

Numerical prediction model performance summary October to December 1996

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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 National Meteorological Centre (NMC) 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 NMC Melbourne are: LAPS (Limited Area Prediction System); TAPS (Tropical Analysis and 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 as follows: GASP (Skinner and Hart 1995c), TAPS (Skinner and Hart 1995d), LAPS (Skinner and Hart 1997), ECSP (Skinner and Hart 1995d), USAVM (Skinner and Hart 1995c), UKGC (Skinner and Hart 1995c and 1995d).

In general, results have been calculated within NMC Melbourne, where the models were verified against their own analyses for the irregular Australian verification area only. The above is true for Figs 1, 2, and 3 but Fig. 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 degrees to 90 degrees South and models are verified against a list of 68 stations.

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 TAPS models were run several hours earlier than GASP and this premature data cut-off, particularly for satellite information, adversely affected their skill compared to GASP.

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

Notes on NWP systems

No known changes to the operational models occurred during this period.

October to December 1996 intercomparisons

Local models: (LAPS, TAPS, GASP)

The local models performed in order GASP, LAPS and TAPS. This order is maintained for skill scores and root mean square (rms) errors and at mean sea level (MSL) and 500 hPa. Both the three-monthly averages (Fig. 1) and the individual monthly scores (Fig. 3) show this performance order. While GASP is the best, its margin over LAPS is quite small, particularly at MSL (Fig. 1(a), Fig. 3(a)).

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Fig. 1(a) Comparison for LAPS/TAPS/GASP from October to December 1996. S1 skill-scores at 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/TAPS/GASP from October to December 1996. S1 skill-scores at 500 hPa for combined base-times 0000 UTC/1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.

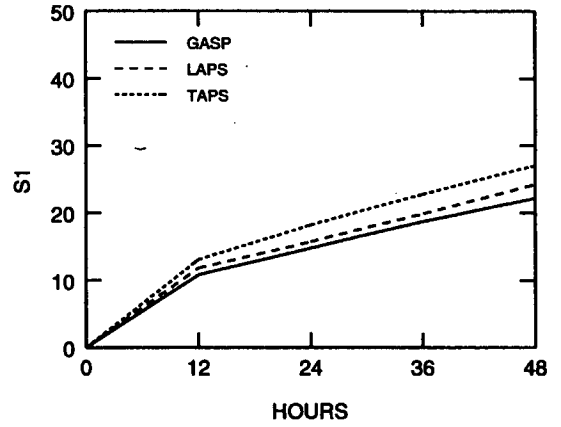
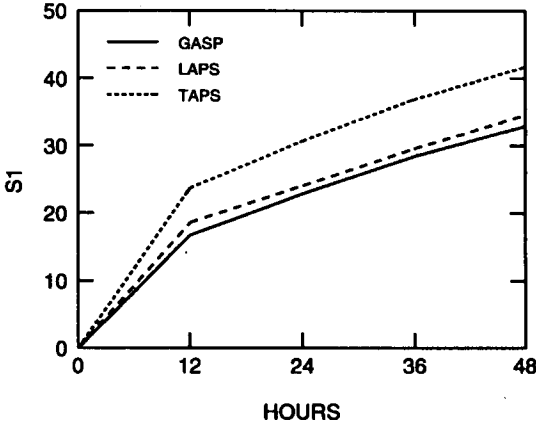
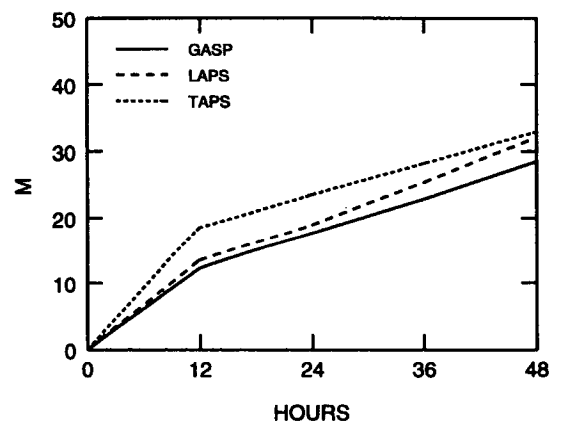
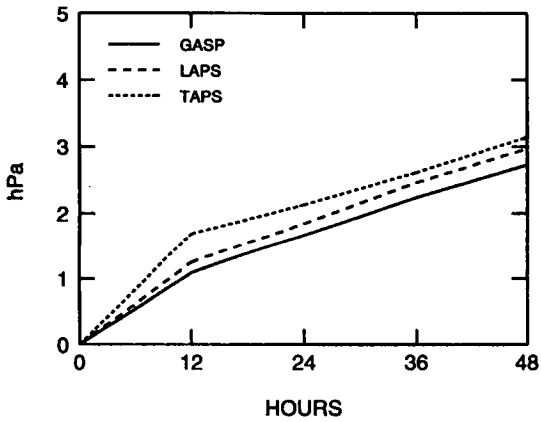


