Global Chemical Transport in a Cloud-Resolving GCM

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✔ MOTIVATION:

✔ In models, the treatment of cloud convective processes affects the atmospheric vertical transport and mixing therefore the chemical state and radiative forcing of the atmosphere. We investigate the implications for the concentrations of short lived atmospheric passive tracers, radon (Rn) and methyl iodide (CH3I) from explicitly resolving cloud physical and dynamical processes. Conventional climate models use implicit treatments for cloud convective processes called "parameterizations"; we use one of those parameterizations here as control case. To test the fidelity of the model we compare simulated v. measured vertical profiles available from field campaigns

✔ CONTROL CASE:

- ✔ **Community Atmosphere Model (CAM) in Chemical Transport Mode (CTM) with NCEP meteorology**: 28 levels; 1.9x2.5; FV; dt=30min
- ✔ Zhang & McFarlane convective scheme for clouds
- ✔ Model for Ozone and Related Chemical Tracers (MOZART)
  - ✔ Rn from land masses
  - ✔ CH3I monthly climatologies (Bell et al JGR). Marine areas and rice paddies.

✔ TEST CASE:

- ✔ **As in CONTROL but the cloud convective processes are from the Colorado State University (CSU) Multi-scale Modeling Framework (MMF): SUPER-PARAMETERIZED CAM (SPCAM)**
- ✔ Embedded 2D Cloud Resolving Model (CRM): 64x1; dx = 2000m; t=20s

✔ RUNS:

- ✔ 11 Years: 1996 → 2006

✔ PROFILE BINNING:

- ✔ Observed and simulated values are binned on discrete vertical levels with midpoints at 0.5, 2, 5, 10, and 18 Km.

✔ LOCAL CONVECTIVE INDEX (LCI):

- ✔ LCI = $\Delta ln(q)/\Delta h$ where q is volume mixing ration and h is height
- ✔ The anomalies in the simulated **LCI** with respect to observations are calculated for the atmospheric layers referred to here as the Planetary Boundary Layer (**PBL**; 0.5–2 Km), Low Troposphere layer (**LTL**; 2–5 Km), Mid Troposphere layer (**MTL**; 5–10 Km), and Upper Troposphere layer (**UTL**; 10–18 Km).

✔ CONCLUSIONS

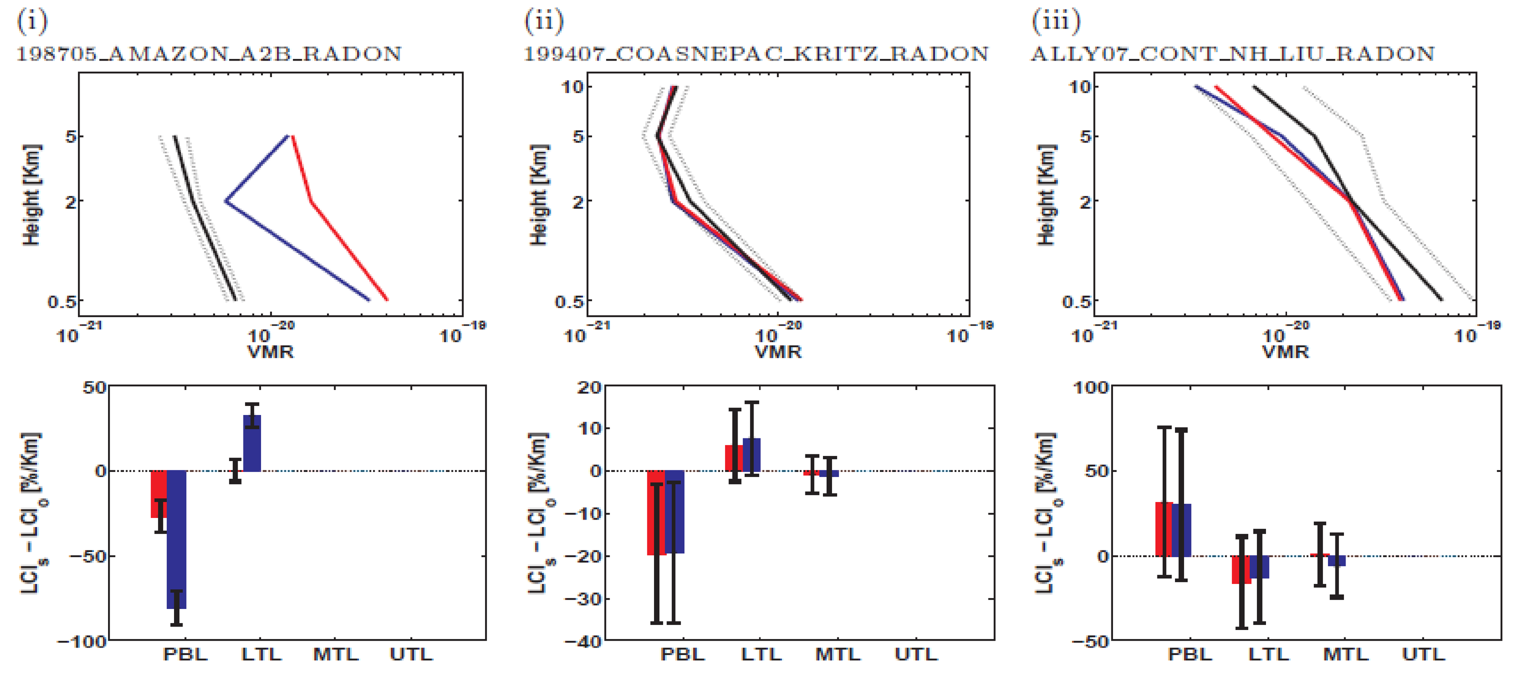
- ✔ **Simulated vertical profiles of tracers concentrations from both models are compared with observed ones and suggest that the cloud-resolving GCM is better than the conventional GCM. Contrasting climatological maps of tracers concentrations from simulations we found consistent and appreciable relative differences between the cloud-resolving GCM and the conventional case that might have important implications for climate and atmospheric chemistry simulations but require further investigations.**

