Assimilation of AMDAR humidity observations

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Outline

1) E-AMDAR humidity observations

2) Impact of E-AMDAR humidity observations in comparison to radiosonde data (IFS-ECMWF)

3) Assimilation of E-AMDAR humidity in HARMONIE-AROME

1) E-AMDAR humidity observations

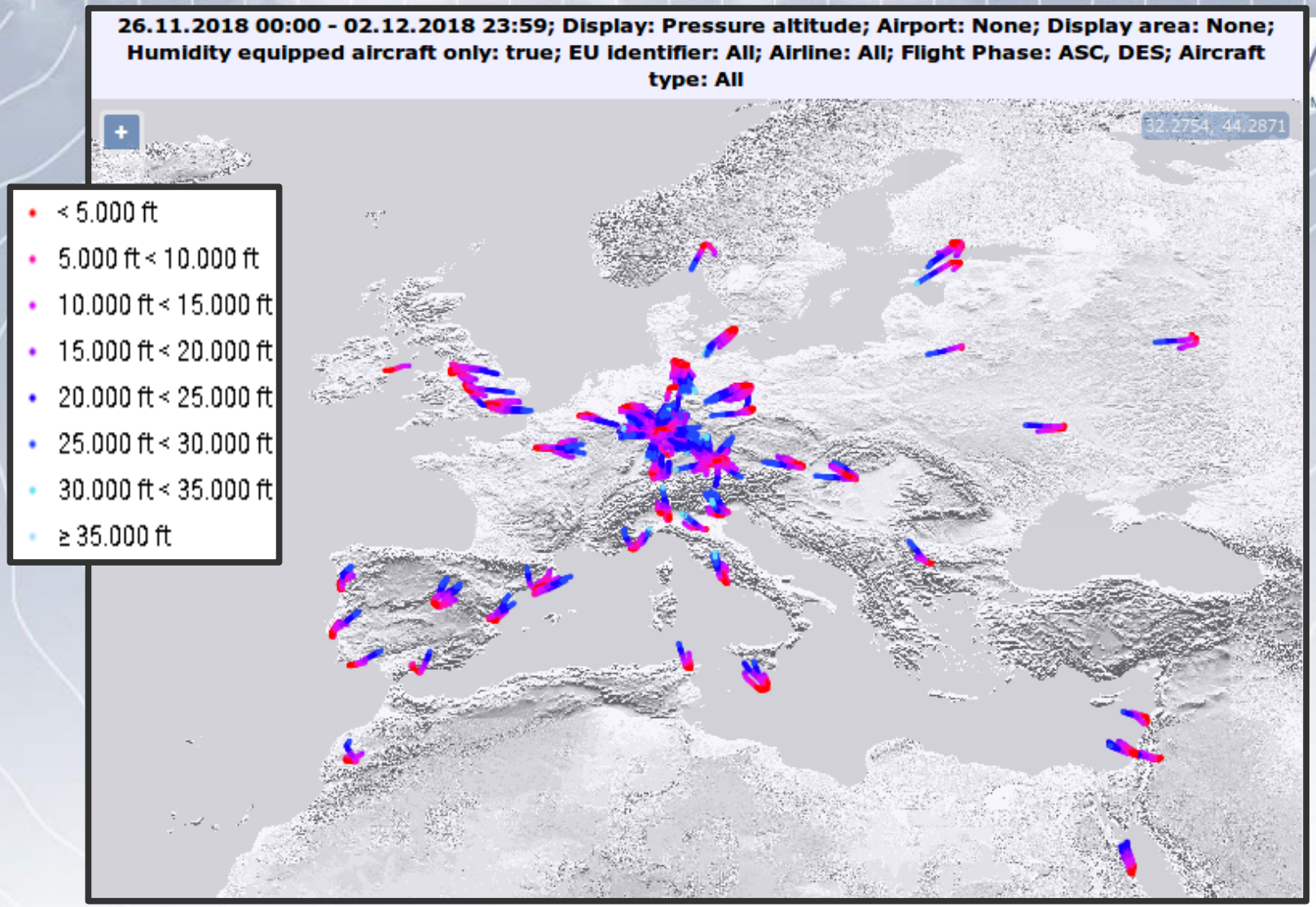
Since June 2016 a group of 9 Lufthansa aircrafts equipped with the WVSS-II humidity sensor are serving a number of airports in Europe.

E-AMDAR profiles are obtained for:

- ascent (samples every 20 seconds from take-off for a period of 900 seconds), and

- descent (samples every 40 seconds from altitude of 18,000 feet).

- Automated aircraft waper vapor reports are at least as accurate as radionsonde observations (Petersen et al., 2016).



E-AMDAR humidity observations from 26th Nov to 2 Dec 2018.

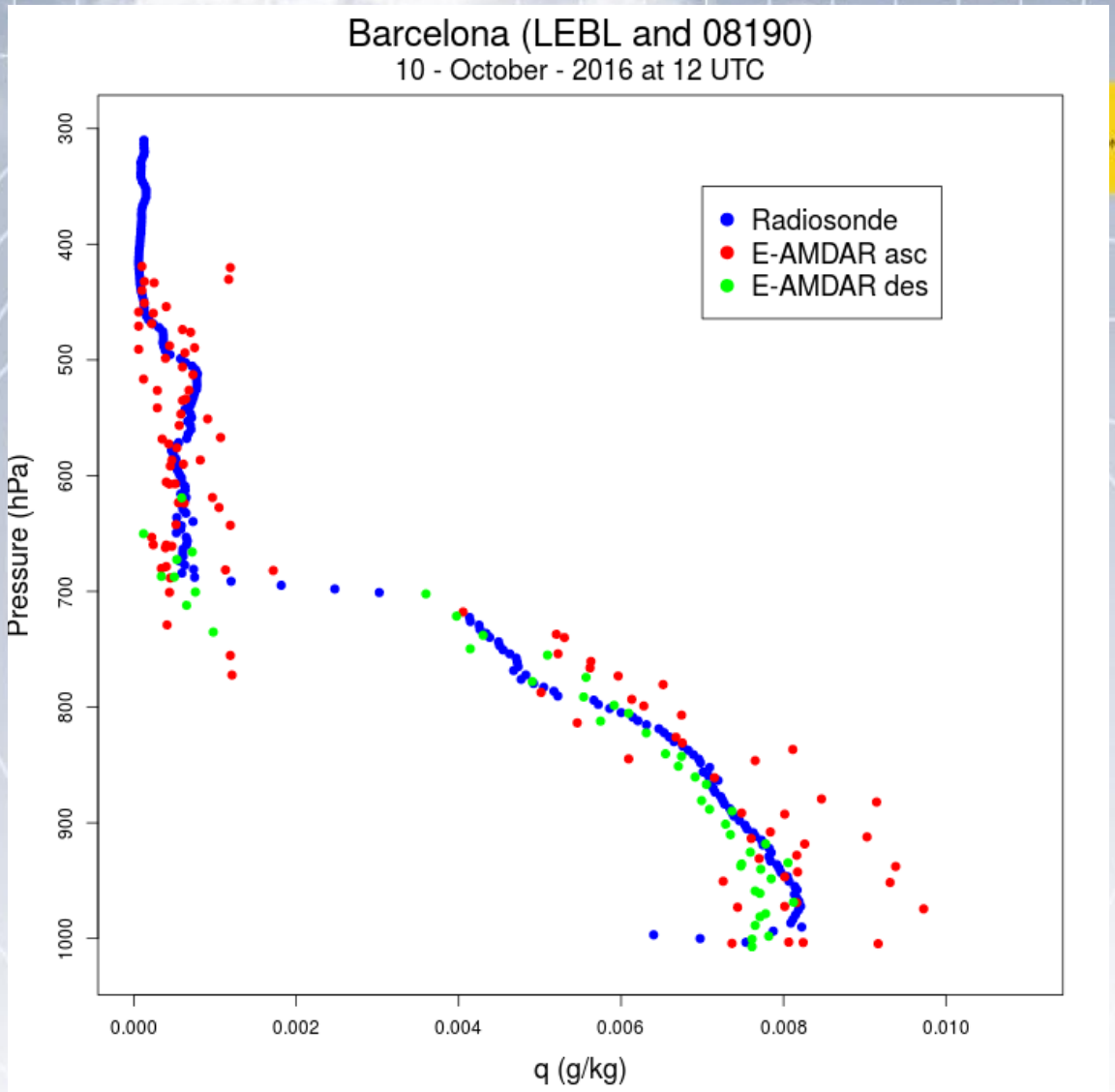
ICAO code	Airport	Gridbox	All profile totals	All profile obs.	[0-3]	[3-6]	[6-9]	[9-12]	[12-15]	[15-18]	[18-21]	[21-24]
EDDT	BERLIN/TEGEL	1540 (WC)	198	6267	-	3	57	29	25	38	42	4
EDDK	COLOGNE/BONN	1511 (WC)	6	199	-	1	-	2	-	-	2	1
EDDC	DRESDEN	1540 (WC)	4	118	-	-	-	-	-	2	2	-
EDDL	DUSSELDORF	1511 (WC)	20	596	-	1	8	2	-	3	5	1
EDDF	FRANKFURT/MAIN	1511 (WC)	1253	44907	-	35	274	256	216	216	234	22
EDDH	HAMBURG	1513 (SS)	162	5441	-	11	40	24	25	30	25	7
EDDV	HANNOVER	1512 (WC)	18	510	-	1	5	3	2	5	1	1
EDDM	MUNICH	1566 (WC)	314	9921	-	3	69	70	40	59	56	17
EDDN	NURNBERG	1539 (WC)	1	32	-	-	-	-	-	-	1	-
EDDS	STUTTGART	1538 (WC)	2	50	-	-	1	-	1	-	-	-

