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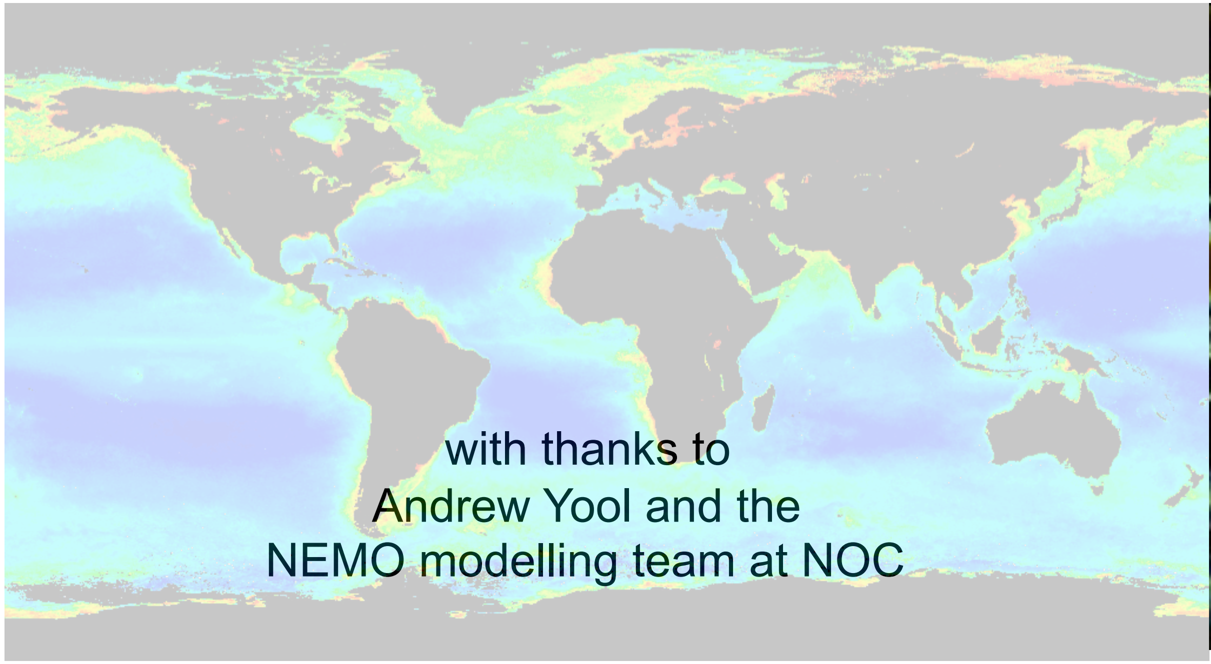
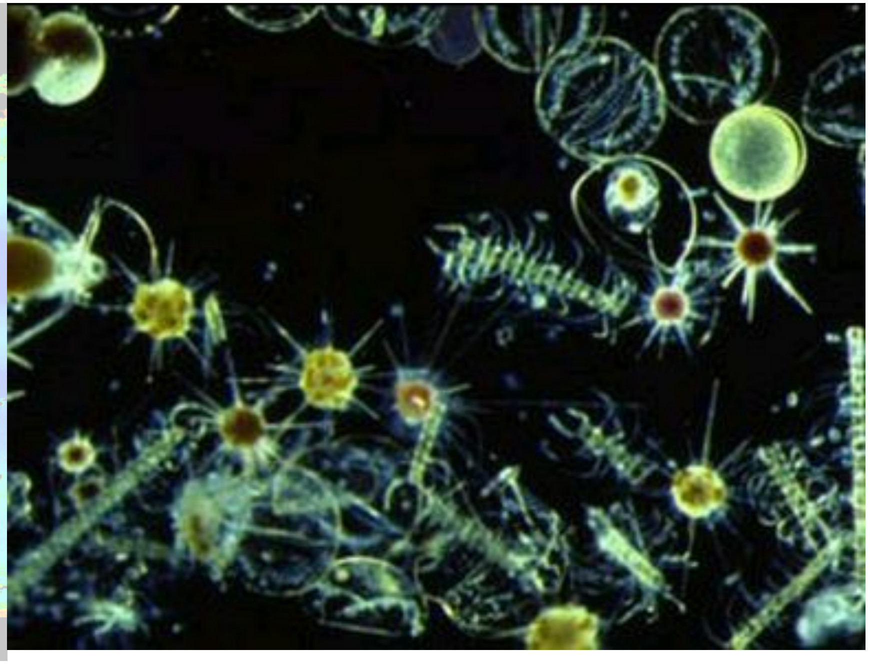
Using Eulerian and Lagrangian Time-series Data to Improve Models of Ocean Biogeochemistry

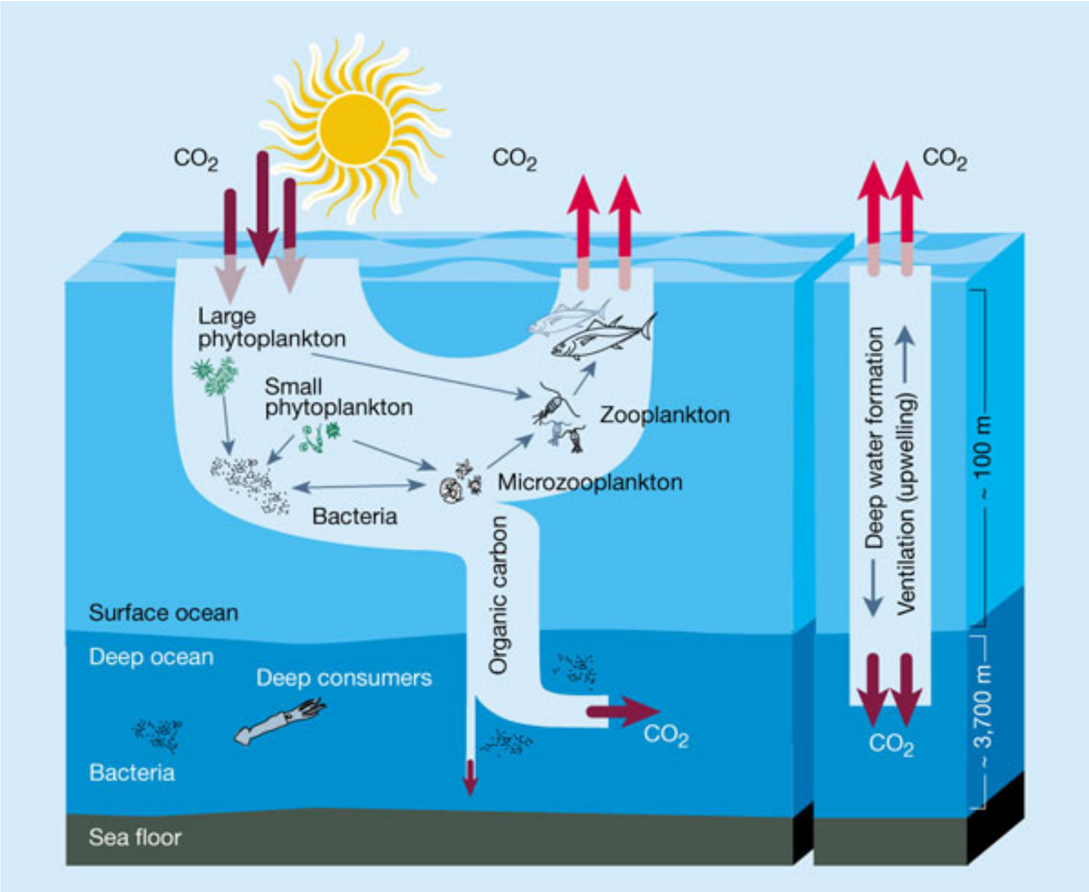
John Hemmings
National Oceanography Centre
Peter Challenor
University of Exeter
College of Engineering Mathematics and Physical Sciences





