

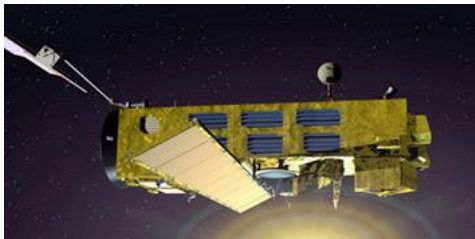


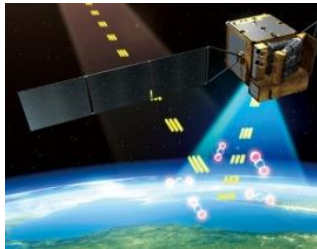
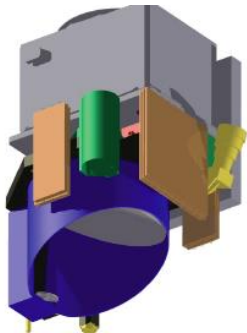

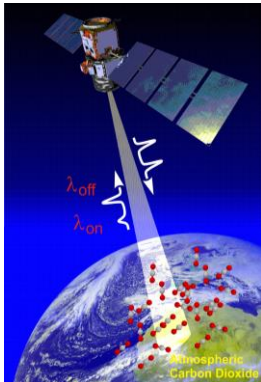
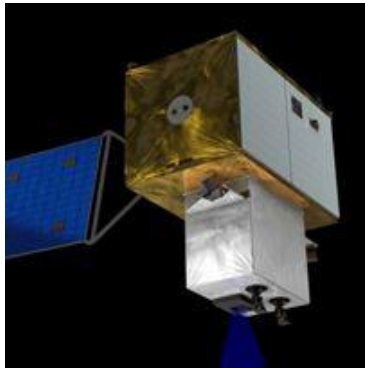


Carbon products: Calibration and validation approaches



TANSO is the only FTS for GHG measurements from space



SCIAMACHY (2002 - 2012)	GOSAT (2009 - ?)	OCO-2 (2014-) OCO-3 (2017)	TanSat (2016)
			
MERLIN (2018)	CNES MicroCarb (2019)	ASCENDS (2021)	ESA CarbonSat (2022)
			



- Intercomparison with OCO-2



Regular complete health checkup - Vicarious Calibration Campaign in Nevada -





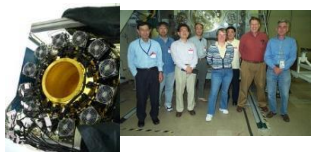
Inter-comparison with OCO-2



2008 2009 2010 2011 2012 2013 2014 2015 2016

Radiometric calibration

Prelaunch
X-CAL



Annual Vicarious Calibration at the desert playa in Nevada



CO₂ & CH₄ profile

In situ CO₂ and CH₄ on AJAX

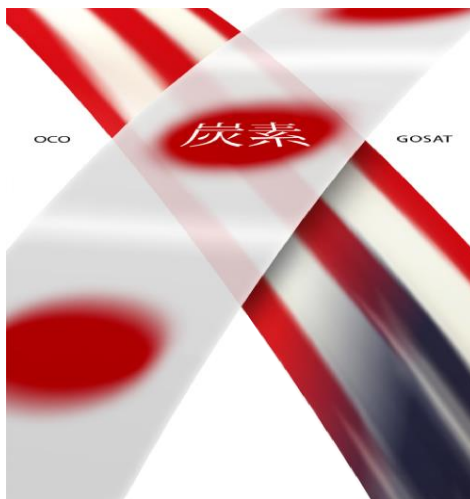
XCO₂ & XCH₄

Column with EM-27 FTS



Coincident
Target

Retrieved
Parameter
Comparison





Golden (OCO2 137-GOSAT36) (forward) and Silver (OCO-2139-GOSAT37) (backward) view day

