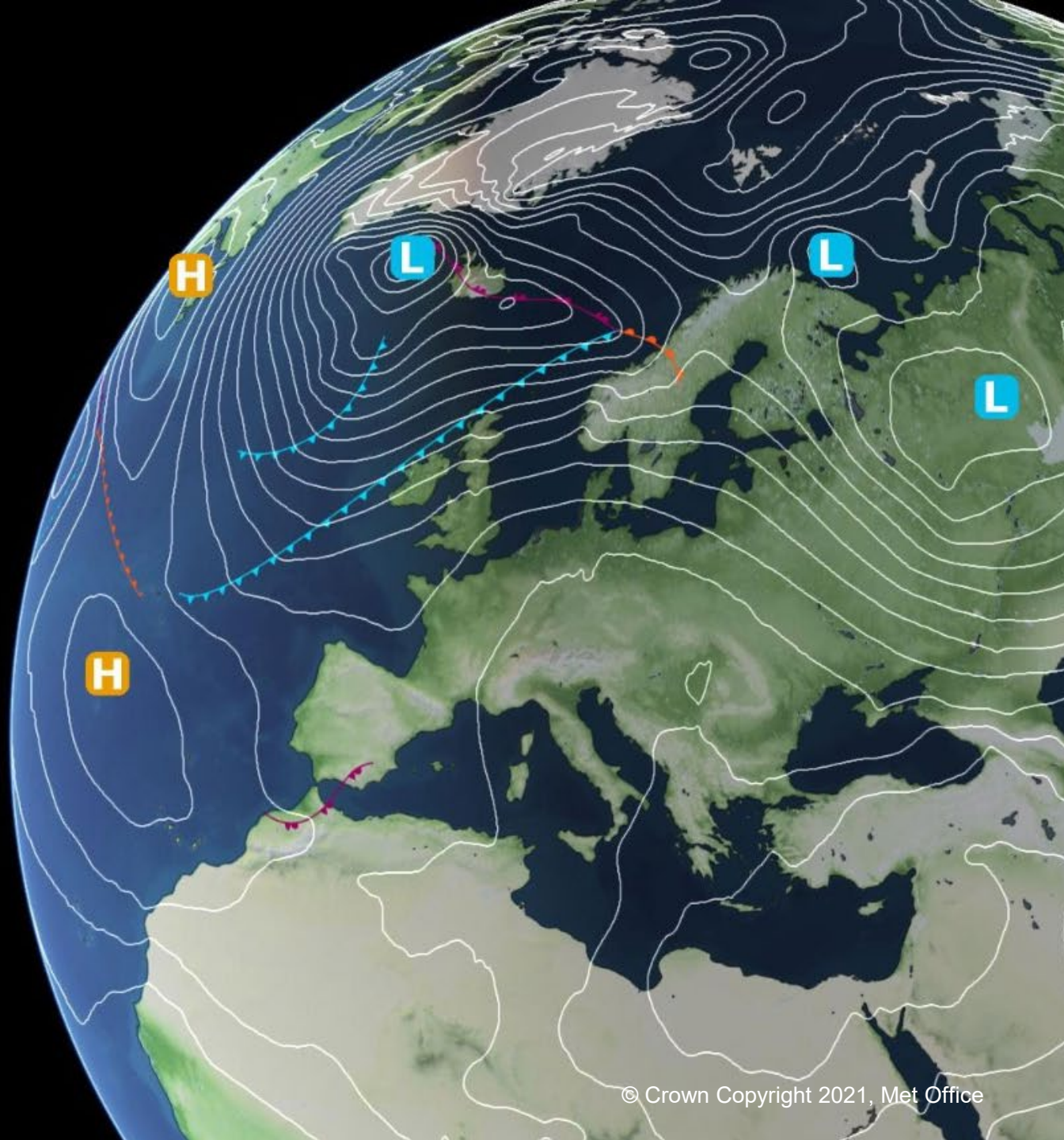
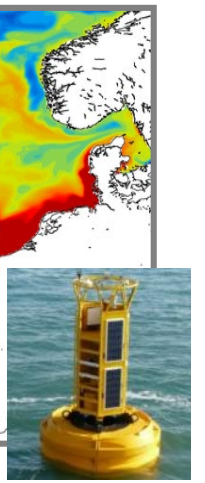
Met Office

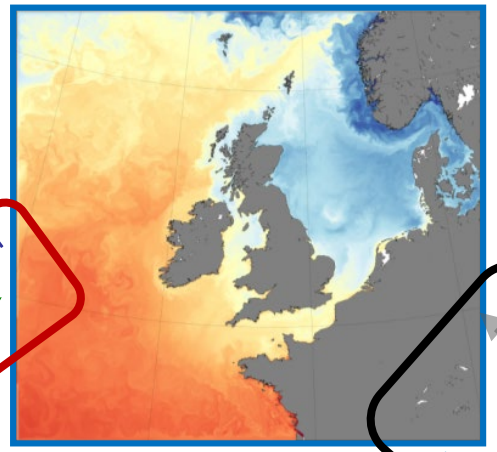
Recent developments in the Regional Coupled Suite



JuanMa Castillo, Ségolène Berthou, Alex Arnold,

Huw Lewis, Sana Mahmood, Claudio Sanchez





ATMOSPHERE: UM

WAVES: WaveWatch III

Wind

Charnock coefficient

Pressure, Radiation, Water flux

SST, Currents

Wave height, Sfc stress, Stokes drift, Wave period

Currents

Surface fluxes

Radiation, Temp, Precip, Evap

Bottom stress

Inundation

Freshwater

OCEAN: NEMO

Water Colour

Currents, Bottom stress

Freshwater, Nutrients, Temperature

LAND SURFACE: JULES

SEDIMENTS/BIOGEOCHEM: ERSEM

UK domain (1.5km):

Numerical weather prediction: **A/O/W**
- Deterministic forecast
- Ensembles

(Case studies)

Climate: Atmosphere-Ocean

Under development:
- Modelled river outflow into the ocean (Lewis et al. 2021)
- Biogeochemistry: ERSEM

