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Numerical prediction model performance summary October to December 1997

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Introduction

This summary continues the series comparing the performances of numerical weather prediction (NWP) models.

Models and methods

A description of the Australian verification methods can be found in a previous article (Skinner 1995). Models are from the National Meteorological Operations Centre (NMOC) Melbourne and from ECMWF (European Centre for Medium-range Weather Forecasts), NCEP (National Centers for Environmental Prediction) and UK (United Kingdom Meteorological Office).

The three models considered from NMOC, Melbourne, are: LAPS (Limited Area Prediction System), TLAPS (Tropical Limited Area Prediction System) and GASP (Global Assimilation and Prediction). Overseas global models included in the comparisons are: ECSP (ECMWF Spectral Assimilation), USAVM (NCEP Washington Spectral model for aviation) and UKGC (United Kingdom Meteorological Office Grid PE model).

Very short summaries of the models can be found in the initial article (Skinner 1995) with updates in subsequent issues.

For Figs 1, 2 and 3, results have been calculated within NMOC Melbourne, where the models were verified against their own analyses for the irregular Australian verification area only. Figure 4 shows verification data supplied by ECMWF and NCEP for models verified against radiosondes in the southern hemisphere. These statistics are in accordance with the recommendations of the World Meteorological Organization's Commission for Basic Systems. In this context the southern hemisphere is 20° to 90°S and models are verified against a list of 66 stations.

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All statistics are a measure of the skill in forecasting geopotential height or MSLP. Other field types are not included in these summaries.

LAPS and TLAPS models are run several hours earlier than GASP and this premature data cut-off, particularly for satellite information, adversely affects their skill compared to GASP.

Note that the Australian region verification grid has southerly points which are outside the TLAPS grid. TLAPS scores are calculated without these points and are therefore not strictly comparable with those from other models.

Notes on NWP systems

ECSP

A number of modifications were made on 27 August 1997, mostly concerning the use of satellite data, but also to ocean albedo, the convective scheme and the computation of saturation vapour pressure.

A four-dimensional variational data assimilation system (4D-Var) was implemented on 25 November 1997. This version of 4D-Var was developed as an evolution from the operational 3D-Var, and is based on six-hourly cycling.

NOAA-11 RTOVS have been assimilated since 1 December 1997.

A number of changes to the physical parametrisation scheme were introduced on 16 December 1997 (Lalaurette 1997).

October to December 1997 intercomparisons

Local models: (LAPS, TLAPS, GASP)

Skill scores still order the local models from best to worst as GASP, LAPS and TLAPS at both MSLP and 500 hPa (Figs 1(a), 1(c)). These represent averages

Fig. 1(a) Comparison for LAPS/TLAPS/GASP from October to December 1997. S1 skill scores of MSLP using combined base-times 0000 UTC / 1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.

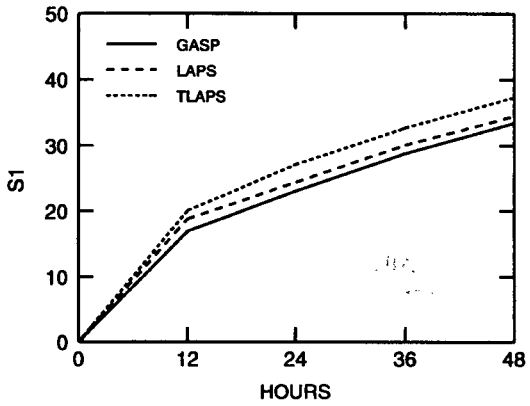


Fig. 1(b) Comparison for LAPS/TLAPS/GASP from October to December 1997. Root mean square errors of MSLP for combined base-times 0000 UTC / 1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.

