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A Consortium for COnvection-scale modelling Research and Development

Use of observations in ACCORD

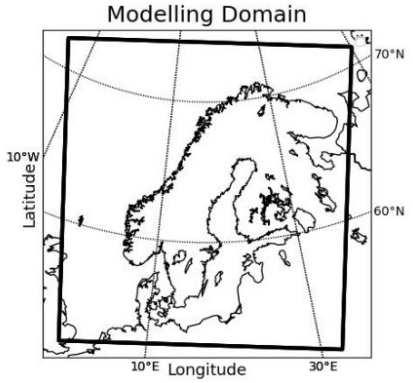
25th EWGLAM 30th SRNWP meeting, 25-28 September 2023, Reykjavik, Iceland
Magnus Lindskog and ACCORD upper-air data assimilation colleagues

Outline

- Conventional types of observations
- GNSS
- Mode-S EHS
- Remote sensing observations
- Crowd-sourced data
- Summary and conclusions

Conventional types of observations

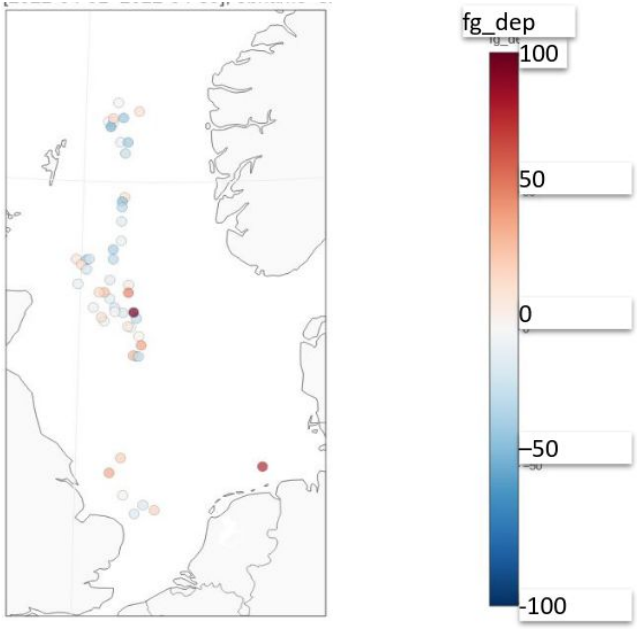
Variational bias correction of SHIP surface pressure observations



Parallel exp March-April 2022

- Without and with bias correction for SHIP surface pressure observations.
- MetCoOp domain
- 2.5 km hor. dist./65 levels
- 3D-Var for upper-air

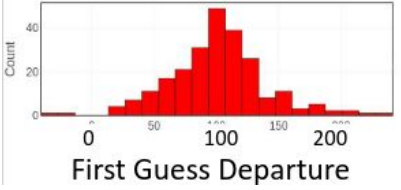
SHIP surface pressure average first guess departures (Pa) April (without bias correction)



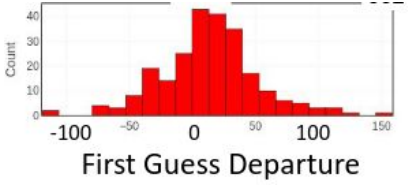
station=62153

Histogram for April

Without bias correction



With bias correction



Functionality demonstrated but non-significant and small impact on average verification scores.

S. Thorsteinsson, M. Lindskog, J. Bojarova, M. Ridal, E. Whelan

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GNSS

EUMETNET OBS-CA A3.10 study

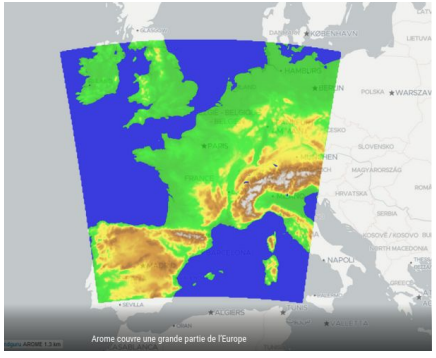
There are three different products available from ground based GNSS, **ZTD**, **ZTD gradients** and **STD**. EUMETNET study A3.10 the assimilation of these three products will be compared.

The project includes SMHI, MF, DGM and KNMI.
Duration is 1 year and the started 1 May 2023

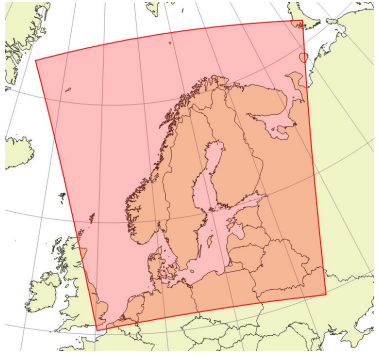
Two domains will be covered, Météo France AROME and MetCoOp

