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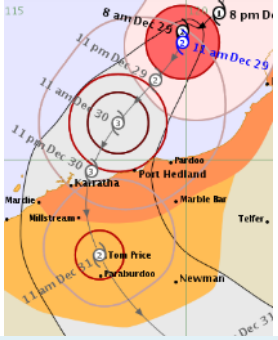

Improved tropical cyclone wind and wave forecasts for offshore industries

Jeff Kepert, Noel Davidson, Paul Gregory, Alister Hawksford, Andy Taylor, Xingbao Wang, Harvey Ye, Stefan Zieger

23 July 2015

Acknowledgements to Shell, Woodside, Inpex, Chevron

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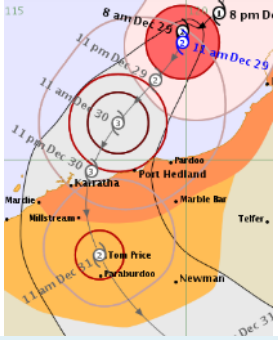
The problem



- Offshore industry operates in a harsh and remote environment
- Tropical cyclone winds and waves present a particular threat
- Industry time-frames for preparing for tropical cyclones are of the order of several days or longer
- Huge safety, logistical, economic challenges
- Stretches capability of current forecast systems.
- Risk management implies must consider alternative scenarios, ideally in a probabilistic manner.

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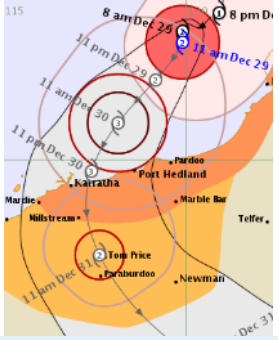
Aims of the project



- Develop improved TC forecast guidance specifically focussed on industry needs
- Three-strand solution
  - Extended-range TC NWP
  - Bias correction of TC structure and intensity in ECMWF ensemble => calibrated wind exceedance probabilities
  - Wave model under both of the above
- Close engagement with industry, Bureau operations
- Committed to operational implementation

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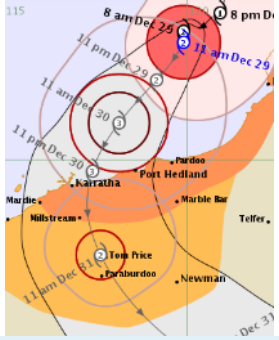
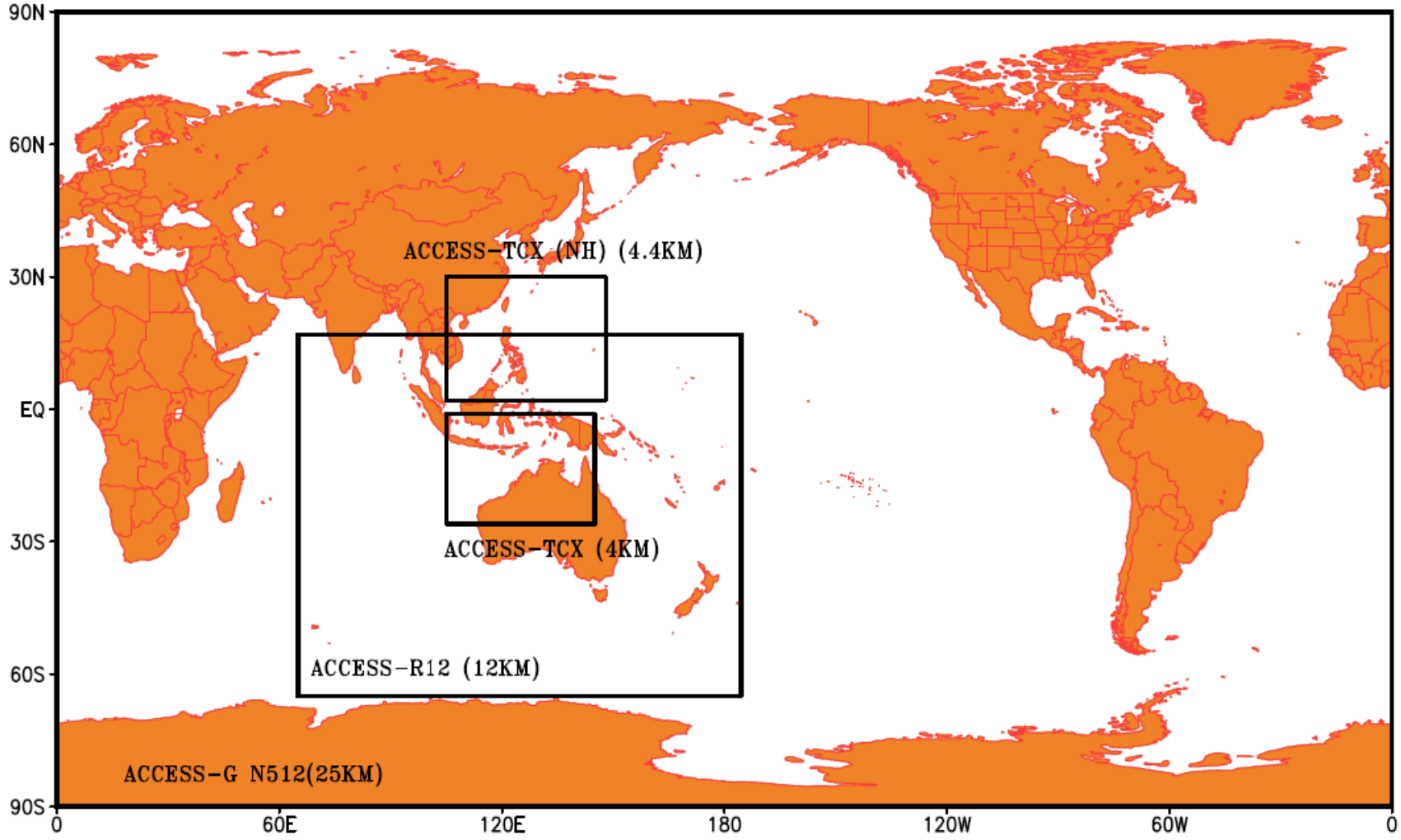
ACCESS-TCX





