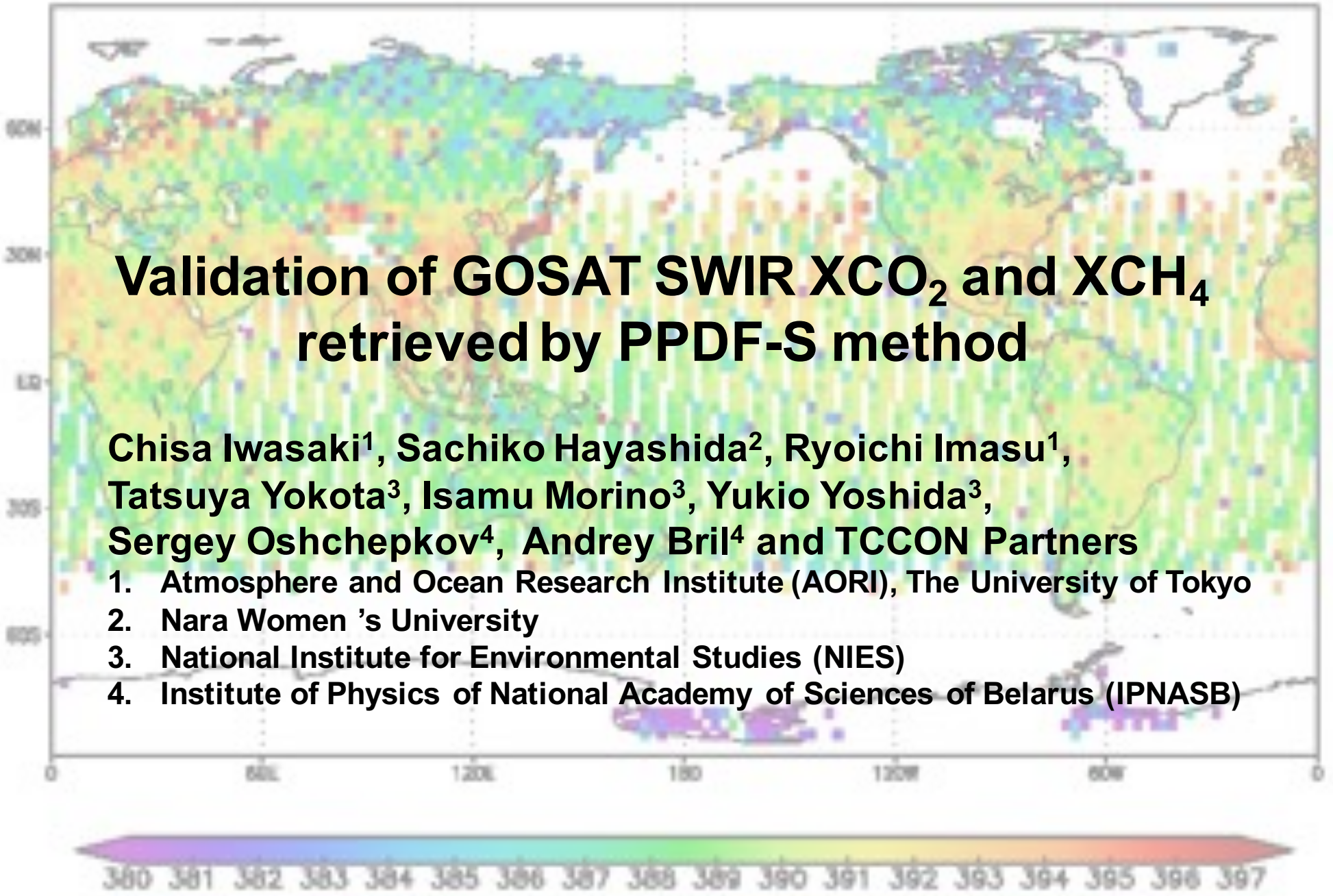


Validation of GOSAT SWIR XCO_2 and XCH_4 retrieved by PPDF-S method

Chisa Iwasaki[1], Sachiko Hayashida[2], Ryoichi Imasu[1], Tatsuya Yokota[3], Isamu Morino[3], Yukio Yoshida[3], Sergey Oshchepkov[4], Andrey Bril[4] and TCCON Partners

1. Atmosphere and Ocean Research Institute (AORI), The University of Tokyo
2. Nara Women 's University
3. National Institute for Environmental Studies (NIES)
4. Institute of Physics of National Academy of Sciences of Belarus (IPNASB)

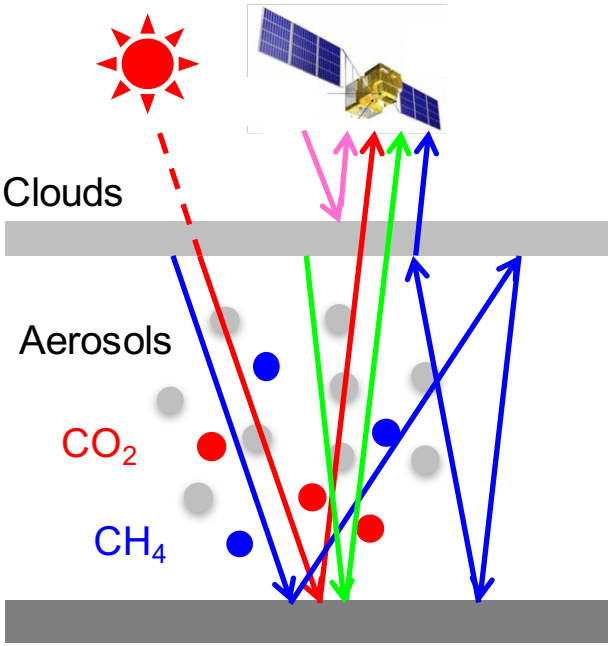
Outline

1. Background and Objectives
2. Method
   - Validation of PPDF-S data using TCCON data
   - Comparison PPDF-S data with FP data
3. Data
4. Results
   - Accuracy of PPDF-S data
   - Global characteristics of PPDF-S data
   - The accuracy of ocean GOSAT data
5. Conclusions

Optical Path of SWIR Radiation

- Solar radiation in short wavelength infrared (SWIR) region
  ↓ Retrieval
  Column averaged dry air mole fraction of CO_2 and CH_4 (XCO_2 and XCH_4)

- Light scattering
  by clouds and aerosols in the atmosphere
  → Light path modification
  → Systematic bias of XCO_2 and XCH_4



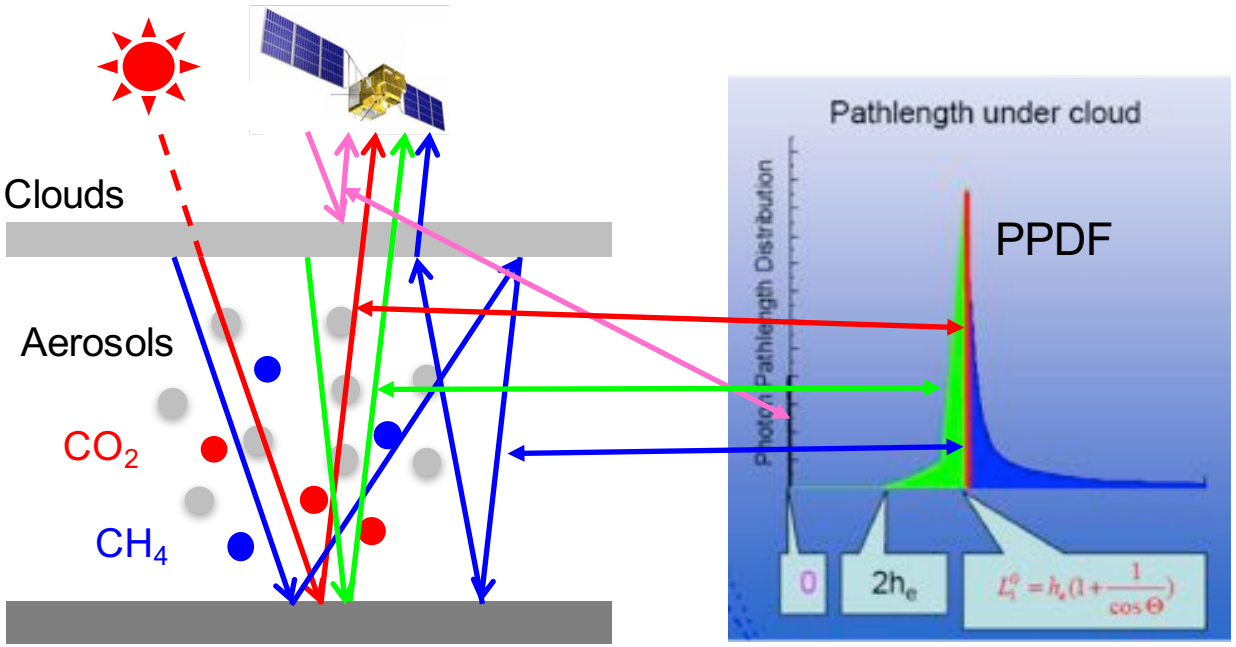
[Changed Bril et al., 2007]

Full Physics (FP) method

- Light scattering effect
  ← Optical and physical parameters

PPDF-S method

- Light Scattering effect
  ← Optical path modification
  ← PPDF (photon path-length probability density function)



[Bril et al., 2007]

Previous Studies

- XCO_2 retrieved by PPDF-S method has fairly good accuracy [Oshchepkov et al., 2013b]

- PPDF-S data have not been well validated
  - XCO_2… Only a few studies [Oshchepkov et al., 2013a; Oshchepkov et al., 2013b]
  - XCH_4… No studies

Objectives

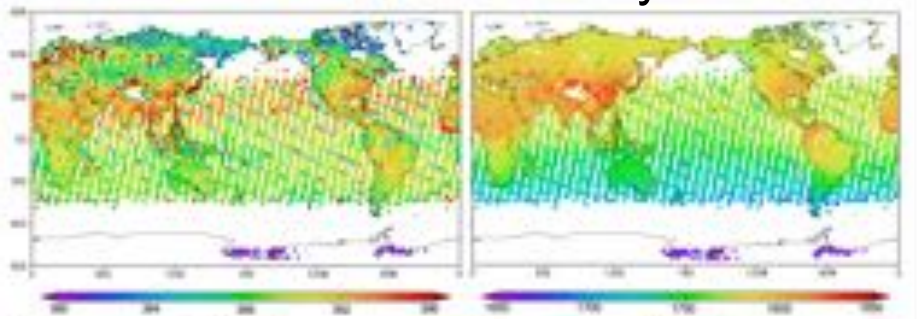
- Evaluation of the accuracy of XCO_2 and XCH_4 retrieved by PPDF-S method