Fig. 1(b) Comparison for LAPS/TAPS/GASP from October to December 1996. Root mean square errors at MSLP for combined base-times 0000 UTC/1200 UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.

Fig. 1(d) Comparison for LAPS/TAPS/GASP from October to December 1996. Root mean square errors at 500 hPa for combined base-times 0000UTC/1200UTC and intervals +12, +24, +36, +48 h over the irregular Australian verification grid.



Examination of the daily MSL synoptic charts for the period often shows very little difference between GASP and LAPS predictions. TAPS can perform quite poorly in low-index situations. However, it should be pointed out that TAPS is principally a tropical model and this verification is over extratropical latitudes.

Tropical cyclones caused least damage to GASP's verification because this model makes no attempt to force in these small-scale intense systems. Hence both starting and verifying analysis have very smoothed rep-

resentations (sometimes none). LAPS and TAPS, on the other hand, have a process for forcing the analysis to try and capture the cyclones. Unfortunately, this is not always done in time for the operational model runs and can cause large pressure differences and large errors if either the starting or verifying analysis misses the feature. Even when the cyclone is properly captured in both analyses, it is not particularly well forecast as it is sometimes close to the limit of resolution. Also, small errors in predicted location lead to larger errors in gra-

Fig. 2(a) Comparison for GASP/EC/US/UK from October to December 1996. S1 skill-scores at MSLP for combined base-times 0000 UTC/1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.

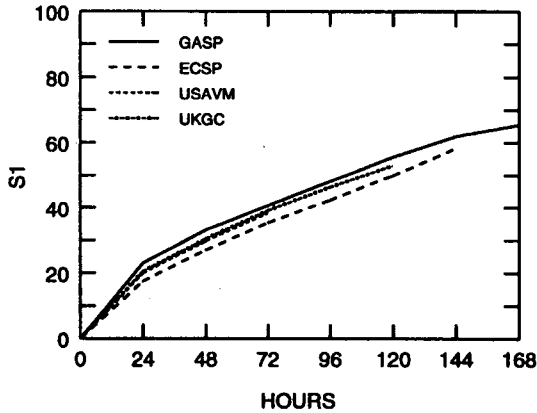


Fig. 2(c) Comparison for GASP/EC/US/UK from October to December 1996. S1 skill-scores at 500 hPa for combined base-times 0000 UTC/1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.

