



**MERCATOR
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INTERNATIONAL

Equatorial biases in biogeochemistry with data-assimilated ocean circulation models: a Lagrangian perspective

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- Introduction
 - Physics, latest development
 - Coupling of BGCM
 - Bias in the biogeochemistry in Equatorial Pacific:
 - Investigation using Lagrangian analysis
 - Results
 - Discussion, Future developments
-

Physical Model (Ocean + Sea Ice)

- NEMO 3.1 OGCM coupled with LIM2_EVP sea-ice model
- Horizontal resolution $1/12^\circ$ and 50 vertical levels (1m at the surface)
- 3h ECMWF atmospheric forcing
- Ice-sheets and glaciers melting added to the runoffs
- Large scale correction of precipitations
- Global steric effect added to SSH

Assimilation & Data assimilated (SAM2 code)

- SEEK (Kalman filter)
- 3D-Var large scales bias correction
- SLA (SL TAC) compared to (SSH - **Hybrid MDT**) from « CNES-CLS13 » MDT
- In Situ T/S profile (INS TAC)
- SST OSTIA (OSI TAC)
- Sea-ice concentration (OSI TAC)
- New Quality Control on 3D T/S observations
- Adaptive tuning of SLA and SST observation errors
- Below 2000 m: T,S climatology (WOA) to avoid model drift

3 different Model Output (daily, 2007-Present)

- “FREE”,
- “BIAS only”
- and “OPER” simulations
- coarsening $1/12^\circ \rightarrow 1/4^\circ$

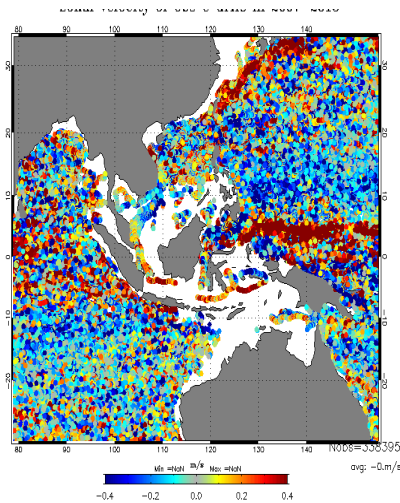
used to force BGC Model PISCES

- NEMO-PISCES 3.6
- GLOBAL $1/4^\circ$, run offline
- 2 different physical forcing: **OPER and FREE physical system coarsened to $1/4^\circ$**
- Daily output from 2007-14
- Initial conditions from climatology (WOA 2013)

Available Observations: Argo surface floats and AOML surface drifters (not yet assimilated ...)

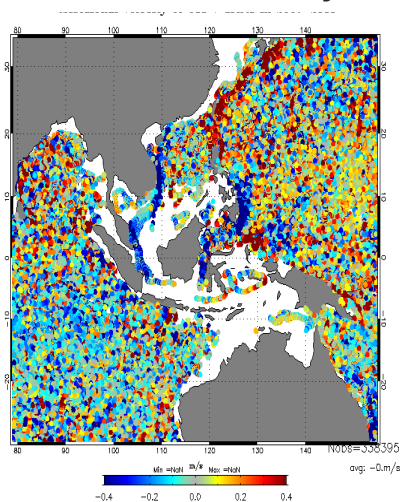
Indonesian region: currents are very difficult to resolve because of the many narrow straits and the strong tidal mixing

Zonal velocity

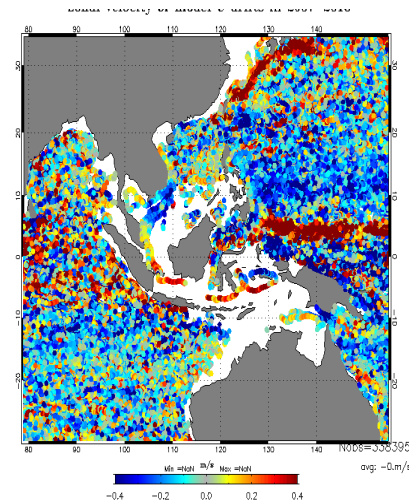


OBS

Meridional velocity

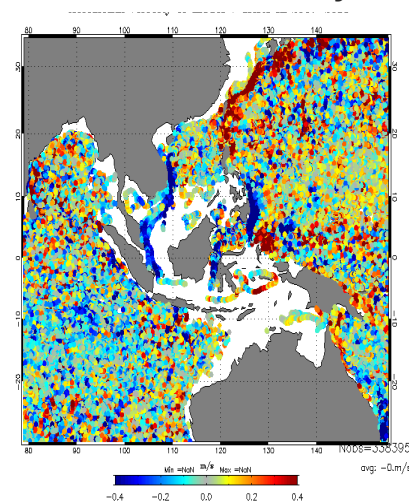


Zonal velocity



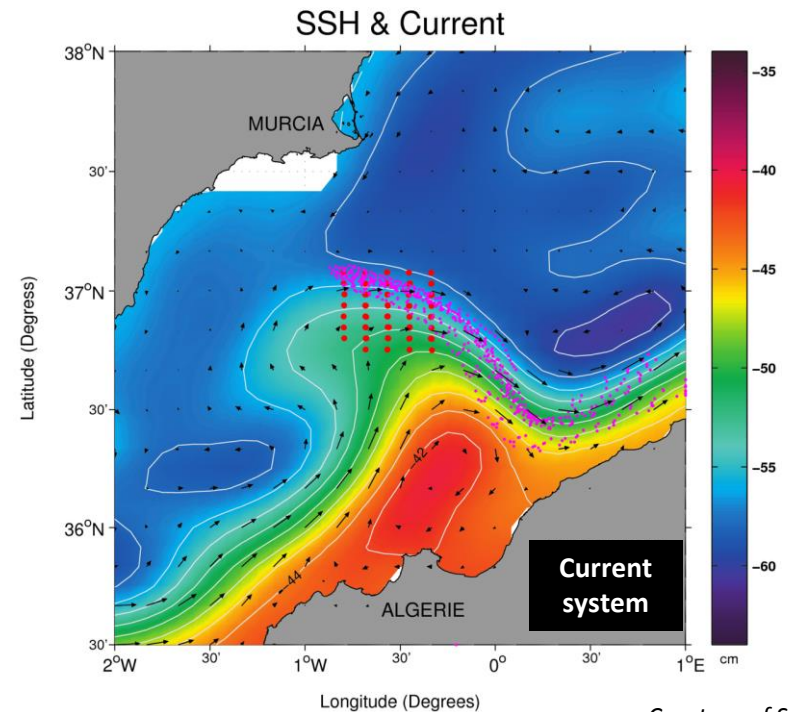
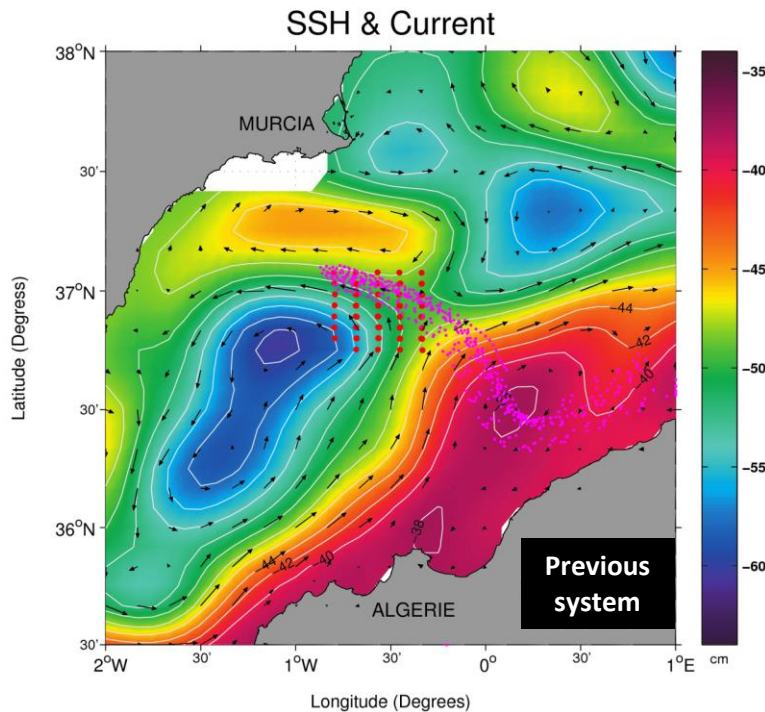
MODEL

Meridional velocity



**Correlation
~ 0.7**

SSH and velocity field from previous and current system

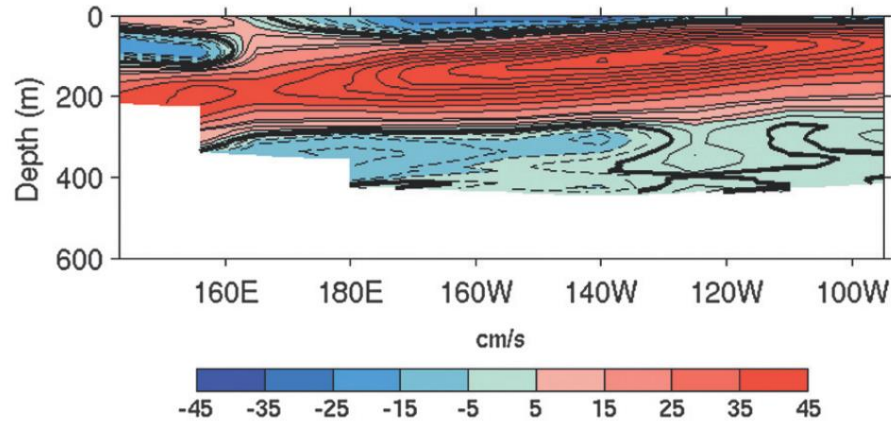


Courtesy of S. Ruiz

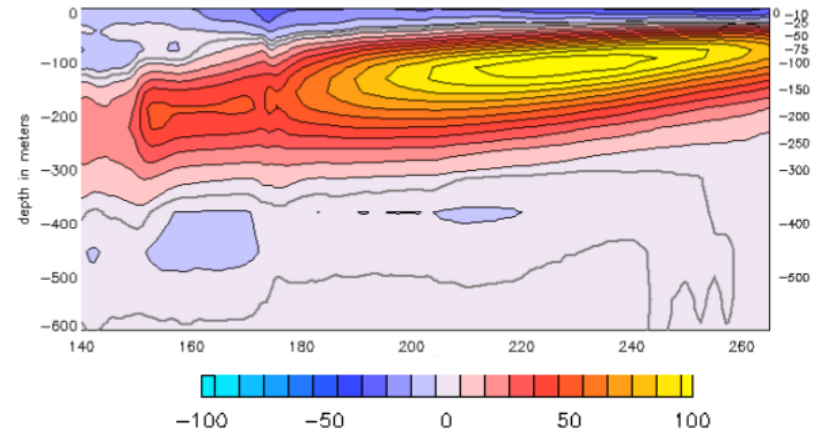
Magenta dots corresponds to ALBOREX drifters positions from 25 May to 1 June 2014

Zonal velocities at the equator

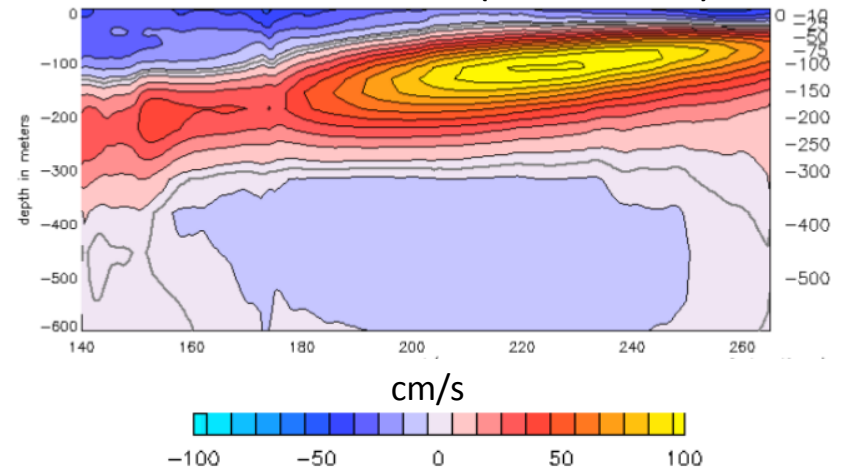
Observations (1985-2000)



GLORYS12 FREE (2003-2014)

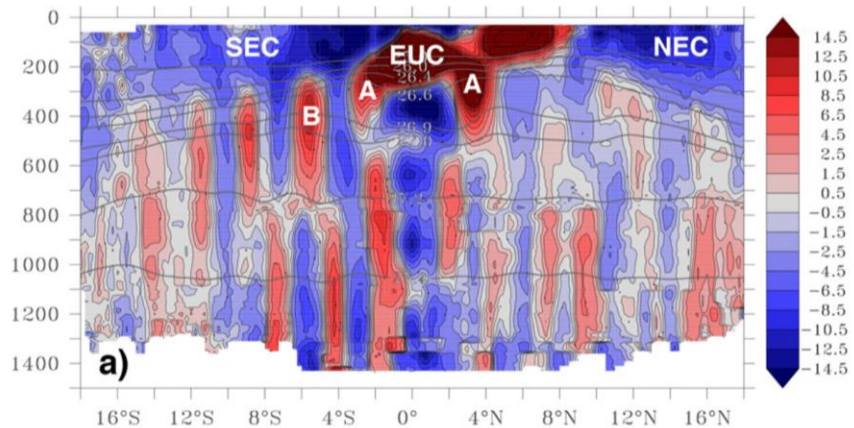


GLORYS12 OPER (2003-2014)



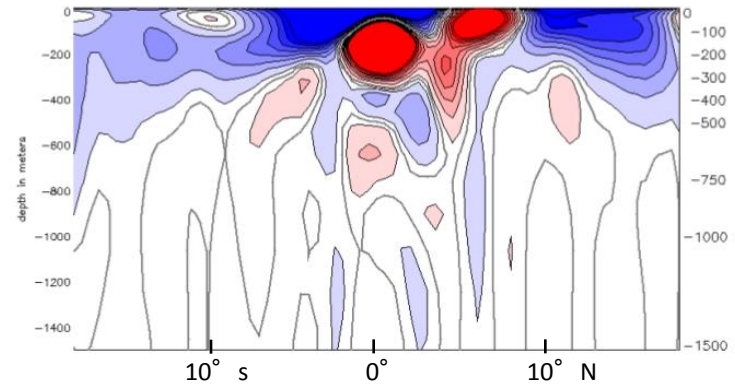
Zonal velocities at 170°W

SADCP Observations (2004-2015)
179° E-160° W

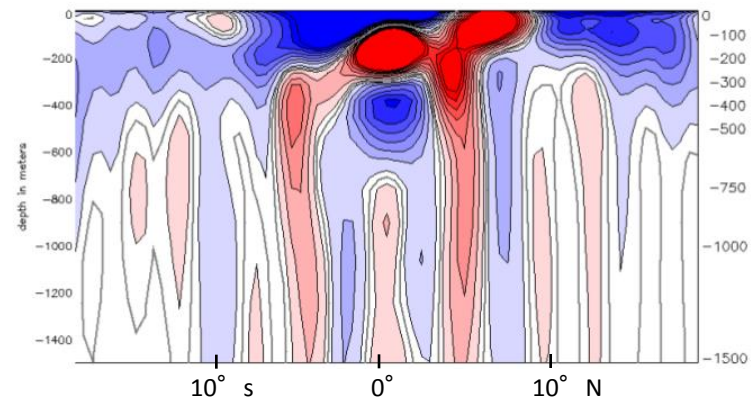


Cravatte et al (2017)

