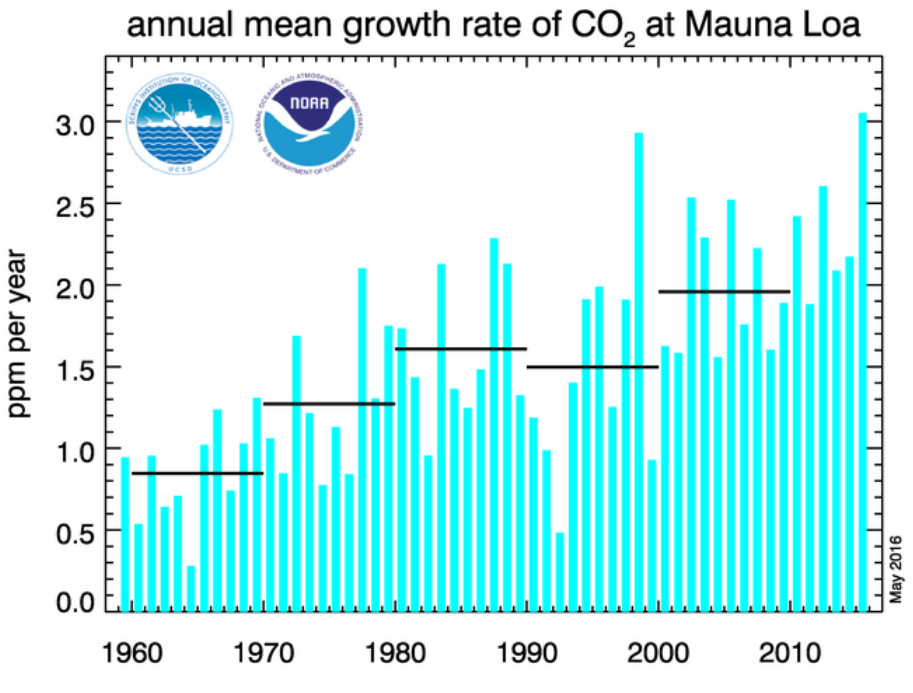
The Carbon Cycle Response to the 2015-16 El Niño

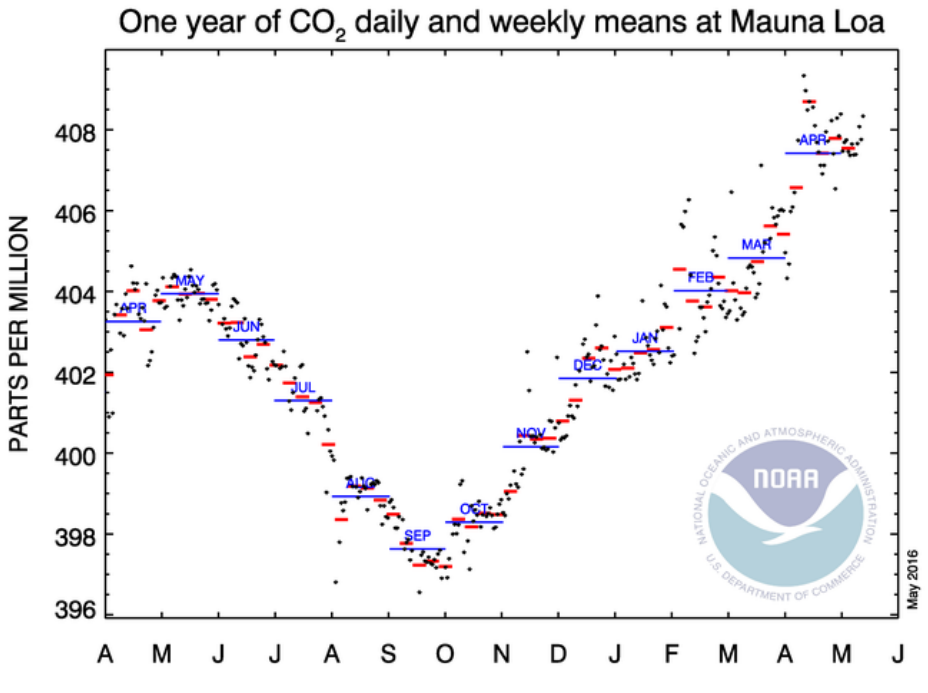
Andrew R. Jacobson, University of Colorado and NOAA Earth System Research Laboratory
David F. Baker, Colorado State University
John B. Miller, NOAA Earth System Research Laboratory
Martin Hoerling, NOAA Earth System Research Laboratory
Rik Wanninkhof, NOAA Atlantic Oceanographic & Meteorological Laboratory
Paul Novelli, NOAA Earth System Research Laboratory
Pieter Tans, NOAA Earth System Research Laboratory
Prabir K. Patra, Japan Agency for Marine-Earth Science and Technology
Christine Wiedinmyer, National Center for Atmospheric Research
Ed Dlugokencky, NOAA Earth System Research Laboratory
Kirk Thoning, NOAA Earth System Research Laboratory
Louis Giglio, University of Maryland

Outline

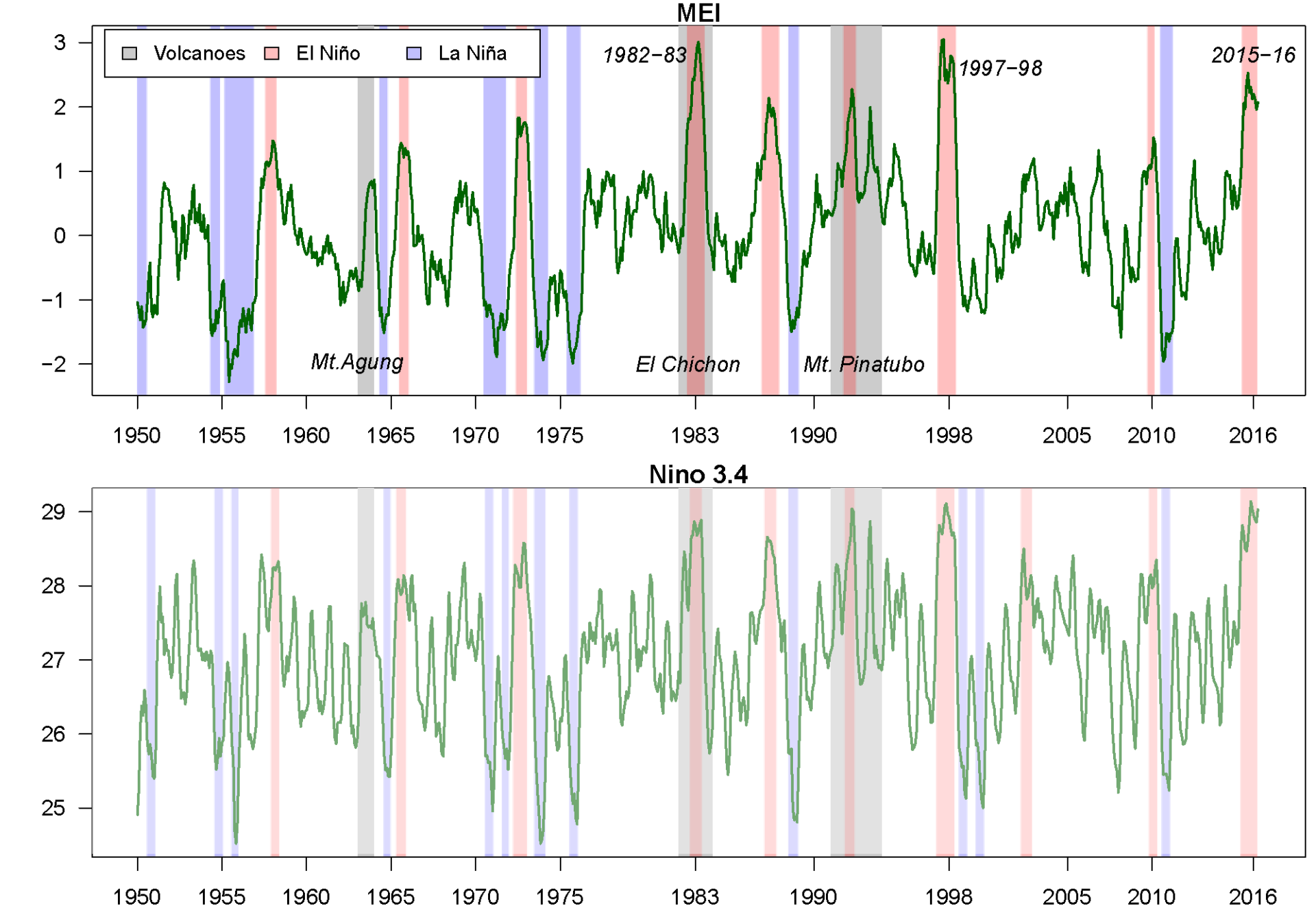
- What kind of El Niño is this?
- How much extra CO_2 is in the atmosphere?
- What did the oceans do?
- How much CO_2 came from fires?
- Can we close the budget?
- Can we model this event?

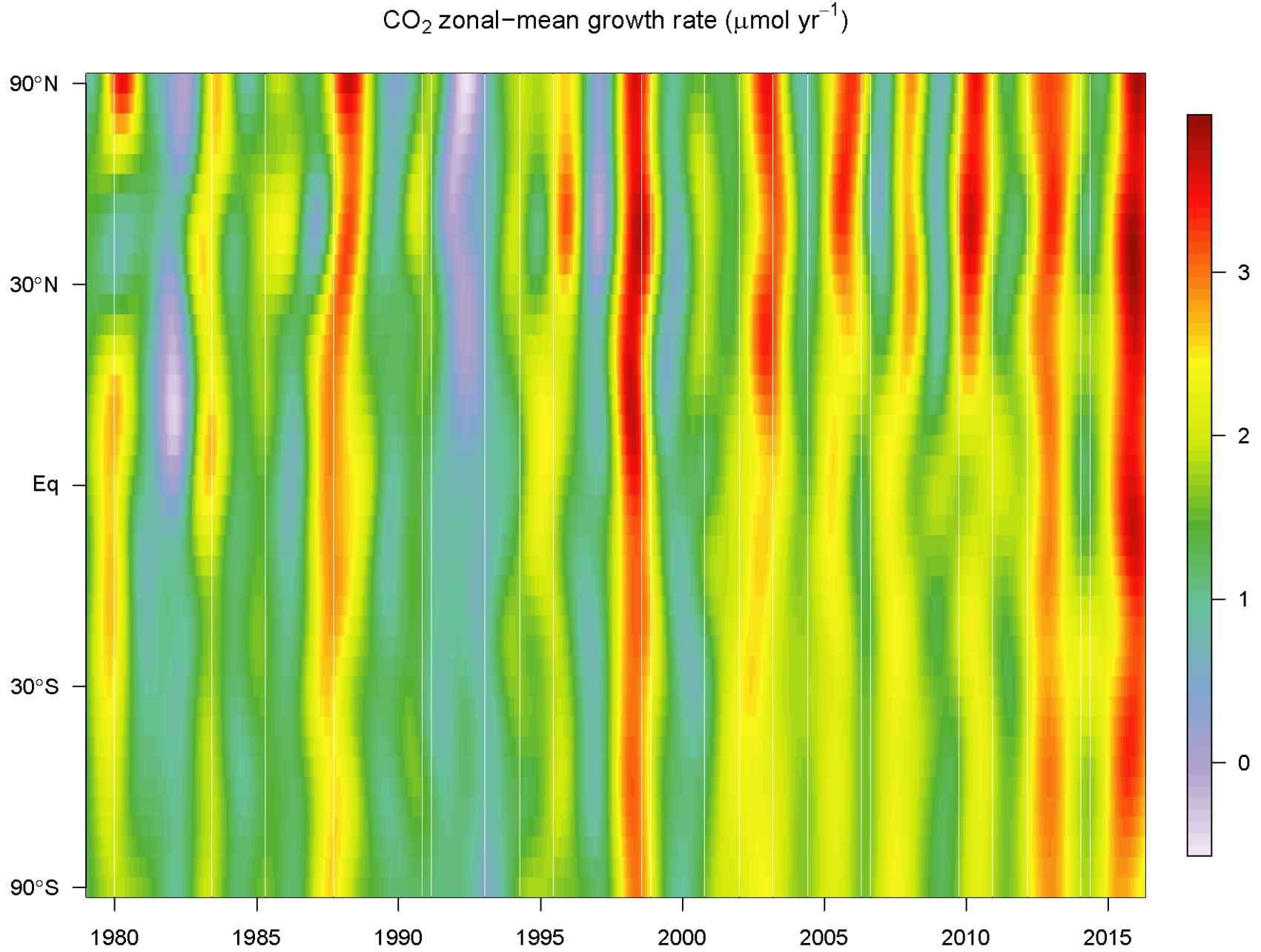
Record CO_2 growth rate at Mauna Loa in 2015

