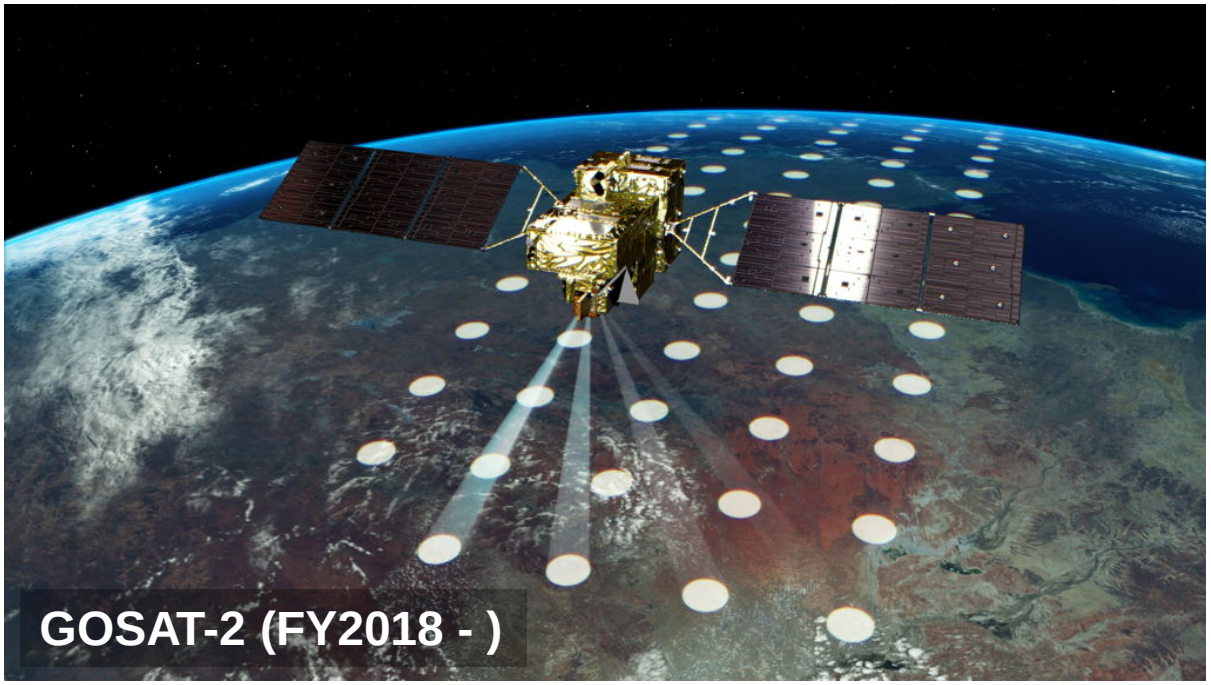
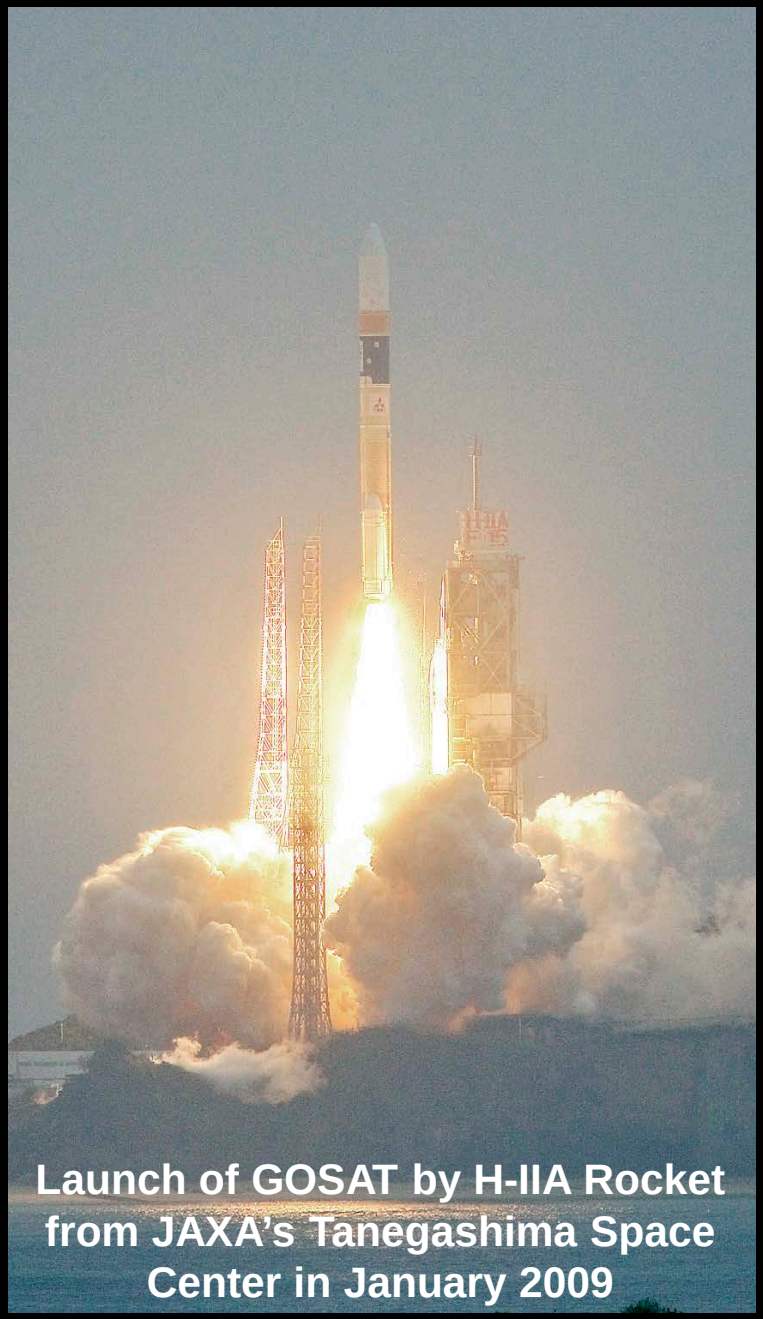
Carbon Dioxide and Methane Emissions Derived from GOSAT Data



Tsuneo Matsunaga
Satellite Observation Center
National Institute for Environmental Studies, Japan



Launch of GOSAT by H-IIA Rocket from JAXA's Tanegashima Space Center in January 2009

GOSAT (Greenhouse gases Observing Satellite) is the world's first satellite dedicated to greenhouse gas monitoring from space and a joint effort among MOE, JAXA, and NIES.

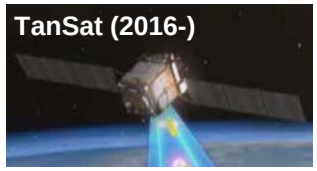
GOSAT was successfully launched in 2009, and has been monitoring the Earth's atmosphere for more than eight years.

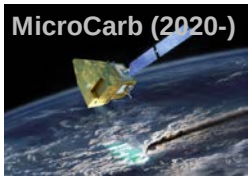
The successor, GOSAT-2, will be launched in FY2018 with more enhanced earth observation capabilities than GOSAT.

The discussion on GOSAT-3 has been already started.

