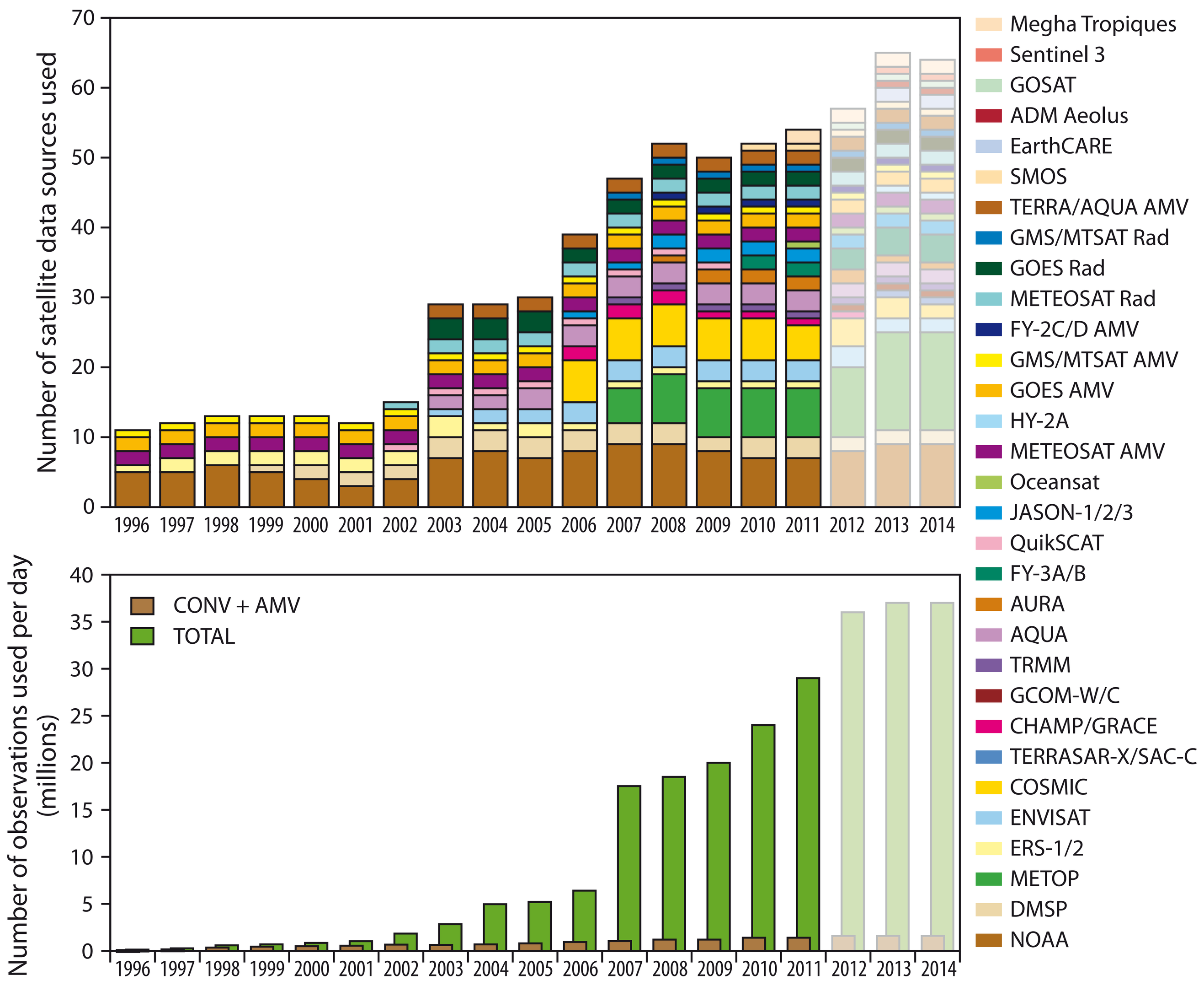
Use of satellite data at ECMWF

Evolution of instruments and data volume



Data types and instruments currently assimilated at the European Centre for Medium-Range Weather Forecasts

ECMWF operationally assimilate observations from 50 satellite sensors, and this will rise to over 60 by 2013.

