Nowcasting with AROME - recent challenges and developments in Austria

Florian Meier, Yong Wang with contributions from Aitor Atencia, Phillip Scheffknecht, Christoph Wittmann and Mirela Pietrisi

LACE
nwp central europe

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Outlook

- Why we do it?
- Technical setup
- Results and issues: Cycling, Spin-Up, Doppler winds
- Conclusions and further plans

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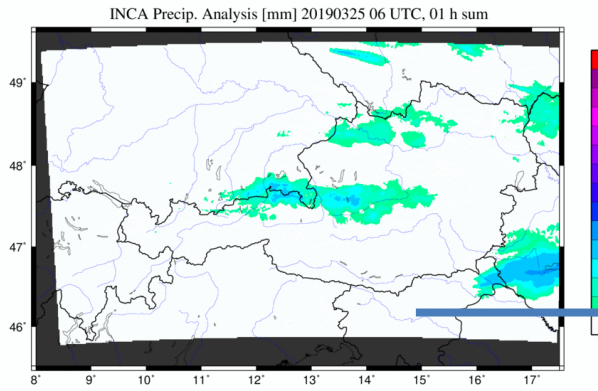
Why AROME-Nowcasting?

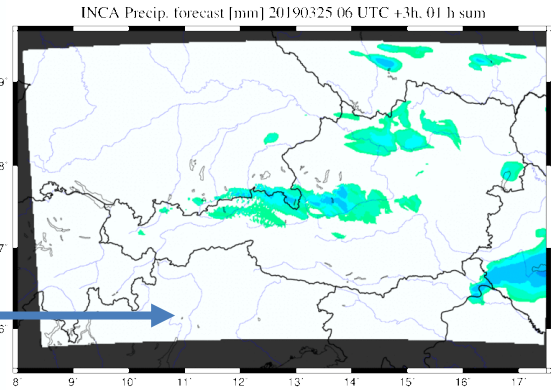
Classical Nowcasting (at ZAMG INCA)

- 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

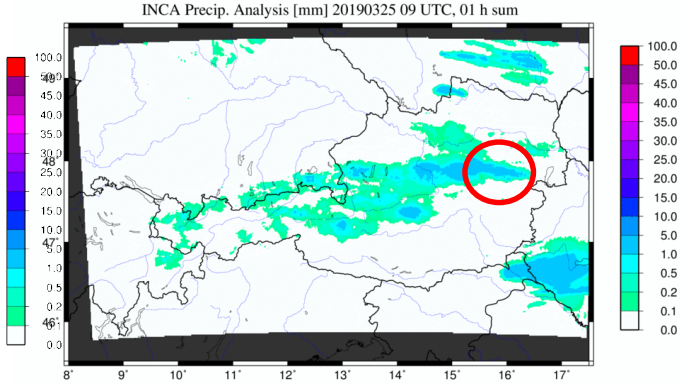
ANA



+3h FCST



+3h ANA=reference



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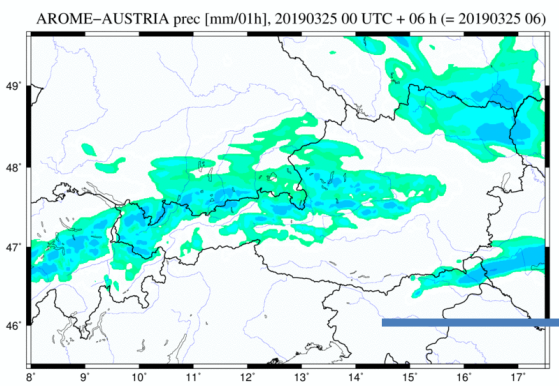
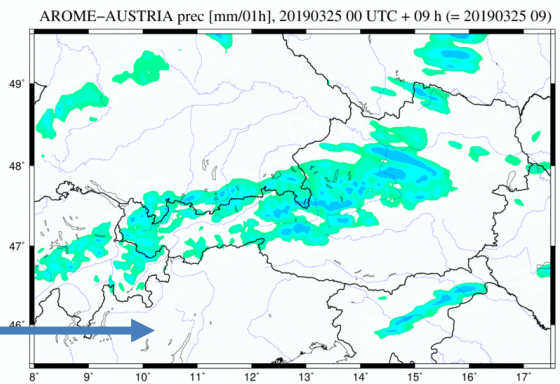
LAM-NWP (at ZAMG AROME 2.5km)

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

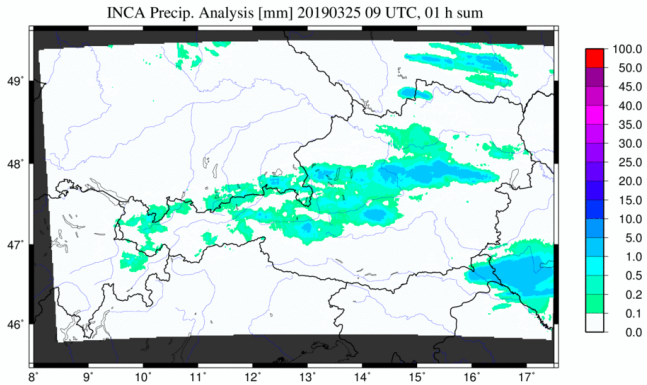
+6h FC



+9h FCST



reference

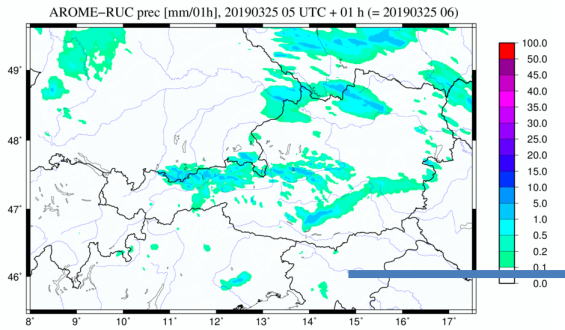


Why AROME-Nowcasting?

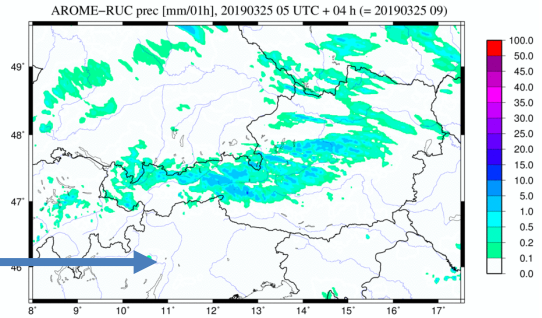
AROME-RUC Nowcasting:

- fill gap inbetween
- every hour, within one hour, hourly (2hourly) cycle, up to +12h
- higher resolution close to INCA (1.2km)
- Computational costly and challanging
- reduced available observation set might cause problems
- similar systems in France (AROME-PI), Norway, Denmark, …
- Operational at ZAMG by the end of 2019

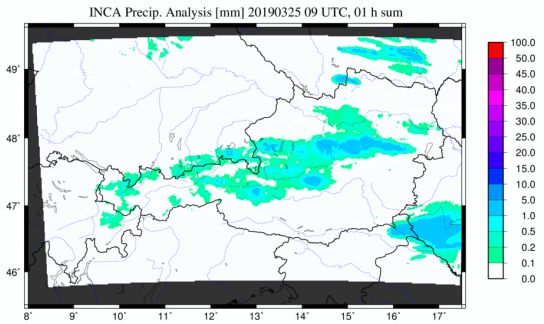
+1h FC



+4h FCST



reference



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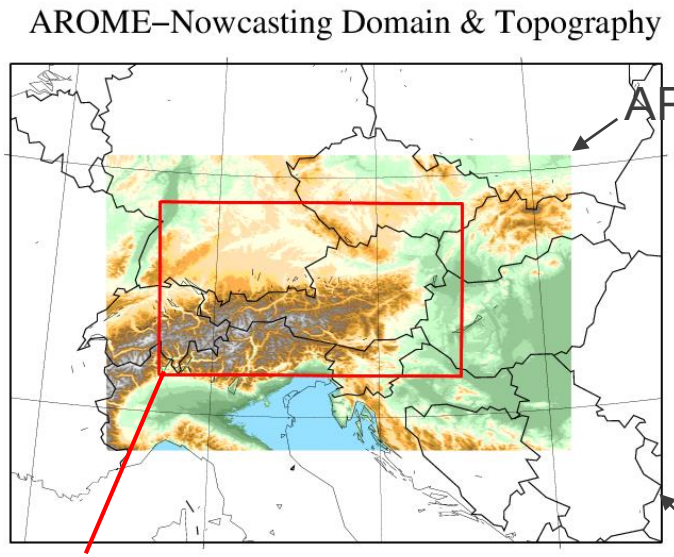
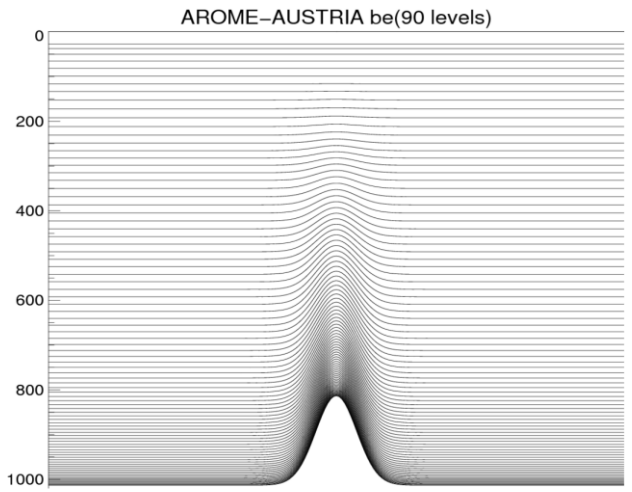
Technical setup of AROME-RUC for Nowcasting at ZAMG

- coupled to most recent AROME 2.5km
- different cycling (1-2h), higher res. (1.2km) and smaller domain than in AROME 2.5km
- feedback from classical Nowcasting via Latent Heat Nudging +35min every 5min
- FDDA-Nudging of T2m/RH2m/10m wind +30min every 10min
- additional observations: RADAR, MODE-S, AMDAR-Q, national GNSS-ZTD
- backphased IAU filtering to control spin-up +5min
- cutoff time +30min; lead time +12h
- Saturated radar RH obs if threshold of reflectivity exceeded (idea of E. Wattrelot)



900x576x90 GP
1.2kmL90
cy40t1 export+
obs window:
-90min+30min



90 vertical layers

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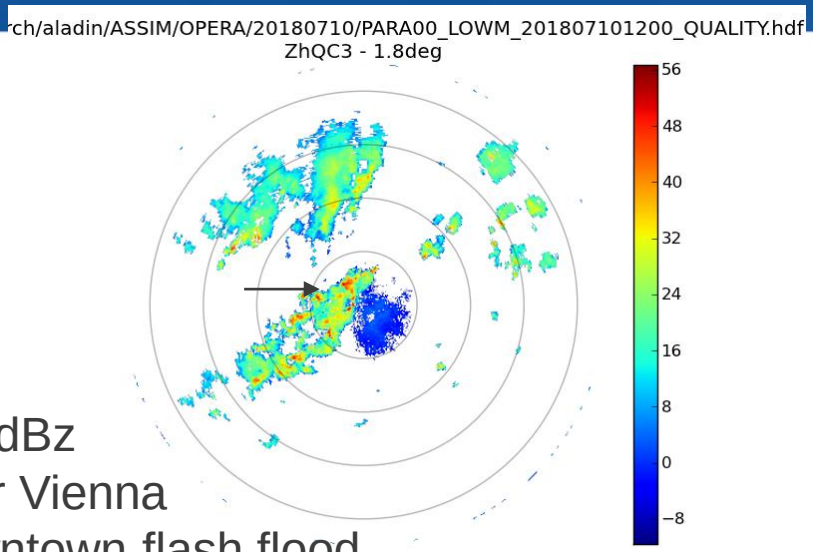
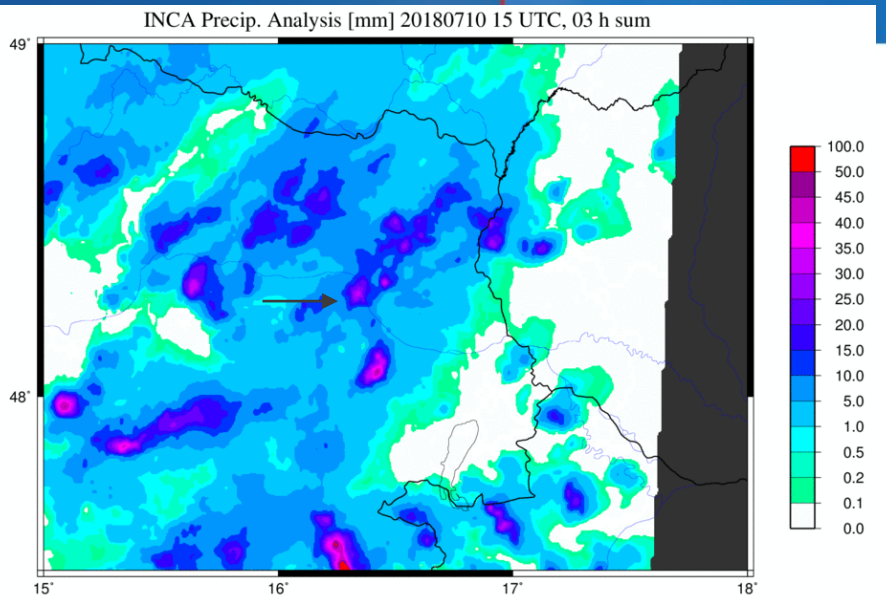
Radar assimilation struggles if no rain in the surrounding, but rain observed

