

# **Sea-level expression of intrinsic and forced interannual variabilities: a global OGCM study**

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DRAKKAR Ocean Modelling Project

*In revision, J. Climate*

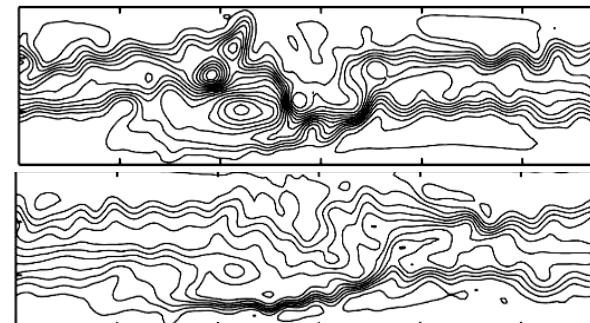
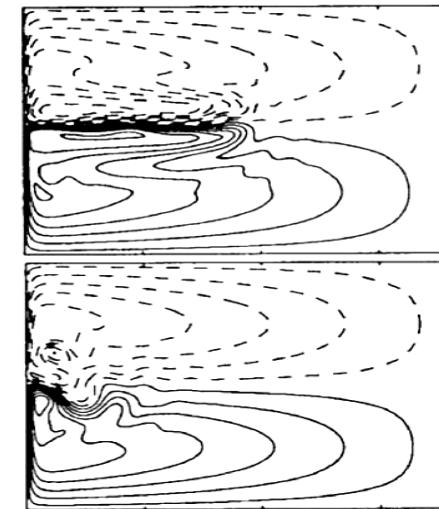


# Idealized studies (e.g. QG, SW, box, channel, sinus wind, ...)

## Mesoscale eddies + constant forcing $\rightarrow$ chaotic intrinsic interannual variability

(e.g. Jiang et al. '95, McCalpin & Haidvogel '96, Dijkstra and Ghil '05, etc)

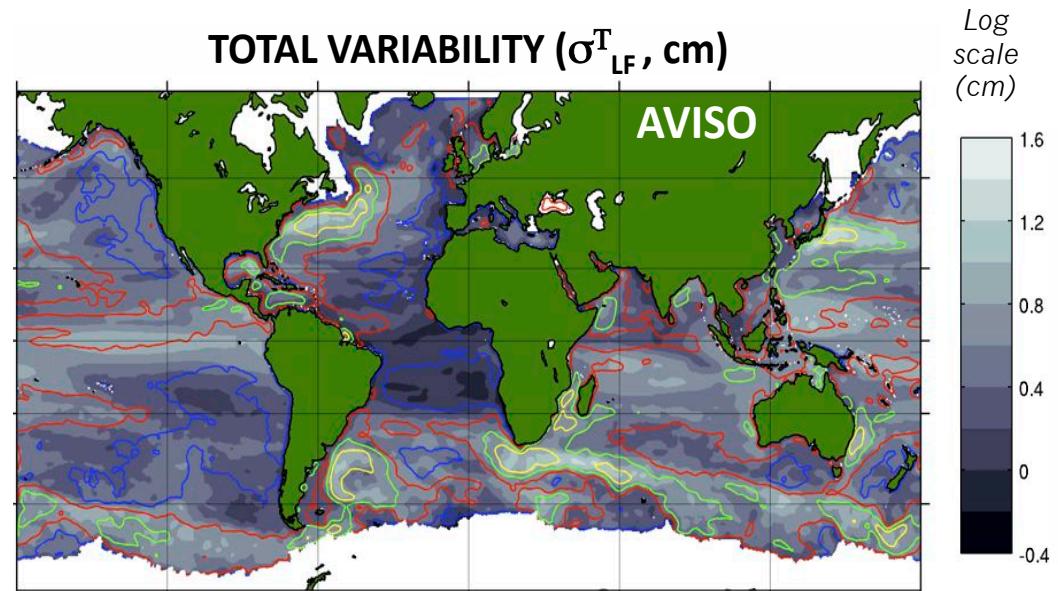
- GS/Kuroshio (path, transport, length)  
*Mean vs. eddy PV advection (Dewar '03; Spall '96)*
- Recirculation gyres (shape, intensity)  
*(Berloff & McWilliams '99)*
- Mode water (thickness, volume)  
*Mean vs. low-freq PV advection (Hazeleger & Drijfhout '00)*
- ACC (path, transport)  
*Mean flow / eddies / topography (Hogg & Blundell '06)*
- Other possible processes  
*Inverse cascade (Kraichnan '67; Scott & Arbic '07)*  
*Integration of atm/eddy noise (Hasselman '76 ; Sura '03)*
- Eddying realistic context ? regional studies only, rare observational references



# This study

Hyp: Total variability = Intrinsic + Forced

Magnitude and distribution  
of intrinsic and forced  
interannual SLA variability  
in a realistic context ?