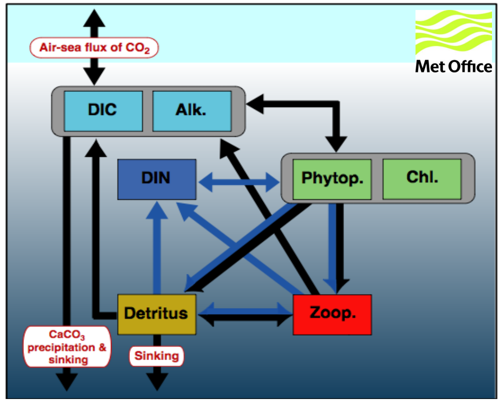
Modelling Biogeochemistry in the Global Ocean

The 'biological pump' is a collective property of a complex phytoplankton-based food web

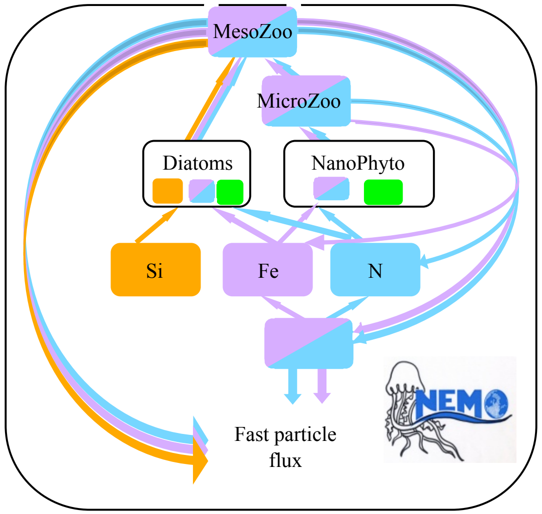


Sallie W. Chisholm
Nature 407, 685-687(12 October 2000)