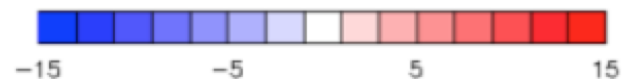
GLORYS12 FREE (2003-2014)



GLORYS12 OPER (2003-2014)

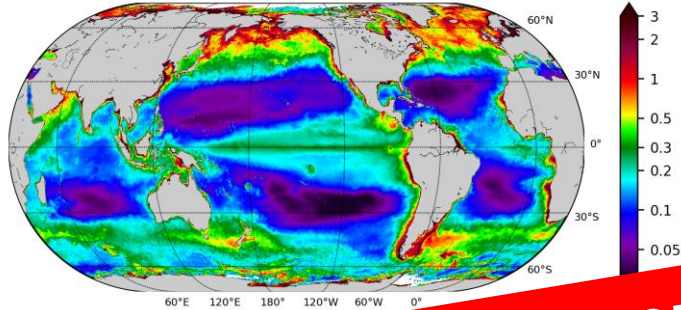


cm/s



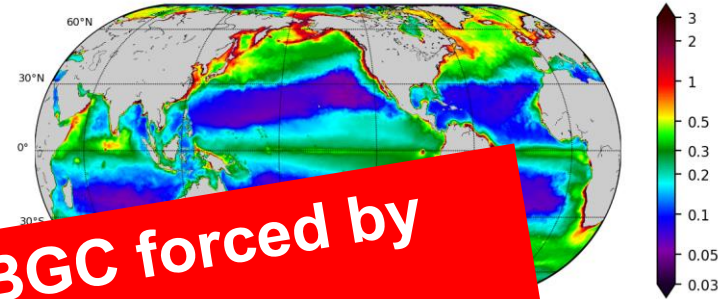
OBS

2008



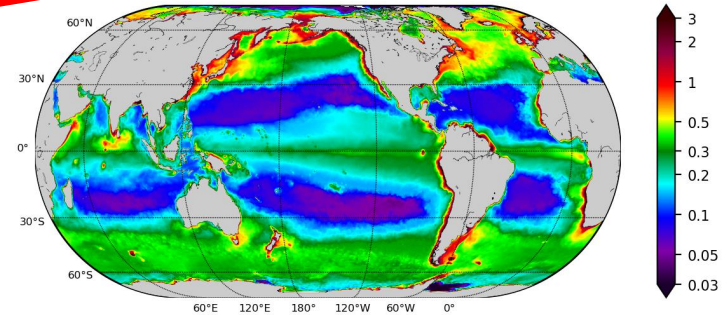
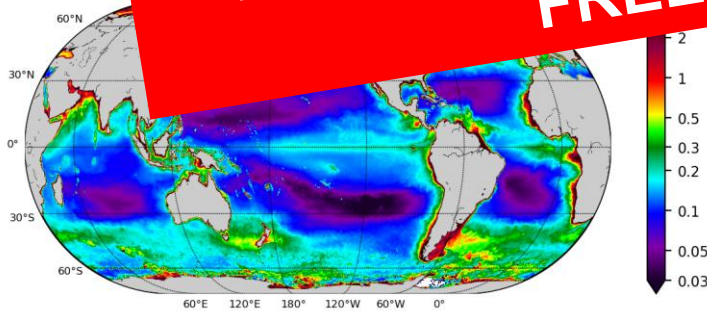
OPER = PHYS ASSIM + BGC libre

2008

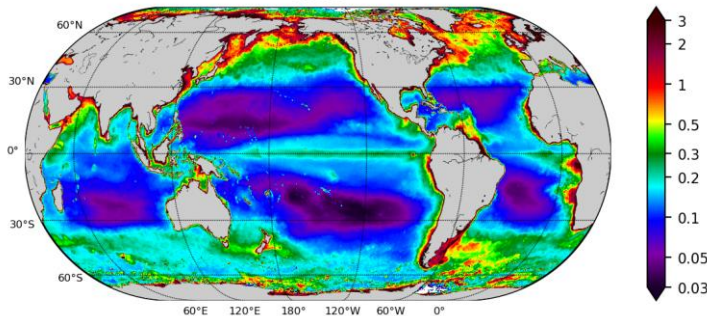


**BIAS not present in BGC forced by
FREE PHYSICS**

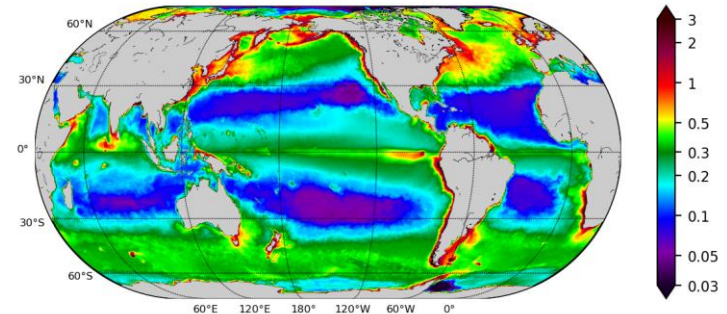
2009



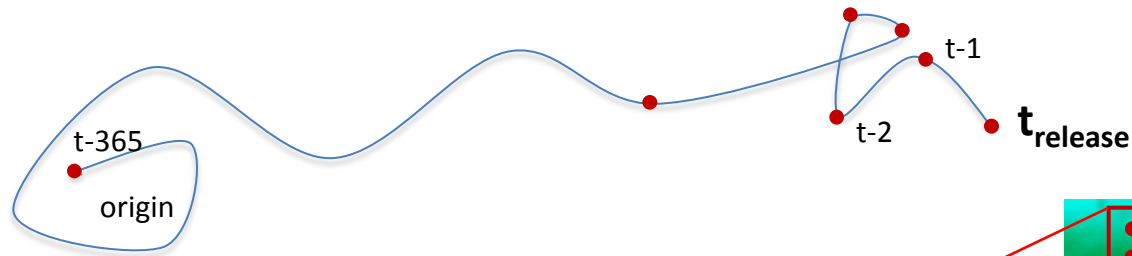
2010



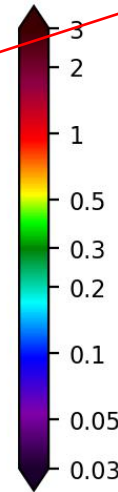
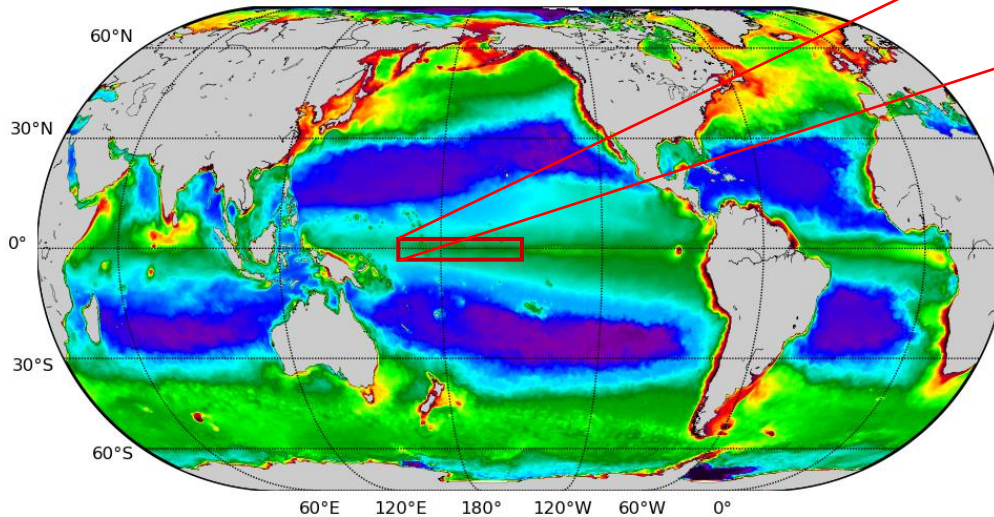
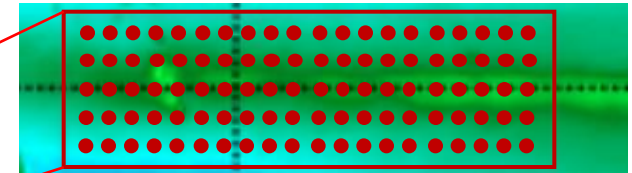
2010



Lagrangian Experiment Setup



Ariane



Particle layout:

- 2° S- 2° N, 170° E- 150° W
- 0-35 m depth
- $1/12^{\circ}$ degree in horizontal
- Every 5 m in the vertical
- ~200,000 release points

- Repeat experiment every 15 days for 2008 (1st and 15th of each month), 24 in total
- => 4,700,000 particles for the year

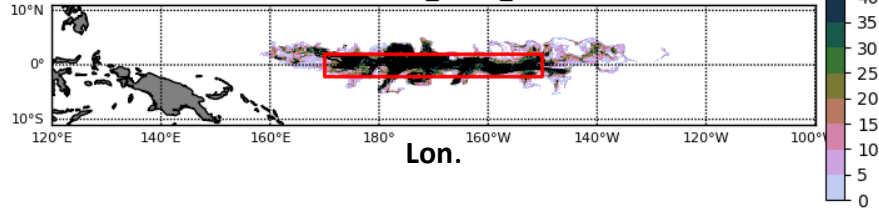
Backtracked in time
for up to 1 year

$T_{\text{RELEASE}} - 30 \text{ days:}$

Positions on 15th of July 2008

FREE

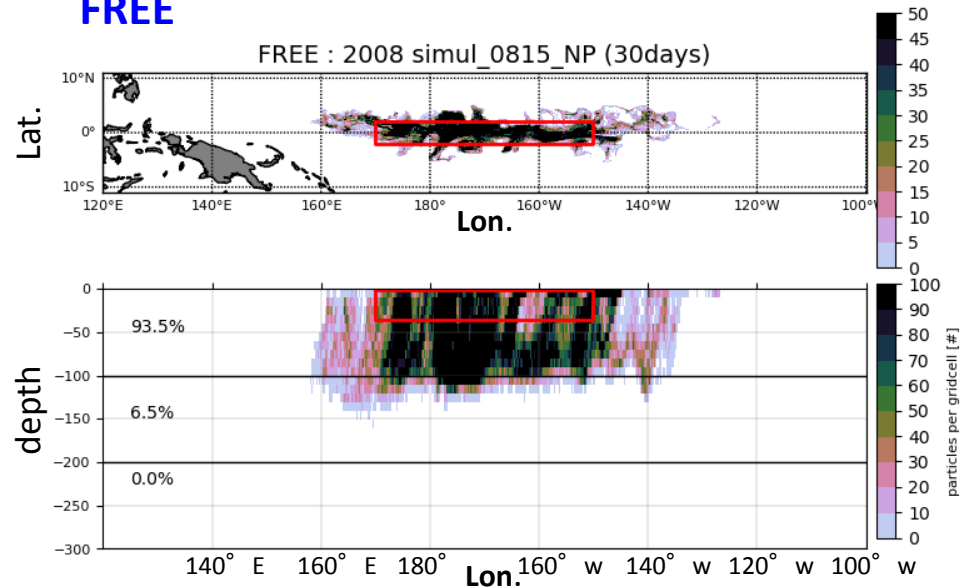
FREE : 2008 simul_0815_NP (30days)



Plan Lon-Lat

$T_{\text{RELEASE}} - 30 \text{ days:}$
Positions on 15th of July 2008

FREE



Plan Lon-Lat

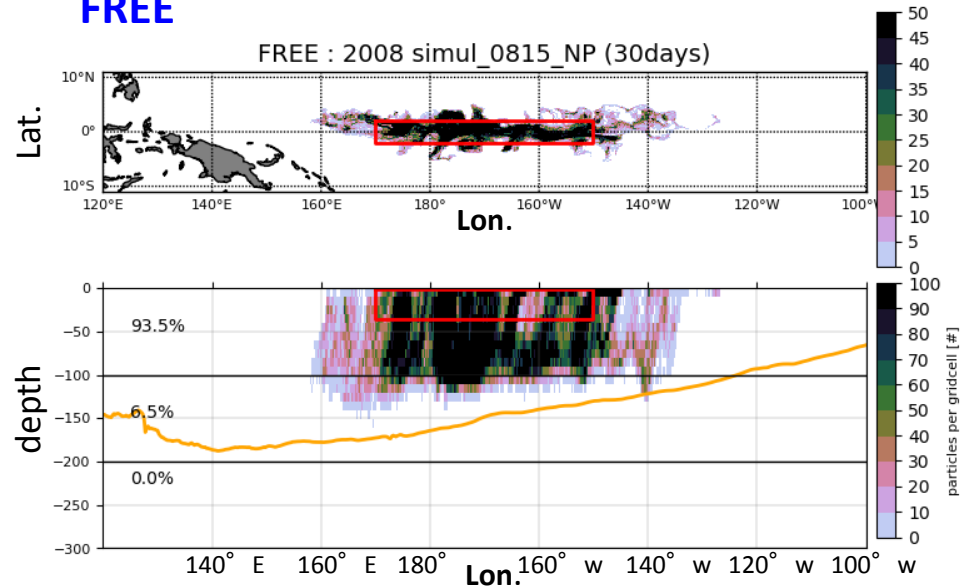
Plan Lon-depth

$T_{\text{RELEASE}} - 30 \text{ days:}$

Positions on 15th of July 2008

FREE

FREE : 2008 simul_0815_NP (30days)



