



A global to port scale operational wave forecast with a focus on Australia and New Zealand coasts

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Presentation Outline

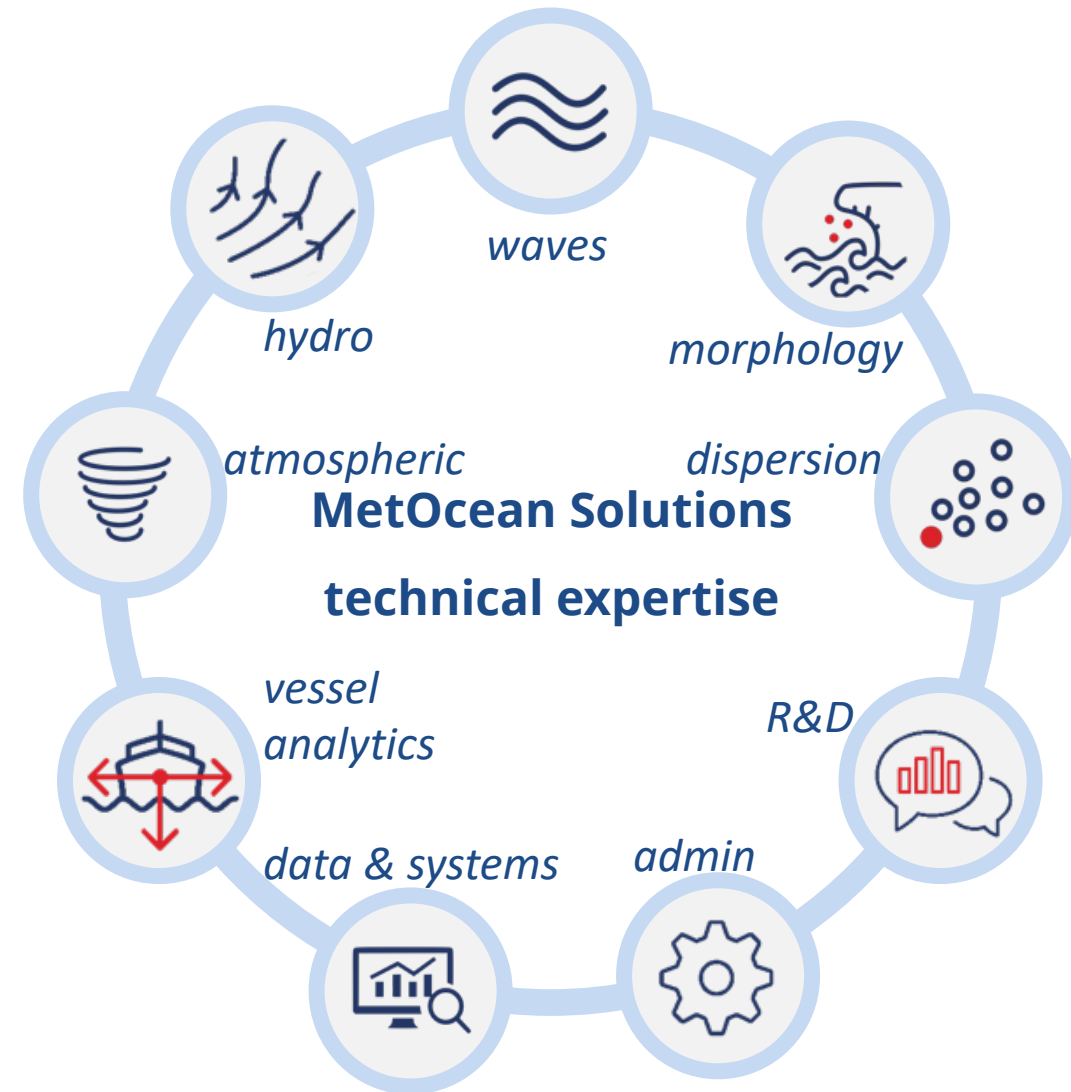
- MetService/MetOcean: Who we are and what we do
- Introduction to MetOcean Solutions (MOS) operational forecast system
- Wave forecasting system
- Global wave model: recent updates
- Coastal wave modelling
- Example: Australian ports
- Forecast assessment
- Development roadmap



MetService – MetOcean

Who we are

- MetService was established under the State-Owned Enterprises Act 1986 (SOE Act): wholly owned by the Crown (two Shareholding Ministers – the Minister of Finance and the Minister for State-Owned Enterprises)
- MetOcean team, the Marine Division of MS:
 - The whole team work closely together in an efficient manner. The three legs consist of:
 - Forecasting capabilities
 - Hindcasting capabilities, and
 - Research/consultancy capabilities
 - while products, services, APIs, customer support and software (the ring around the legs) leverage all the capabilities.



MetService – current MetOcean warning product



Heavy Swell Warning

Area: Wellington - Cape Terawhiti to Turakirae Head
Period: 19hrs from 2pm Thu, 11 Nov - 9am Fri, 12 Nov

Combined wave: Southerly combined waves 4-4.5 metres. Peak period 13 seconds.

Swell: Southerly swell rapidly rising to 4 metres this morning, period 15 seconds. Easing to 3 metres Friday early morning.

Wind wave: Southerly wind waves 1-2 metres.

Pressure: Minimum pressure 1008.4 hPa forecast 10am Fri 12th. Maximum pressure 1013.7 hPa forecast 1pm Thu 11th.

Remarks: Southerly waves caused by a system passing to the south of New Zealand.

Tides: The highest risk period is typically at or within 1-2 hours of high tide.
 Cape Terawhiti high tides: 12:43am Fri 12th.
 Wellington high tides: 11:36pm Thu 11th.

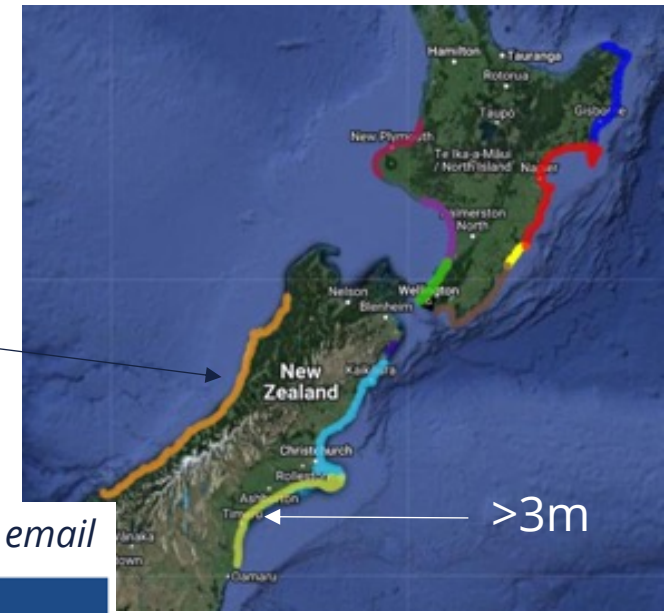
Issued: 2:40pm Thu, 11 Nov
 Next update: 1pm Fri, 12 Nov

Website map and text warning

metservice.com

Thresholds:

>5m or
>4m | t=17s



Warning via email

Heavy Swell Warning for Wellington : 526173

ICE_TEST_AUCKLAND@METSERVICE.COM
 To: Michael Mattens

Heavy Swell Warning for Cape Terawhiti to Turakirae Head

Issued by MetService at 12:15 pm Wednesday 17-Nov-2021

Valid from 12:00am 20 November to 12:00am 21 November

Combined Wave: Southerly combined waves rising to 6 metres early on Saturday, then gradually easing to 2.5-3 metres by late Saturday evening. Peak period 14-16 seconds.

Swell: Southerly swell rapidly rising to 4.5 metres early on Saturday, gradually easing to 2 metres by late Saturday evening. Period 14-16 seconds.

Wind Wave: Southerly wind waves rising to 4 metres early on Saturday, easing to 2 metres late Saturday evening.

Pressure: Minimum pressure 1005.9 hPa forecast 4pm Sat 20th. Maximum pressure 1013.3 hPa forecast 10pm Fri 19th.

Remarks: Note that all wave heights in this forecast are significant heights; occasional wave heights may be 50% higher, and maximum wave heights may be twice the significant height.

Tides: The highest risk period is typically at or within 1-2 hours of high tide.
 Cape Terawhiti high tides: 7:33am Sat 20th, 8:03pm Sat 20th.
 Wellington high tides: 6:26am Sat 20th, 6:56pm Sat 20th.