Outline

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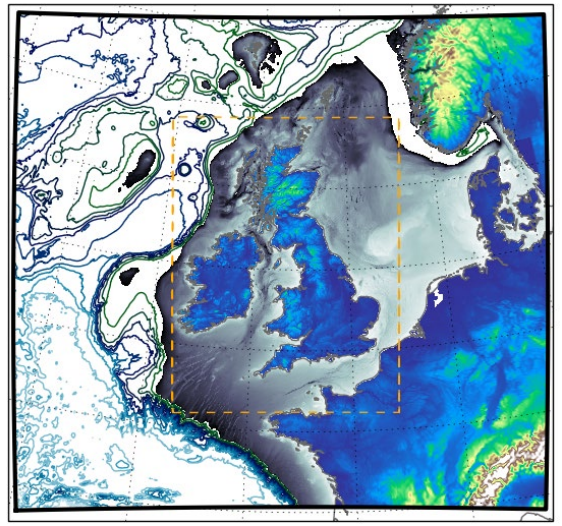
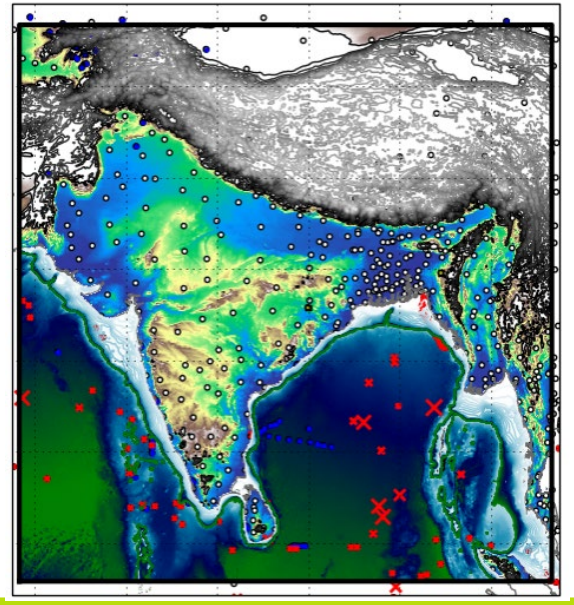
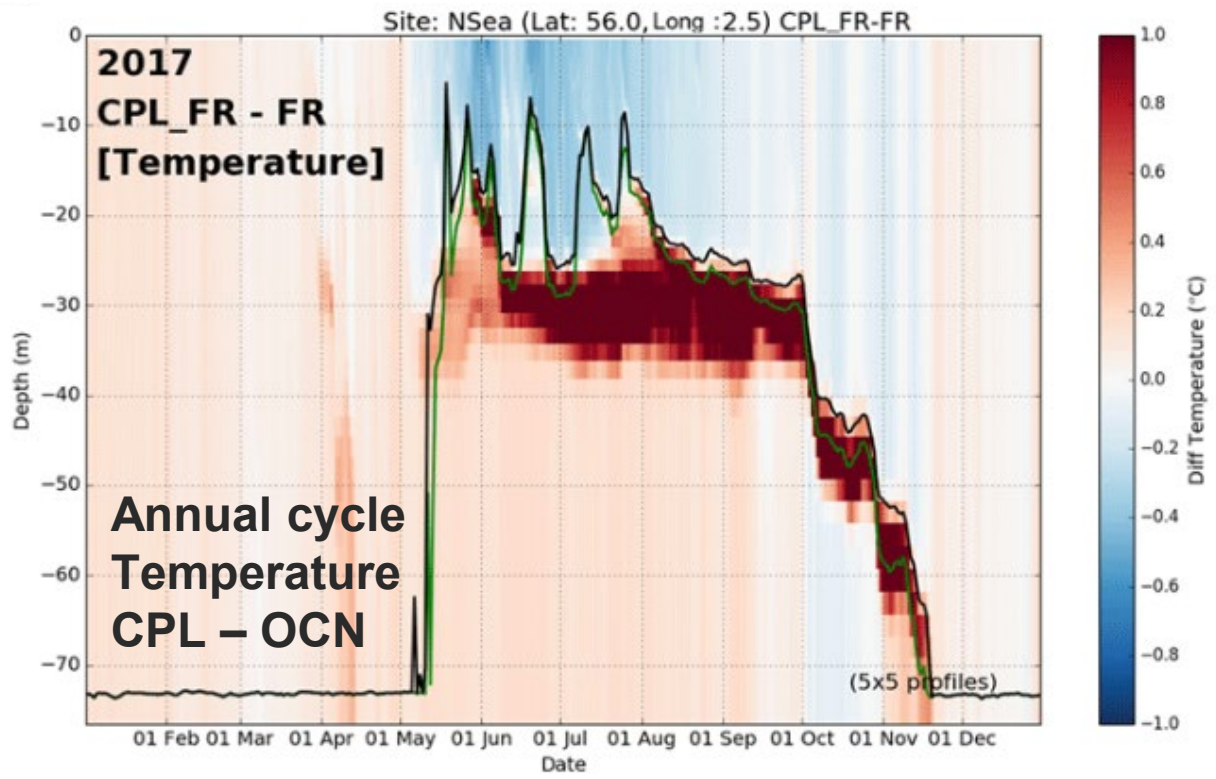


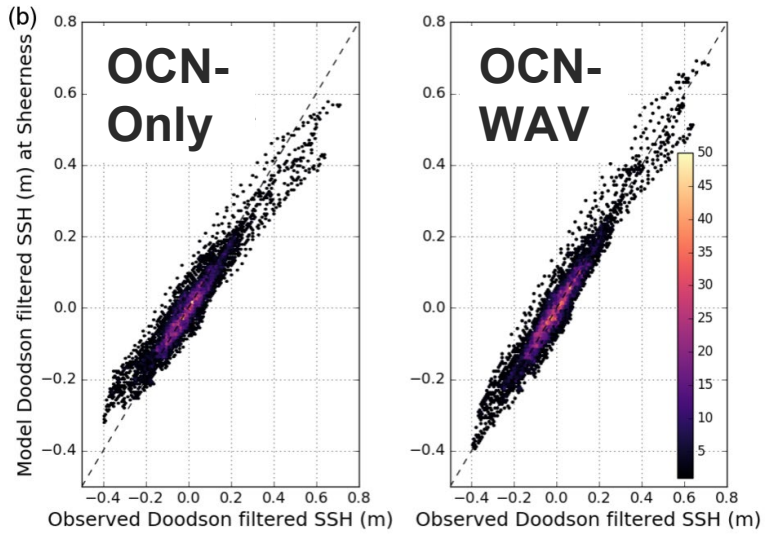


1. Operational improvements: ocean/wave operational coupled system

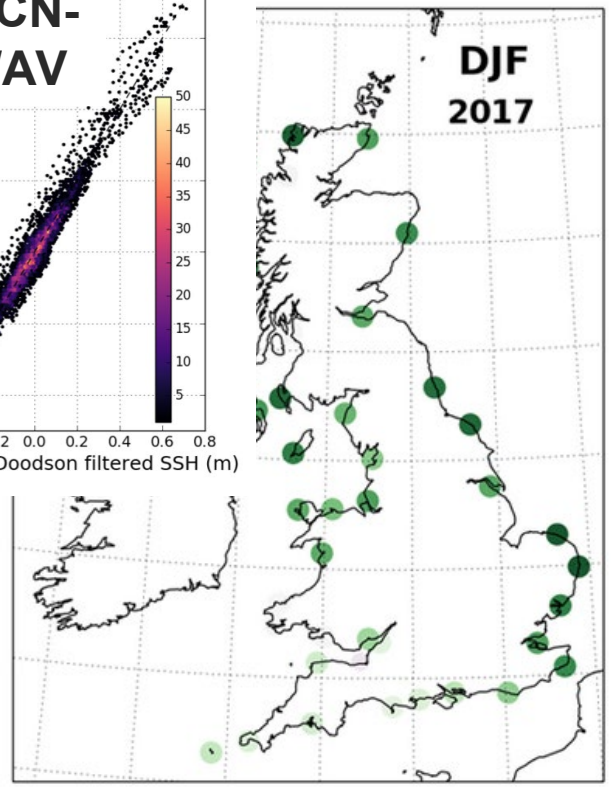
- Regional wave-ocean coupled system operational since **2020 [PS44]**
- Direct pull-through from REP research – coupling infrastructure, experiments + evaluation activities
- Beneficial impacts, especially during storms and in near-coastal regions



