COSIMA workshop, Nov 2022,
on muwinina country, nipaluna (Hobart),
lutrawita(Tasmania)

Revisiting the eReefs hydrodynamic and tidal model

Lessons learnt from recent re-development of the nesting strategy from global to coastal

Clothilde Langlais, Mathieu Mongin, Jenny Skerratt, Jodie Schlaefer, Emlyn Jones, Mark Baird

https://research.csiro.au/cem/

https://ereefs.org.au/ereefs

eReefs project

since Jan 2012

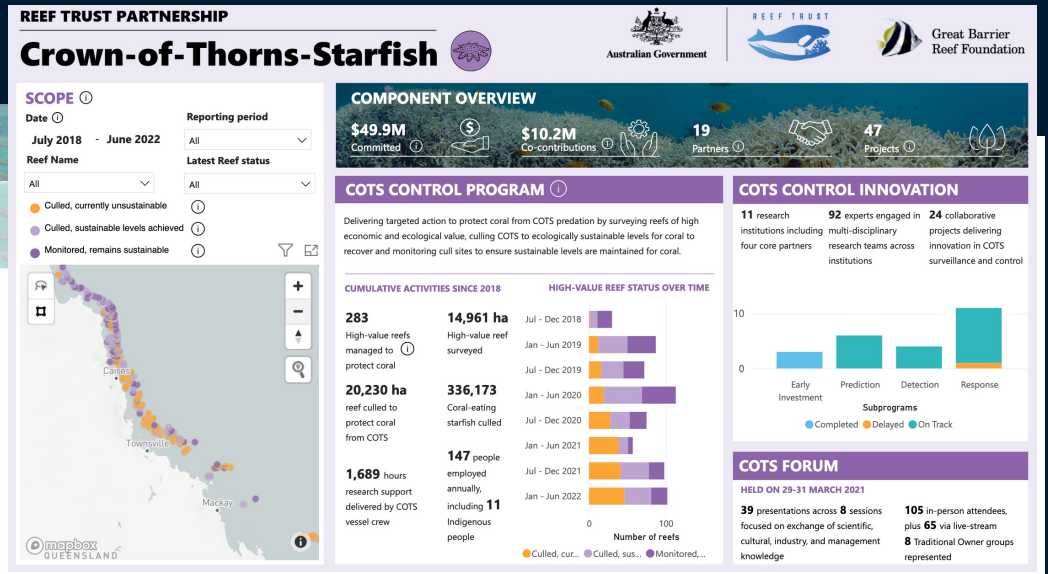
What do GBR managers need to protect the reef ? (apart from reduced carbon emissions)

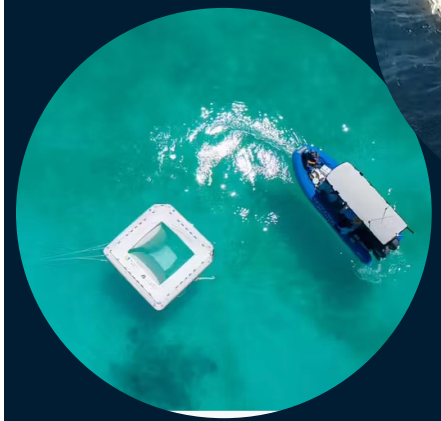
Forecasting and modelling platform:

Assess: water quality and pollution , coral bleaching, Nutrient supply, DIC supply (acidification)

Inform: interventions and restorations:

- Policy strategic plans - estimate reef health with reanalysis
- Catchment repair and management strategies – scenarios of catchment load in the rivers
- RRAP – Reef Restoration and Adaptation Program : moving corals, connectivity , cooling and shading.
- CCIP – Crown of Thorns starfish Control and Intervention program





eReefs modelling platform

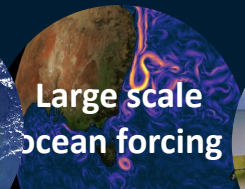
CSIRO Environmental Modelling Suite EMS: hydrodynamics, waves, sediment transport, biogeochemistry, ocean optics, coral model and data assimilation.

Key BGC features:
- C/N/P cycling
- 4 phyto - benthic microalgae – 2 zoo
- 3-stage detrital pathways

Unique features:
- seagrass, macroalgae and corals in sediment zone
- Spectrally resolved optical model, including remote-sensing reflectance

Key sediments
- Suspended particles (silt and mud)
- Settled gravel, silt, mud and sand surfaces

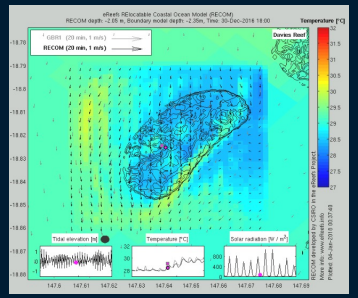
Key hydro features
- Orthogonal Curvilinear grid
- Non-linear free surface - tides
- Fixed z coordinates + Wetting/drying

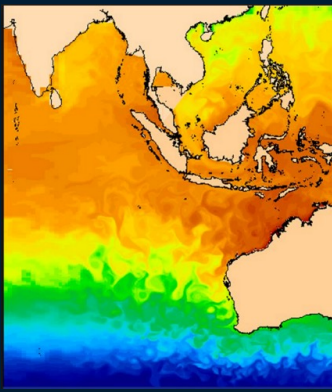


eReefs modelling strategy

Downscaling: A (multiple) 1way-nested modelling approach

Relocatable Coastal Model
RECOM





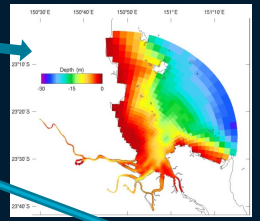
NCI
NATIONAL COMPUTATIONAL INFRASTRUCTURE
nci.org.au

