Characterization of biomass burning from combined analysis using SCIAMACHY, GOSAT and MOPITT

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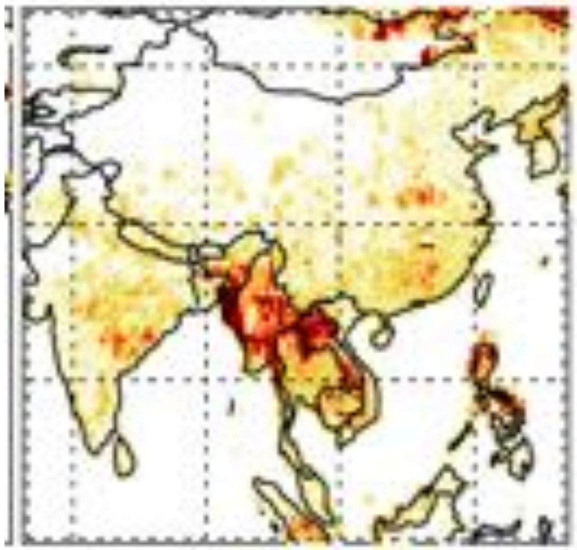
Motivation(1)

Asia in dry season

- Biomass burning is active
- Slash-and- burn agriculture in tropical forest
- Peatland burning
- Burn-off the rice field
- Rice straw and manure are mixed and burned



Hotspot Numbers in MAM (climatology)

Variety of fire types

Photo: Rice field in Myanmar

Courtesy of Yugo Kanaya

Motivation(2):

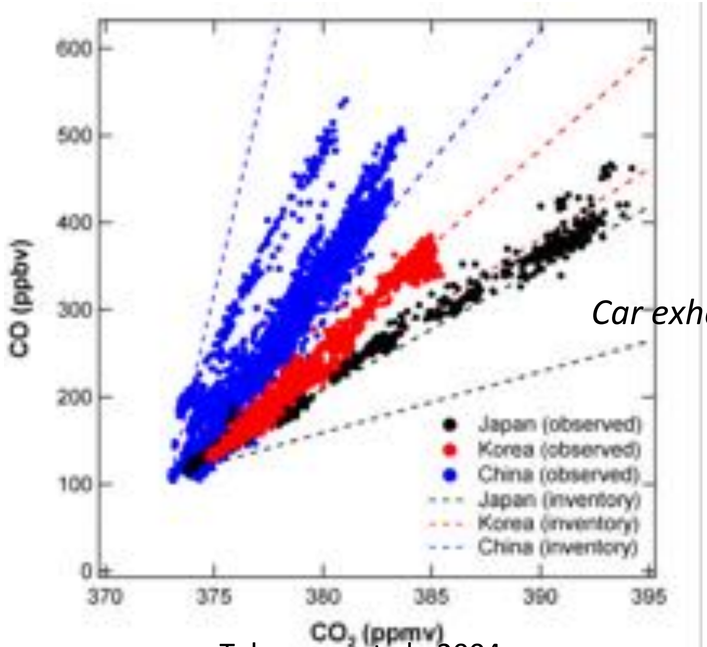
GOSAT-2 plan: addition of CO channel

CO/CO_2 ratios, differentiate sources ?

$$\frac{\delta\, CO}{\delta\, CO_2}$$ => Information on source of plume?

