



OCEANUM
OCEAN NUMERICAL

Southern Ocean Wave Atlas

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Sally Garrett³

¹ Oceanum

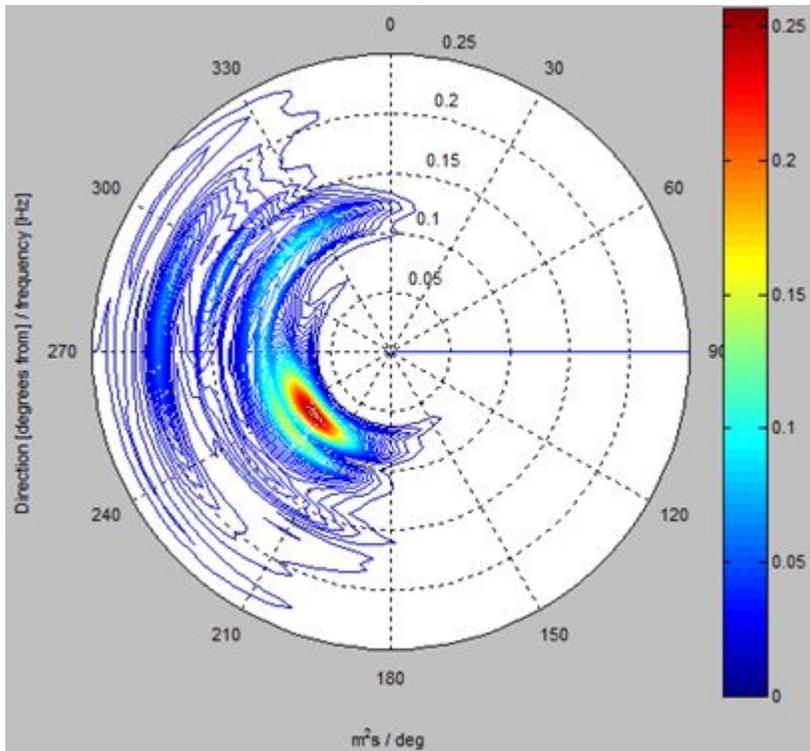
² Metocean Solutions

³ Defence Technology Agency

Outline

- Background
- Observing program
- Modelling Experiments
- Wave Atlas

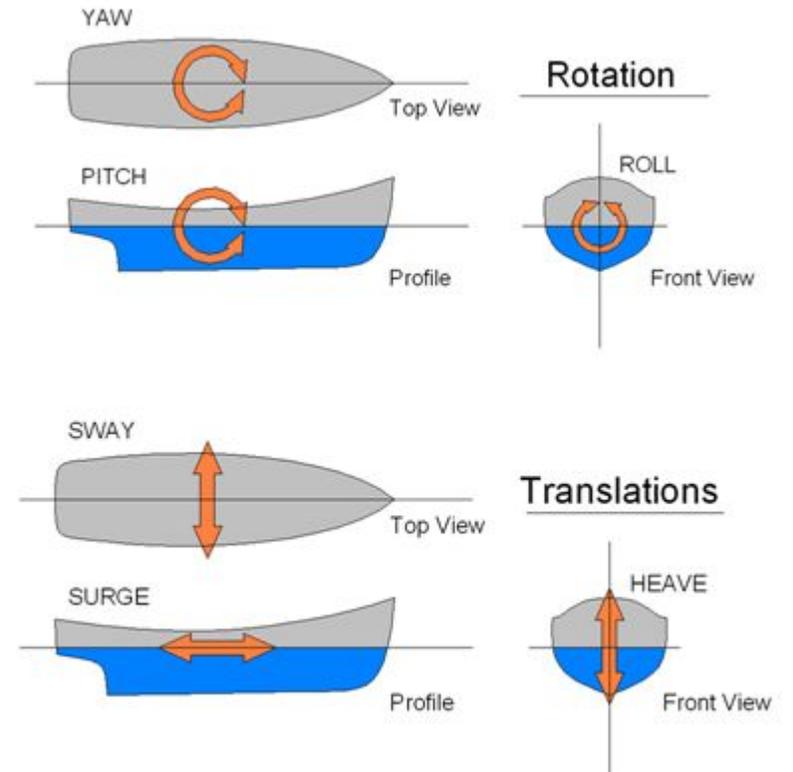
Southern Ocean Challenges for Navy Ships



The storm spectra



The best heading



Ship response in 6 degrees of freedom

Southern Ocean Challenges for Navy Ships



Search & Rescue Region

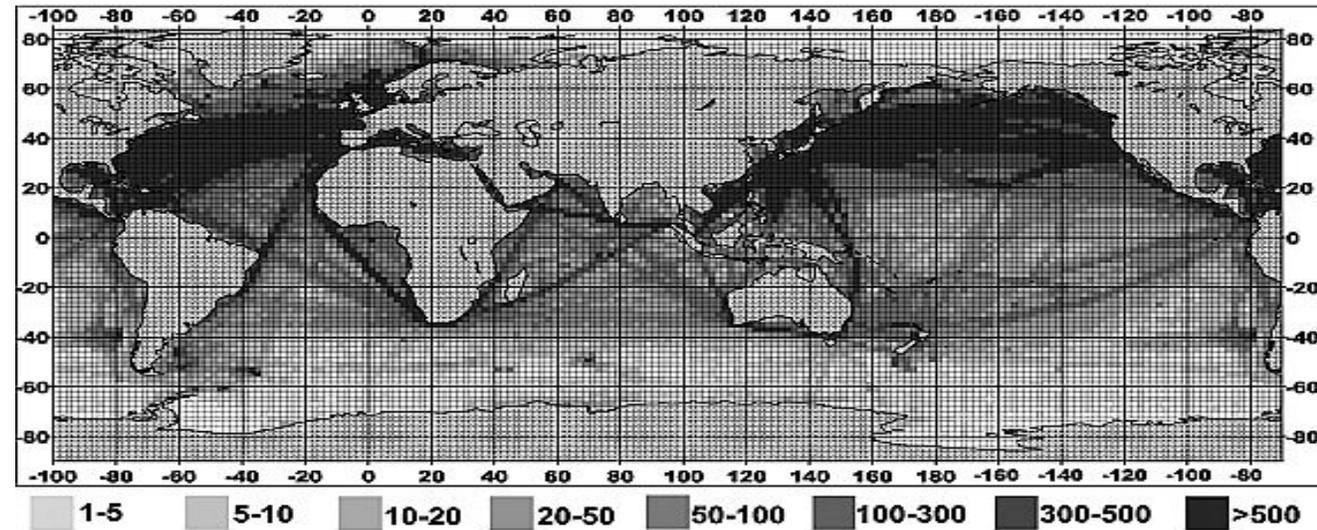
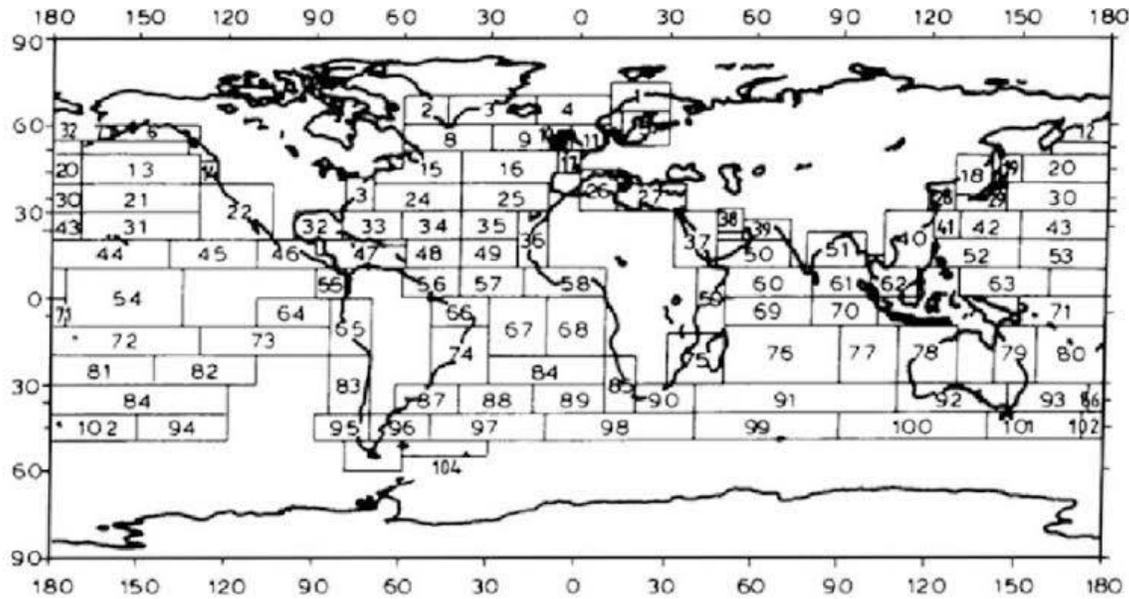


- NZ SAR Region = 30M km²
- From South Pole north to Kiribati group
- From mid Tasman Sea east to Cook Islands
- 844 emergencies (EPIRBs and maydays) in NZ SAR area May 2011 – 2012



HMNZS Otago, May 2016

Existing Information Inadequate



Hogben, N. (Neil), N. M. C. Dacunha, G. F. Olliver, and B. M. T. Ltd (1986), Global wave statistics, London, c1986

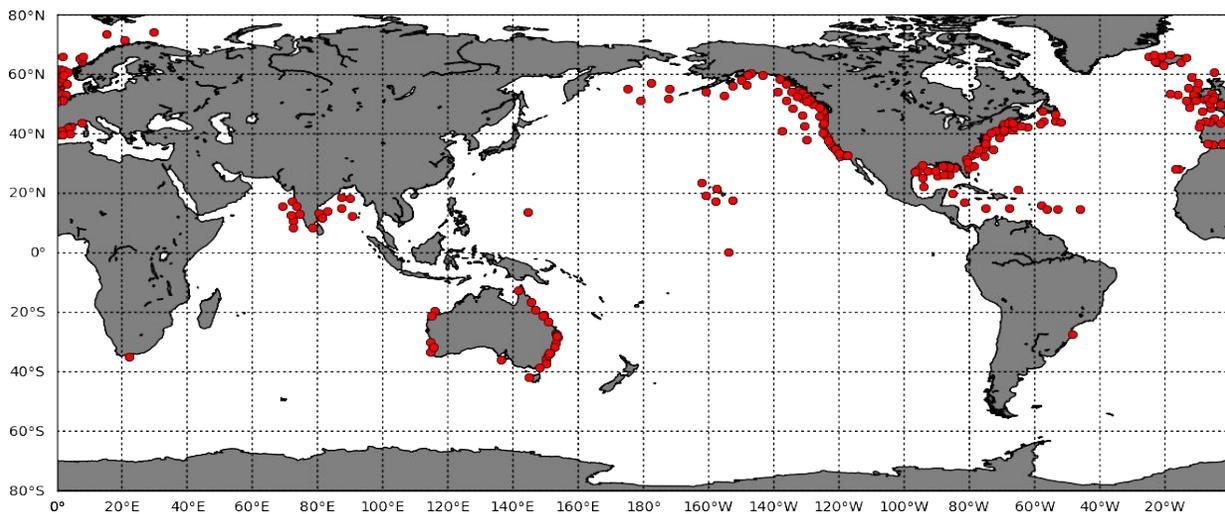
Requirements for new ship design

- Establish an observation program
- Quantify wave climate
- Update existing joint probability H_s/T_p statistics
- Specify historical wave spectra

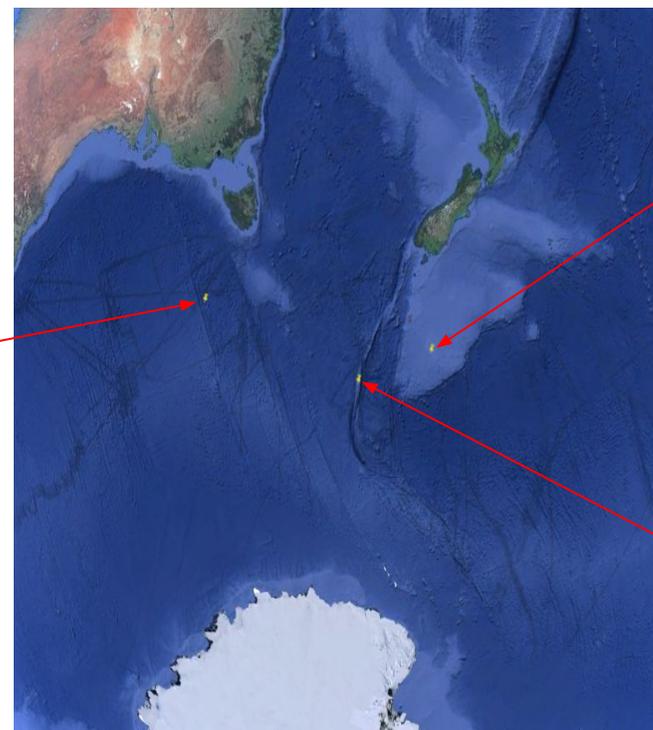
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Existing Information Inadequate