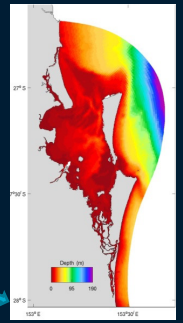
Catalog https://dapds00.nci.org.au/thredds/catalogs/fx3/catalog.html

Dataset

- eReefs GBR4 hydrodynamic v1.85 model data/
- eReefs GBR4 hydrodynamic v2.0 model data/
- eReefs GBR1 Hydrodynamic v1.71 model data/
- eReefs GBR1 Hydrodynamic v2.0 model data/
- eReefs GBR4 BGC and sediments v924 model data/
- eReefs GBR4 BGC and sediments v926 model data/
- eReefs GBR1 BGC and sediments v924 model data/
- eReefs GBR4 rivers v2.0 model data/
- eReefs GBR1 rivers v2.0 model data/
- eReefs GBR1 biogeochemistry and sediments v3.2/
- eReefs GBR4 biogeochemistry and sediments v3.1/

Bay/Estuary models(100-500m)





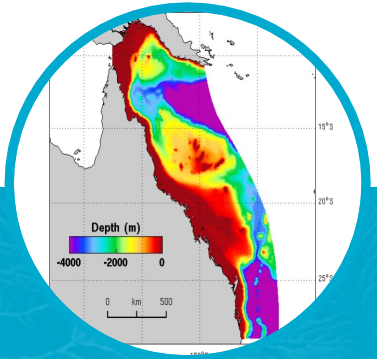
Bluelink
Ocean Forecasting

Hydro v2: Sep 2010 to now
Archive appended with NRT

Dec 2014 to now
Archive appended with NRT

Coastal modelling platform - Environmental Modelling Suite EMS: hydrodynamics, waves, sediment transport, biogeochemistry, ocean optics, coral model and data assimilation.

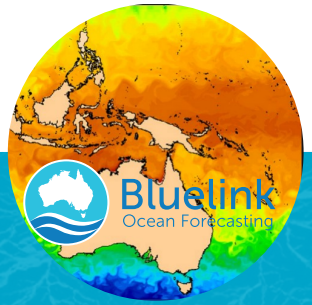
Lessons learnt from recent re-development of the hydrodynamical configuration



GBR4
Hydro v3

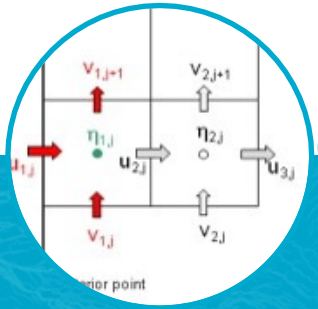
FORCINGS

River forcing update
From 21 to 63 rivers

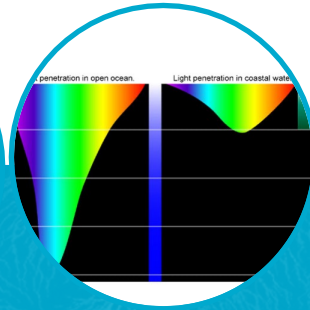


From a NRT growing archive towards an hindcast
+
Land masking

PARAMETERIZATION



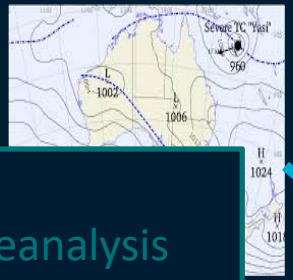
1way nesting update
+
Relaxation update



Heat penetration update

eReefs hydro v3 – hindcast

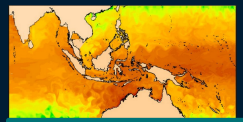
Atmospheric boundary



Hydro v3
BARRAv1 reanalysis
12km
1990-2019

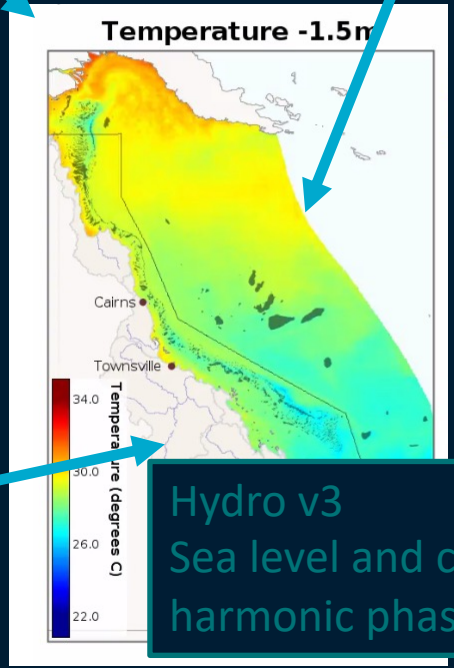
Ocean open boundary conditions

- 3 OBC
- Large scale circulation – U, V, temperature, salinity, sea level



Bluelink Ocean Forecasting

Hydro v3
The latest global ocean reanalysis
BRAN2020
1993-2020



Rivers: flow and temperature

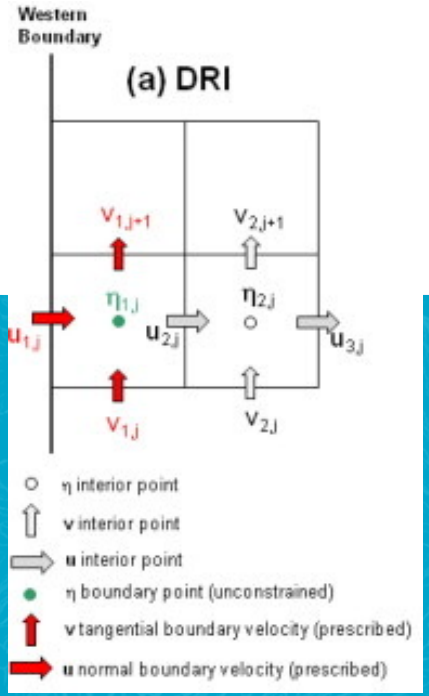
Hydro v3 : 63 rivers
- BoM – G2G model : 58 rivers
- Source catchment model: 4 rivers
- Climatology : Fly river