- Investigation of the global characteristics of PPDF-S data

SATELLITE

GOSAT

by PPDF-S

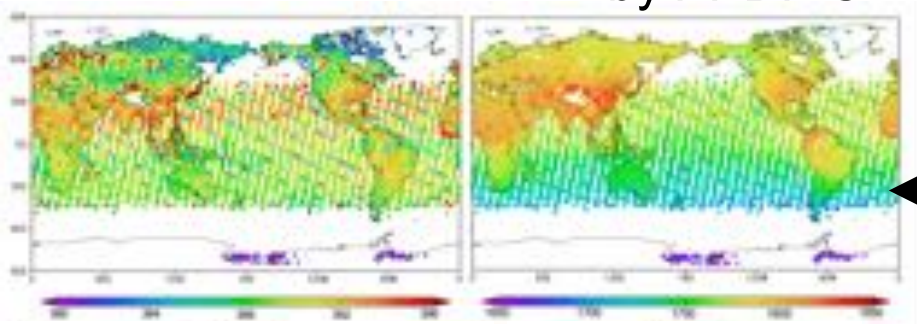


XCO_2 [ppm] XCH_4 [ppb]

SATELLITE

GOSAT

by PPDF-S



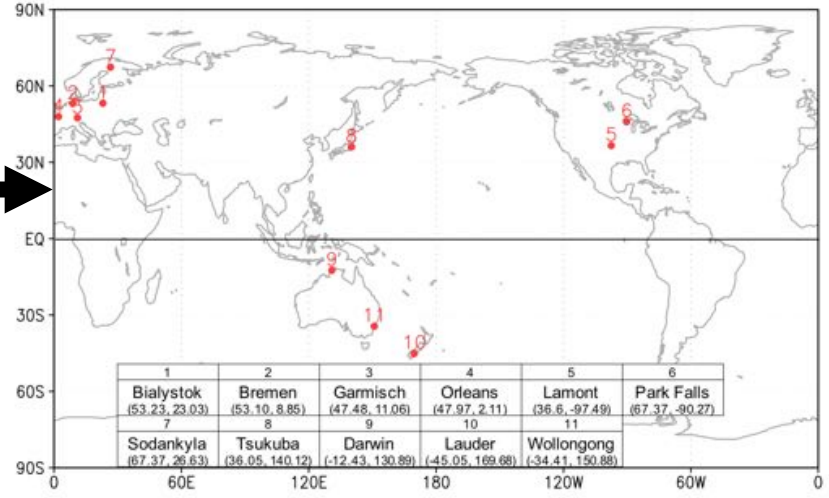
XCO_2 [ppm] XCH_4 [ppb]

①

GROUND

TCCON

(Total Carbon Column Observing Network)

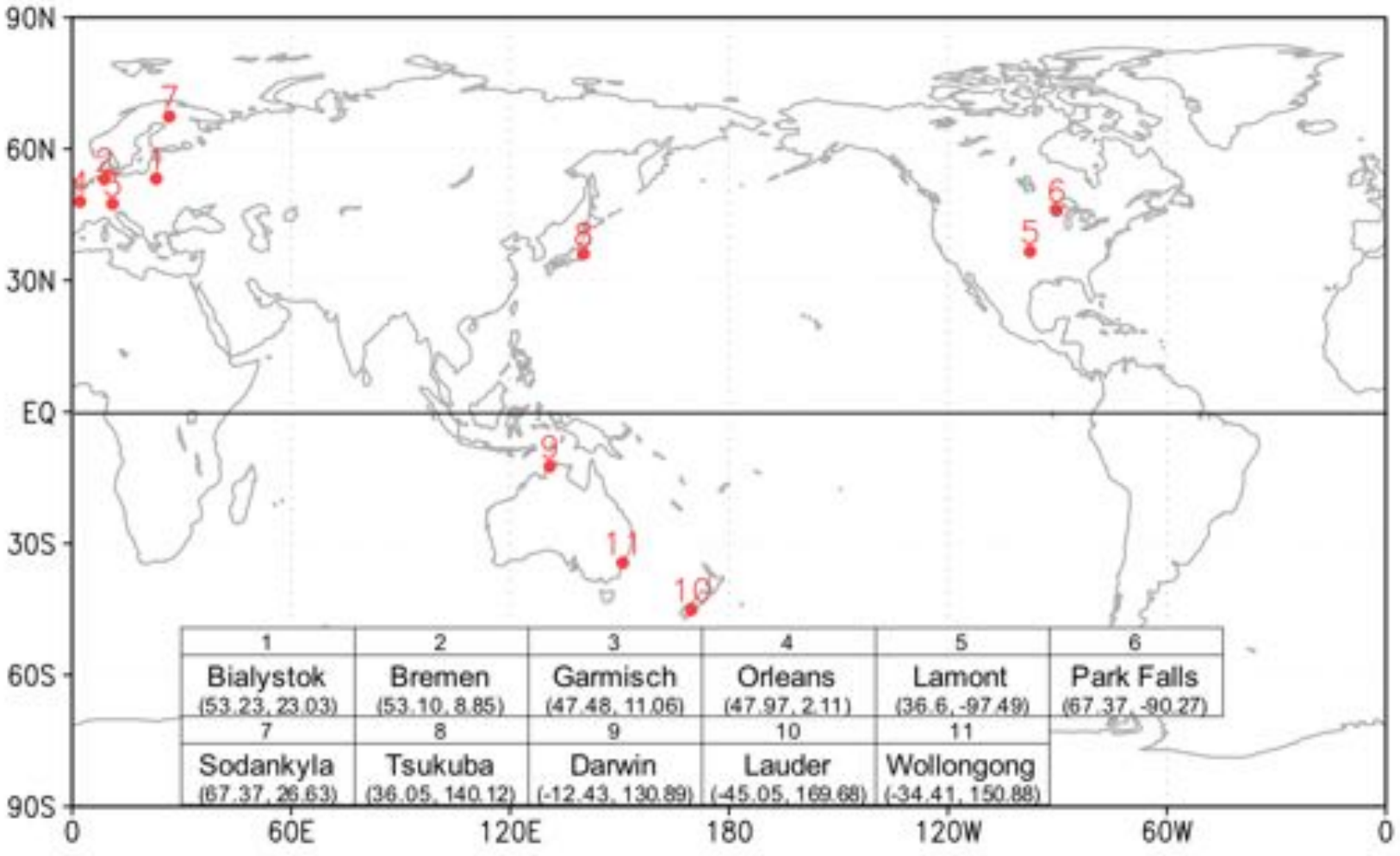


[Wunch et al., 2011] (http://tccon.ornl.gov)

① Validation of XCO_2 and XCH_4 retrieved by PPDF-S method

TCCON
(Total Carbon Column Observing Netwark)

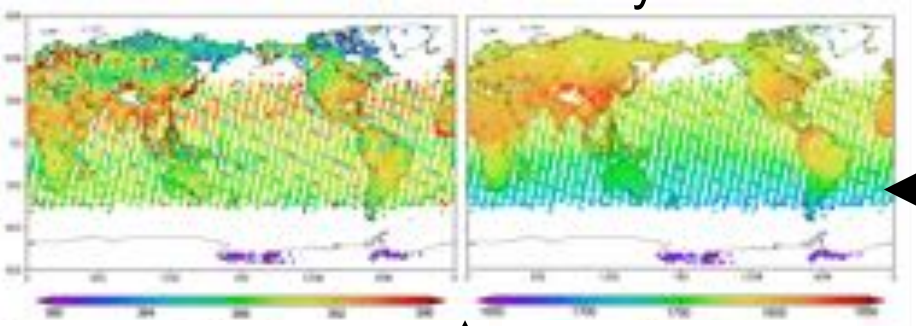
[Wunch et al., 2011] (http://tccon.ornl.gov)



SATELLITE

GOSAT

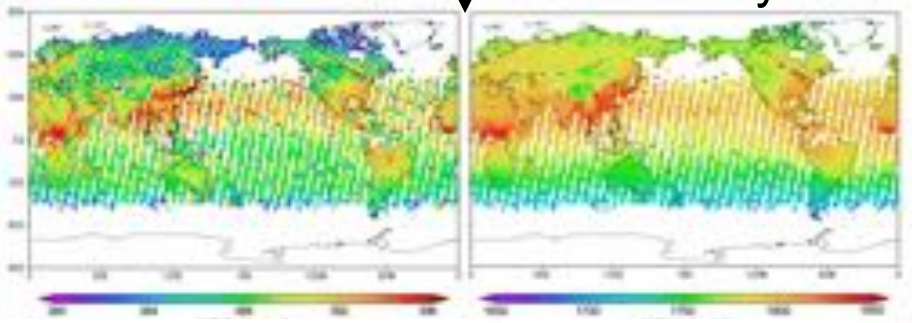
by PPDF-S



XCO_2 [ppm] XCH_4 [ppb]

②

by FP



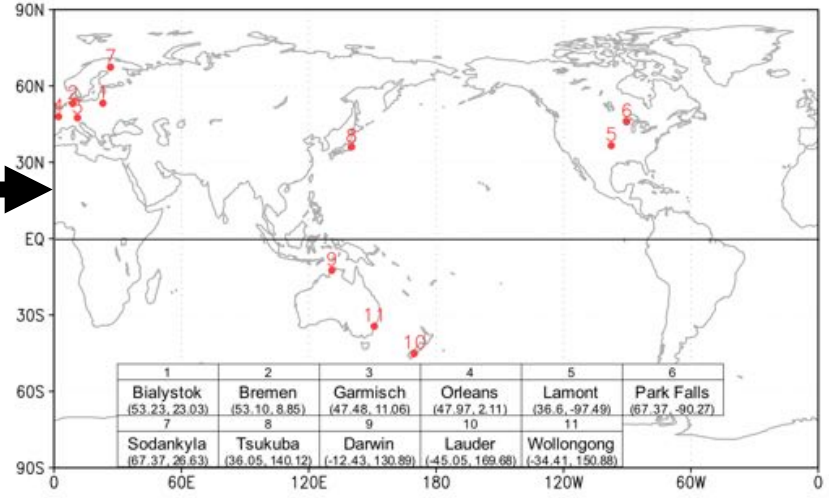
XCO_2 [ppm] XCH_4 [ppb]

