An Ensemble Storm Surge Forecast System For Tropical Cyclones

Stewart Allen[1], Diana Greenslade[1], Andy Taylor[2], Frank Colberg[1]

[1]Science to Services, Ocean Modelling Team

[2]National Operations Centre

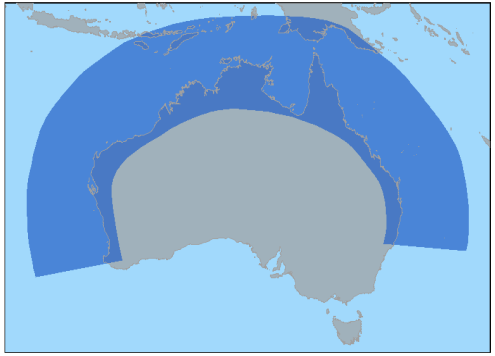
Bureau of Meteorology, Melbourne

Australian Government
Bureau of Meteorology

Two new storm surge forecast systems

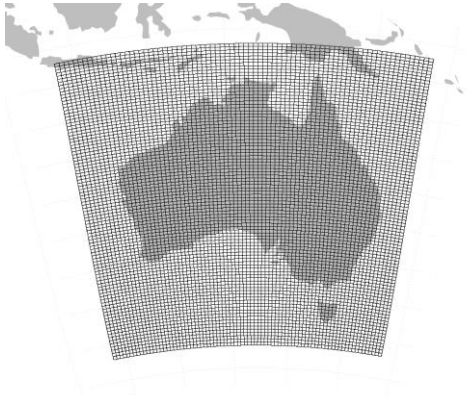
Tropical Cyclone storm surge system

- Event-based, run on demand
- Ensemble prediction system
- Tropical region only



National storm surge system

- Run on routine basis
- Deterministic system
- Mid-latitude storms
- All Australian coastline



Australian Government
Bureau of Meteorology

Tropical cyclone storm surge ensemble prediction system

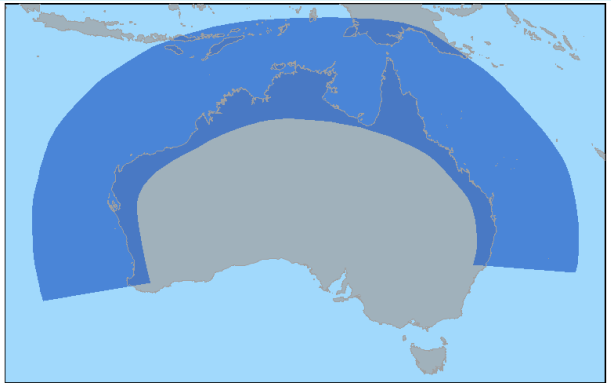
ROMS (Regional Ocean Modelling System)

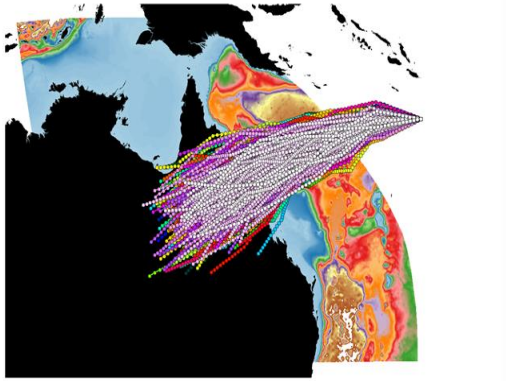
- 2D barotropic mode
- Ribbon domain
- Open boundary conditions
- Coastal spatial resolution ~2.5km

200 ensemble members

- randomly chosen from 1000 tracks
- subset of full grid determined by track ensemble

wave set-up estimate and tides linearly added to surge to provide storm tide at coastline.