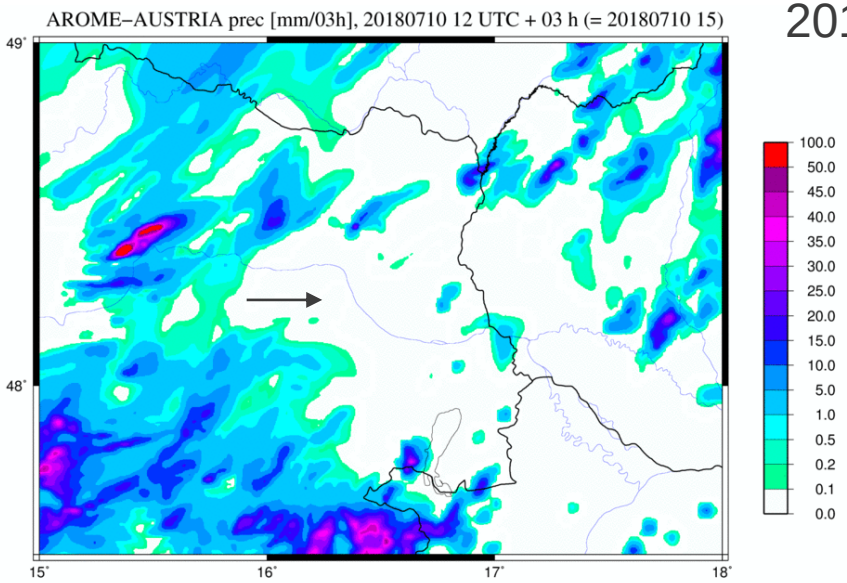


>56dBz
over Vienna
downtown flash flood

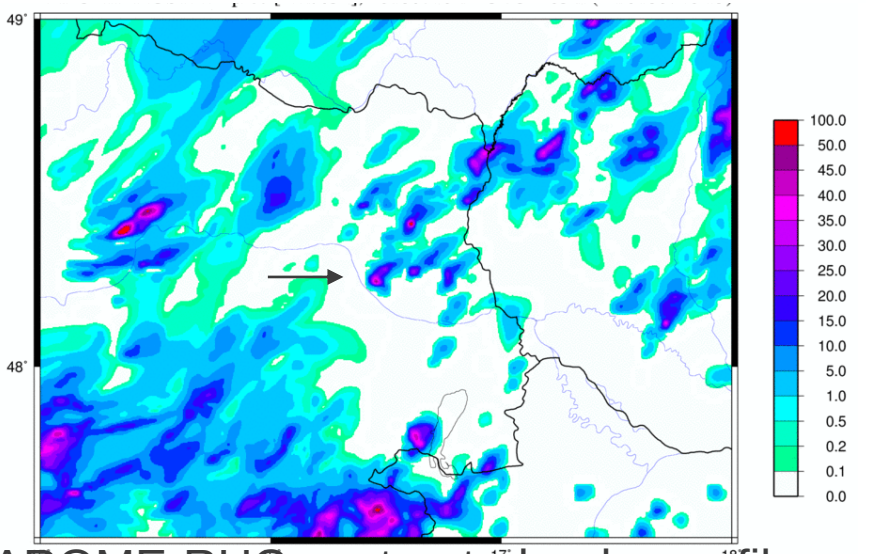
RADAR12UTC
20180710



INCA12-15UTC

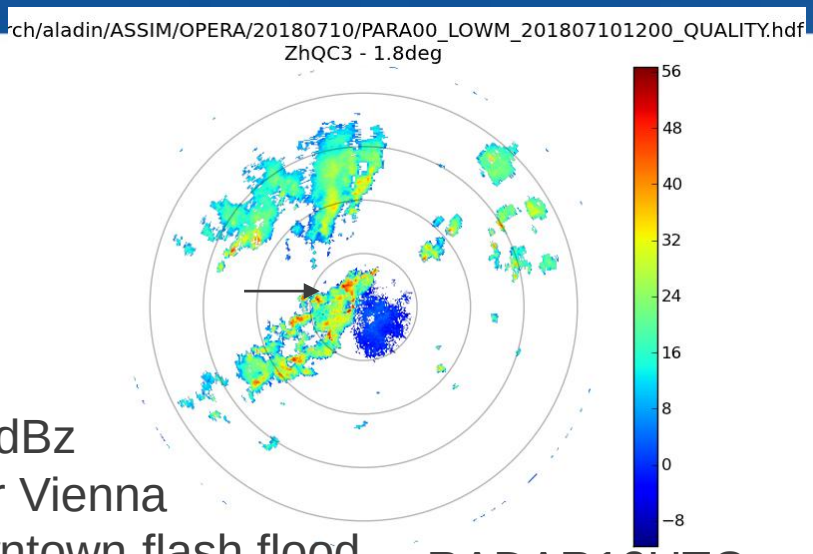


AROME-RUC+RADAR12UTC+3h



AROME-RUC +saturated radar profile

Latent heat nudging can support formation of convection in the model



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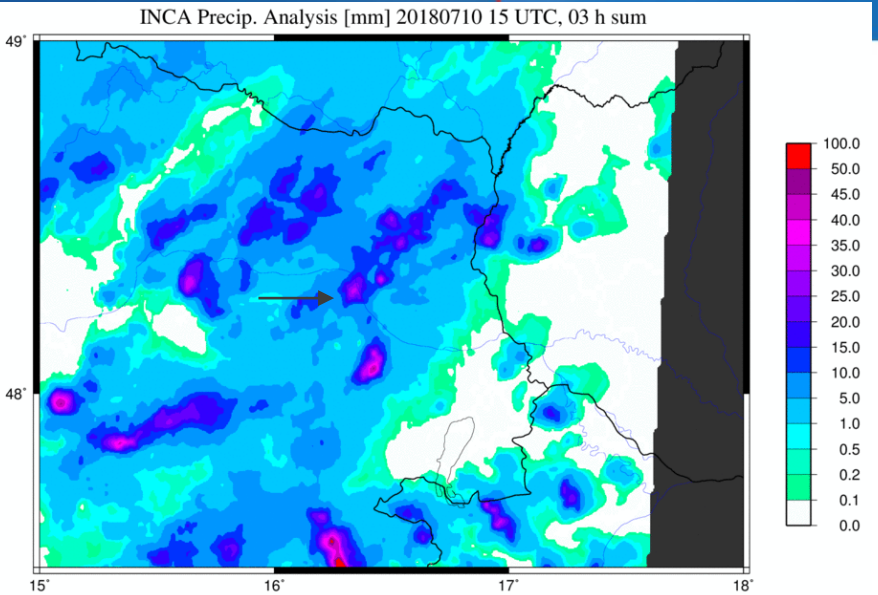
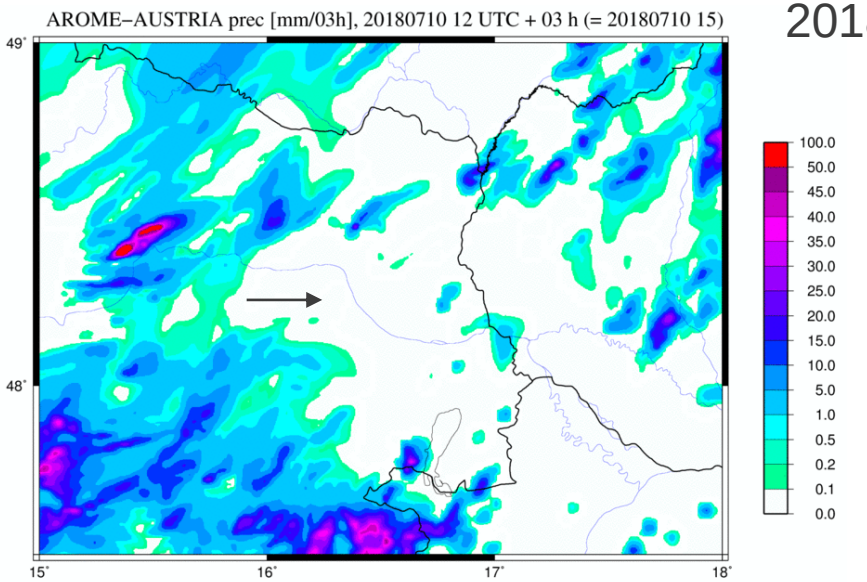
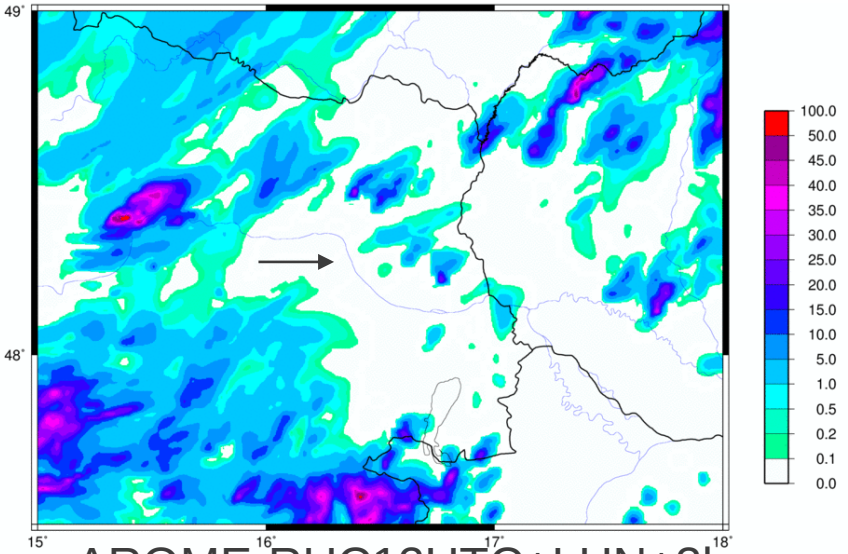