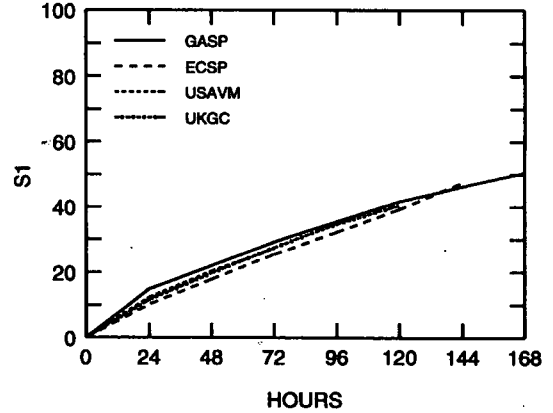


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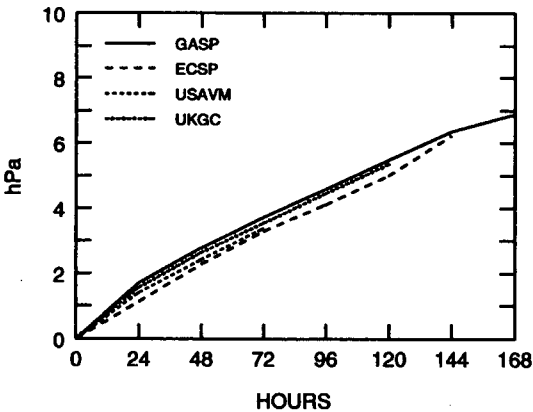
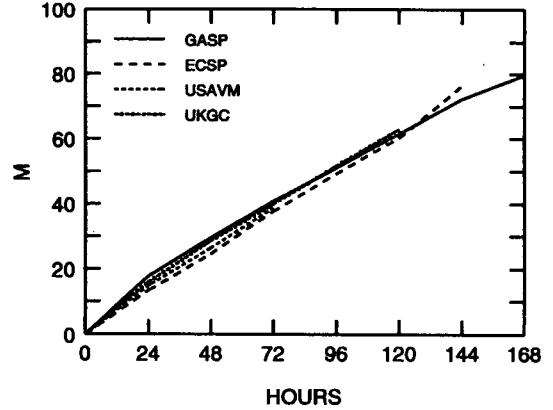


Fig. 2(d) Comparison for GASP/EC/US/UK from October to December 1996. Root mean square errors at 500 hPa for combined base-times 0000 UTC/1200 UTC and intervals +24 h to +168 h over the irregular Australian verification grid.



dient and this impacts adversely on those systems trying to represent the systems. As six tropical cyclones (*Cyril, Melanie, Fergus, Nicholas, Ophelia* and *Phil*) occurred in the Australian region during these three months, there is likely to have been a significant impact on the statistics for LAPS and TAPS.

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

Figures 2 and 3 show that ECSP is still the best performer of the global models that are looked at here. The superiority is evident for each statistic and each level. It

is only at +120 h (Fig. 2(d)) and +144 h (Fig. 2(c)) that GASP outscores ECSP. UKGC consistently outperforms GASP during this period, which is an improvement over the previous three months when this situation was reversed.

A comparison of global models at +120 h

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

A crude measure, the frequency of errors exceeding

Fig. 3(a) Monthly S1 skill-scores at MSLP for LAPS/TAPS/GASP from October to December 1996 for base-time 1200UTC and interval +24 h over the irregular Australian verification grid.

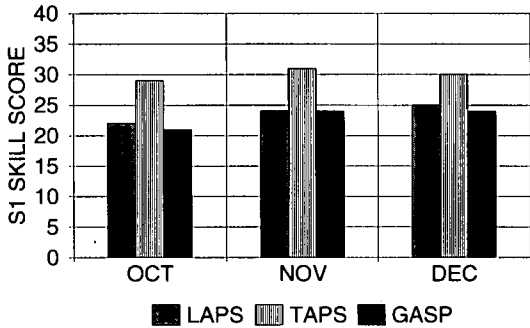


Fig. 3(c) Monthly S1 skill-scores at MSLP for GASP/EC/UK/US from October to December 1996 for base-time 1200 UTC and interval +72 h over the irregular Australian verification grid.

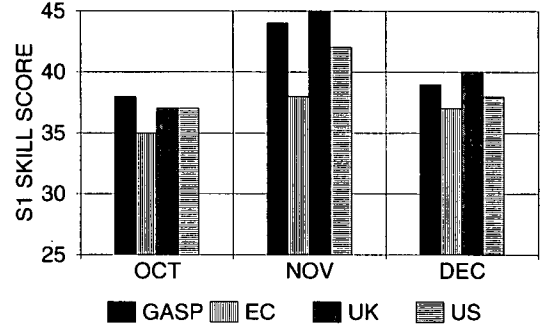


Fig. 3(b) Monthly S1 skill-scores at 500 hPa for LAPS/TAPS/GASP from October to December 1996 for base-time 1200 UTC and interval +24 h over the irregular Australian verification grid.

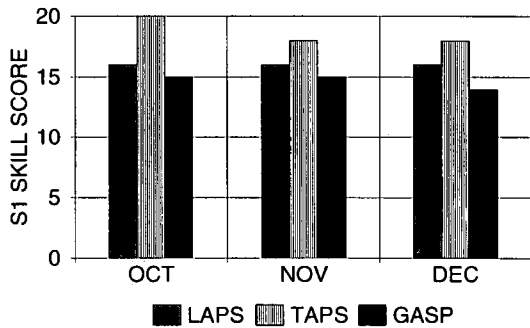
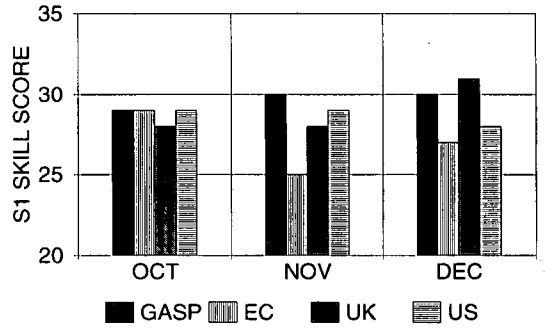


