Salt budget of the upper South-Eastern Arabian Sea in OPA model

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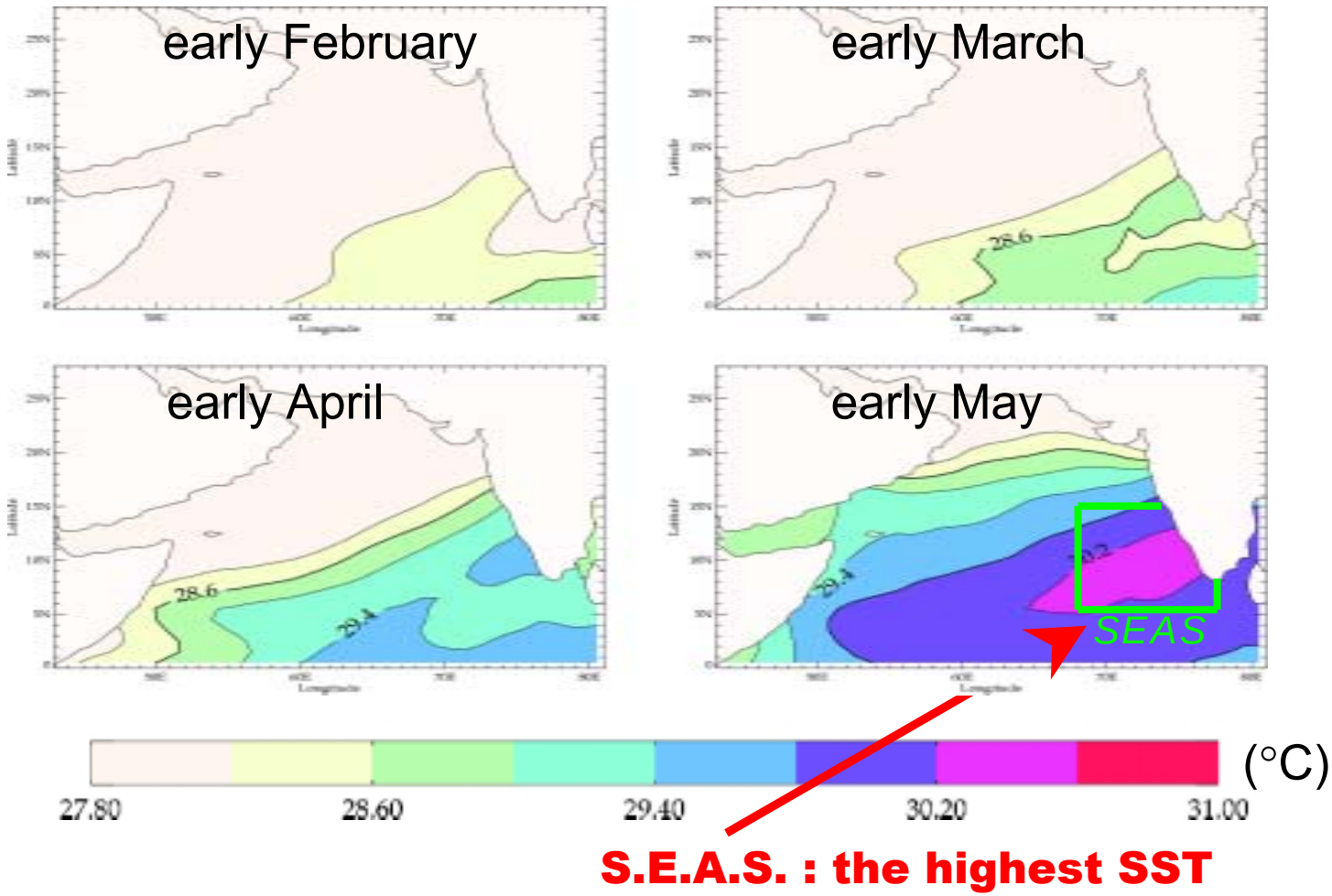
SEAS : a key-area for the coupled system Northern Indian Ocean–summer monsoon

- P.V. Joseph, 1990 : “The time of onset of the monsoon over India depends on the prevailing SST in the Northern Indian Ocean”

- S. Masson, 2004 : salt effects in the SEAS influence the timing of monsoon onset

South-Eastern Arabian Sea : a peculiar thermodynamic structure

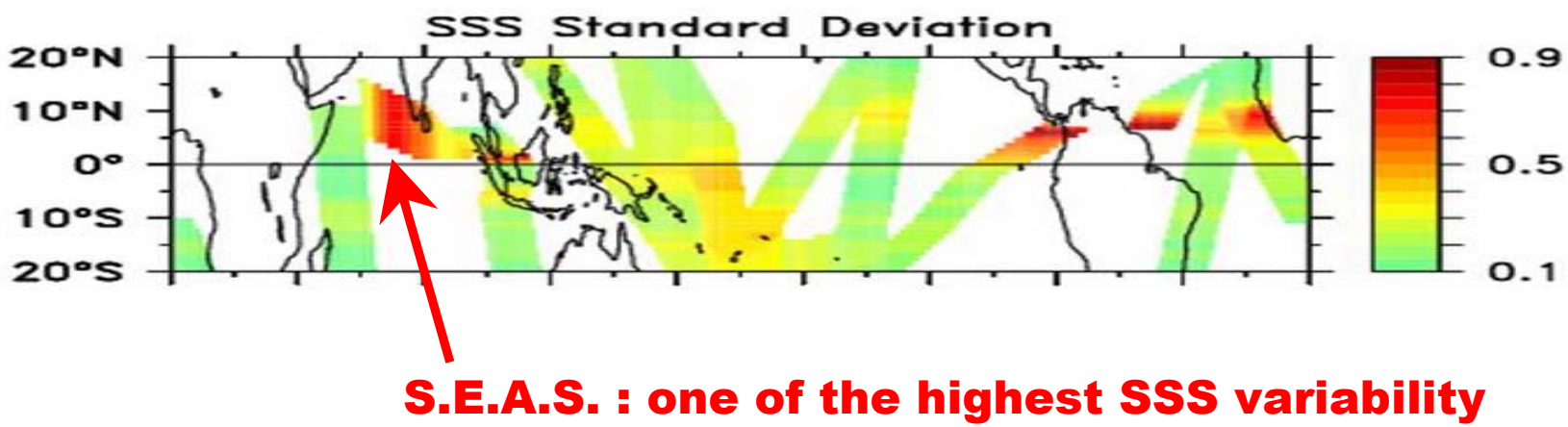
- **Composite of Reynolds SST during the spring warming :**



S.E.A.S. : the highest SST

South-Eastern Arabian Sea : a peculiar thermodynamic structure

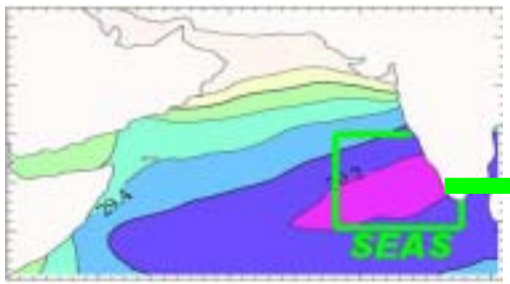
• **SSS variability observed from SOOP TSG network [Delcroix et al., 2004]:**

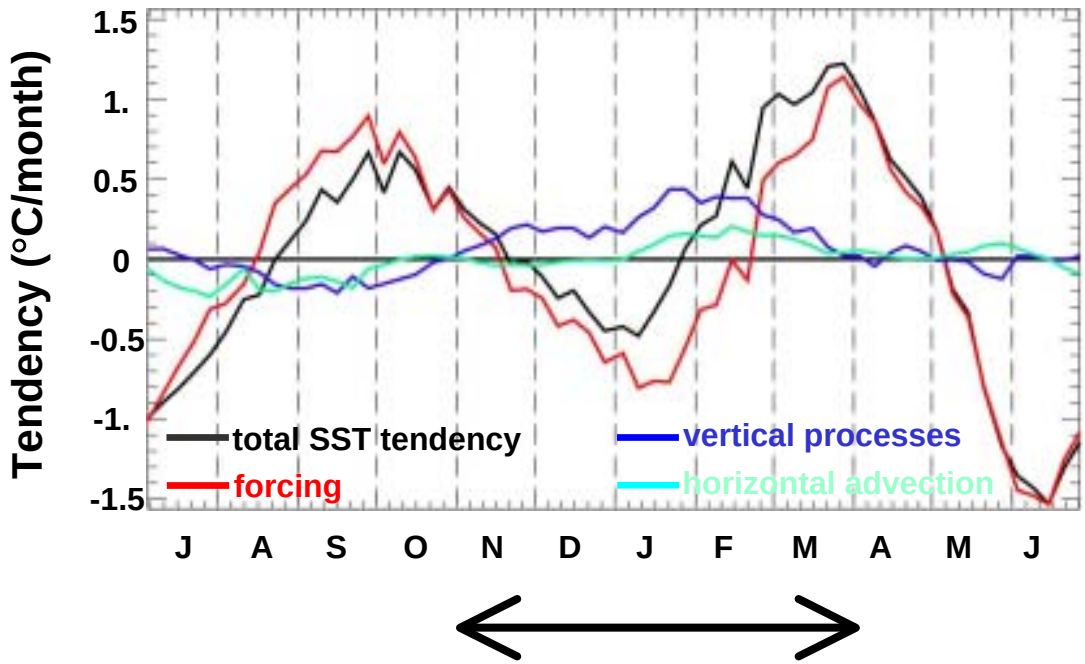


S.E.A.S. : one of the highest SSS variability

Role of salinity on the spring warming : the barrier layer

Time evolution of OPA model SST tendencies over the SEAS area :



