Adding surface wave model coupling to GC5

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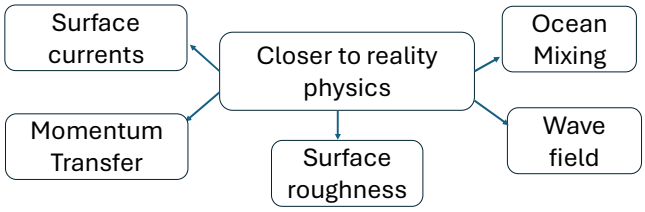
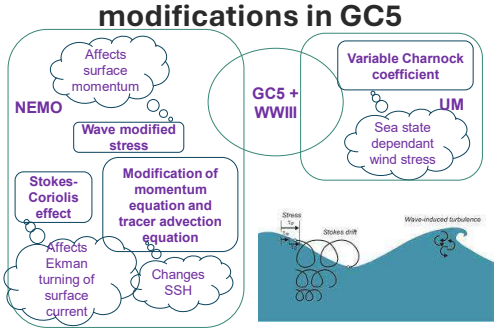
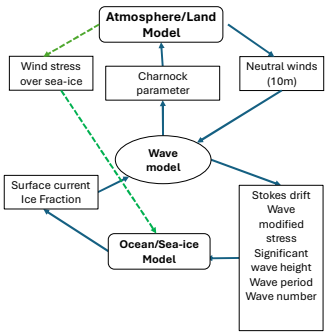
Why does Ocean-Wave-Atmosphere (OWA) coupling matter?



WAVEWATCHIII science modifications in GC5



Coupling



OWA Workflows

CLIMATE

UM	NEMO	WWIII
N96 (~150km) N216 (60km)	ORCA025 (~25 km)	SMC256A 50km grid (NO LEVELS). SMC61250 (4 Levels 6km, 12km, 25 km and 50km)

NWP

UM	NEMO	WWIII
N320 (40km) N1280 (10km)	ORCA025 (~25 km)	SMC256A 50km grid SMC512L3A (3 Levels 5km, 12km, 25 km) SMC512L4EUK(4 Levels 5km, 12km, 25km + additional UK coast level)

Table 1: Climate (left) and NWP (right) workflows and resolutions of individual model components

Various combination of individual model resolutions could be seamlessly selected from the workflow.

GC5Waves vs GC5 (50-year climate run)

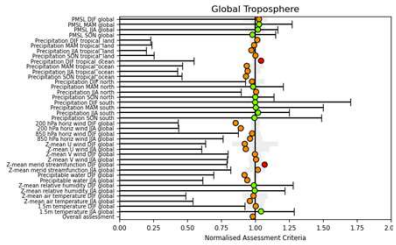


Fig 2: Global tropospheric metrics. Green dots shows improvement when waves are coupled, red shows deterioration and orange shows neutral change

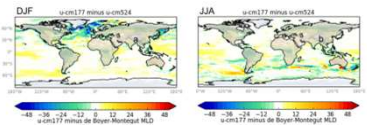


Fig 3: MLD difference (GC5waves-GC5). Strong seasonality in MLD is seen

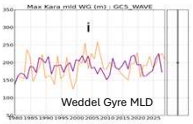


Fig 5: Annual mean MLD at Weddel Gyre GC5waves (amber) and GC5 (purple)

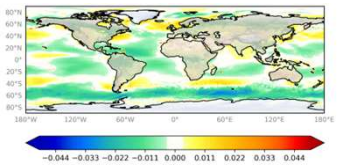


Fig 4: Annual mean difference in zonal wind stress (GC5waves-GC5)

Tropical cyclone NWP case studies

TC AMPHAN (May 2020)

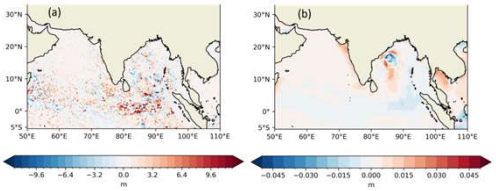


Fig 6: GC5waves-GC5 at 72nd hour (a) SST (b) SSH

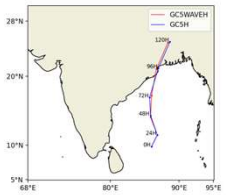


Fig 7: Location of lowest SLP

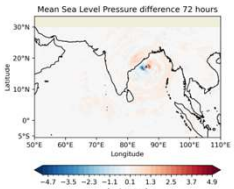


Fig 8: : GC5waves-GC5 at 72nd hour MSLP

- 14 case studies were performed using both OWA coupled, and OA coupled workflows.
- OWA coupling tend to weaken the TC's
- This might be due to increased drag by waves.
- We have put a cap on Charnock parameter to tackle this issue.