HadOCC
Palmer and Totterdell 2001

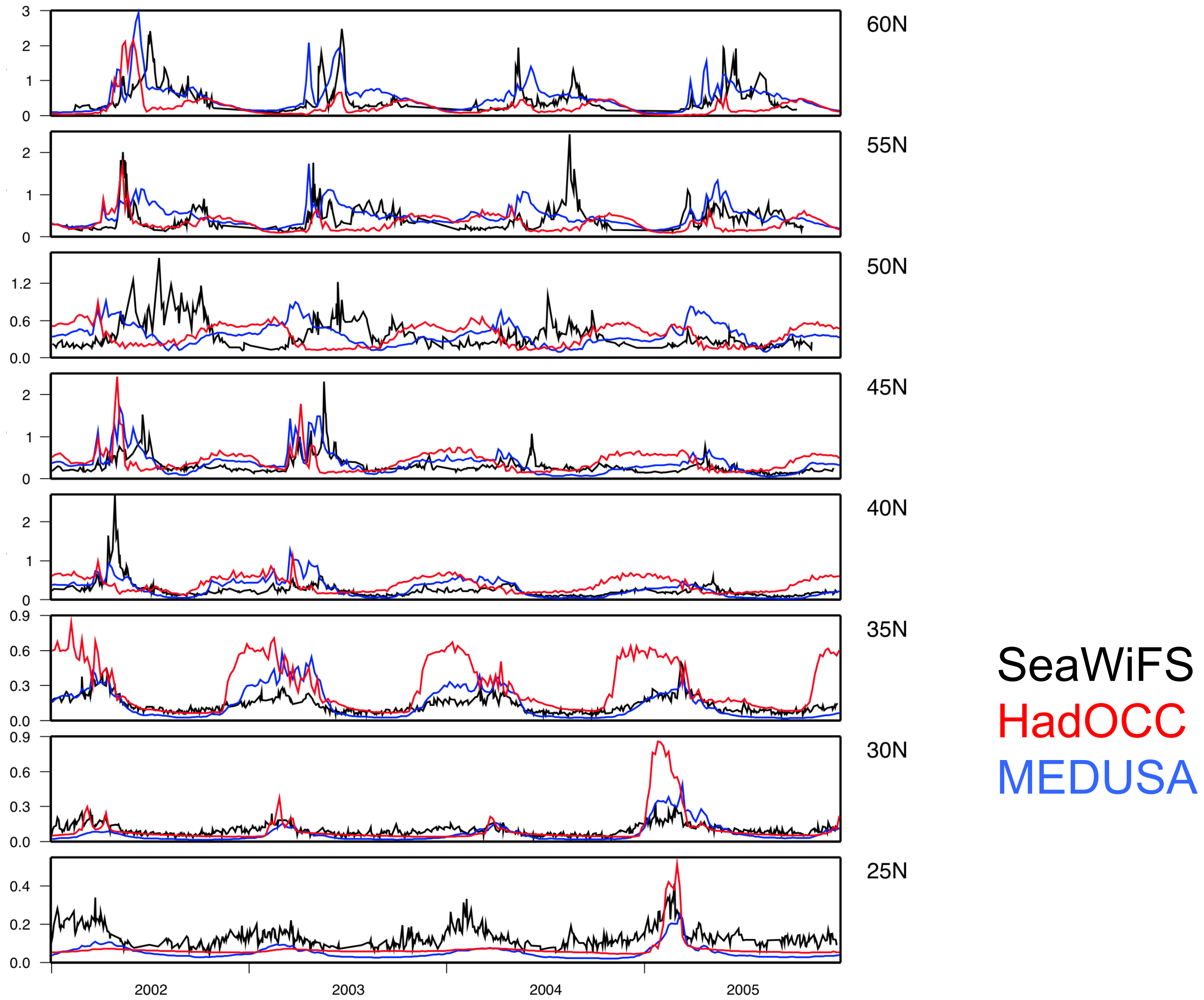


MEDUSA
Yool et al. 2011



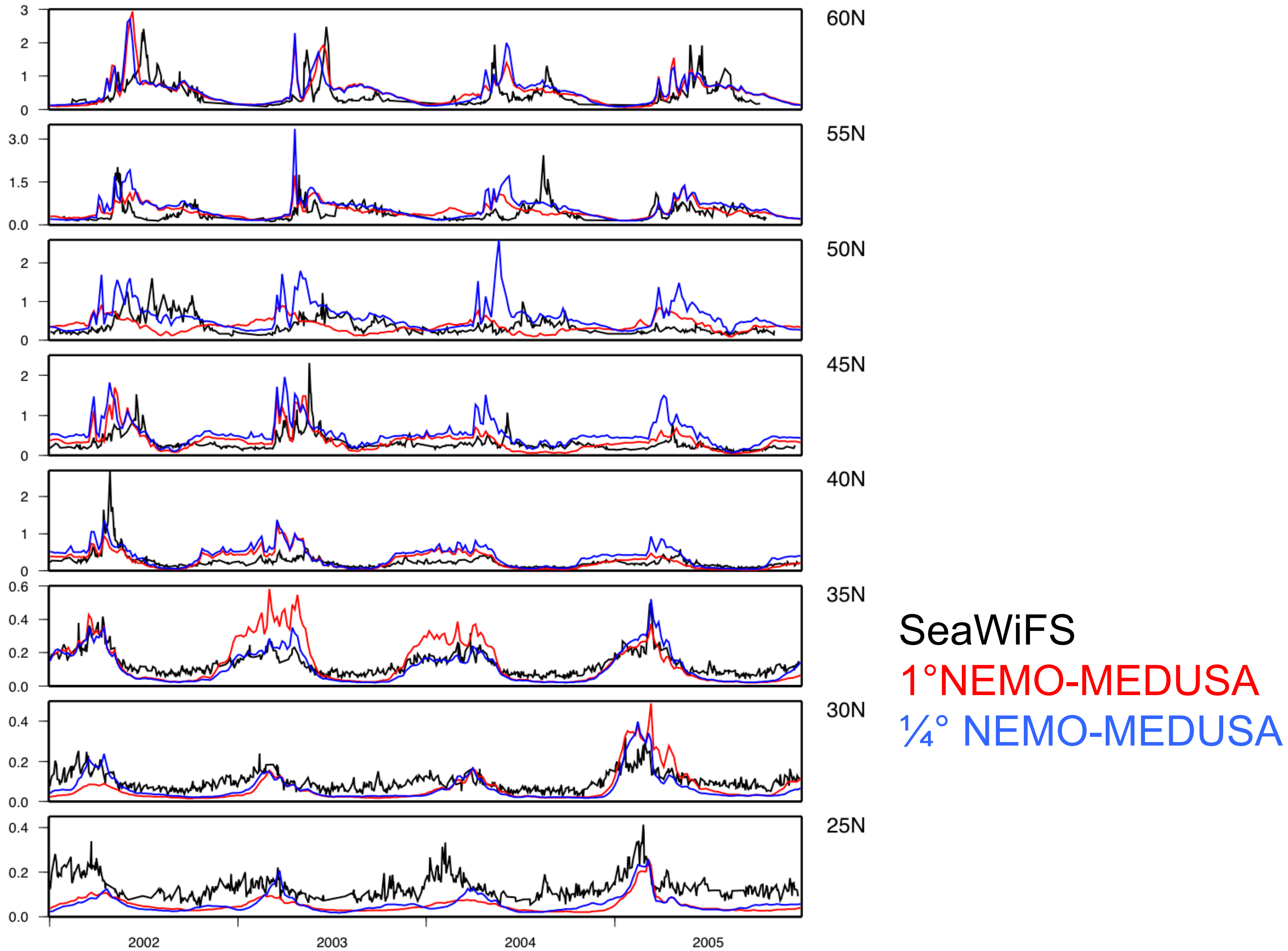
Model Assessment in NEMO (Default Parameters)

Surface Chlorophyll 20°W (mg m^{-3})



