Adding wave model coupling to the Met Office GC5 global coupled modelling system

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4th Workshop on waves and storm surges.

22nd-26th September 2025

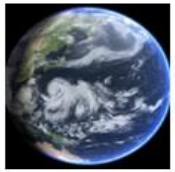
Santander, Spain

Newton Fund

www.metoffice.gov.uk

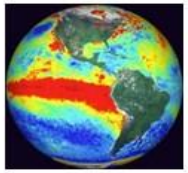
Global Seamless Physical Model

Hours | Days. | Weeks | Months | Seasons | Decades | Centuries



NWP

MOGREPS



CLIMATE

UKESM

Deterministic Atmosphere & Marine

Atmos. Ensemble

GloSea (Seasonal)

DePreSys (Decadal)

Climate Change UKESM1, UKCP18

Component Models

GAL, GO, GSI, GW

Global Coupled

GC Model

GC.x

Met Office Unified Model™ Global Atmosphere

JULES Global Land

NEMO Global Ocean

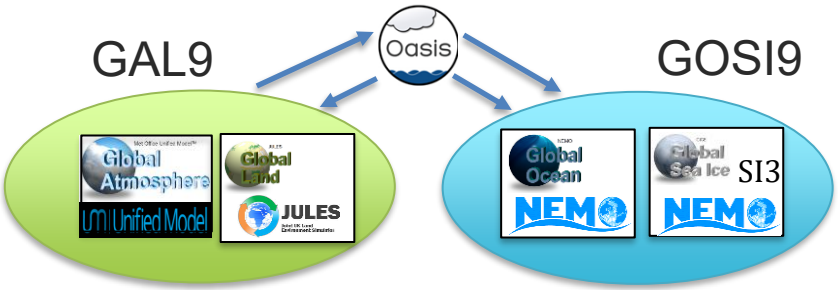
CICE Global Sea Ice

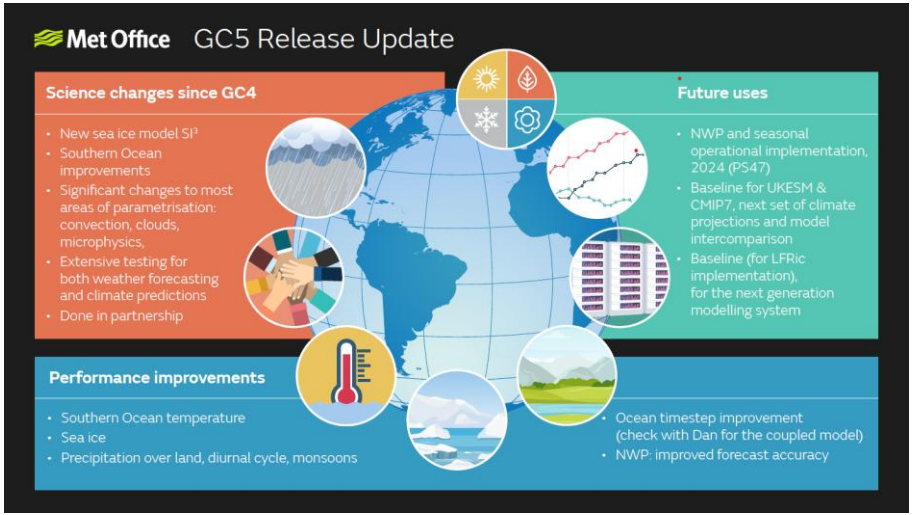
WaveWatch III Global Waves

UKCA

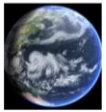
GC5 Release announcement

GC5 Global Coupled Model Configuration





Hours Days. Weeks Months Seasons Decades Centuries



NWP

Deterministic Atmosphere & Marine

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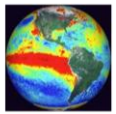


GloSea (Seasonal)

CLIMATE

DePreSys (Decadal)