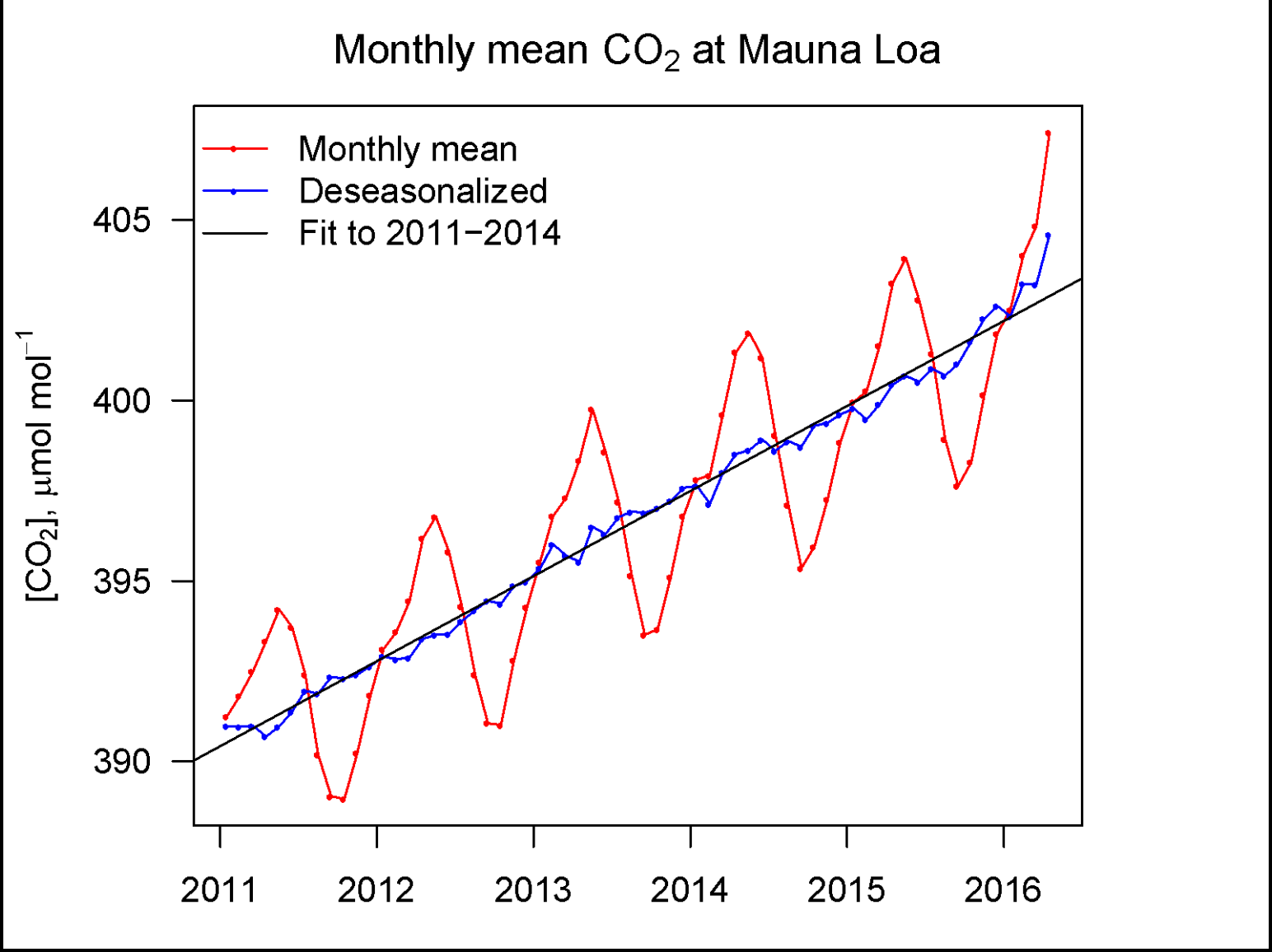


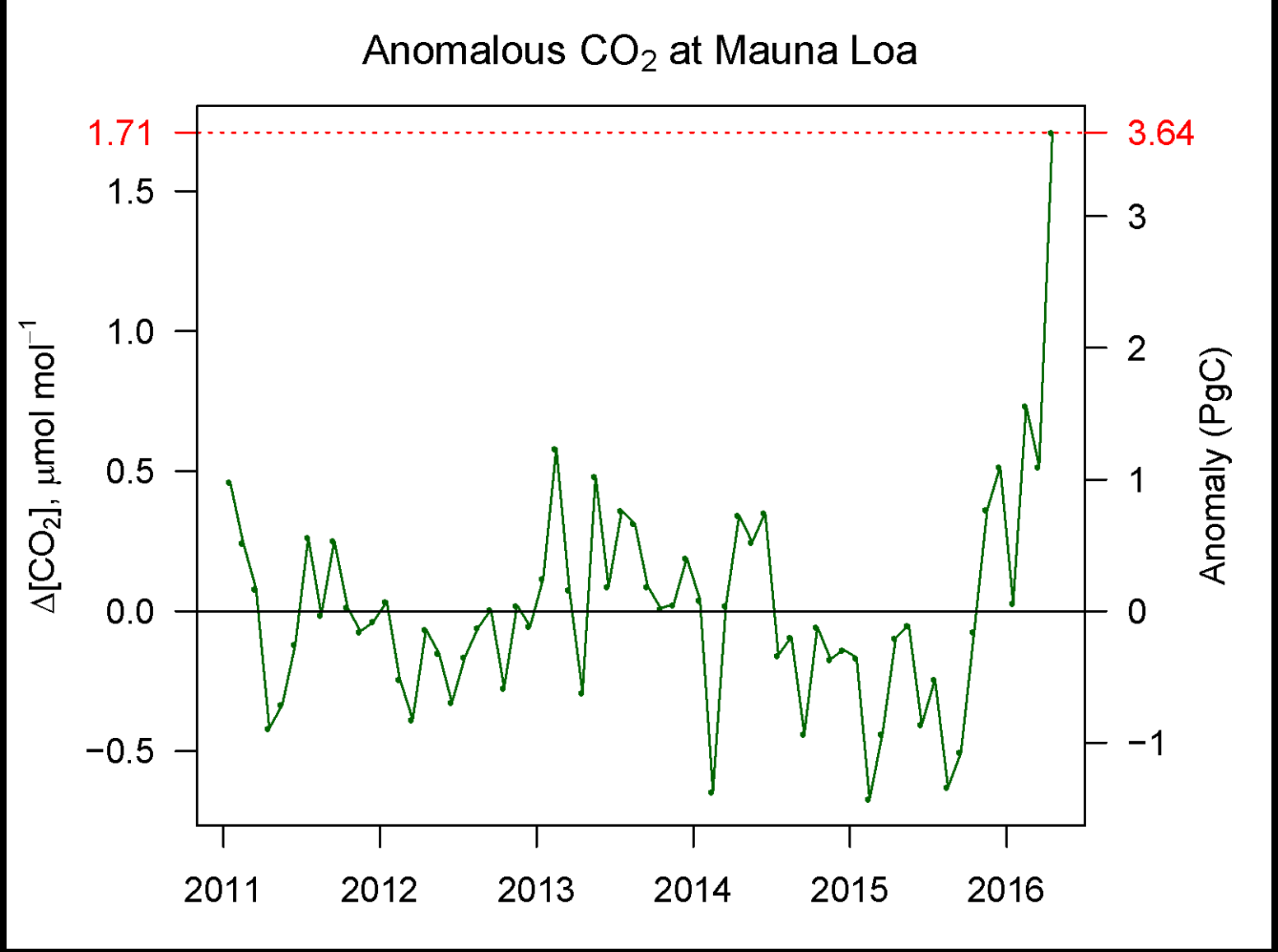


Week ending on May 15, 2016: 407.84 ppm
Weekly value from 1 year ago: 403.83 ppm

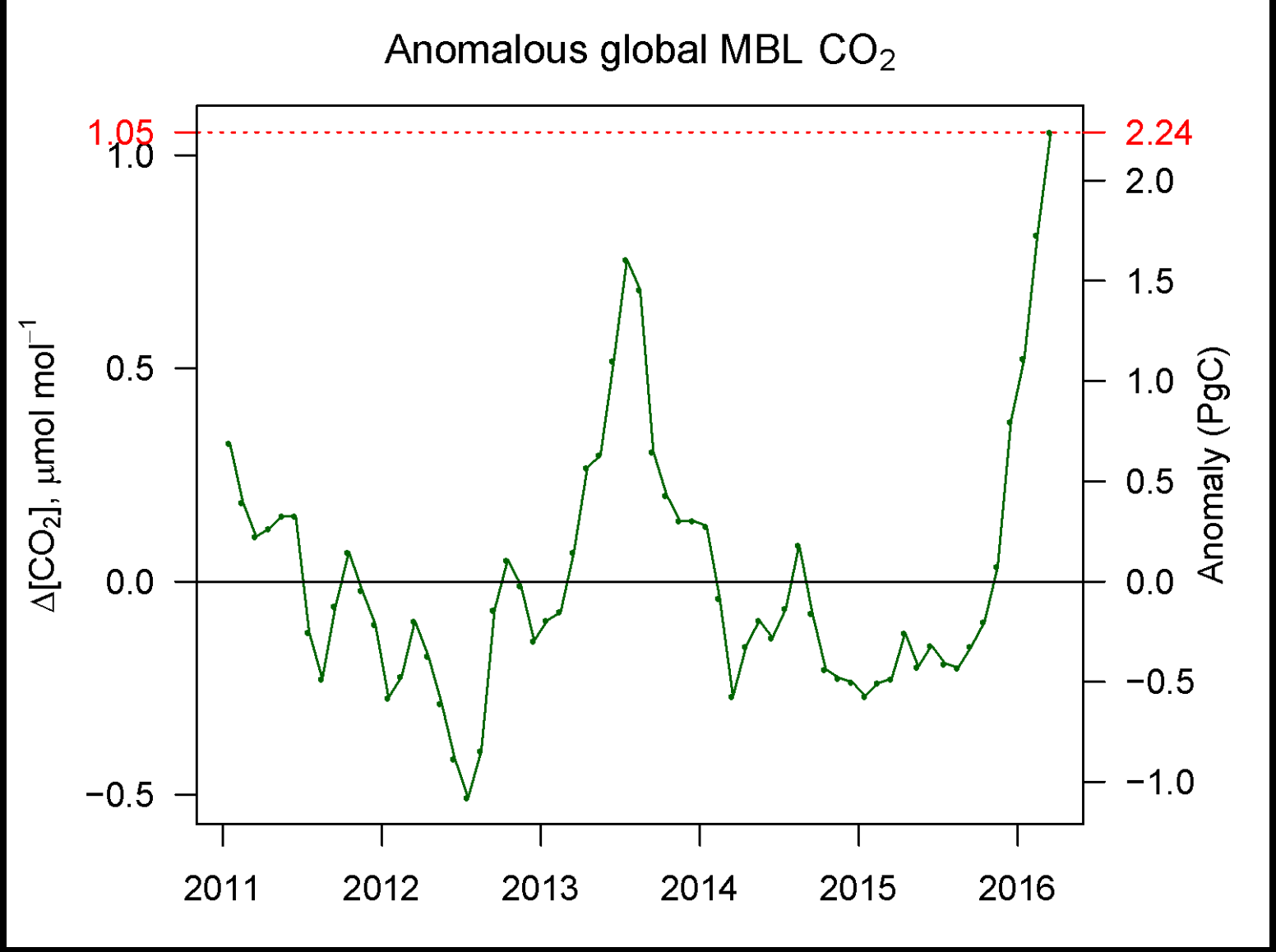

MEI
Volcanoes
El Niño
La Niña
1982−83
1997−98
2015−16
Mt.Agung
El Chichon
Mt. Pinatubo
3
2
1
0
−1
−2
1950
1955
1960
1965
1970
1975
1983
1990
1998
2005
2010
2016
Nino 3.4
29
28
27
26
25
1950
1955
1960
1965
1970
1975
1983
1990
1998
2005
2010
2016


CO_2 zonal−mean growth rate (μmol yr^{-1})
90°N
30°N
Eq
30°S
90°S
1980
1985
1990
1995
2000
2005
2010
2015
3
2
1
0


Monthly mean CO_2 at Mauna Loa
Monthly mean
Deseasonalized
Fit to 2011−2014
405
400
395
390
$[CO_2]$, μmol mol^{-1}
2011
2012
2013
2014
2015
2016


Anomalous CO_2 at Mauna Loa
1.71
3.64
1.5
1.0
0.5
0.0
−0.5
3
2
1
0
−1
$\Delta[CO_2]$, µmol mol^{-1}
Anomaly (PgC)
2011
2012
2013
2014
2015
2016

Note timing

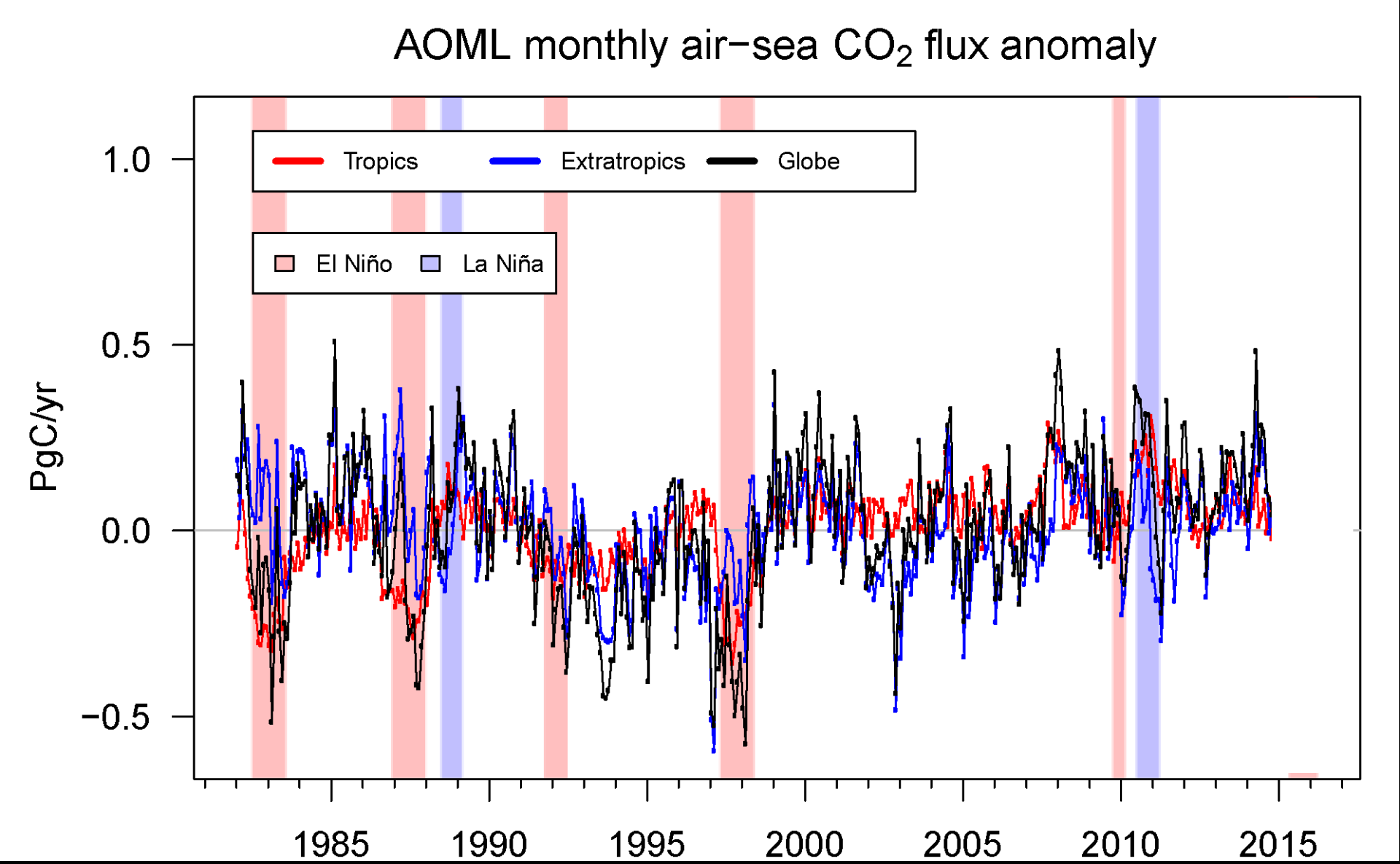

Anomalous global MBL CO_2
1.05
2.24
1.0
0.5
0.0
−0.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
$\Delta[CO_2]$, µmol mol^{-1}
Anomaly (PgC)
2011
2012
2013
2014
2015
2016

