



국립환경과학원

National Institute of Environmental Research



Event-based GEMS ozone evaluation using consecutive ozonesonde measurements during ACCLIP

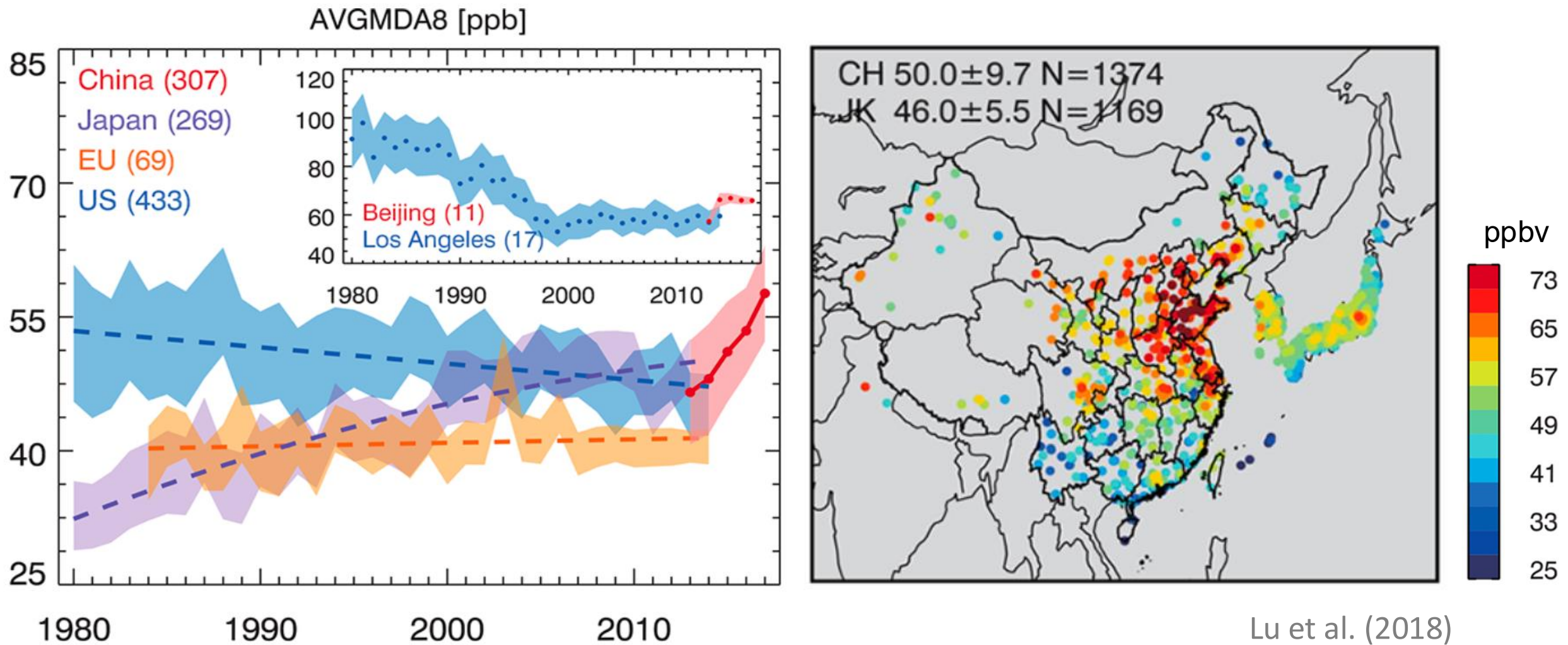
Joowan Kim¹, Subin Oh¹, Juseon Bak², Ja-Ho Koo³, Sang Seo Park⁴, Won-Jin Lee⁵
Sun A Shin⁵, and Jinsoo Park⁵ & ground crews in UNIST, Yonsei, Kongju

¹Kongju Natl Univ, ²Pusan Natl Univ, ³Yonsei Univ, ⁴UNIST, ⁵NIER

Special thanks to NASA SHADOZ team:

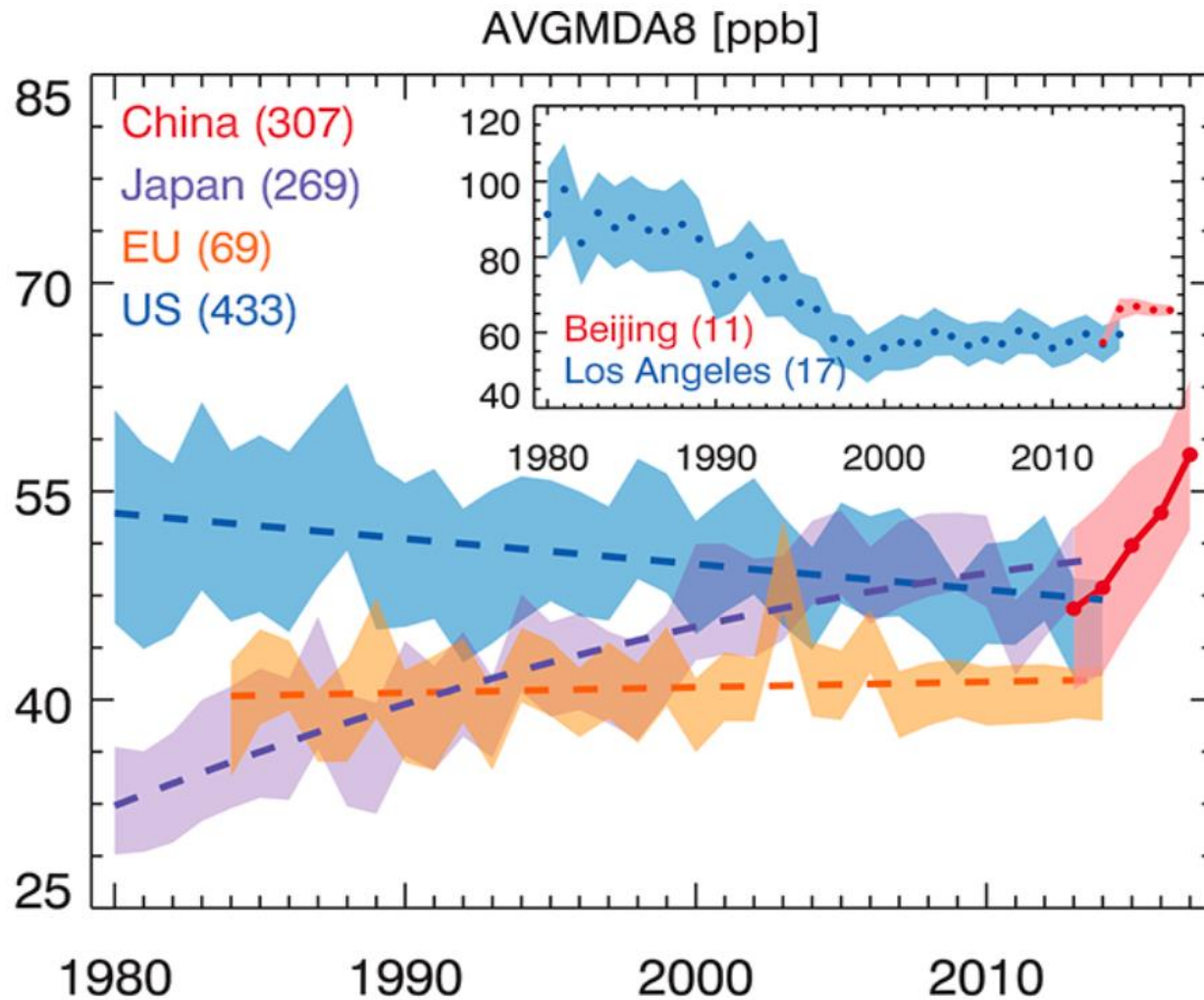
Drs. Anne M. Thompson, Ryan M. Stauffer, Debra E. Kollonige

Ozone issues in East Asia (troposphere)



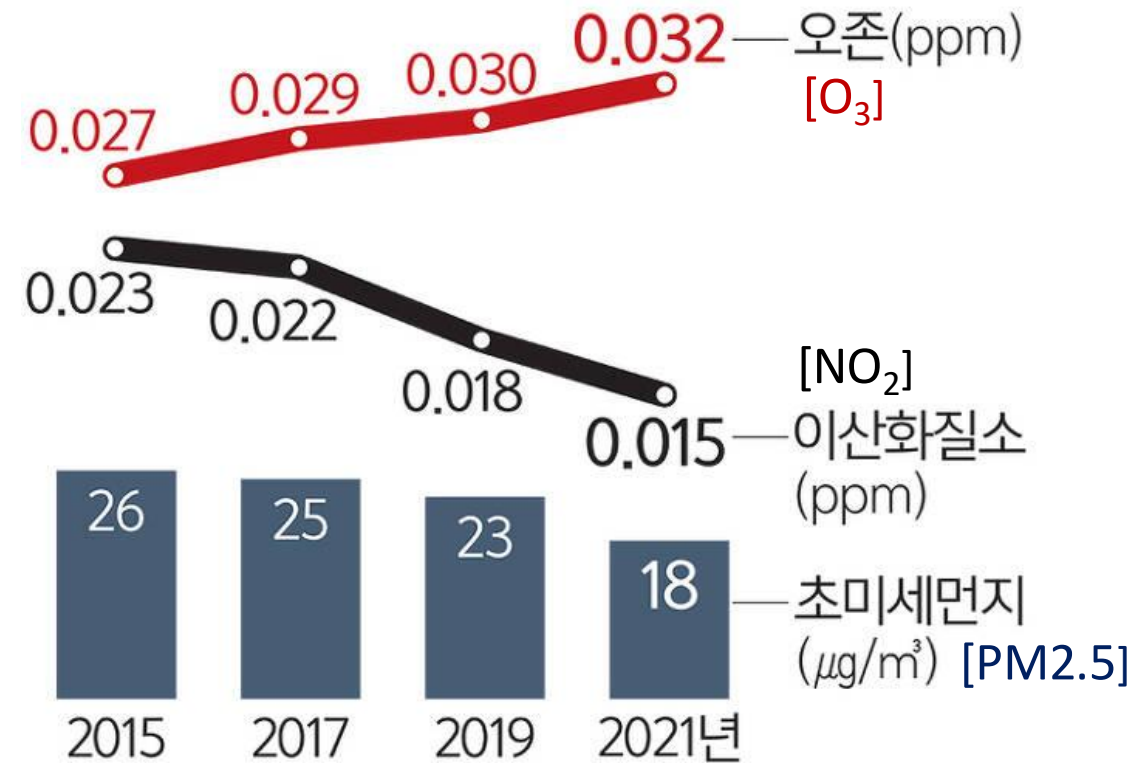
MDA8: daily maximum of 8-hour average (8-hour maximum)
AVG: Apr-Sep average

Ozone issues in East Asia (troposphere)



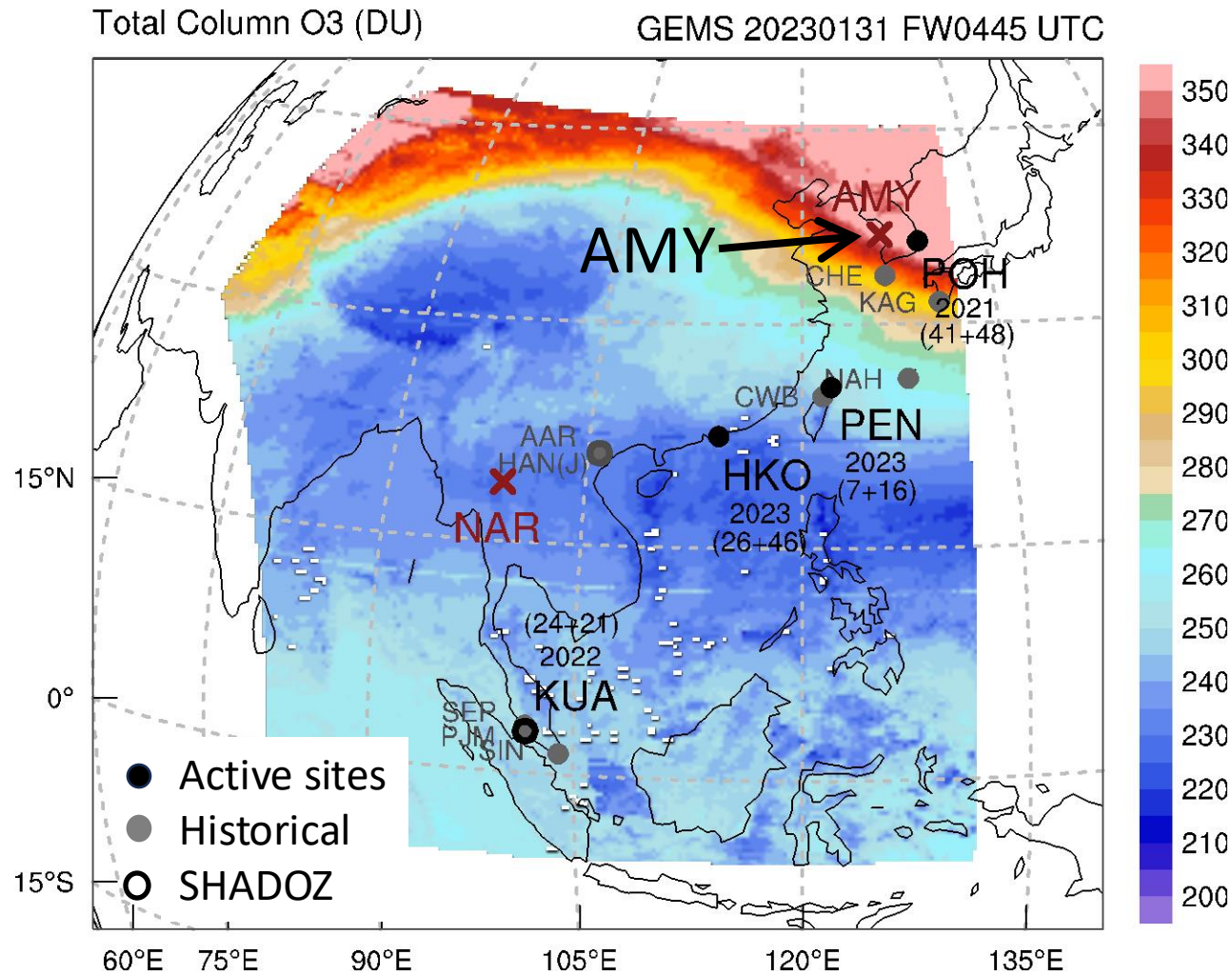
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Pollution trends in S. Korea (annual mean)



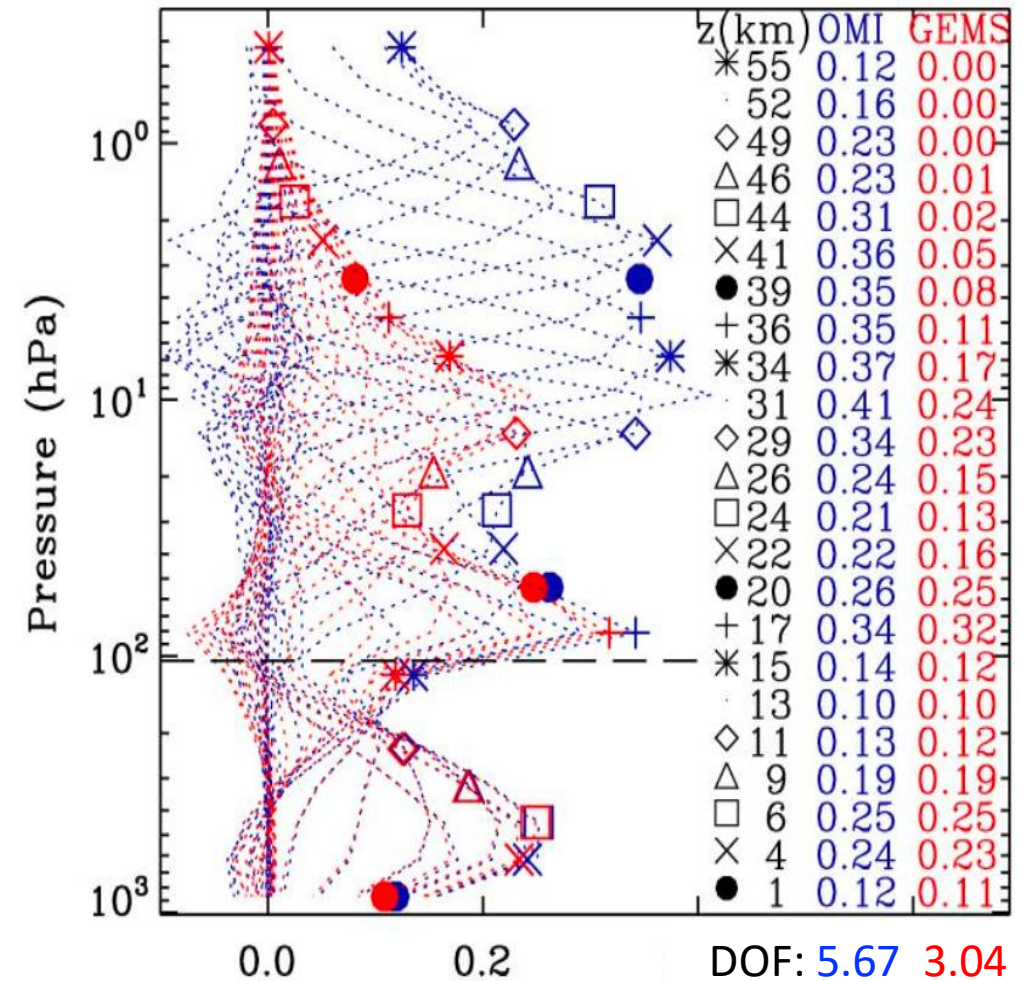
자료: 국립환경과학원·에어코리아

GEMS ozone product (O3P, O3T): obstacles



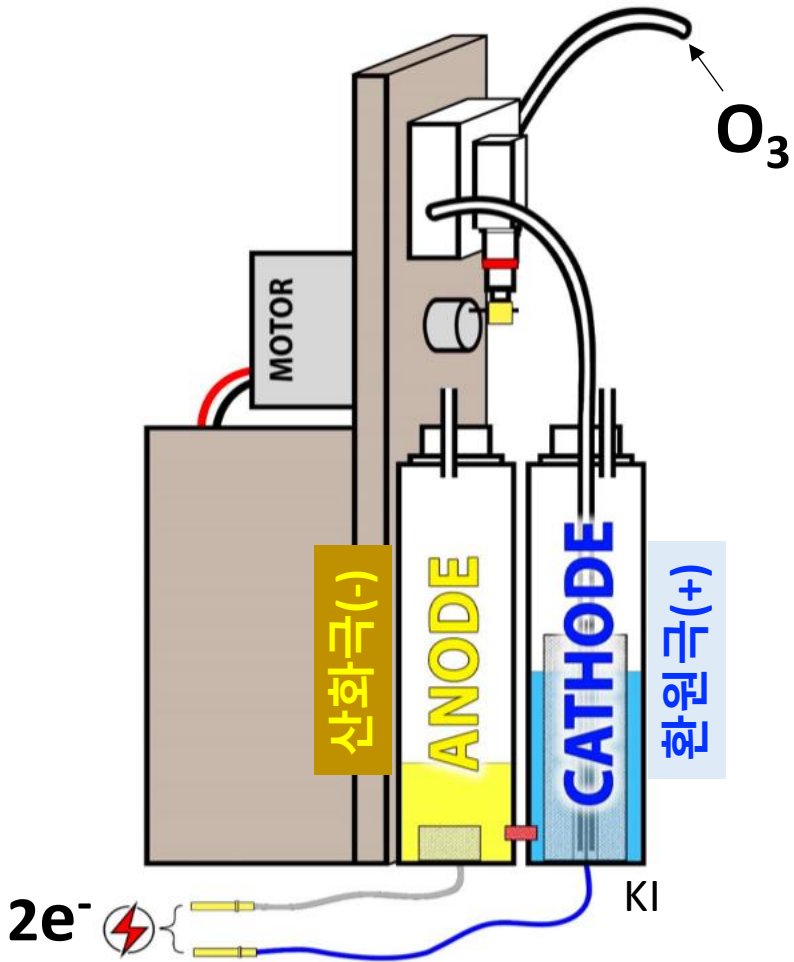
- Limited number of ozone profile measurements

Averaging Kernel calculation with
Solar/viewing zenith angel = 30°/33°



GEMS O3P ATBD (NIER, 2020)

GEMS validation (In-situ measurement)

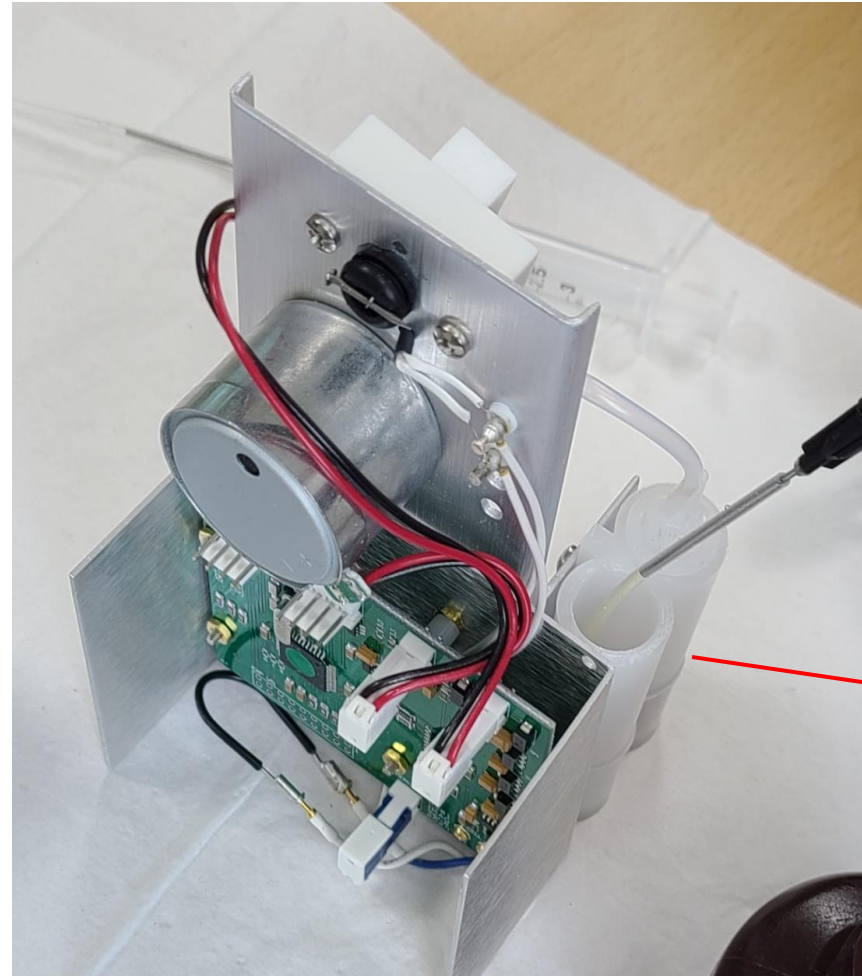


ECC Sensor Cell

(img from EN-SCI Ozonesonde manual)

