



# Recent Progress: North West European Shelf NEMO

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Acknowledgments: OFRD, NOC-L, NCOF & MyOcean



# Outline

- Introduction.
- Developments and testing (MO and NOCL).
- Evaluation (MO and NOCL).
  - SST assessment.
  - Comparisons with climatology.
  - Tidal assessment.
  - Assessment against observations using obs. operator.
- Conclusions and future work.



# Partners



**National  
Oceanography Centre**

NATURAL ENVIRONMENT RESEARCH COUNCIL



**Plymouth  
Marine Laboratory**

This work is very much a  
My Ocean and NCOF team effort



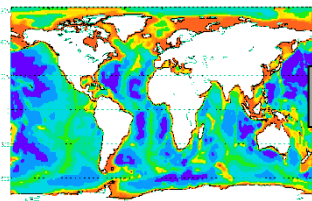
# Timeline

## Met Office

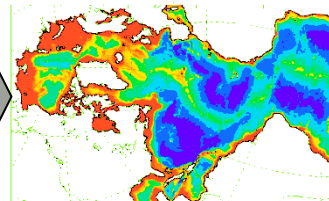
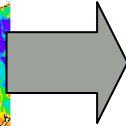
- Since late 2006, developments and evaluation have been undertaken on a new NEMO-based shelf seas model
- NCOF collaboration between the Met Office and NOC-L, using schemes developed by Mercator.
- The new system draws on experience (and algorithms) from the well-tested existing POLCOMS system (Holt et al series & [www.pol.ac.uk](http://www.pol.ac.uk)).
- Based on Forecast Ocean Assimilation Model (FOAM) system using the NEMO ocean (Storkey et al, 2010, JOO).
- A fully, on-line coupled ecosystem and sediment model is currently being evaluated.
- Implemented in the Parallel Suite (in parallel to existing POLCOMS system) in Jan 2011 with daily analyses and 5 day forecasts.
- The NWS NEMO-ERSEM-sediment sediment data will be released as MyOcean V1 products for the North West Shelf from April 2011



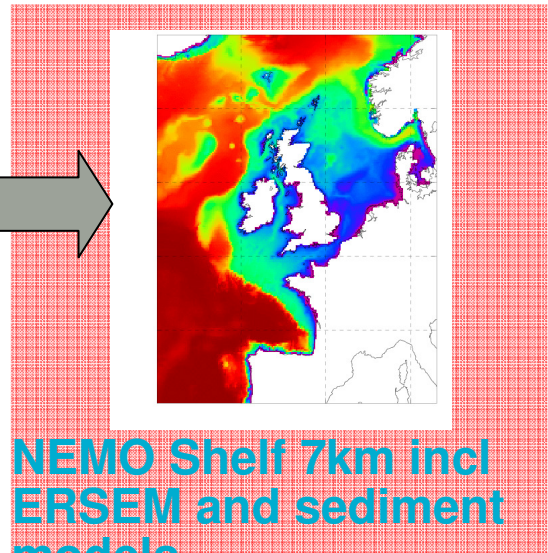
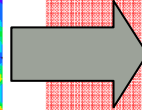
# MyOcean NWS Systems –



1/4° Global  
NEMO FOAM



1/12° N. Atlantic NEMO  
FOAM



NEMO Shelf 7km incl  
ERSEM and sediment  
models

V1 –  
March 11



# (Selected) Development and testing

(Coordinated by Jason Holt (NOCL) and Enda O'Dea (MO))



# NEMO Physics developments (My Ocean 2009-present)

- 2006-2009: Non-linear free surface, tidal boundary condition, harmonic analysis and log layer for constant density tidal testing.
- 2007-2009: Hybrid S coordinates (after Song and Haidvogel, 1994) but with NEMO sub-bed points to remove largest slopes.
- 2008-2009: River input scheme.
- 2008-2009: Pressure Jacobian horizontal pressure gradient scheme.
- 2009-2010: Testing GLS TKE scheme (kindly provided by Mercator) against GOTM.
- 2010: Re-implement and test semi-implicit bed stress with new NEMO bed stress formulation.
- 2010: Lateral diffusion including sponge layer (rotated Laplacian and bi-Laplacian) and option for Smagorinsky (not currently used).
- 2010: Depth dependant attenuation coefficient after POLCOMS.
- 2010: Tide generating force, after POLCOMS.
- 2010: PPM vertical advection, after POLCOMS (not currently used).
- 2010: SST data assimilation.