UKESM

Climate Change UKESM UKCP

Natural Environment Research Council

Australian Government Bureau of Meteorology

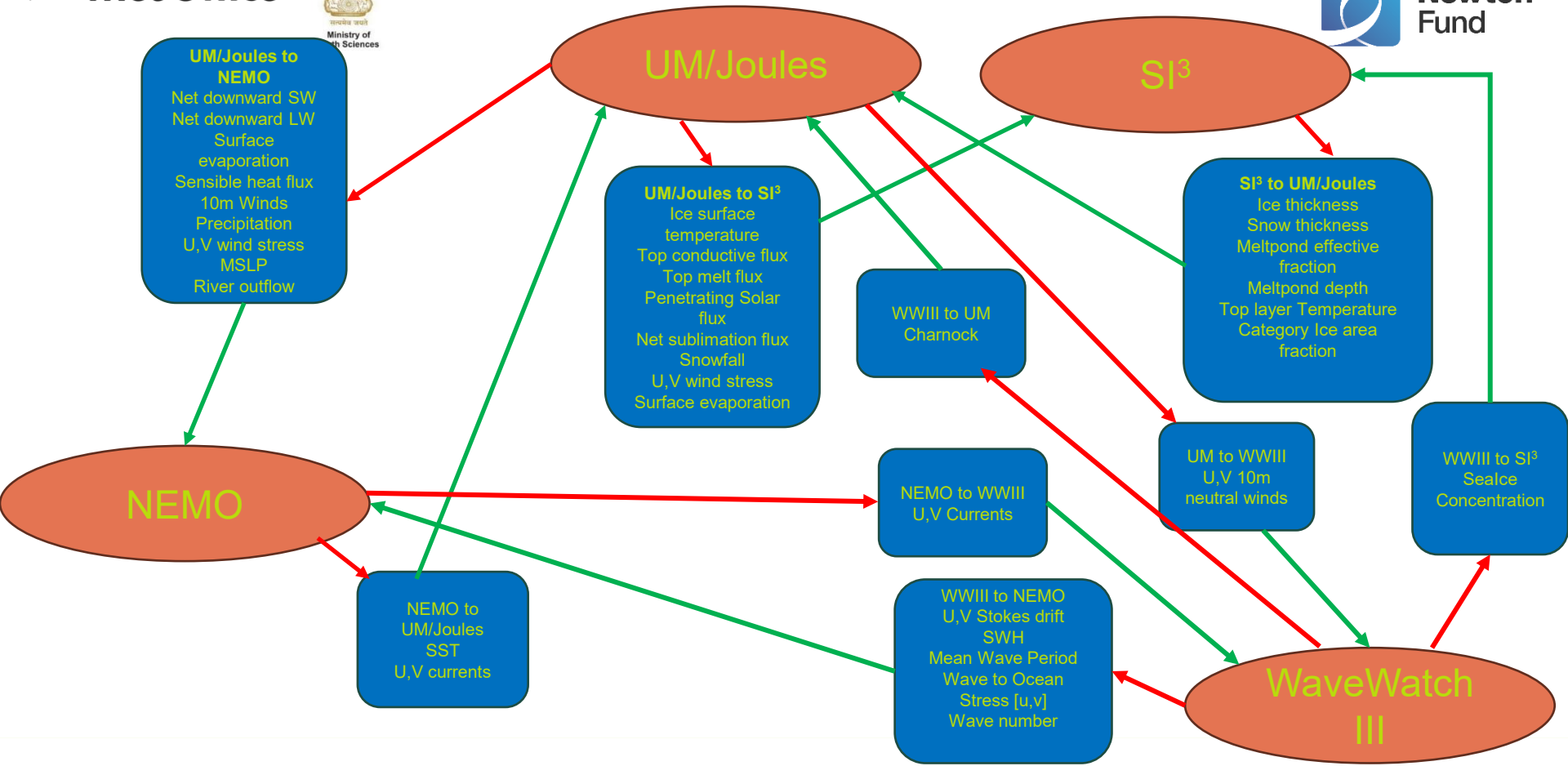
CSIRO

Ministry of Earth Sciences

기상청 Korea Meteorological Administration

NIWA Taihoro Nukurangi

Coupling and variables exchanged



WAVEWATCH III modifications in GC5

NEMO

Affects surface momentum

Mixing by non-breaking waves

Wave modified stress

3D Stokes drift

Modification of momentum equation and tracer advection equation

Stokes-Coriolis effect

Affects Ekman turning of surface current

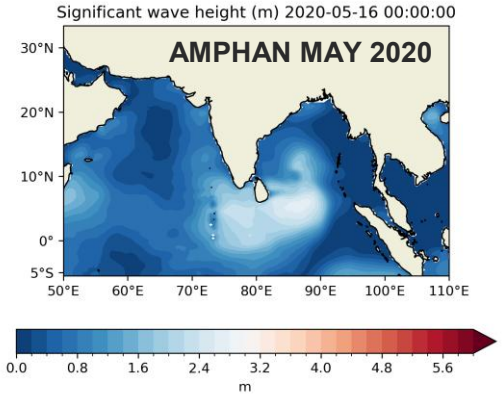
Changes SSH Currents

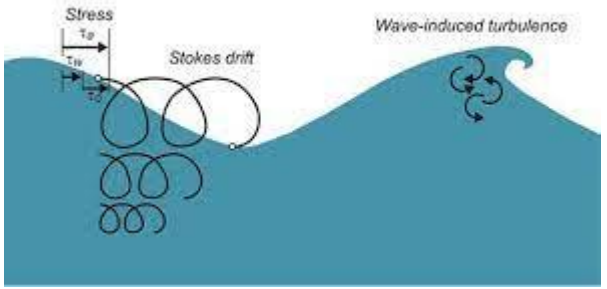
GC5 + WWIII

Variable Charnock coefficient

UM

Roughness length Calculations BL





Current State of Affairs: 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)

Results shown
50-year present day
climate (yr 2000 GHF)

NWP Case Study

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

Same resolution as MO global operational forecast system.