Domains

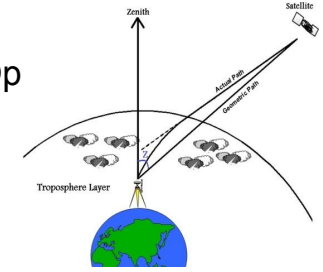
Météo France AROME



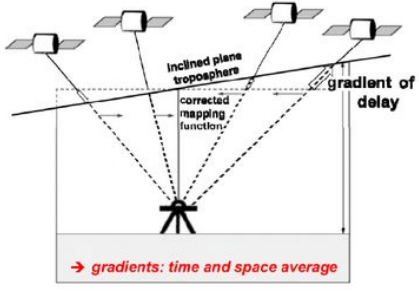
MetCoOp

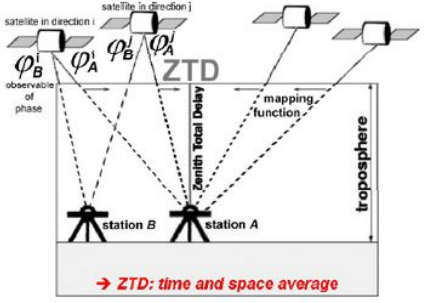


Products



ZTD = ZHD+ZWD mapped to zenith
STD = SHD+SWD for each individual path





M. Ridal, P. Moll, F. Hdidou, S. d. Haan

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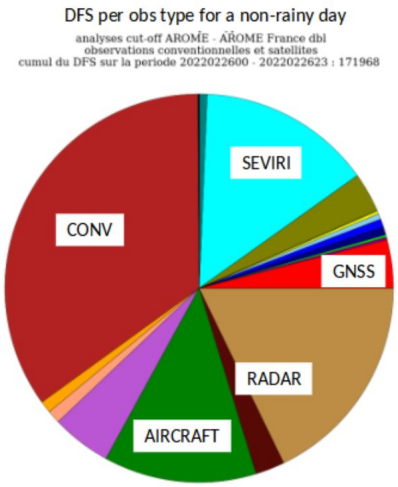
GNSS

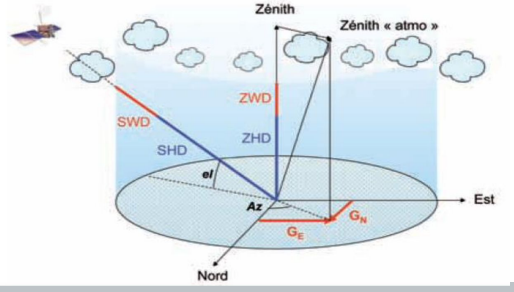
For AROME-France, we know that

- The order of forecast error reduction thanks to GNSS data lies between 1~5 %, depending on the presence of precipitations (and thus on the number of radar data)
- For AROME-NWC, this could be higher as no satellite data are available

→ possible only with faster pre-processing and very short time delivery !

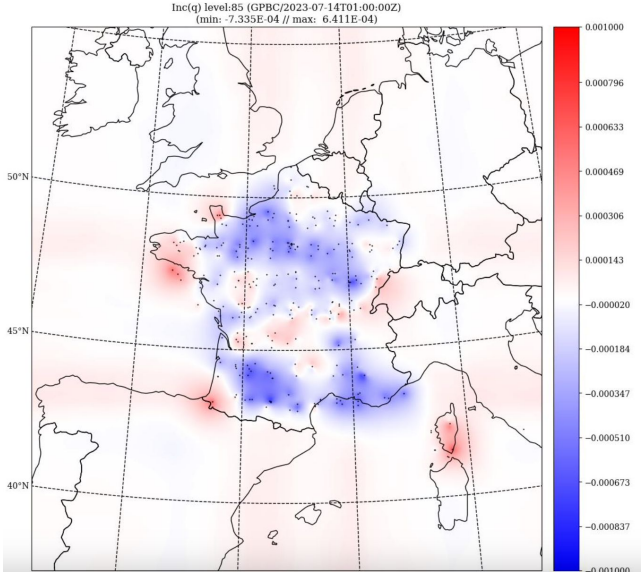
=> Investigating the impact of Tropospheric gradients in complement of Zenithal Total Delays





First map of increments on specific humidity in the lower layers derived from the assimilation of STD.

=> Assessment of impact to be done

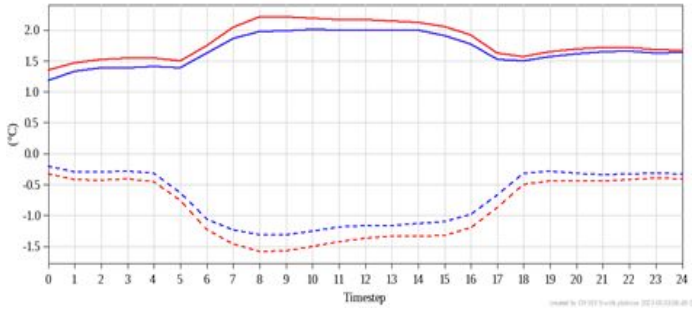


Progress with various GNSS-related data

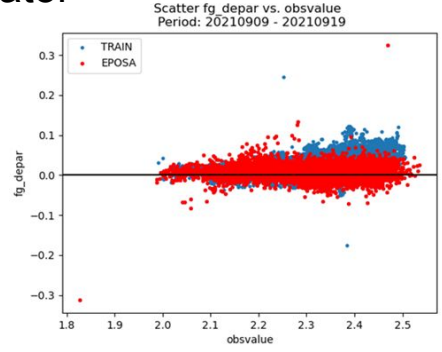
- Switch of data provider in Hungary (Budapest University of Technology and Economics)

  TRain project in Austria: additional tests to mimic possible operational application (using subsets of data due to delayed provision)

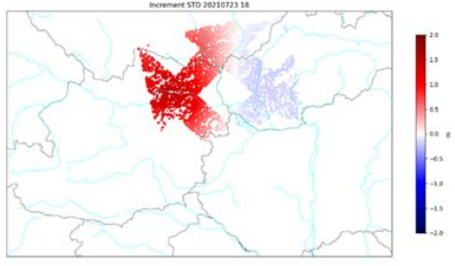
- InSAR Sentinel-1 delay assimilation with STD slant delay operator



T2m verification using ZTD networks SGO1 and BMEG.



