Analysis and Prediction Operations Bulletin Number 73

Operational Upgrade of GASP to 60 Levels

28 February 2008

1. Introduction

The operational GASP system running in NMOC, operating with 33 model levels, was upgraded to a 60 level system on 11 September 2007. It began operational running beginning with the 00 UTC assimilation and forecast. The new system, GASP(L60) was developed by the Data Assimilation and Model Development groups in BMRC.

2. Description of the upgrade

The main purpose of replacing GASP(L33) with GASP(L60) was to allow the 1DVAR assimilation of ATOVS radiance data processed via the ATOVS and AVHRR Pre-processing Package (AAPP). These data are supplied with global coverage by the UK Meteorological Office and, from local direct read-out, by the Bureau's Space Based Observations section. They are considered to be more accurate than the NESDIS-supplied radiances previously assimilated operationally in the GASP(L33) system.

Radiance data are available from five satellites: NOAA-15, 16, 17 and 18 and, from the Met. Office only, AQUA. Previously, only three satellites were used (NOAA-15,16 and 18).

Higher quality data from more satellite instruments are used in the new system. In the old GASP(L33) system, AMSU-A from NOAA-15,16,18 was used. In the new GASP(L60) system there is the addition of the following instruments: HIRS from NOAA-17, AMSU-B from NOAA-16,17,18, AMSU-A from AQUA.

An outline of the historical development of horizontal and vertical resolutions in the GASP systems is shown in Table 1. The differences in the model levels used in the GASP(L60) and GASP(L33) systems are shown in Table 2.

Resolution	Lowest sigma level	Highest sigma level	Operational start
R31L9	0.991	0.0089	1990 October
R31L19	0.991	0.01	1992 December
R53L19	0.991	0.01	1994 March
T79L19	0.991	0.01	1995 December
T239L29	0.991	0.01	1998 December
T239L33	0.9984	0.01	2005 August
T239L60	0.9984	0.0001	2007 September

Table 1: The evolution of the GASP horizontal and vertical resolution along with the lowest and highest sigma levels and the date when they became operational. R and T refer to rhomboidal and trapezoidal spectral horizontal truncation method, respectively, and L refers to the number of vertical levels.

3. Assessment of GASP(L60) versus GASP(L33)

3.1 Objective skill score assessment

During development, and to ensure its suitability for use in operations, results from the new GASP(L60) system were assessed using objective metrics throughout 2007. The period June-July 2007 is used here to demonstrate the differences in the performance of GASP(L60) versus GASP(L33). The results over the Australian region, of particular importance to forecasters, are shown in Figures 1 and 2. The S1 skill scores show that GASP(L60) outperforms GASP(L33) for MSLP and the 500 hPa geopotential heights throughout the 168 hour forecast period, particularly after 72 hours. The other objective measures of model forecast accuracy (RMS Error, Bias and Anomaly Correlation) also generally show that GASP(L60) is superior to GASP(L33).

For the southern annulus (20ºS – 60ºS), objective scores (Figures 3 and 4) show that the GASP(L60) system produces better results than GASP(L33). An exception can be seen late in the forecast period (after about 5 days), where the bias associated with the old GASP(L33) system is better than that of GASP(L60). However, all the other metrics for all time periods show that the GASP(L60) system is an improvement over GASP(L33).

In the tropics (20ºS– 20ºN), the results from the objective assessment of MSLP fields show that GASP(L60) is not a large improvement over GASP(L33), with the Bias showing a degradation (Figure 5). However, for the 500 hPa height, GASP(L60) is superior to GASP(L33) based on all four objective measures.

Overall, the results are very positive (Figures 1 to 6). Although there is not an improvement according to every single objective test, the majority of the results are positive, thereby helping to justify the replacement of GASP(L33) by GASP(L60). This position is further supported by the positive results of the synoptic assessment, discussed in the following section.

3.2 Synoptic assessment

3.2.1 Introduction

In addition to the objective assessment based on skill scores, a synoptic assessment has been conducted in order to show whether the modifications involved in the change from GASP(L33) to GASP(L60) have produced identifiable changes in model forecasts that are likely to be positive from the point of view of an operational forecaster. Evaluations were made based on MSLP forecasts of the colder months from April to September 2007. Key points in the comparison between GASP(L33) and GASP(L60) are outlined in the following section. Two example cases are discussed in Sections 3.2.3 and 3.2.4.

3.2.2 Key points

Forecasts from the GASP(L60) system were found to be generally better than those produced by the GASP(L33) system, especially at time periods beyond +96 hours. This is in agreement with the objective skill scores presented in Section 3.1.

Predictions from GASP(L33) and GASP(L60) were often similar up to forecast times of +48 hours, after which point the forecasts diverge.

Both models can generate significant errors by +120 hours particularly in cases of Tasman Sea cyclogenesis. The GASP(L60) system nevertheless tends to provide better guidance than GASP(L33). Although the depth of cyclogenesis, especially in the Tasman Sea is underestimated in both GASP(L33) and GASP(L60), the forecasts provided by GASP(L60) tend to be better.

The GASP(L60) system tends to capture frontal structures better than GASP(L33), in relation to location and amplitude.

Although GASP(L60) forecasts were not found to be invariably better than GASP(L33), a significant number of cases show a general improvement. The two cases discussed in the following two sections illustrate the general superiority of GASP(L60) over the previous operational GASP(L33) system.

3.2.3 Case 1: 12 UTC 29 August 2007

Significant features present in the MSLP analysis for 12 UTC 29 August 2007 (Figure 7a) are the front crossing the southwest corner of the continent and the low <960 hPa in the Southern Ocean at around 90°E. The GASP(L33) +96 hour forecast valid at 12 UTC 29 August 2007 (Figure 7b), corresponding to the analysis time in Figure 7a, has a major phase error greater than 20° longitude, with the consequent generation of a spurious anticyclone in the western Bight. Although GASP(L60) did not capture the amplitude of the WA front and it progressed the synoptic pattern eastwards too rapidly (Figure 7c), it did produce a better forecast than GASP(L33). Both models indicated the presence of the deep Southern Ocean cyclone, however the GASP(L60) system better represented the latitude and amplitude of this system than did the GASP(L33) system.