GROUND

TCCON

(Total Carbon Column Observing Network)

①



[Wunch et al., 2011] (http://tccon.ornl.gov)

① Validation of XCO_2 and XCH_4 retrieved by PPDF-S method

② Investigation of the global characteristics of PPDF-S data

Period

April, 2009 ~ June, 2014

Versions

- GOSAT [Version: V02.21 (L1 Version: V161.160)]
  - XCO_2, XCH_4 retrieved by PPDF-S method
  - XCO_2, XCH_4 retrieved by FP method (which is released by NIES for general users; NIES GU)

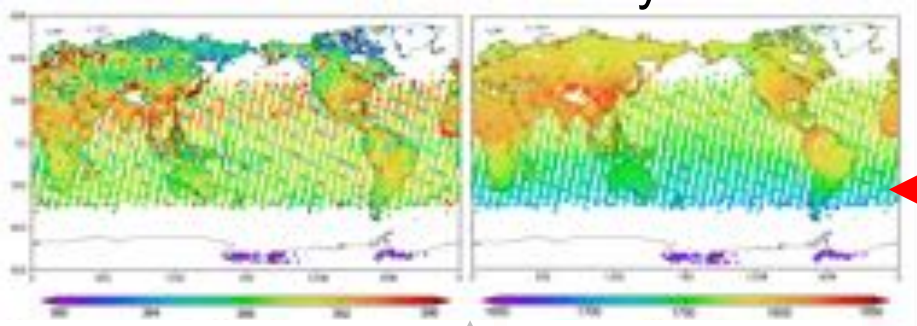
- TCCON [Version: GGG2014]
  - XCO_2, XCH_4 from the 11 sites

"Match up" conditions
- Lat-Lon: ± 2°
- Time: ± 30 minutes

SATELLITE

GOSAT

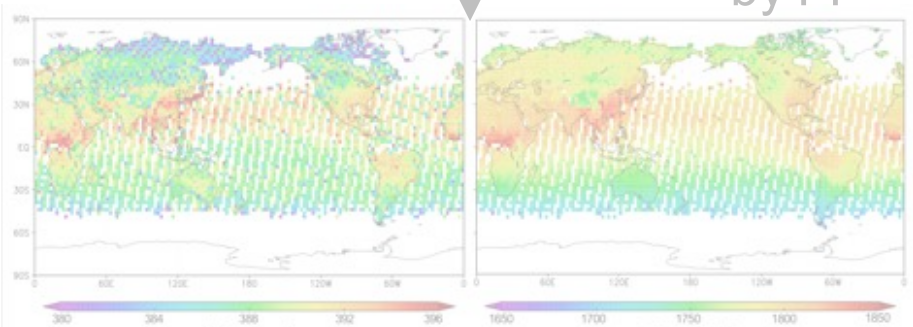
by PPDF-S



XCO_2 [ppm] XCH_4 [ppb]

②

by FP



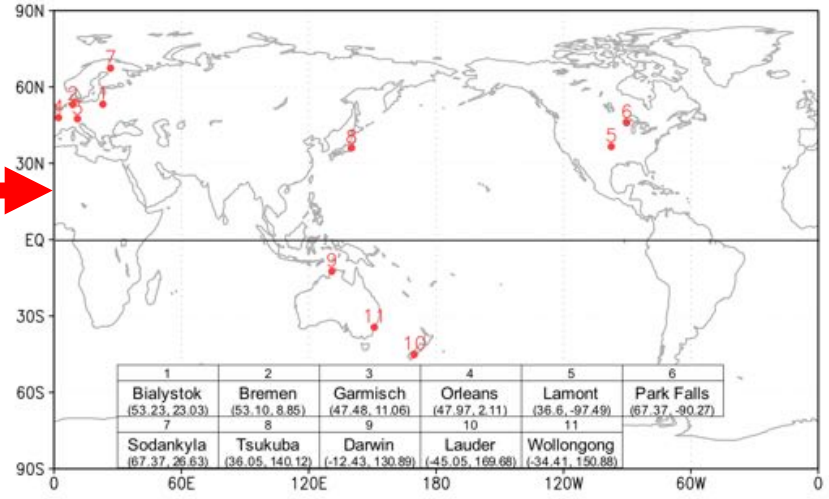
XCO_2 [ppm] XCH_4 [ppb]

①

GROUND

TCCON

(Total Carbon Column Observing Network)

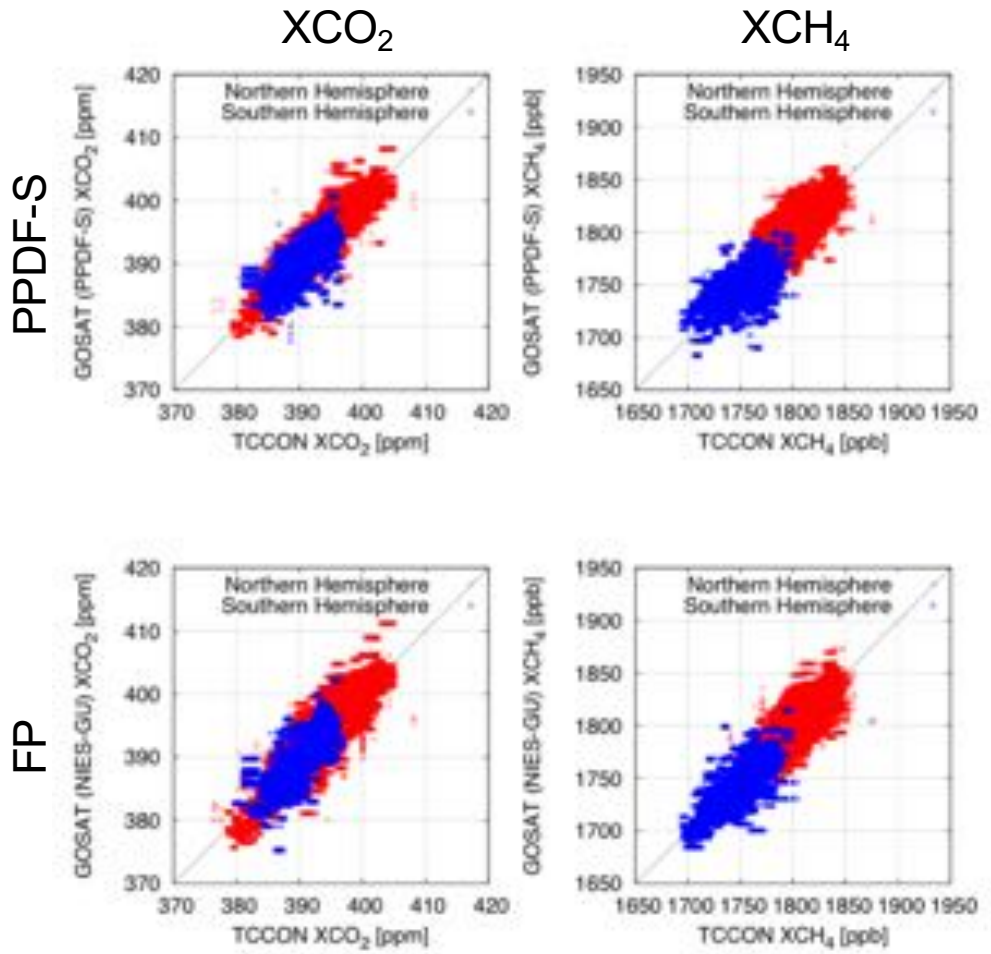


[Wunch et al., 2011] (http://tccon.ornl.gov)

① Validation of XCO_2 and XCH_4 retrieved by PPDF-S method

② Investigation of the global characteristics of PPDF-S data

GOSAT vs. TCCON (for all 11 sites)



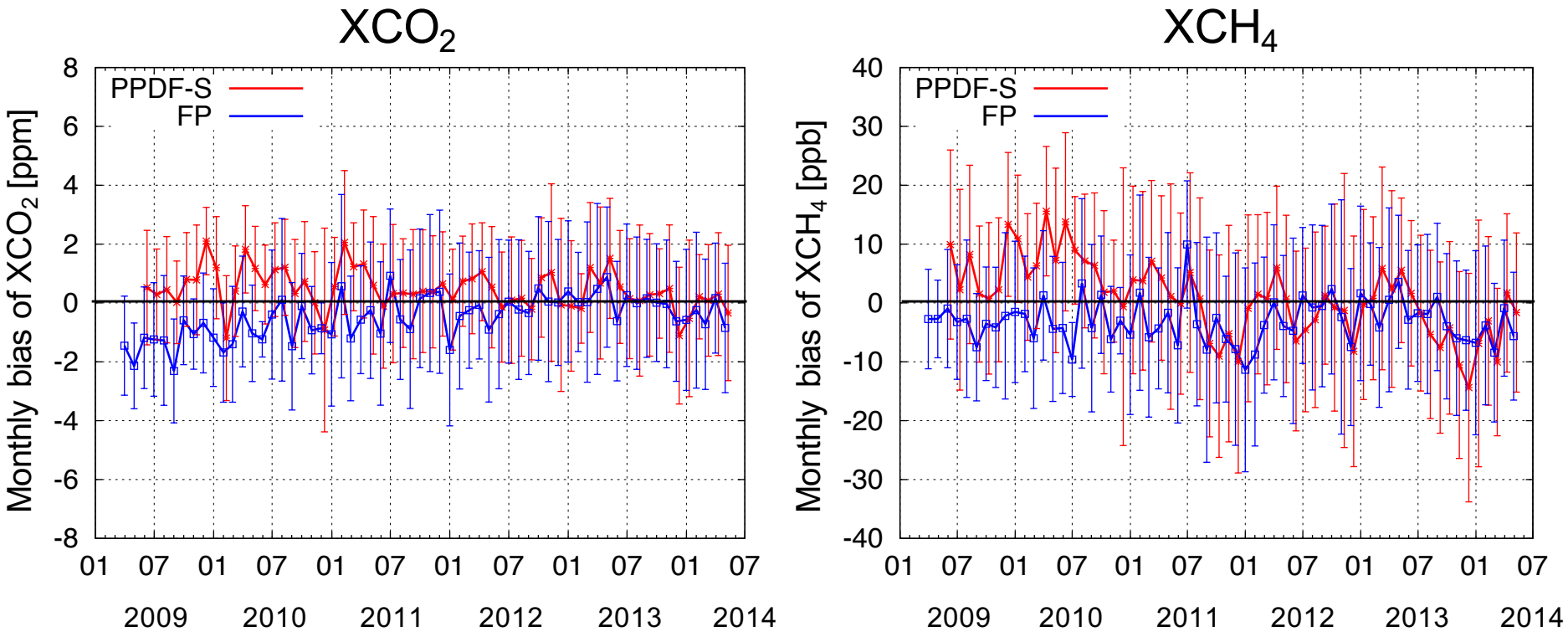
Biases and SD (global mean)