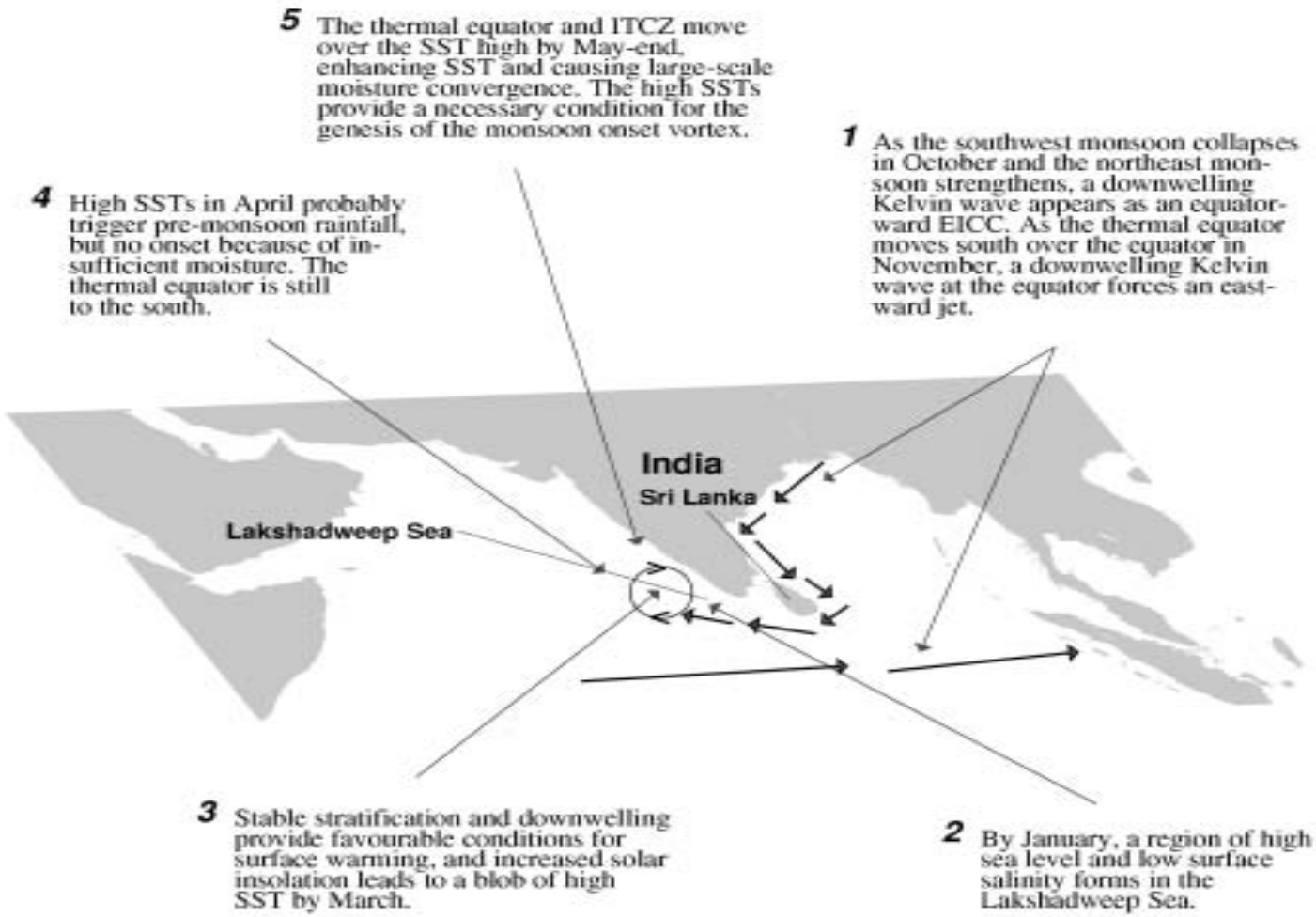


Forcing : - 0.3°C

Vertical processes : +1.1°C !

[Durand et al., 2004]

SEAS : remote forcing of the thermodynamics



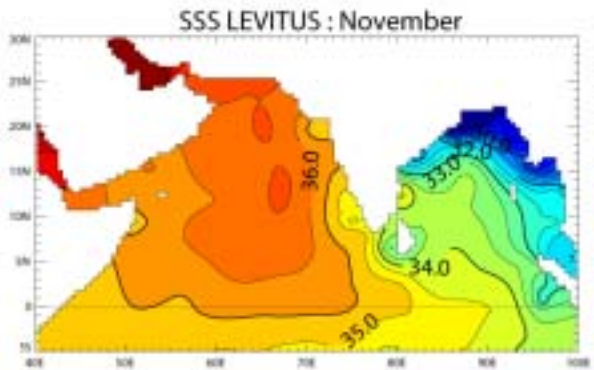
[Shenoi et al., 1999]

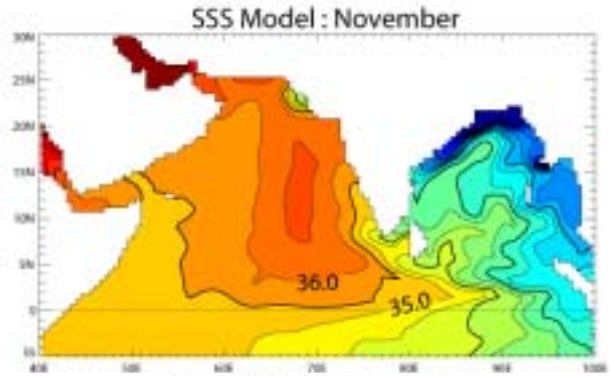
This study : what is the barrier layer formation mechanism ?

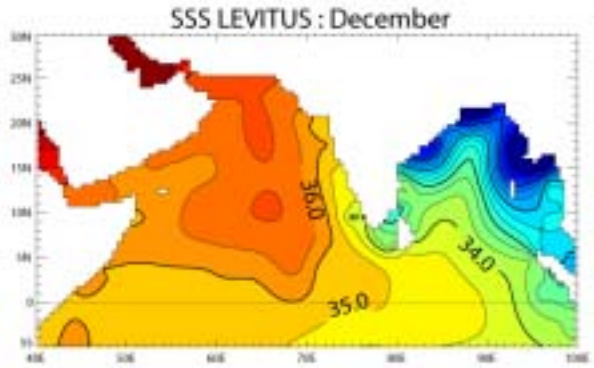
Model : OPA9 [*Madec et al., 1998*].

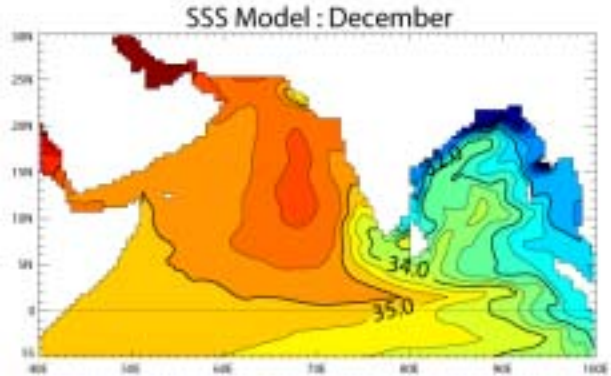
- **0.5° resolution** and 10m vertical resolution
- TKE vertical physics, partial steps, isopycnal lateral diffusion, Gent&McWilliams parameterization of baroclinic instability
- Closed boundaries at 35°S and 120°E
- Forcing : ERS wind stress, heat fluxes and evaporation computed through bulk formulae using NCEP atmospheric variables, CMAP precipitation.
- **No relaxation in SST nor SSS**
- Forcing strategy : we simulate the response of the model to the seasonal cycle of atmospheric fluxes.

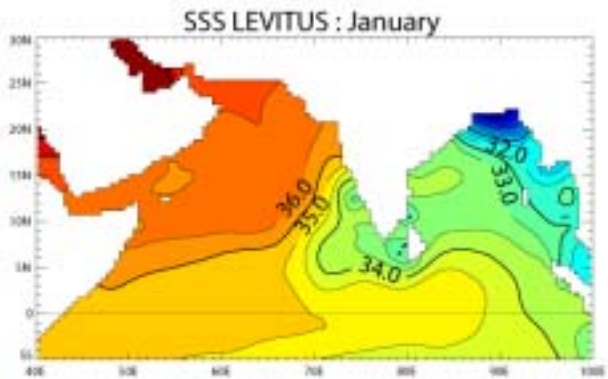
Prerequisite : how to model a «good» salinity in the SEAS at seasonal timescales ?

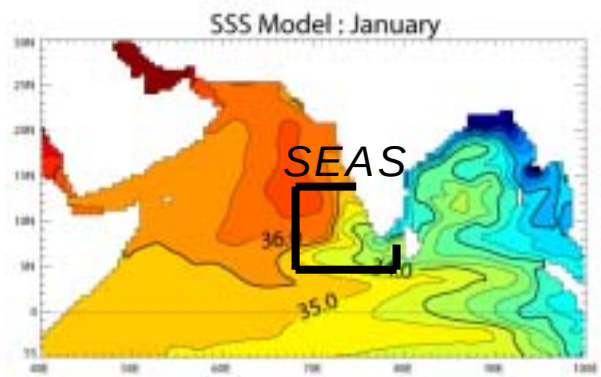








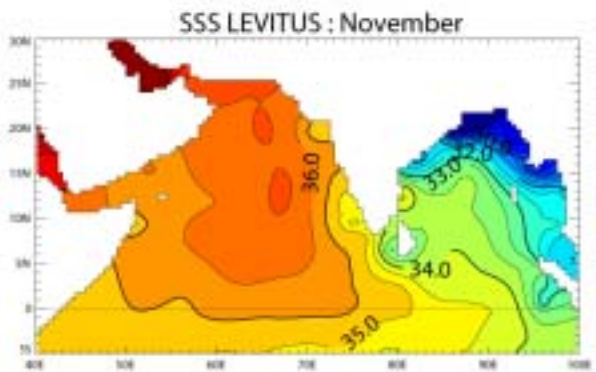


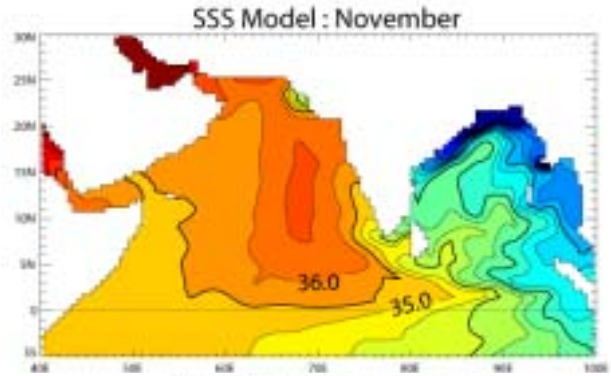


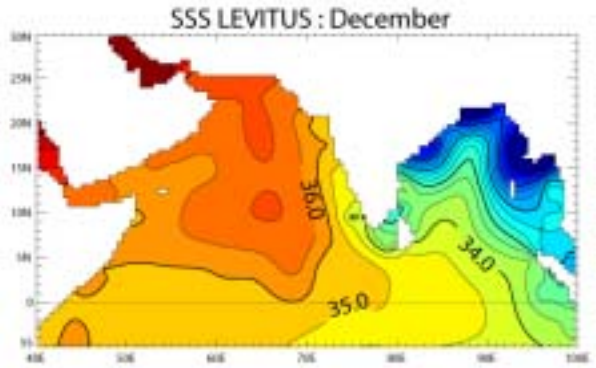
RMSD in SSS between Levitus and model in the SEAS :

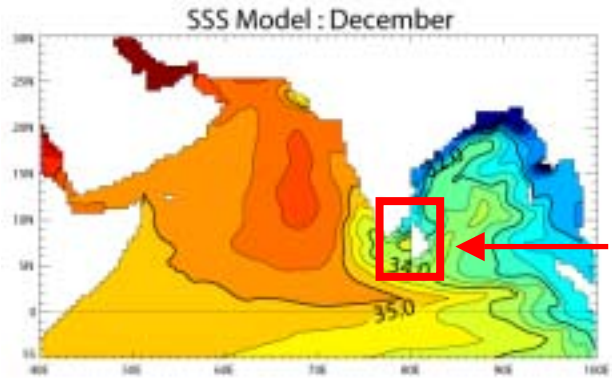
0.68psu

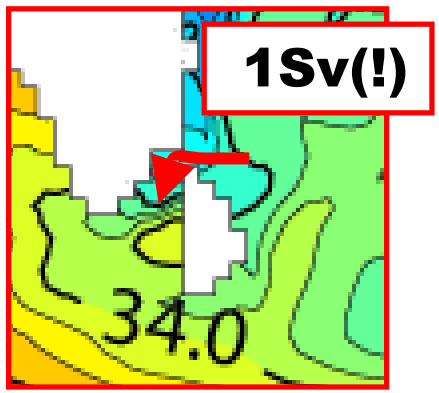
Prerequisite : how to model a «good» salinity in the SEAS at seasonal timescales ?

