SEA LEVEL CHANGE IN THE LAST DECADE- WHAT DO WE UNDERSTAND?

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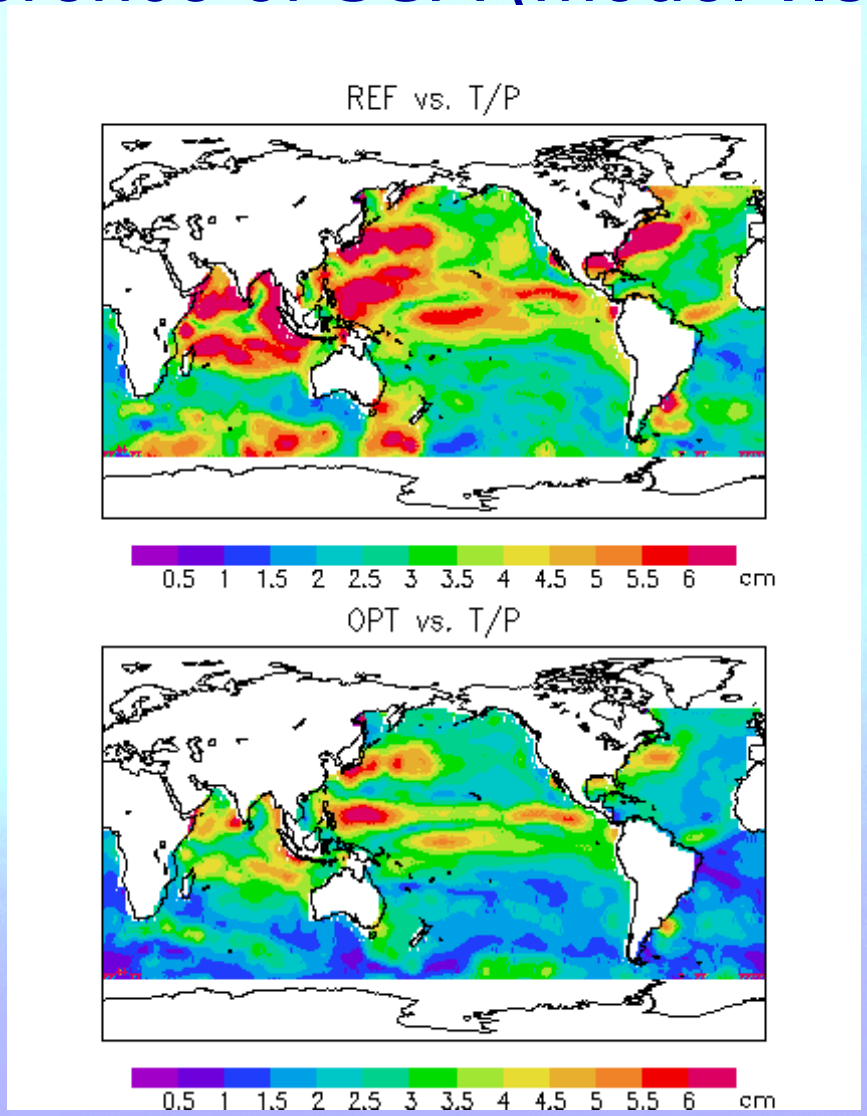
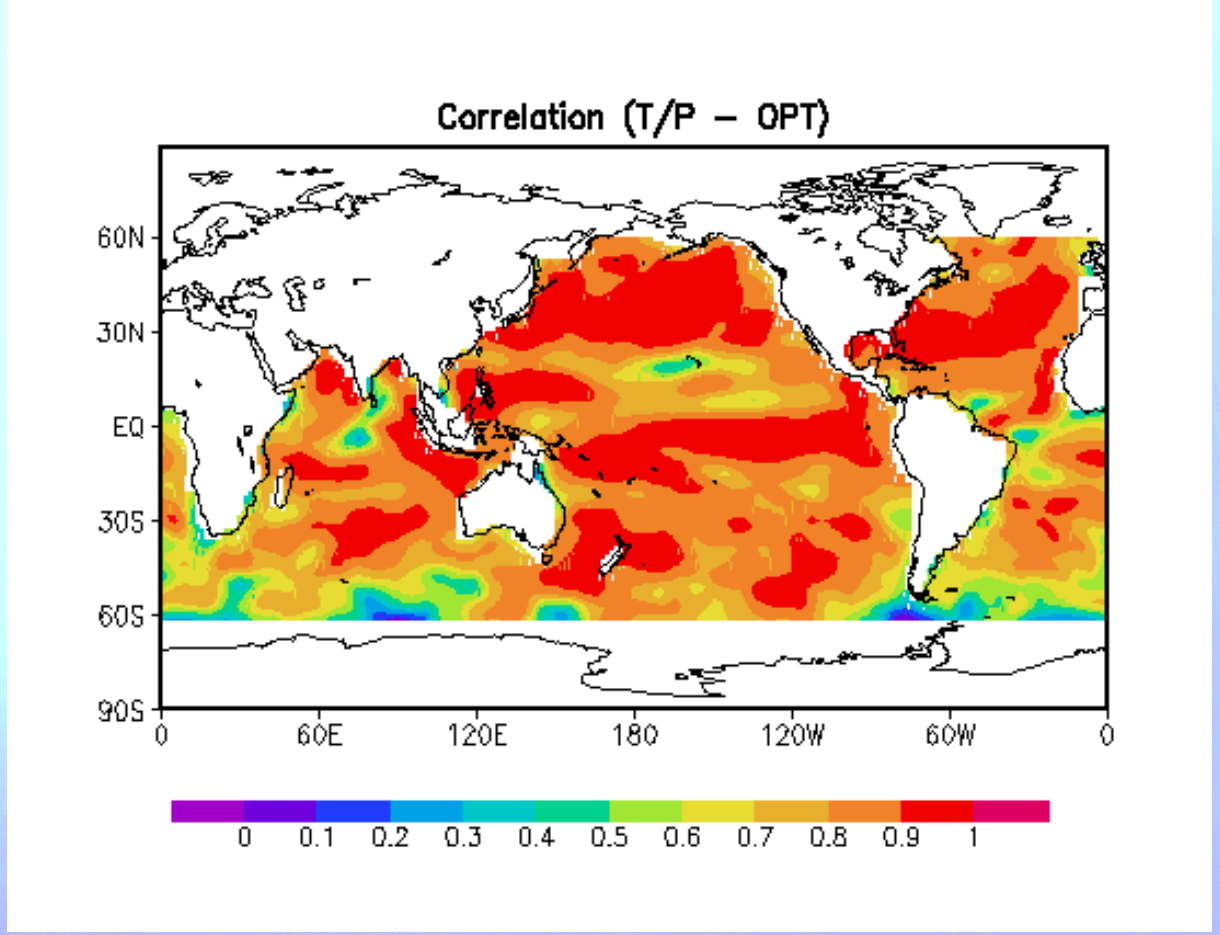
sea level change 1993-2001

- Model: LSG (2° x 2 ° in the horizontal, 23 vertical layers)
- Method: 4D VAR data assimilation
- As control parameters we use the model initial state and the model forcing (heat flux, P-E, wind-stress)
- Nine years (1993-2001) T/P data, Reynolds SST are assimilated into the model
- Additionally Levitus climatology, transports of heat and freshwater are used to constrained the model trajectory (but with low weights)

RMS difference of SSA (model v.s. T/P data)

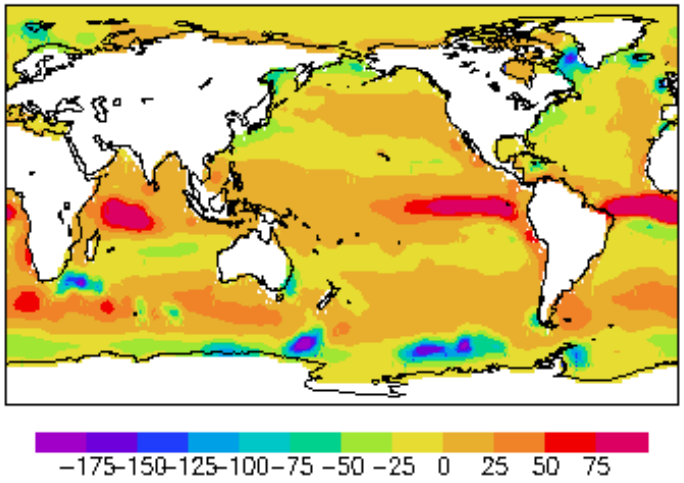


SLA correlation (1993-2001)

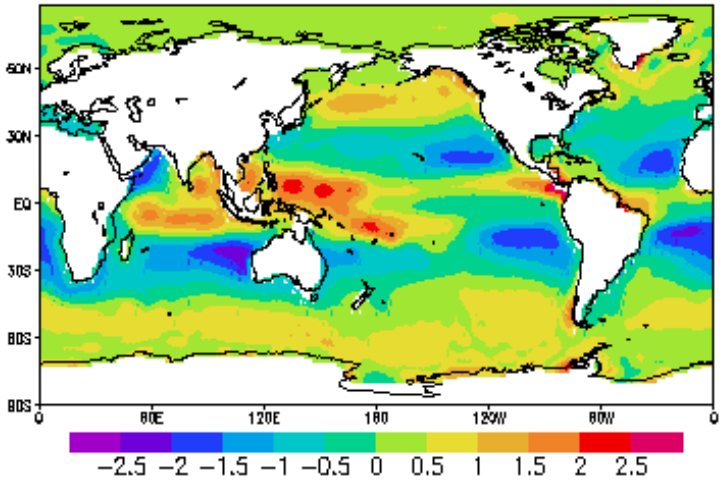


heat and freshwater fluxes

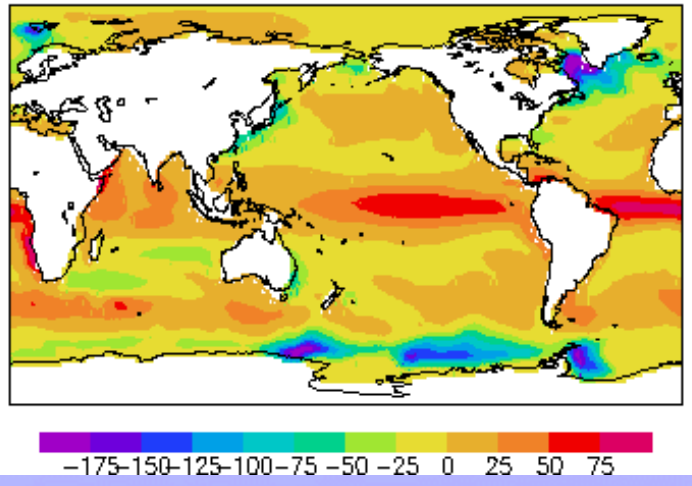
MEAN OPTIMIZED HEATFLUX (W/m²)