- Tides – sea level

Hydro v3
Sea level and currents
harmonic phases and amplitudes from TPXO

1way nesting or the art of getting a stable and realistic solution

Dirichlet conditions [Herzfeld,2009; Herzfeld and Andrewartha, 2012]



prescribe the 3D flow structure through the water column

Hydro v3
+ tidal velocities

<u>To allow waves to freely exit the domain:</u>

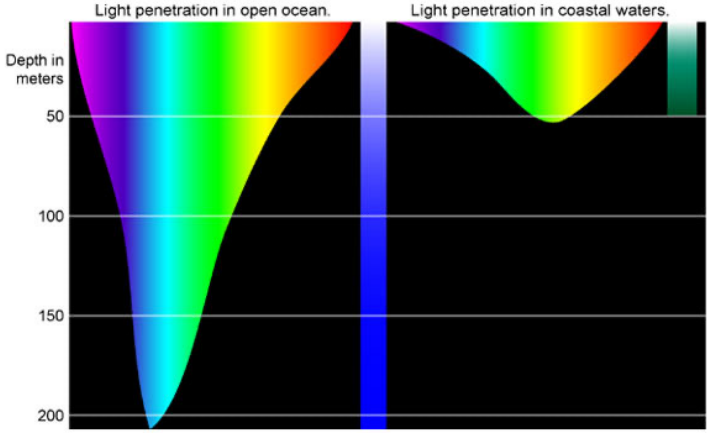
- Elevation is computed via the governing equations
- Normal velocity outside the elevation node
- u2,j unconstrained by prescribed u1,j, in the linear terms of the equations of motion

<u>To maintain volume conservation and allow fluctuation in basin volume: Local flux adjustment</u>

- relax barotropic flow to a target elevation (by inversely solving the continuity equation).
- The target elevation = low frequency elevation from parent model + tidal elevation+ elevation due to the inverse barometer effect.
- Dual relaxation for low frequency elevation and tidal elevation

+ Adjust dual relaxation time-scale to get a realistic solution
+ no more 3D relaxation towards BRAN

Heat penetration parameters in EMS

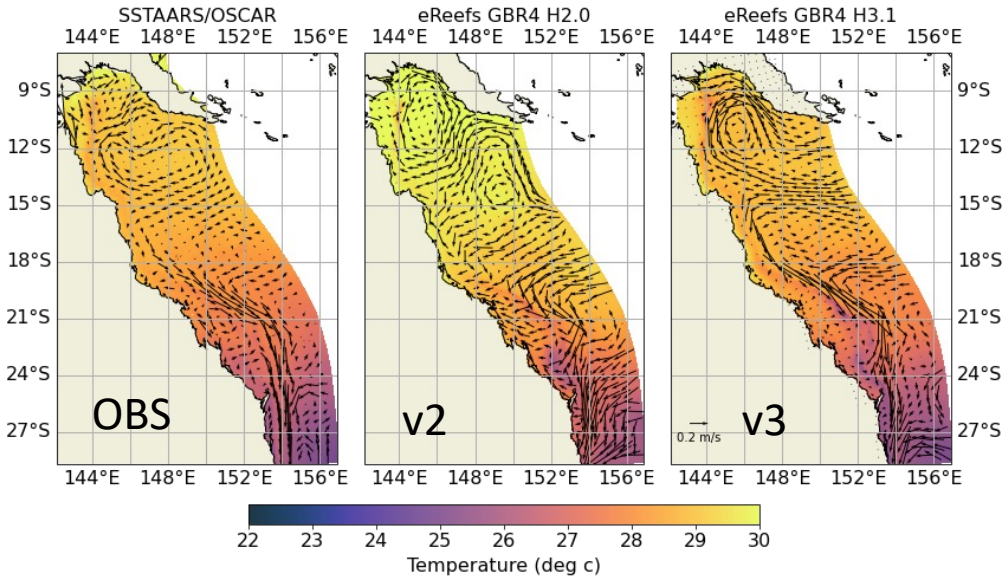


- Short wave radiation attenuation
- Short wave radiation transmission
- Short wave radiation bottom absorption

