Known biases in IAP/LASG FGOALS_g1.0 model and the recent improvements

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Recent analyses on the output of IPCC AR4 runs have reported some biases in the IAP/LASG coupled GCM FGOALS_g1.0, e.g. the cold bias in high latitudes of N. Hemisphere. Combining these reports with our own diagnosis, we make the following announcements on our IPCC AR4 runs:

1. Biases in our IPCC AR4 runs

(1) Overestimated sea ice extension in Northern and Southern Hemispheres

The IAP/LASG FGOALS_g1.0 model shows much more sea ice extension than the observation, and this should be attributed to the weak oceanic poleward heat transport (PHT) in the model, which has a maximum value of 0.6-0.7PW in comparison with the observational estimate of 2.0PW. The same magnitude of PHT is also found in the stand-alone run of the OGCM component of FGOALS_g1.0 when it's forced with observational data. Our diagnosis indicates that this weak PHT is resulted from the strong high latitudes zonal filtering used in our OGCM to prevent numerical instability.

(2) **Weakened Atlantic meridional overturning circulation (AMOC)**

The intensity of North Atlantic Deep Water (NADW) in the stand-alone run of OGCM component of FGOALS_g1.0 is only 10Sv, which is weaker than those of many OGCMs. When the OGCM is coupled to our AGCM, the sea ice extends equatorward due to the insufficient oceanic PHT, which weakens the convection amplitude in the sub-polar region of N. Atlantic and pushes convection center equatorward. The NADW reduces gradually and shuts down after about 100 model years. Associated with the weakened NADW, the strong cold biases are found in the high latitudes of N. Hemisphere especially the sub-polar region of North Atlantic and North Pacific.

(3) Cold Biases in the Tropical Pacific and too Strong ENSO:

As most coupled GCMs without any flux correction, the coupled GCM FGOALS_g1.0 suffers from prominent cold biases in the tropical Pacific or the so-called “Double ITCZ”. Because the simulated SST is 1℃colder than the observed in the central equatorial Pacific in the stand-alone OGCM, then the cold bias is amplified through air-sea coupling and thus 2-3℃ cold bias in SST and uplift of thermocline in the tropical Pacific can be found in the coupled GCM, which results in very strong and regular ENSO variability, e.g., the standard deviation of Nino3 index is about 2.1℃ (the observed value is 0.85℃).

2. Improvements in the updated version IAP/LASG FGOALS_g1.1

In a recent improved version of FGOALS (hereinafter FGOALS_g1.1), we have modified the high latitude zonal filtering scheme to increase the PHT, and adopt mass conservation rather than volume conservation in freshwater exchange to prevent the drift of AMOC. The improvements of FGOALS_g1.1 are shown in the figure 1 and Figure2:

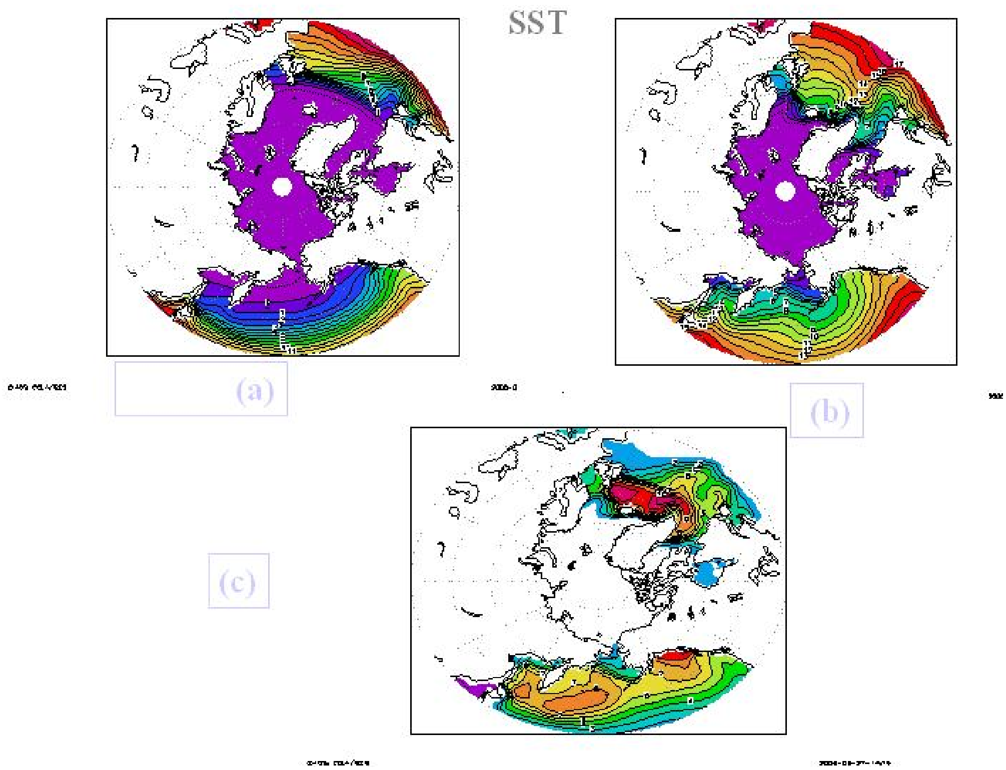
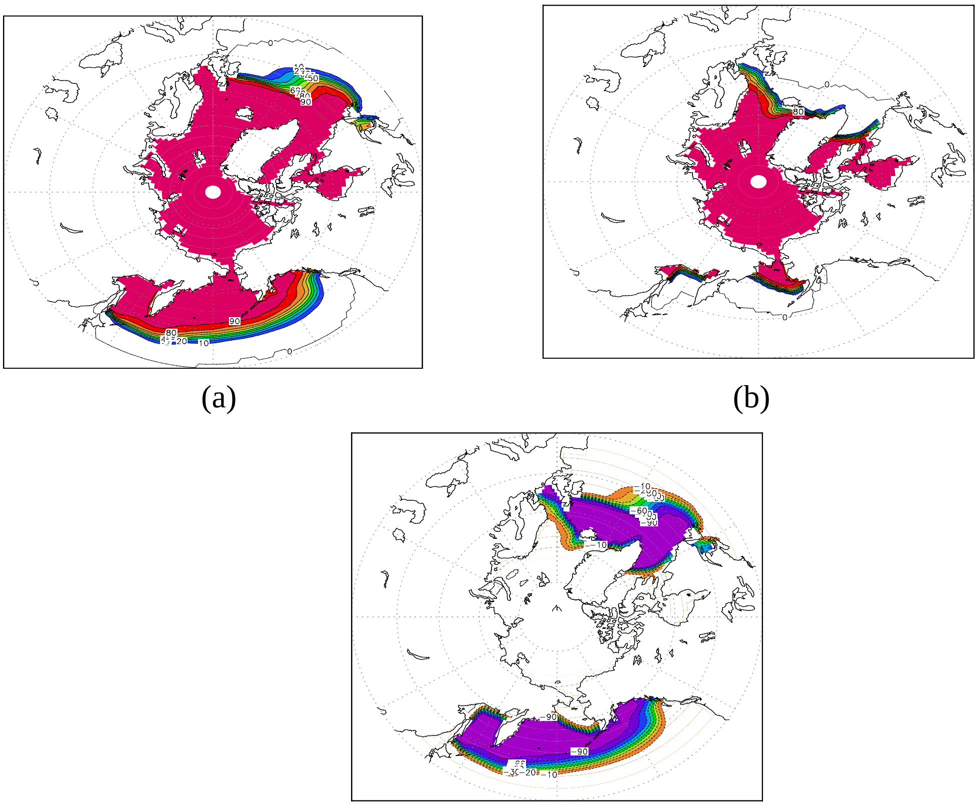


Figure 1: Annual mean SST around the Arctic Ocean: (a) ***FGOALS_g1.0****, (b)* ***FGOALS_g1.1****, and (c) the difference between FGOALS_g1.1 and FGOALS_g1.0. (unit: ℃)*



(a) (b)

(c)

Figure 2: Climatological mean Sea ice concentration in March around the Arctic Ocean (a) ***FGOALS_****g1.0, (b)* ***FGOALS_****g1.1, and (c) the difference between FGOALS_g1.1 and FGOALS_g1.0 (unit: %).*

In the high latitudes of N. Hemisphere, **FGOALS_**g1.1 shows significant warming with maximum center about 12C than that of **FGOALS_**g1.0. The sea ice extension of **FGOALS_**g1.1 is reduced about 40-45% compared with **FGOALS_**g1.0.