Impact of Uncertainty in the Physical Environment

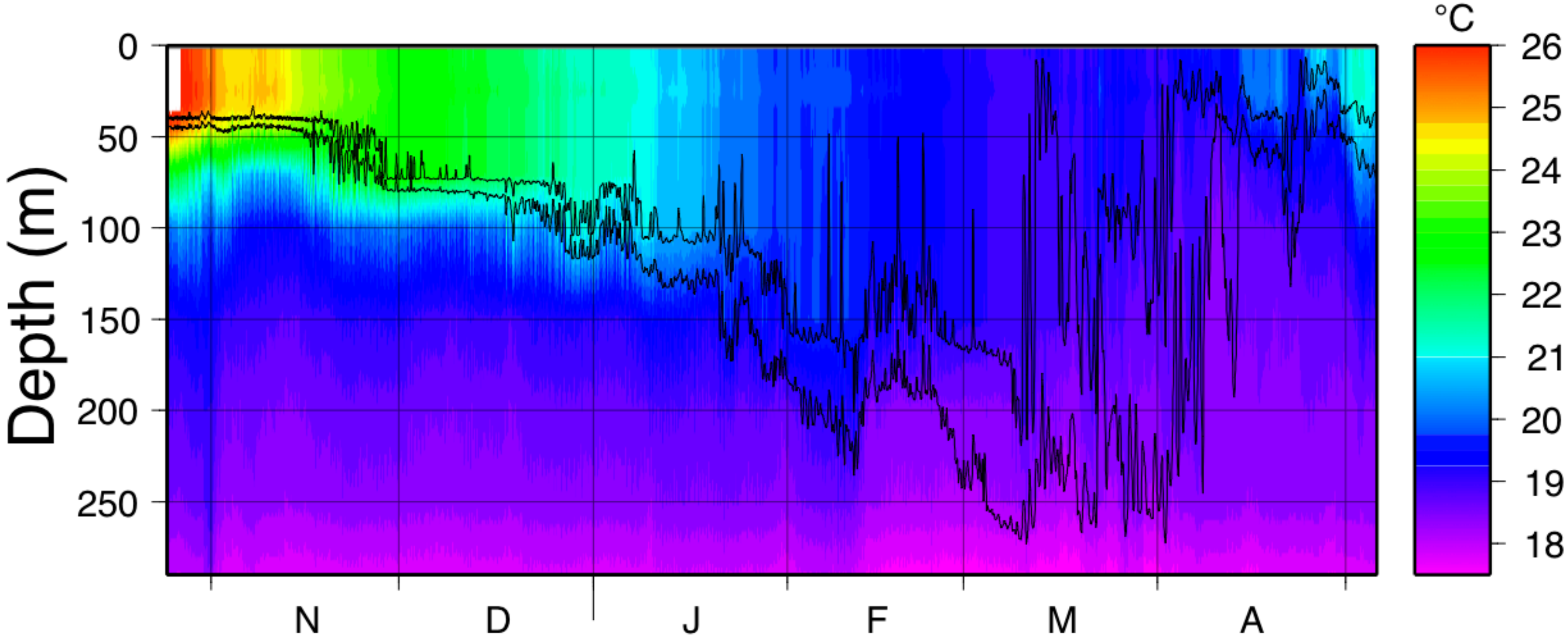
Surface Chlorophyll 20°W (mg m^{-3})



Deriving Physical Forcing from Observations at the Bermuda Atlantic Time-series Study Site

Temperature at Bermuda Testbed Mooring (October 2005 – May 2006)

Tommy Dickey and the Ocean Physics Lab.,
University of California, Santa Barbara



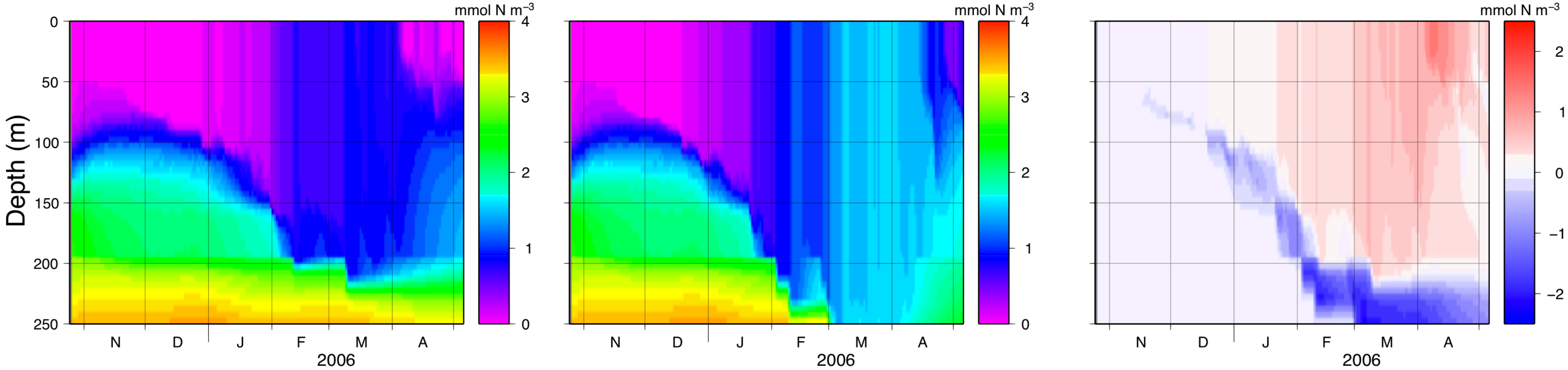
MLD estimates

$\Delta T = 0.2°C$

$\Delta T = 0.8°C$

Impact of Uncertainty in Mixing Depth at BATS

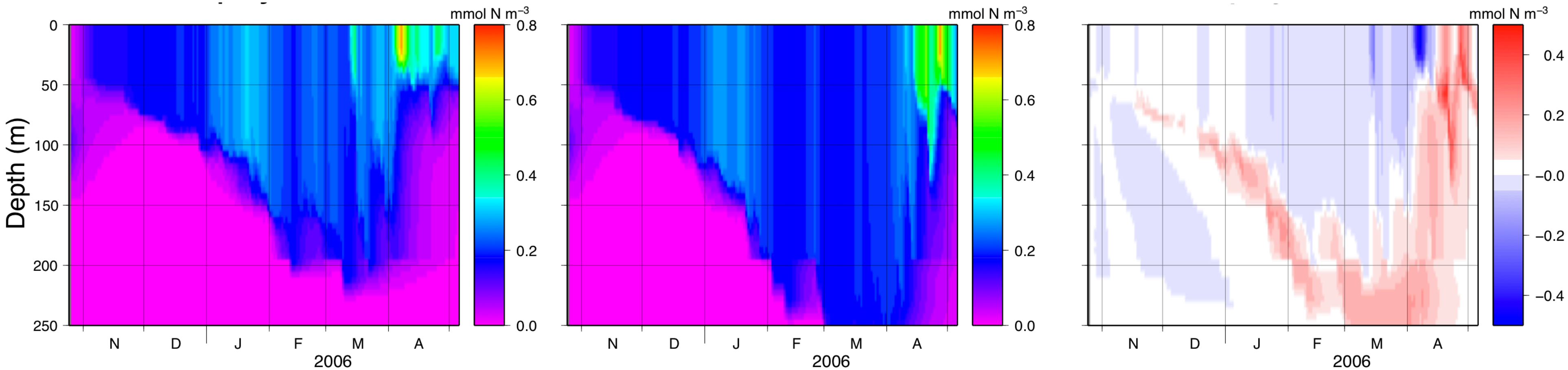
DISSOLVED INORGANIC NITROGEN (mmol N m^{-3})