3.2.4 Case 2: 12 UTC 14 September 2007

The second example shows the MSLP analysis for 12 UTC 14 September 2007 (Figure 8a). This case is interesting to consider because it occurred just a few days after the upgrade from GASP(L33) to GASP(L60). The +120 hour forecast in the GASP(L33) system (Figure 8b) indicates the highly significant and erroneous development of a cut off low over southeast Australia. By contrast, the GASP(L60) system (Figure 8c) has a very good representation of the trough ridge system over southern Australia. The front affecting the south coast of WA is better represented in by GASP(L60), albeit with a phase and amplitude error.

4. Future developments

The next major step will be to replace the GASP system with a global version of the ACCESS NWP system, which is based closely on the UK Met Office Unified Model. Work has commenced on this task, and is expected to be implemented operationally in the Bureau in 2009.

GASP L60 level number	GASP(L60) sigma level	Corresponding GASP(L33) sigma level (approximate)	GASP L33 level number
60	0.0001	---	---
59	0.00018	---	---
58	0.00032	---	---
57	0.00055	---	---
56	0.00093	---	---
55	0.00155	---	---
54	0.00253	---	---
53	0.00405	---	---
52	0.00638	---	---
51	0.0098	0.01	33
50	0.01452	---	---
49	0.0207	0.02	32
48	0.0248	0.03	31
47	0.0375	---	---
46	0.048	---	---
45	0.0594	0.05	30
44	0.0715	0.07	29
43	0.0845	---	---
42	0.099	0.09	28
41	0.115	0.11	27
40	0.133	0.14	26
39	0.1535	---	---
38	0.176	0.17	25
37	0.2	0.2	24
36	0.225	0.23	23
35	0.25	0.26	22
34	0.275	---	---
33	0.3	0.29	21
32	0.325	0.32	20
31	0.35	---	---

30	0.375	0.366	19
29	0.4	---	---
28	0.425	0.433	18
27	0.45	---	---
26	0.475	---	---
25	0.5	0.5	17
24	0.525	---	---
23	0.55	---	---
22	0.575	0.566	16
21	0.6	---	---
20	0.625	0.633	15
19	0.65	---	---
18	0.675	---	---
17	0.7	0.7	14
16	0.725	---	---
15	0.75	0.75	13
14	0.775	---	---
13	0.8	0.8	12
12	0.825	---	---
11	0.85	0.85	11
10	0.875	0.875	10
9	0.9	0.9	9
8	0.925	0.925	8
7	0.95	0.95	7
6	0.972	0.972	6
5	0.9841	0.9841	5
4	0.9911	0.9911	4
3	0.995	0.995	3
2	0.9972	0.9972	2
1	0.9984	0.9984	1

Table 2: Sigma (P/Ps) levels used in the GASP(L60) system, and the approximate corresponding sigma levels used in the previous GASP(L33) system.

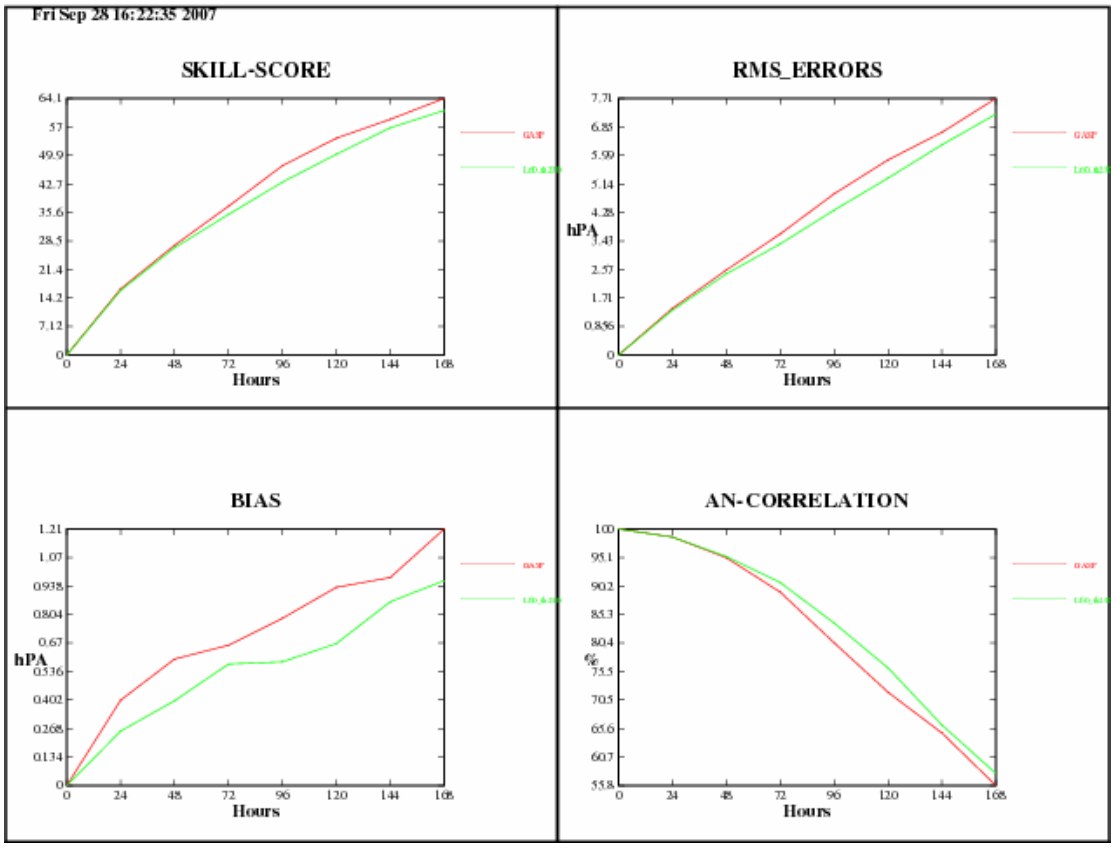

Figure 1: Skill scores of MSLP for the Australian region, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

