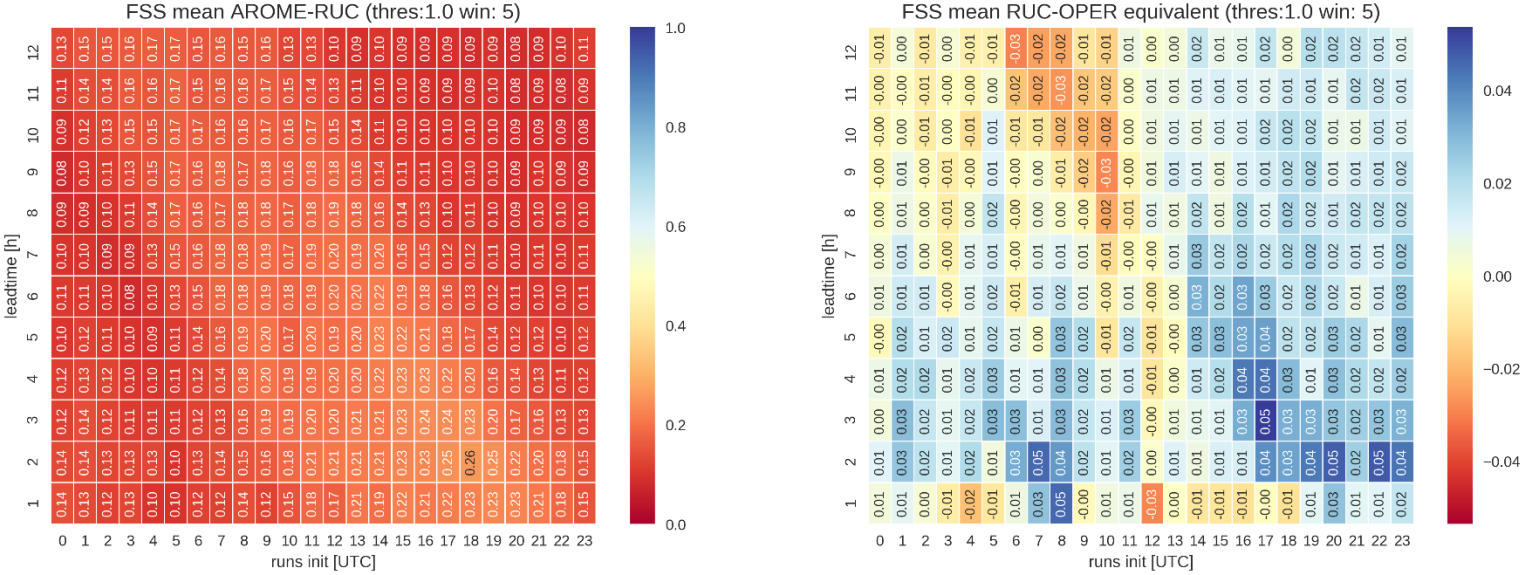
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Validation of precipitation summer



Fraction Skill Score FSS July 2016 difference in FSS to freshest AROME 2.5km

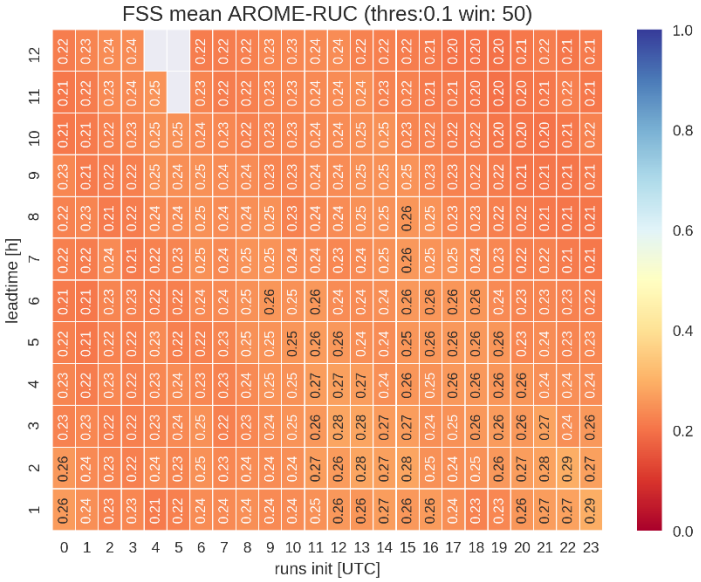
Lead time

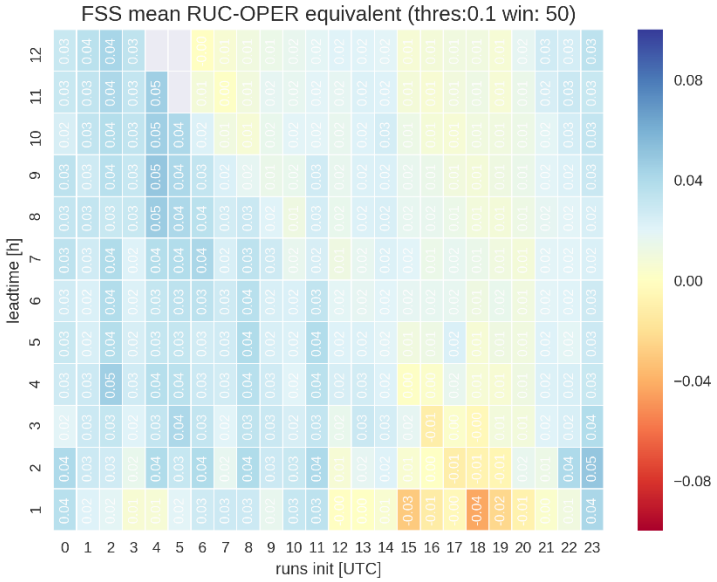


INIT TIMES (24 runs)

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

Validation of precipitation winter

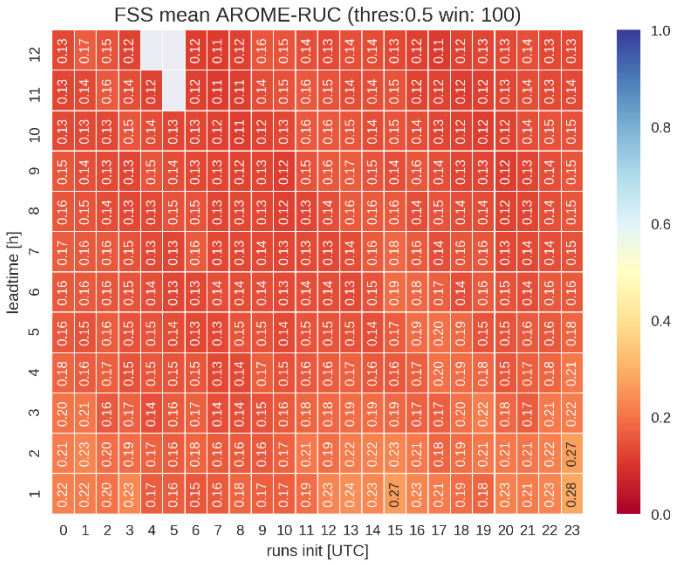


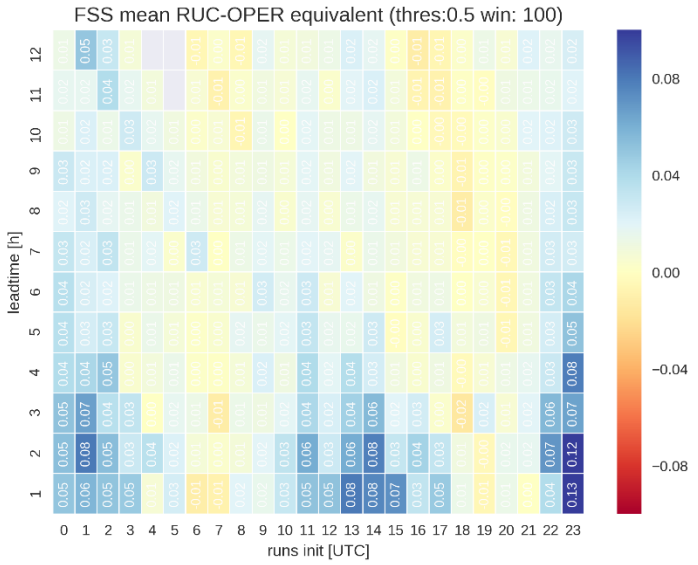


Fraction Skill Score FSS January 2017

Difference in FSS to freshest AROME 2.5km

Lead time

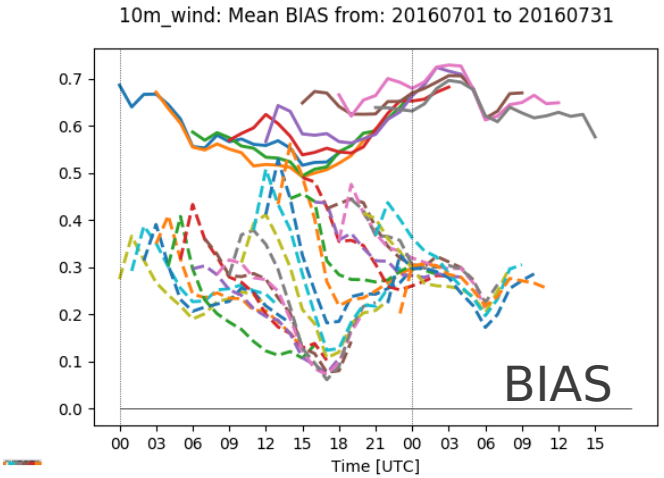




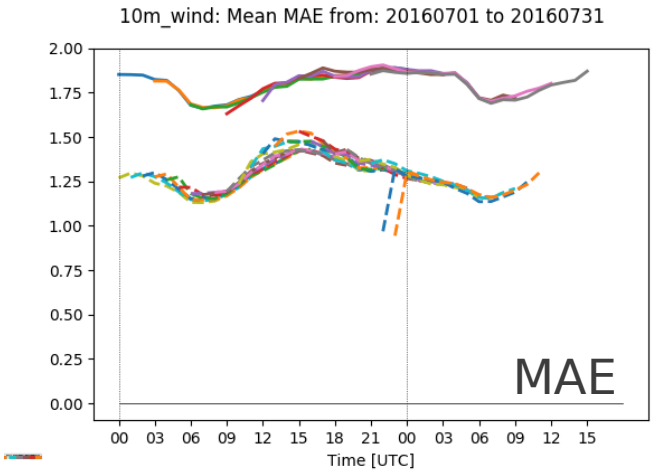
INIT TIMES (24 runs)