Russian fire 2010

Biomass burning $\Delta CO/\Delta CO_2$>40 ppbv/ppmv



Takegawa et al., 2004

Car exhaust～25

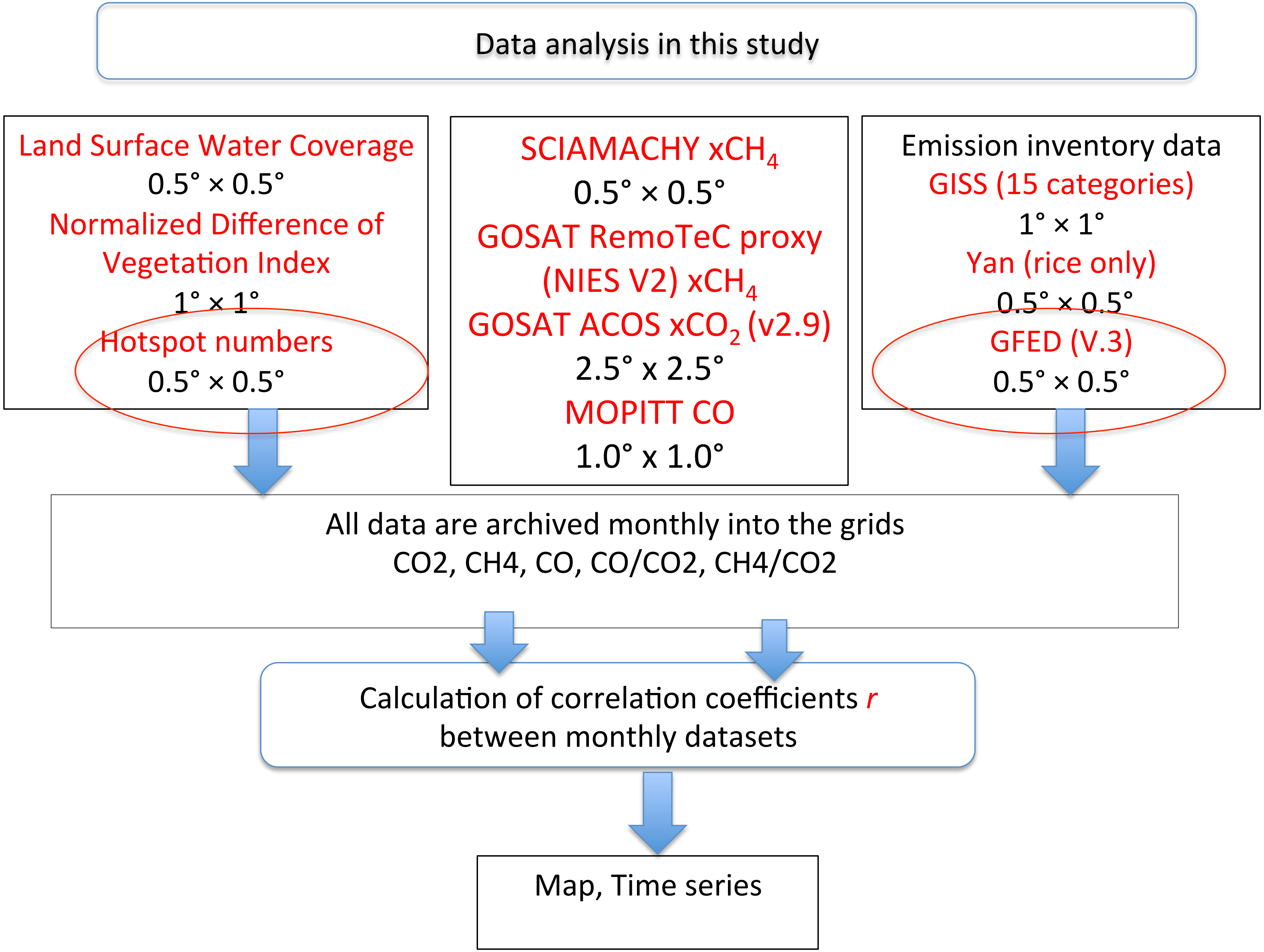
CH_4/CO_2 for various types of fires

Table 5 from Van der Werf et al. (2010), ACP

Table 5. Emission factors used for different fire types, in g specie per kg dry matter burned.

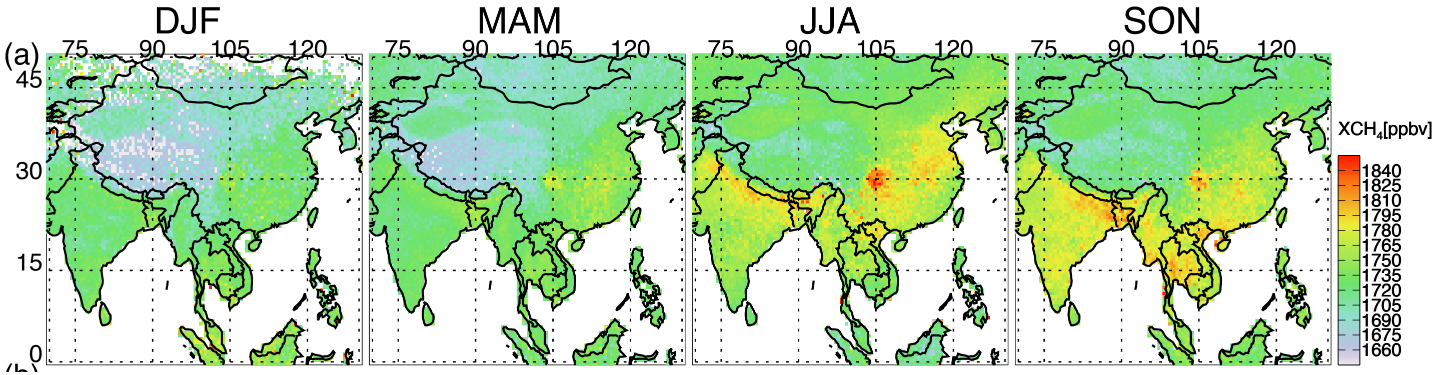
	Deforestation[1]	Savanna and Grassland[1]	Woodland[2]	Extratropical forest[1]	Agricultural waste burning[1]	Peat fires[3]
Carbon[4]	489	476	483	476	440	563
CO_2	1626	1646	1636	1572	1452	1703
CO	101	61	81	106	94	210
CH_4	6.6	2.2	4.4	4.8	8.8	20.8
NMHC	7.00	3.41	5.21	5.69	11.19	7.00

	Deforestation	Savannna and Grassland	Woodland	Extratropical forest	Agricultual waste burning	Peat fires
CH4/CO2	0.41%	0.13%	0.27%	0.31%	0.61%	1.22%
CO/CO2	6.21%	3.71%	4.95%	6.74%	6.47%	12.33%