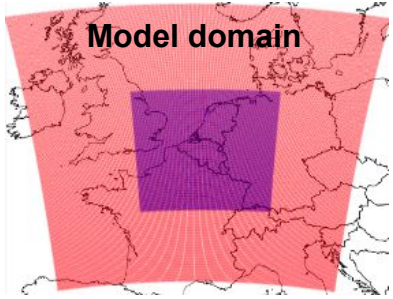
FG departures for permanent GNSS stations and train measurements.



FG departures of derived STD from Sentinel-1.

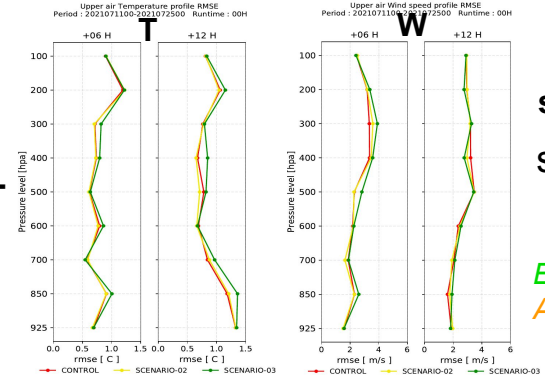
Mode-S EHS

EUMETNET OBS-CA A3.02 study



Model configuration	*AROME (ACCORD consortium)*
Geometry	1.3km, 564x564 grid points , 87 levels
Coupling model	ALARO4.0, every 1 hour
Forecast range	Up to +48h
Surface initialisation	**CANARI_Oimain**
Upper-air initialisation	**3DVar**
Assimilation frequency	3 hours
Observation cut-off	1 hour

Summer period

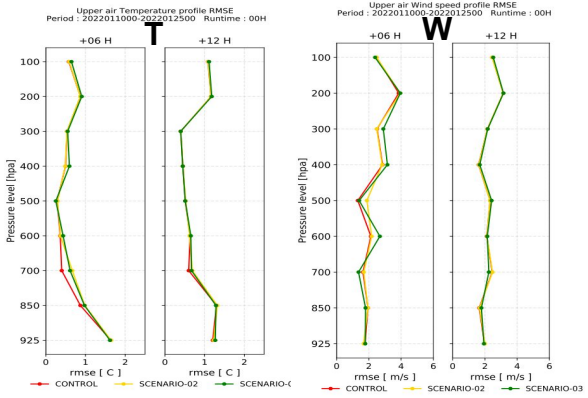


Forecast verification scores (rmse)

summer 2021
winter 2022

EMADDC denial
AMDAR denial

Winter period



Findings

Quality of Mode-S EHS slightly worse for low level temperatures, otherwise as good as quality of AMDAR for winds and temperatures.

*Replacing the AMDAR data by EMADDC in general **does not** degrade the forecast skill at short lead times.*

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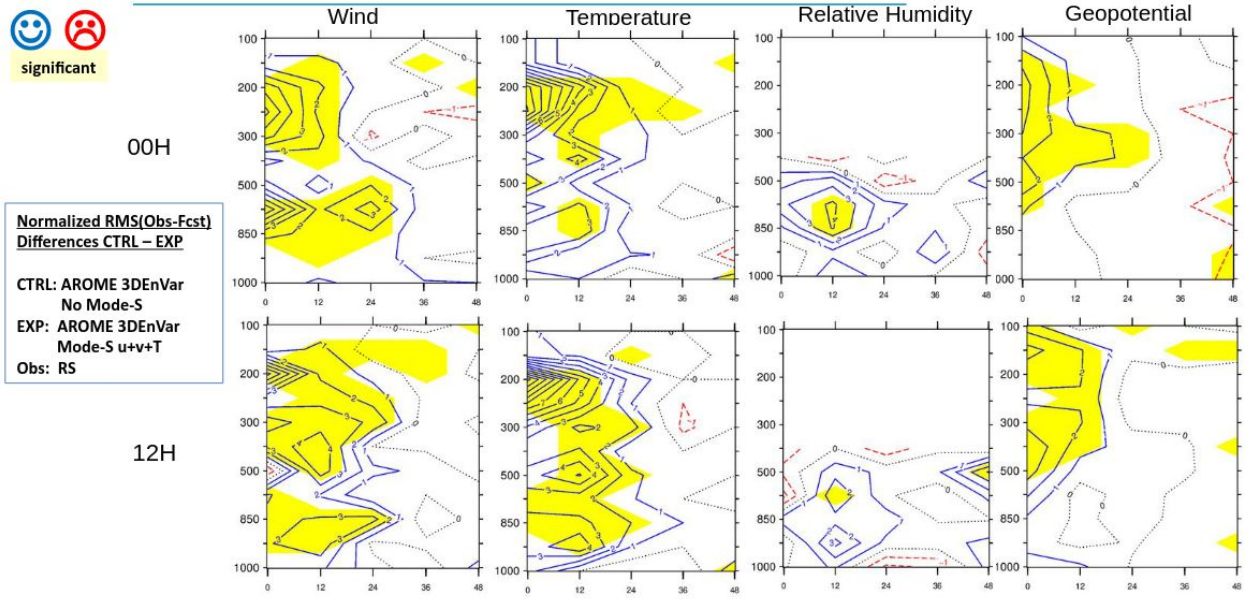
Mode-S EHS

Parallel exp 20210928-20211031



Wind and Temperature: significant and positive impact until 24 hours, whole troposphere

Relative humidity: significant and positive impact until 12 hours, low troposphere.