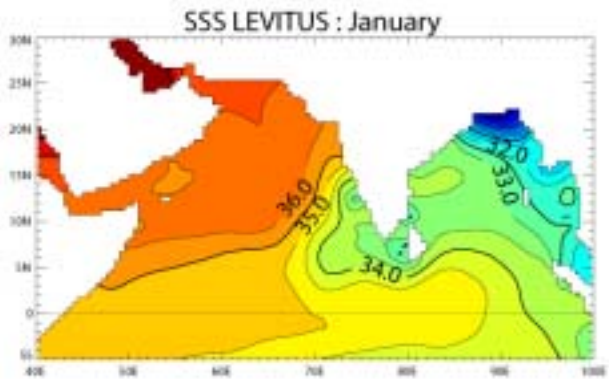


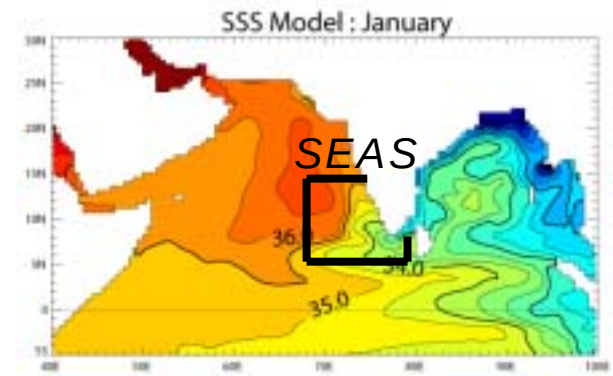


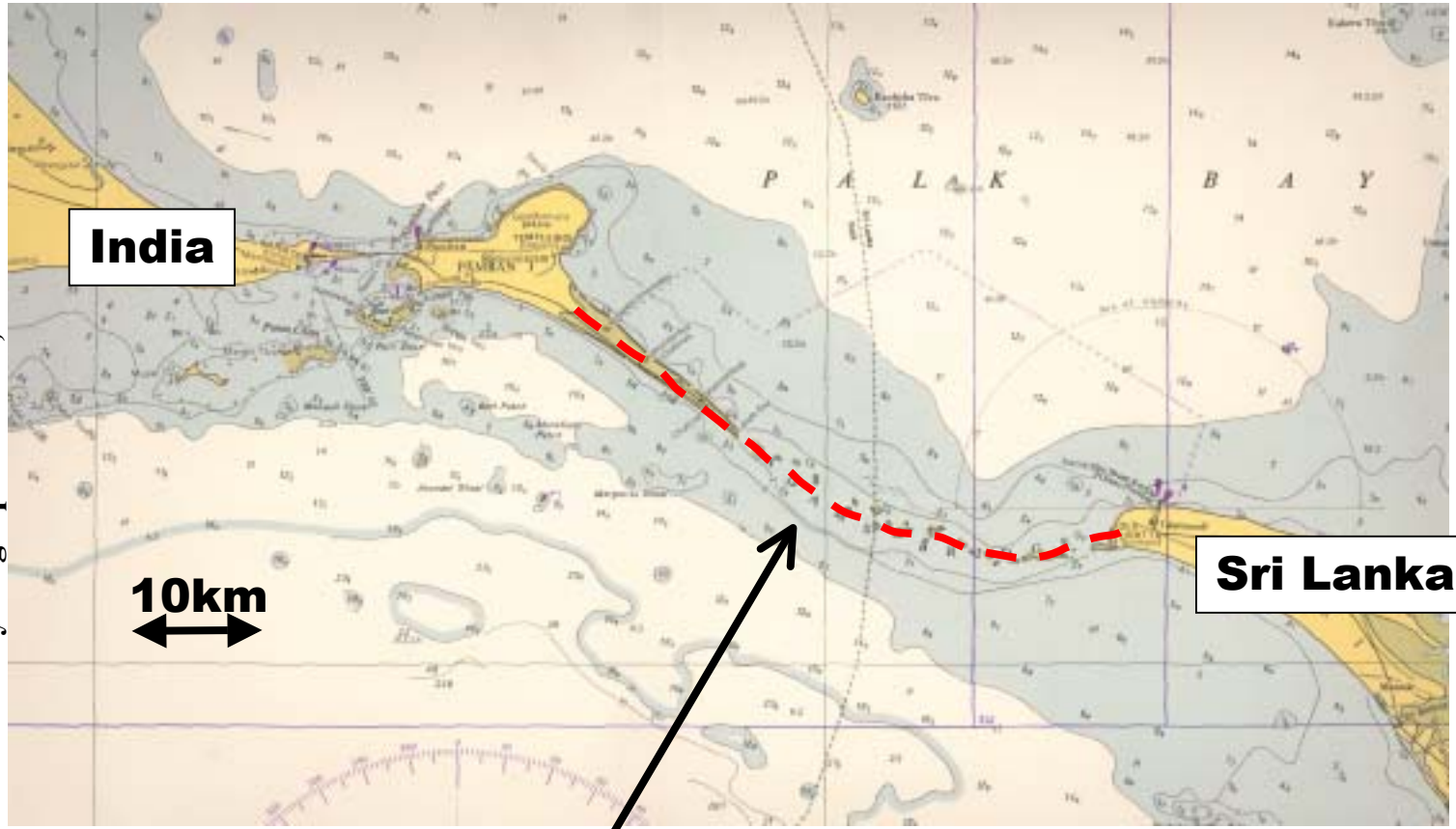








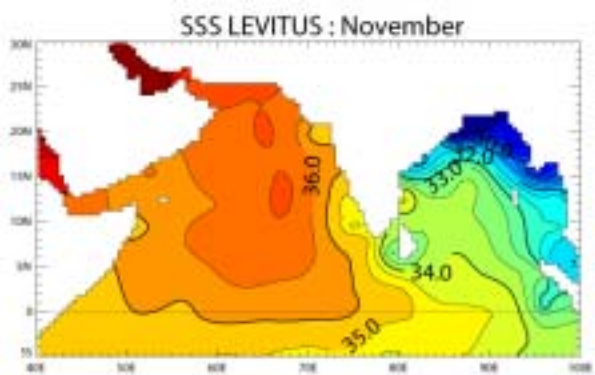


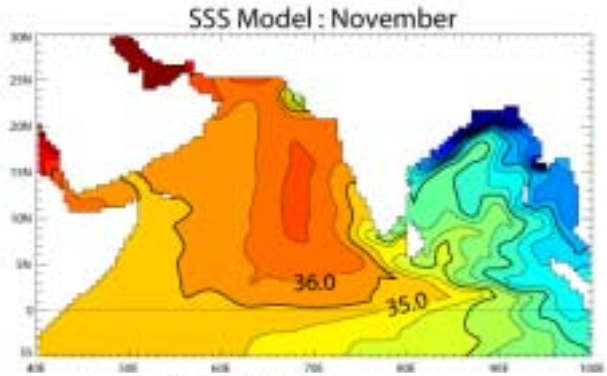


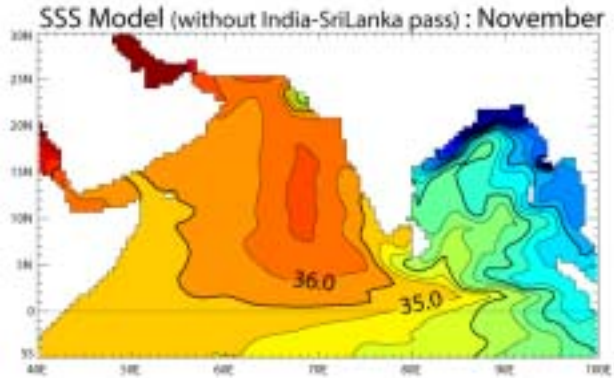
Cross-sectional area : ~25000 m²

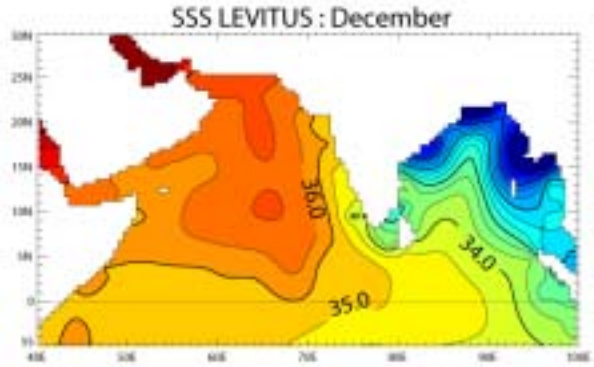
⇒ **Model overestimates the transport by about one order of magnitude**

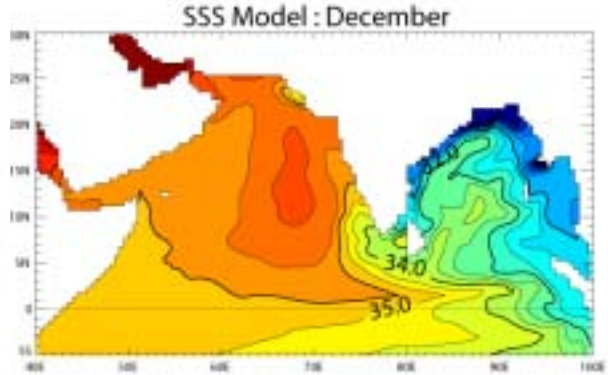
Effect of closing the India-Sri Lanka Channel on modelled SSS

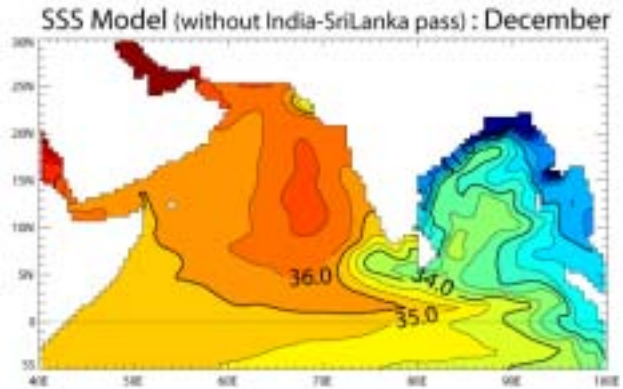


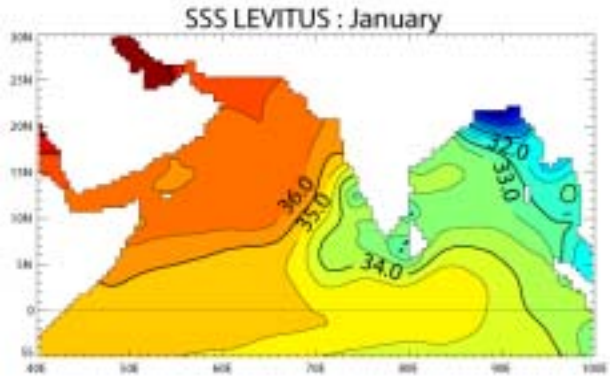


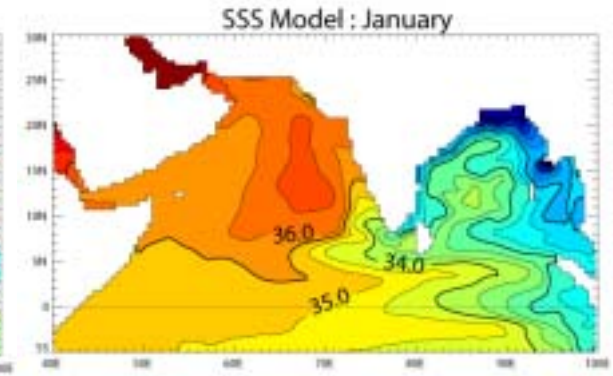


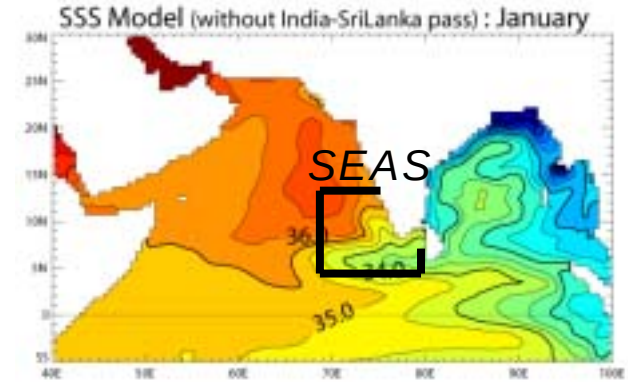












Effect of closing the India-Sri Lanka Channel on modelled SSS in the SEAS :