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

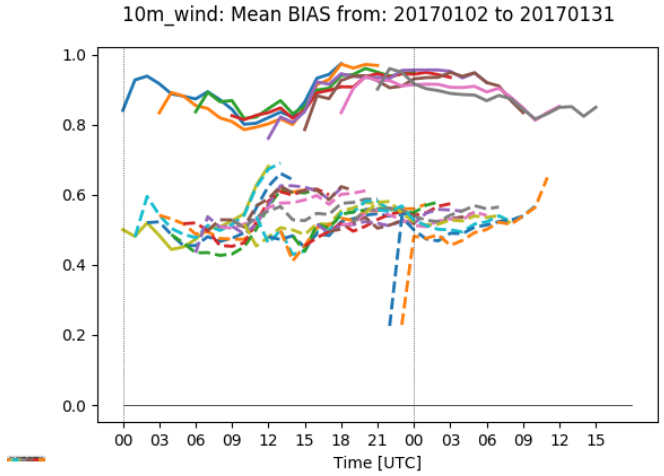
Validation July 2016, January 2017 wind



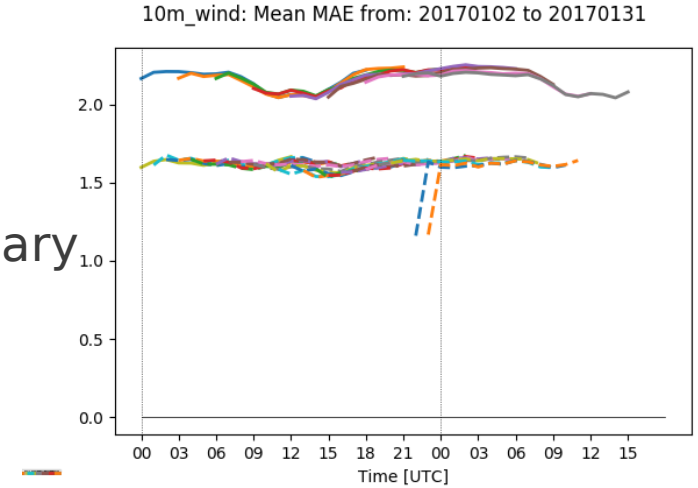
July



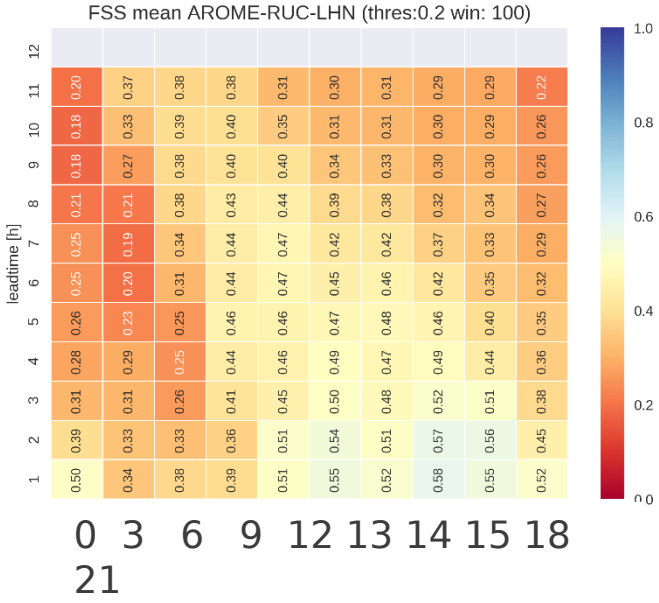
AROME 2.5km soild; AROME-RUC dashed

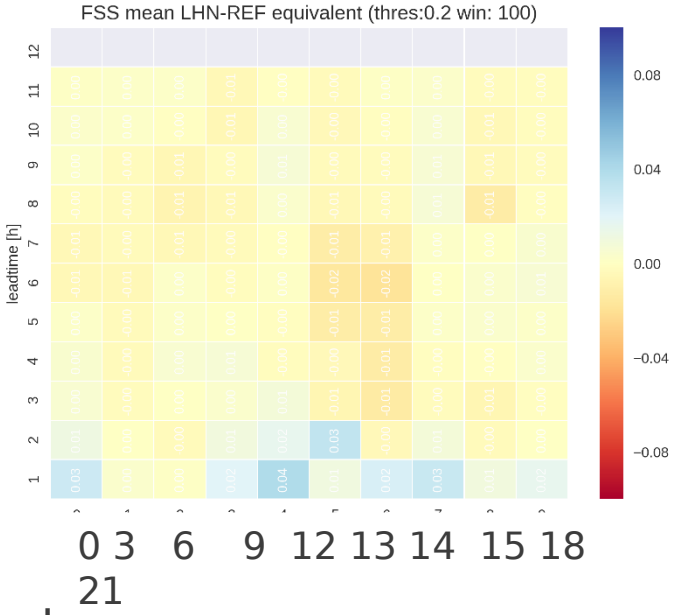


January

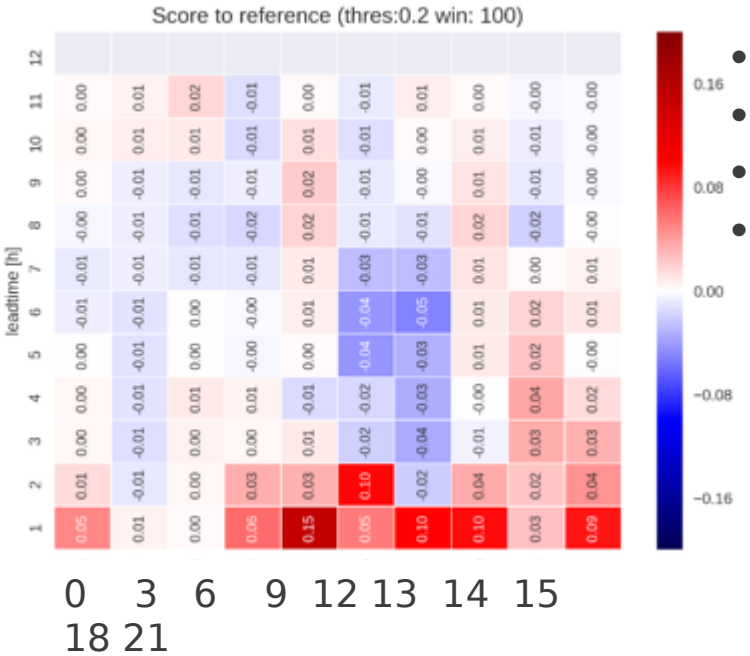


ZAMG
Zentralanstalt für Meteorologie und Geodynamik





Validation of Latent Heat Nudging 1st-16th July 2016

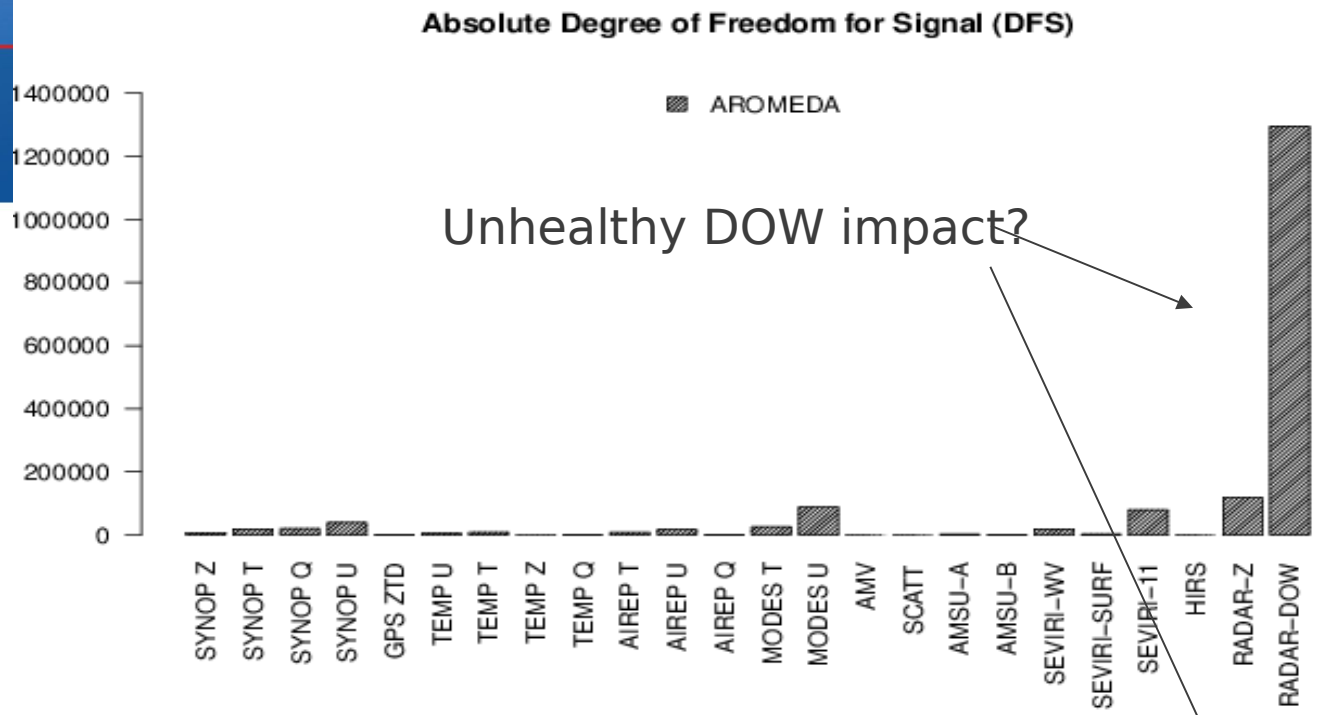


- slight improvement up to +2h
- expectation from literature about +6h