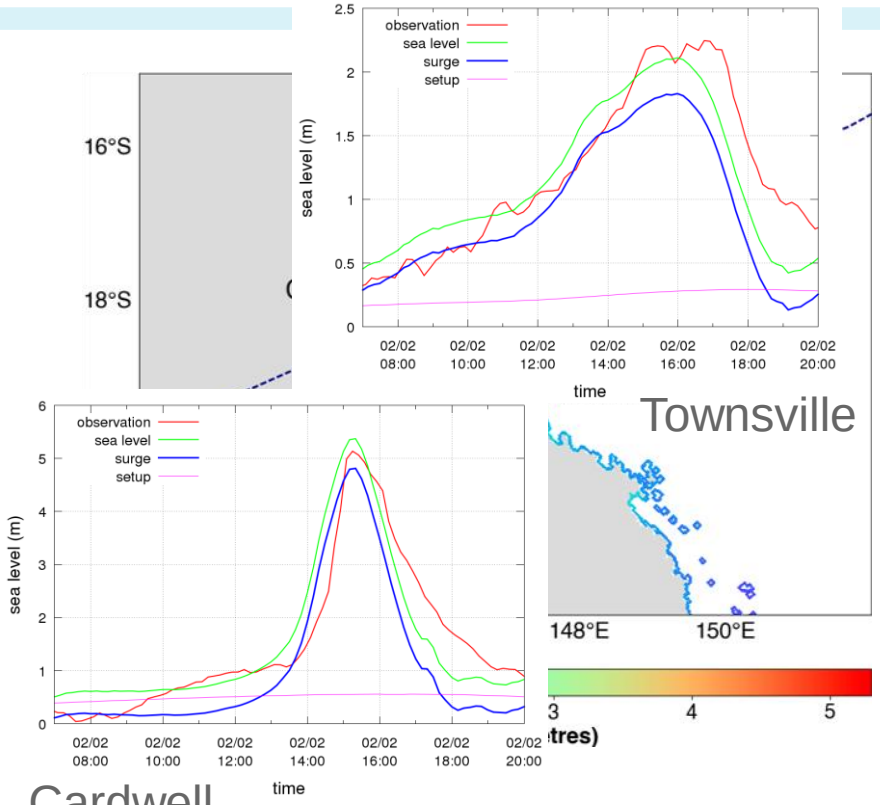




Tropical cyclone storm surge ensemble prediction system

Greenslade et al. (2018) examined the accuracy of the system's hydrodynamics

- 7 event studies using 'best track' hindcast forcing
  - Best available forcing
  - Deterministic forecast
- Validated against observed residual sea-level from available tide gauges.
  - 21 separate observations of surge
  - MAE of peak surge of 26cm
  - Mean bias of -1cm



Australian Government
Bureau of Meteorology

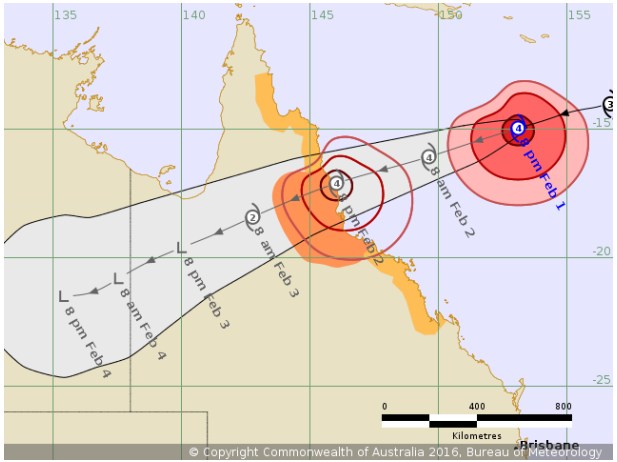
Forecasts based on ensemble prediction systems

- Tropical cyclones are unpredictable
  - OFT represents (at time of forecast) best consensus forecast
  - Forecasts can change frequently and rapidly.
  - Surge is sensitive to track location, system translation speed, intensity, etc.
- Account for uncertainty by produce ensemble of storm surge estimates
  - Storm surge forecasts should be related to existing TC forecasts

