Assimilation of observations from the Microwave Humidity Sounders on board China's FY-3B and FY-3C Meteorological Satellites

ITSC-20

Fabien Carminati
Katie Lean*
William Bell
Nigel Atkinson

Met Office
*now at ECMWF

October 28, 2015

Introduction: Who we are

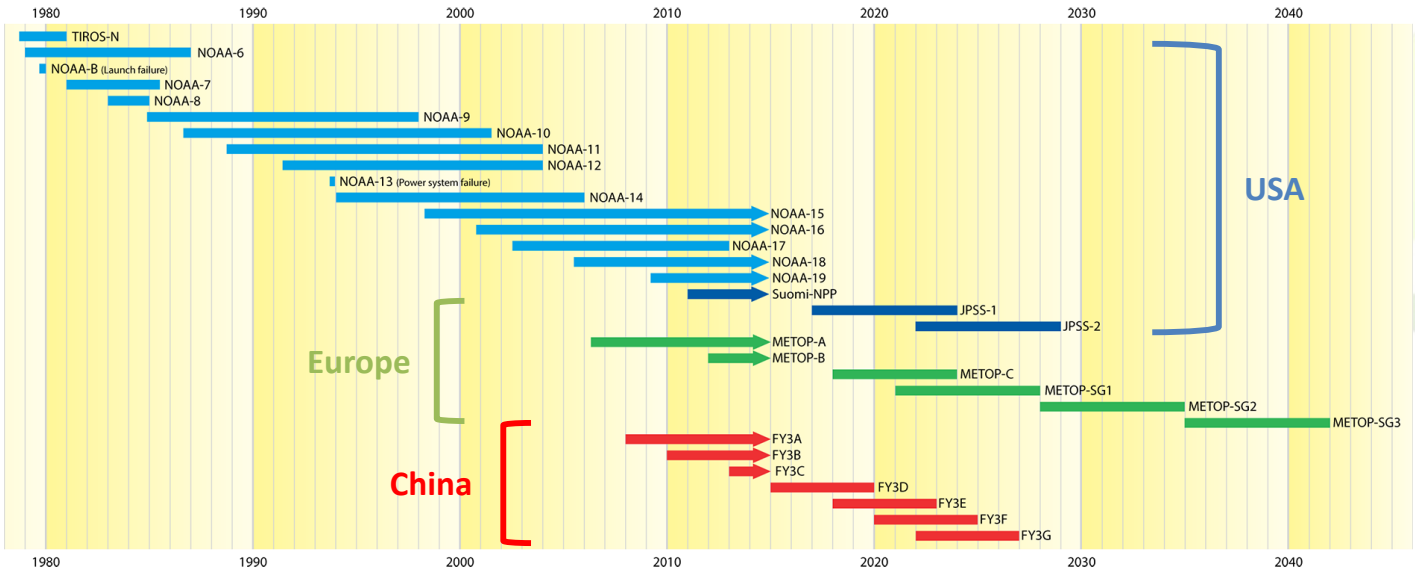
The Met Office (MO) Satellite Radiance Assimilation Group (SRAG)

- Manage Infrared and Microwave sounding data from: AIRS, ATOVS, ATMS, CrIS, IASI, and SSMIS.
- Maintain processing system for operational assimilation into the MO models.
- Carry out research to improve and extend data applications.
- Investigate the introduction of new instruments. Here, the MicroWave Humidity Sounders (MWHS) on board China's FY-3 platforms.

This work is supported by the European Horizon-2020 GAIA-CLIM project and the CSSP:China program, in collaboration with the NSMC-CMA.

Introduction: Source of data

Sounding missions supporting NWP and climate monitoring.



FY-3 polar orbiting satellites will become a major source of data for NWP and climate monitoring over the next decades.

Content

1. Presentation of MWHS-1 and -2
2. NWP-based assessment outlines
3. Assimilation experiments outlines
4. Concluding remarks

Presentation: FY-3B MWHS-1

Channel Number			Frequency (GHz)		
MWHS-1	MWHS-2	ATMS	MWHS-1	MWHS-2	ATMS
-	1	16	-	89 (H)	88.2 (V)
-	2	-	-	118.75 $\pm$ 0.08 (V)	-
-	3	-	-	118.75 $\pm$ 0.2 (V)	-
-	4	-	-	118.75 $\pm$ 0.3 (V)	-
-	5	-	-	118.75 $\pm$ 0.8 (V)	-
-	6	-	-	118.75 $\pm$ 1.1 (V)	-
-	7	-	-	118.75 $\pm$ 2.5 (V)	-
-	8	-	-	118.75 $\pm$ 3.0 (V)	-
-	9	-	-	118.75 $\pm$ 5.0 (V)	-
1-2	10	17	150 (V-H)	150 (H)	165.5 (H)
3	11	22	183 $\pm$ 1.0 (V)	183 $\pm$ 1.0 (V)	183 $\pm$ 1.0 (H)
-	12	21	-	183 $\pm$ 1.8 (V)	183 $\pm$ 1.8 (H)
4	13	20	183 $\pm$ 3.0 (V)	183 $\pm$ 3.0 (V)	183 $\pm$ 3.0 (H)
-	14	19	-	183 $\pm$ 4.5 (V)	183 $\pm$ 4.5 (H)
5	15	18	183 $\pm$ 7.0 (V)	183 $\pm$ 7.0 (V)	183 $\pm$ 7.0 (H)

FY-3B equator crossing time: $\sim$14:20 local time ascending.

