

High Frequency Sea-Level Variations driven by Self-Attraction and Loading from Atmospheric Surface Pressure at the Continents

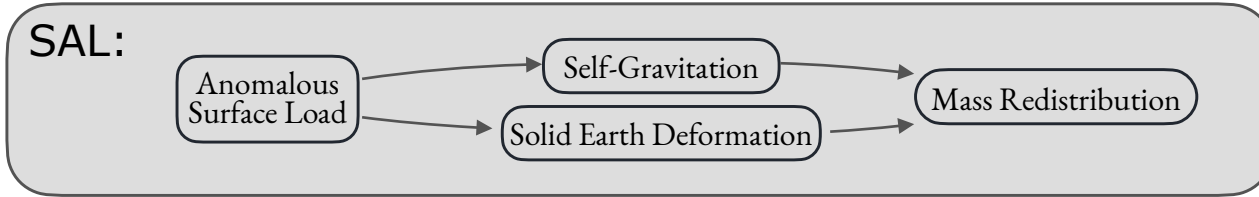
Henryk Dobslaw¹, Linus Shihora¹, Roman Sulzbach^{1,2}

¹GFZ: German Research Centre for Geosciences, Potsdam, Germany

²Institute of Meteorology, Freie Universität Berlin, Berlin, Germany

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Self Attraction & Loading



- Is one component to 'Gravity, Rotation and Deformation' (GRD) [1]
- SAL influence well known to be important for tidal dynamics
- Also significant for high frequency ocean dynamics
- Significant for de-aliasing in satellite gravimetry
- Implemented full SAL feedback into tidal model TiME [2] and OGCM MPIOM

- MPIOM: Max Planck Institute Ocean Model
- OGCM based on primitive equations
- Based on Arakawa C- and z-grid
- TP10L40 Configuration: 1° tri-polar grid & 40 vertical layers
- Atmospherically driven by ERA5 re-analysis fields

- Represent SAL feedback through additional potential term:

$$V(p) = \sum_{n=0}^{\infty} (1 + k'_n - h'_n) \alpha'_n p'_{B,n}(\lambda, \phi)$$

- Spherical harmonic (SH) transformation to d/o 170 SHTns [3]
- Calculate potential term in SH
- Backtransformation to model grid
- Apply gradient in velocity computation

$$\alpha'_n = \frac{3}{\rho_e(2n+1)}$$

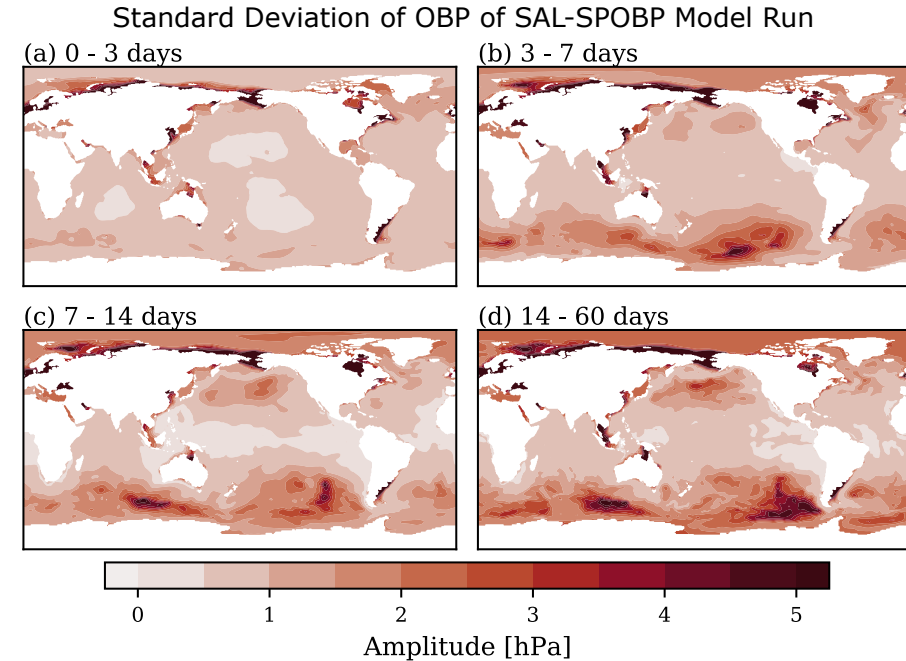
$p'_{B,n}$: Bottom pressure anomalies in SH

h'_n, k'_n : Load Love numbers

- For full implementation: perform SAL computation at every model timestep
- Perform several model runs with different SAL variations:
 - Anomalous surface loads based on ocean bottom pressure (SAL-OBP)
 - Anomalous surface loads based on OBP **and** surface pressure anomalies on continents (SAL-SPOBP)
 - No SAL feedback as a reference (noSAL)
- Analyse feedback of SAL to ocean dynamics by computing standard deviation differences of OBP

