UTLS Chemical Evolution of 2019 Asian Summer Monsoon Season: Model Perspective

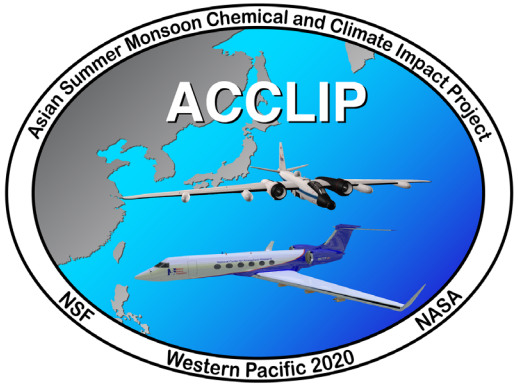
Doug Kinnison

Simone Tilmes, Sofia Chelpon, Ren Smith, Shawn Honomichl, Laura Pan

Whole Atmosphere Working Group

Boulder Co,

10 March 2020



Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP)

Principal Investigators: Laura Pan (NCAR), Paul Newman (NASA)
Lead Co-Investigators: Elliot Atlas (Univ. Miami), William Randel (NCAR), Brian Toon (CU), Troy Thornberry (NOAA)

Location: Western Pacific (Flight Operations planned to be from Naha Okinawa)
Dates: July 15 – August 31, 2020

Laura Pan, NCAR

Project 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

https://www2.acom.ucar.edu/acclip

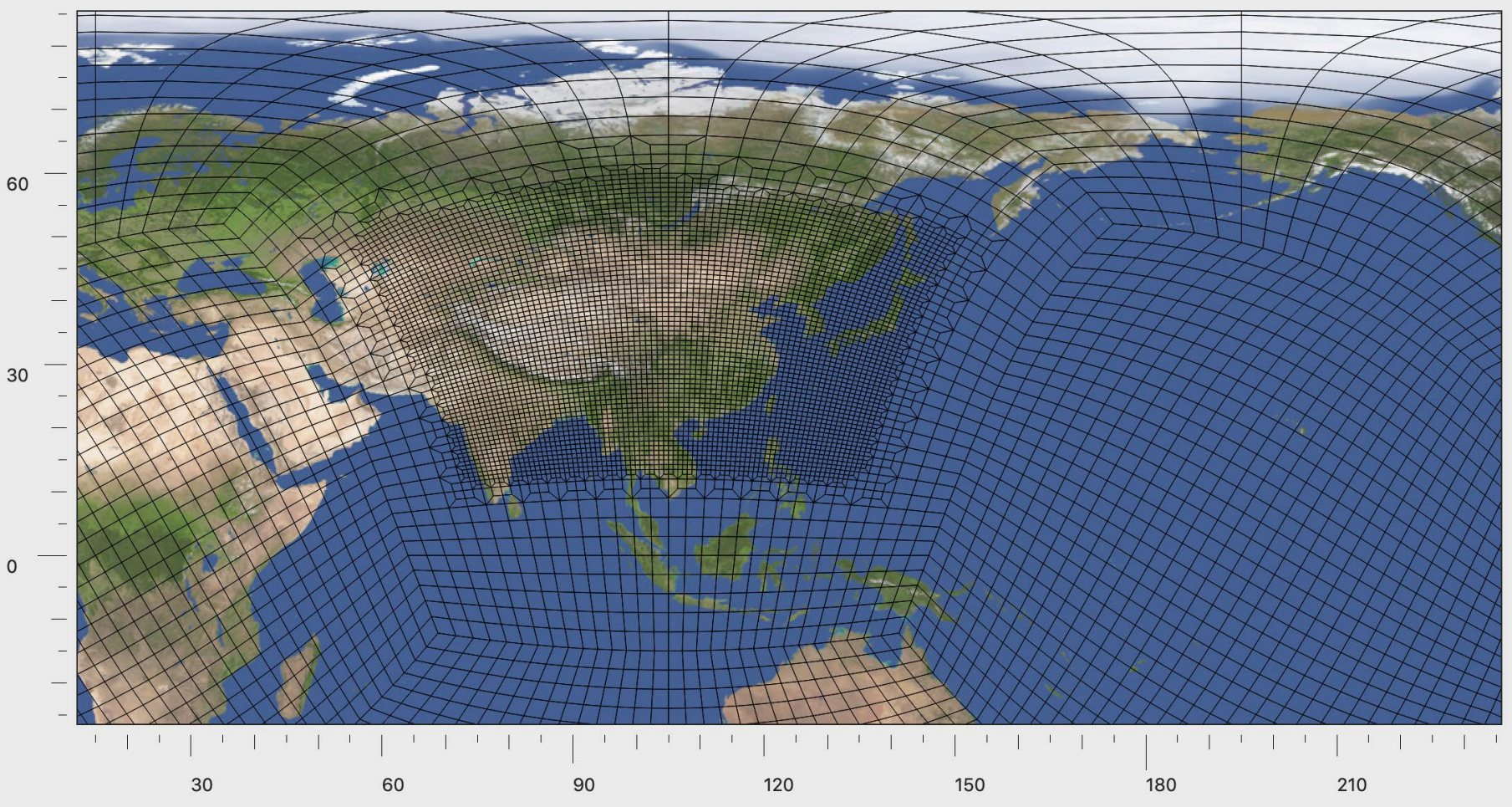
Laura Pan, NCAR

Models used in "dry run" forecasting "2019 period"

Model System	Resolution	Chemistry	Aerosol
NASA GEOS (Assimilation)	0.25 deg, 72L, surf to 80 km ~1km vertical res. in UTLS ~30km horizonal res.	Specified Oxidants (OH, H_2O_2, NO_3 from GMI)	GOCART (Bulk)
ECMWF CAMS (Assimilation)	T511 L137 Surf up to 80km ~0.3km vertical res. In UTLS ~40km horizontal res.	Interactive Chemistry CB05 approach	Bulk Scheme
NCAR CESM2* WACCM6-SD / GEOS5	1-deg, 88L, surf to 140km ~1km vertical res.in UTLS ~100km horizontal res.	Interactive Chemistry 240 species	MAM4 (modal)

*CESM2: may have a regionally refined grid setup for Monsoon Region (~14km horiz. Res.; 0.5km vertical) for forecasts.

Regionally Refined Grid (Future!)



Details: Cube sphere grid; Spectral Element Dynamical Core; resolution around 1 degree down to a fine resolution of 1/8 degree (12-14km)

Figure Courtesy of Simone Tilmes

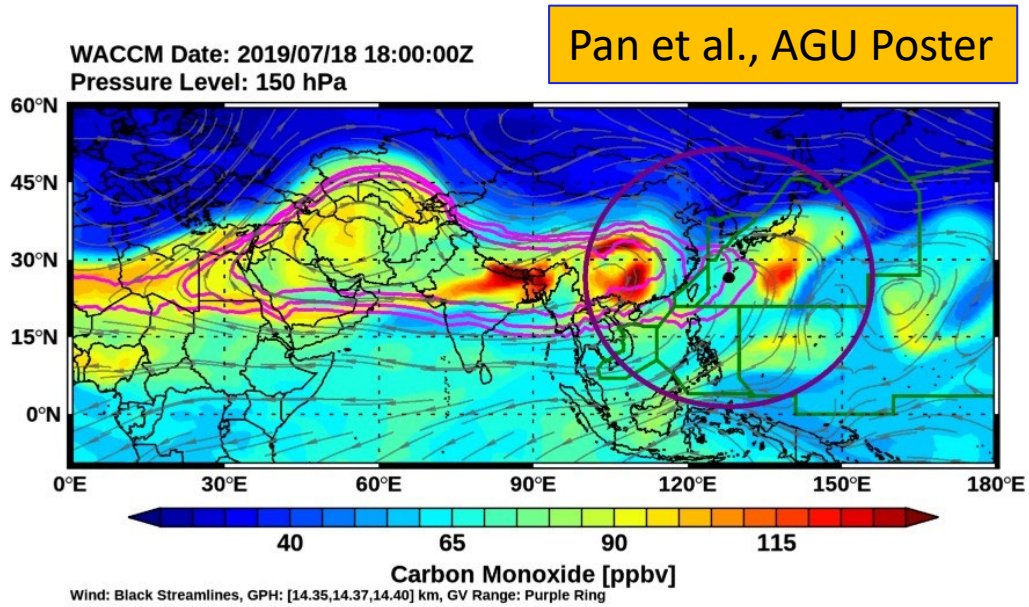
Representation of Carbon Monoxide (CO) during the NH Asian Monsoon Anticyclone – Role of Convection?

