Release of new NWP SAF ERA-5 satellite monitoring

A McNally and M Dahoui
ECMWF

This documentation was developed within the context of the EUMETSAT Satellite Application Facility on Numerical Weather Prediction (NWP SAF), under the Cooperation Agreement dated 7 December 2016, between EUMETSAT and the Met Office, UK, by one or more partners within the NWP SAF. The partners in the NWP SAF are the Met Office, ECMWF, DWD and Météo France.

Change record			
Version	Date	Author / changed by	Remarks
0.1	08.2.18	A McNally	Version for distribution to SG
1.0	07.3.18	A McNally	Include suggestions from SG. Version for release

Brief introduction to the product

The NWP SAF carries out a continuous, real-time monitoring of the quality of operational satellite observations and posts information on its website. This provides valuable feedback to data producers and warnings to data users.

The monitoring information is obtained by comparing the satellite observations (usually measured radiances) against values computed from a reference state of the atmosphere (provided by a high quality NWP short-range forecast or analysis). At any given time the NWP system (which incorporates information from the entire global observing system) represents the best available estimate of the atmospheric state against which the satellite observation quality can be assessed.

Over recent decades the advances in data assimilation techniques and atmospheric modelling have resulted in significant improvements in the accuracy of the NWP reference state. However, these intermittent changes to the reference state (that tend to occur when NWP centres upgrade their systems) make it difficult to assess the long term quality of a particular instrument (e.g. over the lifetime of the satellite) in a consistent manner (which is needed to use the data in any climate applications).

Atmospheric states produced by re-analysis projects are generated using a fixed state-of-the-art NWP system applied to historical observations. As such they provide a much more suitable reference against which we can assess the quality of a satellite over its lifetime. To support users involved in climate applications - long time-series quality statistics for satellites monitored against the ERA-Interim reference have been included as an additional option to the existing operational monitoring web pages.

Monitoring statistics using ERA-5 as a reference

This new release of the product uses the ERA-5 reanalysis as the atmospheric reference state. ERA-5 replaces ERA-Interim as the primary ECMWF reanalysis product, but both will remain openly available and the new satellite monitoring statistics are put on the website as an additional option (i.e. the previous ERA-Interim monitoring will remain available). The main differences between the ERA-5 and ERA-Interim reference systems are summarised in table 1.

	ERA-Interim	ERA5
Period	1979 – present	1979 – present
Production period	August 2006 – end 2018	Jan 2016 – end 2017, then continued in near real-time
Assimilation system	IFS Cycle 31r2	IFS Cycle 41r2
Model input	As in operations (inconsistent SST)	Appropriate for climate (e.g. CMIP5 greenhouse gases, volcanic eruptions, SST and sea-ice cover)
Spatial resolution	79 km globally, 60 levels to 0.1 hPa	31 km globally, 137 levels to 0.01 hPa
Uncertainty estimates	None	From a 10-member Ensemble of Data Assimilations (EDA) at 63 km resolution
Output frequency	6-hourly analysis, 3-hourly forecast fields	Hourly analysis and forecast fields, 3-hourly for the EDA
Input observations	As in ERA-40 and from Global Telecommunication System	In addition, various newly reprocessed datasets and recent instruments that could not be ingested in ERA-Interim
Variational bias scheme	Satellite radiances	Also ozone, aircraft and surface pressure data
Satellite data	RTTOV-7, clear-sky	RTTOV-11, all-sky for various components
Additional innovations		Long-term evolution of CO2 in RTTOV, cell-pressure correction SSU, improved bias correction for radiosondes, EDA perturbations for sea-ice cover

Table 1

Satellite sensors monitored in the new product

An expanded list of satellite sensors (compared to ERA-Interim) are provided in the new ERA-5 products:

Infrared radiances:	AIRS, CrIS, IASI and HIRS
Microwave radiances:	AMSUA, AMSUB, MHS, ATMS, AMSR2, MWHS2 and SSM/IS
Atmospheric Motion Vectors:	AVHRR, MODIS, METEOSAT, GOES, HIMAWARI, MTSAT
Scatterometers:	ASCAT
GPS-RO:	CHAMP, COSMIC, GRAS, TERRA-SARX, SCA-C, TANDEM-X

To assist in the discrimination between anomalies in the satellite observations and the reference state, time series monitoring of conventional (in situ) observations are also provided.