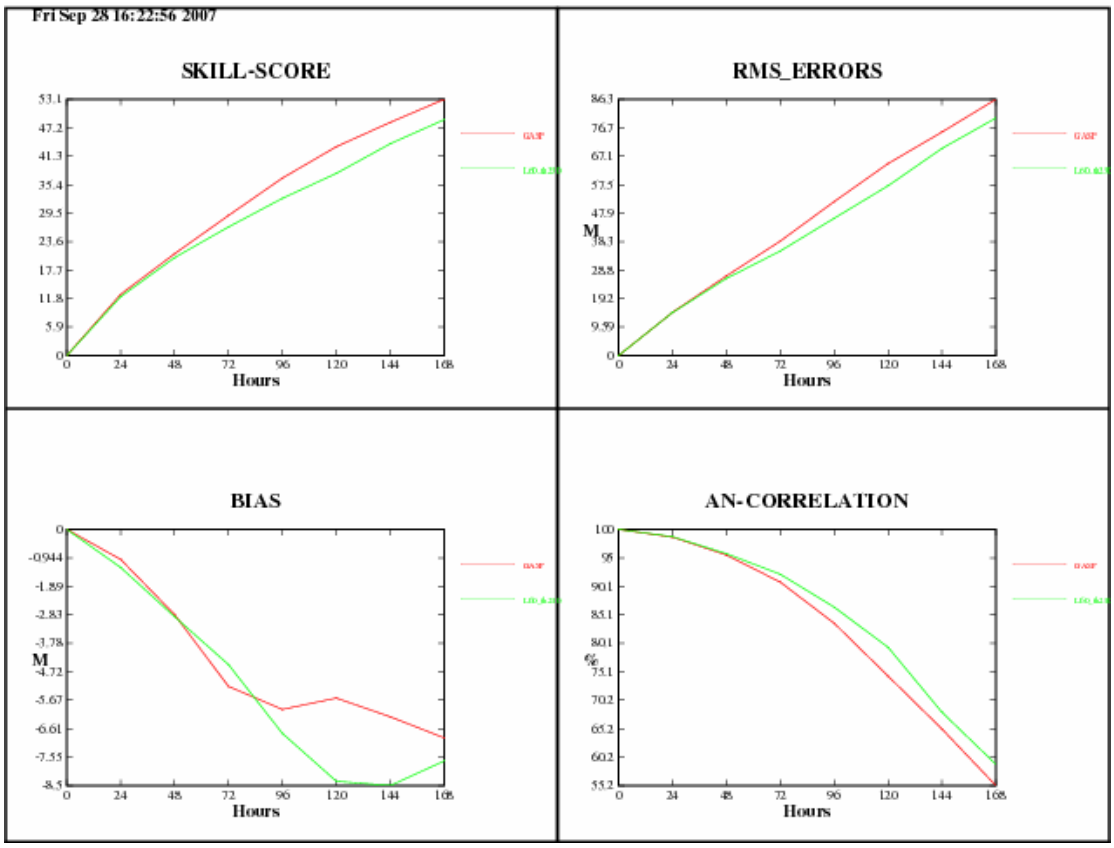

Figure 2: Skill scores of 500 hPa height for the Australian region, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

