High altitude smoke in the NASA GISS GCM

Robert Field

Field, R.D., M. Luo, M. Fromm, A. Voulgarakis, S. Mangeon, J. Worden, Simulating the Black Saturday 2009 smoke plume with an interactive composition-climate model: sensitivity to emissions amount, timing and injection height, submitted.

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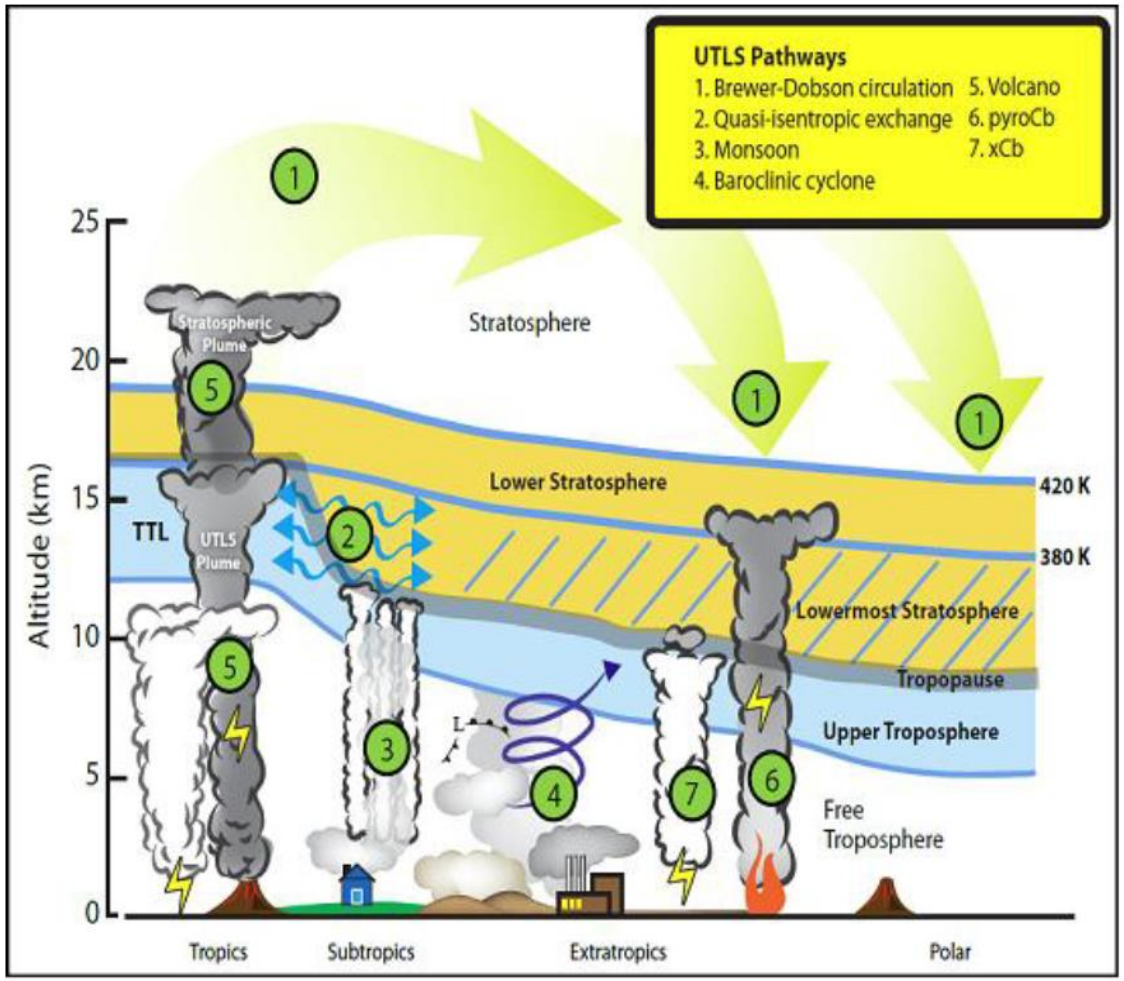
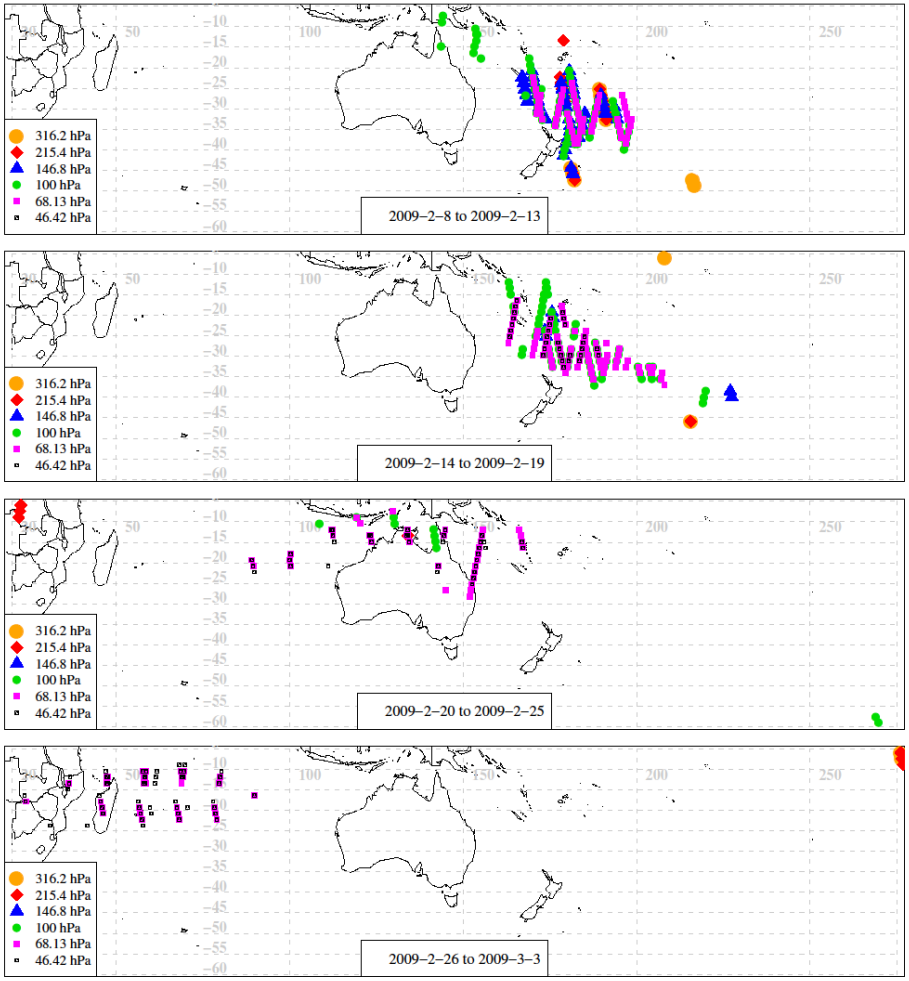
High altitude smoke-plumes from explosive fires were discovered in the late 1990s



(Mike Fromm, NRL)

Black Saturday, 7 February 2009

CO from Aura MLS



Pumphrey et al. (2011, ACP)

Also

Aura TES & MLS
(Luo et al., 2013)

OSIRIS
(Siddaway and Petelina, 2011)

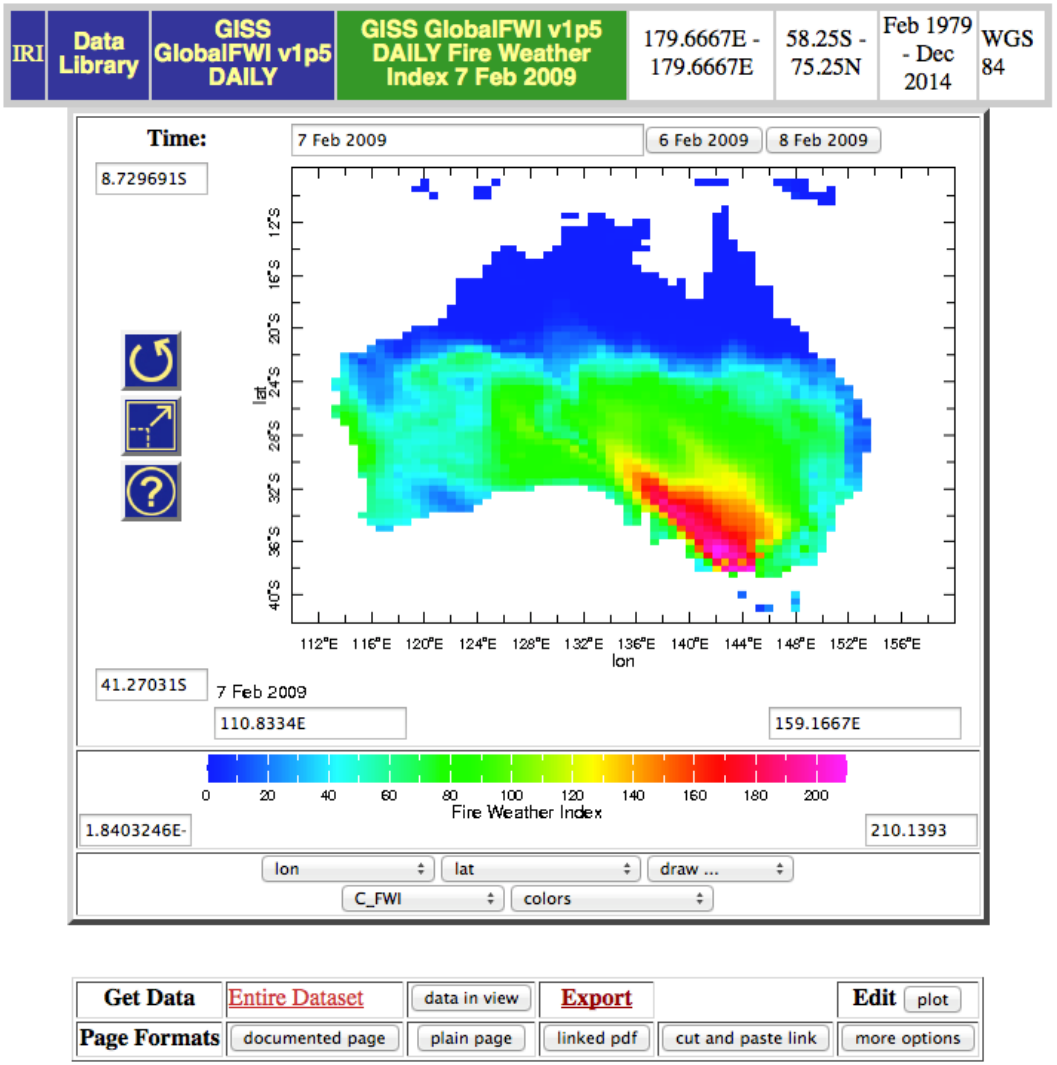
OMI AAI, AIRS CO, MODIS AOD, CALIPSO
(de Laat et al., 2012)

MIPAS Cloud & aerosol top heights
(Sembhi et al., 2012)

MIPAS C_2H_2, HCN, HCOOH
(Glatthor et al., 2013)

