Effects of dynamic physical processes on phytoplankton production and biomass in the tropical-subtropical North East Pacific Ocean off Mexico

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Marzo 24 de 2015

3rd International Symposium of Effects of Climate Change on the World's Oceans

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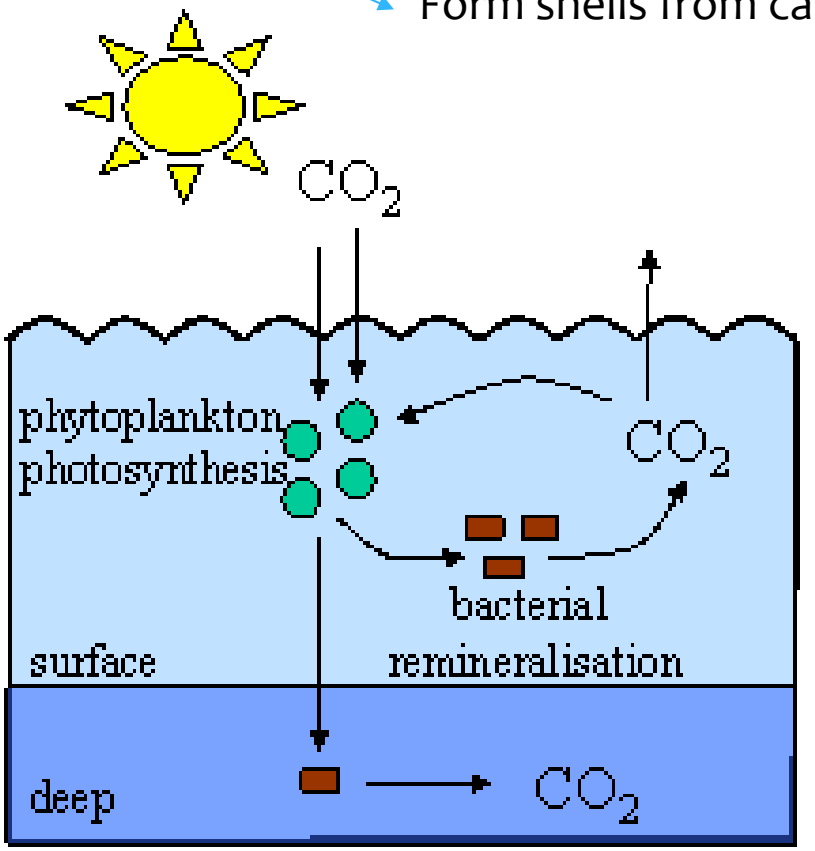
Phytoplankton's importance

Phytoplankton uses inorganic carbon in two ways:

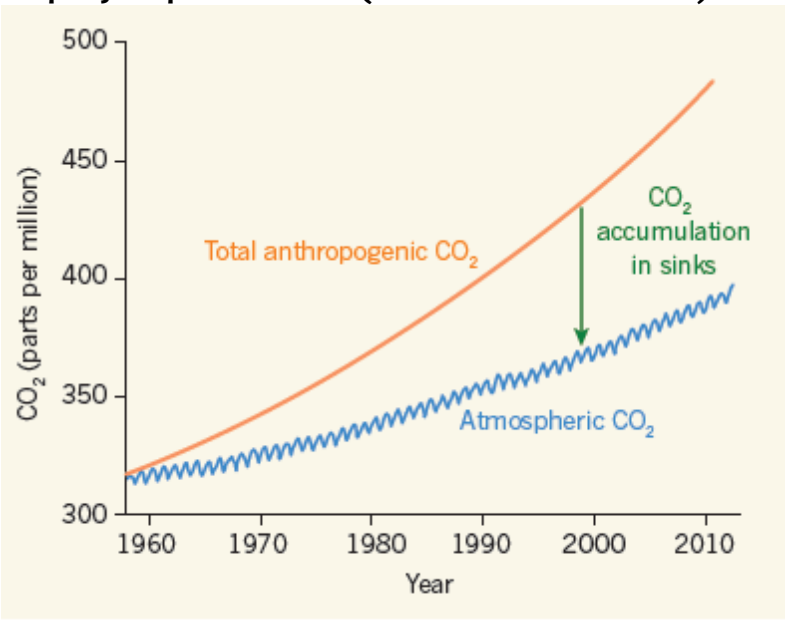
CO_2 → Photosynthesis

CO_2 → Form shells from calcium carbonate



http://www.xplora.org/

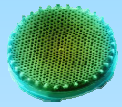
pCO_{2atm} 150-200 µatm above without phytoplankton (Laws *et al.* 2000)



