Analysis of long-term tropospheric Ozone (O_3) concentration in urban areas an observational study using GOSAT and GOSAT-2 TIR band

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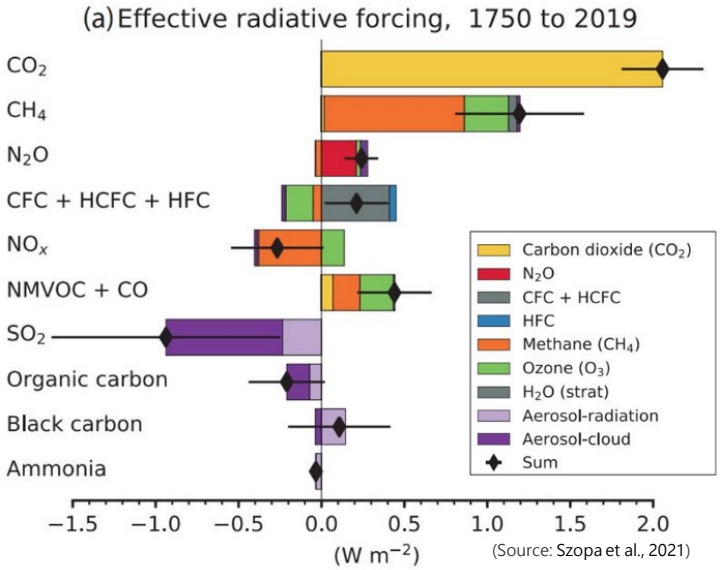
CCSR/AORI & NENV/GSFS



(Source: Szopa et al., 2021)

Why study ozone (O_3)?

Ozone (O_3) is **short-lived climate forcer (SLCF)**

- Third most potent GHGs → 19 days lifetime

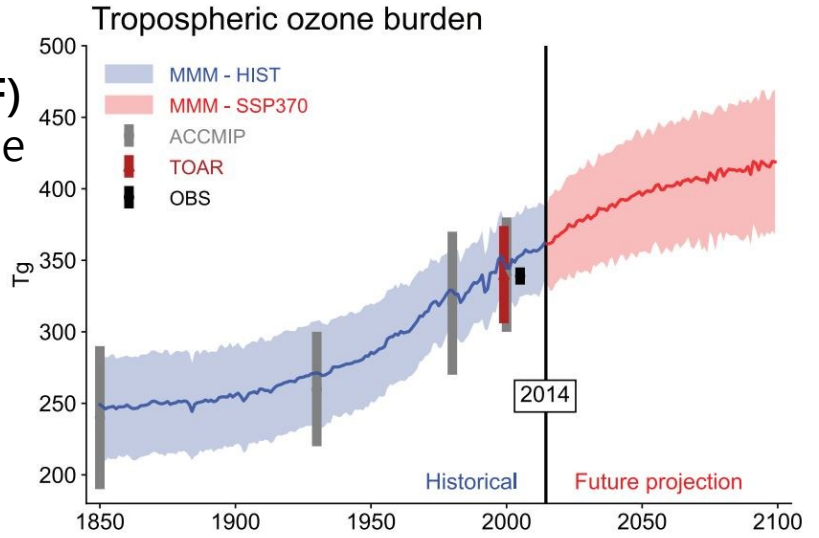
∴ Leads to global warming (plus air pollution)

Ozone (O_3) **originates from metropolitans**

- Precursors: NO_x and VOCs from urban

∴ Urban area considered as source of O_3.

Ozone → environmental issues



(Source: Szopa et al., 2021)

Why do we use satellites?

(Source: WMO/GAW, 2022)

Surface observation sites **sparsely distributed**

- Ground: concentrated in urban areas
- Sonde: few, lacks oceanic obs.

