Tidal flow predictions in support of MAS operations

and other

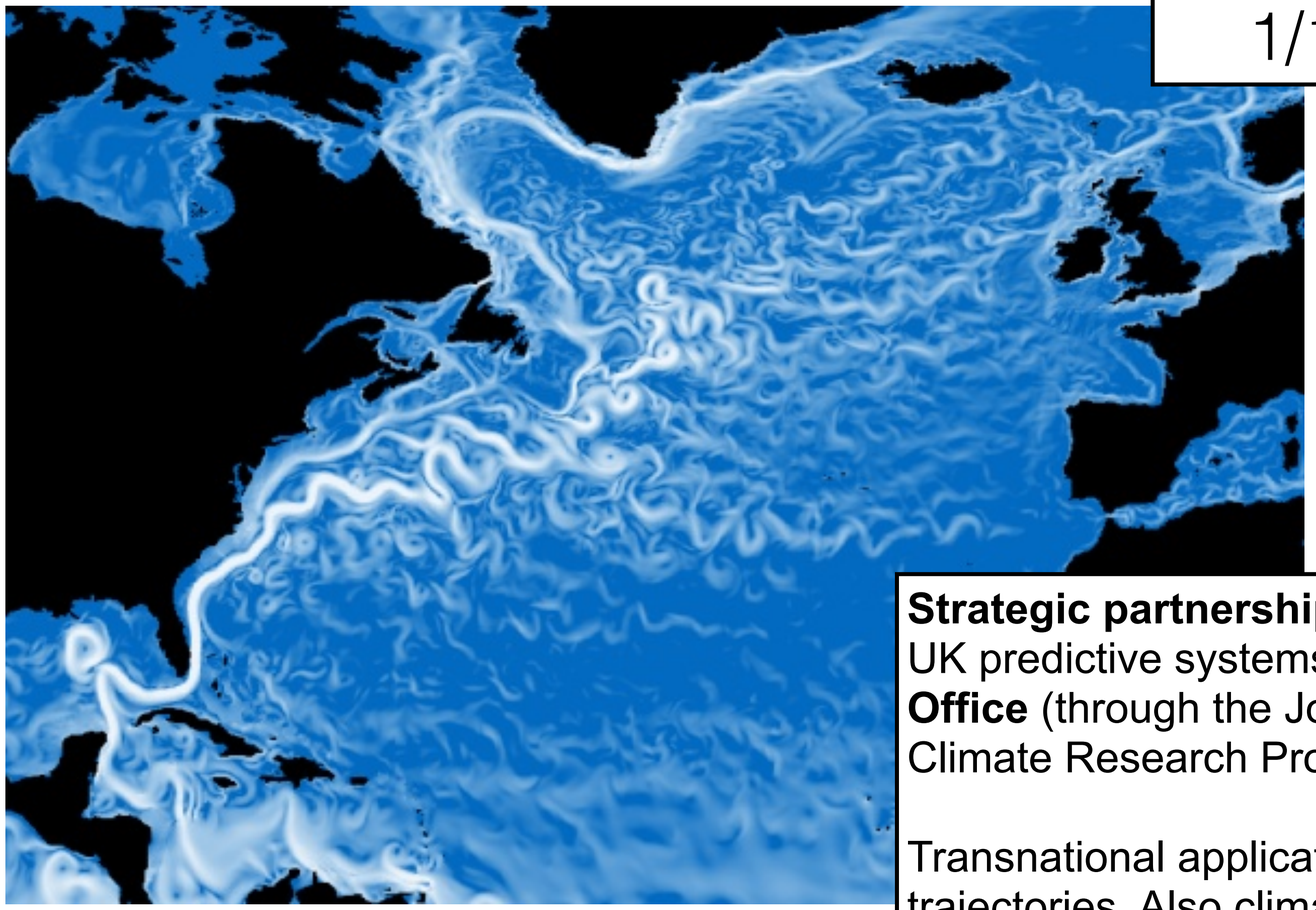
Jeff Polton, National Oceanography Centre

- Modelling overview
- Automated data products - live tides
- Bespoke data products
  - track following tidal data sets,
  - 4D cut out virtual ocean data set
- What's next?
- Summary

1.Marine Systems Modelling at NOC

Global modelling
1/12° (~9km)

NEMO



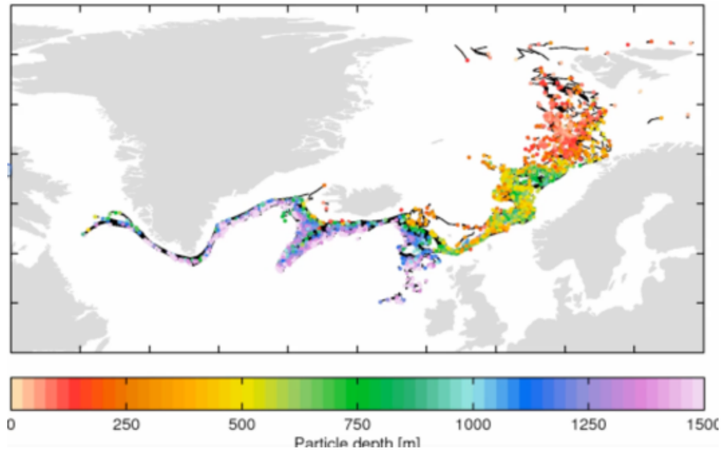
surface current speed (5 day mean) *(A.Coward)*

Strategic partnerships: pull through to UK predictive systems with the **Met Office** (through the Joint Weather and Climate Research Programme)

Transnational applications. e.g. trajectories. Also climate modelling, predictability, sensitivity

If there was an oil rig here and there was a spill

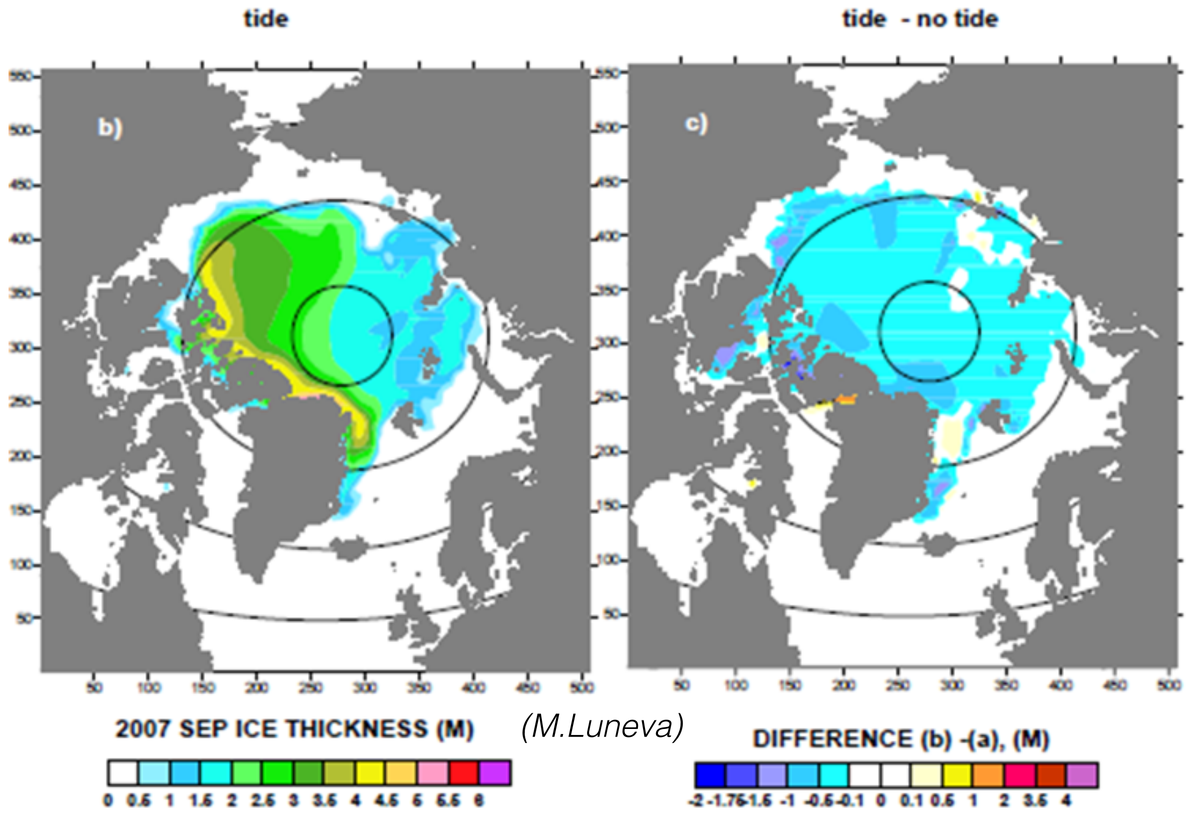
Where might the oil go?



