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A Consortium for COnvection-scale modelling Research and Development

NWP-based nowcasting in ACCORD

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Magnus Lindskog and ACCORD upper-air data assimilation colleagues

Outline

- Introduction
- Observation usage
- Data assimilation/initialisation methods
- Assimilation strategies
- Results
- Towards use of ensembles
- Summary and conclusions

Introduction

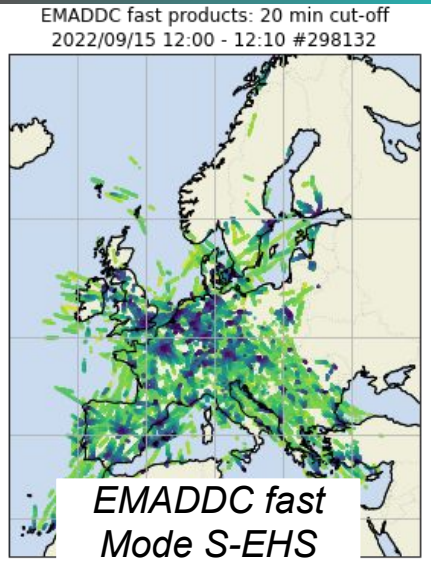
Definition of NWP-based Nowcasting in this presentation

Model-based forecasts up to +12 hours into the future and with an observation cut-off time of up to roughly 35 minutes.

Some challenges

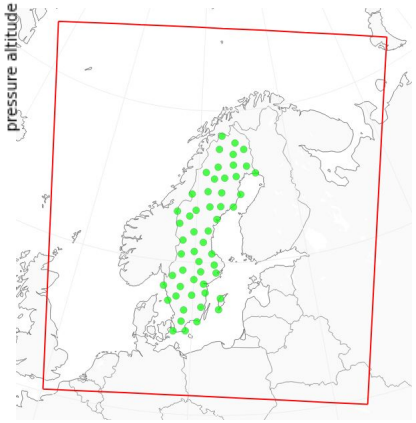
- Identify suitable observations and make available in time
- Observation bias correction/quality control procedures
- Data assimilation methods and cycling strategies
- Spin-up
- Uncertainty and ensemble-based information

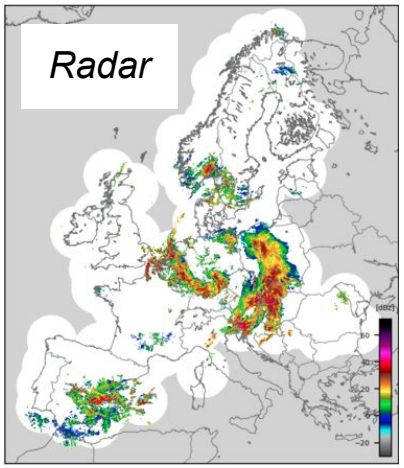
Observation usage

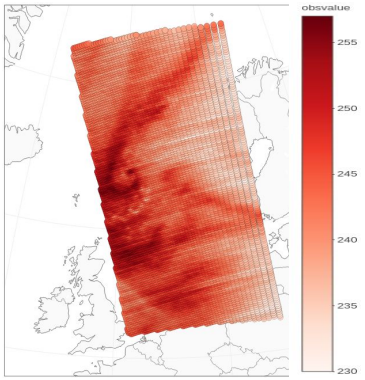


EMADDC fast Mode S-EHS

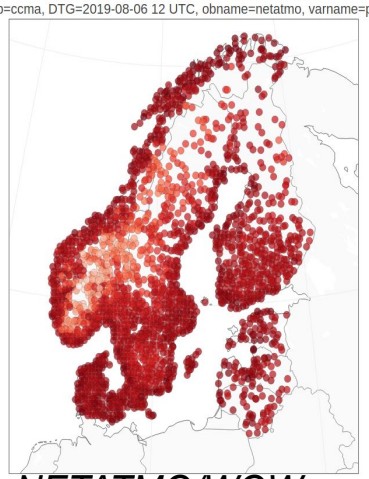
- Radar, ABO, synop/ship, GNSS, crowd-sourced.
- Some satellite data and satellite-based products.