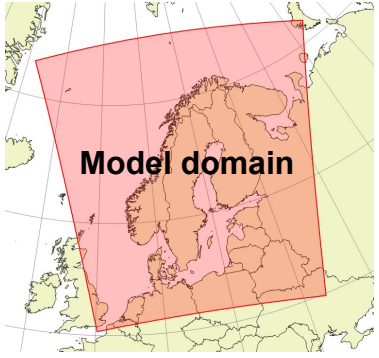
Geopotential: significant and positive impact until 18 hours, high troposphere.

Thinning of Mode-S and use of appropriate background error statistics are important factors.

Assimilation of high resolution radar radial winds

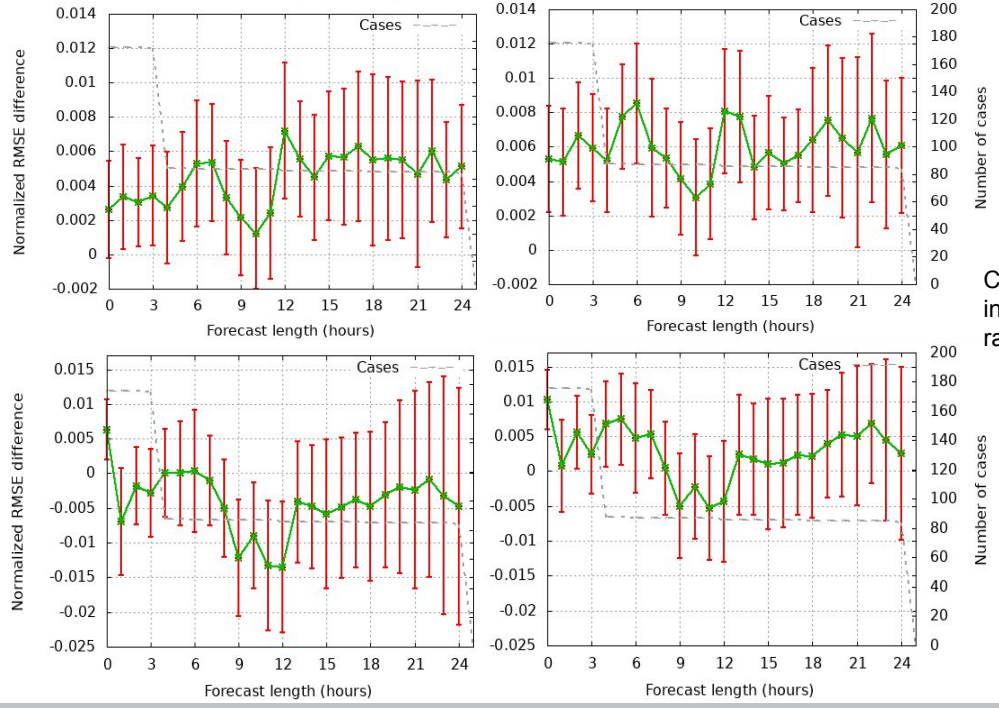
Parallel exp August 2021

- MetCoOp domain
- No dealiasing, use radar with high Nyquist frequency
- Paper almost accepted: *Optimal use of radar radial velocity in the HARMONIE numerical weather prediction system*



Low resolution
(same as reflectivity)

High resolution
(half thinning distance of reflectivity)



RH2m

Comparison against an experiment including conventional obs, satellite radiances and radar reflectivity

MSLP

Positive impact of high resolution radar radial winds.

M. Ridal, J. Sanchez-Arriola and M. Dahlbom

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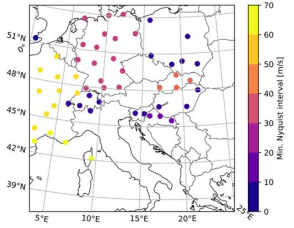
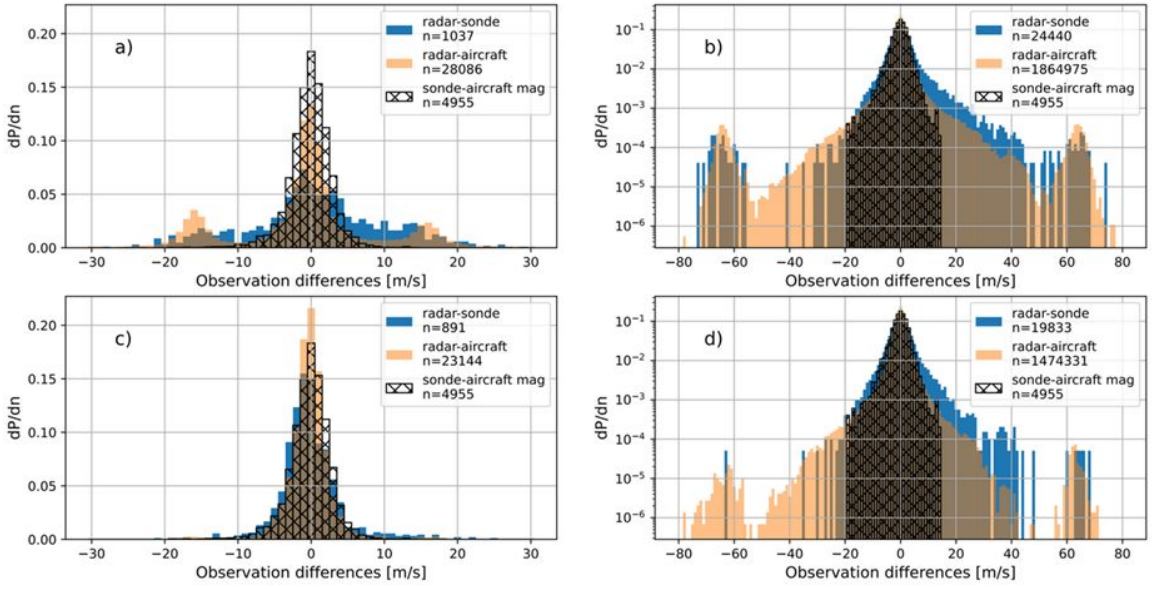
Assimilation of radar radial winds - dealiasing



