Quarterly numerical weather prediction model performance summaries April to June 2010 and July to September 2010

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(Manuscript received December 2010)

Introduction

These summaries cover the two periods April to June 2010 and July to September 2010, and report on the performance of the Australian Bureau of Meteorology’s operational Numerical Weather Prediction (NWP) models.

NWP models - April to September 2010

Local models

On Tuesday 17 August 2010 the Bureau of Meteorology’s ACCESS (Australian Community Climate and Earth-System Simulator) Numerical Weather Prediction (NWP) systems formally replaced the GASP, LAPS, TXLAPS and MESOLAPS NWP systems, which were switched off from that date.

The operational ACCESS suite comprises ACCESS-G (Global domain), ACCESS-R (Regional domain), ACCESS-T (Tropical domain), ACCESS-A (Australian domain) and ACCESS-C (Five city domains). ACCESS-TC (Tropical Cyclone) is currently undergoing development. Implementation of ACCESS-TC is expected early in the 2010–2011 Southern Hemisphere cyclone season.

The configurations of the ACCESS and GASP/LAPS systems are summarised in Table 1.

The initial installation of the ACCESS-G/R/T systems was on the NEC SX-6 supercomputer. These systems were subsequently installed on the new Sun supercomputer, Solar, and were declared operational on 29 June 2010. Up until 28 June 2010 the verification statistics in this summary were based on the systems installed on the SX-6, subsequently the statistics were produced on systems installed on Solar.


ACCESS-G, ACCESS-R and ACCESS-T are expected to provide better forecast guidance than GASP, LAPS_PT375 and TXLAPS_PT375. The quarterly inter-comparison plots of local and overseas models are shown in the Review of performance section. A new verification package called Verify has been used to generate the statistics and associated plots for the ACCESS systems from 1 September 2009. Statistics for the other models (GASP/LAPS and overseas models) are still generated by the old verification package. Verify has been tested against a range of models to ensure that it produces the same scores as the old verification package.

Verify is a Python-based software tool for performing forecast verification. It enables the calculation and plotting of forecast verification scores. It was developed at the European Centre for Medium Range Weather forecasting (ECMWF), primarily by Claude Gibert. For further information on Verify, please refer to http://synopticview.co.uk/metpy_verify.html

Overseas models

The following four operational global models which are run by overseas forecast centres are verified in this paper. The European Centre Spectral Prognosis (ECSP) refers to the European Centre for Medium-Range Weather Forecasts (ECMWF) system, UKGC to the Unified Model from the UK Met Office, United States Aviation Model (USAVN) to the Global Forecast System (GFS) from National Centers for Environmental Prediction (NCEP) and Japan Meteorological Agency Global Spectral Model (JMAGSM) to the global assimilation and forecast model from JMA.

On 24 June 2010 ECMWF introduced a new version of the NWP system called Cycle 36r2. The major changes implemented in this system include an ensemble of data assimilations which provide initial-time perturbations for Ensemble Prediction System (EPS).

On 28 July 2010 NCEP implemented a major upgrade to the Global Forecast System (GFS) system - Q3FY2010 (T574L64 Eulerian). The upgrade incorporated an Earth System Modeling Framework (ESMF) and also included changes to resolution, radiation and cloud, gravity-wave drag parameterization, removal of negative water vapor, hurricane relocation, post processing and utility, snow analysis, upgraded boundary layer scheme, new mass flux shallow convection scheme and updated deep convection scheme.

For further information on the improvements made to overseas NWP assimilation and forecast models refer to the web references given below. Details on the configurations of the assimilation and forecast models are described in an earlier summary (Lee 2005).
Table 1: Model domains and resolutions

