Controlling factors of the OMZ in the Arabian Sea

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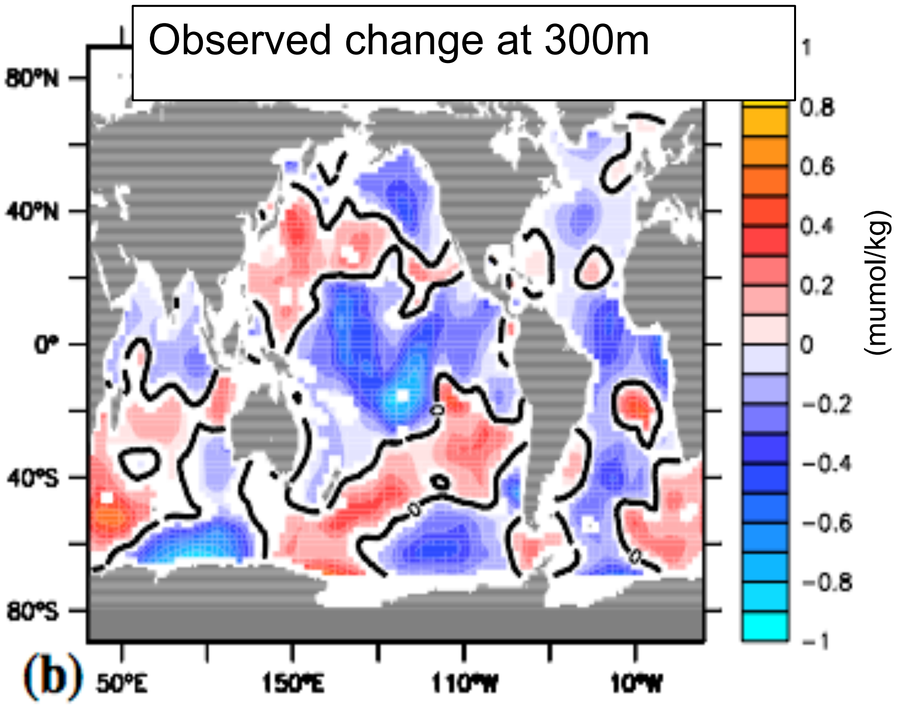
In revision for Biogeosciences

Focus on OMZ sources and sinks

-Temporal evolution of OMZ depends on balance between O_2 sources and sinks

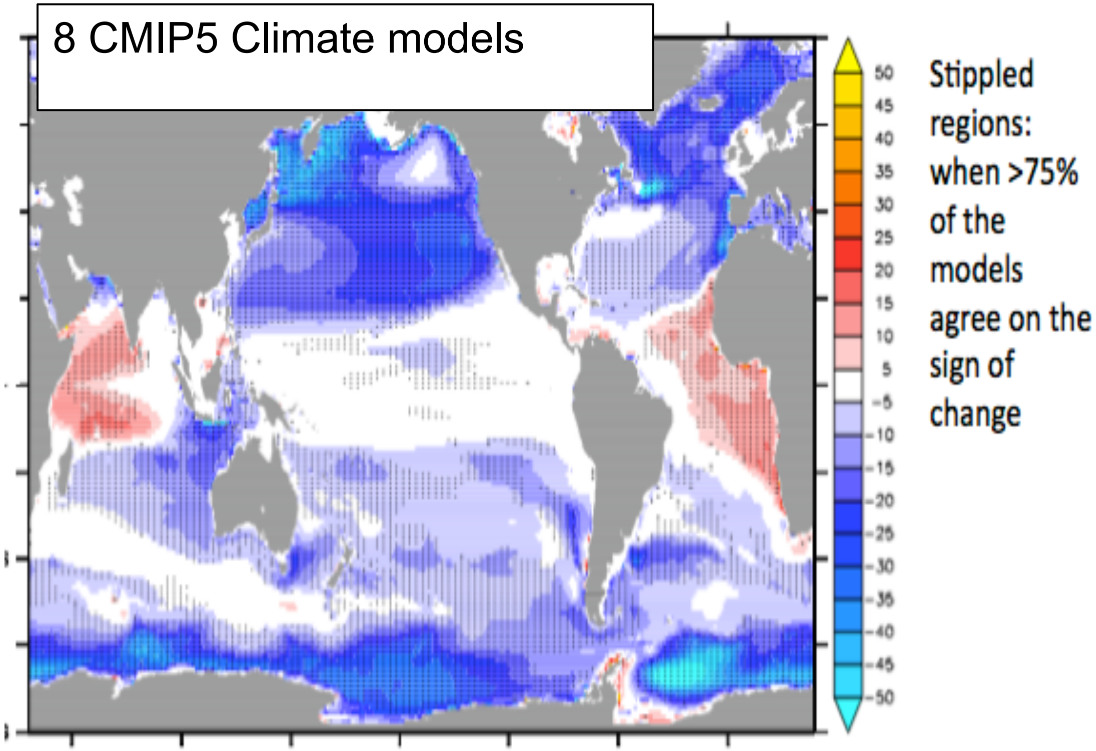
-No consensus on past and future OMZ evolution in the AS:

PAST (1960-2010)



Stramma et al., BG Discuss,2012

FUTURE (2010-2100)



Bopp et al., in prep

Objectives

Examine present day balance of O_2 sources & sinks

using an eddy-resolving biophysical model

Oxygen sources & sinks in model

$$\underbrace{\partial O_2/\partial t = \text{PP} + \text{Remin} + \text{Resp.} + \text{Nitrif}}_{\text{BIO}} + \underbrace{\text{H adv.} + \text{V adv.} + \text{V mixing}}_{\text{DYN}}$$

Outline

1) **Model description and evaluation**
2) **Seasonal balance in 3 contrasted regions**
3) **Role of mesoscale on the balance on annual time scale**

Model configuration

Model:

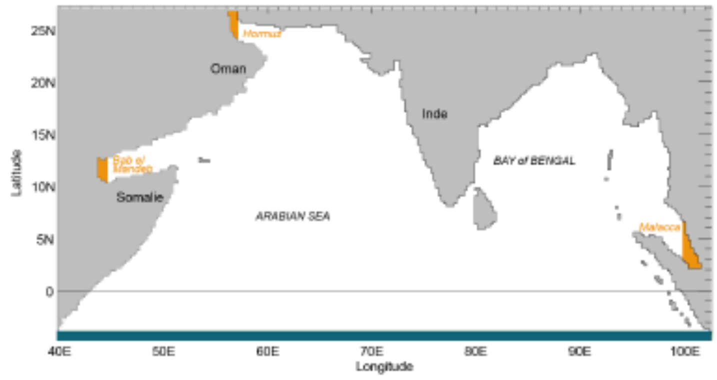
Ocean physical model **NEMO** (Madec, 2008)

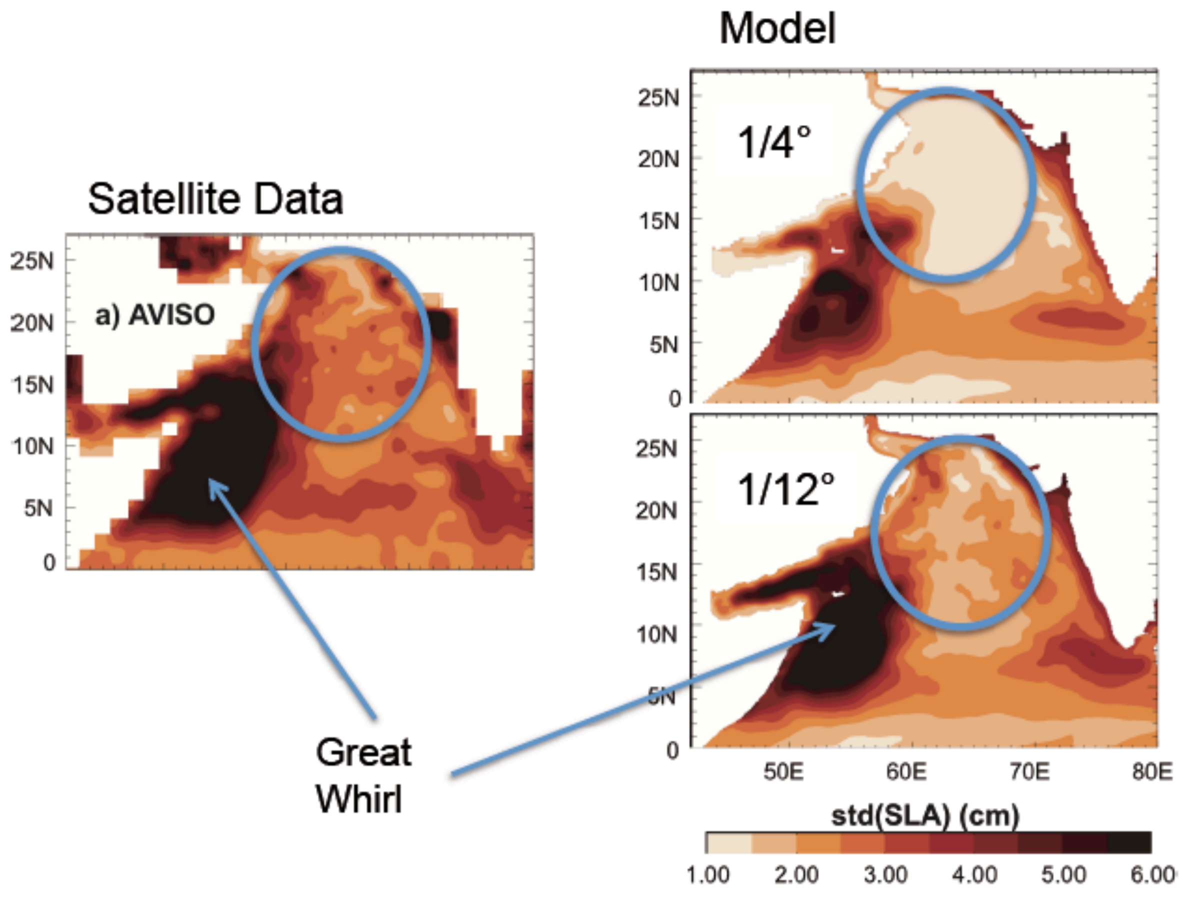
Biogeochemical model **PISCES** (Aumont et al., 2003)