Ballantyne et al. (2012)

Production and phytoplankton biomass

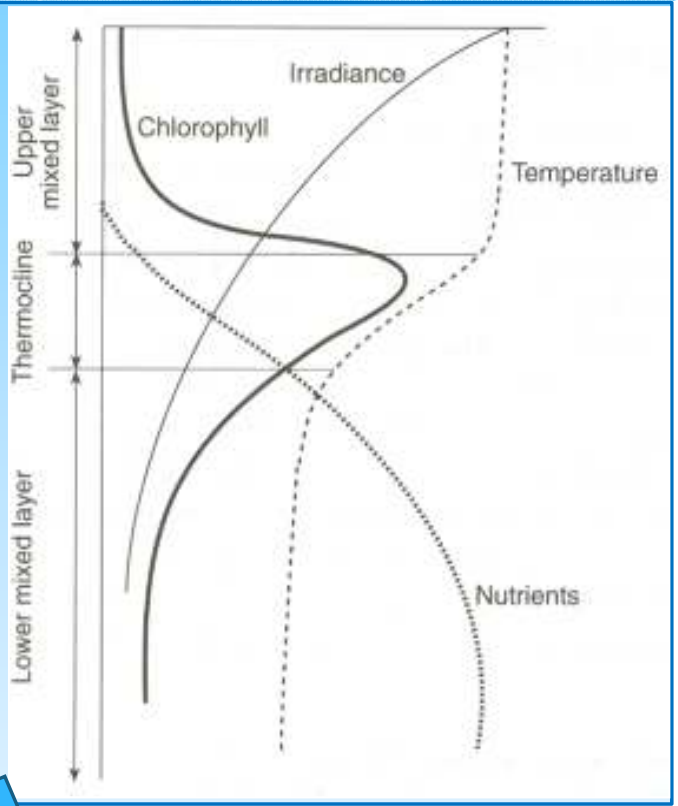
$$nCO_2 + 2nH_2O \xrightarrow{\text{Chl-a}} (CH_2O)n + nO_2 + nH_2O$$



