Real-time ACCESS-TC: Vortex Specification, 4DVAR Initialization, Verification and Structure Diagnostics

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with

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Jim Fraser, Joan Fernon and Hakeem Shaik

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Weather and Environmental Prediction and Environmental System Modelling Programs

CAWCR, Centre for Australian Weather and Climate Research
A Partnership between CSIRO and the Bureau of Meteorology

Acknowledgments: Kamal Puri, Gary Dietachmayer

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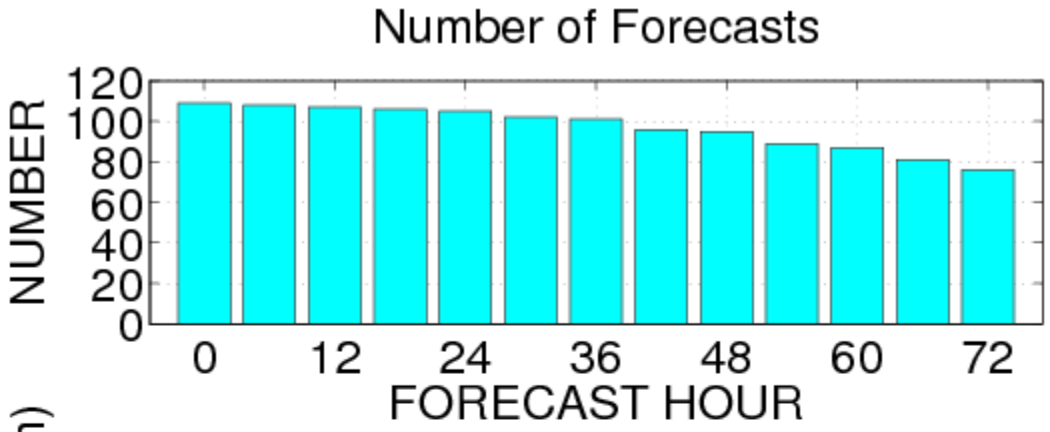
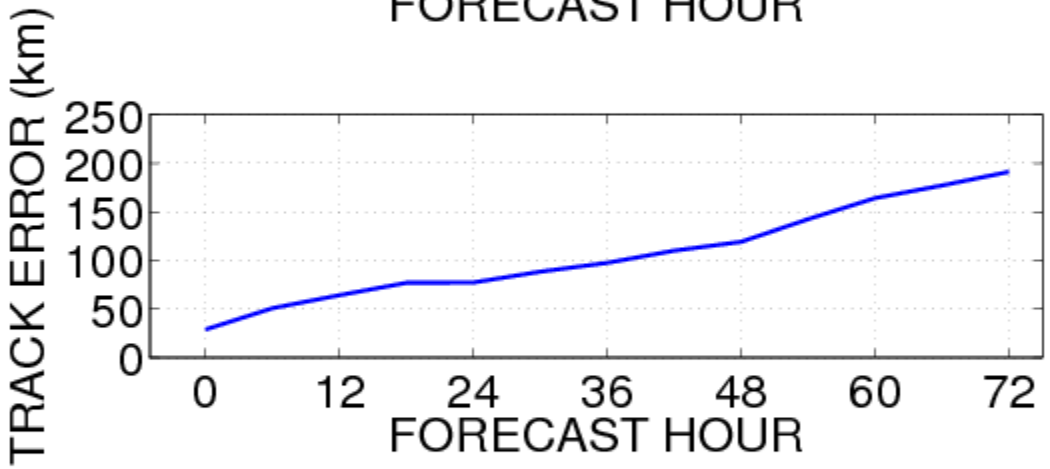
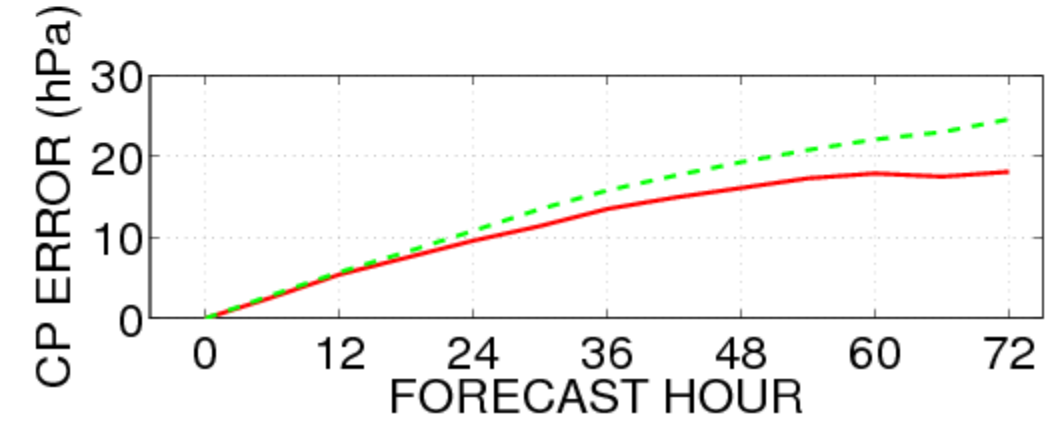
CSIRO

