Alfred Wegener Institute
for Polar and Marine Research

SEA LEVEL CHANGE DURING 1993-2001
- a models interpretation -

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Motivation

Sea level changes can be measured accurately by satellite altimetry. Beside the redistribution of the water masses by internal ocean dynamics two further contributions are responsible for the observed local sea level changes: Steric effects and the oceans freshwater budget, while only their sum is observed. By using an ocean general circulation model (OGCM), that conserves ocean mass rather than volume, we try to separate these contributions.

The models global mean sea level is very sensitive to the global oceans mass budget, i.e. inflow by rivers, melt water from glaciers / ice shields, precipitation and evaporation. This budget is only poorly known in comparison to the evolution of the volume of the ocean as determined from satellite altimetry. Therefore it is reasonable to use the assimilation results to improve the knowledge about the total freshwater flux rather than utilizing measured fluxes to estimate the oceans mass change.

Sea Level Evolution

$$\frac{\partial}{\partial t}\zeta =$$

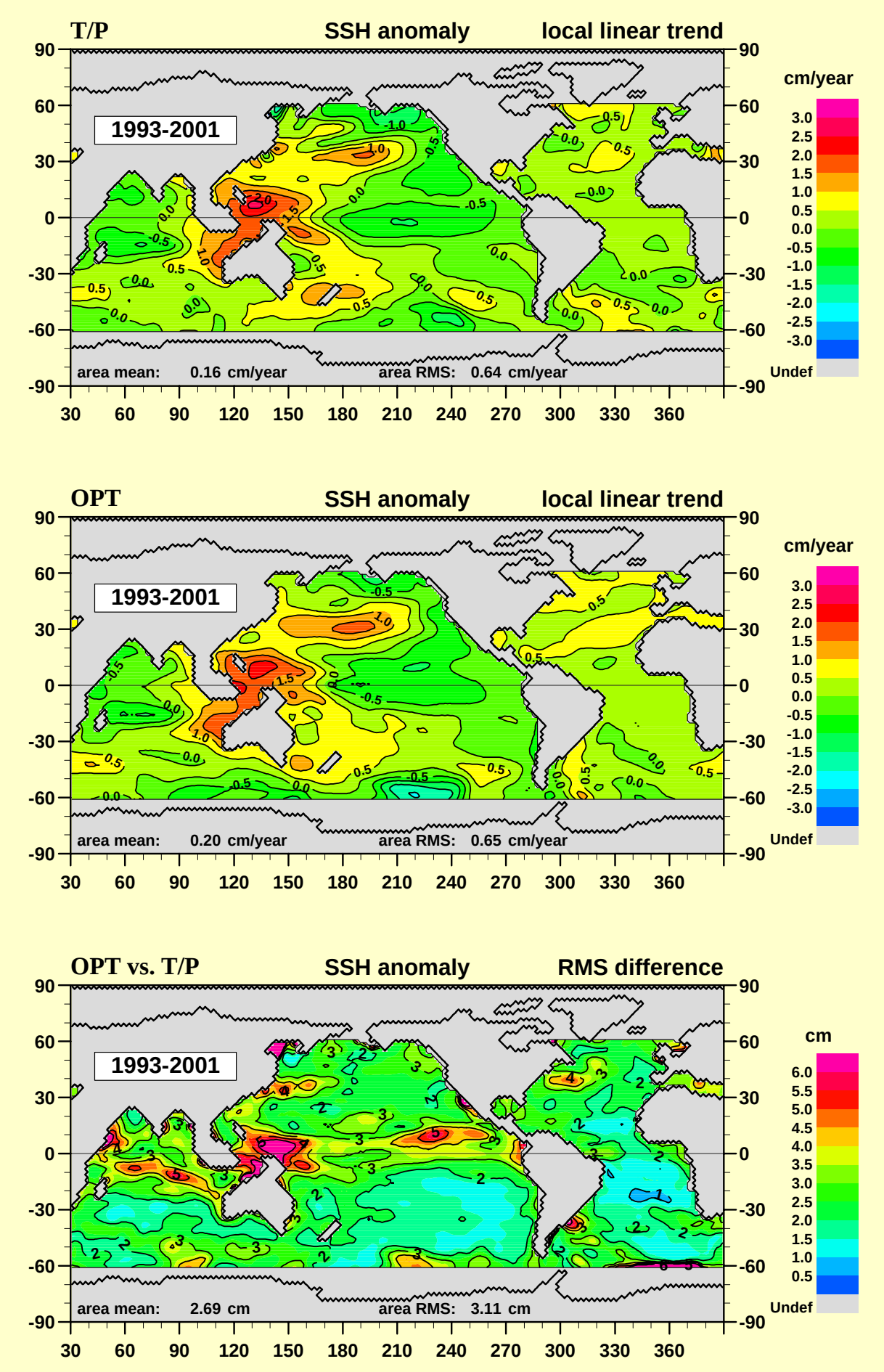
$\mathbf{P-E}$	freshwater flux
$+\nabla\cdot\int_{-H}^{\zeta}\vec{v}\,\mathbf{d}z$	divergence
$+\int_{-H}^{\zeta}\frac{1}{\alpha}\frac{\partial\alpha}{\partial T}\Big\vert_{S,p}\frac{\partial}{\partial t}T\,\mathbf{d}z$	thermosteric effect
$+\int_{-H}^{\zeta}\frac{1}{\alpha}\frac{\partial\alpha}{\partial S}\Big\vert_{T,p}\frac{\partial}{\partial t}S\,\mathbf{d}z$	halosteric effect
$+A_h\,\Delta\,\zeta$	subgrid processes

