

Our experience of using Pandora #146 at Yokosuka, Japan



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Pandora#146 started at Yokosuka in **Nov 2018** with an old tracker till Jul 2019

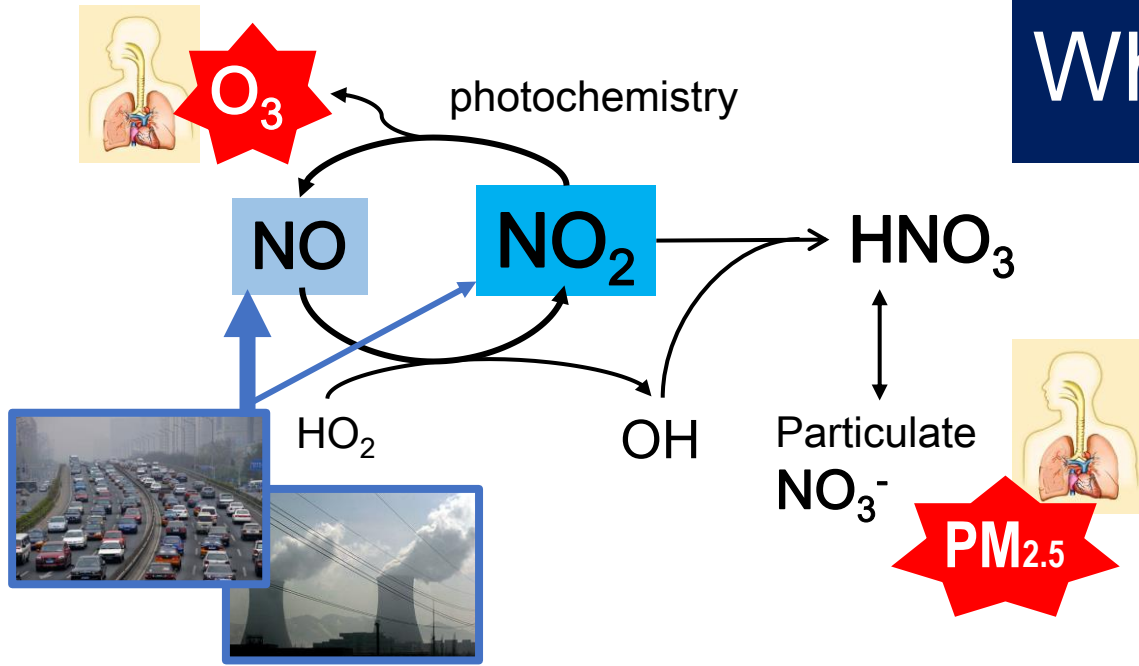


*Upgrade with
tracker etc*



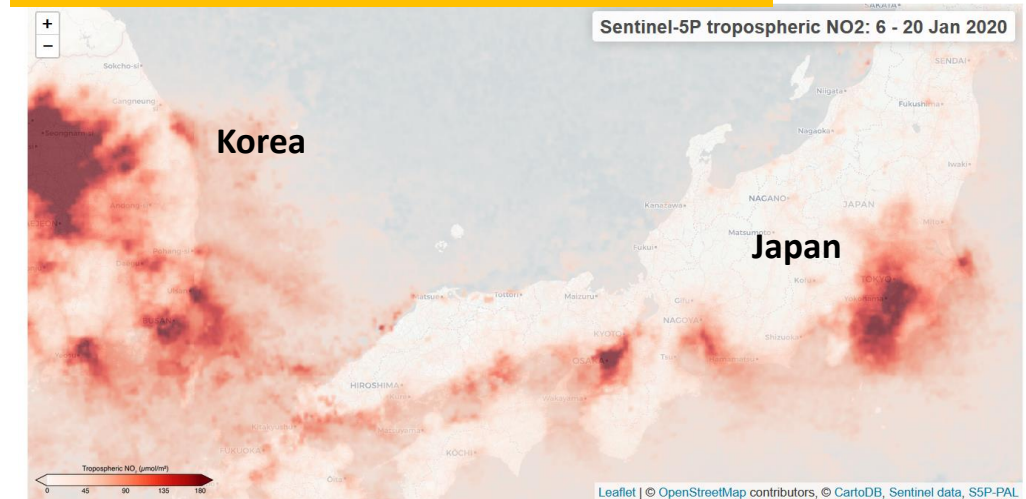
Pandora#146 **restarted** at Yokosuka in **Mar 2020**

Why satellite NO₂?

