A31O-05 Methane Flux Estimation from Point Sources using GOSAT Target Observation: Detection Limit and Improvements with Next Generation Instruments

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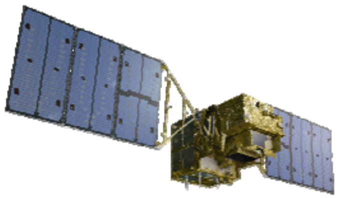
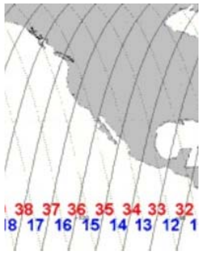
CH_4 Flux estimation by GOSAT

(1) Anthropogenic emission area of CH_4 is generally smaller than CO_2 and type of source can be categorized but emission amount has large uncertainty

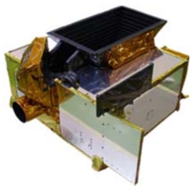
(2) GOSAT since 2009

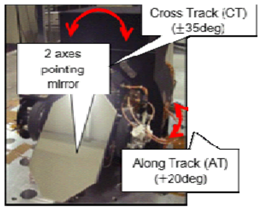




- Frequent: once or twice per 3-day of re-visit cycle
- Long term: almost 9 years
- Uncertainty 13 ppb (0.7 %)
- Larger uncertainty with topography

(3) TANSO-FTS with an agile pointing system

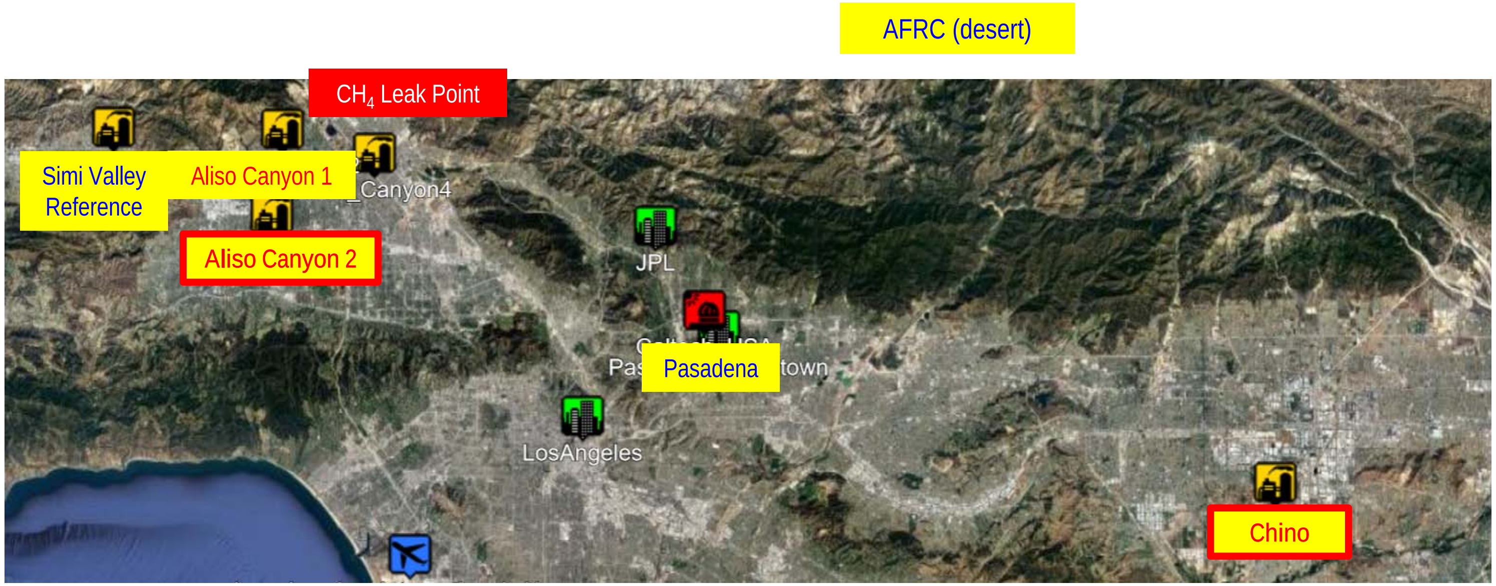




- Covering entire point source horizontally and plume vertically, but large (10.5 km)
- Can target pair of emission point and background (reference)