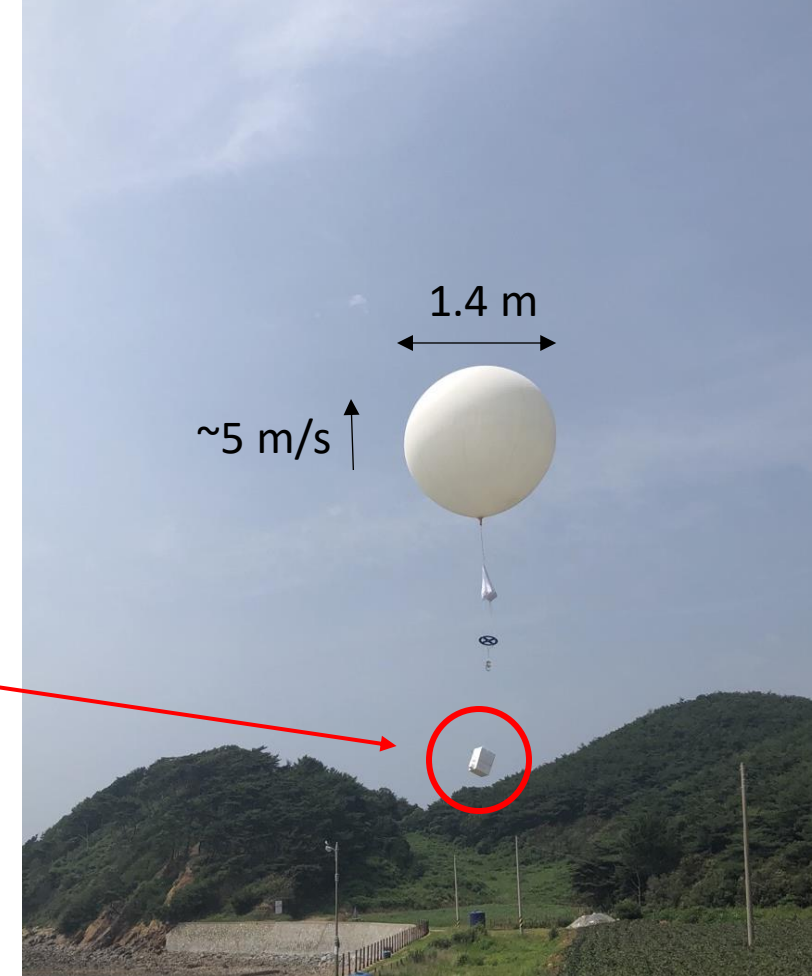
Ozonesonde

Electrochemical Concentration Cell



- Balloon-borne sounding with light weighted sensors (~500 g, > 2 kg total)
- Measures O_3 up to 35 km with ~5 m vertical resolution (phy res ~150 m)
- Accuracy: 5%, Precision: 1 nbar (Komhyr, 1969)

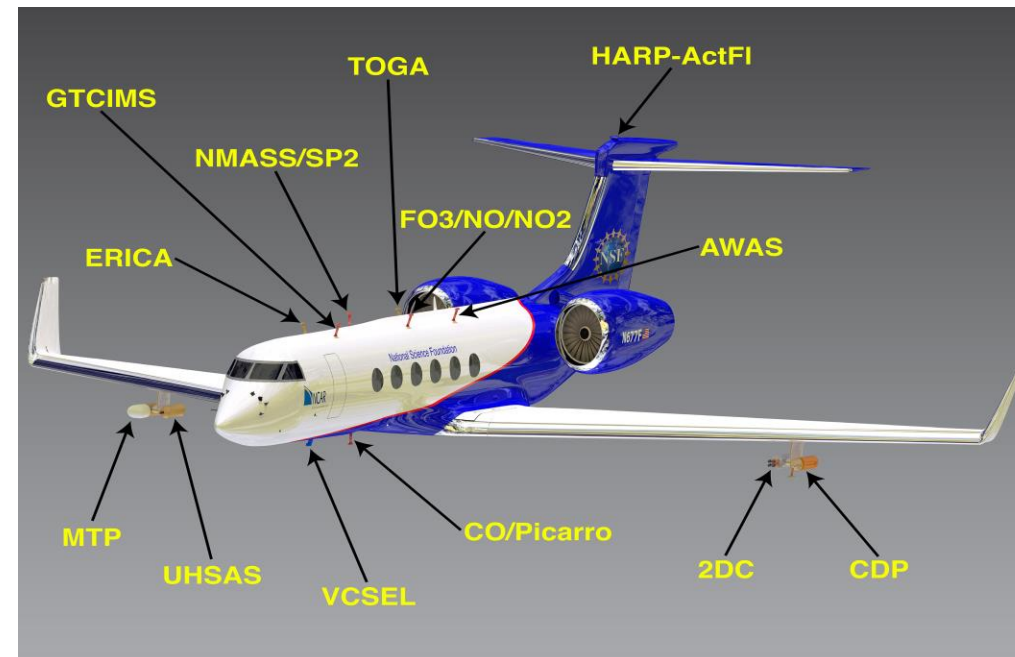
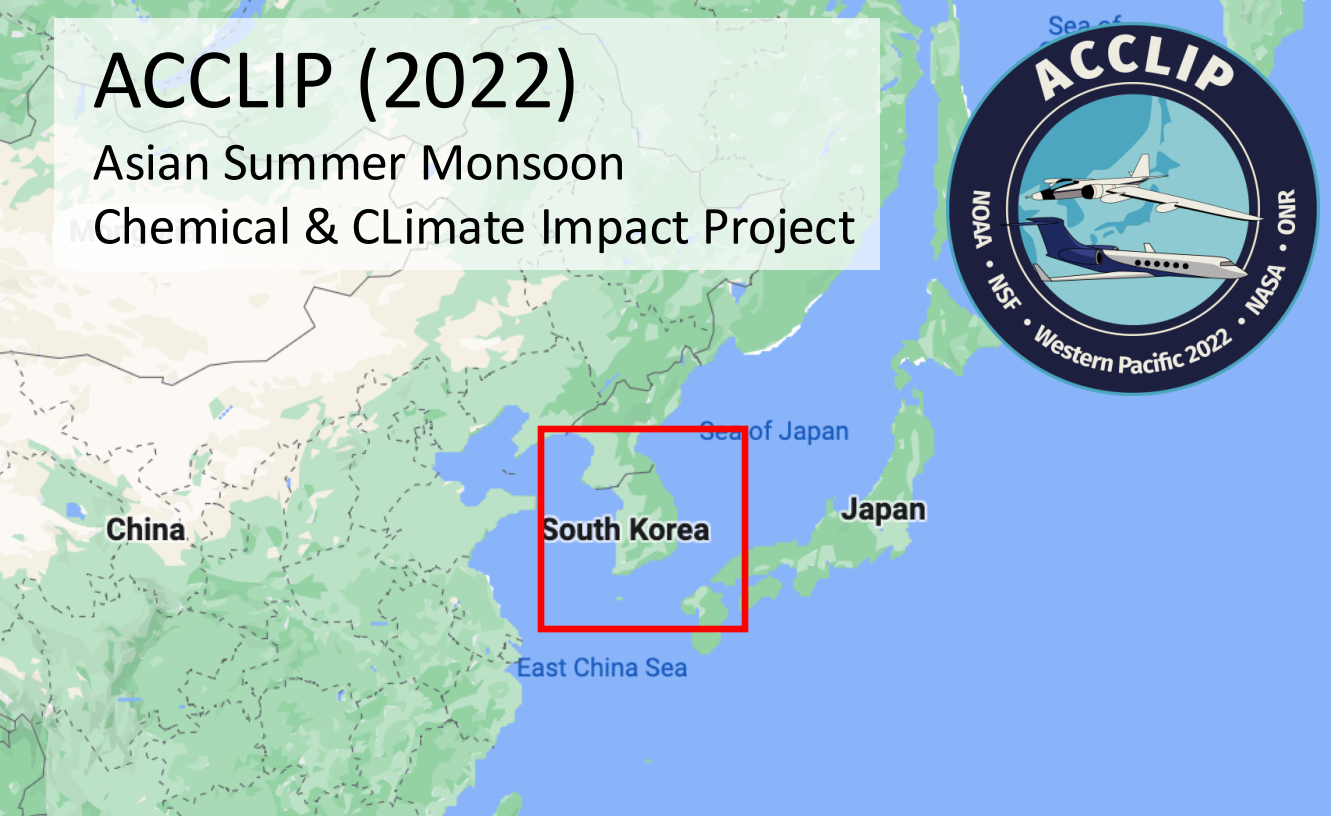
1st Ozonesonde launch during ACCLIP
(Anmyeon site, 27 July 2022)



ACCLIP (2022)

Asian Summer Monsoon

Chemical & CLimate Impact Project



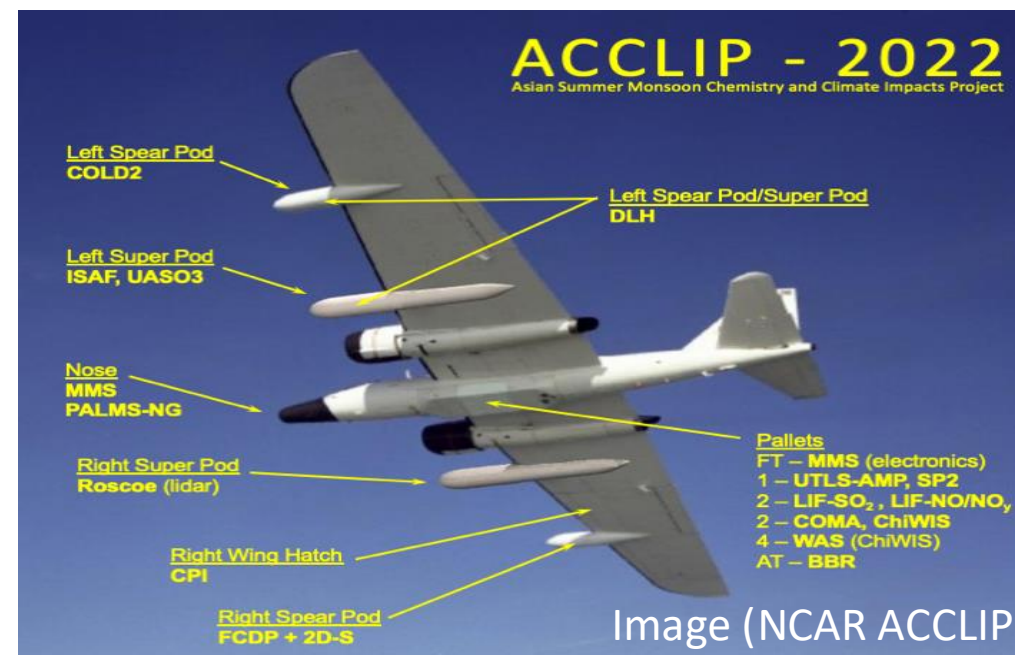
NSF/NCAR Gulfstream V (GV)

Duration: ~ 8 hr flight

1000 ft (0.3 km) and FL 470 (14.7 km)



Image courtesy of NASA ESPO



NASA WB-57

Duration: ~ 6 hr

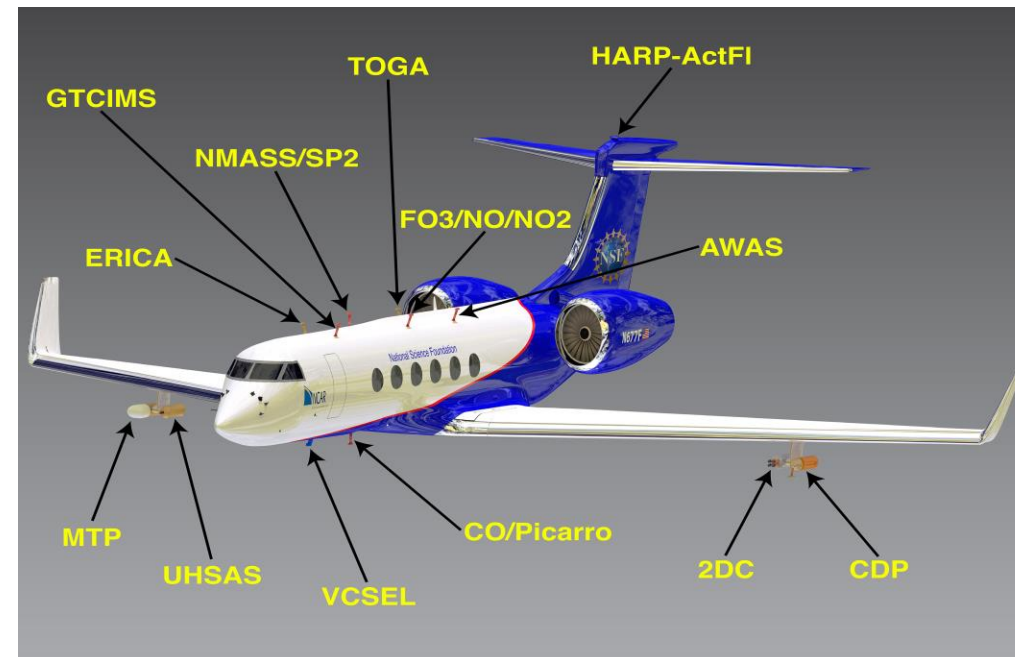
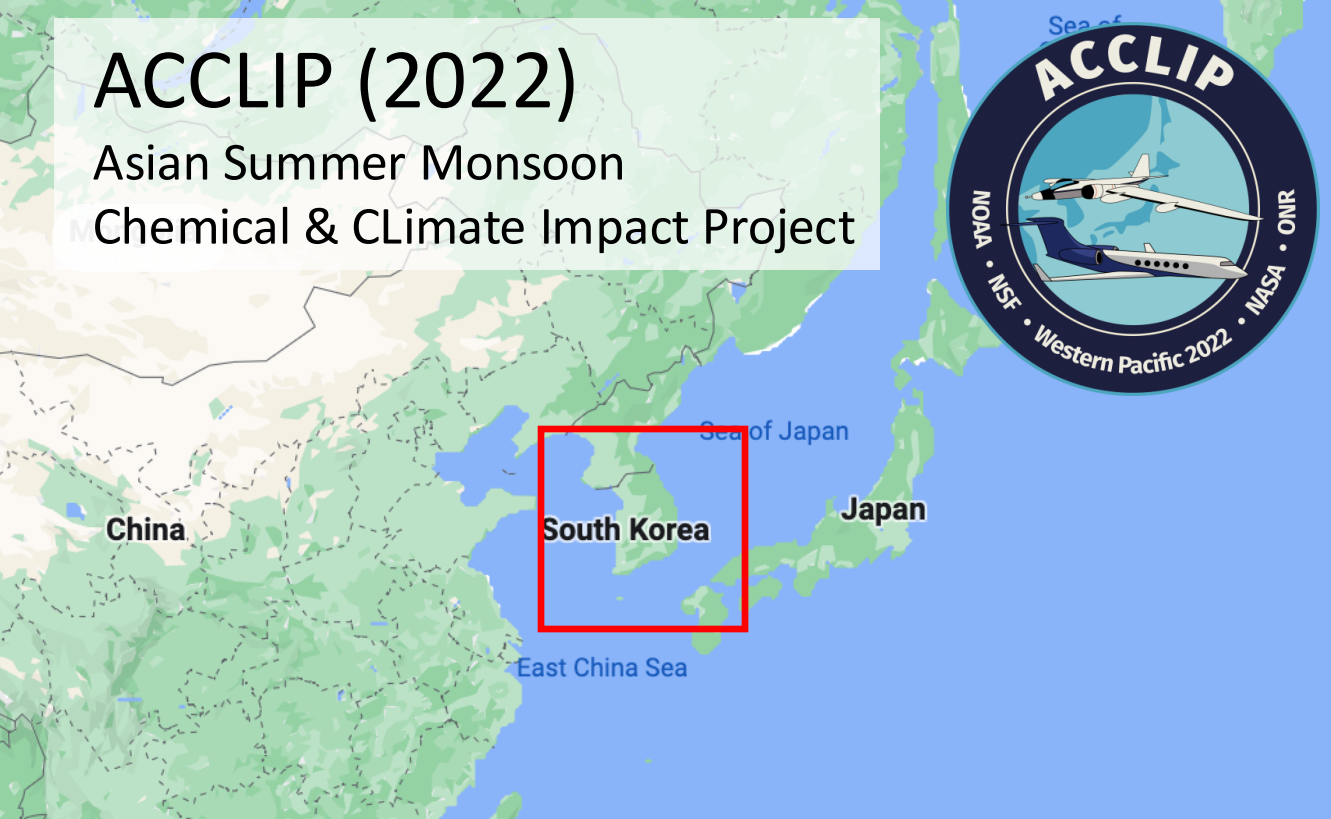
FL 430 (13 km) and FL 620 (19 km)

Image (NCAR ACCLIP)

ACCLIP (2022)

Asian Summer Monsoon

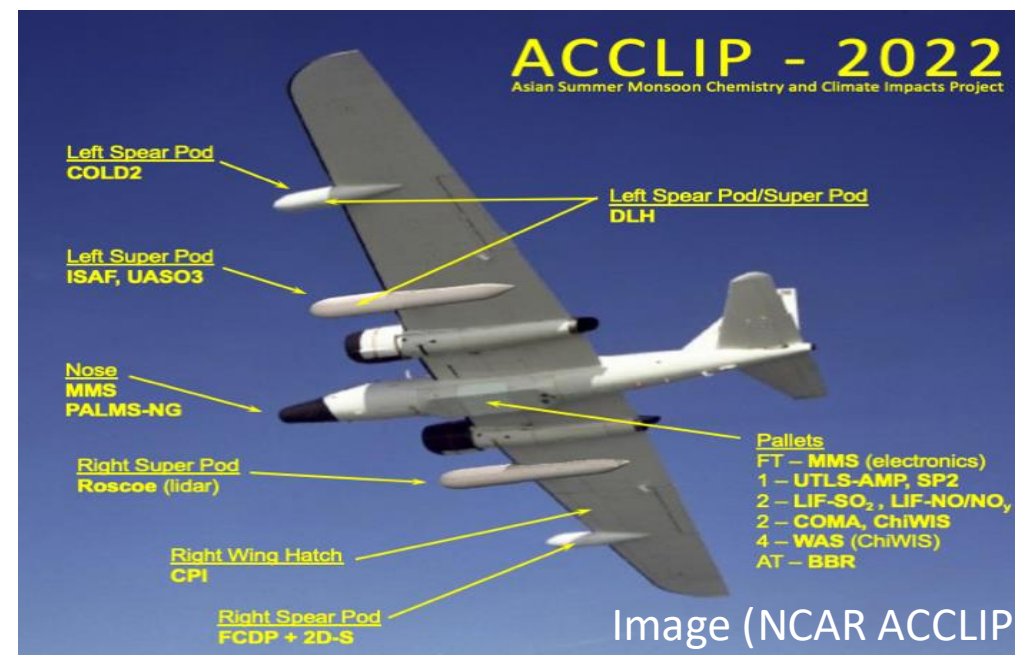
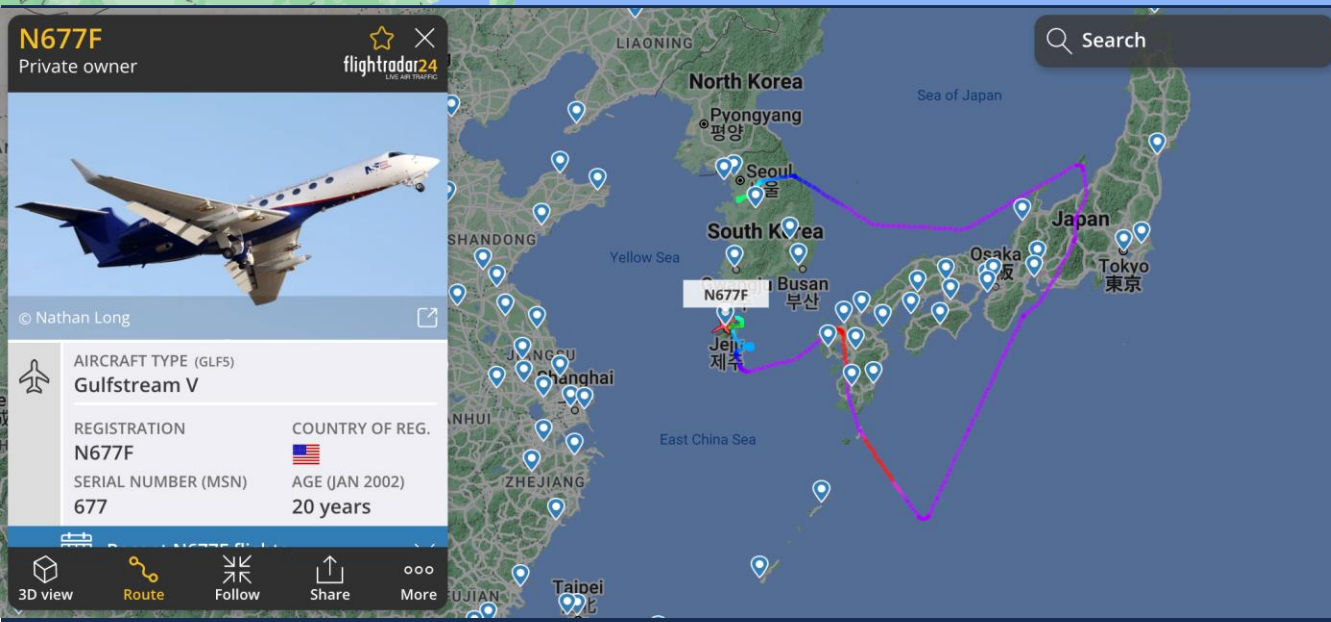
Chemical & CLimate Impact Project



