Analysis of the aerosol optical properties in the Southern of Gobi region of Mongolia

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AERONET Science and Application Exchange

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Contents

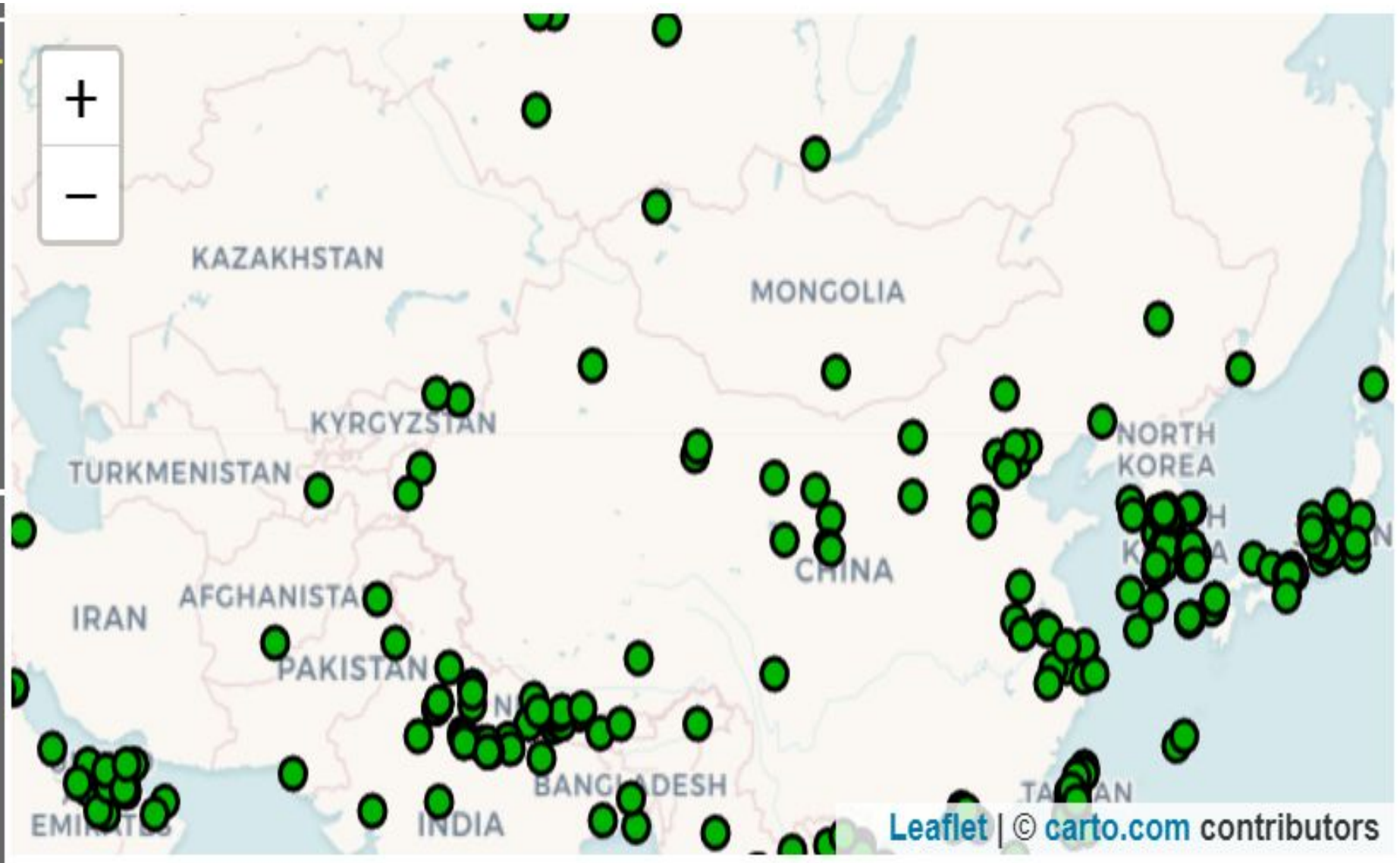
Part 1

- AERONET network and monitoring in Mongolia
- AERONET and Pandora

Part 2

- AERONET and Asian Dust Aerosol Model in case study
- Conclusion and suggestion

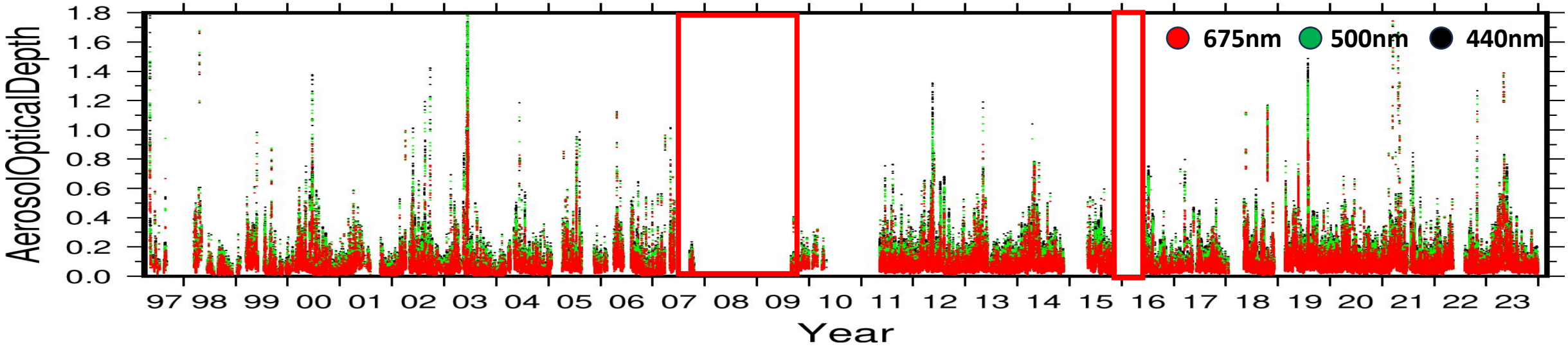
AERONET network in Mongolia

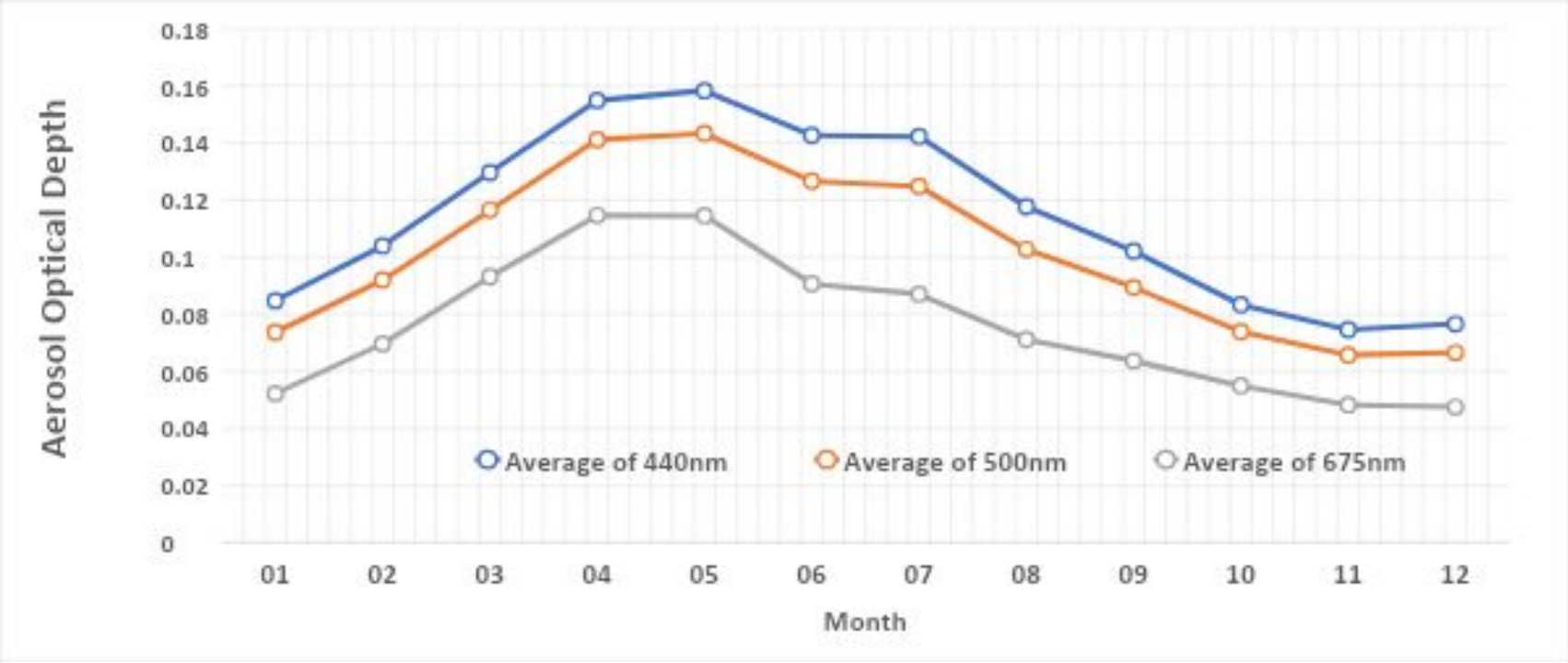


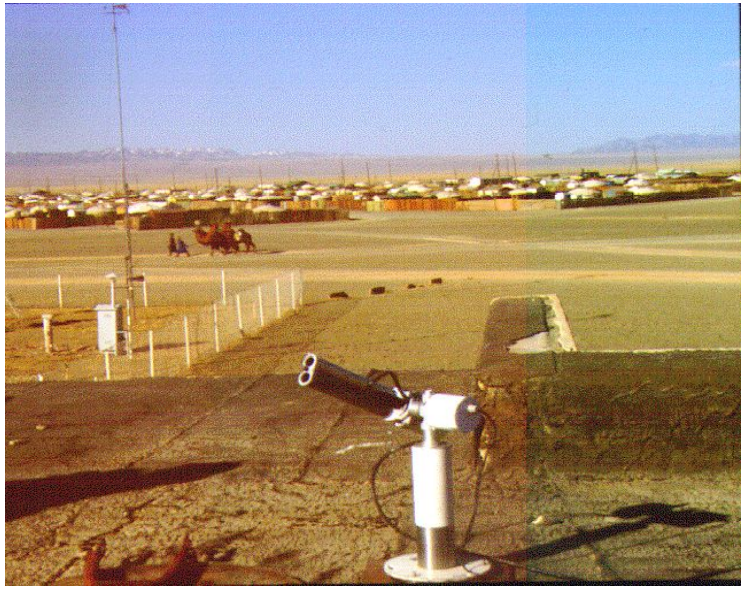
Dalanzadgad
1997~ present

Ulaangom
1998.03-1998.07

AERONET Monitoring in Dalanzadgad







Atmospheric Environment Observation in Mongolia

Global monitoring laboratory (GMD) NOAA CO2, CH4, SF6, N_2O and CO

AERONET Sun-photometer Aerosol Optical Thickness (AOT)