Satellites for Greenhouse Gases Observation (Column observation only)

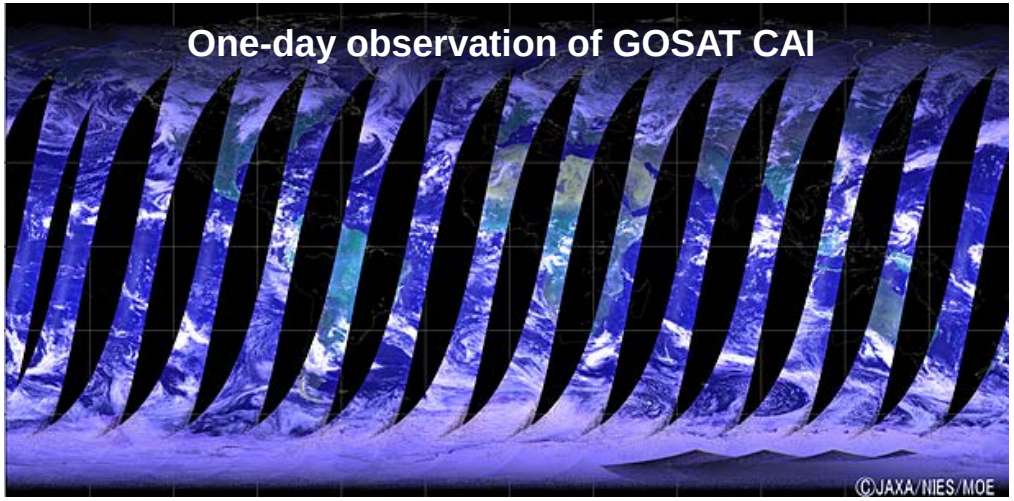
Mission	Country / Company	Period	GHGs	Comments
SCIAMACHY	(ESA)	2002 -2012	CO2, CH4	ENVISAT
GOSAT	Japan	2009 -	CO2, CH4	FTS
OCO-2	US	2014 -	CO2	Grating
CLAIRE	GHGSat (Canada)	2016 -	CO2	Fabry–Pérot
TanSat	China	2016 -	CO2	Grating
TROPOMI	(EC)	2017 -	CH4	Sentinel 5p
GF-5	China	2017 -	CO2, CH4	
FY-3D	China	2017 -	CO2, CH4	
GOSAT-2	Japan	2018 -	CO2, CH4	FTS
OCO-3	US	2018 -	CO2	ISS
MicroCarb	France	2020 -	CO2	
MERLIN	France/ Germany	2021 -	CH4	Laser
geoCARB	US	2022-	CO2, CH4	Geostationary
GOSAT-3	Japan	2022 -	?	?





Atmospheric and Land Observation by GOSAT and GOSAT-2

- GOSAT and GOSAT-2
  - Fourier Transform Spectrometer
    - FTS and FTS-2
      - Trace gases
        - CO2
        - CH4
        - H2O
        - CO
      - SIF
  - Cloud and Aerosol Imager
    - CAI and CAI-2
      - Clouds
      - Aerosols
        - AOT
        - PM2.5
        - Black carbon



GOSAT and GOSAT-2 Timeline

We are here. ★

(Calender year)

	2009	10	11	12	13	14	15	16	17	18	19	20	21	22

GOSAT

★ Launch(Jan. 2009)

Nominal | Extended ••••••••••

- Solar paddle failure (May 2014)
- FTS pointing A => B(Jan. 2015)
- FTS TIR cooler suspension (Aug. 2015)

GOSAT-2

- JAXA PDR (2014)
- JAXA CDR (2015)
- JAXA PQR(2017)
- NIES CDR(2016)
- Philipines TCCON (2017)

★Launch(FY2018)

Nominal

GOSAT Level 4A Products (Maksyutov et al. 2013)

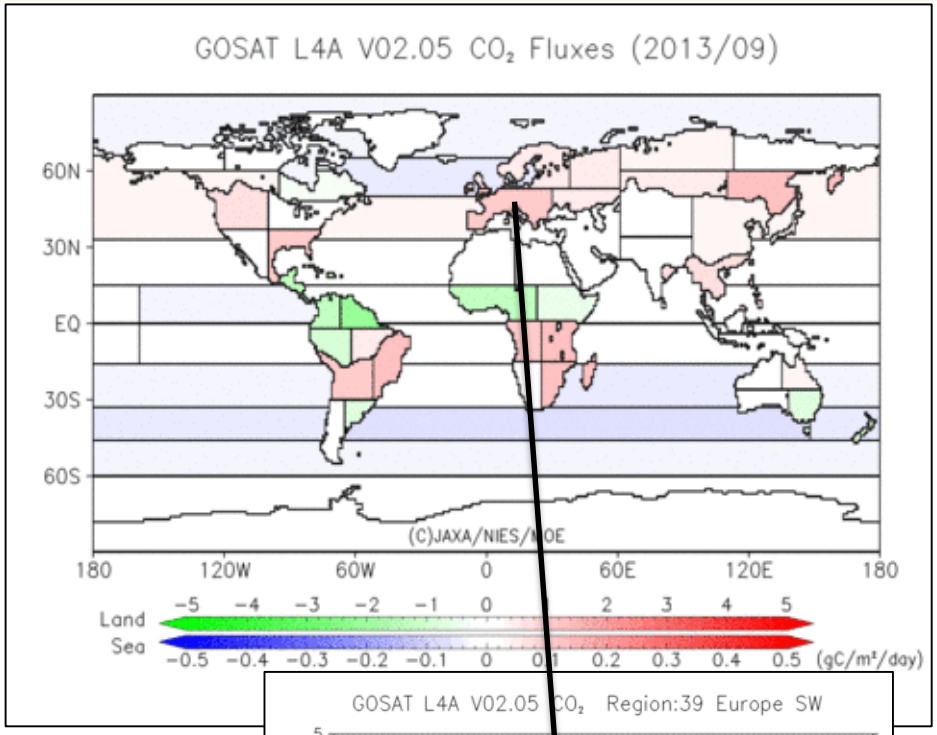
- **Monthly regional net gas flux** data estimated using
  - Fixed-lag Kalman smoother inversion scheme,
  - GOSAT Level 2 gas column concentration data,
  - Surface and airborne gas concentration data,
  - Emission inventories (as a priori data)(ODIAC, GFED, EDGAR),
  - Meteorological data (JMA reanalysis data),
  - Terrestrial vegetation model (VISIT), and
  - Atmospheric transport model (NIES TM).

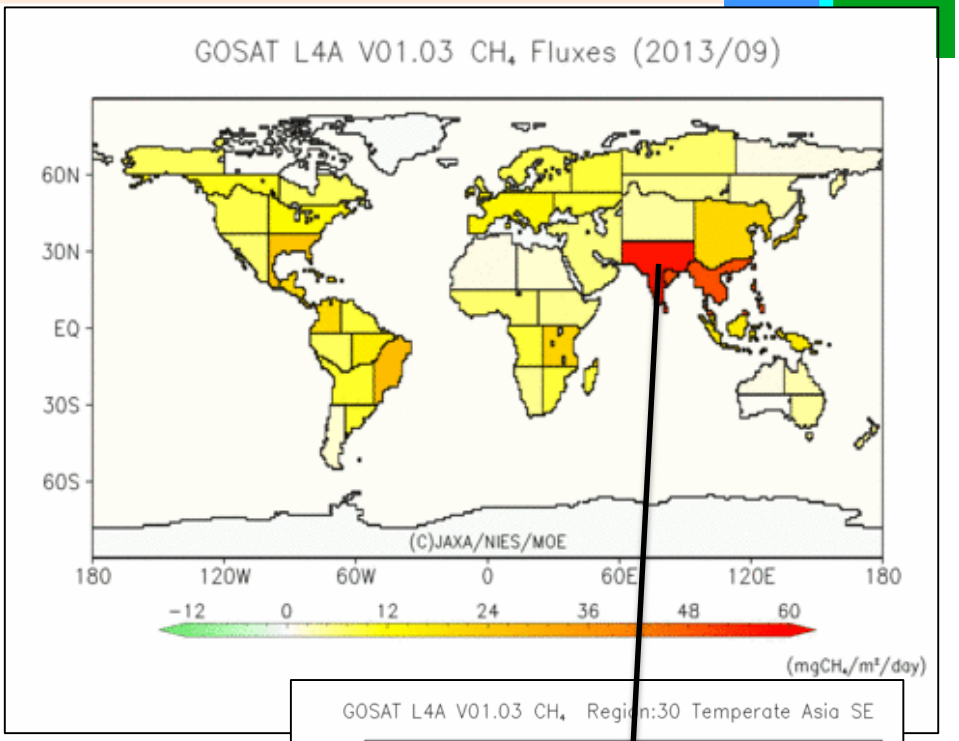
- Latest standard products :

