Ground-based validation of aerosol optical properties by using sky radiometer observations

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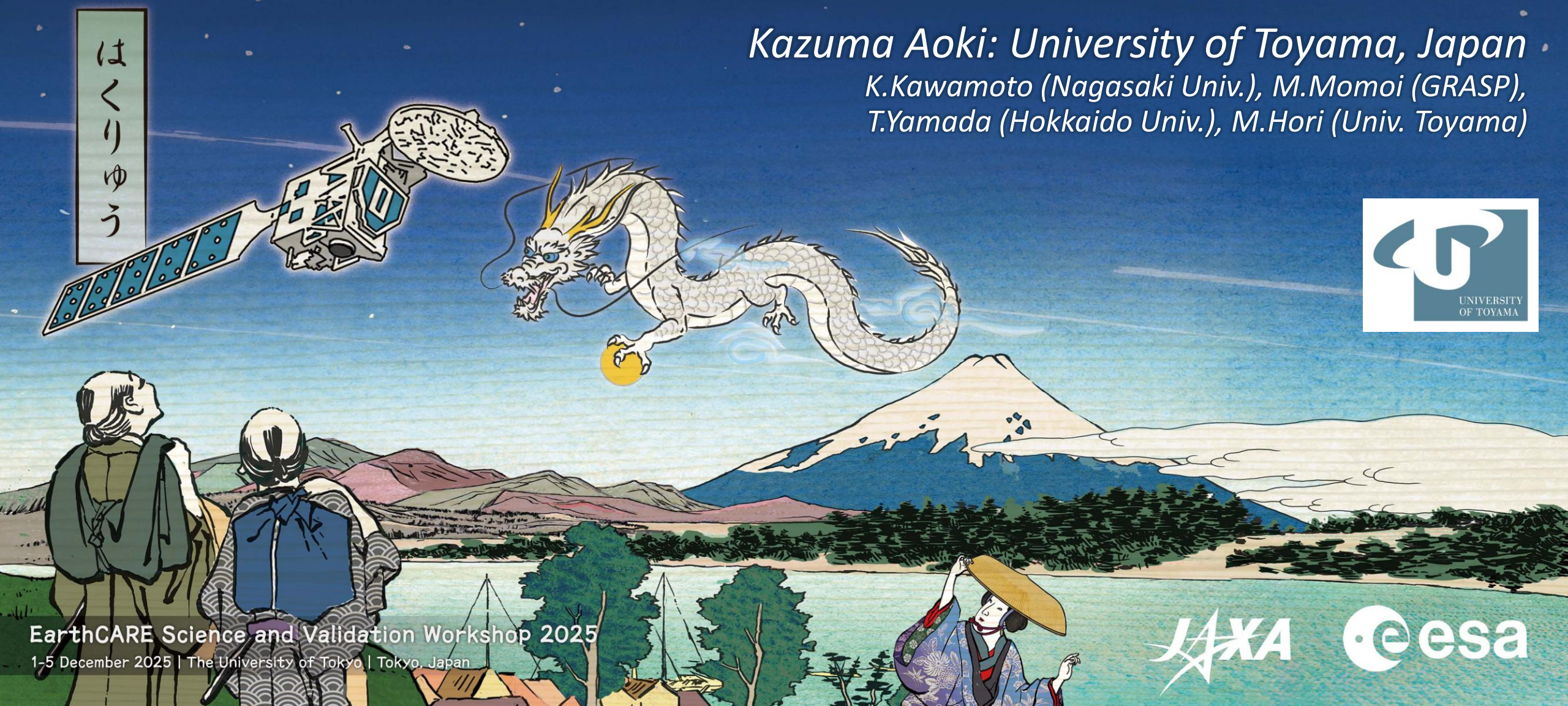

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Introduction

Our Objectives:

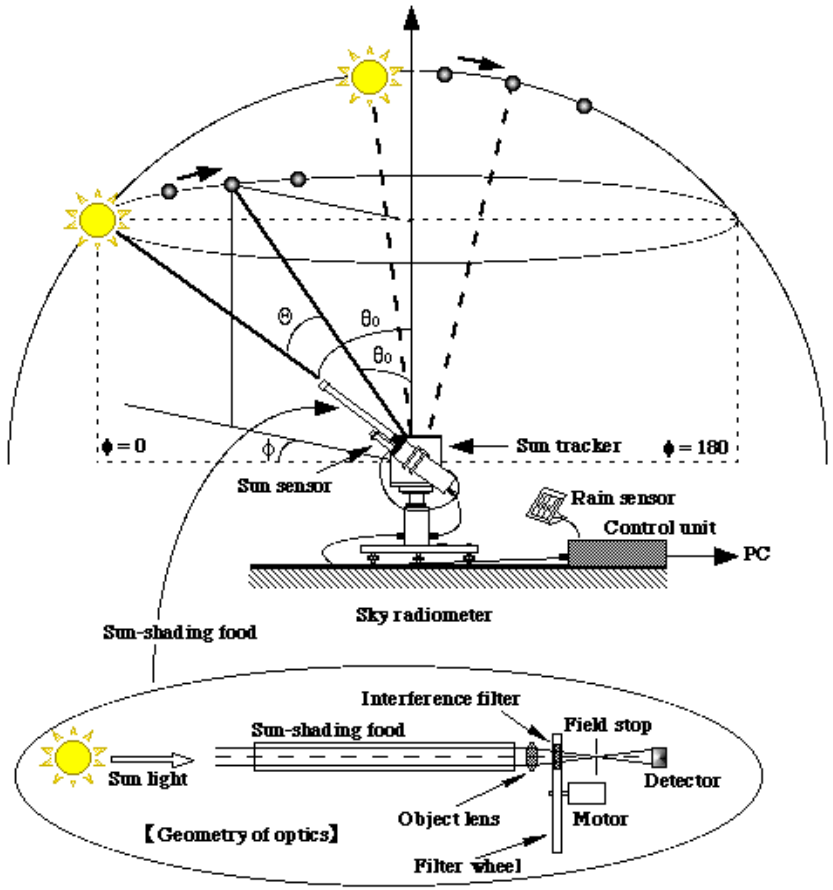
We investigated the long-term monitoring of aerosol and cloud optical properties at ground-based and maritime measurements since 1990's by using the Sky radiometer (PREDE., Co. Ltd., Tokyo, Japan), based on JAXA RA (ex. GCOM-C/SGLI, EarthCARE). One of the objectives was to understand the effect on earth climate change for interaction of aerosol and cloud, and the other was to validate satellite and models.