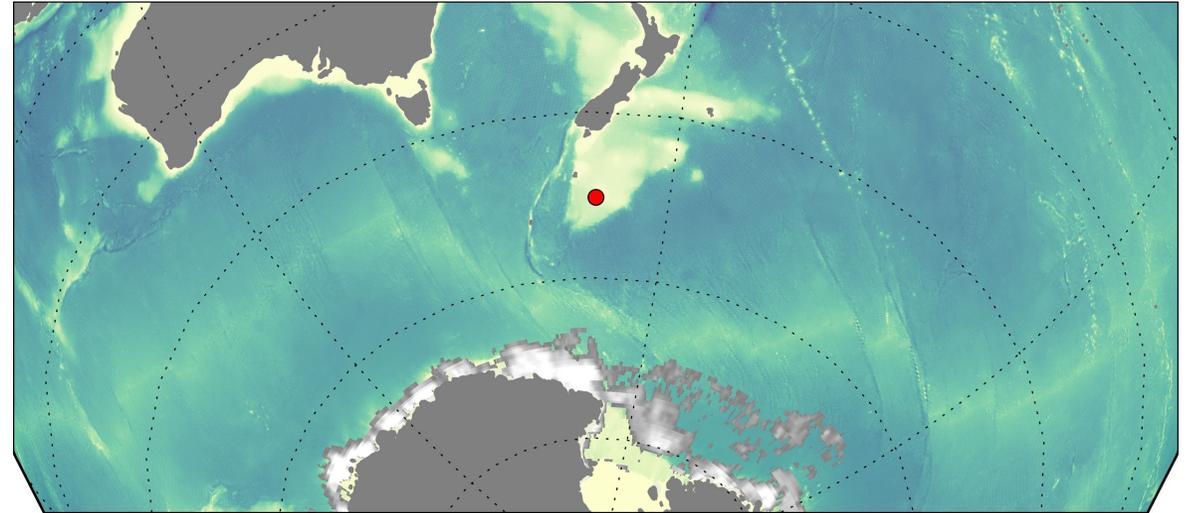
SOFS
(2014-2017)
2D spectra,
various



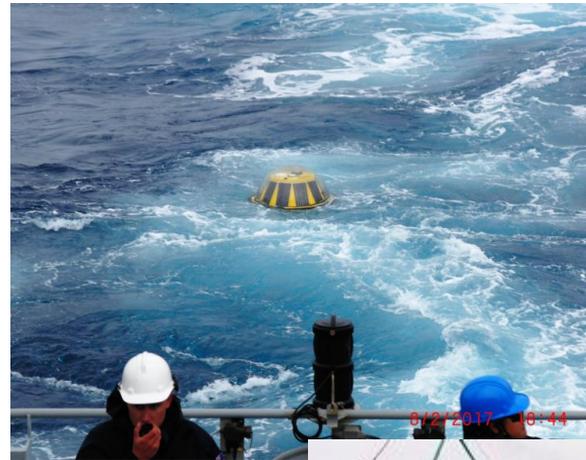
Proposed
site just off
Campbell
Island

MI WRB
(1989)
1D
spectra,
one year

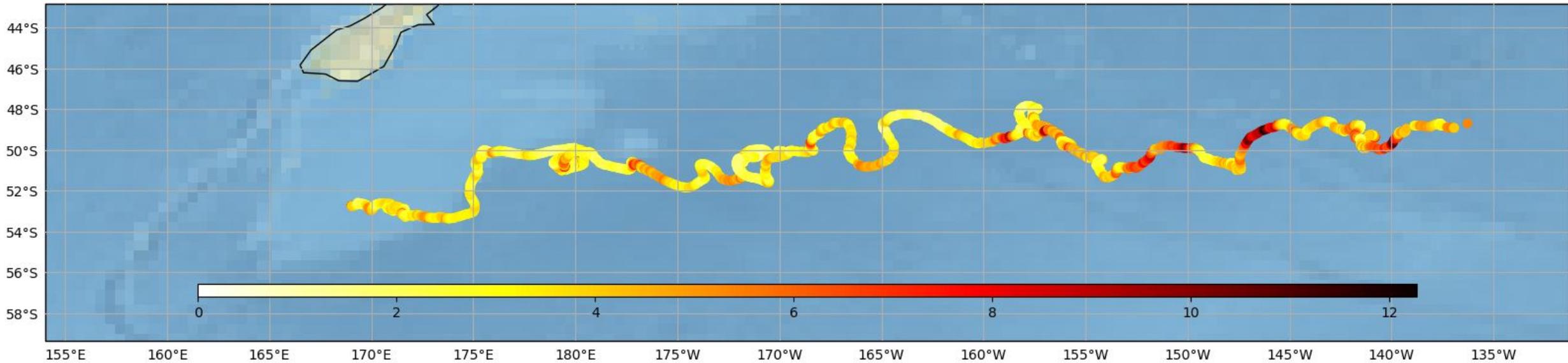
First Deployment



- Deployed 8th of February 2018
- Triaxys directional buoy
- Deployed from the HMS Otago
- 147m depth
- Transmitting full spectra at 3 hourly intervals



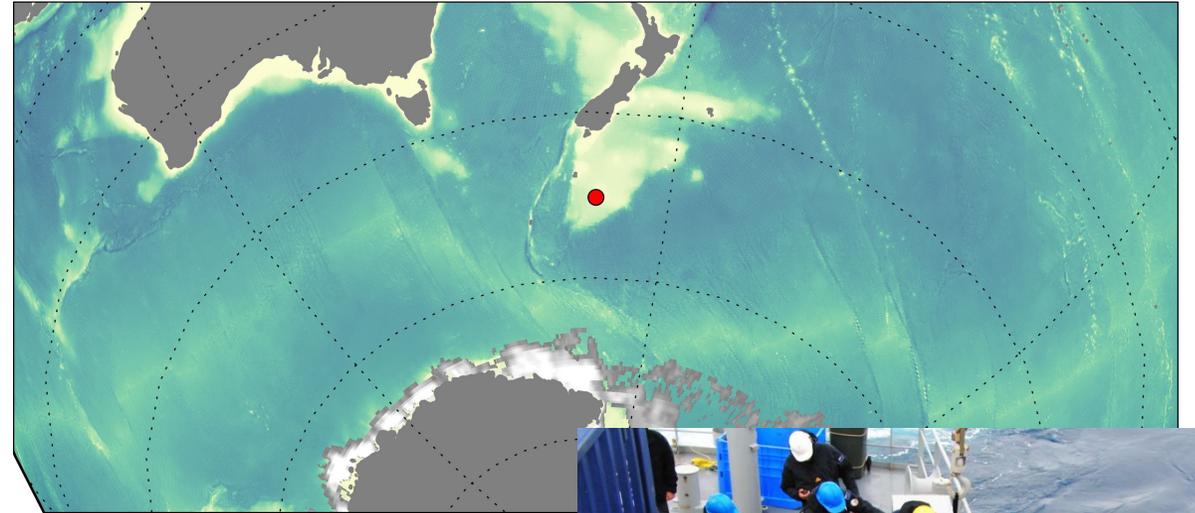
Lagrangian collection phase



- Buoy broke its mooring on 27th July 2017
- Continued to transmit data until August 2018
- Has not yet been recovered

Second Deployment

- Deployed 2nd of March 2018
- Triaxys directional buoy
- Deployed from the HMS Wellington
- 147m depth
- Transmitting full spectra at 3 hourly intervals
- Commitment to service on an annual basis coinciding with NZDF conservations support in subantartic island group



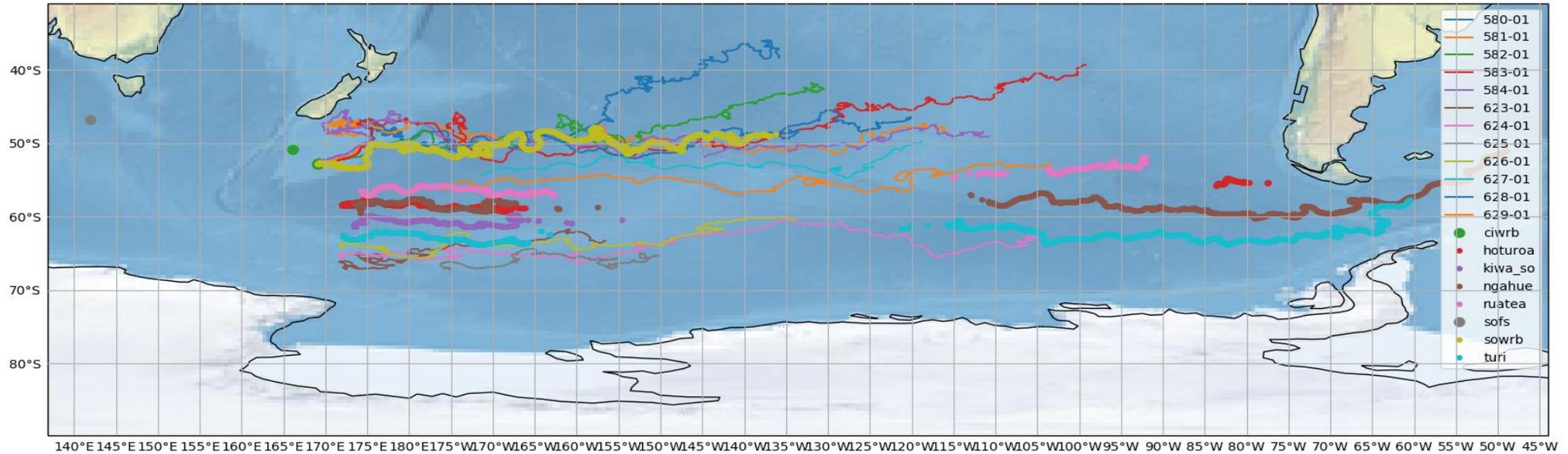
Drifters



SCRIPPS miniature wave buoys

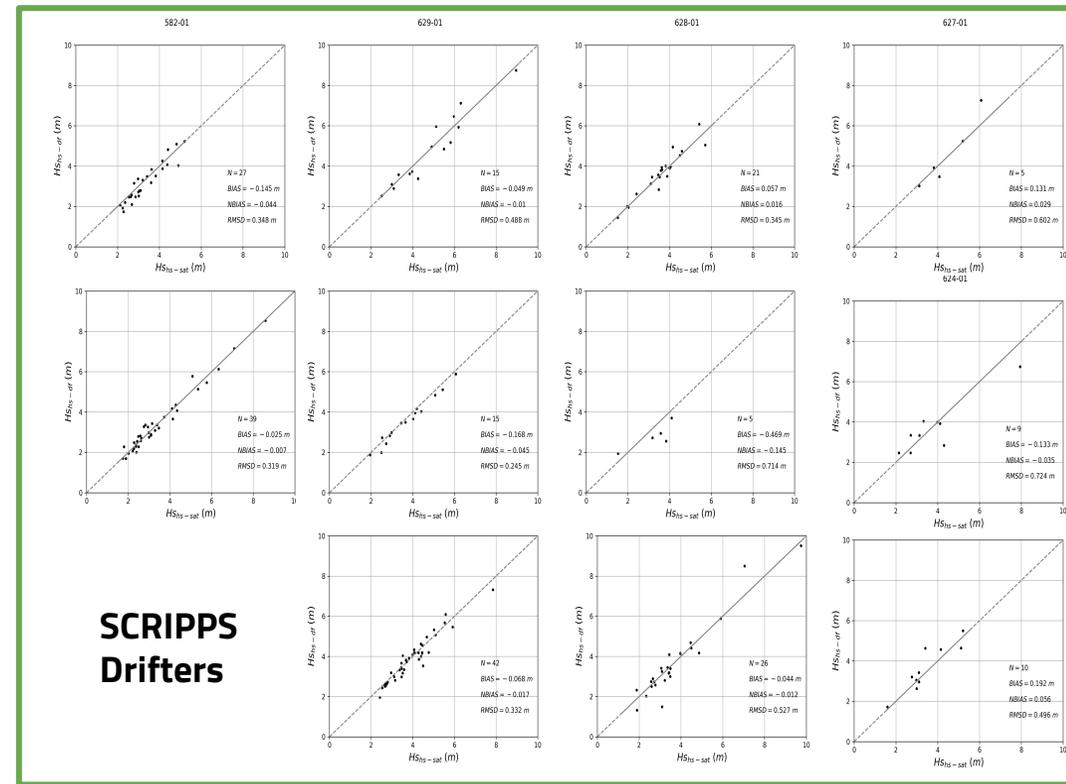
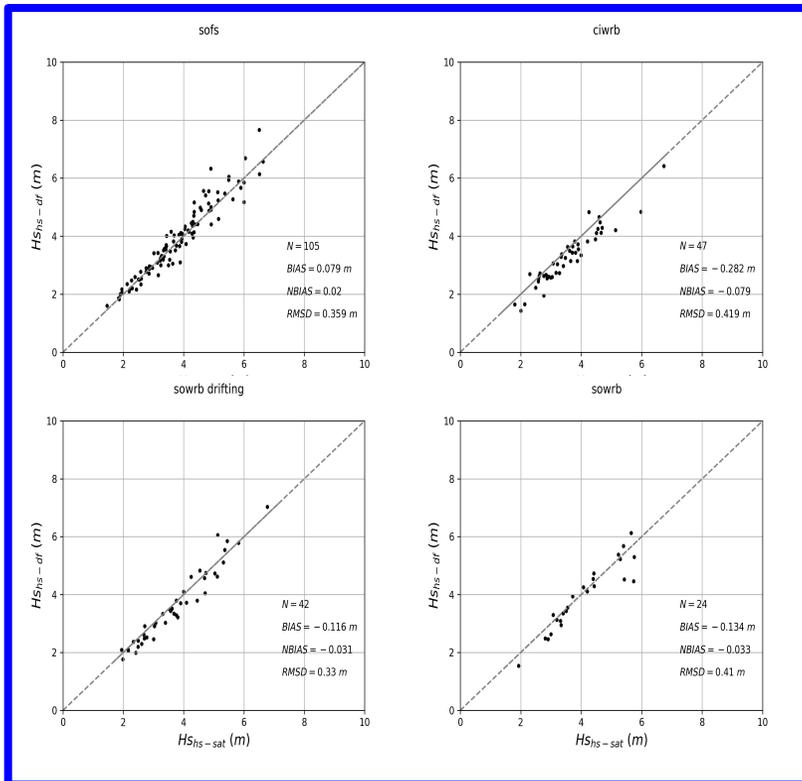
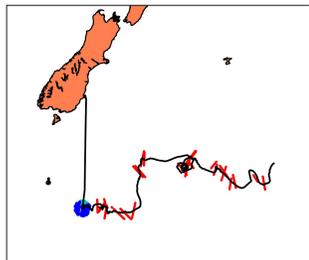
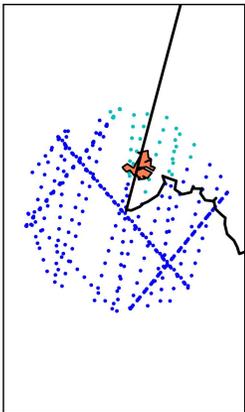


