Asian Summer Monsoon Chemical and Climate Impacts Project (ACCLIP)

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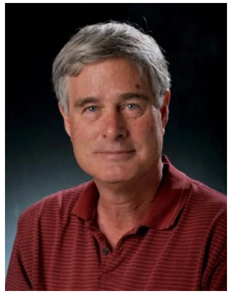

SAGE III/ISS Science Team Meeting

13 Oct. 2022, 1:20 PM EDT

NASA Langley Research Center & virtual

Outline

- ASMA background
- ACCLIP objectives
- ACCLIP platforms and instruments
- August 2022 meteorology
- Compendium of science flights
- Summary

The Asian Summer Monsoon
A regional weather-climate pattern

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NEWS | 02 September 2022 | Correction 02 September 2022 | Correction 16 September 2022

Why are Pakistan's floods so extreme this year?

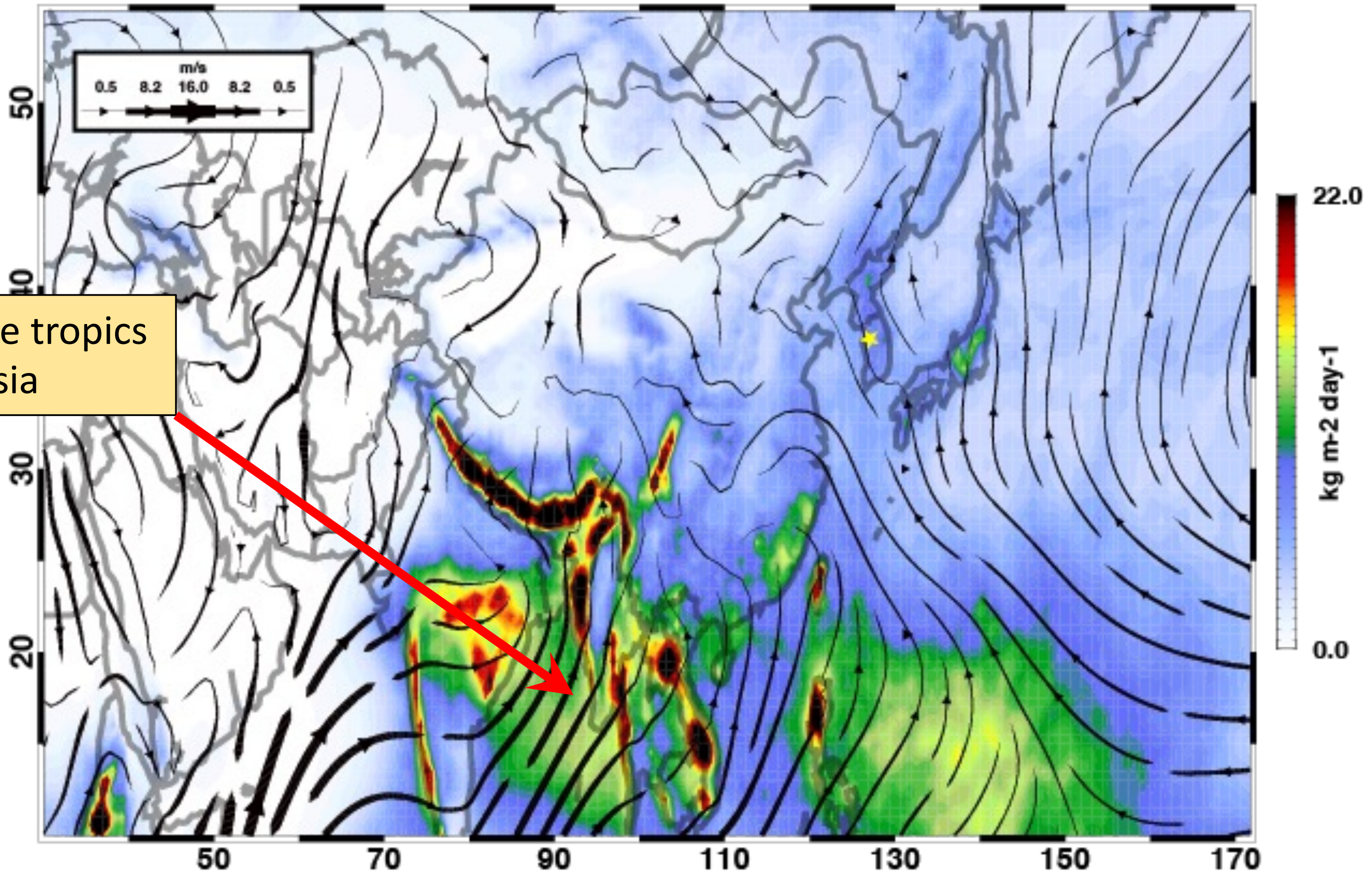
Huge swathes of the country are under water, following an intense heatwave and a long monsoon that has dumped a record amount of rain.

Smriti Mallapaty

Flash flooding has destroyed thousands of kilometres of roads in Pakistan. Credit: Abdul Majeed/AFP/Getty

The Asian summer monsoon is a dominant component of the Earth's climate

Precipitation, Aug. 2000-2021 mean

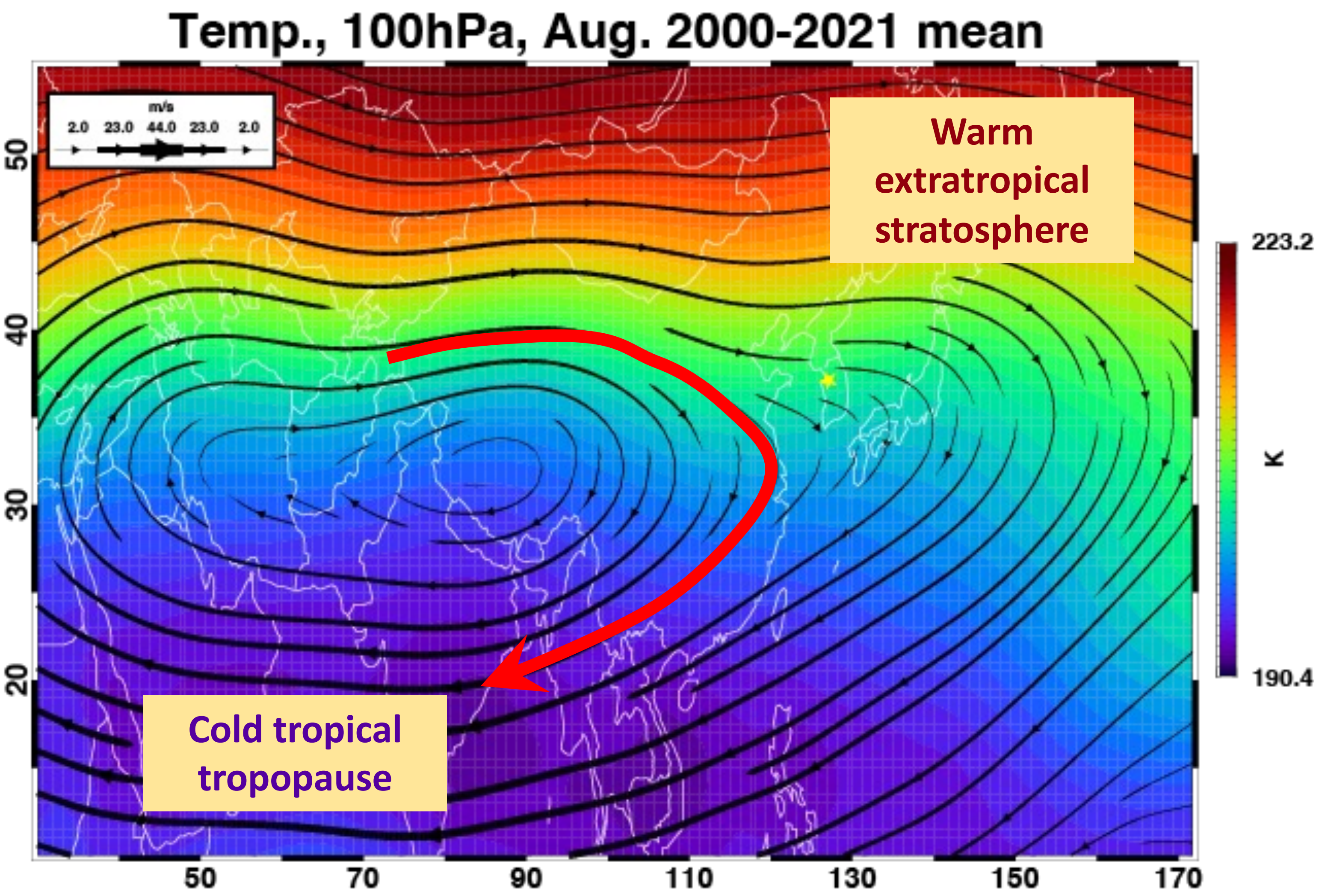


Tropical flow across the tropics into southern Asia

Intense rainfall

- India West coat
- Bay of Bengal
- SE. flank of Tibetan highlands
- Sichuan
- Vietnam
- Phillippines

The monsoon convection drives the formation of a large-scale, anti-cyclonic flow in the upper troposphere / lower stratosphere



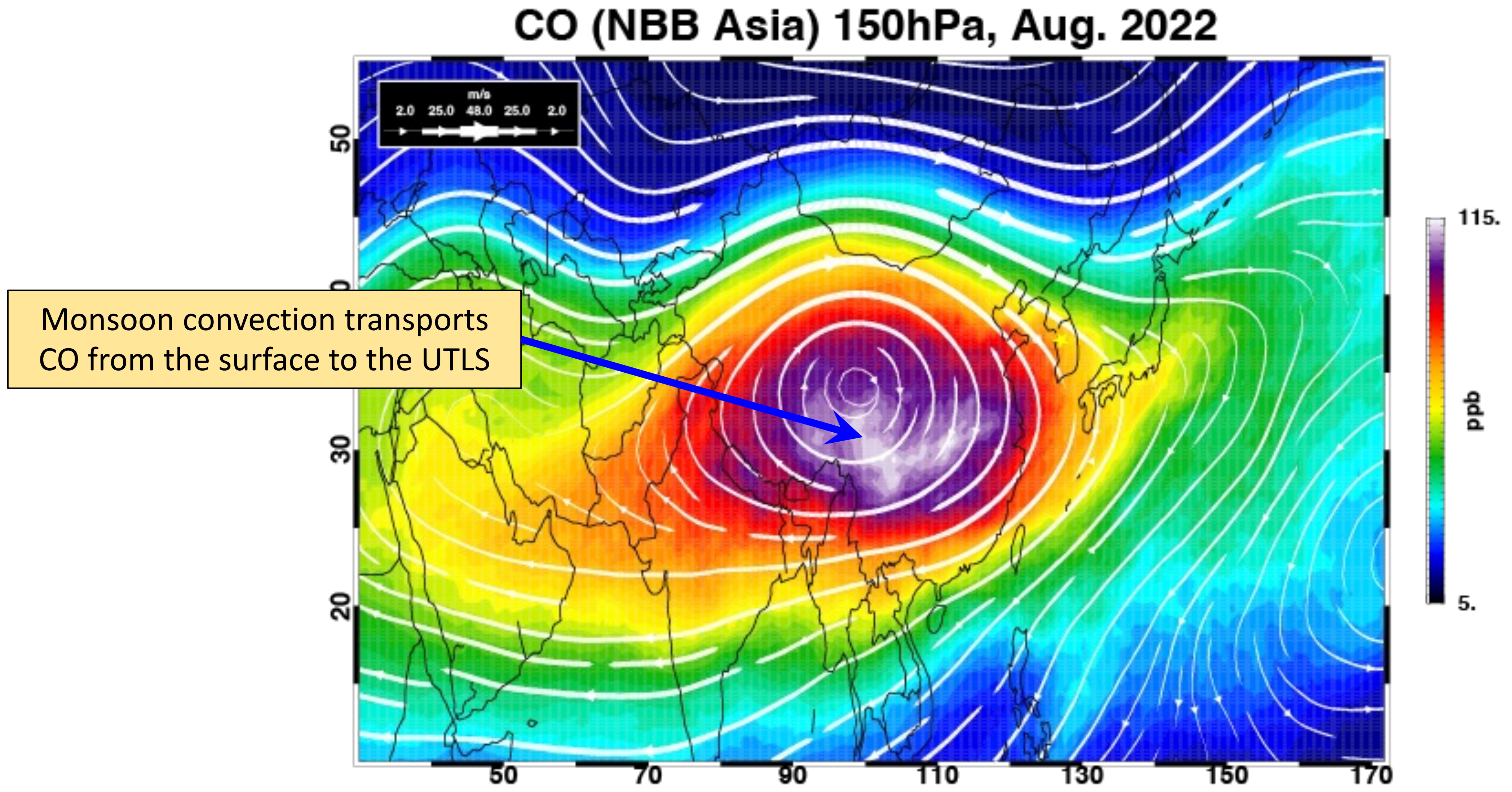
Because of pollution across Asia, monsoon convection pollutes the UTLS

People wear masks on a polluted day in Beijing. Photo: AFP

For weeks, Bangkok has not seen a clear sky, as the Thai capital experiences its worst air quality in years. © Reuters**MASAYUKI YUDA, Nikkei staff writer**January 24, 2019 05:37 JST

An Indian cyclist rides along a street as smog envelops a monument in New Delhi on October 31, the day after the Diwali festival. Money Sharma/AFP/APP Getty Images.