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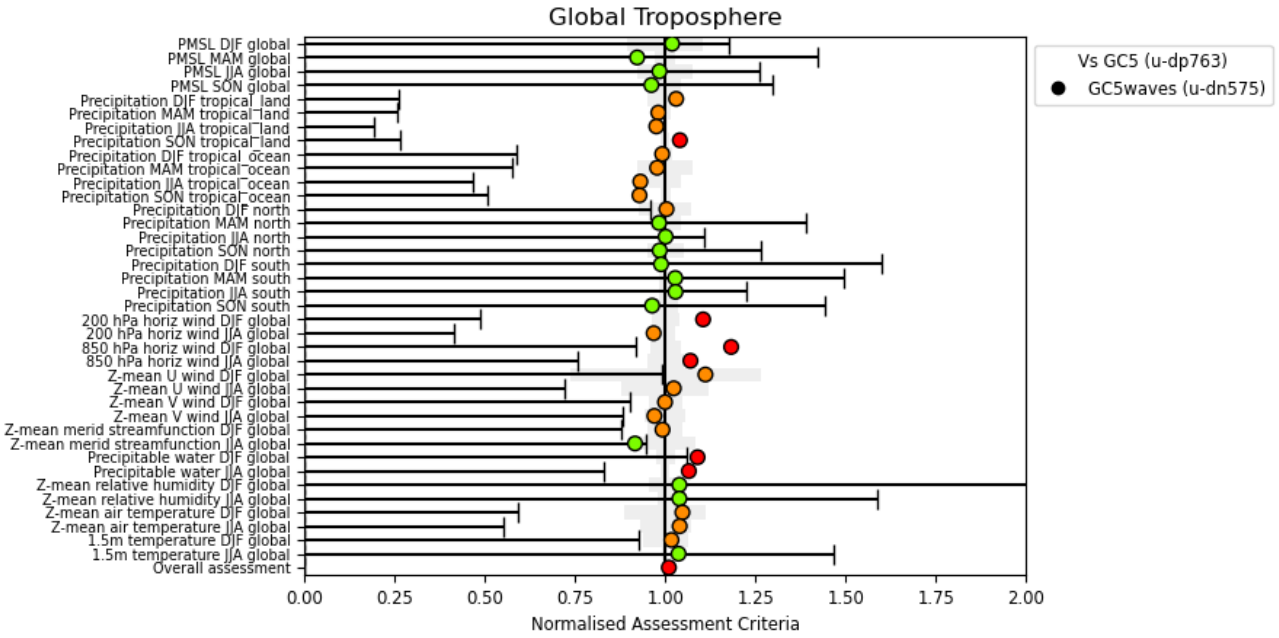
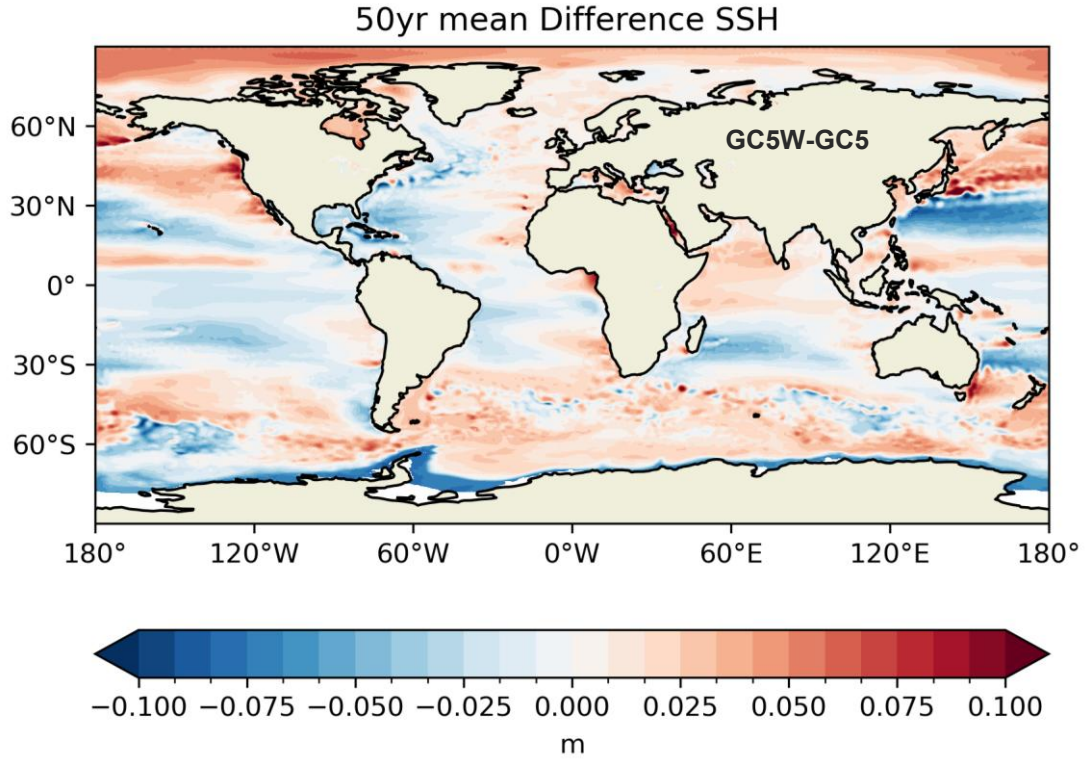
Tropospheric metrices from climate simulation.



