CAM-chem in ACCMIP: Tropospheric ozone

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…with Jean-François Lamarque, Simone Tilmes, Alex Archibald and many others involved in ACCMIP

Outline

- What is ACCMIP?
- Tropospheric ozone evaluation (v brief)
  - Pre-industrial
  - ACCENT type
  - Tilmes et al. update
- O_3 budget and concentrations from “acchist” simulations
  - 1850, 1980, 2000 time slices
- Why might models get different answers?
- Outlook

What is ACCMIP?

Atmospheric **C**hemistry & **C**limate **M**odel **I**ntercomparison **P**roject

Tropospheric (generally) CCM simulations in support of AR5

Historical Simulations

Emissions/Configuration	1850	1890	1910	1930	1950	1970	1980	1990	2000
Emissions and SSTs/GHGs for given year	C	1	1	C	1	1	C	1	C
Given year emissions/1850 SSTs & GHGs				1			1		C

Future Simulations

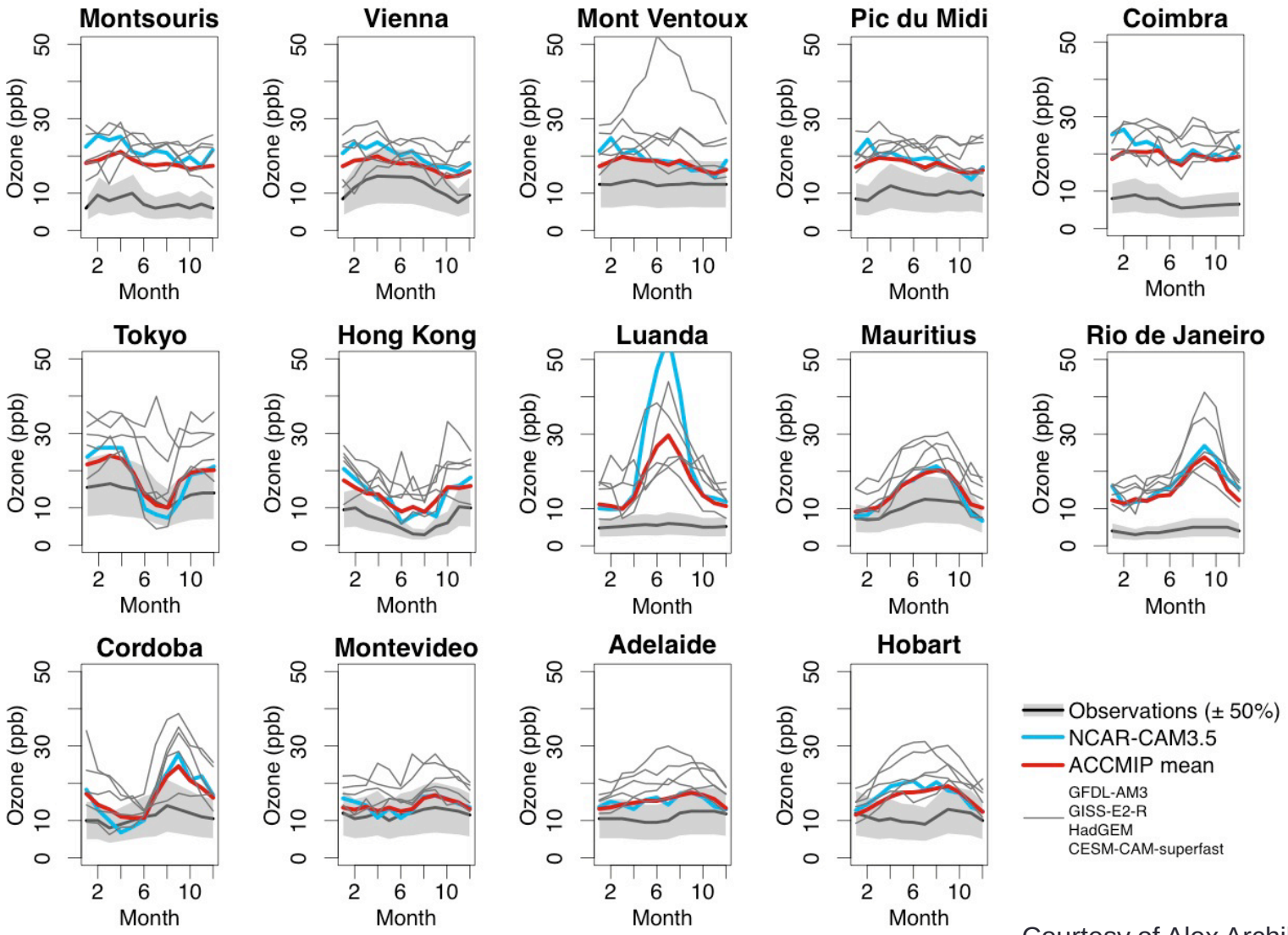
Emissions/Configuration	2010	2030	2050	2100
RCP 2.6		C	1	C
RCP 4.5	1	1	1	1
RCP 6.0	C	C	1	C
RCP 8.5		C	1	C
Year 2000 emissions/RCP 8.5 SSTs & GHGs		C		C

C = core, 1 = Tier 1, blank = not requested

Who's in?

Institute	Model	Other comments
CICERO	CICERO-OsloCTM2	CTM
CCCma	CMAM	No aerosols; simple chemistry
GFDL	GFDL-AM3	
GISS	GISS-E2-R	
LLNL-NCAR	CESM-CAM-superfast	Simplified chemistry
LSCE	LMDzORINCA	No aerosols
MeteoFrance	MOCAGE	No aerosols
NASA-GSFC	GEOSCCM	No aerosols; simple chemistry
NCAR	NCAR-CAM3.5	
NCAR	NCAR-CAM5.1	Limited output
NIES	MIROC-CHEM	
NIWA	UM-CAM	No aerosols
UKMO	HadGEM2	