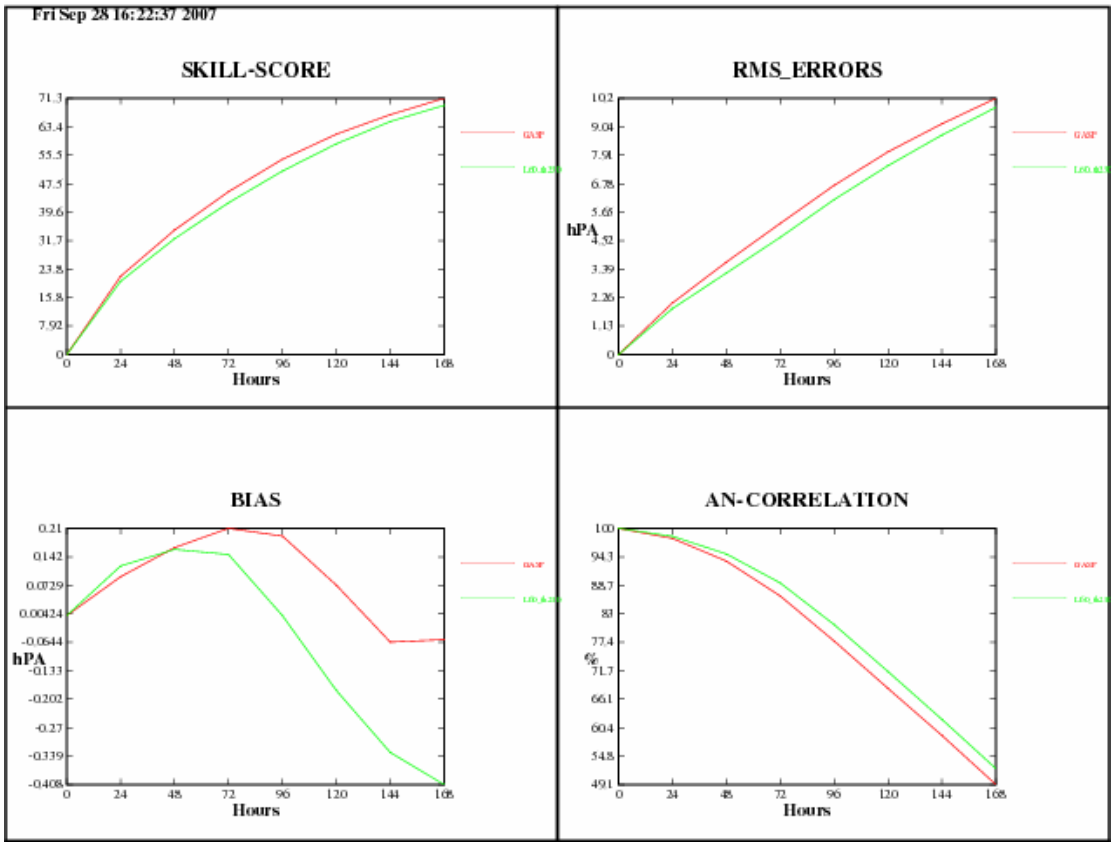

Figure 3: Skill scores of MSLP for the Southern Annulus region, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

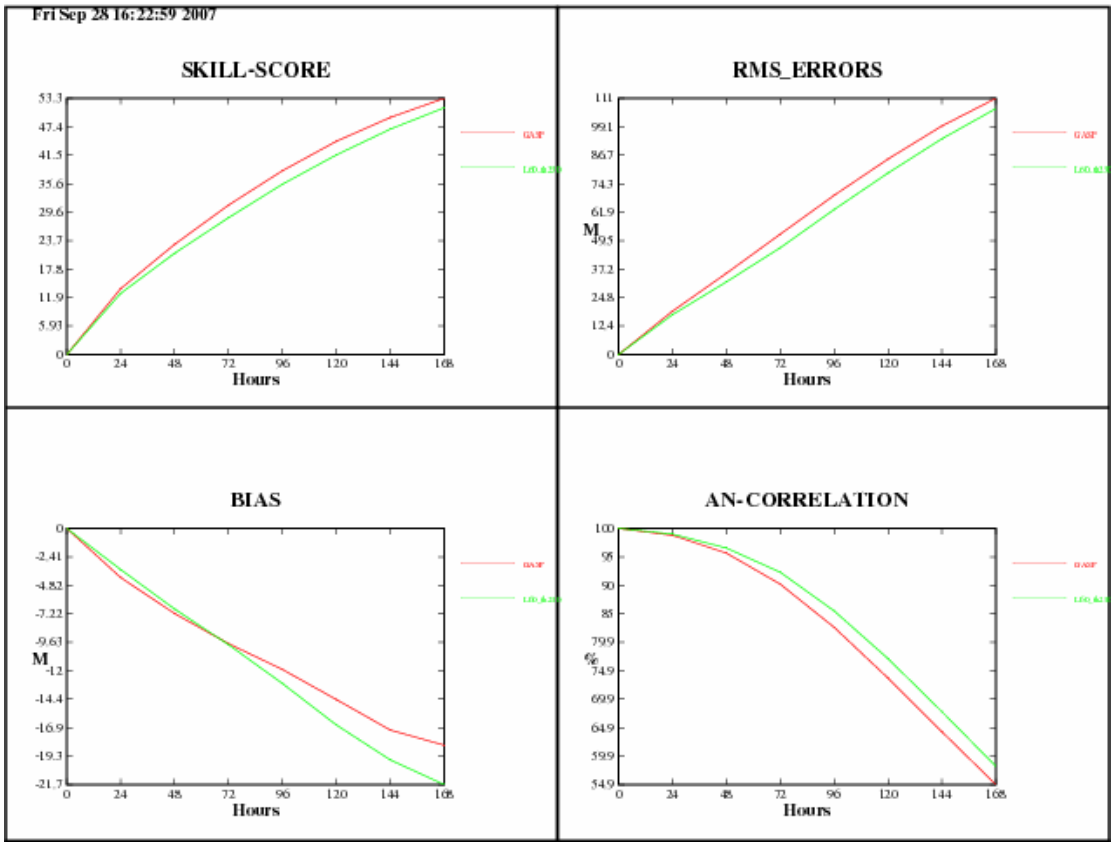

Figure 4: Skill scores of 500 hPa height for the Southern Annulus region, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