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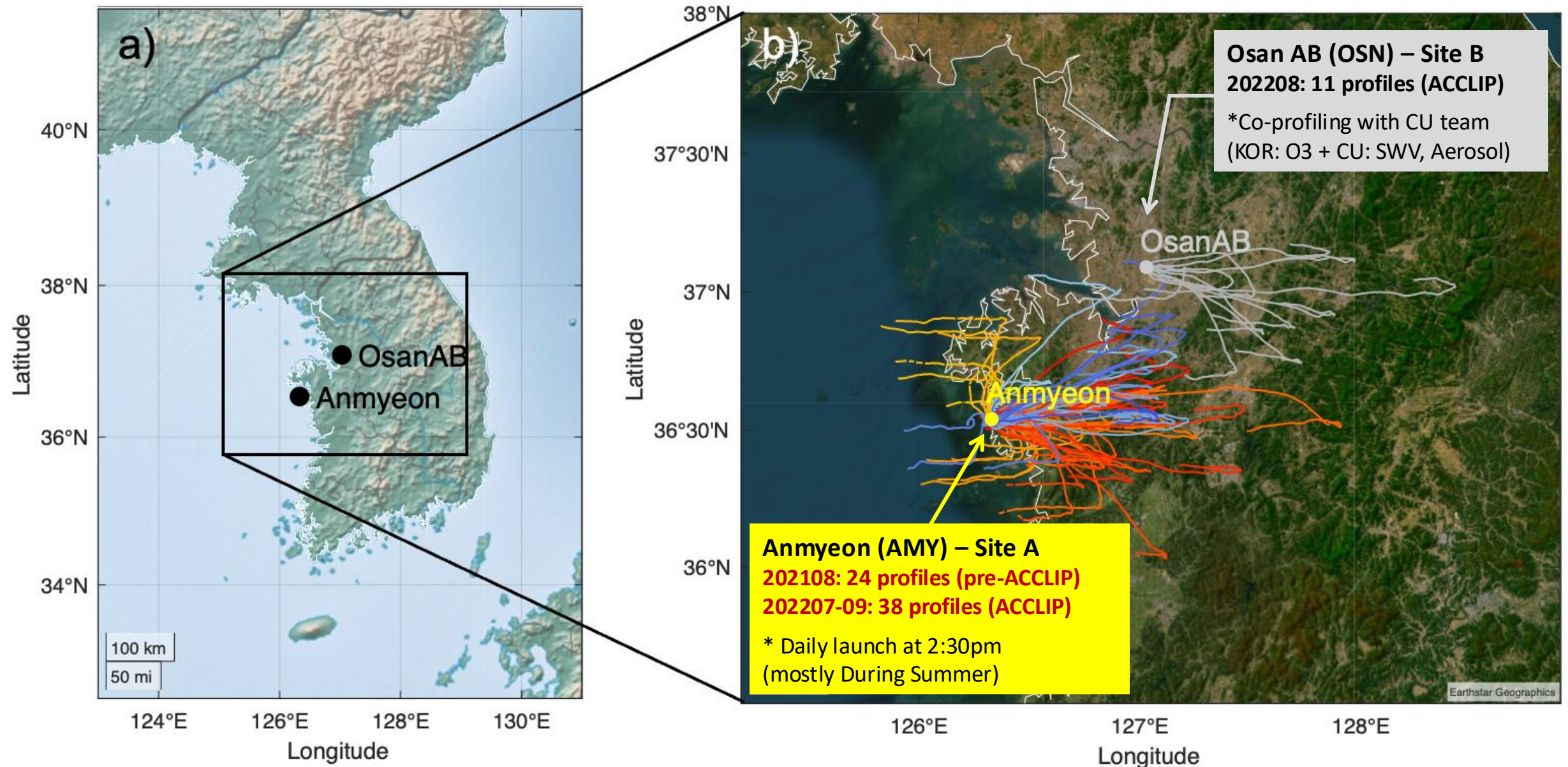


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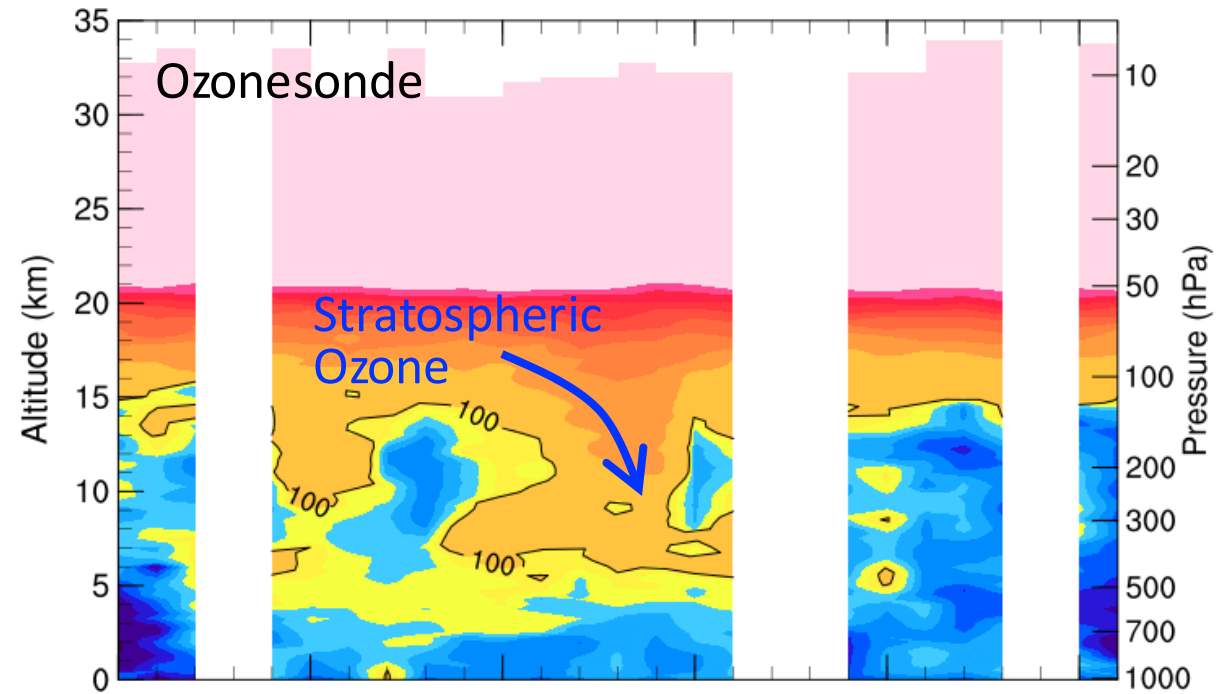
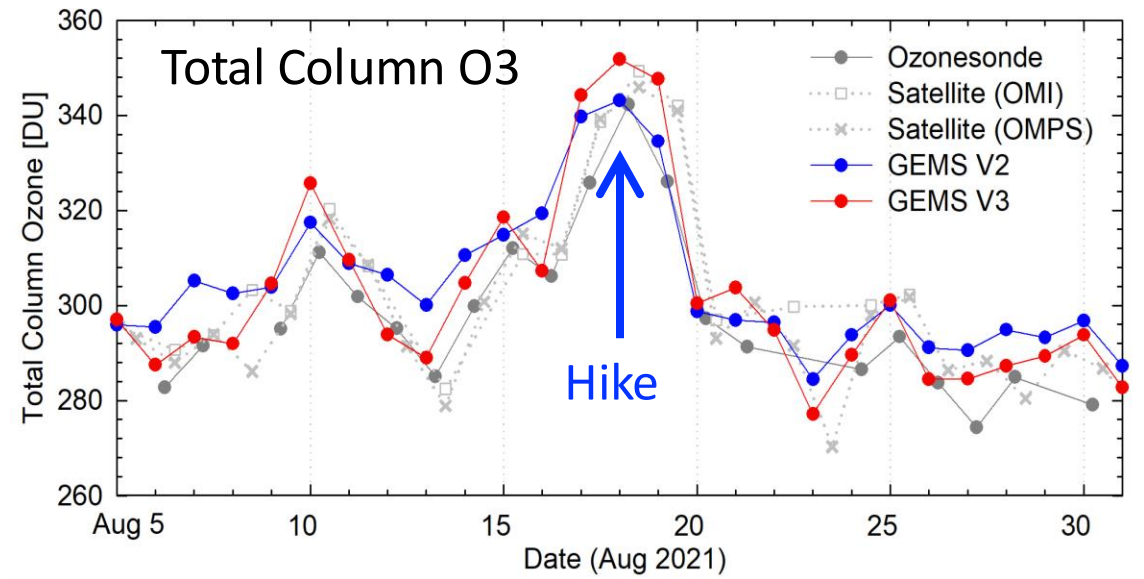
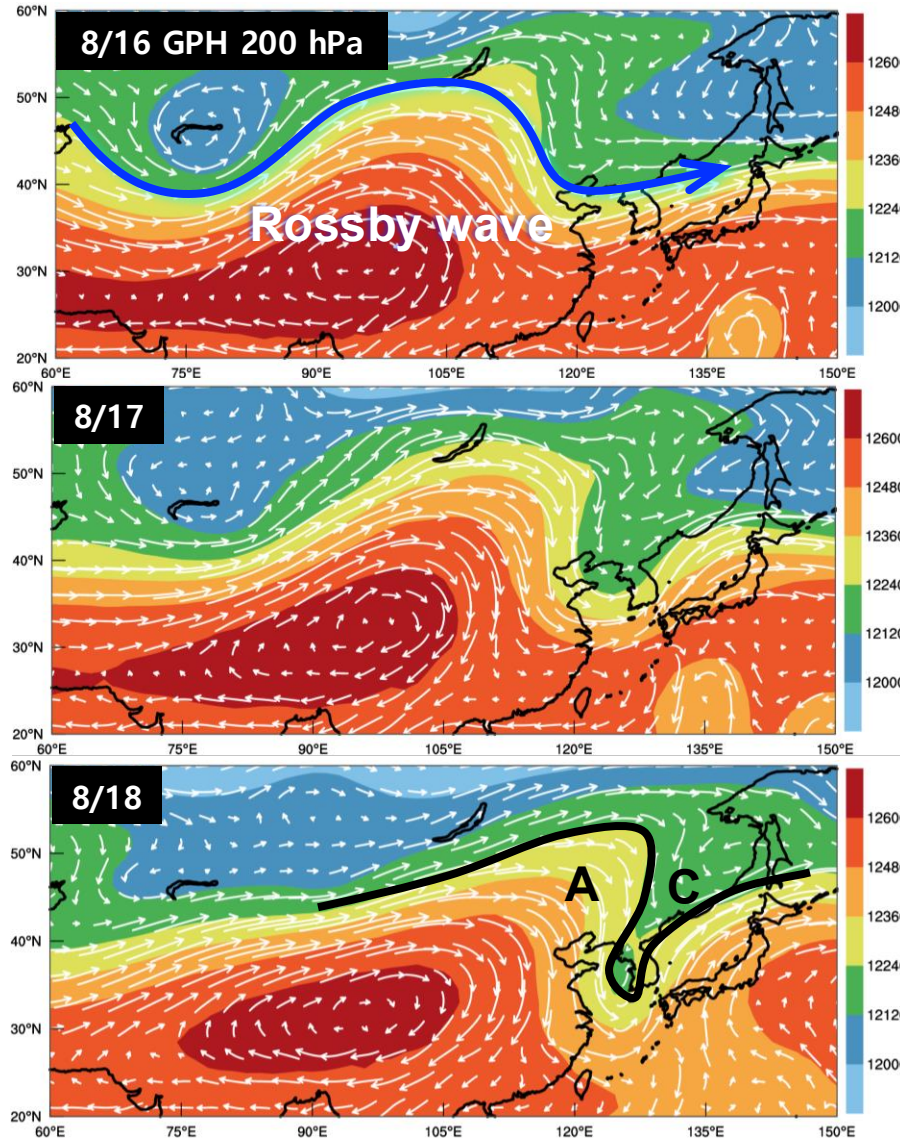
FL 430 (13 km) and FL 620 (19 km)

Ozonesonde measurements (during pre-ACCLIP 2021 & ACCLIP 2022)



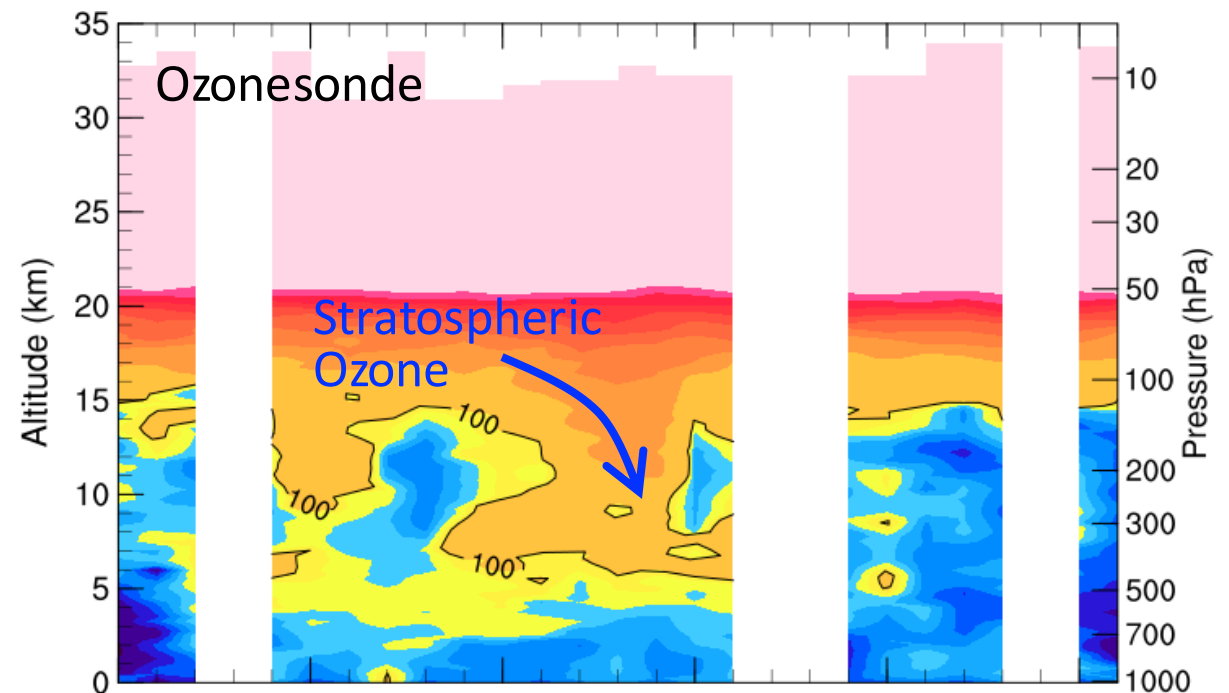
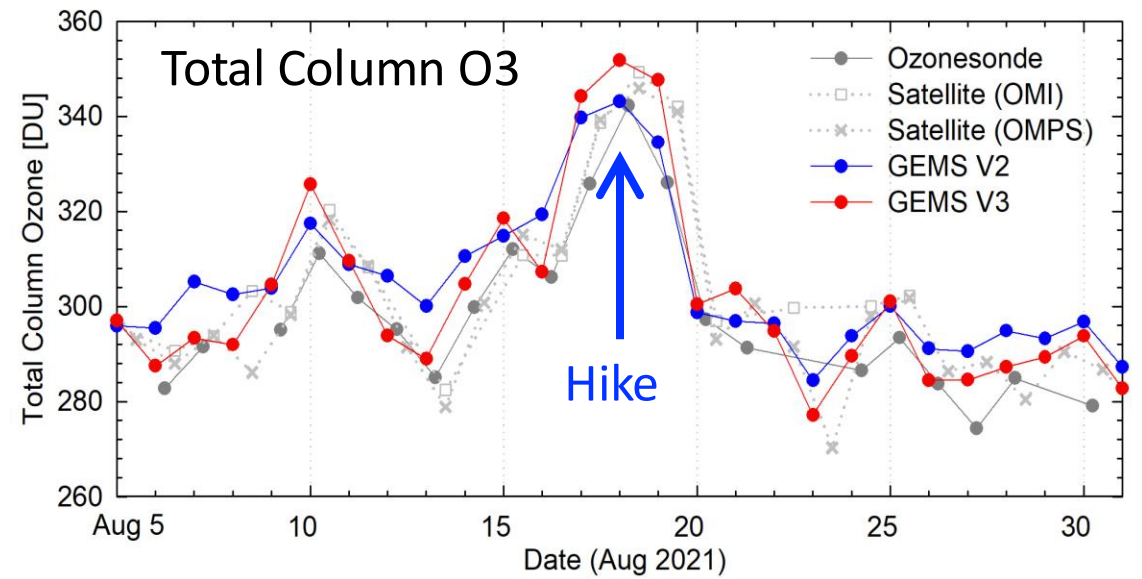
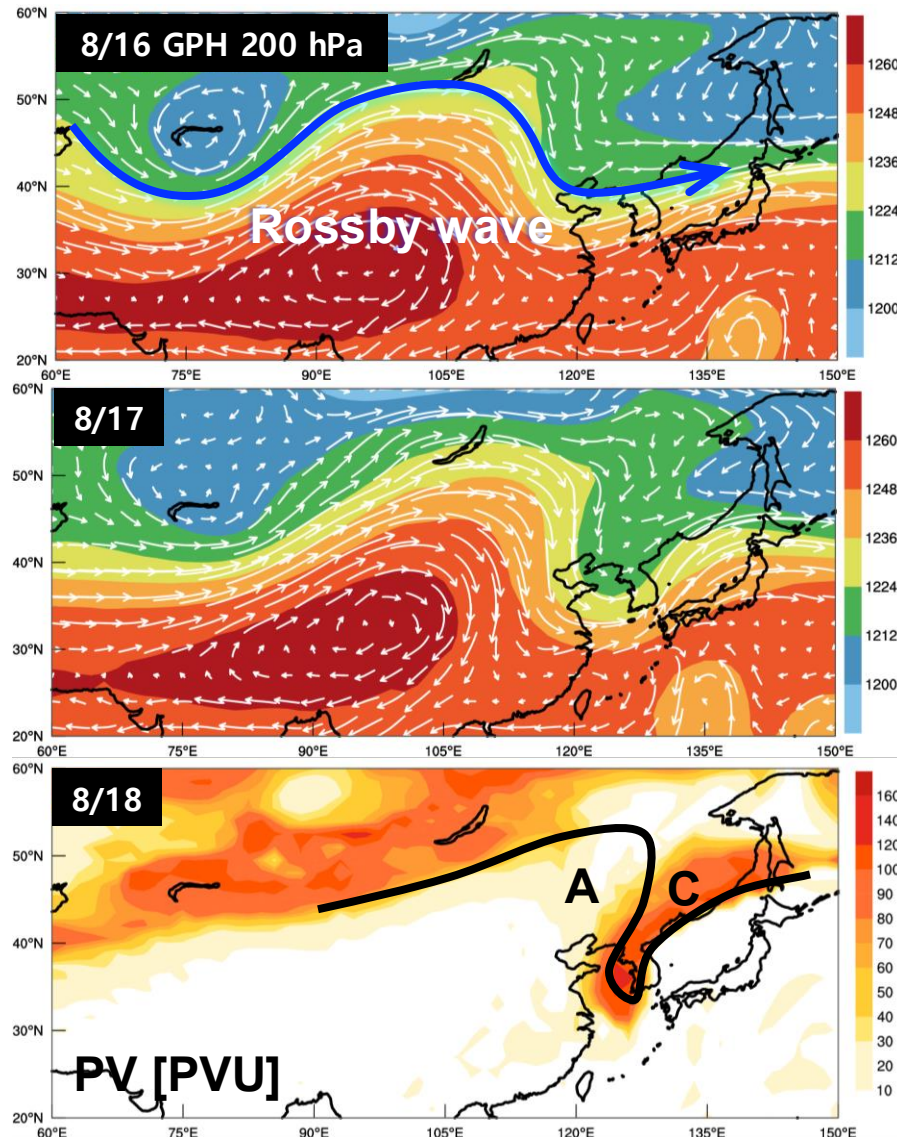
Event ① : STE case in 2021

Rossby wave breaking

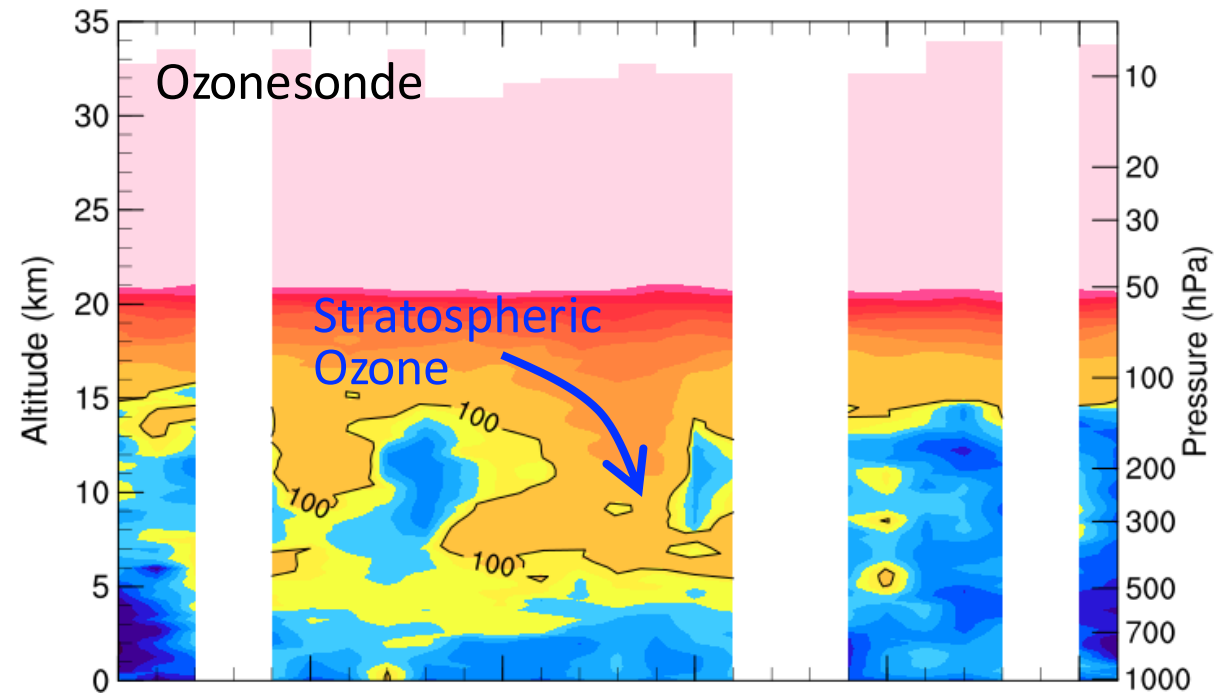
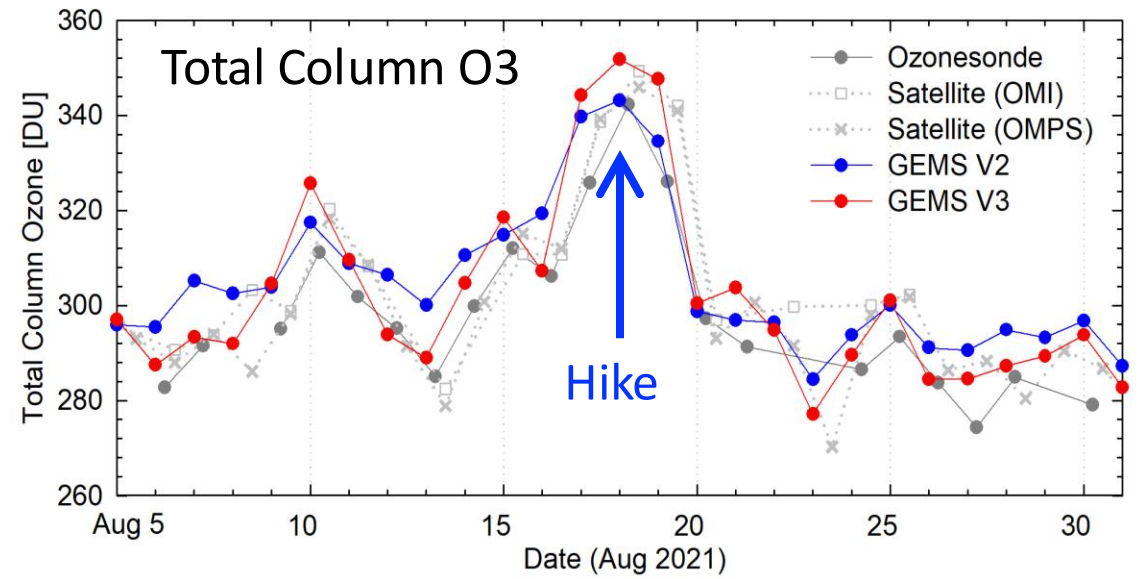
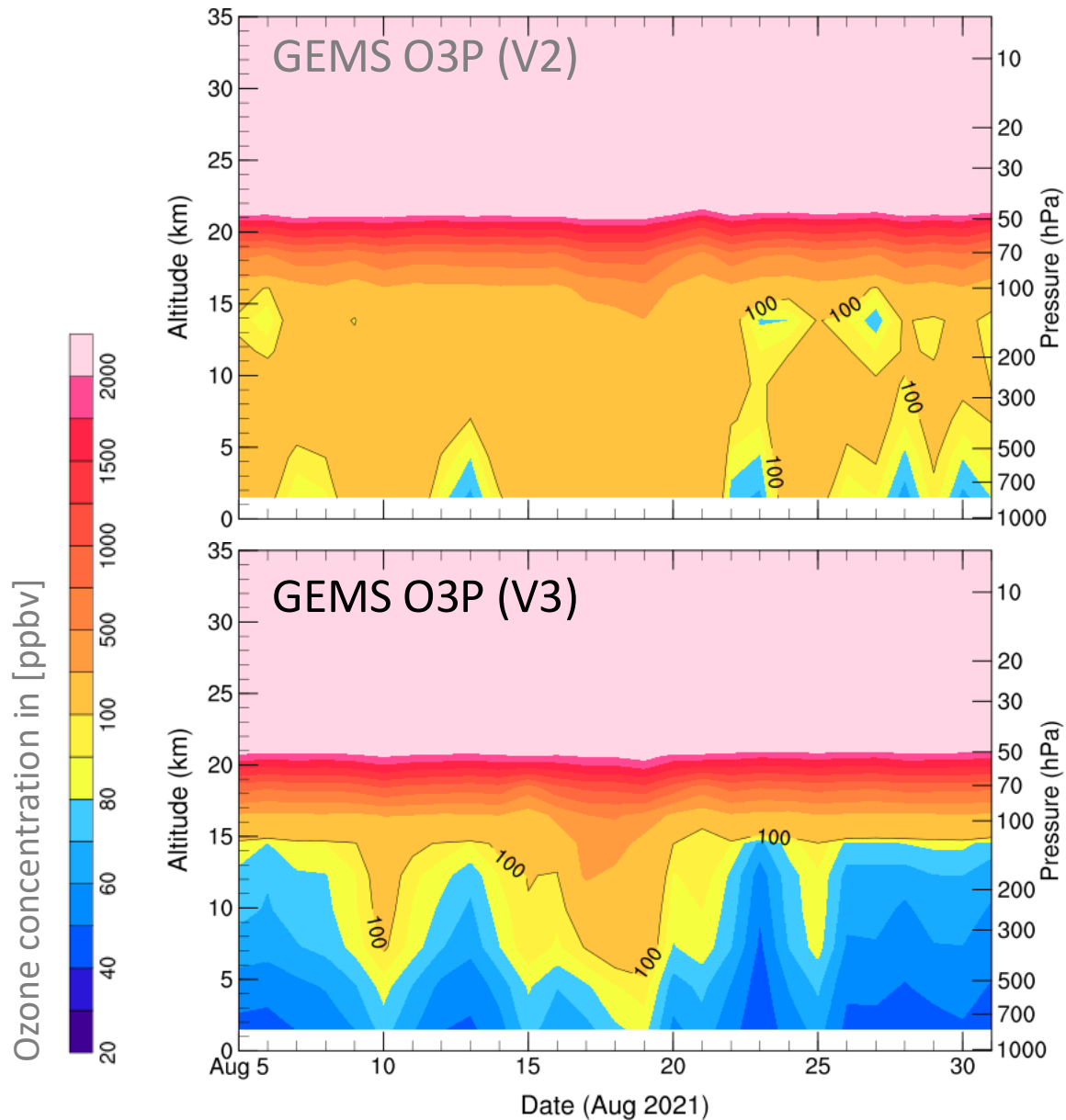