Radiances

- AMSU-A on NOAA-15/18/19, Aqua, MetOp
- MHS on NOAA-18/19, MetOp
- SSM/I on F-15, AMSR-E on Aqua
- HIRS on NOAA-17/19, MetOp
- AIRS on Aqua, IASI on MetOp
- MVIRI on Meteosat-7, SEVIRI on Meteosat-9
- IR imager on GOES-11/12, MTSAT-1R

Bending angles from GPS Radio occultation

- COSMIC (5 satellites), TSX and GRACE-A

Ozone

- SBUV on NOAA-17/18
- OMI on Aura
- SCIAMACHY on ENVISAT

Atmospheric Motion Vectors

- Geo winds on Meteosat-7/9, GOES-11/12, MTSAT-1R
- Polar winds on MODIS on Terra/Aqua

Sea surface parameters

- 10m wind vectors from ASCAT
- Significant wave height from RA-2/ASAR on ENVISAT, altimeter on JASON

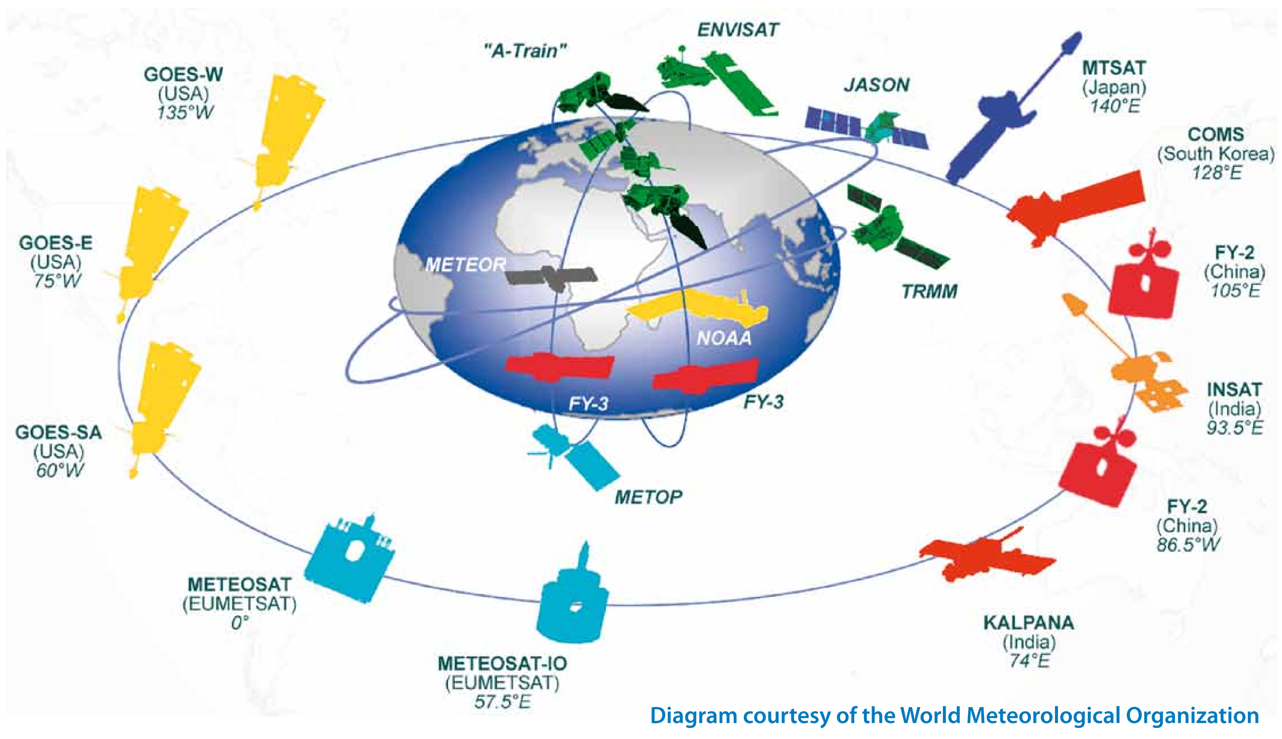


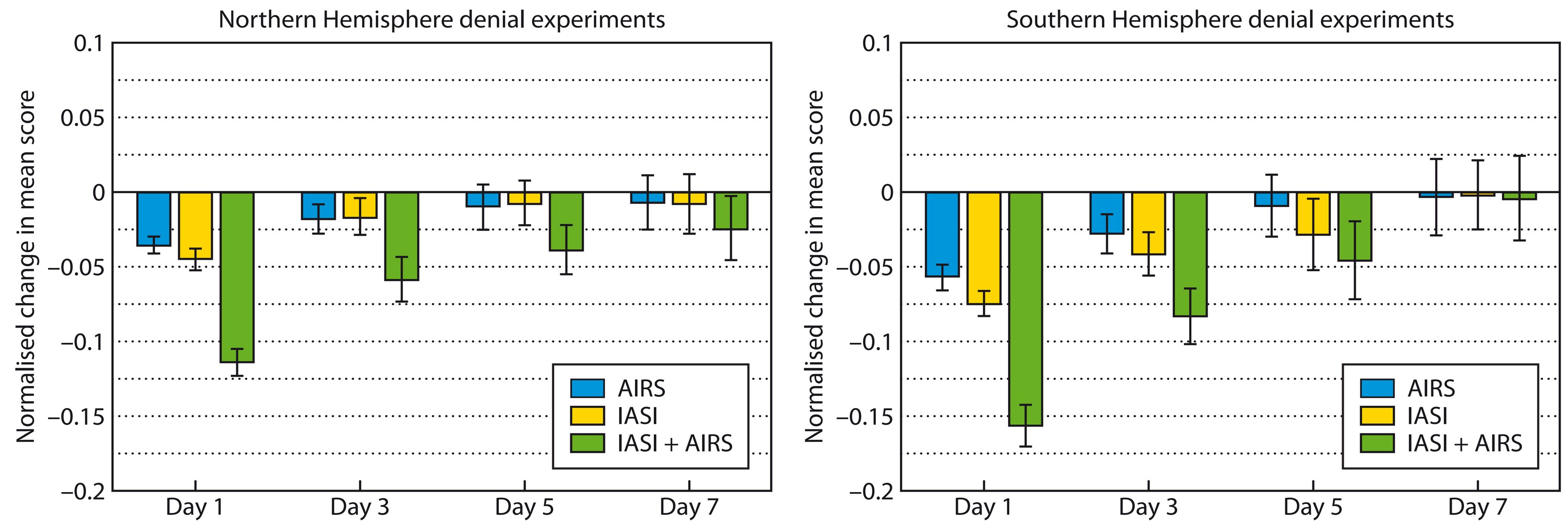
Diagram courtesy of the World Meteorological Organization

IASI and AIRS: Vital components of the Global Observing system for Numerical Weather Prediction (NWP)

The Global Observing System is continually evolving. Sounder data from microwave and infrared radiances constitute the backbone for NWP. For many years microwave sounders have provided most impact, with the TOVS constellation from 1979, and then the ATOVS constellation from 1998. Whilst the microwave sounders remain very important, much progress has been made in the exploitation of hyperspectral infrared sounders: AIRS (from 2002) and IASI (from 2007). Due to their very high resolution sampling of the infrared spectrum, these instruments have the potential to provide more detailed and accurate information about atmospheric temperature and composition.

Results obtained at ECMWF and other centres have clearly demonstrated that the new information from hyperspectral sounders is very beneficial to NWP systems, and improves forecast skill.