- **Global ocean/sea-ice model**

(DRAKKAR Group, '07; Penduff et al '10)

**Seasonal forcing : no interannual forcing**

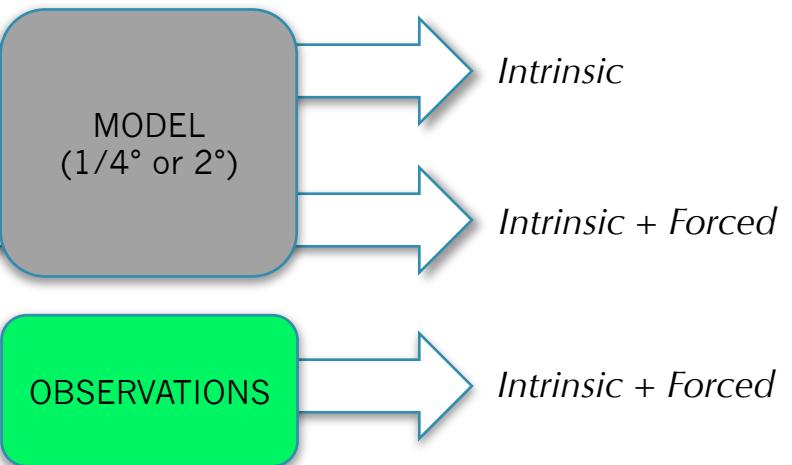
Repeated daily ECMWF climatology

**Full forcing : direct interannual forcing**

1958-2004 daily ECMWF reanalysis (Brodeau et al '10)

- **Observations:** Sea-Level Anomalies (AVISO)