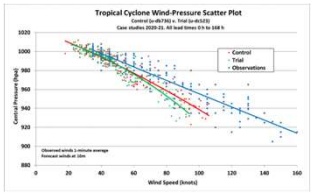


Fig 9: Wind-Pressure scatter from all TC's OWA coupling (green) tends to weaken the TCs.

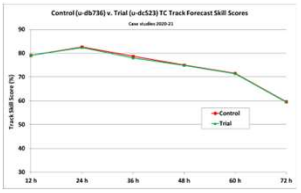


Fig 10: Track forecast skill. Not significantly different.

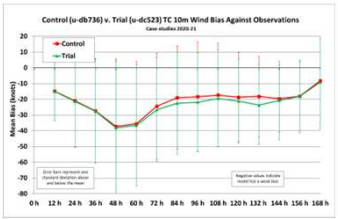


Fig 11: 10m wind bias. Weaker winds in OWA coupling

Initialized on	length	TC name
2020-05-16 T12	7 days	Amphan IO BOB
2020-10-05 T12	7days	Delta Atlantic
2020-10-29 T00	7days	Zeta Atlantic
2020-11-08 T12	7days	Goni Pacific -Philippines
2020-11-10 T00	7days	Theta Atlantic
2021-01-19 T00	7days	Eloise IO Madagascar
2021-04-05 T00	7days	Seroja IO Indonesia
2021-05-14 T12	7days	Tauktae IO Arabian Sea
2021-07-14 T12	7days	Elsa Pacific Caribbean
2021-08-27 T00	7days	Ida Atlantic Cuba
2021-09-07 T00	7days	Typhoon Jolina Philippines
2021-09-24 T00	7days	Gulab IO BOB
2021-12-14 T00	7days	Ruby Pacific Australia
2022-01-28 T00	7days	Ana IO Madagascar

Table 2: List of TC cases explored

Swell surge (*Kallakadal*) events in the Indian Ocean

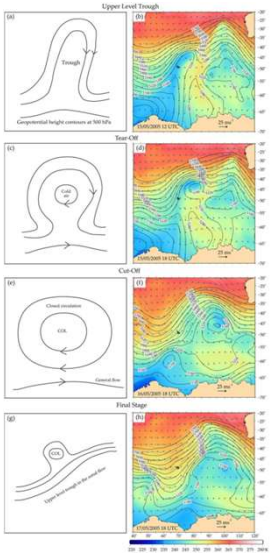


Fig 12; (Left) Schematic of various stages of Cut-Off Low development over southern hemisphere. (Right). Cut off low development during 15-17 May 2005. Temperature (shaded; K), geopotential height (contour; gpm) and winds (vectors; m/s) are used to depict the different stages of Cut-Off Low. Remya et al., (2016)

- Persistent cut-off lows tend to appear in the southern Indian Ocean (SOI).
- These cut-off lows generate swell waves which travels from SOI and reach the Indian coast causing flash floods and swell surges.
- Due to the decoupled nature of these surges with local winds its colloquially known as Kallakadal
- In collaboration with INCOIS, India we are deploying GC5-waves to study the swell surge process.

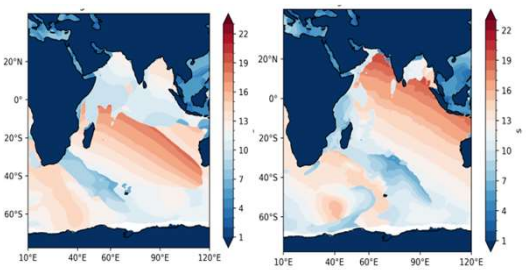


Fig 13: Wave period simulated by GC5 waves which show long period swells travelling from Southern Indian Ocean and reaching the Indian coast.

Currently under development

- Porting all workflows to the new HPC
- Adding sea-ice wave interaction
- Using wave-ocean coupling to enhance TKE mixing scheme, so that wave induced mixing and Langmuir circulation is better represented.
- Modifying sea-ice albedo calculation in Jules to include sea state information coupled from the wave model.
- Coupling wind stress directly from UM to surface wave model instead of neutral winds.

Summary

- A GC5 model with surface wave model is now available.
- Changes associated with OWA coupling with respect to OA is mostly neutral and within the range understood by scientific knowledge
- Deeper investigation is needed to understand the effects of OWA coupling in seasonal to decadal timescales.
- We hope to have OWA coupling as a standard option in GC7.

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