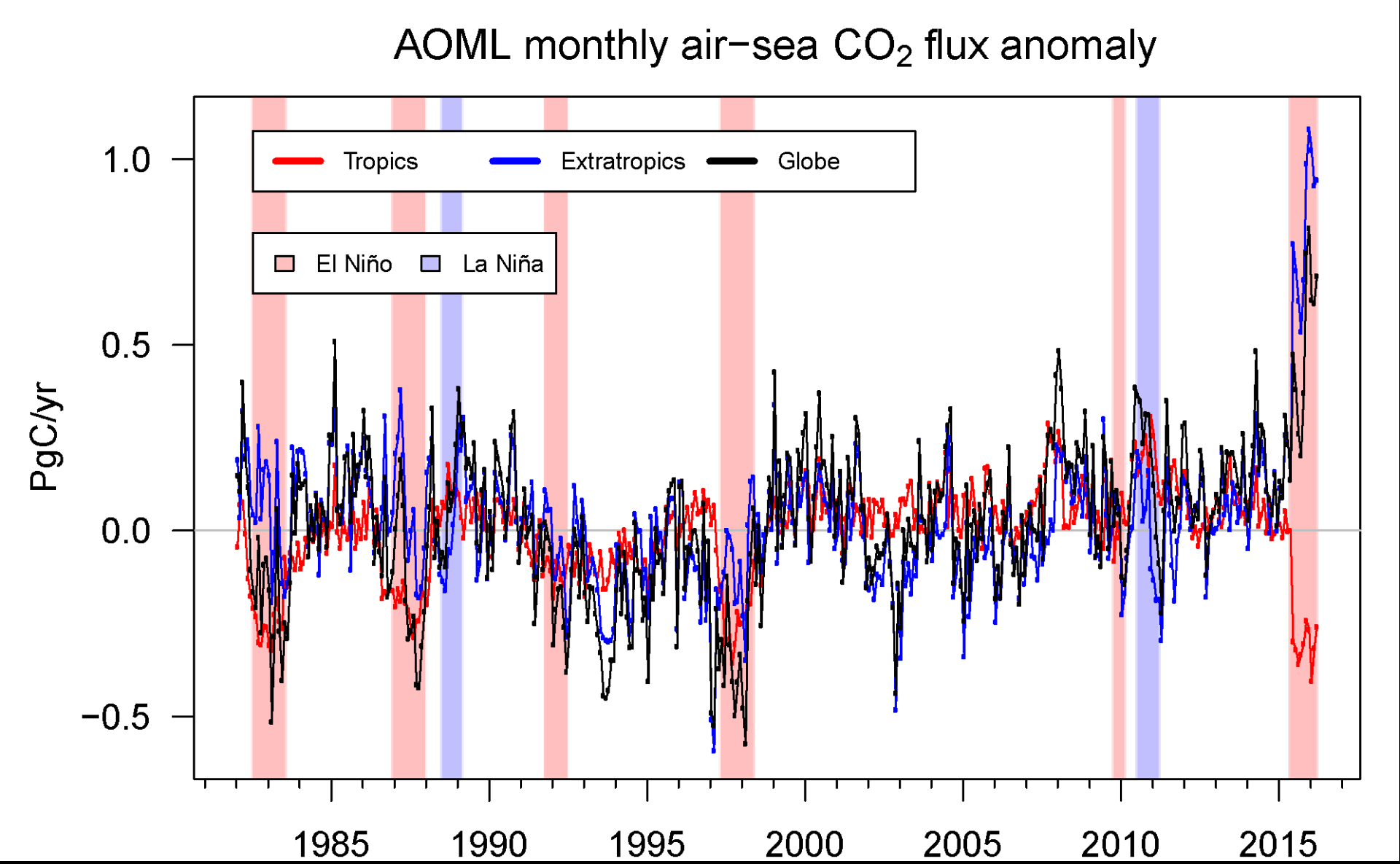
Note timing

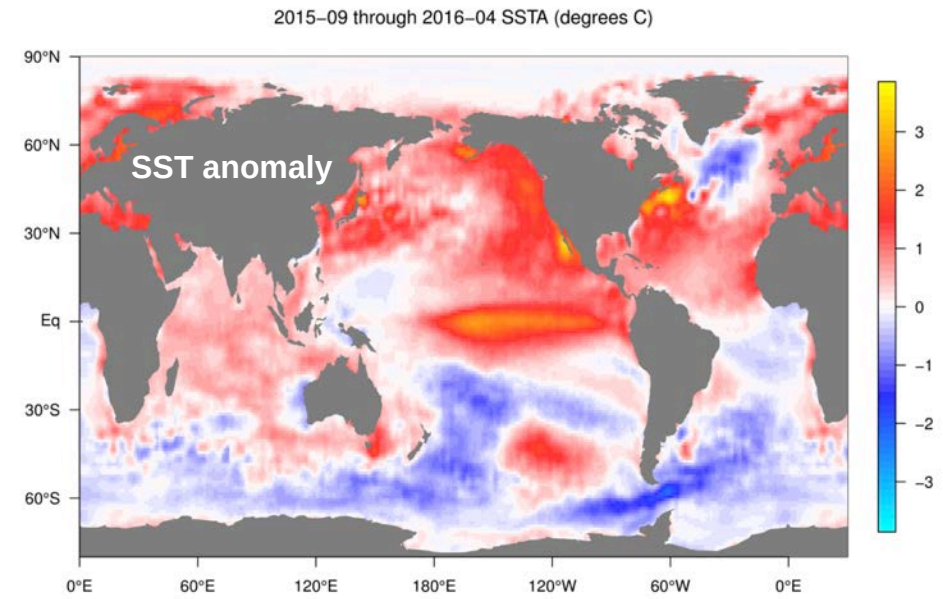
El Niño-driven anomalous CO_2 (PgC)

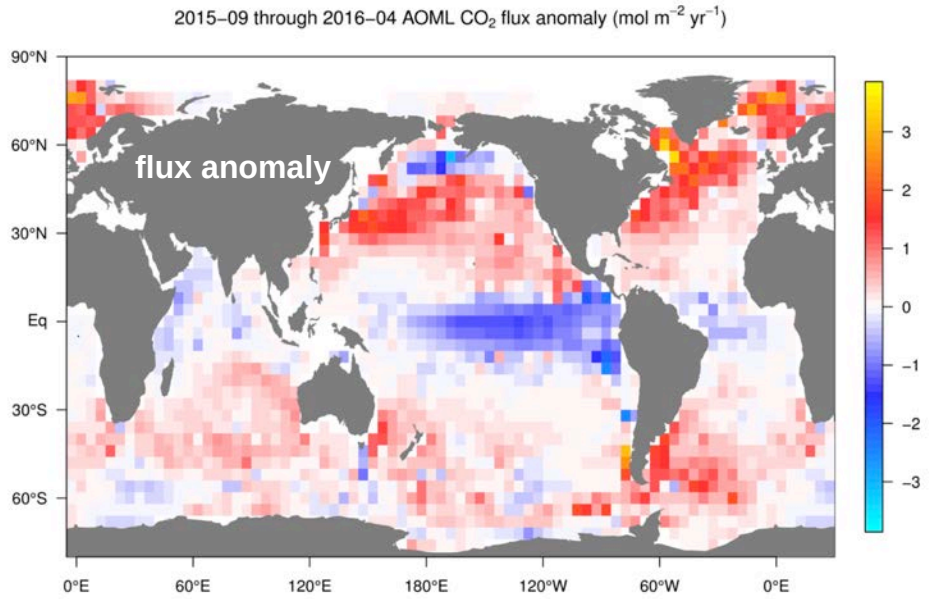
	1997-98	2015-16
Atmosphere	1.9 to 2.2[1]	2.2 to 3.6[1]

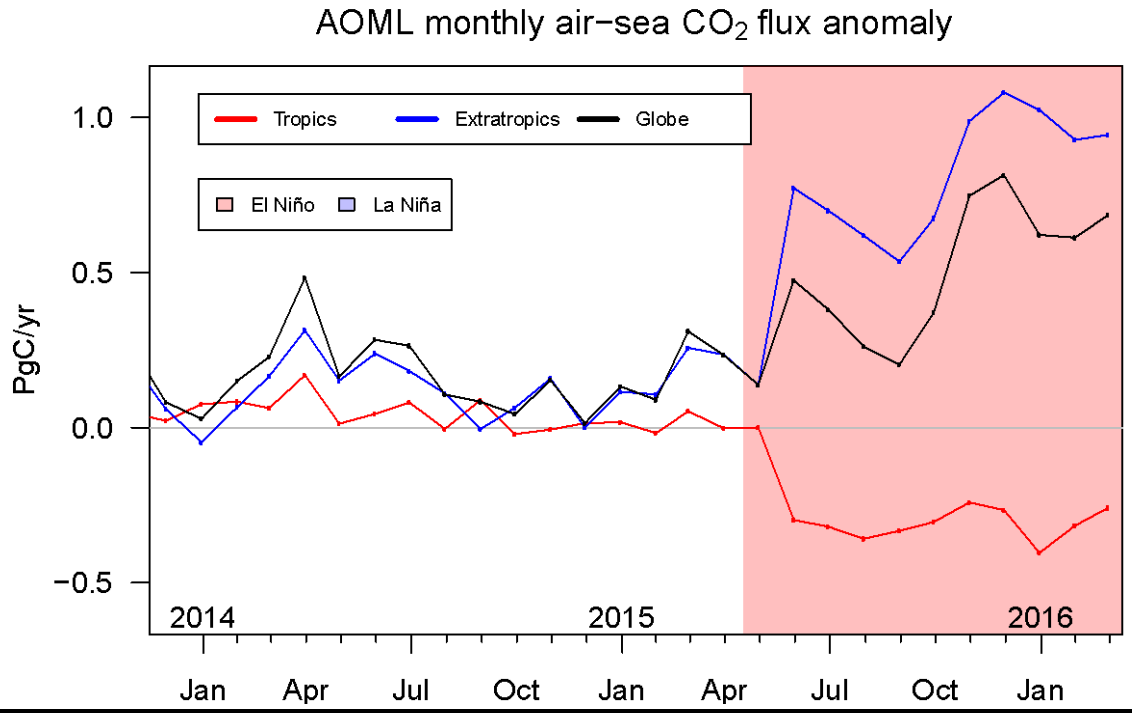
1. This work


AOML monthly air−sea CO_2 flux anomaly
Tropics
Extratropics
Globe
El Niño
La Niña
1.0
0.5
0.0
−0.5
PgC/yr
1985
1990
1995
2000
2005
2010
2015


AOML monthly air−sea CO_2 flux anomaly
Tropics
Extratropics
Globe
El Niño
La Niña
PgC/yr
1.0
0.5
0.0
−0.5
1985
1990
1995
2000
2005
2010
2015


2015–09 through 2016–04 SSTA (degrees C)
SST anomaly
90°N
60°N
30°N
Eq
30°S
60°S
0°E
60°E
120°E
180°E
120°W
60°W
0°E
3
2
1
0
−1
−2
−3


2015–09 through 2016–04 AOML CO2 flux anomaly (mol m−2 yr−1)
flux anomaly
90°N
60°N
30°N
Eq
30°S
60°S
0°E
60°E
120°E
180°E
120°W
60°W
0°E
3
2
1
0
−1
−2
−3


AOML monthly air−sea CO2 flux anomaly
Tropics
Extratropics
Globe
El Niño
La Niña
PgC/yr
1.0
0.5
0.0
−0.5
2014
2015
2016
Jan
Apr
Jul
Oct
Jan
Apr
Jul
Oct
Jan

El Niño-driven anomalous CO_2 (PgC)

	1997-98	2015-16
Atmosphere	1.9 to 2.2[1]	2.2 to 3.6[1]
Oceans	-0.5[2] to -0.7[3]	(-0.3 to) 0.4[2]