Next issue by 1:00pm 18 November

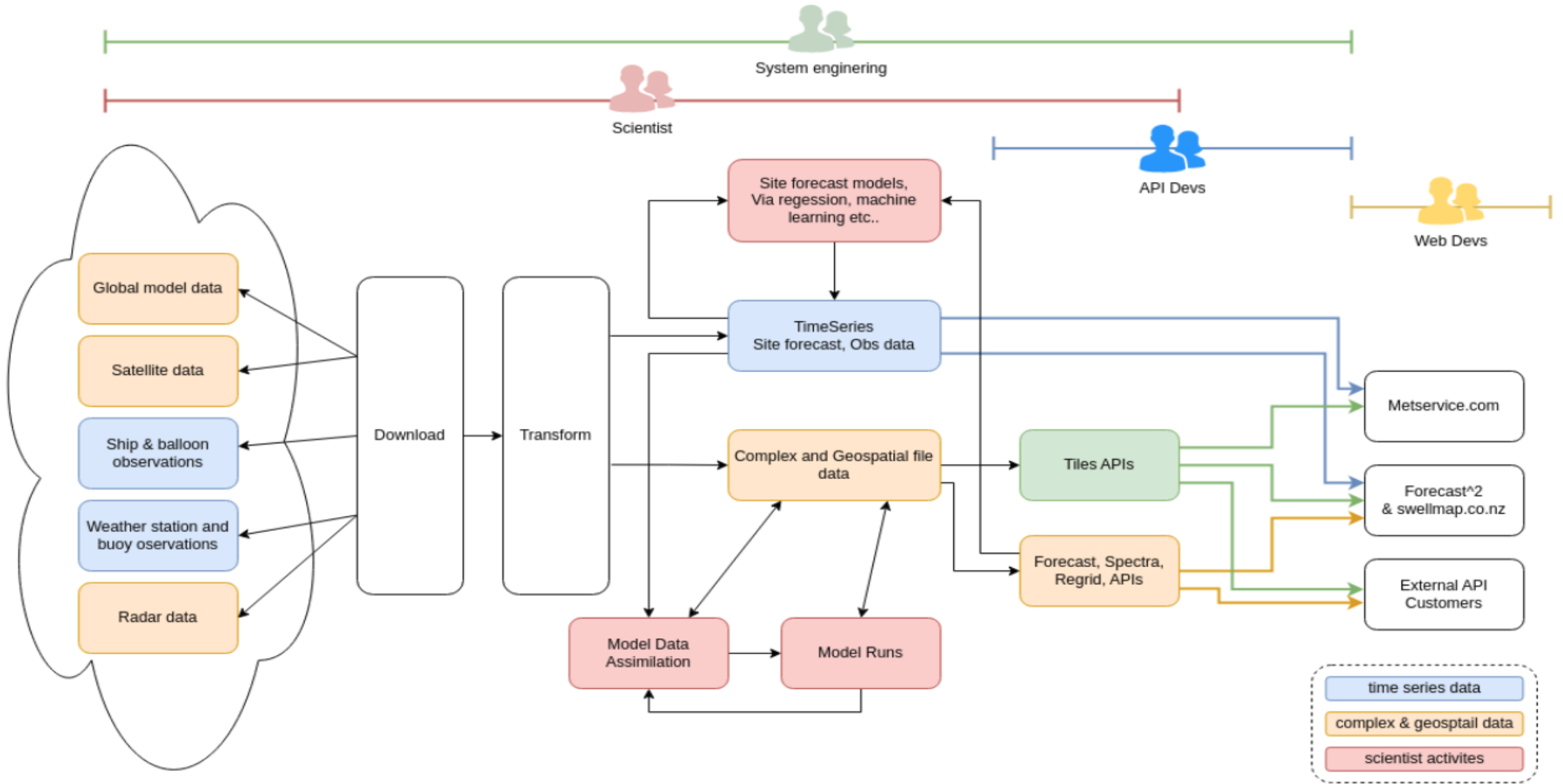
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MetService
 TE RATONGA TIHORANGI

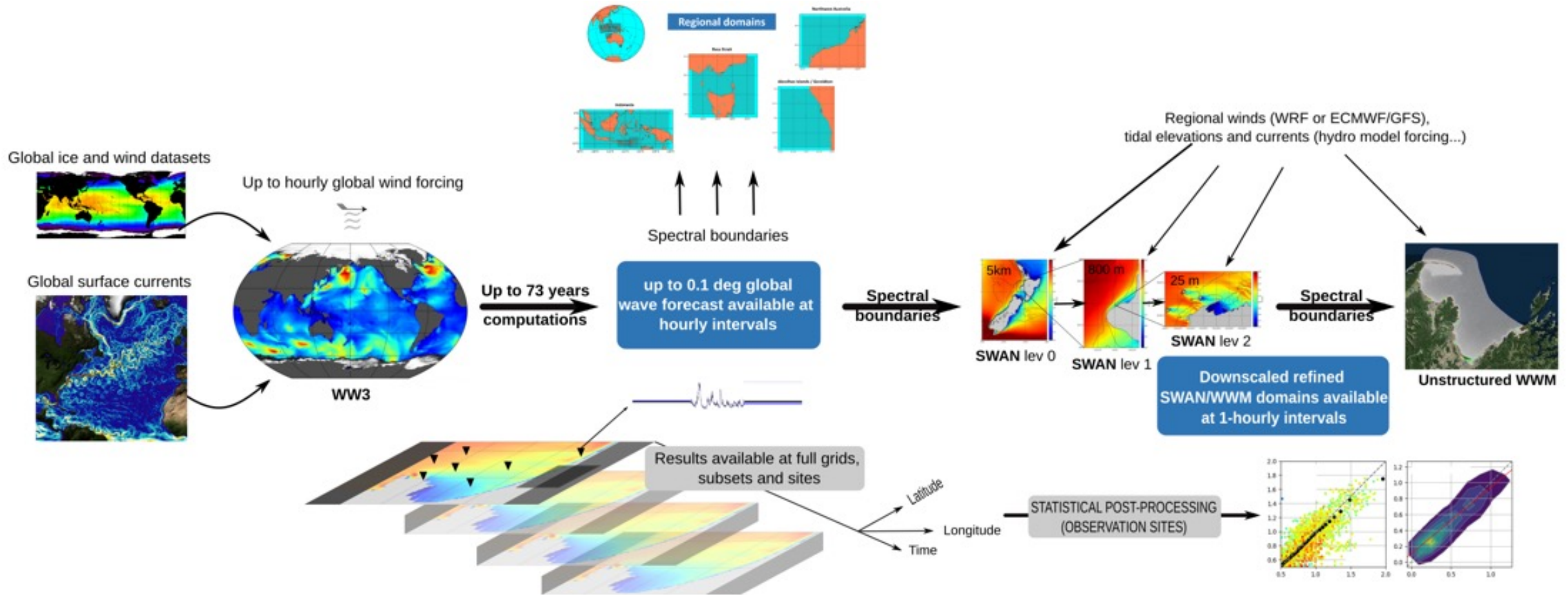
- Swell warnings issued for different parts of coast that are prone to impacts
- Thresholds are varied according to climatology and vulnerability to hazard
- e.g. large swells on western coasts are common, but are rare for eastern coasts where more communities are near the coast



