

# Impact of the Barrier Layer on the variability of the Southeastern Arabian sea

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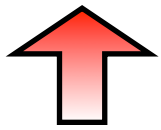
*EU collaborators  
(France-Germany-Italy)*

# Introduction: Seasonal variability of the southeastern Arabian Sea

Precipitation  
monsoon onset



Spring SST warming

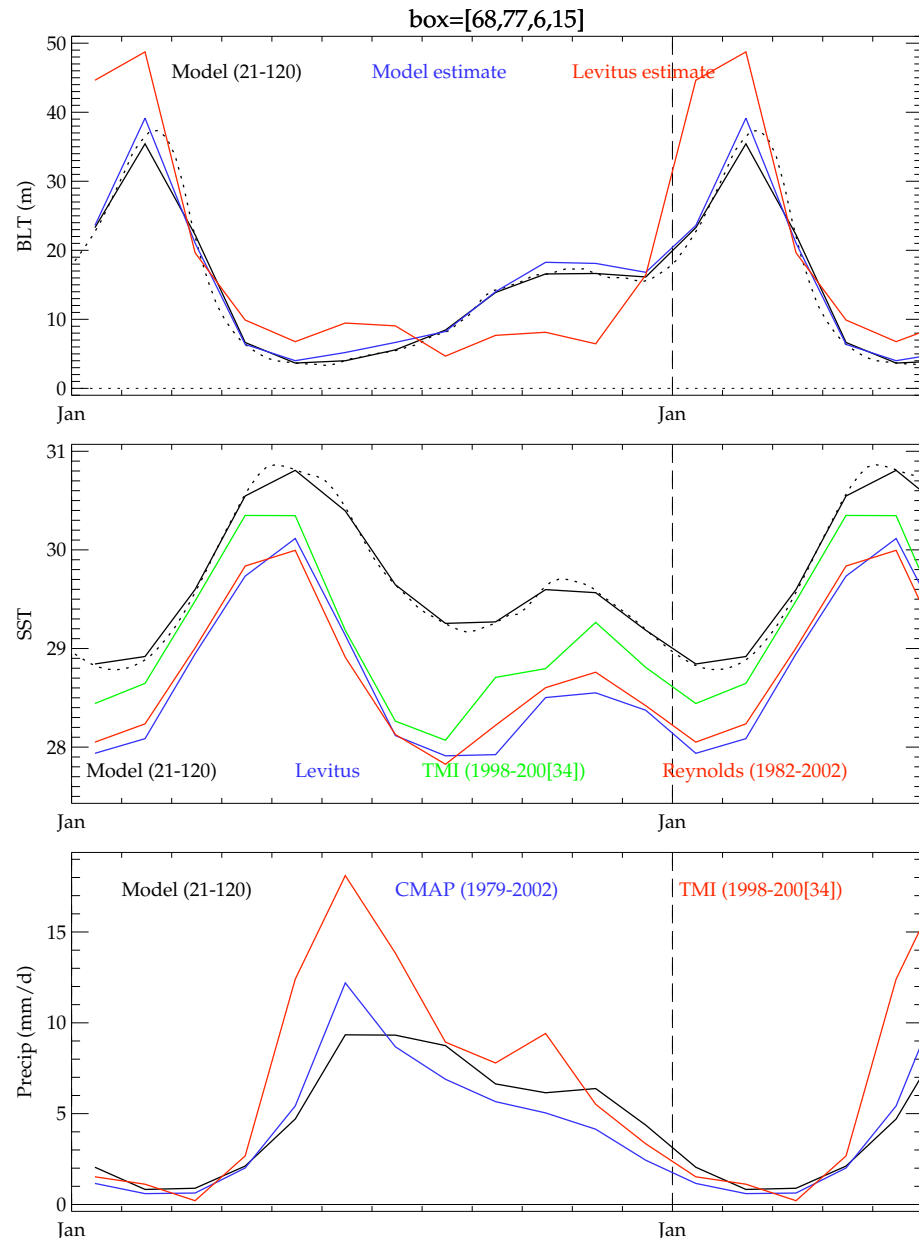


Barrier Layer

Rao and Sivakumar, 1999

Shenoi et al., 1999

Durand et al., 2004



Explore and quantify this hypothesis with a coupled model

# The SINTEX-Frontier CGCM

## 1. Model components: *No flux correction*

**AGCM** (MPI, Germany): ECHAM4 (T106L19)

**OGCM** (LODYC, France): OPA8 (ORCA2: 2° x 0.5°~2°, L31)

**Coupler** (CERFACS, France): OASIS2

## 2. European collaborators:

**LODYC**: OPA group

**INGV (Italy)**: Antonio Navarra's group

**MPI**: ECHAM model group

**CERFACS**: OASIS coupler group

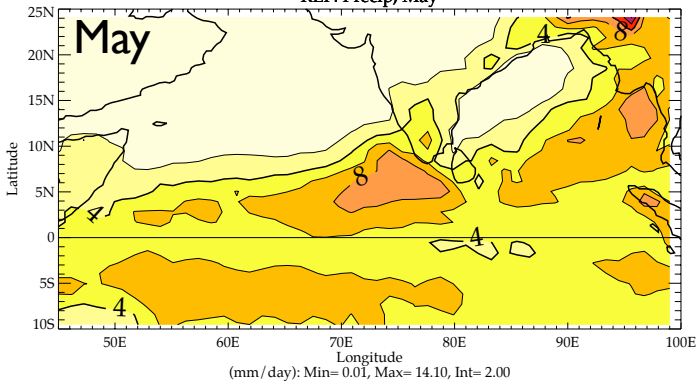