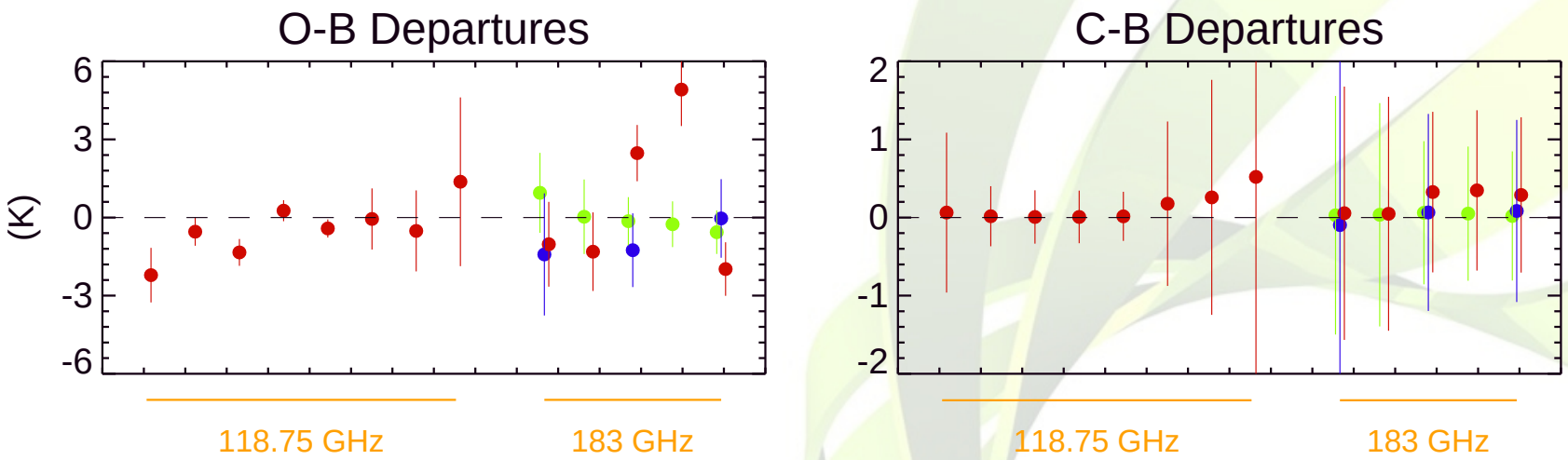
Presentation: FY-3C MWHS-2

Channel Number			Frequency (GHz)		
MWHS-1	MWHS-2	ATMS	MWHS-1	MWHS-2	ATMS
-	1	16	-	89 (H)	88.2 (V)
-	2	-	-	118.75 ± 0.08 (V)	-
-	3	-	-	118.75 ± 0.2 (V)	-
-	4	-	-	118.75 ± 0.3 (V)	-
-	5	-	-	118.75 ± 0.8 (V)	-
-	6	-	-	118.75 ± 1.1 (V)	-
-	7	-	-	118.75 ± 2.5 (V)	-
-	8	-	-	118.75 ± 3.0 (V)	-
-	9	-	-	118.75 ± 5.0 (V)	-
1-2	10	17	150 (V-H)	150 (H)	165.5 (H)
3	11	22	183 ± 1.0 (V)	183 ± 1.0 (V)	183 ± 1.0 (H)
-	12	21	-	183 ± 1.8 (V)	183 ± 1.8 (H)
4	13	20	183 ± 3.0 (V)	183 ± 3.0 (V)	183 ± 3.0 (H)
-	14	19	-	183 ± 4.5 (V)	183 ± 4.5 (H)
5	15	18	183 ± 7.0 (V)	183 ± 7.0 (V)	183 ± 7.0 (H)

FY-3C equator crossing time: ∼10:20 local time descending.

Assessment: August 2015 (MWHS-1, -2, and ATMS)

First guess departure from raw observations (O-B), corrected observations (C-B) and 1σ standard deviation



Channel Number			First Guess Departure (O-B) ±1σ (K)		
MWHS-1	MWHS-2	ATMS	MWHS-1	MWHS-2	ATMS
3	11	22	-1.416±2.346	-1.026±1.629	0.949±1.533
-	12	21	-	-1.313±1.509	0.029±1.431
4	13	20	-1.254±1.417	2.474±1.080	-0.138±0.923
-	14	19	-	4.915±1.400	-0.256±0.879
5	15	18	-0.034±1.509	-1.980±1.028	0.562±0.838

Assessment: Corrected observations

August 2015 corrected observations from 1D-Var static bias correction

Channel Number			First Guess Departure (C-B) $\pm 1\sigma$ (K)		
MWHS-1	MWHS-2	ATMS	MWHS-1	MWHS-2	ATMS
3	11	22	-0.096±2.294	0.055±1.621	0.029±1.528
-	12	21	-	0.048±1.498	0.036±1.429
4	13	20	0.066±1.261	0.326±1.028	0.061±0.916
-	14	19	-	0.348±1.027	0.050±0.859
5	15	18	0.084±1.166	0.289±0.994	0.020±0.827

Apr-Jun 2015* corrected observations from 4D-Var VarBC

Channel Number			First Guess Departure (C-B) $\pm 1\sigma$ (K)		
MWHS-1	MWHS-2	ATMS	MWHS-1	MWHS-2	ATMS
3	11	22	-0.009±2.143	-0.095±1.483	0.011±0.886
-	12	21	-	-0.080±1.378	-0.001±0.849
4	13	20	0.016±1.228	-0.036±0.909	-0.025±0.916
-	14	19	-	-0.011±0.910	-0.050±1.253
5	15	18	0.011±1.333	0.023±0.949	-0.070±1.336

*two different trials: 62 days for MWHS-1 and 79 days for MWHS-2 and ATMS

Assimilation experiments

MWHS-1 and -2 are integrated into a full system, low resolution (N320), for assimilation experiments in the MO global system.