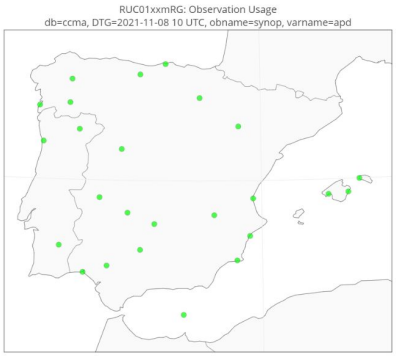




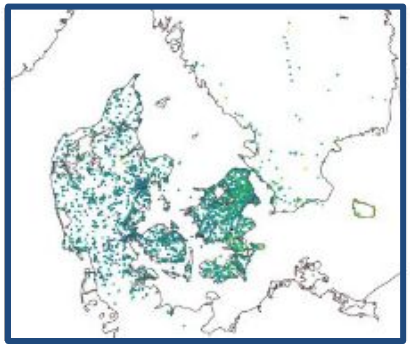
Satellite



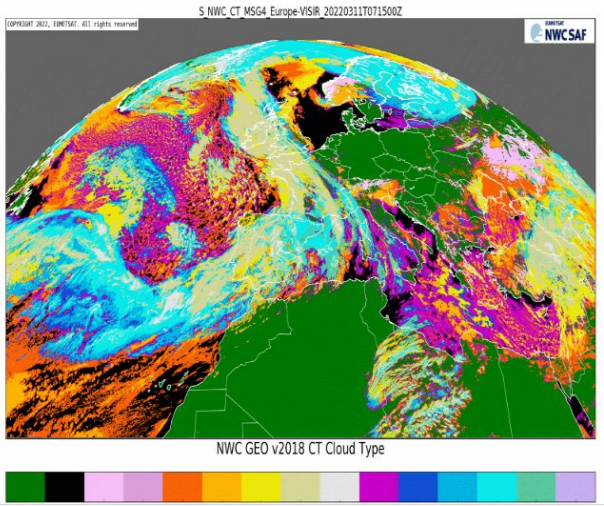
NETATMO/WOW



Fast processing GNSS



Smartphone data



NWC-SAF cloud product

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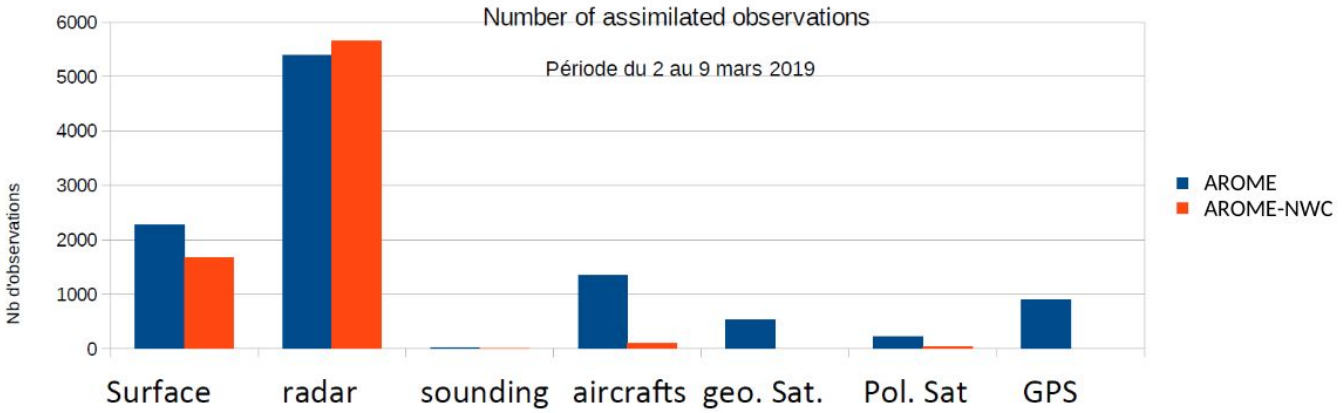
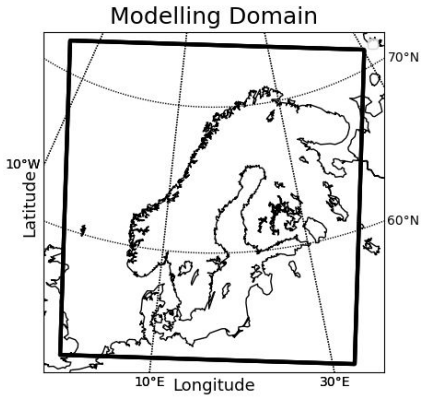
Observation usage

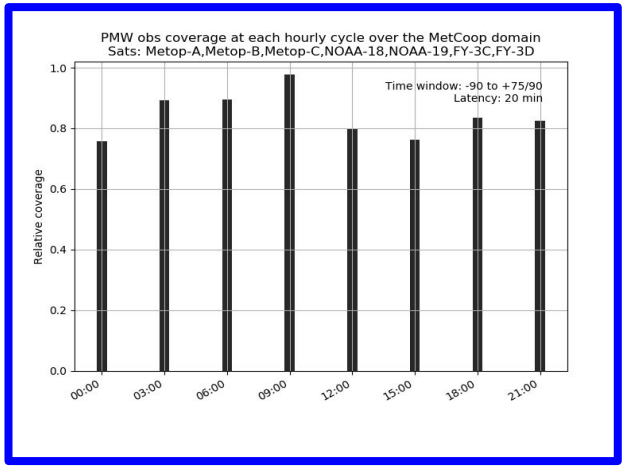
Effect on observation usage of short observation cut-off in nowcasting systems

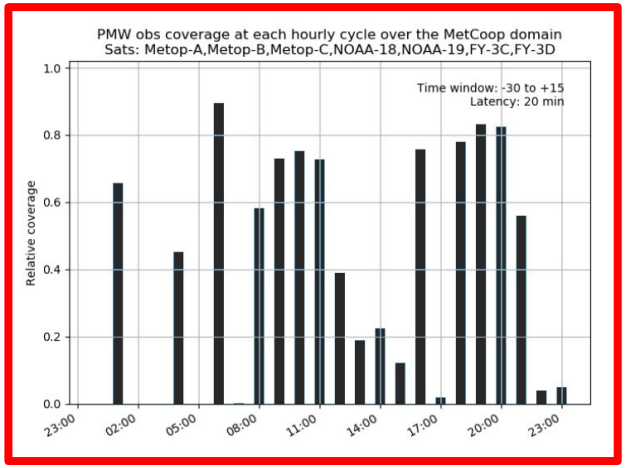
Météo France
Long cut-off (~1h) NWP
Nowcasting (10 min cut-off)



MetCoOp MW Pol. sat usage: Long cut-off (~1h) NWP and Nowcasting (20 min cut-off)







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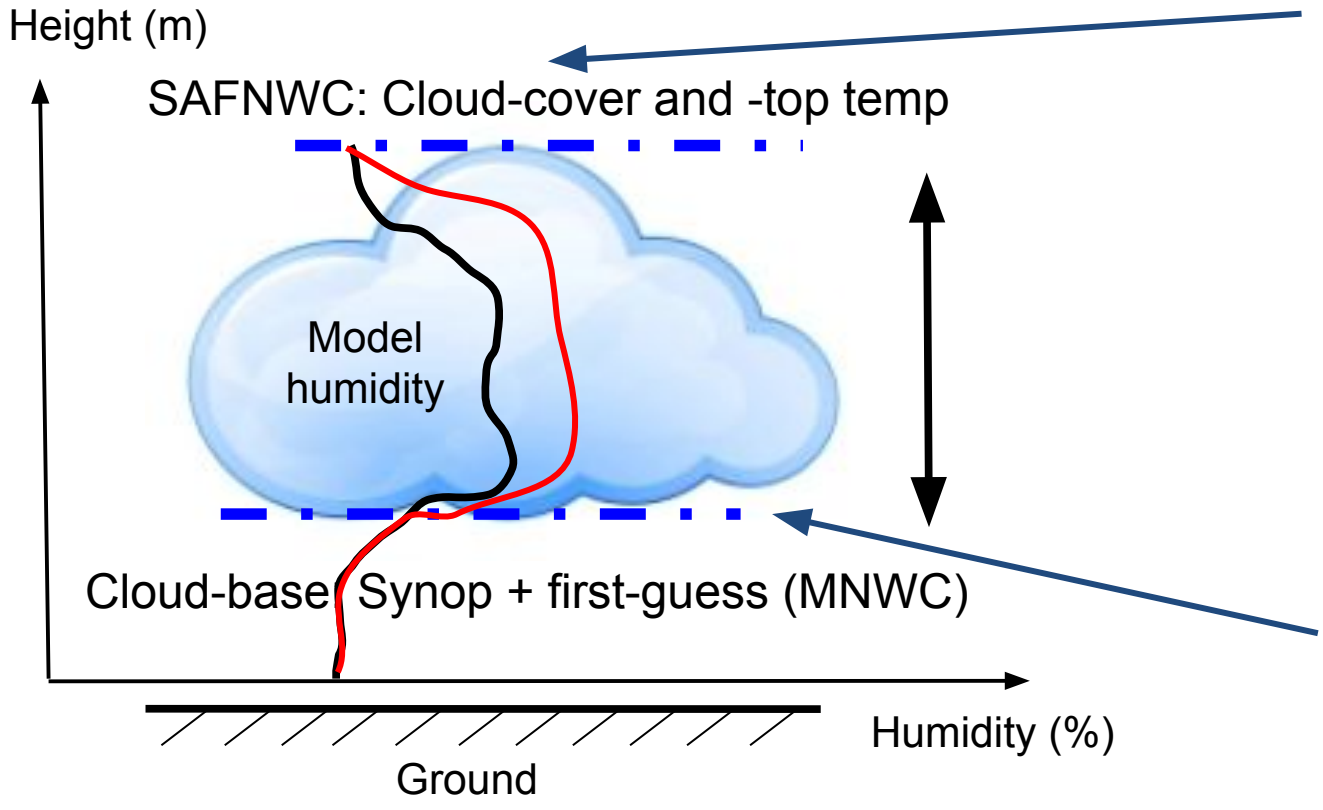
Data assimilation/initialisation methods