Method

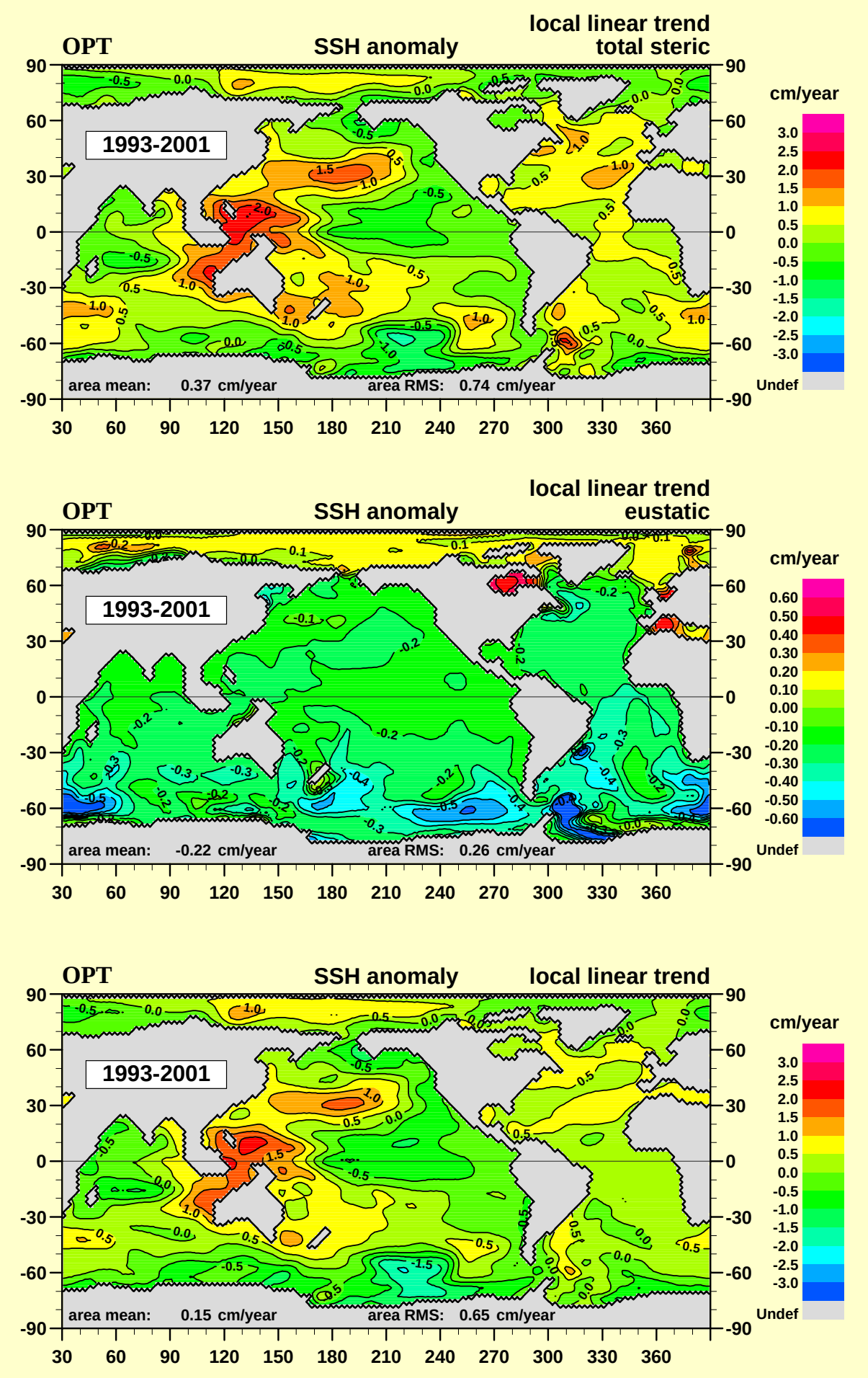
The OGCM that is used to study the oceans sea level changes in detail is based on the Hamburg Large Scale Geostrophic model LSG. The model has a $2^o\times 2^o$ horizontal resolution and 23 vertical layers. Nine years of TOPEX/Poseidon (T/P) sea surface height data relative to the EGM96 geoid model as well as sea surface temperatures and ice cover information from Reynolds (2002) are assimilated into the model. Additionally background information from the Levitus WOA98 is used.