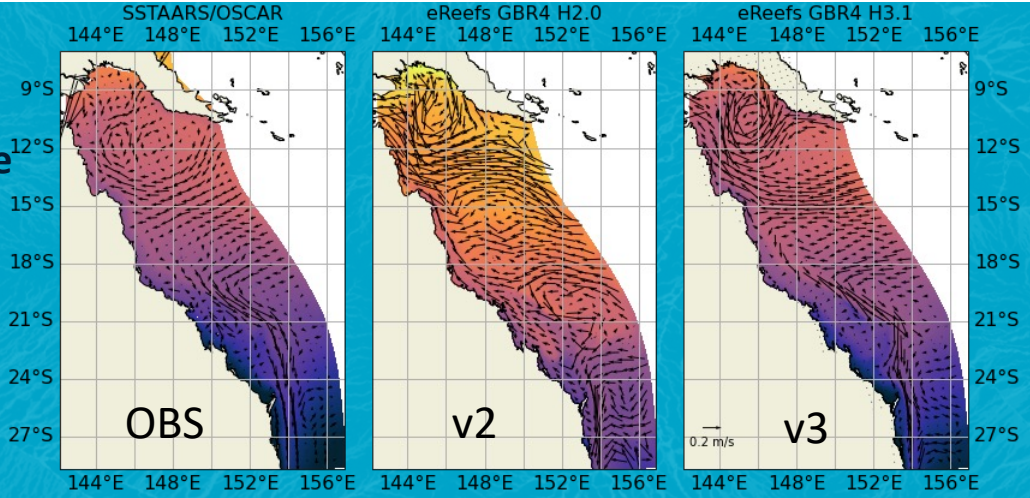
Hydro v2 : static 2D fields

Hydro v3 : time-variant 2D vertical attenuation from the BGC model

Monsoon season temperature and circulation



Trade season temperature and circulation



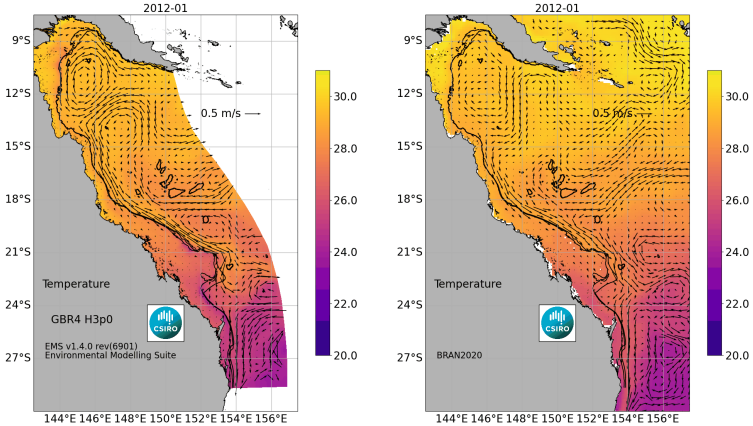
Lessons:

- Regional models will always be as good as their forcing fields
- Heat penetration + land masking : local improvements
- 1way nesting was fiddly but rewarding:
  - Shelf break currents
  - Exchanges
  - No relaxation
- 63 rivers + no relaxation : impact on freshwater budget on the shelf and GBR lagoon

