# Regional Ocean Mass Contribution to Sea Surface Height Variations with Seasonal Timescale

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## Background

- Variation of altimetric SSH minus steric height is caused by ocean mass variation.
- The above relation has been well investigated for global mean seasonal variation. Global ocean mass variation has been explained from total precipitation and evaporation at the ocean surface and total river runoff using atmospheric reanalysis data and observation data.

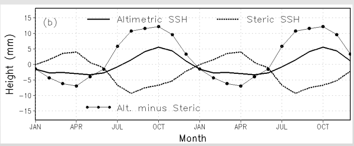
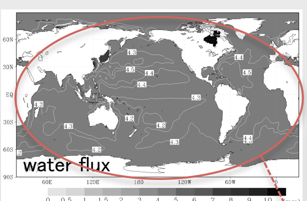



*Fig. 1 Mean seasonal variation (1993–2010) of altimetric SSH and steric height for global ocean (66° S – 66° N).*

- To make clear the ocean mass contribution to the regional SSH variation, distribution of the ocean mass variation should be clarified as:
  a. How does the ocean mass spread in response to inhomogeneous water flux variation?
  b. How does the ocean mass redistribute in response to wind stress and surface pressure variations?
- The mean seasonal variation averaged 1993-2010 will be examined in this poster.

## Barotropic global ocean model experiment

- In order to clarify the above Questions a and b, barotropic SSH variation is examined using a barotropic global ocean model driven by the mean seasonal water flux, wind stress and surface pressure.
- Resolution: 1° x 1°
- Mean seasonal driving forcings are produced from JRA25/JCDAS.
- Result from the 2-nd year of the experiment is used.



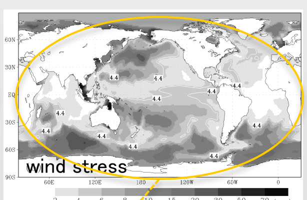
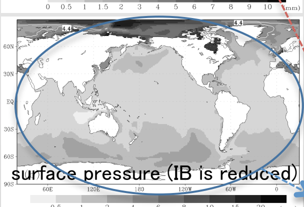
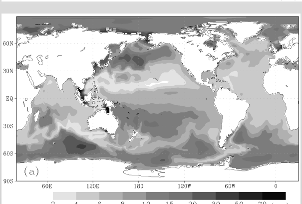




*Fig. 2 Standard deviation of seasonal SSH derived from the model.*




- SSH by water flux varies homogeneously in the entire global ocean.
- SSH variability by wind stress shows geographical dependency.
- SSH variability by pressure is about 1/10 of that by wind stress.



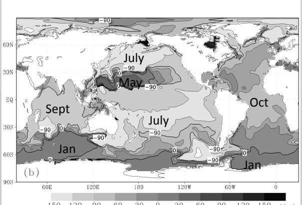




*Fig. 3 Feature of the total SSH by three forcings.*
*(a) seasonal variability as a values of standard deviation, and*
*(b) phase of annual cycle (degree). For example, degrees of −90, 0 and 90 represent the peak of SSH comes to beginning of October, January and April. Months of the peak for some areas are denoted on the lower panel.*

Therefore, in order to estimate regional consistency among SSH, steric height and mass, distribution of the mass should be taken account.

- Seasonal variation of the model SSH is denoted by $\widetilde{H}^{mdl}$.

## Data

- Altimetric SSH: gridded values are obtained by 3D_OI (Kuragano and Kamachi, 2000) applying to SLA (T/P, Jason-1, -2, ERS-1, -2 and ENVISAT). Seasonal variation is denoted by $\widetilde{H}^{alt}$.
- Steric height is calculated from historical subsurface T/S dataset by Ishii and Kimoto (2009). Seasonal variability is denoted by $\widetilde{H}_P^{den}$, which is thickness between pressure-*P* (shown by subscript) level and sea surface. *P* is selected as 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500 dbar.