KOSA monitoring PM10 and PM2.5 surface measurements

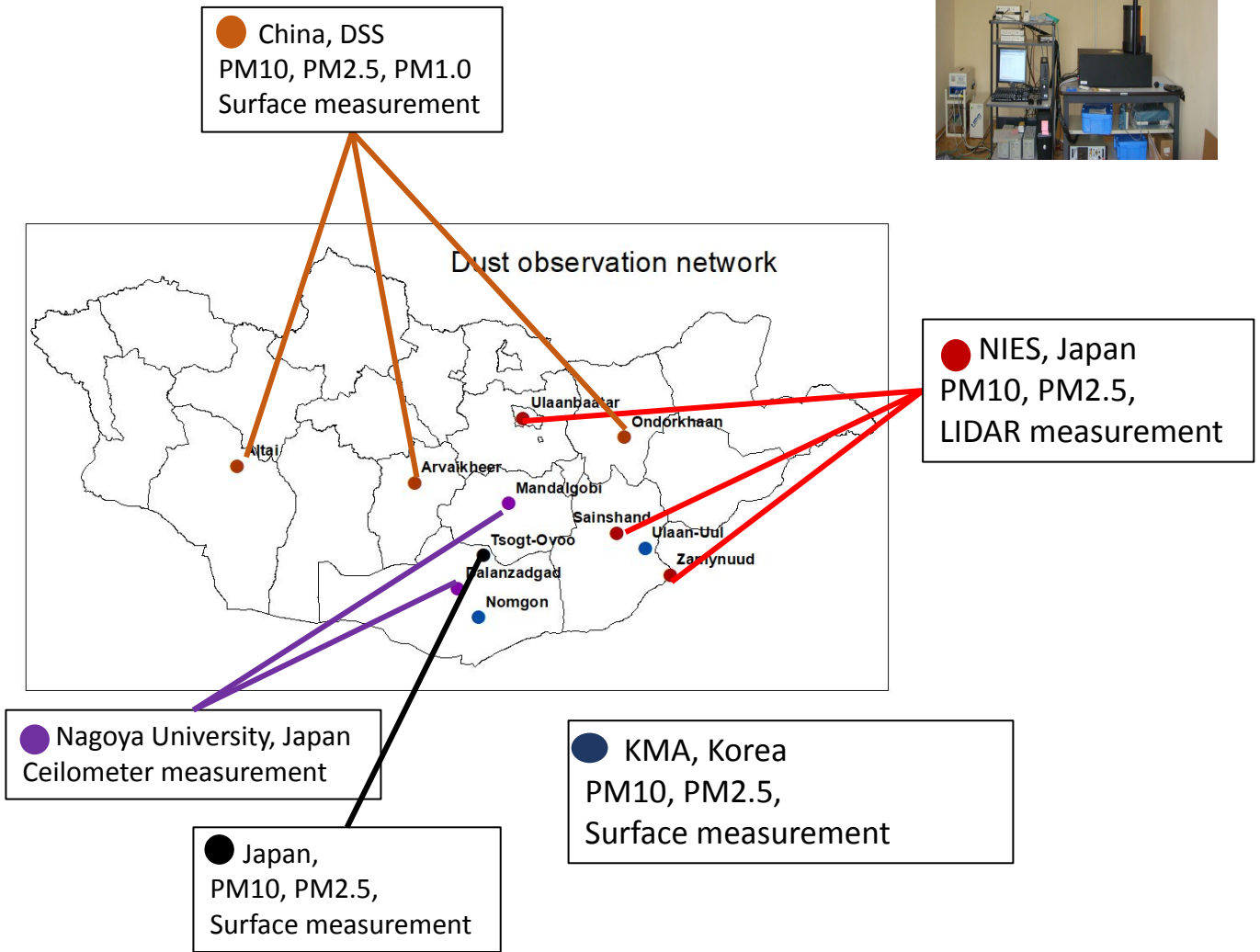
Dalanzadgad (Pandora 217)

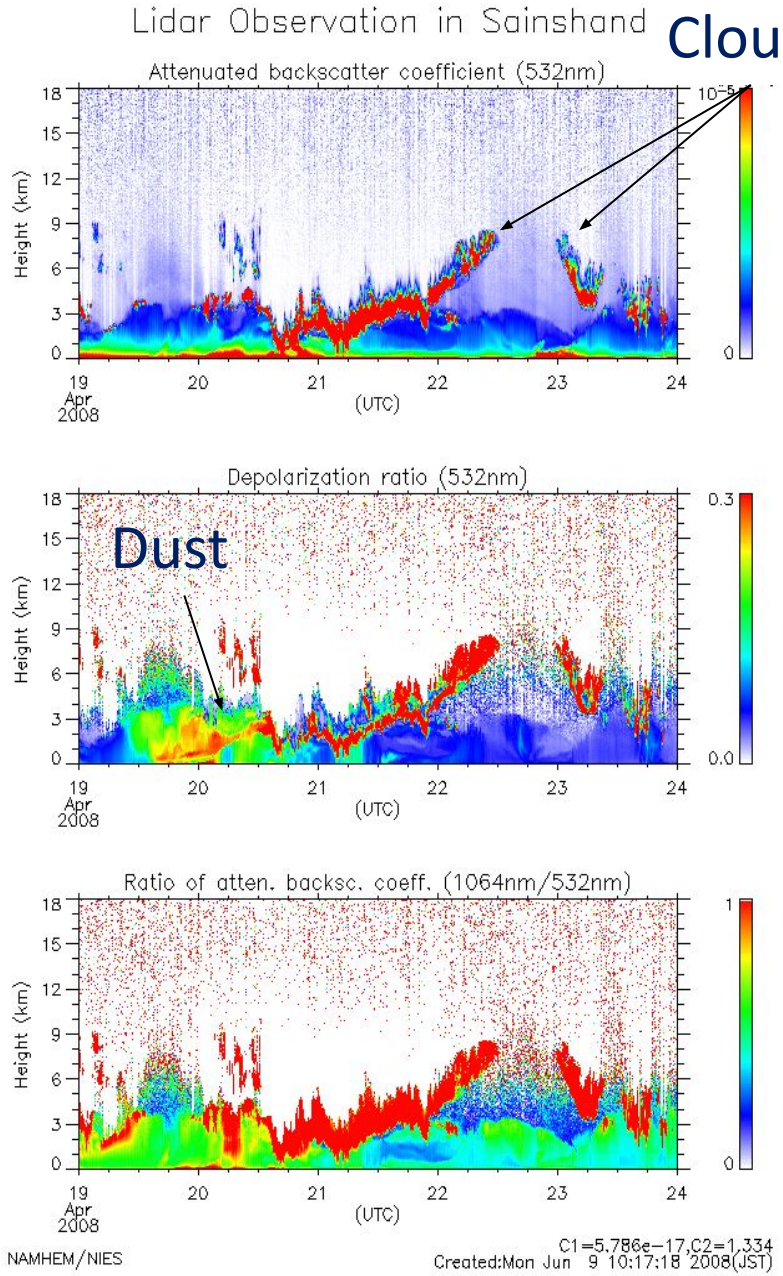
LIDAR Measurement of Depolarization and Backscattering Ratios.

Ceilometer Measurement of Backscattering coefficient and Cloud base height .

AQMS Measurements of SO2, NOx, CO, O3, PM10 and PM2.5

Dust observation network



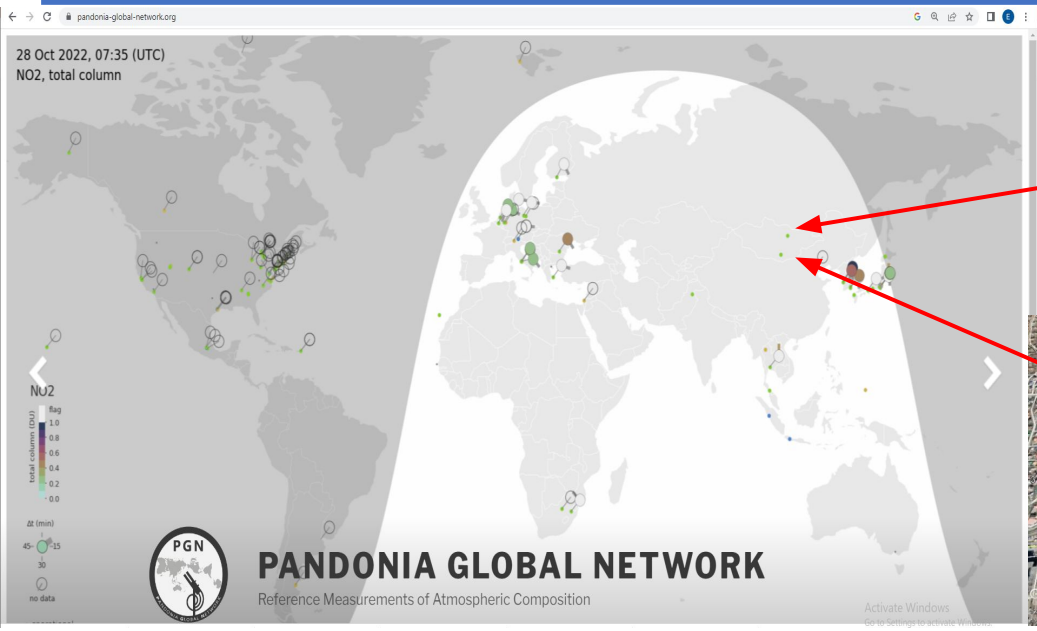


Range-corrected signal at 532 nm (P(532nm))

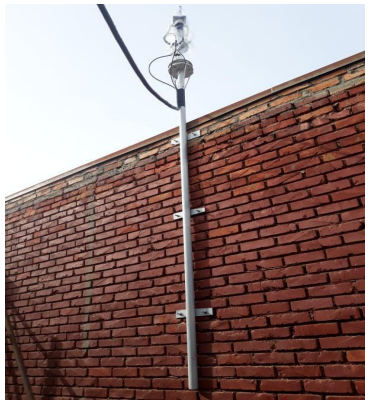
Depolarization ratio at 532 nm

Wavelength ratio P(1064nm)/P(532 nm)

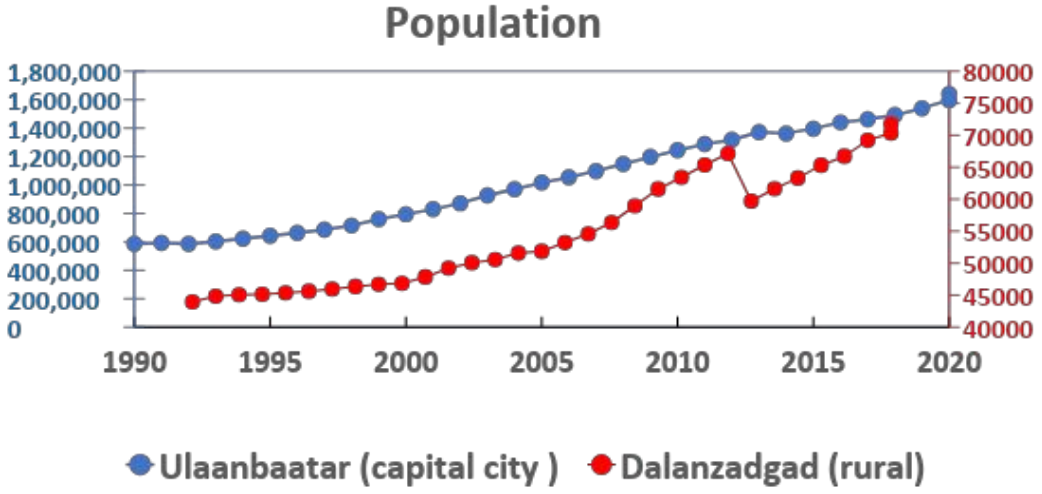
Site information of Pandora instruments



DZ station installed 2022.05.12
PGN generating data from March 2023.



UB station installed 2022.07.25. Broken 2022.11.02



Ulaanbaatar is capital city of Mongolia which is urban area.
Dalanzadgad is developing city of the Mongolia which is suburban area.

