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METEOROLOGY

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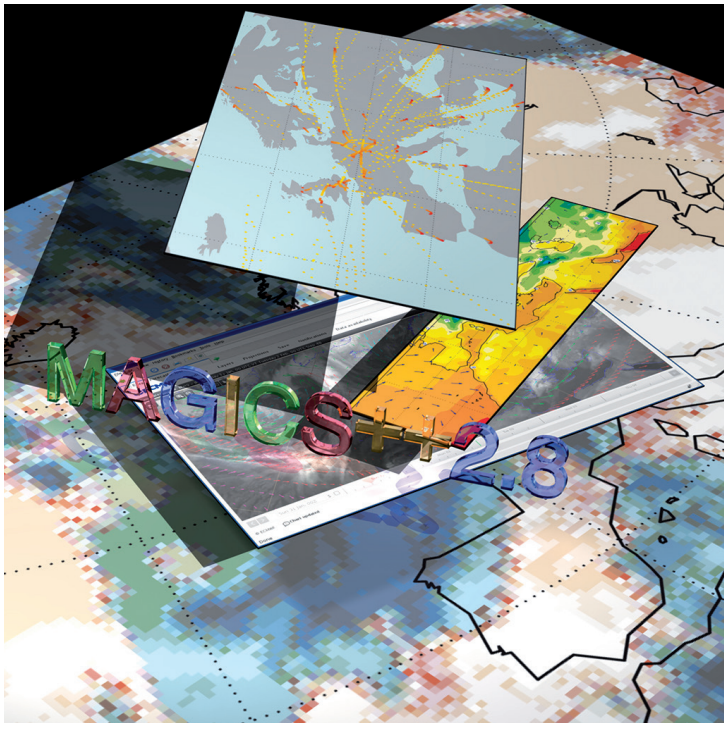


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# Assessment of FY-3A satellite data

Qifeng Lu, Bill Bell, Peter Bauer, Niels Bormann

Over the last year data from a new Chinese meteorological satellite, FY-3A, has been introduced into the ECMWF data assimilation system to assess the quality of the data. Initial results are encouraging and build confidence that the follow-on series of FY-3 satellites will be widely used for NWP data assimilation.

## Satellite FY-3A

Since the launch of China's first polar orbiting satellite (FY-1A) in 1988, China has launched a series of four further polar orbiting satellites and five geostationary satellites. Both polar (FY-3) and geostationary (FY-4) satellite programmes will continue over the next decade and an ambitious schedule of launches is currently planned, accommodating increasingly sophisticated sensors for operational meteorology. FY-3 data will soon become an important component of the global observing system and will provide valuable data for operational NWP, reanalysis and climate research.

FY-3A is the preparatory platform for a subsequent series of seven satellites and was successfully launched from the Taiyuan Launching Center on 27 May 2008. FY-3A carries a suite of 11 instruments. Of particular interest for NWP data assimilation applications are three instruments which make up the Vertical Atmospheric Sounder System (VASS): the Microwave Temperature Sounder (MWTS), the Microwave Humidity Sounder (MWHS) and the Infrared Atmospheric Sounder (IRAS). These instruments are similar in specification to those on NOAA platforms which have been key components of the data assimilation system at ECMWF for the last decade – see Table 1.

Also of interest for NWP is the 10-channel Microwave Radiation Imager (MWRI), an imaging instrument similar in specification to the Advanced Microwave Scanning Radiometer (AMSR-E) currently used in operations at ECMWF and processed via the new *all-sky* assimilation system introduced with cycle 35r2 of ECMWF's Integrated Forecast System (IFS).

