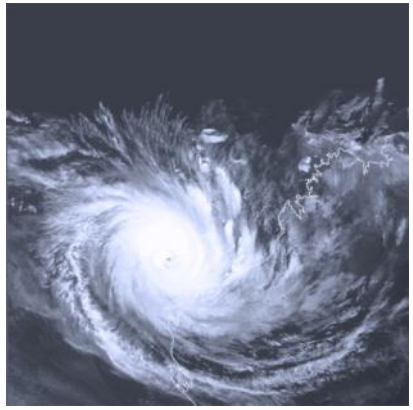
NWS Swell Prediction



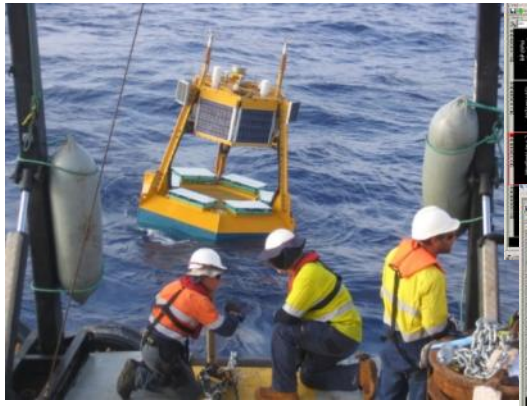


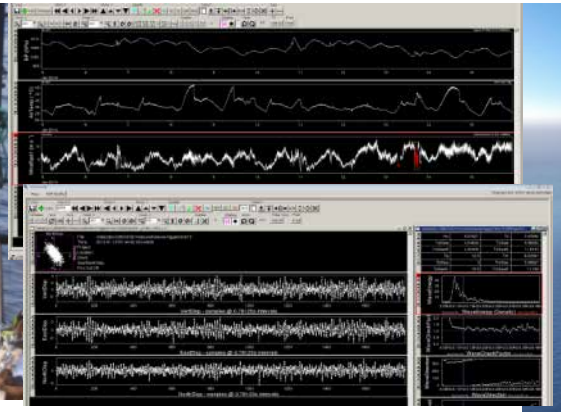


Presented by:
Greg Williams
Steve Buchan
RPS MetOcean Pty Ltd

Company - RPS MetOcean

- History – 40 years of regional metocean experience
- Measurement – 821 sites, 2552 series, 13809 sets, 900m+ records
- Modelling – wind, wave, current, tide, cyclone, soliton, sediment
- Design – involvement in every design study in NWS and Timor Sea
- TC Databases – premier industry reference, ongoing collaboration
- Tidal Databases – over 200 locations, 60+ constituents, calibrated
- Data Management Systems – quality control and data stewardship
- Experience – meteorologists, oceanographers, engineers, analysts





Context – Swell Affected Operations

- Aim to address the challenges facing NWS operations:
  - operability, side-by-side unloading, mooring line fatigue
  - offloading, disconnect/reconnect, post-TC inspection costs
  - loading, under-keel clearance, vessel response, berth management
  - coastal, port, and inland impact assessments, assets, supply chain
- Safety, damage avoidance, risk and downtime minimisation
- Need advance warning of swell events (long-range and cyclones)

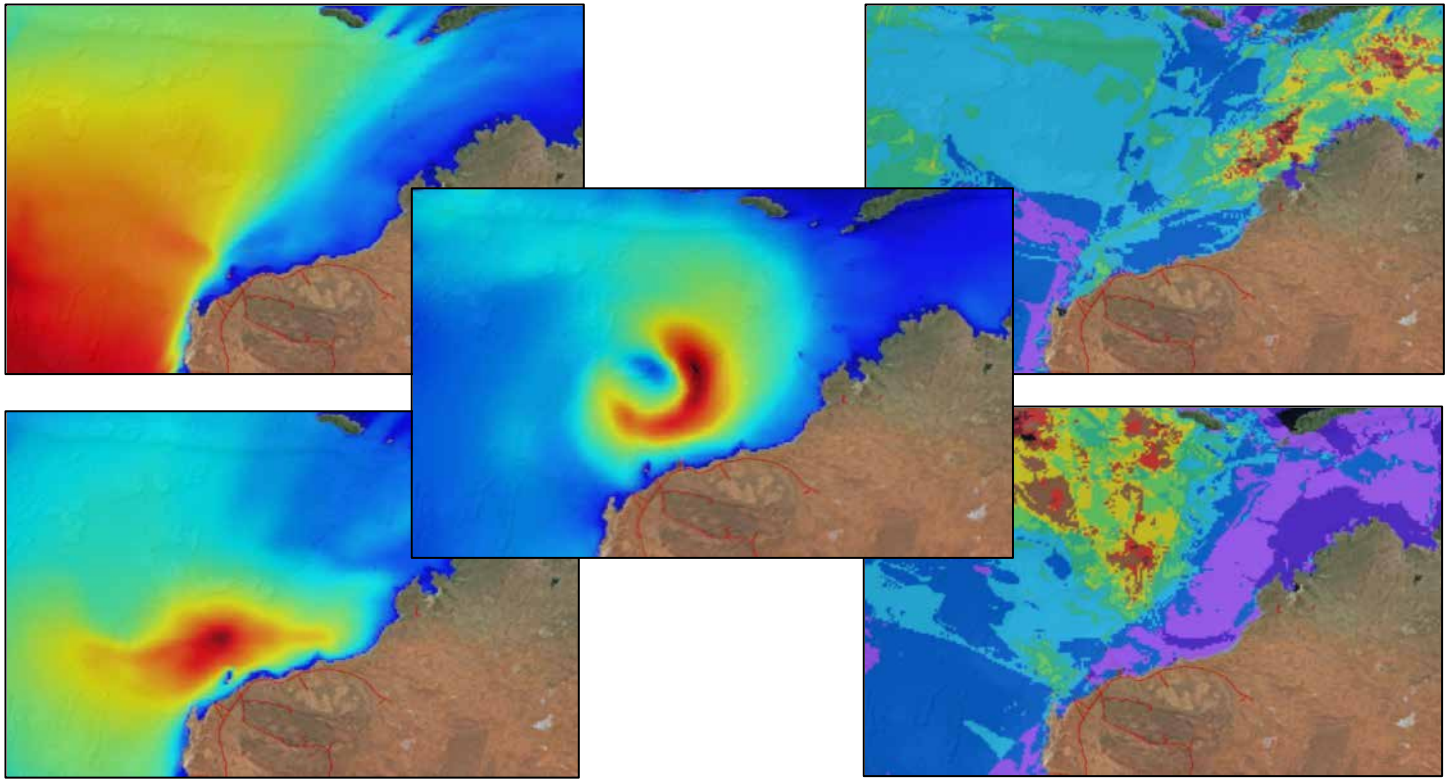
Costs - A Numbers View

- Vessel management: $1m/event (+$1m/day downtime)
- FPSO production downtime: $1m+/day
- Incident causing repair + downtime: $100m+/event
- FLNG shipment: $65m/shipment (average 60/year)
- Berth occupancy: $50k/event (several per year)
- Offshore construction swell-related downtime: $300k+/day

- Aims of safe operations, cost-avoidance, maximising returns, and streamlining procedures that increase operating time/limits.

- Regional aim to decrease costs for all operators through improved coordination and shared measurement applications.

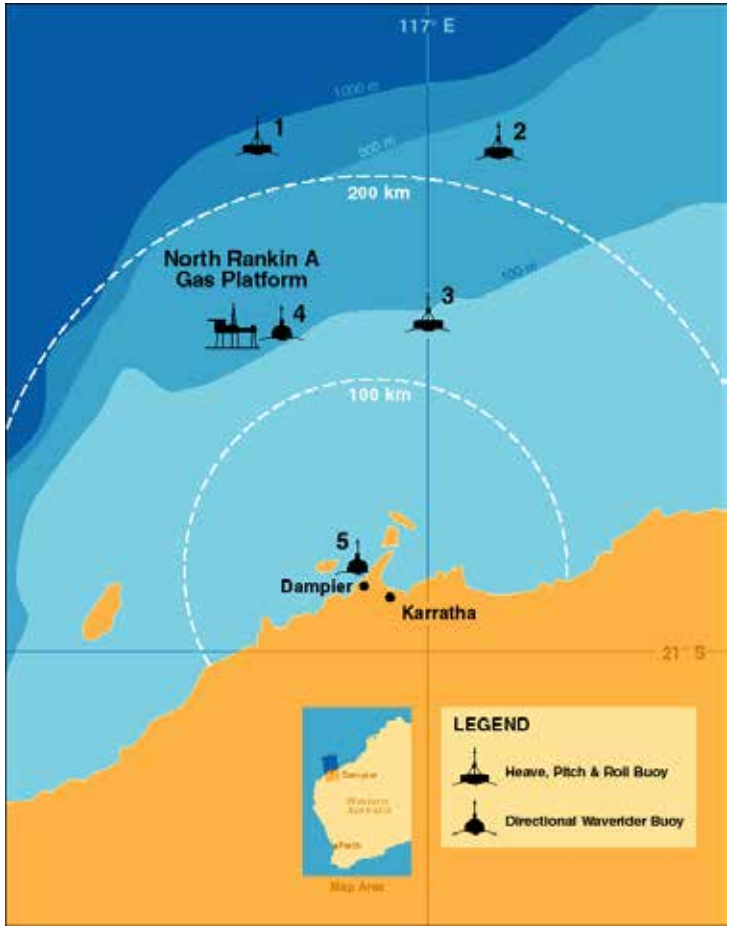
Setting - Regional Wave Climate



- Long-period Southern Ocean swell steered by shelf bathymetry, North East coastal through-flow enhanced by local winds, complex multiple-swell interactions, and Tropical Cyclones

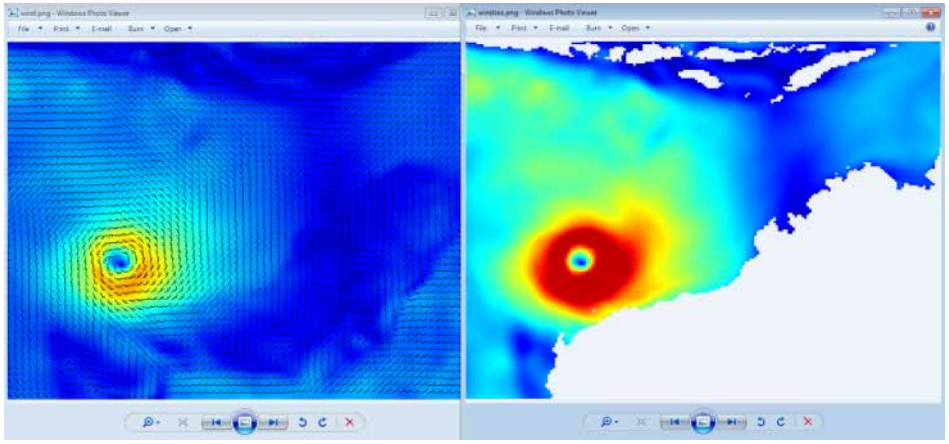
Experience - ROWS

- RPS MetOcean currently operates a Remote Offshore (Swell) Warning System for operations of oil and gas facilities located in Mermaid Sound off Dampier. Operational for 22 years.
- It comprises an array of buoys which feed data into a refraction model to forecast swell arrival times and heights. Continues to work well for operational windows up to 4 hours.
- RPS has now enhanced the system with the addition of long-range swell prediction for the next generation of larger vessels that require 6-8 hour operational lead-times (and beyond).