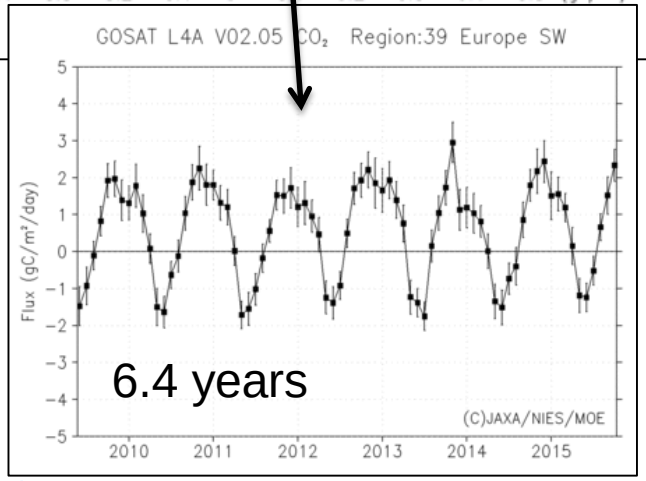
CO2	V02.05	June 2009 - October 2015
		42 land regions and 22 ocean regions
CH4	V01.03	June 2009 – September 2013
		42 land regions and 1 ocean region

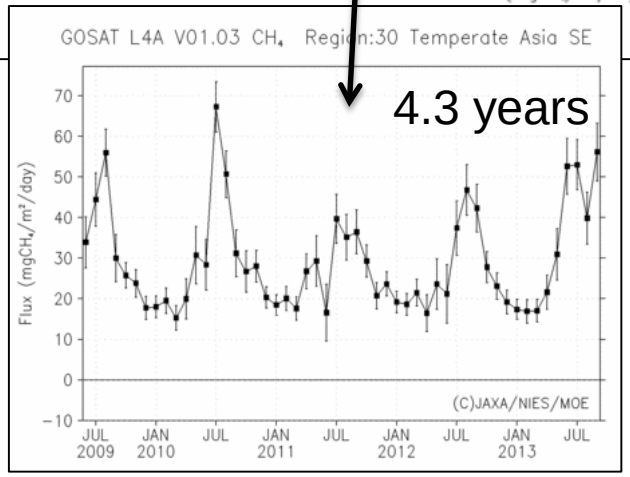
- Freely available from https://data2.gosat.nies.go.jp

GOSAT Level 4A CO2 and CH4 Flux Products Maps and Time Series Charts









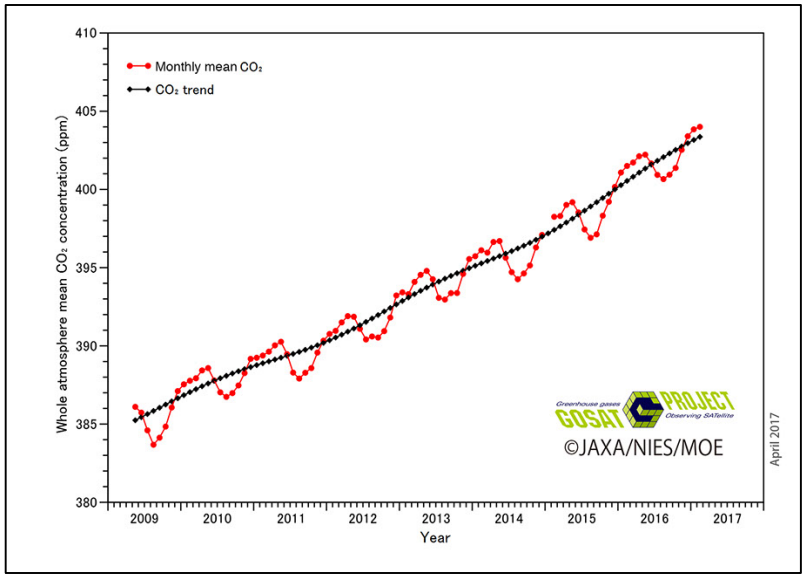
Global Total CO2 and CH4 Annual Net Flux GOSAT and Other Top-down Estimates

CO2

GtC / year	2010	2011	2012	2013	2014
NOAA annual CO2 growth rate*	5.2	3.6	5.0	5.2	4.2
GOSAT L4A CO2 V02.05	5.1	3.5	5.3	5.1	4.0

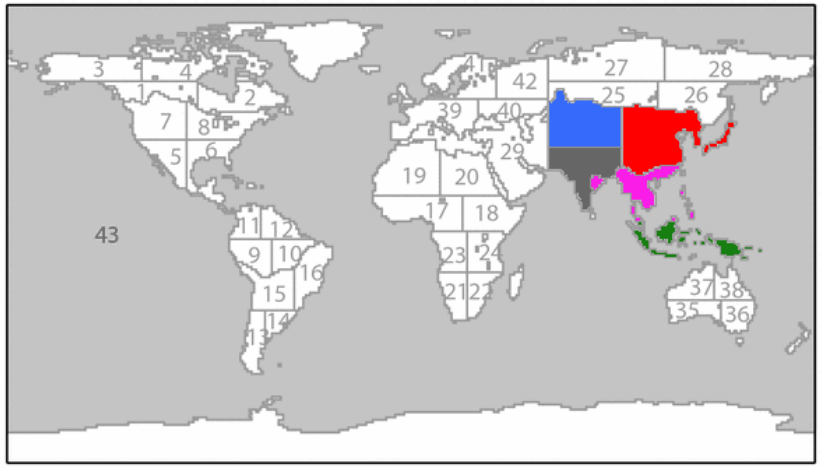
CH4

TgCH4 / year	2012
Saunois et al. 2016 (Top-down)*	542-582
GOSAT L4A CH4 V01.03 + Soil Sink	565