Australian Government
Bureau of Meteorology

Tropical cyclone storm surge ensemble prediction system

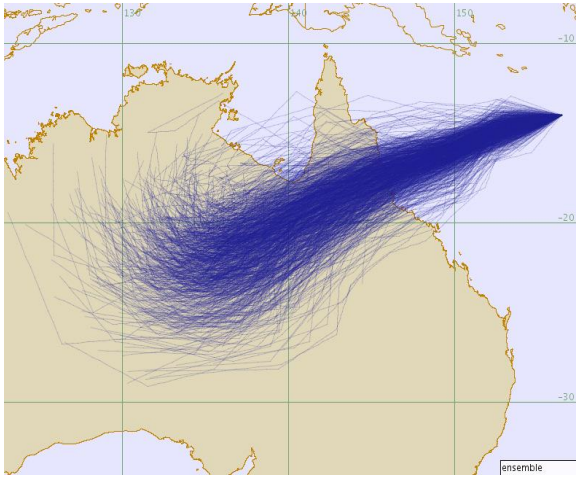
- **Use Official Forecast Track (OFT)**
  - A track is a time series of TC vortices
- Derive ensemble of tracks (DeMaria et al., 2009)
  - Based on track errors over past 5 years
- Derive gridded forcing fields from parametric TC vortex
  - Modified Rankine vortex including asymmetry due to storm forward motion
- Run ensemble of storm surge models



Australian Government
Bureau of Meteorology

Tropical cyclone storm surge ensemble prediction system

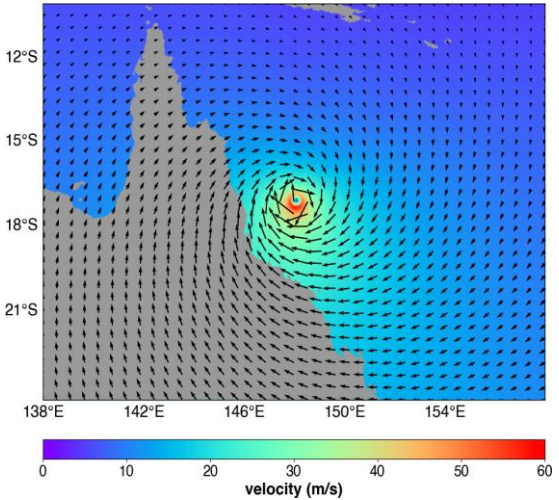
- Use Official Forecast Track (OFT)
  - A track is a time series of TC vortices
- **Derive ensemble of tracks (DeMaria et al., 2009)**
  - Based on track errors over past 5 years
- Derive gridded forcing fields from parametric TC vortex
  - Modified Rankine vortex including asymmetry due to storm forward motion
- Run ensemble of storm surge models



Australian Government
Bureau of Meteorology

Tropical cyclone storm surge ensemble prediction system

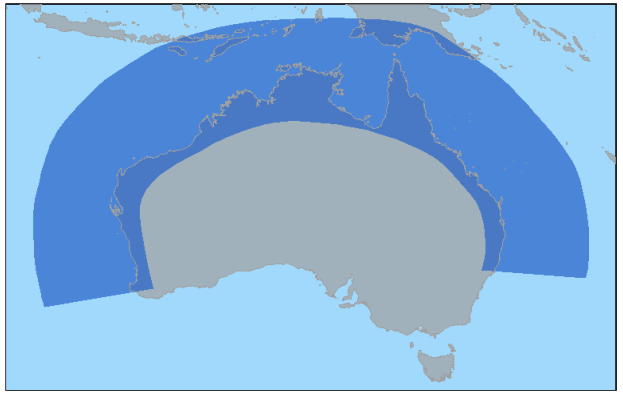
- Use Official Forecast Track (OFT)
  - A track is a time series of TC vortices
- Derive ensemble of tracks (DeMaria et al., 2009)
  - Based on track errors over past 5 years
- **Derive gridded forcing fields from parametric TC vortex**
  - Modified Rankine vortex including asymmetry due to storm forward motion
- Run ensemble of storm surge models