INCA12-15UTC



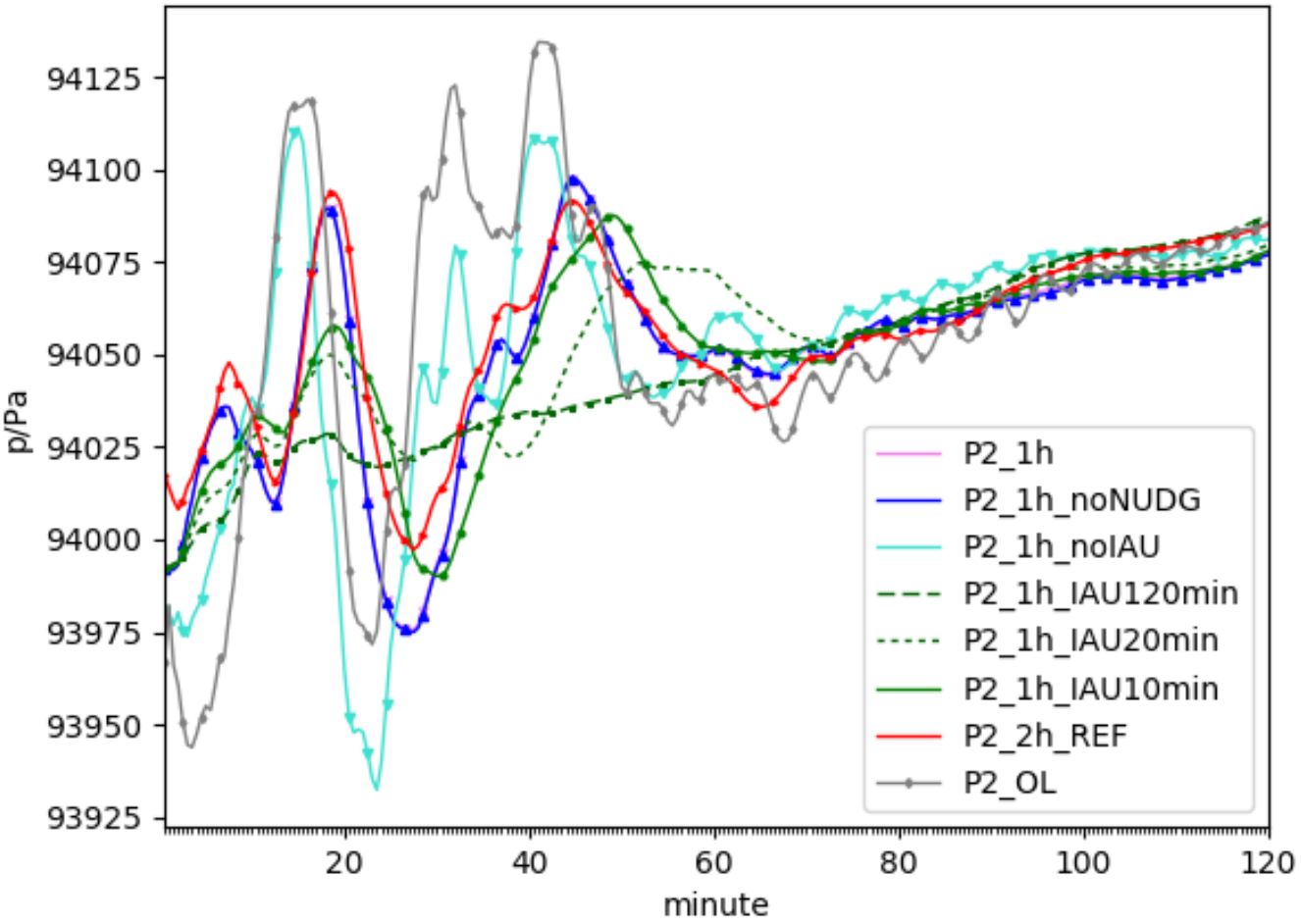
AROME-RUC+RADAR12UTC+3h



AROME-RUC12UTC+LHN+3h

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

<u>Reasons:</u>

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

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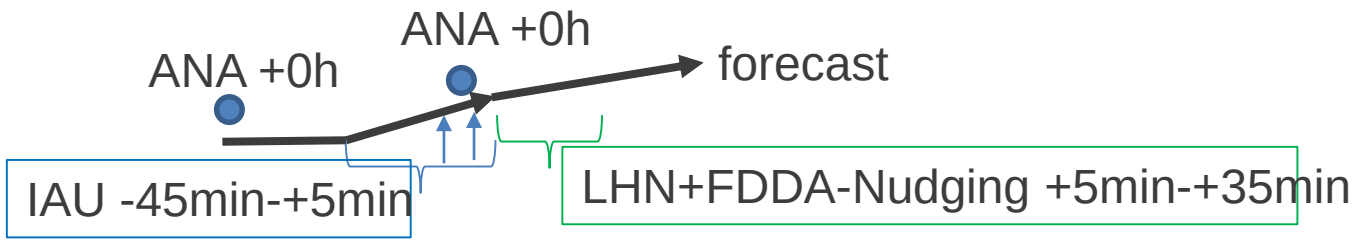
Hourly or 2 hourly cycling?

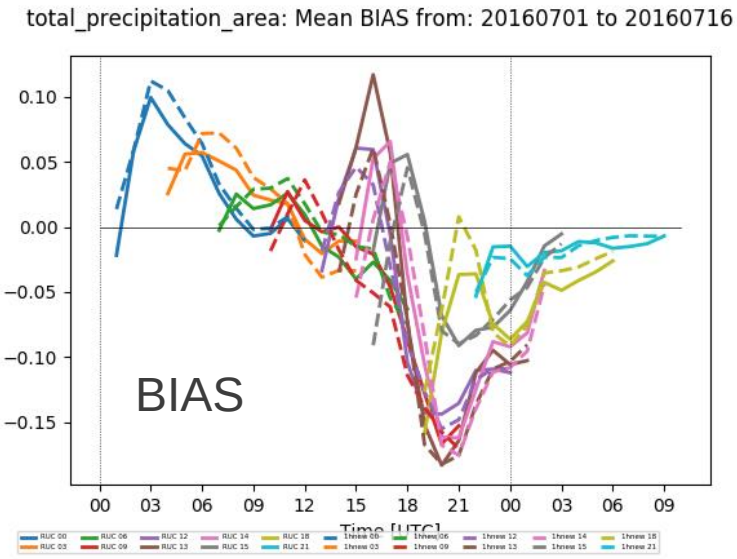
standard hourly cycling performed extremly bad compared to two hourly (Bias+RMSE)

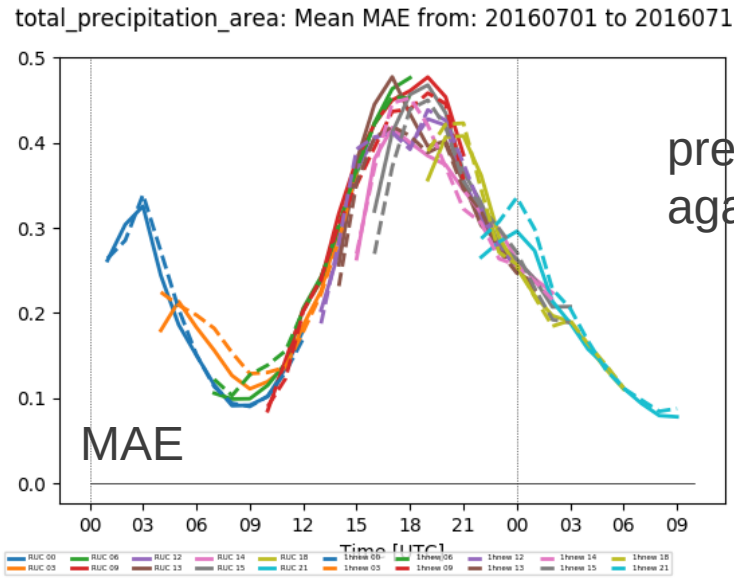
Idea:

Start one hour in advance and push forecast towards analysis to reduce spin-up time

avoid competition of IAU and Nudging







precip.
against INCA

1 Hourly with extended IAU dashed vs 2 hourly solid

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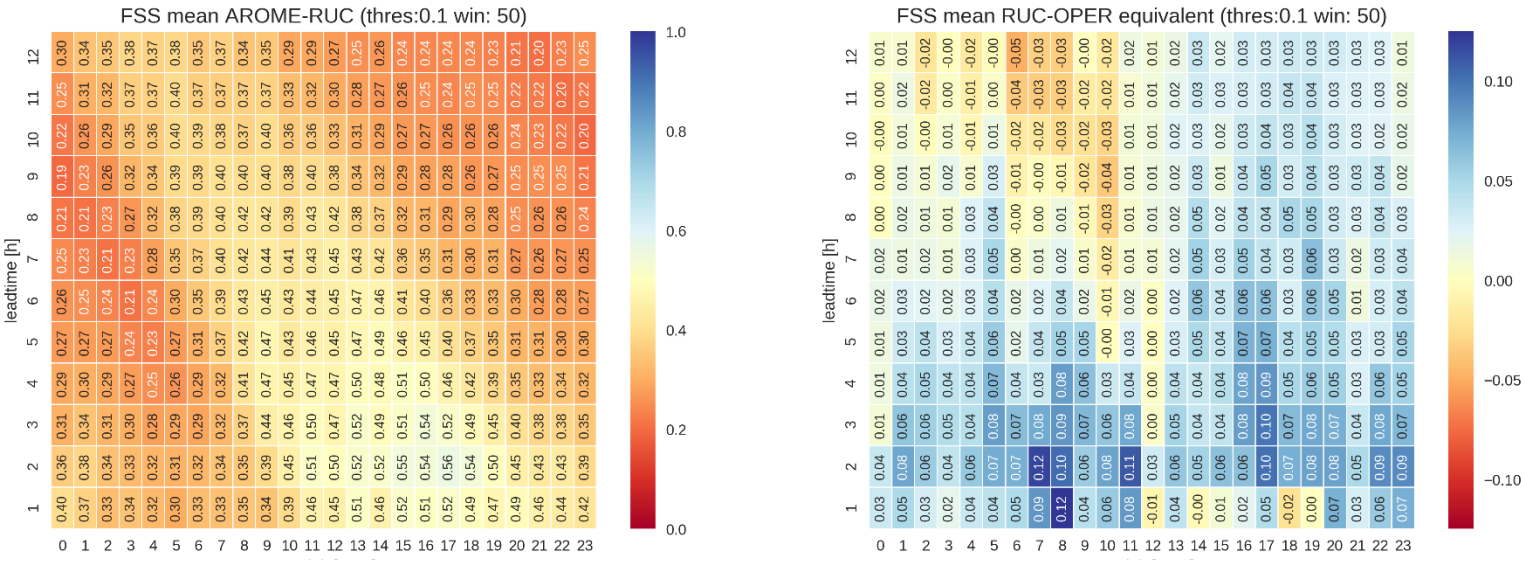
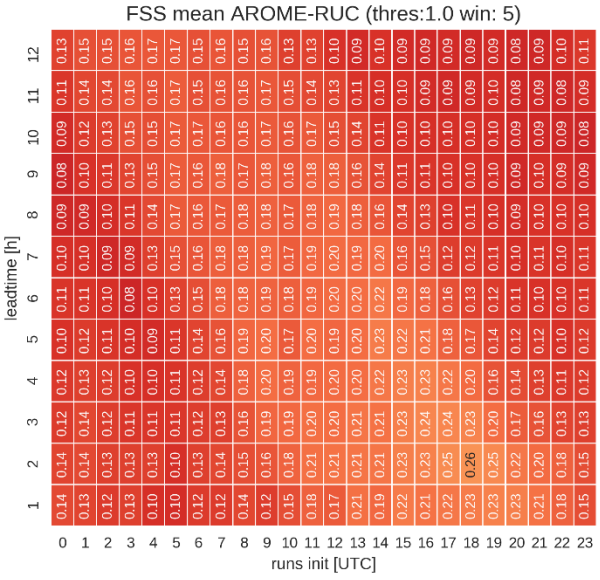
Validation of precipitation summer

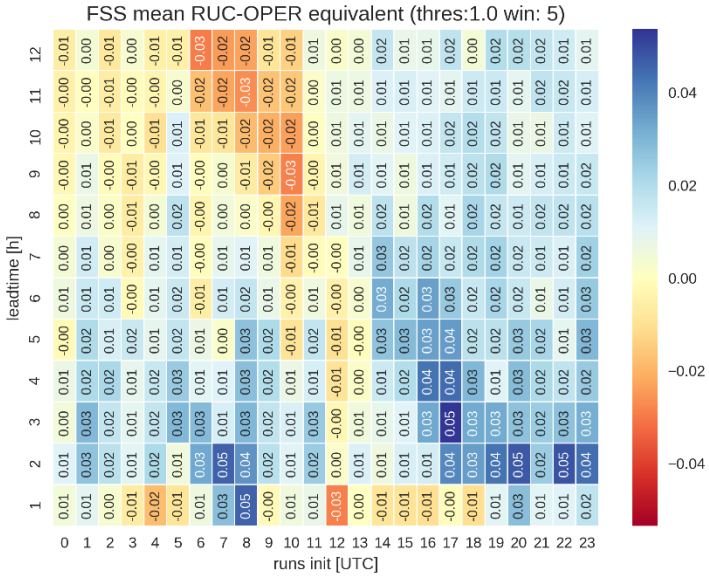


Fraction Skill Score FSS July 2016

difference in FSS to freshest AROME 2.5km

Lead time





INIT TIMES (24 runs)

