Updates on available compsets and their performance

Simone Tilmes, Francis Vitt, Jean-Francois Lamarque,
CAMChem and WACCM team

Compsets: CESM1.1.1 1.9x2.5	Model (phys)/ radiation	Chemistry	Components / Meteorology
B_2000_TROP_MOZART (BMOZ) B_2000_MOZSOA_CN	CAM4, active	trop_mozart +soa chemistry	All active + CLM/CN
F_2000_TROP_MOZART (FMOZ) F_2000_MOZSOA_CN (FMOZSOA)	CAM4, active	trop_mozart +soa chemistry	Prescr. ocn/ice, CLM/CN
F_SD_CAMCHEM_CN F_SD_BAM_CN F_TROP_STRAT_CHEM_CN (FTSC)	CAM4, passive	trop_mozart trop_bam trop/ strat_mozart	Prescr. ocn/ice, CLM/ CN, offline: GEOS5 Prescr. ocn/ice, CLM/CN
B_2000_CN_CHEM (B2000CNCHM) B_1850_CN_CHEM (B1850CNCHM) B_1850-2000_CN_CHEM (B20TRCNCHM) F_1850_CN_CHEM (F1850CNCHM)	CAM4, active CAM4, active	super_fast_llnl	MEGAN VOC emis CLM/CN
B_2000_MOZMAM_CN (BMOZMAM) F_2000_MOZMAM_CN (FMOZMAM) F_2000_STRATMAM3_CN F_2000_STRATMAM7_CN	CAM5, active CAM5 active	trop_mozart mam trop/ strat_mozart mam	All active, CLM/CN Prescr. ocn/ice, CLM/CN

Functional Release: compsets runs out of the box, but is not scientifically wetted

Compsets: CESM1.2 1.9x2.5	Model (phys)/ radiation	Chemistry	Components / Meteorology
B_2000_TROP_MOZART (BMOZ)	CAM4, active	trop_mozart	All active
B_2000_MOZSOA_CN		+soa chemistry	+ CLM/CN
F_2000_TROP_MOZART (FMOZ)	CAM4, active	trop_mozart	Prescr. ocn/ice, CLM/CN
F_2000_MOZSOA_CN (FMOZSOA)		+soa chemistry	
F_SD_CAMCHEM_CN	CAM4, passive	trop_mozart	Prescr. ocn/ice, CLM/
F_SD_BAM_CN		trop_bam	CN, offline: GEOS5
F_TROP_STRAT_CHEM_CN (FTSC)		trop/ strat_mozart	Prescr. ocn/ice, CLM/CN
B_2000_CN_CHEM (B2000CNCHM)	CAM4, active	super_fast_llnl	MEGAN VOC emis
B_1850_CN_CHEM (B1850CNCHM)			CLM/CN
B_1850-2000_CN_CHEM (B20TRCNCHM)			
F_1850_CN_CHEM (F1850CNCHM)	CAM4, active		
B_2000_MOZMAM_CN (BMOZMAM)	CAM5, active	trop_mozart mam	All active, CLM/CN
F_2000_MOZMAM_CN (FMOZMAM)	CAM5 passive		Prescr. ocn/ice, CLM/CN
F_2000_STRATMAM3_CN		trop/ strat_mozart mam	
F_2000_STRATMAM7_CN			

All these compsets have not changed and are still available

Updated and tested compsets in CESM1.2

Compsets: CESM1.2 (1.9x2.5)	Model (phys)/ radiation	Chemistry (JPL 2010)	Components / Meteorology
F_2000_MOZSOA (FMOZSOA)	CAM4, rad active BAM	trop_mozart +soa chemistry	Prescr. ocn/ice, MEGAN2.1
F_2000_STRATSOA (FSTRATSOA)		trop/strat mozart + soa chemistry	
F_2000_MOZMAM_CN (FMOZMAM)	CAM5, rad active MAM3	trop_mozart	Prescr. ocn/ice, CLM/CN
F_2000_STRATMAM3_CN (FSTRATMAM3)	MAM3	trop/ strat_mozart	Prescr. ocn/ice, CLM/CN
F_2000_STRATMAM7_CN (FSTRATMAM7)	MAM7		
Also available as B compsets but not tested			

Goal: Scientifically Supported Compsets:
Evaluation of chemistry and aerosol performance

Updated features in CESM1.2

- **Coupling of tropospheric and stratospheric chemistry with the CAM5 modal aerosol mode 3 and 7**
  - bug fix of SAD_TROP calculation
- **Expansion of the representation of secondary-organic aerosols**
  Implementation of MEGAN 2.0 in CLM, including a flexible framework for assigning MEGAN 2.0 emissions to species represented in the chemistry.
  - CLM bug fix of surface pressure in drydep, MEGAN fix of initial values and units
- **Other updates**
  - Updated chemistry: JPL2010 only SOA and CAM5 compsets
  - Remove organic halogen surrogates (better description of organic species)
  - Updated heterogeneous polar chemistry (stratosphere only)
  - Include better representation of very short-lived (VSL) organic bromine ($CHBr_3$, CH_2Br_2)
  - New SAD dataset

Performance of F2000 model simulations

Type	strat/trop MAM3	trop MAM3	strat/trop MAM7	strat/trop BAM	trop BAM
CH4_BURDEN (Tg)	4084.916	4137.232	4083.071	4108.462	4122.594
CH4_CHEM_LOSS (Tg/yr)	426.628	344.103	420.464	489.974	428.763
CH4_LIFETIME (yr)	9.575	12.023	9.711	8.385	9.615
CO_BURDEN (Tg)	280.386	341.919	281.057	276.543	294.887
CO_EMIS (Tg/yr)	1116.925	1116.925	1116.925	1031.085	1031.66
CO_TDEP (Tg/yr)	118.412		118.448		
CO_CHEM_LOSS (Tg/yr)	1522.102	1464.426	1502.505	1865.086	1558.145
CO_LIFETIME (yr)	0.171	0.233	0.173	0.148	0.189
O3_BURDEN (Tg)	306.612	263.21	305.186	309.427	317
O3_TDEP (Tg/yr)	692.556		688.865	721.533	
O3_LIFETIME (yr)	0.443		0.443	0.429	
O3_NET_CHEM_CHANGE (T	253.273		253.773	288.698	
O3_STE (Tg/yr)	439.283		435.092	432.835	
ISOP_EMIS TgN/yr)	537.408	537.408	537.408	485.535	488.293
Monoterpene_EMIS TgN/	81.795	81.795	81.795	141.223	141.894
Methanol_EMIS TgN/yr)	236.88	236.88	236.88	101.722	102.502
Aceton_EMIS TgN/yr)	26.956	26.956	26.956	67.321	67.522
LNO_PROD (TgN/yr)	3.933	4.105	4.108	4.263	4.034
Total optical depth	0.089	0.088	0.087	0.101	0.098
DUST optical depth	0.02	0.019		0.032	0.032
CLDHGH	38.503	38.408	38.668	31.577	31.48
CLDLOW	44.313	44.135	44.308	34.814	34.774
CLDMED	27.341	27.339	27.401	19.006	18.951
CLDTOT	64.759	64.543	64.849	54.088	53.956

