The Australian Tropical Cyclone Limited Area Prediction System

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The Tropical Cyclone Limited Area Assimilation and Prediction System (TC-LAPS) became operational for the 1999-2000 Australian tropical cyclone season. Details of the system are described in Davidson and Weber (2000).

TC-LAPS has five basic components: (a) Data assimilation to establish the storm's large-scale environment (LSE) and outer structure. (b) Vortex specification to construct the inner core circulation and asymmetries consistent with the estimated size, intensity and past motion. (c) High-resolution (HR) analysis, with appropriate observational errors, length scales and quality control tolerances, to merge the intense vortex into the LSE. (d) Initialisation with diabatic, dynamical nudging, to balance the vortex and insert satellite-defined cloud asymmetries. (e) High-resolution prediction with the generalised LAPS forecast model (Puri *et al*., 1998), which contains high order numerics and sophisticated physical parameterisations.

Data Assimilation and Coarse Resolution Configuration
The LSE assimilation is based on a standard 6-hour analysis-forecast cycle with a multivariate statistical interpolation analysis. It uses standard observational data obtained in real time from the GTS and local satellite temperature retrievals and cloud drift winds. Synthetic moisture profiles obtained from GMS infrared imagery enhance the moisture analysis. Real time sea surface temperature analyses based on weekly collections of ship and satellite data are used.

Domain - Large Scale Environment (LSE):	55.0°S–56.75°N, 70.0°E-164.75°W
Assimilation cycle:	6 hour cycle
Horizontal resolution:	0.75° (150x170 lat-lon grid)
Vertical resolution:	19 sigma levels from 0.991 to 0.05
Analysis Method:	Multi-variate Statistical Interpolation
Analysed Variables:	Geopotential and wind fields
Initialisation:	Digital Filter
Nesting:	Lateral boundary at 6-hour intervals from operational global model
Soil Moisture Analysis:	Daily 0.25°x 0.25° over Australia. Fortnightly 0.8°x 0.8° climatology elsewhere
Sea Surface Temperature Analysis:	Weekly 1.0°x1.0°
GMS Bogus Moisture data:	6 hourly 0.5°x0.5°
GMS Cloud Top Temperature data:	Hourly 0.5°x0.5°

Vortex Specification and Initialisation
Construction of the TC vortex is based on a TC advisory issued by RSMC Darwin on the past motion and structure of the storm. A symmetric vortex is constructed using an empirical surface pressure profile, assuming a moist adiabat at the TC centre, and empirical relations to define the mass field between the centre and the LSE. The wind field is obtained by gradient wind balance. A wave number one asymmetry is constructed such that the observed drift speed equals the sum of the environmental flow and the flow induced by the artificial asymmetry at the observed vortex centre. The synthetic vortex is implanted into the global analysis after filtering to remove any previously existing, weak and misplaced circulation. Synthetic observations are produced at high horizontal resolution to define the inner core structure. 24 hours of diabatic, dynamical nudging is used to balance the vortex and re-define the vertical motion field to be consistent with the satellite cloud imagery.

High Resolution Forecast Model
The TC-LAPS system is double-nested, with the LSE nested within the global forecast, and the HR relocatable domain, centred on the TC, nested within the LSE forecast.

Domain – High Resolution (HR):	Variable 27°x27°, TC centred
Horizontal resolution:	0.15° (180x180 lat-lon grid)
Analysis Method:	Univariate Statistical Interpolation
Vertical resolution:	19 sigma levels from 0.991 to 0.05
Initialisation:	24 hours diabatic, dynamical nudging
Nesting:	Boundary conditions at 3-hour intervals derived from +0 to +72 hour LSE forecasts.

Physical Parameterisations and Surface Grid Fields

Convection:	Earlier version of ECMWF's Mass-flux
Large scale rain:	Supersaturation Scheme
Boundary Layer:	Earlier version of ECMWF's VB Scheme
Short Wave Radiation:	3-hourly, Lacis and Hansen
Long Wave Radiation:	3-hourly, Fels and Schwarzkopf
Topography:	Derived from 0.1^o resolution data
Soil Moisture Analysis:	Daily 0.25^ox 0.25^o over Australia. Fortnightly 0.8^ox 0.8^o climatology elsewhere
Sea Surface Temperature Analysis:	Weekly 1.0^ox1.0^o
Albedo:	Climatology

Verification

The following statistics are for the 2001 North West Pacific season. In situations where multiple storms were present, the principal storm at the base time of the forecast was verified (until November 2001, only one forecast to 48 hours was made per base time).

Total number of TCs verified = 16
Chebi, Durian, Utor, Trami, Kong-Re, Toraji, Man-Yi, Pabuk, Danas, Nari, Vipa, Francis,Lekima, Krosa, Haiyan, Podul

(i) Track errors

Forecast Interval	No. Cases	Error (km)
T+00	117	20.8
T+24	110	138.7
T+48	89	236.9

(ii) Central pressure errors (hPa)

Forecast Interval	No. Cases	**RMS Error**		Mean Error		Abs Error	
		TC-LAPS	**Persistence**	TC-LAPS	Persistence	TC-LAPS	Persistence
T+00	117	**6.5**	**0.0**	-5.0	0.0	5.4	0.0
T+24	110	**11.0**	**13.7**	-5.6	-3.6	8.7	11.0
T+48	89	**16.6**	**21.8**	-10.0	-8.2	13.2	18.0

Operational Output

TC-LAPS now runs over a high-resolution TC centred domain, twice a day to T+72h, based on data valid at 00 and 12 UTC. It can be run twice, centred on two separate systems for both time periods.

Track forecasts are produced within the high-resolution domain out to 72 hours using an automated vortex tracking routine that locates the centre from the MSLP and low-level wind fields. This produces centre location, central pressure and the maximum wind below 850 hPa.

Other guidance products for 6-hourly periods out to 72-hours from TC-LAPS are made available through registered user access to the Darwin RSMC web page at:

http://www.bom.gov.au/weather/nt/rsmc/

These products include:

- MSLP;
- Winds at 950, 850, 700, 500, 250, 200 hPa;
- 24-hour precipitation;
- Forecast and observed track.

References

Davidson, N.E. and H. C. Weber, 2000: The BMRC High-Resolution Tropical Cyclone Prediction System: TC-LAPS. *Mon. Wea. Rev.*, ***128***, 1245–1265.

Puri, K., G.S. Dietachmayer, G.A. Mills, N.E. Davidson, R.A. Bowen and L.W. Logan, 1998: The new BMRC Limited Area Prediction System, LAPS. *Aust. Meteor. Mag*., **47**, 203-223.