Experience of using AMDAR-humidity in Limited Area Models

Balázs Szintai

C-SRNWP Manager

with contributions from ALADIN, COSMO, HIRLAM, LACE, UKMO

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Aircraft based observations workshop

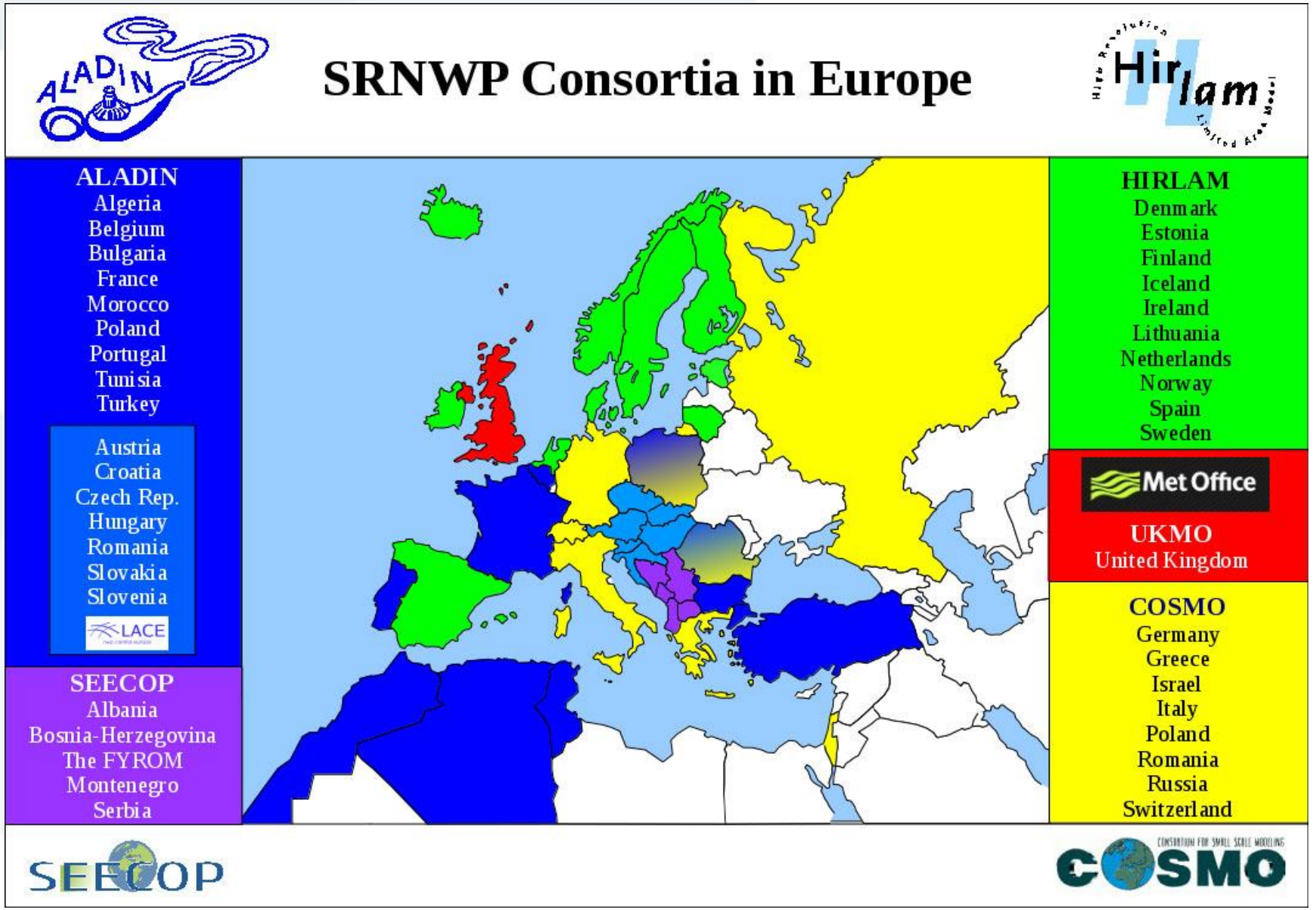
ECMWF, Reading

12-13 February 2020

Outline

- Limited Area Models in Europe
- Mode-S overview
- AMDAR-humidity overview
- AMDAR-humidity experiments in Hungary
- AMDAR-humidity experiments in Spain

Limited Area Models in Europe



Mode-S usage in LAMs

UK-MetOffice

- Winds used operationally (since March 2019), temperature not
- 6 receivers, ~10 more planned

HIRLAM:

- MetCoop: data (T, U/V) from Denmark (EHS, MRAR), Norway (EHS), and MUAC area through EMADDC
- Ongoing studies in the Netherlands, Spain and Ireland

COSMO:

- DWD: used operationally in KENDA-LETKF for COSMO since Oct. 2017.
- Italy: used operationally for COSMO-IT (2.2 km), data available only in a small part in the north of the domain.
- MeteoSwiss: Impact experiment with very small positive impact (on wind and temperature in upper troposphere), but the data cover only about 1/4 of the model domain. Discussions with skyguide to provide Swiss data.
- Other COSMO members: Mode-S not used yet.

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Mode-S usage in LAMs

ALADIN (Meteo-France)

- Plan to assimilate operationally MODE-S winds provided by the French ATC in the AROME model by mid-2021
- developed a VarBC method that allows to bias correct the observation using the true heading and the airspeed as predictors (poster)
- Expand the use/assimilation of MODE-S data to the MUAC area if unbiased winds and heading/airspeed are available, and are provided in real time (following the evolutions of E-ABO)
- Expand the use/assimilation of MODE-S data to the temperature parameter if its accuracy can be improved (following KNMI developments).

LACE

- Mode-S EHS from MUAC area is provided by EMADDC and distributed through OPLACE (data pre-processign system of LACE). Used operationally in AT, CZ and SI. Studies showed clear impact on upper-air T and wind to ~12h into the forecast, and it was proven that it came both from wind and temperature observations.

- Mode-S MRAR from SI and CZ are directly uploaded to OPLACE, and used by a number of countries. Similarly to EHS, there is a positive impact on first few hours of forecast (less than EHS due to much limited spatial coverage).
- Mode-S experiments and discussions on data acquisition started in SK and HU

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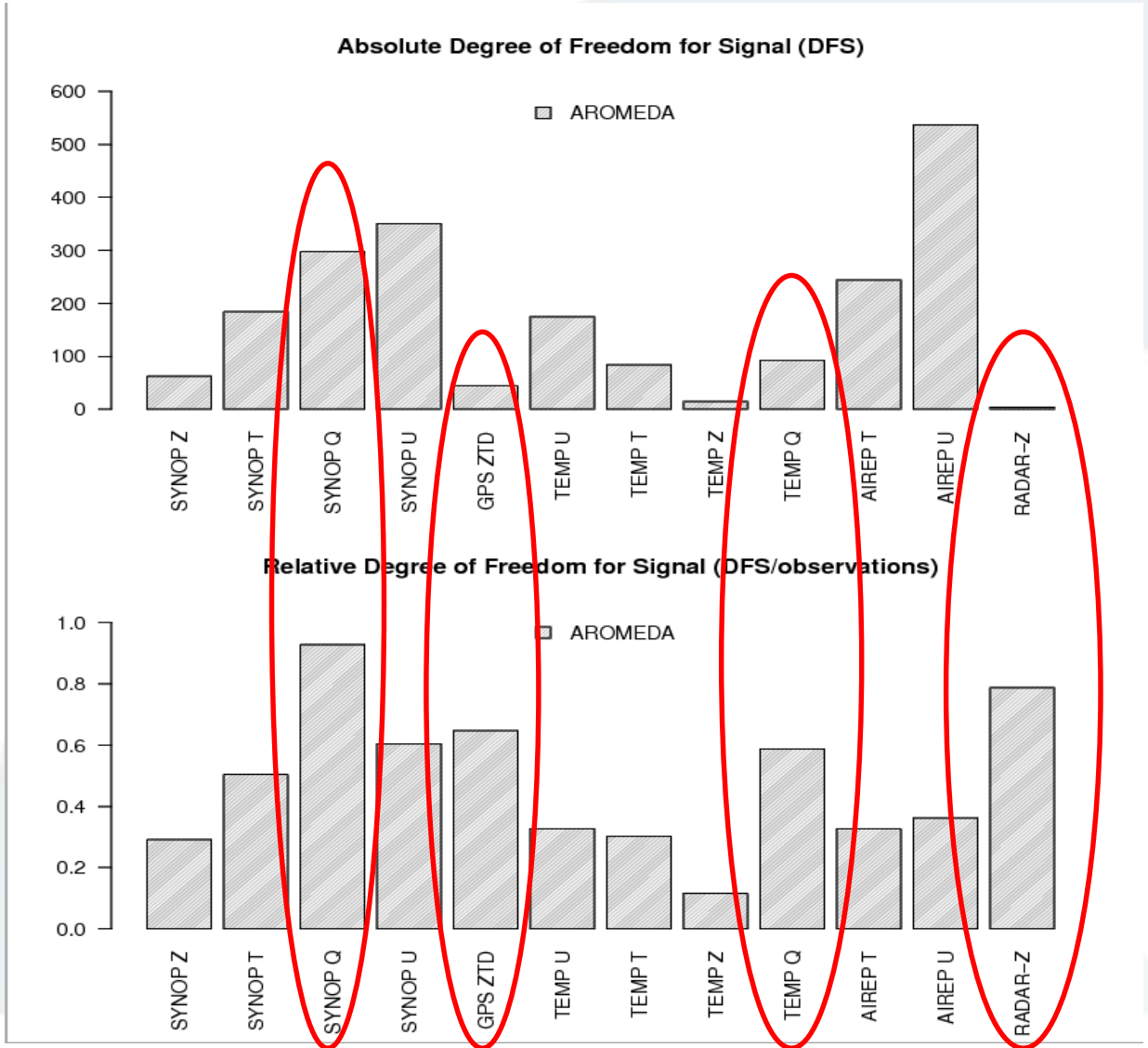
Why use AMDAR-humidity?

