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The Met Office (U.K.) status report to 21st N. America-Europe Data Exchange Meeting at NCDC 17-19 Sep 2008

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1) Introduction

This report describes changes to the use of U.S. satellite and in-situ data in the Met Office NWP models and other forecasting systems since the last Data Exchange Meeting. There are technical reports on many aspects of the use of data for NWP available at:
http://www.metoffice.gov.uk/research/nwp/publications/papers/index.html

2) NWP model and assimilation changes

A global model at 40km and regional model (NAE) at 12km grid is run on 50 levels providing forecasts out to 5 days. Also a 4km model is run over the UK with a relocatable 1.5km model over part of the UK for special weather situations. A 24 member ensemble from the global model out to T+72 and a 24 member ensemble from the regional model out to T+54 are run operationally.

There were no major changes to the model configuration during the past year but it is planned to introduce a 70 level model (model top at 80km) in 2009 with the new IBM supercomputer. The main data assimilation changes during 2007/08 were related to the use of satellite data described below. A 2hr 40min data cut off is used for the main model global run with a 7hr cut-off for the update runs to provide the background for the next assimilation cycle. The "NAE" regional model on a 12km grid, is run 4 times a day with forecasts out to T+48hr with 4D-Var assimilation and a 90 min data cut-off. A summary of the observations received and assimilated in the Met Office NWP models is given in Table 1. Satellite changes are documented in more detail below.

3) ATOVS radiances

The brightness temperatures (BTs) in the Level 1B ATOVS datasets (HIRS, AMSU-A, AMSU-B and MHS) from NOAA-15, 16, 17 and 18 and METOP-A mapped to the equivalent HIRS fovs, are continuously monitored by comparing with calculated BTs from the 6 hour global forecast. See the link to the NWP SAF monitoring plots at: http://www.metoffice.gov.uk/research/nwp/satellite/radiance/atovs/main.html . Feedback on these plots is welcomed to nwpsaf@metoffice.gov.uk .

The Met Office generates NOAA Level 1C ATOVS datasets (i.e. geolocated brightness temperatures), which are passed to ECMWF, DWD and MétéoFrance and are potentially available to other European NWP Centres. The ATOVS level 1C data are pre-processed to level 1D (i.e. brightness temperatures of all ATOVS channels mapped on to the HIRS grid) which are then used in the Met Office global NWP models and also passed to the Bureau of Meteorology in Melbourne who make use of these mapped radiances.

There are still significant delays in the global NOAA-15-17 ATOVS 1B files at some periods of the day due to the 'blind orbit' delays as shown in a recent analysis summarised in Fig. 1. The METOP ATOVS data are not subject to these delays and the timeliness of NOAA-18 data has improved. To mitigate the NOAA delays the Met

Office is also processing the data received from the RARS system, which currently comprises of downloaded ATOVS from 26 stations processed using AAPP. Routine monitoring of the coverage and differences between the RARS data and the NESDIS global 1B ATOVS data is carried out at the Met Office. Monitoring plots for RARS are at:
http://www.metoffice.gov.uk/research/interproj/nwpsaf/ears_report/index.html
These RARS data are assimilated in the global and NAE models due to their much improved timeliness which fills gaps over the Atlantic and Pacific Oceans due to the late arrival of the global ATOVS data from NESDIS.

