

An Information Based Radiance Data Selection Scheme for Efficient Use of a Multi-Satellite Constellation

Brett Harris, Chris Tingwell and Peter Steinle

*Data Assimilation Team
ACCESS**

*CAWCR
Bureau of Meteorology,
Melbourne, Australia*

**Australian Community Climate Earth-System Simulator*

Introduction

In this study we show that using a data selection method, up to six platforms delivering level-1D ATOVS radiances derived using the European ATOVS and AVHRR Processing Package (AAPP) in the BMRC Global Assimilation and Prediction (GASP) system can significantly improve prediction performance in both the mid-latitudes in the Southern Hemisphere and the Tropics. For this project we have implemented the GASP assimilation and prediction systems at a resolution of T239/L60, with the uppermost level at 0.1 hPa. This method of data selection uses only the forward model (RTTOV-7), reducing the need for expensive 1DVAR quality control, which allows a 30% increase in processing time. Moreover, out of the six platforms, NOAA-16, 17, 18, AQUA/AMSU-A, and MetOp, the only satellite fully functional with all the ATOVS instruments is MetOp. All the other platforms have either whole instruments malfunctioning, or a varying degree of usable channels.

1DVAR System

The one-dimensional variational retrieval system (1DVAR) used in both the local and global assimilation systems at the Bureau of Meteorology is based on the ECMWF formulation (Eyre *et. al.* 1993). It performs an iterative retrieval of temperature and moisture at the sounding location using a background first guess, interpolated to the 43 level RTTOV-7 forward model. The temperatures and moistures are converted to thickness and precipitable water layers and the corresponding background and analysis errors are calculated for the same quantities. Following Purser (1990), the analysed increments and analysis errors are scaled dynamically for each sounding, thus allowing the information content to be reflected in the Optimal Interpolation (OI) analysis (Harris *et. al.* 1999). The radiance bias correction (Harris and Kelly 2001) uses background derived bias predictors and a latitudinally varying scan correction.

The 60 Level GASP Model

In order to use AAPP derived radiances without the need for extra information or extrapolation, the operational GASP system with a top at 10hPa had to be extended to 0.1hpa. It currently assimilates NOAA-16, 17, 18, AQUA/AMSU-A and MetOp. The Bureau of Meteorology has been receiving global AAPP processed level-1d radiances from the Met Office for some time and it produced 1DVAR retrievals up to 0.4hPa, and thinned to 250km prior to 1DVAR via the information based selection method.

The Information Based Thinning System

All thinning is done prior to 1DVAR using only one call to RTTOV-7, which allows an extensive testing and classification scheme based on the atmospheric state, the surface type, and the particular peculiarities of the individual satellite. Table 1 shows the status of ATOVS instruments used in GASP, each with their particular variety of malfunction.

Table 1: Status of Sensors by Satellite

	HIRS	AMSU-A	AMSU-B
NOAA-16	X	Ok	Ok
NOAA-17	Ok	X	Ok
NOAA-18	X	Ok	Ok
AQUA/AMSU-A	X	Ok	X
MetOp	Ok	Ok	Ok

To categorise the state of the atmosphere and the surface, there are many checks that are possible. Note to avoid any sort of feedback, none of the (*o-b*) have been bias corrected.

To determine the surface characteristics, (with the exception of NOAA-17), a Grody type AMSU-A Ch 1, 2, 3 and 15 algorithm detects Sea (S), Sea-Ice (I) and Land (L). For NOAA-17, the background model is used, and any discrepancies will probably fail the cloud check.

To determine the atmospheric state, for NOAA-17 and MetOp there is a -2K window check for cloud contamination. If no HIRS, then the Grody algorithm also retrieves a liquid water path, and if it is less than 0.3 and $|o-b| < 5K$ for AMSU-B2, then the state is denoted for historical reasons 'Partly Cloudy'. This means that the IR is contaminated, but the combination of AMSU-A and AMSU-B may be used to produce a water-vapour as well as temperature retrieval. If the above checks fail, then AMSU-B and AMSU-A Ch 4 and 5 are not used. These are the 'Cloudy' soundings.

