Recent changes in the ECMWF NWP system

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Data in		Date		Data out
GOES-15 CSR + AMVs	←	April 2012	→	ENVISAT AIRS Ch. 355
		May 2012		
		June 2012		
		July 2012		
		August 2012		
ATMS	←	September 2012	→	Met-9 AMVS 700-1000
		October 2012	→	AIRS Ch 1119
		November 2012		
Metop B AMSU-A & MHS	←	December 2012	→	NOAA-18 SBUV
OSCAT				
Met 10 AMVs	←	January 2013	→	Met-9 AMVs & CSR
Met 10 ASR	←	February 2013		
		March 2013	→	NOAA-17 SBUV
		April 2013	→	NOAA-19 AMSU-A Ch.7
Metop-B GRAS	←	May 2013		
SMOS in SEKF	←	June 2013		
		July 2013	→	NOAA-19 HIRS
Metop-B ASCAT	←	August 2013		
		September 2013		
		October 2013		
		November 2013	→	Metop-A AMSU Ch.8
		December 2013		
		January 2014		
Metop-B IASI	←	February 2014		
		March 2014		

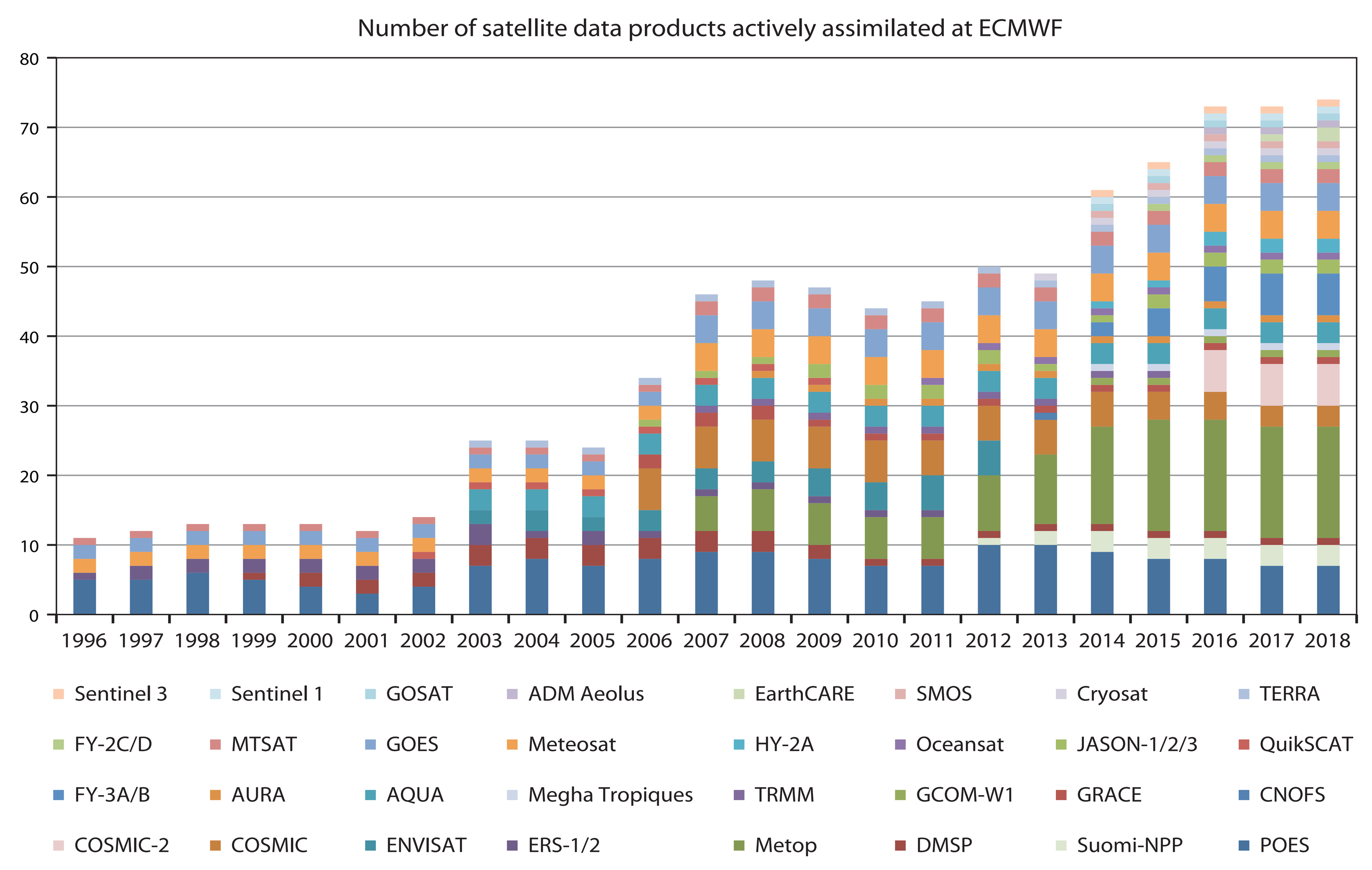
Satellite	Orbital position	Microwave temperature sounder	Microwave humidity soundeE	Microwave imager	Broadband infrared Sounder or Imager	Advanced infrared sounder
NOAA-15	16:44	A	X		X	
NOAA-16	20:37	A	P		P	
NOAA-17	19:03	X	X		X	
NOAA-18	14:58	A	A		P	
NOAA-19	13:34	A	A		P	
Metop-A	21:30	A	A		A	A
Metop-B	21:30	A	A		A	A
Aqua	13:40	A	X			A
SuomiNPP	13:30	A	A			P
FY-3A	10:15	X	P	E	E	
FY-3B	13:30	X	P	E	E	
FY-3C	10:00					
DMSP F16	06:25	P	P	P		
DMSP F17	05:37	P	A	A		
DMSP F18	08:08	P	P	P		
TRMM	Low-inc			A		
GCOMW1	13:30			P		
Coriolis	06:00			P		
MeghaT	Low-inc		E			
Met-7	57.3° E				A	
Met-10	0° E				A	
GOES-13	75° W				A	
GOES-15	135° W				A	
MTSAT-2	145° E				A	
FY-2D	86.5° E				E	
FY-2E	105° E				E	
Active		8	6	2	7	3
Passive		3	5	4	3	1
Under Evaluation		0	1	2	4	0