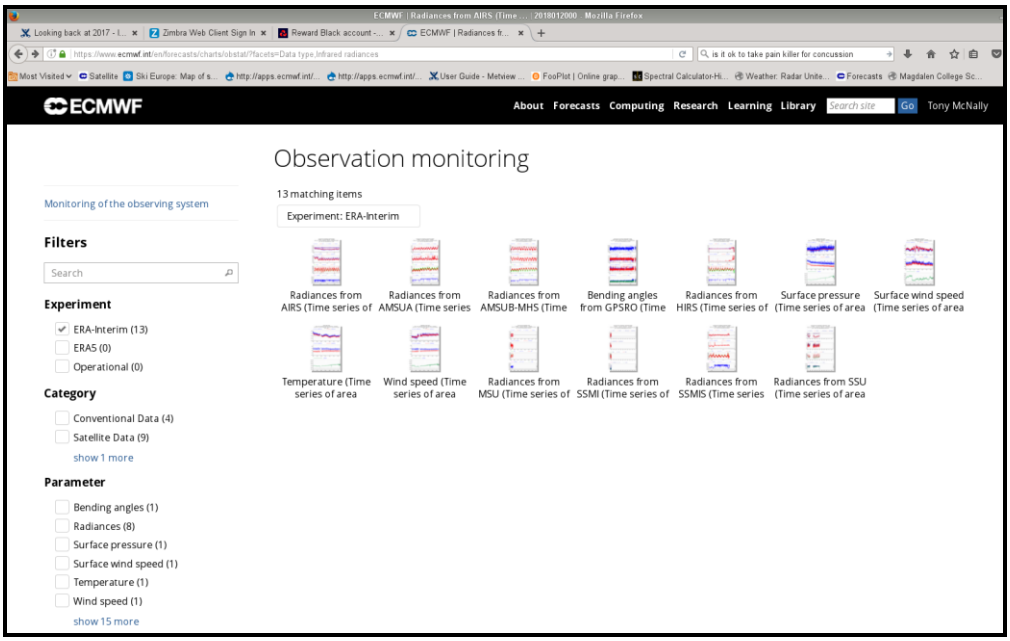
Temperature:	Balloon (land/ship) and aircraft (TEMP, AIREP, AMDAR, ACAR)
Wind Speed:	Balloon (land/ship) and aircraft (TEMP, PILOT, AMDAR, ACAR)
Surface Pressure:	Land/ship surface data and drifting/anchored buoys (SYNOP, METAR, DRIBU, SHIP)

Accessing the new plots

The new plots are openly available on the main ECMWF monitoring site. Having selected an observation type of interest from the main menu (e.g. Infrared sounding radiances) on:

https://www.ecmwf.int/en/forecasts/quality-our-forecasts/monitoring-observing-system#Satellite

The satellite monitoring plots against ERA-5 (or ERA-Interim or ECMWF Operations) can be selected by ticking the appropriate box in the left hand column of options.

