Evaluation of the GOSAT observations of the atmospheric CO_2 seasonal cycle in the northern high latitudes

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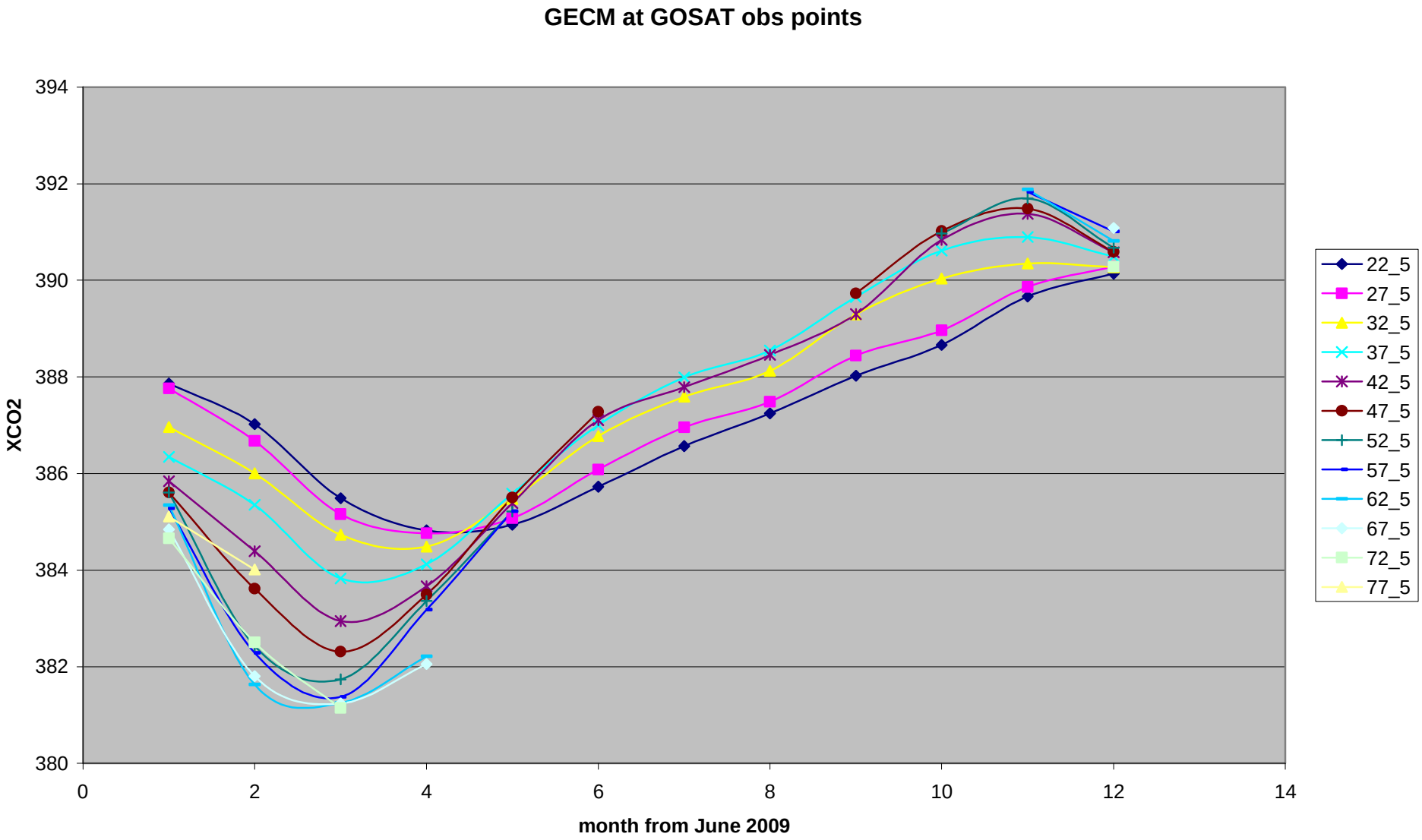
Outline

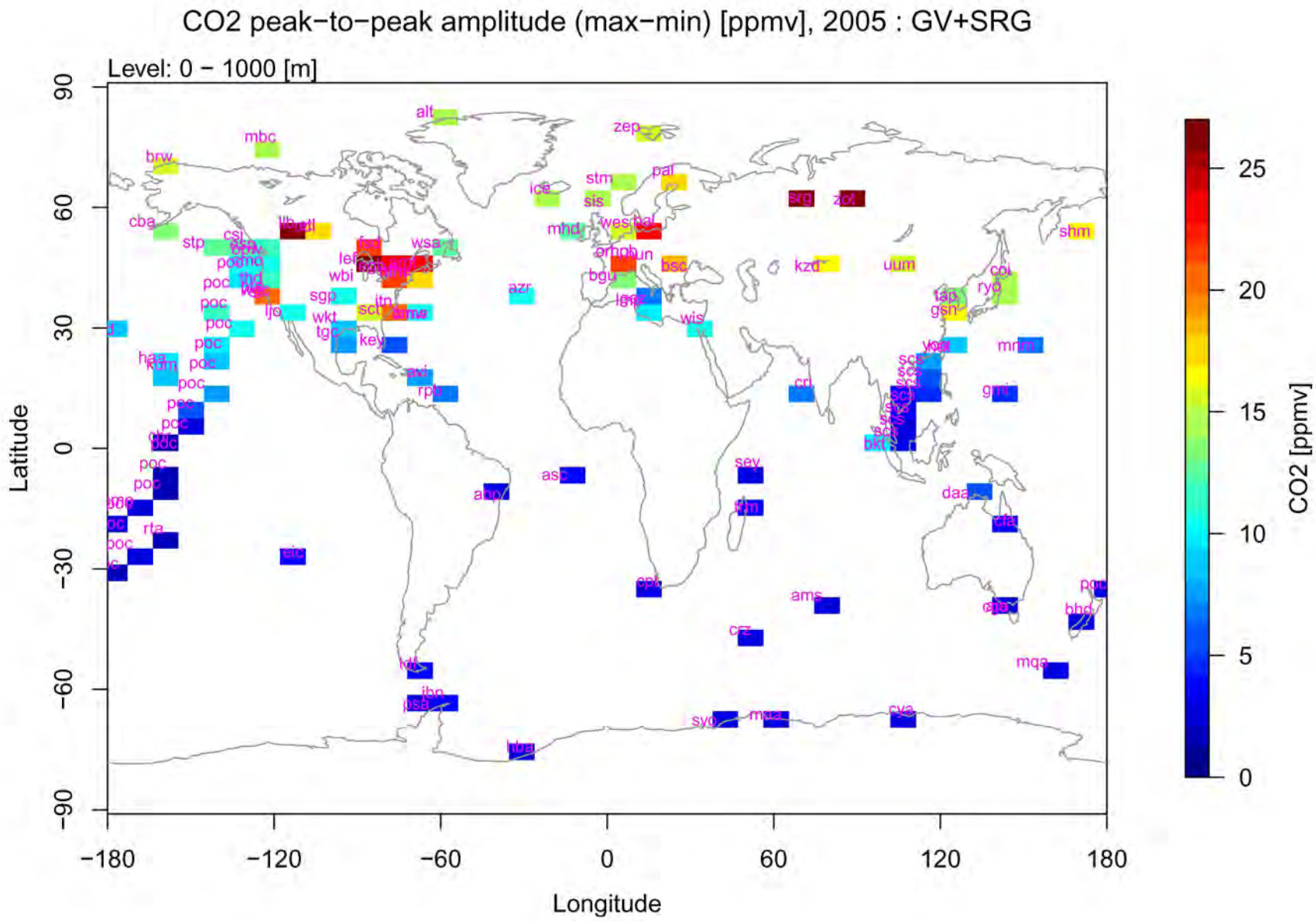
- Climate change and distribution of the terrestrial sinks
- Role of the free-tropospheric observations in the analysis of the terrestrial sink allocation in high latitudes
- Latitudinal/altitude distribution of the CO2 observations in Globalview
- Extension of the Globalview to the total column
- GOSAT observations of the CO2 seasonal cycle vs model climatology
- Conclusions