Fig. 3(d) Monthly S1 skill-scores at 500 hPa for GASP/EC/UK/US from October to December 1996 for base-time 1200 UTC and interval +72 h over the irregular Australian verification grid.



20 hPa, was 30 per cent of occasions for ECSP and GASP and 40 per cent for UKGC. For each of these models these frequencies were considerably less than for July-September, associated with the seasonal weakening of the westerly flow south of 40°S where most of the large errors typically occur. The sign of these errors was again heavily skewed to positive for GASP, reflecting a tendency to miss the strength of troughs and lows. In contrast to July-August, UKGC showed a stronger preponderance of solely negative errors than ECSP and a greater tendency for over-development of low pressure systems.

A series of over-developments in the predictions occurred during early October. The five-day UKGC predictions for 1 and 2 October showed a spurious low pressure system south of the Bight at about 130°E. On 4 October, all three models had a spurious low southwest of Western Australia at about 40°S

110°E which persisted in various forms but further east in the predictions for 5 October; the ECSP predictions for that day showed a low of central pressure 984 hPa south of the Bight with strong cyclonic flow over the Bight compared with a ridge in the verifying analysis. However, on 6 and 7 October the UKGC predictions for the Tasman Sea region, although deficient in the detail, did indicate the development of a trough missed in both the ECSP and GASP predictions. Other cases where the UKGC successfully predicted developments missed by the other two models were 20 October (Tasman Sea), 18 November (a deep low over the Tasman Sea) and 13 December (over the Bight). On the other hand, ECSP predictions were much more successful in predicting low pressure developments on 16 November and 6 December (lows over southeastern Australia) and on 23 November (western Bight).

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

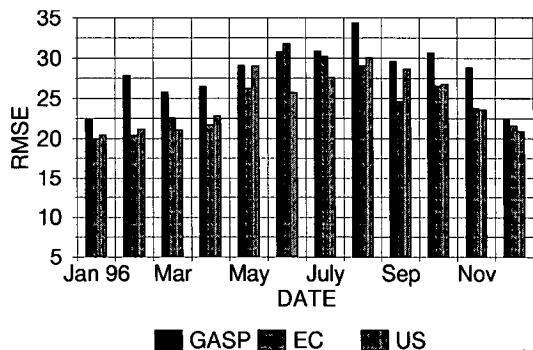


Fig. 4(b) Monthly root mean square errors against radiosondes at 500 hPa for GASP/EC/US from January to December 1996 for base-time 1200 UTC and interval +72 h over the southern hemisphere area 20°S to 90°S.

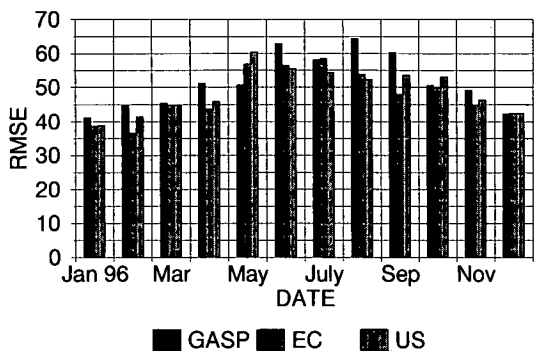
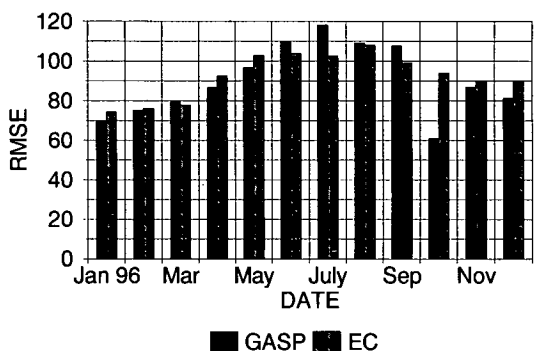


Fig. 4(c) Monthly root mean square errors against radiosondes at 500hPa for GASP/EC from January to December 1996 for base-time 1200 UTC and interval +168 h over the southern hemisphere area 20°S to 90°S.