To adjust the model to the data the adjoint method is employed. The control parameters of this optimization are the models initial temperature and salinity state as well as the forcing fields (windstress, air temperature and surface freshwater flux). The forcing is optimized via an empirical orthogonal function (EOF) decomposition, with the first guess taken from the NCEP reanalysis.

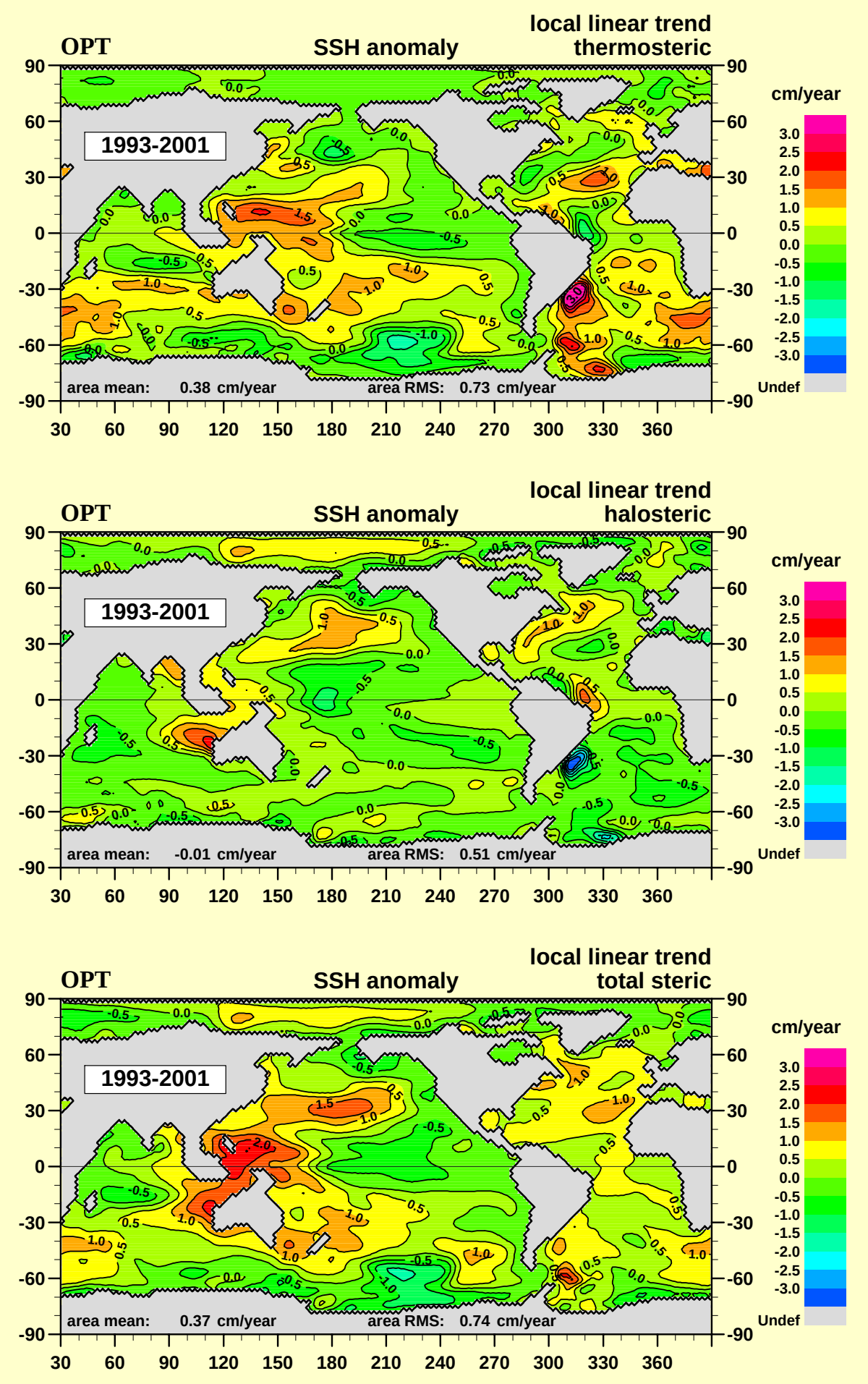
Local Linear Trend (1993-2001)