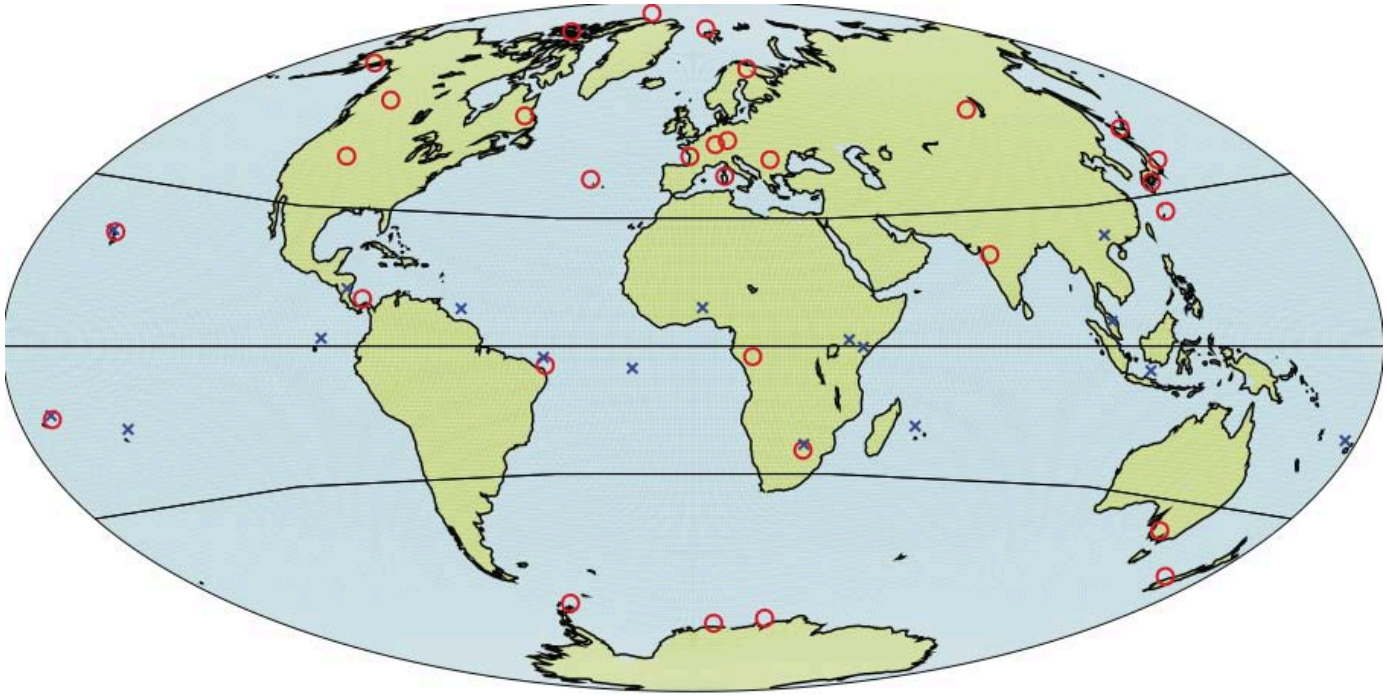
Pre-industrial ozone comparison



Courtesy of Alex Archibald, U. Cambridge

Ozone evaluation: ACCENT

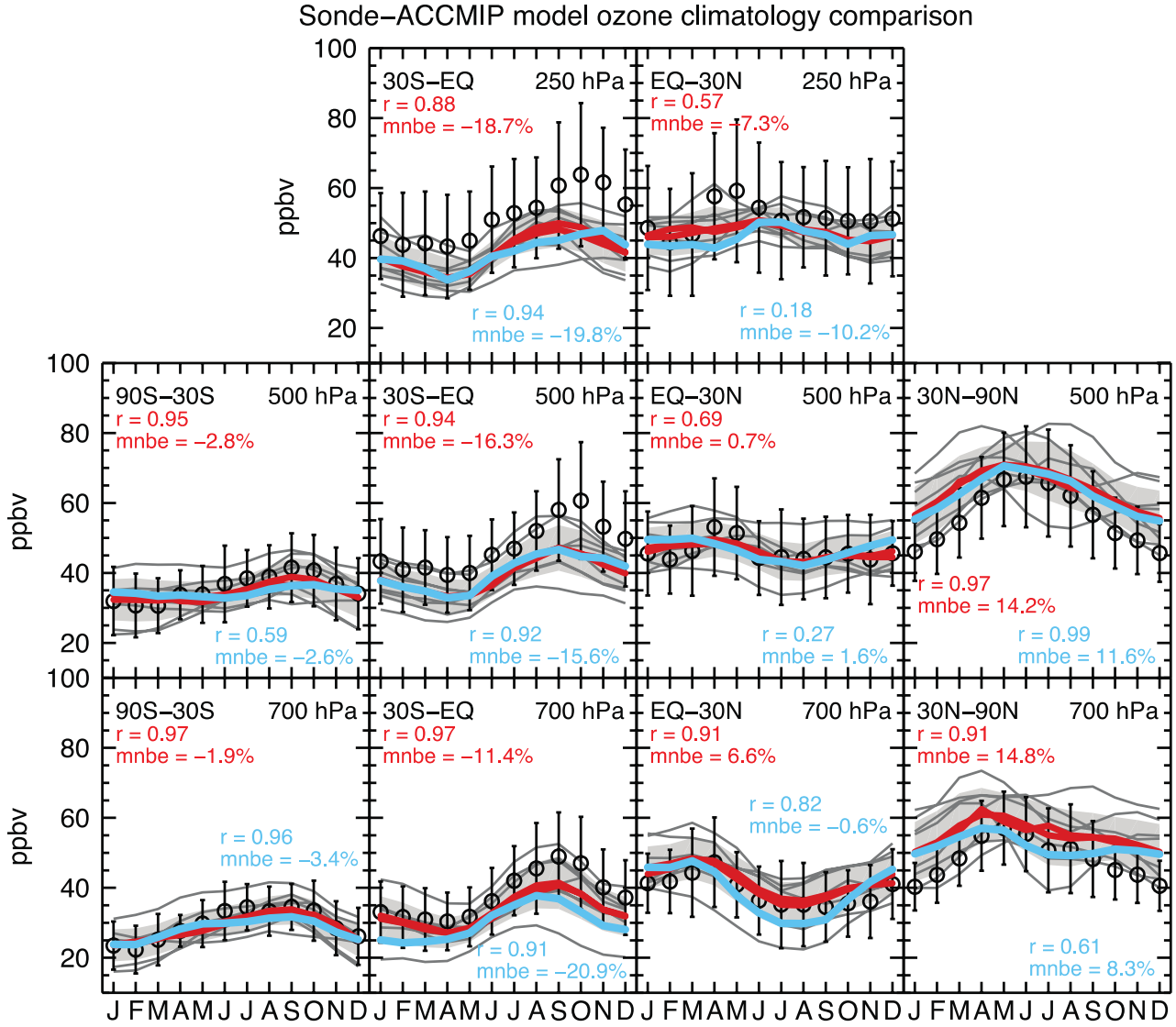
ACCENT divided Logan and SHADOZ sondes into four latitude bands:



Logan locations

SHADOZ locations

ACCENT: 2000 time slice comparison

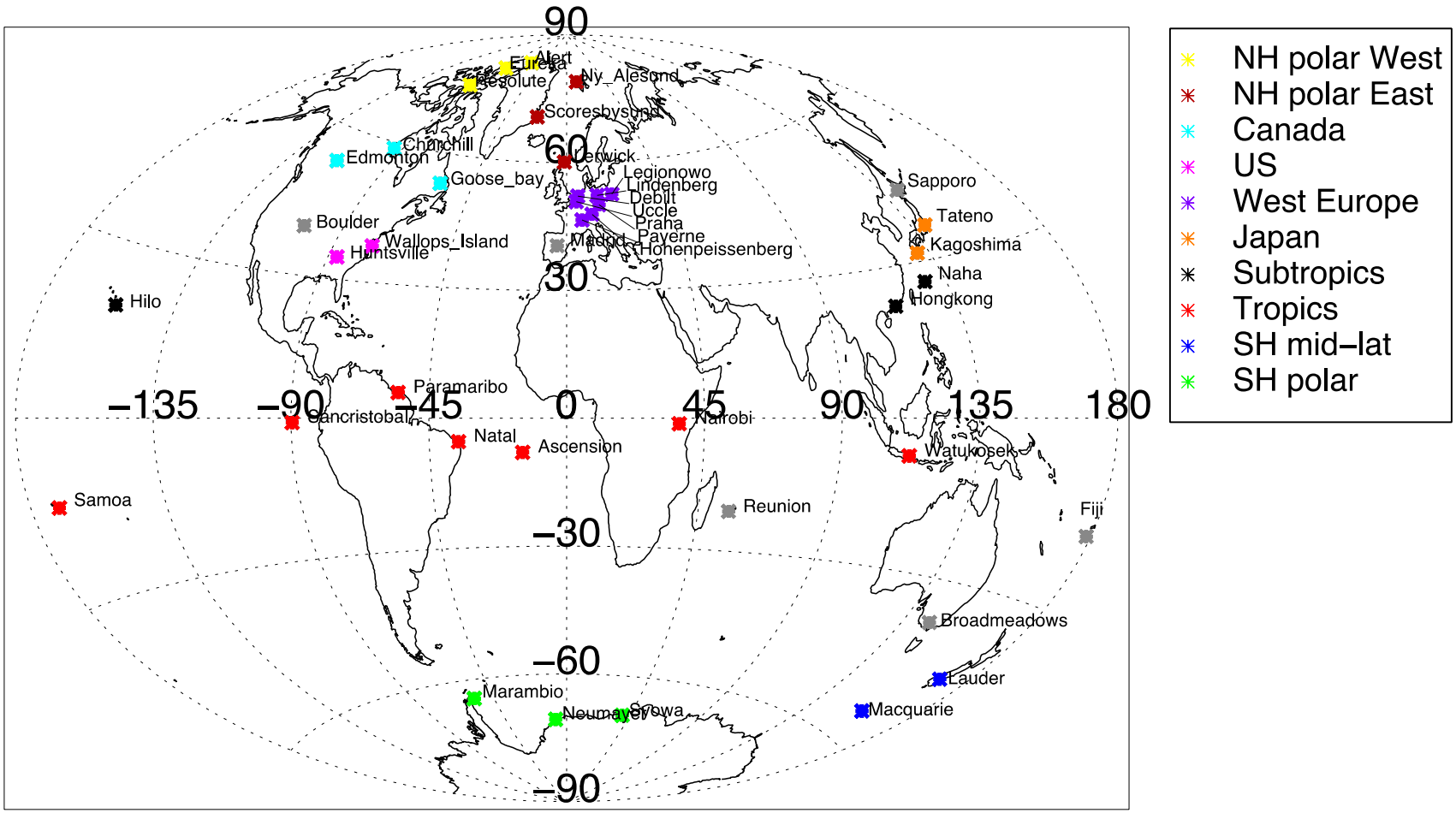


includes:
CESM
CMAM
GFDL-AM3
GISS-E2-R*
HadGEM2
LMDzORINCA#
MOCAGE
NCAR-CAM3.5
UM-CAM

* 1996-2005 avg
\# 1991-2000 avg

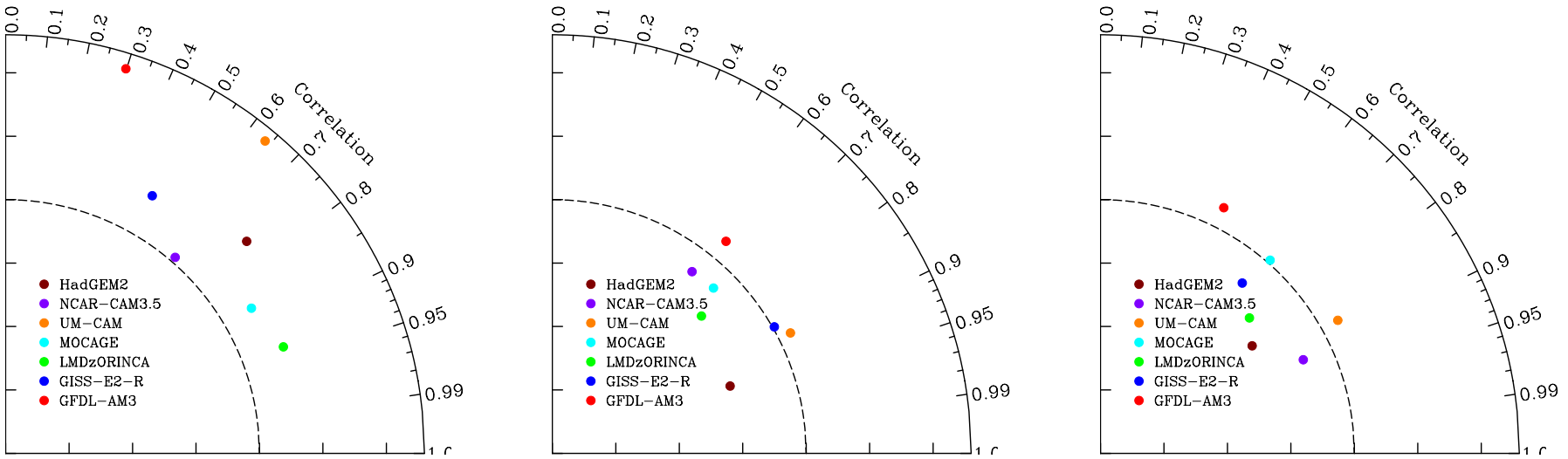
Tilmes et al. compilation

Defines regions (longitudinal gradients) and updates Logan data



Courtesy of Simone Tilmes, NCAR

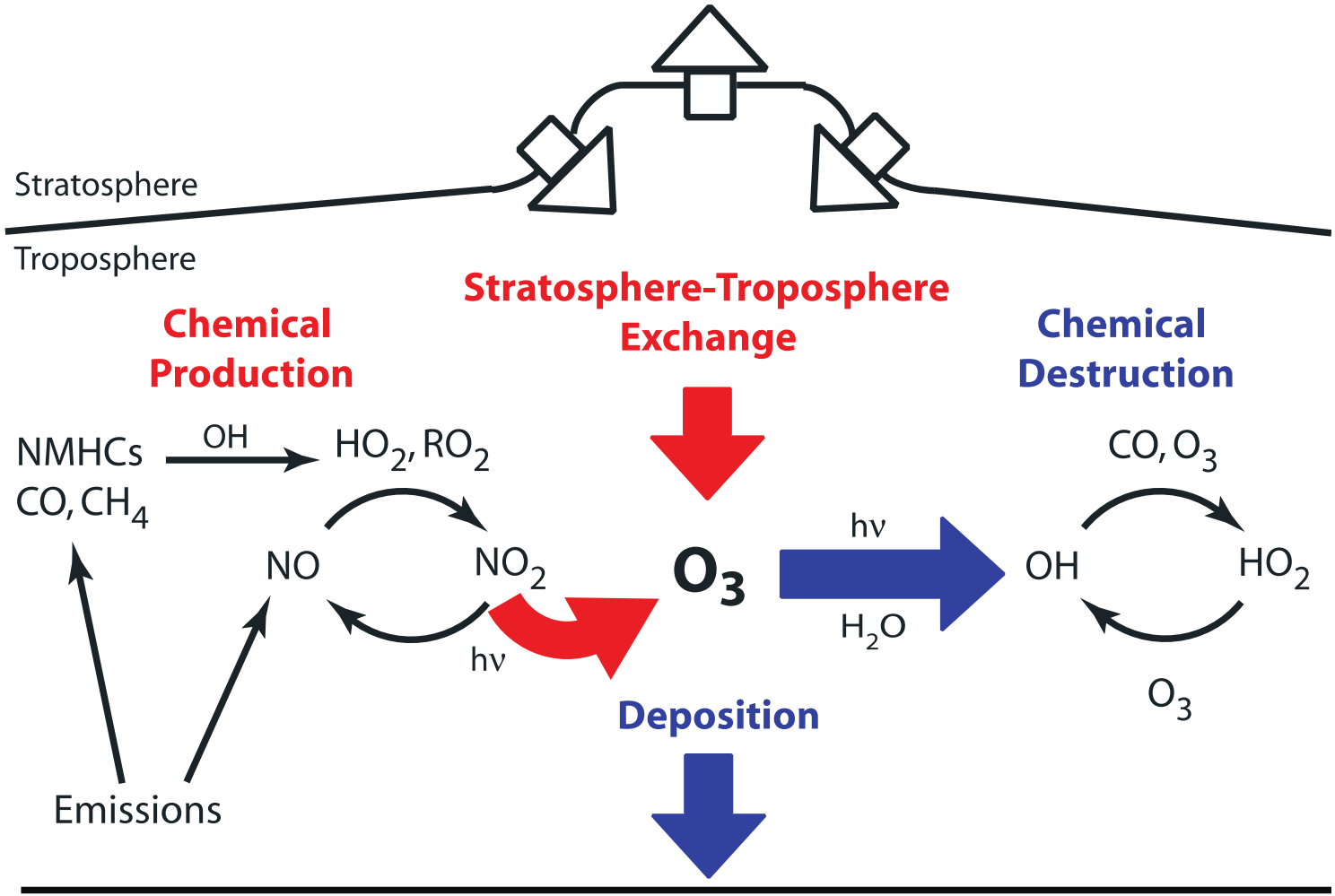
Taylor diagrams for the Tropics



Courtesy of Simone Tilmes, NCAR

Can we use model-observation comparisons to improve our understanding of past/future ozone evolution?

Ozone budget – processes



Terms depend on emissions and climate

O3 budget numbers: 2000 time slice

…1996-2005 for GISS; max and min highlighted

Model	Flux terms / Tg O_3 yr^{-1}					B / Tg	τ / days
	P	L	NCP	D	S_{inf}		
CESM	4484	4027	457	662	205	288	22.4
CMAM	6634	(–)	(–)	767	(–)	316	(–)
GFDL-AM3	5855	5089	766	1240	474	366	21.1
GISS-E2-R*	8010	6924	1085	1378	292	352	15.5
MOCAGE	(–)	(–)	613	875	263	382	(–)
CAM3.5	4758	4359	399	842	443	318	22.3
UM-CAM	4359	3816	542	1205	662	321	23.3
ACCENT	*4974*	*4577*	*397*	*953*	*556*	*336*	*22.2*