(4) No satellite data on wind speed and direction

Targeting Point CH_4 Sources with an Agile Pointing System



Los Angeles Basin

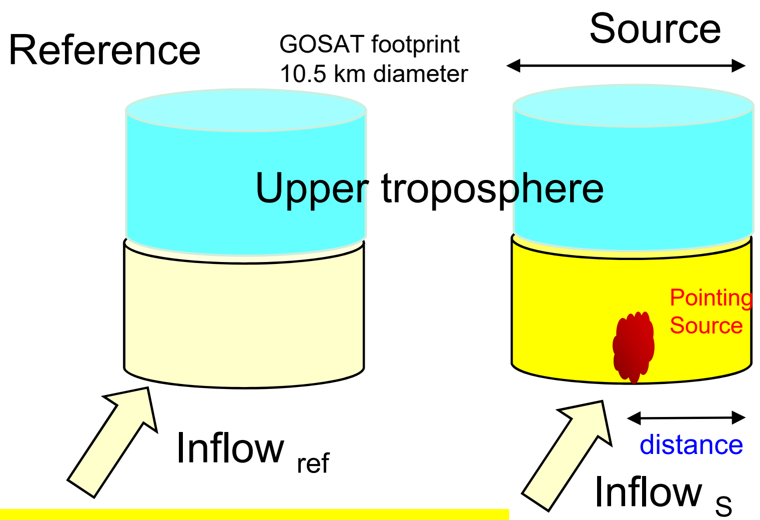
- High clear sky ratio
- Located between GOSAT paths 36 and 37

GOSAT TANSO-FTS
Level 1 Radiance Spectra
V201.202

Level 2 retrieved column-averaged dry air mole fractions of CO_2 and CH_4
RemoteC product by SRON and DLR
Except for Pasadena (RemoteC by JAXA)

Aliso Canyon 	Largest Gas Leak (decrease with time) Start observation since Nov. 2015 Paired with Simi Valley (reference)	Complicated topography and wind direction	Simi Valley (close reference, basin) Aliso Canyon 1 (Leak Point inside) Aliso Canyon 2 (Flat but LP outside) Burbank (air port)
Chino 	Cattle feed lot (constant emission with time) Assuming constant emission Measured wind speed and direction data within IFOV are available Simpler wind field	Enhancement is close to GOSAT uncertainty of 13 ppb	AFRC (far away reference desert) JPL Pasadena (reference) Chino (Emission point, airport inside)

Flux Estimation using Reference XCH_4 and WRF Wind Speed



Emission t/hour
=△XCH_4(ppb)*0.495t*3600s*V(m/s)
/(distance between source and edge)

$$\Delta XCH_4 = XCH_4s - XCH_4ref$$

Errors in UT

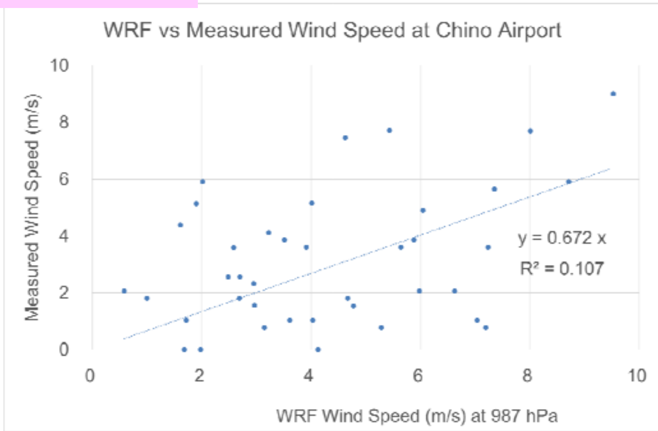
$$\Delta XCH_4(UT) = XCH_4s(UT) - XCH_4ref(UT)$$

Errors in inflow can be reduced by normalizing with XCO_2

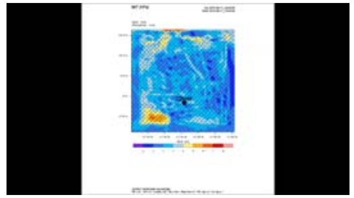
$$\Delta \frac{XCH_4}{XCO_2} = \frac{XCH_4s}{XCO_2s} - \frac{XCH_4ref}{XCO_2ref}$$

Decentered point source within GOSAT footprint

Wind speed



Is Weather Research and Forecasting Model (WRF) accurate?