OBP Variability Reference

- Plot variability of OBP for SAL-SPOBP model run as a reference
- Split into frequency bands by use of Butterworth filters
- Longer frequencies don't contribute to potential aliasing effects for monthly gravity solutions in satellite gravimetry

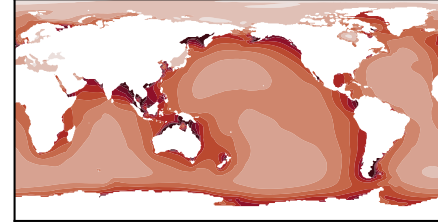


Full SAL Feedback

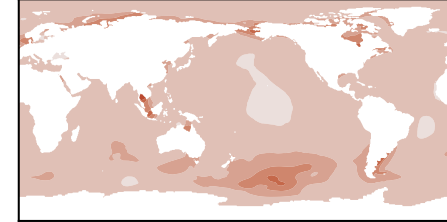
- Compare SAL-SPOBP and noSAL model runs
- Strongest relative impact for high frequency band with up to 1 hPa
- High frequency band: influence on coastal / shelf regions
- Low frequency band: influence on southern ocean

Standard deviation differences btw. SAL-SPOBP & noSAL model runs

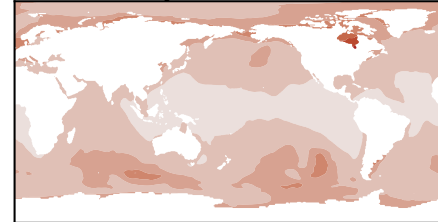
(a) 0 - 3 days



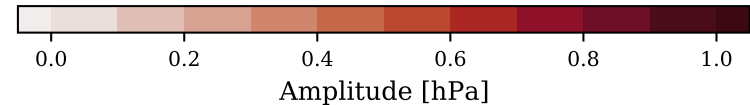
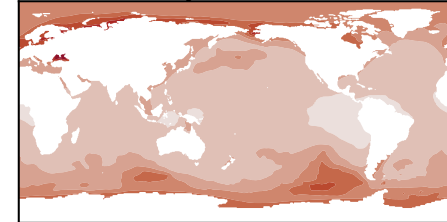
(b) 3 - 7 days



(c) 7 - 14 days



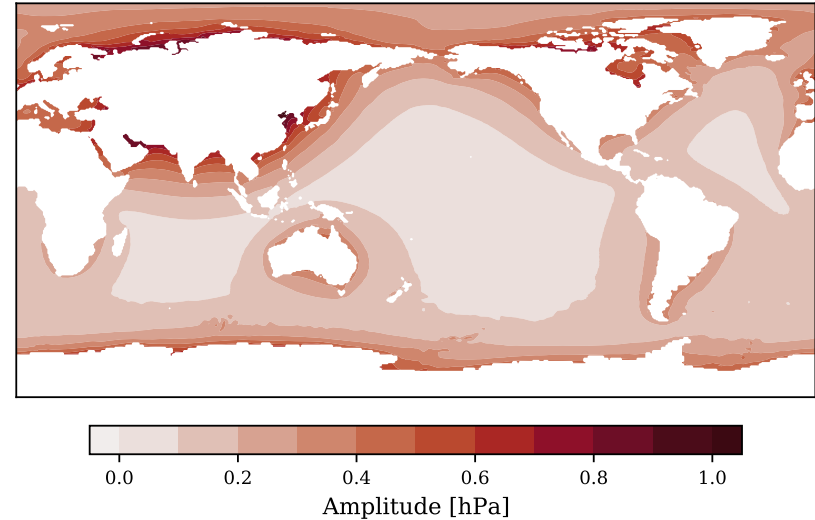
(d) 14 - 60 days



Full SAL Feedback

- Isolate influence of surface pressure anomalies: compare SAL-OBP to SAL-SPOBP
 - Influence of just under 1 hPa around coasts
 - Negligible influence on open ocean
- > comparatively minor influence to ocean dynamics
- If full SAL feedback is implemented, including atmospheric pressure anomalies can be incorporated fairly easily

Standard deviation differences btw. SAL-SPOBP & SAL-OBP



Conclusions

- Implemented full SAL feedback into MPIOM
- Highest relative impact to ocean dynamics for high frequency variability (< 3 d) along coasts
- Largest open ocean influence just below 1 hPa for low frequency band
- Influence of surface pressure anomalies comparatively small but easy to implement
- 1 hPa SAL feedback relevant for de-aliasing in satellite gravimetry
- Will be part of next AOD1B release (RL07) [4]