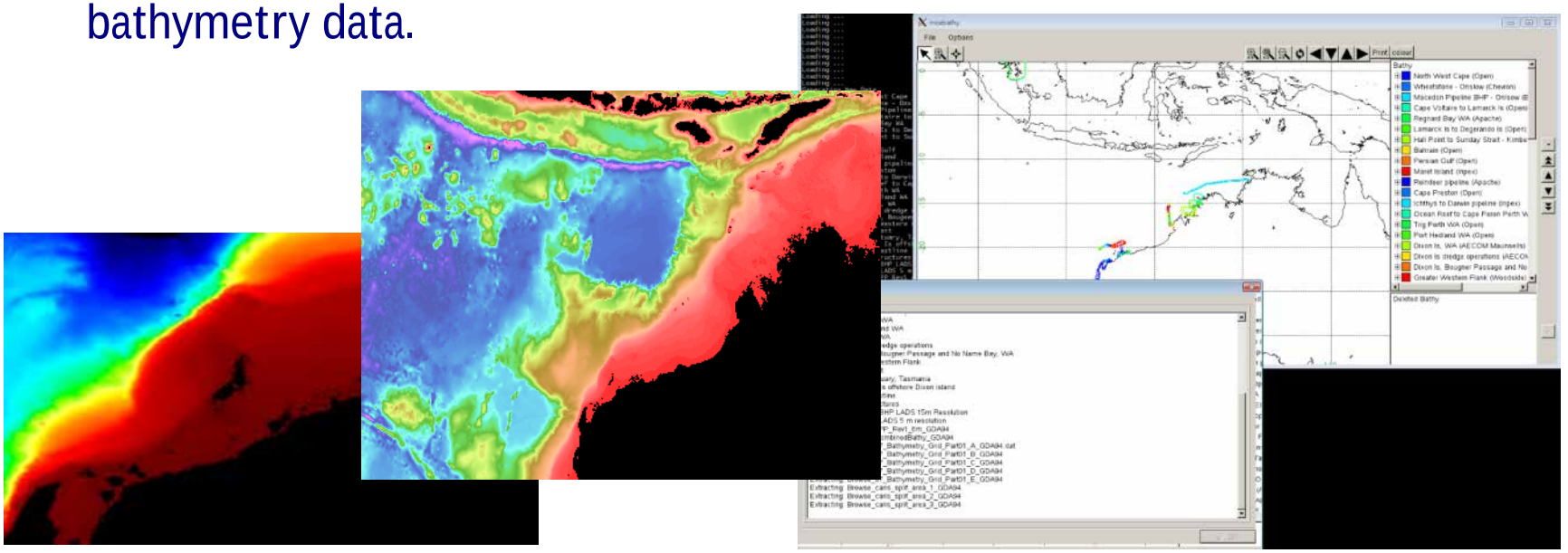
Swell Prediction Infrastructure

- Global Wind Forecasts
- BoM Tropical Cyclone Forecast Tracks
- RPS High-resolution Regional Bathymetry
- RPS Regional MetOcean Measurement Network
- RPS Tidal and Tropical Databases
- RPS Tropical Wind Blending Model
- RPS Nested Wave Model
- RPS Calibration Systems
- RPS Product Generation
- RPS Delivery Systems
- RPS Data Interfaces

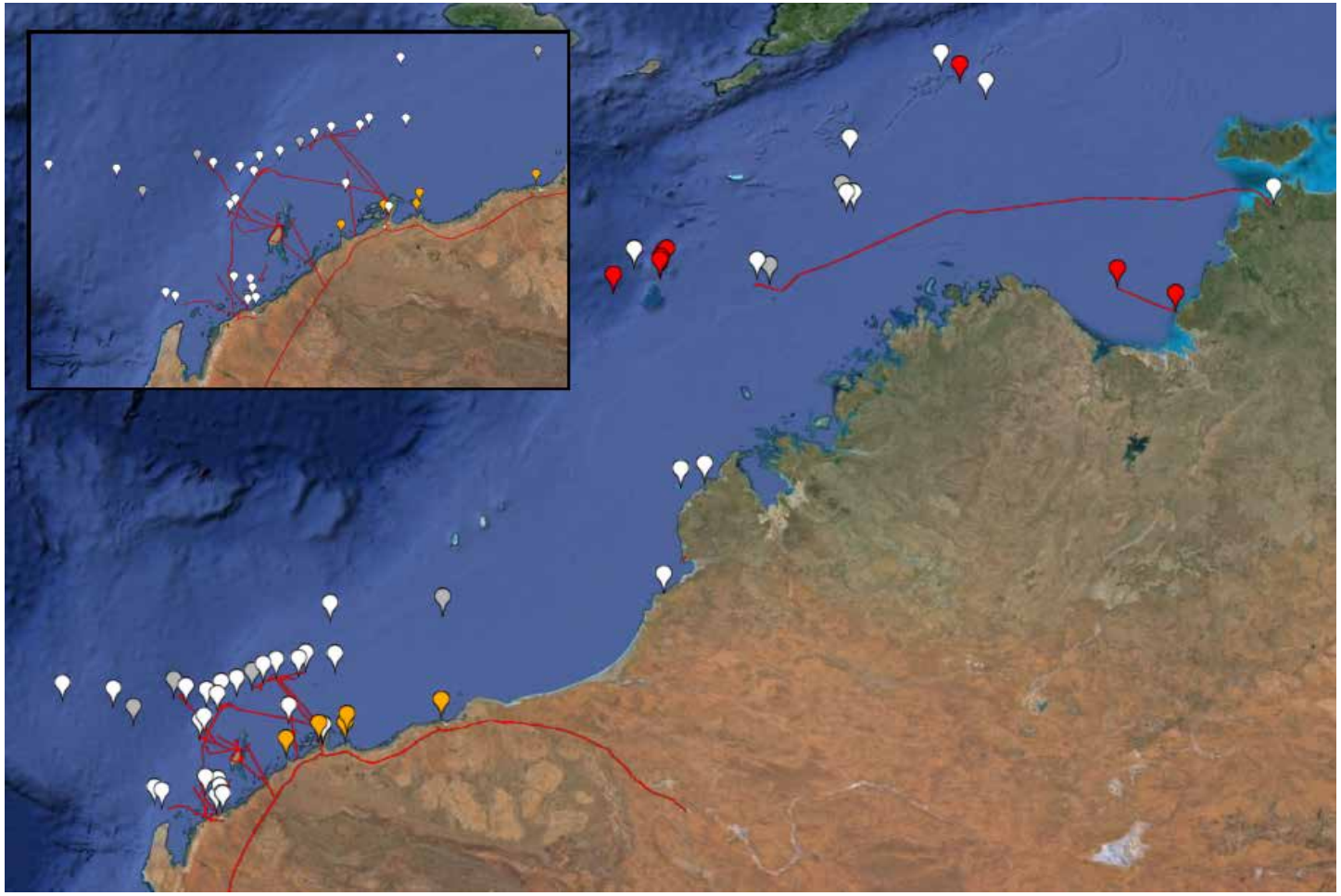


High-res Regional Bathymetry

- GEBCO 30 arc-second bathymetry base, with IHO coastal data.
- AGSO 9 arc-second bathymetry, best for North West Shelf.
- 50+ additional sources of high resolution bathymetry – survey, port, client, private, purchased, and RPS-digitised datasets.
- Calibrated and cross-checked at hundreds of measurement locations.
- In-house tools to easily select, import, edit, combine, calibrate, and evaluate bathymetry data.