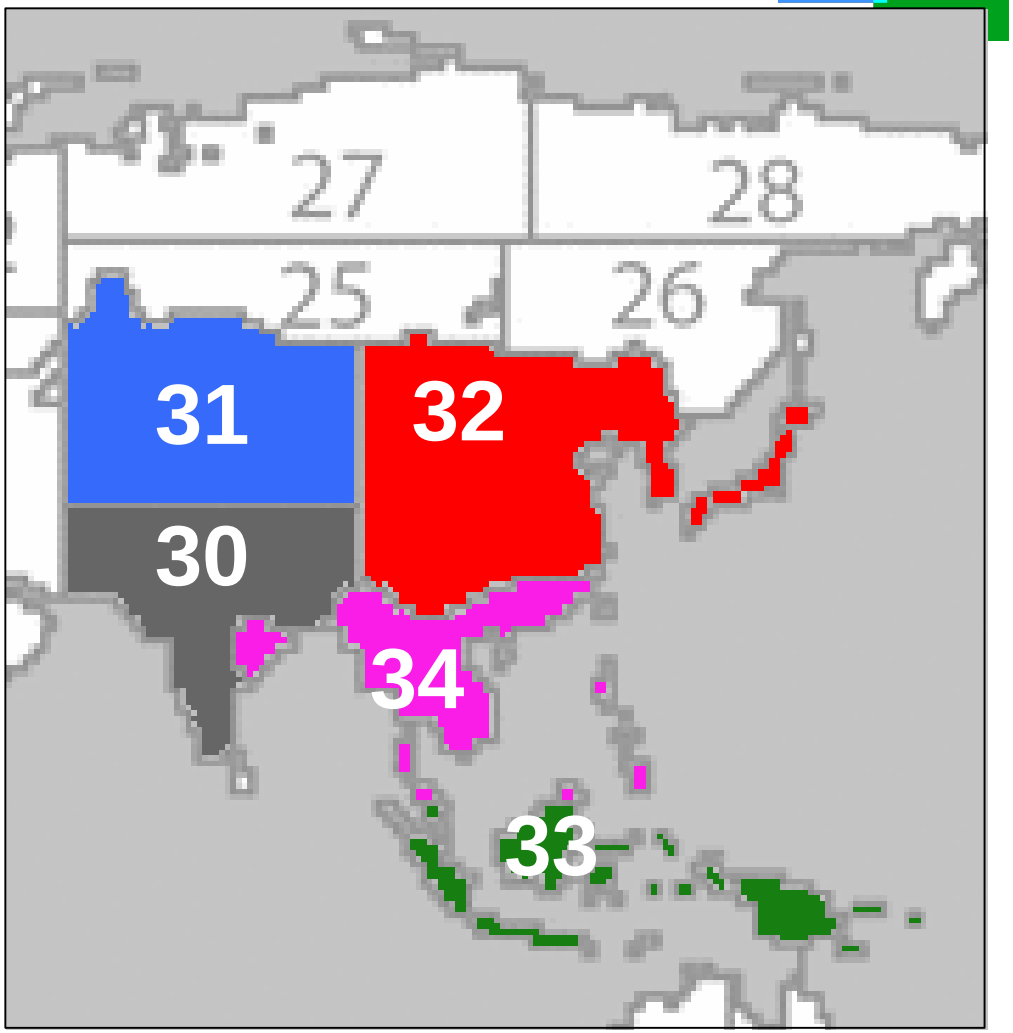


- Source: http://www.globalcarbonproject.org/carbonbudget/16/data.htm
- Source:http://www.globalcarbonproject.org/methanebudget/16/data.htm

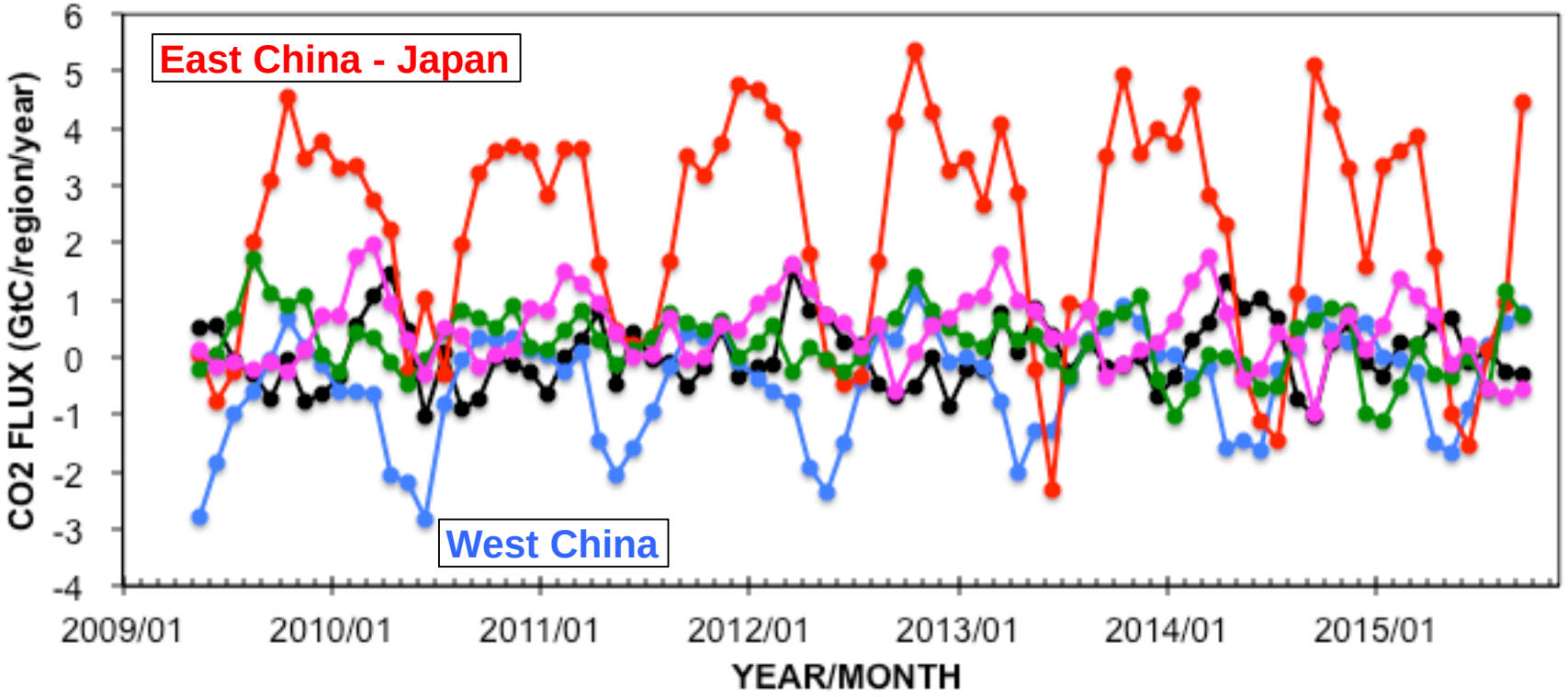
GOSAT L4A Region 30 - 34



R30 India
R31 West China
R32 East China - Japan
R33 South of SEA
R34 North of SEA