In this presentation, I will introduce several observational examples regarding the aerosol optical properties after the launch of the EarthCARE.

What is aureole measurements by Sky radiometer

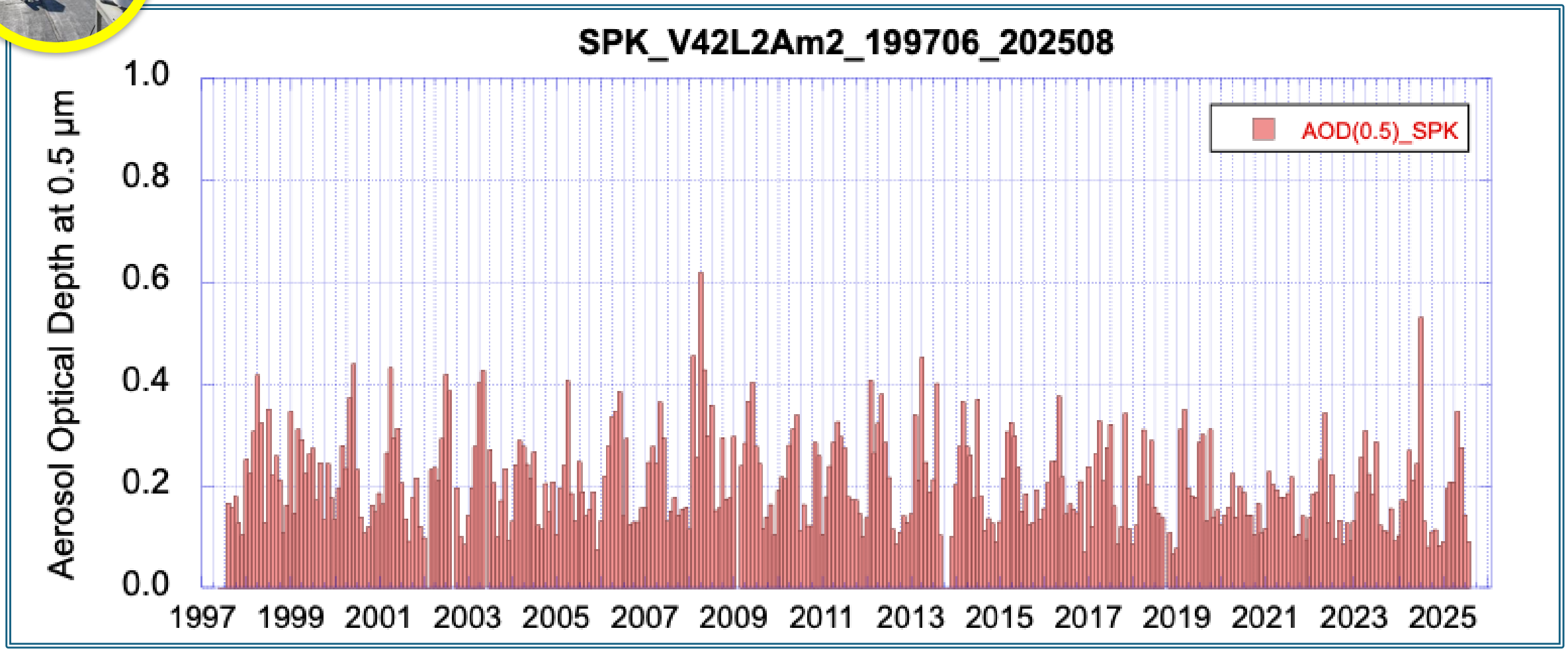
SKYRADio-net website:
http://skyrad.sci.u-toyama.ac.jp

- We observed only in daytime under clear skies at each site.
- Every 10 min/once (aureole)
- Every 1 min/once (direct)
- POM-01: 0.315, 0.4, 0.5, 0.675, 0.87, 0.94, 1.02 μm
- POM-02: 0.315, 0.34, 0.38, 0.4, 0.5, 0.675, 0.87, 0.94, 1.02, 1.627, 2.2 μm
- AOD (0.355 μm) calculated from Alpha as validation data for EarthCARE.
- Data have been analyzed by an inversion software called SKYRAD.pack (Nakajima et al. 1996). Available ver. are SKYRAD.pack 4.2. L0, L1A & L2A.
- Under development using the GRASP algorithm. (Momoi et al.).
- Ref. ex. Aoki., 2013, Nakajima et al, AMT, 2020, Dubovik et al, 2021



Long-term record of AOD at Sapporo_SPK, Hokkaido

AOD@ Sapporo_SPK since 1997



Sky radiometer observation at Japan main sites


Uozu_UOZ
since 2020


Suzu_SUZ
since 2009


Sapporo_ILTS_SPK
since 1997


Monbetsu_MBE
since 2023


Toyama_TOY
since 2002


Mt.Jodo_Tateyama_JOD
since 2005
Alt. 2839 m


Tsukuba_JAXA_TKJ
since 2013


Nagasaki_NGS
since 1996


Mt.Unzen_Nita_UZN
since 2022
Alt. 1100 m


Kasuga_RIAM_KSG
since 2003


Etchujima_ETJ
since 1996


R/V Mirai2

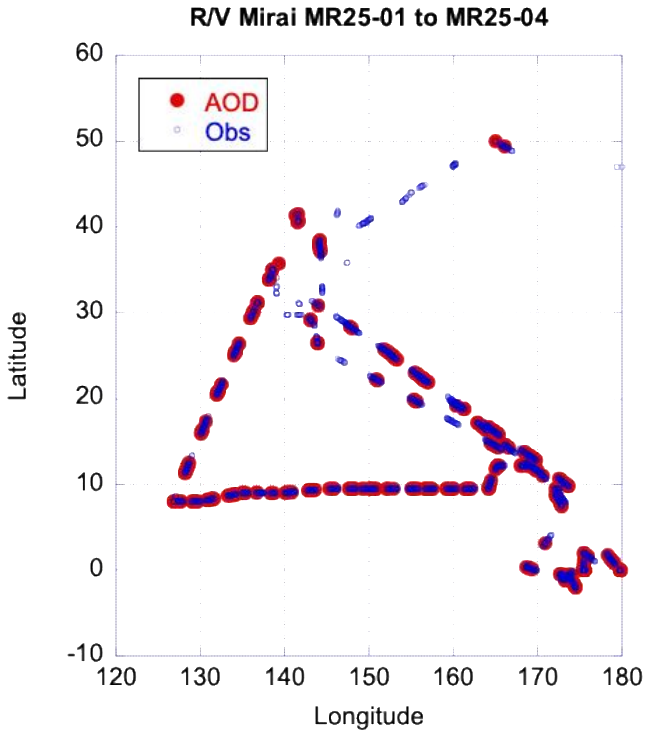
Maritime Cruise plan:
From R/V Mirai to R/V MIRAI 2 in 2027 JFY

