Satellite Data Reprocessing at EUMETSAT

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plus endless people that helped along

ERA-CLIM2 – EUMETSATs Tasks in WP3

WP3 EARTH SYSTEM OBSERVATIONS
Task 3.2: Satellite data rescue, reprocessing, and inter-calibration

- To provide consolidated radio occultation data records for Metop A and Metop-B instruments, and third-party instruments (CHAMP and COSMIC) (D3.14);
- To create an FCDR of SSM/T2 and AMSU-B/MHS radiances in collaboration with CMSAF and UK MetOffice (D3.11);
- Polar wind retrievals from AVHRR data record back to 1982 (D3.10);
- To inter-calibrate of radiance measurements from Meteosat First and Meteosat Second Generation, and for other geostationary satellites in collaboration with NOAA and JMA within SCOPE-CM (D3.12);
- To improve the AMV data records from Meteosat First Generation and Second Generation (D3.13).

D3.14 –FCDR Radio Occultation (2001-2014)

(GRAS/CHAMP/COSMIC/GRACE)

Done

- Completed the update to **W**ave**O**ptics based processor for GRAS on Metop;
- Processed GRAS data (Metop-A and Metop-B) with the **W**ave**O**ptics processor;
- Validation of GRAS bending angles revealed systematic error in height referencing due to non consideration of 26,000 year Earth precession;
- Corrected and reprocessed Metop-A (27/10/2016-31/12/2015) and Metop-B (29/09/2012-31/12/2015) with a further improved **W**ave**O**ptics processor (improved vertical smoothing);
- Processed whole COSMIC mission data;
- Processed whole CHAMP mission data;
- Still work on validation items for COSMIC and CHAMP;
- Drafted deliverable report – to be finished by 12/01/2018.

Processed Data

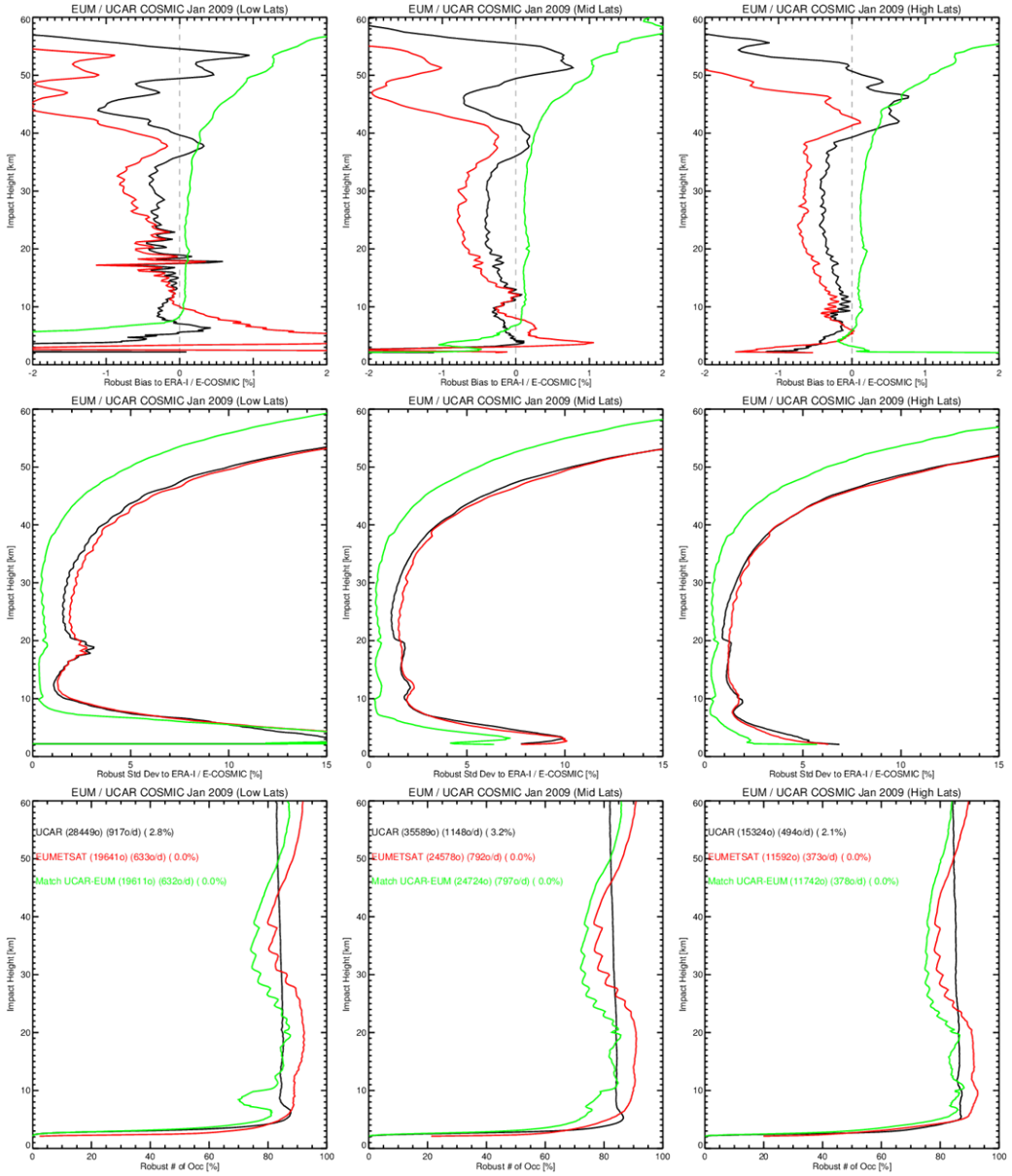
Mission	Start Record	End Record	Total Occs / Degraded Occs	Average Occs / Day
EUMETSAT				
Metop-A	2006 10 27 09:57	2016 12 31 21:54	2,464,280 / 247,104	663
Metop-B	2012 09 29 20:56	2016 12 31 21:55	1,023,436 / 66,167	659
UCAR				
Metop-A	2007 10 01 00:01	2015 12 31 23:07	1,791,657 / 138,207	594
Metop-B	2013 02 01 00:00	2015 12 31 23:57	642,372 / 34,635	604

Mission	Start Record	End Record	Total Occs / Degraded Occs	Average Occs / Day
EUMETSAT				
CHAMP	2001 05 19 00:10	2008 10 05 02:24	412,763/116,071	153
UCAR				
CHAMP	2001 05 19 00:10	2008 10 05 02:24	468,029 / 39,471	174