A small-scale feature missed by all models in the five-day predictions was the cutoff cold pool located at 30°S 150°E on 23 November. This small system was associated with the severe thunderstorms and subsequent local flooding at Coffs Harbour.

During each day of the period 10-13 November there were errors exceeding 20 hPa simultaneously in each of the model predictions, with errors exceeding 40 hPa in some cases. The synoptic situation for this period showed a sequence of deep low pressure systems in the broad westerly flow south of about 40°S. The models did not appear to be able to accurately represent the locations or relative intensities of the individual centres.

The models' performance on some cut-off lows and troughs in the easterlies over the continent was relatively poor. There were several such instances during November and December when situations were poorly handled. The ECSP predictions were generally the best. One example was a low which developed over south-eastern Australia on 16 November. The ECSP predictions for this day were good but those of GASP and UKGC were quite poor. The predictions for the next day (17 November) were all quite poor and the error patterns strikingly similar; each model developed a low over Eastern Australia, with a centre 10-15 degrees northeastwards of the actual centre which was located over the Tasman Sea.

With the warming of the continent, GASP's tendency to overdevelop the heat troughs returned, most noticeably over Western Australia but also over Queensland. A particular example was the prediction for 19 October where the pressures over Western Australia were as much as 10 hPa below the observed. On some occasions the over-development of the Western Australian heat trough led to spurious low pressure systems (such as 21 December over the Bight, or 29 November over the Nullarbor).

It is surprising that the five-day predictions, especially those of ECSP, provided quite useful guidance on the development and subsequent movement of tropical lows which could be interpreted as tropical cyclones. One example was tropical cyclone *Melanie* which formed at about 10°S 95°E on 1 November and drifted slowly westwards. The ECSP predictions for 1 November were the first to depict this system, followed by GASP and UKGC on 3 November. The ECSP predictions tracked the system quite well in its early days but in later stages moved the system too slowly. The GASP predictions were not as good, exaggerating the areal extent of the system and also moving it too slowly. The UKGC predictions were intermediate.

Another very good ECSP prediction was for a tropical depression over the Gulf of Carpentaria, the precursor of tropical cyclone *Phil*, on 25 December which the others missed. Subsequent ECSP predictions also did

very well in the early stages of this tropical cyclone. Later in its life cycle all the models overdeveloped the system and moved it too slowly westwards.

The models were not very convincing in the predictions of the development of tropical cyclone *Fergus* over the Coral Sea at about 12°S 160°E on 24 December. GASP was the only model to predict a closed circulation on 25 December. However, ECSP provided the best guidance on its subsequent development and southeastwards movement through to 31 December.

The GASP and UKGC predictions on 15 December for tropical cyclone *Nicholas* off the Kimberleys were too intense and on 29 December the UKGC spuriously predicted a deep cyclone off the northeast coast.

Comparison of models against radiosondes

Figure 4 shows root mean square errors from a comparison of model forecasts against a list of 68 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 there are not many radiosondes in the Australian region at 1200 UTC.

GASP's performance increases with the longer interval and by +168 h is beating ECSP in the warmer months. At +24 h it is consistently the worst performer. All the statistics show volatile relative performances.

References

- Skinner, W. 1995. Numerical prediction model performance summary April to June 1995. *Aust. Met. Mag.*, 44, 309-12.
- Skinner, W. and Hart, T. 1996a. Numerical prediction model performance summary July to September 1995. *Aust. Met. Mag.*, 45, 59-62.
- Skinner, W. and Hart, T. 1996b. Numerical prediction model performance summary October to December 1995. *Aust. Met. Mag.*, 45, 131-5.
- Skinner, W. and Hart, T. 1996c. Numerical prediction model performance summary January to March 1996. *Aust. Met. Mag.*, 45, 189-92.
- Skinner, W. and Hart, T. 1996d. Numerical prediction model performance summary April to June 1996. *Aust. Met. Mag.*, 45, 261-5.
- Skinner, W. and Hart, T. 1997. Numerical prediction model performance summary July to September 1996. *Aust. Met. Mag.*, 46, 51-55.