Larger Fluctuation in weaker wind

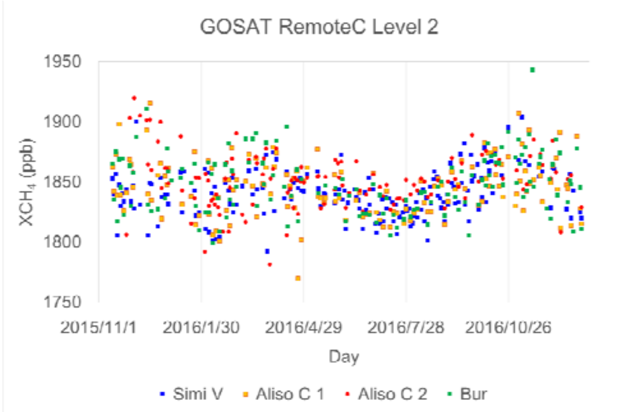
Measured data at Chino Airport
https://www.wunderground.com/

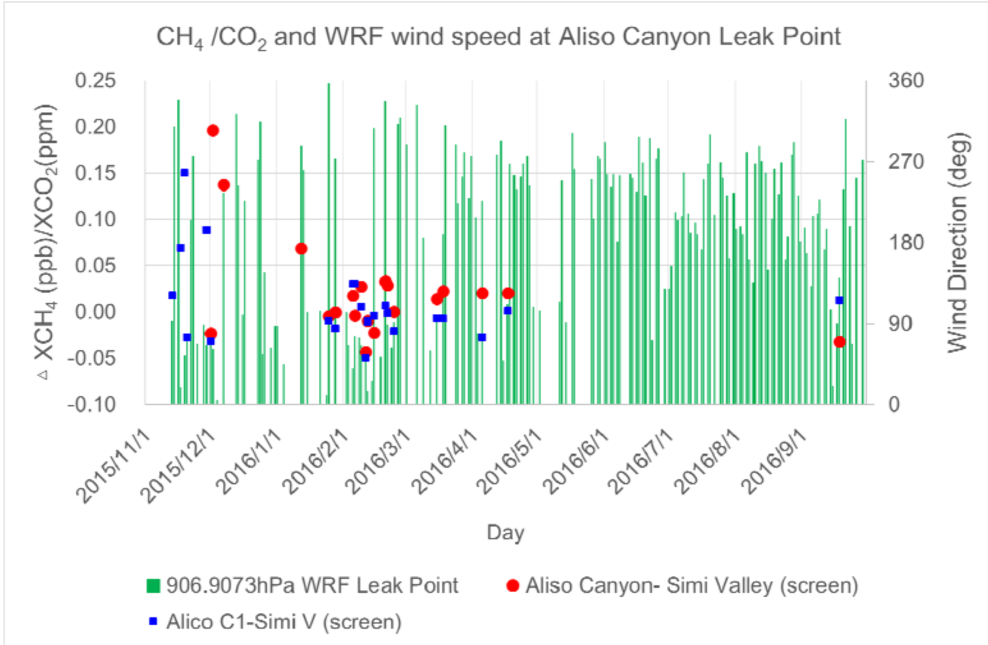
	Aliso Canyon	Chino
Enhancement from background	Large enough	Close to detection limit
Upper Troposphere	Close reference	Far (AFRC) closer (Pasadena)
Inflow	Close reference	Far (AFRC)
CO_2 Emission source inside IFOV	Lower in North	High
Source Location and Wind direction	Near Edge, Unstable	Mostly West
Wind speed	No airport data, not uniform	Measured data at Chino Airport

CH_4 Gas Leak and its Decrease with Time at Aliso Canyon

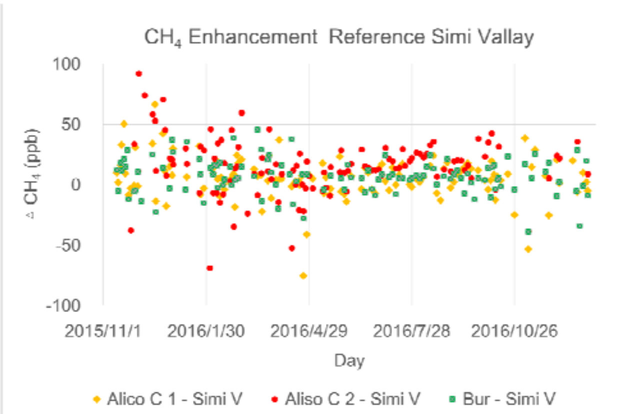
How to screen the data: background, normalize, and wind direction

