Altimeter's Effect on Global Ocean Heat Content and Mean Surface Dynamic Height Analyzed by MRI Global Ocean Data Assimilation System

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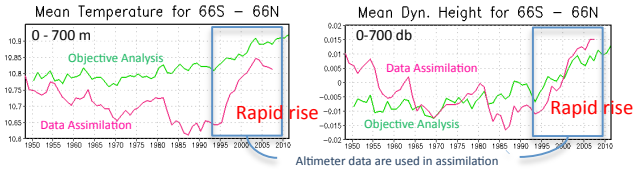
1. Introduction

◆ Sea surface height (SSH) observed by altimetry is used to correct model T-S profile in the MRI data assimilation system.
◆SSH by altimetry includes those caused by ocean water mass variation which is independent of T-S profile.
  ◆Increasing water inflow from land ice with ongoing global warming
  ◆Resulting rapid rises of global ocean heat content and dynamic height by the ocean data assimilation system (below figures)
◆The SSH variation by the mass variation should be removed for appropriate use of SSH in the data assimilation system



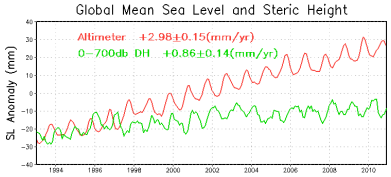
2. Estimation methods

2.1 Estimate global ocean water mass (GOWM) variation from the difference between SSH by altimetry and sea surface steric height
2.2 Estimate GOWM variation using fresh water fluxes in JRA25/JCDAS, JMA Atmospheric reanalysis
2.3 Evaluate areal dependency of GOWM variation

2. 1 SSH by altimetry and SSDH

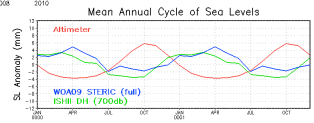
Global (66°S-66°N) mean SSH by TOPEX/POSEIDON, JASON-1, and –2 is compared with global mean steric height (thickness of 0-700 db) for the period from 1993 to 2011.

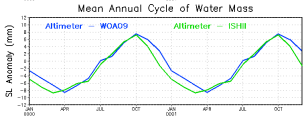
1) Deviation of the trend is 2 mm/yr. → mainly by increasing GOWM
→ inflow flux excesses due to land water melting ?
2) Opposite seasonal cycle → seasonal variation of GOWM
→ total water flux is varying seasonally ?



Objective SSH analysis in JMA
Kuragano & Kamachi

Objective subsurface
T & S analysis in JMA
Ishii and Kimoto(2009)



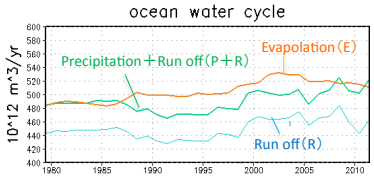


Top: Time series of monthly global Mean SSH and global mean steric height
Middle: Averaged seasonal variation. WOA09 indicates global mean steric height from full level T and S data.
Bottom: Global mean deviation of SSH from steric height

2. 2 Fresh water flux in JRA25/JCDAS

Long term variation of FW flux

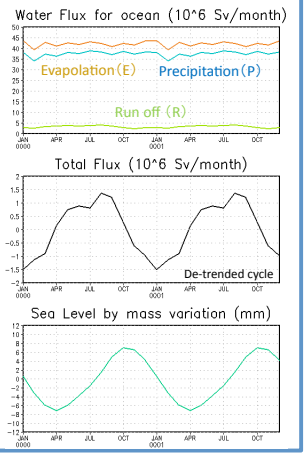
・A value 'Precipitation (P) + Runoff (R) - Evaporation (E)' controls GOWM increment.
・Decrement of 4.2 cm per year is calculated from JRA25/JCDAS
← Disagree with the estimate in 2.1
  ・Given SST in JRA25/JCDAS may cause unrealistic evaporation.
  ・E largely exceeds P + R after 1987, for which SSM/I data are used for assimilation. → Assimilation of SSM/I data may cause the disagreement.
→ It is difficult to estimate long term variation of GOWM from FW fluxes in JRA25 /JCDAS.



2. 2 Fresh water flux in JRA25/JCDAS (cont.)

Seasonal Variation of FW fluxes

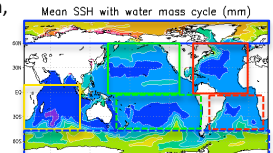
Averaged annual cycle of global mean sea level due to GOWM variation is estimated from global monthly mean fluxes of E, P and R.
1) Run off is main contributor for Seasonal variation of total flux.
2) Inflow (outflow) exceeds from May to Sept (from Nov to Mar).
3) Global mean sea level, estimated by time integration of total flux, has minimum in Apr. and maximum in Oct., and amplitude is 7 mm.
← Agree with estimation in 2.1
(see bottom figure in 2.1)

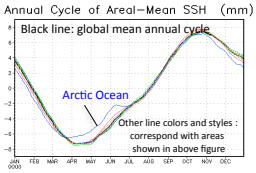


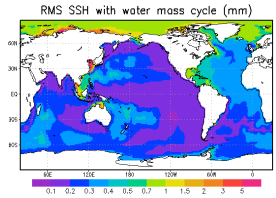
2. 3 Areal dependency of SSH variation by water mass

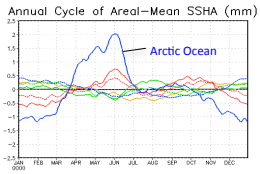
◆If water mass anomaly is adjusted by gravity wave, it should be homogenized in a few days.
◆Evaluate mass distribution using a barotropic global ocean model
  Area and grid : 80°S～87°N, 1°×1°
  FW fluxes : Annual cycle of E and P distributions, and inflow by R at coastal grids are given from JRA25/JCDAS
  Wind stress : not given
  Evaluation: from the result of 2nd year of 2 years run experiment

1) Higher annual mean SSH distributes in high latitudes and lower SSH in mid and low latitudes. Deviation is 3 mm, which is smaller than the amplitude of global mean annual cycle. (top and middle figures)
2) Areal mean annual cycles except for Arctic Ocean coincide with the global mean cycle. (areas are indicated in top figure, Middle right : deviation from mean level of each area, Bottom right : deviation from global mean)
3) Deviation from the global cycle is also large in the marginal seas, as East China Sea, Thailand Bay、Arafura Sea and Caribbean Sea. (bottom left : RMSD from Global mean cycle)









3. Conclusion

◆It is difficult to evaluate long-term variation of GOWM from fluxes of JRA25/JCDAS.
◆Seasonal cycle of GOWM is confirmed by JRA25/JCDAS.
◆Run off is main contributor to the seasonal cycle.
◆Annual mean distribution of water mass seems to be trapped by bottom topography, and may be due to barotropic adjustment.
◆Seasonal variations except for marginal seas are almost homogeneous due to gravity wave adjustment.

⇒We will use SSH corrected for mass variation, at least seasonal mass variation, for Global Ocean Data Assimilation to represent more precise global ocean condition.