Radars sites used in the study with minimum DOW Nyquist interval.

Slovenia (NI = 8m/s)

Radars with NI>30 m/s



raw

dealiased

Torus mapping evaluated over year 2021 by intercomparison with aircraft, sondes and NWP => dealiasing improves DOW, for all radars with sufficiently low amount of noise

P. Smerkol, B. Strajnar, V. Švagelj

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Impact of radar reflectivity

OPERA Reflectivity assimilated using Bayesian inversion (1D+3D-Var) in ALARO 3D-Var

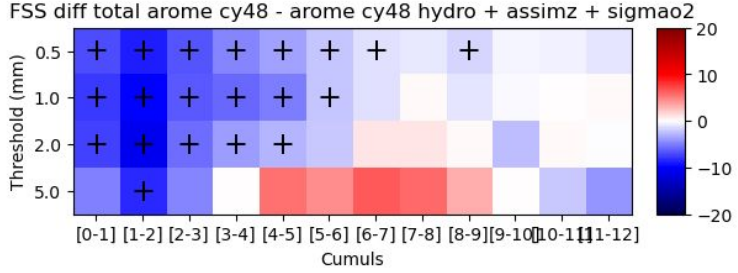
Small but positive impact on precipitation, dry bias in cloudiness and humidity

Main mitigation proposals:

- inflated obs. error for dry “undetect” observations
- using threshold for FG and/or observations to activate reflectivity DA
- use offline estimation of radar sensitivity which is not provided by OPERA (difficult to maintain)

Direct assimilation of reflectivities in AROME-France

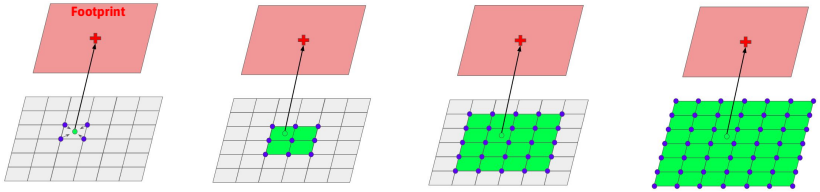
In the framework of 3D-EnVar with hydrometeors in the control variable, no Bayesian inversion needed anymore. Impact on rain forecasts is positive, particularly in the first few hours.



Difference of FSS for 1h rain accumulations for different thresholds.
Blue = direct assimilation of reflectivity is better
Crosses = difference is statistically significative

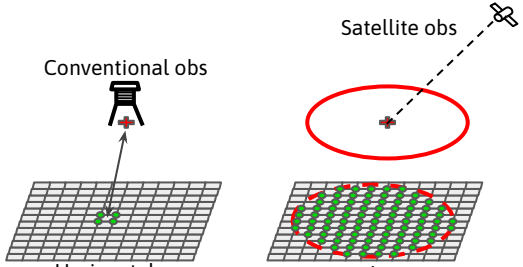
Remote sensing observations

Scatterometer supermodding and the radiance footprint operator



Default assimilation as **Point observation**

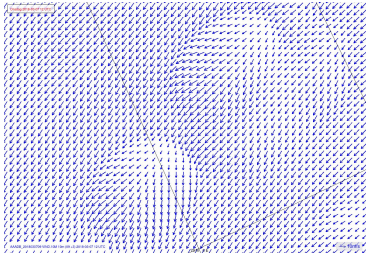
Averaging in model space **Supermodding**



Horizontal interpolation

Averaging in observation space

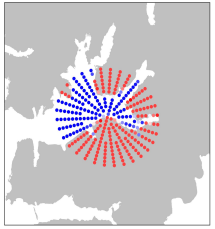
AROME model on full resolution (too strong convection, wind downburst)