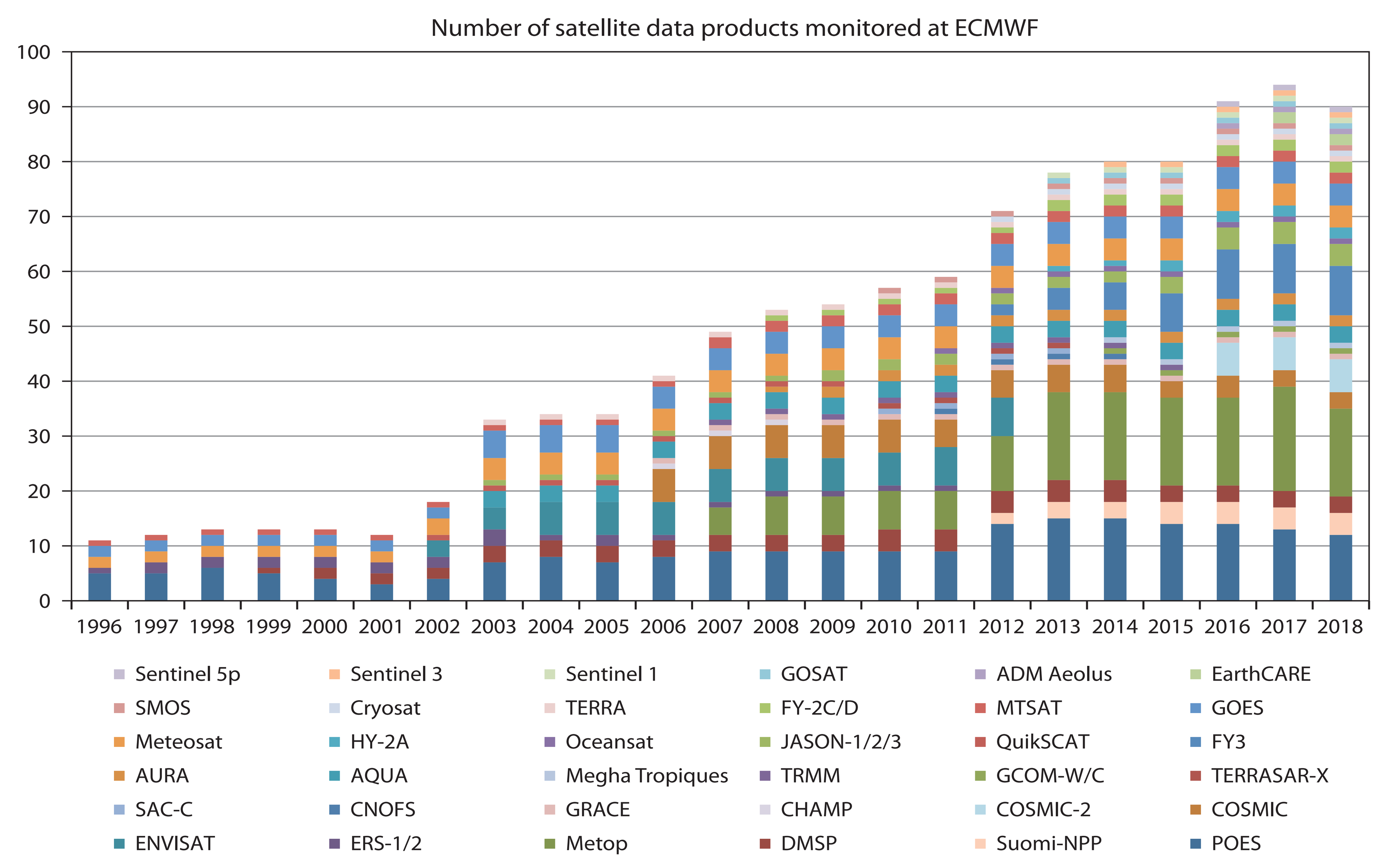
A = Operational (active); P = Operational (passive); E = Evaluation in progress; X = Instrument withdrawn.
Yellow shading shows changes since ITSC-18.