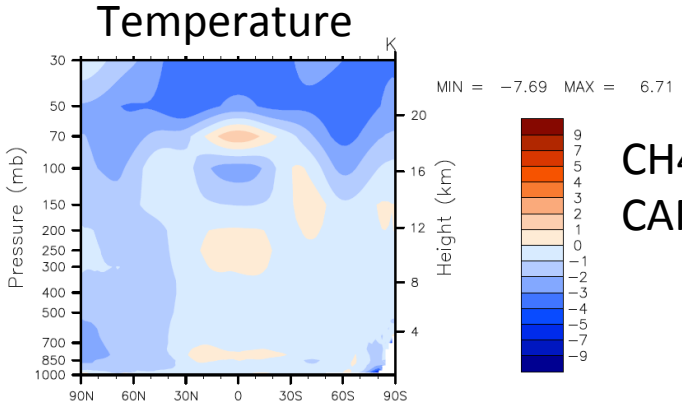
Performance of F2000 model simulations

Type	strat/trop MAM3	trop MAM3	strat/trop MAM7	strat/trop BAM	trop BAM
CH4_BURDEN (Tg)	4084.916	4137.232	4083.071	4108.462	4122.594
CH4_CHEM_LOSS (Tg/yr)	426.628	344.103	420.464	489.974	428.763
CH4_LIFETIME (yr)	9.575	12.023	9.711	8.385	9.615
CO_BURDEN (Tg)	280.386	341.919	281.057	276.543	294.887
CO_EMIS (Tg/yr)	1116.925	1116.925	1116.925	1031.085	1031.66
CO_TDEP (Tg/yr)	118.412		118.448		
CO_CHEM_LOSS (Tg/yr)	1522.102	1464.426	1502.505	1865.086	1558.145
CO_LIFETIME (yr)	0.171	0.233	0.173	0.148	0.189
O3_BURDEN (Tg)	306.612	263.21	305.186	309.427	317
O3_TDEP (Tg/yr)	692.556		688.865	721.533	
O3_LIFETIME (yr)	0.443		0.443	0.429	
O3_NET_CHEM_CHANGE (T	253.273		253.773	288.698	
O3_STE (Tg/yr)	439.283		435.092	432.835	
ISOP_EMIS TgN/yr)	537.408	537.408	537.408	485.535	488.293
Monoterpene_EMIS TgN/	81.795	81.795	81.795	141.223	141.894
Methanol_EMIS TgN/yr)	236.88	236.88	236.88	101.722	102.502
Aceton_EMIS TgN/yr)	26.956	26.956	26.956	67.321	67.522
LNO_PROD (TgN/yr)	3.933	4.105	4.108	4.263	4.034
Total optical depth	0.089	0.088	0.087	0.101	0.098
DUST optical depth	0.02	0.019		0.032	0.032
CLDHGH	38.503	38.408	38.668	31.577	31.48
CLDLOW	44.313	44.135	44.308	34.814	34.774
CLDMED	27.341	27.339	27.401	19.006	18.951
CLDTOT	64.759	64.543	64.849	54.088	53.956

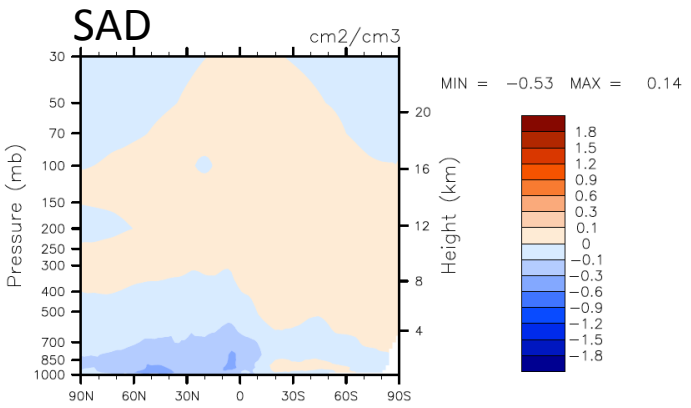
Performance of F2000 model simulations

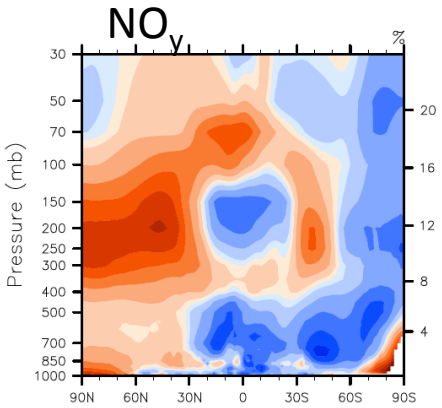
Type	strat/trop MAM3	trop MAM3	strat/trop MAM7	strat/trop BAM	trop BAM
CH4_BURDEN (Tg)	4084.916	4137.232	4083.071	4108.462	4122.594
CH4_CHEM_LOSS (Tg/yr)	426.628	344.103	420.464	489.974	428.763
CH4_LIFETIME (yr)	9.575	12.023	9.711	8.385	9.615
CO_BURDEN (Tg)	280.386	341.919	281.057	276.543	294.887
CO_EMIS (Tg/yr)	1116.925	1116.925	1116.925	1031.085	1031.66
CO_TDEP (Tg/yr)	118.412		118.448		
CO_CHEM_LOSS (Tg/yr)	1522.102	1464.426	1502.505	1865.086	1558.145
CO_LIFETIME (yr)	0.171	0.233	0.173	0.148	0.189
O3_BURDEN (Tg)	306.612	263.21	305.186	309.427	317
O3_TDEP (Tg/yr)	692.556		688.865	721.533	
O3_LIFETIME (yr)	0.443		0.443	0.429	
O3_NET_CHEM_CHANGE (T	253.273		253.773	288.698	
O3_STE (Tg/yr)	439.283		435.092	432.835	
ISOP_EMIS TgN/yr)	537.408	537.408	537.408	485.535	488.293
Monoterpene_EMIS TgN/	81.795	81.795	81.795	141.223	141.894
Methanol_EMIS TgN/yr)	236.88	236.88	236.88	101.722	102.502
Aceton_EMIS TgN/yr)	26.956	26.956	26.956	67.321	67.522
LNO_PROD (TgN/yr)	3.933	4.105	4.108	4.263	4.034
Total optical depth	0.089	0.088	0.087	0.101	0.098
DUST optical depth	0.02	0.019		0.032	0.032
CLDHGH	38.503	38.408	38.668	31.577	31.48
CLDLOW	44.313	44.135	44.308	34.814	34.774
CLDMED	27.341	27.339	27.401	19.006	18.951
CLDTOT	64.759	64.543	64.849	54.088	53.956

CAM5Chem vs. CAM4Chem (strat/trop mechanism)