ASCAT cannot provide such small-scale information to constrain AROME wind fields

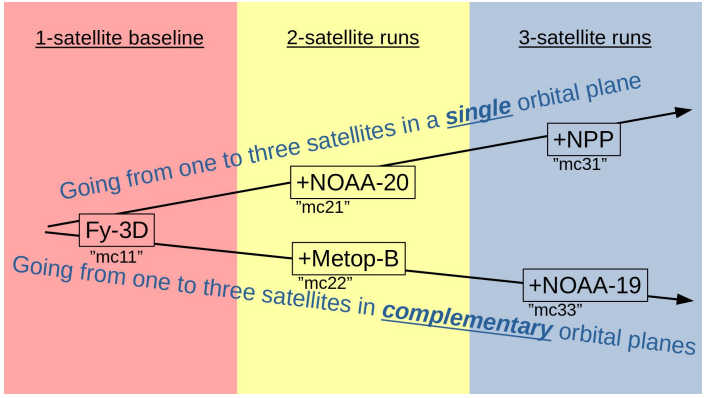
AMSU-A single obs + footprint

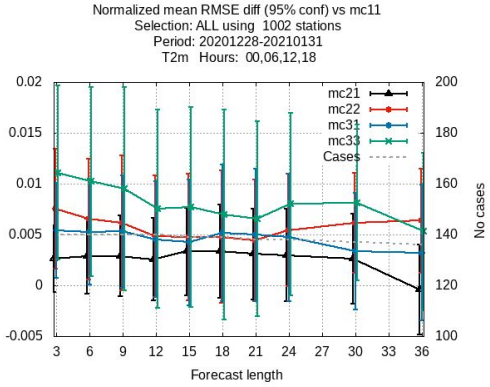
Simulated Tb

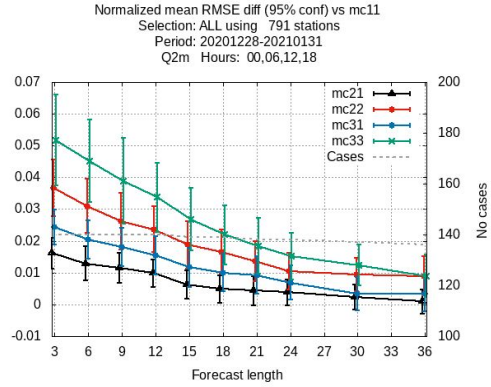


Retrieved emissivity

The impact of microwave sounders in regional 4D-Var







– The context: an ESA-funded project on performance evaluation of the Arctic Weather Satellite (AWS)
– Quantifying the incremental benefit from adding the current MW sounders into the assimilation system one by one
– The experiments are in the operational 2.5 km grids of the MetCoOp and AROME-Arctic NWP groups
– The benefit from each satellite builds up incrementally and reaches up to +5% improvement in terms of forecast RMSE in surface-based verification

R. Eresmaa, D. Schönach, P. Dahlgren, S. Hagelin

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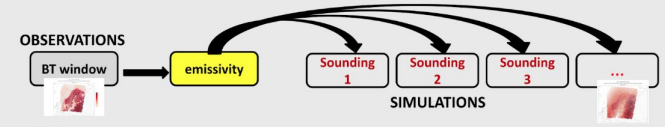
Assimilation of low-peaking channels from satellite instruments

Method for the MW: “LDYN”

Dynamic **emissivity** method: Retrieve the surface emissivity from a window channel & allocate it to adjacent sounding channel (Karbou et al., 2006)

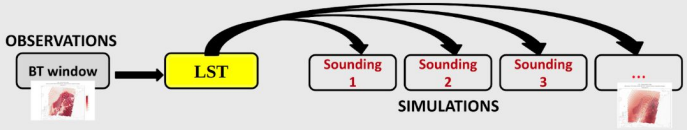


RTTOV inputs:
+LST from background
+Atmospheric profiles

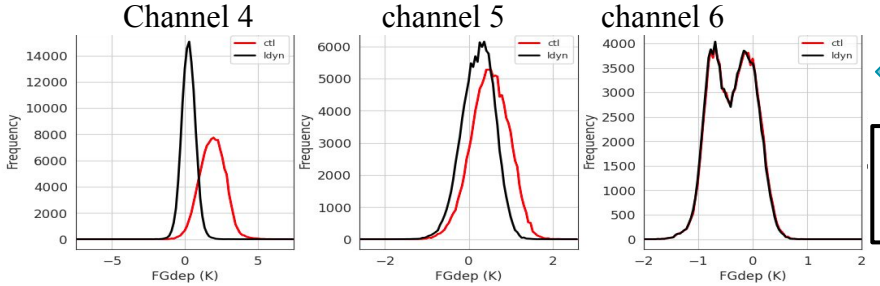
Assumption: non-scattering & plane parallel atmosphere, specular surface, the medium emits at the temperature of the surface skin & **the variability of effective emissivity with frequency is low**.
=> OK over land surfaces but more complex over snow and sea-ice (Karbou et al, 2014) …

Method for the IR: “LSKIN”

Dynamic **land surface temperature** method: Retrieve the surface temperature from a window channel & allocate it to adjacent sounding channel (Karbou et al., 2006)

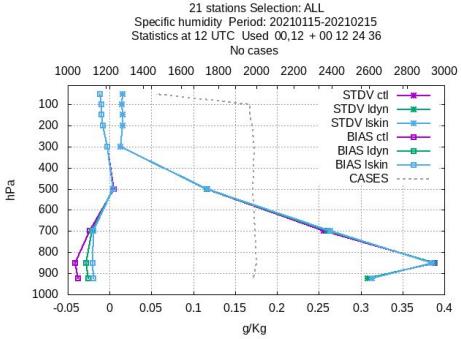


RTTOV inputs:
+Emissivity atlases
+Atmospheric profiles



Important for low peaking channels

Impact of LDYN and LSKIN applied to MW in MetCoOp



S. Guedj et al.

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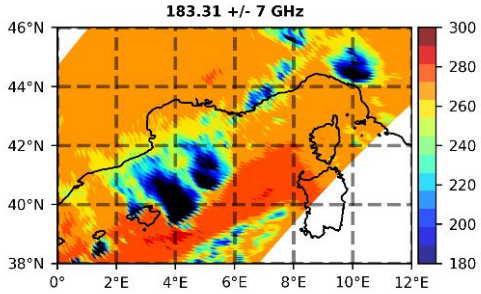
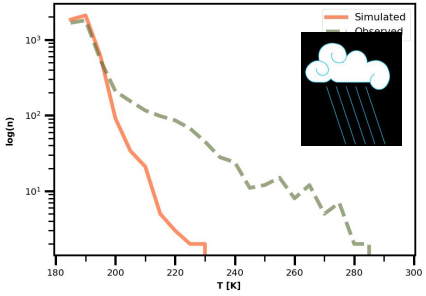
Preparing the all-sky assimilation