In order to reduce the tropical biases in the model, we also introduce a new advection scheme (Yu et al, 1994)) and a modified flux algorithm from Dr. Luo in J. Climate (Luo et al, 2005) in the updated version FGOALS_g1.1. Compared with the original version FGOALS_g1.0, the new version simulated more reasonable climatological mean SST and ENSO variability in the tropical Pacific as follows (Figure 3 and Figure 4).

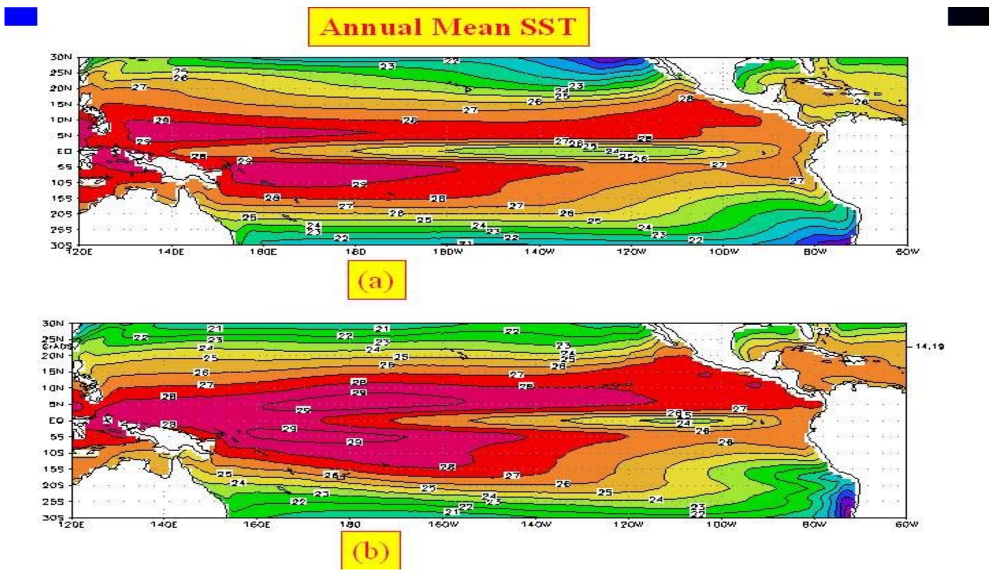


Figure 3 Climatological mean SST in the tropical Pacific by FGOALS_g1.0 (a) and FGOALS_g1.1 (b).

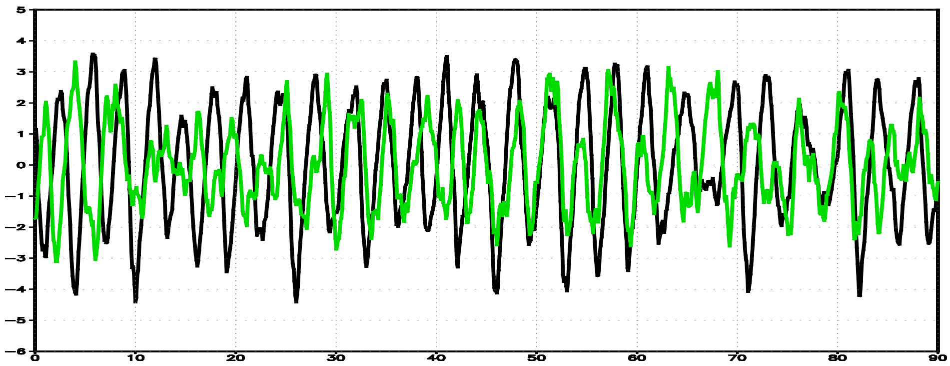


Figure 4 Simulated Nino3 indices by FGOALS_g1.0 (green line) and FGOALS_g1.1 (black line).

4. Disclaimer for the analysis of our IPCC AR4 outputs

The high latitude cold bias in our coupled model has been improved in the revised version. Due to the limitation of our computer resources, however, it is impossible for us to re-submit all required data of the IPCC AR4 runs by using the improved version of our model. For the analyst of IPCC AR4 runs, while our submitted model data are suitable for tropical and subtropical climate studies, we do not suggest to use these data in mid-high latitudes climate studies. We also put in the data of simulated climate change in the 20th century from the revised version (IAP/LASG FGOALS_g1.1) at http://web.lasg.ac.cn/FGCM/index.htm for your reference.