Deeper ocean mixed layer with wave coupling



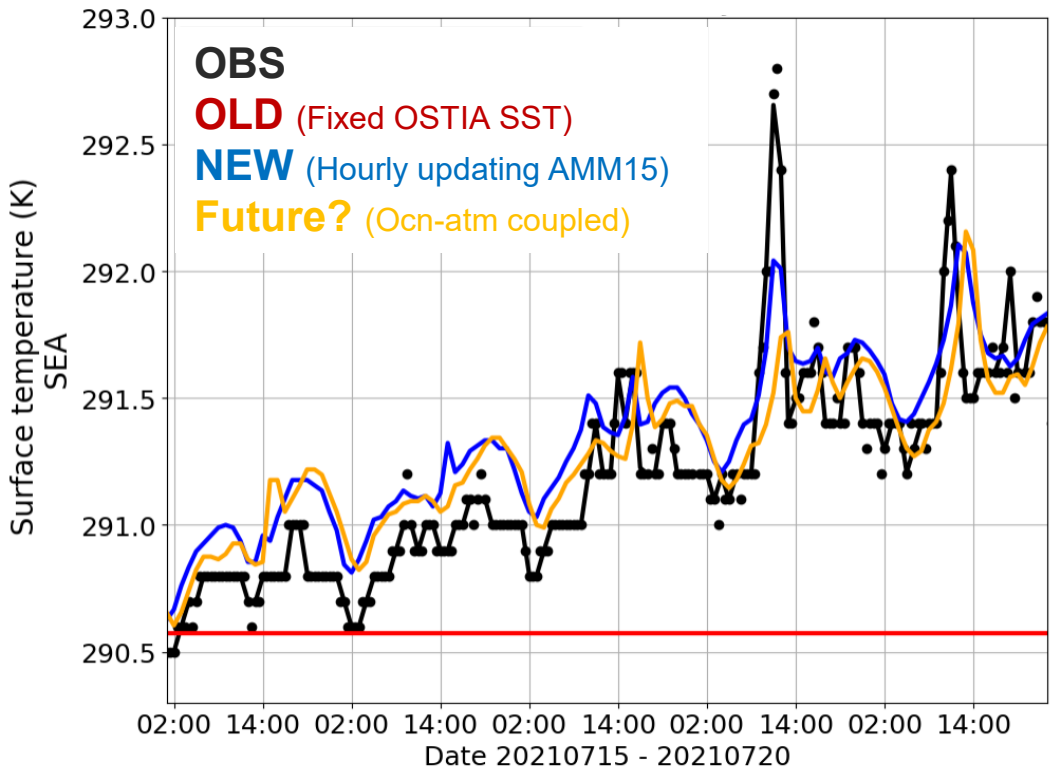
Improved sea surface height prediction (esp. storm surges)

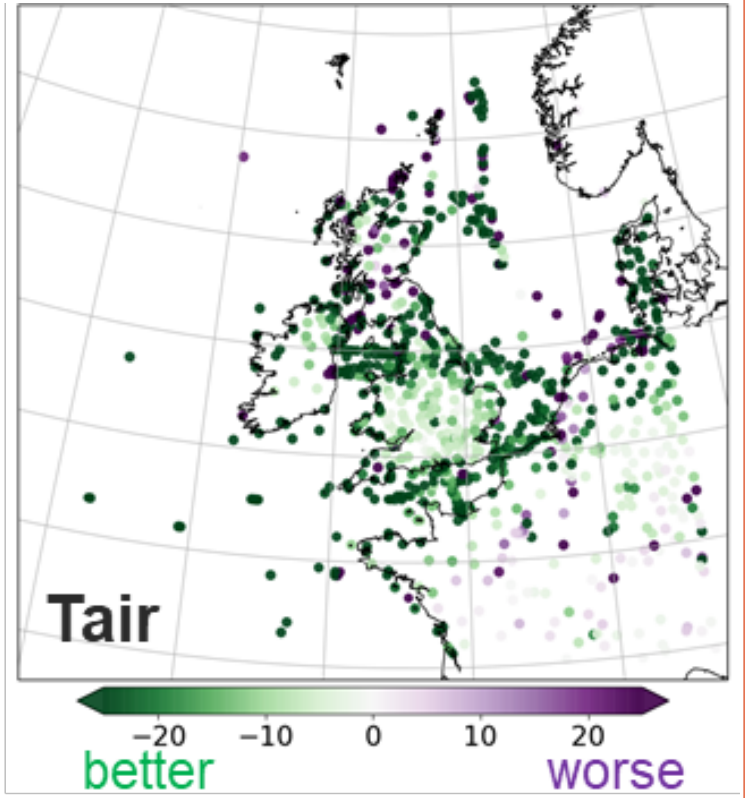


Lewis et al. (2019) *Ocean Sci.* **Bruciaferri et al. (2021) *JGRO*** **Valiente et al. (2021) *JMSE***

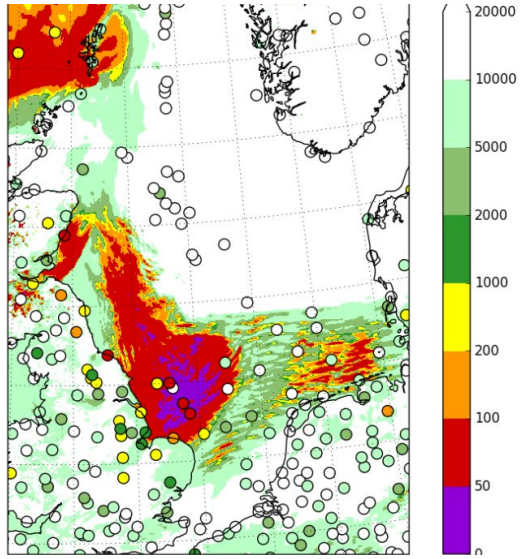
1. Operational improvements: Sea Surface Temperature from marine forecast

- Regional operational ocean(-wave) forecast SST used as lower boundary in deterministic and ensemble UK NWP since **2022 [PS45]**
- Direct pull-through from REP research – technical + evaluation activities
- Reduces evolving cold bias over 5-day simulation, improved mean/max temperatures, improved sea fog prediction

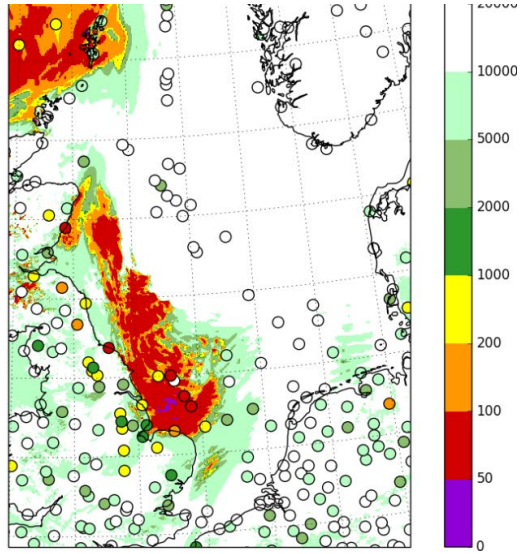




OLD (Fixed OSTIA SST)



Future? (Ocn-atm coupled)