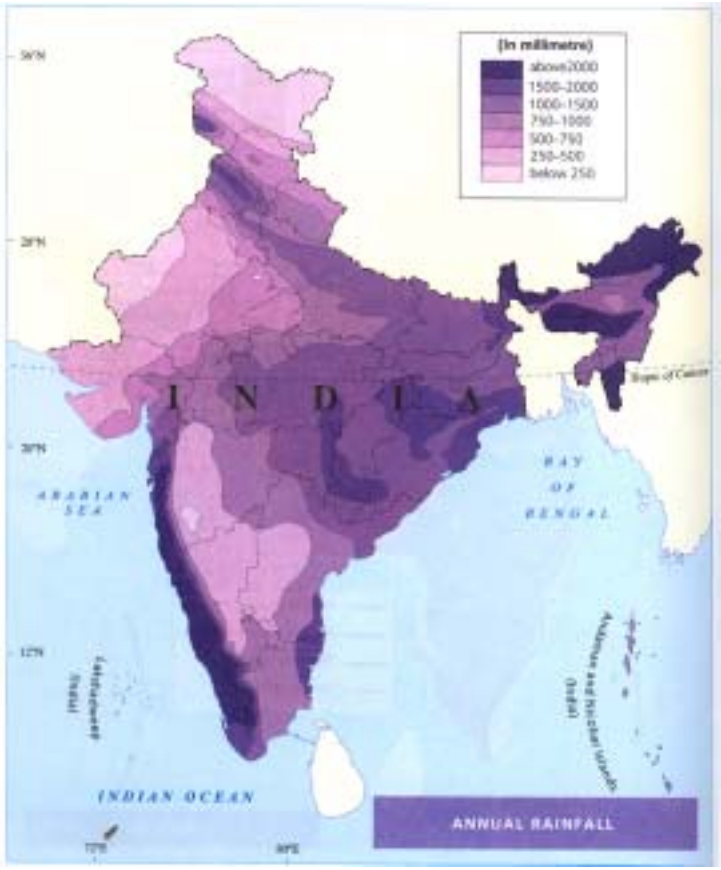
RMSD in SSS between Levitus and model in the SEAS :

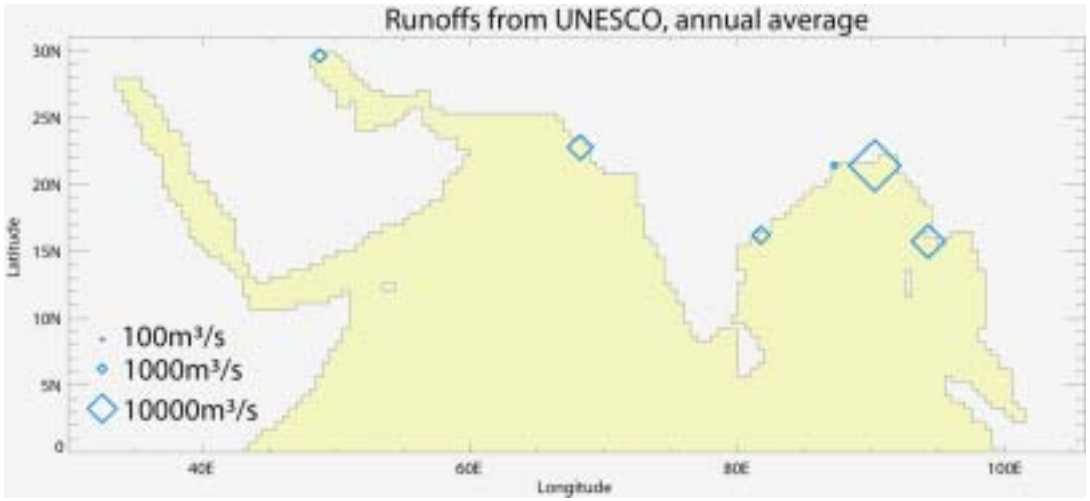
rises from 0.68psu to 0.81psu.

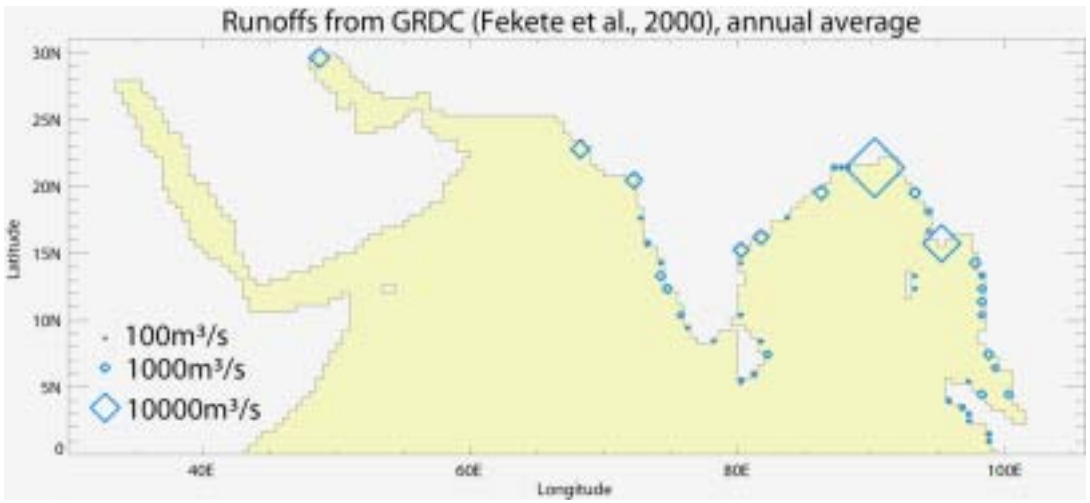
Why ?...

- **wrong physics or too coarse resolution ?**
- **wrong E-P flux ?**
- **wrong runoff ?**

An erroneous runoff ?







Effect of switching from UNESCO to GRDC runoffs on modelled SSS

SSS RMSD (Levitus – model) in the SEAS :

- with India-SriLanka channel open : 0.68psu

- with India-Sri Lanka channel closed : 0.81psu

- with India-Sri Lanka channel closed and GRDC runoffs : 0.69psu

What are the processes driving BL formation in the SEAS ?

averaging the model temperature tendency terms over the 253
time-varying mixed layer thickness, distinguishing between 254

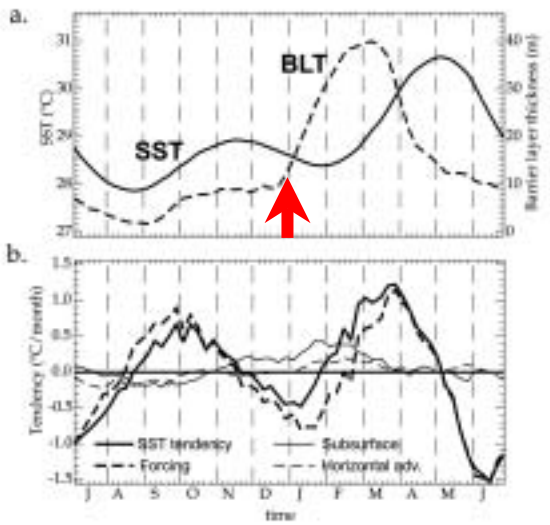
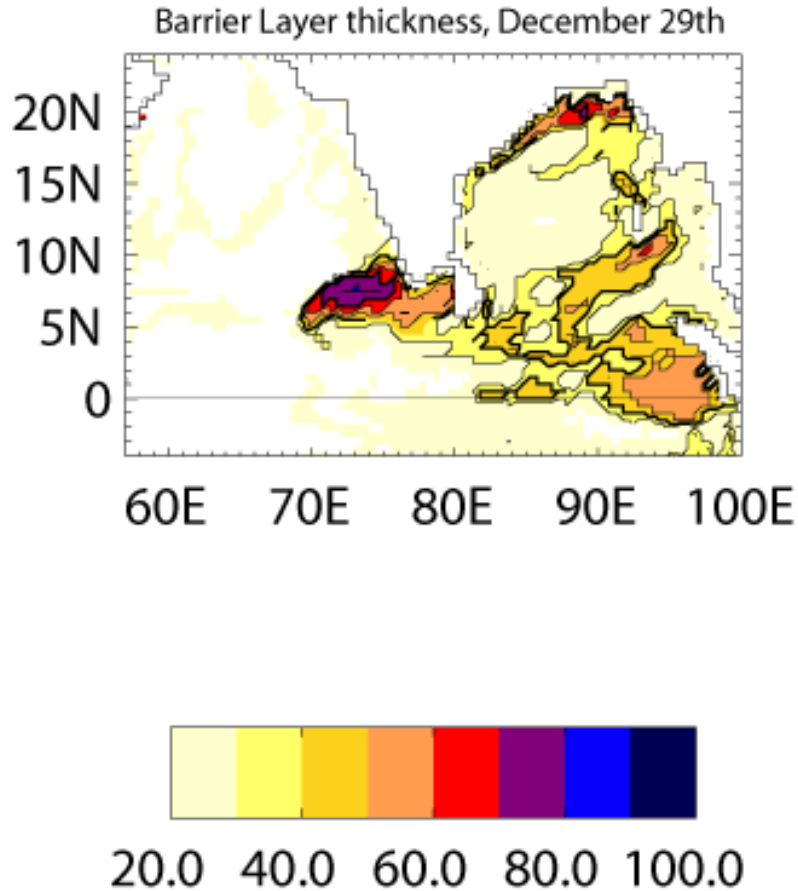


Figure 3. Time evolution of the model SST (continuous line) and barrier layer thickness (dashed line) in the SEAS area (a). Corresponding time evolution of SST tendencies in the model, in °C/month (b). Effect of the atmospheric forcing (thick dashed line). Horizontal advection (thin dashed line). Subsurface tendency (thin continuous line). Total SST tendency (thick continuous line).

