Measuring Atmospheric Carbon Dioxide with the NASA Orbiting Carbon Observatory-2 (OCO-2)

David Crisp
(Jet Propulsion Laboratory, California Institute of Technology)
for the OCO-2 Science Team

22 March 2019

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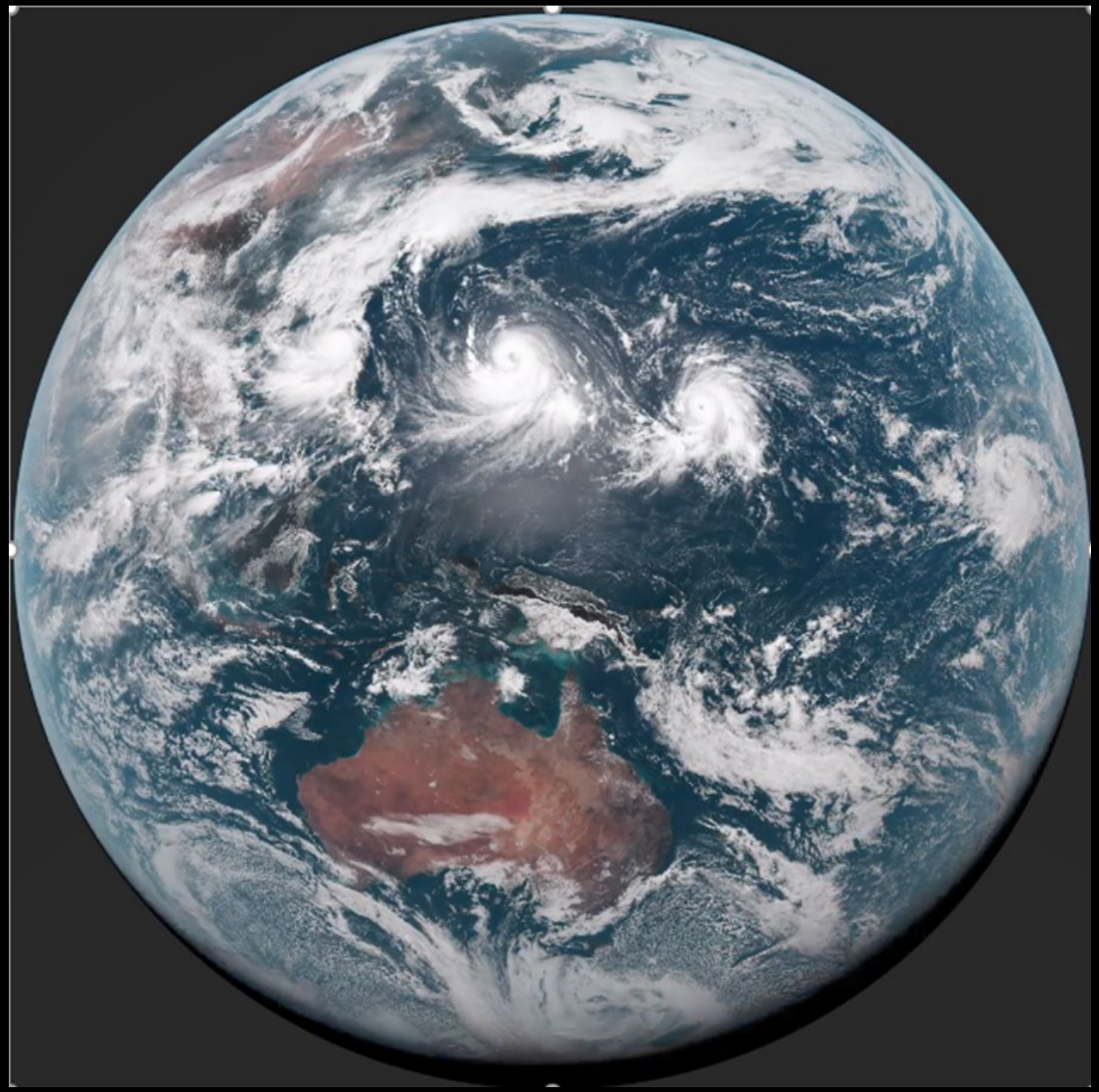
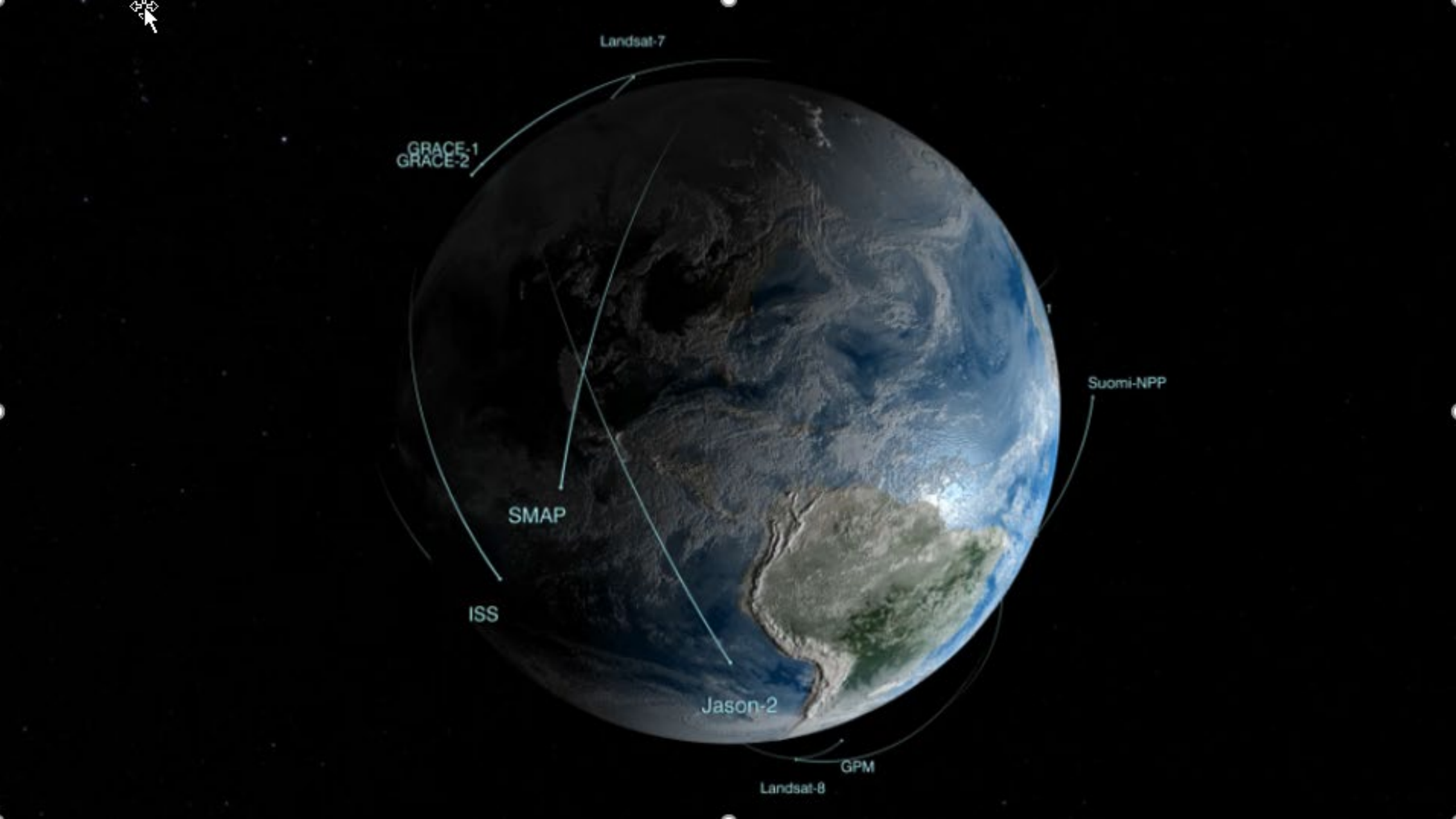
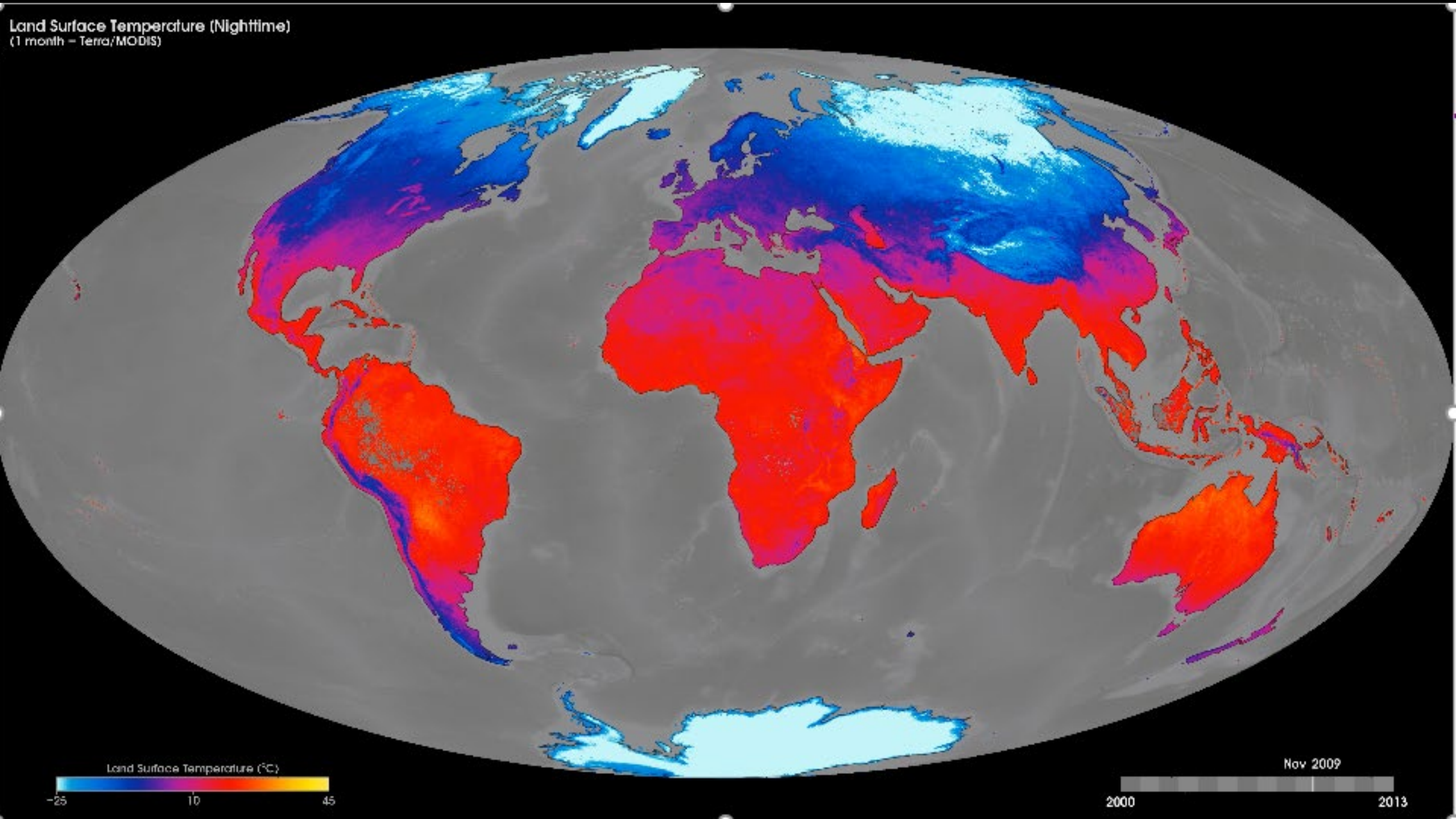
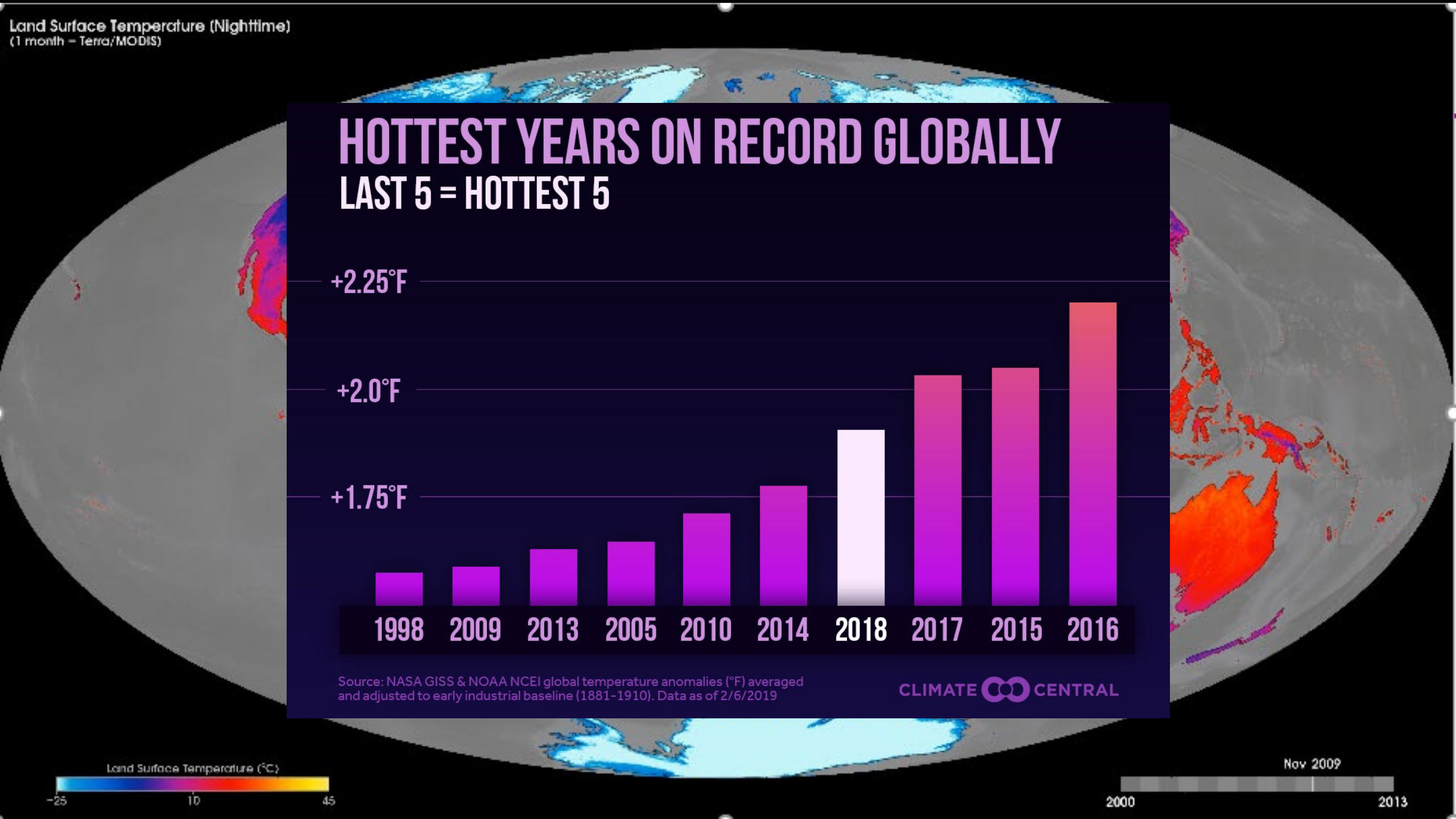
Government sponsorship acknowledged.