Spotters

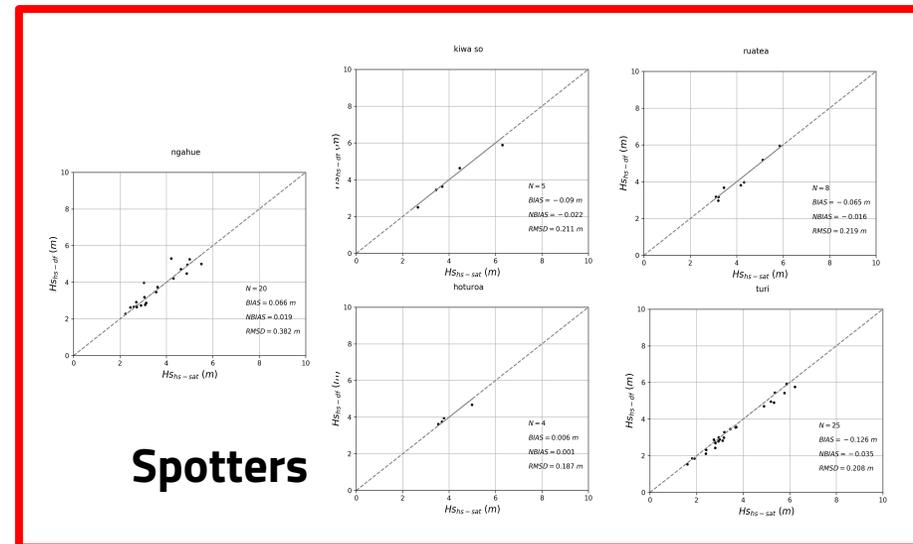


Buoy Validations against altimetry

Moored buoys



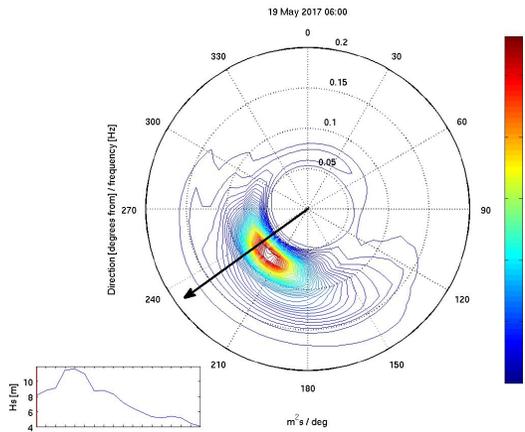
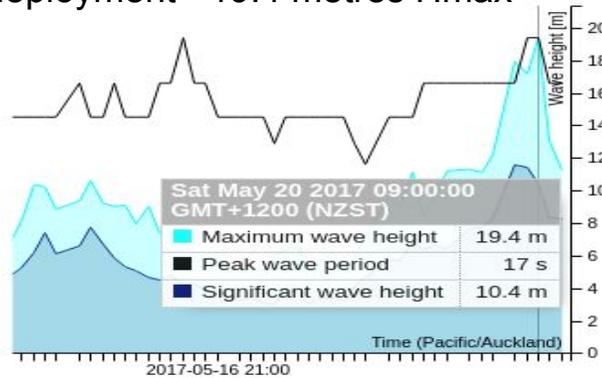
SCRIPPS Drifters



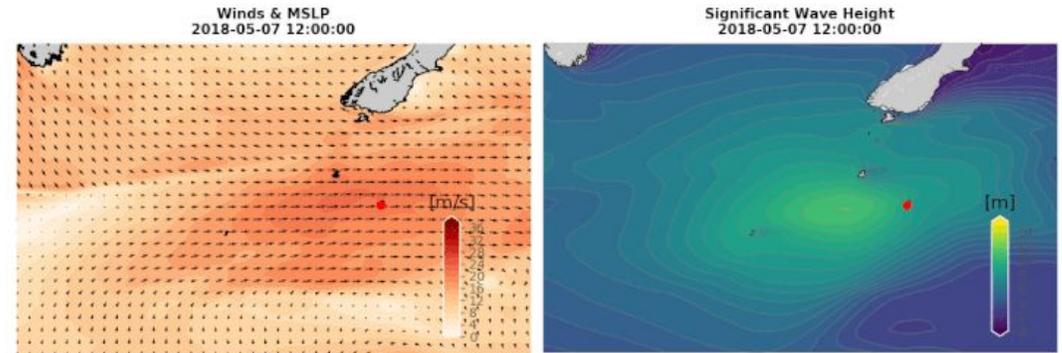
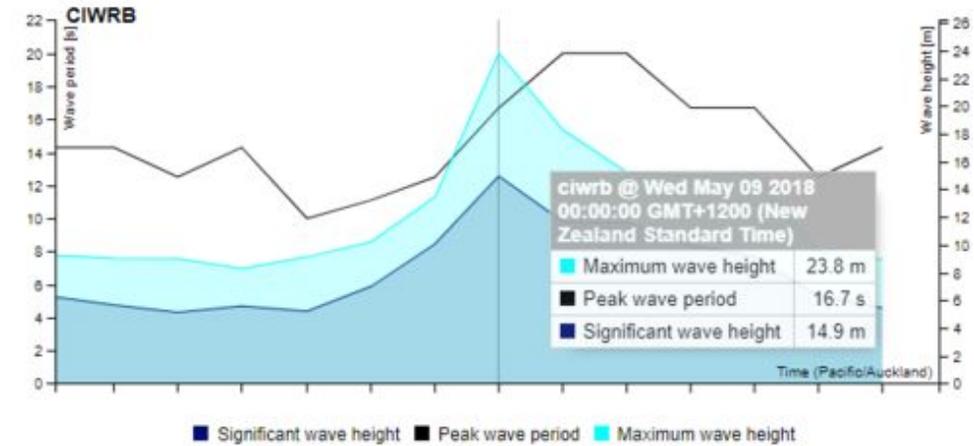
Spotters

Large Waves

First deployment - 19.4 metres Hmax



Second deployment - 23.8 Hmax
Largest recorded wave in the
Southern Hemisphere



F.Barbariol, A.Benetazzo, L.Bertotti, L.Cavaleri, T.Durrant, P.McComb, M.Sclavo, Large waves and drifting buoys in the Southern - Ocean Engineering - 2019

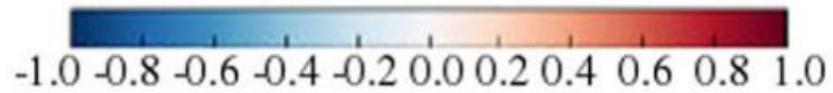
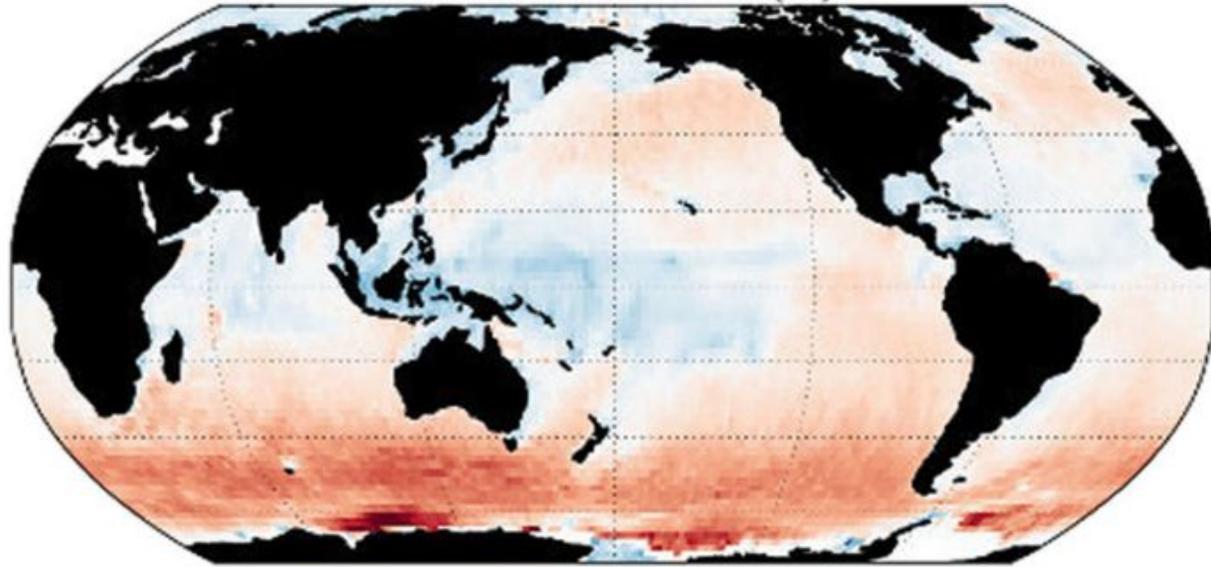
Largest recorded wave in the Southern Hemisphere

Outline

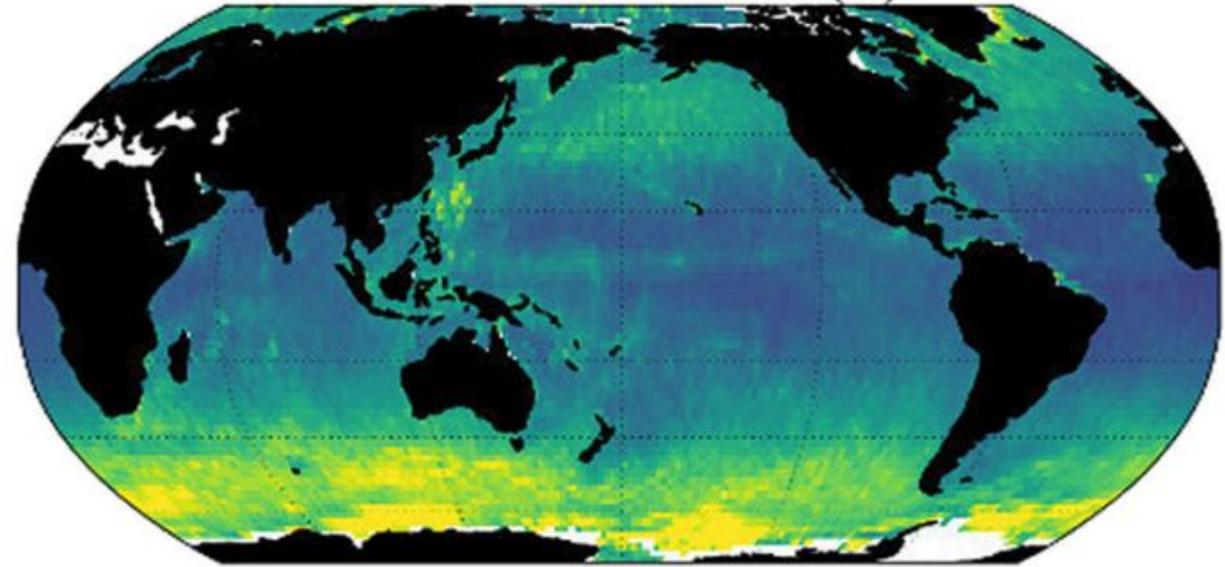
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Southern Ocean

Bias No Currents (m)



RMSE No Currents (m)