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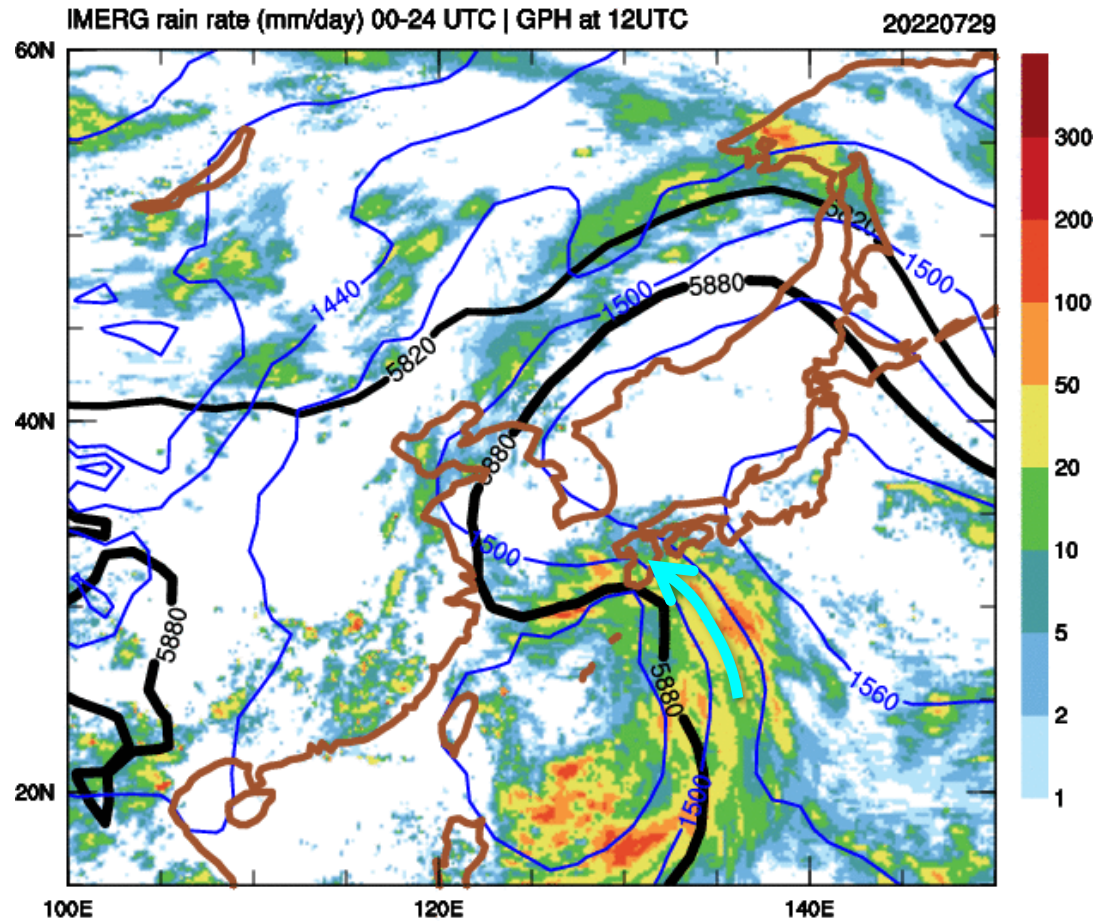


Event ① : STE case in 2021

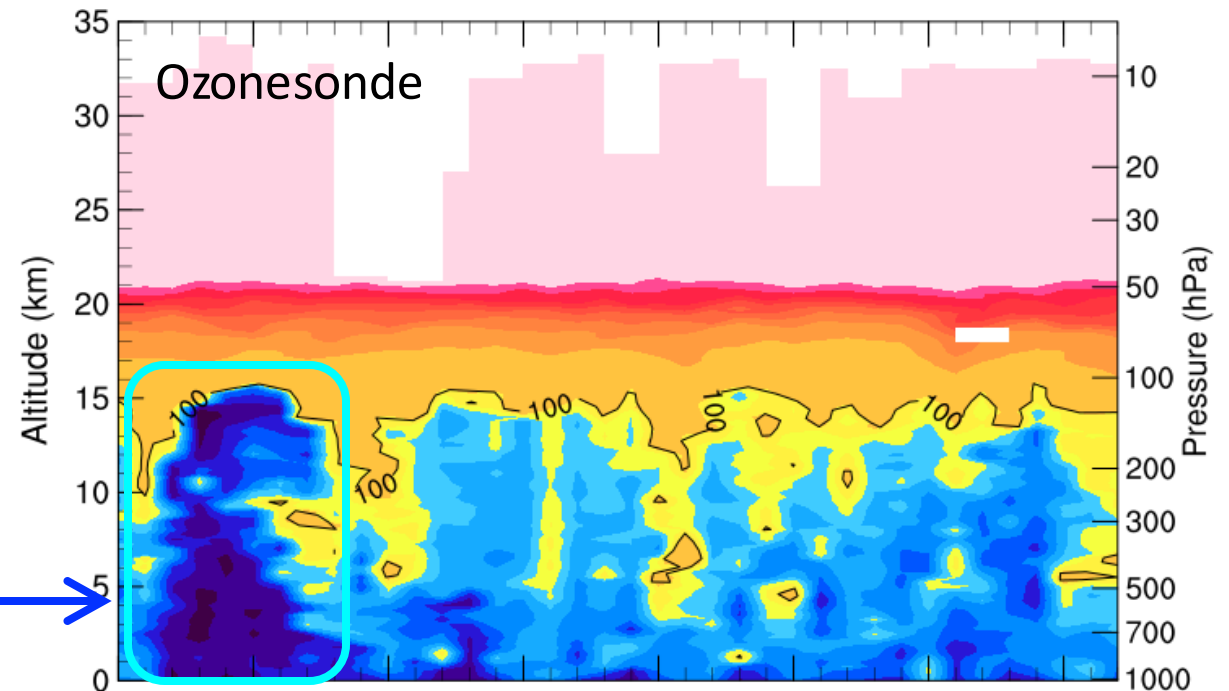
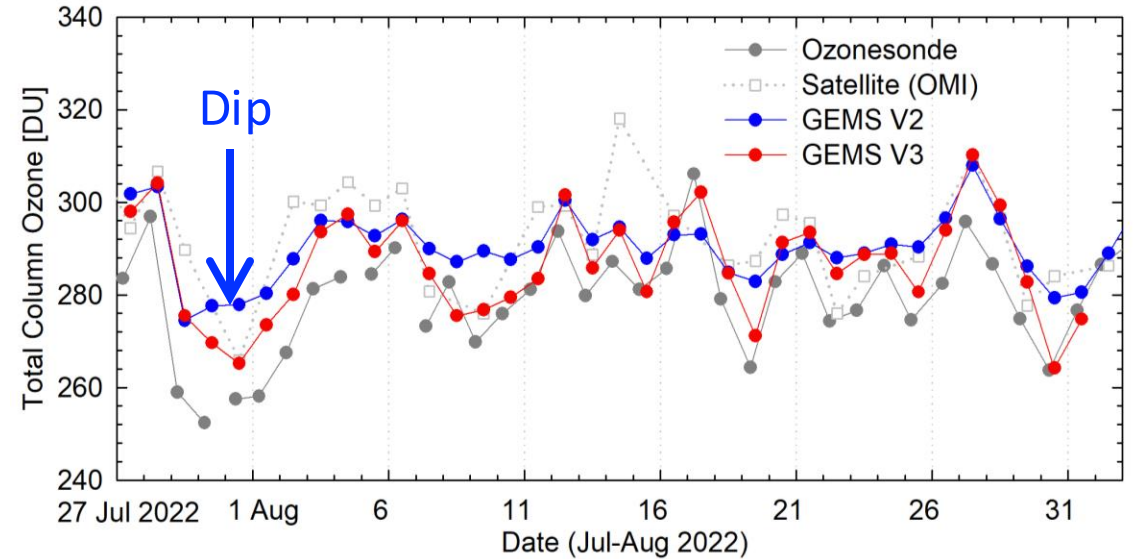


Event ② : Low-O₃ air transport in 2022

Convective activity

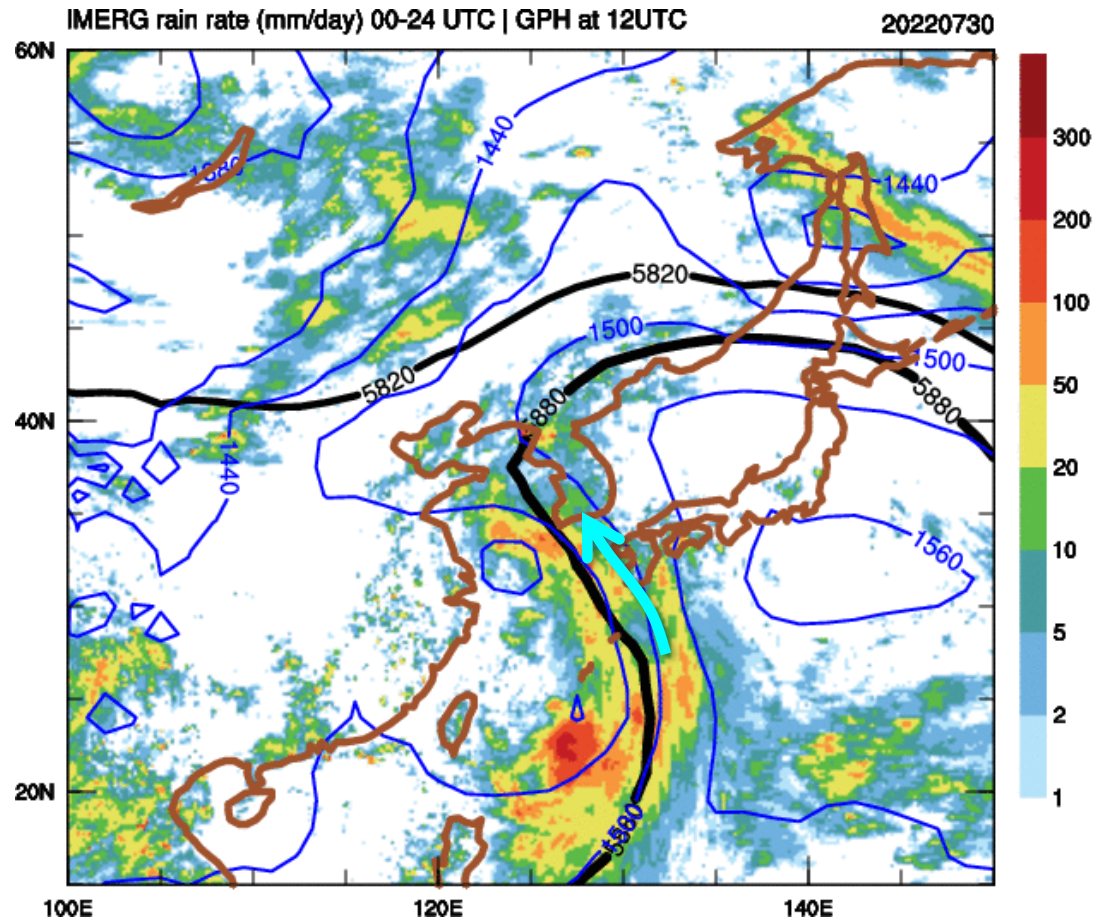


Imerg rain rate (24hr)
GPH 850/500 hPa

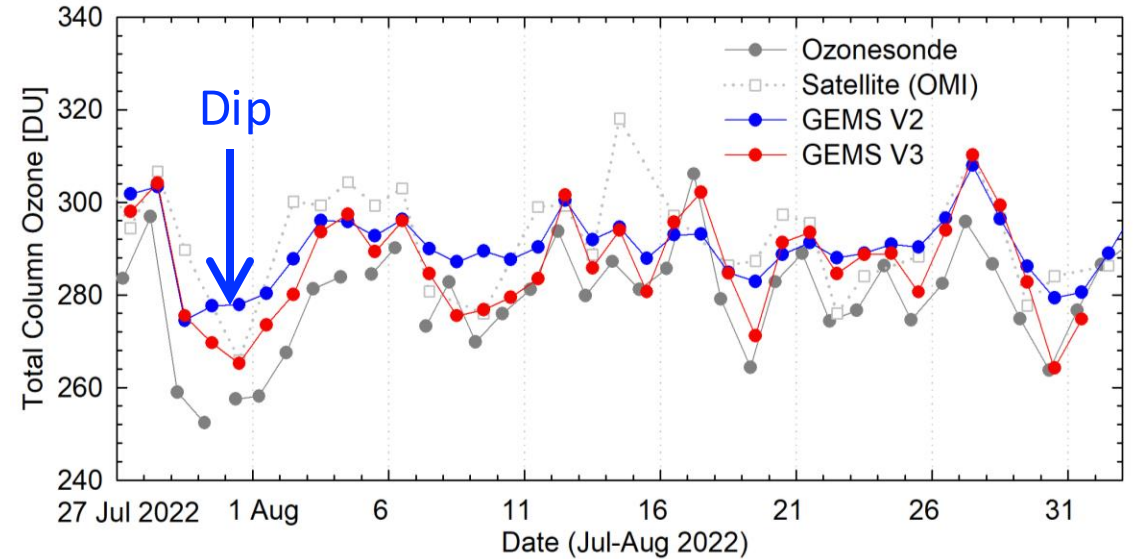


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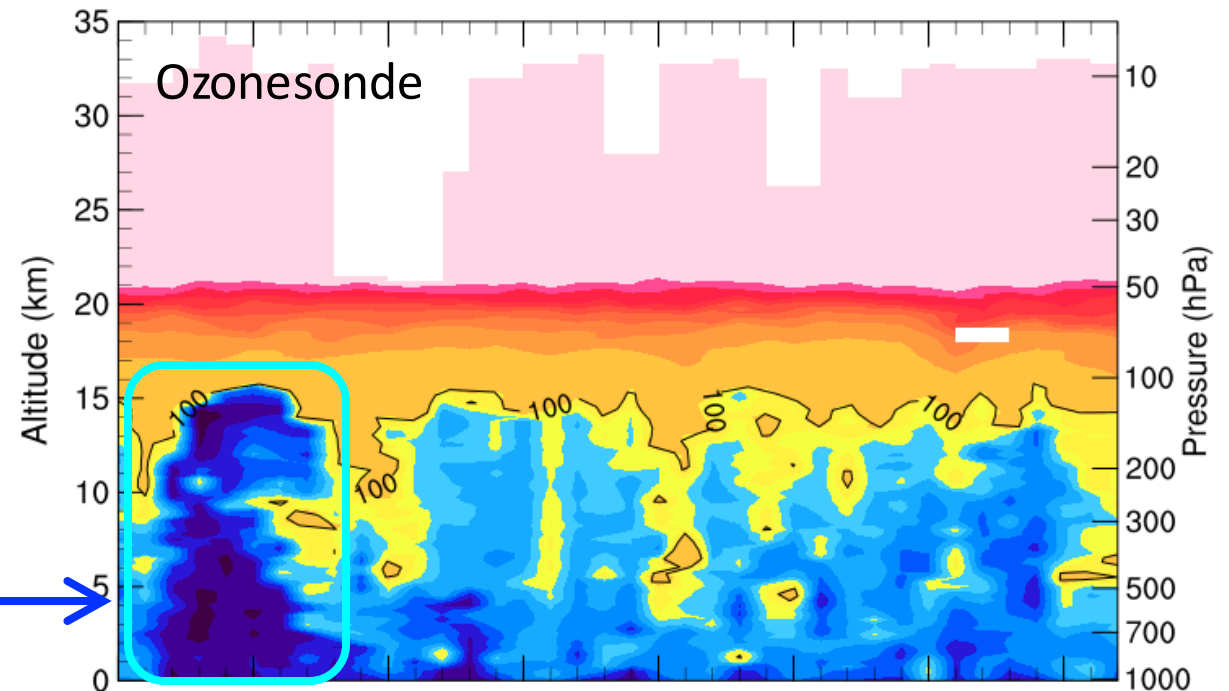
Convective activity



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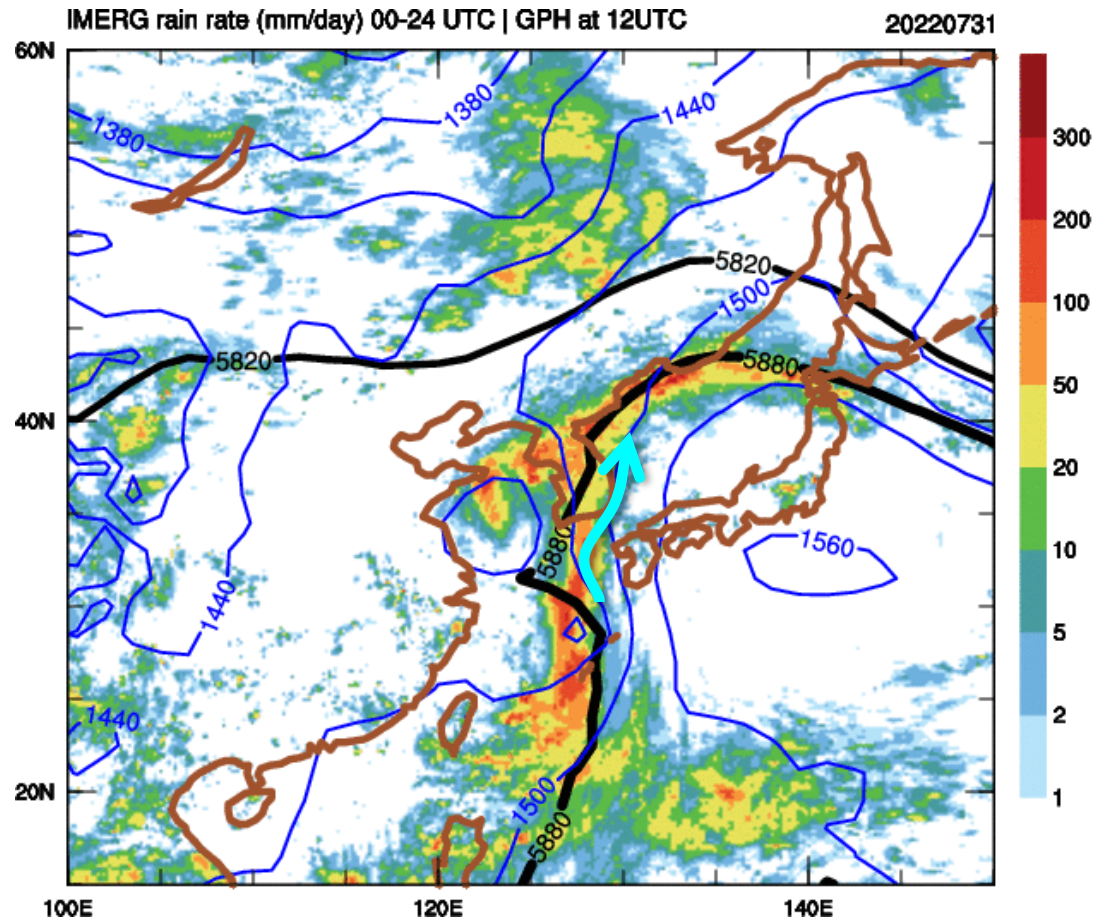