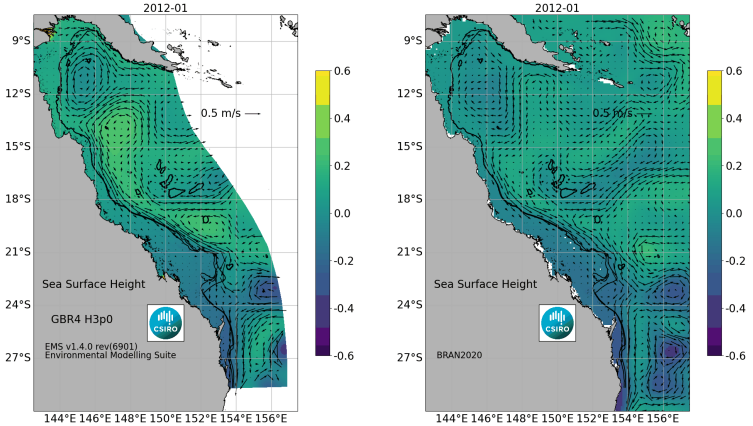
Hydro v3

BRAN

SST



SSH



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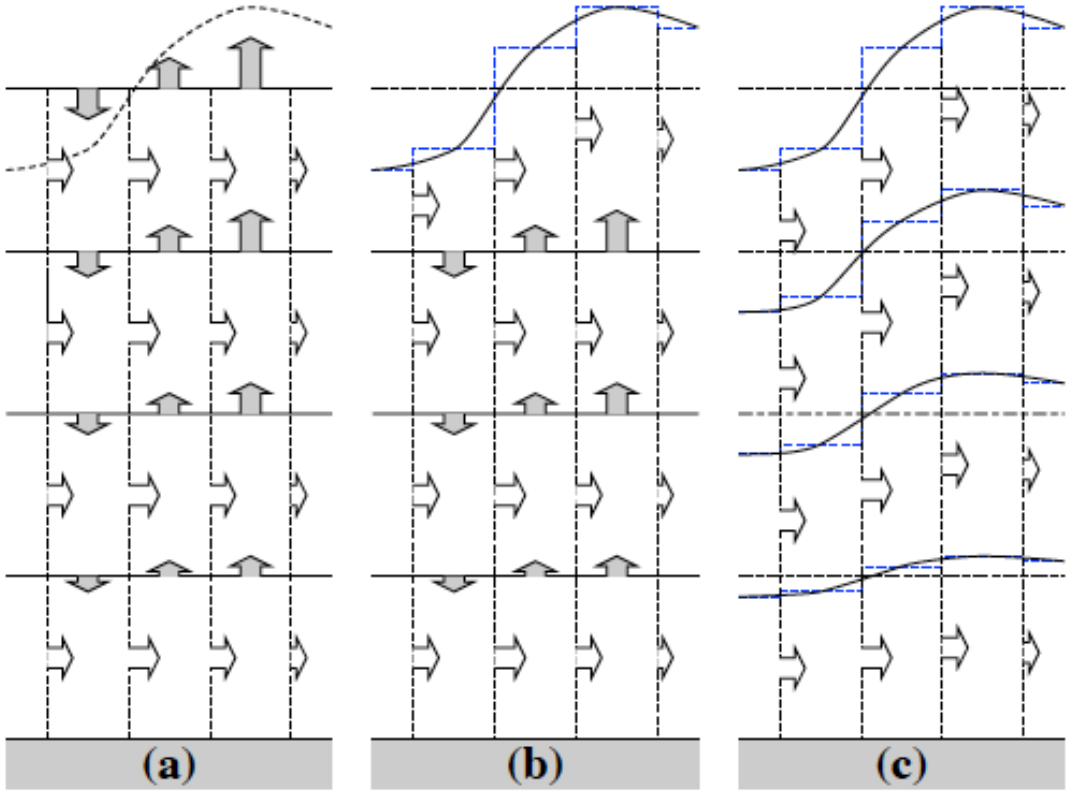
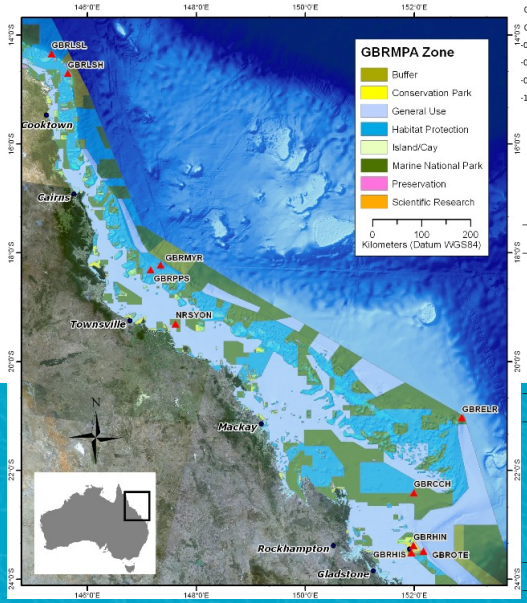
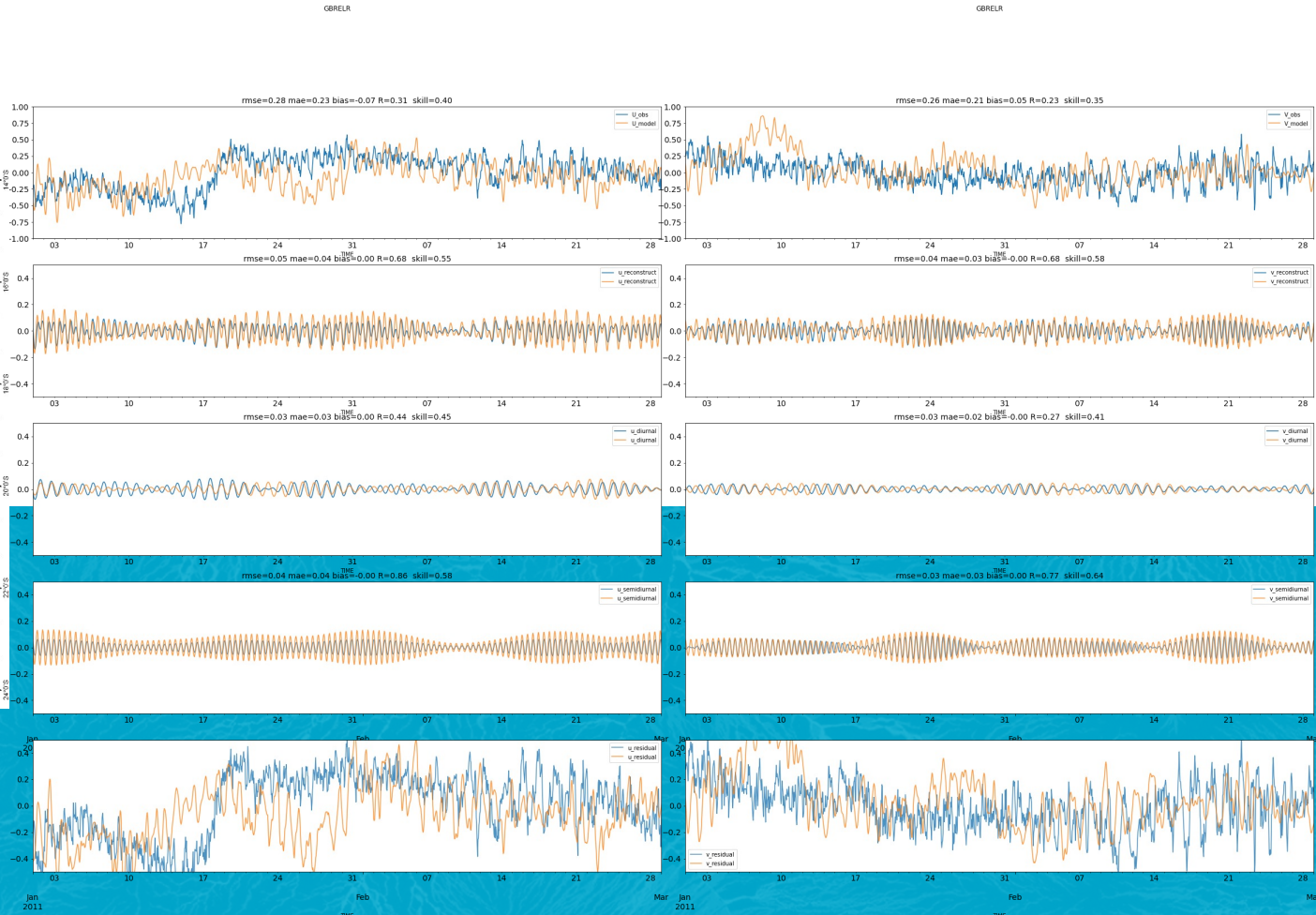


Figure 2.3: (a) z-coordinate in linear free-surface case ; (b) $z-$coordinate in non-linear free surface case ; (c) re-scaled height coordinate (become popular as the z^*-coordinate [Adcroft and Campin 2004]).