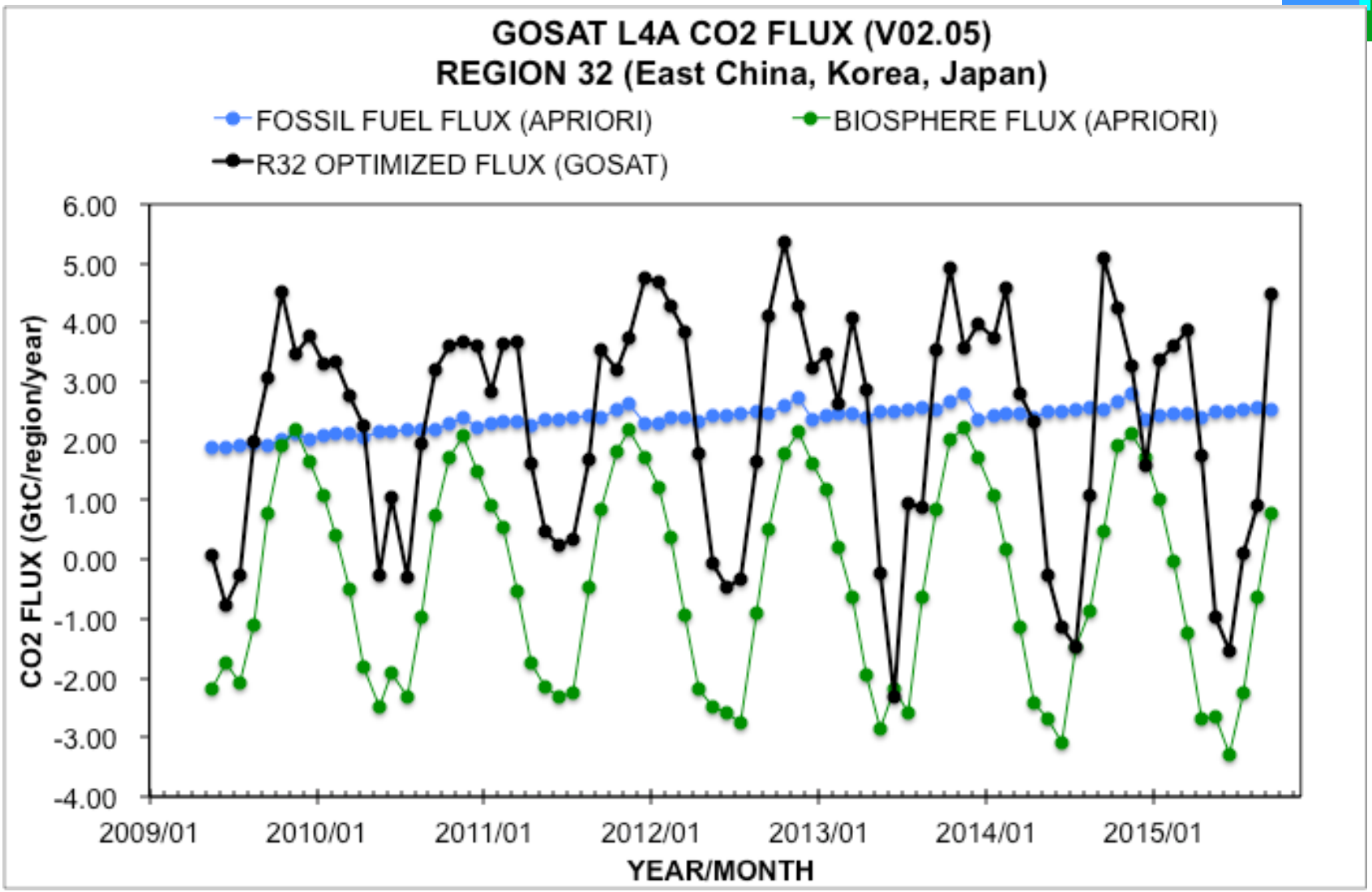


GOSAT L4A CO2 Net Flux V02.05
Region 30 – 34

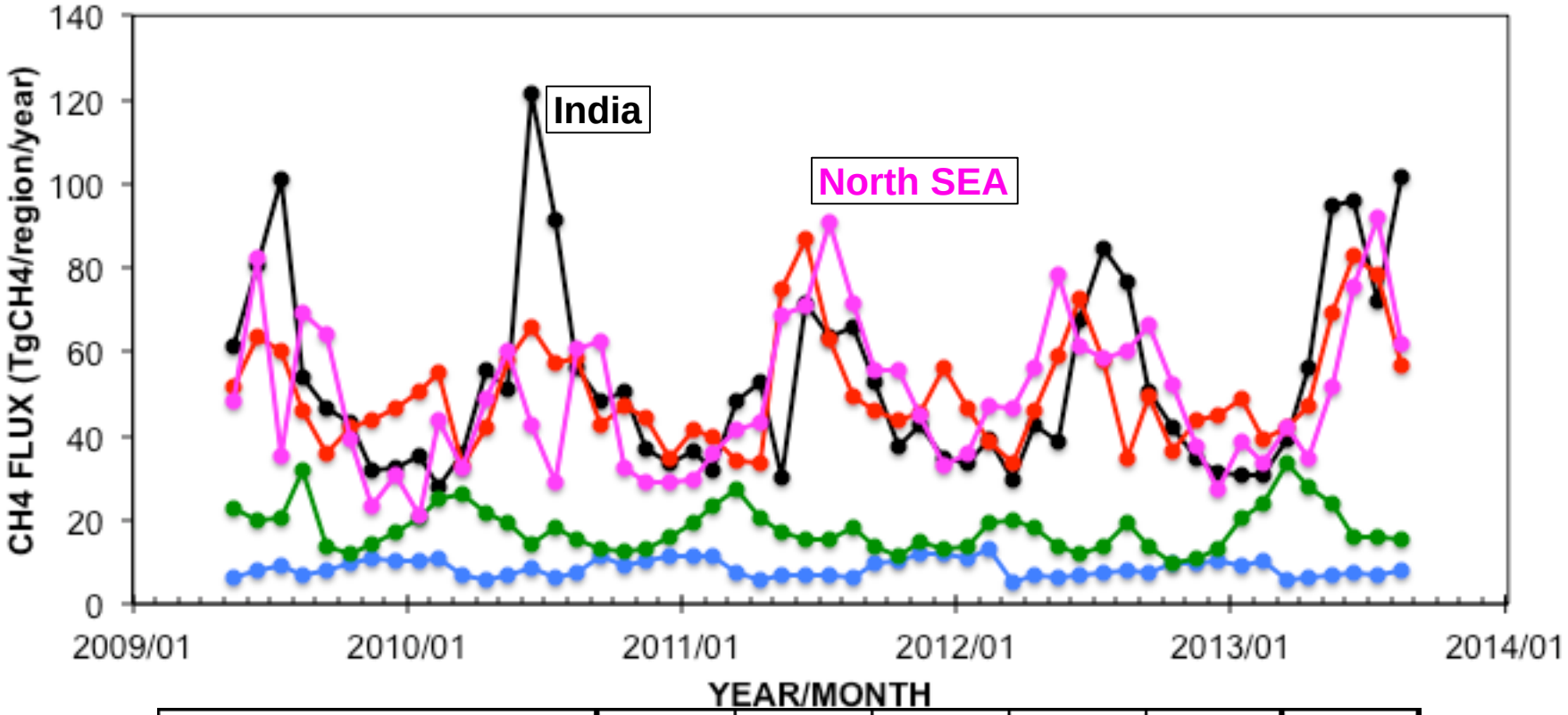


ANNUAL NET FLUX	2010	2011	2012	2013	2014	Average
R30 : India	0.0	0.0	0.1	0.0	0.2	0.1
R31 : West China	-0.7	-0.4	-0.5	-0.3	-0.3	-0.4
R32 : East China - Japan	2.4	2.4	2.8	2.3	2.4	2.4
R33 : South SEA	0.0	0.0	0.1	0.0	0.2	0.1
R34 : North SEA	0.0	0.0	0.1	0.0	0.2	0.1

GOSAT L4A CO2 Flux V02.05 : Region 32 (East China - Japan)