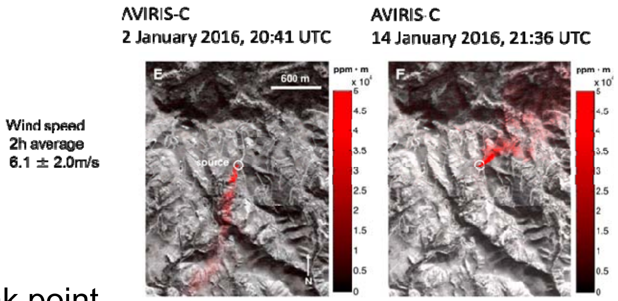
<u>Raw Level 2 data</u>

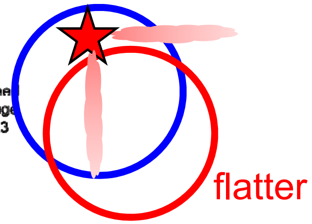




<u>Screening 1</u>
Background-Subtract
using Simi Valley
Enhancement of 30 ppb >
uncertainty of 13ppb







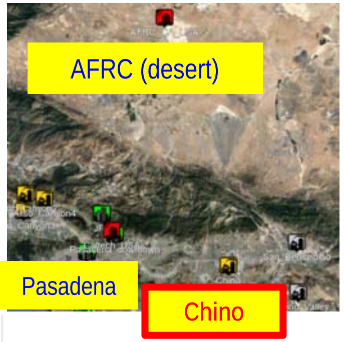
Thompson et al. GRL (2016)

<u>Screening 2</u> (normalized) with XCO_2 for urban Contaminated Inflow

Assuming CH_4/CO_2 ratio is the same, can be minimized.

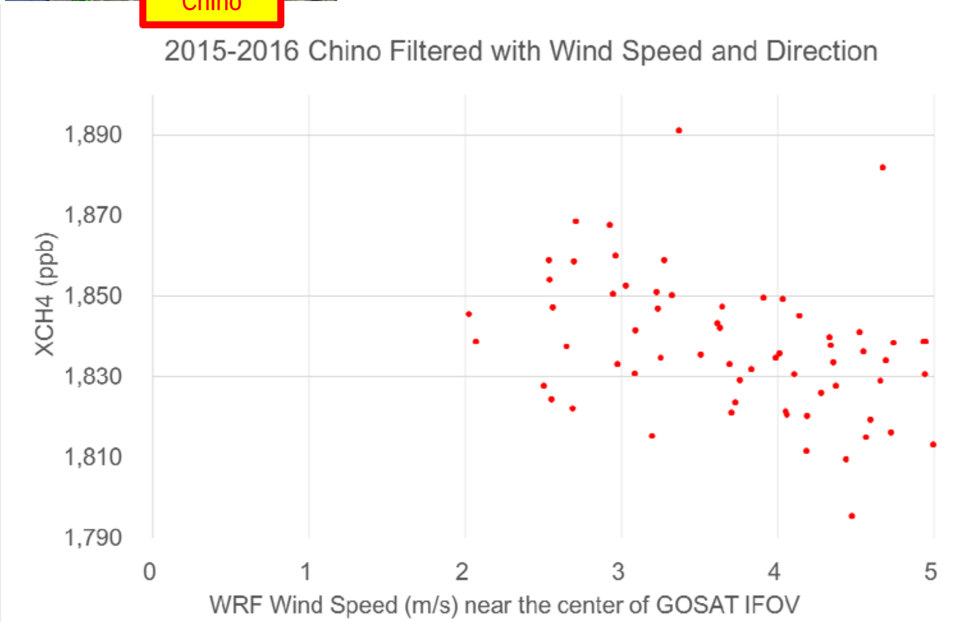
<u>Screening 3</u> Filter out East –South –North West using WRF wind direction at leak point