Processed Data

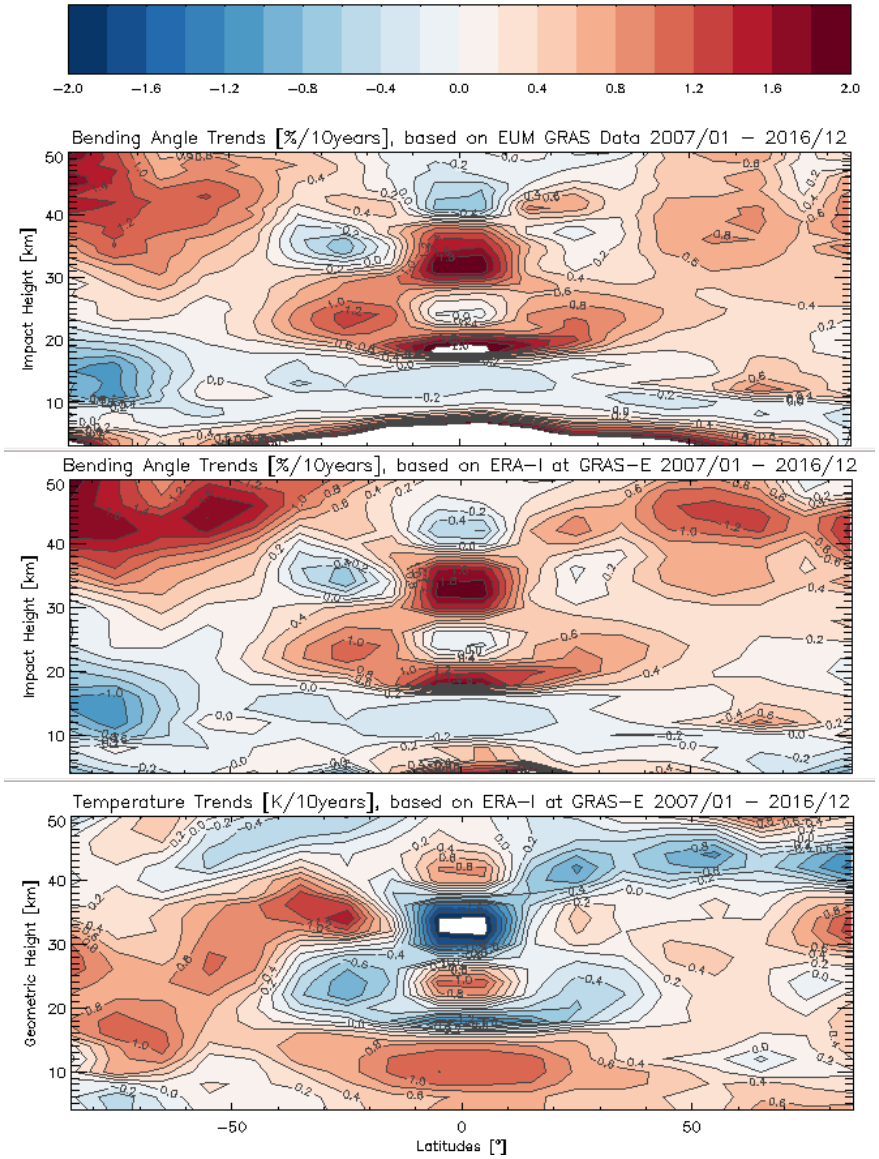
Mission	Start Record	End Record	Total Occs / Degraded Occs	Average Occs / Day
EUMETSAT				
C01	2006 07 13 23:59	2016 12 31 19:39	1,372,262/457,442	359
C02	2006 08 02 00:01	2016 09 24 01:05	822,,751/262,009	222
C03	2006 07 14 00:04	2010 07 05 18:30	442,481/172,923	305
C04	2006 07 21 02:42	2015 07 07 16:20	1,030,179/335,402	315
C05	2006 07 14 00:23	2016 04 16 12:45	1,091,378/377,307	306
C06	2006 07 14 00:00	2016 12 31 17:54	1,132,440/461,412	296
UCAR				
C01	2006/04/23 00:03	2014/04/30 23:46	1,208,727 / 195,304	413
C02	2006/05/01 19:29	2014/04/30 21:18	834,404 / 115,471	286
C03	2006/04/24 04:07	2010/07/05 18:32	421,146 / 55,458	274
C04	2006/04/22 00:27	2014/04/30 23:48	1,085,769 / 139,293	370
C05	2006/04/28 20:17	2014/04/30 23:52	992,412 / 135,824	339
C06	2006/04/22 13:46	2014/04/30 23:40	973,914 / 242,639	332

COSMIC Data Evaluation

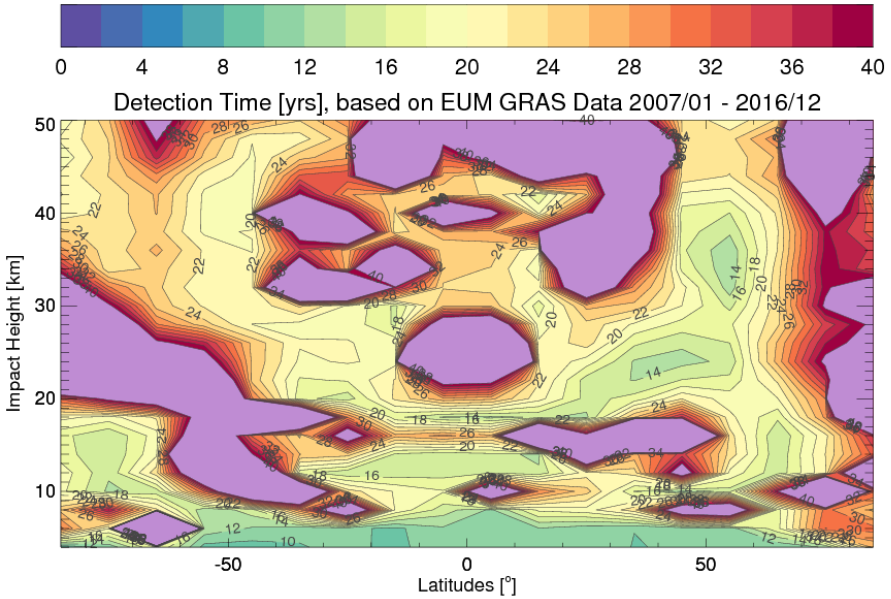


- (top plot) EUMETSAT bias structures above 8km, visible for all latitudes, more pronounced when comparing to ERA-I, but roughly constant around 0.2% against the UCAR processing for 8km to 35km. This increases then further at higher altitudes;
- (top plot) different bias structures below 8km in particular at low/mid latitudes, due to different wave optics implementations at UCAR and EUMETSAT, thus generally no issue;
- (middle plot) standard deviations look similar, slightly higher for EUMETSAT data, but that is just a question of smoothing, thus no issue;
- (middle plot) EUMETSAT doesn't have the artificial bump around 20km where the UCAR data processing changes;
- (bottom plot) outliers increase between about 20-25 and 45km for all latitudes in the EUMETSAT data;
- (bottom plot) average number of occultations per day as given in legend (o/d entry), is some 30% higher for UCAR data.

Deriving Trends from 10 years of GRAS data



(left): Reprocessing v1.4 bending angle trends for 10yrs of GRAS / Metop-A data, after seasonal correction (top); ERA-I bending angle trends at GRAS locations, after seasonal correction (middle); ERA-I temperature trends at GRAS locations, after seasonal correction (bottom). Note: no sampling correction applied. (bottom): detection time of trends (purple >40yrs)