Observation group	Observation Sub-group	Items used	Daily extracted	% used in assimilation
Ground-based vertical profiles	TEMP	T, V, RH processed to model layer average	1300	86,93,52
	PILOT	As TEMP, but V only	800	93
	PROFILER	As TEMP, but V only	6500	34
Satellite-based vertical profiles	METOP-A, Aqua NOAA-15/16/17,18 AIRS, HIRS, IASI, AMSU-A/B, MHS, DMSP-SSMIS	Radiances directly assimilated with channel selection dependent on surface instrument and cloudiness.	ATOVS: 4,000,000 IASI: 324,000 AIRS: 324,000	4 4 4
	Radio-occultation COSMIC, Champ, Grace, GRACE	Profiles of refractive index	COSMIC: 1600 GRAS: 600 Champ+ Grace: 400	60 70 65
Aircraft	*Manual* AIREPS	T, V as reported with duplicate checking and blacklist	24000	17, 16
	Automated AMDARS		220,000	28, 2
Satellite atmospheric motion vectors	GOES 11,12 BUFR	High resolution IR winds	110,000	10
	Meteosat 7, 9 BUFR		190,000	5
	MTSAT BUFR	IR, VIS and WV winds		
	MODIS AMVs	IR, VIS and WV winds		
	AVHRR AMVs	IR winds	21,600	8
Satellite-based surface winds	DMSP-SSM/I-13	In-house 1DVAR wind-speed retrieval	3,000,000	0.5
	Seawinds ERS-2 scatt METOP ASCAT	NESDIS retrieval of ambiguous winds. Ambiguity removal in 4DVAR.	1,800,000 ERS-2 not included	1.5
Ground-based surface	Land SYNOP	Pressure only (processed to model surface), V, T, RH	58,000	97,87,87,86
	SHIP	P, V, T, RH	4,500	93,94,94,94
	Fixed Buoy	P, V, T	6,000	87,85,82
	Drifting BUOY	P	13,500	88
	GPS IWV	Total column water	150,000	1
Cloud/Rain observations	METEOSAT-9 SEVIRI and UK rain radar network	Nimrod – MOPS cloud and rain in NAE.	15000 rain 12000 cld	100 100

Table 1. Observations assimilated into global and NAE model in Sep 2008.

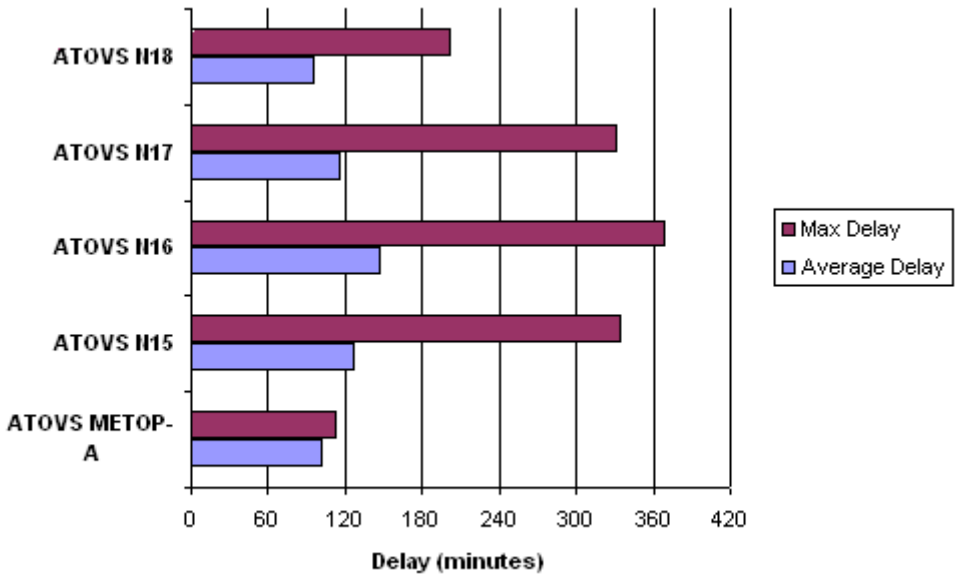

Figure 1. Mean and maximum data delays as seen at the UK Met Office in Aug 08

4) Advanced infra-red sounders (AIRS/IASI)

The Met Office continues to provide monitoring statistics of the AIRS 324 channel radiances on Aqua in near real time on the web at: http://www.metoffice.gov.uk/research/nwp/satellite/infrared/sounders/airs/index.html
AIRS radiances from a subset of ~50 channels are used operationally in the global and NAE models.