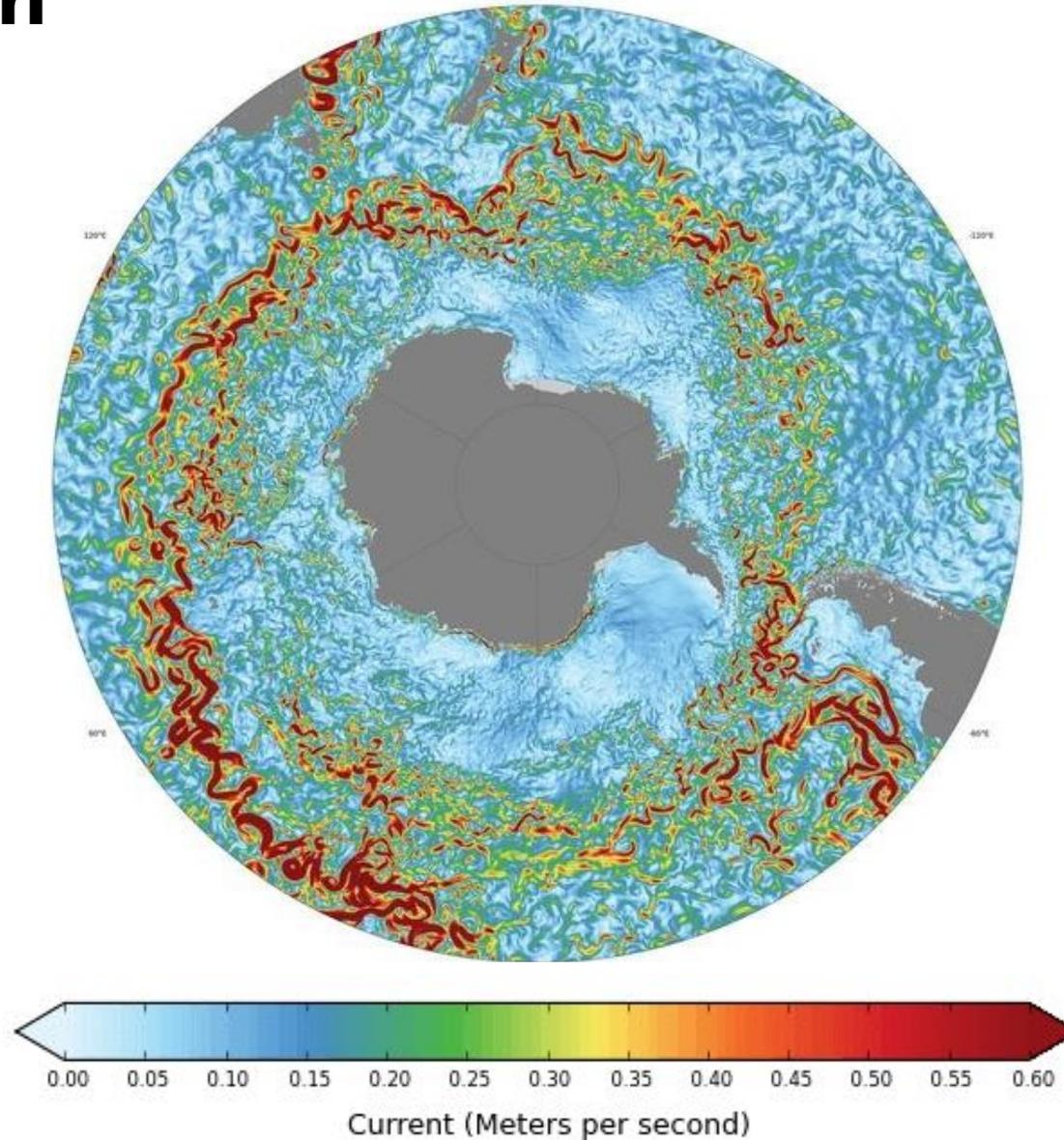


WAVEWATCH III, ST4, CFSR Forcing

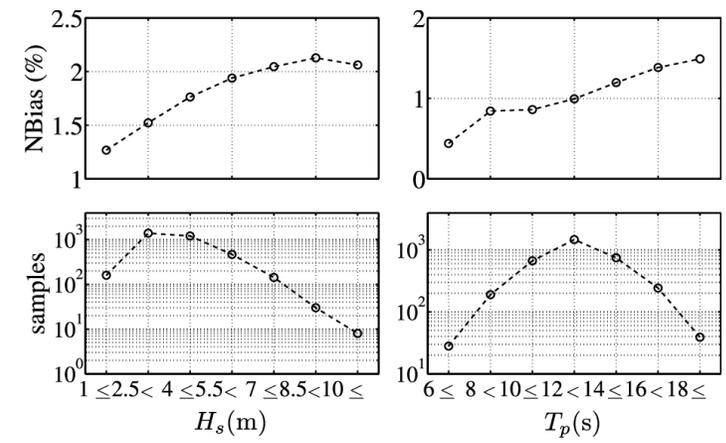
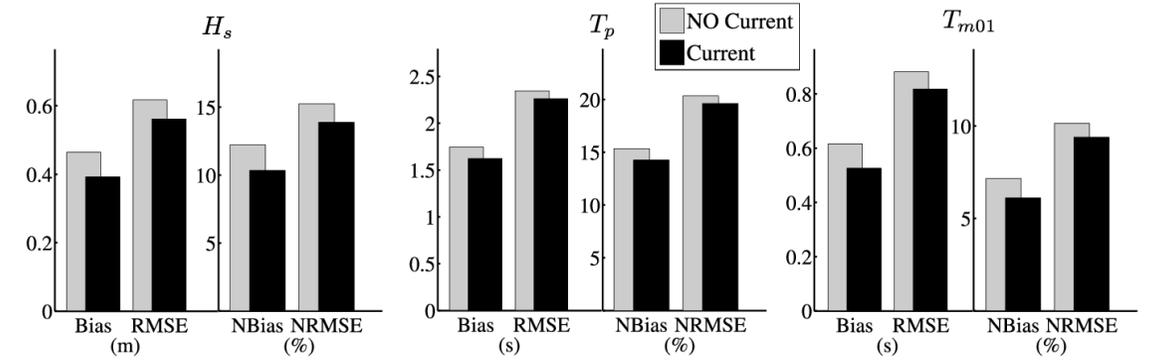
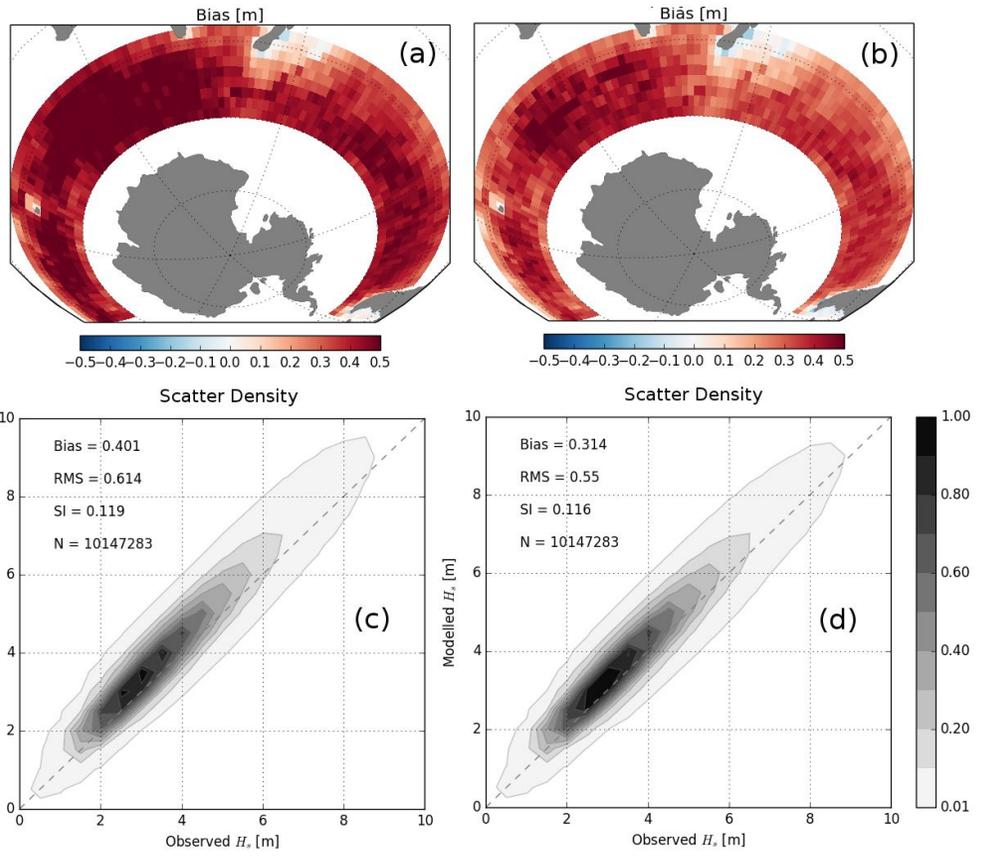
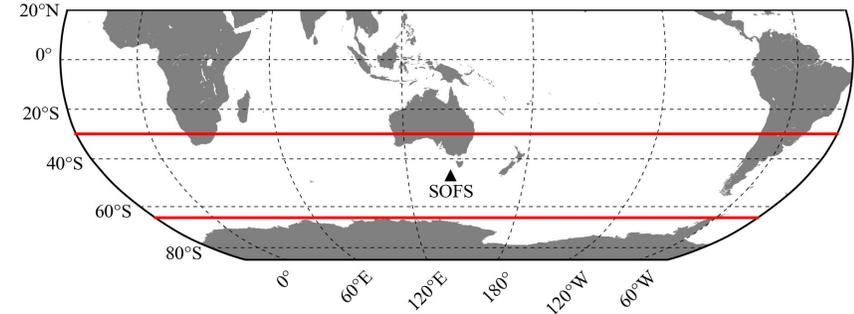
Southern Ocean Currents

The Antarctic Circumpolar Current (ACC) is the largest ocean current (>100 Sv).

The ACC produces changes in the waves because of both refraction and reduction of relative wind speed

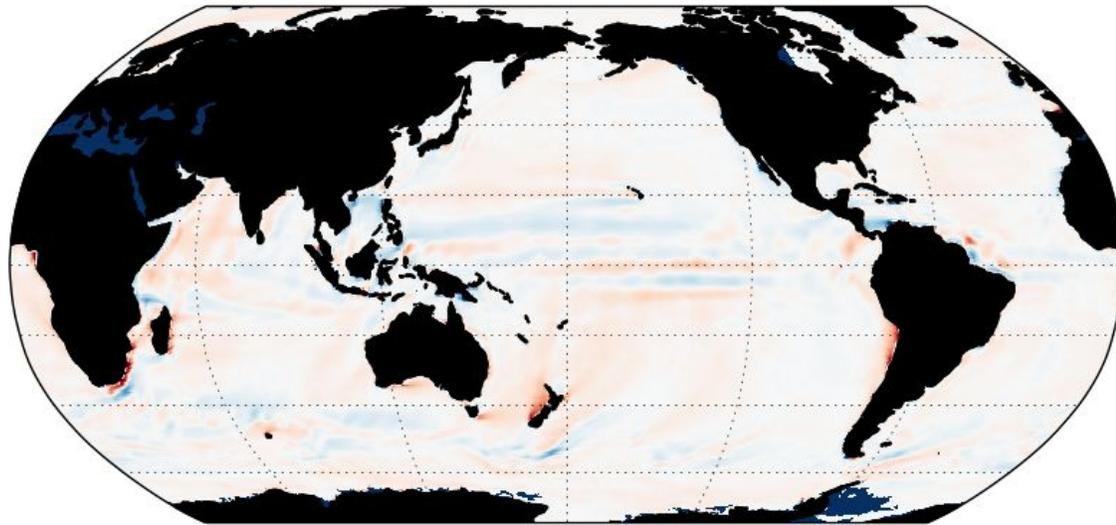


Currents - Hindcast Results

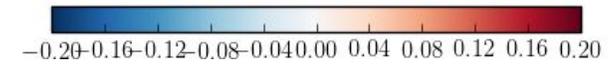
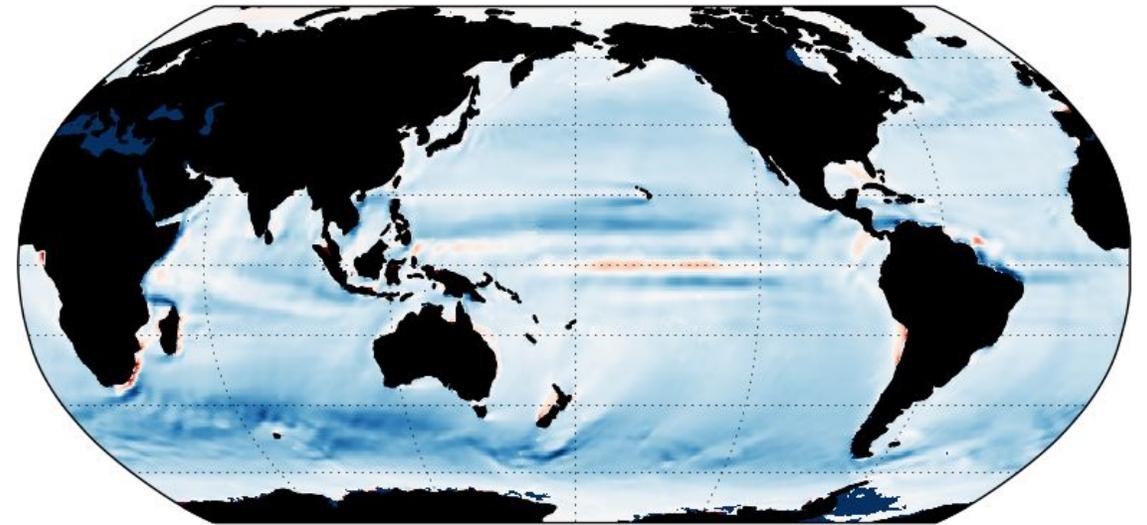