Analysis sensitivity to observations

DFS in AROME at OMSZ (figure: Máté Mile)

- Relative DFS: important influence from individual humidity-related observations
- Absolute DFS: The weight of humidity obs is rather low within the full network
- Need to increase the amount of humidity observations (e.g. aircrafts)

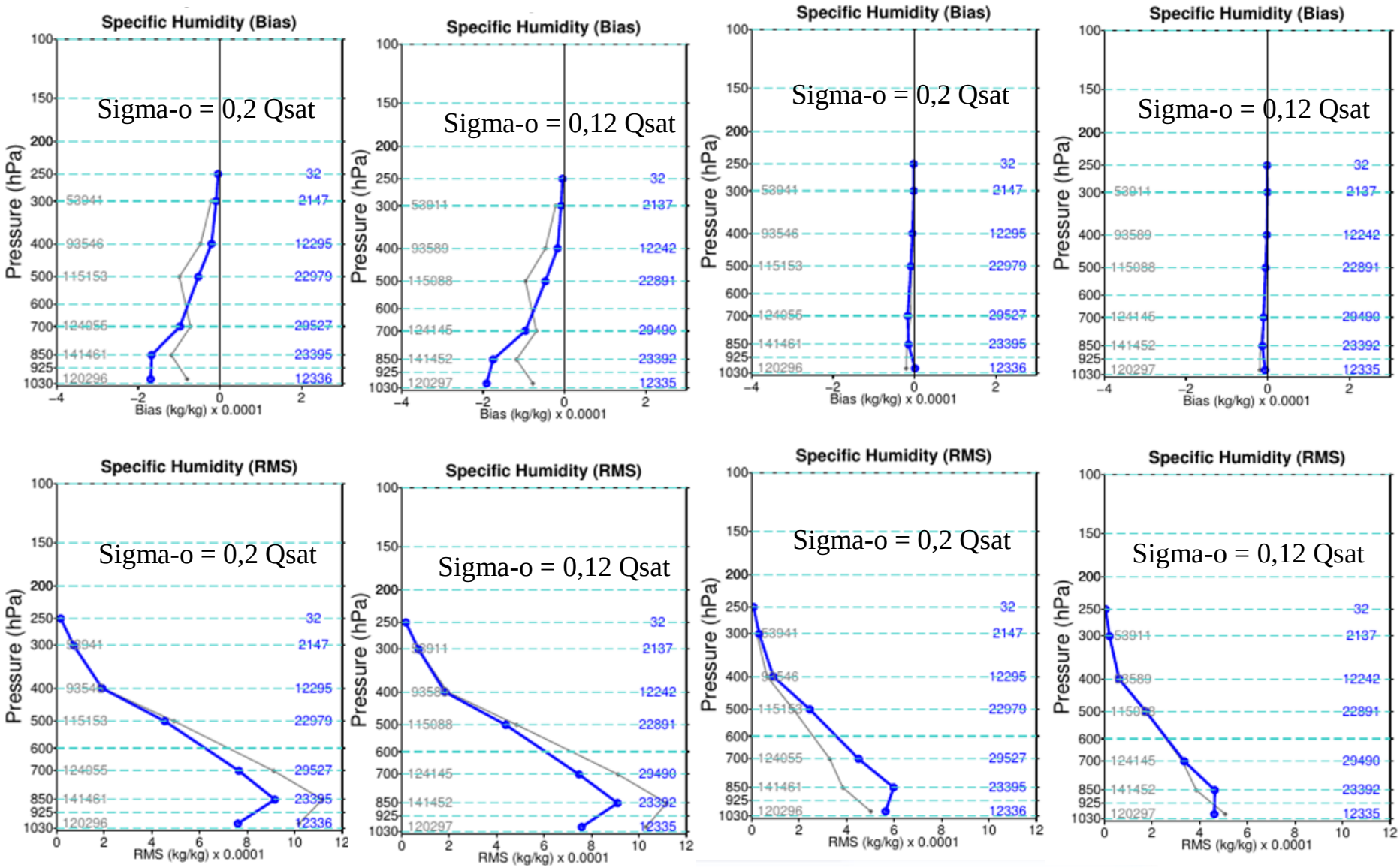


AMDAR-humidity usage in LAMs

ALADIN (Meteo-France)

- AMDAR-humidity not operational yet
- AMDAR-q dry in the lower levels
- experiments undertaken with AROME and ARPEGE (sigma-o tests)
- AROME: impacts are not clear enough, especially in the lower levels

Obs – Guess | **Obs – Analysis**



A. Doerenbecher, Y. Cengiz

AMDAR-humidity usage in LAMs

UK-MetOffice

- AMDAR-humidity used operationally, but no specific impact studies performed

HIRLAM:

- Experiments in Spain (details presented in this talk and on poster)

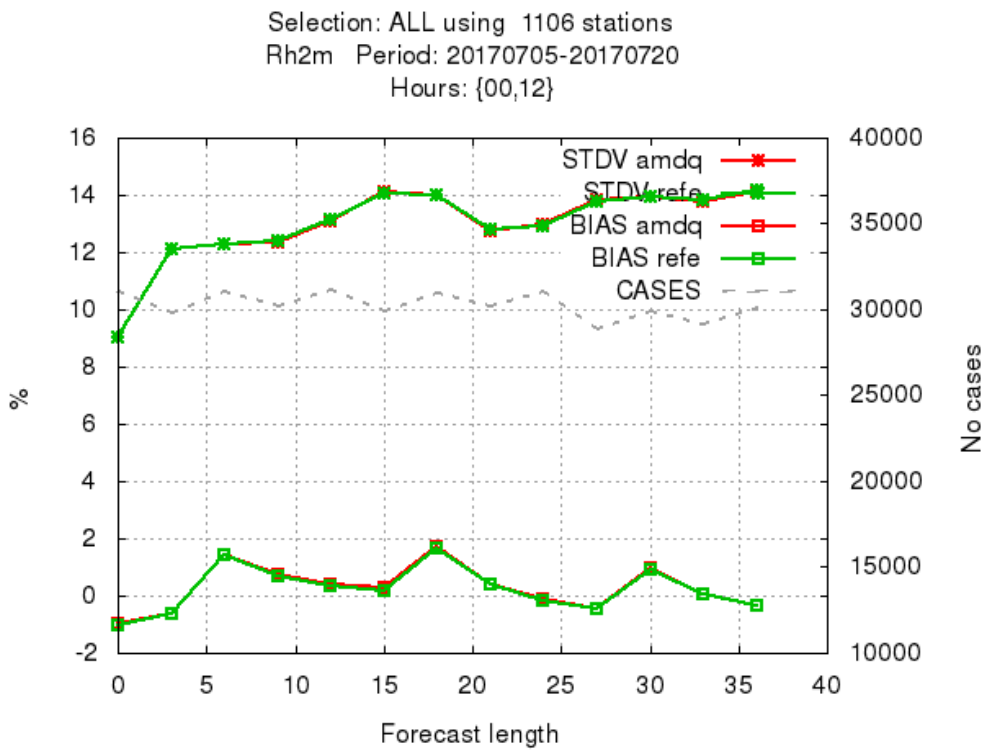
COSMO:

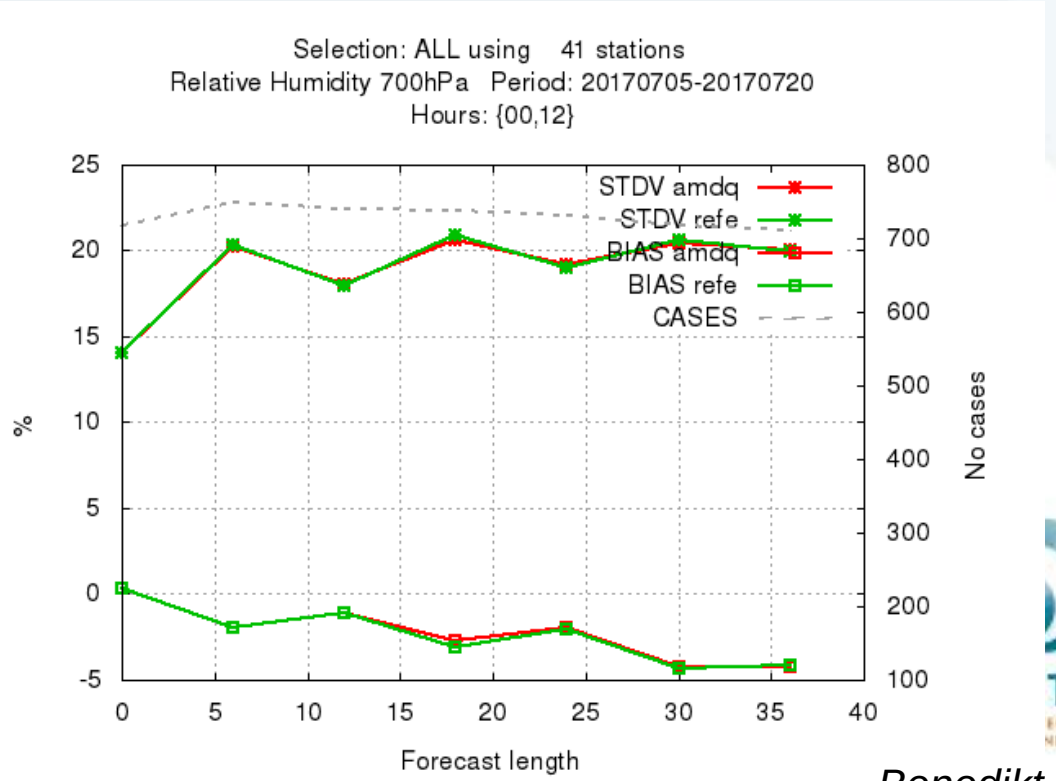
- Status presented by Alexander Cress

AMDAR-humidity usage in LAMs

LACE:

- Hungary: operational since Nov 2016 (details presented in this talk)
- Austria: AMDAR-humidity operational in AROME-RUC
- Slovenia, Czech Republic: AMDAR-humidity operational in ALARO





AMDAR-humidity experiments in Hungary

Viktória Homonnai, Balázs Szintai

AROME at the Hungarian Met Service

- Operational since 2010
- 2.5 km horizontal resolution
- 60 vertical levels
- 8 runs daily out to +48h
- Surface OI assimilation
- Upper-air 3DVAR
  - SYNOP
  - TEMP
  - AMDAR
  - Slovenian Mode-S (since Nov 2016)
  - GNSS ZTD (since Sept 2018)