P from prodo3via terms; L backed out from P and NCP (from prodo3–losso3)

…and 1850 time slice

…1850-1859 for GISS; max and min highlighted

Model	Flux terms / Tg O_3 yr^{-1}					B / Tg	τ / days
	P	L	NCP	D	S_{inf}		
CESM	1889	1902	-13	360	373	186	29.9
CMAM	3506	(–)	(–)	514	(–)	239	(–)
GFDL-AM3	3284	3046	238	756	518	264	25.4
GISS-E2-R*	4600	4172	428	788	360	251	18.5
MOCAGE	(–)	(–)	-32	560	592	271	(–)
CAM3.5	2340	2307	33	474	441	216	28.4
UM-CAM	1951	2169	-218	754	972	226	28.2

P from prodo3via terms; L backed out from P and NCP (from prodo3–losso3)

1850 to 2000 time slice changes

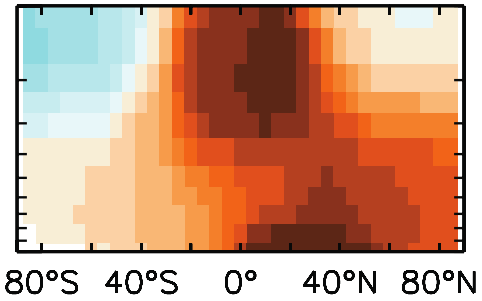
max and min *changes* highlighted; NCP changes relative to absolute 1850 value

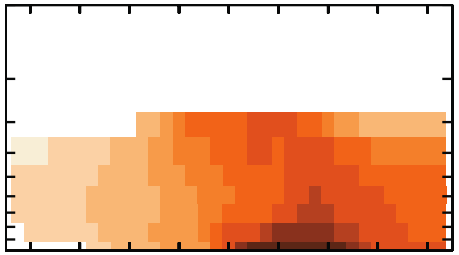
Model	Flux terms / Tg O_3 yr^{-1}					B / Tg	τ / days
	P	L	NCP	D	S_{inf}		
CESM	137%	112%	(3615%)	84%	-45%	55%	-25%
CMAM	89%	(–)	(–)	49%	(–)	32%	(–)
GFDL-AM3	78%	67%	222%	64%	-8%	39%	-17%
GISS-E2-R*	74%	66%	154%	75%	-19%	40%	-16%
MOCAGE	(–)	(–)	(2016%)	56%	-56%	41%	(–)
CAM3.5	103%	89%	1109%	78%	0%	48%	-21%
UM-CAM	123%	76%	(349%)	60%	-32%	42%	-17%

P from prodo3via terms; L backed out from P and NCP (from prodo3–losso3)