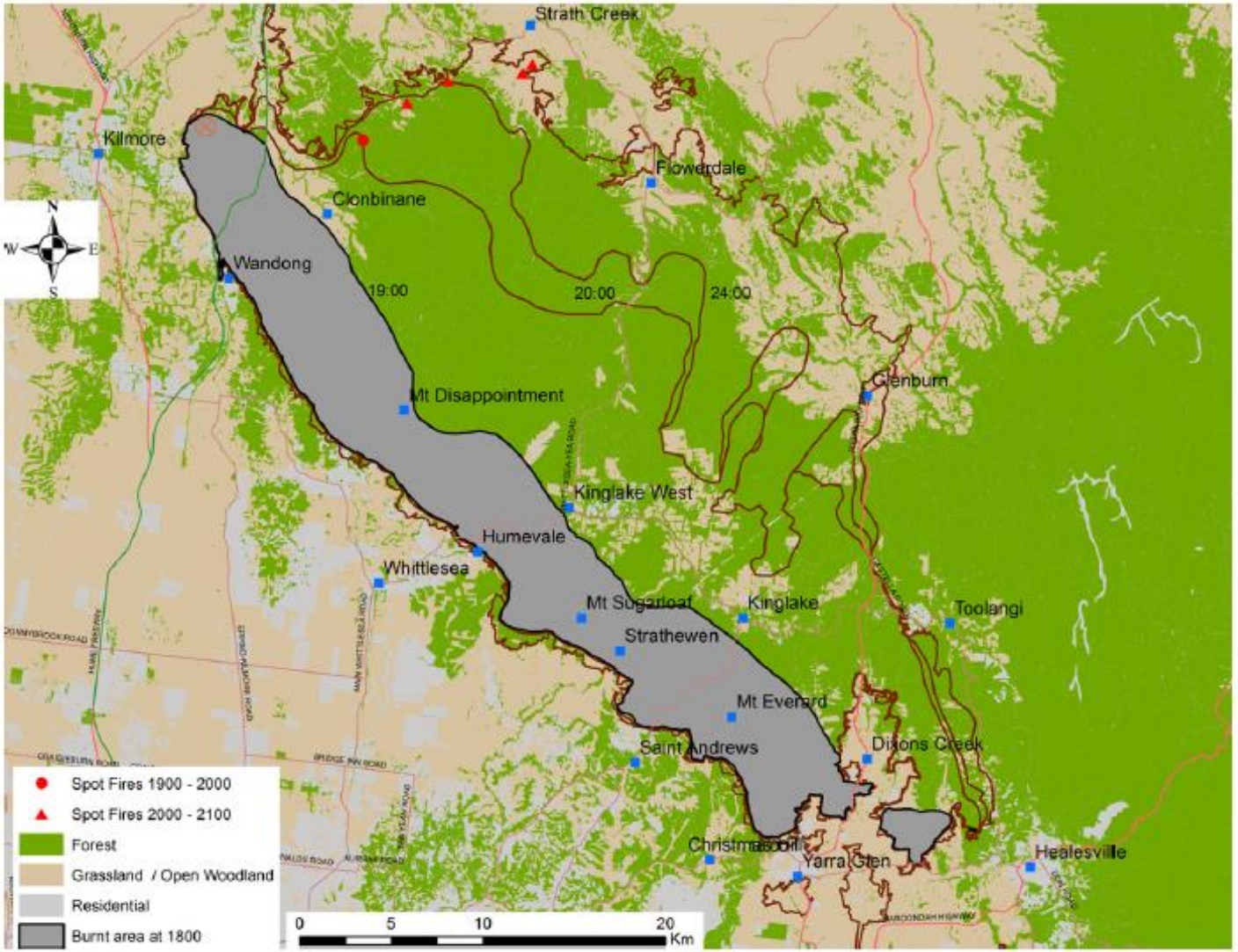
CALIOP
(Vernier et al., 2011)

February 7 Fire Weather Index



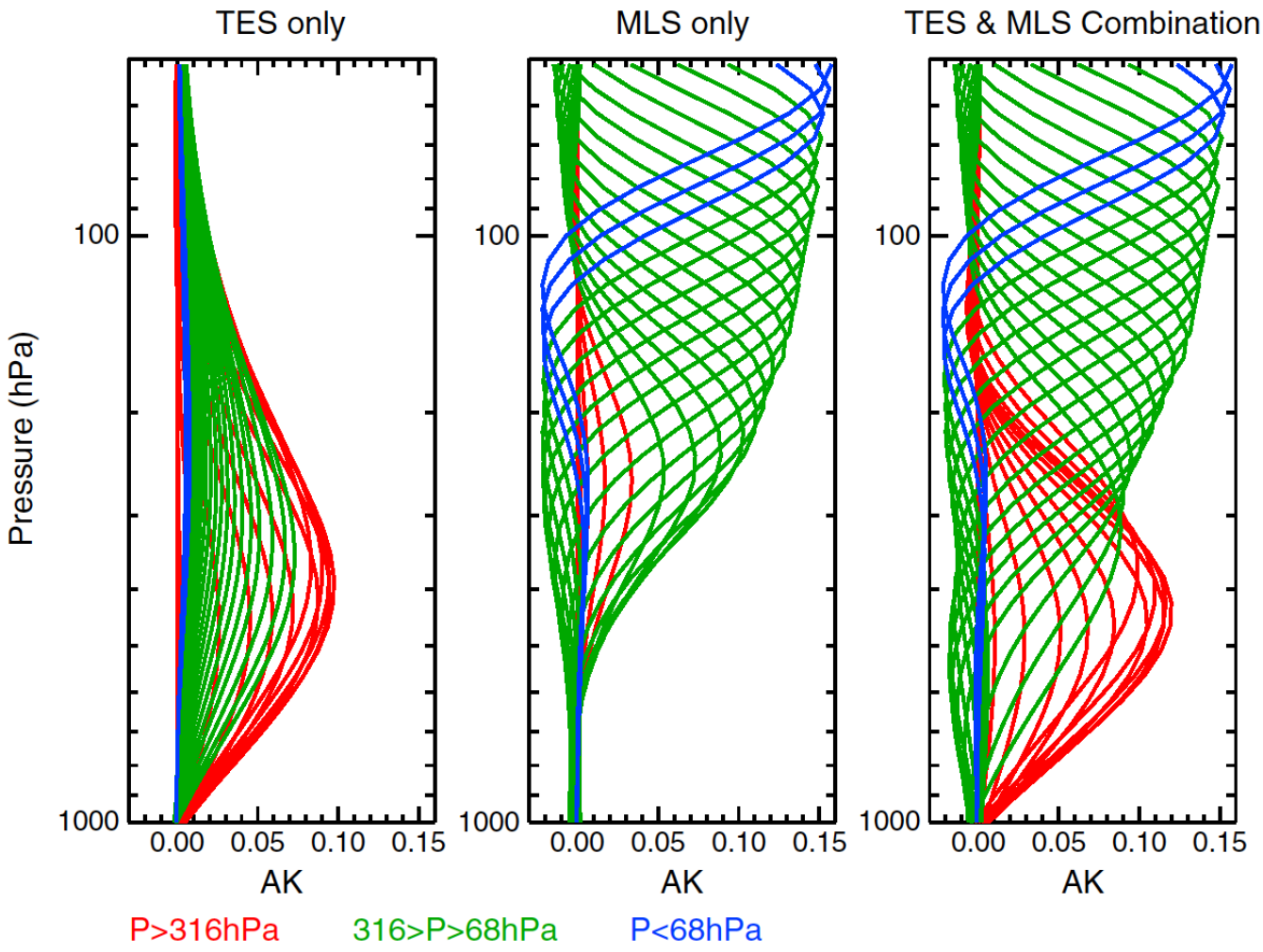
Kilmore East Fire

Photo: Melbourne Herald Sun



Cruz et al. (2011, *For. Ecol. Mgmt.*)

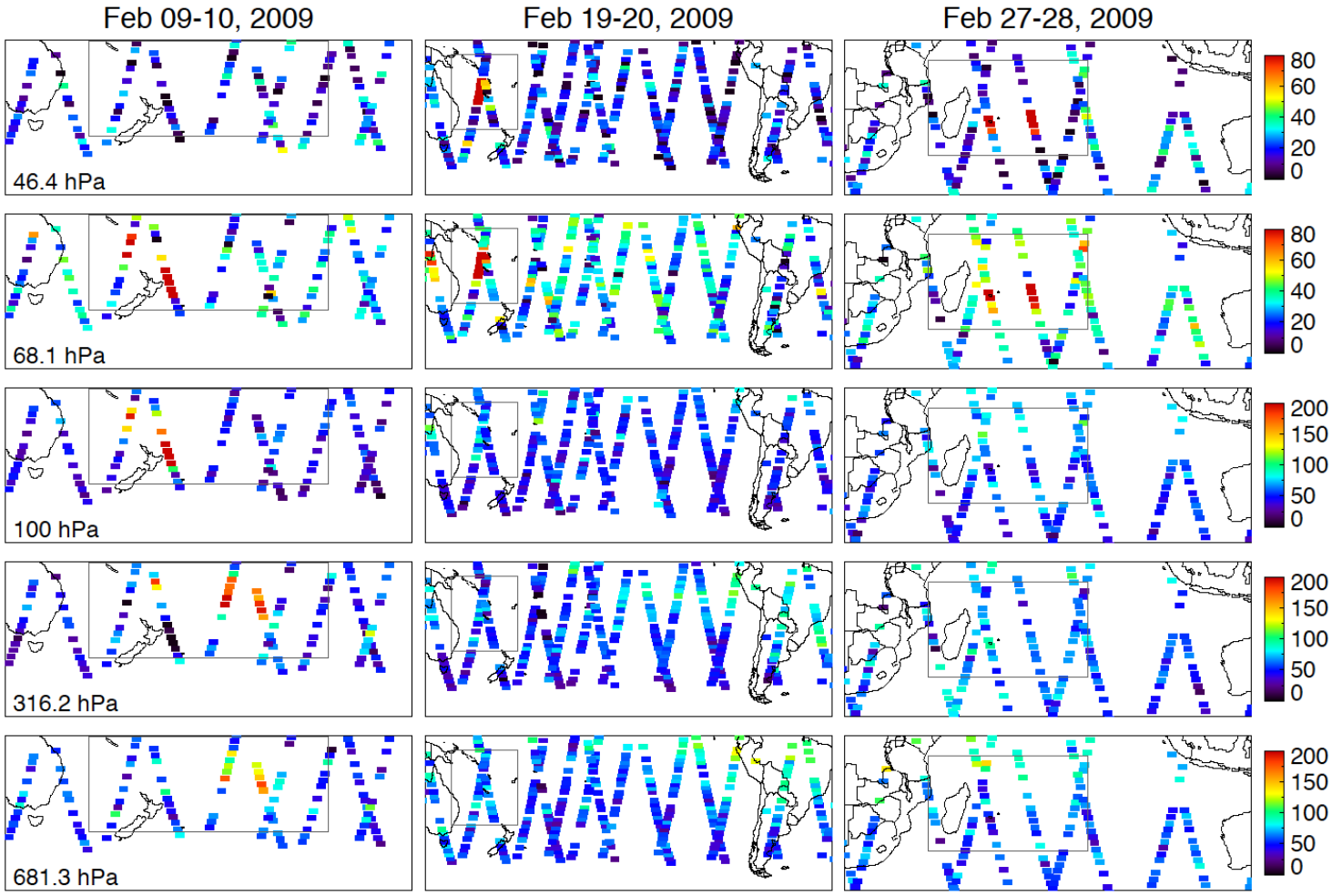
Jointly retrieved CO from Aura TES & MLS



Luo et al. (2013, *JGR*)

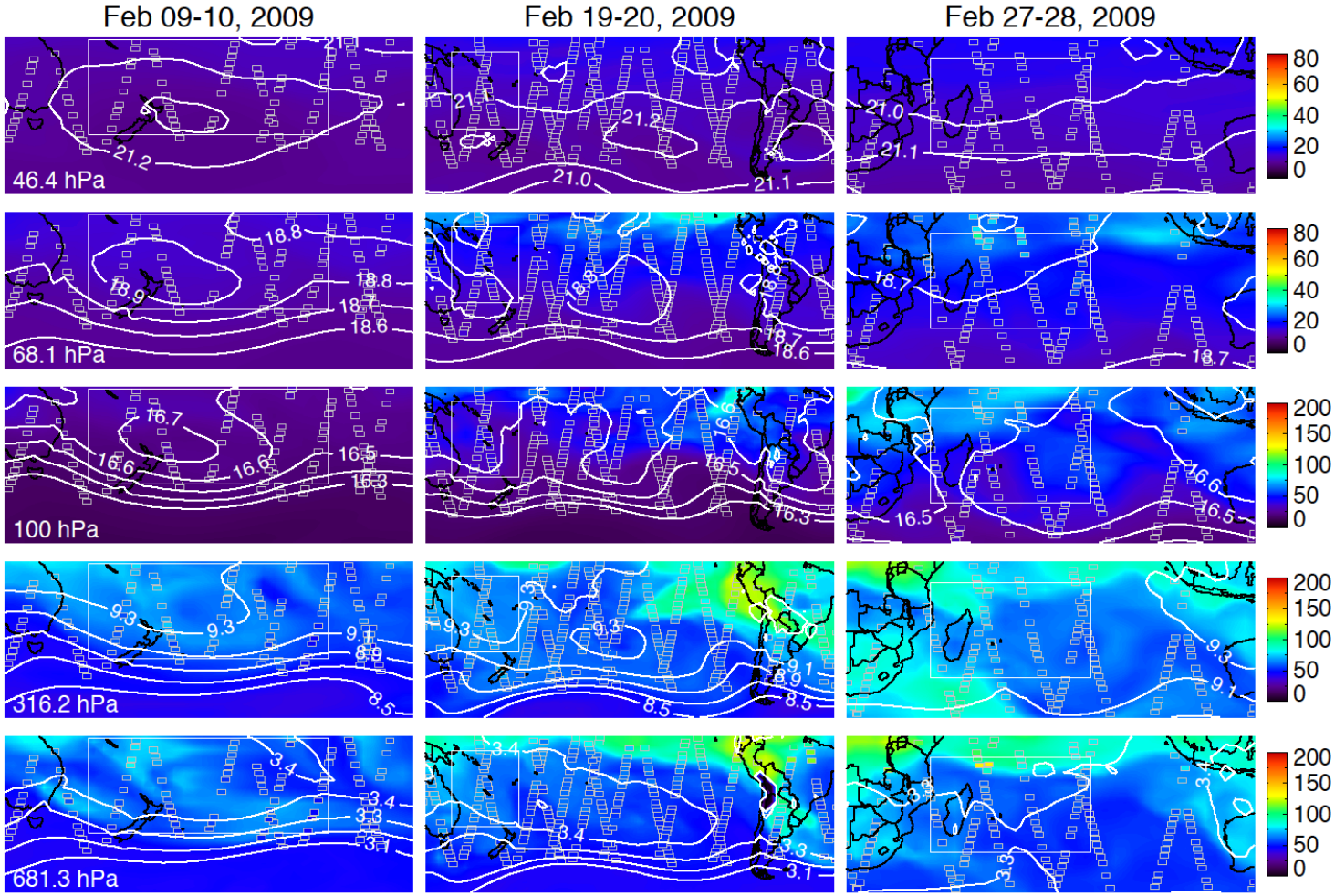
Aura TES / MLS

CO (ppbv)