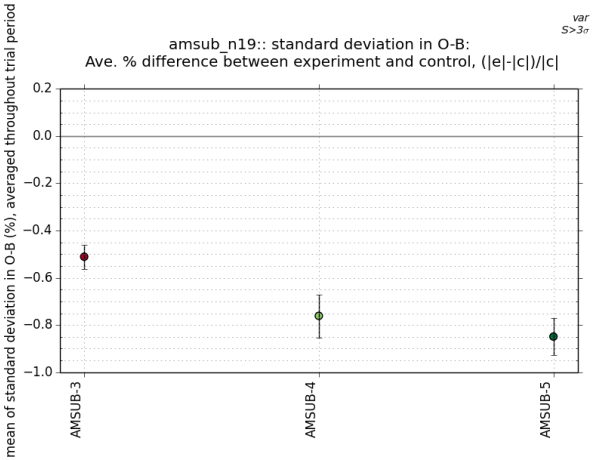
- Exp 1 MWHS-2 with static bias correction scheme . . . . . 49 days long
- Exp 2 MWHS-2 with variational bias correction scheme . . . . . 23 days long
- Exp 3 MWHS-1 with variational bias correction scheme . . . . . 62 days long

Channel number		Observation errors (K)		Assimilated channels			Cloud screening	
MWHS-1	MWHS-2	MWHS-1	MWHS-2	Sea	Sea-ice	Land	Bennartz rain*	Cirrus cost
-	1	-	7.67	NO	NO	NO	-	-
-	2-9	-	3-6	NO	NO	NO	-	-
1-2	10	5	5	NO	NO	NO	-	-
3	11	4.5	4.5	YES	NO	NO	Rejected	-
-	12	-	4	YES	NO	NO	Rejected	-
4	13	4	4	YES	NO	NO	Rejected	Rejected
-	14	-	4	YES	NO	NO	Rejected	Rejected
5	15	4	4	YES	NO	NO	Rejected	Rejected

* only for MWHS-2

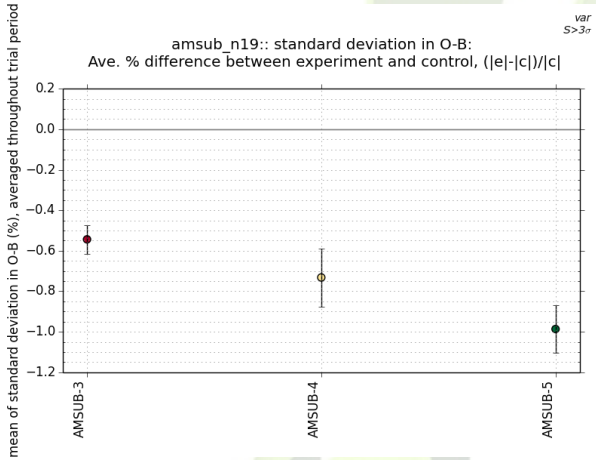
Assimilation experiments

Change in standard deviation of the fit to the model background for MHS-NOAA19 (relative to the control).



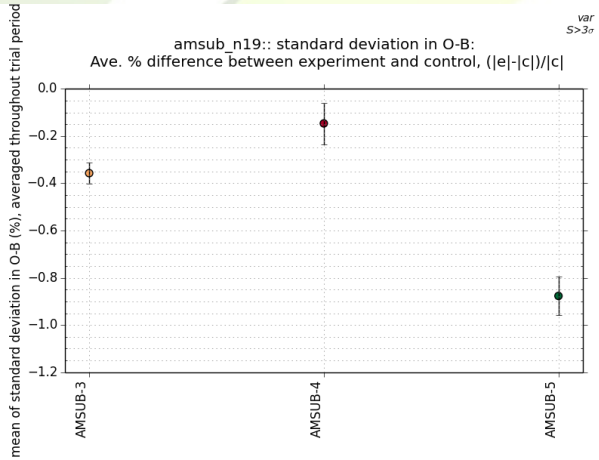
Exp 1

(MWHS-2 with static bias correction)



Exp 2

(MWHS-2 with VarBC)