- poor statistics (16 days) and small domain
- further tuning necessary

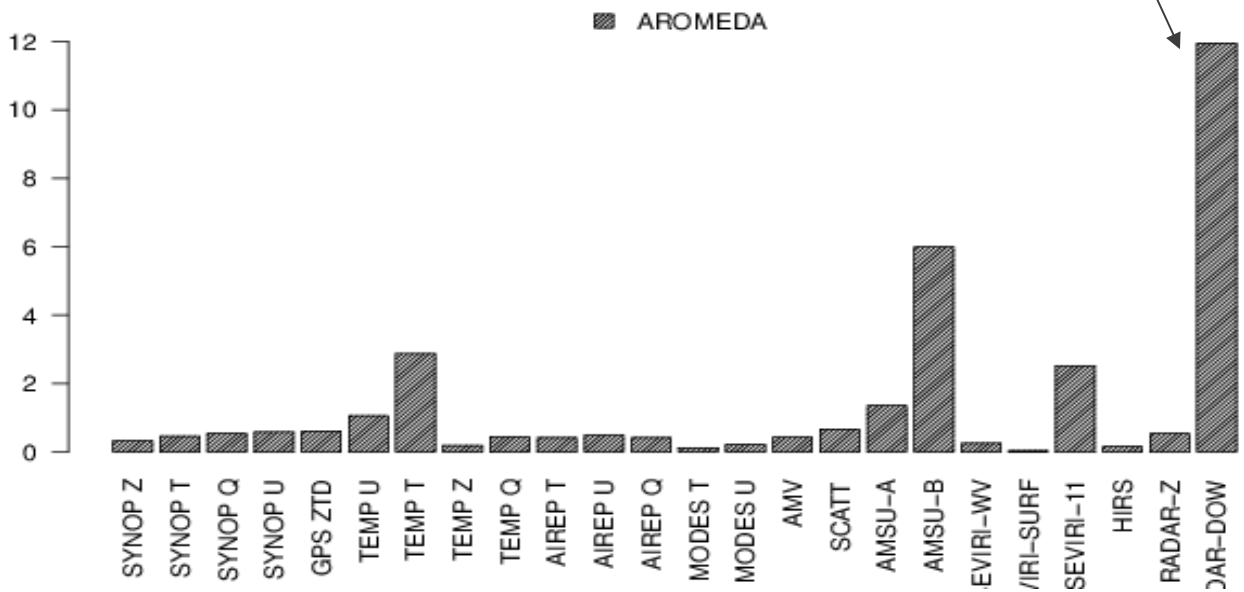
$$\sum \frac{FSS_{exp} - FSS_{ref}}{1 - Fss_{ref}} \quad if\ Fss_{exp} > Fss_{ref}$$

$$+ \sum \frac{FSS_{exp} - FSS_{ref}}{1 - Fss_{exp}} \quad \text{else}$$

ZAMG
Zentralanstalt für Meteorologie und Geodynamik

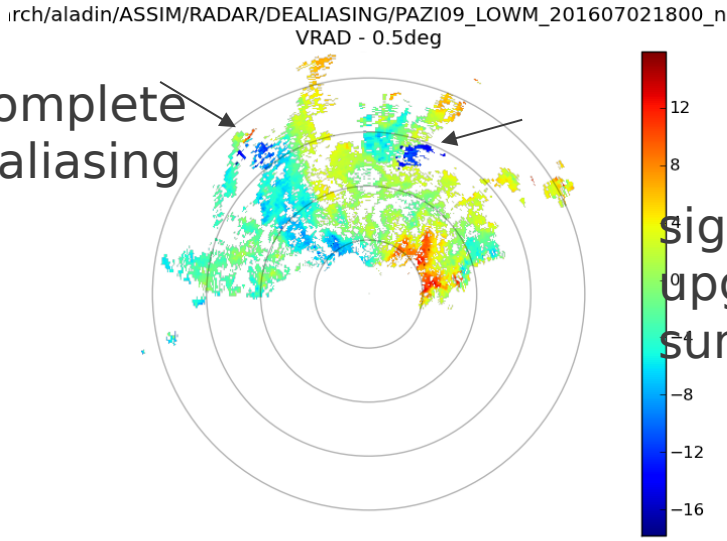


Unhealthy DOW impact?



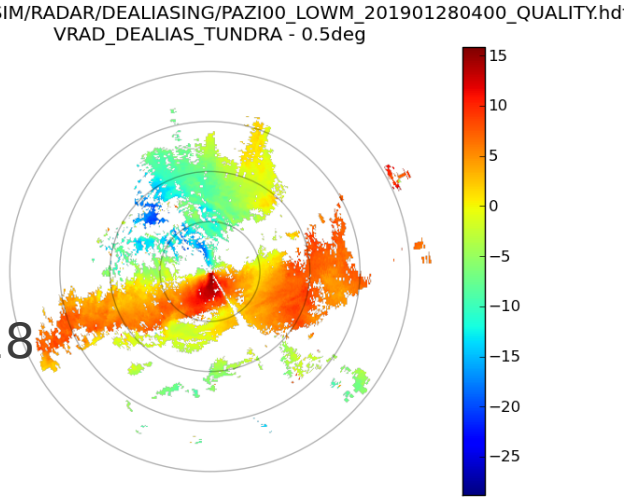
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

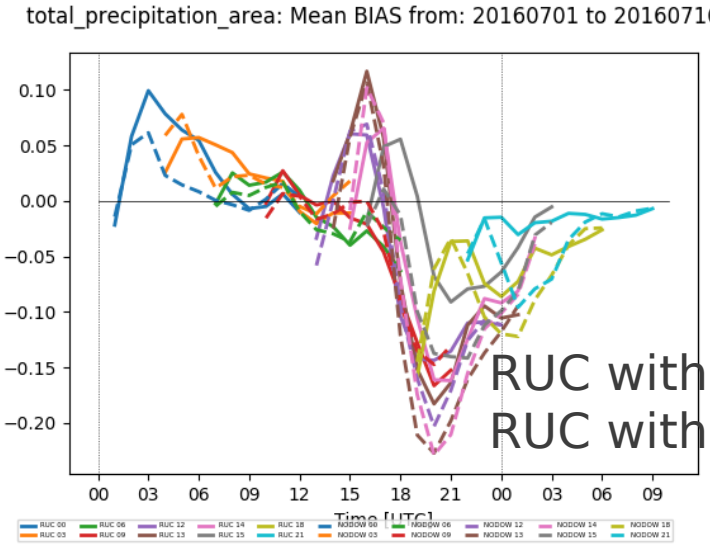
Radar DOW assimilation still problematic