Case Studies

Name	Tracer	Pts	Period	Lat×Lon [°N×°E]	Alt. [Km]	Mission	Reference
199609_SPCZ_PMT	CH_3I	2242	(1996-08-31,1996-10-05)	(-50,15)× (102,310)	(0,11)	PEM-Tropics A	*Hoell et al.* [1999]
199609_ITCZ_PMT	CH3I	533	(1996-08-21,1996-10-05)	(-15,35)× (137,277)	(0,10)	PEM-Tropics A	*Hoell et al.* [1999]
199904_TROP_PAC_PMB	CH_3I	1612	(1999-03-06,1999-04-13)	(-49,35)× (144,275)	(0,12)	PEM-Tropics B	*Raper et al.* [2001]
199909_UTGMEX_ACCENT	CH_3I	135	(1999-09-03,1999-09-20)	(10,54)× (212,331)	(10,19)	ACCENT	*Murphy et al.* [1998]
200103_SUBCPAC_TRP	CH_3I	1383	(2001-02-26,2001-04-09)	(1,56)× (110,288)	(0,12)	TRACE-P	*Jacob et al.* [2003]
200103_SUBWTPAC_TRP	CH_3I	3721	(2001-02-27,2001-04-03)	(-8,61)× (62,210)	(0,12)	TRACE-P	*Jacob et al.* [2003]
200401_UTPANAGMEX_PRE_AVE	CH_3I	138	(2004-01-16,2004-02-02)	(-18,53)× (213,329)	(8,19)	Pre-AVE	N/A
200407_EUS_INTEXA	CH_3I	2654	(2004-07-06,2004-08-14)	(12,69)× (200,360)	(0,13)	INTEX-A	*Singh et al.* [2006]
200601_UTPANA_CR_AVE	CH_3I	151	(2006-01-17,2006-02-09)	(-17,26)× (219,333)	(12,19)	CR_AVE	N/A
200603_GMEX_INTEXB	CH_3I	893	(2006-02-24,2006-03-22)	(-1,50)× (205,324)	(0,12)	INTEX-B	*Singh et al.* [2009]
200604_SUBTEPAC_INTEXB	CH_3I	1058	(2006-04-17,2006-05-15)	(4,65)× (134,285)	(0,12)	INTEX-B	*Singh et al.* [2009]
200605_GALASKA_INTEXB	CH_3I	369	(2006-05-01,2006-05-15)	(35,78)× (140,275)	(0,12)	INTEX-B	*Singh et al.* [2009]
200806_SFOBAY_ARCTAS	CH_3I	807	(2008-06-18,2008-07-13)	(17,57)× (182,295)	(0,10)	ARCTAS	*Jacob et al.* [2010]
200807_CANADA_ARCTAS	CH_3I	699	(2008-06-26,2008-07-13)	(30,75)× (190,328)	(0,12)	ARCTAS	*Jacob et al.* [2010]
198705_AMAZON_A2B	Rn	61	(1987-04-20,1987-05-08)	(-19,15)× (249,360)	(0,6)	ABLE-2B	*Pereira et al.* [1991]
199407_COASNEPAC_KRITZ	Rn	127	(1994-06-03,1994-08-16)	(19,56)× (184,296)	(0,13)	N/A	*Kritz et al.* [1998]
ALLY07_CONT_NH_LIU	Rn	150	(1970-07-01,1970-08-31)	(19,64)× (0,321)	(0,12)	N/A	*Liu et al.* [1984]

