

A Consortium for COnvection-scale modelling
Research and Development

Algorithmic developments in ACCORD

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with contributors from the ACCORD DA teams

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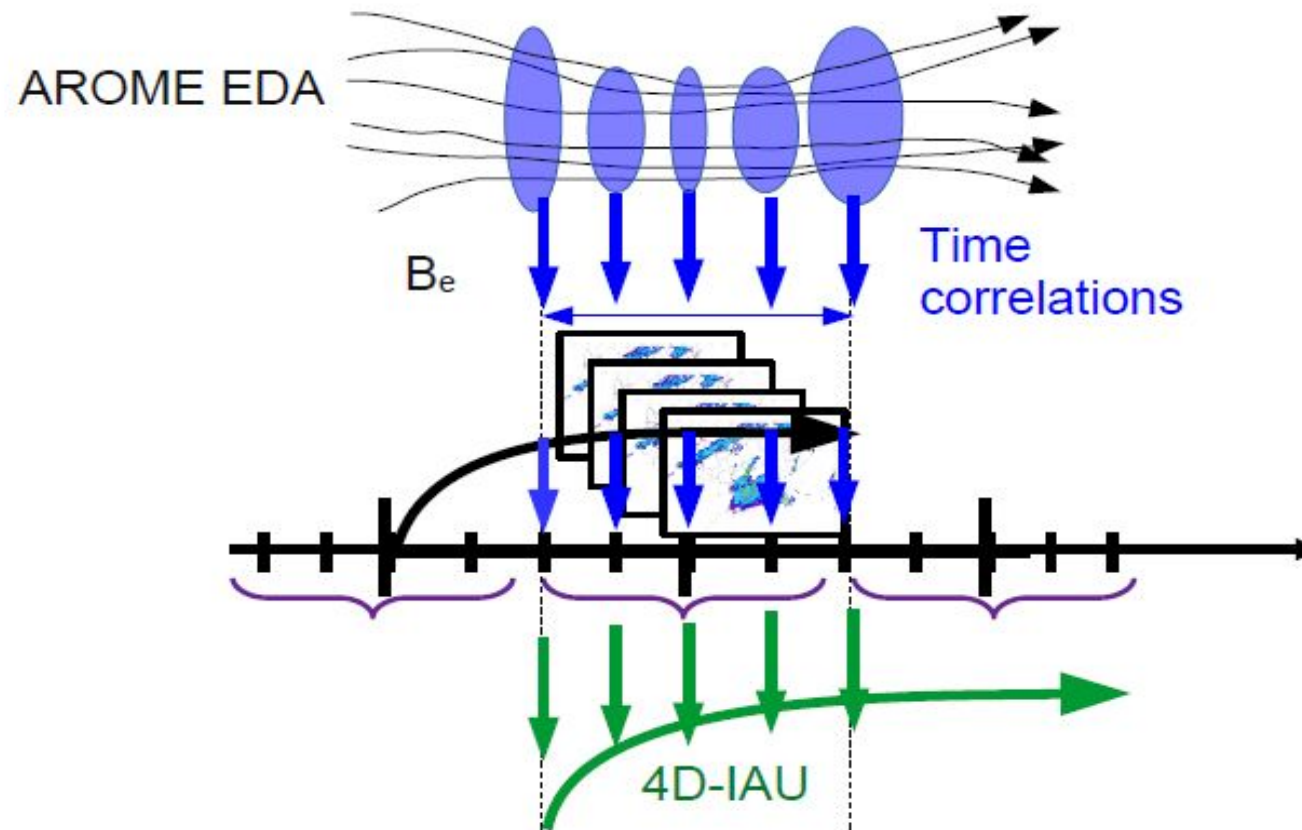
- **OOPS-driven DA algorithms**
 - 3D/4D EnVar implementation at Météo France
 - EnVar tests and developments at other ACCORD members
 - Variational assimilation for surface analysis
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- **Conclusions**

Towards OOPS implementation all DA algorithms

- Object-oriented prediction system (OOPS), a high-level C++ layer of abstract classes implementing building blocks for data assimilation
- Opens way to rapid development of new advanced algorithms or relaxing traditional assumptions
 - Application of novel algorithms (3D/4DEnVar, hybridization)
 - Extensions of control vector in EnVar (e.g. hydrometeors for reflectivity assimilation)
 - Reuse of DA components (e.g. observation operators for all variables verification)
 - New approaches for surface assimilation (2D-EnVar)
- The Consortium reaches first operation-ready configurations

3D/4D-EnVar developments with OOPS at Météo-France

- AROME 3D-EnVar in the current OOPS E-suite at Météo-France: see V. Vogt's talk
- AROME 4D-EnVar is then considered as the next operational target at Météo-France