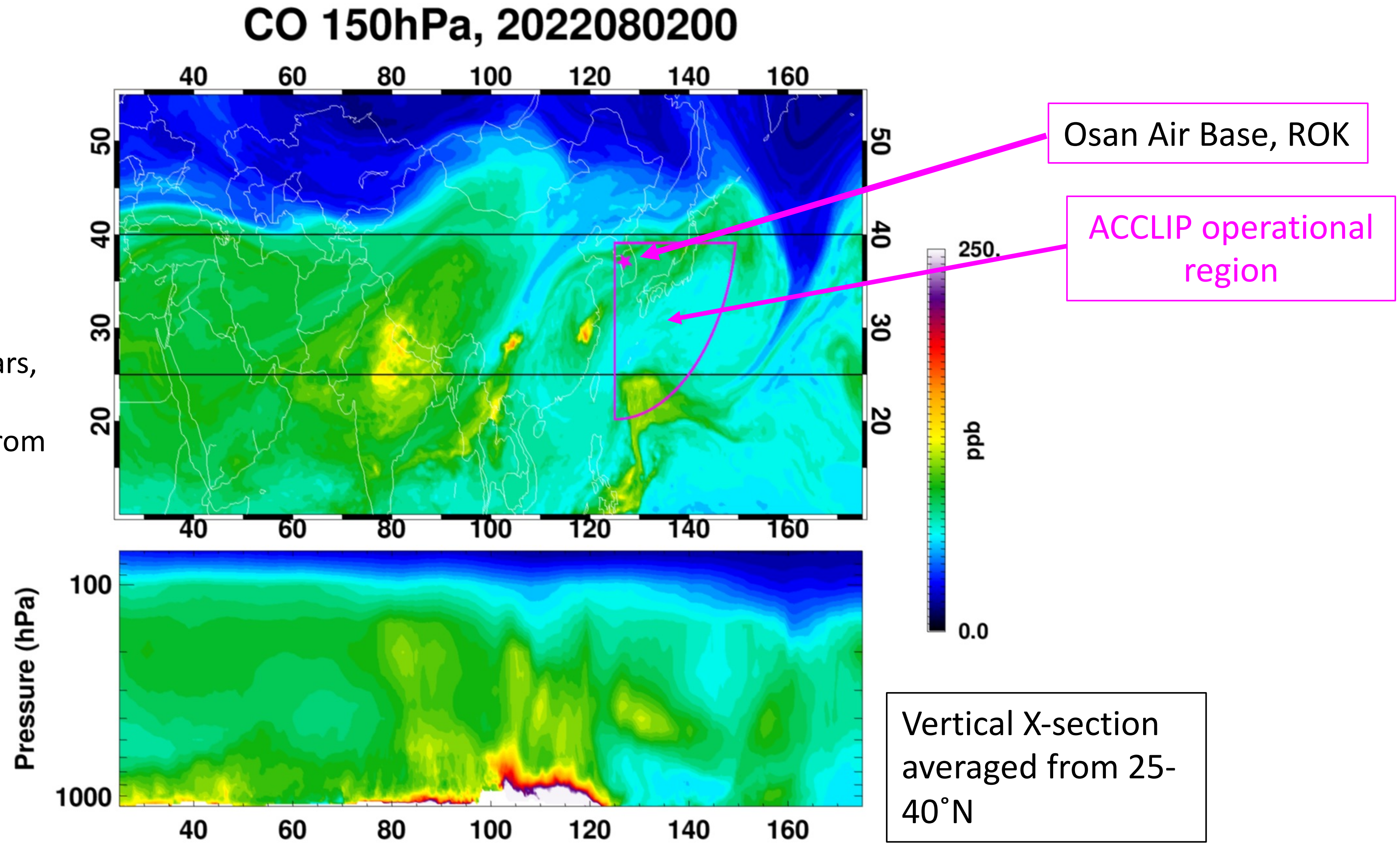
The monsoon convection also transports surface pollution to the upper troposphere / lower stratosphere



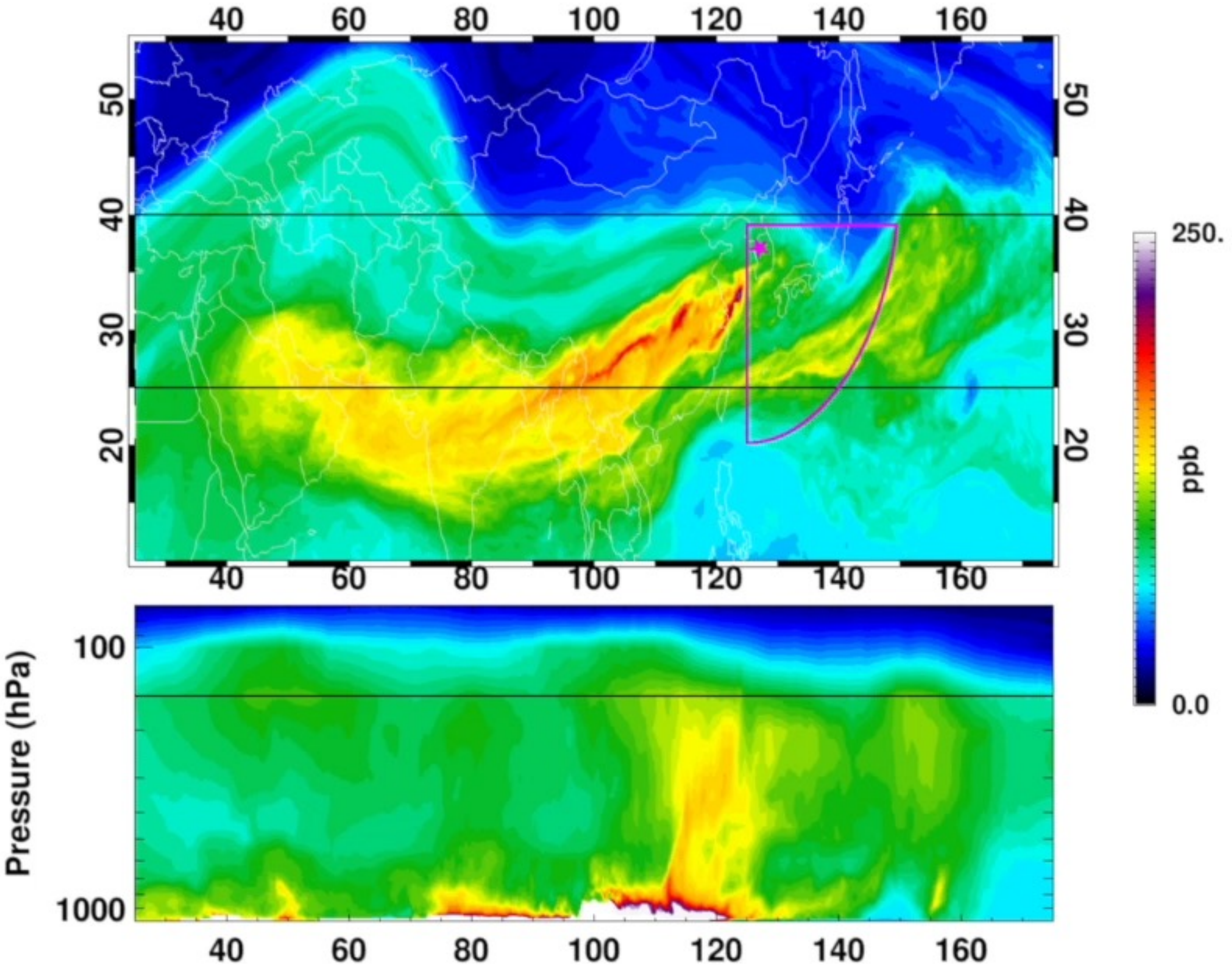
Carbon monoxide is a tracer of surface emissions.
What happened in 2022?

Carbon monoxide (CO)

- CO is a byproduct of incomplete combustion
- Sources include:
  - anthropogenic incomplete combustion of fossil fuels (cars, trucks, etc.) and biofuels
  - Oxidation of hydrocarbons from biogenic emissions
  - biomass burning
  - plant leaves (minor source)
  - Ocean (minor source)
- Lifetime: 1-3 months