3, 9, 15, 21 UTC runs lacking upper air humidity observations

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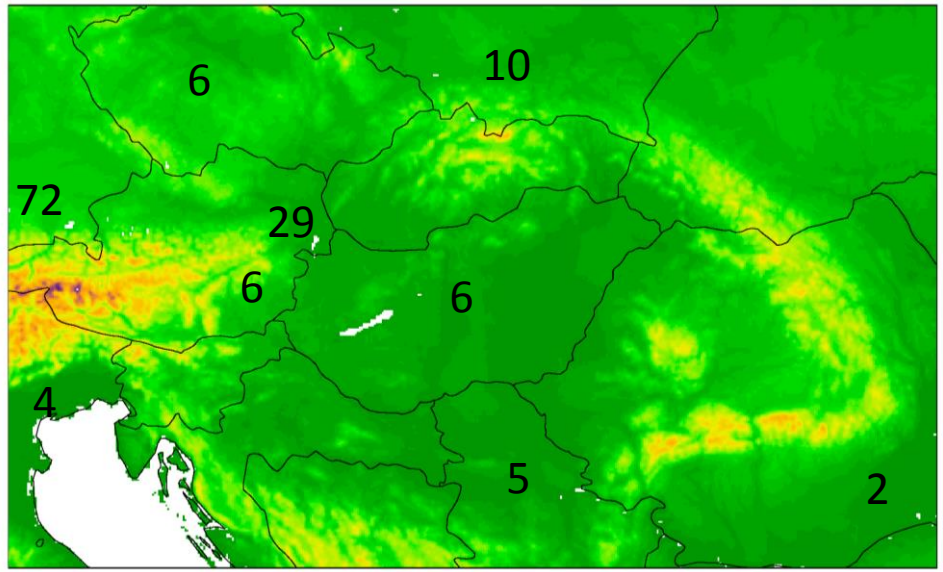
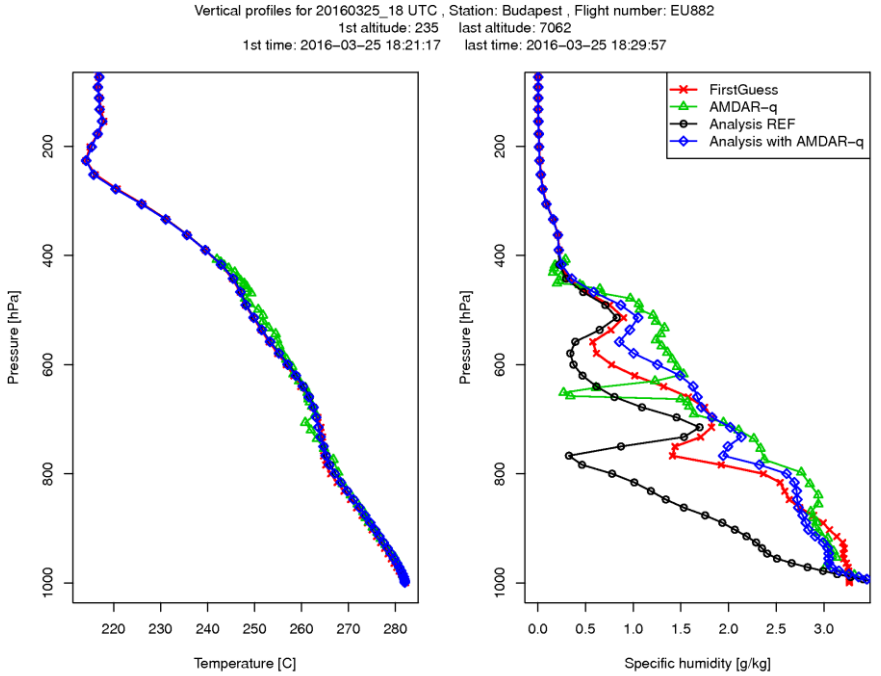
Number of AMDAR humidity profiles over AROME/HU domain in January 2020

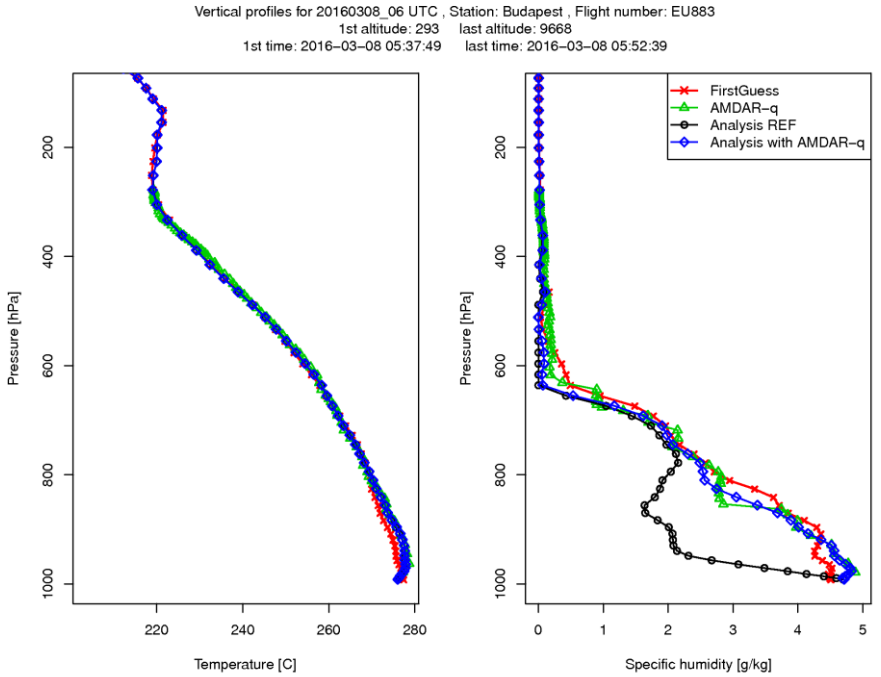


Airport	All profile totals
BELGRADE/NIKOLA TESLA	5
BUCHAREST/HENRI COANDA	2
BUDAPEST/FERIHEGY	6
GRAZ	6
KRAKOW/BALICE	10
MUNICH	72
PRAGUE/RUZYNE	6
VENICE/TESSERA	4
VIENNA/SCHWECHAT	29

Assimilation of AMDAR humidity

- useful information about the vertical structure of the troposphere beside radiosondes → more frequent observations and good agreement with TEMP profiles
- temperature and specific humidity profiles at 06 UTC and 18 UTC (on different days)
- all available conventional observations were assimilated (no TEMP at this time) AMDAR humidity included or not





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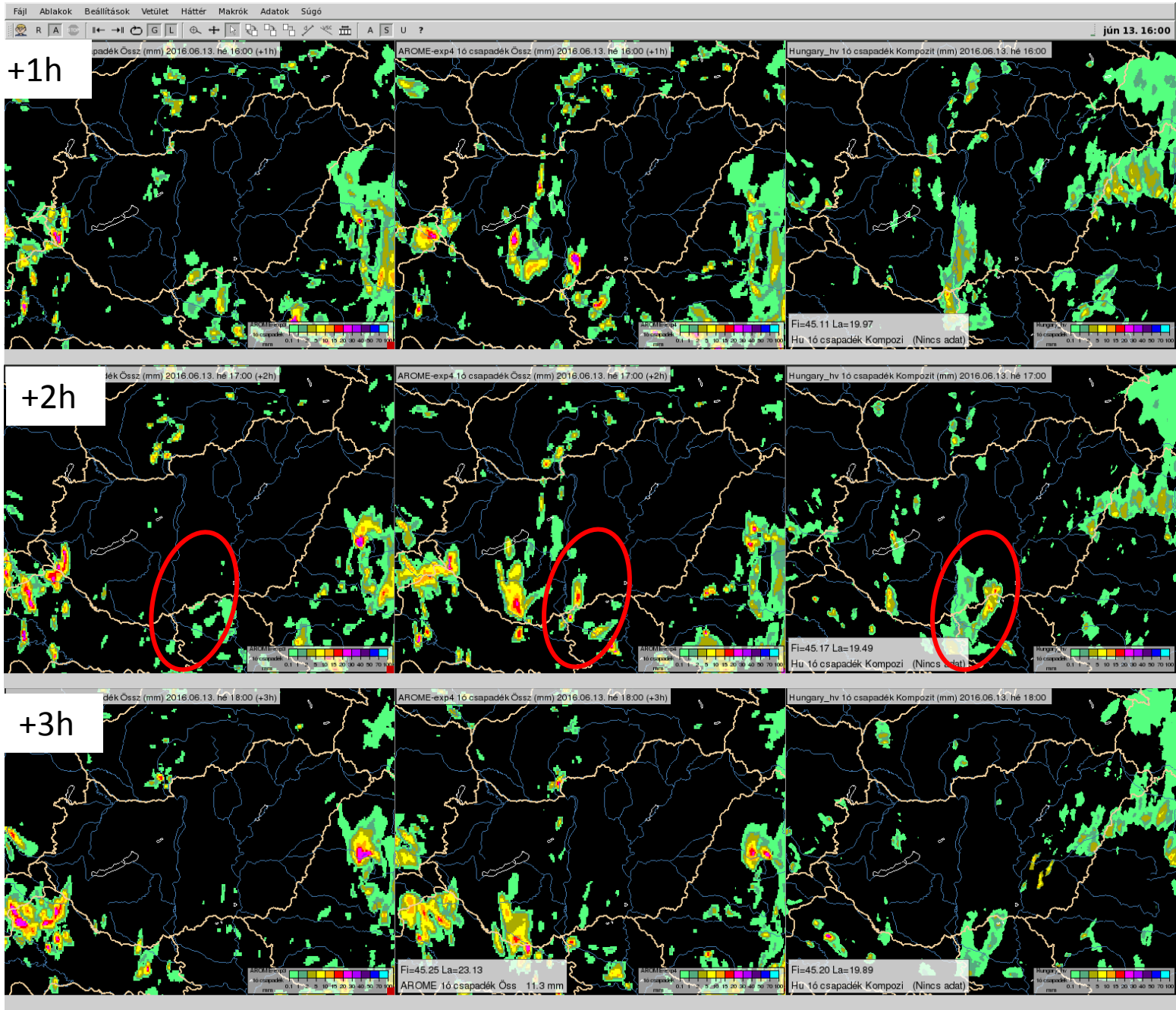
Assimilation of AMDAR humidity

Case study: 13th June 2016 15UTC run

Cyclone over Middle-Europe → heavy precipitation in Hungary

1h precipitation

REF AMDAR-q RADAR



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Obs – Guess and Obs – Analysis statistics for AMDAR humidity observations

