Geophysical Research Abstracts,
Vol. 10, EGU2008-A-08051, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-08051
EGU General Assembly 2008

Understanding Land-Sea Warming Contrast in Response to Increasing Greenhouse Gases

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Climate model simulations consistently show that in response to greenhouse gas forcing surface air temperature over land increases more rapidly than over sea. The enhanced warming over land is not simply a transient effect, since it is also present in equilibrium conditions. In this paper, the mechanisms responsible for enhanced land surface warming are elucidated using equilibrium and transient sensitivity experiments carried out with an atmospheric GCM. The GCM is forced by doubling CO2, by increasing SST, or both. In the case of SST forcing the SST anomaly is derived from a coupled model simulation forced by increasing CO2. The equilibrium experiments demonstrate that the enhanced warming over land is partly a direct response to CO2 forcing and partly an indirect response to SST changes, with the SST forcing explaining about 70% and the CO2 forcing explaining about 30% of the land warming signal. The results also indicate that including both forcings reproduces many features of the land sea warming contrast seen in the coupled model. The enhanced warming over land is closely associated with local feedbacks due to changes in the hydrological cycle. The warming over land induced by SSTs is mainly caused by enhanced surface shortwave radiation resulting from a decrease in cloud cover. In contrast, the warming over land induced by CO2 forcing is mainly caused by a decrease in evaporation resulting from a reduction in stomatal conductance. SST forcing leads to decreases in precipitation over land and decreases in soil moisture, whereas CO2 forcing leads to enhanced precipitation over land and increases in soil moisture. Analysis of the transient experiments reveals distinct stages and timescales for the establishment of the

land/sea warming contrast; these findings will be discussed.