*PRISM project group*

## 3. Reference experiment: we keep 100 years from 21 to 120

# Monsoon onset in the SE Arabian Sea

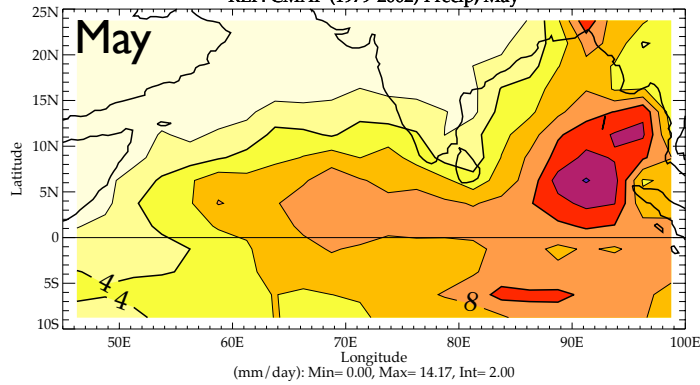
## Model

REF: Precip, May



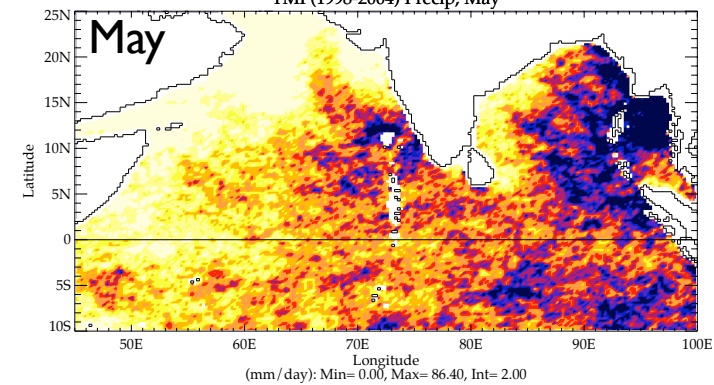
## CMAP

REF: CMAP (1979-2002) Precip, May

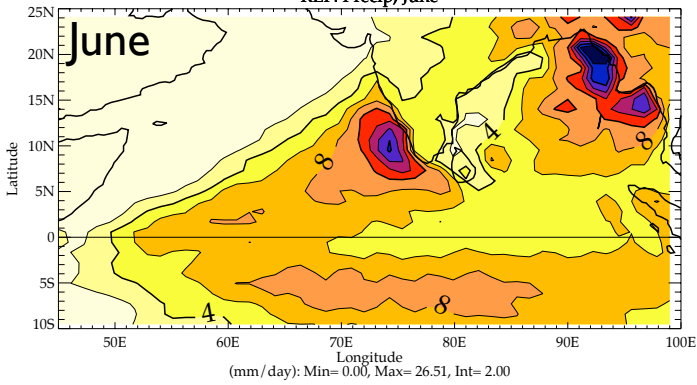


## TMI

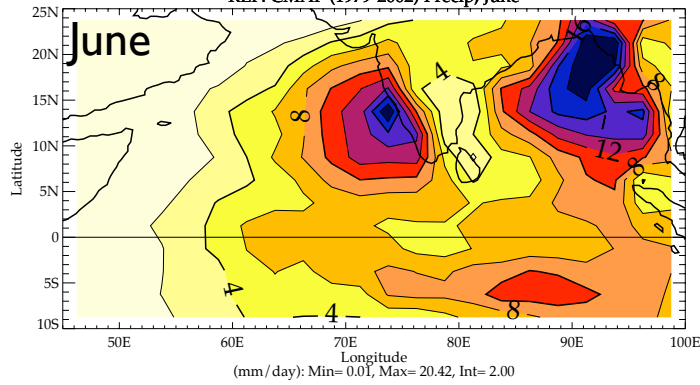
TMI (1998-2004) Precip, May



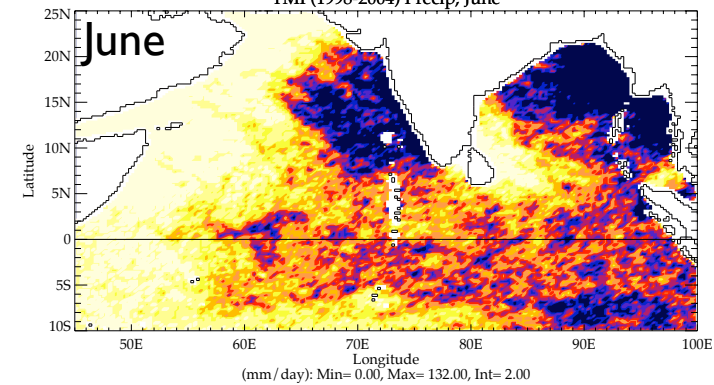
REF: Precip, June



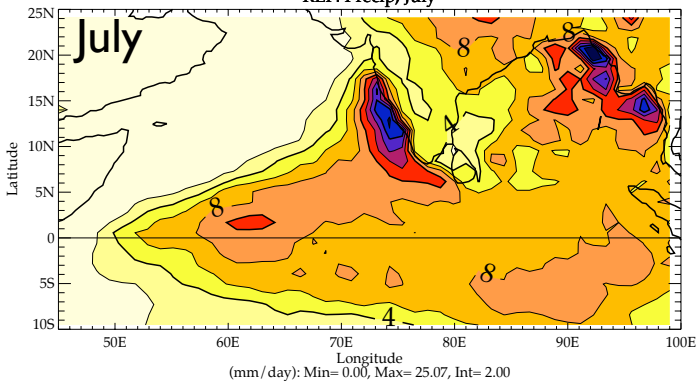
REF: CMAP (1979-2002) Precip, June



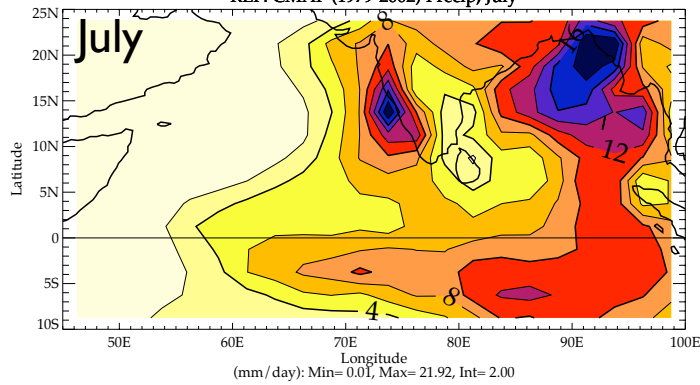
TMI (1998-2004) Precip, June



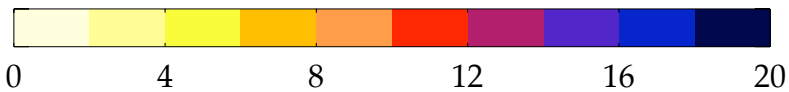
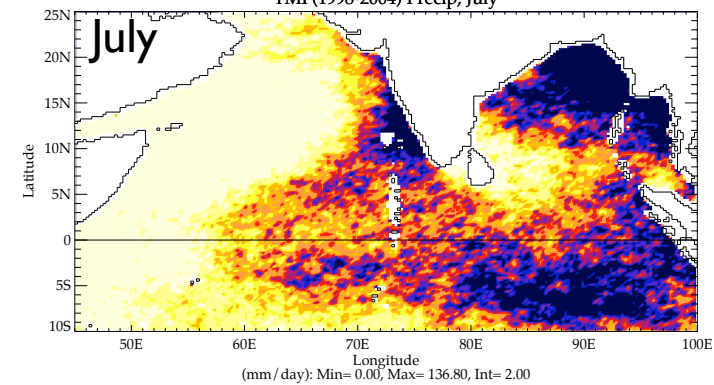
REF: Precip, July