Case 1: ΔT = 0.2°C

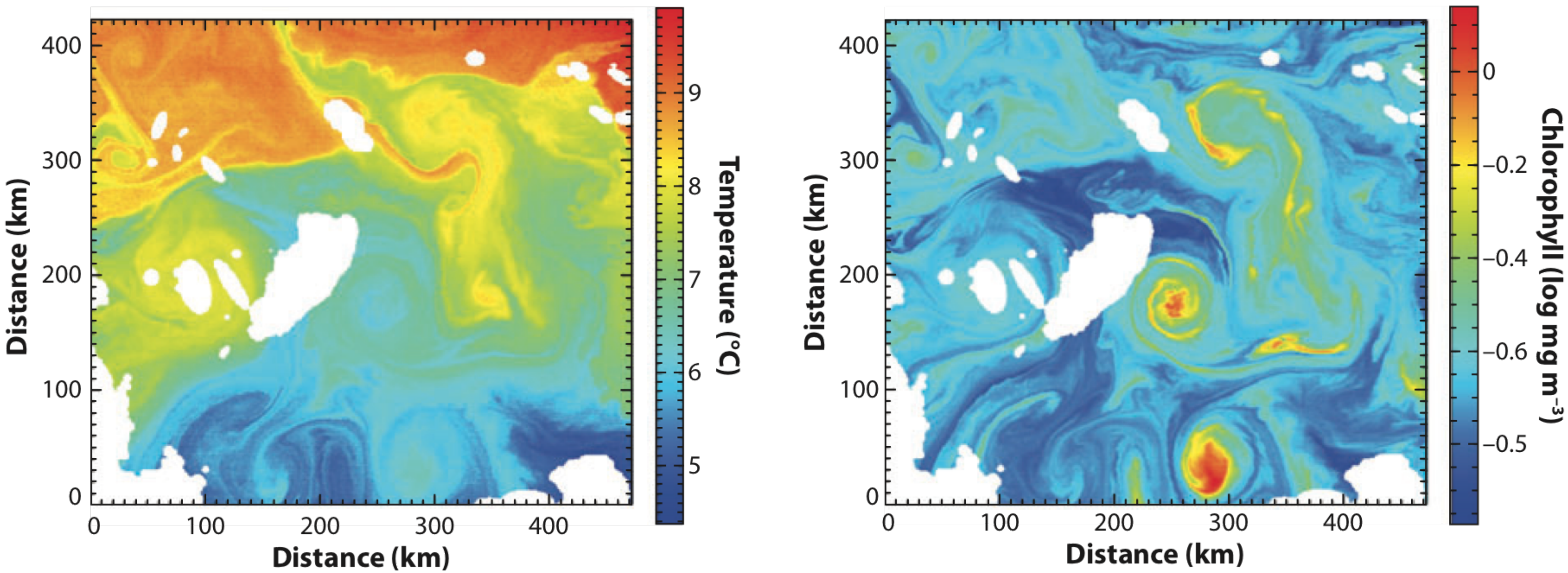
Case 2: ΔT = 0.8°C

Case 2 – Case 1



PHYTOPLANKTON (mmol N m^{-3})

Additional Requirement:
Flow Field Information from Remote Sensing

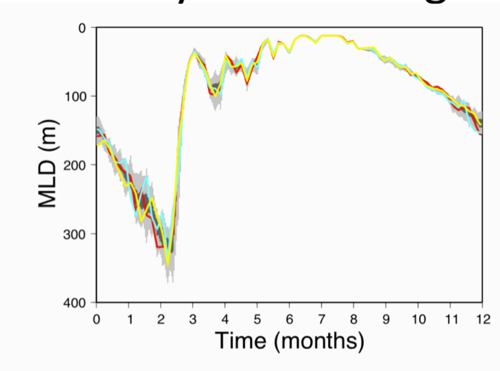


From Klein & Lapeyre 2009
Annu. Rev. Mar. Sci. 1, 351-75

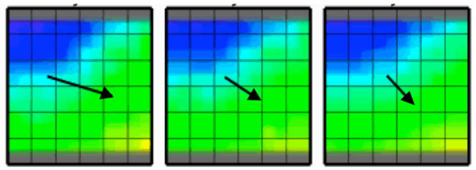
Ensemble-based Treatment of Environmental Uncertainty

