MIDDLE EAST TECHNICAL UNIVERSITY
INSTITUTE OF MARINE SCIENCES

Carbon Export Algorithm Advancement in Models

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TÜBİTAK

EURO-BASIN
BASIN SCALE ANALYSIS, SYNTHESIS AND INTEGRATION

MOTIVATION

- Due to the complexity of processes controlling particle aggregation, sinking and decomposition, existing ecosystem models necessarily parameterize carbon sequestration using simple algorithms often derived from very limited datasets.

- Improved parameterization of carbon sequestration within ecosystem models is vital to better understand and predict changes in the global carbon cycle

- Development of new algorithms for particle export and decomposition, and implementation of those into simple or complex 1D/3D models is vital in order to better calculate global carbon budget

AIM

- Achieving advancements in ecosystem model algorithms requires access to the latest observations and measurement techniques

- Partners of EUROBASIN are conducting cruises, mesocosm experiments and laboratory work focused on the fate of carbon in the water column, and data collected will be utilized for generation of new algorithms and parameterizations

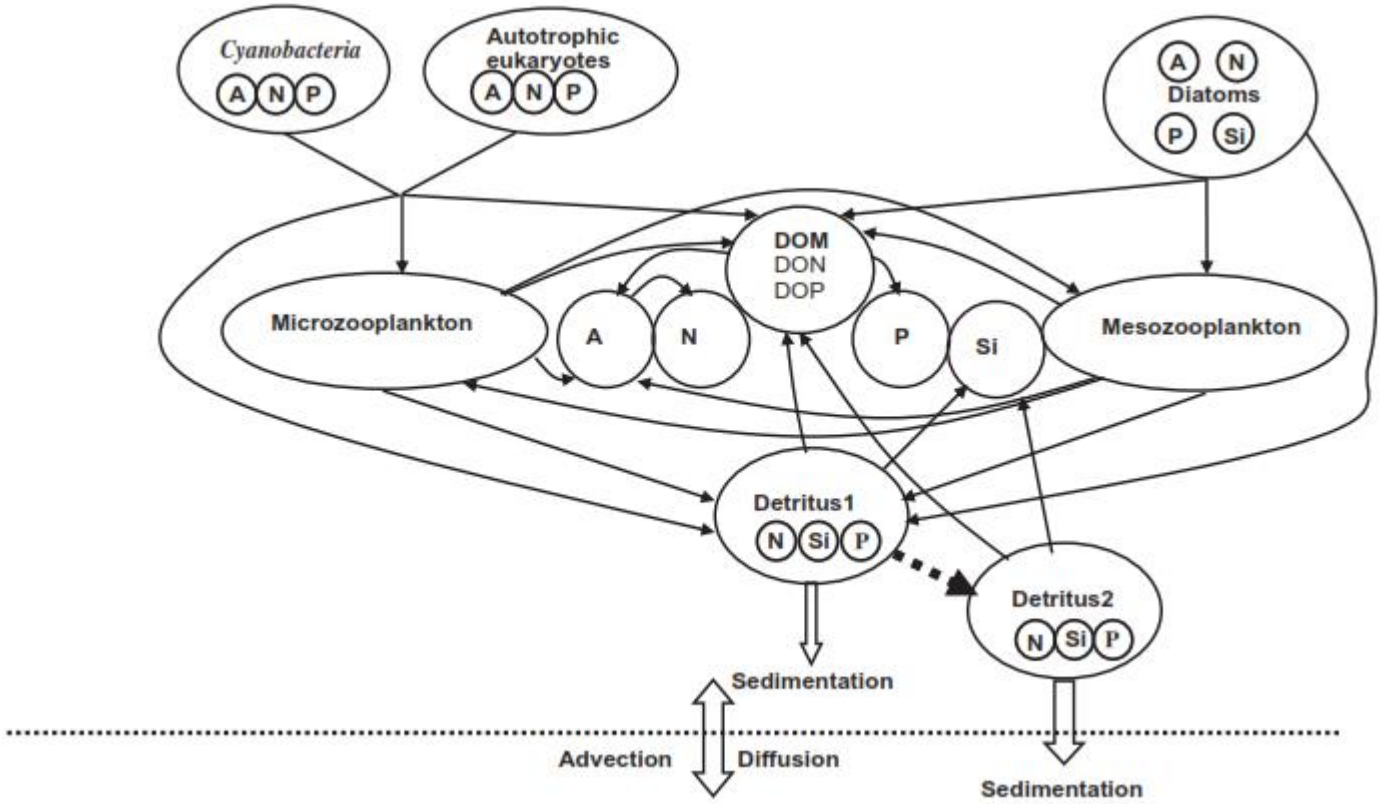
- **The main aim of my research is to incorporate these improved algoritms of the downward flux of particulate organic carbon in 1D ecosystem models, compare and test their effectiveness and success with respect to existing algorithms**