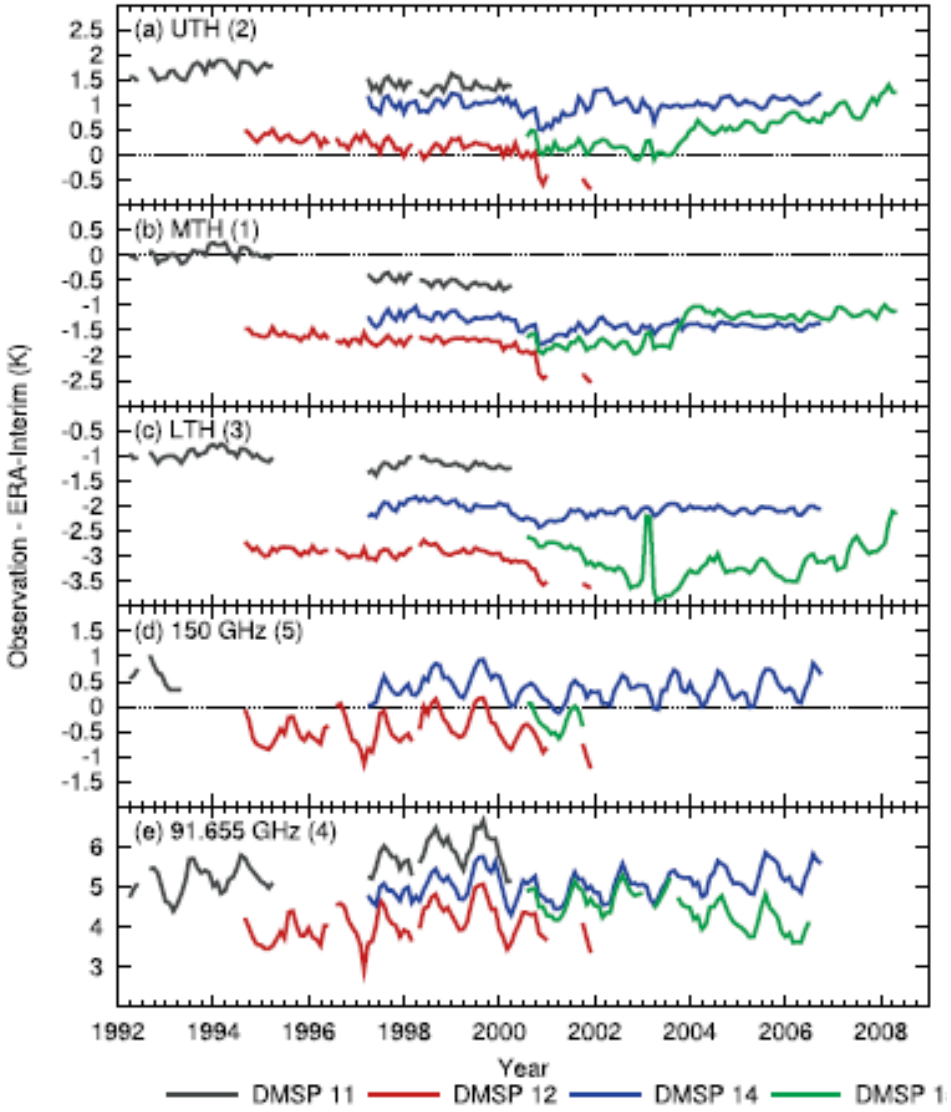


D3.11 - FCDR SSM/T2 and AMSU-B/MHS radiances (1991-2012)

In collaboration with CM SAF (MetOffice)

Done:

- CM SAF evaluated the following issues: scan & time dependent biases, diurnal cycle aliasing (orbit drift), assessment of inter-calibration method;
- CM SAF prepared inter-calibration ATBD for SSM/T2, AMSU-B and MHS, and delivered first data record which had not the quality expected;
- Revised the method for all instruments using the ERA Interim feedback archive and generated FCDR;
- Validated and delivered D3.11 in August 2017.



Metop-A MHS vs. NOAA-18 MHS after correction

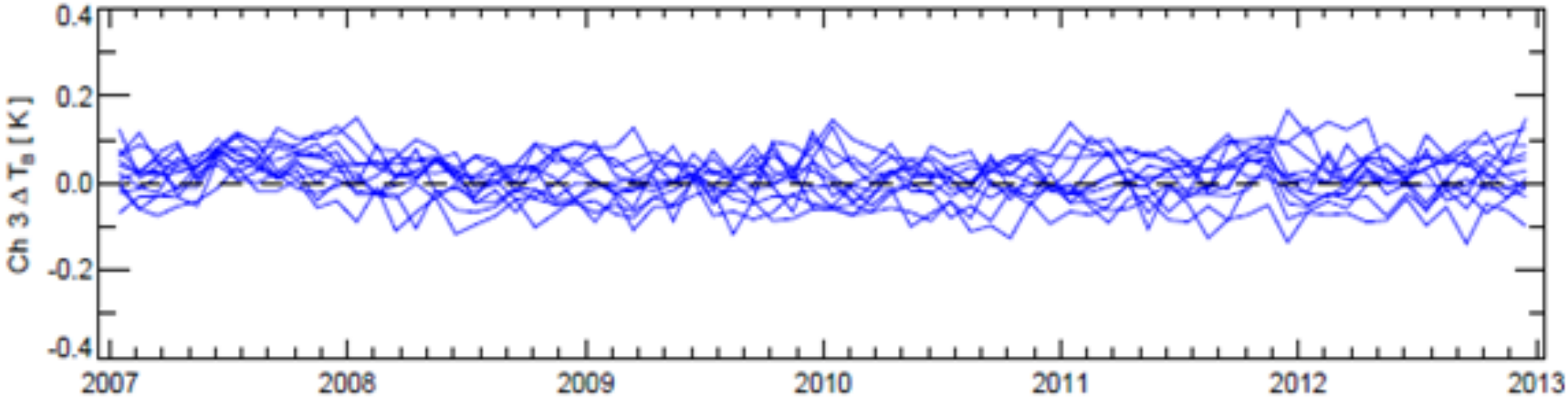
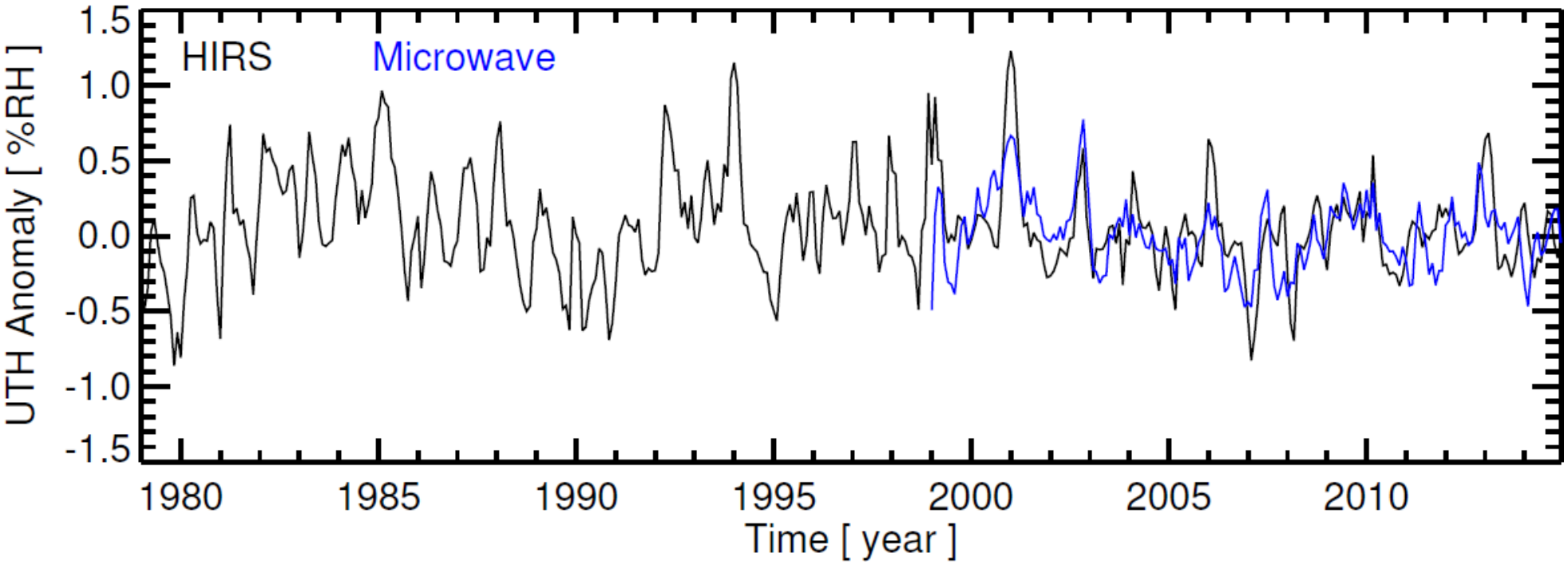


Figure 4: Monthly mean biases for METOP-A MHS compared to NOAA18 MHS channel 3 (183.311 ± 1.0 GHz) using the ERA-Interim O-B archive. Only quality controlled and clear-sky data are used. Different lines represent biases estimated for the each of the 10^0 zonal bins.