Trop.
O₃ min →

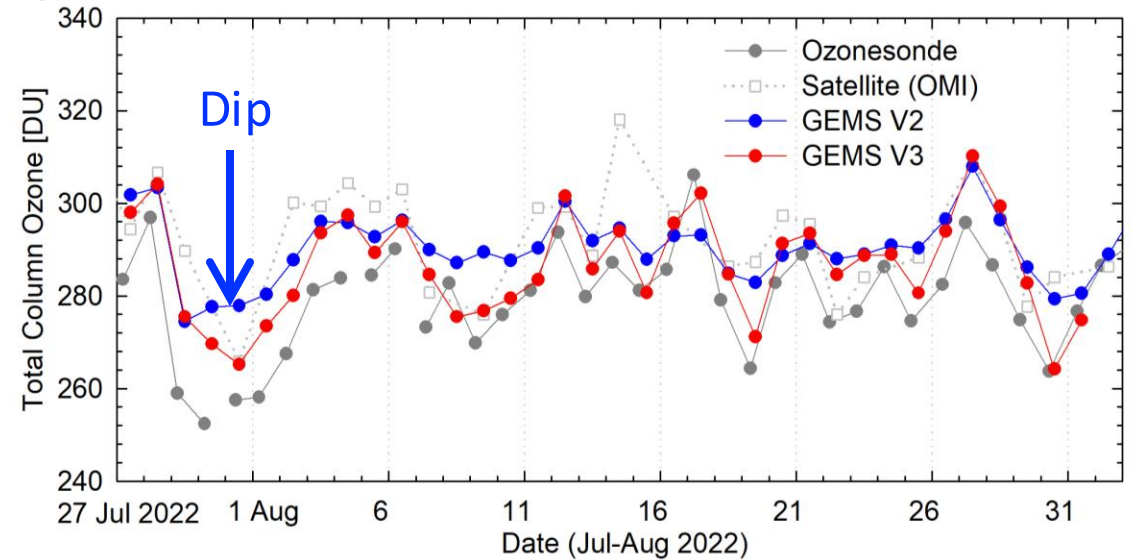


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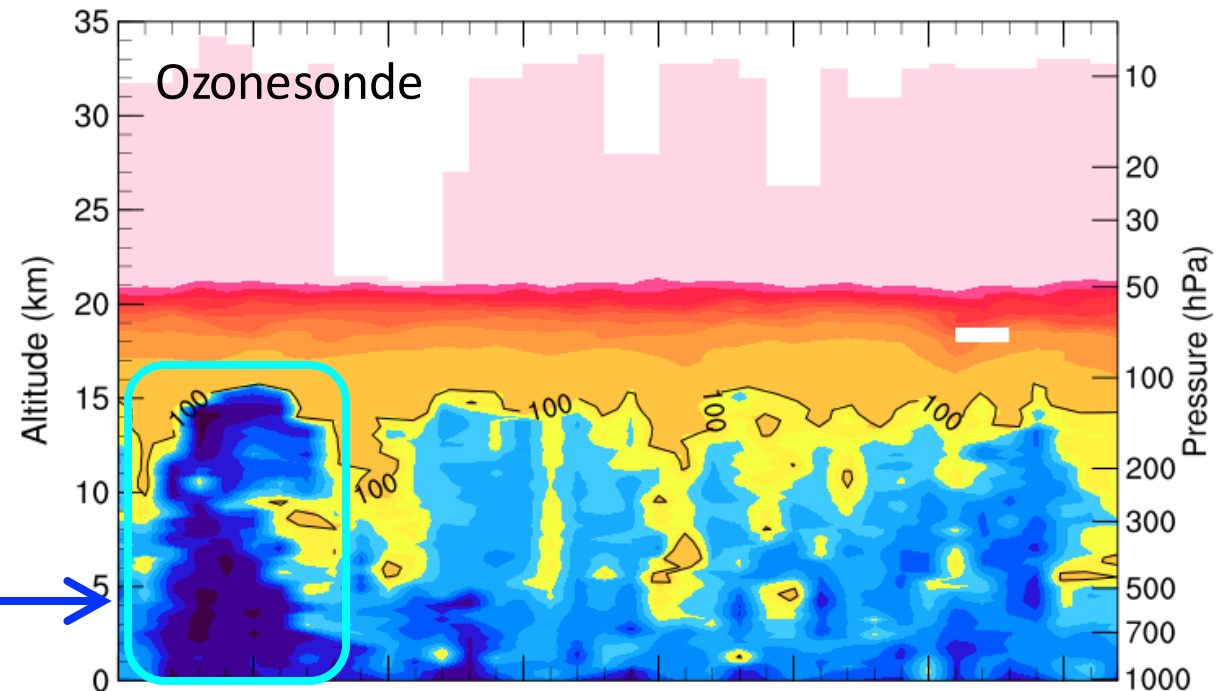
Convective activity



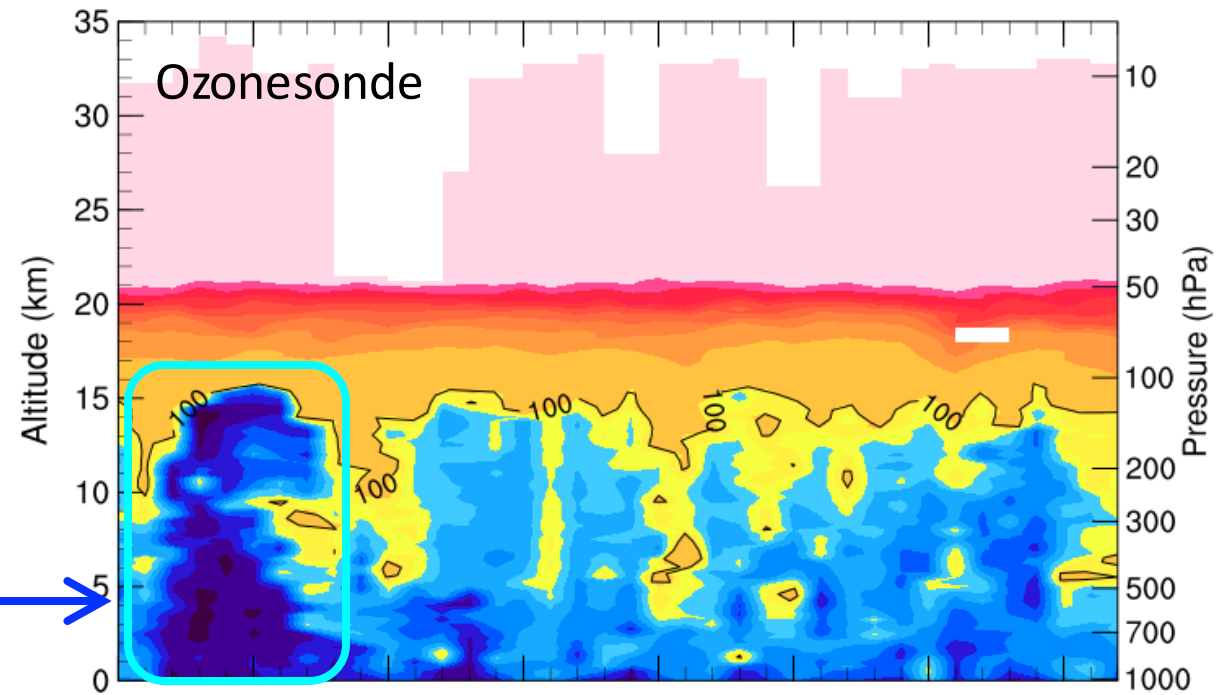
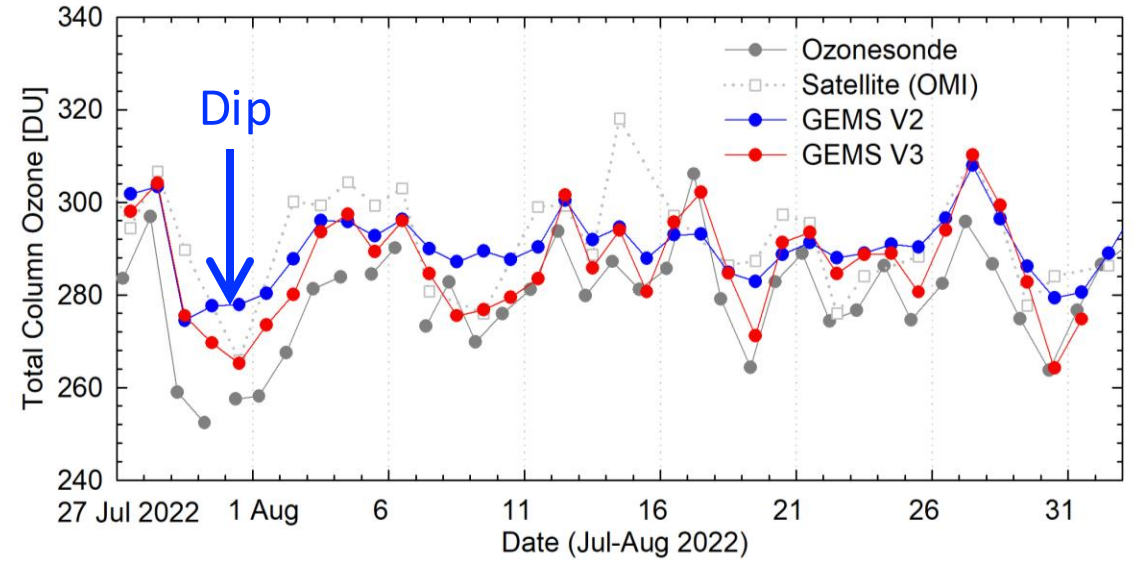
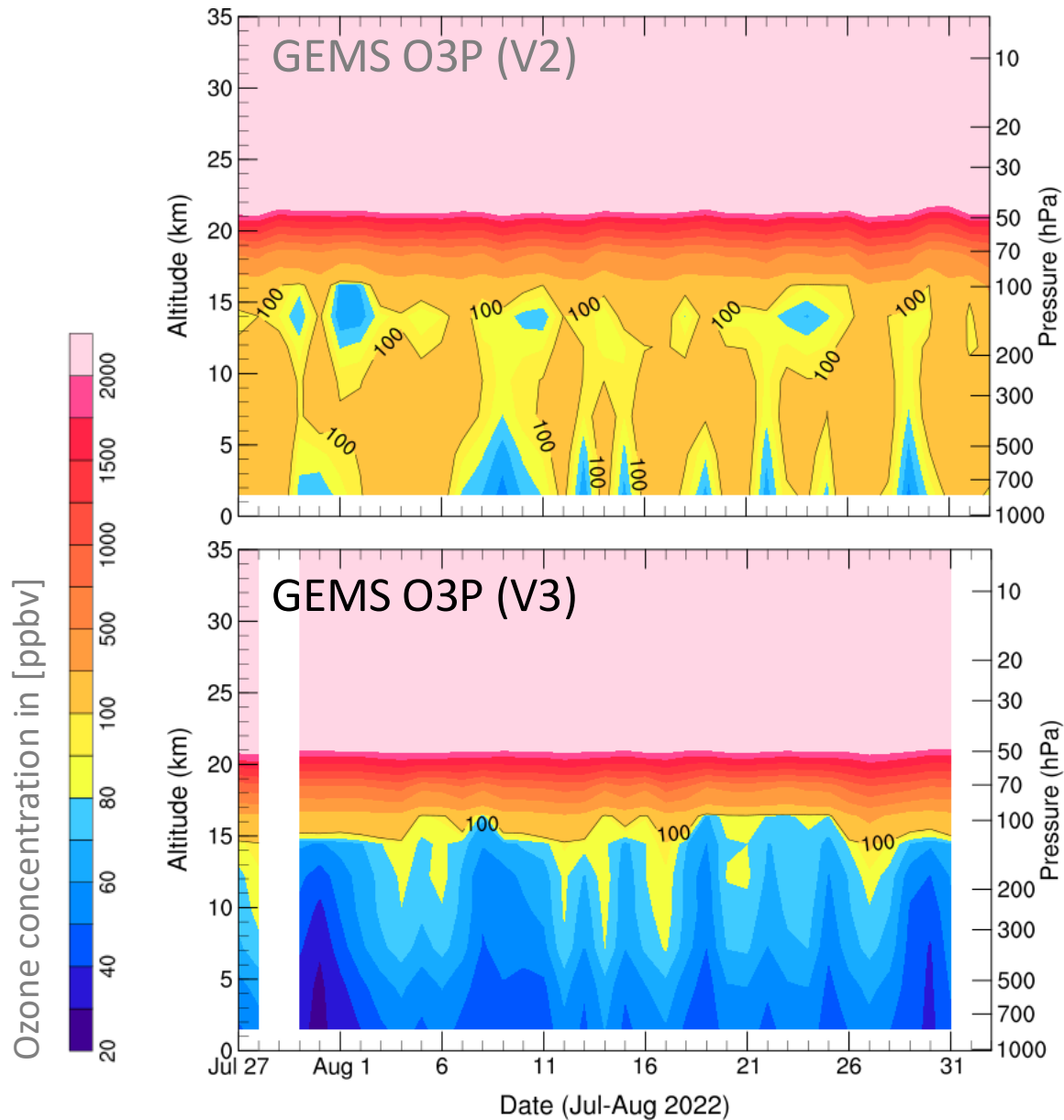
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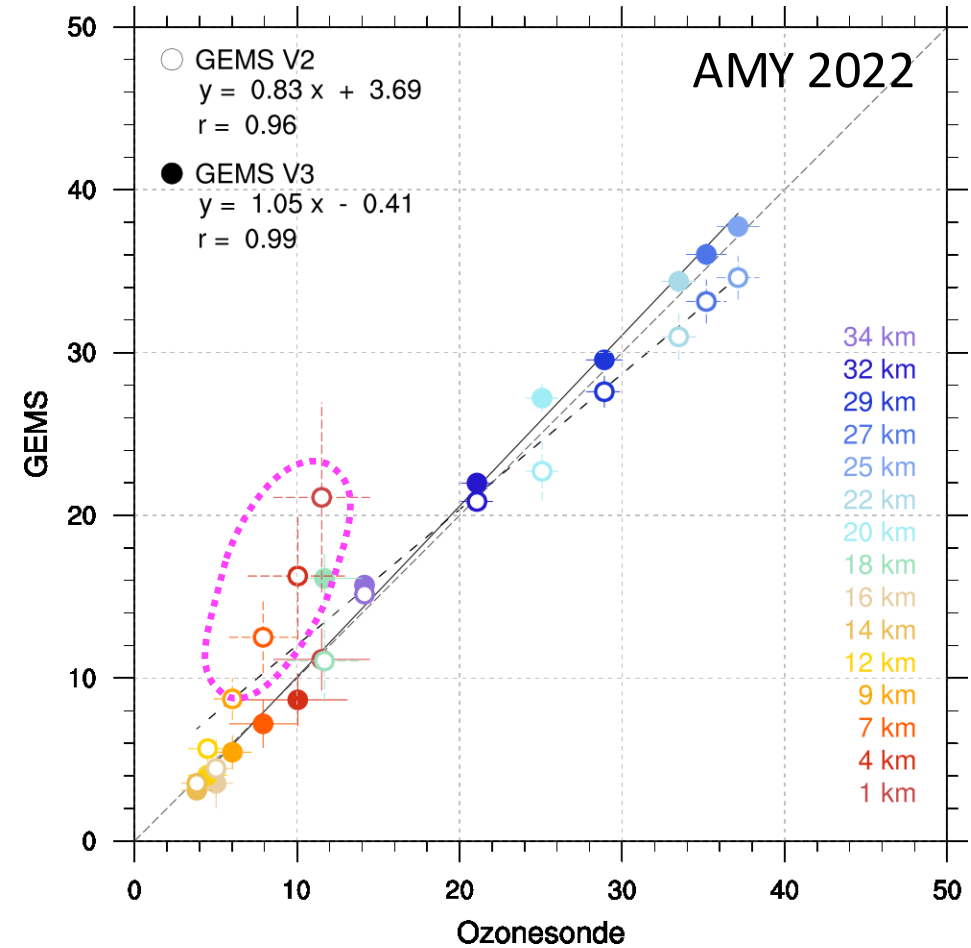
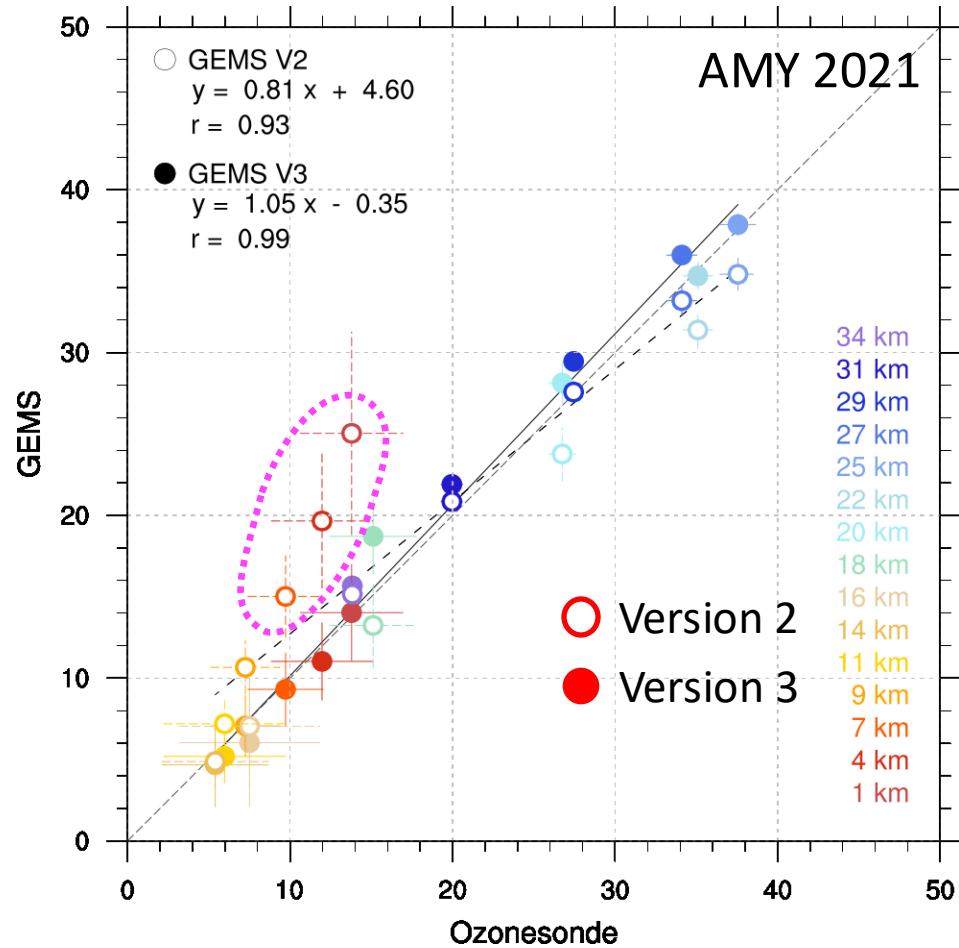
Trop.
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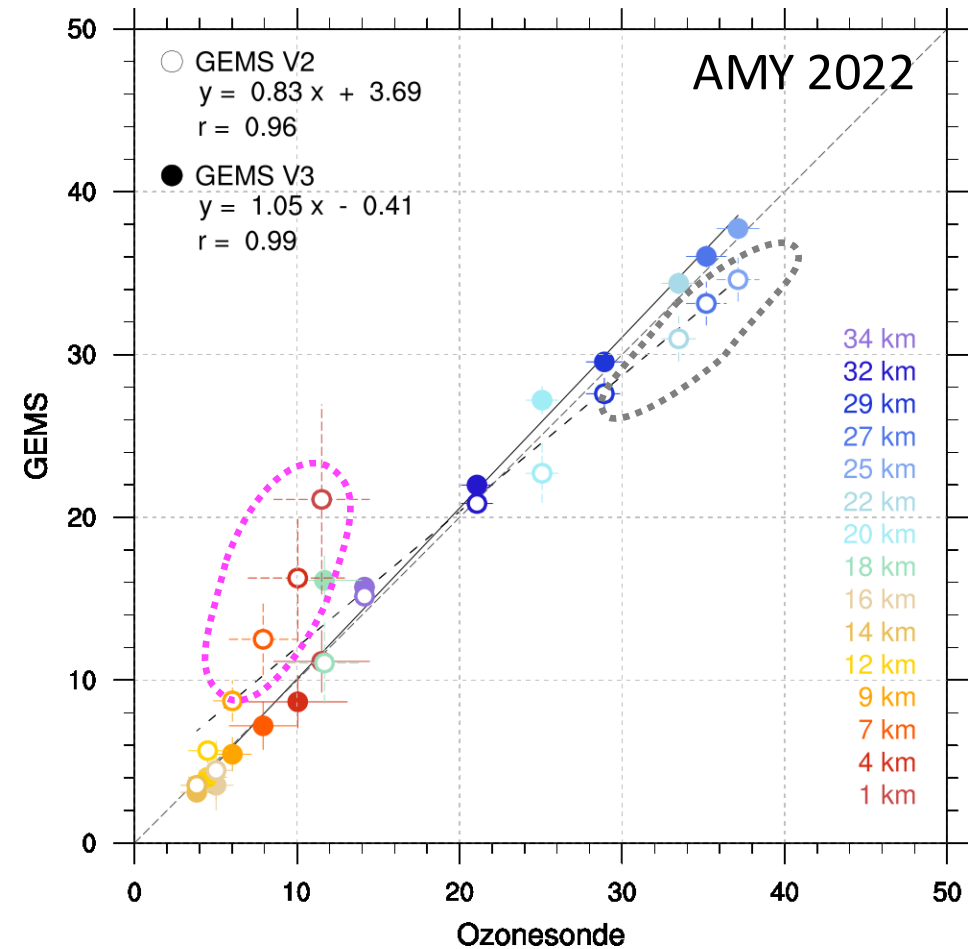
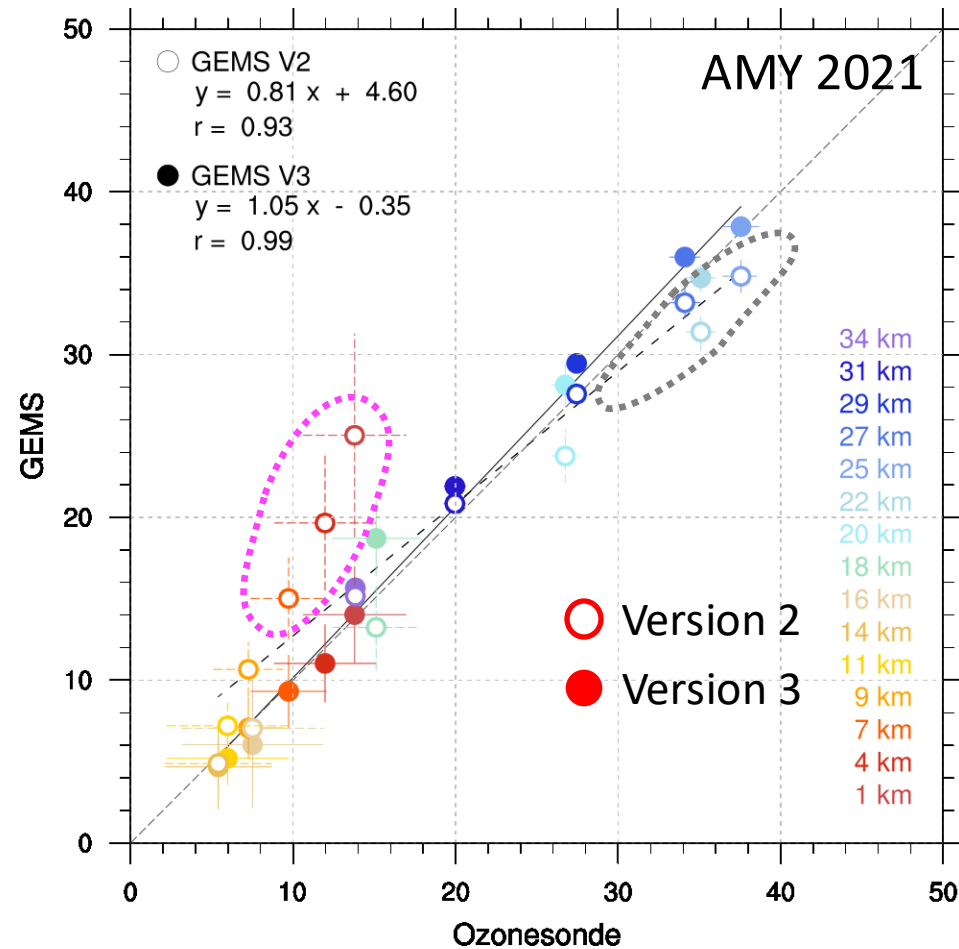