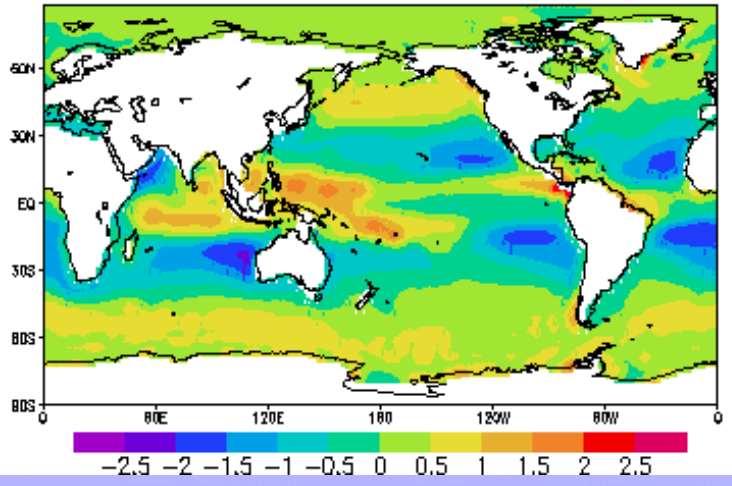
MEAN OPTIMIZED FRESHWATER FLUX (m/year)



MEAN HEATFLUX (W/m²)



MEAN FRESHWATER FLUX (m/year)

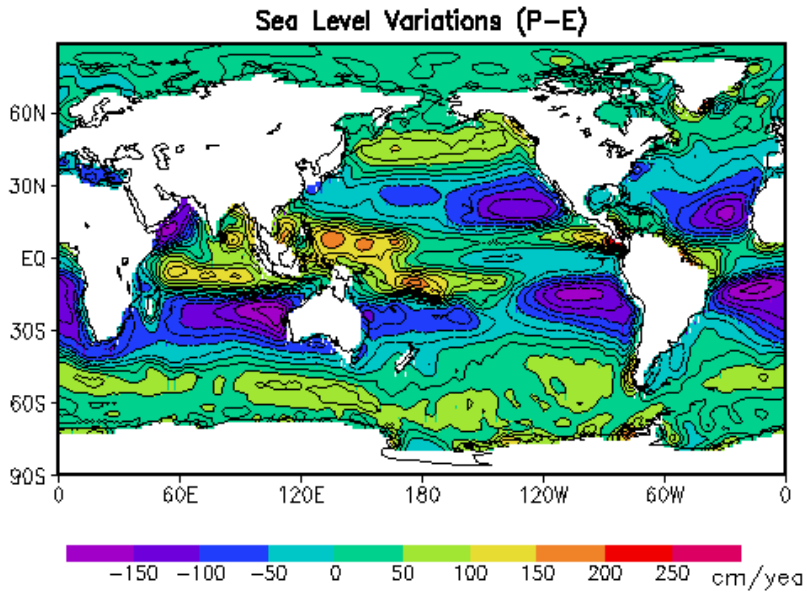


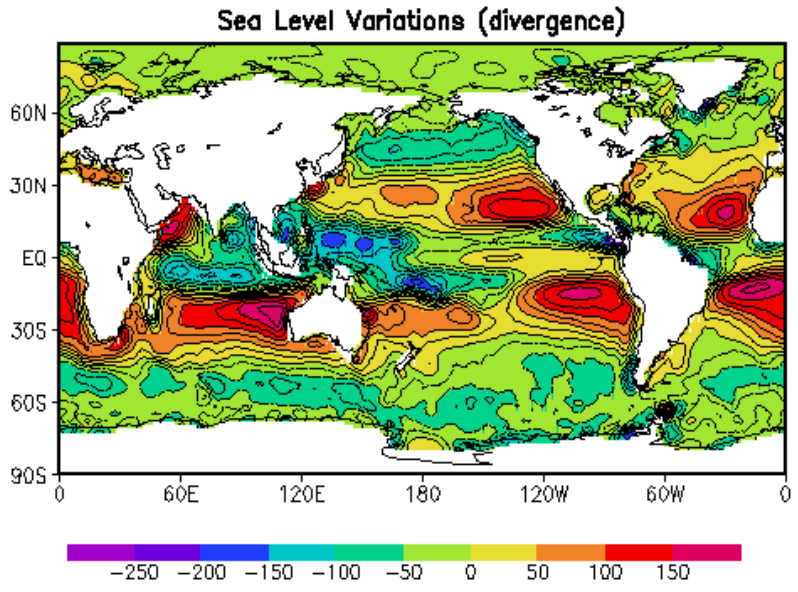
local sea level changes due to:

$$\frac{\partial}{\partial t}\zeta = P - E + \nabla . \int_{-H}^{\zeta} \vec{v}\, dz + A_h \Delta\zeta + \int_{-H}^{\zeta} \frac{1}{\alpha}\frac{\partial \alpha}{\partial T}\bigg|_{S,p} \frac{\partial}{\partial t} T\, dz + \int_{-H}^{\zeta} \frac{1}{\alpha}\frac{\partial \alpha}{\partial S}\bigg|_{T,p} \frac{\partial}{\partial t} S\, dz$$

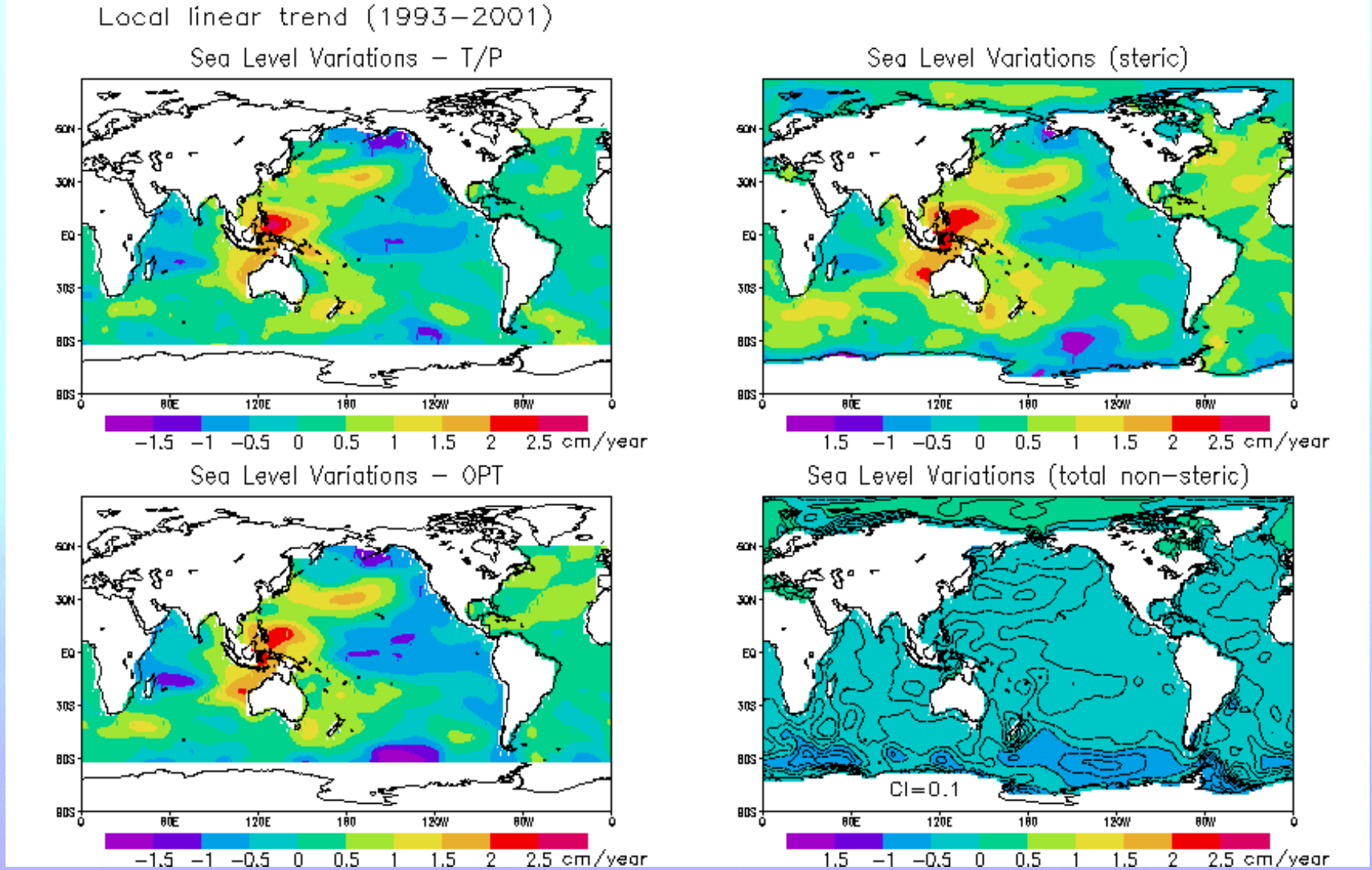
- freshwater flux
- divergence
- sub grid gravity waves
- thermosteric
- halosteric