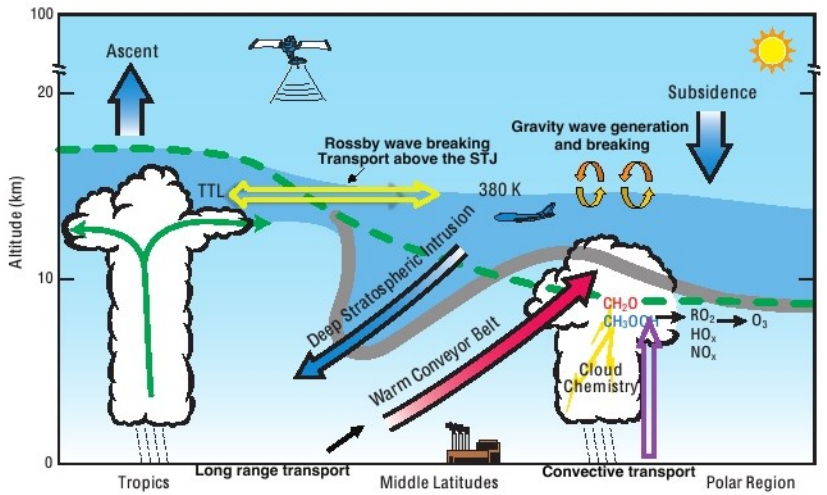
∴ Fill in the gaps in ozone distribution

Vertical exchange of ozone affects surface

- Stratosphere-troposphere interaction

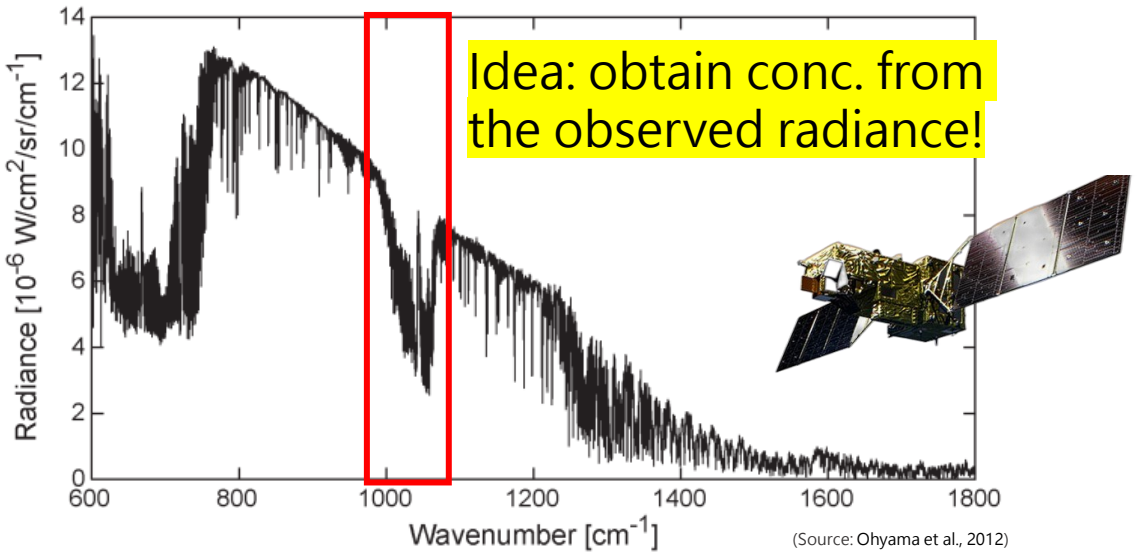
∴ Simultaneous obs. of vertical ozone conc.

