Measurements and Modeling of Contemporary Carbon-14 Levels in the Stratosphere to Constrain Stratospheric Dynamics & the Global Carbon Cycle

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$^{14}\text{CO}_2$ as a Tracer in the Stratosphere

<table>
<thead>
<tr>
<th>Altitude (km)</th>
<th>12</th>
<th>25</th>
<th>38</th>
<th>50</th>
<th>62</th>
</tr>
</thead>
</table>

$^{14}_7\text{N} + ^1_0\text{n} \rightarrow ^{14}_6\text{C} \rightarrow ^{14}\text{CO}_2 \sim 15-33\text{km}$

Ft. Sumner, NM (34°N)

Background is $^7\text{Be}$ production from Koch & Rind 1998

Balloon Sampling
Fall 2003, 2004, & 2005

Accelerator Mass Spectrometry (LLNL CAMS)
Model Setup

- IMPACT: LLNL chemistry transport model,
- 1960-2006 simulations,
  - (many e-fold times needed for spinup),
- 3 different GCM metadata.
- 3 tracers:
  - $^{14}$C-trop (historical surface concentrations),
  - $^{14}$C-strat (cosmogenic prod. in strat; zero in trop),
  - N$_2$O (historical surface concentrations + strat loss).
Model vertical profiles generally match obs.

- Deviations from model could be described by transport from other latitudes.
- Model vertical profiles generally match obs.
- Note $\text{N}_2\text{O}$ annual increase is small.
- Path of chemical loss is longer than from $^{14}\text{C}$ production.
N2O relation to 14C seems to be captured, except 2005 (signature of different transport?).
\( \Delta^{14}\text{CO}_2 \) (per mil) vs. \( \text{N}_2\text{O} \) (ppbv)

- \( \text{MACCM3} \ 34^\circ\text{N} \ (2004) \)
- \( \text{FVCCM} \ 34^\circ\text{N} \ (2004) \)
- \( \text{FVDAS} \ 34^\circ\text{N} \ (2004) \)

- Fall 2003 Obs
- Fall 2004 Obs
- Fall 2005 Obs

- \( \text{N}_2\text{O} \) relation to \( ^{14}\text{C} \) seems to be captured by different metadata corresponding to an extreme stratospheric circulation year.
Conclusions

- IMPACT model seems to give reasonable simulation.
- $^{14}$C observations give additional information about stratospheric dynamics.
- Results will help constrain natural $^{14}$C production rate, with implications for carbon cycle studies.

Future

- Run with assimilated (observed) meteorology.
- Run with solar-cycle effect on $^{14}$C production.
The End
Archived CO₂ Samples at UCB: Spatial (5S-88N) and Temporal (1996-2007) Distribution
$^{14}\text{CO}_2$ is a Fossil Fuel CO$_2$ Tracer

- Atmospheric CO$_2$, $\Delta^{13}\text{C}$, and $\Delta^{14}\text{C}$ as reconstructed in tree-rings and ice cores for the pre-atmospheric weapons testing. The decrease in $\Delta^{14}\text{C}$ and $\Delta^{13}\text{C}$ is caused by the burning of fossil fuels.
- Present day atmospheric $^{14}\text{CO}_2$ has returned to near “pre-bomb” levels.
Carbon Cycle Partitioning of Bomb $^{14}$C