Calculated Flux using WRF at Chino Center

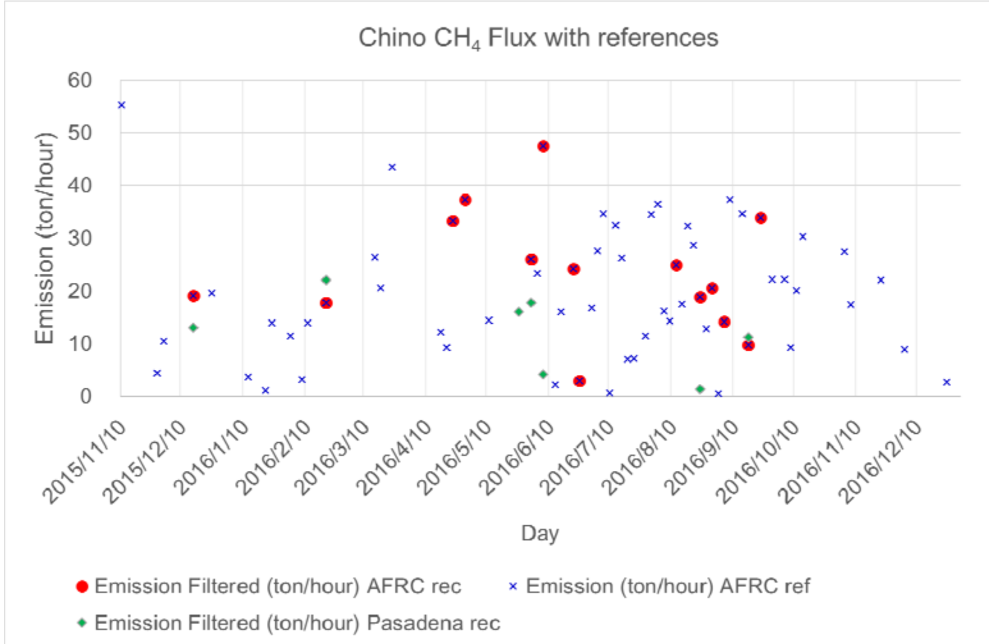


Assuming CH_4 emission is constant with time

$$\Delta XCH_4 \propto \frac{1}{V}$$



Data selection: wind speed between 2 and 5m/s and wind direction between 180 and 270 deg.



Emission t/hour

= △XCH_4(ppb)*0.495t*3600 s*V(m/s)/5000 m

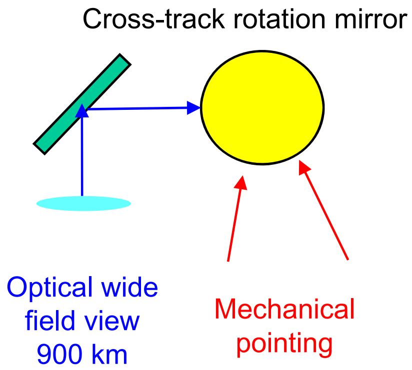
=(XCH_4(Chino)-$XCH4_4$ (Ref)) *0.495 t *3600 s * WRFWRF V(m/s) @ city center/5000 m