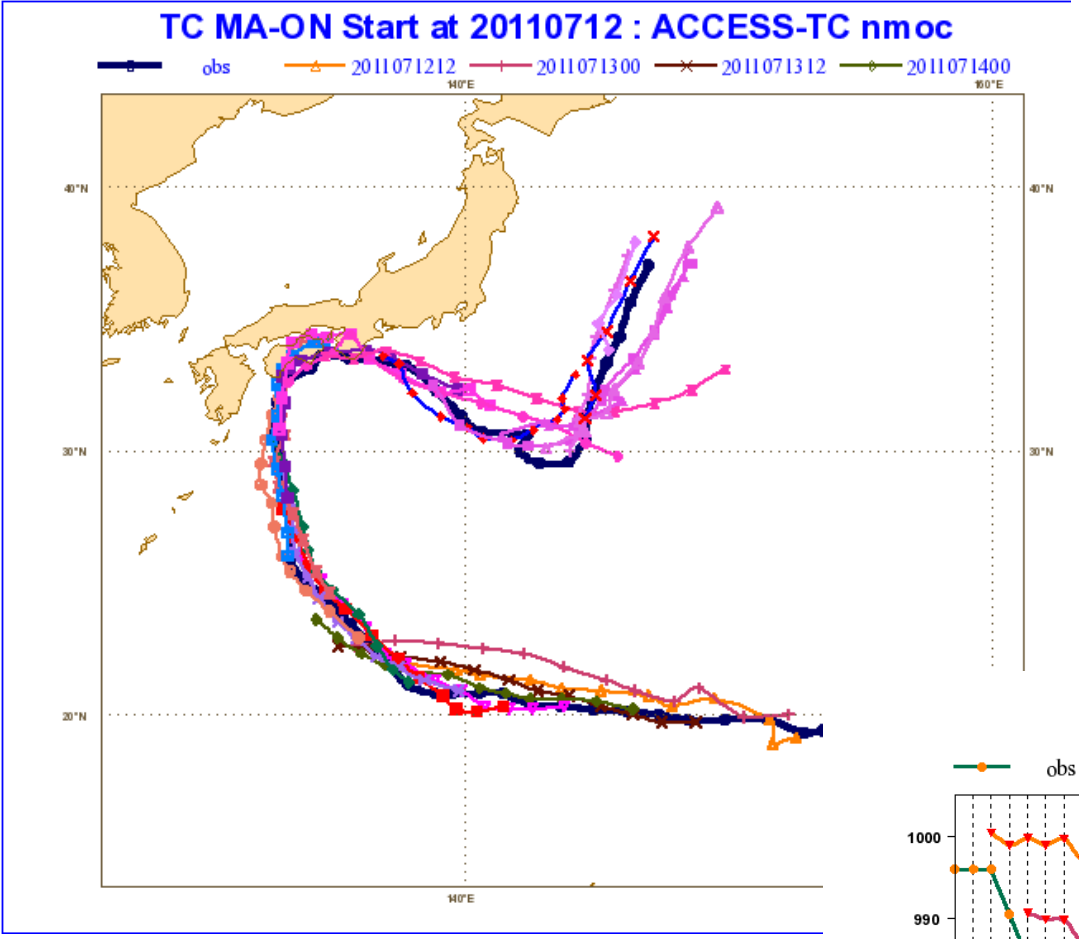


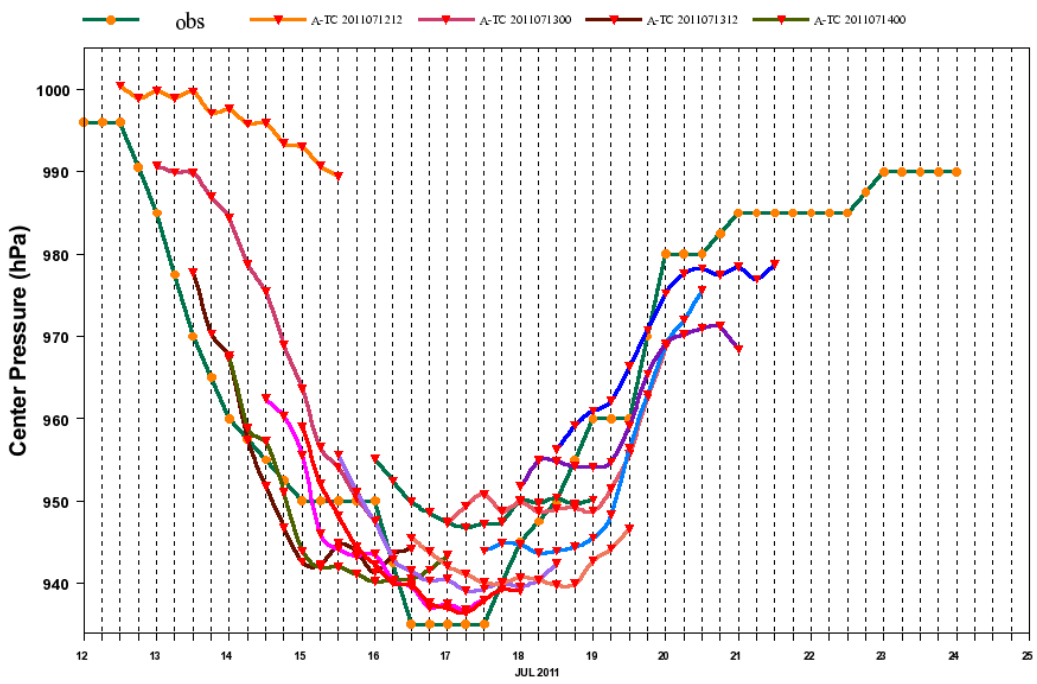




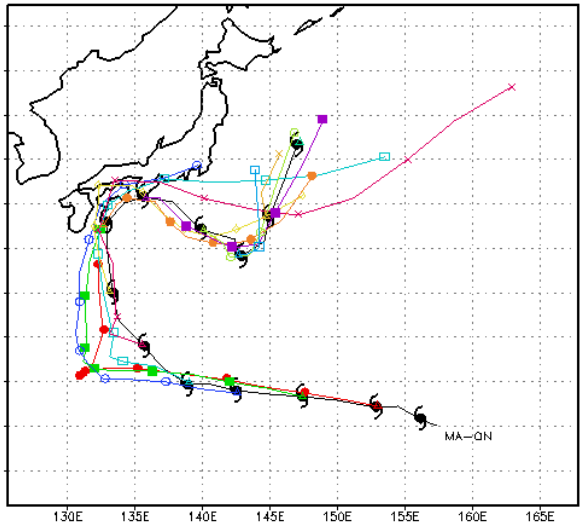
ACCESS-TC Verification:
NMOC Real-time Forecasts
2011 WNP Region, 10 TCs:

Number of Forecasts
Mean Track Error,
Mean ABS Central Pressure Error,
(B-corrected), A-TC and Persistence


TC MA-ON Start at 20110712 : ACCESS-TC nmoc
obs
2011071212
2011071300
2011071312
2011071400
140°E
160°E
40°N
30°N
20°N
140°E


TC MA-ON : ACCESS-TC
obs
A-TC 2011071212
A-TC 2011071300
A-TC 2011071312
A-TC 2011071400
Center Pressure (hPa)
1000
990
980
970
960
950
940
12
13
14
15
16
17
18
19
20
21
22
23
24
25
JUL 2011

MET OFFICE GLOBAL MODEL FORECAST TRACKS of TYPHOON MA-ON

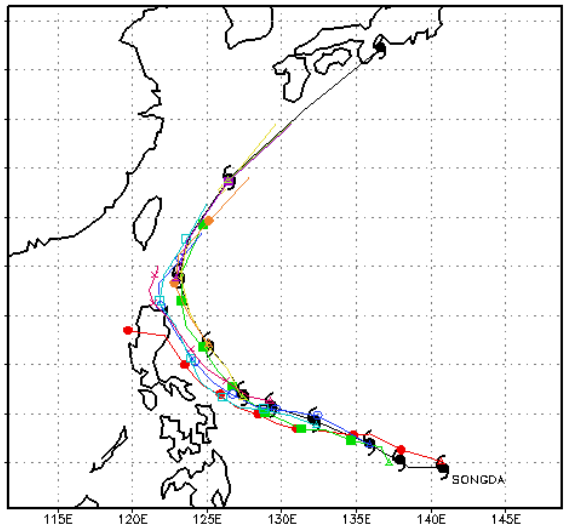


MG 20110713 MG 20110714 MG 20110715 MG 20110716 MG 20110717
MG 20110718 MG 20110719 MG 20110720 MG 20110721 MG 20110722
MG 20110723 MG 20110724

KEY to FORECAST TRACKS
(Triangles denote analysed positions)

24 HOURLY REAL TIME OBSERVED POSITIONS

MET OFFICE GLOBAL MODEL FORECAST TRACKS of SUPER TYPHOON SONGDA



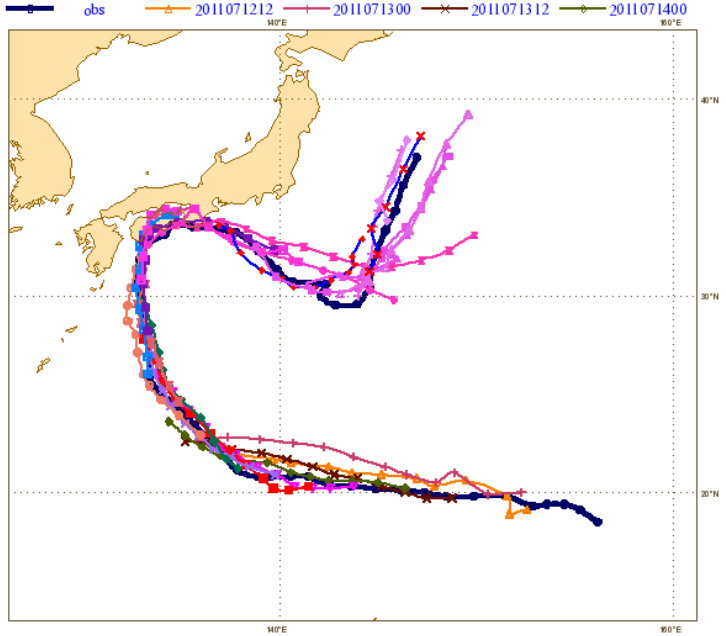
MG 20110520 MG 20110521 MG 20110522 MG 20110523 MG 20110524
MG 20110525 MG 20110526 MG 20110527 MG 20110528

KEY to FORECAST TRACKS
(Triangles denote analysed positions)