	XCO_2 [ppm]	XCH_4 [ppb]
PPDF-S	0.47 ± 2.11	0.76 ± 15.49
FP	-0.28 ± 2.34	-2.16 ± 13.26

- PPDF-S and FP data have almost same order of accuracy.
- Bias of PPDF-S: Positive (+)
- Bias of FP: Negative (–)

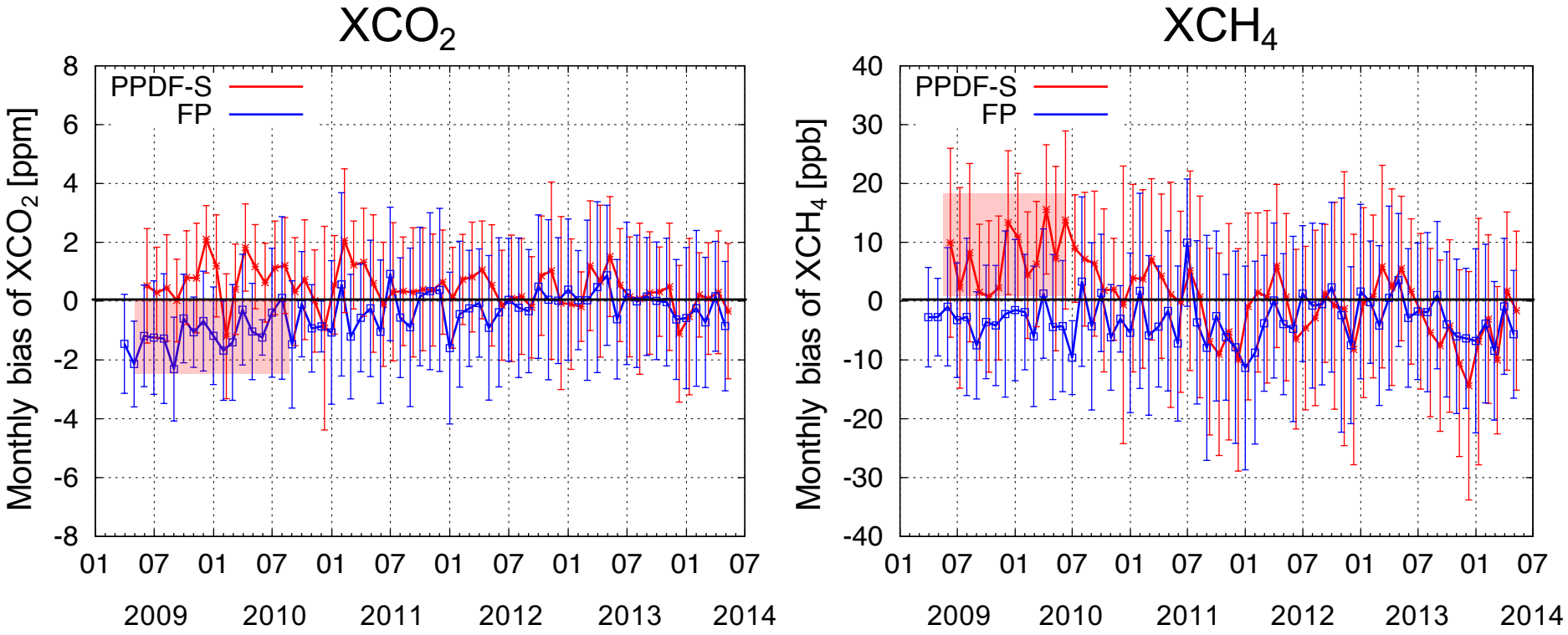
GOSAT vs. TCCON (for all 11 sites)

Time series of monthly bias of GOSAT XCO_2 and XCH_4



GOSAT vs. TCCON (for all 11 sites)

Time series of monthly bias of GOSAT XCO_2 and XCH_4

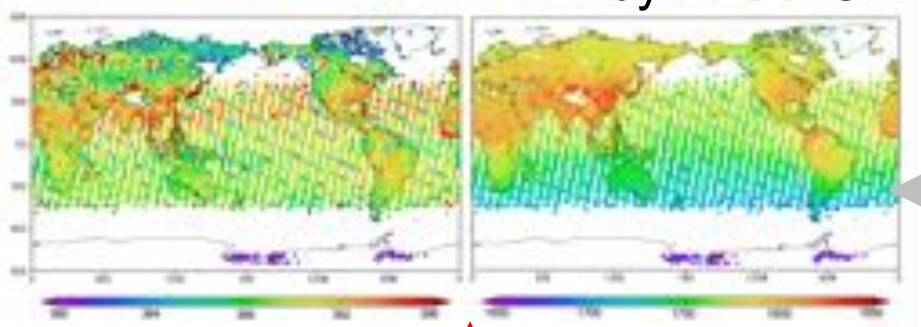


- From 2009 to 2010
  - FP XCO_2: large negative bias
  - PPDF-S XCH_4: large positive bias

SATELLITE

GOSAT

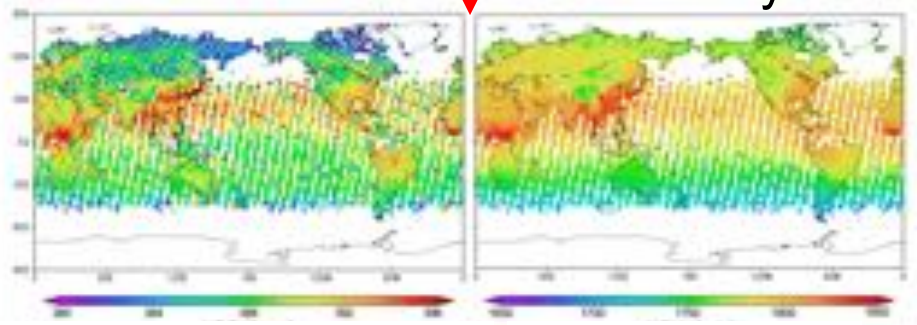
by PPDF-S



XCO_2 [ppm] XCH_4 [ppb]

②

by FP



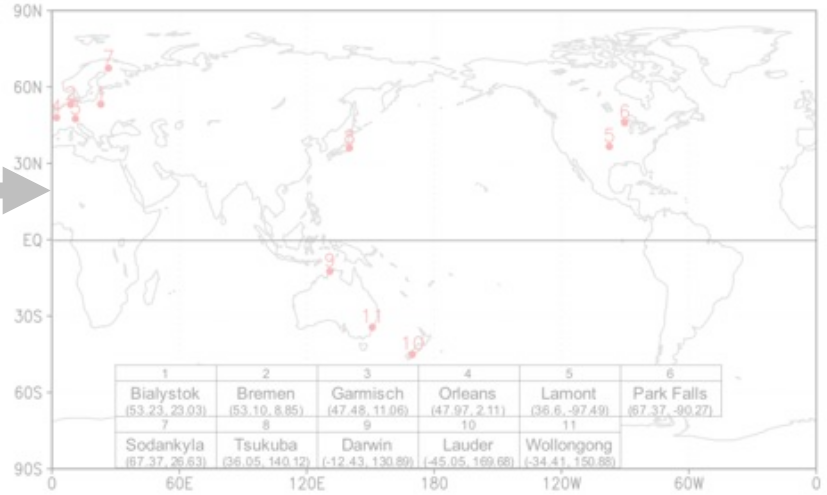
XCO_2 [ppm] XCH_4 [ppb]

①

GROUND

TCCON

(Total Carbon Column Observing Network)



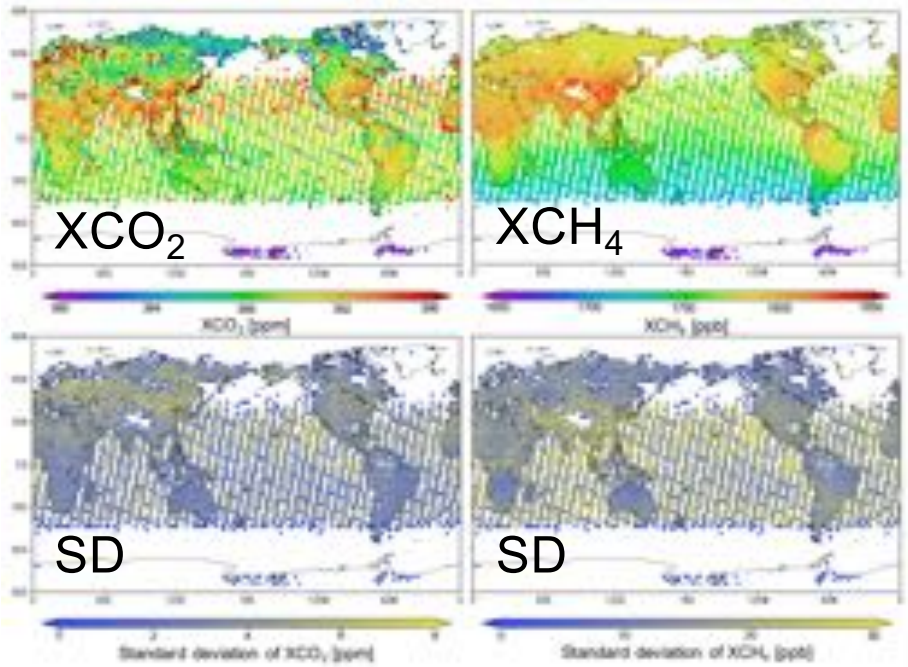
[Wunch et al., 2011] (http://tccon.ornl.gov)