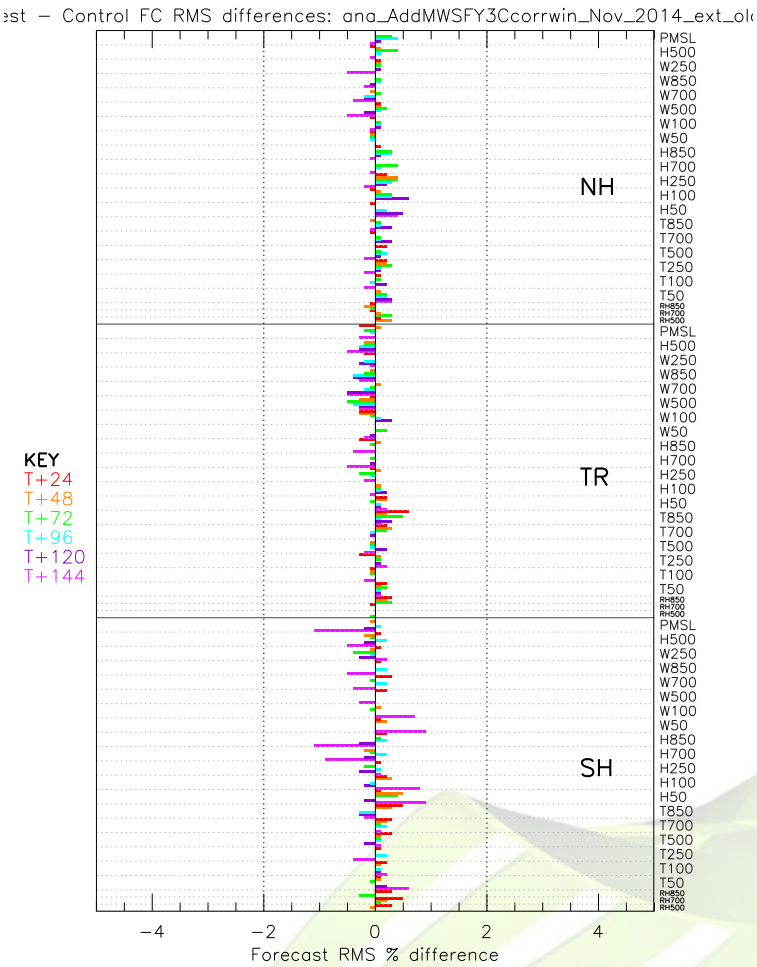


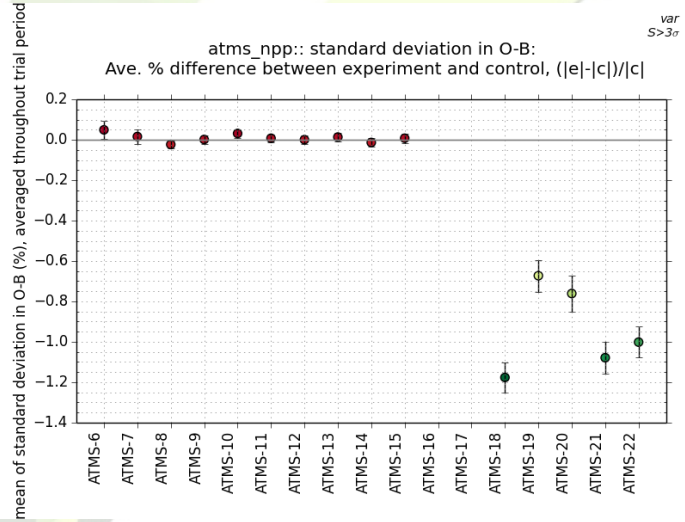
Exp 3

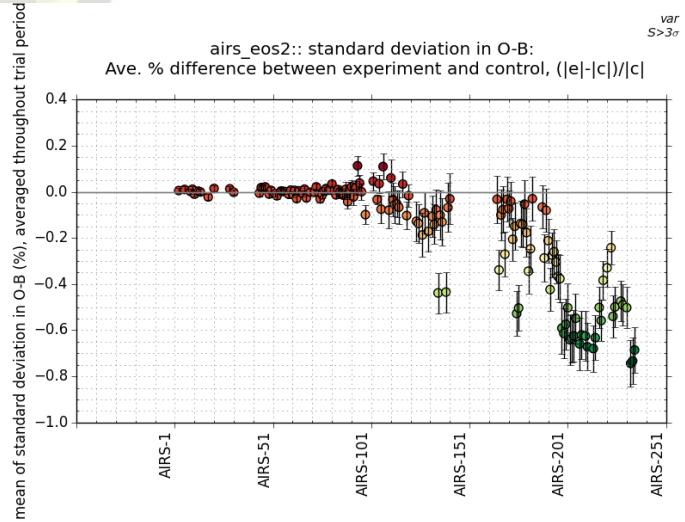
(MWHS-1 with VarBC)

Assimilation experiments: Exp 1 (MWHS-2 with static BC)

Similar improvement for other sounders in Exp 1 (and 2) ...