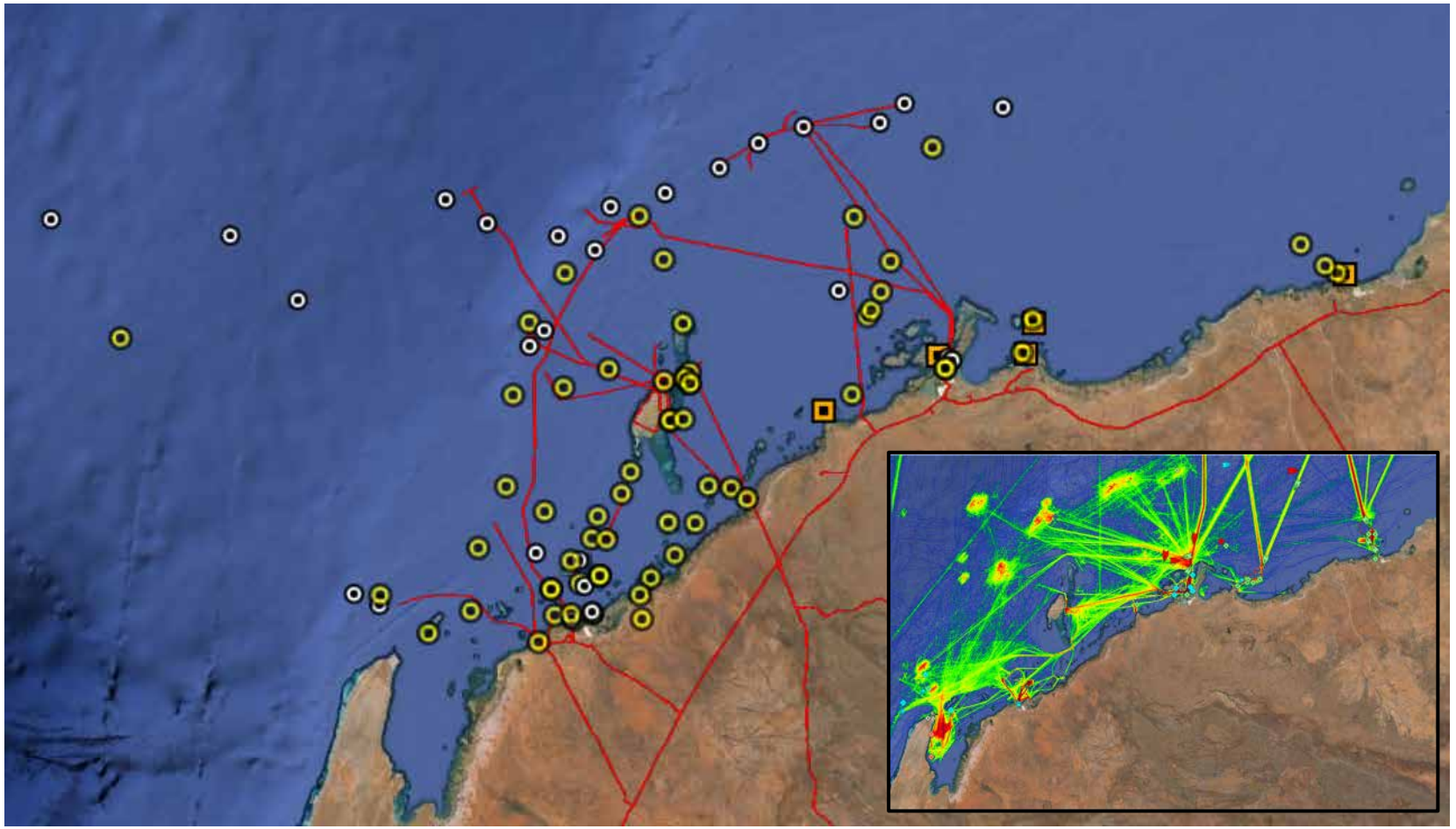


Real-time Measurement Network



Met, wave, current, and tide obs at offshore, nearshore, coastal sites.

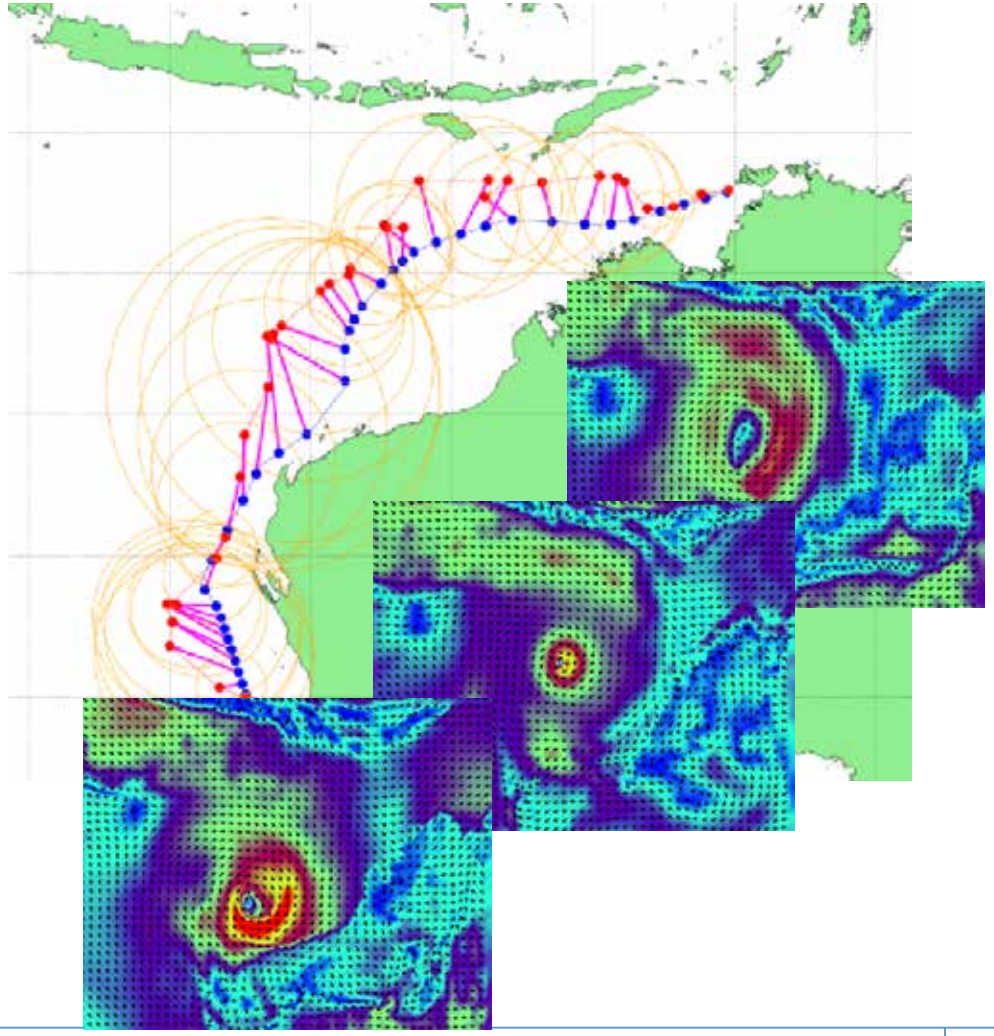
Tidal Database and Validation Sites



Tidal constituents and real-time measurements at ports and platforms.

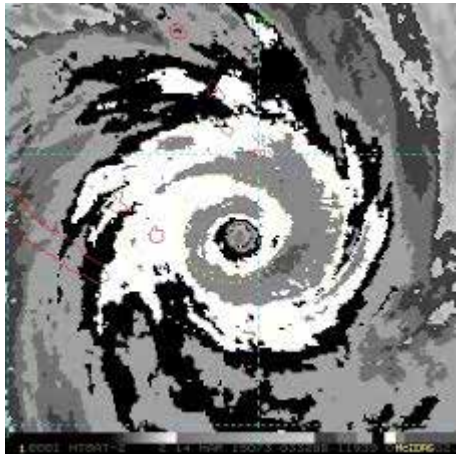
Need for Tropical Wind Blending

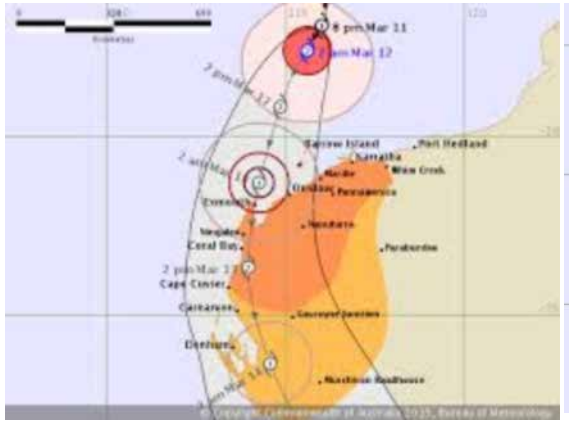
- Manual TC analysis (position and intensity) and forecast tracks by experienced forecasters are superior to existing models.
- In-situ cyclogenesis is difficult for models. Meteorologists can produce better results.
- Storm proximity and timing are key factors for operations.
- Wave model predictions are only as good as the wind inputs.

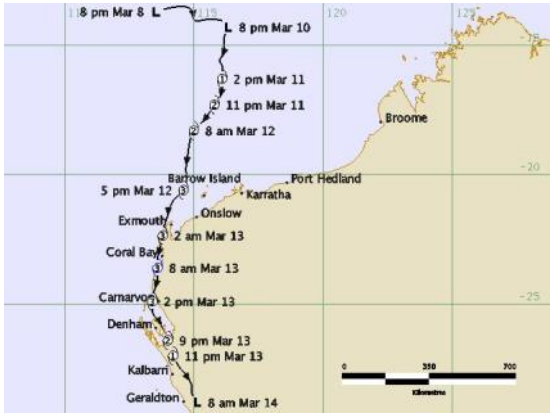


BoM Analysis and Forecast Tracks

- Manual analysis, forecasts, and 24x7 updates
- Predicts cyclone formation, position, and evolution
- Regional responsibility (official WMO TC Warning Centres)
- Focus on public safety, coastal impact, landfall – not industry, ports
- Continuous improvement and funding (eg. public, private, ITF)
- Automatic ingestion into RPS tropical wind field blending model