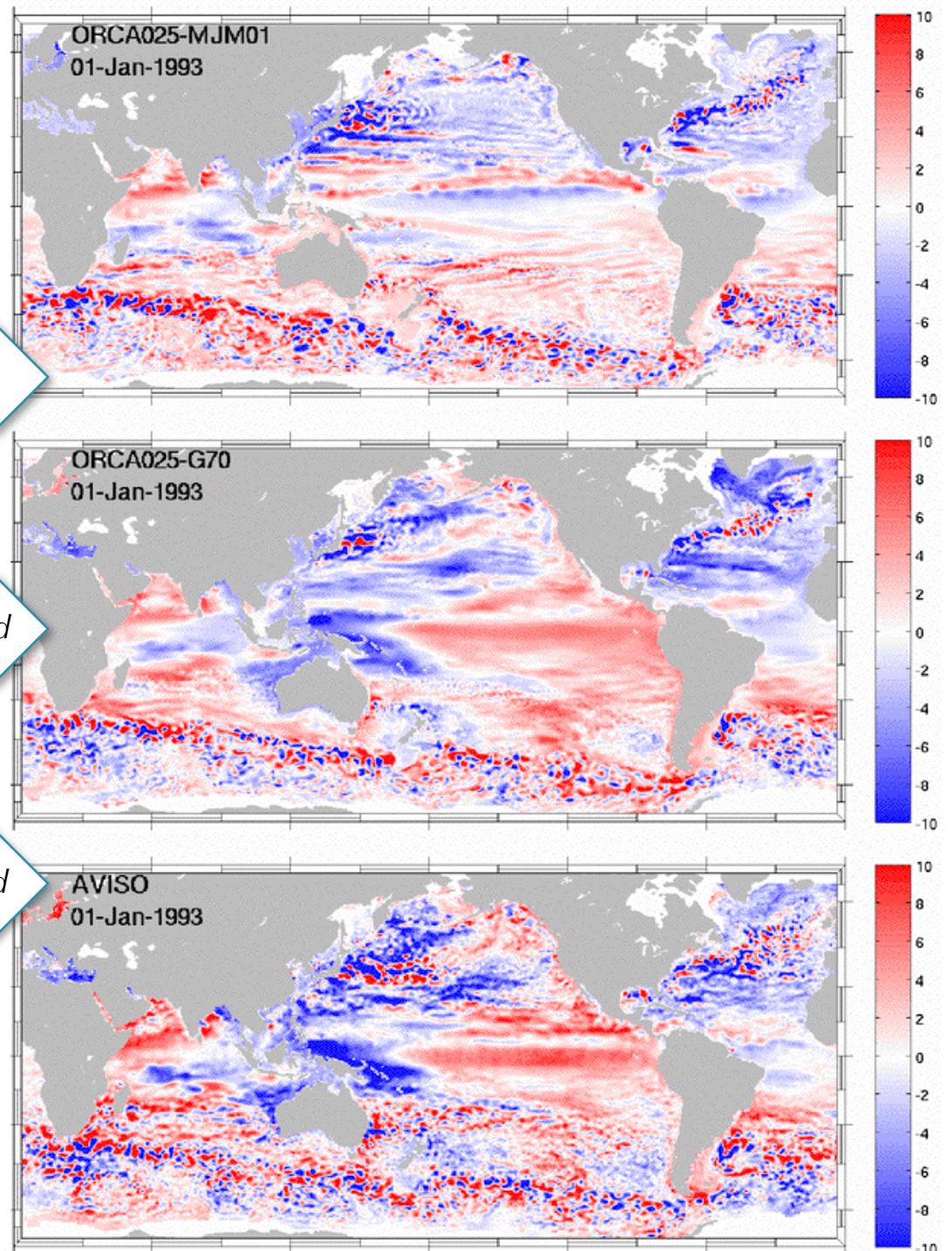
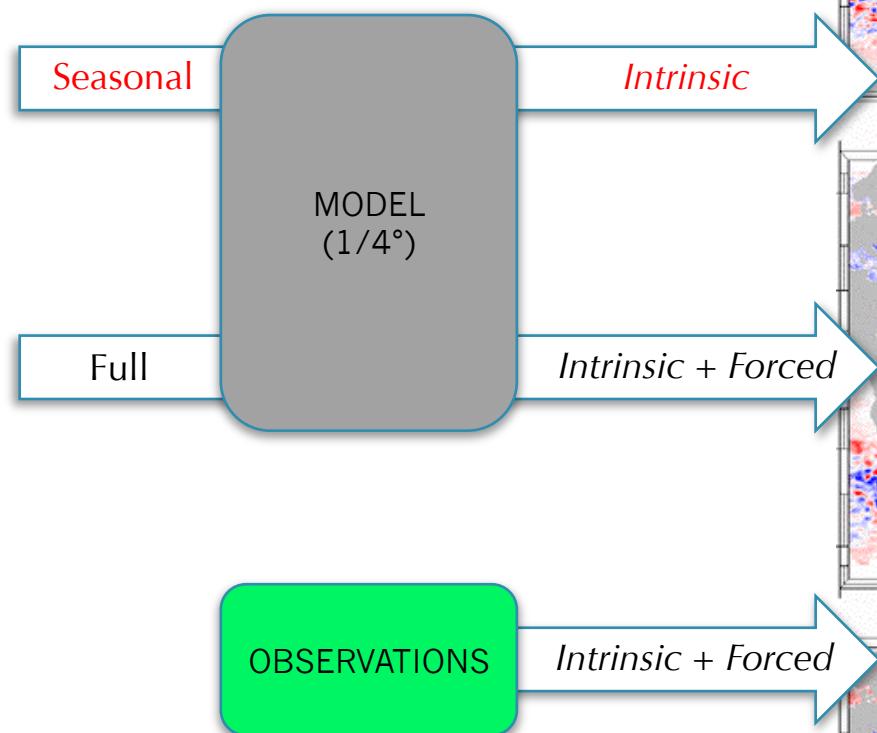
Altimetry : 1993-present, weekly maps



