Osmosis

Developing multi-satellite products for the marine resources management

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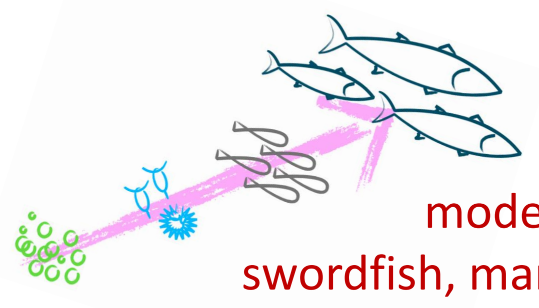
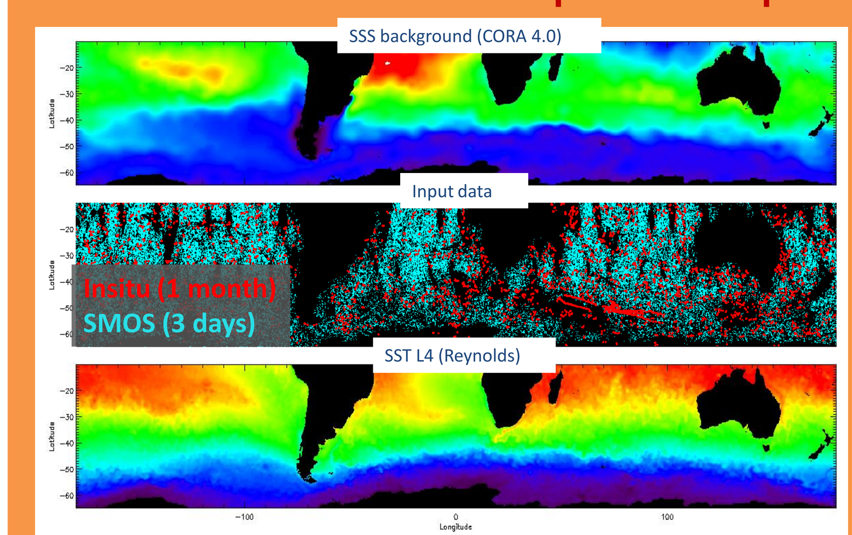
The OSMOSIS project aims at prototyping a system based on the synergetic use of several satellite-derived variables (Sea level, Earth Marine geoid, Sea Surface Salinity, Sea Surface Temperature, Ocean color) for the modeling of the distribution of micronektonic organisms



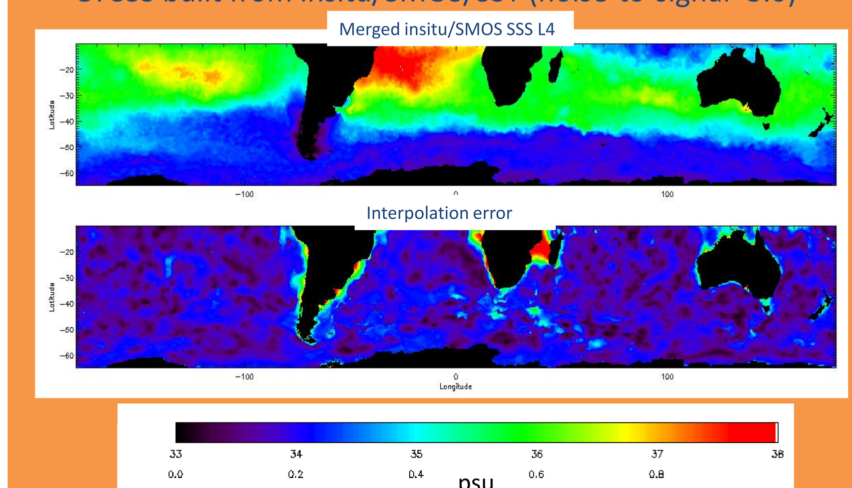
Why is micronekton important? Micronekton organisms (size ~1-20 cm) are both prey of large oceanic predators and predators of eggs and larvae of many of these large species. Micronekton distribution is key explanatory variable usually missing in ecosystem models to understand individual behaviour and population dynamics of large oceanic predators that are either targeted by fisheries (tuna, swordfish, marlin, etc.), strictly controlled in by-catch (bluefin tuna, sharks), or fully protected (marine turtles, seabirds, marine mammals).