GBRMPA Zone
Buffer
Conservation Park
General Use
Habitat Protection
Island/Cay
Marine National Park
Preservation
Scientific Research
0 100 200
Kilometers (Datum WGS84)
GBRLSL
GBRLSH
Cooktown
Cairns
GBRMYR
GBRPPS
NRSYON
Townsville
Mackay
GBRELR
GBRCCH
GBRHIN
GBROTE
GBRHIS
Rockhampton
Gladstone
N
146°0'E
148°0'E
150°0'E
152°0'E
14°0'S
16°0'S
18°0'S
20°0'S
22°0'S
24°0'S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Jan 2011
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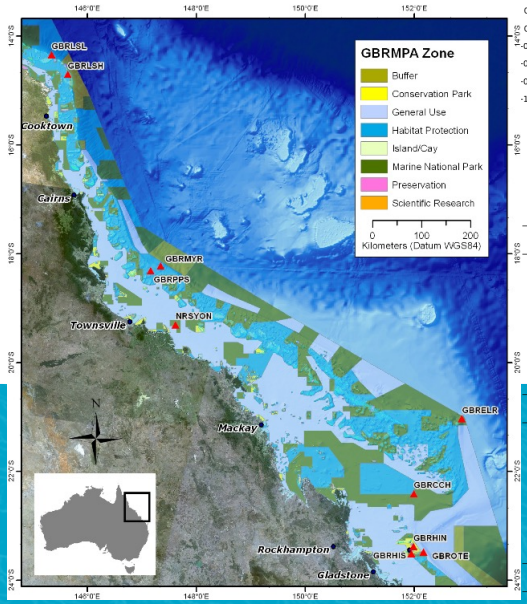
TIME