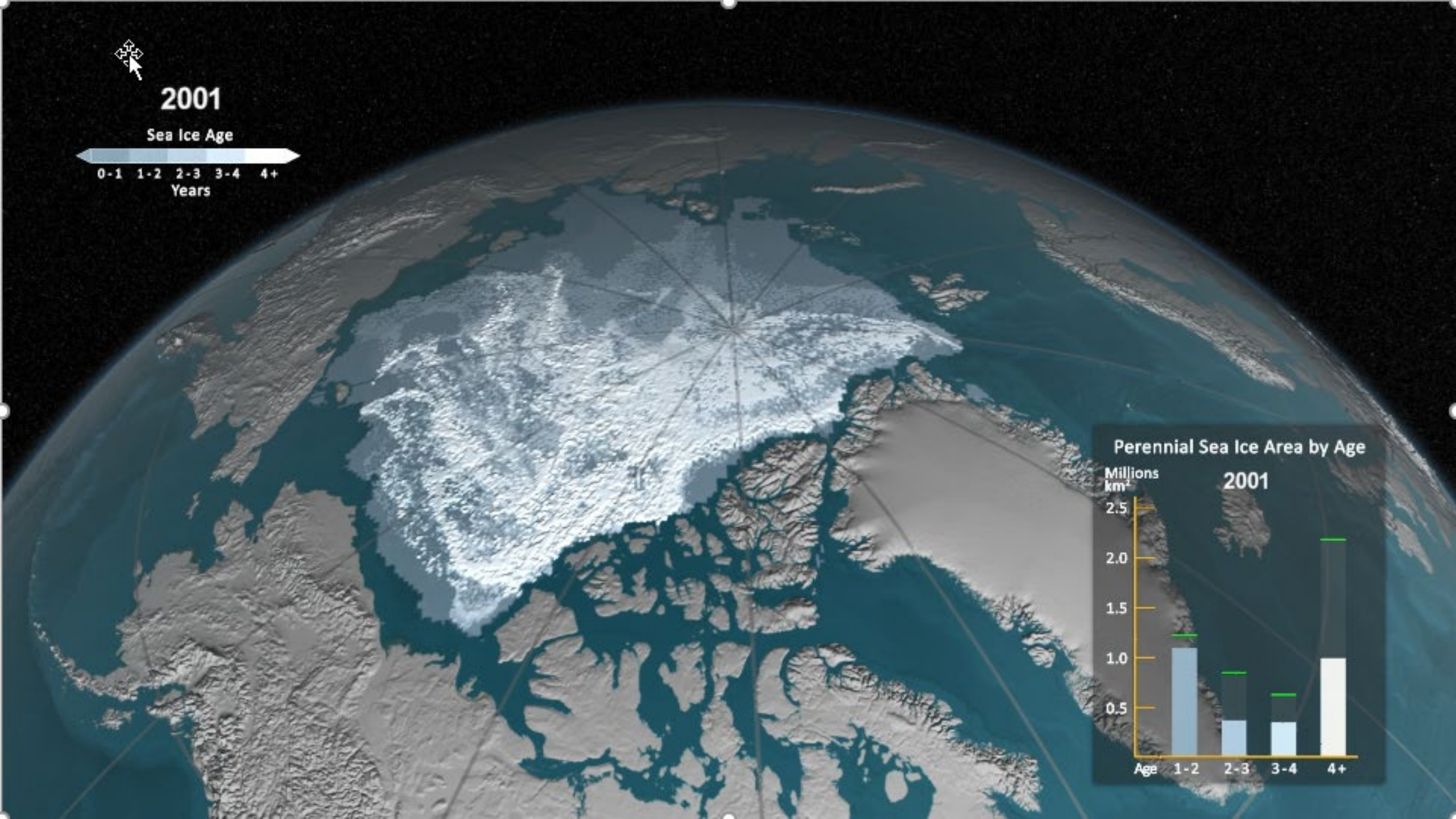
December 24, 1968



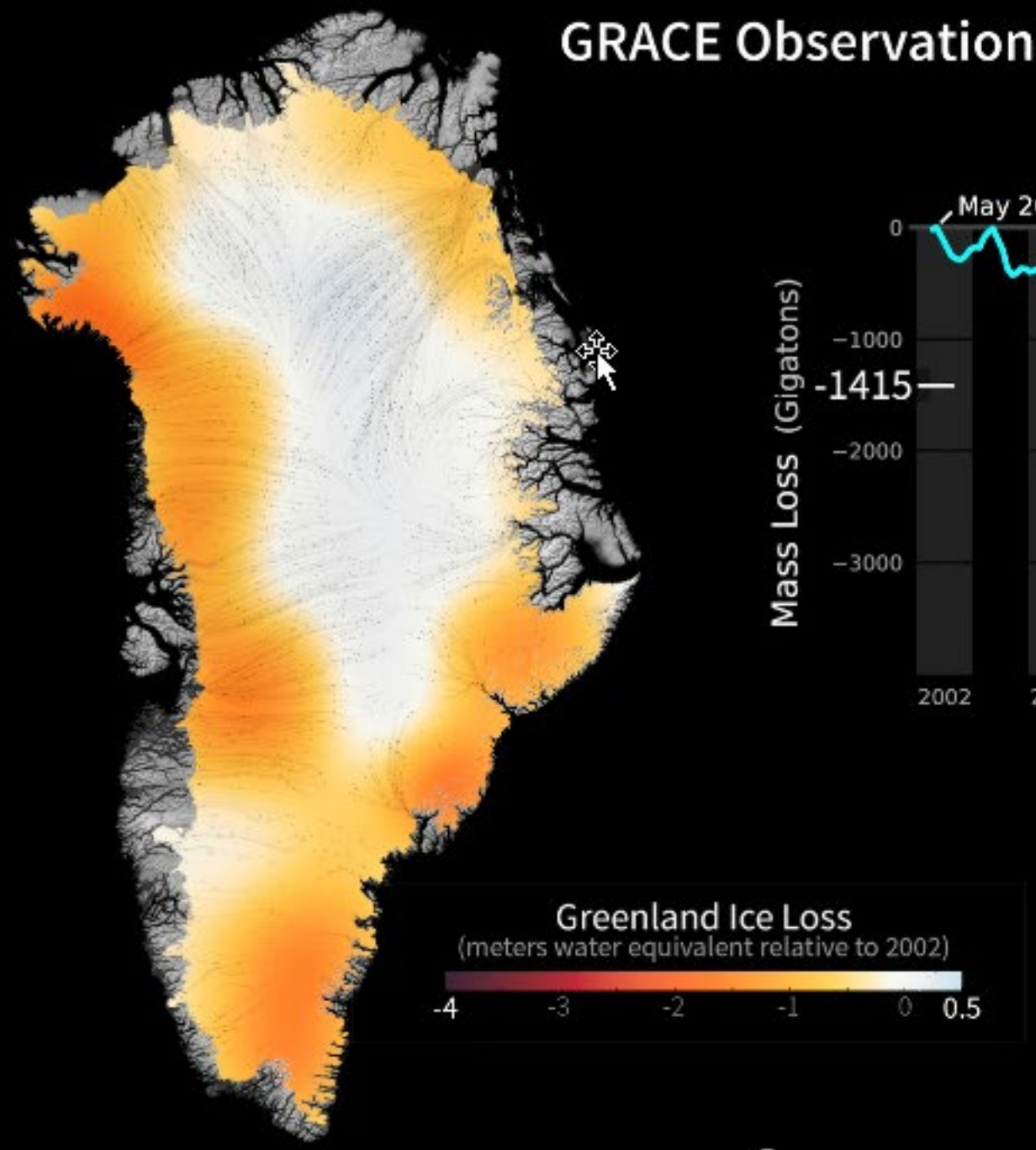

Landsat-7
GRACE-1
GRACE-2
Suomi-NPP
SMAP
ISS
Jason-2
GPM
Landsat-8

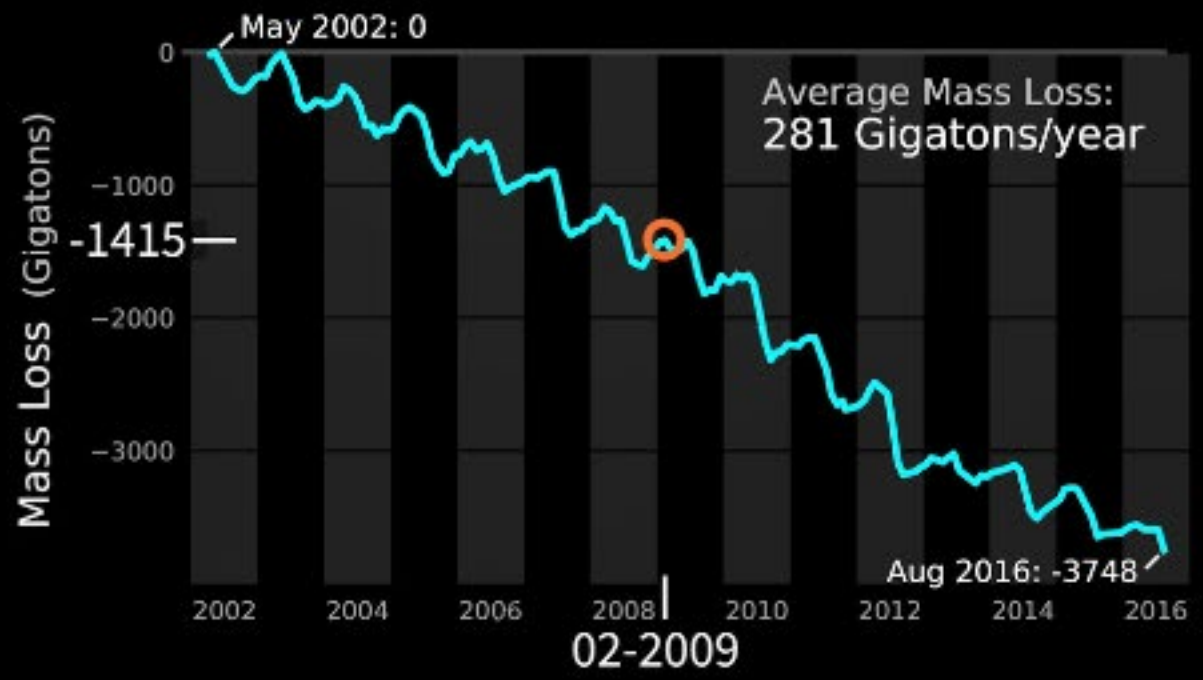

Land Surface Temperature (Nighttime)
(1 month – Terra/MODIS)
Land Surface Temperature (°C)
-25
10
45
Nov 2009
2000
2013


Land Surface Temperature (Nighttime)
(1 month – Terra/MODIS)
HOTTEST YEARS ON RECORD GLOBALLY
LAST 5 = HOTTEST 5
+2.25°F
+2.0°F
+1.75°F
1998
2009
2013
2005
2010
2014
2018
2017
2015
2016
Source: NASA GISS & NOAA NCEI global temperature anomalies (°F) averaged and adjusted to early industrial baseline (1881-1910). Data as of 2/6/2019
CLIMATE CENTRAL
Land Surface Temperature (°C)
-25
10
45
Nov 2009
2000
2013

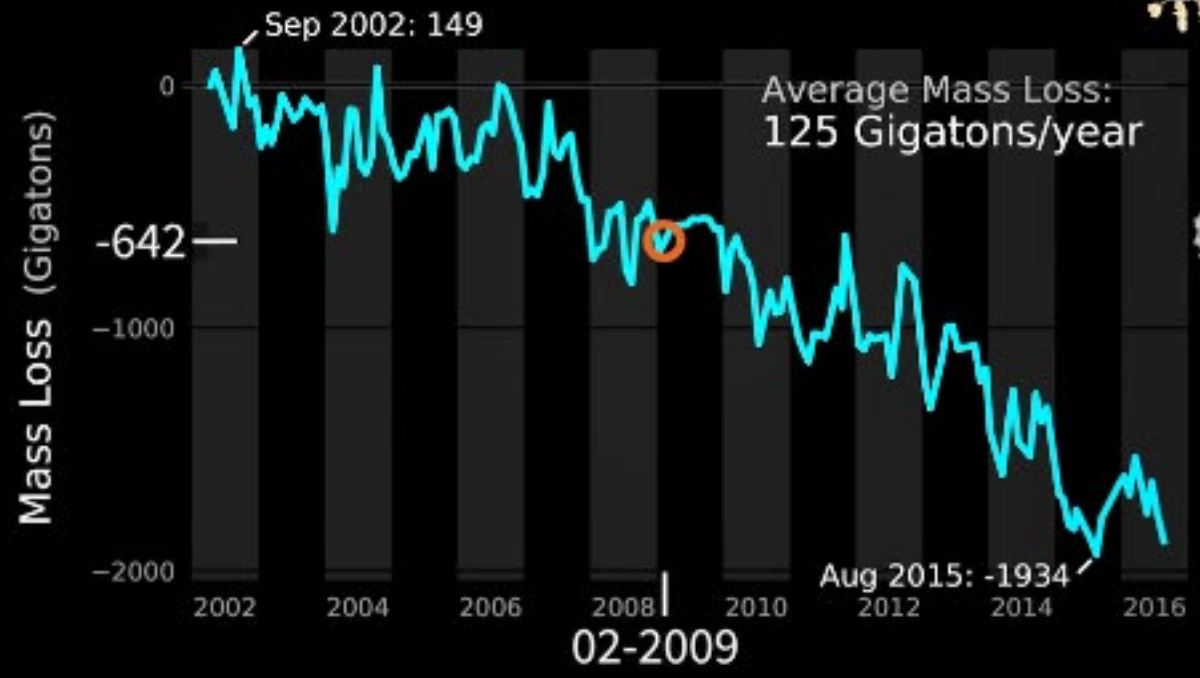

2001
Sea Ice Age
0-1 1-2 2-3 3-4 4+
Years
Perennial Sea Ice Area by Age
Millions km²
2001
2.5
2.0
1.5
1.0
0.5
Age 1-2 2-3 3-4 4+

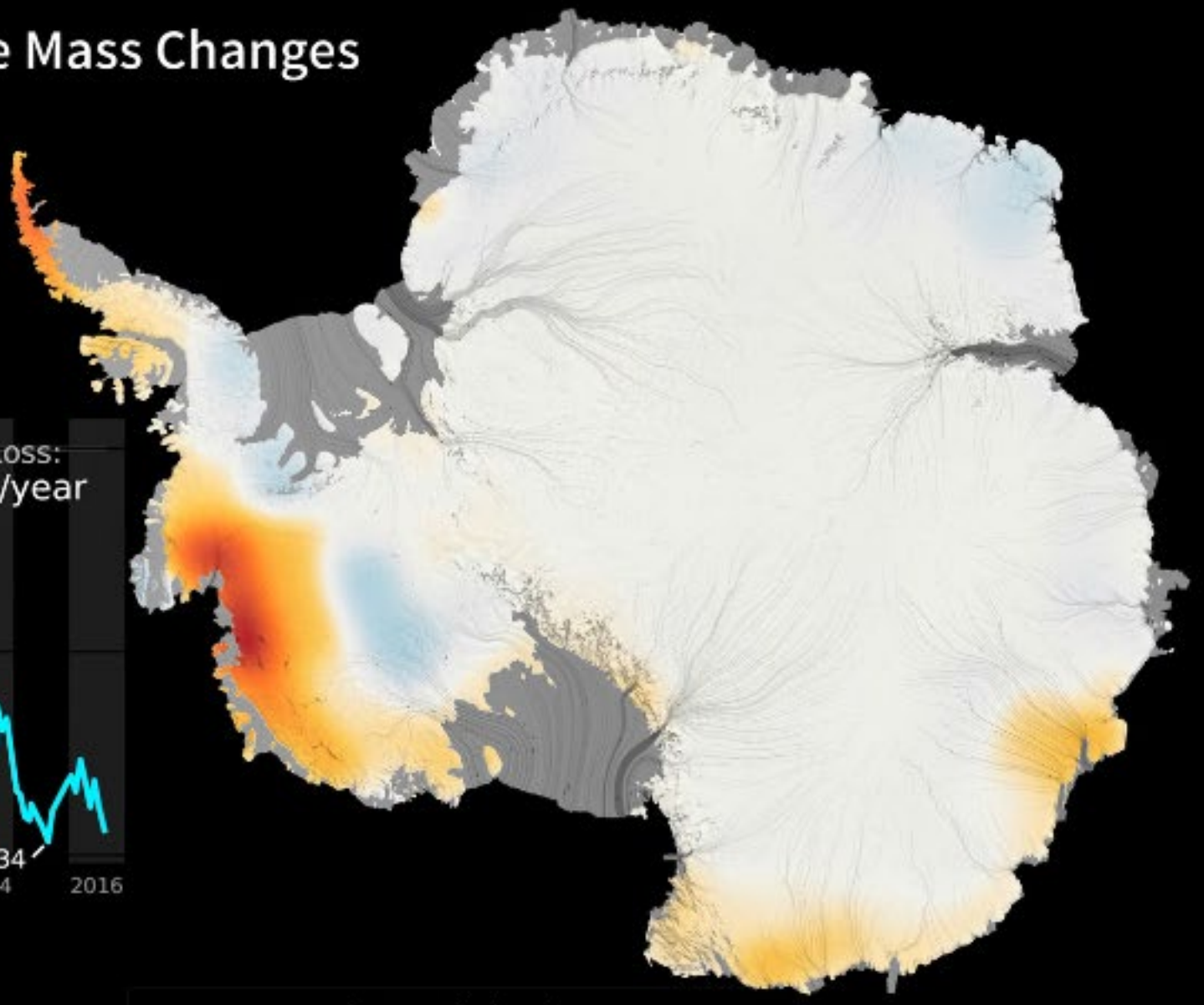
GRACE Observations of Greenland Ice Mass Changes