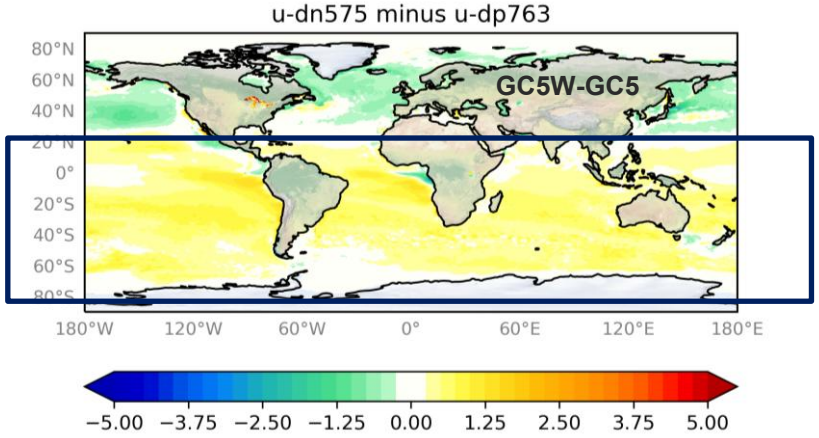
- Most changes in the Atmosphere model are neutral.
- Slightly better seasonal precipitation.
- Slight modifications in sea surface albedo.

SSH changes in NEMO with Wave coupling

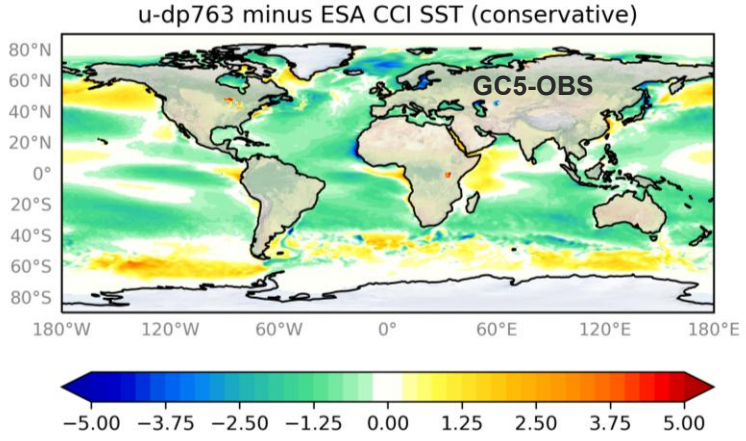


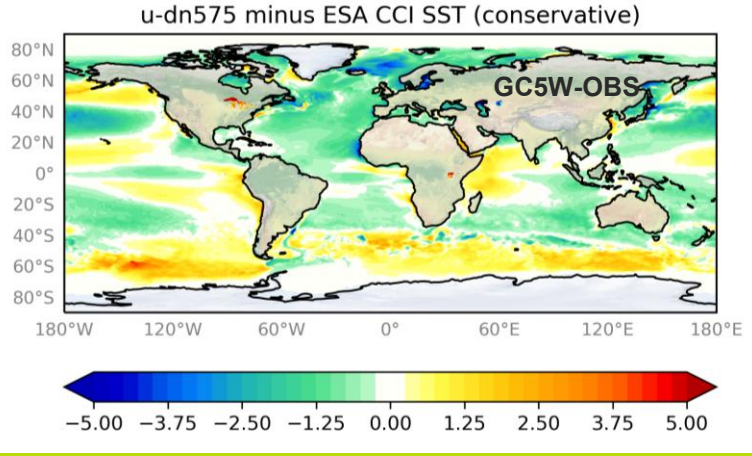
- Significant changes in SSH
- Indicating strong influence on Upper ocean dynamics

SST changes and the curious case of SO warming



- Warm bias in SH.
- Reduces cold bias in tropical SH
- Exasperate warm bias in Southern Ocean (NOT GOOD)