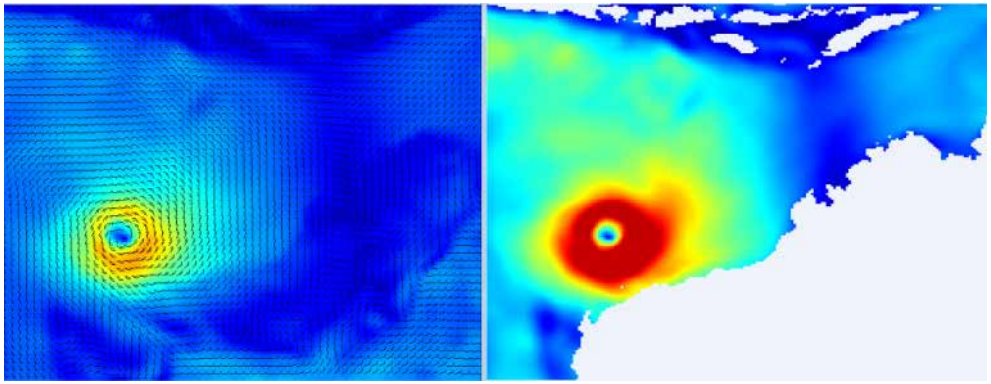


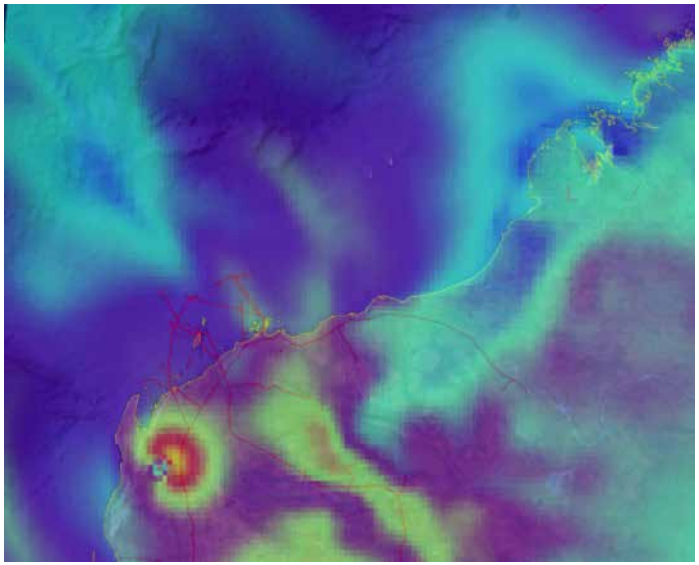




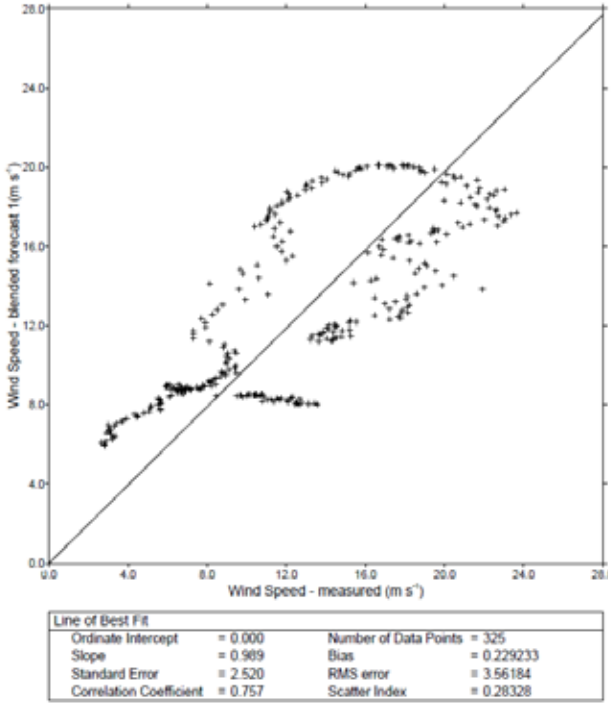
RPS Tropical Wind Blending

- Proven parametric wind field blending model developed for design
- Restores storm structure, intensity, and coherence into wind fields
- Well-calibrated against 40+ years of regional measurement
- Key in (ongoing) development of tropical cyclone databases
- Used in global and regional design studies and operational systems
- Continuous improvement
- Now deployed in automatic mode



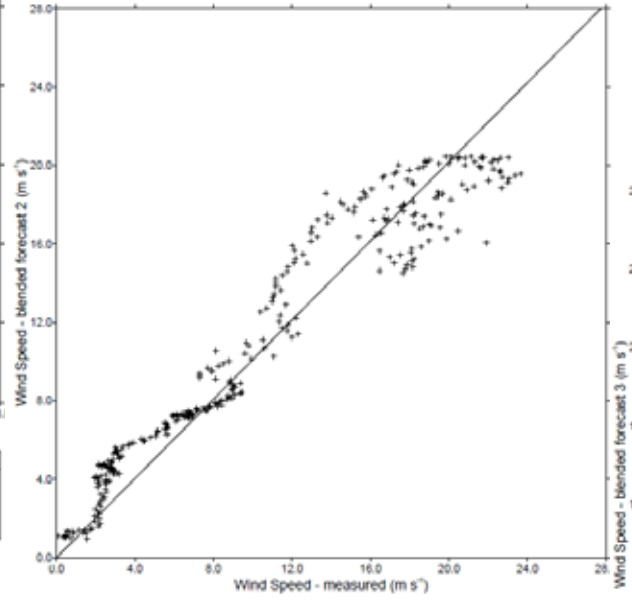


RPS Wind Model Results

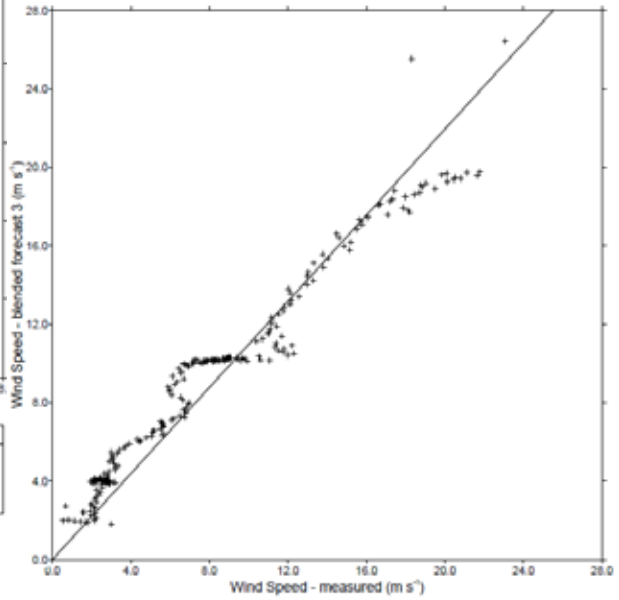


Line of Best Fit			
Ordinate Intercept	= 0.000	Number of Data Points	= 325
Slope	= 0.989	Bias	= 0.229233
Standard Error	= 2.520	RMS error	= 3.56184
Correlation Coefficient	= 0.757	Scatter Index	= 0.28328

- TC-Olwyn – blended winds against North Rankin measurements.



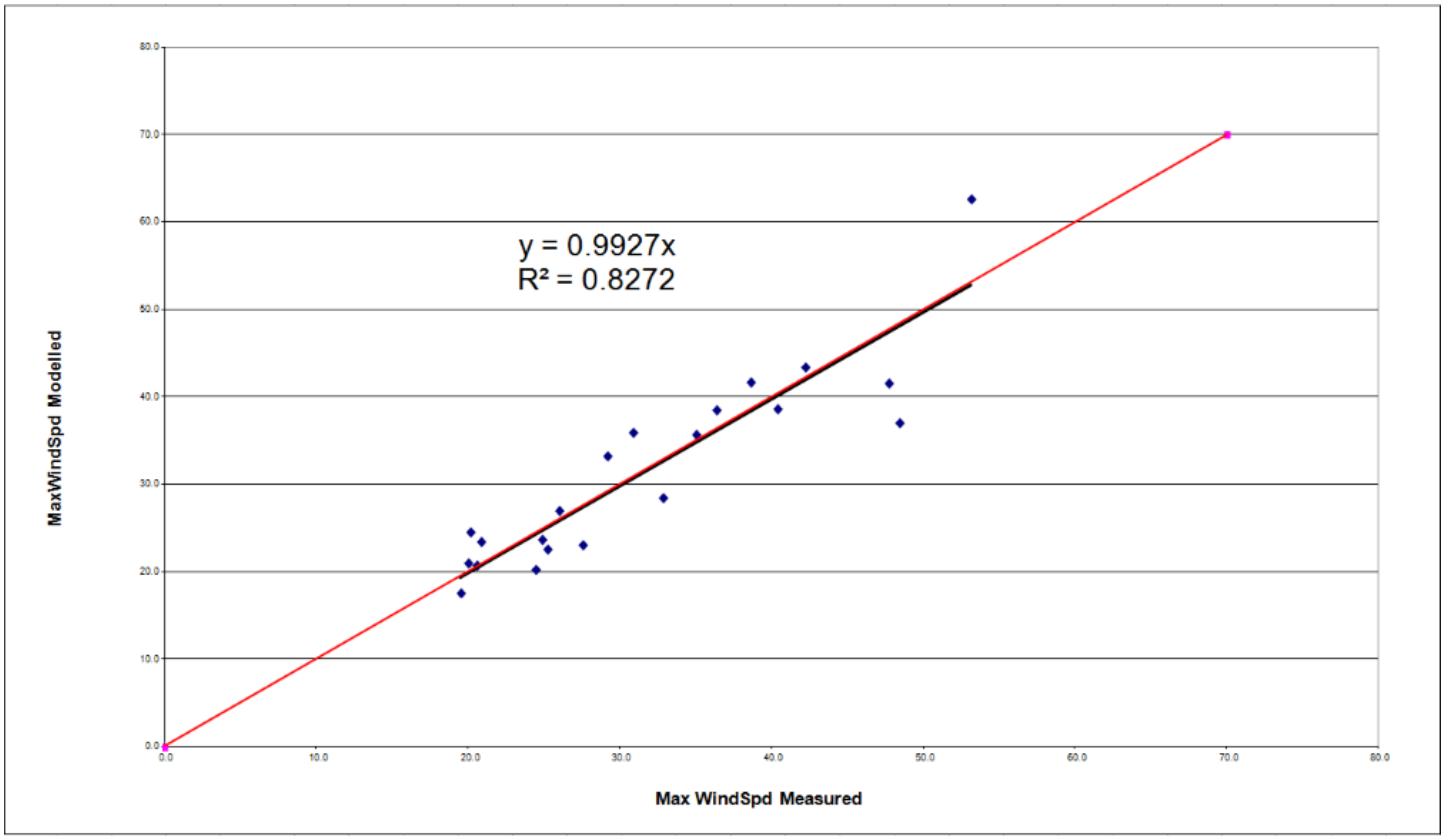
Line of Best Fit			
Ordinate Intercept	= 0.000	Number of Data Points	= 325
Slope	= 1.009	Bias	= 0.544117
Standard Error	= 1.289	RMS error	= 1.82283
Correlation Coefficient	= 0.970	Scatter Index	= 0.17765



Line of Best Fit			
Ordinate Intercept	= 0.000	Number of Data Points	= 246
Slope	= 1.097	Bias	= 1.25803
Standard Error	= 0.986	RMS error	= 1.67756
Correlation Coefficient	= 0.979	Scatter Index	= 0.20998

- Excellent results – even better as BoM track improves over successive forecasts.