IASI radiances received via EUMETCAST from 138 channels have been assimilated since Nov 2007. Monitoring of the IASI radiance subset available on the GTS of 314 channels is available at:
http://www.metoffice.gov.uk/research/nwp/satellite/infrared/sounders/iasi/index.html.
The impact on the forecasts were significant even with a limited number of channels used.

5) SSM/I & SSMIS

Orbit-by-orbit brightness temperatures are received from F-13 and F14 in near real-time from NESDIS. These data are passed to ECMWF where they are BUFR-encoded and returned to Exeter for onward transmission to other European centres.

At the Met Office the brightness temperatures are processed through a 1D-Var analysis which provides retrieved total column water vapour, surface wind speed and cloud liquid water path. Surface wind speeds from F13 are assimilated.

DMSP F-16 SSMIS radiances are also received in near real time in BUFR from NESDIS. Significant pre-processing steps are required to remap, average and quality control the SSMI(S) radiance data. The assimilation of the 50GHz temperature sounding channels, heavily quality controlled, has been operational since September 2006 mainly as a backup against the loss of NOAA-15 ASMU-A.

The Met Office has been liaising with NRL on setting up a unified SSMIS processor at NRL which would replace the Met Office pre-processing of SSMIS.

6) Scatterometers

Seawinds observations are received from NESDIS and assimilated in the global model with the ambiguities being removed with the 4D-Var scheme. A revised scheme was developed to prepare for the new product expected in the near future from NESDIS.

ERS-2 scatterometer winds are still used, with 50% coverage of the Northern Hemisphere as ESA have added more direct reception stations. As these products contain only a single wind vector, the backscatter data are processed in-house to produce ambiguous winds which are then de-aliased within the 4D-Var scheme.

METOP ASCAT ambiguous ocean wind data are now being assimilated and provide good impacts on the forecast scores. ASCAT soil moisture data are now being received and will be used for assimilation trials.

NRT data from the WindSat-Coriolis mission are being received from NRL. For assimilation purposes, ambiguous winds from this passive microwave system are processed as if they were scatterometer winds. Initial results show some positive benefit, and we plan to assimilate these data operationally within the next few months.

Under the NWP SAF, monitoring of all the above scatterometers (including Coriolis) is reported at:
http://www.metoffice.gov.uk/research/interproj/nwpsaf/scatter_report/index.html

7) SST products

A new SST analysis, OSTIA, which uses AVHRR, AATSR and AMSR-E satellite SSTs in addition to the conventional in situ data was made operational in October 2007. A motivation for this was to improve the SST analysis over the arctic. More details of the OSTIA SST analysis can be found at: *http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/index.html*

8) Snow and Sea-ice products

The NESDIS Interactive Snow and Ice Mapping System data is used to define the snow cover over the Northern Hemisphere. Trials have shown the snow cover in the model is improved with this product although being more than 24hrs old does cause some problems which are being addressed. This is planned to become operational in Oct 2008. We are now ready to receive the product in GRIB-2.

The OSI-SAF sea-ice analysis has replaced the NCEP sea-ice analysis for the NWP models since July 2008.

9) Cloud-tracked wind

GOES BUFR IR winds (thinned to one per 2 deg box) are assimilated and monitored. The details of the current use of the winds in the global model are at:
http://www.metoffice.gov.uk/research/interproj/nwpsaf/satwind_report/ukmodel.html
The monitoring results are at:

http://www.metoffice.gov.uk/research/interproj/nwpsaf/satwind_report/index.html
The Meteosat-7/9, GOES-11/12 BUFR and MTSAT BUFR winds, MODIS Aqua and Terra and AVHRR polar winds are all being monitored and assimilated. MODIS direct broadcast winds have significantly improved the coverage for the main model runs.

A new processing applied to the AMVs varies the observation error for each wind dependent on various factors including the vertical wind shear. It would be desirable for all AMV producers to include an estimation of wind height assignment errors with their product.