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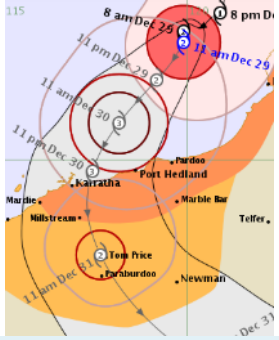
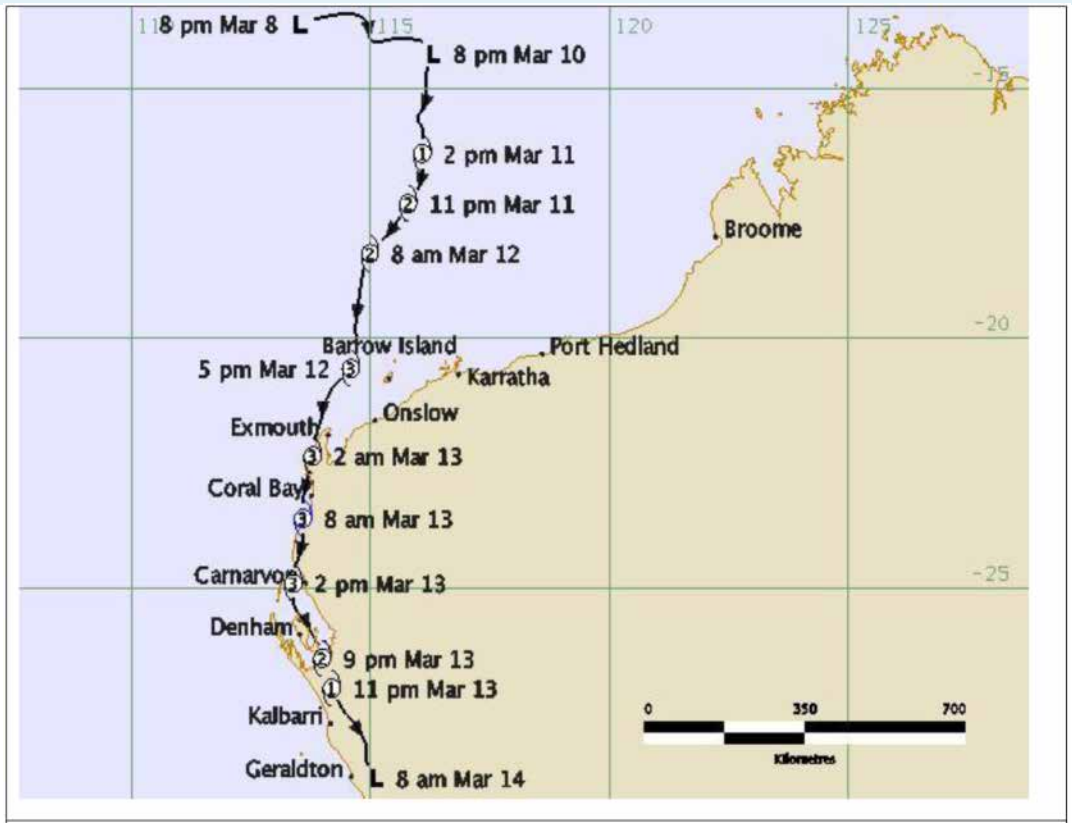
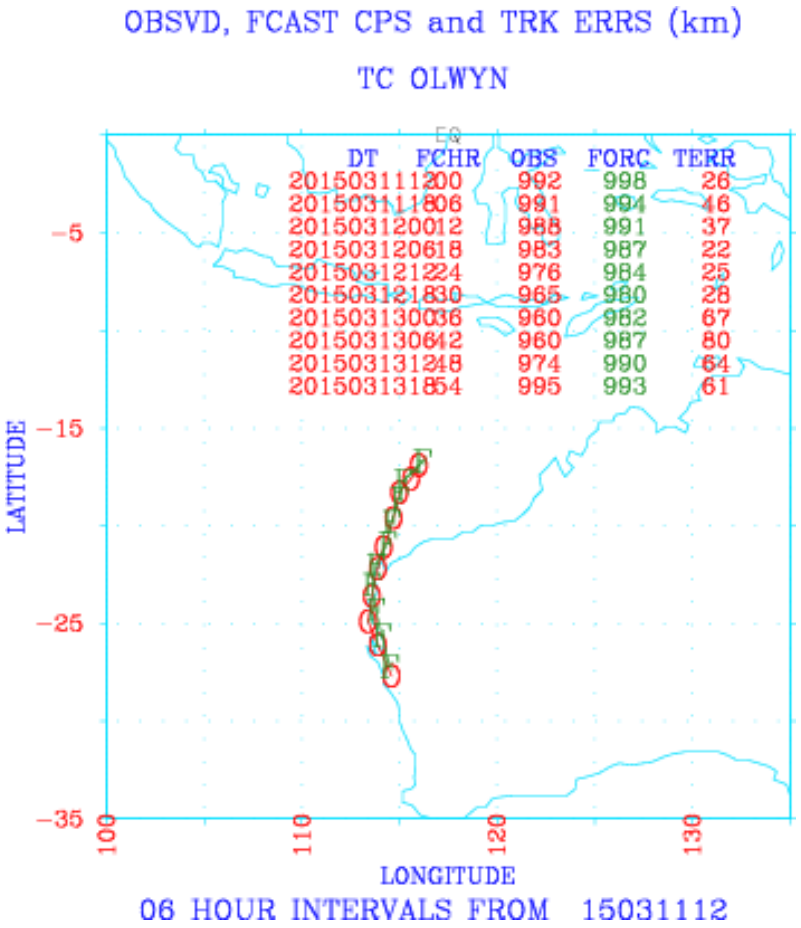
TC Olwyn