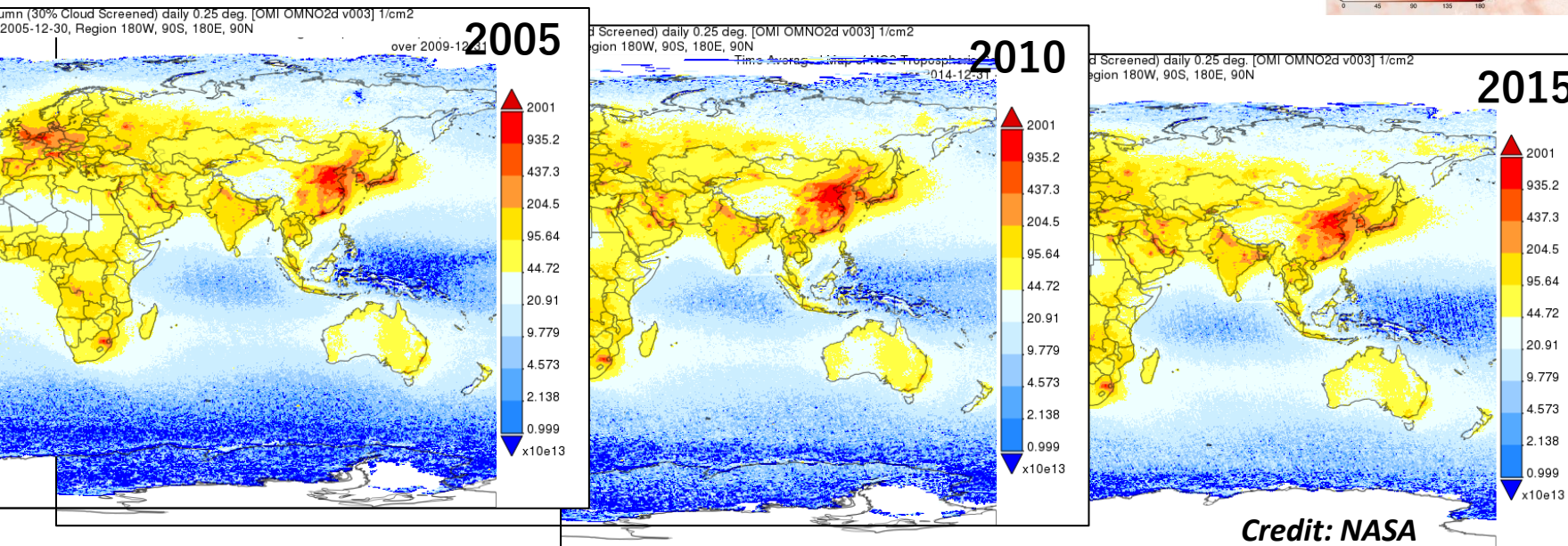


Emission sources are pinpointed from gapless map

Credit: ESA



decadal changes are tracked



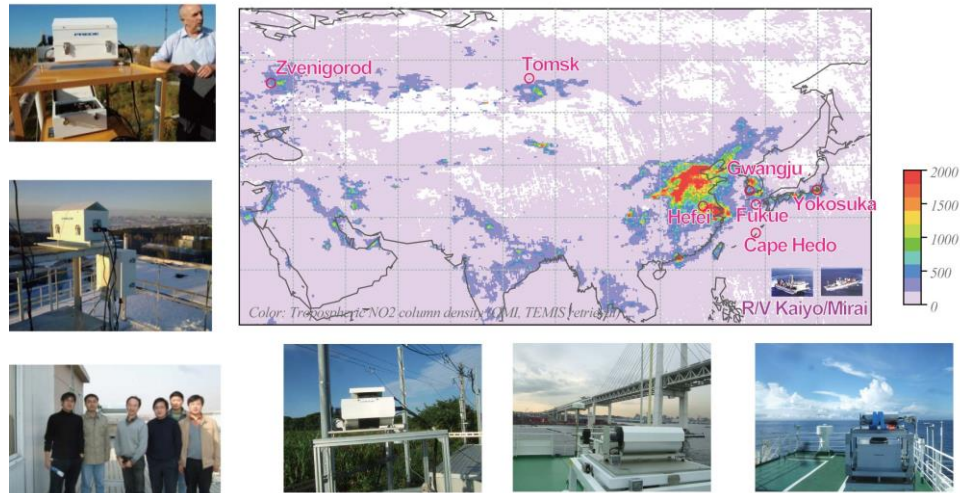
Diurnal variations



Weakness: tropospheric NO₂ amounts are often low-biased