Dalanzadgad (Pandora 217)

Geographical coordinate of the site

(Roof top of the building)

- LAT : 43.57722
- LON: 104.4180555

HEIGHT: 1462 a.s.l

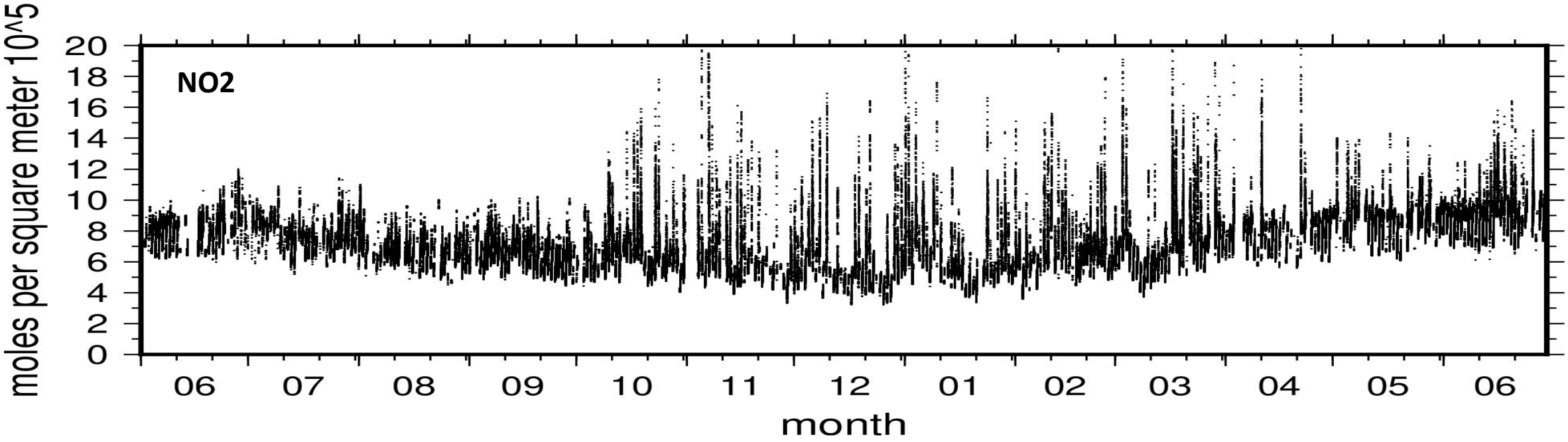
Ulaanbaatar city (Pandora 216)

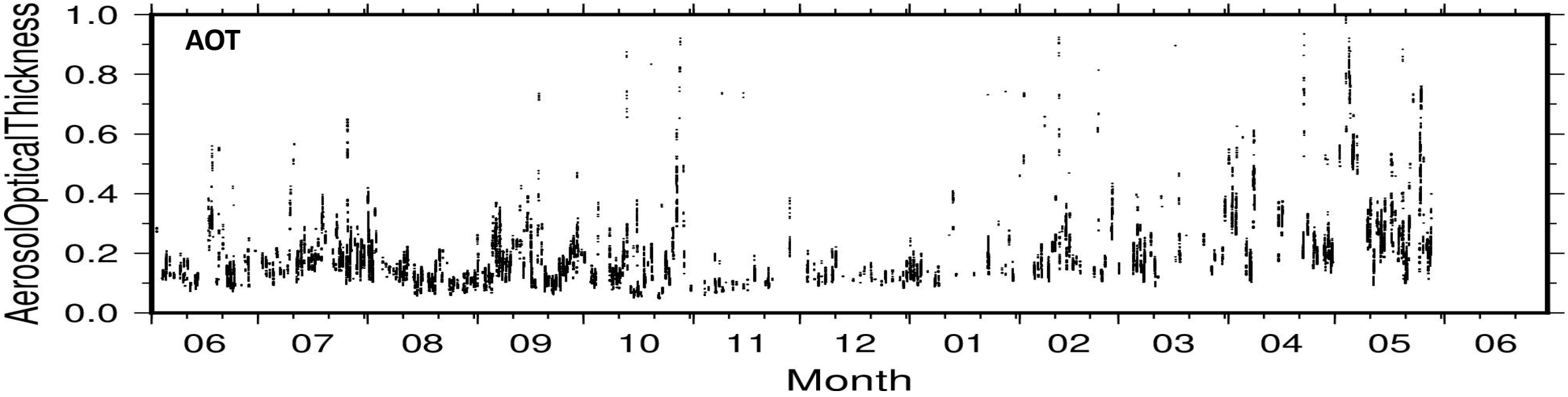
Geographical coordinate of the site

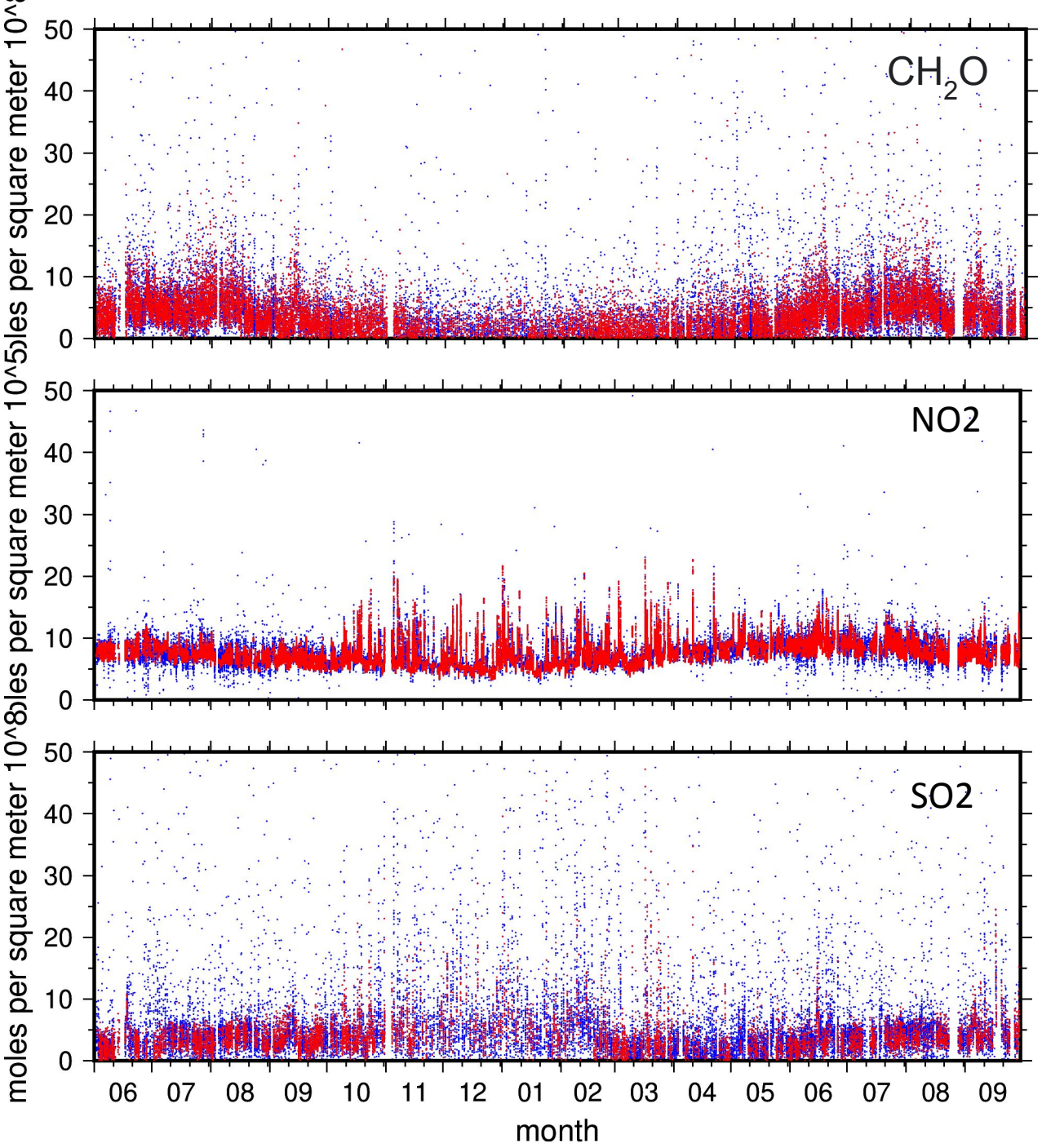
- LAT : 47.92038333
- LON: 106.9118222

HEIGHT: 1303.34 a.s.l

Data of the DZ P217 Pandora instruments

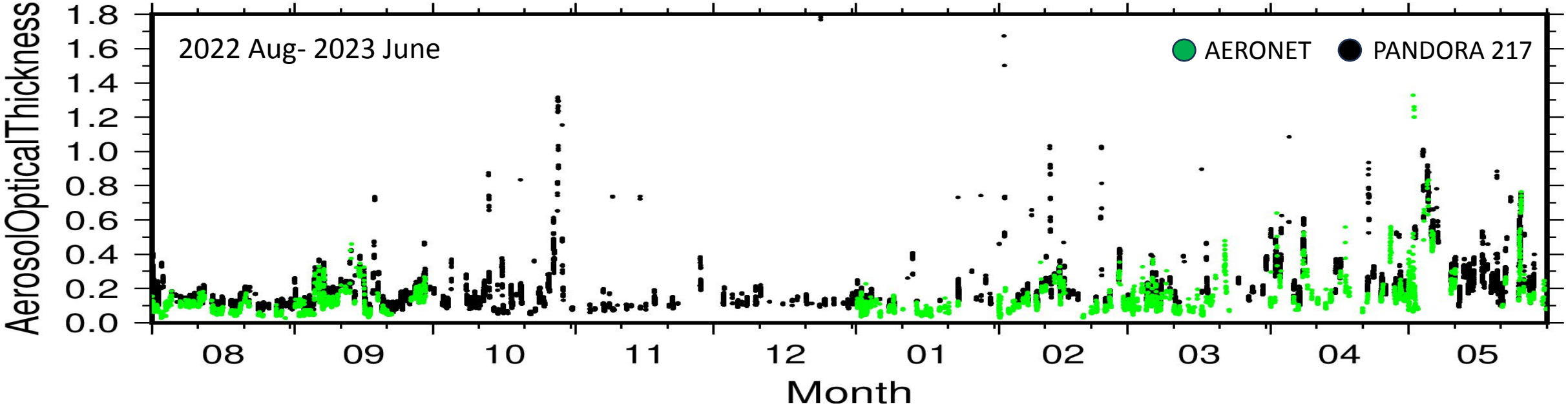


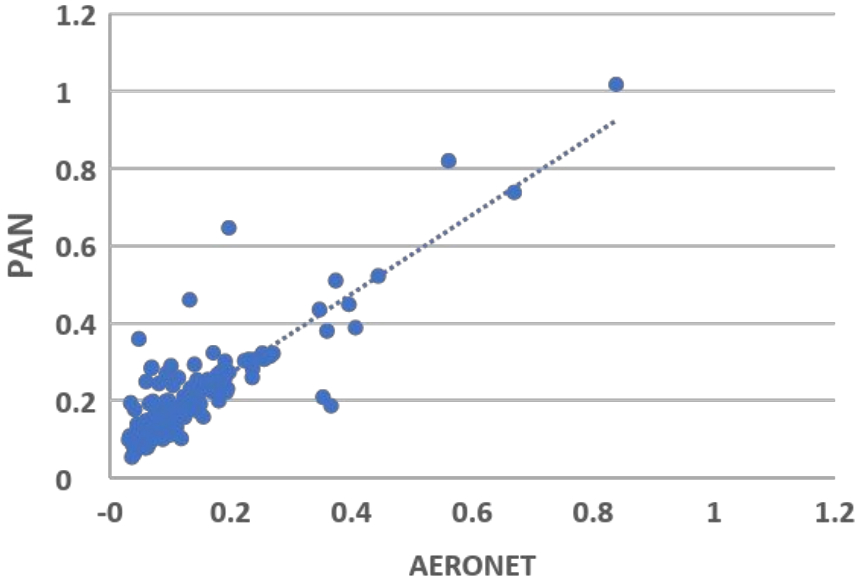




Dalanzadgad station P217 Time series plots for **NO2, HCHO, and SO2**
(2022/06/01-2023/09/30)