Comparison Microwave vs. HIRS WV Band



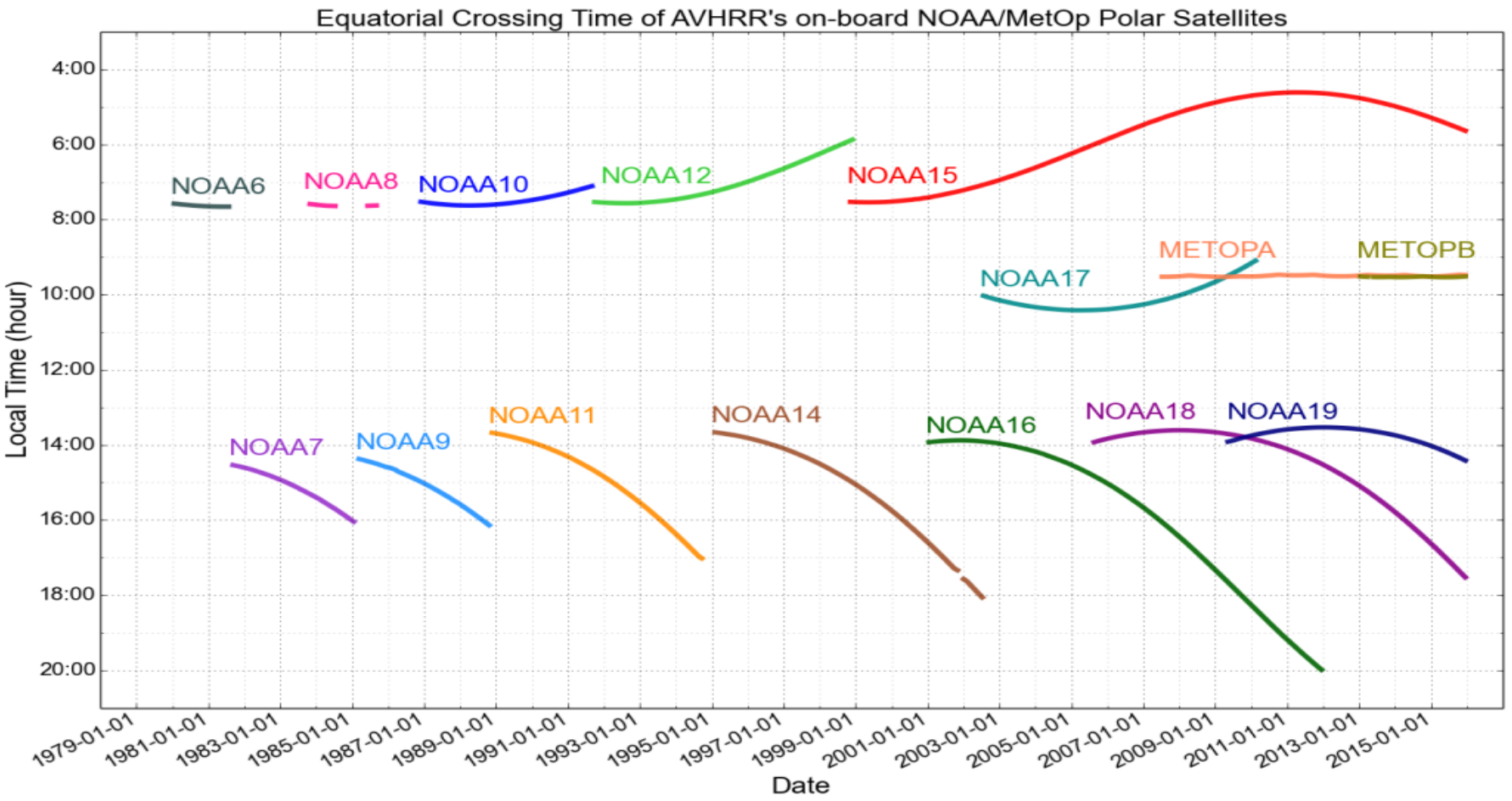
Time series of upper tropospheric humidity anomalies using HIRS (Shi and Bates, 2011) (black) and microwave (blue) datasets. Data during overlapping time periods are averaged for both datasets. The anomalies are computed with respect to the 2001–2010 average, and the time series are smoothed to remove variability on time scales shorter than three months.

D3.10 - AVHRR polar winds (1982-2011)

Done

- Collected AVHRR GAC data (1982-2014) from the CM SAF (based on NOAA PATMOS-X AVHRR L1b data);
- Implementation, testing and verification of AVHRR-GAC based polar winds;
- Ingestion of AVHRR GAC data into EUMETSAT algorithm;
- Adaptation of EUMETSAT algorithm to AVHRR GAC resolution. Verified that GAC data do not look different compared to LAC data
- Implementation, test and verification of EUMETSAT algorithm;
- Processing and validation with EUMETSAT algorithm (ongoing);
- Drafting of report (ongoing);
- D3.10 expected on 12 January 2018.