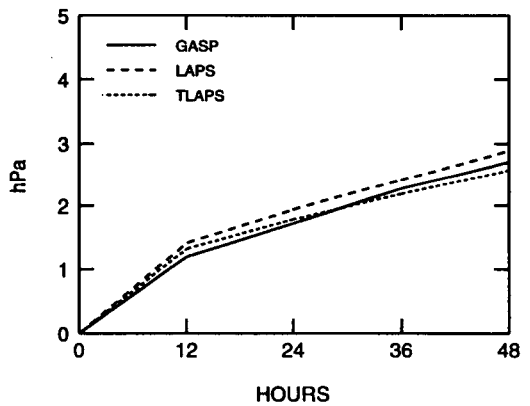


Fig. 1(c) Comparison for LAPS/TLAPS/GASP from October to December 1997. S1 skill scores of 500 hPa geopotential height (m) for combined base-times 0000 UTC / 1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.

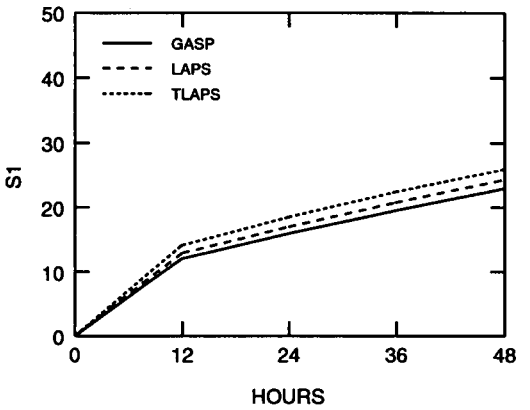
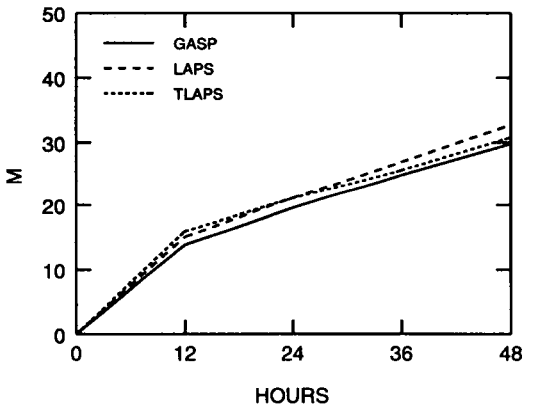


Fig. 1(d) Comparison for LAPS/TLAPS/GASP from October to December 1997. Root mean square errors of 500 hPa geopotential height (m) for combined base-times 0000 UTC / 1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.



over the whole three-monthly period but the same pattern is evident (Figs 3(a), 3(b)) where the +24 h skills are split into individual months. The difference between GASP and LAPS is only apparent in November. TLAPS performs as well as the other models at 500hPa in December but is otherwise slightly worse.

The rms errors, however, show a general improvement of TLAPS over LAPS at both MSLP and 500 hPa with the single exception of +12 h forecasts at 500 hPa (Figs 1(b), 1(d)). TLAPS also outperforms GASP for intervals greater than 36 h at MSLP. However, it should be noted that the verification points absent from the TLAPS scores come from the mid-latitude region where variance is greatest. A longer time series (Figs 3(e), 3(f)) from July 1995 shows the improvement of TLAPS over TAPS and the Australian region LAPS over its predecessor RASP.

Fig. 2(a) **Comparison for GASP/EC/US/UK from October to December 1997. S1 skill scores of MSLP for combined base-times 0000 UTC / 1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.**

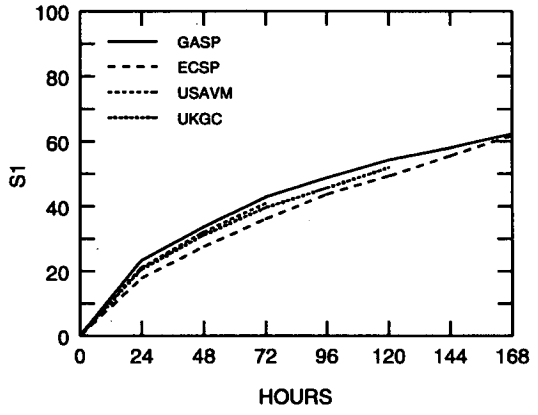


Fig. 2(b) **Comparison for GASP/EC/US/UK from October to December 1997. Root mean square errors of MSLP for combined base-times 0000 UTC / 1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.**