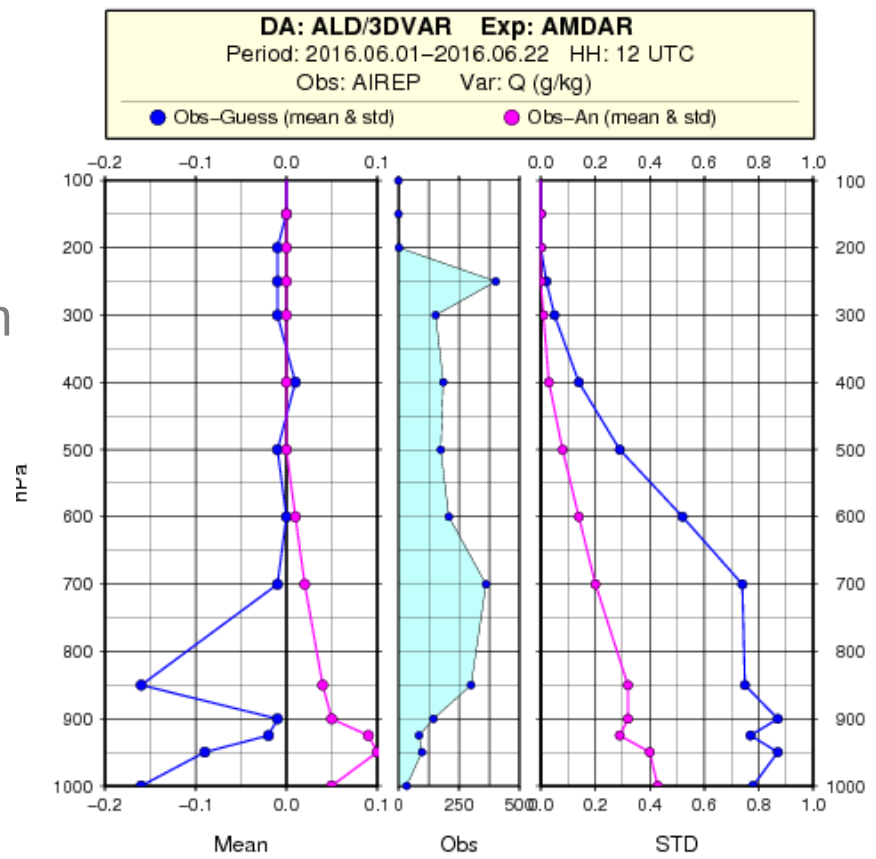
Longer summer period:
01 – 22 June 2016

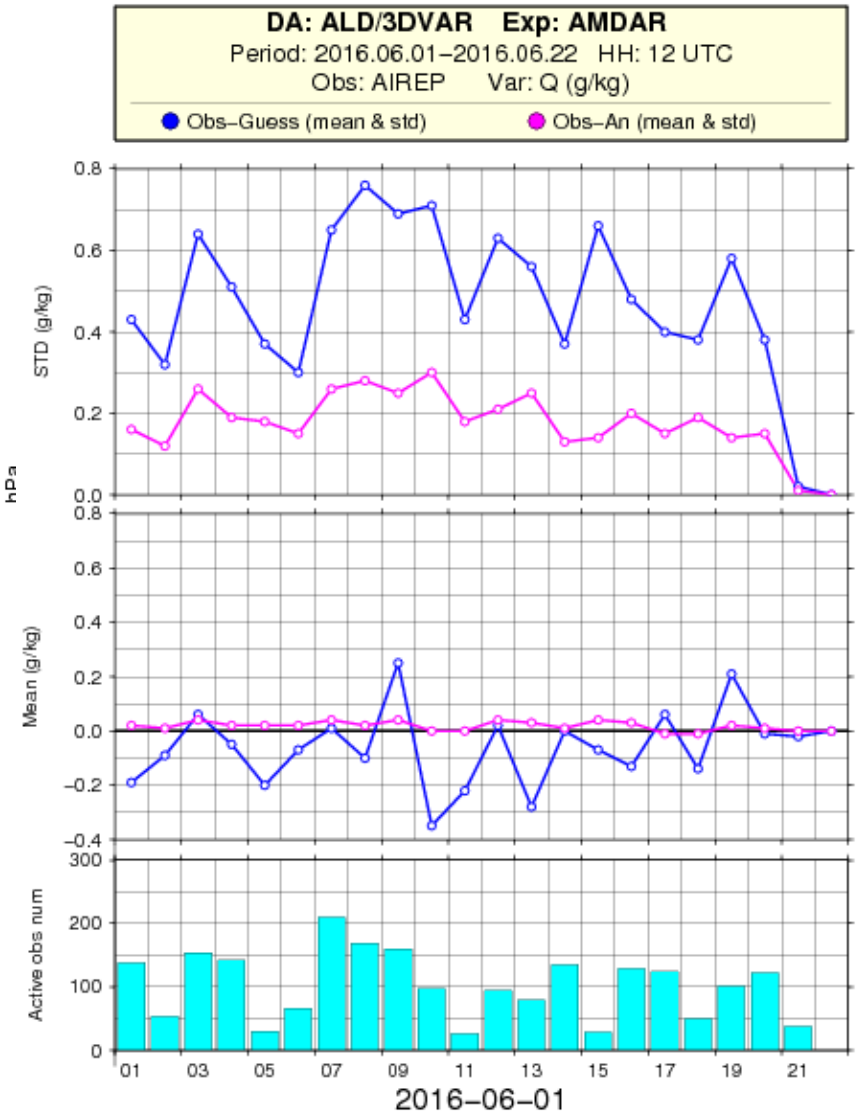
+24h forecasts from

00 UTC

09 UTC

12 UTC





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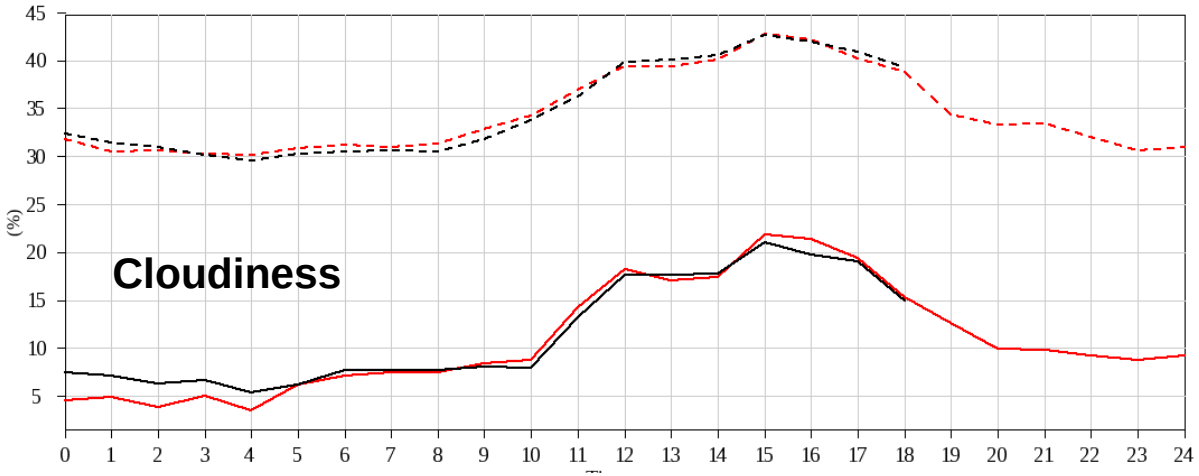
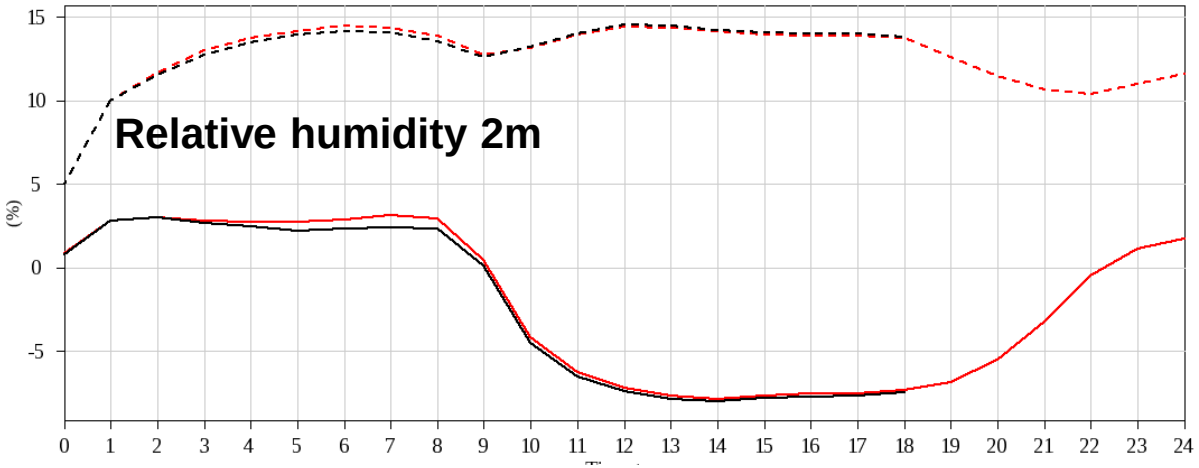
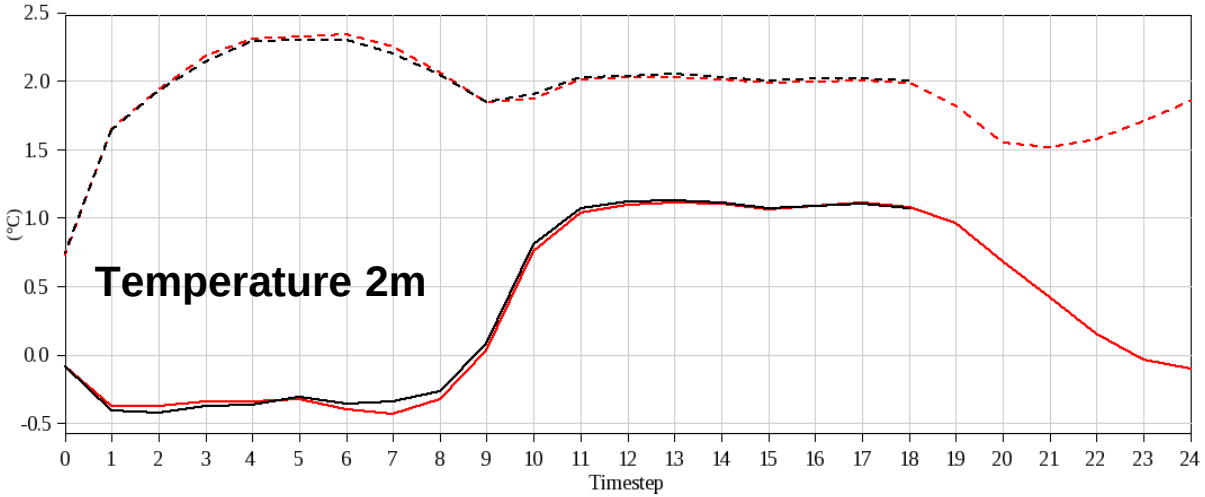
Verification scores (BIAS, RMSE)