Diatoms

Synechococcus

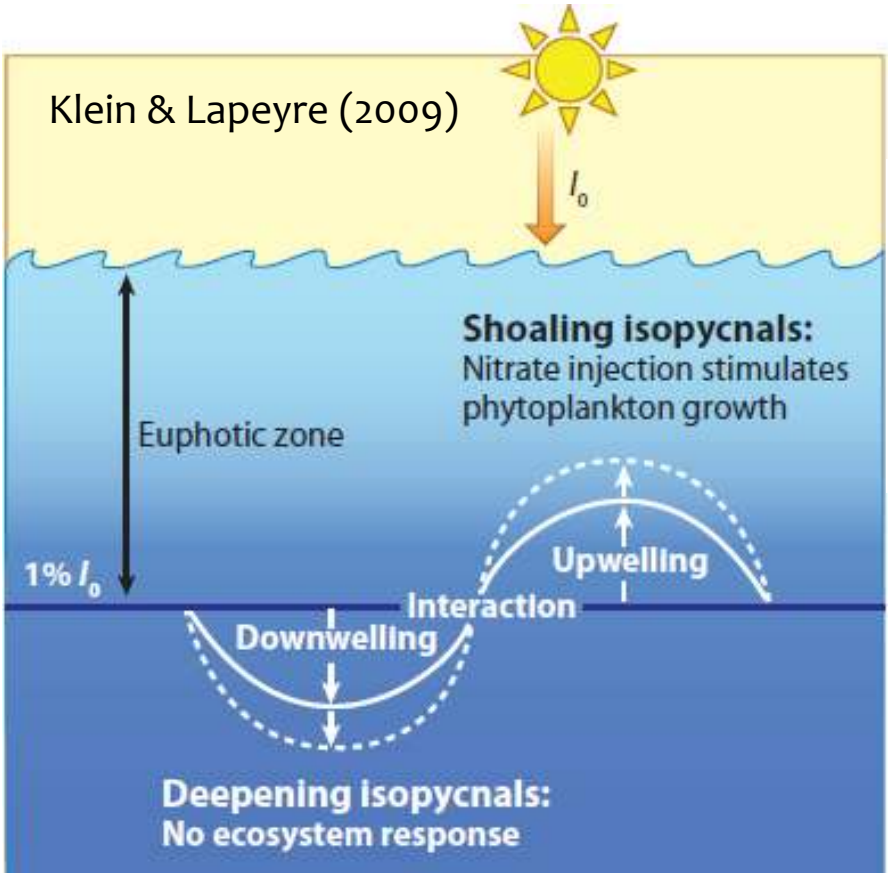
Prochlorococcus

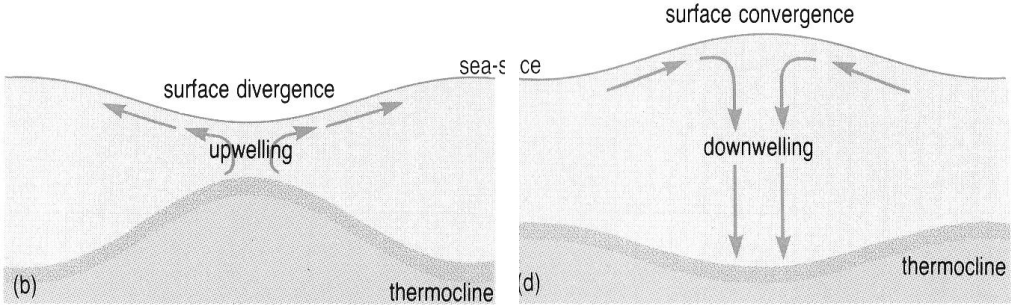


Light

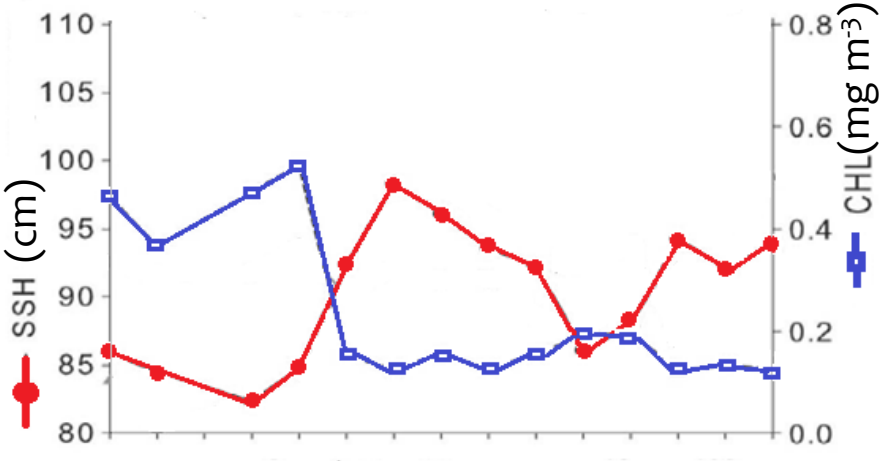
Availability of nutrients

Availability of nutrients





Modificated from Espinosa-Carreón et al. (2012)



Variability of phytoplankton production

Variability in the light-limited (PAR)

Vertical variability in phytoplankton biomass (Chl*a*)