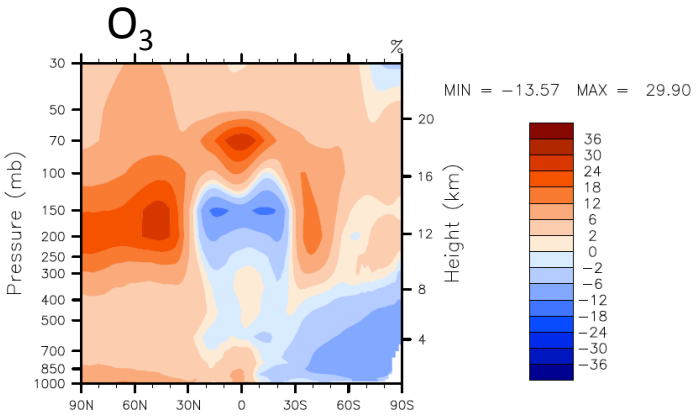


CH4 Lifetime:
CAM5 9.6, CAM4 8.4

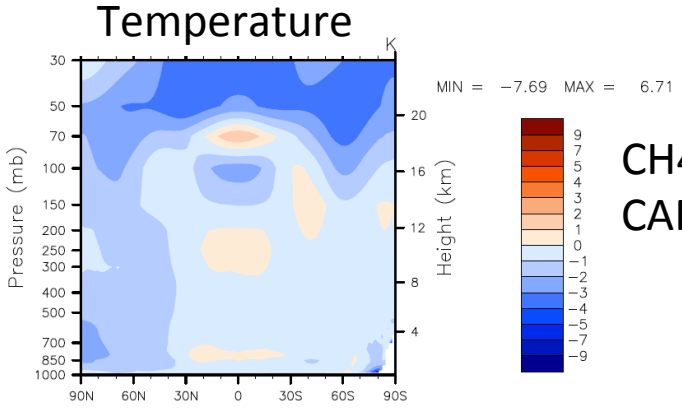




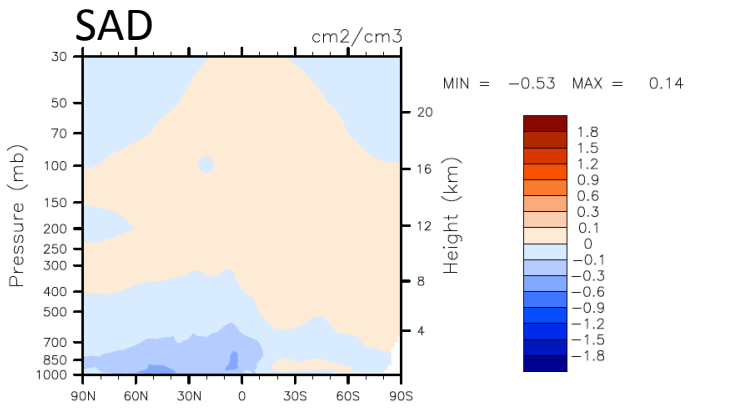
Colder temperatures, clouds, and transport differences:
More ozone and NOy in the LMS, troposphere
-> change in photolysis rates

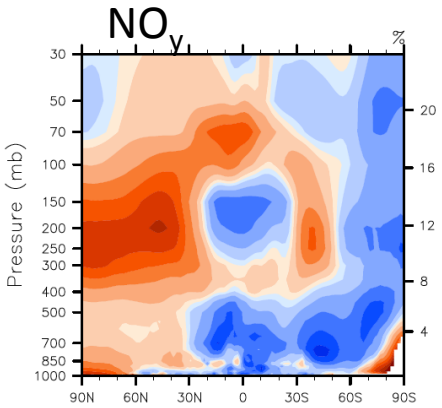


CAM5Chem vs. CAM4Chem (strat/trop mechanism)

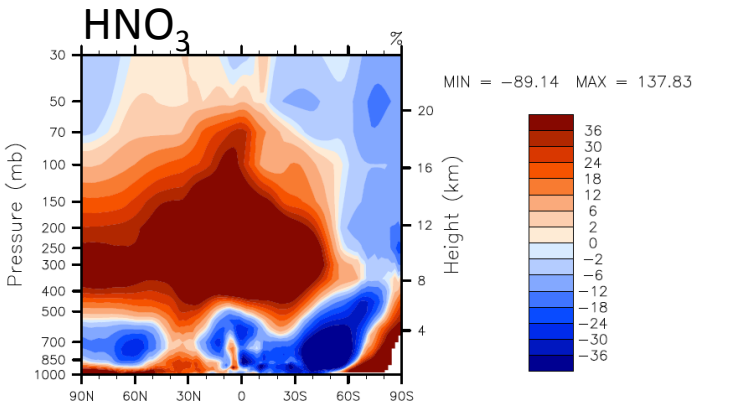


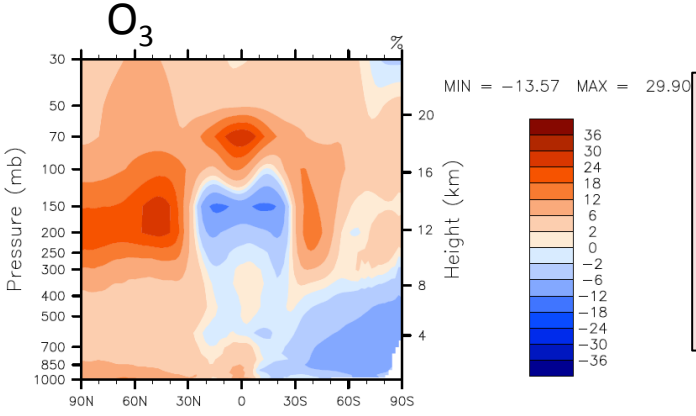
CH4 Lifetime:
CAM5 9.6, CAM4 8.4



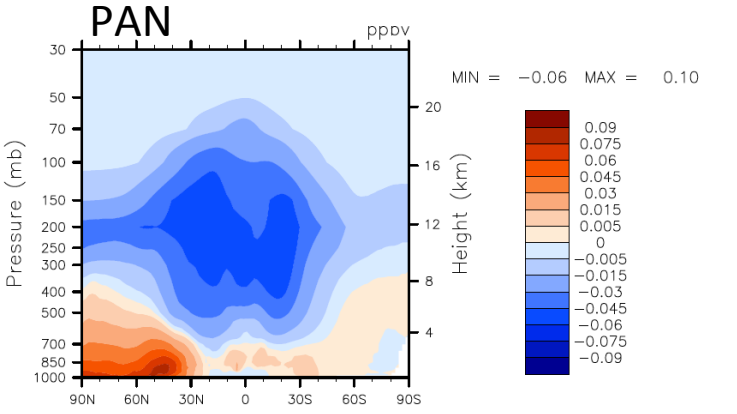


Colder temperatures, clouds, and transport differences:
More ozone and NOy in the LMS, troposphere
-> change in photolysis rates