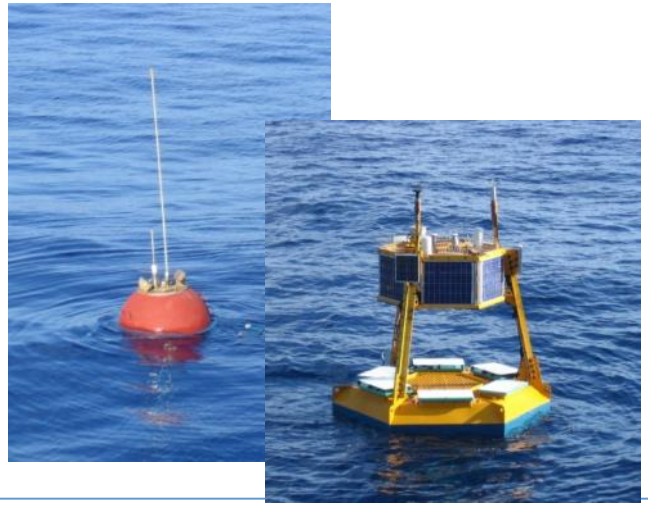
RPS Wind Model Results

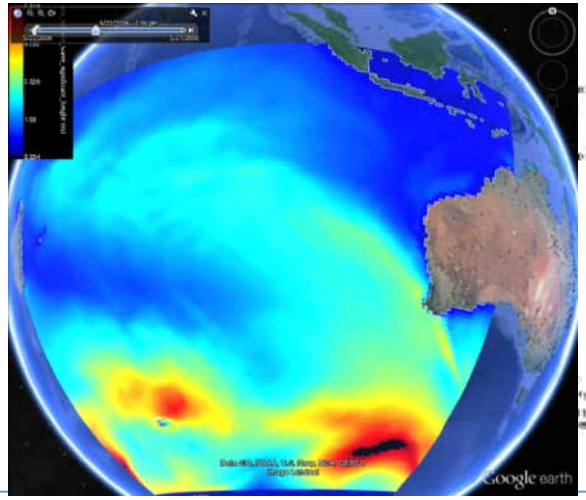


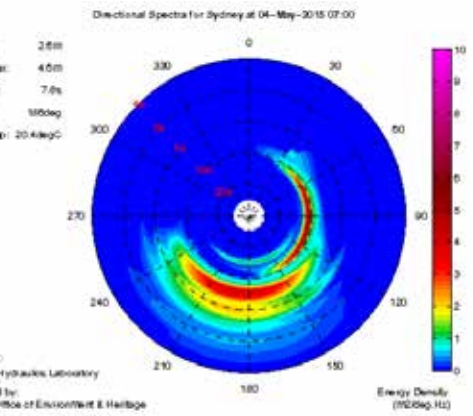
- RPS wind blending performance. Peak-to-peak comparisons against 30 years of Australian tropical cyclones. Excellent.

RPS Wave Model

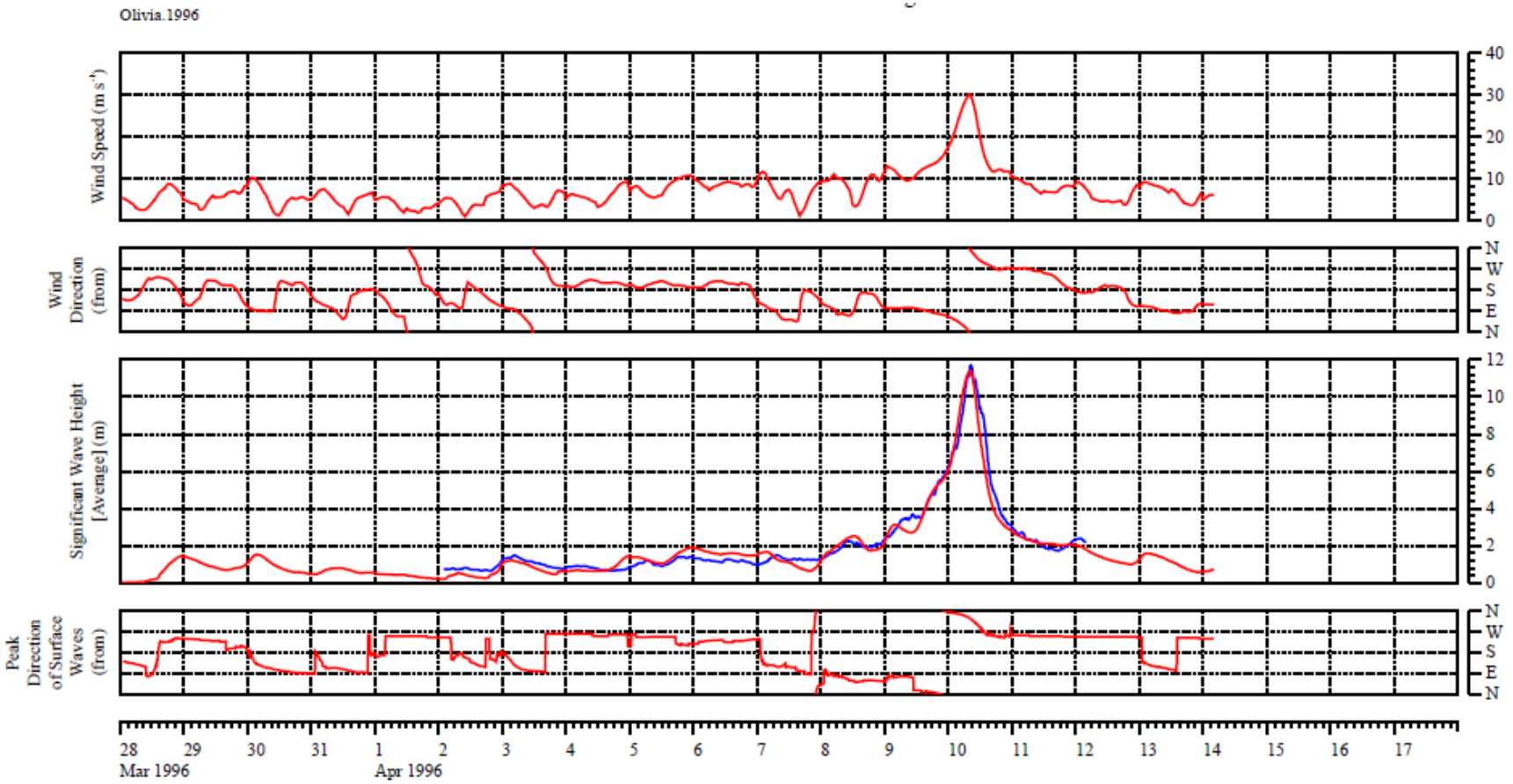
- Based on latest WW3 release with features relevant to NWS
- Comprehensive calibration and tuning options
- Able to ingest spectral measurement data (eg. buoy and satellite)
- Supports data assimilation of measurements and coefficients
- Support for moving TC nests and wave-system tracking
- Output spectra suitable for vessel motion/response/port systems