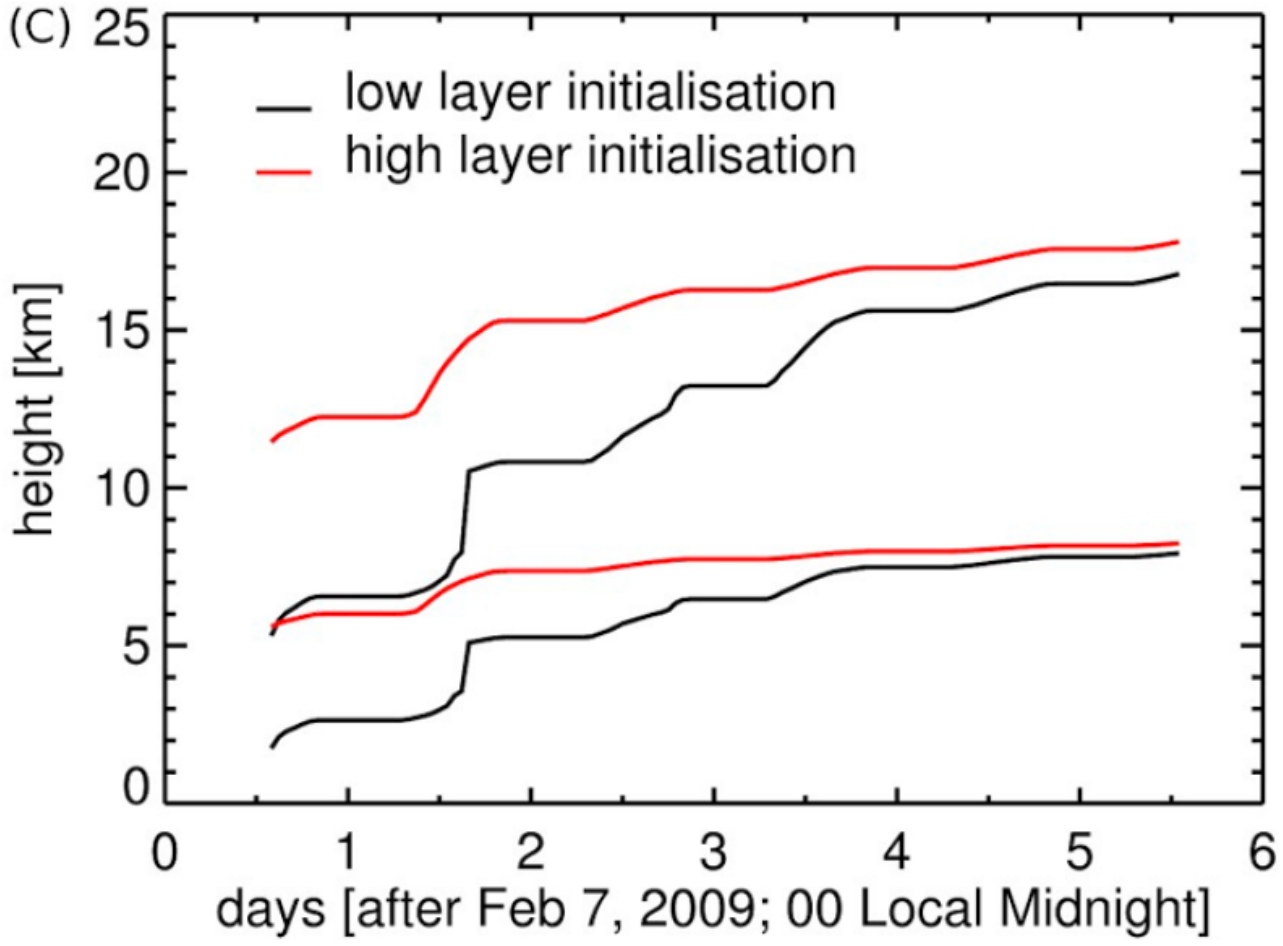


CTRL (no fire)

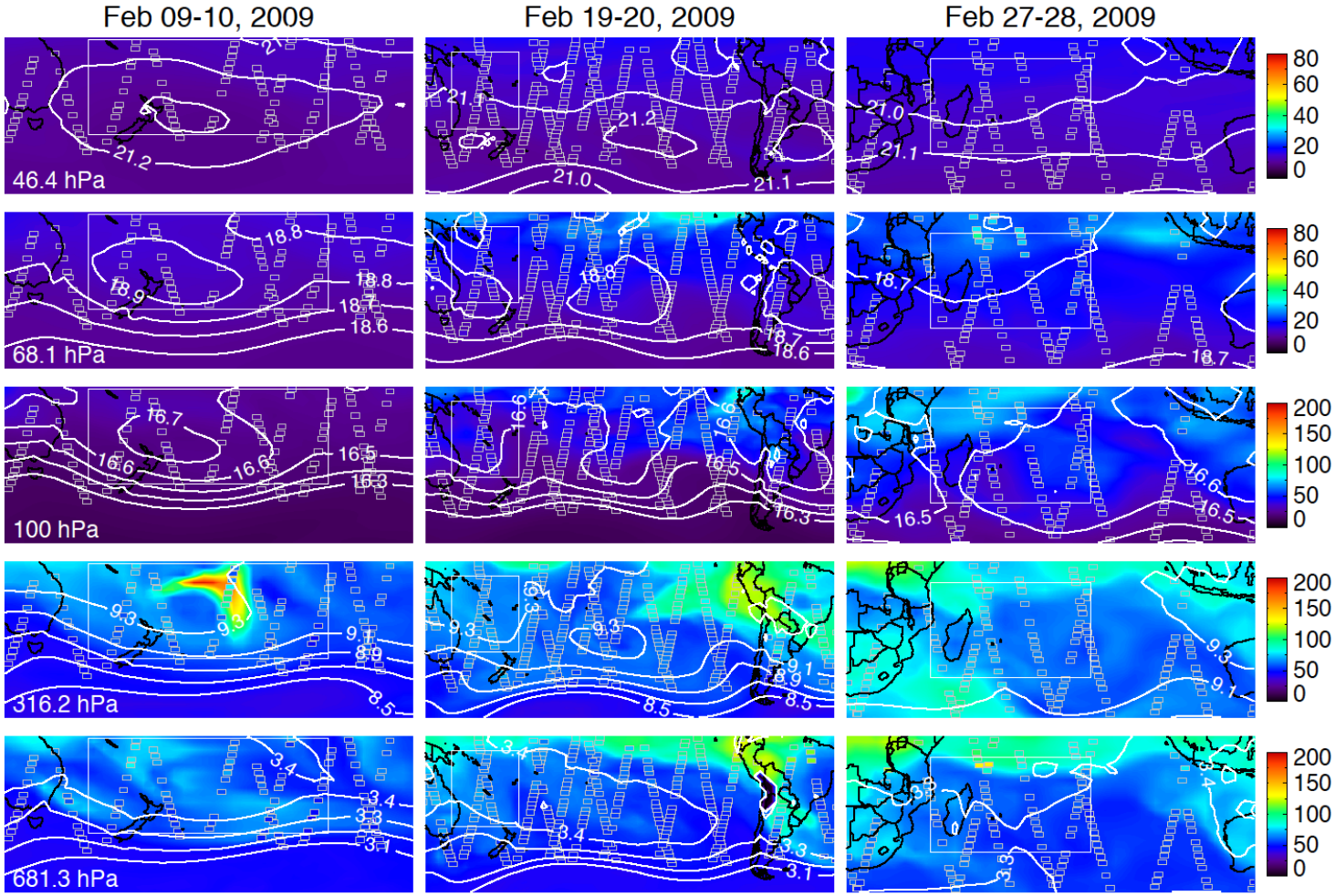
CO (ppbv)

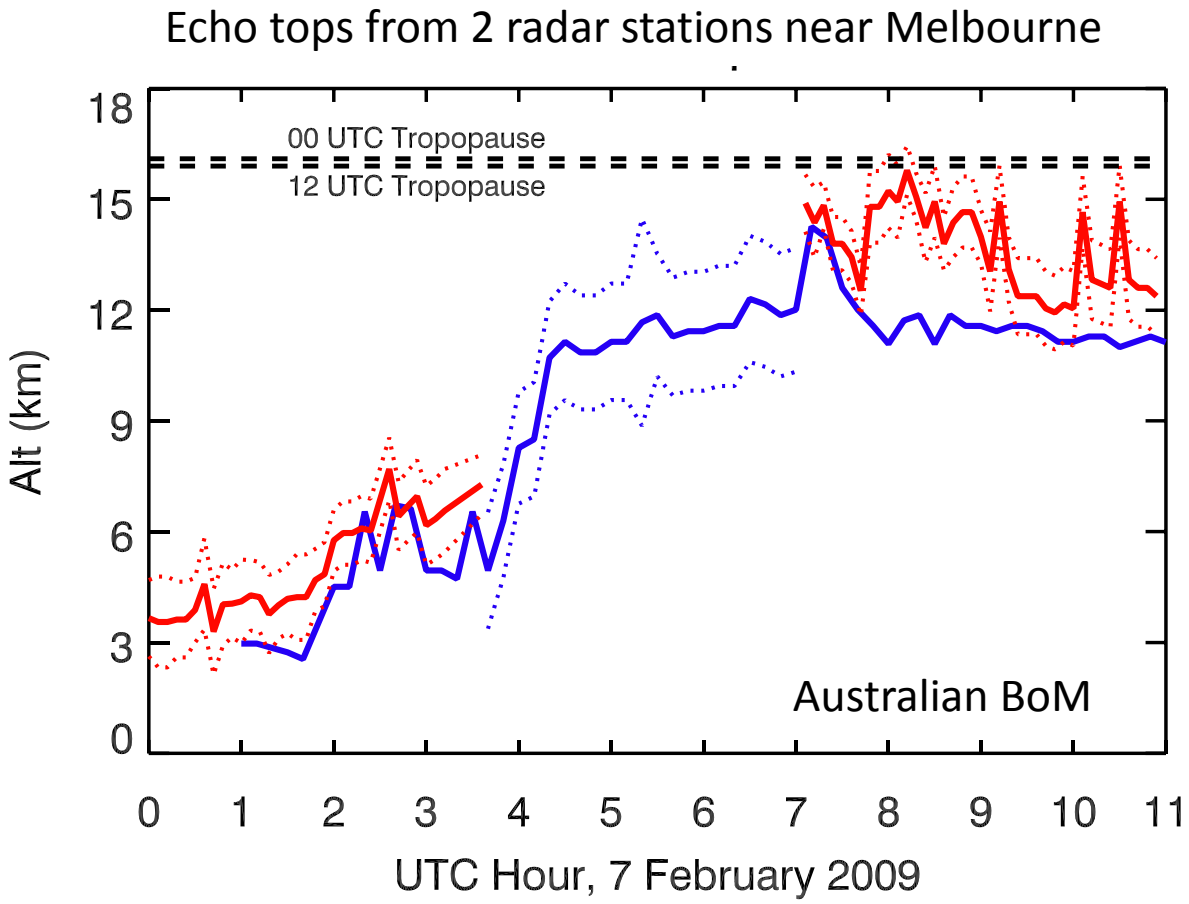


Injection heights for idealized model from de Laat et al. (2012)

