Convective Transport and Wet Removal in the GEOS-5 CCM and GMI CTM

(Funded under ROSES-08/MAP)

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Tasks

- **Tracer transport and wet removal of soluble species will be simulated in individual convective events observed during recent and upcoming major field experiments (e.g., TC4, AMMA, SCOUT-O3/ACTIVE, TROCCINOX, DC3) using a cloud-resolving domain in the NASA Unified WRF model.**

- **The resulting chemical fields from WRF will be evaluated using data observed by research aircraft in flight segments through the anvils of the storms of interest.**

- **A single-column version of the GEOS-5 CCM will be run for the same convective events.**

- **Tracer transport and wet removal in the single-column model will be evaluated using averaged fields from the WRF simulation.**

- **Sensitivity studies will be conducted with the single-column model to determine the most appropriate improvements to the convection and wet scavenging schemes.**

Tasks (continued)

- **Full GEOS-5 CCM and offline GMI CTM simulations with the improved algorithms will be conducted.**

- **Global model simulations will be evaluated against broader-scale aircraft data, sonde data, and a wide array of satellite data from the Aura, Aqua, and Terra platforms. These simulations will be contrasted with those run with the standard convection and wet removal algorithms.**

- **Simulations with improved process representation will be used to determine the global net effects of convection on tropospheric chemistry in current and future climates.**