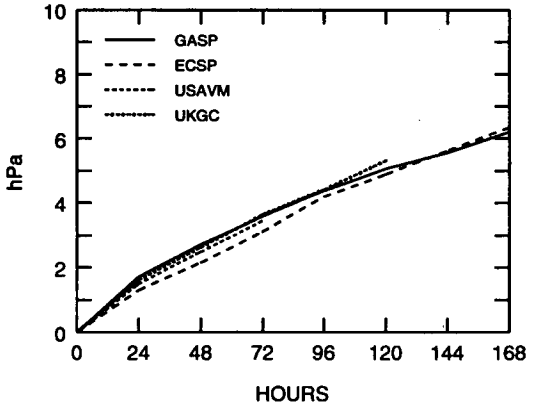


Fig. 2(c) **Comparison for GASP/EC/US/UK from October to December 1997. S1 skill scores of 500 hPa geopotential height (m) for combined base-times 0000 UTC / 1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.**

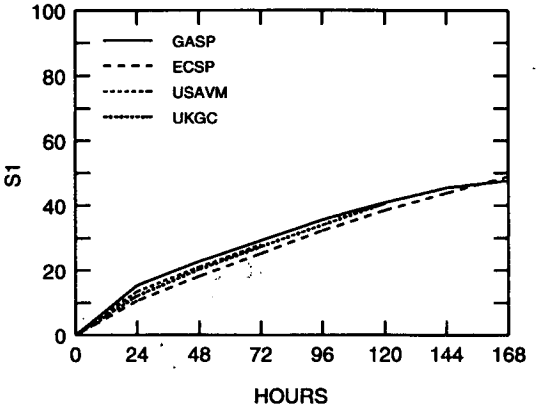
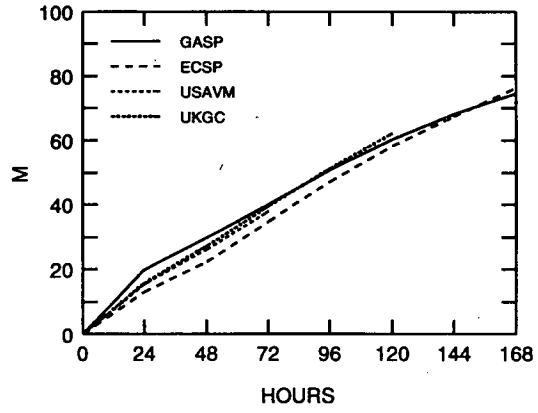


Fig. 2(d) **Comparison for GASP/EC/US/UK from October to December 1997. Root mean square errors of 500 hPa geopotential height (m) for combined base-times 0000 UTC / 1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.**



Synoptic overview for 24 h predictions

All models had difficulty with the prediction of several easterly troughs over central and southeastern Australia during October. Both position and intensity caused problems during a period of close to normal zonal flow. At the end of October (30/31) all local models successfully developed a cut-off low in the easterly trough over eastern Australia. The initial development tended towards underdevelopment and subsequent movement proved slower than expected, but the overall pattern was fairly well captured. There were some large errors in the prediction of Southern Ocean troughs although these tended to fall outside the verification area and hence did not always affect the scores.

November and December showed below normal

Fig. 3(a) Monthly S1 skill scores of MSLP for LAPS/TLAPS/GASP from October to December 1997 for base-time 1200 UTC and interval +24 h over the irregular Australian verification grid.

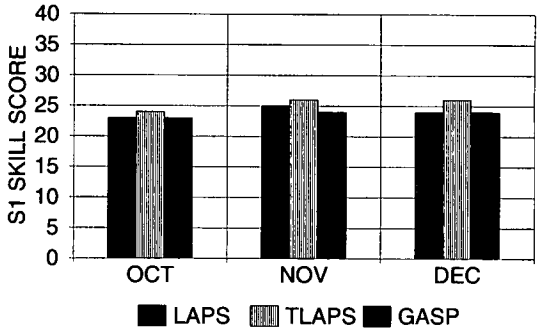


Fig. 3(b) Monthly S1 skill scores of 500 hPa geopotential height (m) for LAPS/TLAPS/GASP from October to December 1997 for base-time 1200 UTC and interval +24 h over the irregular Australian verification grid.