Australian Government
Bureau of Meteorology

Tropical cyclone storm surge ensemble prediction system

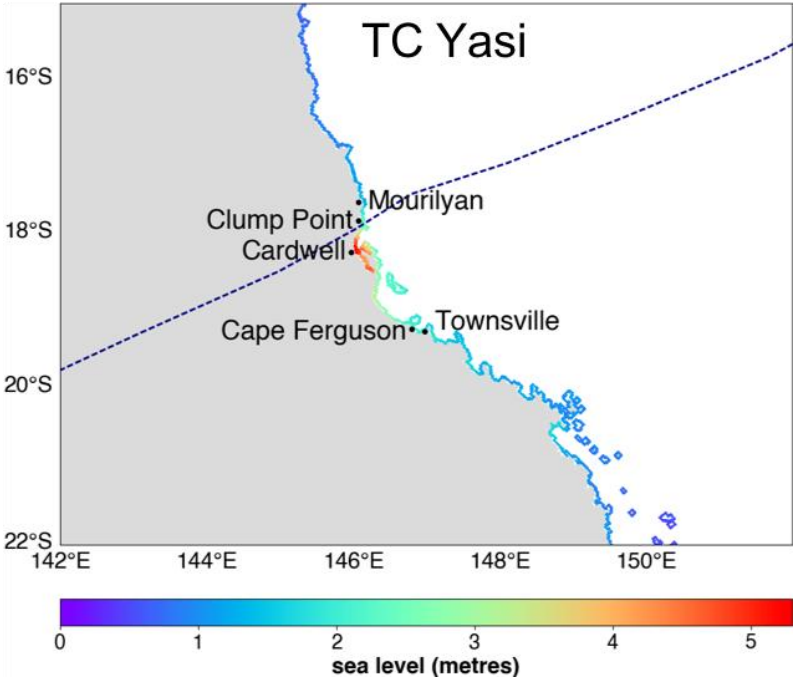
- Use Official Forecast Track (OFT)
  - A track is a time series of TC vortices
- Derive ensemble of tracks (DeMaria et al., 2009)
  - Based on track errors over past 5 years
- Derive gridded forcing fields from parametric TC vortex
  - Modified Rankine vortex including asymmetry due to storm forward motion
- **Run ensemble of storm surge models**



Australian Government
Bureau of Meteorology

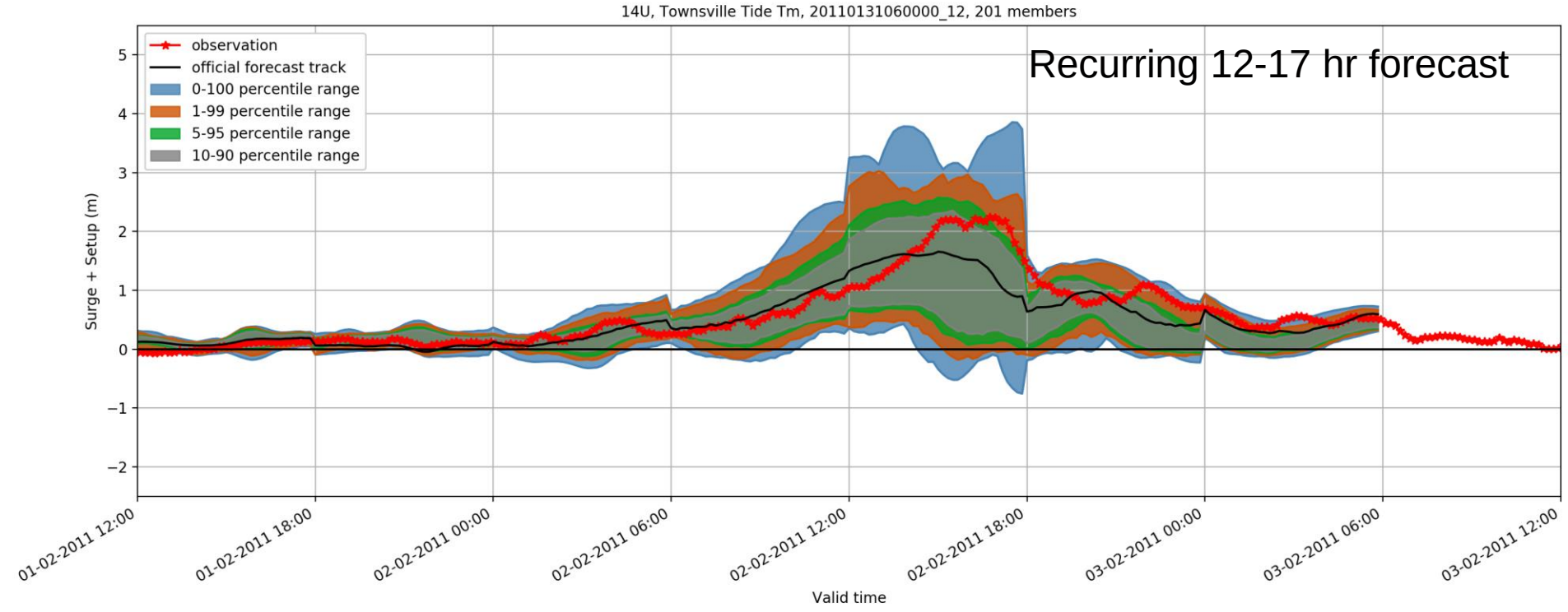
How does the ensemble prediction system behave?

