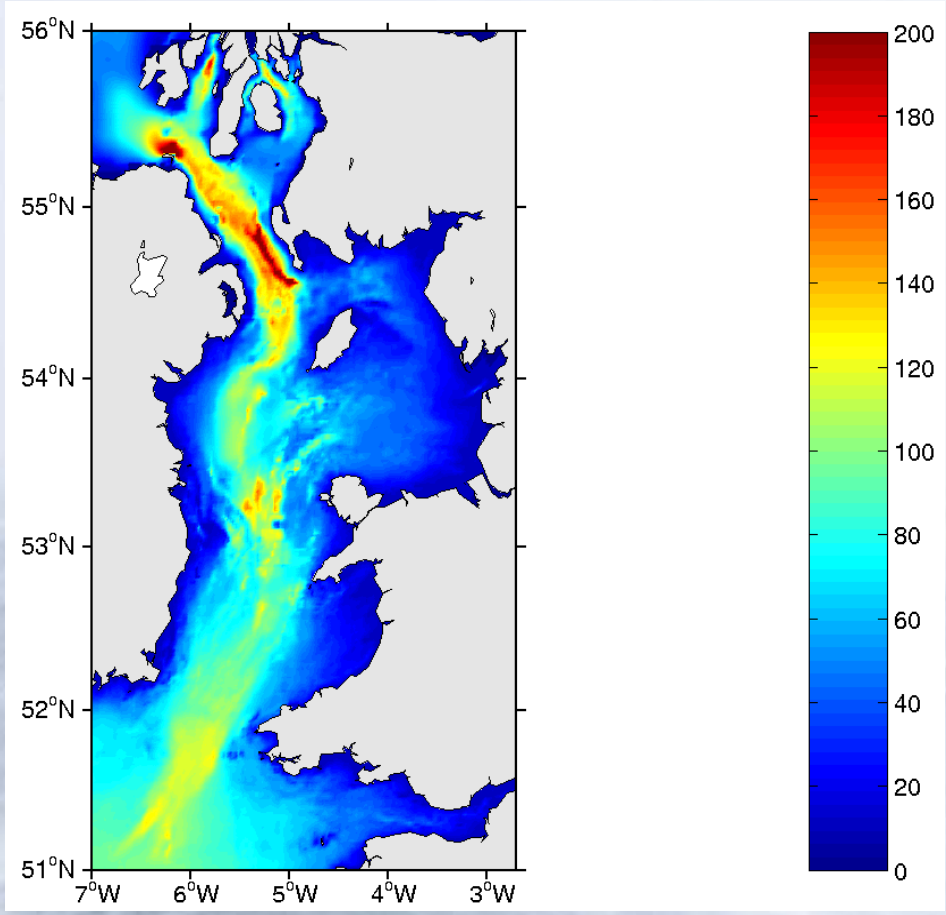
# Data Assimilation in the Irish Sea using the EnKF

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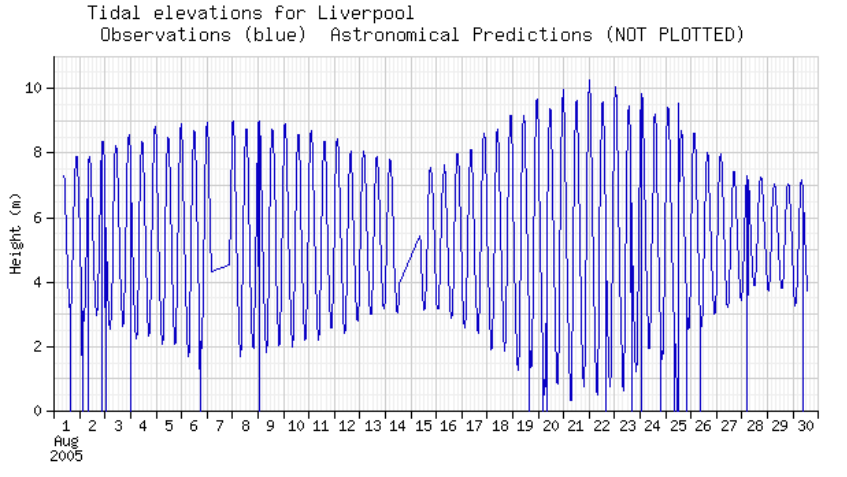
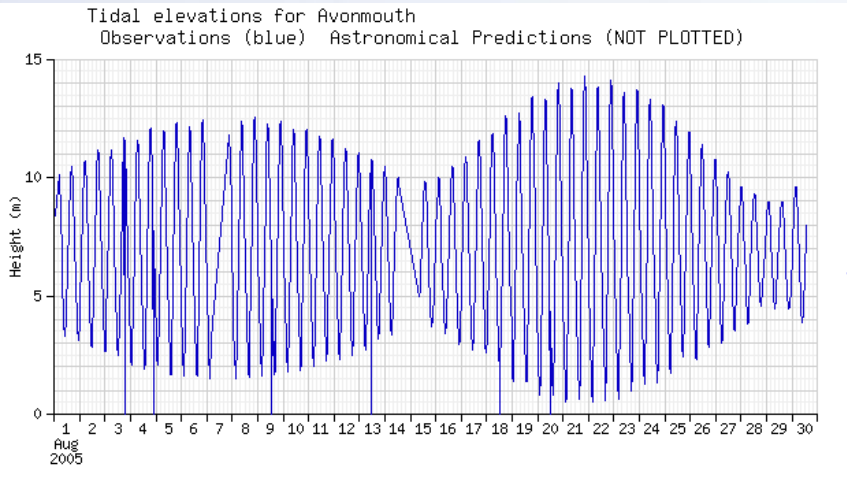
Mike Ashworth#
Coastal Observatory team*