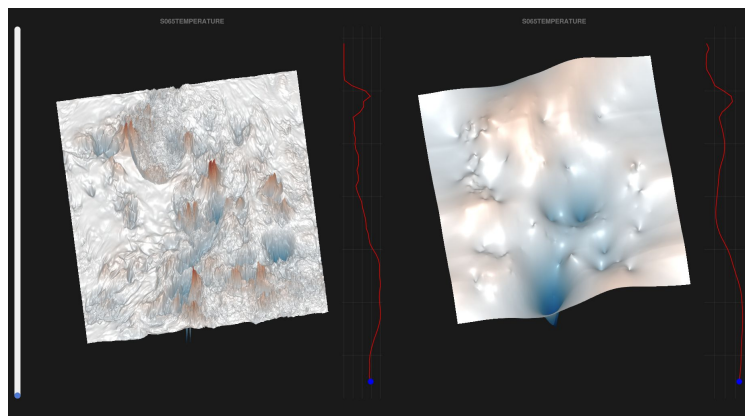


*Schematic diagram of AROME 4D-EnVar
(P. Brousseau)*

OOPS 3D-EnVar validation at Met Norway

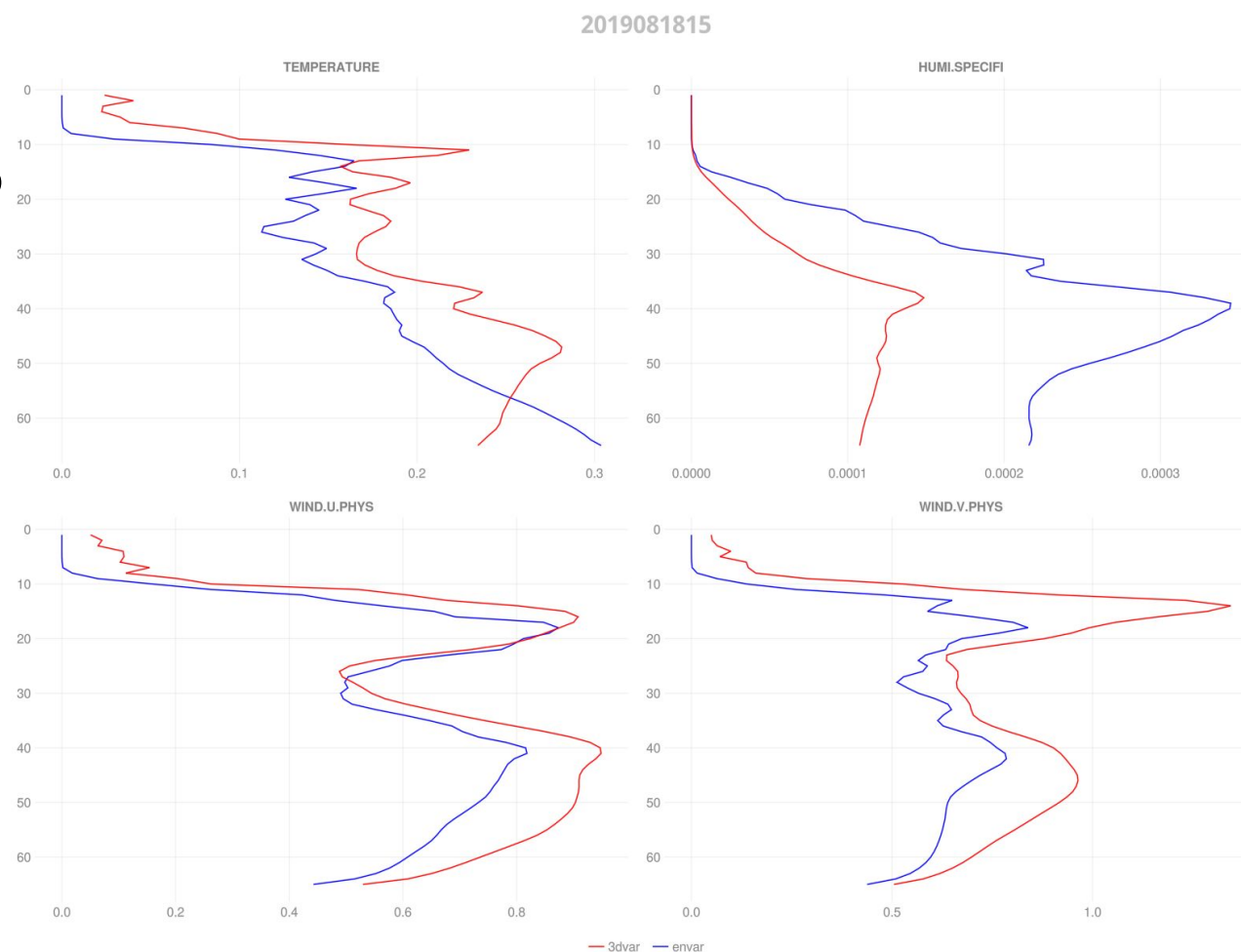
- OOPS 3D-EnVar implemented in Harmonie scripting system
- 3D-EnVar (16 members Harmonie-AROME 2.5 km compared with 3D-Var over Denmark)
 - 3D-EnVar analysis increments smaller in magnitude, except for q and low-level T
 - 3D-EnVar increment much more detailed

3D-
EnVar



3D-Var

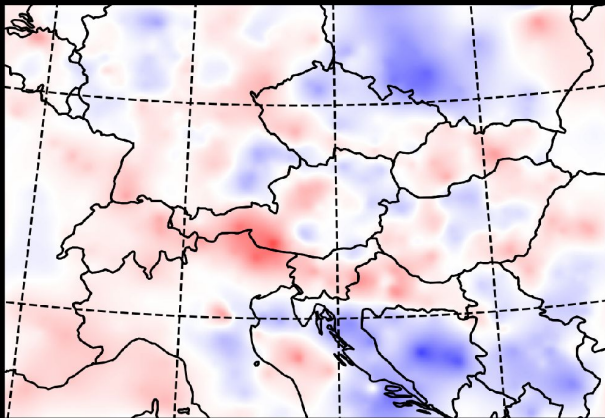
Mean profile of analysis increments (3D-Var, 3D-EnVar)



