Title

Low sea surface salinity in the Japan Sea during the last glacial maximum

Members' names and affiliations

Name	Institution and Department	Employment position	
Kailun Du	Ocean University of China	Master course student	
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Aim

This project aims to clarify the sea surface salinity in the Japan Sea during the last glacial maximum (LGM) and to estimate the impacts of the volume transport through Tsushima Strait as well as evaporation and precipitation on the reduction of sea surface salinity. It also aims to promote cooperation and students exchange between the College of Environmental Science and Engineering of Ocean University of China and the Center for Marine Environmental Studies (CEMS) of Ehime University.

Procedure

The principal investigator (PI) made an oral presentation "Low sea surface salinity in the Japan Sea during the last glacial maximum" and showed the recent studies including:

1 The lower sea surface salinity in the Japan Sea is due to the evaporation and precipitation and the weakening of water exchange in the Tsushima Strait during the LGM.

2 The annual mean precipitation exceeds evaporation and the fresh water input the Japan Sea during the LGM.

3 The reduction of volume transport through Tsushima Strait due to the decrease in sea level plays a vital role in the change of sea surface salinity over the Japan Sea.

Results

1. The precipitation and evaporation simulated by PMIP3 models

We collect LGM simulations from the Paleoclimate Modelling Intercomparison Project, Phase

3 (PMIP3) and compare these simulations to the experiments of Preindustrial (PI) and Mid-Holocene (MID). The annual mean precipitation and evaporation are given in Figure 1, simulated by the PMIP3 models. The LGM precipitation is slightly less than the PI and MID, and simultaneously, the evaporation also decreases compared with that in other periods, which is related to the reduction of air temperature and weakening of solar radiation during the LGM. These indicate that the net freshwater input in Japan Sea was mainly caused by the decrease of evaporation rather than by the increase of precipitation in the LGM.

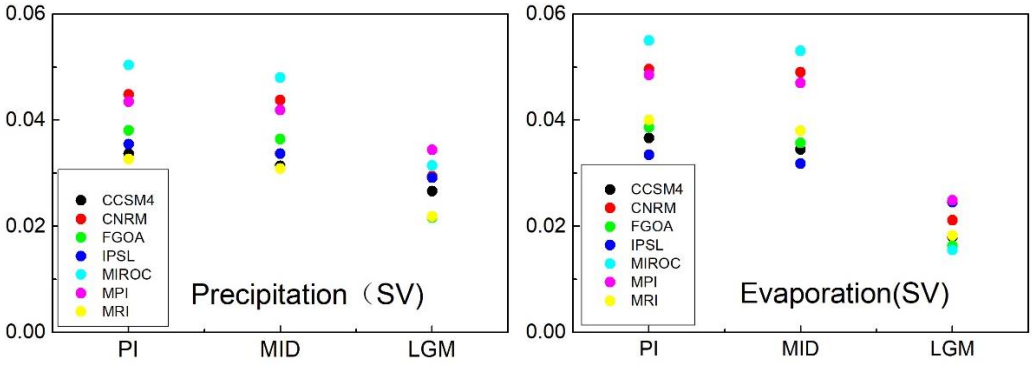


Fig. 1. The annual mean precipitation and evaporation for PI, MID and LGM, simulated by each of the seven PMIP3 models (CCSM4, CNRM, FGOA, IPSL, MIROC, MPI, MRI).

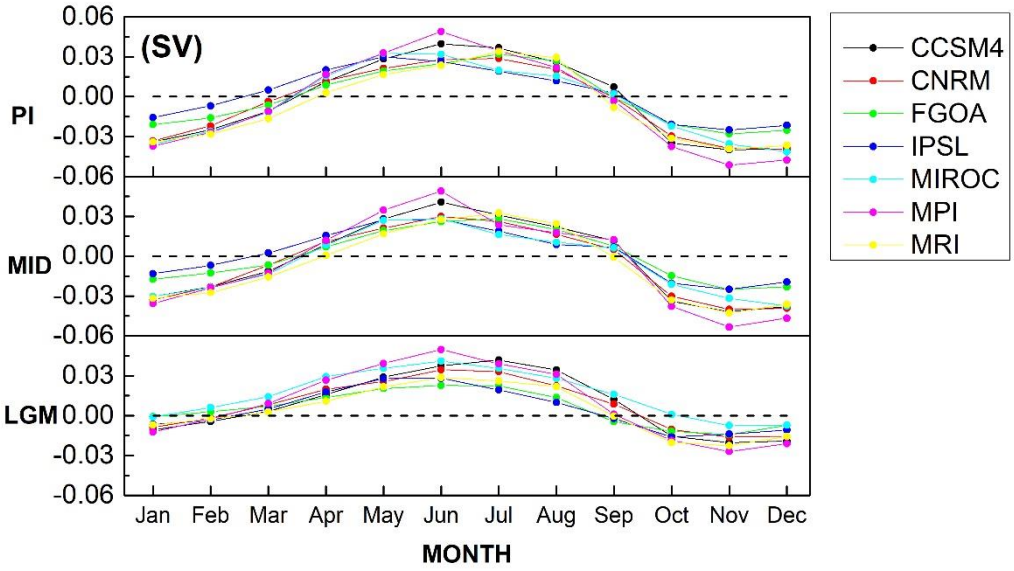


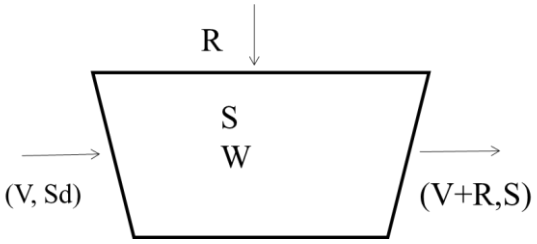
Fig. 2. The seasonal variation of the precipitation minus evaporation for PI, MID and LGM, simulated by each of the seven PMIP3 models (CCSM4, CNRM, FGOA, IPSL, MIROC, MPI, MRI).