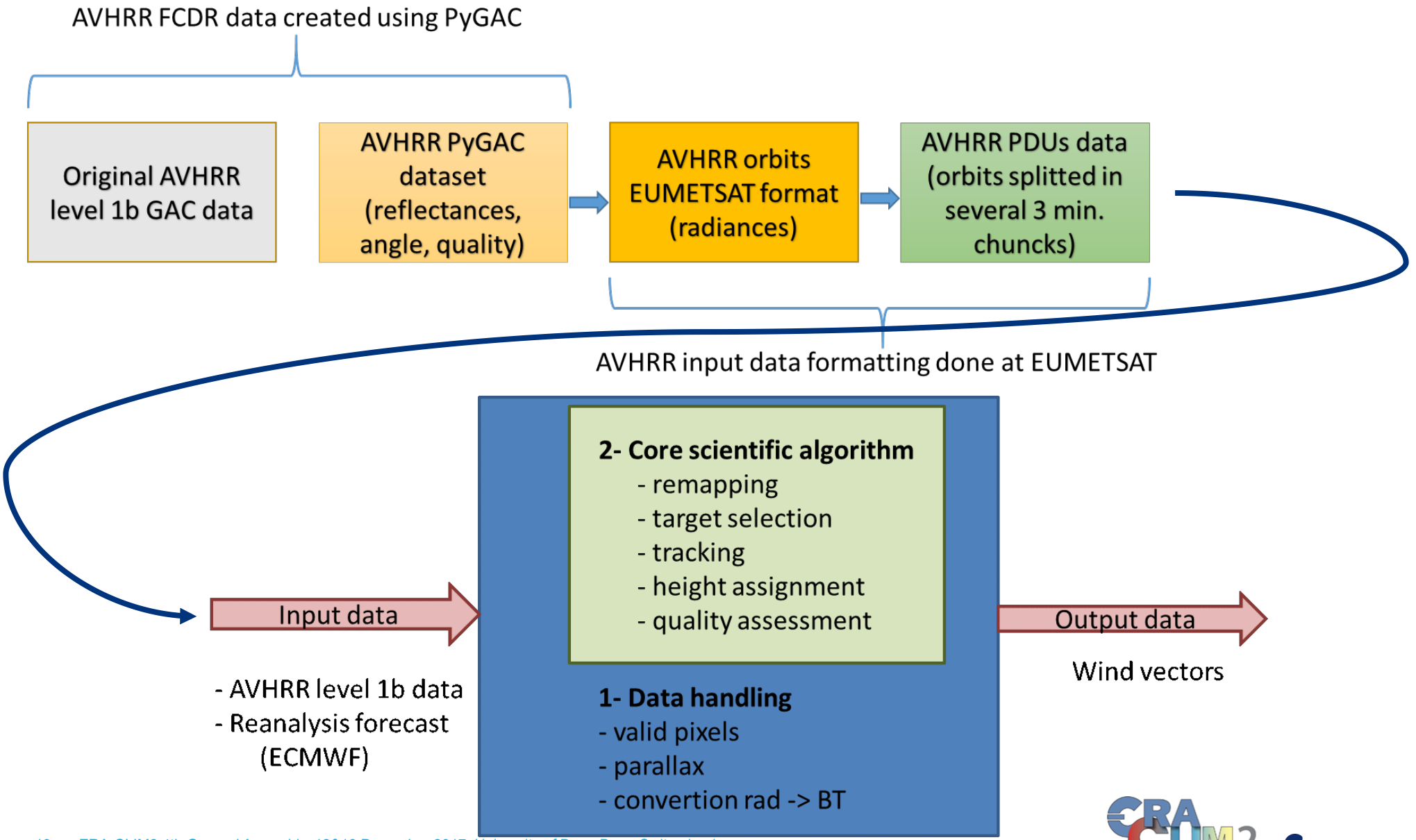
AVHRR Data Used



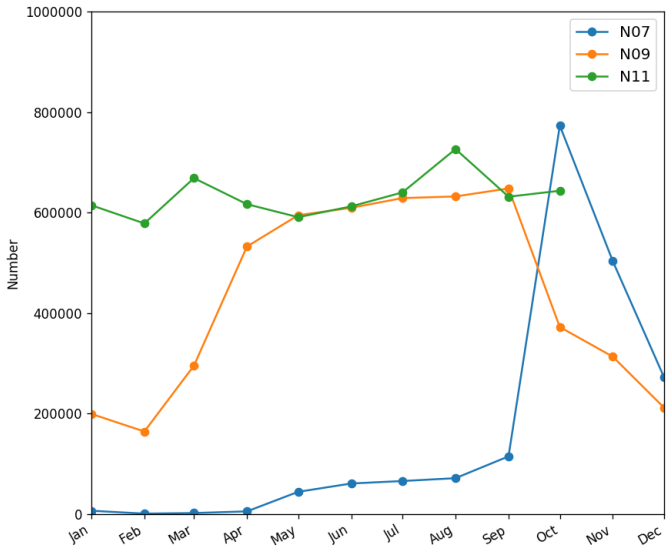
Global view of AVHRR instruments onboard NOAA and MetOp satellites used for this polar AMVs reprocessing.

The satellites comprise of ~90 years of data of which 50% have been processed. It is estimated that the processing will finish 20 December 2017.

AVHRR AMV Algorithm Setup



AVHRR AMVs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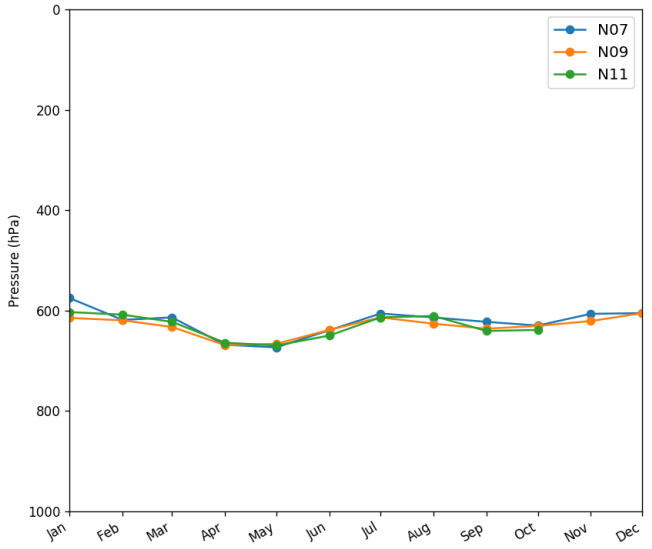
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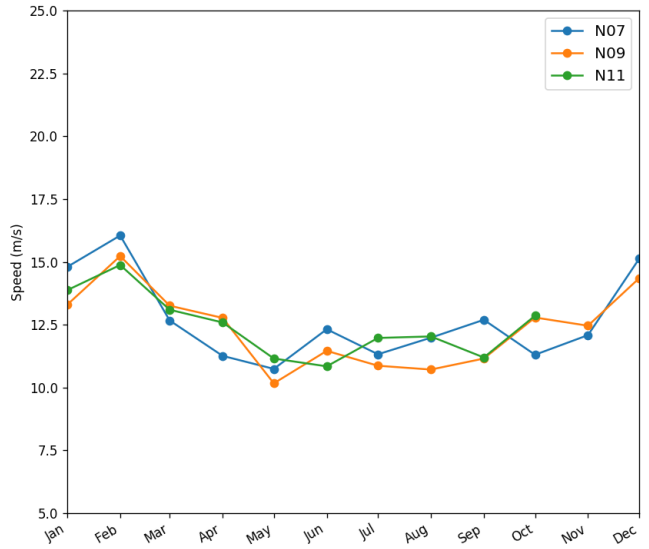
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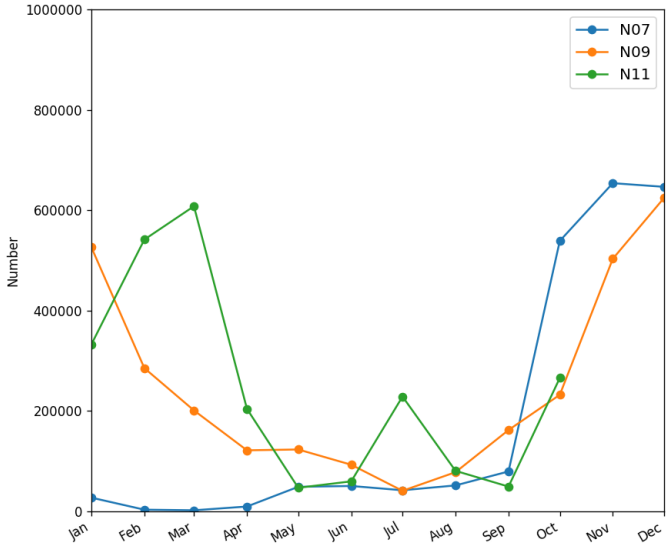
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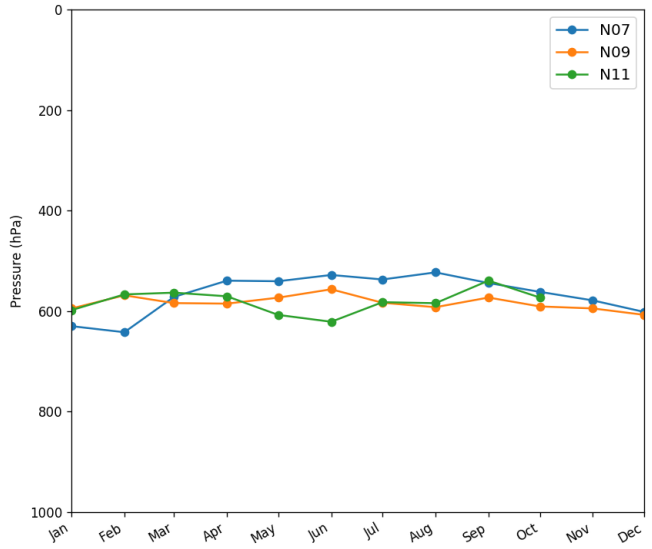
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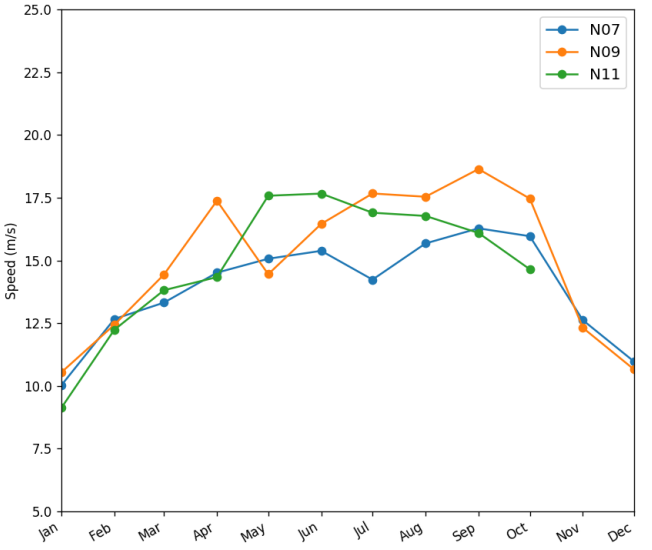
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Speed (m/s)
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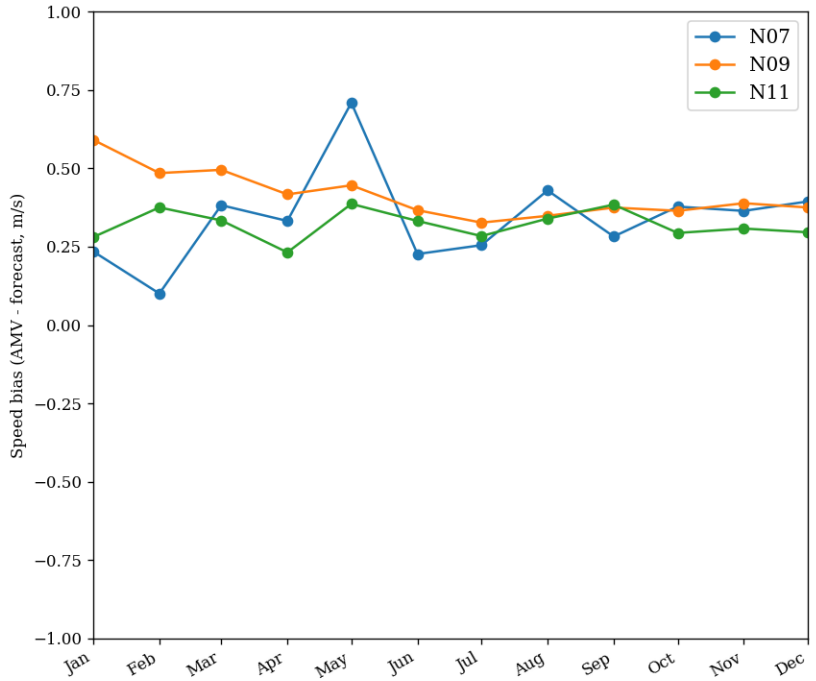
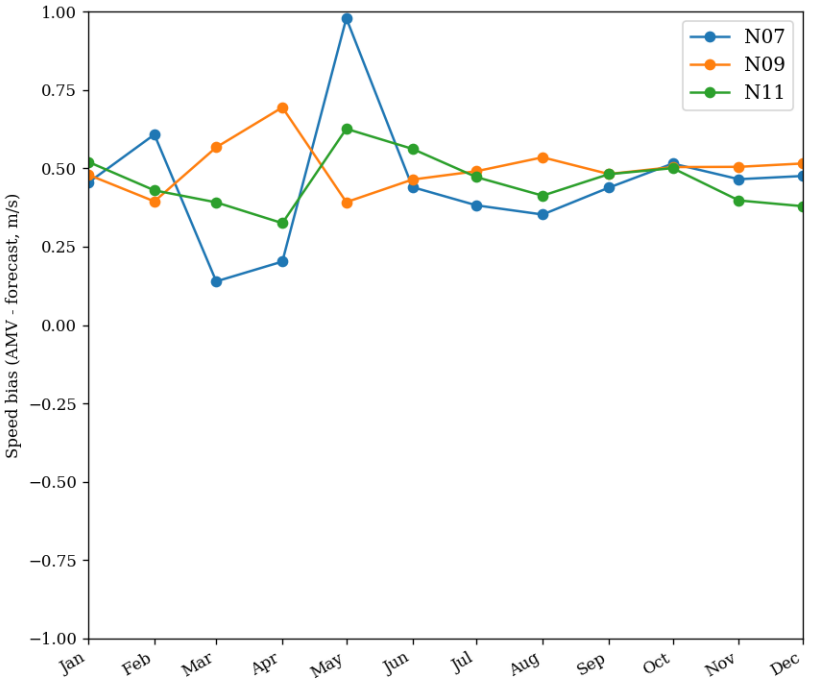
Comparison vs. ERA-Interim