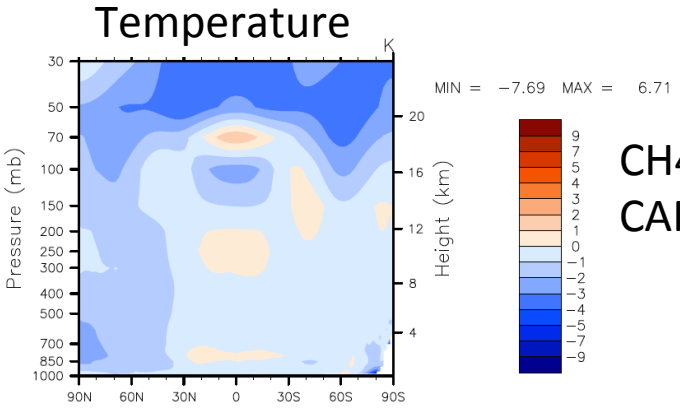




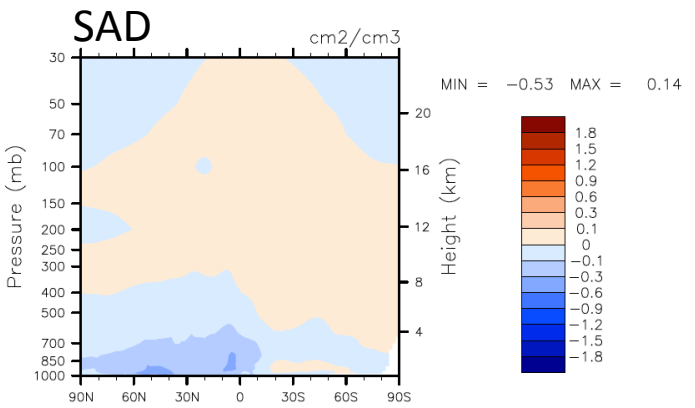
More SAD: at night more N_2O_2 converted to HNO_3 -> less PAN formation

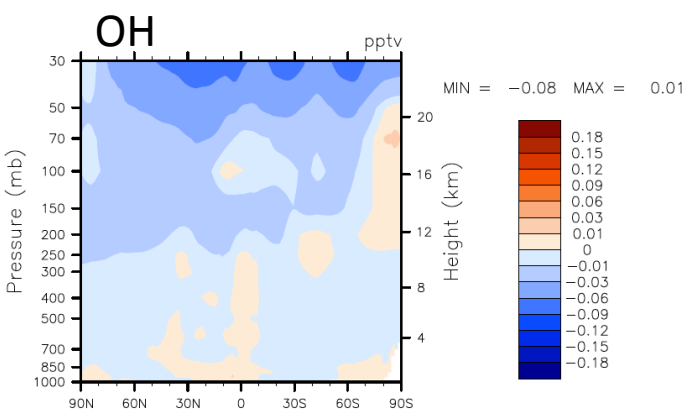


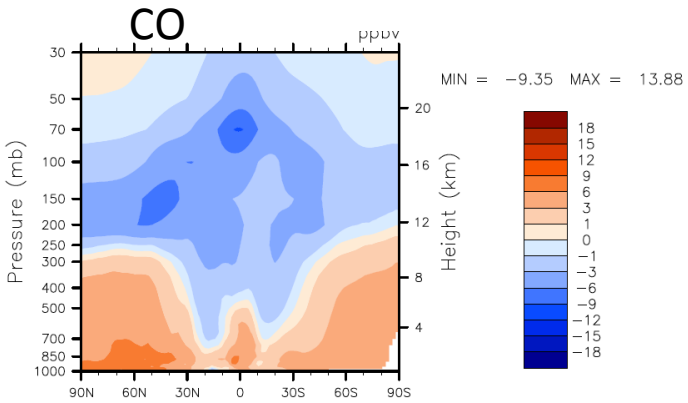
CAM5Chem vs. CAM4Chem (strat/trop mechanism)



CH4 Lifetime:
CAM5 9.6, CAM4 8.4



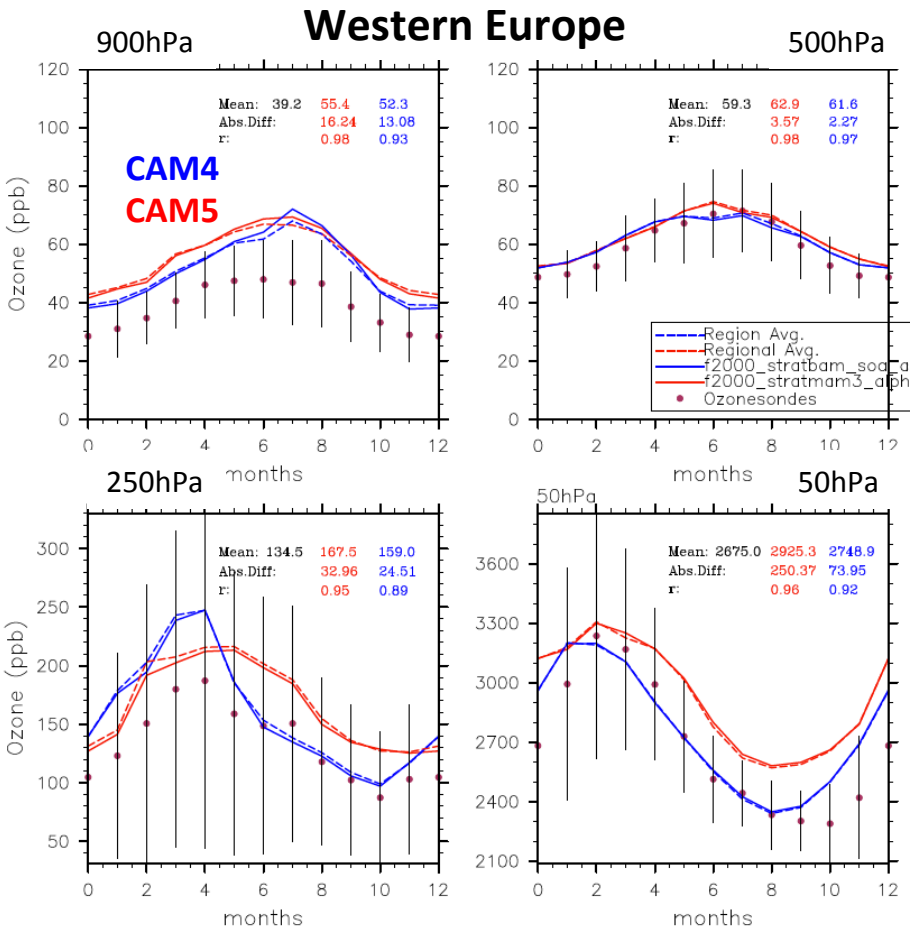




Both differences in meteorology and SAD influence tropospheric chemistry and therefore the lifetime of methane.