# Dataset

Atmospheric  
Forcing

Sea-level anomalies  
1993-2004  
 $T > 18\text{months}$



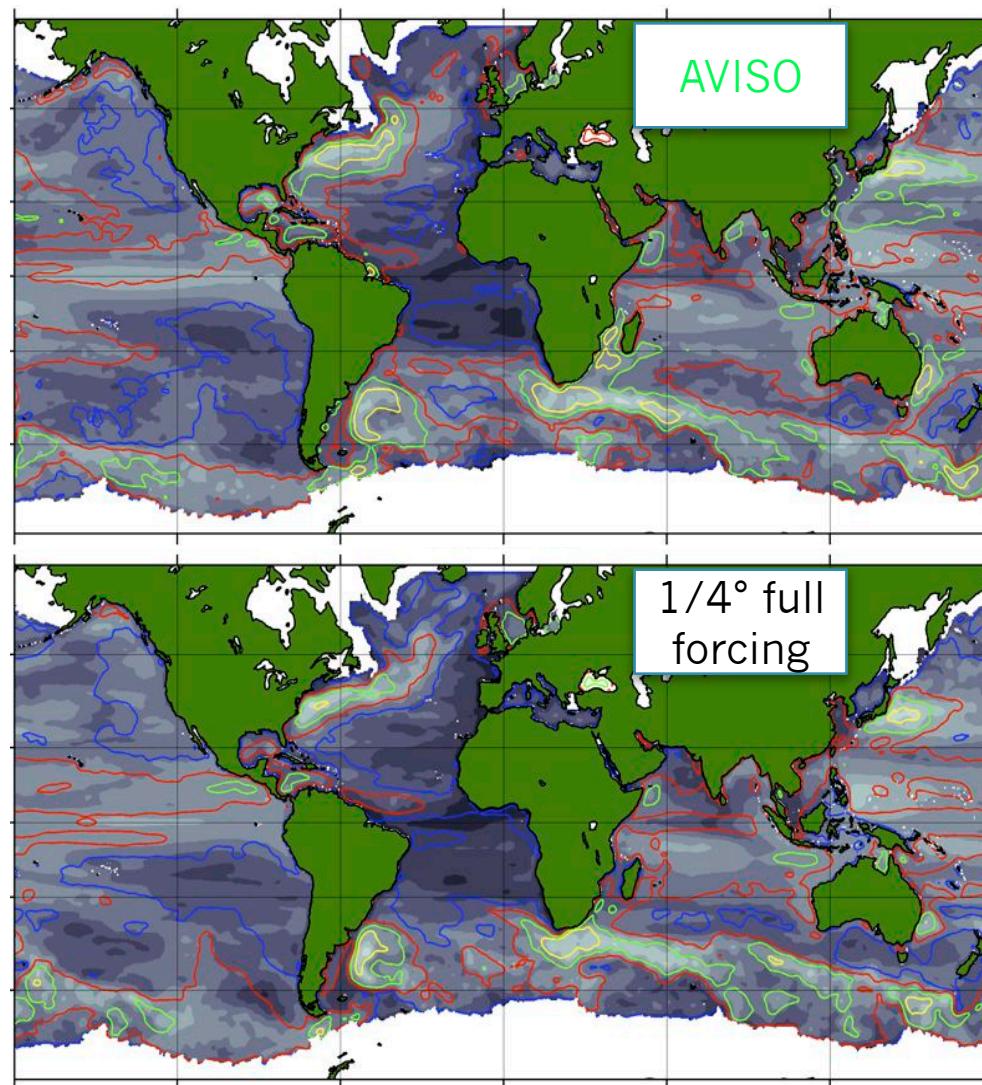
# Total STD's: AVISO vs $1/4^\circ$ run

Realistic magnitudes

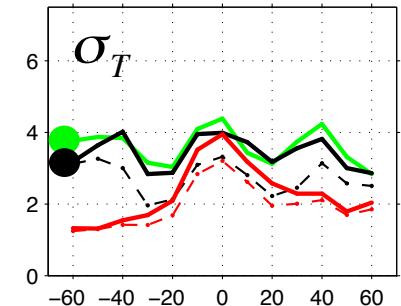
Realistic patterns

**Realistic  
interannual  
variability in the  
« pivot » experiment**

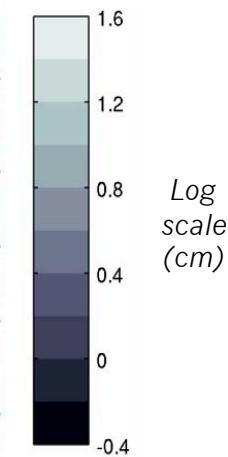
Further assessed in  
*Barnier et al., 2006;*  
*DRAKKAR Group, 2007;*  
*Treguier et al., 2007;*  
*Penduff et al., 2007;*  
*Lique et al., 2009;*  
*Lombard et al., 2009;*  
*Penduff et al., 2010*