REF: CMAP (1979-2002) Precip, July



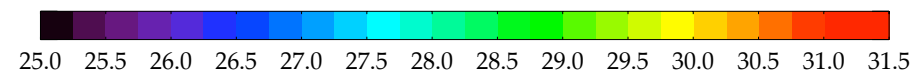
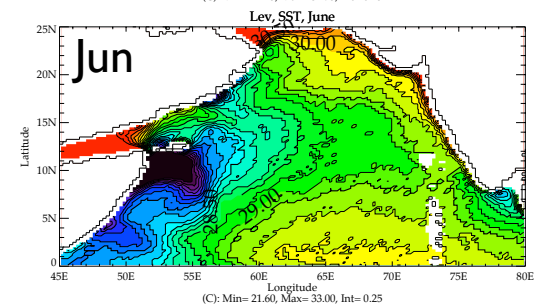
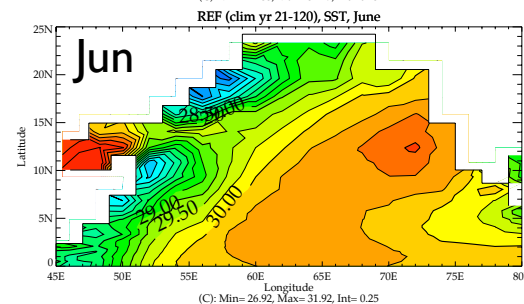
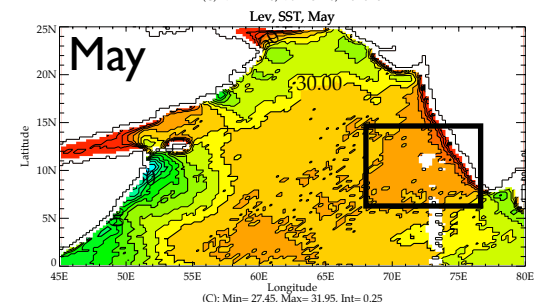
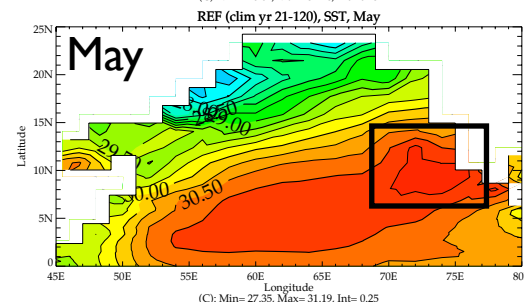
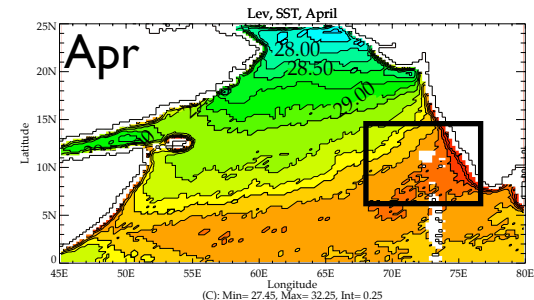
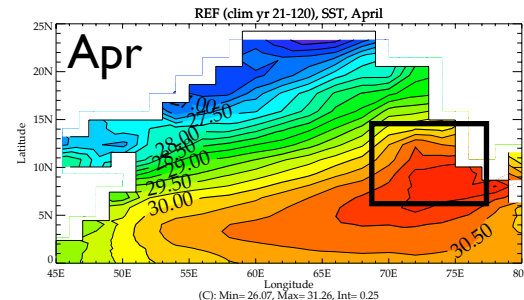
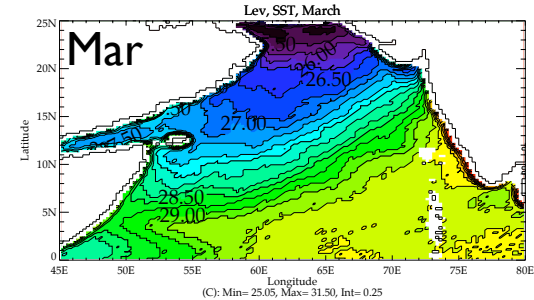
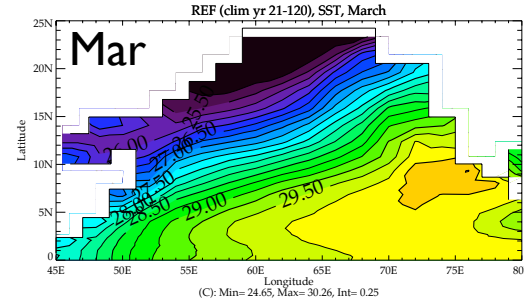
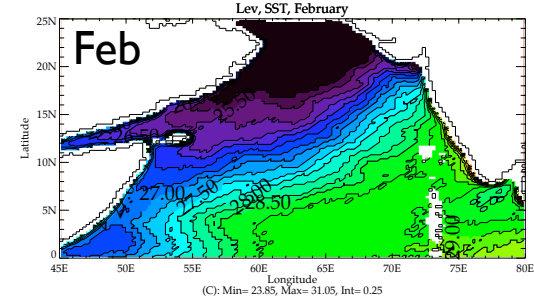
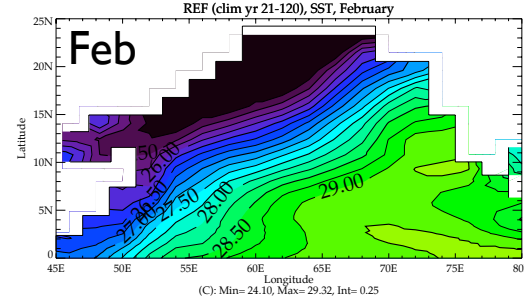
TMI (1998-2004) Precip, July