(K.Popova)

1.Marine Systems Modelling at NOC

Basin scale regional modelling
(smaller domain —> more physics e.g. tides)

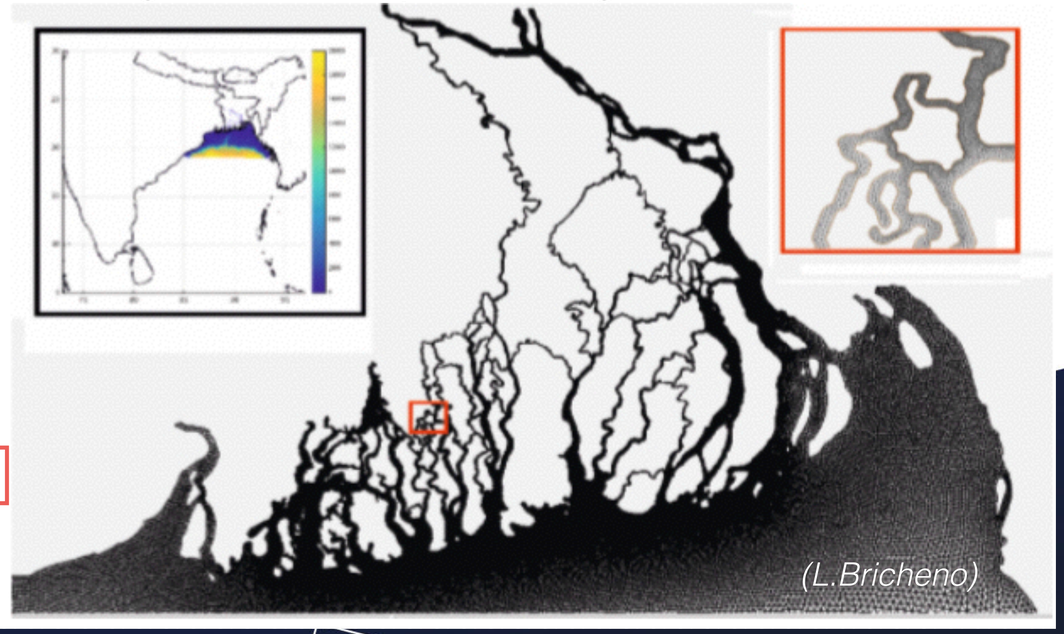


(M.Luneva)

With tides, terrain following coordinates and advanced mixing

=> improved representation of recent sea ice loss

Unstructured model of the Bangladesh Ganges-Brahmaputra-Meghna delta



(L.Bricheno)

Impact of salt intrusion from tides and varying sea level on agrarian mega-population

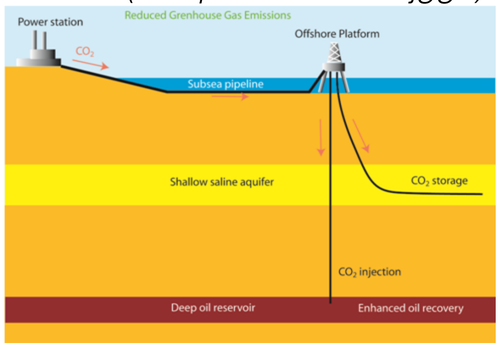
Winner of 2015 ARCHER (HPC) IMPACT AWARD

1.Marine Systems Modelling at NOC

European regional modelling

The High-Resolution Coastal Ocean Modelling

Many applications e.g.
pH perturbations for CCS leak
(Phelps et al. 2015 ijggc)



Coupled Regional Modelling:

(i) coupled atmosphere-ocean-wave interactions
(ii) coastal impacts of climate change - surges and waves

Coastal Impacts Modelling:

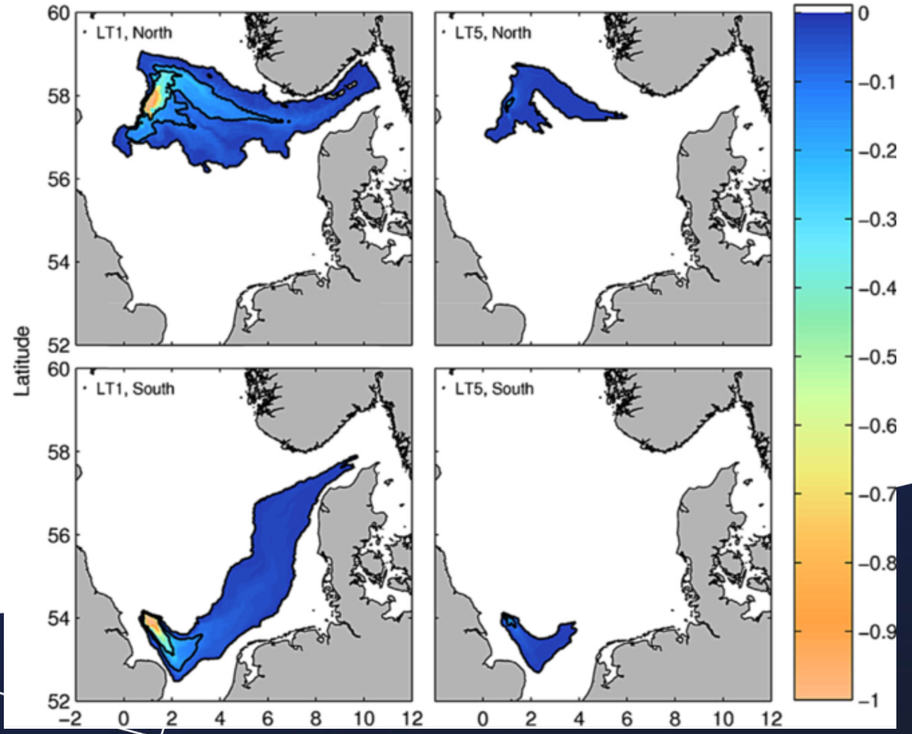
(i) offshore renewable energy (unstructured modelling) (ii) tidal prediction on mobile phones
(iii) Carbon Capture and Storage leakage scenarios (iv) Larvae dispersal

NEMO Code Development:

(i) Advection routines & wetting and drying
(ii) Next generation (unstructured) ocean models

Shelf Sea Processes Attribution:

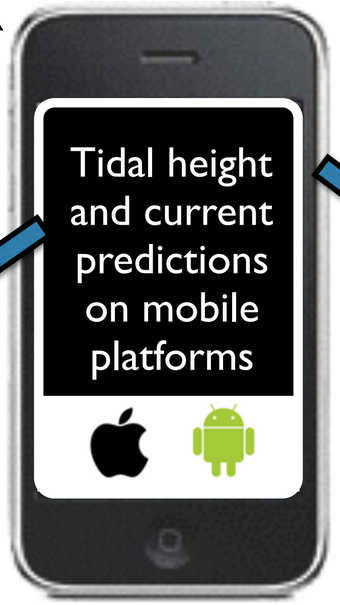
(i) Large Eddy Simulation: pycnocline mixing
(ii) Tidal / bathymetry interaction and Shelf Exchange processes