[Durand et al., 2004]



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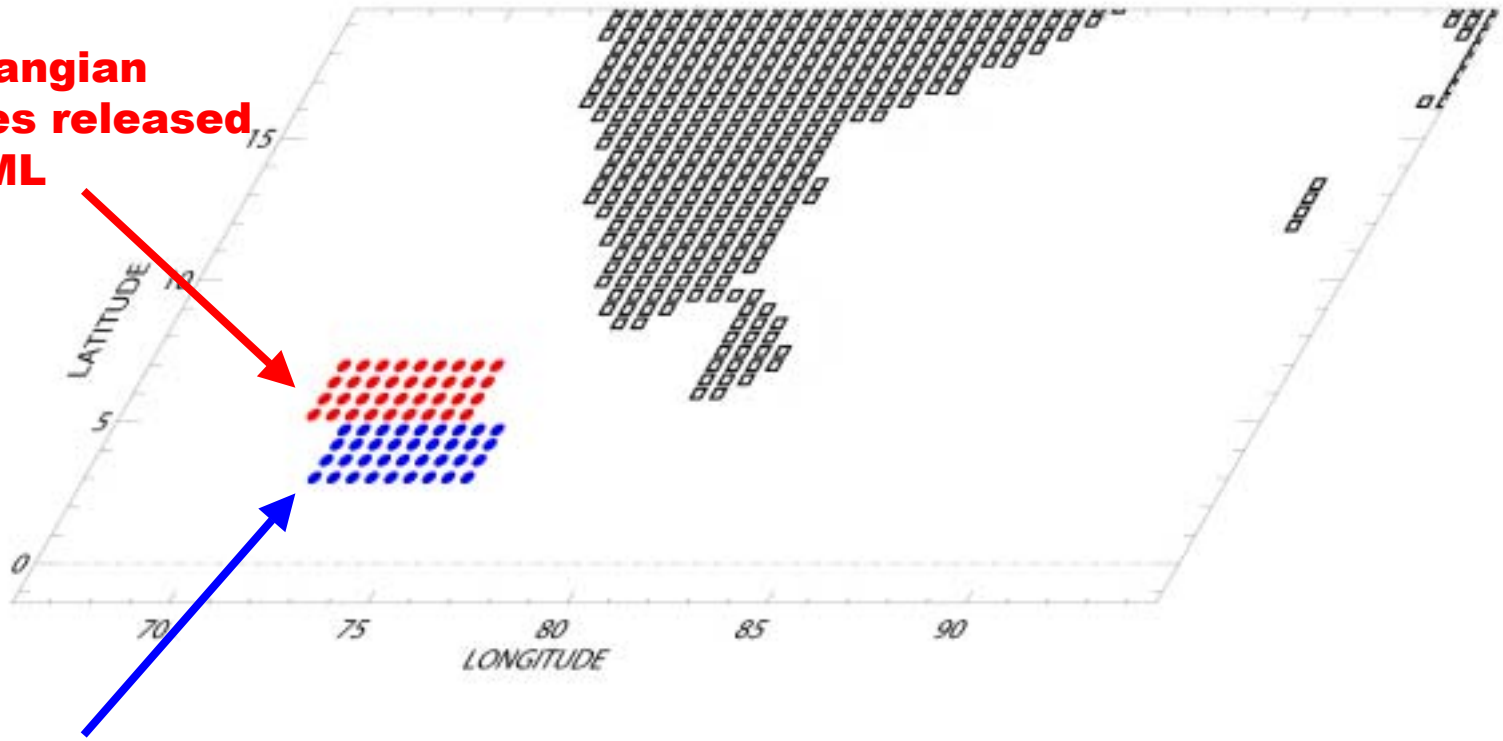
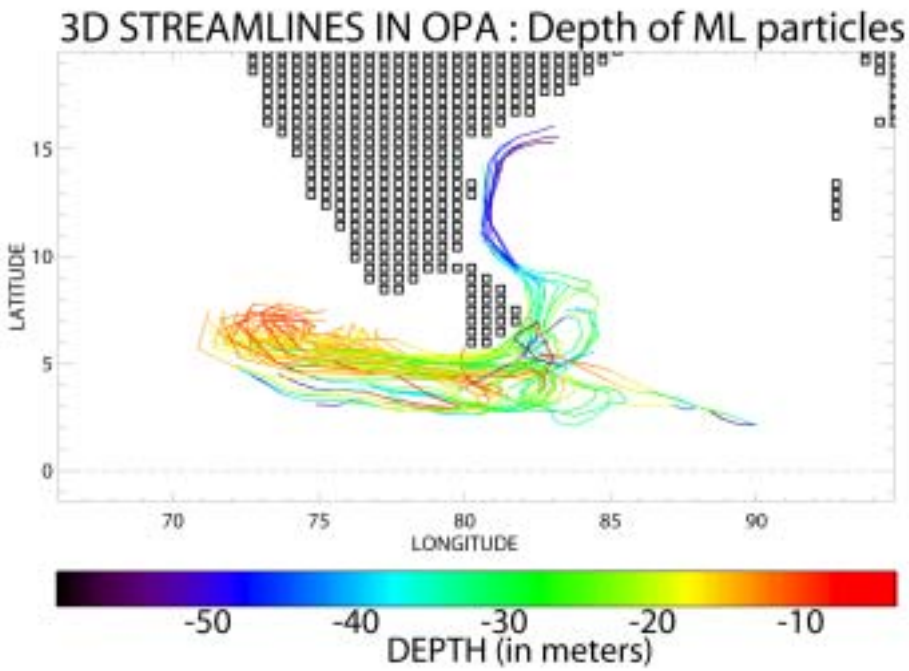
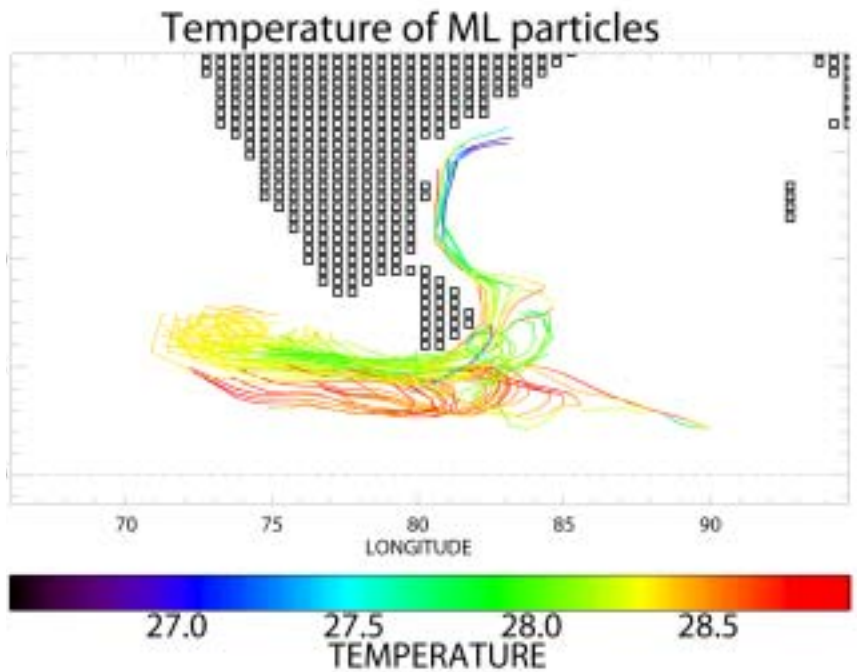


reverse integration of model 3D velocities from 29th December backwards …

Origin of the ML water mass :





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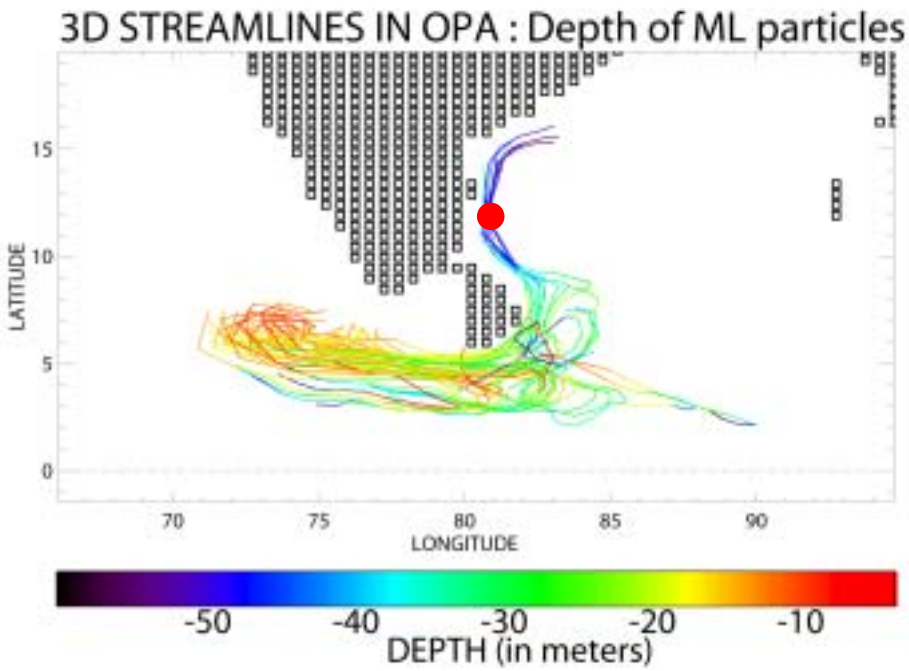
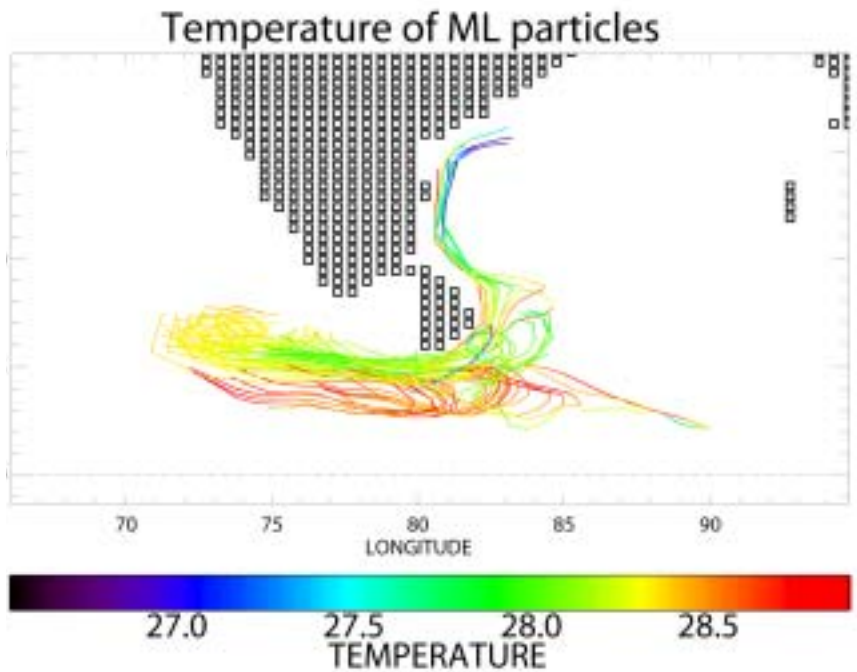
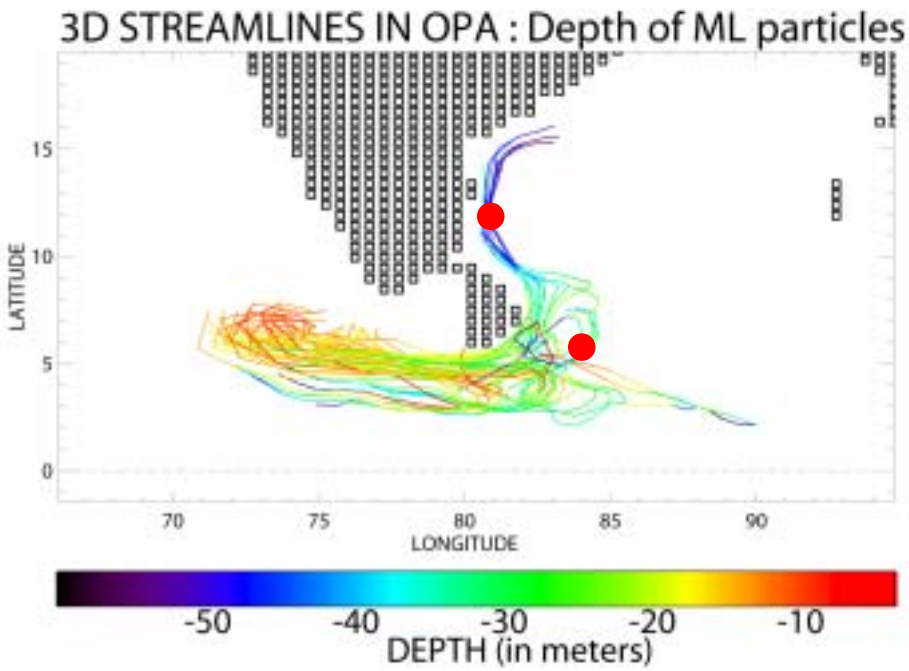
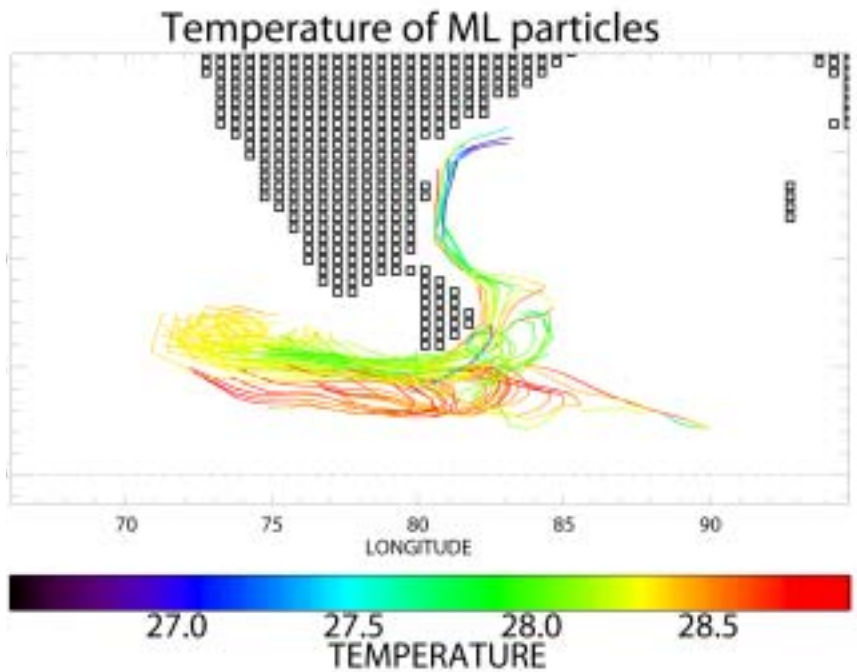