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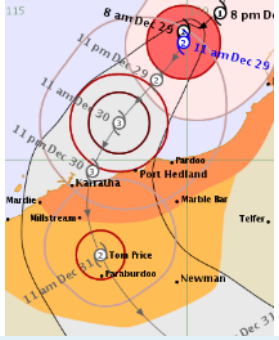
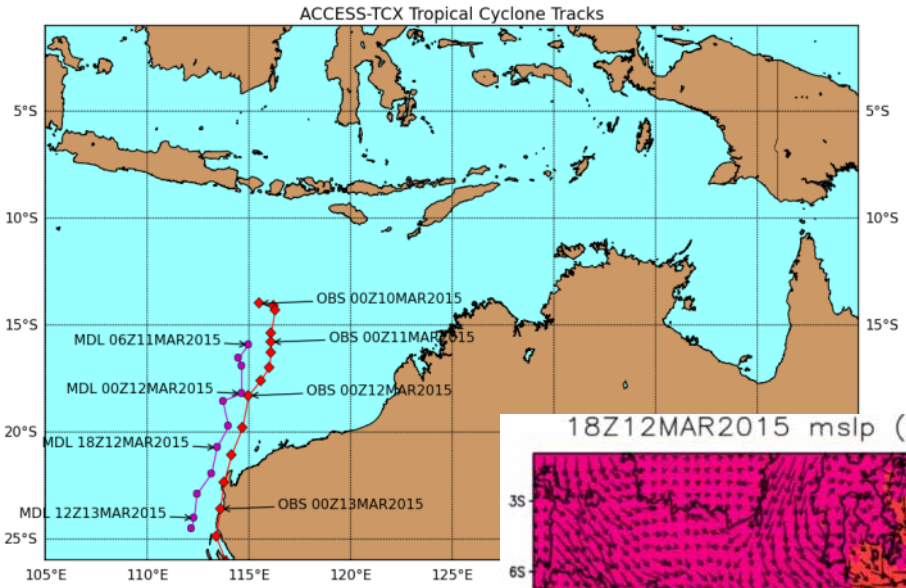
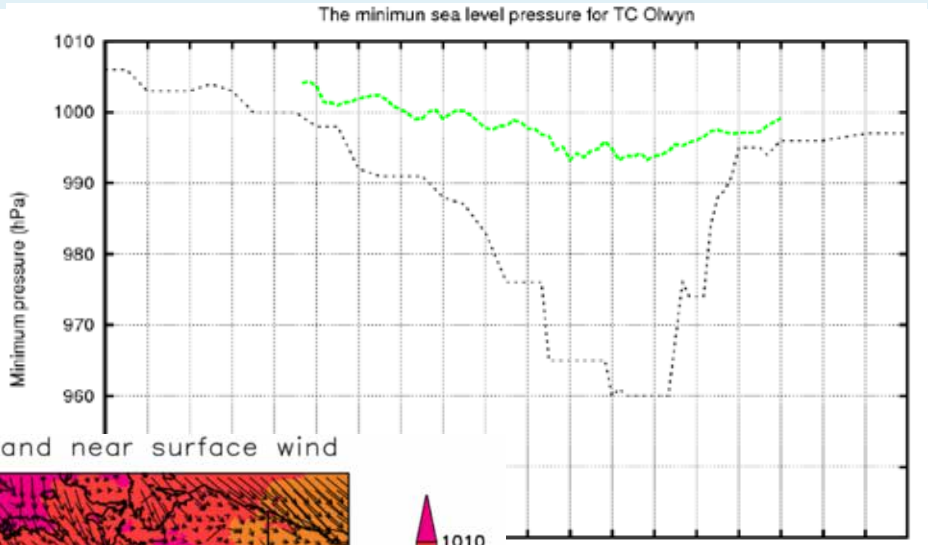
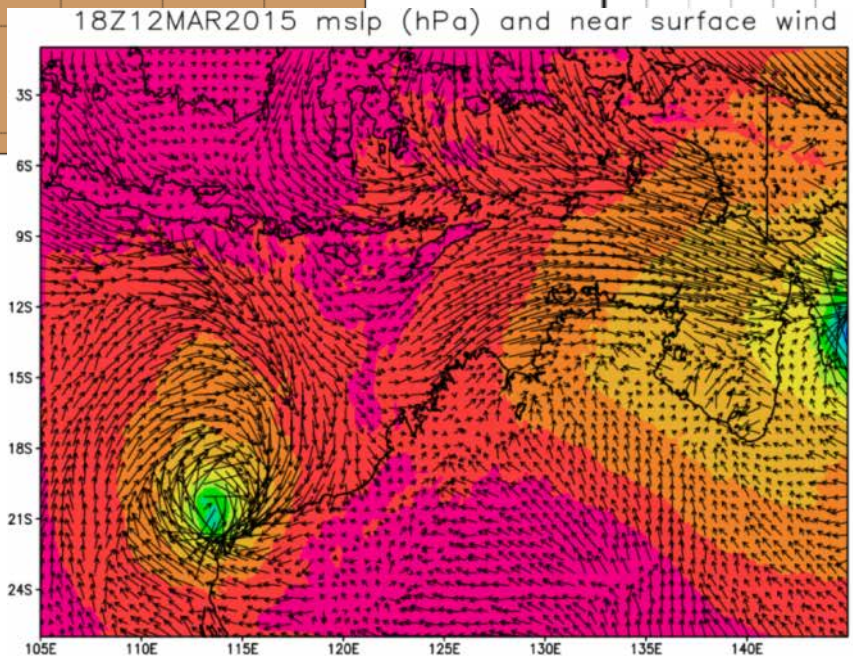
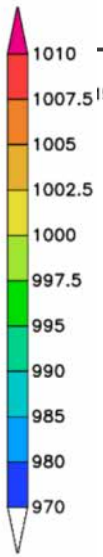
Version 1