*Proudman Oceanographic Laboratory
#CCLRC Daresbury Laboratory

# Dynamics of the Irish Sea - tides



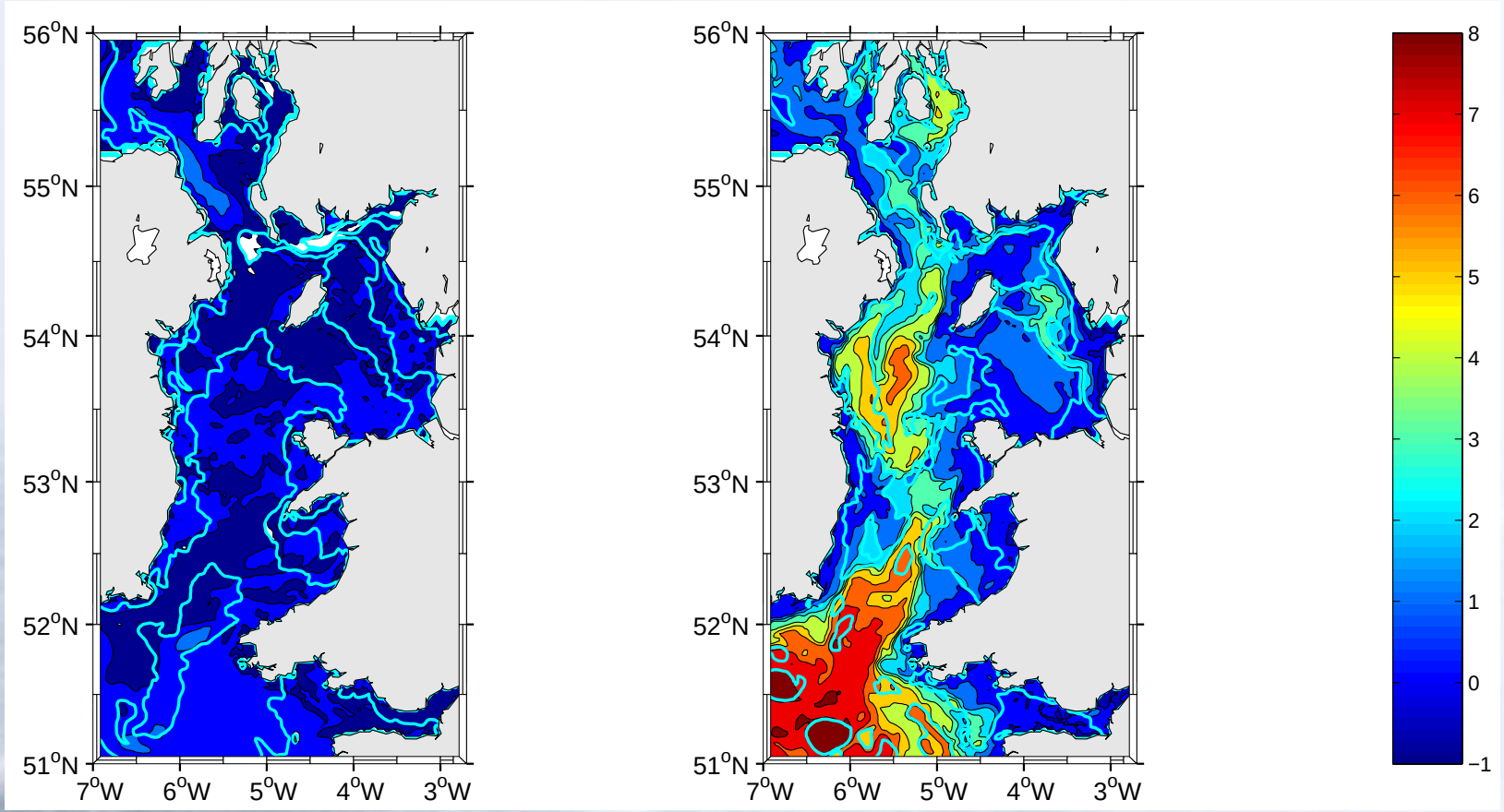




# Irish Sea: seasonal stratification

$T_{surface} - T_{bed}$

31/01/2001

31/07/2001

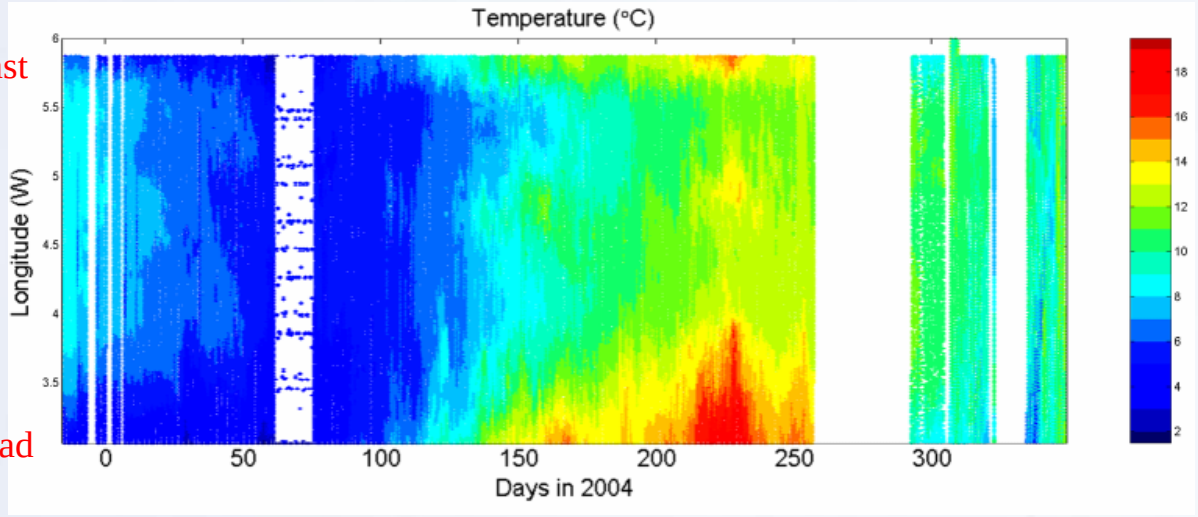


# Irish Sea: Sea Surface Temperature

Ferry

Belfast

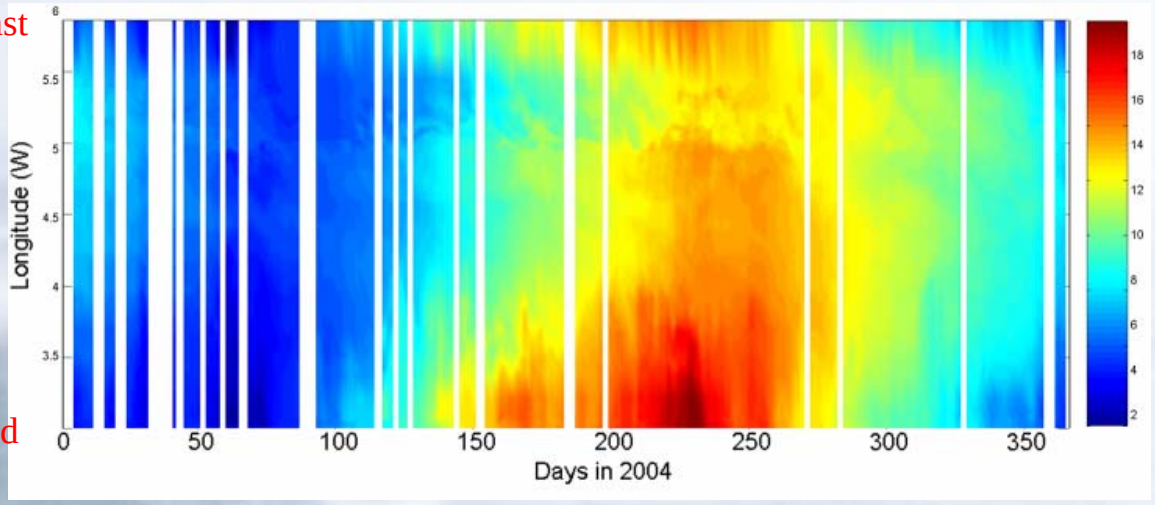
Birkenhead

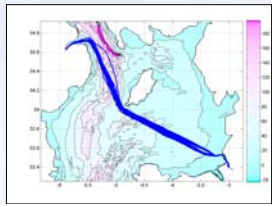



IRS model

Belfast

Birkenhead



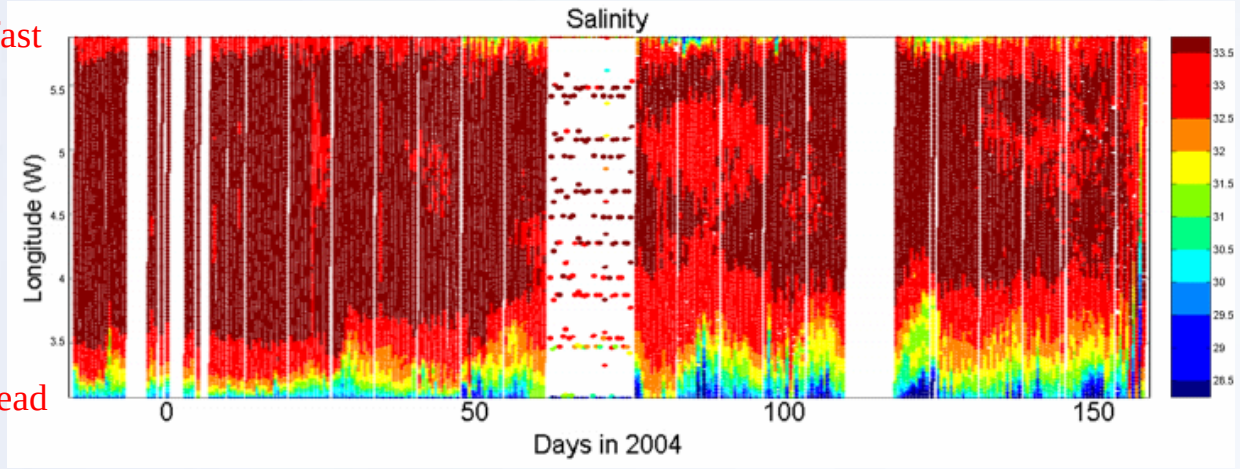



# Irish Sea: Sea Surface Salinity

Ferry

Belfast

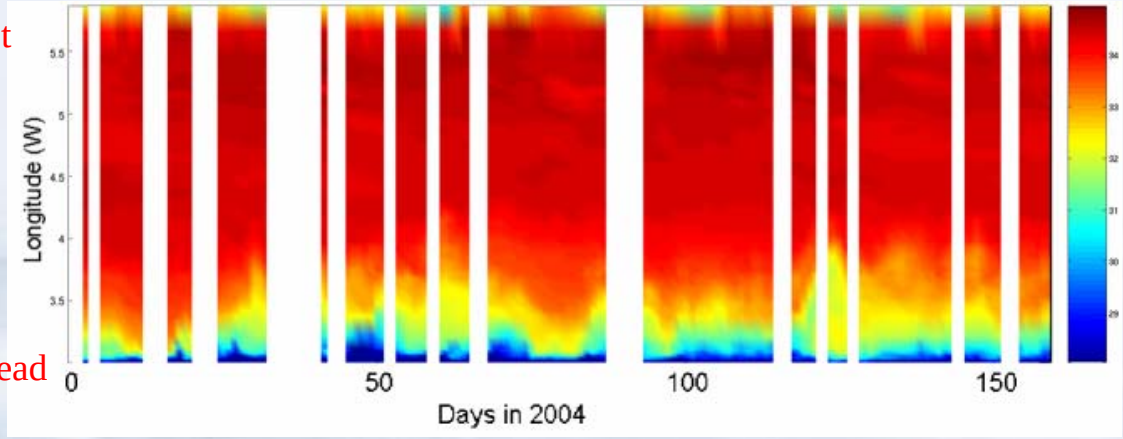
Birkenhead



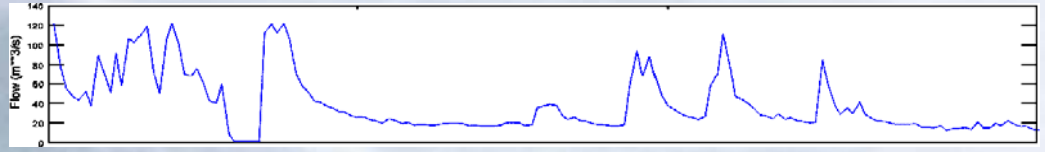

IRS model

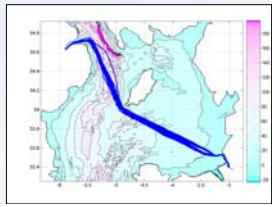