Table 2: Ranking by Satellite, Surface and Atmospheric State

	CS	PS	CIS	CI	PI	CII	CL	PL	CIL
N-16	X	5	9	X	14	18	X	22	26
N-17	2	X	X	11	X	X	X	X	X
N-18	X	4	8	X	13	17	X	21	25
Aq/A	X	X	6	X	X	15	X	X	23
MetOp	1	3	7	10	12	16	19	20	24

Once the surface and atmospheric type has been determined, this allows the obvious unusable combinations such as NOAA-17 partly cloudy etc to be easily discarded. For the usable combinations, a determination is made as to which platform can extract the most information for a given combination of (Satellite X Surface X Atmosphere) and a ranking number is given.

Effect of Inclusion of MetOp in GASP

A global analysis was done on 00Z on 13 January 2008, one using the (then) operational system which did not use MetOp, against an experimental run using MetOp in addition to the other four satellites.

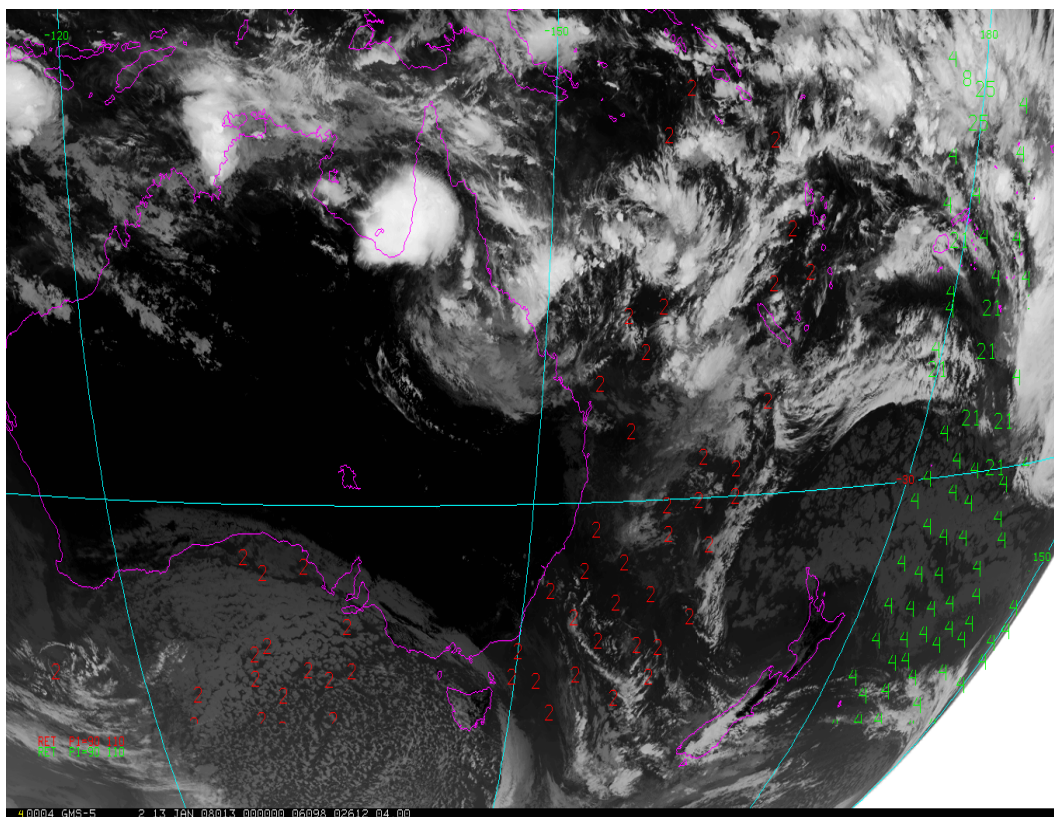


Fig. 1: Australian Region Data Selection Without MetOp.
(NOAA-17 = RED, NOAA-18 = GREEN)

Note at the time there were some type-4 (NOAA-18, PS) east of New Zealand, but the only other platform in the general Australian region was type-2 (NOAA-17, CS), only able to retrieve clear spots over the sea.