Surface Salinity Retrieval from SMOS, SST and Argo floats

Method: Multi-variate Optimal Interpolation to combine in situ/SMOS SSS and satellite SST



OI SSS built from insitu/SMOS/SST (noise-to-signal=3.0)



$$x_{analysis} = x_{background} + C(R+C)^{-1}(y_{obs.} - x_{background})$$

Hypothesis:

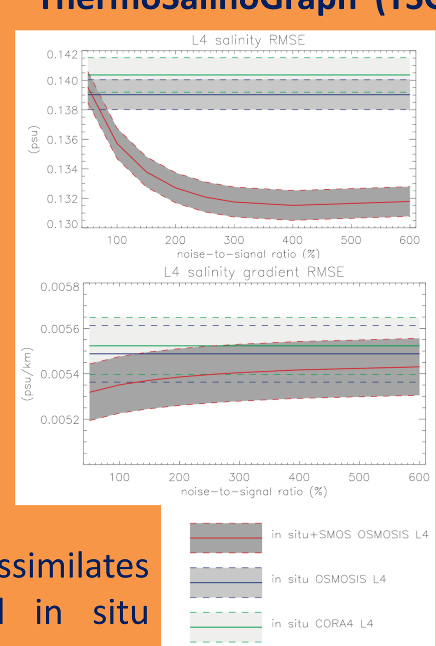
sea surface temperature (SST) and **sea surface salinity (SSS)** variations correlated at scales smaller than the ones dominating atmospheric variability (in the open ocean)

→ **T and S** pairs identify **water masses**, thus **basically modified only by advection and mixing once large scale variations are filtered out**

$$C(Dr,Dt,DSST) = e^{-\left(\frac{Dt}{t}\right)^2} e^{-\left(\frac{Dr}{L}\right)^2} e^{-\left(\frac{DSST_{filtered}}{T}\right)^2}$$

Multi-dimensional covariance model

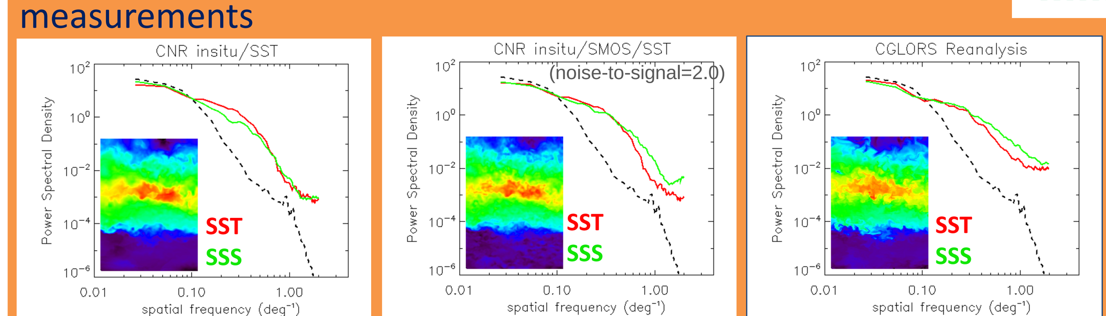
Validation through comparison to independent ThermoSalinoGraph (TSG) surface salinity



RMSE of SSS L4 (a) and SSS L4 gradient (magnitude) (b) vs TSG SSS and TSG SSS gradient magnitude in the different OI configurations as a function of filtered SMOS noise-to-signal level used in the analysis. Gray shaded areas represent the confidence interval on the statistics. This plot was built using only TSG data at a distance of at least 600 km from land.