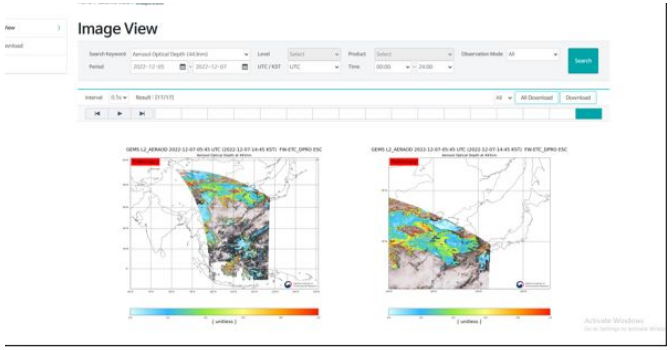
Comparison of the Pandora data with GEMS and AERONET



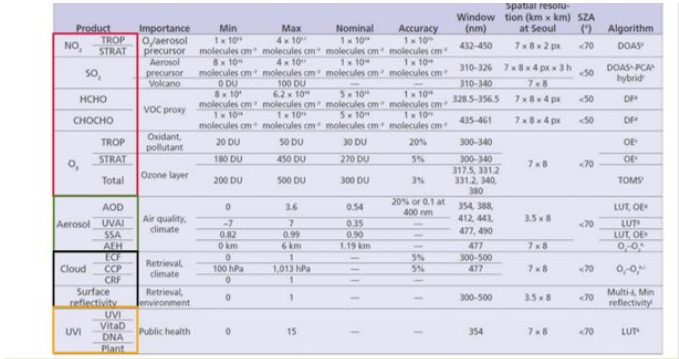


Difference 5 meter between AERONET and PANDORA

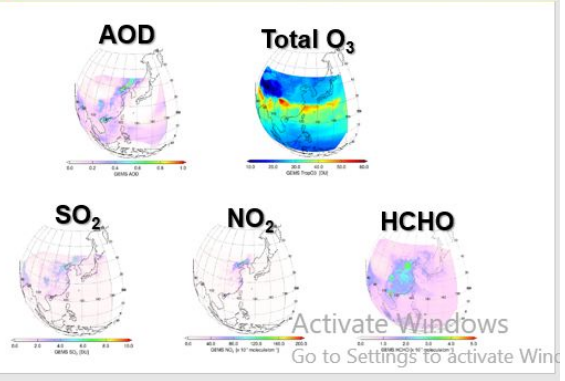
GEMS satellite

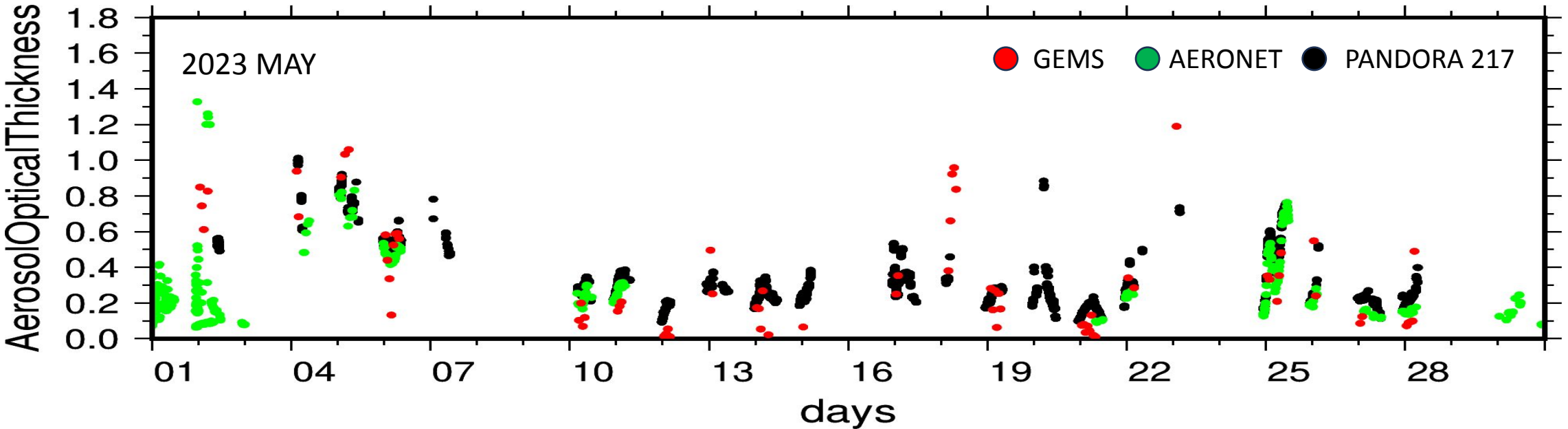


month	07:45	08:45	09:45	10:45	11:45	12:45	13:45	14:45	15:45	16:45
1	-	-	HE	HK	FC	FW	FW	FW	-	-
2	-	-	HE	HK	FC	FW	FW	FW	FW	-
3	-	HE	HK	FC	FC	FW	FW	FW	FW	-
4	HE	HK	FC	FC	FC	FW	FW	FW	FW	FW
5	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW
6	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW
7	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW
8	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW
9	HE	HK	FC	FC	FW	FW	FW	FW	FW	FW
10	-	HE	HK	FC	FC	FW	FW	FW	FW	-
11	-	-	HE	HK	FC	FW	FW	FW	-	-
12	-	-	HE	HK	FC	FW	FW	FW	-	-

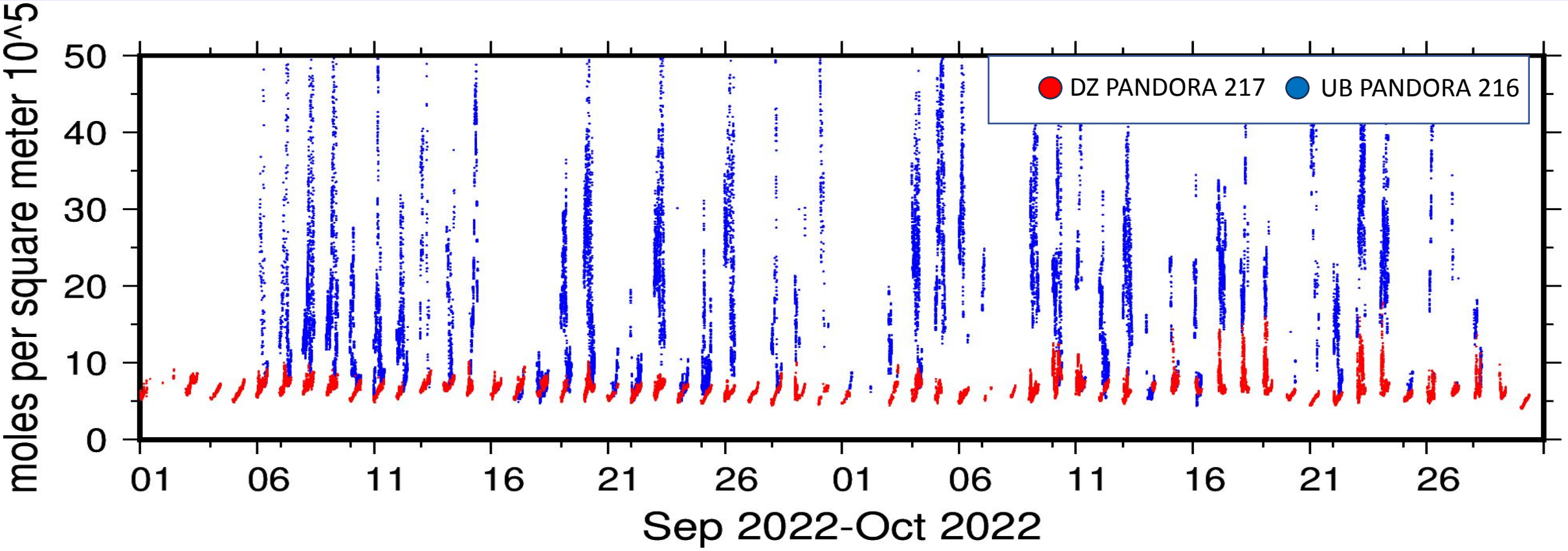


Product		Importance	Min	Max	Nominal	Accuracy	Window (nm)	Spatial resolution (km × km) at Seoul	SZA (°)	Algorithm
NO_2	TROP	O_3/aerosol precursor	1 × 10^{13} molecules cm^{-2}	4 × 10^{15} molecules cm^{-2}	1 × 10^{14} molecules cm^{-2}	1 × 10^{14} molecules cm^{-2}	432–450	7 × 8 × 2 px	<70	DOAS[a]
	STRAT	Aerosol precursor	8 × 10^{13} molecules cm^{-2}	4 × 10^{15} molecules cm^{-2}	1 × 10^{14} molecules cm^{-2}	1 × 10^{14} molecules cm^{-2}	310–326	7 × 8 × 4 px × 3 h	<50	DOAS[a]–PCA[b] hybrid[c]
SO_2		Volcano	0 DU	100 DU	—	—	310–340	7 × 8		
HCHO		VOC proxy	8 × 10^{14} molecules cm^{-2}	6.2 × 10^{16} molecules cm^{-2}	5 × 10^{15} molecules cm^{-2}	1 × 10^{15} molecules cm^{-2}	328.5–356.5	7 × 8 × 4 px	<50	DF[d]
CHOCHO			1 × 10^{14} molecules cm^{-2}	1 × 10^{16} molecules cm^{-2}	5 × 10^{14} molecules cm^{-2}	1 × 10^{15} molecules cm^{-2}	435–461	7 × 8 × 4 px	<50	DF[d]
O_3	TROP	Oxidant, pollutant	20 DU	50 DU	30 DU	20%	300–340	7 × 8	<70	OE[e]
	STRAT		180 DU	450 DU	270 DU	5%	300–340			OE[e]
	Total	Ozone layer	200 DU	500 DU	300 DU	3%	317.5, 331.2 331.2, 340, 380			TOMS[f]
Aerosol	AOD	Air quality, climate	0	3.6	0.54	20% or 0.1 at 400 nm	354, 388, 412, 443, 477, 490	3.5 × 8	<70	LUT, OE[g]
	UVAI		−7	7	0.35	—				LUT[g]
	SSA		0.82	0.99	0.90	—				LUT, OE[g]
	AEH		0 km	6 km	1.19 km	—	477	7 × 8		O_2–O_2[h]
Cloud	ECF	Retrieval, climate	0	1	—	5%	300–500			
	CCP		100 hPa	1,013 hPa	—	5%	477	7 × 8	<70	O_2–O_2[h]
	CRF		0	1	—	—				
Surface reflectivity		Retrieval, environment	0	1	—	—	300–500	3.5 × 8	<70	Multi-λ, Min reflectivity[i]
UVI	UVI	Public health	0	15	—	—	354	7 × 8	<70	LUT[a]
	VitaD									
	DNA									
	Plant									