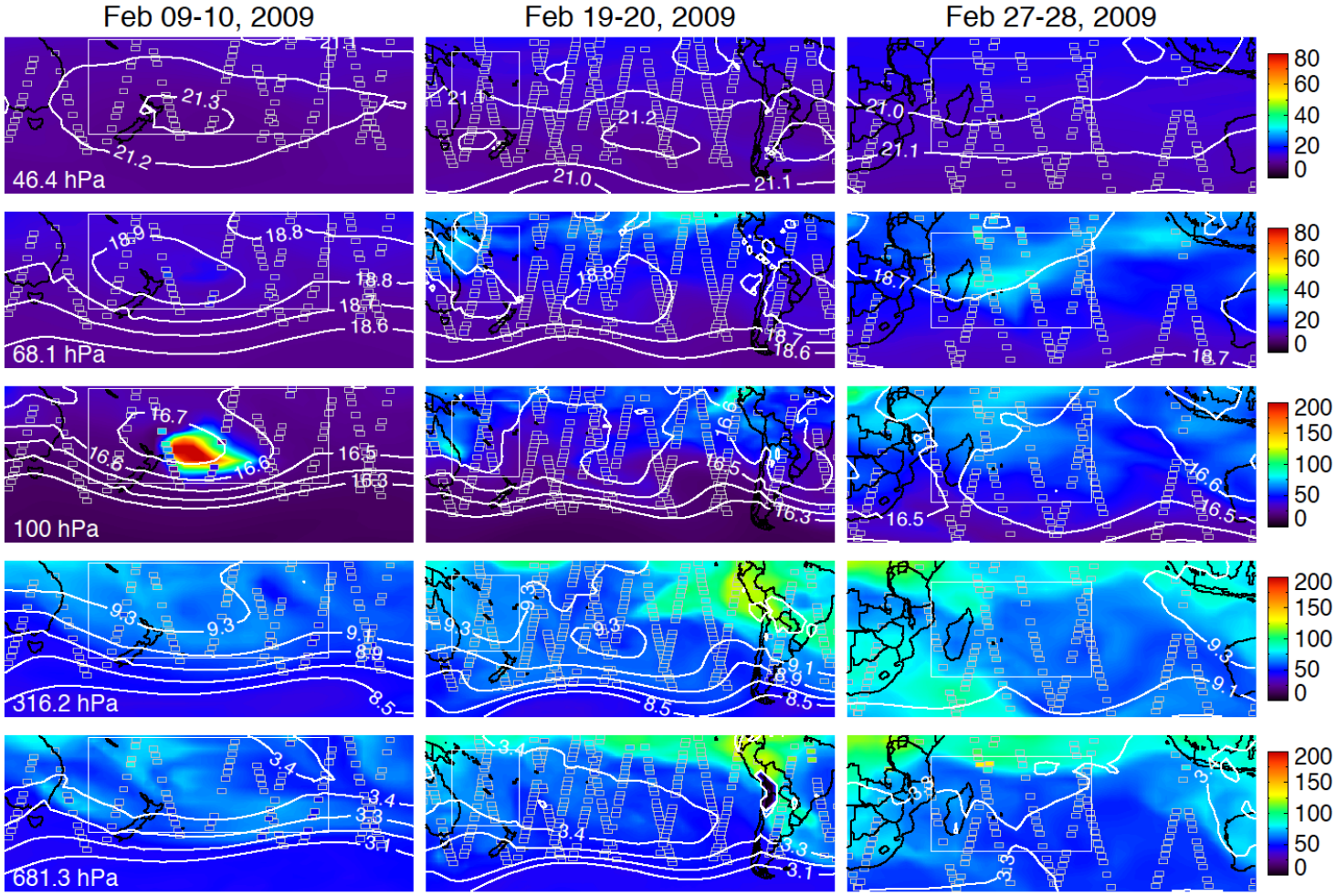


8.5 km injection height, baseline emissions CO (ppbv)




Echo tops from 2 radar stations near Melbourne
00 UTC Tropopause
12 UTC Tropopause
Australian BoM
Alt (km)
UTC Hour, 7 February 2009
0
3
6
9
12
15
18
0
1
2
3
4
5
6
7
8
9
10
11

13.5 km injection height, baseline emissions CO (ppbv)