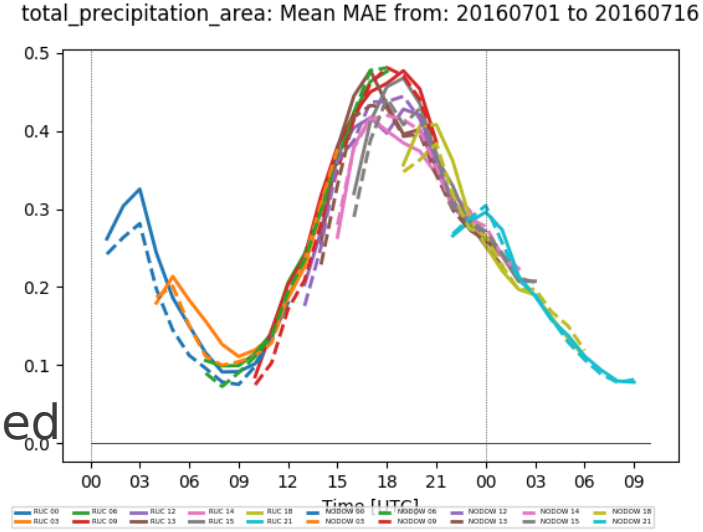
incomplete
de-aliasing

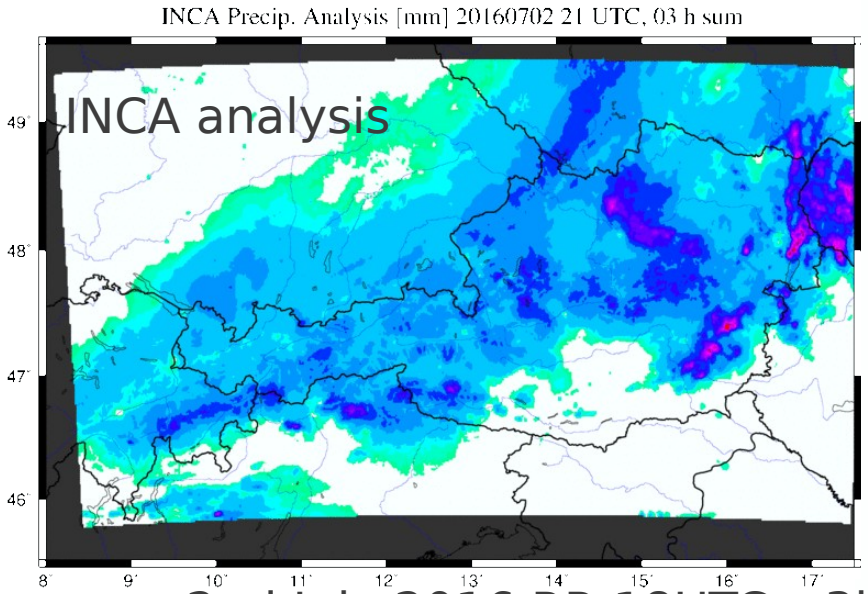
signal processor
upgrade in Austria
summer/autumn 2018

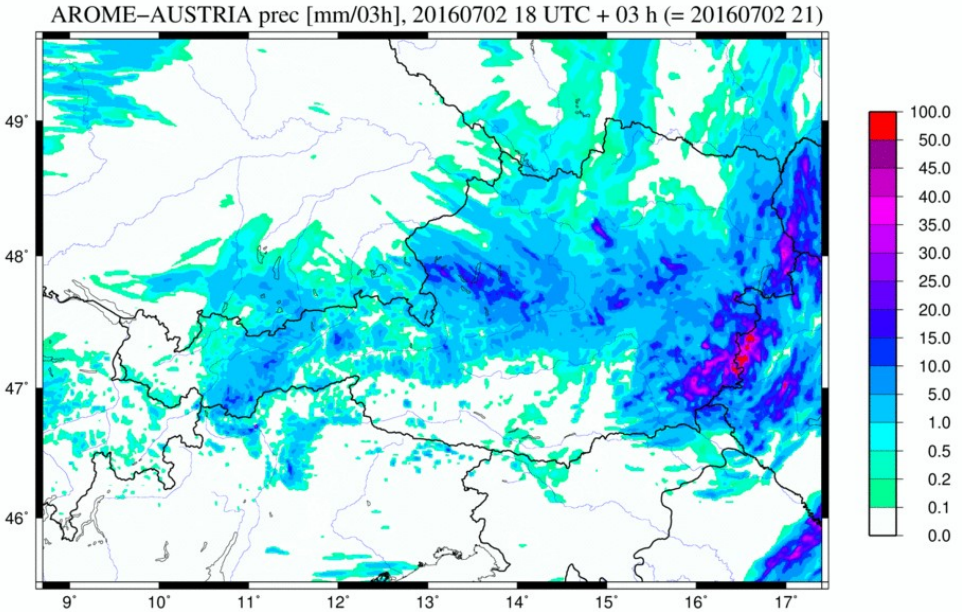




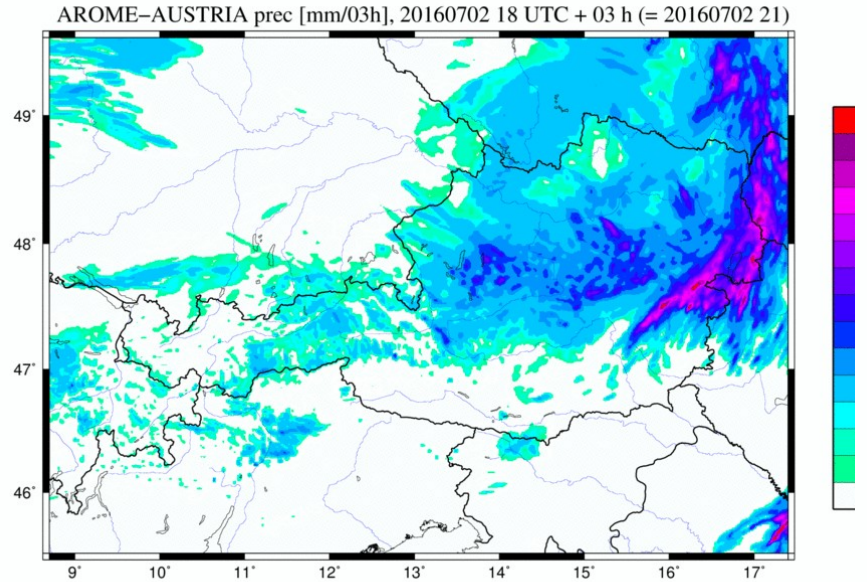
RUC with Doppler solid
RUC without Doppler dashed