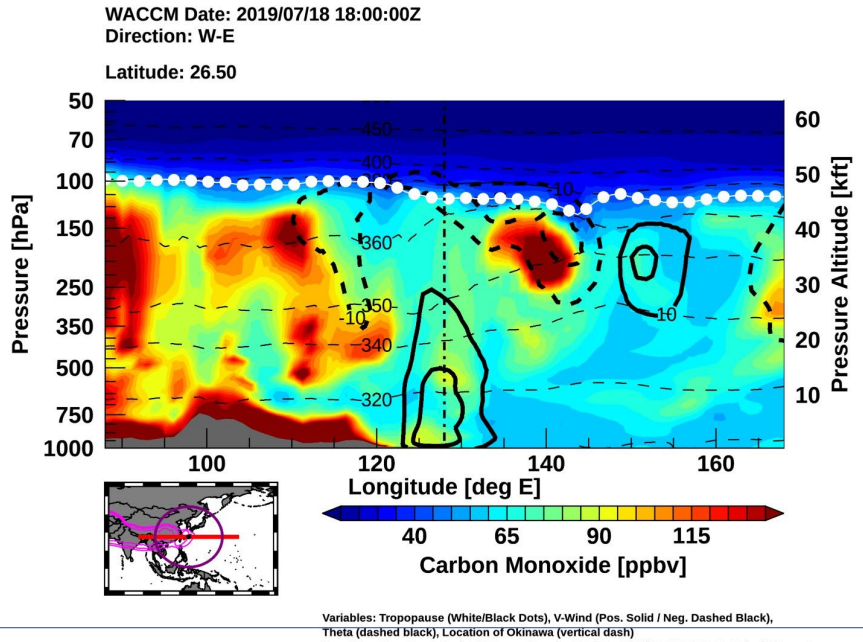
1) Large Eastward Shedding Event : August 1st, 2019.
2) Typhoon Outflow: August 8th 2019
3) Shedding Event Spreads into low latitude following anticyclonic flow: August 15-18th 2019

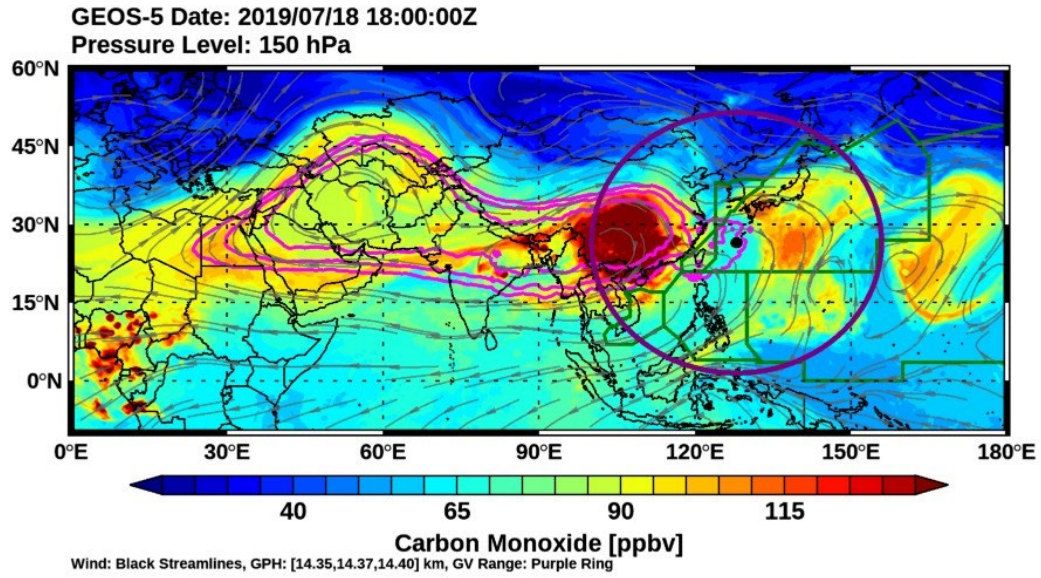
Movie courtesy of Shawn Honomichl

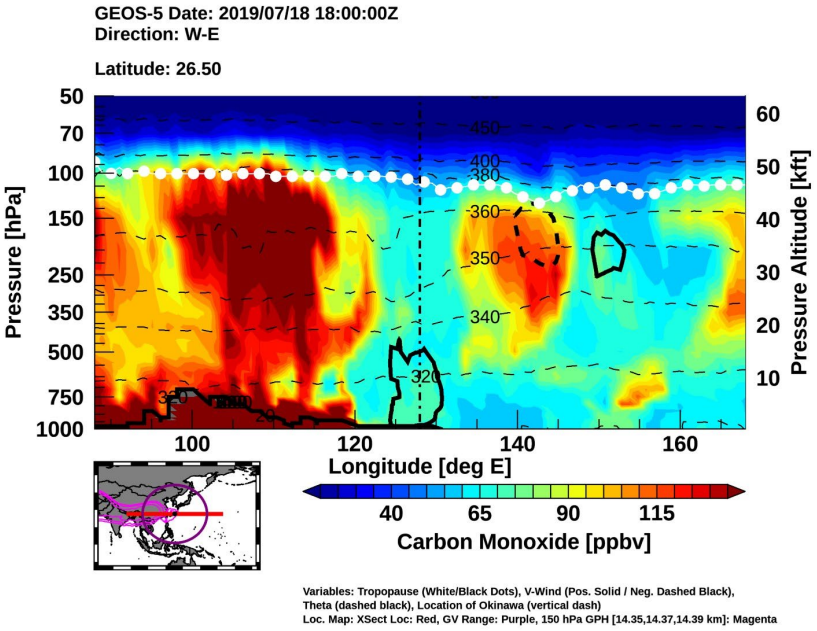
CO (ppbv) *** WACCM6 (88L) vs GEOS5 *** 2019-07-18