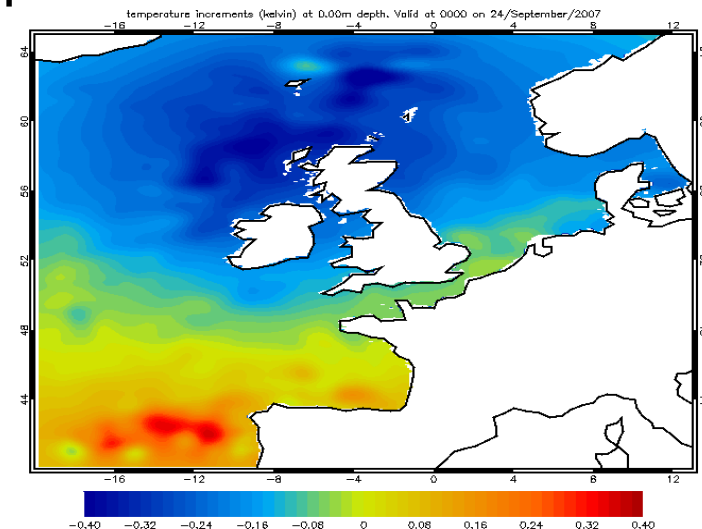


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# Shelf seas data assimilation

- SST assimilation: Both satellite & *in situ*.
- Optimal interpolation scheme.
- New observation operator that can deal with s-coordinates.
  - Includes SST, T&S profiles.
- New error-covariances calculated for the AMM domain with tides.

**Example increments  
24/9/2007**





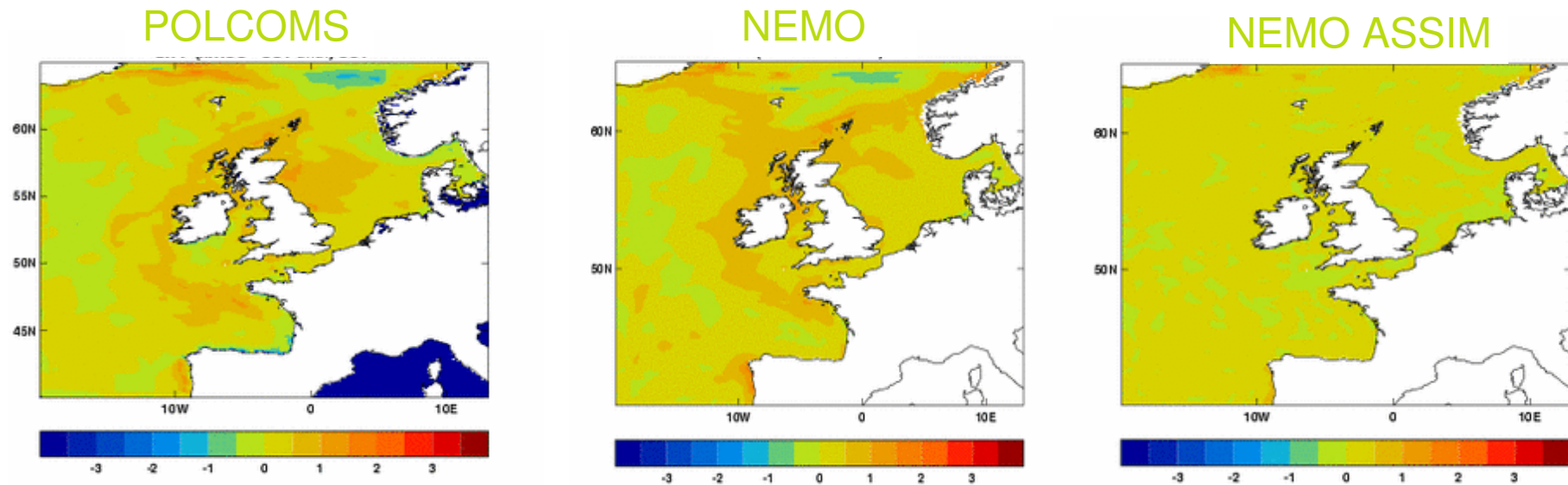


# (Selected) Evaluation



# Sea surface temperature comparisons

# SST errors versus OSTIA: Annual mean 2008



- NEMO and POLCOMS SST errors are roughly equivalent.
- There is a warm patch along shelf edge in both POLCOMS and NEMO (too much slope current heat transport).
- SST errors are much reduced with SST data assimilation (as expected and not independent data).