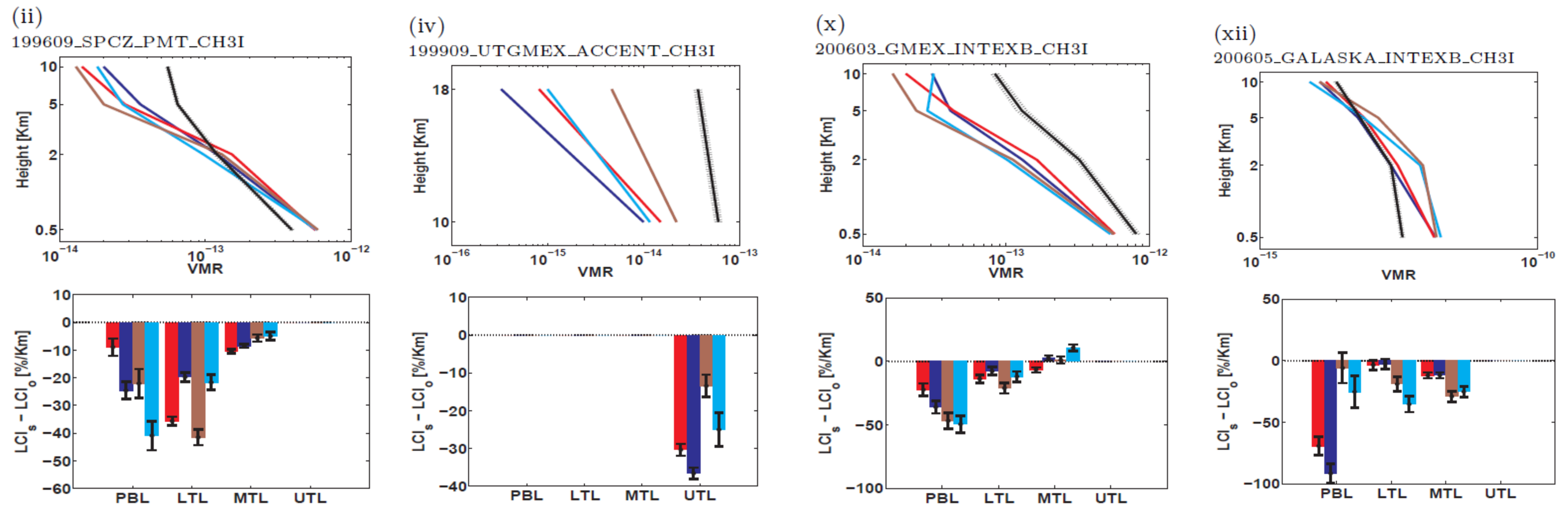
Radon Profiles & Relative VMR Change with Height

Simulated and observed vertical profiles and LCI anomalies in the PBL, LTL, MTL, and UTL for Rn. Climatological values are shown in red for SP-CAM and blue for CAM. **Observed** profiles are shown in black.