Environmental Input Data

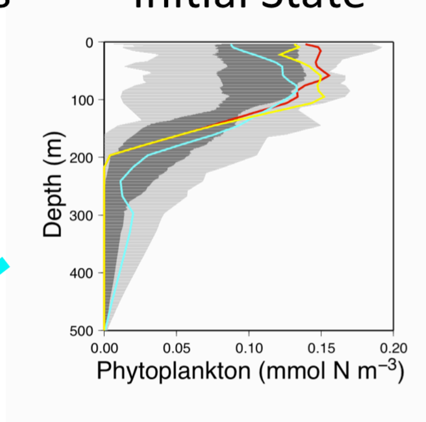
Physical Forcing



Horizontal Flux Divergences



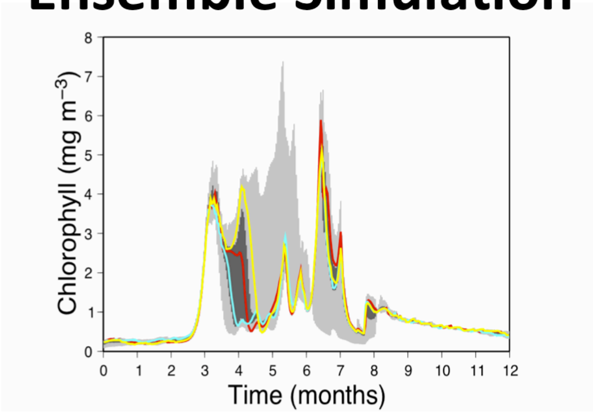
Initial State



Adjustable Parameters

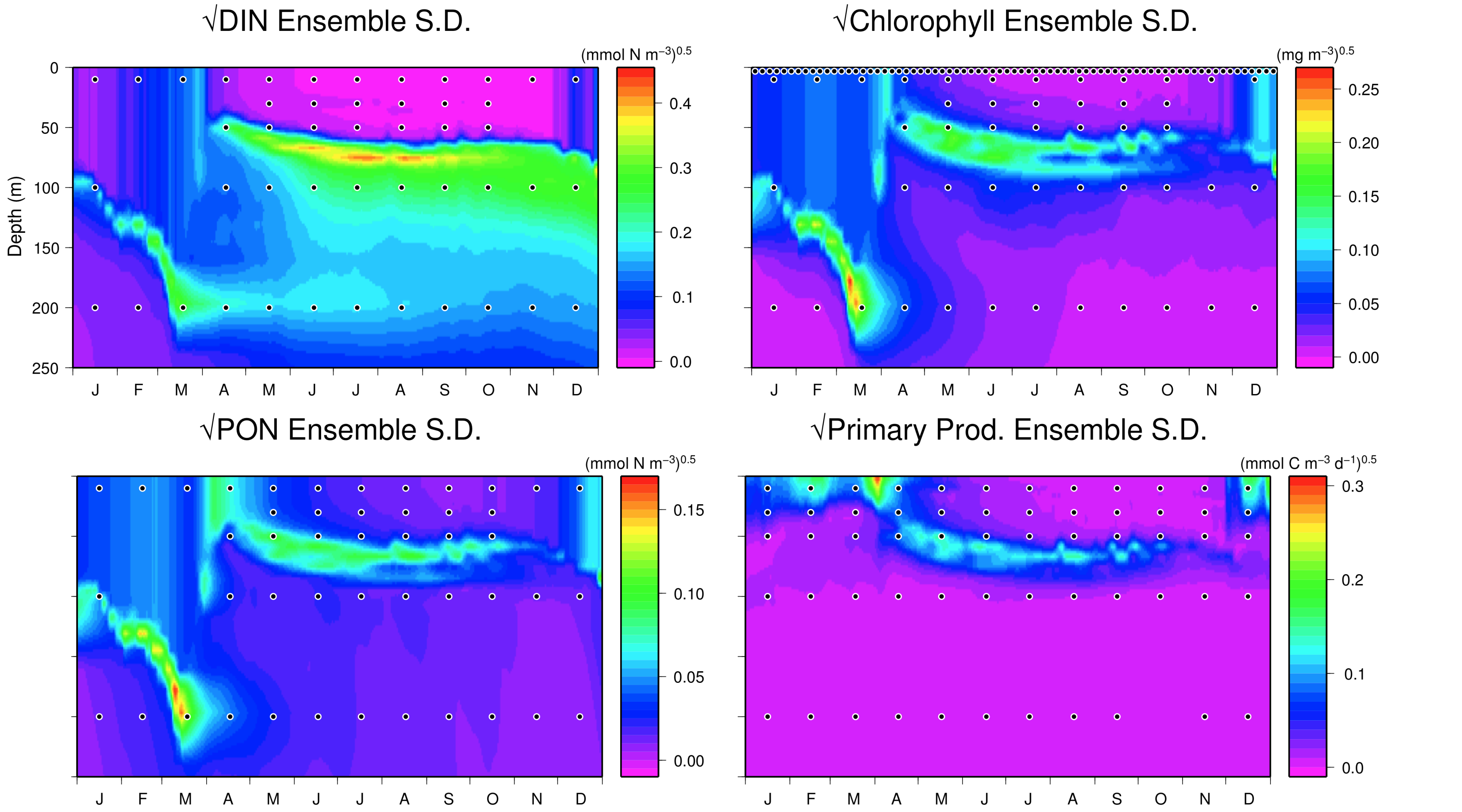
MarMOT optimization testbed 1-D

Ensemble Simulation



Likely impact of uncertainty are investigated with synthetic realizations of the environment at 3 contrasting N. Atlantic sites

Expected Simulation Error based on Synthetic Environmental Uncertainty (31N 64W)



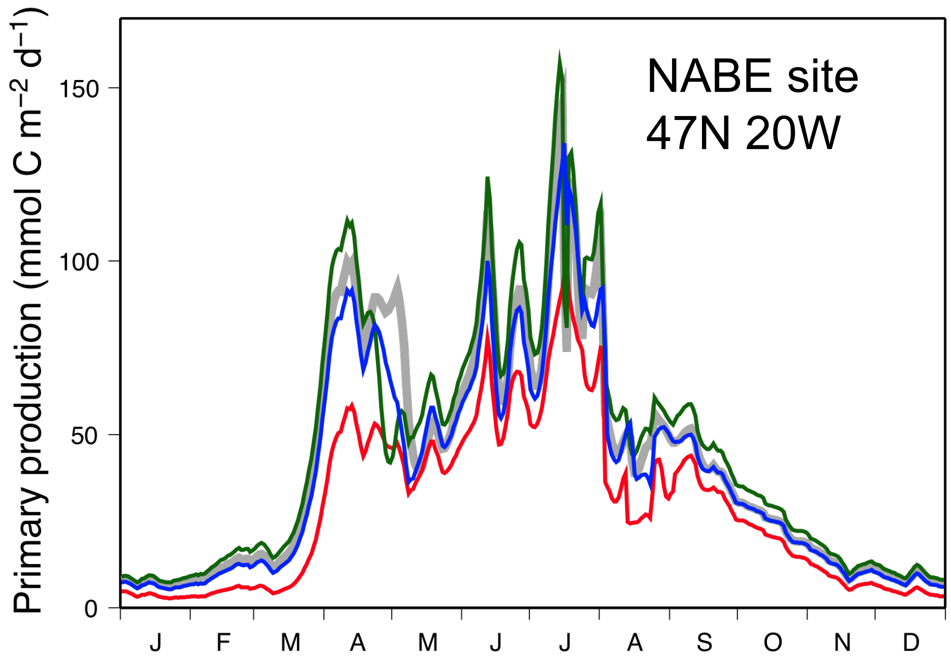
Data Assimilation Twin Experiments: Calibrated Model Performance