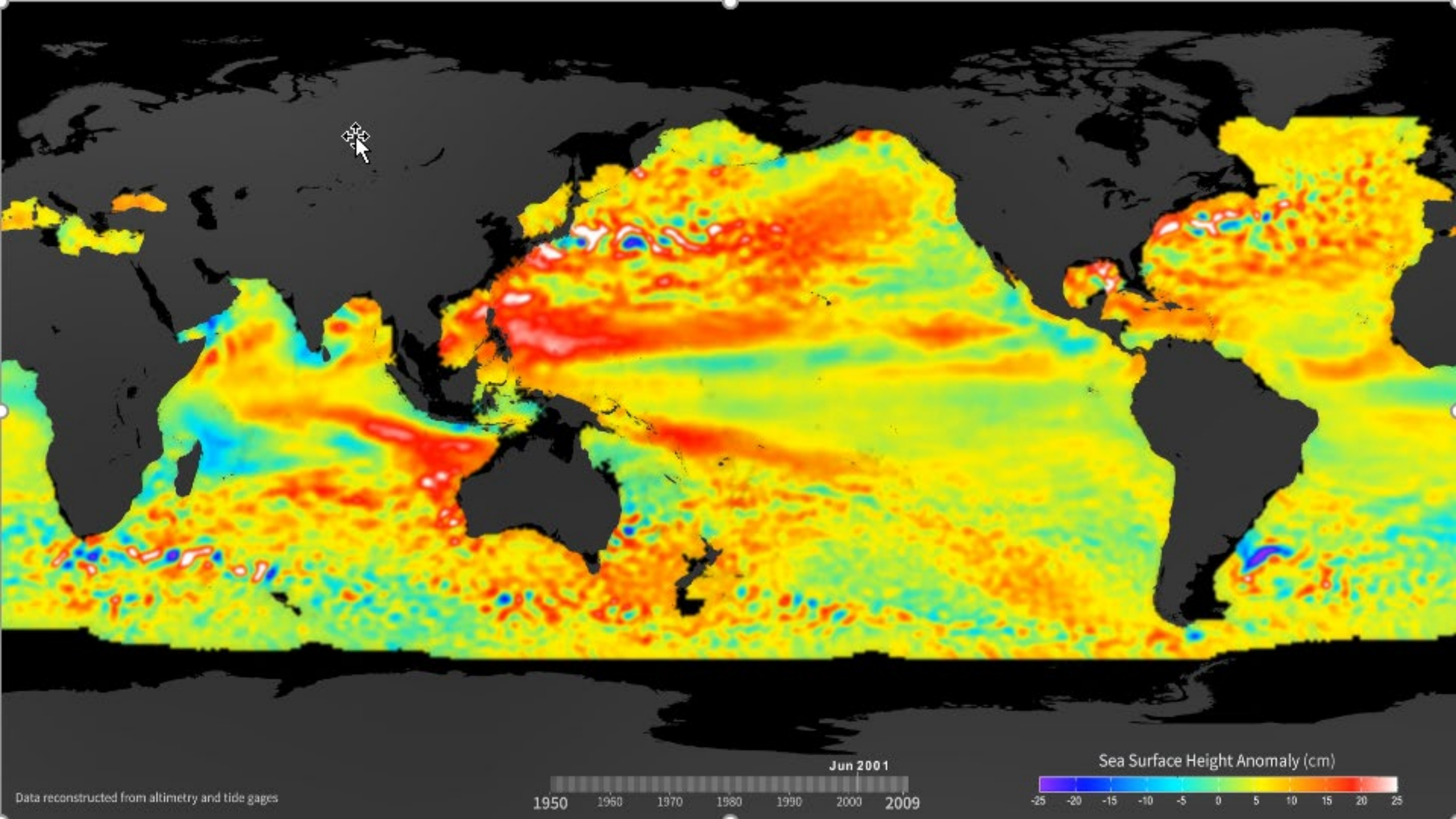


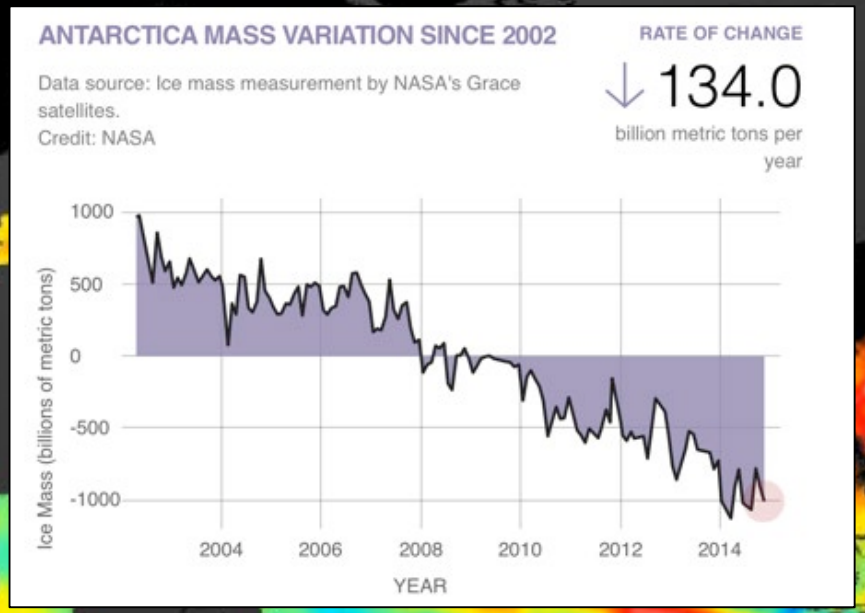


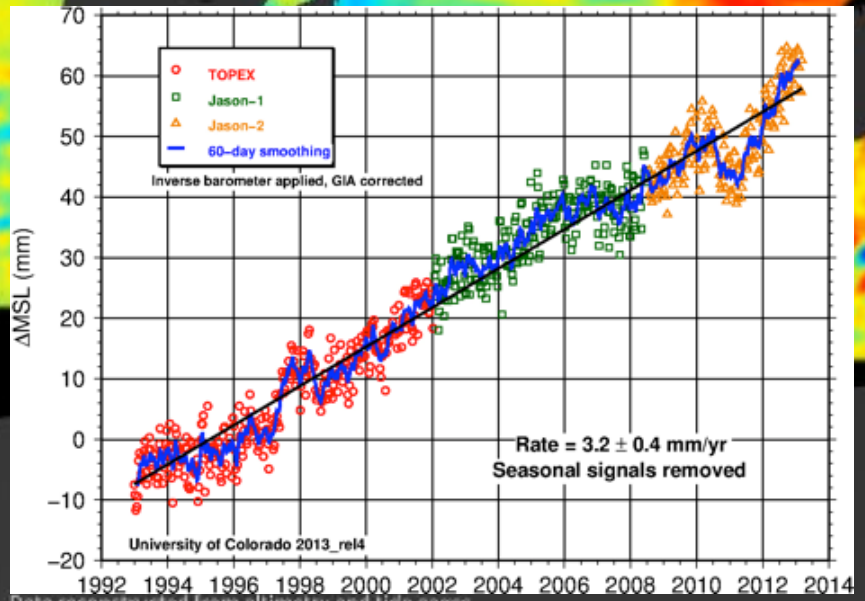
GRACE Observations of Antarctic Ice Mass Changes



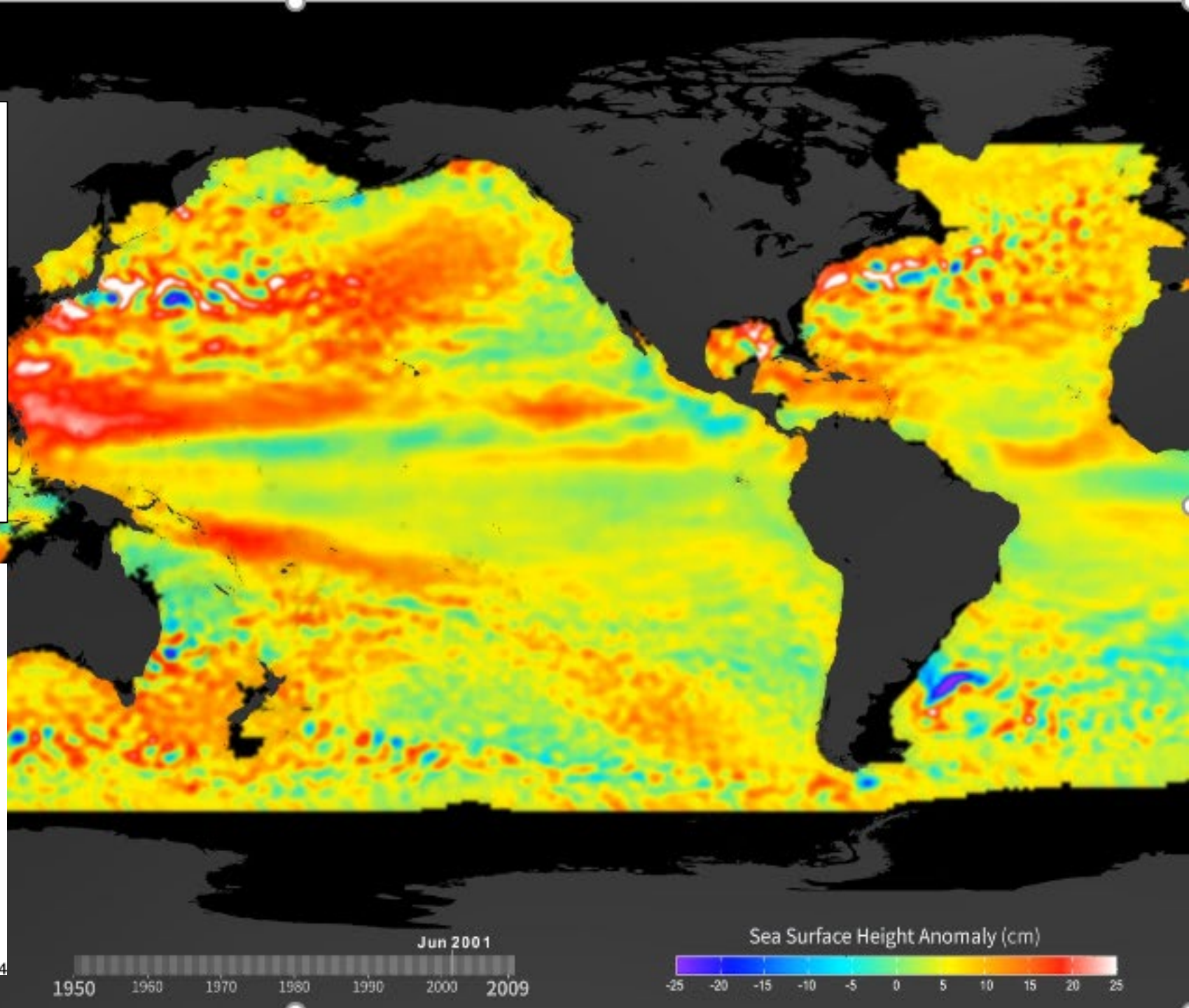


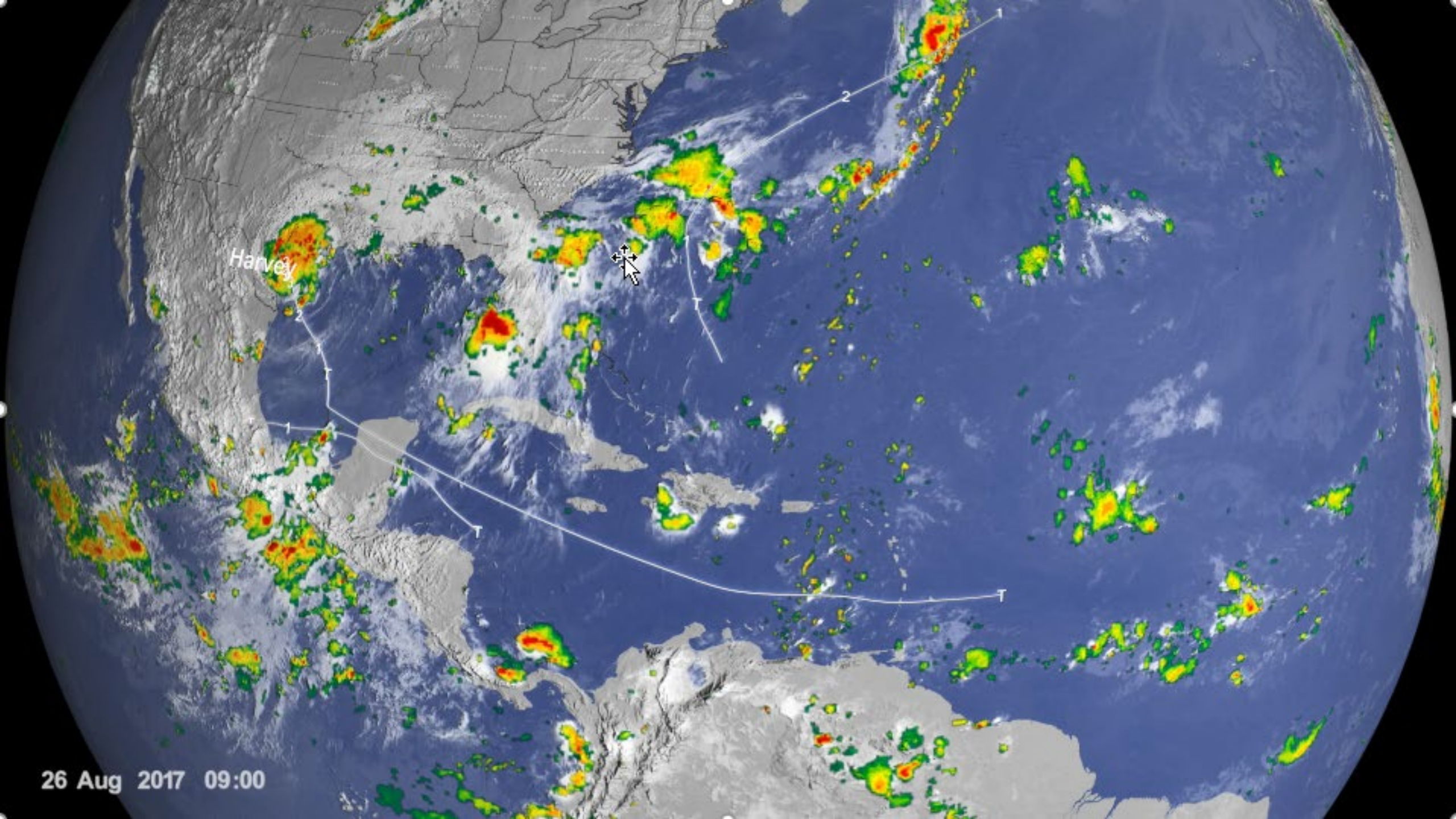

Jun 2001
1950
1960
1970
1980
1990
2000
2009
Sea Surface Height Anomaly (cm)
-25
-20
-15
-10
-5
0
5
10
15
20
25
Data reconstructed from altimetry and tide gages