As a preparatory platform it is essential that the performance of the FY-3A instruments is assessed carefully, so that any deficiencies in the design or on-orbit performance of the instruments can be rectified in future instruments. As part of a comprehensive calibration and validation programme data from the FY-3A instruments has been introduced into the IFS and assessed by Qifeng Lu from the Chinese National Satellite Meteorology Centre during a successful 12 month visit to ECMWF which ended in December 2009. This work has included a comparison of the FY-3A observations with model equivalents as well as an assessment of the impact of the data on analyses and forecasts, through observing system experiments (OSEs).

| **Instruments on FY-3A** | **Similar instruments on NOAA/NASA platforms** |
|---|---|
| Microwave Temperature Sounder (MWTS) | Microwave Sounding Unit (MSU) |
| Microwave Humidity Sounder (MWHS) | Advanced Microwave Sounding Unit-B (AMSU-B) |
| Infrared Atmospheric Sounder (IRAS) | High Resolution Infrared Radiation Sounder (HIRS) |
| Microwave Radiation Imager (MWRI) | Advanced Microwave Scanning Radiometer (AMSR-E) |

**Table 1** Some of the instruments on FY-3A and those on NOAA/NASA platforms with similar specifications.


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## Data quality

Histograms of background departures for the three sounding channels of the MWTS (channels 2–4) are shown in Figure 1. Also shown for comparison are the statistics from the equivalent channels for NOAA-18 AMSU-A obtained for the same period. These statistics measure the fit of the ECMWF model to the measured radiances and give a good early indication of data quality as any gross errors in the data would be manifested as a large spread in the background departures. The fit of the measured MWTS radiances to the model is better than 0.3 K (standard deviation), only slightly larger than the equivalent AMSU-A statistics. The larger standard deviations are to be expected and result from the higher noise levels in the MWTS measurements, consistent with the instrument's pre-launch specifications. A bias, of up to 2 K, in the MWTS brightness temperatures relative to AMSU-A is under investigation but is adequately corrected by the variational bias correction.

Histograms for the background departures for the Microwave Humidity Sounder (MWHS) are also shown in Figure 1 alongside equivalent histograms for the MetOp-A MHS instrument. The MWHS data is similar in quality to the MHS data and was judged to be of sufficient quality to include in assimilation experiments. Similar analyses of the infrared sounder (IRAS) data exposed some orbital biases in the highest peaking temperature sounding channels (1–3). However, the departure statistics for the channels equivalent to HIRS channels currently used in operations, not shown here, showed the data to be of similar quality.