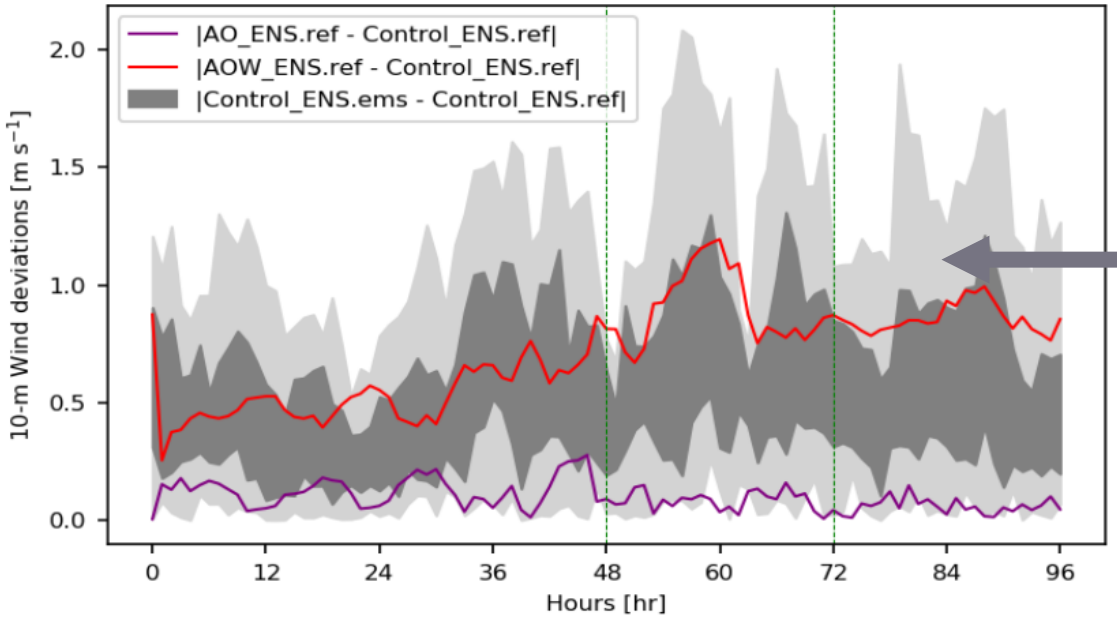


Fallmann et al., 2019, *QJRMS*

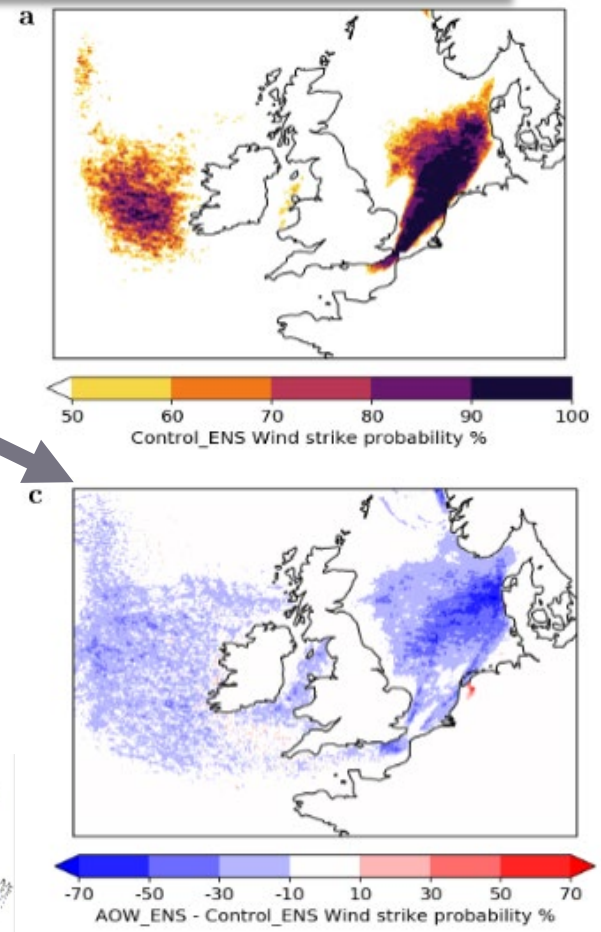
Mahmood et al. 2021, *Met. Apps.*

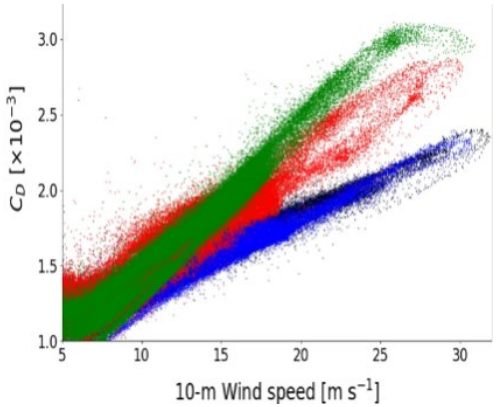
1. Operational improvements: atmosphere/wave coupling impact on wind

Wave coupling reduces high wind speeds in mid-latitude winter storms: young, growing wind waves reduce the wind speed by increasing the sea-surface aerodynamic roughness



Impact of wave coupling is as large as inter-member spread in ensemble forecasting





⇒ **Operational implementation of new drag parameterisation COARE 4.0 parametrization with the Donelan (2018) cap and drag reduction**

Gentile et al. (2021) Boundary Layer Meteorology ; Gentile et al. (2022) QJRMS

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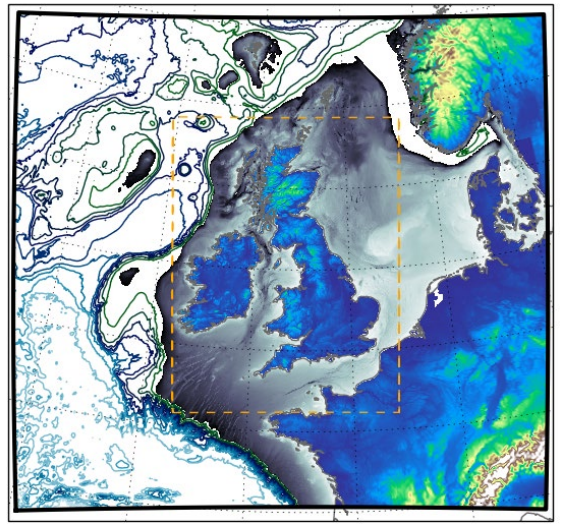
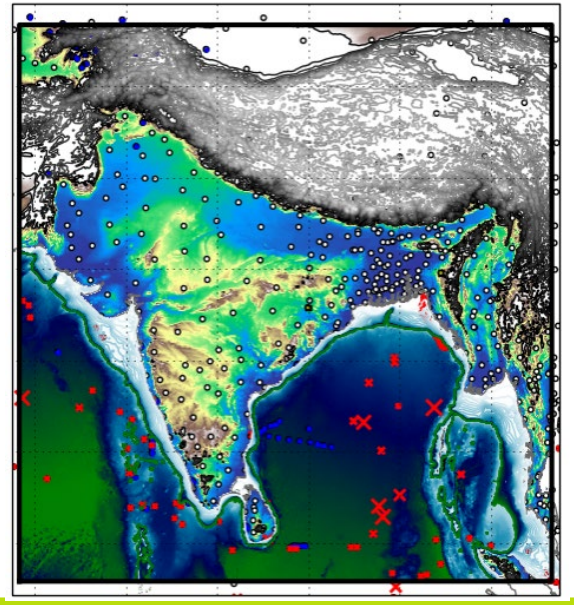
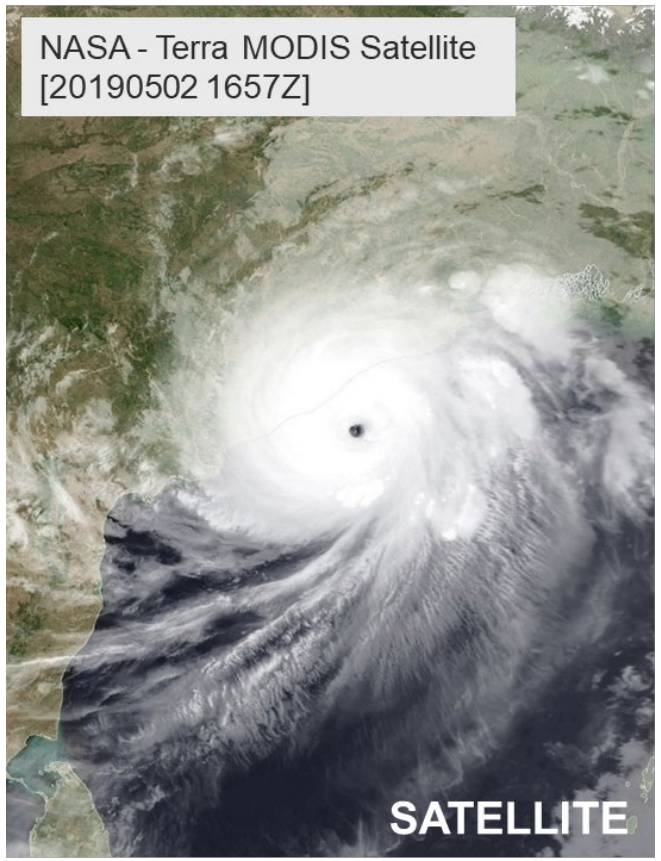
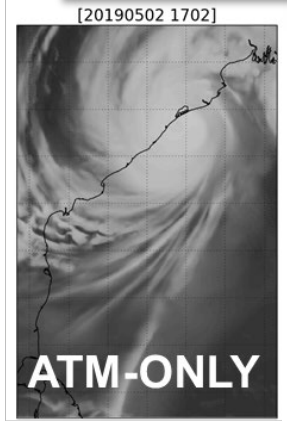
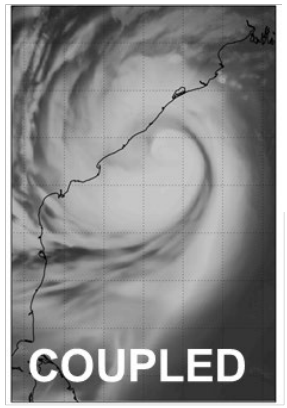