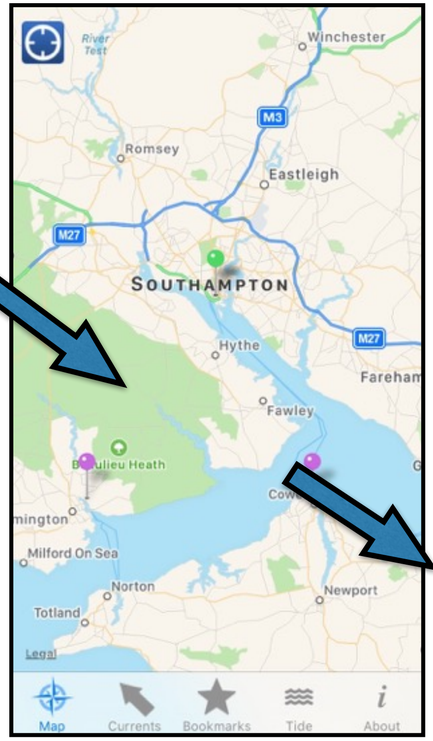


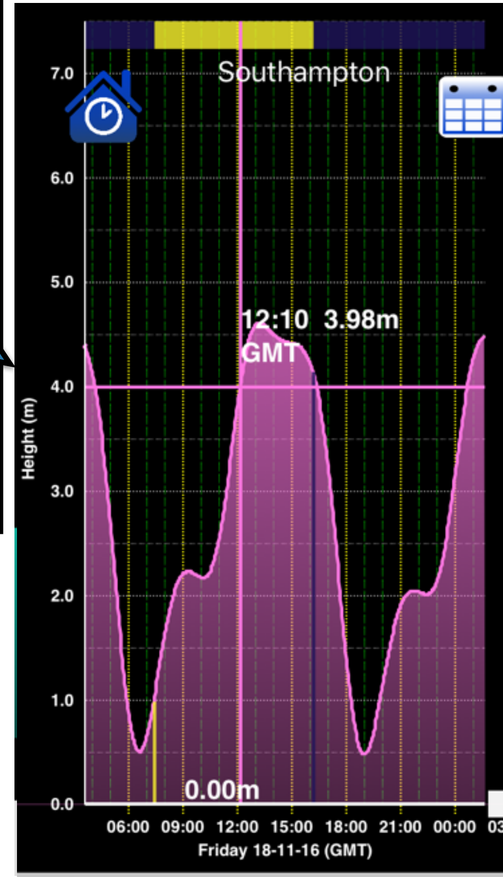
2.Automated data products - live tides

- Tidal current predictions for entire NW European at 1.8km resolution
- Tidal height predictions for NW European coastlines at 1.8km resolution
- Blend of NOC model and observational data
- Front end to modelling that we already do

GPS







NOC Server holds the data
Device queries server
=> device constructs predictions

Where we are:

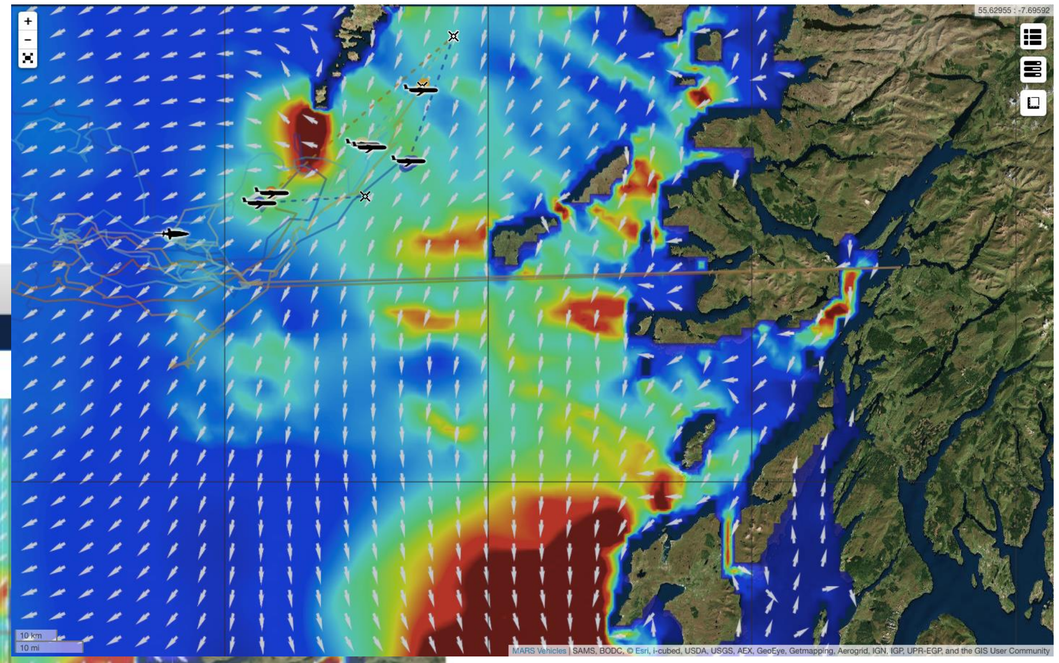
- smart phone front end
- MARS glider pilot front end
- ***Next step:***
  interface for 3rd party software

NERC
SCIENCE OF THE ENVIRONMENT

2.Automated data products - live tides

anyTide

MASSMO 3



mars.noc.ac.uk/missions/massmo-3

MARS Portal Browse

MASSMO 3

- Inactive
- Part of MASSMO
- Began on 2016-09-15 (2 months ago)
- Last Updated 2016-11-01 12:14:04
- Finished on 2016-10-02 (a month ago)

MASSMO3 involves up to ten surface and submarine gliders collecting marine environmental data over a two-week period off northwest Scotland, in support of the Royal Navy's Unmanned Warrior. This is the largest simultaneous deployment of marine robotic vehicles attempted in UK waters, and includes seven submarine gliders operating southwest of Barra to the shelf edge, and three surface gliders operating north of Lewis.

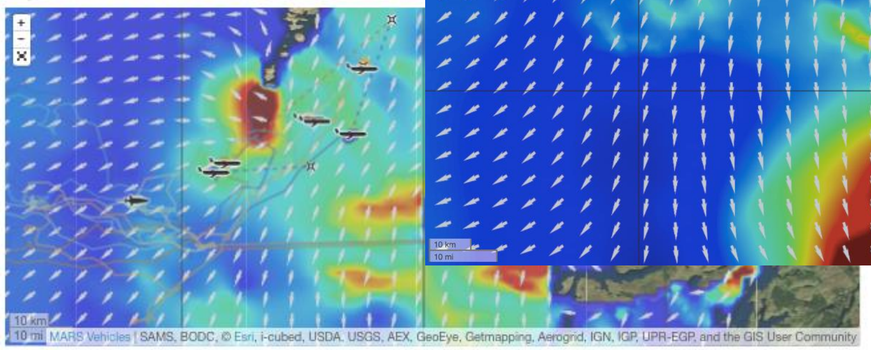
Vehicle Activity

Vehicle	Deployed	Recovered	Last Update	Distance (N. Mi.)	
Nelson	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 14:39:05 (a month ago)	179.22	No Public Data Available
Drake	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 14:21:15 (a month ago)	167.98	No Public Data Available
Talisker	2016-09-15 (2 months ago)	2016-09-30 (a month ago)	2016-09-30 14:22:28 (a month ago)	157.51	No Public Data Available
Blue Ocean unit_491	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 12:10:19 (a month ago)	233.27	No Public Data Available
Royal Navy unit_544	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 18:06:10 (a month ago)	200.40	No Public Data Available
Royal Navy unit_552	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 17:50:58 (a month ago)	269.87	No Public Data Available
Royal Navy unit_553	2016-09-15 (2 months ago)	2016-10-01 (a month ago) - End of Mission	2016-10-01 15:16:37 (a month ago)	266.59	No Public Data Available
Waimea	2016-09-19 (2 months ago)	2016-10-02 (a month ago) - End of Mission	2016-10-02 23:58:06 (a month ago)	406.83	No Public Data Available
Boeing SHARC 117	2016-09-19 (2 months ago)	2016-10-03 (a month ago)	2016-10-03 00:00:00 (a month ago)	458.31	No Public Data Available
Boeing SHARC 127	2016-09-19 (2 months ago)	None	2016-10-02 23:55:36 (a month ago)	472.53	No Public Data Available