From ice-resistant
ships to icebreakers


R/V Mirai_RVM/JAMSTEC

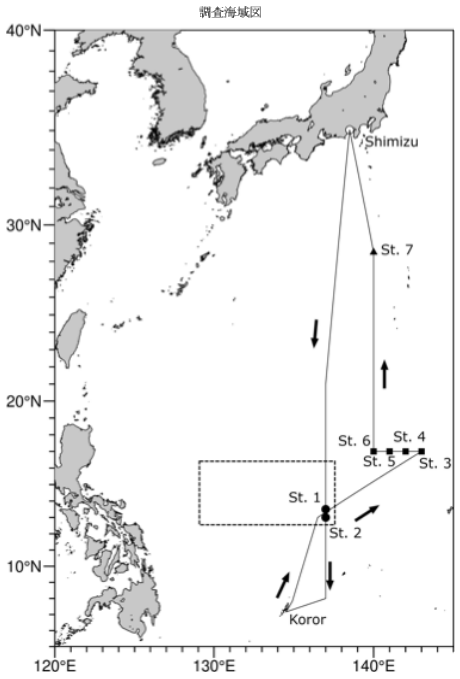
Main observation sites of SKYRADio for Aerosol optical properties during after lunch of EarthCARE 2024.05 to now

EarthCARE			2024												2025											
Site name / 202405 - 202512	Code	Lat, Long	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
GSFC_Greenbelt, MD, USA	GGB	38.993N, 76.839W						from NGS			O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Etchujima, Tokyo, Japan	ETJ	35.667N, 139.793E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Kasuga, Fukuoka, Japan	KSG	33.524N, 130.475E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Monbetsu, Hokkaido, Japan	MBE	44.334N, 143.375E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Nagasaki, Nagasaki, Japan	NGS	32.786N, 129.865E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Sapporo, Hokkaido, Japan	SPK	43.084N, 141.339E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Suzu, Ishikawa, Japan	SUZ	37.451N, 137.359E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Tomakomai, Hokkaido, Japan	TMK	42.676N, 141.600E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Toyama, Toyama, Japan	TOY	36.699N, 137.187E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Tsukuba_JAXA, Tsukuba, Japan	TKJ	36.068N, 140.130E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Unzen_Nita, Nagasaki, Japan	UZN	32.751N, 130.286E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
Uozu, Toyama, Japan	UOZ	36.822N, 137.395E						O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O		
R/V MIRAI, JAMSTEC	RVM	ocean						O	O			O	O		O	O		O	O		O	O		O	O	→
Site name: 202405 - 202512	Code	Lat, Long	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12