ICAO code	Airport	Gridbox	All profile totals	All profile obs.	[0-3]	[3-6]	[6-9]	[9-12]	[12-15]	[15-18]	[18-21]	[21-24]
LEBL	BARCELONA/EL PRAT	1534 (WM)	69	2576	-	4	7	13	19	13	6	7
LEBB	BILBAO	1479 (FA)	2	65	-	-	-	-	2	-	-	-
LEMD	MADRID/BARAJAS	1478 (IB)	49	1797	-	4	8	8	13	3	7	6
LEMG	MALAGA	1504 (IB)	14	517	-	-	-	5	8	1	-	-
LEPA	PALMA DE MALLORCA	1534 (WM)	6	204	-	-	-	2	-	3	1	-
LEVC	VALENCIA/MANISES	1506 (IB)	12	398	-	-	1	8	2	-	-	1

Number of humidity profiles/observations (ascending and descending) for airports in Germany and Spain at 3-h interval (November 2018)

- The majority of profiles are generated over Germany, but there are a significant number of profiles produced in other countries (e.g. Spain).

- Diurnal and seasonal variability of E-AMDAR data availability.



Humidity profiles assimilated by the IFS run at 12 UTC on 10 October 2016 over Barcelona: E-AMDAR humidity ascent/descent profiles obtained by Lufthansa aircrafts (in red/green) and TEMP profile (in blue).

2) Impact of E-AMDAR humidity observations in comparison to radiosonde data (IFS-ECMWF)

EUMETNET OBS-Programme endorsed AEMET to carry out a study on the “Impact of E-AMDAR humitiy observations (‘conditional’ FSOI assessment) in comparison to radionsonde data” (Study 1 – Case 3, EMT_OBS_2016_02).

Goal:
To assess the impact of E-AMDAR and TEMP humidity observations on short-range **IFS-ECMWF** forecasts by using **FSOI** diagnostics.

FSOI (**Forecast Sensitivity Observation Impact**) is the adjoint-based tool used at ECMWF to monitor the impact of observations on the quality of the Integrated Forecasting System (IFS) short-range forecasts (Cardinali, 2009).

- FSOI data for E-AMDAR and TEMP humidity observations from the IFS operational setup, two times a day:

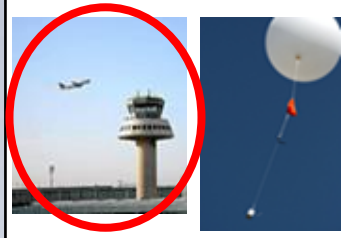
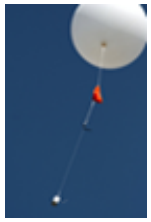
  00 UTC run (uses observations from 21 UTC to 09 UTC)
  12 UTC run uses observations from 09 UTC to 21 UTC)

- Separate statistics for 00 and 12 UTC

- Period: June 2016 to November 2017 (18 months)

- FSOI Radiosonde data used only p >= 400 hPa

- The Final Report was delivered to EUMETNET OBS Programme in December 2018.

Group A (AMDAR)	Group B (TEMP)	Group C (AMDAR)	Group D (TEMP)
			
dist <50km	dist <50km	No nearby RS station	No nearby airport serving AMDAR-q

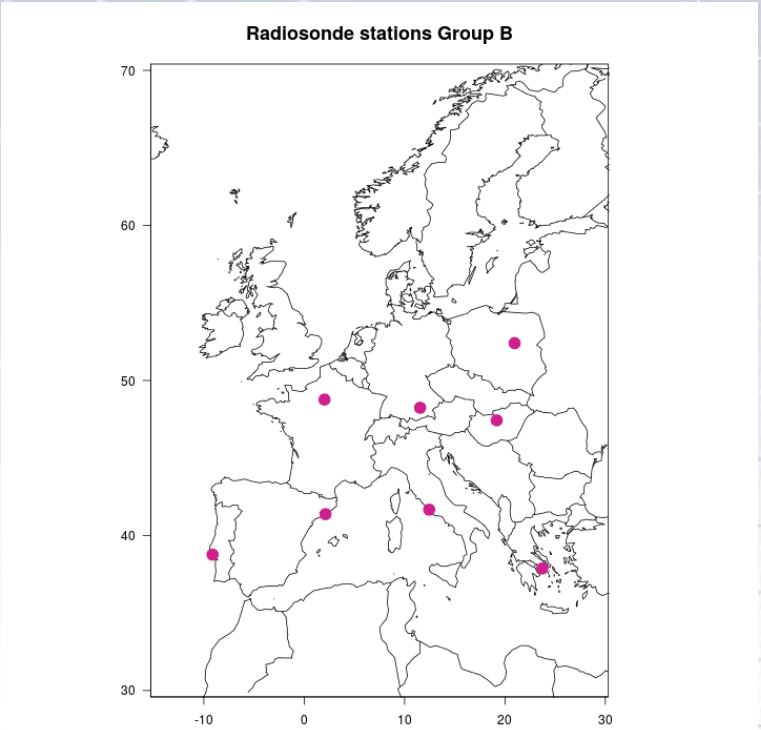
A: E-AMDAR humidity data for selected airports with a radiosonde station nearby
B: TEMP humidity data for selected radiosonde stations with a nearby airport sometimes serving E-AMDAR humidity observations

C: E-AMDAR humidity data for selected airports without a radiosonde station nearby
D: TEMP humidity data by selected radiosonde stations without a nearby airport serving E-AMDAR humidity observations

Groups A and B

Selection of close airports (A) and radiosonde stations (B) :

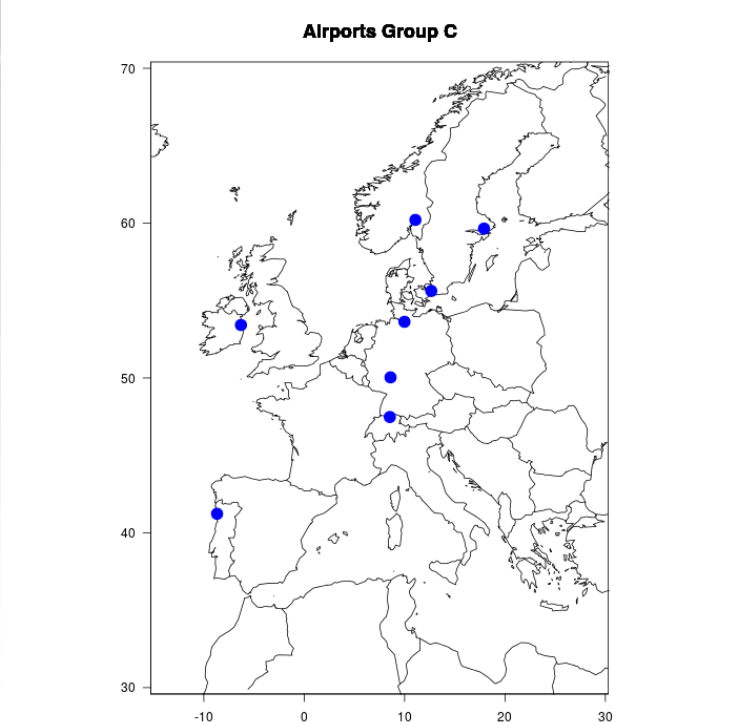
Munich:	EDDM	and	10868
Paris:	LFPG	and	07145
Warsaw:	EPWA	and	12374
Budapest:	LHBP	and	12843
Rome:	LIRF	and	16245
Lisbon:	LPPT	and	08579
Barcelona:	LEBL	and	08190
Athens:	LGAV	and	16716



Group **C**

Set of airports where no radiosonde station is nearby:

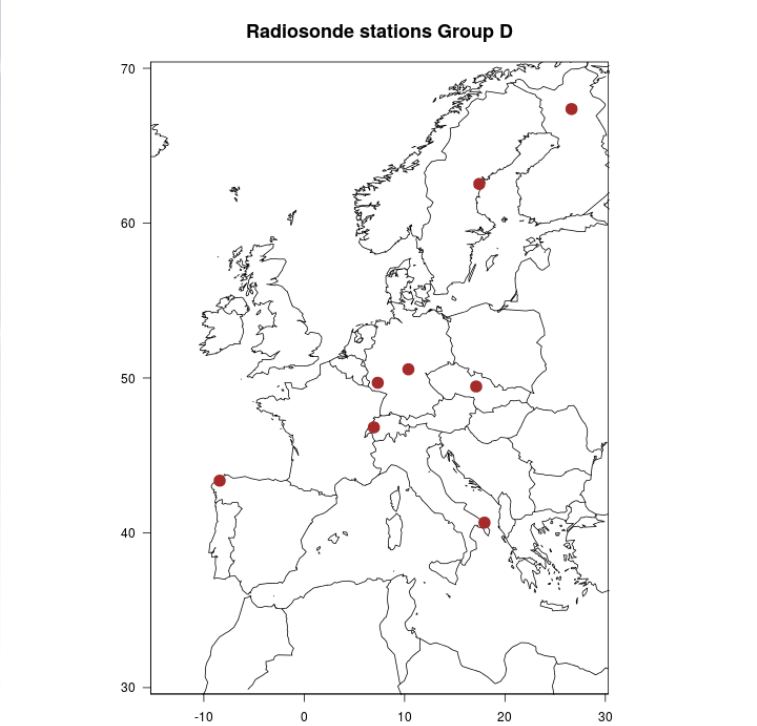
Frankfurt:	EDDF
Dublin:	EIDW
Hamburg:	EDDH
Stockholm:	ESSA
Oslo:	ENGM
Copenhagen:	EKCH
Zurich:	LSZH
Porto:	LPPR

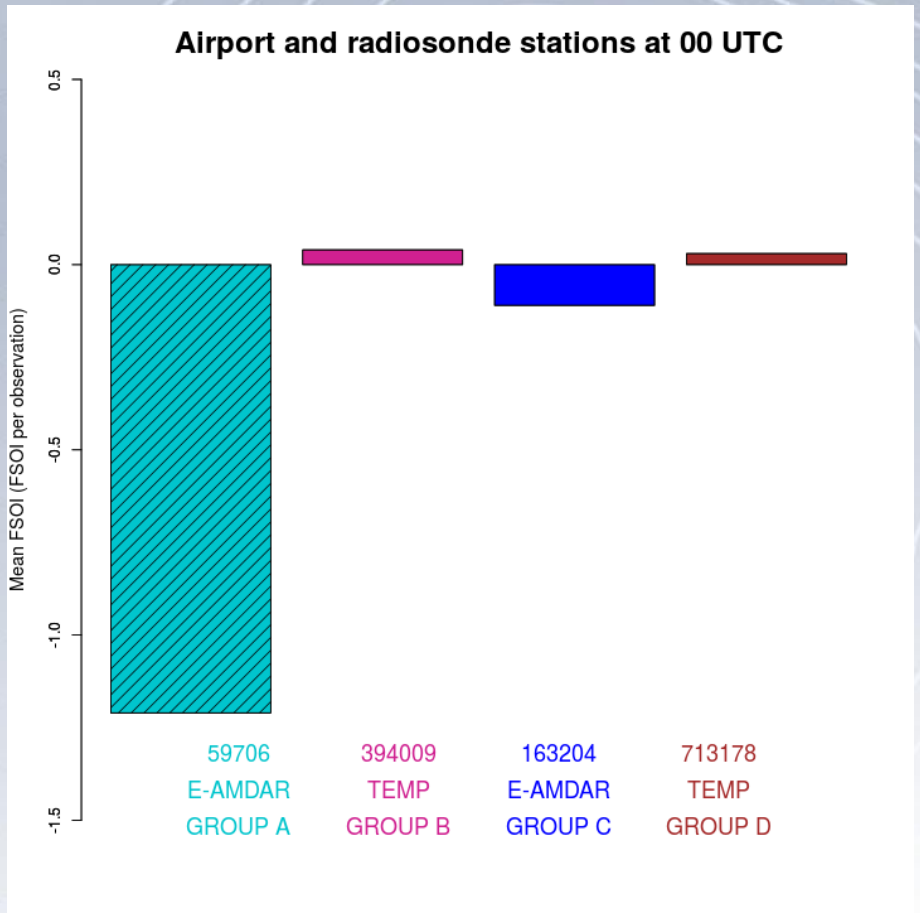


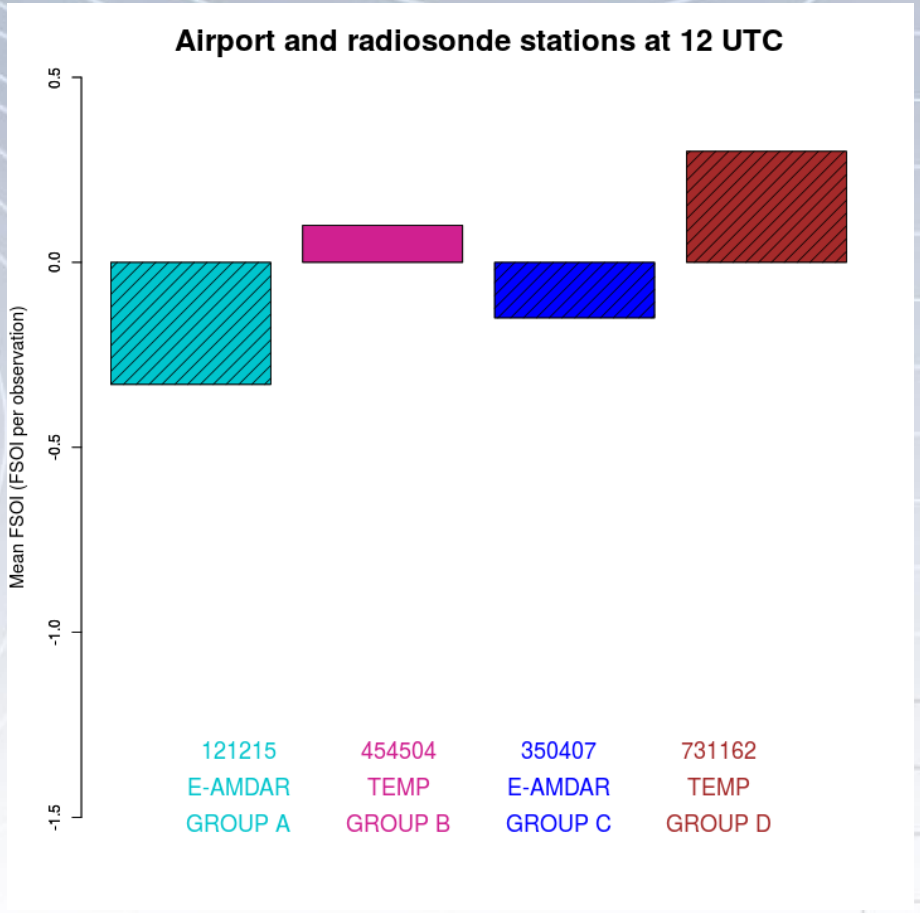
Group **D**

Set of radiosonde stations where no airport is nearby:

Idar-Oberstein:	10618
Meiningen:	10548
Sundsvall:	02365
Payerne:	06610
Protejow:	11747
Sodankyla:	02836
La Coruña:	08001
Brindisi:	16320







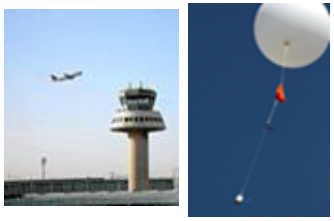
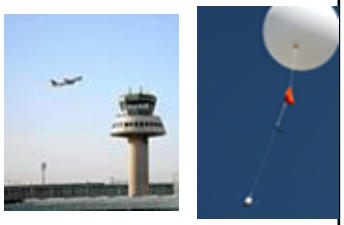
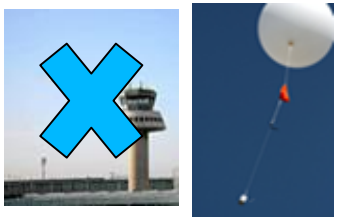
Mean FSOI for groups A, B, C and D at 00 and 12 UTC (when bar striped the result is statistically significant at the 95 % confidence level).