Impact of IASI on global NWP

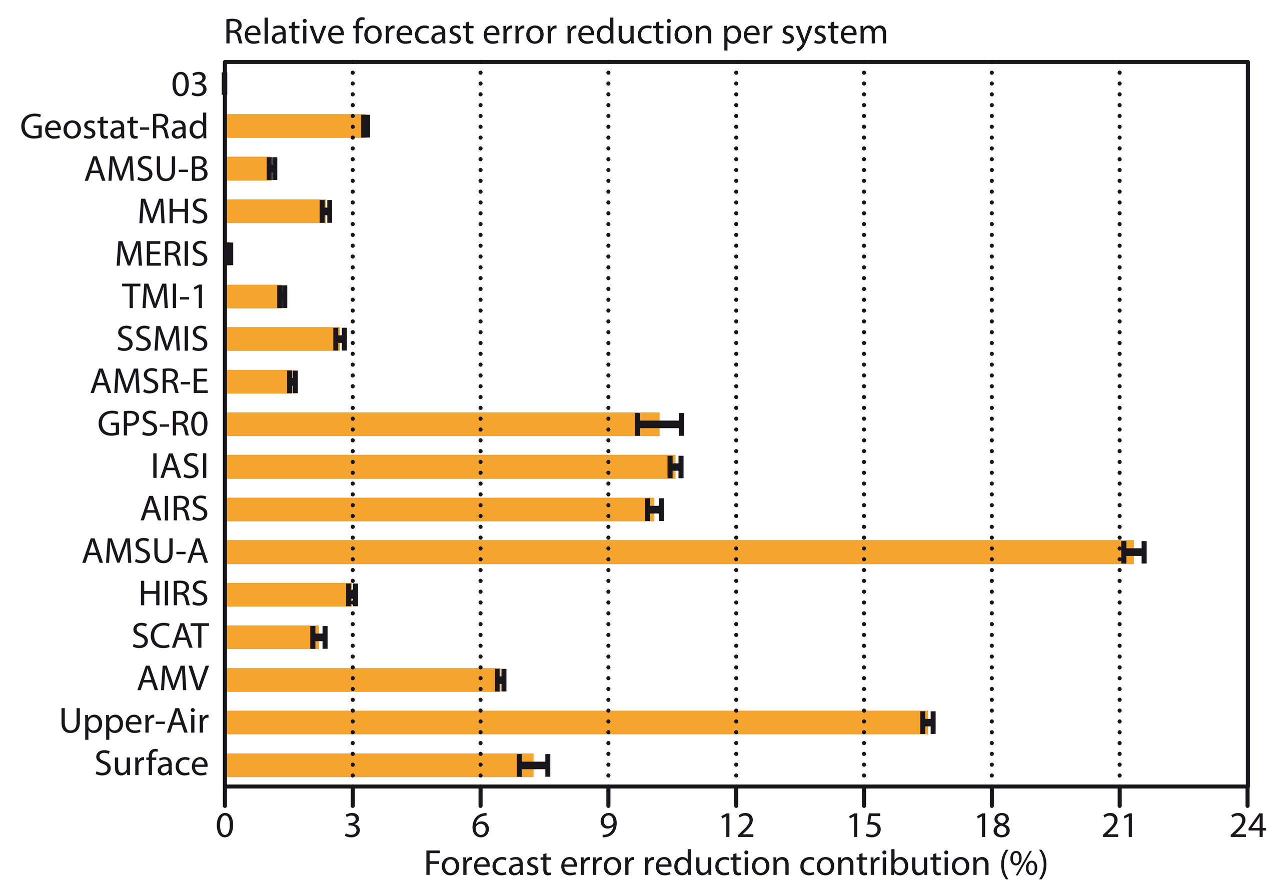


Degradation in the one-year average root mean square forecast error for 500 hPa geopotential height when AIRS and IASI are denied from a baseline system for the Northern Hemisphere (NH) and Southern Hemisphere (SH). The vertical black lines indicate 95% confidence intervals on the normalized mean change.

Forecast sensitivity

There are many techniques and metrics to measure the value of the observing system, but forecast sensitivity can provide information on the impact of each observation on a chosen target, usually a 24-hour forecast of tropospheric mass, wind and moisture. This measure shows that AMSU-A is the single most valuable source of data, though the hyperspectral sounders, GPS radio occultation and conventional upper air observations are still important.

Impact assessment with Forecast Sensitivity to Observations (FSO)

