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.

Barotropic global ocean model experiment
- In order to clarify the above, Question 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-nrd year of the experiment is used.

Regional consistency
- Define fluctuation of isobaric surface of pressure $P$ as below:

$$\bar{H}^{\text{sst}} = \bar{H}^{\text{alt}} - \bar{H}^{\text{baro}} = \bar{H}^{\text{alt}} - \bar{H}^{\text{ctrl}}$$

- 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).

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

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 $\bar{H}^{\text{alt}}$.
- Steric height is calculated from historical subsurface T/S dataset by Ishii and Kimoto (2009). Seasonal variability is denoted by $\bar{H}^{\text{ctrl}}$ 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.