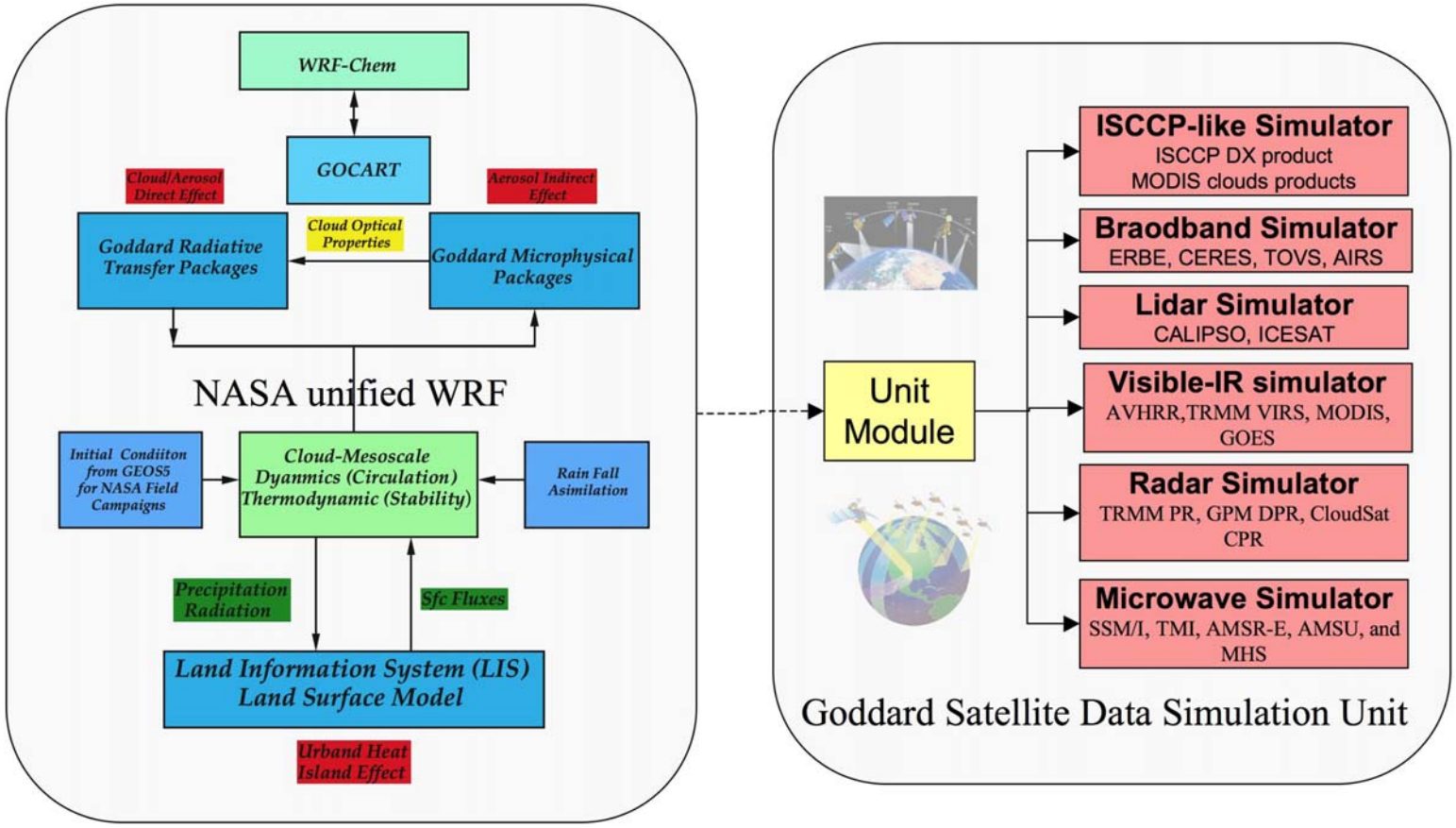
NASA Unified WRF

- Infrastructure Proposal -

Co-PIs: **Wei-Kuo Tao**, Christa Peters-Lidard, William Lapenta

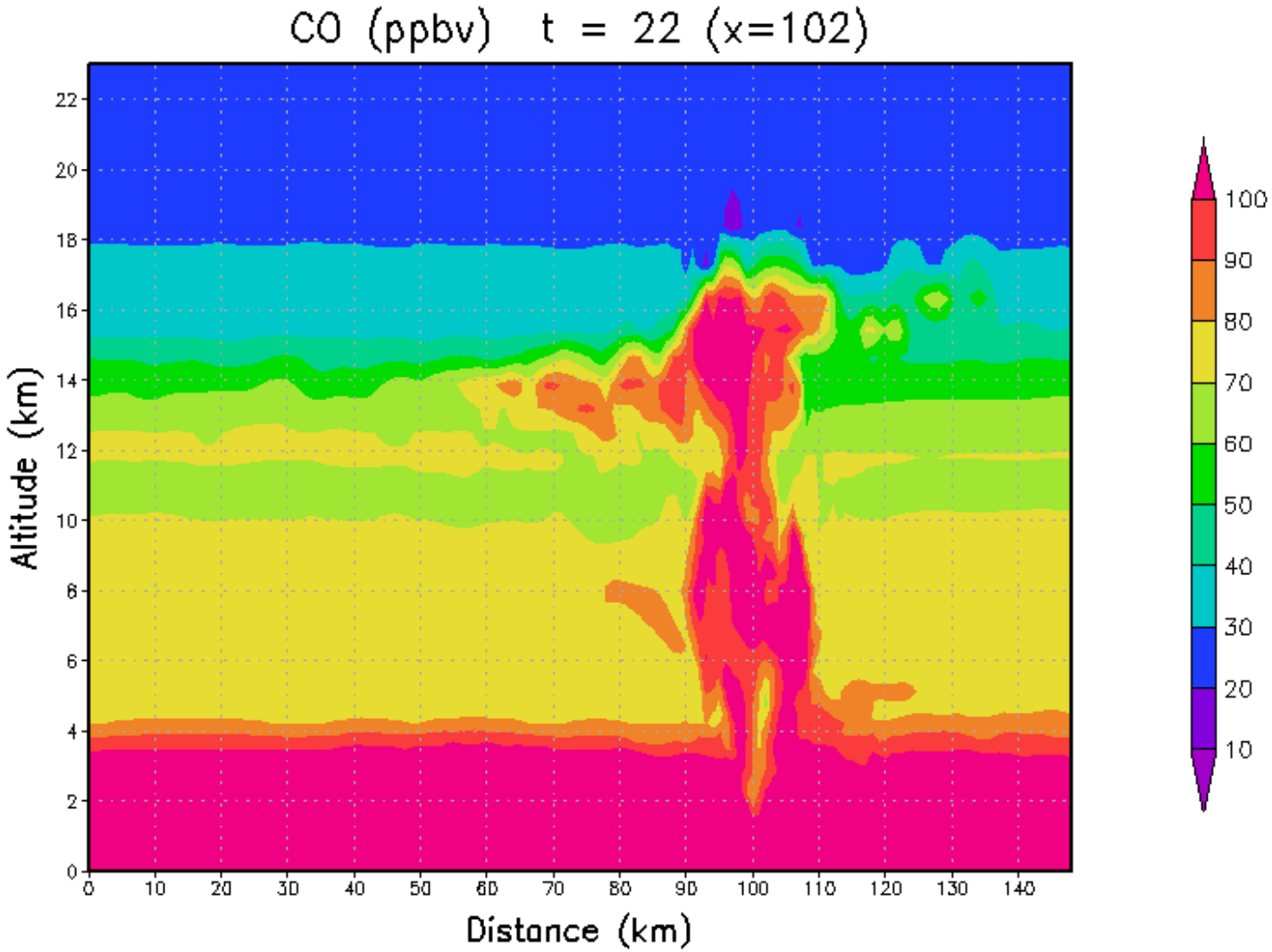
Co-Is: Scott Braun, Jonathan Case, Mian Chin, Thomas Clune, **Arthur Hou**, Sujay Kumar, William Lau, **Toshi Matsui**, **Roger Shi**, Qian Tan, Sara Zhang