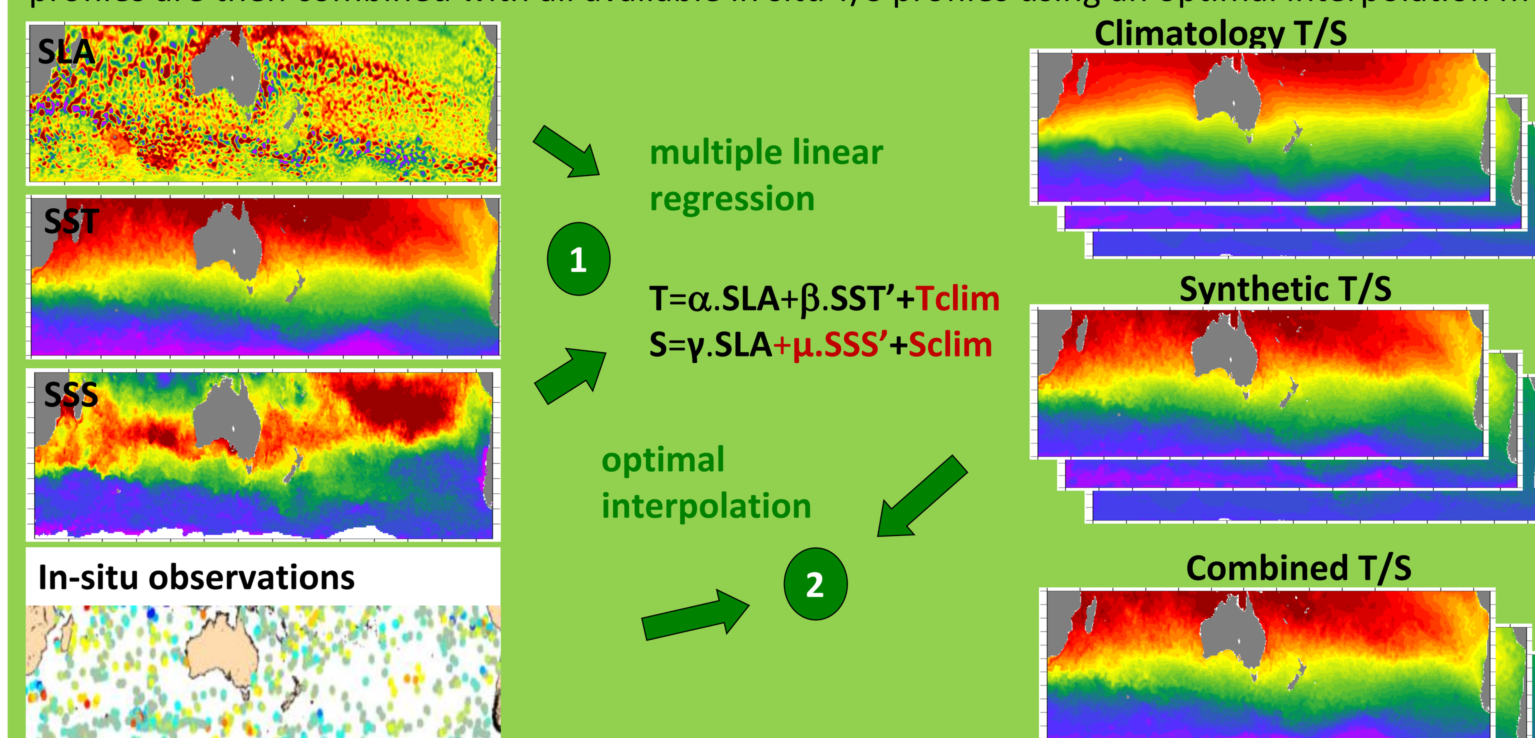
Validation through wavenumber spectra calculation

Wavenumber spectra obtained with OSMOSIS L4 algorithm closely reproduce those obtained from CGLORS 1/4°ocean model reanalysis (CGLORS also assimilates satellite SST, altimeter sea level estimates and in situ measurements