Comparison: level-to-level



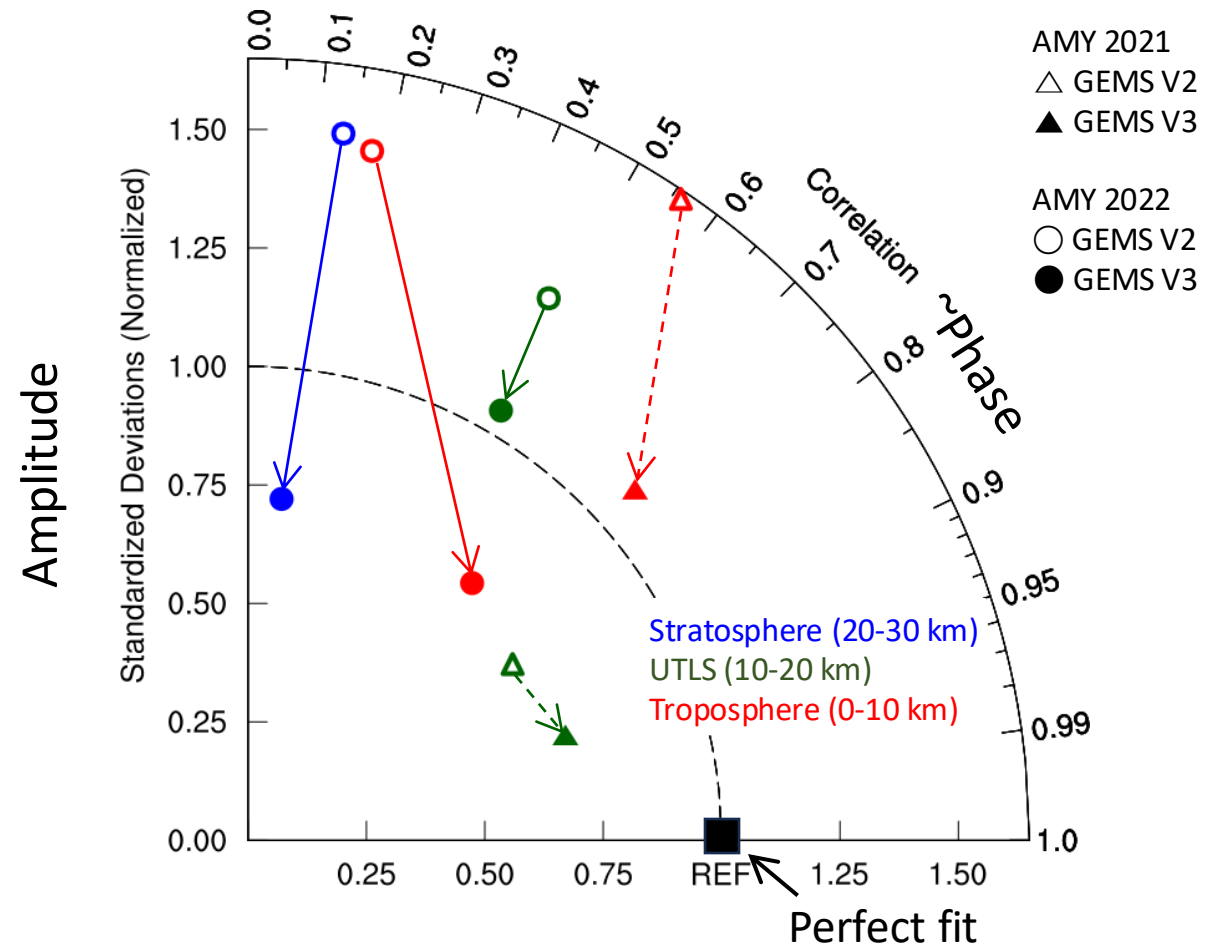
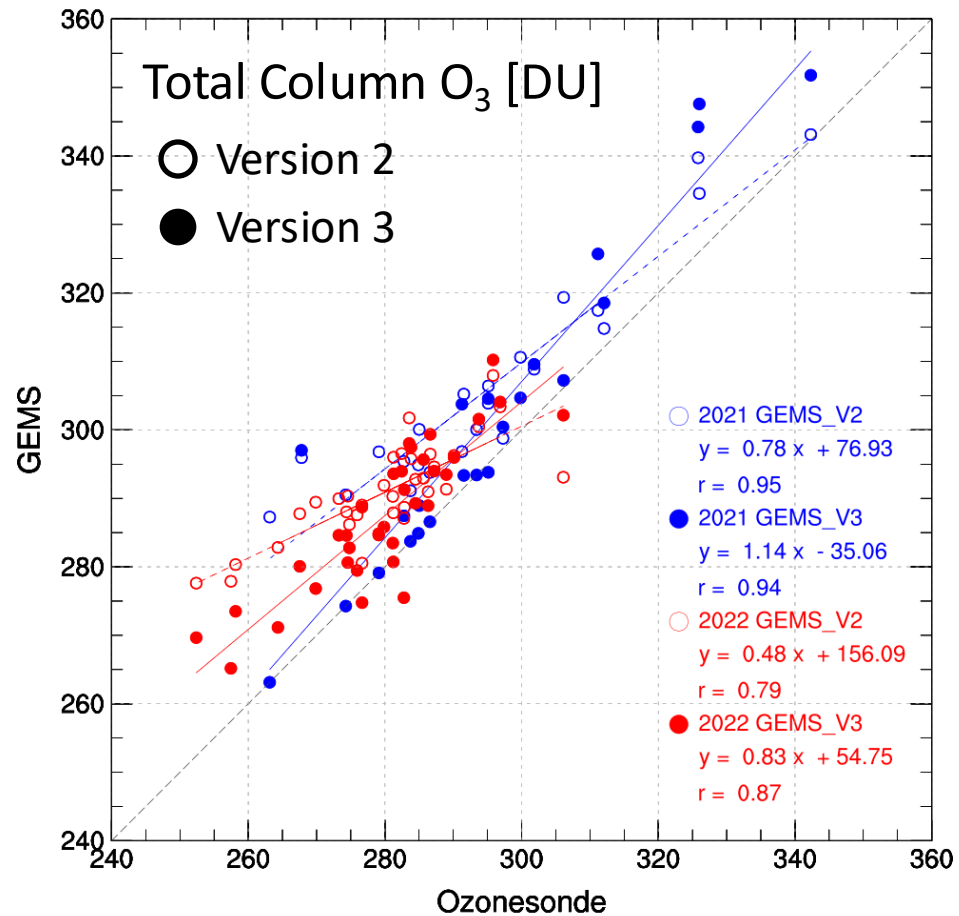
Significant improvements are made in the troposphere (largest near the surface),

Comparison: level-to-level



Significant improvements are made **in the troposphere** (largest near the **surface**), accompanied by notable upgrades in the stratosphere as well.

Comparison: day-to-day (synoptic time scale)



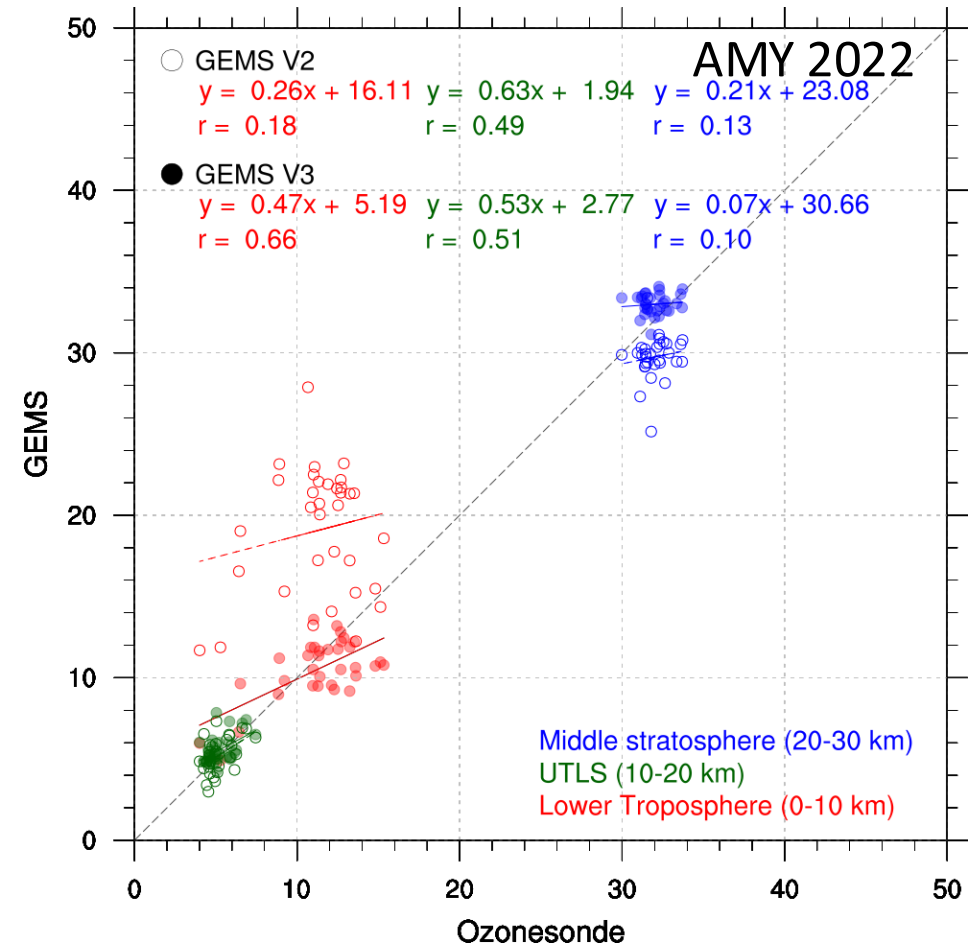
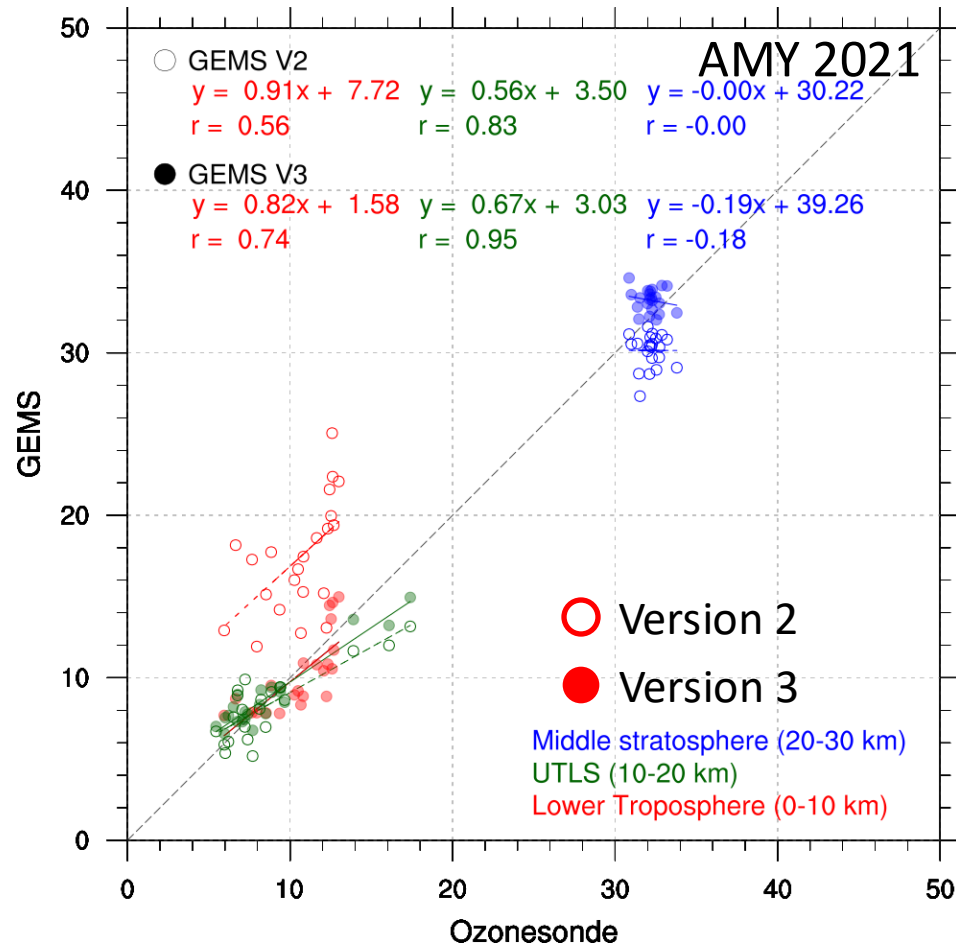
Daily variability shows a better fit to the ozonesonde observation
RMSEs in temporal variance are significantly reduced in most levels

Summary

- Daily variability in O_3 (due to STE, transport, convective influence, etc.) provides a good opportunity for (geo-ring) satellite data evaluation.
- GEMS O3P (ver.3) is significantly improved in terms of both accuracy and temporal variability.
(Large improvement in tropospheric and near-surface values)
- ACCLIP Ozonesonde data are available (https://data.eol.ucar.edu/master_lists/generated/acclip/)
[Site A: AMY] Daily (**INTERP100m: 100-m interpolated**) [Site B: OSN] O_3 + SWV + Aerosol PC
Just google "EOLACCLIP"



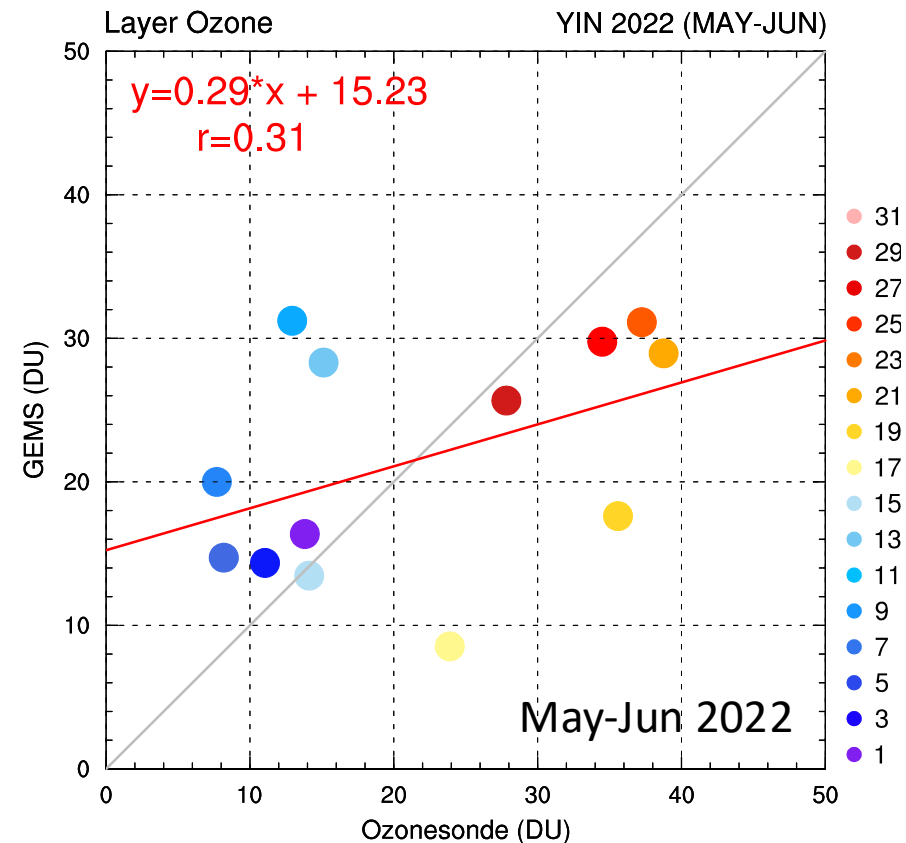
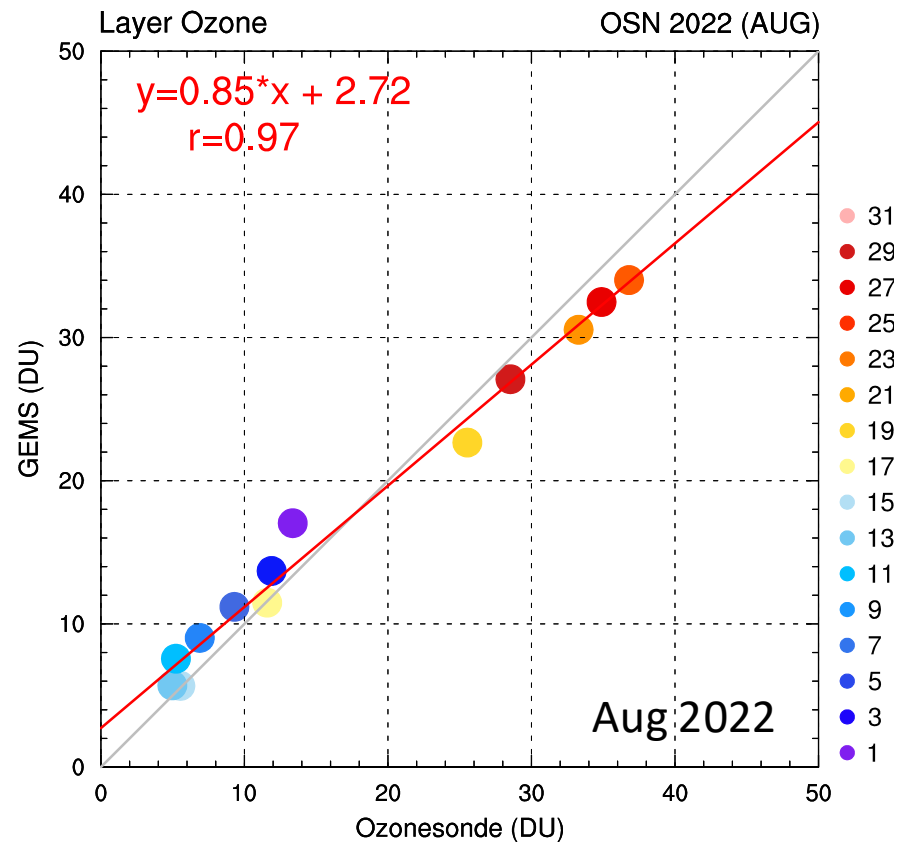
Daily variability



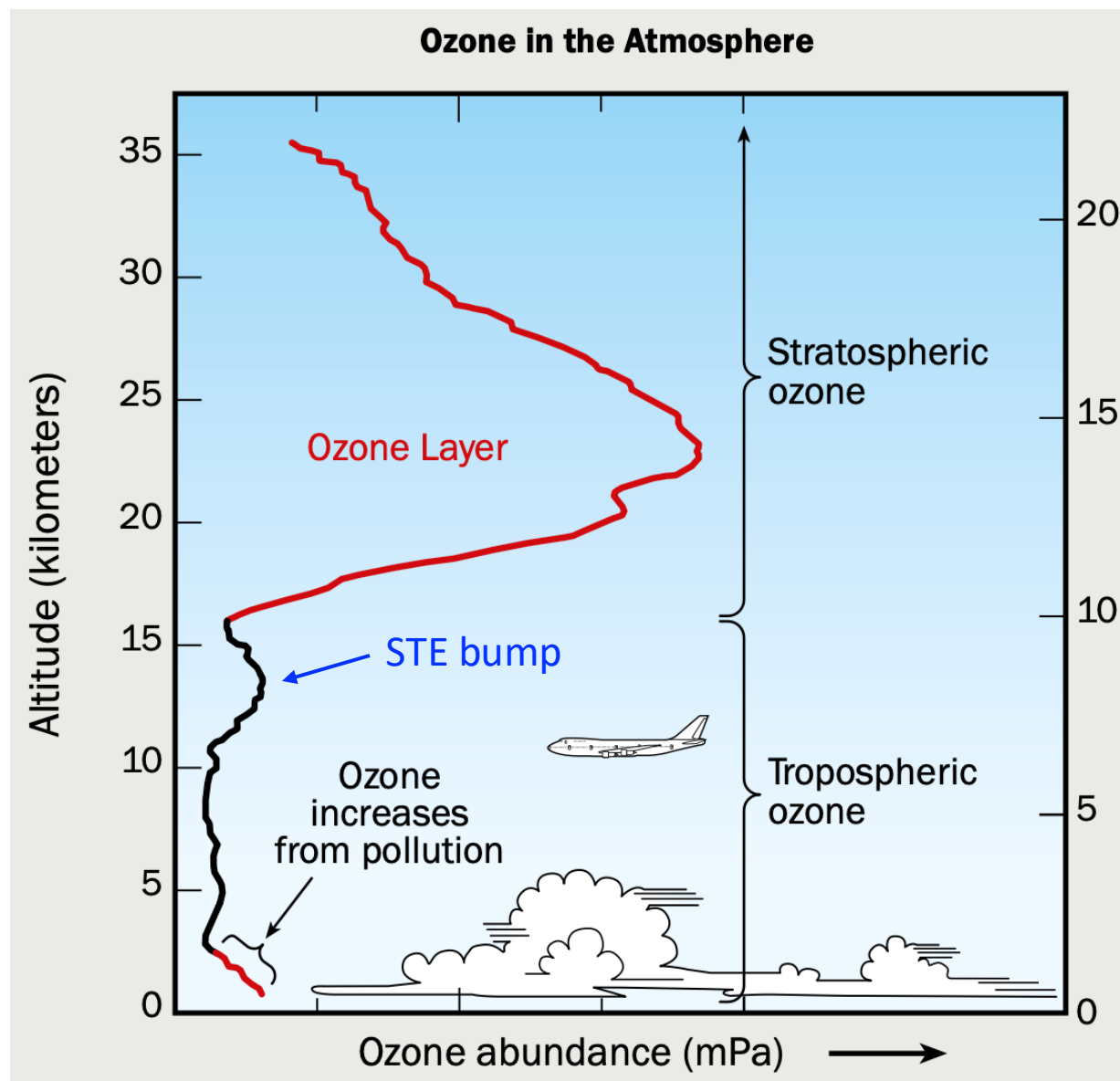
Significant improvements are made in the troposphere (largest near the **surface**), accompanied by notable upgrades in the stratosphere as well.