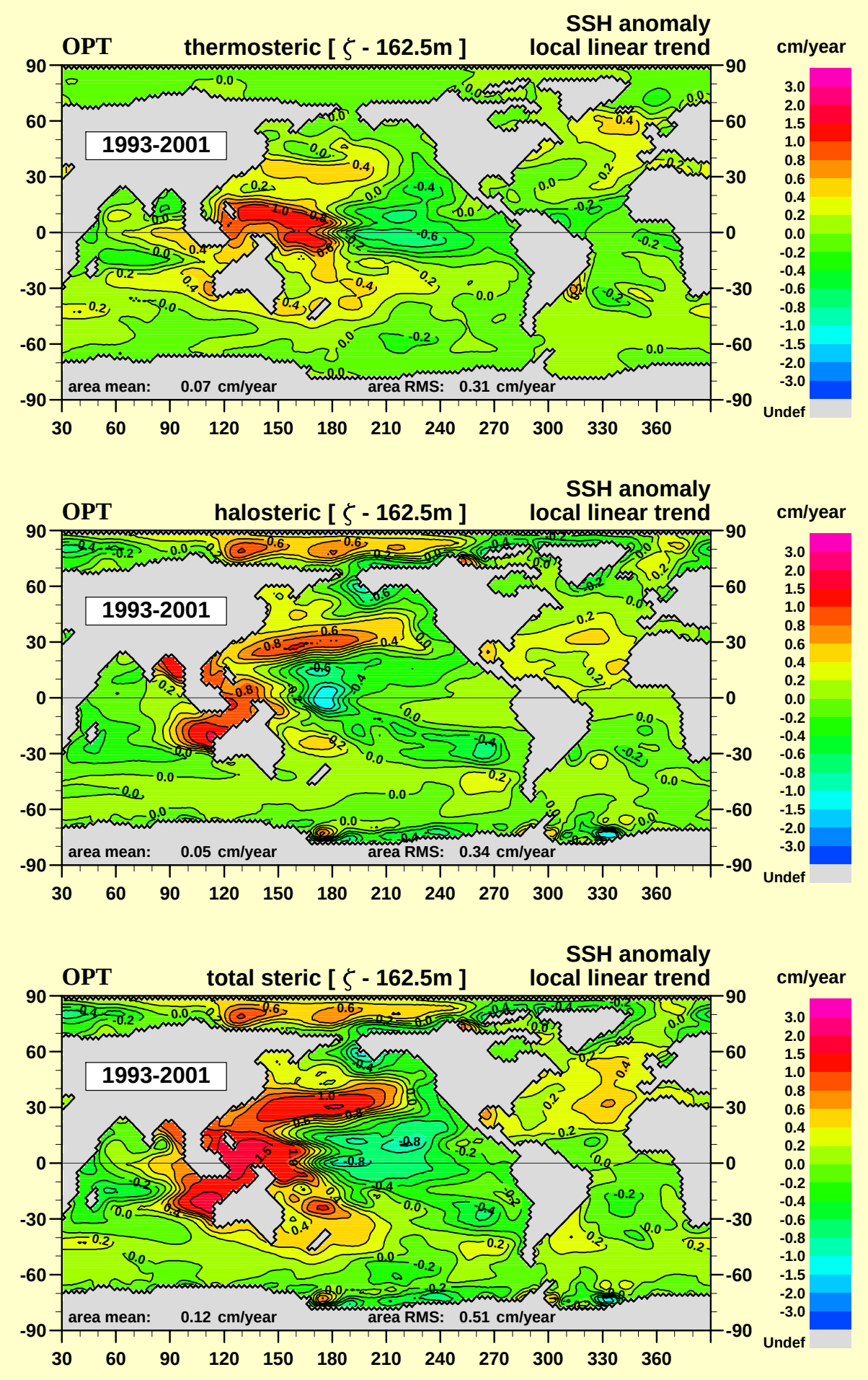
SSH trend from the T/P data (top) and the optimized solution **OPT** (middle). The bottom figure gives the RMS difference for the corresponding SSHA