- **Eddy-permitting = 1/4° (27 km)**
- **Eddy-resolving = 1/12° (9 km)**

Initialization and boundaries: global model ½°

10 years climatology



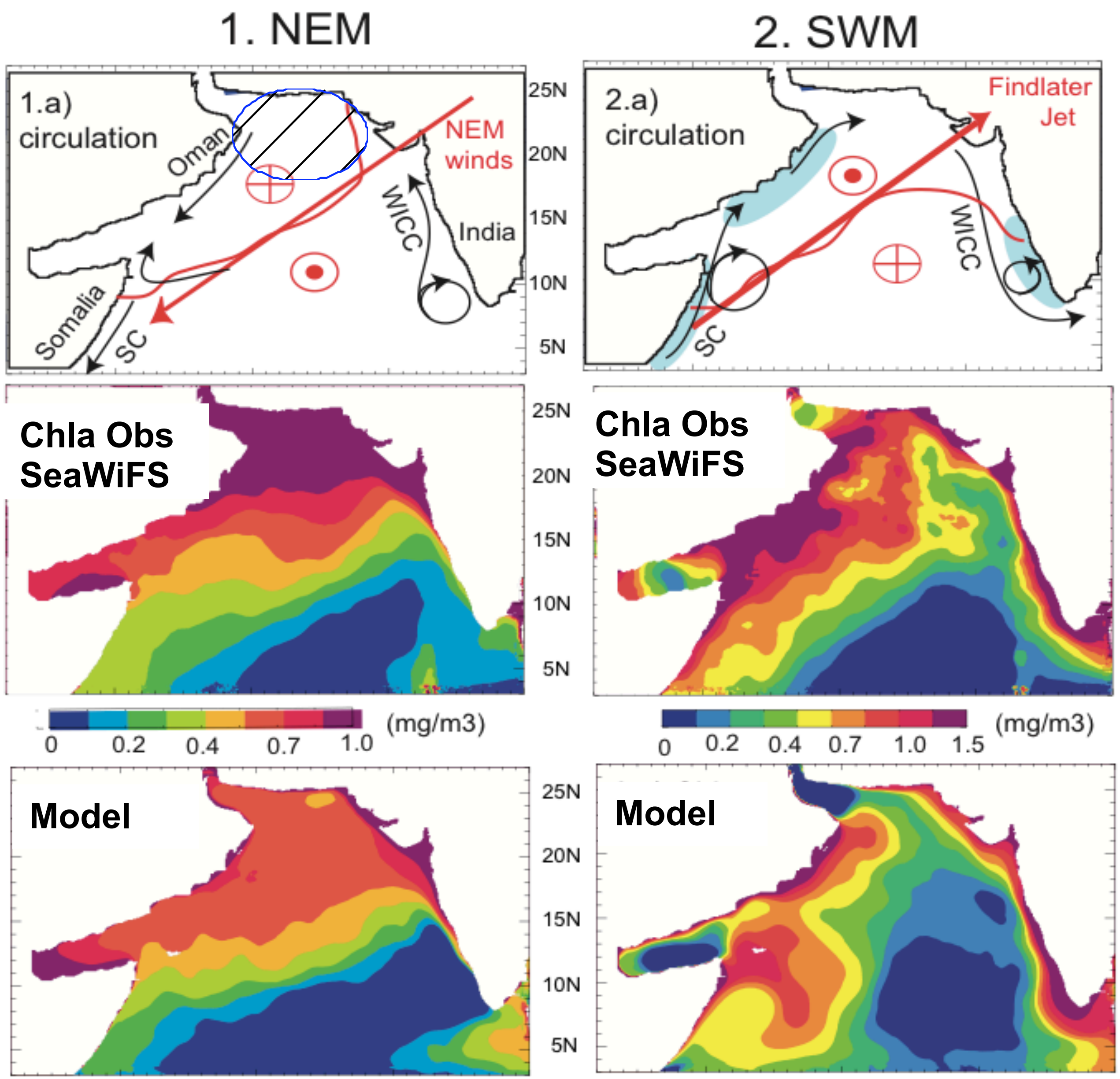


Resplandy et al. (2011)