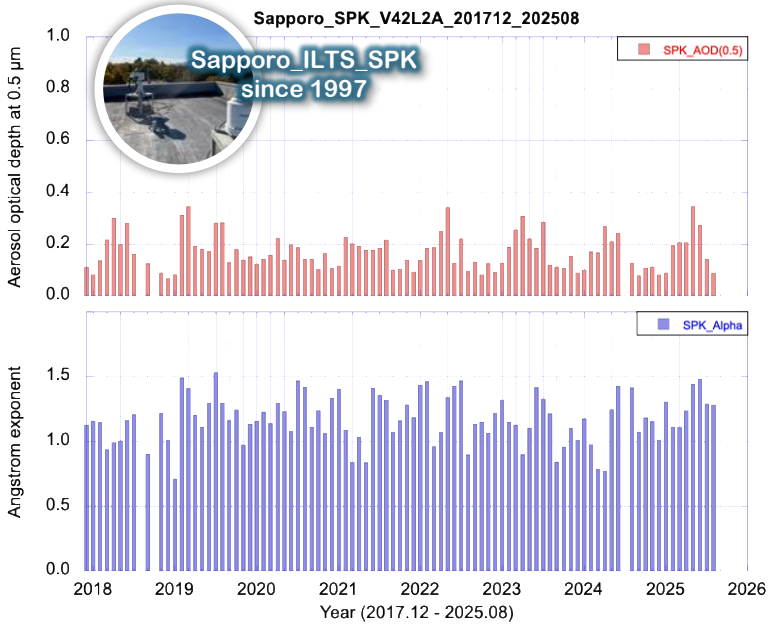


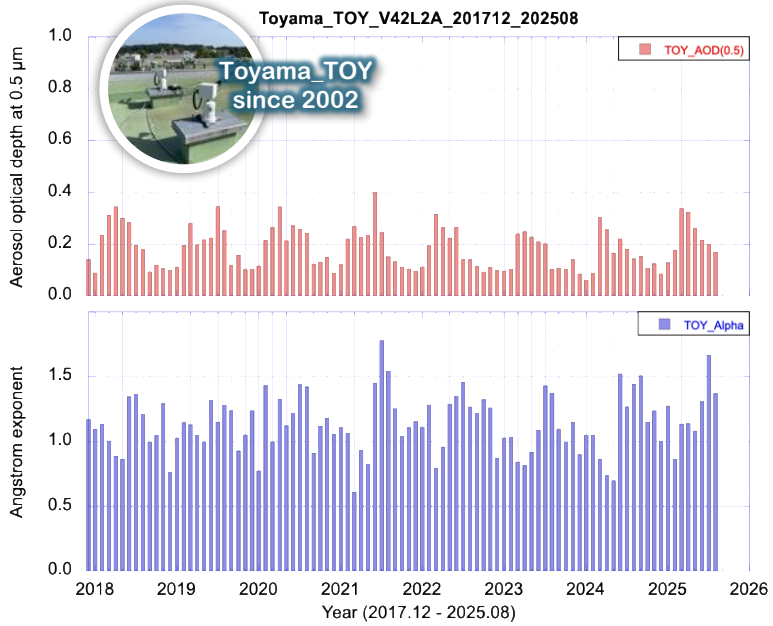
R/V Mirai/JAMSTEC: MR25-01 to 04

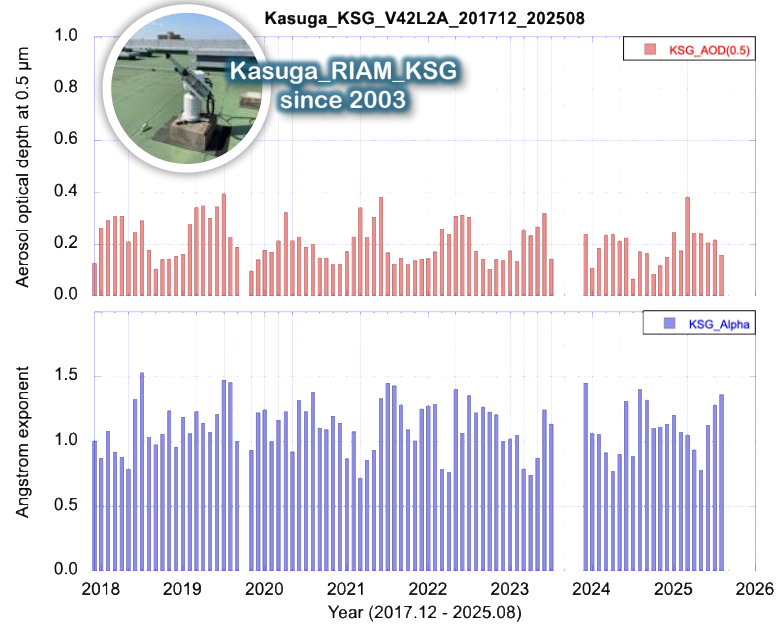
MR25-06

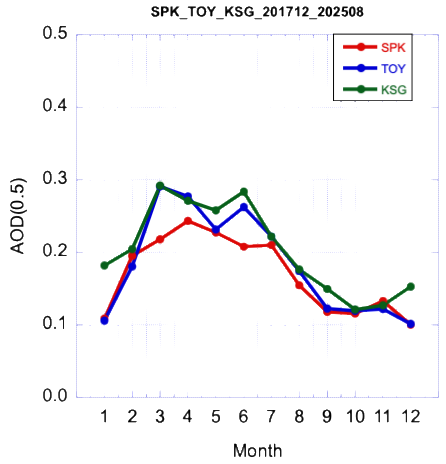


Aerosol optical depth after lunch at SPK, TOY &KSG





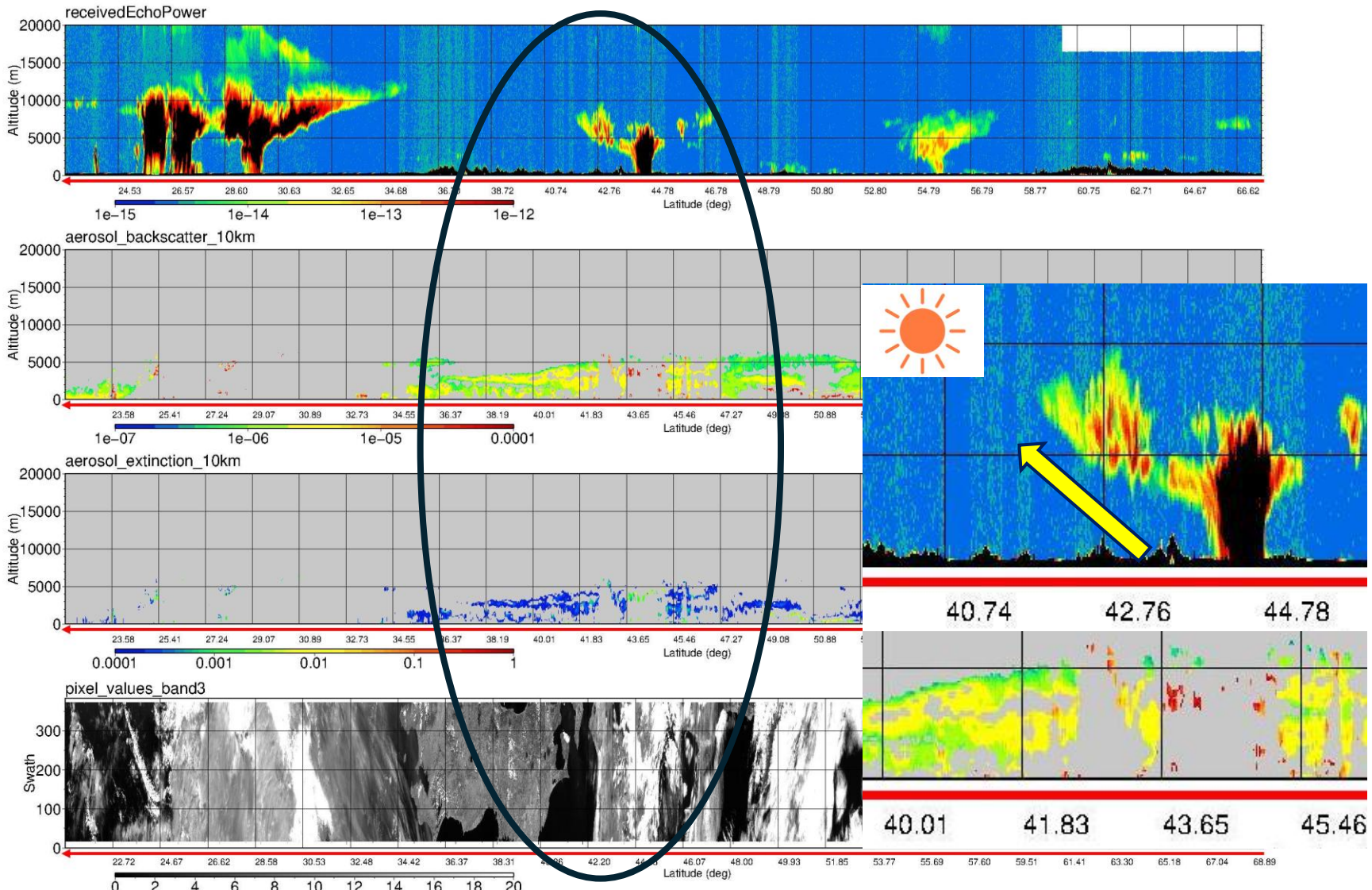


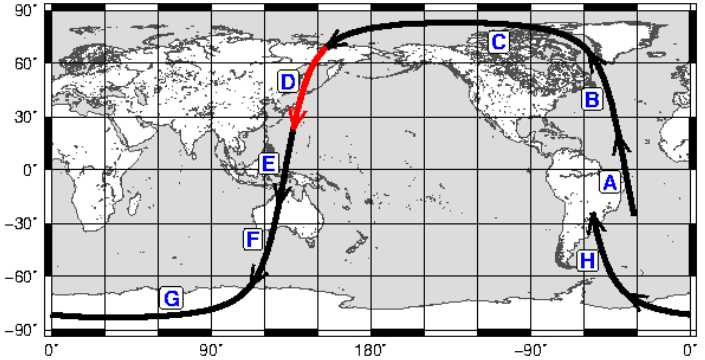


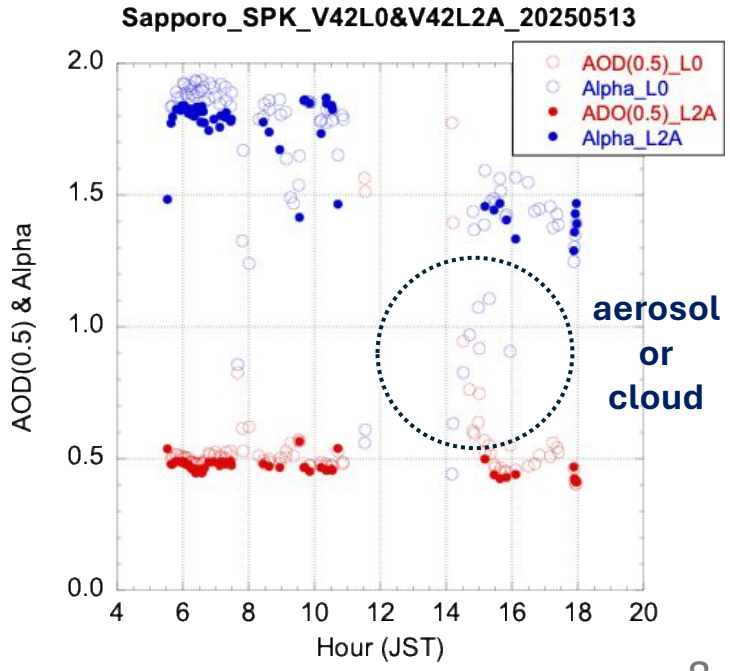
We show the observation of EarthCARE priopd (May 2024 to now) that aerosol optical properties with temporal and spatial variability. The optical thickness