Trans-Pacific transport of CO in the upper troposphere
&
Meridional transport across the tropopause in the mid-latitudes

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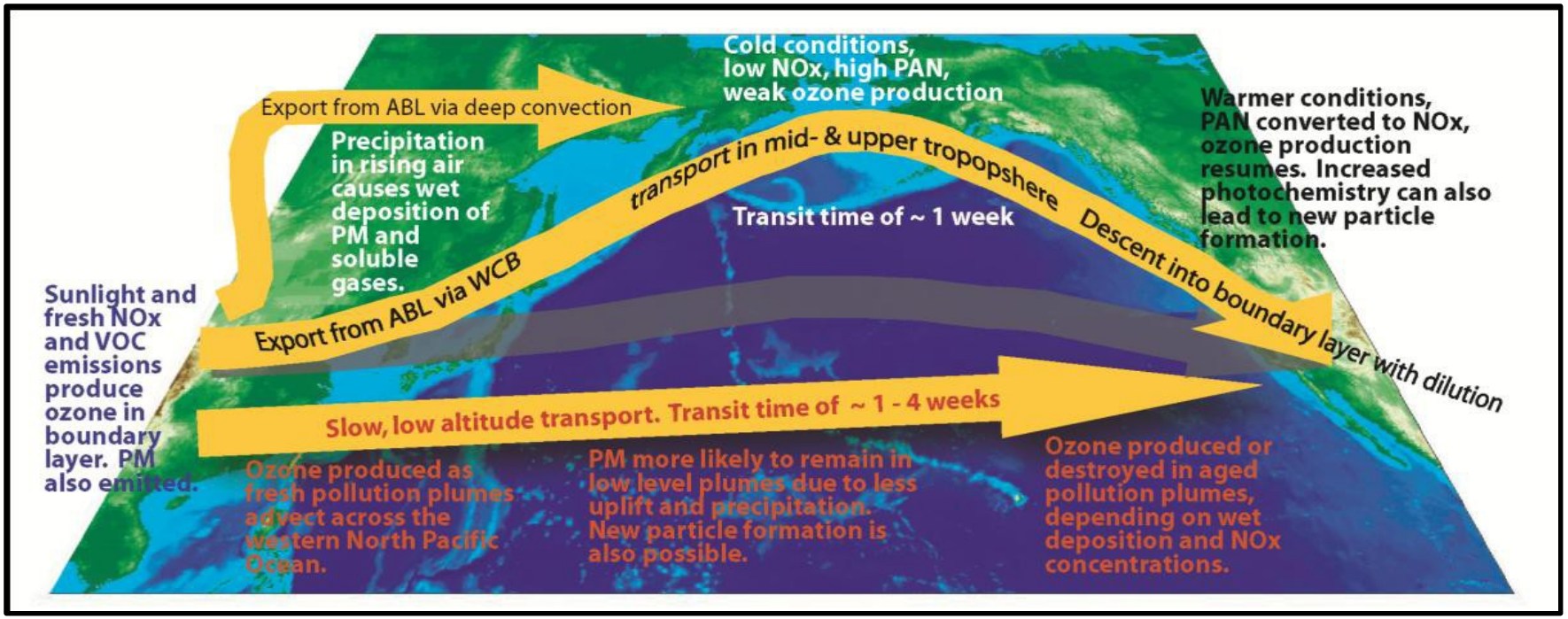
Trans-Pacific transport pathways of Asian air pollution



[Cooper et al., 2010, HTAP report]

215 hPa

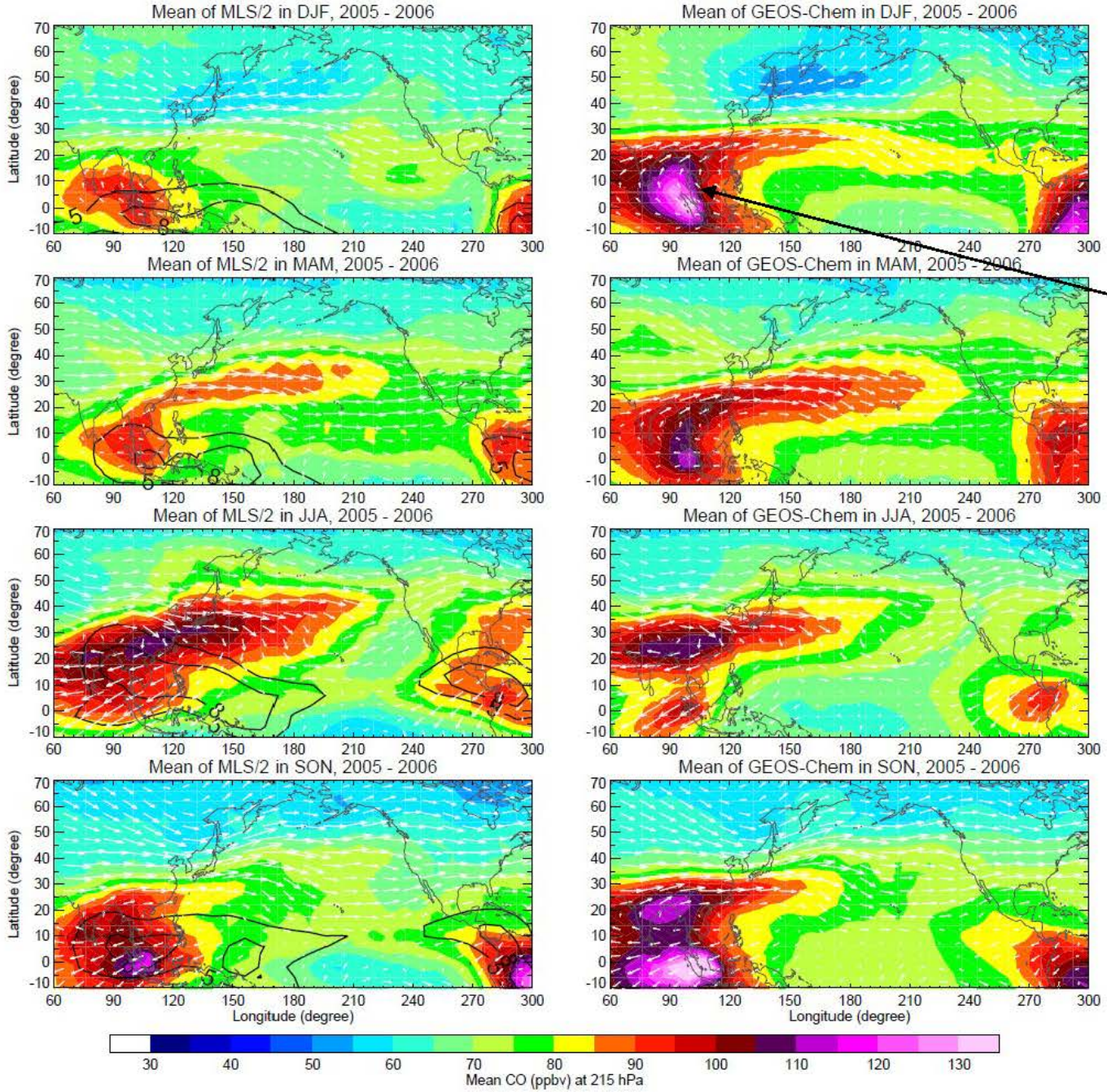
MLS/Aura (2005-2006) GEOS-Chem (2005-2006)

DJF

MAM

JJA

SON



> 40% larger.