Pan et al., AGU Poster









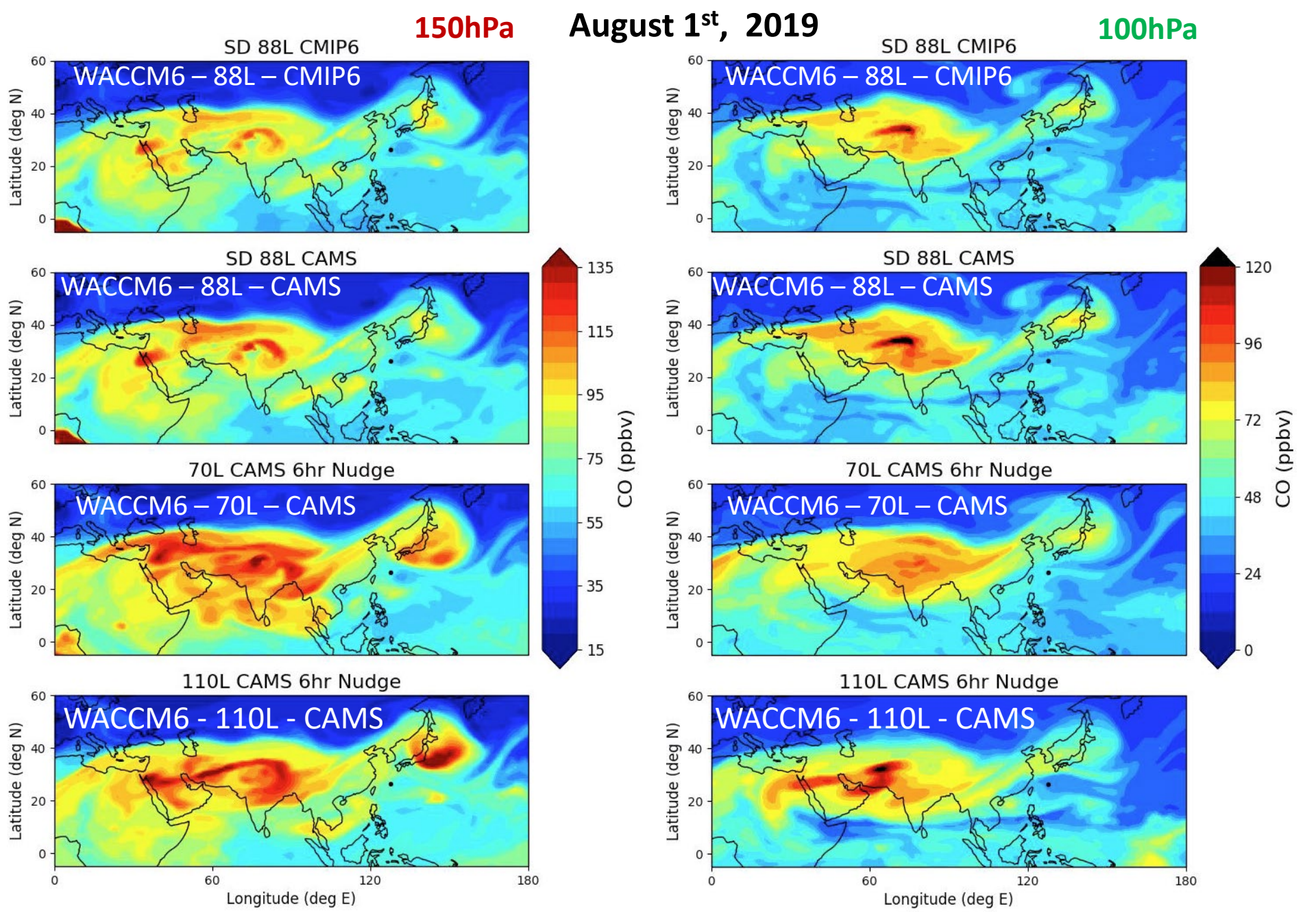
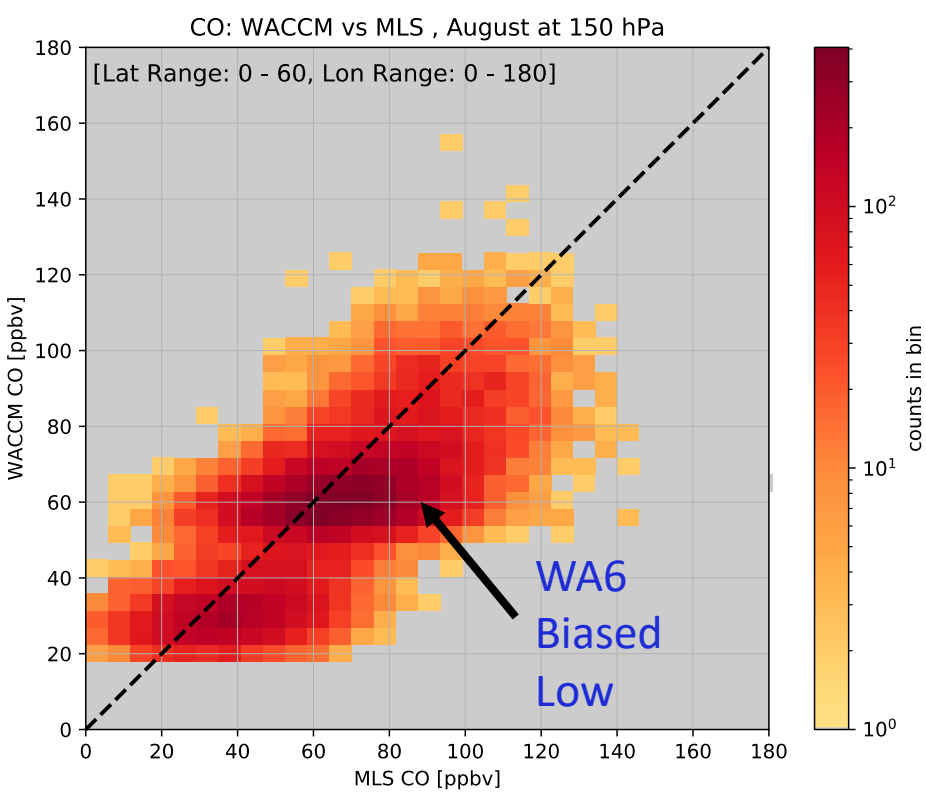
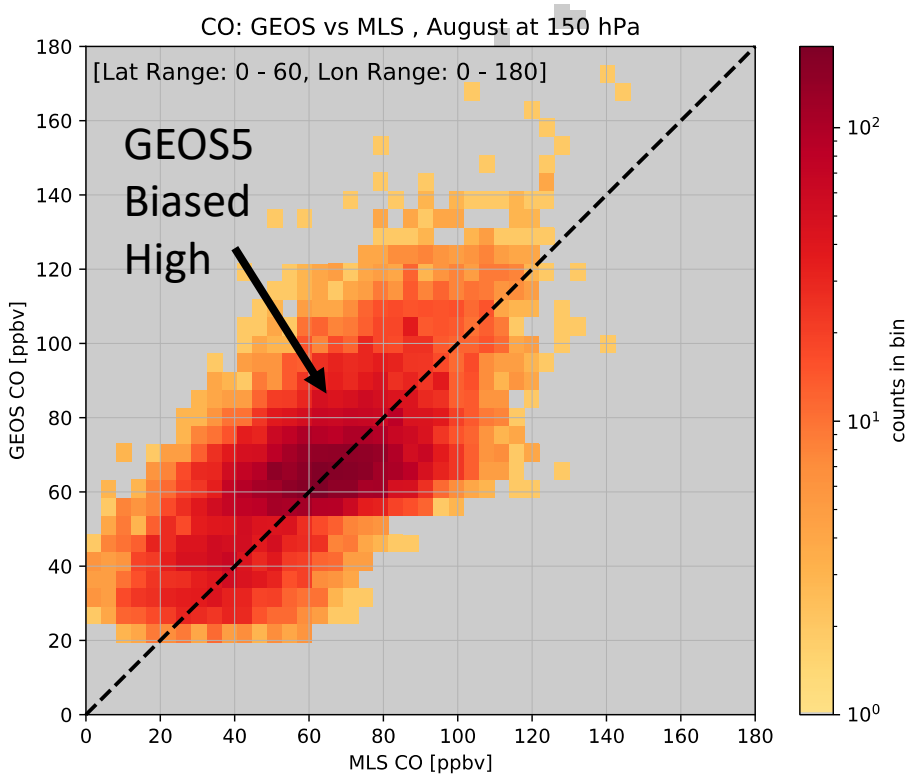


Figure courtesy of Ren Smith, NCAR

Models versus Aura MLS *** August

WACCM6 (88L) **150hPa** **GEOS5**





Approach:

- All done for area [-10 S → 60 N, 0 → 180 E]
- Applied MLS averaging kernel to WACCM6

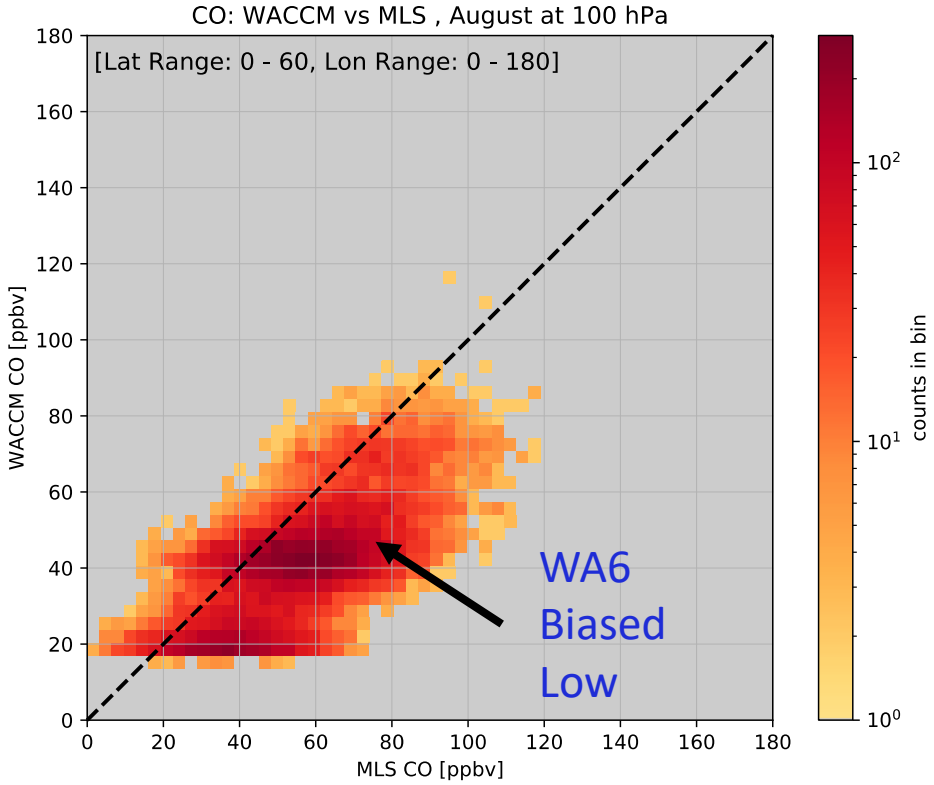
Courtesy of Sofia Chelpon, City Univ. of New York