24 HOURLY REAL TIME OBSERVED POSITIONS

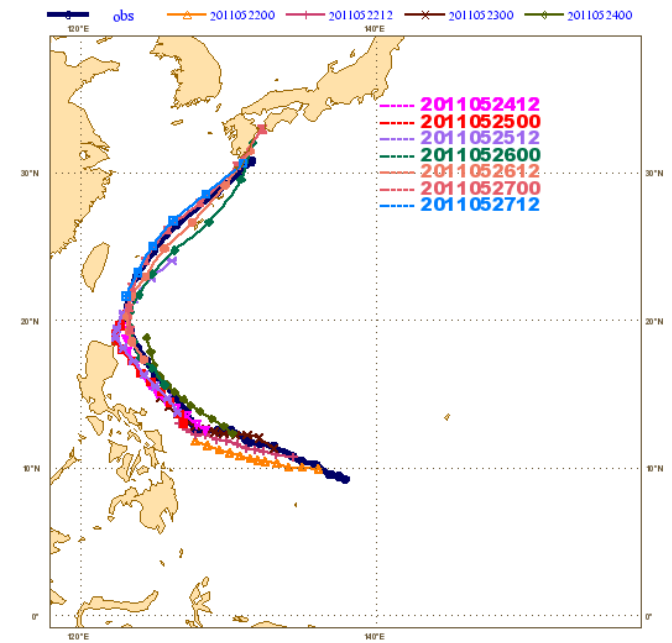
Met Office

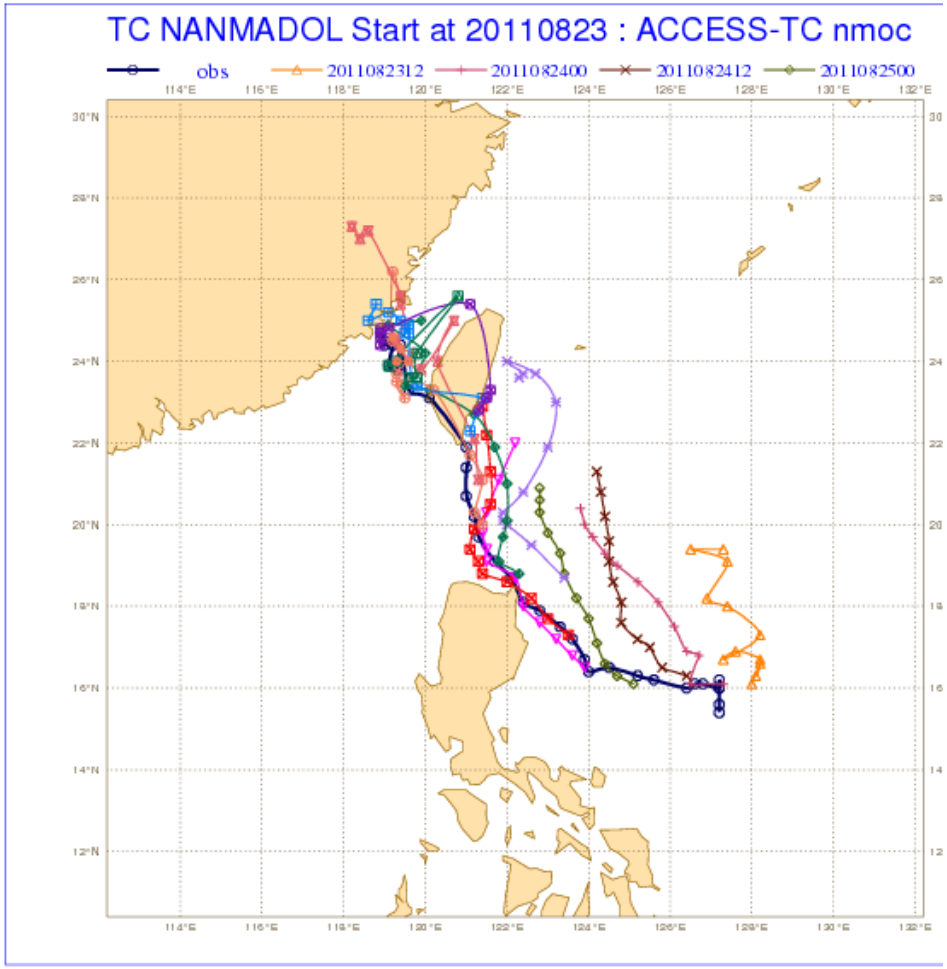
TC MA-ON Start at 20110712 : ACCESS-TC nmoc