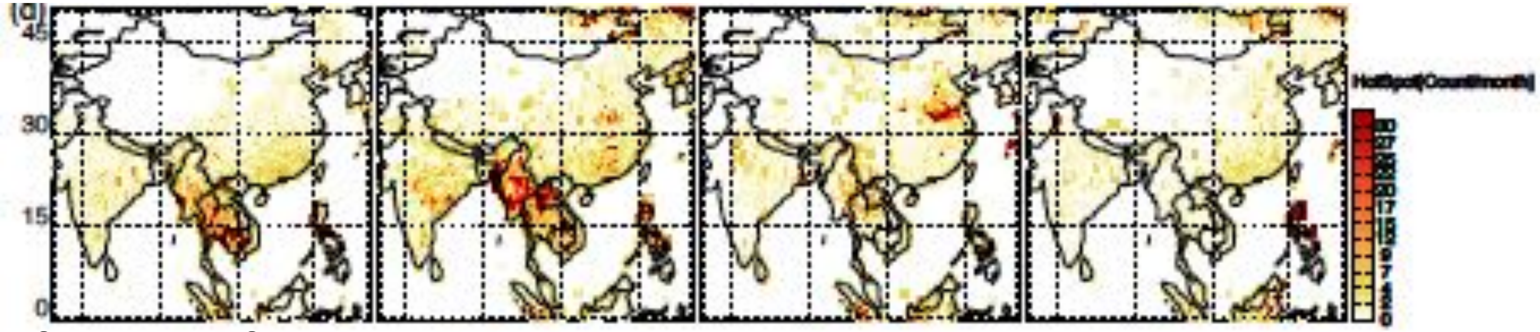

Data analysis in this study
Land Surface Water Coverage
0.5° × 0.5°
Normalized Difference of Vegetation Index
1° × 1°
Hotspot numbers
0.5° × 0.5°
SCIAMACHY xCH_4
0.5° × 0.5°
GOSAT RemoTeC proxy (NIES V2) xCH_4
GOSAT ACOS xCO_2 (v2.9)
2.5° x 2.5°
MOPITT CO
1.0° x 1.0°
Emission inventory data
GISS (15 categories)
1° × 1°
Yan (rice only)
0.5° × 0.5°
GFED (V.3)
0.5° × 0.5°
All data are archived monthly into the grids
CO2, CH4, CO, CO/CO2, CH4/CO2
Calculation of correlation coefficients *r* between monthly datasets
Map, Time series

SCIAMACHY xCH4 (6-year climatology)