## Regional consistency

- Define fluctuation of isobaric surface of pressure *P* as below:

$$\widetilde{H}_P^{iso} = \widetilde{H}^{alt} - \widetilde{H}^{mdl} - \widetilde{H}_P^{den}$$

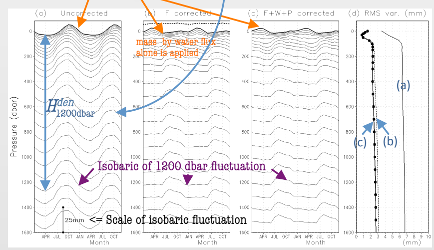



*Fig. 4 Isobaric surface fluctuation for global ocean (66° S – 66° N) The way to detect the isobaric surface of 1200 dbar is shown for example.*

- Fluctuation of isobaric surface in the lower layer has large amplitude (a).
- If the model SSH by water flux is removed from the altimetric SSH, the amplitudes of isobaric surface fluctuations diminish(b and d).
- Correction of the model SSHs by wind stress and surface pressure further diminishes the isobaric surface fluctuation (c and d).

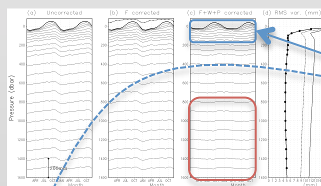


*Fig.5 Subarctic North Pacific (155°E–140°W, 40°N–50°N)*

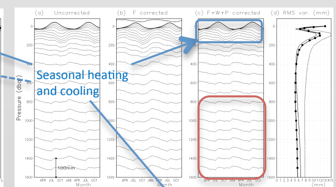



*Fig. 6 Subtropical North Pacific (140°E–120°W, 10°N–30°N)*

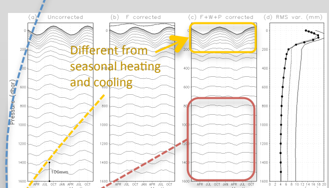



*Fig. 7 Equatorial Pacific (170°E–90°W, 10°S–10°N)*

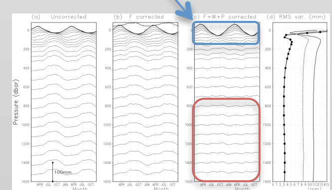


*Fig. 8 Subtropical South Pacific (180°W–90°W, 40°S–10°S)*

- Correction by model SSH diminishes the isobaric surface fluctuation in the lower layer indicating that model SSH well represents mass related SSH.
- The isobaric surface in the upper layer seems to be controlled by the seasonal heating and cooling at surface layer in the higher latitude.
- The isobaric surface in the upper layer does not seem to be controlled by the seasonal heating and cooling in the equatorial region.

## Discussion

- Baroclinic response to the wind stress variation also ought to affect the ocean mass, i.e. the bottom pressure.

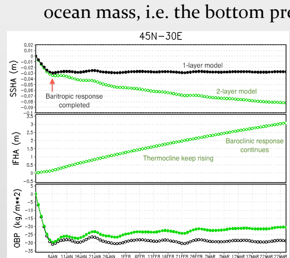



*Fig. 9 Test of 1–layer and 2–layer models.*

- 1-layer test shows that barotropic response completes within one week after stationary wind stress.
- 2-layer test shows that baroclinic response continues changing SSHA, interface level and ocean bottom pressure. Response of ocean bottom pressure is much slower than that of barotropic response.

- Seasonal fluctuation is too fast for baroclinic adjustment to affect the ocean bottom pressure.

## Conclusion

The seasonal variation of the lower-layer pressure is controlled by barotropic response to the wind stress and surface pressure variations in addition to homogeneous mass variation by surface water flux. Baroclinic response is not so important for lower-layer pressure variation in the seasonal timescale. The upper-layer pressure fluctuates with the baroclinic response to the wind stress variation as well as the seasonal heating and cooling of the surface layer. The seasonal heating and cooling of the surface layer seems more prominent in mid- and higher latitudes due to strong seasonality of surface heat flux. The baroclinic response in the upper layer seems more prominent in the equatorial region due to the faster baroclinic response.