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Sensitivity of simulated CO_2 concentration to regridding of global fossil fuel CO_2 emissions

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Abstract. Errors in the specification or utilization of fossil fuel CO_2 emissions within carbon budget or atmospheric CO_2 inverse studies can alias the estimation of biospheric and oceanic carbon exchange. A key component in the simulation of CO_2 concentrations arising from fossil fuel emissions is the spatial distribution of the emission near coastlines. Regridding of fossil fuel CO_2 emissions ($FFCO_2$) from fine to coarse grids to enable atmospheric transport simulations can give rise to mismatches between the emissions and simulated atmospheric dynamics which differ over land or water. For example, emissions originally emanating from the land are emitted from a grid cell for which the vertical mixing reflects the roughness and/or surface energy exchange of an ocean surface. We test this potential "dynamical inconsistency" by examining simulated global atmospheric CO_2 concentration driven by two different approaches to regridding fossil fuel CO_2 emissions. The two approaches are as follows: (1) a commonly used method that allocates emissions to grid cells with no attempt to ensure dynamical consistency with atmospheric transport and (2) an improved method that reallocates emissions to grid cells to ensure dynamically consistent results. Results show large spatial and temporal differences in the simulated CO_2 concentration when comparing these two approaches. The emissions difference ranges from −30.3 TgC grid cell^{-1} yr^{-1} (−3.39 kgC m^{-2} yr^{-1}) to +30.0 TgC grid cell^{-1} yr^{-1} (+2.6 kgC m^{-2} yr^{-1}) along coastal margins. Maximum simulated annual mean CO_2 concentration differences at the surface exceed ±6 ppm at various locations and times. Examination of the current CO_2 monitoring locations during the local afternoon, consistent with inversion modeling system sampling and measurement protocols, finds maximum hourly differences at 38 stations exceed ±0.10 ppm with individual station differences exceeding −32 ppm. The differences implied by not accounting for this dynamical consistency problem are largest at monitoring sites proximal to large coastal urban areas and point sources. These results suggest that studies comparing simulated to observed atmospheric CO_2 concentration, such as atmospheric CO_2 inversions, must take measures to correct for this potential problem and ensure flux and dynamical consistency.

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