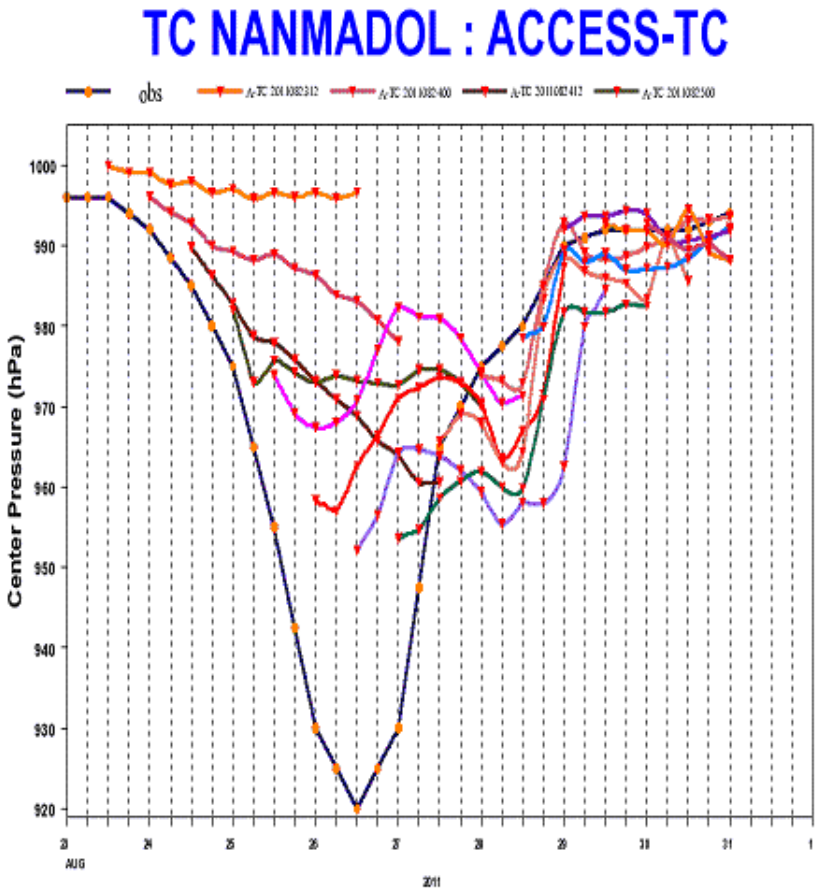


Met Office

TC SONGDA Start at 20110521 : ACCESS-TC

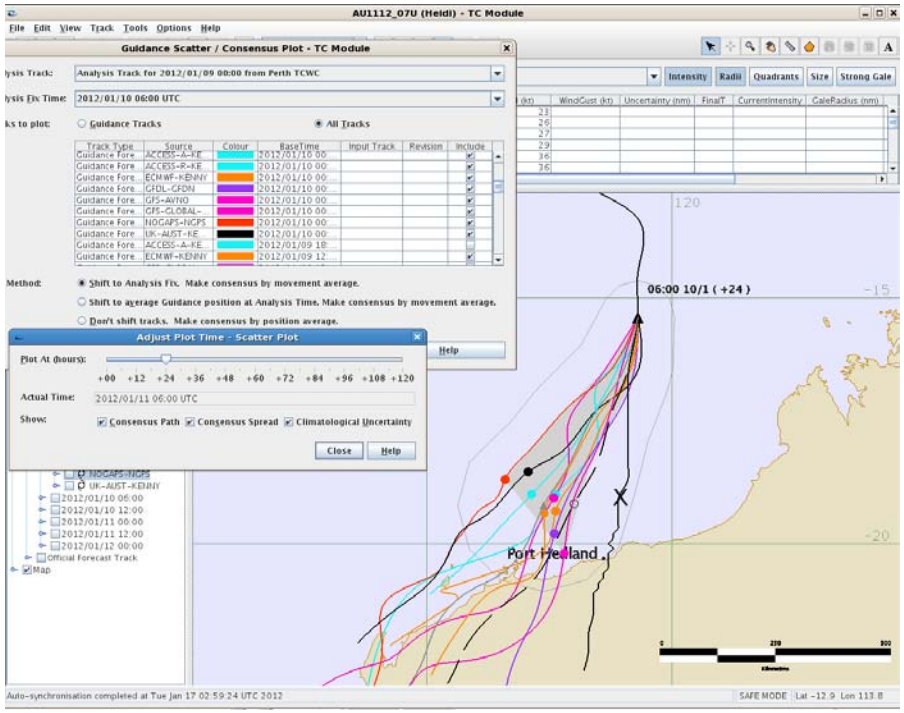


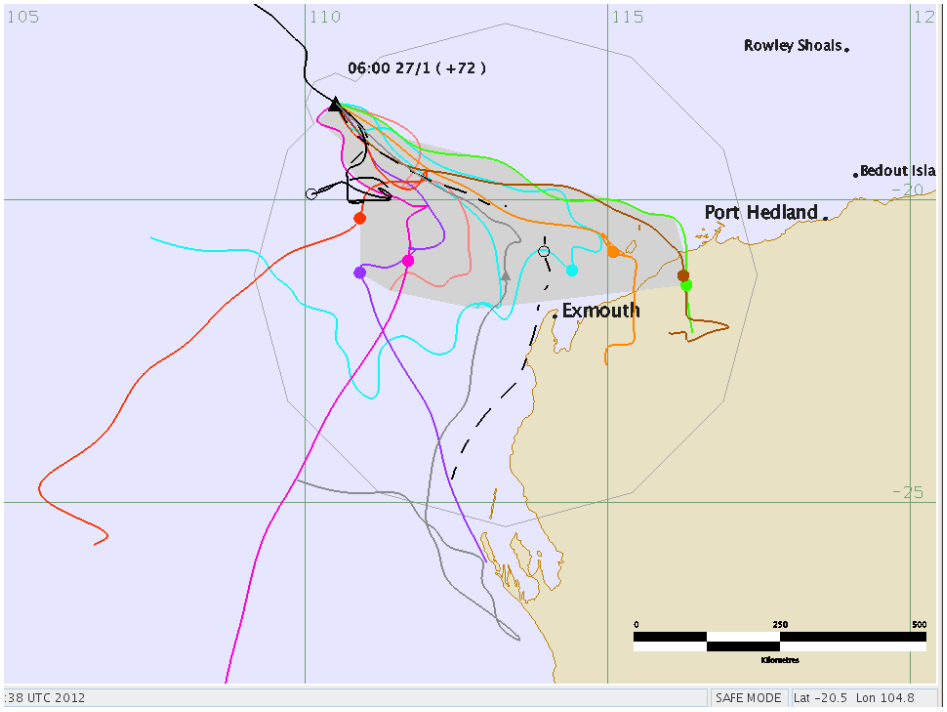




Not All Good News …

Track Forecasts from available operational systems for Heidi and Iggy (A-TC, EC, UK, JMA, GFS, NGP, GFDN)





LSE and/or Vortex Structure ??

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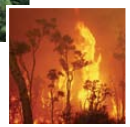
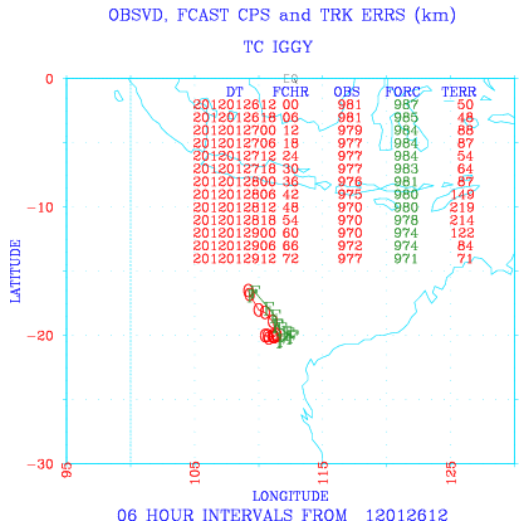
ACCESS-TC vs ECMWF for TC IGGY from base times 20120126/12Z and 20120127/00Z

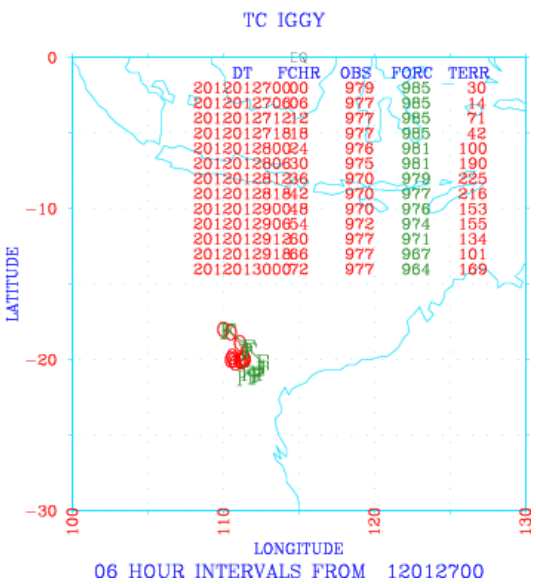
Left Panels: Observed and forecast tracks and central pressures from ACCESS-TC

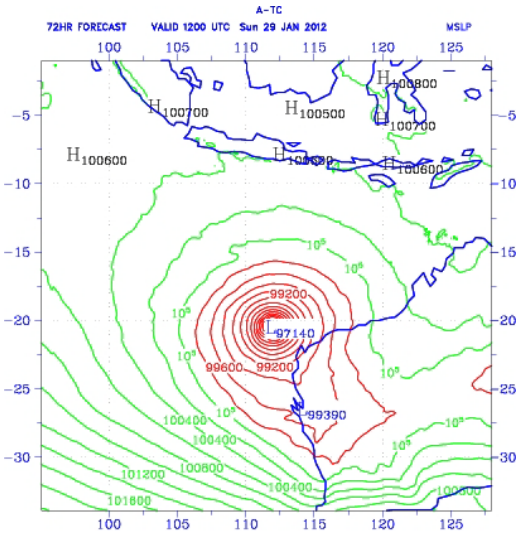
Centre Panels: 72-hour forecasts of MSLP from ACCESS-TC;

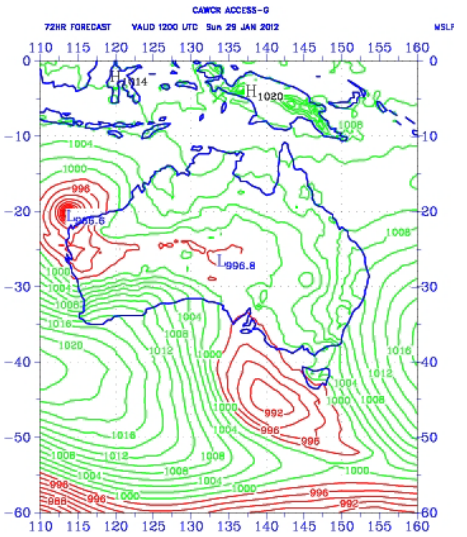
Right Panels: 72-hour forecasts of MSLP from ECMWF

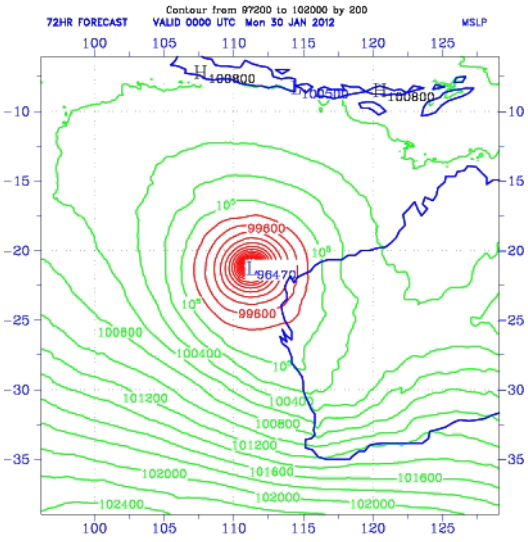


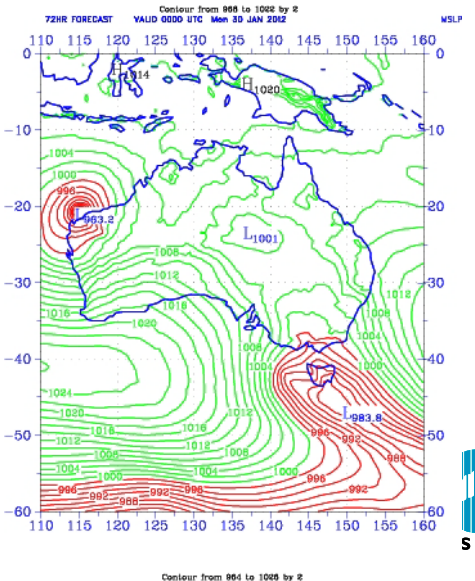












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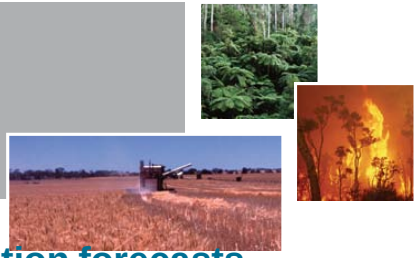
ACCESS-TC for Operations and Research



1. Resolution:

0.11^{0}X50L, re-locatable grid, with TC near centre of domain, option for higher-resolution forecasts.