Belfast

Birkenhead




River flow (Mersey)

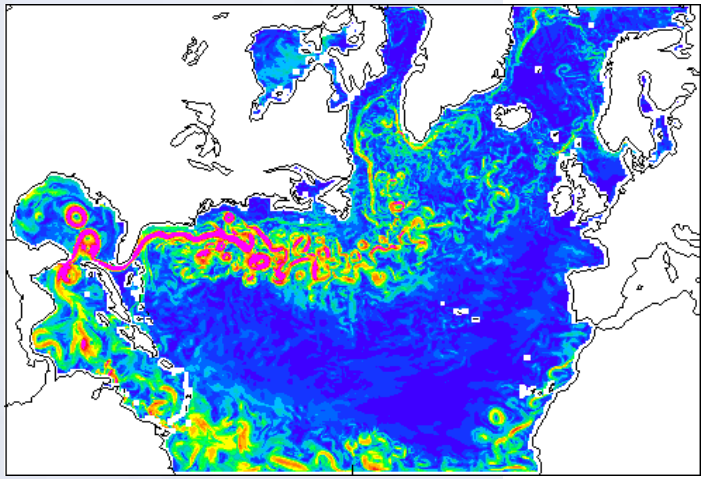




# The POLCOMS model

- POLCOMS: Proudman Oceanographic Coastal Ocean Modelling System.
  - Finite difference model that solves for velocity (u,v,w), potential temperature (T), salinity (S), surface elevation and turbulent kinetic energy on an Arakawa B-grid.
  - 15 tidal constituents.
  - Uses the 'Piecewise Parabolic Method' (PPM) for scalar and velocity advection.
  - Contains a 2.5 turbulence closure scheme based on Mellor-Yamada-Galperin.
  - Activates a convective adjustment scheme in cases of static instability.
  - Can run coupled to other models (wave, ecosystem, sediment transport, …).

