Respondence to the paper Atmospheric Response to North Pacific SST: The Role of Ocean-Atmosphere Coupling

The two-way interaction between the atmosphere and ocean is one of the hot topics in the atmospheric and oceanic sciences. Generally, most people believe that ocean drives the atmosphere in the tropics while the atmosphere drives the ocean in the midlatitude. Recently, most scientists in the author’s climate group in Wiscosin are focusing on showing evidences of the atmospheric forcing on ocean in midlatitude. So it motivates me to read his earlier paper on the ocean-atmosphere coupling issue.

His argument is very elegant. And also his style of presenting the conclusion before the detailed the explanation is quite unique. So reading his paper is much more like reading a story. The main conclusion of the paper is that SST forcing have a warm-ridge response on the downstream area, while the heat flux forcing have a warm-low response on the downstream area. Due to this basic difference, he explained why in the fully coupled ensemble(FCE), the warm-ridge response is stronger than that in the thermodynamically coupled ensemble (TCE) and Atmospheric Model Intercomparsion Project. (We first have to know that fully coupled experiment include both the dynamically and thermodynamically coupling. The former is mainly the advection by the Ekman flow.) The heat flux in TCE and AMIP are stronger than that in the FCE. and Assume that the TCE is the sum of the FCE and the additional heat flux forcing, then the warm-ridge and warm-low response by the FCE and additional heat flux forcing tends to cancel with each other, and it follows a weak warm-ridge response in the TCE. If the above logics are true, then there two questions arise. One is why there is additional heat flux or excessive heat flux in the TCE and AMIP. The other is why the stronger heat flux forcing is associated with warm-low response.

The answer to the first question which is shown in the Figure 9 is very clear. With the dynamic coupling, the warm SST induces warm ridge which is associated with easterly winds. It follows the northward Ekman flow advecting warm SST to the north. Then there is positive feedback on the SSTA, so that the SST forcing is stronger in the FCE. However, without the Ekman flow in the TCE, there is strong surface cooling which will destabilize the surface of ocean and induces a stronger convective warming. The warming causes much stronger surface heat loss and enhance the damping of SSTA, as well as enhance the forcing (upward) heat flux to the atmosphere.

The answer to the second question is through the additional experiment which is flux forced ensemble. And results in Figure 10 shows a warm low in the downstream region.

I also want to mention the application of a new way to estimate the atmospheric response to midlatitude SST. First of all, we need to know that atmospheric variability in the midlatitude are caused by midlattude SST as well as the atmospheric internal variability. To filter out the noise associated with the atmospheric internal variability, the author used SST-lead variance rather than the instantaneous covariance (See equation (1) ).

However, there remain two questions which are not addressed in the paper. One is due to the limitation of the model they used, which have only the monthly data, so that the transient eddy heat and vorticity flux cannot be calculated without the daily outputs. The other is due to their assumption of the separation of the SST forcing and heat forcing. Whether they are independent or dependent are unknown. But physically, SST forces the atmosphere through the changes in heat flux, and therefore is not independent from heat flux forcing.