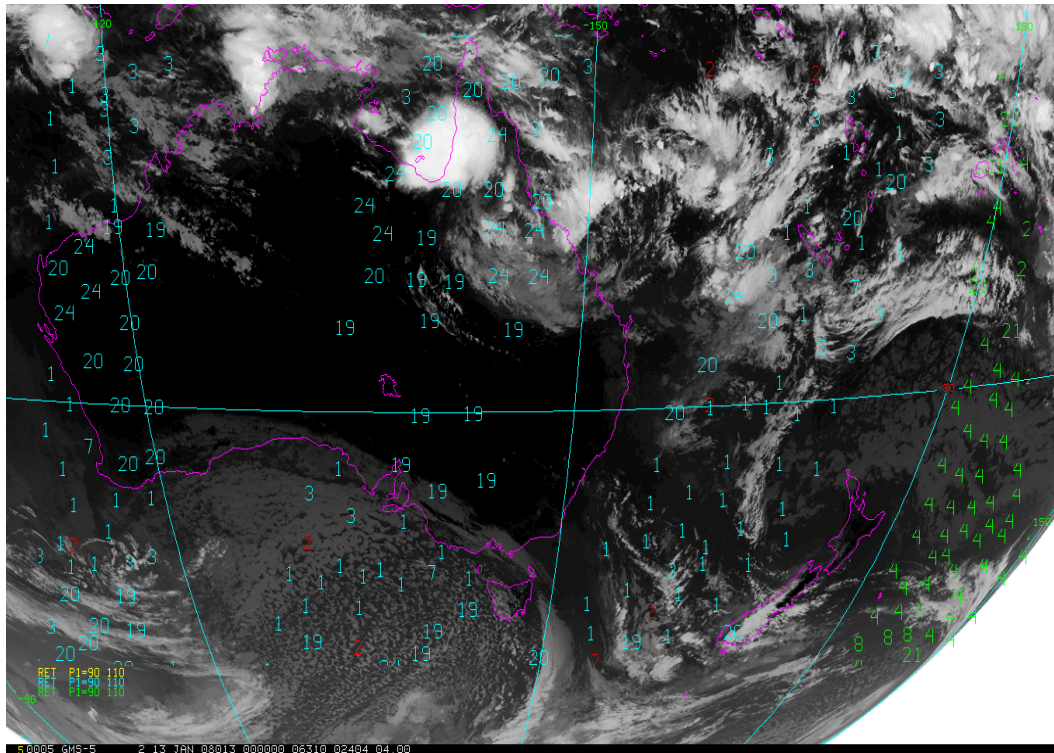


Fig. 2: Australian Region Data Selection With MetOp.
 (NOAA-17 = RED, NOAA-18 = GREEN, MetOp = BLUE)

Notice here that almost all of the type-2 NOAA-17's have been replaced by MetOp, with many different sounding types {1, 3, 7} for sea and {19, 20, 24} for land. Anomalous sounding types such as type-19/20 over the sea indicate that the quality control has flagged a problem and fewer channels ("land") have been used. Notice the variety of MetOp sounding types {1,3,7,20} north and west of New Zealand. This indicates that the different sounding channels are being appropriately chosen in a region with a unstable tropical air-mass. This is likely to be related to the increase in forecast skill.