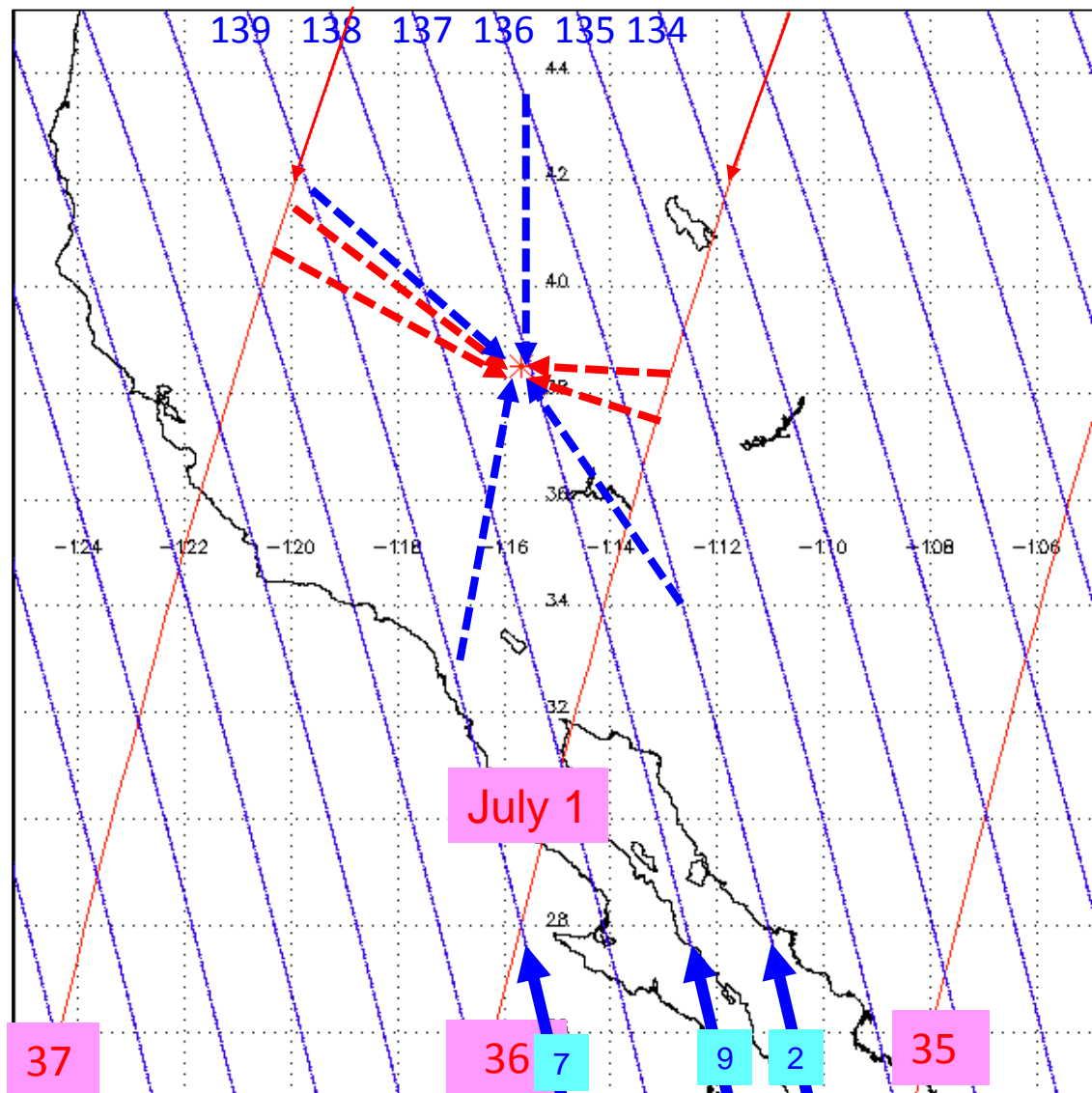


OCO2

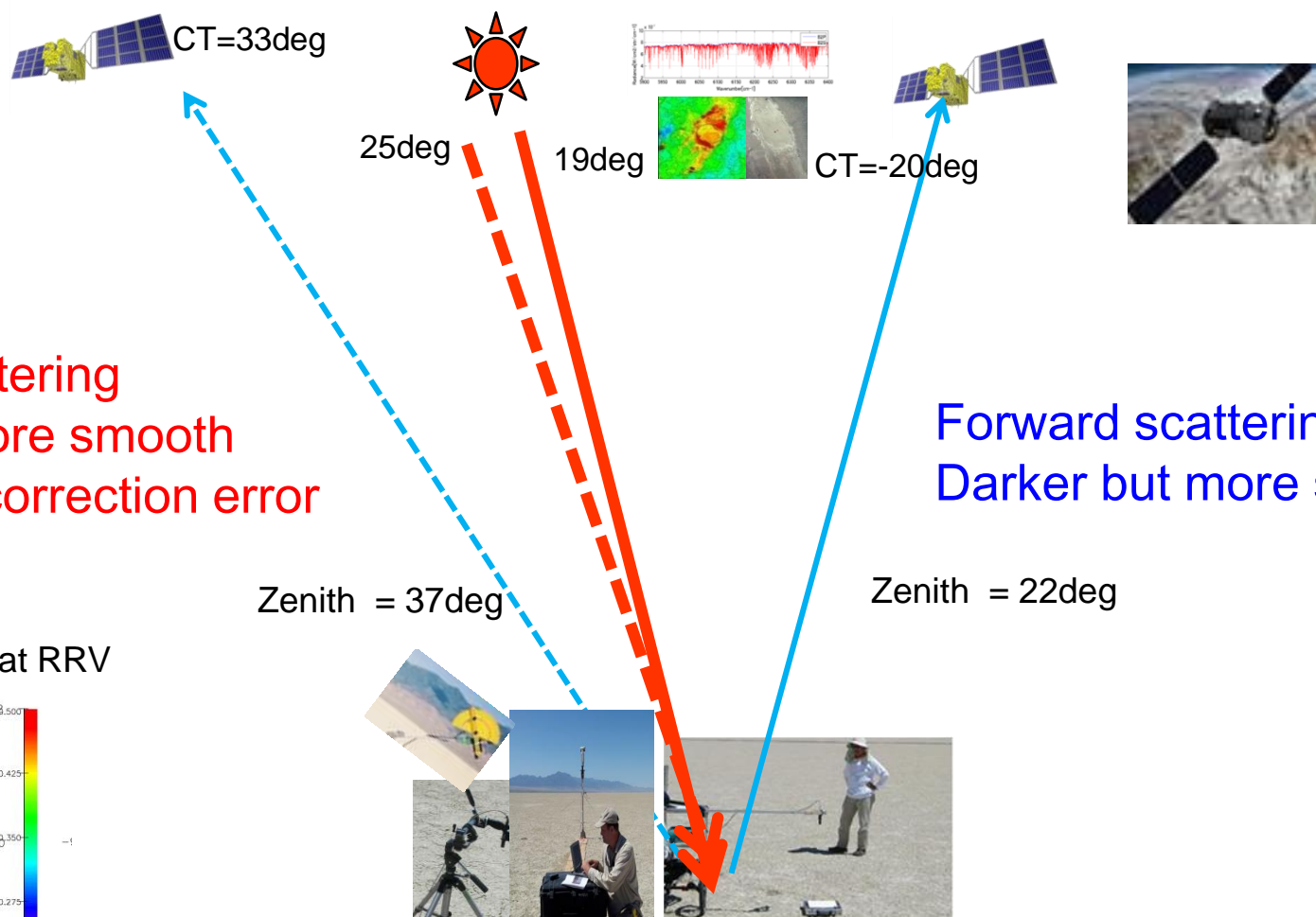
The BRDF correction is the largest uncertainty in cross calibration. Coincident data with BRDF differences < 0.01 are selected.

Golden (137-36) (forward)
and Silver (139-37)
(backward) days come
every 48 day.
2014 July 1, Aug 18, Oct. 5,
Nov. 22
2015 Jan. 9,June 1

