# A TEST OF THE REPRESENTATION OF CONVECTIVE CLOUD TRANSPORT IN A MODEL OF $CO_2$ TRANSPORT

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**ABSTRACT**

We present here a test of convection uncertainty within a single model framework driven by the same meteorological fields. Our primary goal is to explore to what extent do convection schemes impact atmospheric $CO_2$ distribution, by testing three referred cloud convection schemes ranging from a very simple to a relatively complex form [Table 1]. Our second goal is to examine the sensitivity of atmospheric $CO_2$ to its regional emission/sink uncertainty [Fig. 1] constrained by IPCC 2001 at a "fixed" convection scheme to clarify the pros and cons of the convection schemes.

**Table 1**. The main features and differences in three convection algorithms

| | **Conv1** | **Conv2** | **Conv3** |
|---|---|---|---|
| References | Kawa 2004 | Allen 1996 | Hack 1994; Zhang & McFarlane 1995 |
| Implemented in | PCTM | GOCART; GEOS-CHEM | MATCH; GEOS-CHEM |
| Differentiate tracer in & out cloud | NO | YES | YES |
| Numerical scheme | a semi-implicit | an upstream differencing | an upstream differencing |
| Differentiate shallow & deep cloud | NO | NO | YES |
| Constrained by | cloud mass flux | cloud mass flux; detrainment; entrainment | shallow: shallow cloud mass flux; overshot parameter<br>deep: updraft; downdraft; updraft entrainment; updraft detrainment; downdraft entrainment |

Note PCTM, GOCART, GEOS-CHEM and MATCH are names of global CTMs.

## RESULTS AND CONCLUSIONS

Global $CO_2$ in the year of 2000 is simulated by a unified chemistry transport model (UCTM) driven by assimilated meteorological fields from NASA's Goddard Earth Observation System version 4 (GEOS_4). A 'standard' simulation is designed to repeat $CO_2$ simulation in Kawa et al. [2004] by adopting the same driving data (emission denoted as Emi1) and transport algorithms (convection as Conv1).

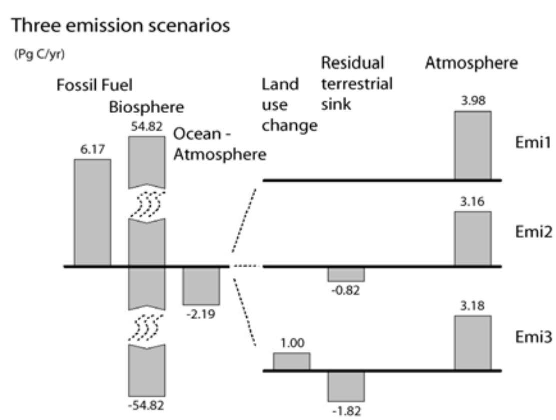


Fig. 1. Chart showing three emission scenarios constrained by IPCC 2001 framework.

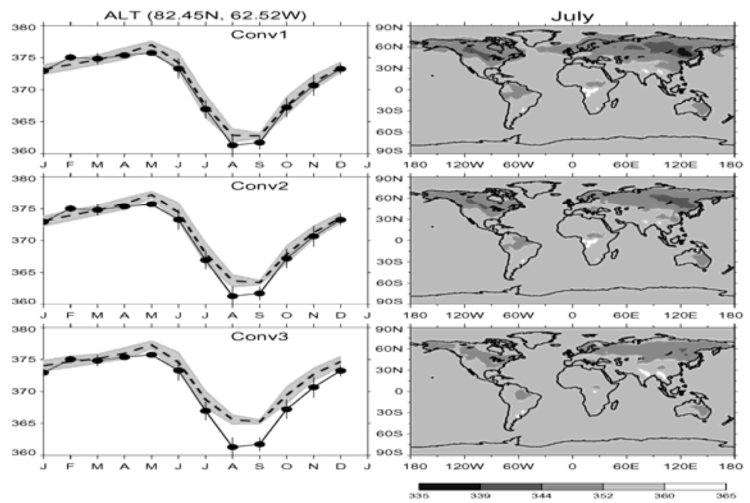


Fig. 2. Surface model-observation comparisons at station Alert (ALT) and surface global $CO_2$ (ppm) in July with three convection schemes.

We re-play UCTM by replacing Conv1 with Conv2 and Conv3 respectively to test the impact of the convection algorithm. $CO_2$ seasonality is apparently reduced with the latter approaches indicated in surface $CO_2$ model-observation comparisons at station Alert in Fig. 2. Global surface CO2 distributions [Fig. 2] further demonstrate $CO_2$ is overestimated over land sink regions with Conv2 and Conv3. The largest discrepancies occur between Conv1 and Conv3, resulting in $CO_2$ differences of about 7.7 ppm in July Northern Hemisphere (NH) boreal forest, which is about a quarter of the $CO_2$ seasonality for that area. Further diagnoses reveal that this NH summer's largest discrepancy is primarily associated to the season's deep cloud activities which are represented in different ways in three transport approaches.

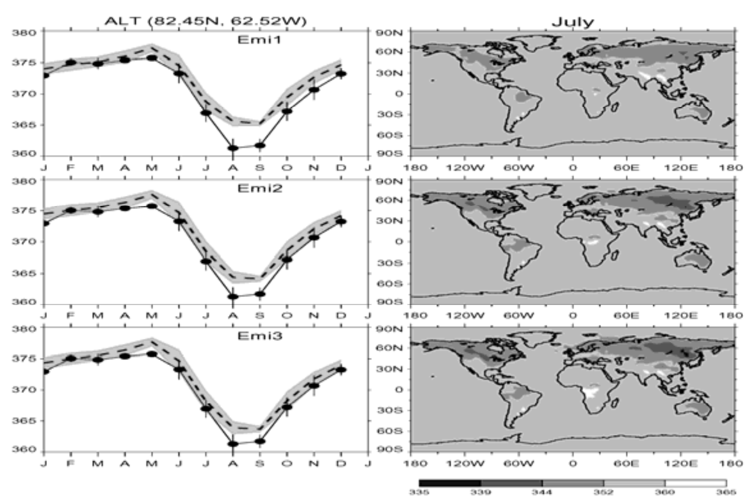


Fig. 3. Same as Fig. 2 but with three emission scenarios under convection scheme Conv3.

Two supplemental emissions in Fig. 1 substitute Emi1 to examine whether Conv3 still stands for the 'worst' algorithm in terms of the agreement of models and observations. Fig. 3 shows the same distributions as in Fig. 2 but altering emission scenarios under the same convection Conv3. An interesting finding is that the overestimated $CO_2$ driven by Conv3 with Emi1 can be offset by introducing these supplemental emissions.

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