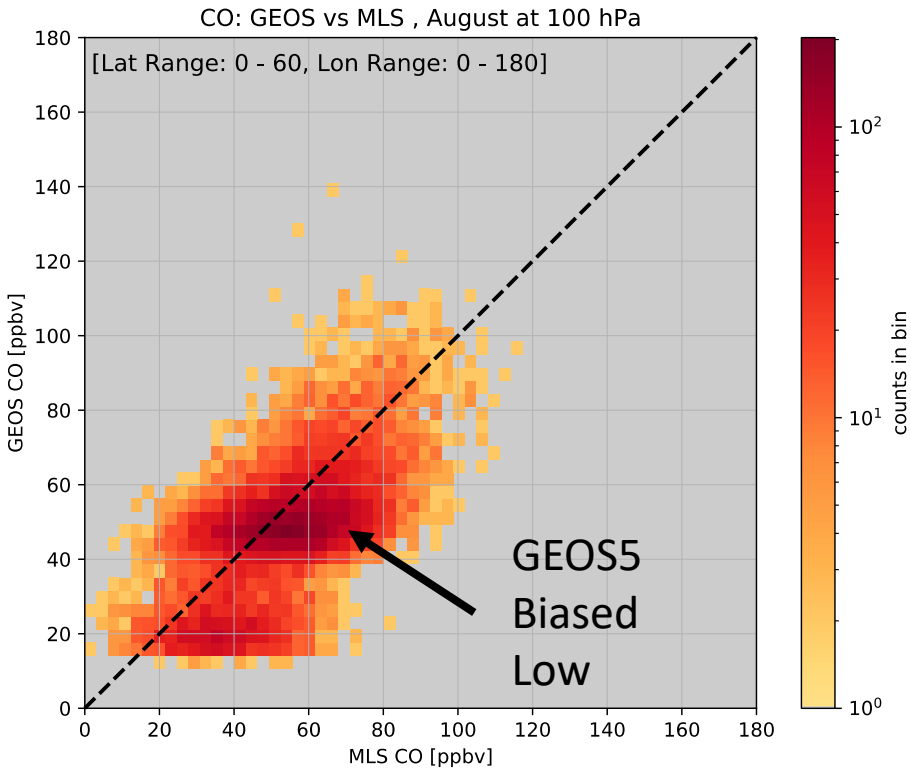
Models versus Aura MLS *** August

WACCM6 (88L)

100hPa

GEOS5





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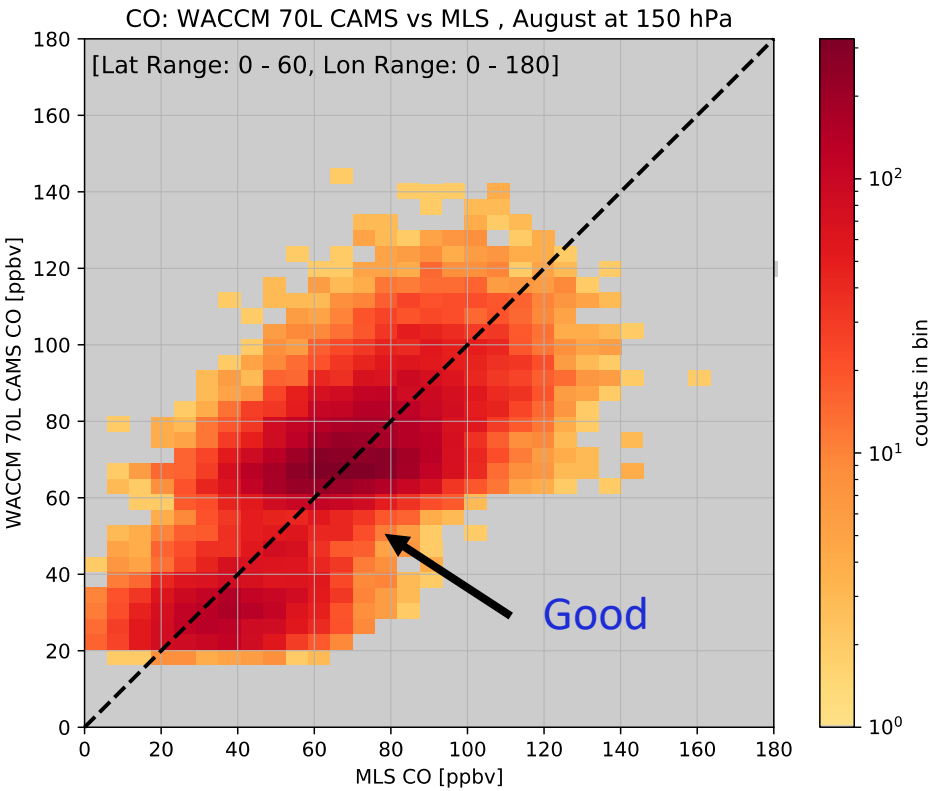
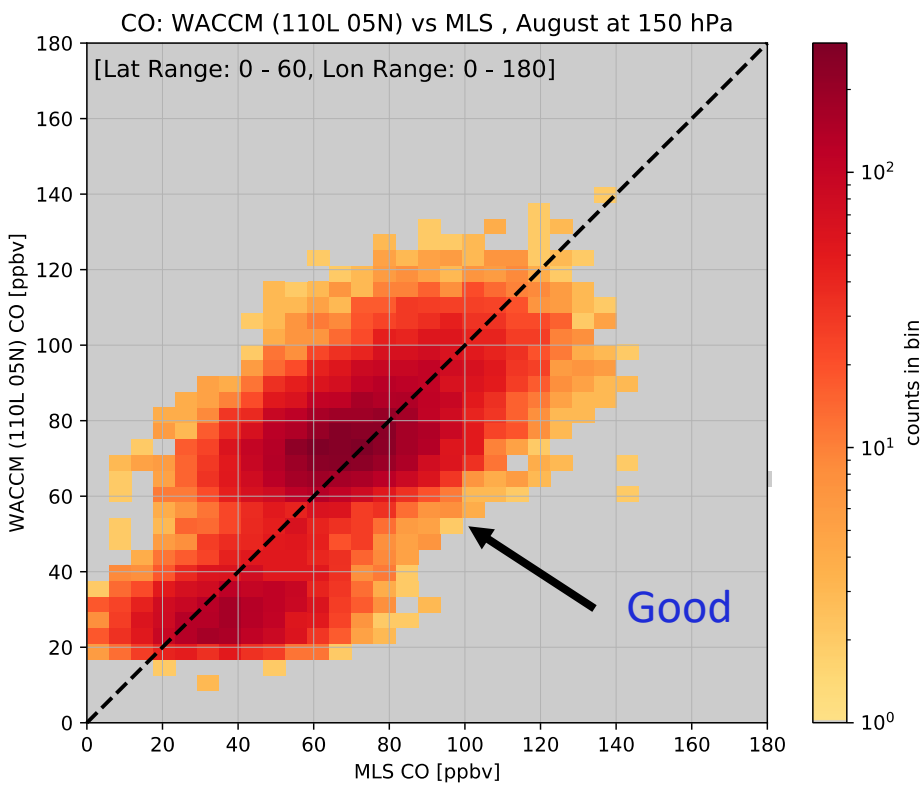
Models versus Aura MLS *** August

WACCM6 (70L) 150hPa WACCM6 (110L)





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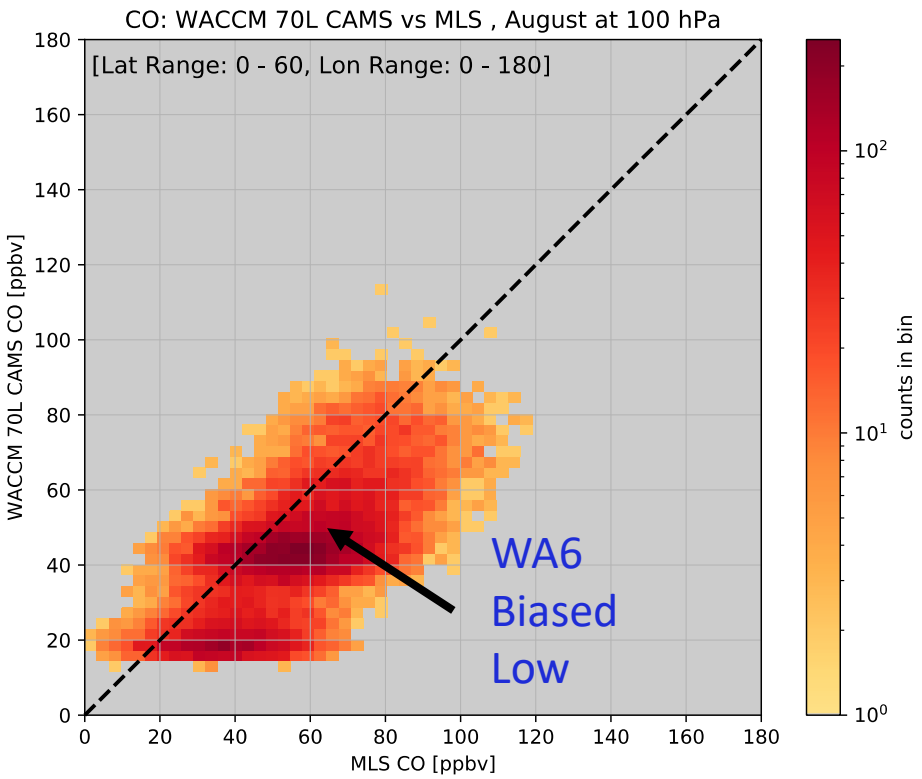
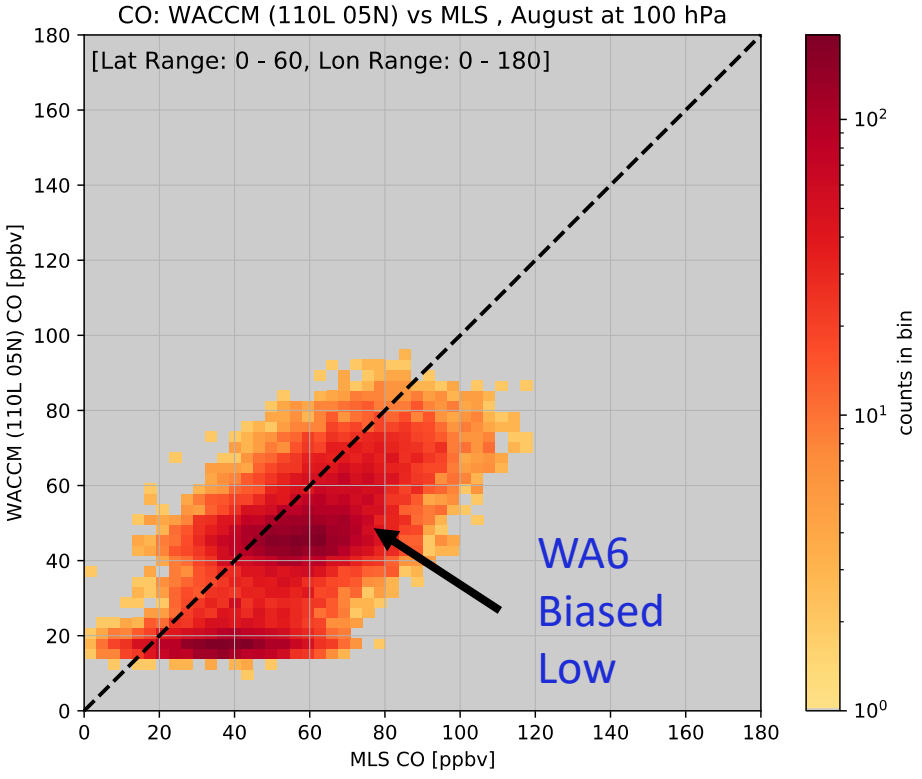
Models versus Aura MLS *** August