Objectives is to integrate/maintain the NASA Unified WRF infrastructure, including Goddard physics package, GSFC LIS, GOCART *aerosol transport model*, Rainfall assimilation, Real-time GOES5 forcing, Goddard SDSU.



WRF-AqChem Simulation of SCOUT-O3/ACTIVE "Hector" Storm

November 16, 2005



Huntemann et al., in prep.

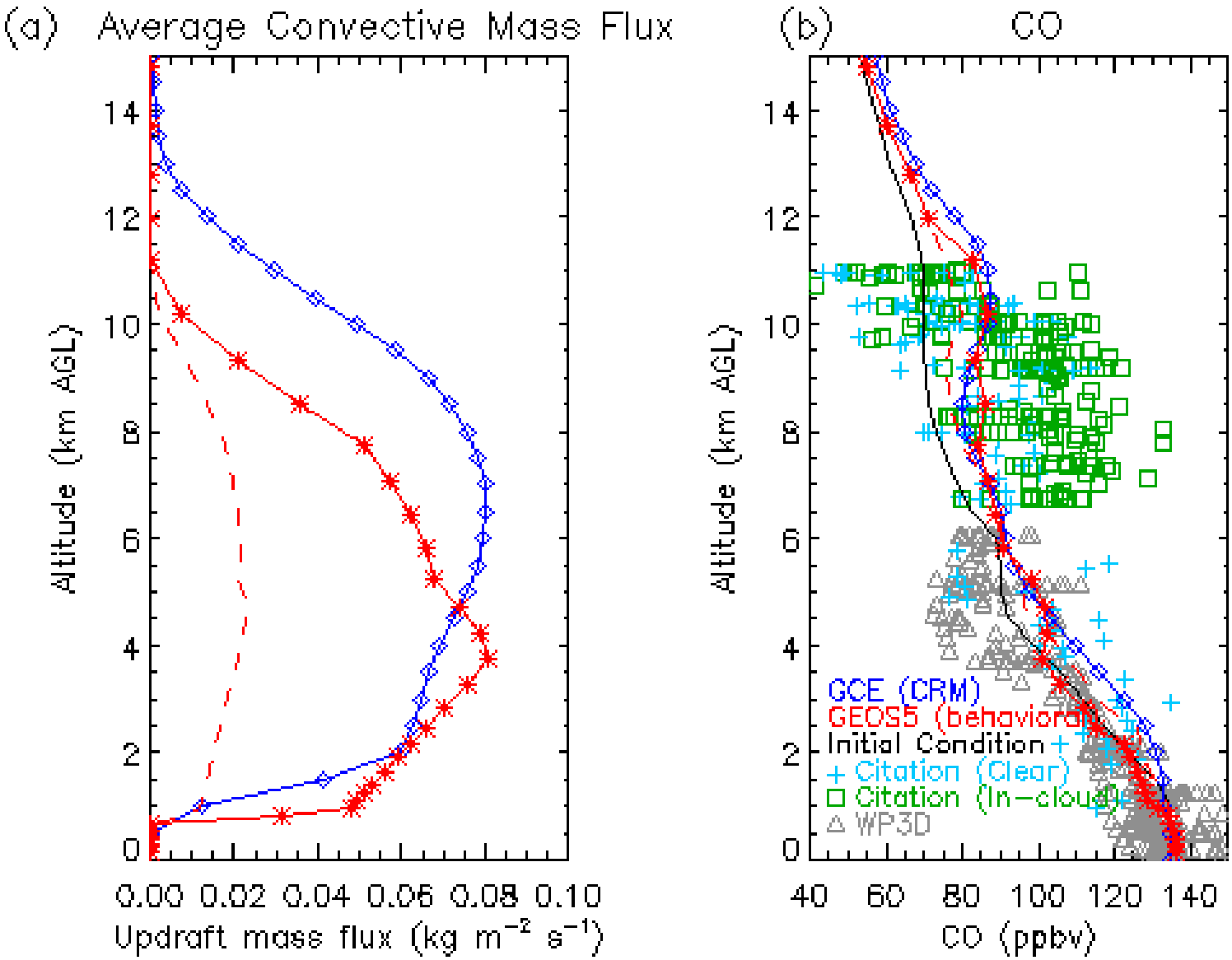
Aircraft Data from Convective Field Campaigns