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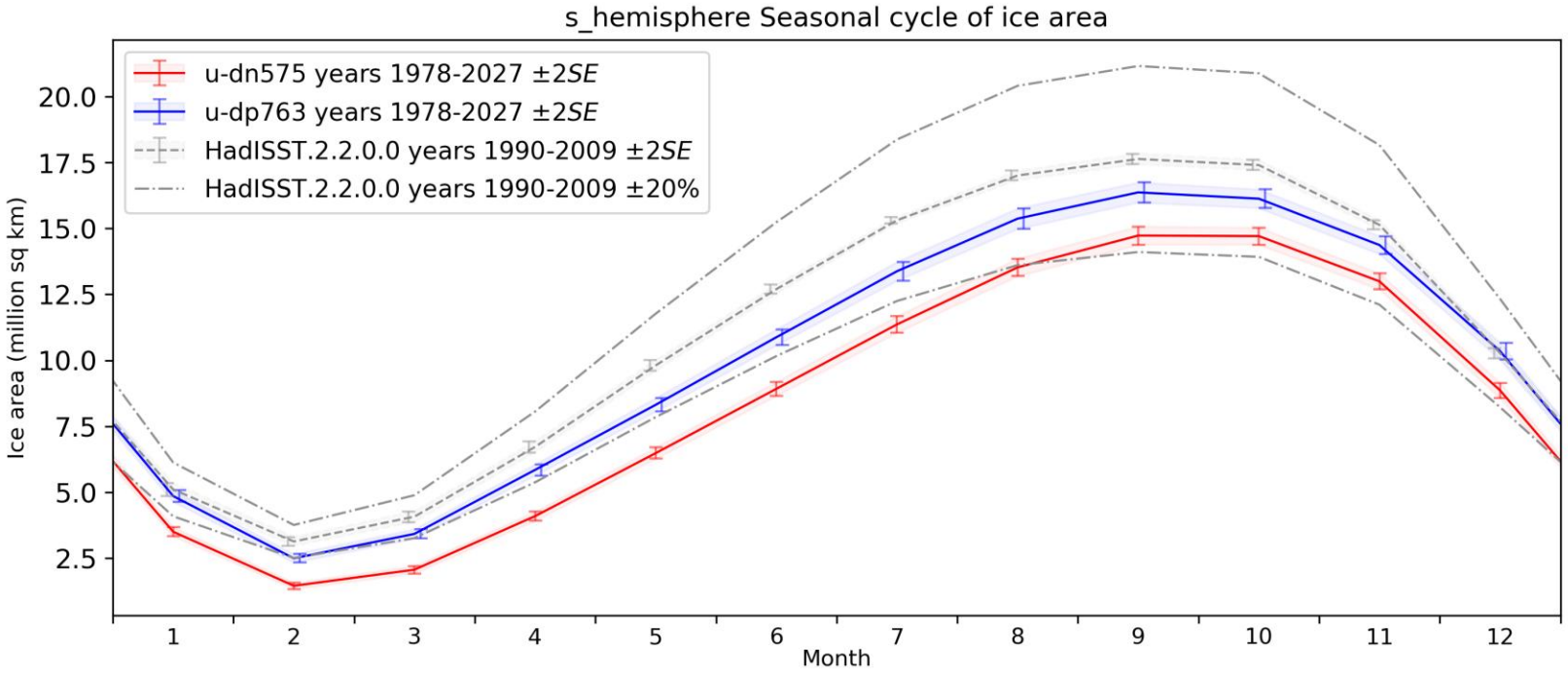