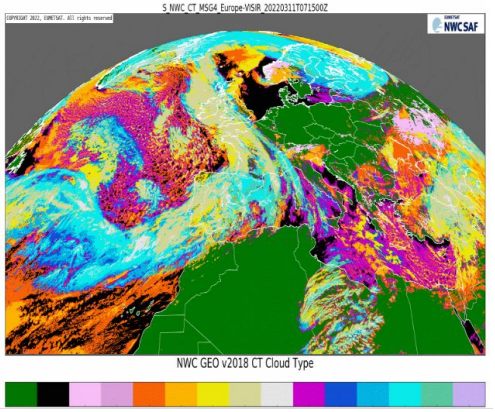
- 3D-Var
- 4D-Var
- Cloud-ingest
- Field-alignment
- Nudging
- VC, DFI and IAU

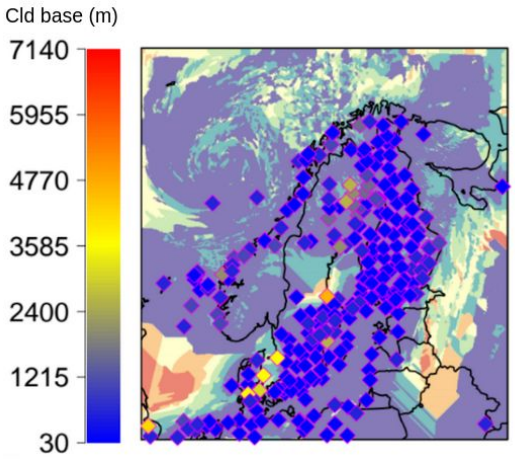
Data assimilation/initialisation methods

Illustration of Cloud-ingest

Satellite says cloud, model says no cloud







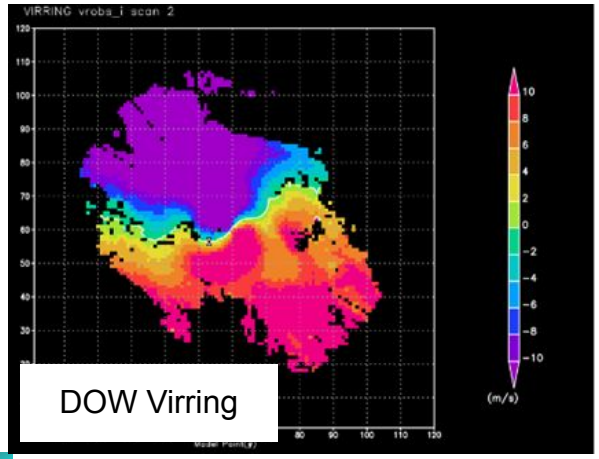
Data assimilation/initialisation methods

Field-Alignment (FA) Algorithm for Radar DOW Data

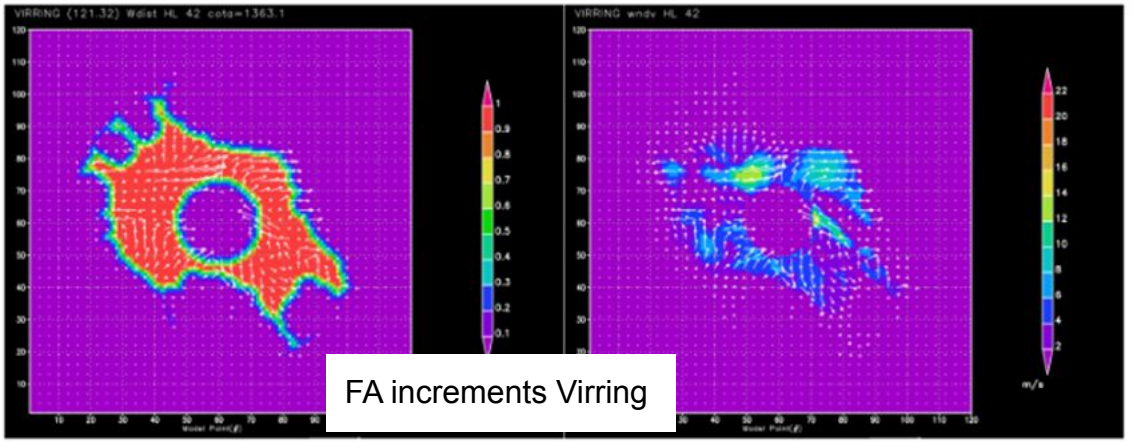
- The method is based on ideas of Ravela et al. (2007) : aligns the model wind fields to the DOW radar image by solving the alignment equation

$$\Delta\vec{q}+\nabla\left(\nabla\cdot\vec{q}\right)=\left(\nabla X^{f}{}_{|\vec{p}}\right)^{T}H^{T}\,R^{-1}\left(Y-H\,X^{f}(\vec{p})\right)$$

- Well tested and validated with data from different radars (AEMET, SMHI, DMI)
- The radar volume scanning schedule is important to the algorithm's performance
- Different radars processed in parallel (MPI app). Processing times suited for NWC applications (~2 min)
- Verification experiments carried out so far show consistently positive impact