CO 150hPa, 2022072000



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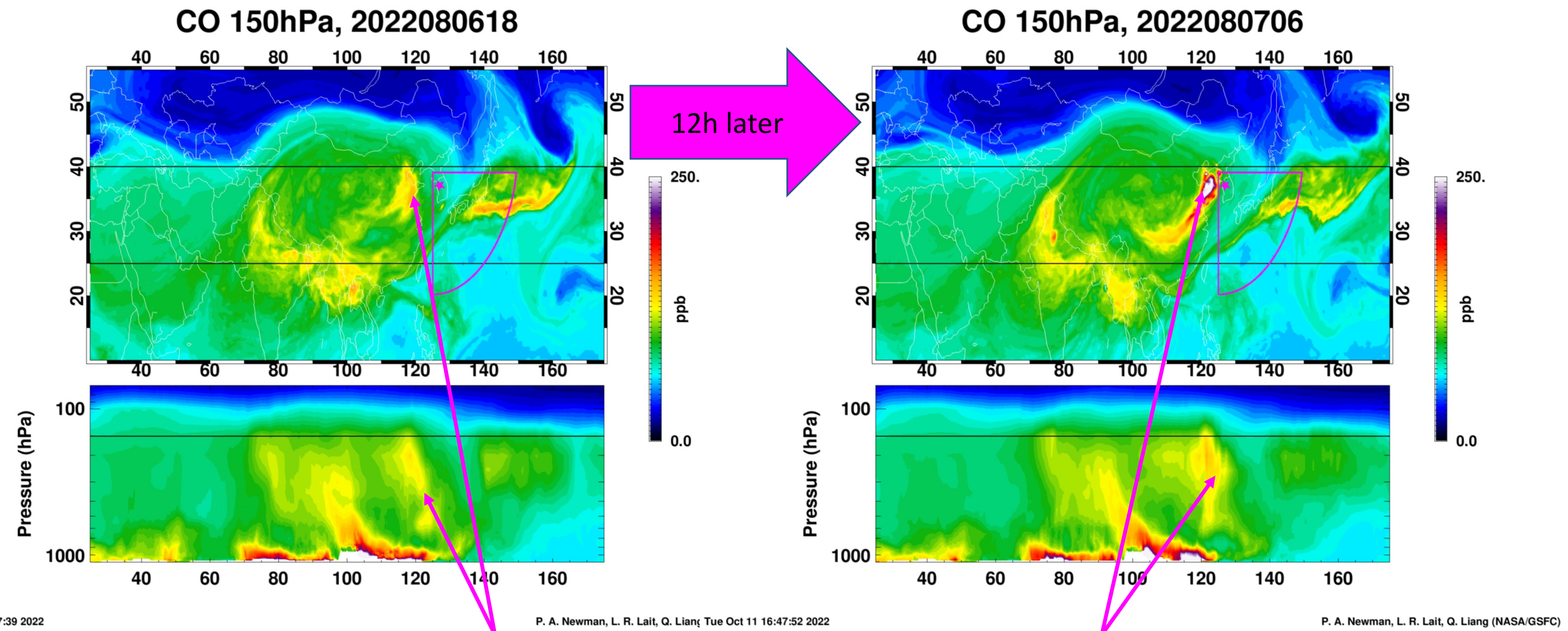
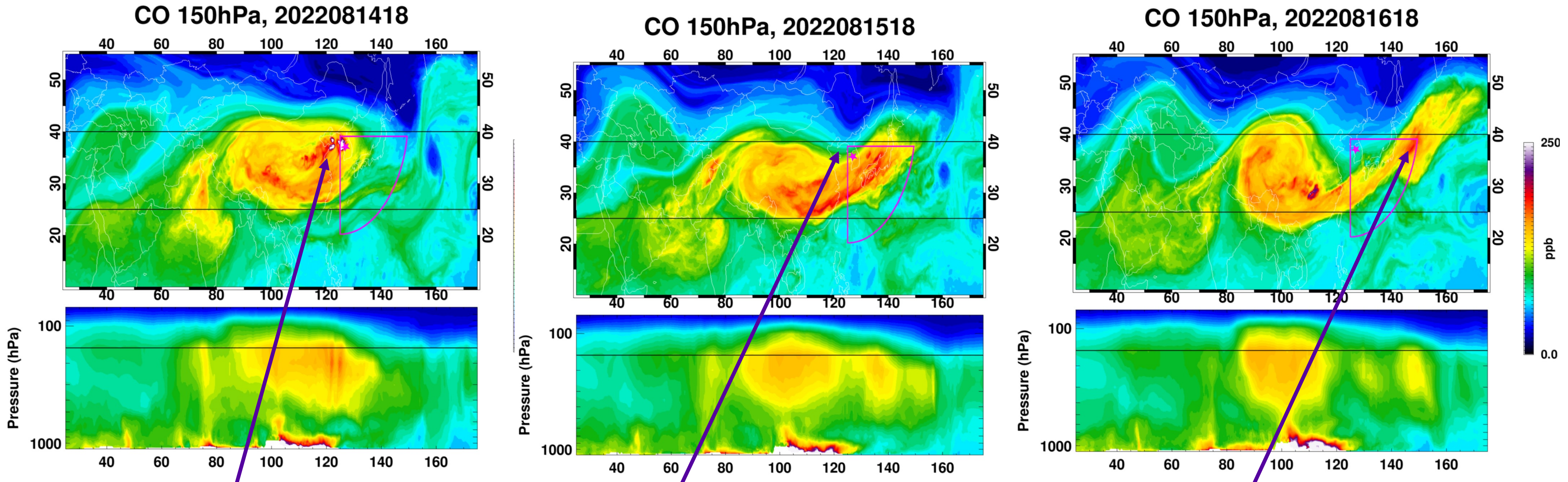
P. A. Newman, L. R. Lait, Q. Liang (NASA/GSFC)

Routine convective event funnel high CO events into the UTLS



Convection associated with a cold front convects high CO into the UTLS

Convected CO is detrained to the NH during the passage of synoptic scale waves



Convection elevates CO in UTLS

Synoptic-scale Rossby wave pulls CO eastward

The Rossby wave pulls elevated CO into higher latitudes over the Pacific

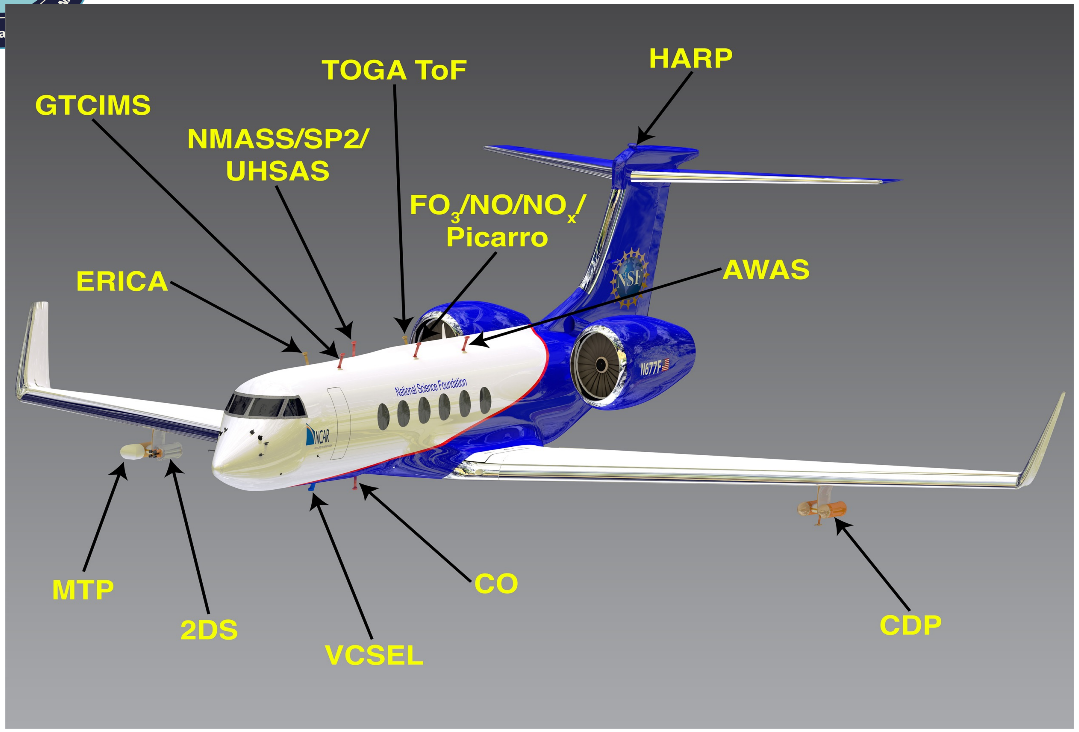
ACCLIP Goals, Objectives & Hypotheses

Primary Goal: To investigate the impacts of Asian gas and aerosol emissions on global chemistry and climate via the linkage of Asian Summer Monsoon (ASM) convection and associated large-scale dynamics

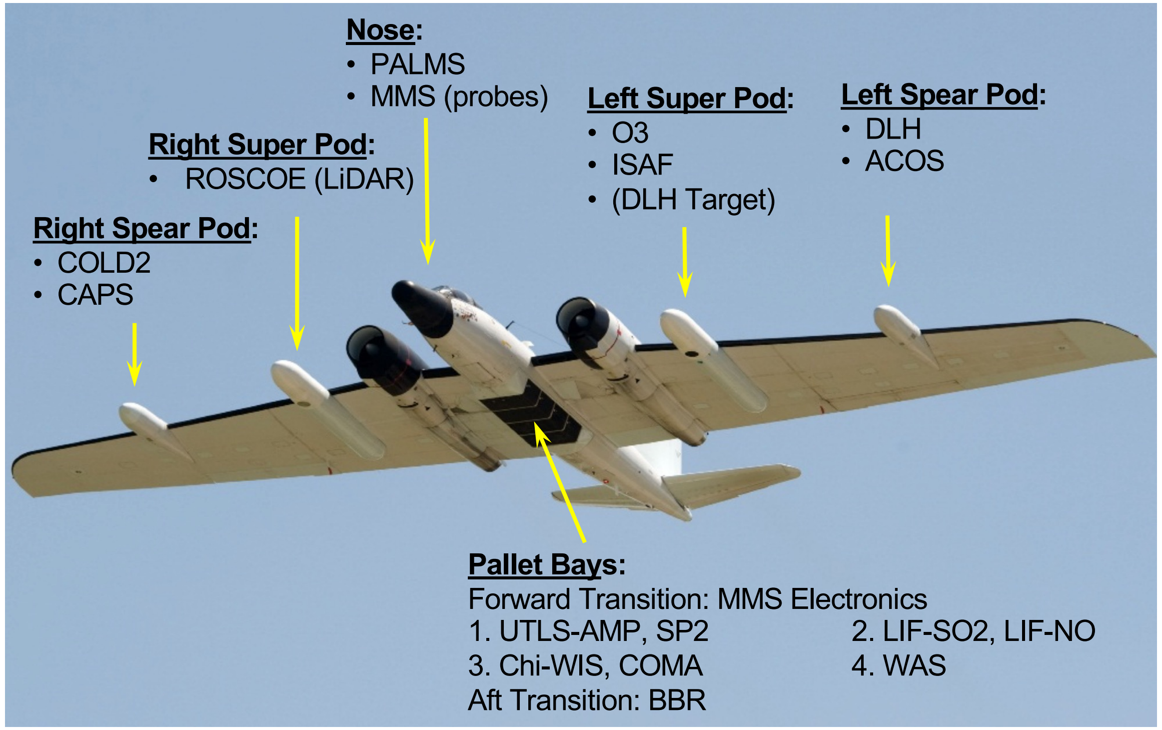
Scientific Objectives: Obtain a comprehensive suite of dynamical, chemical and microphysical measurements in the region of ASM anticyclone to address:

1) the **transport pathways** (vertical range, intensity, and time-scale) of the ASM uplifted air from inside of the anticyclone to the global upper troposphere and lower stratosphere (UTLS)
2) the **chemical content** of air processed in the ASM for UTLS ozone chemistry, and short-lived climate forcers
3) the information on **aerosol** size, mass and chemical composition for determining the radiative impact
4) the **water vapor** distribution associated with the monsoon dynamical structure

ACCLIP Observations



NSF/NCAR Gulfstream V (GV)
Duration: ~ 8 hr flight
1000 ft (0.3 km) and FL 470 (14.7 km)



NASA WB-57
Duration: ~ 6 hr
FL 430 (13 km) and FL 620 (19 km)

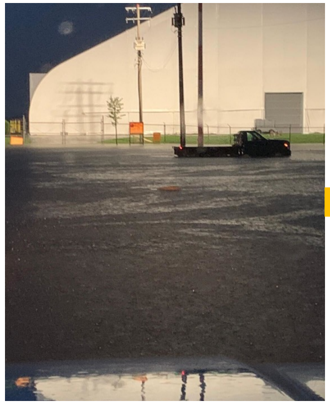
Balloons

Osan, KR						Anmyeondo, KR		Pohang, KR		Lijiang, CN				Koror, PW				Pengjia Islet, TW
ECC ozone	CFH H2O	POPS-aerosol	LOPC-aerosol	STAR-aerosol	RAOB	ECC ozone	RAOB	ECC ozone	RAOB	ECC ozone	CFH H2O	POPS-aerosol	COBALD (backscatter)	Lidar (aerosol)	ECC ozone	CFH H2O	COBALD (backscatter)	ECC ozone
11	11	11	2	6	30	38	38	9	4	3	3	3	3	23	10	2	2	8

ACCLIP observations

Measurement	WB-57	GV
State Parameters		
Position, Pressure,Temperature, Winds, RH	Aircraft, MMS	Aircraft, VCSEL
Temperature profile (above/below aircraft)		MTP
Trace Gases		
CO	COMA, COLD2, ACOS	Aerodyne
CO_2	(ACOS)	Picarro
CH_4		Picarro
N_2O	COMA	Aerodyne
O_3	UAS O3	FAST_O3
NO, NO_2	NO-LIF	NO_NOy
SO_2	SO2-LIF	GTCIMS
HCl, HO_2NO_2, HNO_3 HCOOH, CH_3COOH		GTCIMS
CH_2O	ISAF	TOGA
COS	ACOS	AWAS
H_2O	DLH, CHiWIS	VCSEL
H_2O Isotopes	ChiWIS	
VOCs (many)	WAS	TOGA, AWAS
Aerosols		
Particle size/mass distributions	NMASS, UHSAS, POPS, CAPS	NMASS, UHSAS
Chemical composition/size	PALMS	ERICA
cloud particle size/imaging	CAPS	2DS
cloud droplet size	CAPS	CDP
Cloud/aerosol distributions above/below aircraft	ROSCOE	
Radiation		
Radiative flux/Photolysis frequencies	BBR	HARP