- **Second goal of this work will be to transfer the set of successful algorithms into 3D models that are run globally with the aim of improving our understanding of the global carbon budget**

METHODS

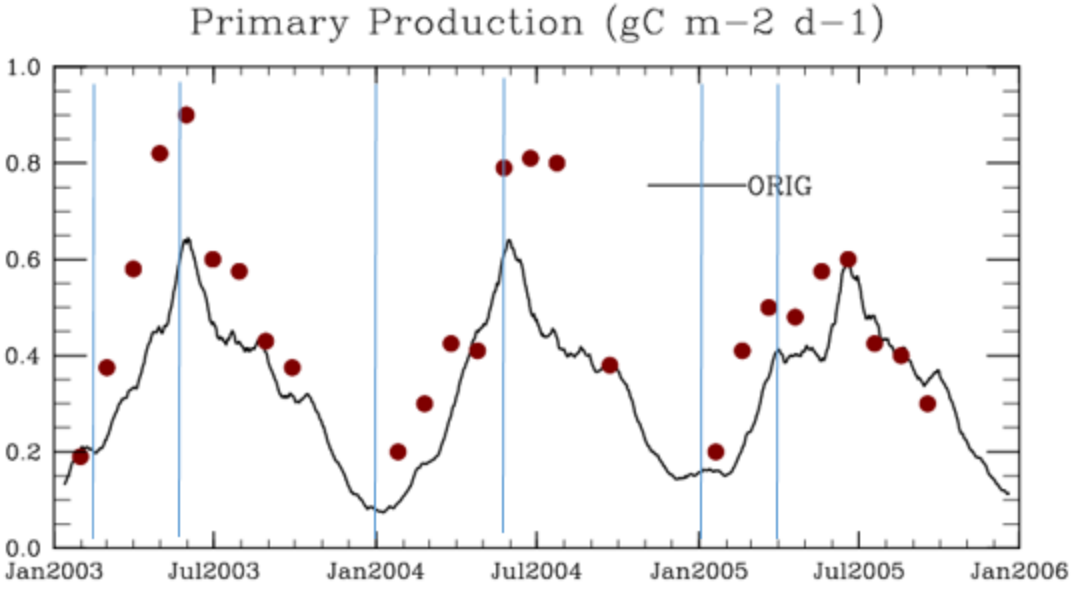
- ❑ Evaluation of existing model algorithms
  - Initially the three models were evaluated (ERSEM, PISCES, MEDUSA)
  - Investigation and evaluation of algorithms in literature
- ❑ Preparation of a generic 1D model framework within each of the algorithms can be tested
- ❑ Test the algorithms and the 1D model and its generic capabilities
  - Modelling study in different environments will be done at three sites in the NA with different characteristic. This will give us the chance to evaluate the algorithms at different locations and environments.
    BATS
    ESTOC
    PAP – I will present initial results in this talk

1D MODEL



- 1D lower trophic level ecosystem model designed for Bermuda Atlantic Time-Series (Salihoglu et al., 2008, DSR)
- Includes 3 algal groups and represents growth via cell quota approach; C/N/P/Si/Chl are decoupled