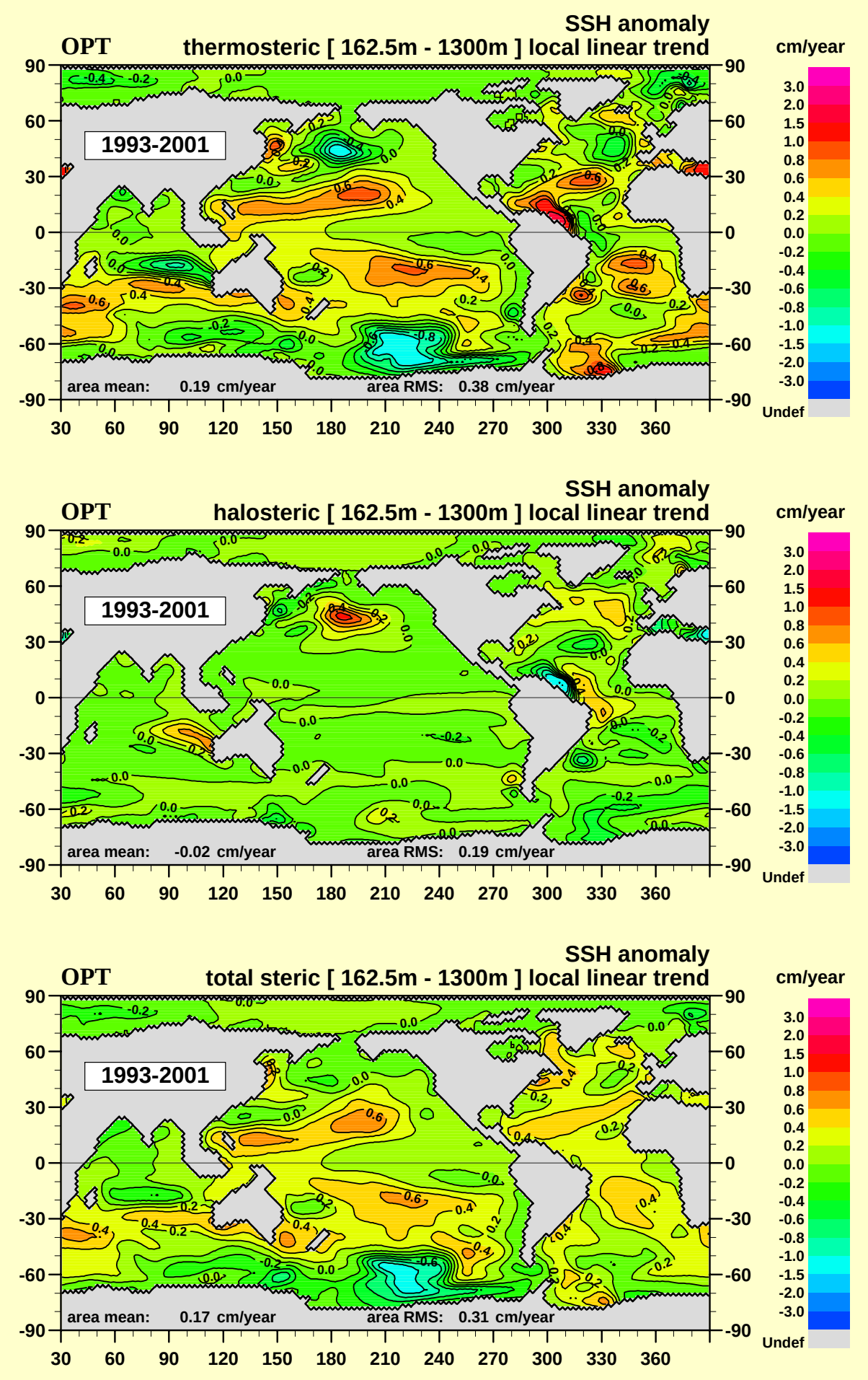
Total steric (top) and eustatic (middle) trend and its sum (bottom)