- **25% of the particles come from EICC**

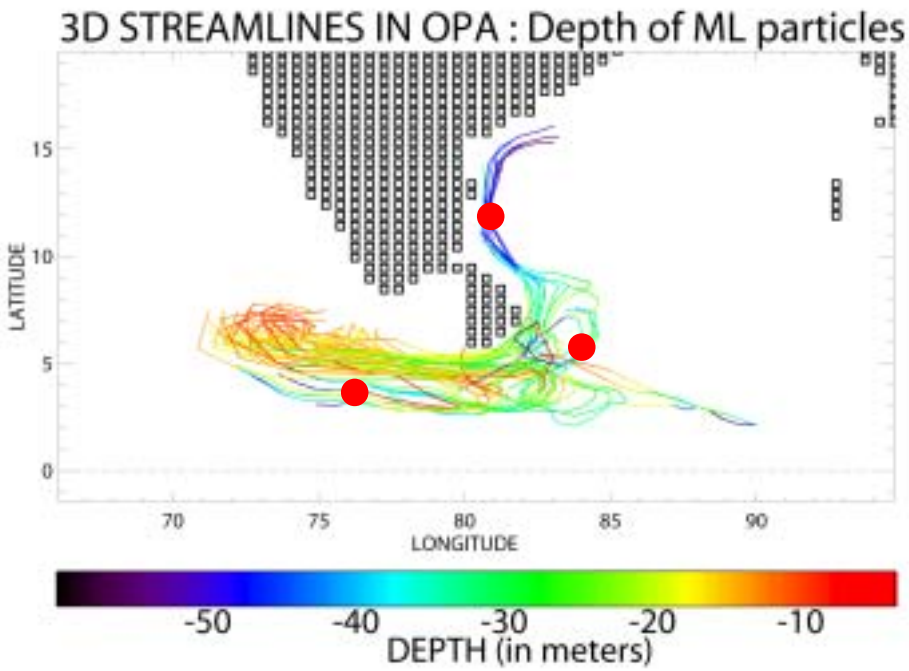
Origin of the ML water mass :

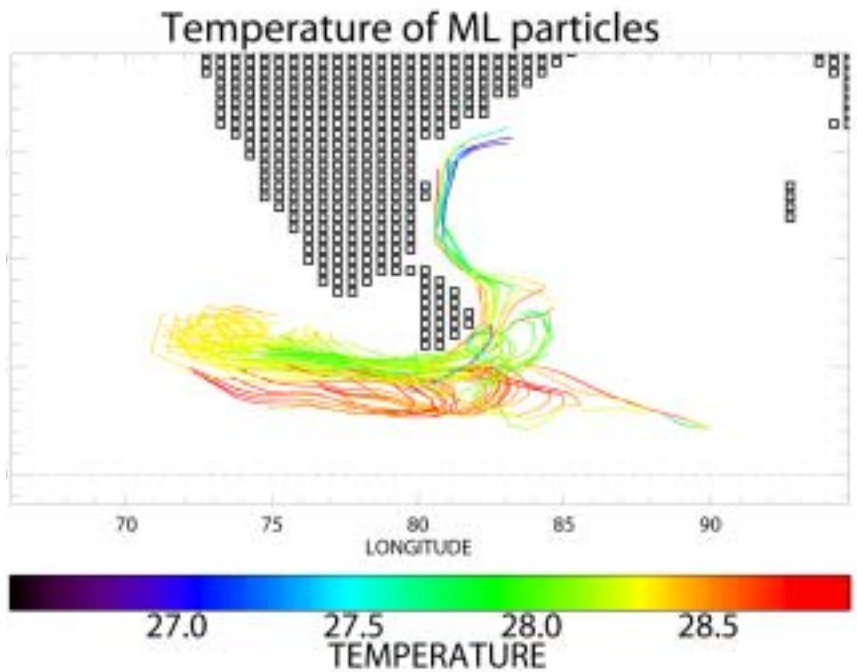




- **25% of the particles come from EICC**
- **25% of the particles come from Sri Lanka dome**

Origin of the ML water mass :





- **25% of the particles come from EICC**
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- **50% of the particles recirculate from SEAS**

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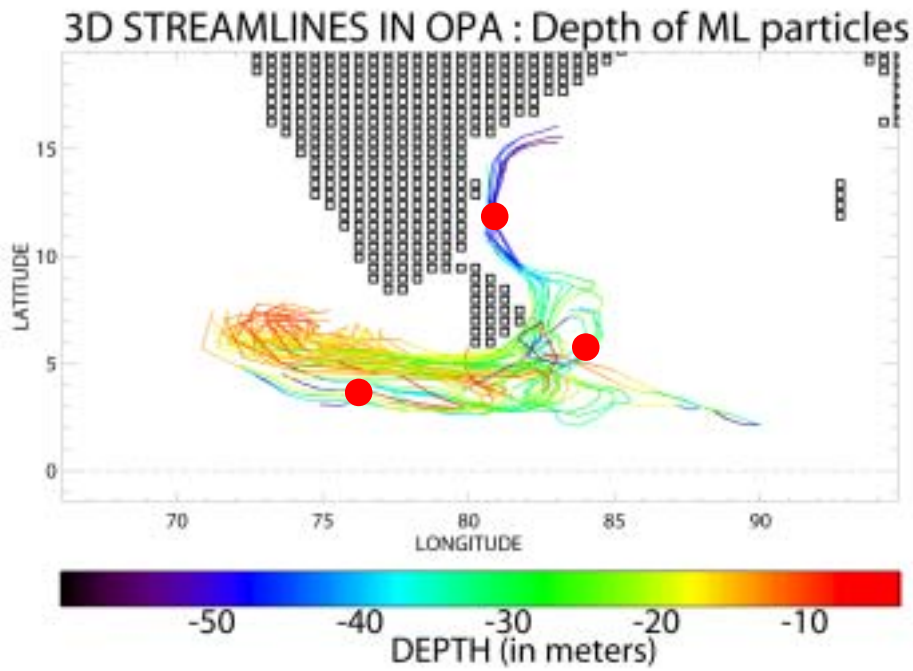
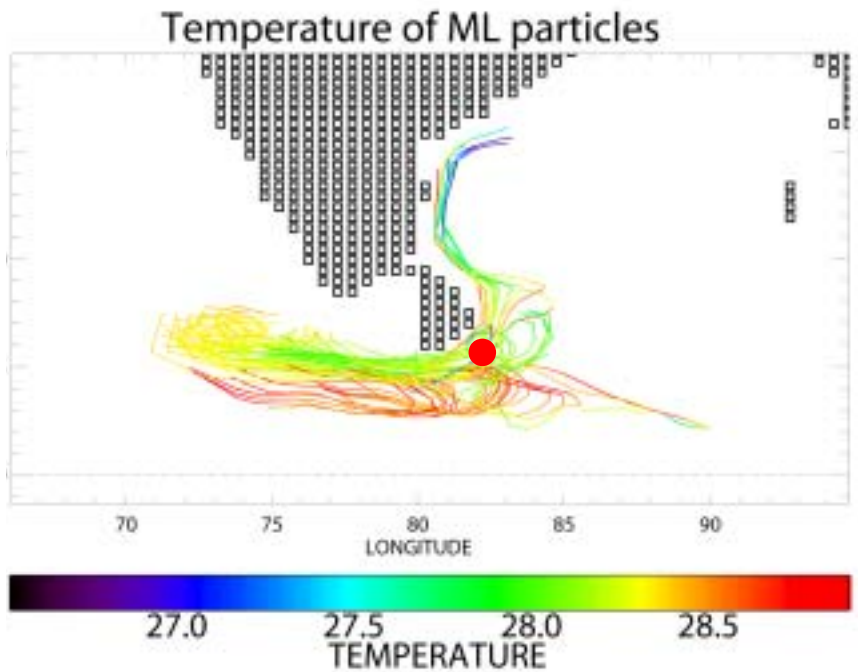
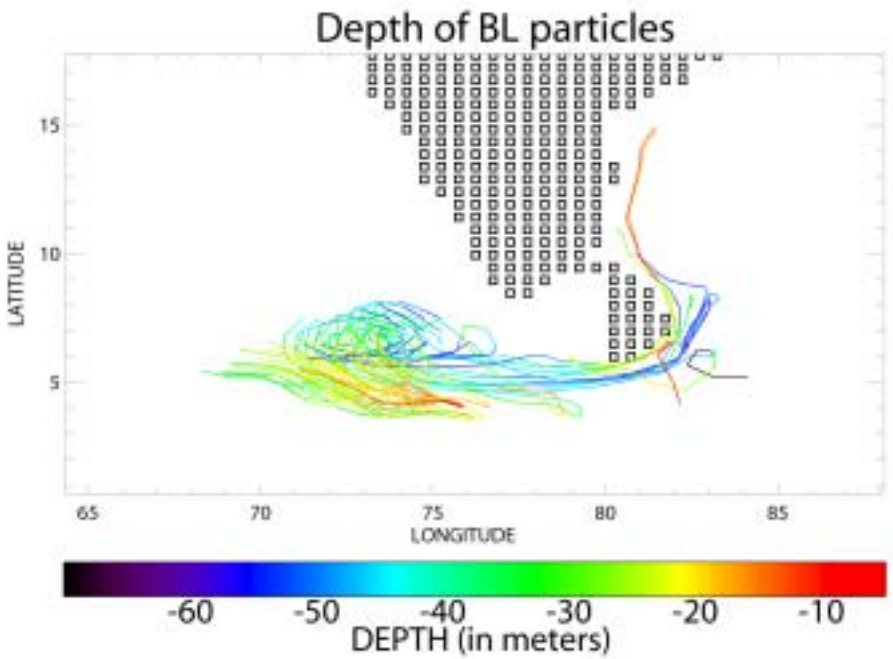