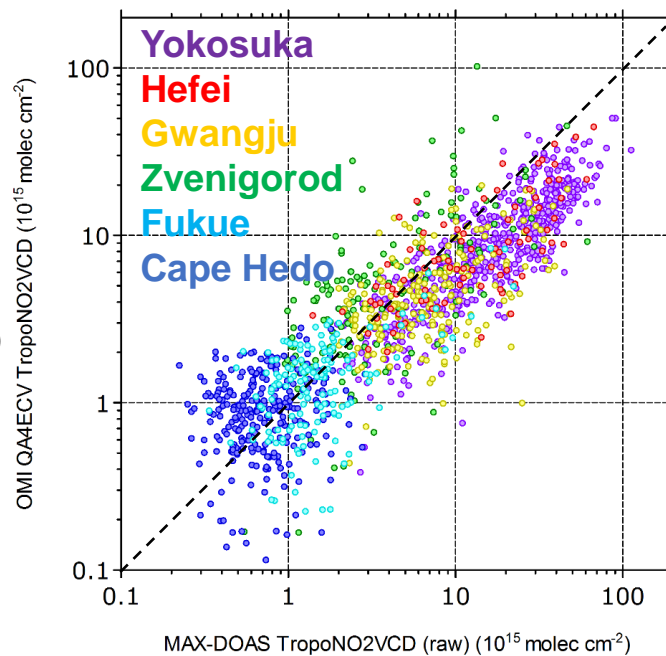
Satellite NO₂ is often low-biased: co-existing aerosol shielding effect?

MAX-DOAS network over Asia and Russia



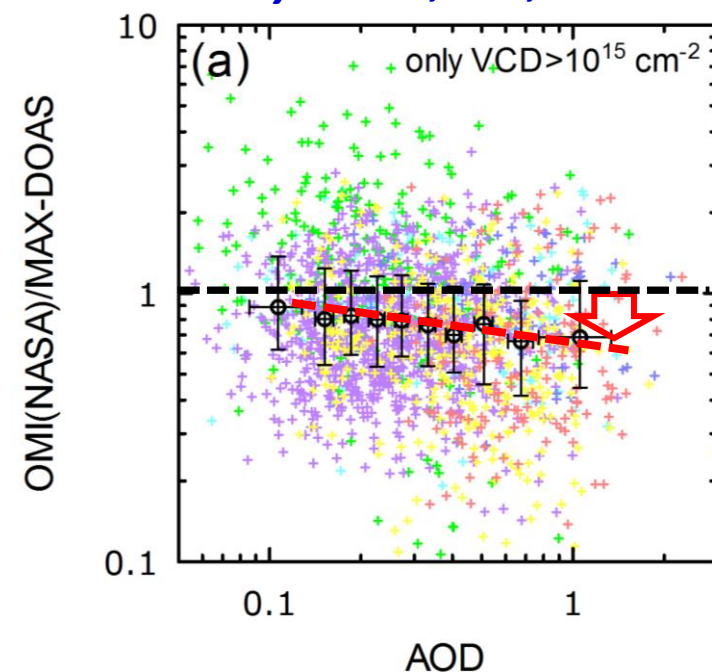
<https://ebcrpa.jamstec.go.jp/maxdoashp/index.html>

