The role of clouds and surface radiation balance change in the sensitivity of near-surface temperature to the change of CO_2

Evgeny M. Volodin (PI),
Nikolai A. Diansky,
Institute for Numerical Mathematics of Russian Academy of Science
Gubkina 8, Moscow 119991 GSP-1, Russia
E-mail: volodin@inm.ras.ru
Phone: +7 095 9383904
Fax: +7 095 9381821

Background and objectives

The analysis of CMIP2 data show (Covey et. al, 2000) that the sensitivity of global averaged near-surface temperature to CO_2 change differs from 1 to 3 K for years 61-80. It is known that there are two main factors that determine the sensitivity: change of cloud radiation forcing (CRF) and ocean heat uptake.

Our runs with INM model performed under CMIP2 program show that: INM model has minimum sensitivity of near surface air global temperature in comparison with other CMIP-models: 1 K for years 61-80.
Main reason of small sensitivity is decreasing of incoming radiation due to increasing of PBL stratus cloud amount (2.5 W/m^2). The role of ocean heat uptake is much smaller. Net heat flux to ocean in CO_2 run in years 61-80 is only 1.0 W/m^2.
The reason of increasing of PBL stratus clouds is that in INM model there is strong dependence of low cloud amount from vertical temperature profile. In the case of inversion we have much more clouds than without inversion. For CO_2 run we have stronger warming in the troposphere than at the surface. Therefore, we have more inversion conditions and more low stratus clouds.

The aim of this study is to understand the role of cloud radiation forcing and ocean heat uptake in determination of near-surface temperature sensitivity to CO_2 increase for CMIP models. There are some CMIP projects that consider the role of ocean heat uptake in the explanation of different sensitivity to CO_2. We try to compare the importance of these two factors.

Methodology

Direct data of CRF change at the surface due to CO_2 change are not available for CMIP2. But we try to estimate it from available solar and IR radiation balance in assumption that change of clear-sky radiation balance at the surface for different models depends linearly from near-surface temperature response, and that clear-sky balance change for INM model is known.

We study the connection between CRF change and global near-surface warming for all CMIP2 models; the connection between ocean heat uptake and global warming, and the connection between CRF change + ocean heat uptake and global warming.

Another point is that in some places (eastern tropical Pacific, southern midlatitudes) mean SST error in the present-day climate simulation is connected closely with reproduction of low stratus clouds under inversion. We try to look for simple connection between mean SST error (or heat flux correction value) in these places in control experiment, global CRF response and near-surface global temperature response to change of CO_2. If we find simple connection between SST error and temperature response, we can hope to estimate sensitivity of real climate system assuming that SST error for real climate system is zero. It is important, because real climate system sensitivity can not be measured directly.

Data requirements

Monthly mean surface air temperature;
20-year means of:
net surface heat flux at the air-sea interface,
flux adjustment,
surface latent heat flux,
surface sensible heat flux,
surface net IR radiation balance,
surface solar radiation balance,
zonal mean atmospheric temperature.

References

Covey C., AchutaRao K.M., Lambert S.J., Taylor K.E. 2000. Intercomparison of present and future climates simulated by coupled ocean-atmosphere GCMs. PCMDI Report N66.