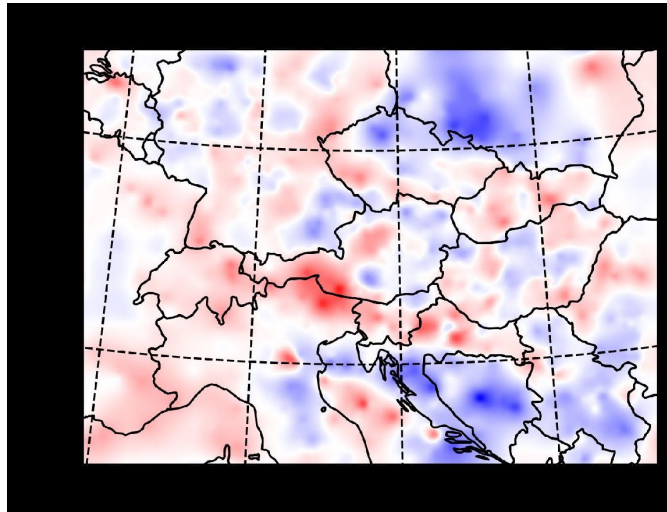
Work of R. Stappers

OOPS 3D-EnVar tests at GeoSphere Austria

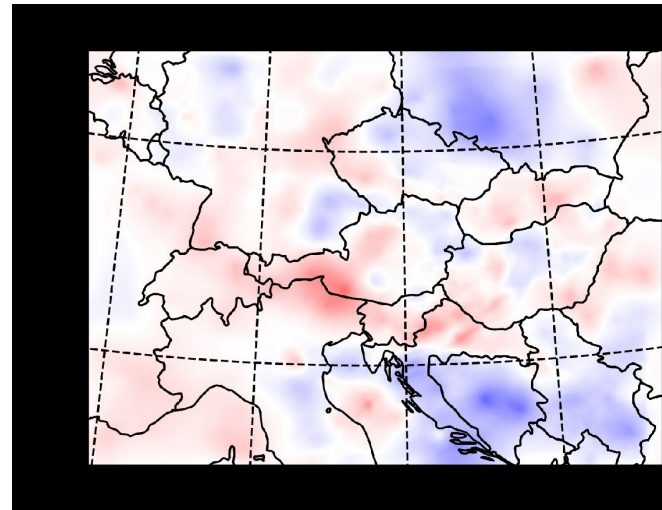
- OOPS cy48t1 installed at ECMWF and DA components tested
- EnVar-OOPS in C-LAEF 1 km test setup (16 members L90 AROME-EPS 3D-Var EDA)
- Plans: extend ensemble size by downscaled and lagged members, reconsider localization
- Successful test in the 1h AROME-RUC 1.2 km with EnVar, using the 2.5 km EPS
- At IMGW: tests with hybridization level, increase of ensemble by time-shifting



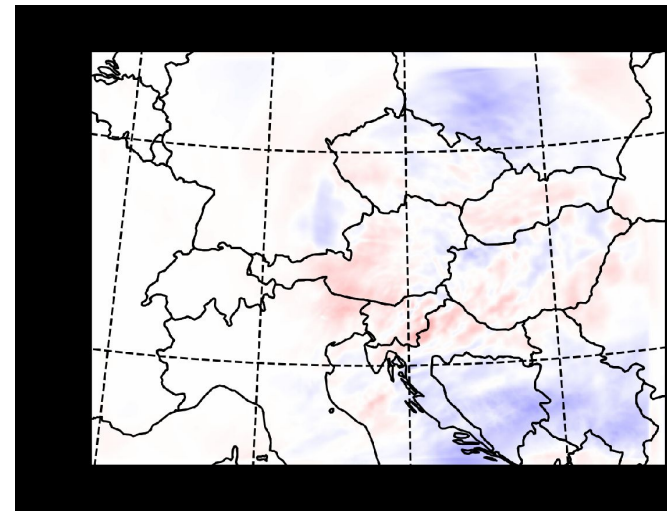
3D-Var



Work of F.Meier, F.Weidle, K.Jyoti



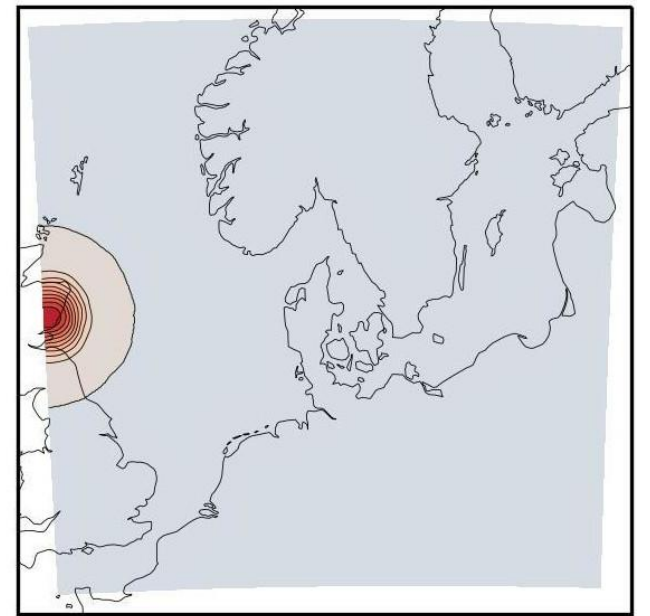
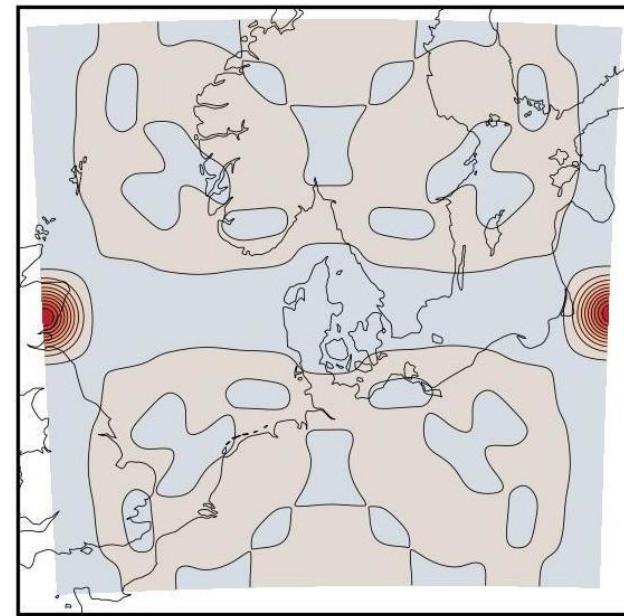
pure 3D-EnVar



SABER interfacing with OOPS

- **SABER** (**S**ystem-**A**gnostic **B**ackground **E**rroR **R**epresentation) is the generic background error modeling tool of the JEDI project, interfaced with OOPS (JEDI version). Work is ongoing to interface it with OOPS (ECMWF version)
- SABER can diagnose correlation and localization functions, and estimate hybrid weights. It can apply correlation and localization functions on any kind of model grid in an EnVar framework

Example of localization function with the current spectral formulation (left) and with SABER (right), which does not have the periodicity issue.