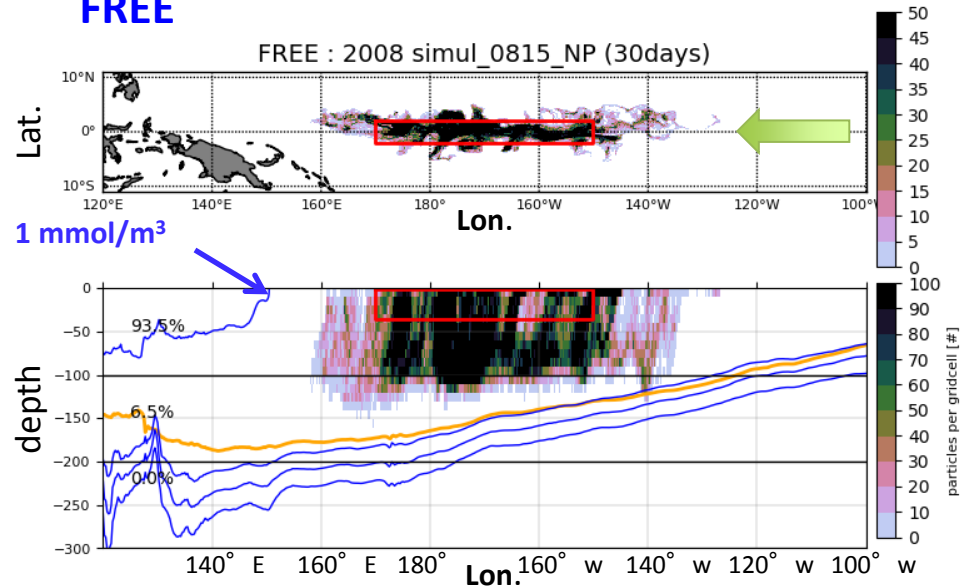
Plan Lon-Lat

Plan Lon-depth

Isotherm 20° C

$T_{\text{RELEASE}} - 30 \text{ days:}$
Positions on 15th of July 2008

FREE



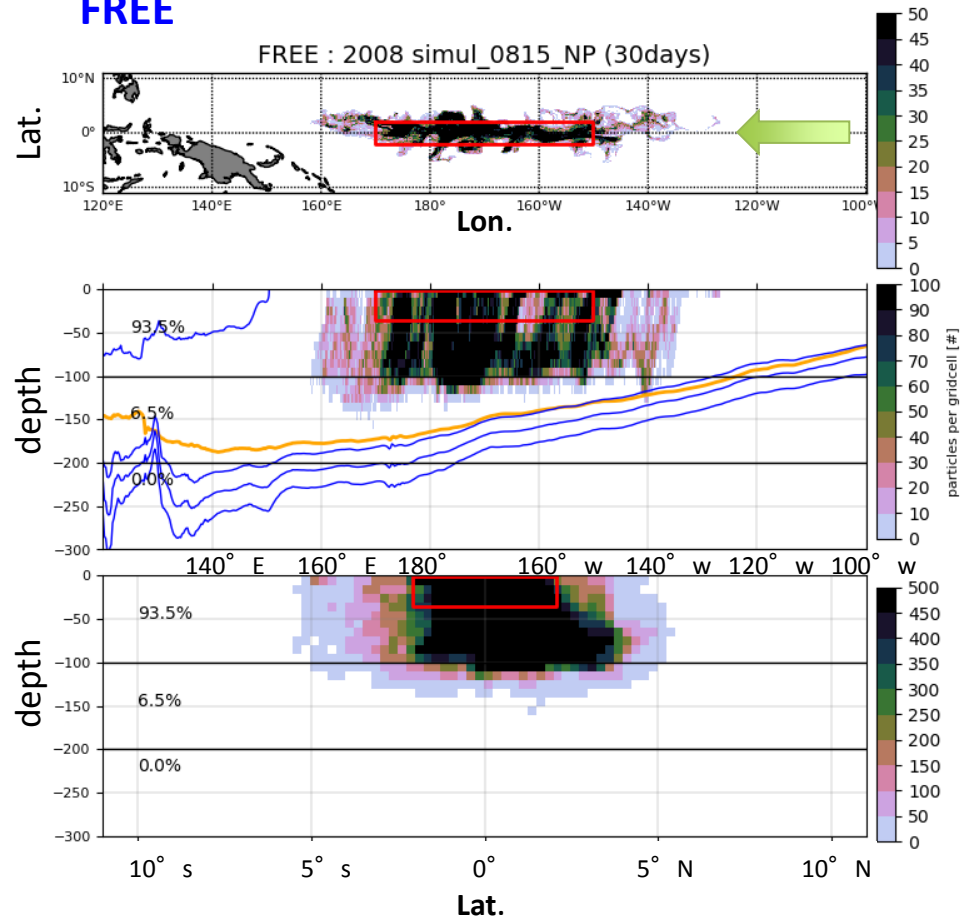
Plan Lon-Lat

Plan Lon-depth

- Isotherm 20° C
- nitrate lines 14-18 mmol/l

$T_{\text{RELEASE}} - 30 \text{ days:}$
Positions on 15th of July 2008

FREE



Plan Lon-Lat

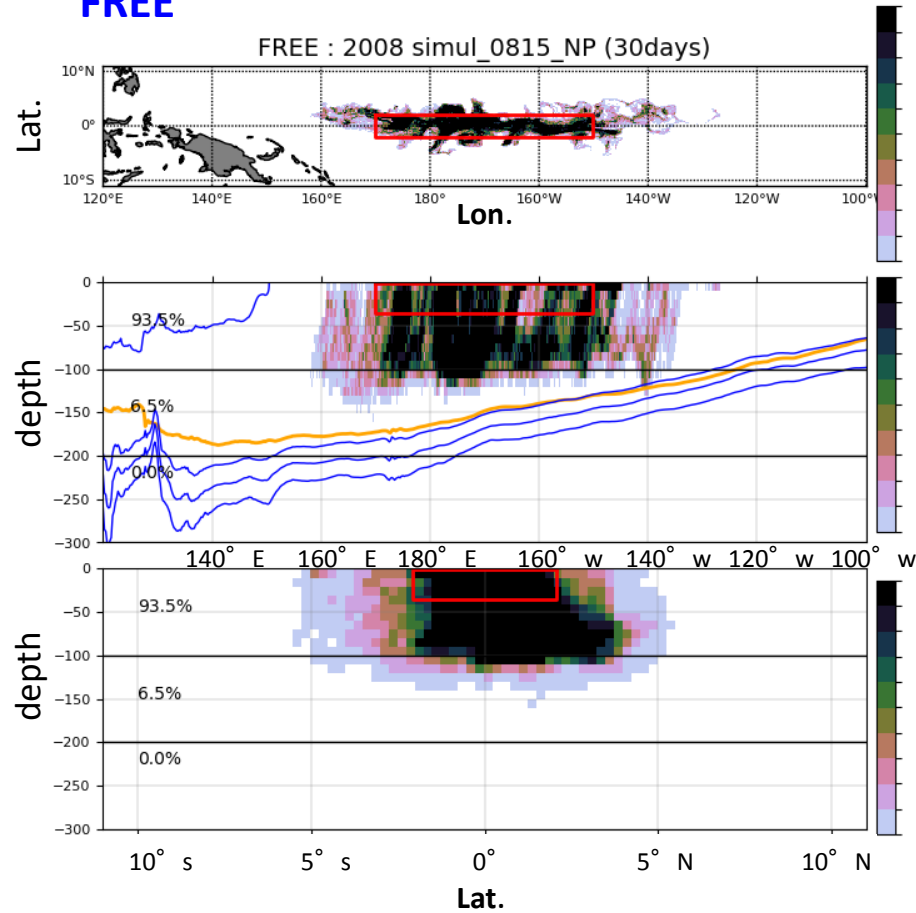
Plan Lon-depth

Plan Lat-depth

$T_{\text{RELEASE}} - 30 \text{ days:}$
Positions on 15th of July 2008

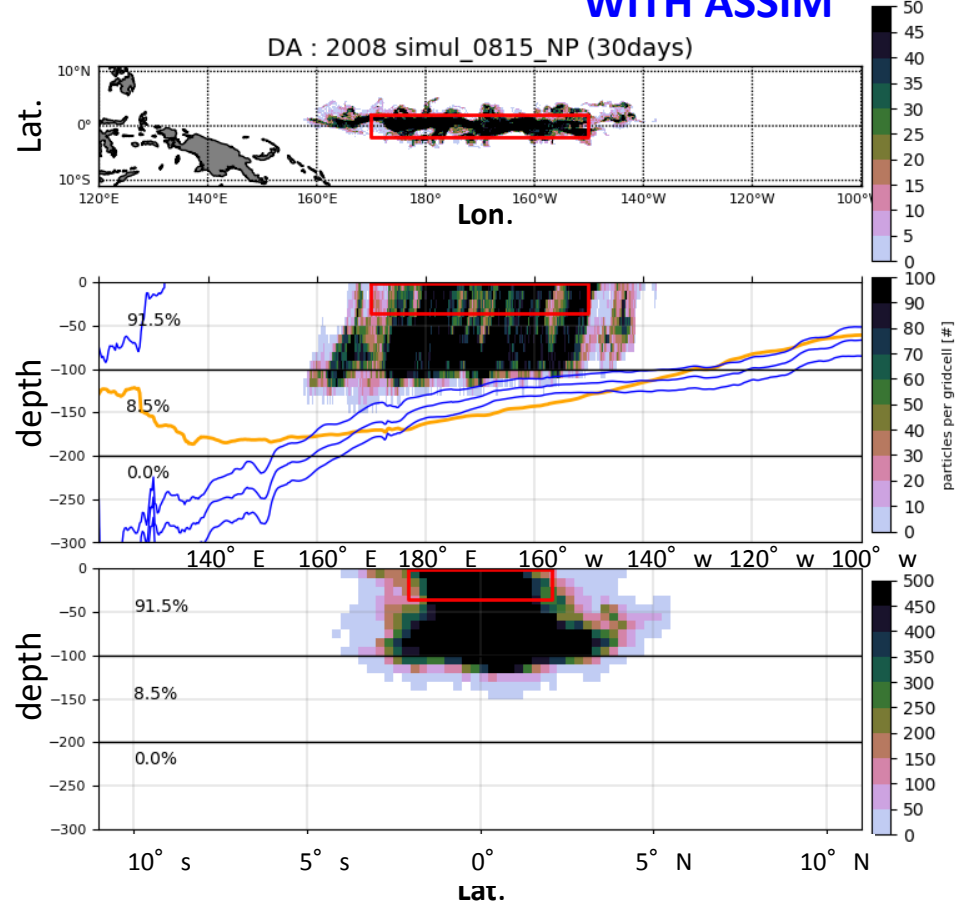
FREE

FREE : 2008 simul_0815_NP (30days)



WITH ASSIM

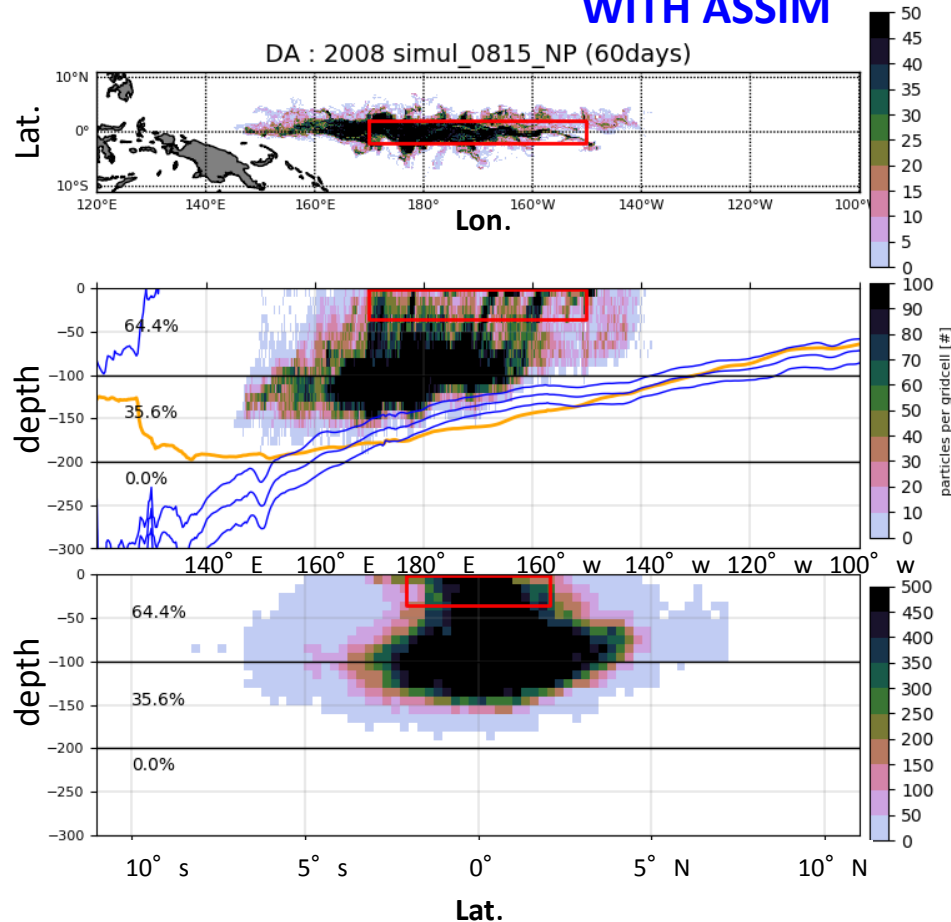
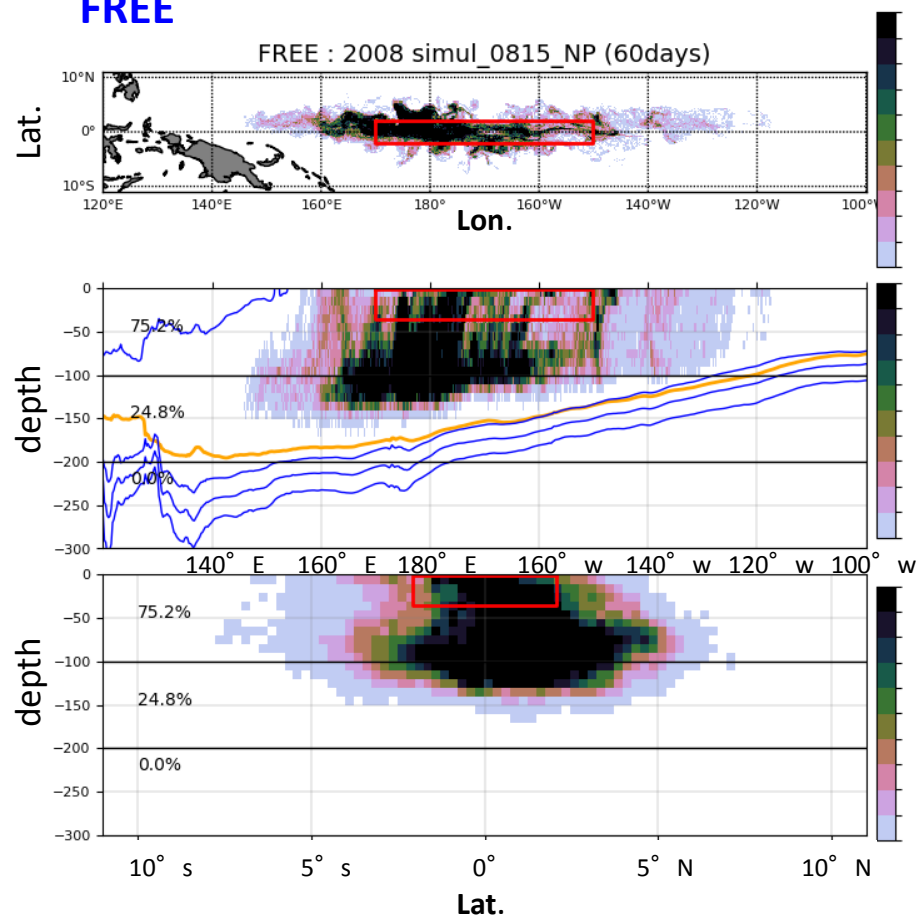
DA : 2008 simul_0815_NP (30days)