1. This work
2. NOAA AOML monthly pCO_2
3. Chavez *et al.* (Science, 1999)

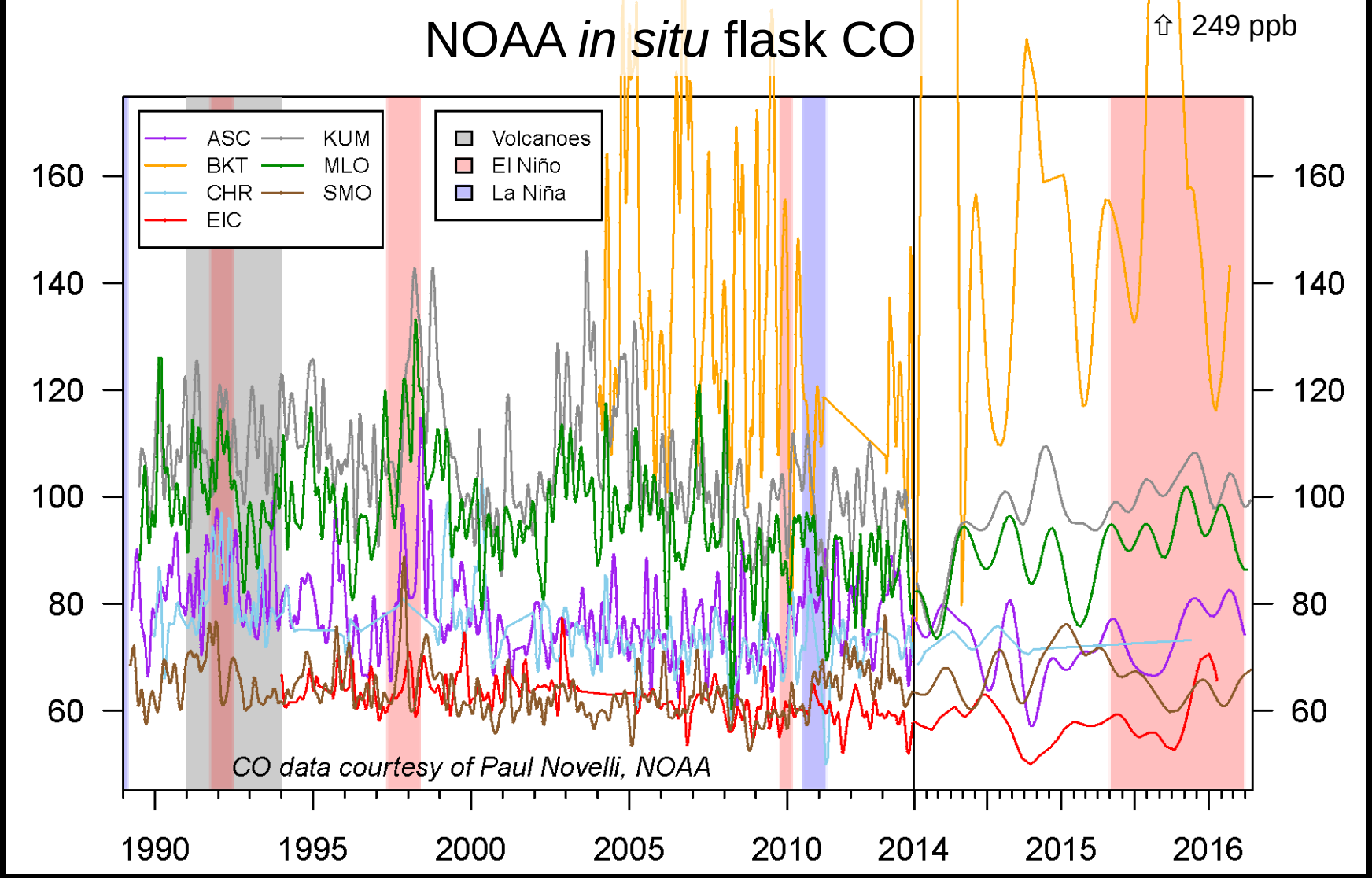
Apocalyptic fire season?

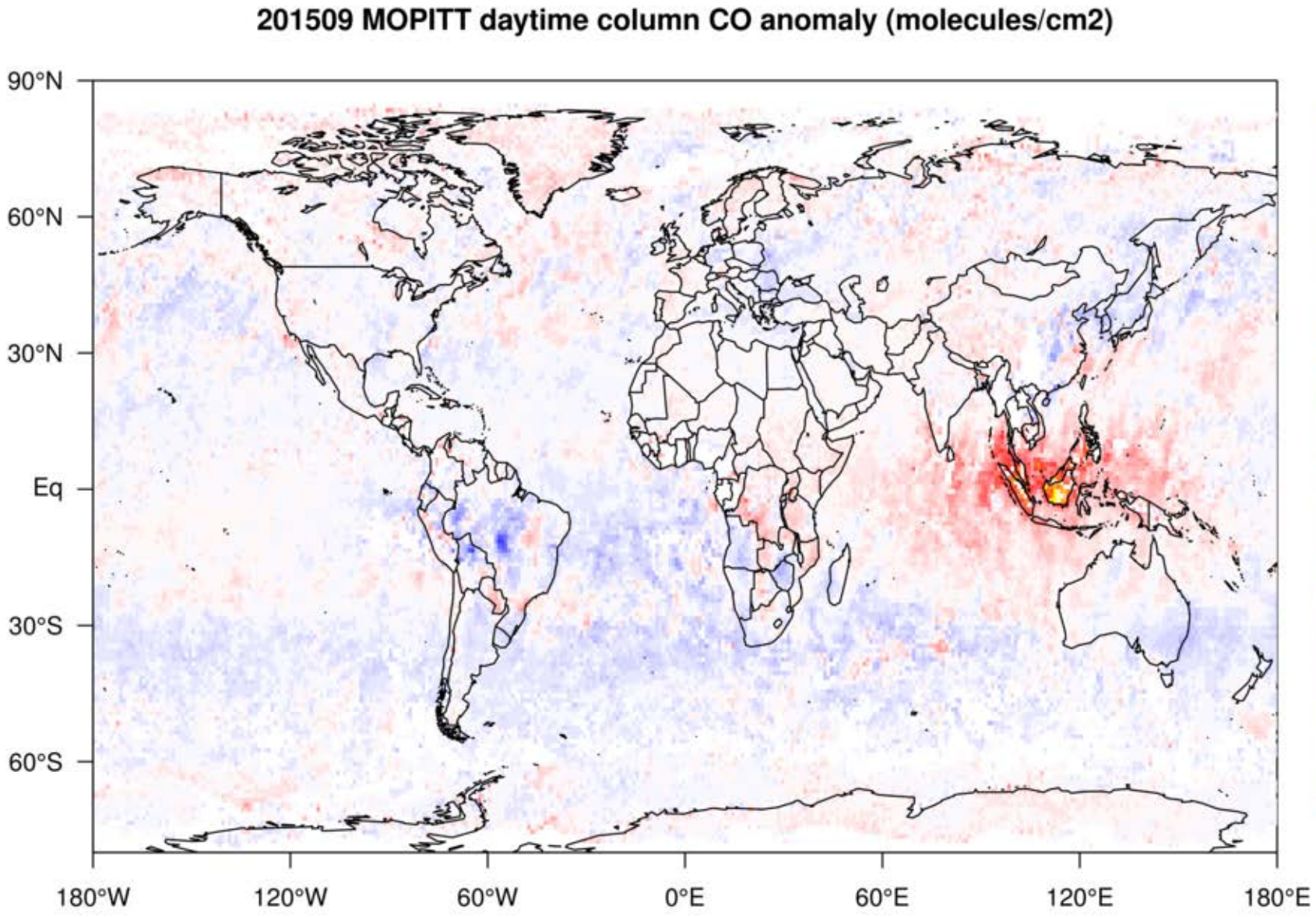
Not according to MODIS-driven fire models (GFAS and FINN).

Perhaps smoldering peat fires?

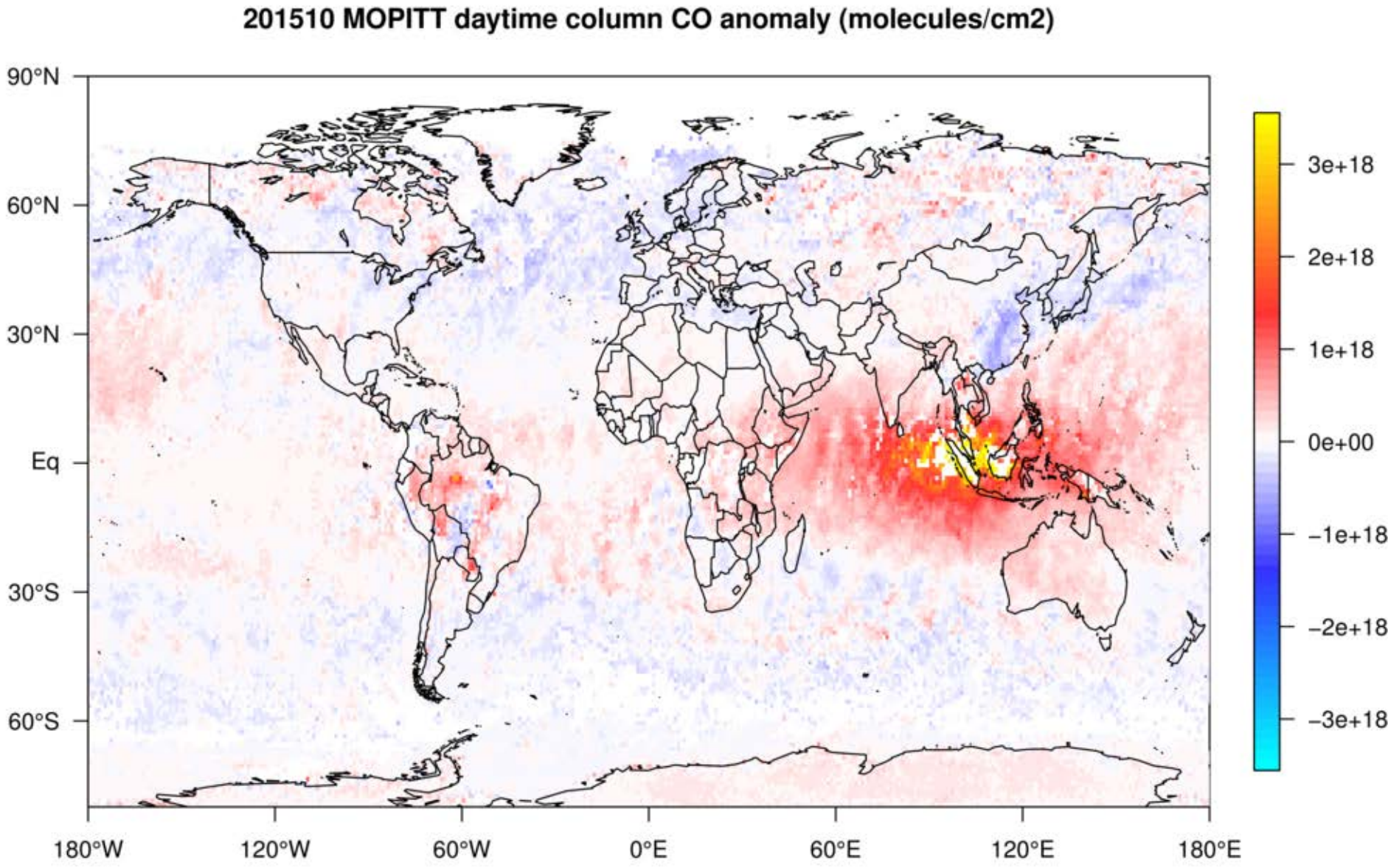
Photo credit: Martin Wooster

NOAA *in situ* flask CO





Referenced to 2000-2014 MOPITT CO climatology



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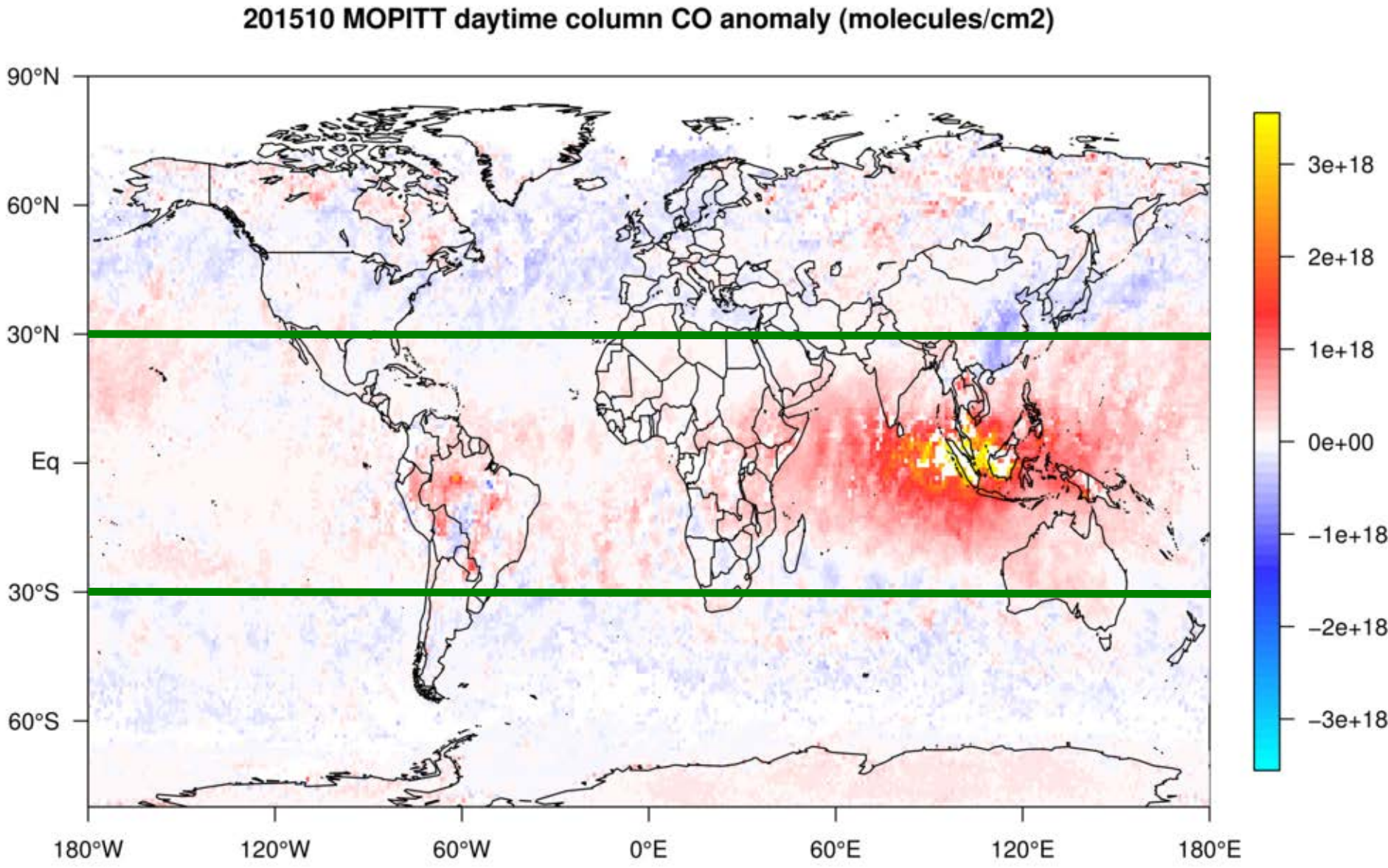