# Spring variability of the SST: mini-warm pool formation

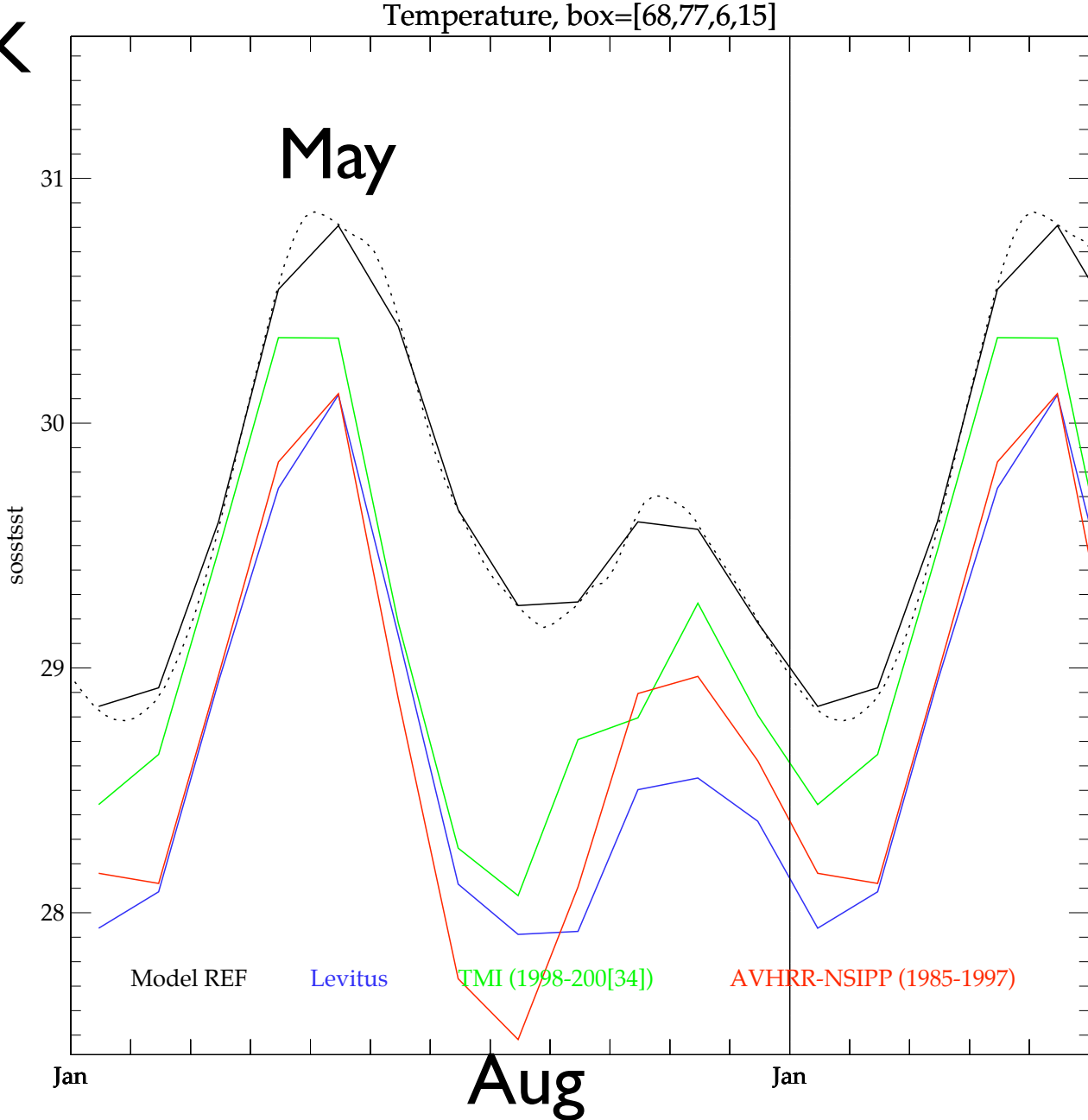
Joseph, 1990

Rao and Sivakumar, 1999



Seasonal Variability : OK  
Model Bias :  $\sim 1^{\circ}\text{C}$

Spring warming :  
Feb  $\Rightarrow$  May OK

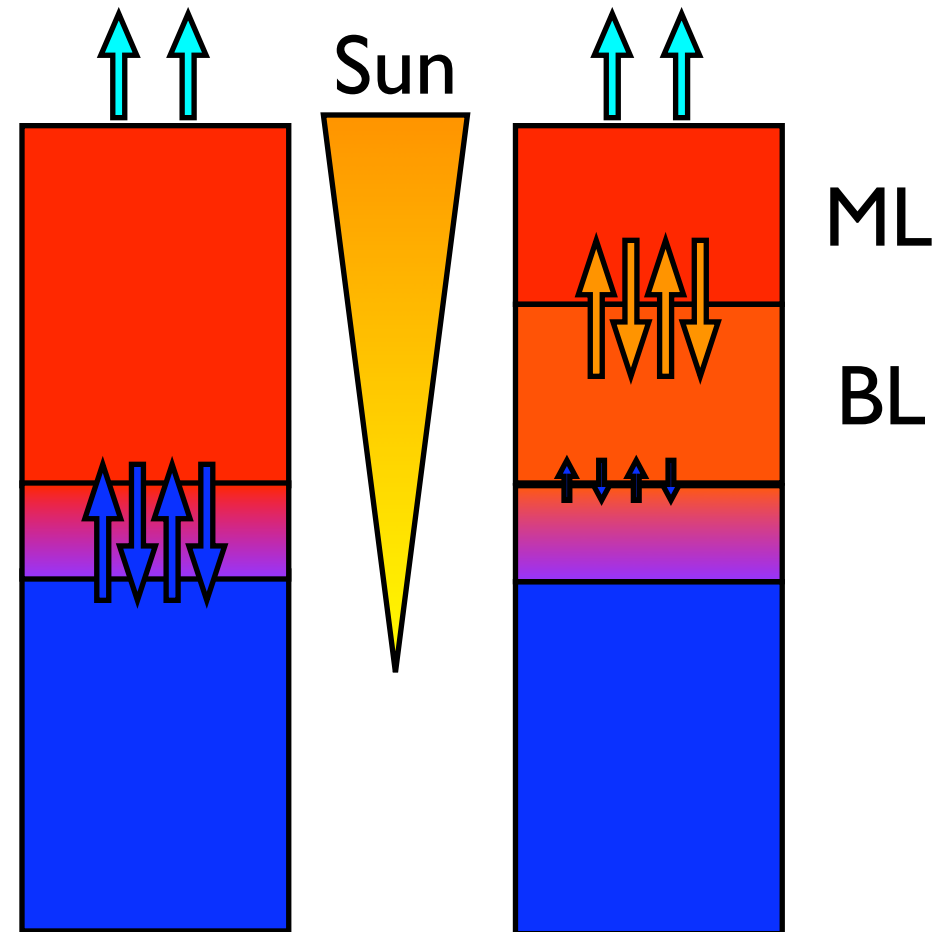


# How to explain the spring warming?

## 1) heat fluxes

- Shenoi et al. 1999
- Sengupta et al. 2002

Problems:  
early SST warming  
late SST decrease



## 2) Barrier layer

- Shenoi et al. 1999