Main conclusions (Groups A, B, C and D)

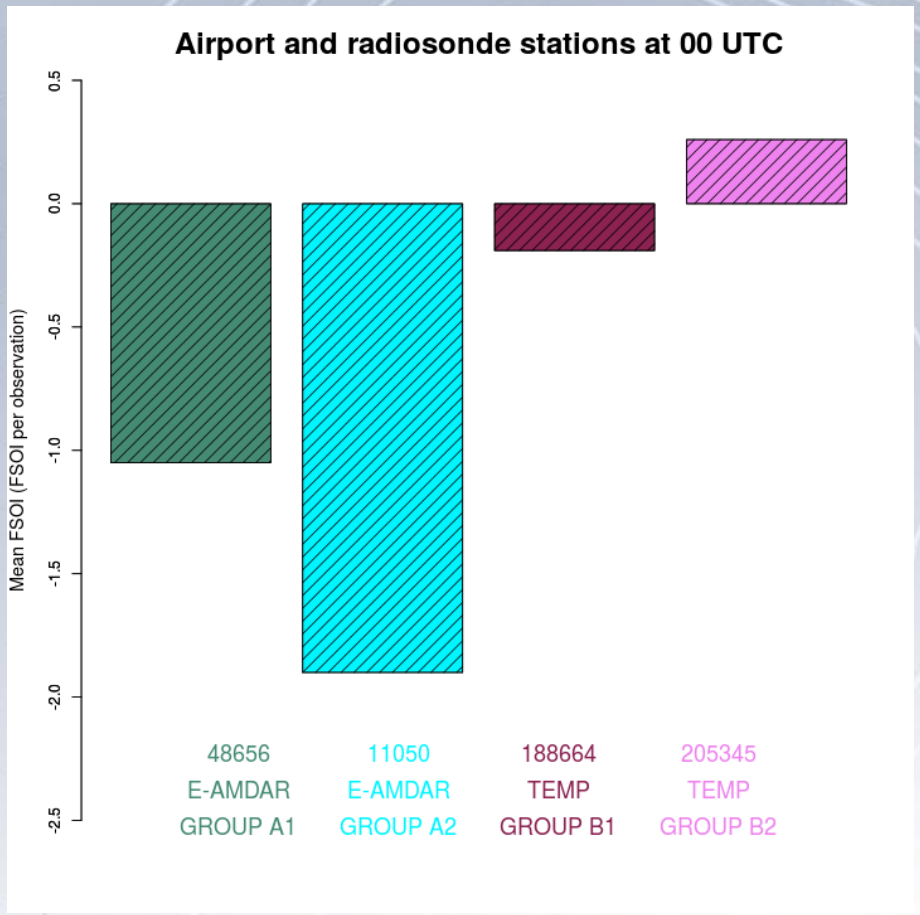
1. E-AMDAR humidity have had a clear overall beneficial forecast impact according to IFS FSOI statistics over the analyzed period (June 2016-November 2017)

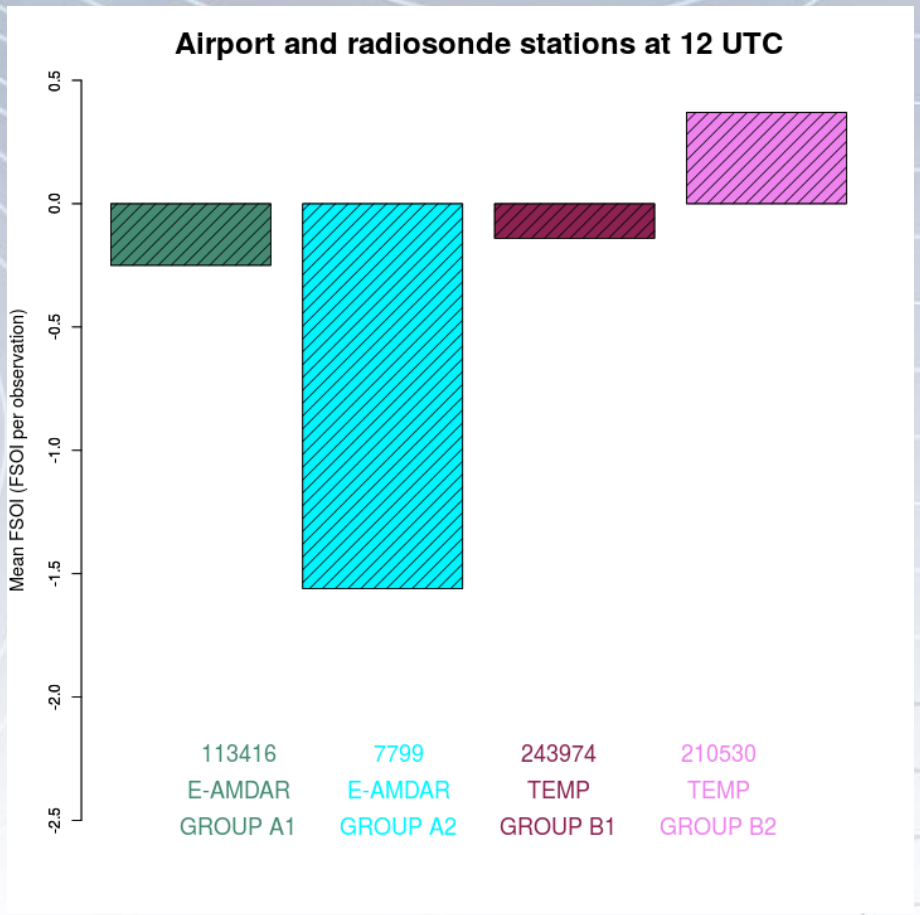
2. EUMETNET TEMP humidity observations have had an overall detrimental forecast impact over the analyzed period

‘Conditional FSOI statistics’

Group A1 (AMDAR)	Group A2 (AMDAR)	Group B1 (TEMP)	Group B2 (TEMP)
			
When AMDAR-q + TEMP-q assimilated	When only AMDAR-q assimilated	When AMDAR-q + TEMP-q assimilated	When only TEMP-q assimilated

A1: E-AMDAR-q data for those days when TEMP-q data was also assimilated.
A2: E-AMDAR-q data for those days when **TEMP-q data was NOT assimilated**.
B1: TEMP-q data for those days E-AMDAR-q data was also assimilated.
B2: TEMP-q data for those days when **E-AMDAR-q data was NOT assimilated**.



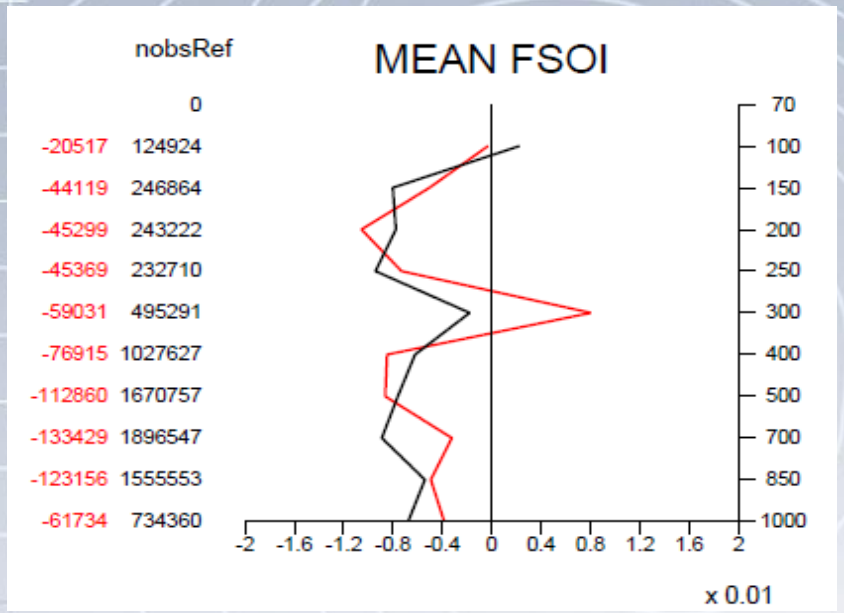


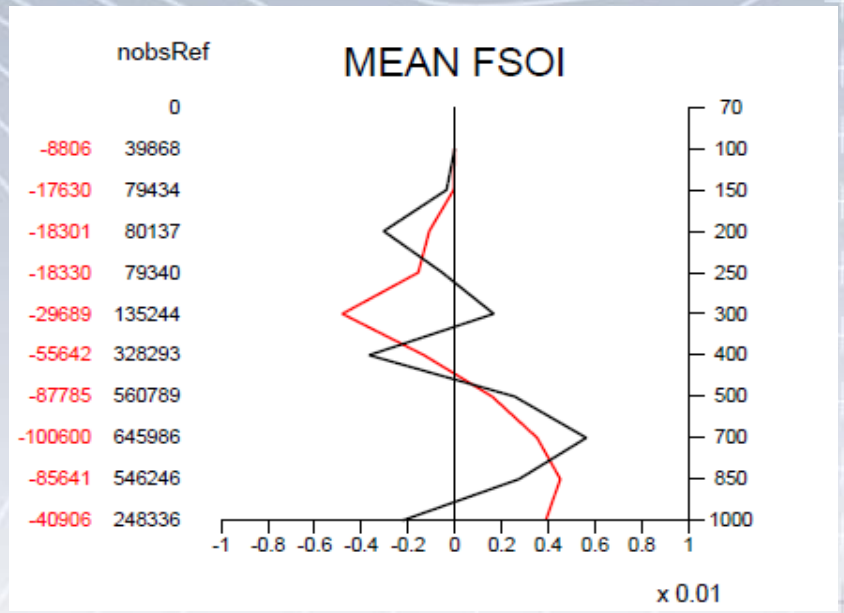
Mean FSOI for groups A1, A2, B1 and B2 at 00 and 12 UTC (when bar striped the result is statistically significant at the 95 % confidence level).