Satellites → global to regional

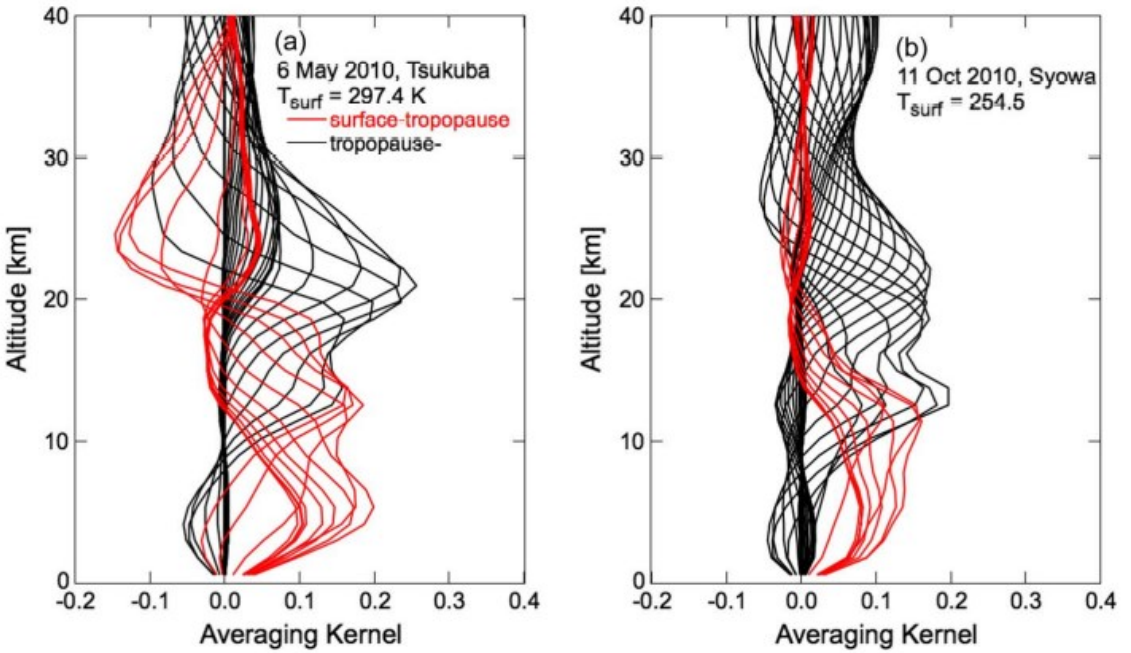


(Source: NOAA, 2022)

Methodology: GOSATs and inverse method



	GOSAT	GOSAT-2
Launch date:	January 23, 2009	October 29, 2018
Orbit and altitude:	Sun syn. (666 km)	Sun syn. (613 km)
Repeating cycle:	6 days	3 days
Sensors:	TANSO-FTS & TANSO-CAI	TANSO-FTS-2 & TANSO-CAI-2
Designed life:	5 years	5 years



Optimal estimation by Rodgers (2000):

$$\boldsymbol{y} = \boldsymbol{F}(\boldsymbol{x}, \boldsymbol{p}) + \boldsymbol{\varepsilon_O} = \boldsymbol{K}\boldsymbol{x} + \boldsymbol{\varepsilon_O}$$

&

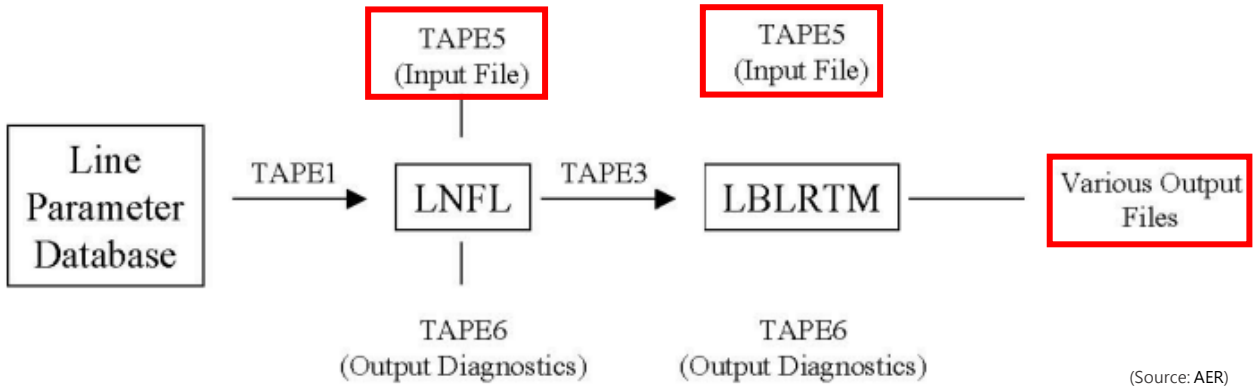
$$P(\boldsymbol{x}|\boldsymbol{y}) = \frac{P(\boldsymbol{y}|\boldsymbol{x})P(\boldsymbol{x})}{P(\boldsymbol{y})}$$