<table>
<thead>
<tr>
<th>NWP system</th>
<th>Domain</th>
<th>Type</th>
<th>Resolution</th>
<th>Domain limits S-N, W-E (lat x lon)</th>
<th>Duration (hours)</th>
<th>Runs (UTC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCESS-G</td>
<td>Global</td>
<td>Assim + Forc</td>
<td>N144 (1.25° lon x 0.833° lat)</td>
<td>-90.0 to 90.0, 0.00 to 358.75 (217 x 288)</td>
<td>+240</td>
<td>00, 12</td>
</tr>
<tr>
<td>GASP</td>
<td>Global</td>
<td>Assim + Forc</td>
<td>T239 (~0.75°)</td>
<td>-90.0 to 90.0, 0.00 to 358.75 (240 x 480)</td>
<td>+240</td>
<td>00, 12</td>
</tr>
<tr>
<td>ACCESS-R</td>
<td>Regional</td>
<td>Assim + Forc</td>
<td>0.375° (~37.5 km)</td>
<td>-65.00 to 17.125, 65.00 to 194.625 (220 x 320)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
<tr>
<td>LAPS_PT375</td>
<td>Regional</td>
<td>Assim + Forc</td>
<td>0.375° (~37.5 km)</td>
<td>-65.00 to 17.125, 65.00 to 194.625 (220 x 320)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
<tr>
<td>ACCESS-T</td>
<td>Tropical</td>
<td>Assim + Forc</td>
<td>0.375° (~37.5 km)</td>
<td>-45.00 to 55.875, 60.00 to 217.125 (270 x 420)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
<tr>
<td>TXLAPS_PT375</td>
<td>Tropical</td>
<td>Assim + Forc</td>
<td>0.375° (~37.5 km)</td>
<td>-45.00 to 55.875, 60.00 to 217.125 (270 x 420)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
<tr>
<td>ACCESS-A</td>
<td>Australian</td>
<td>Assim + Forc</td>
<td>0.11° (~12 km)</td>
<td>-55.00S to 4.73N, 95.00E to 169.69E (680x544)</td>
<td>+48</td>
<td>00, 06, 12, 18</td>
</tr>
<tr>
<td>MesoLAPS_PT125</td>
<td>Australian</td>
<td>Assim + Forc</td>
<td>0.125° (~14 km)</td>
<td>-55.00S to 4.875N, 95.00E to 169.875E (480x600)</td>
<td>+48</td>
<td>00, 06, 12, 18</td>
</tr>
<tr>
<td>ACCESS-C</td>
<td>Brisbane</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-31.00S to -22.05S, 148.00E to 155.95E (180x160)</td>
<td>+36</td>
<td>00, 12</td>
</tr>
<tr>
<td></td>
<td>Perth</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-37.00S to -28.05S, 112.00E to 119.95E (180x160)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adelaide</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-39.50S to -30.55S, 132.00E to 141.95E (180x200)</td>
<td>+36</td>
<td>00, 12</td>
</tr>
<tr>
<td></td>
<td>VICTAS</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-46.00S to -34.05S, 139.00E to 150.95E (240x240)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sydney</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-38.00S to -30.05S, 147.00E to 154.95E (160x160)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MesoLAPS_PT050</td>
<td>Brisbane</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-31.00S to -22.05S, 148.00E to 155.95E (180x160)</td>
<td>+36</td>
<td>00, 12</td>
</tr>
<tr>
<td></td>
<td>Perth</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-37.00S to -28.05S, 112.00E to 119.95E (180x160)</td>
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</tr>
<tr>
<td></td>
<td>Adelaide</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-39.50S to -30.55S, 132.00E to 141.95E (180x200)</td>
<td>+36</td>
<td>00, 12</td>
</tr>
<tr>
<td></td>
<td>VICTAS</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-46.00S to -34.05S, 139.00E to 150.95E (240x240)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sydney</td>
<td>Forc</td>
<td>0.05° (~5 km)</td>
<td>-38.00S to -30.05S, 147.00E to 154.95E (160x160)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACCESS-TC</td>
<td>Tropical Cyclone</td>
<td>Assim + Forc</td>
<td>0.11° (~12 km)</td>
<td>Relocatable within the ACCESS-T domain: (300x300)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
<tr>
<td>TCLAPS</td>
<td>Tropical Cyclone</td>
<td>Assim + Forc</td>
<td>0.10° (~10 km)</td>
<td>Relocatable within the TXLAPS_PT375 Domain: (300x300)</td>
<td>+72</td>
<td>00, 12</td>
</tr>
</tbody>
</table>

Verification method

A description of the S1 skill-score, as applied in NMOC, can be found in the paper by Skinner (1995). All results have been calculated within NMOC Melbourne, where each of the models was verified against its own analysis. From the large number of objective verification results routinely produced, the statistics presented here cover only the mean sea level pressure (MSLP) and 500 hPa geopotential height fields over the irregular Australian verification area (Miao 2003). It is noted that this particular verification grid has southerly points that are outside the TXLAPS_PT375 and ACCESS-T's southern domain boundary and, hence, the TXLAPS_PT375 and ACCESS-T scores are not strictly comparable with those from GASP, ACCESS-G/R and LAPS_PT375. Also the results for the 0000 and 1200 UTC base-times have been combined. For the locally run, limited-area models, the verified forecast periods go out to a maximum of 72 hours and for the global models to a maximum of 192 hours.