Main conclusions ('Conditional FSOI‘)

3. There is a very clear positive synergy of the joint assimilation of TEMP and E-AMDAR humidity observations

Lars Isaksen (ECMWF) obtained FSOI statistics for Jan-May 2018 for TEMP and AMDAR observations, globally and for Europe





TEMP-q Globe

Fc sensitivity (12UTC)

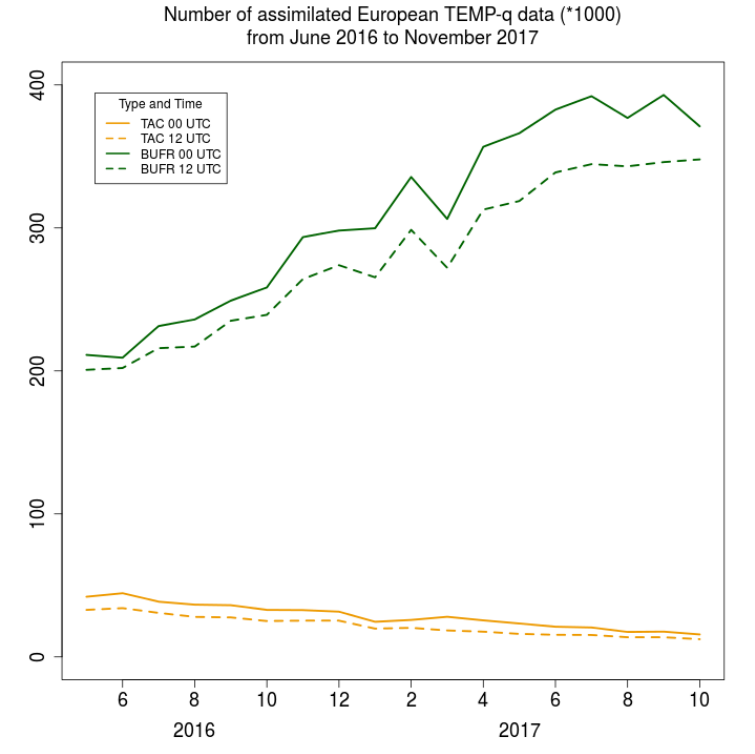
Fc sensitivity (00UTC)

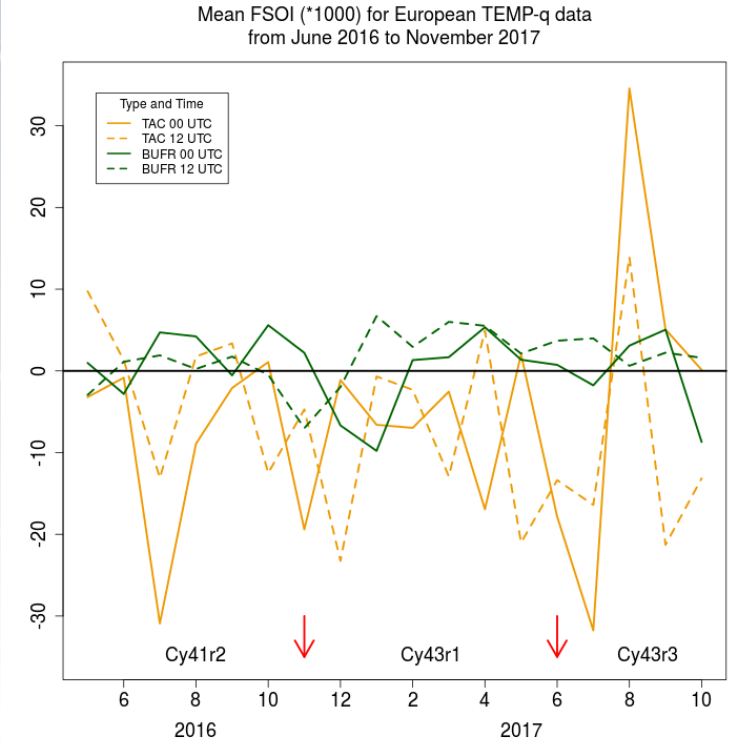
TEMP-q Europe

Globally radiosonde humidity is beneficial, but detrimental in Europe. Among other reasons, it has to be taken into account that whereas in Europe most TEMP-q data is exchanged encoded in BUFR format, it is very likely that TAC encoding still dominates globally.

Influence of change of TEMP encoding format (TAC ot BUFR).

The number of assimilated TEMP-q observations encoded in TAC/BUFR has show and steady growth/decrease until July 2017.





TAC: Positive impact, larger at 00 UTC (not statistically significant)
BUFR: Negative impact, larger at 12 UTC (statistically significant at 12 UTC).

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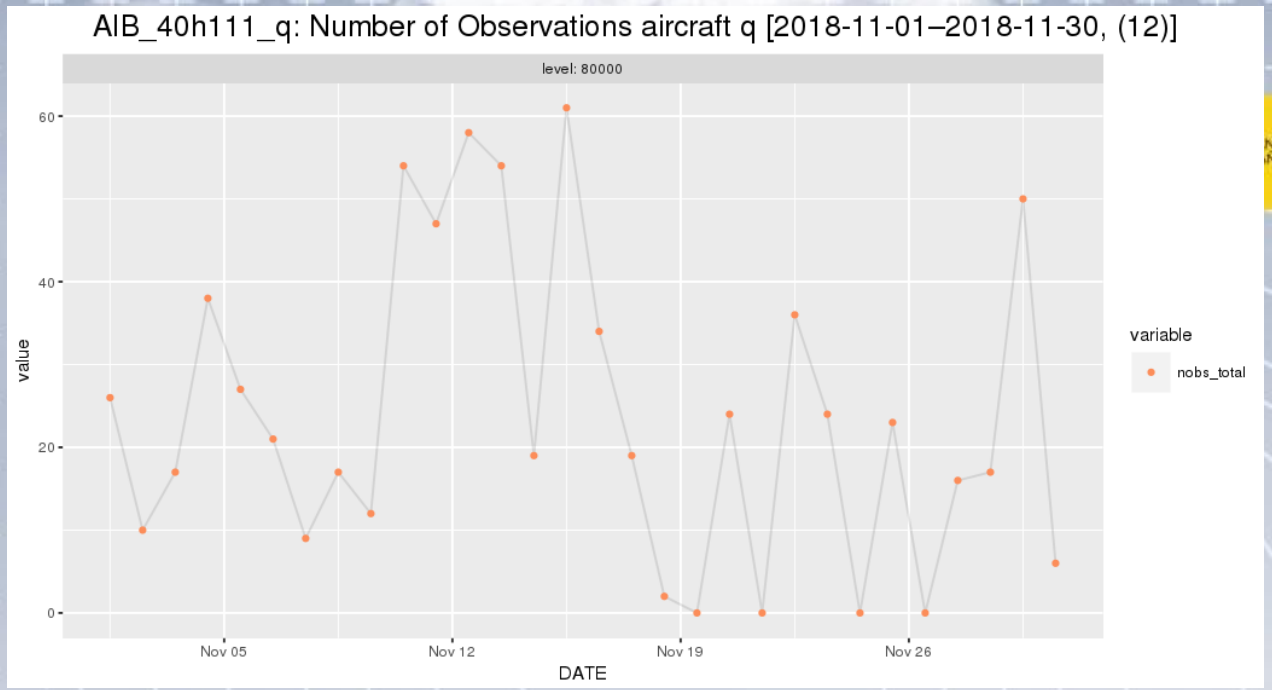
3) Assimilation of E-AMDAR humidity in HARMONIE-AROME