Model evaluation: Chla and its seasonal variations

Main seasonal processes (convection, upwelling) modulated by Ekman pumping

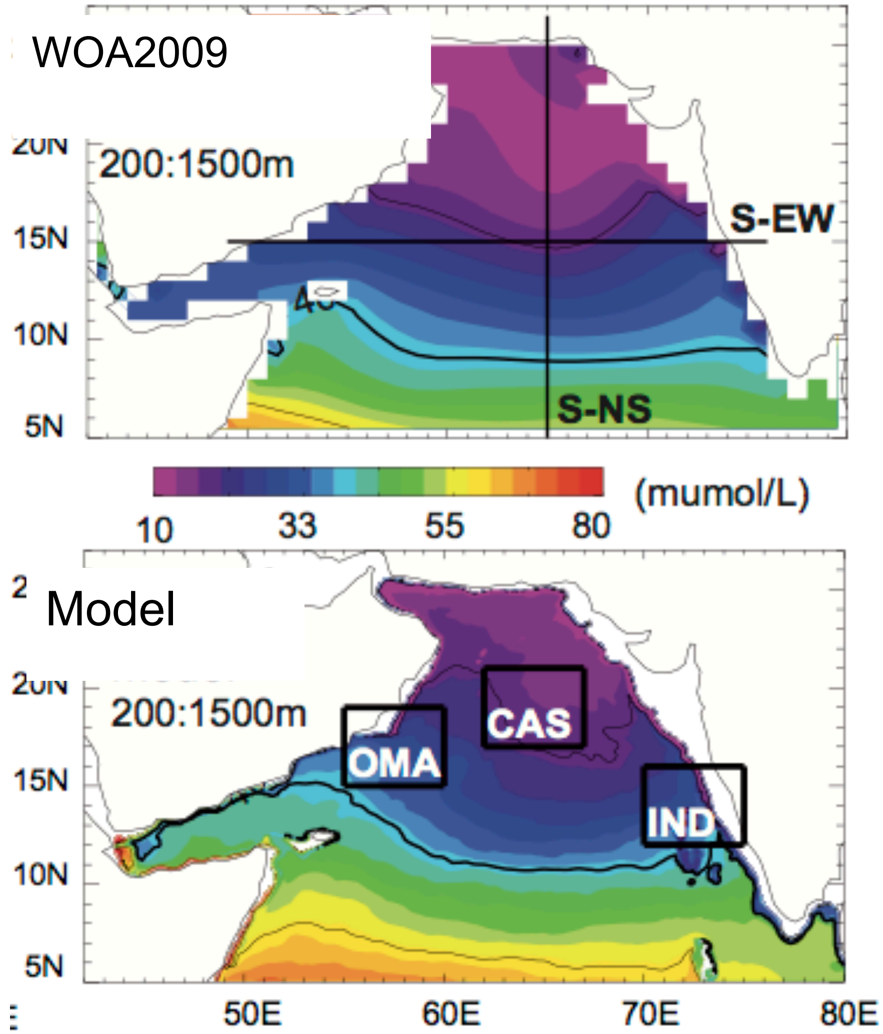
convection

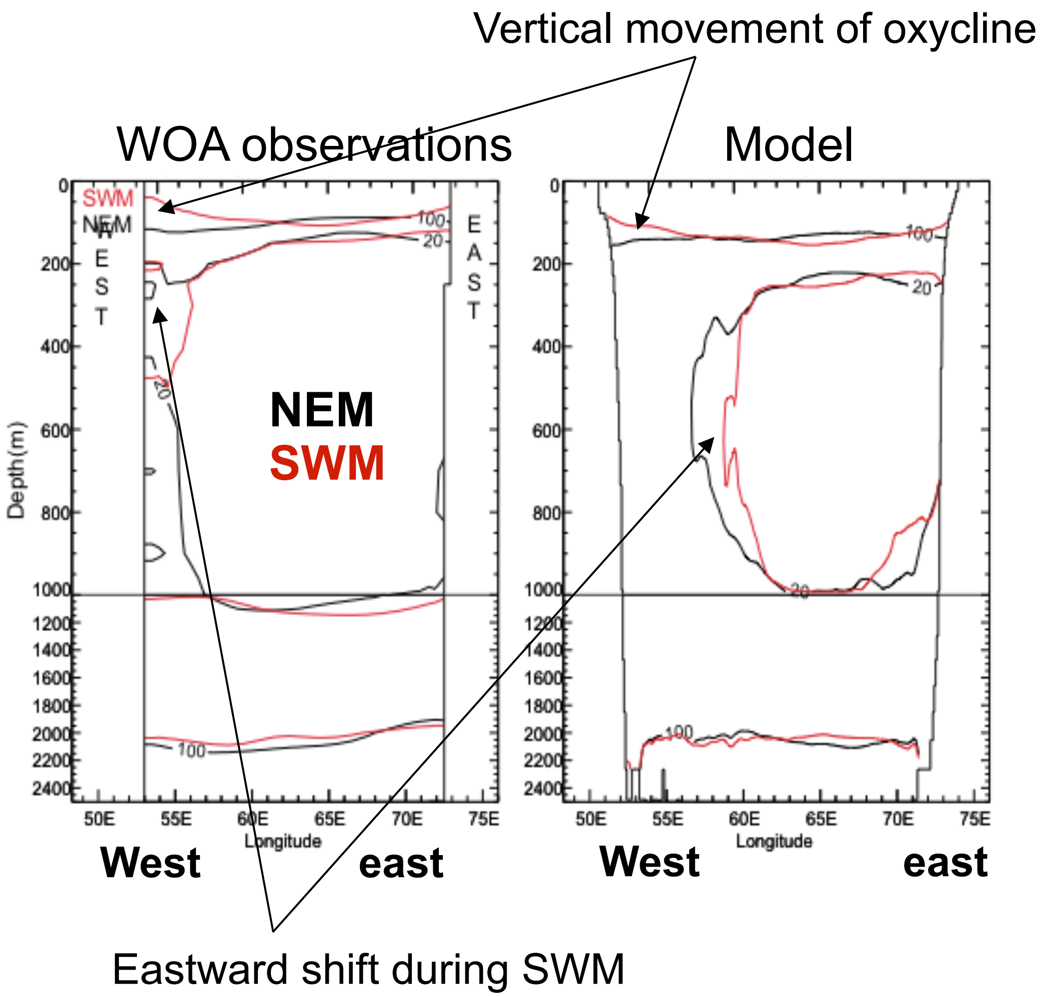


upwelling
systems

Model Evaluation : OMZ and its seasonal variation

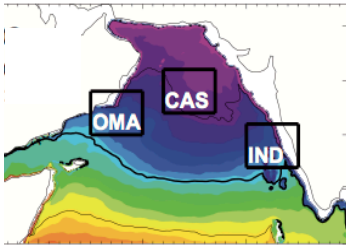
Volume of OMZ
Core (< 20 µmol/L) underestimated (-15%)
Total volume (< 100 µmol/L) ok
Due to z diffusion at oxycline





Model [O2] seasonality in AS:
~5% of annual mean in OMZ
~15% of annual mean in oxycline