Experiment	Location	Aircraft	Chemical species (partial list)
STERAO	NE Colo.	Citation	CO, O3, NO
		NOAA P-3	CO, O3, NO, NOy, peroxides, HCHO
CRYSTAL-FACE	S. Florida	WB-57	CO, O3, NO, NOy, CO2
		Twin Otter	CO, O3, aerosols
TROCCINOX	Brazil	DLR Falcon	CO, O3, NO, NOy, CO2, aerosols
		Geophysica	CO, O3, NO, NOy, CO2, aerosols, CFCs
		Bandeirante	CO, O3, NO, NOy
SCOUT-O3	Darwin	DLR Falcon	NO, NOy, SO2
		Geophysica	CO, O3, NO, NOy
ACTIVE	Darwin	Egrett	CO, NO, NO2, CN, BC
		Dornier	CO, O3, NO, NO2, VOCs, aerosols, BC
AMMA	W. Africa	DLR Falcon	CO, O3, NO, NOy, CO2, HCHO, HNO3, SO2, aerosols
		Geophysica	CO, O3, NO, NOy, CO2, aerosols, CFCs
TC4	Costa Rica	DC-8	CO, O3, NO, NO2, CO2, peroxides, HNO3, HCHO, SO2, aerosols, VOCs, halogenated species
		WB-57	CO, O3, CO2, aerosols, VOCs, halogenated species
TC4 follow-up (2011)	W. Pacific	WB-57	
		DC-8	
DC3 (2011)	Central US	NCAR G-V	
		C-130	

GEOS-5 Single Column Model

- Computationally efficient tool for evaluating physical parameterizations
- Includes same physical parameterizations as the 3-D AGCM
- Initialized with profiles of temperature, moisture, winds, and trace gases
- Impact of large-scale circulation included through specified advective tendencies
- Convective transport of passive trace gases calculated online within the Relaxed Arakawa-Schubert (RAS) scheme
- Wet scavenging in convective plumes can be treated in RAS by specifying scavenging efficiencies for soluble species and removing an amount proportional to layer depth
- Proposed work may require inclusion of GMI chemistry scheme

STERAO (NE Colorado) – July 10, 1996



Ott et al., *JAS*, 2009

GEOS-5 CCM and GMI CTM Simulations

Evaluate convective transport and wet removal in

<u>GEOS-5 CCM V3</u> and <u>GMI Combo</u> model simulations using

standard convection and scavenging schemes and improved schemes suggested from GEOS-5 SCM runs