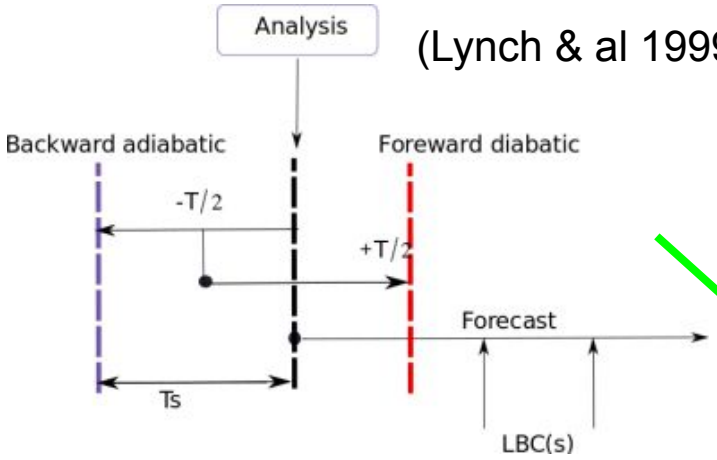
DOW Virring



FA increments Virring

Data assimilation/initialisation methods

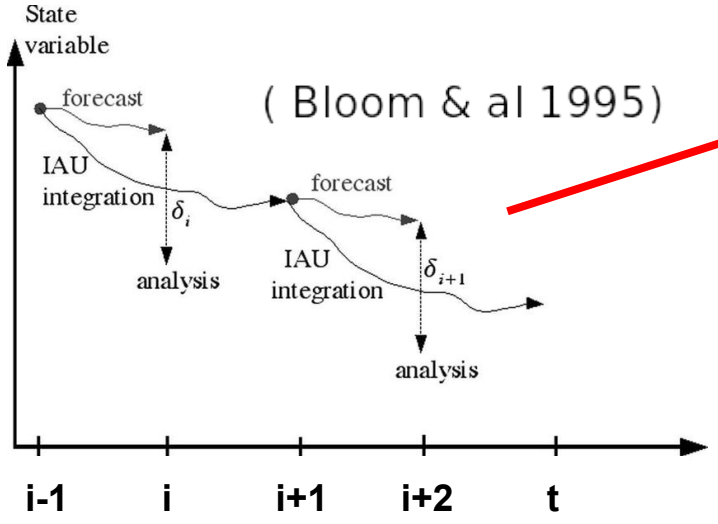
Digital Filter Initialisation (DFI)



(Lynch & al 1999)

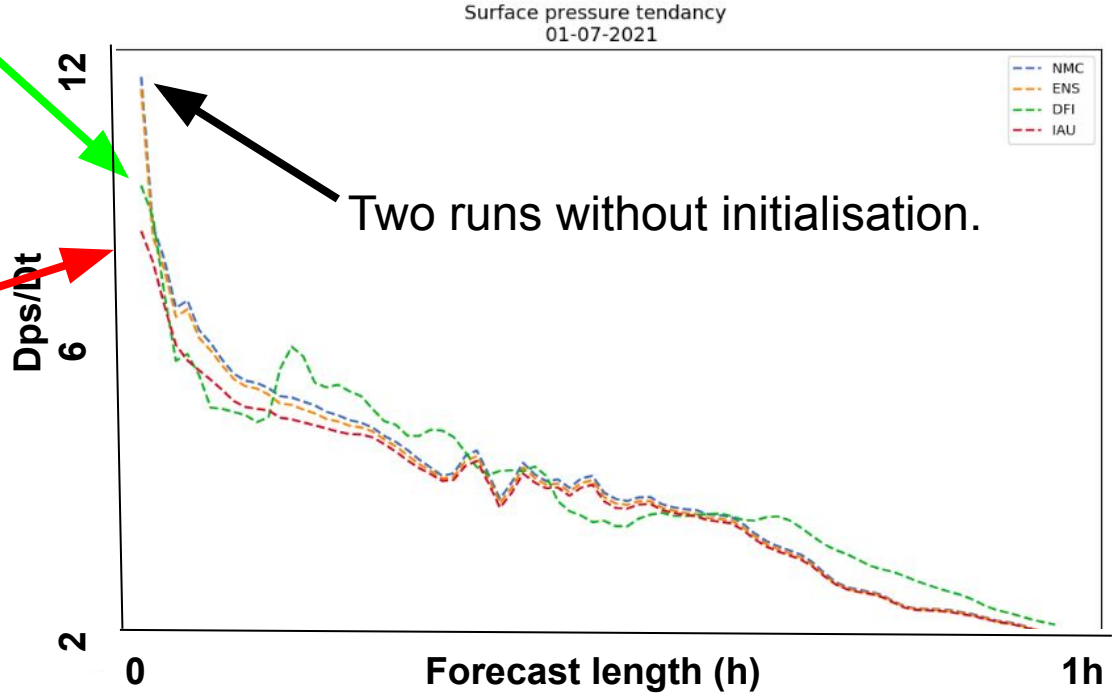
- Reduce model spin-up
- Avoid smearing out characteristics of high intensity events

Incremental Analysis Updates (IAU)



(Bloom & al 1995)