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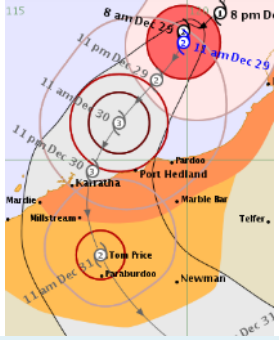
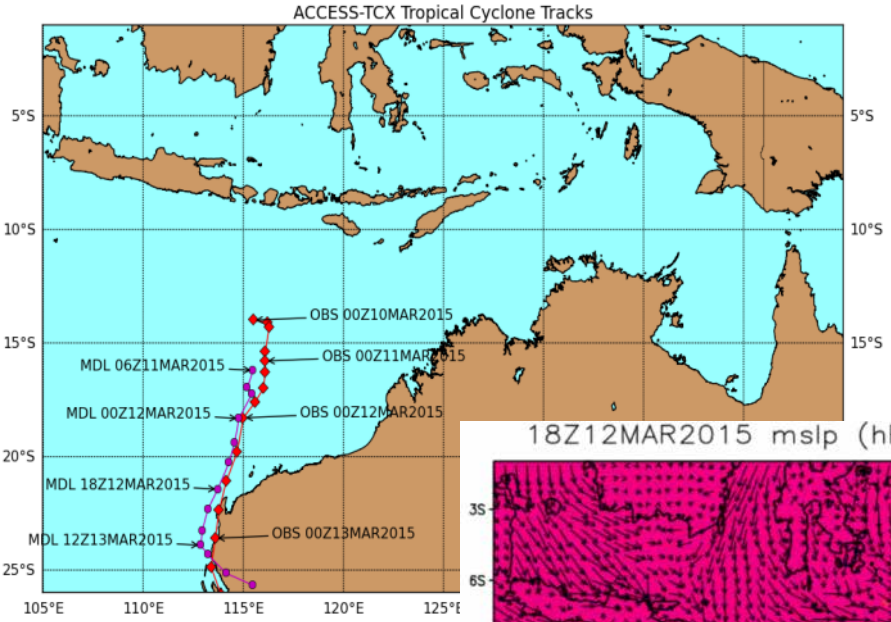
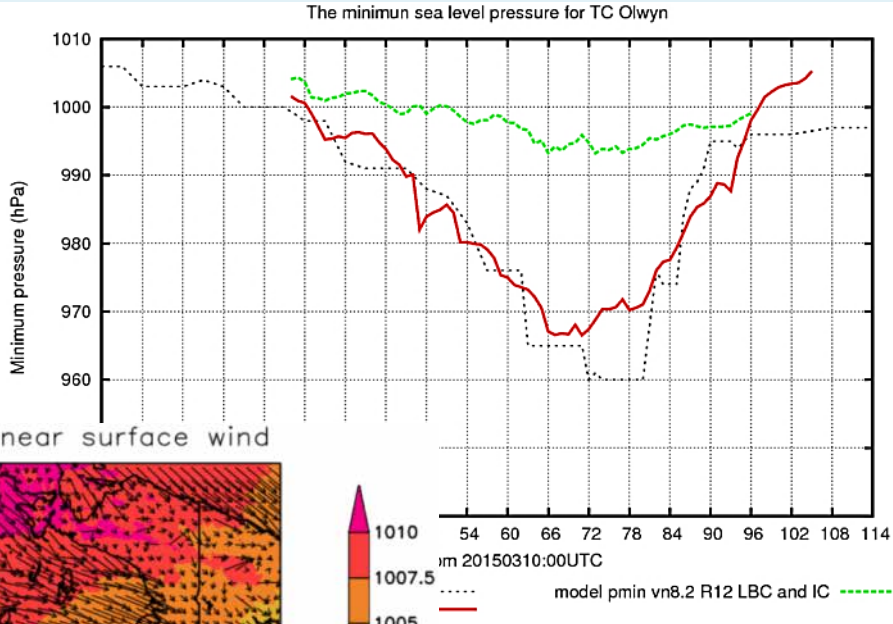
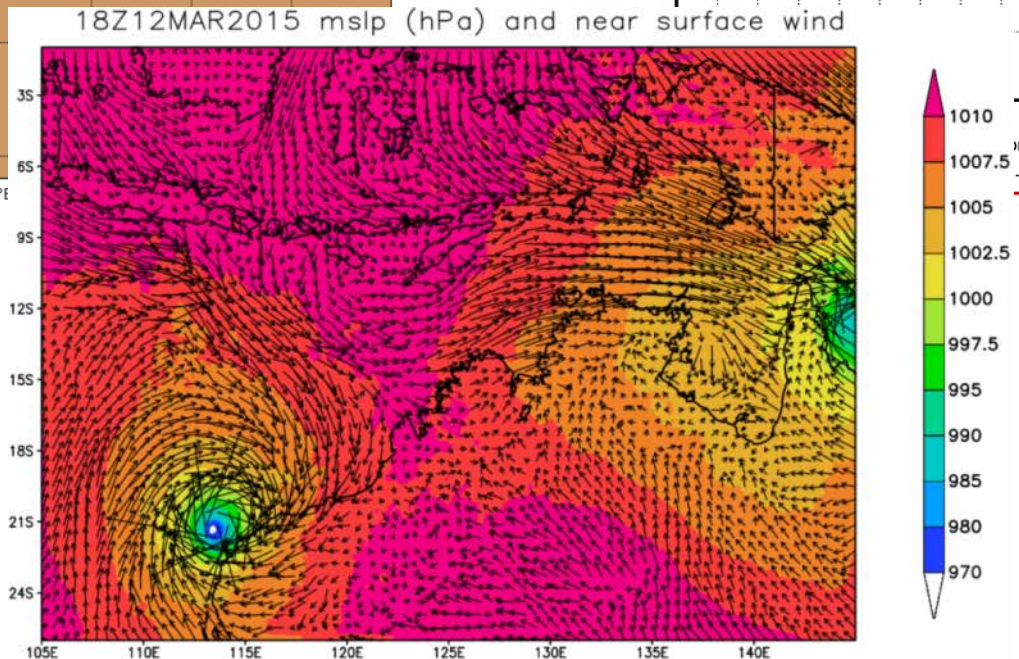
After much work …