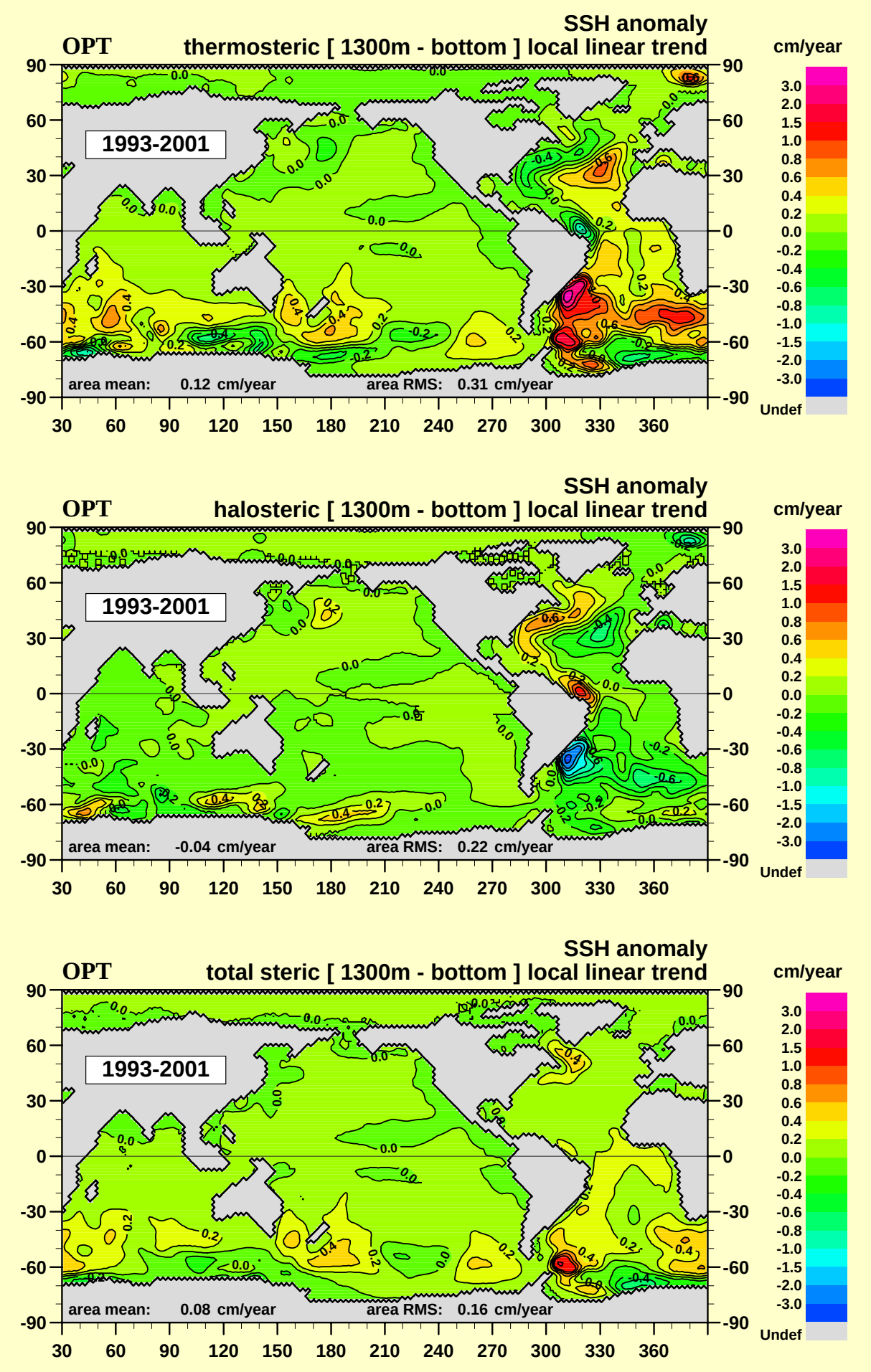
Thermo- (top), halo- (middle) and total (bottom) steric trend from the whole ocean depth **[ζ-H]**.



Thermo- (top), halo- (middle) and total (bottom) steric trend from the oceans surface layers **[ζ-162m]**.