Spin-up during first hour of model integration

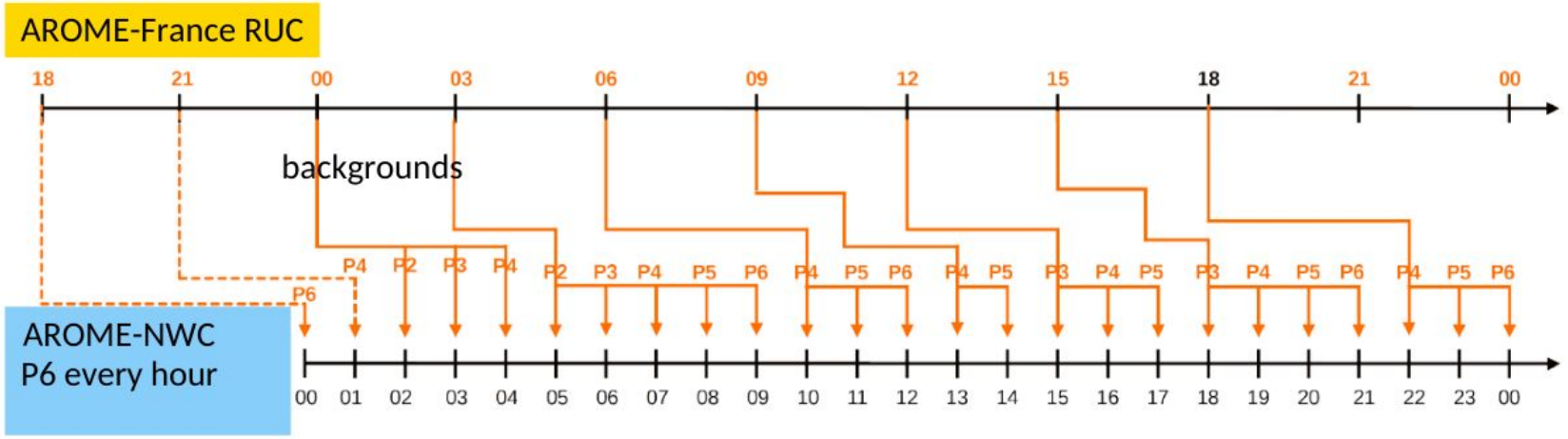


Assimilation strategies

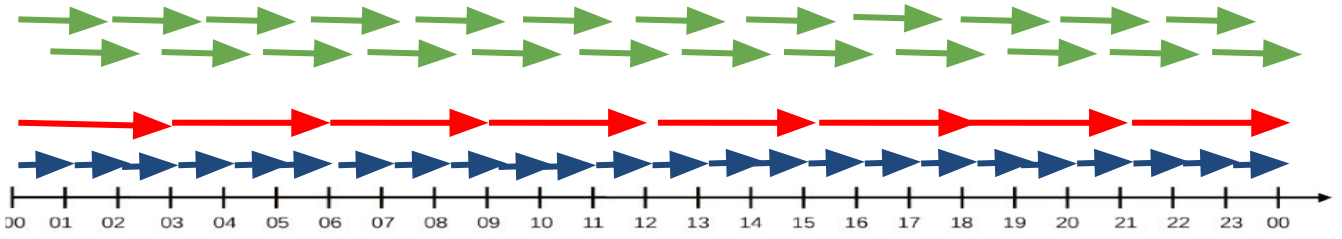
- Use background from a longer cut-off suite
- 1-3 h cycling in nowcasting suite
- Sub-hourly cycling strategies
- Towards overlapping windows and continuous data assimilation

Assimilation strategies

Background from long cut-off suite (Météo France, MetCoOp et al.)



Cycling (1h, 3h or two shifted 2h Slovakia, Spain, Slovenia, Denmark et al.)

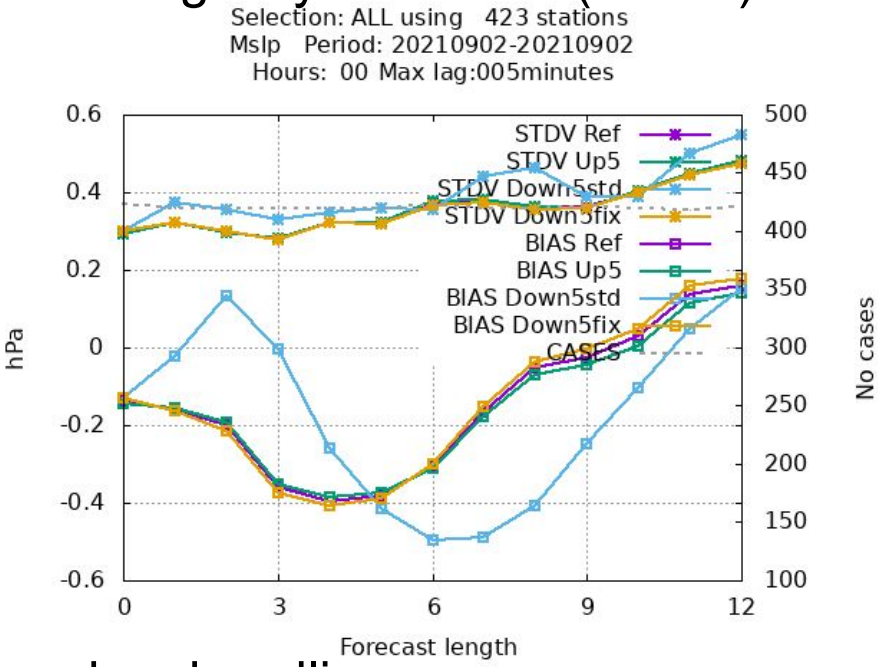


Assimilation strategies

Test with sub-hourly cycling (shift +/- 5min)

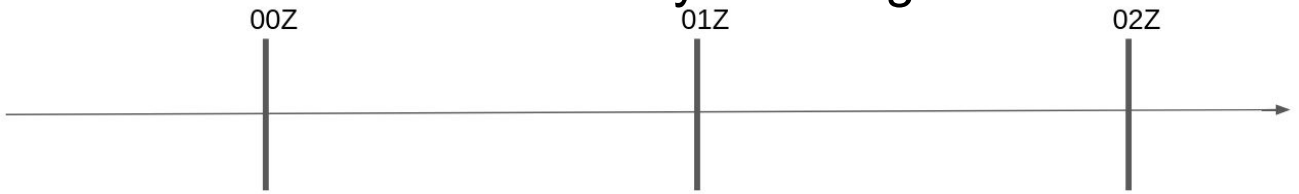
Exp. design	Cycling	Window 3DVAR (min)	Window surf. DA (min)
Ref	00-21;3	-90:90	-30:30
Up5	00:05-21:05;3	-95:85	-35:25
Down5std Down5fix	02:55-23:55;3	-85:95	-25:35

Single cycle scores (MSLP)



Scores support proper functionality and show handling of lateral boundaries important.