- What is the spread of ensemble forecasts?
  - Compared to OFT
  - Compared to observations
- What is the general skill of the ensemble system?
- How stable are forecast parameters?
- Focus on TC Yasi event.



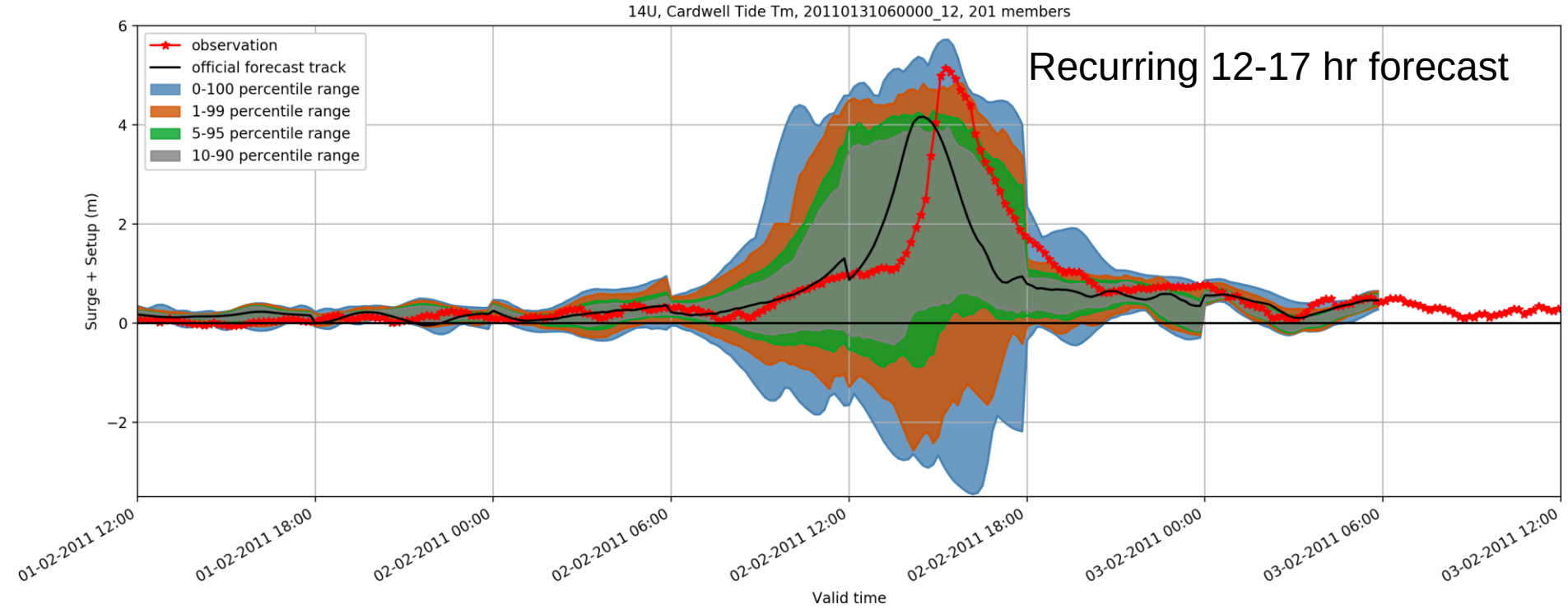
Australian Government
Bureau of Meteorology