CAM5Chem vs. CAM4Chem (strat/trop mechanism)

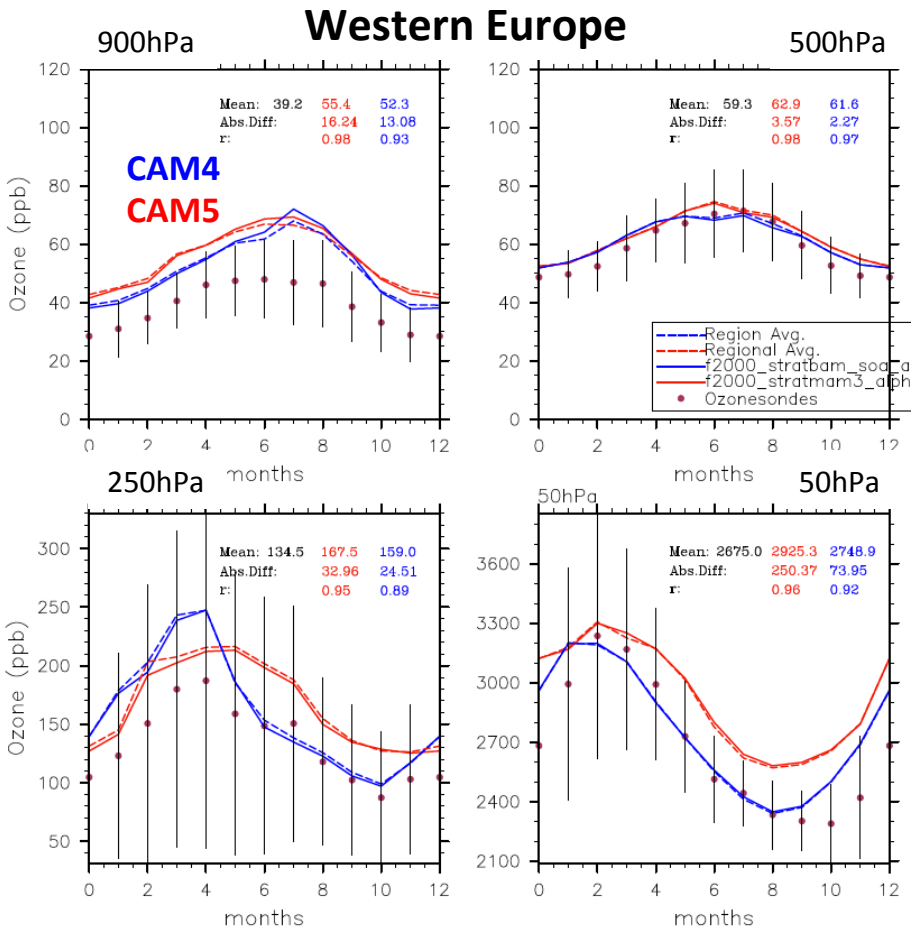
Comparison to Ozonesonde Observations

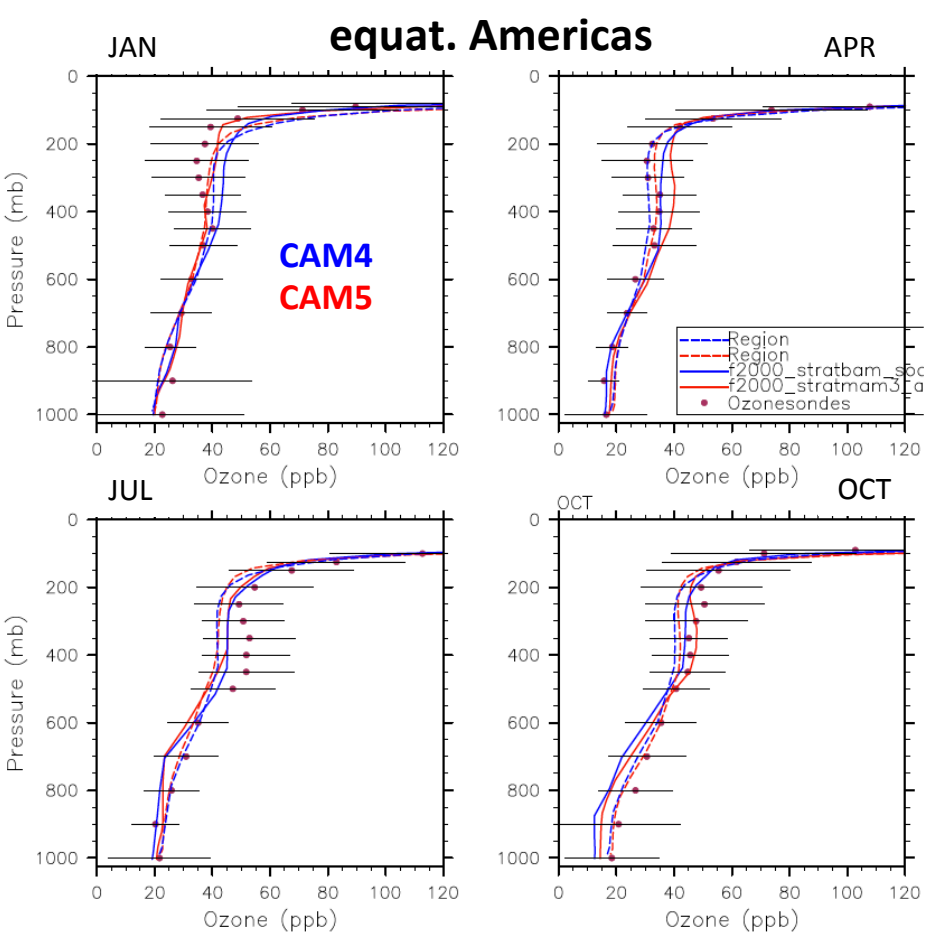


Difference between the models in comparison to observations is small.
Too much ozone in 50hPa in CAM5Chem due to too cold temperatures.

CAM5Chem vs. CAM4Chem (strat/trop mechanism)