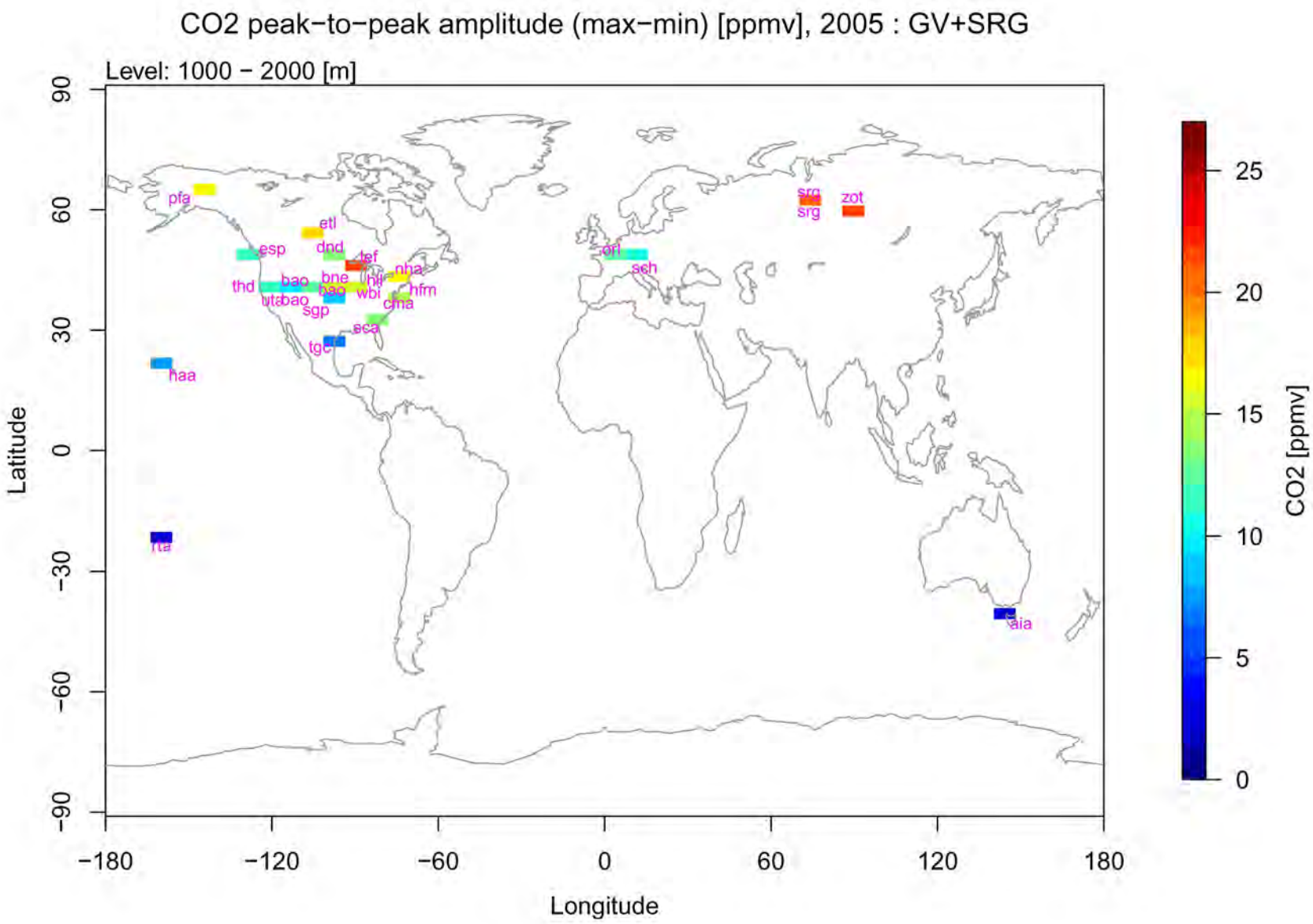
Climate change and distribution of the terrestrial sinks between tropics and high latitudes