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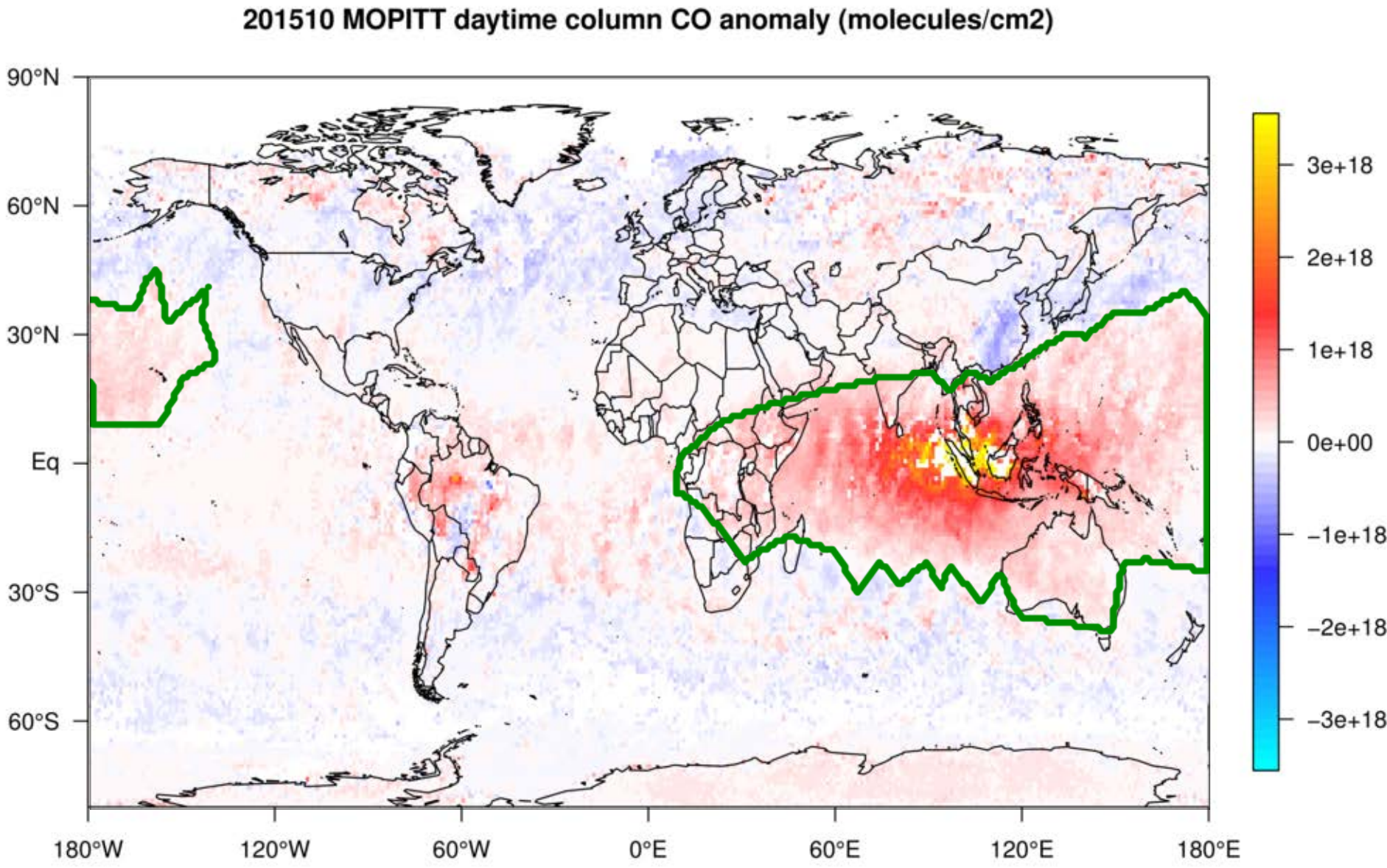

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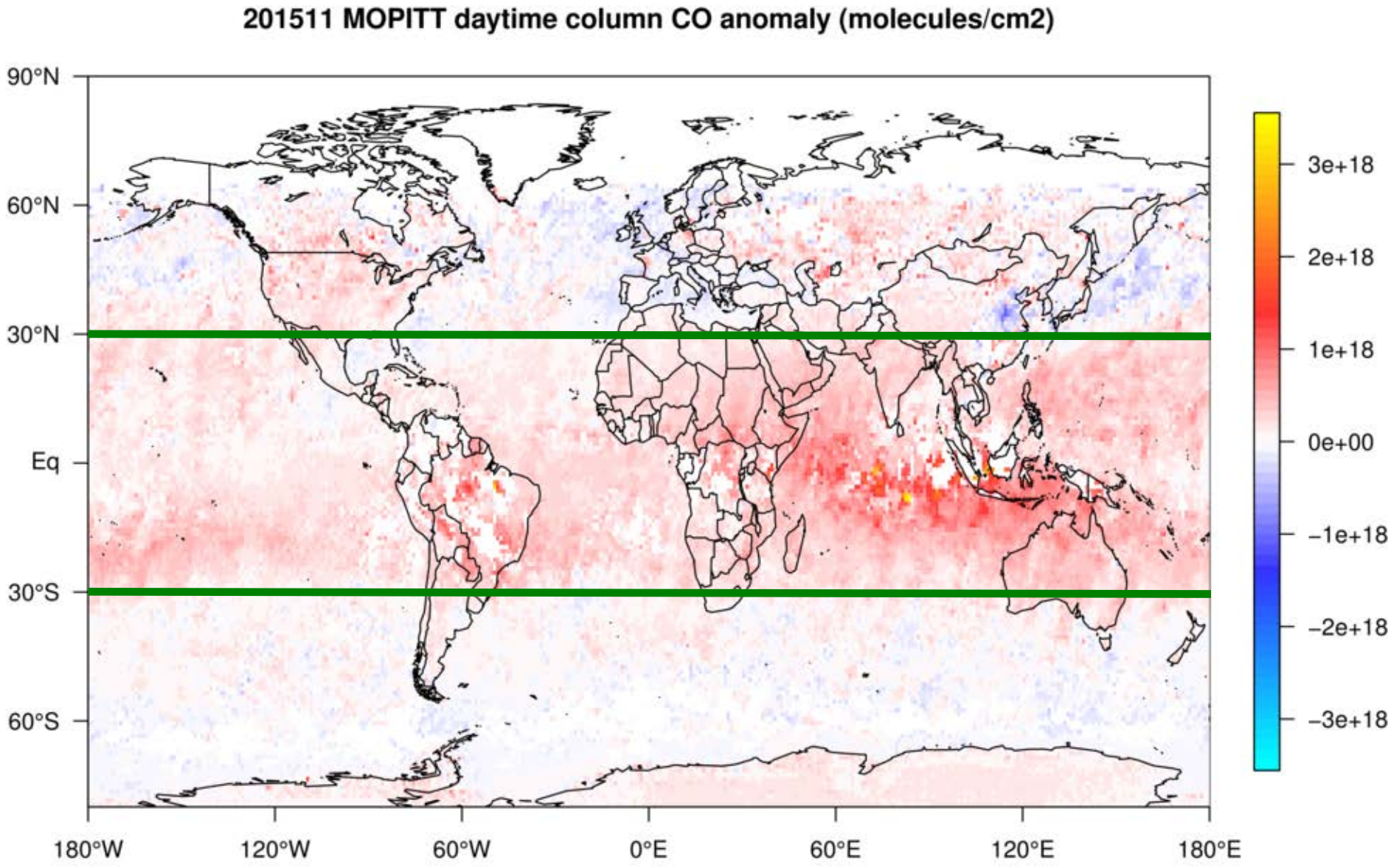


Referenced to 2000-2014 MOPITT CO climatology

2015 fire CO_2 emissions estimated from CO (TgC)

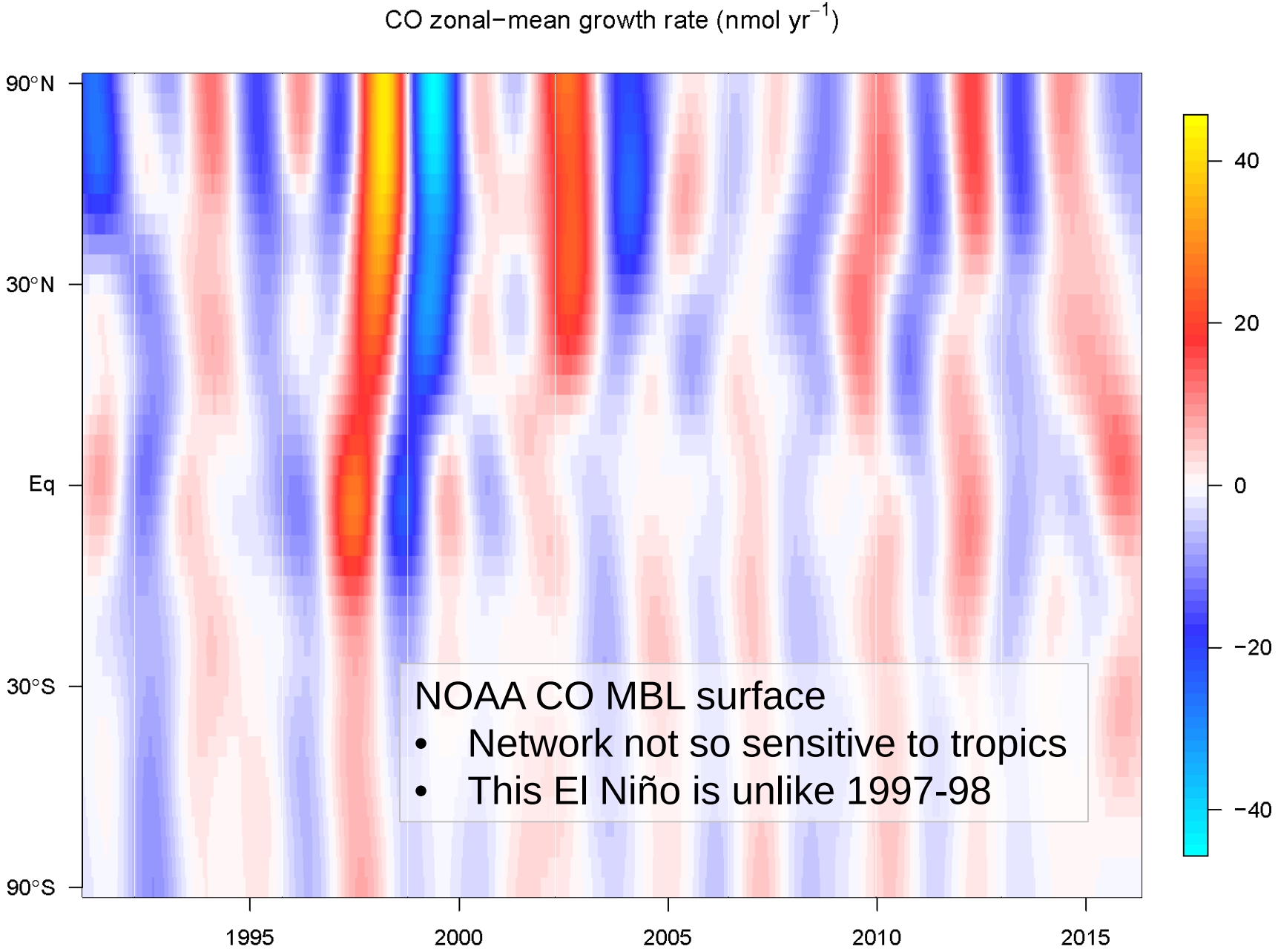
	Emission ratio (ppb CO per ppm CO_2)		
	50 *grasslands*	**100** *forest*	**150** *forest & peat*
Sep 2015 – 30° S to 30° N	45.0	22.5	15.0
Oct 2015 – 30° S to 30° N	239.9	119.9	80.0
Oct 2015 - plume	209.2	104.6	69.7
Nov 2015 – 30° S to 30° N	302.1	151.0	100.7
Sep through Nov 2015 total ***assumes 1 month CO decay time***	**587.0**	**293.4**	**195.7**

Thanks to John Miller for help in this analysis

El Niño-driven anomalous CO_2 (PgC)