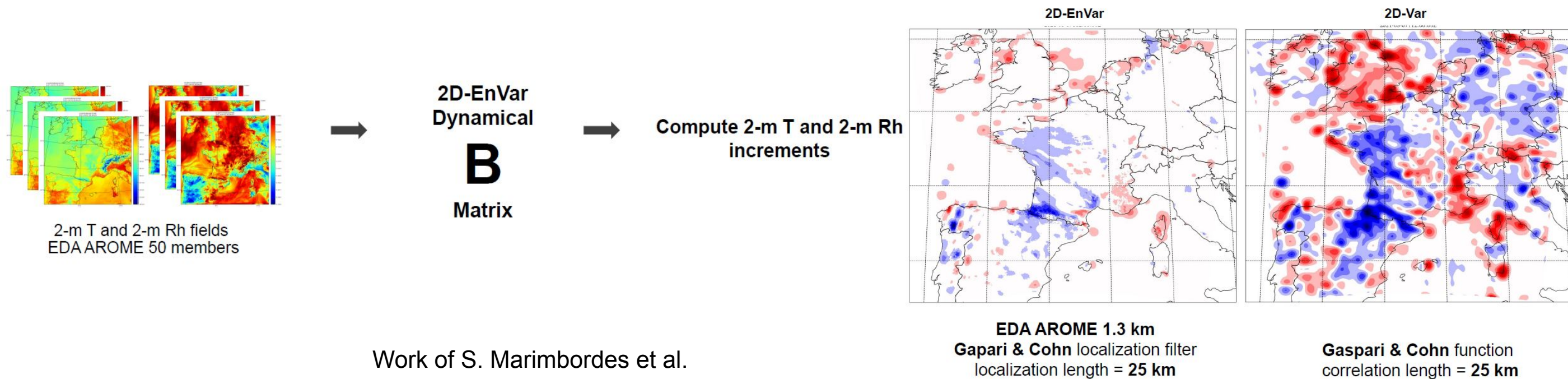
Work of B. Menetrier

Towards ensemble-based surface analysis in OOPS at Météo-France

- Implemented a 2D variational approach to replace the 2D OI surface analysis
- Used AROME-France EDA to implement a 2D ensemble-variational surface scheme

Implementation of 2D-Var $\Rightarrow$ robust results of 2D-Var compared to CANARI-OI

Implementation of 2D-EnVar $\Rightarrow$ encouraging results with 2D-EnVar (AROME EDA 1.3 km)



LAM 4D-Var developments in Hirlam

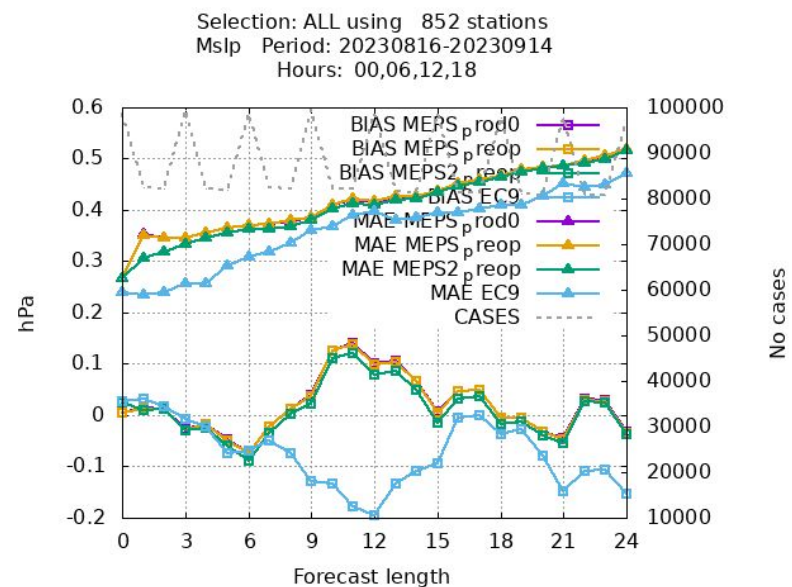
- LAM 4D-Var used in pre-operational MetCoOp, daily runs also by UWC-West and tests by AEMET
- Ongoing activities:
 - Implementation in cy46 and inclusion of radar DOW
 - Exploring 4D-Var functionality at sub-km horizontal resolution (DE_330)
 - Introduction of 4D-Var in EDA ensemble system (MEPS)
 - Applied in externally funded projects: ESA-AWS and ESA-Aeolus
- Ambition and ongoing efforts to implement LAM 4D-Var in OOPS

Verification of MetCoOp runs:

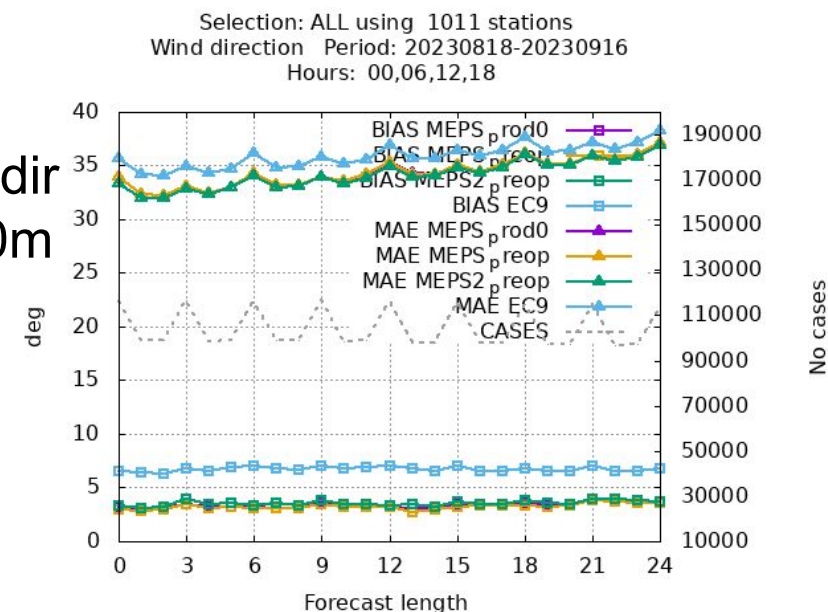
Oper 3DVAR
Preop 3DVAR
Preop 4DVAR
ECMWF

