Global Chemical Transport of Radon and Carbon Monoxide using the Colorado State University Multi-scale Modeling Framework

Rosa, D. (EPS, UC Berkeley, drosa@berkeley.edu) & Collins, W.D. (LBL, wdcollins@lbl.gov)

Motivation:

The treatment of cloud convective processes determines most of the atmospheric vertical transport and mixing which affect the chemical state and radiative forcing of the atmosphere. **We investigate the implications for the concentrations ([..]) of a short and a long lived passive tracers, radon (Rn) and carbon monoxide (CO), from explicitly simulating cloud physical and dynamical processes**. [Rn] is sensitive to convective processes throughout the troposphere and observations are available for a few locations; the upper troposphere [CO] is sensitive to the rate of convective replacement above burning biomass and global scale satellite observations are available.

Control Case:

Community Atmosphere Model (**CAM**) in Chemical Transport Mode (**CTM**) with 6 hourly NCEP meteorology: 28 levels; 1.9x2.5; **Zhang & McFarlane convective scheme for clouds**. Model for Ozone and Related Chemical Tracers (MOZART).

Rn uniform surface emission from all non-frozen land masses; 2 tags: Americas & Not-Americas. CO surface emission from monthly climatologies (from 2000 for anthropogenic emissions and from 1996-2006 for biomass burning).

Runs: 5/2005 → 10/2005 (Preliminary tests on an ENSO intermediate stage).

Test Case:

As in CONTROL but the cloud convective processes are simulated with the Colorado State University (CSU) Multi-scale Modeling Framework (MMF). This GCM is called SUPER-PARAMETERIZED CAM (**SPCAM**) and contains an embedded **2D Cloud Resolving Model** in each GCM column (64x1x26; dx = 2000m; dt=20s).

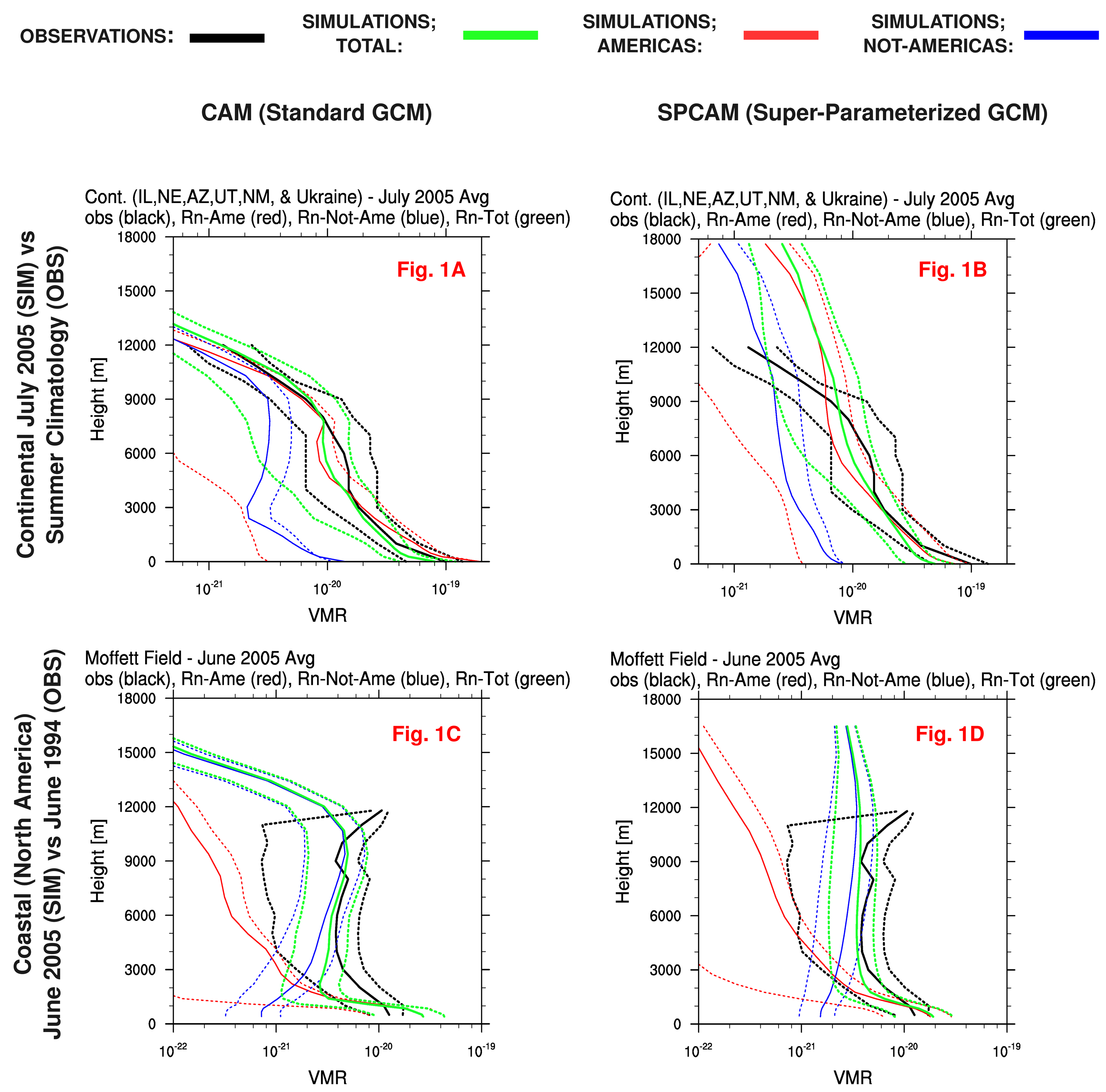
Observations:

Rn: Continental and coastal profiles; **CO**: MOPITT satellite data for the tropical upper troposphere

Preliminary Results & Future work:

With respect to CAM, SPCAM simulates BL [Rn] higher over land and lower over water in the NH (Fig. 1, Fig. 2A); SPCAM is closer than CAM to BL observations for coastal [Rn] profile (Fig. 1D) but not for continental [Rn] profile (Fig. 1B). Both models describe the UT [Rn] as resulting from long range transport (Fig. 1C,D & Fig. 2D). UT [Rn] is higher for SPCAM vs CAM (Fig. 1 & Fig. 2B,D) but Rn observations cannot help identify which model is closer to the real world; comparisons with [CO] should help address that. With respect to CAM, between -30° & 30° N, SPCAM simulates higher [CO] in the UT (Fig. 3A), and in the BL region of significant CO emission (Fig. 4A). Instead of monthly climatological CO surface emissions, we will use monthly specific CO surface emission and compare SPCAM and CAM MOPITT expected retrievals (Fig. 5) with MOPITT retrieved profiles. We will include methyl iodide as a diagnostic tracer for maritime areas. We will simulate a period that includes different ENSO stages.

Radon



Above, Fig. 1: **Comparison of simulated vs observed [Rn] profiles** for the continental (A,B) and the (C,D) coastal cases.
Below, Fig. 2: **Differences between SPCAM and CAM simulated [Rn] maps** for different levels in the atmosphere: 995-884 hPa (A), 436-372 hPa (C), 133-42 hPa (B), and only for Not-Americas radon at 133-42 hPa (C).