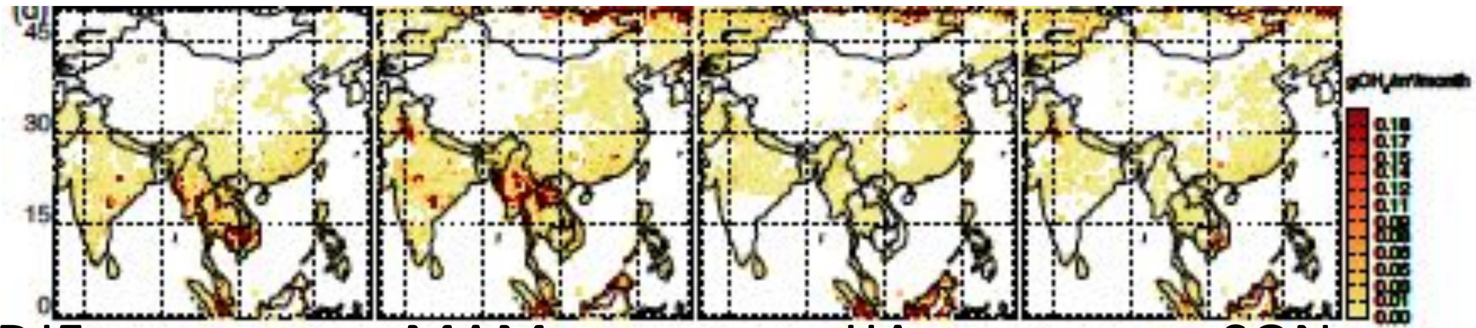
DJF MAM JJA SON



Hotspot numbers

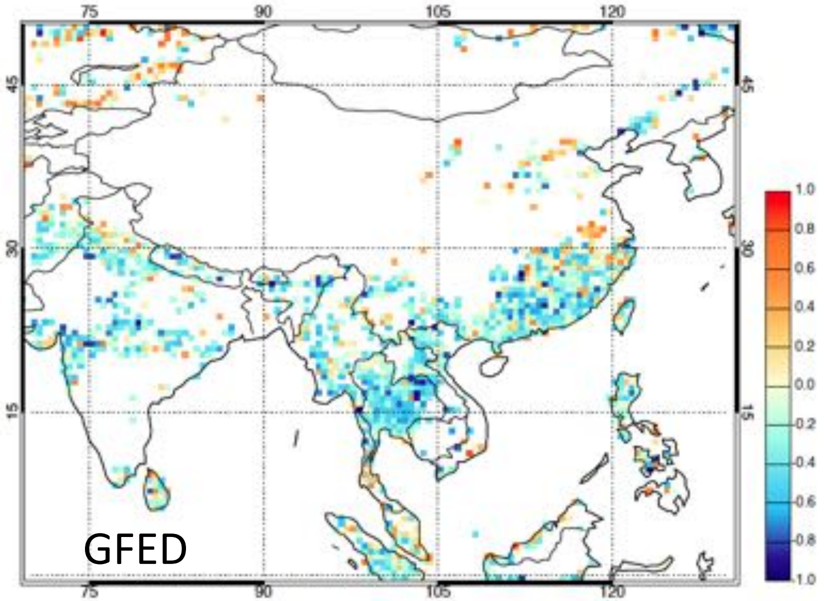


Emission estimate GFED V.3

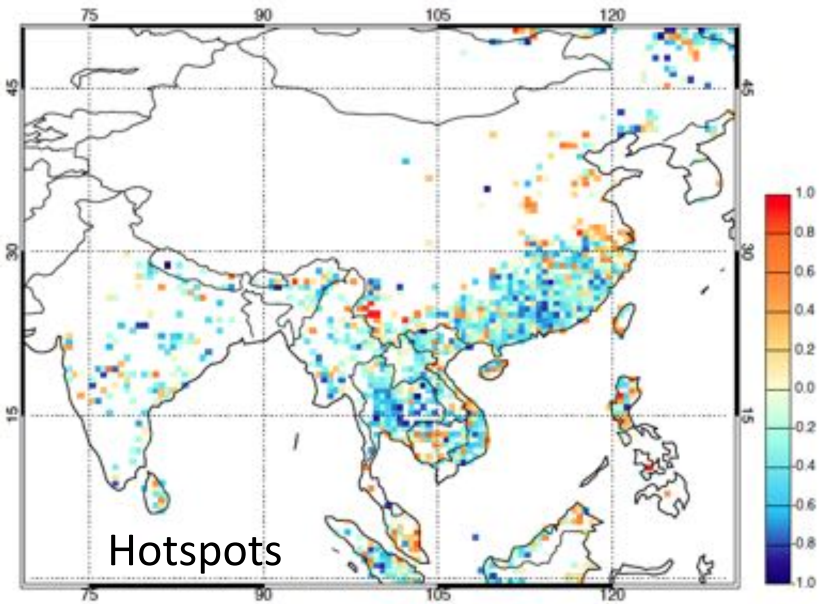


DJF MAM JJA SON

Correlation with xCH_4(SCIA)



SCIA_6years_monthly_vs_GFED_correlation



SCIA_6years_monthly_vs_HOTSPOT_correlation

N:matching pairs >= 6

Correlation with:
LSWC => high
NDVI => very high
Rice emission => very high
(as presented at GOSAT-PI meeting on Wednesday)
Hotspots => low
GFED => low

> Overall seasonality is corresponding to rice emission.
> Biomass burning effect is limited to dry season when the CH_4 concentration is the lowest.

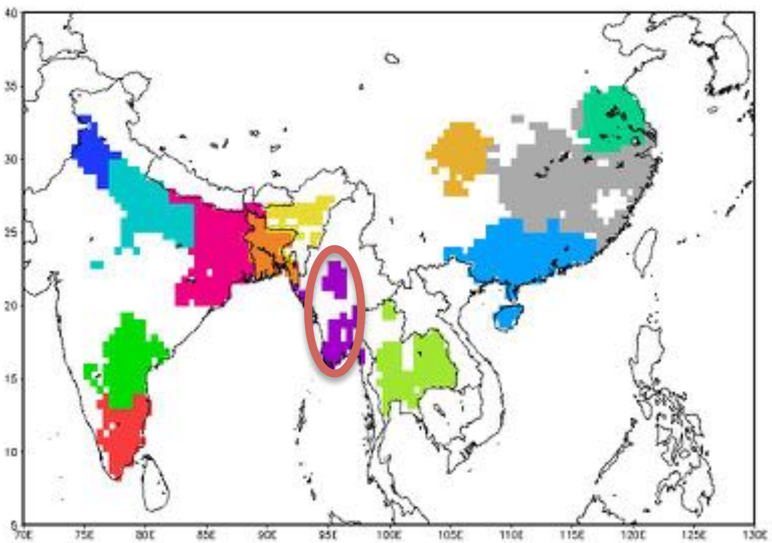
Detection of biomass burning is not straight-forward

Definition of “anomaly”

six-year-average

$$\Delta(\mathrm{xCH_4})(\%) = \frac{\left\{\mathrm{xCH_4}(i) - \overline{\mathrm{xCH_4}}\right\}}{\overline{\mathrm{xCH_4}}} \bullet 100$$