ACCLIP August 2022

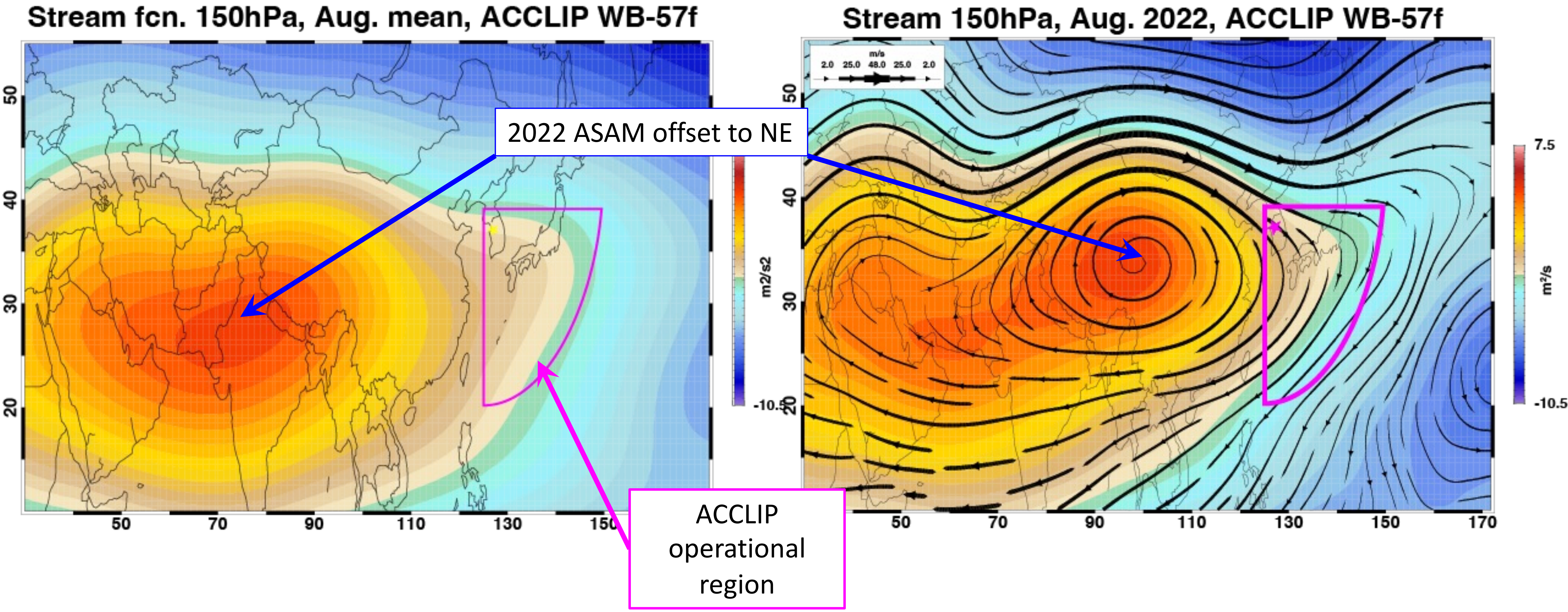


Sun	Mon	Tue	Wed	Thu	Fri	Sat
GV-RF01 31	Aug 1	2 WB-RF03	3 OS/WV/POPS	GV-RF02 4 WB-RF04	5 OS/WV/POPS/ LOPC	GV-RF03 6 WB-RF05
GV-RF04 7	8 100-year flooding event	9	10	11	GV-RF05 12 WB-RF06 OS/WV/POPS/ STAC	13 WB-RF07
14	GV-RF06 15 WB-RF08	GV-RF07 16 WB-RF09 OS/WV/POPS	17	18 OS /WV/POPS	GV-RF08 19 WB-RF10 OS/WV/POPS/ STAC	20 OS/WV/POPS
21 WB-RF11 OS/WV/POPS	GV-RF09 22	GV-RF10 23 WB-RF12 OS/WV/POPS/ LOPC	24	GV-RF11 25 WB-RF13 OS/WV/POPS/ STAC	GV-RF12 26 WB-RF14	27 OS/WV/POPS/ STAC
28	GV-RF13 29 WB-RF15	30	GV-RF14 31 WB-RF16	Sep 1 WB-RF17	2	3
4	5	6	7	8	9	10

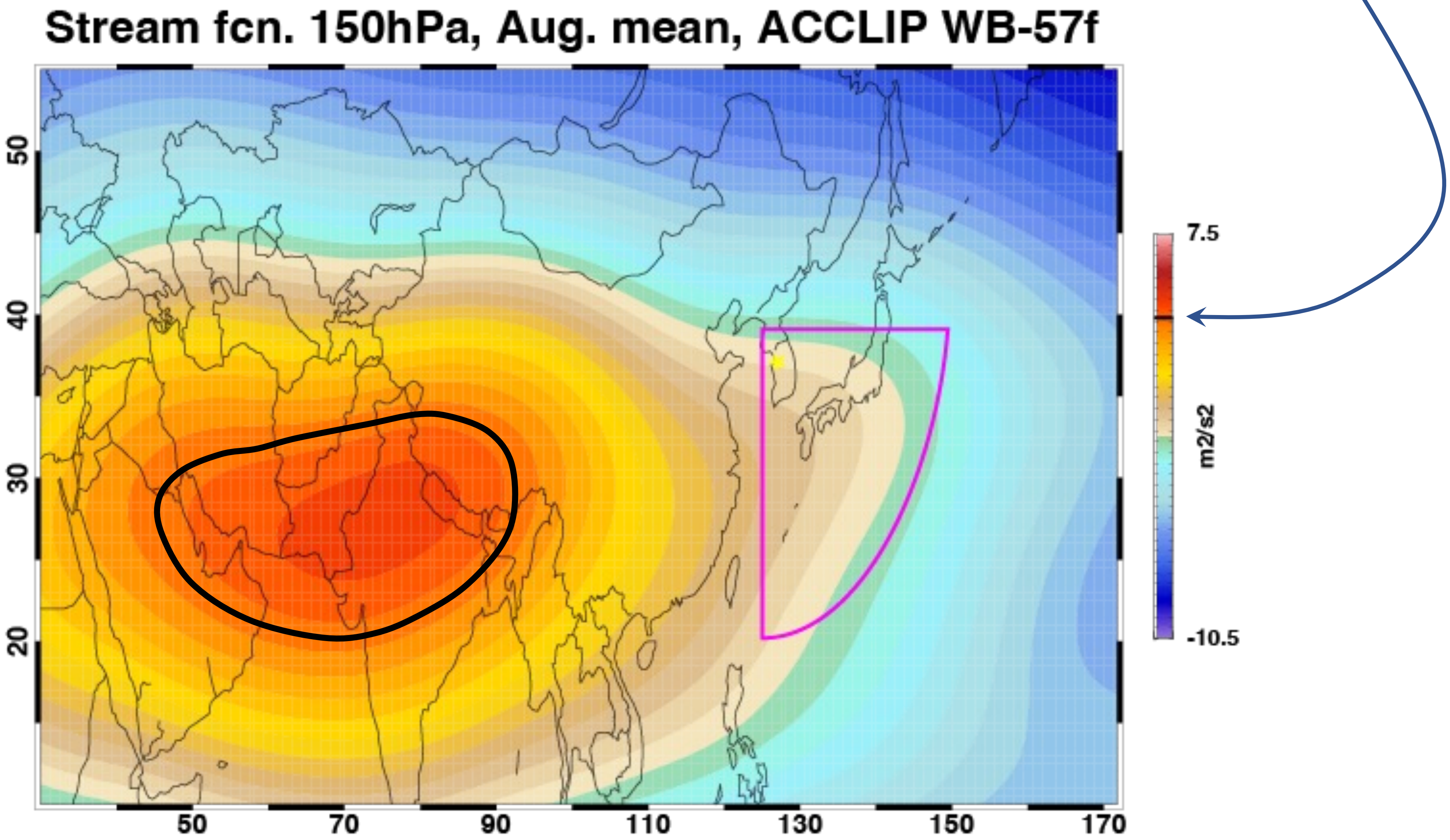
2022 ACCLIP Meteorology & Transport

ACCLIP temporary hangar, Osan Air Base

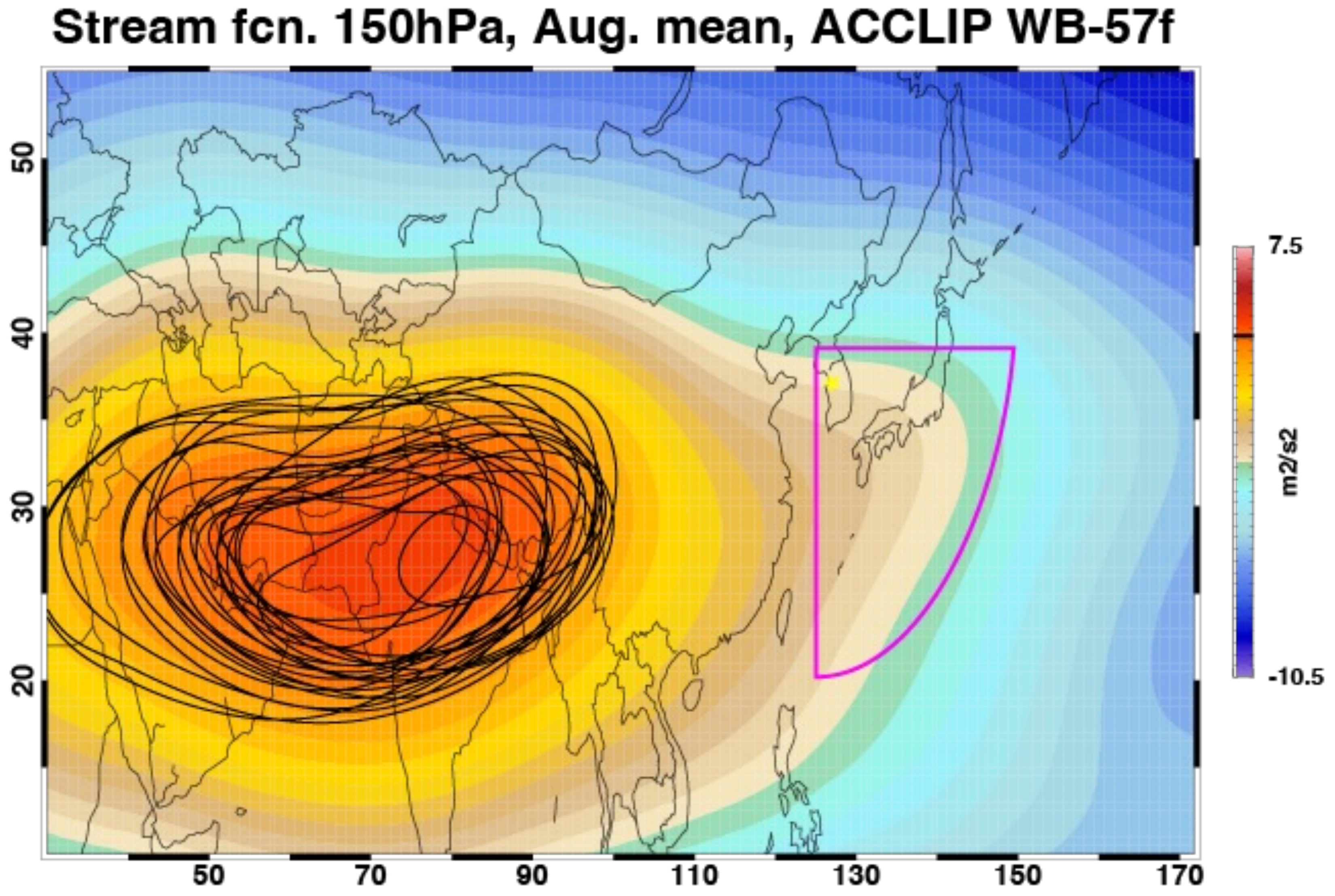
Flow center located over China with a strong extension eastward to Korea/Japan