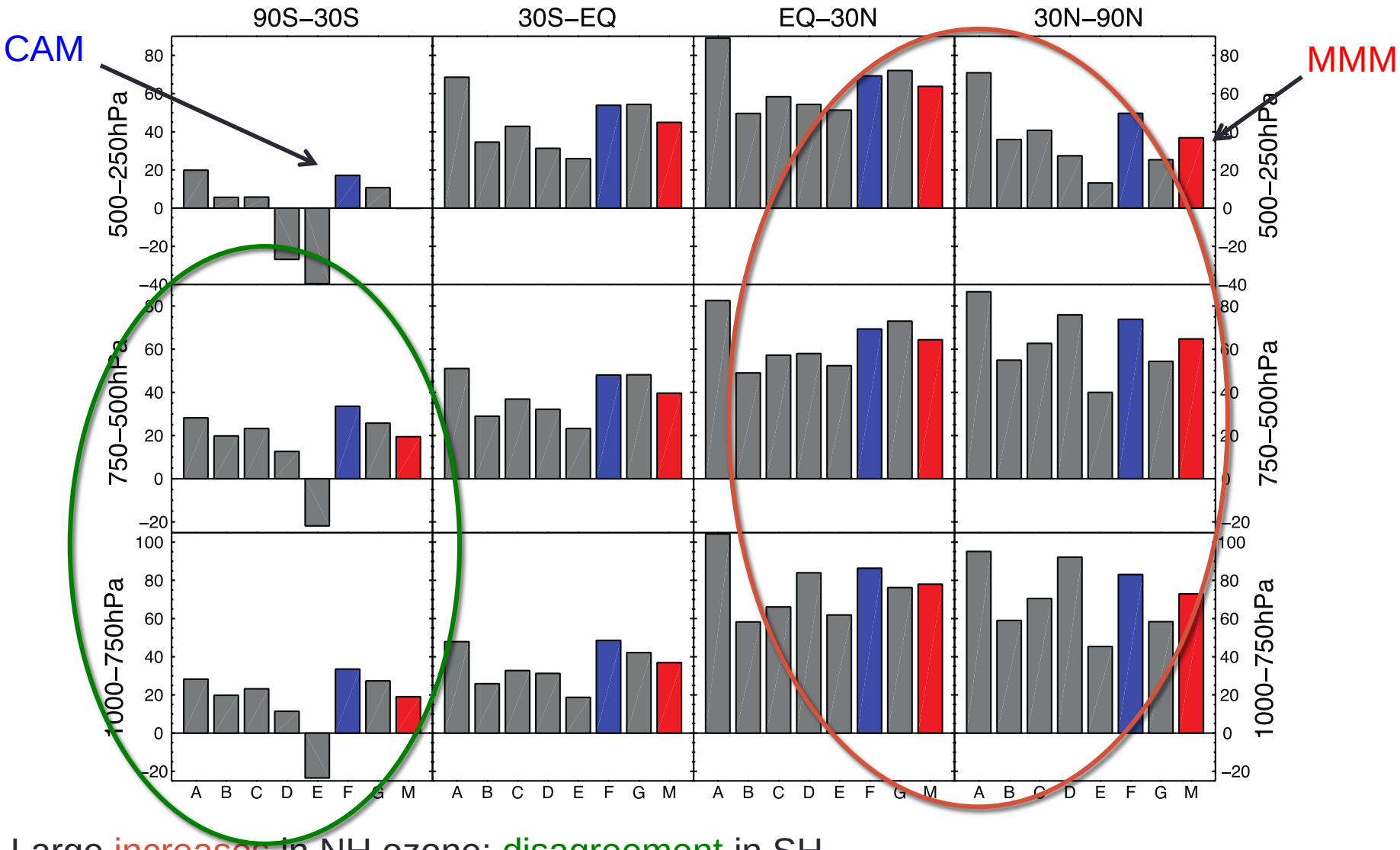
…still waiting on better NCP estimates

ΔO3 conc. (%): 2000 minus 1850



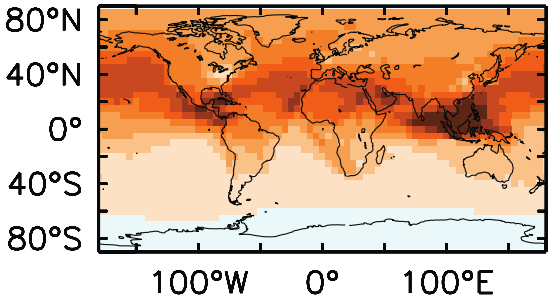


ΔO3 burden (%): 2000 minus 1850



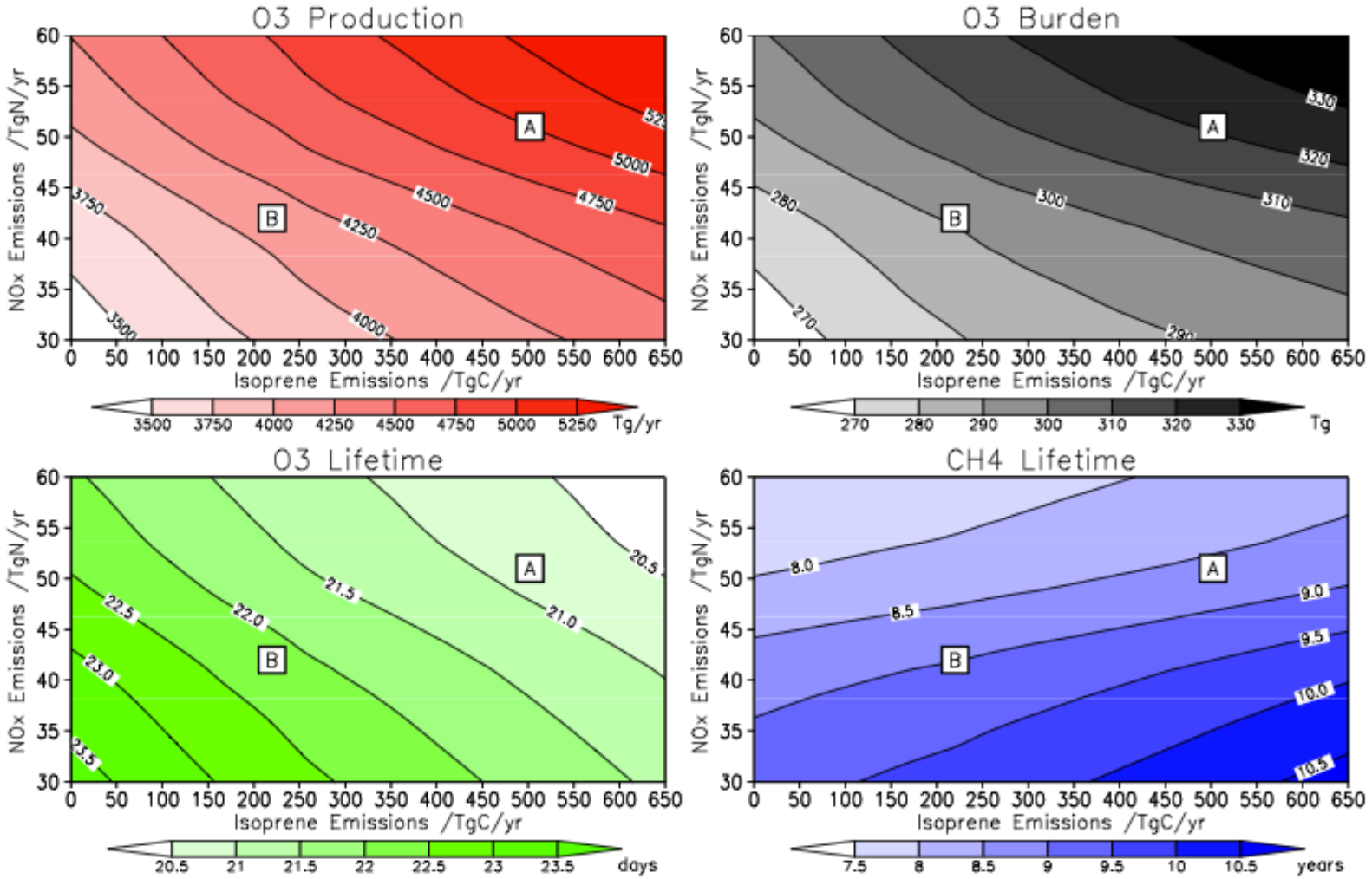
Large increases in NH ozone; disagreement in SH