- Durand et al. 2004

Less Solar heat flux  
Smaller thermal inertia  
weak or positive entrainment

# BLT

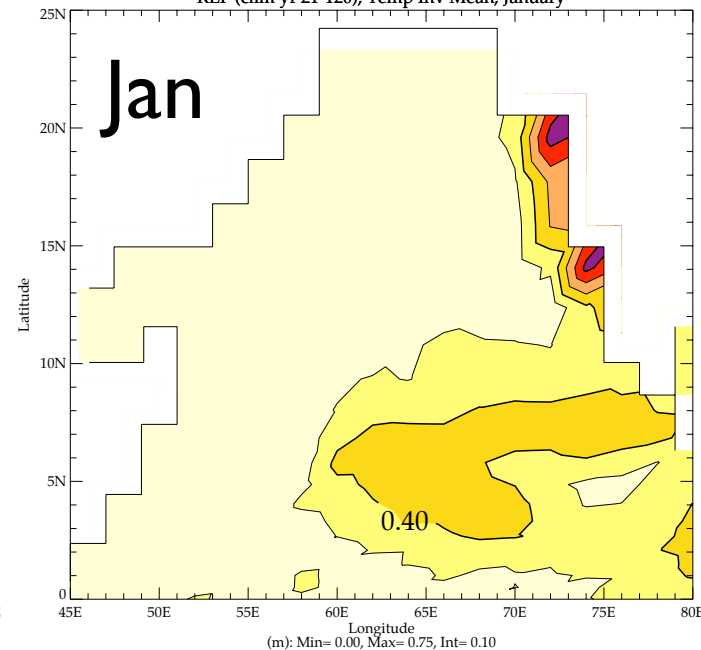
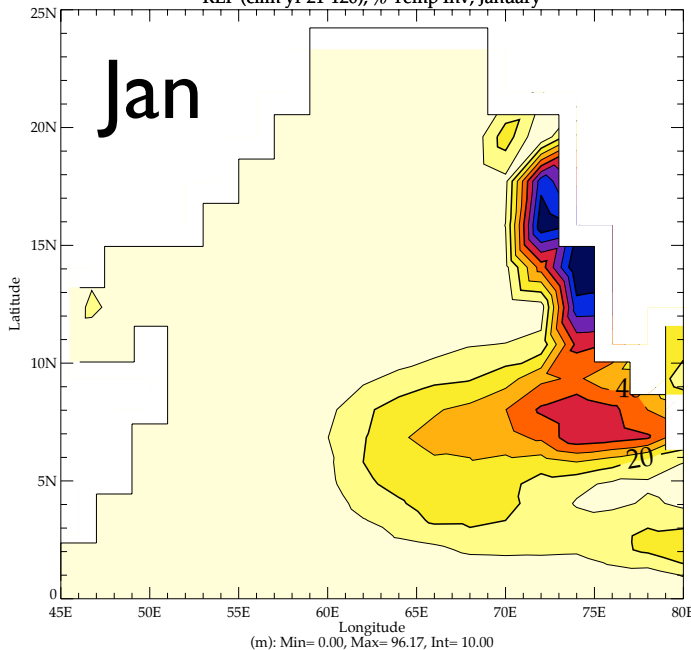
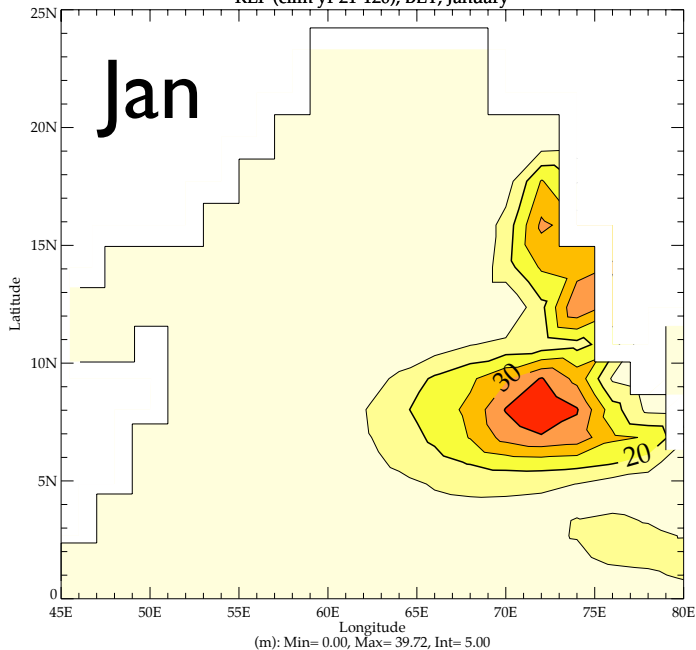
# % temp inv.

# Men temp inv.

REF (clim yr 21-120), BLT, January

REF (clim yr 21-120), % Temp Inv, January

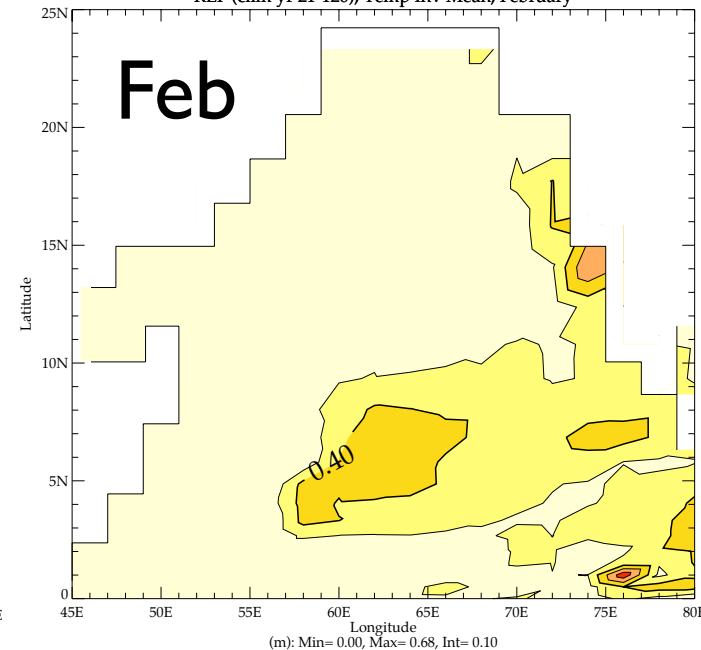
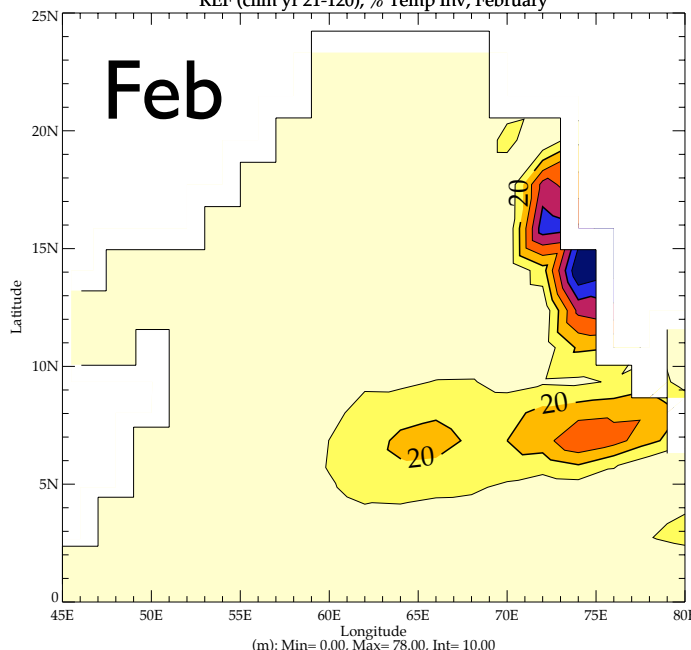
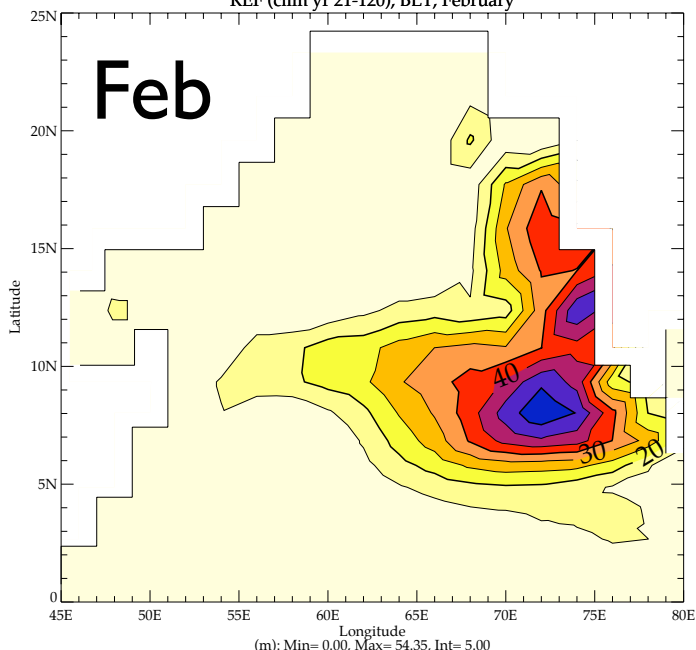
REF (clim yr 21-120), Temp Inv Mean, January