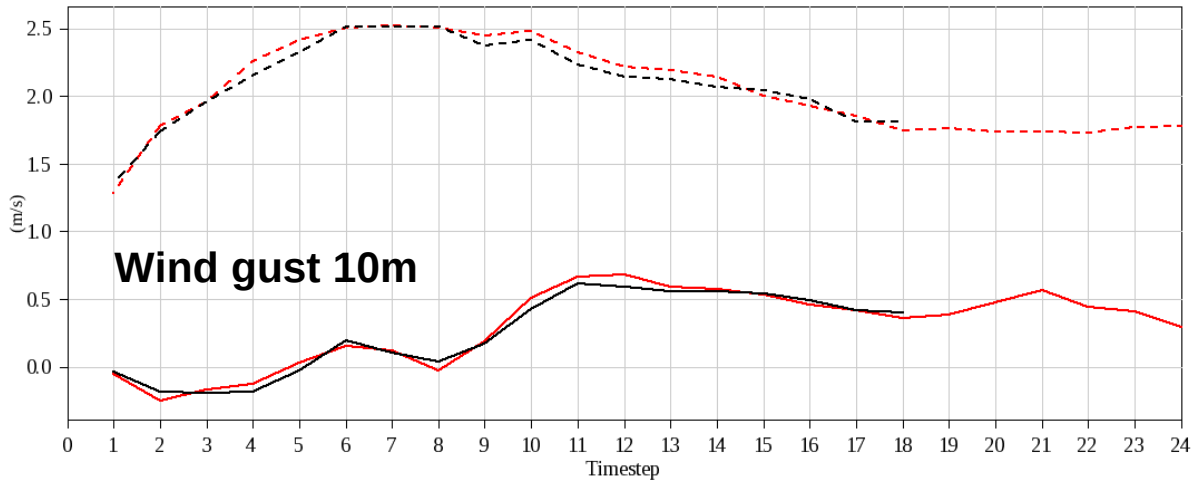
Longer summer period: 01 – 22 June2016
+24h forecasts from 00 UTC, 09 UTC & 12 UTC
OPER – operational run (no AMDAR-q; +18h forecast)
EXP – with AMDAR-q data

09 UTC run









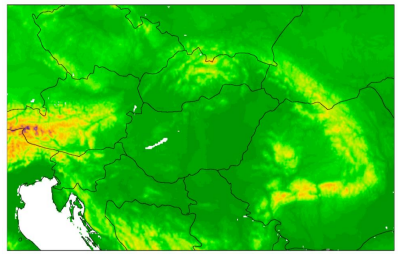
The number of active AMDAR humidity observations

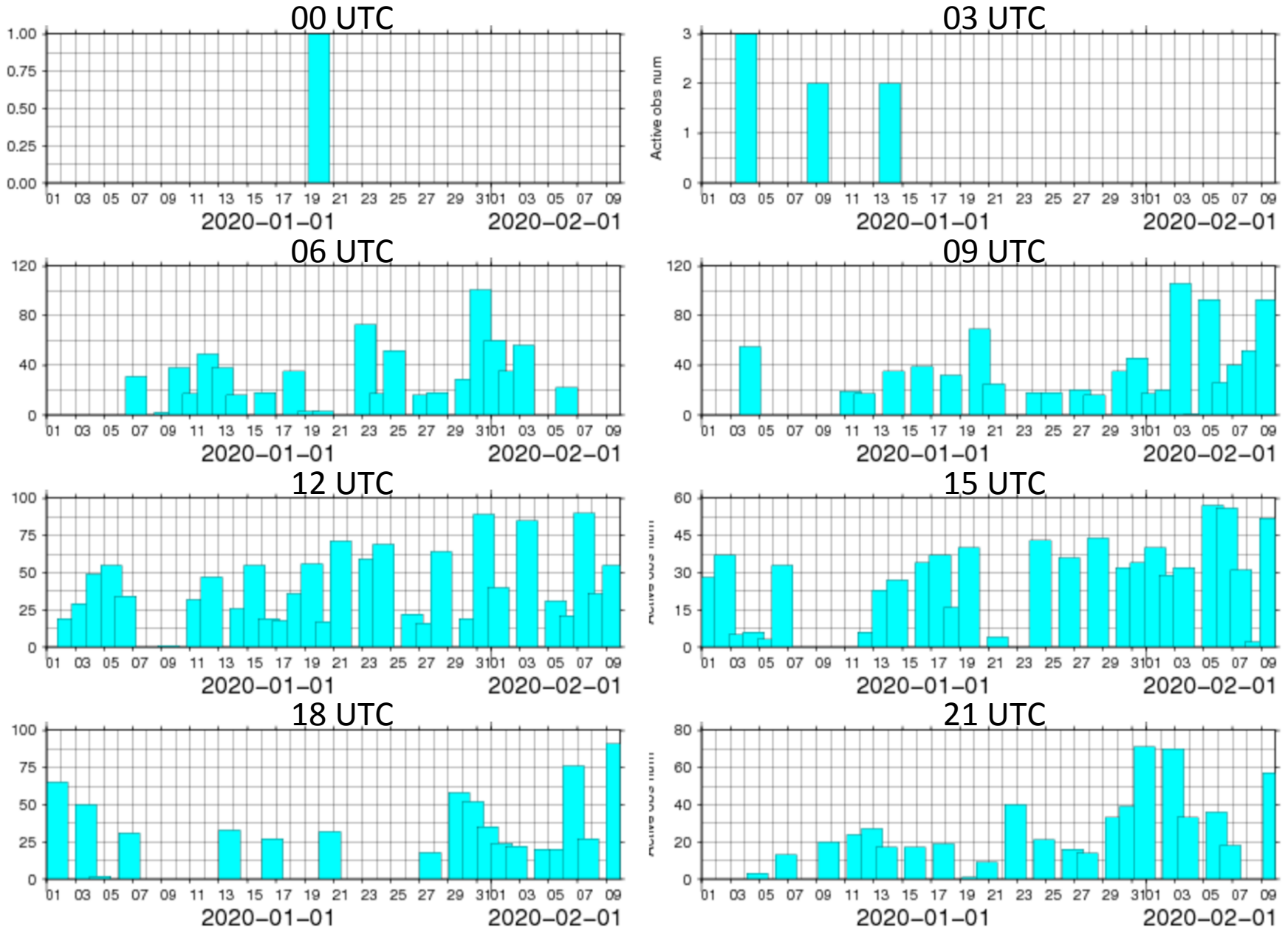
Period: 01/01/2020 – 09/02/2020

Winter period: after introduction of GNSS assimilation

AMDAR-q observations mainly in the daytime

useful information in the frequent assimilation cycle





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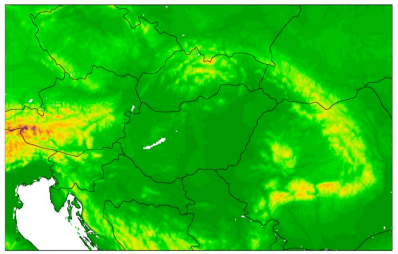
The number of active AMDAR humidity and temperature observations