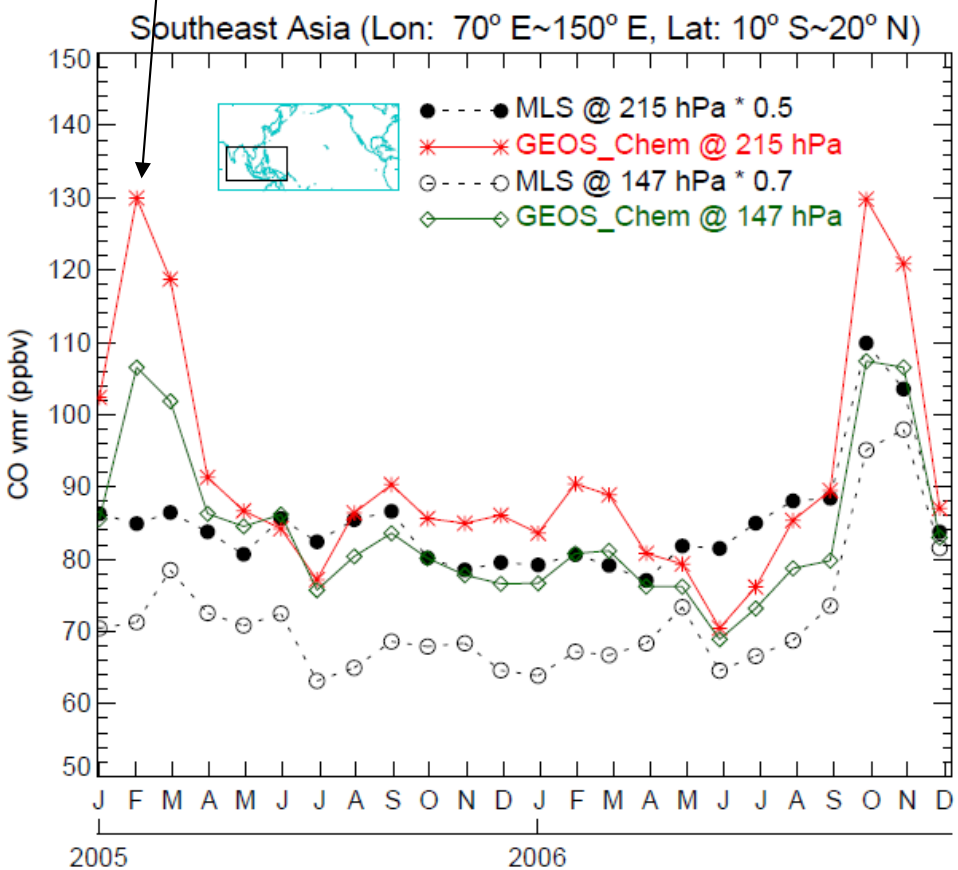
GEOS-5

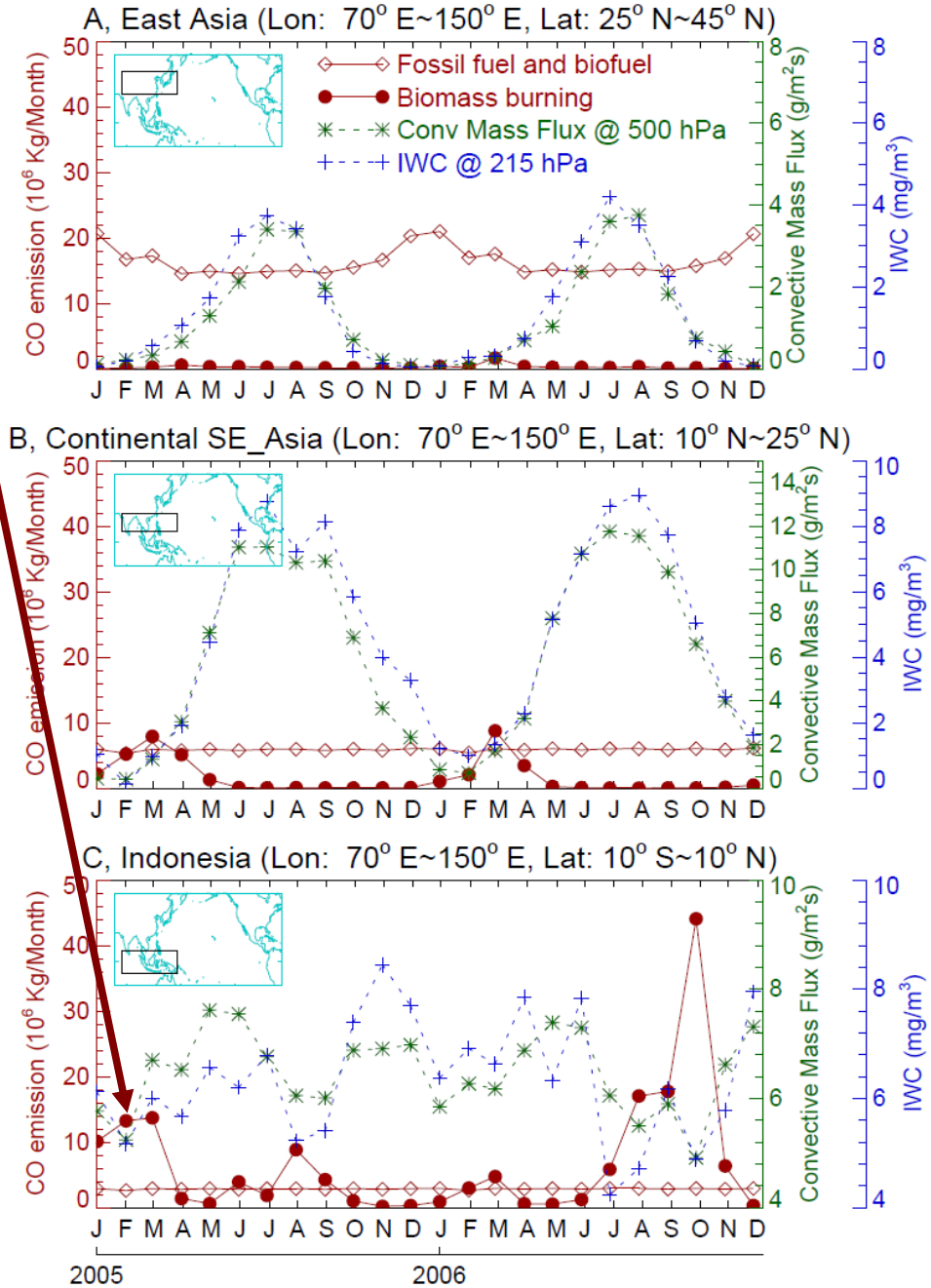
GEOS-chem v8-3-2

Large biomass burning emission (GFEDv2_8_day)

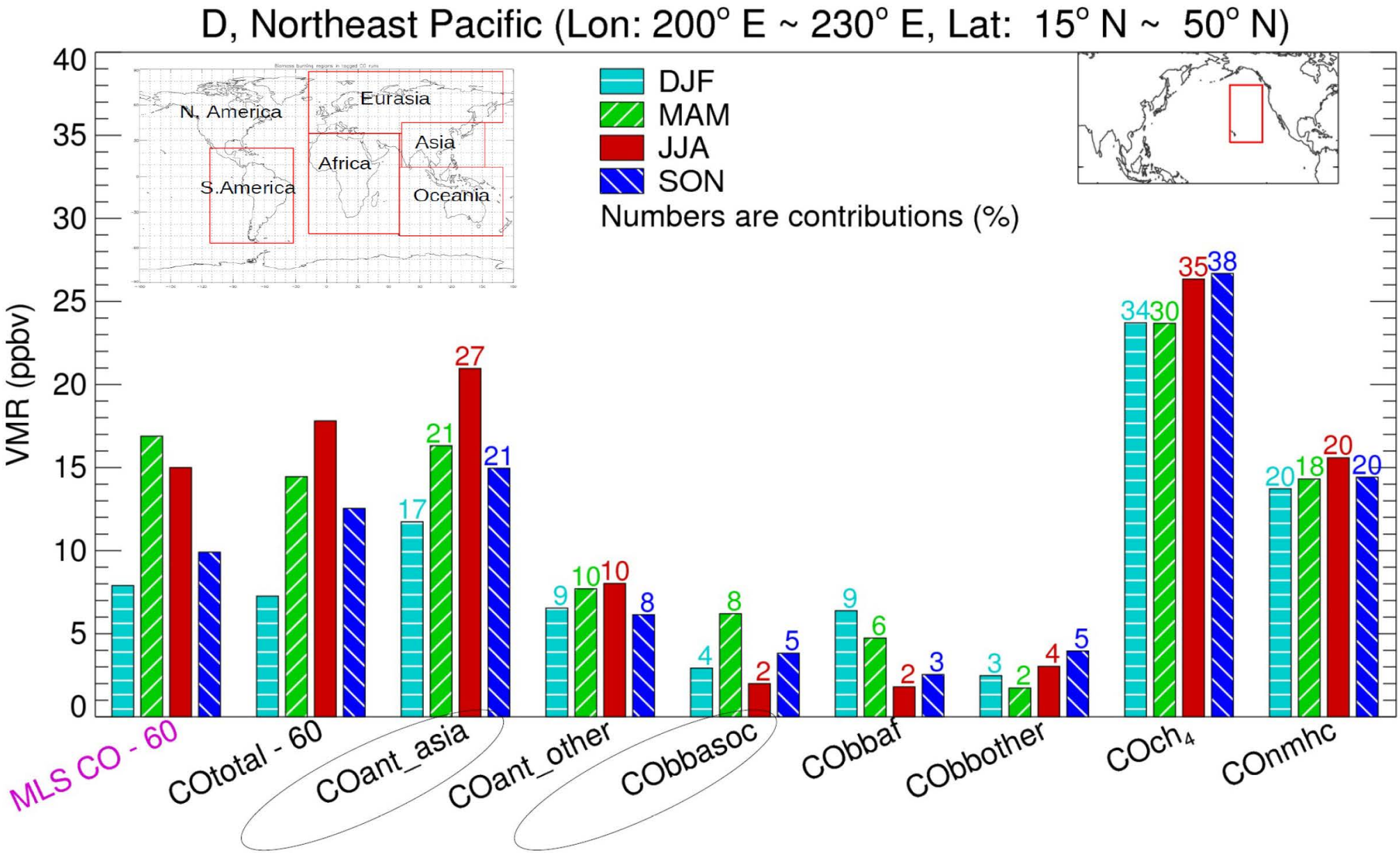
(GFEDv3 is smaller by ~30 % in Indonesia in early 2005)