Calculating 3D fields of Temperature and Salinity from space and in-situ data

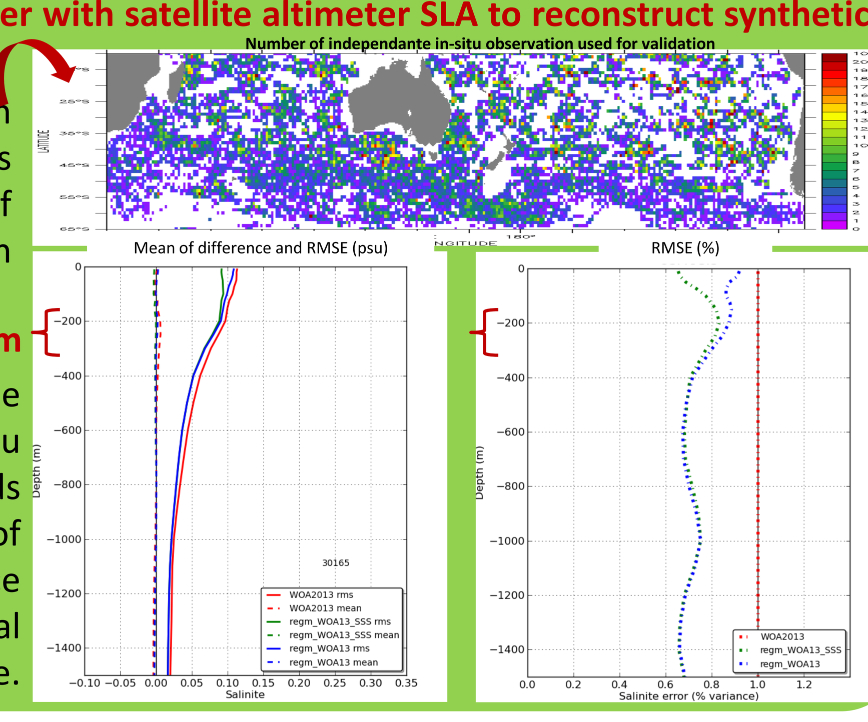
Method: The method uses hereafter is fully described in Guinehut et al. (2012) . First a multiple linear regression is applied to derive synthetic T/S profiles from the satellite measurements . These synthetic profiles are then combined with all available in situ T/S profiles using an optimal interpolation method.