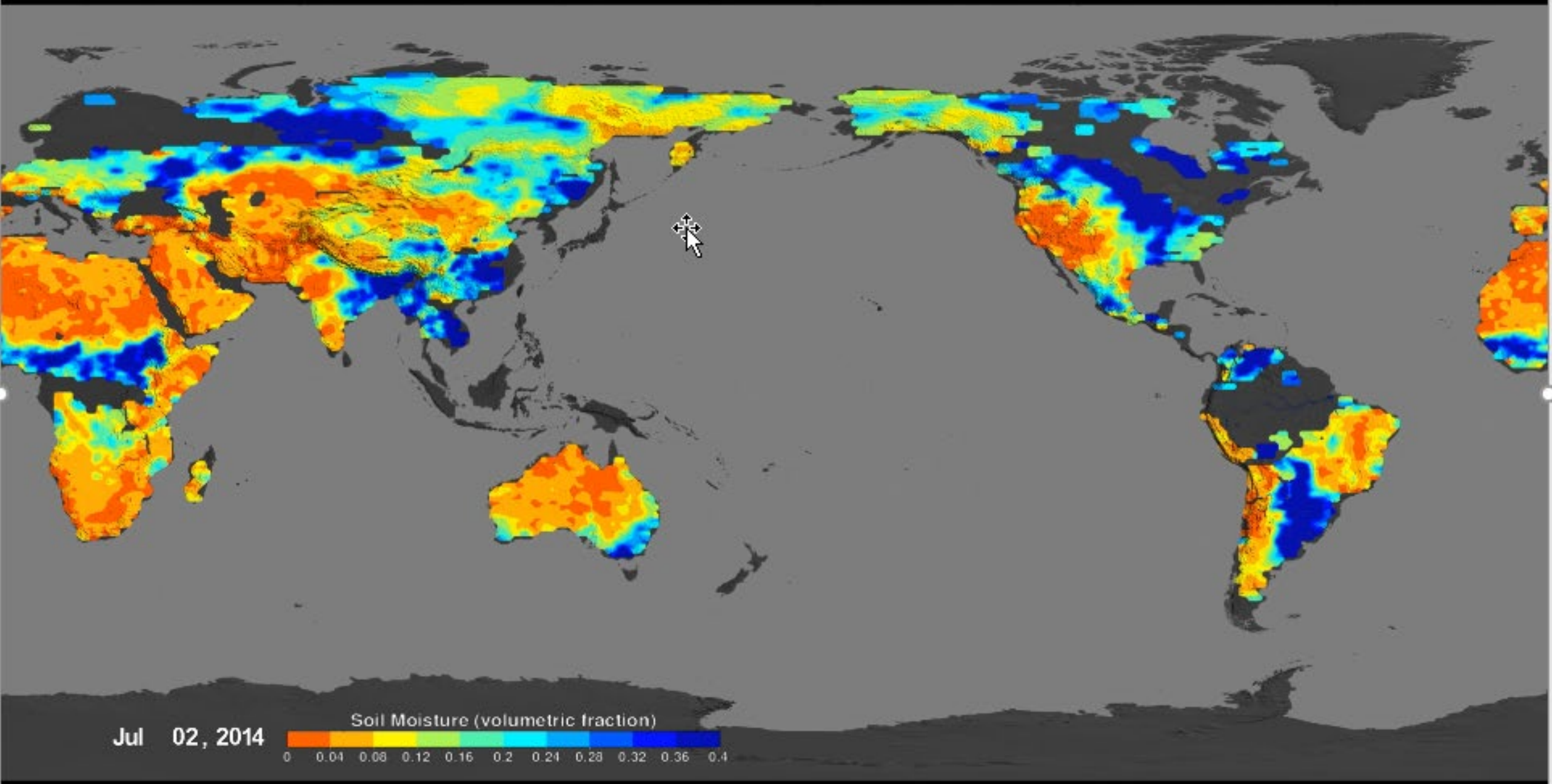


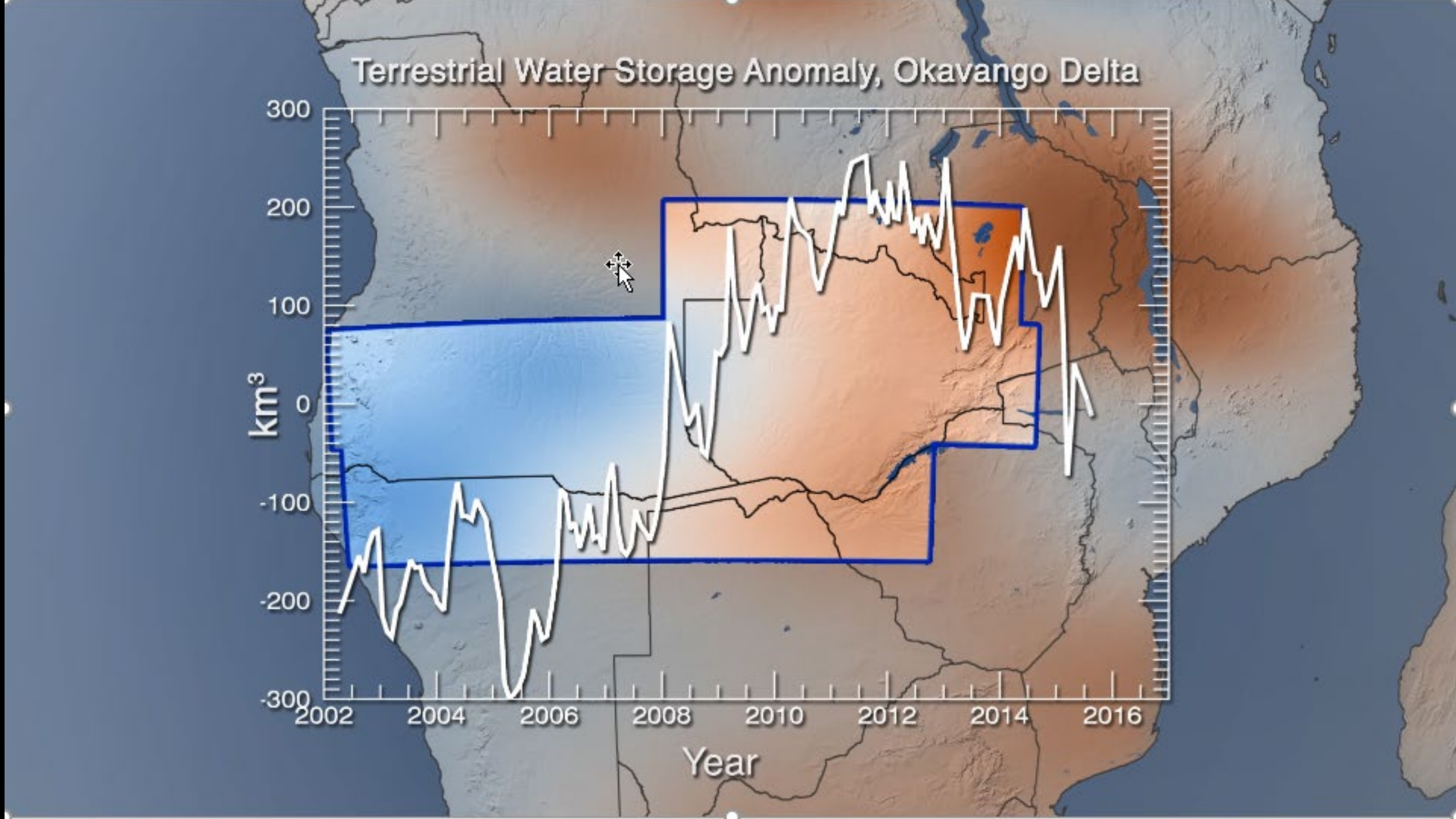


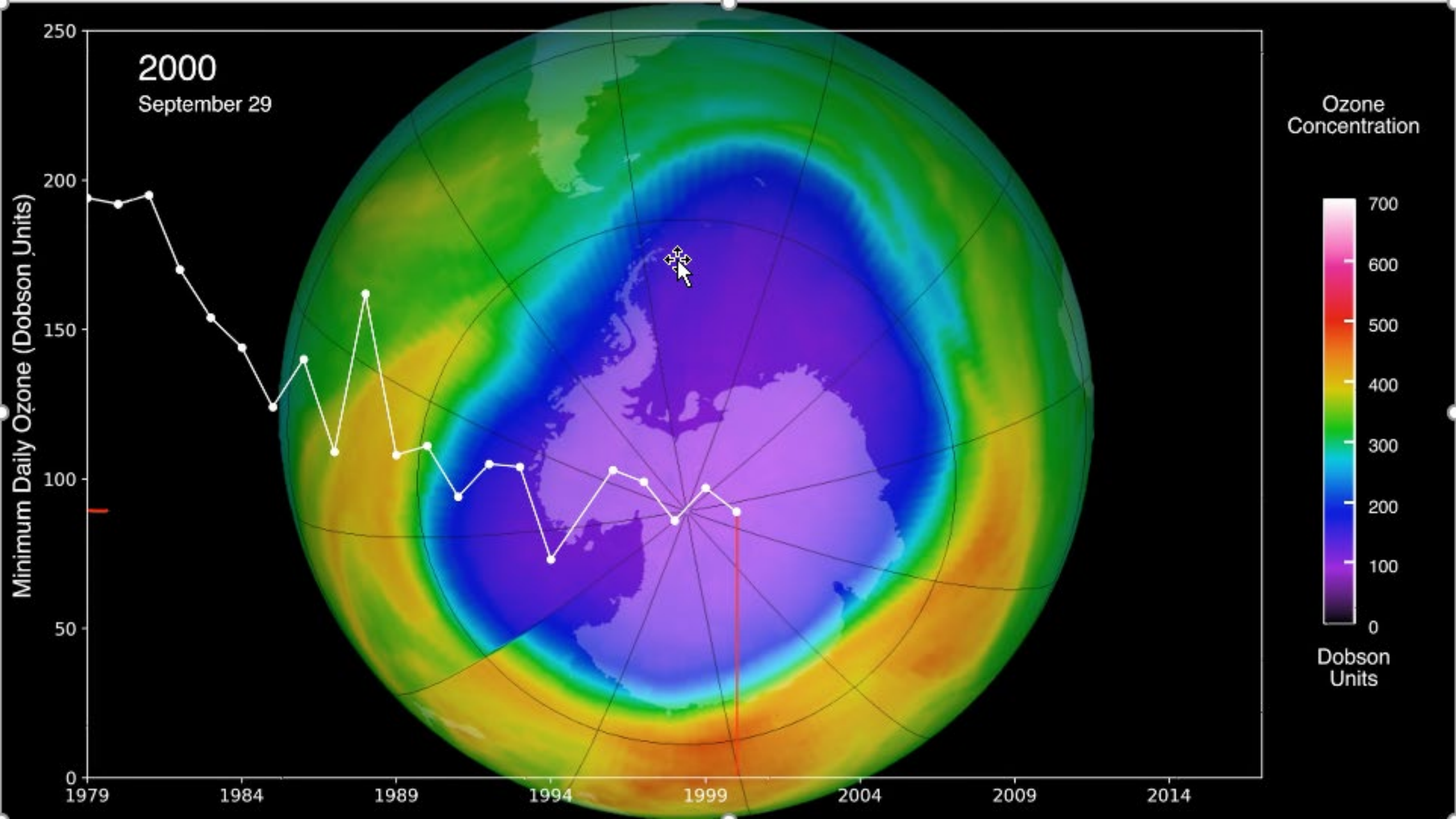
Data reconstructed from altimetry and tide gages