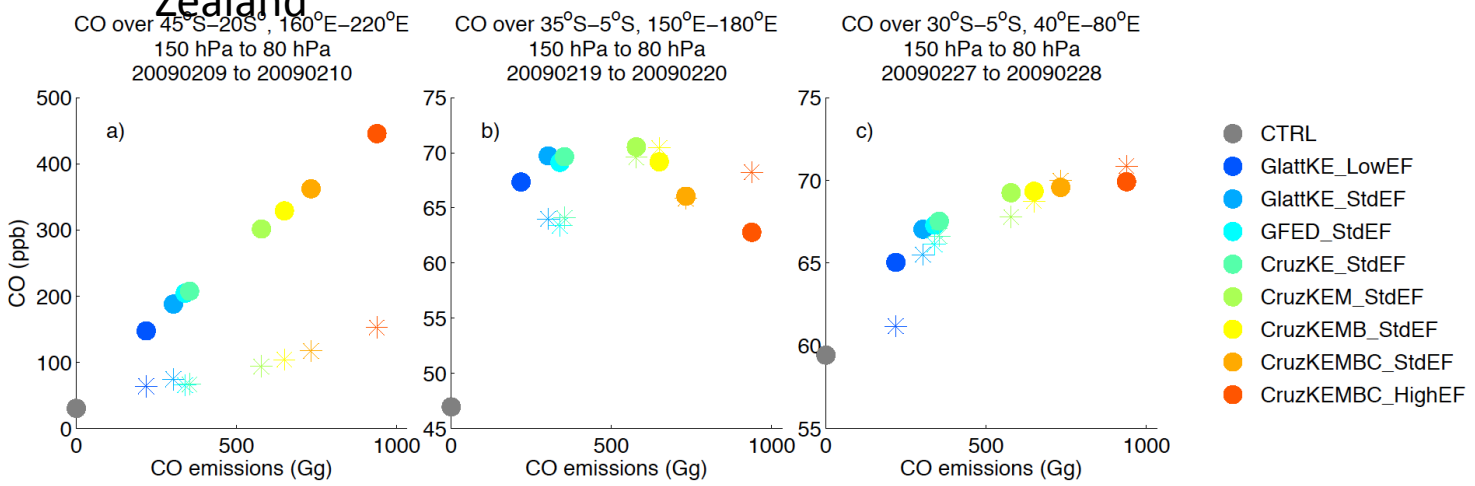


New Zealand

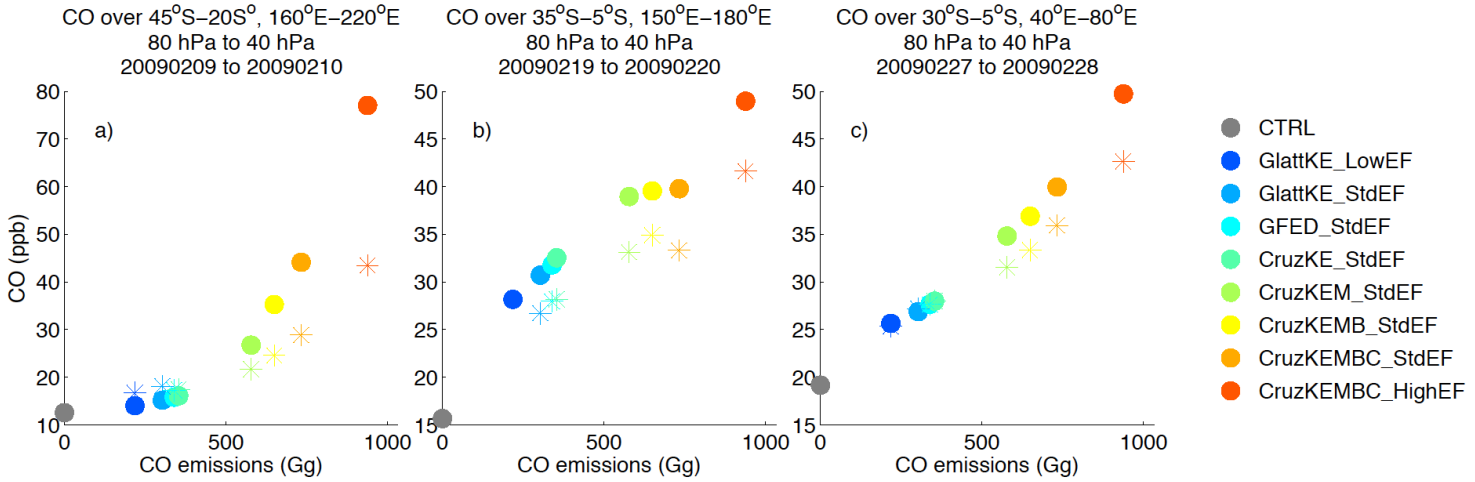
NE Australia

E. Indian Ocn.

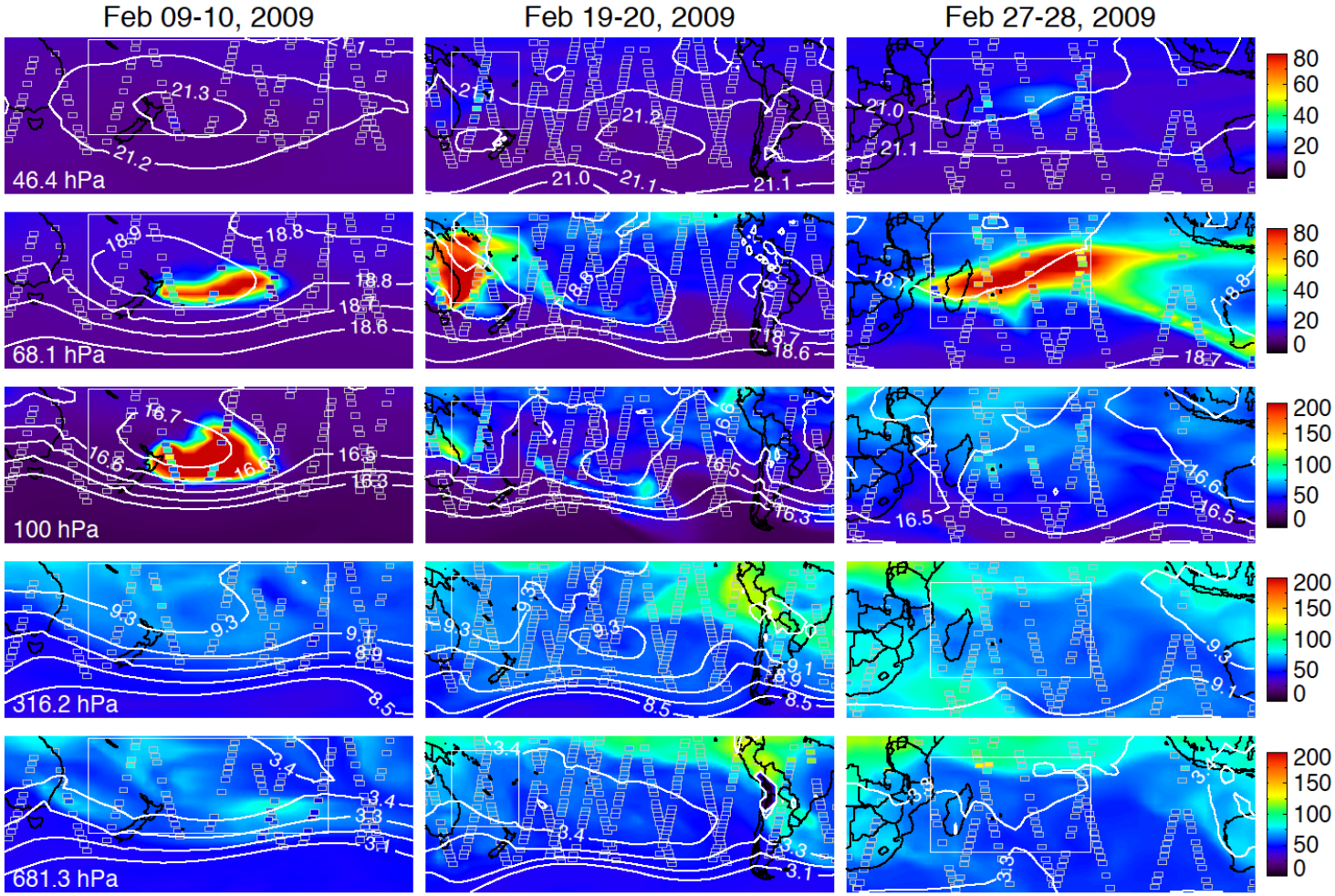
Upper troposphere



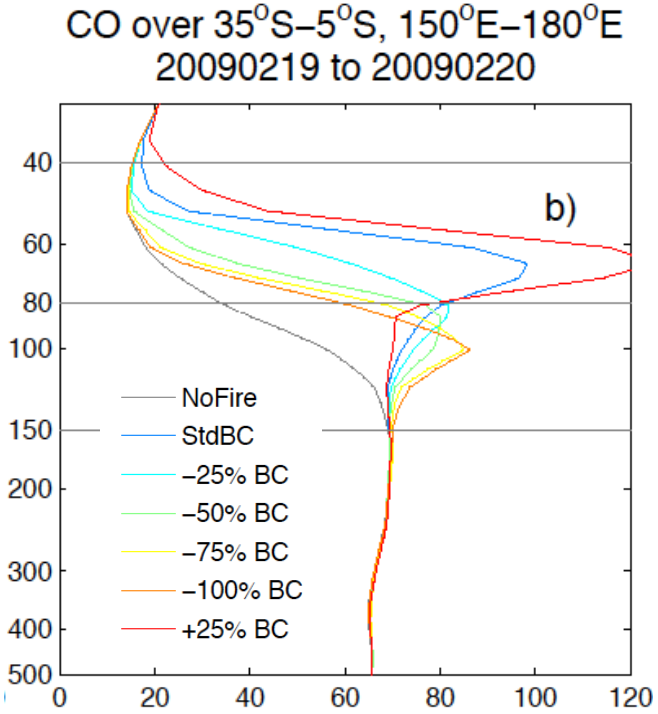
Lower stratosphere

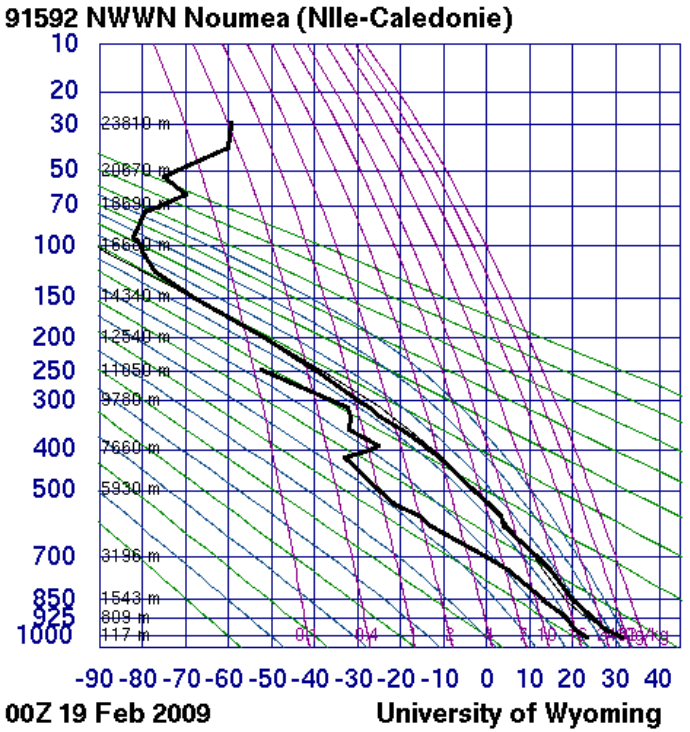


13.5 km injection height, high emissions, hourly emissions CO (ppbv)



CO sensitivity to BC / OC mix: self-lofting?



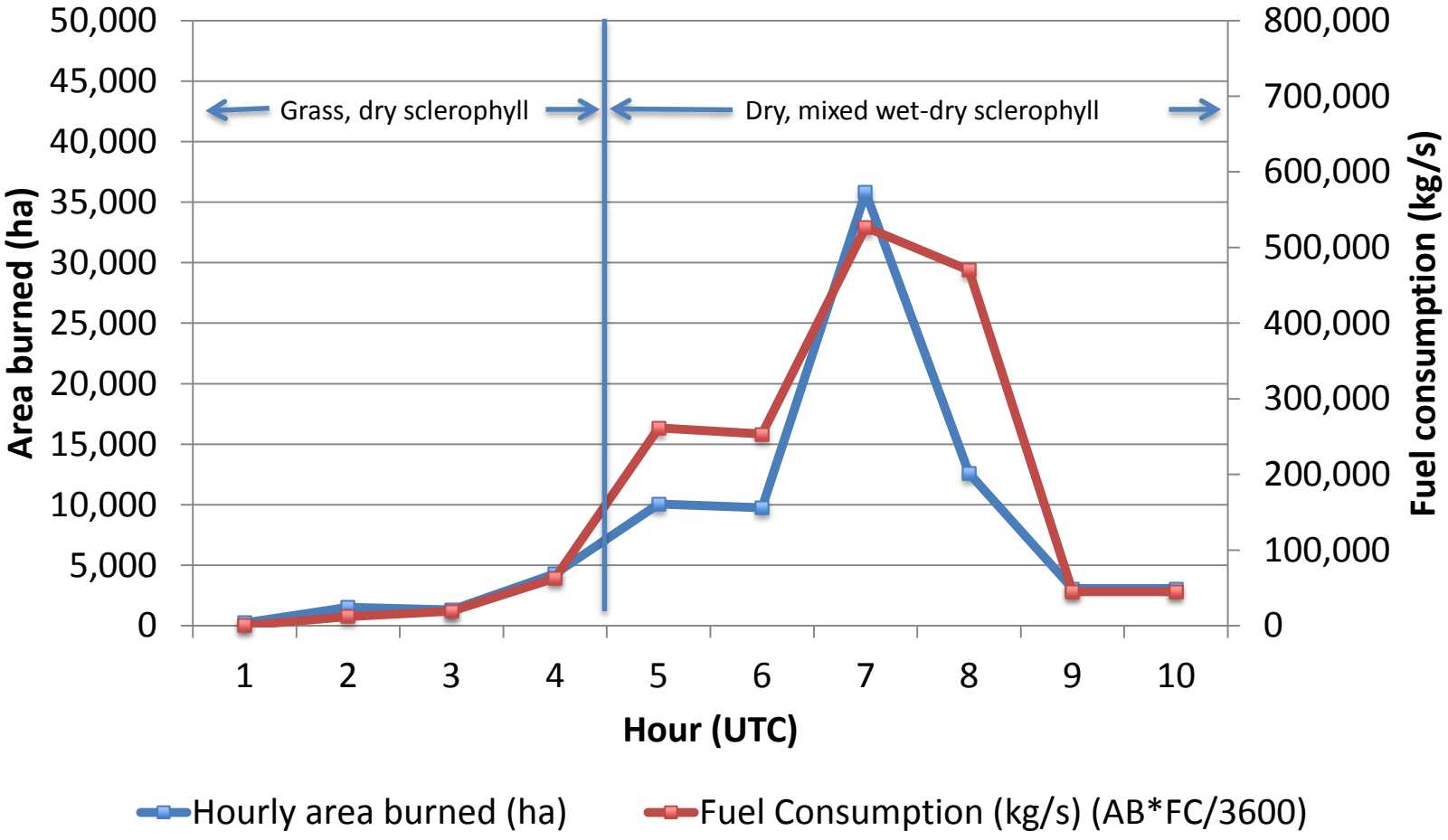


Summary

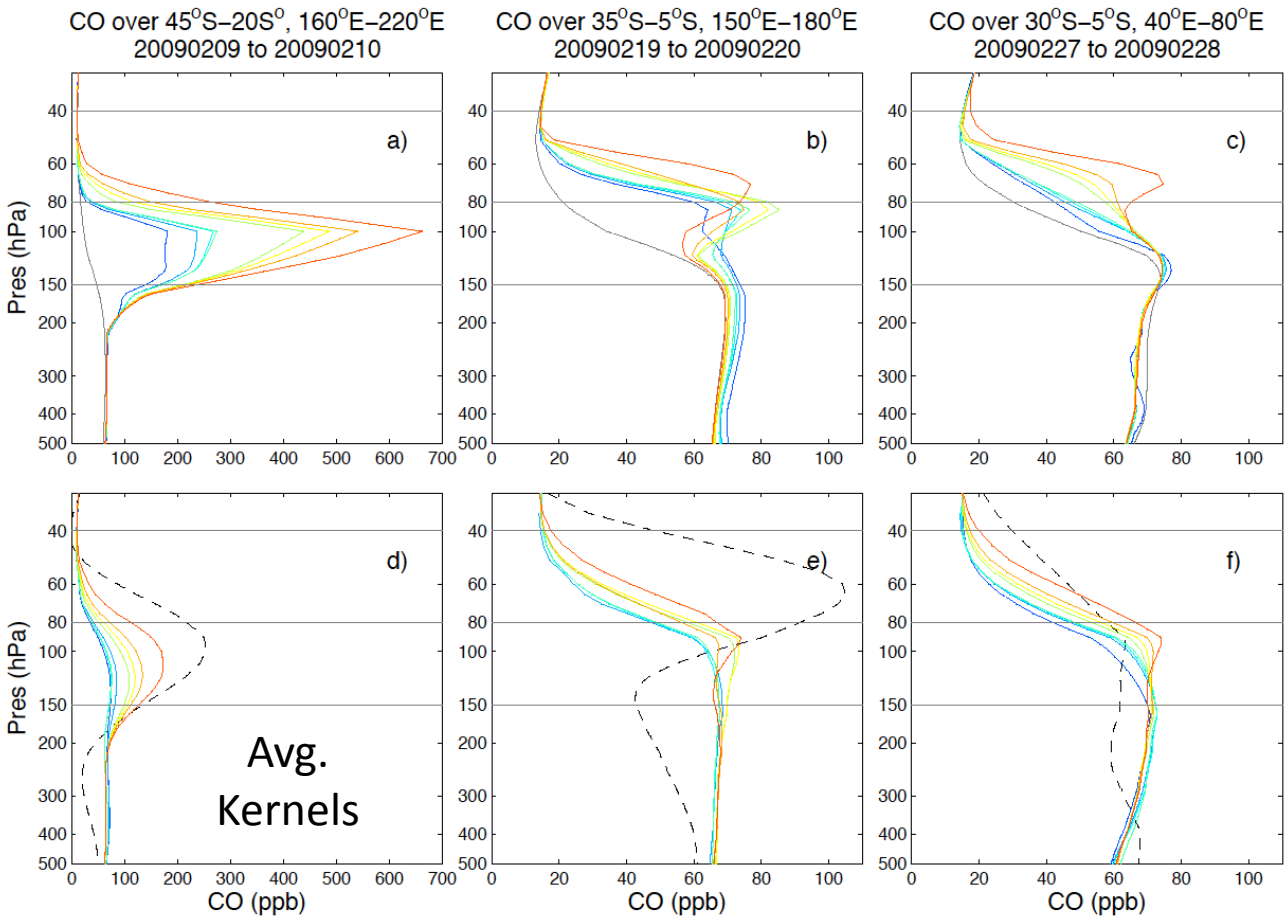
- Plume fate is highly sensitive to injection height and emissions, somewhat sensitive to timing
- Upper tropospheric injection required to simulate plume persisting in LS through Feb 2009
- Preliminary results suggests that diabatic ‘self-lofting’ plays a role in the plume’s persistence

Extras

Kilmore East area burned and fuel consumption
(Cruz et al., 2012)



Grass: 0.45 kg/m2
Dry sclerophyll, low understory: 5.3 kg/m2
Mixed wet-dry sclerophyll forest: 13.4 kg/m2



Aura
CTRL
GlattKE_LowEF
GlattKE_StdEF
GFED_StdEF
CruzKE_StdEF
CruzKEM_StdEF
CruzKEMB_StdEF
CruzKEMBC_StdEF
CruzKEMBC_HighEF

Higher emissions

Goddard Institute for Space Studies

Evaluating GISS ModelE2 using new Aura CO profiles

Field, R.D., M. Luo, D. Kim, A. D. Del Genio, A. Voulgarakis, J. Worden, Sensitivity of simulated tropospheric CO to subgrid physics parameterization: a case study of Indonesian biomass burning emissions in 2006, Journal of Geophysical Research – Atmospheres, 120, doi:10.1002/2015JD023402.

Cumulus parameterization changes that improve GCM performance in some ways **can sometimes worsen it in others**. It is thus useful to examine the effects on other fields.