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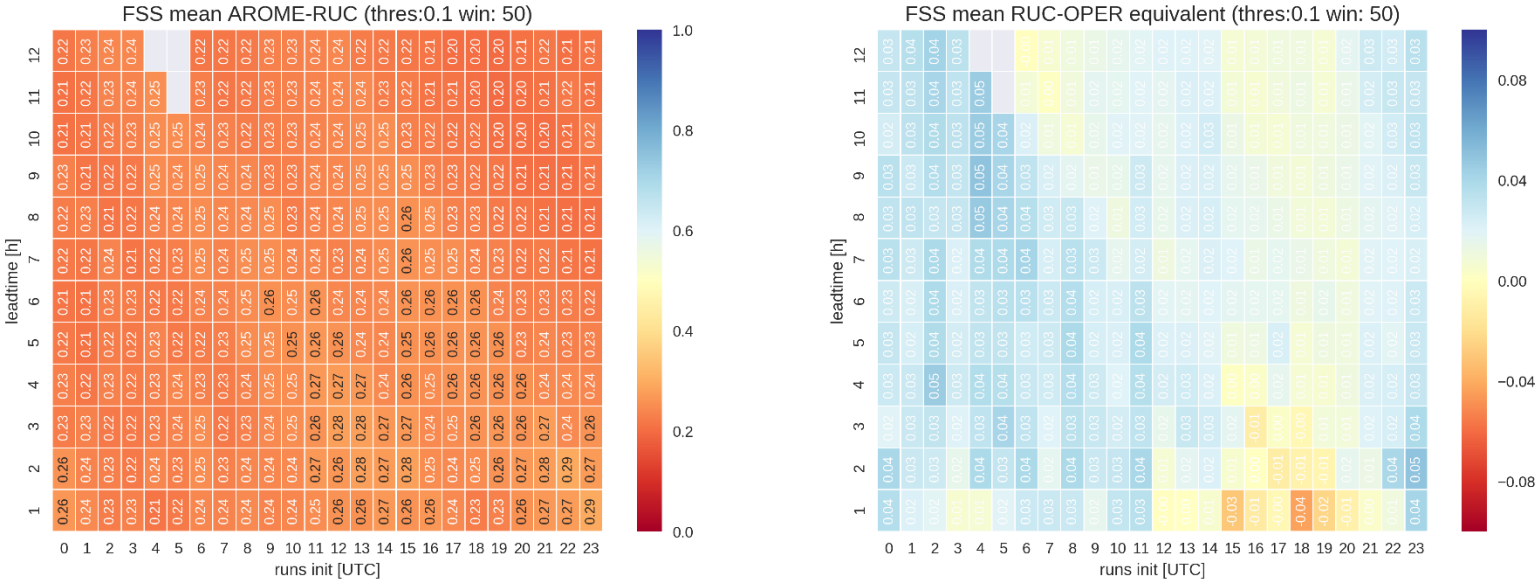
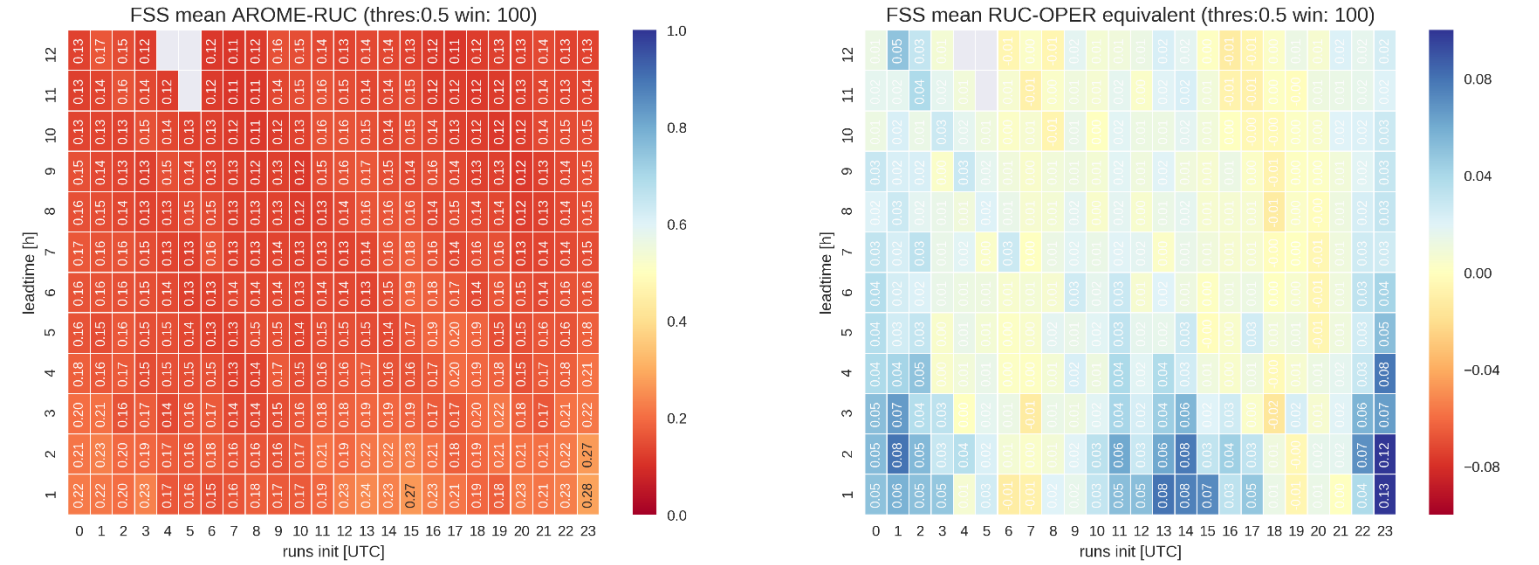
Validation of precipitation winter



Fraction Skill Score FSS January 2017 difference in FSS to freshest AROME 2.5km

Lead time



INIT TIMES (24 runs)

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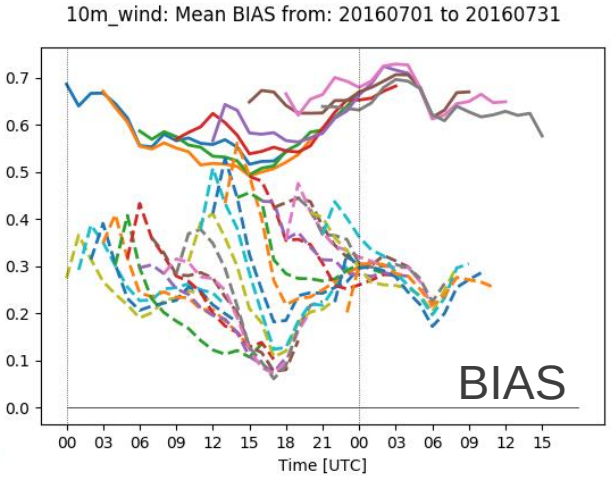
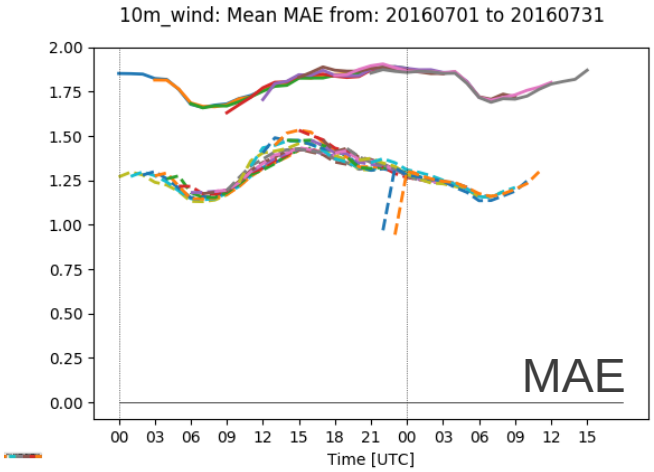
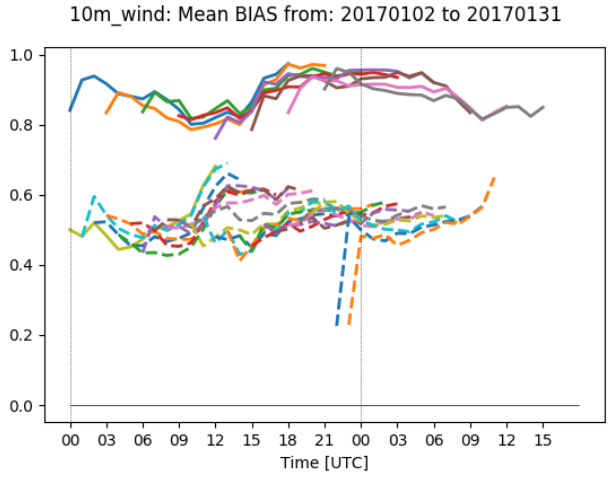
Validation July 2016, January 2017 wind



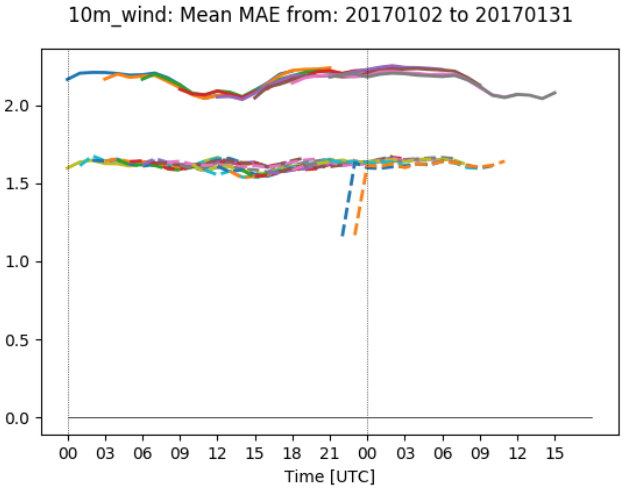
July



AROME 2.5km soild; AROME-RUC dashed



January



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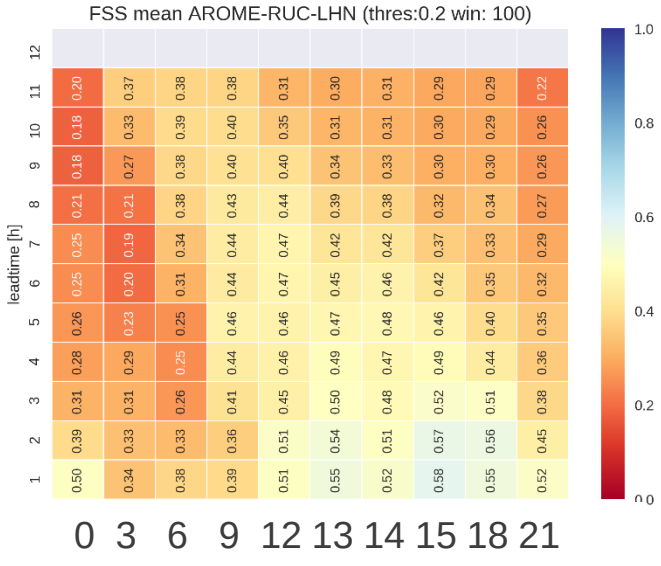
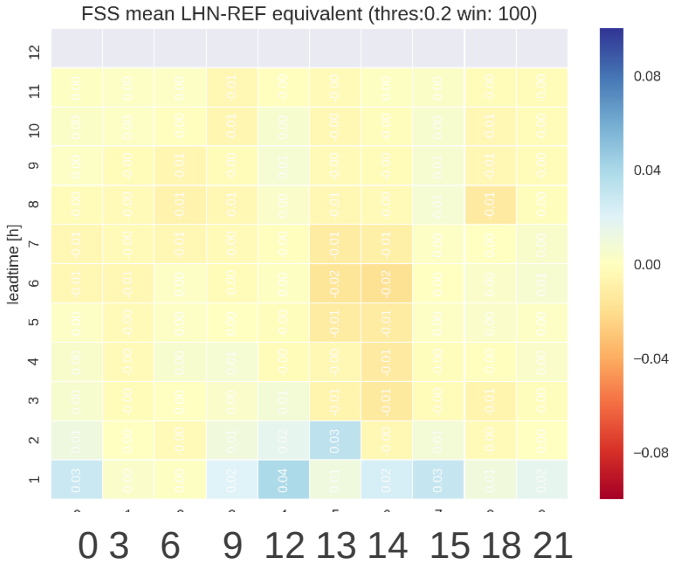
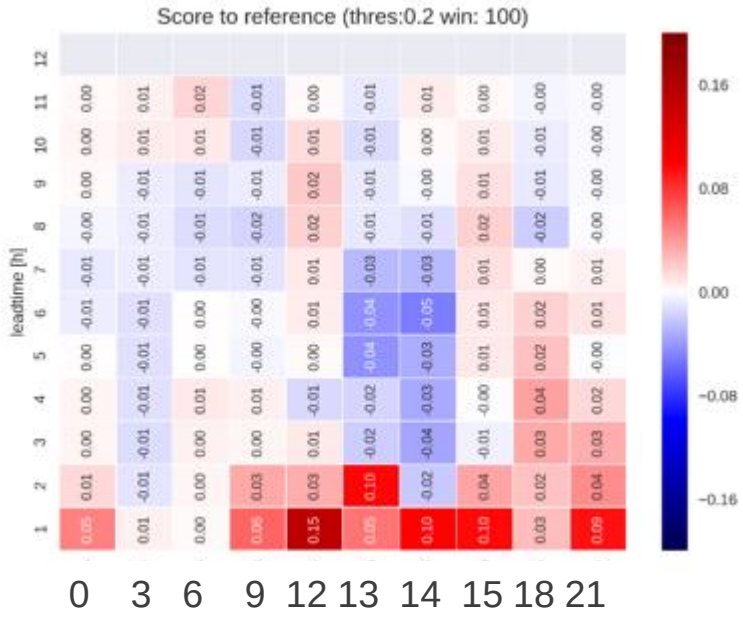