Boundary handling



Ref	Initial/LBC0 (00:00)	LBC1 (01:00)	LBC2 (02:00)
Up5	Initial/LBC0 (00:05)	LBC1 (01:00)	LBC2 (02:00)
Down5std	Initial/LBC0 (23:55) **LBC1** (00:00)	**LBC2** (01:00)	**LBC3** (02:00)
Down5fix	Initial/LBC0 (23:55)	LBC1 (01:00)	LBC2 (02:00)

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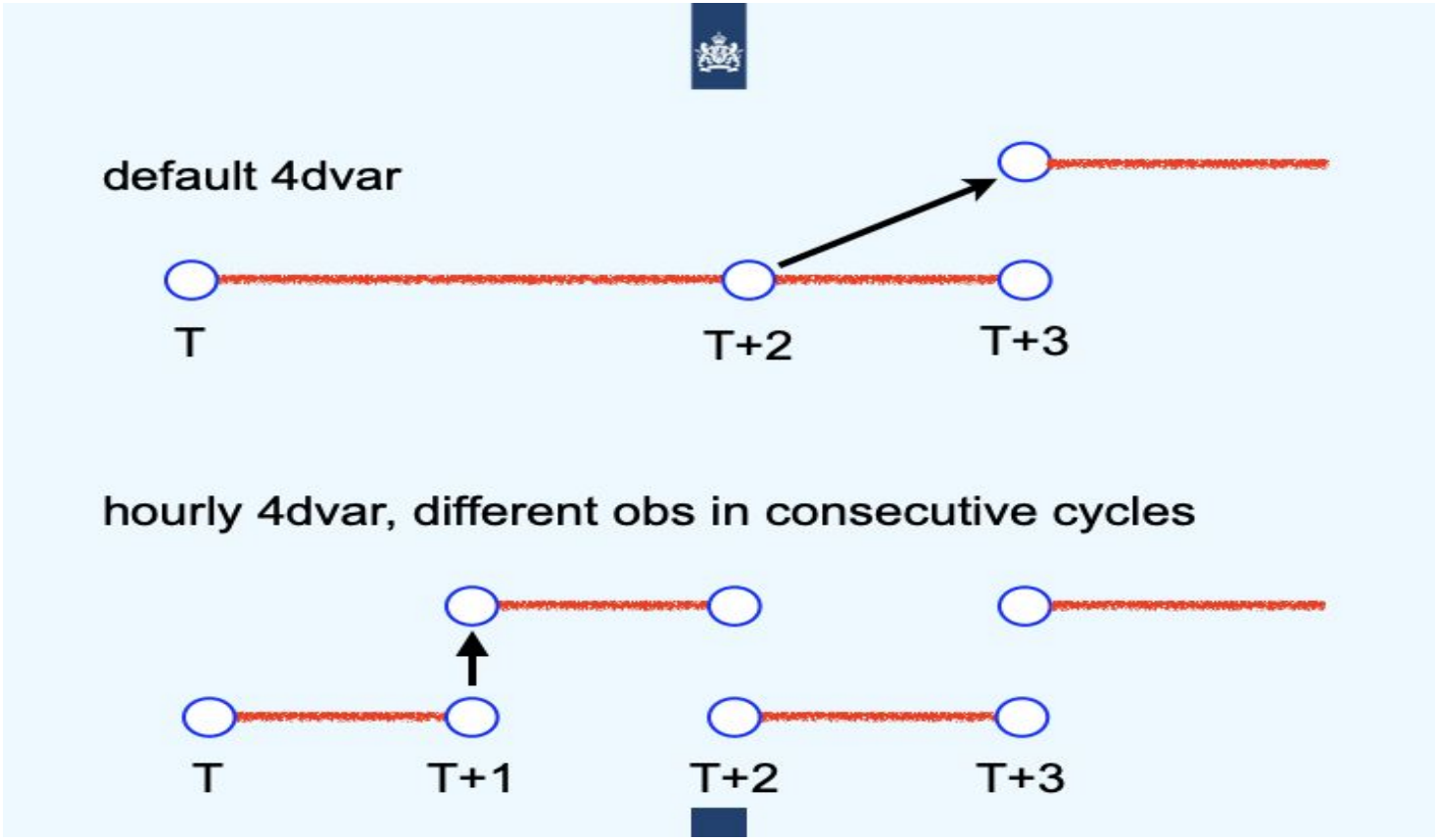
Assimilation strategies