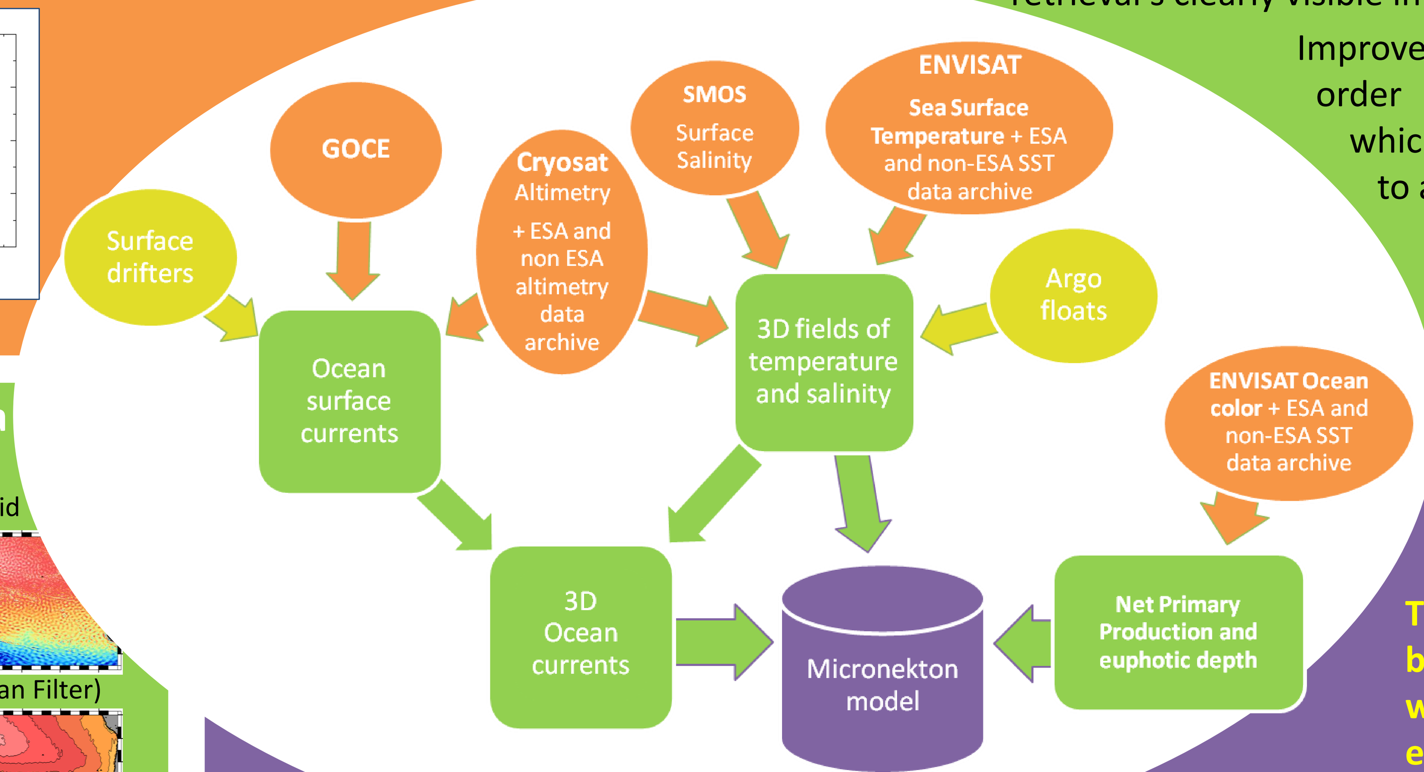


Compared to the existing method, a number of improvements have been implemented :

- 1- The use of WOA13 climatology instead of ARV11 climatology as first guess - 2- The use of new parameters in the optimal interpolation method and -3- **The use of the OSMOSIS SSS product together with satellite altimeter SLA to reconstruct synthetic salinity fields at depth**

In-situ observations for the year 2012 have been used to validate the synthetic salinity fields computed using only SLA and a combination of SLA+SSS. Impact of the use of SSS field as an additional constraint in synthetic salinity field retrieval s clearly visible in **the top 200m**. Improvement is of the order of 0.02 psu which corresponds to about 25 % of the surface signal variance.



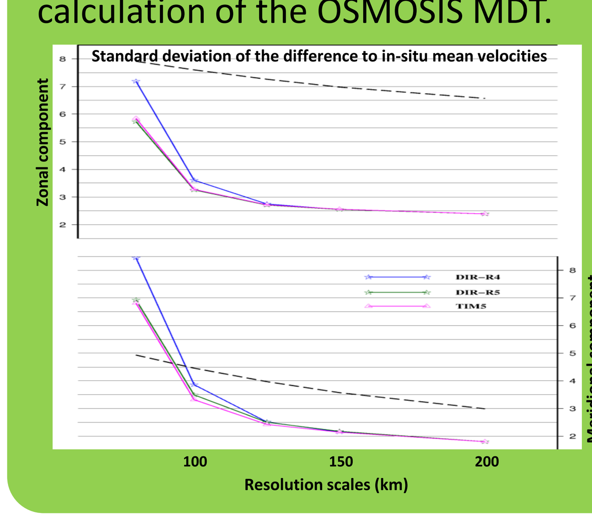


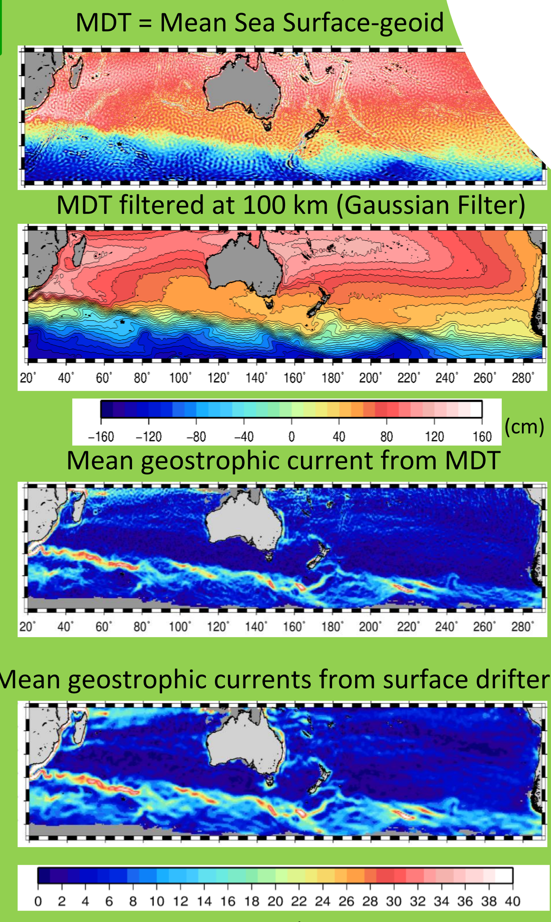
Surface Currents Retrieval from GOCE and altimeter data

$$u(z=0) = -\frac{g}{f}\frac{\partial(MDT+SLA)}{\partial y} \qquad v(z=0) = \frac{g}{f}\frac{\partial(MDT+SLA)}{\partial x}$$

SLA=Sea Level Anomaly
MDT = Mean Sea Surface-geoid

Different recent geoid models based on GOCE data have been tested for calculating mean geostrophic velocities. RMS differences to in-situ mean velocities (from drifters) show that the TIM-5 solution (Brockmann et al., 2014) performs slightly better. It was thus chosen for the calculation of the OSMOSIS MDT.