has a clear seasonal cycle at Japan site, with a spring to early summer maximum and an autumn to winter minimum. Ångström exponent seems large variability, with a summer maximum and an spring minimum.

(1) Case study of anthropogenic Aerosol to Cloud interactions

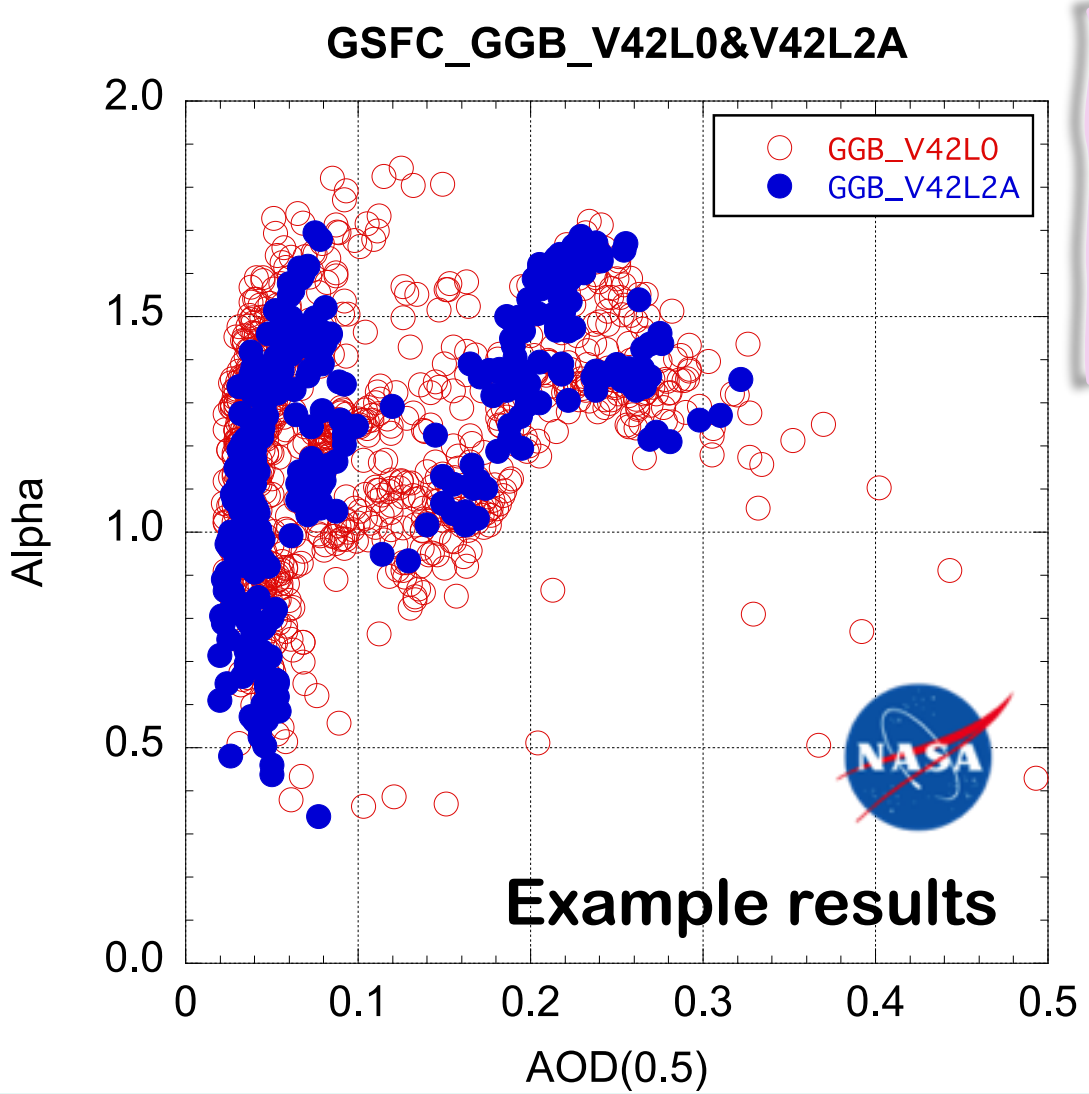
@ Aerosol optical properties : Sapporo_SPK_2025.05.13 (05434D)







Quality control in clouds and various factors



We had many observational data, however clouds and various other factors may prevent us from analysis of aerosols.