divergence (almost) compensates P-E



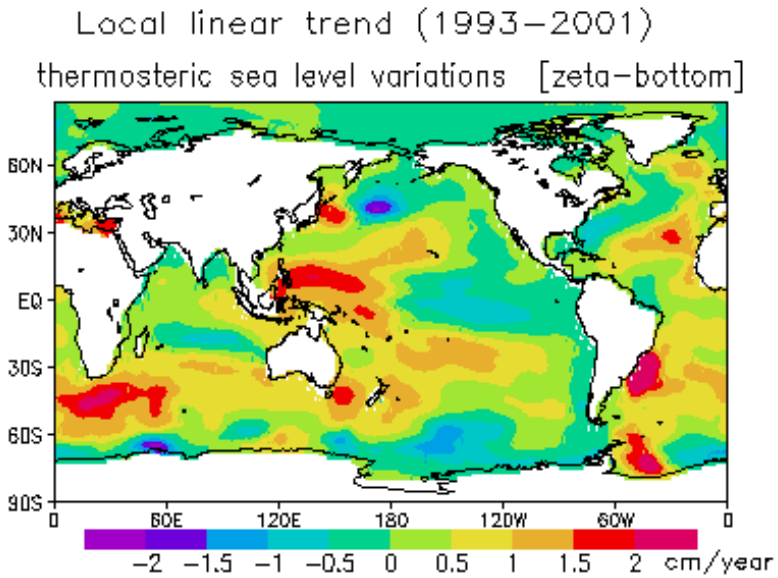


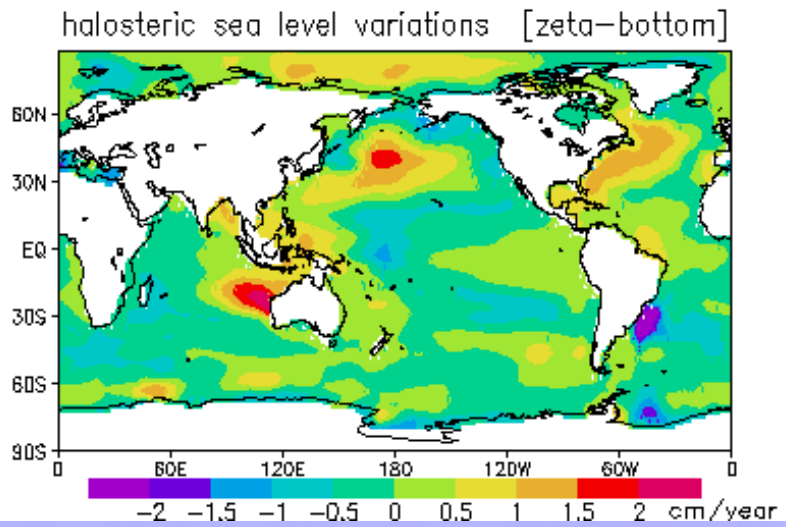
sea level trends



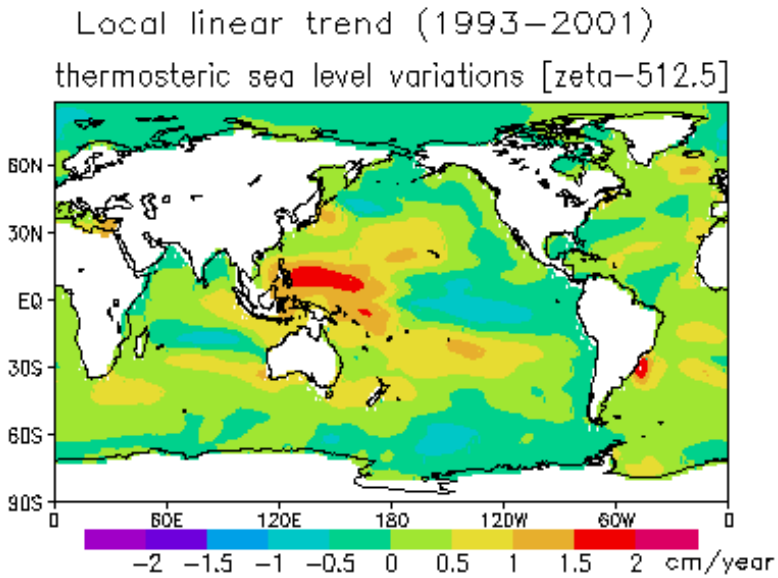
steric sea level trends

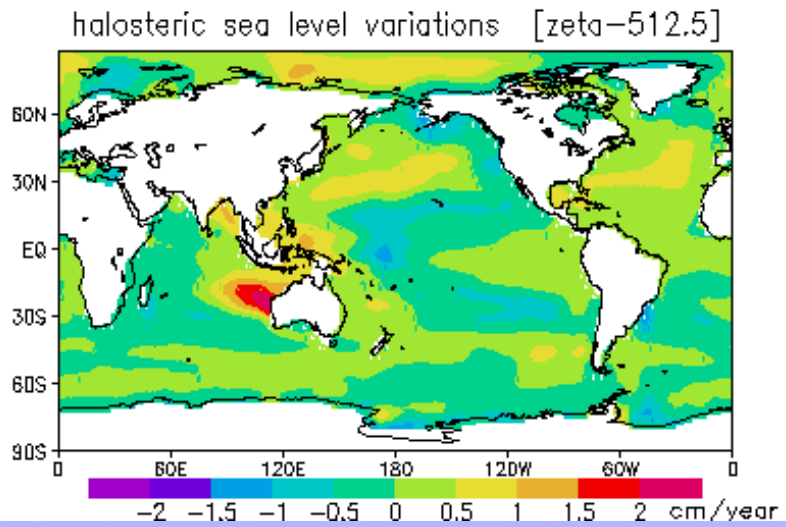
full depth





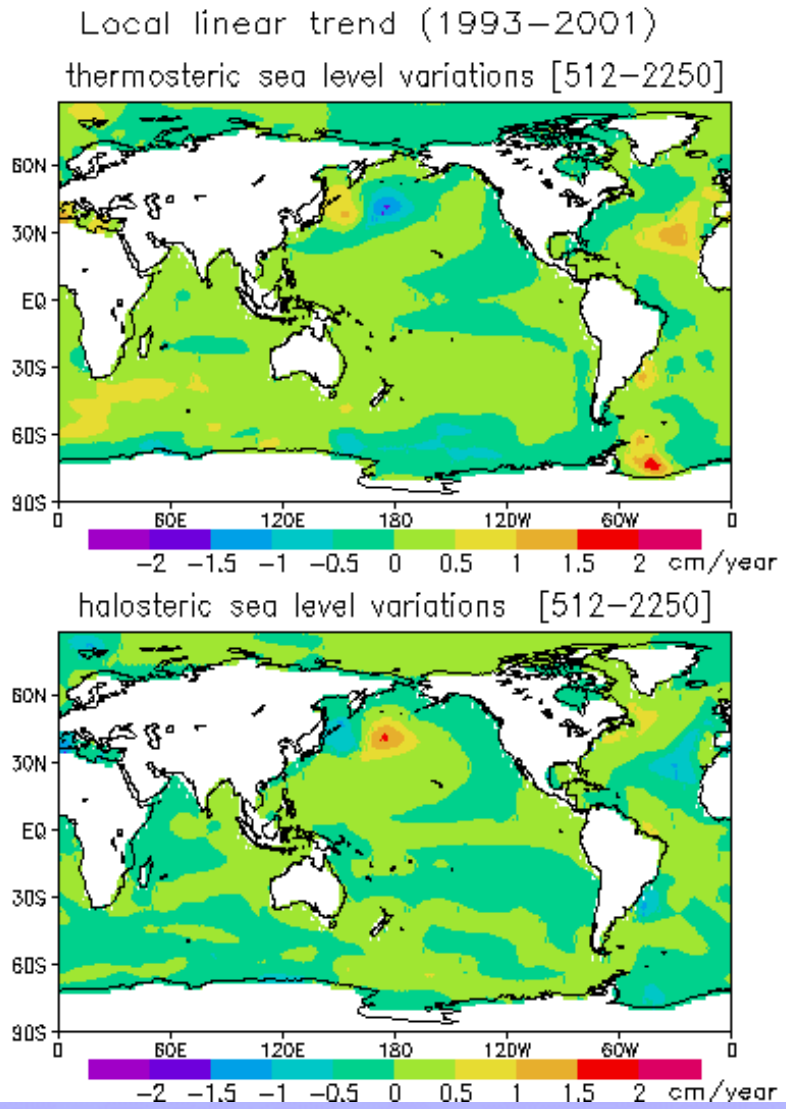
upper 512 m



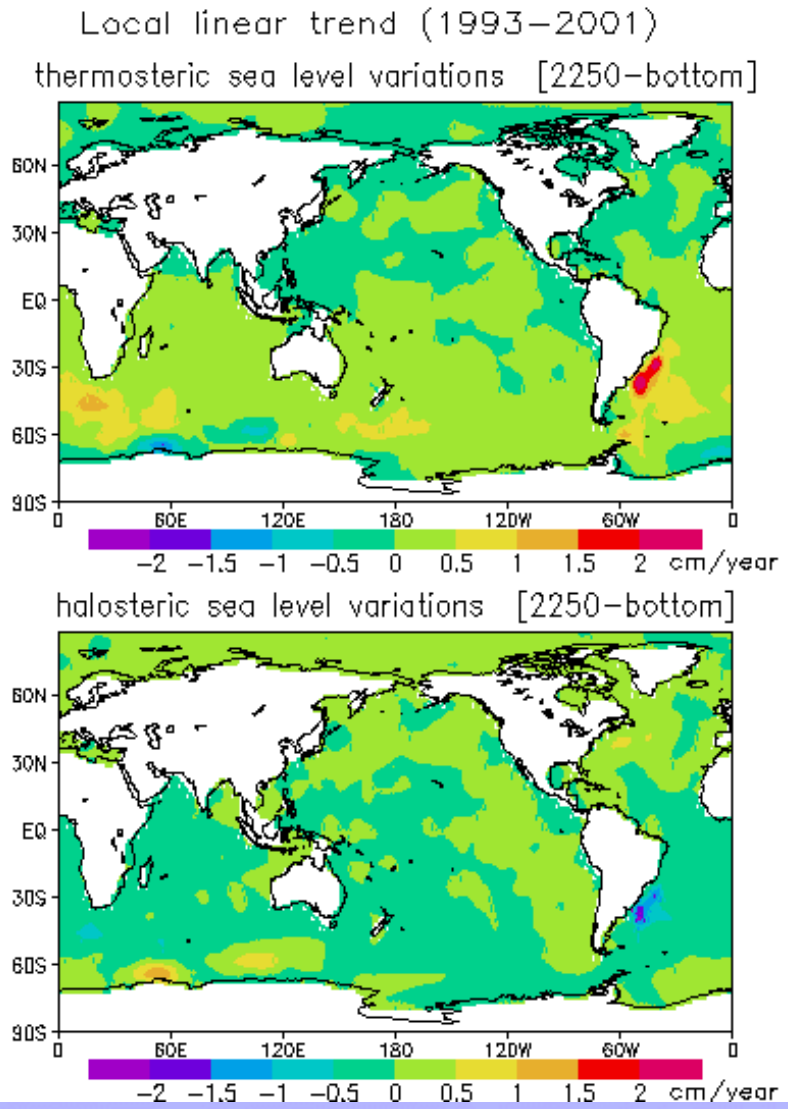


steric sea level trends

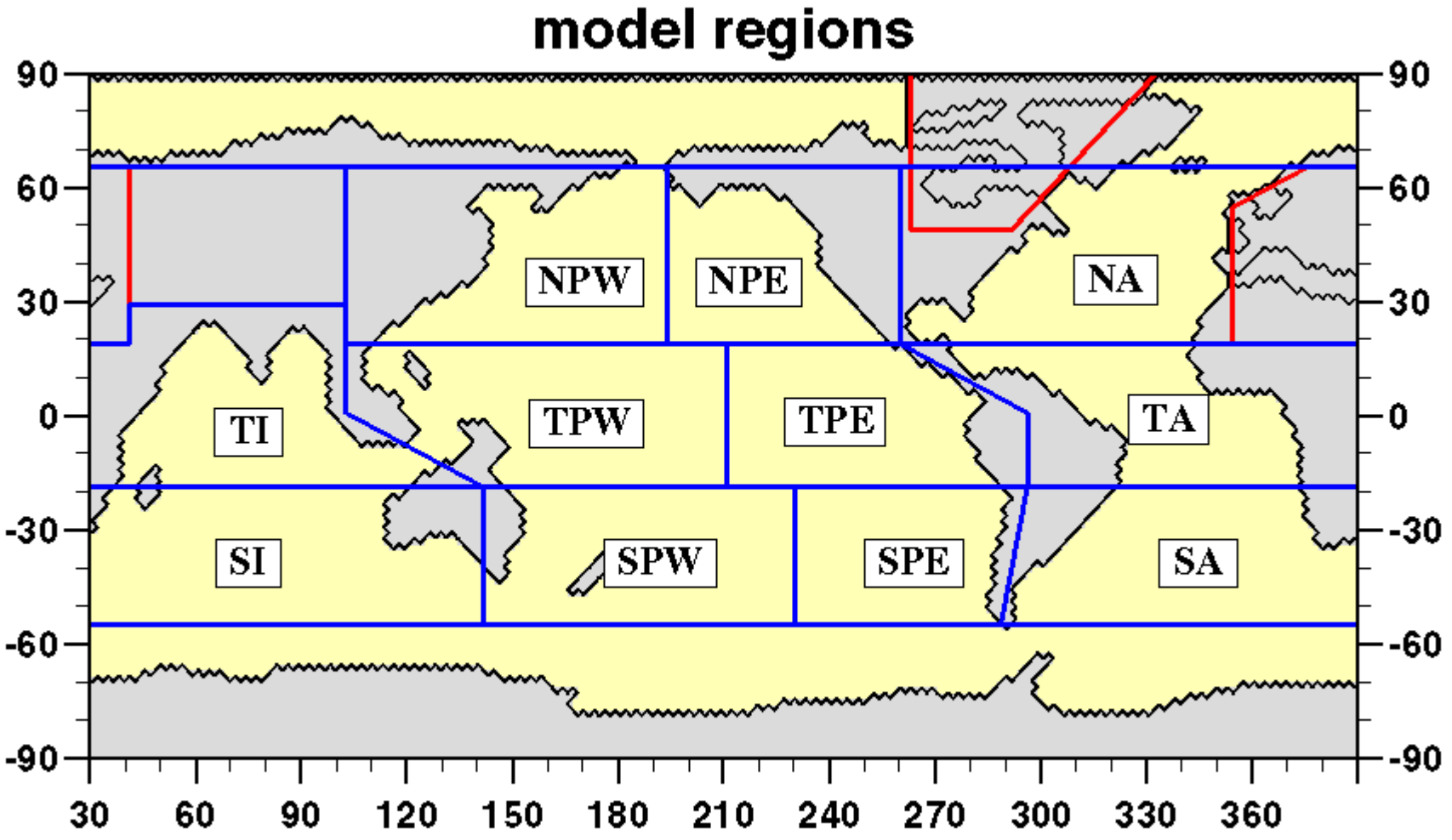