AROME: 8 times a day, convection-permitting, 2.5 km, 60 levels

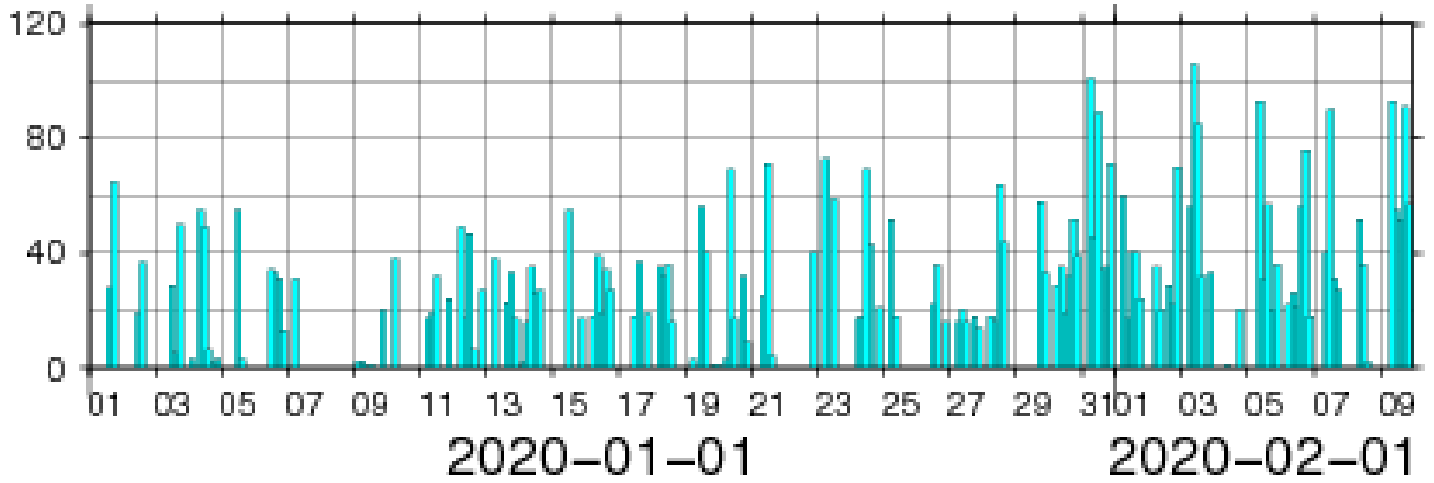
observations mainly in the daytime

useful information in the frequent assimilation cycle

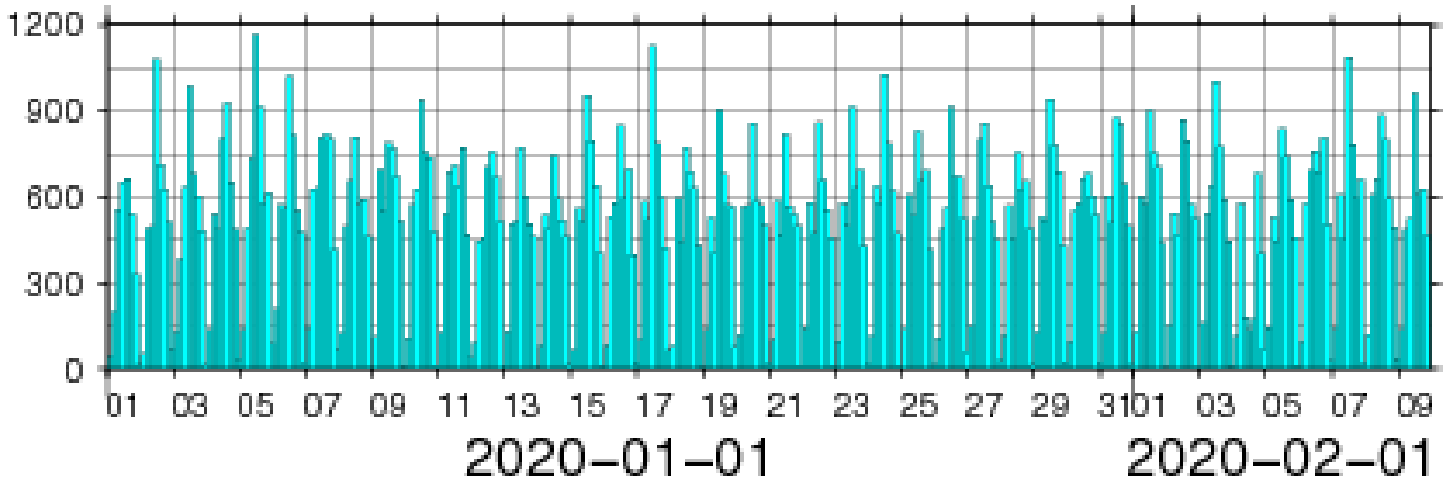


Period: 01/01/2020 – 09/02/2020

all UTC



AMDAR humidity observations



AMDAR temperature observations

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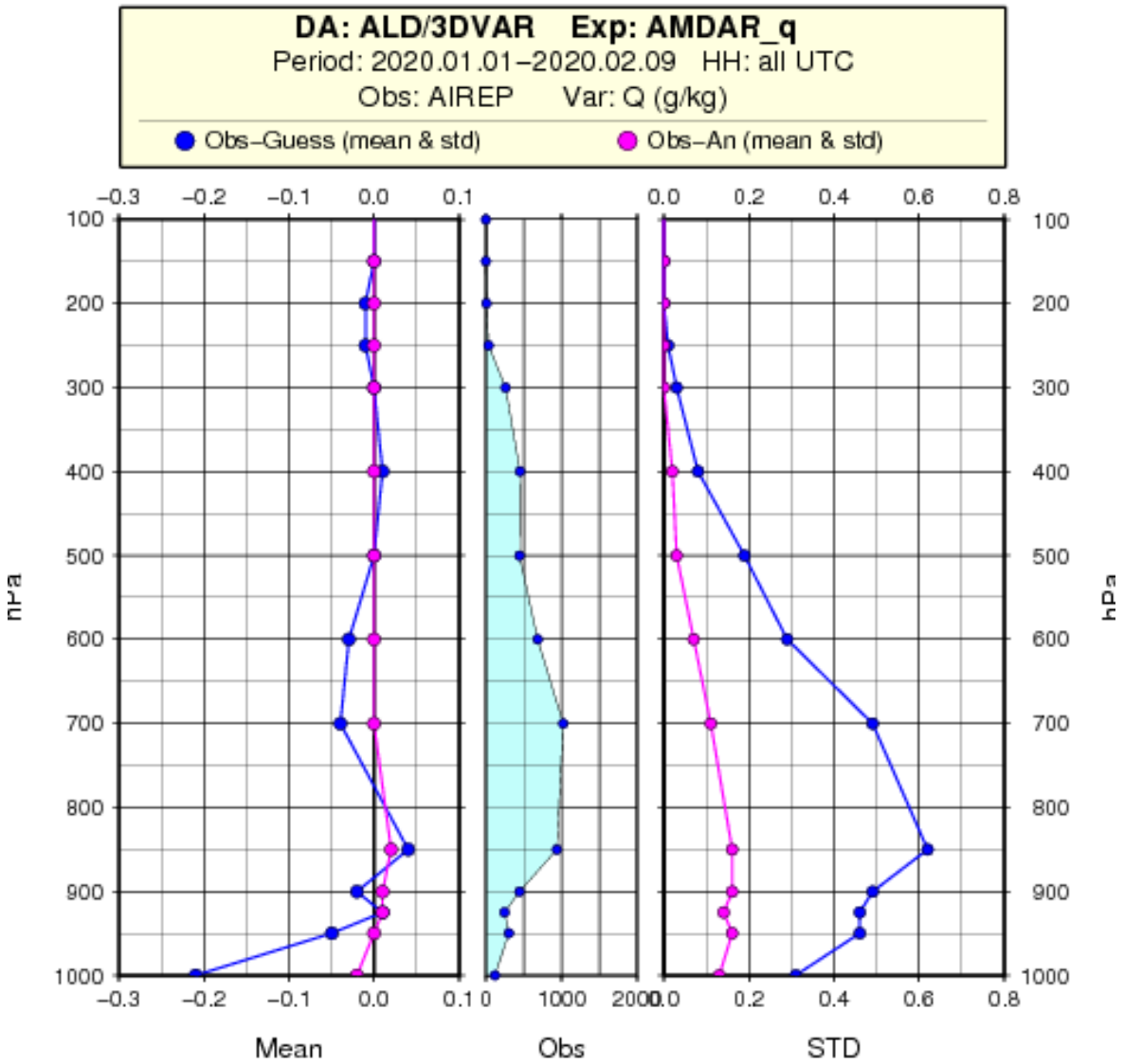
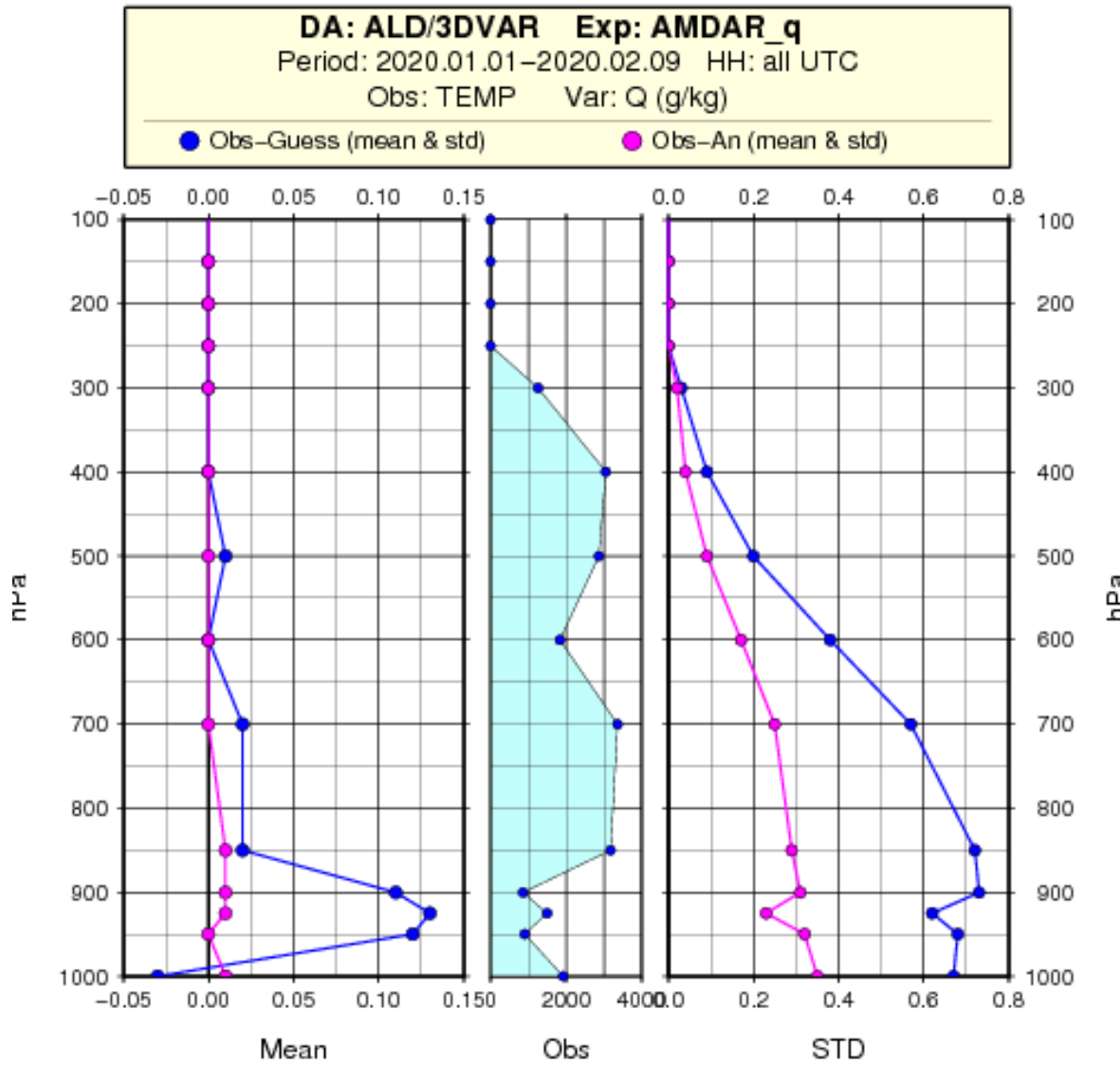
Obs – Guess and Obs – Analysis statistics for AMDAR and TEMP humidity observations