$T_{\text{RELEASE}} - 60 \text{ days:}$
Positions on 15th of June 2008

FREE

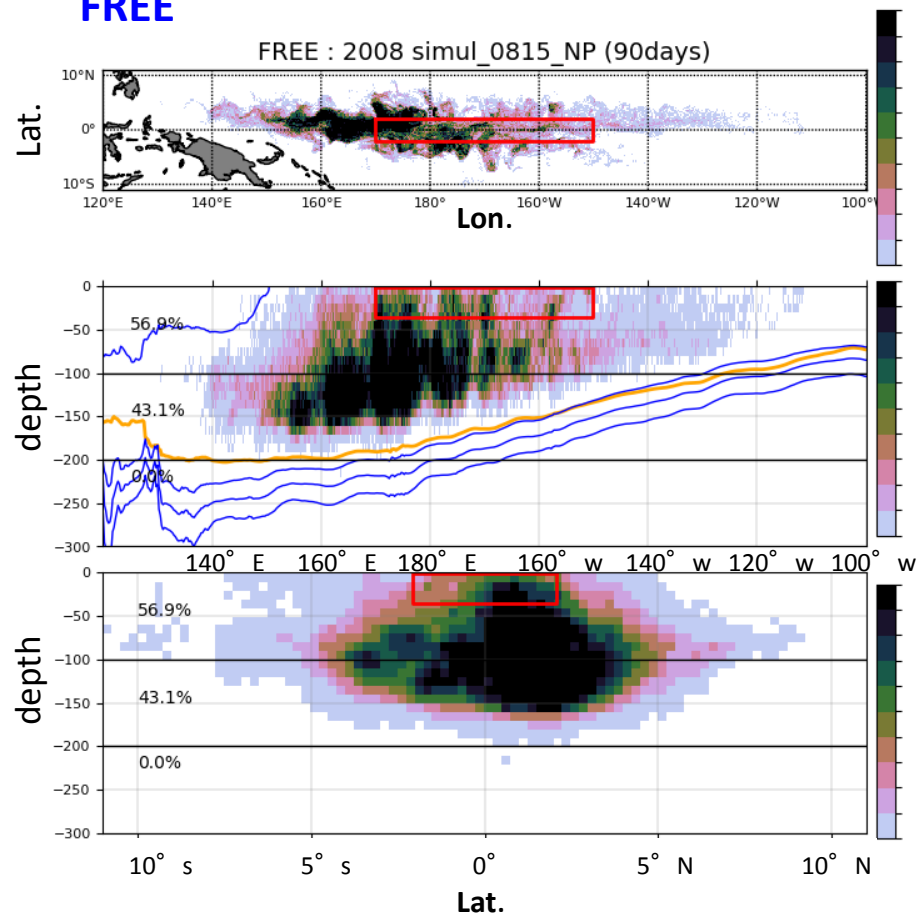
WITH ASSIM



$T_{\text{RELEASE}} - 90 \text{ days:}$
Positions on 15th of May 2008

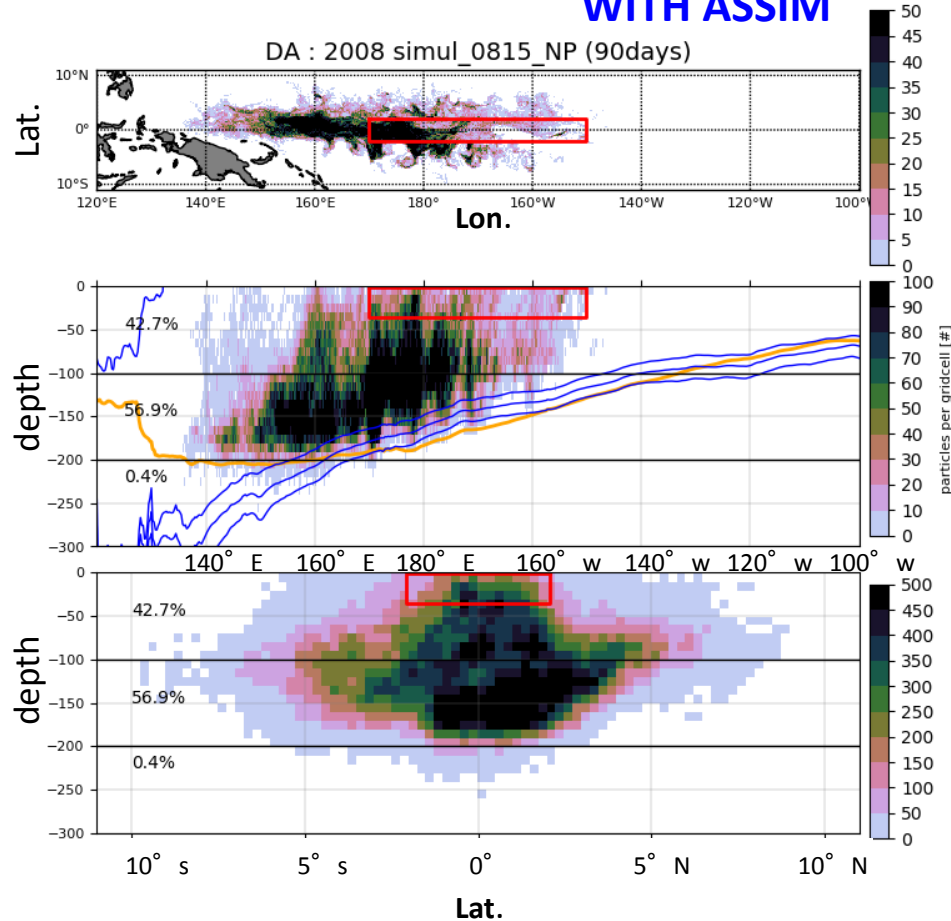
FREE

FREE : 2008 simul_0815_NP (90days)



WITH ASSIM

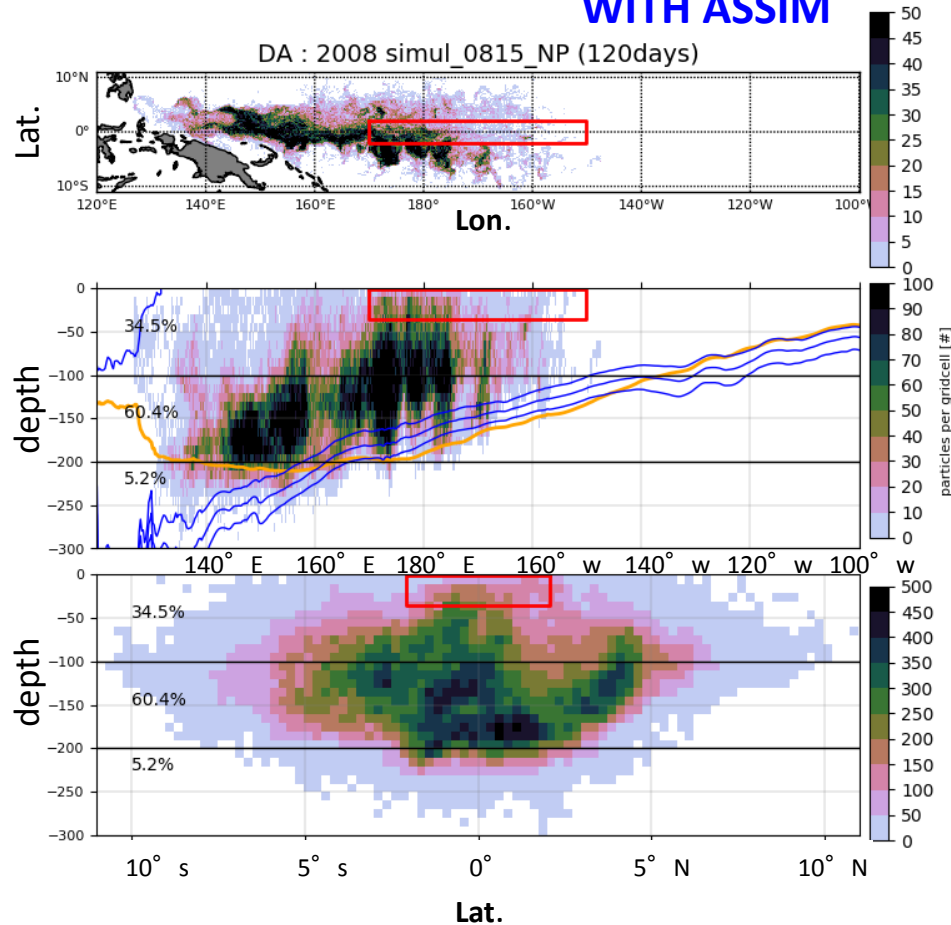
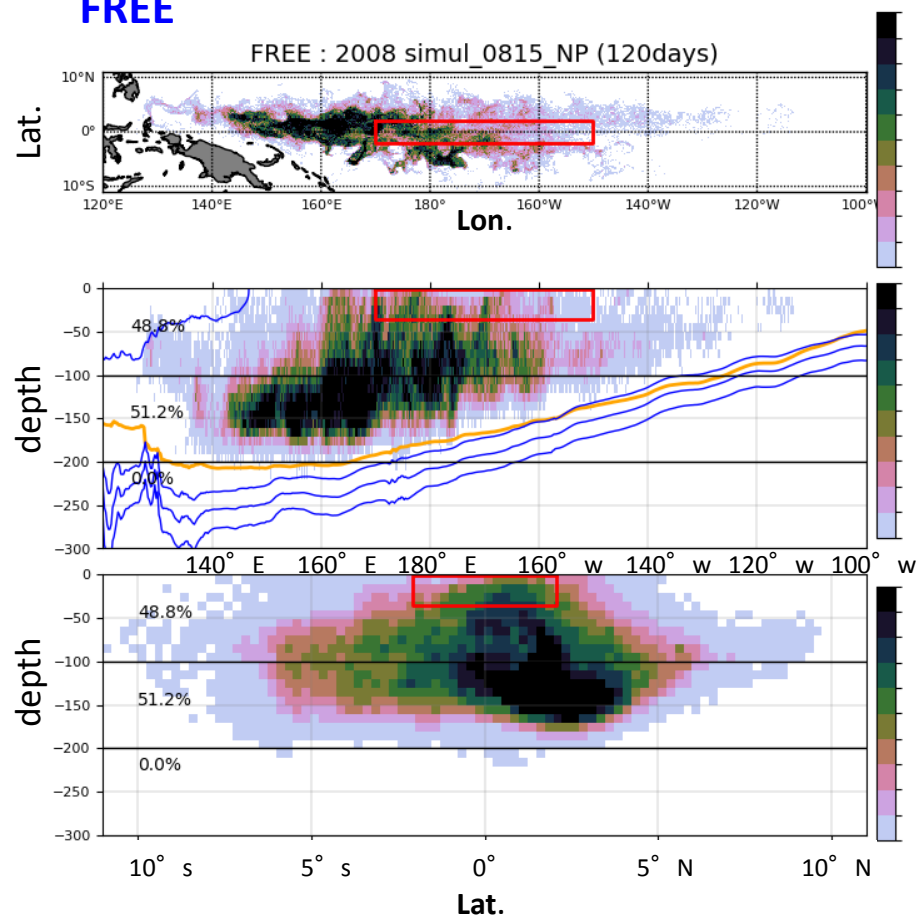
DA : 2008 simul_0815_NP (90days)



$T_{\text{RELEASE}} - 120 \text{ days:}$
Positions on 15th of April 2008

FREE

WITH ASSIM

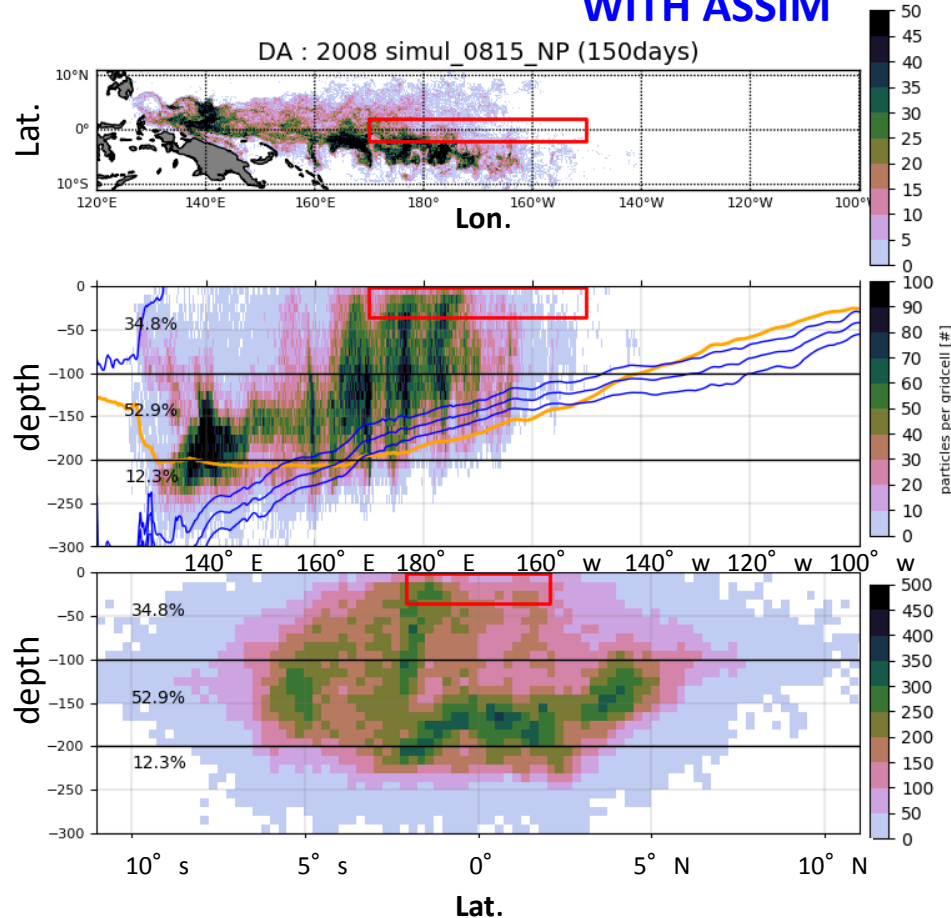
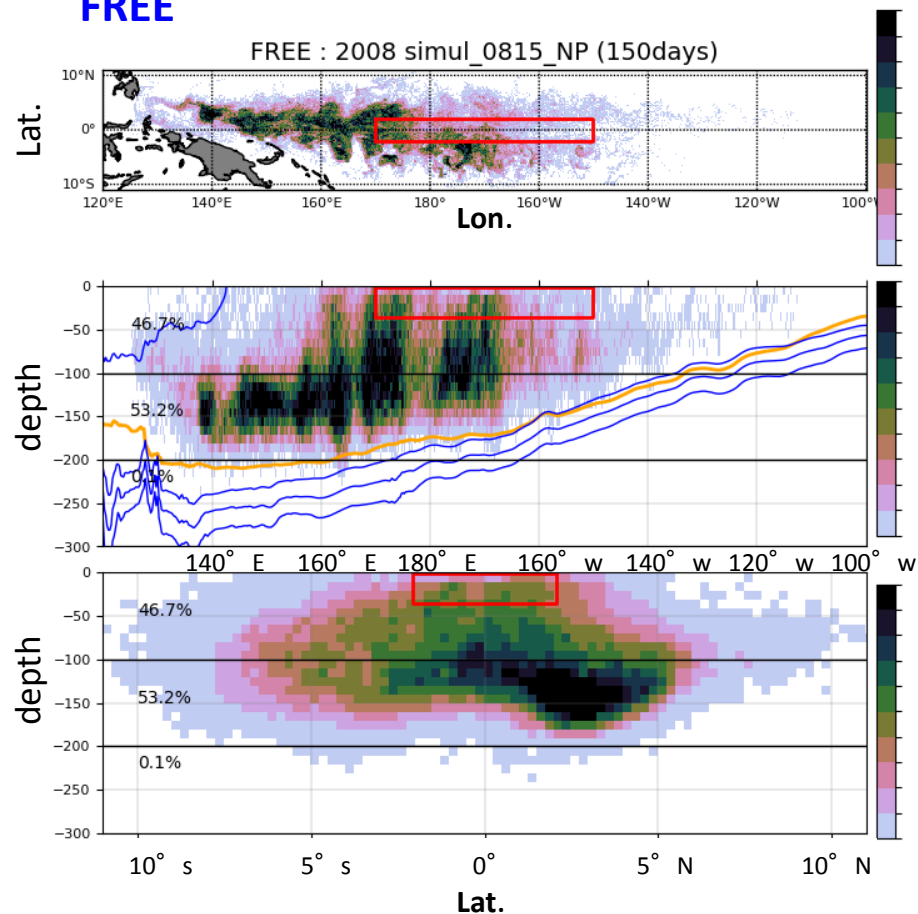