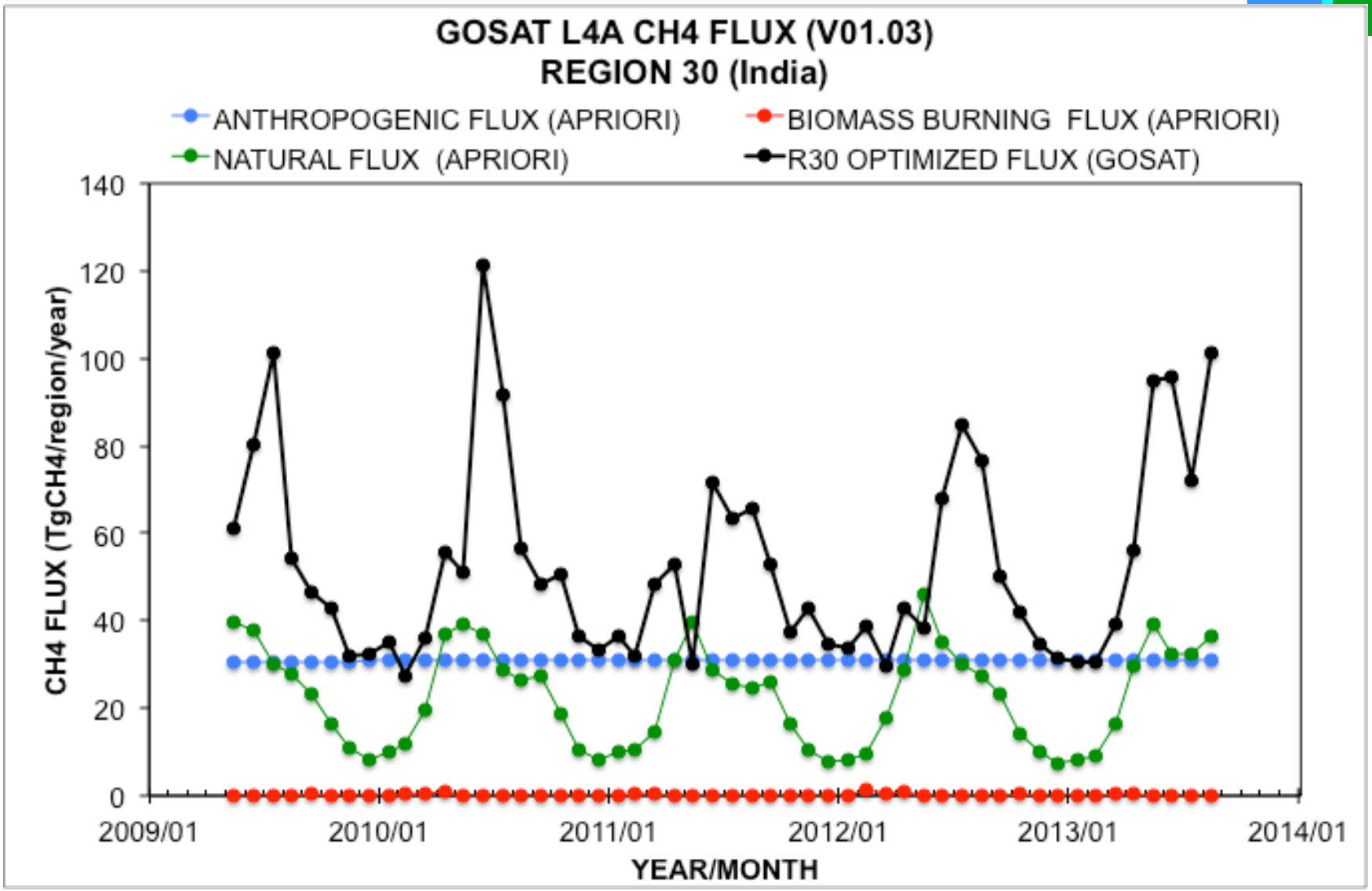


GOSAT L4A CH4 Net Flux V01.03
Region 30 – 34

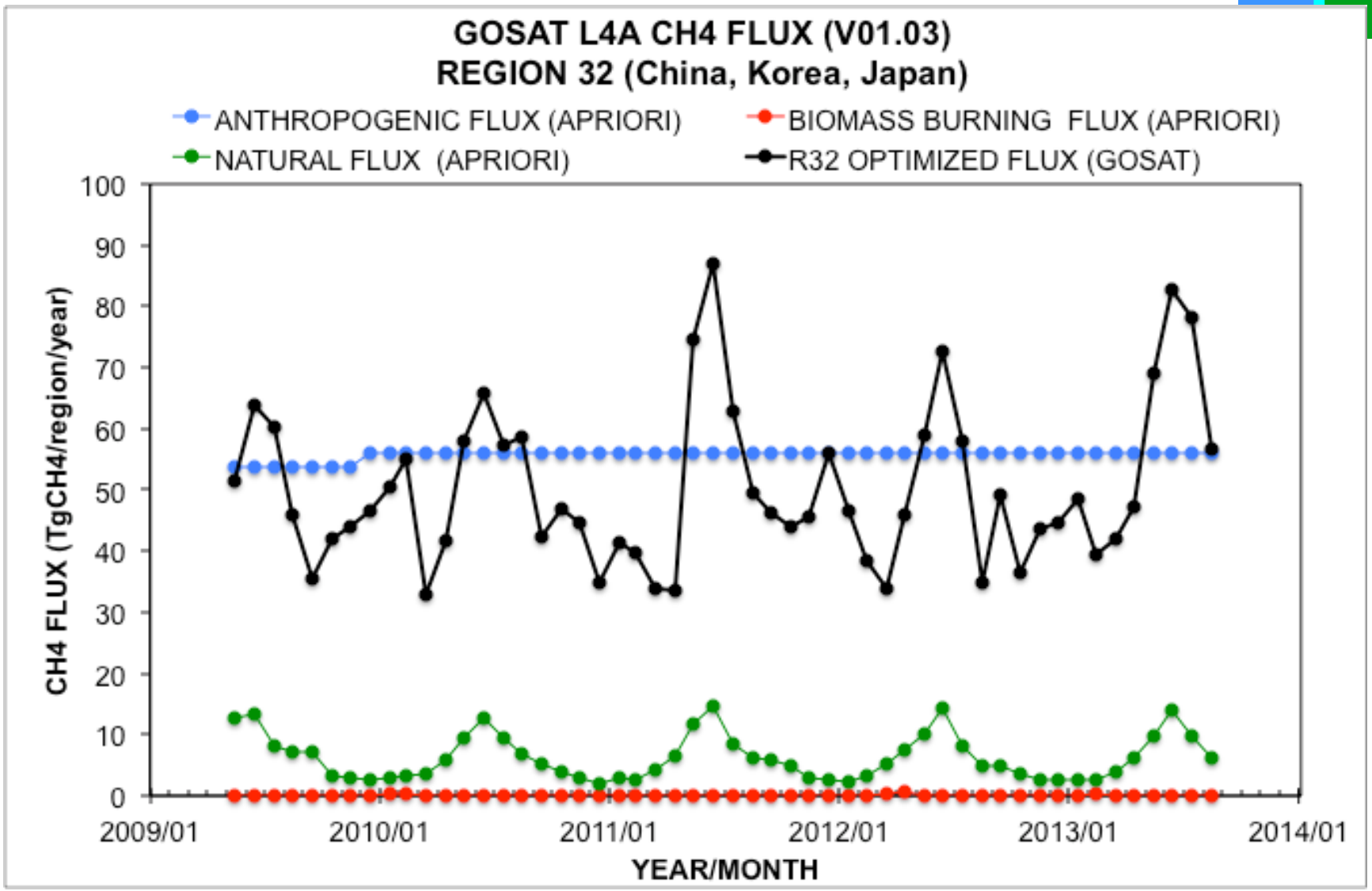


ANNUAL NET FLUX	2010	2011	2012	2013	2014	Average
R30 : India	53.6	47.2	47.9			49.6
R31 : West China	8.6	8.9	8.6			8.7
R32 : East China - Japan	50.0	49.4	47.9			49.1
R33 : South SEA	18.0	17.7	14.7			16.8
R34 : North SEA	41.1	53.1	52.7			49.0