GOSAT



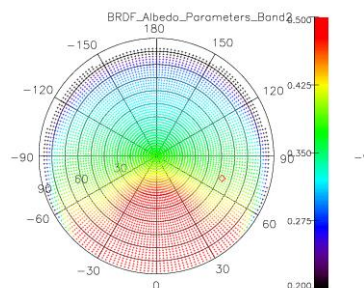
Need for BRDF Correction



Backward scattering
Brighter but more smooth
Larger BRDF correction error

Forward scattering
Darker but more smooth

MODIS BRDF model at RRV





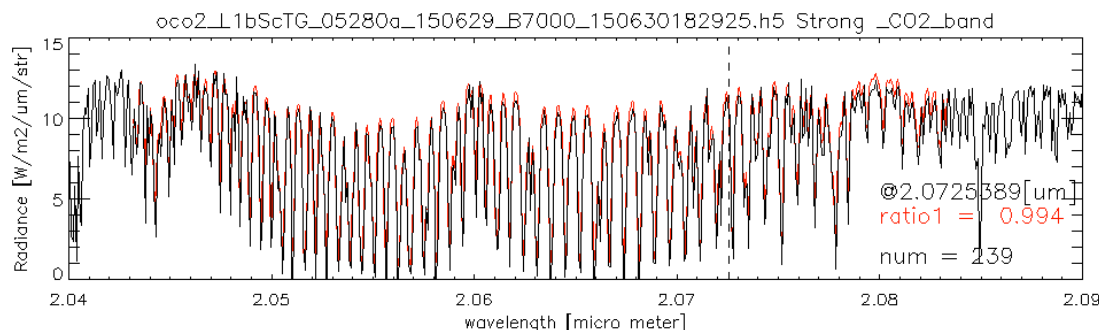
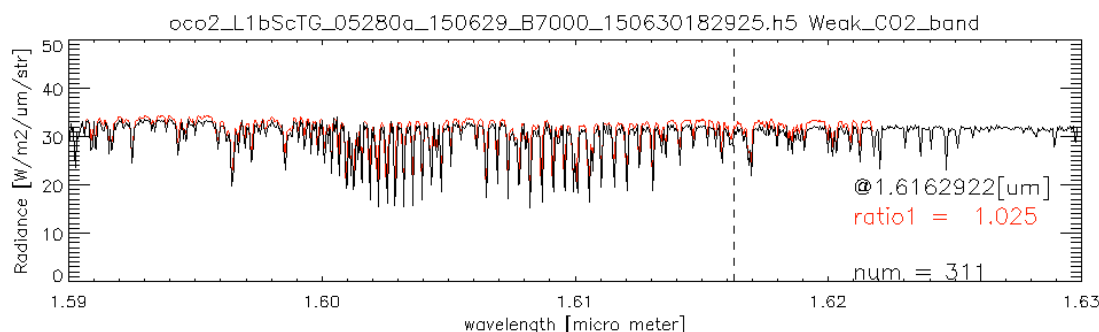
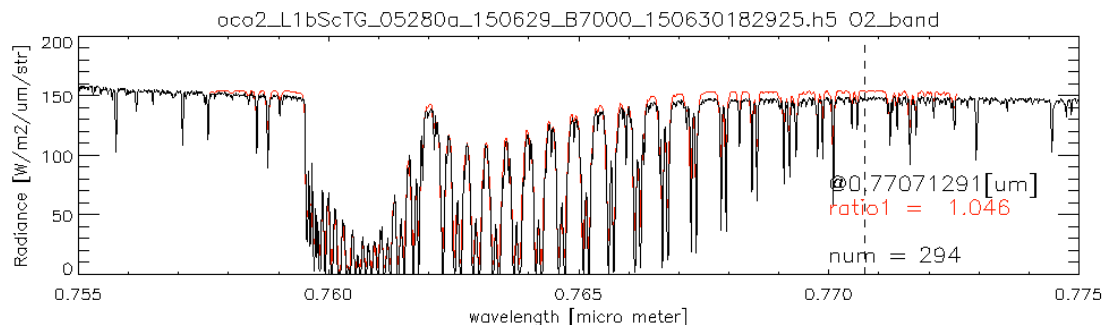
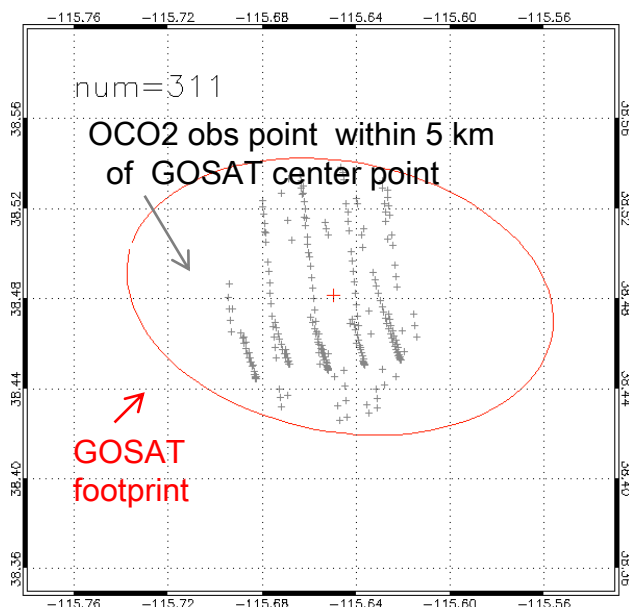
OCO2- GOSAT Radiance Spectra Comparison