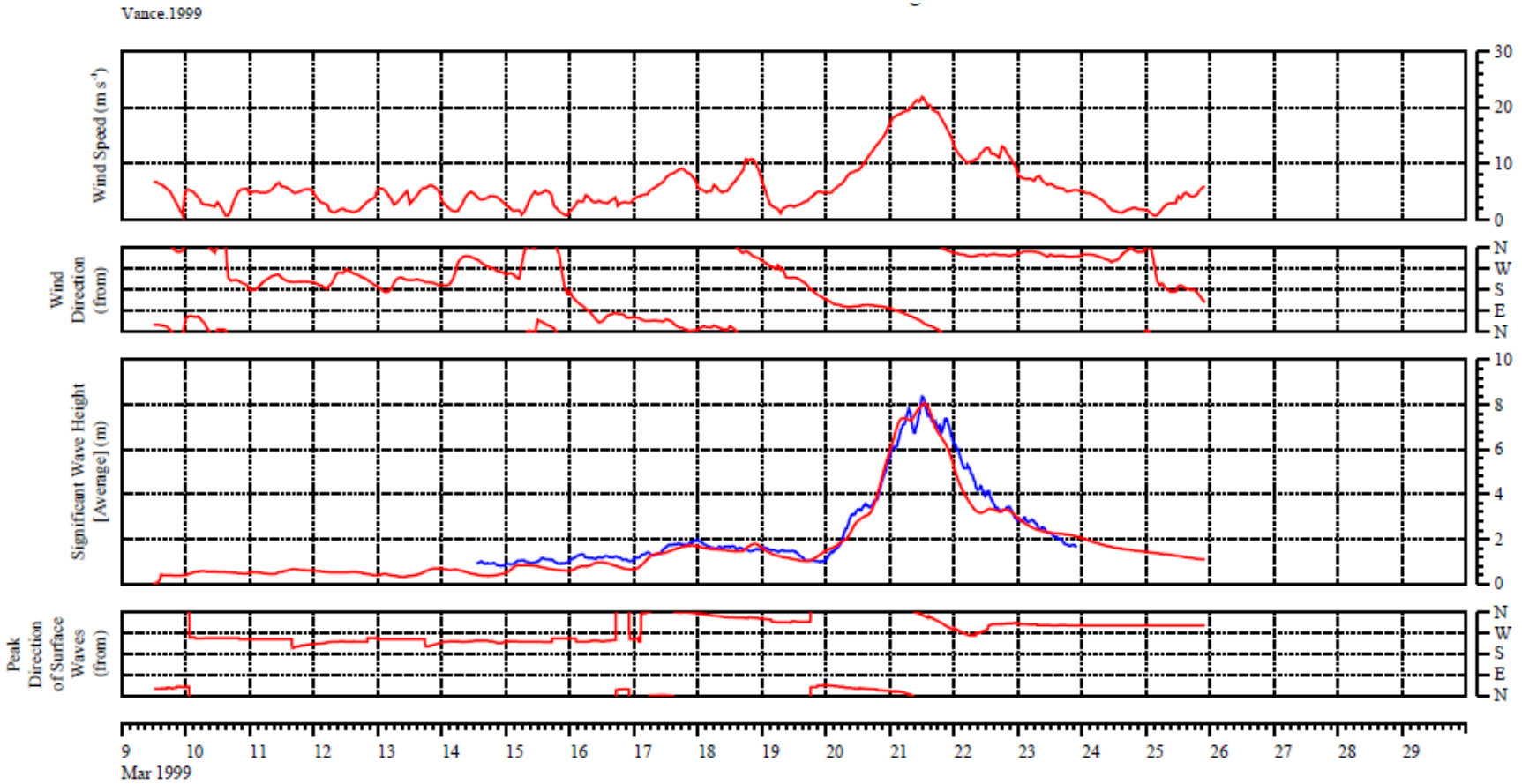


RPS Wave Model Results



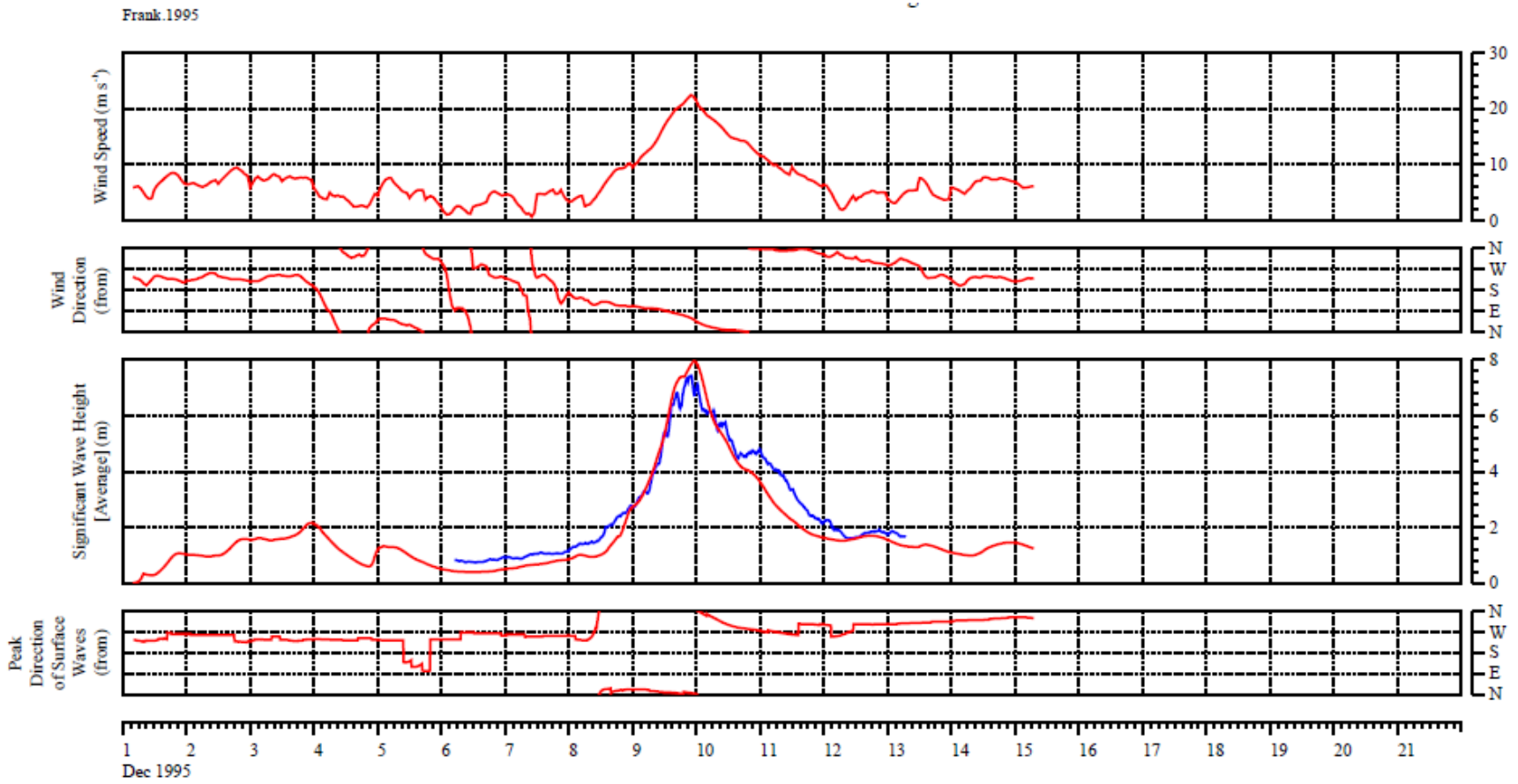
- TC-Olivia - RPS wave model (red) against North Rankin measurements (blue).

RPS Wave Model Results



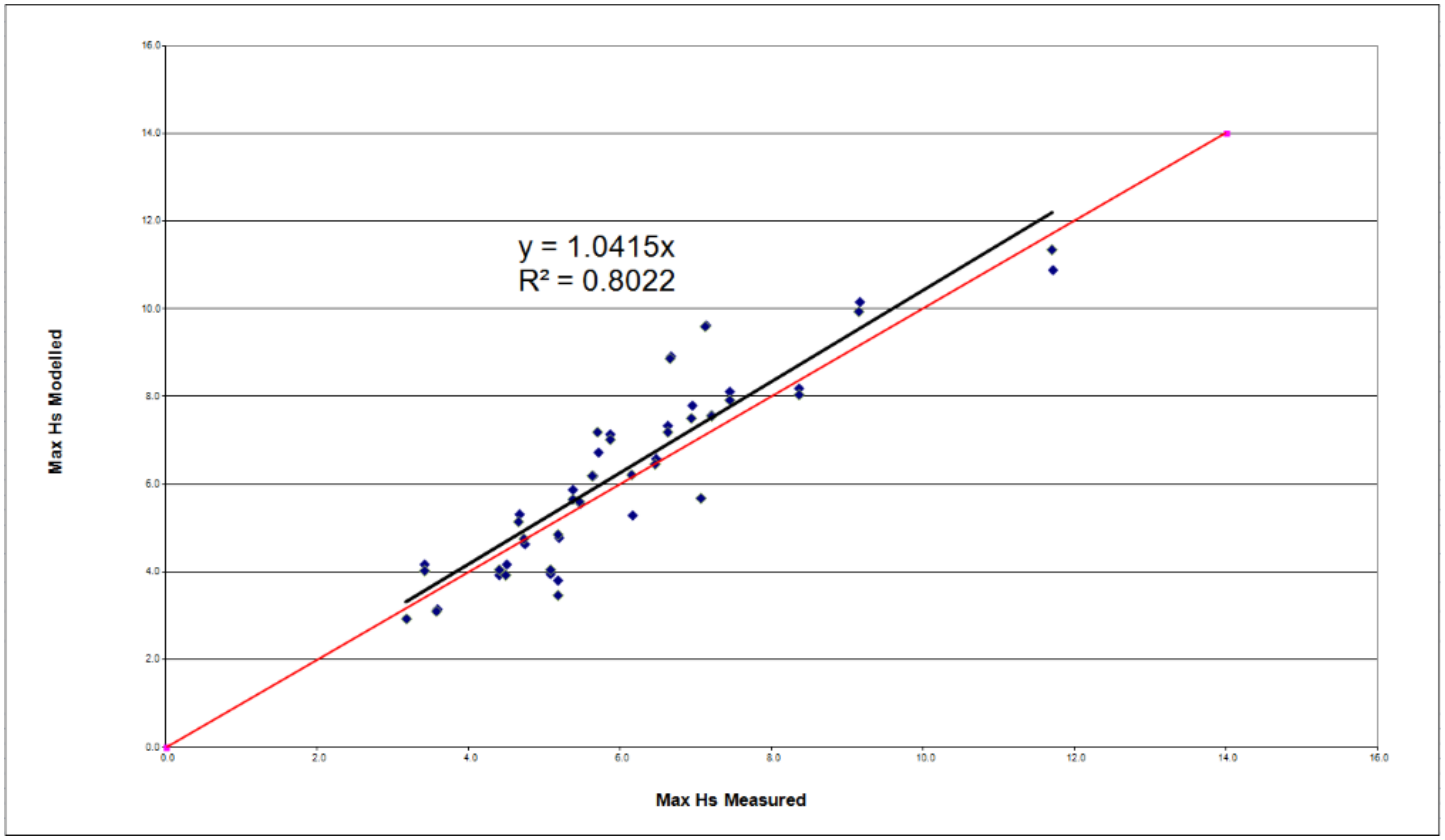
- TC-Vance - RPS wave model (red) against North Rankin measurements (blue).

RPS Wave Model Results



- TC-Frank - RPS wave model (red) against North Rankin measurements (blue).

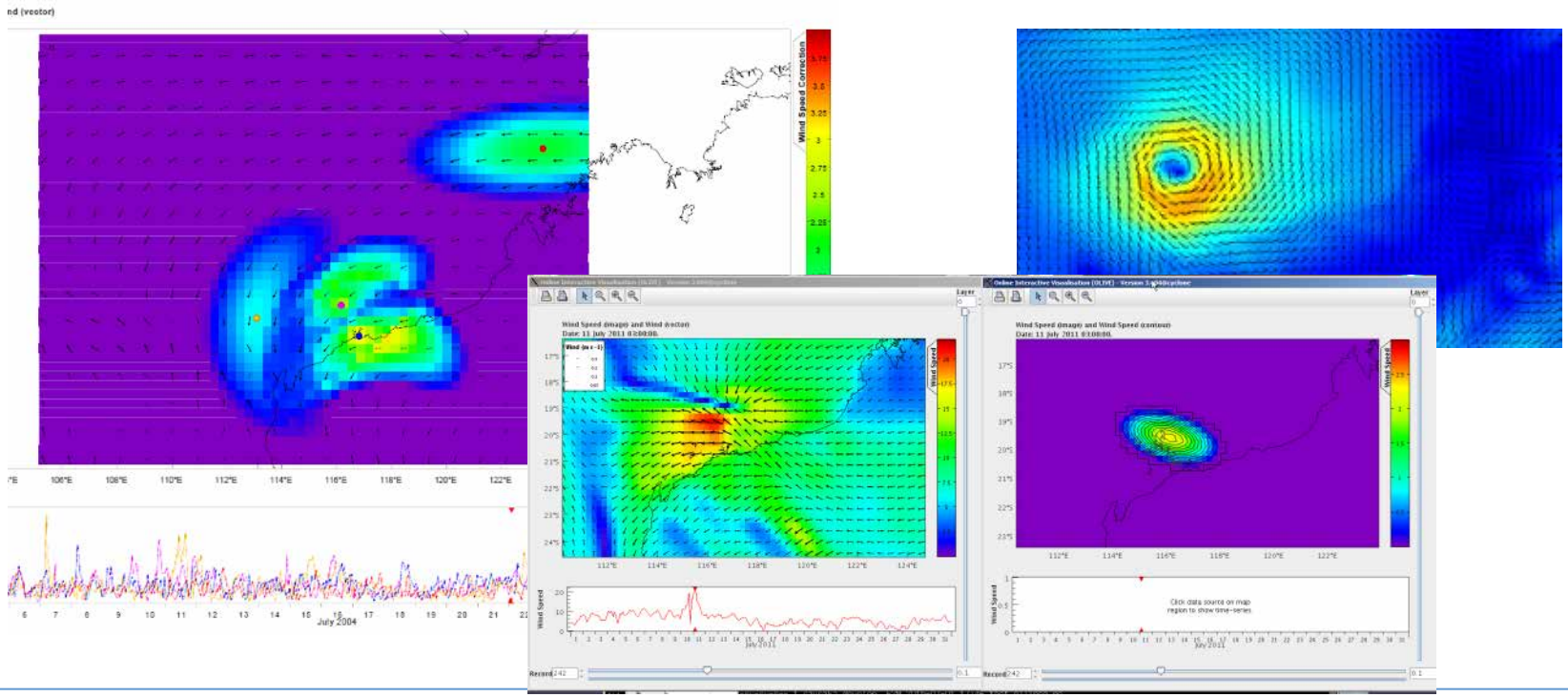
RPS Wave Model Results



- RPS wave model performance. Wave height comparisons against 30 years of Australian tropical cyclones. Excellent.