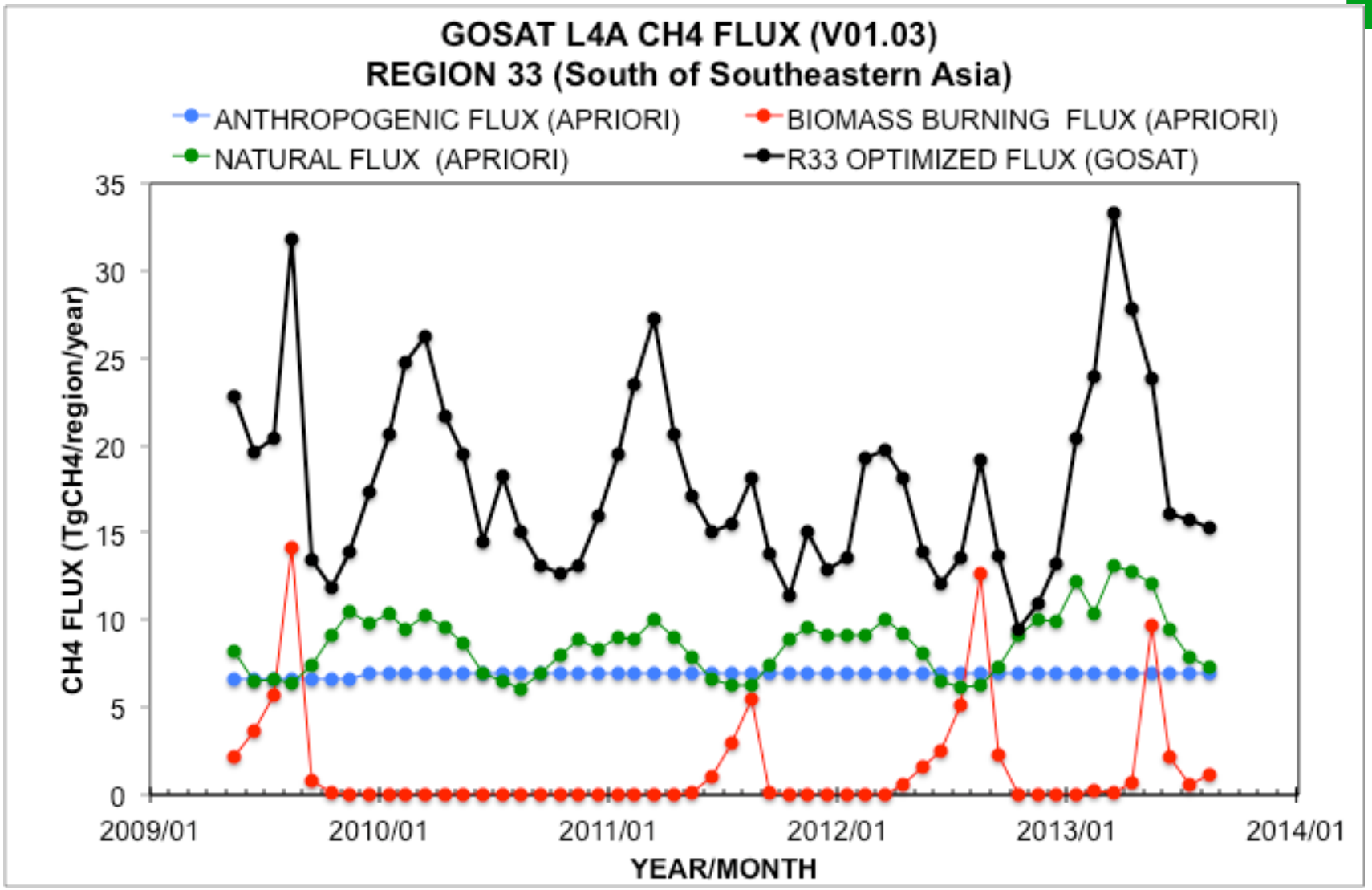
GOSAT L4A CH4 Flux V01.03 : Region 30 (India)



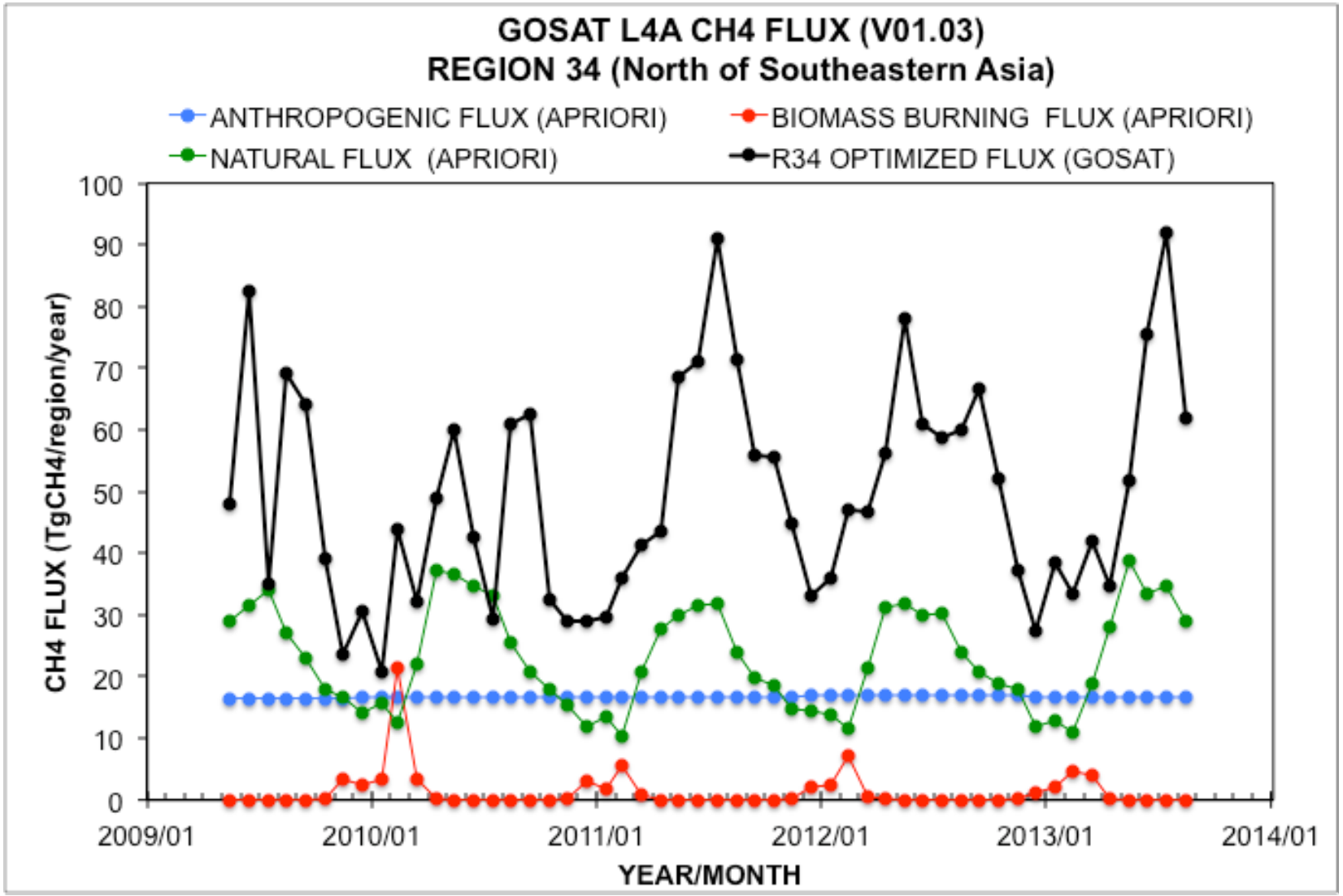
L4A CH4 Flux V01.03 : Region 32 (East China- Japan)