Sensor Data

Nelson Drake Talisker Blue Ocean unit_491 Royal Navy unit_544 Royal Navy unit_552 Royal Navy unit_553 Waimea Boeing SHARC 117 Boeing SHARC 127

Map



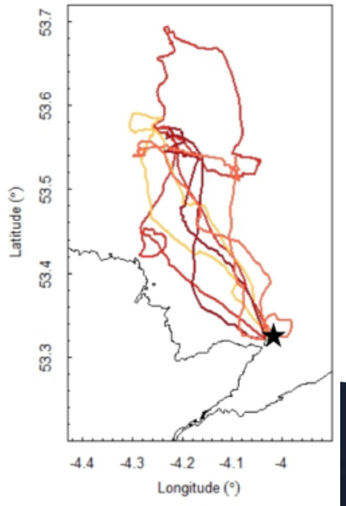
Partners

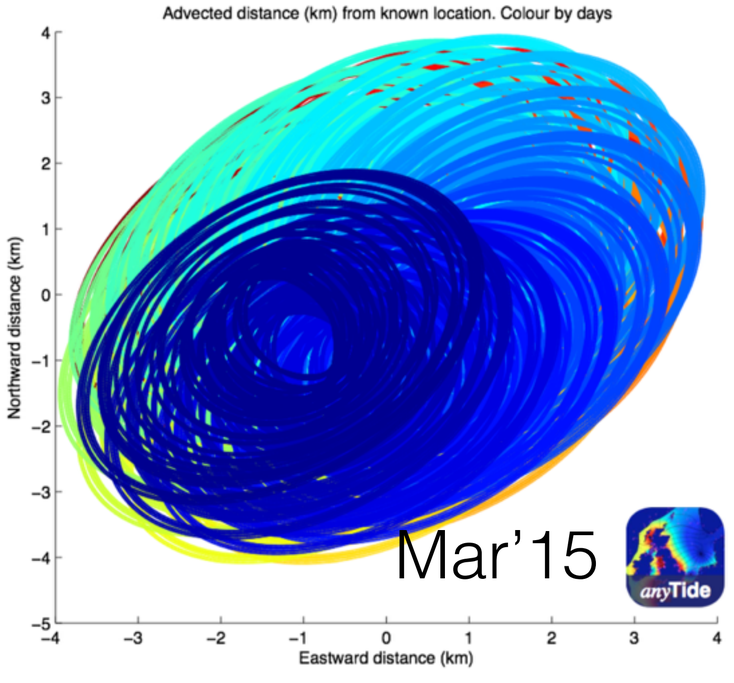
- Tidal currents data layer
- direction (vectors)
- magnitude (heat colour)
- user control time scroll
- seamless delivery of updates

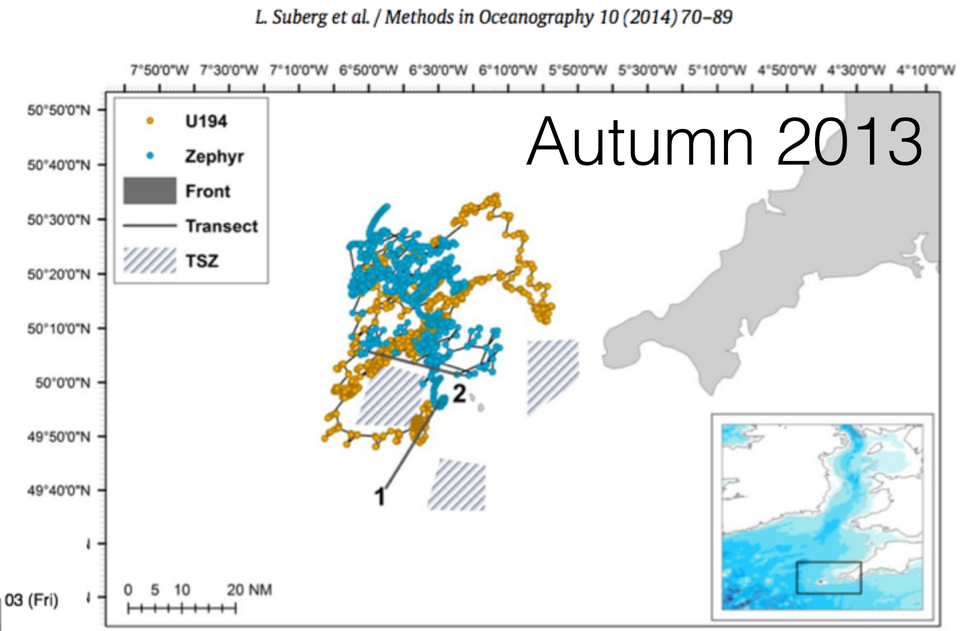
2.Bespoke data products - a) tidal data sets and interpretation

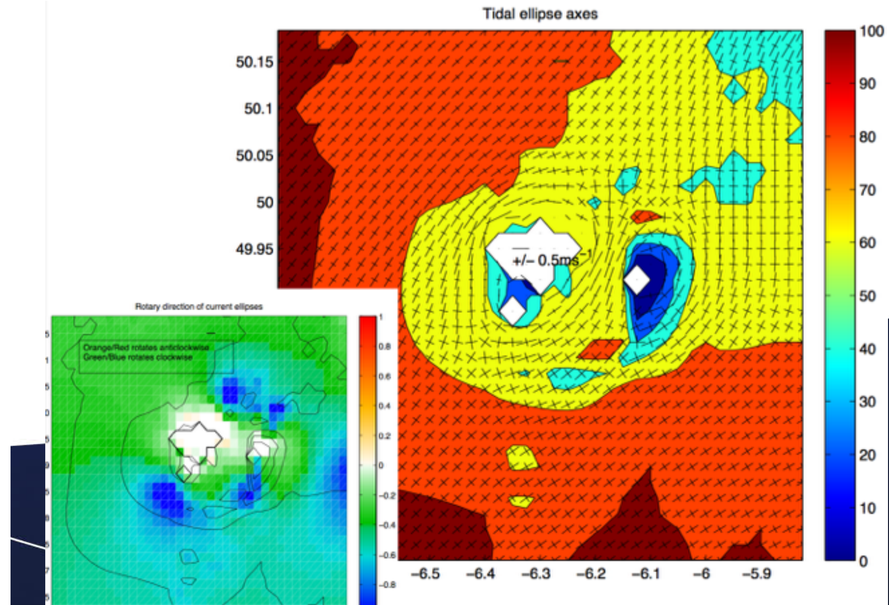
- Recovery assist
  - Scilly Isles, nowcast tidal atlas, Autumn'13
- Lost mooring fast response management
  - search radius given last known location/time and recovery vessel availability, Mar'15
- Post mission data analysis (Tides along tracks):
  - glider pressure+altimetry regression to predicted tides (A. Baker)
  - sea bird tracks, foraging statistics (A.Trevail, UoL)