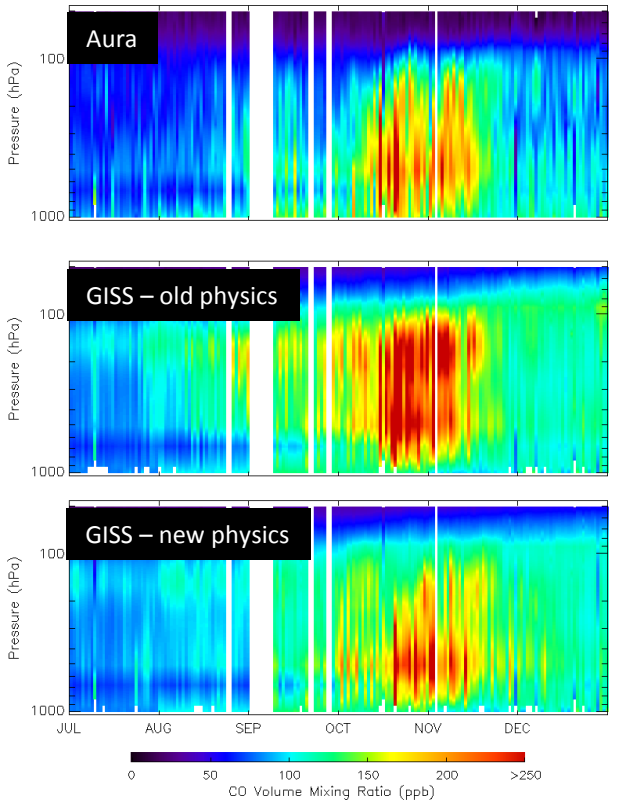
New CO profiles retrieved from Aura TES and MLS[1] provide **an independent check** on new convection physics that led to the successful simulation of an MJO in GISS ModelE2[2].

Upper tropospheric CO during late 2006 over Indonesia was amongst the highest during the MLS period[3] due to uncontrolled peat burning.

With the old (AR5) convection physics, upper tropospheric CO was unrealistically high.

With the new convection physics, the vertical distribution of CO is in better agreement with Aura because of changes in the timing and depth of convection.

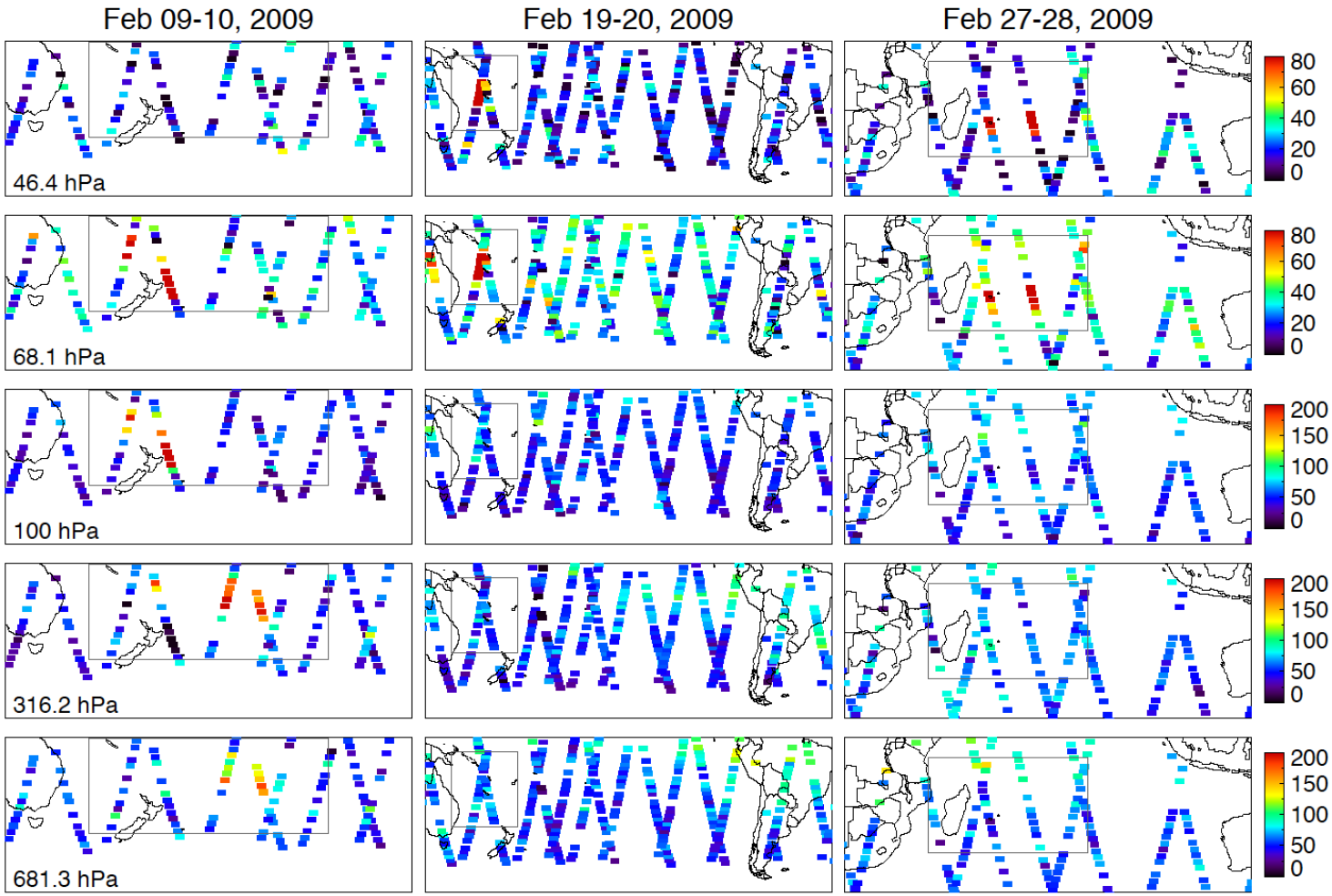
CO over Western Indonesia, Jul-Dec 2006



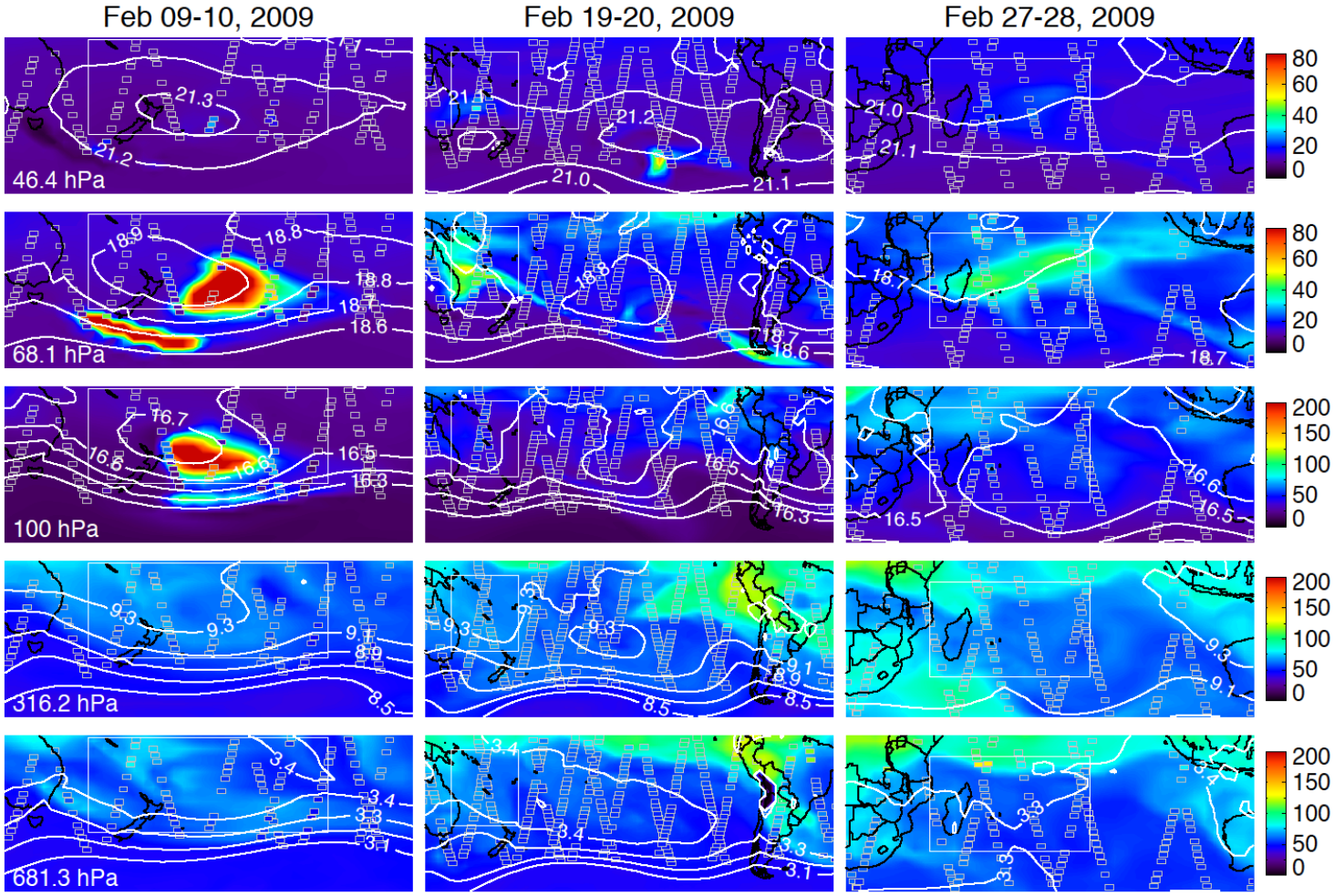
1. Luo et al. (2013, JGR) ***2.*** Kim et al. (2012, J. Clim.) ***3.*** Livesey et al. (2013, ACP)

Aura TES / MLS

CO (ppbv)



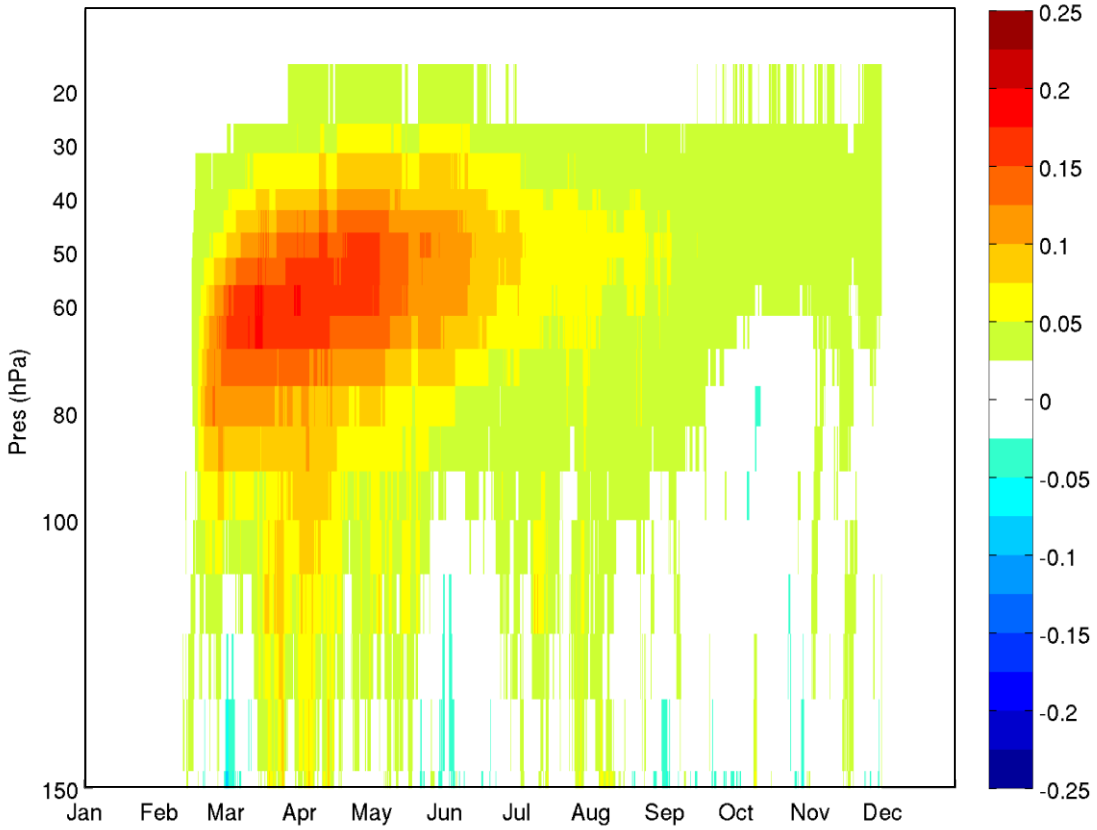
16.5 km injection height, baseline emissions CO (ppbv)