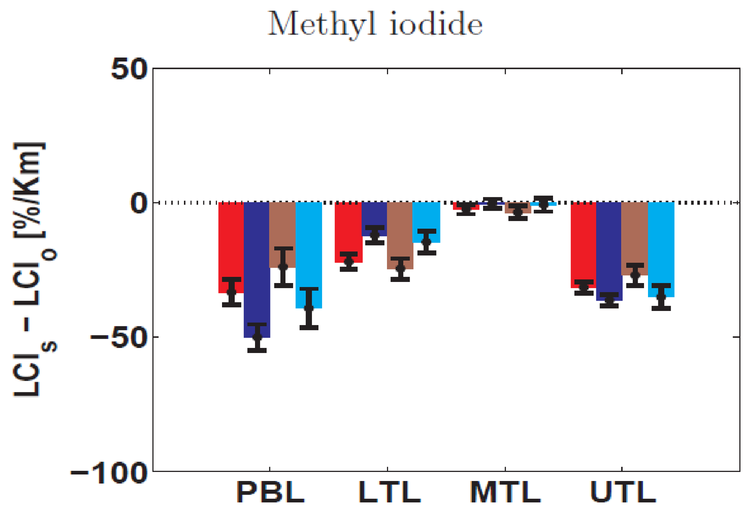


Methyl iodide Profiles & Relative VMR Change with Height

Simulated and observed vertical profiles and LCI anomalies in the PBL, LTL, MTL, and UTL for Methyl iodide. Climatological values are shown in red for SP-CAM and blue for CAM. Precise values are shown in brown for SP-CAM and cyan for CAM. **Observed** profiles are shown in black.



Methyl iodide 14 Profiles Synthesis

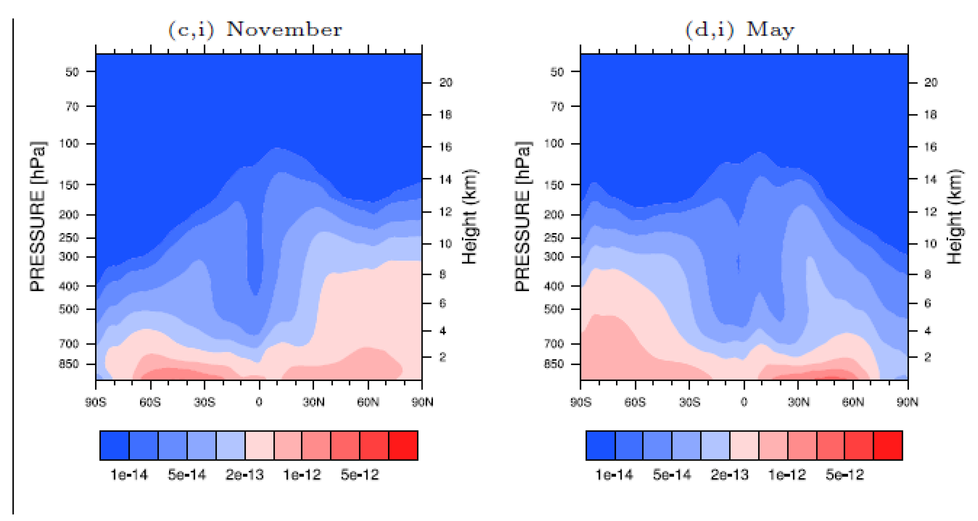


SUMMARY SPCAM v. CAM DIFFERENCES FROM SIMULATIONS ONLY:

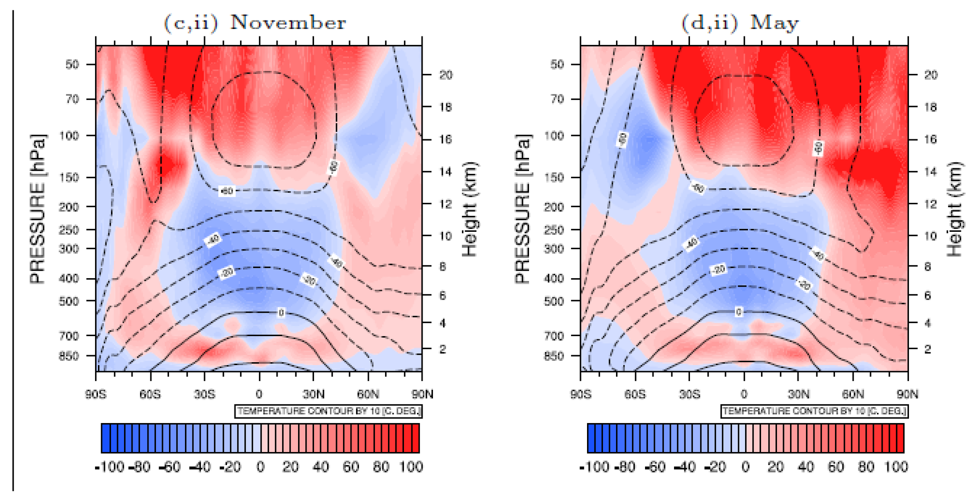
At latitudes where most of the convective precipitation occurs, with respect to CAM, SP-CAM depletes the PBL, enriches the layers of shallow convection, and depletes the layer of deep convection up to approximately 2 Km below the tropopause above which it enriches the atmosphere.