$$i = 1, 2, 3 \ldots 12$$

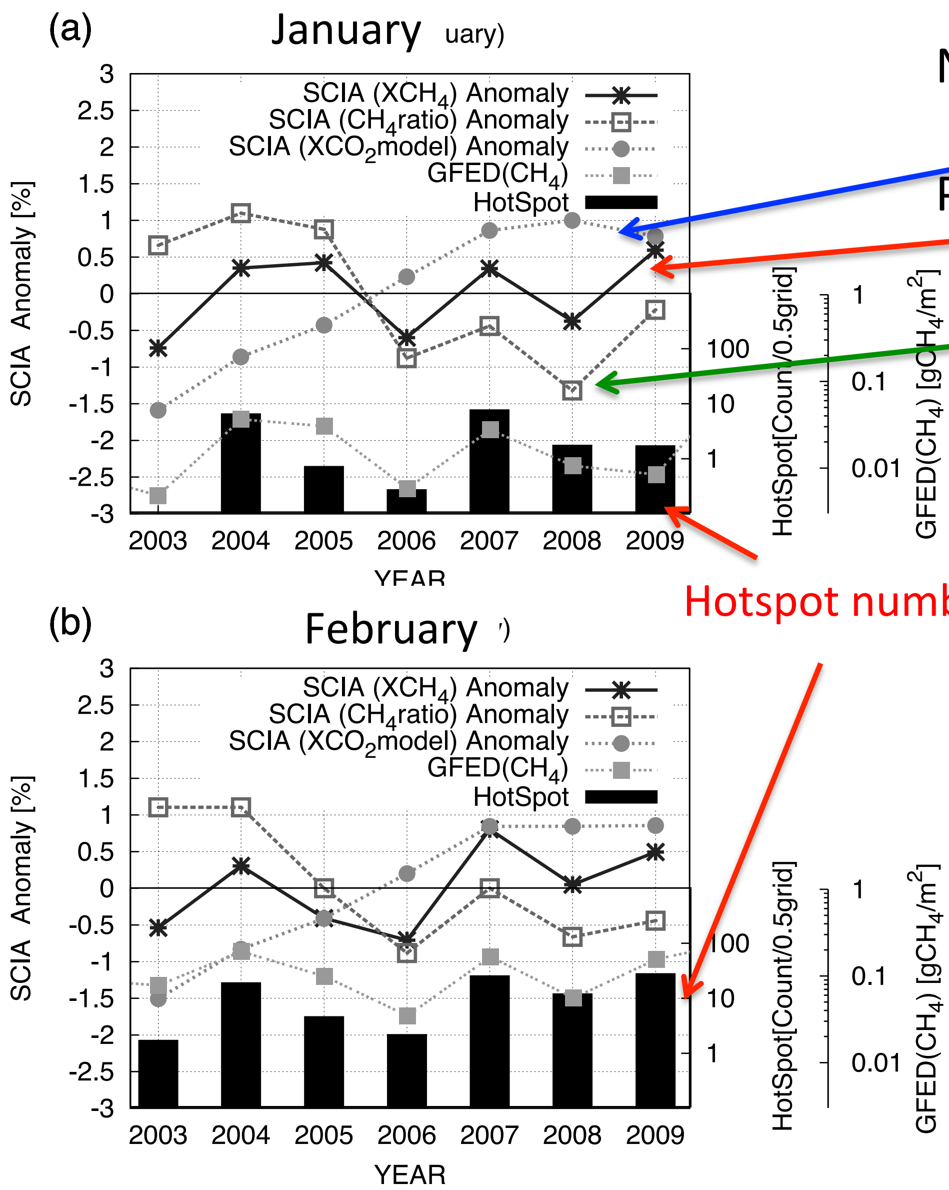


Typical rice paddy field was selected

Myanmar : many hotspots in dry season

Anomaly of CH_4/CO_2

Over Myanmar (rice field)



Hotspot numbers

xCH4: Proxy products

Note that :

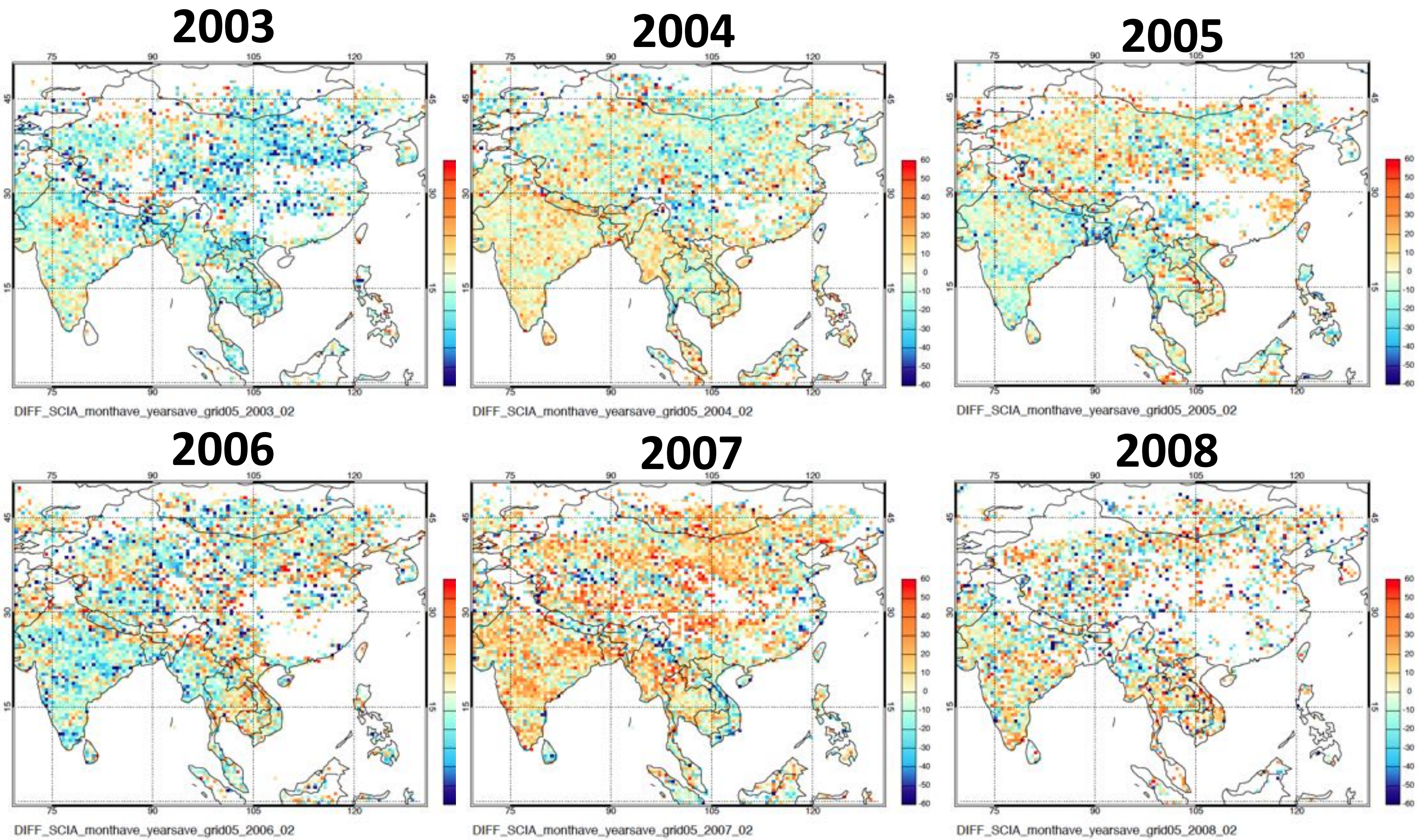
Proxy xCH4 = CCH_4/CCO_2 * CO2(model)