$T_{\text{RELEASE}} - 150 \text{ days:}$

Positions on 15th of March 2008

FREE

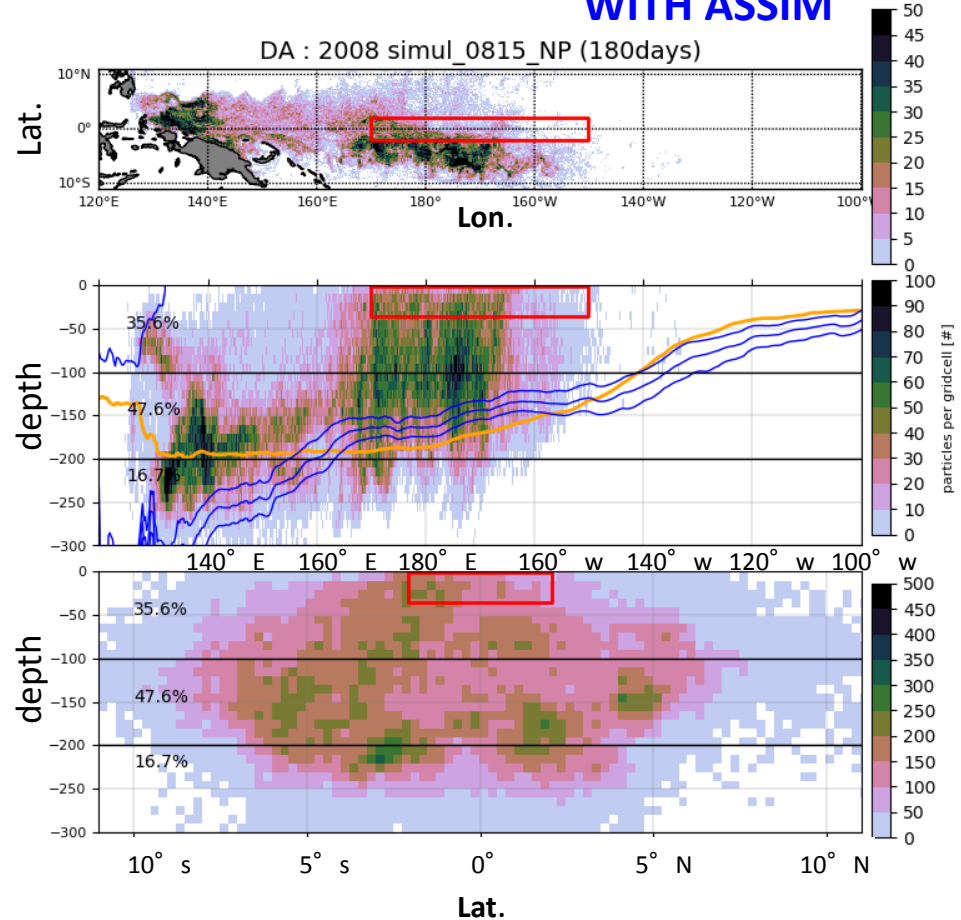
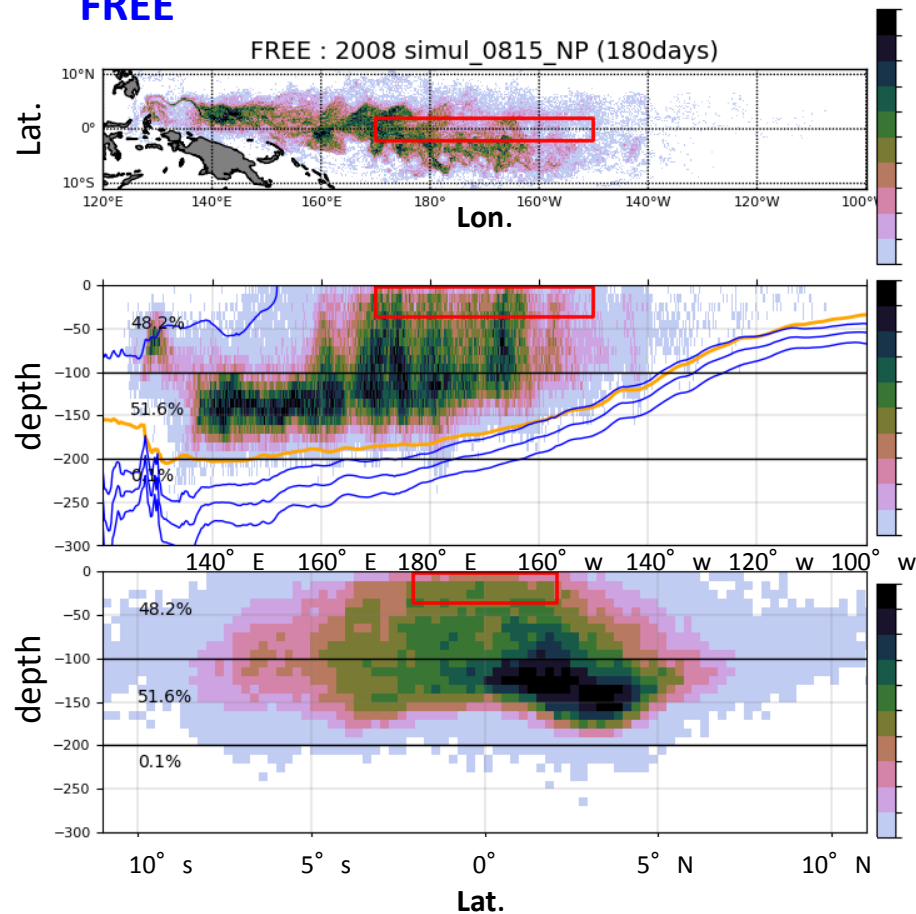
WITH ASSIM



$T_{RELEASE} - 180$ days:
Positions on 15th of Feb. 2008

FREE

WITH ASSIM

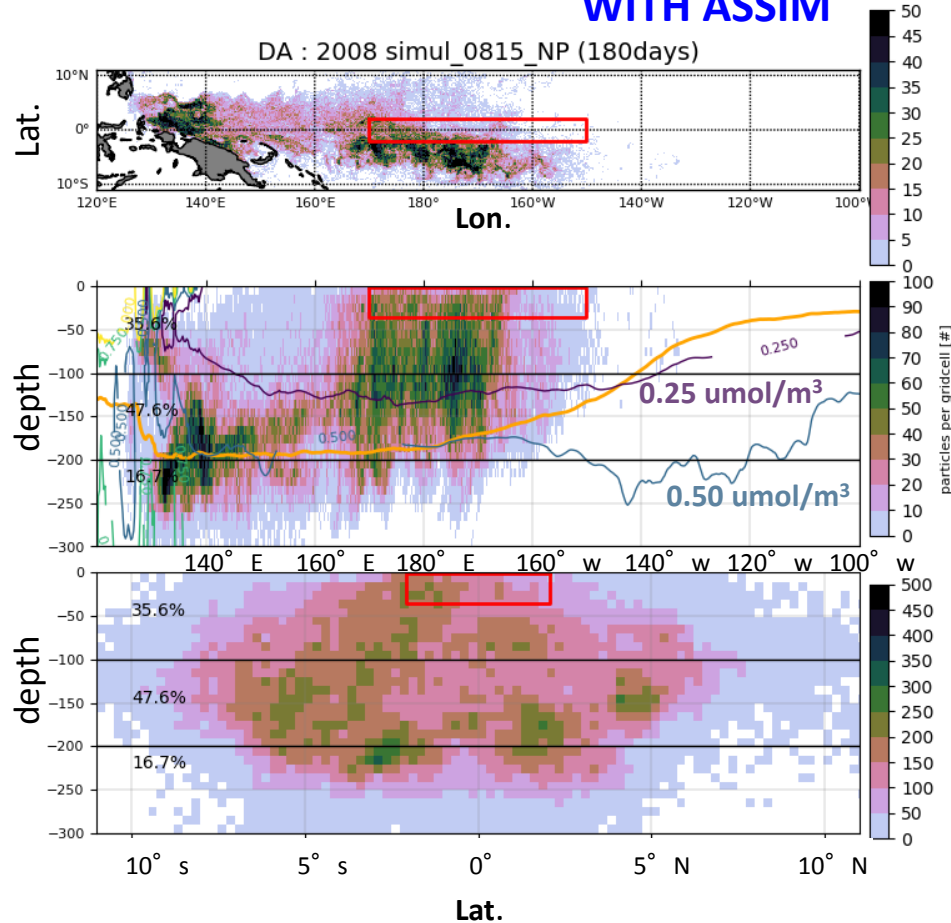
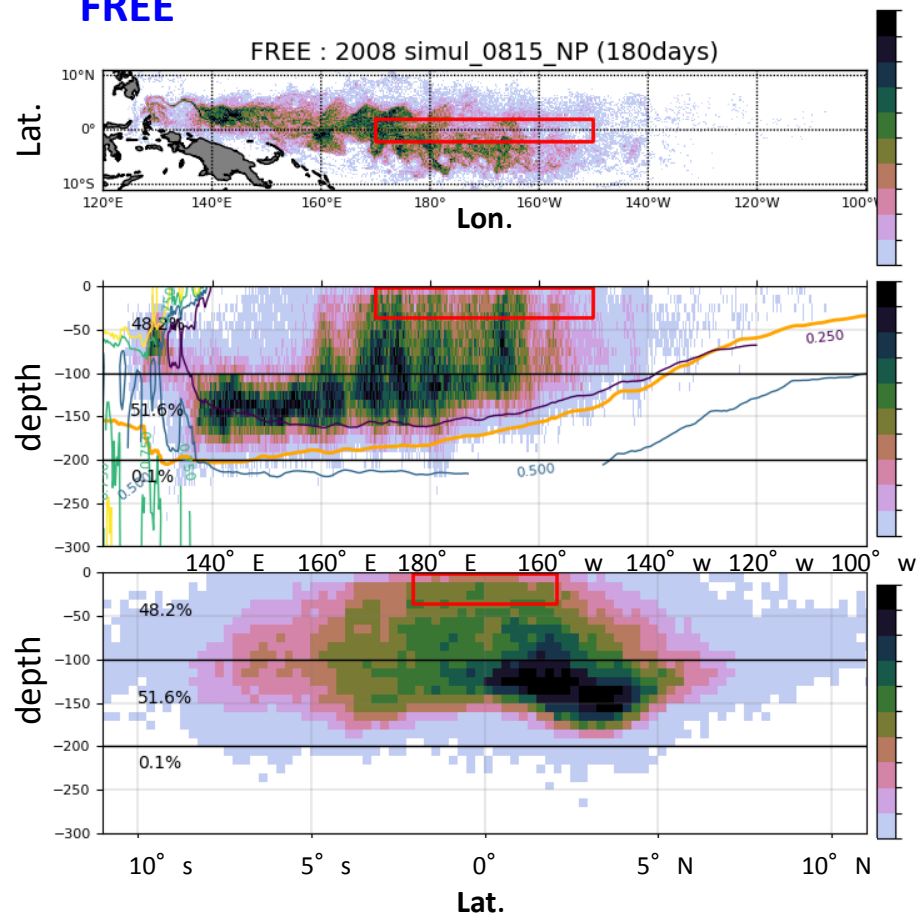