Table 1 Overview of the current use of the main meteorological satellites at ECMWF with TOVS heritage instruments

For more information on ECMWF developments

Infrared sounding		
1p.11	Reima Eresmaa	Assimilation of Cross-track Infrared Sounder radiances at ECMWF
7.01	Marco Matricardi	Direct assimilation of Principal Component data for operational Numerical Weather Prediction
7.04	Reima Eresmaa	Implications of observation error correlation on the assimilation of interferometric radiances
9p.07	Stefano Migliorini	All-sky assimilation of selected water vapour infrared IASI channels at ECMWF: strategy and initial trials
Microwave and broadband infrared sounding		
1p.13	Heather Lawrence	An update on the assimilation of ATMS data at ECMWF
1.13	Qifeng Lu	The data quality and performance of four FY3 instruments for NWP
1p.16	Keyi Chen	Assessment of Chinese Satellite FY3A/B MWHS
5p.05	Heather Lawrence	Situation-dependent observation errors for AMSU-A tropospheric channels in the ECMWF forecasting system
5p.06	Stephen J. English	Prospects for assimilating more sounder radiances over snow covered surfaces
9.01	Stephen J. English	All-sky assimilation of MHS and HIRS sounder radiances
Microwave imagers		
5.01	Masahiro Kazumori	Use of the ocean surface wind direction signal in microwave radiance Assimilation
5.02	Louis Francois Meunier	Impact of whitecap coverage derived from a wave model on the assimilation of radiances from microwave imagers
Data assimilation tools and validation		
4p.03	Cristina Lupu	Evaluation of RTTOV-11 in the IFS
10p.04	Niels Bormann	Situation-dependent estimates of background errors in radiance space
11.01	Cristina Lupu	The impact of satellite data within the ECMWF system
11p.05	Stephen English	The role of satellite data in the ECMWF forecasts of Hurricane Sandy