Calculation of 3D geostrophic velocities

Method: Thermal wind Equation

Surface currents from GOCE and altimetry (see above!)

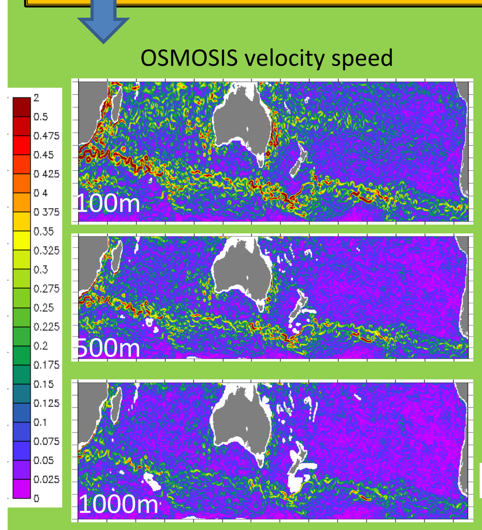
OSMOSIS 3D fields of Temperature and Salinity (see above!)

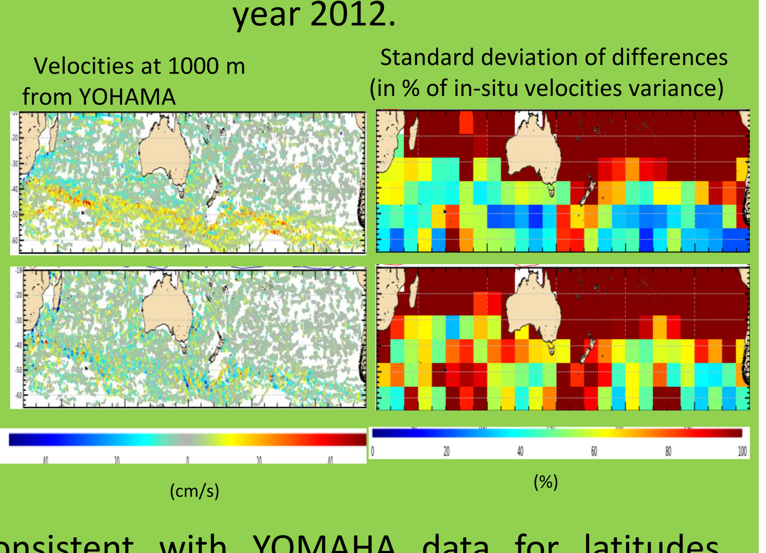
$$u(z=z_i) = u(z=0) - \frac{g}{\rho f}\int_{z=z_i}^{z=0}\frac{\partial}{\partial y}\rho(z)\,dz$$

$$v(z=z_i) = v(z=0) + \frac{g}{\rho f}\int_{z=z_i}^{z=0}\frac{\partial}{\partial x}\rho(z)\,dz$$

Mulet et al., 2012

Validation: Comparison to independant velocities at 1000m deduced from the displacement of Argo floats (YOMAHA-07 database) for the year 2012.