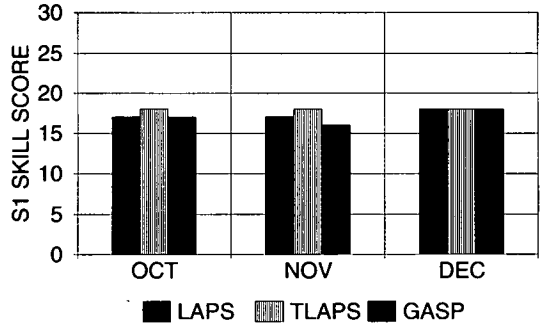


Fig. 3(c) Monthly S1 skill scores of MSLP for GASP/EC/UK/US from October to December 1997 for base-time 1200 UTC and interval +72 h over the irregular Australian verification grid.

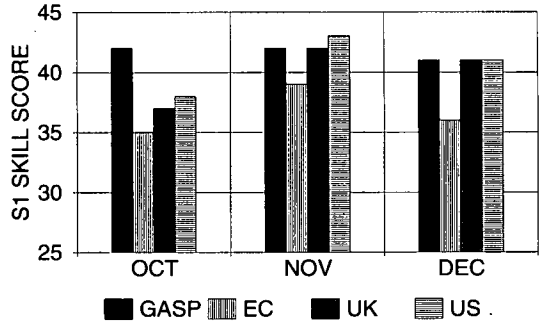


Fig. 3(d) Monthly S1 skill scores of 500 hPa geopotential height (m) for GASP/EC/UK/US from October to December 1997 for base-time 1200 UTC and interval +72 h over the irregular Australian verification grid.

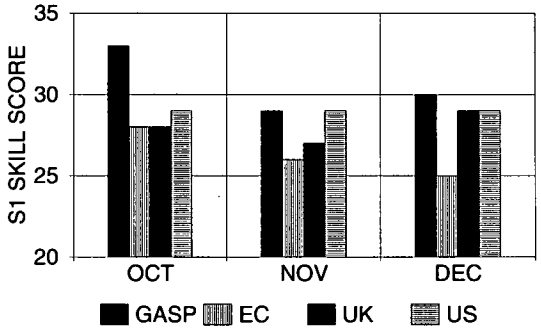


Fig. 3(e) Monthly S1 skill scores of MSLP for RASP/LAPS/TAPS/TLAPS from July 1995 to December 1997 for base-time 1200 UTC and interval +24 h over the irregular Australian verification grid.

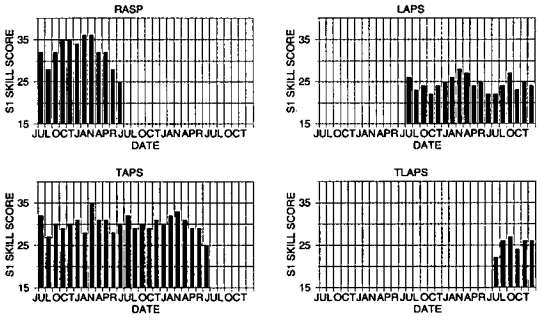
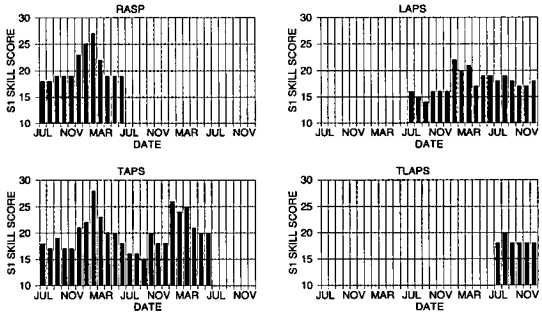


Fig. 3(f) Monthly S1 skill scores of 500 hPa geopotential height for RASP/LAPS/TAPS/TLAPS from July 1995 to December 1997 for base-time 1200 UTC and interval +24 h over the irregular Australian verification grid.