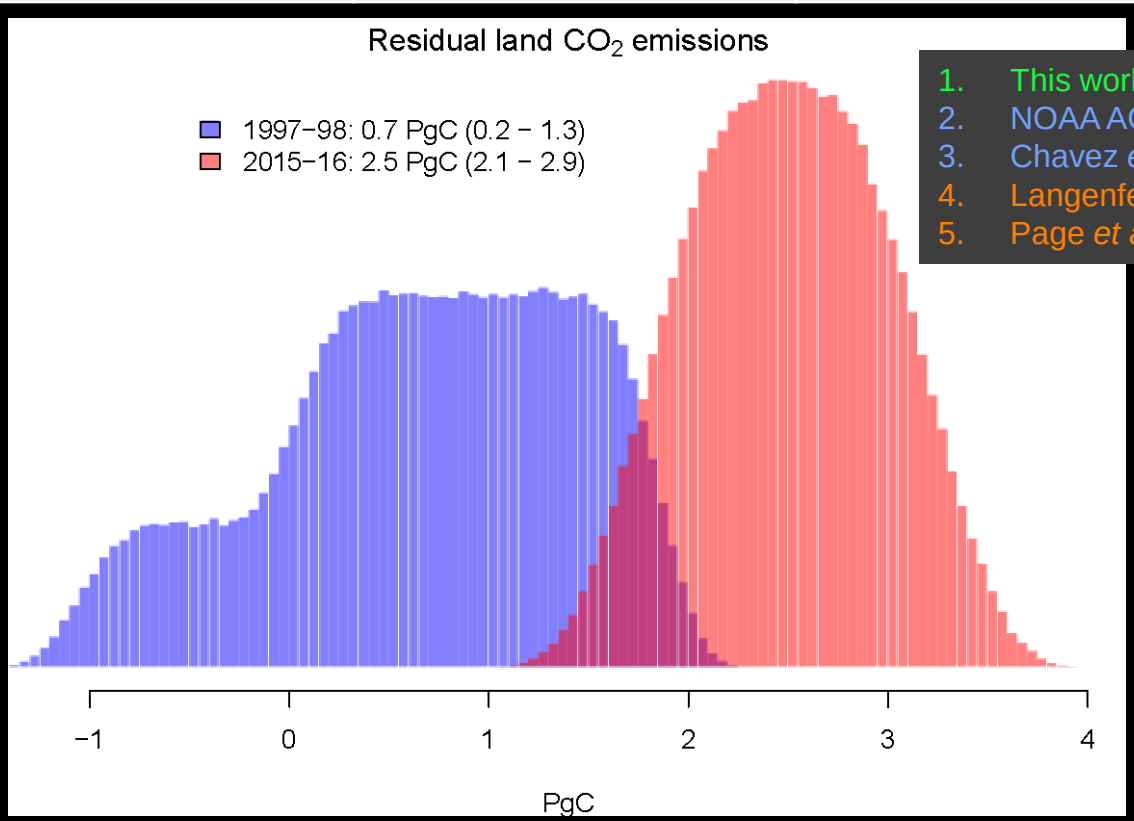
	1997-98	2015-16
Atmosphere	1.9 to 2.2[1]	2.2 to 3.6[1]
Oceans	-0.5[2] to -0.7[3]	(-0.3 to) 0.4[2]
Fire	0.8 to 3.7[4] 0.8 to 2.6[5]	0.1 to 0.3[1]

1. This work
2. NOAA AOML monthly pCO_2
3. Chavez *et al.* (Science, 1999)
4. Langenfelds *et al.* (GBC, 2002)
5. Page *et al.* (Nature, 2002)


CO zonal−mean growth rate (nmol yr^{-1})
90°N
30°N
Eq
30°S
90°S
1995
2000
2005
2010
2015
40
20
0
−20
−40
NOAA CO MBL surface
• Network not so sensitive to tropics
• This El Niño is unlike 1997-98

El Niño-driven anomalous CO_2 (PgC)

	1997-98	2015-16
Atmosphere	1.9 to 2.2[1]	2.2 to 3.6[1]
Oceans	-0.5[2] to -0.7[3]	(-0.3 to) 0.4[2]
Fire	0.8 to 3.7[4] 0.8 to 2.6[5]	0.1 to 0.3[1]
Residual land	0.2 to 1.3[1]	2.1 to 2.9[1]



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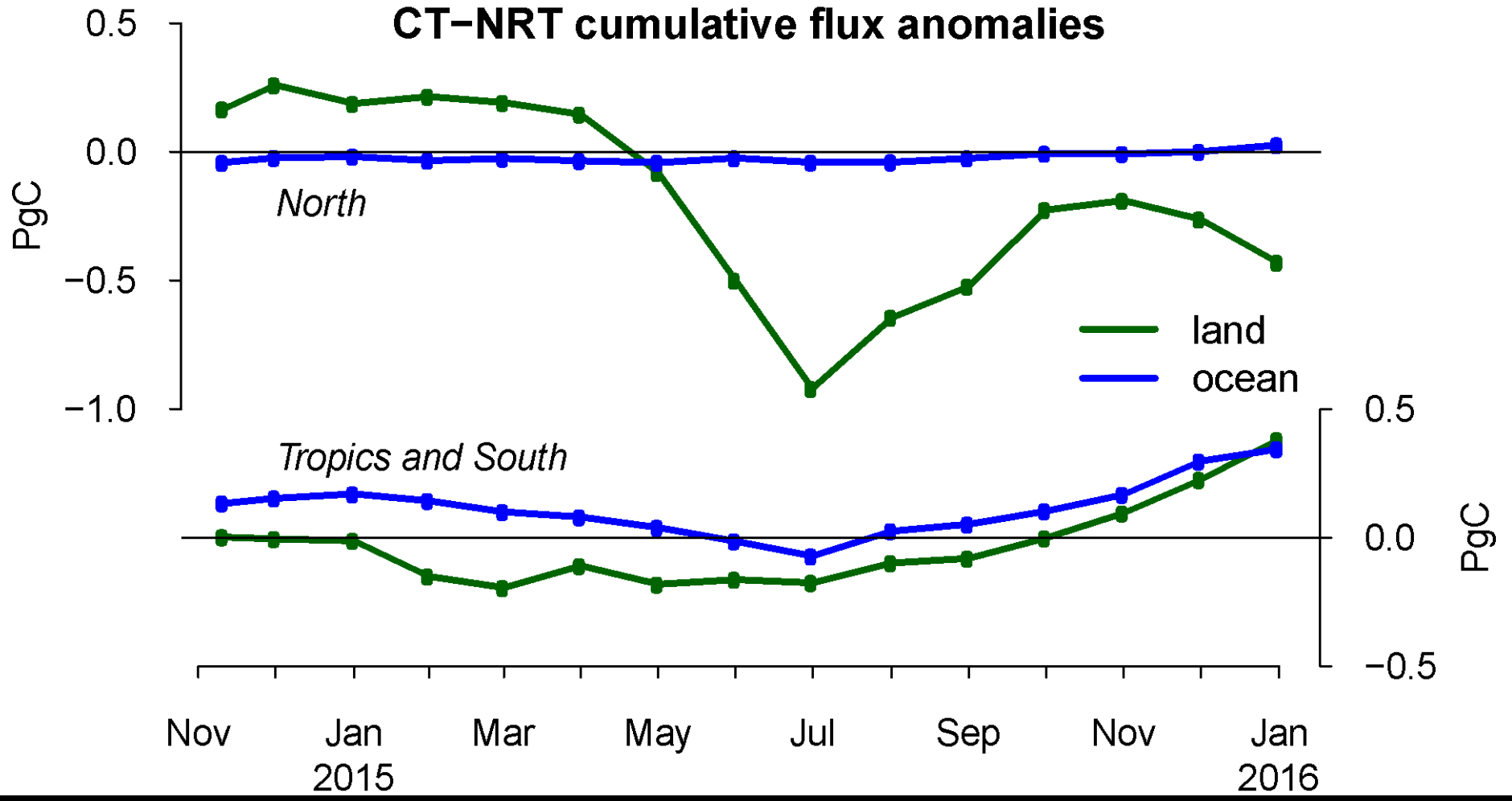
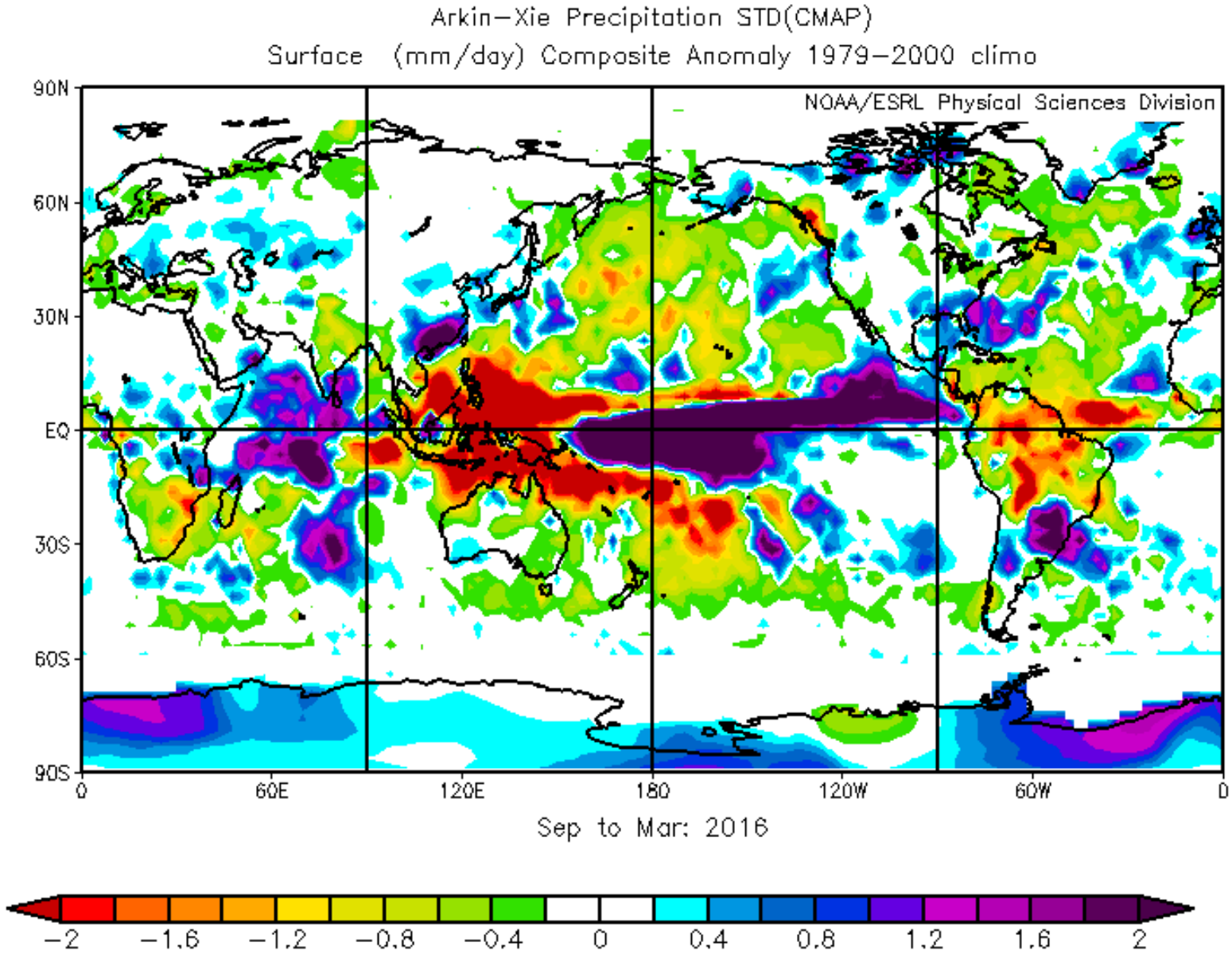
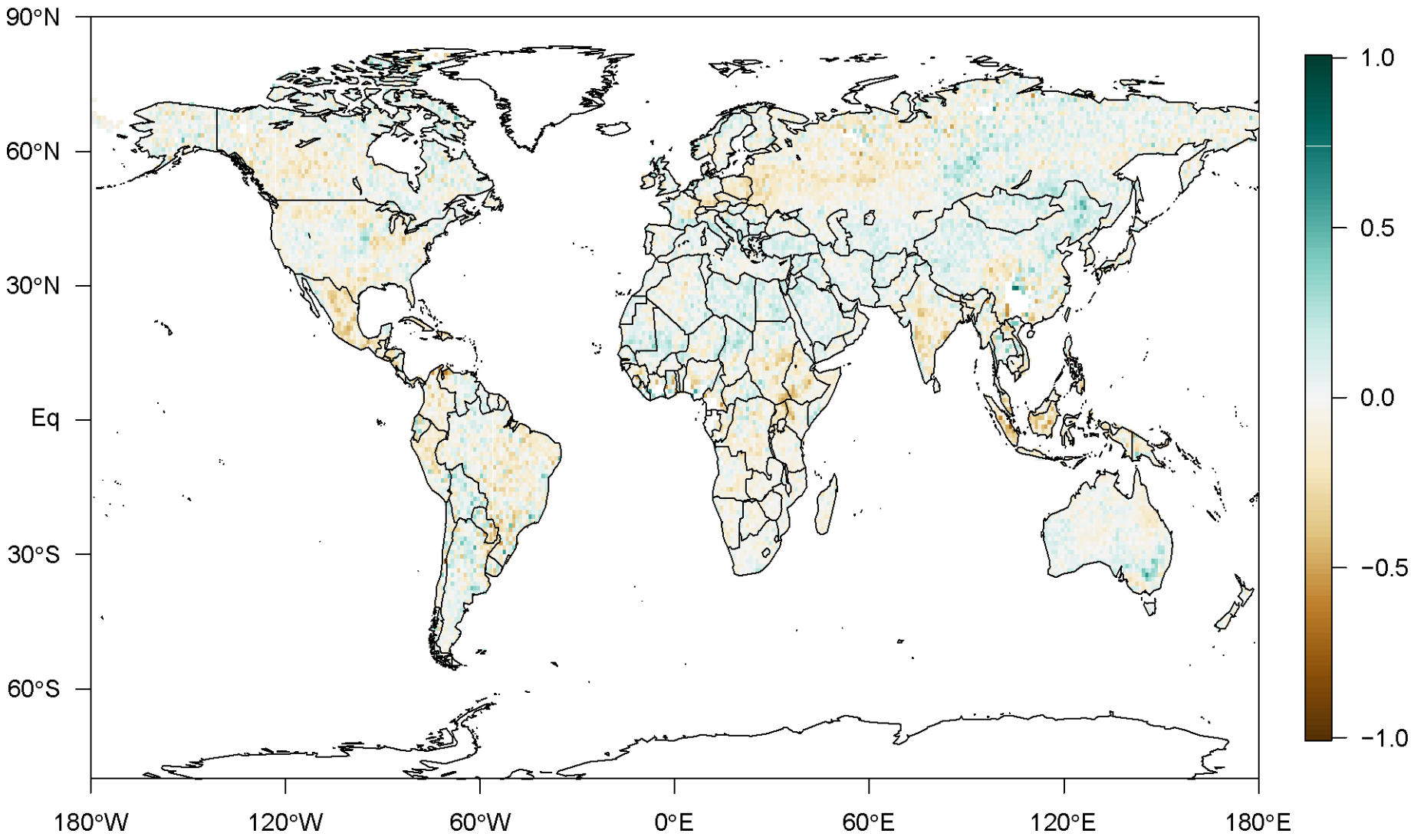
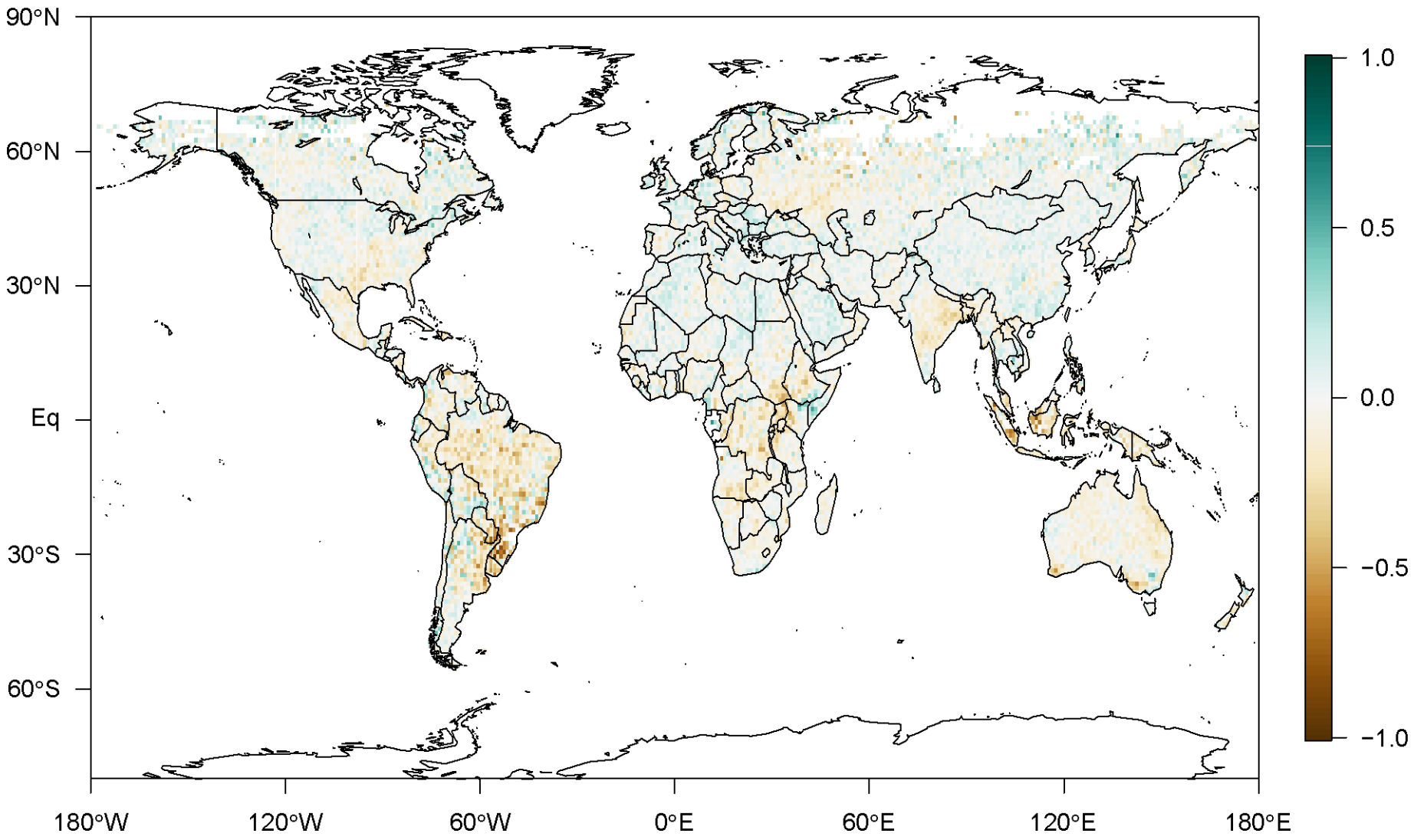