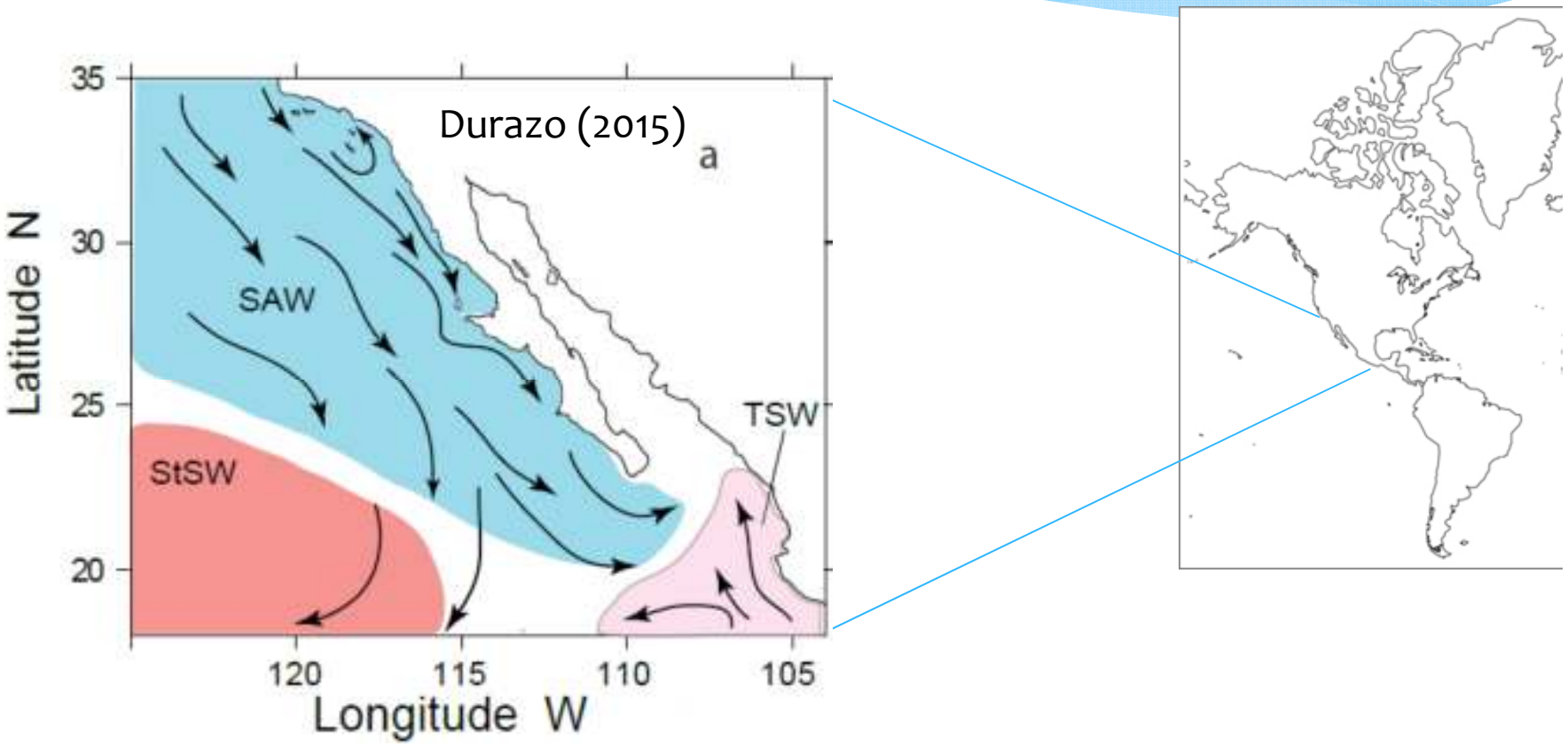
Behrenfeld & Falkwoski (1997)

But… What about ecosystem disturbance processes? (physical dynamic processes!!!)

Not accounted for bio-optical models Siegel et al. (2001)

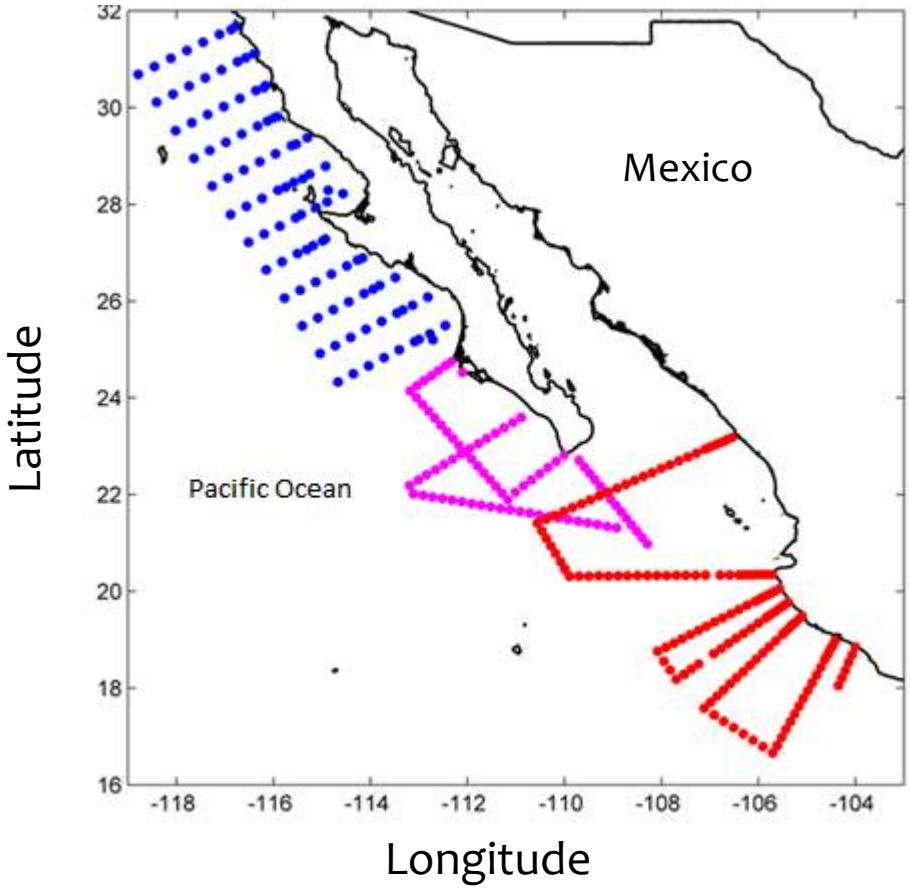
How is the effect of the physical dynamic processes on production and biomass of phytoplankton?