Current Effects

CFSR wind, ice and current forcing



Propagation effects only



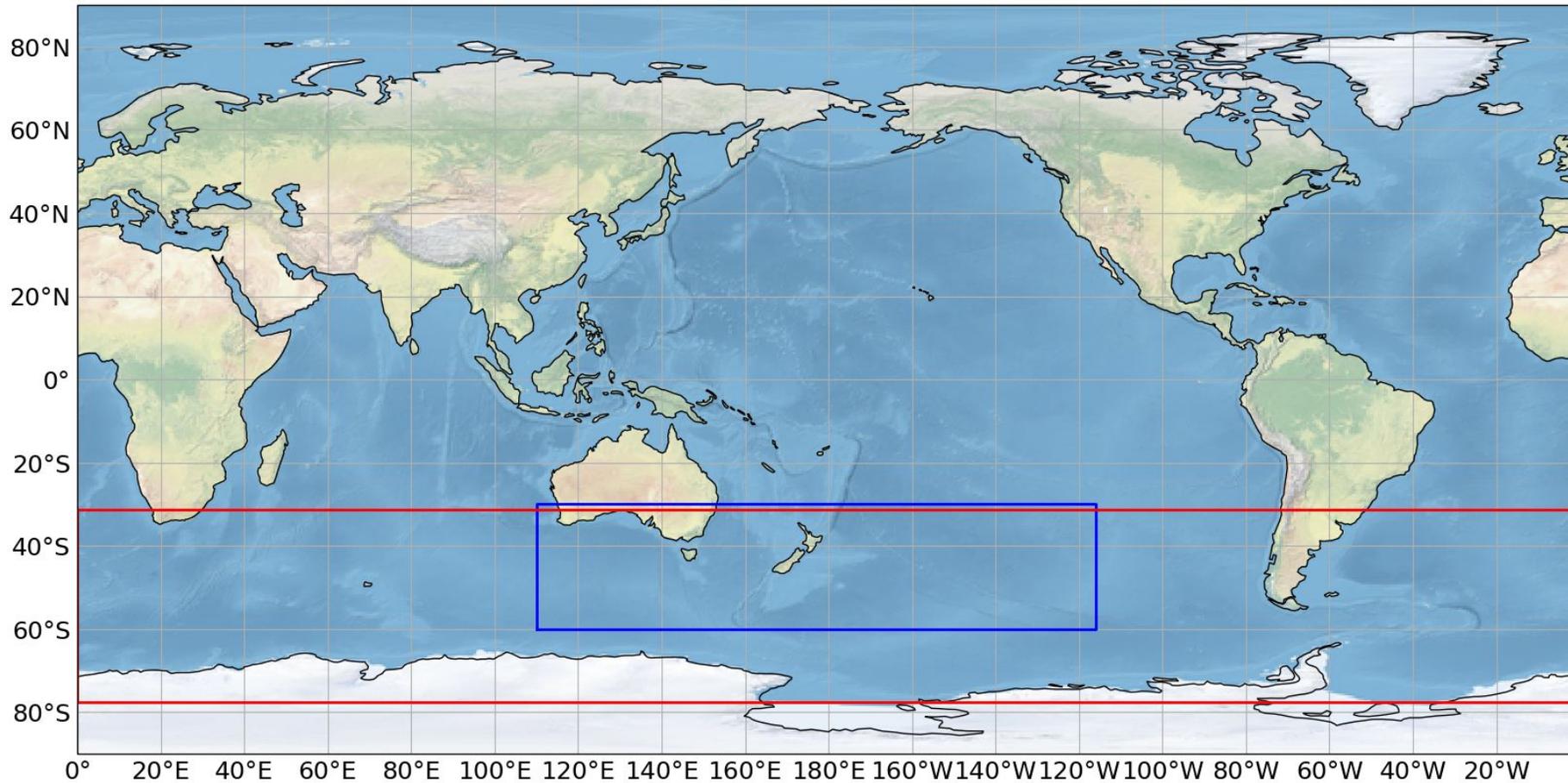
Propagation and relative wind effects



Experiments

- Comparison between ERA5 and CFSR as forcings
- Testing of different ice concentration thresholds
- Inclusion of icebergs
- Effect of ocean currents: CFSR, HYCOM, GLORYS

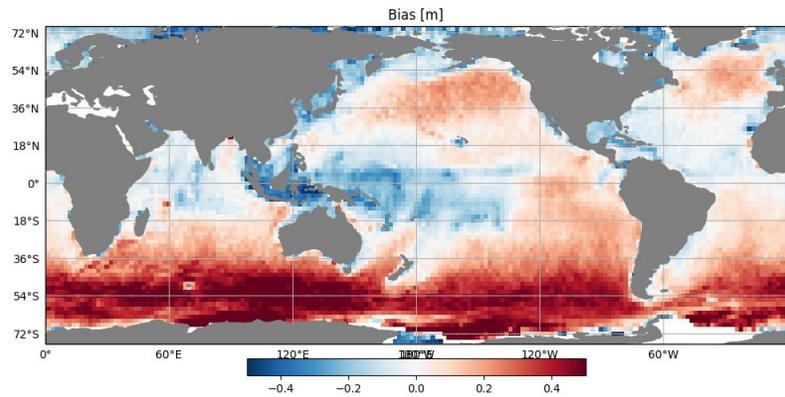
Model Grids



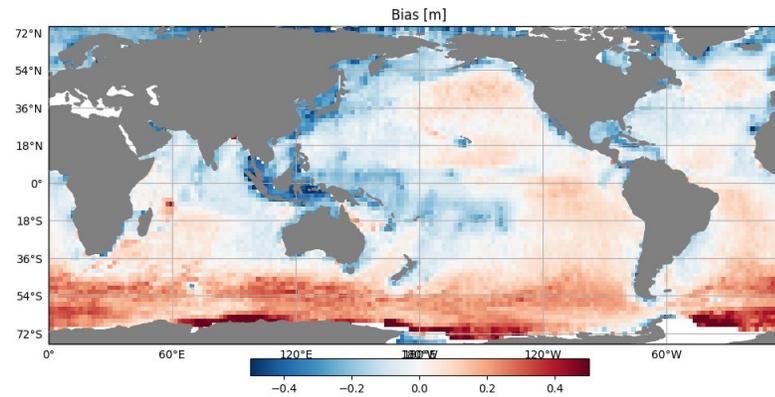
- Global grid
0.50x0.50 deg.
- Regional grid
0.25x0.20 deg.
- Regional grid
0.10x0.10 deg.

ERA5 vs CFSR

CFSR

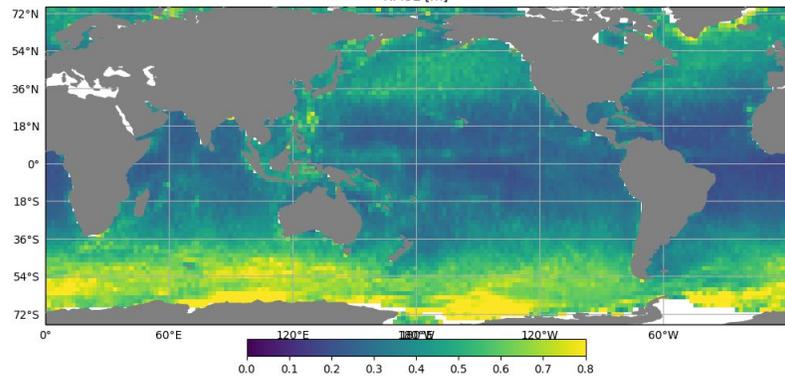


ERA5 BETAMAX = 1.60

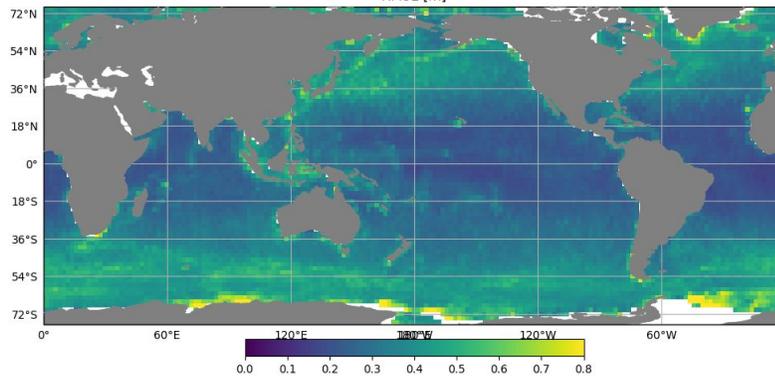


Altimeter comparisons for the full year of 2012

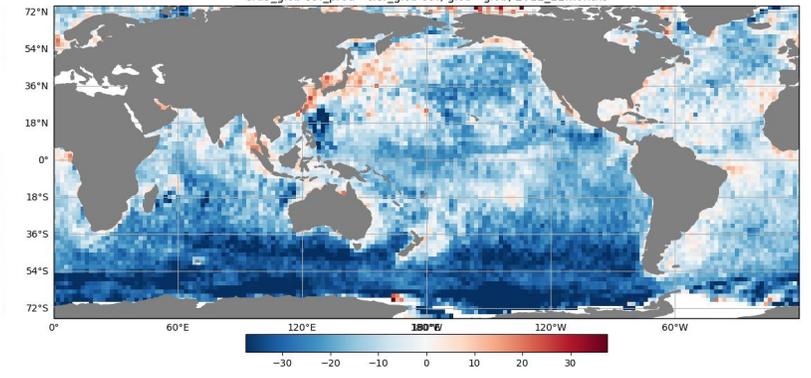
RMSE [m]



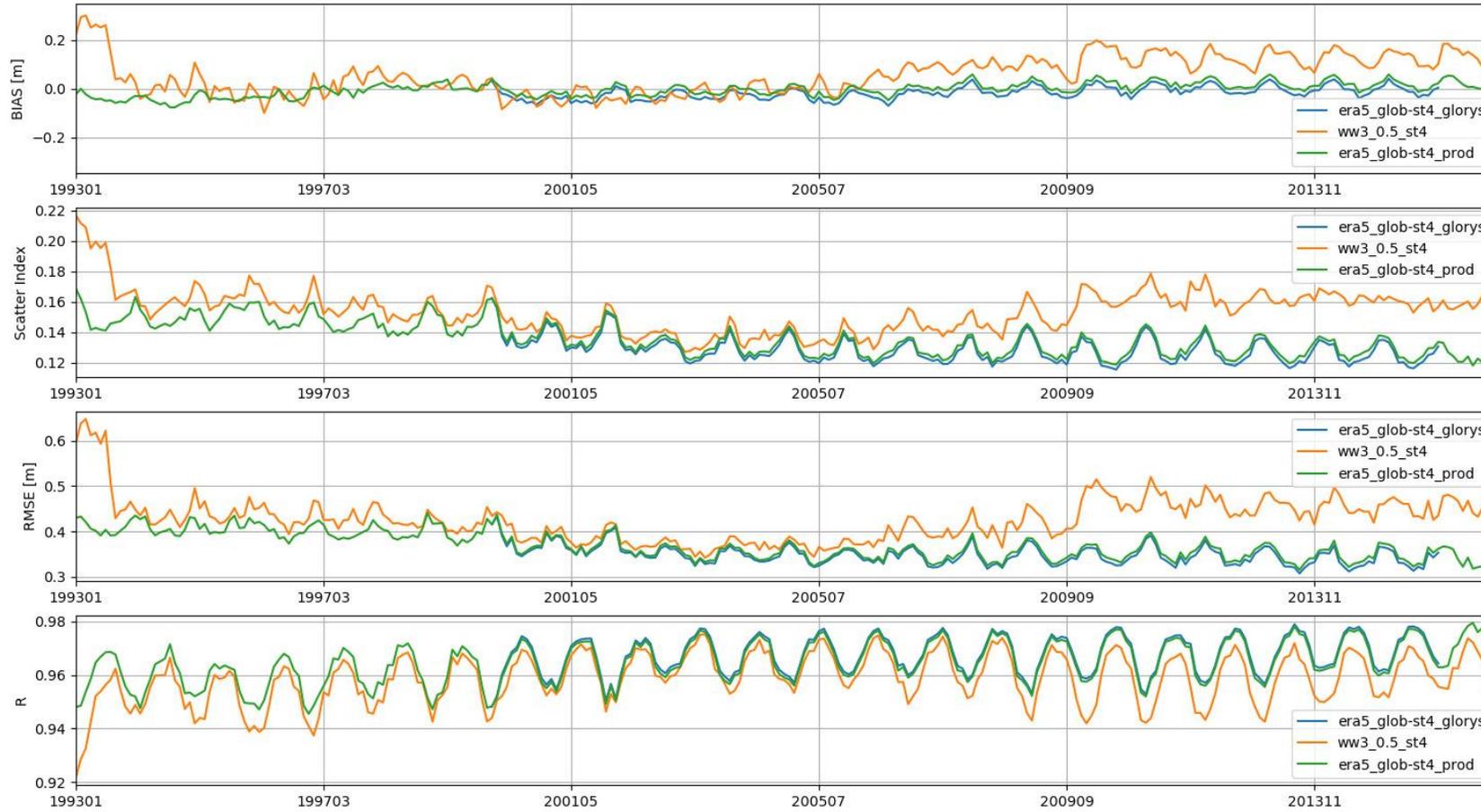
RMSE [m]