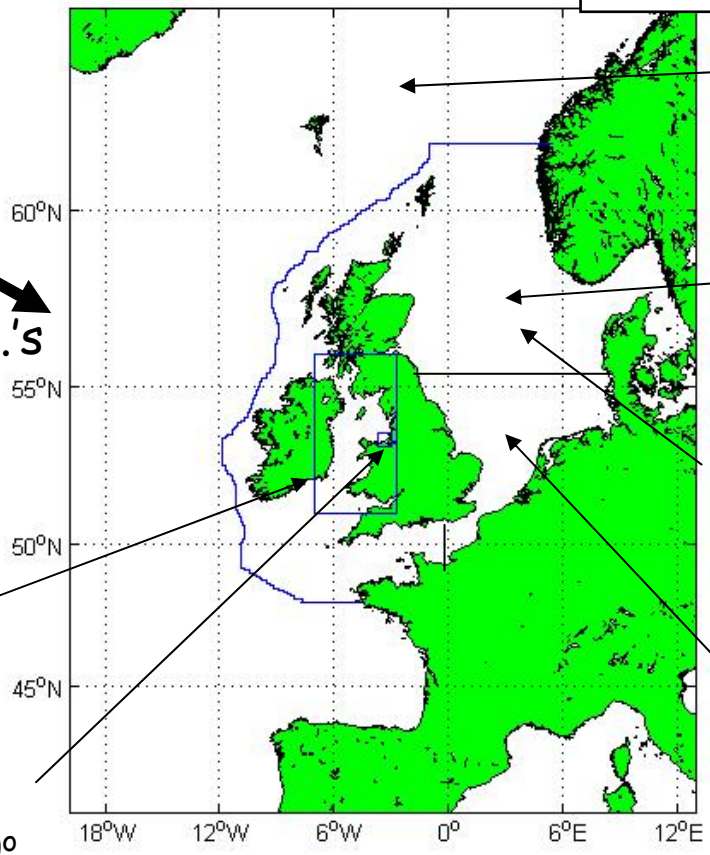
# Model domains



Met office FOAM model

b.c.'s

POLCOMS
POLCOMS-ERSEM




Atlantic Margin
1/6°x1/9°

Medium resolution
Continental shelf
1/10°x1/15°

High resolution
Continental shelf
1/40°x1/60°

S. North Sea
1/40°x1/60°

Irish Sea
1/40°x1/60°

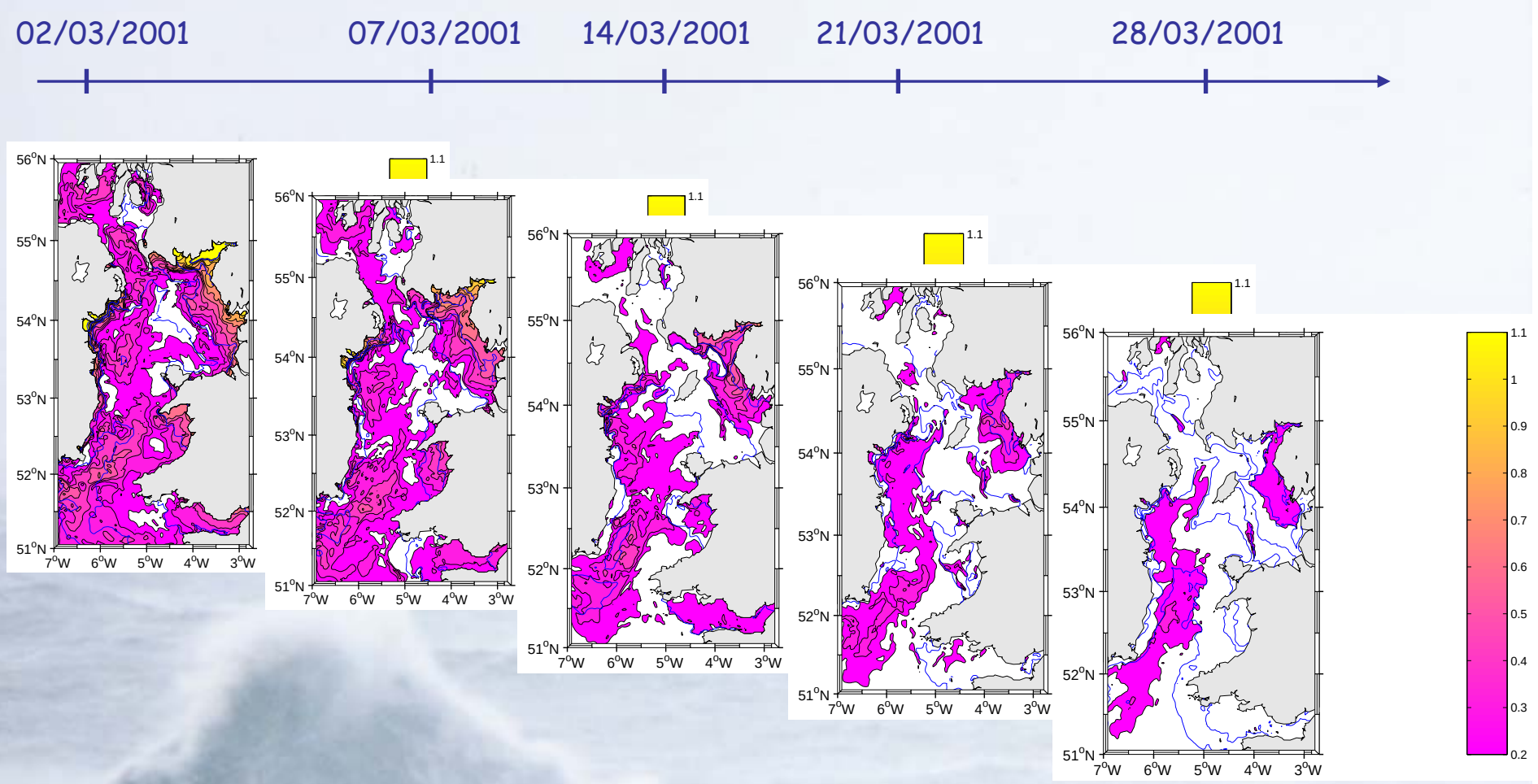
Liverpool Bay
1/400°x1/600°

Aiming at a fully coupled hydrodynamics-wave-ecosystem-sediments system

# Experiment setup

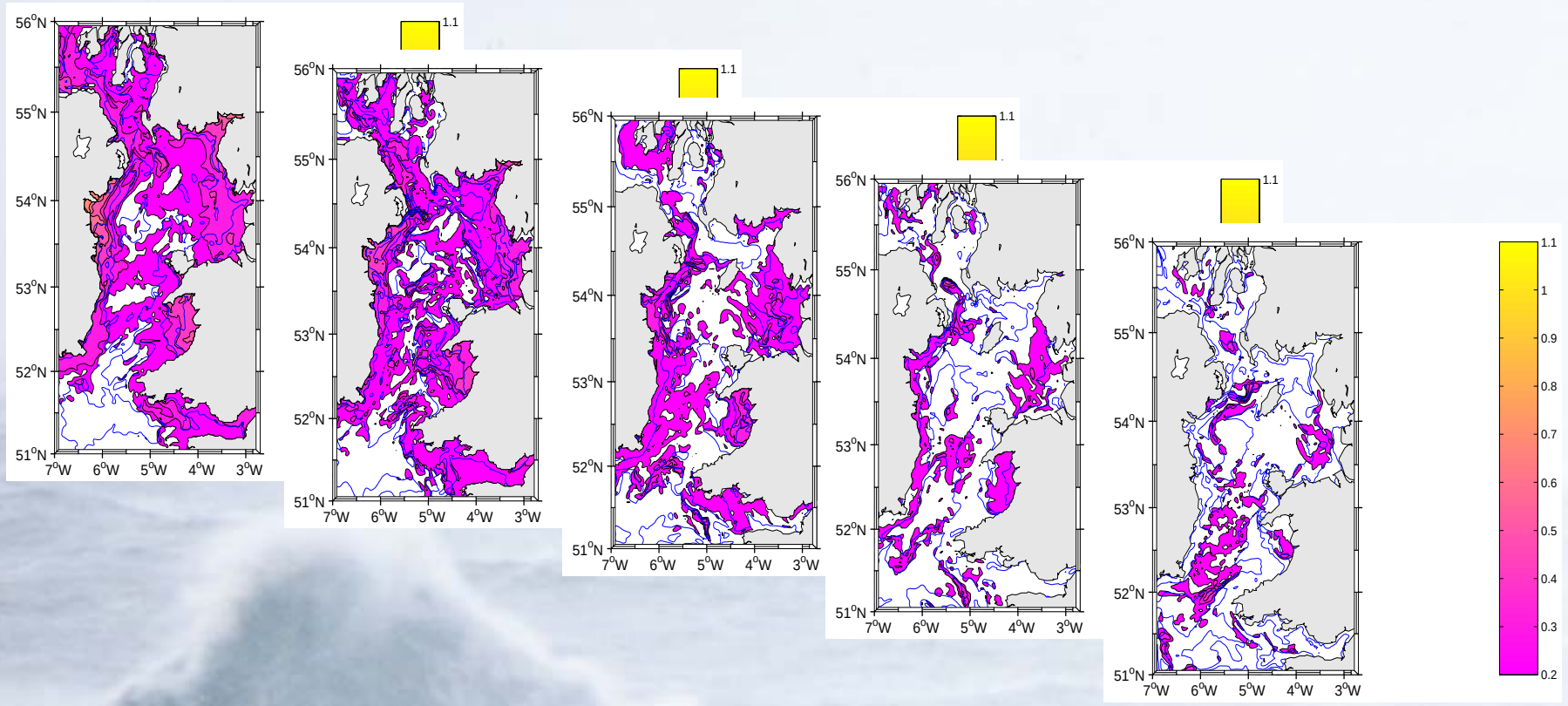
- Objective: Investigate sources of model error in the framework of ensemble simulations and assimilate SST observations using an EnKF.
- EnKF code: http://www.nersc.no/~geir/EnKF/Code/
- Model error:
  - Wind (geostrophic red noise)
  - Turbulence parameters
  - Cloud cover
- Simulated period: winter-summer 2001.
- Irish Sea, 1.8 km horizontal resolution
- State-vector : (T,S,u,v,$\zeta$,$\kappa$,l,...)
- 10 members
- I. C. sampled from 4 month daily model output (Evensen, 2004, Ocean Dynamics).