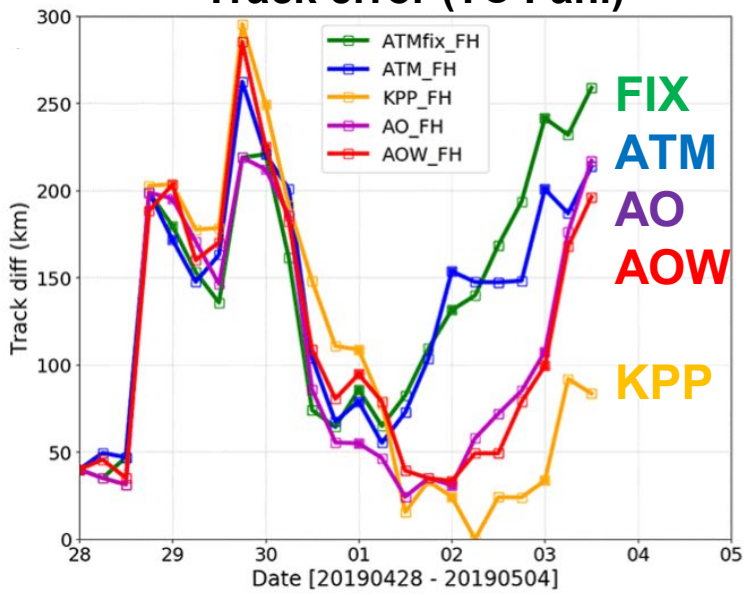
2. Better understanding: tropical cyclones



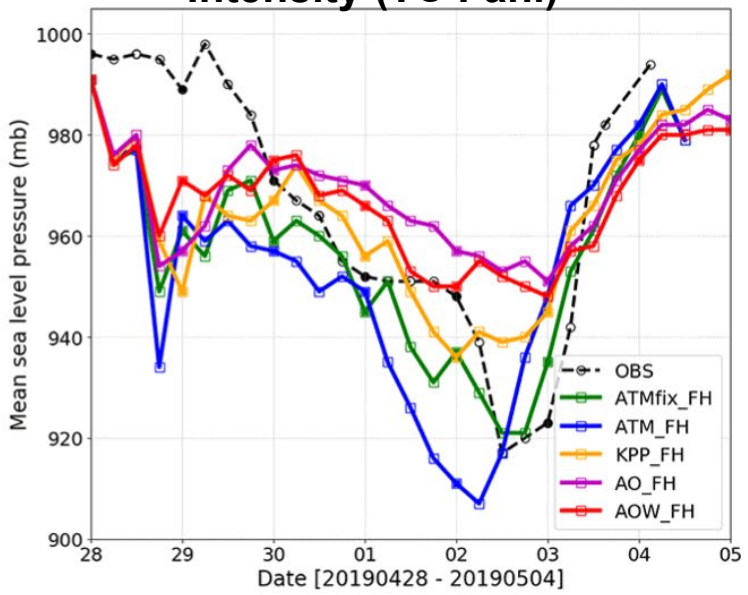




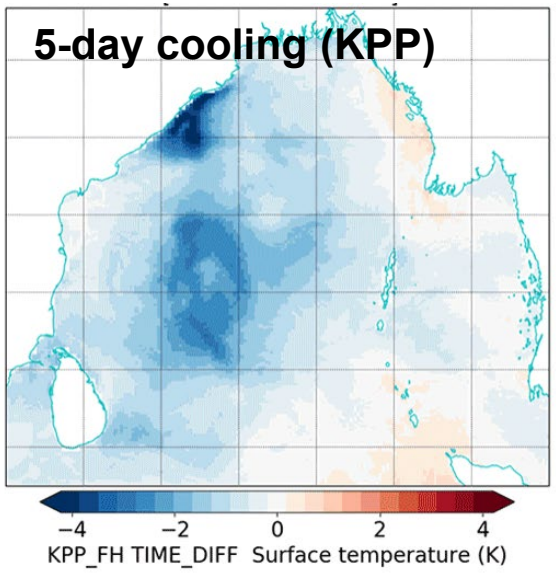
Track error (TC Fani)



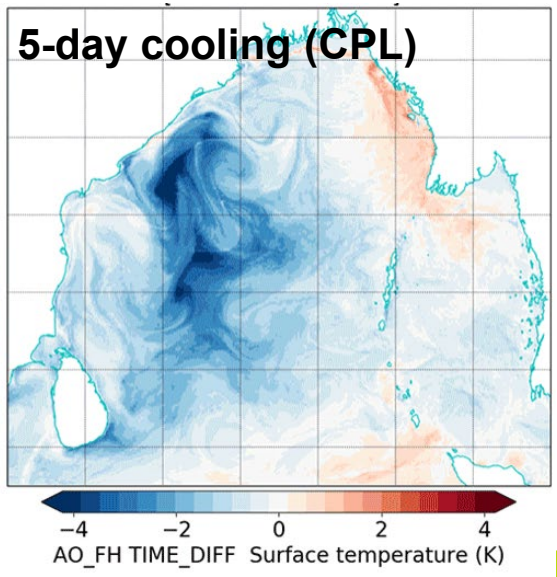
Intensity (TC Fani)



5-day cooling (KPP)



5-day cooling (CPL)



- Systematic reduction in TC intensity due to atmosphere-ocean coupling
- First-order impact captured with 1D mixed layer KPP, but neglects influence of (e.g. coastal) currents
- Coupling ‘enables’ simulation with frictional heating