Collaborative work of Hirlam
4D-Var team led by J. Barkmeijer

MSLP



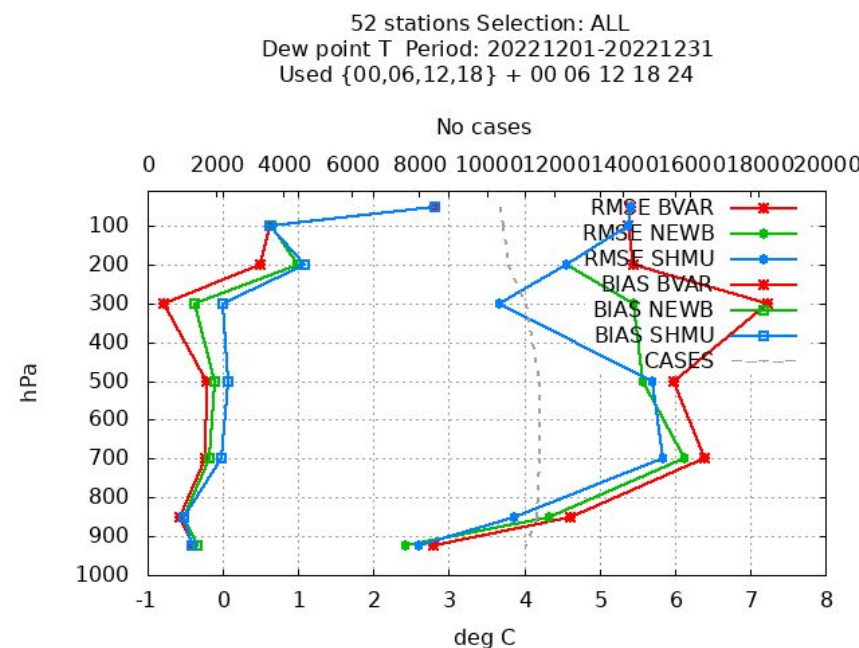
Wdir
10m



Blend-Var implementation in RC-LACE

- BlendVar: a 3D-Var with large-scale information blended using incremental DFI
- Operational at SHMU since April 2023 (replaced upper-air blending)
- Static but updated B-matrix: decrease of q length scales lead to improvement of the humidity-related parameters
- BlendVar vs. VarBlend setup evaluated, little sensitivity shown

Work of M. Derkova et al.

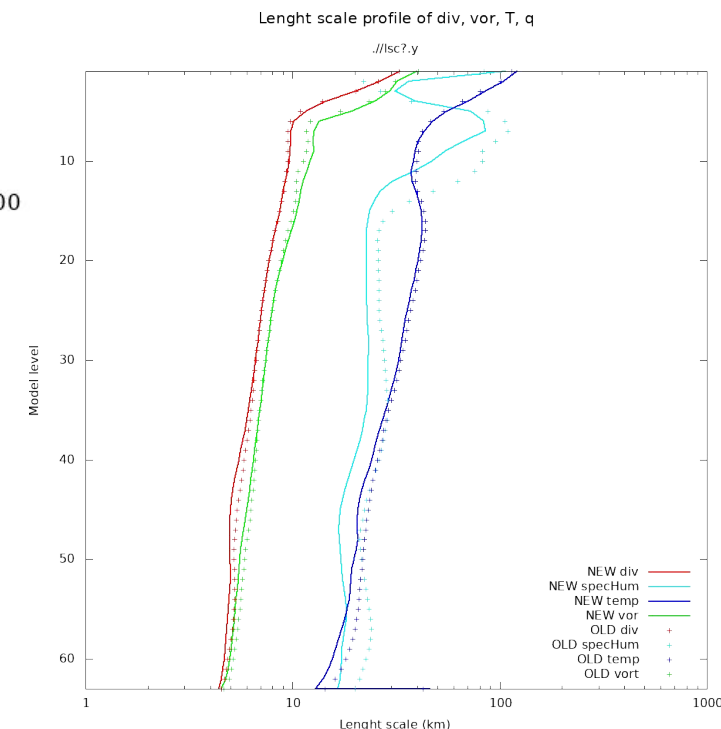


Verification (RMSE, bias) for
dew point temperature:

Blending (previous oper)