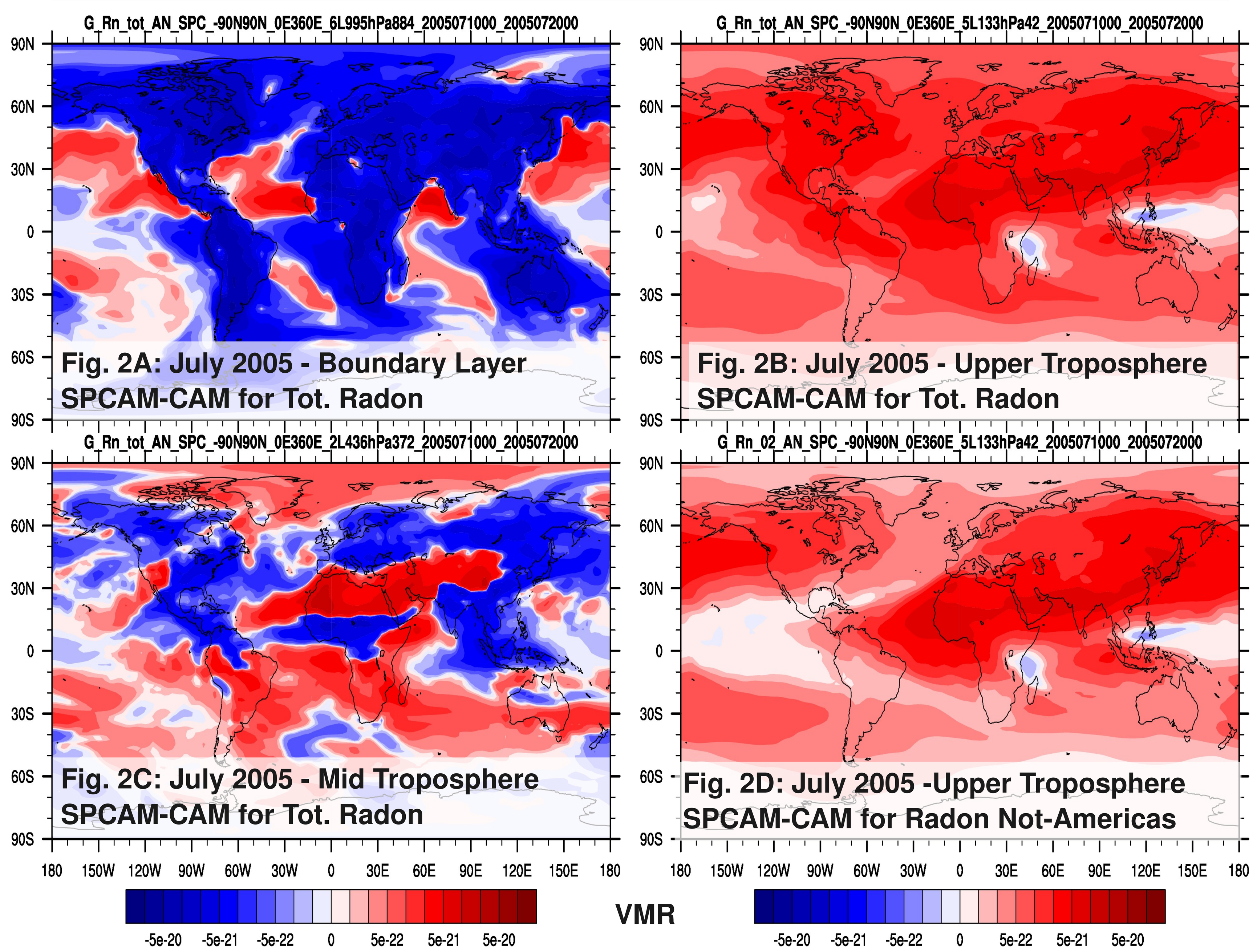


Fig. 2A: July 2005 - Boundary Layer SPCAM-CAM for Tot. Radon
Fig. 2B: July 2005 - Upper Troposphere SPCAM-CAM for Tot. Radon
Fig. 2C: July 2005 - Mid Troposphere SPCAM-CAM for Tot. Radon
Fig. 2D: July 2005 -Upper Troposphere SPCAM-CAM for Radon Not-Americas