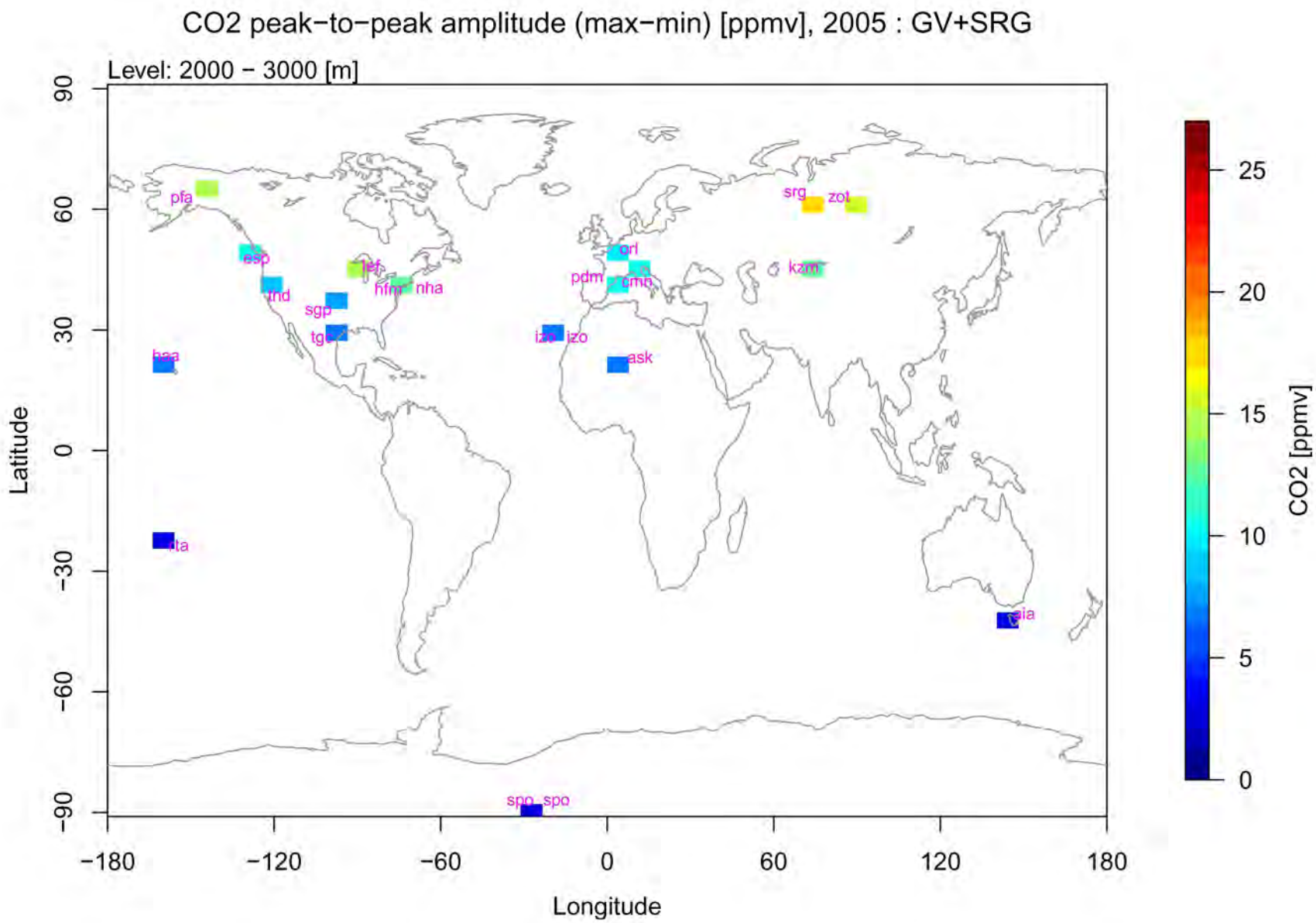
- Net global terrestrial sink of carbon in recent decades was estimated to amount to ~1Gt/a ($^{13}CO_2$ C.D. Keeling at al). Larger number will appear if deforestation is added
- Various studies attribute the sink to the disequilibrium in terrestrial biosphere due to climate change – global warming, increased nitrogen input and CO_2 fertilization
- Atmospheric observations. Tans et al Science 1990 looked at suspiciously low observed North-South concentration gradient (vs model), suggested the sink in N. hemispheric land
- Vertical profiles are important. Stephens et al, Science, 2007 looked at correlatin between inverse model derived sinks and vertical gradient, and suggested the net Northern land sink of ~1Gt/a and net neutral tropics give reasonable match with observed profiles