Test BlendVar

Oper BlendVar

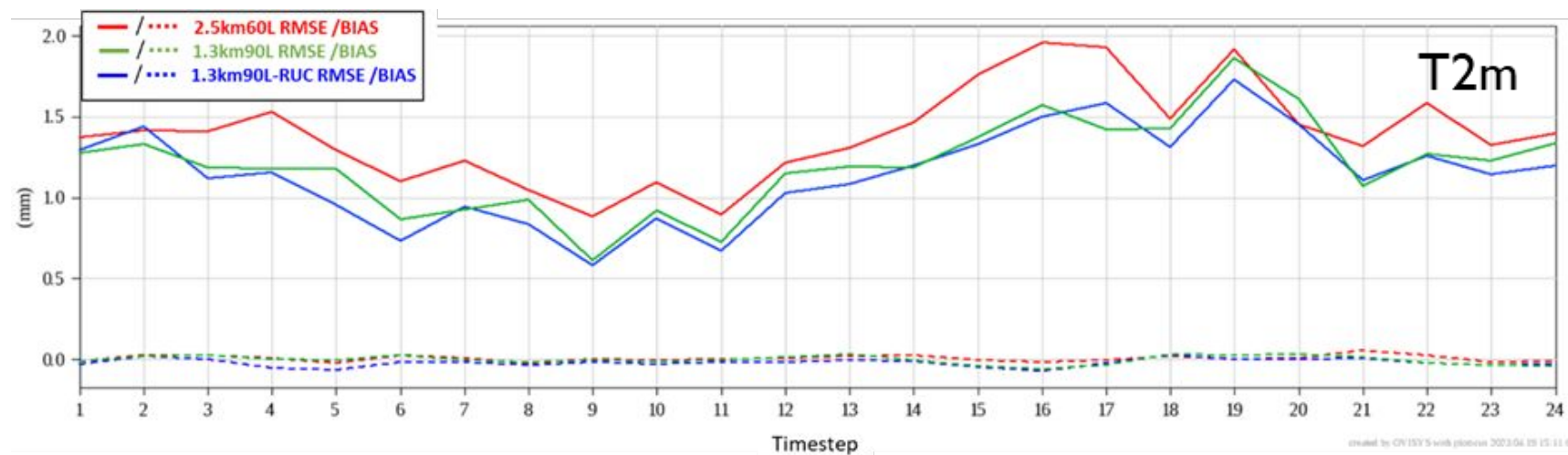


Refined correlation
length-scale for
background errors in
BlendVar.

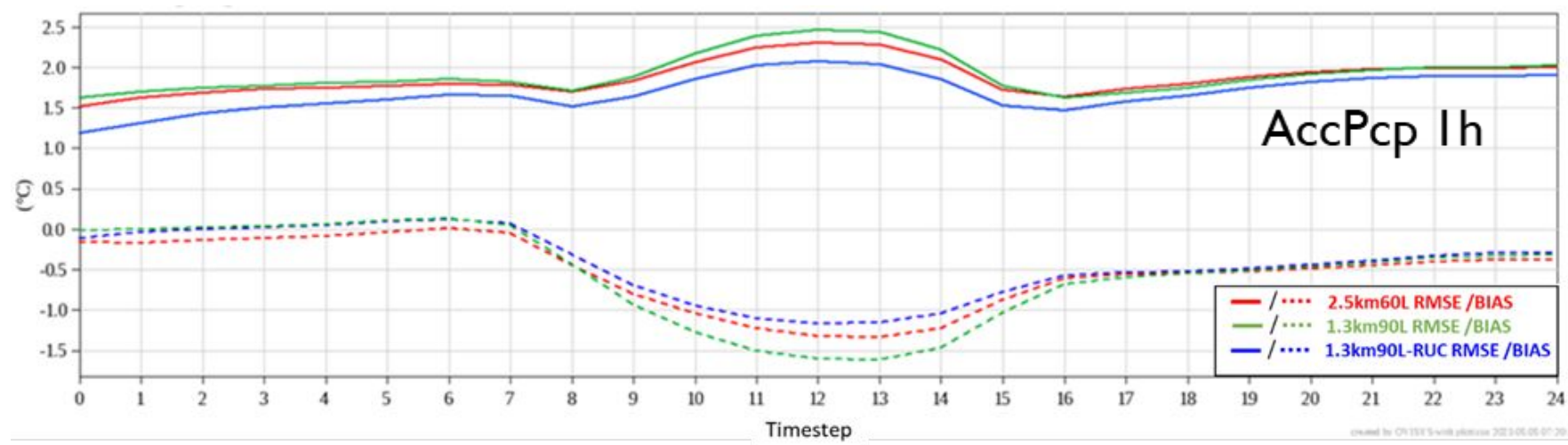
3D-Var in cycled RUC mode

- 1.3 km hourly RUC with 3D-Var + simplified extended Kalman filter (SEKF) at OMSZ Hungary
- Clear additional benefit of hourly DA for precipitation in summer and temperature in winter
- Tested a combination with less frequent surface assimilation
- Issues with observation timeliness