Low-Frequency



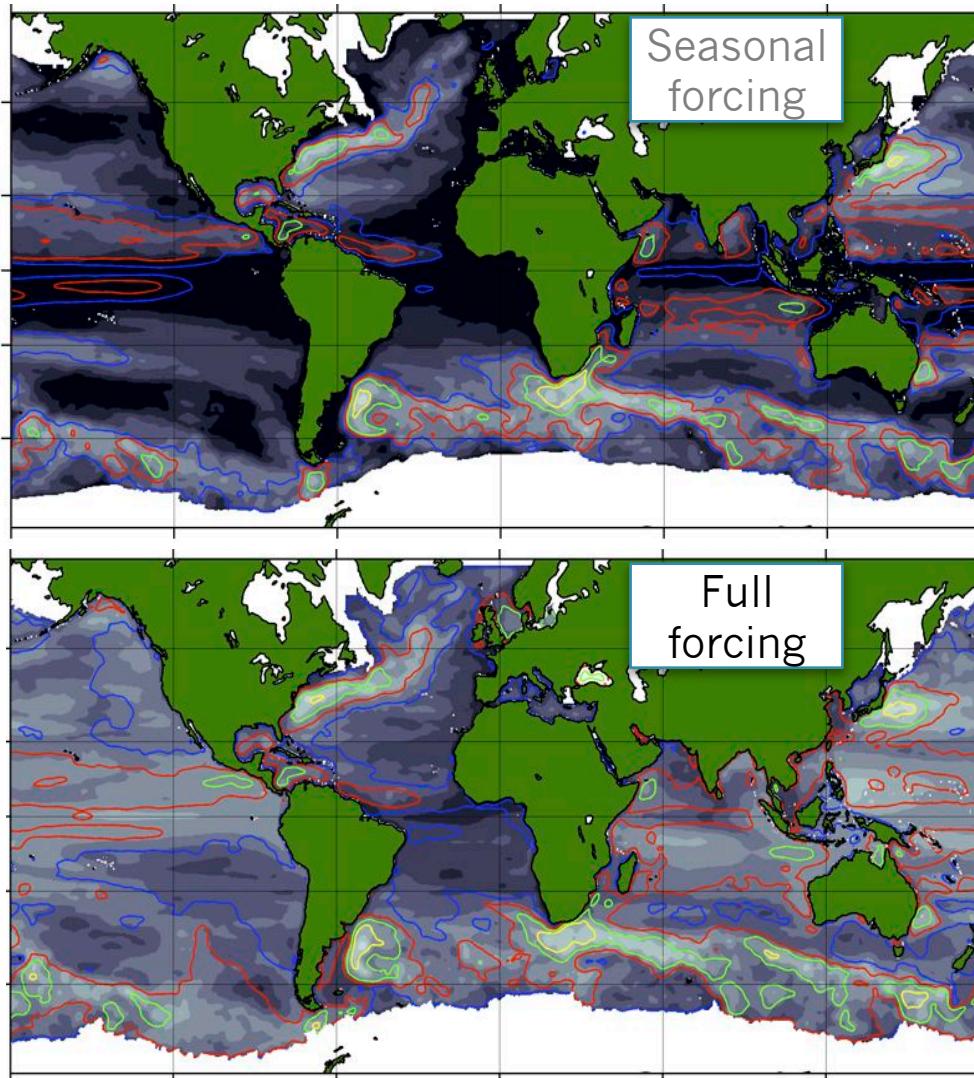
Latitude



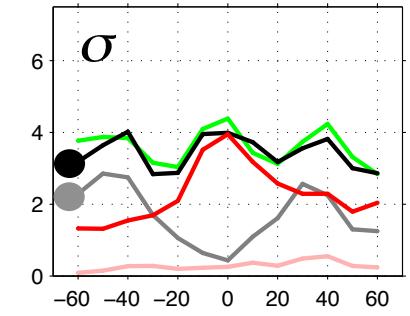
# $1/4^\circ$ runs: Total vs Intrinsic STD's

Southern Ocean and mid-latitudes:  
50-80% interannual variance without direct forcing