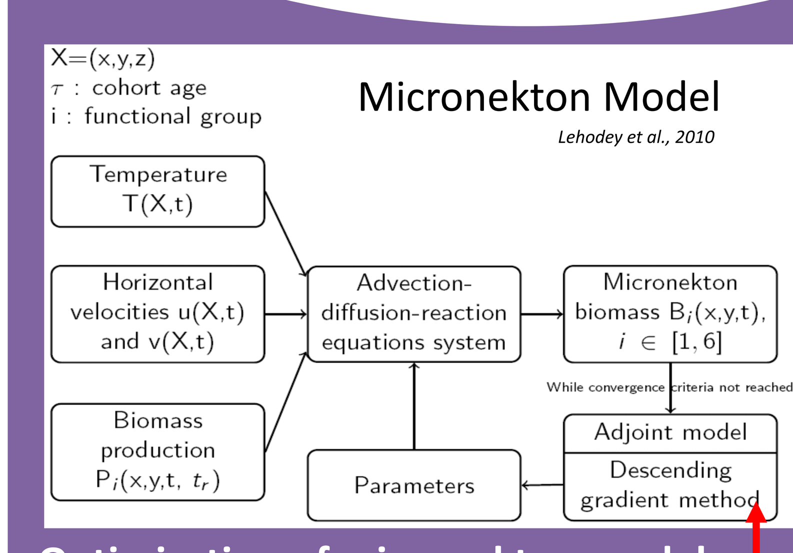




The OSMOSIS fields are consistent with YOMAHA data for latitudes southern than 40°S with Root Mean Square (RMS) of the difference lower than 100%. In particular **zonal currents show very good consistency with Argo float with RMS of the difference almost everywhere less than 20%.** At more equatorward latitudes the signal is much less energetic (RMS less than 3 cm.s^{-1}) and lies in the error bar of both velocity fields.

Micronekton as a validation test for Primary production Models

Three bio-physical forcings with the same physics (ECCO model) butdifferent primary production variables (VGPM, CLS, EPPLEY) were tested. Micronekton model (SEAPODYM-MTL) outputs are evaluated using 38 kHz acoustic (NASC) data (14 and 10 transects in Indian and Pacific Oceans respectively) that provide observed abundance indices of micronekton between surface and ~1000 m depth.