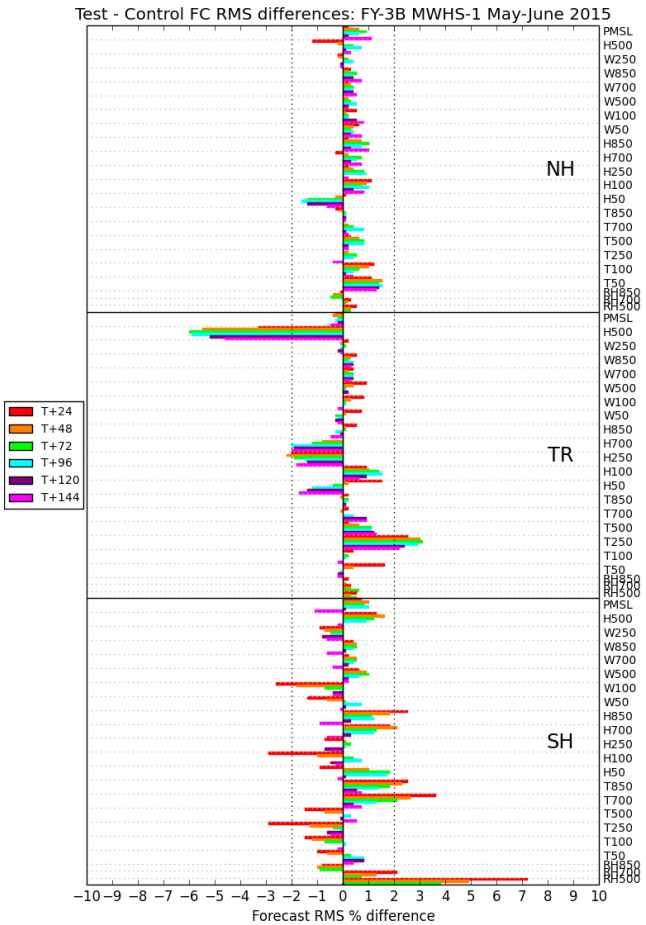




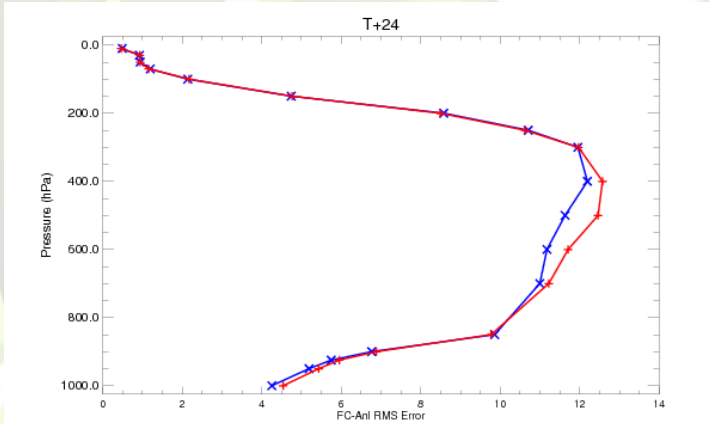


Assimilation experiments: Exp 3 (MWHS-1 with VarBC)

... But mixed picture in Exp 3.



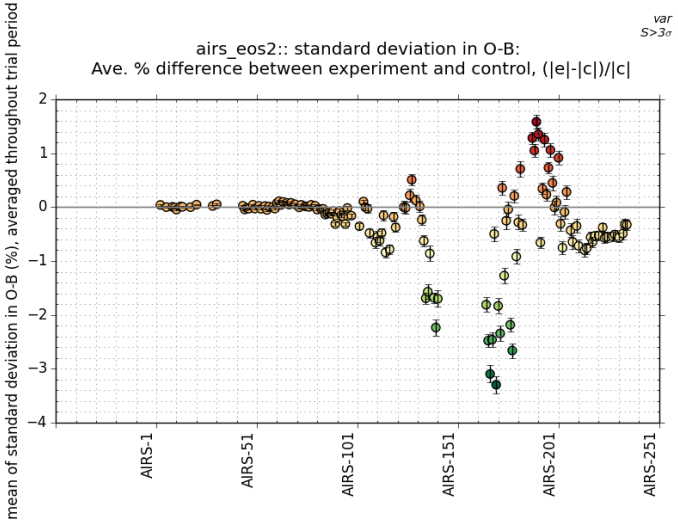
Significant degradation in Relative Humidity in lower and mid-troposphere.

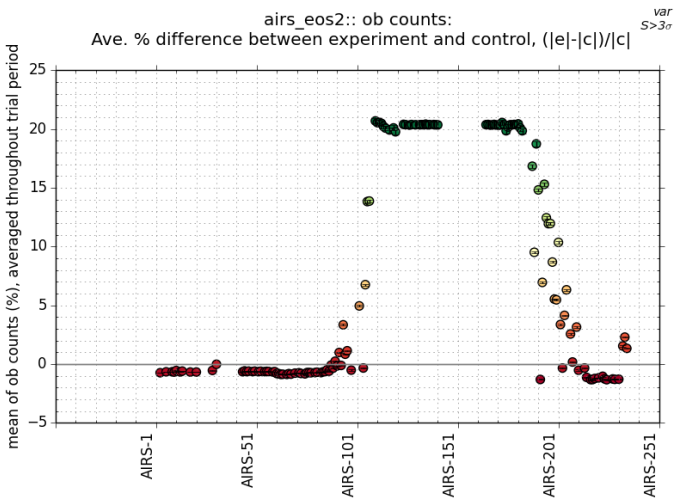


Exp
Control

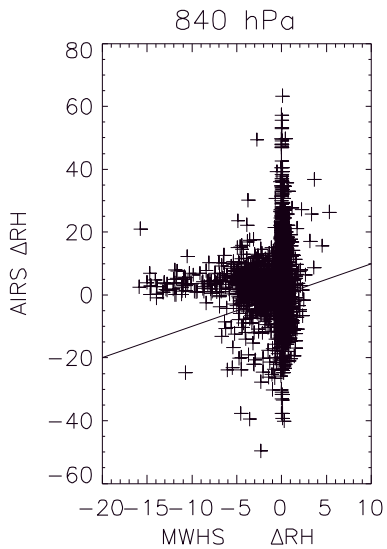
Assimilation experiments: Exp 3 (MWHS-1 with VarBC)

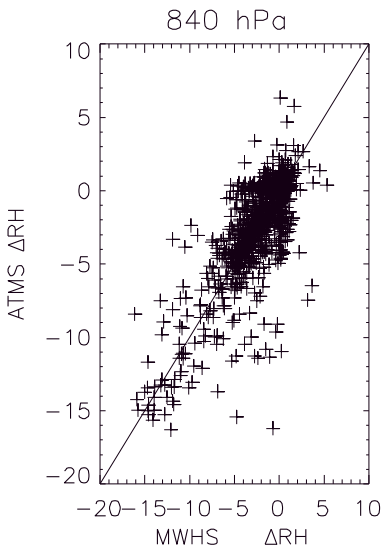
Could we indirectly introduce bad data? (Hypothesis)





1D-Var RH – RH_{bg}





Concluding remarks

- MWHS-2 (likely) to be operationally assimilated in the next MO system update.
- MWHS-1 operational use postponed until we work out RH issues.