REF (clim yr 21-120), BLT, February

REF (clim yr 21-120), % Temp Inv, February

REF (clim yr 21-120), Temp Inv Mean, February

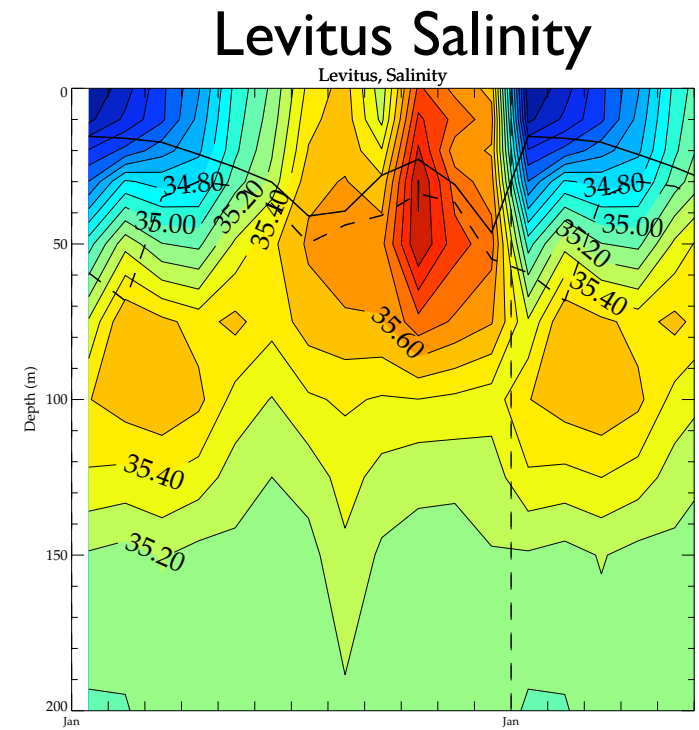
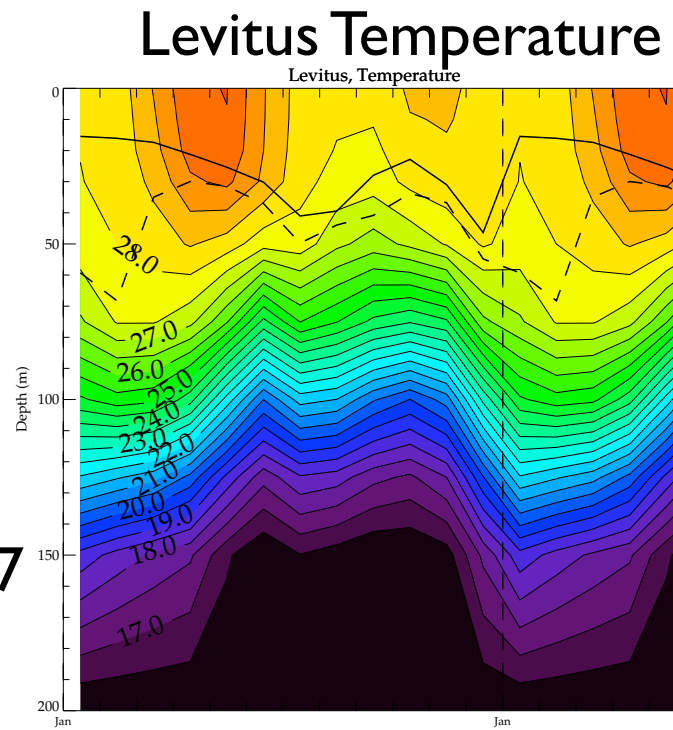




# BL formation mechanism

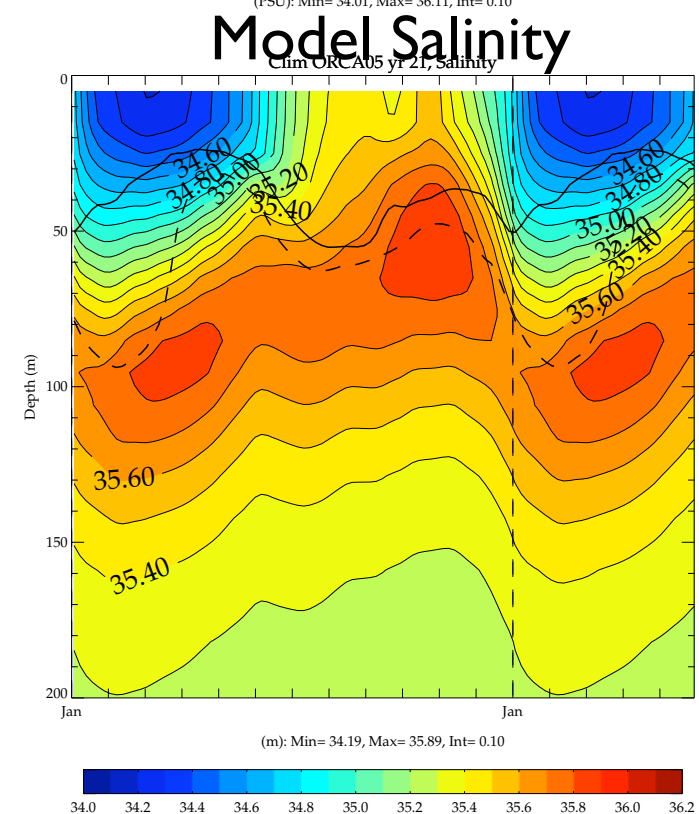
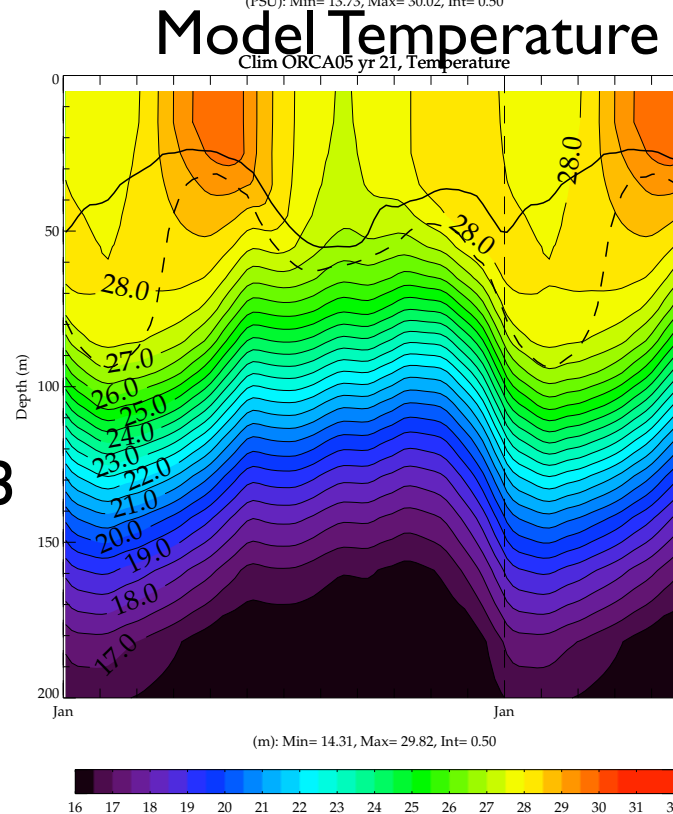
## 1) Downwelling