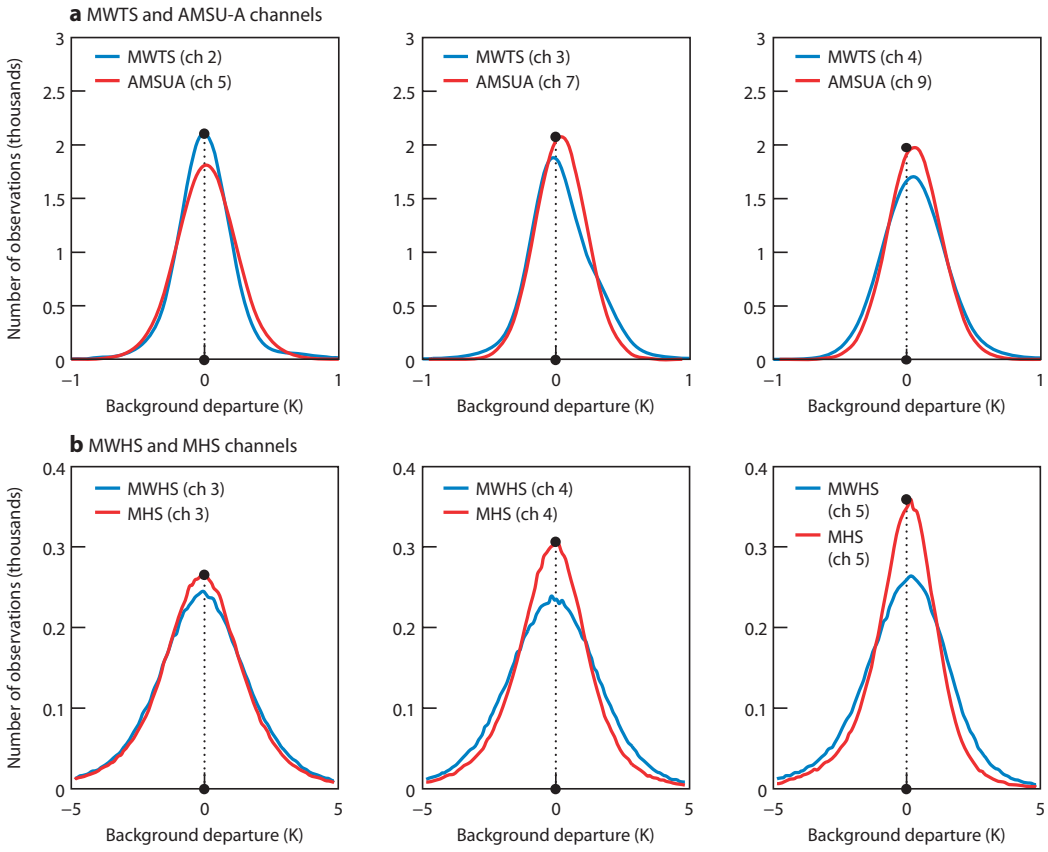


**Figure 1** (a) Histograms of background departures for MWTS channels 2 (53.6 GHz), 3 (54.9 GHz) and 4 (57.3 GHz) along with the results for the equivalent AMSU-A channels (channels 5, 7 and 9). (b) As (a) but for background departures for MWHS channels 3 (183±1 GHz), 4 (183±3 GHz) and 5 (183±7 GHz) along with the results from the equivalent MHS channels (channels 3, 4 and 5).

Histograms of background departures for the Microwave Imager (MWRI) channels are shown in Figure 2. Also shown for comparison are the departures for the equivalent channels of AMSR-E. The MWRI data are of similar quality to the AMSR-E data and build confidence that the instrument design is sound. Due to mechanical interactions with the platform the MWRI has been activated only intermittently and the dataset is therefore relatively sparse, thereby preventing a meaningful assessment through assimilation experiments.

The impact of the FY-3A sounding instruments on analyses and forecasts was assessed in a series of assimilation experiments. In a baseline experiment using an observation depleted system, the impact of FY-3A data was compared with that from the MetOp-A sounding instruments. The following configurations were used.

- Control (conventional observations + NOAA 18/AMSU-A + ozone data + scatterometer data)
- Control + MetOp (AMSU-A (ch.5, 7, 9) + MHS + HIRS)
- Control + FY-3A (MWTS + MWHS + IRAS)

The results in terms of the anomaly correlation of the forecasts in the northern and southern hemispheres over the period 30 July to 1 November 2008 are shown in Figure 3. In the northern hemisphere the impact of the FY-3A data is very similar to that from the MetOp-A instruments. In the southern hemisphere the impact is, for forecast ranges to day 7, positive for the FY-3A data and a significant fraction of that obtained from MetOp-A. In assimilation experiments in which FY-3A data is added to *a full observing system* the impacts are, as expected, neutral.