# Evolution of background error



# Evolution of forecast ensemble spread

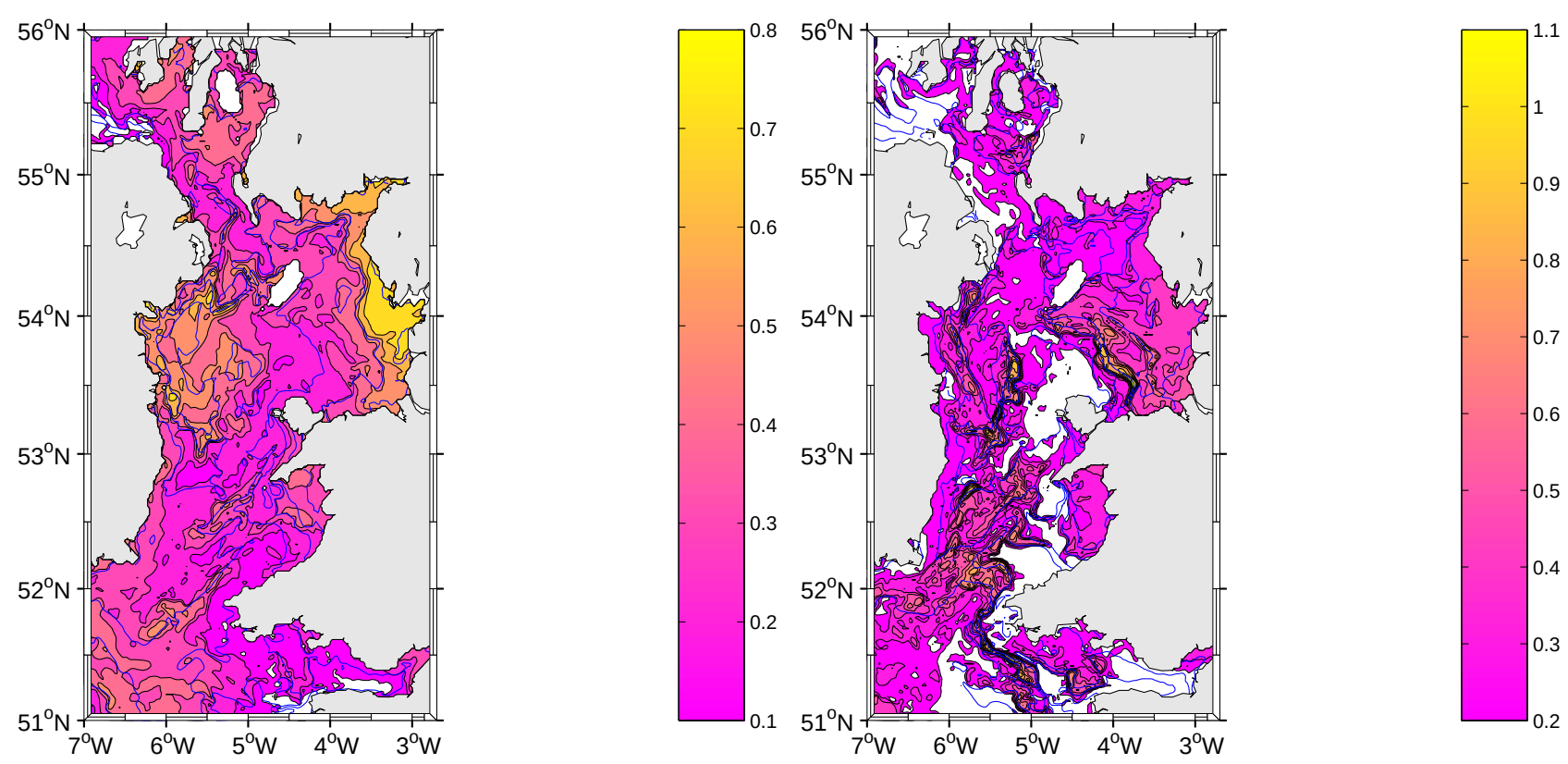
02/05/2001 07/05/2001 14/05/2001 21/05/2001 28/05/2001



# Modelling the background error

01/05/2001 01/06/2001 01/07/2001

X




Sources of error: wind, turbulent parameters, cloud cover

# Analysis step

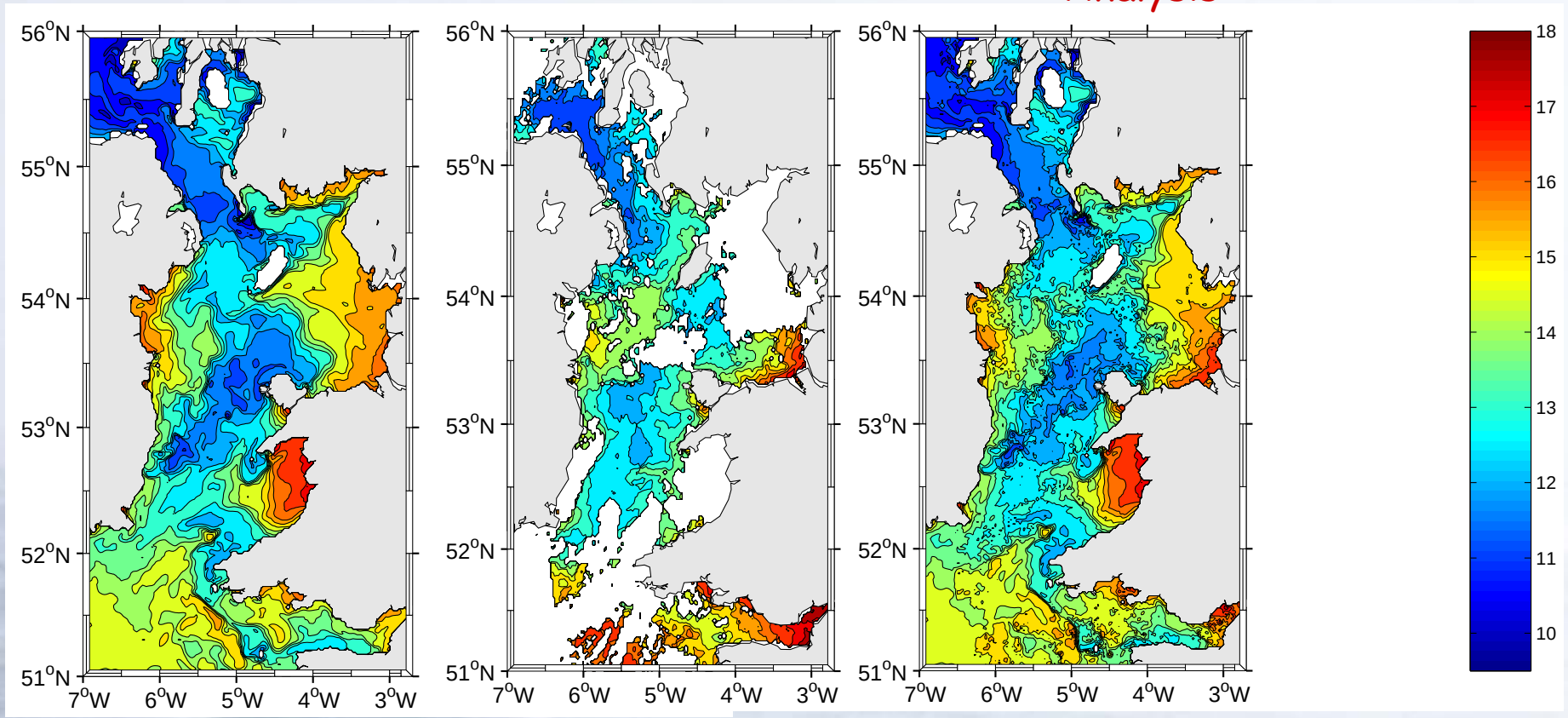
## (analysis6c algorithm)

On 02/07/2001:

Forecast

Observations

Analysis

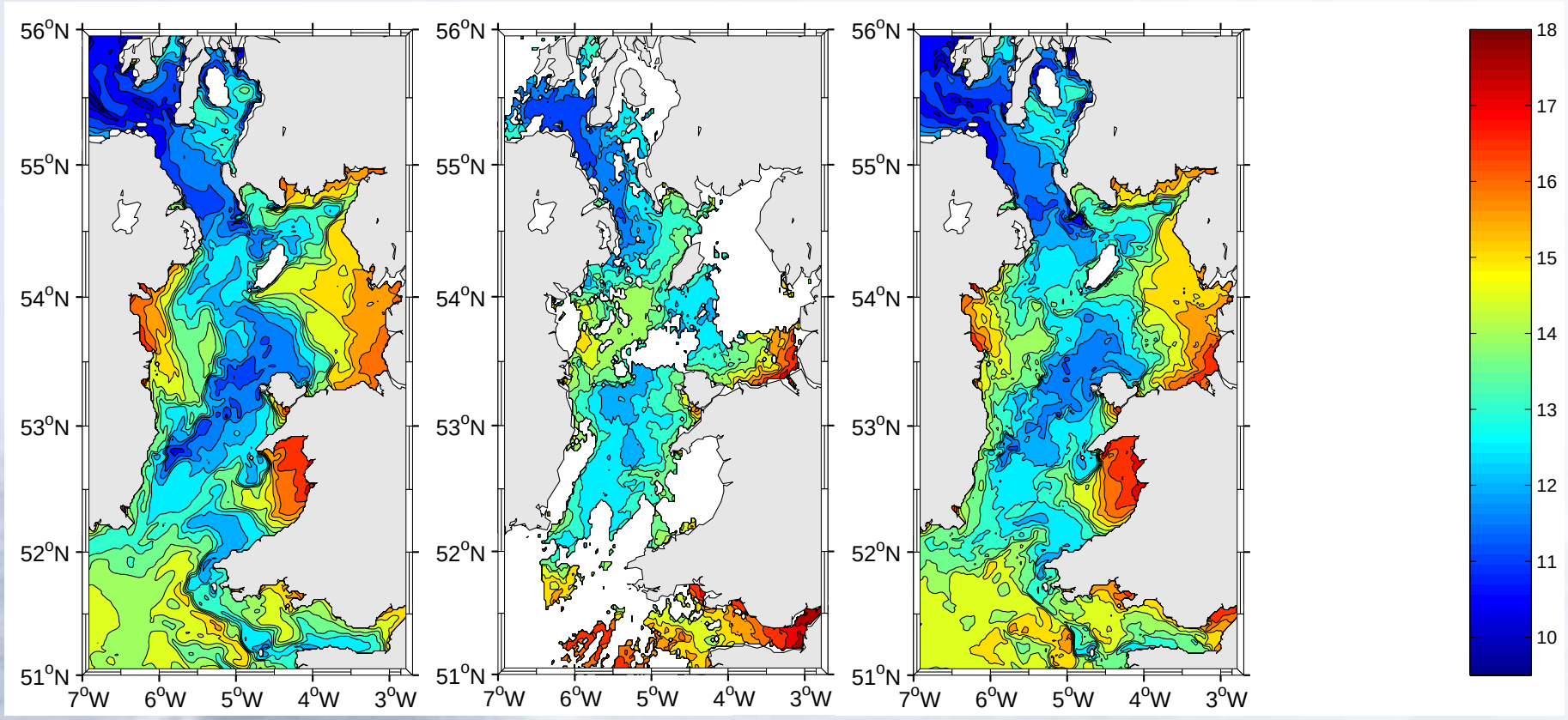


# Analysis step

## (analysis2 algorithm)

On 02/07/2001:

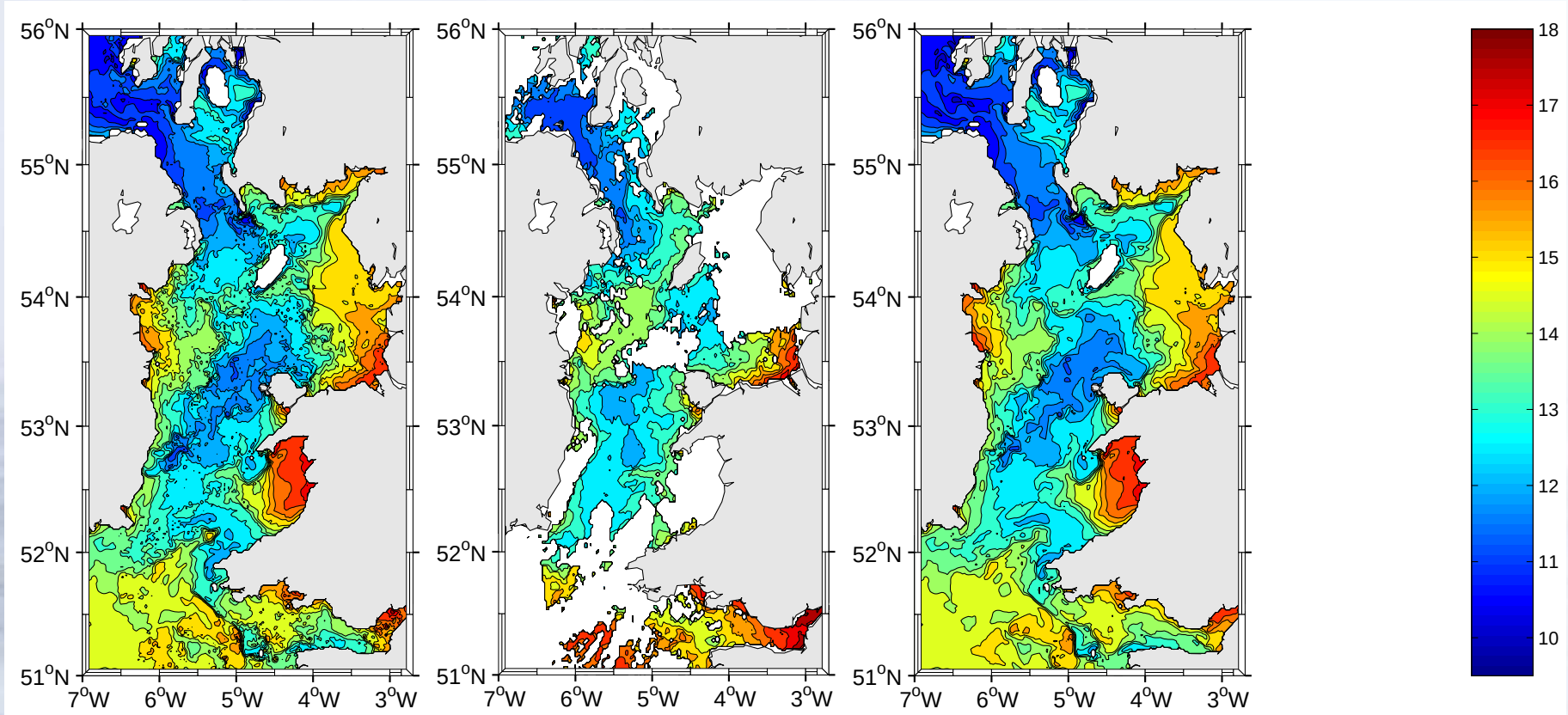
Forecast | Observations | Analysis



# Which algorithm is best suited?
## (analysis6c vs. analysis2)

On 02/07/2001:

analysis6c | Observations | analysis2



# Evolution of ensemble spread after analysis

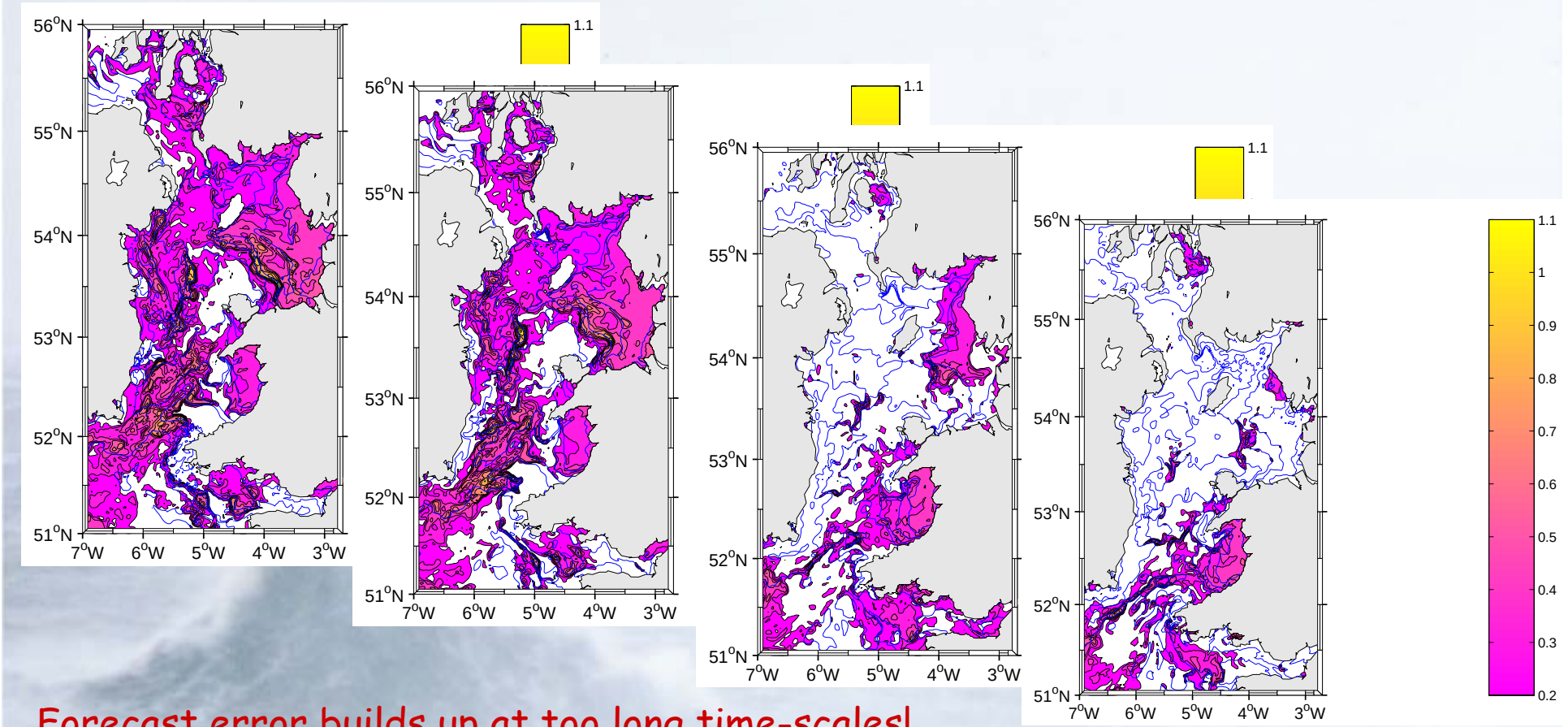
(analysis6c)

First analysis
01/07/2001

02/07/2001

03/07/2001

04/07/2001




Forecast error builds up at too long time-scales!

# Evolution of ensemble spread after analysis

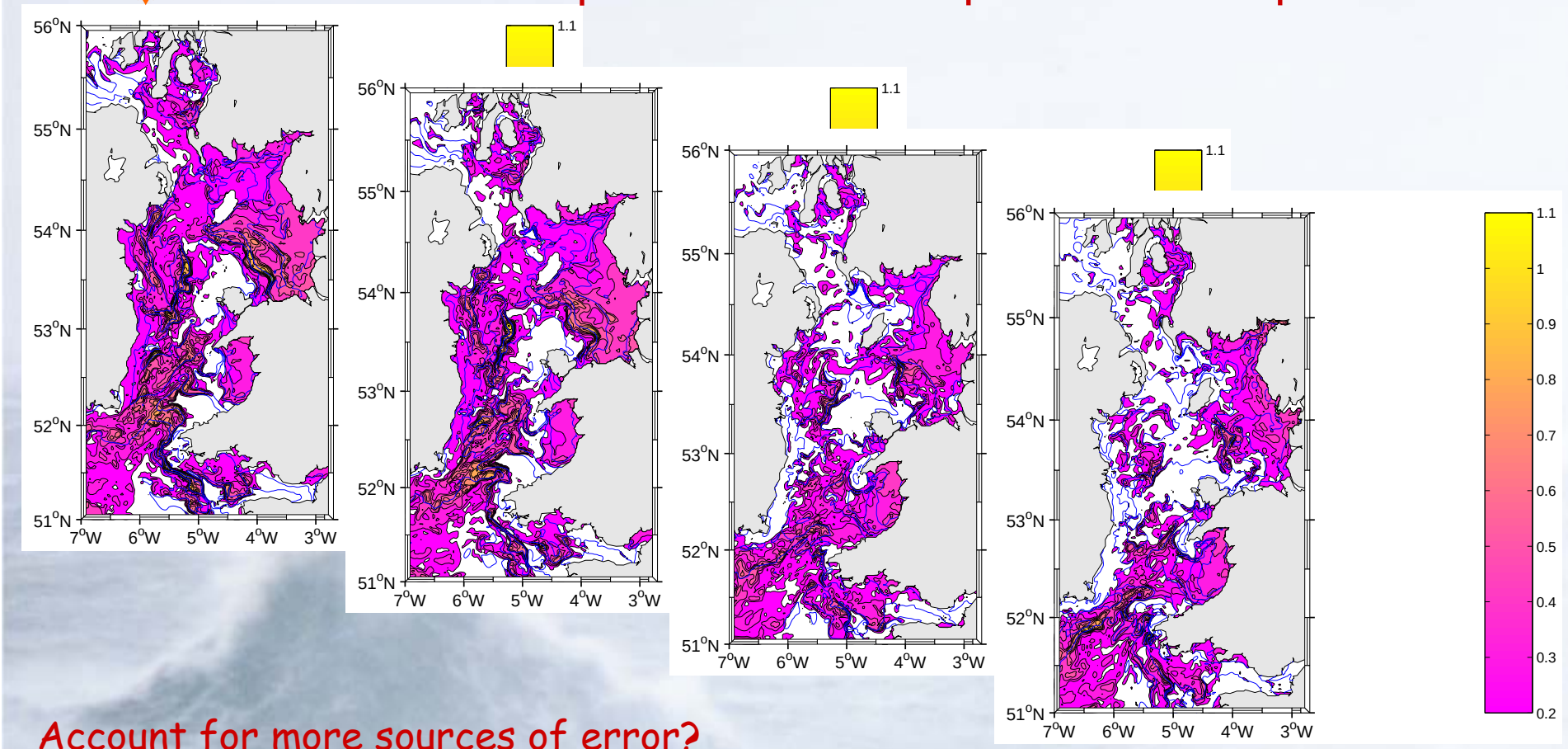
(analysis2)

First analysis
01/07/2001

02/07/2001

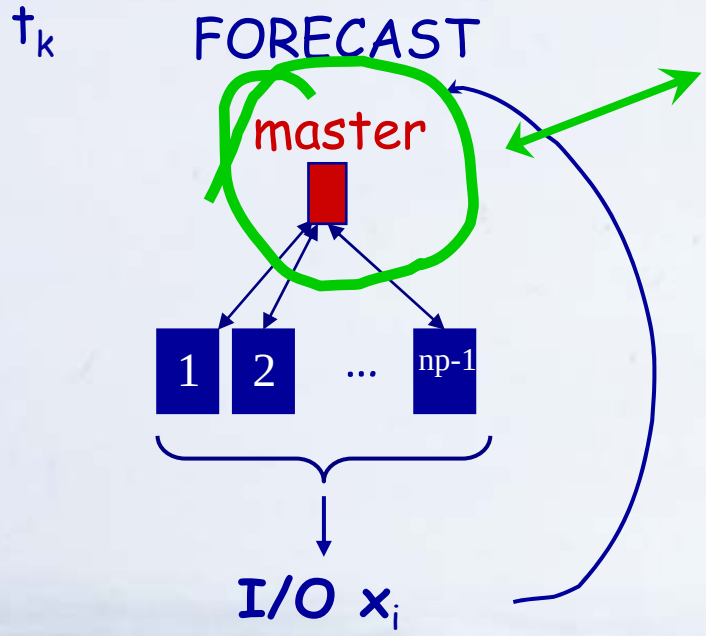
03/07/2001

04/07/2001




Account for more sources of error?