WACCM6 (70L)

100hPa

WACCM6 (110L)





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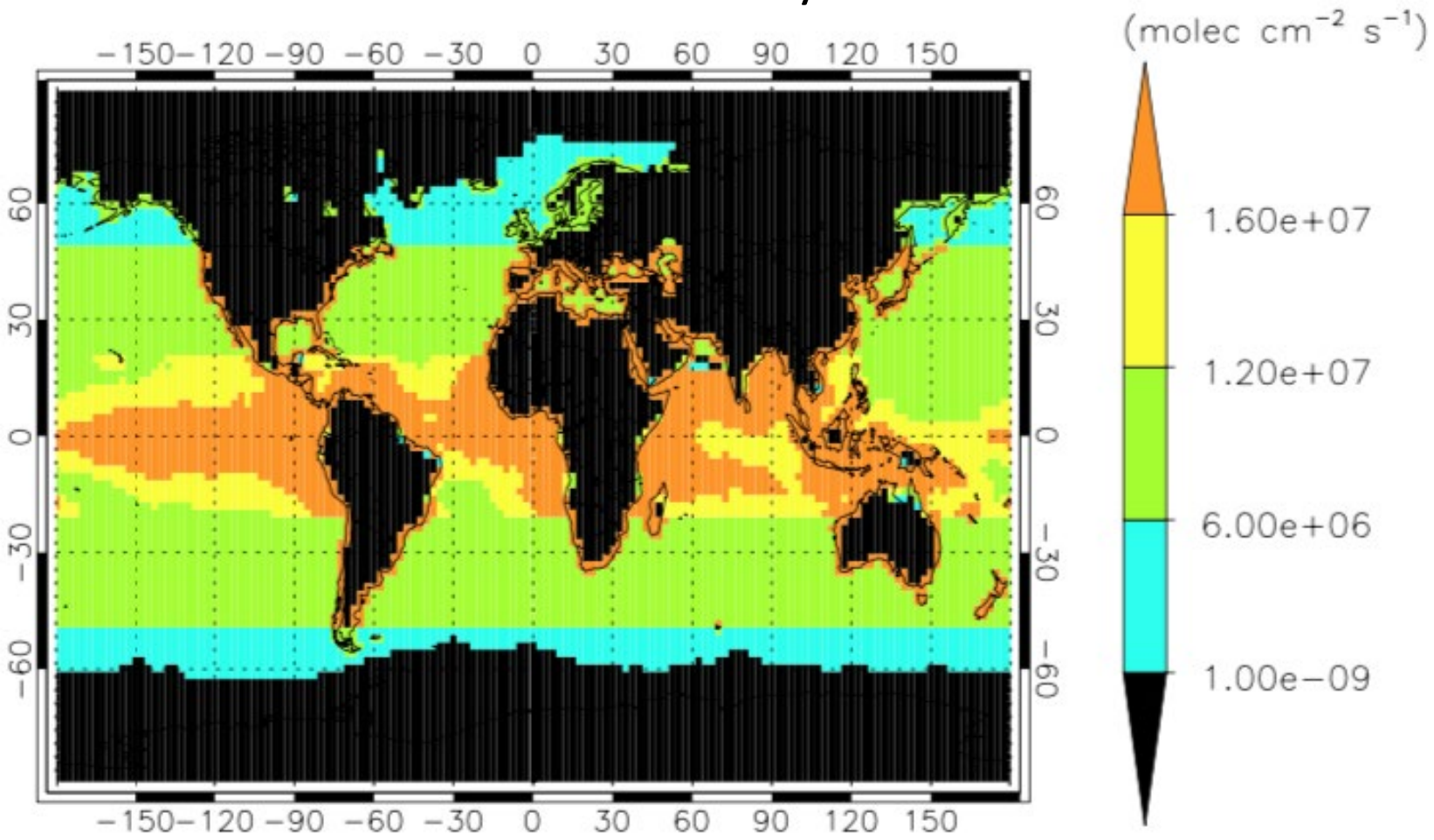
All WACCM Versions underestimate CO at 100hPa?

Courtesy of Sofia Chelpon, City Univ. of New York

Typhon Outflow Influences on Chemical and Aerosol Distributions?

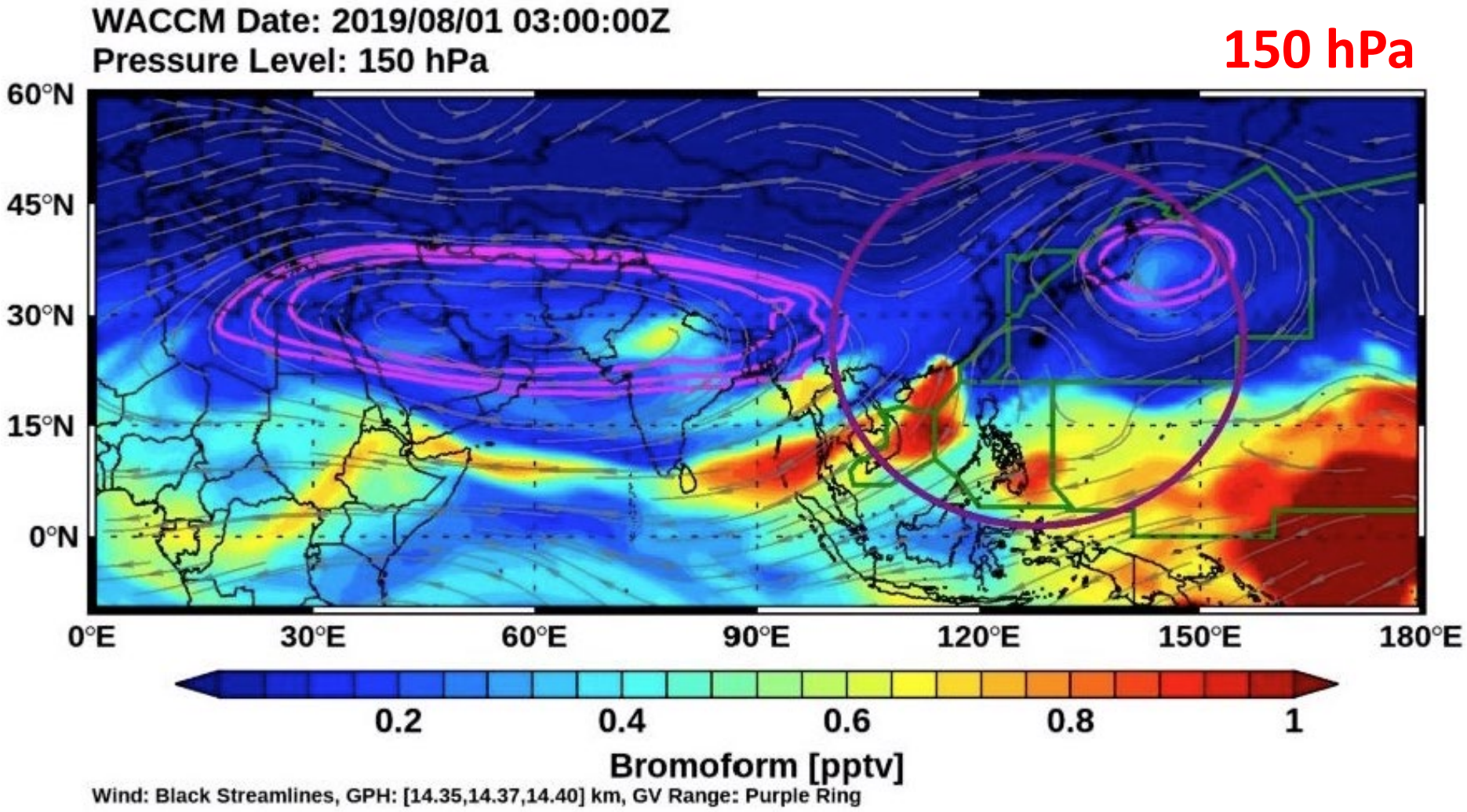
Marine Boundary Layer Influence in the UTLS?