Seasonal oxygen balance in 3 contrasted regions



$\partial O_2/\partial t$ = BIO + DYN

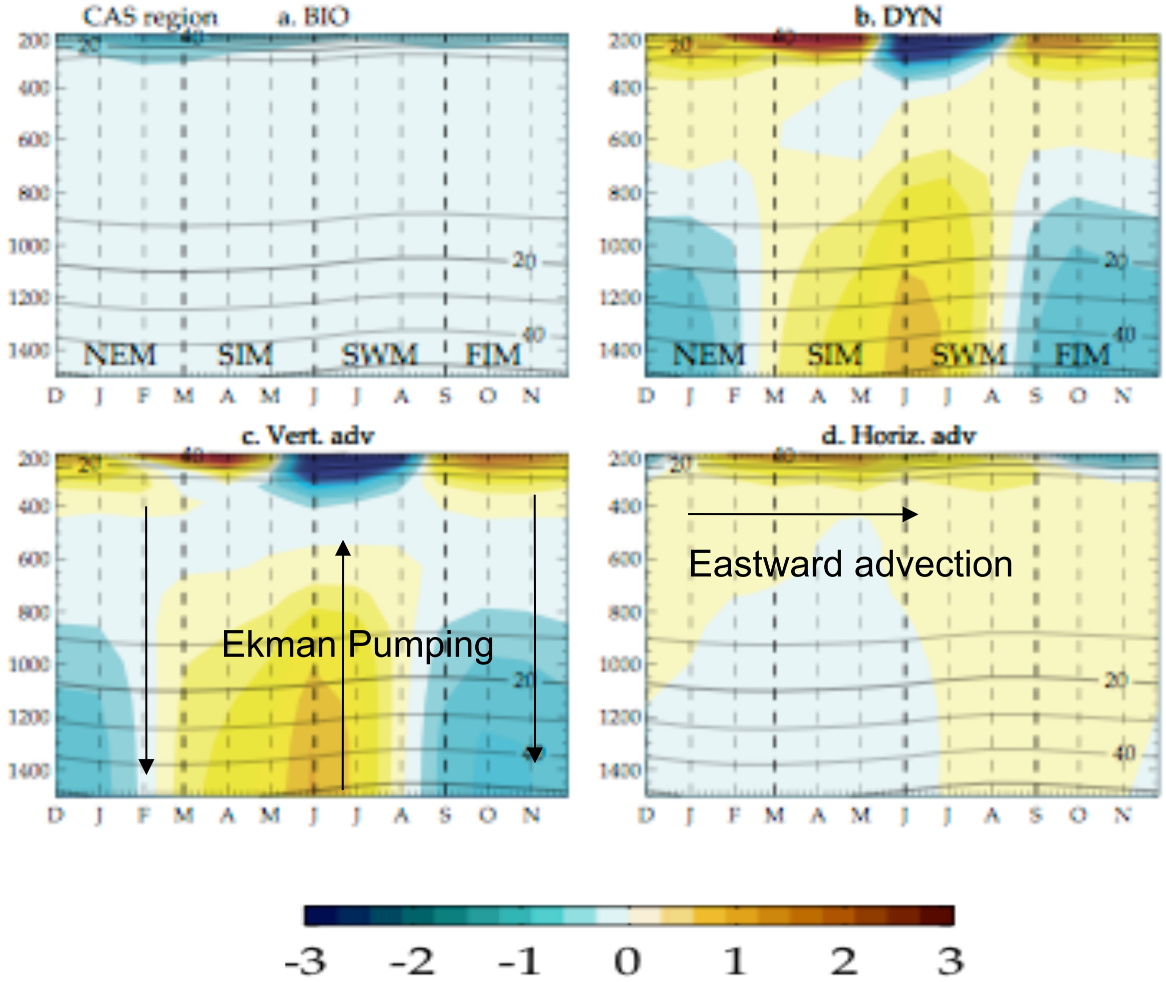
DYN= Vert adv + Horiz adv

Central AS:

Weak biological uptake following blooms

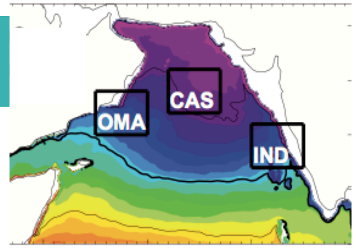
Dynamical transport dominates seasonality:

1. Ekman pumping
2. Eastward horizontal advection to CAS



sinks (mumol/L/month) sources

Seasonal oxygen balance in 3 contrasted regions



Oman upwelling region

1. Ekman pumping

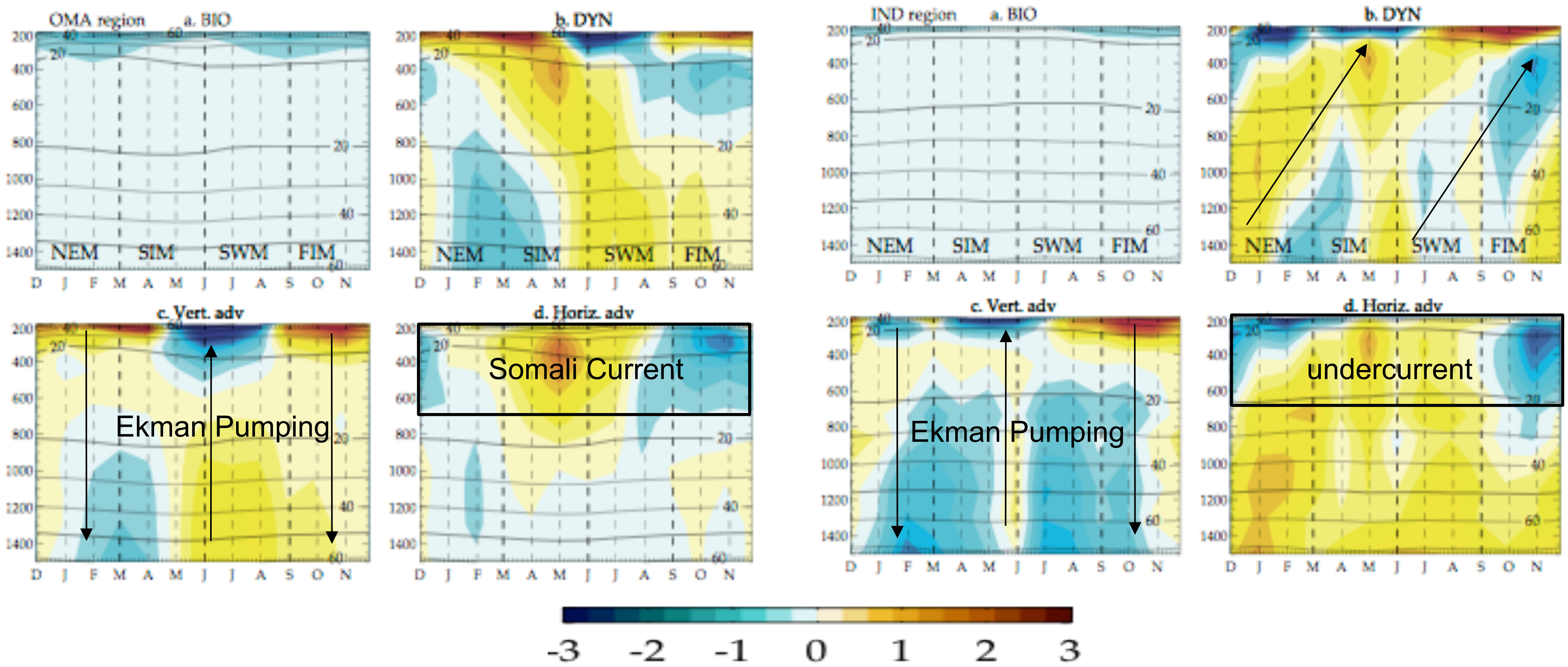
2. Lateral advection by reversing boundary current (Somali Current)