Railroad Valley, Nevada, Jun29,2015

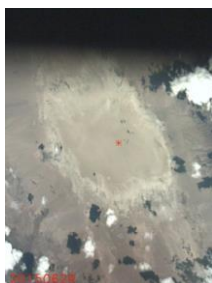


oco2_L1bScTG_05280a_150629_B7000_150630182925.h5
GOSATFTS2015062921160370242_1BSP0D161161.01

— GOSAT Rad
— OCO2 average Rad within 5km of GOSAT cnt point X 2
ratio1 = OCO2/GOSAT



OCO2: path139 (looking from West)
GOSAT: path37 (looking from West)



March, 2016, Canberra



OCO2- GOSAT Radiance Comparison



		Prelaunch Cross Calibration (radiometric Standard Comparison)	OCO2/ GOSAT	GOSAT IFOV averaged albedo	OCO-2 IFOV averaged albedo	OCO2/ GOSAT
		Dec, 2008, at JAXA	Radiance Spectra Comparison	MODIS	MODIS	Corrected
O2A	0.76μm	±1.8%	1.046	0.395	0.396	4.1%
WCO2	1.6μm	±1.6%	1.025	0.570	0.587	-0.4%
SCO2	2.0μm	±1.4%	0.994	0.358	0.367	-3.3%

- (1) OCO2 and GOSAT Spectral Radiance agree **with better than 5%**.
- (2) Both OCO-2 and GOSAT has larger degradation in the O₂A bands
- (3) SCO2 deep absorption spectra need further tuning



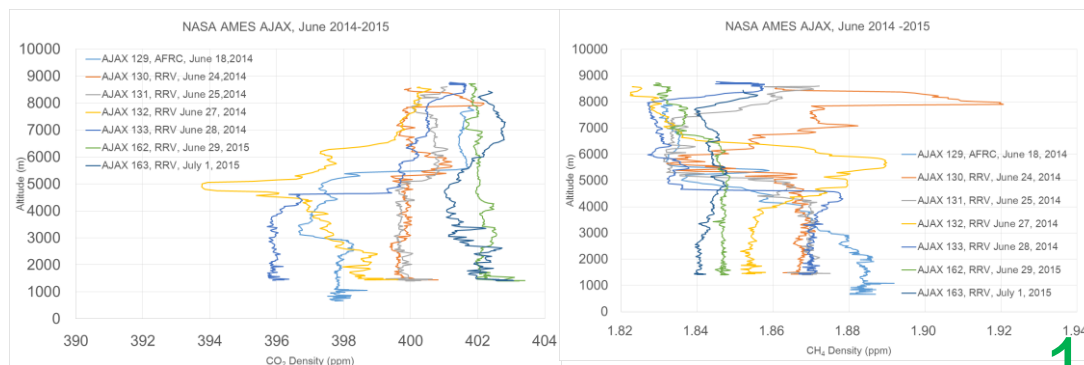
Retrieved parameters comparison



GOSAT data acquisition time	GOSAT NIES Level 2 with min χ^2 out of 4 soundings from GOSAT Level 1 V161				OCO-2 Level-2 lite Coincident Footprint average (6/29 : 1481data7/1 : 353data			Basecamp weather station	RRV Aeronet	AJAX airplane	
	P _{surf} (hPa)	AOD (500nm)	XCO ₂ (ppm)	XCH ₄ (ppm)	P _{surf} (hPa)	AOD	XCO ₂ (ppm)	P _{surf} (hPa)	AOT (500nm)	XCO ₂ (ppm)	XCH ₄ (ppm)
2014/06/24 20:46:35	851.1	0.035	401.9	1.810	N/A	N/A	N/A	851.099	0.0927	398.5	1.811
2014/06/25 21:18:56	844.5	0.024	402.3	1.812	N/A	N/A	N/A	849.223	0.0756	398.7	1.808
2014/06/27 20:46:37	849.1	0.025	400.5	1.803	N/A	N/A	N/A	851.711	0.0645	397.6	1.807
2014/06/28 21:18:54	846.0	0.018	400.4	1.807	N/A	N/A	N/A	851.512	0.0347	397.5	1.809
2015/06/29 21:17:20	853.3	0.068	406.2	1.806	861.1	0.246	401.1	856.889	0.1187	401.3	1.784
2015/07/01 20:44:54	847.3	0.095	402.7	1.799	855.6	0.122	400.0	856.326	0.1026	401.2	1.784