Large CO simulation in early 2005





Sources of CO above the NE Pacific at 215 hPa, result from tagged CO run (2005-2006)



Effect of deep convection (GEOS-Chem results) at 215 hPa

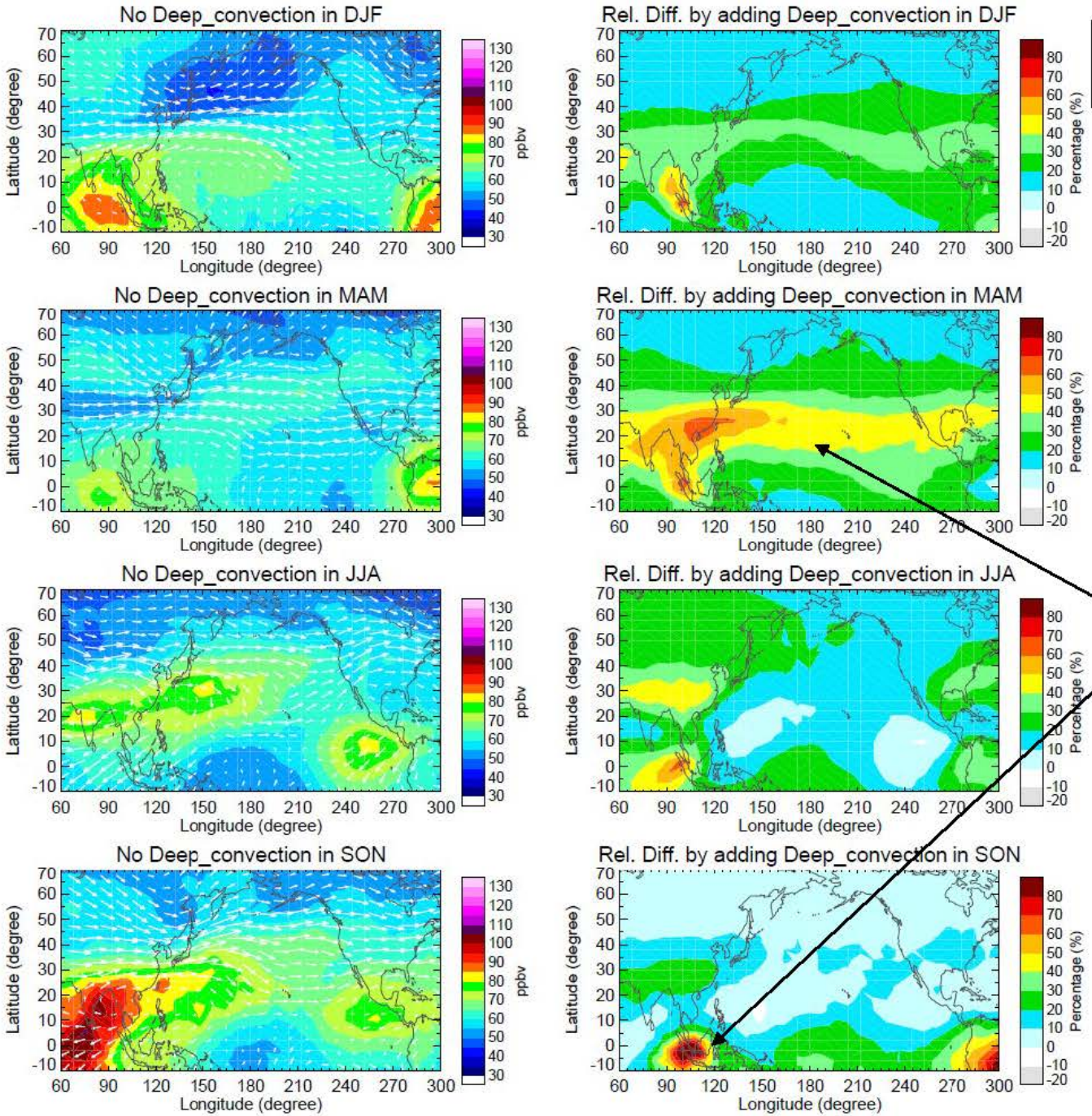
No deep Convection | Increase (%) by deep convection

DJF

MAM

JJA

SON

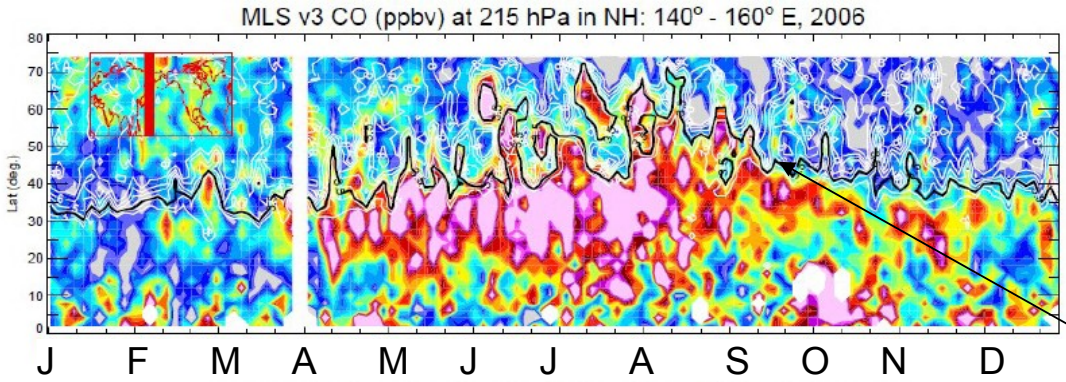


(Conservative estimates)