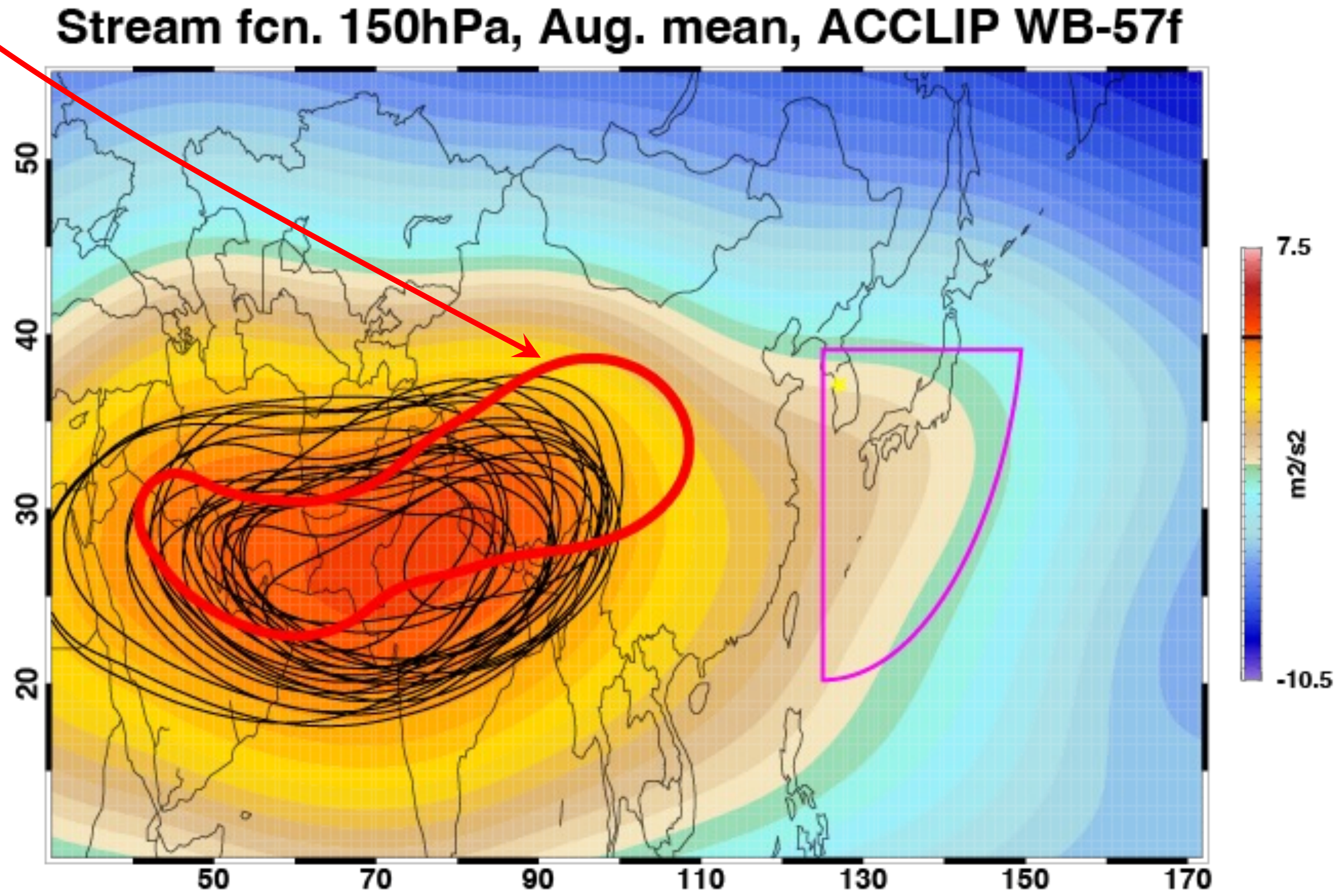
The approximate center of the ASMA can be located with the 3.77/a contour



Adding the individual contours (2000-2021) shows the year-to-year variation of the ASMA



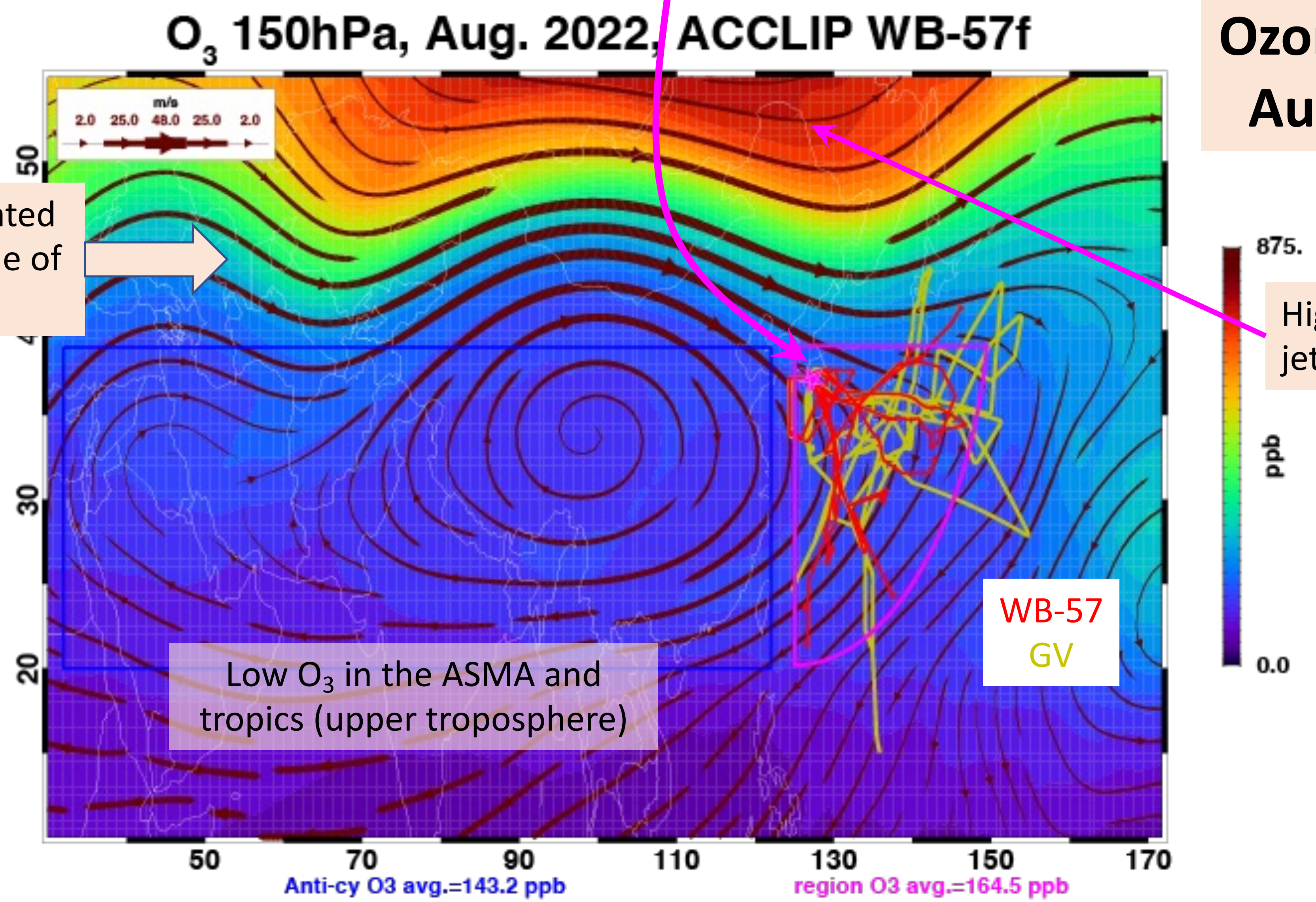
The 2022 ASMA was exceptionally displaced relative to the 2000-2021 climatology