① Validation of XCO_2 and XCH_4 retrieved by PPDF-S method

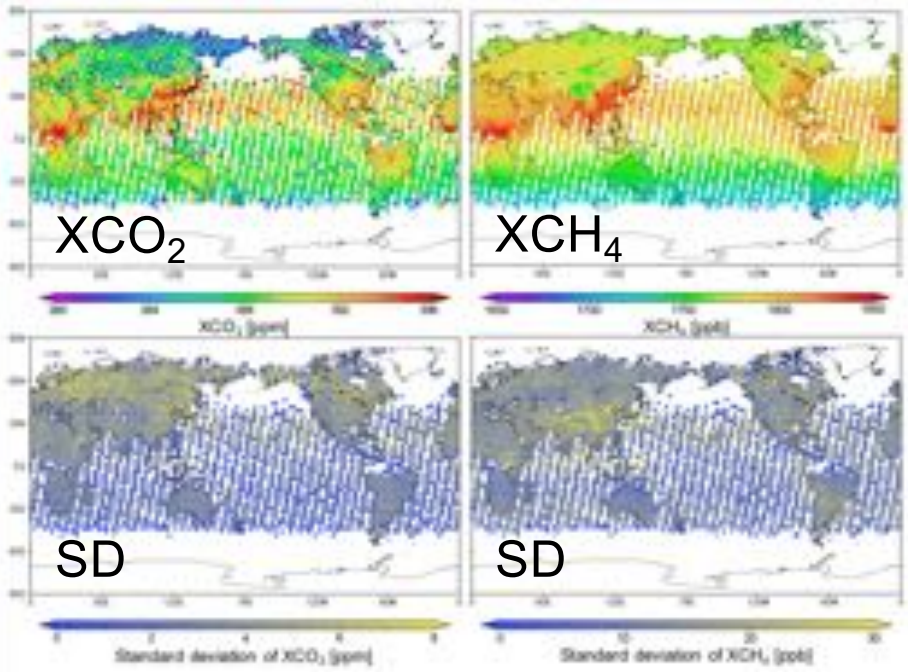
② Investigation of the global characteristics of PPDF-S data

PPDF-S data vs. FP data

PPDF-S data



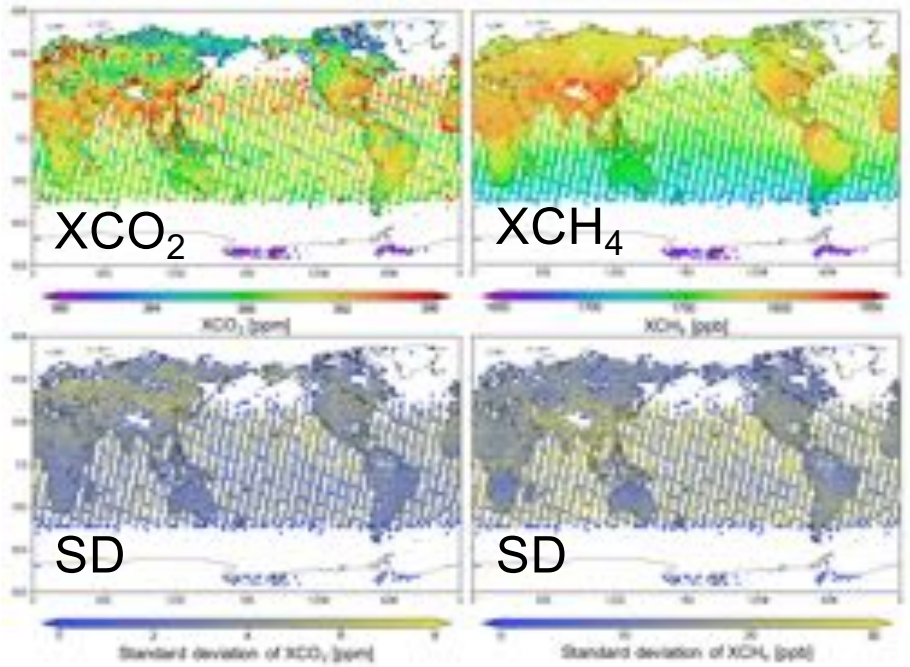
FP data



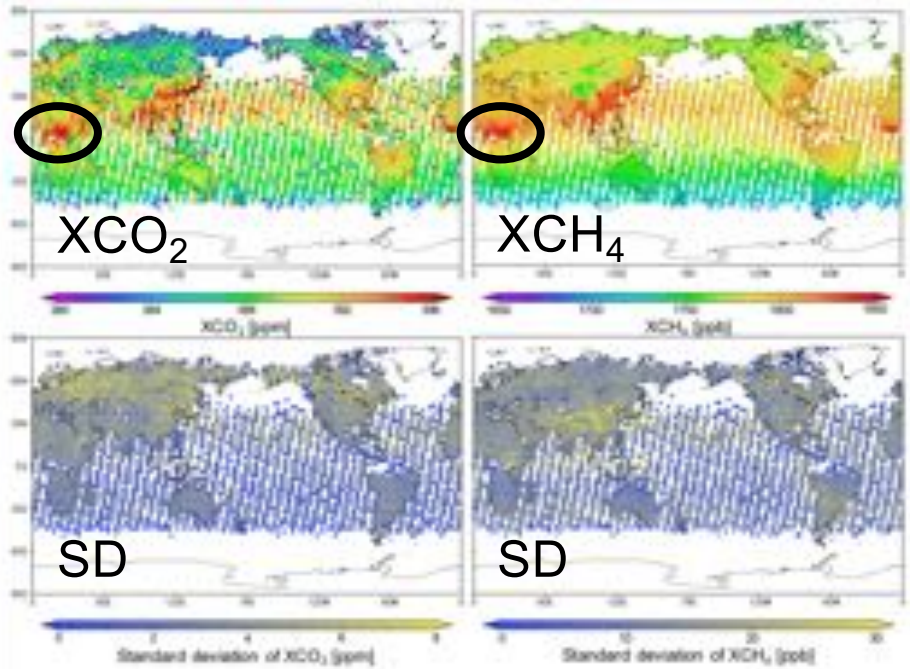
(2.5° × 2.5°)

PPDF-S data vs. FP data

PPDF-S data



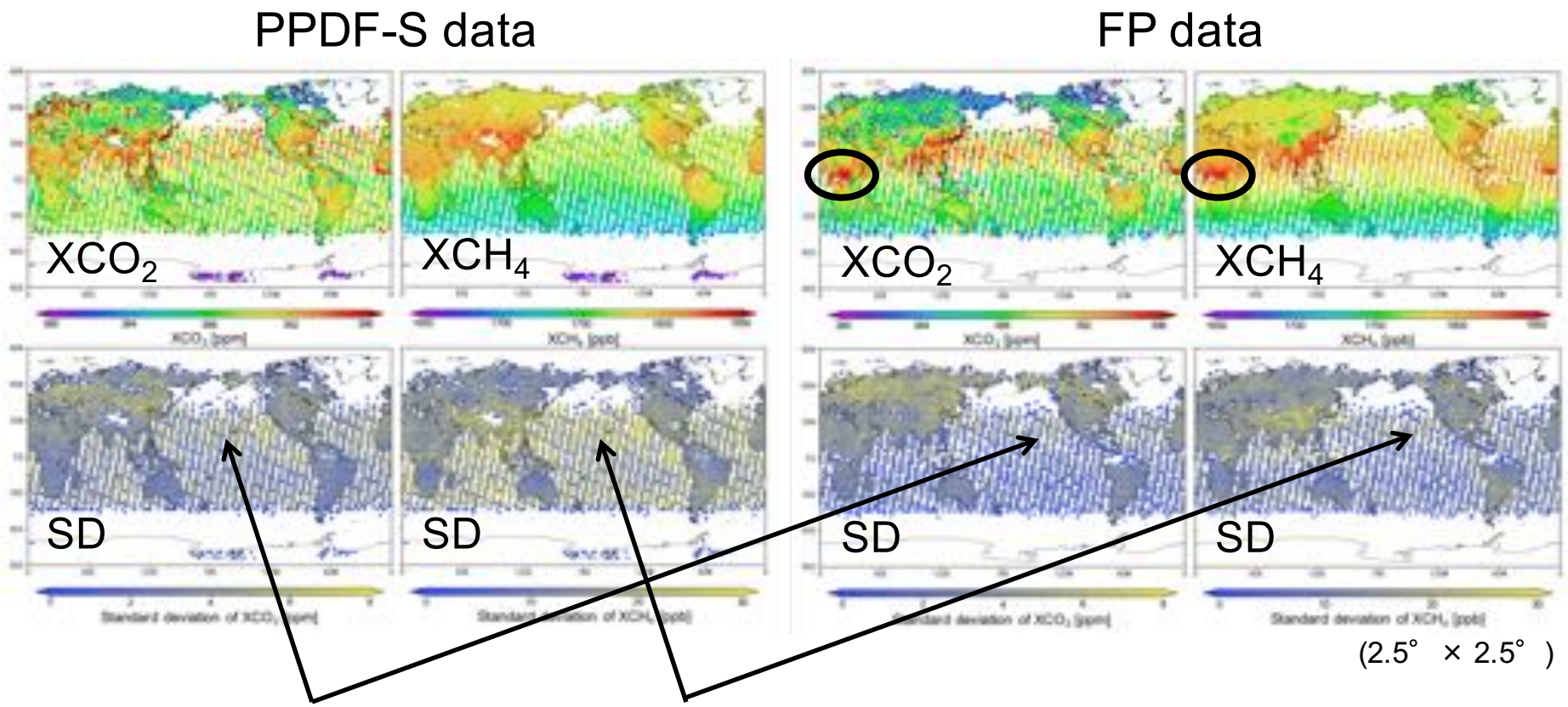
FP data



(2.5° × 2.5°)

- Over the middle of Africa,
  FP data has larger XCO_2 and XCH_4 than PPDF-S data.
  → Africa: Biomass burning area

PPDF-S data vs. FP data



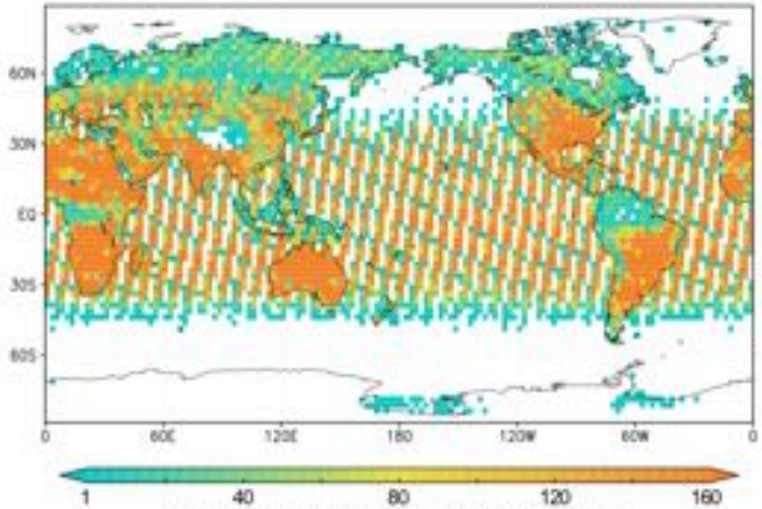
- Over the ocean,
  PPDF-S data has larger SDs of XCO_2 and XCH_4 than FP data.