CCH_4/ CCO_2

Looks dependent on activity of BB

Map of anomaly (February)

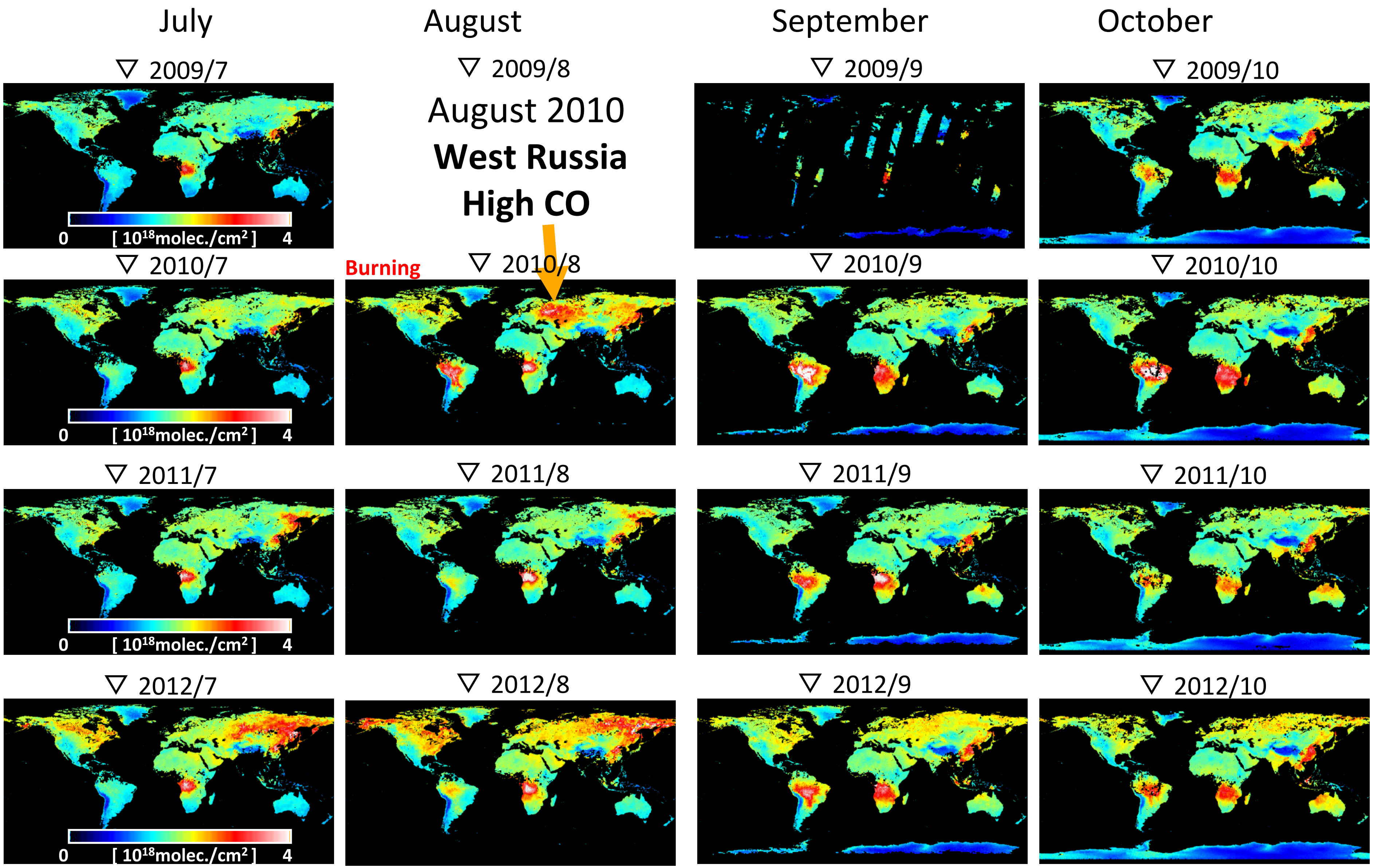
$$\Delta(xCH_4)(\%) = \frac{\left\{xCH_4(i) - \overline{xCH_4}\right\}}{\overline{xCH_4}} \bullet 100$$