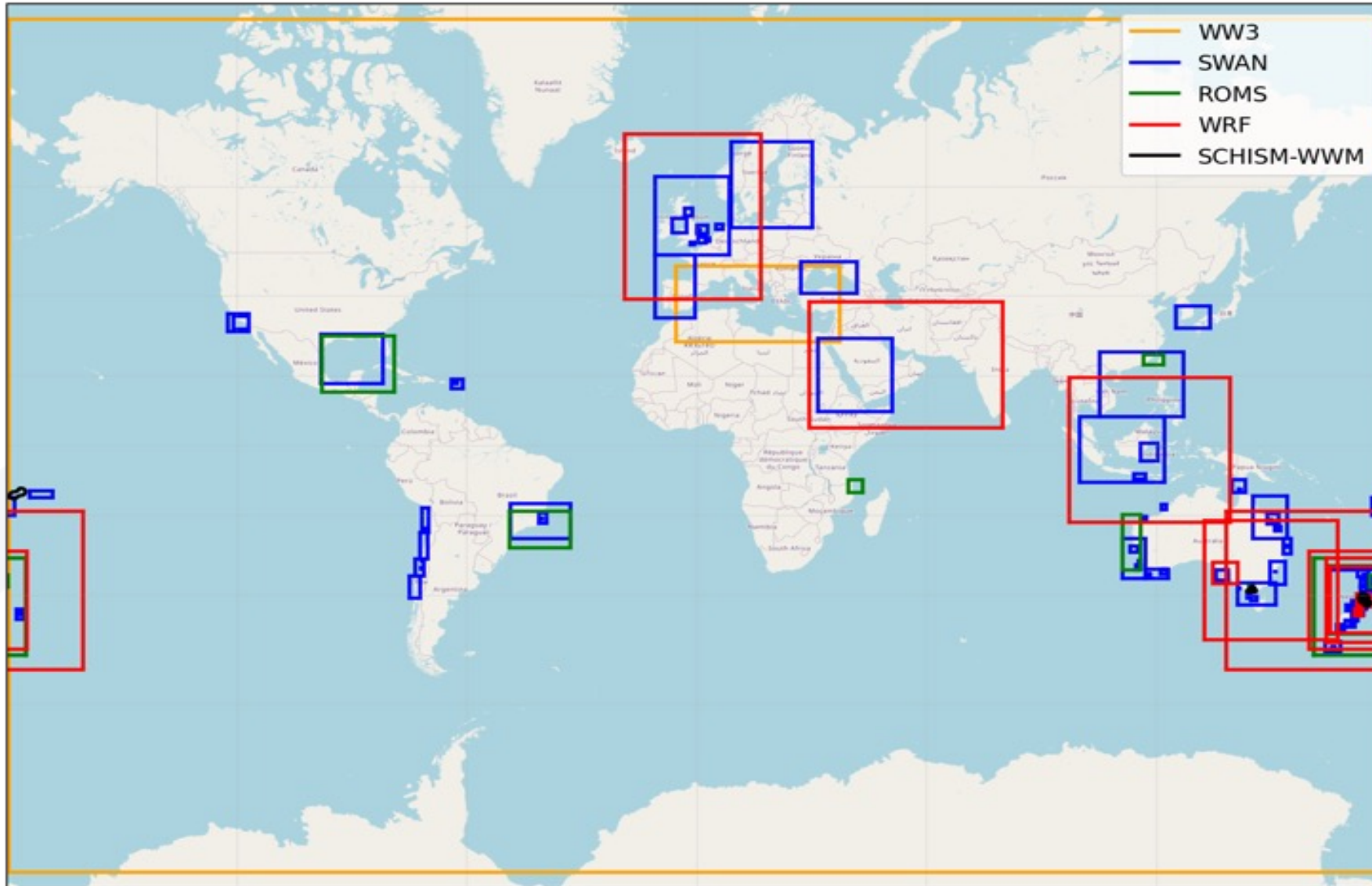
MOS Operational System - overview



MOS Forecast System - wave model-data workflow



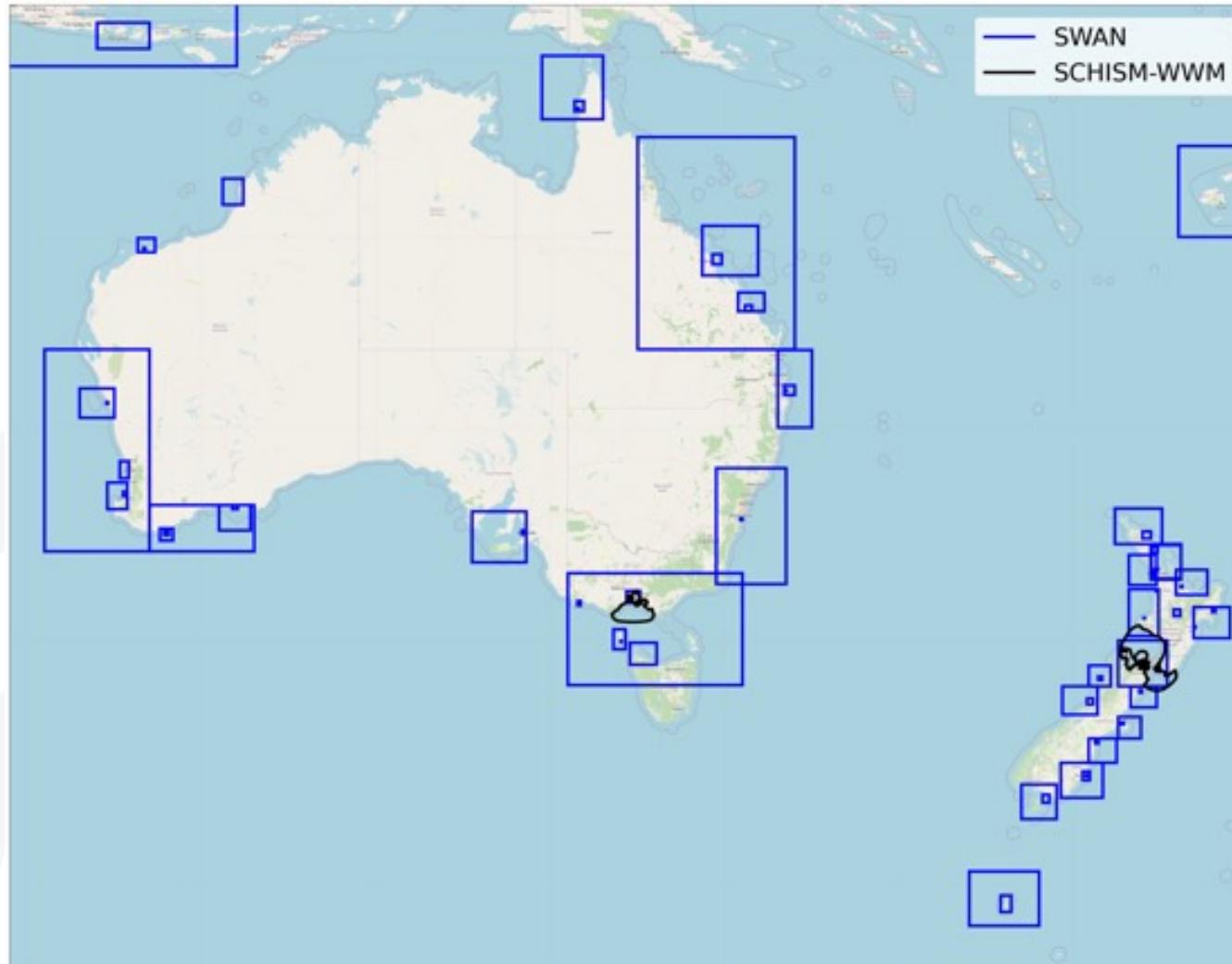
MOS Forecast System – full model stack



- Duplicated stack for GFS and ECMWF forcing (waves only)
- Total of 112 SWAN grids
- Coastal SWAN models down to 30m resolution
- 10 Regional hydrodynamic models (ROMS)
- 6 Unstructured coupled hydro-wave models (SCHISM-WWM)
- High-resolution winds up to 300m



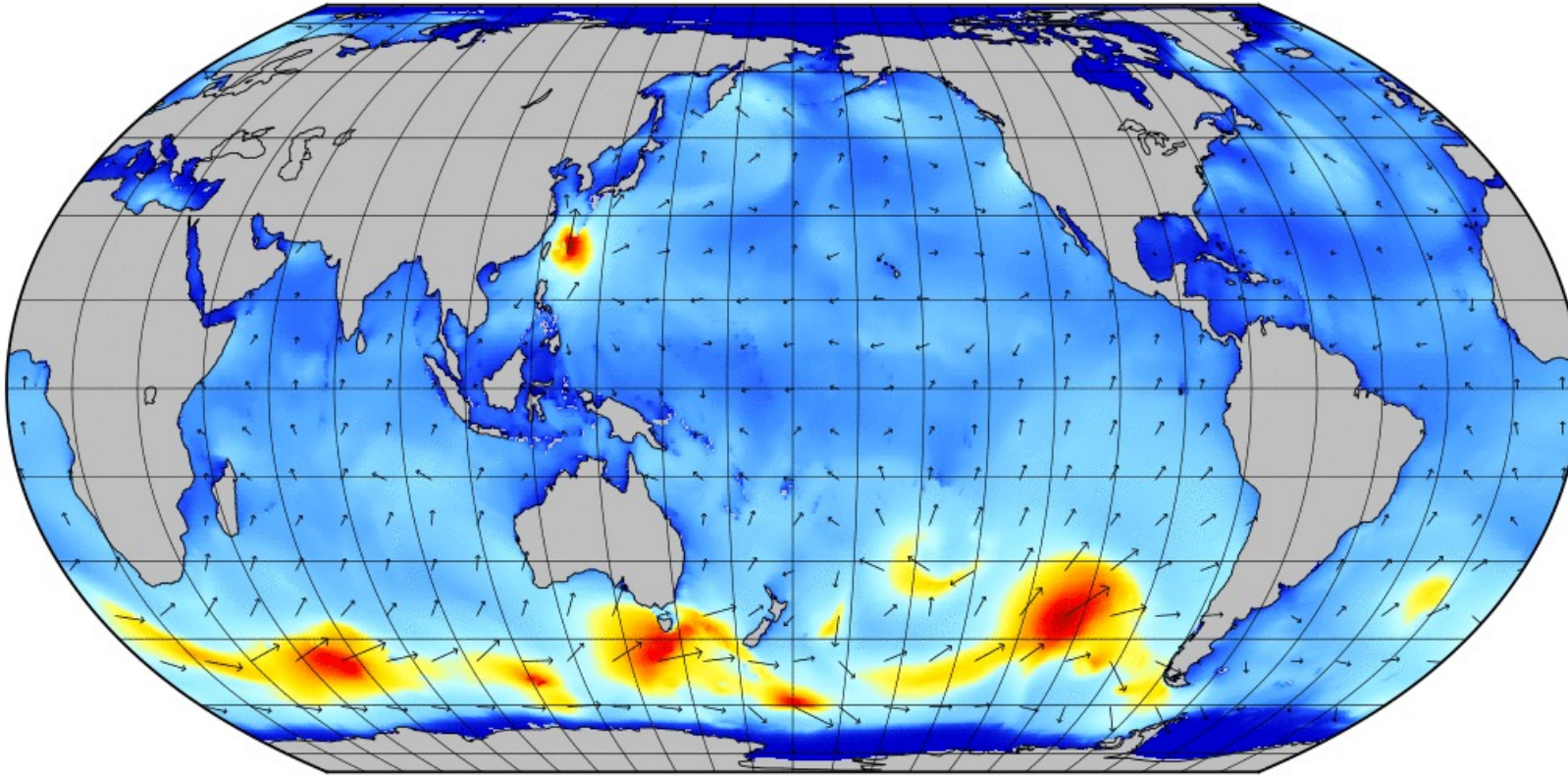
MOS Forecast System – coastal wave model stack AUS-NZ



- Comprehensive coverage of NZ and Aus (main ports) coasts
- A more thorough coverage of NZ due to govt warning/contractual obligations
- Australia domains: 36 SWAN and 1 SCHISM-WWM
- NZ domains: 37 SWAN and 4 SCHISM-WWM
- Unstructured coupled: Port Phillip Bay (with CSIRO) and Cook Strait



