Geophysical Research Abstracts,
Vol. 11, EGU2009-476, 2009
EGU General Assembly 2009

Energetics responses to increases in greenhouse gas concentration

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Because of increasing greenhouse gas concentrations, the atmosphere warms up. However, it is not so evident whether this warming implies changes in the energetics of the atmosphere, i.e., the generation of available potential energy, its conversion into kinetic energy, and further dissipation. The Lorenz Energy Cycle (LEC) describes these processes, and provides a fundamental view of the atmosphere's behavior from which other properties may be inferred (like storm activity from the eddy components, for example).

To study the energetics responses of the atmosphere, we diagnose changes in the LEC due to higher CO2 concentrations in the global atmosphere-ocean ECHAM5/MPI-OM model. We analyze a 100-year 1xCO2 control run, 2 ensembles (of 50 runs each) of 10-year runs forced with 3% increase of CO2 per year, and a 100-year 2xCO2 equilibrium run. The results show a general decrease in strength of the cycle, but a strong increase in zonal mean kinetic energy. Vertical cross sections of the different terms reveal a strengthening of the cycle in the upper troposphere and lower stratosphere, which is responsible for the increase in zonal mean kinetic energy, and a decrease in strength across the middle and lower troposphere, which is responsible for the overall decrease in activity. Splitting the atmosphere at 350hPa and computing the LEC for each region together with the corresponding boundary fluxes, further supports this hypothesis.

The upper-level strengthening may be related to the increase in meridional temperature gradients due to the strong tropical upper-tropospheric warming (due to moisture effects), while the lower and middle-level weakening is consistent with the reduced pole to equator and land-sea contrasts in lower levels of the troposphere. Experiments to test the role of moisture in the LEC are planned as a follow-up of these results.