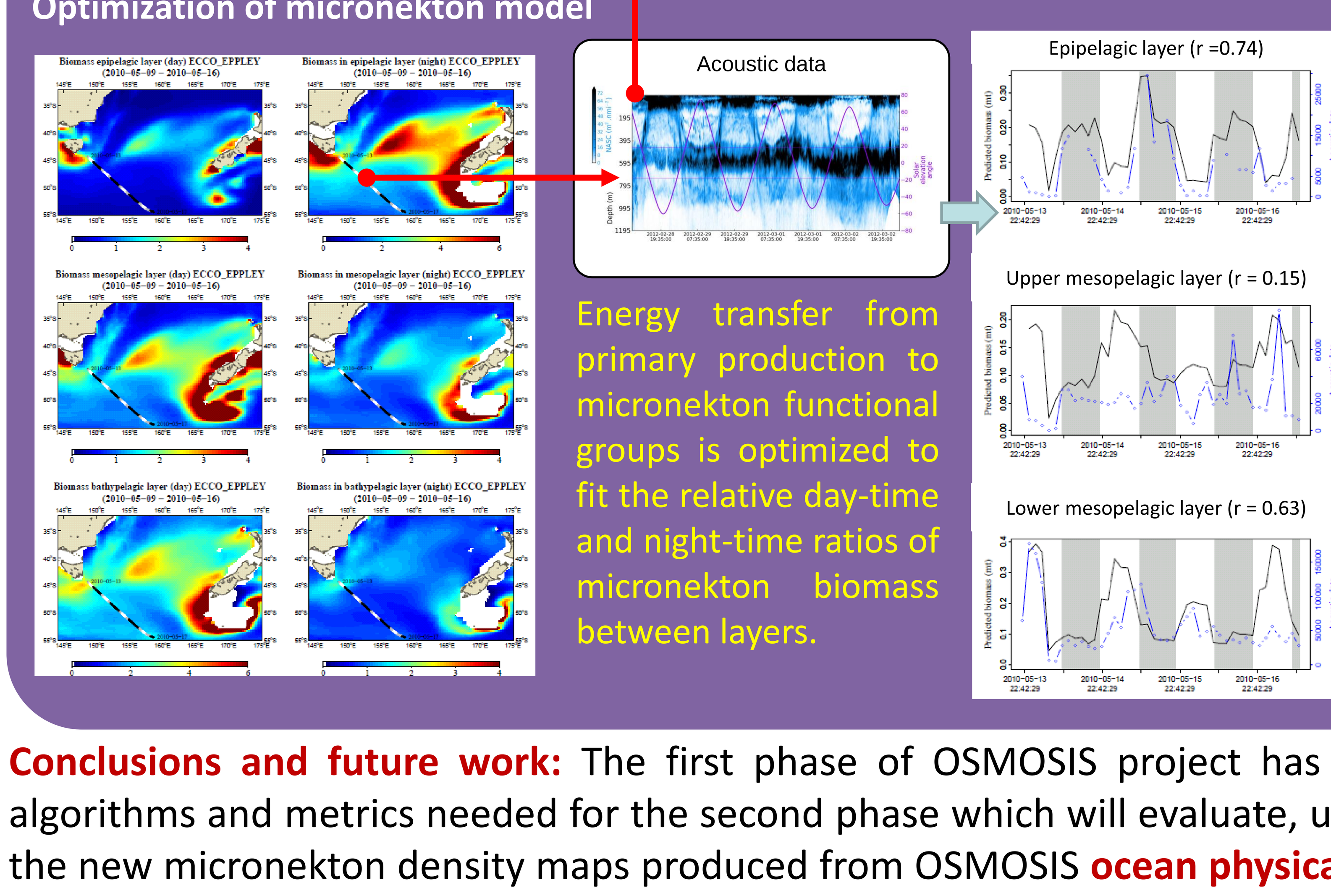


Validation metrics (Pearson coefficient **R**, Normalized Variance **Var**, Centered Root-mean squared error **RMSE** and R-squared goodness of fit **RSGF**) allowed detecting differences when comparing data and model prediction between vertical layers and oceans.

Layer	R	Variance	RMSE	RSGF
Epi	0.48	0.976	0.988	0.15
Upper-meso	0.1	0.833	1.291	0
Lower-meso	0.6	1.654	1.049	0.156

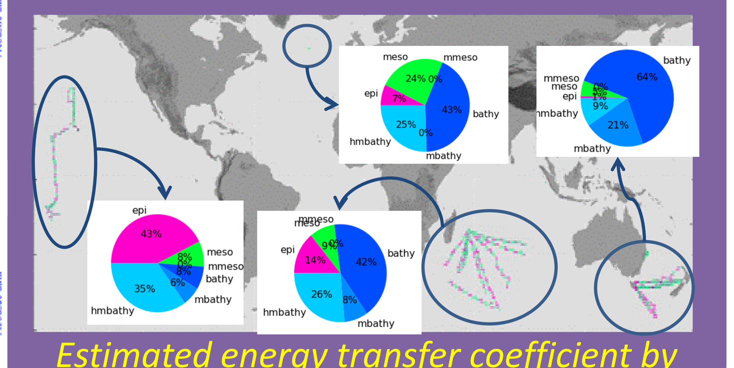
The acoustic transects are better predicted in the Pacific than in the Indian Ocean. The **ECCO-EPPLEY model provides the best scores**. It differs from the two others by its relationship to temperature used to estimate primary production from satellite ocean color data.

Optimization of micronekton model



Energy transfer from primary production to micronekton functional groups is optimized to fit the relative day-time and night-time ratios of micronekton biomass between layers.

First optimization results suggest that optimal solutions may be ecosystem–dependent and vary seasonally. However, there are several sources of uncertainty in model (definition of vertical layers) and data (NASC is not directly proportional to biomass) that need to be investigated .



Estimated energy transfer coefficient by ecosystem and functional group

Conclusions and future work: The first phase of OSMOSIS project has focused on the development of algorithms and metrics needed for the second phase which will evaluate, using independent in-situ datasets, the new micronekton density maps produced from OSMOSIS **ocean physical fields**. These **observation-based 3D reconstructed fields** have been significantly improved, especially for salinity and mean currents, using **SMOS data together with in-situ salinity data and the latest GOCE geoid models**.

References: Guinehut S., A.-L. Dhomps, G. Larnicol and P.-Y. Le Traon, 2012: High resolution 3D temperature and salinity fields derived from in situ and satellite observations. Ocean Sci., 8, 845-857, doi:10.5194/os-8-845-2012. Mulet, S., M.-H. Rio, A. Mignot, S. Guinehut and R. Morrow, 2012: A new estimate of the global 3D geostrophic ocean circulation based on satellite data and in-situ measurements. Deep-Sea Res. II., 77-80, 70-81, doi:10.1016/j.dsr2.2012.04.012. Lehodey P., Murtugudde R., Senina I. (2010). Bridging the gap from ocean models to population dynamics of large marine predators: a model of mid-trophic functional groups. Progress in Oceanography, 84: 69–84