GPS logger attached to feathers with Tesa® tape



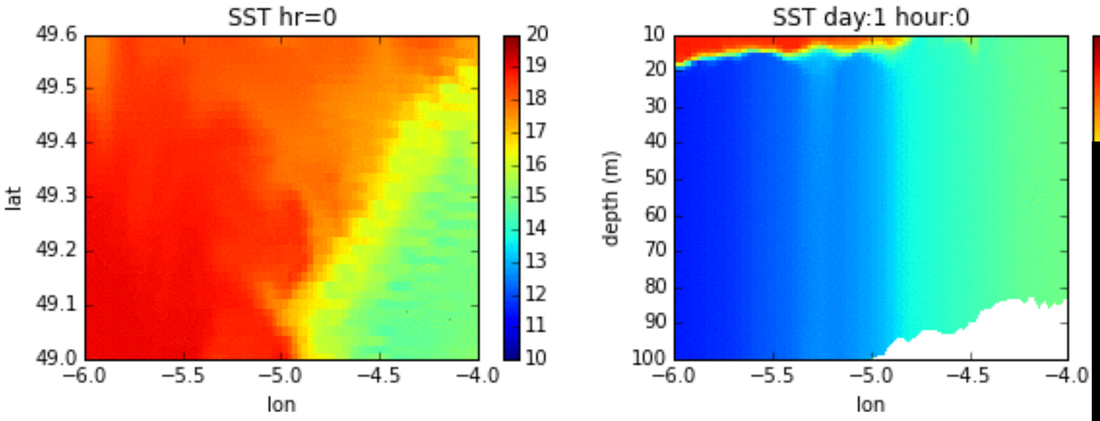


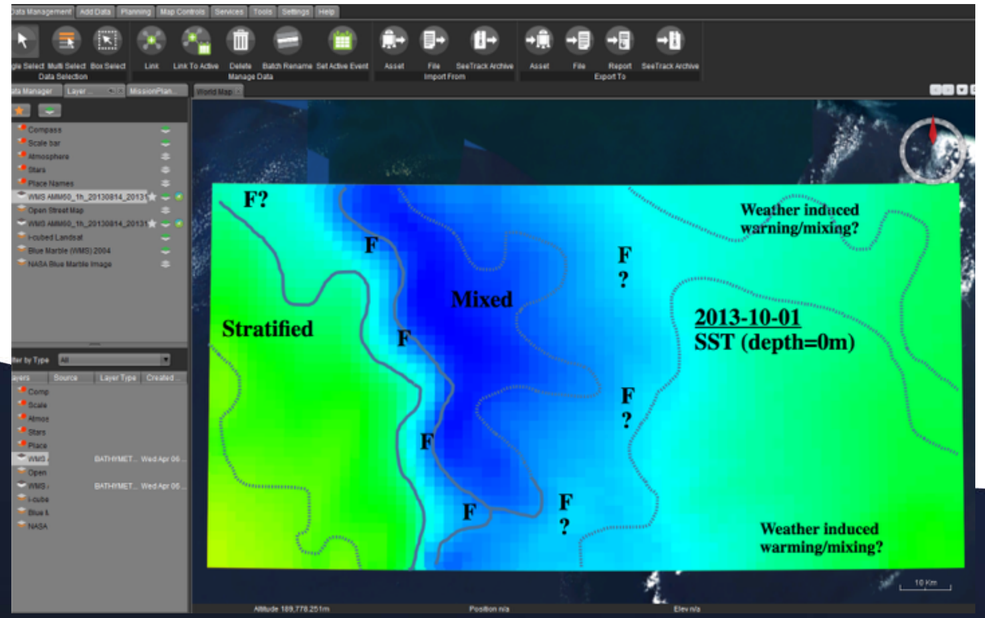


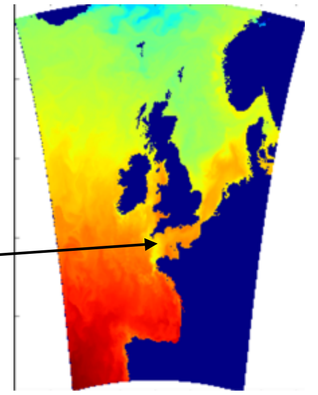


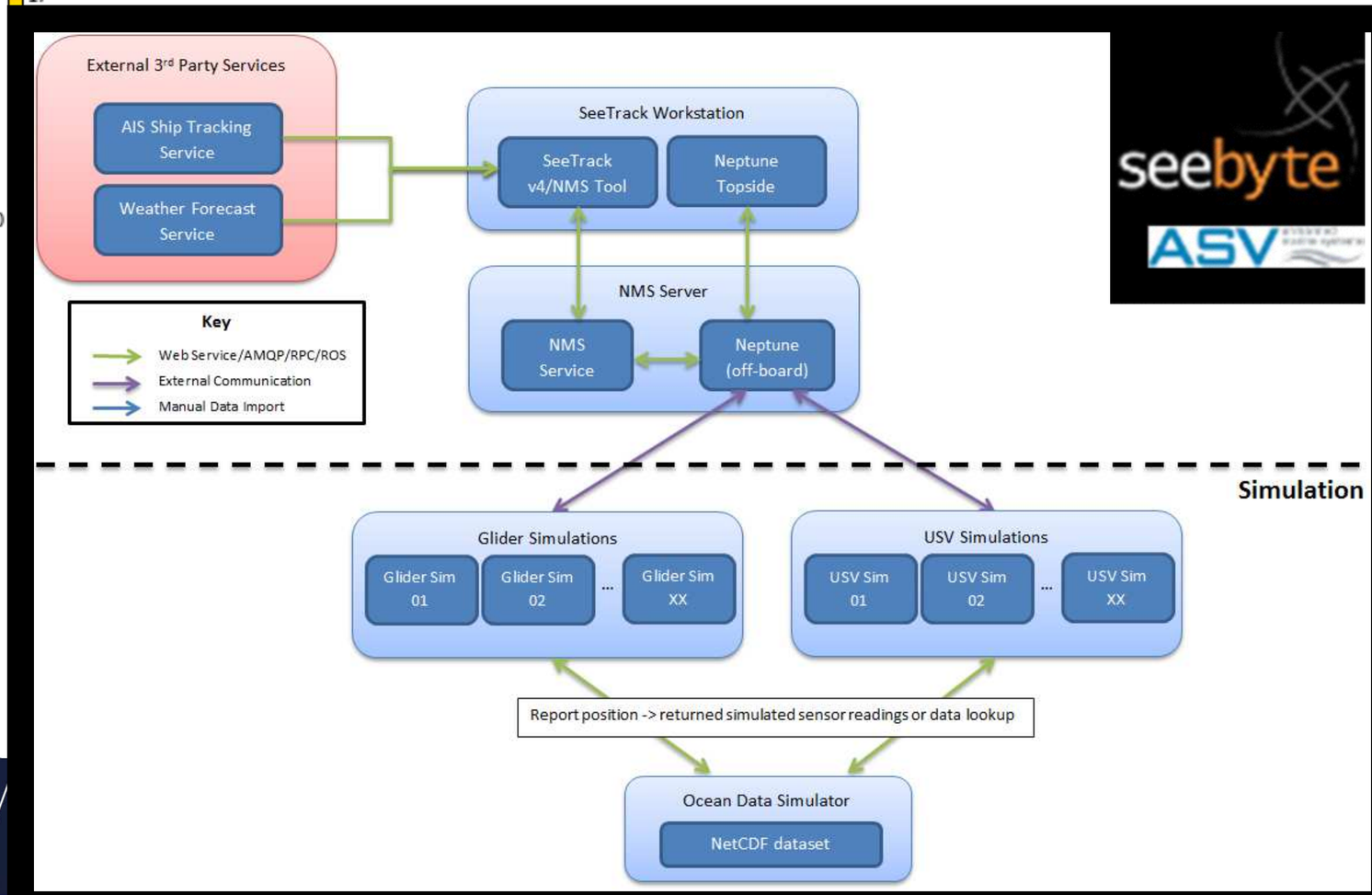
2.Bespoke data products - b) 4 dimensional synthetic ocean

- Mission planning / synthetic ocean - Mar 16
  AAOSN - Adaptive Autonomous Ocean Sampling Network