- ✓ Cloud and/or high aerosols
- ✓ Clouds at scattering angles of 30 degrees and/or more
- ✓ Other and unkown

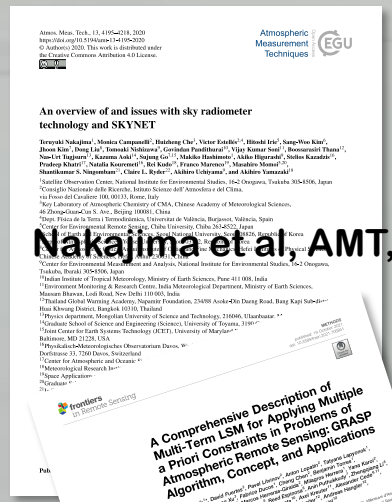
Mean AOD(0.5) = 0.114
Mean Alpha = 1.207
No. = 956

Mean AOD(0.5) = 0.113
Mean Alpha = 1.234
No. = 333

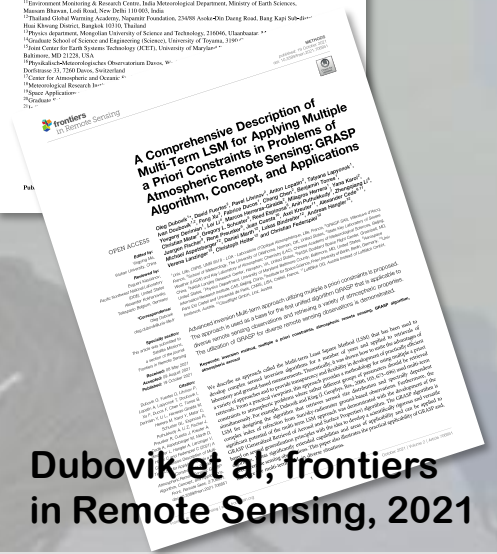
elimintate data of one third. 956 -> 333 data
Are you (Am I) sure that's the right thing to do?
Especially, aerosol to cloud interactions

Intercomparison of SKYRAD & Aeronet for GRASP

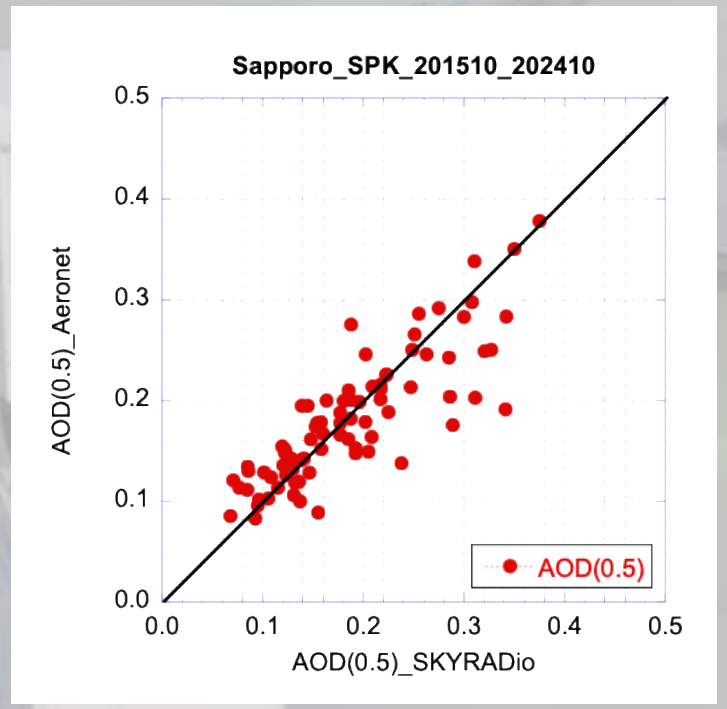
- Comparison between SKYRAD.pack and GRASP-SKYRAD of aerosol optical properties with temporal and spatial variability in the long-term record.
  - Therefore, they are considering how to obtain more detail results of aerosol optical properties