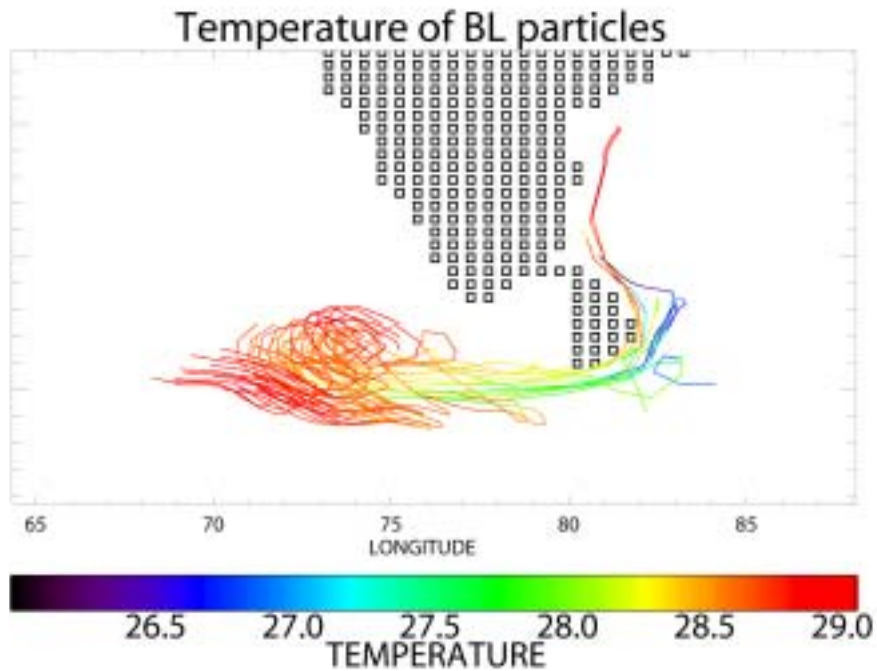


- **25% of the particles come from EICC**
- **25% of the particles come from Sri Lanka dome**
- **50% of the particles recirculate from SEAS**

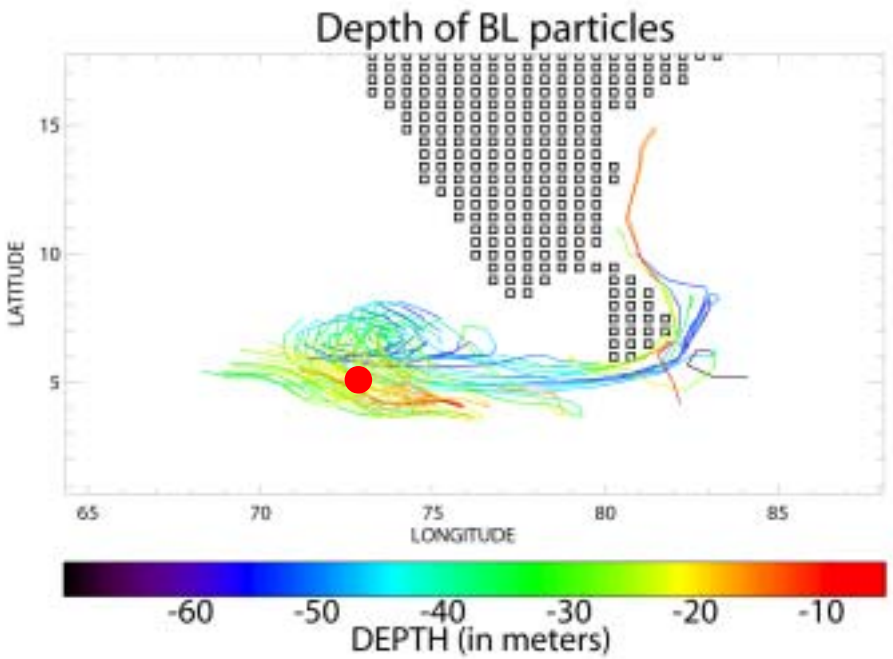
- **water mass is partly cooled in the NMC, south and east of SriLanka**

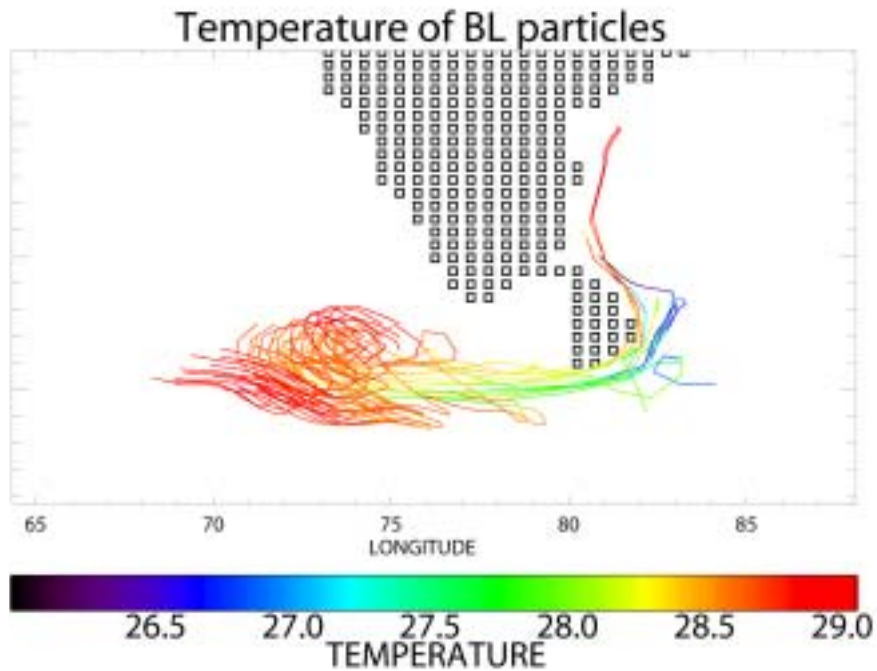
Origin of the BL water mass :





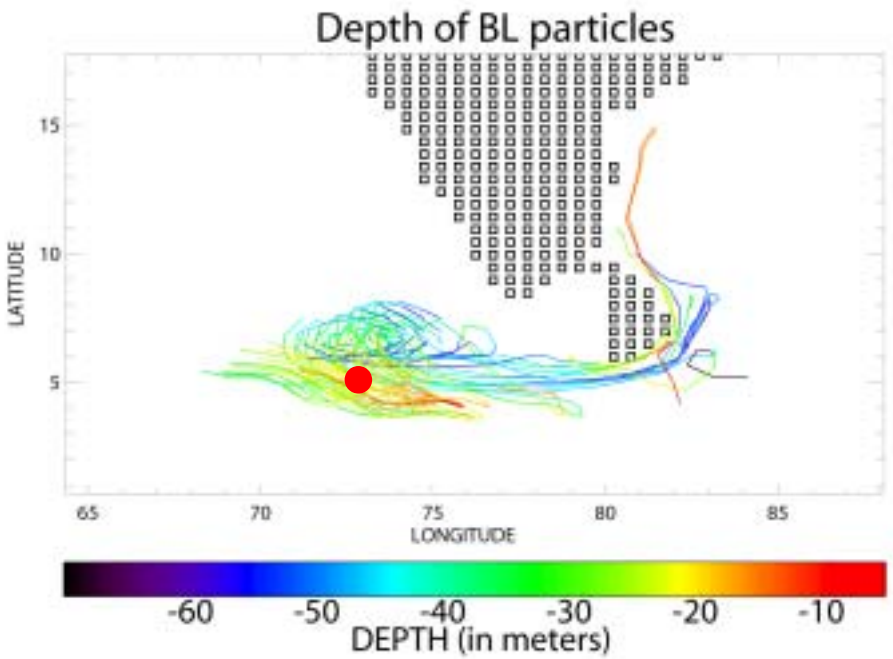
Origin of the BL water mass :

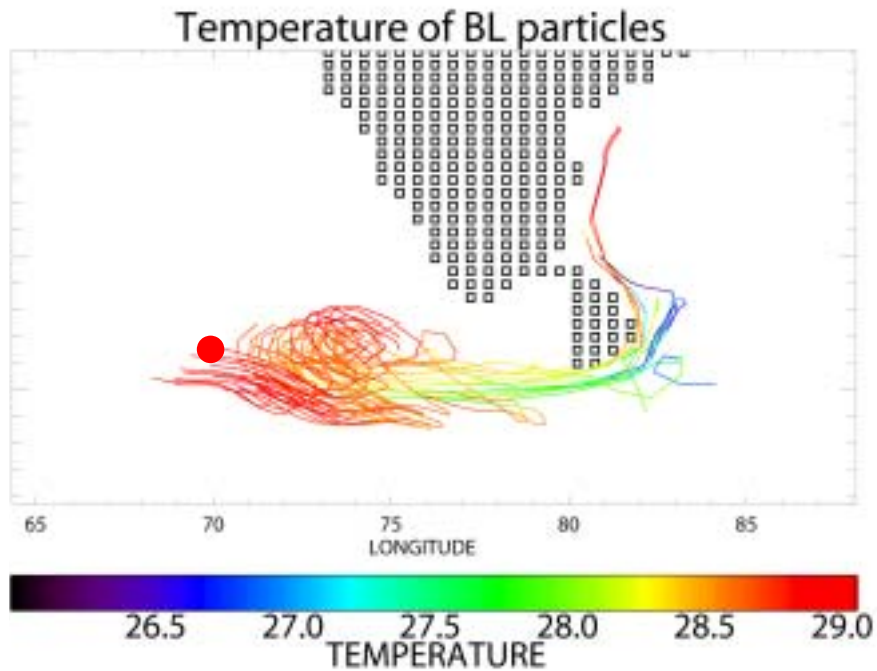




- **2/3 of the BL particles are downwelled locally**

Origin of the BL water mass :