Methyl iodide zonal maps SPCAM v. CAM for November and May

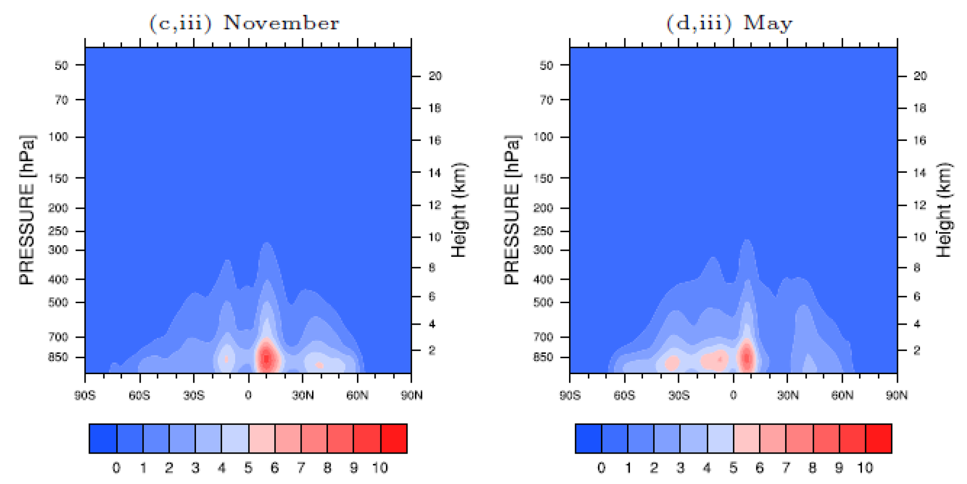
SPCAM CH3I VMR



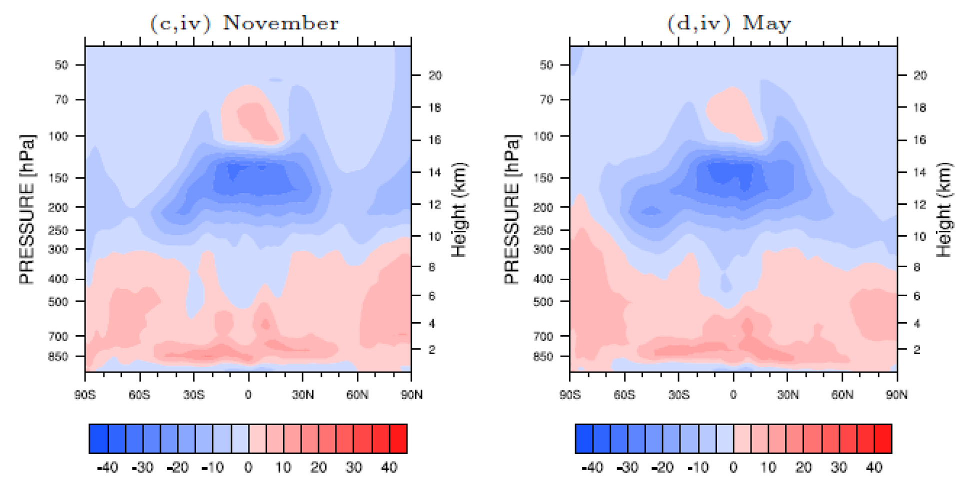
SPCAM v. CAM CH3I VMR % CHANGE



SPCAM CONVECTIVE PRECIPITATION



SPCAM v. CAM RELATIVE HUMIDITY CHANGE



Radon global maps SPCAM v. CAM for July in 4 atmospheric layers