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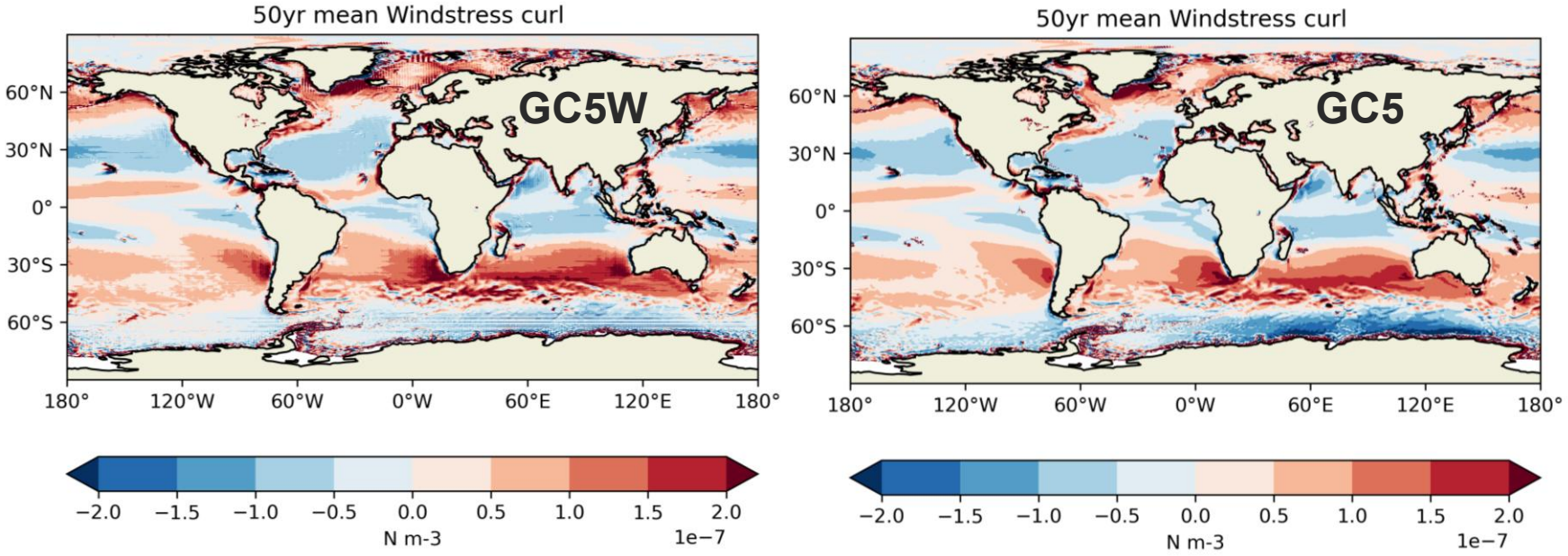
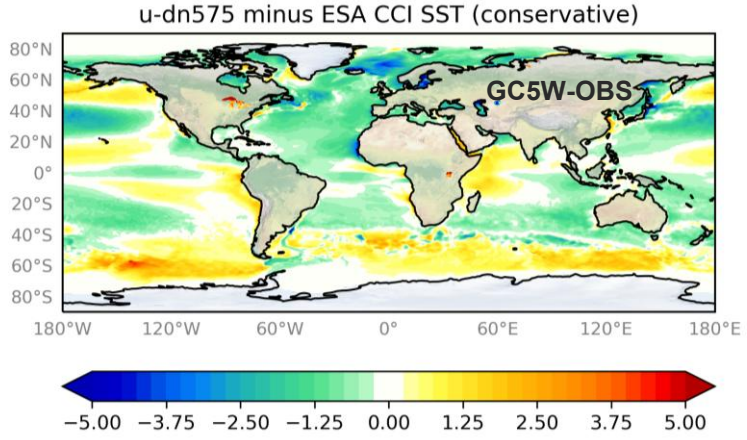


Choosing an apt tuning for NEMO when waves are coupled

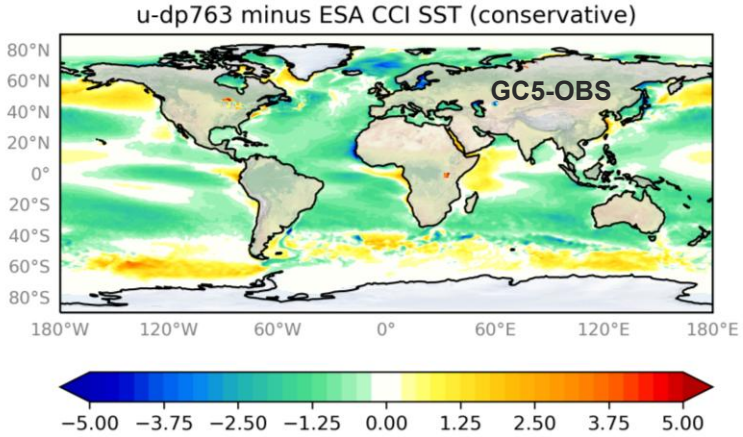
- nn_htau → Parameter which controls the depth of mixing within the TKE mixing scheme in NEMO.
- In GC5 (without waves), it is tuned to provide extra mixing to account for wave activity south of 40S.
- Series of experiments were done to stop “double counting of wave activity”