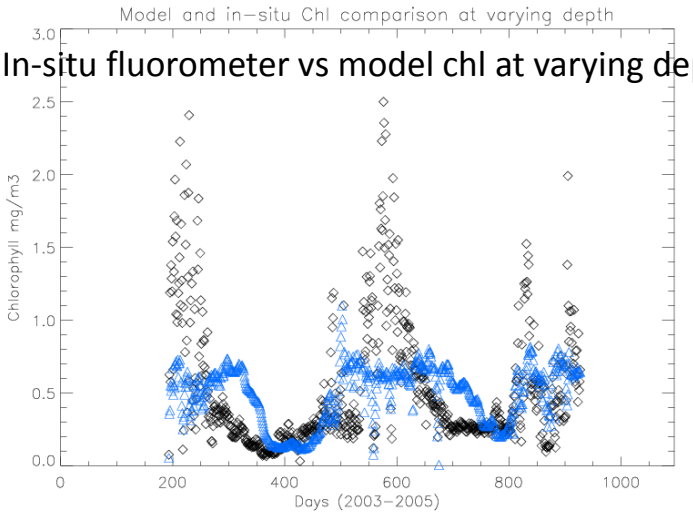
MODEL RESULTS PAP SITE



Deep mixing

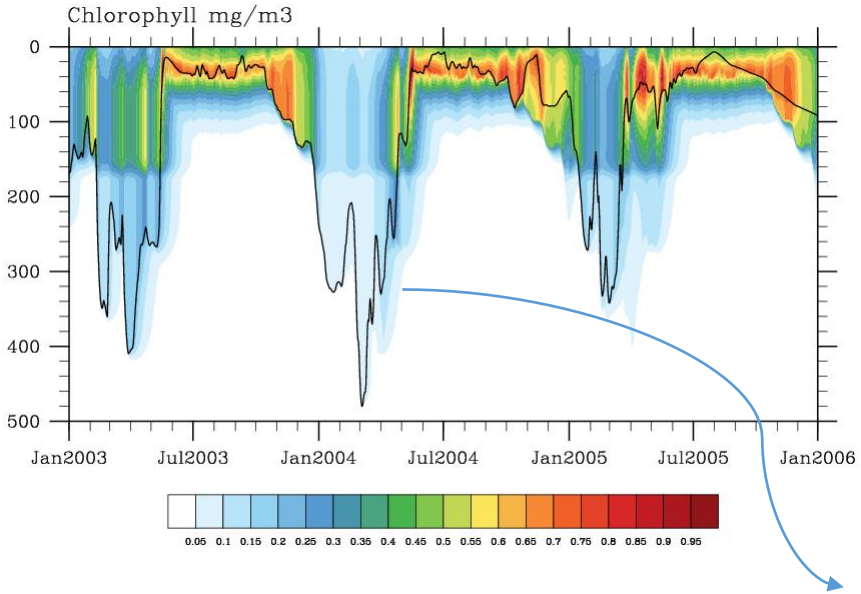
SeaWIFS derived PP Data (Hartman *etal* 2010)