- Over the middle of Africa,
  FP data has larger XCO_2 and XCH_4 than PPDF-S data.
  → Africa: Biomass burning area

PPDF-S data vs. FP data

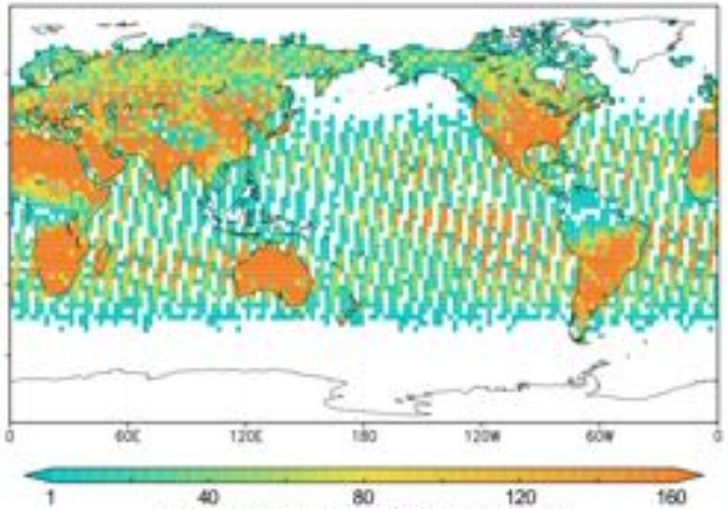
Number of XCO_2 and XCH_4 data

PPDF-S data



Number of PPDF-S data (XCO_2)

FP data



Number of PPDF-S data (XCO_2)

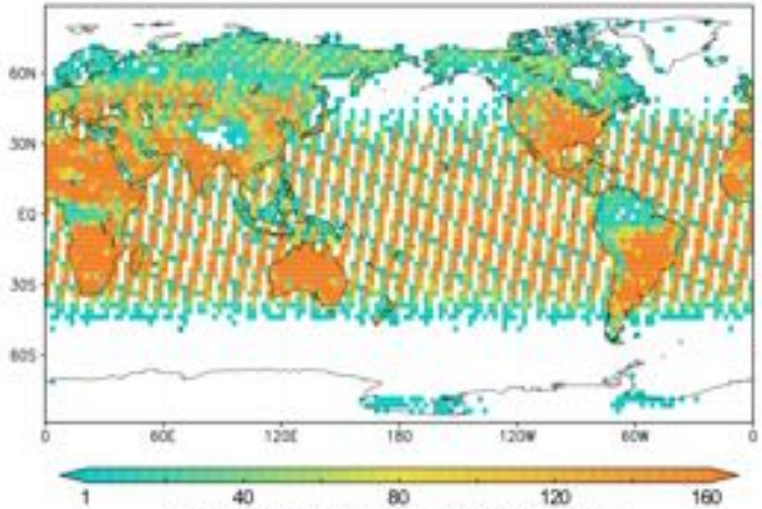
(2.5° × 2.5°)

	Land	Ocean	Mixed	All
PPDF-S	289131	519806	43928	852865
FP	331567	116706	46474	494747

PPDF-S data vs. FP data

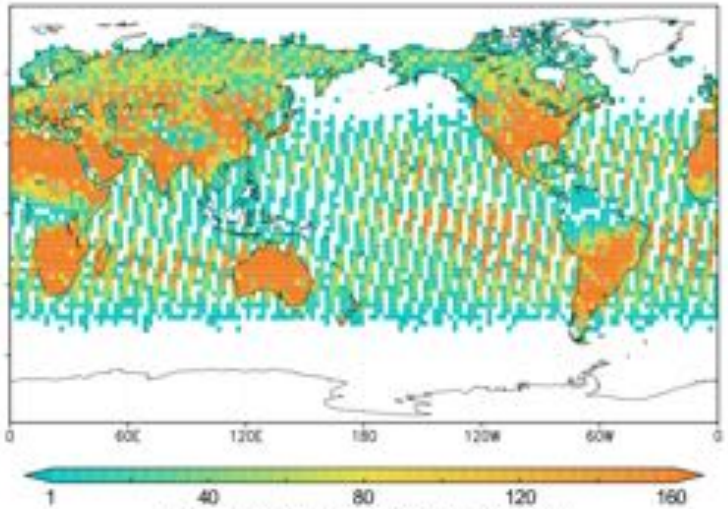
Number of XCO_2 and XCH_4 data

PPDF-S data



Number of PPDF-S data (XCO_2)

FP data



Number of PPDF-S data (XCO_2)

(2.5° × 2.5°)

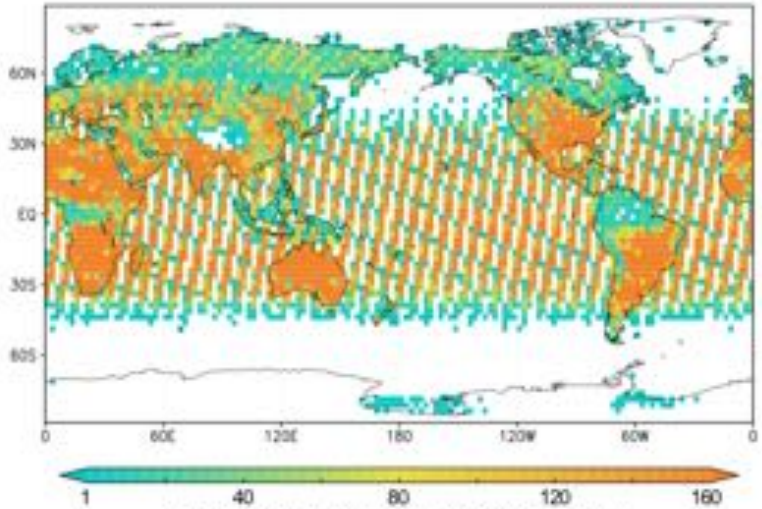
	Land	Ocean	Mixed	All
PPDF-S	289131	519806	43928	852865
FP	331567	116706	46474	494747

- Over the ocean, PPDF-S method can retrieve larger number of data than those of FP method by about five times.
- However, the SD of the ocean data is also larger…

PPDF-S data vs. FP data

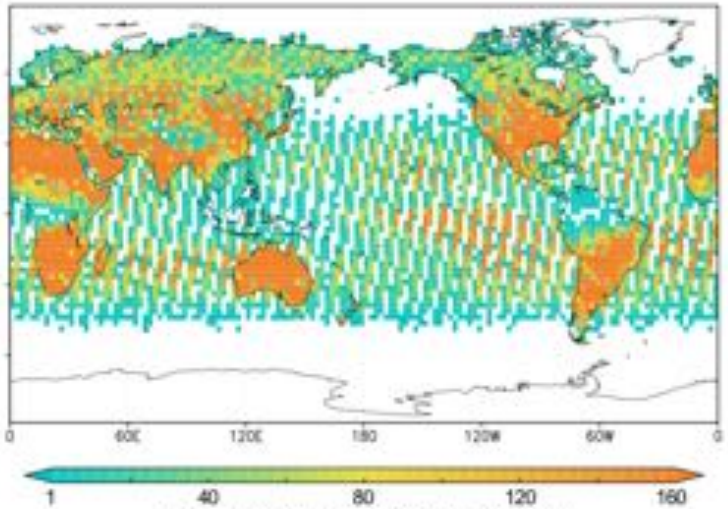
Number of XCO_2 and XCH_4 data

PPDF-S data



Number of PPDF-S data (XCO_2)

FP data



Number of PPDF-S data (XCO_2)

(2.5° × 2.5°)

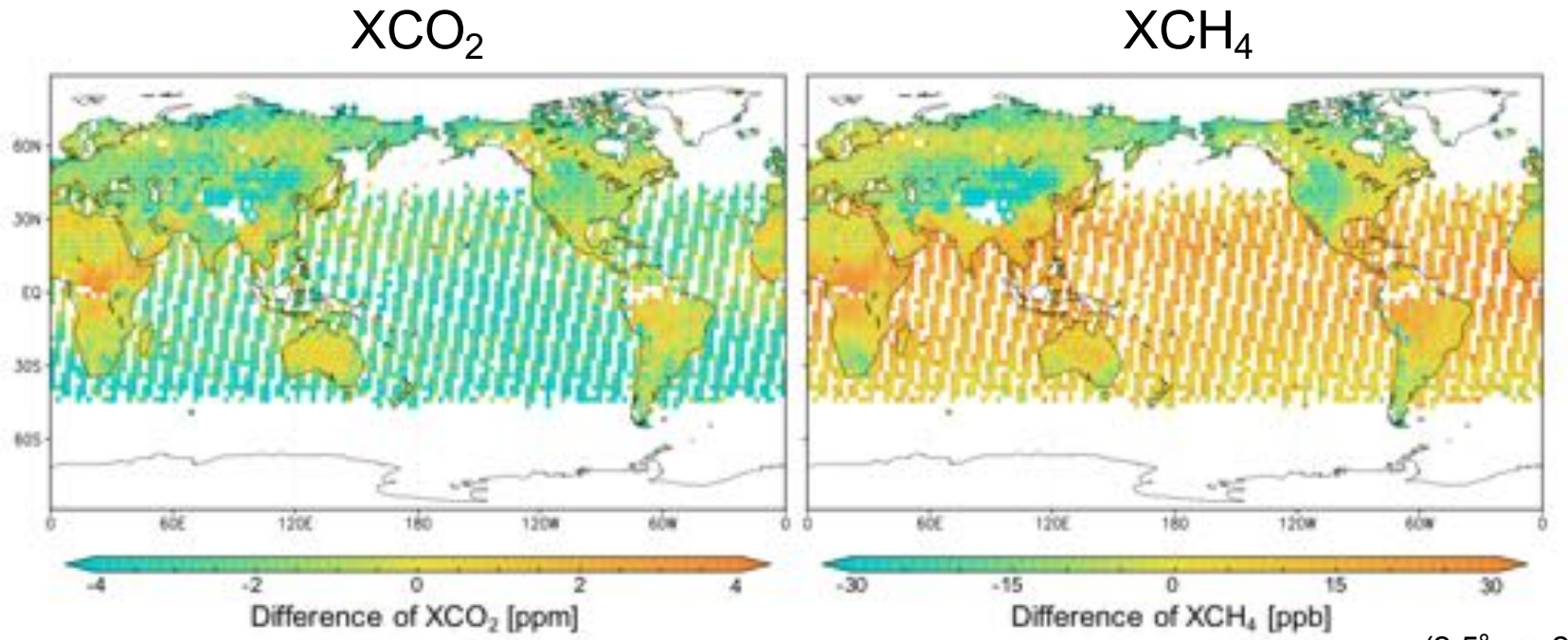
	Land	Ocean	Mixed	All
PPDF-S	289131	519806	43928	852865
FP	331567	116706	46474	494747