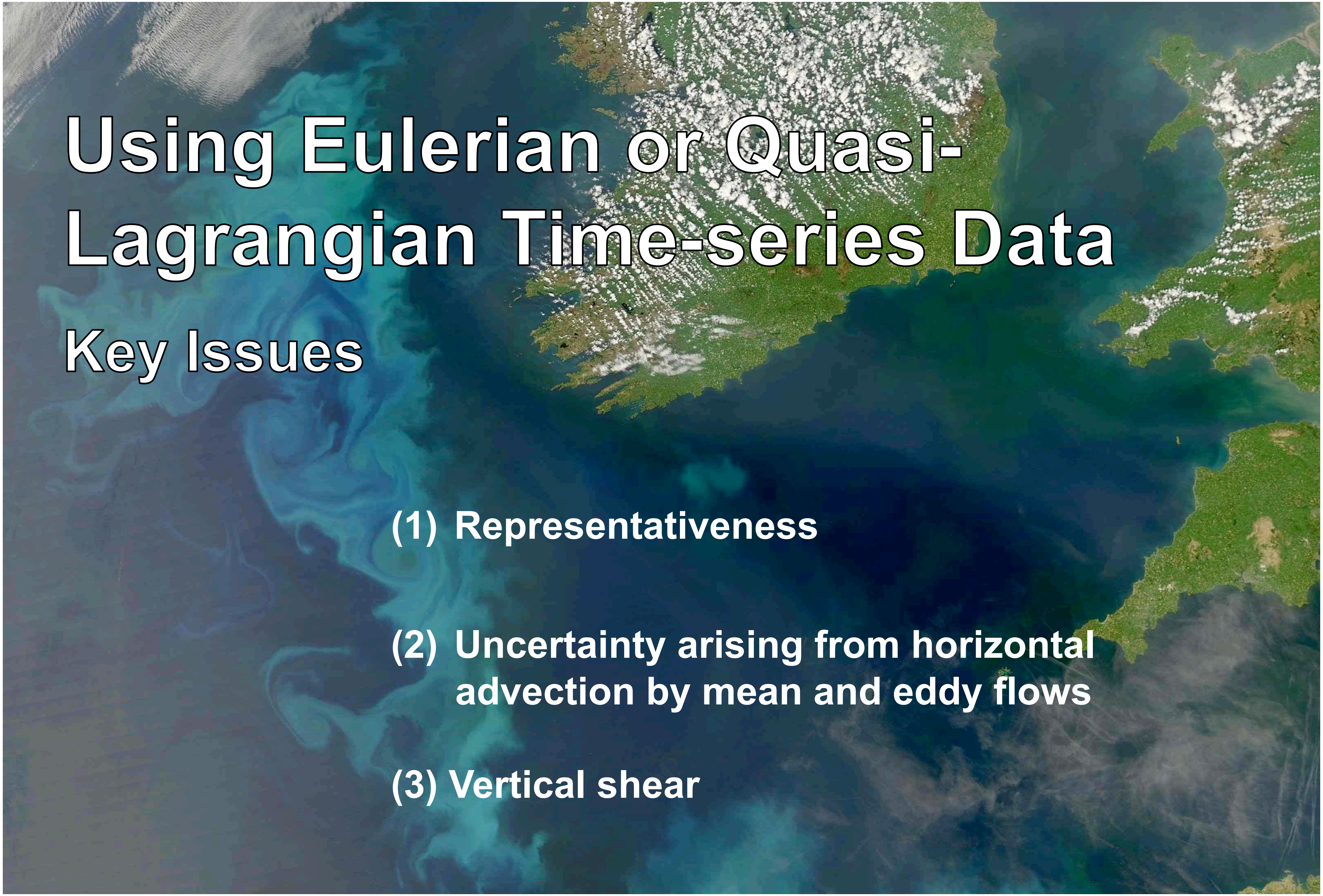
Established Calibration Schemes

1: Characteristic Scale Weighting
2: Observation Error Weighting

New Scheme (Hemmings & Challenor, 2012)

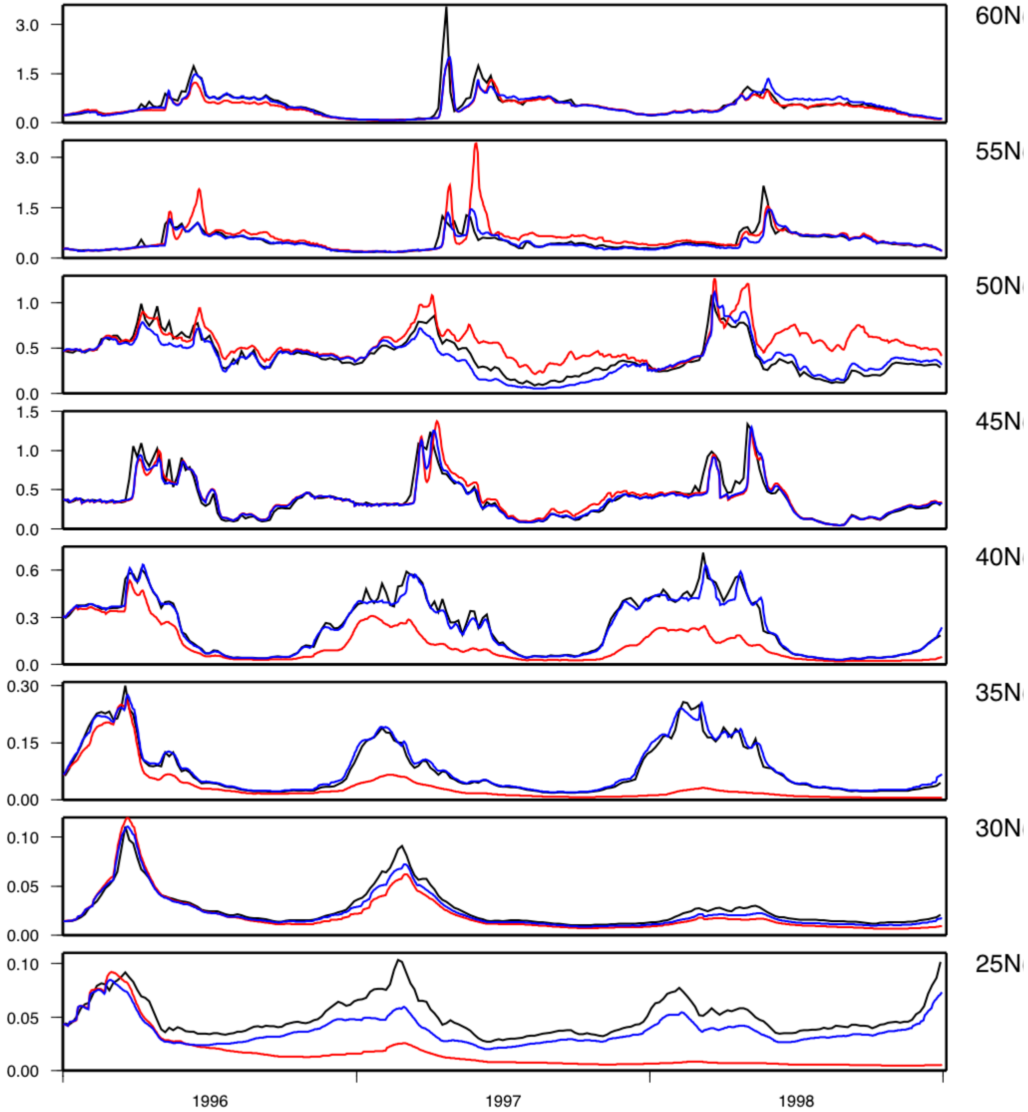
3: Observation & Environment Error Weighting