MOS Forecast System – Global Wave Model

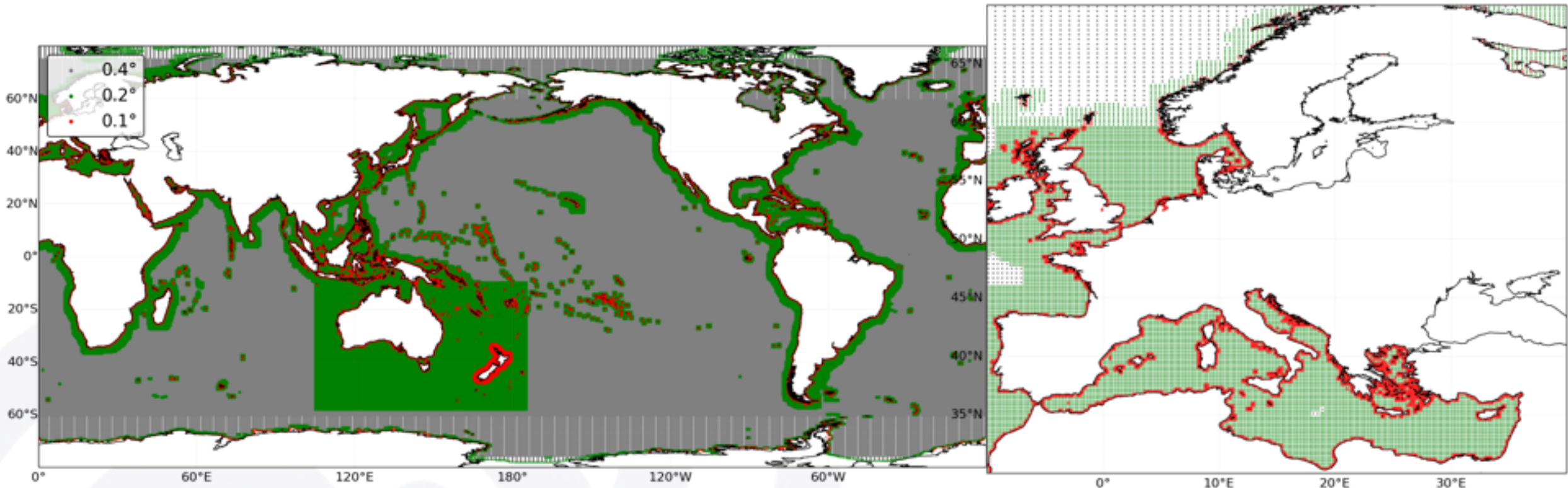


- WAVEWATCH III modified version 7.14 (2023)
- Dual stack GFS – ECMWF
- Short (8 days) and long (15 days) forecast ranges
- 10-member ensemble forecast, which is further downscaled to some NZ regions
- ST4 physics (betamax calibrated to the different wind sources)
- Corrections of extremes applied to ECMWF winds (WCOR1, WCOR2)
- Spectral spacing:
 - 34 freqs from 0.034 Hz
 - 15° resolution
- Dedicated Mediterranean grid



MOS Forecast System – Global Wave Model: Recent Upgrades

Recent upgrades – Spherical-Multiple-Cell grid (SMC)



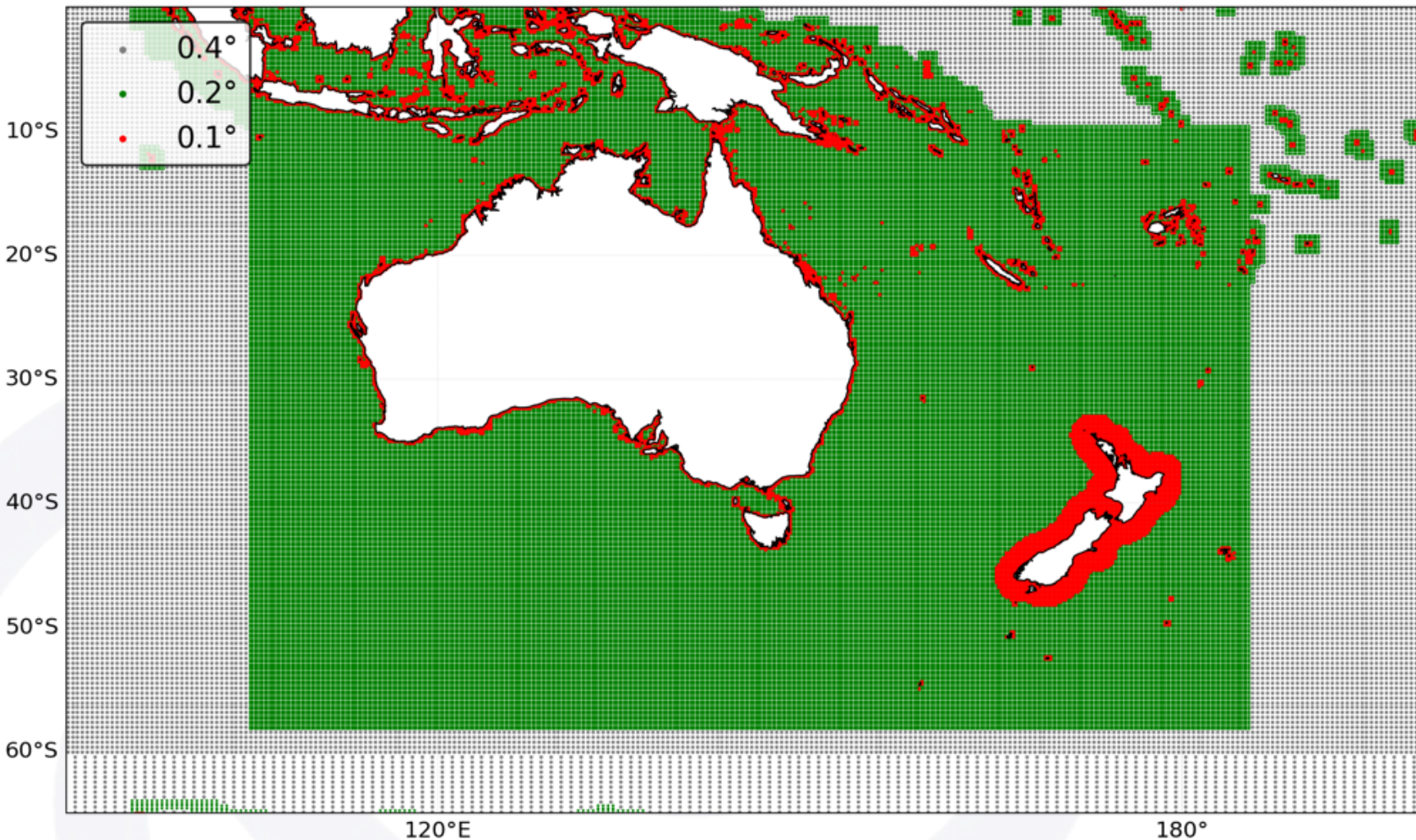
- Unstructured grid preserving quadrilateral cells
- 3-level resolution: 0.4°, 0.2° and 0.1°
- Merged cells at high latitudes to relax CFL limit
- Distance to coast- and depth-based resolution criteria

- Additional refinement around grid points with high obstruction mask values
- Tailored polygons for Aus-NZ surrounding oceans
- Aiming at resolving coastline and shallow areas, improving coastal SWAN boundaries



MOS Forecast System – Global Wave Model: Recent Upgrades

Recent upgrades – Spherical-Multiple-Cell grid (SMC)

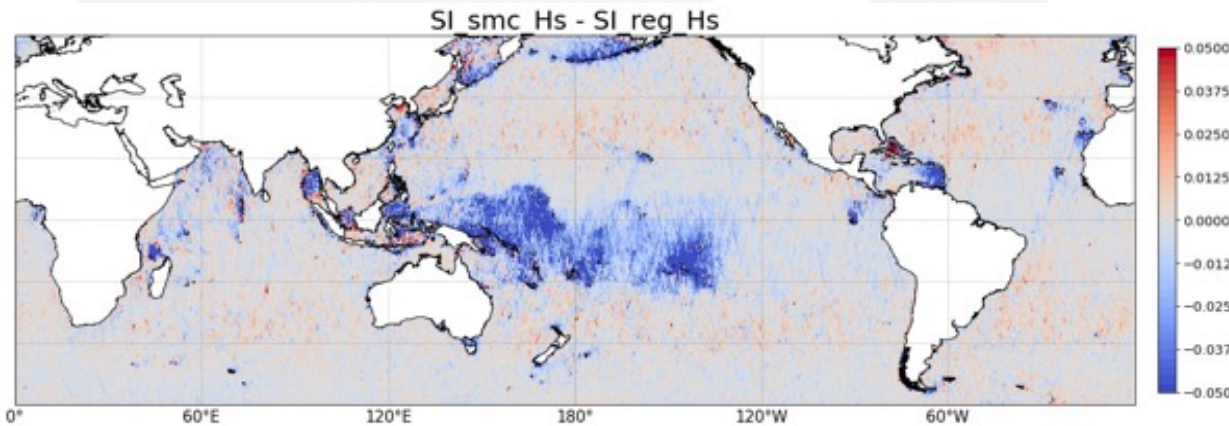
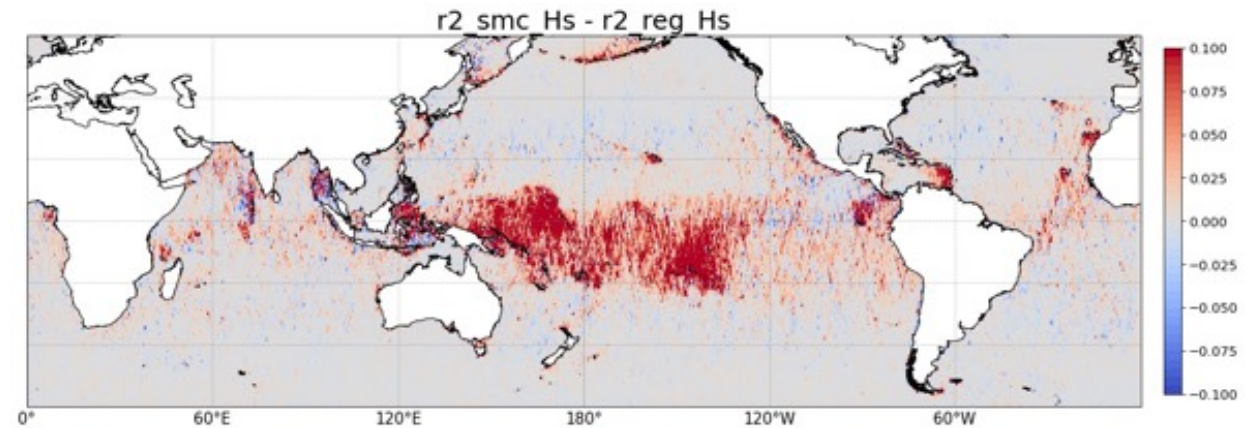
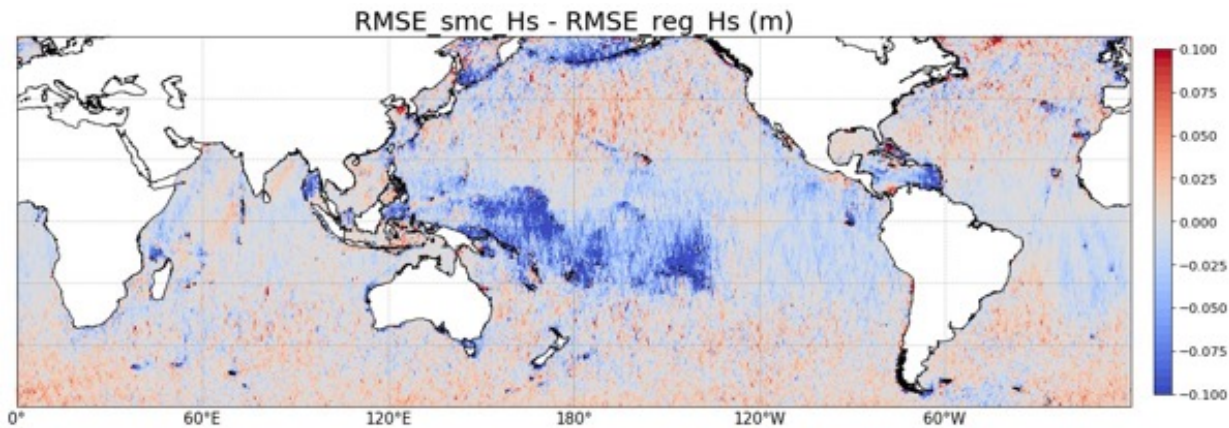