ACCLIP was able to extensively sample the eastern flank of the ASMA

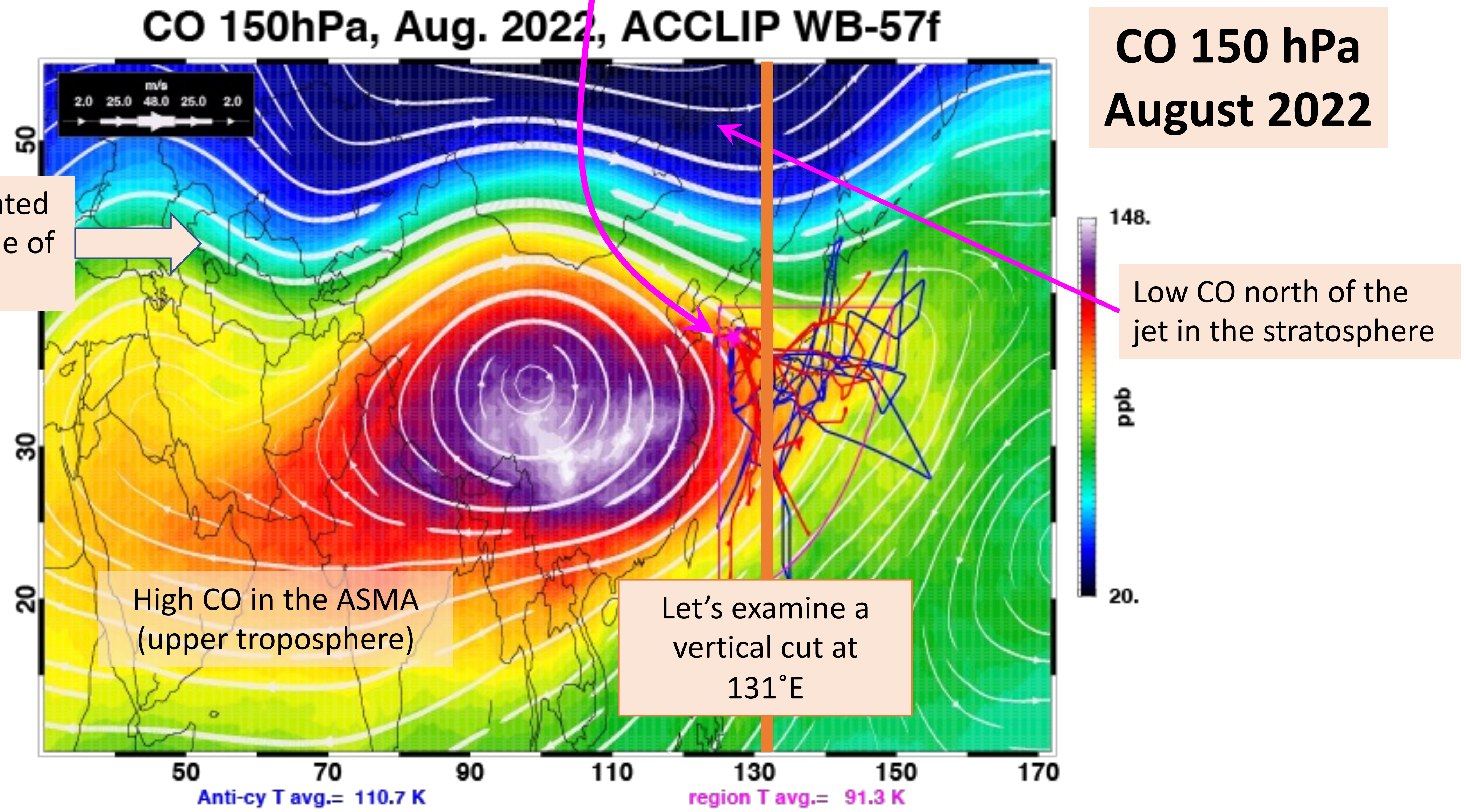
Ozone 150 hPa August 2022

Subtropical jet located to the northern side of the ASMA

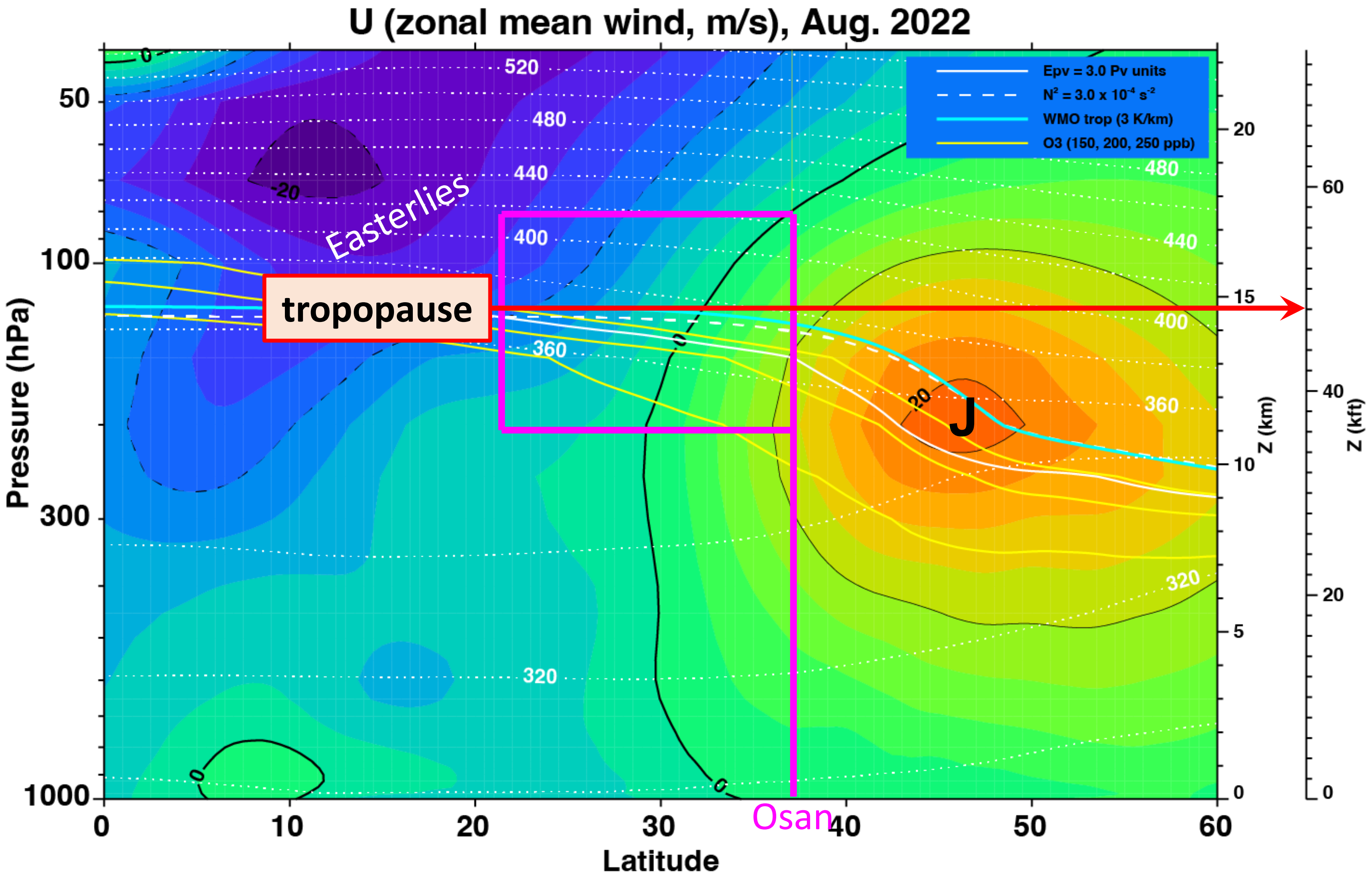


High O_3 north of the jet in the stratosphere

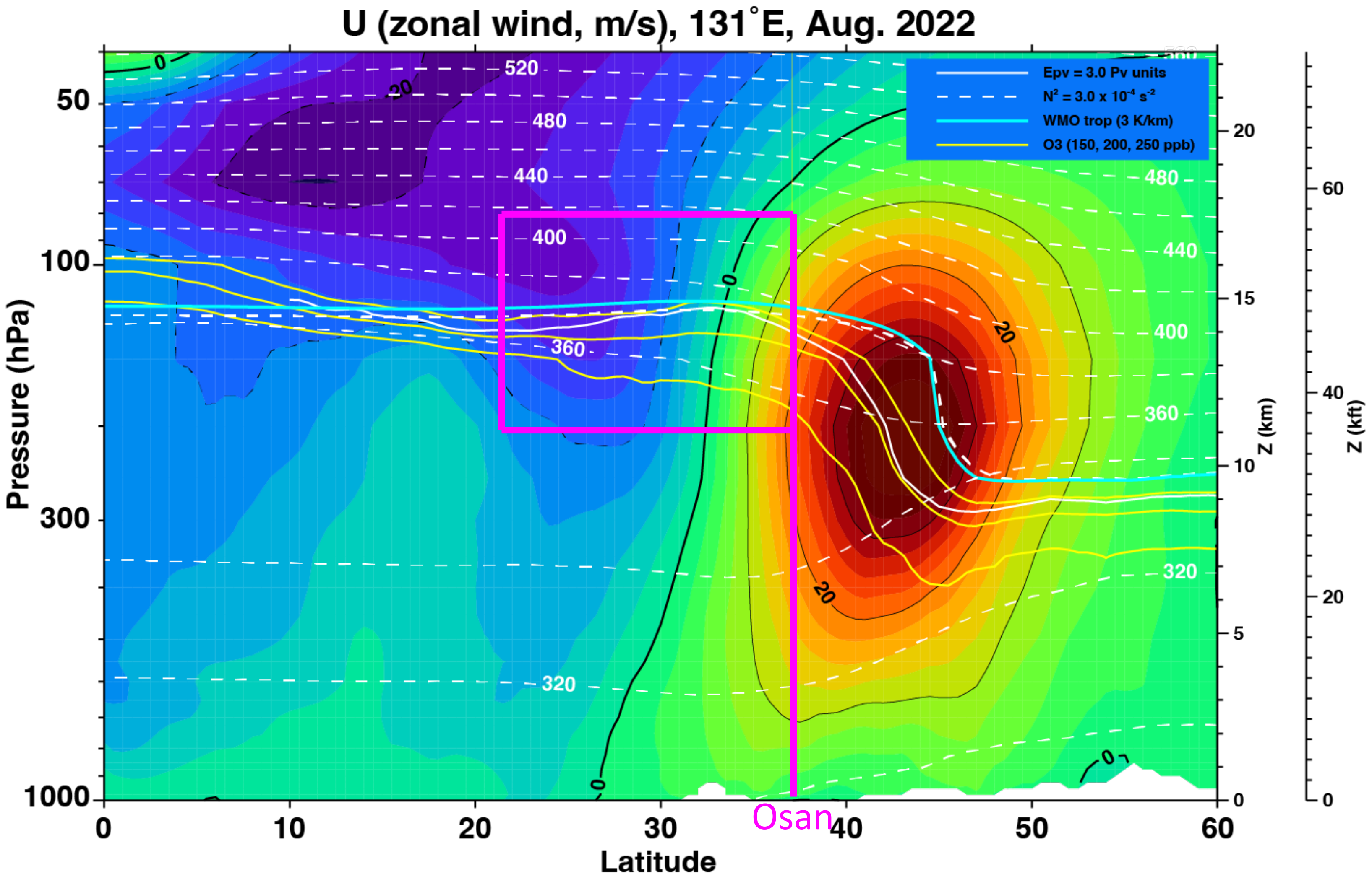
ACCLIP was able to extensively sample the high CO on the eastern flank of the ASMA



The zonal mean flow is dominated by the subtropical jet at 45˚N, with easterlies to the south of 30˚N in the UTLS ACCLIP region



The zonal wind in the ACCLIP region (131˚E) was exceptionally strong (as we would have guessed from the climatology)



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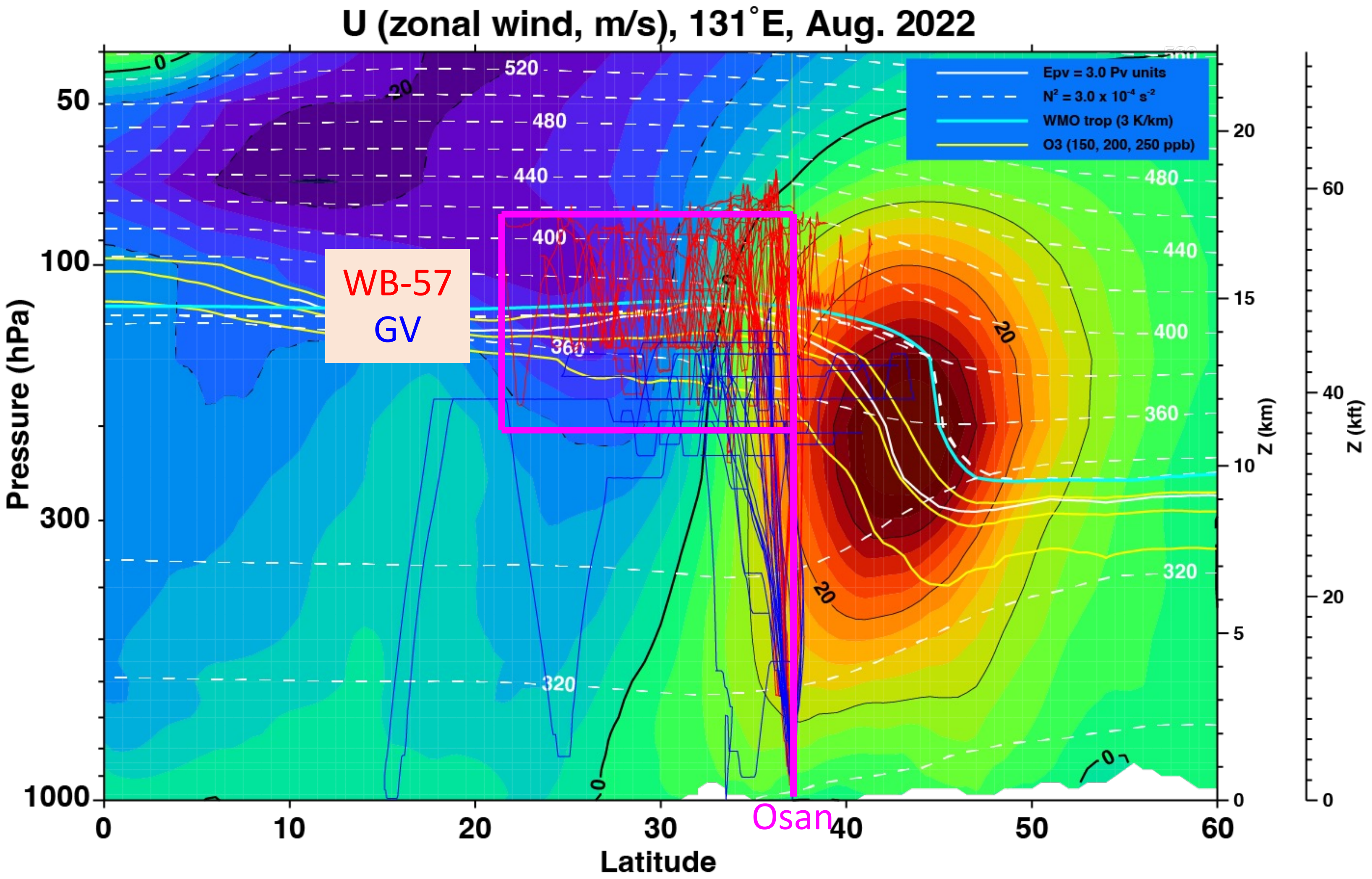
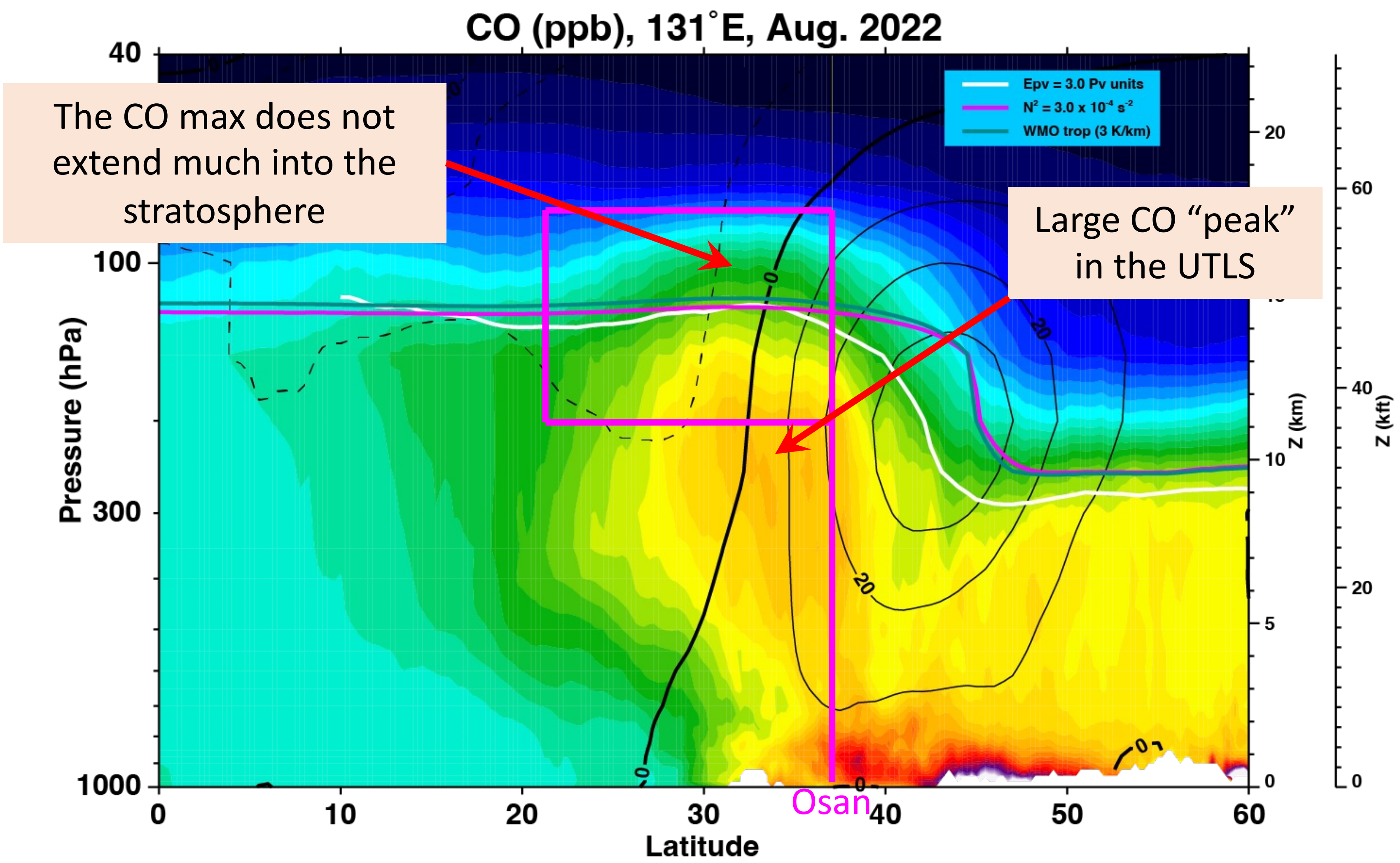