Comparison of the NO2 Ulaanbaatar's Pandora data P216 with P217



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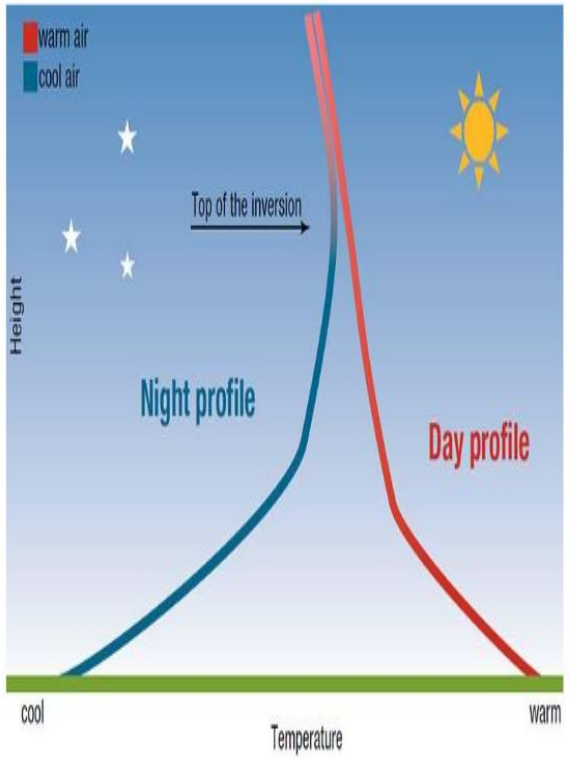
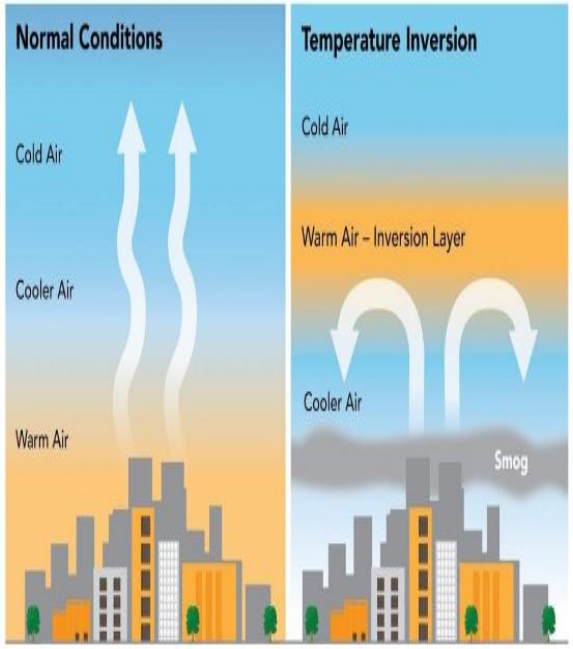
NO2 vertical profile DZ station

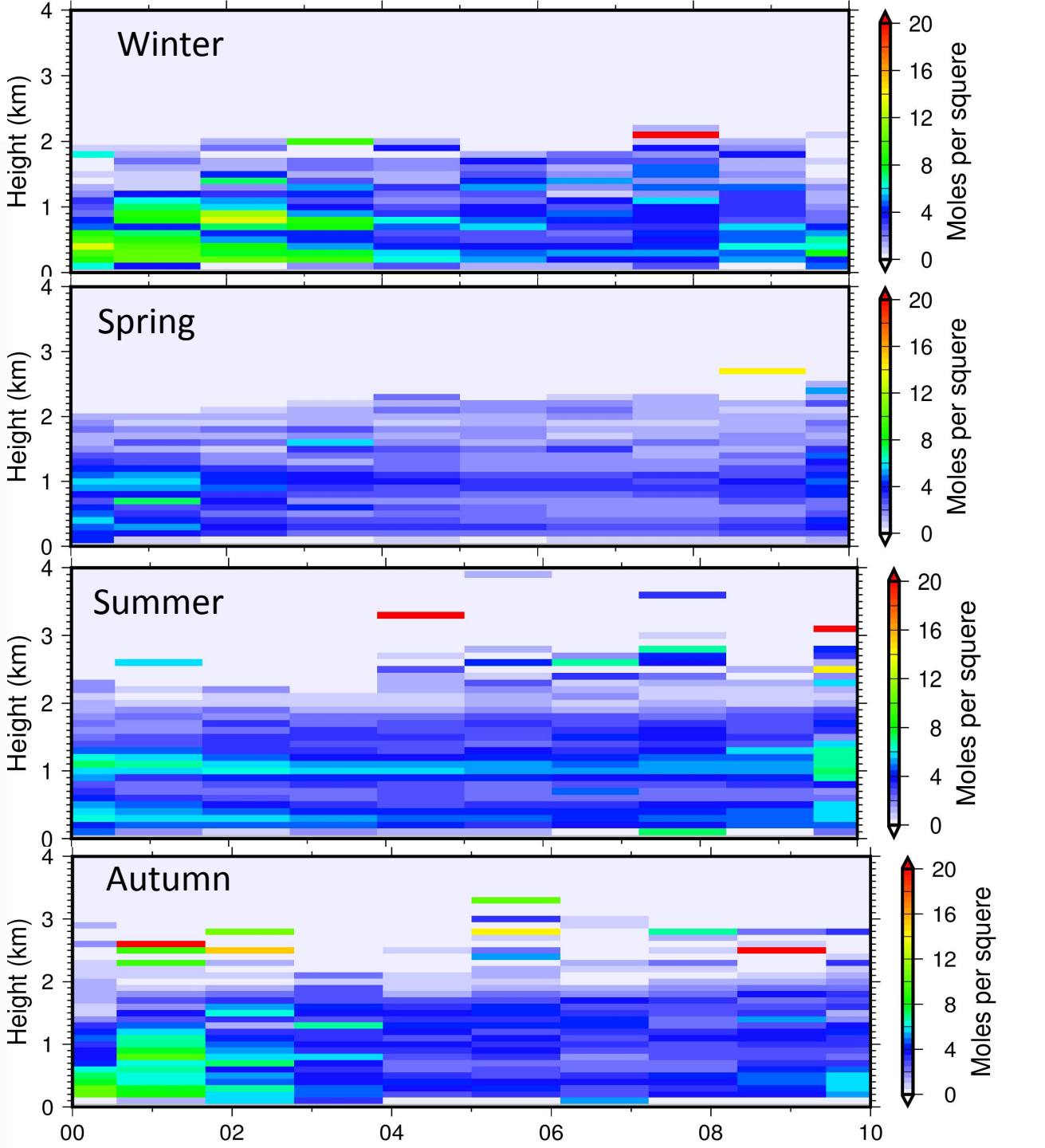
Low-lying temperature inversion

Remember Ideal Gas Law:

$$PV = nRT, \quad \text{or.} \quad \rho = \frac{P}{RT}$$







AERONET and Asian Dust Aerosol Model in case study

Dust storm in Mongolia

- The Gobi desert region is dust storm one of the source of Asian dust.
- The AERONET is located southern of Mongolia.

Source: http://olnodo.com/mn/post/24184

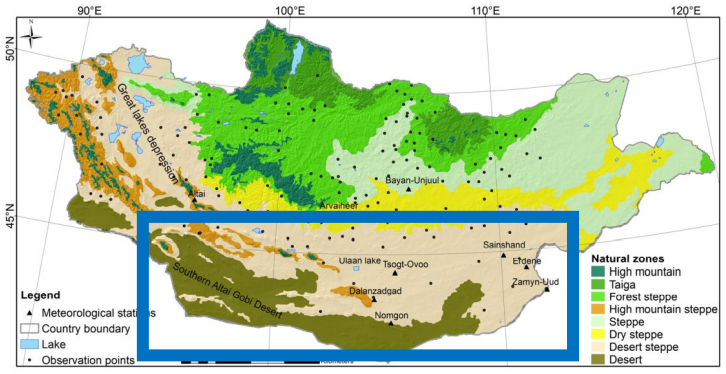


Fig. 2 Natural zones (Dorjgotov 2009) and geographic distribution of observation points for pasture plants. Dots indicate 161 observation points for pasture plants

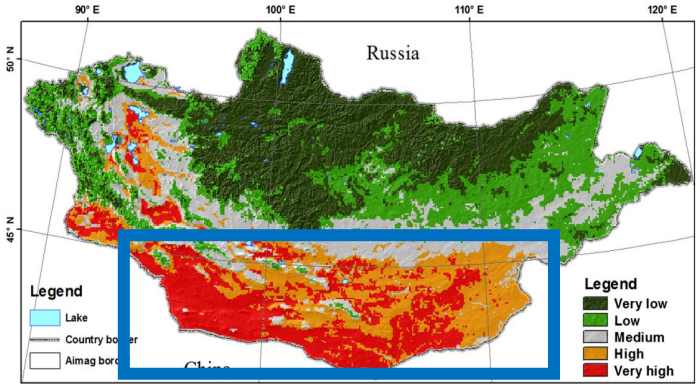


Fig. 10 Integrated soil erodibility map over Mongolia

The trajectories of air mass confirmed that dust can be transported from the dust source areas in Mongolia and China to the Korean Peninsula and Japan (Purevsuren et.,al 2019).

D. Jugder, B. Gantsetseg, **E. Davaanyam,** M. Shinoda (2018). **"Developing a soil erodibility map across Mongolia,"** Natural Hazards: Journal of the International Society for the Prevention and Mitigation of Natural Hazards, Springer; International Society for the Prevention and Mitigation of Natural Hazards, vol. 92(1), pages 71-94, November.

WRF-CMAQ/ADAM3-Haze

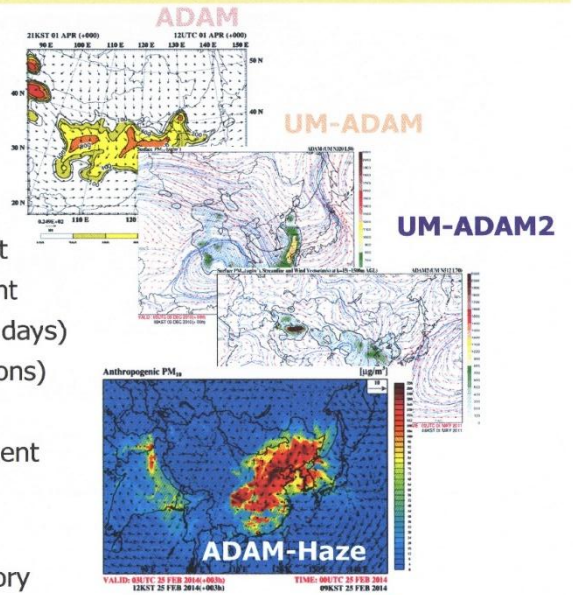
ADAM3-Haze High Resolution (1km) ADAM3 for Ulaanbaatar

1. Overview of ADAM

Development history of ADAM

ADAM

2001 : Launching ADAM development
2002 : Test run at KMA Intranet
2005 : Posting at KMA Hompage
2006 : Test run at KMA's supercom
2007 : ADAM operation
2008 : Improvement of vegetation effect
2009 : Launching UM-ADAM development
2010 : UM-ADAM operation(2 days → 3 days)
UM-ADAM2 operation (Four-seasons)
2011 : UM-ADAM2(N512) operation
2014 : Launching ADAM-Haze development
2015 : ADAM-Haze operation
Applying optimal interpolation
2016 : Improvement of emission inventory