Validation of Latent Heat Nudging 1st-16th July 2016



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

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

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

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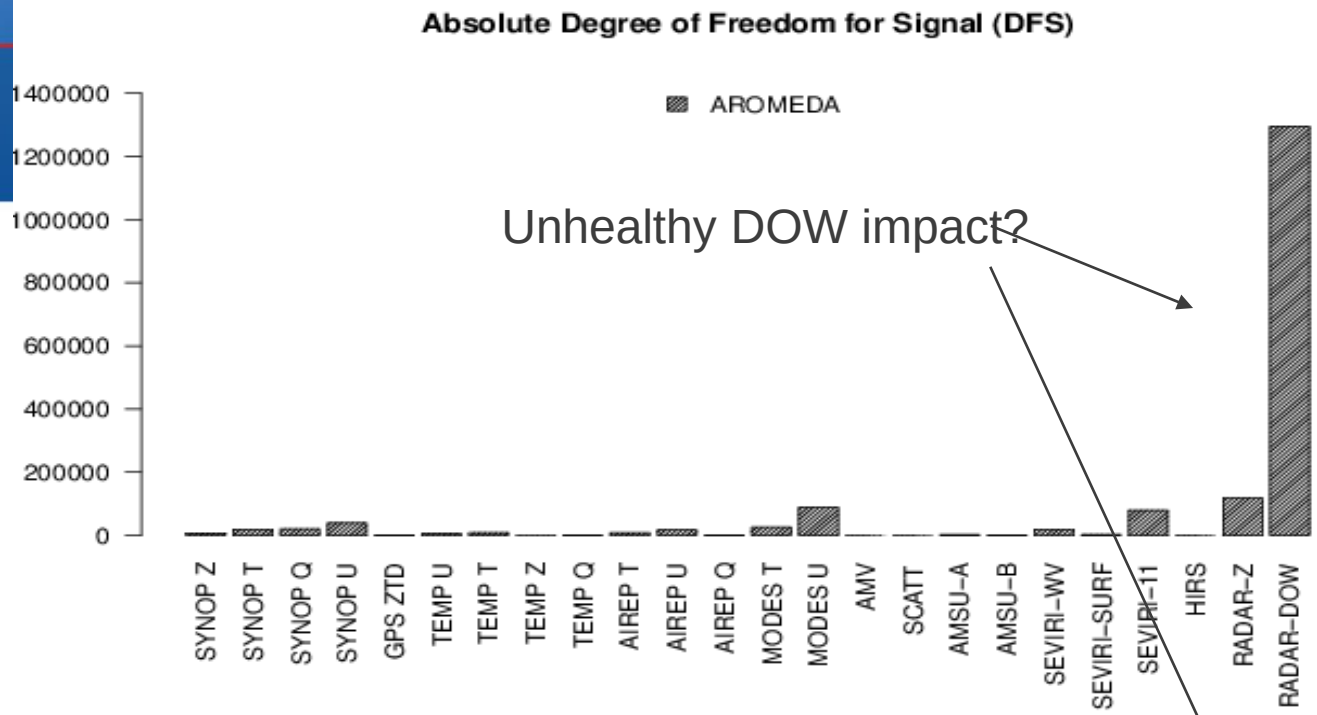
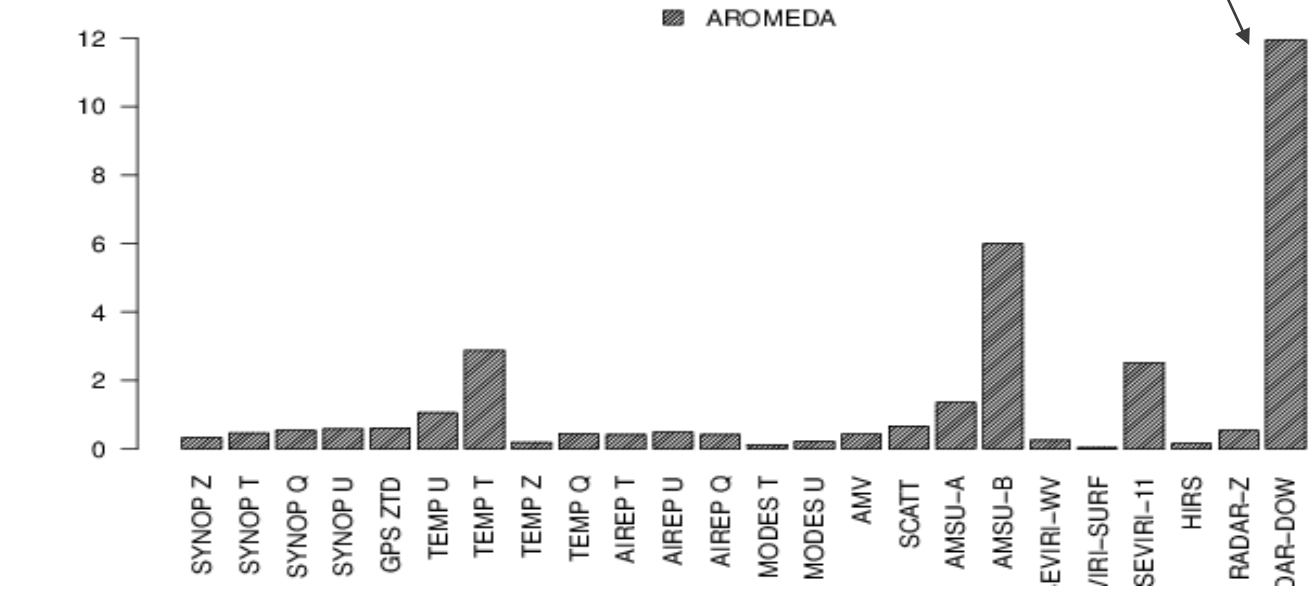


Unhealthy DOW impact?



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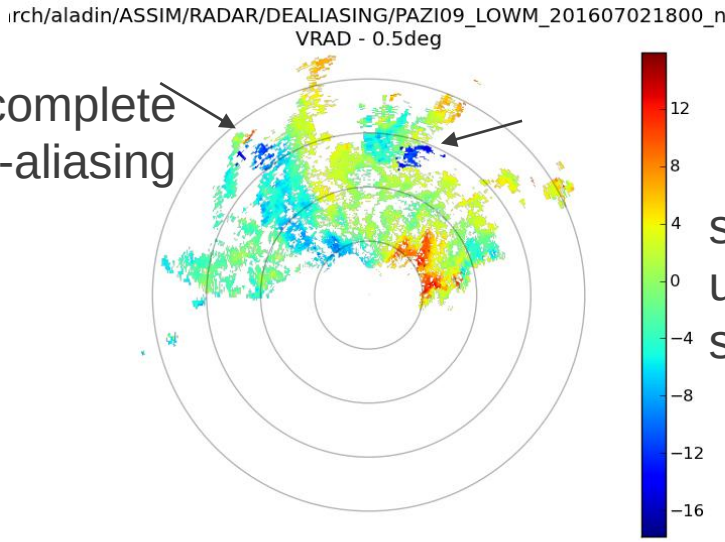
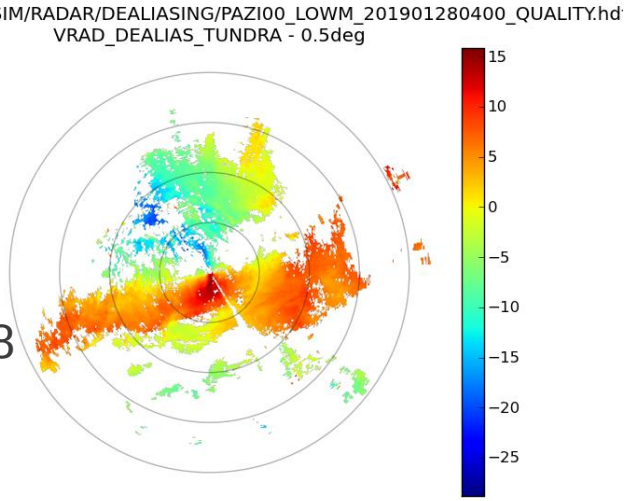
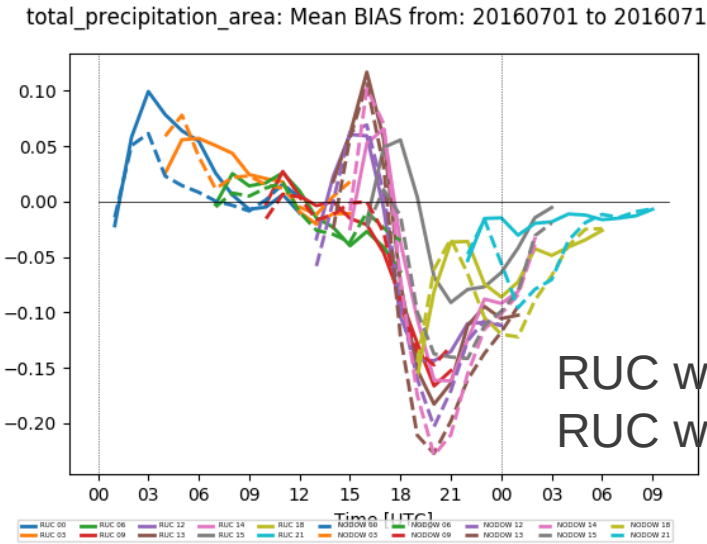
Radar DOW assimilation still problematic



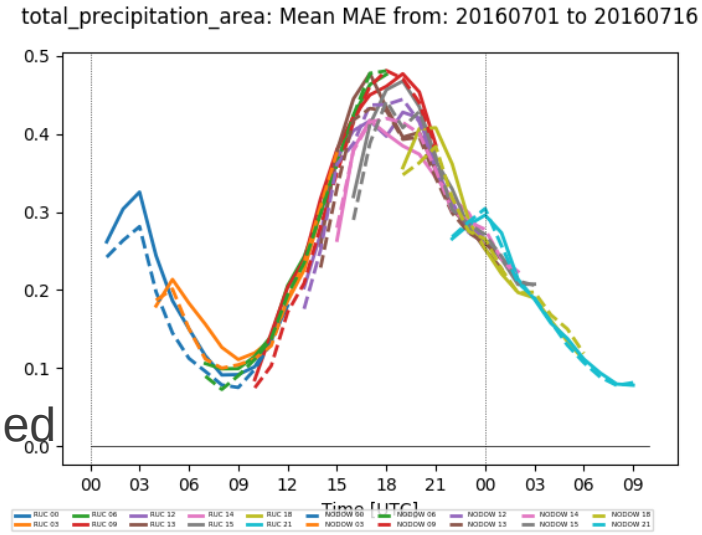
incomplete de-aliasing

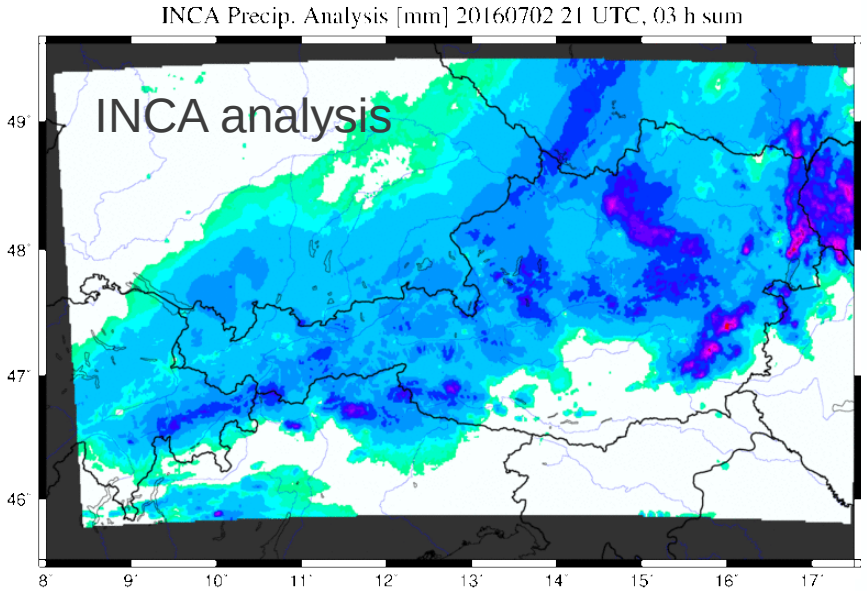
signal processor upgrade in Austria summer/autumn 2018