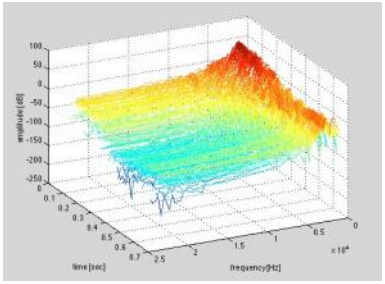
Wind Calibration Systems

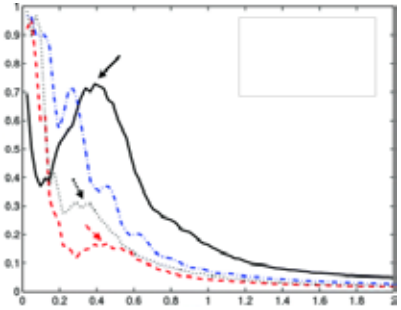
- RPS cycwind – blends tropical cyclone tracks into gridded wind fields to create vortex-corrected wind forcings for the wave model.
- RPS obswind – uses marine and terrestrial met observations to create superior wind fields and predictions.

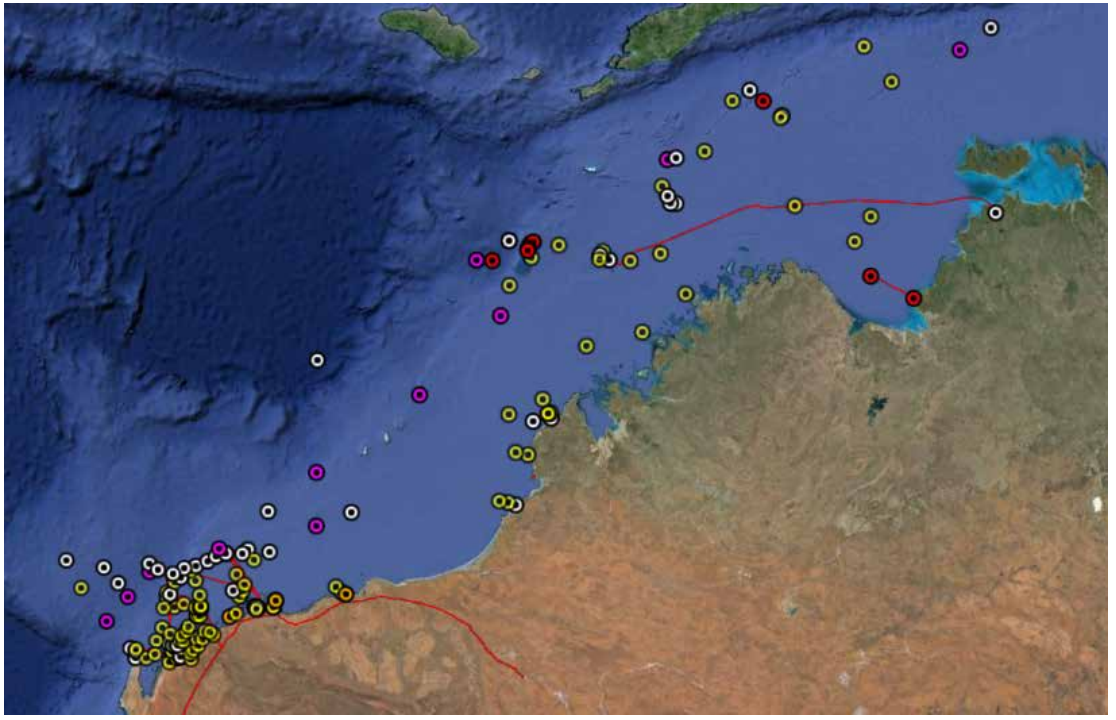


Spectral Wave Calibration Systems

- RPS obswave – uses wave measurements to calibrate spectral wave predictions at coastal and offshore operational locations.
- RPS QC database – provides profile coefficients from quality-controlled measurement datasets during data-assimilation.

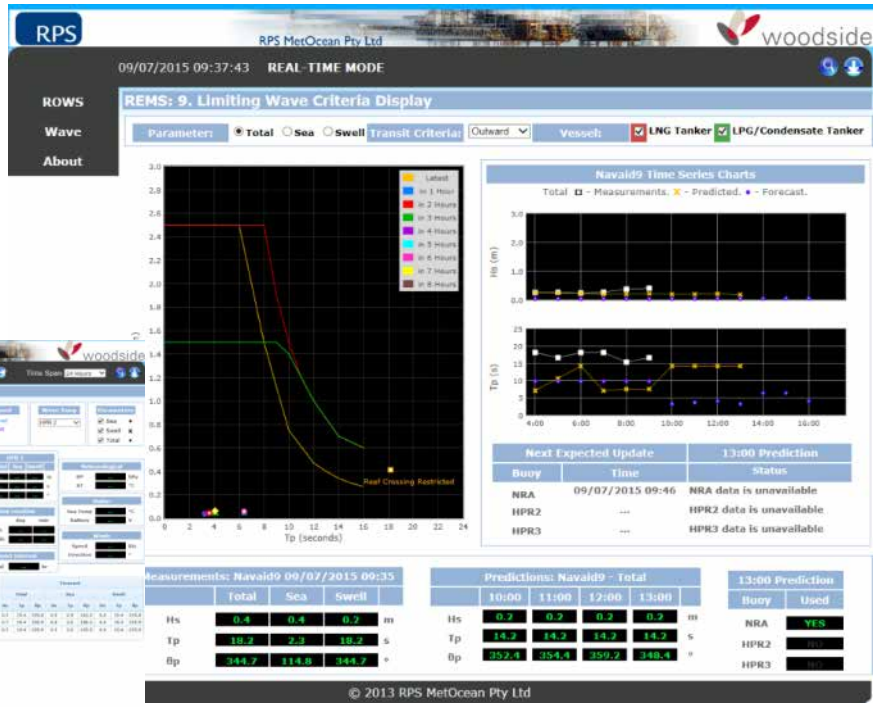


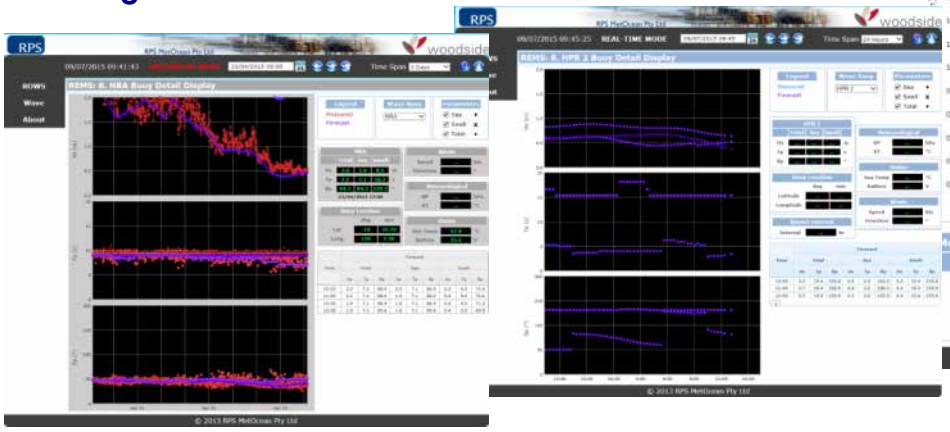




Products – ROWS-NG

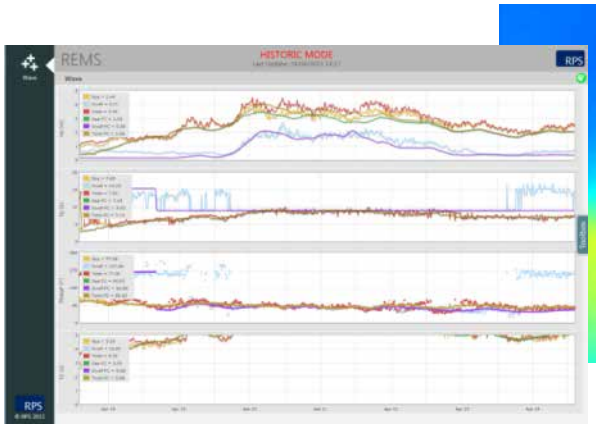
- Measurement-based Remote Offshore Warning System
- Limiting wave criteria, reef-crossing advice, familiar interface to pilots
- Proven ROWFRAC algorithm enhanced with long-range swell prediction
- On-site TC formation alerts
- Extended 8 hour predictions
- 24x7x365 operational support
- Site-calibrated ‘virtual buoys’ during off-season

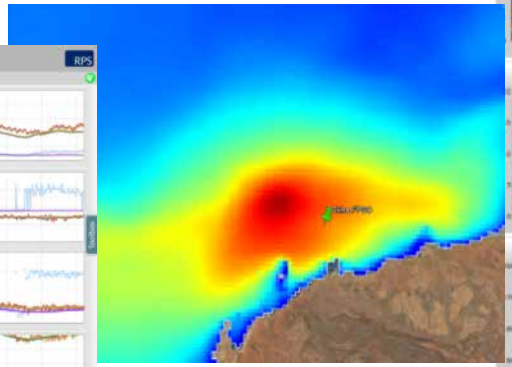




Products – REMS

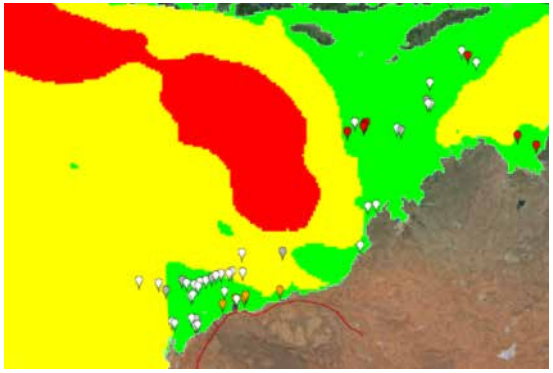
- Monitoring systems for port operations, safety, loading, clearance
- Integrated display of met, radiation, water level, swell, etc
- Now with spectral swell predictions to extend operational view
- Remotely measured data enhances prediction at operational sites
- Realtime calibration of spectral forecasts from site measurements
- Site-calibrated ‘virtual buoys’
- Extended 6-8 hour predictions
- Longer 7-day trends





Products – Swell On-Site alerts

- On-site formation alerts
- Incoming site-events/alerts
- Time-series forecast products
- Spatial area-forecast products (go/no-go animations)
- Delivery by web, FTP, email, SMS, query interfaces, mobile apps, other.