Arctic (North of 60°N)



Antarctica (South of 60°S)

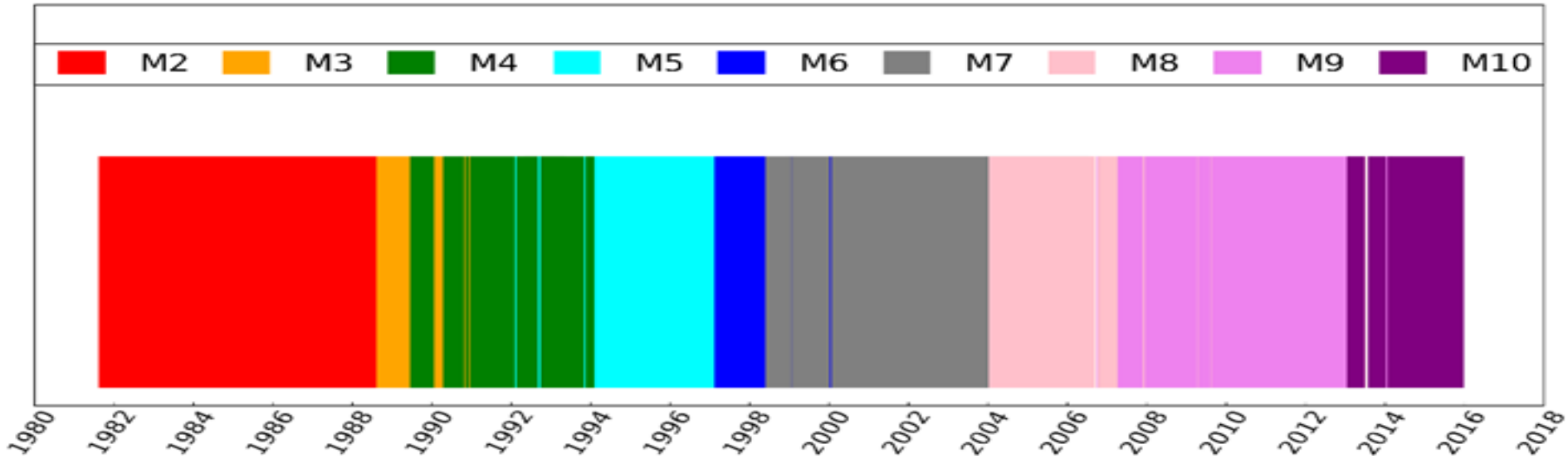


D3.12 - FCDR MFG and MSG radiances (1982- 2014)

Done:

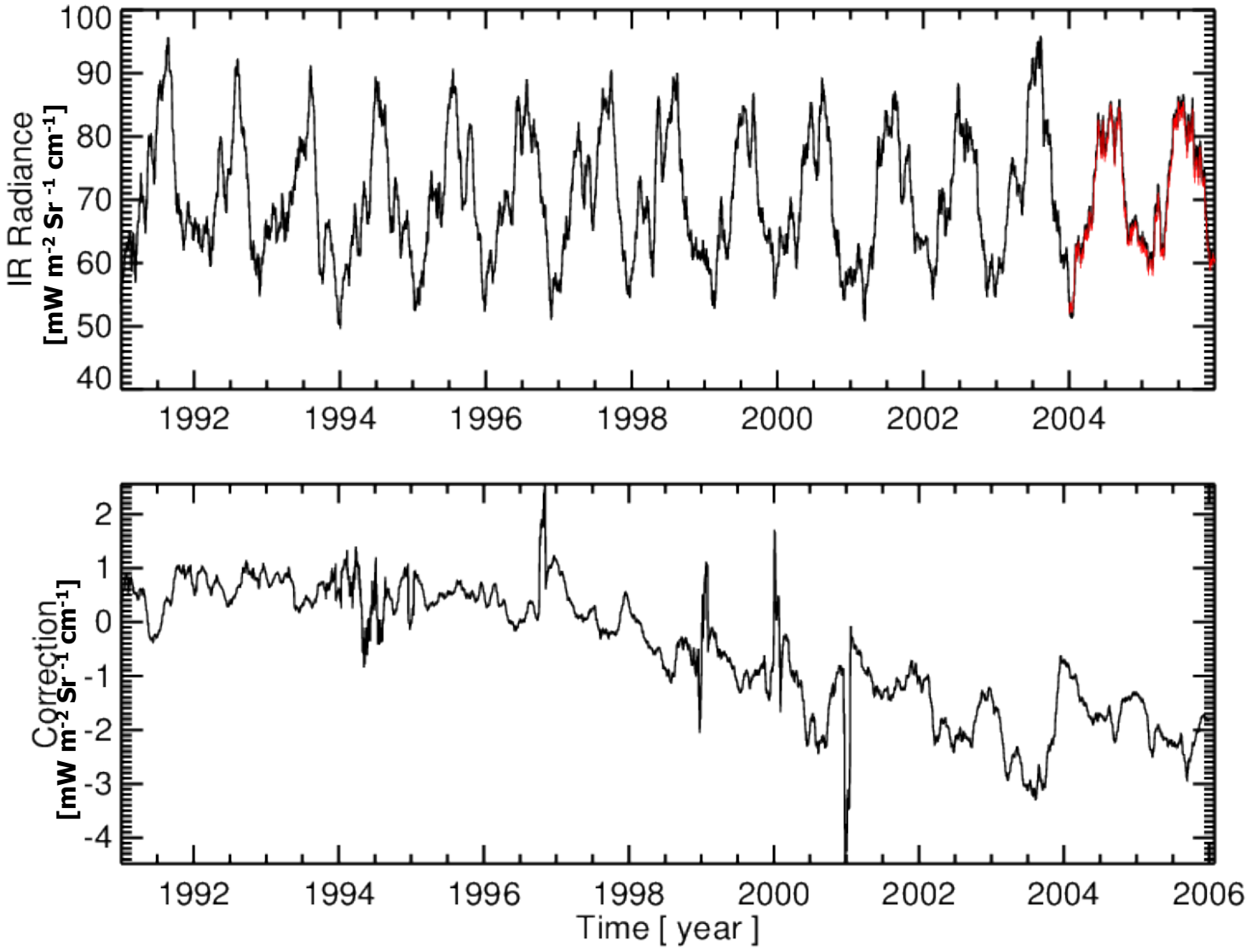
- Developed infra-red (IR) and water vapour (WV) re-calibration method;
- Generated IR and WV re-calibration coefficients for each individual MFG and MSG instrument (could not finish until end of 2016 because of not enough disc space for IASI data in the old compute environment);
- Generated band adjustment factor matrix (to enable homogenisation of the time series to any of the Meteosat satellites);
- Presented method in several conferences (EUMETSAT, ESA Living Planet, SPIE Asia), publication in preparation;
- Verified impact of re-calibrated IR/WV data for land surface temperature retrieval (CM SAF);
- Defined standard NetCDF format of the FCDR of MFG and MSG radiances;
- Generated the MFG and MSG image files containing the re-calibration coefficients in standard NetCDF format and standalone calibration coefficient files;
- Wrote report and submitted D3.12 in August 2017.

Meteosat Data



Satellite	*Operational mission and SSP*	*Main Operational Years*
Meteosat-2 (MVIRI)	0-degree (0.0°, 0.0°)	1981-1991
Meteosat-3 (MVIRI)	0-degree (0.0°, 0.0°)	1988-1991
Meteosat-4 (MVIRI)	0-degree (0.0°, 0.0°)	1989-1994
Meteosat-5 (MVIRI)	0-degree (0.0°, 0.0°)	1991-1998
Meteosat-5 (MVIRI)	IODC (0.0°, 63.0°)	1998-2007
Meteosat-6 (MVIRI)	0-degree (0.0°, 0.0°)	1993-2003
Meteosat-7 (MVIRI)	0-degree (0.0°, 0.0°)	1997-2006
Meteosat-7 (MVIRI)	IODC (0.0°, 57.0°)	2006-2015
Meteosat-8 (SEVIRI)	0-degree (0.0°, -3.4°)	2004-2008
Meteosat-9 (SEVIRI)	0-degree (0.0°, 0.0°)	2006-2013
Meteosat-10 (SEVIRI)	0-degree (0.0°, 0.0°)	2012-2016