- Over the ocean, PPDF-S method can retrieve large
  than those of FP method by about five times.
- However, the SD of the ocean data is also larger…

The accuracy of PPDF-S data over the ocean must be validated well

PPDF-S data vs. FP data

"diff." ([FP data] - [PPDF-S data])

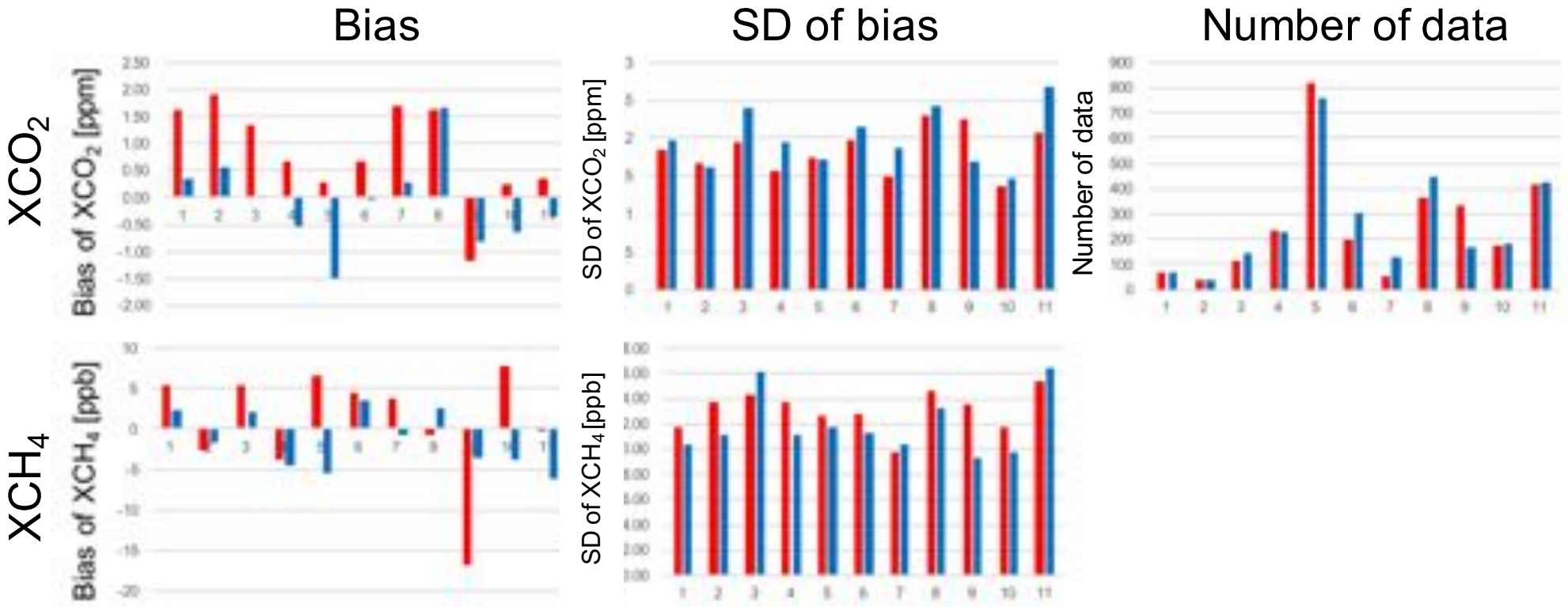


(2.5° × 2.5°)

- Over the land, "diff." shows same feature between XCO_2 and XCH_4.
- Over the ocean, PPDF-S data are larger for XCO_2 and smaller XCH_4 than FP data.

GOSAT vs. TCCON

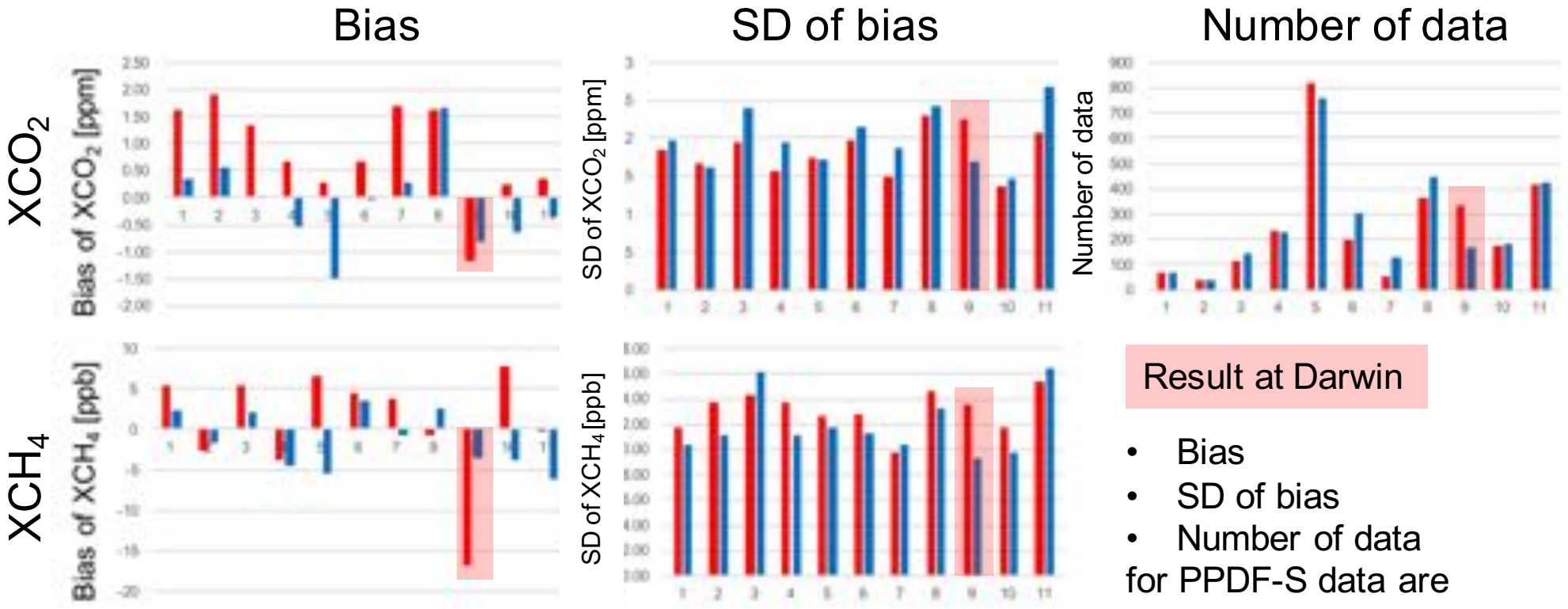
Validation results for each TCCON site ▪ PPDF-S ▪ FP



1	2	3	4	5	6
Bialystok	Bremen	Garmisch	Orleans	Lamont	Park Falls
7	8	9	10	11	
Sodankyla	Tsukuba	Darwin	Lauder	Wollongong	

GOSAT vs. TCCON

Validation results for each TCCON site ▪ PPDF-S ▪ FP



1	2	3	4	5	6
Bialystok	Bremen	Garmisch	Orleans	Lamont	Park Falls
7	8	9	10	11	
Sodankyla	Tsukuba	Darwin	Lauder	Wollongong	

Result at Darwin

- Bias
- SD of bias
- Number of data

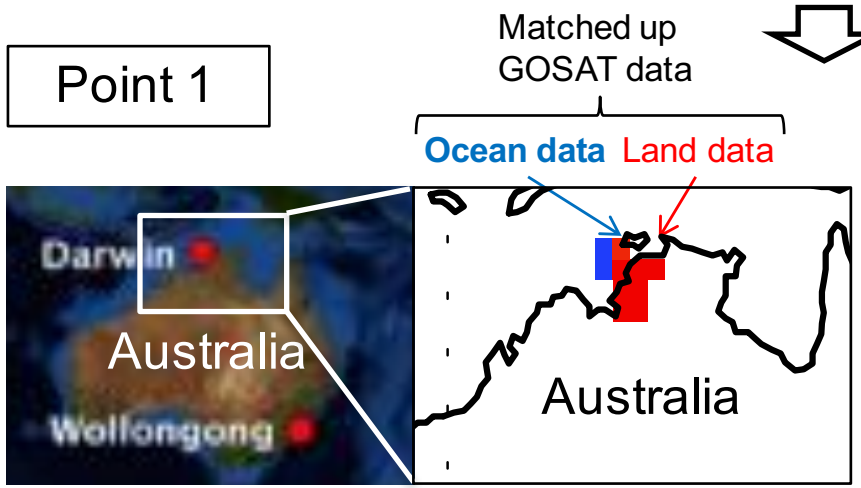
for PPDF-S data are larger than FP data

⇒ "Why PPDF-S data shows worse result than FP data?"

The relative accuracy of ocean GOSAT data

- "Why PPDF-S data shows worse result than FP data?"