blocking in Australian longitudes and rapidly moving high latitude systems. Early in November, the models tended to move low pressure systems too slowly and overdevelop them. This occurred again late in November with an easterly trough over eastern Australia. In mid November, however, an east coast trough was under-forecast and was moved too rapidly southeastwards. On 1 December, an amplifying Southern Ocean trough dominated the ocean south of Tasmania while LAPS and TLAPS in particular had a significant trough development well to the northwest. Another set of poor forecasts on 3 and 4 December underestimated the strength of a trough moving into the southern Tasman and then deepened the easterly trough over the Australian Bight too much. A small cut-off low in the Tasman off the NSW coast on 7 December also was overestimated. Other overdevelopment of lows by LAPS occurred in the eastern Bight on 12 and 17 December and by GASP to a lesser extent on the same dates.

Overall during November and December, the models had some difficulty depicting the high mobility of systems. Tropical cyclones *Sid* and *Selwyn* caused some forecast errors from 26 December with the usual problem of a small displacement of a small intense system producing large errors.

Global models: (GASP, ECSP, UKGC, USAVM)

The series of graphs in Fig. 2 demonstrate the ongoing superiority of ECSP at both levels and for both skill score and rms error. The UKGC model had the second-best skill scores, reversing the relative position with USAVM during the last summary for July to September (Figs 2(a), 2(c)). The USAVM model did outperform UKGC when rms errors were considered although the margin between the models was slight in all cases (Figs 2(b), 2(d)). GASP performed best at longer forecast ranges, but was, in general, the least skillful.

The skill scores at +72 h for individual months (Figs 3(c), 3(d)) show a similar pattern with the order of decreasing skill being ECSP, UKGC, USAVM, and GASP.

A comparison of 1200 UTC 120-hour predictions from the global models

The use of +120 h restricts this synoptic comparison to GASP, ECSP and UKGC as the USAVM model is only issued to +72 h.

Errors exceeded 20 hPa in magnitude somewhere over the region 10 to 50°S and 100 to 160°E on about 30 per cent of occasions over the three-month period October to December 1997 for each of the three models. This is about the same rate as for the corresponding period in 1996. The error decreased considerably in December except for UKGC, associated with the seasonal weakening of the high latitude westerly circulation. These large errors were fairly evenly distributed in sign for ECSP but heavily biased to positive in GASP and UKGC, associated with their failure to capture the intensity of higher latitude systems.

Over the land area of Australia and the Bight region north of 40°S, such 'forecast busts' were much rarer with only six cases for ECSP and four for GASP and UKGC. Errors of 10 hPa in MSLP would still be classed as major by forecasters and these occurred on about half the occasions. In contrast to results over the larger domain, the errors for GASP were skewed towards negative sign, a reflection of GASP's tendency to lower pressure over the continent in the warmer months and to over-develop heat lows.

The cases of the 'busts' over the land and Bight region were:

- 2 October. Failure of UKGC (and to a lesser extent GASP) to predict a deep mid-latitude trough over southeastern Australia. Conversely the ECSP trough was too strong.
- 3 October. Spurious low near Adelaide in ECSP predictions.
- 9 October. A similar situation to 2 October but in West Australian longitudes.
- 31 October. Failure of GASP to predict a cut-off low over Victoria/Tasmania; ECSP predictions were too mobile; UKGC was good in phase but too weak.
- 7 November. GASP - too strong a trough over eastern Australia associated with over-development of a low over northern Australia.
- 11 November. Over-development of the WA trough in all three models
- 17 November. Failure in GASP and UKGC to develop a mid-latitude trough in east Australian longitudes; spurious low over eastern Australia in ECSP.
- 6 December. ECSP - spurious low centred over Bass Strait.
- 12 December. GASP and UKGC - phase, shape and intensity problems in a deep low pressure system centred southwest of Tasmania.
- 16 December. ECSP and UKGC - failure to predict a deep mid-latitude trough extending over Tasmania.
- 20 December. ECSP and UKGC - similar to 16 December but over Bight longitudes.

Note dates in this list refer to the verifying date of the five-day forecasts considered.

Troughs in the easterlies continued to be an area of generally poor performance. Particularly poor cases occurred in the predictions for 6 to 8 October, 30 October, 18 November and 18 to 19 December.