The CO "high" in the ACCLIP region extended upward from about 500 hPa to the lower stratosphere



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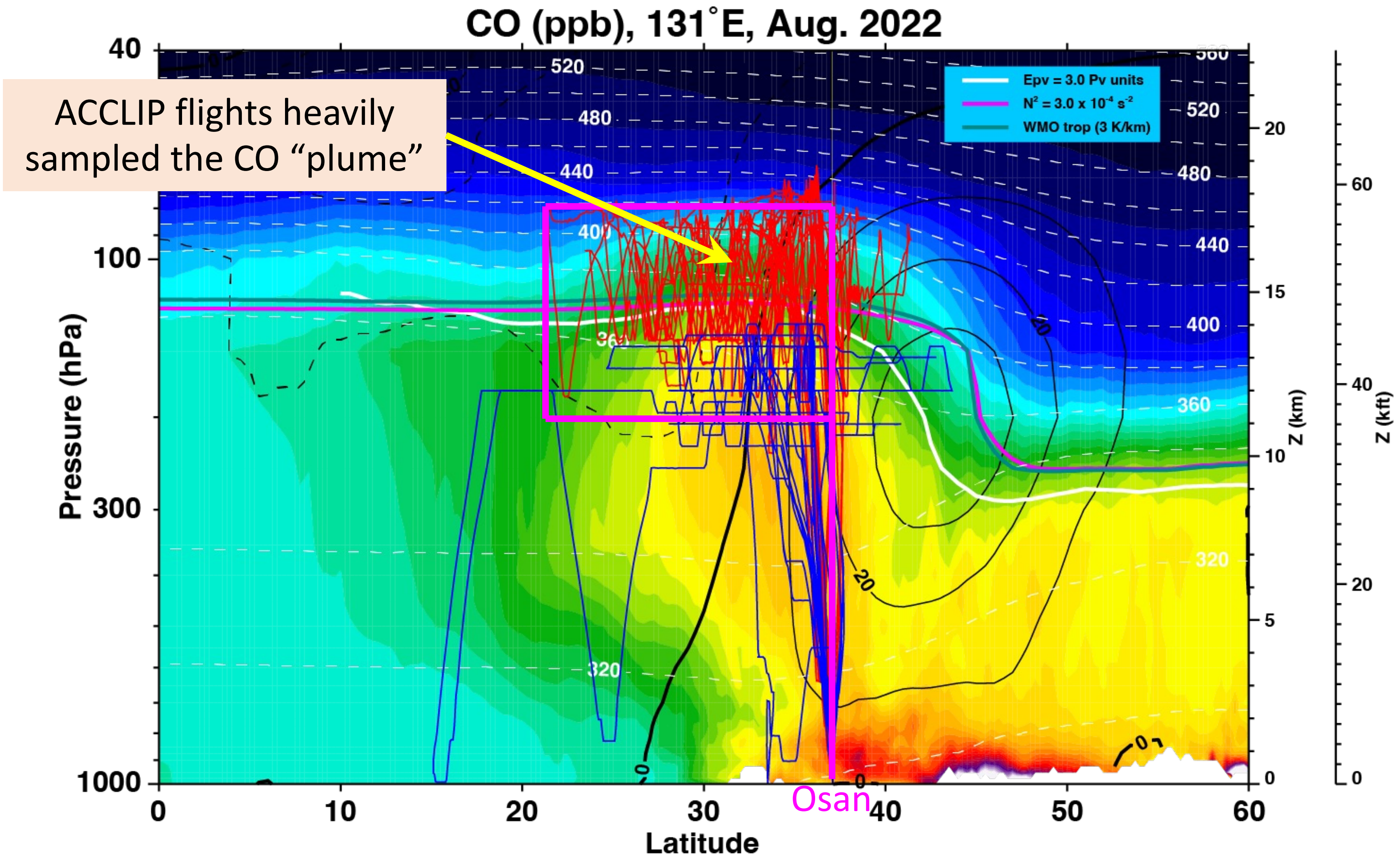
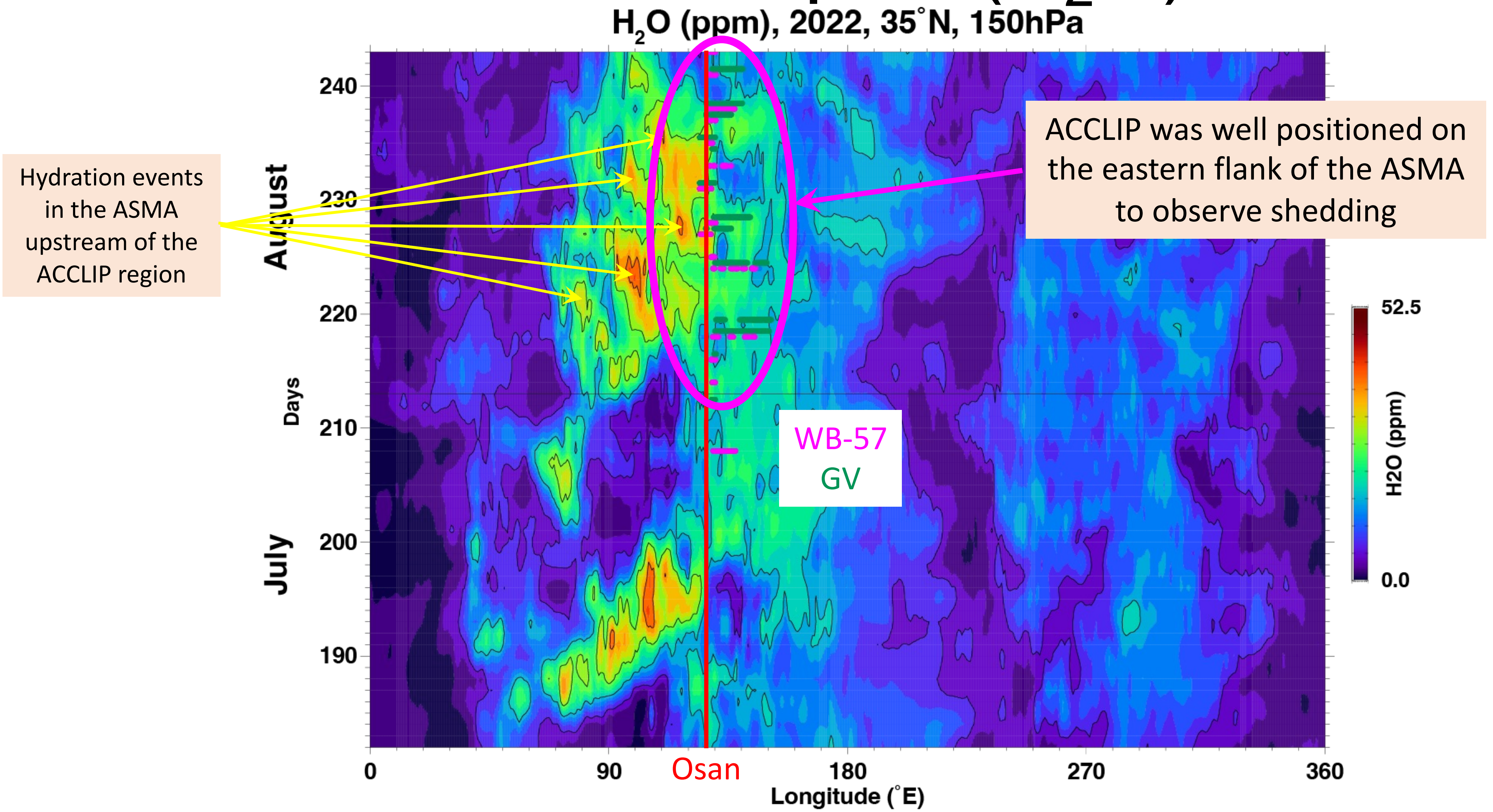
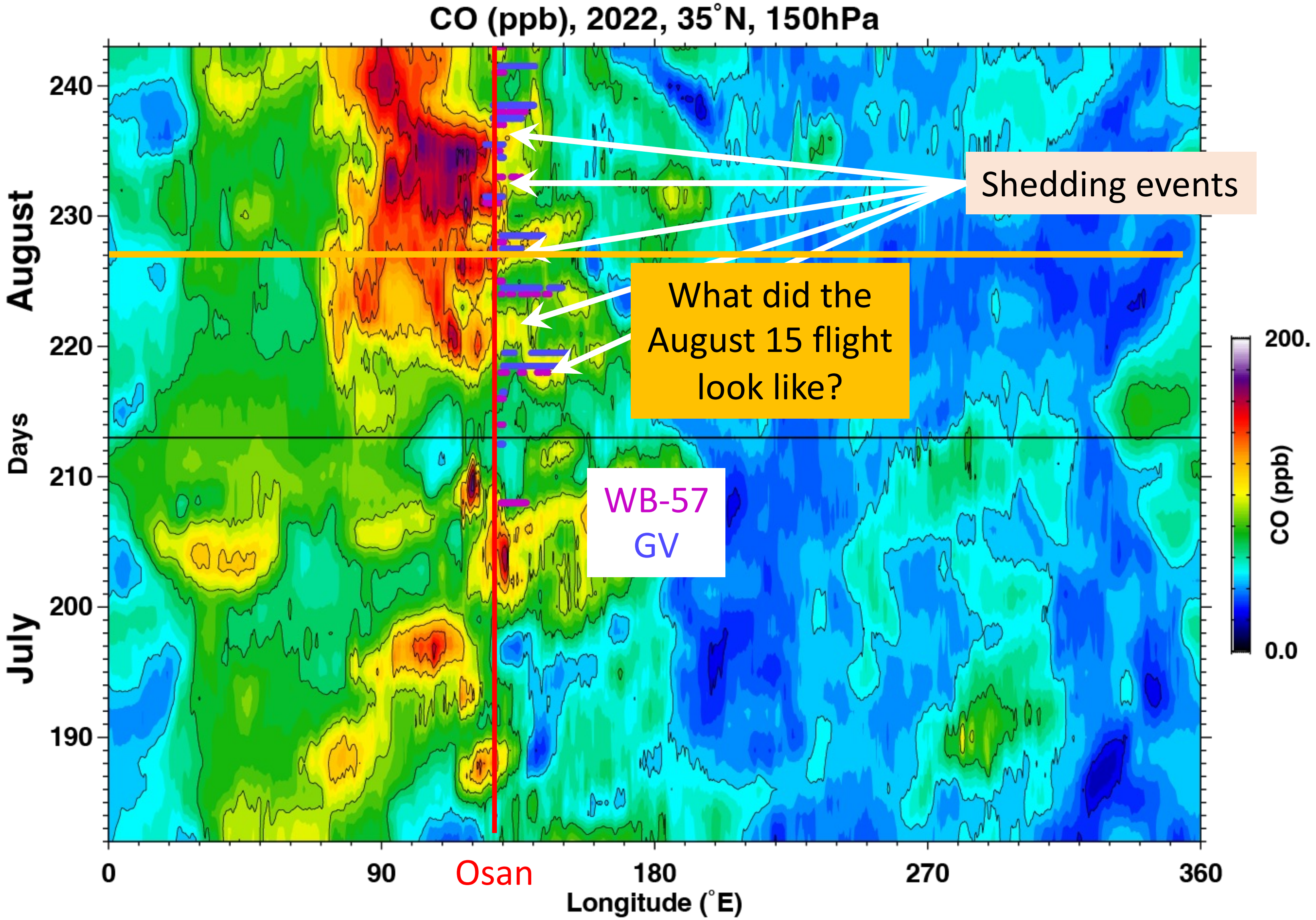