2. Vortex Specification:

(a) Structure based on observed location, central pressure and size (tuned and validated using ~6000 dropsonde observations from the Atlantic)

(b) Only synthetic MSLP obs used in the 4DVAR to (a) relocate the storm to observed location, (b) define the inner-core circulation, and (c) impose steering flow asymmetries consistent with the past motion.

3. Initialization using 4DVAR Assimilation:

5 cycles of 4DVAR over 24 hours. Uses all standard obs data, plus synthetic MSLP obs (no upper air synthetic obs).

4DVAR then:

(a) Defines the horizontal structure of the inner-core at the observed location, (CP, VMAX, RMW, R34)

(b) Builds the vertical structure from MSLP obs,

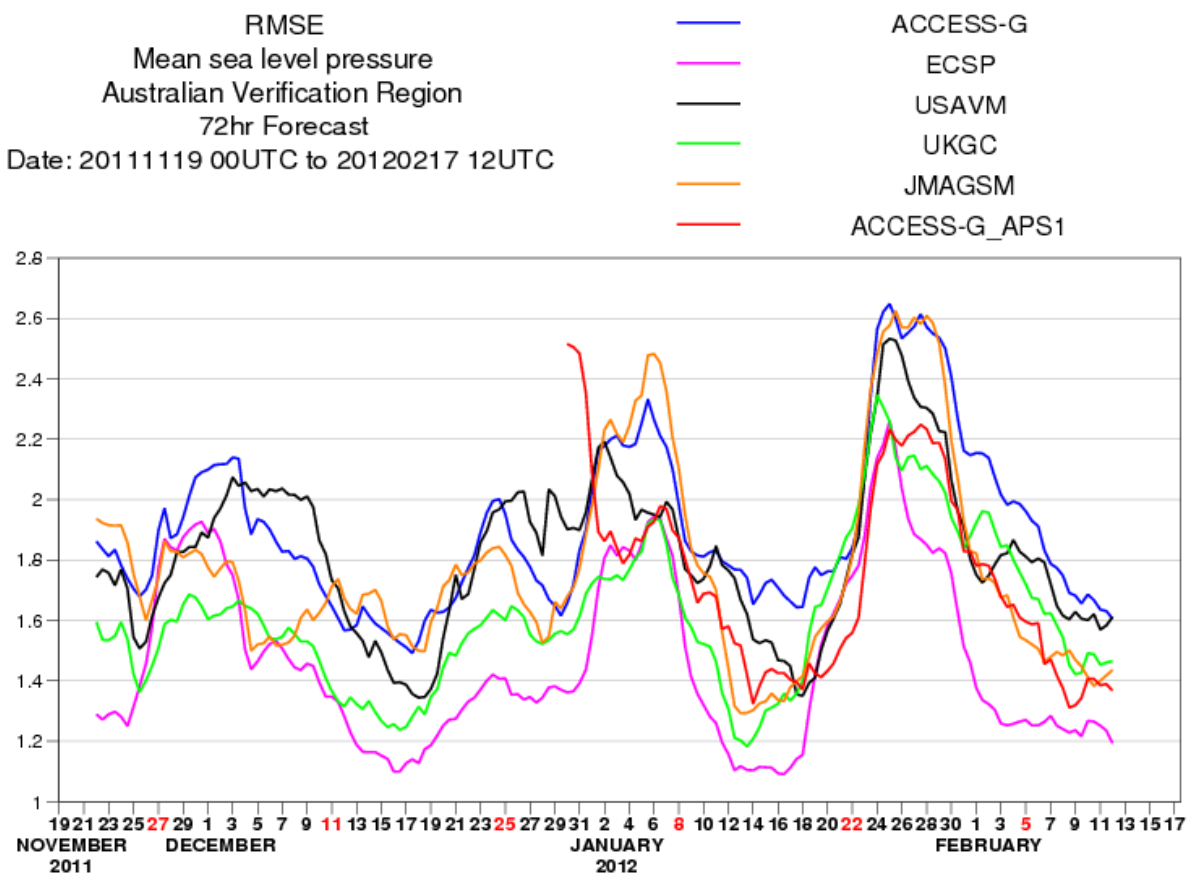
(c) Constructs the secondary circulation, and

(d) Creates a balanced TC circulation at the observed location, with correct (?) structure and intensity.

(e) Creates a structure which is responsive to environmental wind shear without imposing constraints on the vertical-stacking or tilt of the circulation. (important for vortex dynamics and cloud asymmetries)

4. Forecast Model:

UKMO Unified Model from ACCESS.

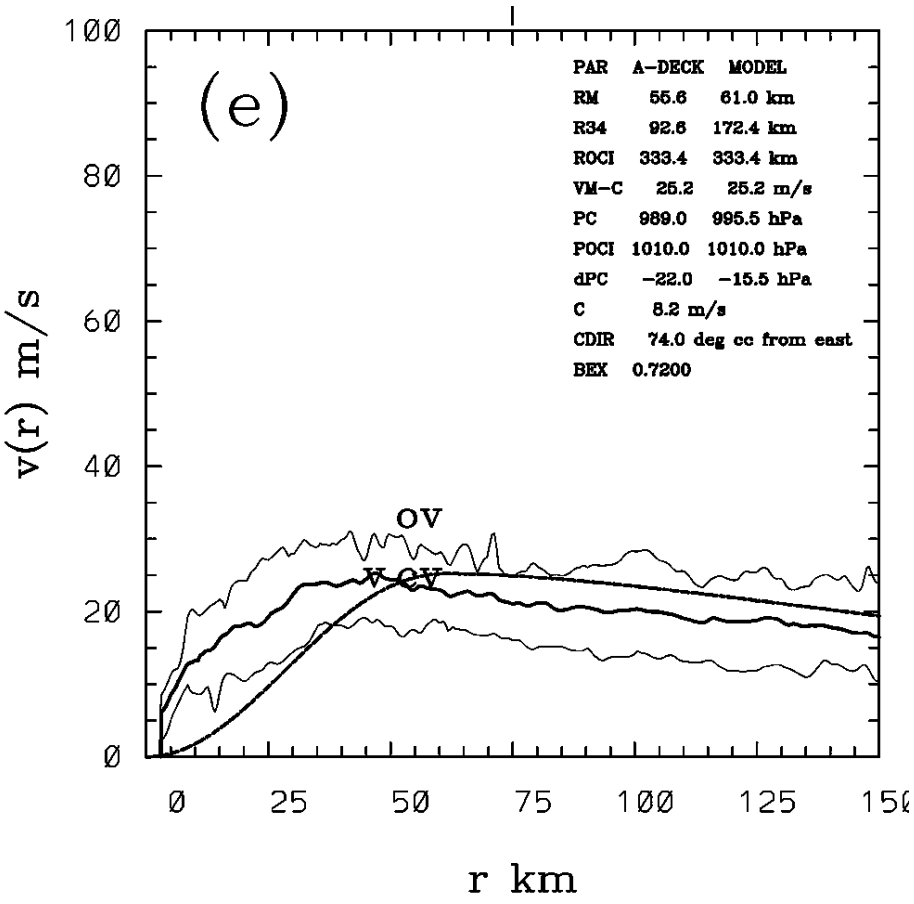


Verification of large scale forecasts

MSLP RMSE: Global forecasts over the Australian Region

=> Improved Prediction of the LSE of storms (compared to previous Global System)

Vortex Specification (Weber, 2011)