Using Eulerian or Quasi-Lagrangian Time-series Data
Key Issues
(1) Representativeness
(2) Uncertainty arising from horizontal advection by mean and eddy flows
(3) Vertical shear

Correcting for Advection Effects in 1-D Simulations

Surface Chlorophyll 20°W (mg m^{-3})

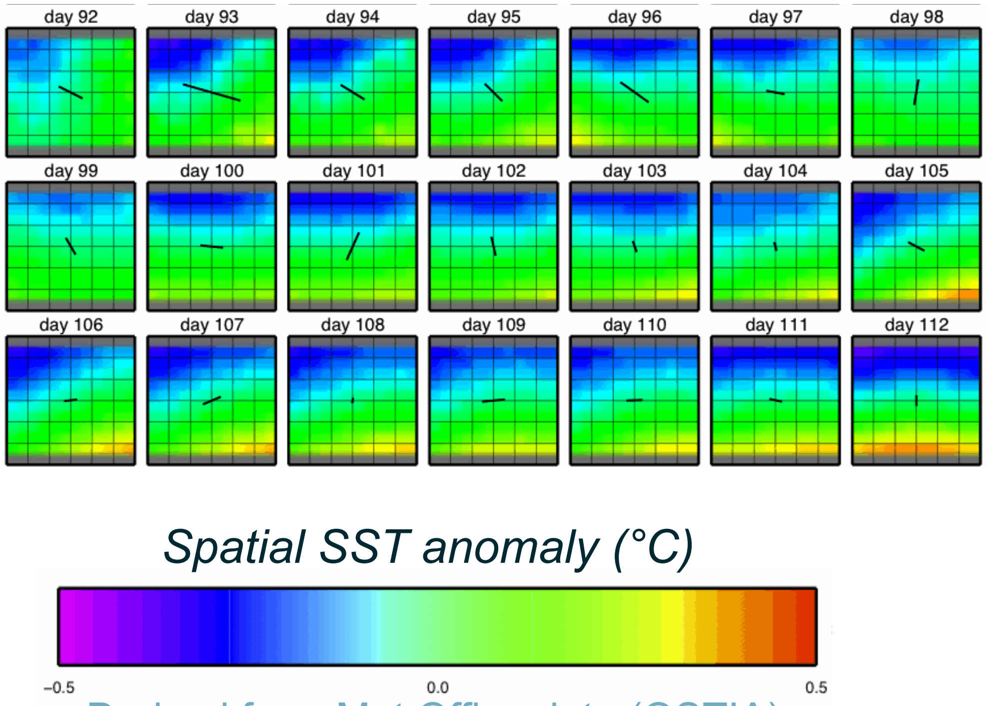


1°NEMO-MEDUSA
MarMOT-MEDUSA no lateral fluxes
MarMOT-MEDUSA with advective flux divergence

Advection: rate of change = current velocity × upstream tracer gradient

Data Constraints for Advective Flux Divergence

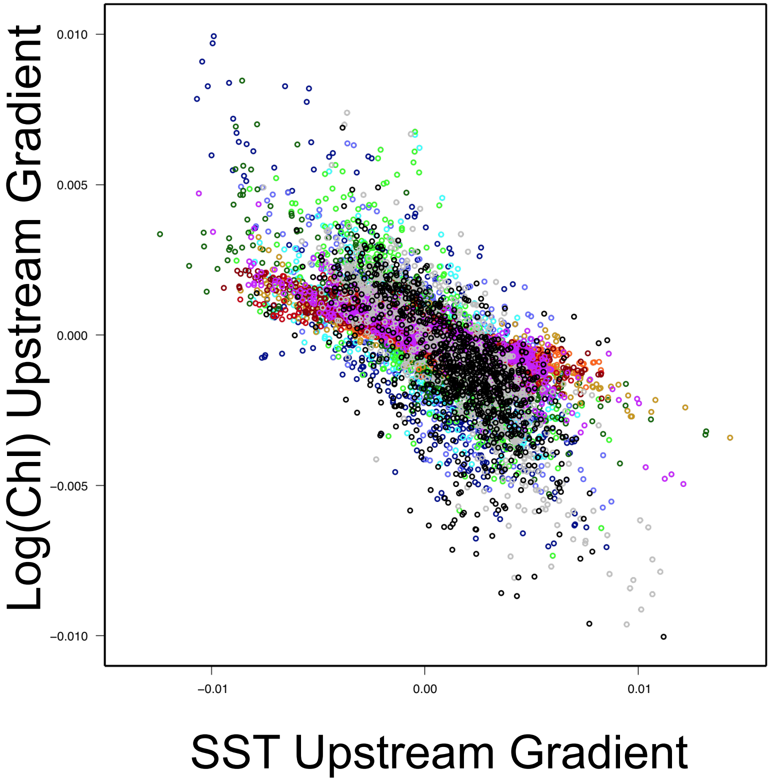
Daily displacement from near-surface currents measured at the Bermuda Testbed Mooring close to the BATS site



Derived from Met Office data (OSTIA)
Each grid square is 10 km

Horizontal tracer gradient v SST gradient

from NEMO-MEDUSA output (1996-2006) within 50 km of BATS site



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Elements of a Global Testbed Facility for Models of Ocean Biogeochemistry

- **Global biogeochemical time-series data set for constraining parameters and quantifying model uncertainty**

Supporting Cast:

- Statistical descriptions of upper ocean physics local to each 1-D time series (i.e. site or float track)
- Probability distributions for upstream gradients of model tracers
- Probability distributions of model tracer concentrations for initialization