Percentage Improvement nrmsd era5_glob-st4_prod - cfsr_glob-st4, glob - glob, 2012_12months

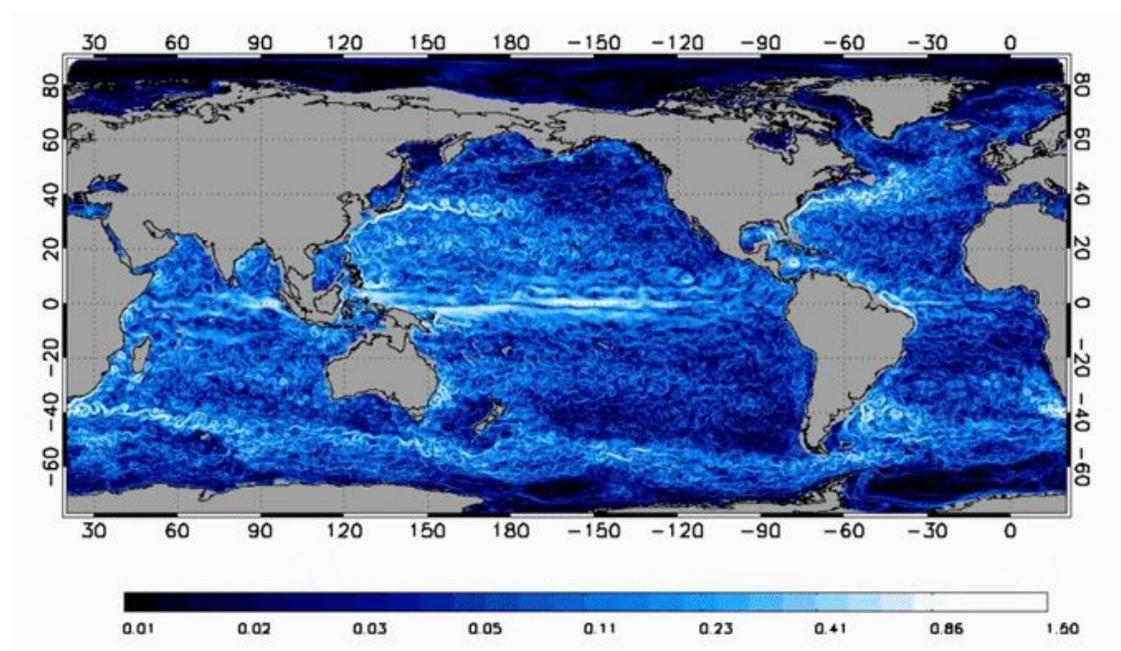


ERA5 vs CFSR



Monthly global statistics against altimetry

Current source Sources



Reanalysed current speed (m/s) at 97 m depth on 3 may 2003 in GLORYS2V1

CFSR - NOAA

- 1/2 degree spatial resolution (non eddy resolving)
- 6 hourly temporal resolution

HYCOM

- 1/12 degree spatial resolution (eddy resolving)
- 3 hourly/daily resolution

GLORYS - Mercator

- 1/4 degree spatial resolution (eddy permitting)
- Daily

CFSR + Currents

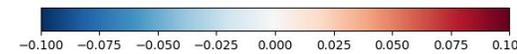
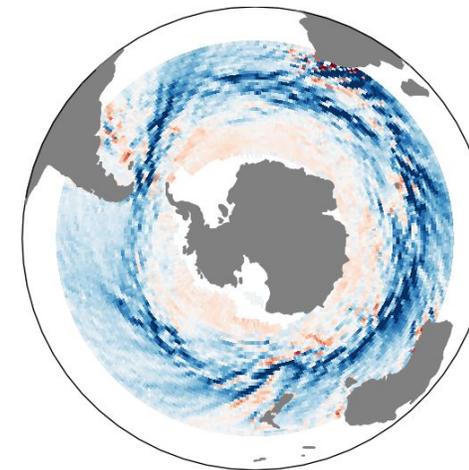
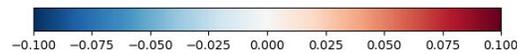
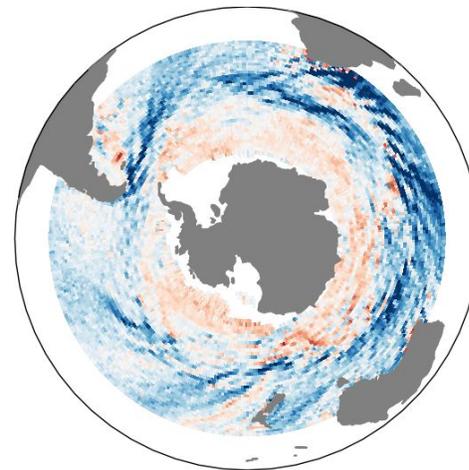
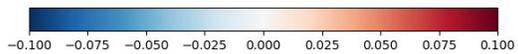
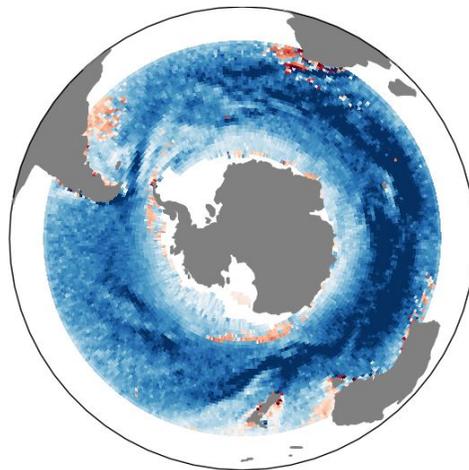
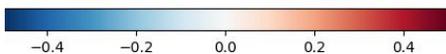
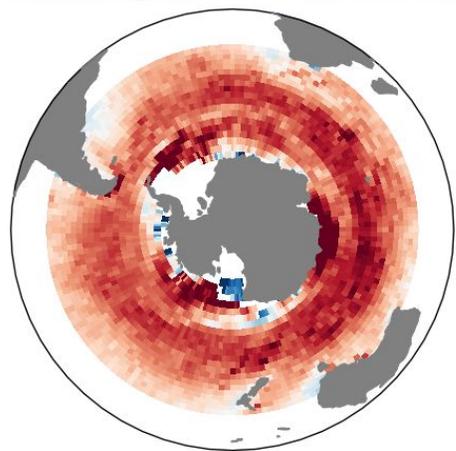
Changes with different ocean currents databases

CFSR

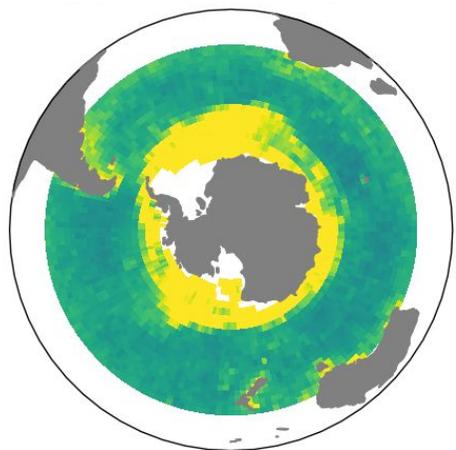
HYCOM

GLORYS

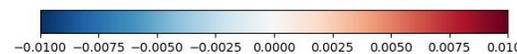
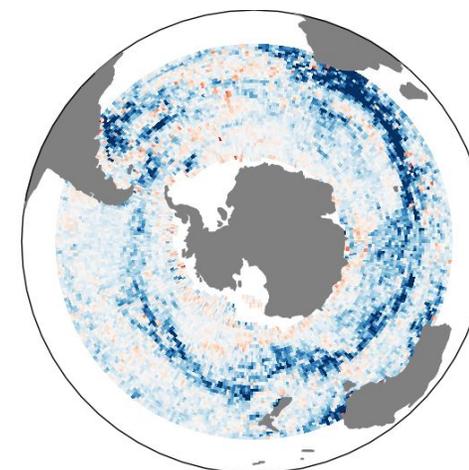
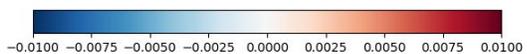
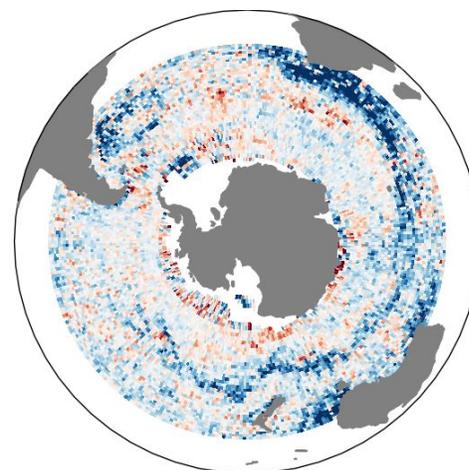
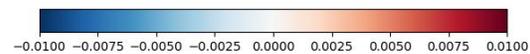
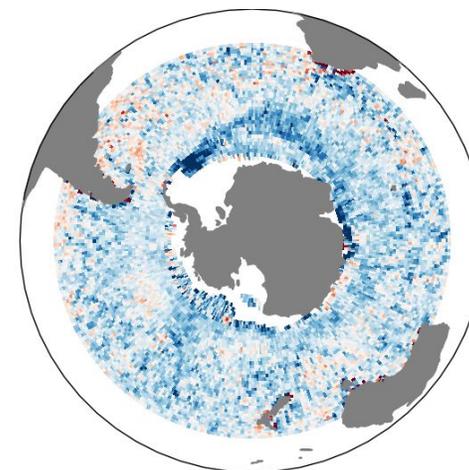
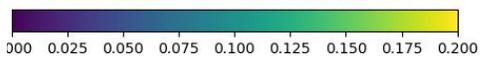
Bias (m)



Scatter Index



(%) IS



ERA5 + Currents

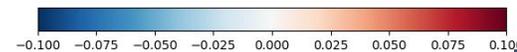
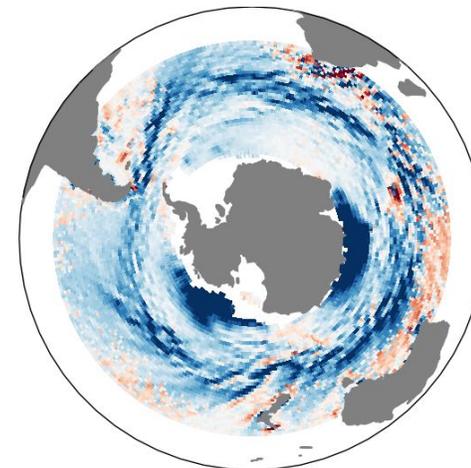
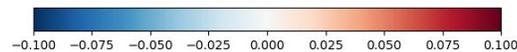
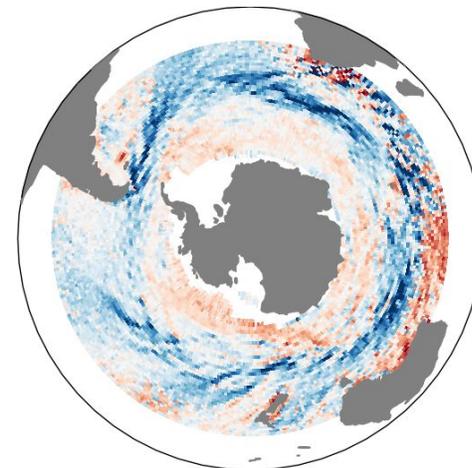
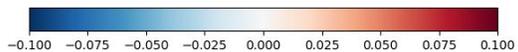
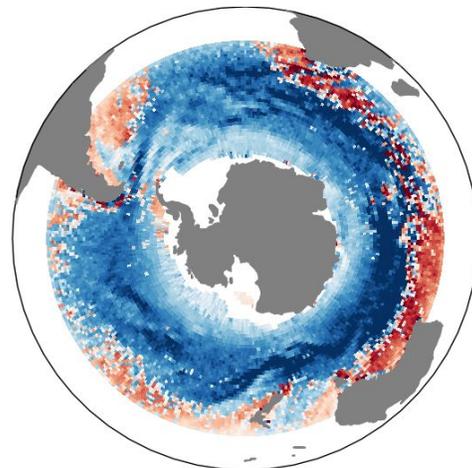
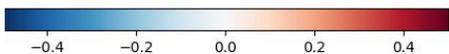
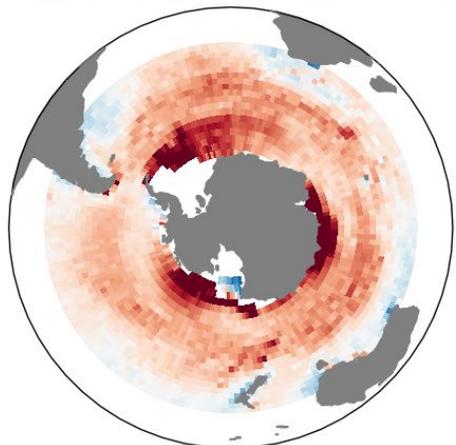
Changes with different ocean currents databases