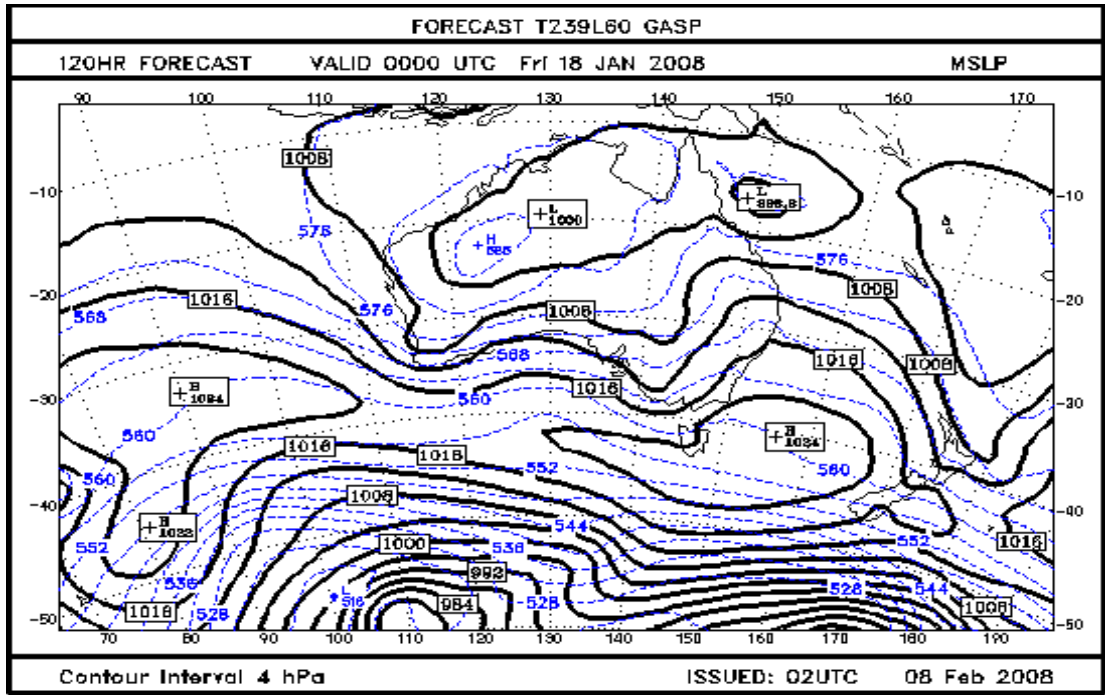


Fig. 3: 120 hour forecast with Operational GASP (no MetOp).