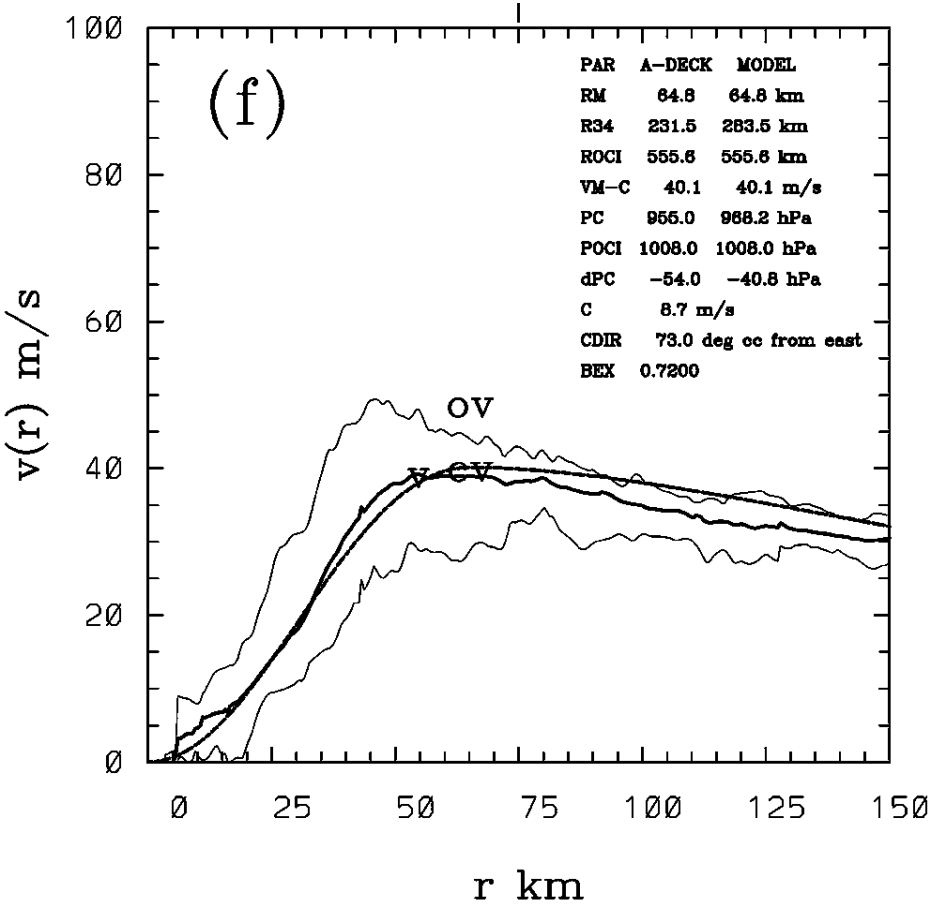
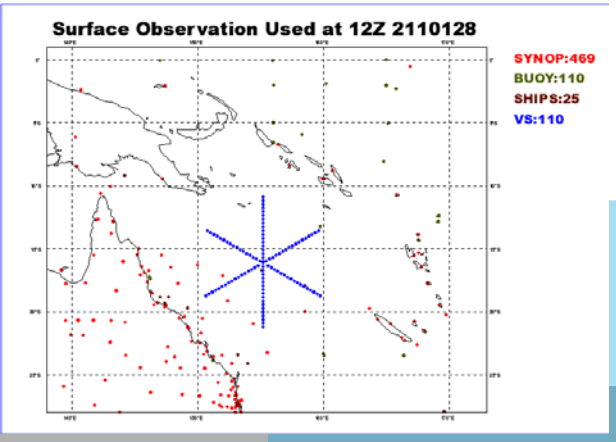
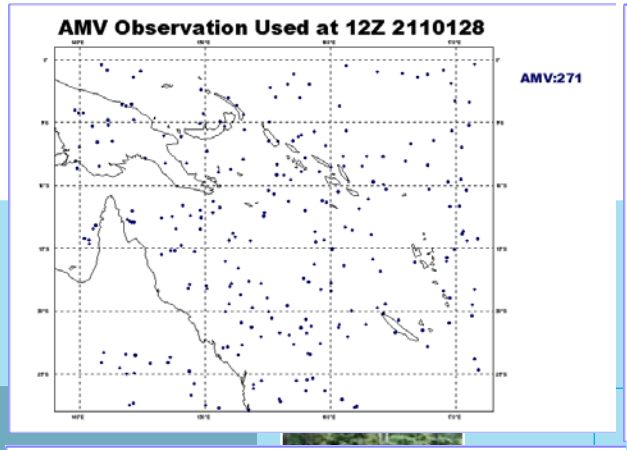


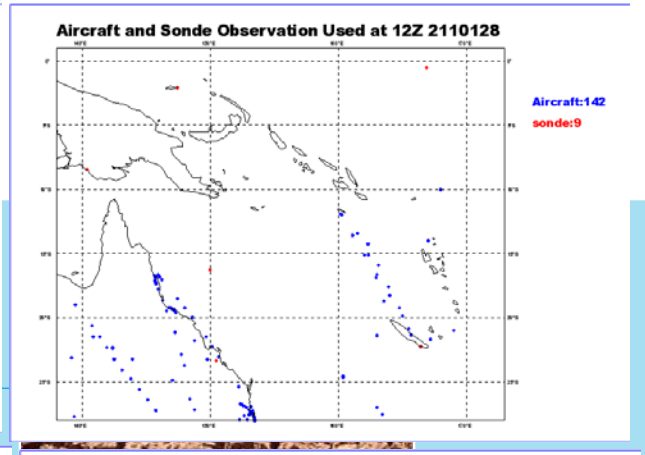
Figure 2: Tangential wind v(r) in m s^{-1} as a function of radius in km of Hurricane Fran on September 29, 1996 (top) and Hurricane Floyd on September 19, 1999 (bottom). Thick lines represent the average v(r) of all flight passes and the AVSM output v(r) (smoother curve). The thin lines define an envelope given by the minimum and maximum v(r) of all flight passes at each radial grid point. The input parameters of AVSM are operational estimates of roci and vm – c in (e), (f).

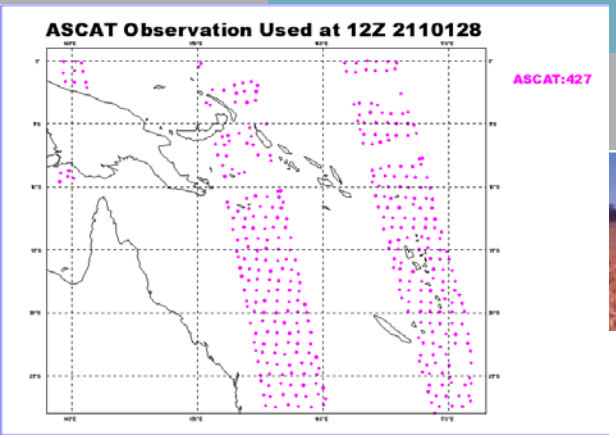
Validation of Vortex Structure: Use EXBT data sets for the NA and NP to validate TC structures obtained from the Vortex Specification (RMW, R34). (CLOK: Charlie Lok)

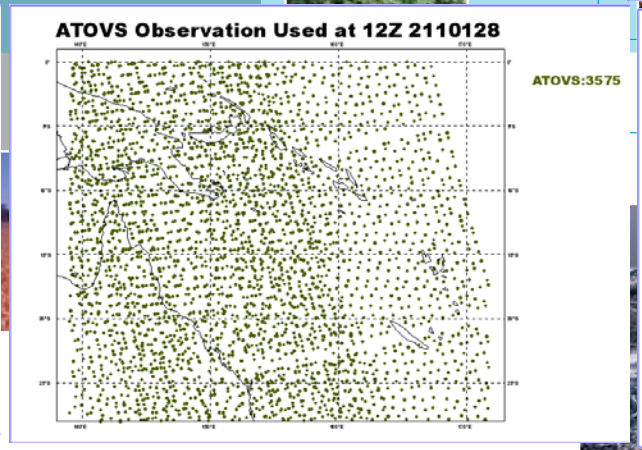
OBS Network

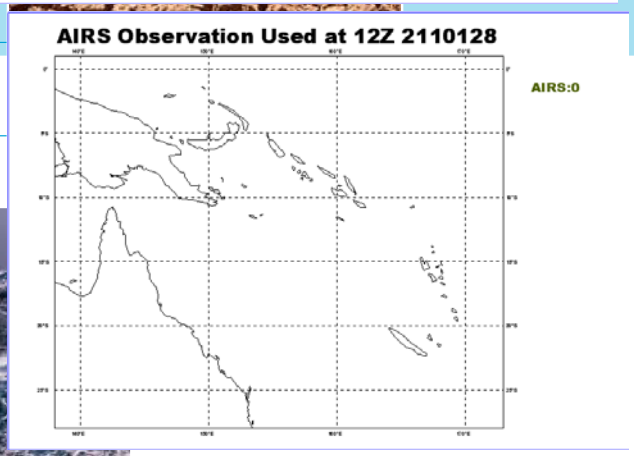












Without Vortex Specification : Initial Position/Intensity Errors for TC Anthony were ~ 230km and 5hPa

With Vortex Specification: Initial Position/Intensity Errors reduced to 40km and 0hPa

VS: blue MSLP obs in upper left panel:

dense enough to define Vmax at RMW, extensive enough to merge with LSE.