Period: 01/01/2020 – 09/02/2020

AMDAR



TEMP



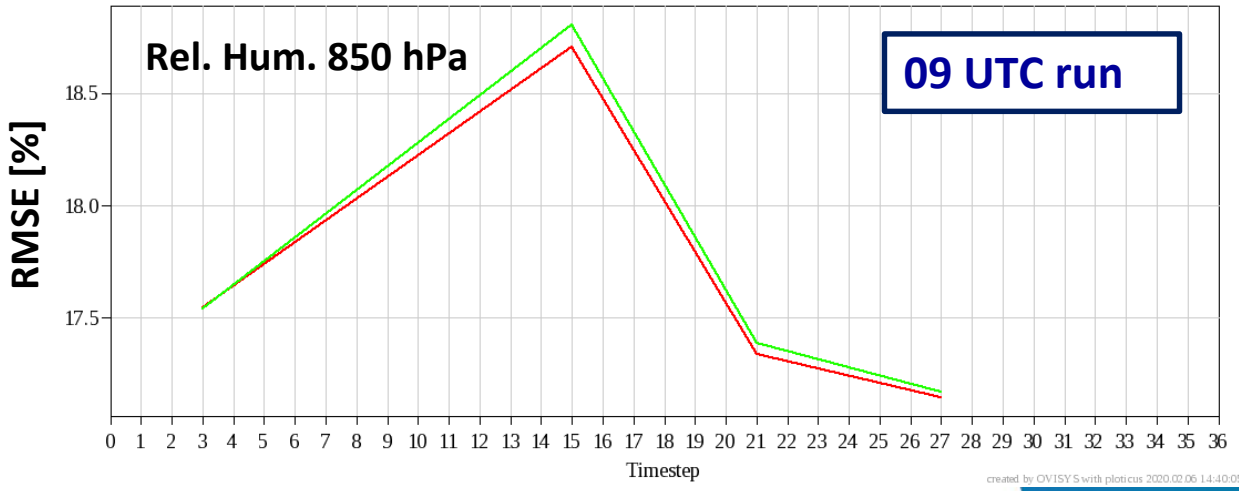
AMDAR-humidity assimilation – verification scores

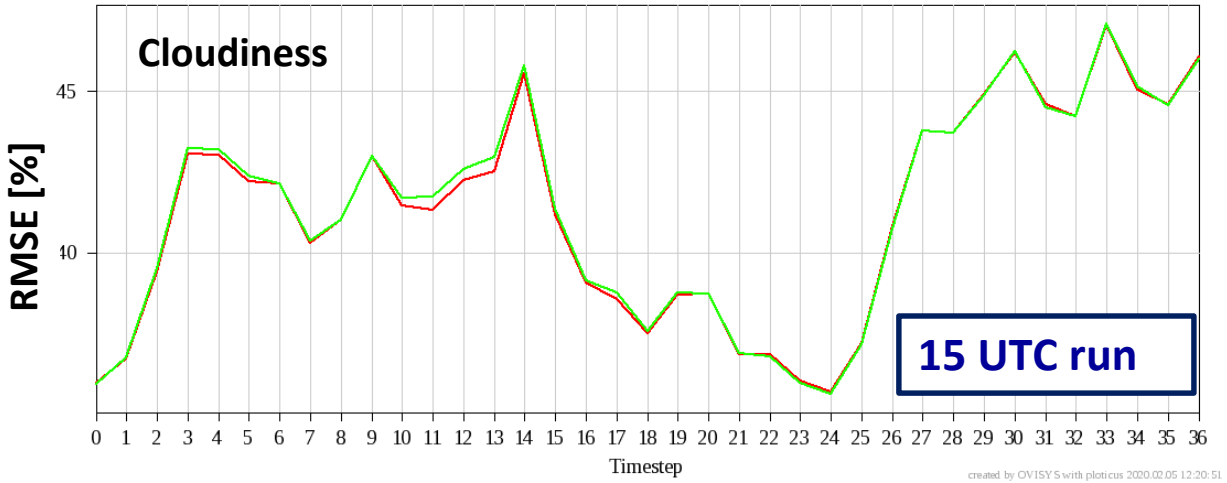
Period: 06/01/2020 – 01/02/2020

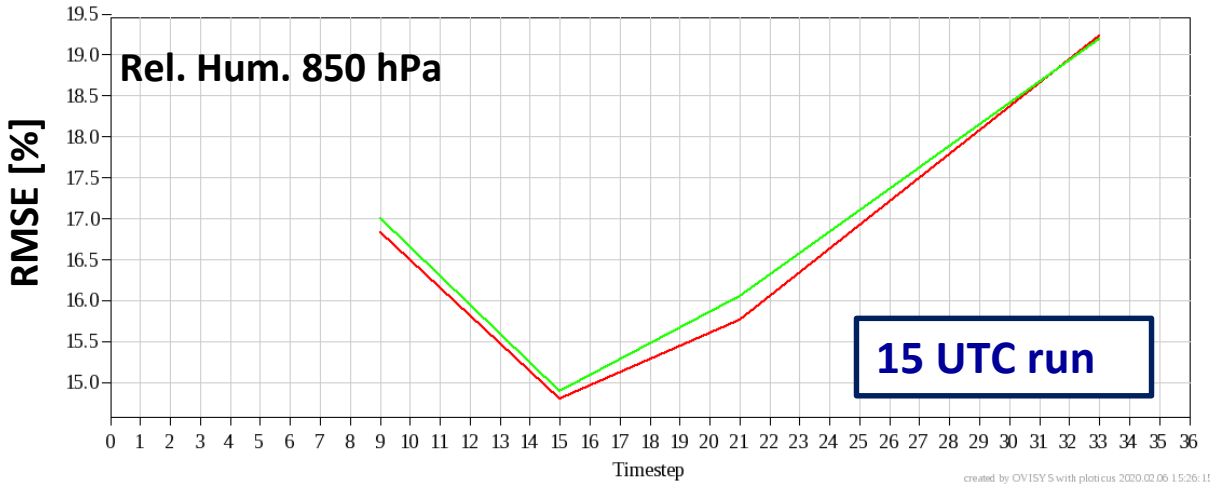
Verification against SYNOP: ~100-200 stations over verification domain

Verification against TEMP: 3 stations (Budapest, Szeged, Zagreb) over verification domain

OPER – with AMDAR-humidity
EXP – without AMDAR-humidity

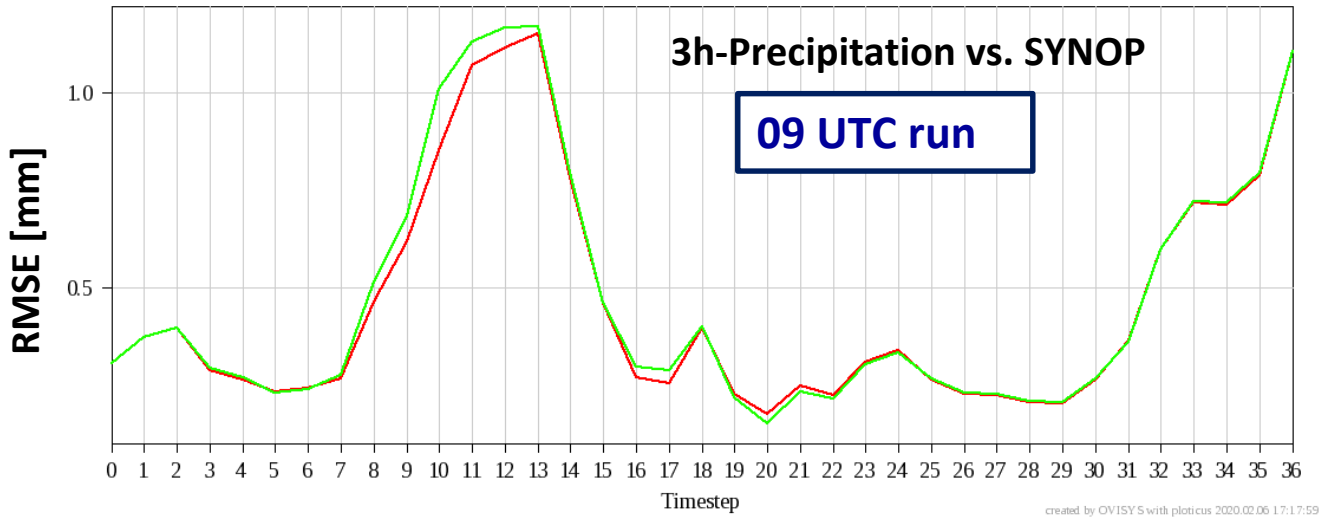


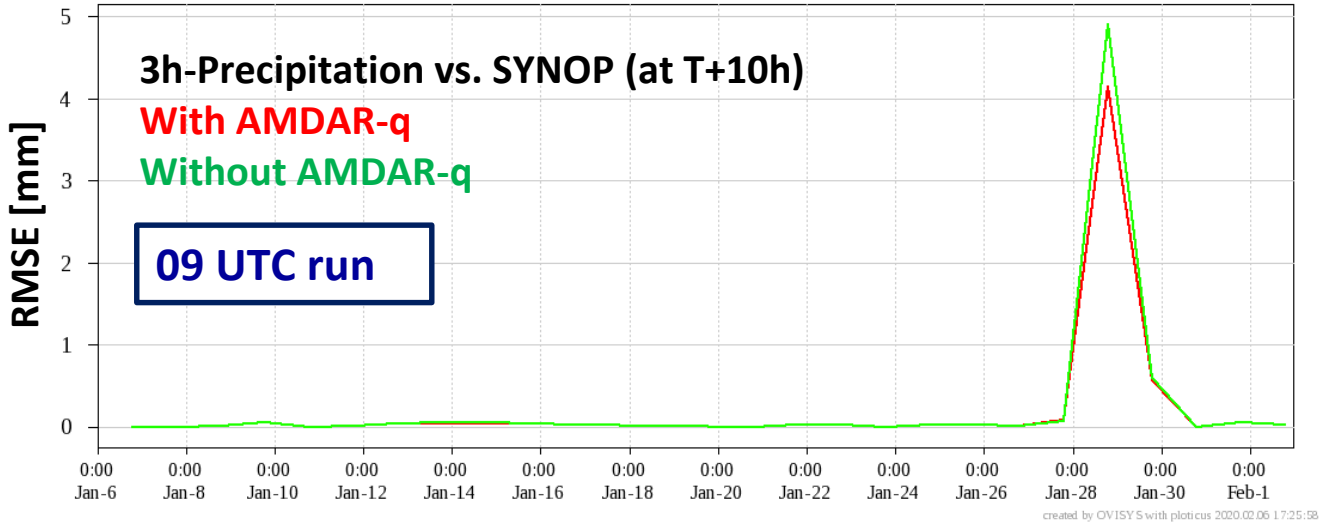




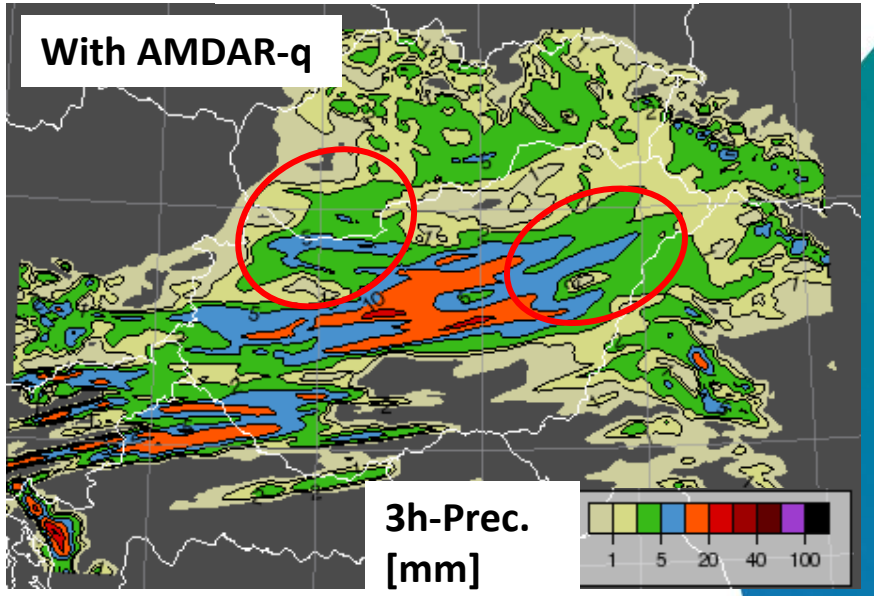
AMDAR-humidity assimilation – verification scores