- Deeper Particles
- within more nutrient rich waters

$T_{\text{RELEASE}} - 90 \text{ days:}$
Positions on 15th of Feb. 2008

FREE

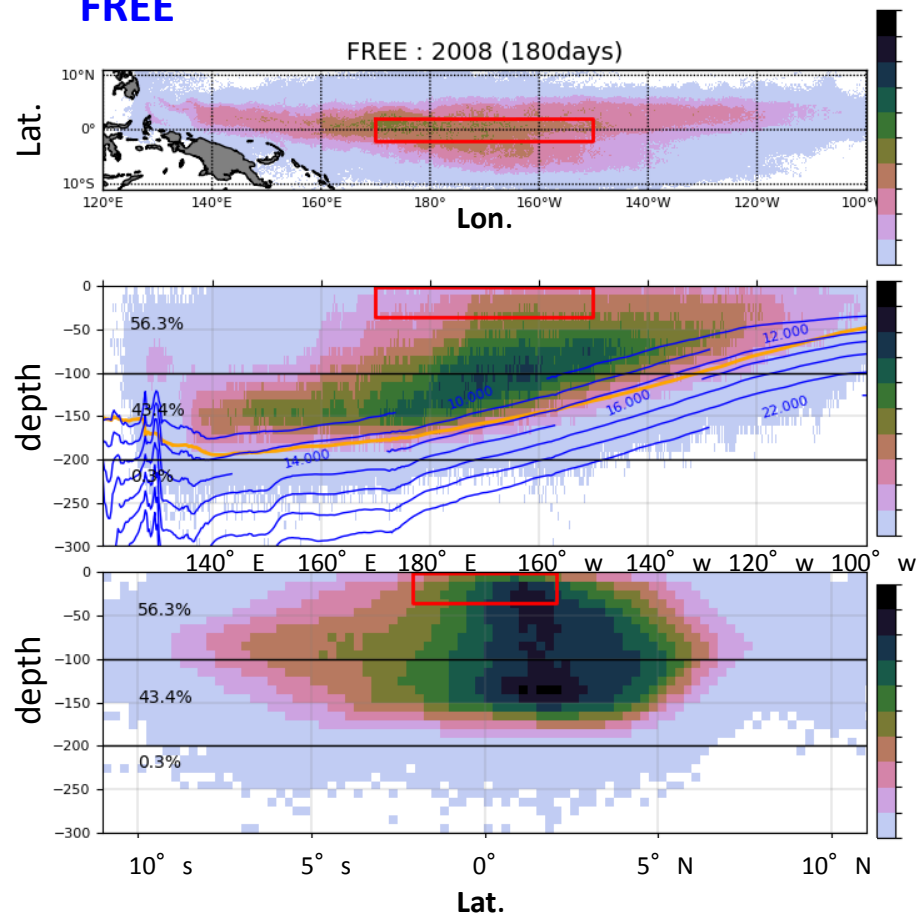
WITH ASSIM



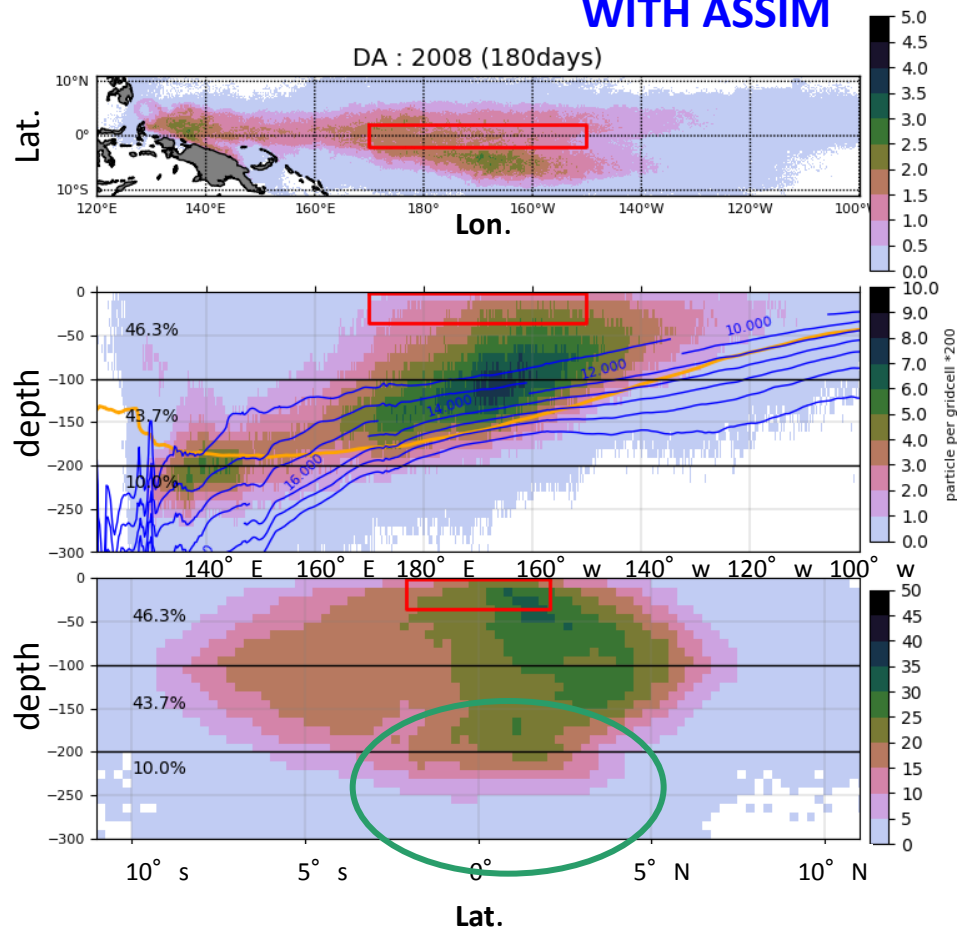
- Deeper Particles
- within more nutrient rich waters