In-situ fluorometer vs model chl at varying depth



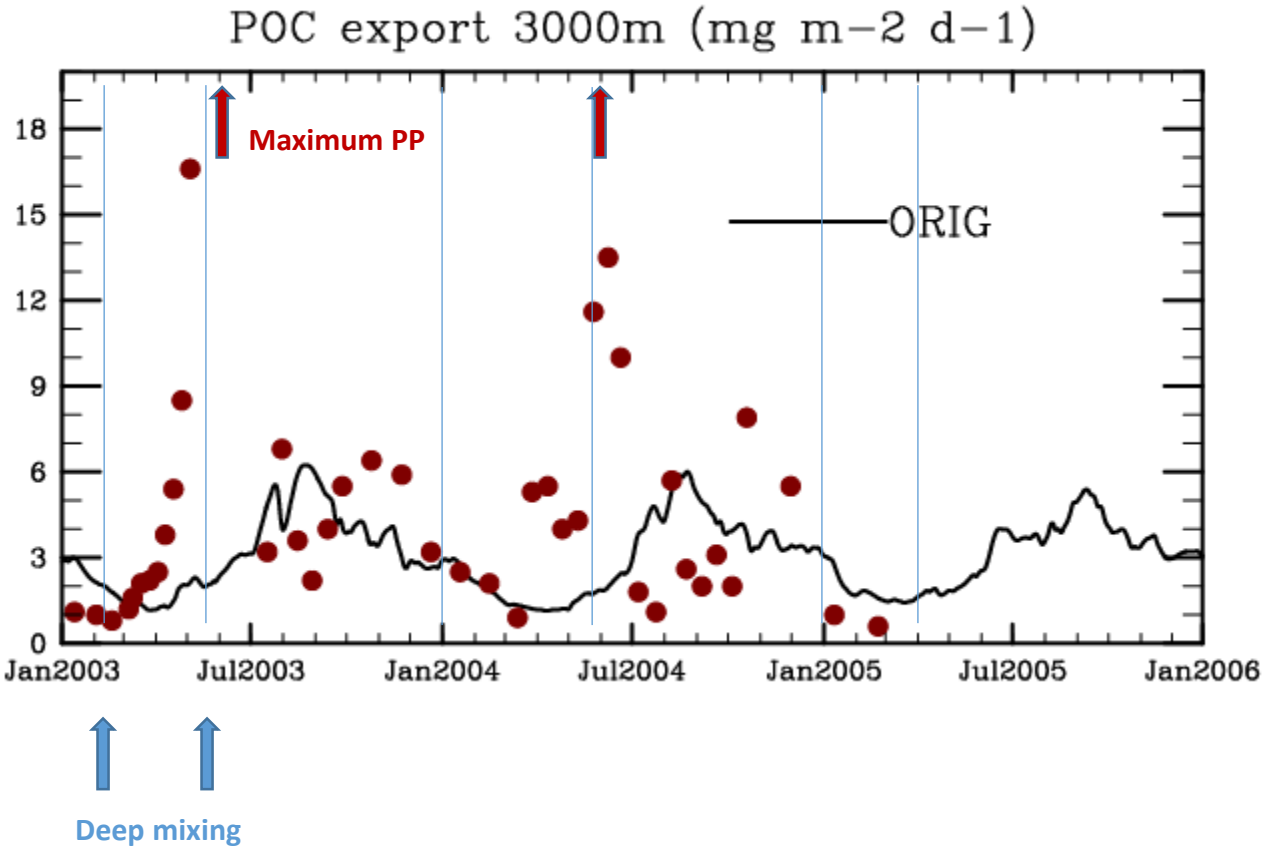
Model Setup

- PAP Mooring physics data was used to calculate MLD, and model uses MLD and Temp as forcing fields
- 5 year spin-up, and model runs for 2003-2005
- Surface irradiance fields from ERA-interim data
- 3000 levels with 1m resolution
- Nutrient bottom conditions from WOA



Mixed Layer Depth

MODEL RESULTS



● Trap Data (Lampitt *etal* 2010)

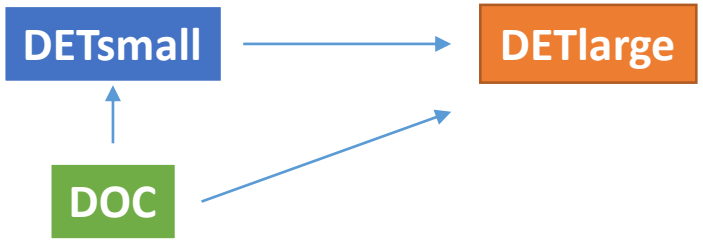
ALGORITHMS

AGGREGATION:

1. **Original Code: [ORIG]**

2. **MLD dependent Aggregation [AGG]**

3. **Particle Collusion & Differential Settling [PISC]**



Original Code

Small particles aggregate to large particles with constant aggregation rate

MLD Dependent Aggregation

Mixing increases the rate of aggregation
Constant rates are used

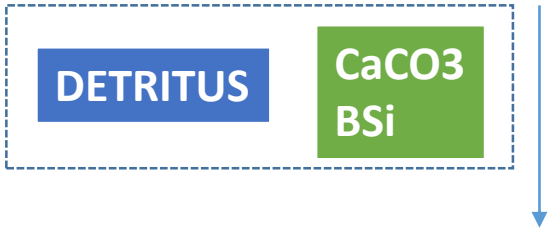
Particle Collusion & Differential Settling

Mixing and particle concentration dependent aggregation

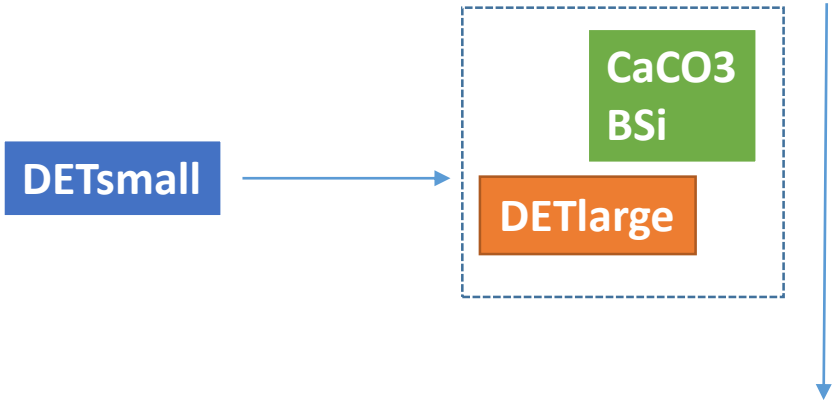
ALGORITHMS

SINKING:

1. **Ballasting effect on sinking rates [BAL]**



2. **Ballasting effect together with particle collusion & differential settling [BAL+PISC]**



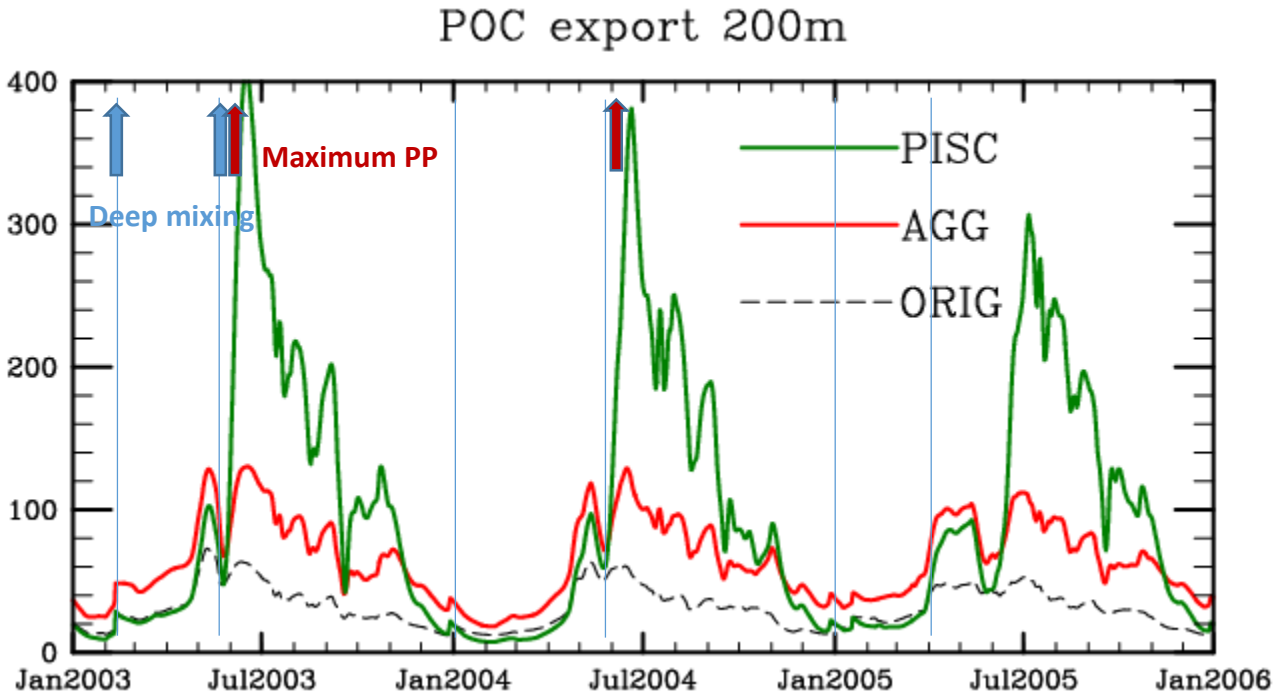
Ballasting effect on sinking rates

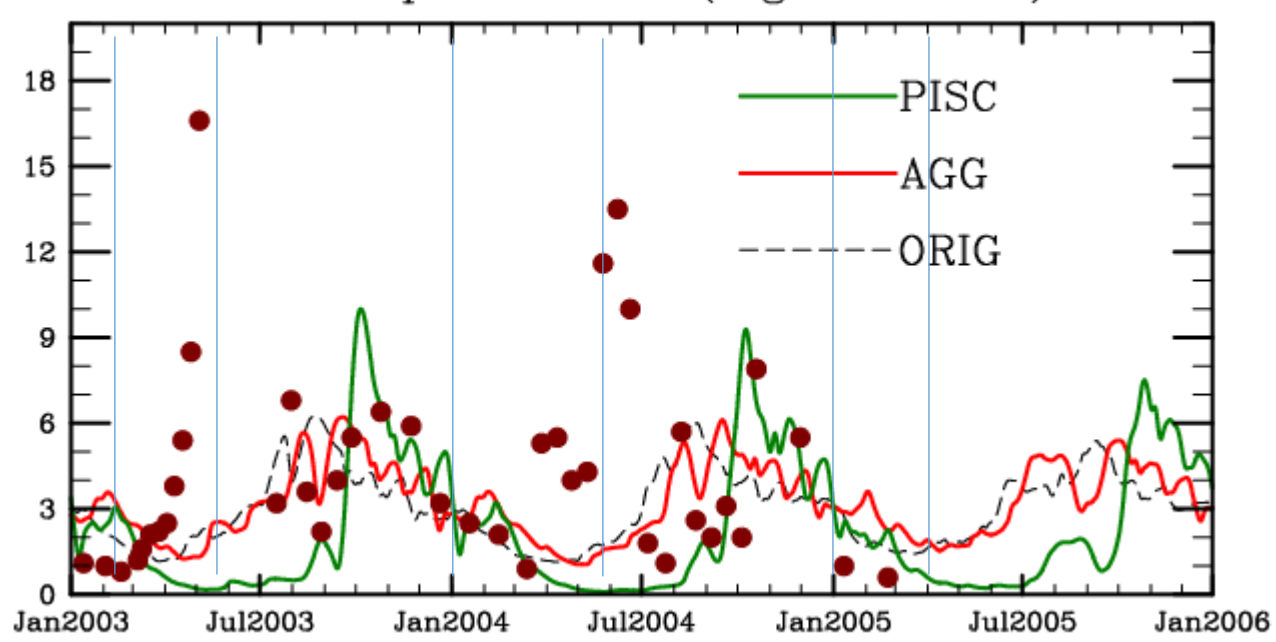
Presence of CaCO3 and Bsi increases the density of the detritus, thus increases its sinking speed (Gehlen *etal* 2006)