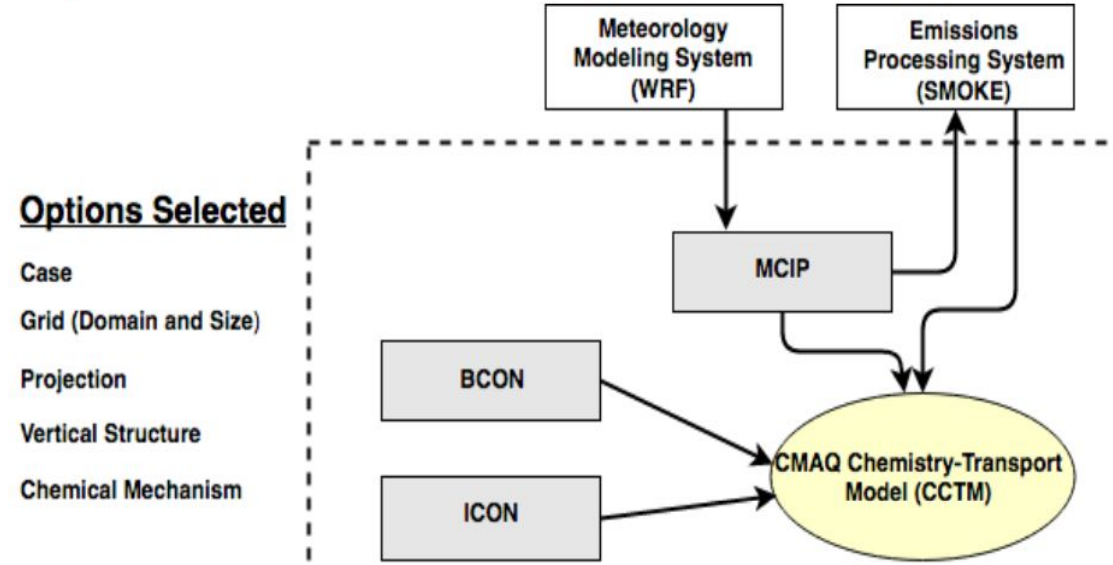


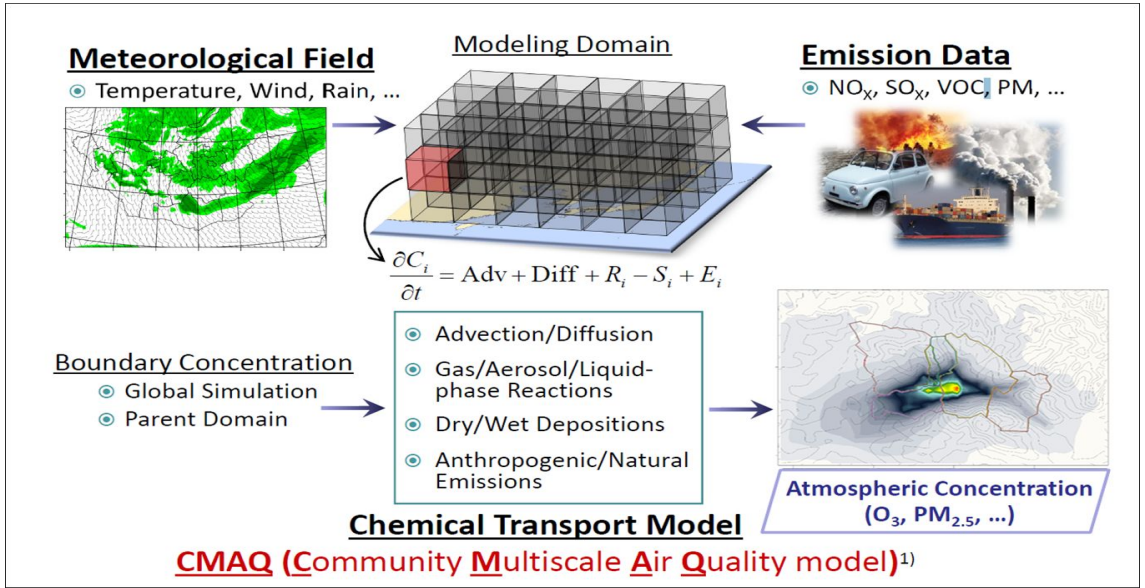
In 2017, ADAM-HAZE was installed at NAMEM in Mongolia.

National Institute of Meteorological Sciences

- The initial conditions processor ICON
- The boundary conditions processor BCON
- The Meteorology-Chemistry Interface Processor MCIP
- The CMAQ Chemistry-Transport Model CCTM

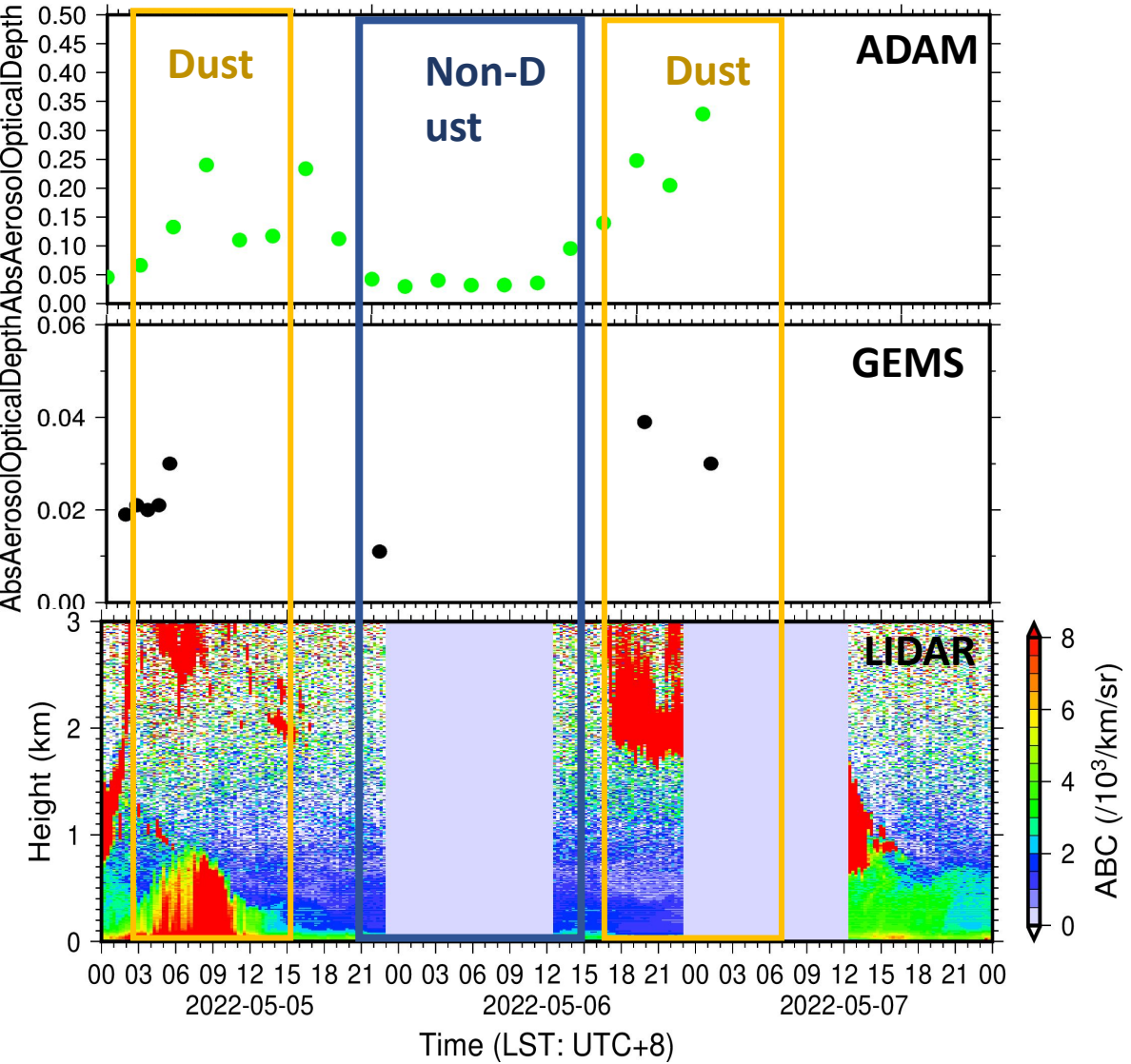
CMAQ Modeling System Flow Chart

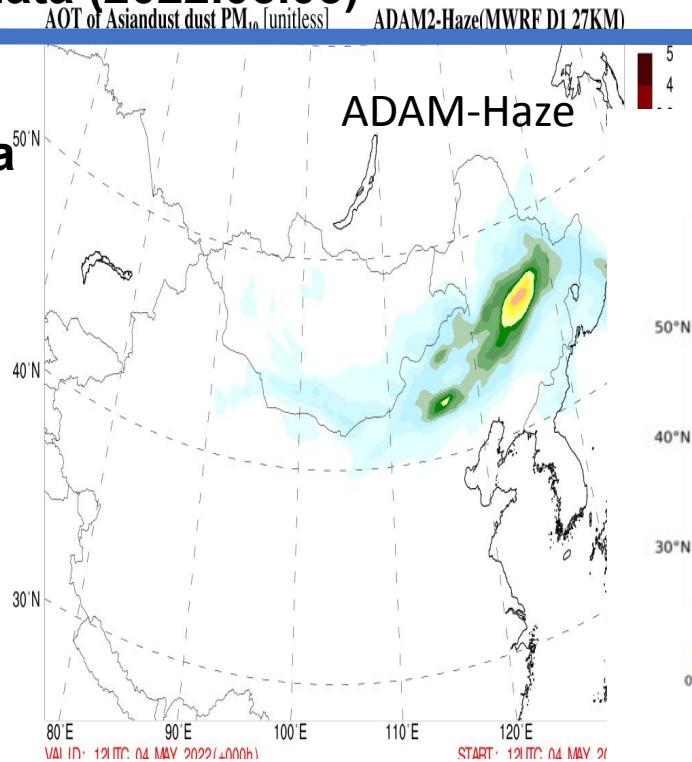




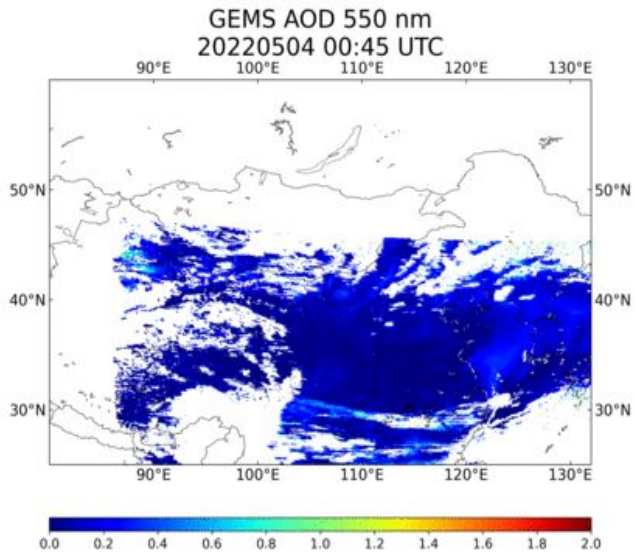
CASE 1: Comparison of the ADAM model and GEMS data (2022.05.05)