$$\hat{\boldsymbol{x}} = \boldsymbol{A}\boldsymbol{x} + (\boldsymbol{I_n} - \boldsymbol{A})\boldsymbol{x_A} + \boldsymbol{G}\boldsymbol{\varepsilon_O}$$

$$\hat{\boldsymbol{S}} = \underbrace{(\boldsymbol{I_n} - \boldsymbol{A})\boldsymbol{S_A}(\boldsymbol{I_n} - \boldsymbol{A})^{\boldsymbol{T}}}_{\text{Smoothing error}} + \underbrace{\boldsymbol{G}\boldsymbol{S_O}\boldsymbol{G}^{\boldsymbol{T}}}_{\text{Observational error}}$$

$$\boldsymbol{A} = \boldsymbol{G}\boldsymbol{K} = \left(\boldsymbol{K}^{\boldsymbol{T}}\boldsymbol{S_O^{-1}}\boldsymbol{K} + \boldsymbol{S_A^{-1}}\right)^{-1}\boldsymbol{K}^{\boldsymbol{T}}\boldsymbol{S_O^{-1}}\boldsymbol{K}$$

Progress: Line-By-Line Radiative Transfer Model (LBLRTM)



(Source: AER)

Key *TAPE* files	*TAPE5*	LNFL & LBLRTM input file (configuration file)
	TAPE28	Formatted file containing transmittances
	TAPE29	Formatted file containing radiances (or equivalent brightness temperature)

Workflow of LBLRTM:

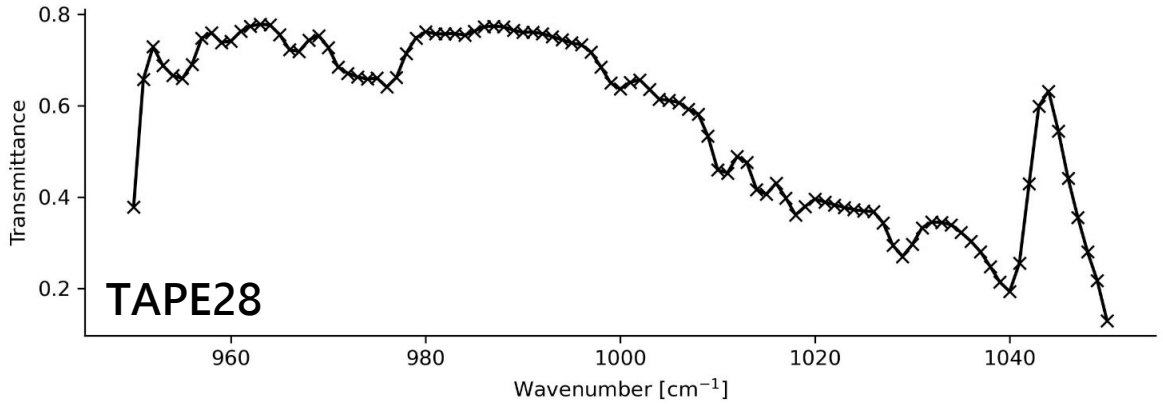
- Line Parameter Database (HITRAN2016)
- LNFL: translates to LBLRTM format (ref. TAPE5)
- LBLRTM: compile outputs (ref. TAPE5)