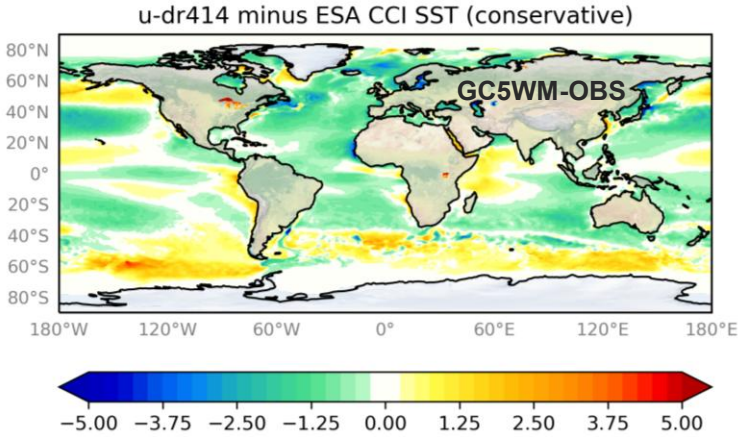
Shout out to Diego Bruciaferry

Paradoxical wave-ocean interaction



Taking out extra mixing in NEMO in SO reduced the warm bias





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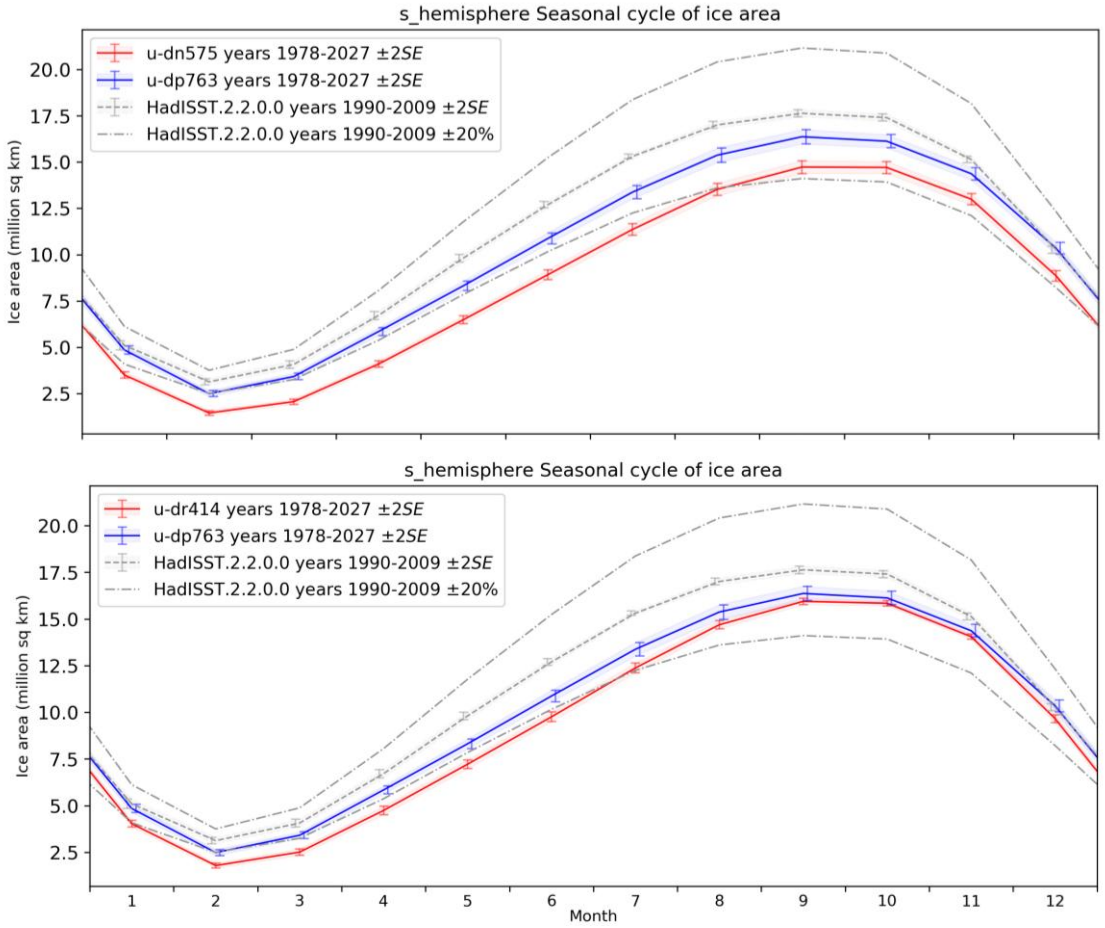
- Reduction of warm bias increased the sea-ice area.
- Wave-Ocean interactions are much more complex than expected.
- Does Ocean current feedbacks to waves explain this?
- Stokes Coriolis effect?
- Internal Waves?



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Summary

- WavewatchIII is coupled to the GC5 system.
- Currently effect of wave coupling to the atmosphere model is neutral.
- Ocean-Wave coupling is rather complex and need further investigation.
- Hopefully by GC7 wave coupling will be a part of Met Office global coupled model.

Questions?