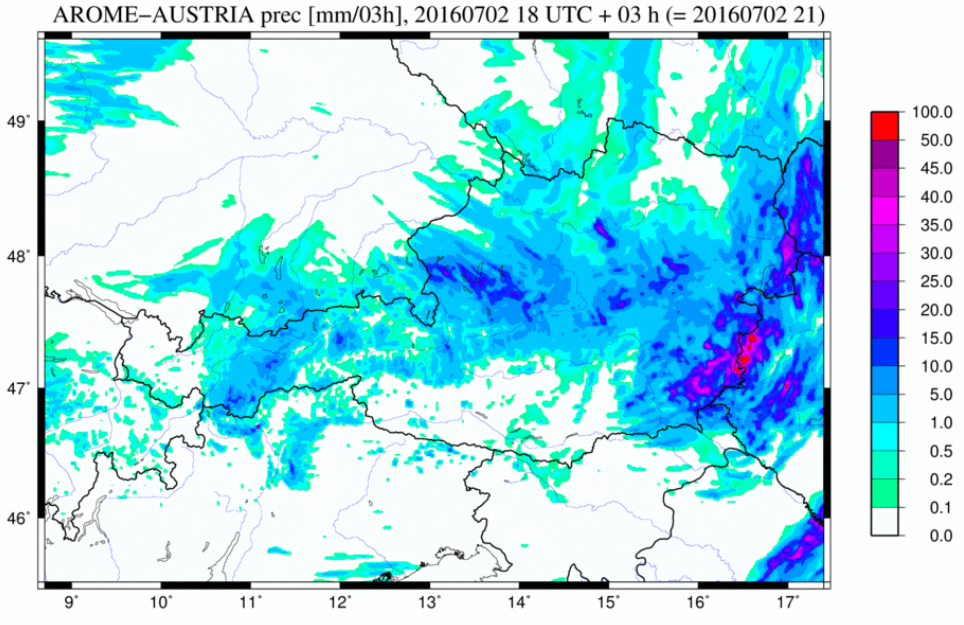


RUC with Doppler solid
RUC without Doppler dashed

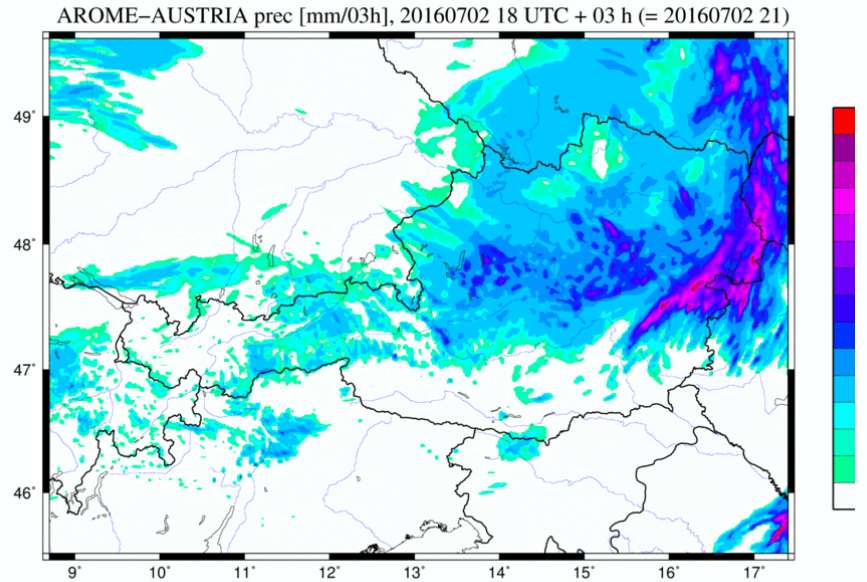




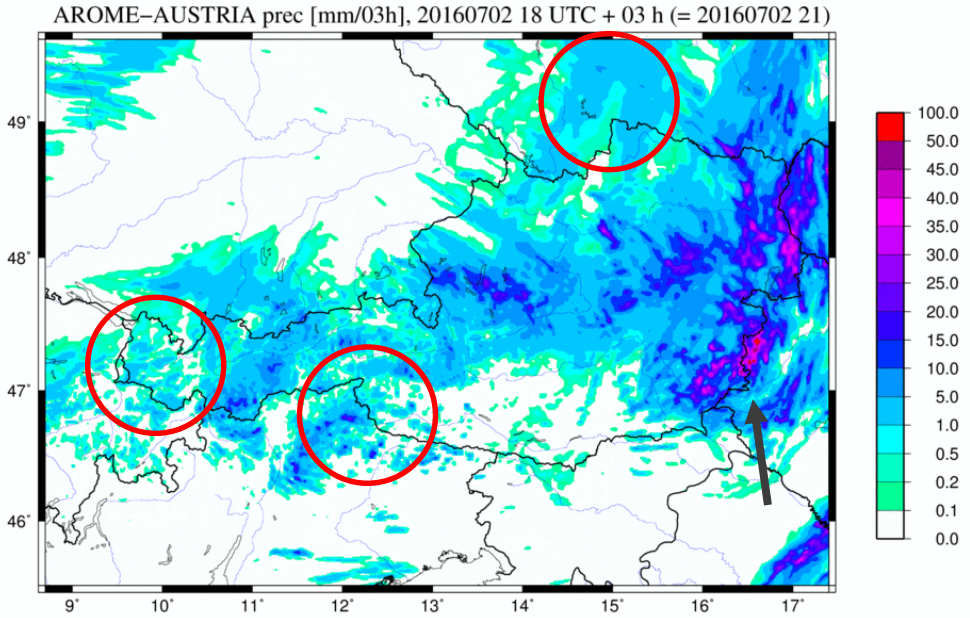
2nd July 2016 RR 18UTC +3h



AROME-RUC with radar DOW+REF

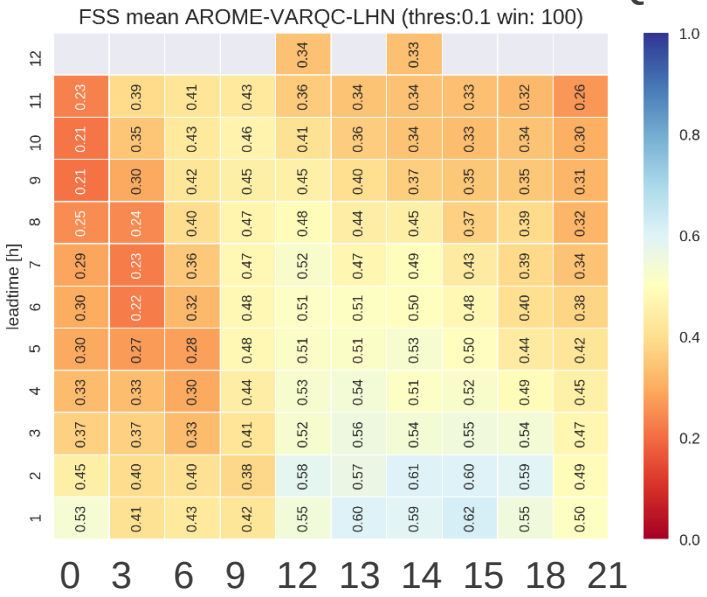


AROME-RUC without Doppler wind assim

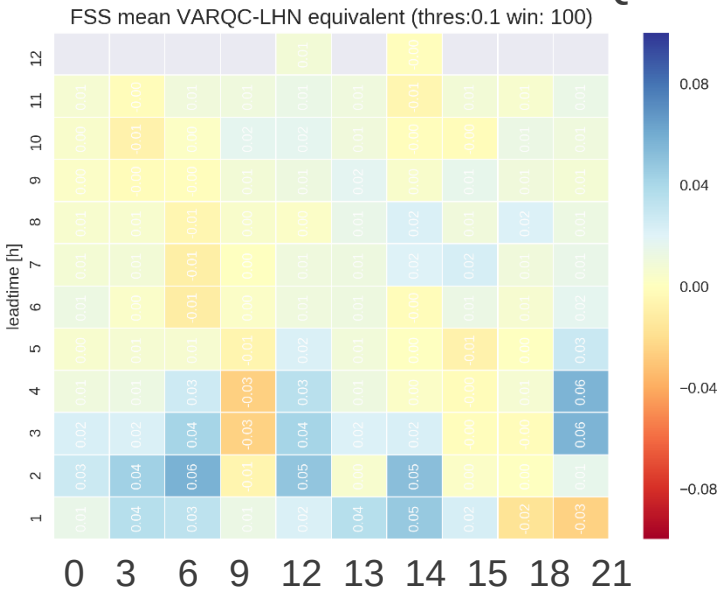


AROME-RUC+DOW+VARQC

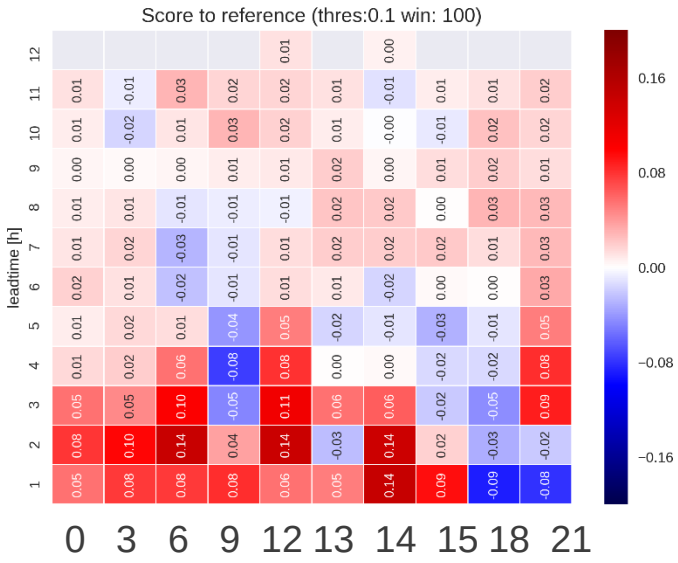
FSS AROME-RUC+VARQC



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

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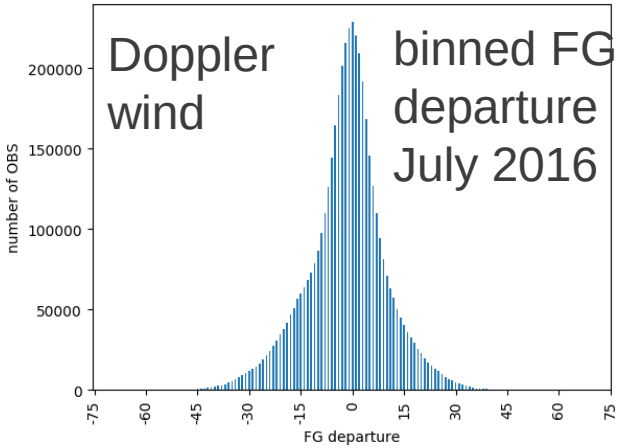
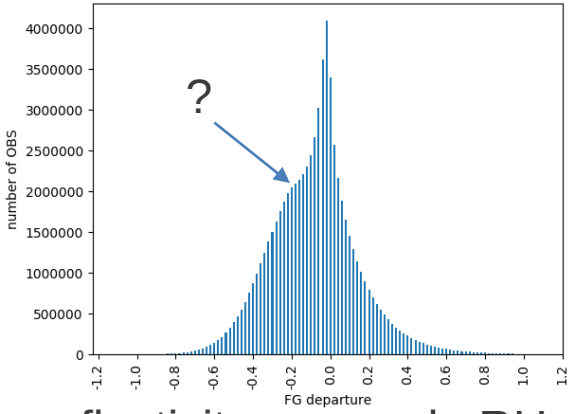
VARQC of radar? (gross errors get reduced weight)