- Bruce 1994, 1998
- Shankar et Shetye 1997



## 2) Input of fresh water

- Shetye et al. 1991
- Rao et Sivakumar 2003



## A perturbation experiment

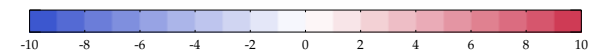
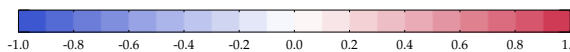
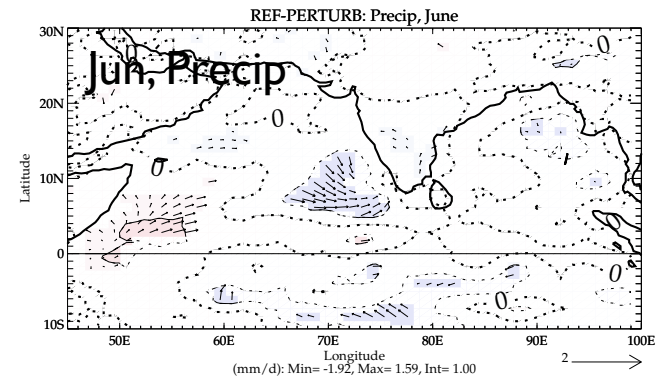
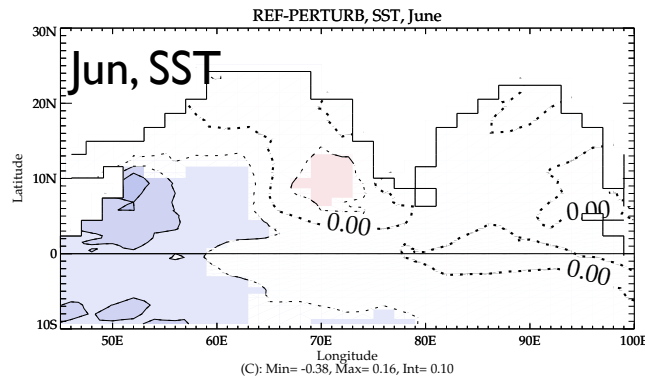
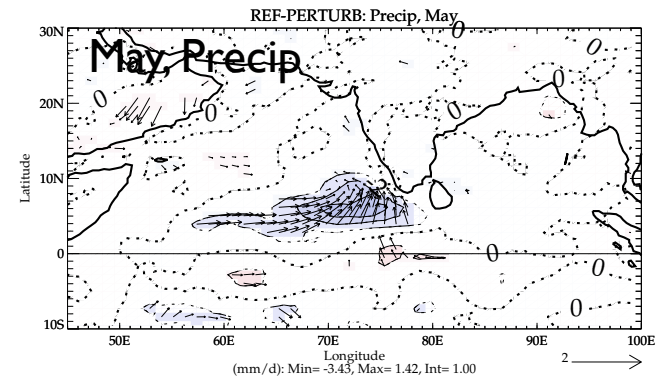
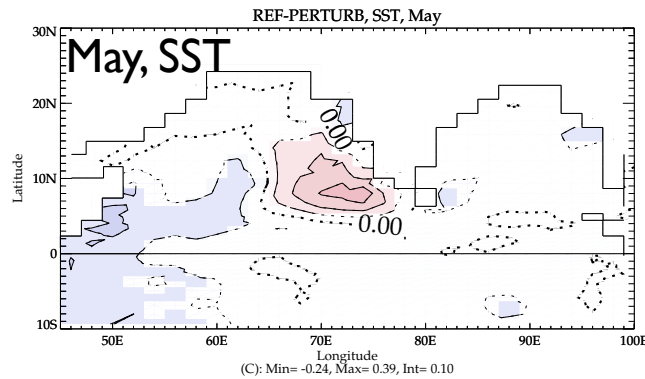
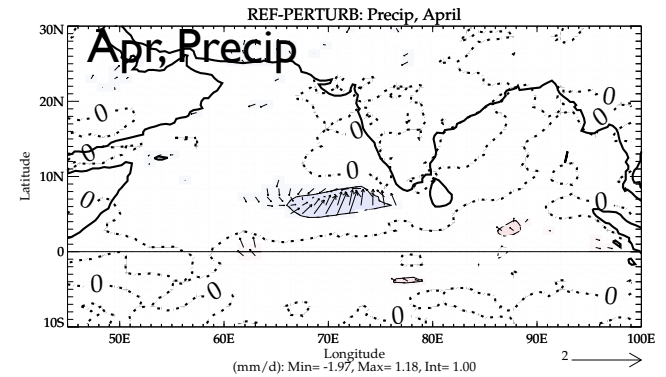
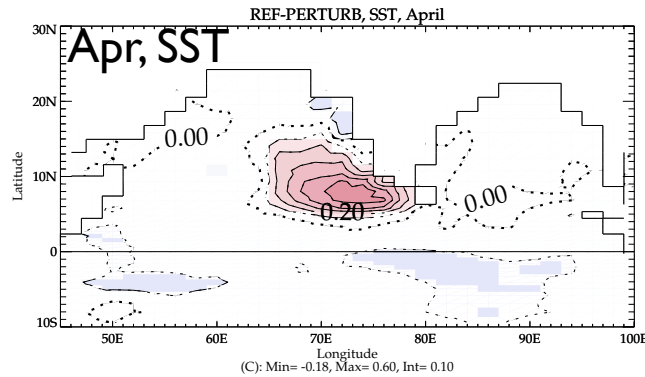
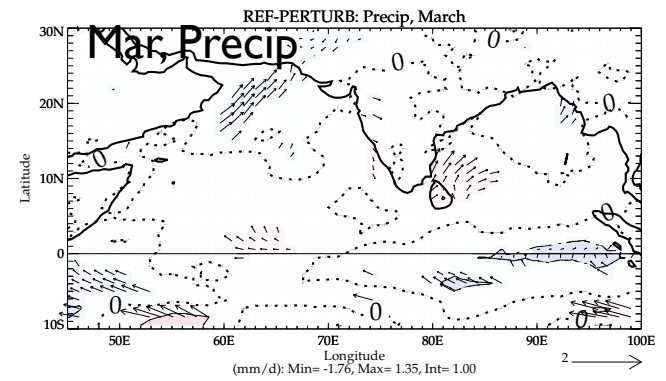
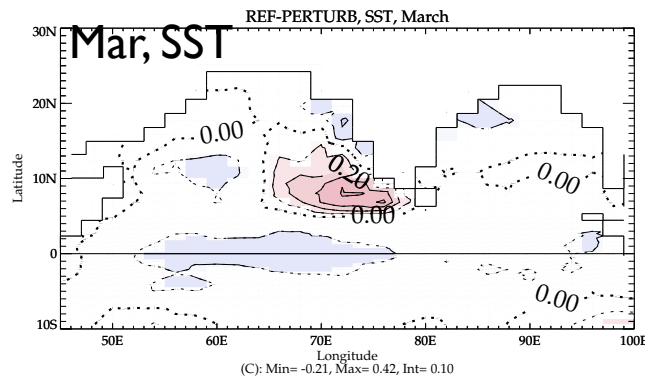
Suppress, in the SE Arabian Sea, the salt impact on the vertical stratification which controls the depth of the mixed layer