# Daily comparisons with OSTIA products: stats

**2008 only (May 29 to June 10 removed as missing for POLCOMS AMM)**

Domain	7km	7km	AMM	AMM	MRCS	MRCS
Param	Mn	RMS	Mn	RMS	Mn	RMS
POLCOMS-AMM	n/a	n/a	0.18	0.69	0.33	0.74
POLCOMS-MRCS	n/a	n/a	n/a	n/a	0.21	0.67
NEMO	0.30	0.67	0.30	0.66	0.47	0.76
NEMOASSIM	0.10	0.39	0.10	0.38	0.07	0.36

**2007-2008 (all dates included)**

Domain	7km	7km	AMM	AMM	MRCS	MRCS
Param	Mn	RMS	Mn	RMS	Mn	RMS
POLCOMS-MRCS	n/a	n/a	n/a	n/a	0.21	0.73
NEMO	0.30	0.69	0.29	0.68	0.50	0.78
NEMOASSIM	0.15	0.43	0.15	0.41	0.12	0.38

(spin up issue)

(several missing days)

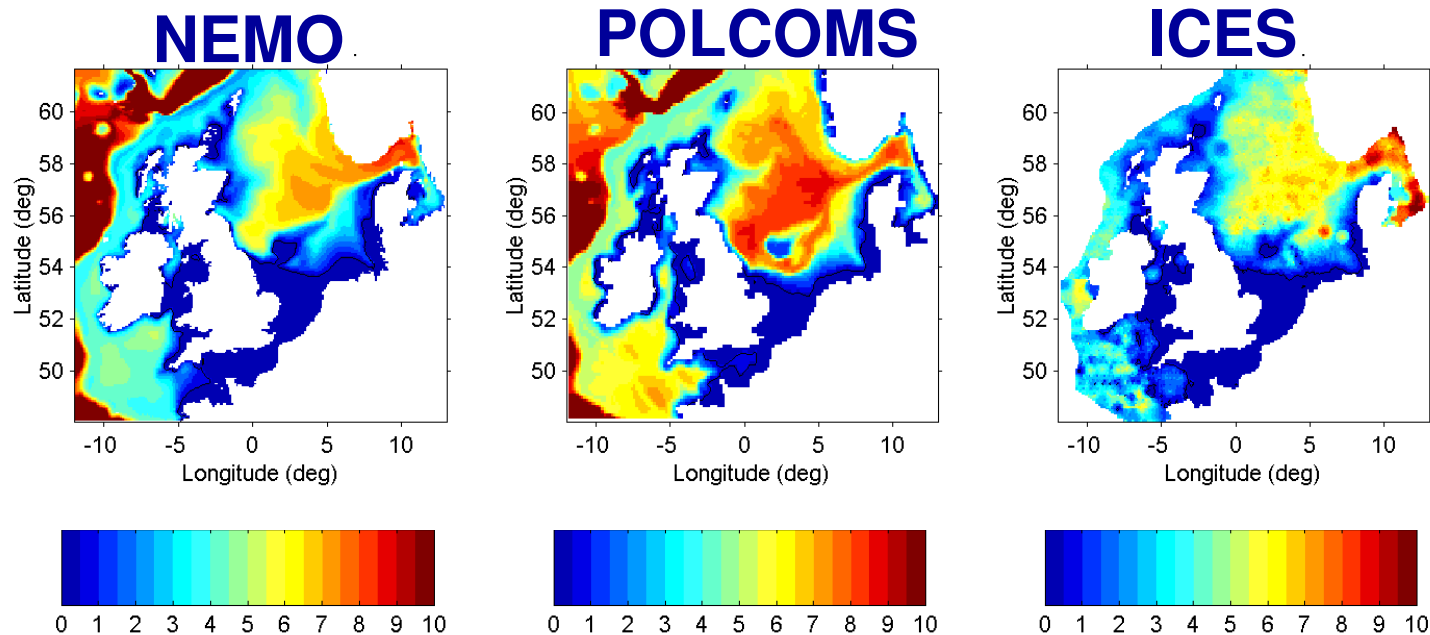
- RMS for NEMO ~ POLCOMS (bias is slightly worse).



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# Evaluation against the ICES climatology

- Plots below show seasonal (Jun-Aug 2008) top minus bottom temperature difference
- Stratification and frontal locations closer to ICES climatology in NEMO than POLCOMS (better TKE scheme?).