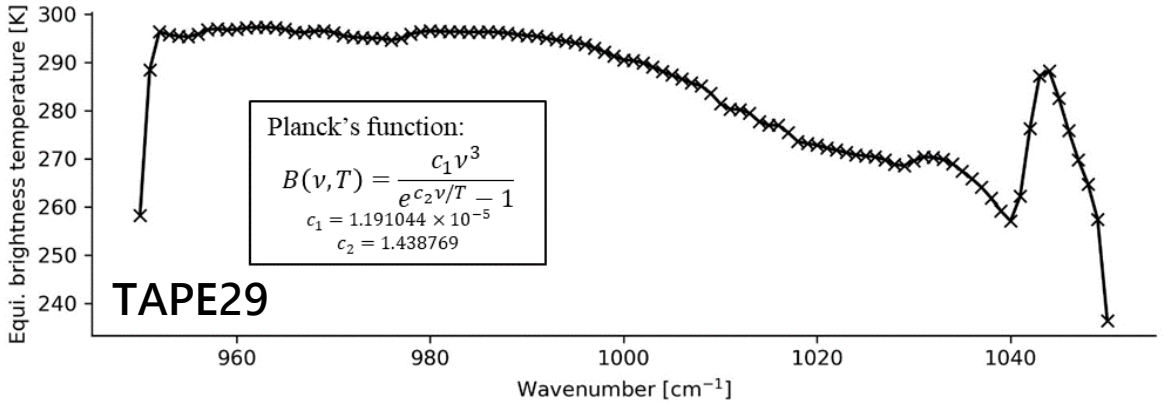
(sample outputs are plotted below)

TAPE5 contains "flags" for computing radiative transfer

LBLRTM is used as forward model **F** in the inversion

$$\boldsymbol{y} = \boldsymbol{F}(\boldsymbol{x}, \boldsymbol{p}) + \boldsymbol{\varepsilon_o} = \boldsymbol{K}\boldsymbol{x} + \boldsymbol{\varepsilon_o}$$