ΔT in stratosphere

Tropical zonal mean

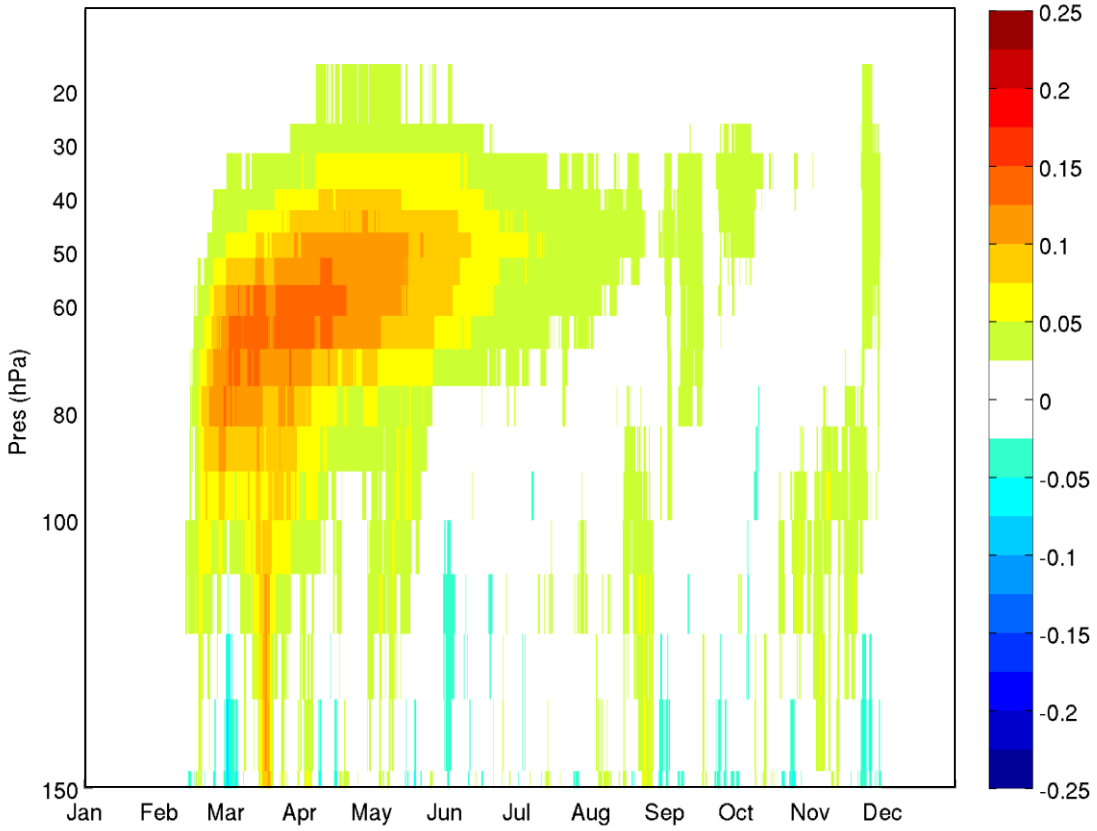
High emissions scenario, 13.5km injection