ECMWF Forecast model changes relevant to satellite sounding since ITSC-18

The main model change was the transition from 91 to 137 levels. The change provides a vertical resolution increase that is consistent with the continuous effort to increase the realism of simulations by increasing both vertical and horizontal resolution. The physics in the model has benefited from several notable advances since ITSC-18. Building on improvements made shortly before ITSC-18 these have generated a more realistic representation of cloud microphysics, e.g. supercooled water at the top of stratocumulus, and the timing of tropical convection. These have been long standing problems in NWP models and their improvement further enhances the value of all-sky assimilation of satellite sounder and imager data. Comparison of model fields with CloudSat (radar) and Calipso (lidar) show that the model captures the 3D structure of real cloud systems remarkably well. In the past Strong Sudden Stratospheric warmings were not always captured well by the model, a situation made worse by subsequent observation rejection as the background was too far from truth. A weak instability in the semi-Lagrangian trajectory calculation has been found to cause these problems in the stratosphere. In addition, there are on-going efforts to reduce long-standing biases in the troposphere-stratosphere exchange. Changes will be made in Cycle 40r3 that will significantly improve this, leading to less rejection of stratospheric AMSU-A data, and much better forecasts for the subsequent development of these events. There is a significant effort for land surface processes, complementing the effort in data assimilation that may lead to more accurate land surface skin temperatures. This will be very helpful for satellite data assimilation over land where often knowledge of the skin temperature is critical (both for cloud screening and the radiative transfer model accuracy). Some key changes are listed below.

Cycle 38R1

- Cloud physics changes (e.g. ice supersaturation, ice melting to rain) – Richard Forbes

Cycle 38R2

- Change from 91 to 137 levels – ECMWF Tech Memo 704 Peter Bauer et al 2013
- Modification of surface drag – Anton Beljaars
- Adjustments to boundary layer and convection schemes to reduce impact of resolution on clouds – Irina Sandu and Maike Ahlgrimm

Cycle 40r1

- Modification of convection to address diurnal cycle of precipitation – Peter Bechtold
- Changes to boundary layer diffusion and sub-grid orography to improve near surface wind profiles and Northern Hemisphere winter scores – Irina Sandu and Anton Beljaars
- Correction of handling of snow albedo in radiation – Gianpaolo Balsamo

ECMWF Data Assimilation changes relevant to satellite sounding since ITSC-18

ECMWF's data assimilation system is still based on a 4D-Var analysis. It has been a hydrid system since 2011, where flow-dependent background errors are provided by an Ensemble of 4D-Vars (EDA). Since ITSC-18 the hybrid system has been significantly improved, with the EDA now supplying flow-dependent estimates of the unbalanced components of error variance (in addition to the originally implemented balanced components). In October 2013, EDA-based flow-dependent covariances have been introduced. The covariance estimation required the number of EDA members to be increased from 10 to 25. Effort has also been given to using EDA information in satellite data background checks, to make these more flow dependent. Significant effort was needed to adapt the DA system to 137 levels (e.g. background error revision). The number of outer loops was increased from 2 to 3 in the 'early delivery' 6-hour 4D-Var cycle, like it is in the 'delayed cut-off' 12-hour 4D-Var cycle. This was found to give significant benefits for the analyses of a number of tropical cyclones. ECMWF are also investing effort in improved land surface data assimilation, for example for snow, where error estimates were revised in the new OI analysis, more observations were gathered from member states, and the use of IMS snow cover satellite data was improved. There are strong interactions with the forecast model and satellite observation related activities at ECMWF. ECMWF staff are also undertaking ground breaking research into improved scalability for 4D-Var, to ensure its long term future. Some key changes in 2012 and 2013 are listed below.