OMI



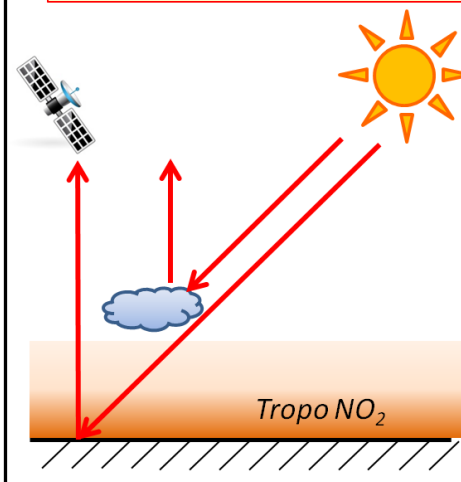
MAX-DOAS

Kanaya et al., ACP, 2014



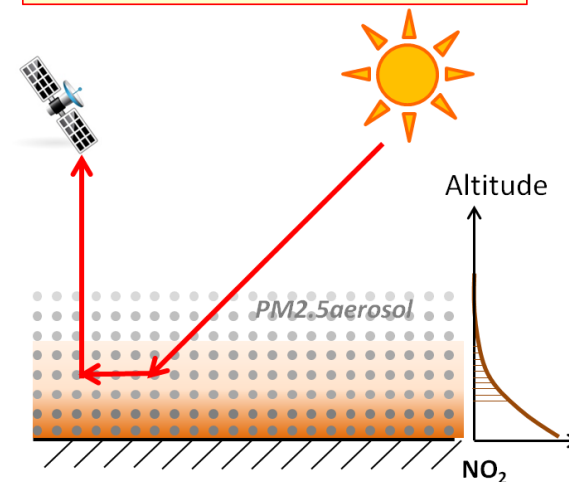
? implicit case

Aerosols are represented by "cloud" to explain observed radiance



● Real case with aerosols

Sunlight does not reach the surface, NO₂ near the ground is missed



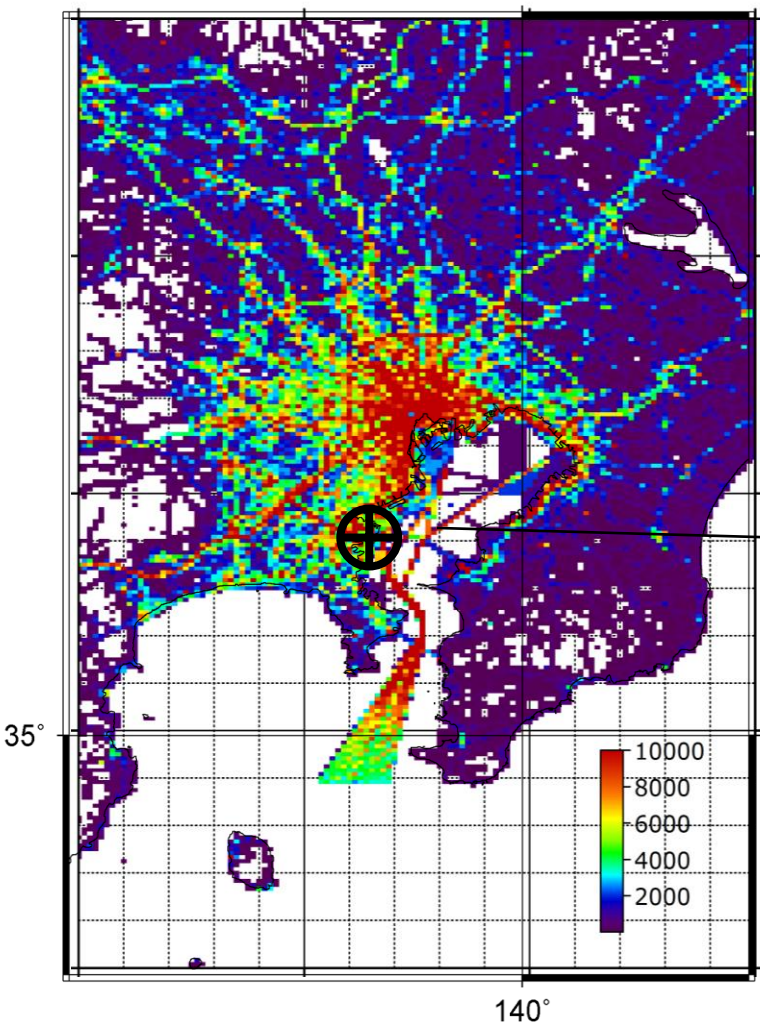
MAX-DOAS: our ground-based standard for >10 yrs,
measuring "scattered sunlight" at multiple
elevation angles (3, 5, 10, 20, 30° from horizon
& zenith)

To further confirm the validity of our MAX-DOAS,
we are motivated to introduce **Pandora** "direct
sun" observations for comparison.

Yokosuka, where we located PAN#146



1x1km NO_x emission map



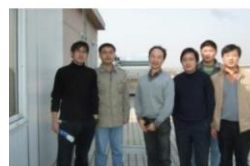
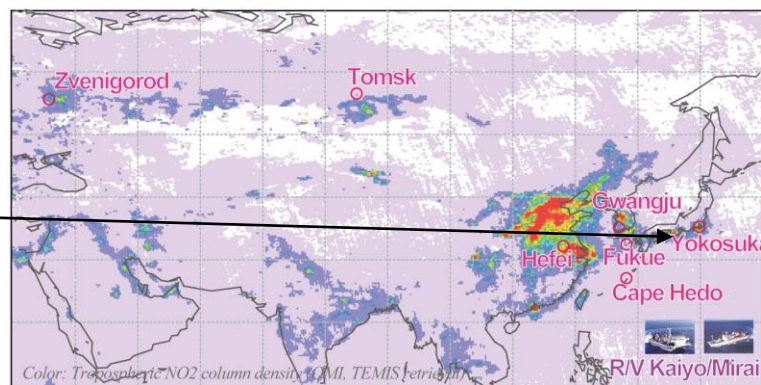
Yokosuka

(35.32N, 139.65E)

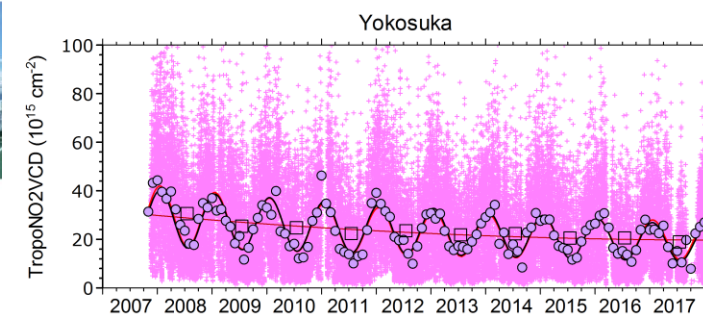
South edge of Tokyo-Yokohama metropolitan area