CFSR

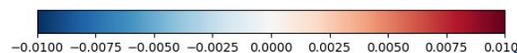
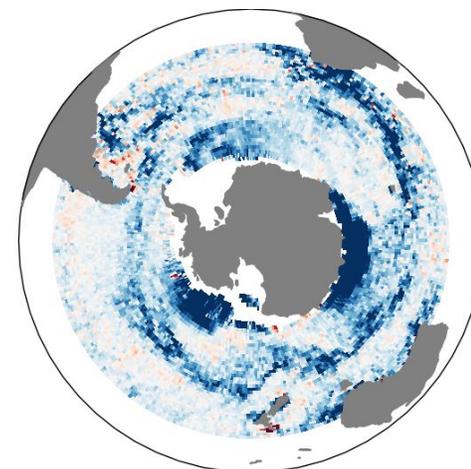
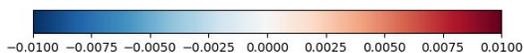
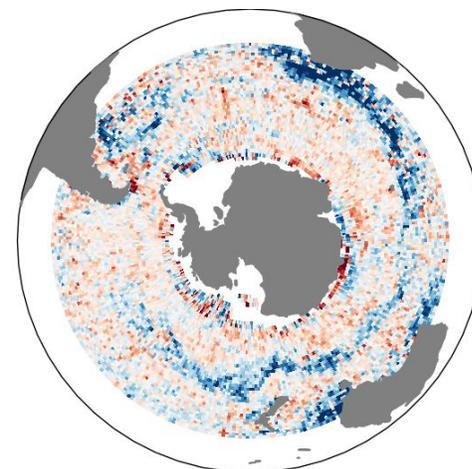
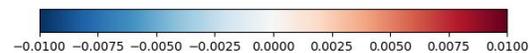
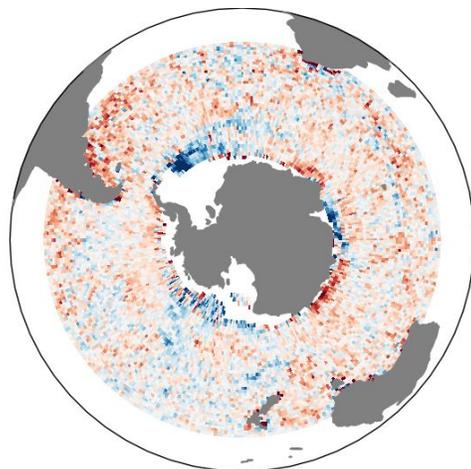
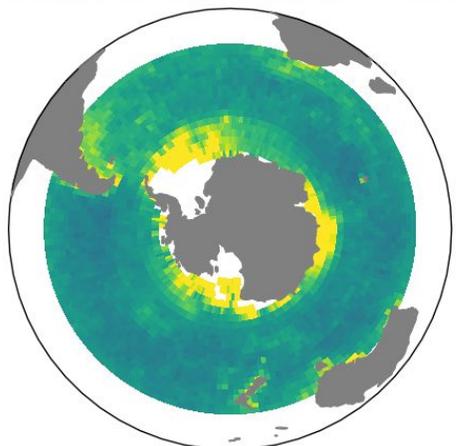
HYCOM

GLORYS

Bias (m)



Scatter Index

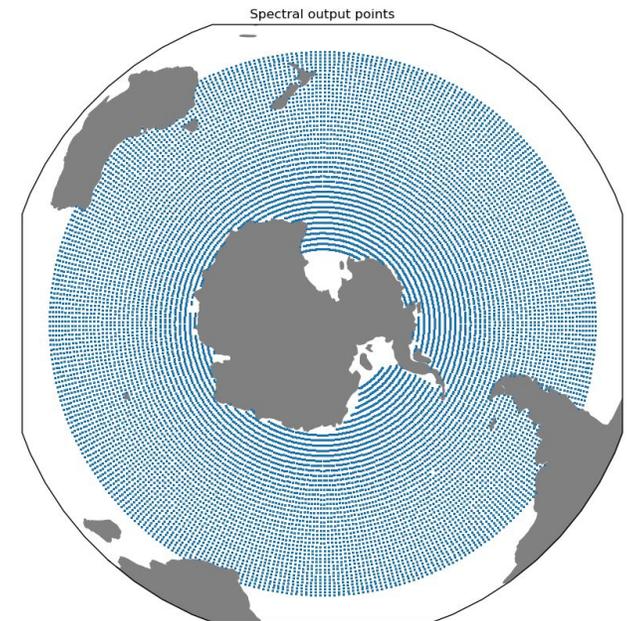
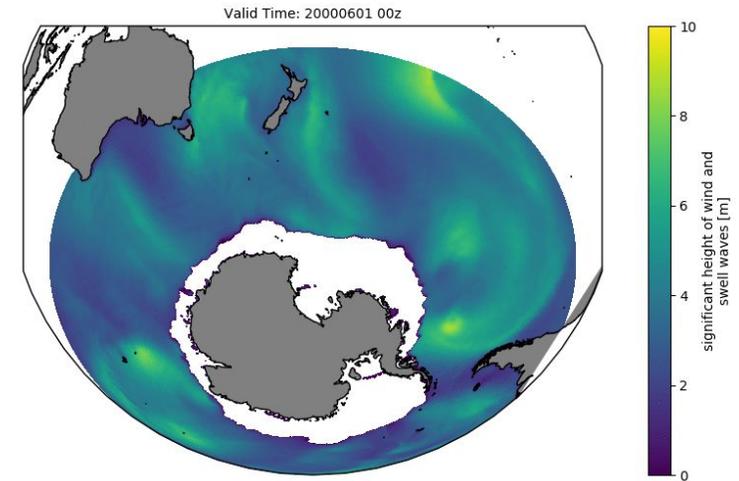


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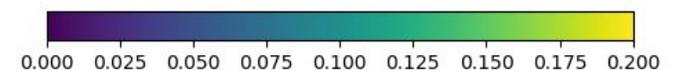
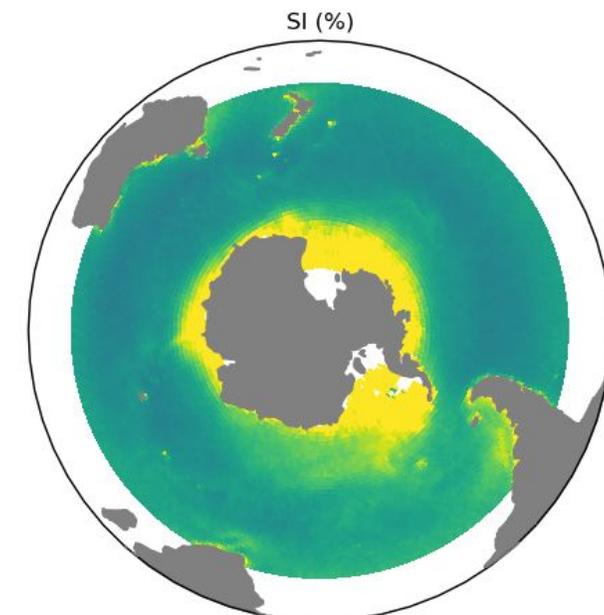
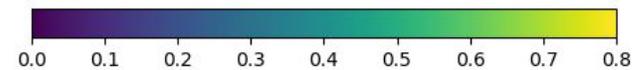
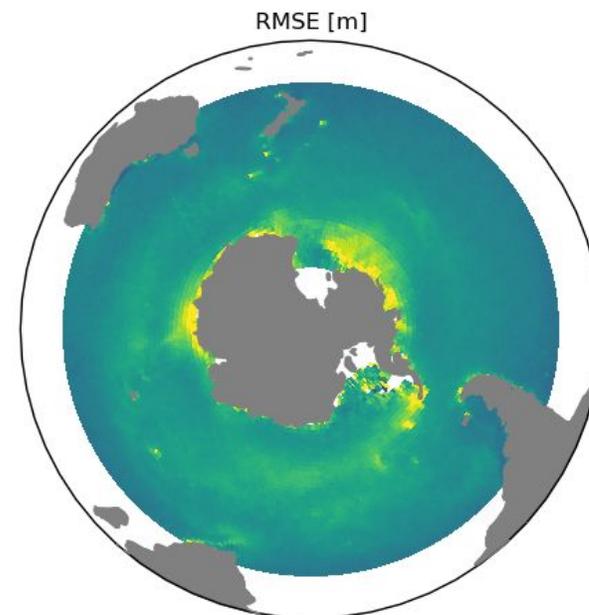
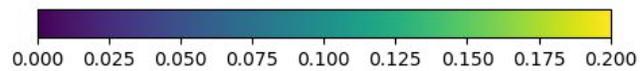
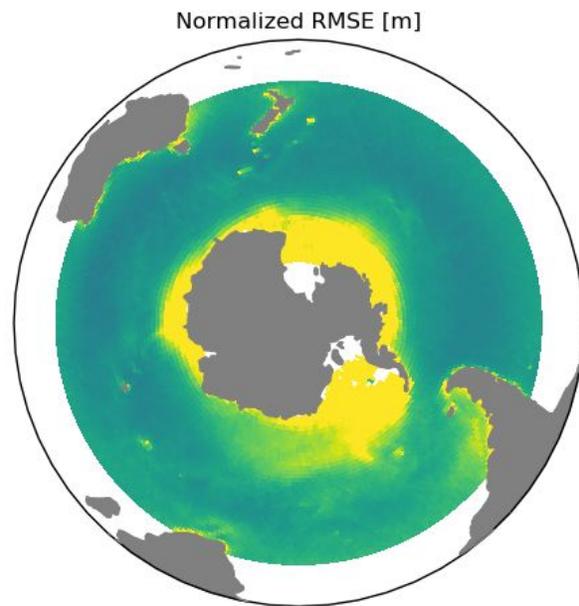
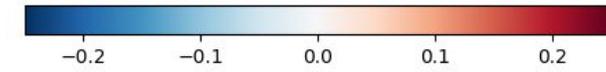
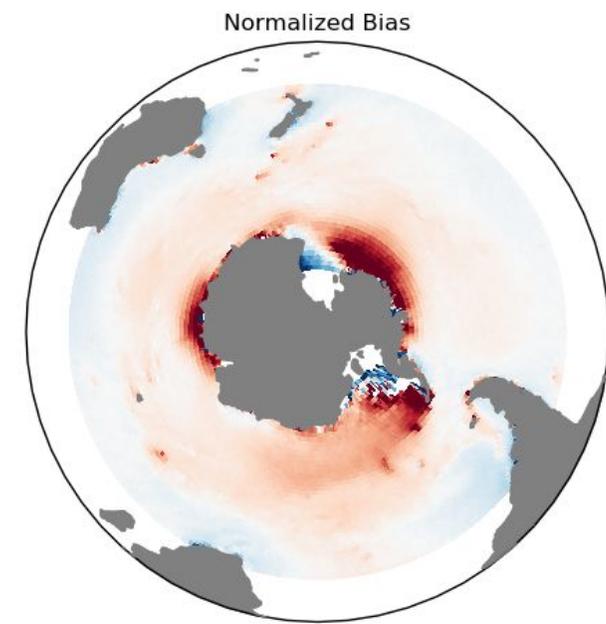
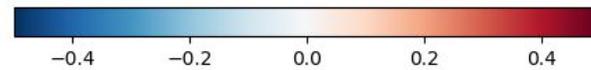
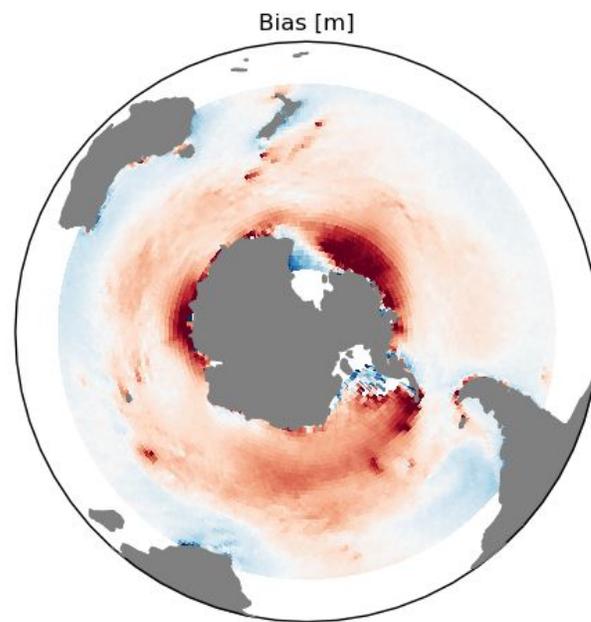
Southern Ocean Wave Atlas

- WAVEWATCH III ST4
- Optimized configuration (ERA5 + icebergs + GLORYS currents)
- Wave parameters at 0.25x0.20 deg. resolution
- 2D spectral data at 1 deg. resolution