Non-soluble tracers: CO, C2H2, C2H2/CO

Partially soluble tracers: CH3OOH, CH2O, SO2

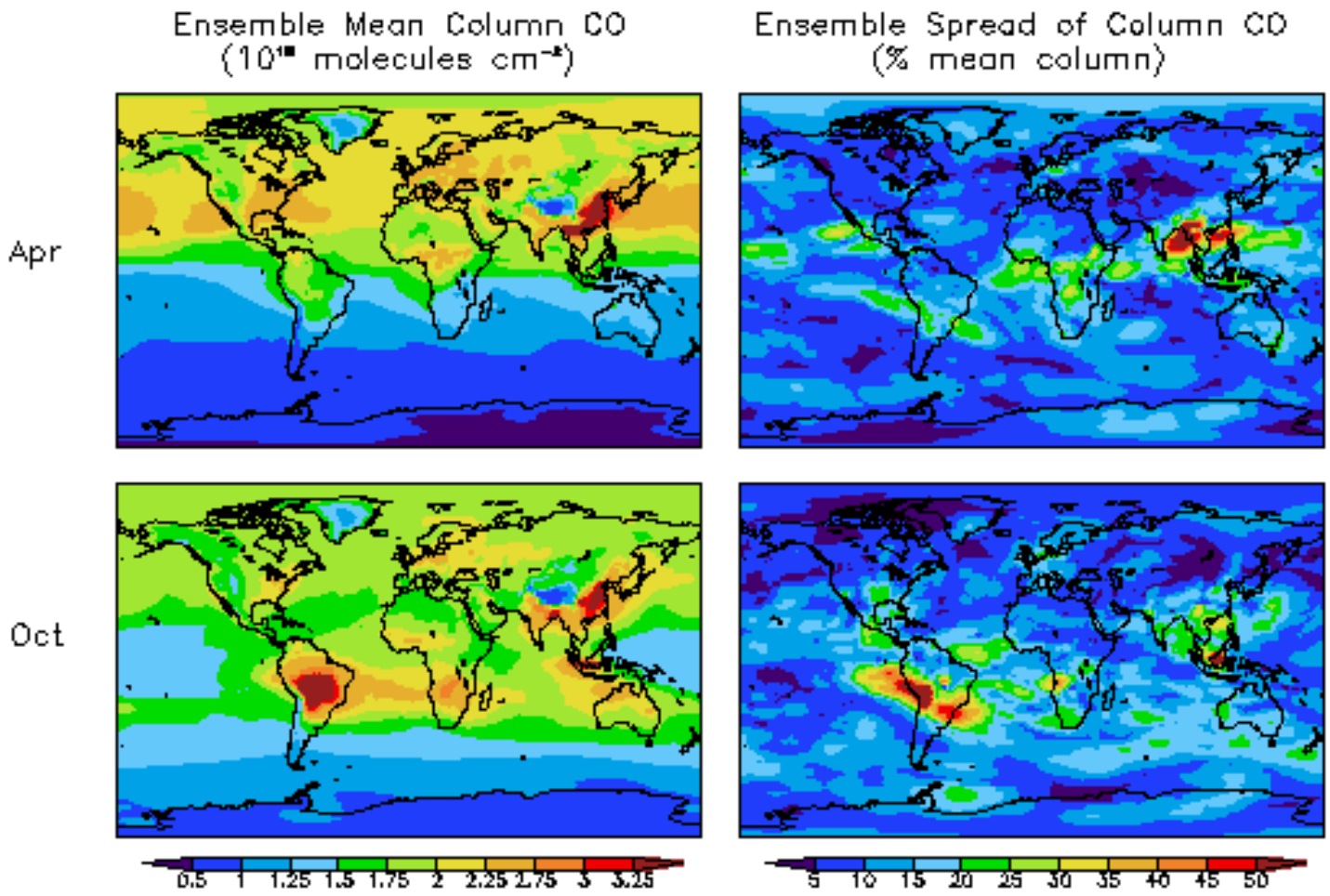
Soluble tracers: HNO3, H2O2

Marine convection: CH3I

Markers for convection: NOx/HNO3, H2O2/CH3OOH

Transport time from source: C2H2/CO

Evaluations using broader-scale aircraft data and satellite observations. GMI Combo can be evaluated in direct comparisons; CCM evaluated in a statistical fashion.


Ensemble Mean Column CO
(10¹⁸ molecules cm⁻²)
Ensemble Spread of Column CO
(% mean column)
Apr
Oct
0.5 1 1.25 1.5 1.75 2 2.25 2.75 3 3.25
5 10 15 20 25 30 35 40 45 50