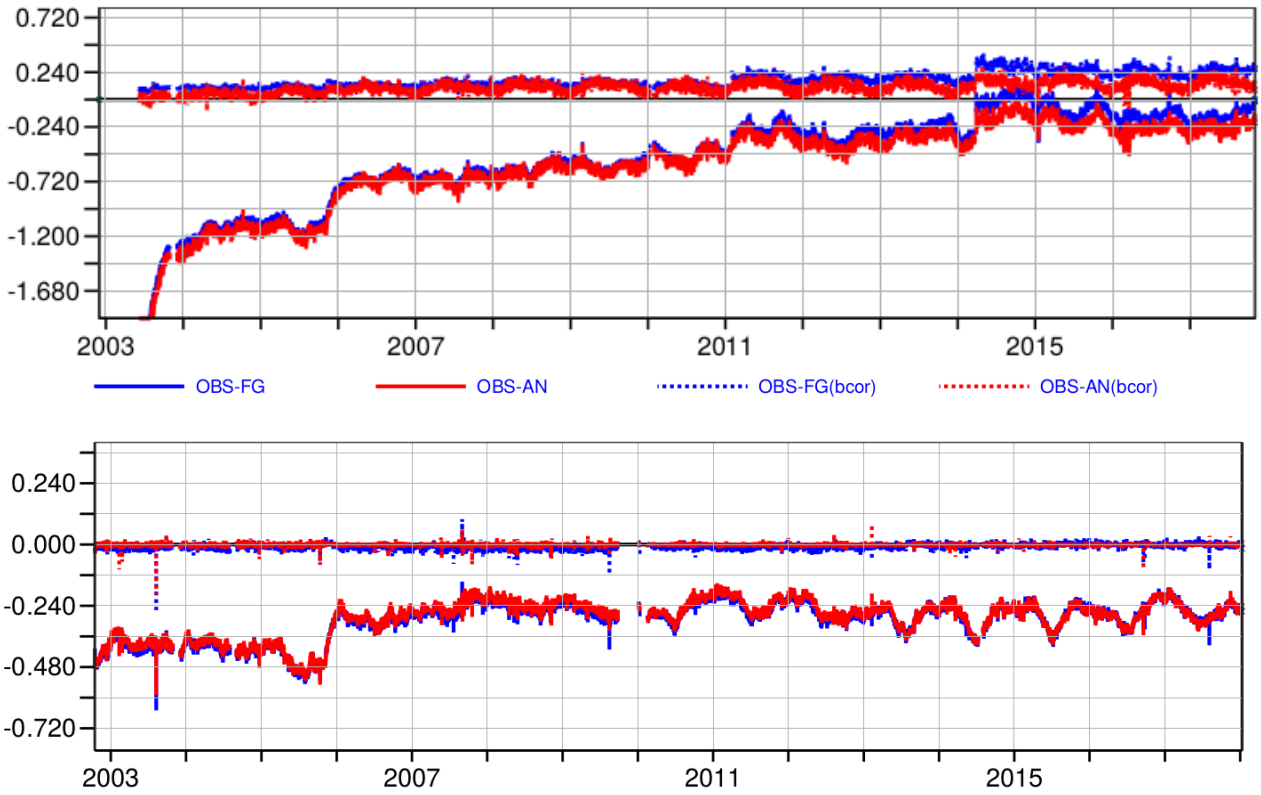


Validation of the new ERA-5 monitoring

In so far as these monitoring statistics have been generated by the ERA-5 system they have already undergone an extensive checking and validation process within the context of the ERA-5 reanalysis project. These include an automated alarm system checking for anomalies in departure statistics and a manual follow up of any detected issues. The ERA-5 atmospheric reference itself has been checked internally at ECMWF, by science partners in the Copernicus consortium and extensively in the wider scientific community.

A supplementary validation of the new product has cross checked long time-series radiance monitoring statistics from the ERA-5 reanalysis reference against those generated from the previous ERA-Interim reference. Where differences have been found – these can generally be attributed to the superior quality of ERA-5 compared to ERA-Interim.

An example is shown in figure 2 for monitoring the window channel (787) on AIRS. In the upper panel it ERA-Interim shows an apparent drift in long term negative bias from 2003 to the present day. This anomaly has been traced to a problem with the initialisation of bias corrections for this channel and adverse interactions with cloud detection in the subsequent data assimilation.



The lower panel shows the same time series for AIRS 787 in ERA-5 where the bias initialisation problem was addressed. There is now no evidence of a drift in this channels and it is believed that this is a much more realistic representation of the excellent stability of this channel and the AIRS instrument in general.

There are a number of other examples where the ERA-5 reference atmosphere has improved relative to ERA-Interim (e.g. representation of orographic gravity waves, sudden stratospheric warmings) and these lead to more reliable long term assessments of the satellite observation quality.

Ongoing validation and user feedback

Obviously a product as large, comprehensive and complex as this cannot be validated in any definitive sense, but every effort has been made to ensure it is free from major errors or anomalies. We expect that as more people begin to make use of the new time series, issues may be found and these can be addressed as incremental product improvements. We will also respond to user feedback regarding the content and presentation of the website as part of our ongoing commitment to satellite monitoring.