Kanaya et al., ACP 2014

MAX-DOAS network over Asia and Russia

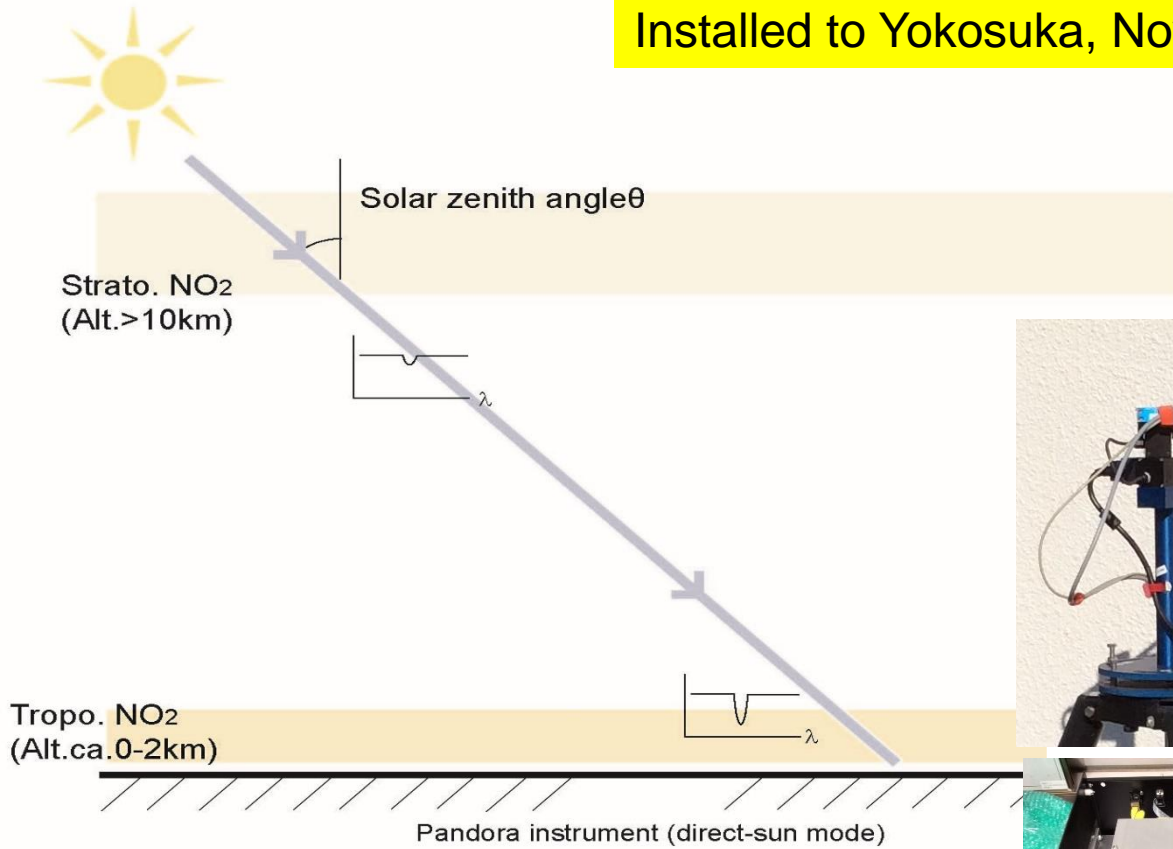


<https://ebcrpa.jamstec.go.jp/maxdoashp/index.html>



Pandora146, direct-sun spectrum obs. at Yokosuka

Installed to Yokosuka, Nov 2018



Field of view	1.5°
Spectrometer	2048 pixels, Avantes
Spectral range	290-520 nm
Spectral resolution	~0.6 nm
Temperature	+20.00°C



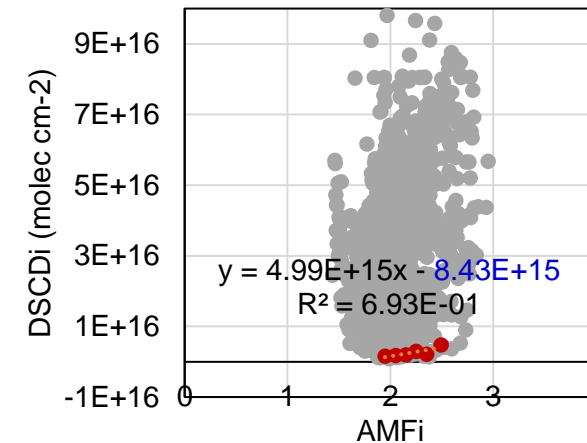
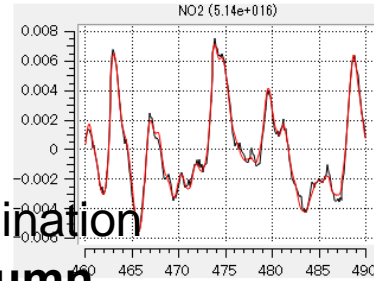
◎ Advantage: path well defined

◎ Centralized processing by Pandonia project (**LuftBlick**, ESA) & our own analysis

● **Absolute** NO₂ column determination requires “reference” slant column quantification:

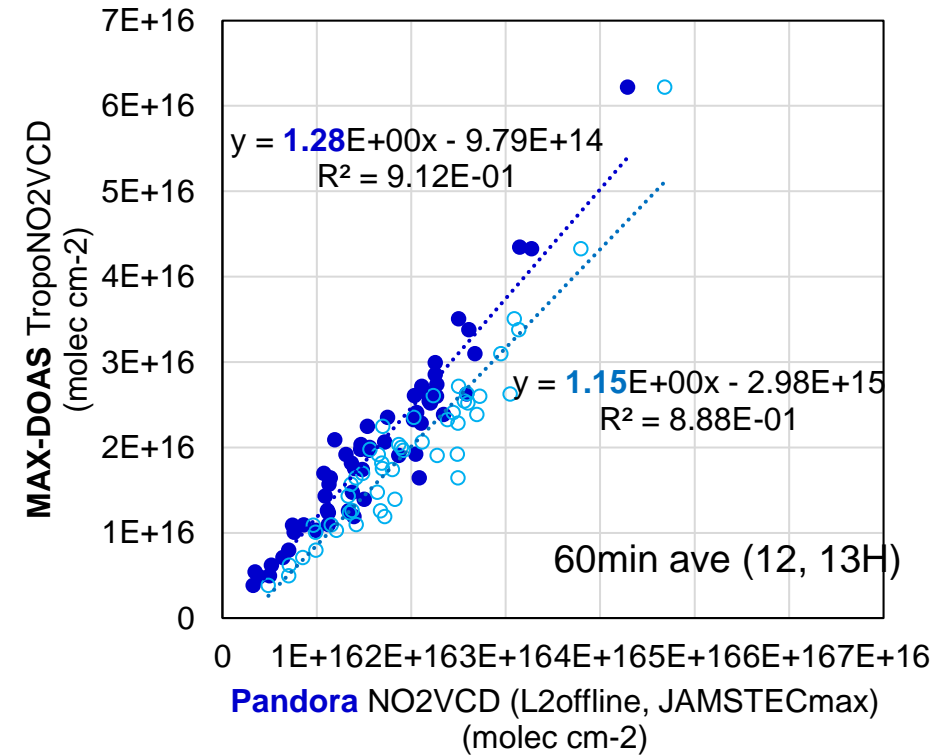
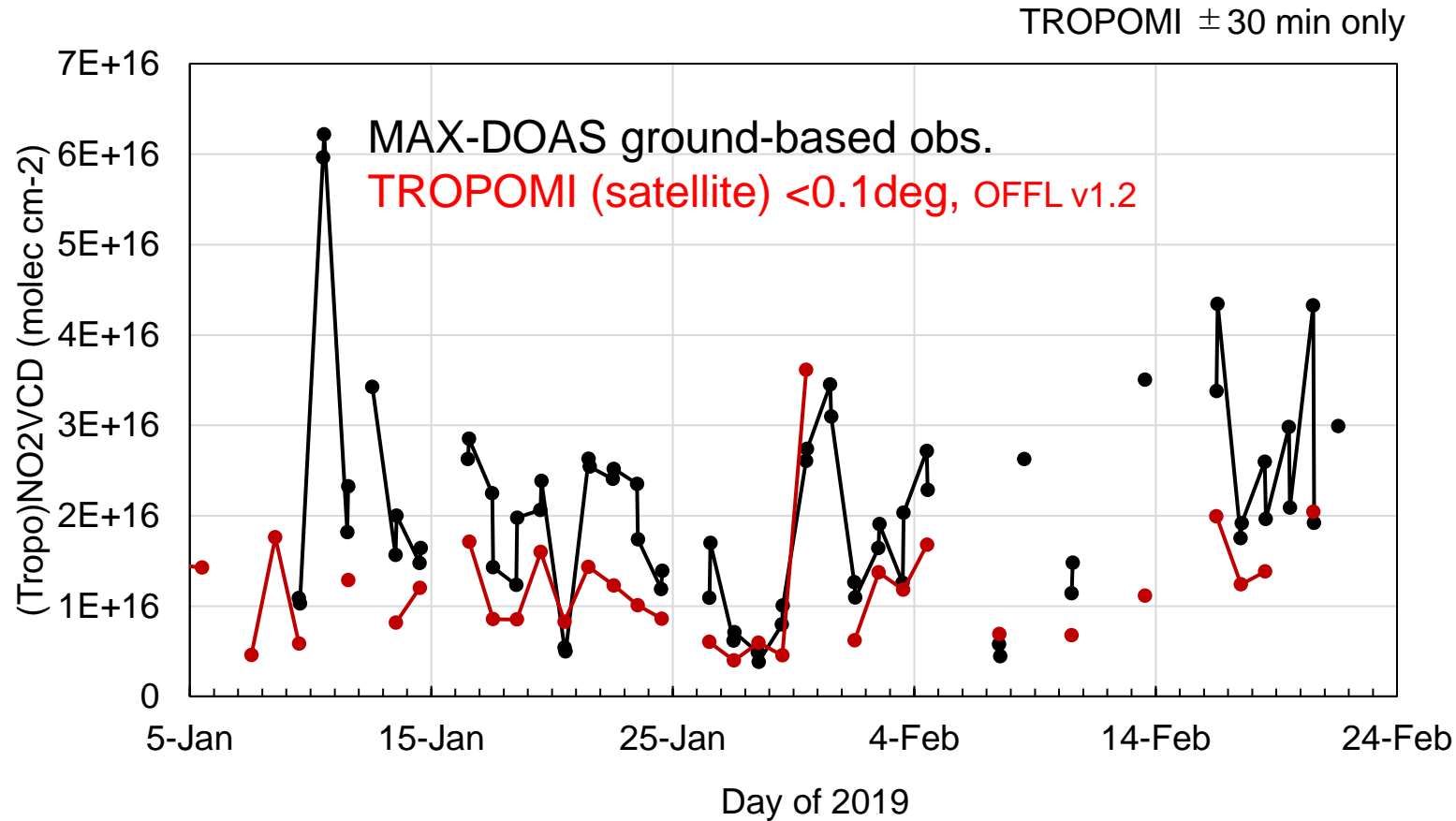
→ **Modified Langley method**