GBRMPA Zone
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146°0'E
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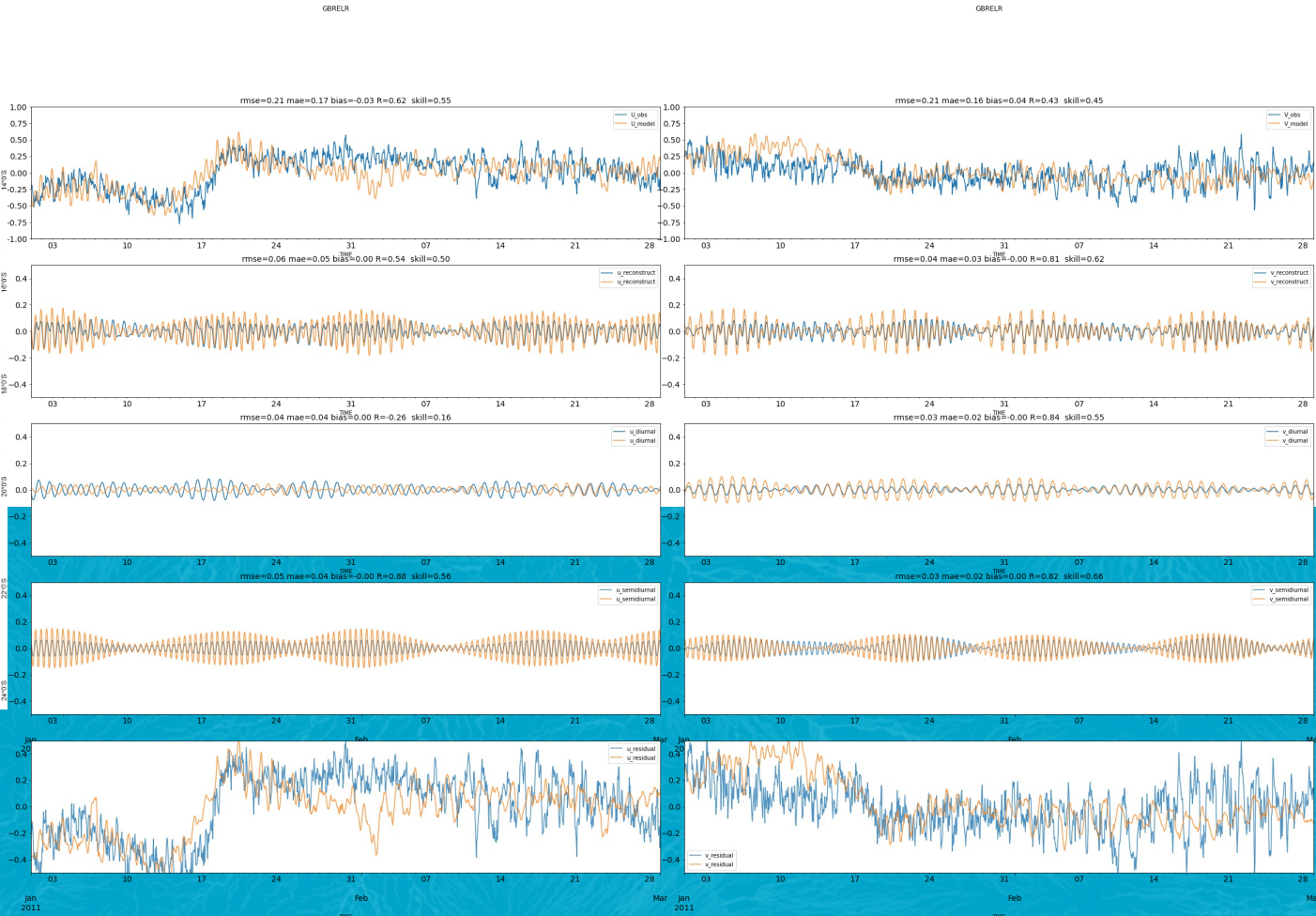
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U_model
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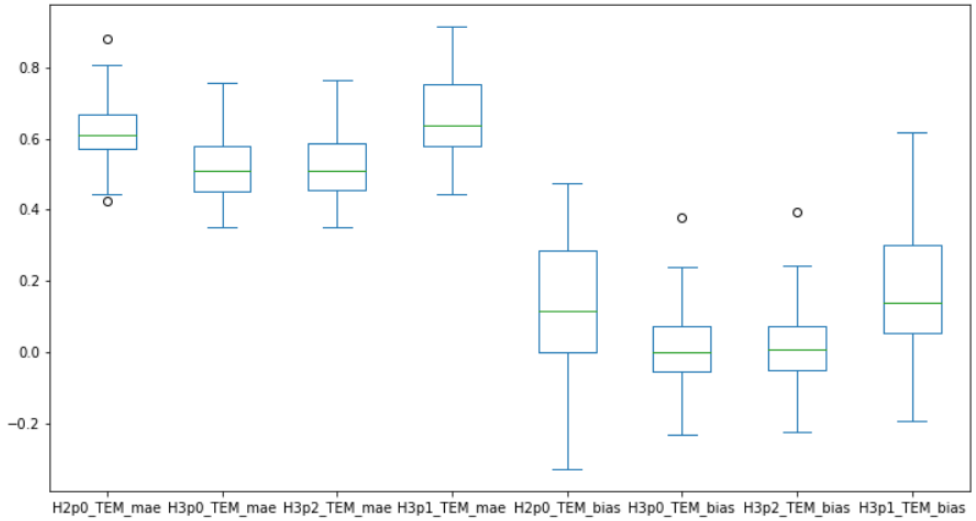
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H3p0_TEM_mae
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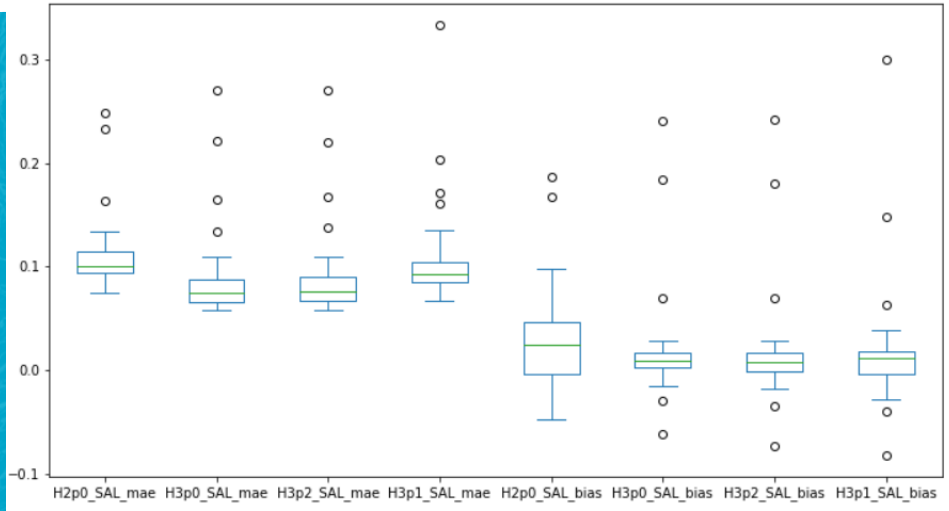
H3p0_TEM_bias
H3p2_TEM_bias
H3p1_TEM_bias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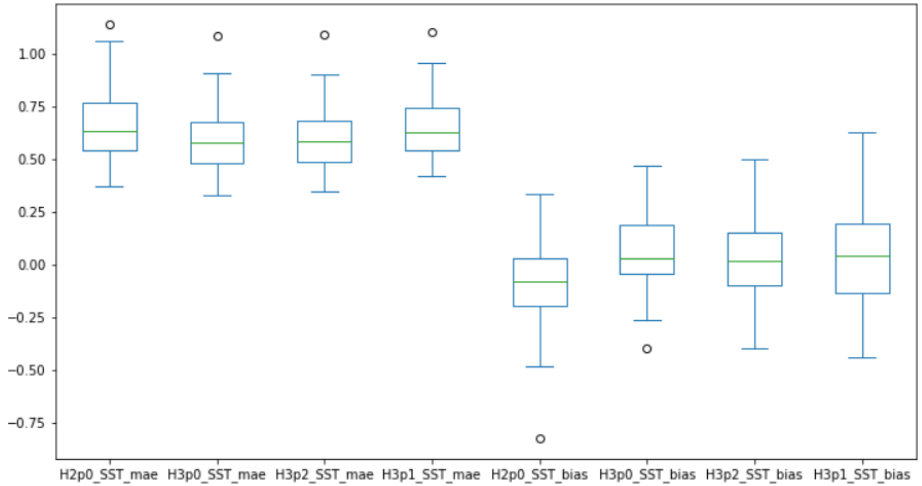
H3p2_SAL_bias
H3p1_SAL_bias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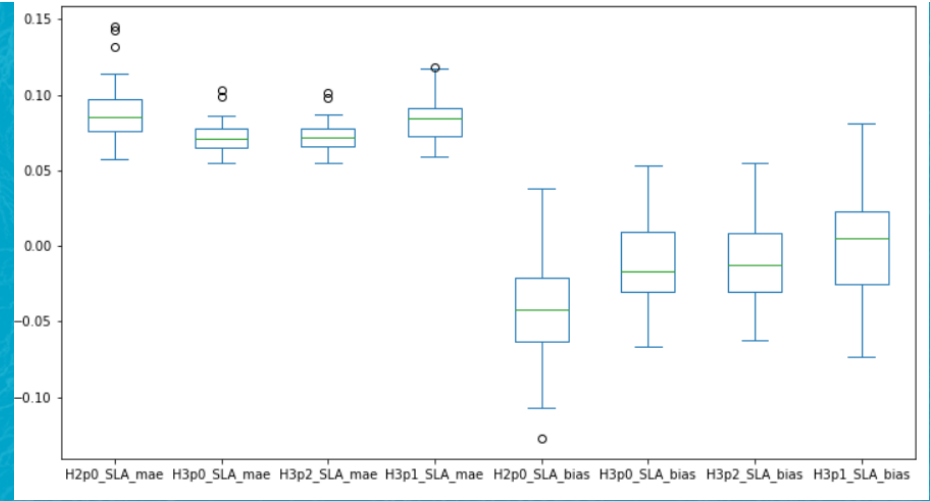
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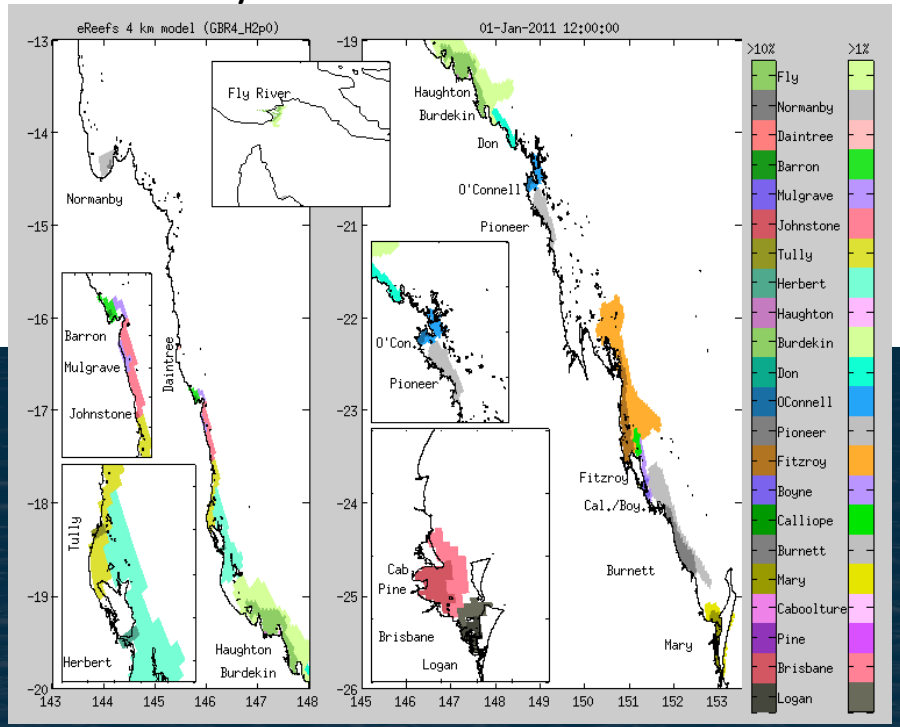
H3p0_SLA_bias
H3p2_SLA_bias
H3p1_SLA_bias