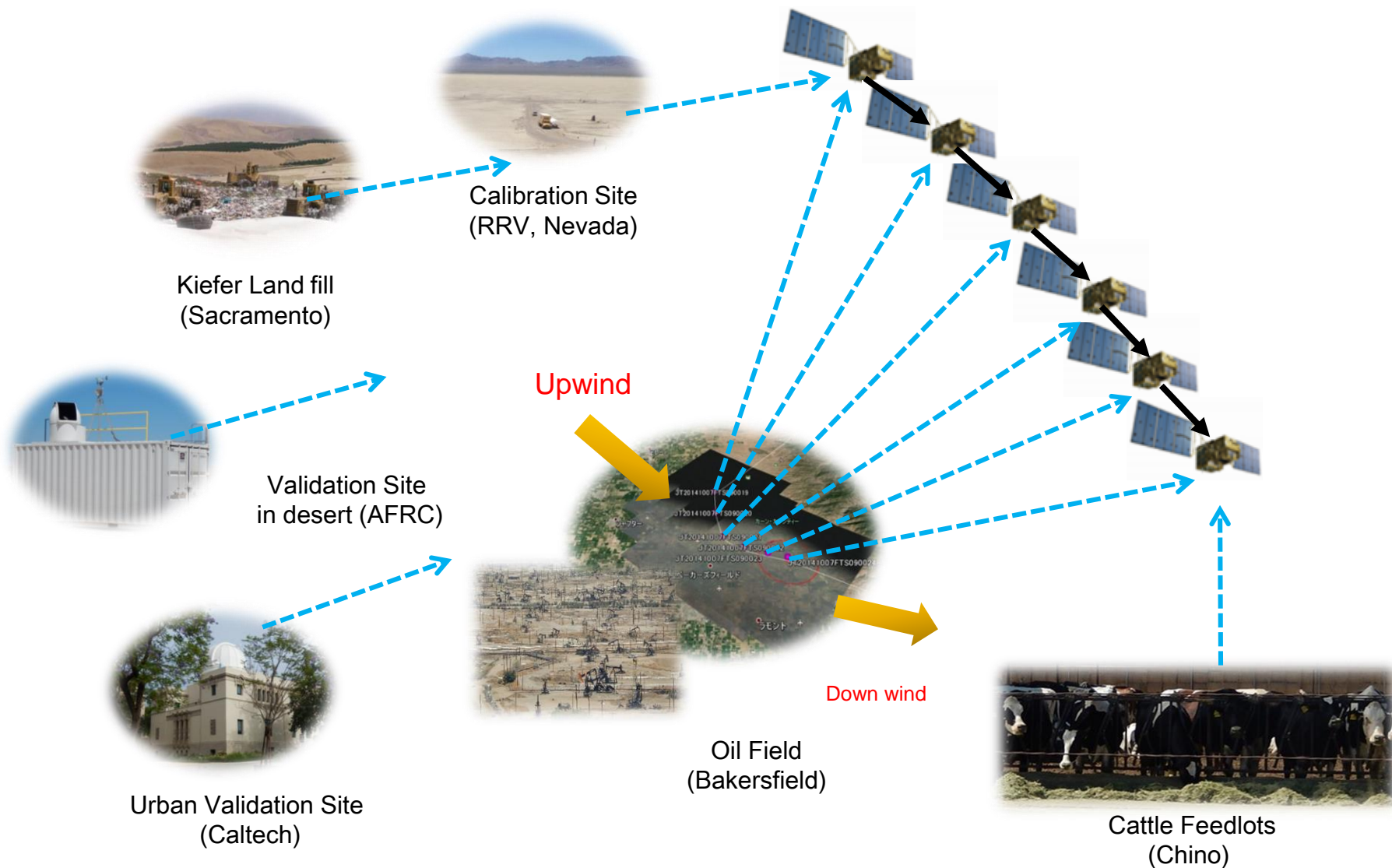
2015/7/1 thin cirrus cloud, AOT 2015 is thicker. AJAX: Courtesy of L. Iraci, T. Tanaka of NASA AMES, NIES L2: T. Yokota

OCO2 L2_LITE
Footprint average(6/29:
1481data7/1 : 353data
AOD, NIES, CIMEL @500nm