512 m-2250 m



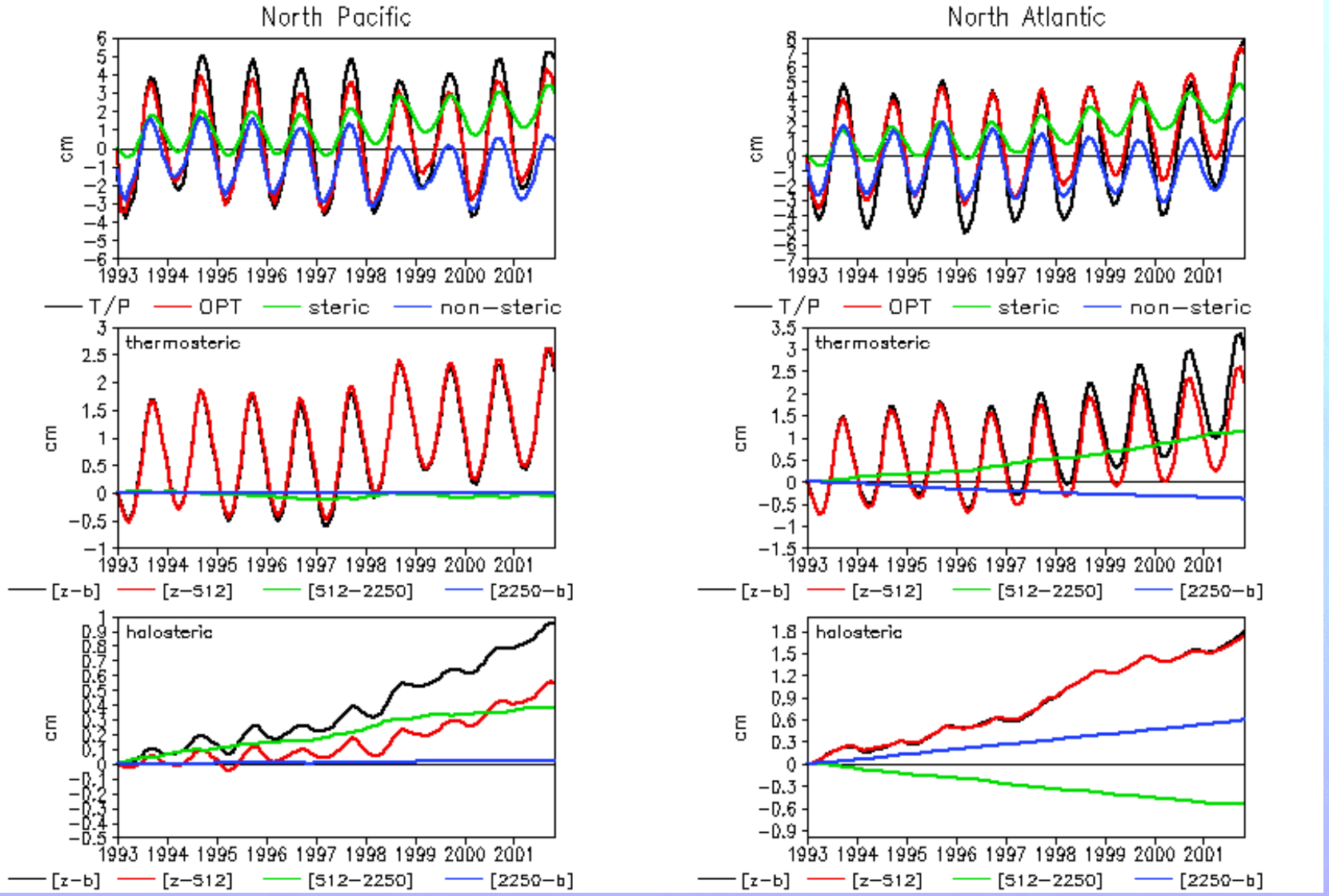
2250 m-bottom



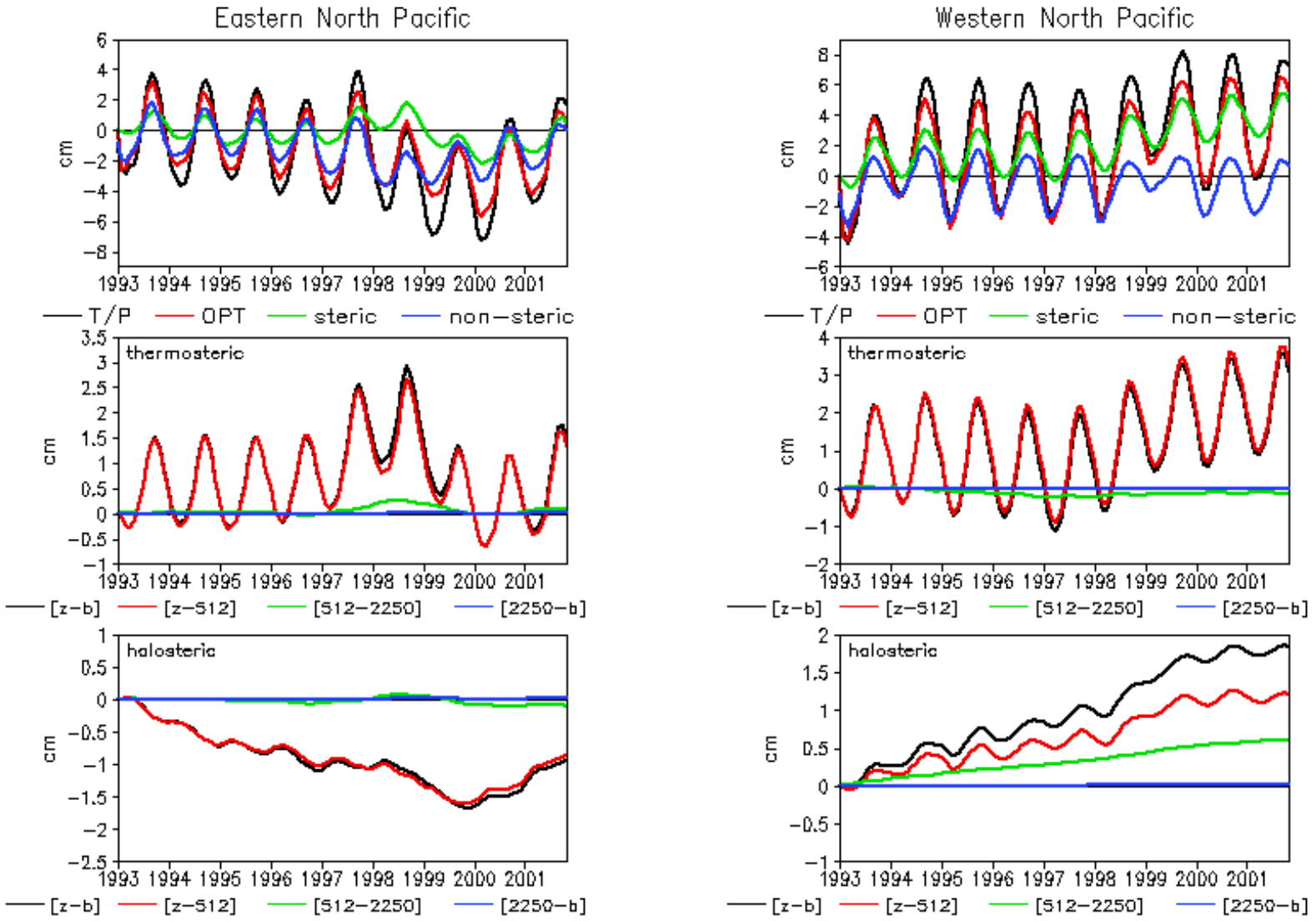
model regions



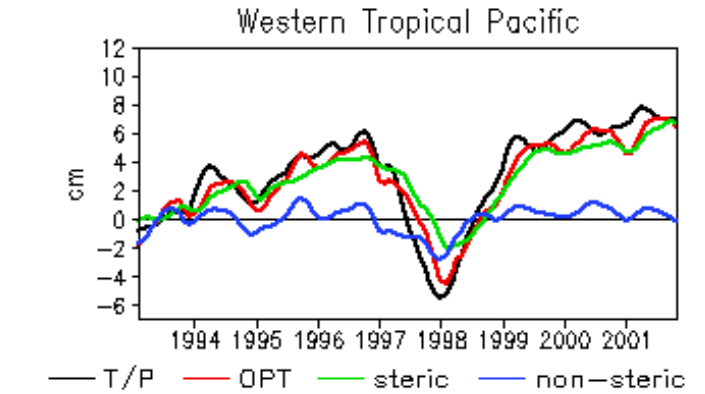
North Pacific and Atlantic

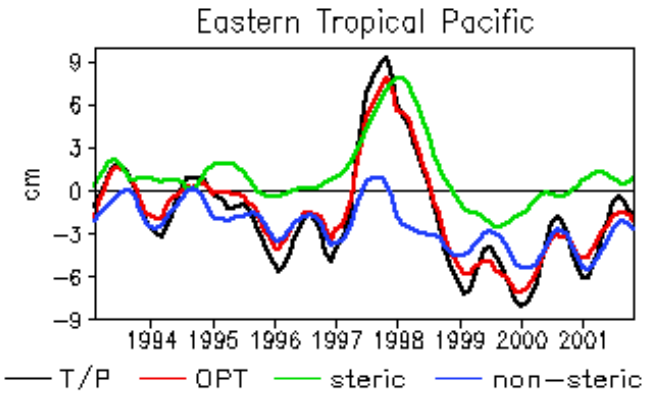


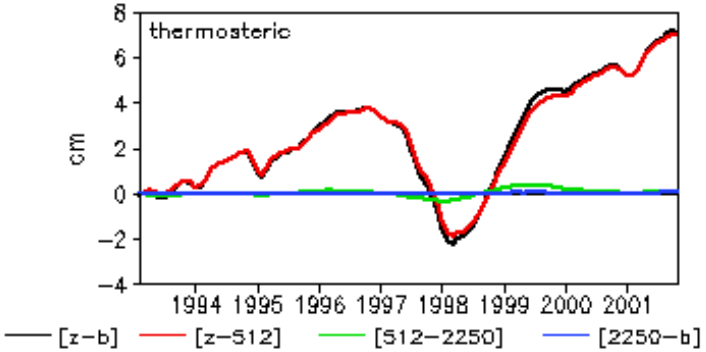
Northern and Western Pacific

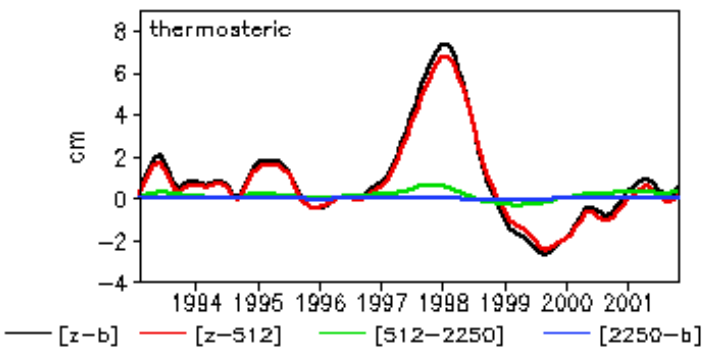


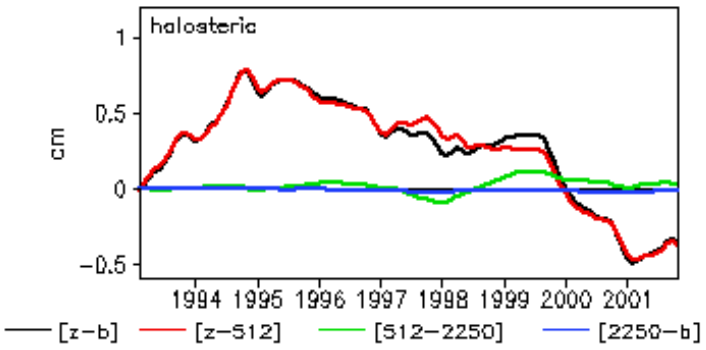
Tropical Pacific