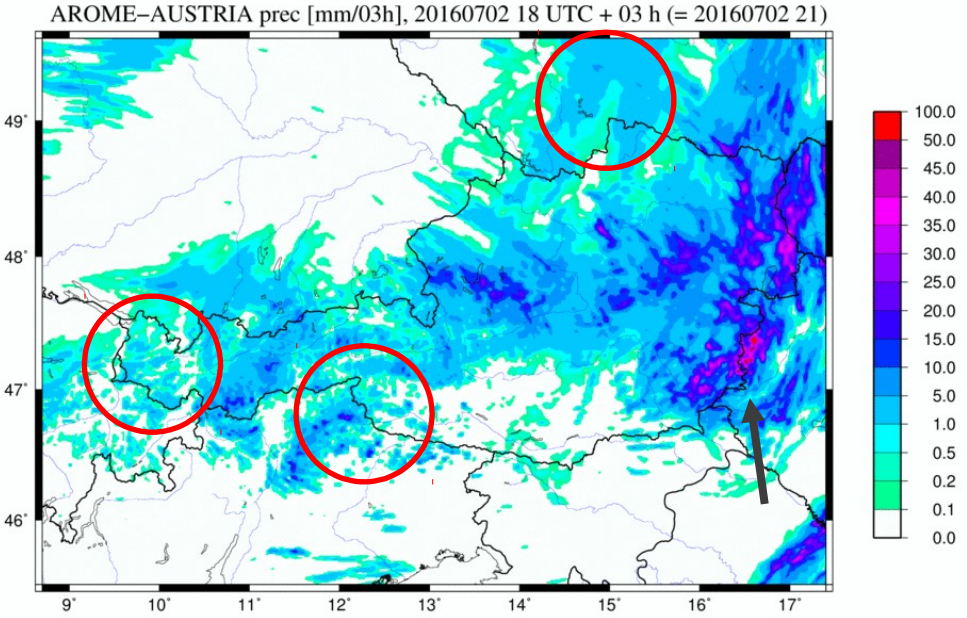




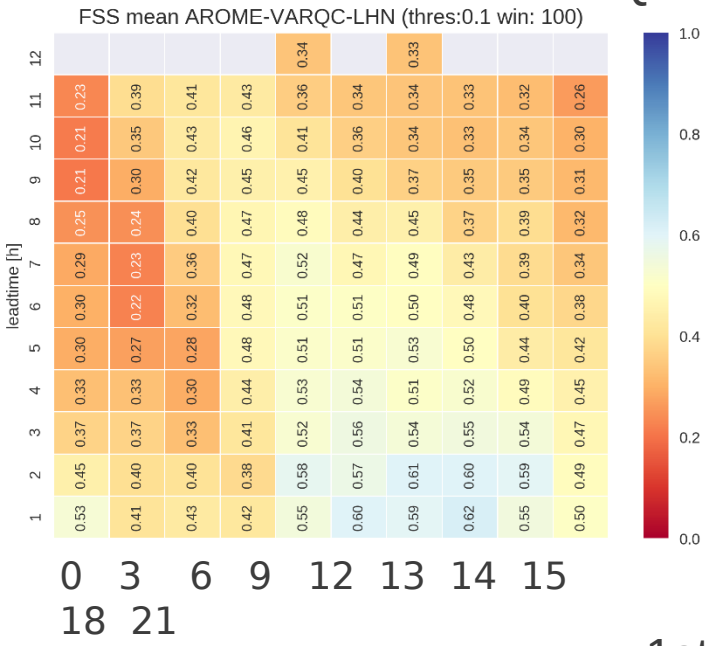


2nd July 2016 RR 18UTC +3h

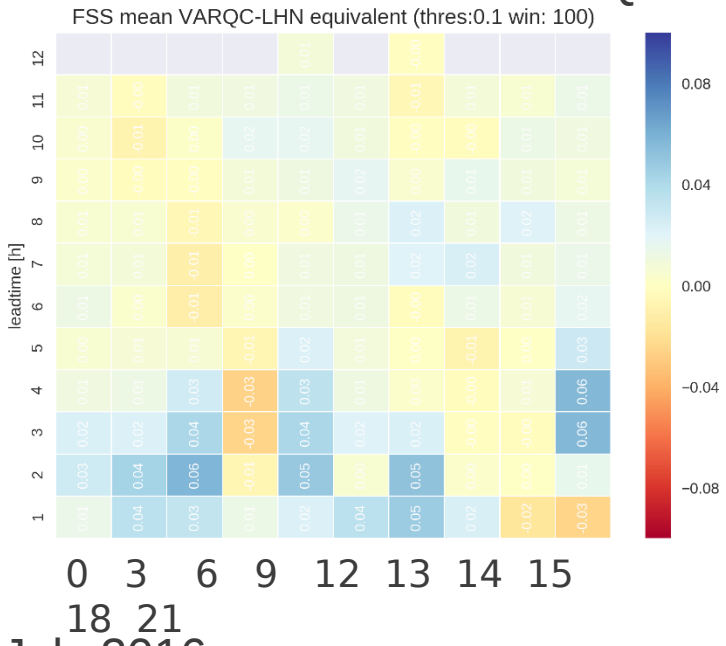




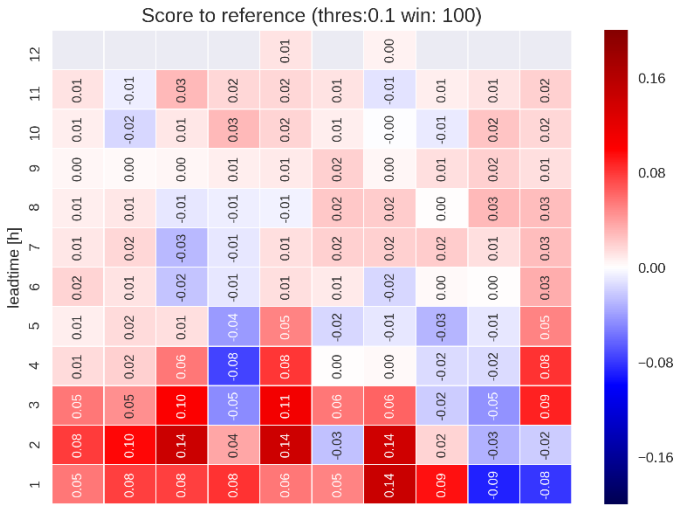
FSS AROME-RUC+VARQC



FSS AROME-RUC+VARQC-noVARQC



1st-16th July 2016

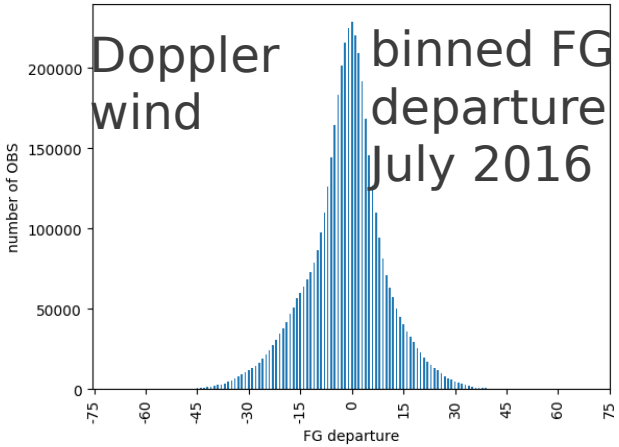


- even the not tuned VARQC can improve the precip. forecast
- difficult to switch on VARQC for only one obstype

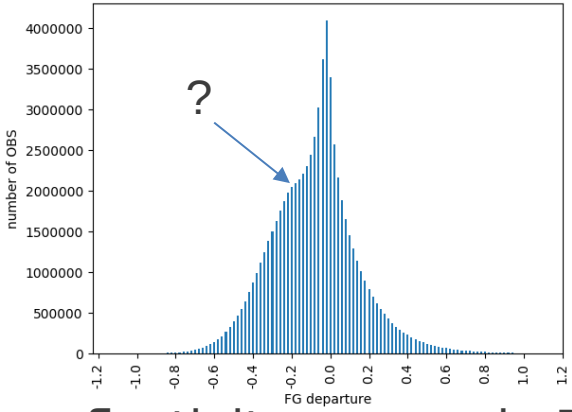
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

VARQC of radar? (gross errors get reduced weight)

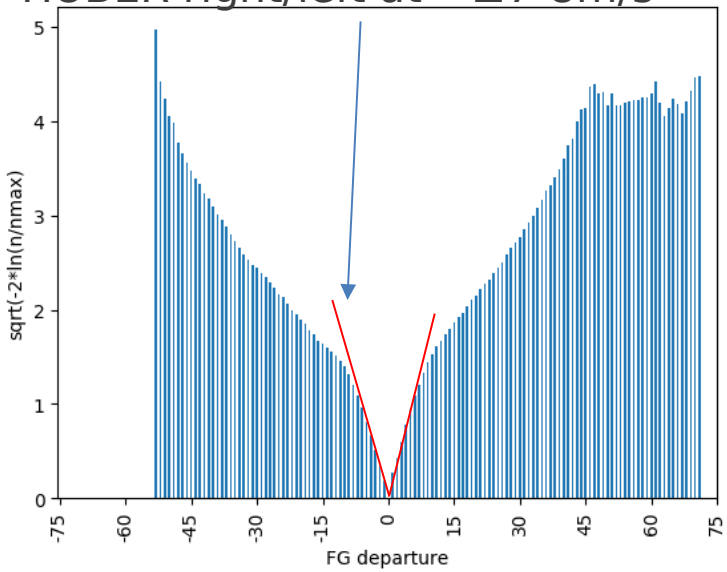
Ingleby &Lorenc 1993



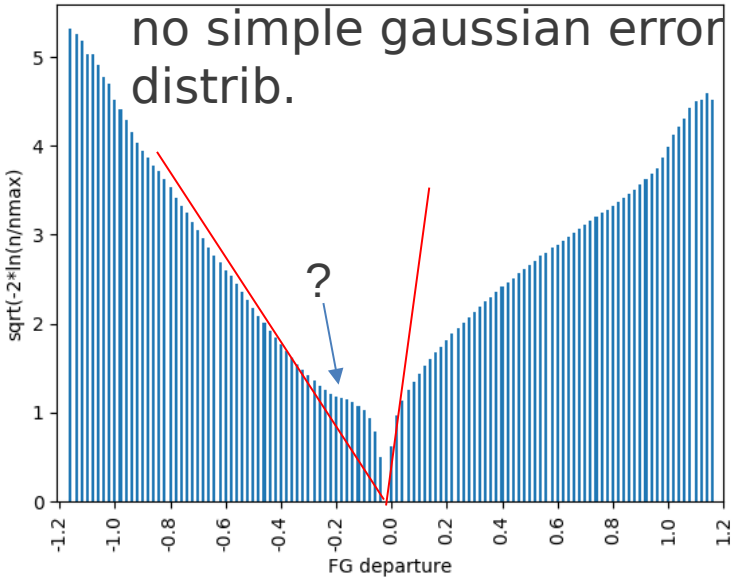
Austrian radars only



switch from gaussian to gross error
HUBER right/left at ~±7-8m/s



reflectivity ->pseudo RH obs
no simple gaussian error distrib.