Future work

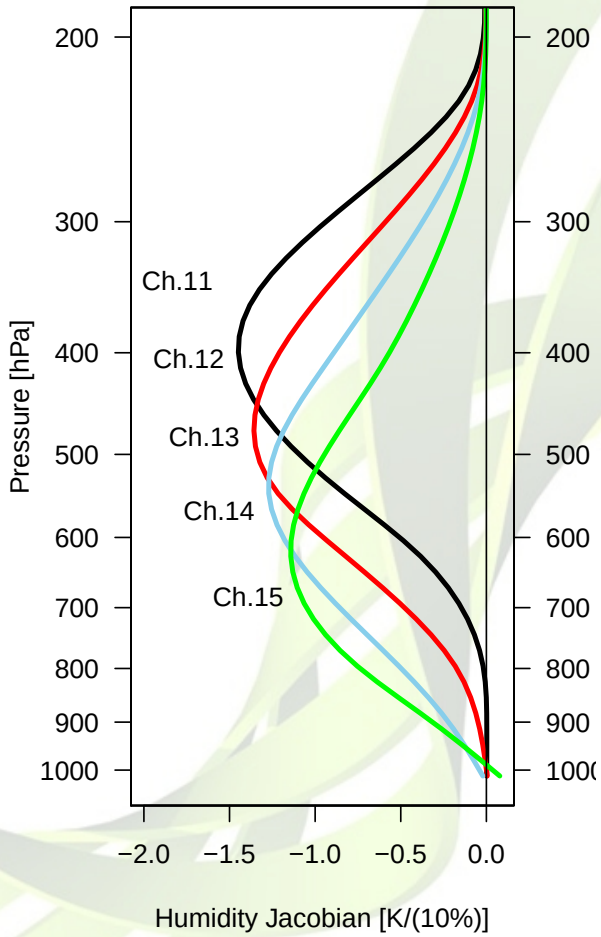
- Further investigate MWHS-1 impact on relative humidity.
- Test the assimilation of MWHS-1 and -2 183 GHz over land.
- Test MWHS-2 118 GHz channels.

© Crown copyright

Supplementary material: Errors

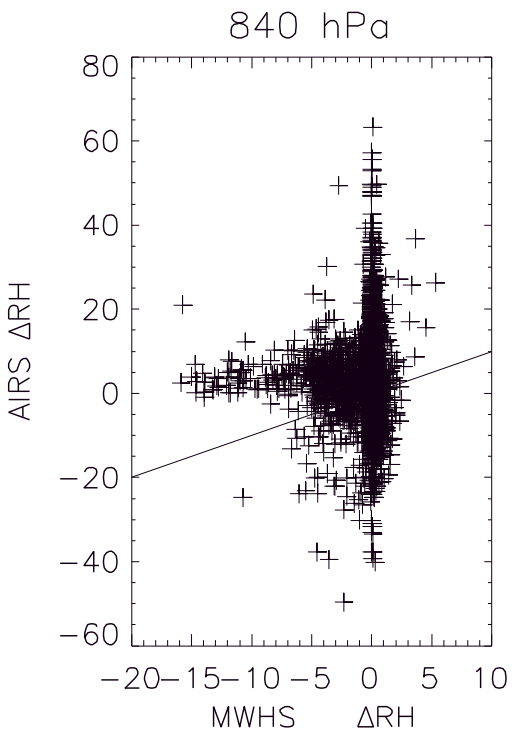
Channel Number		NEΔT (K)		Observation errors (K)	
MWHS-1	MWHS-2	MWHS-1 (2x2)	MWHS-2 (3x3)	MWHS-1	MWHS-2
-	1	-	0.14	-	7.67
-	2	-	1	-	4
-	3	-	0.37	-	3
-	4	-	0.32	-	3
-	5	-	0.3	-	4
-	6	-	0.28	-	4
-	7	-	0.28	-	4
-	8	-	0.17	-	6
-	9	-	0.2	-	6
1	-	0.30	-	5	
2	10	0.29	0.15	5	5
3	11	0.37	0.25	4.5	4.5
-	12	-	0.2	-	4
4	13	0.20	0.16	4	4
-	14	-	0.13	-	4
5	15	0.19	0.15	4	4

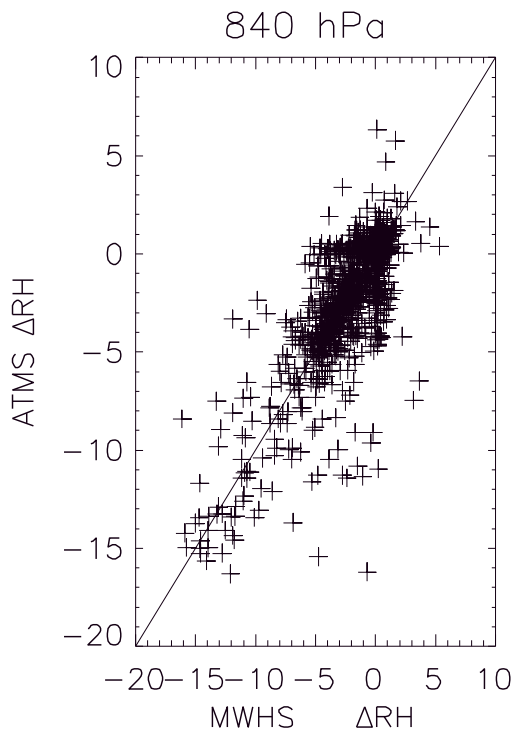
Supplementary material: Humidity Jacobian