Bromoform Emission Flux - July



Ordonez, C., J-F Lamarque, Simone Tilmes, D. E. Kinnison, E. L. Atlas, D. R. Blake, G. S. Santos, Guy Brasseur, and A. Saiz-Lopez, Bromine and iodine chemistry in a global chemistry-climate model: Description and evaluation of very short-lived oceanic sources, *Atmos. Chem. Phys.,* 2012.

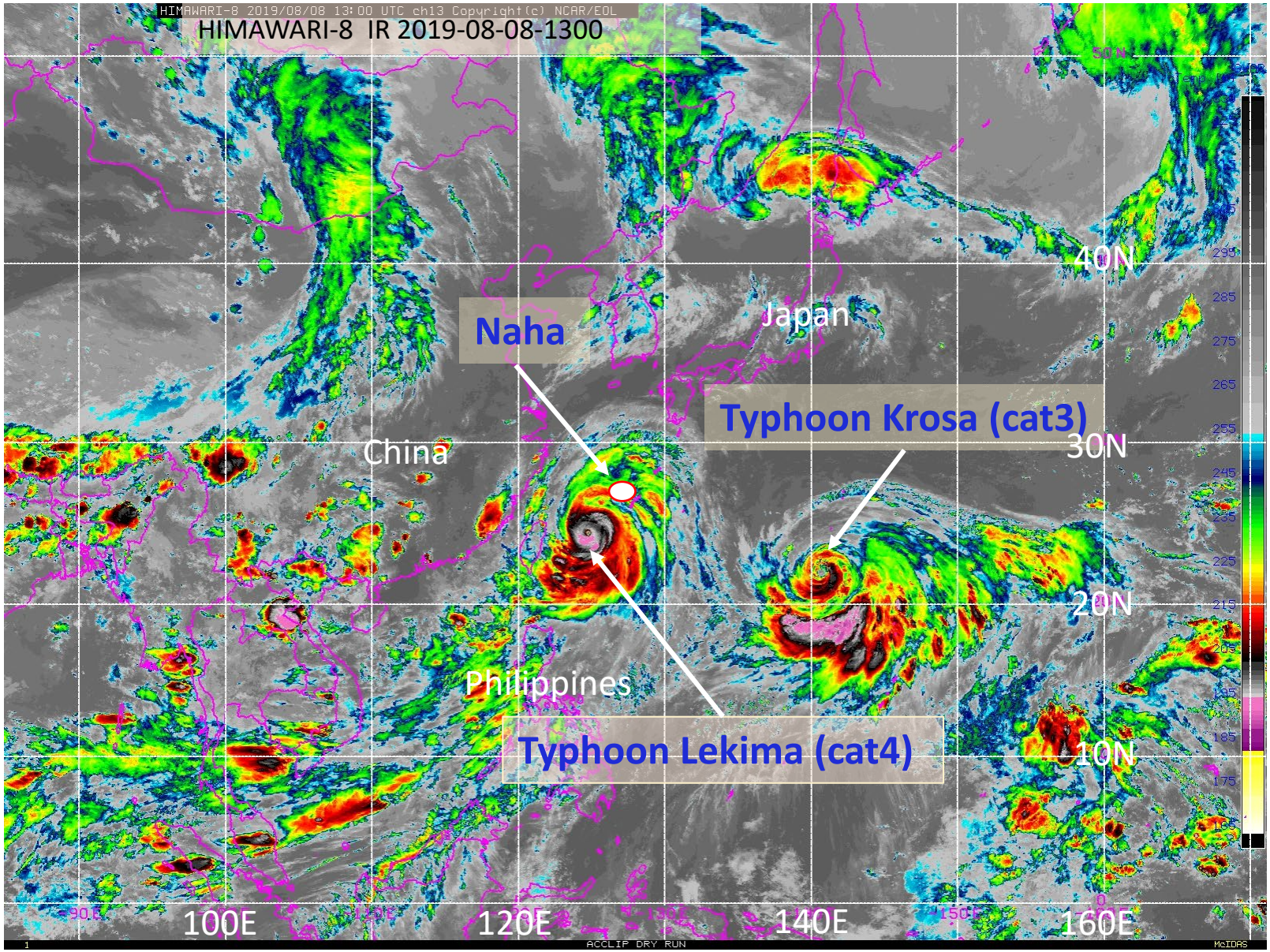
Low Bromoform in the shedding event: Aug 1st, 2019



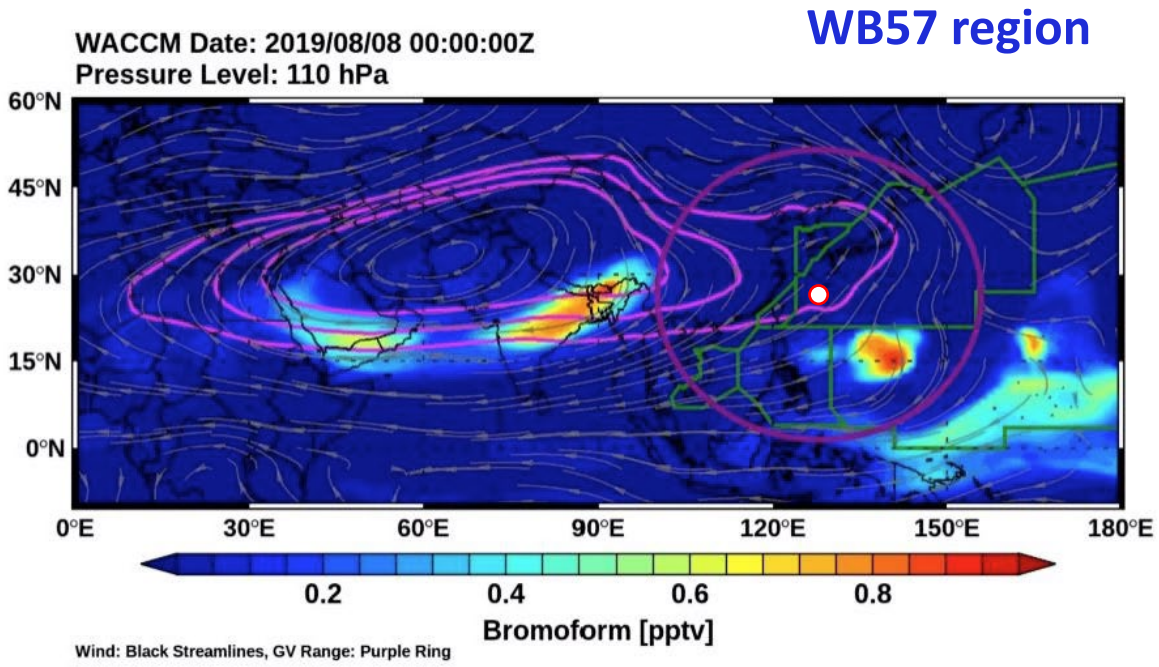
Minimal influence of marine air in the shedding event.