The seasonal variation of precipitation minus evaporation over the Japan Sea in the three periods is very similar (Fig.2). In winter, the precipitation was less than the evaporation, and in summer, the precipitation was greater than the evaporation. During the PI and Mid-Holocene, the precipitation exceeds the evaporation from April to August. The Japan Sea has fresh water input and the value is 0.0005-0.05 SV (1 Sverdrup = 10^6 m^3/s). The Japan Sea has also fresh water input from

March to September (0.001-0.05 SV) in the LGM. Because the change of precipitation and evaporation is so uncertain, the precipitation minus evaporation value is given as the constant during our calculation.

2 The salinity simulation

We use a simple ocean model (Fig.3) and attempt to simulate the paleoclimatic change of the Japan Sea in th last glacial maximum. In the present work, only the upper 200 m layar of the Japan Sea is included in the model, and interactions with the lower are omitted. The volume of the upper layer is fixed in the model, W = 1.5 $\times 10^{14}$ km^3(Yanagi, 2002).The salinity of the Tsushima Strait is chosen to be Sd = 33±1.0 ‰ (Matsui et al., 1998). The fresh water flux includes river discharge (0.0044 Sv) and precipitation minus evaporation.



$$\frac{dS_t}{dt} = \frac{V_t \times Sd - (V_t + R) \times S_t}{W} \quad (1)$$

$$V_t = f(t) \quad (2)$$

Fig. 3. A box model of the upper 200 m layer of the Japan Sea. V is the volume transport through Tsushima Strait to the Japan Sea. Sd is the salinity of the Tsushima Strait and S is the salinity of the upper 200m layer in the Japan Sea. The volume of the box is W. The fresh water input, R, is given as precipitation minus evaporation and river discharge.

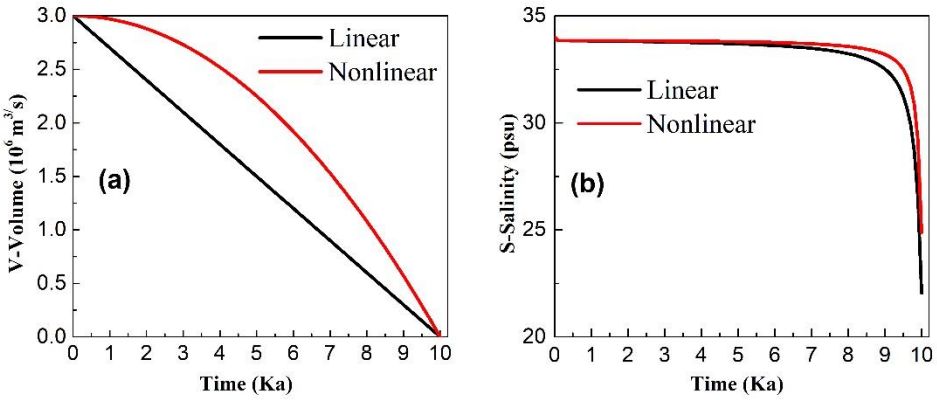


Fig. 4. Forcing parameters variation in the LGM (30 ka-20 ka) simulation. (a) V-Volume, the volume transport through Tsushima Strait to the Japan Sea. (b) S-Salinity, the salinity of the upper 200m layer of the Japan Sea.

The model is forced with the value of variables as V_t = 3 Sv, S_t = 34. Numerical calculations are carried out for ten thousand years (t), with various initial conditions. The volume (V_t) decreases with time due to the low sea level. We assume that the relationship between volume transport through the Tsushima Strait and time is linear or nonlinear. The evolution is shown in Fig.4. The salinity values greatly decrease during the LGM. The final salinity is 22.0 in the case of linear decreasing of volume transport with time and 24.8 in the case of nonlinear decreasing of volume transport with time. Since the fresh water value is fixed, a complete shutoff reduces the upper layer salinity to about 10.

References:

Matsui H, Tada R, Oba T. Low-salinity isolation event in the Japan Sea in Response to Eustatic

Sea-Level drop during the LGM: Reconstruction based on salinity-balance model[J]. The Quaternary Research(Jpn), 1998,37(3):221-223.

Yanagi T . Water, Salt, Phosphorus and Nitrogen Budgets of the Japan Sea[J]. Journal of Oceanography, 2002, 58(6):797-804.

Publication/conference presentation

Oral presentation (LaMer):

Title: Low sea surface salinity in the Japan Sea during the last glacial maximum
Lecturer: Kailun Du.
Time: December 3, 2018.
Location: Ehime University.

Perspectives in future

We will clarify the change of volume transport through the Tsushima Strait with sea level dropping and the impacts of the volume transport through Tsushima Strait on the reduction of sea surface salinity during the LGM, which can provide reference and basis for paleoceanography research. We will enhance the cooperation researches and exchanges of faculties and students between the Ocean University of China and CEMS of Ehime University.