Particular cases of GASP over-developing lows over the northwest of the continent into spurious systems further south occurred in the predictions for 16 October, 28 November and 3, 18, 19 and 20 December.

The identification of major errors should not hide the fact that there are many very accurate predictions of

Fig. 4(a) Monthly root mean square errors of 500 hPa geopotential height (m) against radiosondes for GASP/EC/US from January 1996 to December 1997 for base-time 1200 UTC and interval +24 h over the southern hemisphere area 20°S to 90°S.

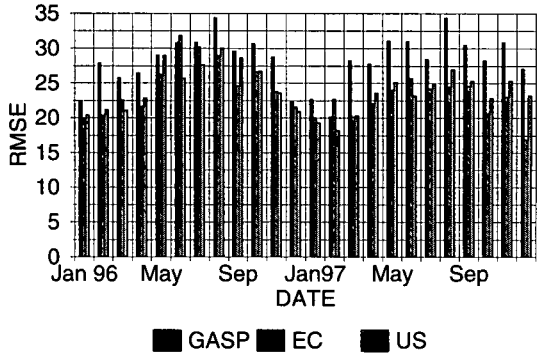


Fig. 4(b) Monthly root mean square errors of 500 hPa geopotential height (m) against radiosondes for GASP/EC/US from January 1996 to December 1997 for base-time 1200 UTC and interval +72 h over the southern hemisphere area 20°S to 90°S.

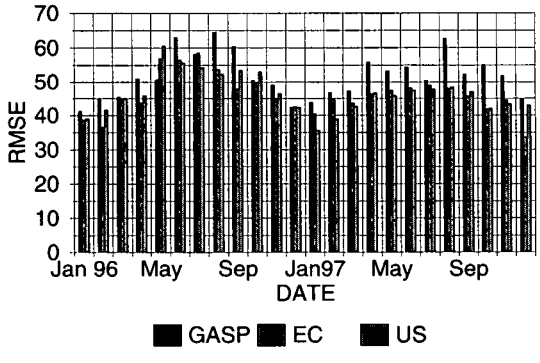
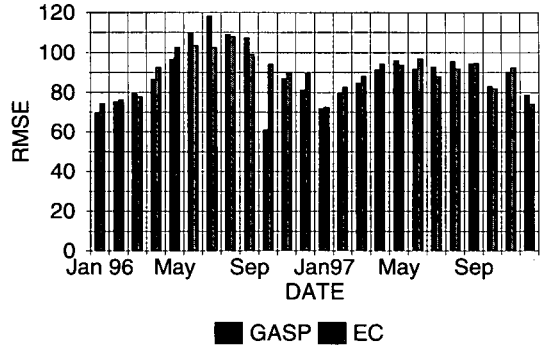


Fig 4(c) Monthly root mean square errors of 500 hPa geopotential height (m) against radiosondes for GASP/EC from January 1996 to December 1997 for base-time 1200 UTC and interval +168 h over the southern hemisphere area 20°S to 90°S.



detailed synoptic structure in the five-day predictions. One notable case was the ECSP prediction for 19 October. This accurately depicted the main synoptic features of a strong high over the Bight and a trough over the Tasman Sea. What was impressive was the detail of the Tasman trough, lying back through Bass Strait and into the Bight high. GASP and UKGC had the larger scale features but did not capture this smaller scale structure.

Comparison of models against radiosondes

Figure 4 shows rms errors from a comparison of model forecasts against a list of 66 WMO-nominated radiosonde stations. The level is 500 hPa and intervals +24 h, +72 h and +168 h. Only GASP and ECSP can be shown at +168 h but USAVM is available up to +72 h. The verification area is from 20°S to 90°S and 0° to 360°E. The southern hemisphere area is used here, rather than the Australian region only, as it has a better coverage of radiosondes at 1200 UTC.

References

Lalaurette, F. 1997. Changes to the Operational Forecasting System. *ECMWF Newsletter Number 77*(Autumn 1997),1.

Skinner, W. 1995. Numerical prediction model performance summary April to June 1995. *Aust. Met. Mag., 44*, 309-12.