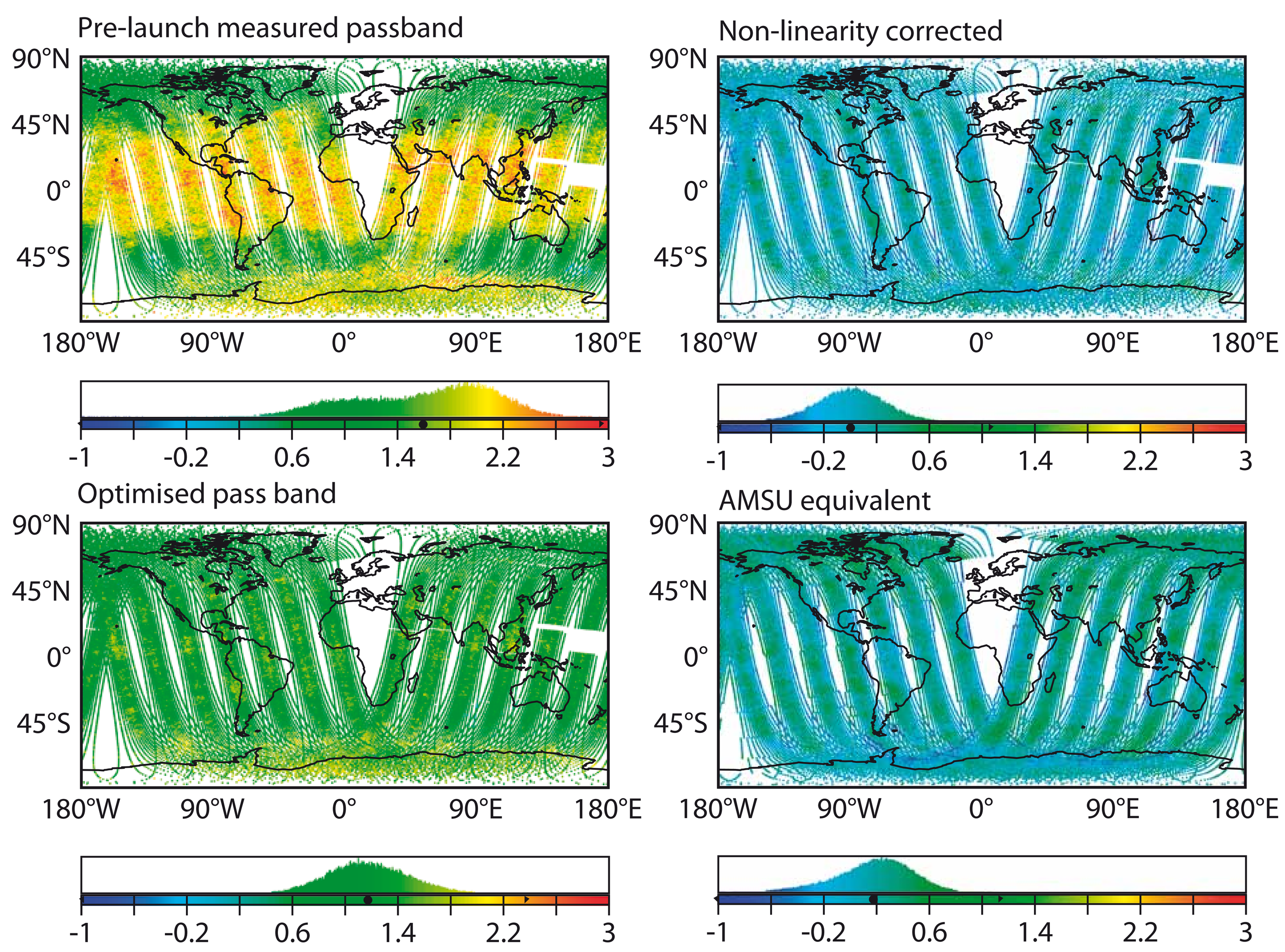


Global mean impact of data on reduction of error of a 24-hour forecast using forecast sensitivity. The forecast sensitivity technique is complementary to full observing system experiments. Note that conventional upper air includes all aircraft as well as radiosondes.

The role of ECMWF in calibration and validation of new observations

Comparison of observations against a model short range forecast confronts new observations with our best possible existing analysis of the atmospheric state. ECMWF has been building partnerships with satellite agencies to assist with the calibration and validation phase of new observations, to ensure the highest possible quality of data is available, not only for ECMWF, but also for our member states. ECMWF has a long history of working with NOAA, NASA, ESA and EUMETSAT. More recent examples include collaboration with the Defense Military Satellite Programme to characterise post-launch the SSMIS sensors, and with the Chinese Meteorological Administration for the FY-3 sensors.

The figure shows an example of the improvement in FY-3 data fit to the model short-range forecast before and after the cal/val collaboration with CMA.