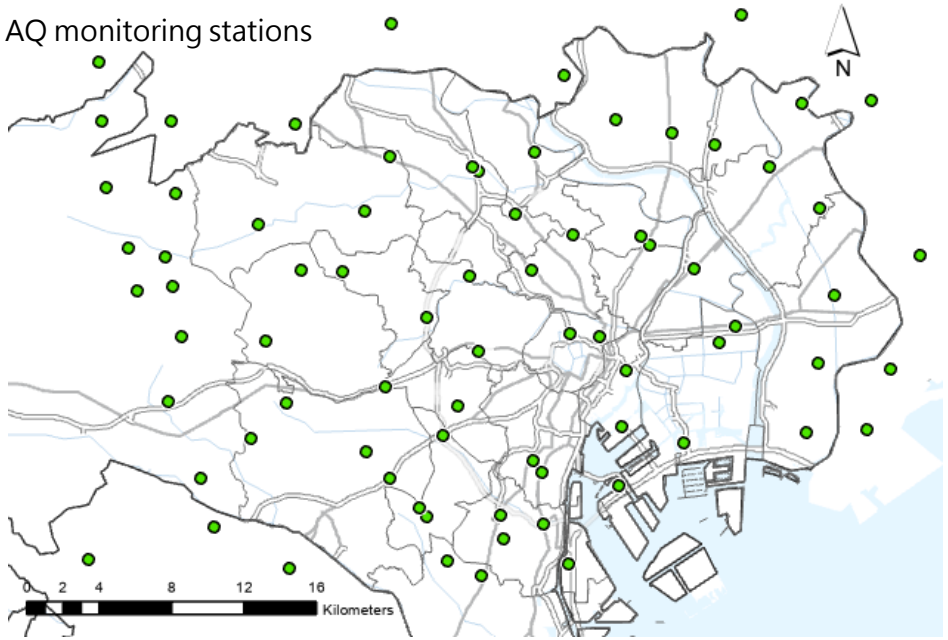
Conclusion: next steps

In a nutshell…

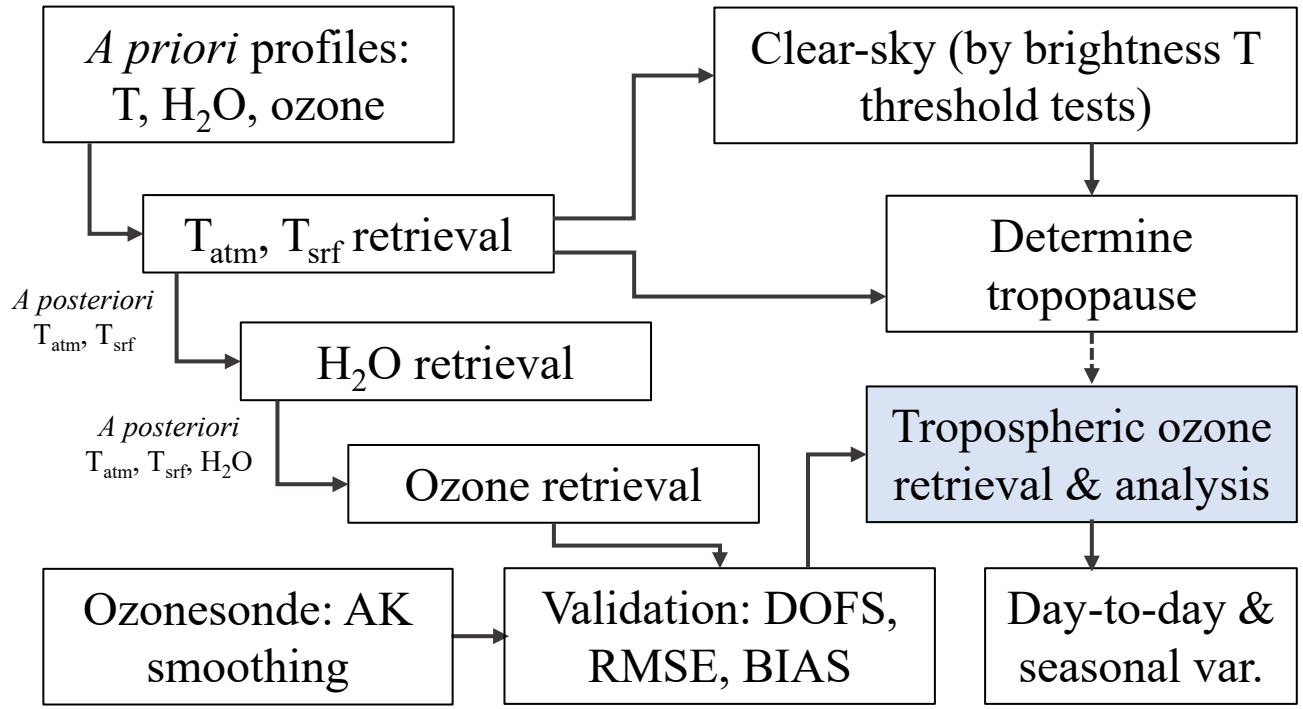
- Learnt retrieval and inverse method
- Learnt and tested LBLRTM program
- Maths, stats, phys, CS…

How to proceed?

Retrieval over a metropolitan area!



Retrieval of tropospheric ozone using TANSO-FTS-2 on GOSAT-2: a regional trend analysis of metropolitan area in Japan



Key references for the retrieval process:

- Rodgers, C. D. (2000): inverse method and algorithms
- Ohyama et al. (2012): GOSAT trop. ozone retrieval with validation in JP
- Someya et al. (2020): Ammonia retrieval (TIR band) and compare IASI

Thank you for listening!
Q & A