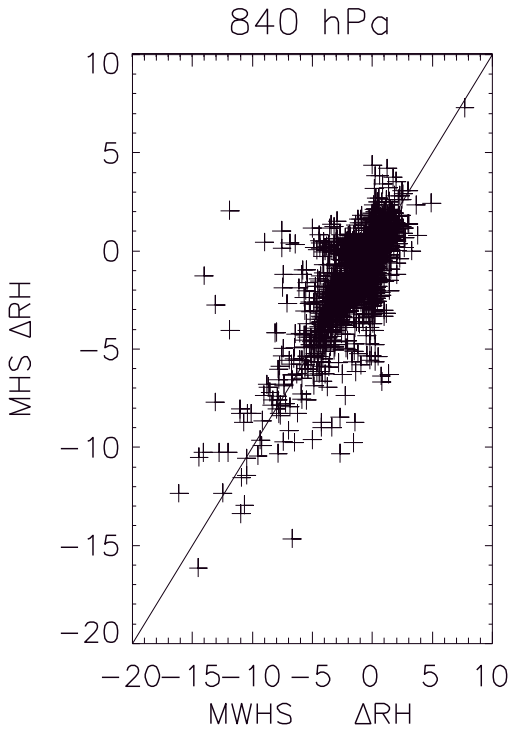


Supplementary material: RH correlation

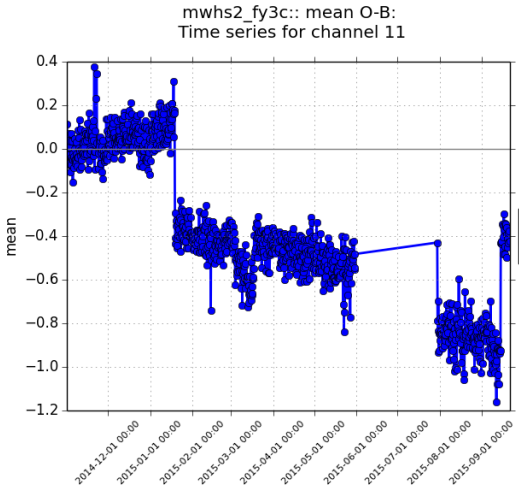
RH - RH background in analysis

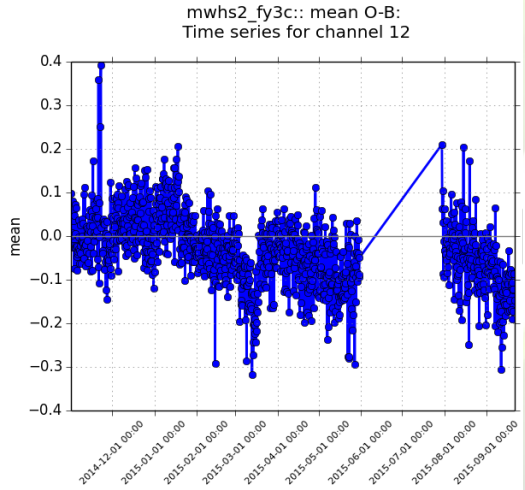


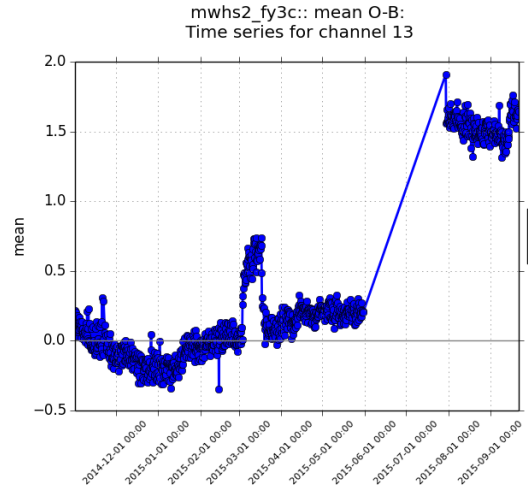


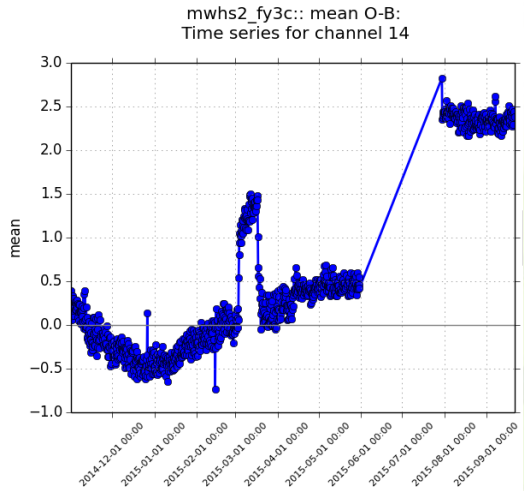


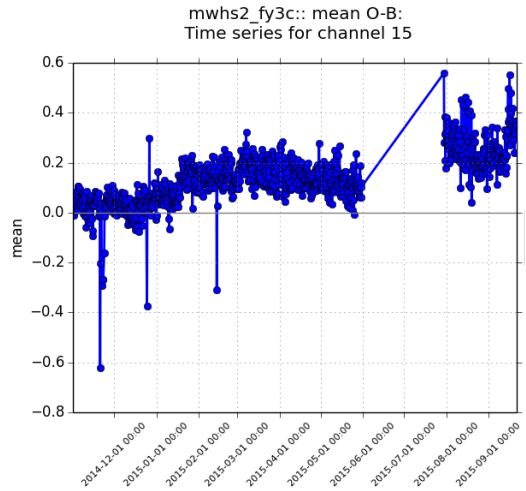