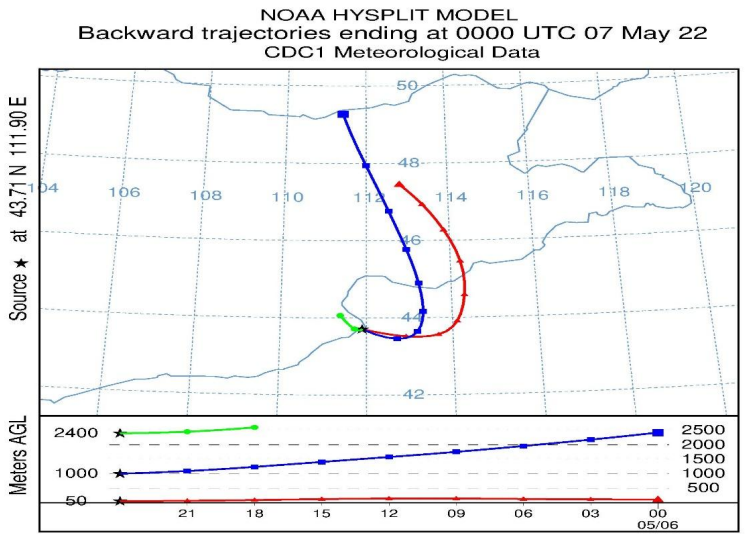
Comparison of the Measurement Lidar and GEMS data





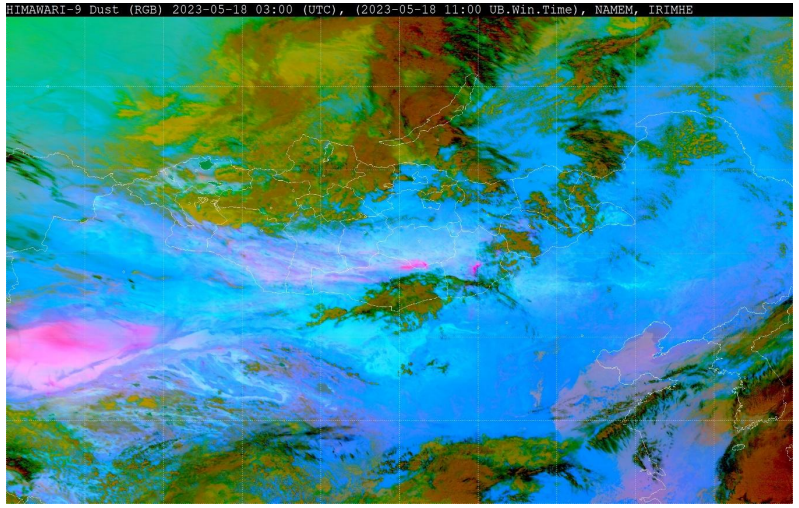
GEMS





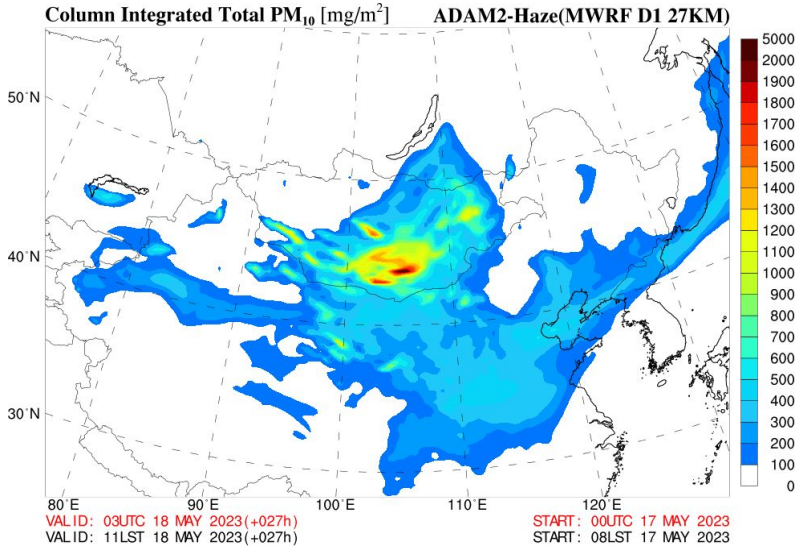
CASE 2: Comparison of the ADAM model and GEMS data (2023.05.18)

HIMAWARI



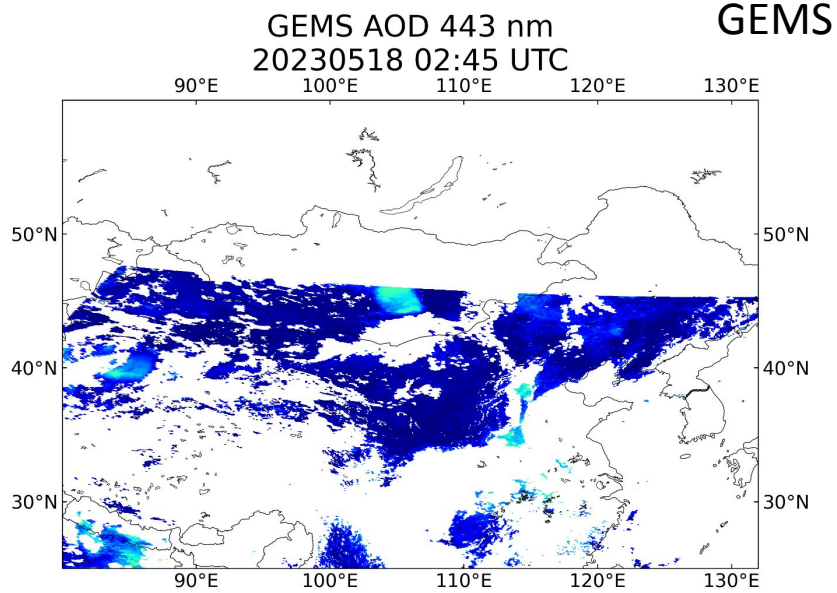
(2023.05.18 03:00 UTC)

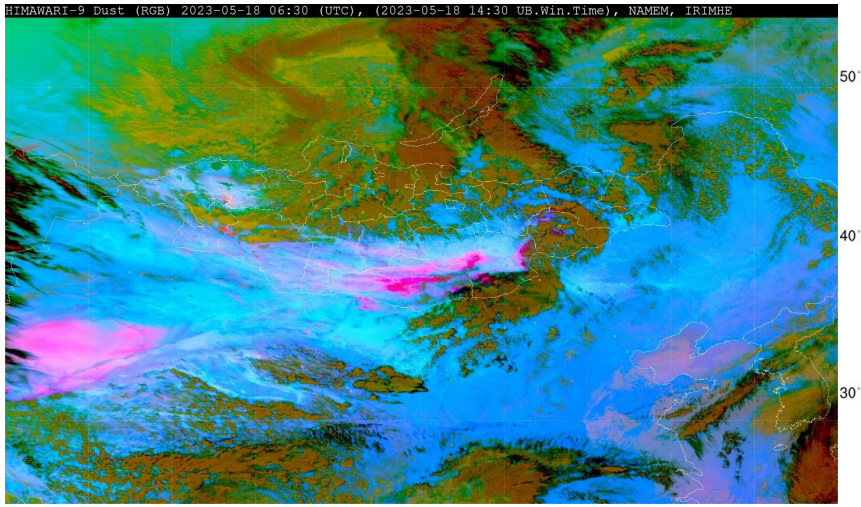
ADAM-Haze



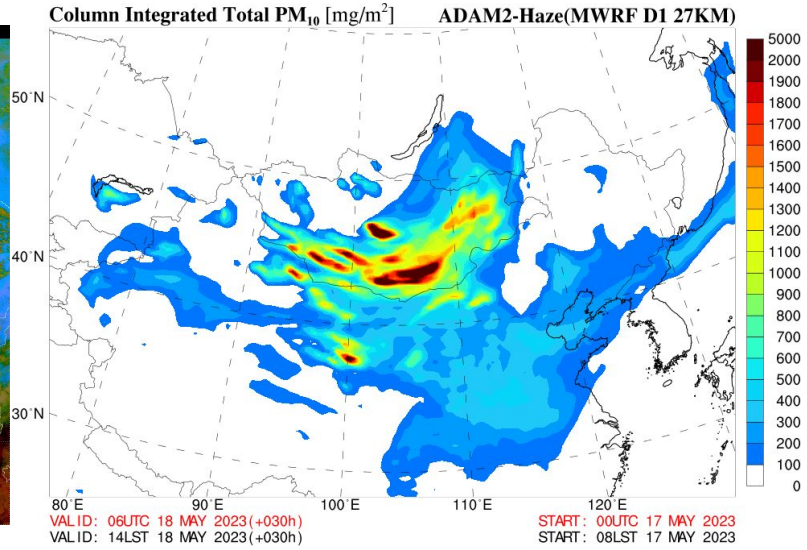
(2023.05.18 03:00 UTC)