Carbon Monoxide

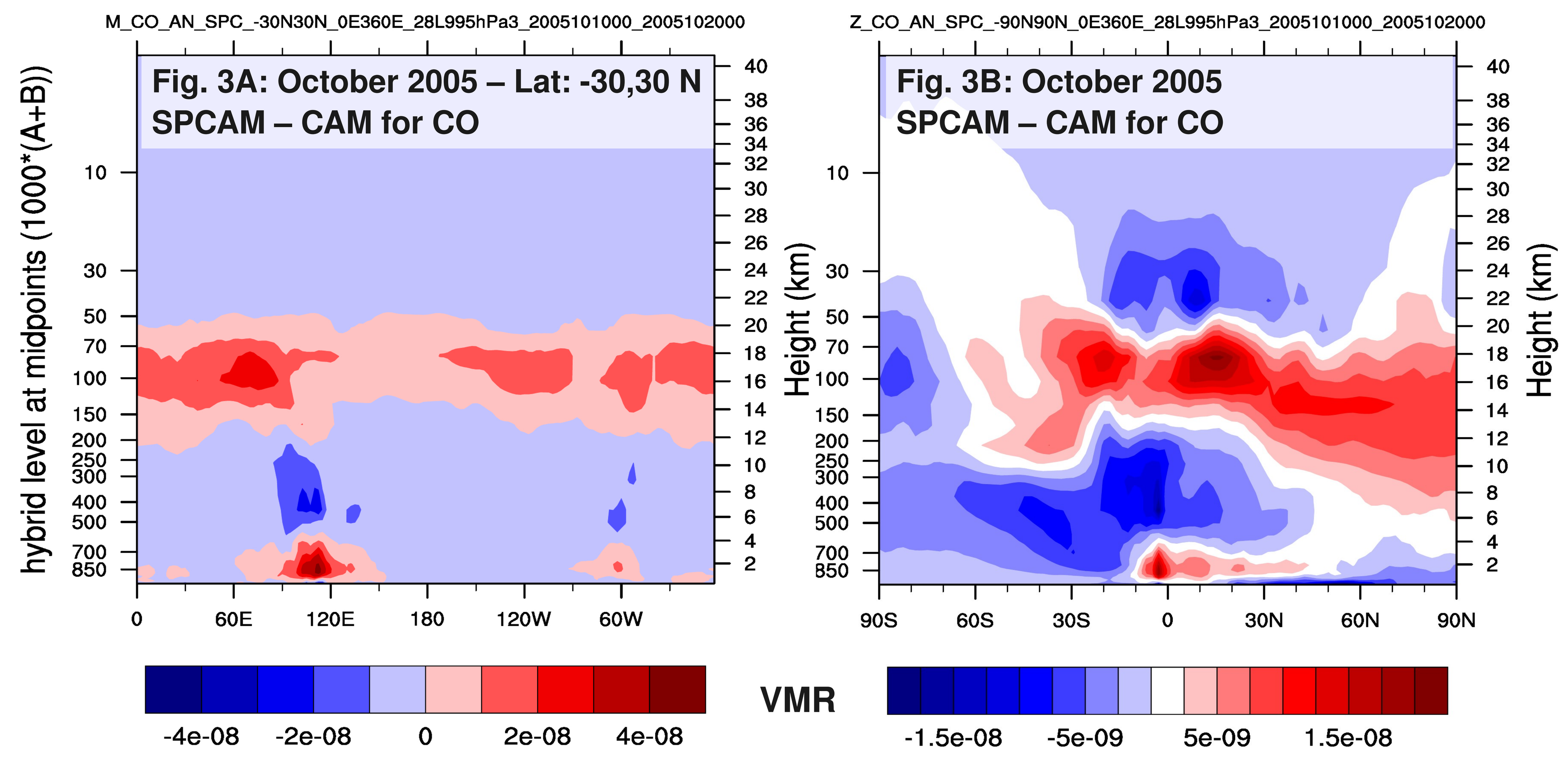


Fig. 3A: October 2005 – Lat: -30,30 N SPCAM – CAM for CO
Fig. 3B: October 2005 SPCAM – CAM for CO