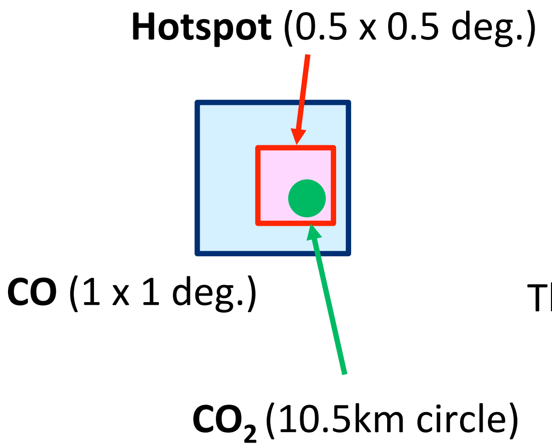
Need more validation on year-to-year variability of SCIAMACHY dataset

Case study: Russian fire 2010

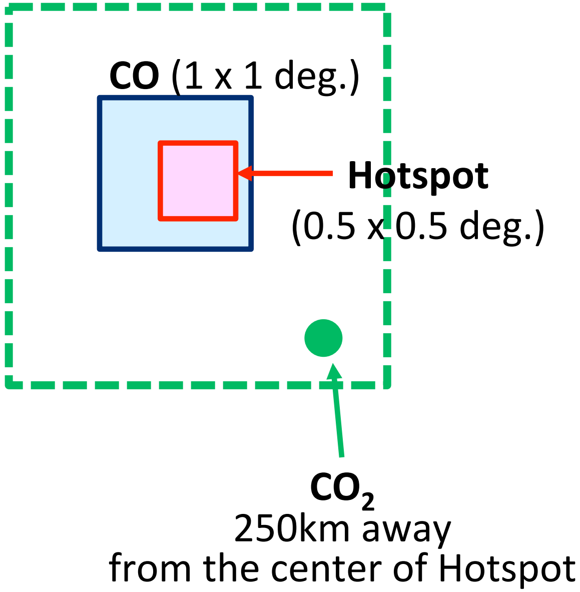
○ MOPITT CO (Day_product)

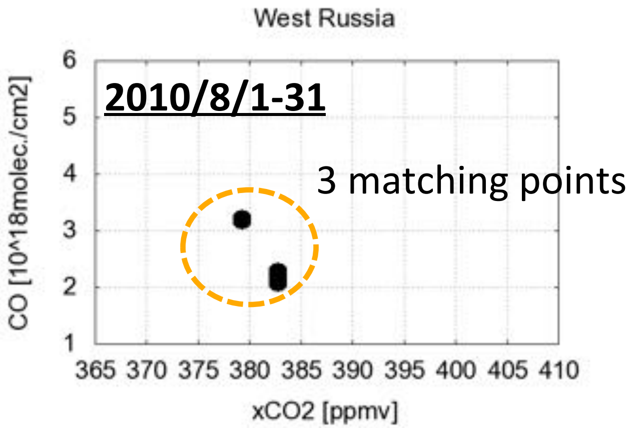


Analysis method (Comparison method of three products)



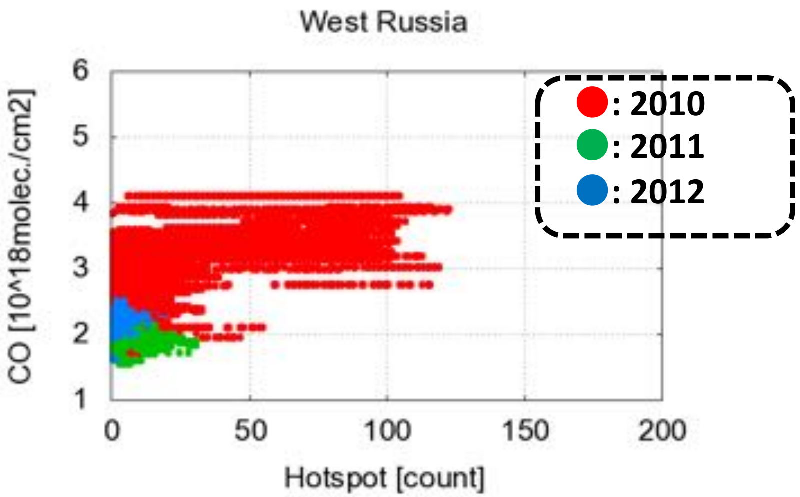
The selection area of CO_2 is extended.





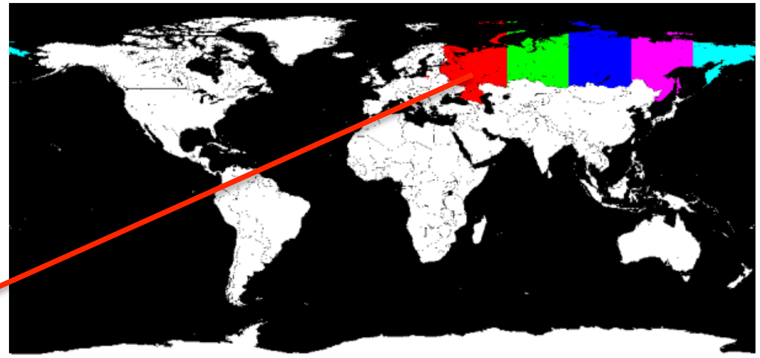
There are few matching points of three products (Hotspot, CO, and CO_2).