Through January 2016, CT-NRT sees an anomaly of only about 0.4 PgC.


Arkin–Xie Precipitation STD(CMAP)
Surface (mm/day) Composite Anomaly 1979–2000 climo
NOAA/ESRL Physical Sciences Division
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
Sep to Mar: 2016
−2
−1.6
−1.2
−0.8
−0.4
0
0.4
0.8
1.2
1.6
2



Referenced to 2007-2014 GOME-2 SIF climatology



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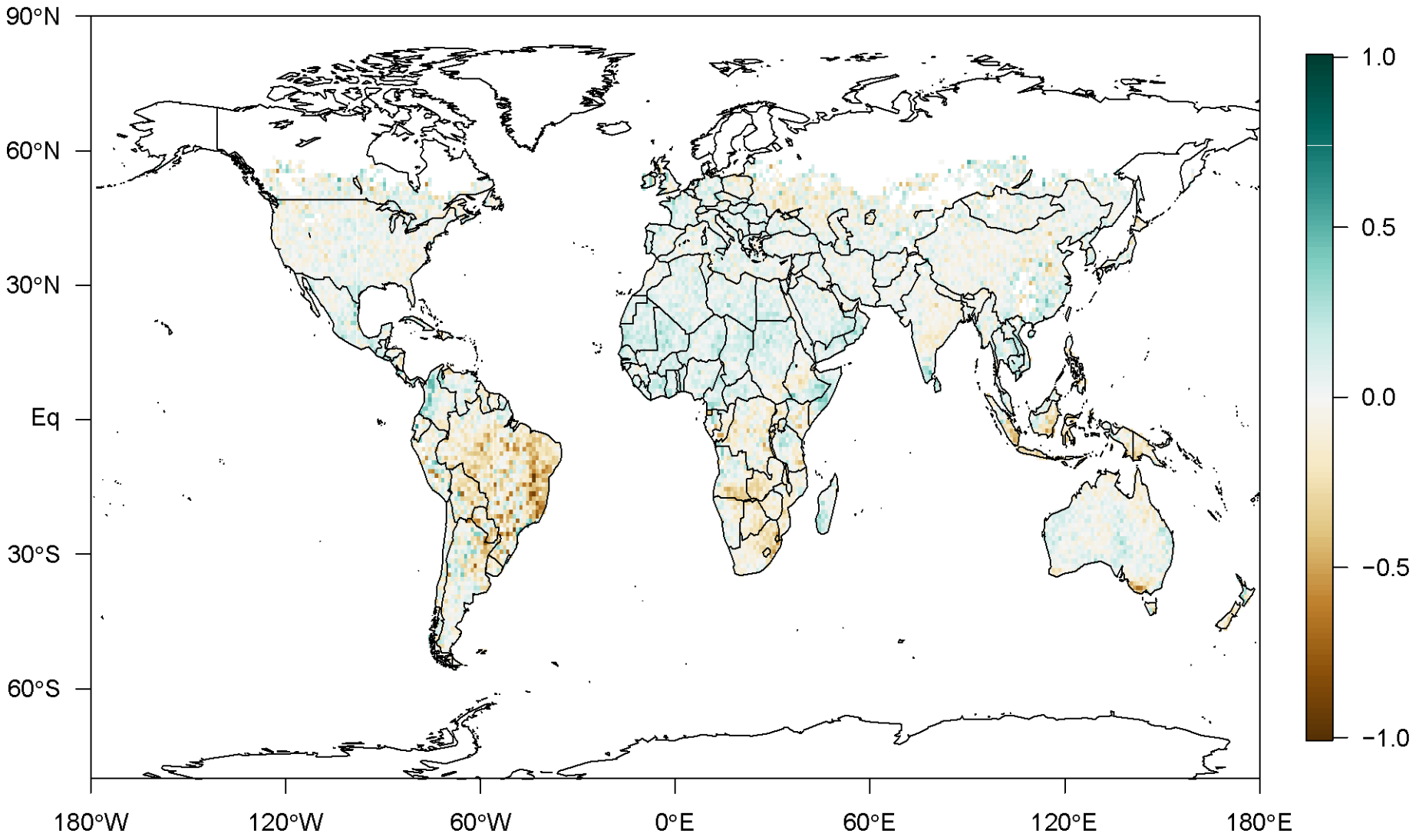

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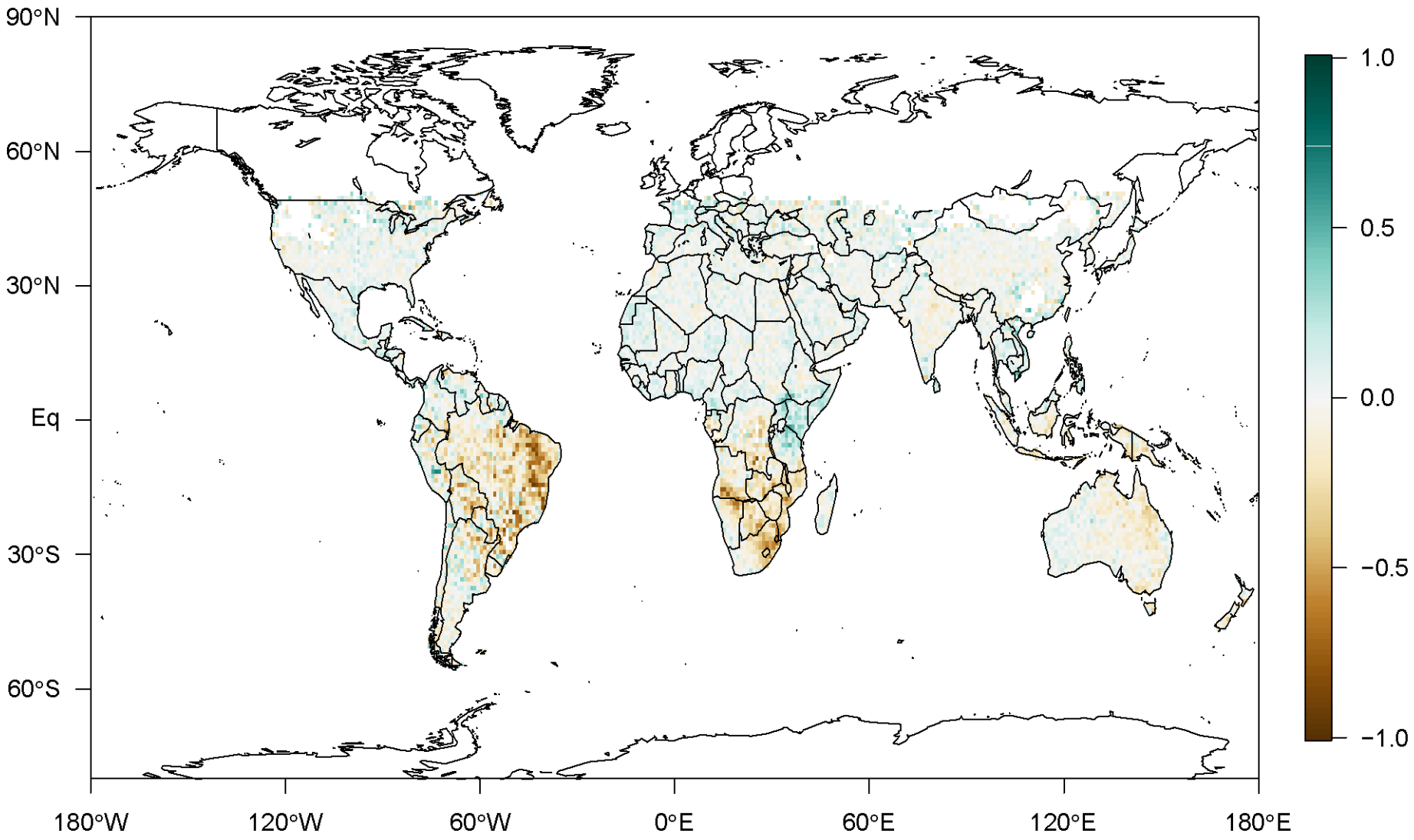