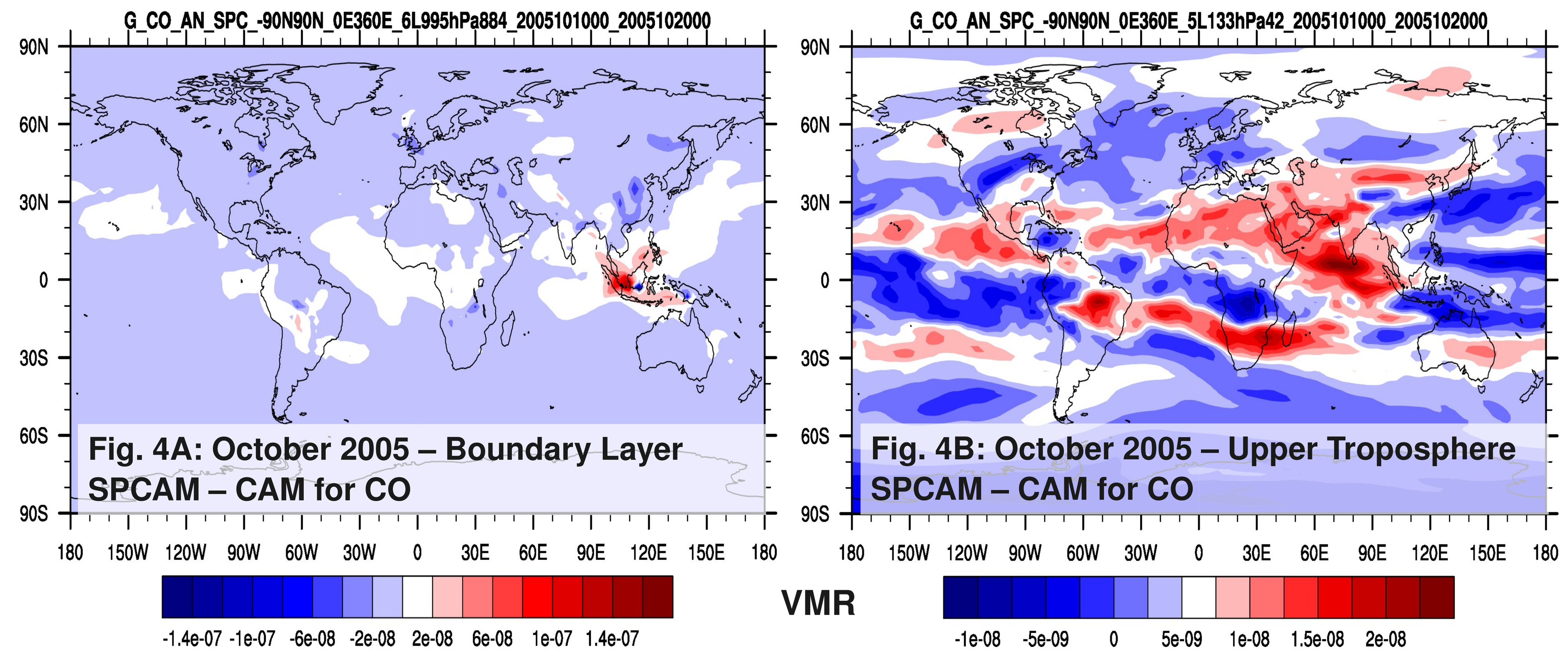


Fig. 4A: October 2005 – Boundary Layer SPCAM – CAM for CO
Fig. 4B: October 2005 – Upper Troposphere SPCAM – CAM for CO

Above, Fig. 3: **Differences between SPCAM and CAM simulated height vs pressure [CO] maps** for the tropical band (A) and zonal integrated (B).
Above, Fig. 4: **Differences between SPCAM and CAM simulated [CO] maps** for different levels in the atmosphere: 995-884 hPa (A), and 133-42 hPa (B).
Below, Fig. 5: **Differences between SPCAM and CAM calculated MOPITT [CO] expected retrievals maps** for different levels in the atmosphere: 300 hPa (A), and 100 hPa (B)