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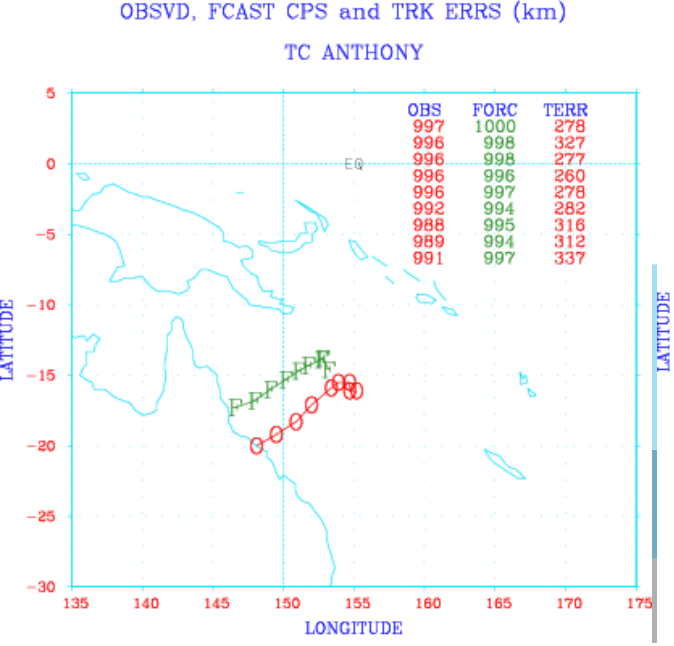
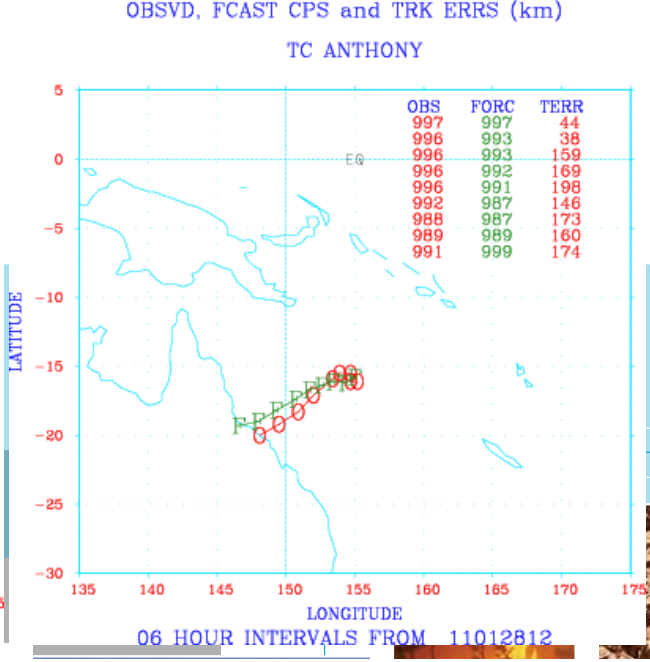
A partnership between CSIRO and the Bureau of Meteorology

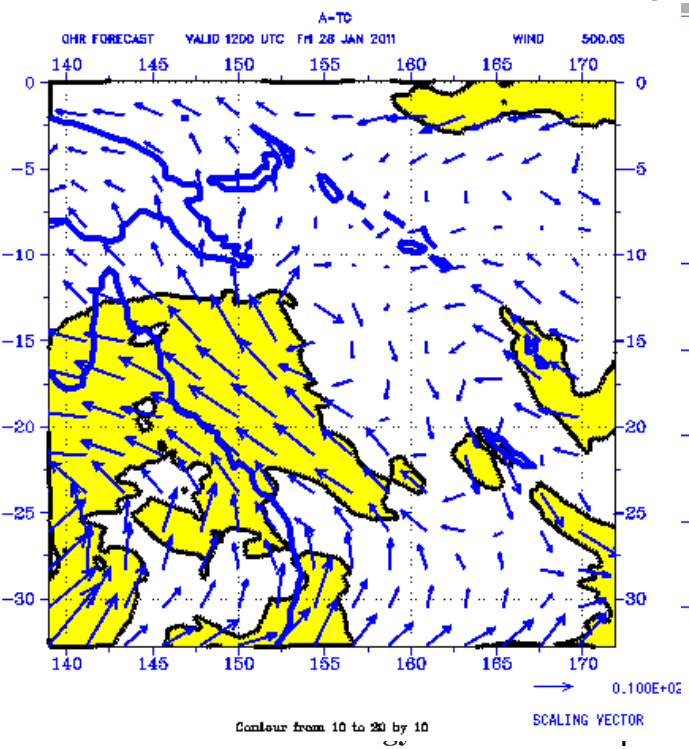
CSIRO

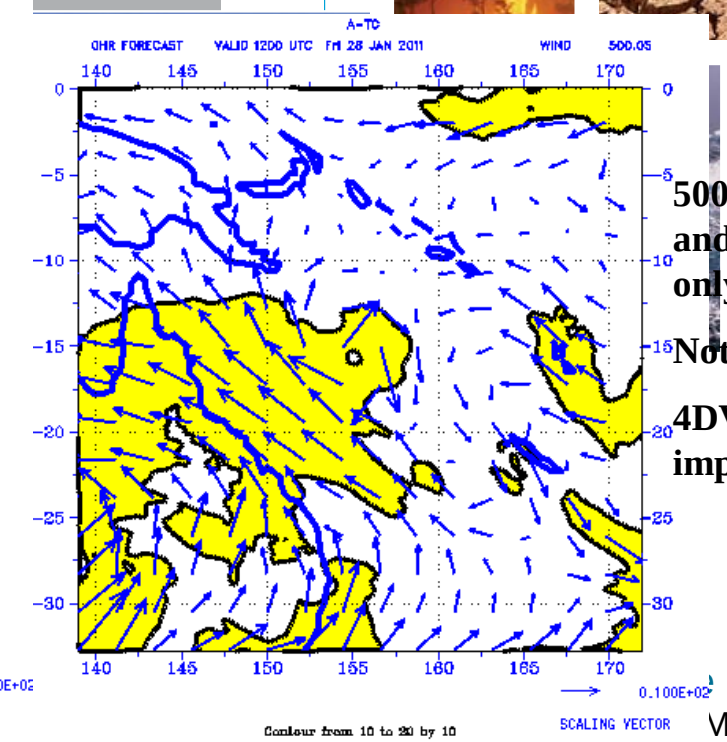




For Anthony at Landfall:

Obsvd and fcast track and intensity without and with VS





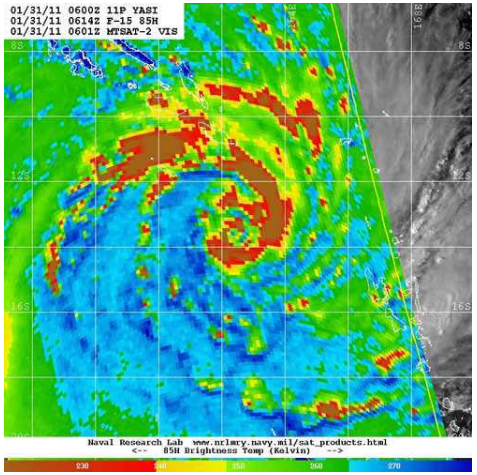
500 hPa Initial Condition without and with VS (synthetic MSLP obs only)