Hourly 4D-Var configuration

observations



second 3h cycle

first 3h cycle

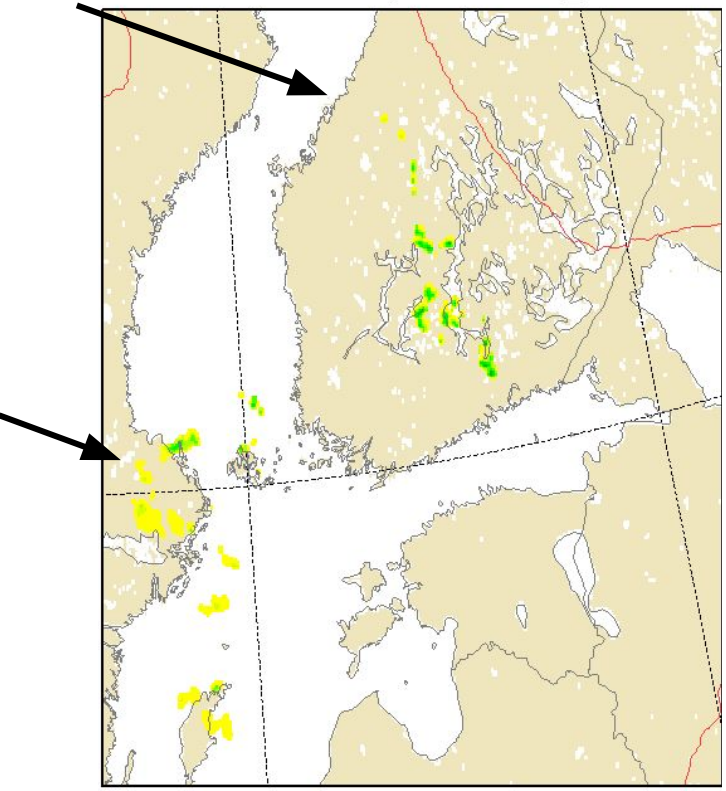
second 3h cycle

first 3h cycle

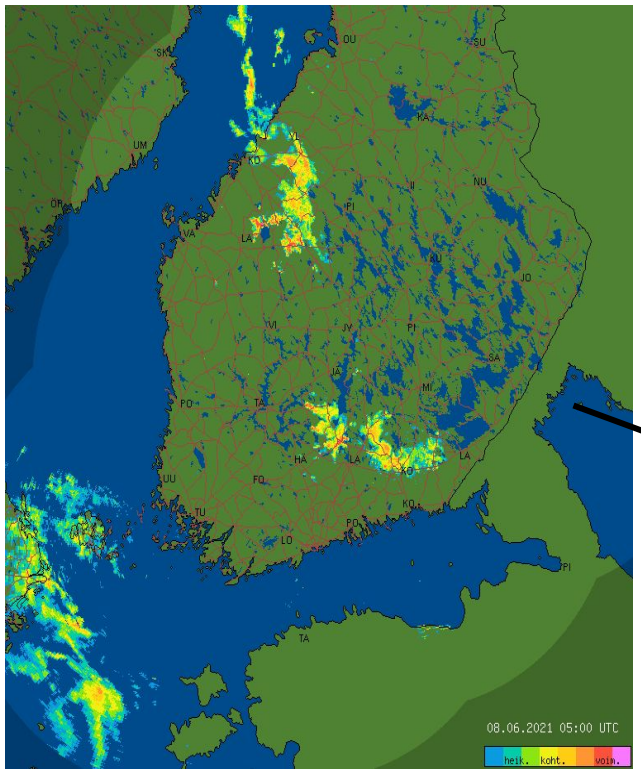
Results

Example of case with good impact of Cloud-ingest on precipitation forecast

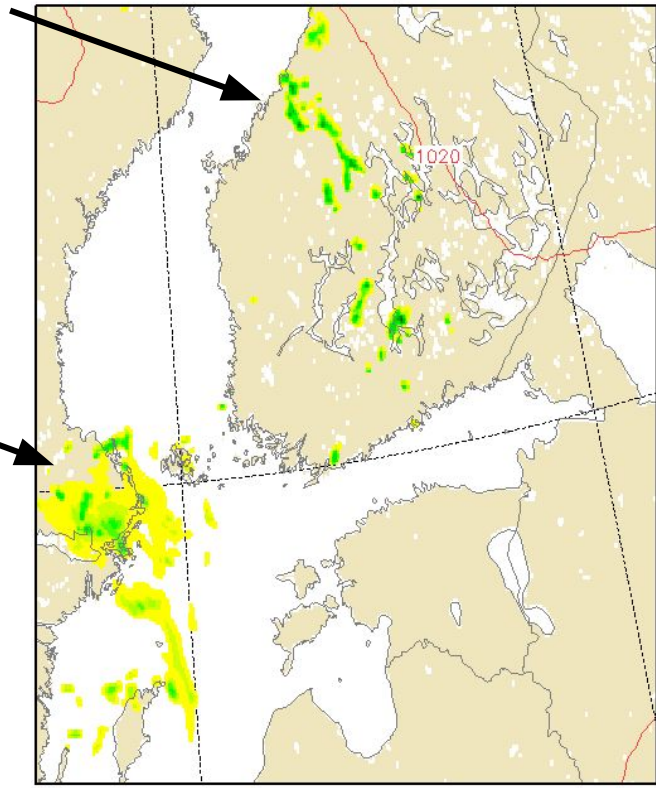
Long latency, no Cloud-ingest MEPS 03Z + 2h fc



Radar 08.06.2021, 05Z



MNWC, with Cloud-ingest, 03Z + 2h fc

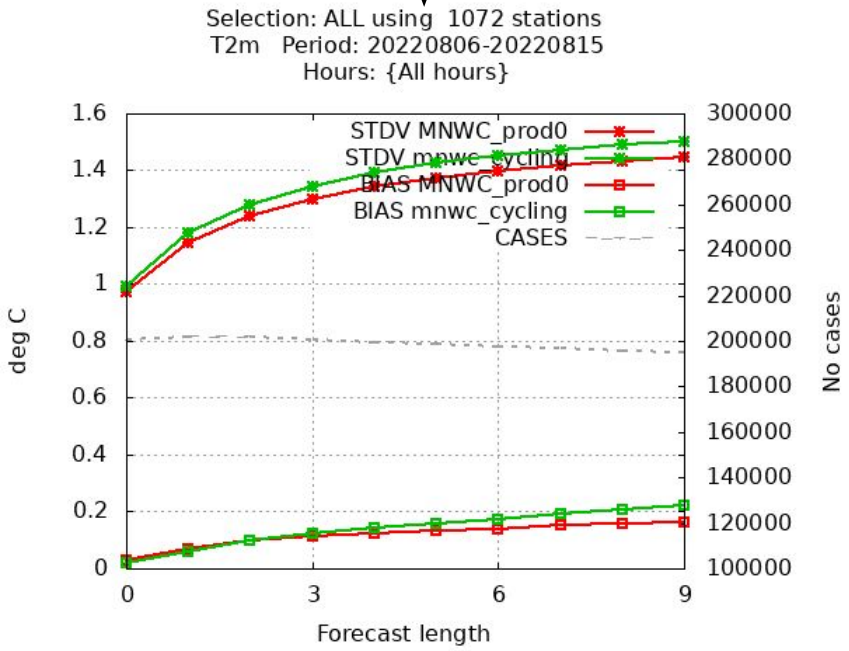


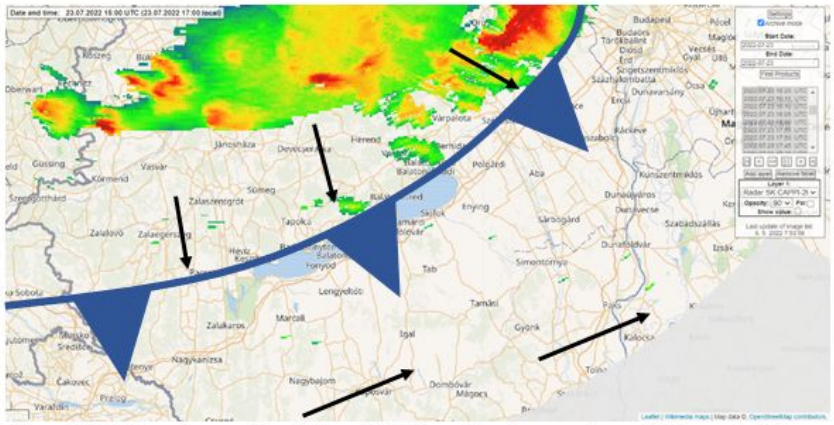
Results

Challenges of short observation cut-off

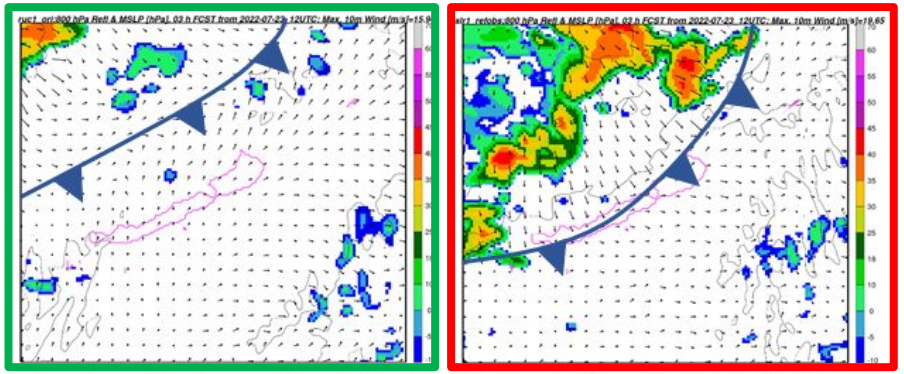
Case study: Lack of upper-air observations in short cut-off (35 min) surpresses convection as compared with long cut-off.