L. Ott

Evaluations Using Aircraft and Satellite Data

- **Broader-scale aircraft data from field campaigns:**

  INTEX-A, INTEX-B, TC4, ARCTAS

- **Satellite data**

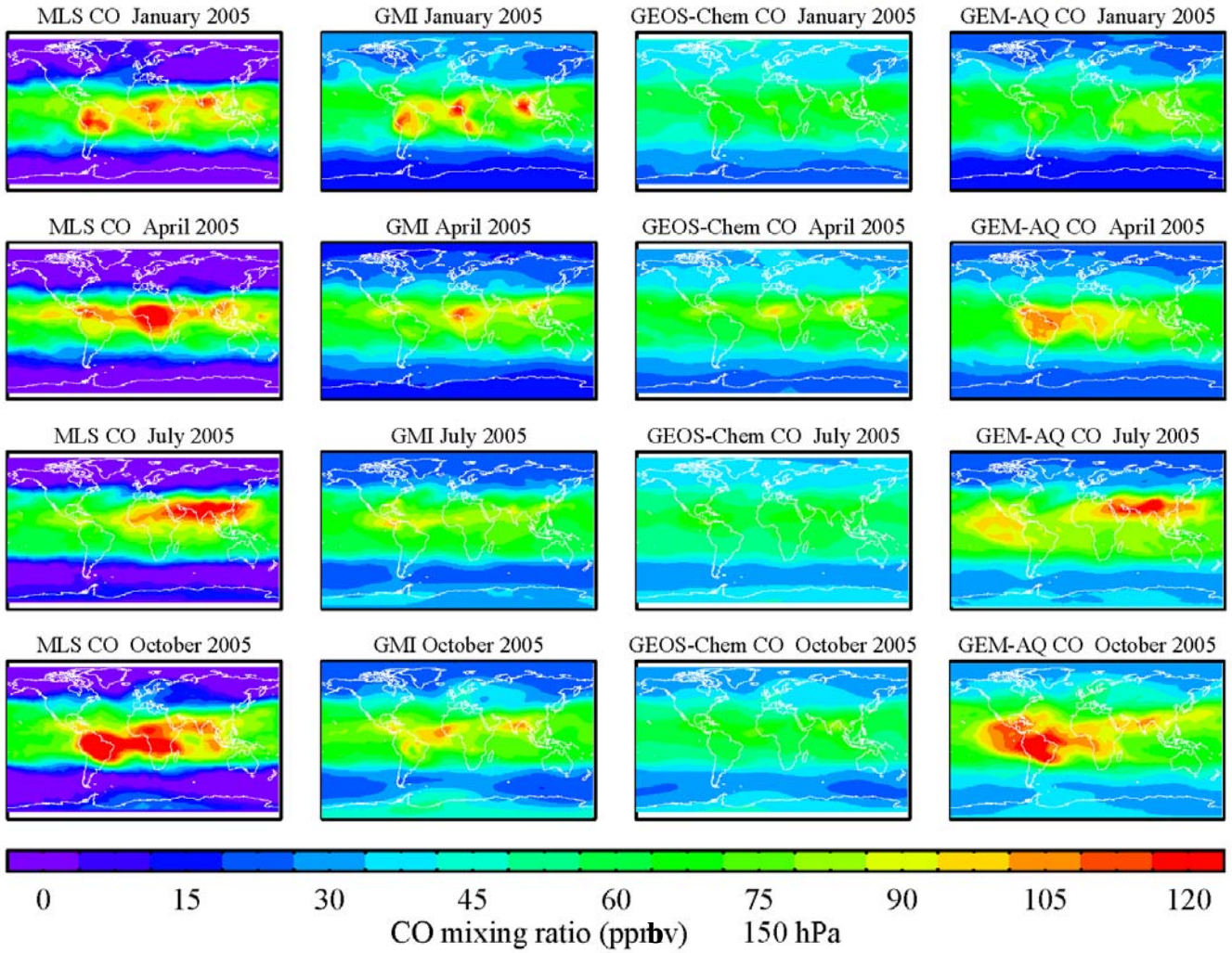
  CO – MLS v3 (down to 215 hPa), MOPITT, AIRS, TES

  O_3 – MLS v3 (down to 300 hPa), OMI-MLS for convective clouds

  HNO_3 – MLS v3 (down to 215 hPa)

  CloudSat – IWC, LWC

Seasonal variation of CO in the upper-trop (150mb)



J. Jiang

Collaborator Roles

- **Bacmeister – advice on the GEOS-5 convection scheme**
- **Barth – cloud-resolved wet removal scheme and provide advice on its implementation in the NASA Unified WRF**
- **Emmons – advice on use of MOPITT CO data in model comparisons**
- **Joiner – advice on use of AIRS CO in model comparisons**
- **Mari – provide AMMA data and information on her cloud-resolved vs. 1-D comparisons**
- **Osterman – advice on use of TES data in model comparisons**
- **Pawson – advice on the GEOS-5 models**
- **Rodriguez – collaborate concerning the usage of the GMI Combo CTM**
- **Schlager – provide aircraft data from TROCCINOX, SCOUT-O3 and AMMA**
- **Stolarski – advice on the GEOS-5 CCM, as PI of that project**
- **Vaughan – provide aircraft data from ACTIVE**
- **Ziemke – advice on tropospheric ozone from OMI-MLS**