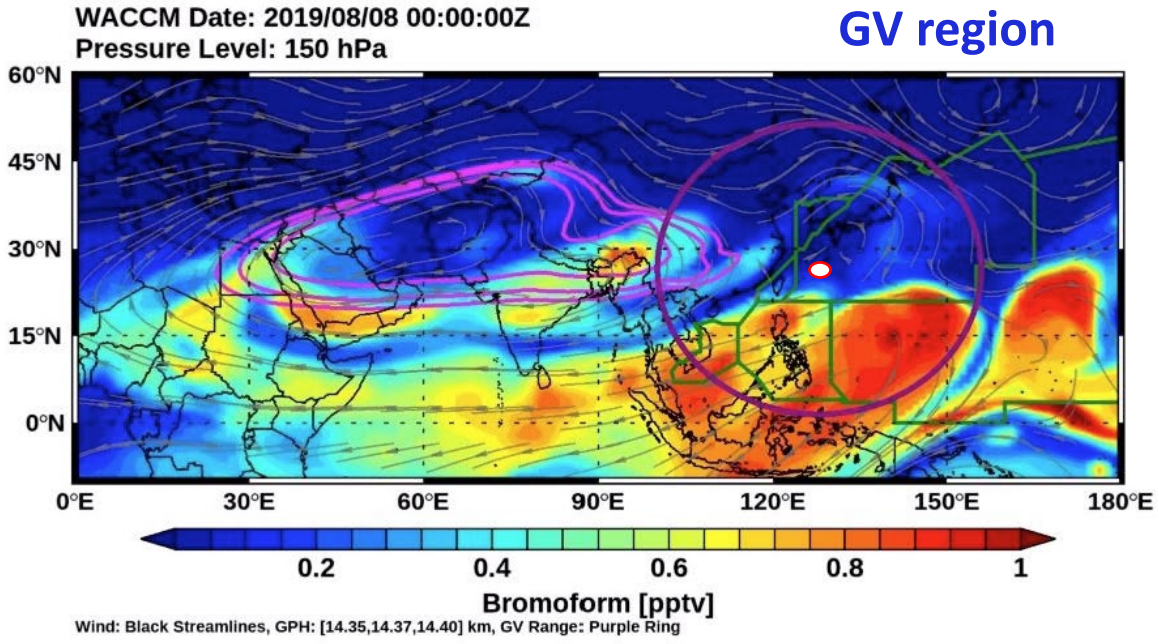
Figure courtesy of Shawn Honomichl

Typhoon Influence in the ACCLIP domain ** August 8, 2019



Himawari-8 Japanese Weather Satellite (16 channel multispectral imager) in IR and Visible





Typhoon Outflow:

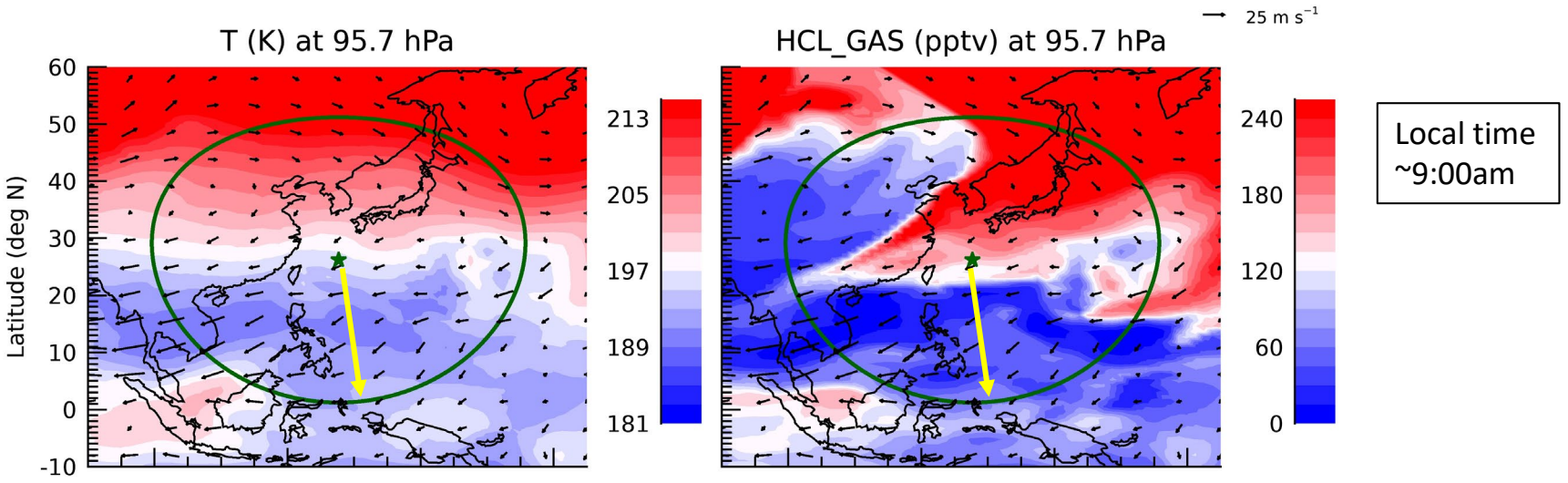
August 8th 2019

Bromoform ($CHBr_3$)

- WB57: Marine air is not significantly affecting the 110hPa region. There is a signature of the Krosa typhoon.
- GV: The southern flank shows strong outflow from both typhoons.

Subtropical Heterogeneous Chemistry in the NH Asian Monsoon Anticyclone – Can this be detected by Aircraft?

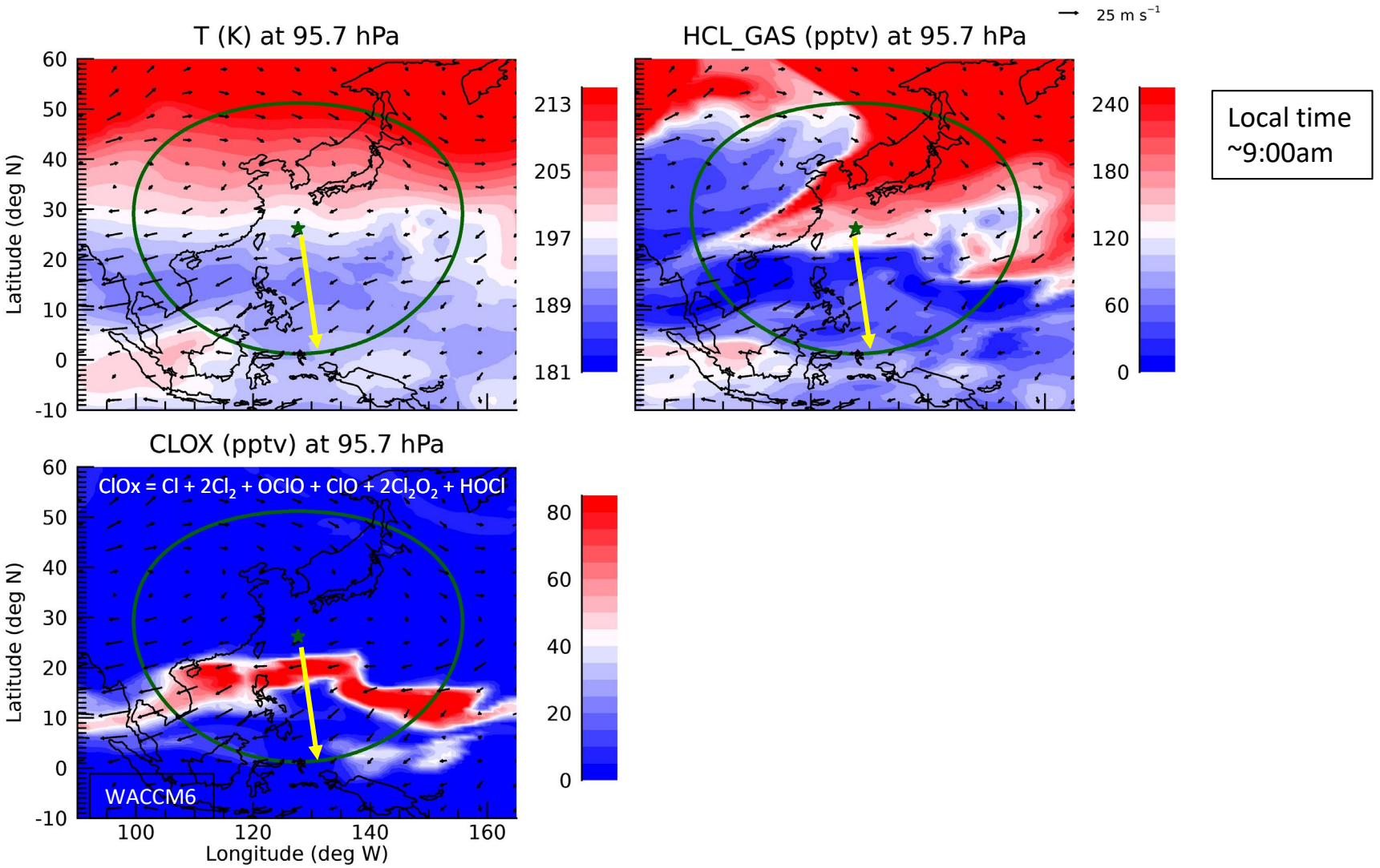
Cold Subtropical Temperatures? August 11, 2019



Solomon et al., Monsoon circulations and tropical heterogeneous chlorine chemistry in the stratosphere, *Geophys. Res. Lett.,* doi:10.1002/2016GL071778, 2016.