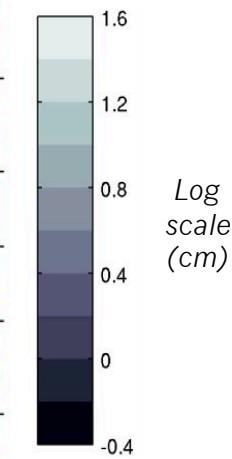
Large interannual intrinsic variability in eddying regions



Low-Frequency



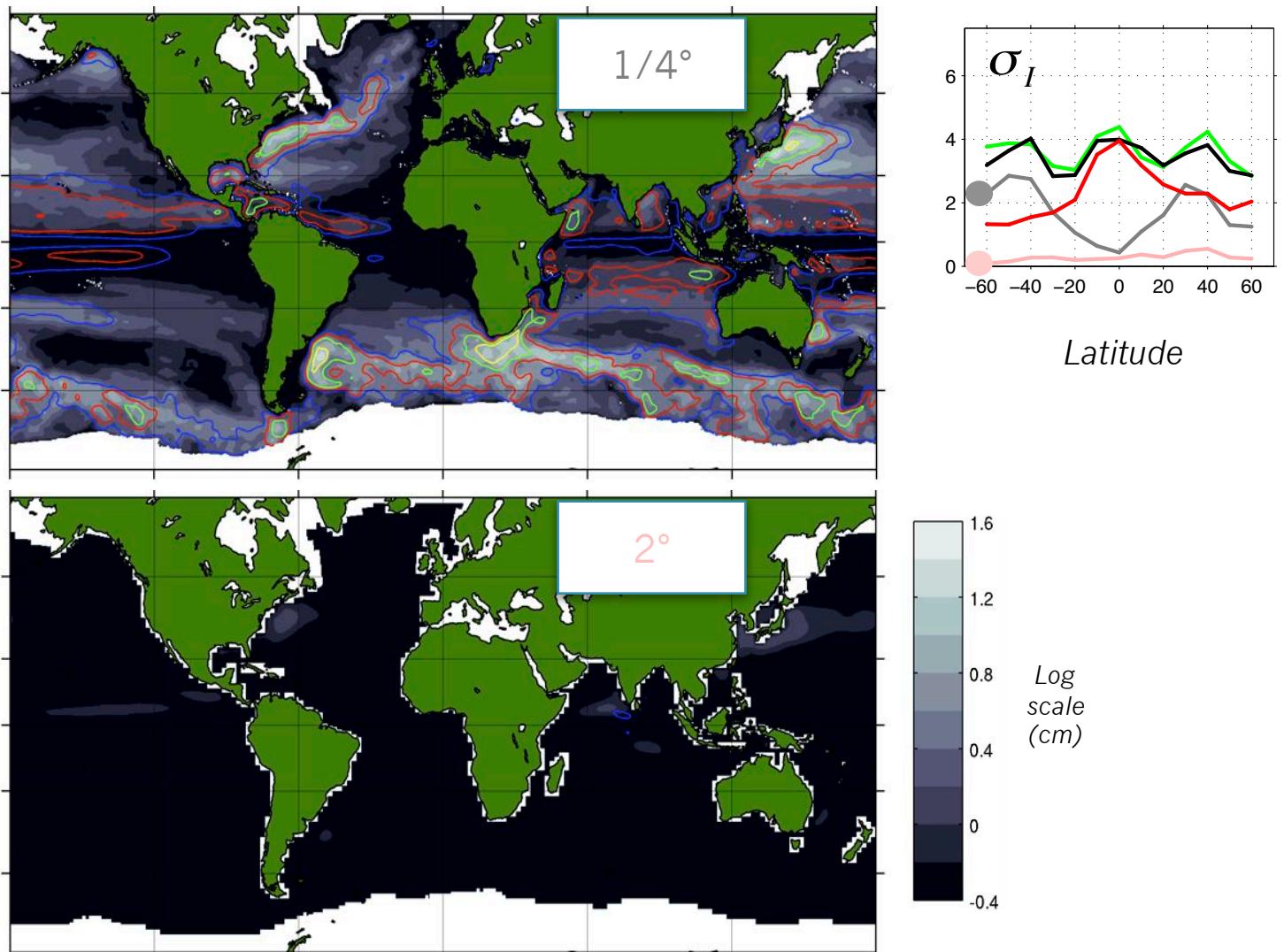
Latitude



# Intrinsic STD's: $1/4^\circ$ vs $2^\circ$

Coarse resolution  
(IPCC-like) →  
Huge decrease in  
intrinsic variab.