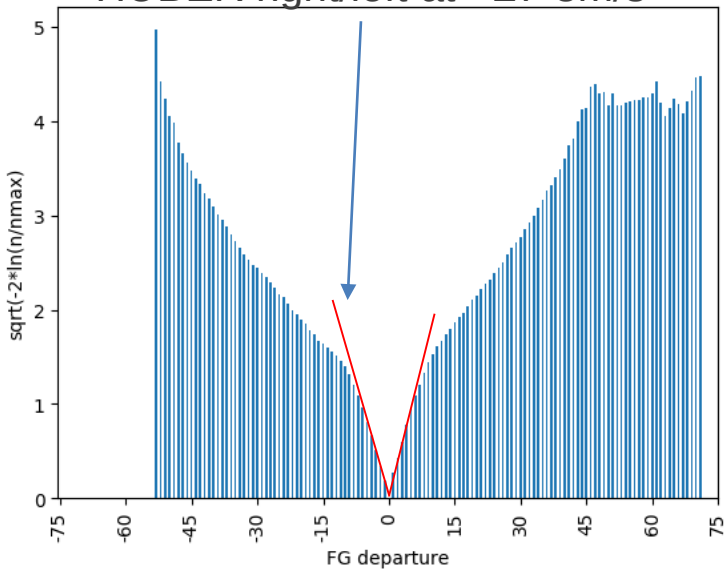
Ingleby &Lorenc 1993



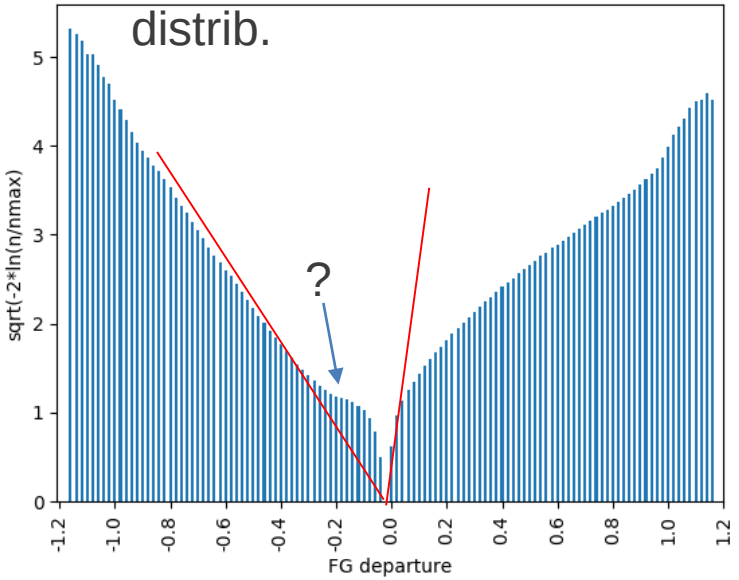
Austrian radars only



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
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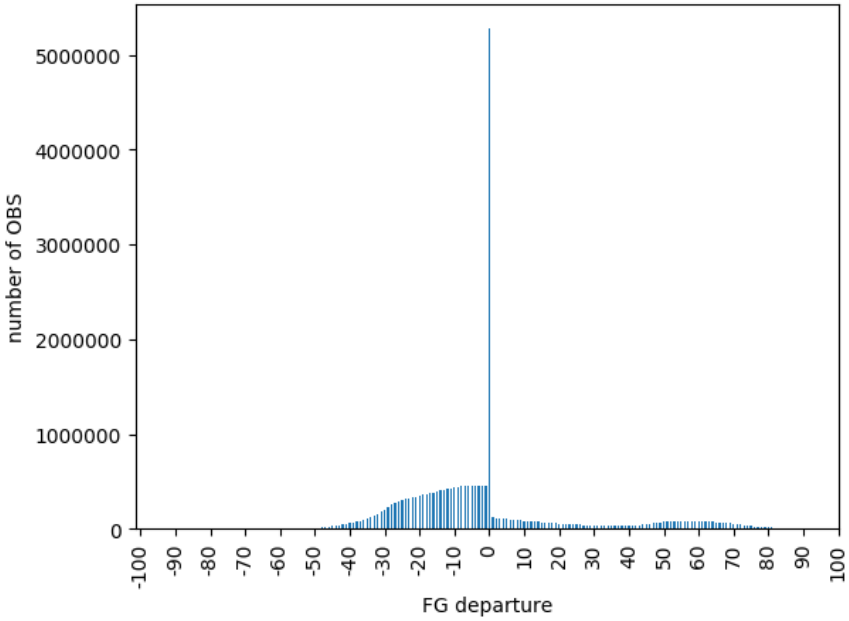

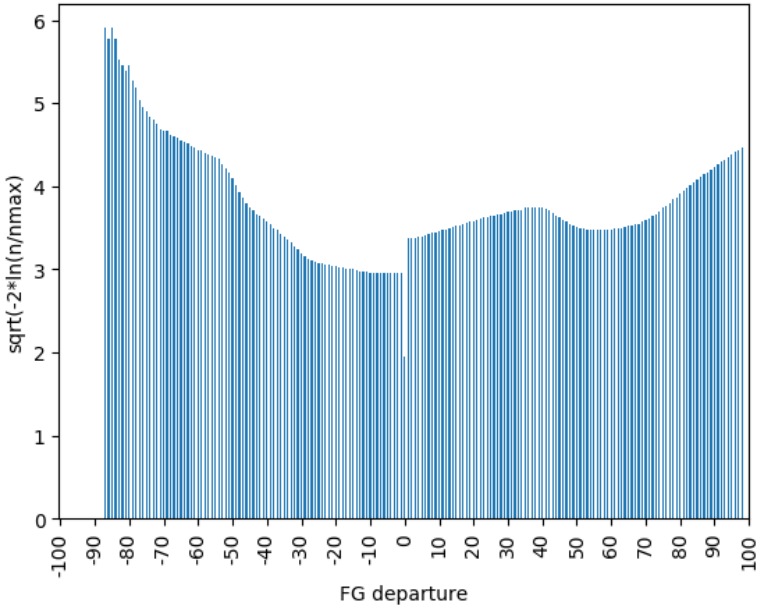

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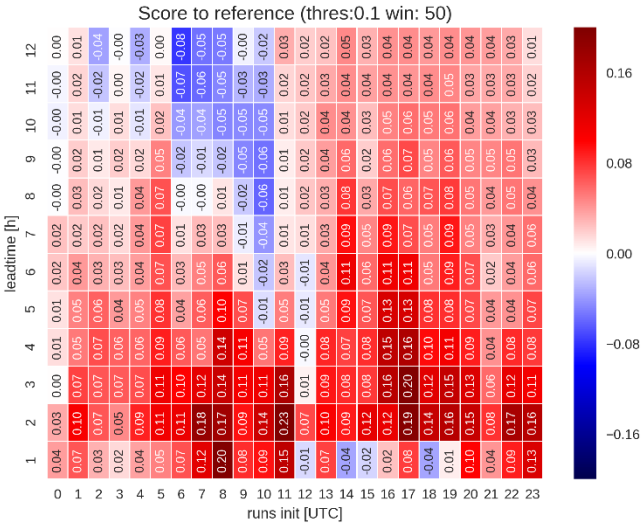

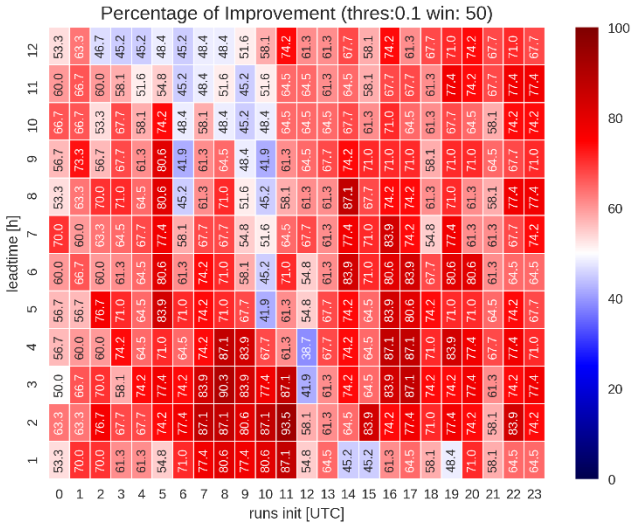

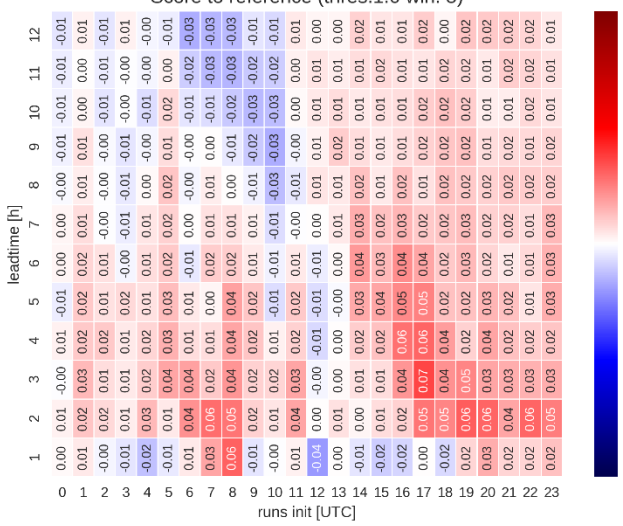

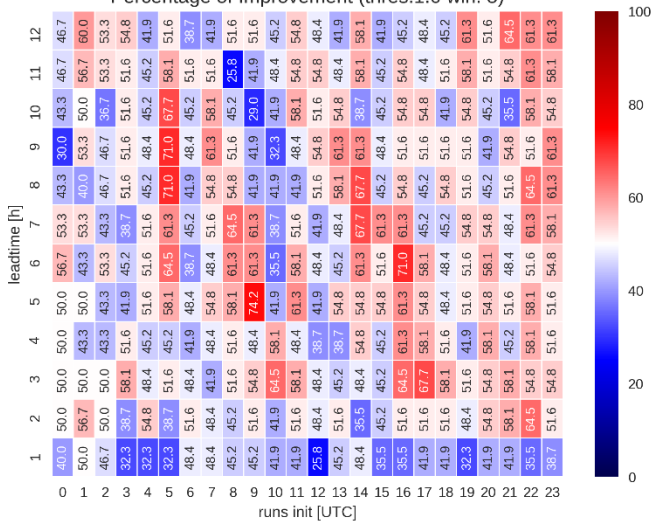

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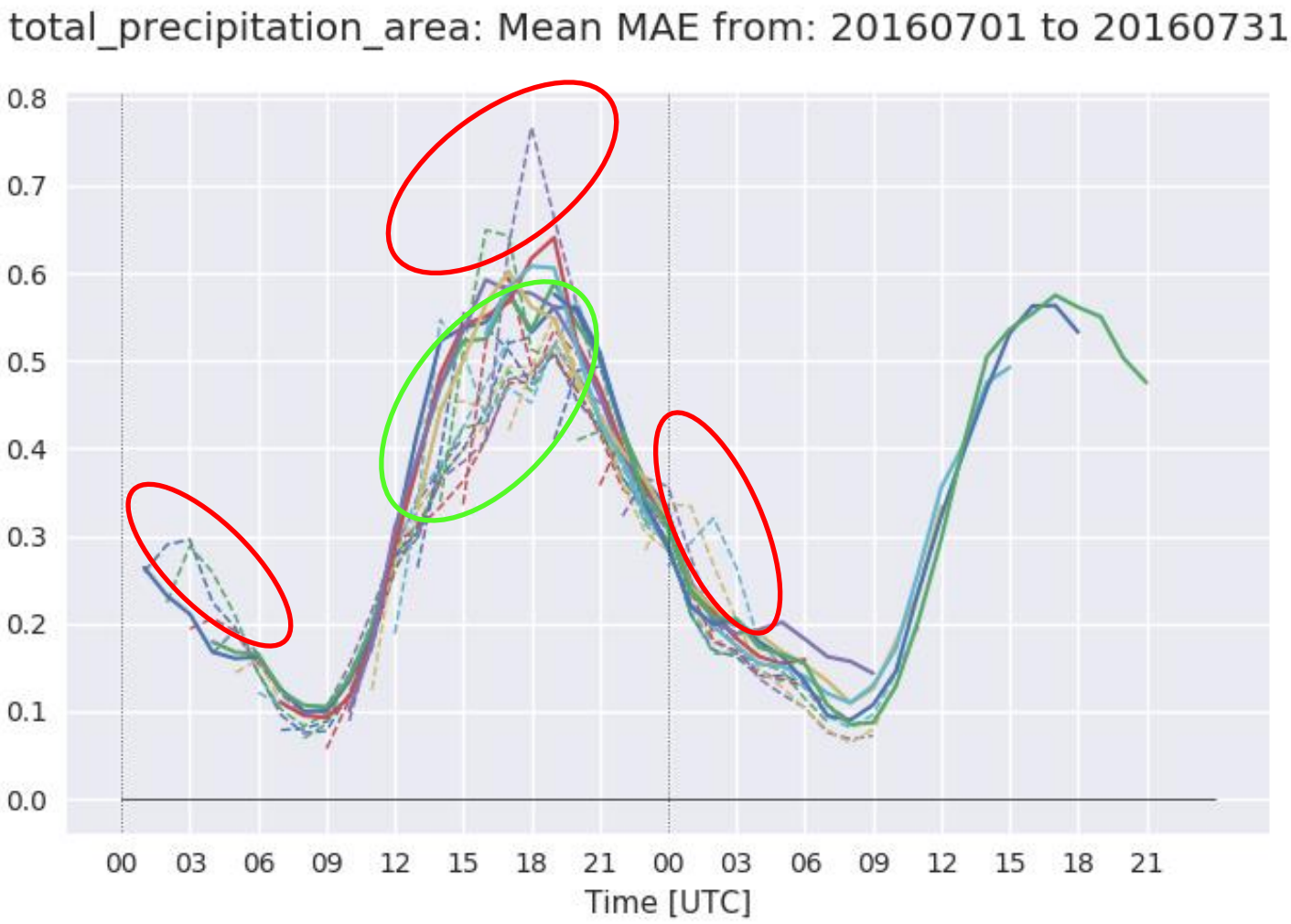
Score to reference (thres:0.1 win: 50)
leadtime [h]
runs init [UTC]
0.16
0.08
0.00
−0.08
−0.16