- 0.2° polygon to resolve Tropical Cyclones and Tropical/Sub-Tropical Low systems in the Aus-NZ surrounding oceans
- Leverages from global GFS/ECMWF wind resolutions (0.117° and 0.125°)
- 0.1° NZ polygon to increase SWAN boundary accuracy
- Reduce SWAN grid domains



MOS Forecast System – Global Wave Model: Recent Upgrades

Recent upgrades – Spherical-Multiple-Cell grid (SMC)



- SMC vs Previous operational regular grid:
 - Very similar in deep ocean (away from the coast)
 - Major improvements in island dominated regions (e.g. Polynesia and west Pacific)
 - Overall good improvements in nearshore and shallow areas

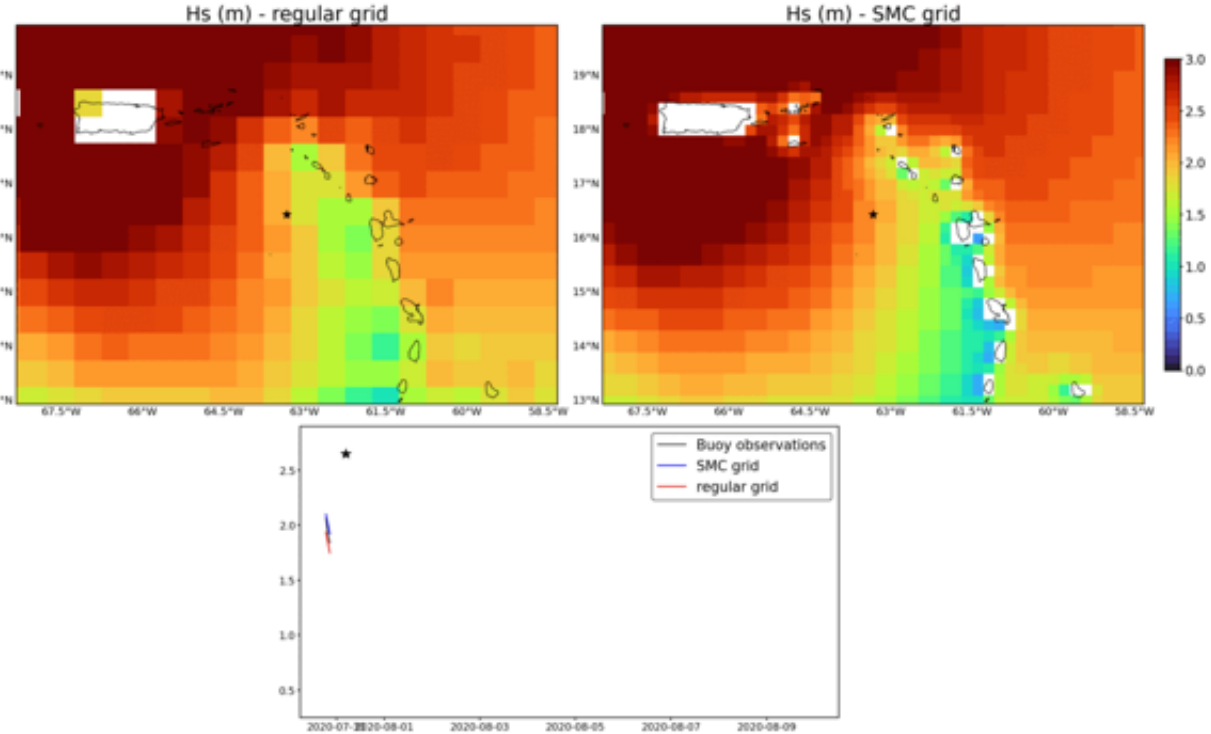
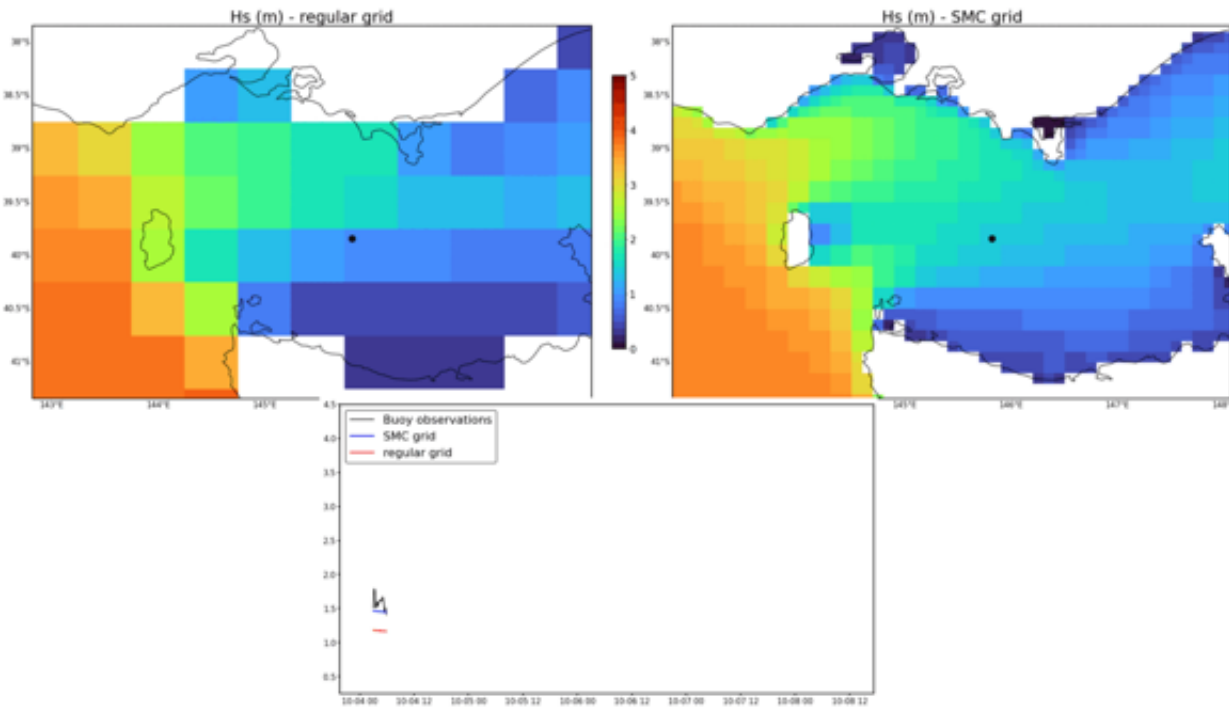


MOS Forecast System – Global Wave Model: Recent Upgrades

Recent upgrades – Spherical-Multiple-Cell grid (SMC)