Comparison to Ozonesonde Observations

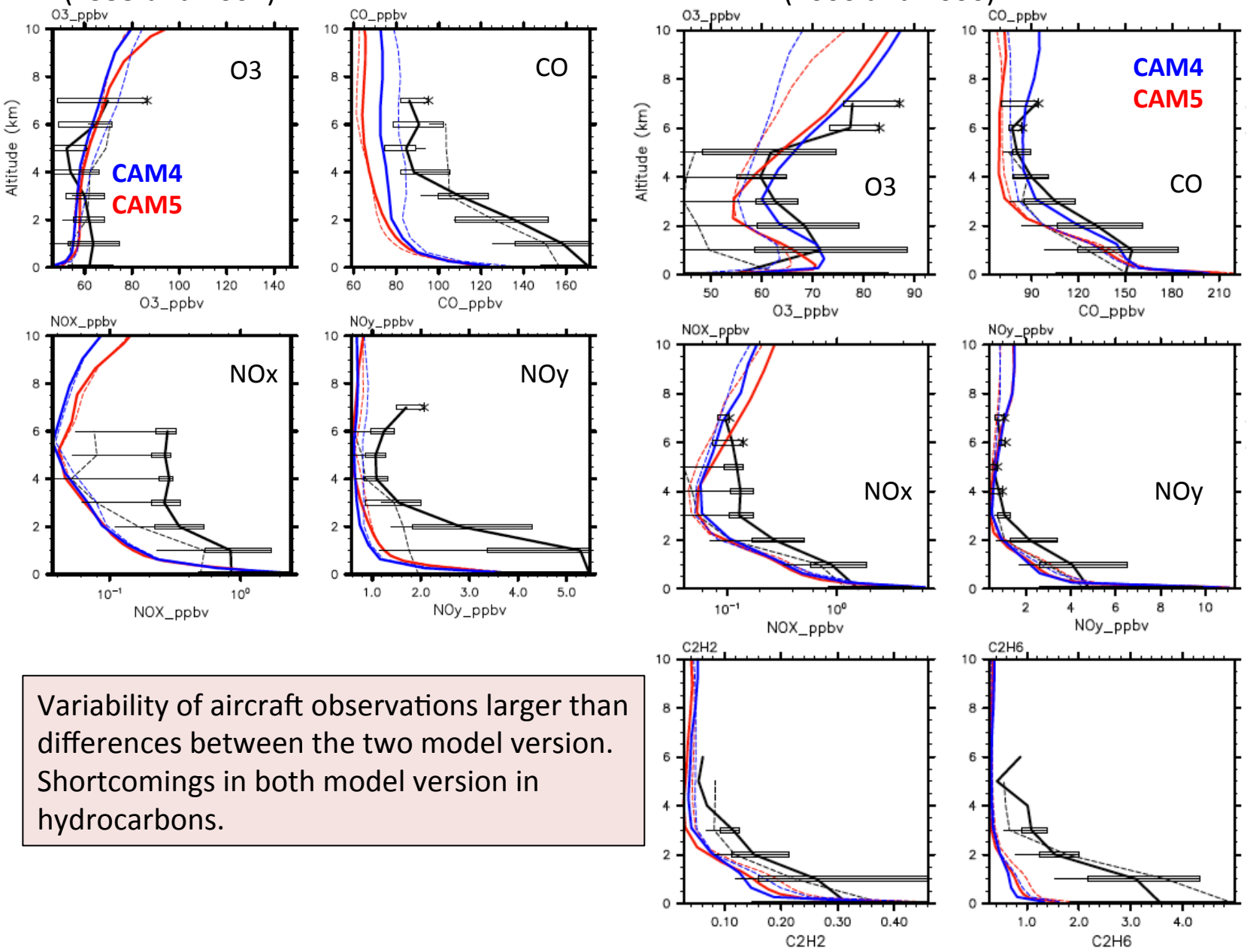




Difference between the models in comparison to observations is small.
Too much ozone in 50hPa in CAM5Chem due to too cold temperatures.

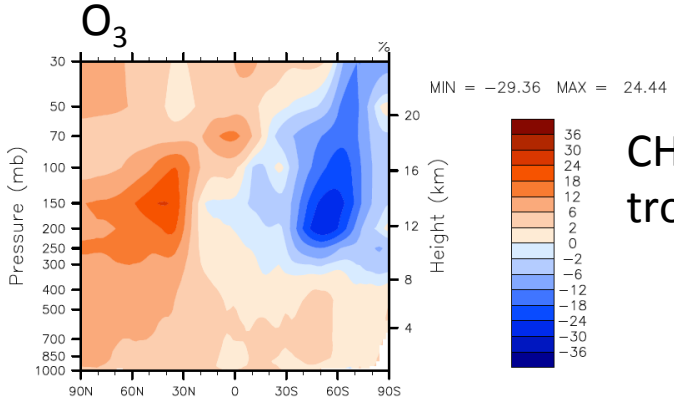
Comparison to Aircraft Observations

(1999 and 2004) EastCoast (2000 and 2006) Texas

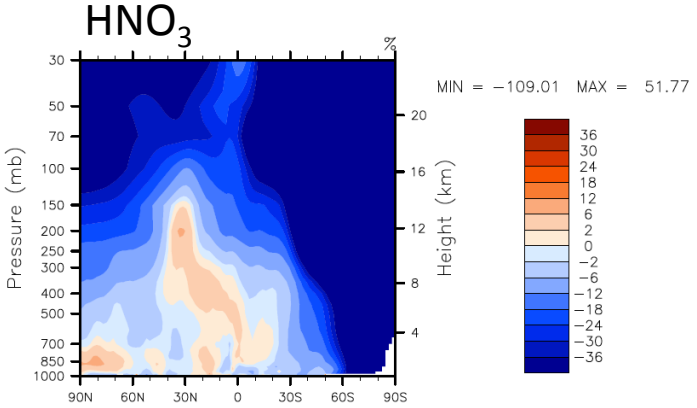


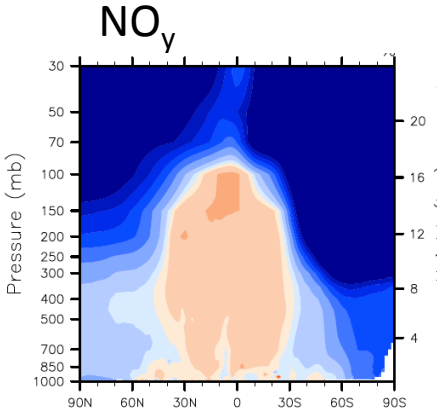
Variability of aircraft observations larger than differences between the two model version. Shortcomings in both model version in hydrocarbons.

Prescr. Stratosphere vs. calculated Stratosphere

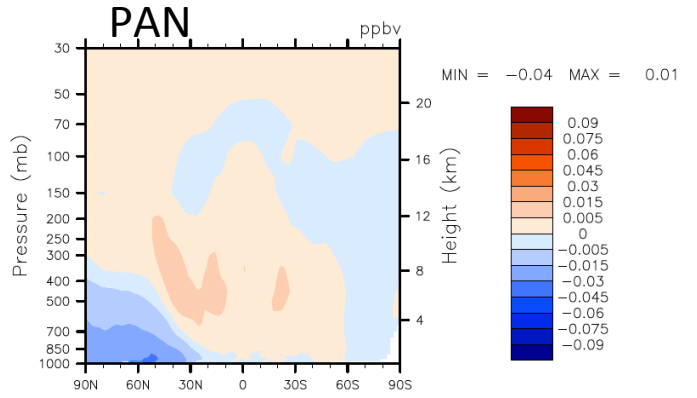


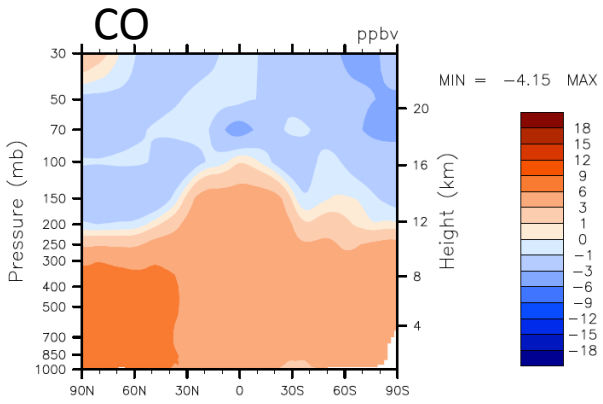
CH4 Lifetime:
trop: 9.6, trop-strat: 8.4