Indian upwelling region

1. Ekman pumping

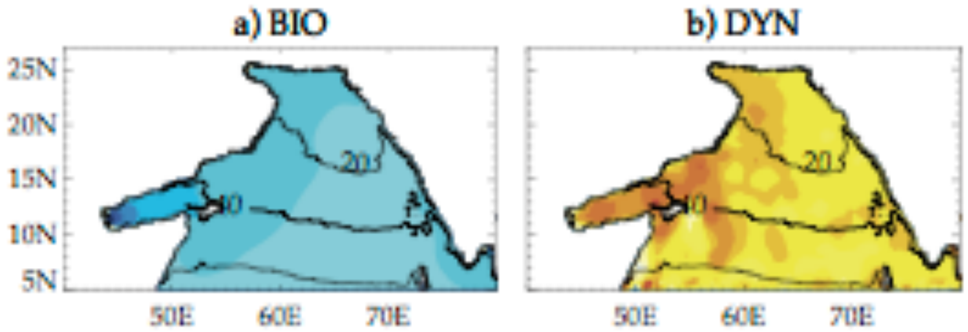
2. Lateral advection by undercurrent

3. Modulation by coastal Kelvin and Rossby waves



sinks (mumol/L/month) sources

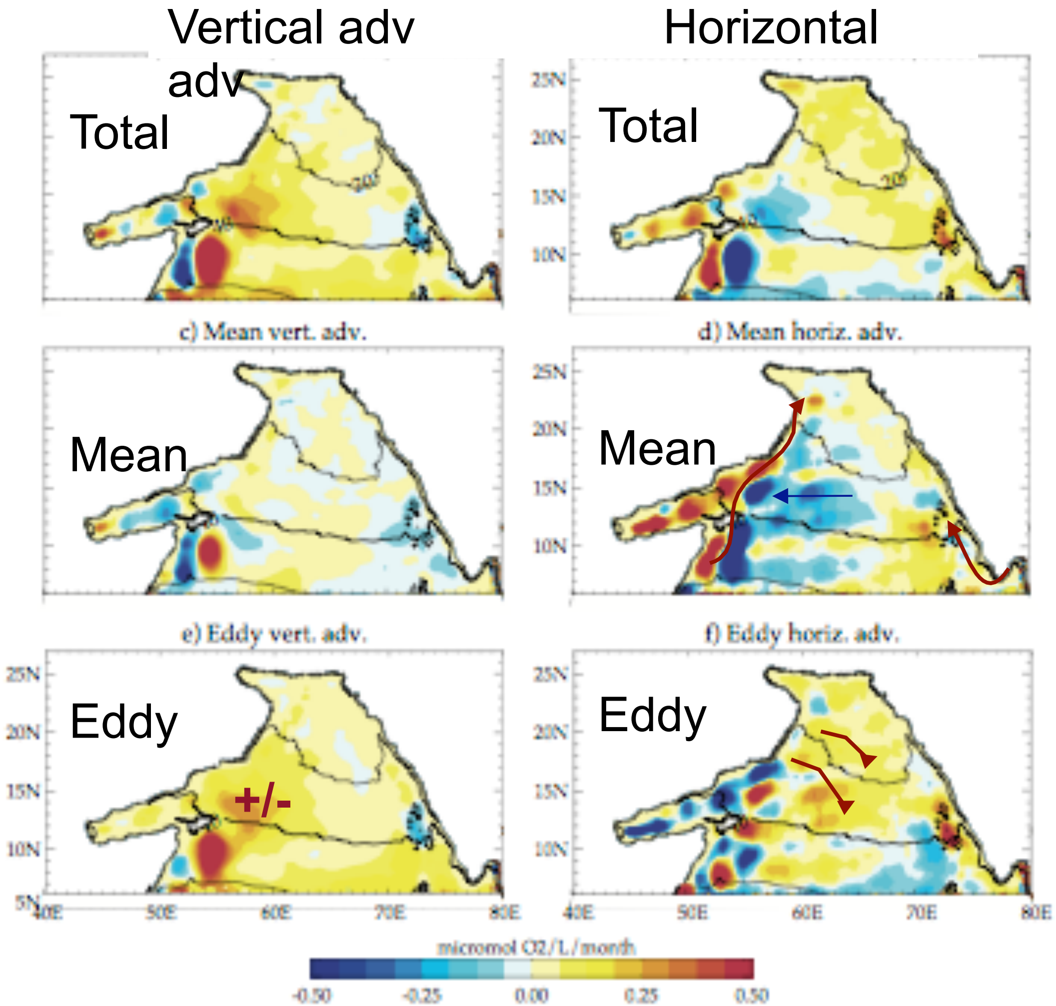
Balance on annual time scales



Dynamical supply counterbalances biological uptake

-Vertical: O2 sources by eddies

-Horizontal:
Mean: O2 sources along boundaries
Eddy: O2 sources into interior



Mean & Eddy transport of O_2 200-1500 m (Reynolds decomposition, mumol/L/month)

Conclusions

•**Seasonality of the OMZ of 5-15%**
Difficult to assess such variability in WOA observations (undersampling)

•Vertical displacement of OMZ by **Ekman pumping,**
in agreement with in-situ **ARGO float** showing oxycline seasonal vertical variations (Prakash et al, Journal of Sea Res. 2012)

Compensation of Ekman pumping on annual time scales

•**Reversing horizontal advection** along western and eastern coasts

•Influence of **coastal Kelvin and Rossby waves** along Indian western coast

•**Important contribution of eddies to the ventilation**

Eddy vertical advection across oxycline and OMZ base in particular in western AS
Eddy horizontal advection offshore Oman