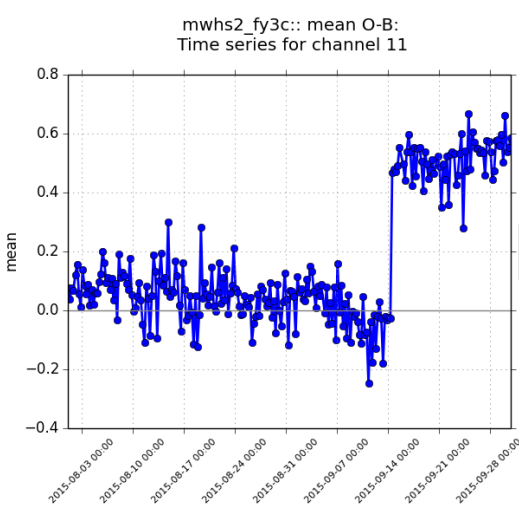
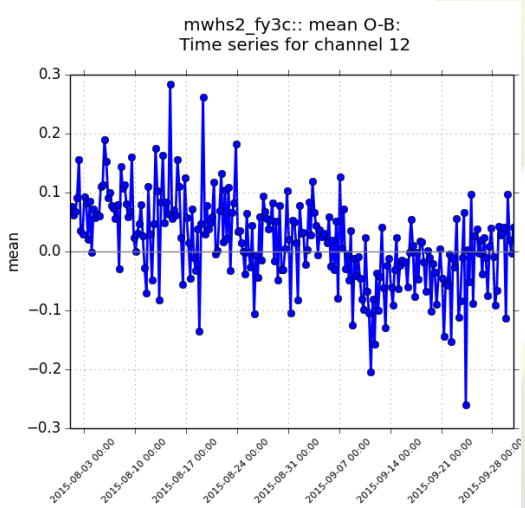
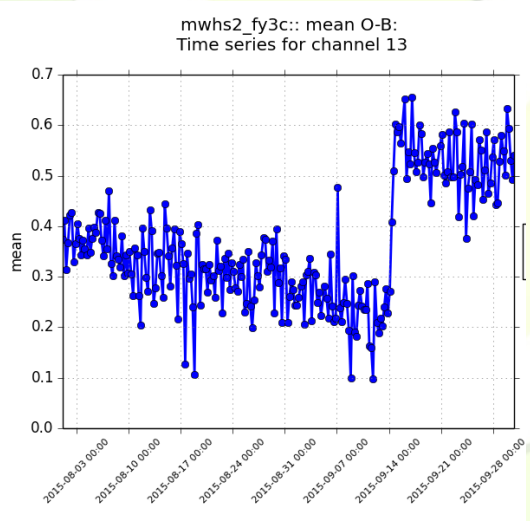
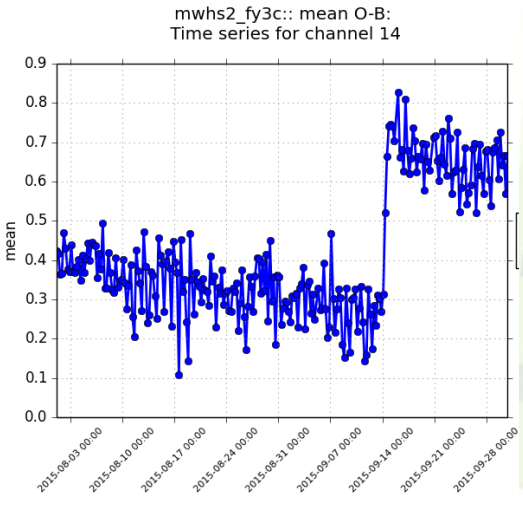
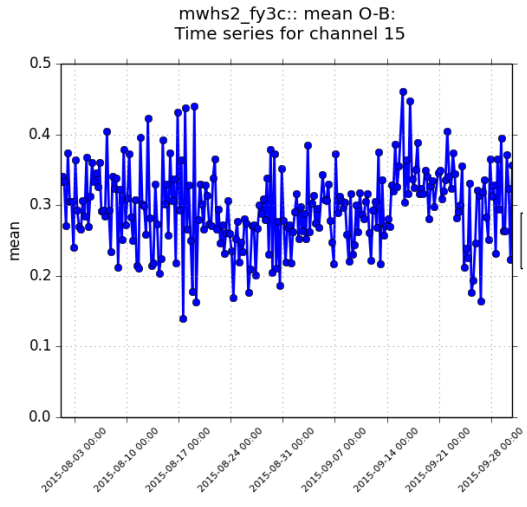
Supplementary material: Long term variability











Supplementary material: Recent variability