Castillo et al. (2022) *GMD*

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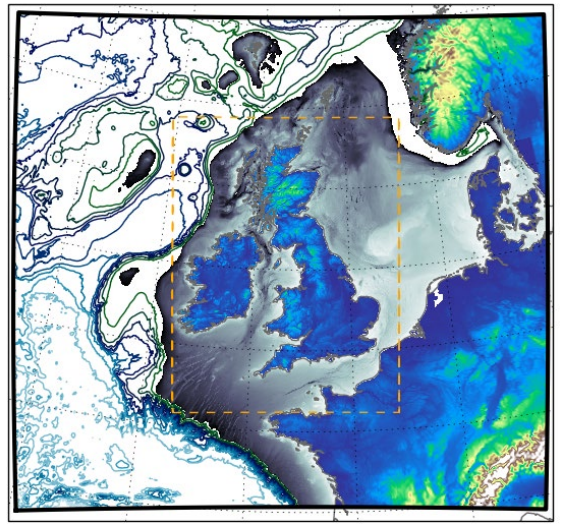
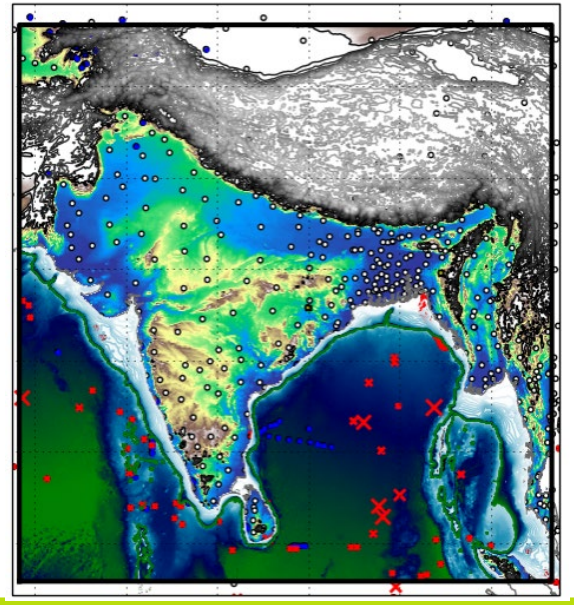
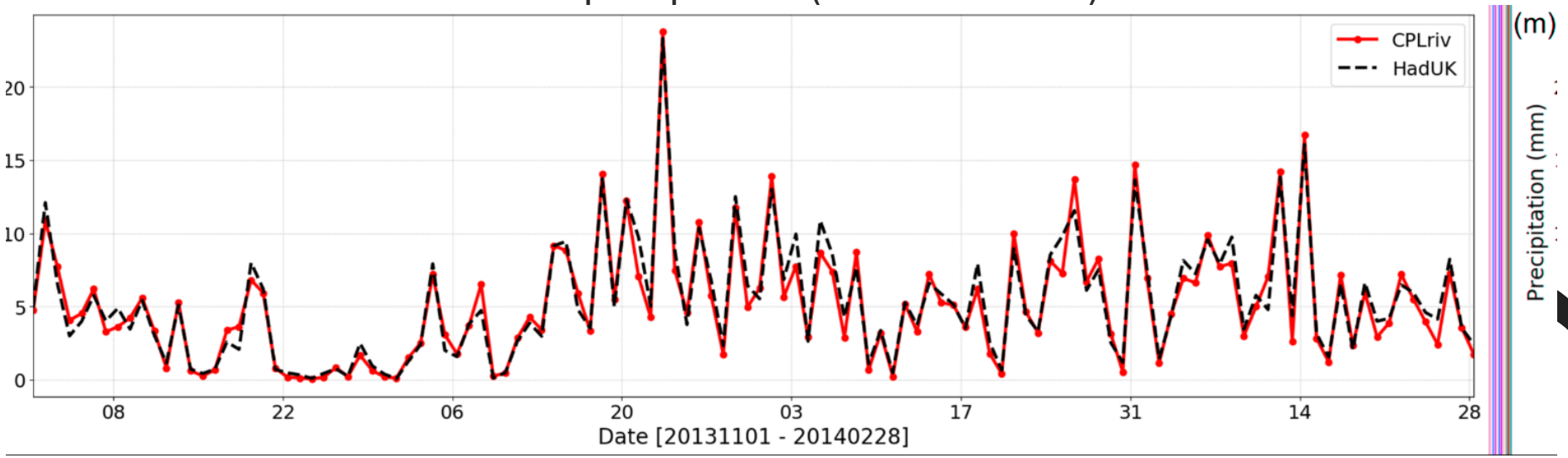


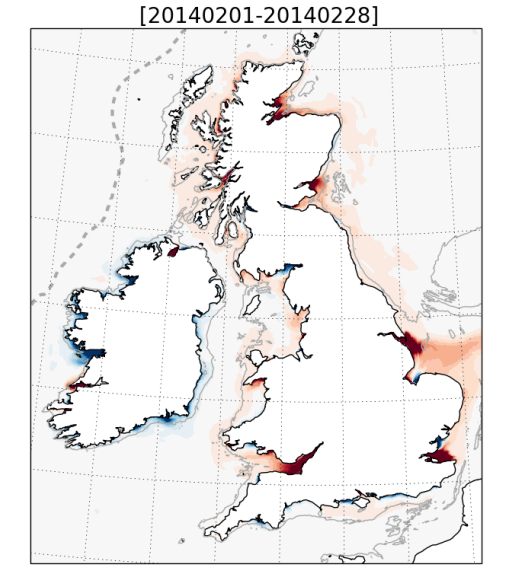


3. On-going research / future implementation: integrated hydrology

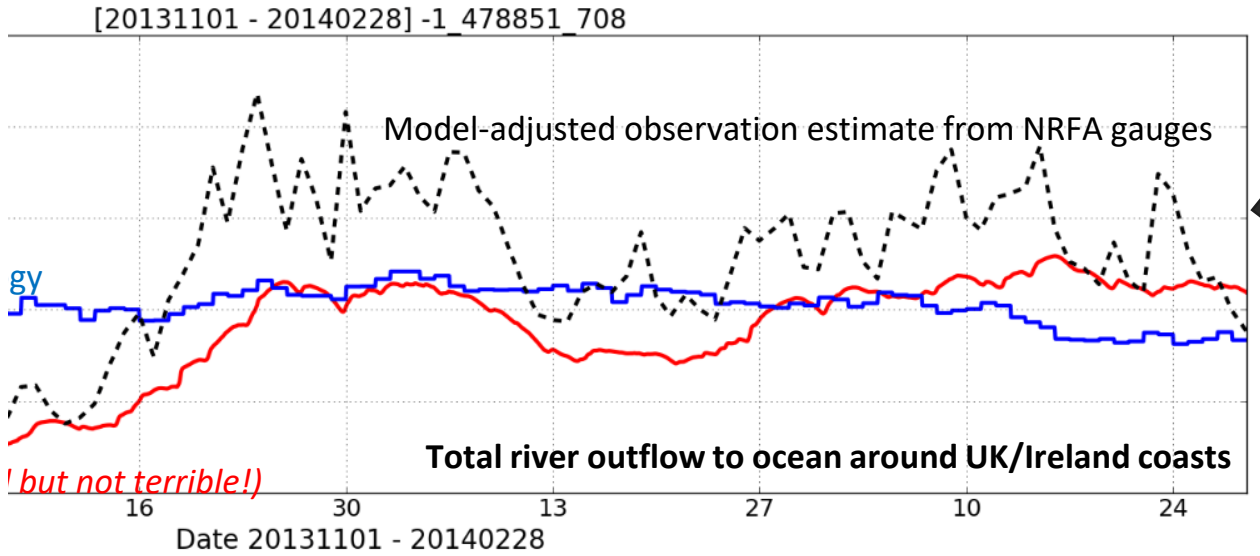
UK wide precipitation (winter 2013-14)