- Reference (yr 21 $\Rightarrow$ 120) :  
    **with** active salinity in the vertical stratification
- Perturbation (yr 21 $\Rightarrow$ 120) :  
    **without** active salinity in the vertical stratification

# REF - PERTURB yr 21 $\rightarrow$ 120

REF: +0.6°C in Apr

REF: +3mm/d in May



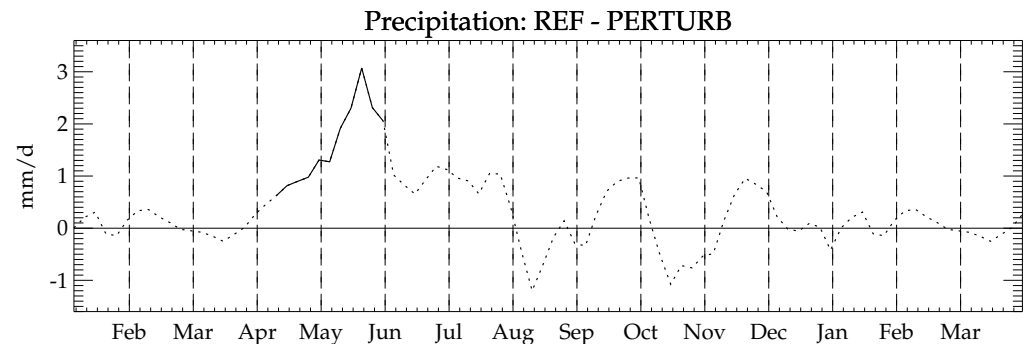
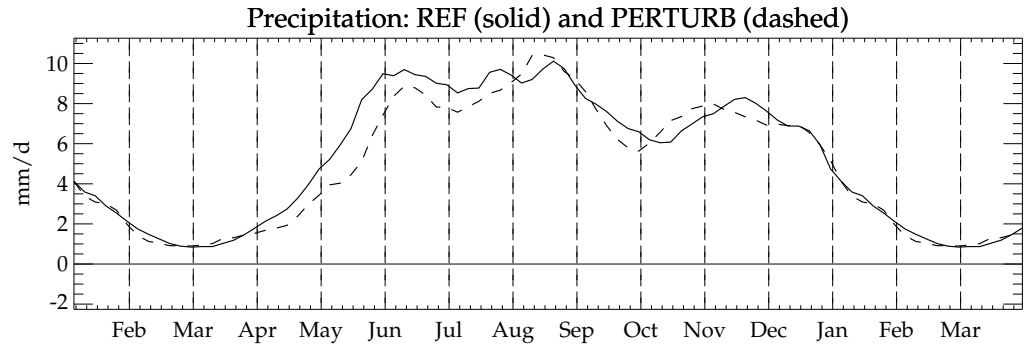
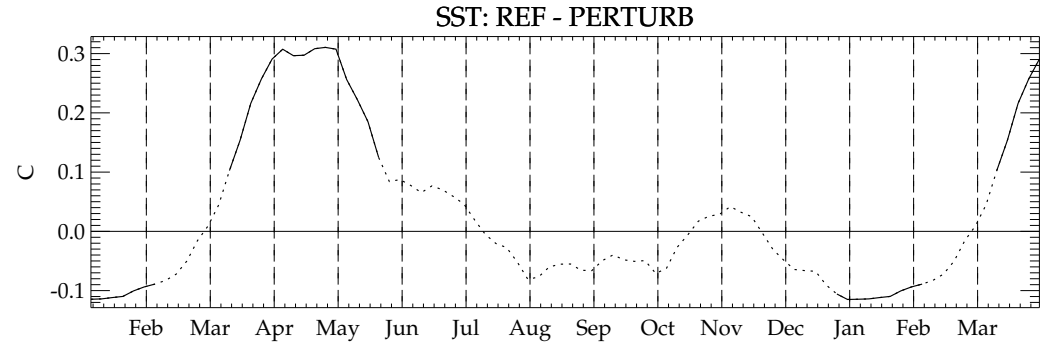
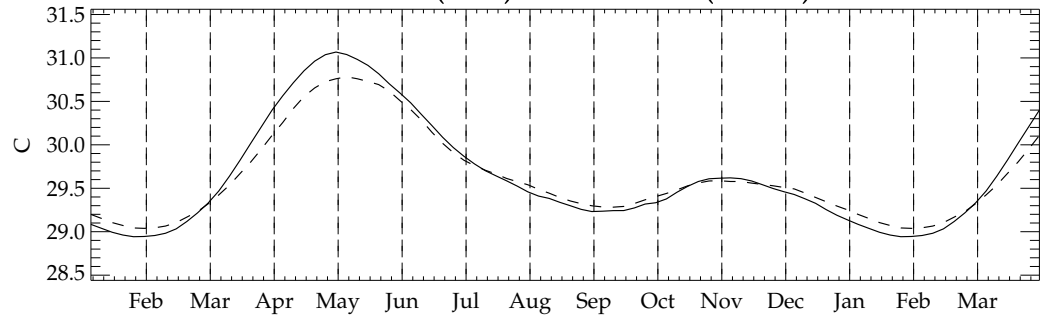
REF:

Warmer in April

More precipitation  
from April to July

REF:

earlier monsoon  
onset (15 days)



# Conclusion

Significant impact of the Barrier Layer in the SE Arabian Sea

+0.6°C in Apr

+3mm/d in May

earlier monsoon onset (15 days)

## Remaining Questions

- ▣▣▣▣ Impact of the Ocean resolution
  - better ocean circulation in the SouthEast Arabian Sea
  - thinner salinity stratification
- ▣▣▣▣ Impact on the onset of the monsoon => interannual variability