Figure courtesy of Ren Smith, NCAR

Signature of Halogen Heterogeneous Chemistry? August 11, 2019



Local time ~9:00am

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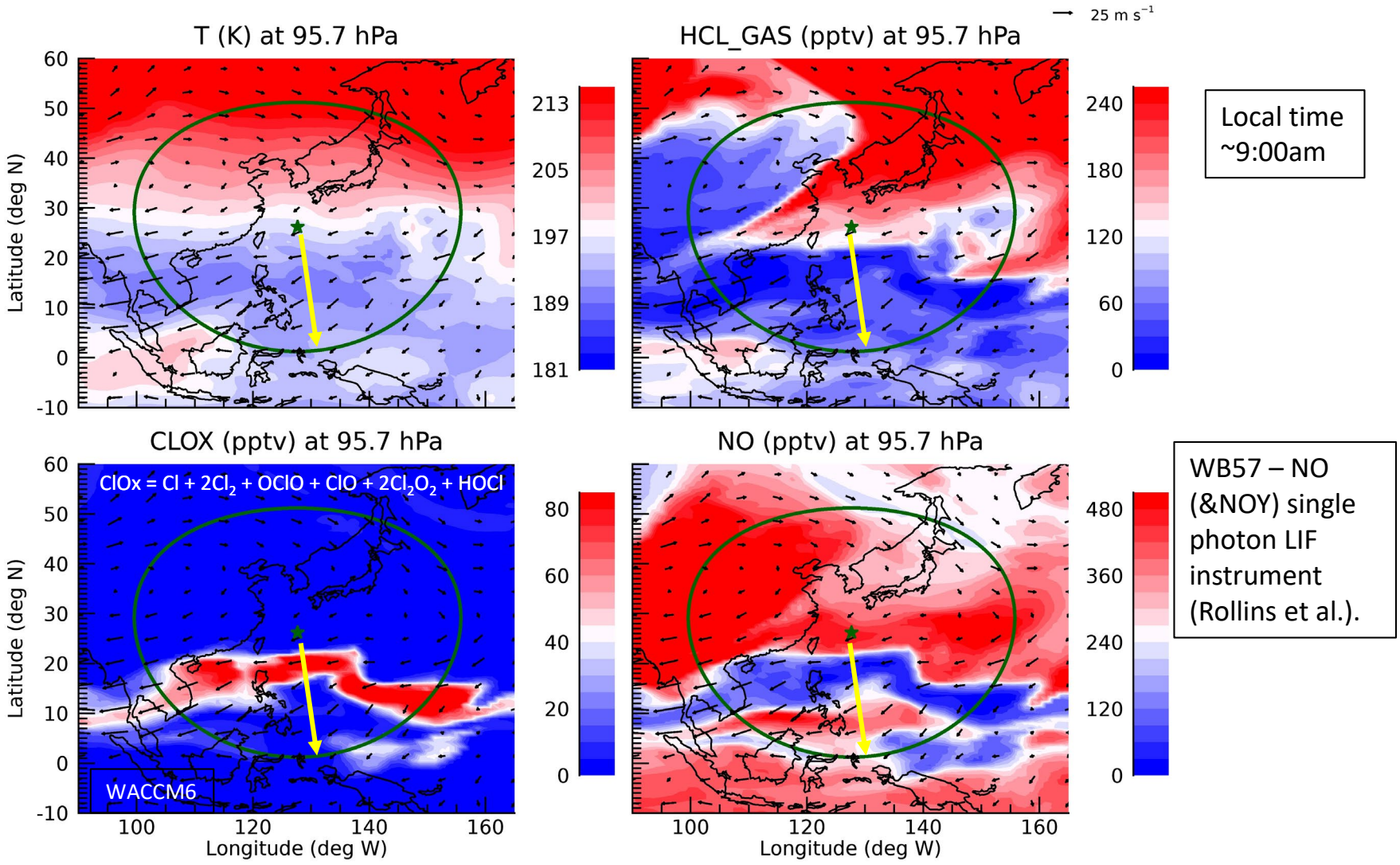

Local time ~9:00am

WB57 – NO (&NOY) single photon LIF instrument (Rollins et al.).

$ClONO_2 + HCl \Rightarrow Cl_2 + HNO_3$

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Without Halogen Heterogeneous Chemistry? August 11, 2019

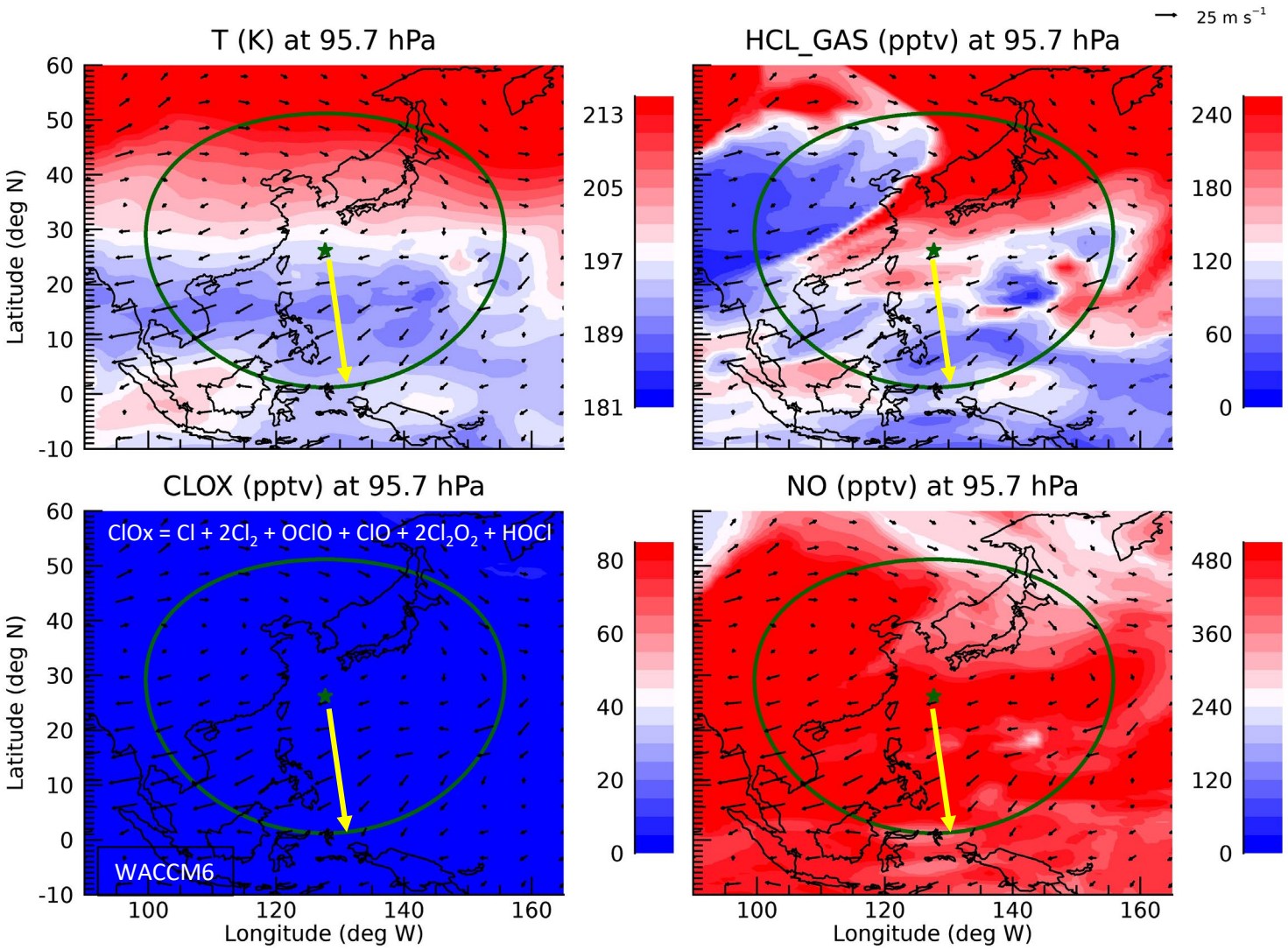

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Figure courtesy of Ren Smith, NCAR

Summary

- The 2019 Asian Monsoon season gave us many opportunities to examine airmasses that were lofted by the ASM convection from the Asian boundary layer and subsequently transported to Western Pacific UTLS via sub-seasonal-scale eastward eddy shedding.

- WACCM6 70L and 110L versions best represent CO at 150hPa. All WACCM6 versions (88L, 70L, 110L) underestimate CO at 100hPa??

- Typhoon(s) can clear out the continental pollution, in addition there are interesting chemical signatures in the outflow.

- The model indicates there are many opportunities to sample region <100hPa that have been influenced by heterogeneous halogen chemistry.

- We are in good shape to have forecasts models that can support the mission objectives (GEOS, CAMS, WACCM). We hope to have the refined grid version ready to go by mid-July.

Thank you for your attention