3.What's next? next generation ocean modelling

better predictive skill: assimilation of UAV data

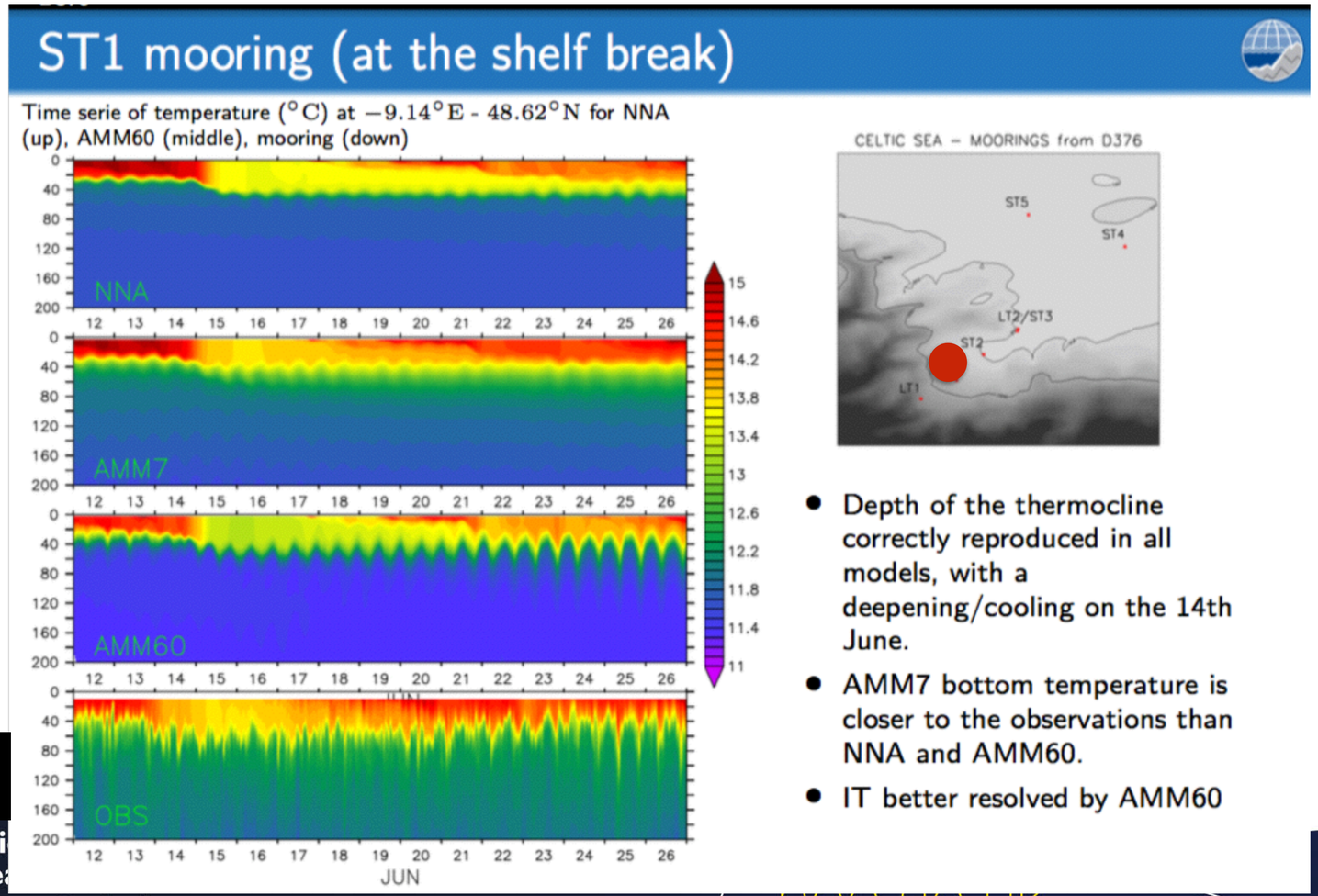
better physics: *ultra*HD resolution —> internal tides