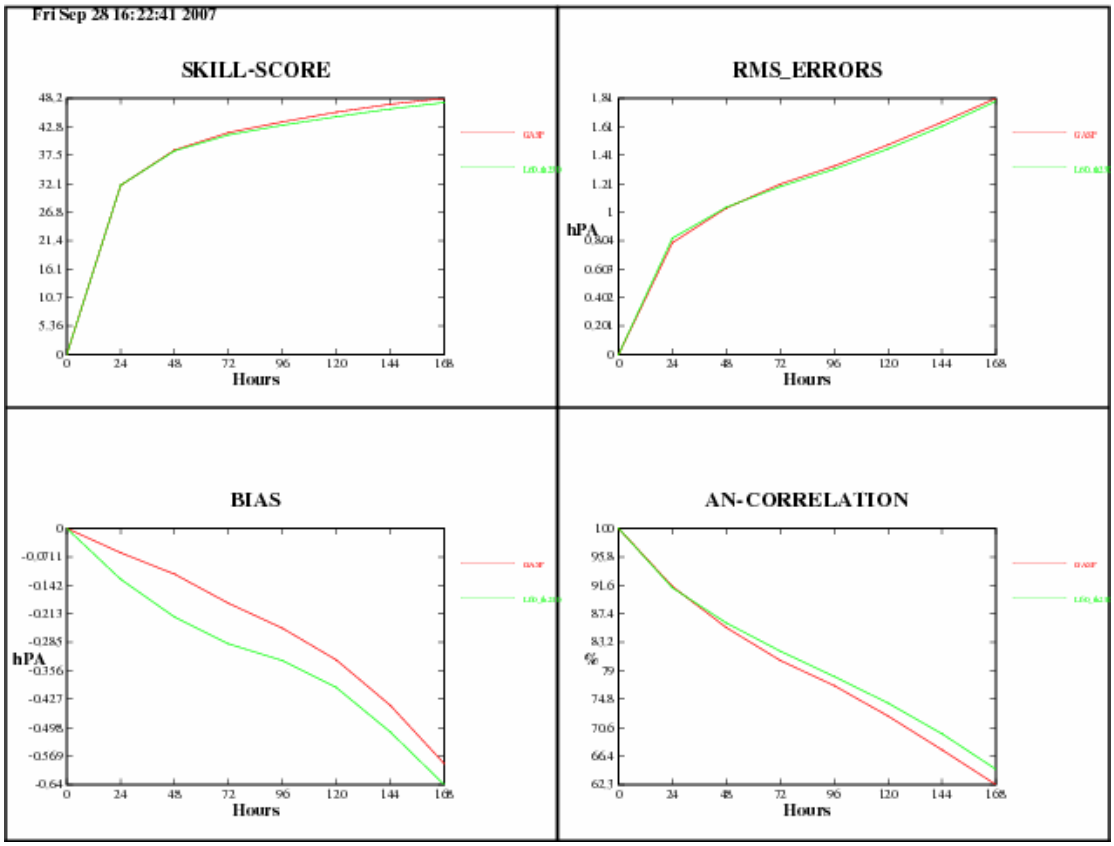

Figure 5: Skill scores of MSLP for the tropics, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

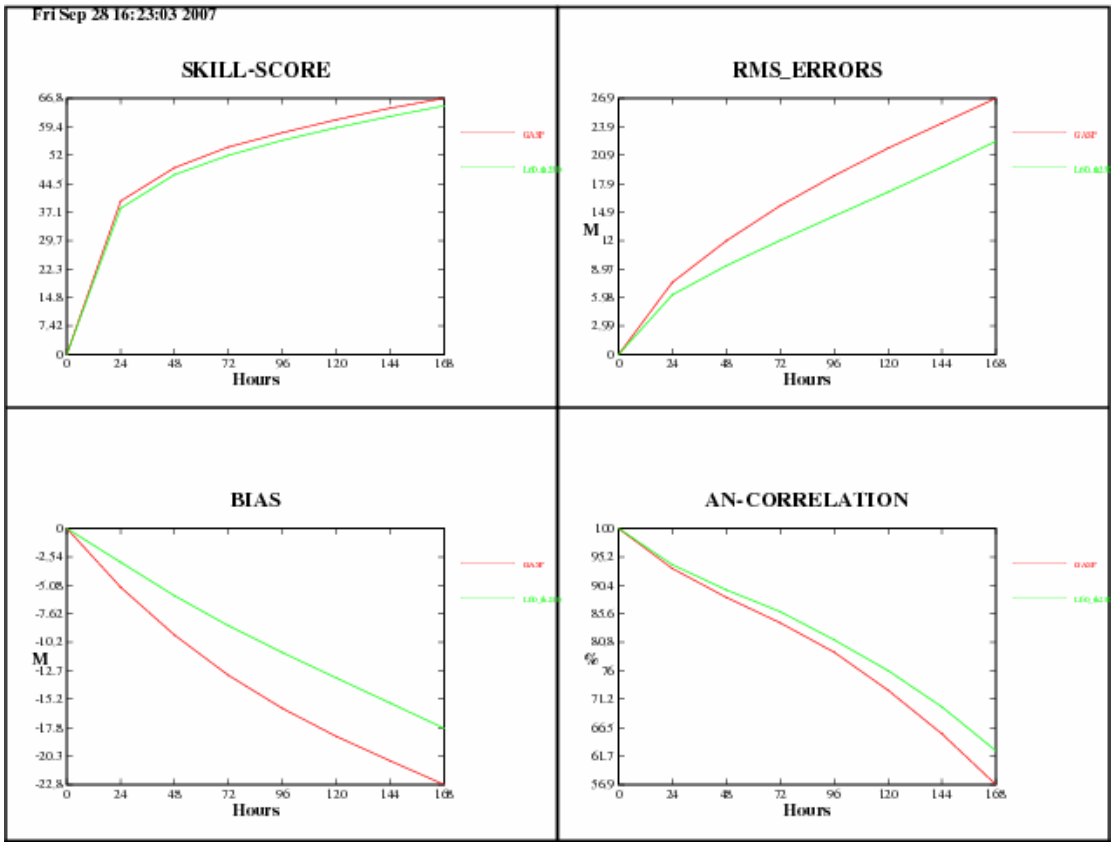

Figure 6: Skill scores of 500 hPa height for the tropics, comparing GASP(L60) (green lines) with GASP(L33) (red lines).