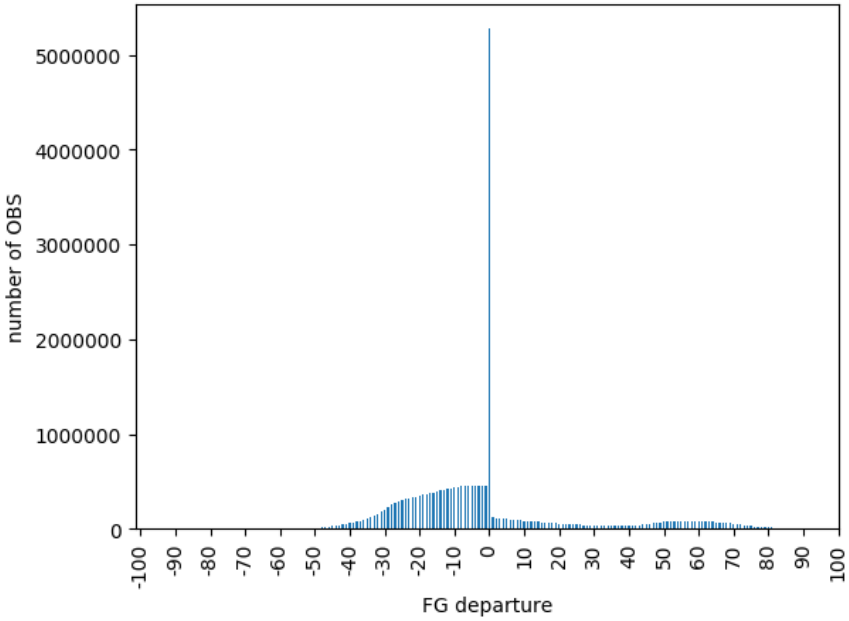


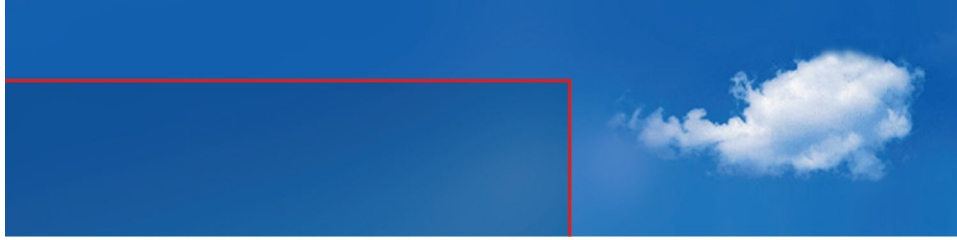
Conclusions and plans

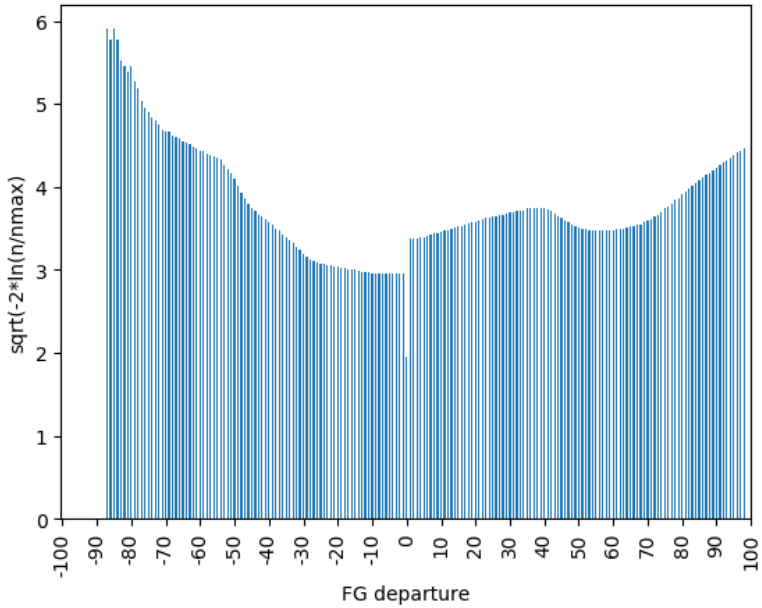
- AROME-based Nowcasting is feasible
- Improvement in 10m wind (and gusts) (BIAS+MAE) and summer precipitation (FSS until +6h)
- Latent heat nudging improves mostly up to +2h, in single case more
- for us: hourly cycling only possible with long IAU filtering (complex terrain+B-Matrix?)
- Doppler wind has to much impact (aliasing remnants) -> VARQC might help
- Radar assimilation struggles, if no fitting feature is included in the first guess in the surrounding of an observation -> saturation of profile can help, but is dangerous if OBS has error, LHN can also help

- Put AROME-RUC to operations within this year
- Consider post-processing and visualisation
- B-Matrix is currently updated with EDA approach coupled to C-LAEF ->tests
- Quality control, especially for Doppler wind has to be re-considered
- Inclusion of further observations:
  wind profiler, cloud assimilation, private weather stations, HRV AMVs

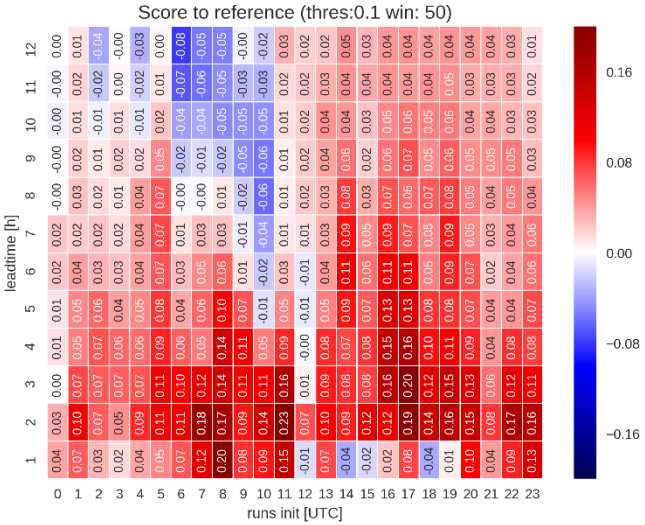
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