GEMS evaluation

- GEMS Total Column Ozone compares well with the ozonesonde measurements
- GEMS Ozone profile product reasonably captures UTLS O3 reduction during Aug 2022
- However, it still needs improvement for cases with strong UTLS O3 mixing
(need further evaluation for different seasons)



Ozonesonde distribution (vertical)



Stratospheric Ozone

Feature: 90% of atmospheric ozone

Benefit: Primary UV radiation shield

Issues: Antarctic ozone hole each year

Arctic ozone losses

Decreasing trends in LS?

Tropospheric Ozone

Feature: 10% of atmospheric ozone

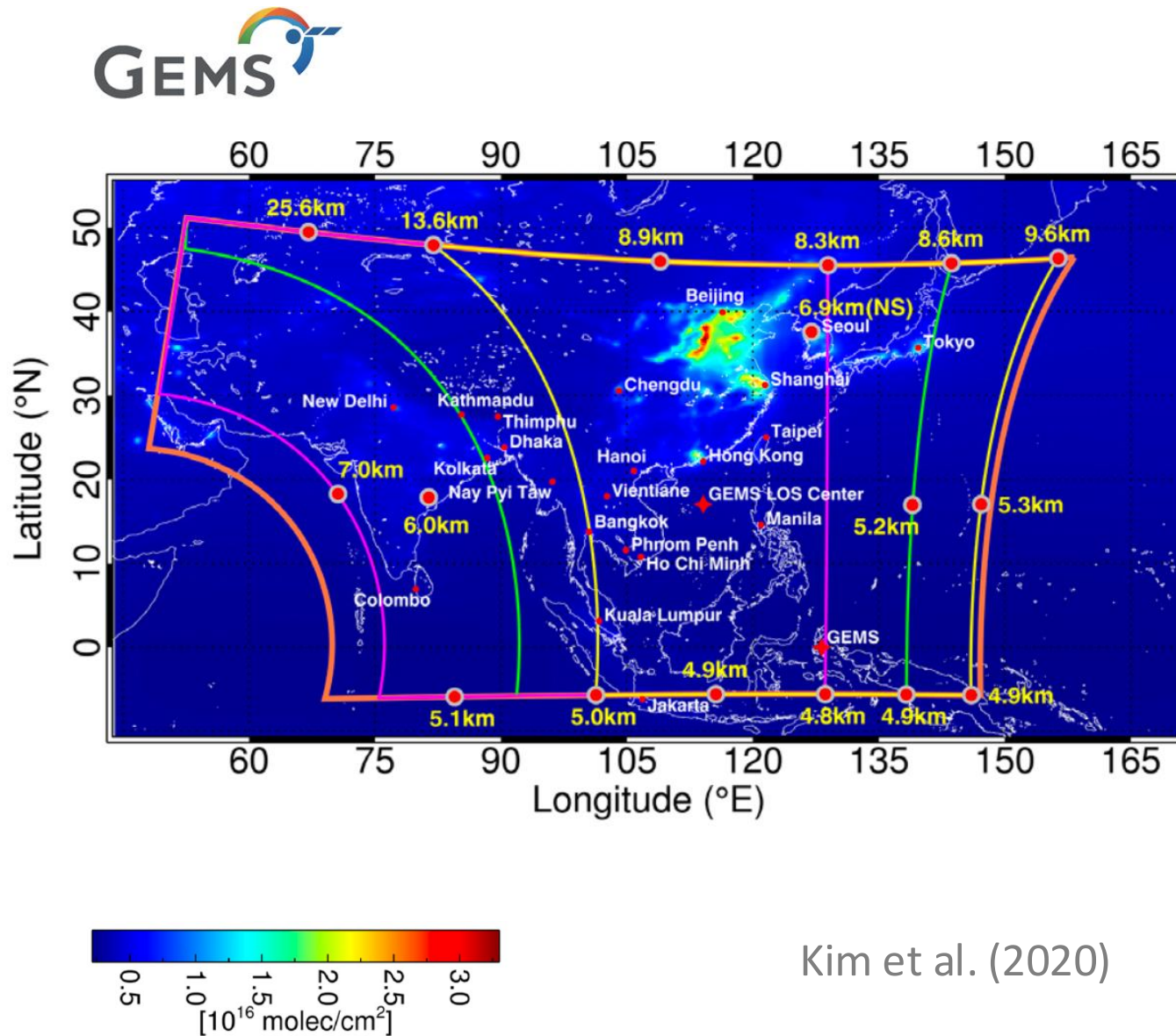
Impact: toxic to living creatures

Issues: High ozone events in cities

Increasing trends in Asia

Scientific Assessment Of Ozone Depletion (2014)

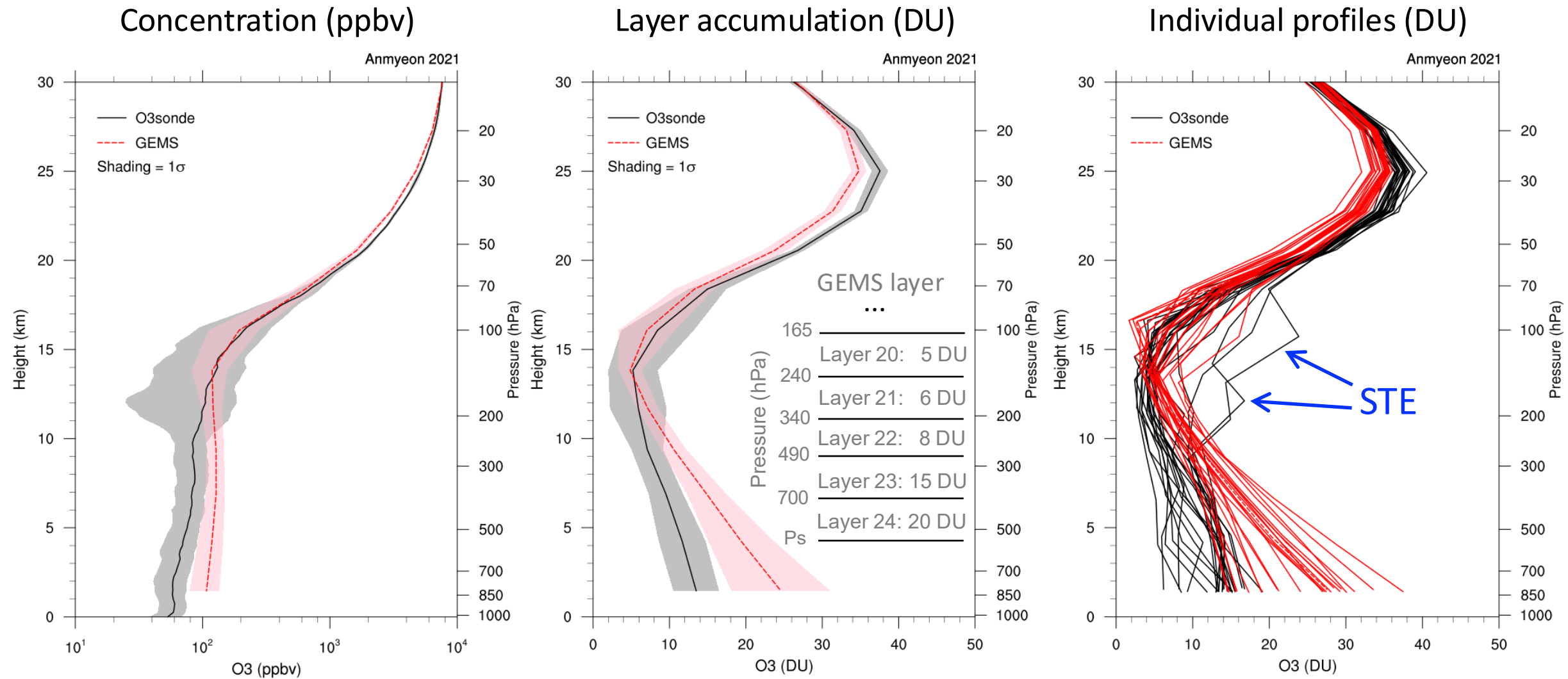
GEMS ozone product (O3P, O3T)



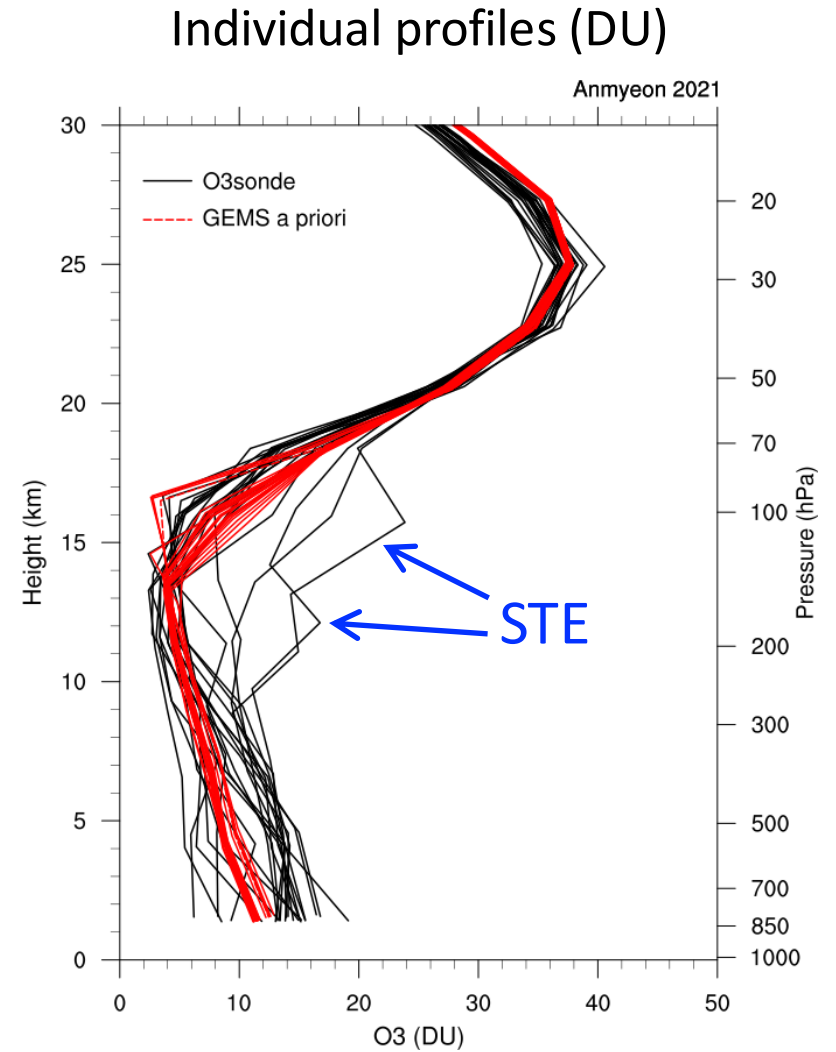
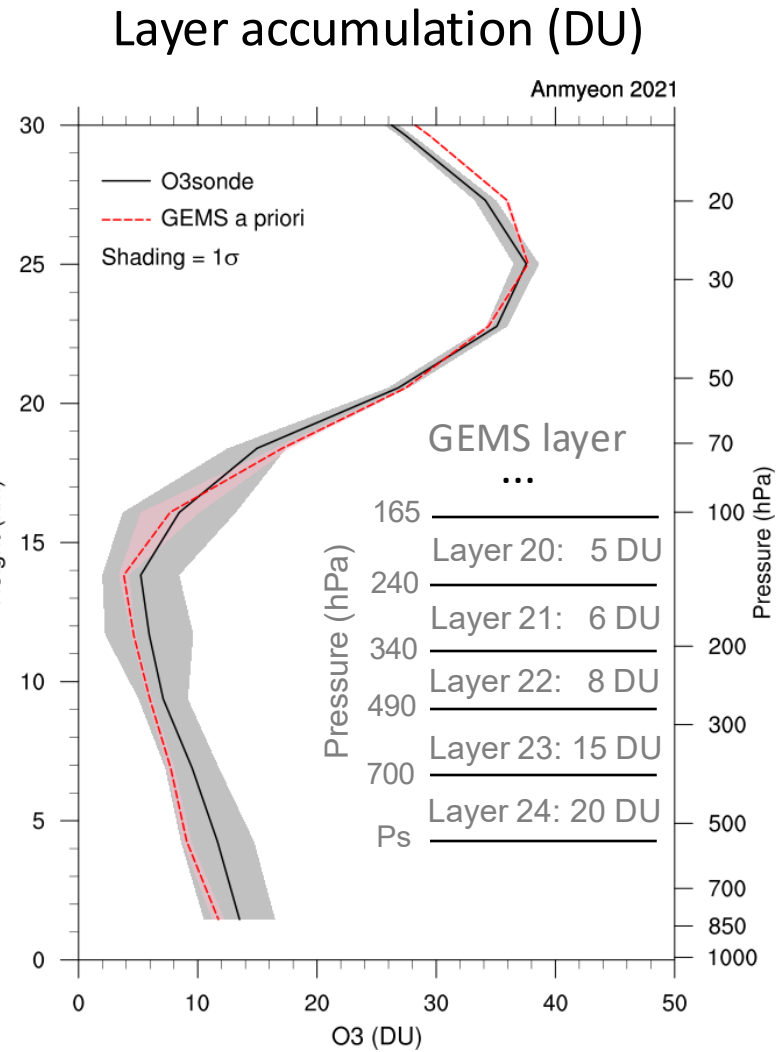
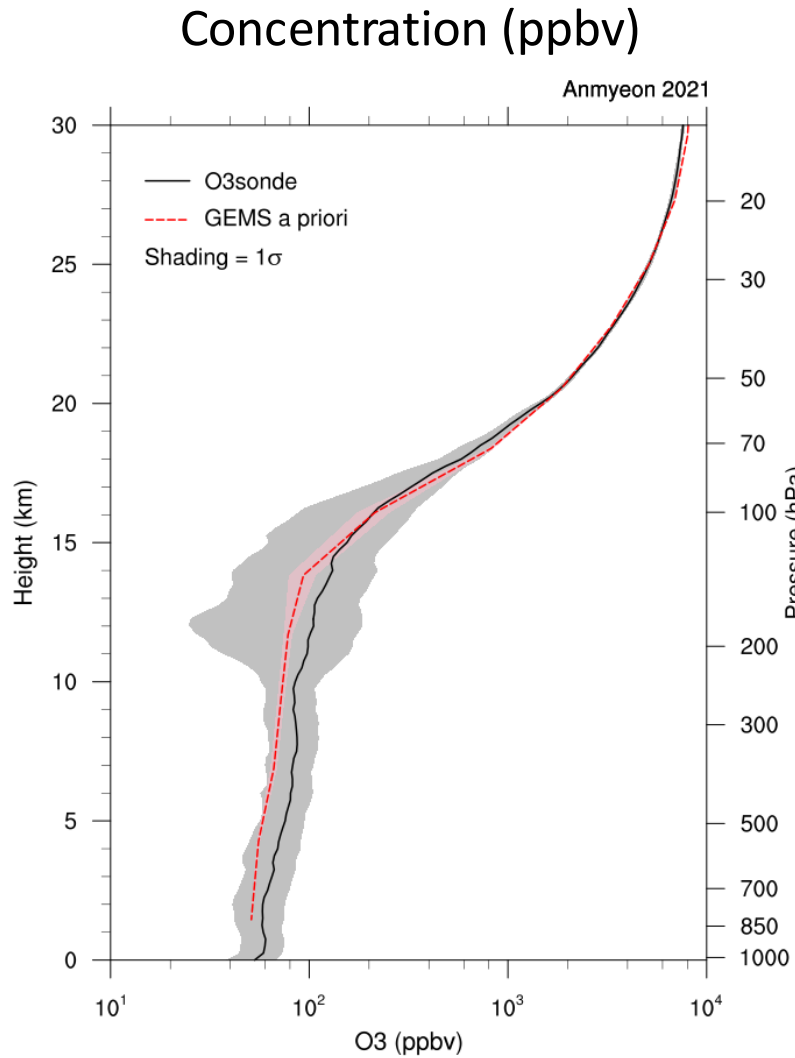
Kim et al. (2020)

Product	Importance	Accuracy	Window (nm)
NO ₂	TROP STRAT	O ₃ /aerosol precursor 1 × 10 ¹⁵ molecules cm ⁻²	432–450
SO ₂	Aerosol precursor	1 × 10 ¹⁶ molecules cm ⁻²	310–326
	Volcano	—	310–340
HCHO	VOC proxy	1 × 10 ¹⁶ molecules cm ⁻²	328.5–356.5
CHOCHO		1 × 10 ¹⁵ molecules cm ⁻²	435–461
O ₃	TROP	Oxidant, pollutant 20%	300–340
	STRAT	5%	300–340
	Total	Ozone layer 3%	317.5, 331.2 331.2, 340, 380
Aerosol	AOD	Air quality, climate	20% or 0.1 at 400 nm 354, 388,
	UVAI		412, 443,
	SSA		477, 490
	AEH		477
Cloud	ECF	Retrieval, climate	5% 300–500
	CCP		5% 477
	CRF		—
Surface reflectivity	Retrieval, environment	—	300–500
UVI	UVI	Public health	354
	VitaD		
	DNA		
	Plant		

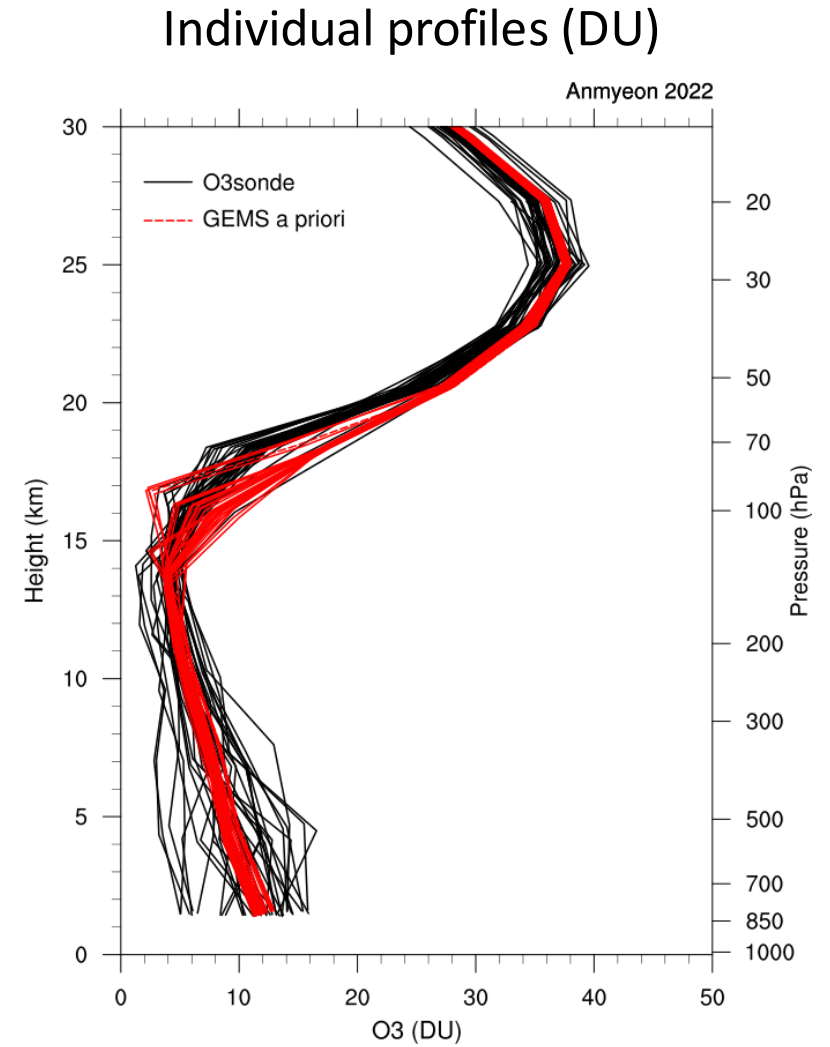
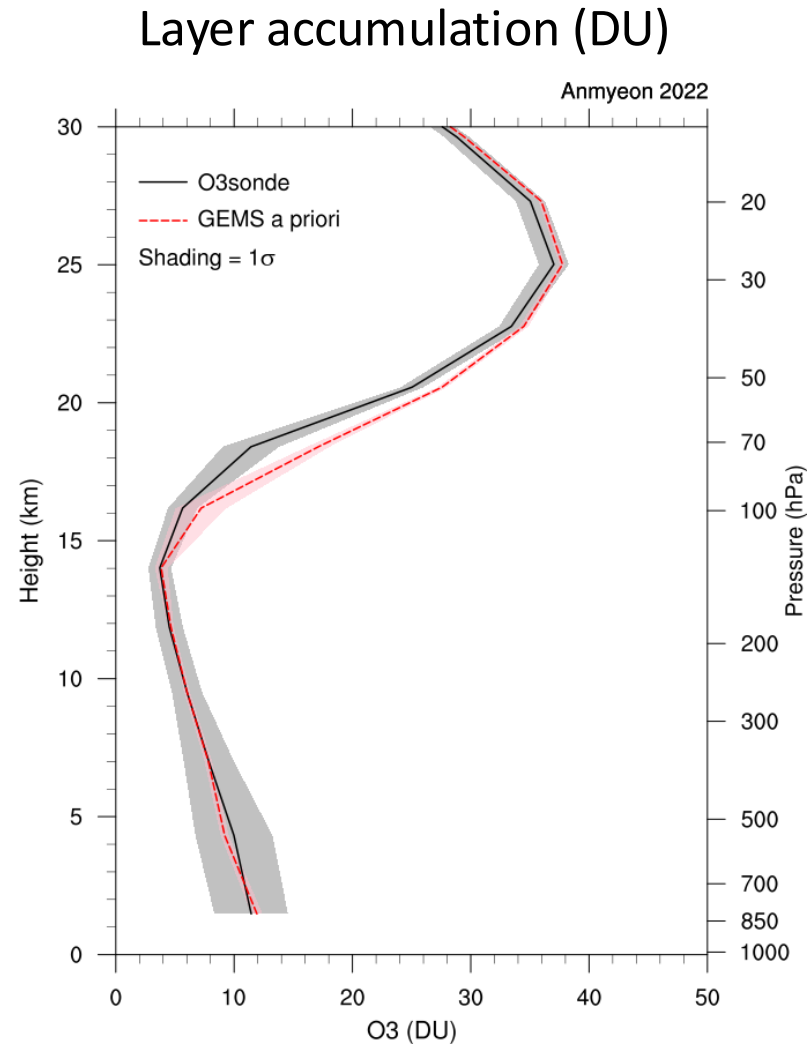
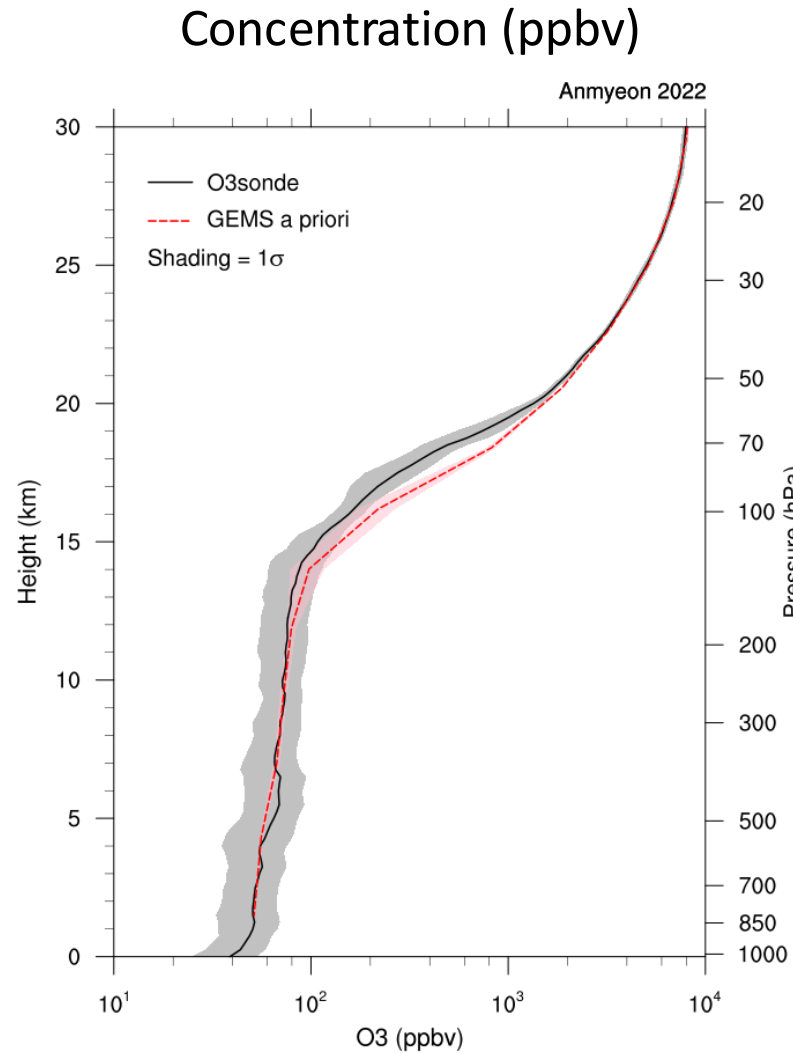
Anmyeon (Aug 2021, 23 profiles) – 03