Optimizing pointing patterns Example: US west coast

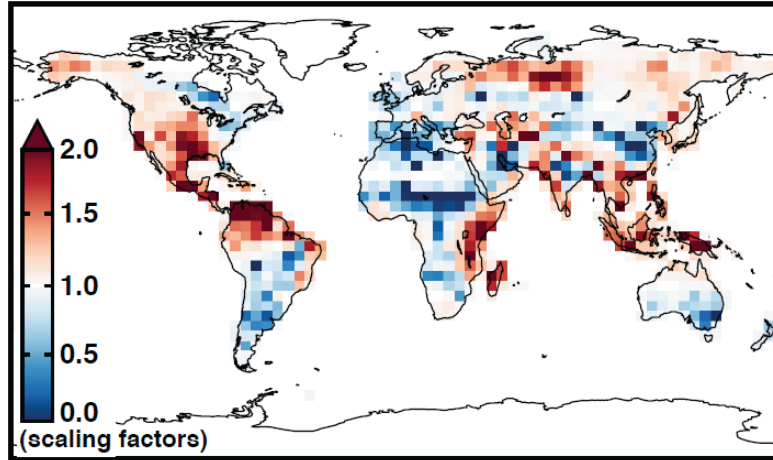




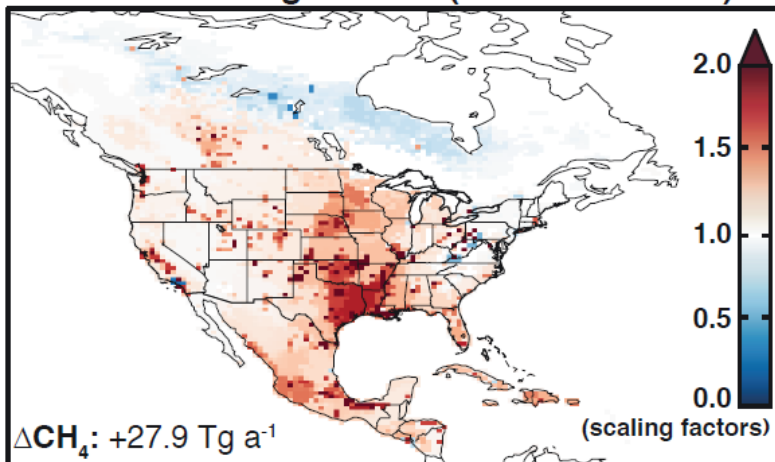
Toward emission inventory



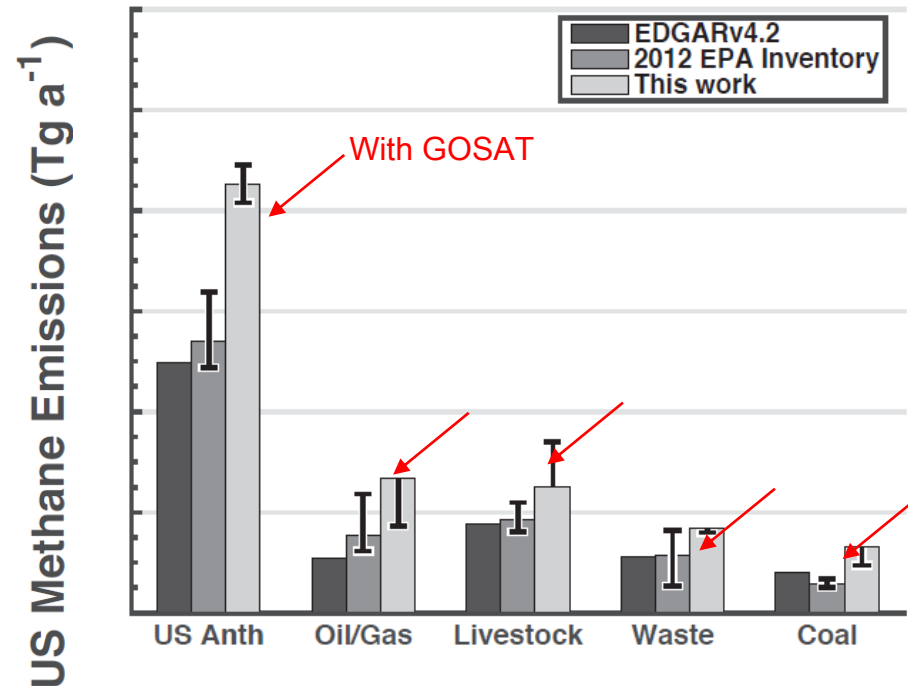
Emission Scaling Factors (Posterior / Prior): +2 Tg a⁻¹