Study Area: North East Pacific Ocean off Mexico



Upwellings, eddies and interaction of water masses (Durazo & Baumgartner, 2002; Durazo et al., 2010; Kurczyn et al., 2012; Durazo, 2015)

Methods



3052 oceanographic stations from 1997 to 2012

In situ data

PP *and* Chl*a* and hydrographic data from three programs:

- IMECOCAL
- ISFOBAC
- PROCOMEX

PP integrated from surface to euphotic zone depth; Chl*a* integrated to 100 m.

Satellite data

ADT

Winds

Ekman pumping

Weekly
1/3° x 1/3 °

6 hourly
1/4° x 1/4 °

Methods: Relationship between variables

* Generalized Additive Models (GAMs)→ Find nonlinear relationships between variables.

$$PP = \beta_0 + s(X_1) + \ldots + s(X_i) + \varepsilon$$
$$Chla = \beta_0 + s(X_1) + \ldots + s(X_i) + \varepsilon$$

The variables tested were:

$$s(X_i) -> EkP, ADT$$

Where "EkP" is Ekman Pumping and "ADT" is the Absolute Dynamic Topography.

The best model was chosen by means of Akaike's criterion:

$$AIC = -2Log(likelihood) + 2p$$

Results

GAMs models

Smooth splines

Effects of EkP and ADT in PP and Chla

Conceptual model

GAMs models

* The best models fitted for primary production and Chlorophyll-*a* were:

$$PP = s(EkP_1) + s(ADT)$$

$$Chla = s(EkP_2) + s(ADT)$$

The parameters of the models were statistically significant and the variables have not linear correlation.

GAMs Models

* The best relationship between the production and phytoplankton biomass with Ekman pumping were at different "lags" because:

Time response of hours because PP is a rate ($gCm^{-2}d^{-1}$)

$$PP = s(EkP_1) + s(ADT)$$

$$Chla = s(EkP_2) + s(ADT)$$

Time response of days, because biomass depends of phytoplankton to growth

GAMs models

Probability that observed data occurs given the models was:

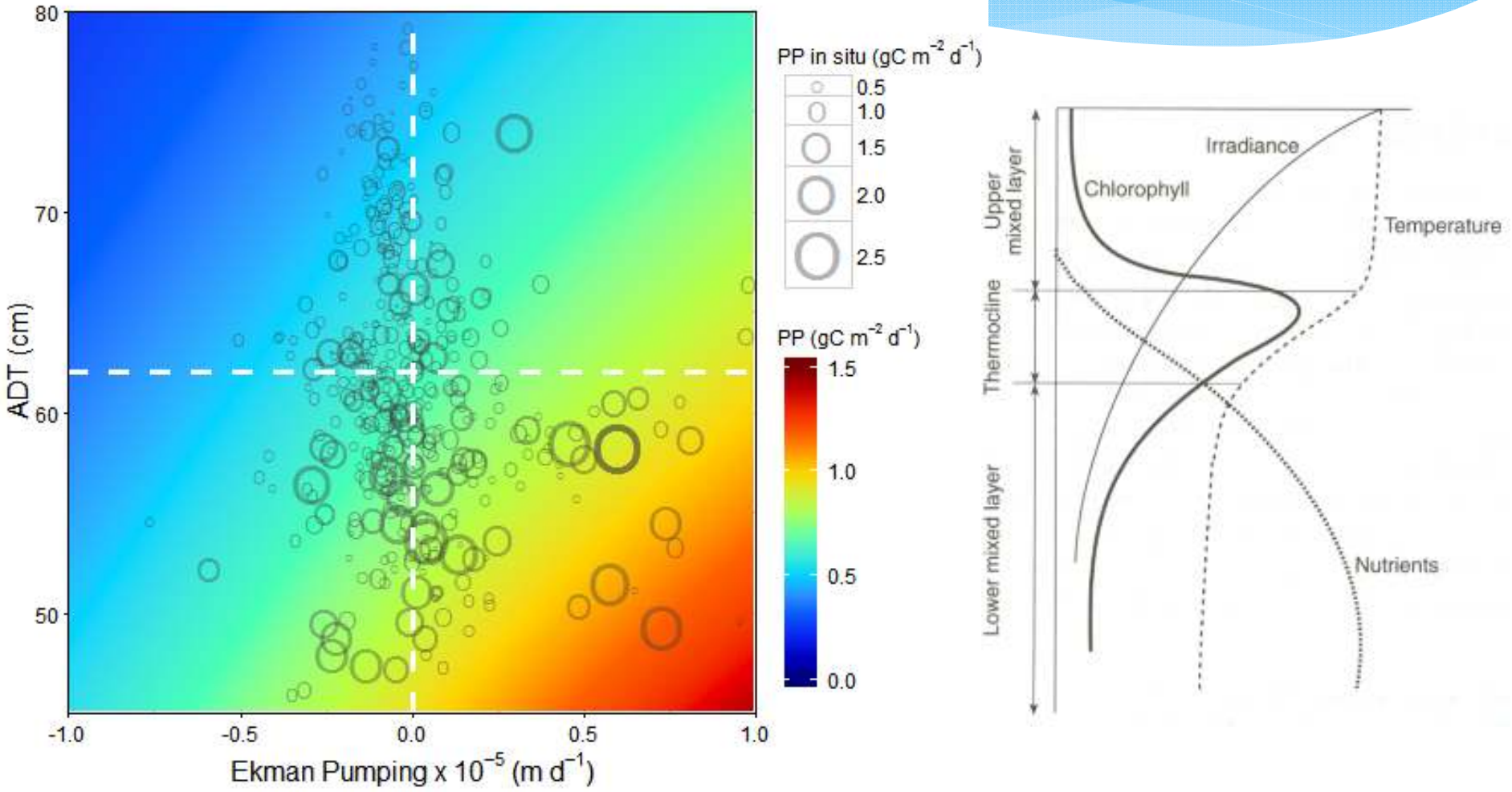
PP D^2=13% $Chla$ D^2=12%

In other GAMs studies :

$$PP = s(PAR) + s(Nitrates) + s(Chla)$$ D^2=96% Lamont et al. (2014)