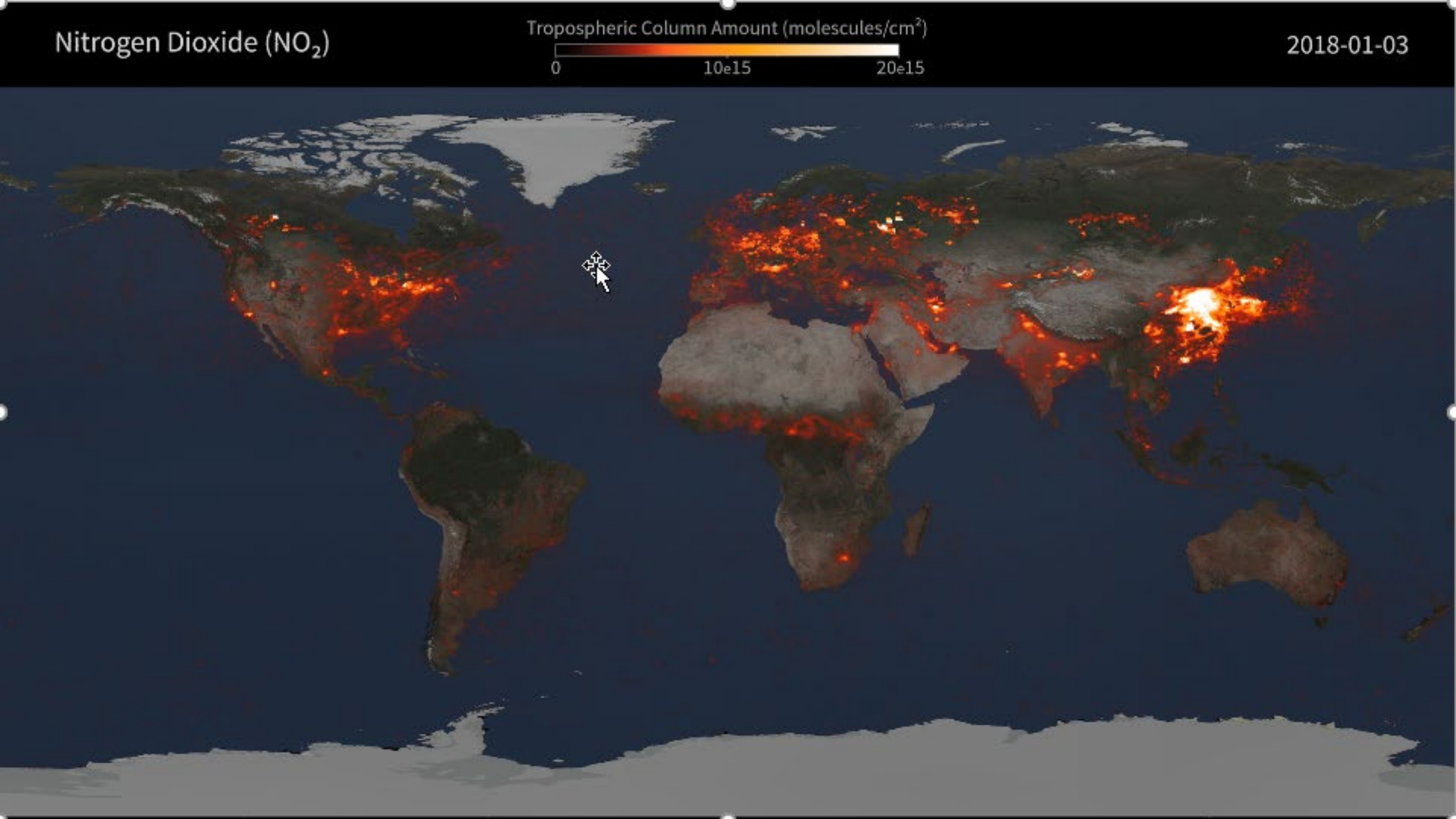


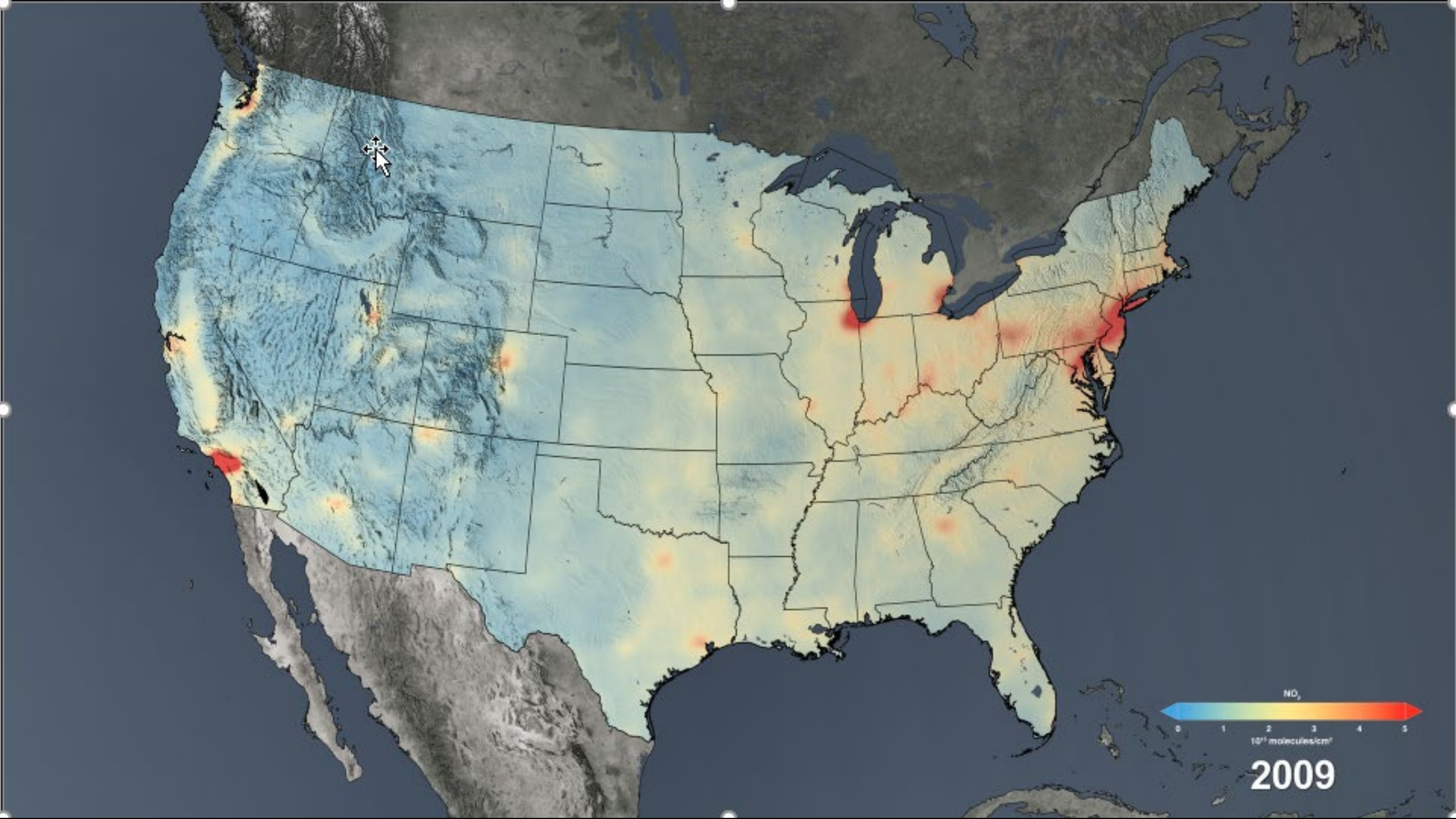

Harvey
26 Aug 2017 09:00

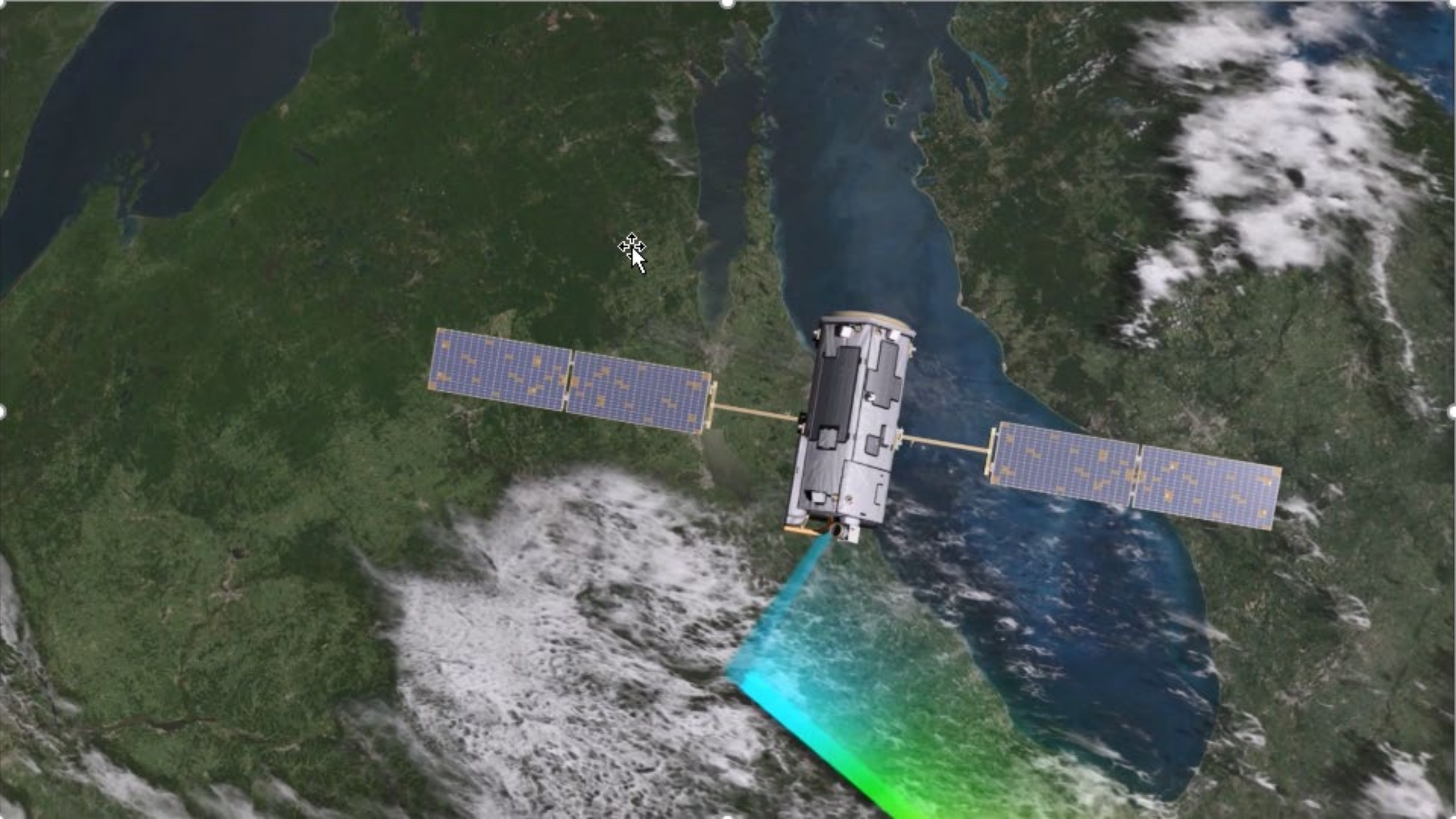

Jul 02, 2014
Soil Moisture (volumetric fraction)
0 0.04 0.08 0.12 0.16 0.2 0.24 0.28 0.32 0.36 0.4

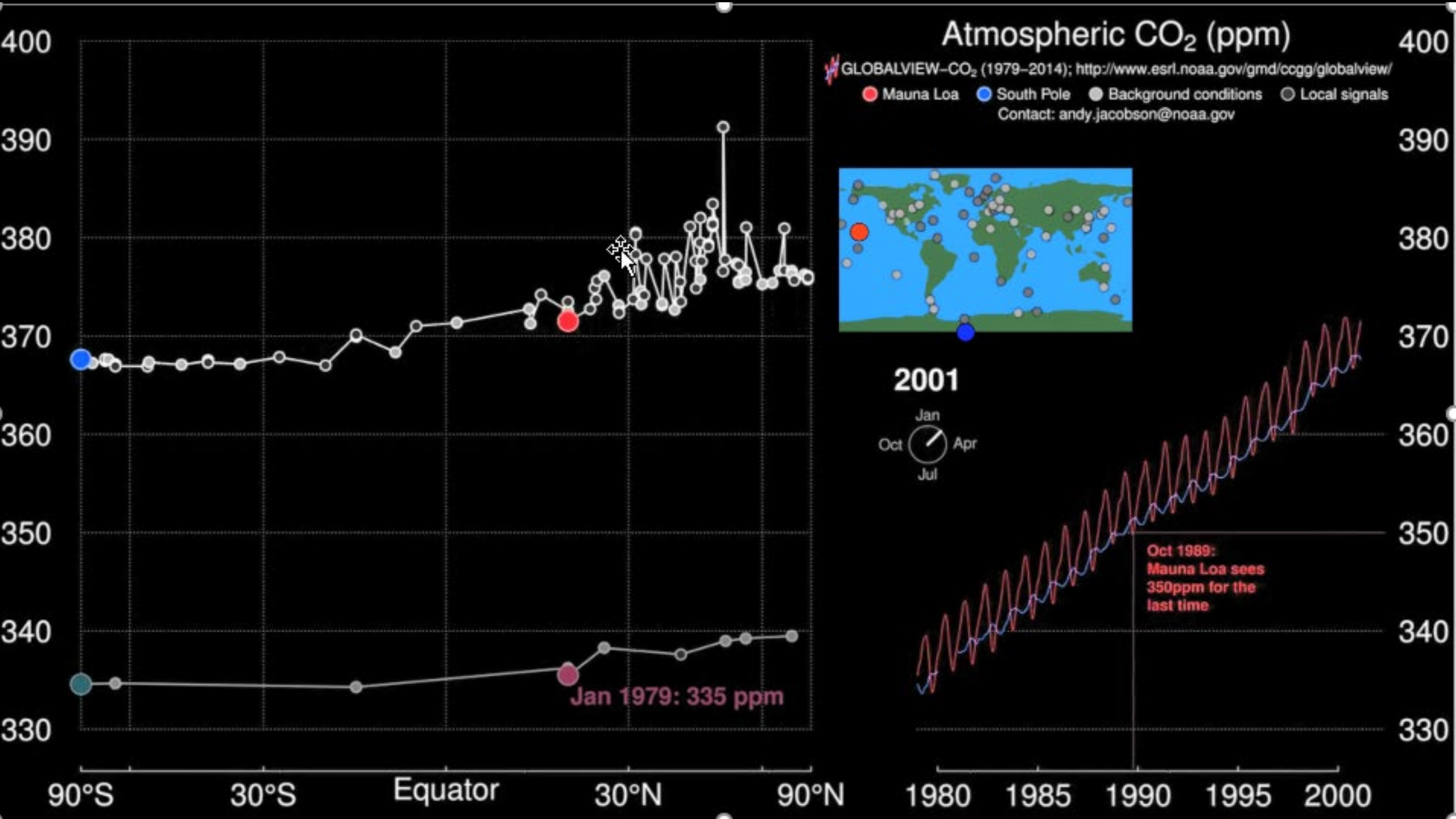

Terrestrial Water Storage Anomaly, Okavango Delta
300
200
100
0
-100
-200
-300
km³
2002
2004
2006
2008
2010
2012
2014
2016
Year

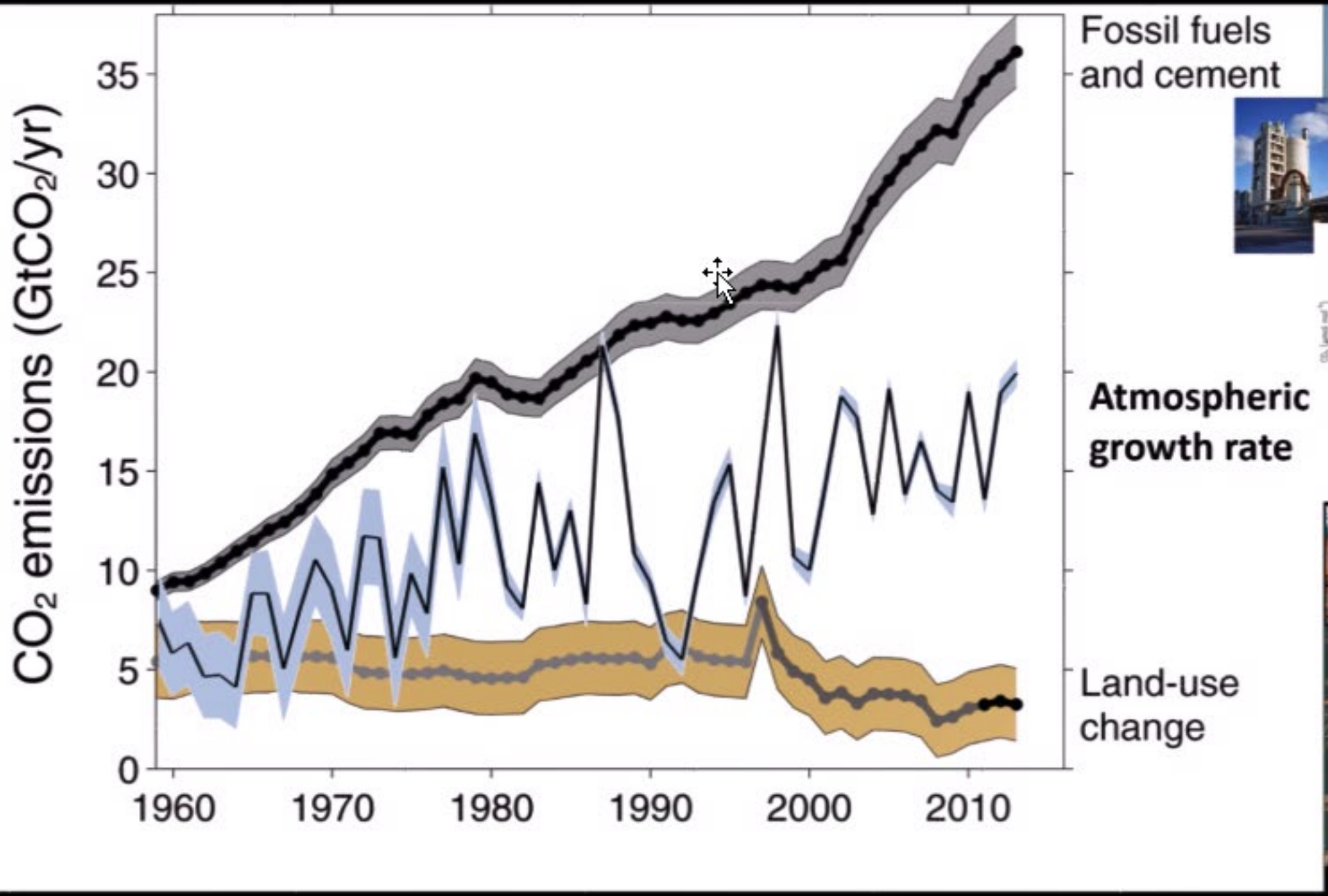

2000
September 29
Minimum Daily Ozone (Dobson Units)
250
200
150
100
50
0
1979
1984
1989
1994
1999
2004
2009
2014
Ozone Concentration
700
600
500
400
300
200
100
0
Dobson Units

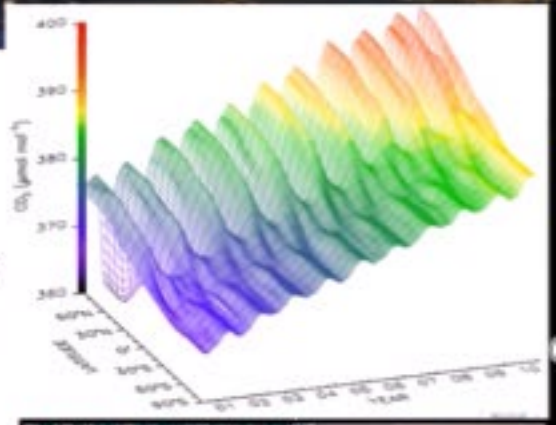

Nitrogen Dioxide (NO_2)
Tropospheric Column Amount (molescules/cm^2)
0
10e15
20e15
2018-01-03