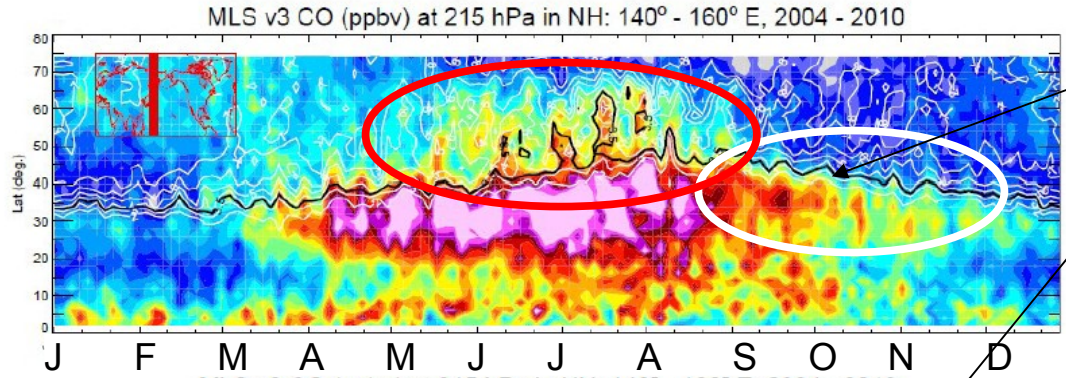
Large effect

MLS v3 CO at 215 hPa at ~150° E in NH

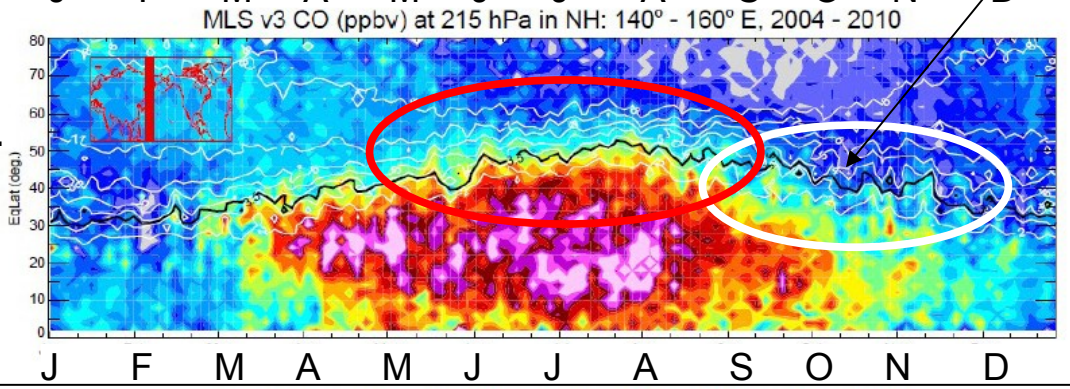
Lat. (0~90° N) 2006

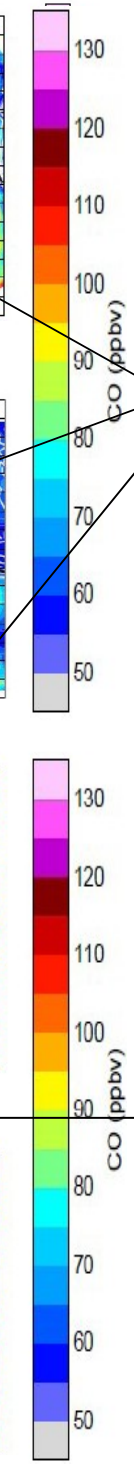


Lat. (0~90° N) 2004-2010



Equivalent Lat. (0~90° N) 2004-2010

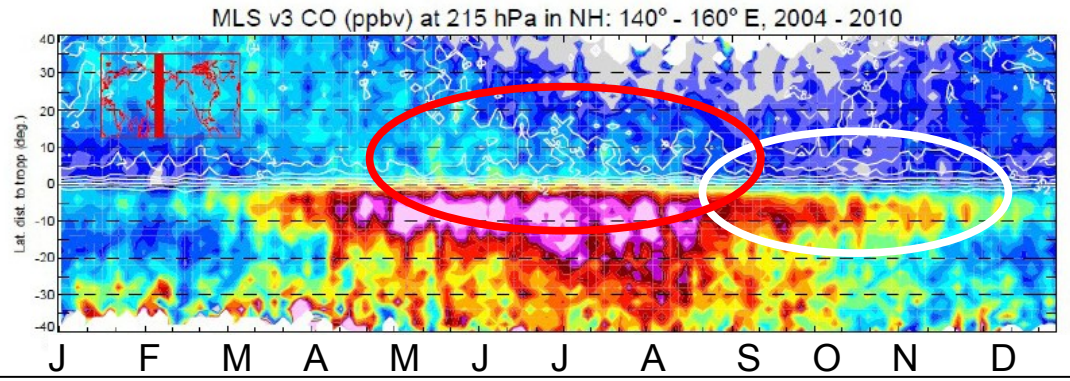




Black: 3.5 PVU tropopause

White, potential vorticity (PV) contours, which controls transport and is a dynamical tracer.

"Tropopause coordinate" (-40°~ 40°, Lat) 2004-2010



Tropopause => 0°, Lat

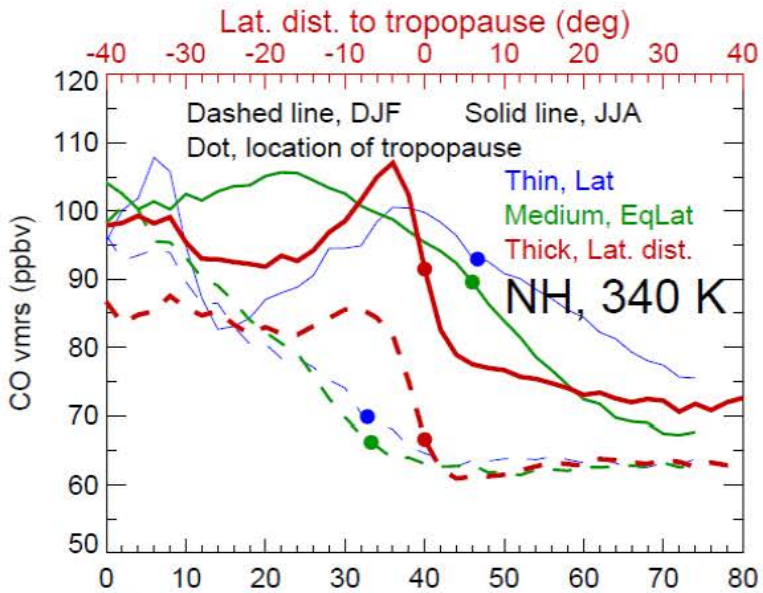
PV > 3.5 PVU => stratosphere (north side)

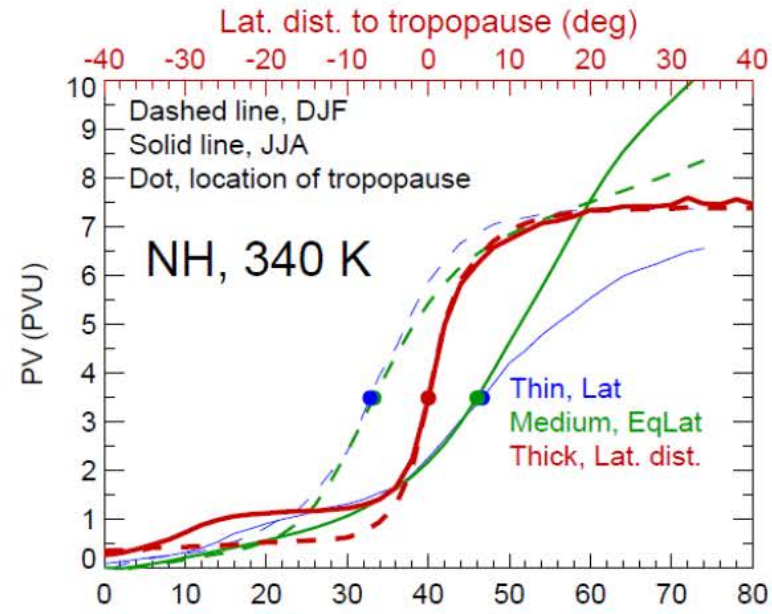
PV < 3.5 PVU, or Theta < 380 K (20° S – 20° N) => troposphere (south side)

Dashed lines: DJF solid lines: JJA

Red, results in "tropopause coordinates"

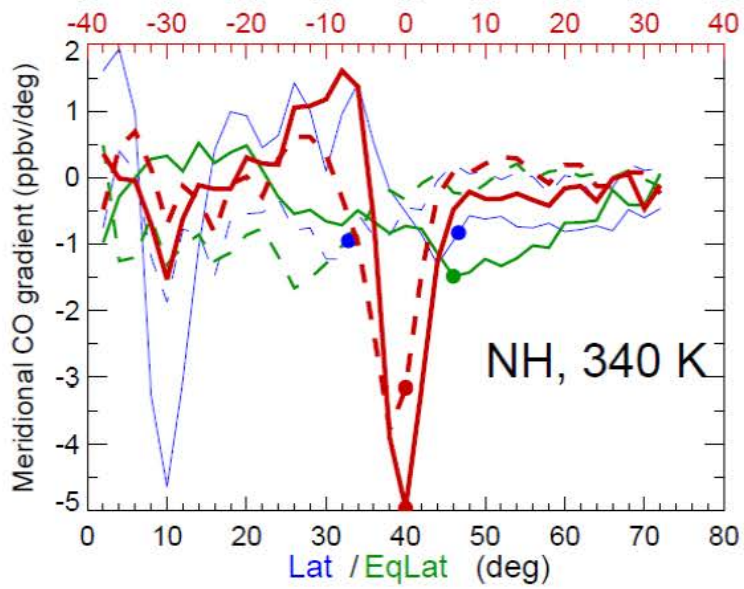
N.H. zonal mean CO

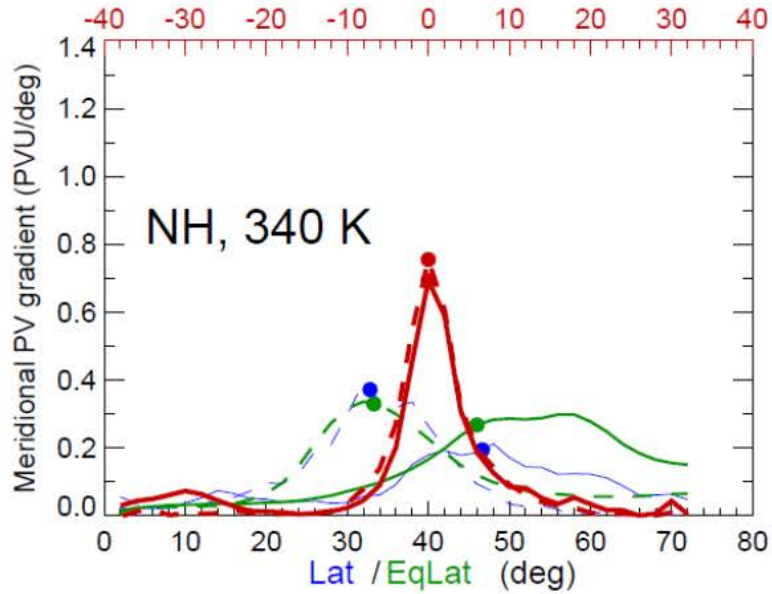




N.H. zonal mean Potential Vorticity (PV)