Work of A. Varkonyi, D. Lancz



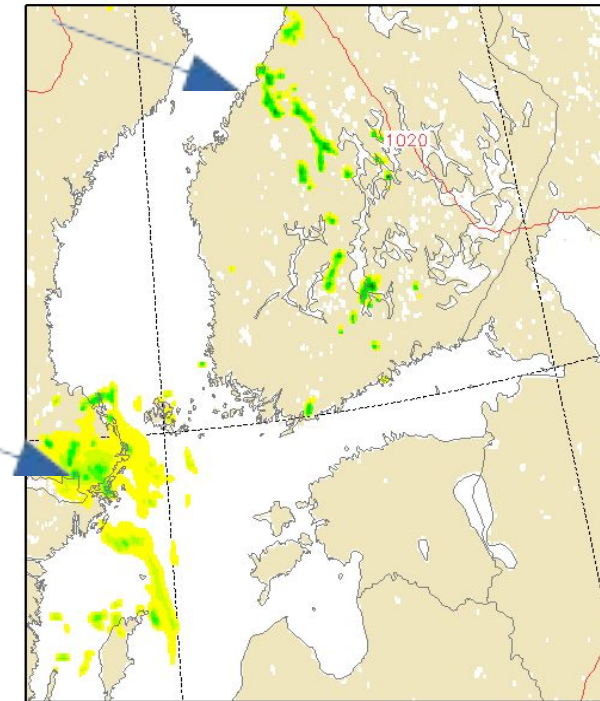
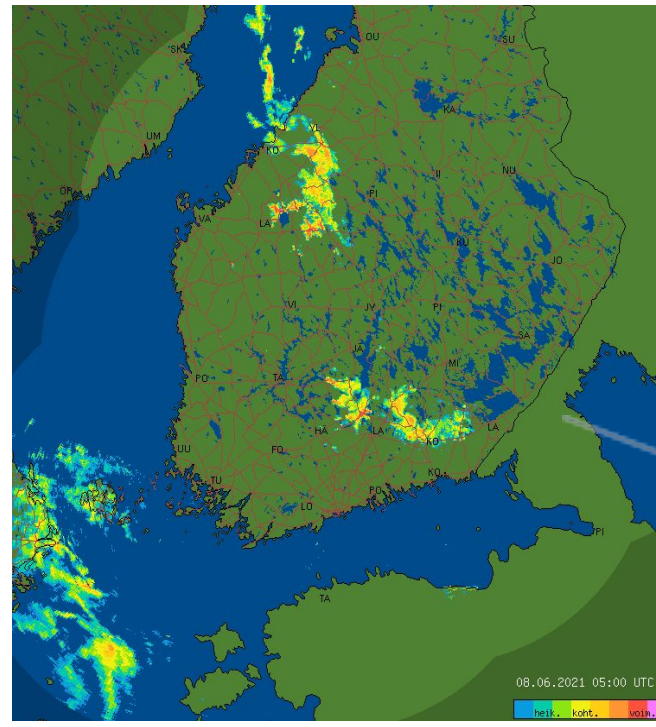
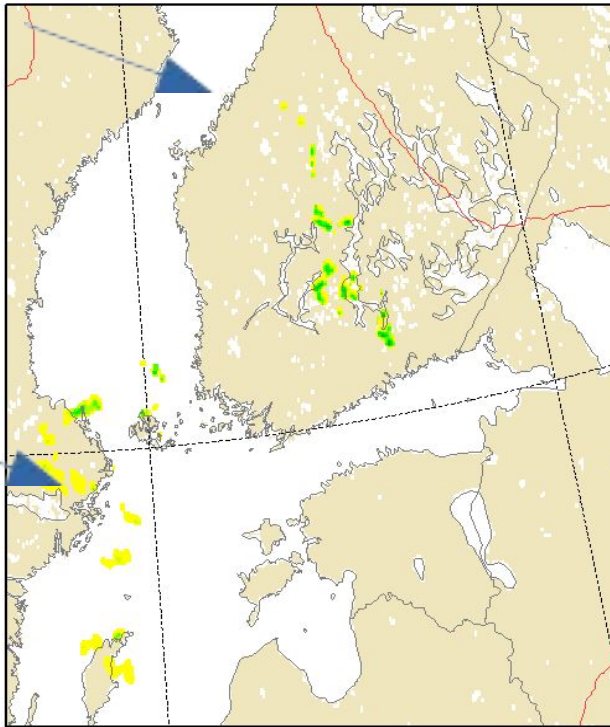
3D-VAR RUC 1.3km 3D-VAR 3h 1.3km 3D-VAR 3h 2.5km



3D-Var in nowcasting setup: enhancing realism by cloud ingest

- MetCoOp-Nowcasting (MNWC), 2.5 km, hourly runs, rapid refresh
- Cloud ingest: Initialization of T,q profiles with NWCSAF cloud top and SYNOP cloud bases just before the model integration => decreases bias of low cloudiness and affects precipitation

without
MSG cloud
ingest



with
MSG cloud
ingest

Work of
E. Gregow,
D. Schonach

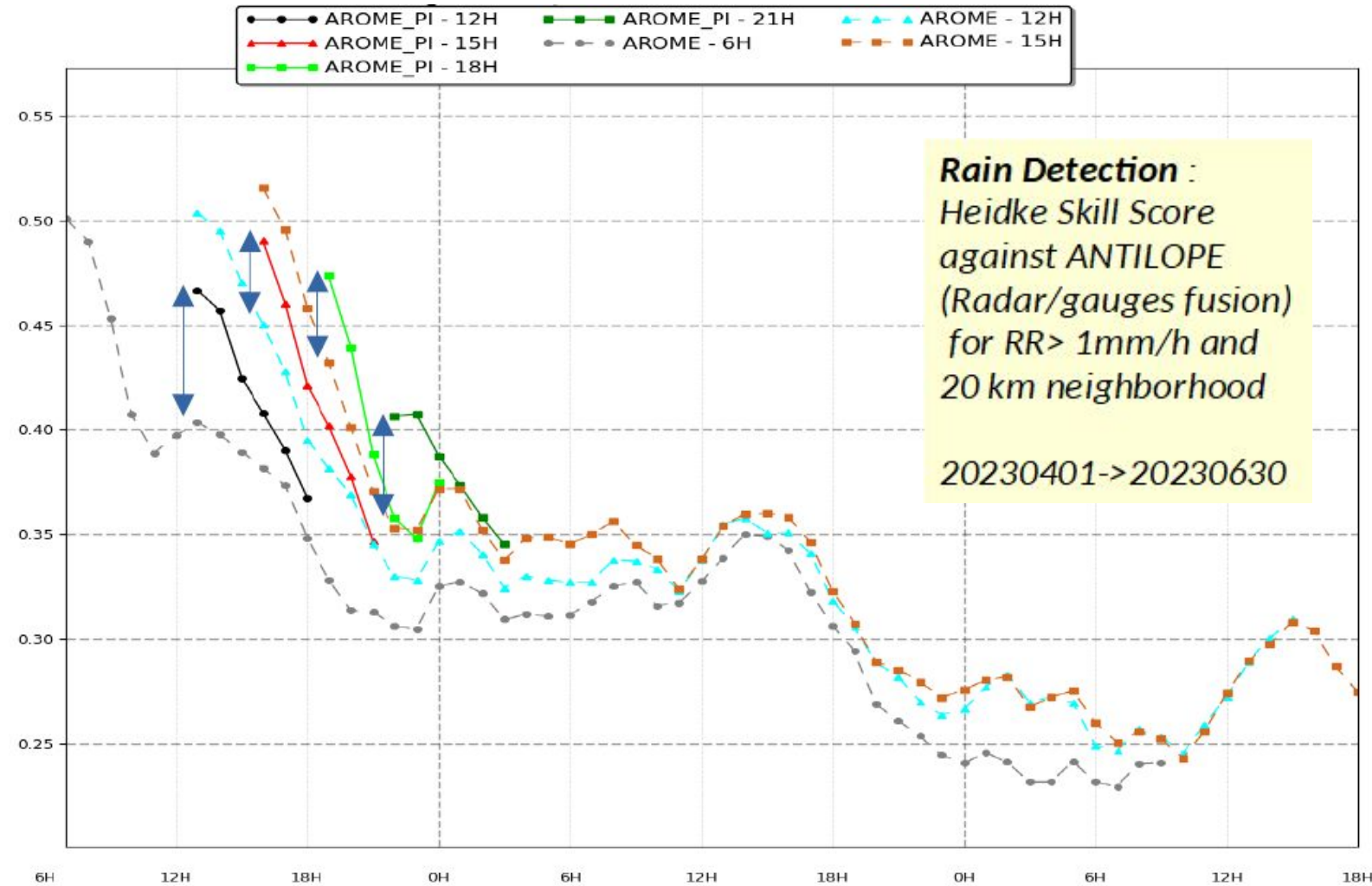
Very-short cut-off nowcasting at Météo-France: AROME-PI