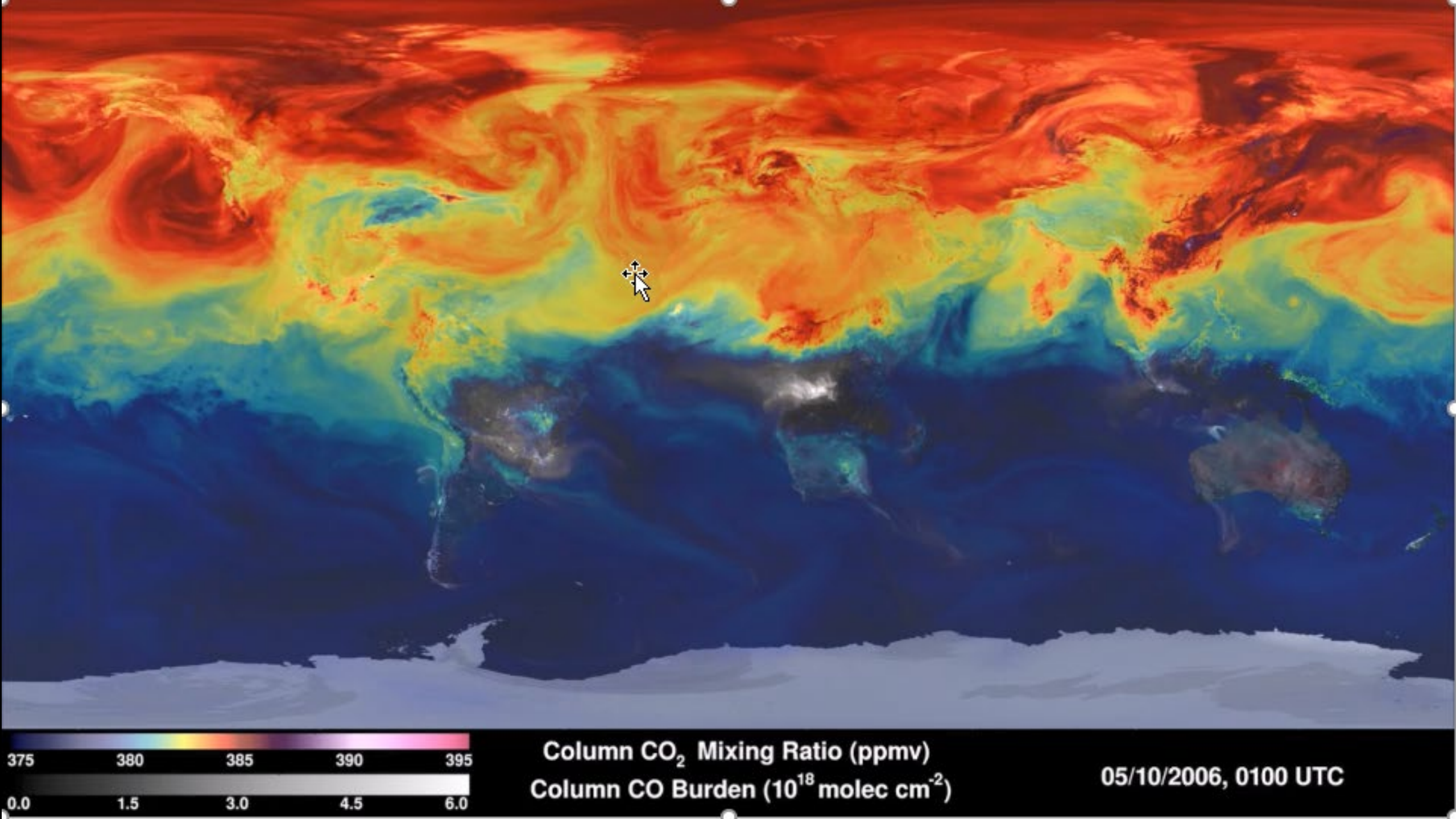

NO_2
0
1
2
3
4
5
10^{15} molecules/cm^2
2009

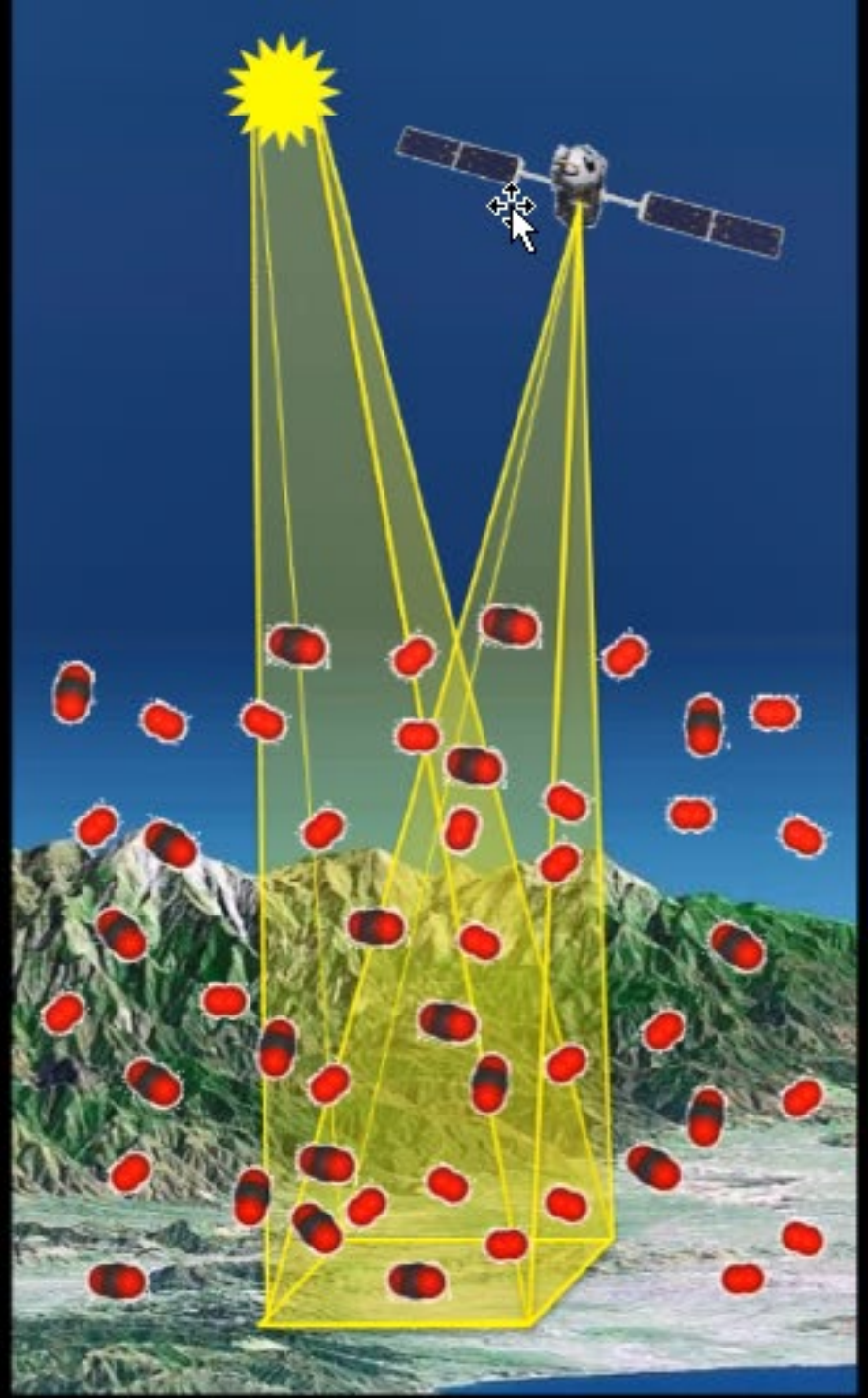


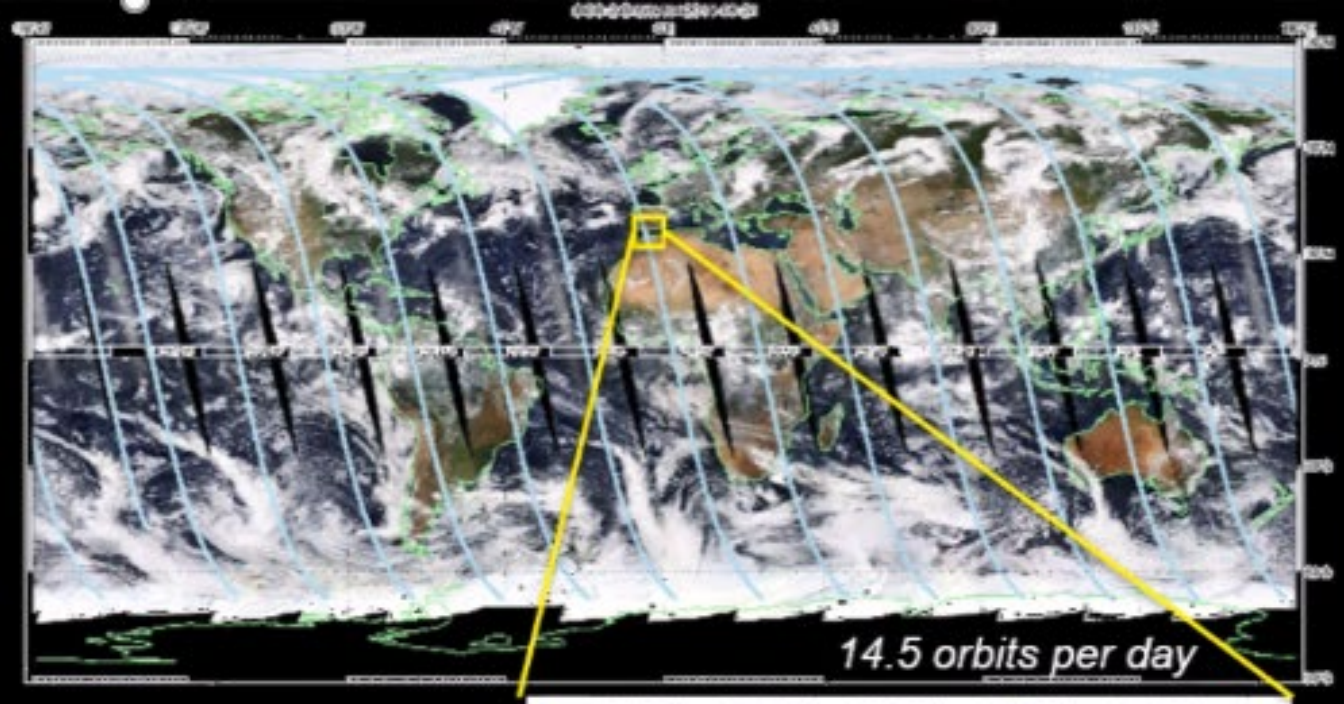

Atmospheric CO_2 (ppm)
GLOBALVIEW-CO_2 (1979–2014); http://www.esrl.noaa.gov/gmd/ccgg/globalview/
Mauna Loa
South Pole
Background conditions
Local signals
Contact: andy.jacobson@noaa.gov
400
390
380
370
360
350
340
330
Jan 1979: 335 ppm
90°S
30°S
Equator
30°N
90°N
2001
Jan
Apr
Jul
Oct
Oct 1989:
Mauna Loa sees
350ppm for the
last time
1980
1985
1990
1995
2000

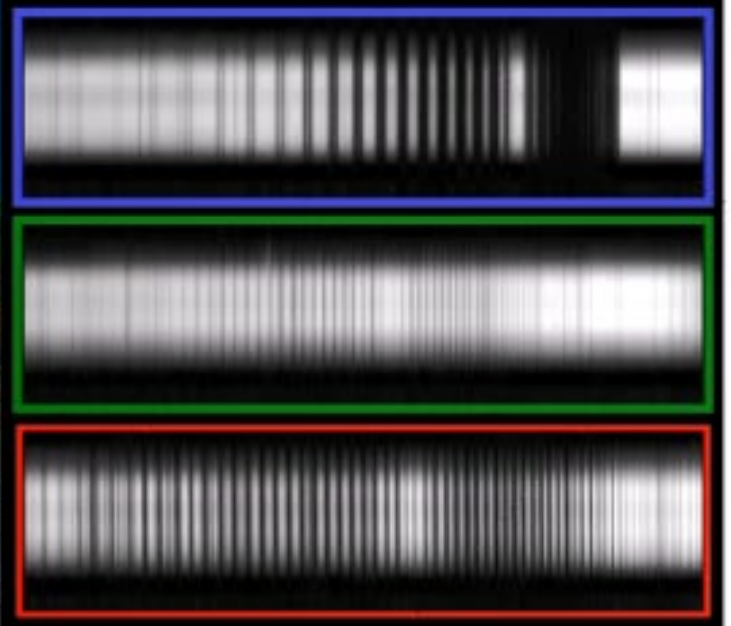

CO_2 emissions ($GtCO_2$/yr)
35
30
25
20
15
10
5
0
1960
1970
1980
1990
2000
2010
Fossil fuels and cement
Atmospheric growth rate
Land-use change

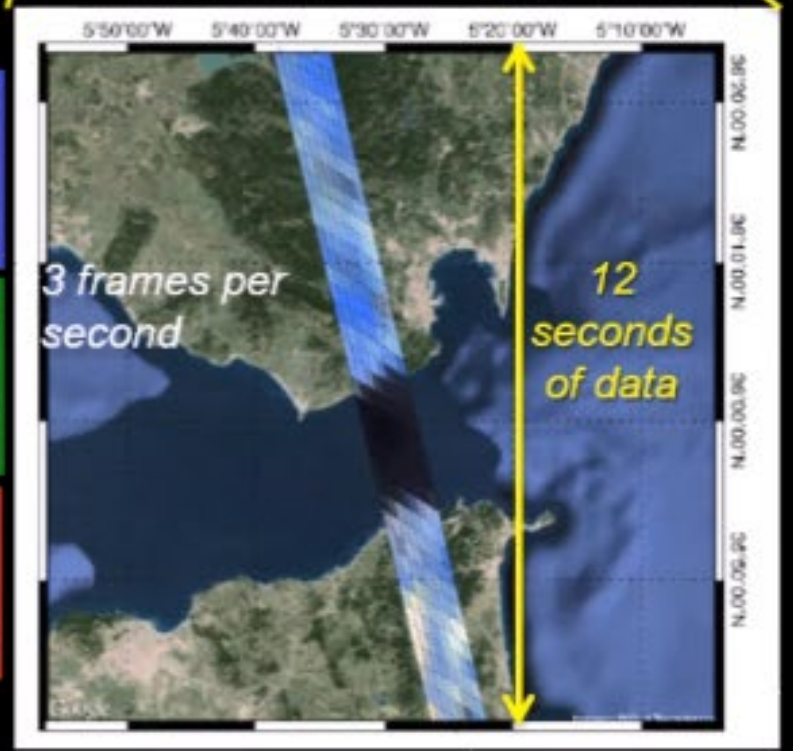


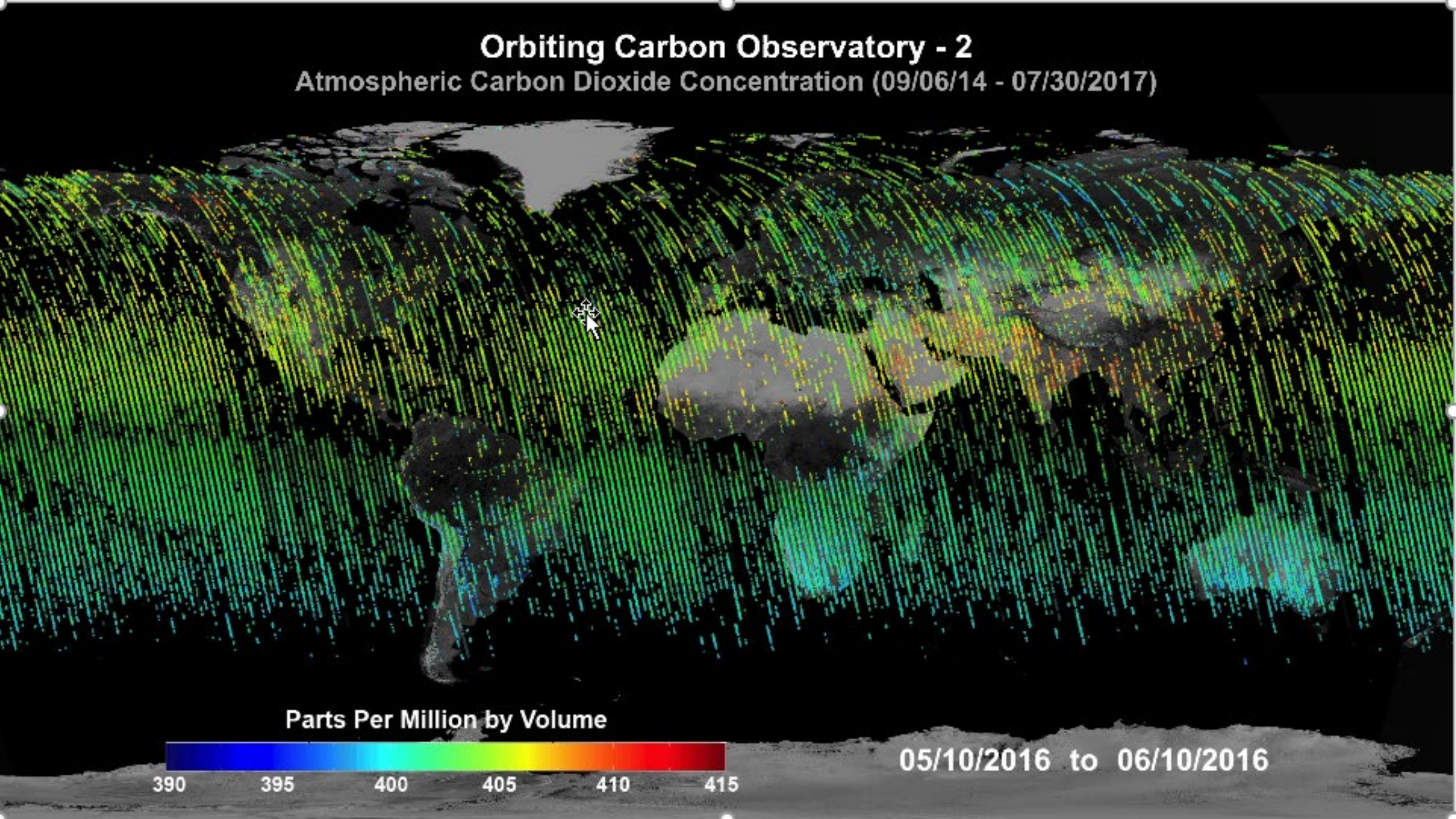

375
380
385
390
395
0.0
1.5
3.0
4.5
6.0
Column CO_2 Mixing Ratio (ppmv)
Column CO Burden (10^{18} molec cm^{-2})
05/10/2006, 0100 UTC