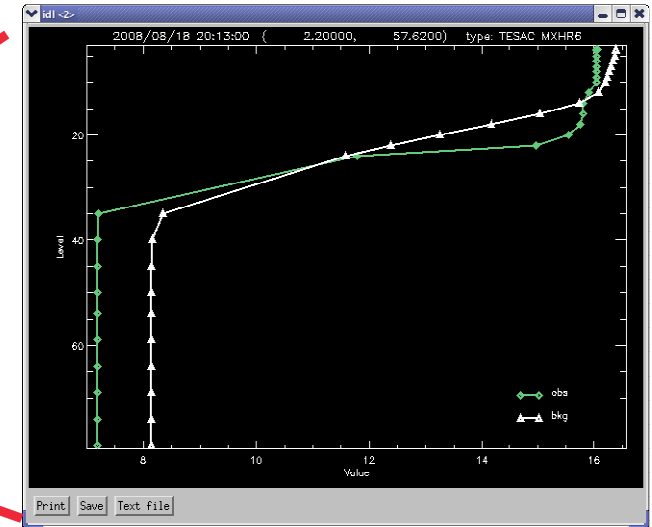
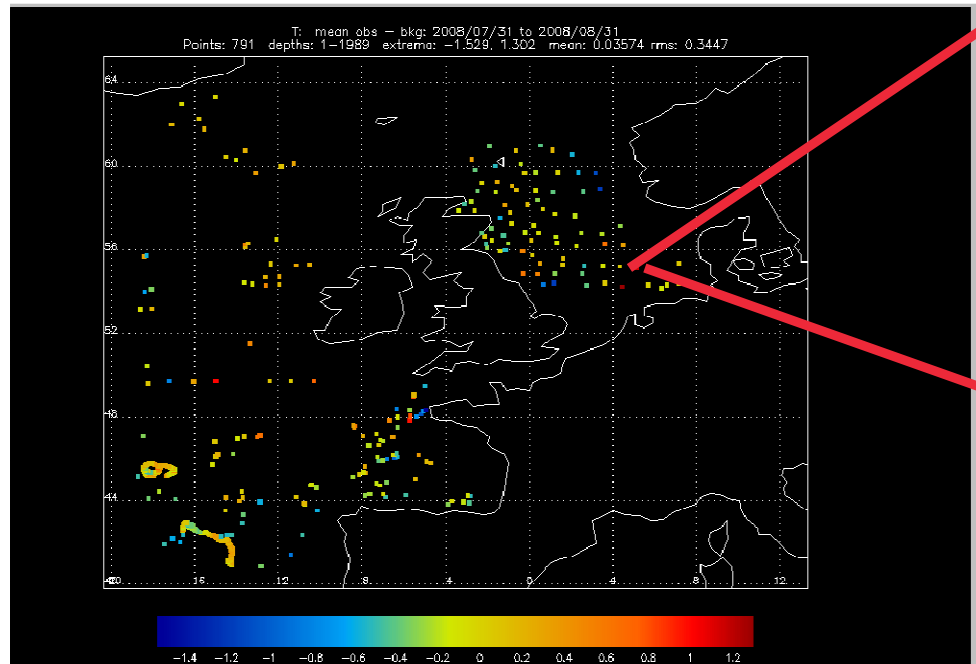
- Some errors remain in NEMO stratified patch in NW Irish Sea.