$$DSCD_i + SCD_{ref} = VC_0 * AMF_i$$



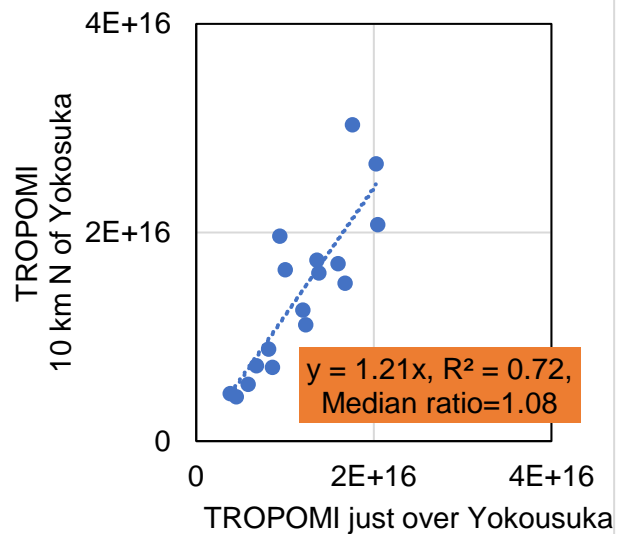
The **two retrievals** (L2offline, JAMSTEC max) with VCD difference
~+4 × 10¹⁵ molec cm⁻²