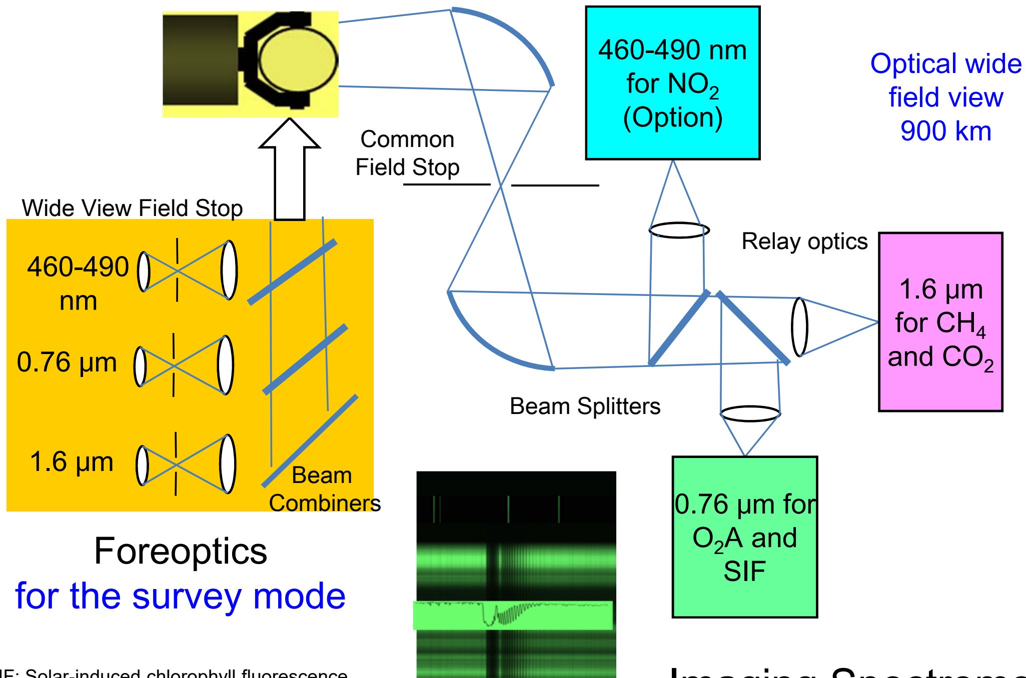
AFRC is far away and not an ideal reference.
Inflow in Pasadena is also contaminated.
CO_2 emission within Chino IFOV. XCO_2 at AFRC is low.
Normalized with XCO_2 does not work well.

Future Plans: Next Generation Instruments

Combination of staring and coverage

2-axis pointing system
for the staring mode
the side view for the survey mode





Foreoptics
for the survey mode

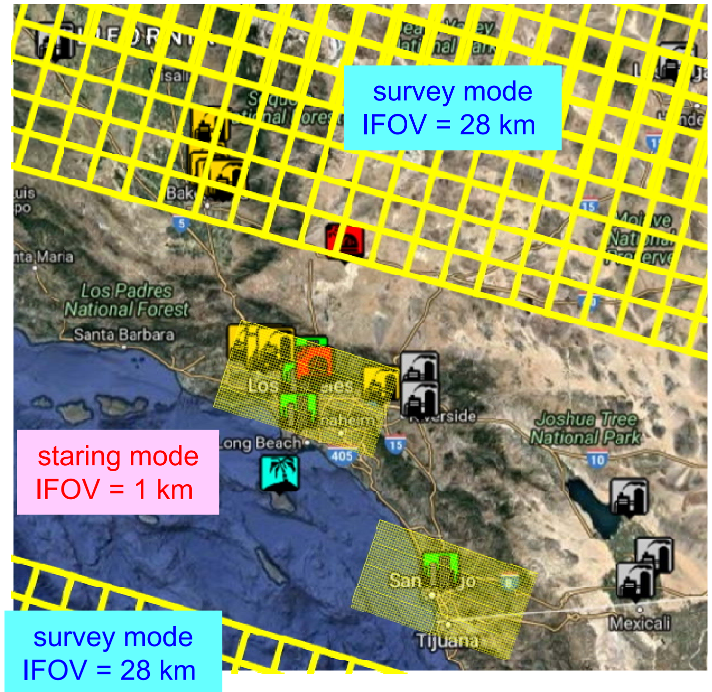
SIF: Solar-induced chlorophyll fluorescence

Imaging Spectrometer Suites

Survey entire earth's surface
Selecting Proper reference

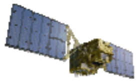
Staring

- 1 km resolution will enhance dCH_4
- Image can detect plume and has closer reference



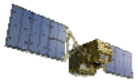
Conclusions

<Demonstrated with GOSAT>



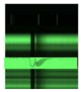
- Frequent, long-term target observations together with background reference can detect CH_4 enhancement from local point emission source.
- Fluctuating satellite data needs proper screening.
- Wind speed is the largest uncertainty.
- GOSAT can monitor emission change with time. Flux estimation has large uncertainty.

<Can be improved with GOSAT>



- Target the center of the emission point to cover plume for any wind direction (robust algorithm against topography)
- Two-tropospheric-layer retrieval using both SWR and TIR can remove inflow in upper atmosphere.

<Remaining issue and next generation instruments>



- Much higher spatial resolution, imaging capability, simultaneous measurement of short-lived species such as NO_2 wind speed information will improve anthropogenic GHG emission estimation.