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

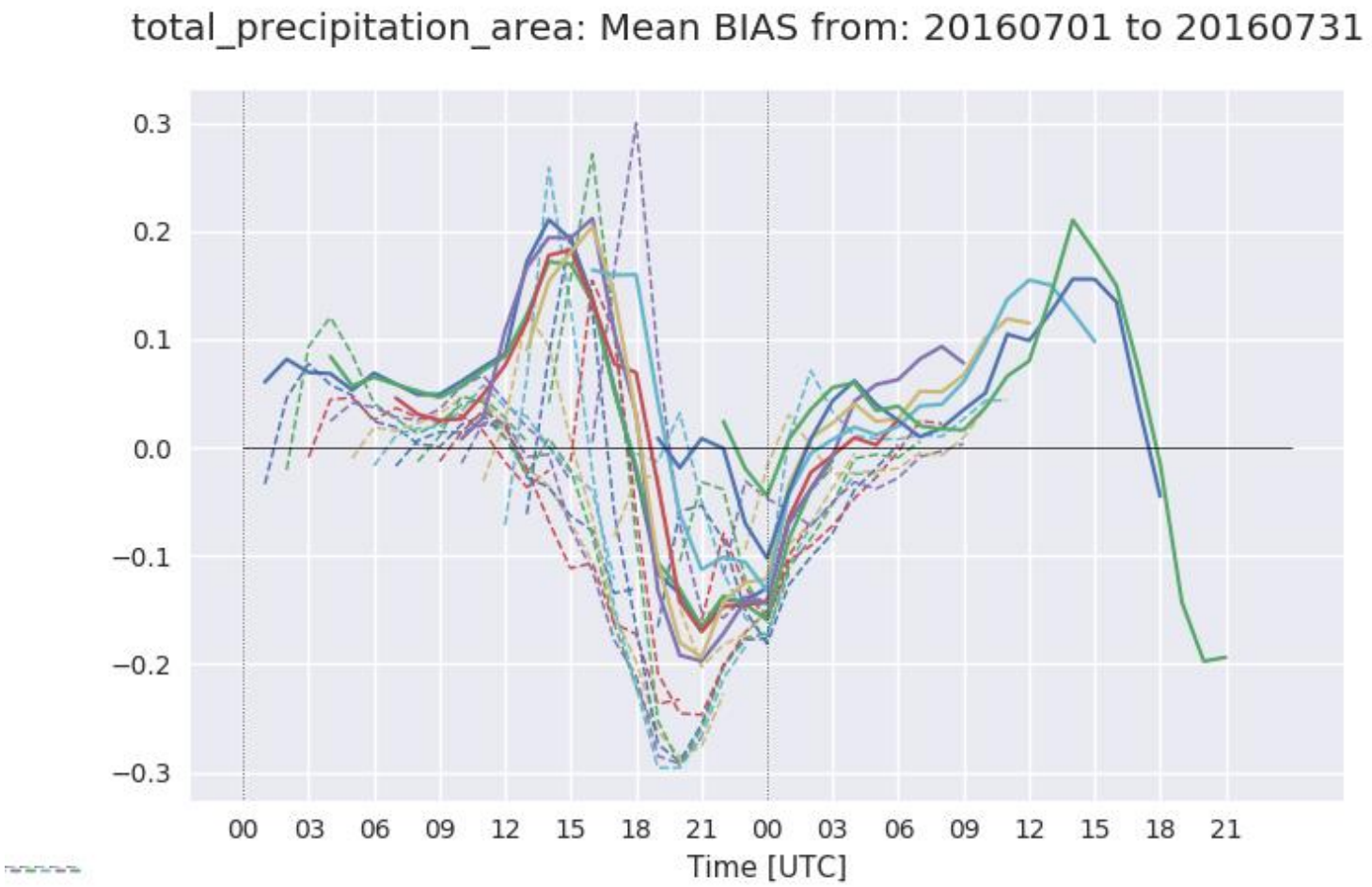
Percentage of Improvement (thres:0.5 win: 100)
leadtime [h]
runs init [UTC]
100
80
60
40
20
0

MAE (area mean)



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

BIAS (area mean)



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

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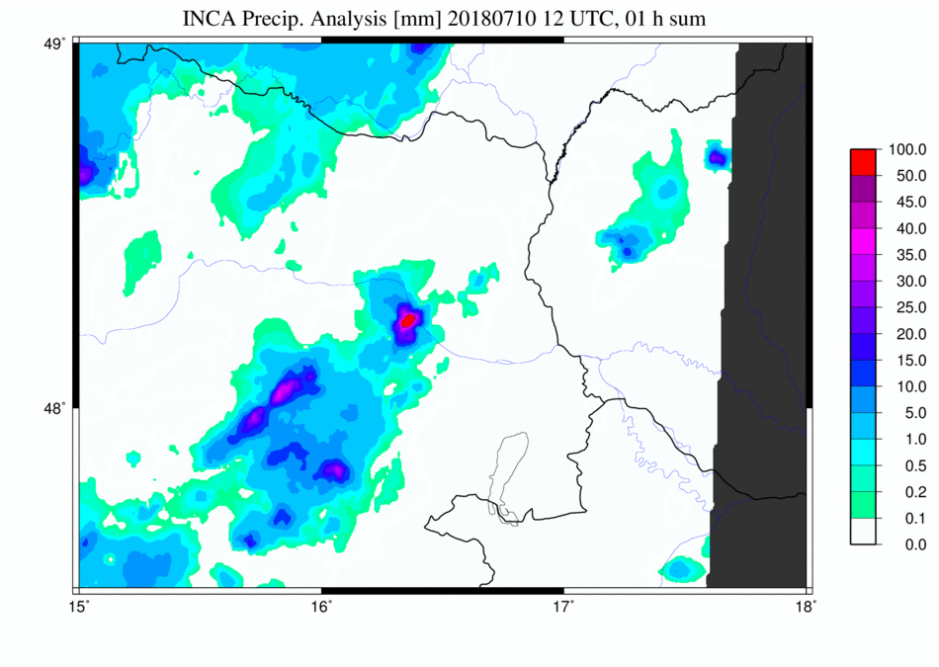

INCA Precip. Analysis [mm] 20180710 12 UTC, 01 h sum
49°
48°
15°
16°
17°
18°
100.0
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
1.0
0.5
0.2
0.1
0.0

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

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

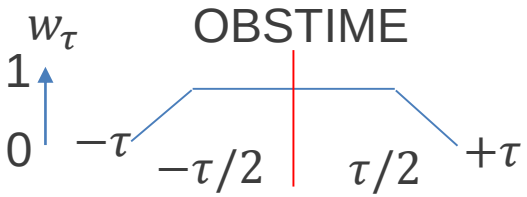
$$w_{xy} = \frac{R^2 0.75^2 - DISTANCE'^2}{R^2 0.75^2 + DISTANCE'^2}\left(\frac{ps_{GP}}{500hPa} + 1\right)$$

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

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

R=20km
G_c=0.00433
τ=6
(namelist switches)

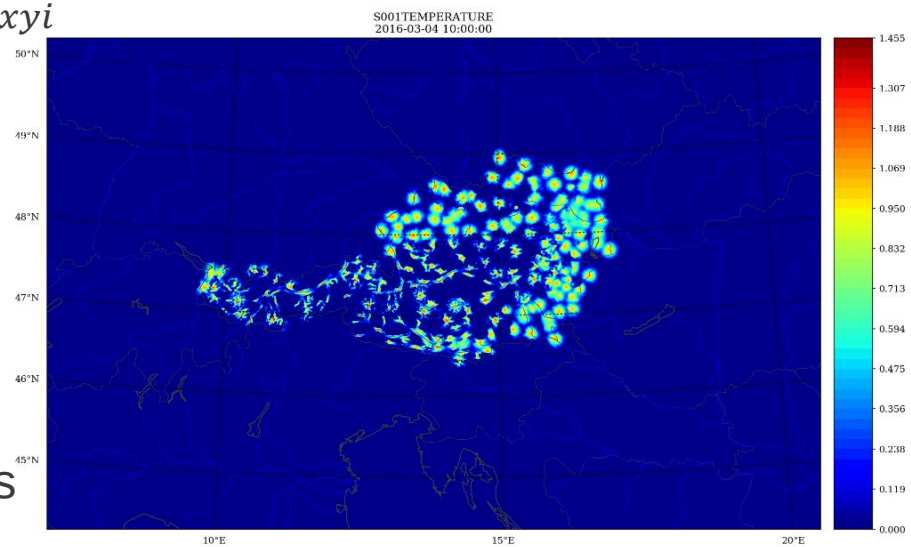
$$G = G_c * w_\tau$$



Observations at: +10 / 20 / 30min

x=T2m/RH2m/U10m

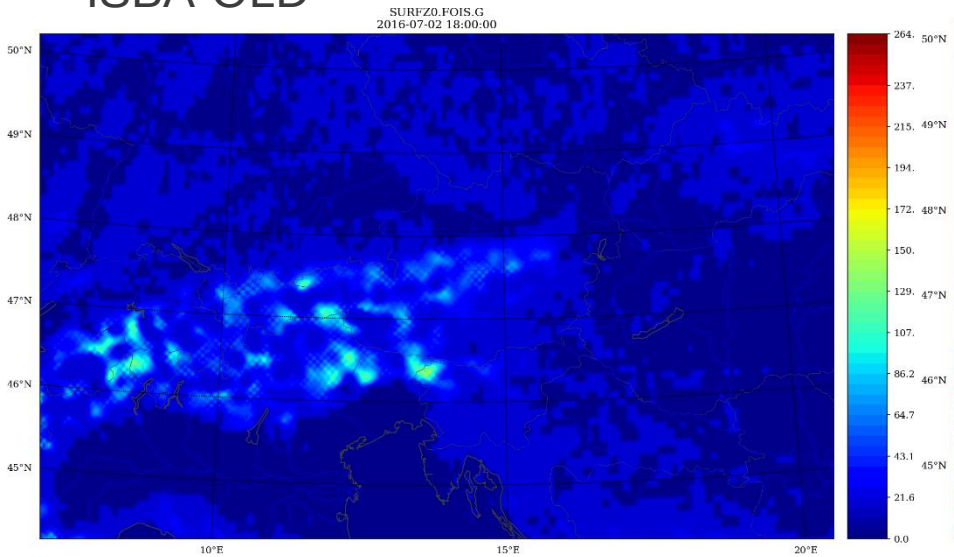
called from apl_arome.F90 after microphysics



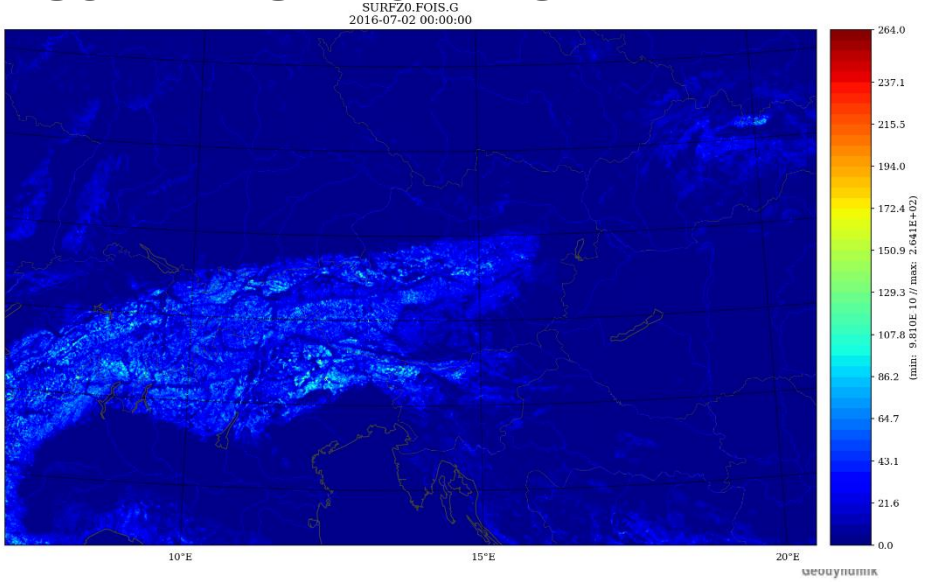
Crashes without abort in minimization - NaN cost function

- 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 so far

ISBA-OLD



SURFEX: SFX.ZORELIG



Why AROME-Nowcasting?

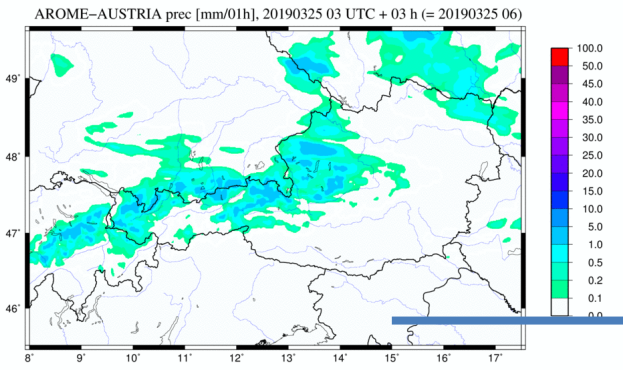
Classical Nowcasting (at ZAMG INCA)

- 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

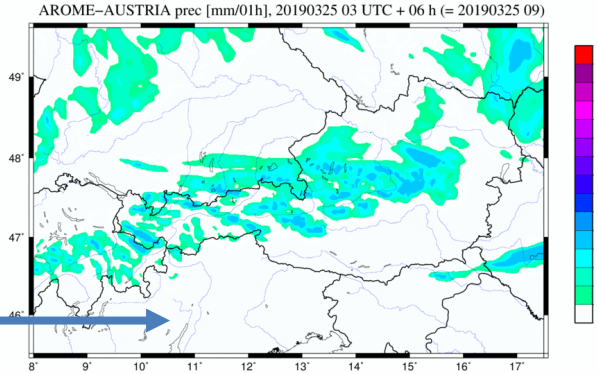
LAM-NWP (at ZAMG AROME 2.5km)

- Slower: available within several hour
- 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