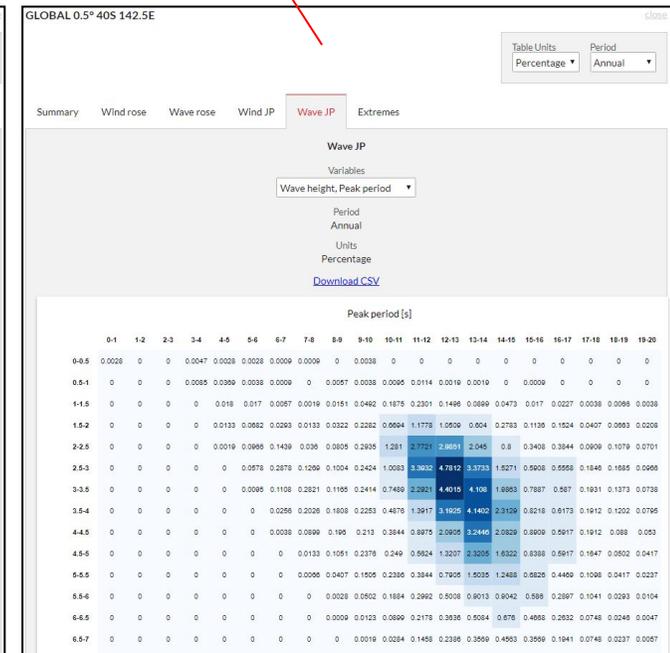
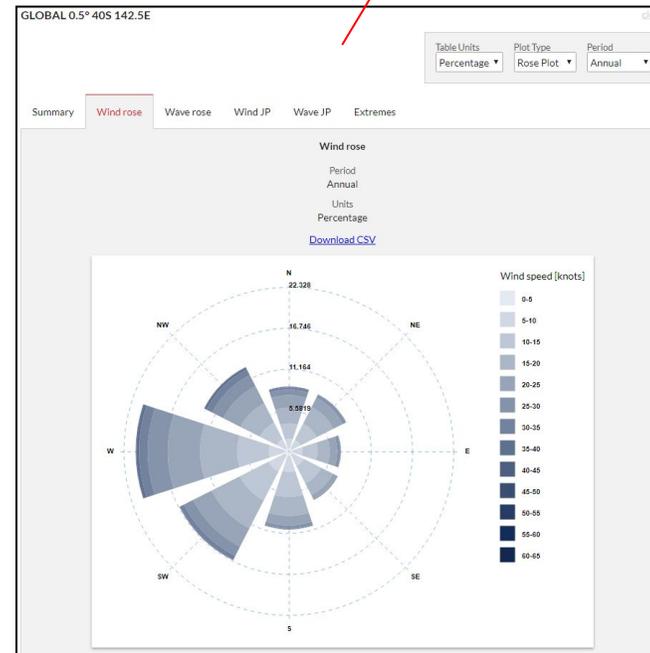
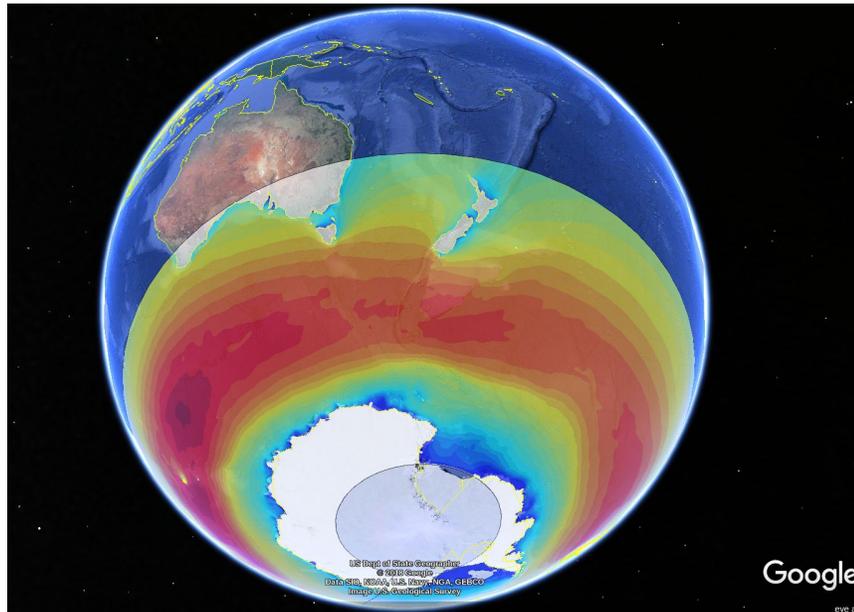
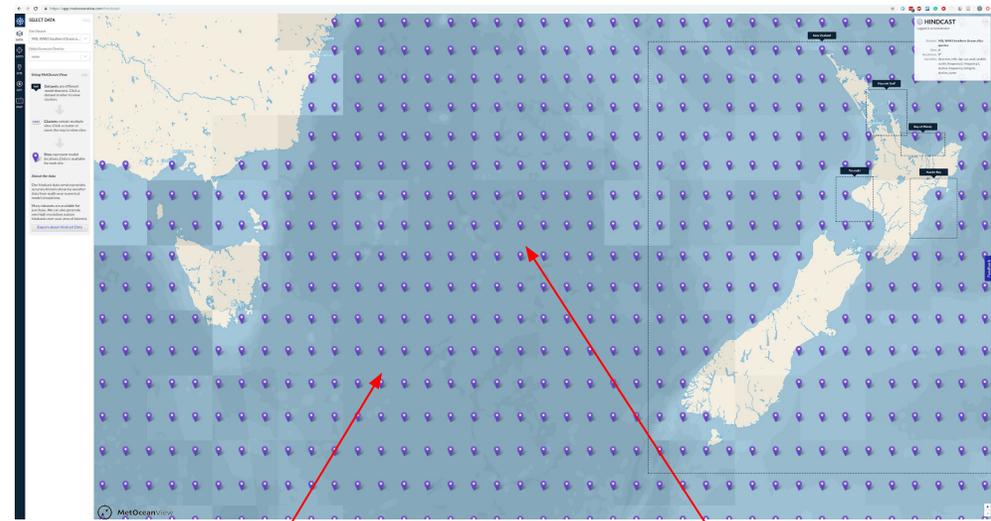
Validation

Altimeter validation for
1993 - 2017

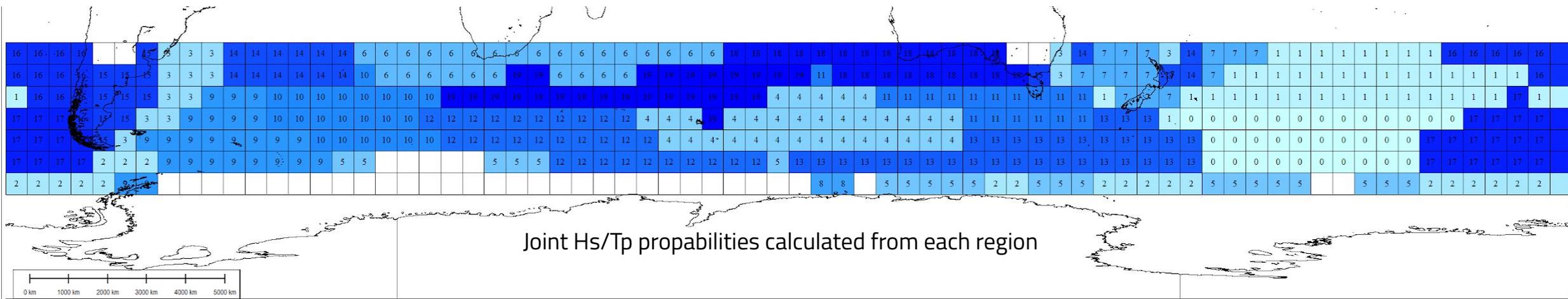
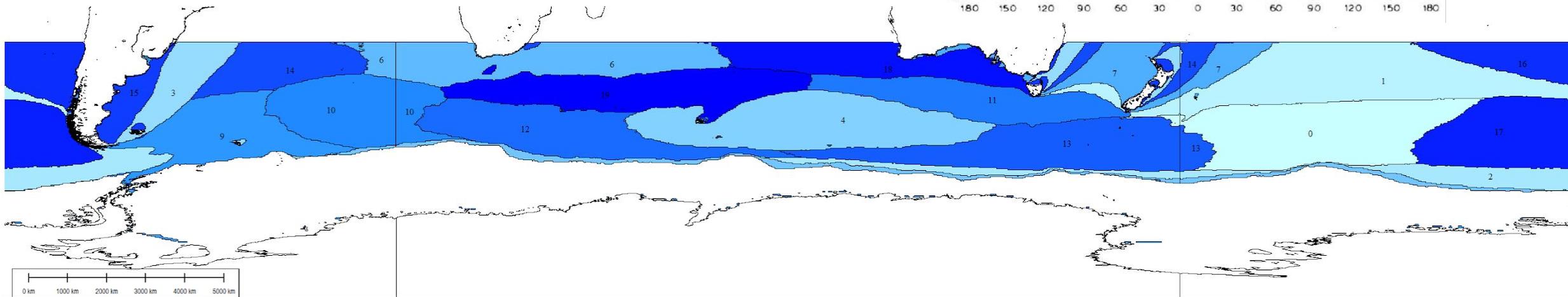
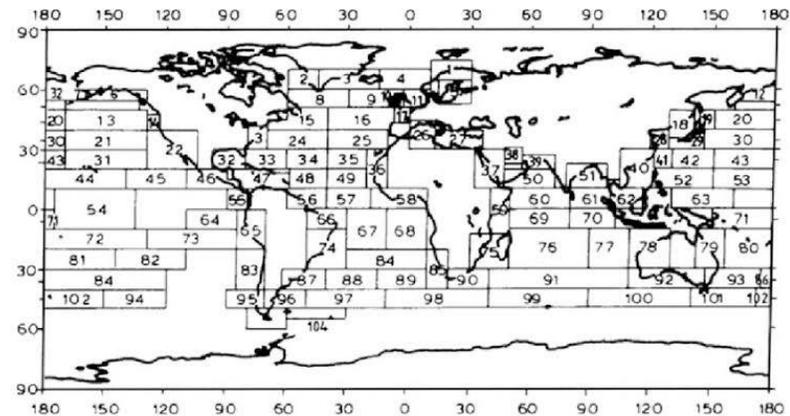


Southern Ocean Wave Atlas

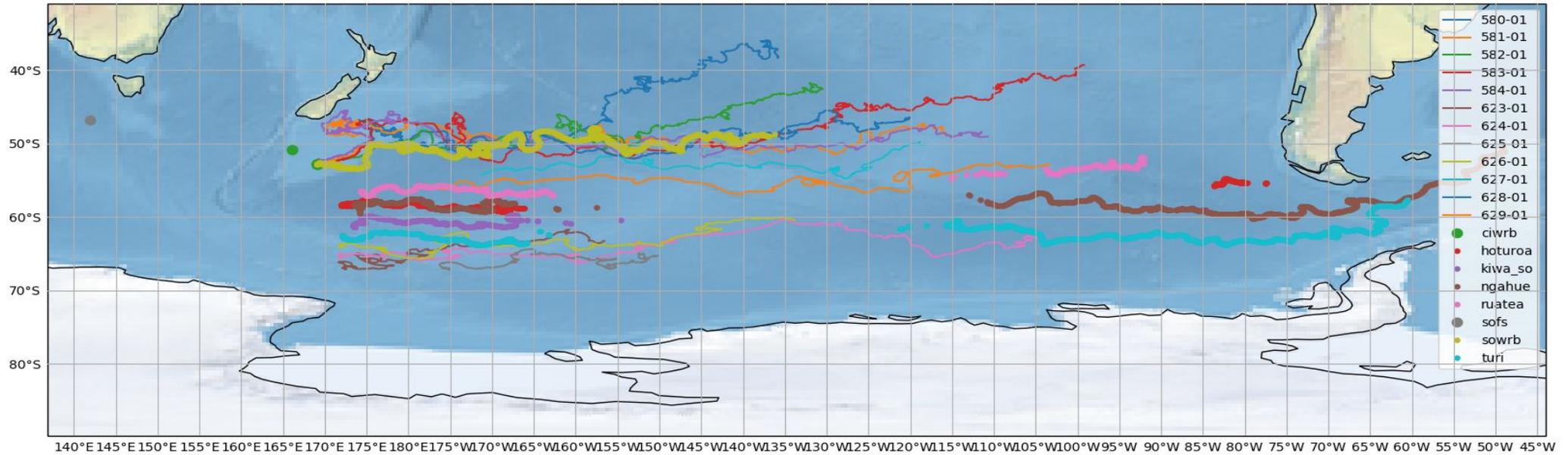
- Timeseries, tp/hs joint probability statistics, rose plots etc available at metoceanview.com
- Contact us for spectra



Similarity Statistics



Further work



- Glorys currents only cover up until 2017 which didn't cover the observations period - there is much more work that can be done with these observations - more work needed

Conclusions

- Increased availability of wave observations in the Southern Hemisphere.
- Significantly better wave results with ERA5 forcings than with CFSR forcings.
- Ocean currents have a positive effect, reduces Southern Ocean positive bias.
- GLORYS currents give better results than CFSR and HYCOM for ERA5 forced wave hindcasts

Ongoing Deployments



Buoy loading onto the HMS Canterbury on 9th of November, 2019



Thank you!

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