eReefs - River footprints in the GBR

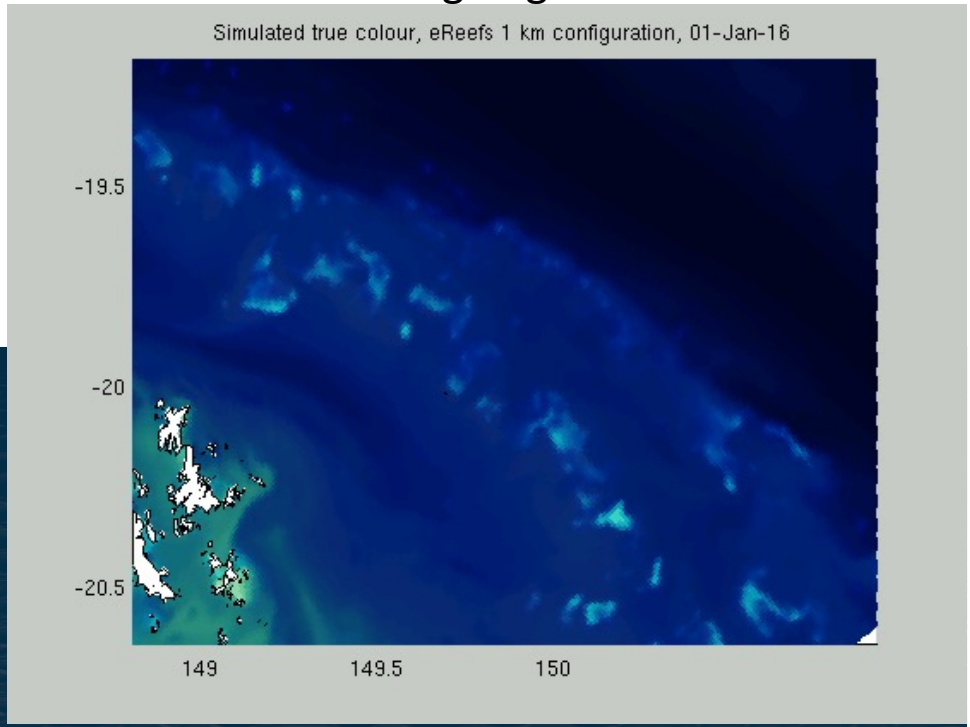
Mark Baird- Mathieu Mongin

Buoyant plume dynamics + tidal influence + filaments

Fitzroy river travels over 1000 km to far north Queensland during large rain events



GBR4 – 2011 flood



True colour GBR1 – 2016

Using the remote-sensing reflectance calculated by the optic model

RIVER forcing Summary

Previously (20 oz rivers) we had **332**
Same 20 rivers with BOM is **402**

Add 40 rivers an extra **124**

H3p0 as **527**