10) Polar and Geostationary Imagery

Forecasters now make use of the images on the NOAA aviation weather site:
http://aviationweather.gov/obs/sat/intl/

Products from the Meteosat-9 satellite are used in real time every 15 minutes to provide radiances and cloud cover/top height for the nowcasting systems, forecasters and disaster monitoring. Fog, volcanic ash/SO2, aircraft icing, dust, precipitation and snow cover imagery products are produced every 15 minutes.

11) Profiler data update

The hourly reports from ~33 U.S. profilers (inc Alaska) and ~31 from Japan are assimilated in 4D-Var. For some profilers the lower portion of the sounding (below 700hPa) are rejected. The European profiler data are monitored and a report is issued quarterly (available on request). Currently about 20 of the European stations are assimilated. The VAD winds from about 64 European weather radars are also used.

12) GPS Radio-occultation

COSMIC (UCAR), CHAMP (GFZ), GRACE-A (GFZ) and METOP GRAS (DMI) radio-occultation data (9 satellites in total) are assimilated in the form of refractive index profiles and have shown beneficial impacts especially in the upper-tropospheric and stratospheric temperature fields.

13) GPS ground-based total column water vapour

Under the EUMETNET E-GVAP project, Europe-wide experimental data has been placed on the GTS since March 2004 with a timeliness of about 1h45m from observation time. The Met Office is running its own operational NRT processor for the growing UK network of currently 120 GPS stations.

GPS zenith total delay (ZTD) data in the Met Office's NAE model as a proxy for integrated water vapour have shown positive impacts and have been assimilated operationally since March 2007. This could be extended to the global model should timely ZTD data be available from other areas of the globe.

14) Ozonesonde Ascents

The Met Office continues to launch ozonesondes from Lerwick once a week (normally Wednesday at 12Z) and during the winter months additional sondes are launched in support of various campaigns.

15) NWP Satellite Application Facility

In March 2007, the NWP Satellite Application Facility (SAF) commenced a new "continuous development and operations" phase, funded for 5 years. Activities include:

- Developing and maintaining software, including
  - AAPP software for processing ATOVS data;
  - the fast RT model RTTOV;
  - Diverse atmospheric profiles;
  - an SSMIS pre-processing package;
  - interface and processing software for MetOp-A instruments, including IASI and ASCAT;
  - 1D-Var retrieval packages.
- Monitoring operational data against NWP, with results presented on the NWP SAF web site:
  - cloud track winds, comparing results from different NWP centres.
  - scatterometer winds.
  - ATOVS radiances.
  - etc.

Major new versions and intermediate updates of the software products are released from time to time, for example:

- AAPP version 6.7 has been released for MetOp-A including IASI
- version 9 of the RTTOV model released in March 2008;
- IASI PCA-based compression package
- New diverse profile dataset from ECMWF model

For more details, including how to obtain the SAF's software products, see the NWP SAF web site at: http://www.nwpsaf.org.

16) GPS - GRAS Satellite Application Facility

The Met Office is a partner of the GRAS (GNSS Receiver for Atmospheric Sounding) Meteorology Satellite Application Facility (SAF). (see http://www.grassaf.org). Recent activities include the following.

The BUFR format for Radio Occultation (RO) was ratified by WMO in 2005; allowing RO data from COSMIC, GRAS, CHAMP and GRACE-A to be put on the GTS. A GRAS SAF Level 2 format for non-GTS use has been defined using the netCDF transport mechanism (as used by UCAR/CDAAC, though different in detailed content).

The Radio Occultation Processing Package (ROPP) software development continues, with the release of the 2nd update version in August 2008 (ROPP-1 v1.2), containing principally netCDF file I/O interfaces, BUFR support,, forward models for refractivity or bending angles and 1dvar retrieval codes. ROPP-2, a follow-on release (end-2008) will include code to pre-process excess phase to bending angle and thence to refractivity. The ROPP-1 release can be obtained from http://garf.grassaf.org/

Data flow and quality monitoring of RO products can be viewed on the GRAS SAF web site at http://monitoring.grassaf.org/ Data currently being monitored include GRAS (DMI), COSMIC (UCAR), CHAMP (UCAR), CHAMP (GFZ), GRACE-A (GFZ).