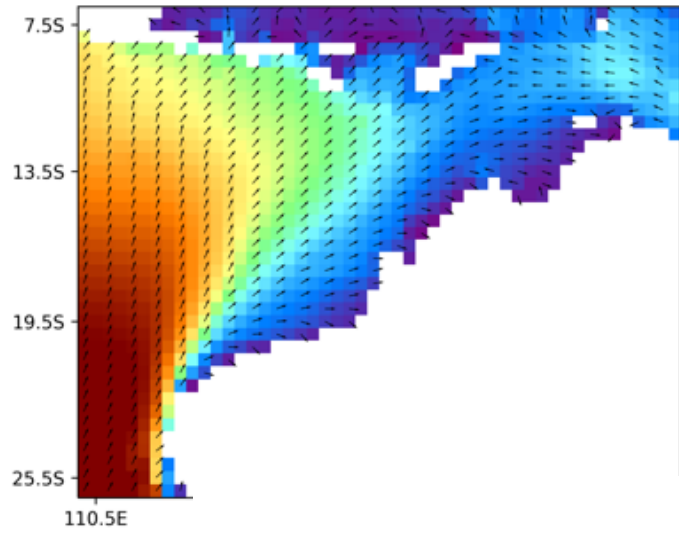
Bass Strait

Eastern Caribbean



MOS Forecast System – Global Wave Model: Recent Upgrades

Nesting efficiency to SWAN coastal models – NWWA old vs new setup

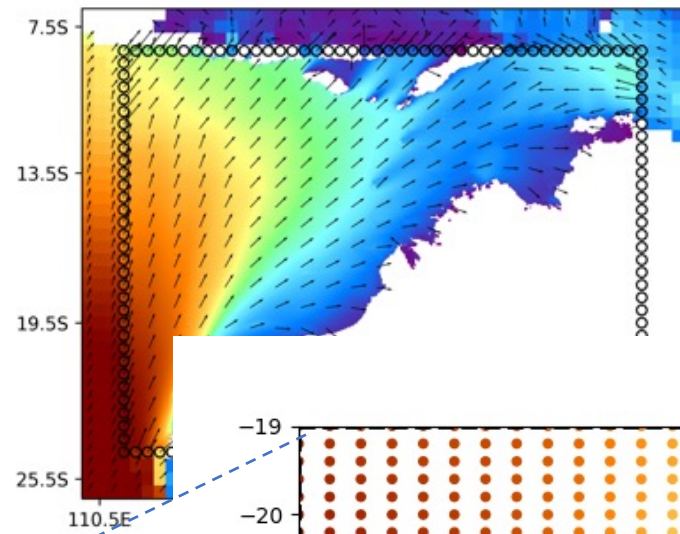


PREVIOUS

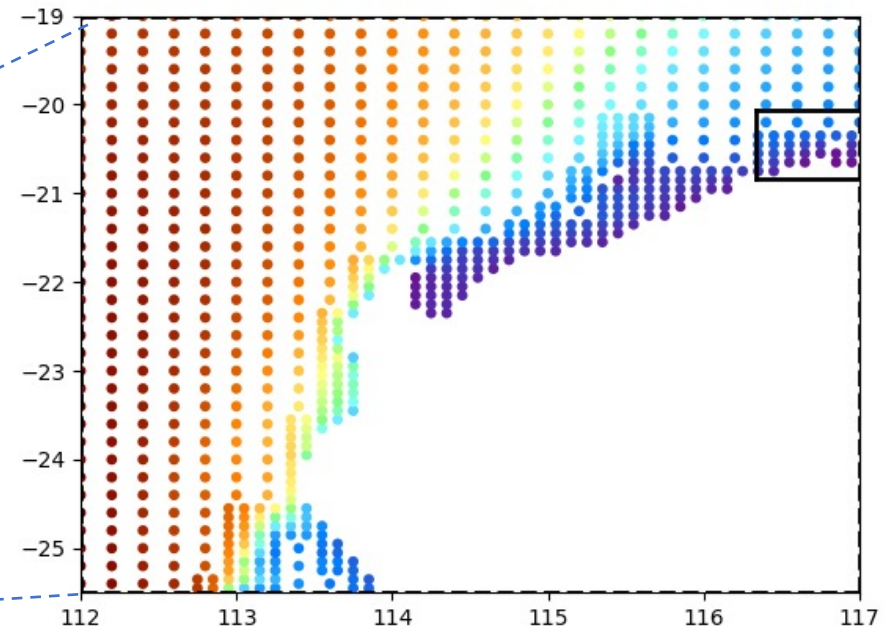
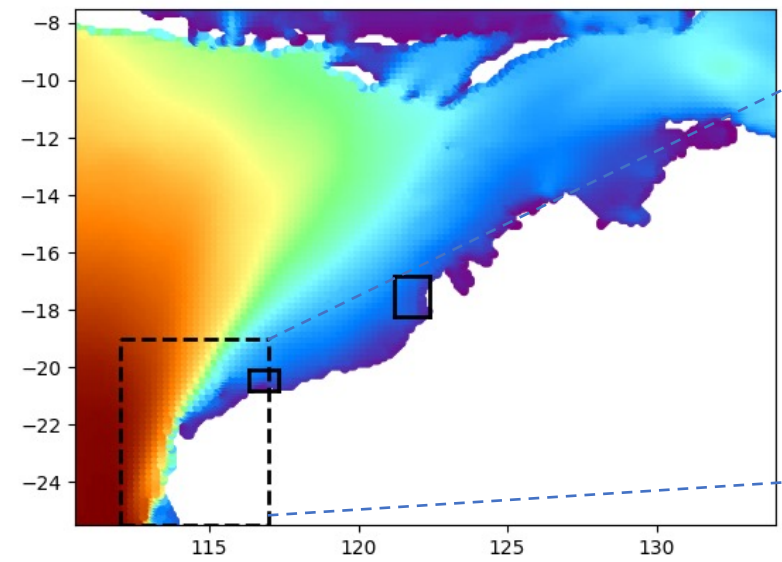
Poor resolution



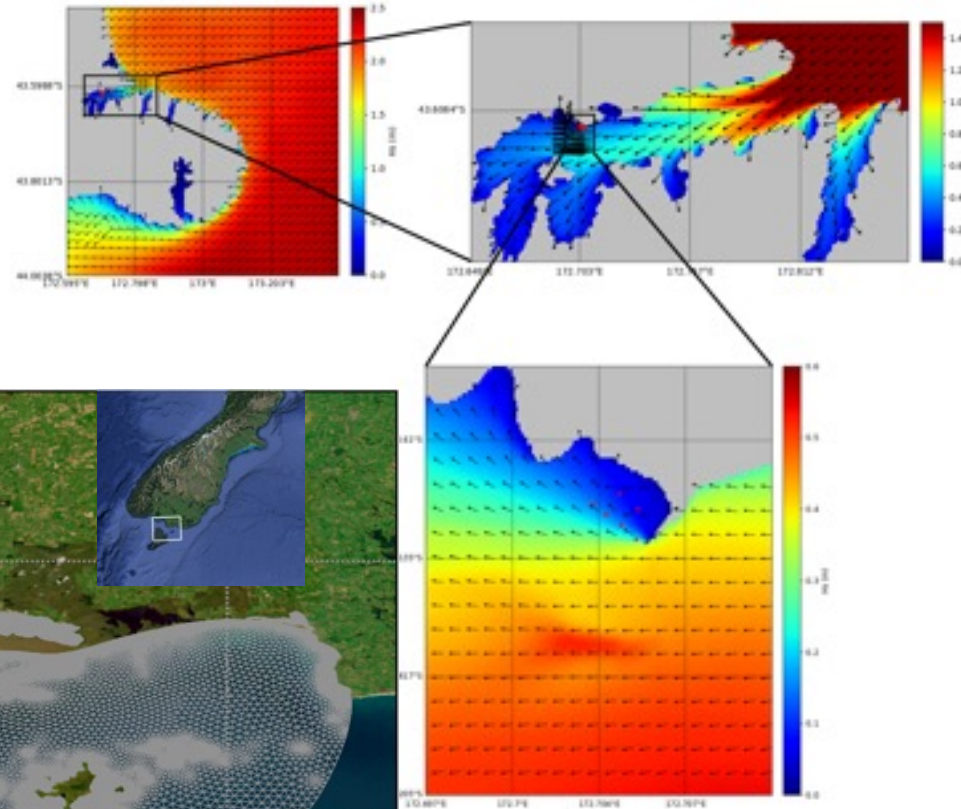
Large downscaled
SWAN nest needed



NEW



MOS Forecast System – Coastal Wave Model (SWAN - WWM)