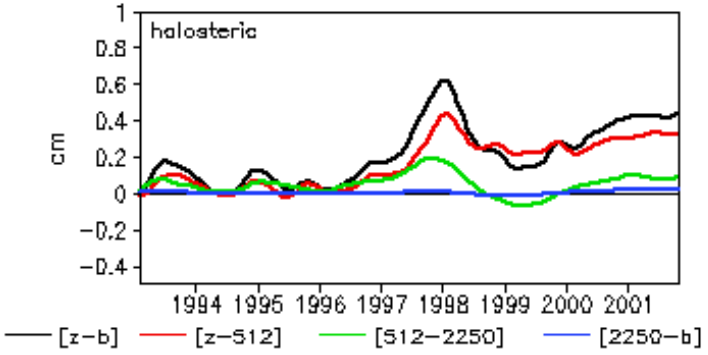




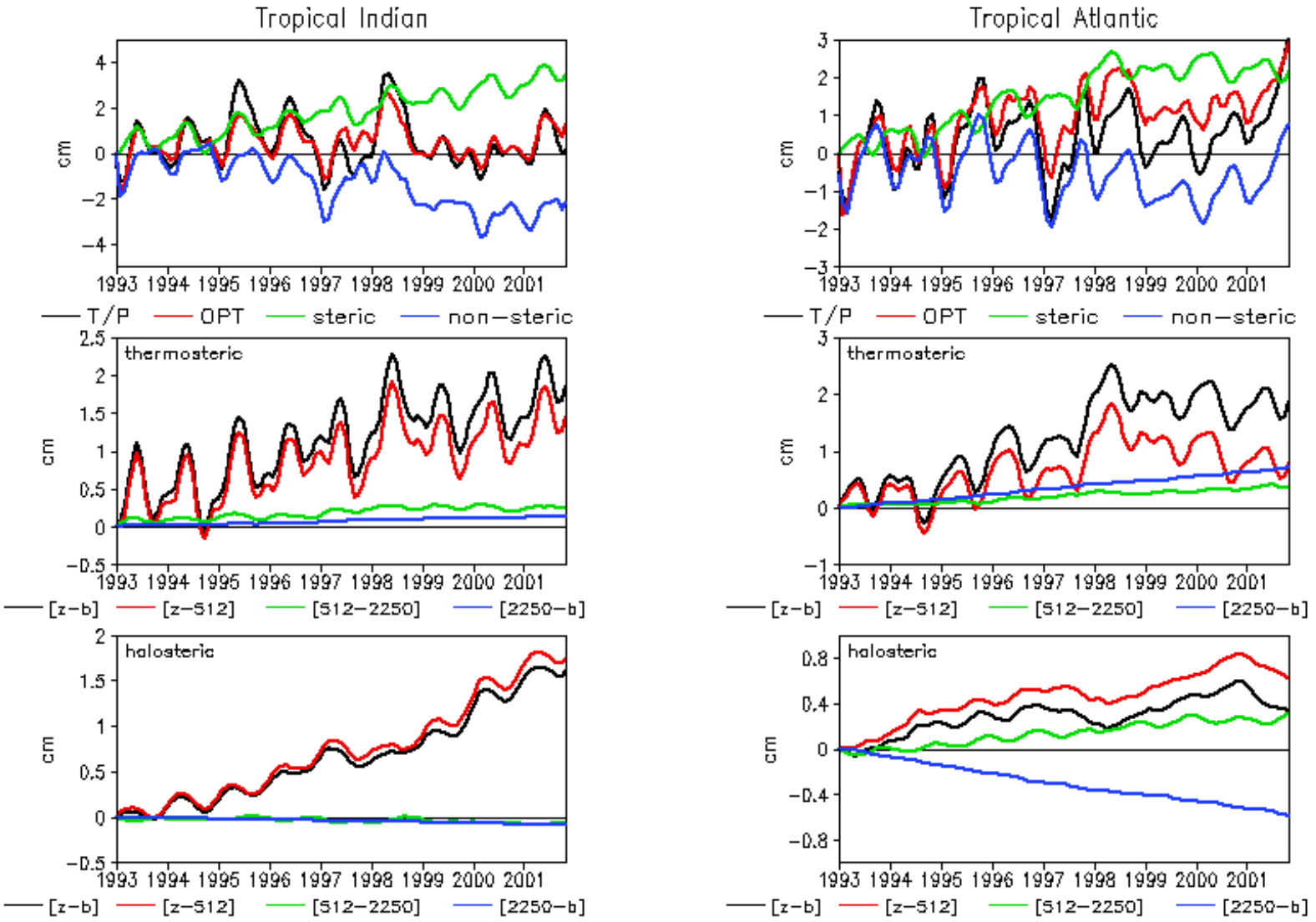




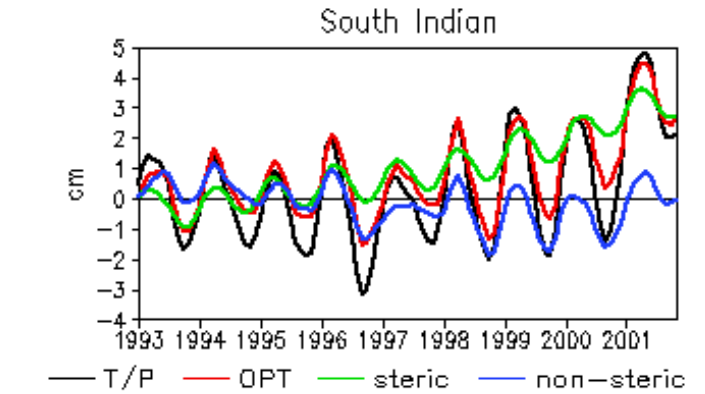


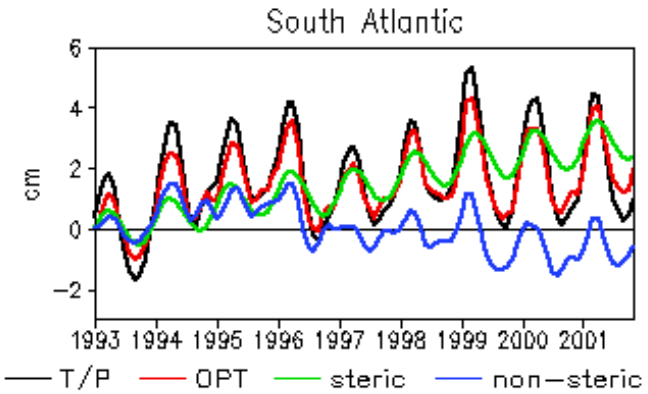


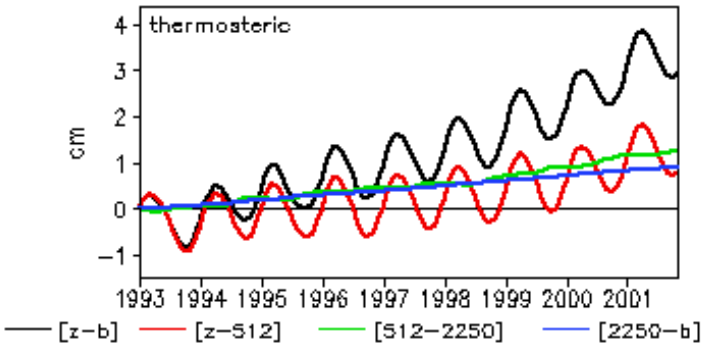
Tropical Indian and Atlantic

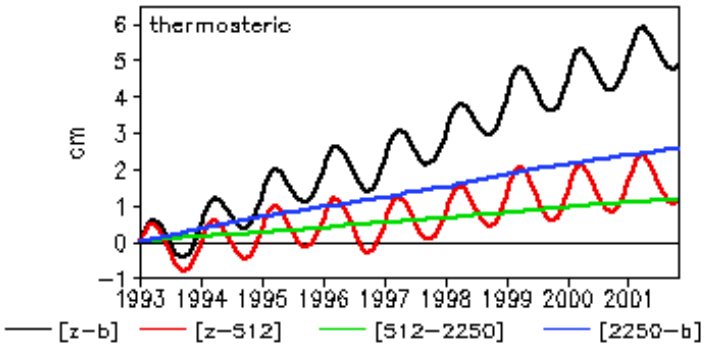


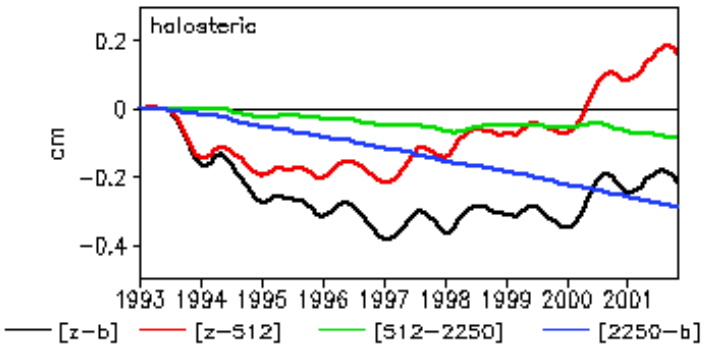
South Indian and Atlantic

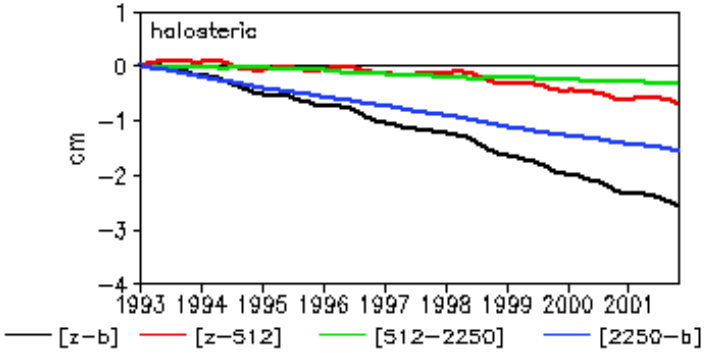




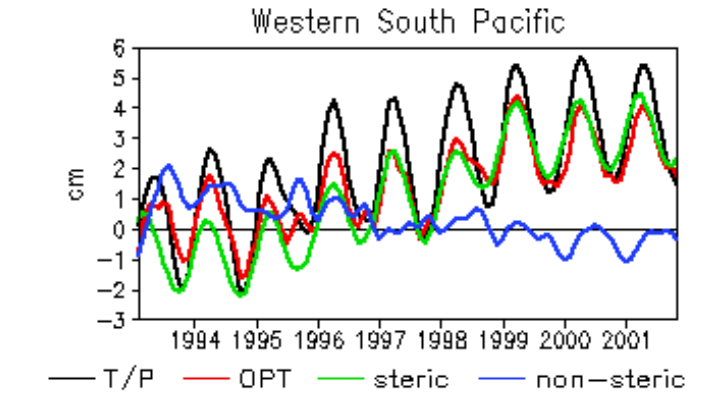