Verification scores: Nowcasting with 30 min observation cut-off. 3h DA cycle vs background from long cut-off suite.





2km CAPPI radar reflectivity [dBz] and schematics of the cold front position and flow on 23 July 2022 15 UTC after observations



Simulated radar reflectivity [dBz], MSLP [hPa], 10m wind [m/s] from the original RUC1 run (left) using short cut-off and from experiment with long cut-off data (right)

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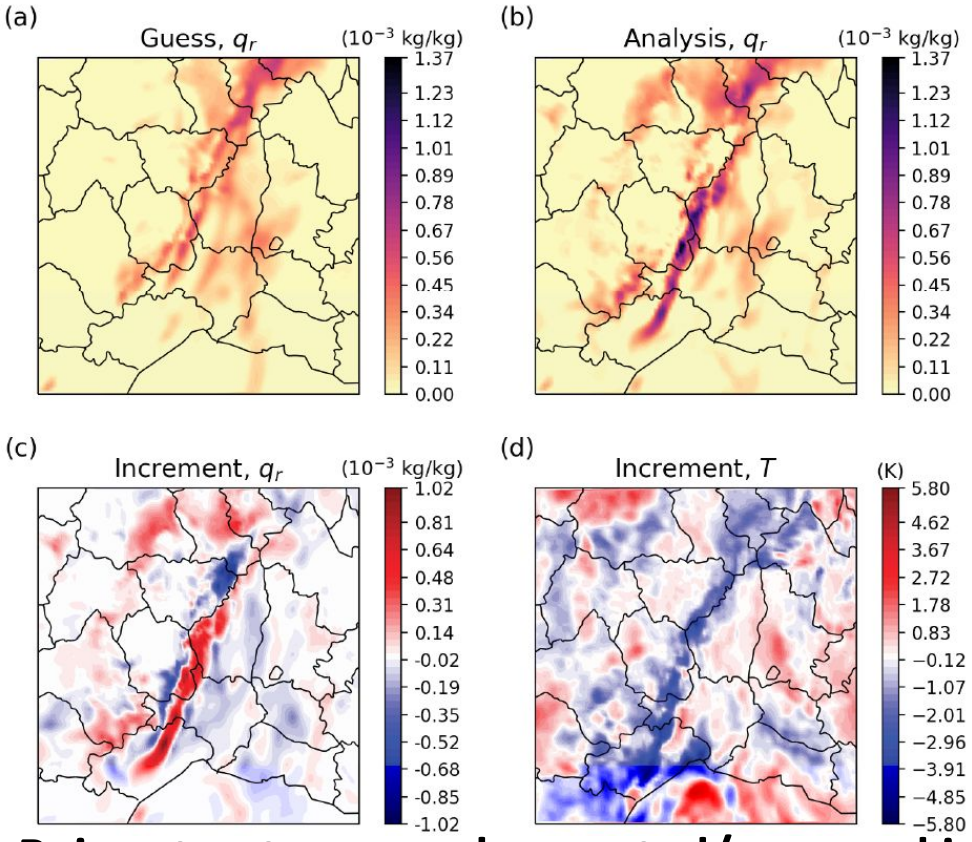
Towards use of ensembles

- Probability aspect from ensembles or pseudo-ensembles (using existing model runs combined with post-processing).
- Application of EnVar and Hybrid En/Var including use of Hydrometeor control variables.



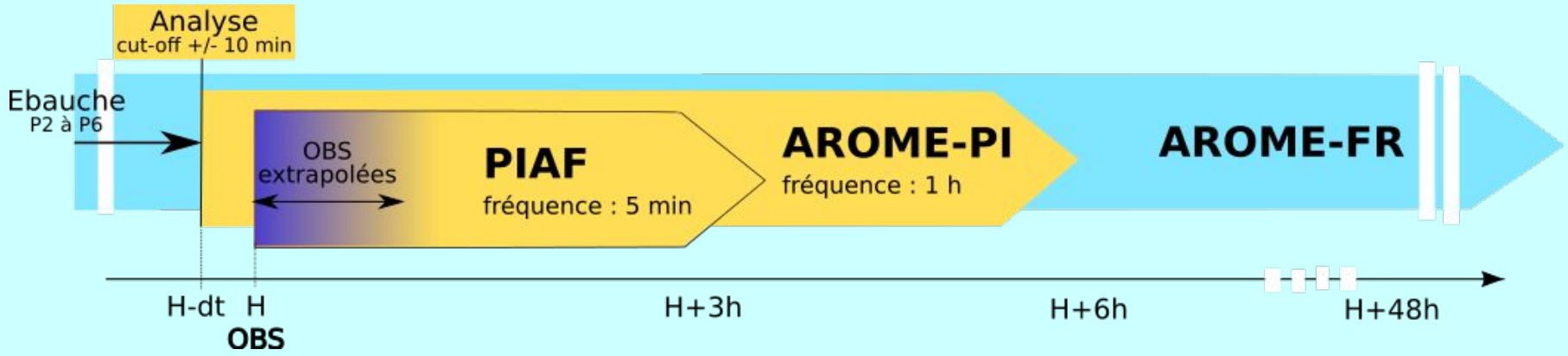
The use of balanced (although localized) background error covariances for Hydrometeors **clearly improve spin-up** and short term hydrometor forecasts.

→ particularily interesting for blending algorithms used in NWC

Rainy structures can be created/removed in the analyses thanks to cross-correlations and RH observations deduced from reflectivities

Summary and conclusions

- An increased focus on NWP-based nowcasting suites in the ACCORD consortium.
- Several adaptions of NWP system towards nowcasting.
- Remaining challenges related short observation cut-off, imbalances and spin-up.
- Note as well that operational systems combining pattern matching extrapolation methods and NWP-based methods exist (for example **Météo France PIAF system**).
- Future plans include adaptions towards ensemble-systems (for example, on longer term, application of En-Var, Hybrid En/Var) and computational speed-up by running parts of the system in single precision.



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