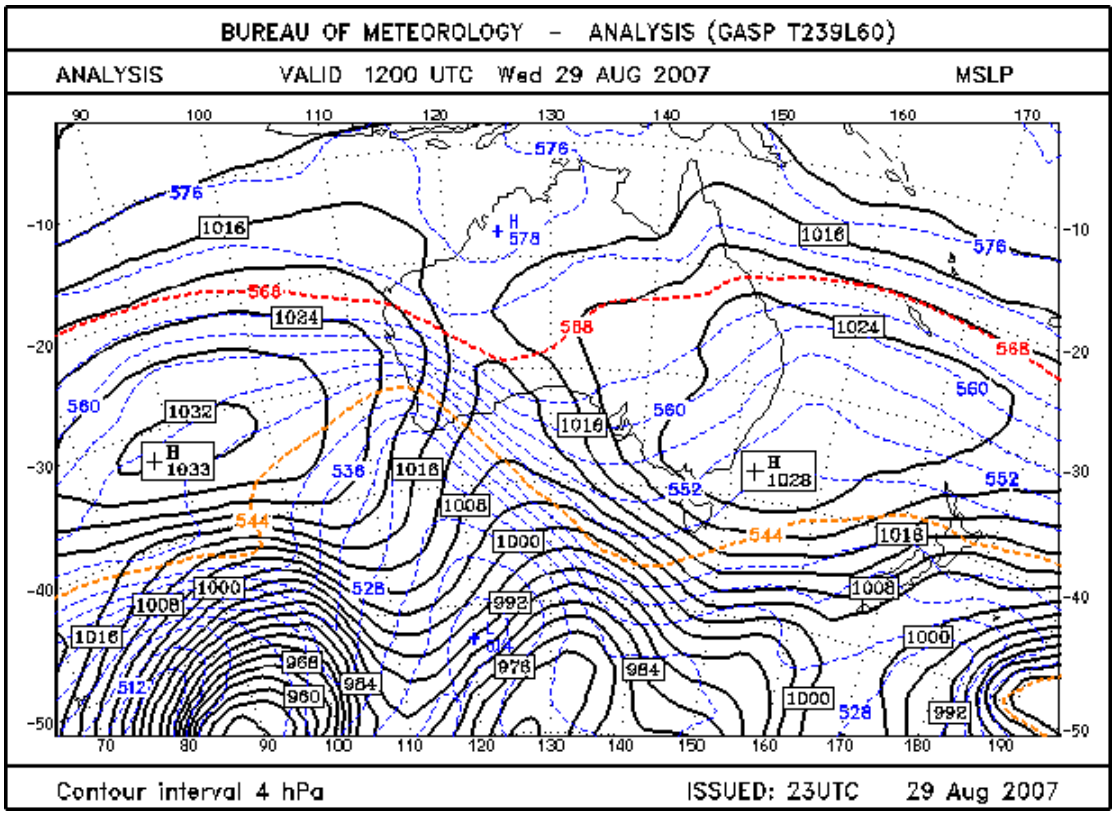

Figure 7a: MSLP analysis for 20070829 12UTC, as produced by GASP(L60)

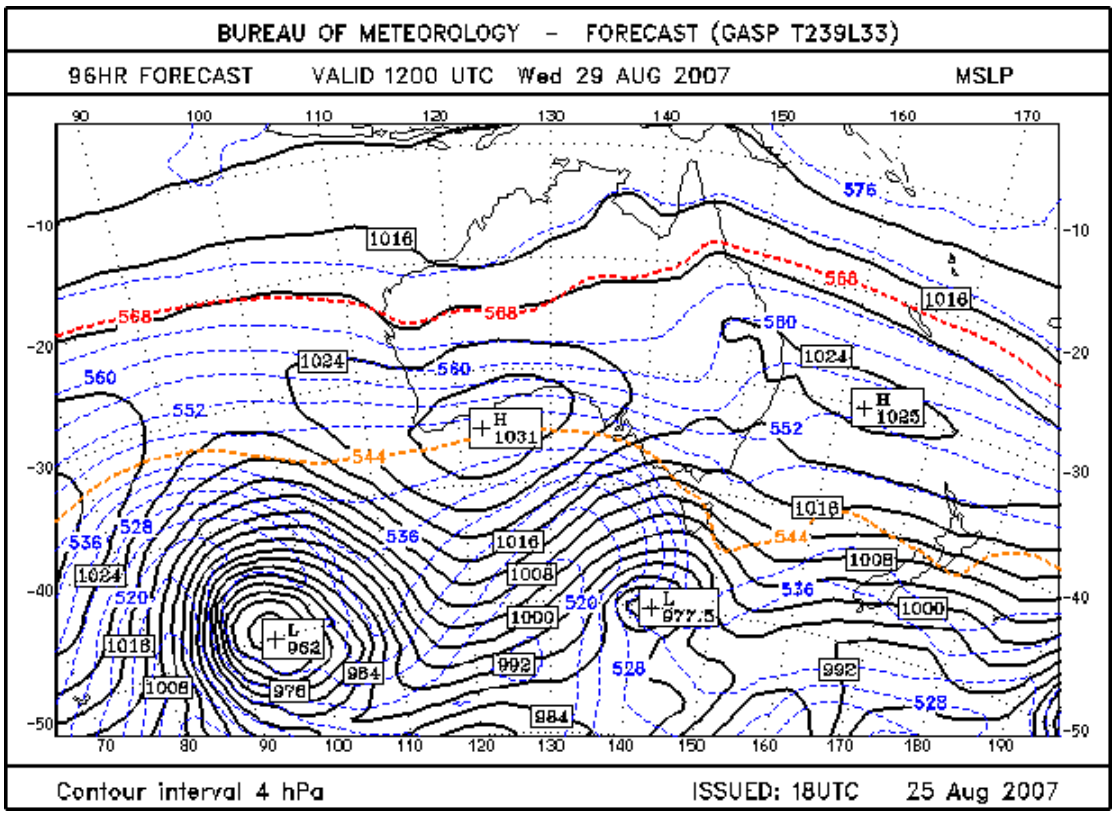

Figure 7b: GASP(L33) 96-hour MSLP forecast for 20070829 12UTC.