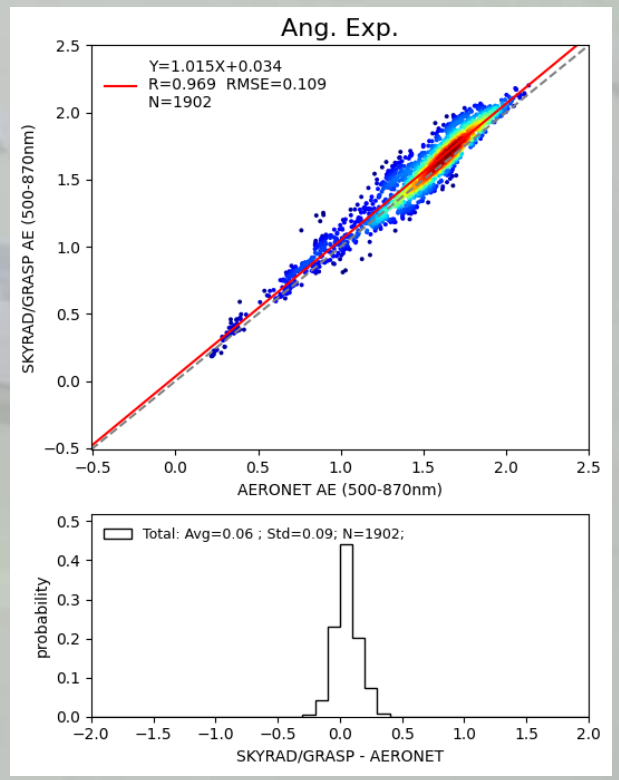


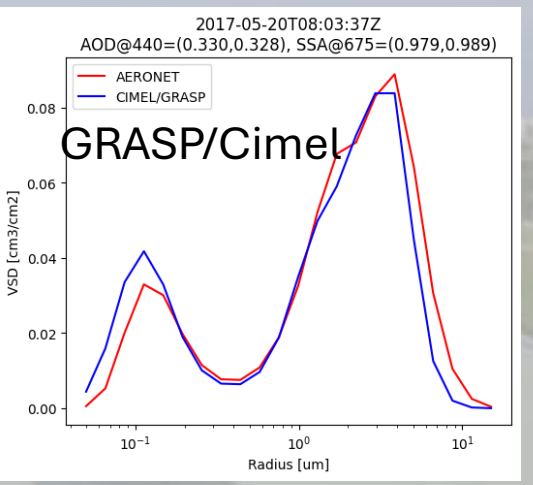
Nakajima et al, AMT, 2020

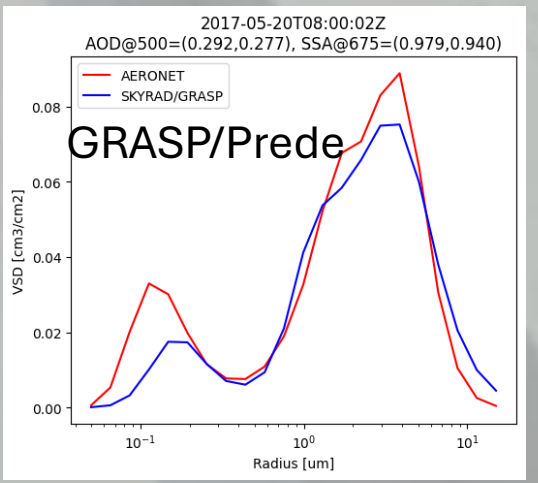


Dubovik et al, frontiers in Remote Sensing, 2021









Preliminary results of Aoki and Momoi et al, 2025

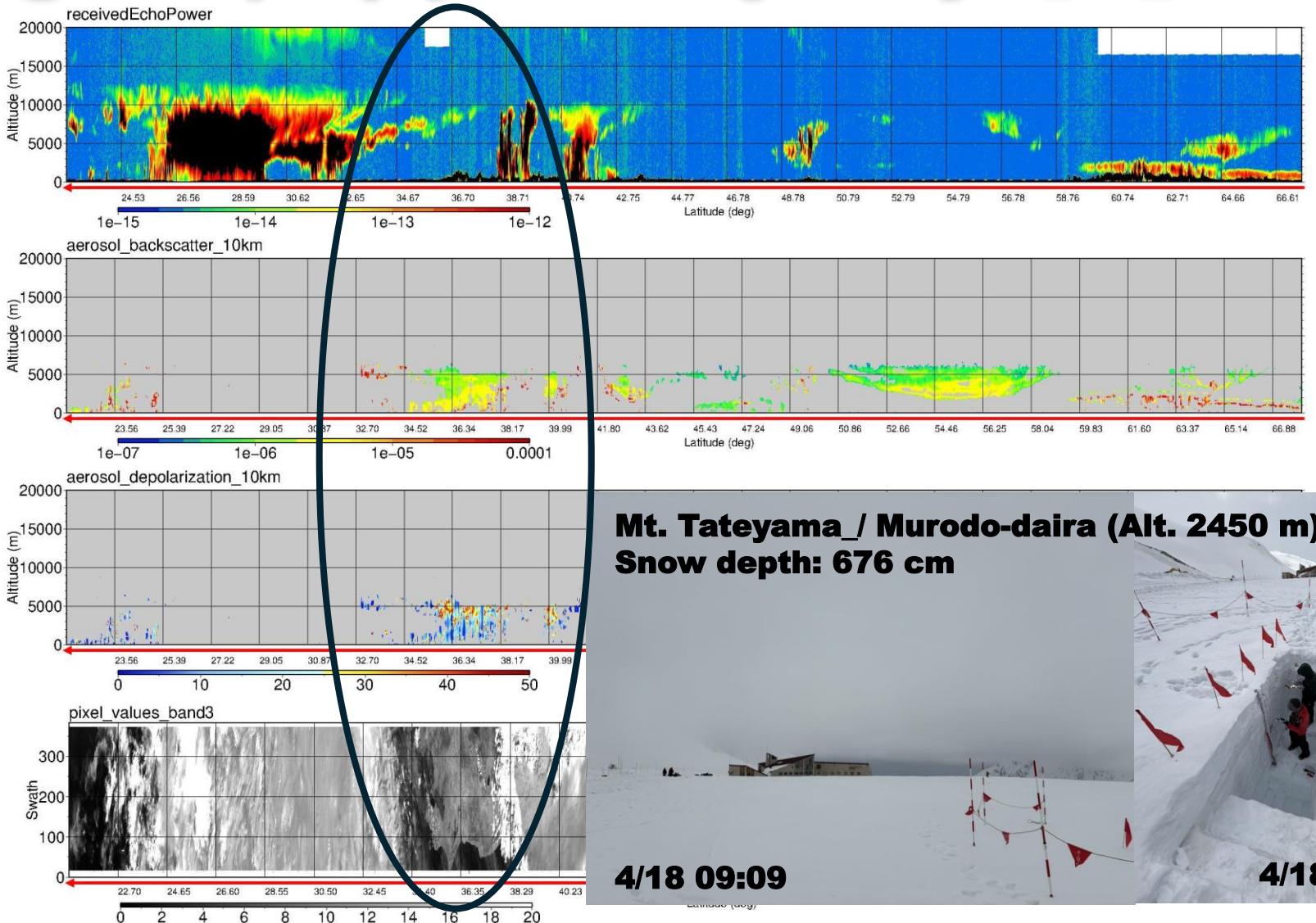
(2) Case study of Natural Aerosol (Snow & Dust) to Cloud interactions

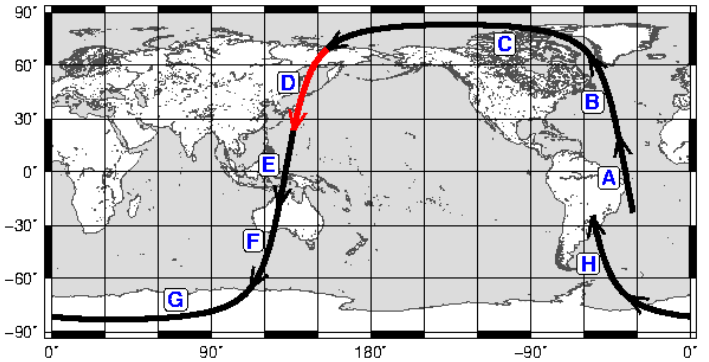
(2) Case study of Natural Aerosol (Snow & Dust) to Cloud interactions