# Observational Operator comparisons



# Example: profile comparisons using monitoring suite





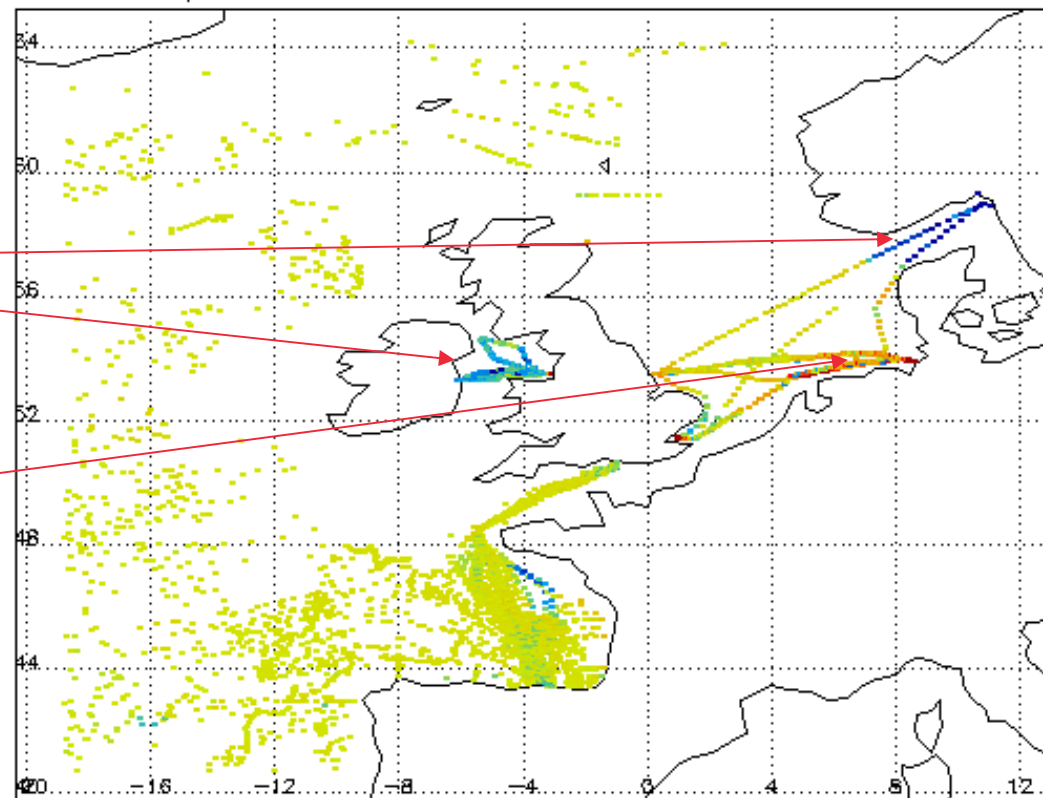
# Surface salinity (over 2007)

## FerryBox data is very useful

Model  
salinity too  
high

Model  
salinity too  
low

S: mean obs - bkg: 2007/01/01 to 2007/12/31  
Points: 19736 depths: 0-2994 extrema: -5.265, 9.195 mean: 0.001288 rms: 0.5889





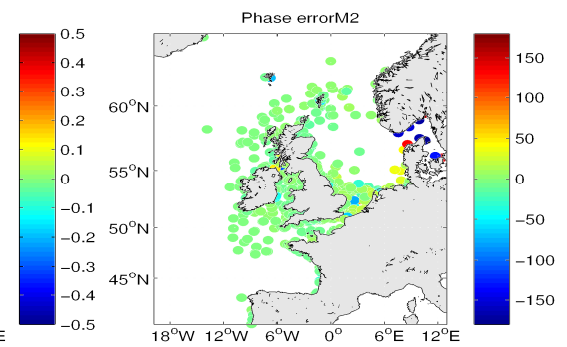
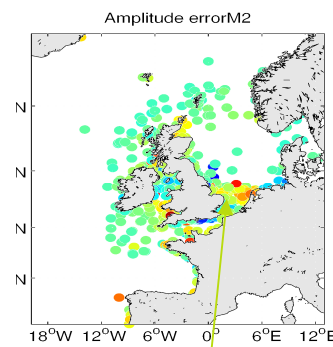
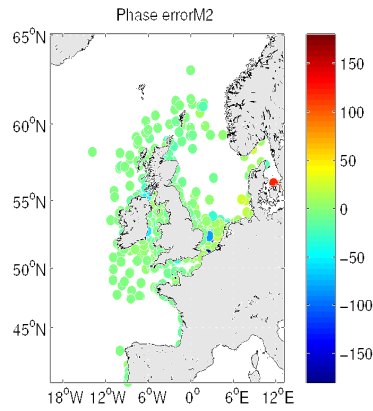
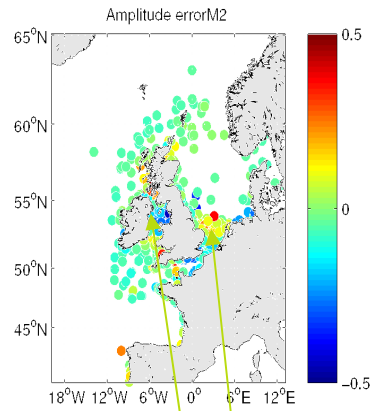