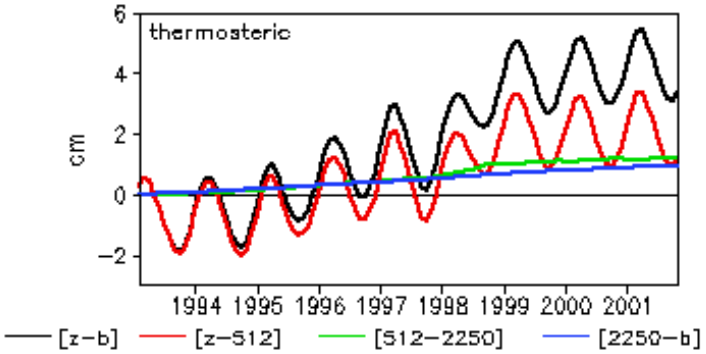


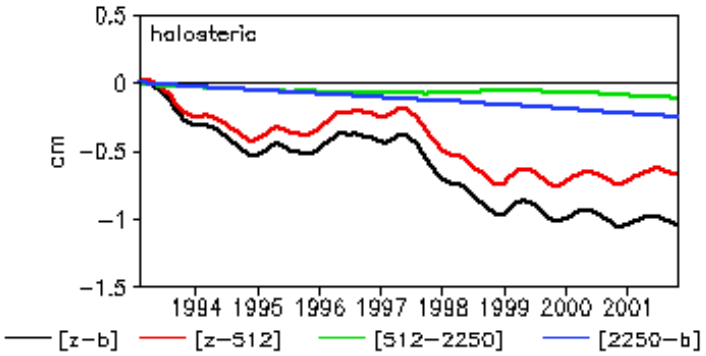


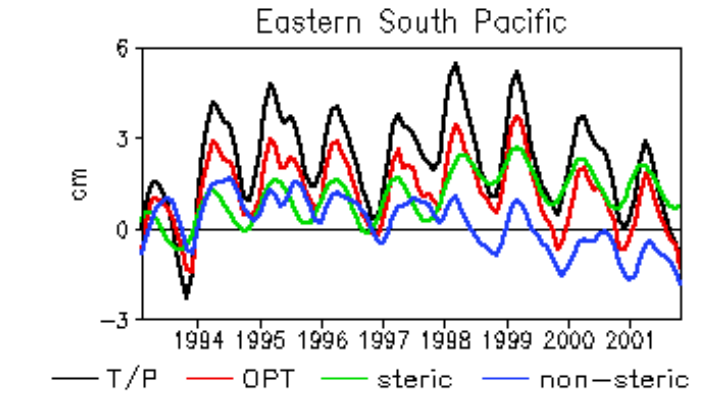


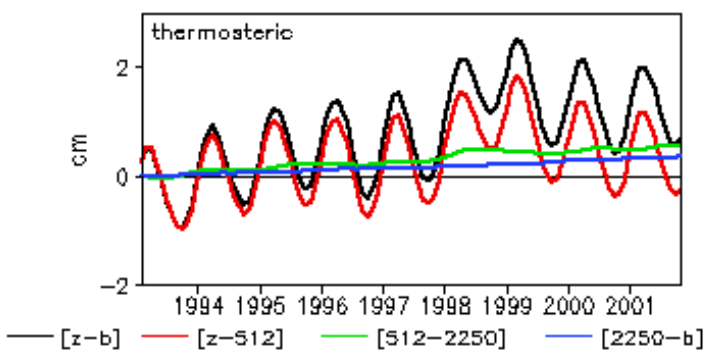
South Pacific

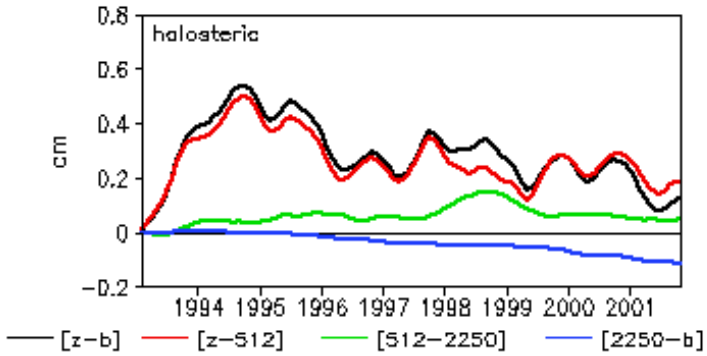




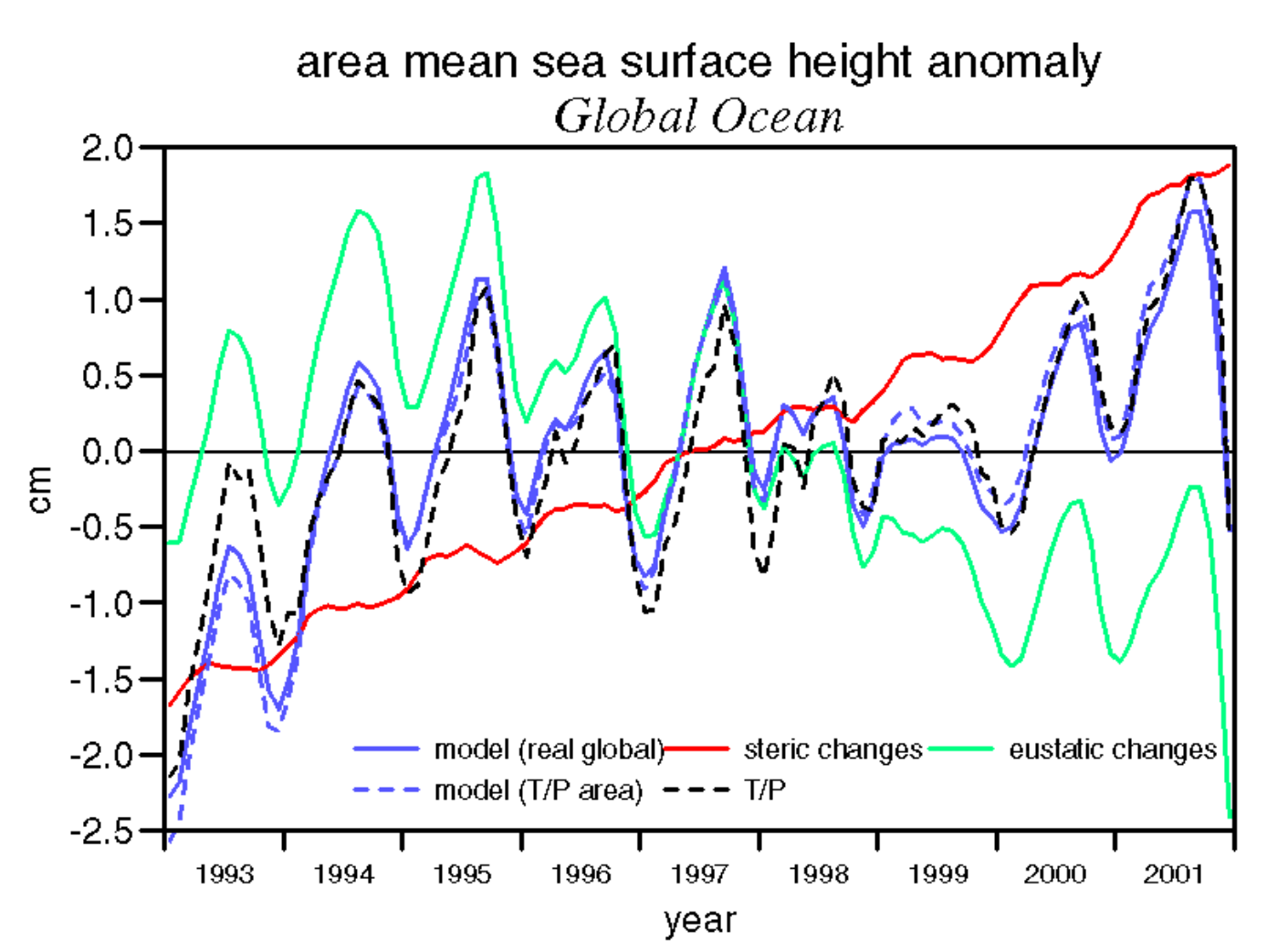




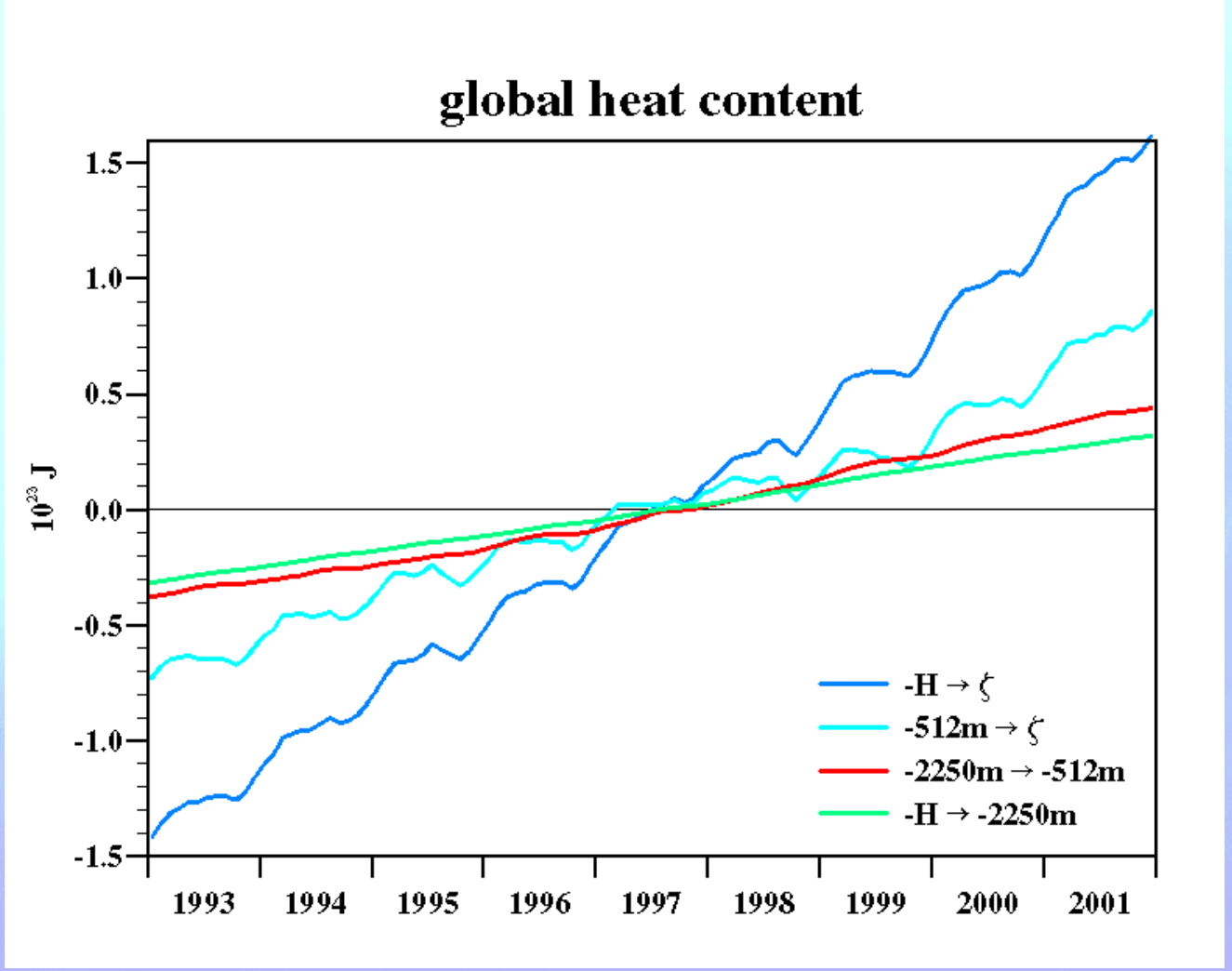




temporal evolution of area mean sea level



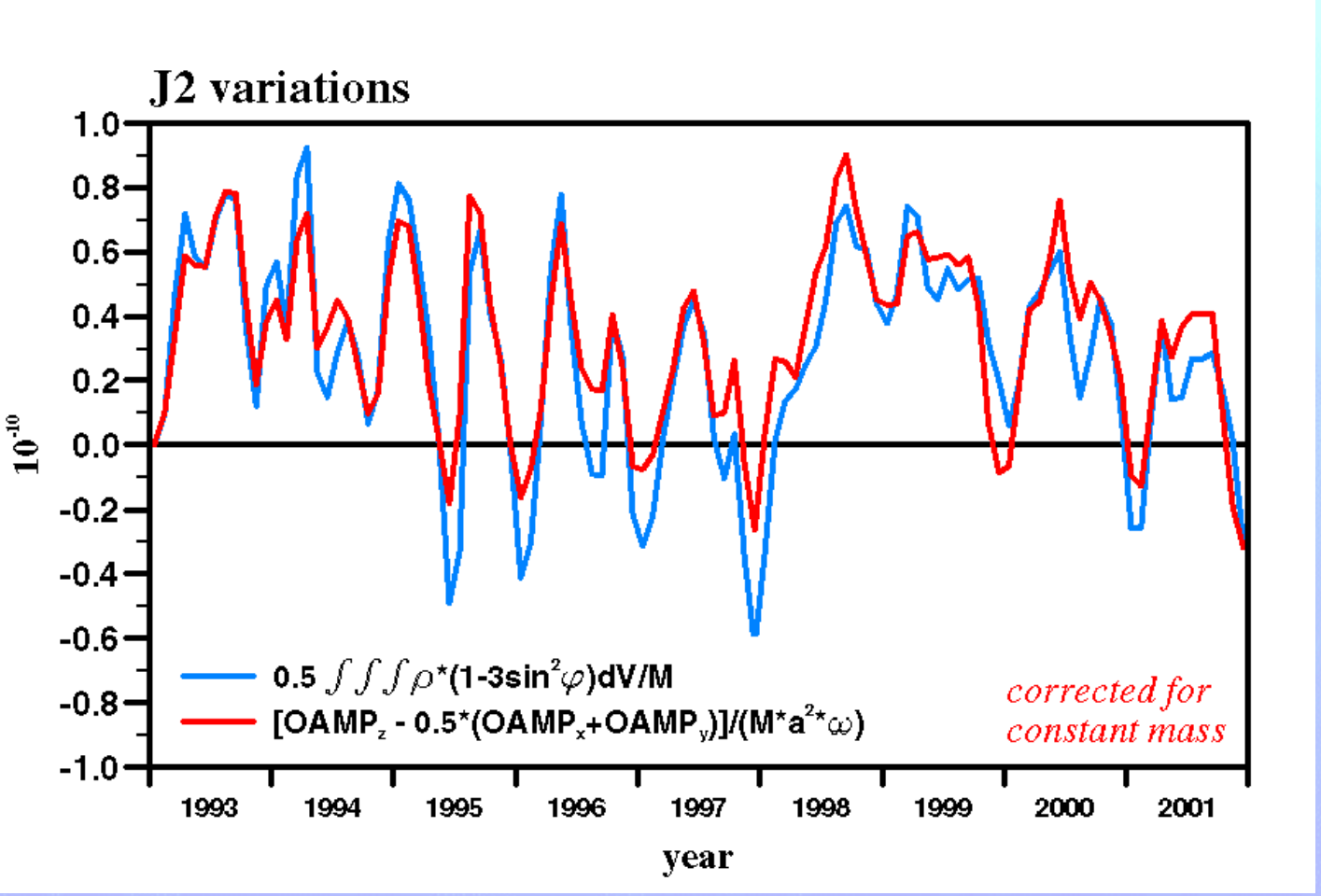
Global heat content