CO meridional gradients





PV meridional gradient

Acknowledgments

- GEOS-Chem development and support team.
- NASA

Summary

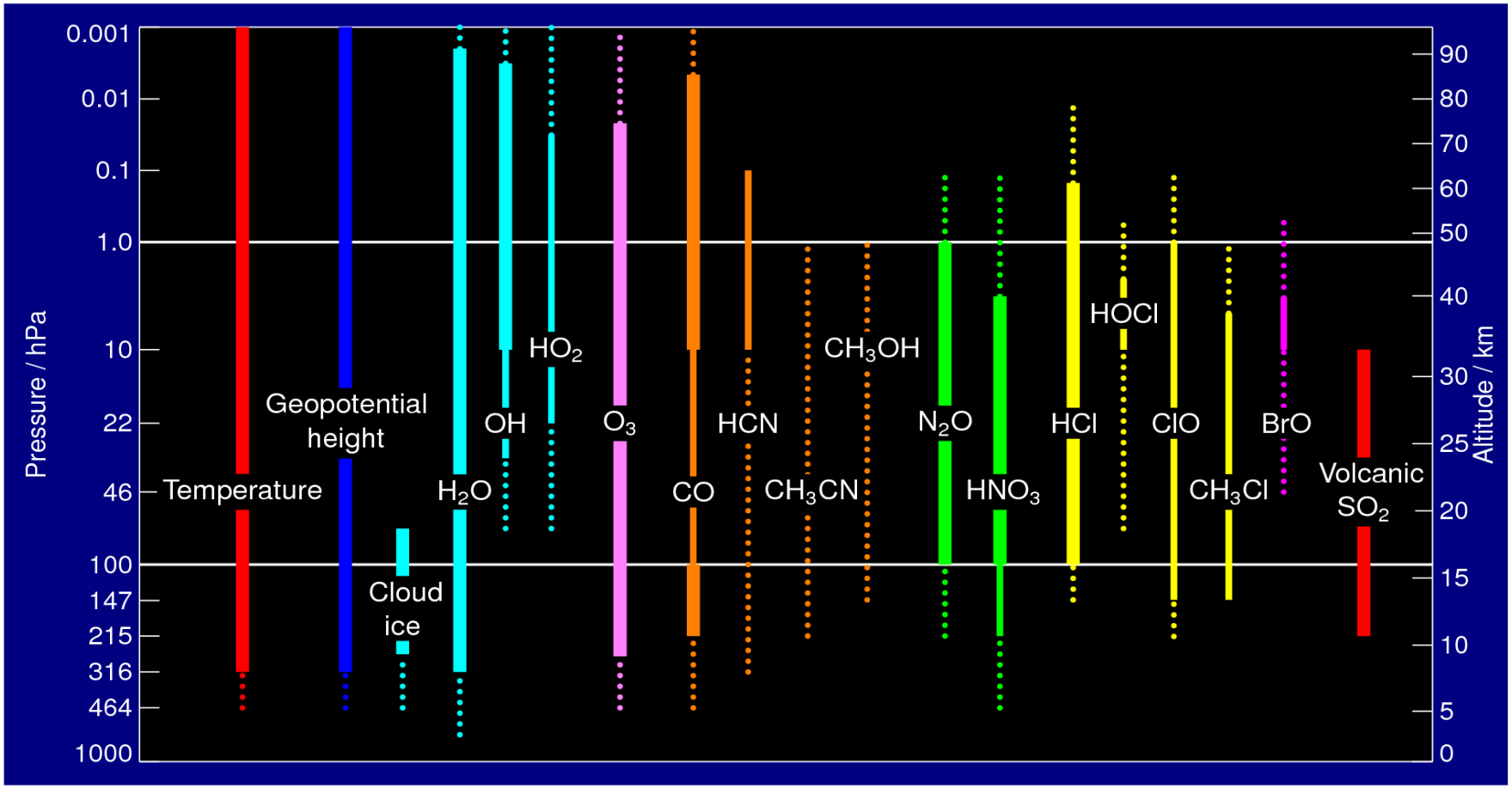
- MLS show largest CO in the upper troposphere (UT) above the Northeast Pacific in May-June.
- GEOS-Chem generally has good agreement with MLS observations, over-estimates UT CO vmr above SEA in early 2005 (using GFED v2_8day).
- Asian anthropogenic emission is the largest source of CO in the UT above the North Pacific in all seasons.
- Deep convection has the largest impact on CO in UT in spring.
- Air pollutants transported into stratosphere? No indication of strong seasonal variation in the 'permeability' of the tropopause, shown by CO and PV in “tropopause coordinates”.

Thank you!

Backup plots

Microwave Limb Sounder (MLS)

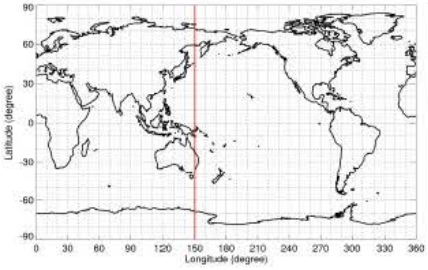
- On Aura satellite, launched in August 2004.
- Measures thermal emission of the atmosphere (118 GHz, 190 GHz, 240 GHz, 640 GHz, and 2.5 THz).
- CO (version 2) is used in this study. It has a factor of ~2 of bias at 215 hPa.

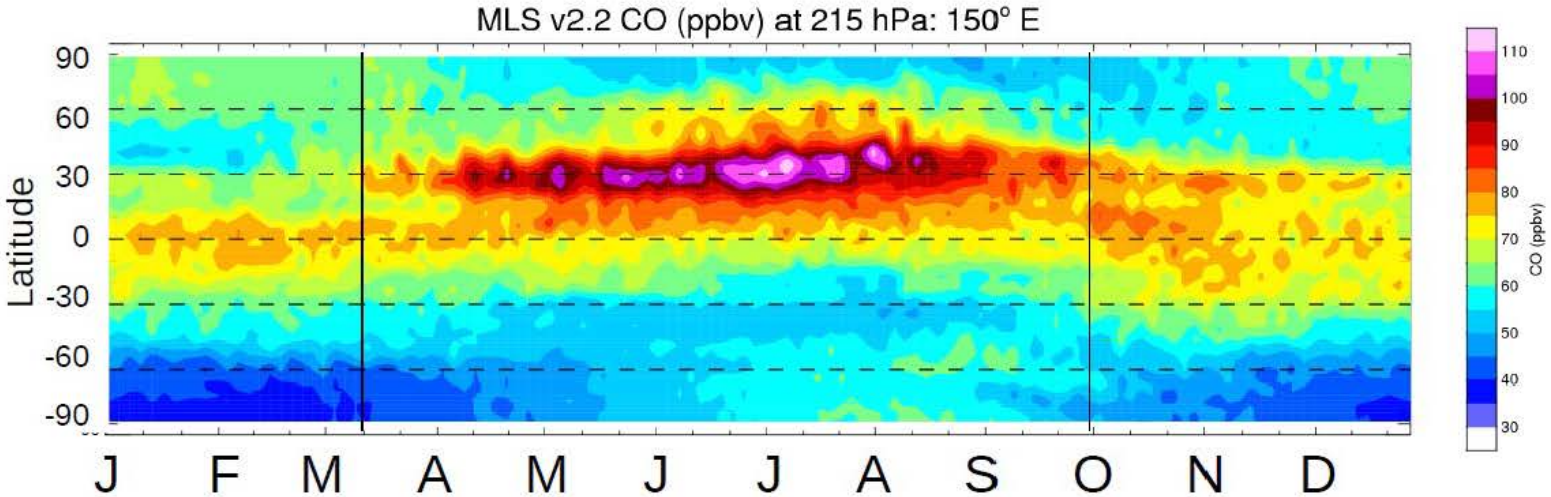


MLS v2 CO (vmr, divided by 2) time-latitude cross-sections at 215 hPa between 2004 – 2010