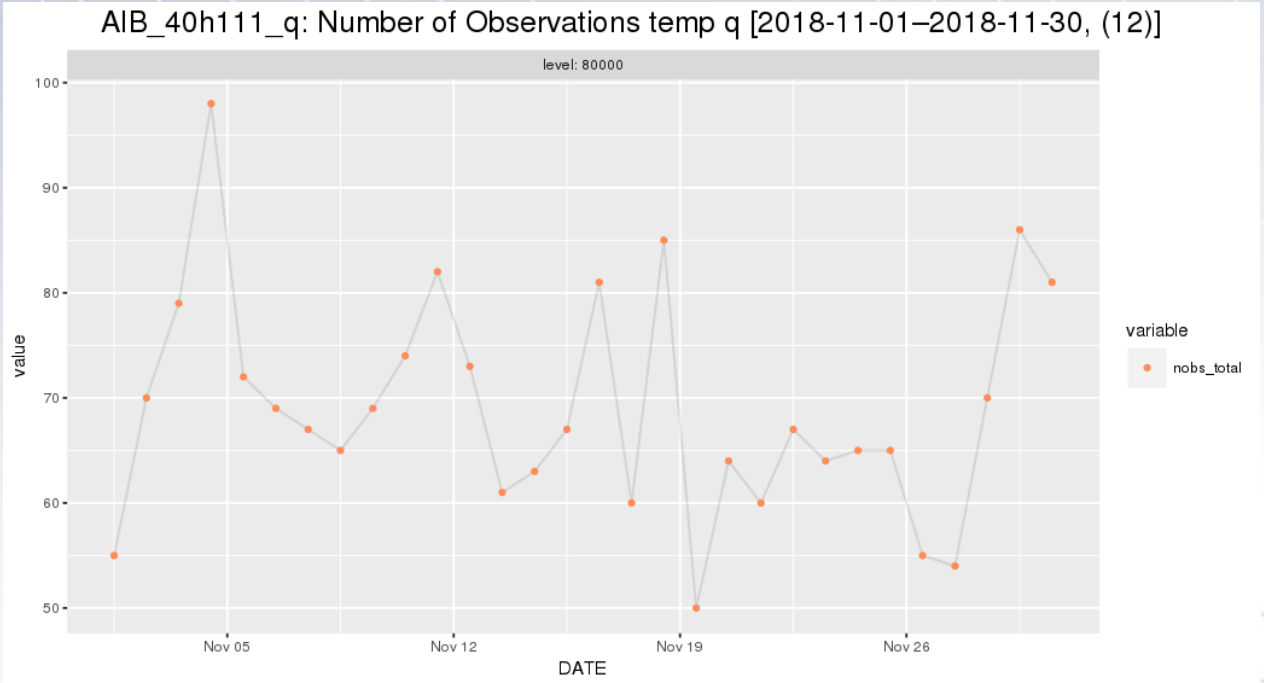
Control Experiment **AIB_40h111**

- Model version 40h1.1.1
- Resolution: 2.5 km and 65 levels
- Domain: Iberia
- Boundaries: ECMWF BC every hour
- DA Cycle: 3 hours
- DA upper air: 3D-Var, only conventional obs.
- Forecast length: 12 hours (00, 06, 12 and 18 UTC)

Experiment **AIB_40h111_q**: Control + AMDAR-q assimilation

Period: 1st to 30th November 2018





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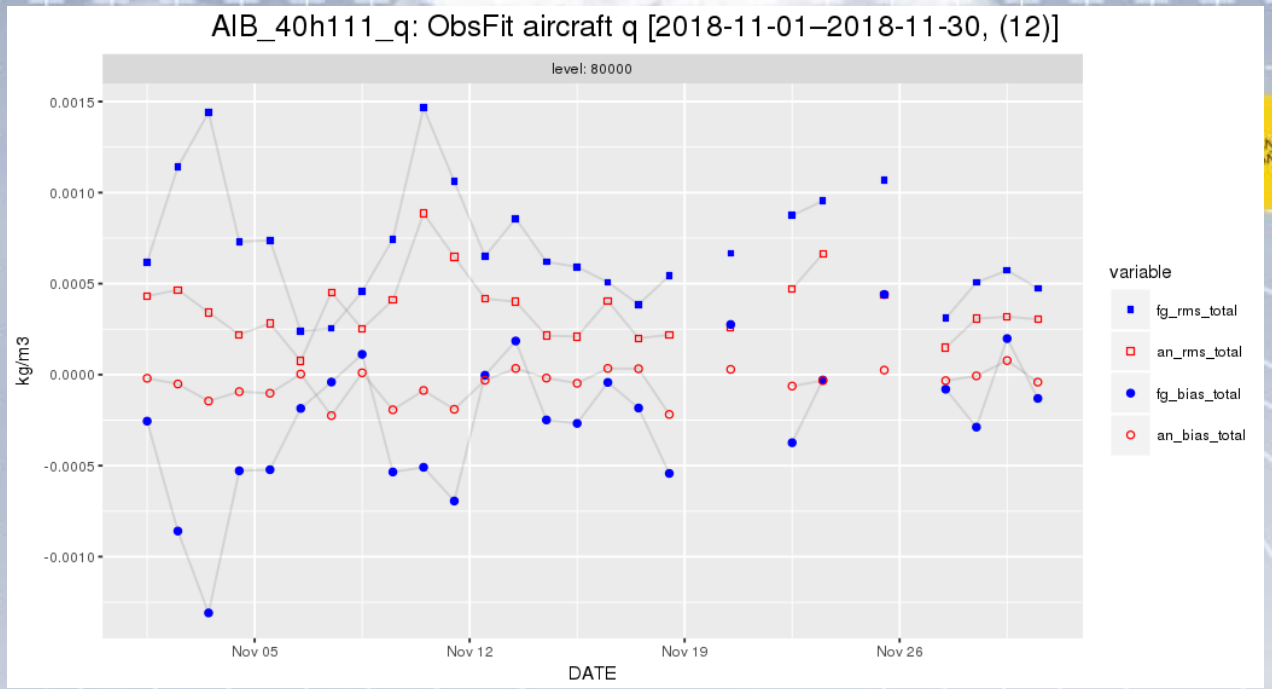
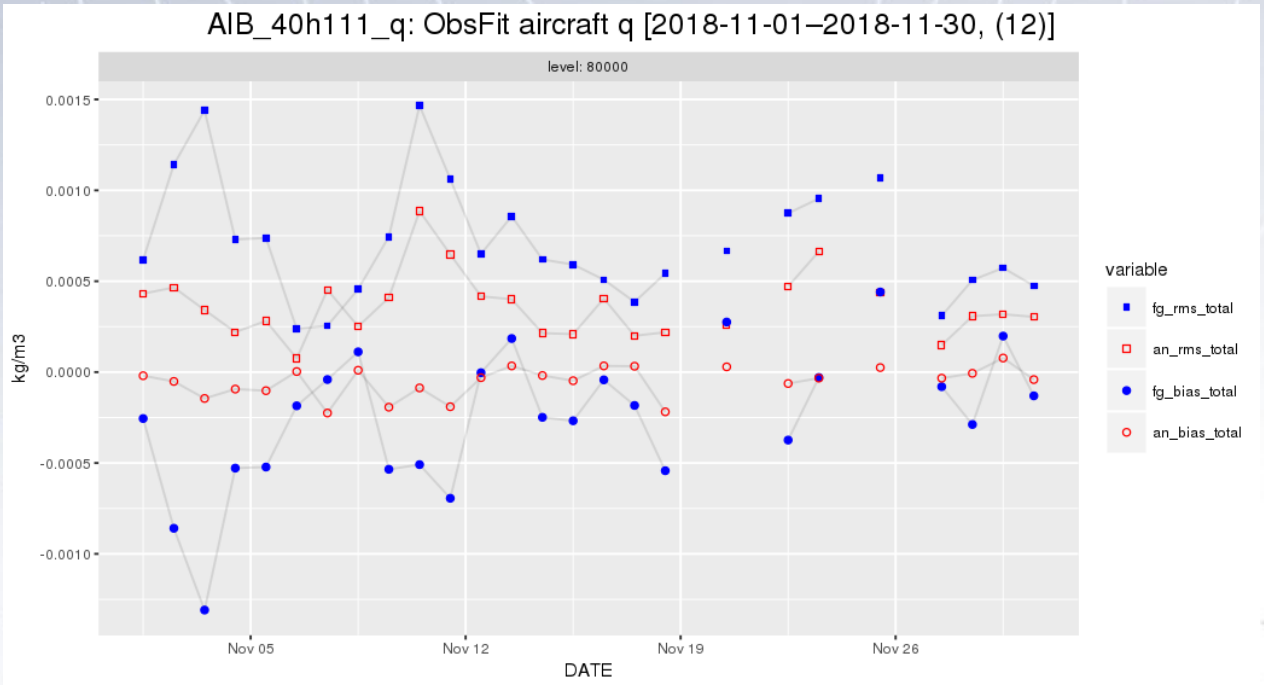
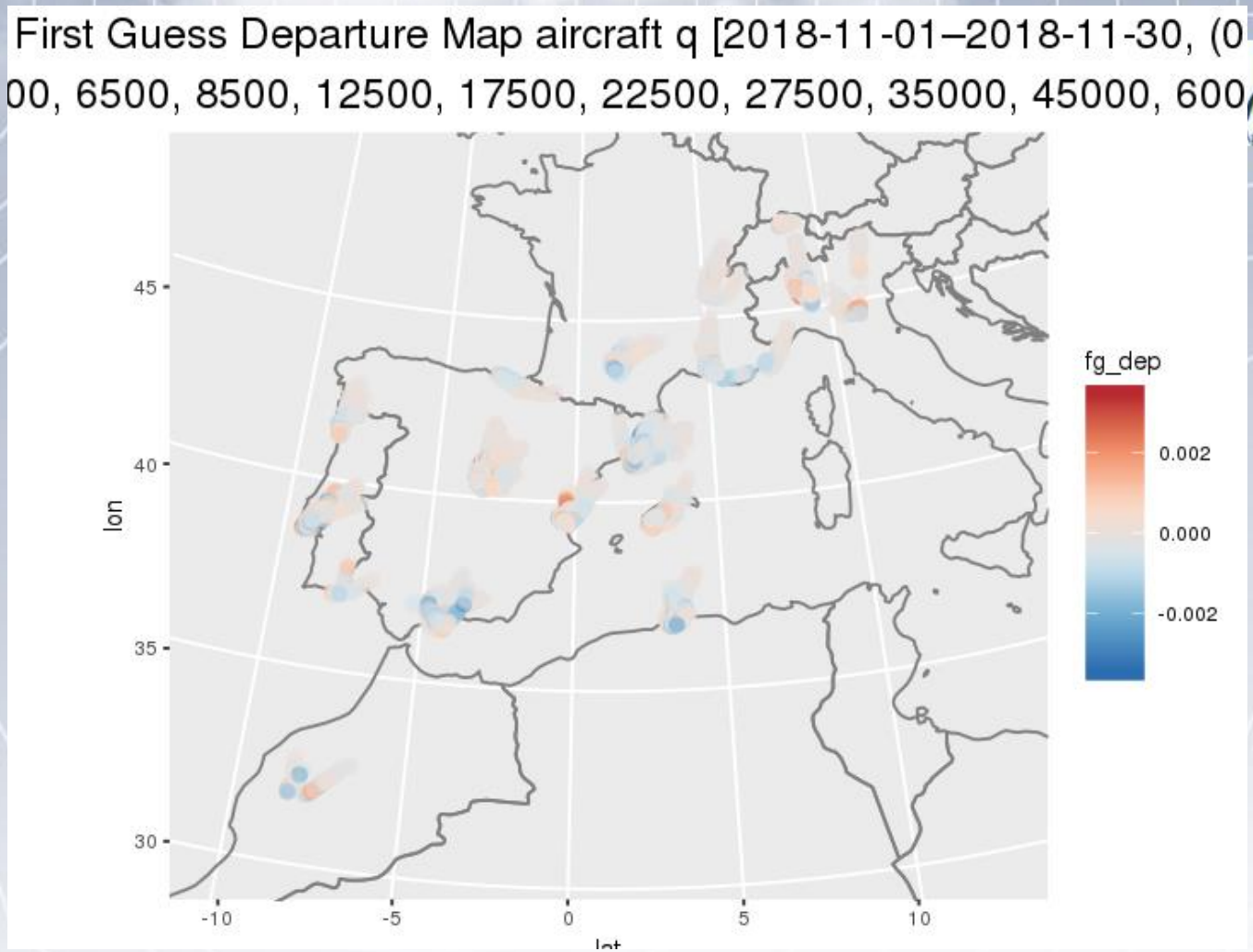
Number of observations for for AMDAR-q (top) and TEMP-q (bottom) observations around 800 hPa at 12 UTC.