GEMS

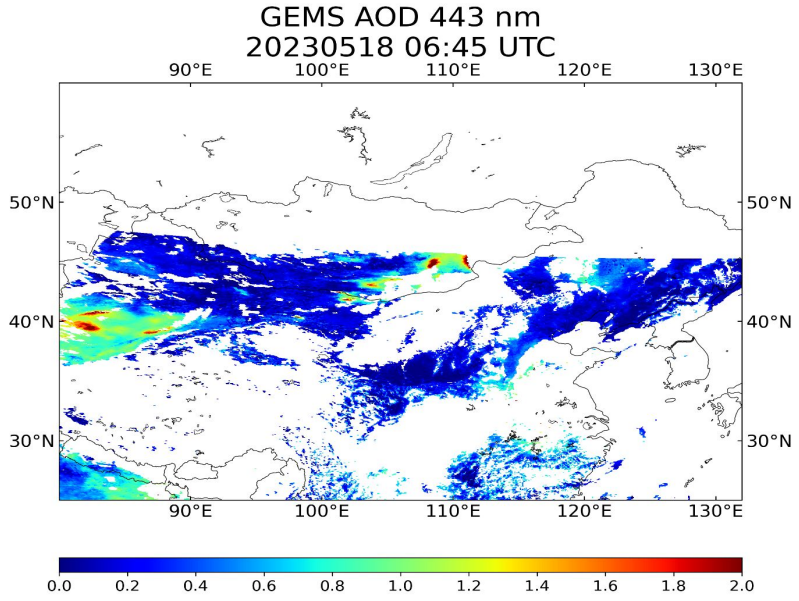




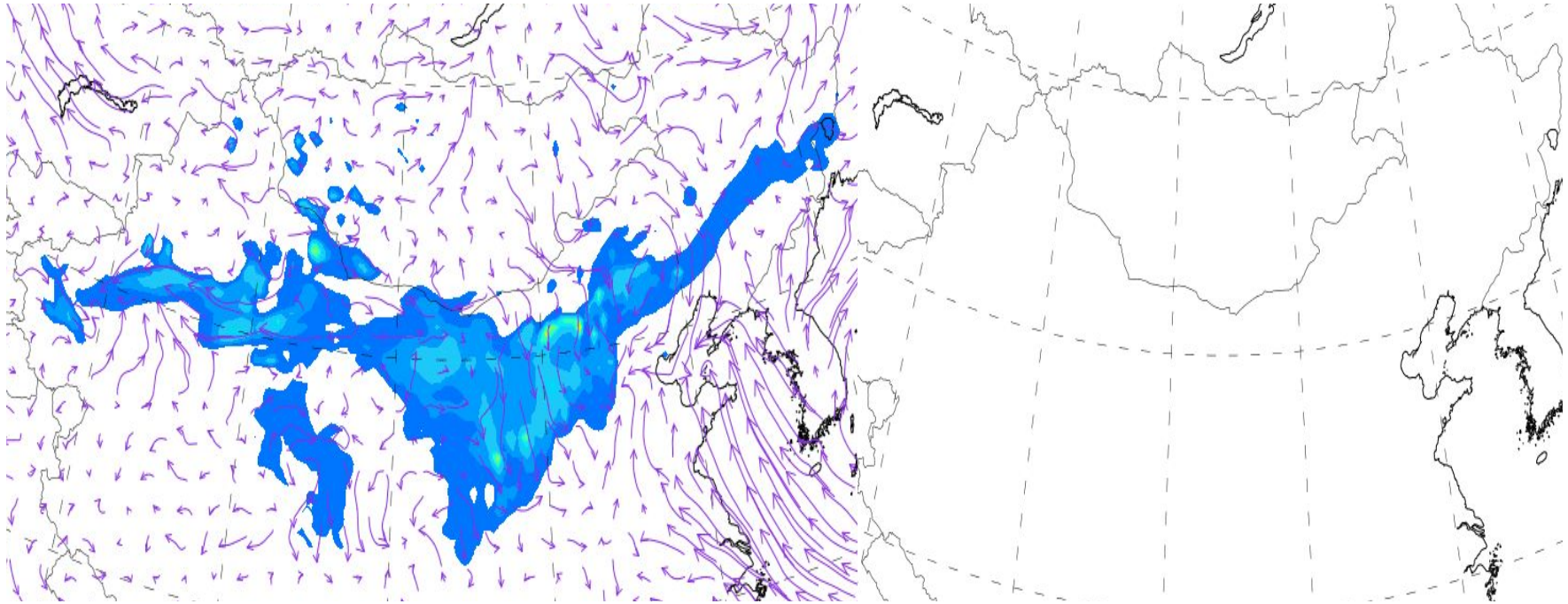
(2023.05.18 06:30 UTC)

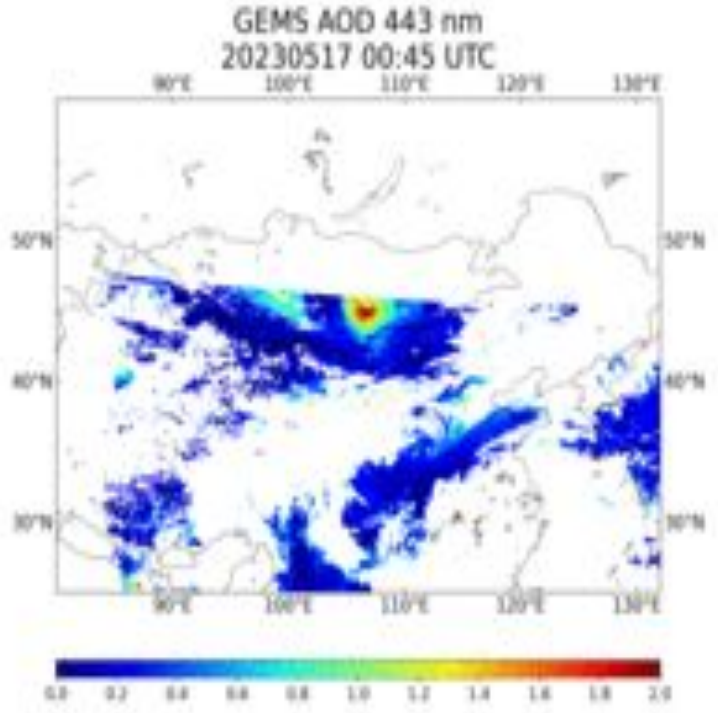


(2023.05.18 06:00 UTC)



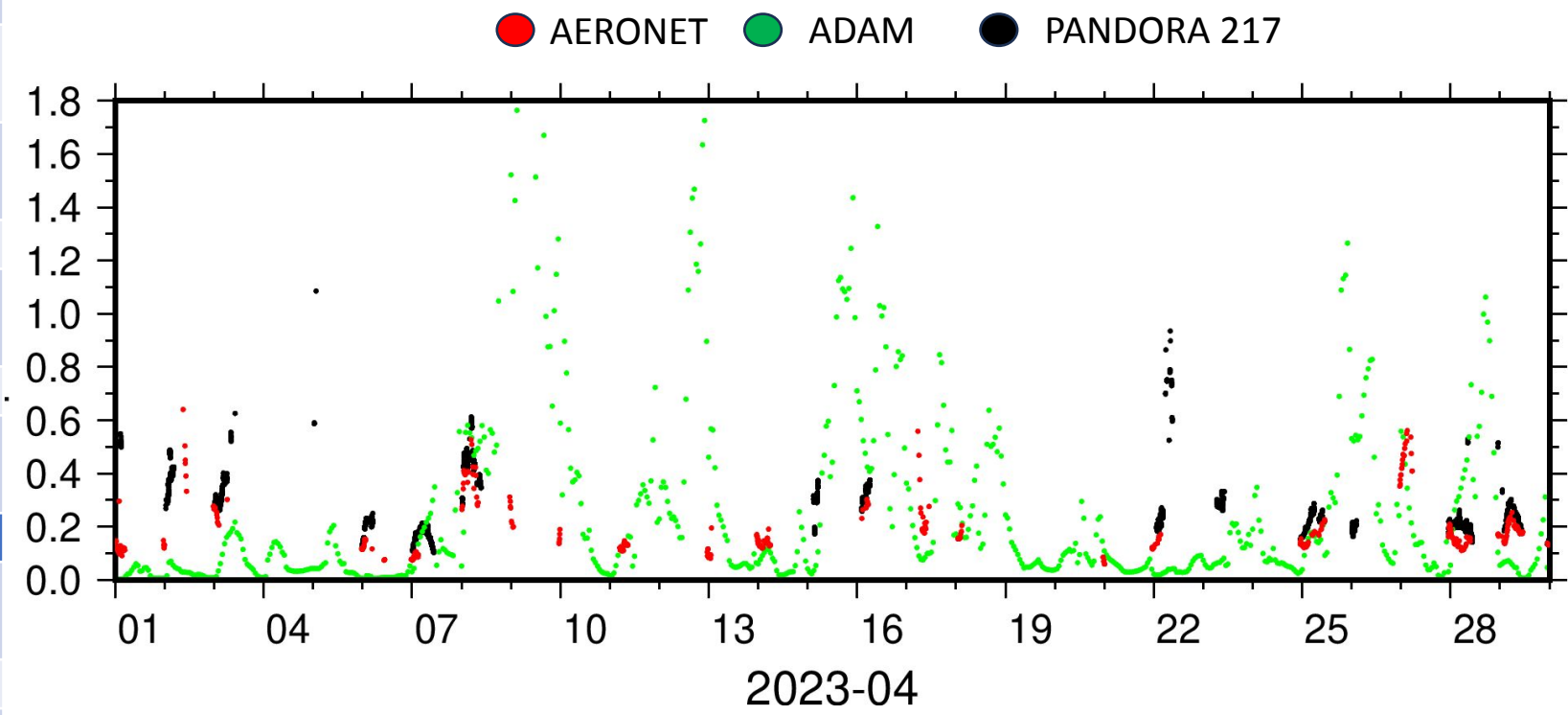
CASE 2: Comparison of the ADAM model and GEMS data (2023.05.18)





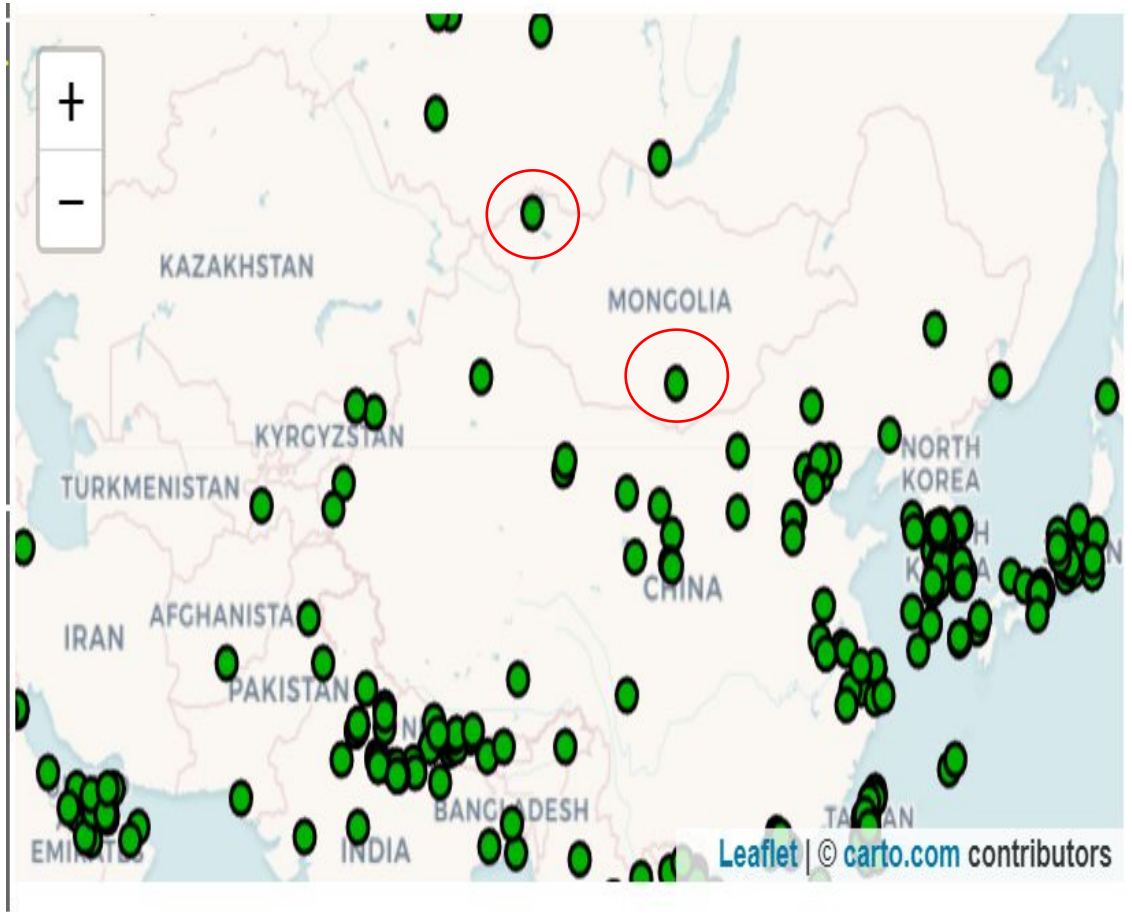
Comparison of the AERONET, PANDORA and ADAM model simulation April, 2023

Name	Selection
Model and version	MGLADAM model
Dynamic core	Advanced Research WRF (ARW)
Horizontal grid resolution (size)	D1: 27x27 km (190x170 grid)
Vertical levels	34
Initial and lateral boundary conditions	NCEP GFS reanalysis data (0.25 degree)
Simulation length	720 hour
Time step	D1:6 seconds
Physics schemes	
Cloud microphysics	WRF Single-Moment 6-class scheme
Shortwave radiation	Dudhia scheme
Longwave radiation	RRTM scheme
PBL physics	Yonsei University scheme
Land Surface Physics	Noah Land Surface Model
Surface Layer Physics	MM5 similarity
Cumulus Parameterization	Kain-Fritsch scheme



Suggestions

- To repair the Ulaangom AERONET station
- To increase AERONET network in Mongolia



Thank you very much for attention