West Pacific

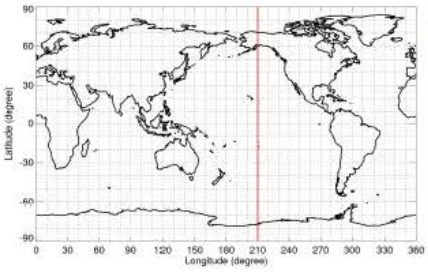
(150° E)

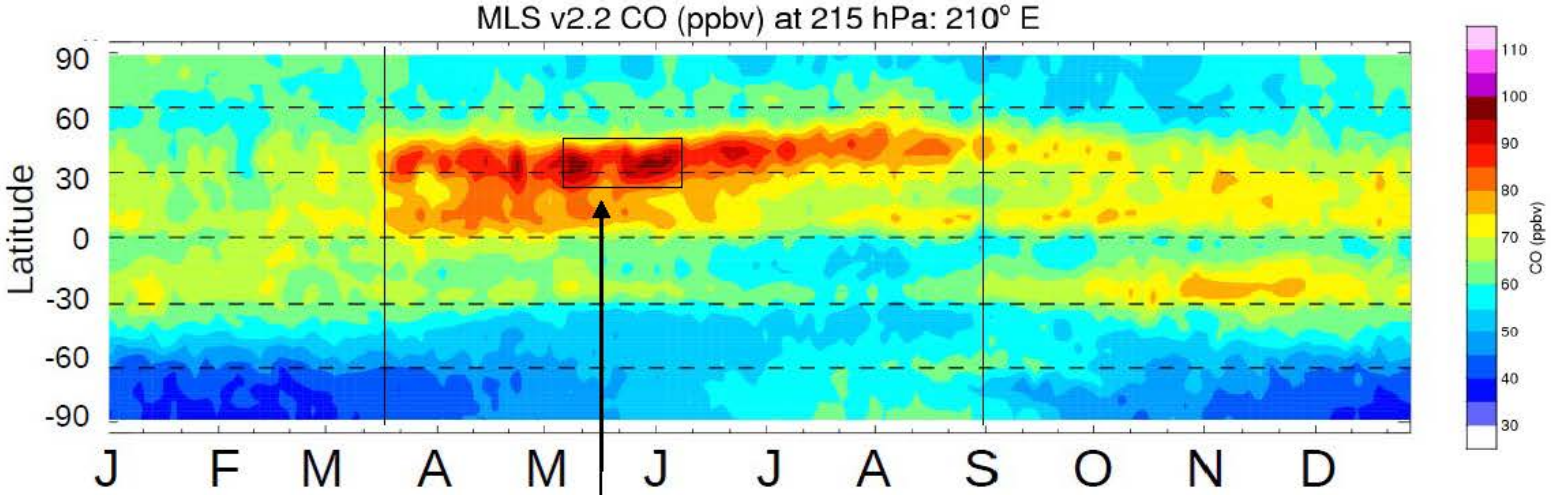




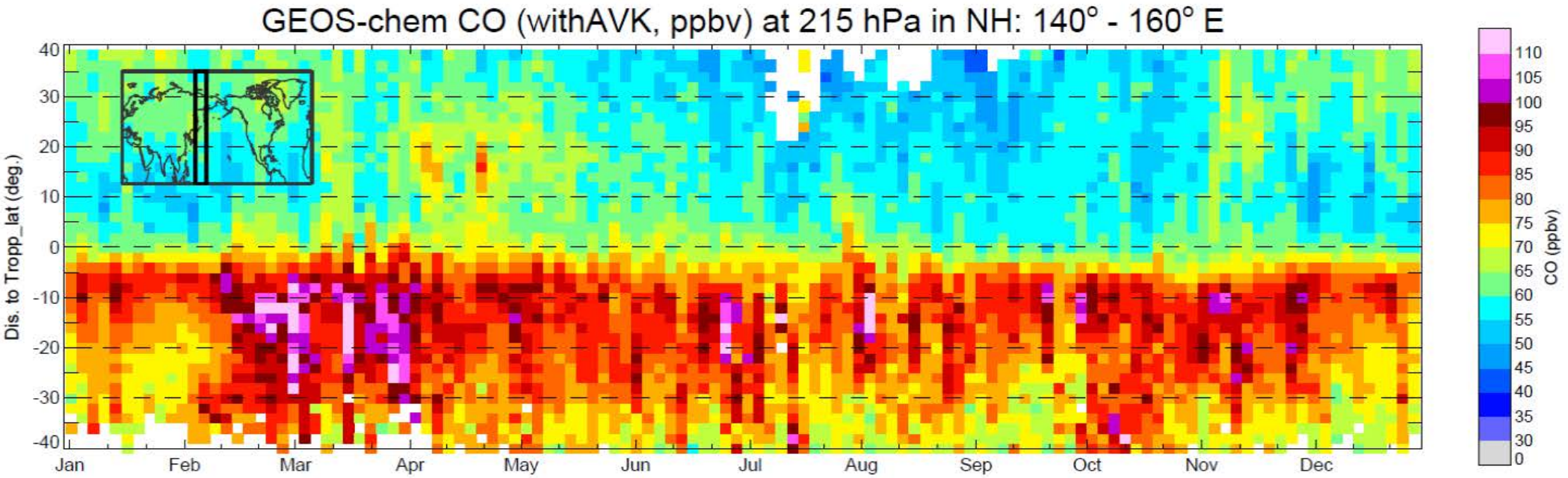
East Pacific

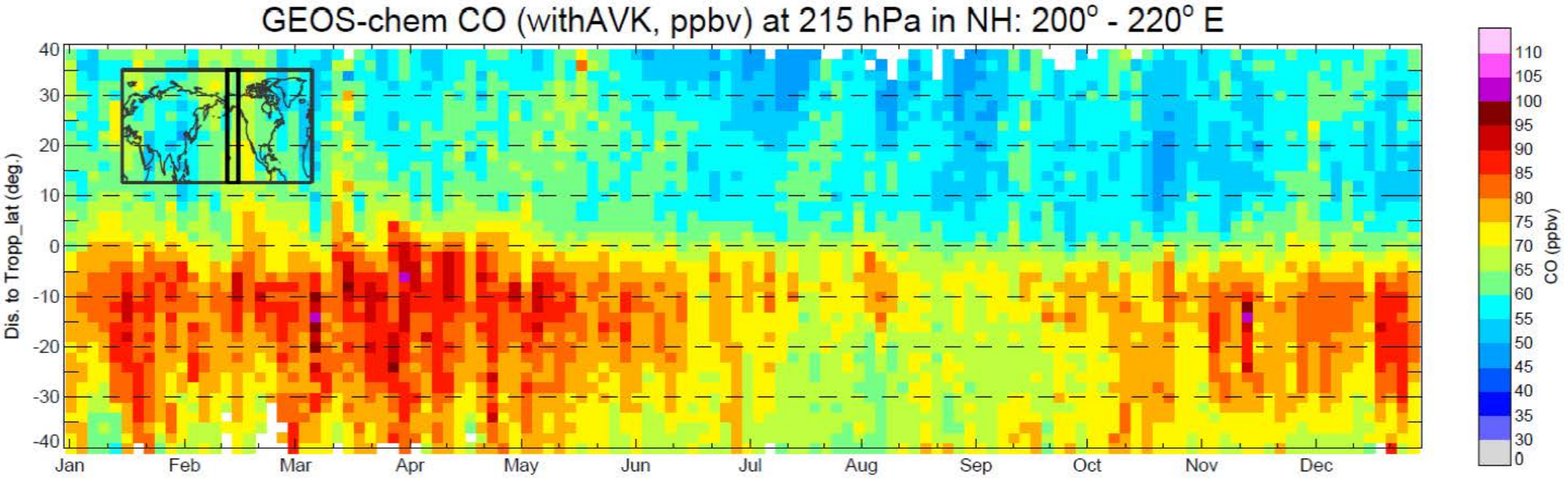
(210° E)