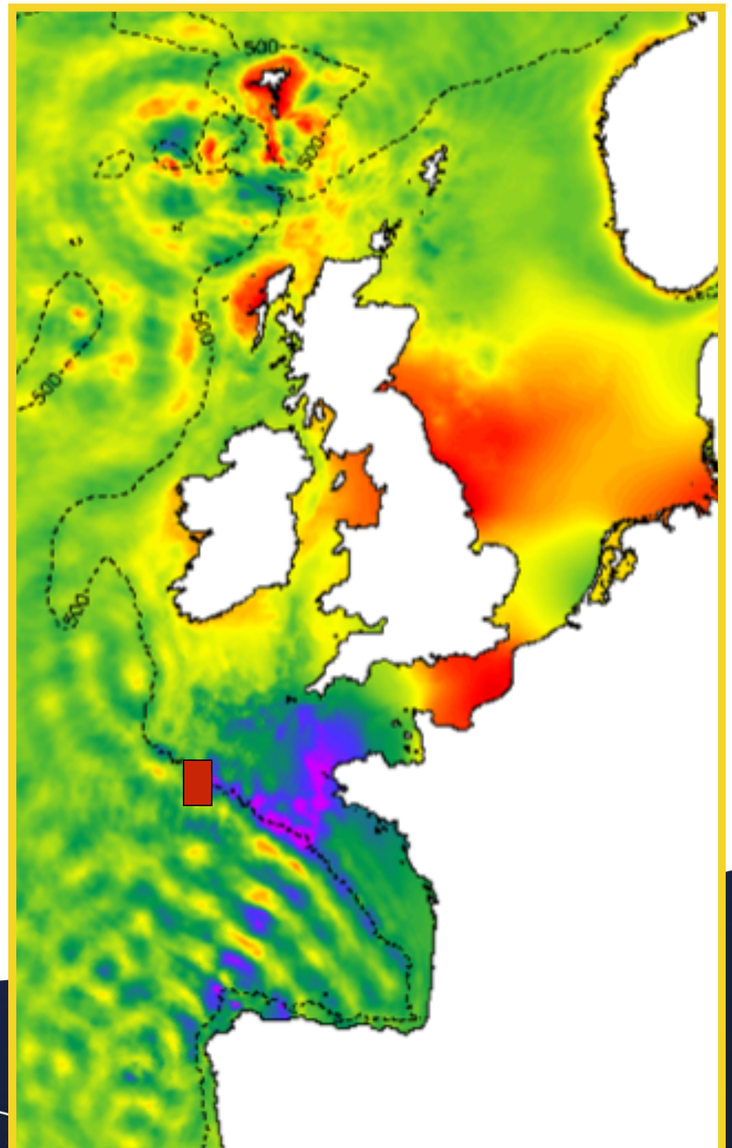
12km

7km

1.8km

obs

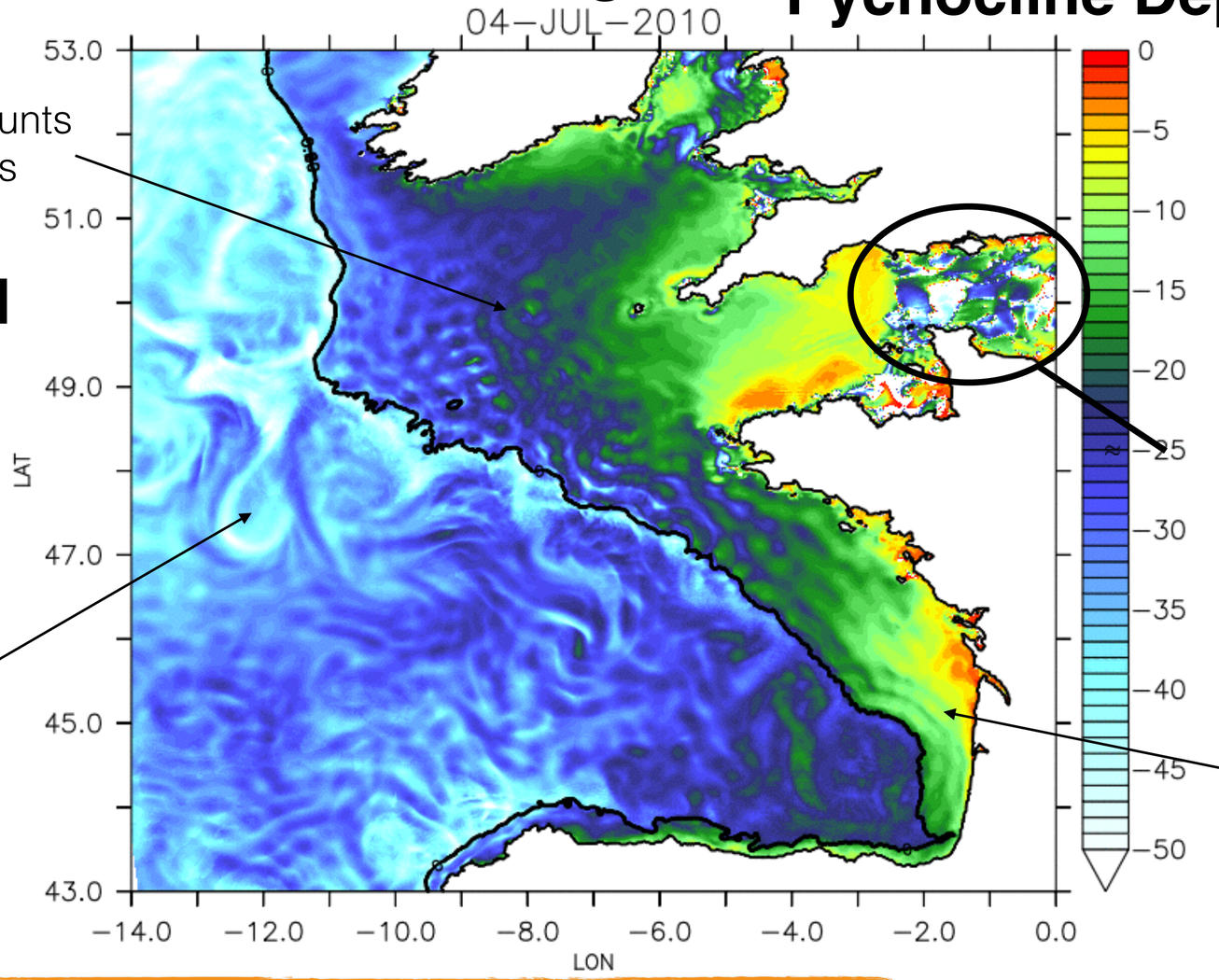




3.What's next? next generation ocean modelling

Pycnocline Depth

Celtic Sea internal tide field



multiple sea mounts
spiral waveforms

Off-shelf mesoscale and sub-mesoscale features

strat 0

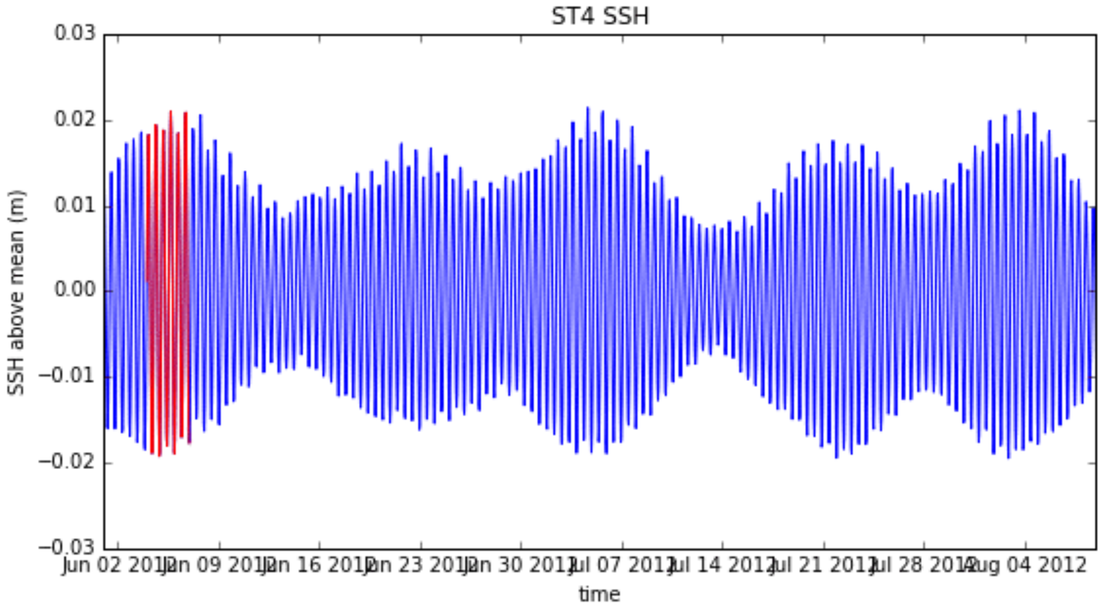
(ignore)

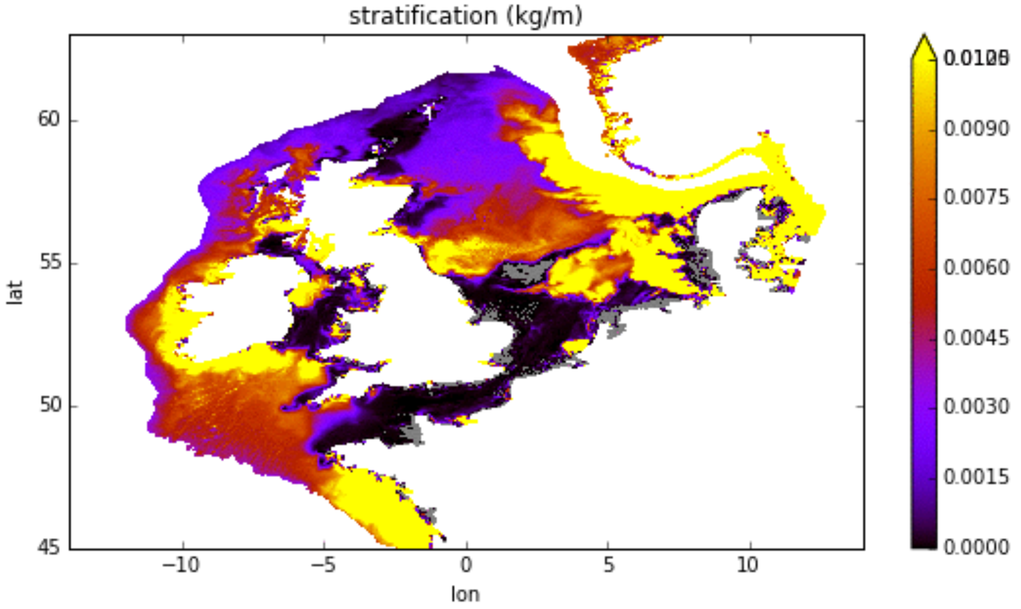
shelf break diffraction grating

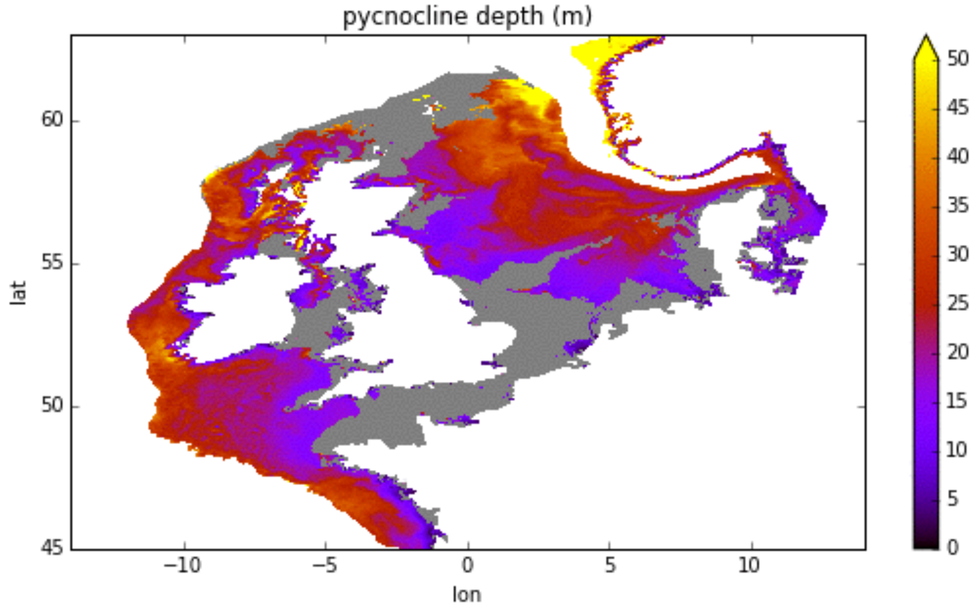
Energy in internal wave field propagate onto shelf —> vertical mixing —> vertical fluxes of T,S, BGC