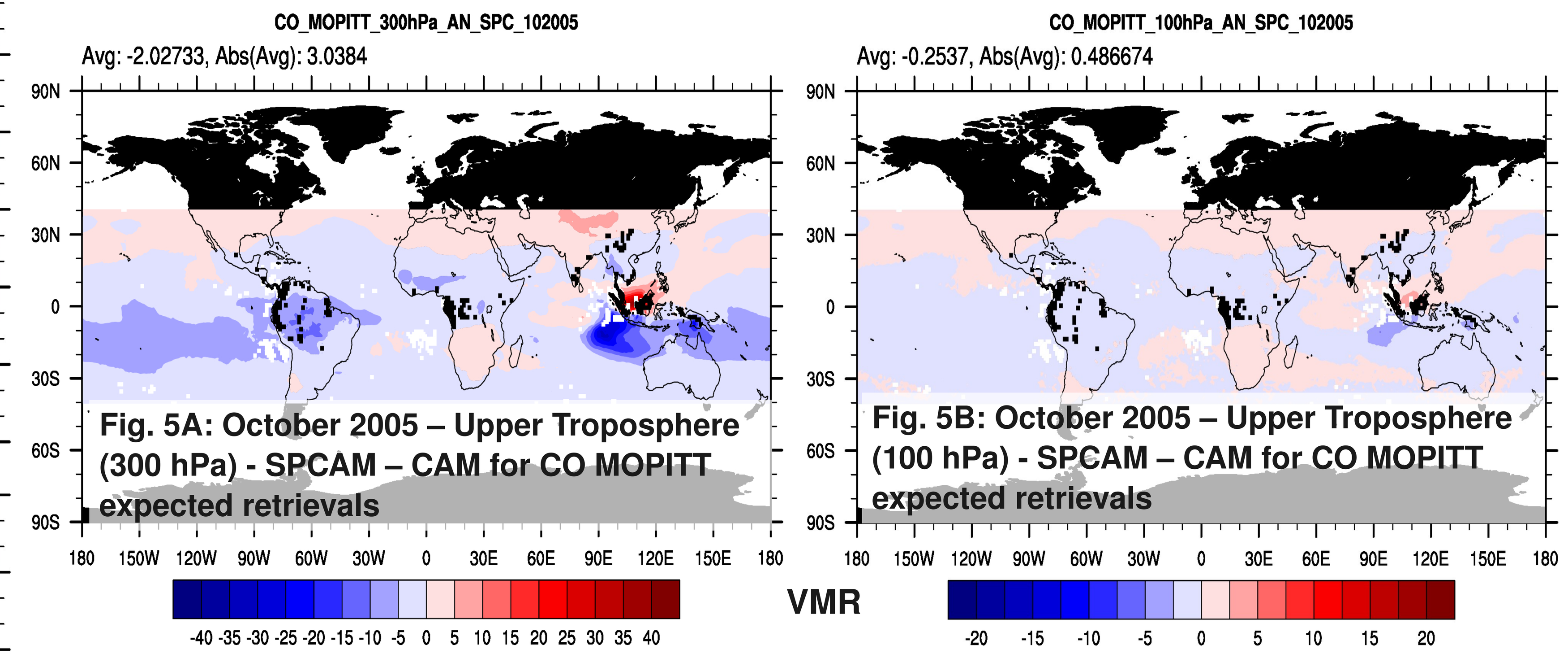


Fig. 5A: October 2005 – Upper Troposphere (300 hPa) - SPCAM – CAM for CO MOPITT expected retrievals
Fig. 5B: October 2005 – Upper Troposphere (100 hPa) - SPCAM – CAM for CO MOPITT expected retrievals

References & Acknowledgments

Donner et al. 2007 JGR – Folkins et al. 2006 JGR – Khairoutdinov & Randall 2001 GRL – Kinnison et al. 2007 JGR – Kritz et al. 1998 JGR – Liu et al. 1984 JGR – Mahowald et al. 1997 JGR – Randall et al. 2003 BAMS

Thanks to our collaborator Dr JF Lamarque (NCAR), the CMMAP for funding our research (www.cmmap.org), and the Earth and Planetary Science Dept. at UC Berkeley, CA, USA for having me