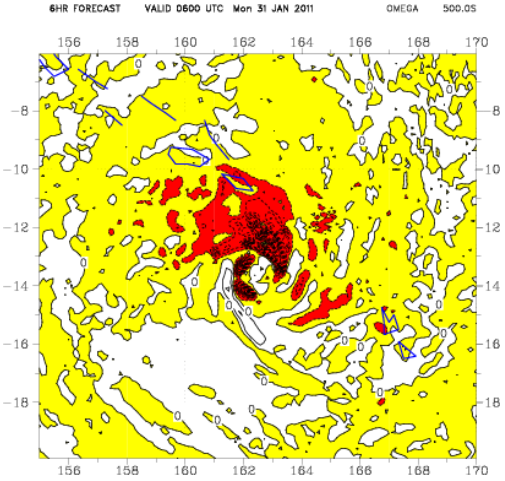
Note construction of 3-D structure

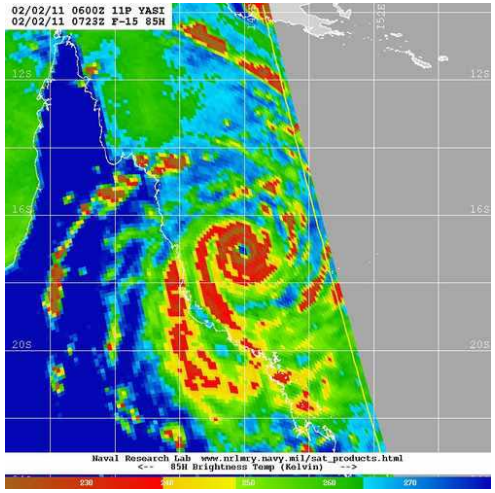
4DVAR defines depth and tilt, important for evolution of vortex

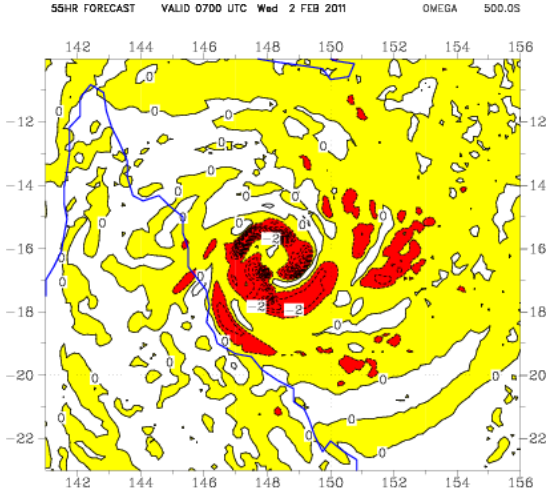
Research
Meteorology

CSIRO







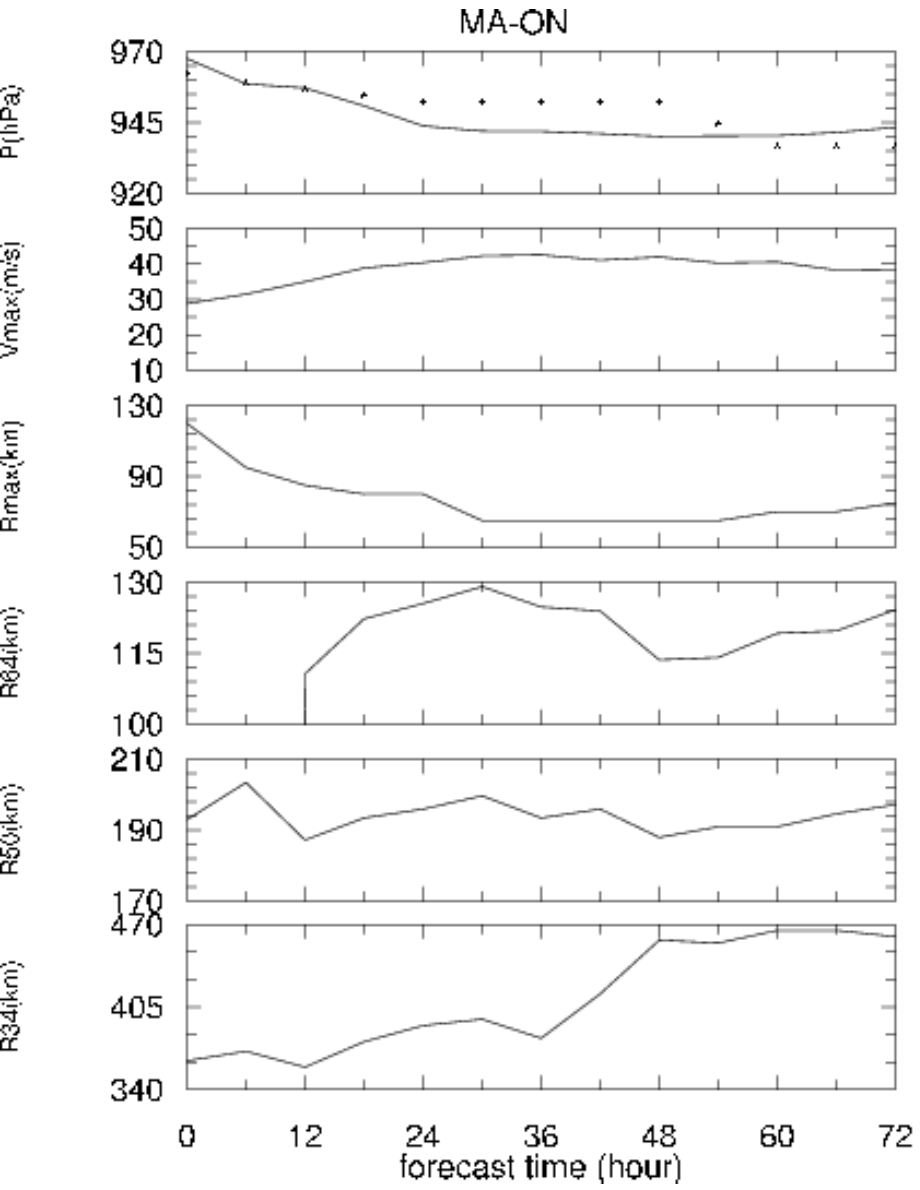


Validation of Vortex Structure.

II: Cloud Bands and Convective Asymmetries

85GHz Imagery (left panels) and ACCESS-TC 500 hPa vertical motion field at t = 6 (initialized with 4DVAR) and t = 55 hours for Yasi from base time 00Z, 20110131

- **Note regions of observed active inner rainbands and eyewall convection, and corresponding forecast regions of strong and weak ascent.**
- **Based on use of synthetic MSLP obs and 4DVAR, structures are consistent from even the early hours of the forecast.**



Preliminary Validation of Vortex Structure.
III: Intensity and Windfields

(Y. Ma)

Critical for Storm Surge and Rainfall

For Yasi from base time 00Z, 20110131:

Time series of forecast

(a) Central Pressure,

(b) Maximum Wind,

(c) Radius of Maximum Wind,

(d) Radius of 64, 50 and 34 knot winds.

Symbols indicate estimated values, where available

Encouraging preliminary verification

******* What defines size and the RMW? <<<<<**

Future Plans

Upgrades to APS1 (more satellite data, higher resolution, improved physics, ….)

Enhancements to 4DVAR (inner and outer loops) ; Impact of extra observation types; Hybrid DA

NWP and basic research applications from special experimental data sets:
TPARC/TCS08, PREDICT: Genesis and Rapid Intensification

Enhancements to the Boundary Layer Parameterization for ACCESS-TC. (Cd high wind speeds, Sea Spray)

Secondary Eyewall Formation and Eyewall Replacement Cycles in Tropical Cyclone Simulations

Genesis Applications of ACCESS-TC – Prediction and Diagnostics.

Amplifying Planetary Rossby Waves, TC Extreme Rain Events, Extratropical Transition and RI.

Inner-core Dynamics (eg, What defines RMW and R34?)

Challenge: Initialize CAT 3 - 5 storms without the use of reconnaissance data or vortex specification?