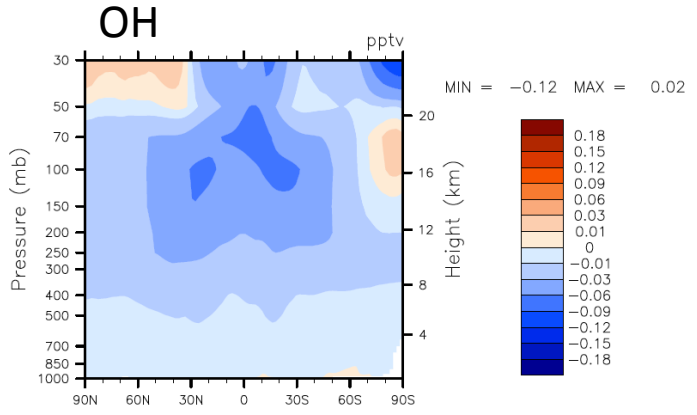


Less HNO_3 in the stratosphere, with reduction in the LMS and high latitudes. More NOy in the Tropics.

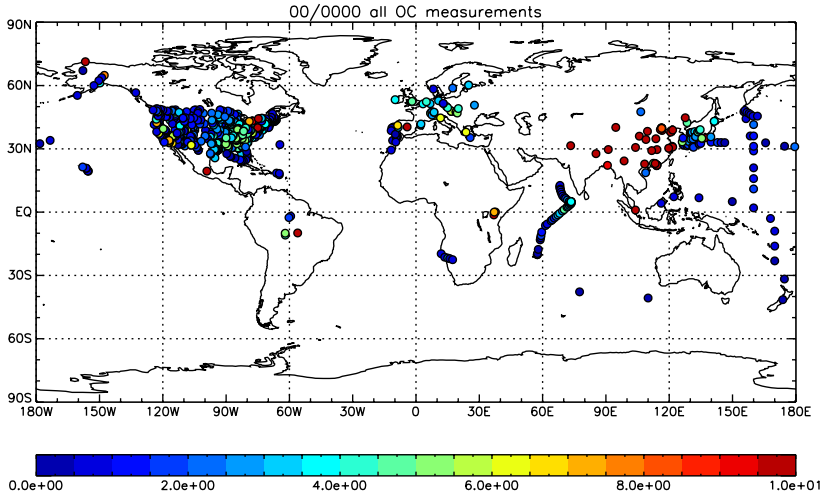


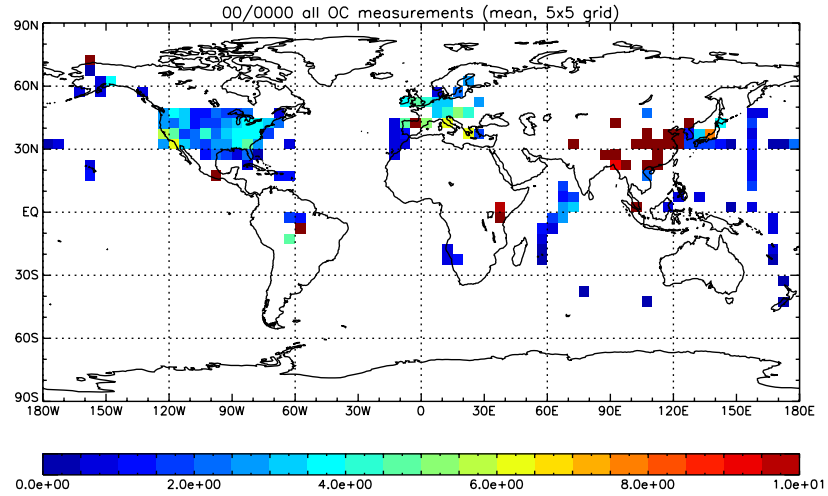


Increased CO consistent with reduced OH.
Need for updated prescribed stratospheric values.



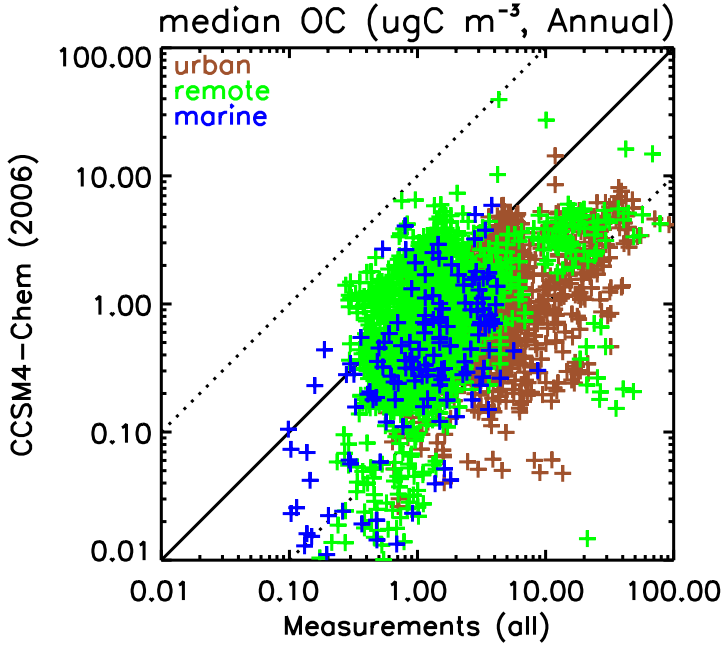
Evaluation of Organic Aerosols





Tsigaridis et al., to be submitted: An AeroCom intercomparison exercise on organic aerosol global modeling (to ACP, 70+ authors, 40+ affiliations)

- Uses ground based, filters, period anywhere between 1980 and 2007
- CAM4Chem, SOA advanced chemistry