All the models are verified using a common 2.5° latitude/longitude grid except USAVN which is verified on a 2.5° latitude/5.0° longitude grid. However this use of coarser grid spacing for USAVN is not thought to have affected the inter-comparison.
Review of performance – April to September 2010

Figures 1 to 3 are the plots covering the period from April to June 2010 which include the GASP/LAPS systems and Figs 4 to 6 are the plots from July to September 2010 which exclude GASP/LAPS as the systems were turned off in mid August.

Local models (GASP, ACCESS-G, LAPS, ACCESS-R, TX-LAPS, ACCESS-T)

The intercomparisons of the S1 skill scores of the MSLP forecasts for the six local models covering the period April to June and July to September 2010 are shown in Figs 1(a) and 4(a). The S1 skill-scores are averaged over the three-month period for various forecast periods ranging from 0 to 72 hours. S1 skill-score comparisons of the 500 hPa geopotential height forecasts are shown in Figs 1(b) and 4(b).

Fig. 1(a) MSLP S1 skill-score comparison, for different forecast periods, between GASP, ACCESS-G, LAPS_PT375, ACCESS-R, TXLAPS_PT375 and ACCESS-T (April to June 2010).

Fig. 1(b) 500 hPa geopotential height S1 skill-score comparison, for different forecast periods, between GASP, ACCESS-G, LAPS_PT375, ACCESS-R, TXLAPS_PT375 and ACCESS-T (April to June 2010).

Fig. 2(a) MSLP S1 skill-score comparison, for different forecast periods, between ACCESS-G, GASP, ECSF, UKGC, USAVN, and JMAGSM (April to June 2010).

Fig. 2(b) 500 hPa geopotential height S1 skill-score comparison, for different forecast periods, between ACCESS-G, GASP, ECSF, UKGC, USAVN and JMAGSM (April to June 2010).

Fig. 3 Anomaly correlation of MSLP comparison, for different forecast periods, between ACCESS-G, GASP, ECSF, UKGC, USAVN and JMAGSM (April to June 2010).
The plots Figs 1(a) and 1(b) indicate the new ACCESS system is much more skilful than the GASP/LAPS system. In general, the coarser-resolution global model outperforms the finer-resolution limited area models. This result is partly due to the later data cut-off of the assimilation for the global models. It is also due to the disadvantage suffered by the limited area models which obtain their initial first guess and boundary conditions from the earlier run of the global model forecasts. Forecasts from earlier runs tend to be poorer than forecasts produced from later runs. One other contributing factor for the better-than-expected scores for the global models is the verification method used here, which disadvantages finer resolution models through “double penalty” scoring. For example, a location error of a deep low pressure system from a more realistic high resolution forecast is counted once for misplacing the low where the verifying analysis does not have it and twice for not placing it where the verifying analysis does. Care needs to be taken.
to filter out scales below which a verification method was not intended to measure if models that are run at different resolutions are to be objectively compared.

Global models (ACCESS-G, GASP, ECSP, UKGC, USAVN, JMAGSM)
The Bureau’s new operational global spectral models ACCESS-G and the four global models from overseas NWP centres are operationally used by forecasters. The outputs from the models are also postprocessed to produce various objective guidance products used in and outside of the Bureau. Hence their forecast performance is of great interest to the forecasters and other users. The S1 skill scores for MSLP and 500 hPa geopotential height forecasts for the period April to June are presented in Figs 2(a), 2(b), 5(a) and 5(b). Anomaly correlations for the MSLP forecasts are shown in Figs 3 and 6.

Assuming the commonly used cut-off of 60 per cent as the criterion for useful forecasts (Murphy 1989), for the April to June quarter the anomaly correlation scores for the ECMWF show useful skill to beyond seven days, JMAGSM also shows useful skill to around seven days, ACCESS-G to around six days. In general, ACCESS-G is much more skillful than GASP at all forecast lead times, although still less skillful than JMAGSM, UKGC and ECMWF. At short lead times, USAVN is marginally more skillful than ACCESS-G at three days. For the July to September quarter all the long term models ECMWF, JMAGSM and ACCESS-G show useful skill to beyond seven days.

Acknowledgments
Thanks are extended to Joan Fernon (NMOC) for providing NWP information updates and helpful comments.

References

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For NCEP:
For JMA:
  http://ddb.kishou.go.jp
For ACCESS:
For Verify:
  http://synopticview.co.uk/metpy_verify.html