Example for MW sounders and imagers within AROME-France

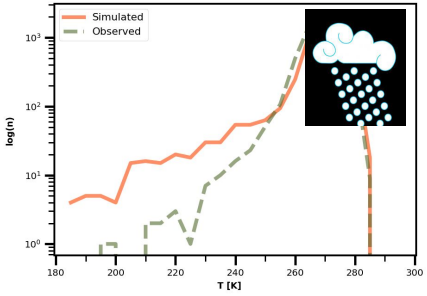
Example of GPM/GMI overpass for an extreme event which occurred in the Mediterranean Sea in August 2022



GMI Channel 3 (36.5v GHz) over Sea



GMI Channel 13 (183.31 7 GHz) over Sea



Model forecasts tend to underestimate the occurrence of rainfall and overestimate the occurrence of snowfall => Ongoing work on assimilation with AROME France 3D-EnVar with hydrometeor in the control vector

E. Chardon–Legrand, M. Borderies, H. Dumas, P. Chambon

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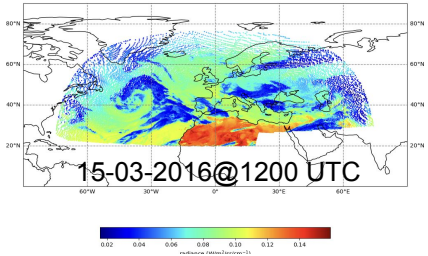
Preparation for new satellites and instruments

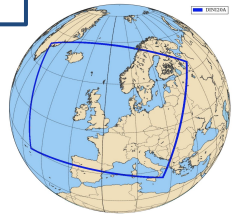
On-going preparations of NWP system for MWS, AWS, MTG-IRS

Example: UWC-W preparations to MTG-IRS

- IRSPP_v1.2 pre-processing package;
- Synthetic test data in PC format similar to future NRT EUMETSAT dissemination;
- Same channel selection as Météo-France for AROME (Coopmann et al., 2023).



Reconstructed radiances in BUFR format



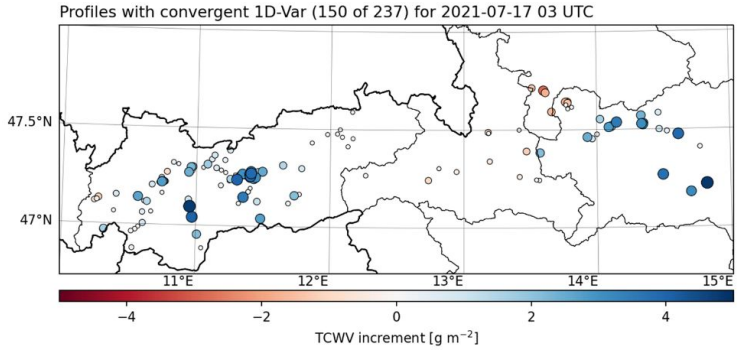
Model domain

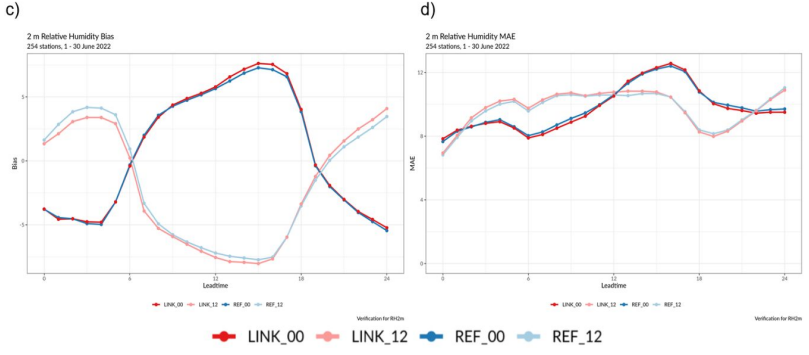
Status: preparing HARMONIE-AROME code prior to the computation of normalised first guess departure (Bator).

Implementation and testing with **4D-Var** to take full advantage of the 30 min frequency of these data.