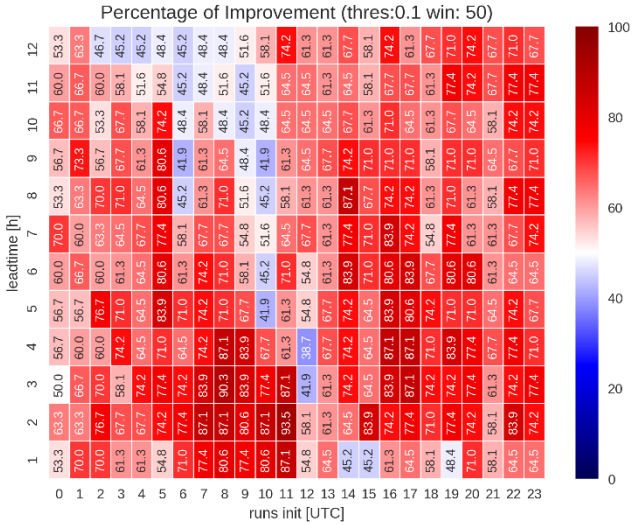


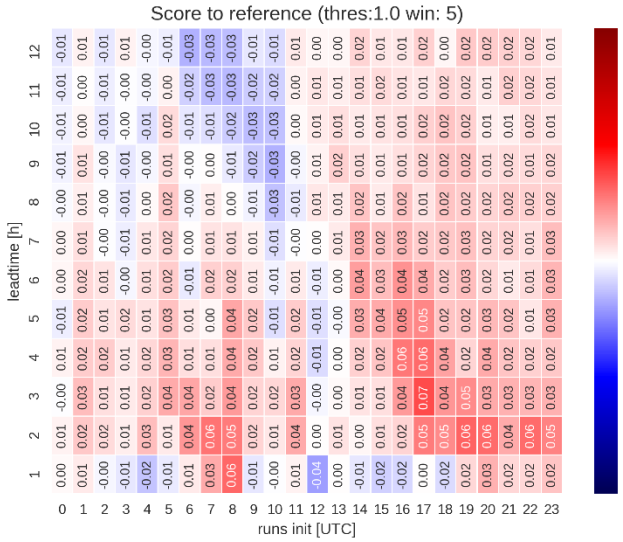


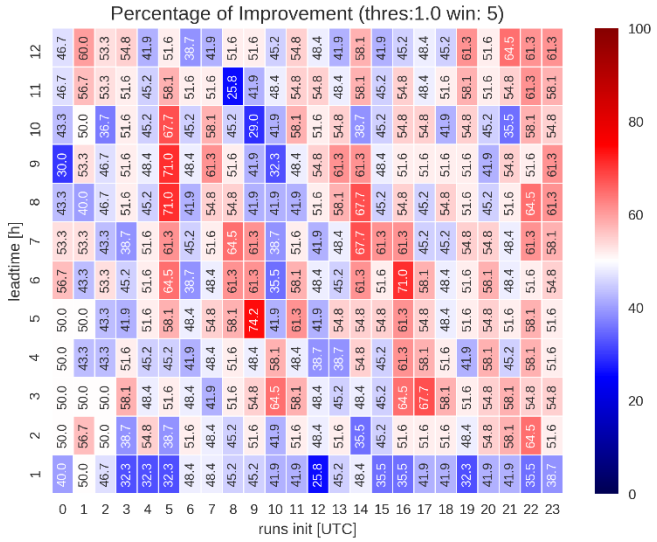


ZAMG
Zentralanstalt für Meteorologie und Geodynamik









ZAMG
Zentralanstalt für Meteorologie und Geodynamik

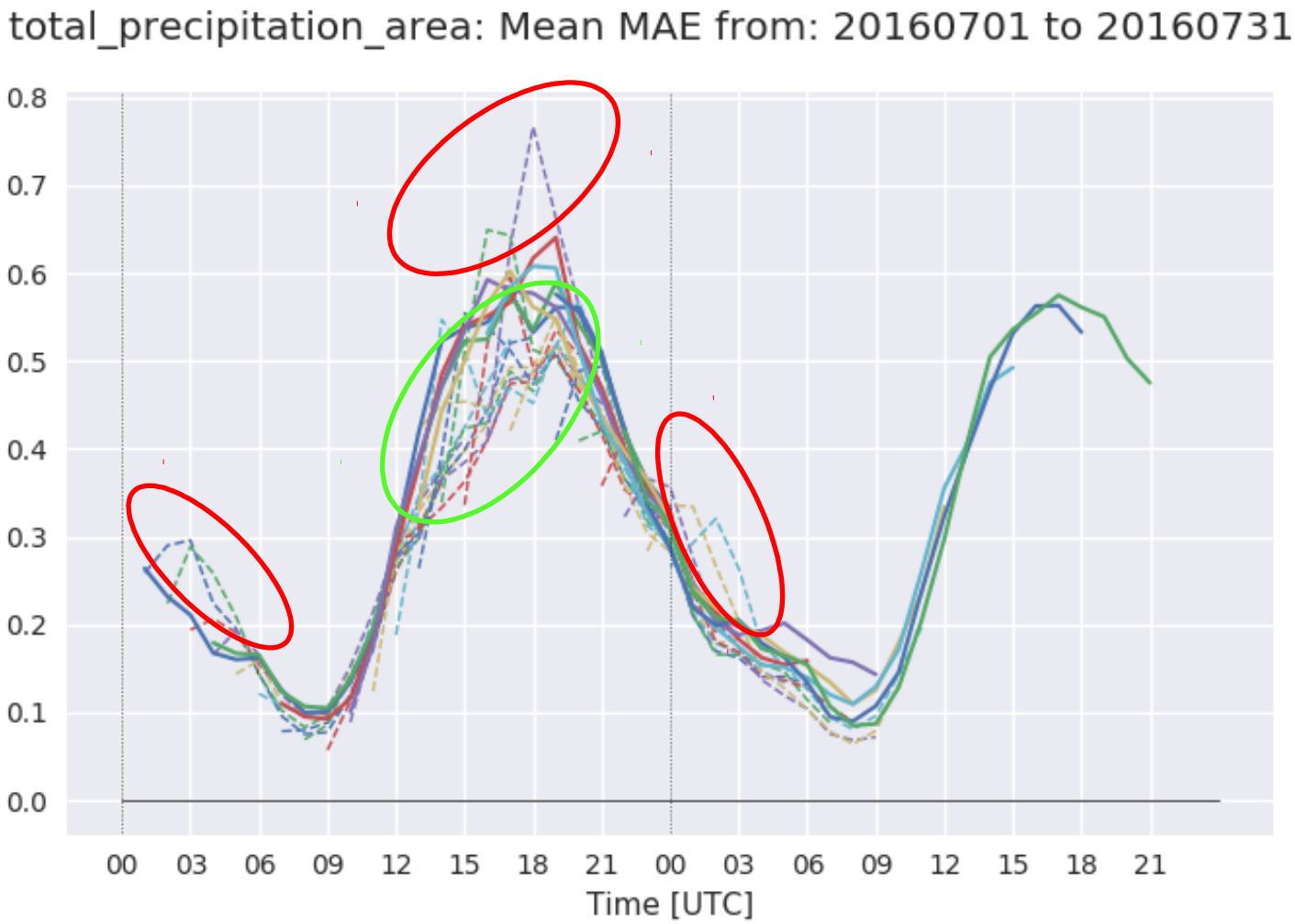
Score to reference (thres:0.1 win: 50)
leadtime [h]
runs init [UTC]
0.16
0.08
0.00
−0.08
−0.16

Percentage of Improvement (thres:0.1 win: 50)
leadtime [h]
runs init [UTC]
100
80
60
40
20
0

Score to reference (thres:0.5 win: 100)
leadtime [h]
runs init [UTC]
0.16
0.08
0.00
−0.08
−0.16

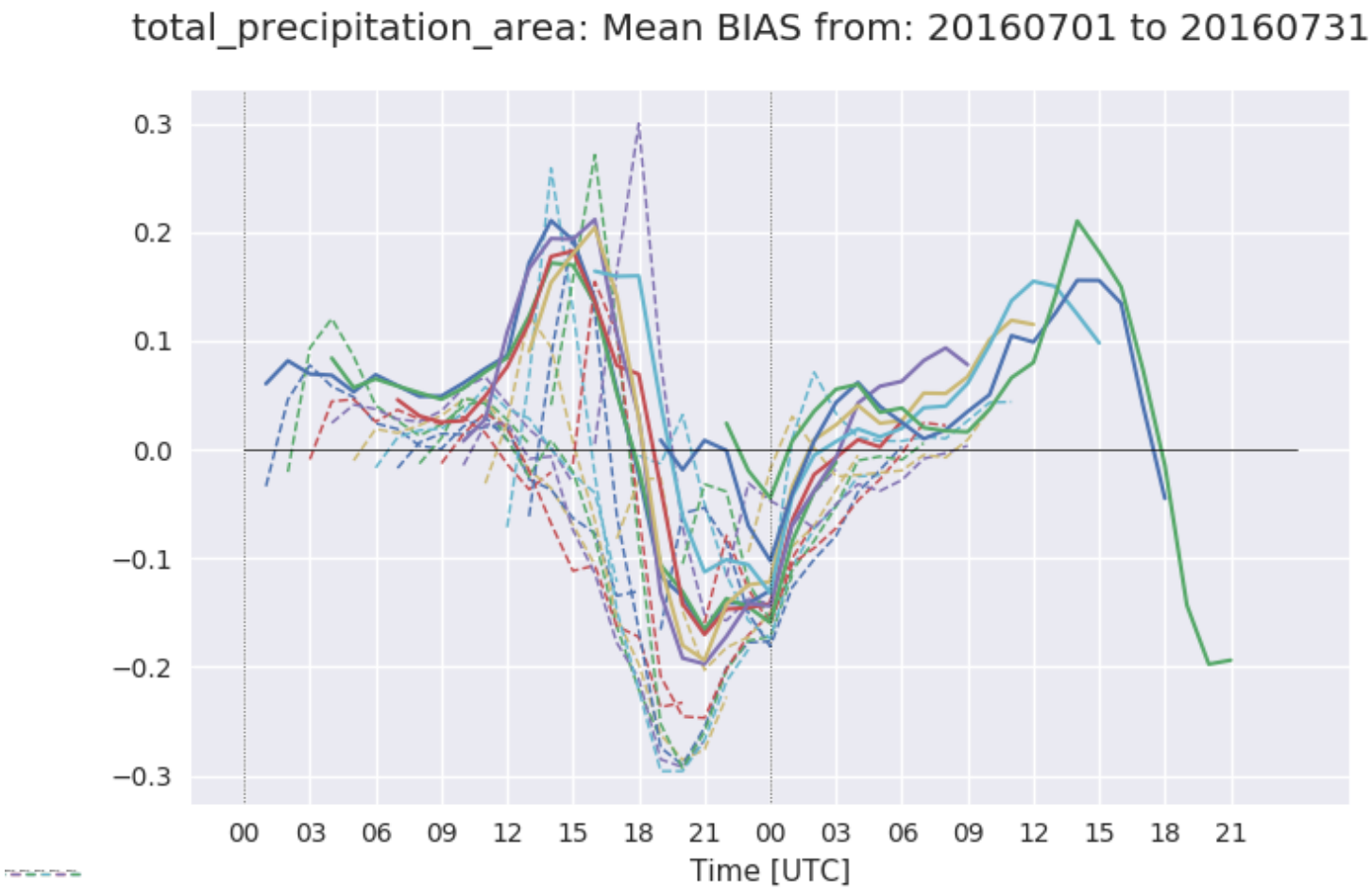
Percentage of Improvement (thres:0.5 win: 100)
leadtime [h]
runs init [UTC]
100
80
60
40
20
0

MAE (area mean)



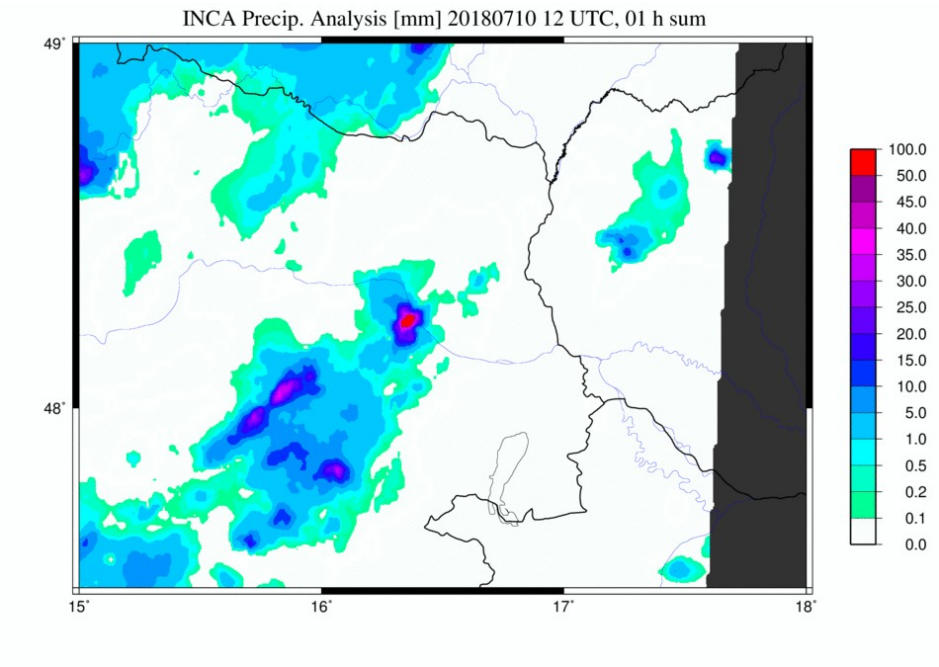
AROME-OPER: thick lines
AROME-RUC: dashed lines

BIAS (area mean)



AROME-OPER: thick lines
AROME-RUC: dashed lines

ZAMG
Zentralanstalt für Meteorologie und Geodynamik


INCA Precip. Analysis [mm] 20180710 12 UTC, 01 h sum
49°
48°
15°
16°
17°
18°
100.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
1.0
0.5
0.2
0.1
0.0