Annual footprint for particles deployed across 2008

FREE

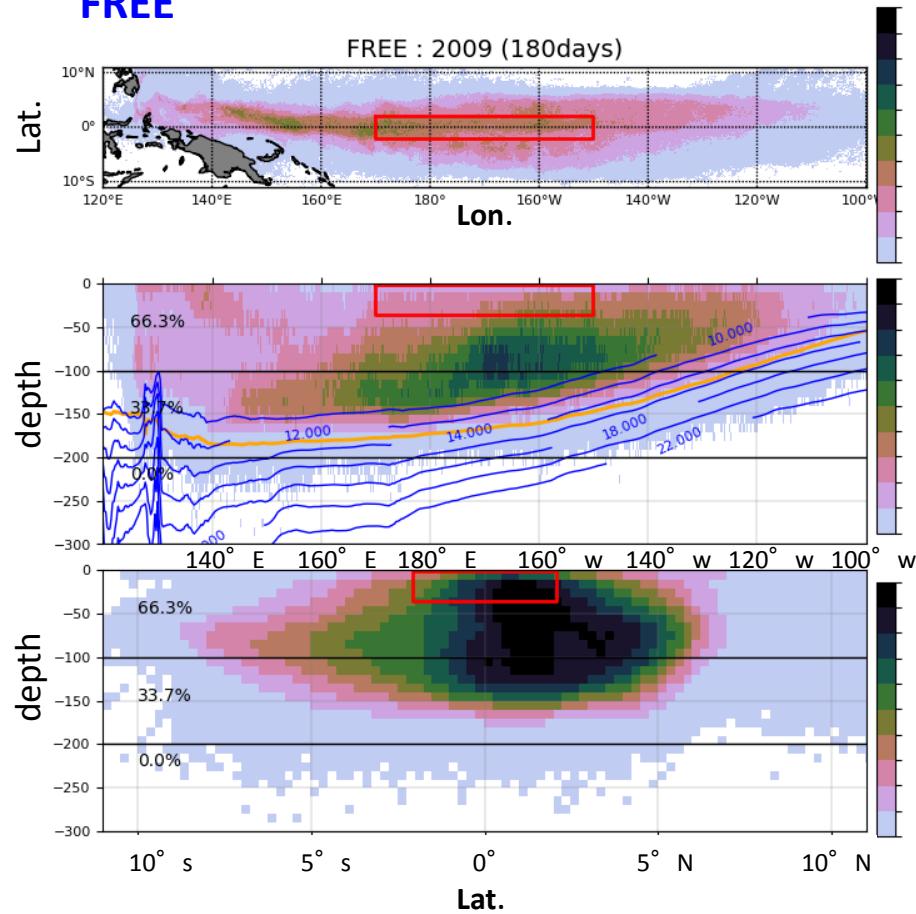


WITH ASSIM

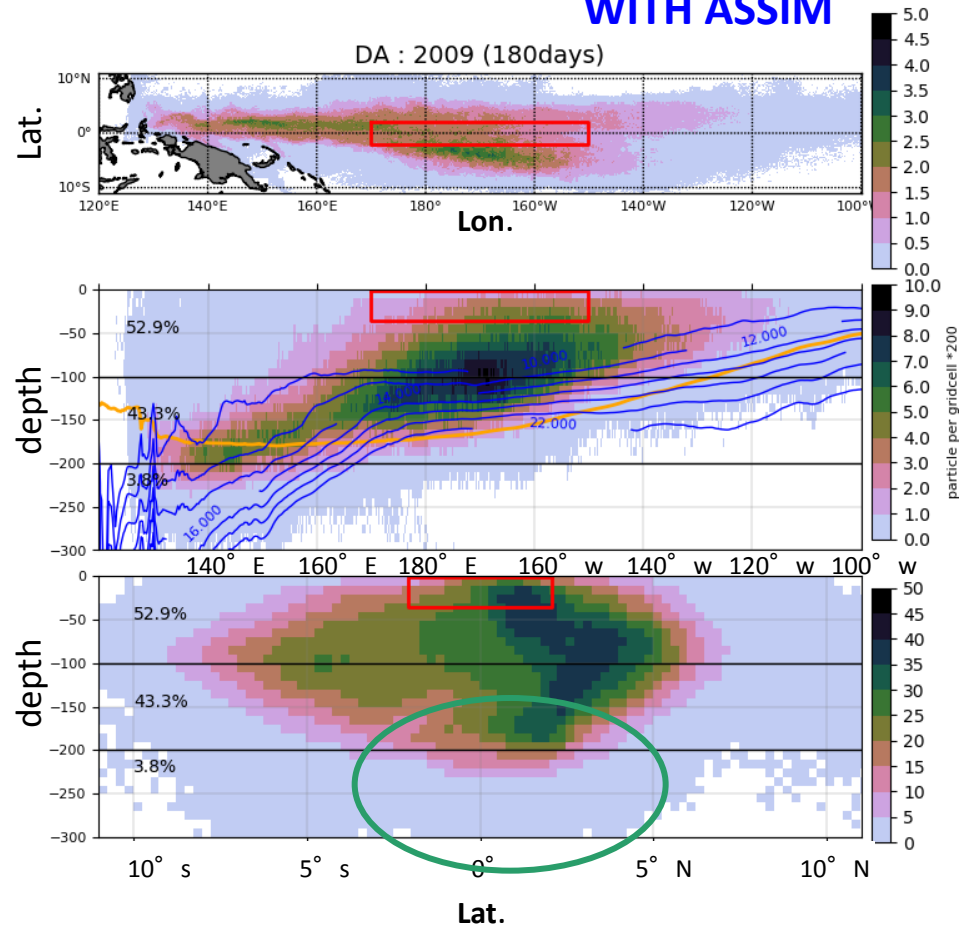


Annual footprint for particles deployed across **2009**

FREE

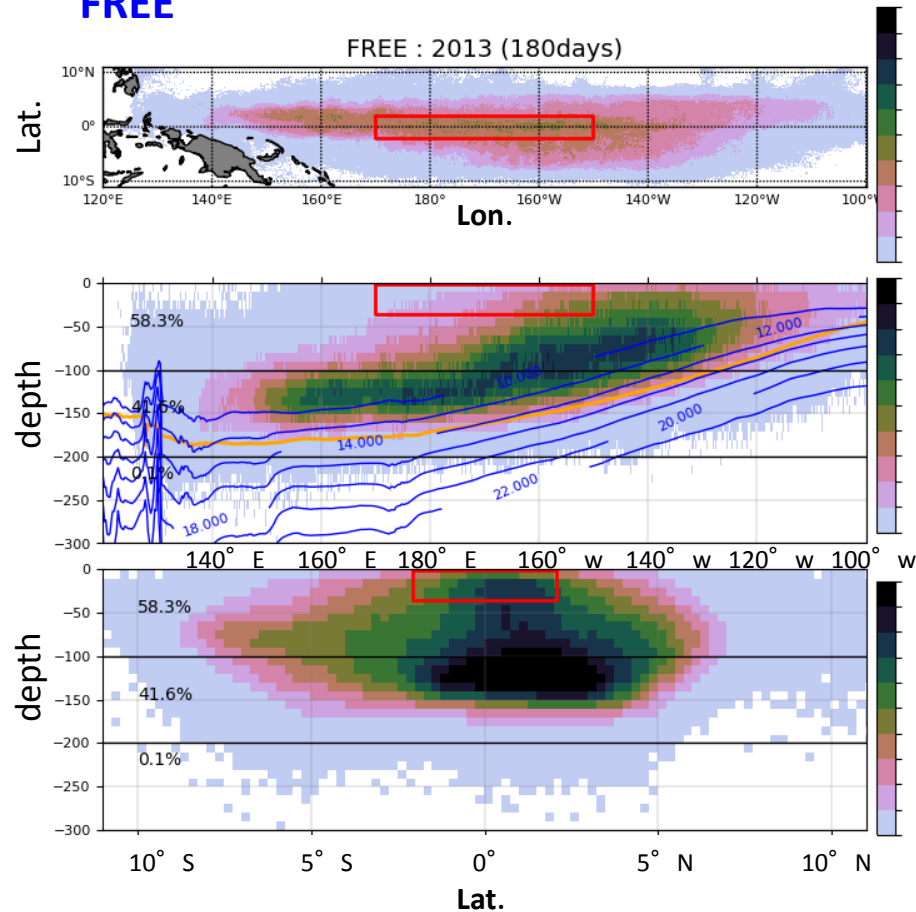


WITH ASSIM

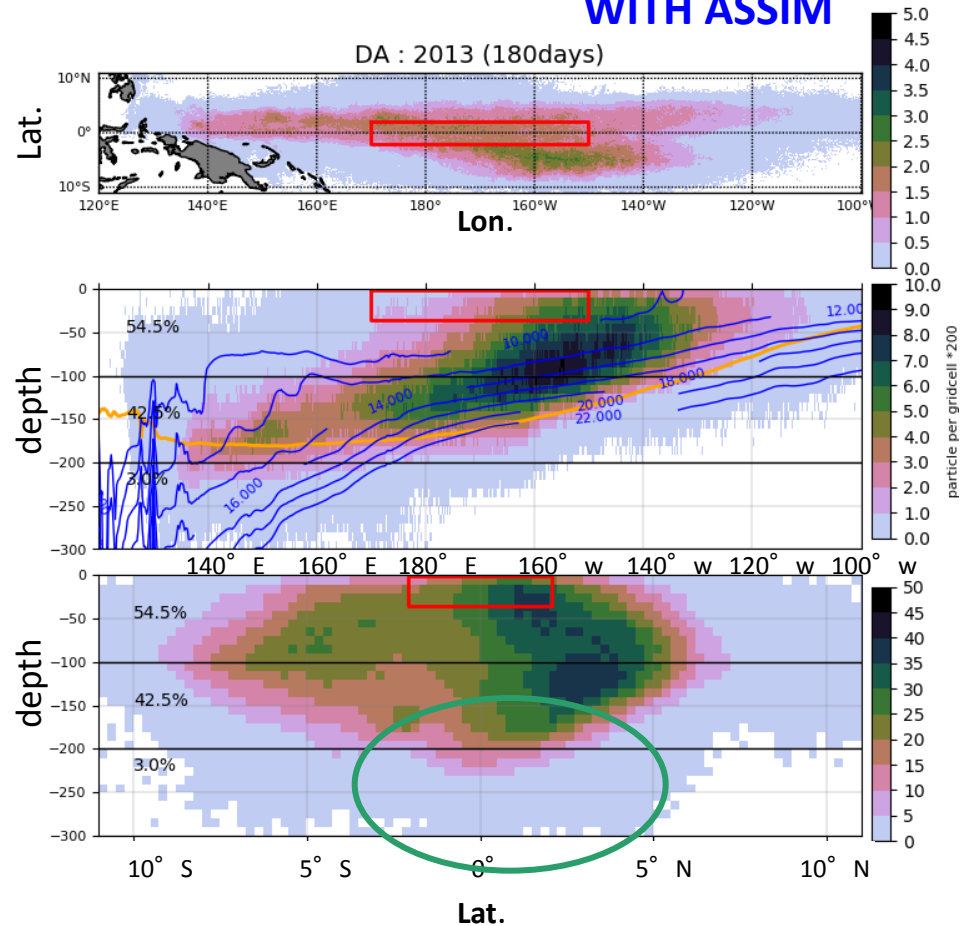


Annual footprint for particles deployed across **2013**

FREE

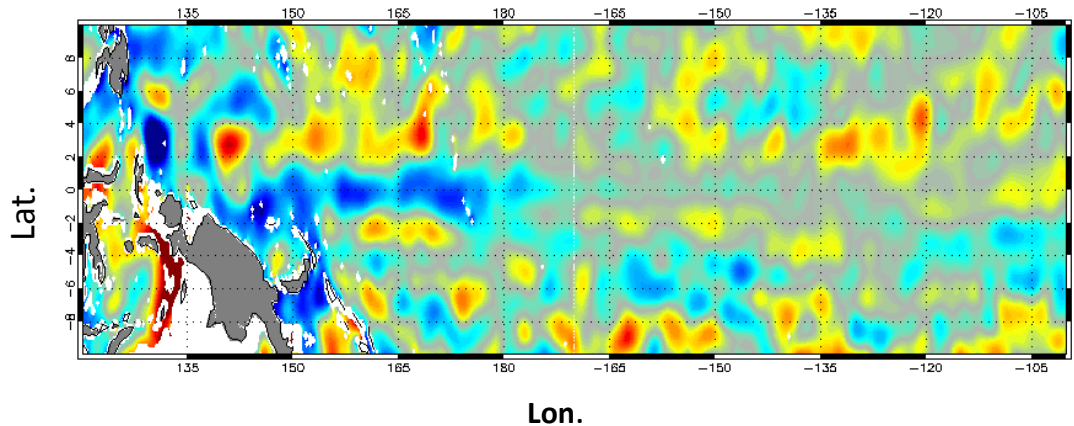


WITH ASSIM

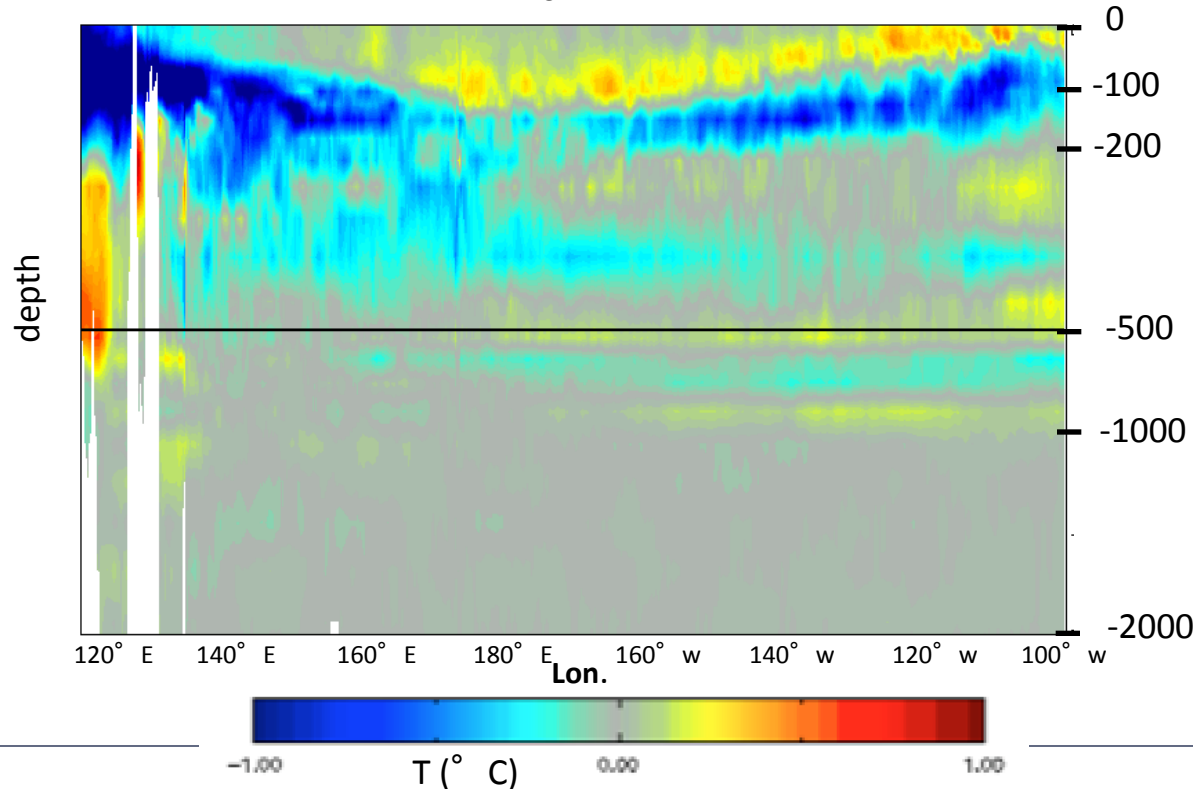


- Systematic deeper origin for particles deployed in Model with ASSIM
- Upward long-term trend in nitrate isolines

ASSIM – ASSIM(NO SLA) 300m 2009

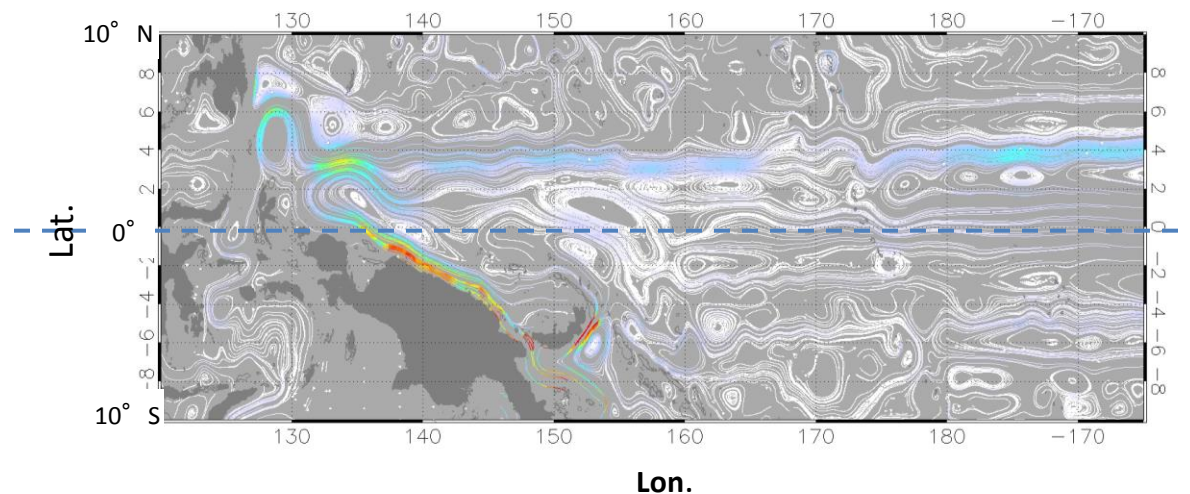


Presence of colder waters at 300m west of 180°E in the ASSIM run



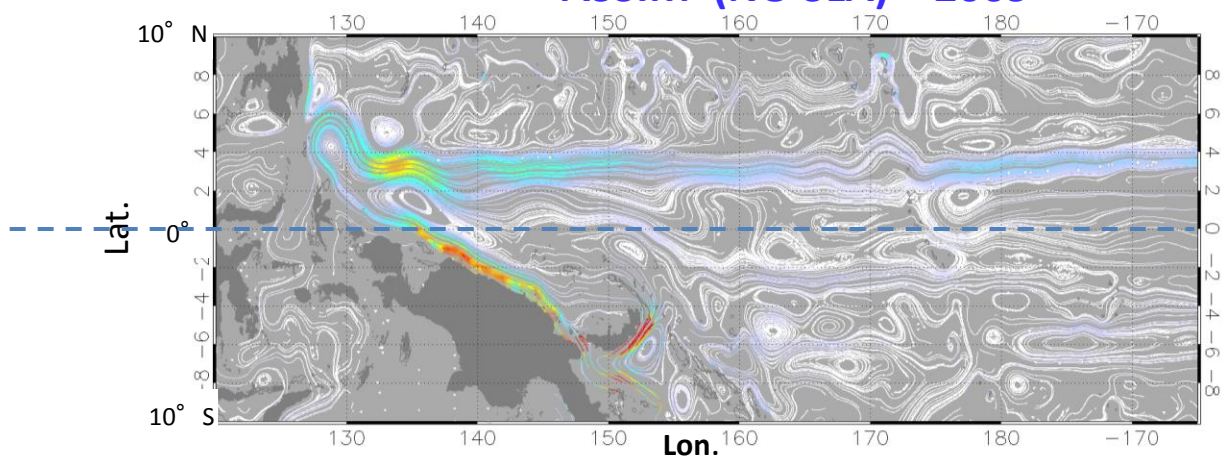
Raising of isolines west of dateline at equator (0° N)

ASSIM (with SLA) 2009



Annual Mean UV
200-500m

ASSIM (NO SLA) 2009

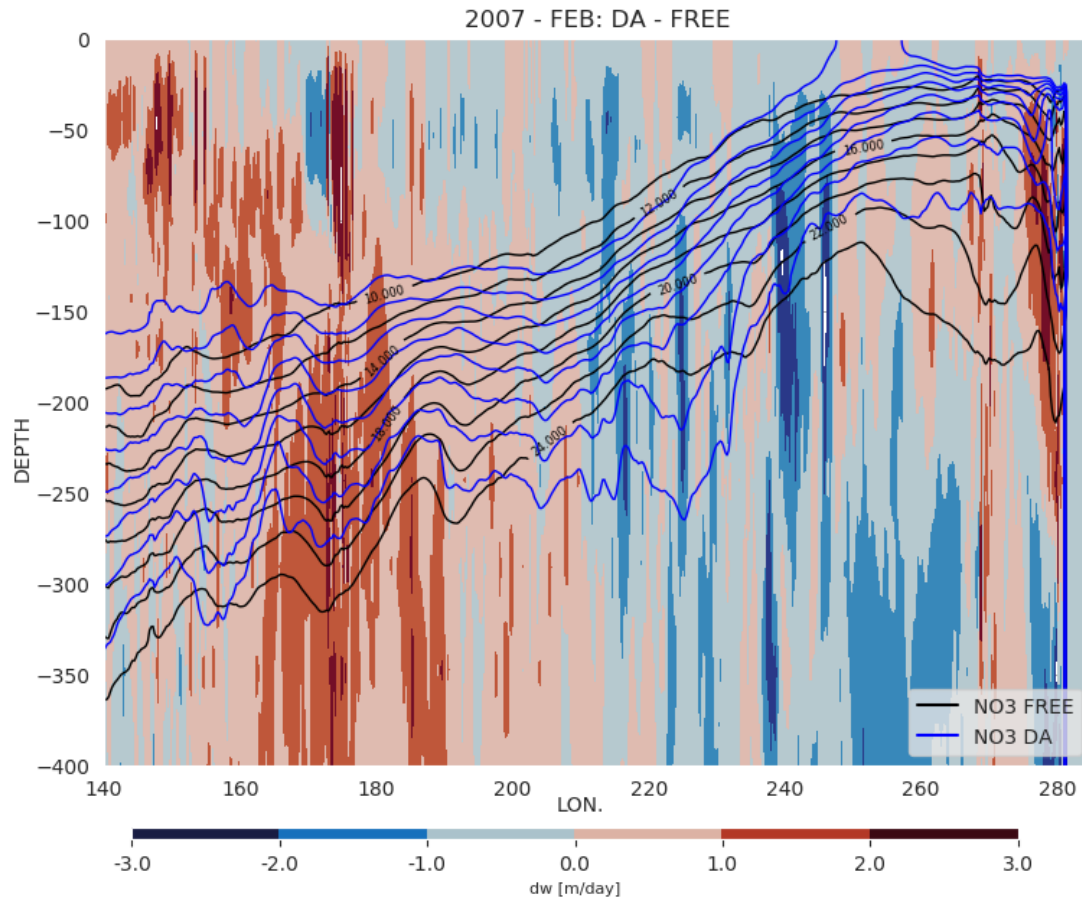


Min = 0.000 m/s Max = 0.749

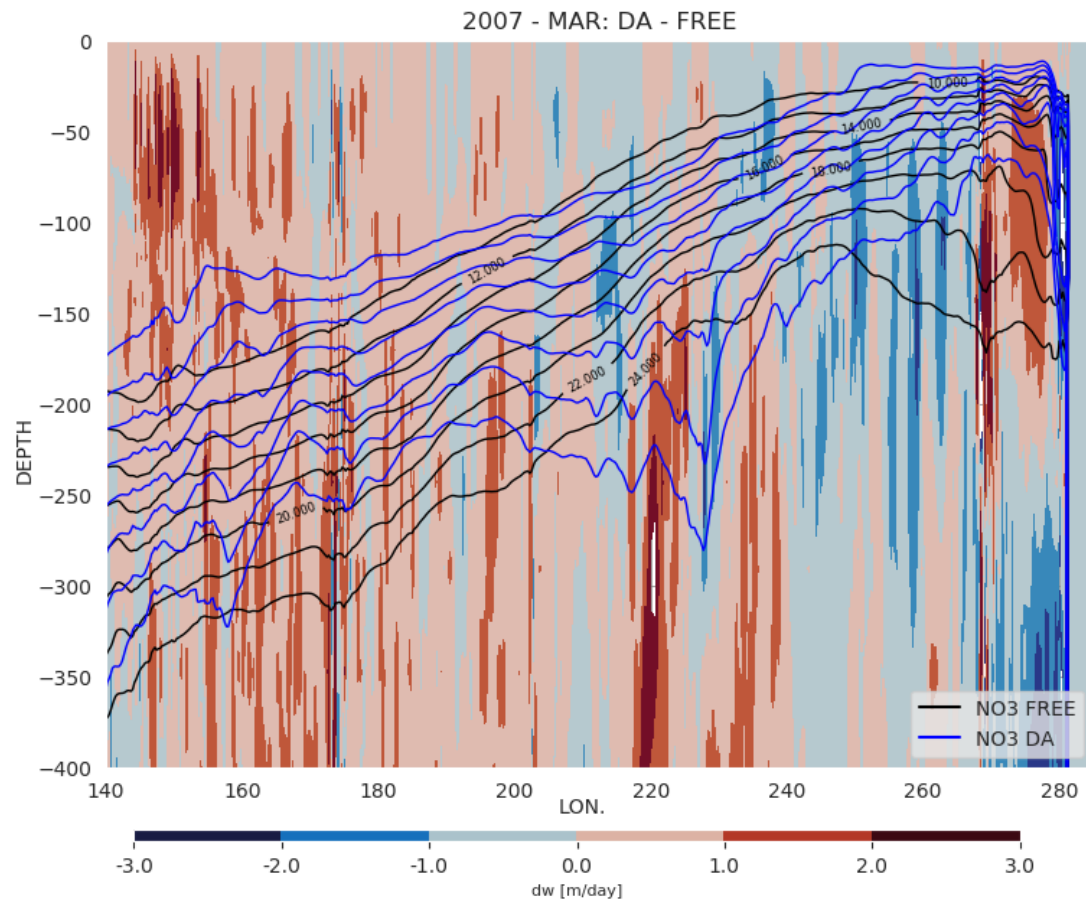
avg: -1.m/s

0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40

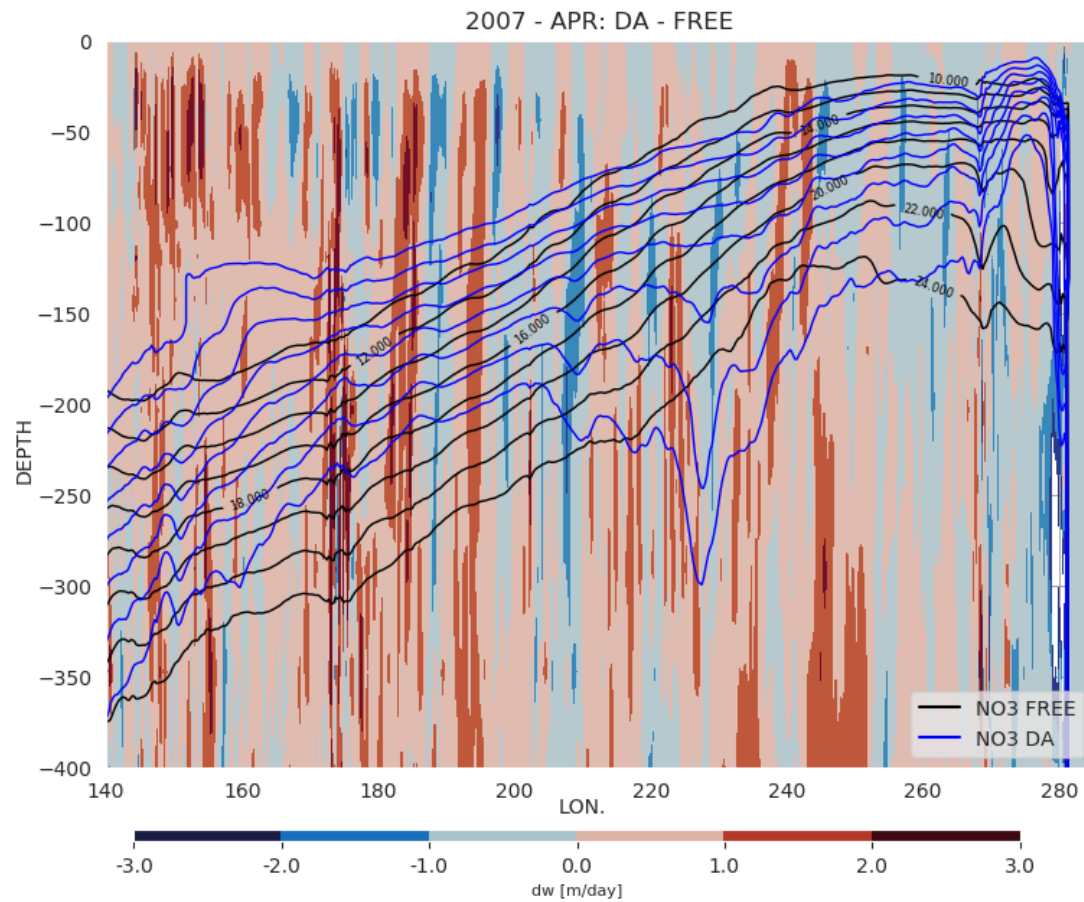
$$\overline{W_{\text{ASSIM}}}^{\text{monthly}} - \overline{W_{\text{FREE}}}^{\text{monthly}}$$