What is the spread of ensemble forecasts?



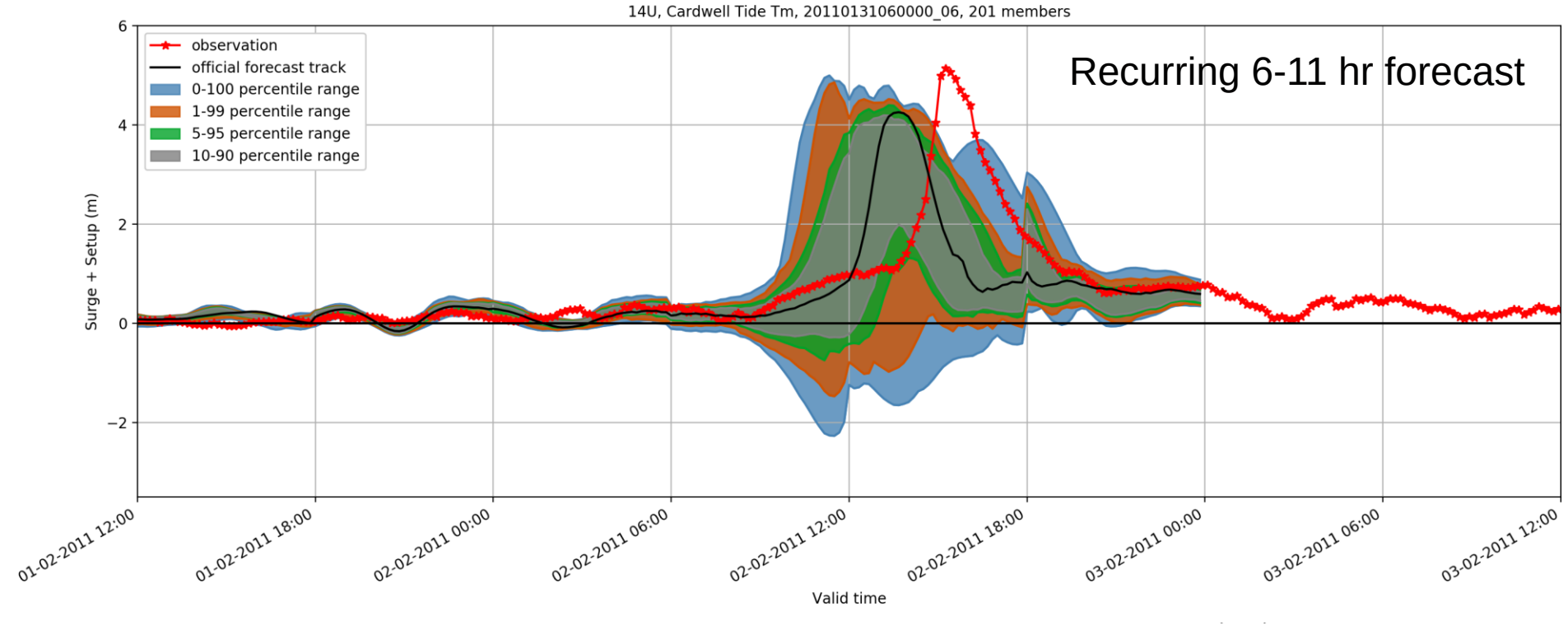
Australian Government
Bureau of Meteorology

What is the spread of ensemble forecasts?