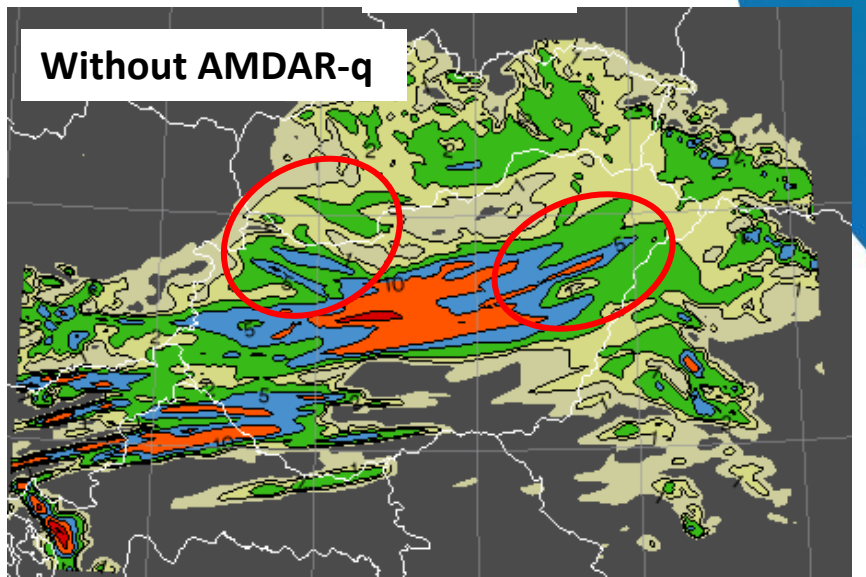
Period: 06/01/2020 – 01/02/2020





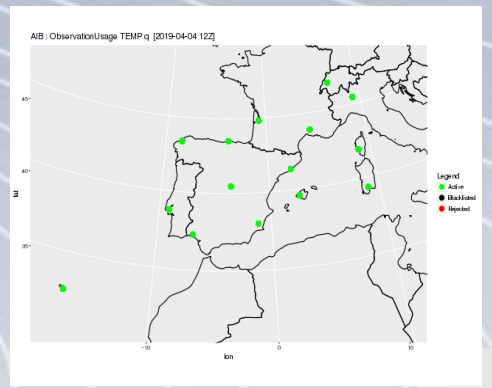
2020-01-28 09 UTC + 10h

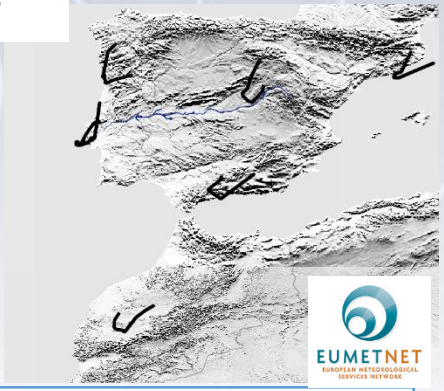




Humidity Sensor of E-AMDAR.

- Due the lack of upper air observation over the West part of the operational domain, the humidity sensor of E-AMDAR is very valuable.
- A test have been done with HARMONIE-AROME over the operational domain of the Iberian Peninsula in AEMET.
  - Local ATOS HPC.
  - Conventional observation + ATOVS + GNSS + Scatterometer winds.





- Green.
  - Radiosonde stations.
- Black.
  - Aircraft with provided with humidity sensor.
  - Profiles of the 04.01.2020 00:00 - 04.01.2020 23:59

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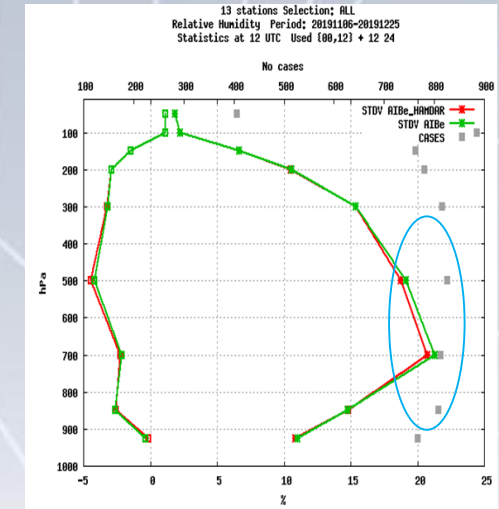
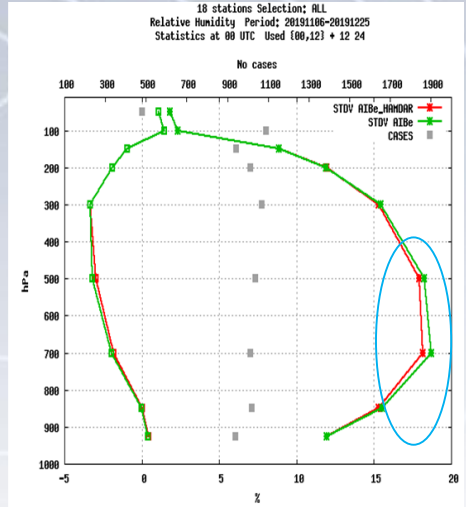
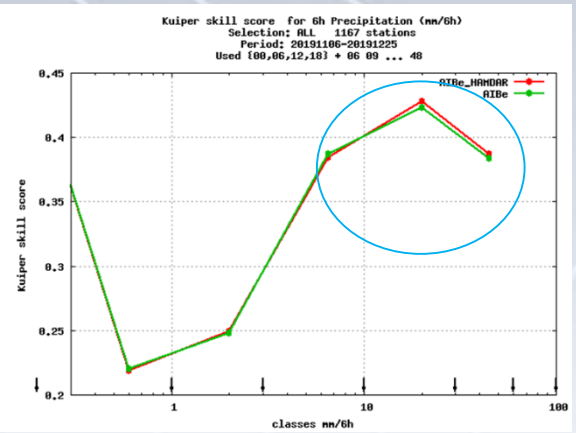
Humidity Sensor of E-AMDAR.

- After one month and a half. From 20191106 to 20191226
- RED using humidity information and green is the control.







- A slight improvement of STDV in q in middle levels, neutral for other variables and surface.

- Small improve for high rate of precipitation.

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Conclusions

- Upper air humidity data is important for LAMs
- Current coverage of E-AMDAR-humidity observations is too sparse to arrive at conclusive results (perhaps except for Germany)
- Monitoring suggests a dry bias of AMDAR-humidity observations at lower levels
- Studies conducted so far show:
  - neutral scores, with small improvements in cloudiness, precipitation and upper-air humidity
  - some improvement in convective precipitation on selected cases

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Thank you for your attention!

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SPARE SLIDES

Limited Area Models in Europe

	ALADIN (AROME, ALARO)	LACE (AROME, ALARO)	HIRLAM (HARMONIE)	COSMO	SEECOP (NMMB)	UKMO (UM)
Horizontal resolution	1.3 km, 2.5 km, 4 km	1.2 km (AT), 2.5 km, 4.5 km	2.5 km	1.1 km, 2.2 km	4 km	1.5 km
Vertical levels	90, 60	60/90, 87	65	80, 60	64	70
DA method (Upper-air)	3D-Var	3D-Var	3D-Var	LETKF	LETKF	4D-Var
DA method (surface)	OI	OI	OI	EKF		EKF
Runs per day	8, 4	24 (AT), 8, 4	4, 8	8, 4	2	24
Data cut-off time	45-105 min	90-240 min	90-240	90-240		45-80

After Gustafsson et al., 2018

Limited Area Models in Europe

	ALADIN (Meteo-France)	LACE	HIRLAM	COSMO (DWD)	SEECOP	UKMO
Conventional	TEMP, PILOT, BUOY, SYNOP, SHIP, AIREP, ACARS, AMDAR, MESONET	TEMP, PILOT, SYNOP, SHIP, AIREP, AMDAR, Mode-S	TEMP, PILOT, BUOY, SYNOP, SHIP, AIREP, AMDAR, Mode-S	TEMP, PILOT, SYNOP, SHIP, AIREP, Mode-S	ADPUPA, ADPSFC, SFCSHP, AIRCFT	TEMP, PILOT, BUOY, SYNOP, SHIP, AIREP, AMDAR, Mode-S
Radar	Doppler winds Reflectivities	Doppler winds Reflectivities (AT)	Multi-national reflectivities	Surf. precip rate by LHN		Doppler winds Surf. precip rate by LHN
GPS	ZTD	ZTD	ZTD	ZTD	GPS-RO	ZTD
Satellites	SEVIRI, AMSU-A, MHS, IASI, ATMS, SSMIS, MHS, GMI, AMV, MWHS-2, Scatterom. winds	SEVIRI, TOVS, IASI, HIRS, AMV, Scatterom. winds	ATOVS, IASI, Scatterom. winds, ATMS, GPS-RO, AMV		AIRS, AMSUA-A, ATMS, CRIS, IASI, HIRS4, MHS, SEVIRI, SSMIS Satellite wind (SATWND)	AMV, Scatterom. winds, AMSU-B, IASI, CRIS, AIRS, ATMS, SEVIRI
Other						Roadside sensors WPR GeoCloud
Bias correction	VarBC partly shared with global system	VarBC sat. and GPS	VarBC sat. and GPS			VarBC sat.
Obs impact diag.	OSE, DFS, Error Variance reduction diag.	OSE, DFS	OSE, OSSE, DFS	OSE		OSE

After Gustafsson et al., 2018