Bias (circles) and RMS (squares) FG (blue) and AN (red) departures for AMDAR-q (top) and TEMP-q (bottom) observations around 800 hPa at 12 UTC.

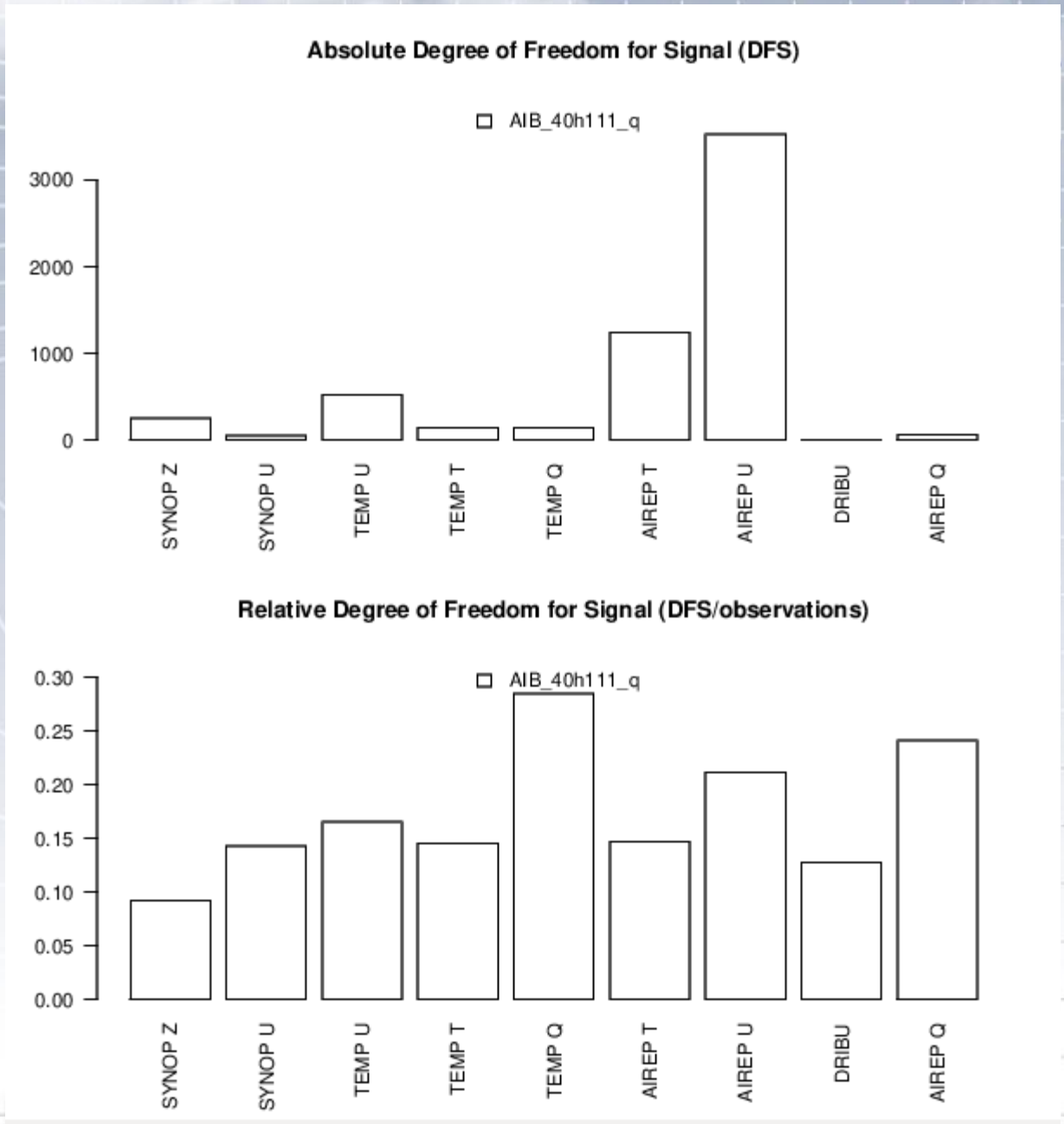


Average first guess departure map for all AMDAR-q observations

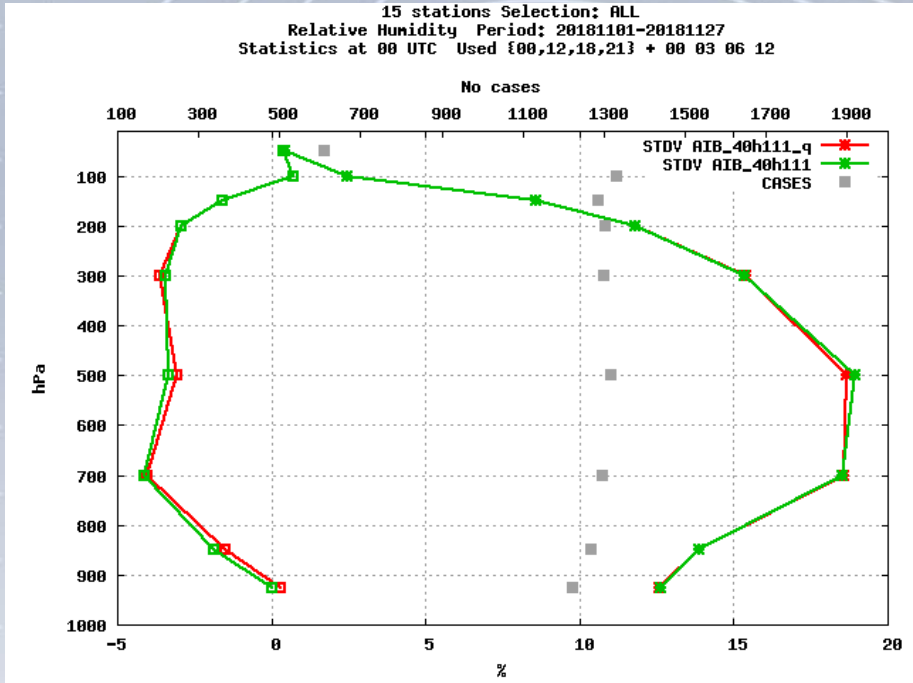
Degrees of freedom for signals

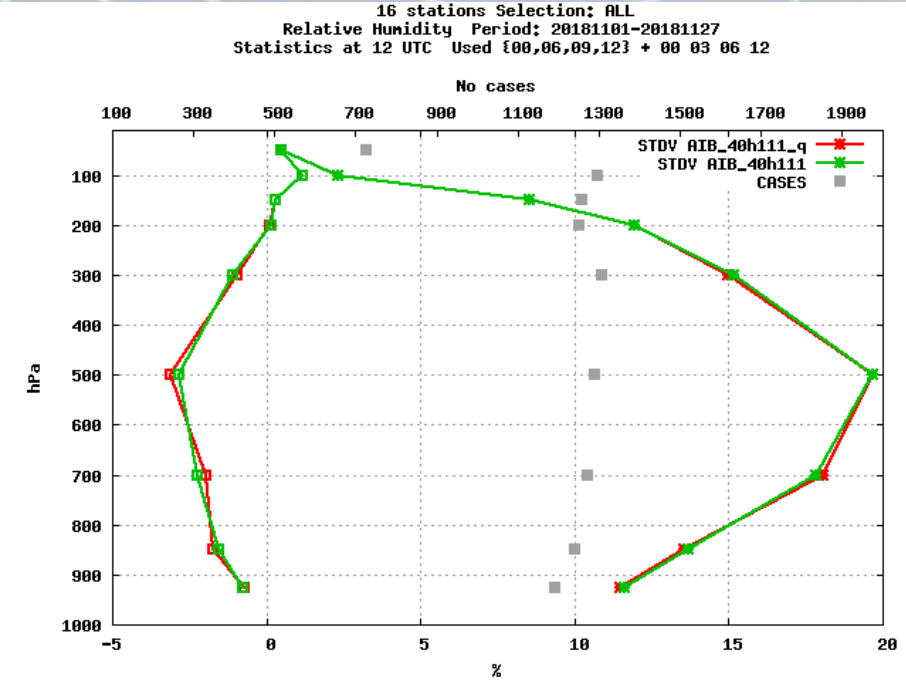
DFS is a dignostic tool to evaluate the impact of observations on the analyses.

15 Nov 2018
(00 to 21 UTC)



Verification

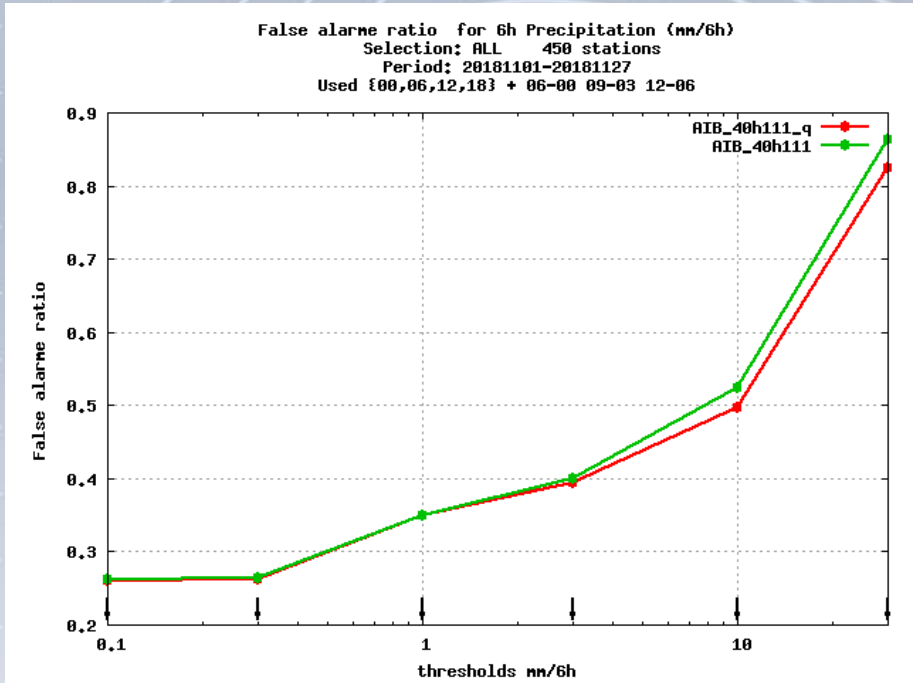


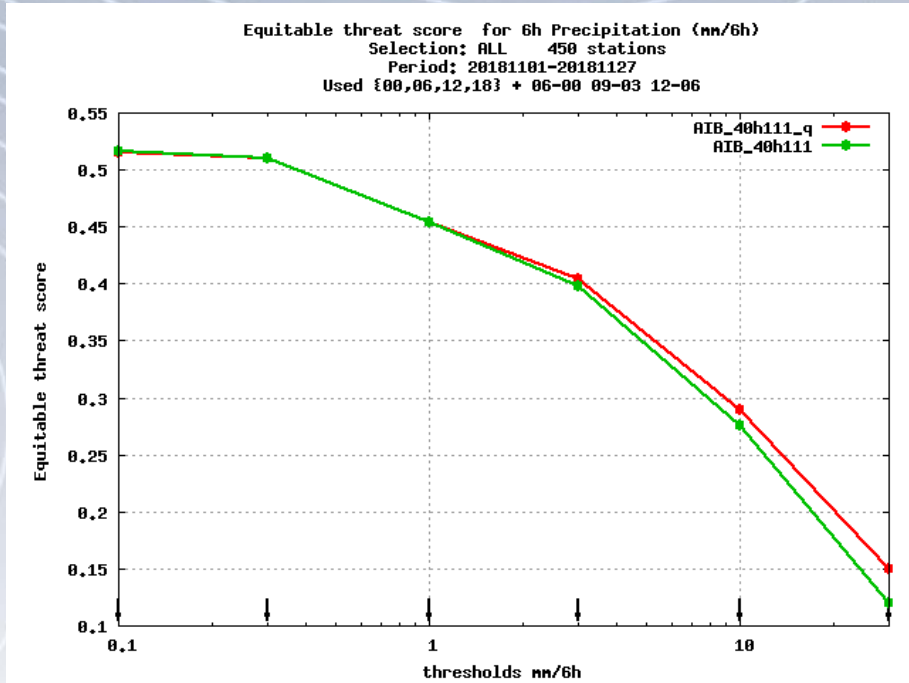


Vertical profiles: Bias and Stdv for RH (%) at 00 UTC (left) and 12 UTC(right).

AMDAR-q exp (AIB_40h111_q) CONTROL (AIB_40h111)

Verification





6h precipitation (mm/6h): False Alarm Ratio (left) and Equitable Threat Score (right).

AMDAR-q exp (AIB_40h111_q) CONTROL (AIB_40h111)

Results and further work

- The assimilation of E-AMDAR humidity have had a clear overall beneficial impact on IFS-ECMWF short-range forecasts.

- Preliminary tests in HARMONIE-AROME shows that the assimilation of EMDAR-q has an overall neutral impact.

- A basic HARMONIE-AROME setpup was used as Control, where only TEMP-q data as humidity observation was included.

Results and further work

- The present AEMET operational run assimilates GNSS and ATOVS radiances, and in the very near future radar reflectivities will also be assimilated. New tests with this improved setup are planned.

- E-AMDAR-q might be also usefull as anchoring for other biased humidity observations (as GNSS and ATOVS).

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Thank you for your attention!!

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