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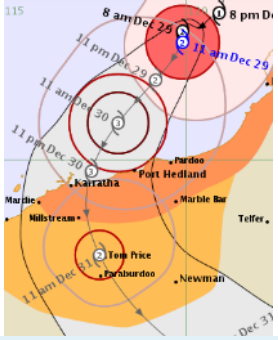
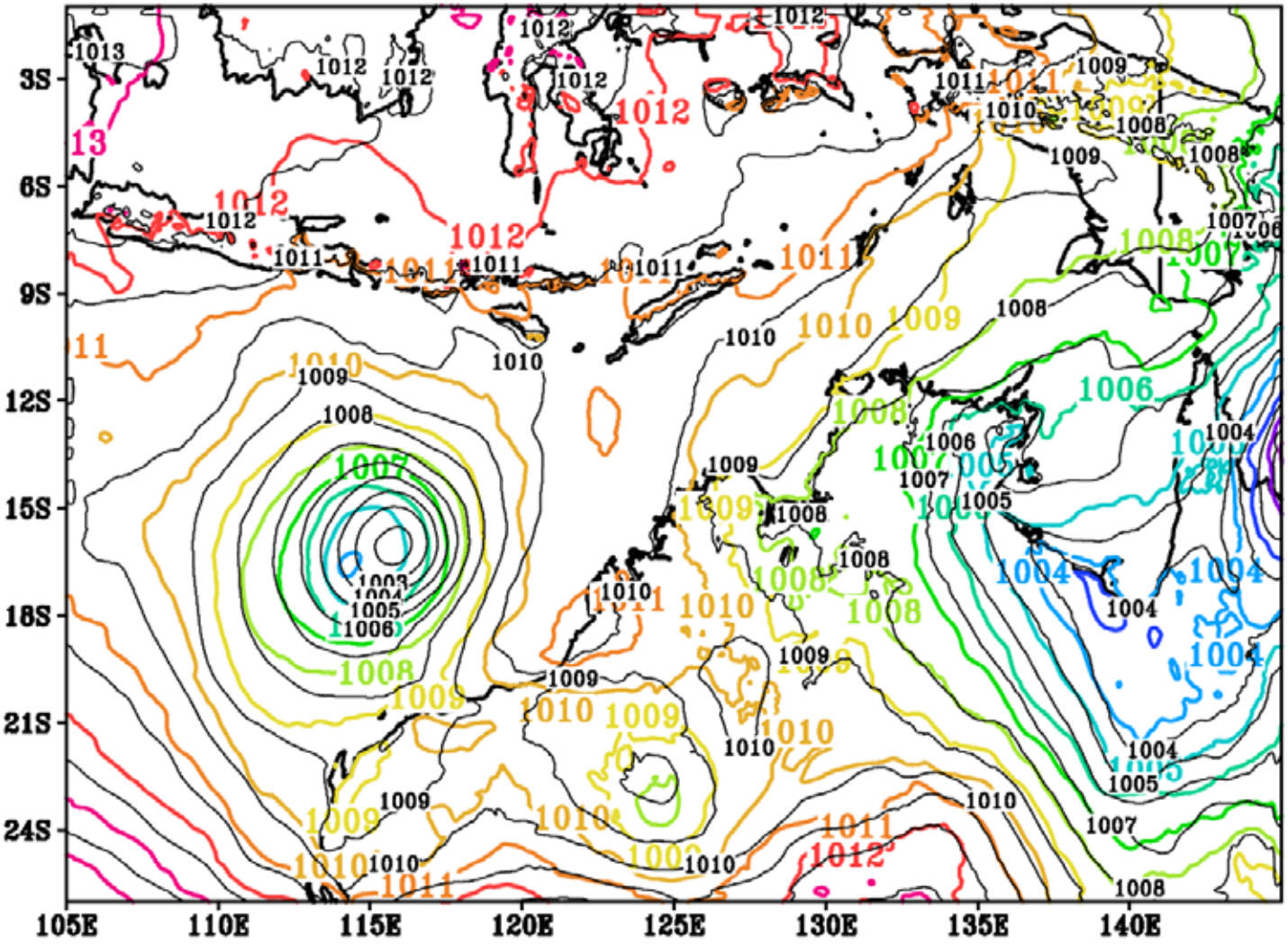
Quality of Initial Condition





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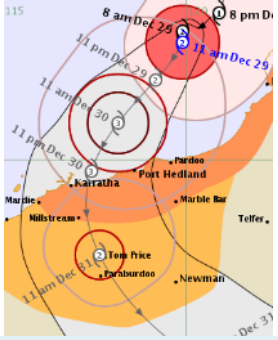
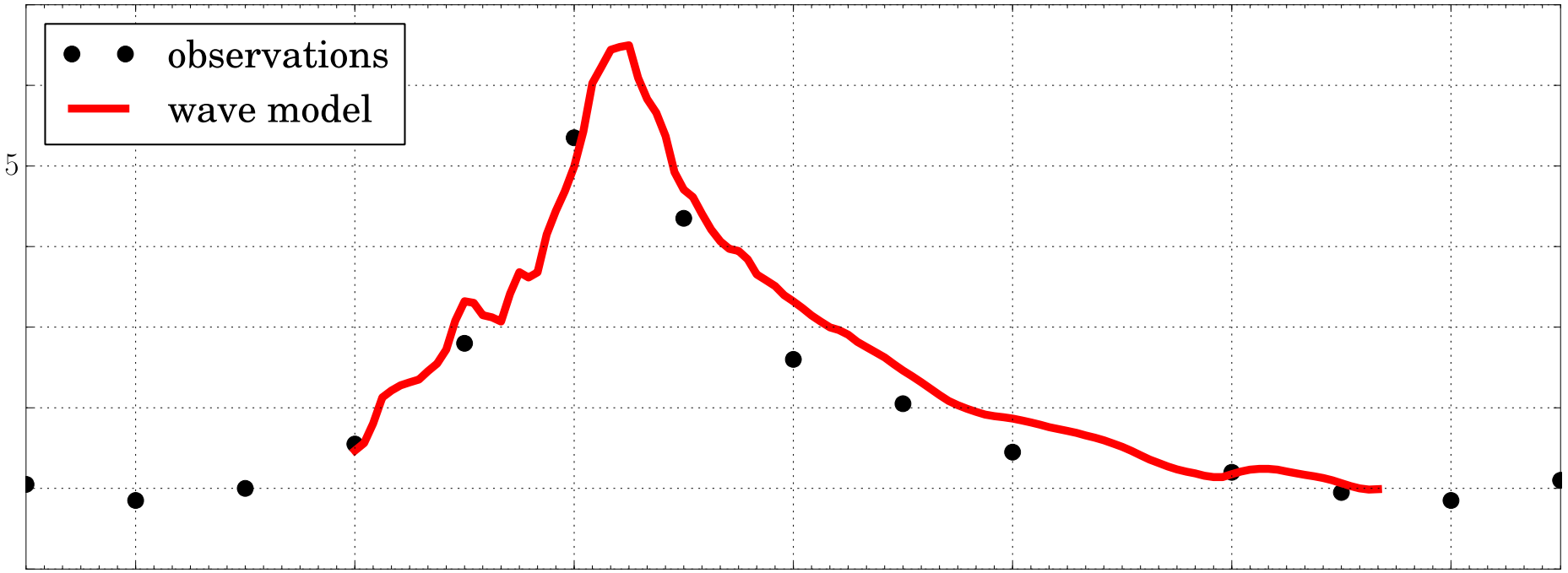
Wave Modelling