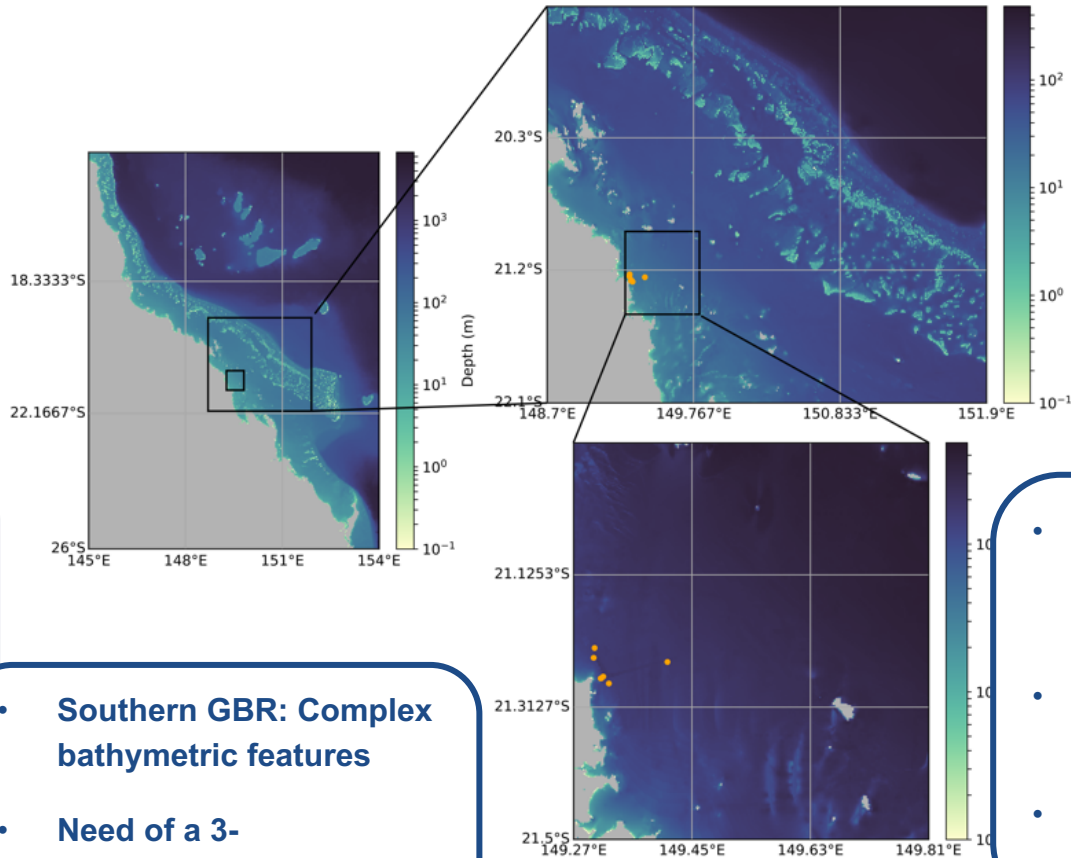


- SWAN modified version 41.45 (2023)
- More than 200 nests worldwide
- 5 unstructured grids (WWM coupled with hydrodynamic SCHISM)
- Up to 20m resolution.
- frequency range from 0.034 to 2 Hz
- Up to 4-level regular nesting
- ST6 SWAN physics since 2019: more consistent with global physics
- Regular grids over Unstructured:
 - advantages: fast deploy, calibration, maintenance, computational cost
 - disadvantages: offshore reef systems, complex bathymetry, no two-way nesting for such cases, need of multiple grids



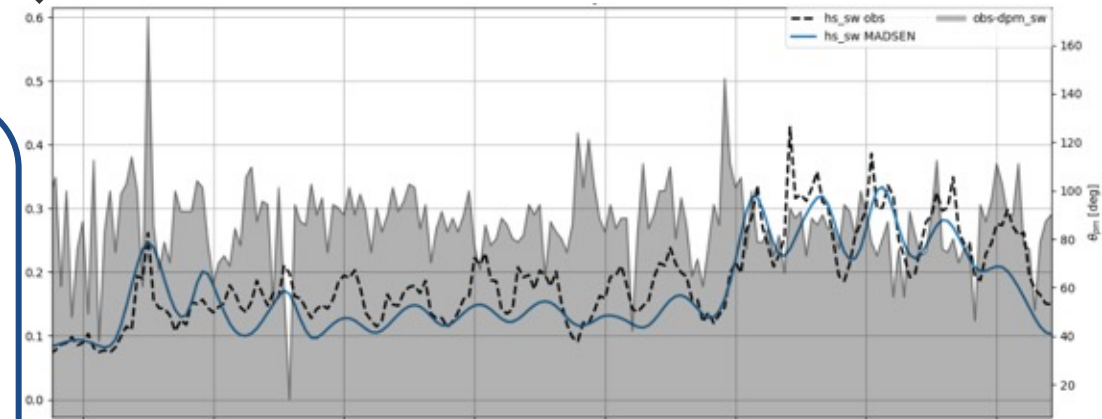
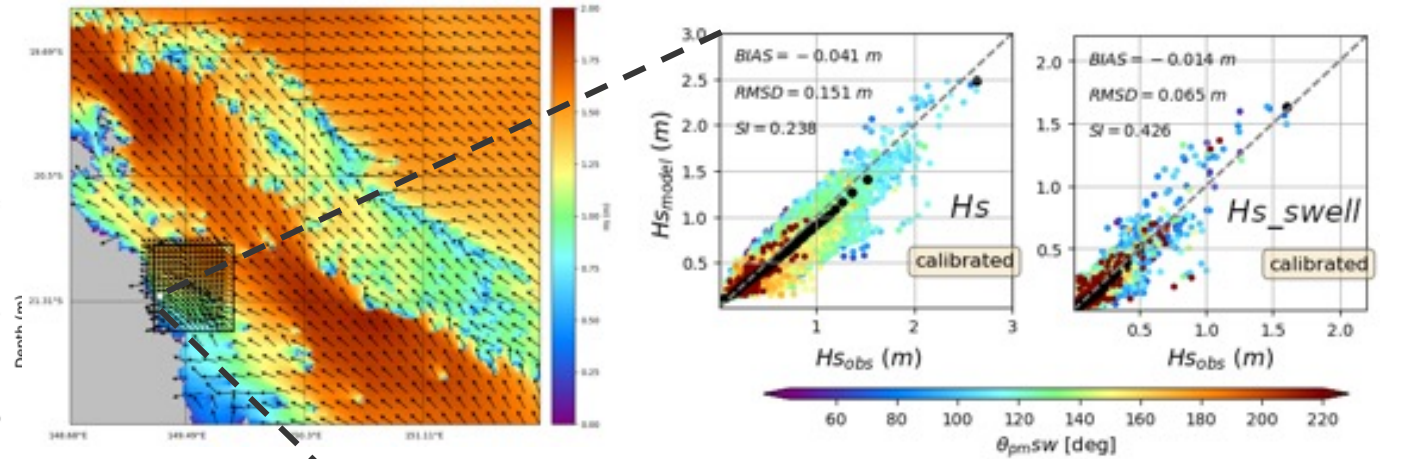
MOS Wave Forecast System – Port examples

Hay Point



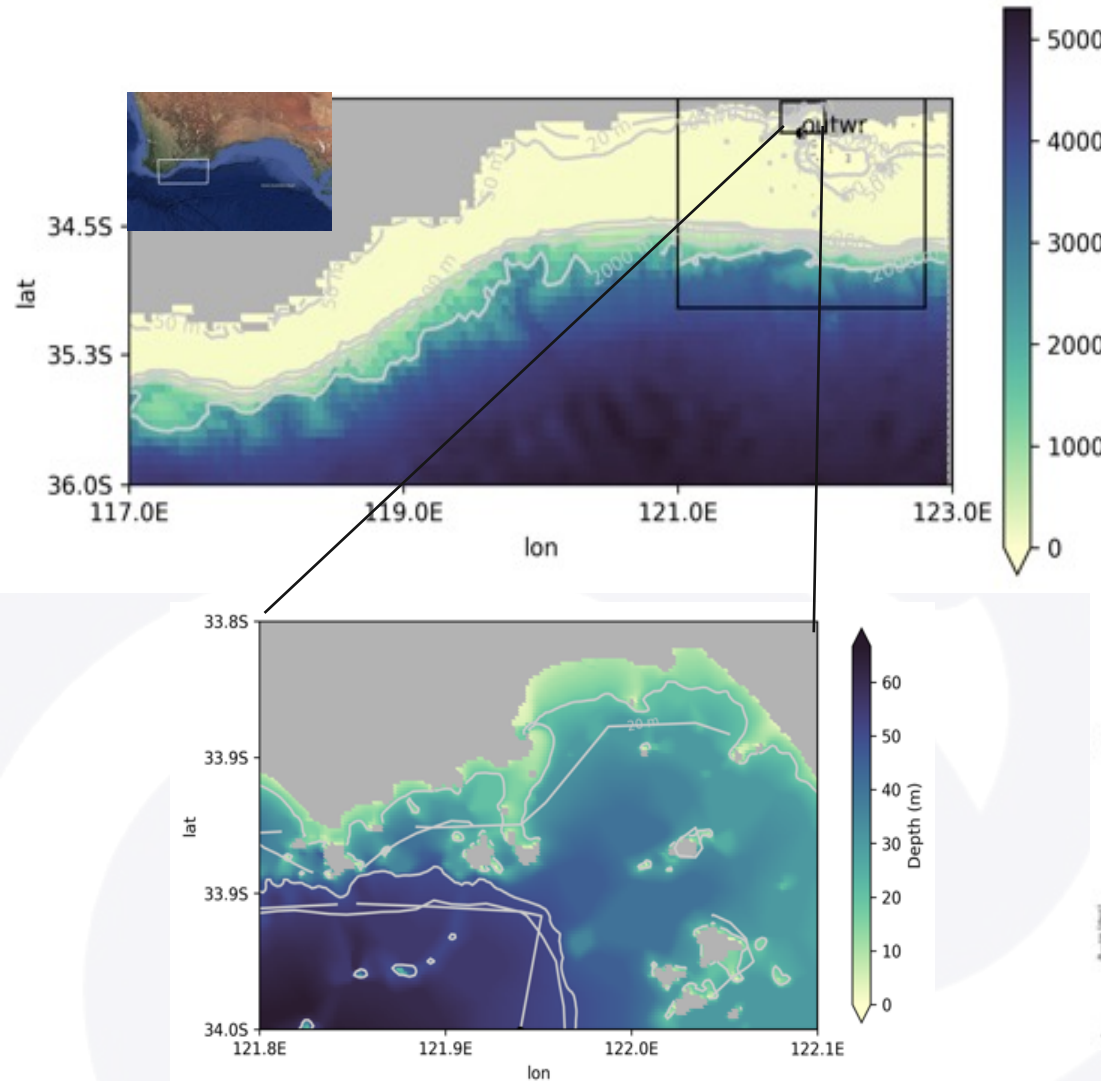
- Southern GBR: Complex bathymetric features
- Need of a 3-level downscaling: 5km to 200m

- Calibration of several shallow water physics
- Strong tidal modulation
- Obstacle transmission