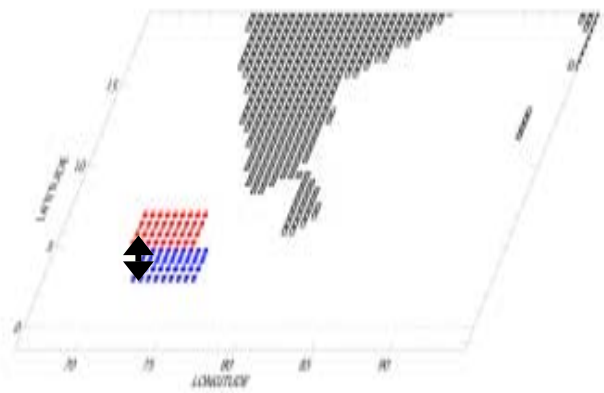


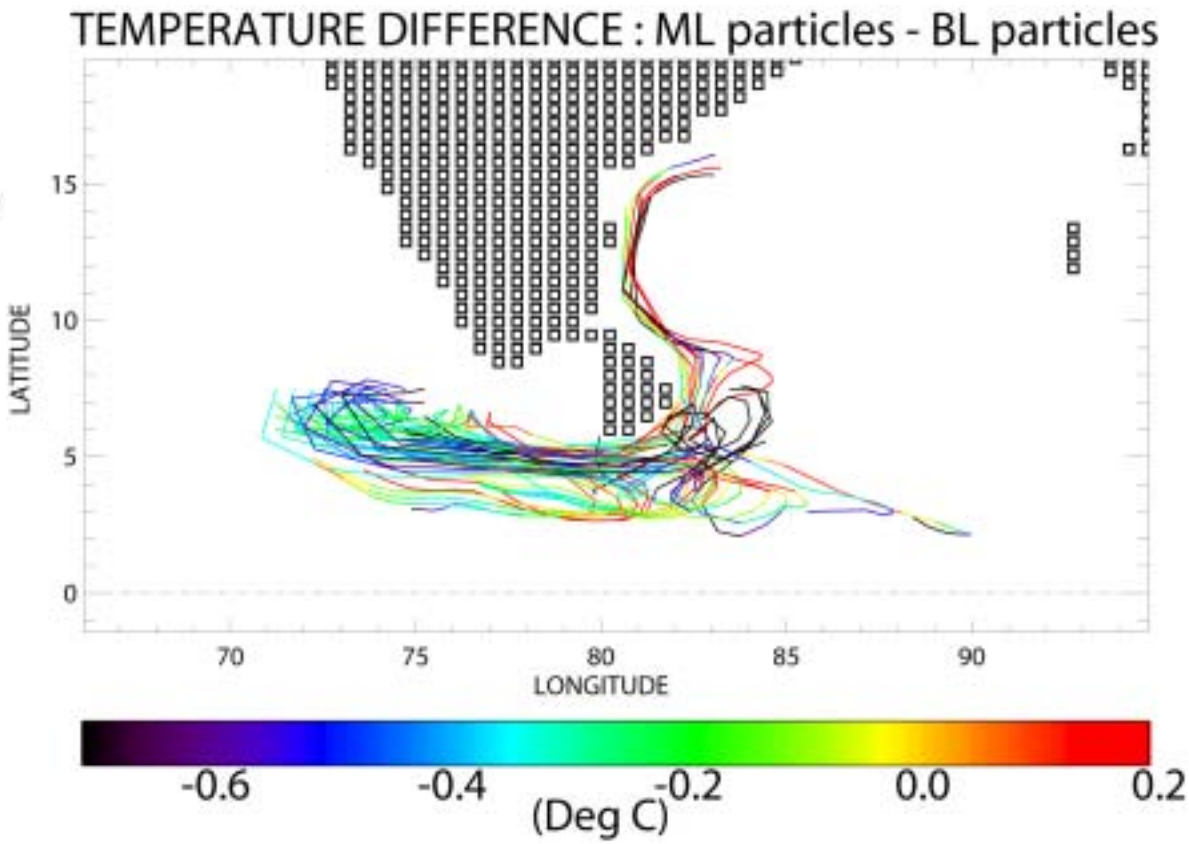


- **2/3 of the BL particles are downwelled locally**

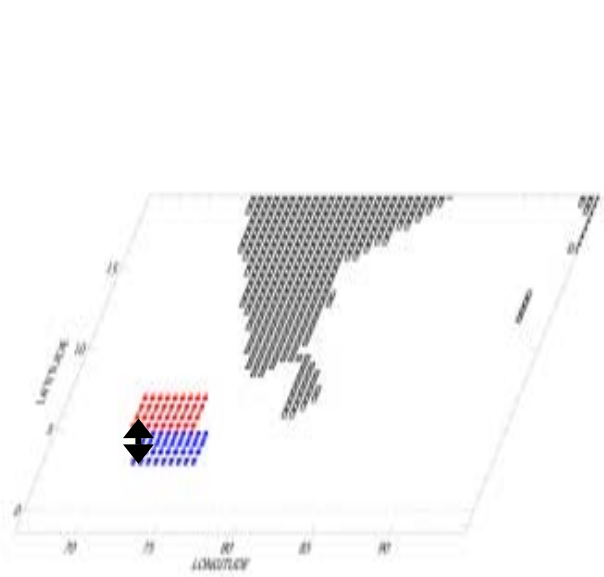
- **downwelled water mass has been warm (28.5°C +) for at least 3months**

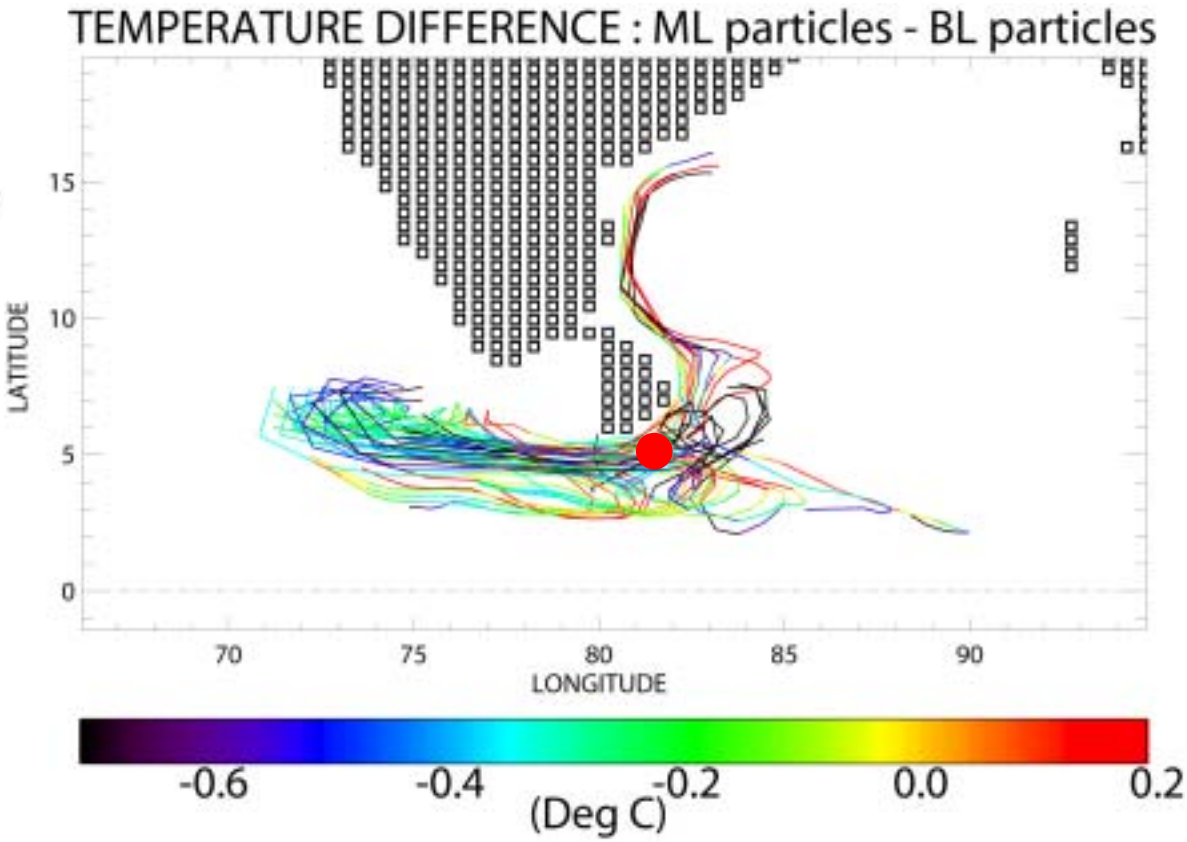
Origin of the temperature inversion :





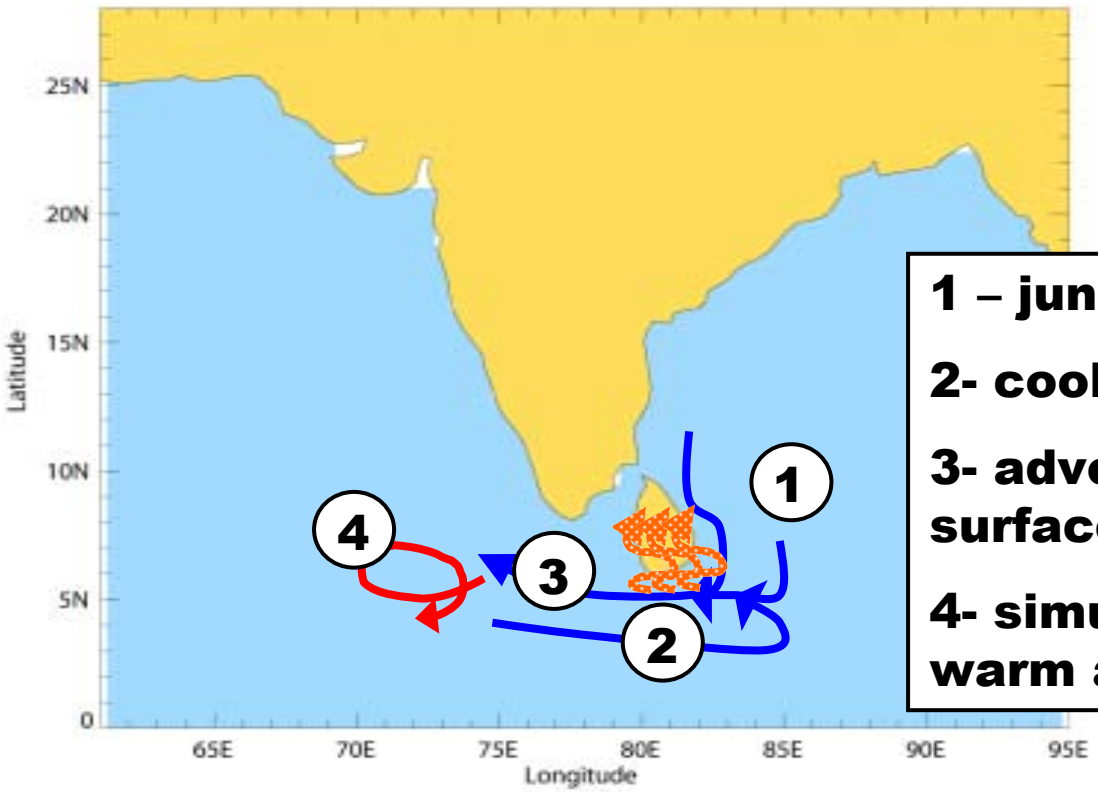
Origin of the temperature inversion :





- **temperature inversion has its origin about 1month earlier, East and South of Sri Lanka**

Conclusion



1 – junction of 3branches

2- cooling by atmosph. heat flux

3- advection of cold and fresh surface water by NMC

4- simultaneous downwelling of warm and salty water by RW

Some remaining questions :

-To what extent are processes #3 and #4 dynamically linked ?

- What is the year-to-year variability of this picture ? What is the link with year-to-year variability of summer monsoon onset ?

Effect of switching from UNESCO to GRDC runoffs on modelled SSS