Assimilation of commercial microwave links

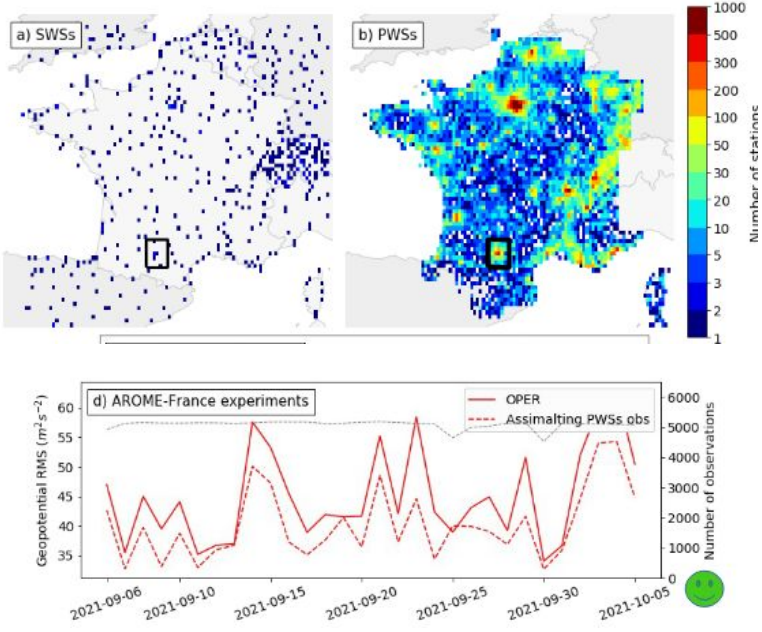
- quantitative rain rates based on ML provided to GeoSphere (LINK project)
- 1D+3D-Var method by P. Lopez (past version of linearized IFS physics), adjusts first guess RH profile over observation and assimilates it
- Stable observations with quick processing time of 2-5 minutes
- Small and mixed impact, humidity bias slightly improved

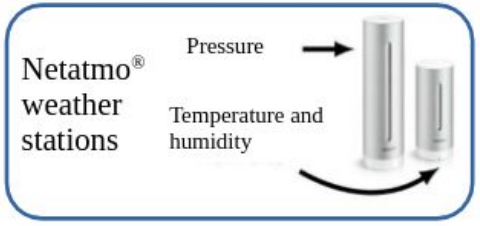




Private weather stations

Surface pressure





- Identify suitable observations and make available in time
- Observation bias correction/
- Data assimilation method

Encouraging results surface pressure observations and EnVar. Localised flow-dependent statistics found important. Assimilation of temperature observations more challenging.

A. Demortier, V. Pourret, M. Mandement, O. Caumont

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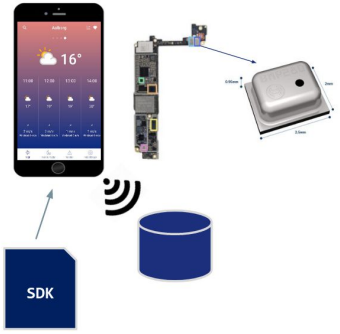
Smartphone data and hot-air balloon data

Surface pressure from Smartphones



- SDK (Software Development Kit) accesses barometer with consent from user
- Barometer is there, to track altitude changes (height curves after biking/running)
- Unfortunately, GPS altitude has low accuracy, so determining the altitude of the phone is the hard part.

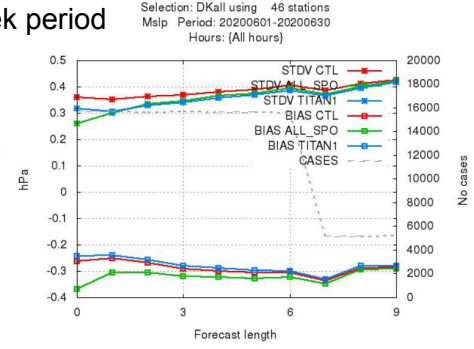
Exp: 3D-Var, 750 m hor res., 4 week period

Red: No SPOs (Reference)

Green: No screening (inflated obs error)

Blue: QC done with Titan

SPO now part of cy46h



Wind observations from hot-air balloons and the application in an NWP model *J. Met. Appl.* https://doi.org/10.1002/met.2128

K. Hintz, E. I. F. de Bruijn, F. C. Bosveld, S. de Haan, G-J Marseille, A. A. M. Holtslag

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Summary and conclusions

- The benefit of Mode-S EHS observations has been demonstrated.
- Several ongoing enhancements concerning handling of remote sensing observations.
- Encouraging results with various types of crowd-sourced observations.

A highly valued colleague

Sigurdur Thorsteinsson

Some of Many Research Highlights

- A Diagnostic Study of the Flateyri Avalanche Cyclone, 24-26 October 1995, Using Potential Vorticity Inversion
- Orogenic blocking and deflection of stratified air flow on an f-plane
- The structure and evolution of an explosive cyclone near Iceland
- Phase-locking of a rapidly developing extratropical cyclone by Greenland's orography
- Potential vorticity-based interpretation of the evolution of ˜The Greenhouse Low, 23 February 1991
- Orographic influence of E Greenland on a polar low over the Denmark Strait
- Sensitivity of forecast errors to initial and lateral boundary conditions
- Three-dimensional variational data assimilation for a limited area model : Part I and II
- Four-dimensional variational data assimilation for a limited area model
- Data assimilation of GNSS zenith total delays from a Nordic processing centre
- Variational bias correction of GNSS ZTD in the HARMONIE modeling system
- Data assimilation of GNSS zenith total delays from a Nordic processing centre
- 10 m winds and 2m relative humidity observation operators
- Bias correction for ship surface pressure and assimilation of low peaking channels

A highly valued colleague

Meeting Icelandic President during GNSS COST meeting in Reykjavik.

After HIRLAM working week in Dublin.

ACCORD working week Madeira.

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Thank you Sigurdur!

A highly valued colleague, Sigurdur Thorsteinsson, is retiring. I would like to thank Sigurdur for his extensive contributions to HIRLAM/ACCORD throughout the years … and for being a wonderful colleague and friend. Sigurdur now it time for you to enjoy your retirement and your leisure interests.