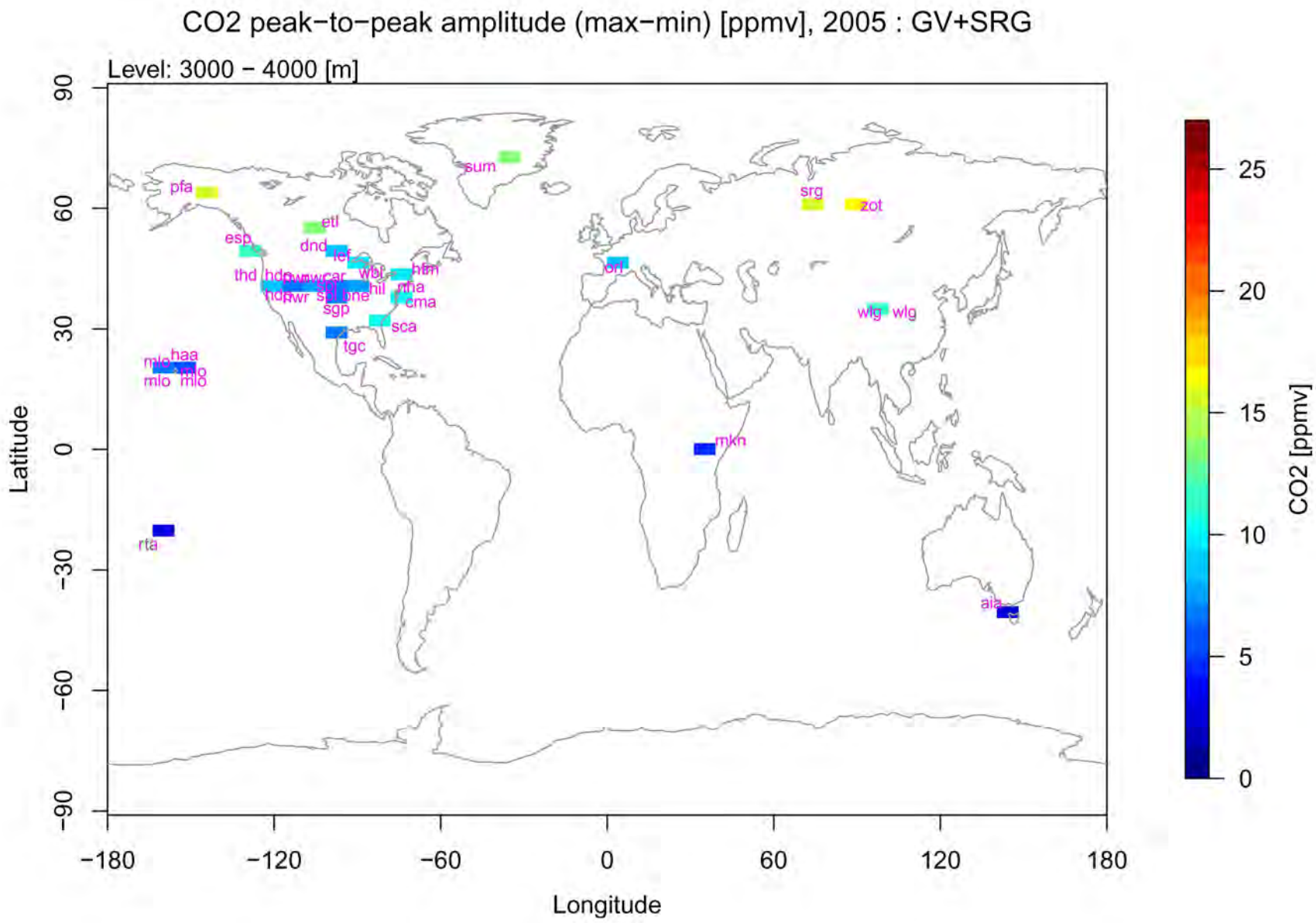
Latitudinal distribution of the seasonal cycle amplitude in the Northern hemisphere




CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 0 − 1000 [m]
Latitude
Longitude
CO2 [ppmv]
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
25
20
15
10
5
0


CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 1000 − 2000 [m]
Latitude
Longitude
CO2 [ppmv]
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
25
20
15
10
5
0
pfa
etl
esp
dnd
tef
nha
thd
bao
bne
hil
wbi
hfm
sgp
cma
sca
tgc
haa
srg
zot
orl
sch
aia


CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 2000 − 3000 [m]
Latitude
Longitude
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
pfa
esp
lef
ind
sgp
nha
hfm
tgc
haa
orl
pdm
cmn
izo
ask
srg
zot
kzm
spo
25
20
15
10
5
0
CO2 [ppmv]


CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 3000 − 4000 [m]
Latitude
Longitude
CO2 [ppmv]
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
25
20
15
10
5
0
pfa
sum
srg
zot
etl
esp
dnd
orl
thd
hdp
car
wbi
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nha
cma
sgp
sca
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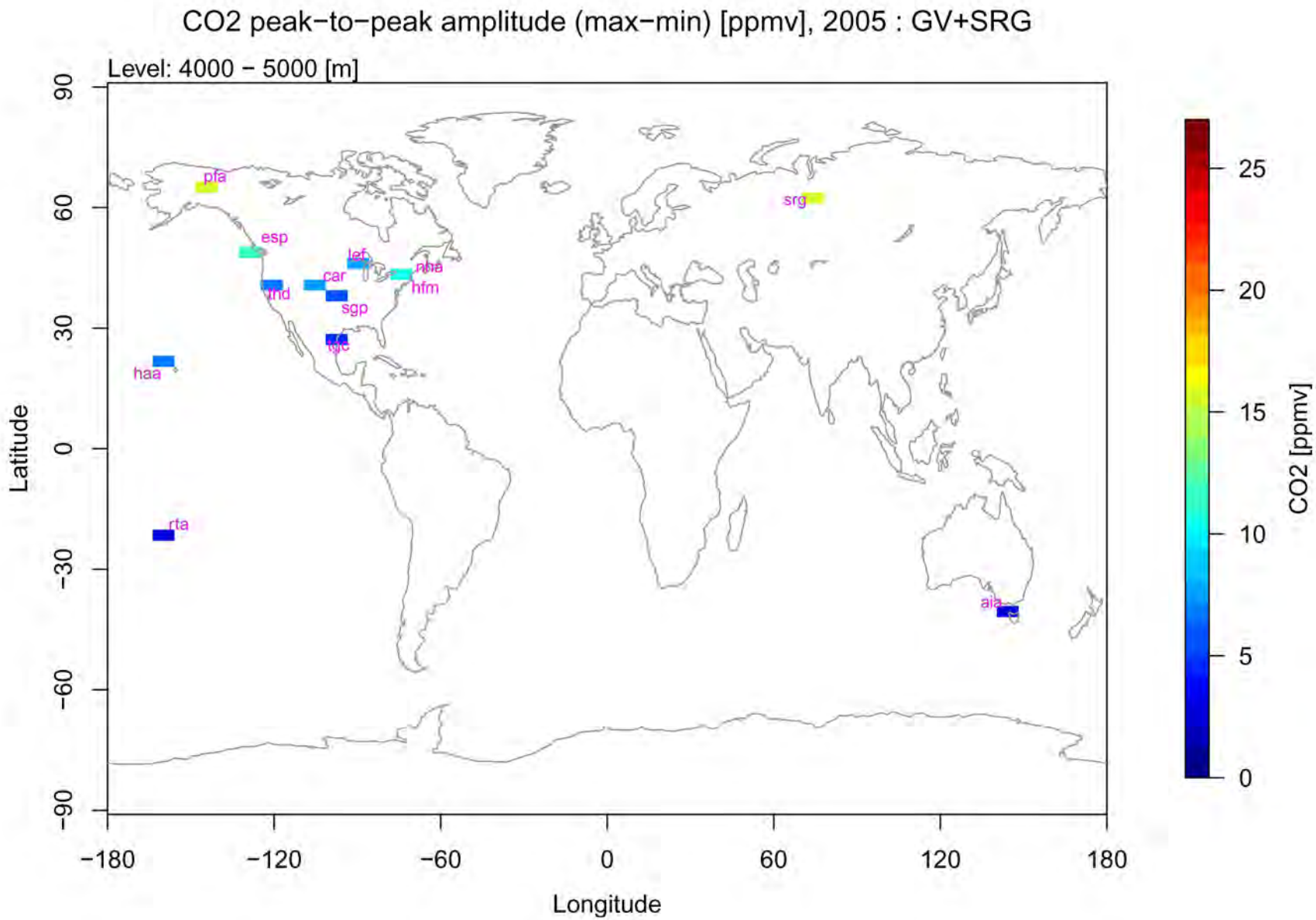
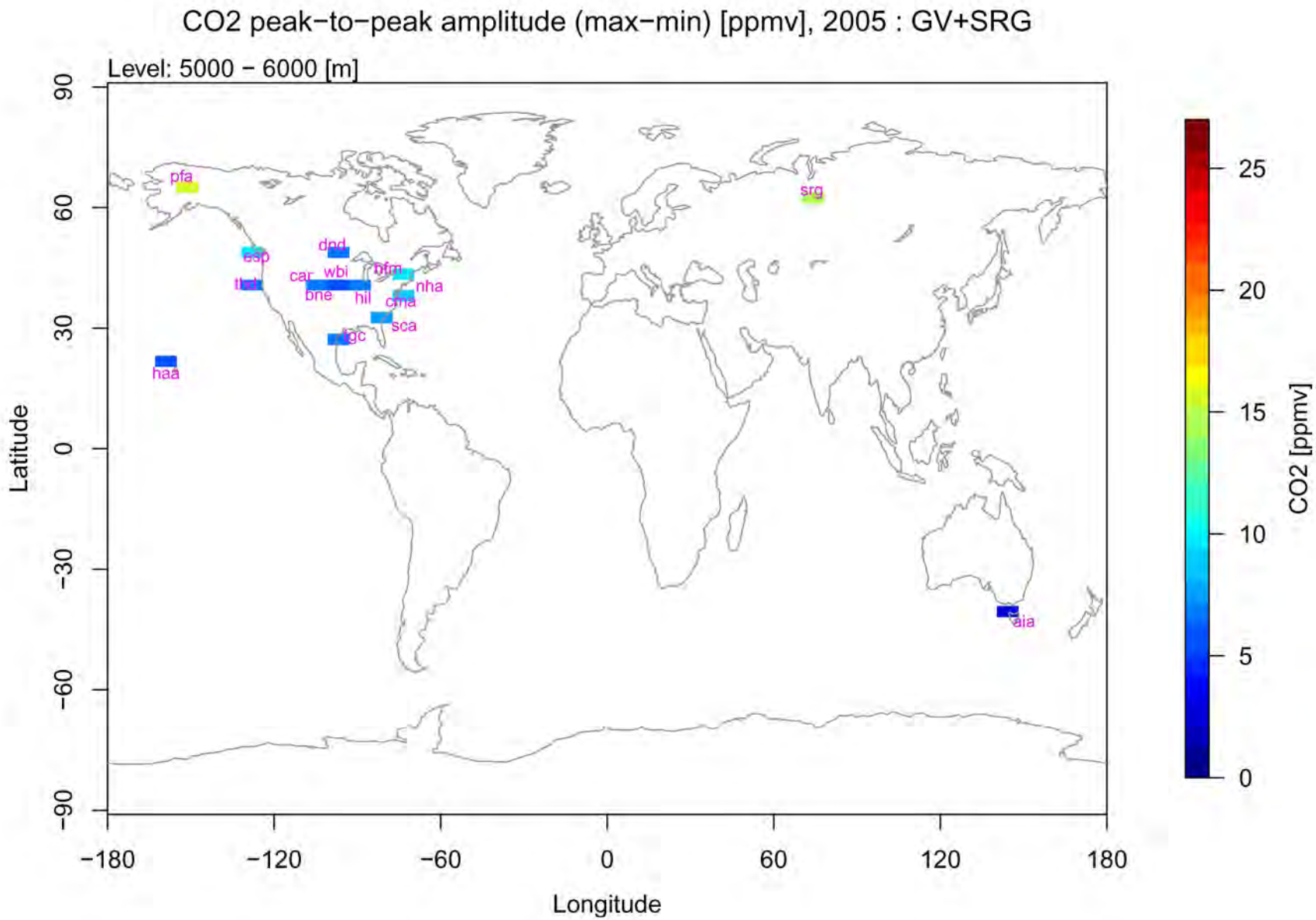
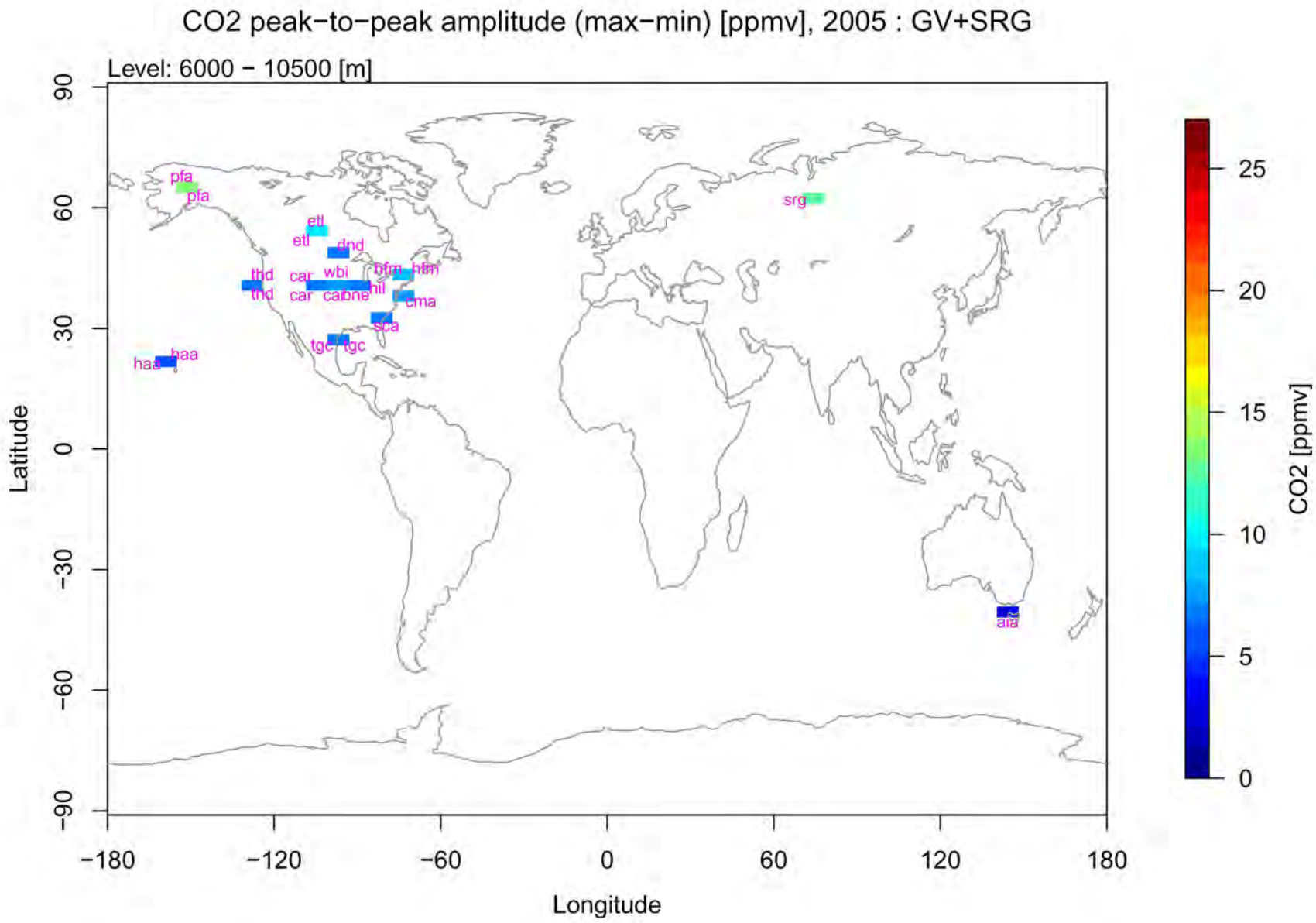
haa
mlo
wlg
mkn
rta
aia


CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 4000 − 5000 [m]
Latitude
Longitude
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
pfa
esp
lef
nha
car
hfm
ind
sgp
haa
rta
srg
aia
CO2 [ppmv]
25
20
15
10
5
0


CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 5000 − 6000 [m]
Latitude
Longitude
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
pfa
srg
esp
dnd
car
wbi
bfm
nha
thd
bne
hil
cma
sca
igc
haa
gia
CO2 [ppmv]
25
20
15
10
5
0

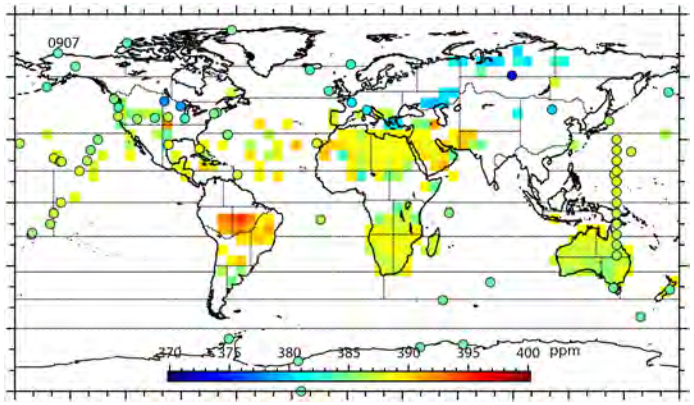

CO2 peak−to−peak amplitude (max−min) [ppmv], 2005 : GV+SRG
Level: 6000 − 10500 [m]
Latitude
Longitude
90
60
30
0
−30
−60
−90
−180
−120
−60
0
60
120
180
pfa
pfa
etl
etl
dnd
thd
car
wbi
bfm
hfm
thd
car
car
hil
cma
sca
tgc
tgc
haa
haa
srg
ala
CO2 [ppmv]
25
20
15
10
5
0

Since 2009/06: observations by GOSAT

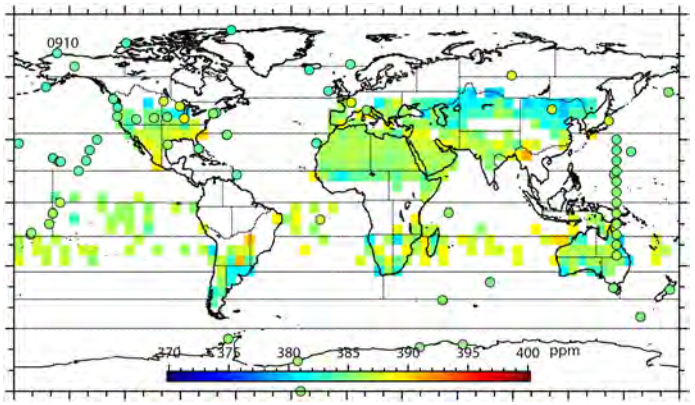
GOSAT – Japanese greenhouse gases observing satellite project by JAXA, NIES, MOE. Observing column averaged mixing ration of CO_2 and CH_4, access data at www.gosat.nies.go.jp

Circles – observations in GLOBALVIEW-CO_2 2011. 5x5 rectangles – monthly mean values of GOSAT CO_2 L2 product (bias corrected using data by Morino et al, 2010).