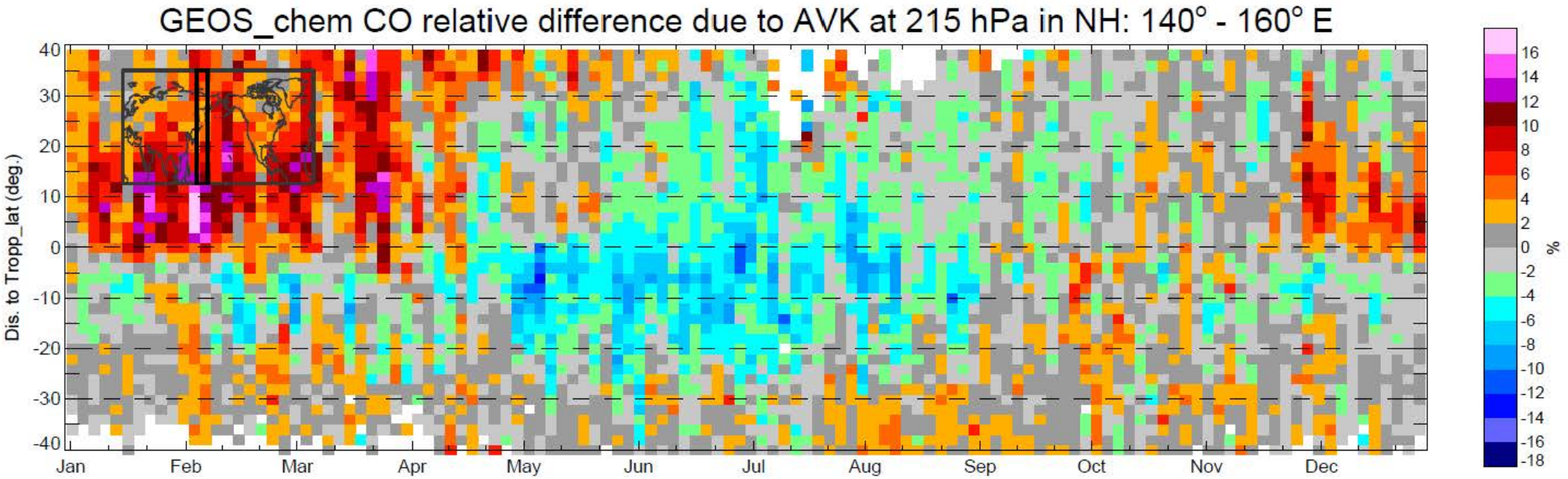


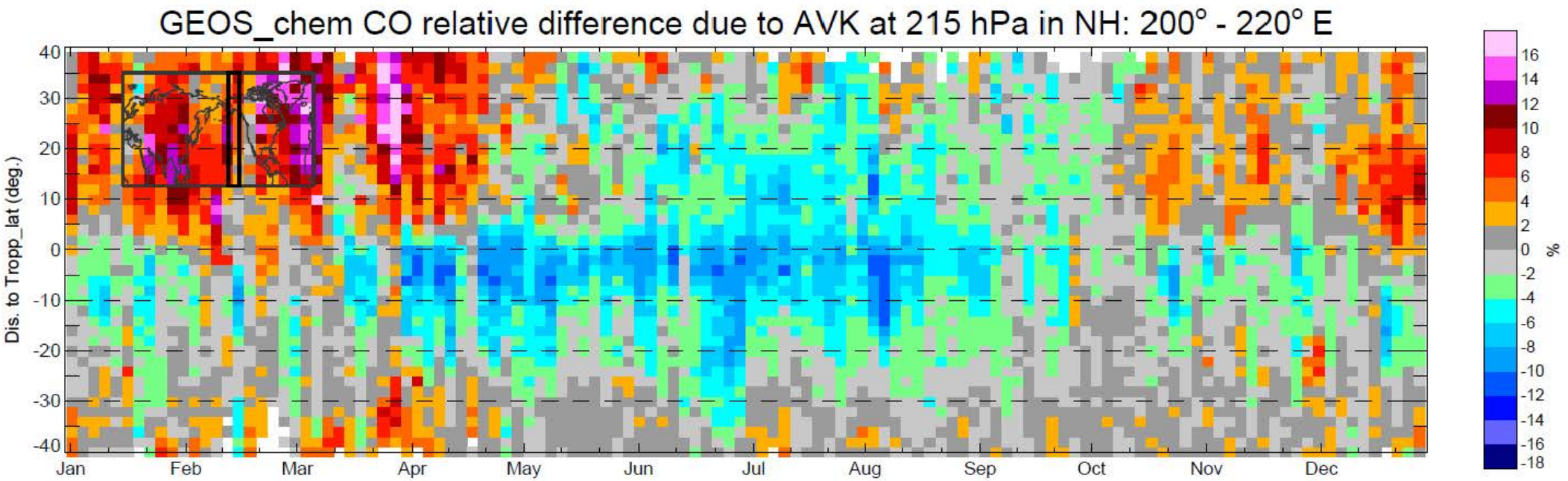
Largest CO vmr above the northeast Pacific in May - June.


GEOS-chem CO (withAVK, ppbv) at 215 hPa in NH: 140° - 160° E
Dis. to Tropp_lat (deg.)
40
30
20
10
0
-10
-20
-30
-40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
CO (ppbv)
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
0


GEOS-chem CO (withAVK, ppbv) at 215 hPa in NH: 200° - 220° E
Dis. to Tropp_lat (deg.)
40
30
20
10
0
-10
-20
-30
-40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
CO (ppbv)
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
0

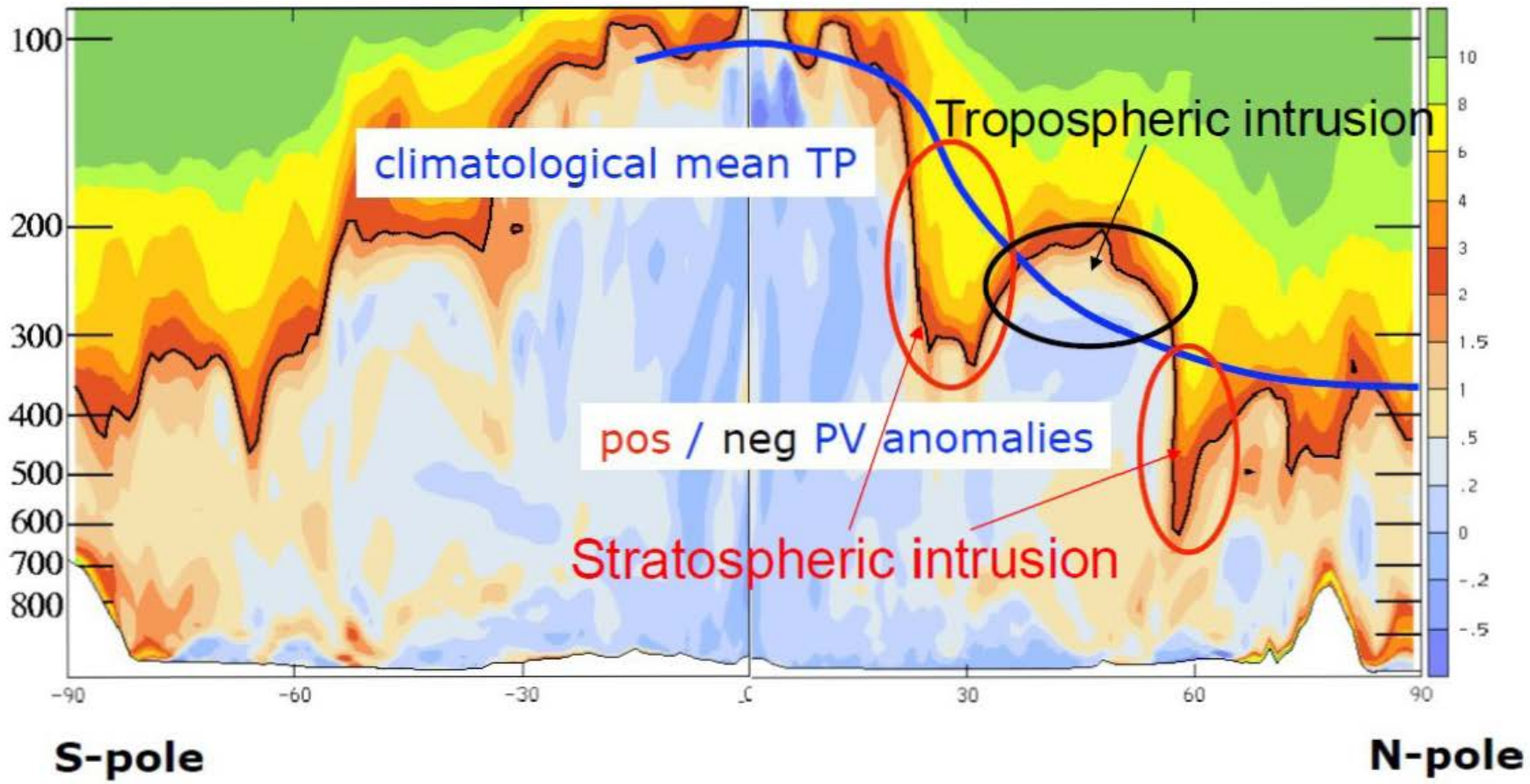
Relative difference (%) due to average kernel (MLS v2)