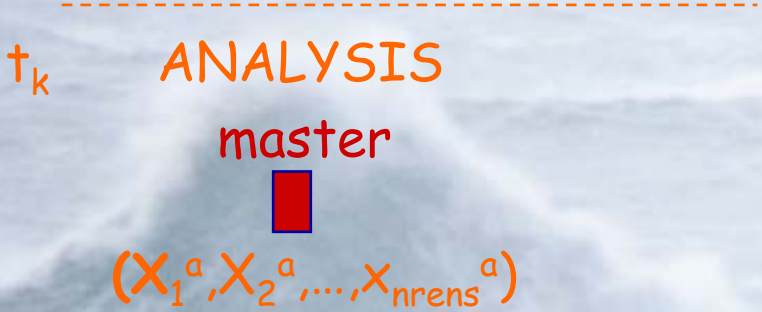
# Present implementation




Model error parameterization: Some CPU and memory consuming computations are still performed in the master processor!

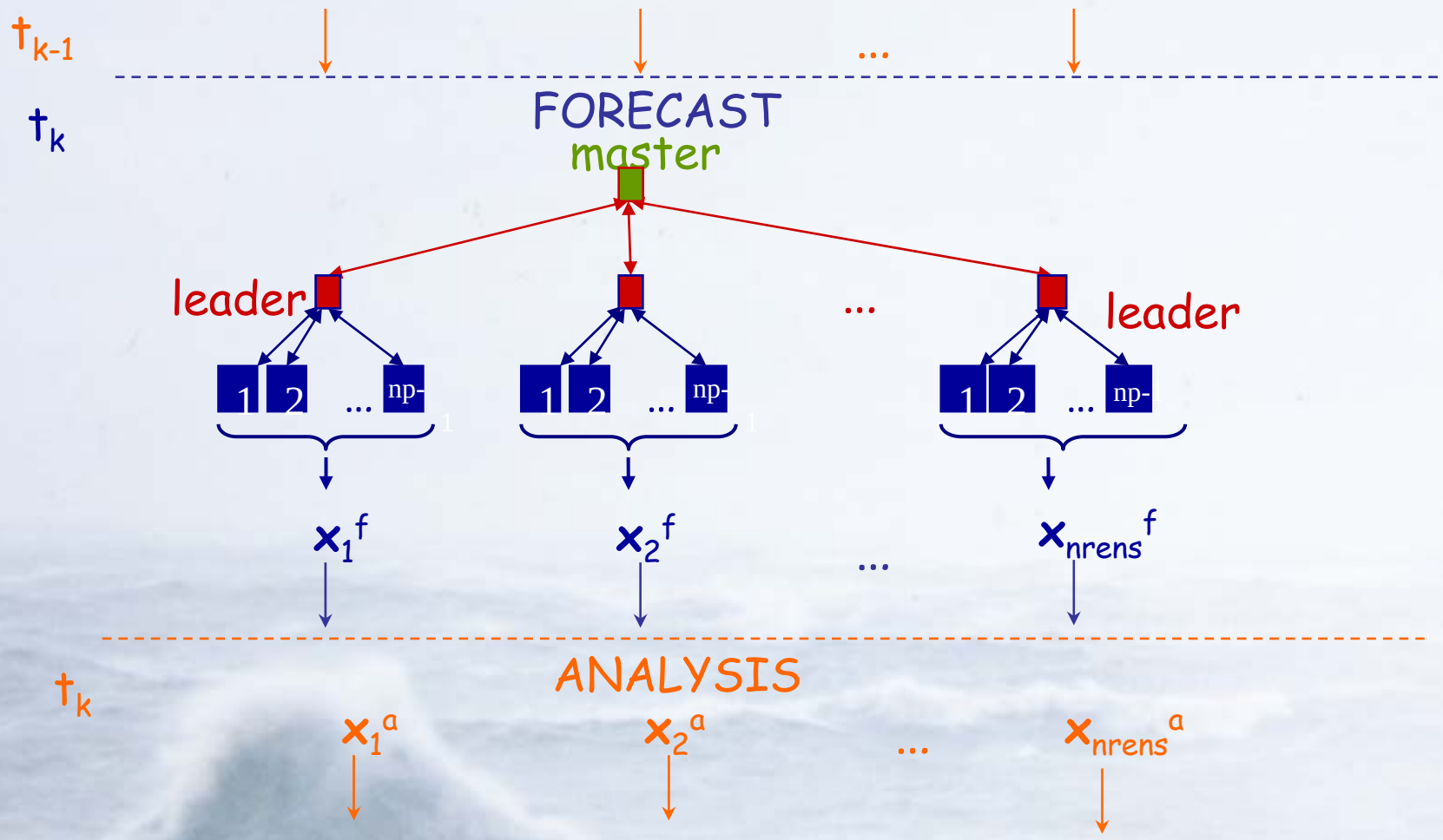
⇓

Need to parallelize.




- CSAR's green - SGI Origin 3800 with 512 MIPS R12000 processors and 512 GBytes memory.
- HPCx - 50 IBM POWER4+ Regatta nodes (1600 processors).
- POL cluster: 196 Pentium 4 processors.

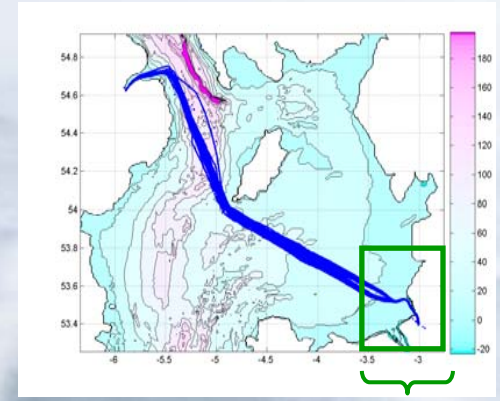
# EnKF parallel implementation



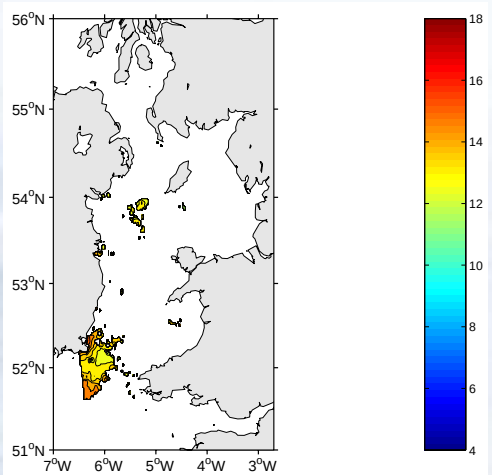
# Present studies

- ODON: OSSEs
- FerryBox: *Assessment of the impact of assimilating high resolution in situ observations*

Ferry line




Satellite SST



# To synthesize…

- An EnKF has been successfully implemented and is able to run with POLCOMS.
- Two different algorithms have been compared and a choice is to be made.
- Model error appears to be well accounted for,
- but assimilation of SST data quickly reduces the spread of the ensemble -> Solutions? (adding other sources of error?, improving sampling?...)
- Improvements in the code are under development (parallelization of some computations).
- Some applications are on the way…