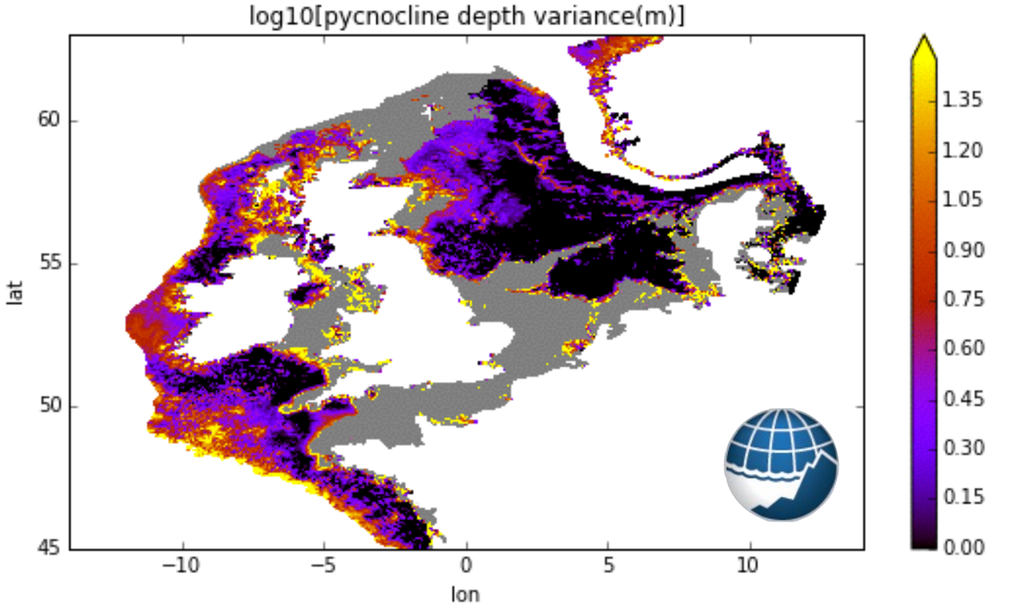
$$\delta = \frac{\int_{-H}^{0} z \frac{\partial \rho}{\partial z} \, dz}{\int_{-H}^{0} \frac{\partial \rho}{\partial z} \, dz}$$

2012-06-04 00:30:00 to 2012-06-06 23:30:00









4. Summary

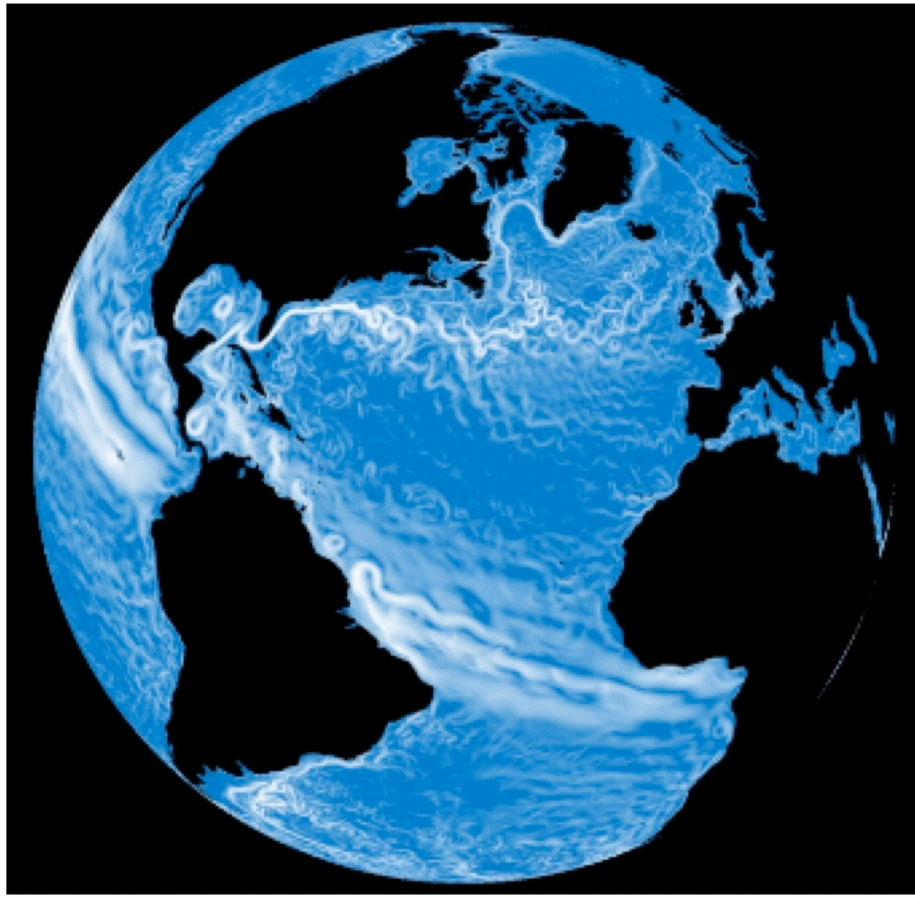
Global to regional modelling at fine resolutions

Host of applications:

- wave coupling,
- Next gen. Met Office models
- trajectory tracking, etc

Supporting MAS operations

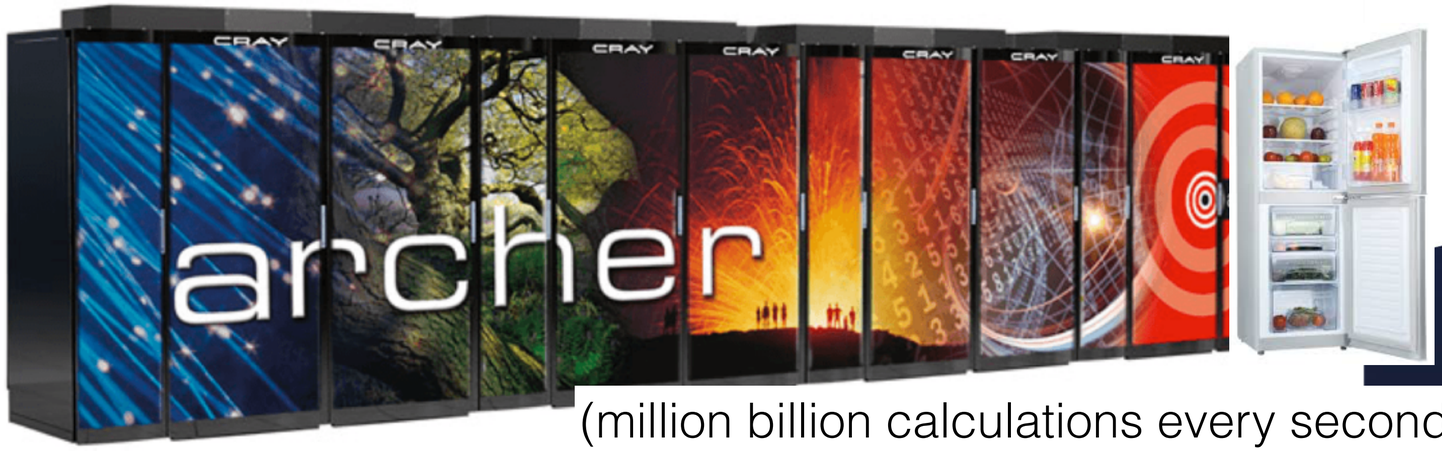
- recovery assist now-casting —> tidal current data layer on
- MARS glider pilot portal
- lost mooring search planning
- bespoke tidal products along lat,lon tracks



Next steps

- anyTide interface for 3rd party software e.g. AUV basestation
- internal tide data products

jelt@noc.ac.uk



(million billion calculations every second)
140,000 calc/s x world pop.

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