High resolution is  
required for  
substantial  
interannual intrinsic  
variability



# Forced STD's: $1/4^\circ$ vs $2^\circ$

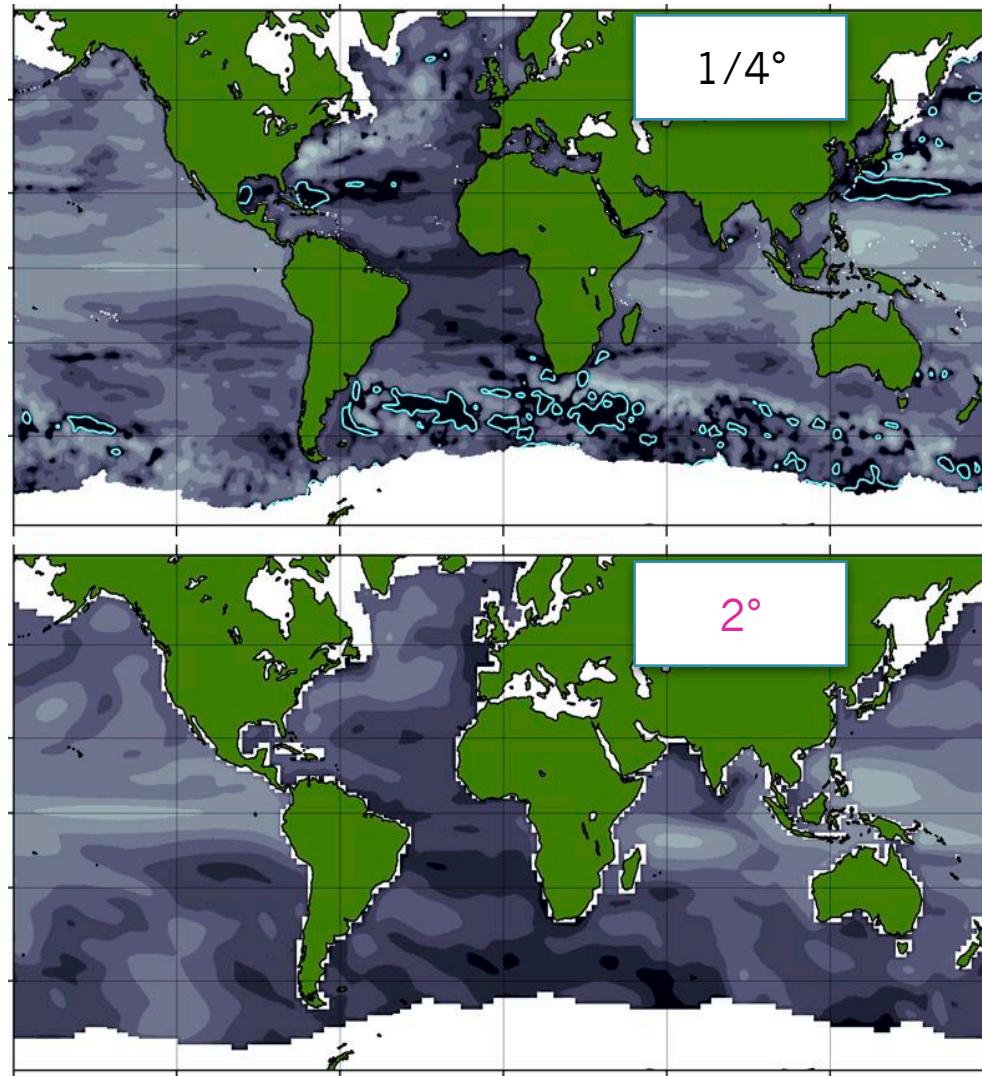
Assuming  
 $C(\text{Forced}, \text{Intr.})=0$

(exceptions) →

$$\sigma^F = \sqrt{(\sigma^T)^2 - (\sigma^I)^2}$$

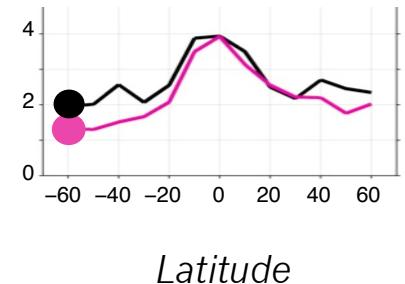
Forced variability  
weakly depends on  
resolution