Lewis & Dadson (2021) Hydro. Proc.



wide rivers outflow to the ocean (dec. 2013-14)

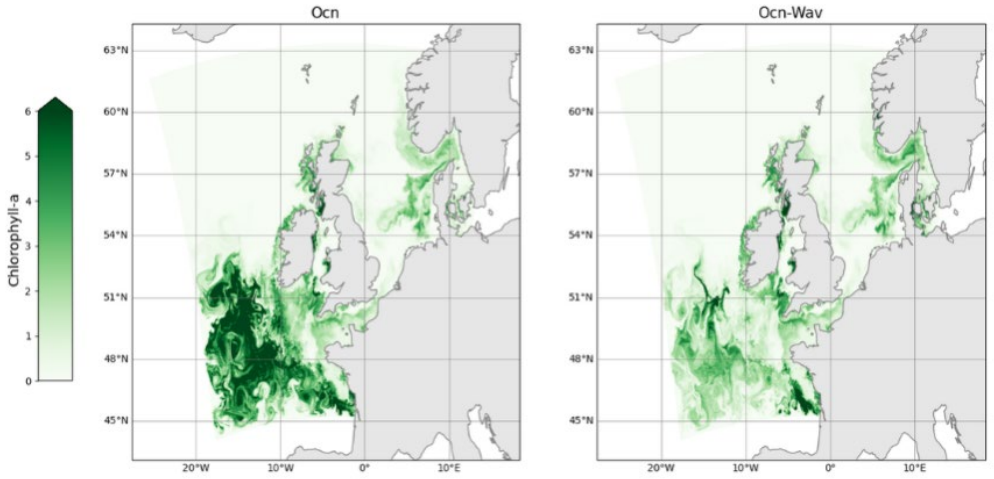


First time that river routing has been implemented online

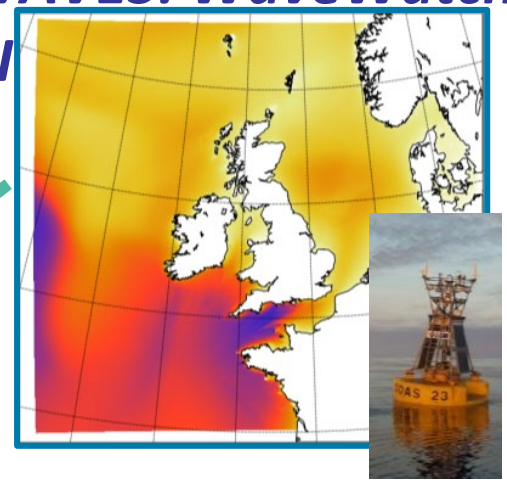
Test sensitivity to JULES set-up
Test inclusion of groundwater scheme from HydroJULES

3. On-going research / future implementation: impact of ocean/wave coupling on biogeochemistry modelling

Impact of wave-ocean coupling on biogeochemistry:
- Delayed spring bloom
- More summer variability in chlorophyll

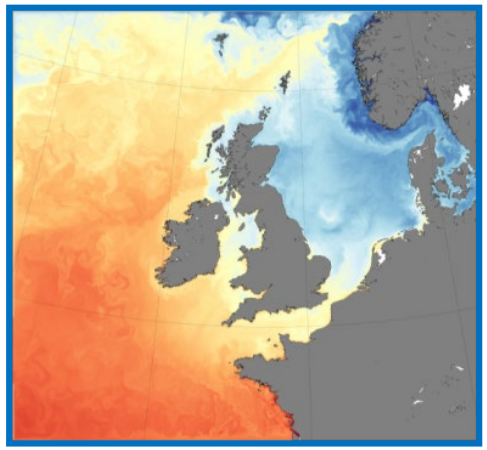


WAVES: WaveWatch III



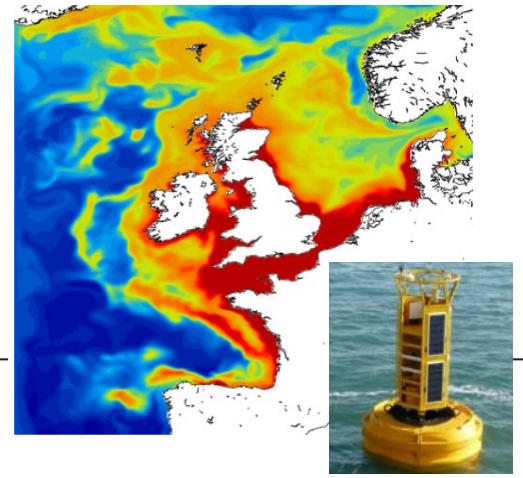
Wave height, Sfc stress, Btm stress, Dissipation

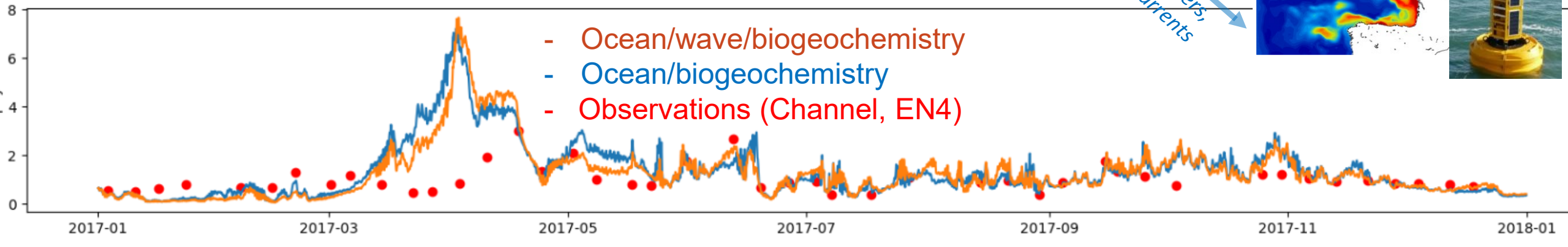
Currents, Depth



OCEAN: NEMO

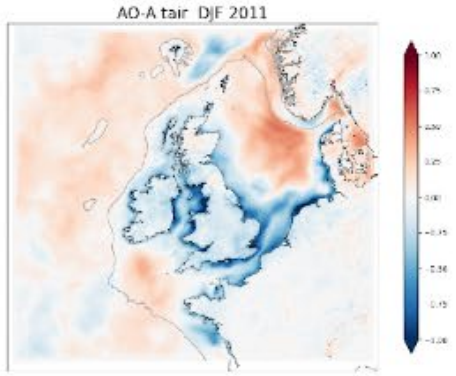
Tracers, currents

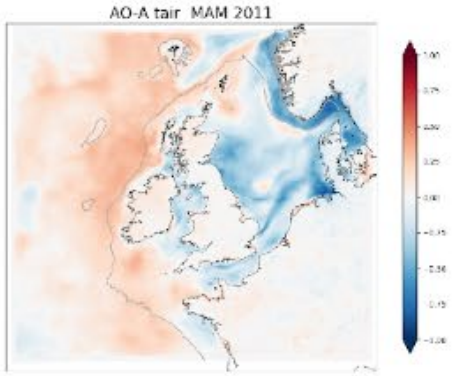


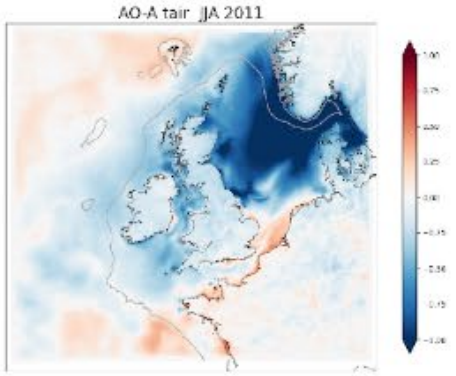


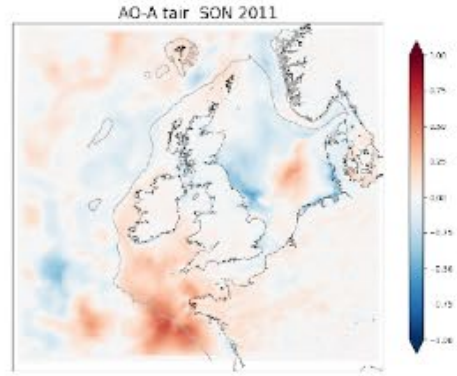
3. On-going research / future implementation: climate simulations