For more information please contact

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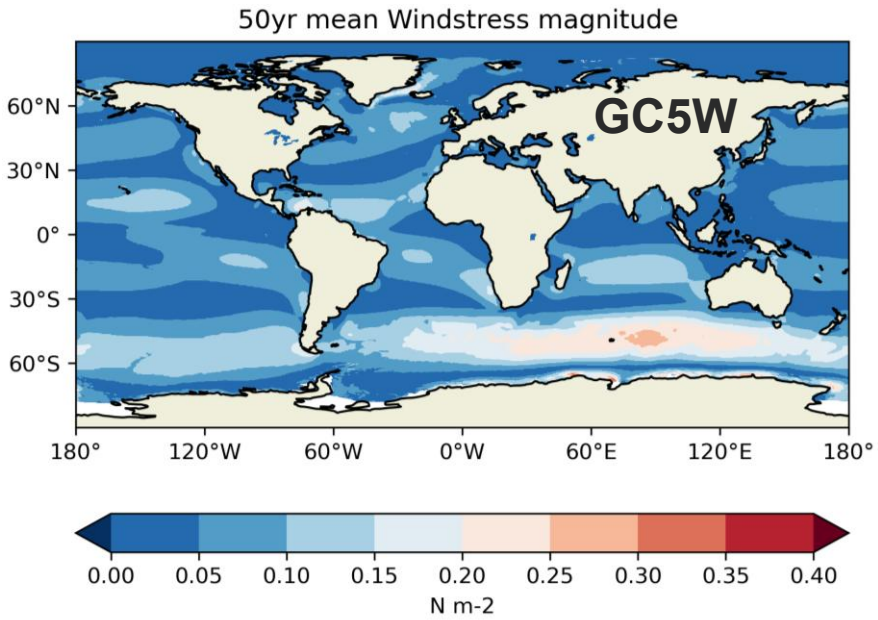
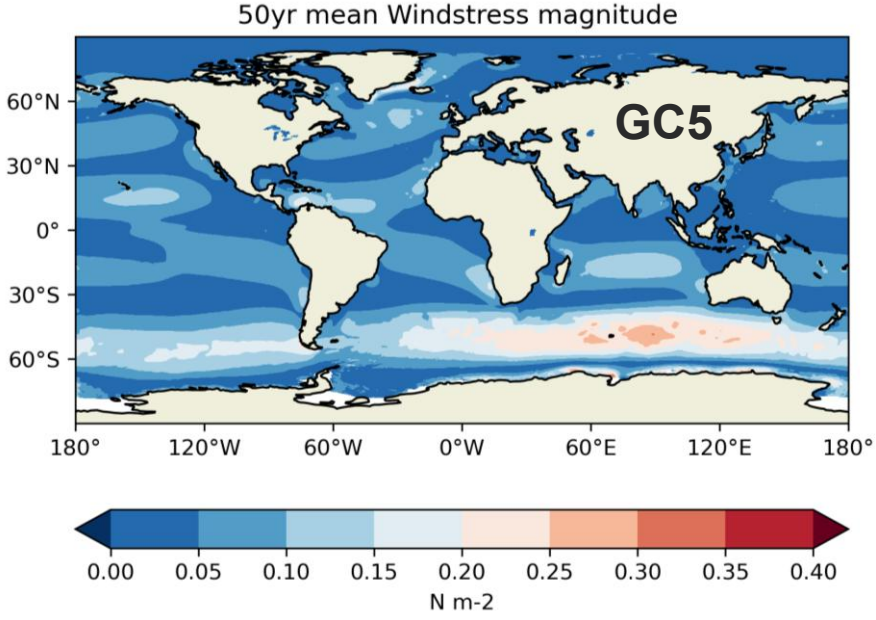
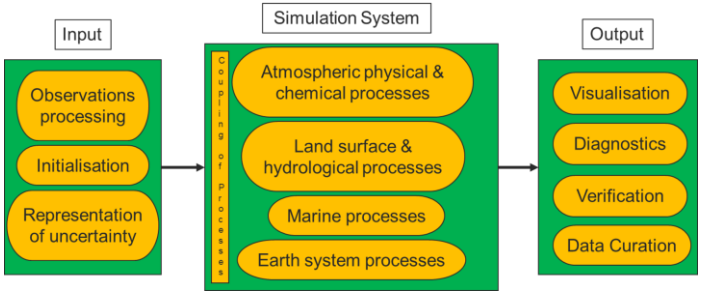


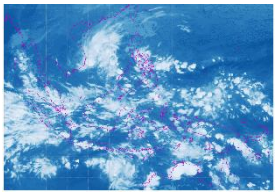


What is the Next Generation Modelling Systems Programme?

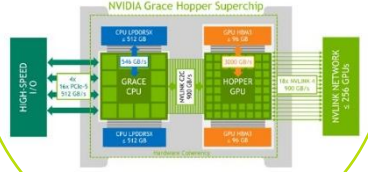
"To reformulate and redesign our complete weather and climate research and operational/production systems, including oceans and the environment, to allow the Met Office and its partners to fully exploit future generations of supercomputer for the benefits of society."



Enable new science



Exploit supercomputer



Improved scalability & flexibility

Grow external collaborations

Why do OWA coupling.

Roughness length calculations made better

Drag feedback by waves

Wahle et al., 2017; Wu et al., 2017

TC induced sea surface cooling

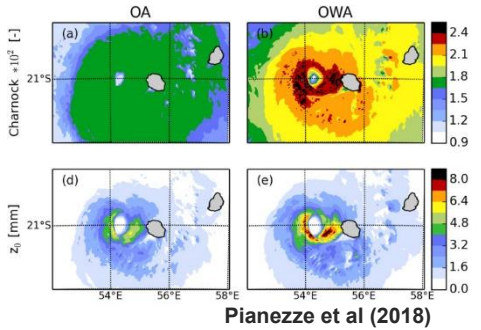
Enthalpy flux changes

Lee and Chen 2014, Pianezze et al., 2018

Ardhuin et al. 2010

Increased accuracy of wave model

Better representation of TC boundary layer processes



Pianezze et al (2018)