GOSAT L4A CH4 Flux V01.03 : Region 33 (Southof Southeastern Asia)

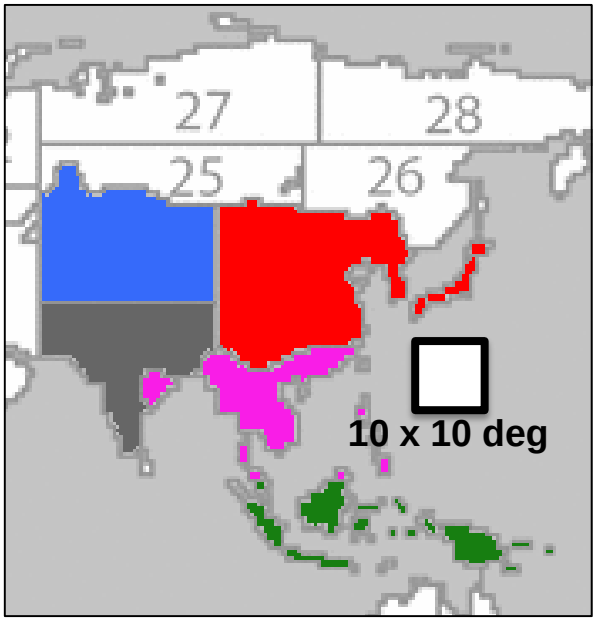


GOSAT L4A CH4 Flux V01.03 : Region 34 (North of Southeastern Asia)



Summary

- ✓ GOSAT L4A CO2 and CH4 monthly regional net flux products are available for 2009 – 2015 (CO2) and 2009 – 2013 (CH4).
- ✓ “East China – Japan” region is a largest CO2 emitter in Asia. South and Southeastern asian regions are almost CO2 neutral.
- ✓ As for CH4, “East China – Japan”, “India”, and “ North SEA” are important emitters. And models / inventories may underestimate the amplitudes of seasonal variations.
- ✓ The region size of GOSAT-2 Level 4A standard product will be about 10 x 10 deg...



Thank you for your attention.

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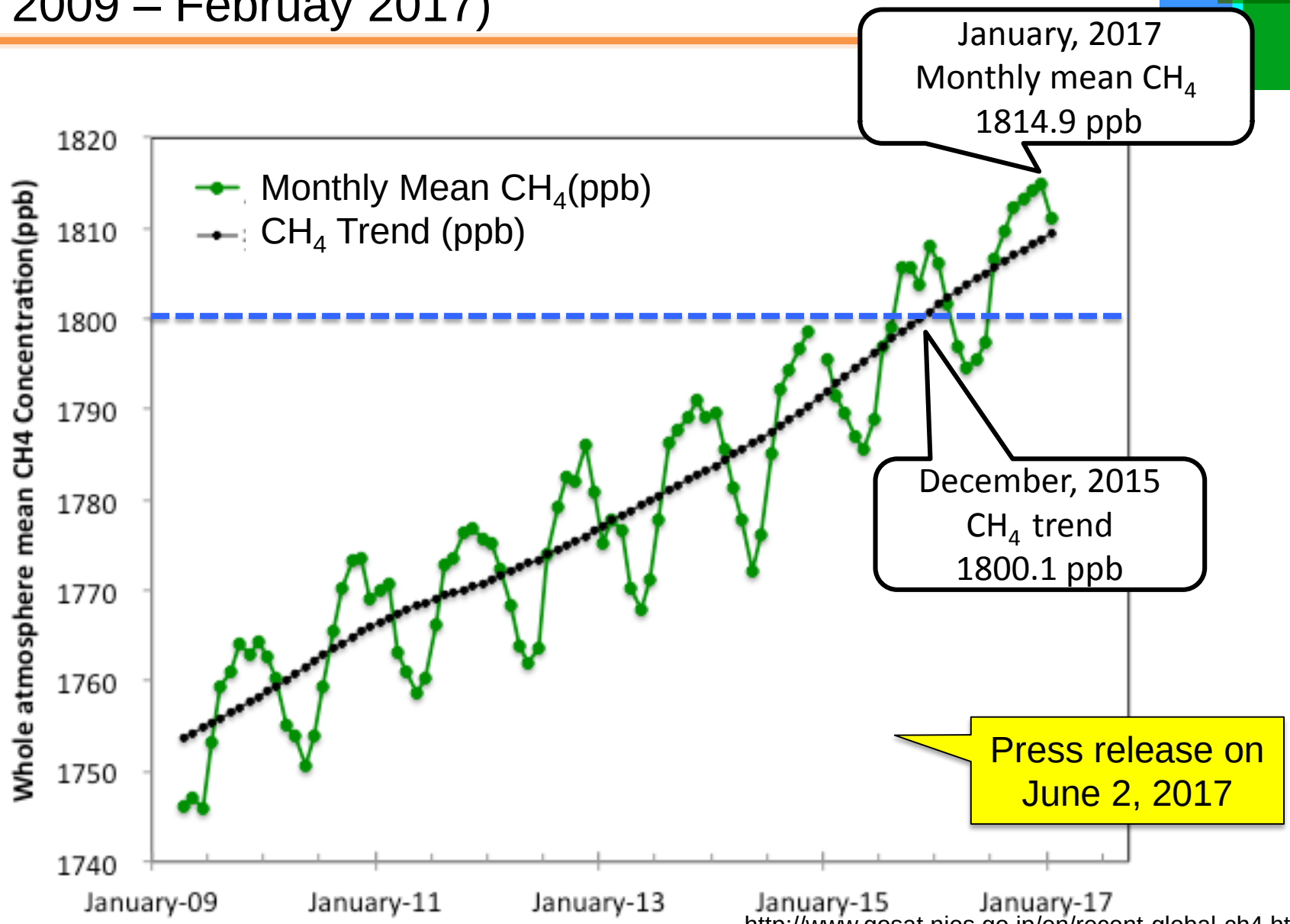
Website
http://www.nies.go.jp/soc/en/
http://www.gosat.nies.go.jp/en/
http://www.gosat-2.nies.go.jp

GOSAT standard products are freely available from
GOSAT Data Archive Service
https://data2.gosat.nies.go.jp

GOSAT Whole-atmosphere Mean Methane Concentration (May 2009 – Februay 2017)



http://www.gosat.nies.go.jp/en/recent-global-ch4.html