Evaluation of the sea surface temperature of 5-year coupled runs (atmosphere-ocean, 2007-2012)





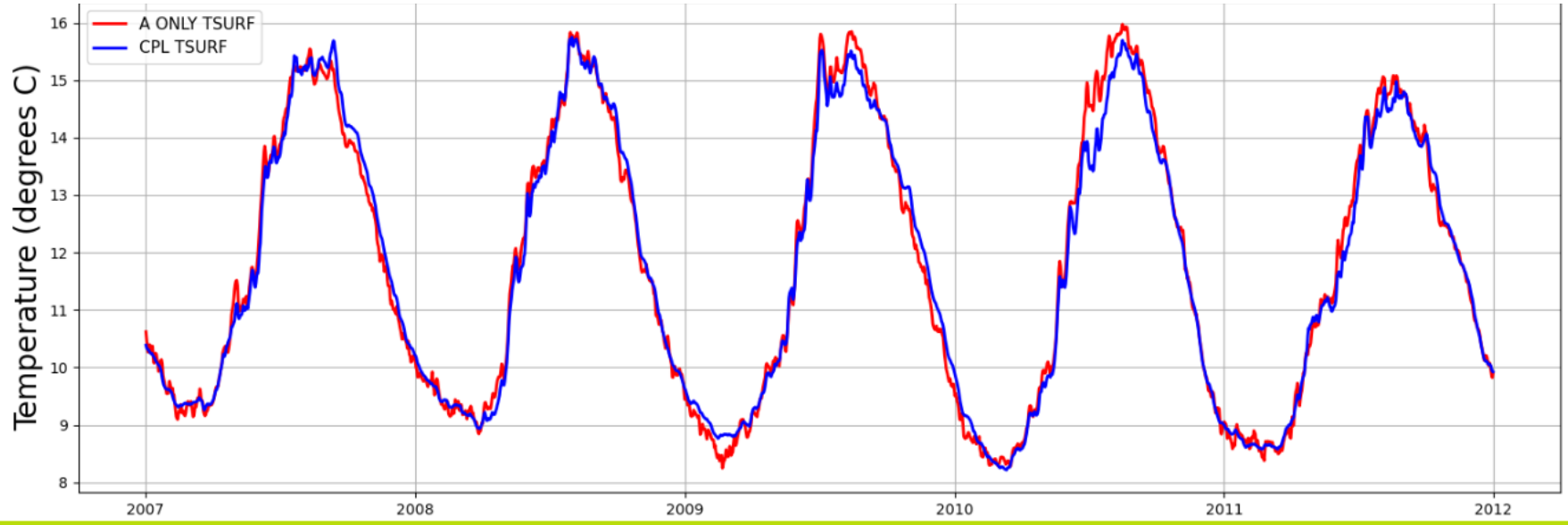




No evident drift in coupled runs

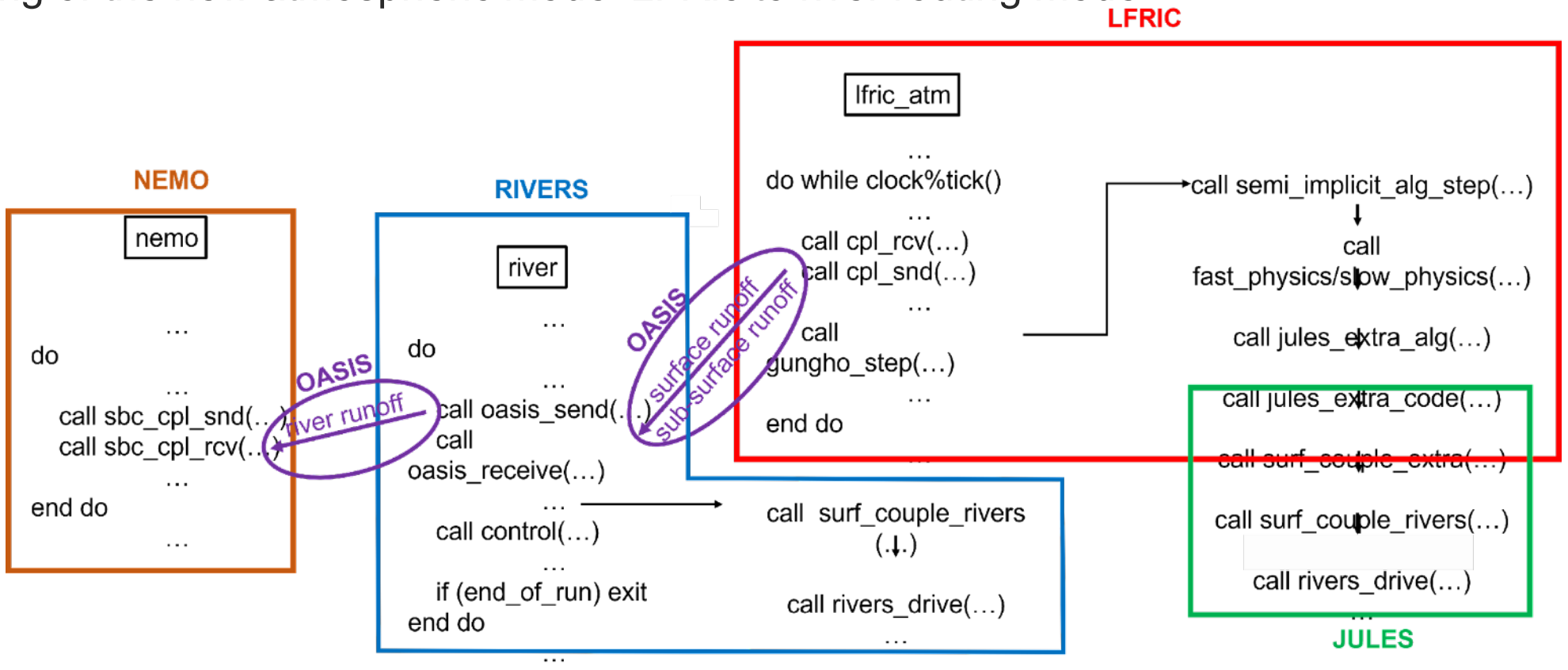
Most seasons are close to observations, but the SST is too cool in late summer.

This version of the Regional Atmosphere is too cloudy – now testing a newer configuration.



3. On-going research / future implementation: LFRic/River routing

Coupling of the new atmospheric model LFRic to river routing model



This approach eliminates the need for multiple regridding, as it is done by OASIS

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- New wave/ocean coupling exchanges