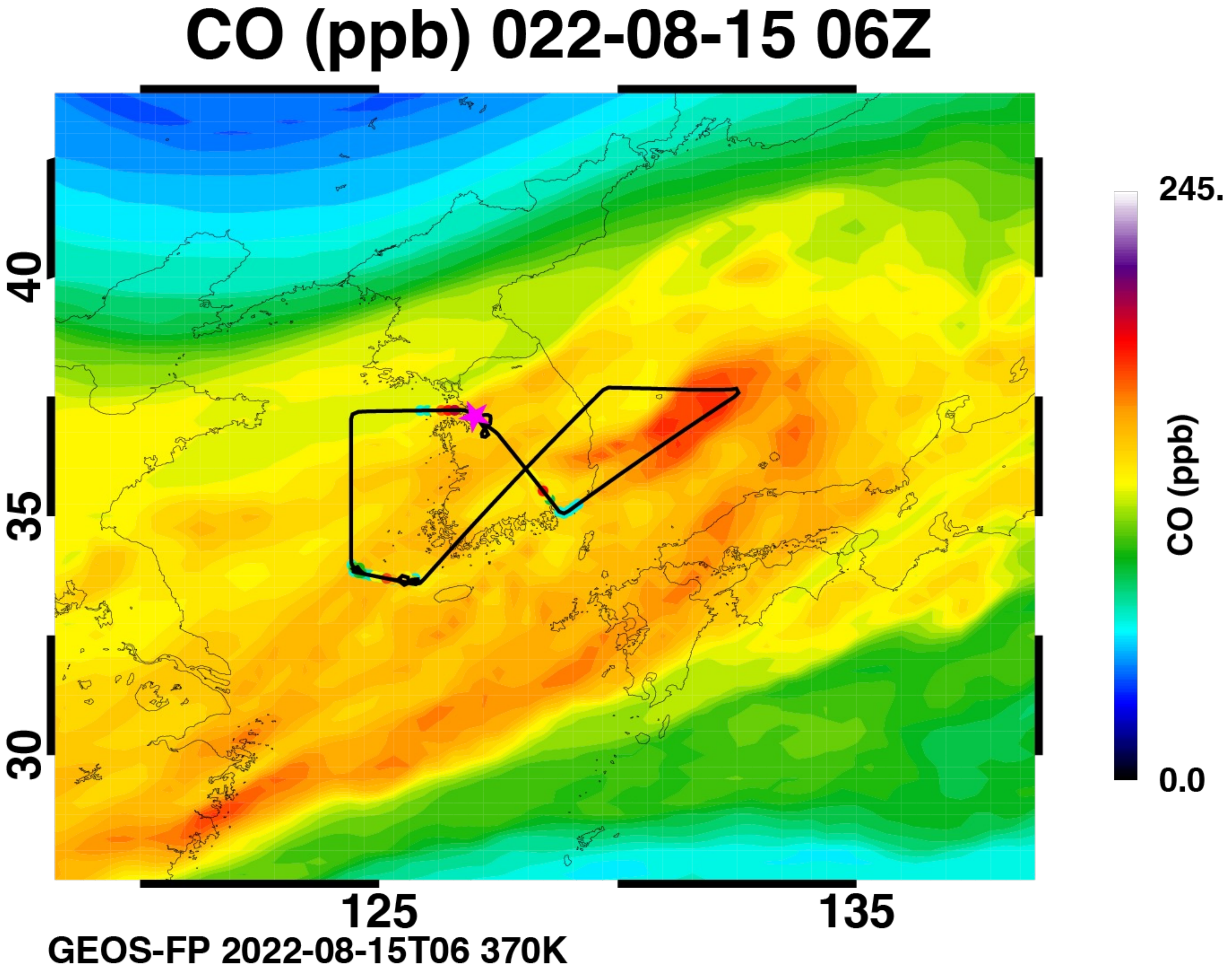
Shedding of ASMA into the northern extra-tropics (H_2O)



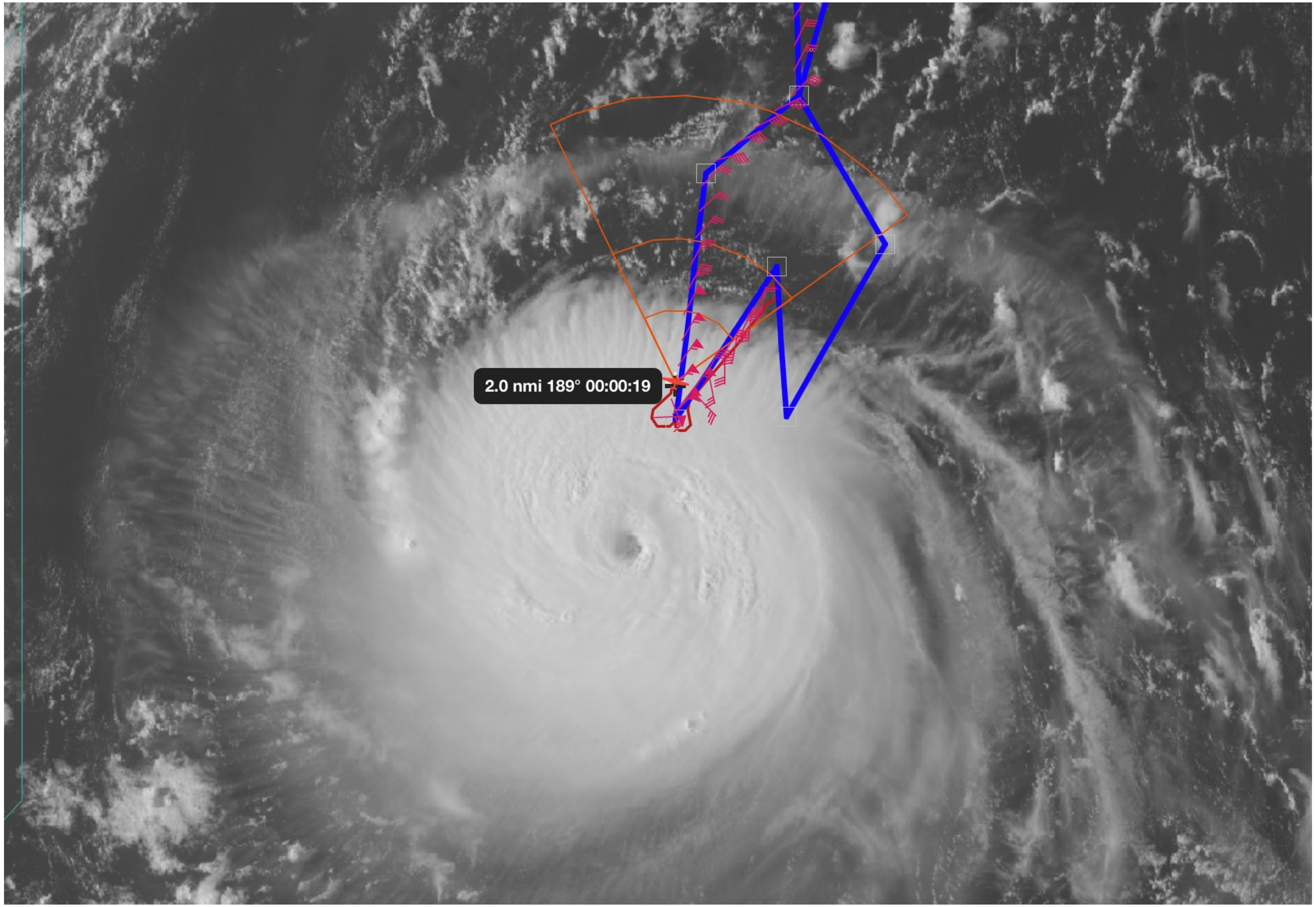
Shedding of ASMA into the northern extra-tropics (CO)



ACCLIP WB-57 flight

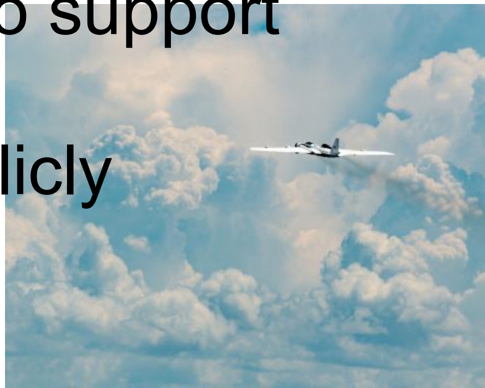


WB-57 over Super Typhoon Hinnamnor
31 August 2022



What did we achieve?

- We flew 12 and 15 local flights of the GV and WB-57f, respectively. Not including transit and test flights.
- Extensive sampling of the Asian Summer Monsoon Anti-cyclone’s eastern flank – mapping of the vertical and horizontal structure in the UTLS. A large number of ozonesonde, particle, and water vapor sondes on on this eastern flank.
- Vertical and horizontal structure of ASMA shedding events in the western Pacific
- Sampled Super Typhoon Hinnamnor – partially characterizing the upper side of the typhoon and outflow
- Boundary layer sampling, including the Yellow Sea region, to support the Korean A/Q research
- Science team meeting: 14-17 Nov. 2022, Boulder. Data publicly available in spring 2023.



Thank you for your attention!