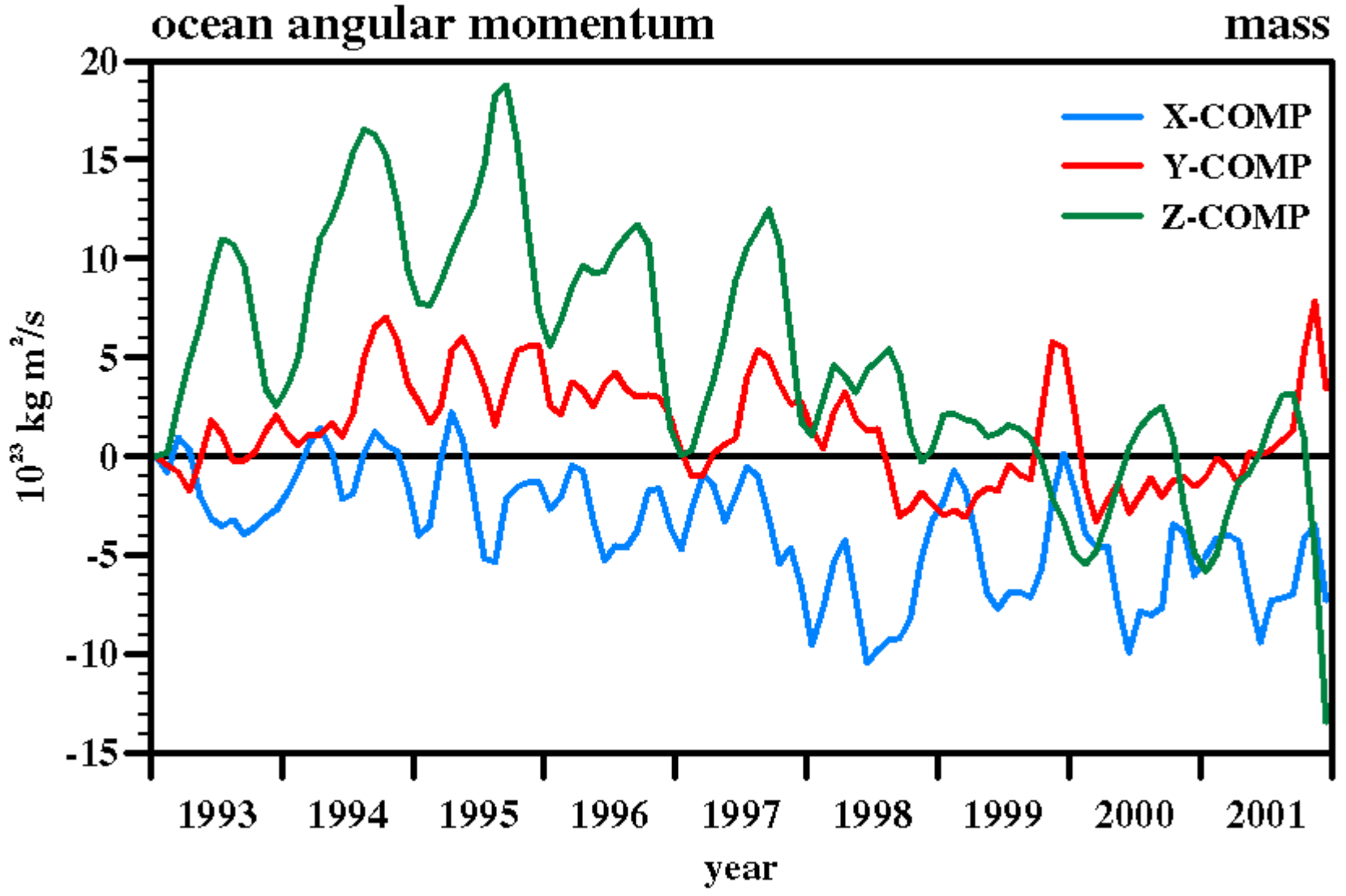


conclusions

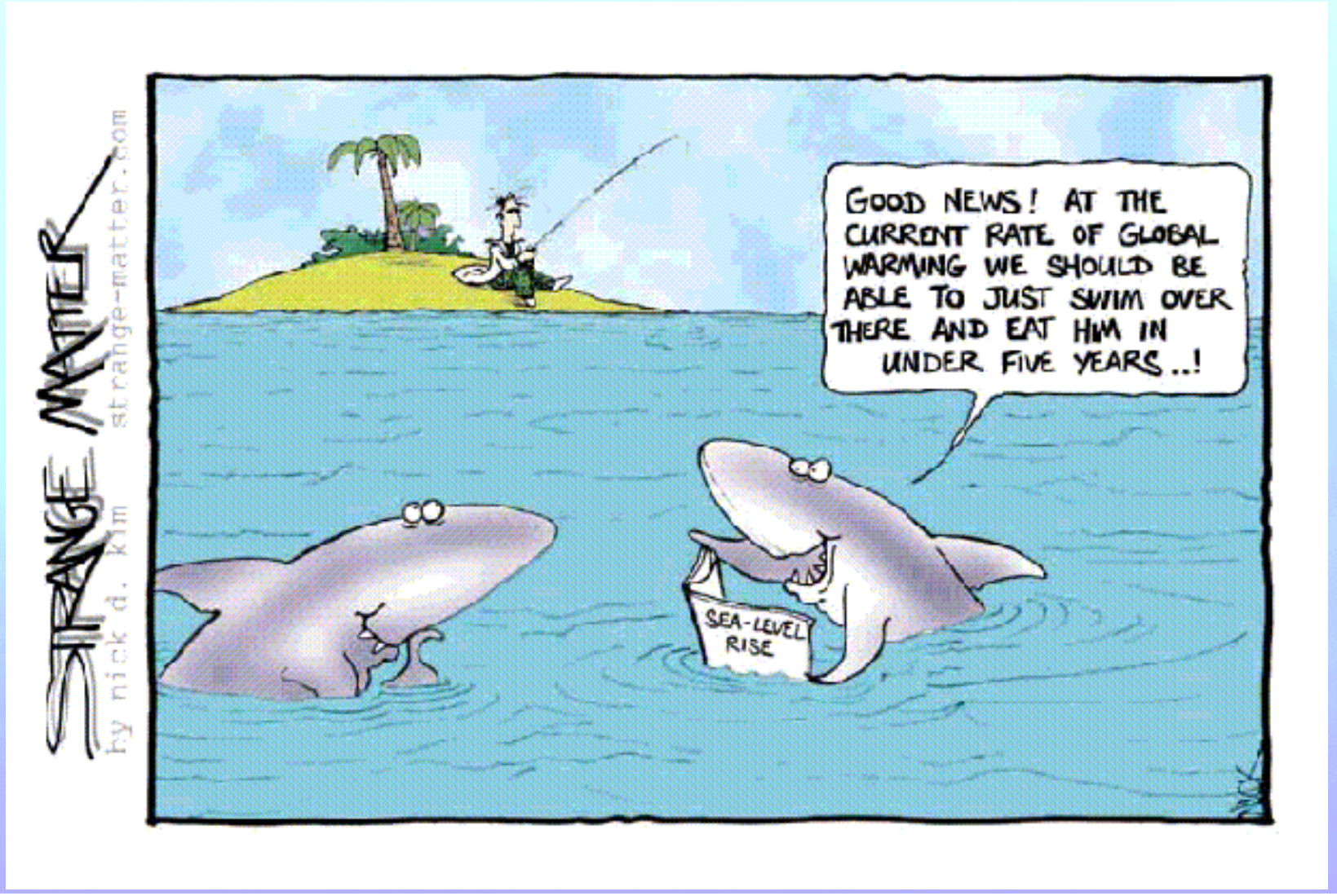
- We obtained an optimal dynamic ocean evolution for 1993 to 2001 using 4D-VAR data assimilation.
- The correlation between the model and T/P SSA is significantly improved in the constrained model.
- The analysis reveals a large regional variability of the local sea level trends.
- The model trend is a combination of steric sea level rise (mostly in the upper layers) and eustatic sea level fall.
- The warming seems very strong, additional data are needed to constrain the total ocean mass.
  (such as OAM, J2, GRACE etc.)

J2 variations




ocean angular momentum
mass
X-COMP
Y-COMP
Z-COMP
20
15
10
5
0
-5
-10
-15
10^{23} kg m^2/s
1993
1994
1995
1996
1997
1998
1999
2000
2001
year

Good News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