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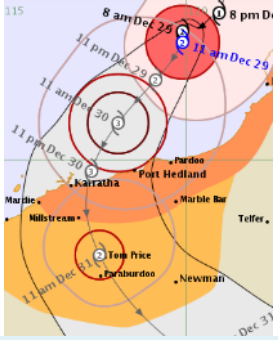
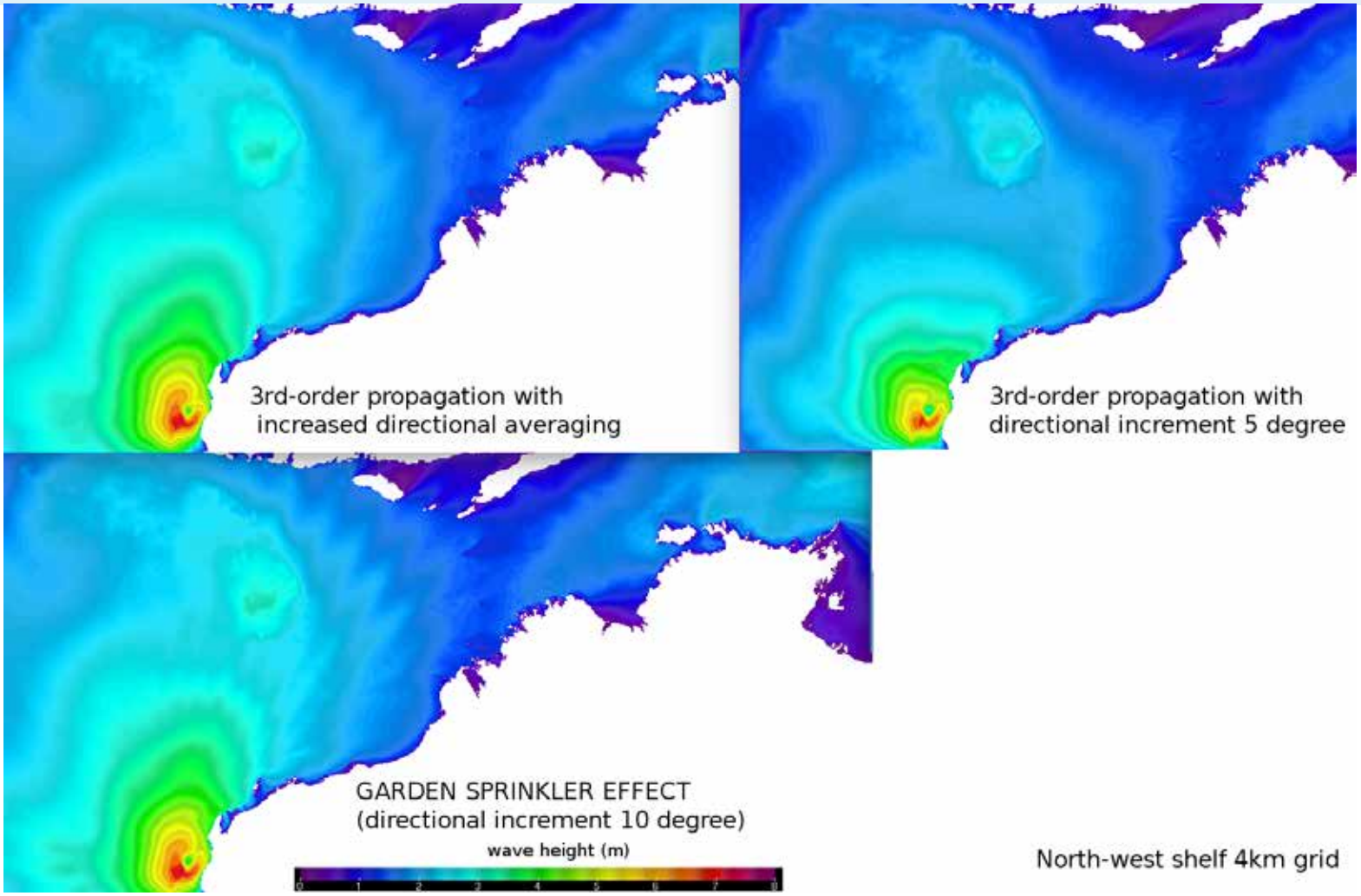
Sensitivity to Numerics





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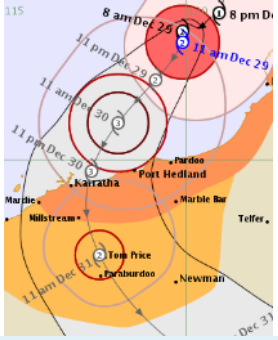
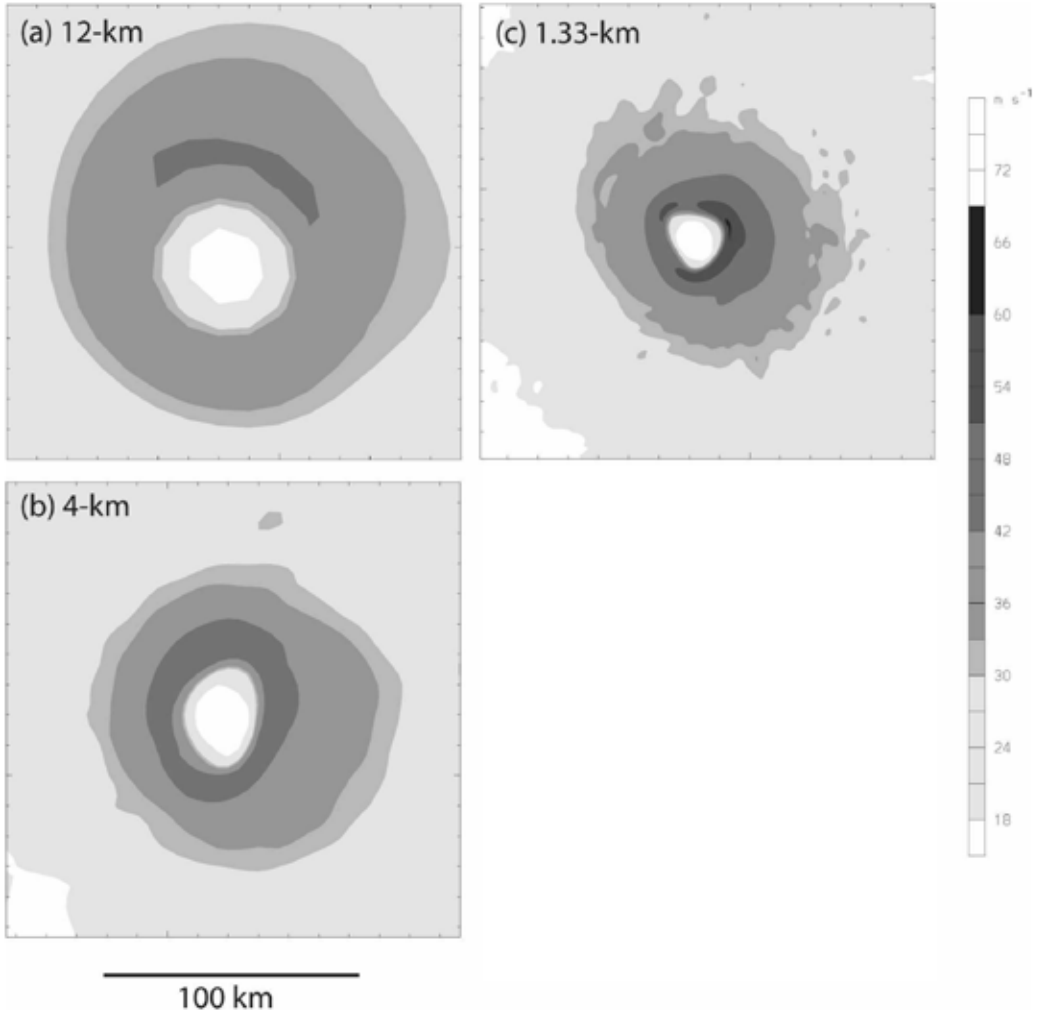
Ensemble bias correction