Work is in progress to further improve SOA in CAMChem

Updated CCMI compsets based on CESM1.1.1

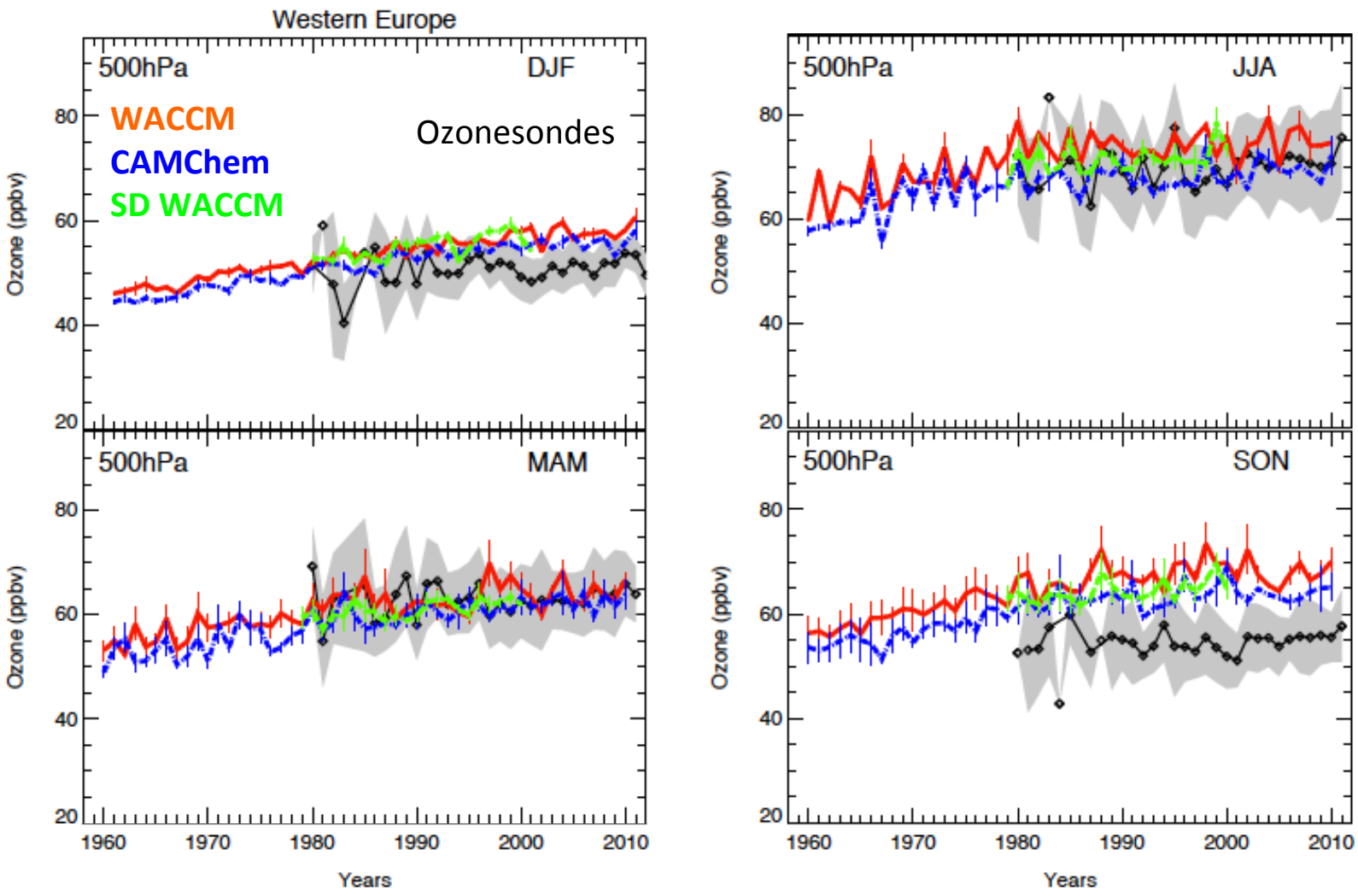
CCMI Compsets: CESM1.1.1 (1.9x2.5)	Model (phys)/ radiation	Chemistry (JPL 2010)	Components / Meteorology
REFC1: F_1950-2010_CCMI_REFC1_TROP_STRAT (BCCMITSREFC1)FCCMITSREFC1	CAM4, active BAM	trop/strat mozart + soa chemistry	Prescr. ocn/ice, MEGAN
REFC1 SD: F_SD_1975-2010_CCMI_REFC1_TROP_STRAT (FSDCCMITSREFC1)			MERRA driven, 10% nudging, MEGAN
REFC2: B_1950-2100_CCMI_REFC2_TROP_STRAT (BCCMITSREFC2)	CAM4, active ocn/ ice		active ocn/ice, MEGAN

Updated features in CESM CESM1.1, CAM4, 1.9x2.5

In addition to release changes:

- Rate approach added to pre-processor
- New volcanic heating calculation (R. Neely and A. Conley)
- Updated SAD_TROP and SAD in the stratosphere
- Inclusion of QBO and TMS
- Inclusion of solar proton events (in progress)
- In progress: updated gravity wave forcing to fix stratospheric temperatures (cold pole)
- Plans to run SD-CAMChem in 0.5x0.63
- Plants to tests nudging/overwriting

Performance of CCMI model simulations



Outlook and Discussion on Chemistry Compsets

Changes to existing compsets (sandbox, and next release):

- Update of compsets with prescribed stratosphere
- SO_2 emissions in CAM4
- Dry deposition code fix (Maria ValMartin and Steve Arnold)
- Adding the CCMI functionality

Update all SD transient compsets using new chemistry mechanism:

- Need new emissions for SD transient CAM5 aerosols (so far only available from CMIP5, and for POLMIP)
- Test new aerosol wet deposition and convection changes
- Setup and test CAM4 Carbon/Nitrogen cycle with MEGAN 2.0 (B-cases)

Update superfast chemistry compsets?

Outlook and Discussion on Chemistry Compsets

New Compsets (setup and evaluate performance) ?

- MAM4?
- Spectral Element core?
- CAM5 SD chemistry compsets?
- NOx tagged mechanism?
- SD compsets with 0.5x0.63 or higher resolution B1850?
- Transient B-cases for CAM5 (CAM4 at this point from 1960)?
- F2000 with different resolutions?
- 60L chemistry compsets?
- Priorities?

Chemistry/Aerosol Diagnostic Package

Aerosol metrics

- Aerosol optical depth (satellite, AERONET)
- Aerosol absorption optical depth (AERONET)
- Surface concentrations of SO_2, sulfate, black carbon, organic carbon, sea salt, mineral dust at sites (IMPROVE, EMEP, U. Miami, Mahowald)
- Surface deposition measurements (Mahowald)
- Ice core records of black carbon deposition
- Aerosol size distribution (Heinzenberg)
- CN vertical profiles (Minikin)
- Vertical profiles of CCN concentration at 0.1% supersaturation (Ghan et al. 2001)
- Aircraft measurements of vertical profiles of black carbon (ARCTAS, ARCPAC, CARB, HIPPO)

Chemistry/Aerosol Diagnostic Package

Tropospheric Chemistry

- Tables: Budgets, lifetime, biogenic emissions
- Ozone climatology comparison (Tilmes et al., 2012)
- Surface O_3 (Lamarque et al., 2012)
- Nitrate, Sulfate and Ammonium Deposition (Lamarque, et al., 2013)
- Aircraft: Emmons climatology of key species
- Aircraft: HIPPO CO, O_3, PAN
- OH climatology
- SOA diagnostics?

Stratospheric Chemistry

- Total Ozone Column, comparison to Halley (Kinnison)
- Stratospheric Chemistry comparison with ACE data?
- Temperature comparison with MERRA?

Chemistry/Aerosol Diagnostic Package

Timeline

- Produce/update diagnostics by September 1st
- Merge to AMWG, October 1st
- Testing done by November 1st
- Merge with Swift
- Release by the end of the year