Homogenised MFG and MSG radiances

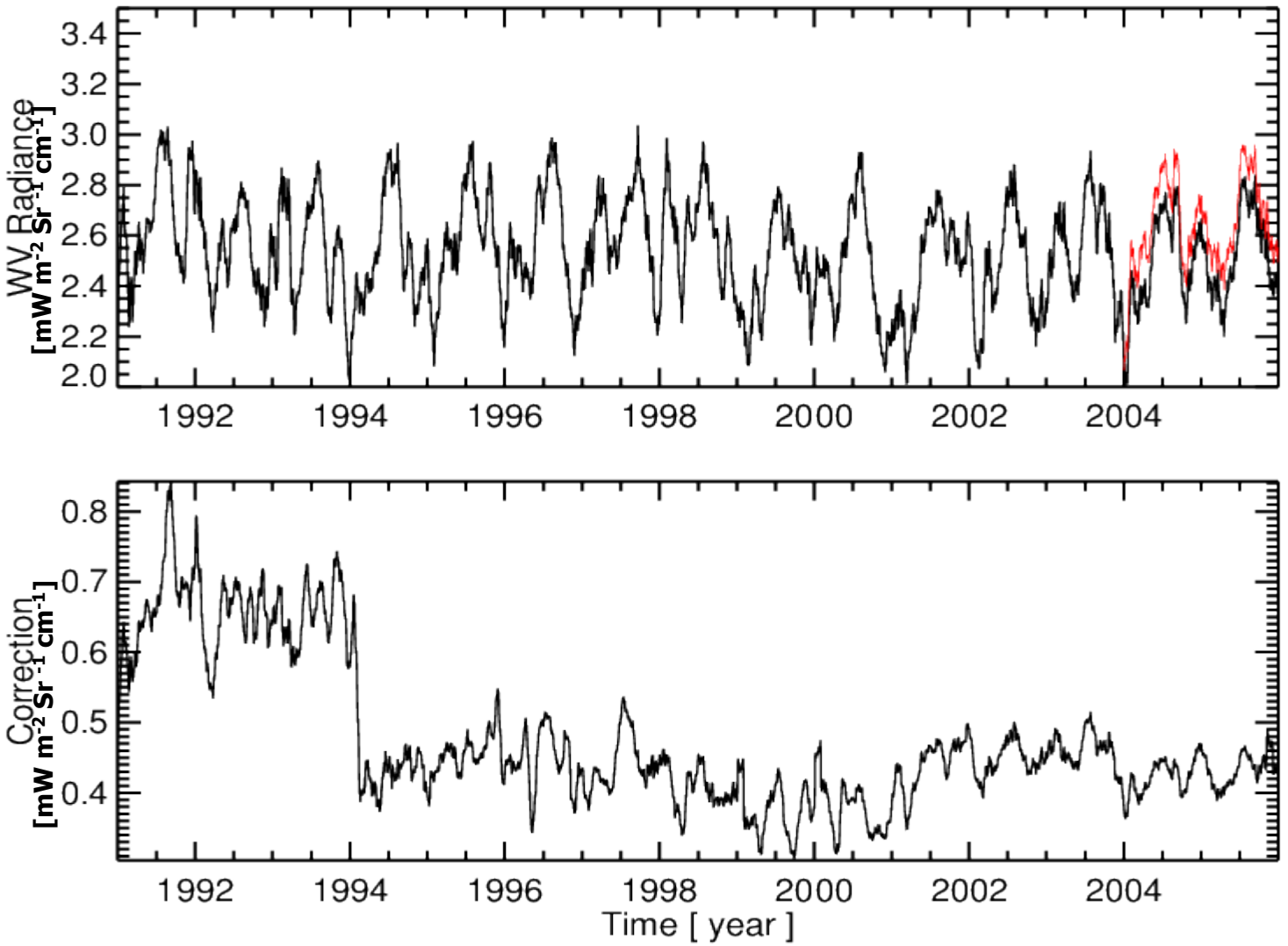


MFG

MSG

Homogenised IR 10.8 μm at Payerne site with original calibration (top) and absolute correction (bottom).

Homogenised MFG and MSG radiances



MFG

MSG

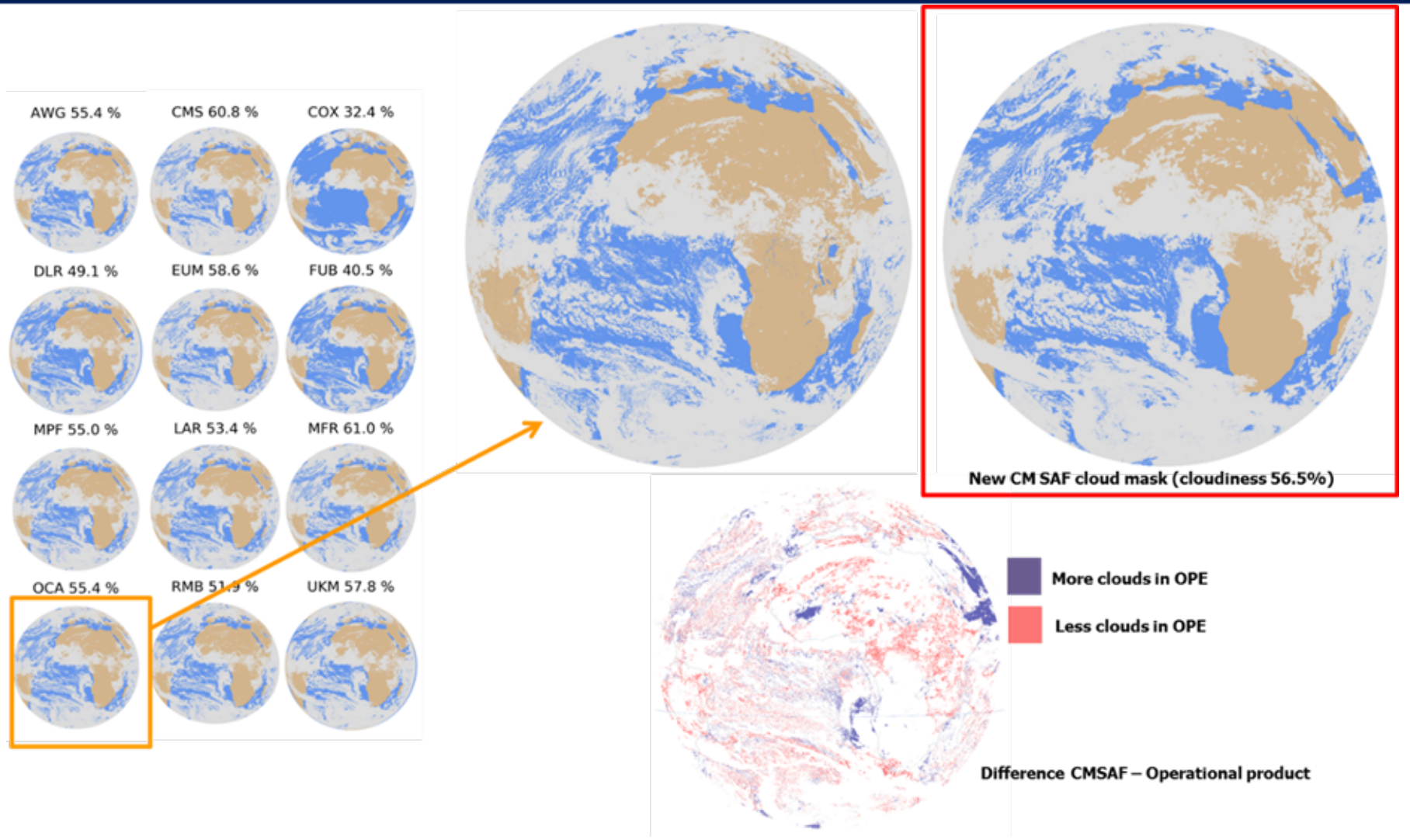
Homogenised IR 6.3 μm at Payerne site with original calibration (top) and absolute correction (bottom).

D3.13 - TCDR MFG and MSG AMVs (1982 - 2014)

Item	Development	Integration	Processing
Processing Environment	Modified framework on new infrastructure	Completed	N/A
Cloud Detection	Integration of CM SAF algorithm for MFG/MSG	Completed	Completed
Cloud Top Height	MFG development, MSG exist (based on EUMETSAT method)	Completed	Completed
ASR	None (reuse of EUMETSAT method)	Completed	Completed
CSR	None (reuse of EUMETSAT method)	Completed	Completed
AMV	Adaptation of MSG algorithm to MFG	Completed	Ongoing

- Uses new images from D3.12;
- AMV processing will need until early January 2018;
- Final report can only be finished by 25 January 2018.

Example of Cloud Mask Retrieval



Example of CLM retrieval. Several other clouds produced using the various algorithms taking part of the ICWG inter-comparison exercise. A comparison with the EUMETSAT operational product is also shown.

Summary

- Made very good progress during 2017 but stillhave 3 outstanding deliverables mostly due to technical issues;
- Peer reviewed papers (~5) for each data record addressed are in preparation for 2018;
- ERA-CLIM 1 and 2 have greatly helped to develop an activity on climate at EUMETSAT;
- In total we dealt with 9 geostationary and 33 polar orbiting instruments (13 AVHRRs, 4 SSM/T2, 3 AMSU-B, 4 MHS, 2 GRAS, 1 CHAMP, 6 COSMIC);
- The first re-calibration of the IR and WV channel for the Meteosat satellites covering both satellite generations has been achieved. ERA-CLIM2 method has been used to re-calibrate JMA satellites;
- The first re- and inter-satellite calibration for the microwave sounders SSM/T2, AMSU-B and MHS using the ERA-I observation feedback archive has been achieved;
- The new EUMETSAT radio occultation wave optics operator has been successfully used to produce data records for GRAS, CHAMP and COSMIC satellites;
- Time series of Atmospheric Motion Vectors have been produced for AVHRR and Meteosat data. Historic AVHRR (prior NOAA-18) for the first time at EUMETSAT;
- ERA-CLIM provided the ramp up for an even bigger set of activities in C3S – Good bye ERA-CLIM – Welcome C3S_311b.