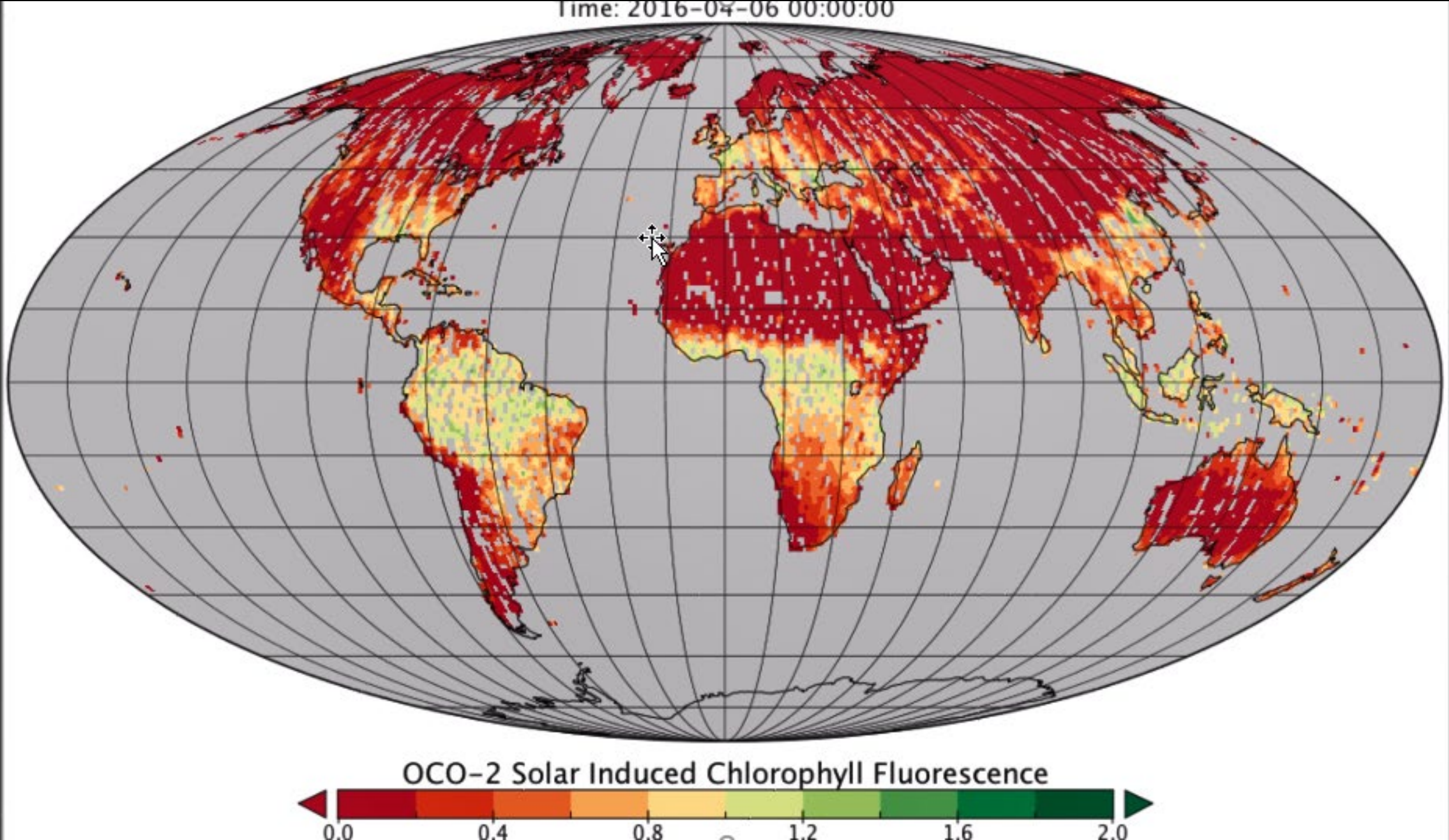


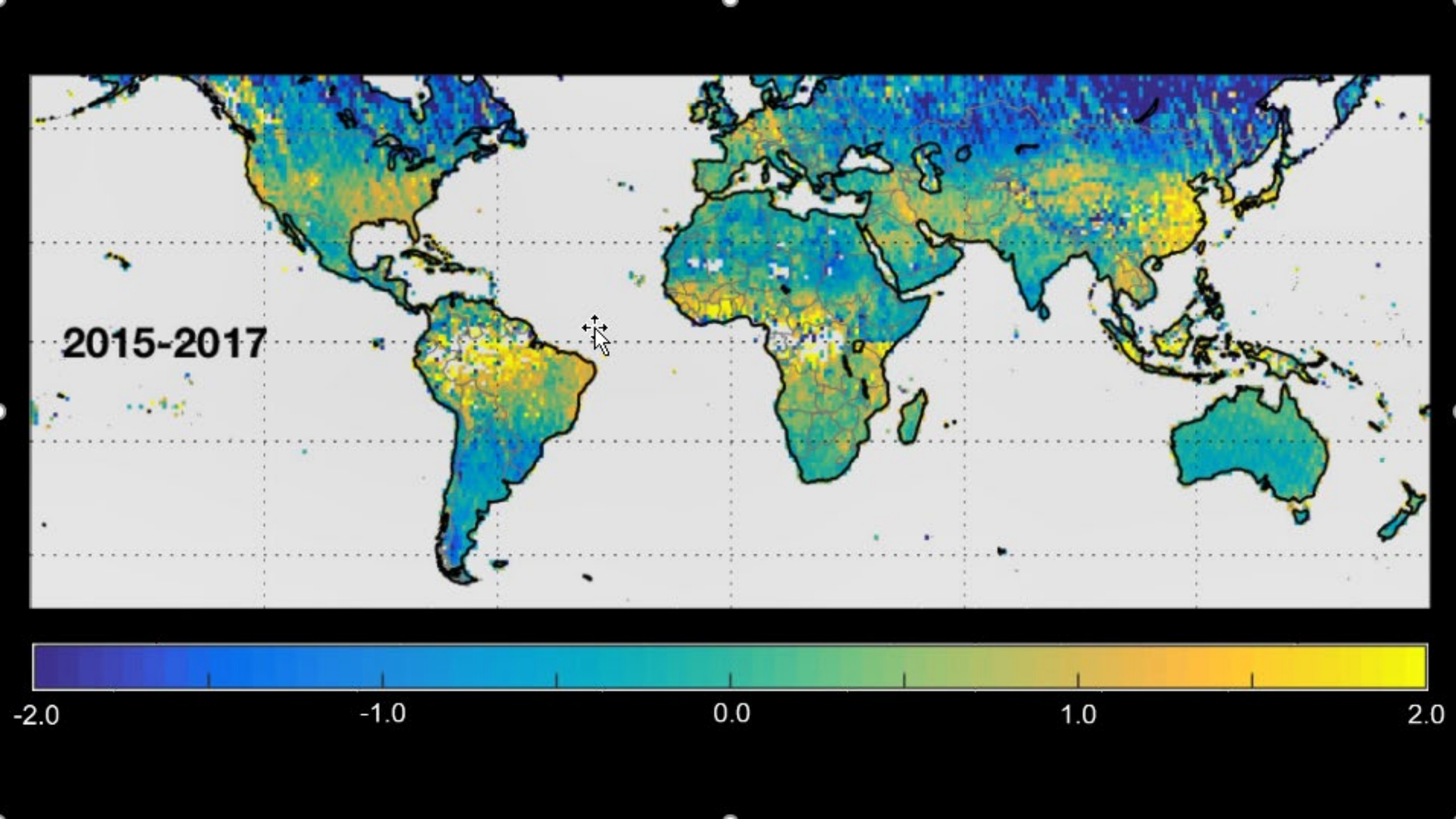

14.5 orbits per day

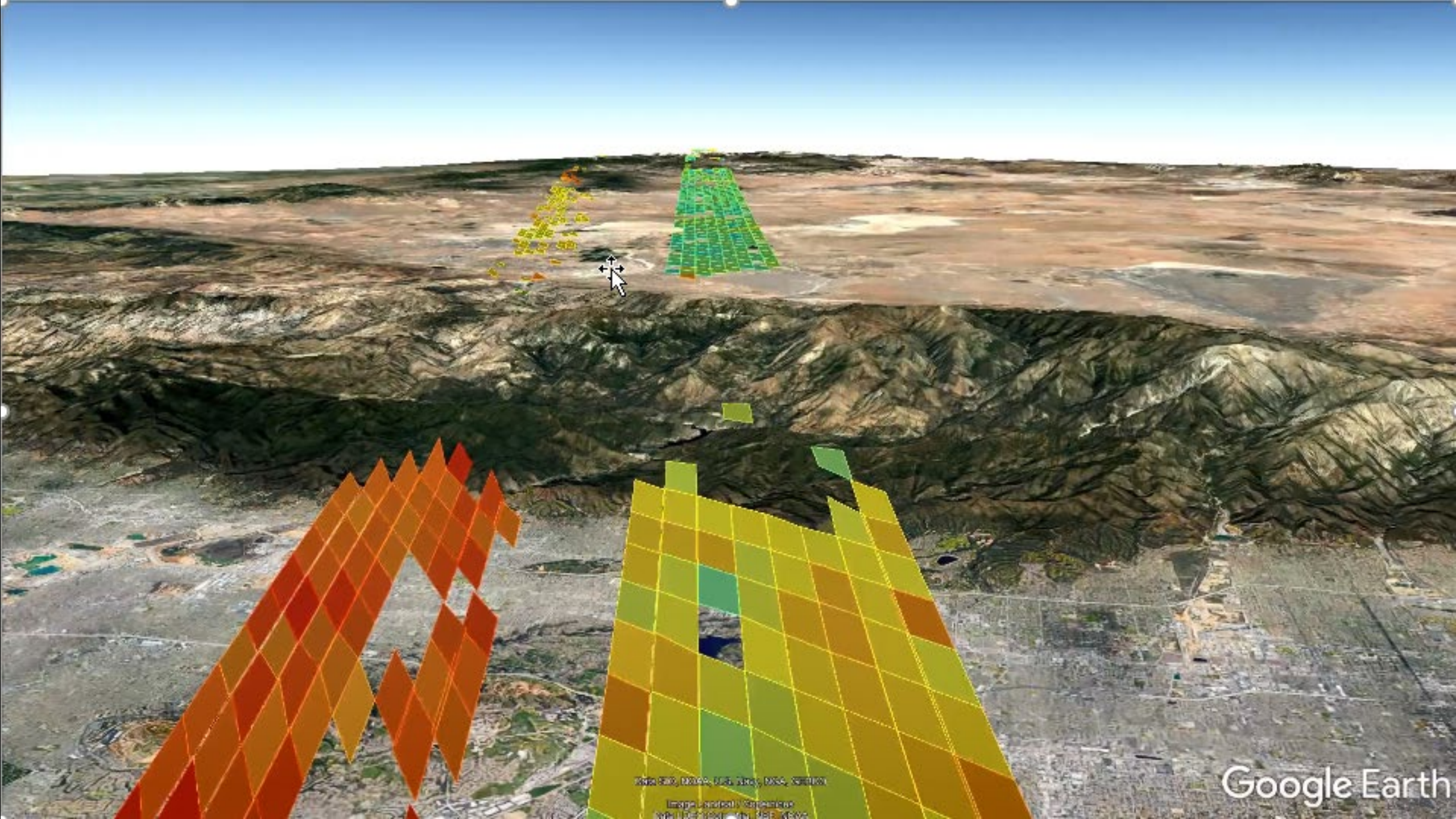


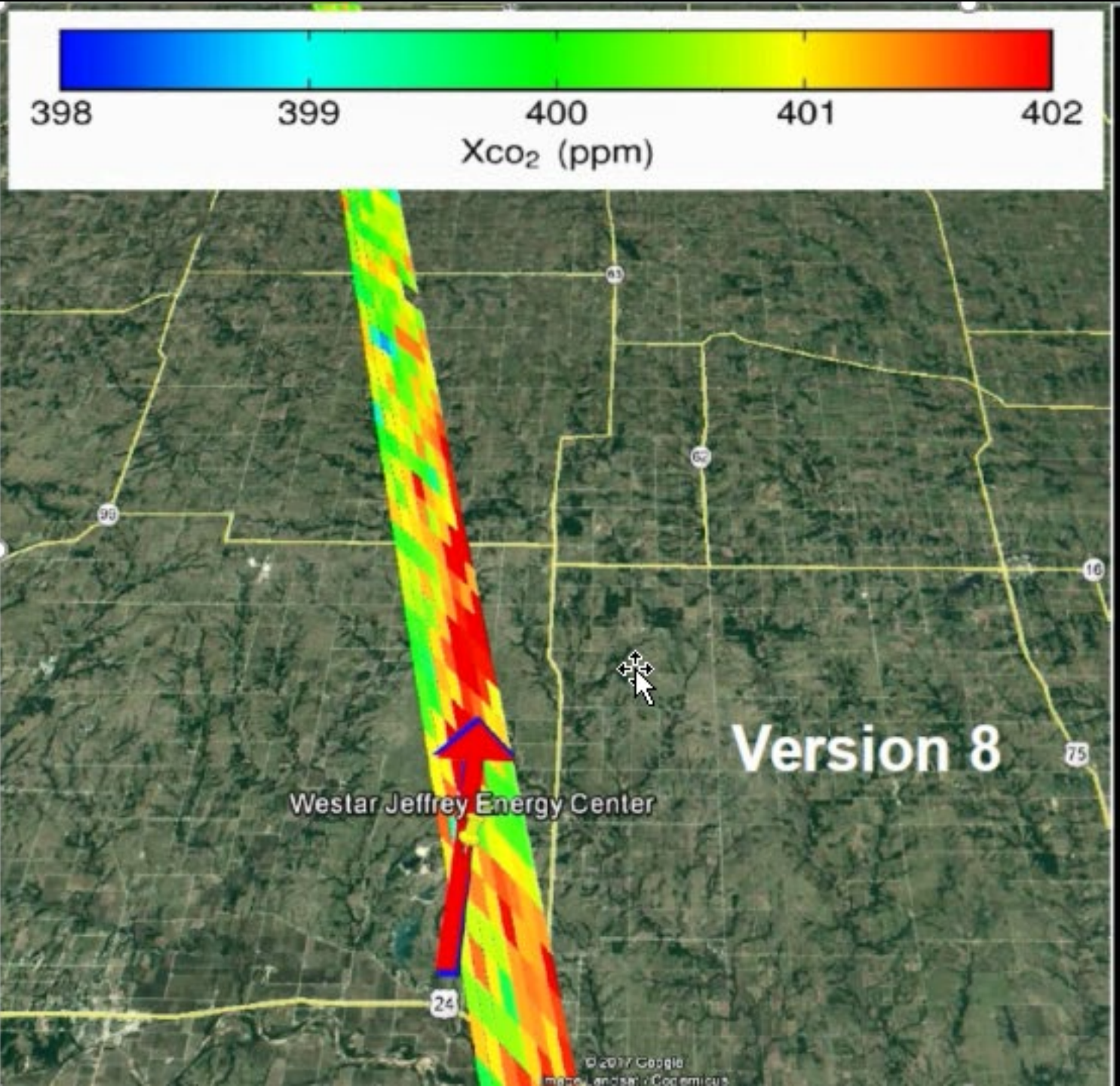

3 frames per second
12 seconds of data


Orbiting Carbon Observatory - 2
Atmospheric Carbon Dioxide Concentration (09/06/14 - 07/30/2017)
Parts Per Million by Volume
390
395
400
405
410
415
05/10/2016 to 06/10/2016

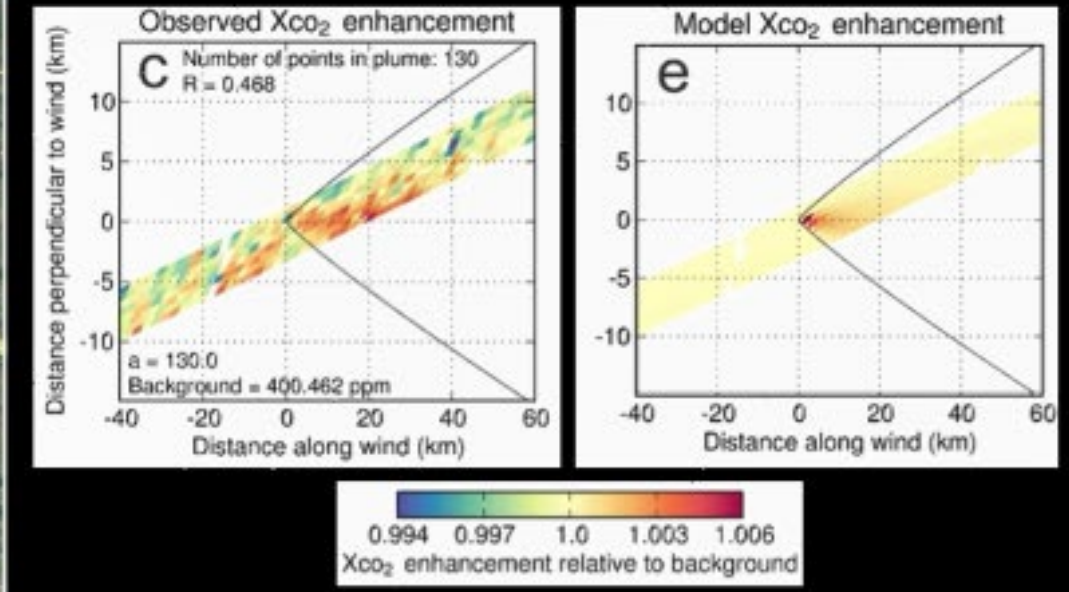

Time: 2016-04-06 00:00:00
OCO-2 Solar Induced Chlorophyll Fluorescence
0.0
0.4
0.8
1.2
1.6
2.0


2015-2017
-2.0
-1.0
0.0
1.0
2.0


Google Earth

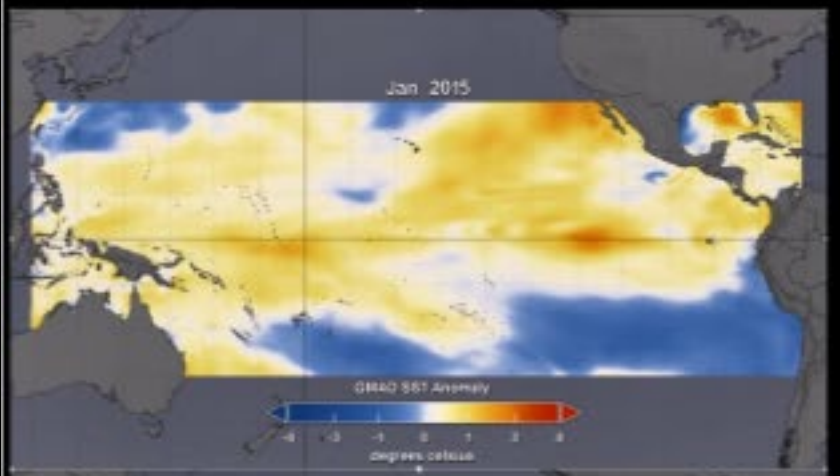


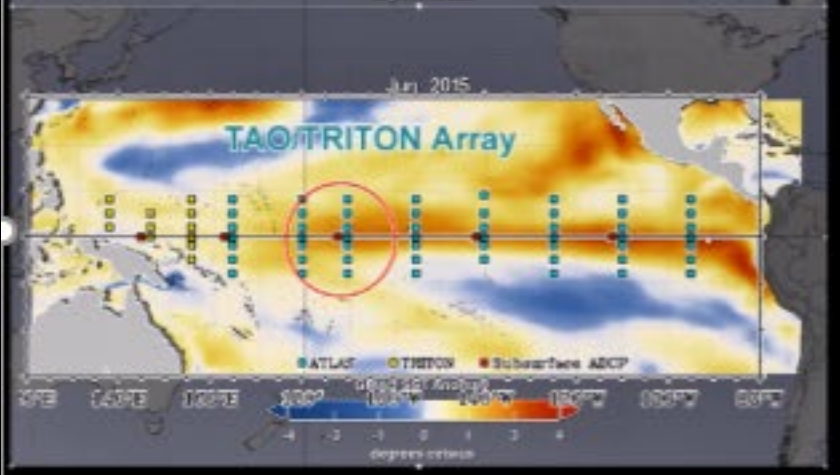
Westar Jeffrey Energy Center, Kansas, USA December 4, 2015