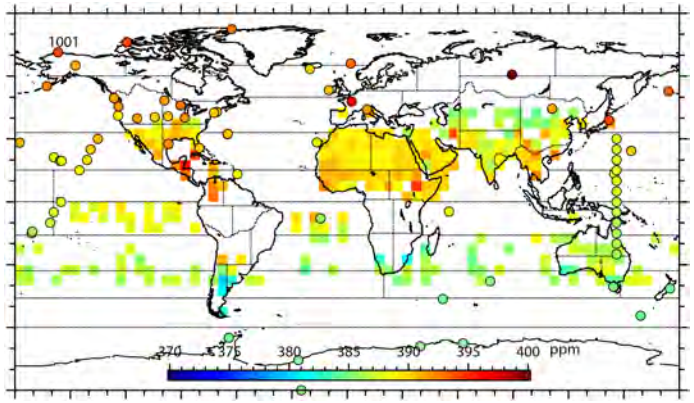
2009/07



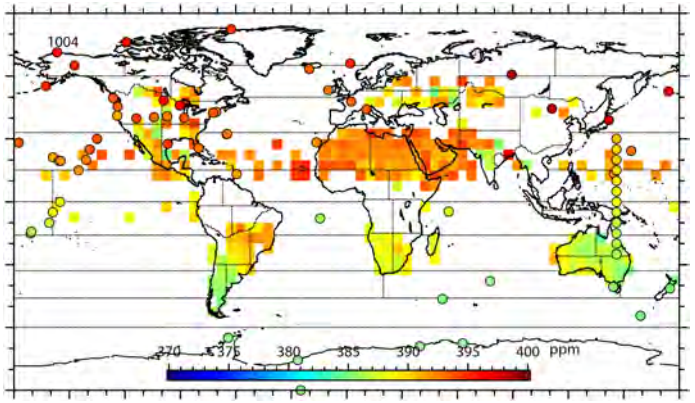
2009/10



2010/01

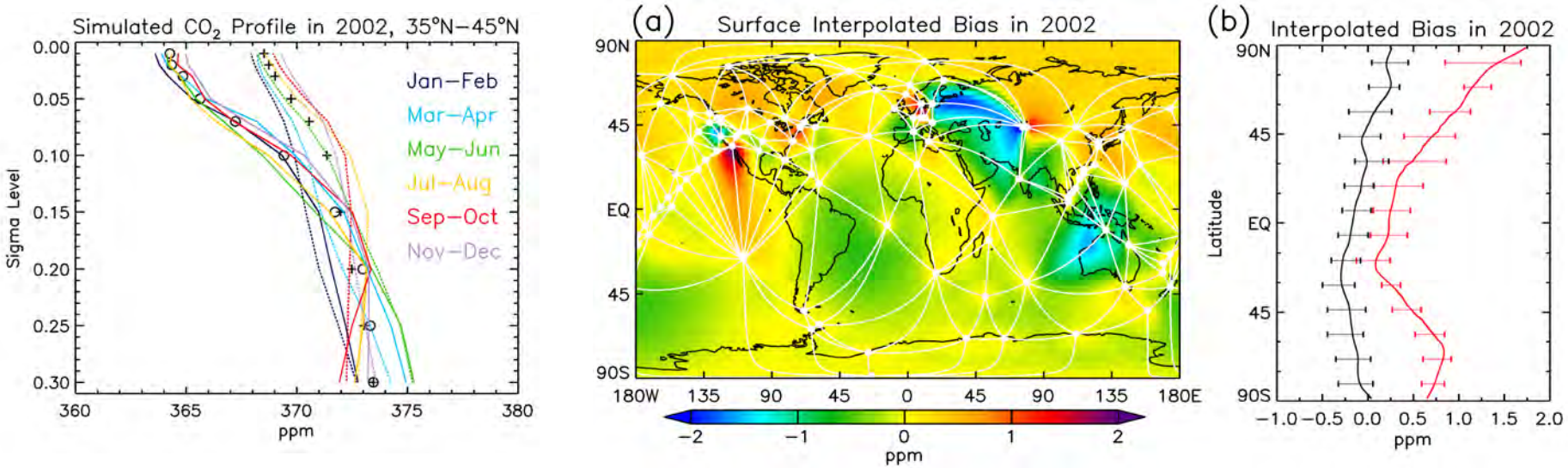


2010/04



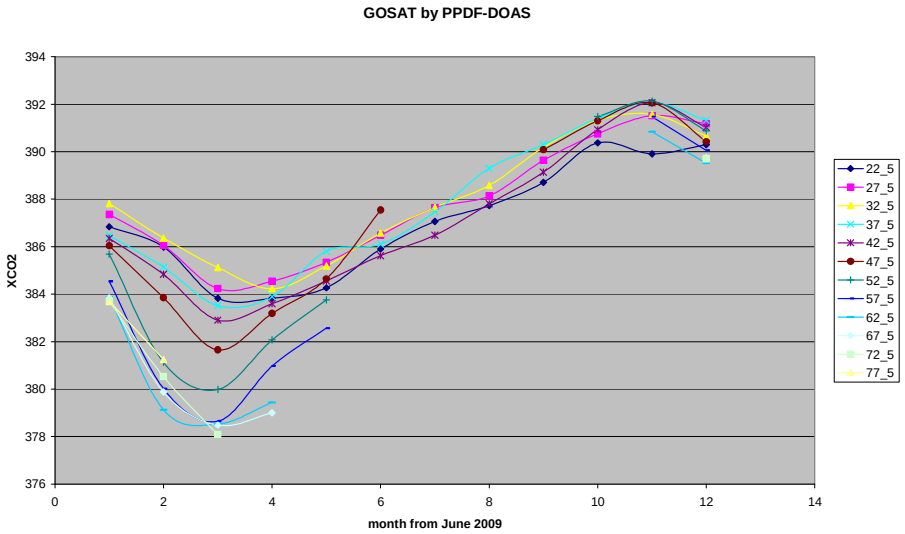
Model derived 3-D climatology of CO_2

1. In a study by R. Saito et al, JGR 2011, 5 global tracer transport model were used to construct a model mean and bias corrected climatology of the atmospheric CO_2
2. Carbontracker fluxes for 2002-2003 were used
3. The climatology was corrected using surface and vertical profile observations in Globalview database, and stratospheric balloon observations.