Australian Government
Bureau of Meteorology

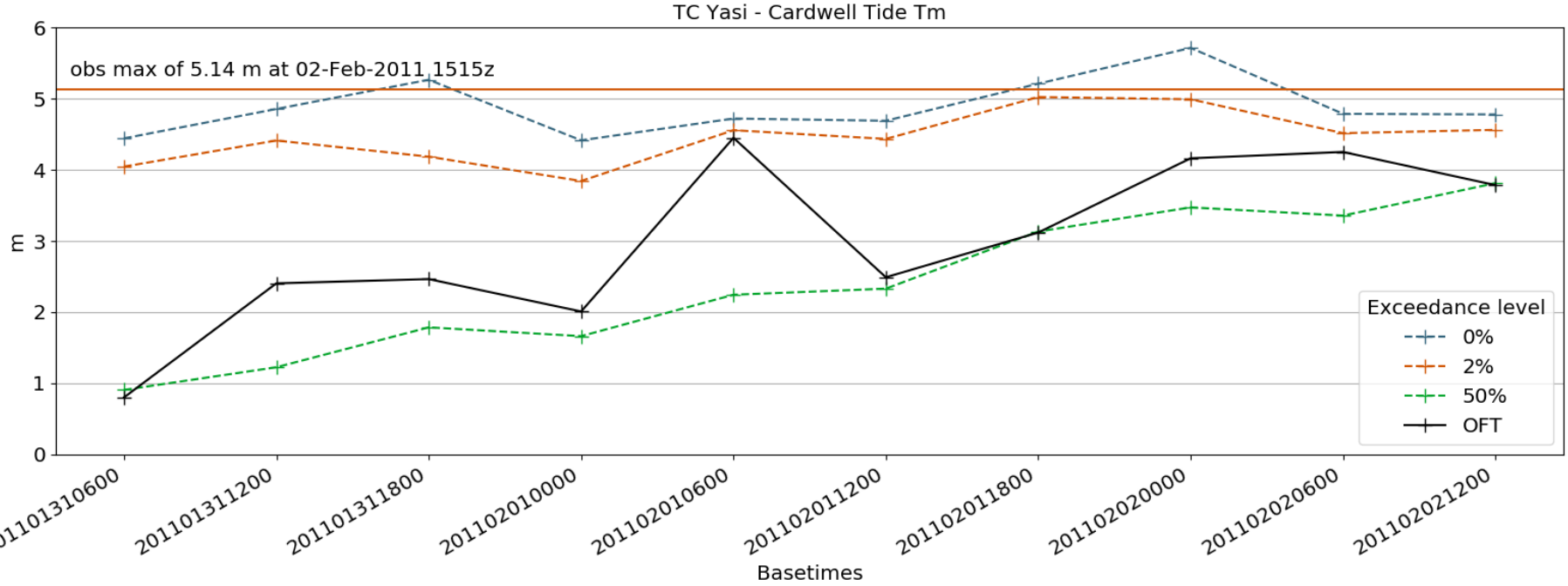
General Skill of System



Australian Government
Bureau of Meteorology

Forecast Stability: Peak Surge

- A key forecast parameter is maximum or peak surge.
- How does the peak surge vary from forecast to forecast?



Australian Government
Bureau of Meteorology

Summary

- New ensemble prediction system for TC-based storm surge
  - 200-member ensemble prediction system
  - Run on demand, linked to TC forecasts
- Ensemble spread capable of capturing surge variability
  - Model skill gernally improves with reduced lead time, but spread is possibly too low
- System trialed operationally in 18/19 TC season.
- Goal is to document and verify model, ready for operational use in 2019-20 TC season.
- Planned further enhancements for coming season.

Thank you

Stewart Allen
stewart.allen@bom.gov.au