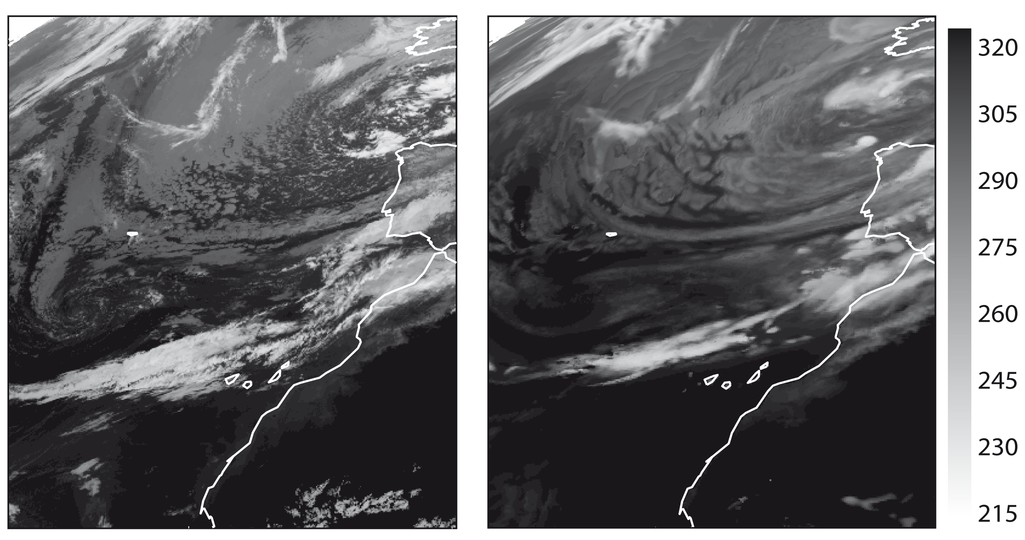


The first-guess departures for channel 4 of the MWTS sounder on FY-3A showing the improved fit following collaboration between ECMWF and CMA, and the fit of the closest equivalent AMSU-A channel.

The improvements of NWP models and their increased level of realism (see figures) make it possible to further the use of satellite observations in data assimilation schemes

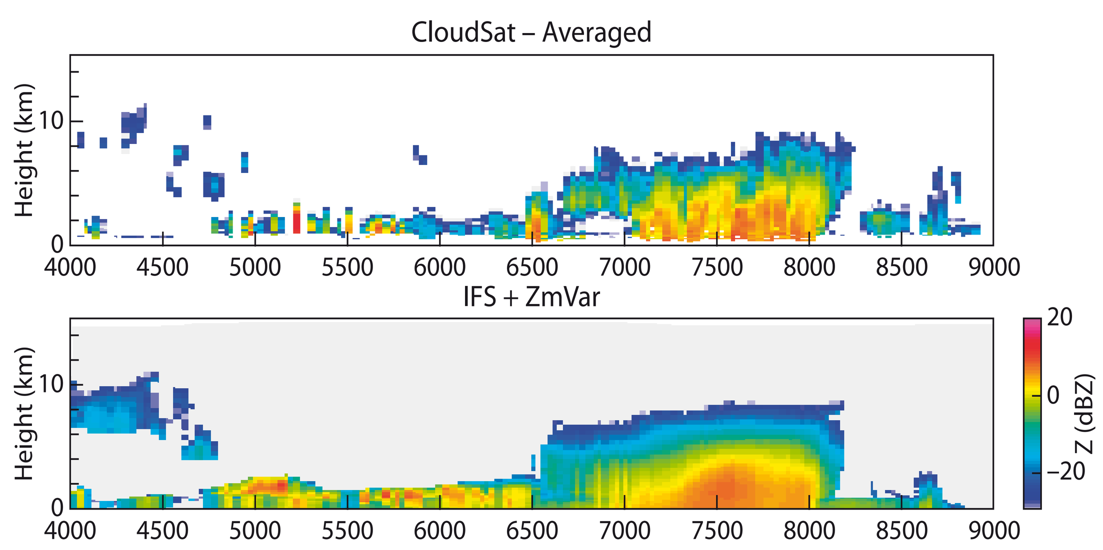
Areas of active research include

- Using water vapour, ozone and cloud information from advanced sounders
- Improved characterisation of surface reflection and emission to make better use of radiances partially sensitive to the surface.
- Improved bias correction of satellite data, including use of variable gases, better radiative transfer models, and pre and in-flight characterisation of new instruments.
- New data assimilation techniques, such as Principal Component assimilation, modelling of observation error, including correlated error and techniques to represent more realistically the impact of clouds.



Comparison between a Meteosat image at 10.8 µm (left) and the model equivalent from a 48-hour ECMWF forecast model (right).

The EU funded FP7 Monitoring Atmospheric Composition and Climate (MACC) project is also making use of satellite data in the area of environment and atmospheric composition monitoring and forecasting.



Reflectivity relative to cloud systems as observed by CloudSat on January 2, 2007. The top panel shows the CloudSat reflectivities gridded and averaged to the IFS model resolution. In the bottom panel are shown the corresponding simulated reflectivities calculated from ECMWF short-range forecasts using a radiative transfer model known as 'ZmVar'.

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