Point 1



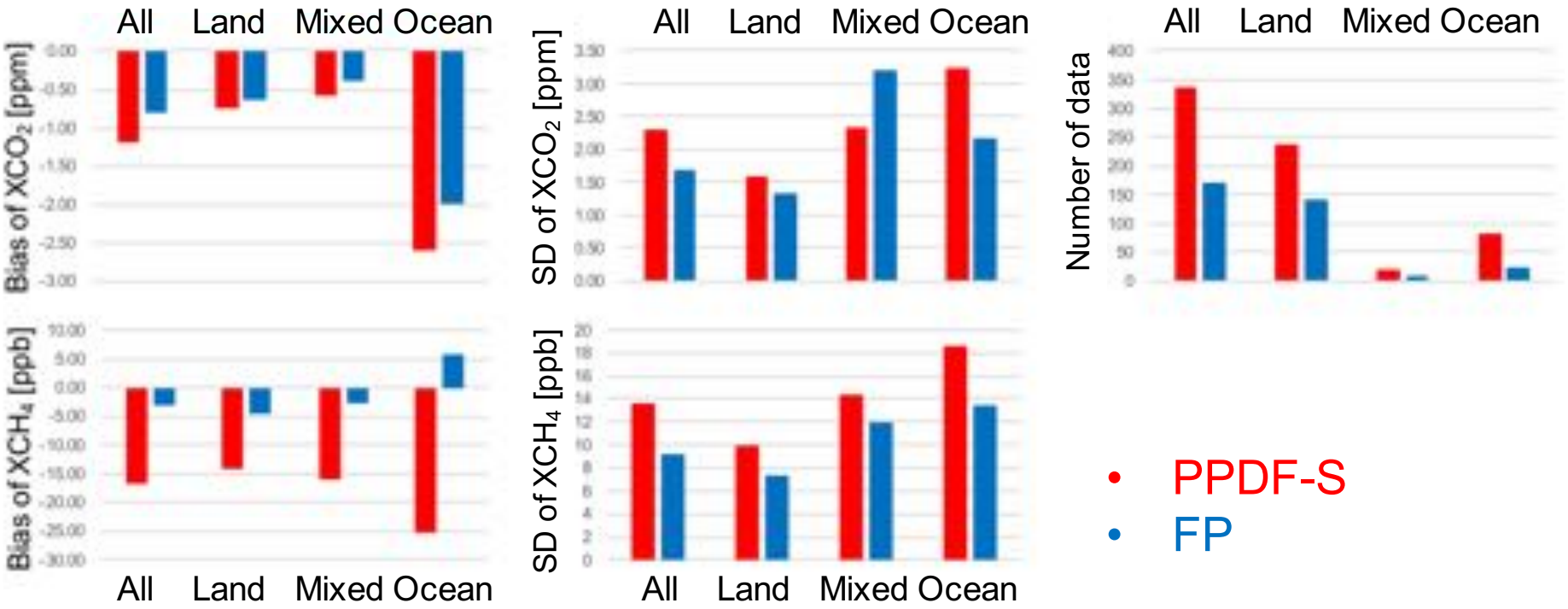
Matched up GOSAT data included **ocean data**

Point 2

PPDF-S method can retrieve larger number of **ocean data** than those of FP method, but its SD is larger.

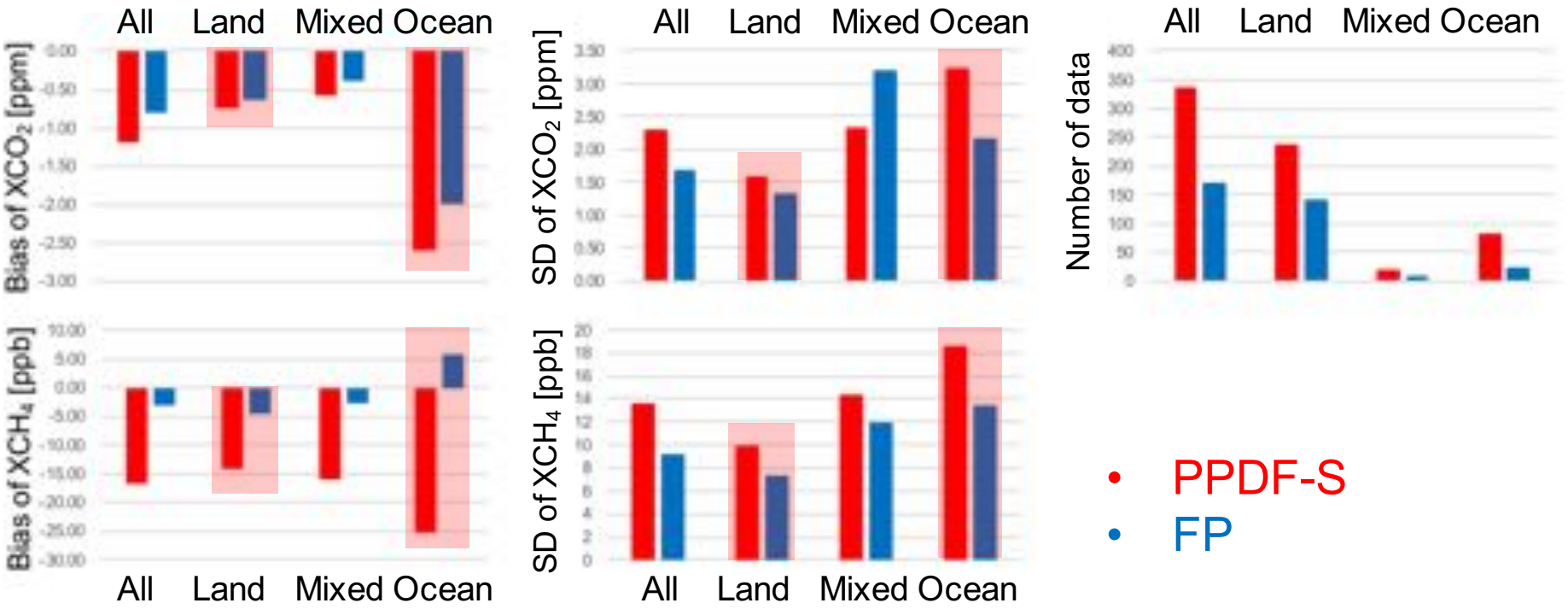
- Comparison of the validation result between land and ocean data
  → Estimation of the relative accuracy of **ocean data**

The accuracy of ocean GOSAT data



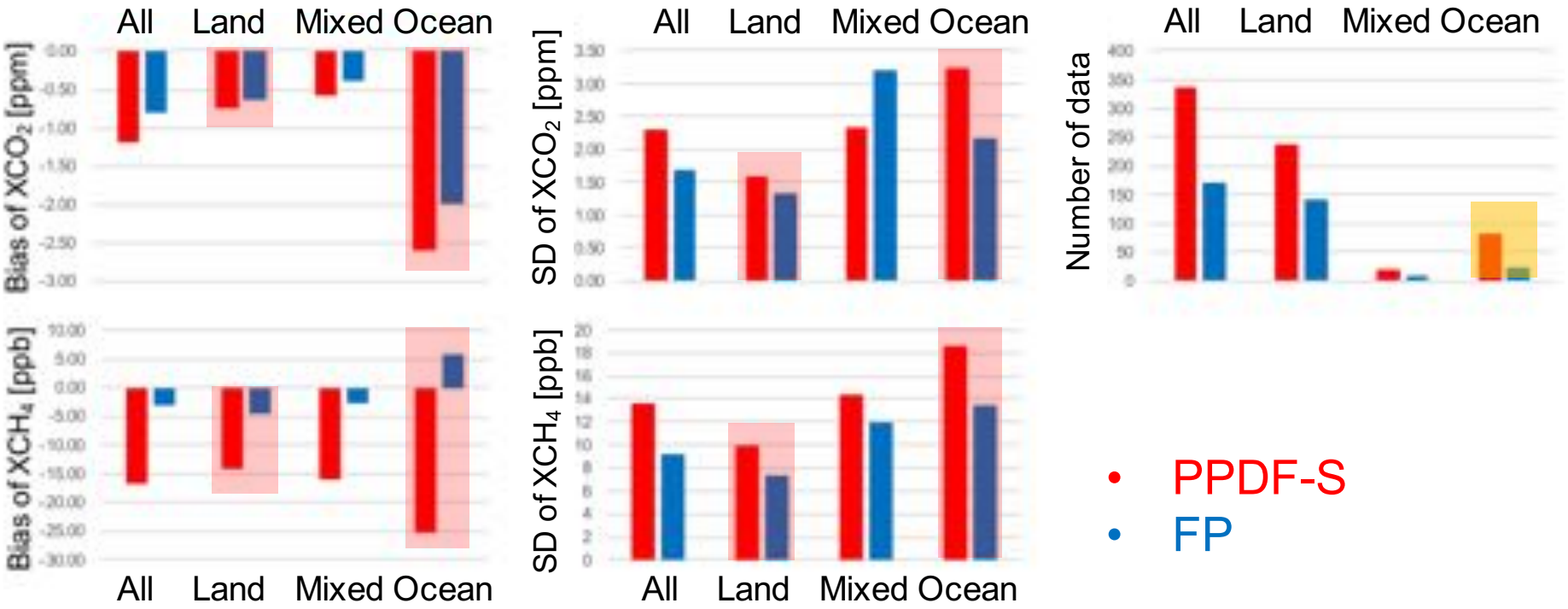
- PPDF-S
- FP

The accuracy of ocean GOSAT data



- Ocean data have larger biases and its deviation than land data.

The accuracy of ocean GOSAT data



- Ocean data have larger biases and its deviation than land data.

★ Reason for the worse result for PPDF-S data:
PPDF-S data at Darwin include larger number of ocean data than FP data

- Although PPDF-S and FP data have almost same order of accuracy, PPDF-S data show positive biases in both XCO_2 and XCH_4, while FP data show negative biases against the TCCON data.

- Monthly bias of GOSAT XCO_2 and XCH_4 was not constant (for April, 2009 ~ June, 2014);
  - FP XCO_2: large negative bias
  - PPDF-S XCH_4: large positive bias

- Although the number of PPDF-S data was larger than those of FP data over the ocean by about five times, their accuracy must be validated well in the future studies.

Acknowledgement
TCCON data were obtained from the TCCON Data Archive (http://tccon.ornl.gov), hosted by the Carbon Dioxide Information Analysis Center (CDIAC).