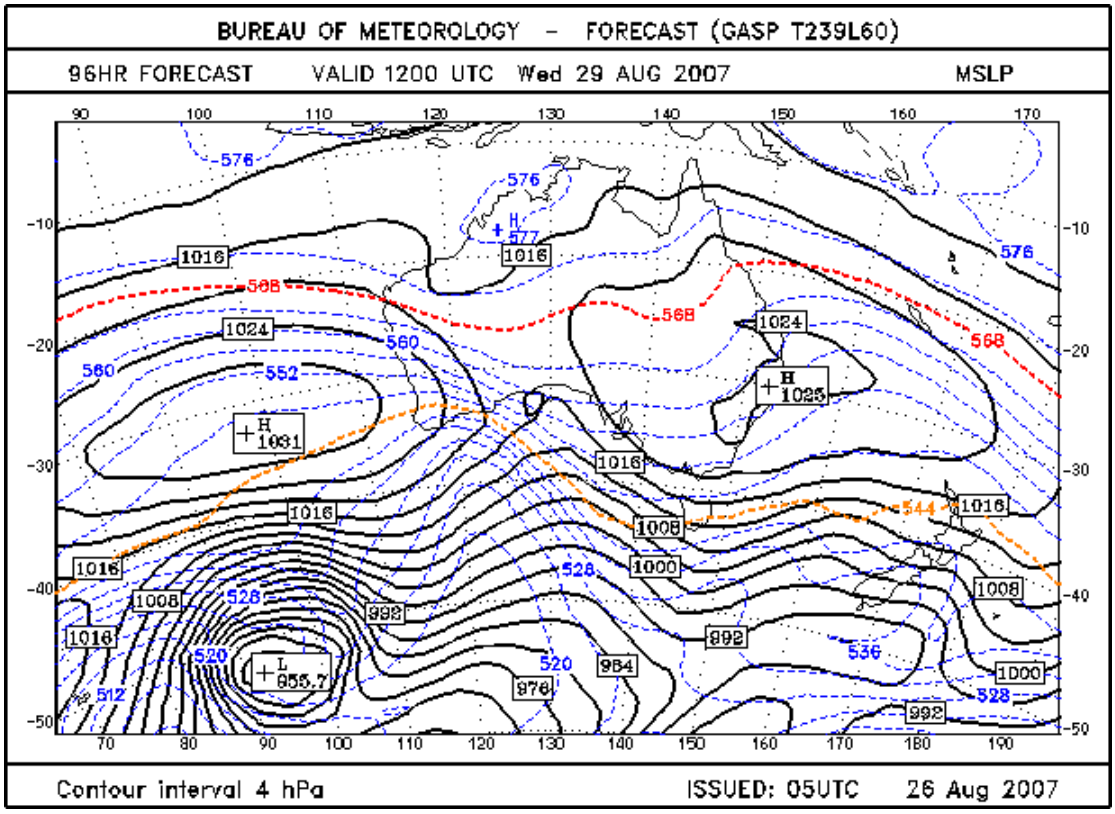

Figure 7c: GASP(L60) 96-hour MSLP forecast for 20070829 12UTC.

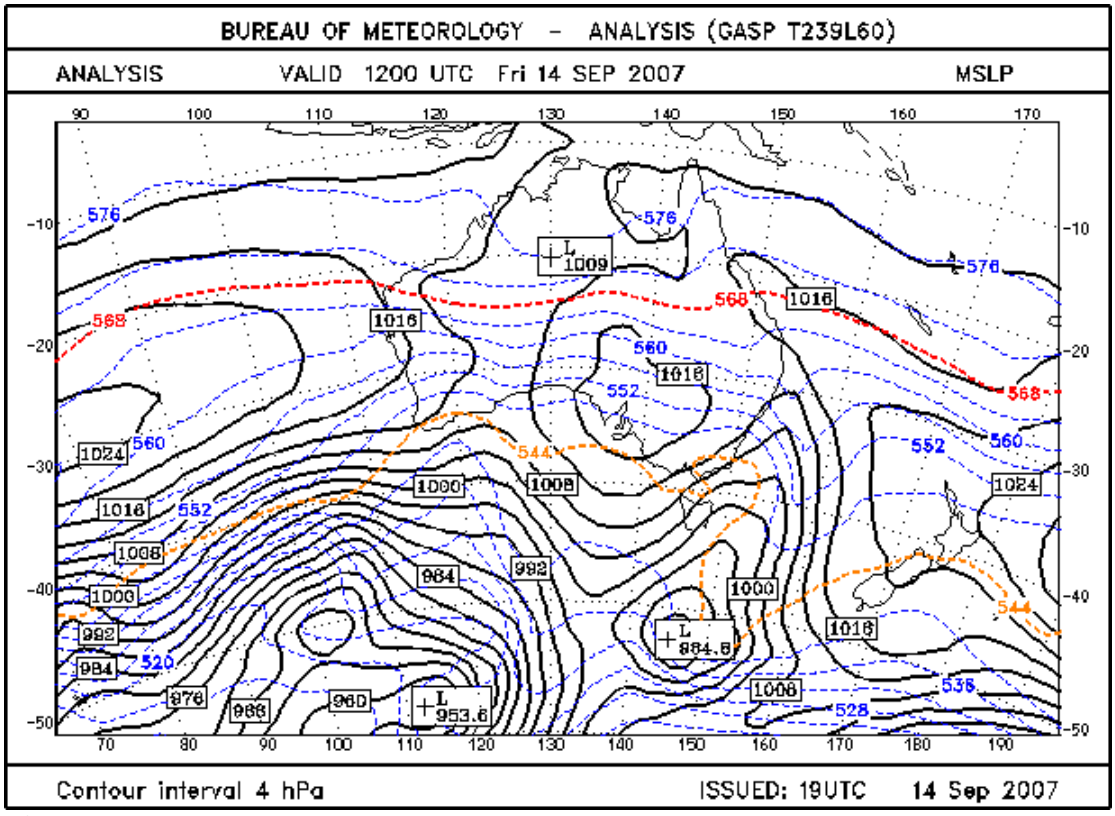

Figure 8a: MSLP analysis for 20070914 12UTC, as produced by GASP(L60).