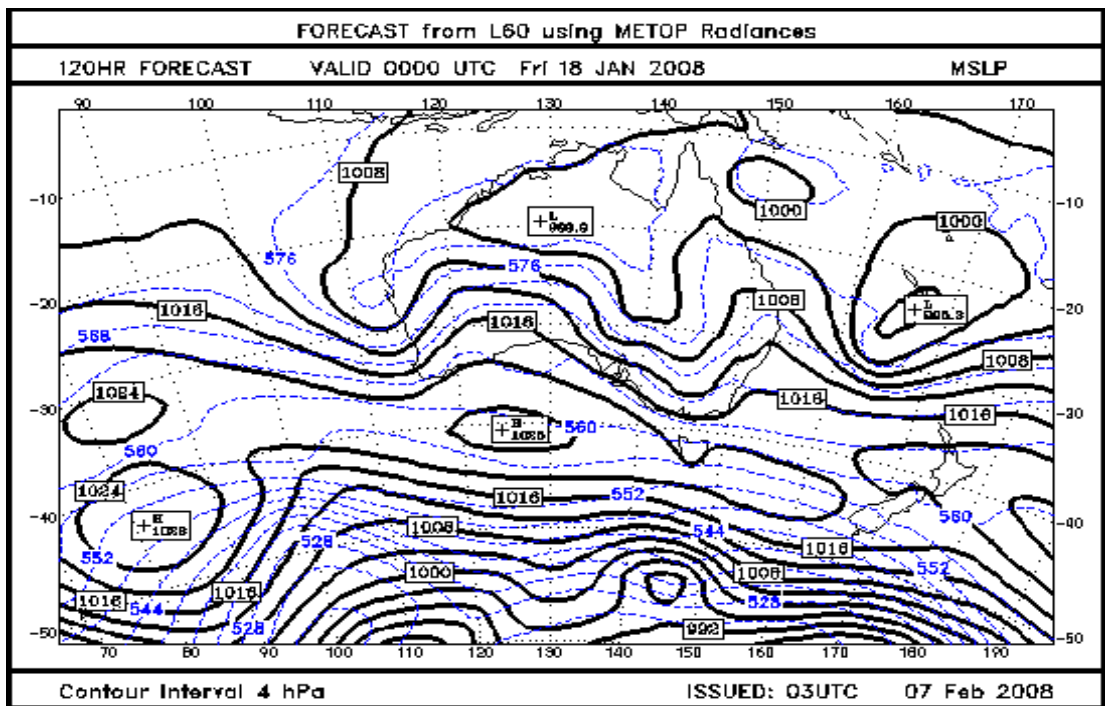


Fig. 4: 120 hour forecast from analysis trial using MetOp.

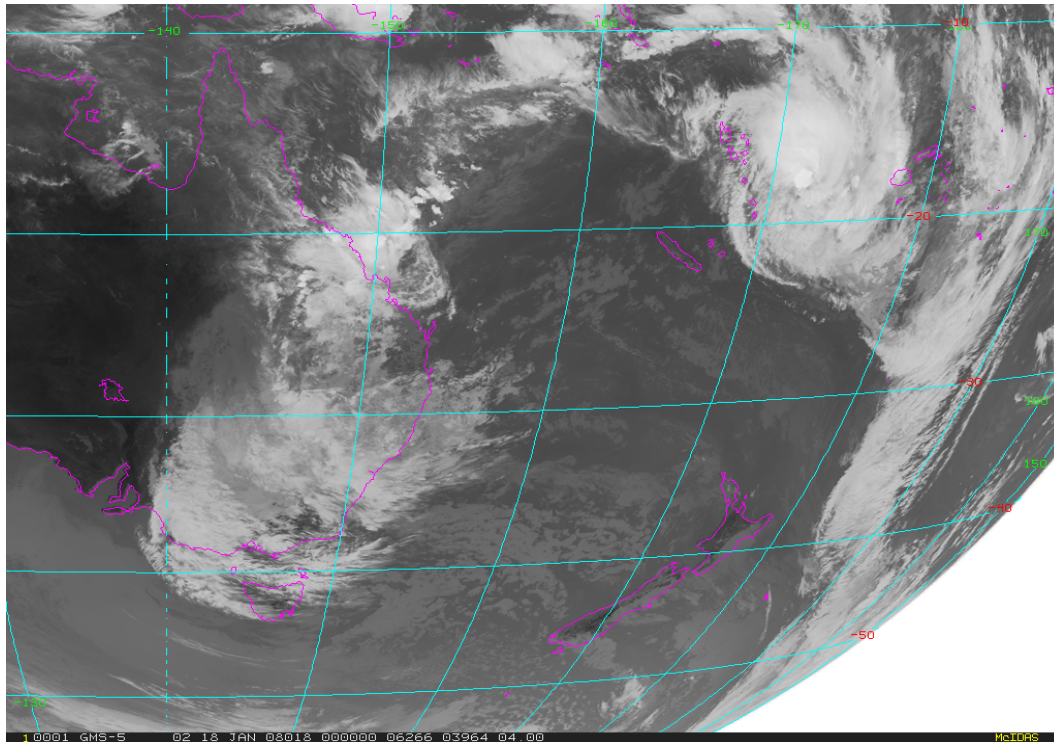


Fig. 5: GMS image for 00Z on January 18, 2008.

Discussion

This has been a demonstration of the utility of a fast satellite thinning technique based on choosing the platform which can extract the most information from a given situation. We have shown that by simply adding the satellite with the most information content (MetOp) to the analysis, has given rise to a forecast of a tropical storm near New Caledonia at 120h, whereas the analysis without MetOp produced only a weak trough. As a result of this case, and general improvement in forecast skill over a period of over a month, MetOp ATOVS radiances were included in the operational GASP system.

References

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