ΔT in stratosphere

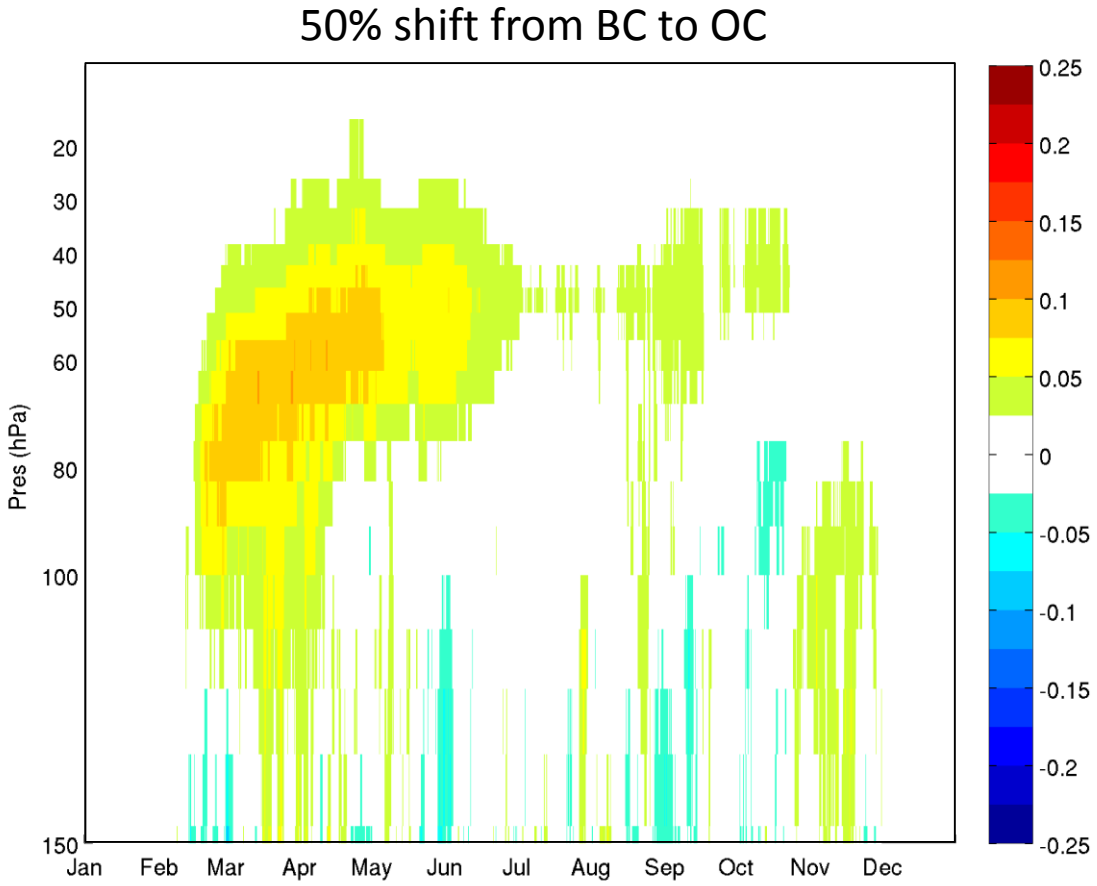
Tropical zonal mean

25% shift from BC to OC



ΔT in stratosphere

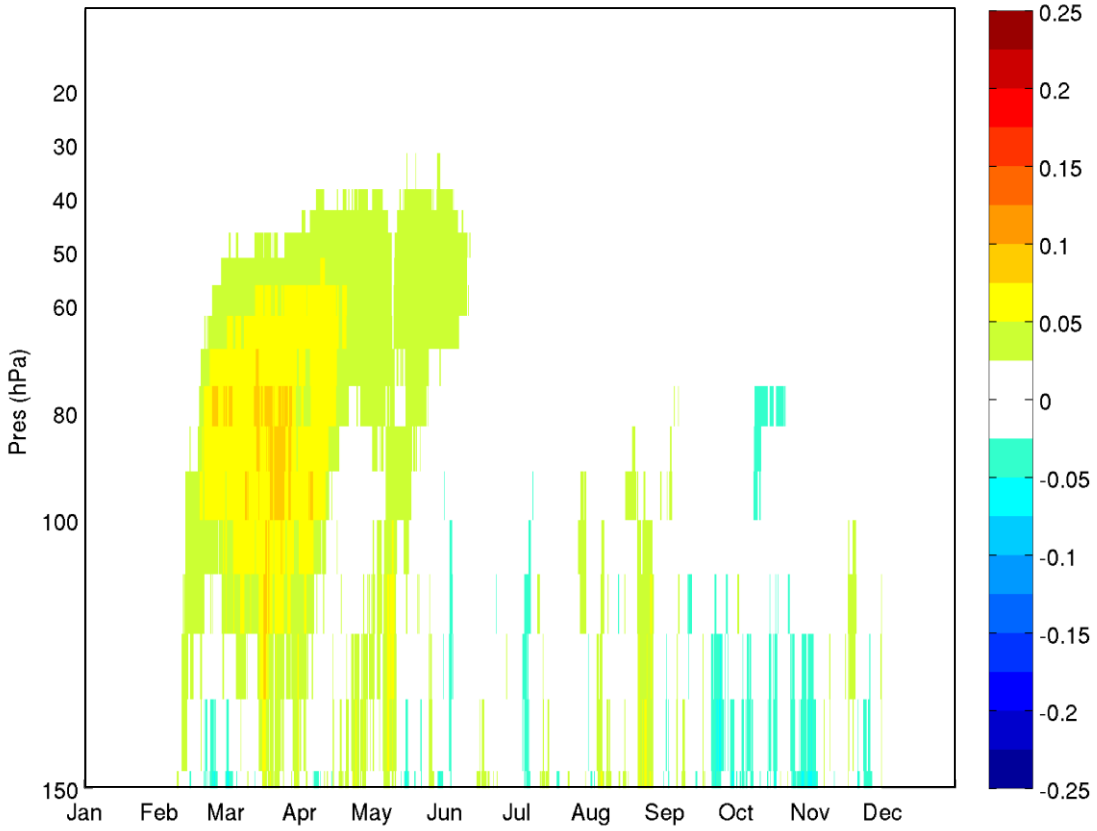
Tropical zonal mean



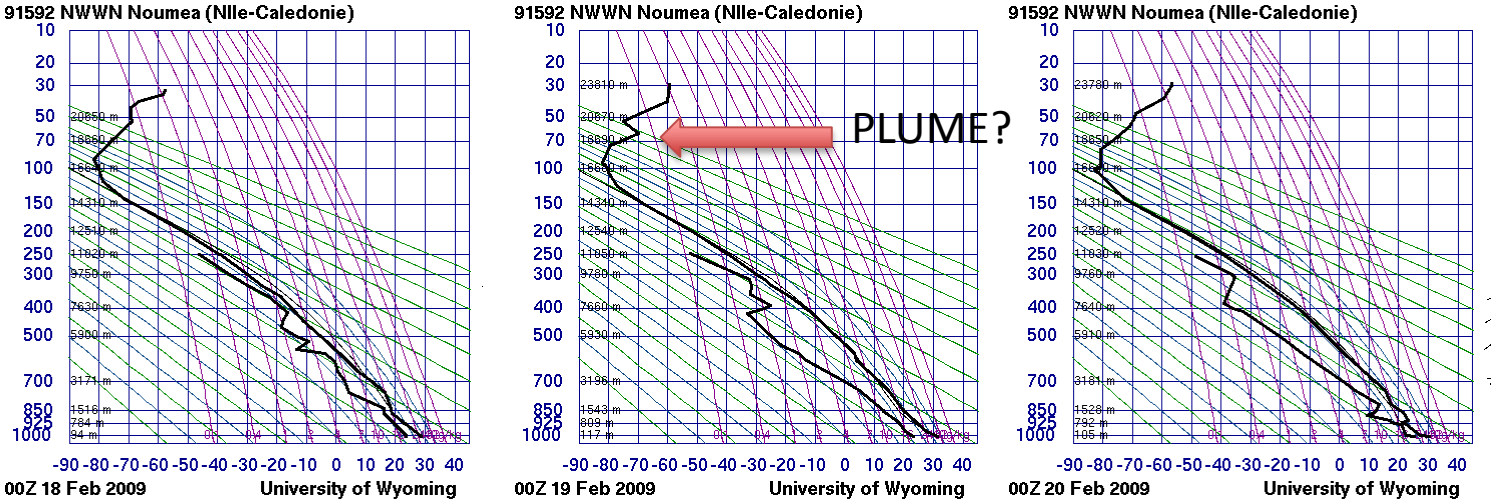
ΔT in stratosphere

Tropical zonal mean

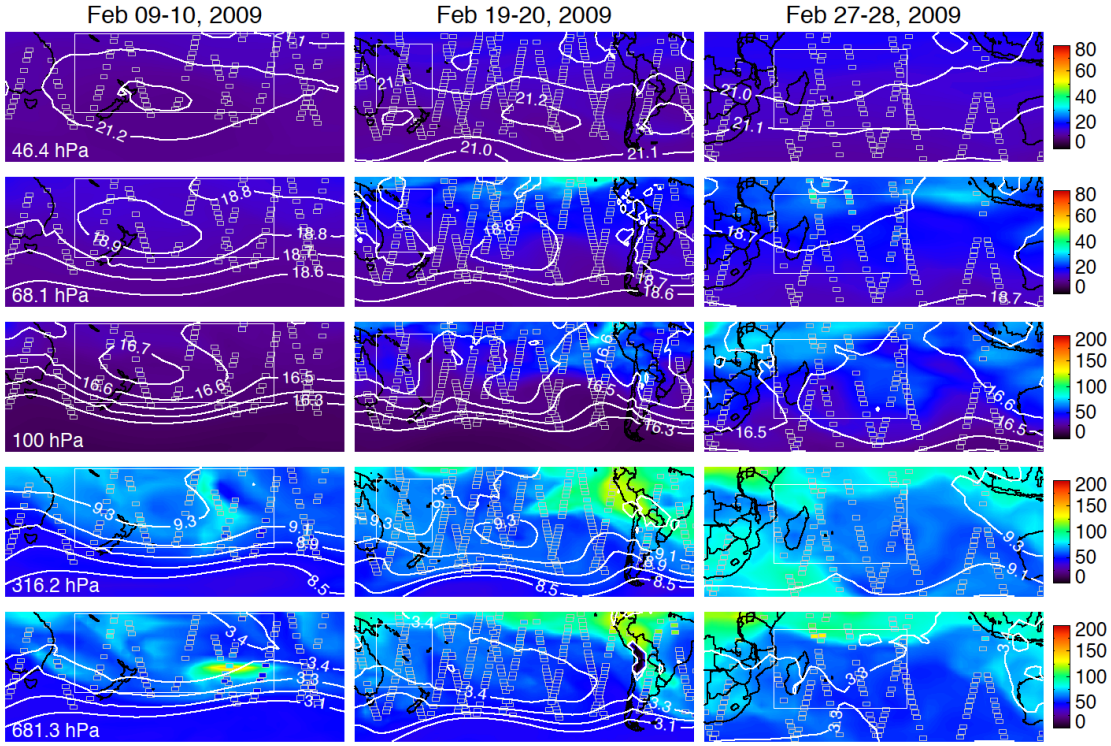
75% shift from BC to OC

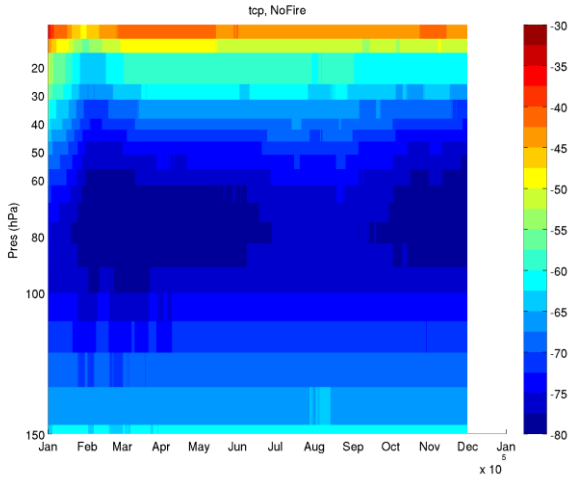


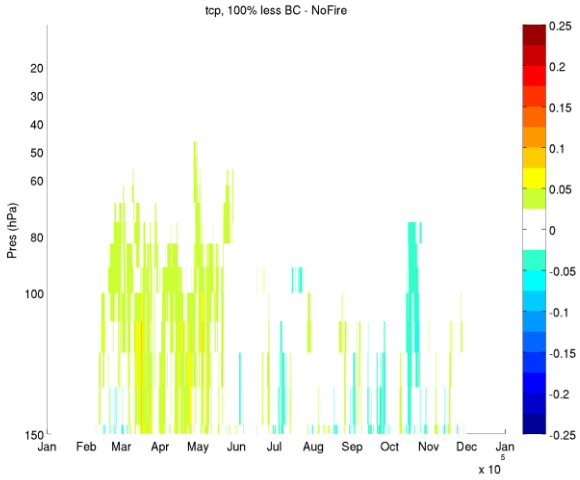
Radiosonde from Noumea, New Caledonia

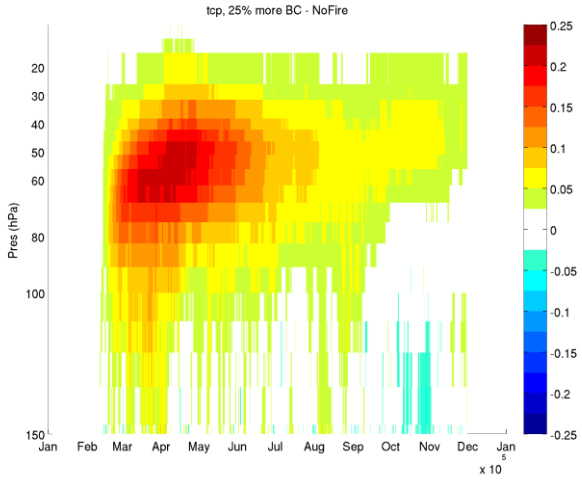


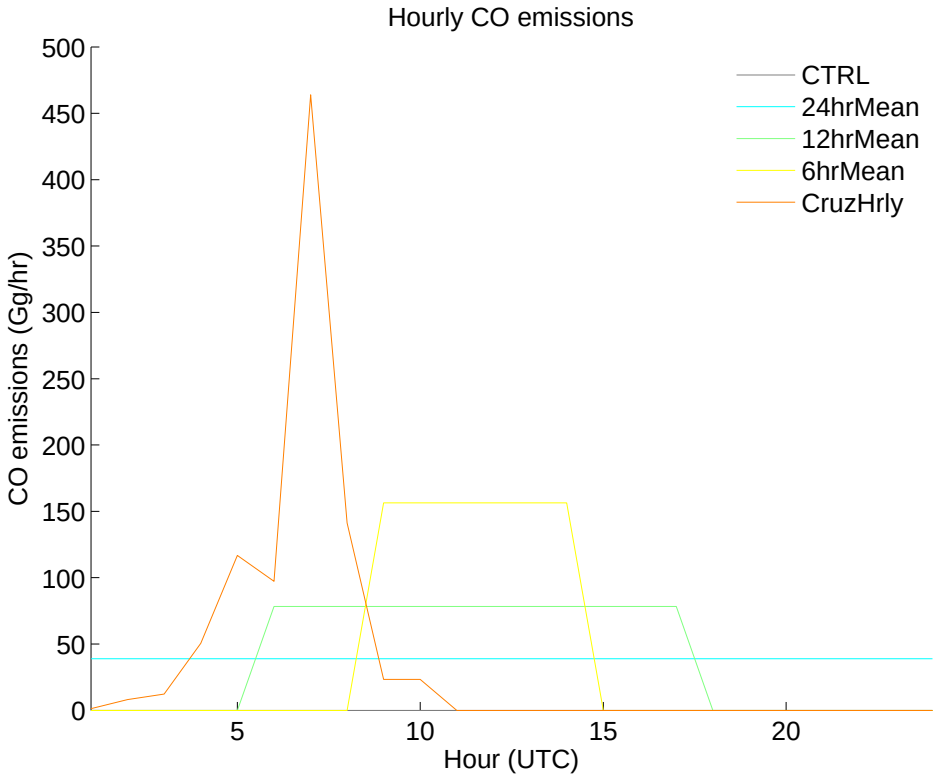
CO (ppb): deLaat_3.5

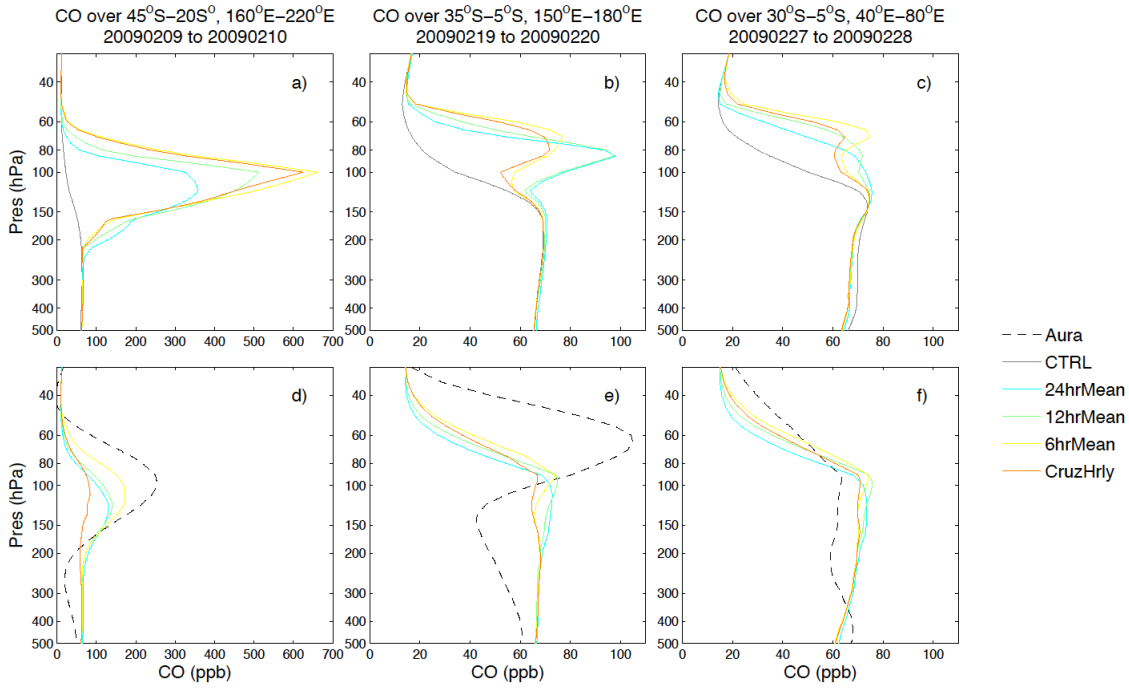



tcp, NoFire
Pres (hPa)
20
30
40
50
60
80
100
150
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
x 10^5
-30
-35
-40
-45
-50
-55
-60
-65
-70
-75
-80


tcp, 100% less BC - NoFire
Pres (hPa)
20
30
40
50
60
80
100
150
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
x 10^5
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25


tcp, 25% more BC - NoFire
Pres (hPa)
20
30
40
50
60
80
100
150
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
x 10^5
0.25
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25


Hourly CO emissions
CO emissions (Gg/hr)
Hour (UTC)
0
50
100
150
200
250
300
350
400
450
500
5
10
15
20
CTRL
24hrMean
12hrMean
6hrMean
CruzHrly


CO over 45°S–20S°, 160°E–220°E
20090209 to 20090210
CO over 35°S–5°S, 150°E–180°E
20090219 to 20090220
CO over 30°S–5°S, 40°E–80°E
20090227 to 20090228
a)
b)
c)
d)
e)
f)
Pres (hPa)
CO (ppb)
Aura
CTRL
24hrMean
12hrMean
6hrMean
CruzHrly

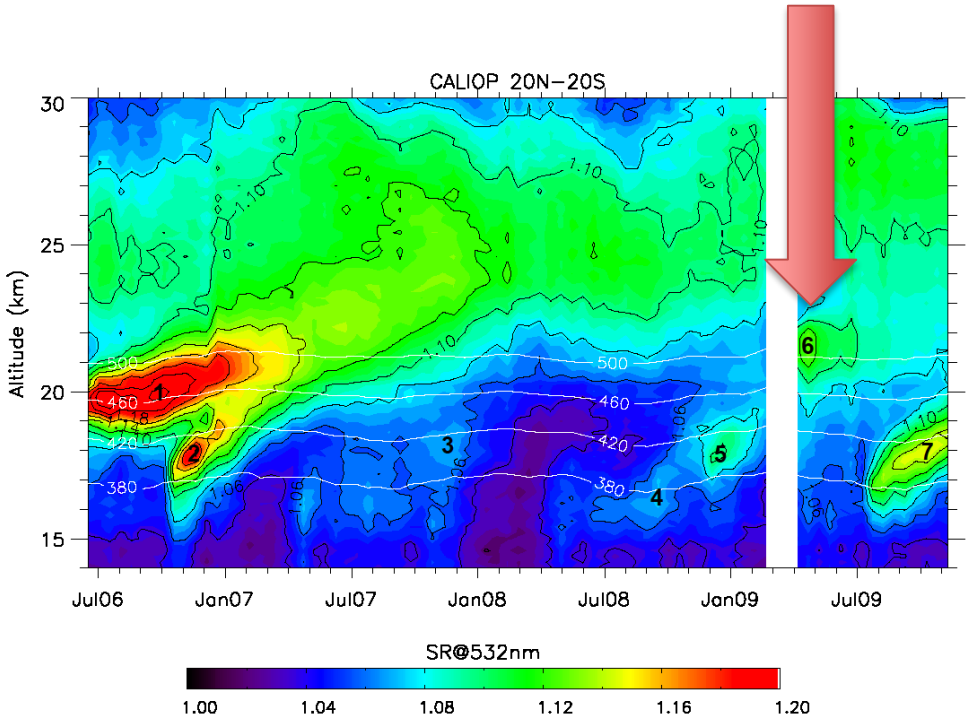


Table 1. List of volcanic eruptions with their corresponding Volcanic Explosivity Index (VEI) or fires that have produced a plume detected by CALIPSO during the 2006–2009 period.

Volcano/Fire	Date	Latitude	VEI
Soufrière Hills (1)	20-May-06	16° N	4?
Tavurvur (2)	7-Oct-06	4° S	4?
Jebel Al-Tair (3)	30-Sep-07	15° N	4?
Okmok (4)	12-Jul-08	55° N	4
Kasatochi (5)	7-Aug-08	55° N	4
Fire/Victoria (6)	7-Feb-09	37° S	
Sarychev (7)	12-Jun-09	48° N	4?

Vernier et al. (2011, ACP)