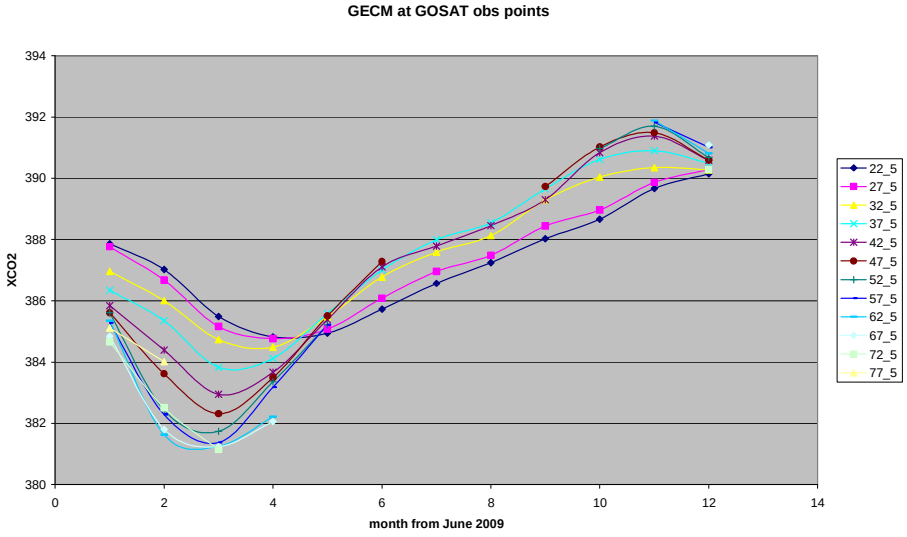


left – stratospheric bias correction, right bias kriging vs Globalview network

Comparison of XCO_2 seasonal cycle GECM vs GOSAT



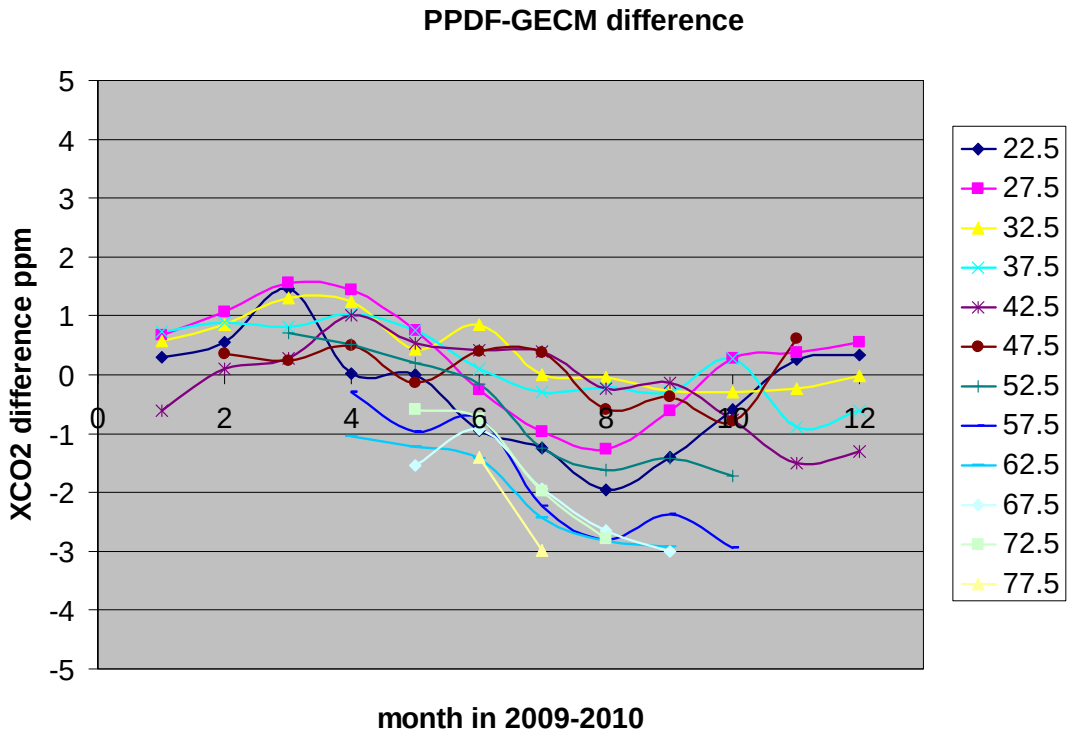
GOSAT PPDF-DOAS XCO2
Oshchepkov et al JGR 2011



GECM XCO2
Saito et al JGR 2011

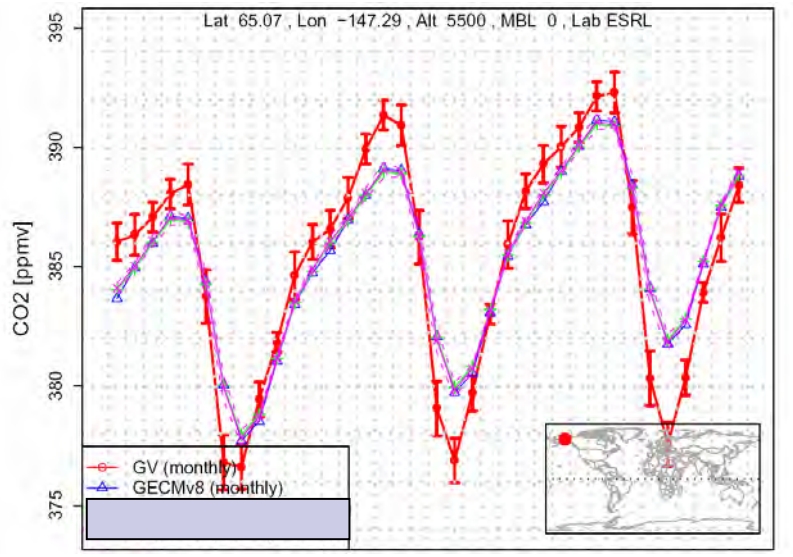
PPDF-GECM seasonal

Seasonal cycle difference between of GECM and GOSAT



Difference between GECM and GOSAT is within 1 ppm except for high latitudes, where diffrence of 2 ppm or more is found. GOSAT bias?

GECM itself has same size bias, so GOSAT (PPDF) is right?



Outline

- Free tropospheric carbon dioxide observations are important for quantification of the carbon sinks with inverse modeling
- The deficiency on the observation network coverage in high latitude free troposphere is evident along with significantly stronger CO_2 seasonal cycle
- GOSAT observations of the CO2 are available to close the gap in summer time
- GOSAT observations compare well with model derived and bias-corrected climatology, suggesting the biases of the order of 1 ppm