Pandora supported MAX-DOAS, confirming low-bias from TROPOMI satellite

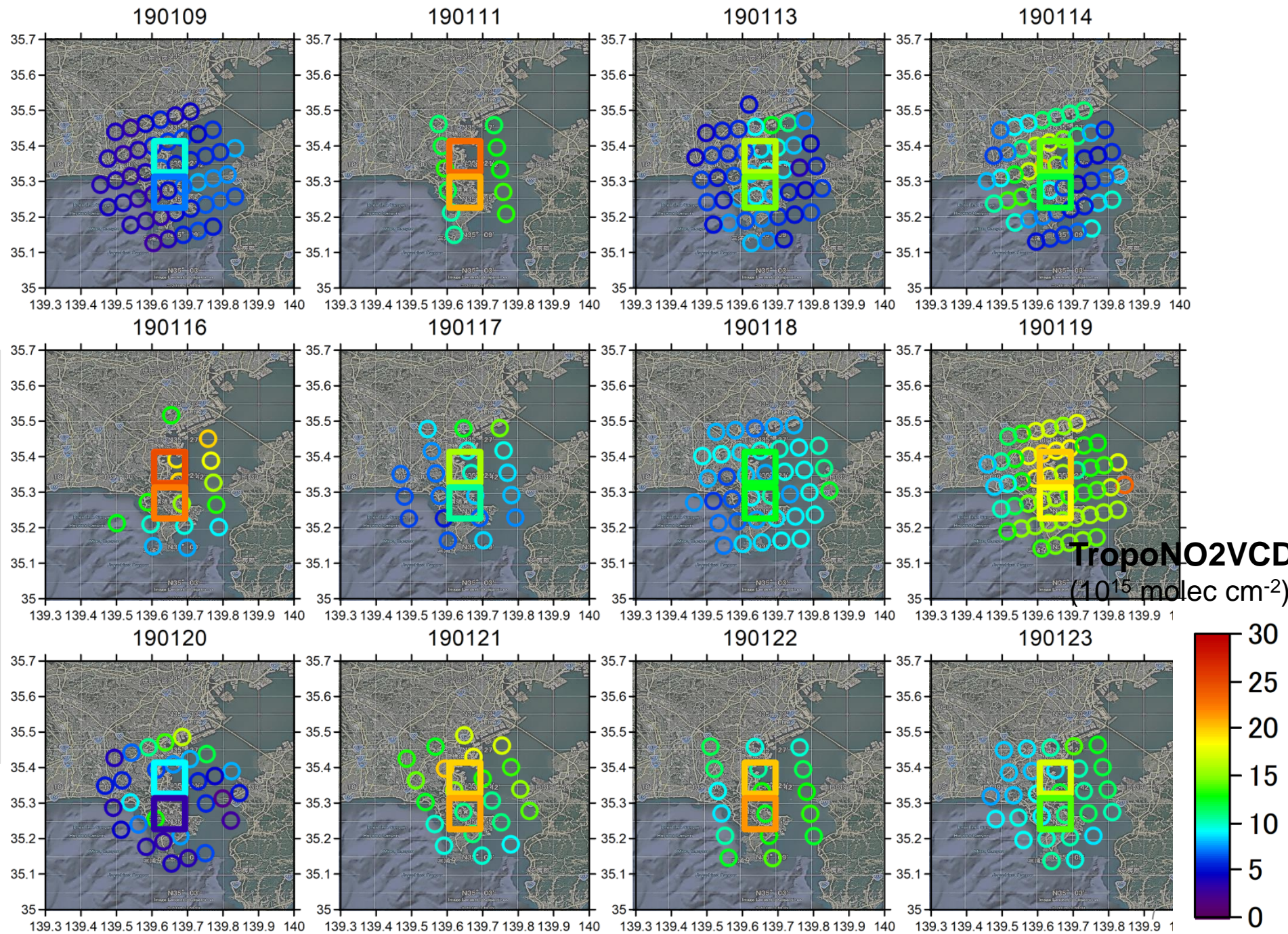


TROPOMI was 1.6 times lower than MAX-DOAS
Pandora basically supports MAX-DOAS (rather than TROPOMI),
but MAX-DOAS is likely +15-28% high biased than Pandora

But why MAX-DOAS
was higher?
systematic North-
South NO_2 gradient



N-S gradient explains
8-21% out of MAX-
DOAS (north-looking)
high bias (15-28%)



Summary (1)

Pandora direct-sun observations supported our MAX-DOAS & retrievals at Yokosuka and provided more firm basis for satellite validation.

Cause of low-bias (x1.6) of TROPOMI at Yokosuka during winter:

1. Overestimation by MAX-DOAS (15-28%),
partly from 2. Spatial heterogeneity of NO₂ (7~21%)
3. Vertical profile shape assumption (11%)
4. aerosol/surface albedo (rest; ~ 20%?)

Summary (2): Our satisfaction with Pandora

1. More robust satellite validation:

- **improve certainty** of ground-based observations combining Pandora & MAX-DOAS to provide a robust basis for satellite validation (**TROPOMI**, **GEMS** etc)
- **Multiple species**: Extend qualification of MAX-DOAS from NO_2 to **HCHO** (and then satellite validation)

2. International data harmonization:

- Pandora regarded as “an internationally certified transfer standard”; difficulty in regularly attending intercomparison campaigns in Europe is saved
- **Centralized standard processing** is very much appreciated (DOAS, VCD determination etc).

Suggestions from my experience:

Instruments would become more robust **if adapted to “humid” conditions in Asia.**

Attendance of local operator at least once per week is recommended.

Network manager with hardware skills in the Asian time zone will help.

GOSAT-GW (Global Observing SATellite for Greenhouse gases and Water cycle): as a Japanese upcoming satellite mission

TANSO-3 (*Total Anthropogenic and Natural emissions mapping SpectrOmeter-3*)

Project: NIES, funded by MoE-Japan

Development: JAXA, Mitsubishi

Expected Launch: FY2023 (Apr 2023 – **Mar 2024**)

Lifetime: 7 yrs

Orbital altitude: 666 km

Sensor: grating imaging spectrometer

Band: VIS, NIR 0.7, SWIR 1.6 μm

Species: **CO₂**, **CH₄**, **NO₂**

Swath: 911 km/90 km

Spatial resolution: 10 km/1-3 km

Global coverage: 3 days

Local time: 13:30

your join to the
validation program
is very much
appreciated (details
tbd)!!

NO₂ Team:

- Joint NIES-JAMSTEC-NICT project (NIES-algorithm, JAMSTEC-validation, NICT-data processing) – **H. Tanimoto**, Y. Kanaya, Y. Kasai
- NIES-JAMSTEC-JAXA collaboration on aircraft obs., power plants, modeling, etc. – A. Kuze

Toward Global Stocktake 2023/2028:

- Monitoring of global-mean atmospheric column of GHGs, on monthly basis
- Evaluation of national inventories of anthropogenic emissions of GHGs
- Identification of large point sources