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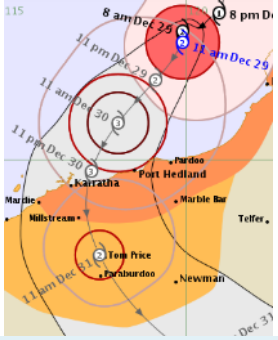
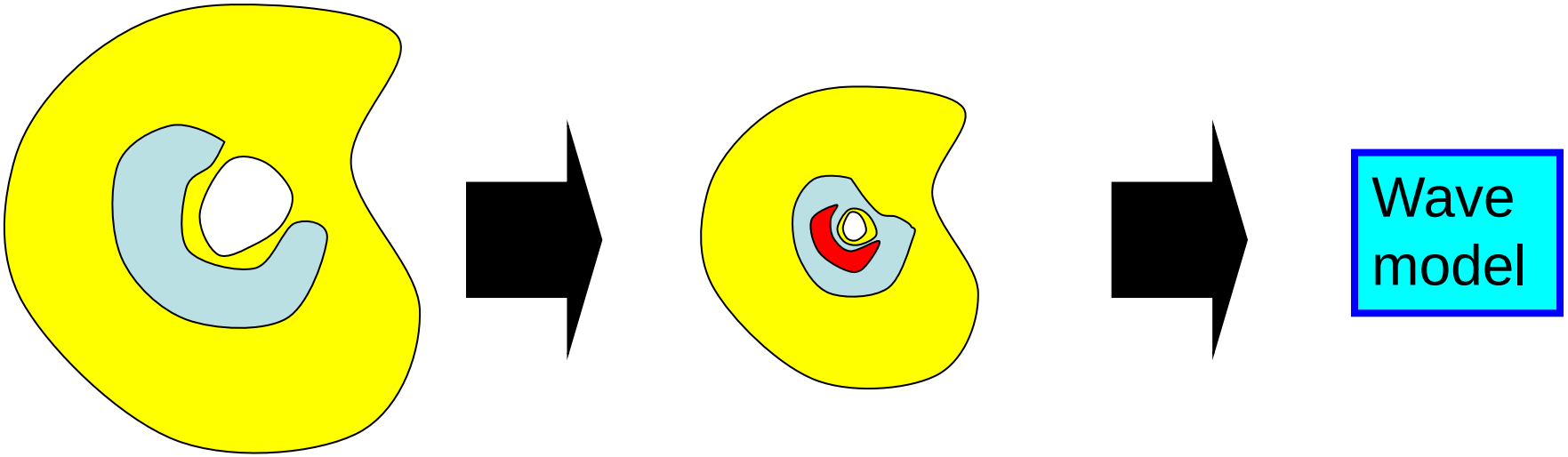
Bias correct TC winds from EPS





Raw EPS output has systematic biases

Replace with bias-corrected TC (All 51 members)

Run AUSWAVE on bias-corrected winds

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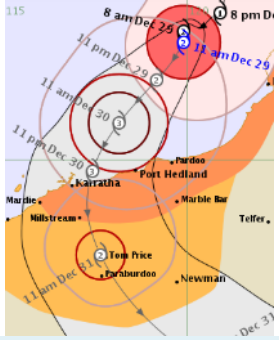
ECMWF bias correction



- Potential predictors: intensity, various wind radii, integrated kinetic energy to various radii.
- Applied to 3 years of ECMWF data from TIGGE archive
  - Several model generations
  - 51 members, twice daily = 154 model runs per week (times 3 years?)
- Also 20 year of ECMWF hindcast runs from ECMWF
  - Single model generation
  - 5 members, once weekly, 20 years = 100 model runs per week

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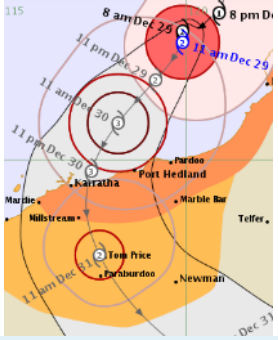
Best-track verification



- Prepared for each storm, after the event
- Data include track, intensity, various structure parameters (radius to gales, radius to storm and hurricane-force winds, radius of outer closed isobar)
- Here focus on radius to gales (R34)

- Project needs a source of “truth” for storm structure
- Best-track is the prime candidate, but much relies on it
- How reliable is it?
- Compare to climatology by Chan and Chan (2015)