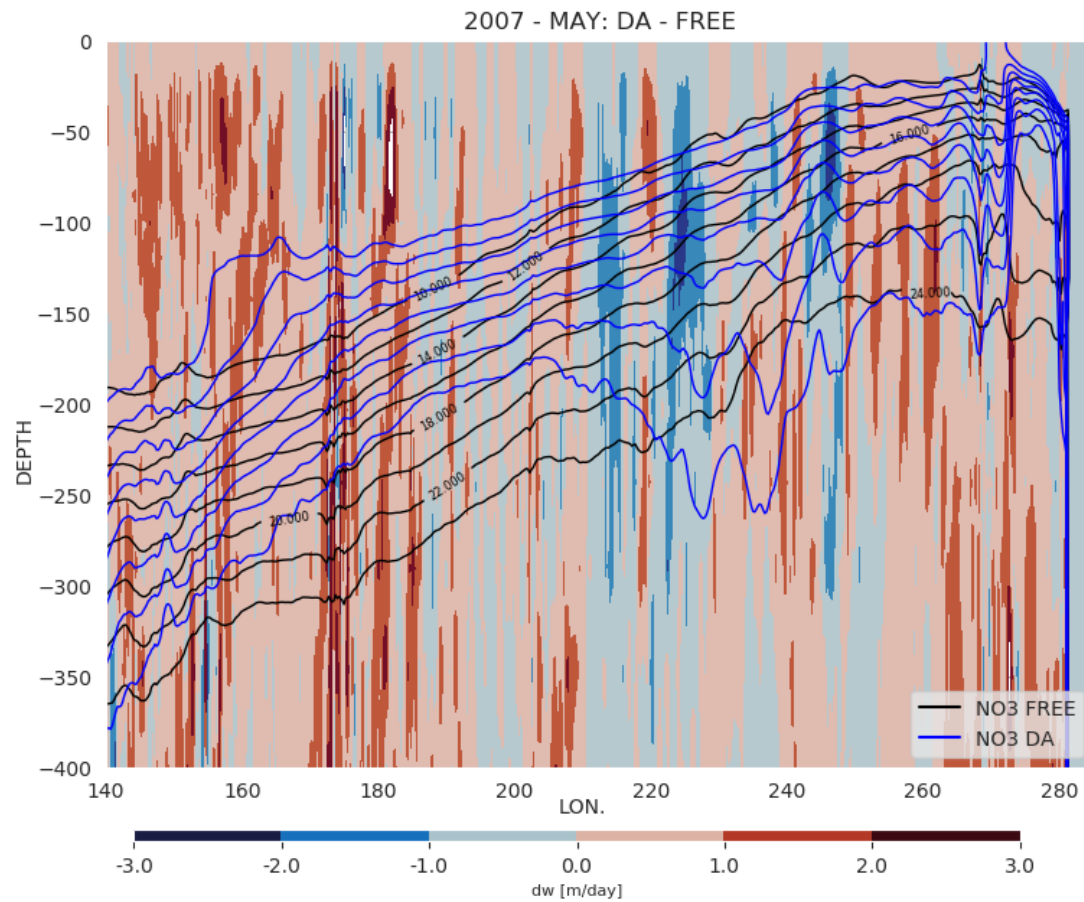
$$\overline{W_{\text{ASSIM}}}^{\text{monthly}} - \overline{W_{\text{FREE}}}^{\text{monthly}}$$



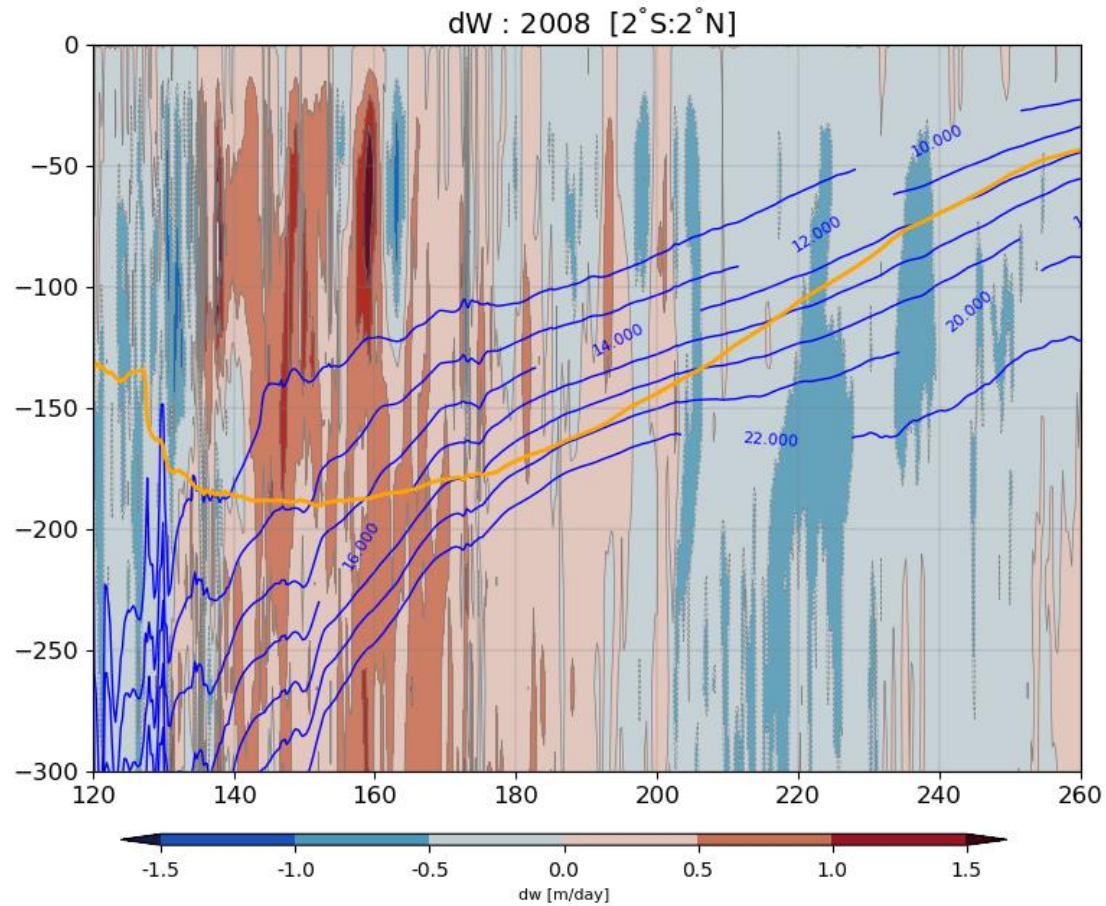
$$\overline{W_{\text{ASSIM}}}^{\text{monthly}} - \overline{W_{\text{FREE}}}^{\text{monthly}}$$



$$\overline{W_{\text{ASSIM}}} - \overline{W_{\text{FREE}}}$$



$$\overline{W}_{\text{ASSIM}}^{\text{annual}} - \overline{W}_{\text{FREE}}^{\text{annual}}$$



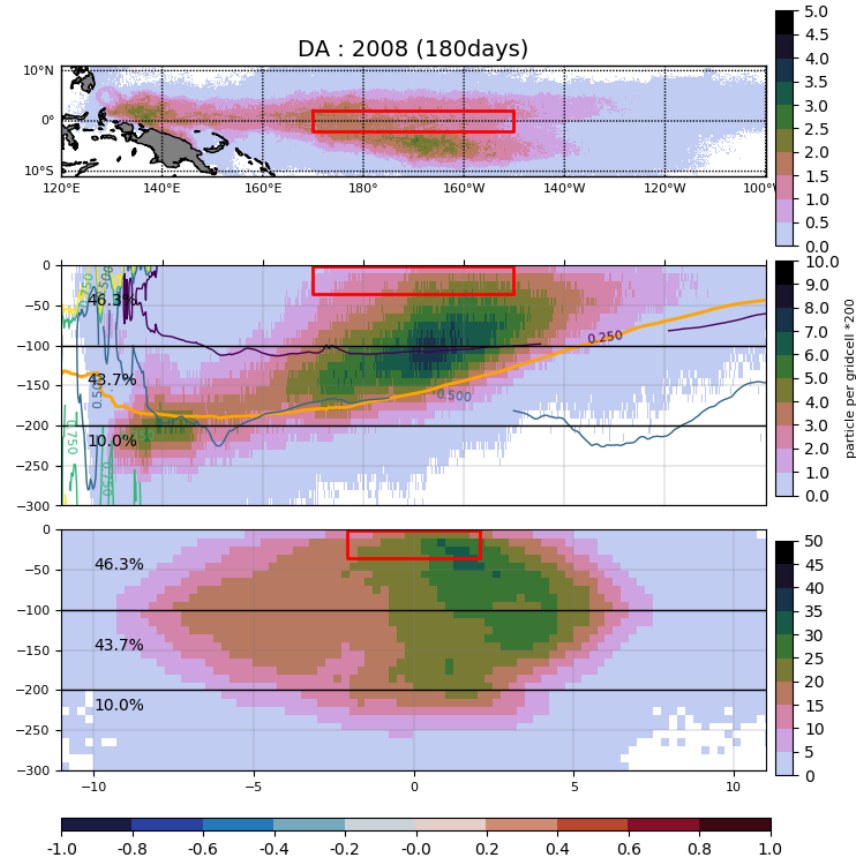
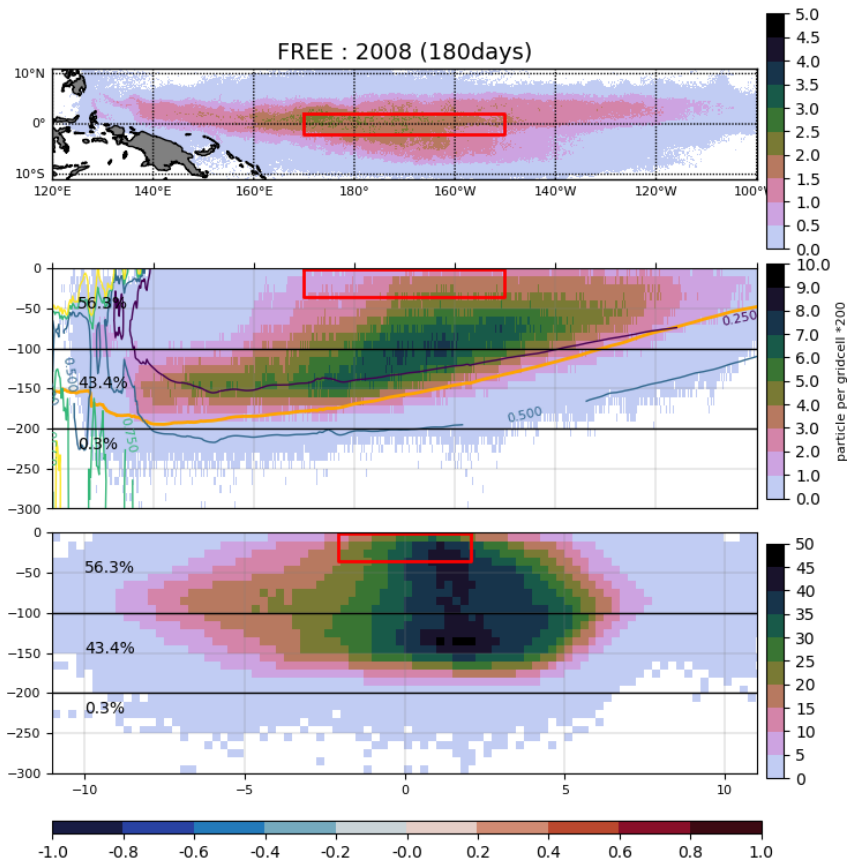
- Use improved mean dynamic topography product for assimilation of SLA (MDT too low in Equatorial West Pacific)
 - Assimilation scheme of data within Equatorial band
 - Interaction with atmospheric forcing: wind products too strong within Equatorial band.
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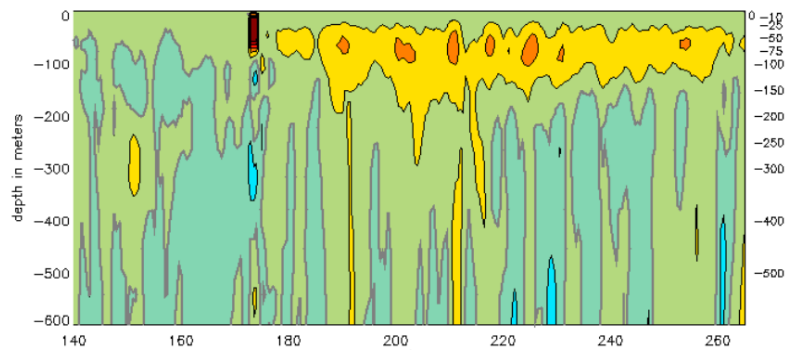
Many thanks!!!!

Simon van Gennip, Marie Drévillon, Charly Régnier, Jean Michel
Lellouche, Eric Greiner, Coralie Perruche, Mathieu Hamon,
Elisabeth Rémy, Florent Gasparin, Alex Mignot, Yann Drillet



Vertical velocities along the equator

GLORYS12 FREE (2003-2014)



GLORYS12 DA (2003-2014)