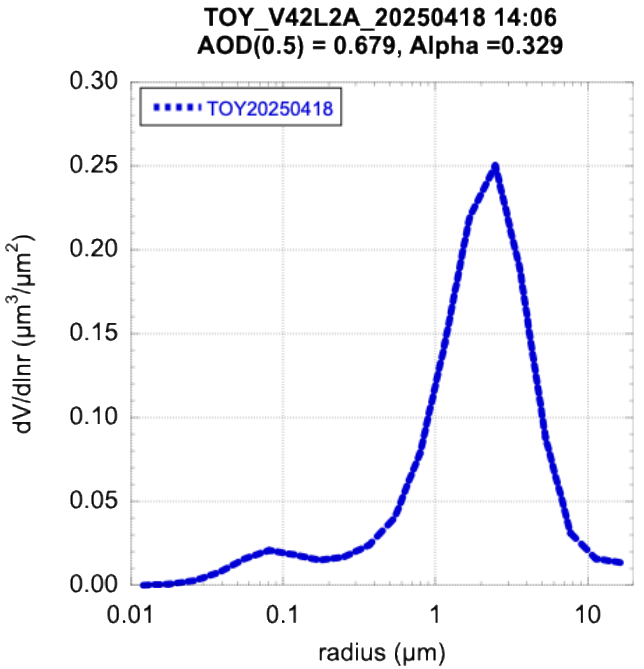
Mt. Tateyama_/ Murodo-daira (Alt. 2450 m)
Snow depth: 676 cm (2025.04.19)

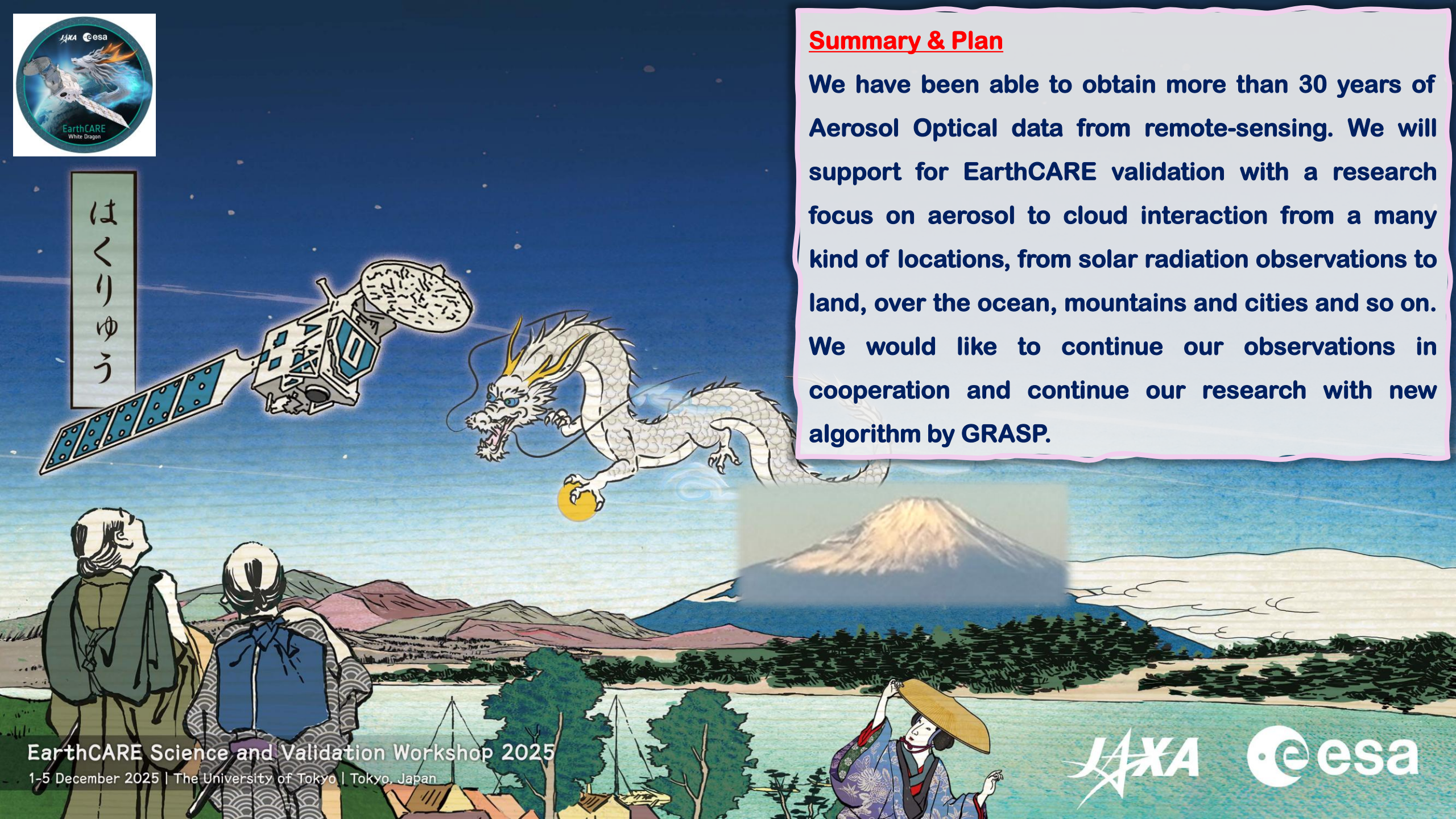
(2) Case study of Natural Aerosol (Snow & Dust) to Cloud interactions

@ Aerosol optical properties : Mt. Tateyama & Toyama_TOY_2025.04.18 (05045D)









Summary & Plan

We have been able to obtain more than 30 years of Aerosol Optical data from remote-sensing. We will support for EarthCARE validation with a research focus on aerosol to cloud interaction from a many kind of locations, from solar radiation observations to land, over the ocean, mountains and cities and so on. We would like to continue our observations in cooperation and continue our research with new algorithm by GRASP.