Location: North Rankin (J2790)
Latitude: 19° 35' 8" S
Longitude: 116° 8' 12" E

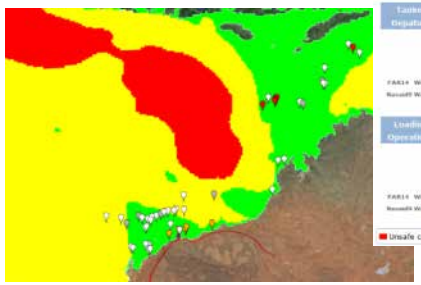
Realtime + Forecast Data: Alert notification at current time: 2015-06-27

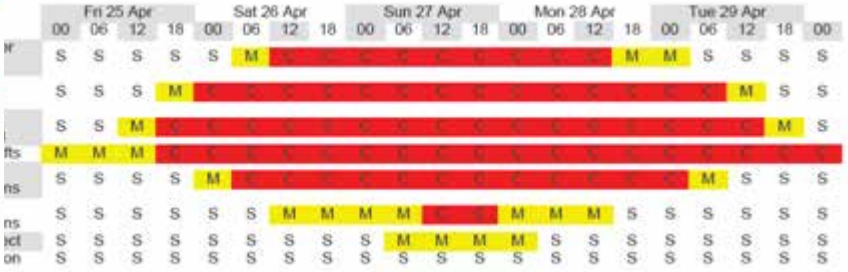
Current Warning (Dual) | Current Warning (Single) | Previous Warning | Normal State

Forecast	Max. Wave Height (m)	Hs Swell (m)	Tp Swell (seconds)
2015-06-28T02:30:00Z	4.39	2.19	17.77
2015-06-28T02:00:00Z	4.40	2.20	17.77
2015-06-28T01:30:00Z	4.42	2.21	17.77
2015-06-28T01:00:00Z	5.64	2.82	17.77
2015-06-28T00:30:00Z	4.45	2.23	17.77
2015-06-28T00:00:00Z	4.36	2.18	17.77
2015-06-27T23:30:00Z	5.77	2.89	17.77
2015-06-27T23:00:00Z	5.78	2.89	17.77
2015-06-27T22:30:00Z	4.39	2.20	17.77
2015-06-27T22:00:00Z	4.40	2.20	17.77
2015-06-27T21:30:00Z	6.42	3.21	17.77
2015-06-27T21:00:00Z	4.42	2.21	17.77
2015-06-27T20:30:00Z	4.43	2.21	17.77
2015-06-27T20:00:00Z	4.44	2.22	17.77
2015-06-27T19:30:00Z	4.45	2.22	17.77
2015-06-27T19:00:00Z	4.46	2.23	17.77
Realtime	**Max. Wave Height (m)**	**Hs Swell (m)**	**Tp Swell (seconds)**
2015-06-27T18:37:00Z	5.60	2.80	18.18
2015-06-27T18:36:00Z	4.58	2.29	18.18
2015-06-27T18:34:00Z	4.52	2.26	18.18
2015-06-27T18:33:00Z	4.55	2.28	18.18
2015-06-27T18:32:00Z	4.52	2.26	18.18
2015-06-27T18:30:00Z	4.59	2.29	18.18
2015-06-27T18:29:00Z	4.46	2.23	18.18
2015-06-27T12:37:00Z	3.06	1.53	18.18

Products – Operations and Safety

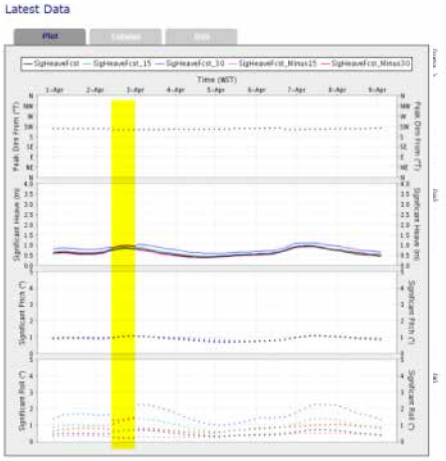
- Time-series forecast products (sea/swell/tide tables and graphs)
- Spatial area-forecast products (go/no-go animations)
- ‘Traffic-light’ dashboards (clear go/no-go per operation type)
- Planning products (swell-window calendar using ops thresholds)
- Interactive tools allowing thresholds to be set/changed
- Delivery by web, FTP, email, SMS, query interfaces, other.

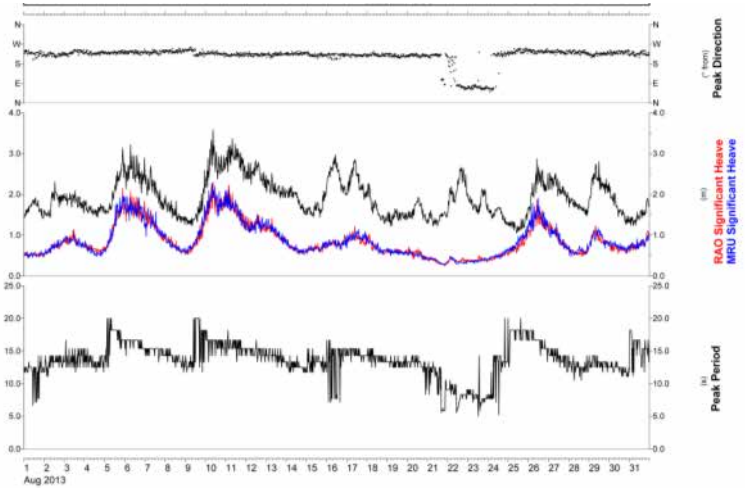


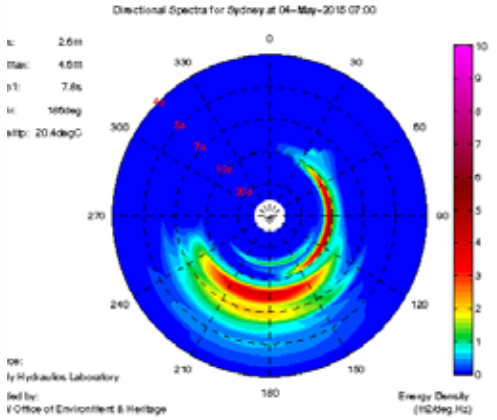


Products – Offloading and RAO

- Spectral data products (report or interactive)
- Interactive tools allowing thresholds to be set/changed
- Hybrid measurement + prediction solutions for complex situations
- Export/delivery formats suitable for use by port/vessel systems
- Delivery by web, FTP, email, request/query interfaces, other.

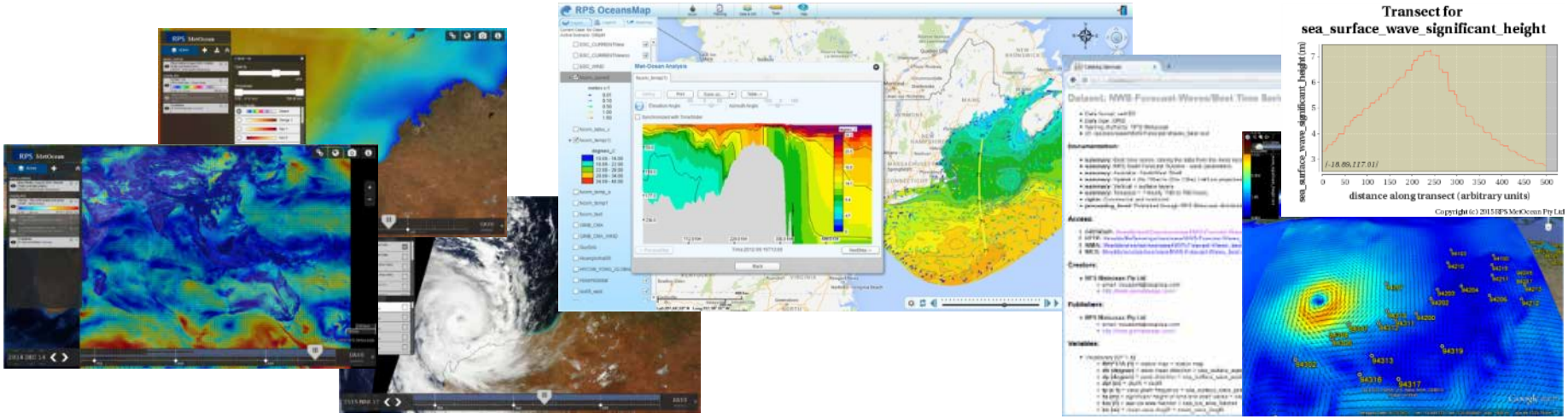




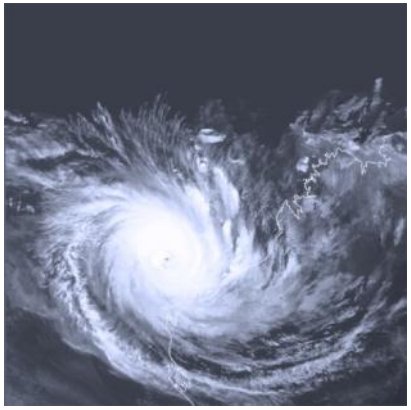


Data Interfaces – Client Integration

- Consistent views of realtime and forecast data are available via a number of data interfaces to enhance Client Integration:
- In-situ systems – ROWS, REMS, on-board port/vessel systems
- ‘Traditional’ interfaces – simple HTTP, FTP, Email, SMS
- Enhanced interfaces – OPeNDAP, RESTful (web-query)
- GIS/desktop integration – ESRI, OGC WMS/WCS/WFS/KML
- Interactive interfaces – CoastMap, EDS, web browser/tablet/etc



Thank you



For further information:
info@rpsmetocean.com