Operational AROME-PI:

- Configuration based on AROME-France, non-cycled 3D-Var
- [-30,+10] min cut-off window, +6h forecast every hour
- Relies on radar (reflectivity, wind) and surface stations

AROME-PI e-suite:

- Initialization from AROME 3D-EnVar
- assimilation of SEVIRI RSS radiances
- R&D: semi-cycled 3D-Var, 3D-Var + IAU, assimilation cycle...

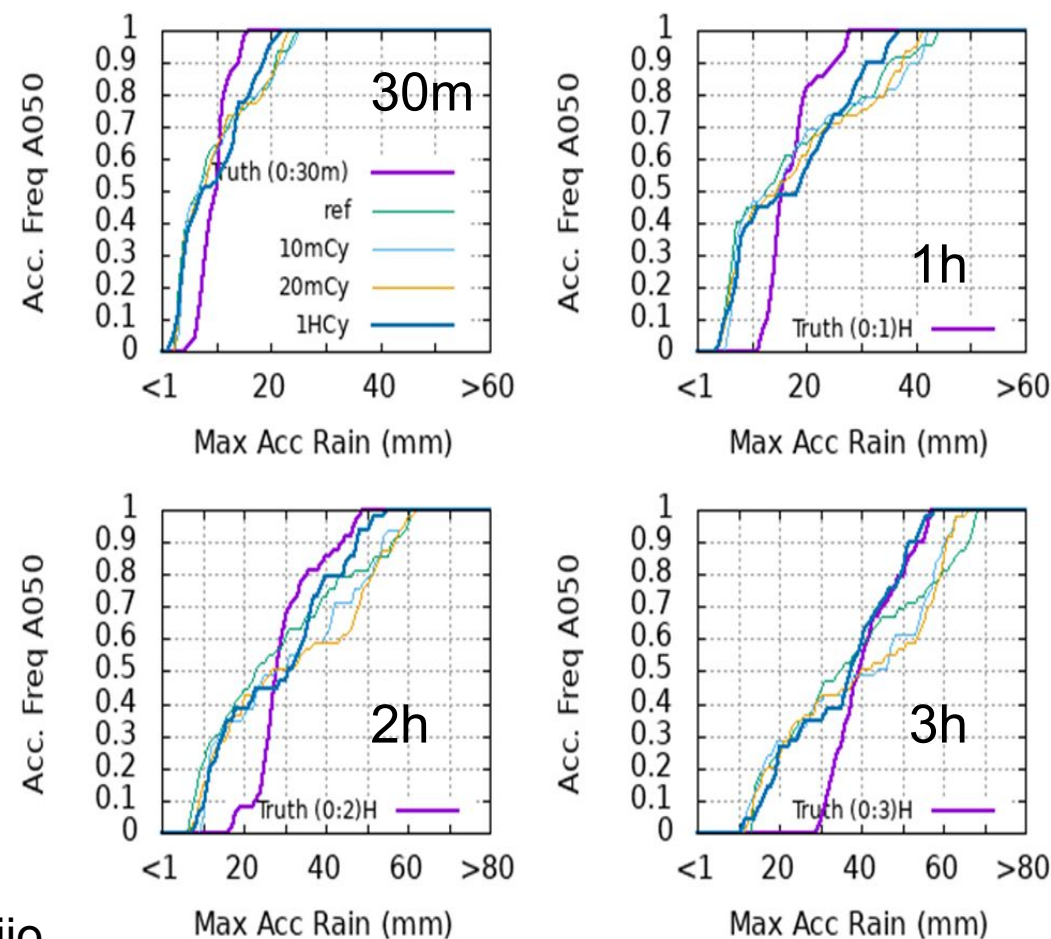


Work of T. Montmerle et al.

Towards sub-hourly DA cycling

- Motivation: explore DA methods for “on-demand” NWP
- OSSE framework:
 - twin experiments (truth, reference free run)
 - synthetic local radar data (Malaga radar) deduced from “truth” twin and assimilated with FA and 3D-Var
 - frequent cycling (1h, 30m, 20m, 10m) in 4 consecutive steps before each 3h forecast
 - the variational constraint (VH) algorithm used to provide increments on NH prognostic variables
- Implementation with Harmonie-AROME shows that even 10 minute cycling/refresh is potentially within reach
- Sub-hourly experiments do not improve on the hourly setup, possibly due to inefficient variational DA setup (3D-Var, B-matrix, initialization)

Maximum accumulated rain around the radar



Work of C. Geijo

Conclusions

- The ACCORD consortium is progressively implementing DA solutions in the OOPS system
- This offers multiple opportunities and innovations, e.g.:
 - new algorithms (ensemble-variational, hybrid) for atmosphere and surface
 - enhanced use of observations (e.g. hydrometeors to enhance feedback from radar and radiance DA)
- Ongoing developments of short-range deterministic systems (3D-Var, BlendVar)
- Developments of DA systems to provide short-cutoff hourly NWP:
 - Cycled (RUC) and non-cycled approaches (rapid refresh)
 - Exploratory work on sub-hourly DA

Thank you for attention!

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