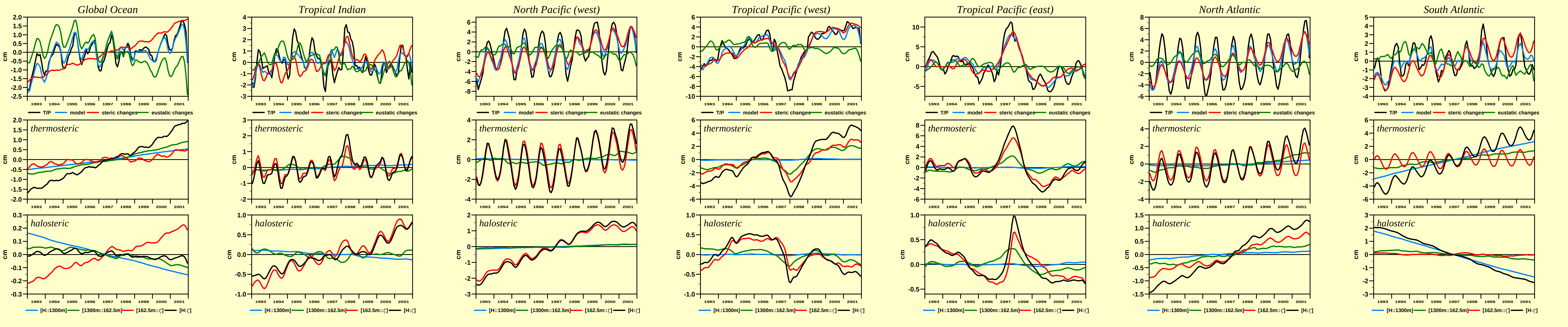


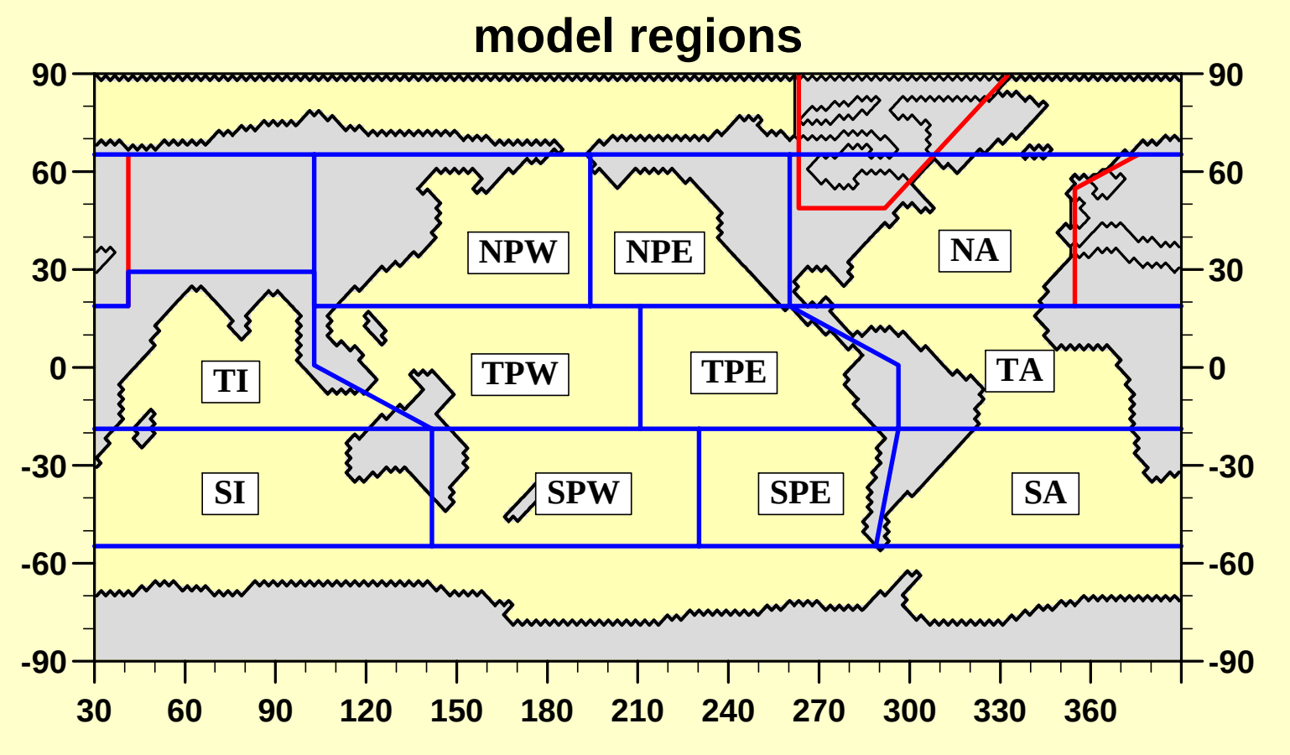
Thermo- (top), halo- (middle) and total (bottom) steric trend from the oceans intermediate layers **[162m-1300m]**.



Thermo- (top), halo- (middle) and total (bottom) steric trend from the oceans bottom layers **[1300m-H]**.

Area Mean Sea Level





Model regions

Summary

- The analysis of the T/P sea level anomalies reveals large regional variability in the local trends which is well reproduced by the optimized model.
- The models global mean trend is a composition of steric sea level rise and eustatic sea level fall.
- The regional variability in the sea level trends is mainly reproduced by the steric contribution, while the eustatic changes show up fairly constant in space.
- The major contribution to the steric changes stem from the upper layers.
- The halosteric changes cannot be neglected on regional scale. In many regions it is opposite in sign to the thermosteric thus partly compensating.
- The quantitative decomposition into steric and eustatic sea level changes as demonstrated on this poster is still preliminary, because we do not utilize any constraint on the total ocean mass (e.g. bottom pressure, OAM, J2 etc.) nor on the oceans total heat content.

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