(large-scale Sverdrup,  
RW dynamics)

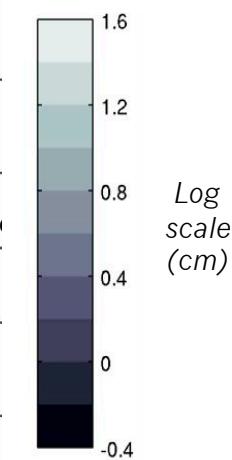


Low-Frequency

$\sigma_F$



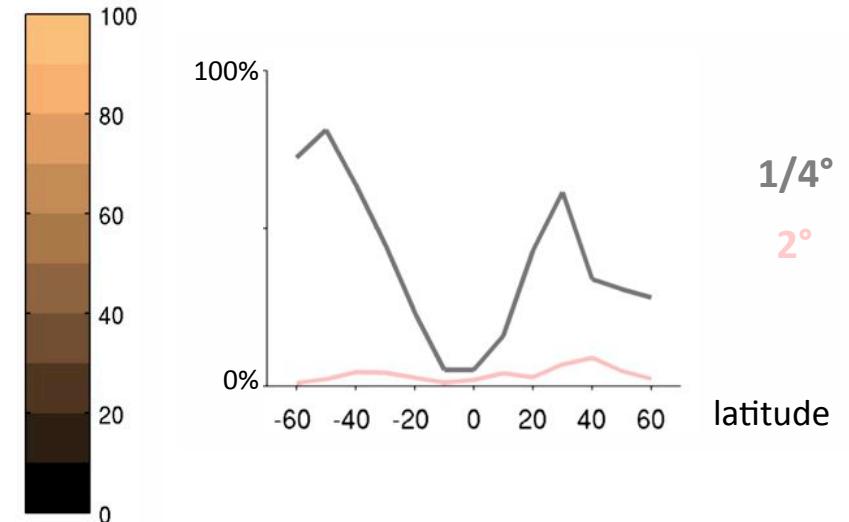
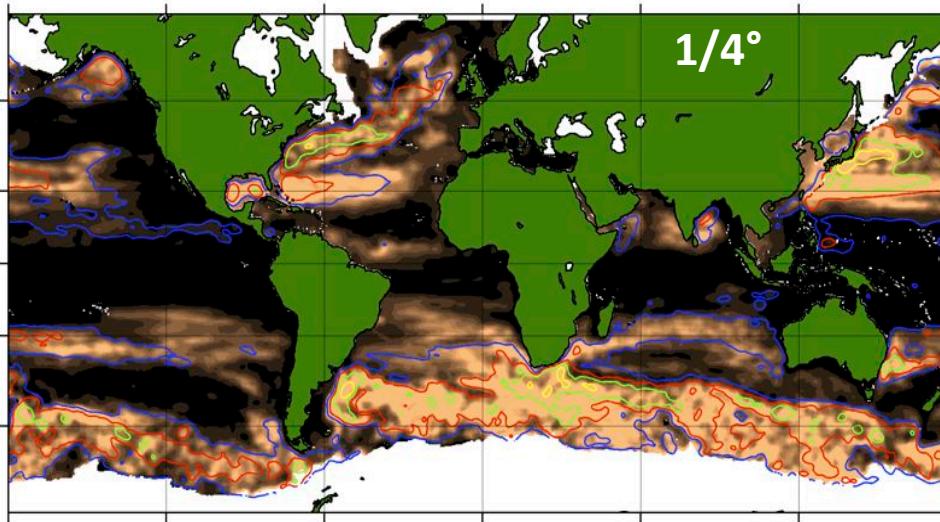
Latitude



Log  
scale  
(cm)

# SLA interannual variability: Conclusions

Percentage of total SLA variance due to intrinsic



- **Total interannual variability ( $1/4^\circ$ )** : close to **observations** (magnitude, distribution)

## Intrinsic SLA variability:

- ✓ Where mesoscale activity
- ✓ Up to **50-70%** of total (zonal aver.)
- ✓ T~2-10 years

## Forced SLA variability:

- ✓ Comparable at  $1/4^\circ$  and  $2^\circ$
- ✓ More linear?
- ✓ Interaction with intrinsic?

- **Total interannual variability at  $2^\circ$**  is 2-3 times too small : no intrinsic component
- If SST variance affected → atmospheric response ? Finer resolution?