ΔO3 surf. (%): 2000 minus 1850



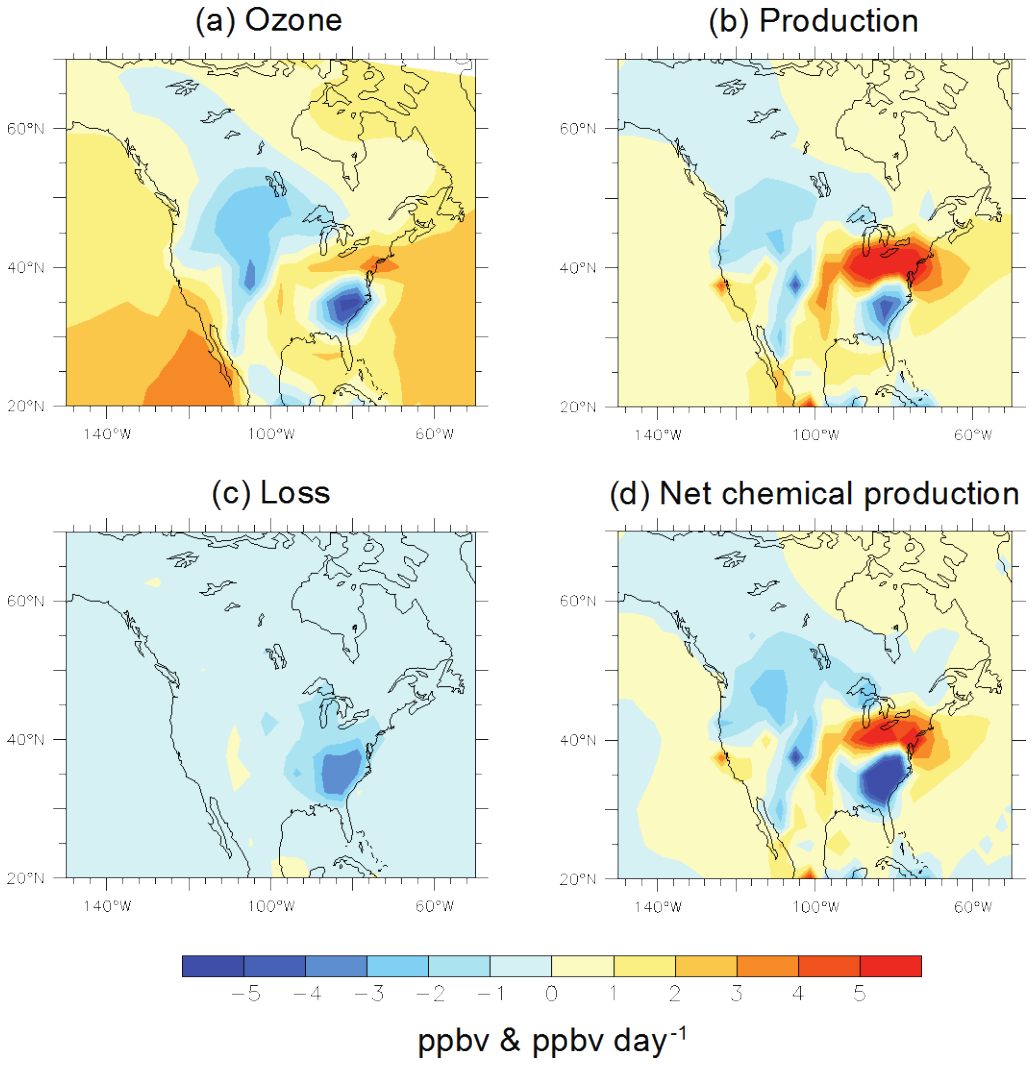
UM−CAM

How do Δemissions relate to ΔO3?



Wild, *Atmos. Chem. Phys.*, 2007

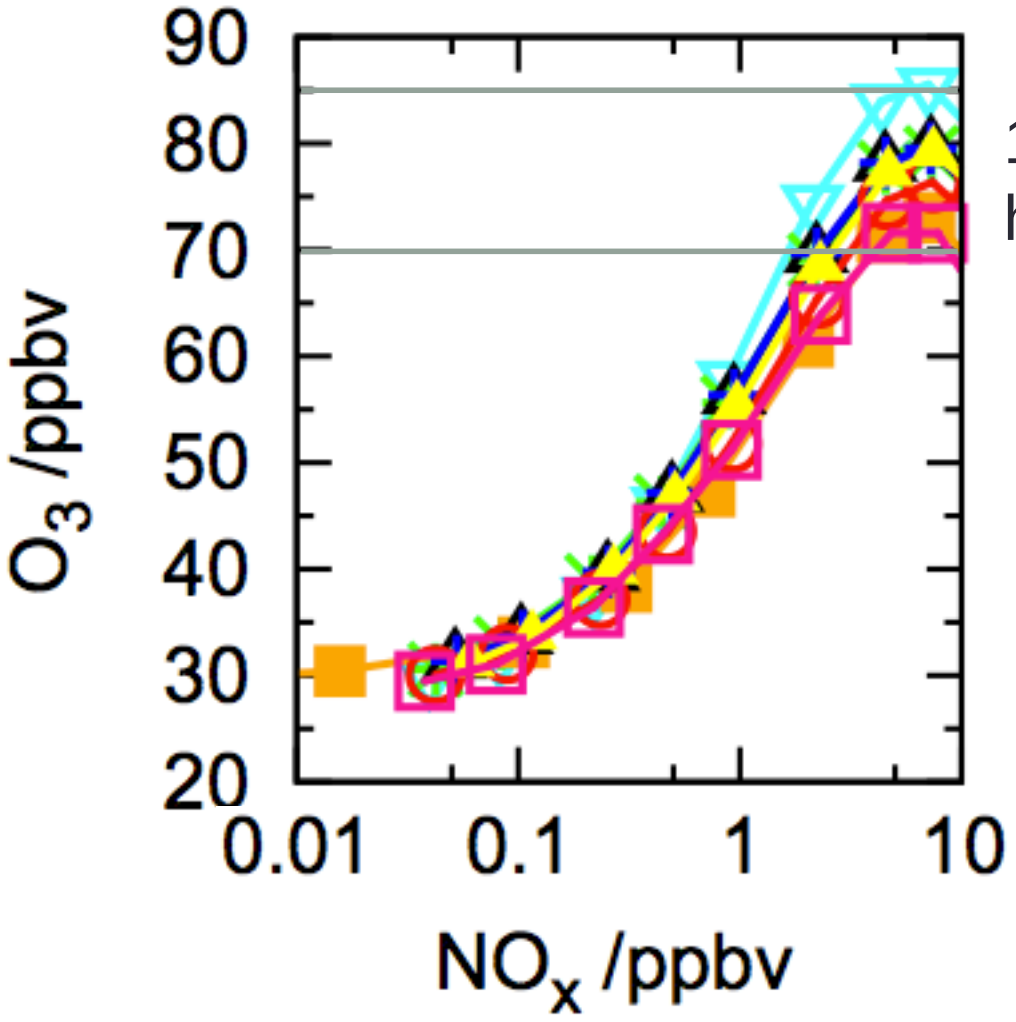
Some VOCs are complicated…



Impacts on O3, PO3, LO3 and NCPO3 from ~doubling of isoprene emissions

➔ Nitrate production vs. ozonolysis

…but depends on mechanism



15 ppbv difference at high NOx

…different climates also important

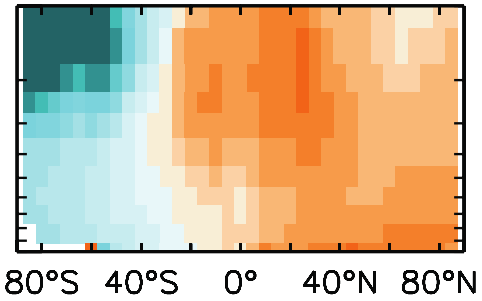
Archibald et al., *Atmos. Environ.*, 2010