Cycle 38R1

- New climatological background errors – Elias Holm
- Correction of observation error for radiosondes in the stratosphere – Lars Isaksen

Cycle 38R2

- Number of outer loops increased from 2 to 3 – Massimo Bonavita
- Unbalanced error variances estimated from EDA – Massimo Bonavita, Elias Holm
- Increase of number of vertical levels from 91 to 137 in EDA – Massimo Bonavita, Elias Holm
- Model error cycling in stratosphere switched off – Yannick Tremolet

Cycle 40R1

- EDA increased to 25 members – Massimo Bonavita
- On-line estimation of background error covariances – Massimo Bonavita, Elias Holm
- Perturbation of land surface observations in the EDA – Patricia de Rosnay and Anne Fouilloux
- Revised snow analysis – Patricia de Rosnay and Anne Fouilloux

ECMWF Satellite assimilation changes since ITSC-18

Several of the satellite data improvements reported at ITSC-18 were implemented soon after in ECMWF cycle 38R1. Notably improved use of MHS over land and the first attempt to use sounding radiances from AMSU-A in the all-sky assimilation framework (i.e. analysing cloud and precipitation). Cycle 38R2 was the vertical level upgrade from 91 to 137 levels, so satellite changes were kept to a minimum. However Cycle 40R1 had a large number of important changes in use of satellite data, especially for sounder radiances. Notable was the move of a humidity sounder radiance assimilation into the all-sky system for the first time. This is being presented at ITSC-19 (9.01), alongside the use of SSMIS humidity channels in an all-sky framework over land. The ability to use EDA information on quality control for sounder radiances is an important step in fully utilising the power of the EDA system and is presented by Bormann in 10p.04. Significant process was also made in assimilating radiances over sea ice and cold seas, allowing a large increase in the use of MHS in high latitude regions. Note that introduction of new satellite data types are not listed here below, as these are given in the data use change panel above.

Cycle 38R1

- Assimilation of MHS channel 5 over land – Enza Di Tomaso
- Passive assimilation of AMSU-A channel 4 using all-sky approach – Alan Geer
- Switch to FASTEM-5 – Niels Bormann

Cycle 38R2

- Fix to footprint averaging and enhancements to the quality control of ATMS data – Niels Bormann

Cycle 40R1

- Assimilation of all-sky SSMIS 183 GHz using discrete dipole snow scattering – Alan Geer
- Increased use of AMSU-A/B/MHS data over sea-ice – Enza Di Tomaso
- Use of calibrated EDA spread in QC check for ATOVS – Niels Bormann
- Flow-dependent observation errors and revised QC for AMVs – Kirsti Salonen
- Improved refractivity interpolation between model levels in the stratosphere – Sean Healy
- Imager-assisted cloud detection for IASI radiance data – Reima Eresmaa
- SSMIS radiance monitoring over land – Fabrizio Baordo
- Quality control for ATMS lunar intrusions – Niels Bormann
- Improved post-processing of Aerosol Optical Depth in MACC IFS – Richard Engelen
- Observation operators for GOSAT CO_2 and CH4 retrievals – Richard Engelen

Acknowledgements ECMWF gratefully acknowlege the invaluable funding from EUMETSAT and ESA and collaboration with other agencies, notably CMA, JMA, NOAA and NASA. Thanks to Anabel Bowen for her help with this poster.

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