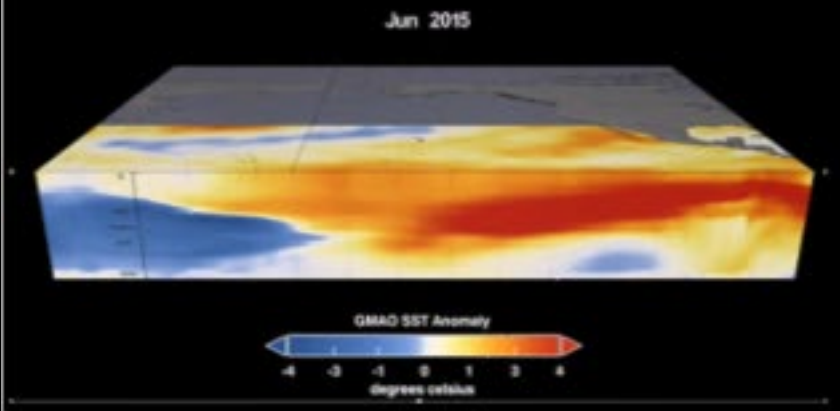


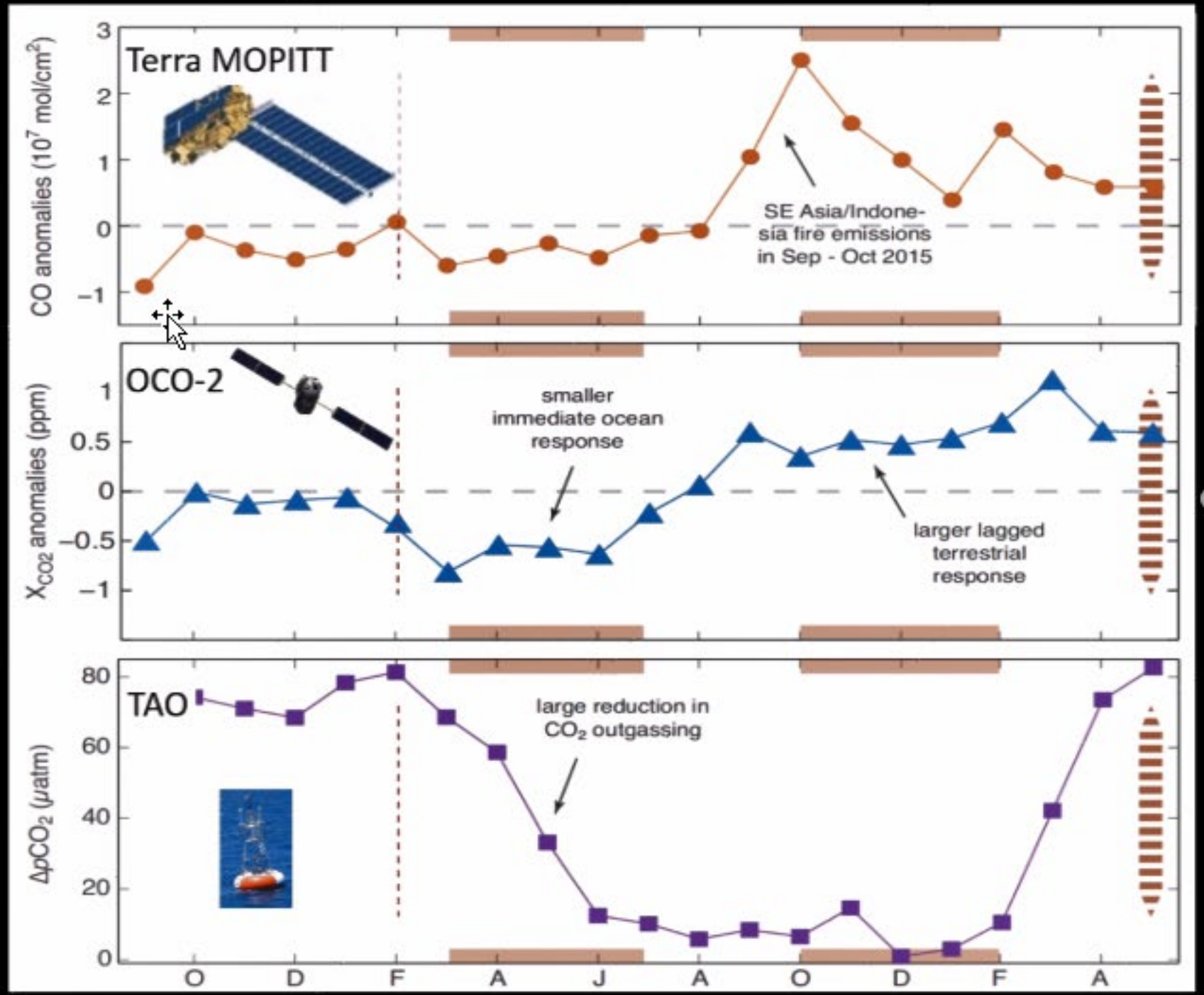
Reported: 26.7 kT/d

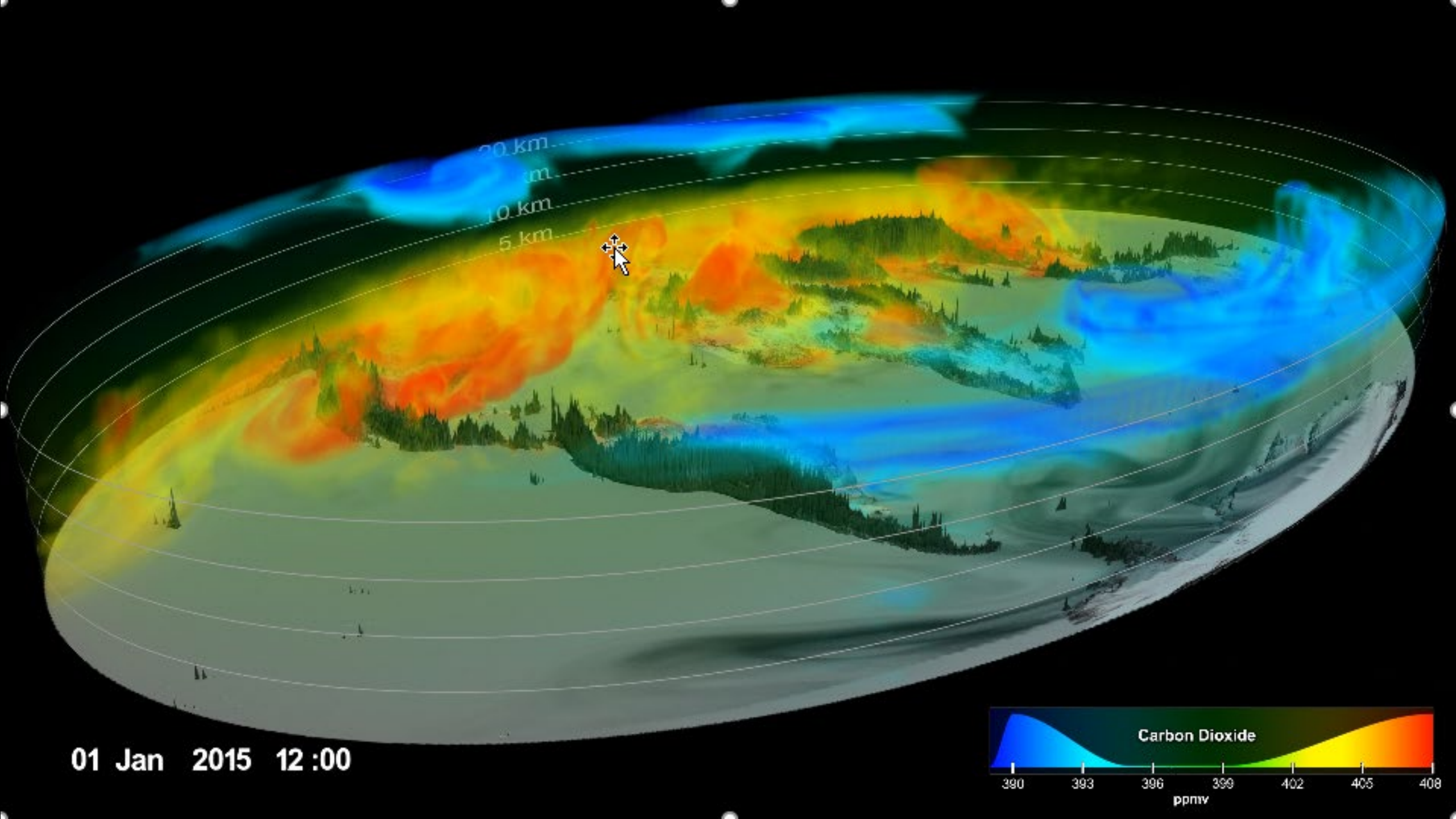
Estimated: 31.2 ± 3.7 kT/d

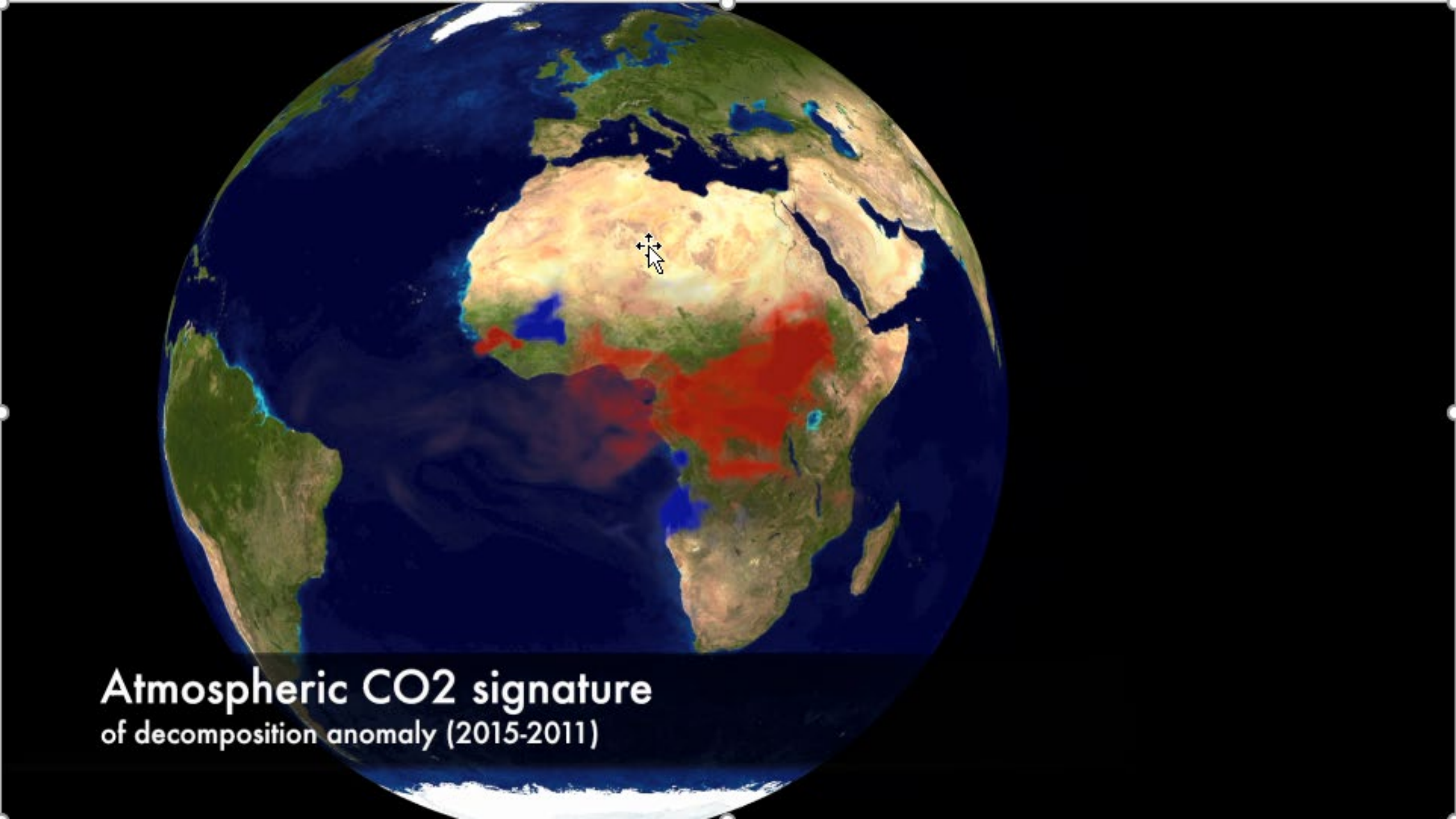

Jan 2015
GMAO SST Anomaly
degrees celsius

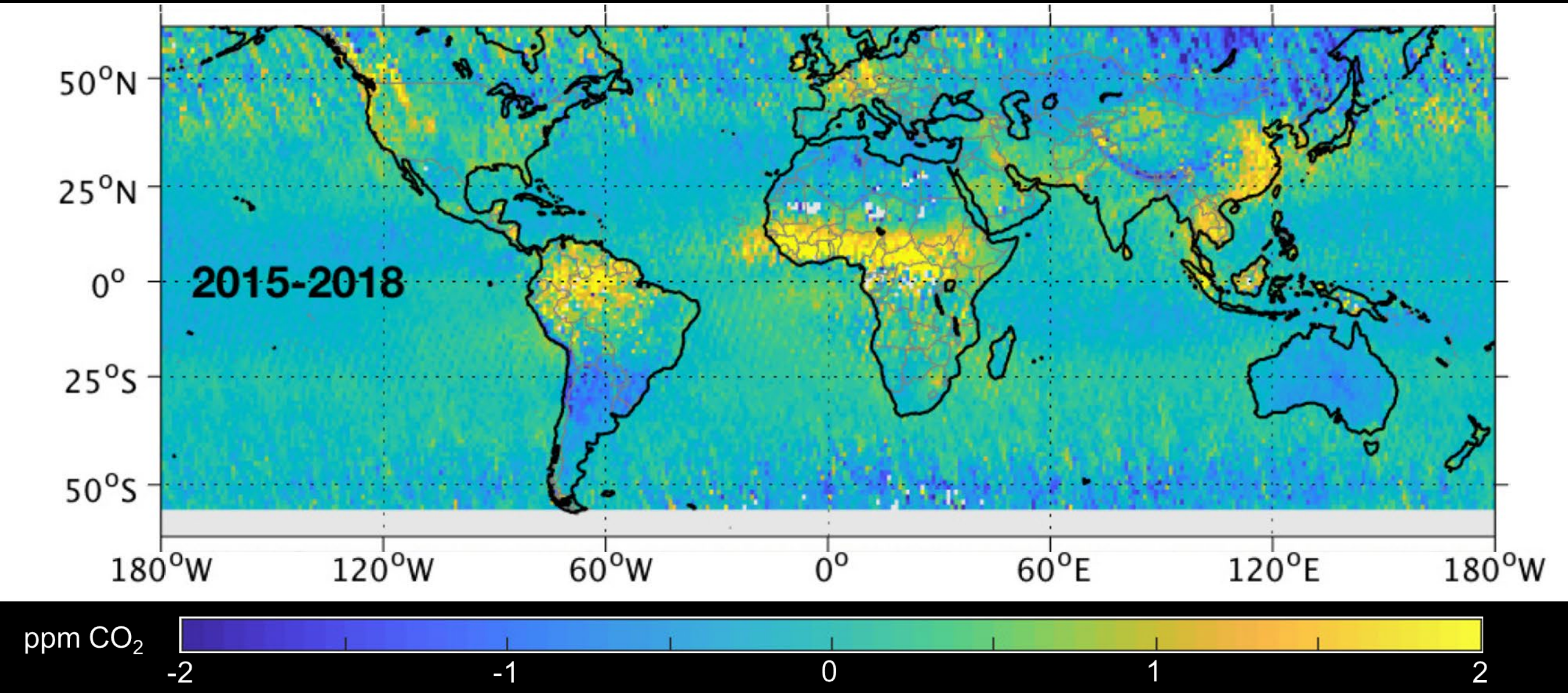

Jun 2015
TAO/TRITON Array
ATLAS
TRITON
Subsurface ADCP
degrees celsius


Jun 2015
GMAO SST Anomaly
degrees celsius


Terra MOPITT
CO anomalies (10^7 mol/cm^2)
SE Asia/Indonesia fire emissions in Sep - Oct 2015
OCO-2
X_{CO2} anomalies (ppm)
smaller immediate ocean response
larger lagged terrestrial response
TAO
ΔpCO_2 (μatm)
large reduction in CO_2 outgassing
O
D
F
A
J
A
O
D
F
A


20 km
10 km
5 km
01 Jan 2015 12 :00
Carbon Dioxide
390
393
396
399
402
405
408
ppmv


Atmospheric CO2 signature
of decomposition anomaly (2015-2011)


2015-2018
50°N
25°N
0°
25°S
50°S
180°W
120°W
60°W
0°
60°E
120°E
180°W
ppm CO_2
-2
-1
0
1
2

OCO-2