▽ **Hotspot vs. CO**

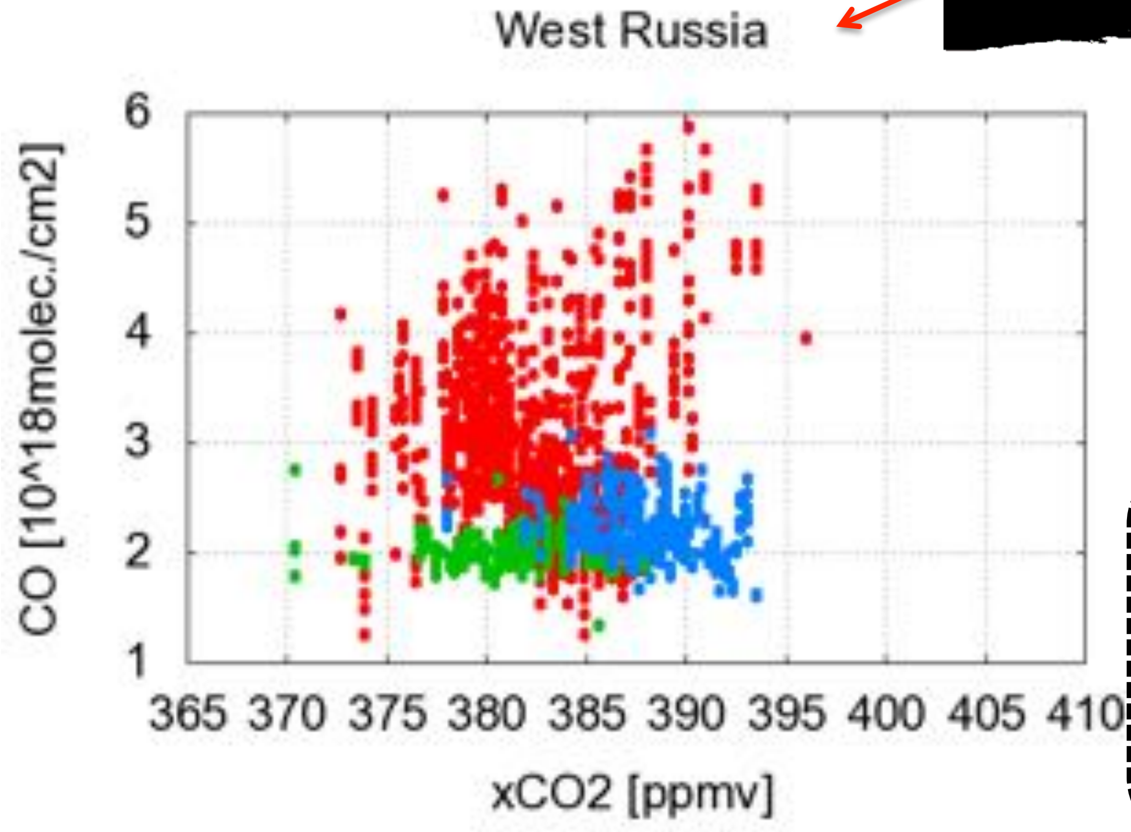


○ CO_2 (ACOS) vs. CO

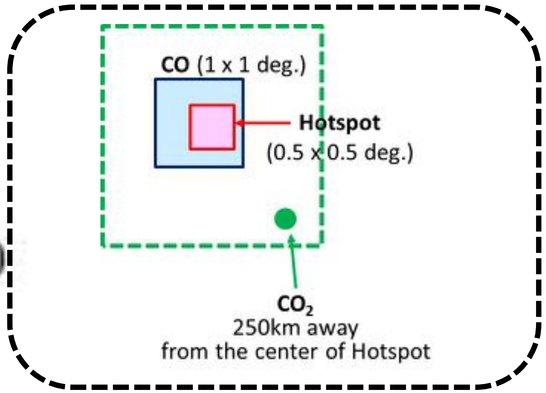
[8/1-31 daily data, with Hotspot]



●: 2010 Year of Big fire
●: 2011 ●: 2012



Comparison method



Summary

- Only limited numbers of the matching pairs of CO_2/GOSAT and CO/MOPITT
  - Independent sensors: no simultaneous obs.
  - Difficulty of GOSAT retrieval due to smoke from fires?
  - xCO_2 is column average: sensitivity to the lower atmosphere?
  - No correlation was found between CO and CO_2.
- Southeast Asia
  - SCIAMAHY xCH4 shows interannual variability: it looks corresponding to biomass burning? More validation is needed
  - Enhancement was observed in xCH_4 (GOSAT/RemoteC proxy) corresponding to enhancement of hotspots and CO
  - Statistical analysis for anomaly of xCH_4 and xCH_4/xCO_2 is needed (will be done soon!)
- Case study of fire in Siberia in August 2010
  - CO and hotspots enhancement -> outstanding
  - xCO_2 large variability and no correlation with CO
- Feasibility study is needed for GOSAT-2 plan
  - CO channel is useful to detect fires?