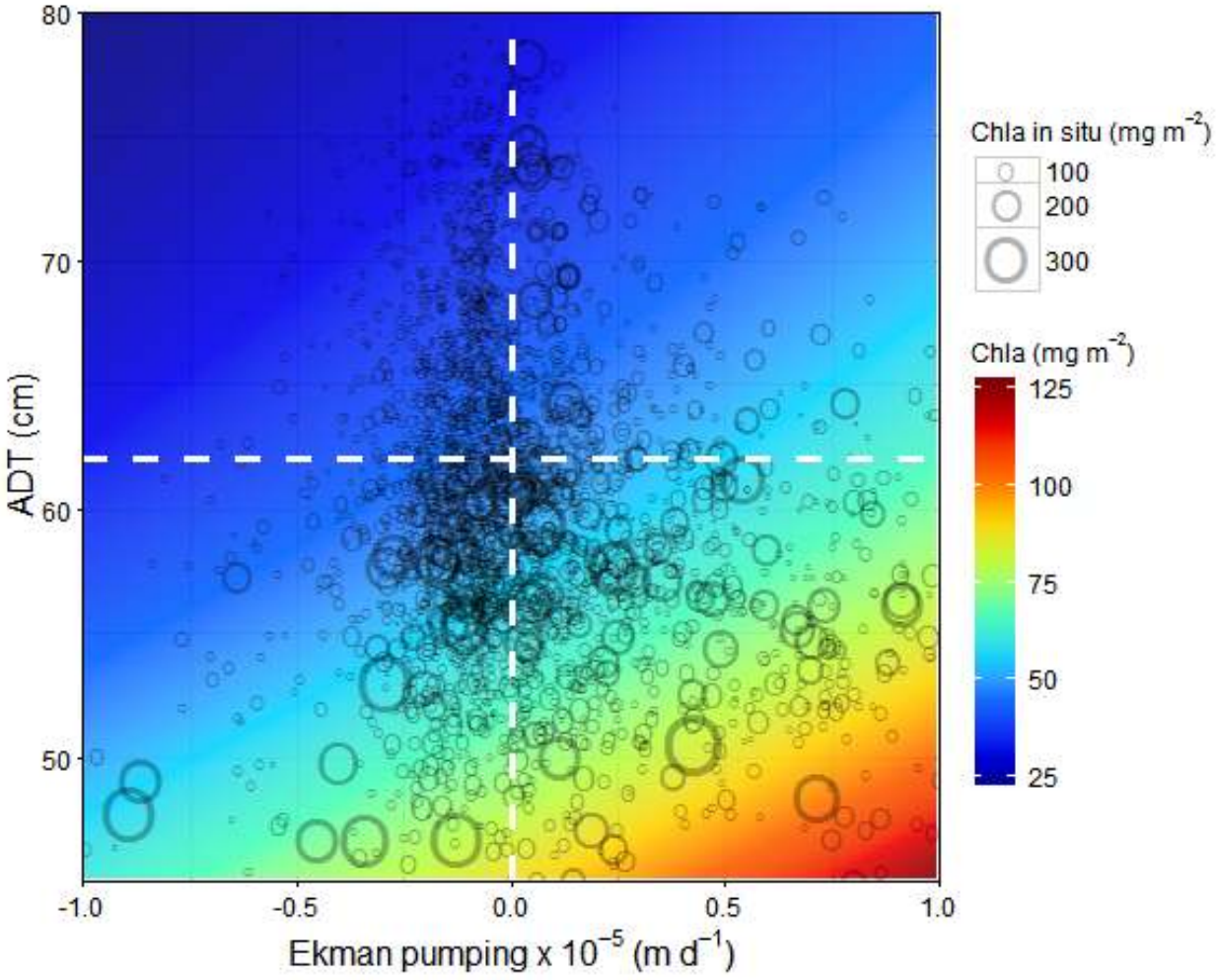
$$Chla = s(Phosphates) + s(Nitrates) + s(MLD) + s(Salinidad) + s(SST)$$ D^2=70% Raitsos et al. (2012)

Effects of ADT and EkP on PP



Ekman pumping > 0 md^{-1} and ADT < 60 cm showed the **higher** values of **PP *in situ* (circles)** and **PP inferred from the GAM model (colors)**

Effects of ADT and EkP on Chl*a*



Ekman pumping > 0 md^{-1} and ADT < 60cm showed the higher values **of Chl*a* *in situ* (circles)** and **Chl*a* inferred from the GAM model (colors).**

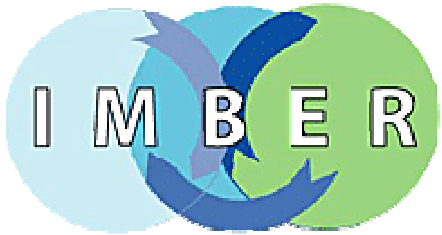
Conclusions

* Chl*a* and PP inferred from GAMs models allow us to observe the effects of both: EkP and ADT on PP and Chl*a*. This tool maybe can be useful to infer the tendency of PP and Chl*a* because of changes in ADT and EkP along the time.

* The relationships found showed that EkP > 0 md^{-1} and ADT < 62 cm are the optimal conditions for enhance PP and Chl*a*.

* Thermocline inside of euphotic zone could be explaining the enhance of PP and Chl*a* when ADT < 62 cm and EkP~ 0 md^{-1}.

Acknowledgements



IAEA
International Atomic Energy Agency


Photo: Alejandro Tapia
¡¡GRACIAS!!
OBRIGADA!!
THANK YOU!
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