Ballasting effect together with particle collusion & differential settling

Remember: Two POC size classes

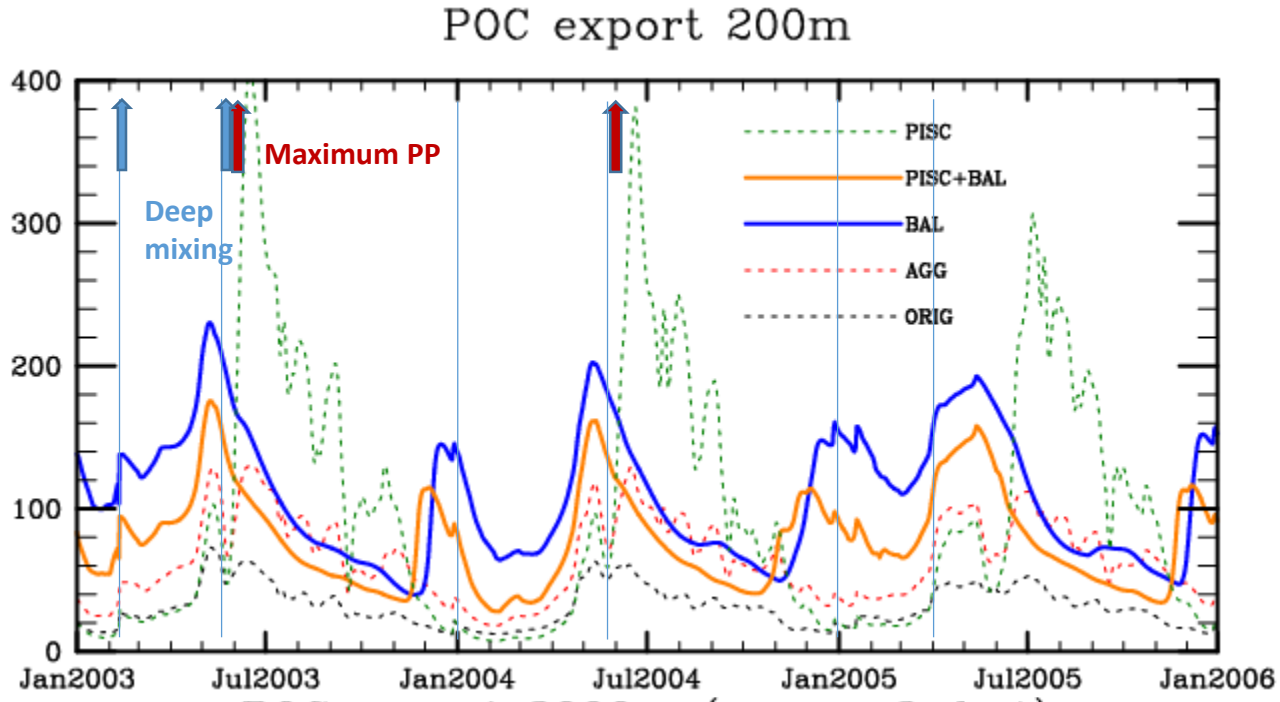
MODEL RESULTS

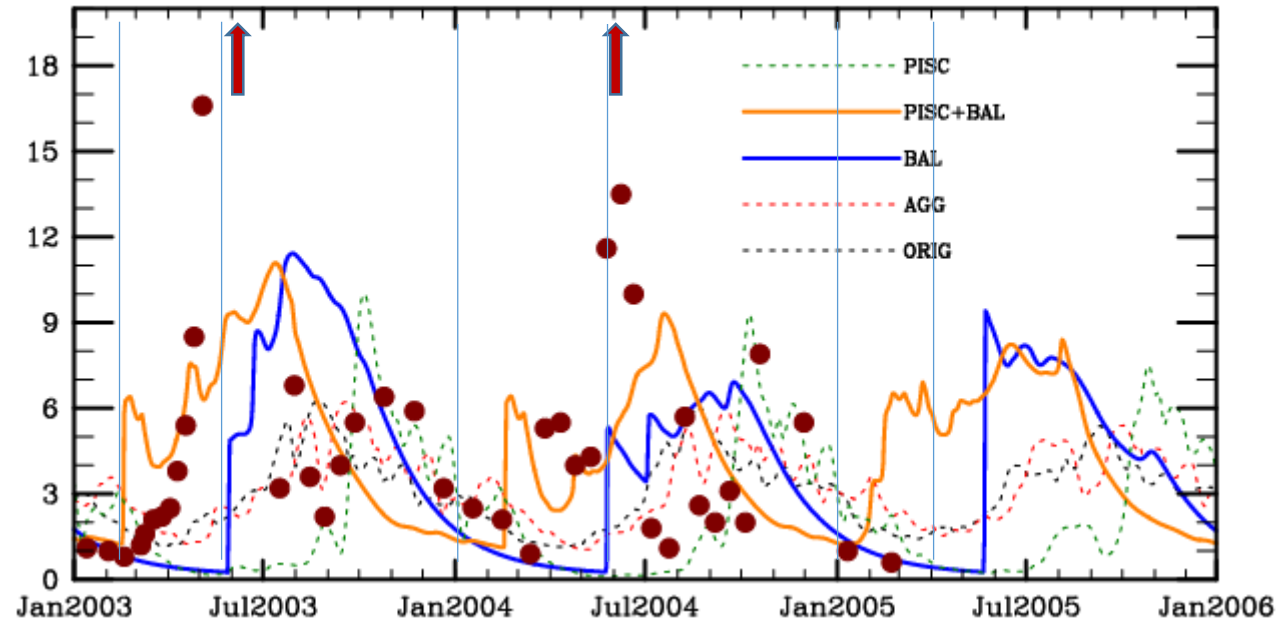




● Trap Data
(Lampitt *etal* 2010)

MODEL RESULTS





- Trap Data (Lampitt *etal* 2010)

SUMMARY

I have developed a means through which different model algorithms can be tested within an identical framework

Dynamics of aggregation play a major role at 200m where PP, mixing, dissolved and particulate matter dynamics are highly coupled

Conversely in the deep ocean, we do not see such a difference between the different aggregation algorithms, suggesting decomposition breaks down most of the particles from the sinking compartment into dissolved organic compartment

The aggregation routine that defines particle collusion and differential settling responds more to the changes in physical environment near the surface, however we need additional data in order to formulate more conclusive ideas about the relative performance of the algorithms tested.

Even simple changes in functioning of different algal community structures may play a major role in shaping the export of carbon

DISCUSSION

FUTURE WORK

- algal community structure
- algal aggregation
- ballasting
- particle aggregation
- T dependent decomposition of POM & DOM by bacteria
- preferential remineralization of P,N,Si
- vertical migration and active transport by zooplankton
- fragmentation and repackaging of detrital material by mesozooplankton
- Mixotrophy

- SPATIAL COVERAGE IS A MUST and improved algorithms should also be transferred İnto global 3D models