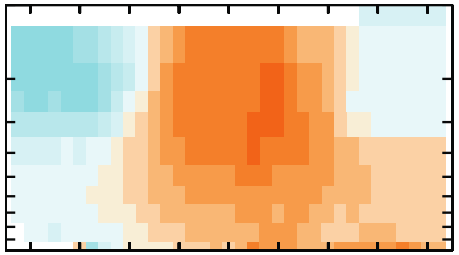
Still to do / Things to think about

- Working up more budget data for RCPs
- Processes?
  - Relate change in O_3 budget terms to NO_x/VOC chem and emissions
  - Mechanism intercomparison forthcoming (Archibald)
  - Links with OH and methane lifetime (Naik, Voulgarikis)
- Additional data comparison with TES etc. (Bowman)
- **Write paper!**

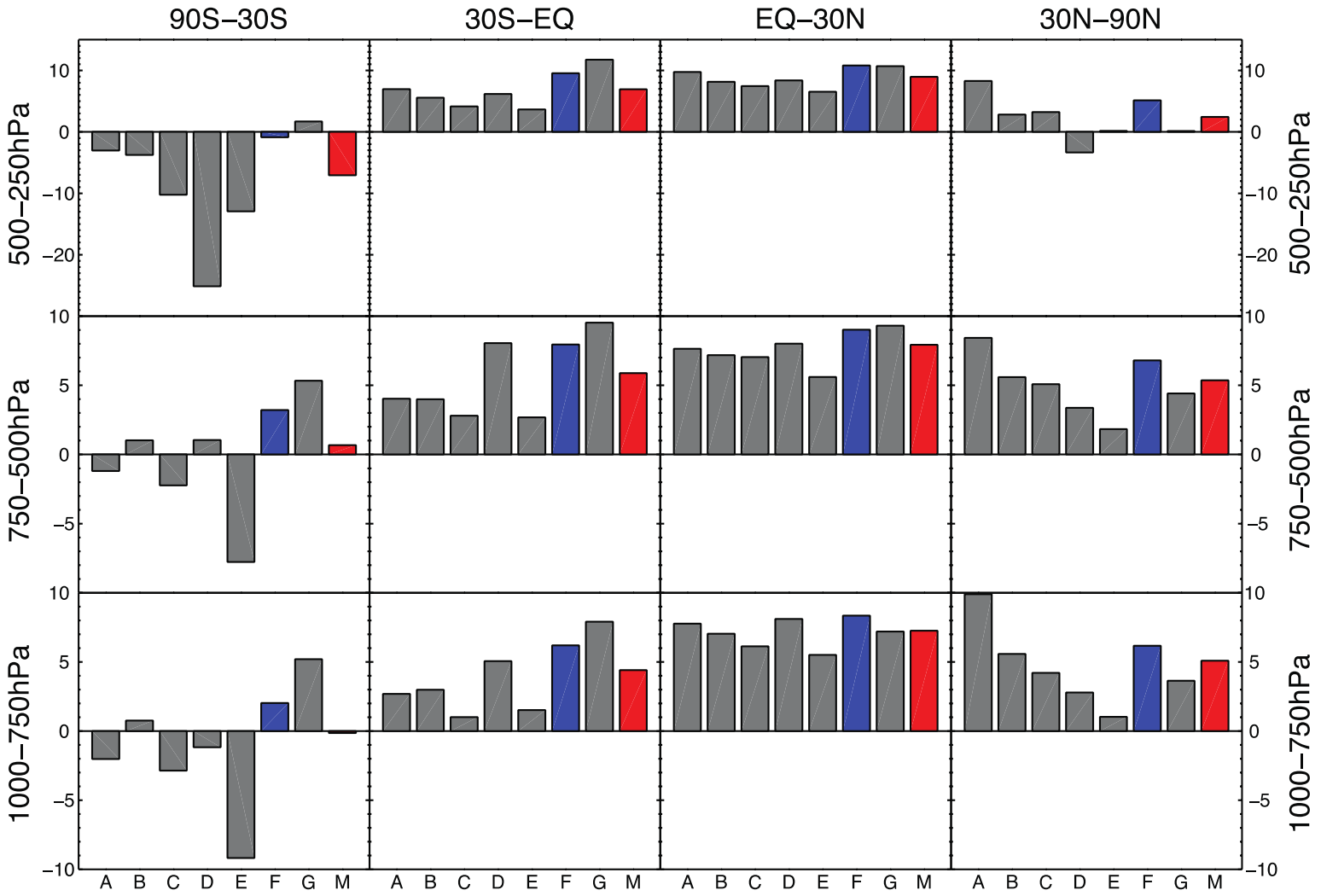
2000 minus 1980 changes