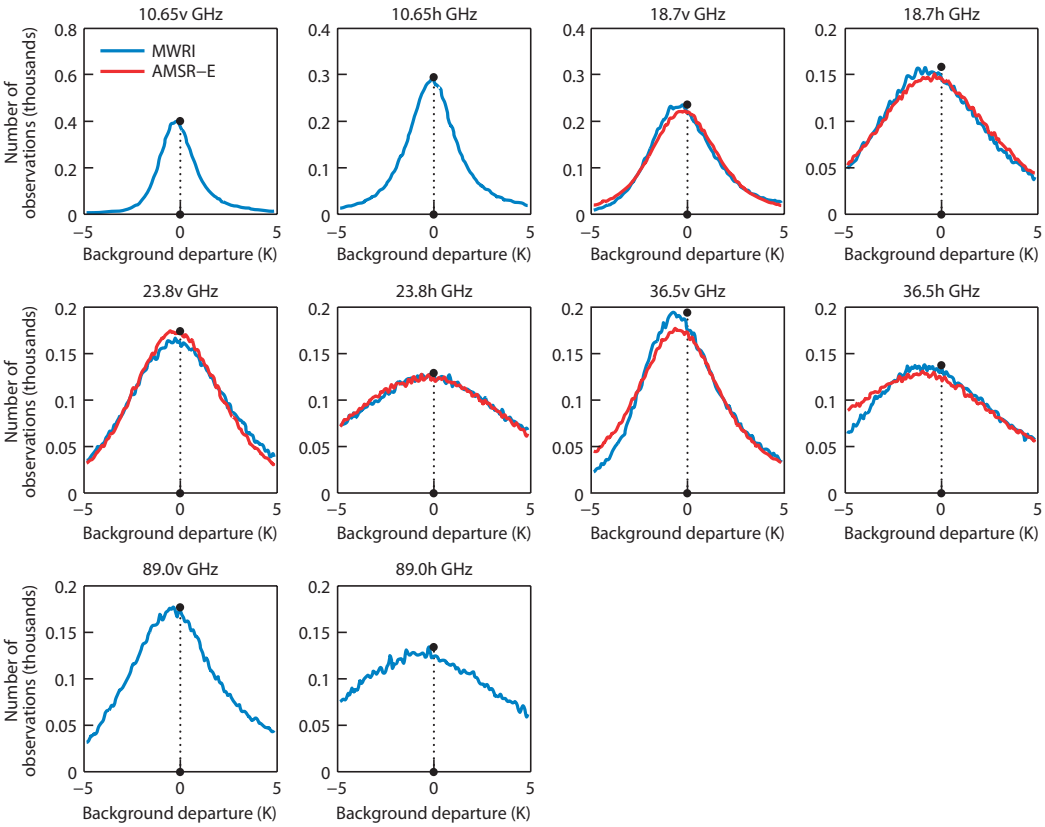


**Figure 2** Histograms of background departures for the MWRI channels and equivalent AMSR-E channels where available.


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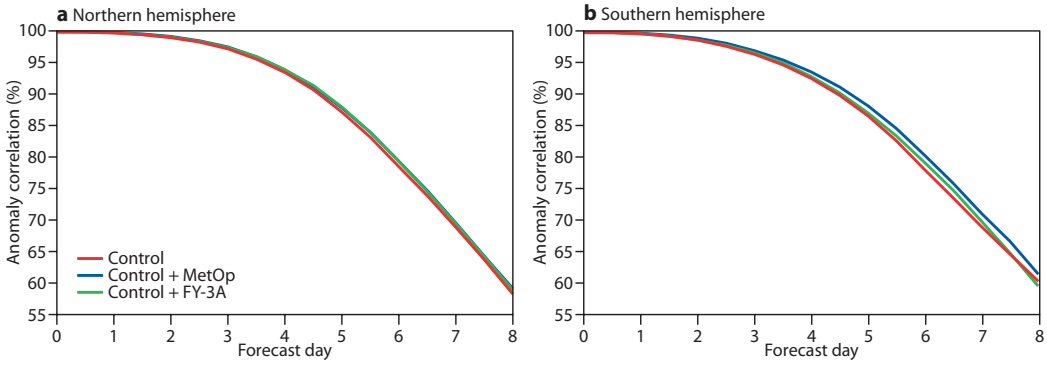


**Figure 3** Anomaly correlation for 500 hPa geopotential height in (a) the northern hemisphere and (b) the southern hemisphere for an observing system depleted control experiment (red) as well as experiments in which either FY-3A (green) or MetOp-A (blue) sounding data has been added.

## Future collaboration

Collectively these are very encouraging results and build confidence that, with further improvements in the specification and on-orbit performance of future sensors, FY-3 will soon become an integral component of the global observing systems. This work also marks the beginning of a collaborative programme between the Chinese Meteorological Agency (CMA) and ECMWF, aimed at optimising the benefits of FY-3 data. It is currently planned to monitor FY-3A data as part of the spring 2010 upgrade to IFS cycle 36r3.



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