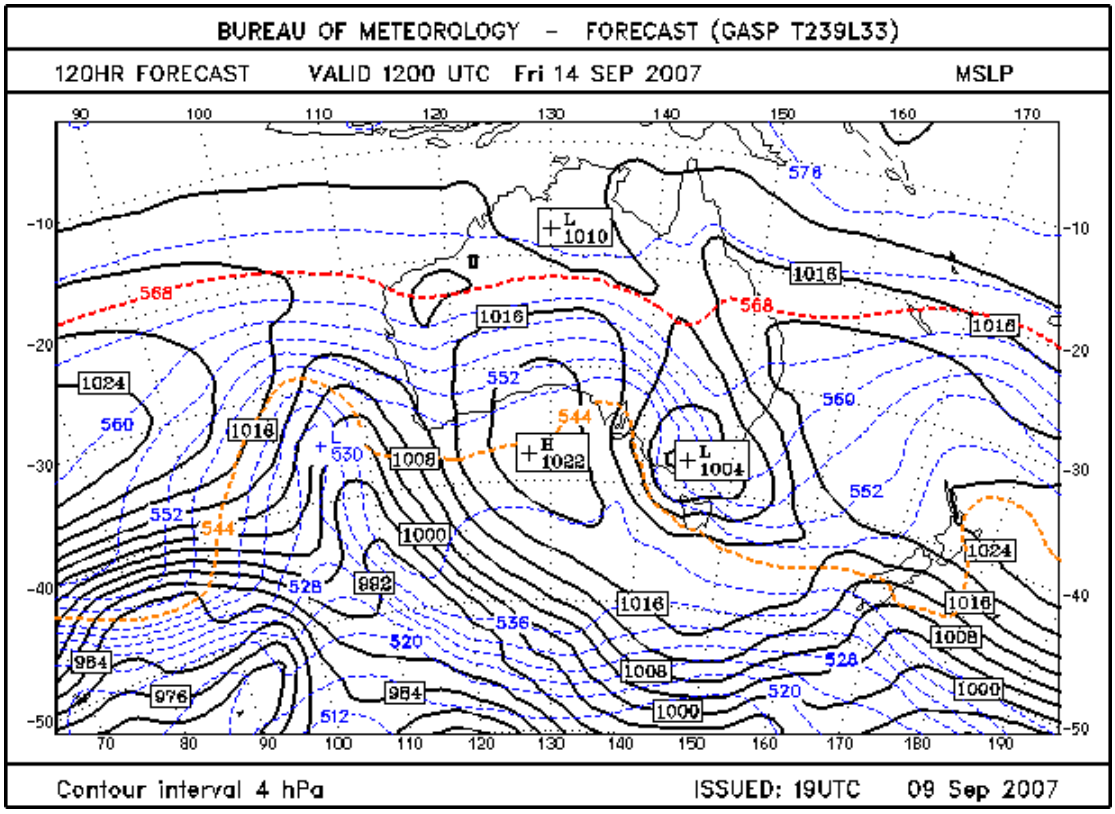

Figure 8b: GASP(L33) 120-hour MSLP forecast for 20070914 12UTC.

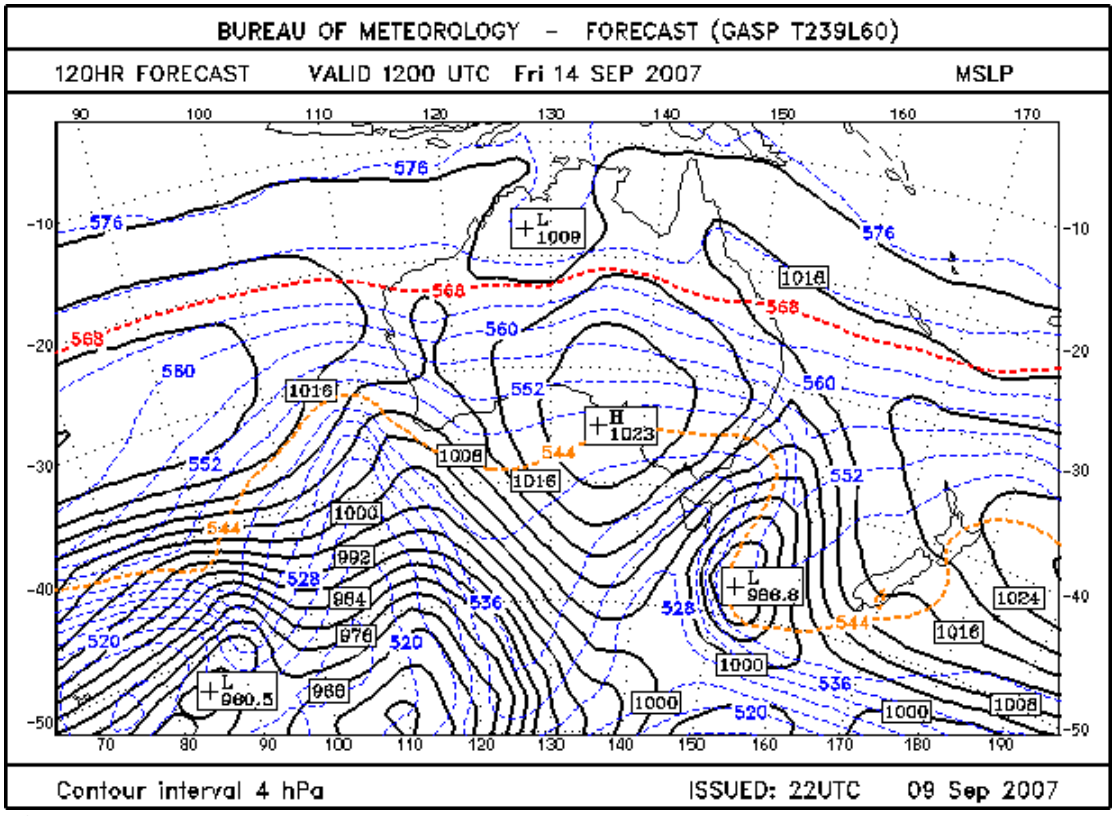

Figure 8c: GASP(L60) 120-hour MSLP forecast for 20070914 12UTC.