Introduction: PV and tropopause

Snapshot of the 2-pvu tropopause

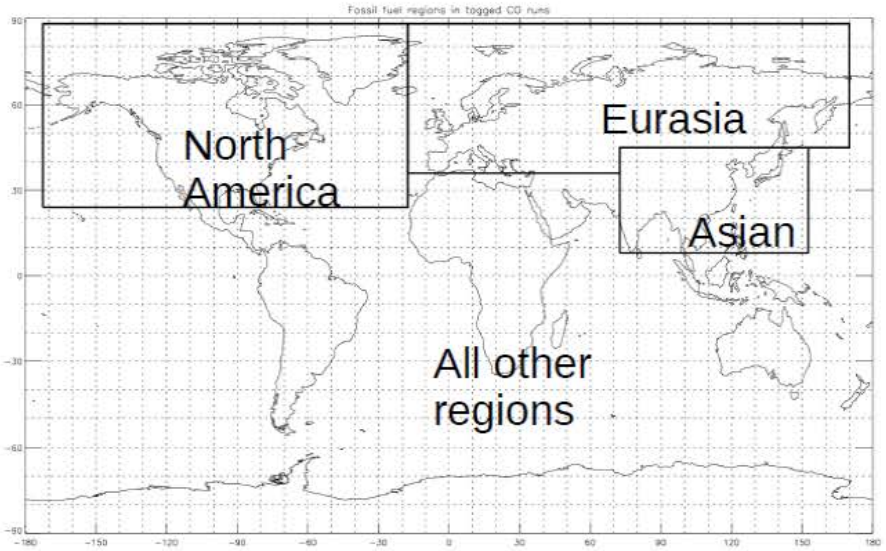


(Courtesy of Heini Wernli, ETH, 2005)

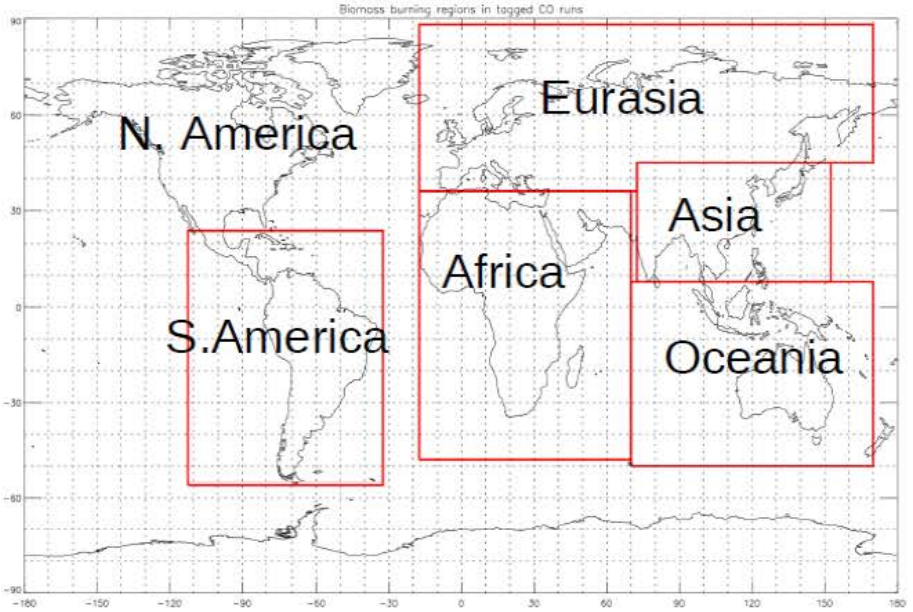
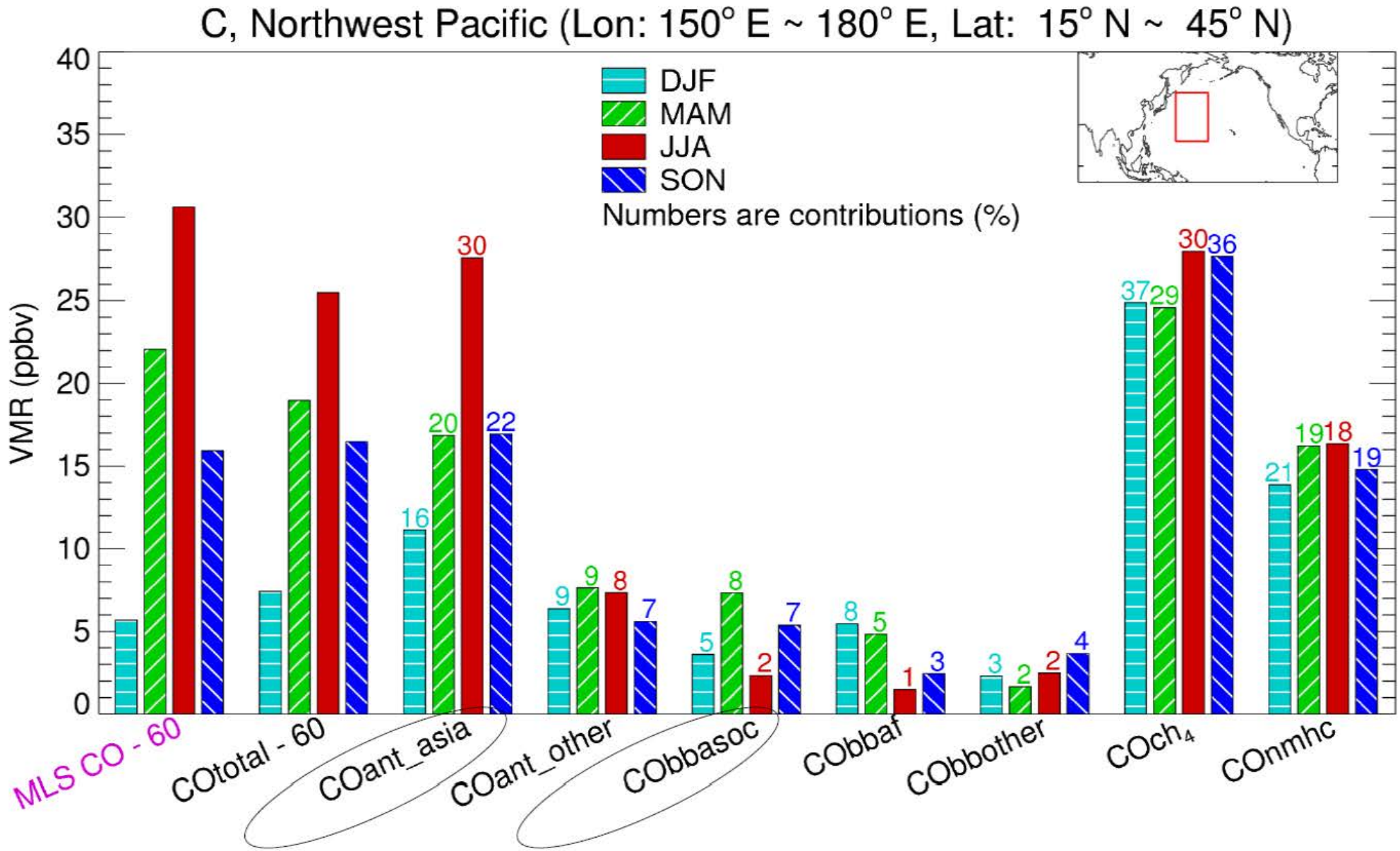
Tagged CO simulations

- Simulations for January 1, 2005 – December 31, 2006.
- Using prescribed OH, produced from previous run.
- Regional sources + CH_4 + non-methane hydrocarbons

Fossil fuel



Biomass burning



CO at 215 hPa over the northwest Pacific (2005-2006)