FDDA nudging in AROME (TAWES observations; Liu et al. 2006)

$$DISTANCE' = DISTANCE + R\frac{|z_{OBS} - z_{GP}|}{dzthres = 300m}$$

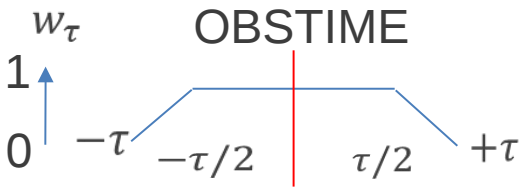
$$w_{xy} = \frac{R^2 0.75^2 - DISTANCE'^2}{R^2 0.75^2 + DISTANCE'^2}\left(\frac{ps_{GP}}{500hPa} + 1\right)$$

$$\frac{\partial x}{\partial t} = \frac{\partial x}{\partial t_{phys}} + G\frac{\sum_i w^2{}_{xyi}(y_{iobs} - x_{model})}{\sum_i w_{xyi}}$$

$$\frac{\partial x}{\partial t} = \frac{\partial x}{\partial t_{phys}} + G\frac{\sum_i w^2{}_{xyi} y_{iobs}}{\sum_i w_{xyi}} - G\frac{\sum_i w_{xyi}\, x_{model}}{\sum_i w_{xyi}}$$

R=20km
G_c=0.004333
τ=6
(namelist switches)

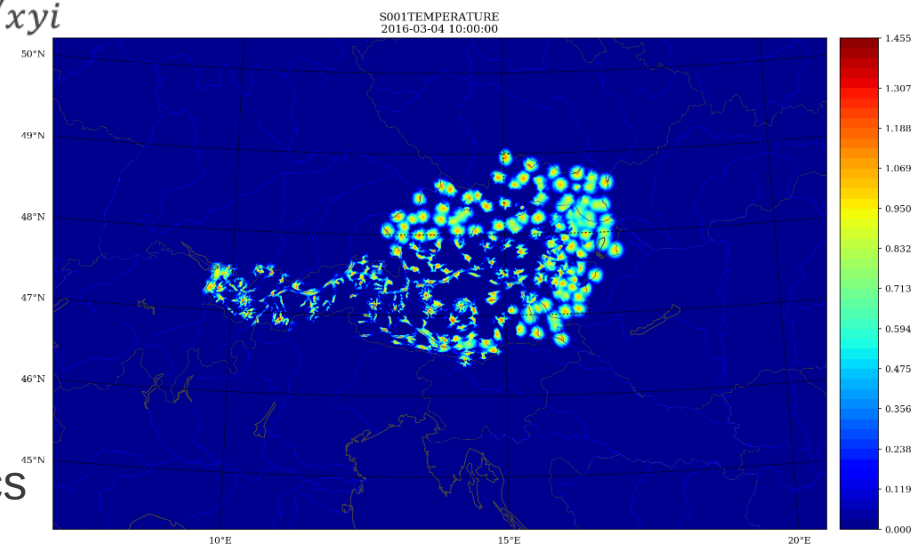
$$G = G_c * w_\tau$$



Observations at: +10 / 20 / 30min

x=T2m/RH2m/U10m

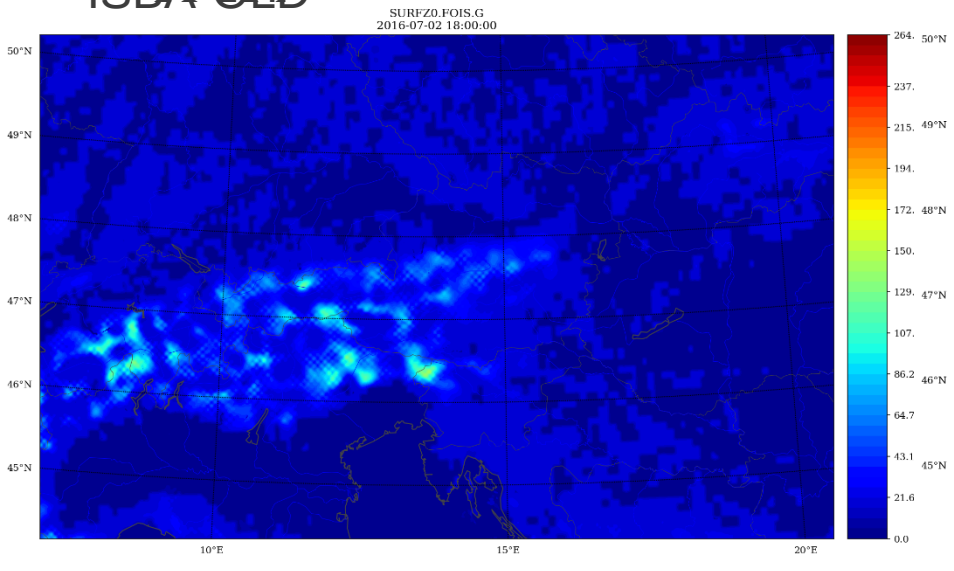
called from apl_arome.F90 after microphysics



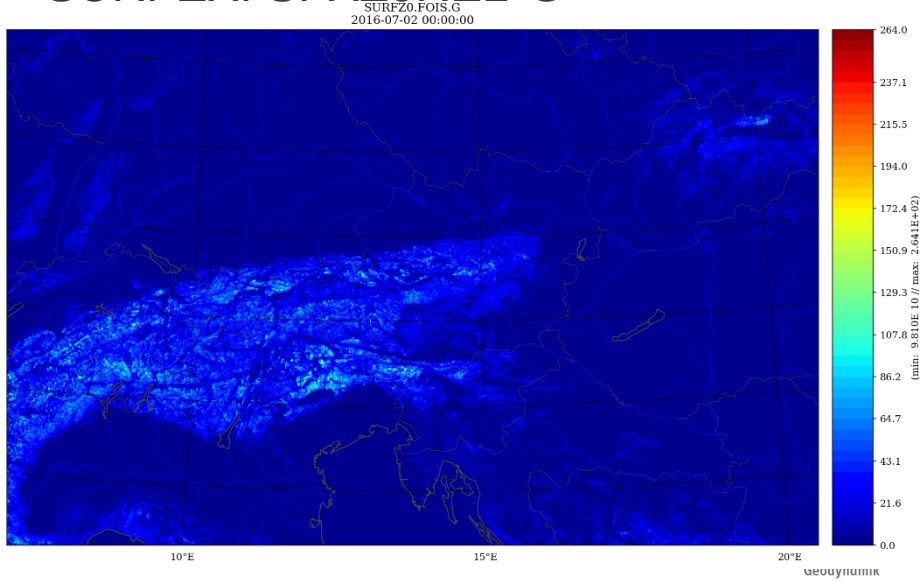
Crashes without abort in minimization - NaN cost function

- GOM arrays NaN (simulated synop observations) due to negative exchange coefficients PCH/PCD(5) in achmttl.F90/acntclstl.F90
- Most crashes avoidable, if synop stations Leiser Berge, Ptuj and Kostelní Myslová blacklisted
- MF-Solution (P. Brousseau) NFPCLI =3 in 927 for old ISBA fields else NFPCLI =1
- old ISBA surface fields (ADDSURF) are still used (roughness, vegetation, emissivity?)!
- Idea: exchange fields with SURFEX values -> all crashes avoided

ISBA-OLD



SURFEX: SFXZ0REL*G



Why AROME-Nowcasting?

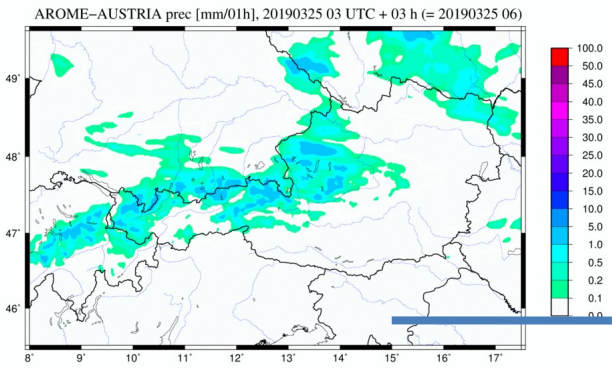
Classical Nowcasting (at ZAMG INCA)

- fast (within few minutes)
- high resolution (<=1km)
- frequent: every 15/5min
- simple combination of observations +NWP
- simple dynamics (motion vectors)
- struggles to predict rapidly envolving non-linear events

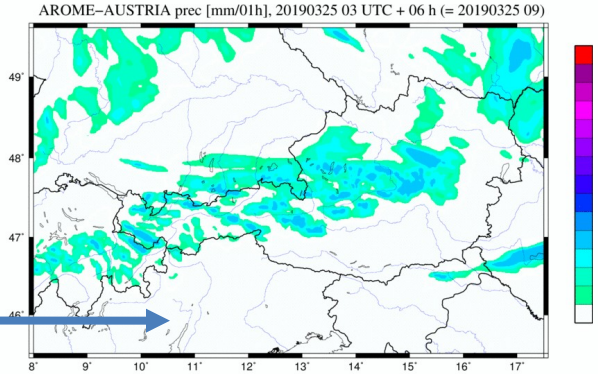
LAM-NWP (at ZAMG AROME 2.5km)

- Slower: available within several hou
- coarser resolved
- less frequent (3 hourly)
- 3D-VAR + OI soil
- Full 3D-dynamics/complex physics
- Long lead time beyond nowcasting range (+60h)

3h FC



6h FCST



reference