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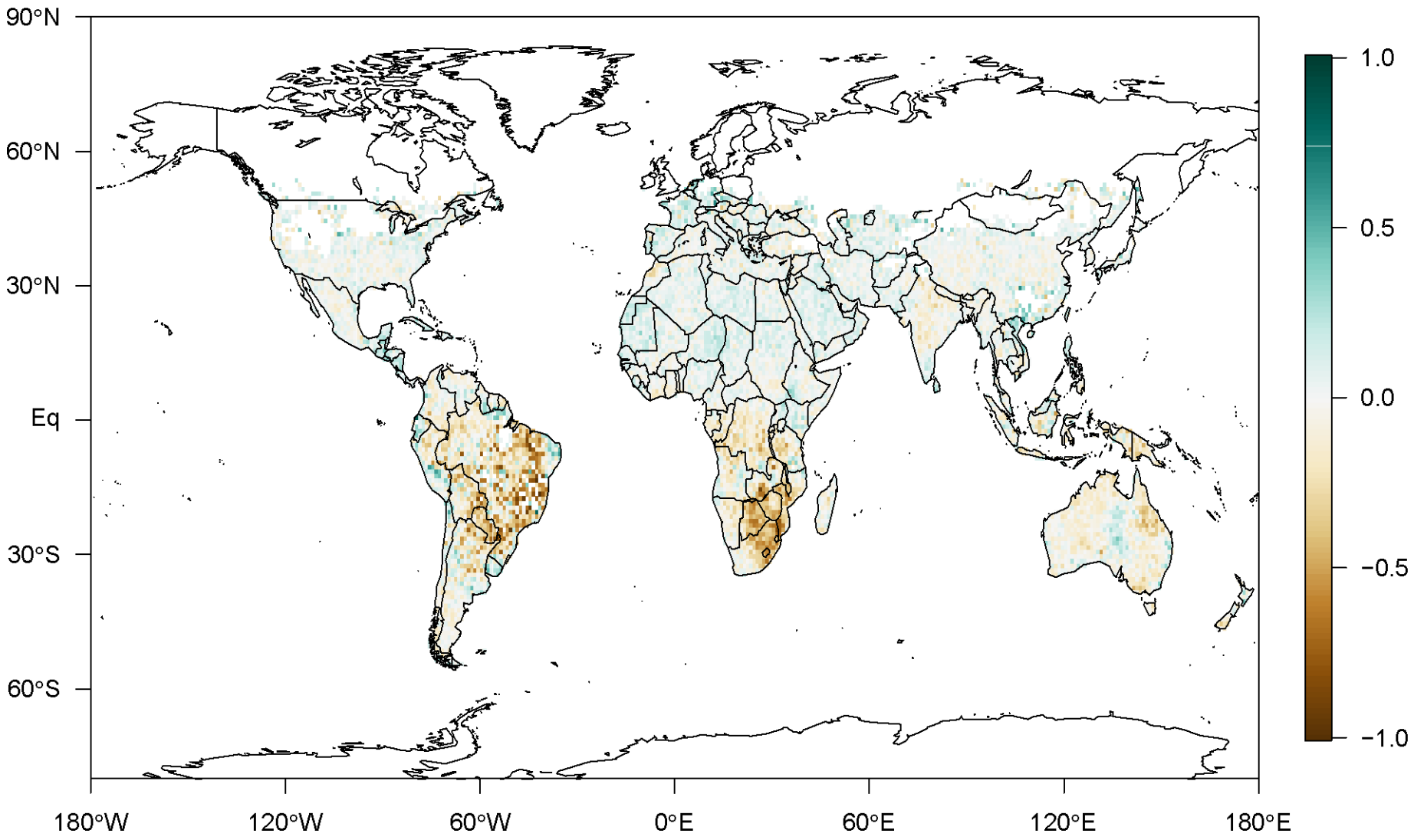

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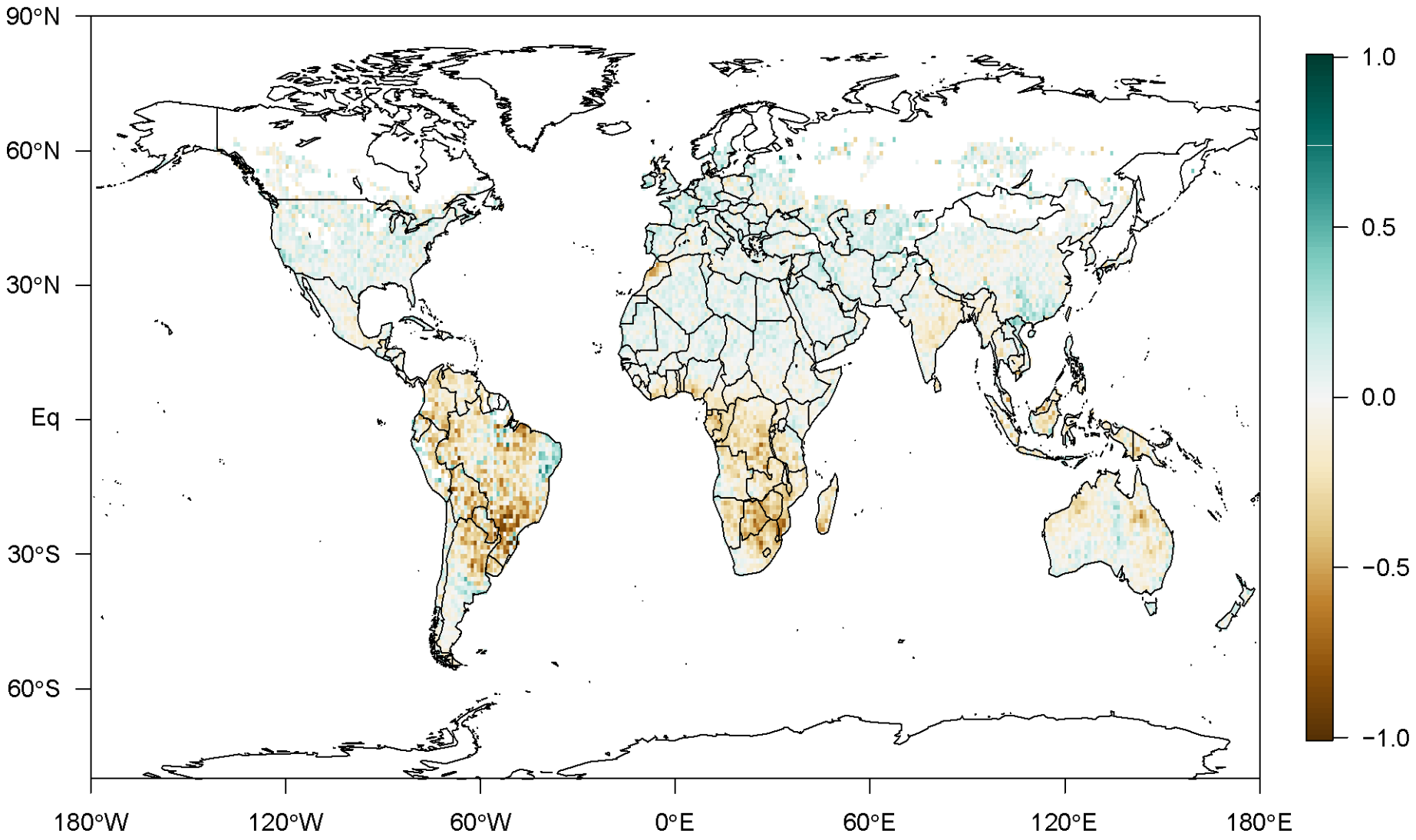

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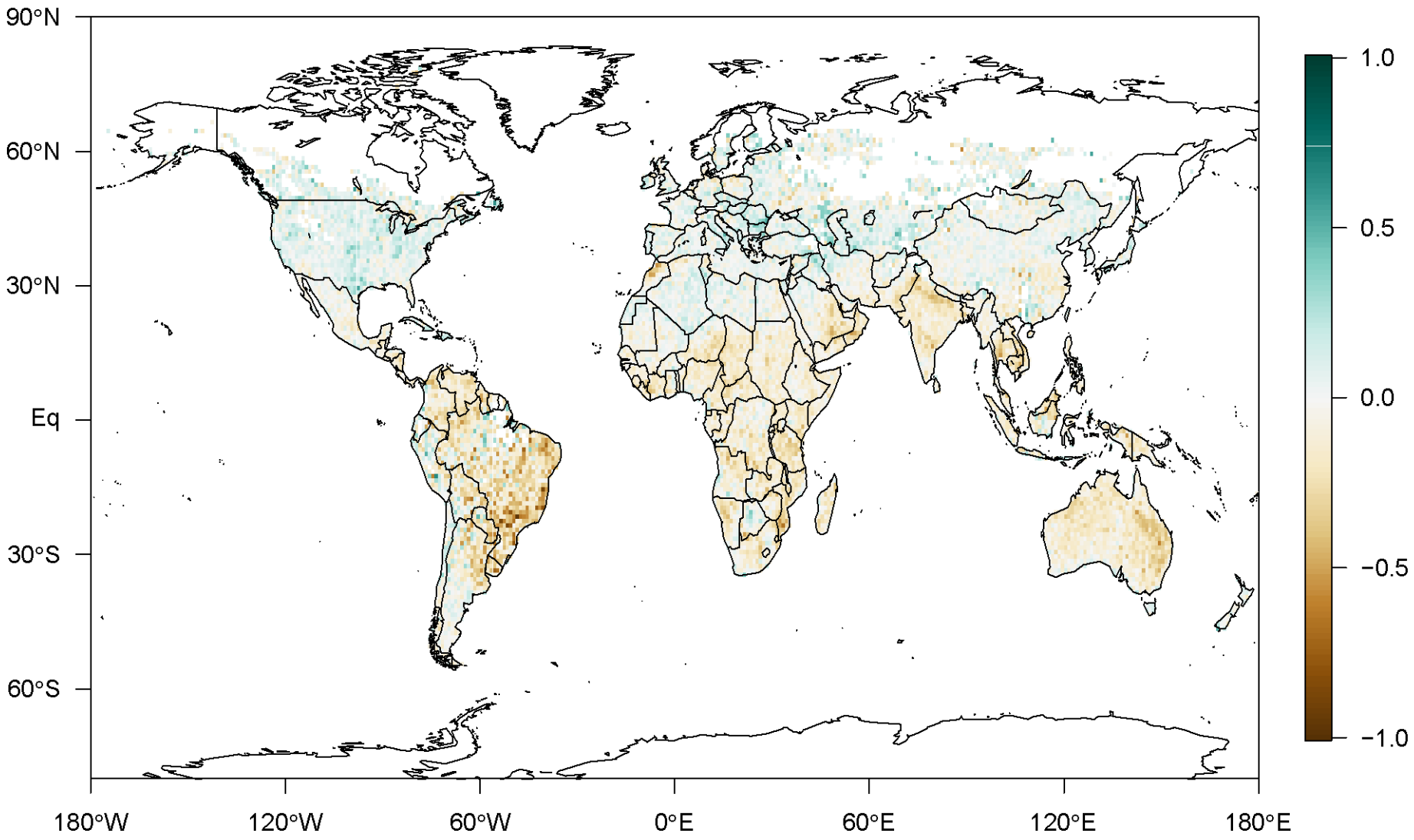

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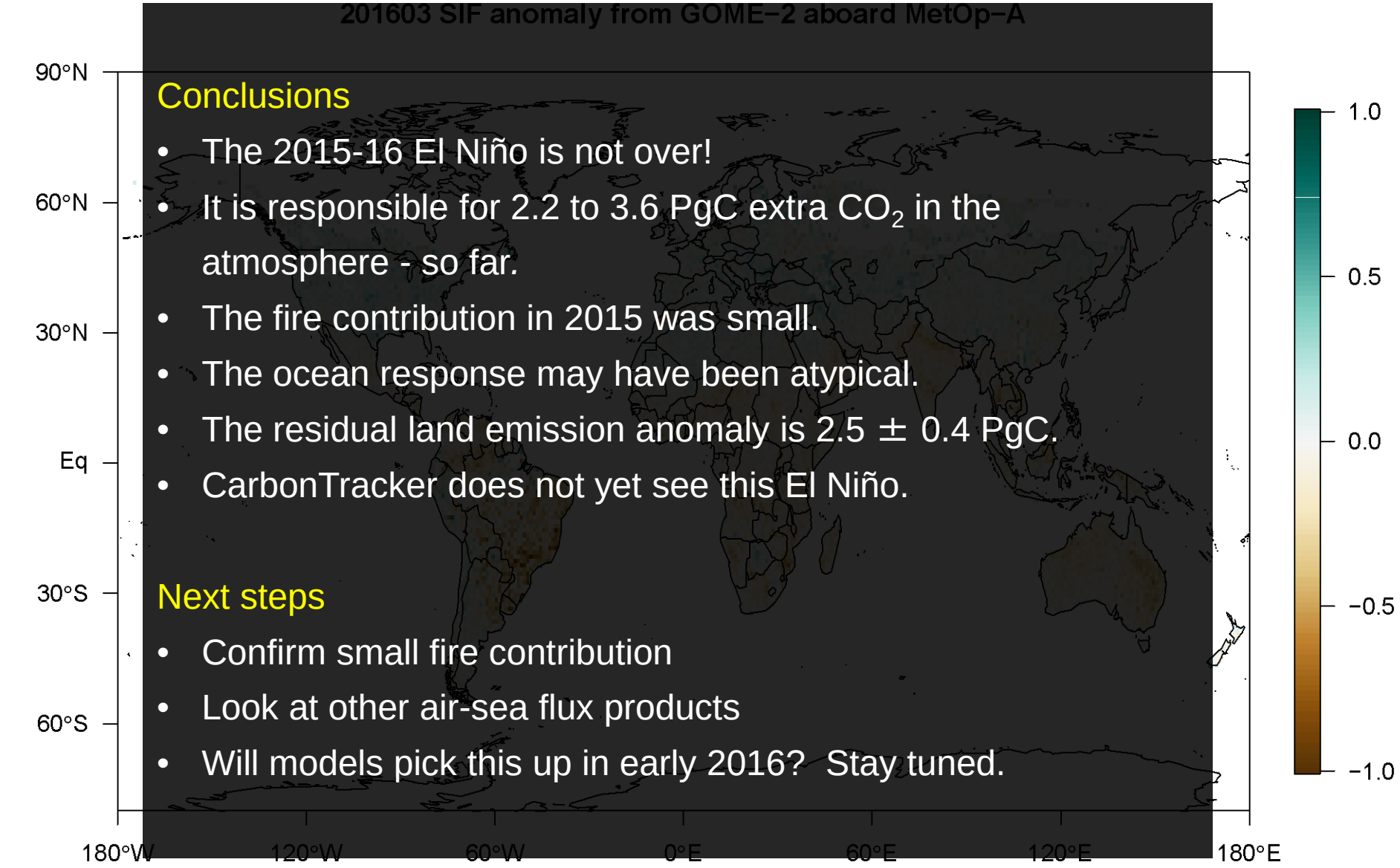

Conclusions

- The 2015-16 El Niño is not over!
- It is responsible for 2.2 to 3.6 PgC extra CO_2 in the atmosphere - so far.
- The fire contribution in 2015 was small.
- The ocean response may have been atypical.
- The residual land emission anomaly is 2.5 ± 0.4 PgC.
- CarbonTracker does not yet see this El Niño.

Next steps

- Confirm small fire contribution
- Look at other air-sea flux products
- Will models pick this up in early 2016? Stay tuned.