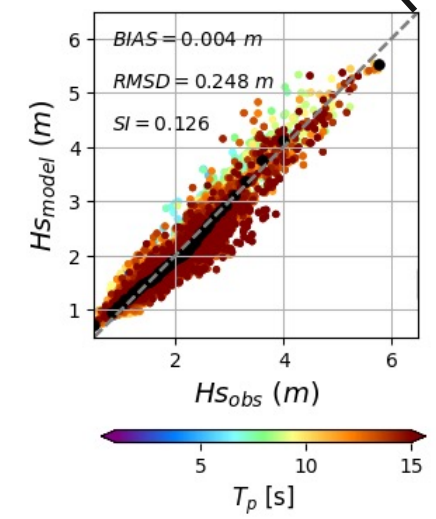
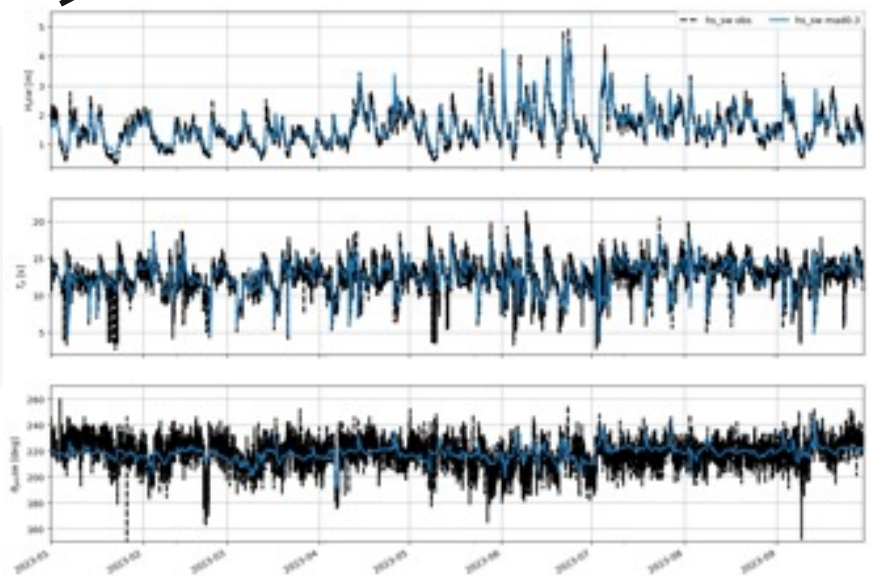
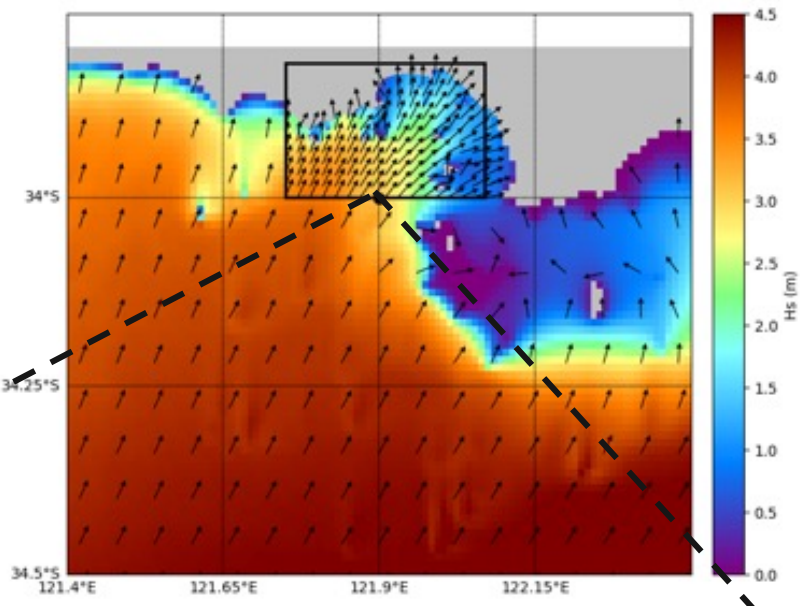


MOS Wave Forecast System – Port examples

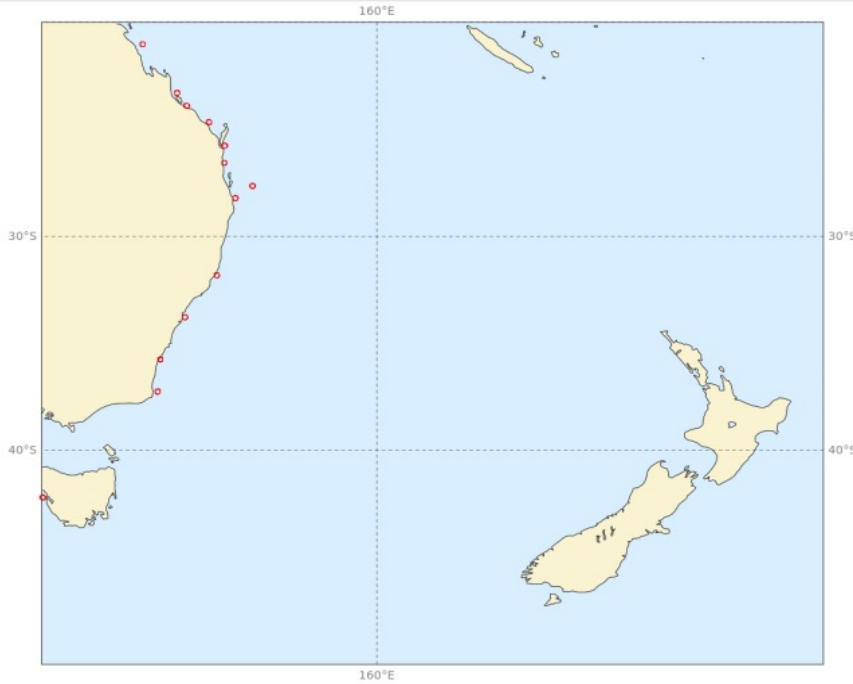
Esperance



- Similar case, complex island/reef structure
- 2-level nesting, after deployment of new global SMC grid

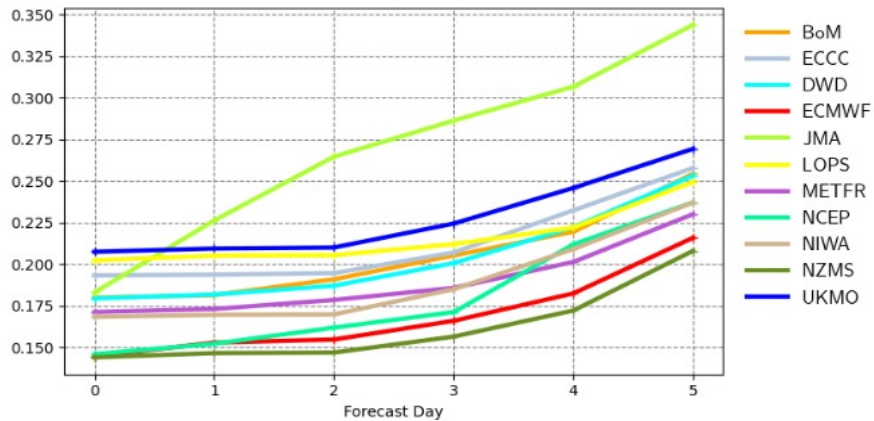


MOS Wave Forecast System – WFV

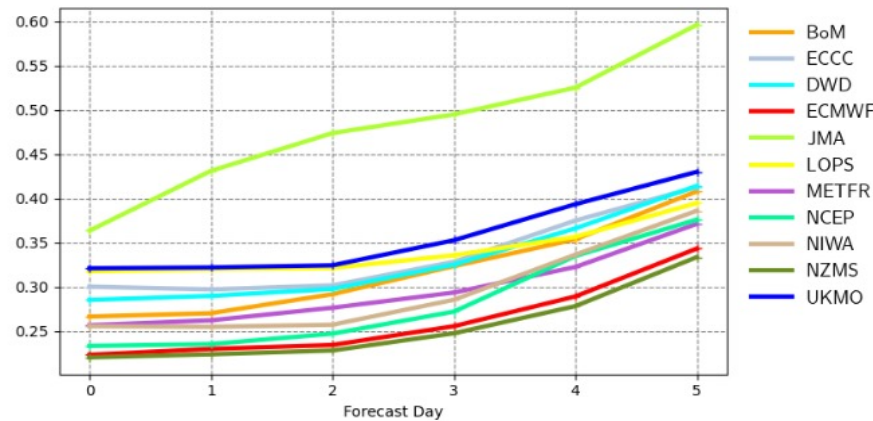


- WMO Wave Forecast Verification WFV, led by ECMWF (old JCOMM program)
- ~15 participant centres
- Global and region-based performance
- Latest report for JJA: MS had best performance for Aus-NZ in terms of SI and RMSE

Scatter index | significant wave height | Eastern Australia and New Zealand
20230601 00z to 20230831 12z | waveapi lw wave prod mean_fair



Root mean square error | significant wave height | Eastern Australia and New Zealand
20230601 00z to 20230831 12z | waveapi lw wave prod mean_fair



DevOps Roadmap

- Global current forcing into WW3: Mercator+TPOXv2 blend (under testing)
- Integration of ROMs currents in the regional SWAN nests
- Statistical downscaling of model grids: 2 testing nests operational (Taranaki, Wellington)
- Statistical downscaling applied to Ensemble Probabilistic Forecast: testing operational
- Global data assimilation (DA) of altimetry Hs
- Coastal DA of buoy spectra
- Improving statistical post-processing of site forecast using ML methods





Thank you