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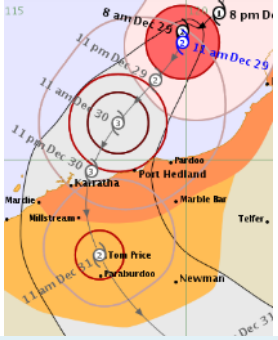
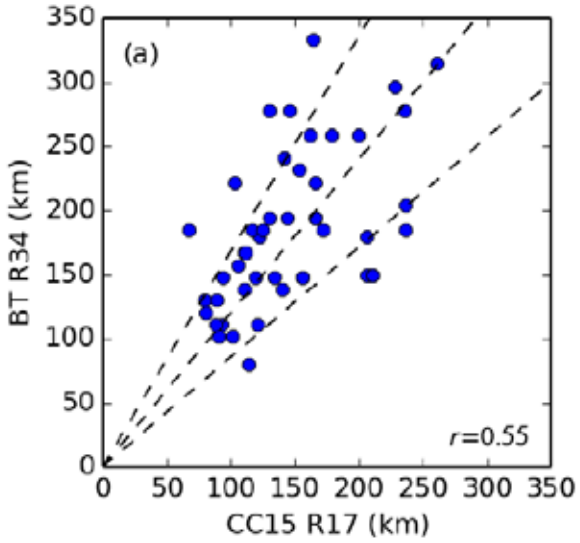
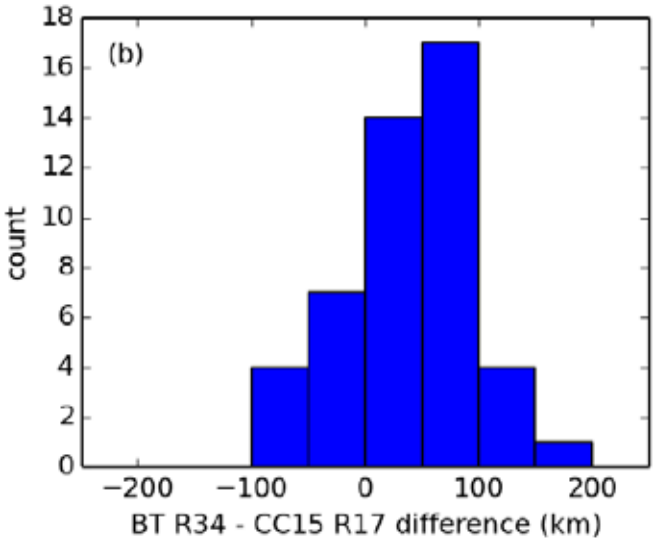
Storm-by-storm







- Find common storms in Chan and Chan (2015) and best-track, compare radius to gales (R34 kt vs R17 m/s)
- BT is about 20% or 40 km larger, significant scatter, correlation r = 0.55
- Difference corresponds to a wind speed difference of 4 kt (2 m/s)

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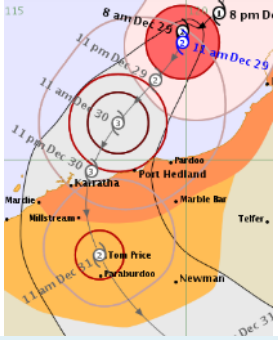
Delivering Value



Tailored TC research	Operational services …means…	Enhanced industry processes …means…	Trained and engaged operational staff …means…	Enhanced decision making …means…	Improved safety and efficiency …means…
Feedback and improvement cycle	Key features				
	• Consistent, reliable, robust products for industry • Forecast busts are reduced • Probabilistic information is enhanced on forecasts • Threshold exceedance info is highly flexible • Weather elements are communicated • Forecast performance/ uncertainty is communicated • Product delivery is timed with business needs • Models are consistently refined to increase accuracy • State of the art visualisation	• Processes align with safety regulations • Thresholds consider probabilistic information • Responses are based upon weather elements rather than storm categories • Response thresholds are standardised • Processes map to risk management policies • Processes are integrated with service providers (e.g. aviation, port authorities) • Procedures are updated to utilise modern forecasts	• Most likely and worst case scenarios are understood • Confidence in forecasts is increased • Industry-wide user education is standardised • New tools are utilised to their full potential • Forecasters understand industry requirements	• Safety decisions are quantifiable • Response deadlines are accepted and adhered • Response models are standardised across assets and service providers • Decisions are consistent across industry • Ship and sailing FPSO routes are optimised • Reconnection times are optimised	• Reportable near misses are reduced • Occurrences of staff stuck on site are reduced • HSG exposure hours are reduced • Deviations from plan are reduced • Unnecessary flights are reduced • Days of down-time are reduced • Production losses reduced
	Key gaps				
	• Industry focused ongoing model and forecast product improvements • Timing alignment of industry business needs with Bureau operations	• Alignment of regulators with industry and Bureau • Understanding of limitations of the TC categorisation system • Aligning risk management policy (10^{-4}) with Bureau verification	• In-depth forecaster knowledge of industry • In-depth industry knowledge of forecast limitations • Provision of confidence in forecasts to decision makers	• Ability of decision makers to justify decisions	• Feedback to Bureau

Tom Butcher

Australian Government
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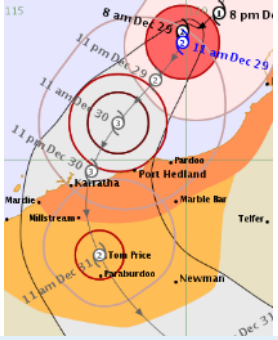
Governance



Steering Committee

Research Project Board

Implementation Project Board

Industry

Bureau of Meteorology

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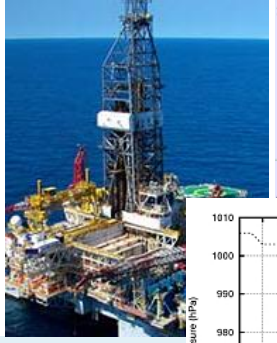
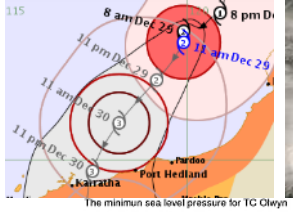
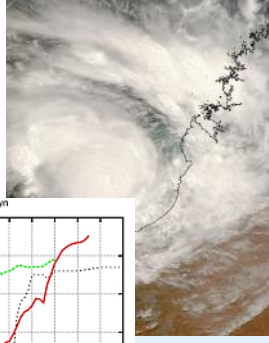
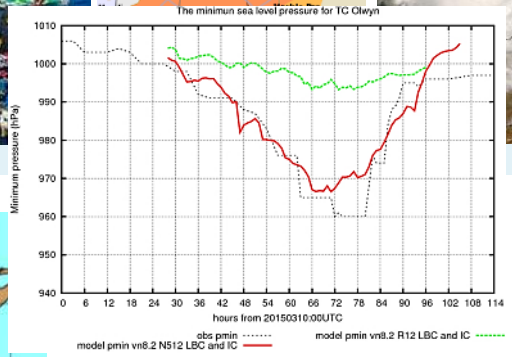
Summary









- Science
  - Extended-range TC model
  - TC-bias-corrected global ensemble
  - Wave model
- Operational implementation planning
- Integration into forecast process
- User decision-making