Emission Scaling Factors (Posterior / Prior)



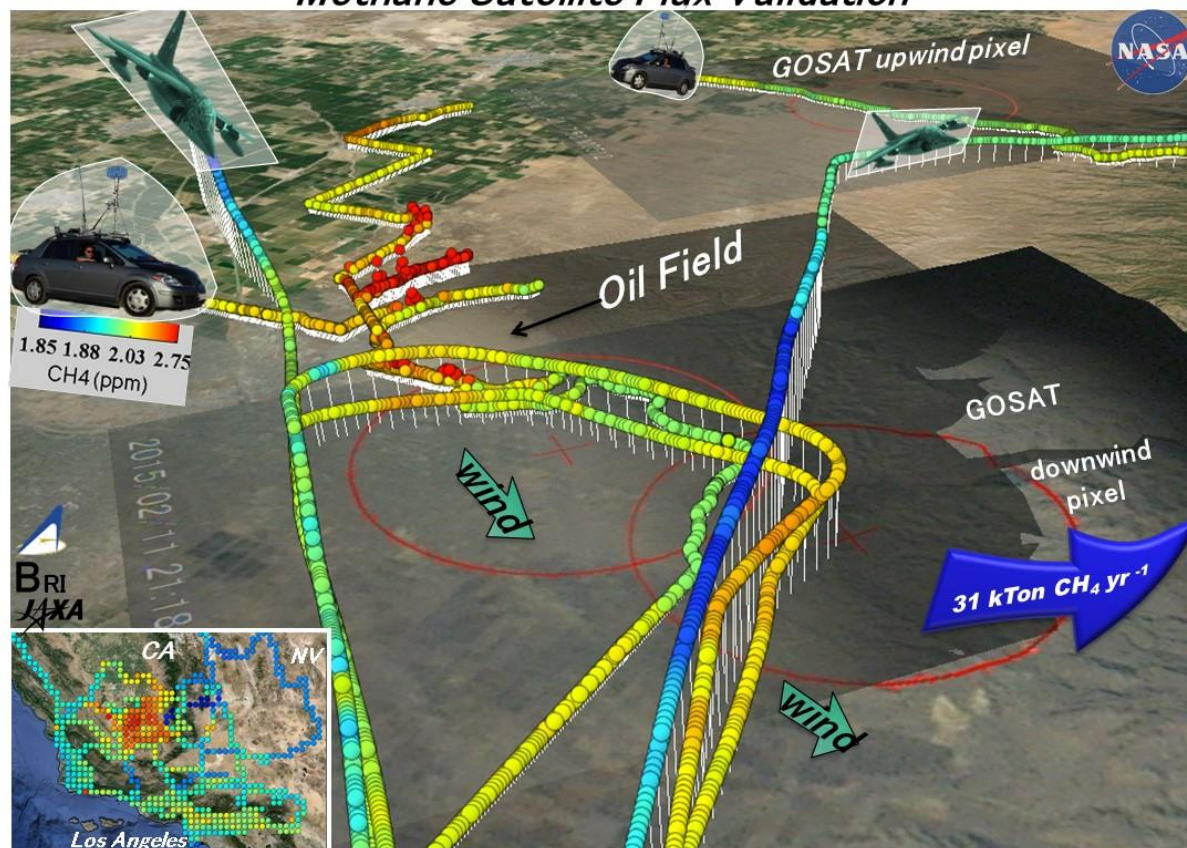
US Estimated methane emissions with GOSAT



EDGARv4.2 (Model), the 2012 EPA inventory (EPA, 2014) and GOSAT (Turner et al., 2015, ACP)

How to validate the flux (emission amount)

Methane Satellite Flux Validation



- Airborne (AJAX - NASA Ames) and surface (AMOG-BRI) data are combined to estimate methane emissions for validation of satellite (JAXA - GOSAT) observations. Methane (CH₄) legend for *in situ* data on figure.
- Inset. 9-km pixel map of surface data suggests what a methane mapping satellite would see for S. California.

Courtesy of Ira Leifer