ΔO3: 2000 minus 1980



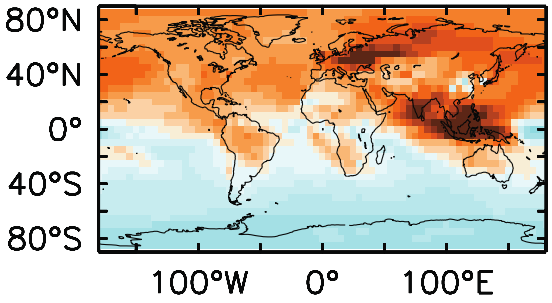


ΔO3 burden: 2000 minus 1980



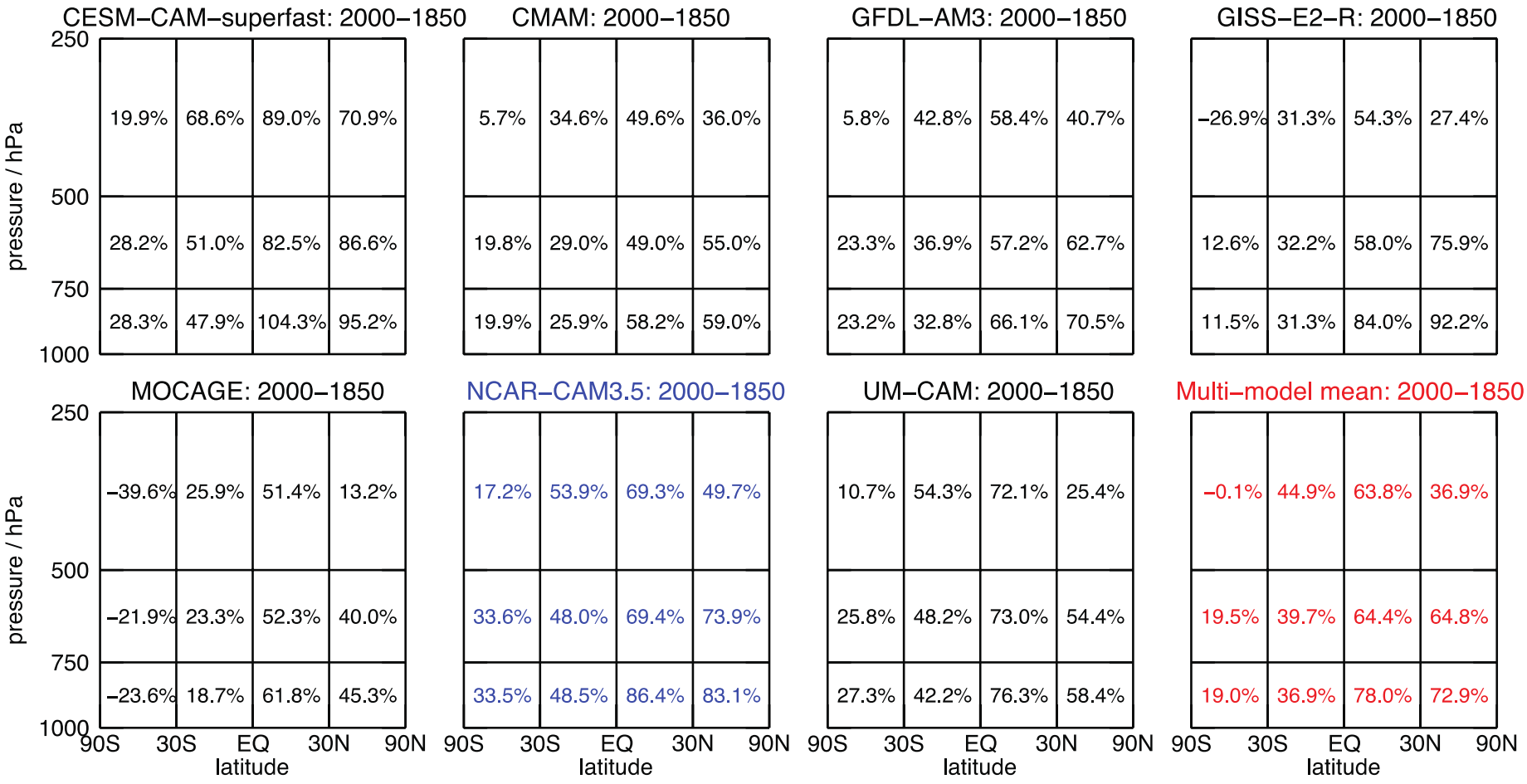
Increases in NH ozone; disagreement in SH for troposphere and ozone hole

$\Delta O3_{surf}$: 2000 minus 1980



UM – CAM

ΔO3 burden: 2000 minus 1850



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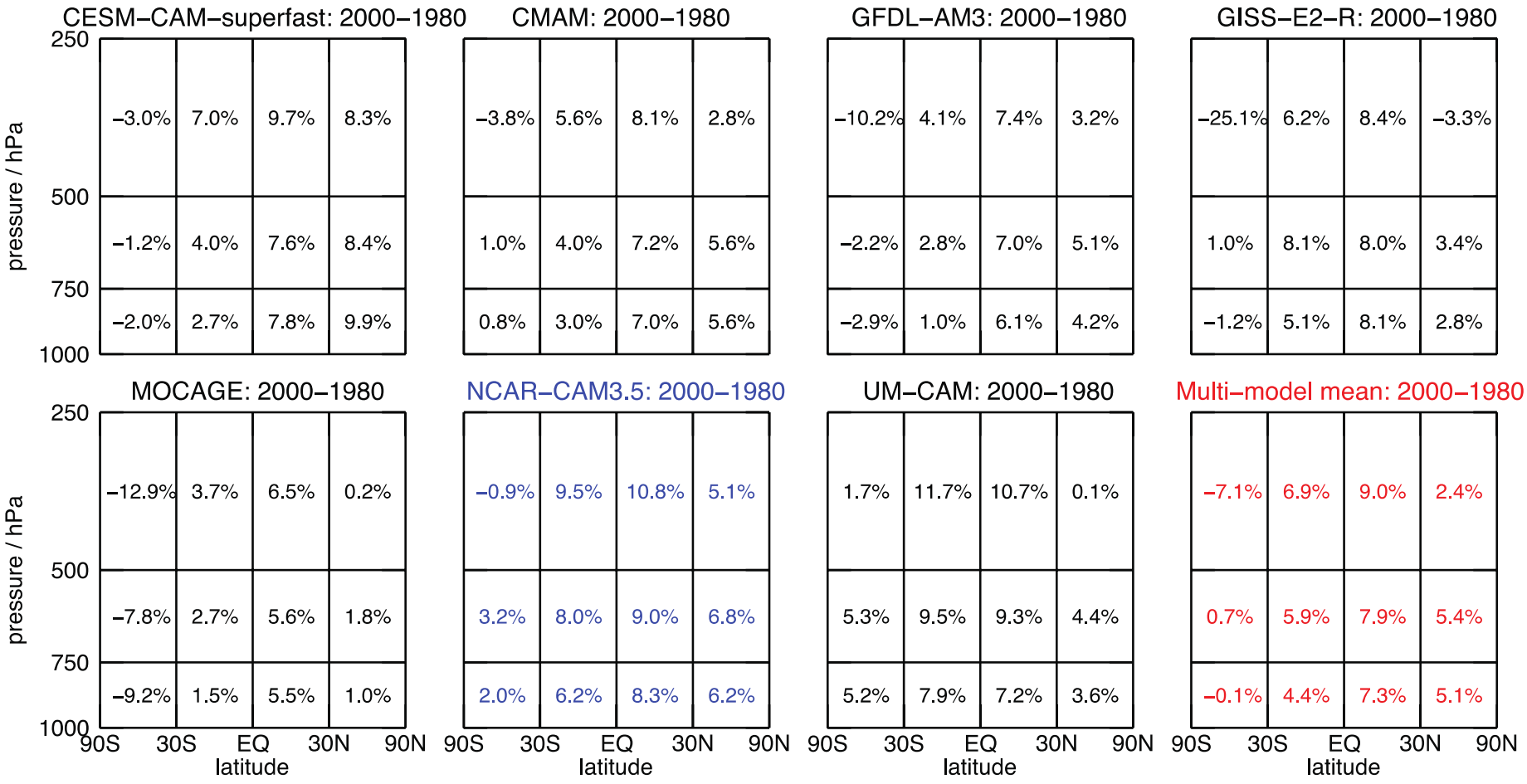

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