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The Response of the Atmosphere to Local CO_2 Asymmetries

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Carbon dioxide is generally considered as a well-mixed greenhouse gas in the Earth atmosphere, due to its long residence time. Nevertheless, the actual CO_2 distribution shows some spatial inhomogeneity.

The aim of this study is to evaluate the atmospheric response linked to a localized and stationary CO_2 distribution forcing. The observed pattern of CO_2 concentration reflects the distribution of surface sources and sinks (natural and anthropogenic), and the fundamental role of the main atmospheric transport pathways. For this reason, we have focused our attention on regions indeed characterized by strong carbon emission (South East Asia and North America).

We present here a set of idealized experiments performed with numerical models of different complexity taking into account a stationary and localized carbon dioxide forcing. The experiments have been performed with the atmospheric component of the NCAR Community Earth System Model (CESM). Nonlinear experiments have been complemented with linear forced experiments performed with a new linearization of the current version of the spectral Eulerian Dynamical Core of the atmospheric model. The linearization is fully compatible with the numeric formulation of the nonlinear general circulation model. This new linear model is a simple but powerful tool to investigate the features of the stationary state of the atmosphere and the response of the system to stationary external forcing.

The combined use of the general circulation model and the linear model has permitted us to identify which region is more sensitive to the localized forcing and the pattern of the local and remote response. The analysis we have performed has allowed to emphasize the global extension of the CO_2-linked pattern for both the considered forcing regions, and to identify the signature of the response due to localized sources of heating deriving from CO_2 local distributions.