Anmyeon (Aug 2021, 23 profiles) – O3 a priori

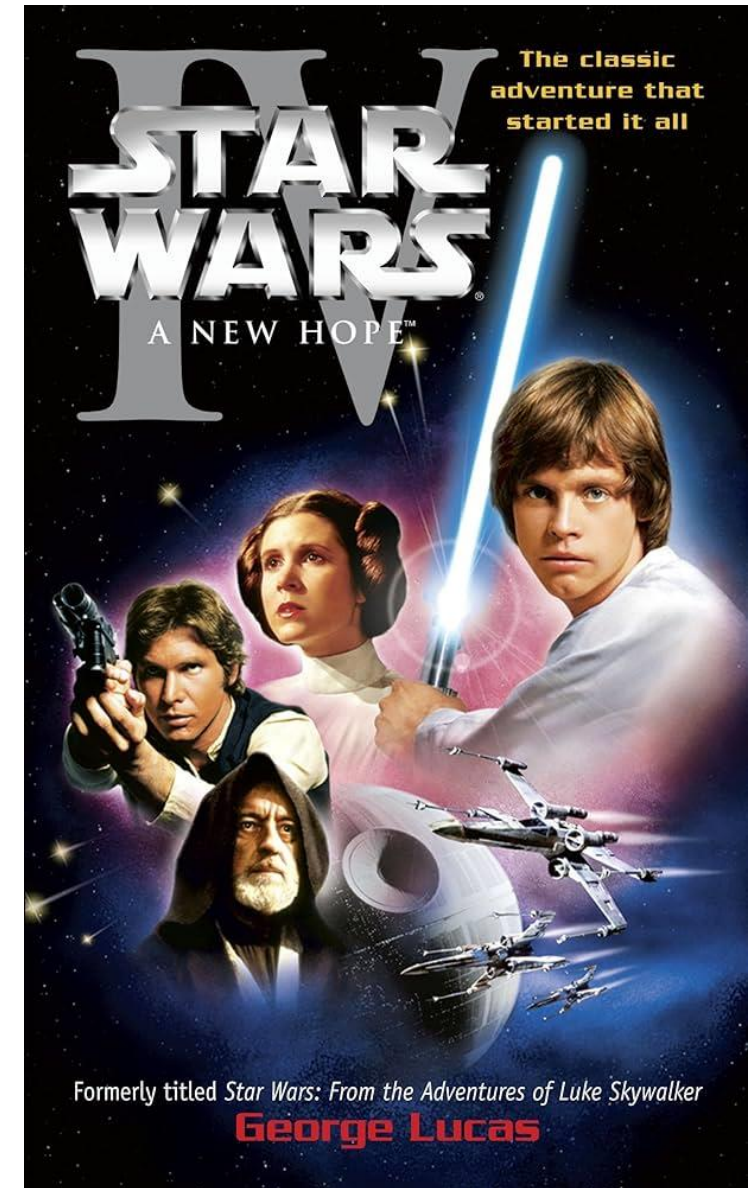
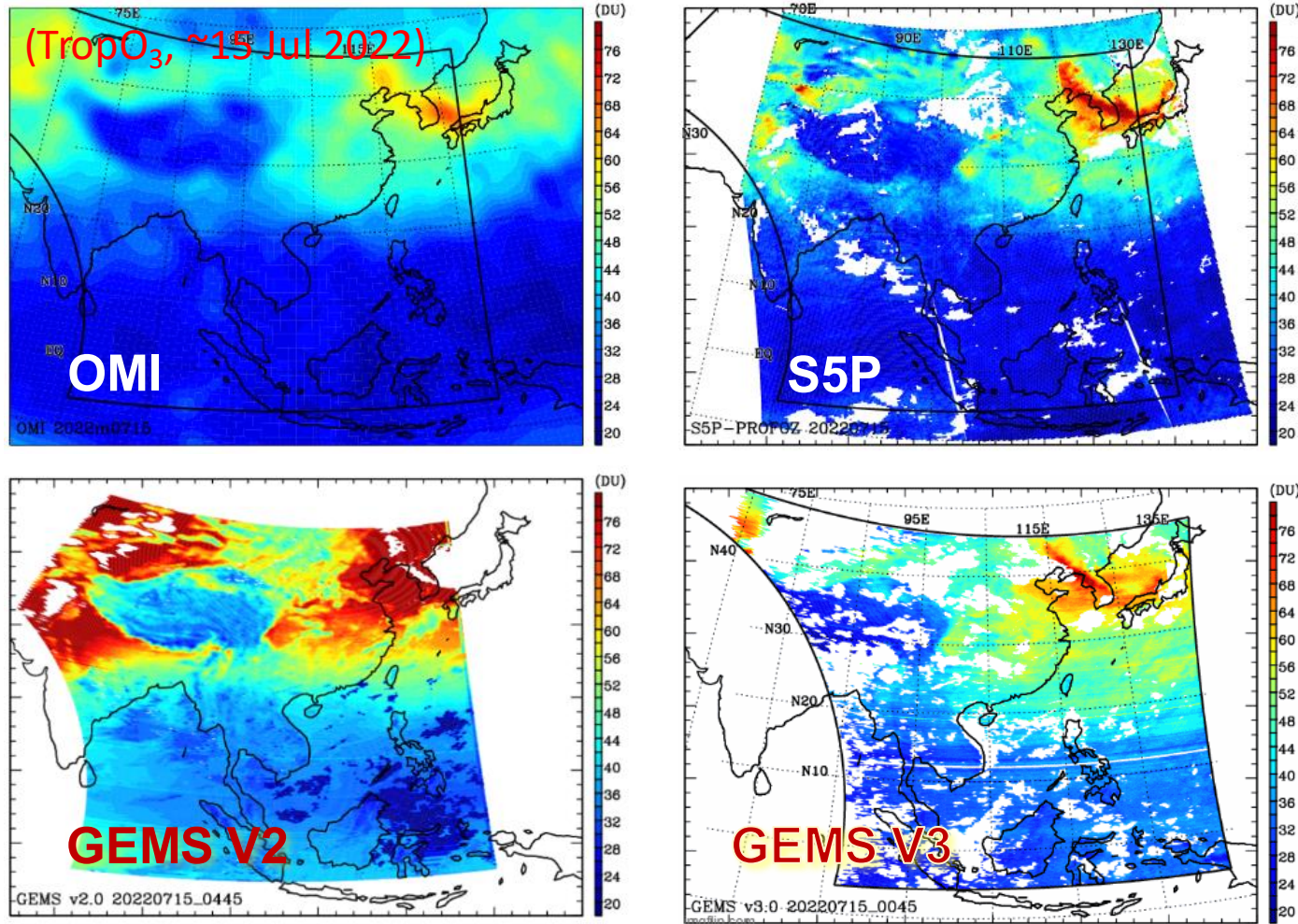


Anmyeon (Jul-Sep 2022, 38 profiles) – O3 a priori



A New Hope: GEMS O3P v3

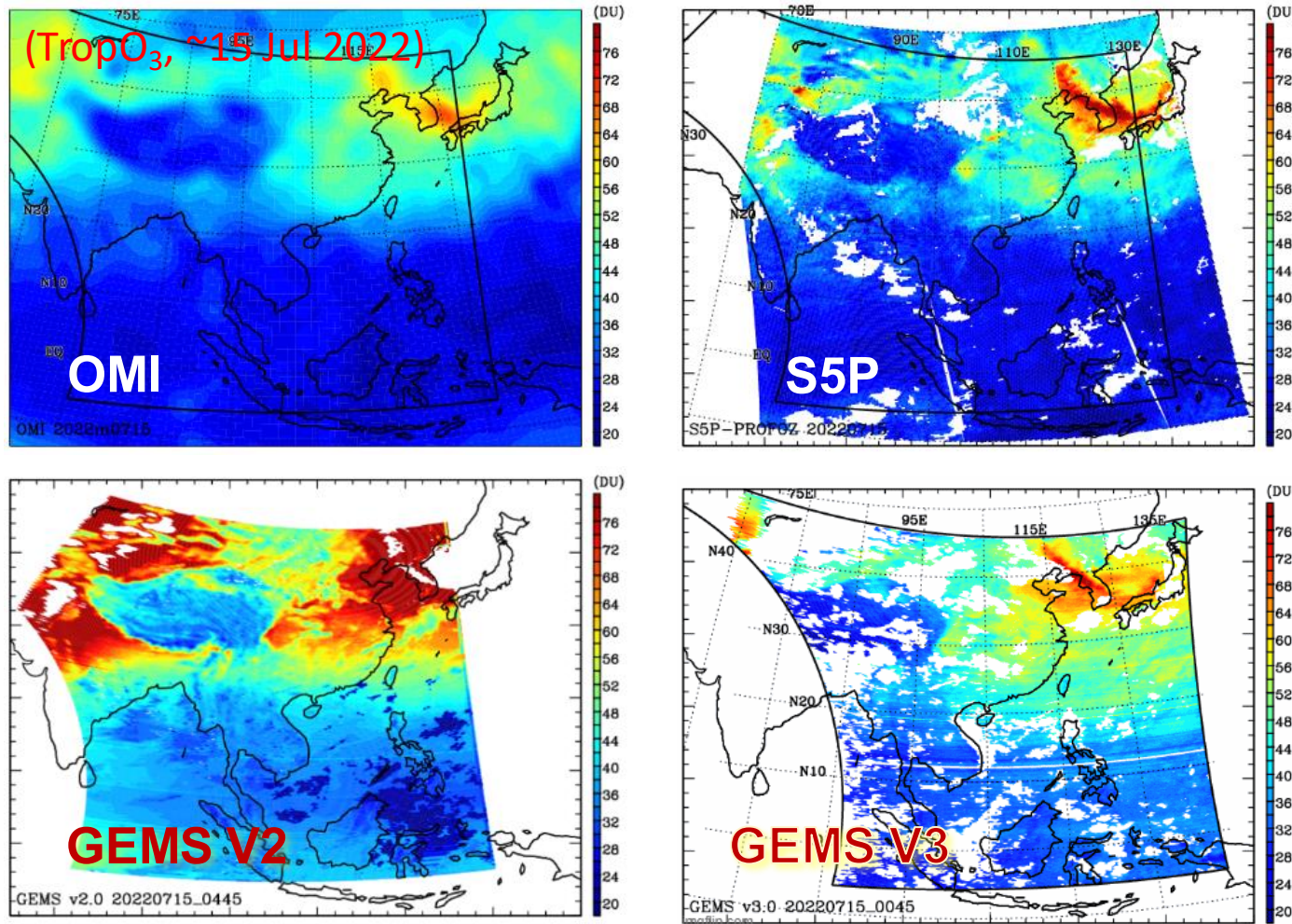
[Preliminary] Courtesy of Dr. Juseon Bak



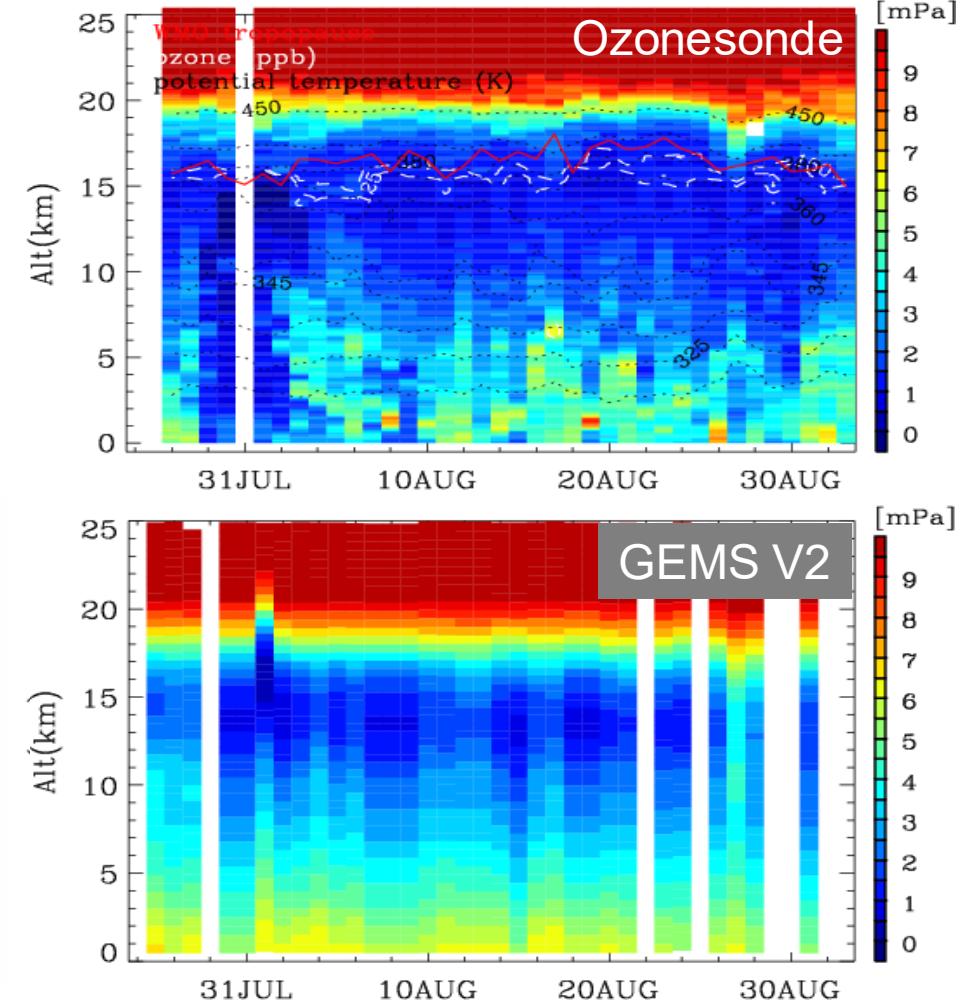
- GEMS v3 product shows more reasonable tropospheric ozone distribution

A New Hope: GEMS O3P v3

[Preliminary] Courtesy of Dr. Juseon Bak



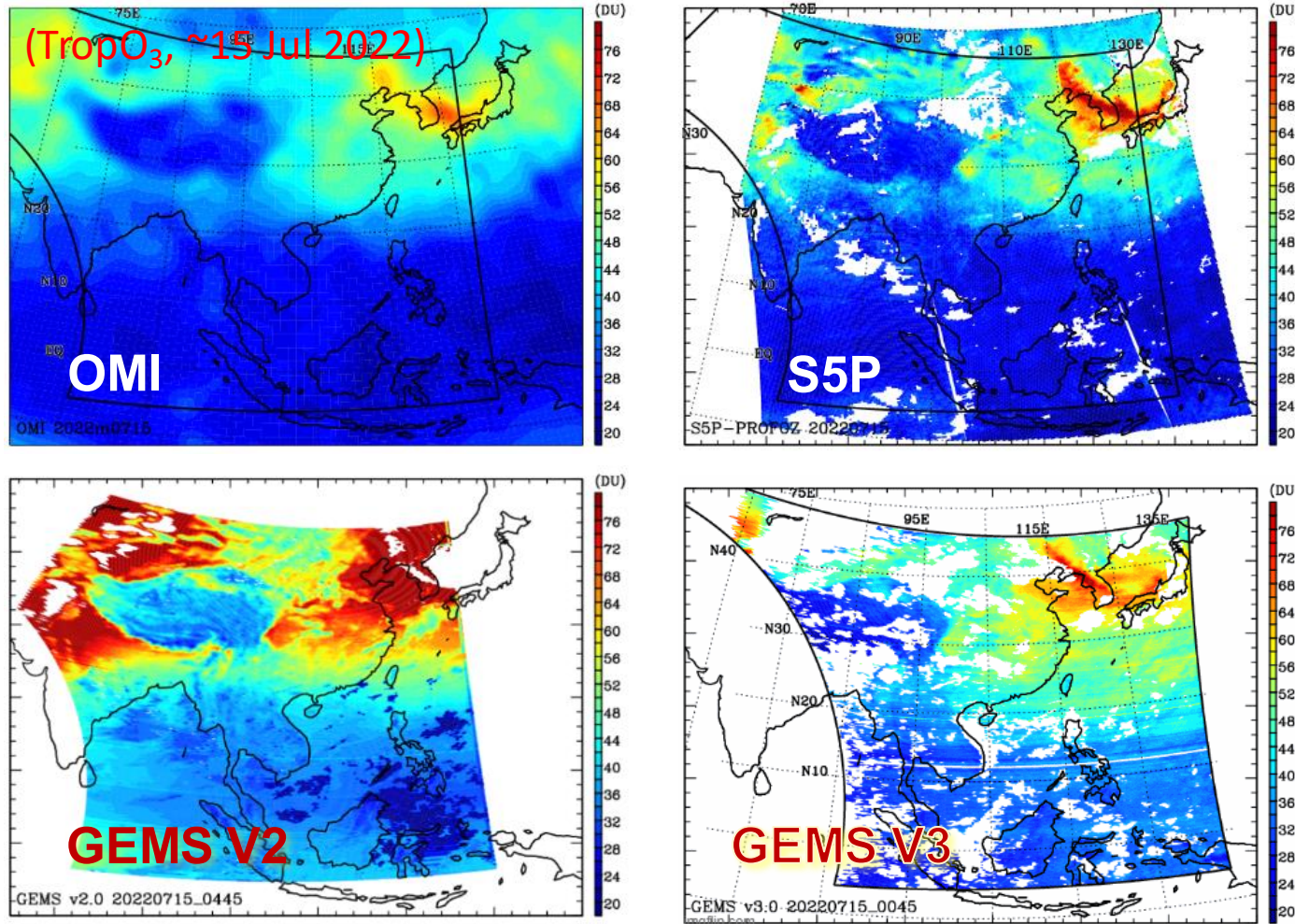
AMY O3 variability (ACCLIP 2022)



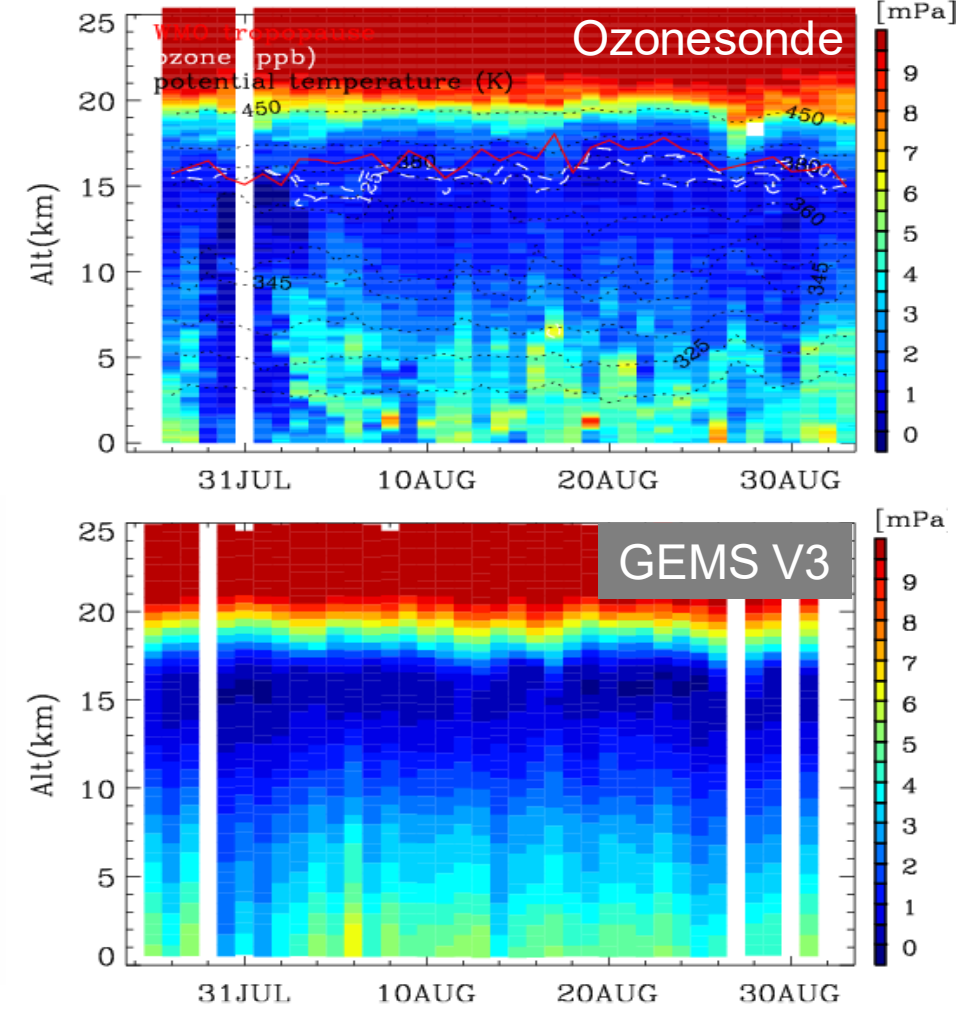
- GEMS v3 product shows more reasonable tropospheric ozone distribution

A New Hope: GEMS O3P v3

[Preliminary] Courtesy of Dr. Juseon Bak



AMY O3 variability (ACCLIP 2022)



- ACCLIP Ozone sonde measurements significantly contribute to improvement of the GEMS O3 product!