# Tidal comparisons



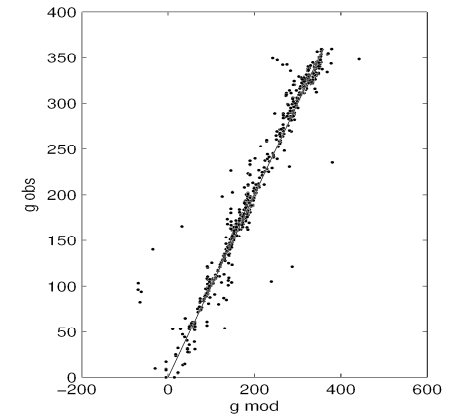
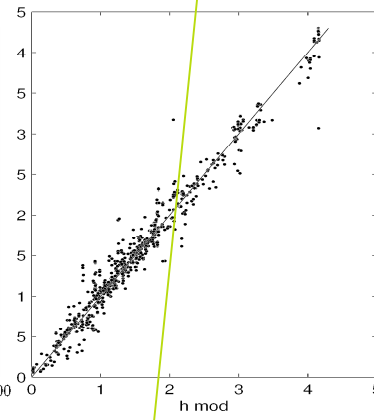
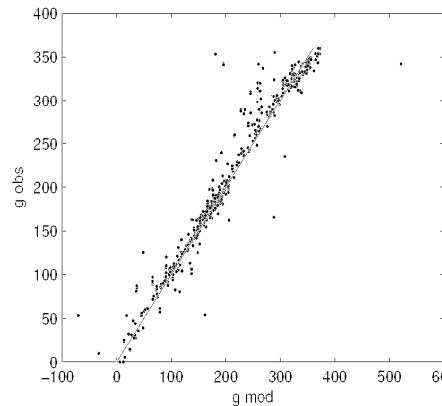
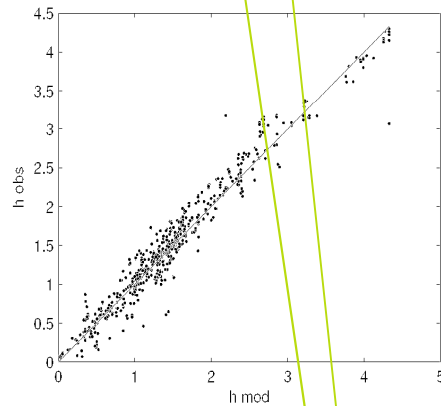
# M2 tidal errors

(possibly partially due to bathymetry errors)



POLCOMS

NEMO



Irish Sea and SW N Sea  
are poor

SW North Sea  
poor

# Tidal statistics

	M2	M2	S2	S2	M2&S2 run
	Mn	RMS	Mn	RMS	
NEMO baroclinic	-0.047	0.188	-0.005	0.060	
NEMO barotrop	-0.014	0.188	-0.008	0.066	
POLCOMS op	-0.029	0.173	0.034	0.079	
POLCOMS POL	0.055	0.179	n/a	n/a	

- RMS errors in NEMO and POLCOMS M2 tides are roughly equivalent.

# Conclusions and future work



# Conclusions

- After considerable development and testing effort since 2006, we have a working version of NEMO shelf using s coordinates which has similar performance to the existing POLCOMS system.
- Some errors remain:
  - Simulated tide errors, e.g. Irish Sea and SW North Sea.
  - A warm bias  $\sim 1^{\circ}\text{C}$  is evident throughout the year, but particularly during winter, which appears to be related to too much slope current heat transport (due to over-smoothed bathymetry based on 12km AMM).
  - Both of these errors should be reduced by carefully optimising bathymetry.
- Preliminary results suggest that data assimilation appears to reduce the warm bias in the model free run whilst not seriously degrading the sub-surface structure.
- Efficiency remains an issue (4 times less efficient than POLCOMS) but further optimisation is possible.
- The system has now been frozen for operational implementation early in 2011 but optimisation is ongoing and improvements may be implemented prior to the My Ocean V1 system next June.



# Ongoing and future work

- Aims to address the key issues identified by evaluation, e.g. warm bias and tidal errors.
- There is an ongoing effort at MO and NOCL to regenerate and optimise the bathymetry for tidal simulations and slope current (e.g. conservative interpolation at NOCL and investigation of Sikiric et al, 2010 interpolation method used in ROMS at MO).
- More work generally is needed/planned to optimise horizontal and vertical diffusion/viscosity.
- A run has been completed with increased bi-Laplacian (only possible on model levels) to reduce grid scale noise in vertical velocities.
- More observations, e.g. scan fish, are needed to assess 3-D structure!
- Coupled ecosystem and sediment model runs and evaluation are underway (initial results look promising).
- Further system evaluation (cal/val) is planned by WP7 partners.
- In the longer term, work is planned to test hydrological model river input and new Baltic boundary condition to try to improve representation of salinity structure.



# Questions and answers