Transport by Asian Summer Monsoon Convection to the UTLS during the 2022 ACCLIP Campaign

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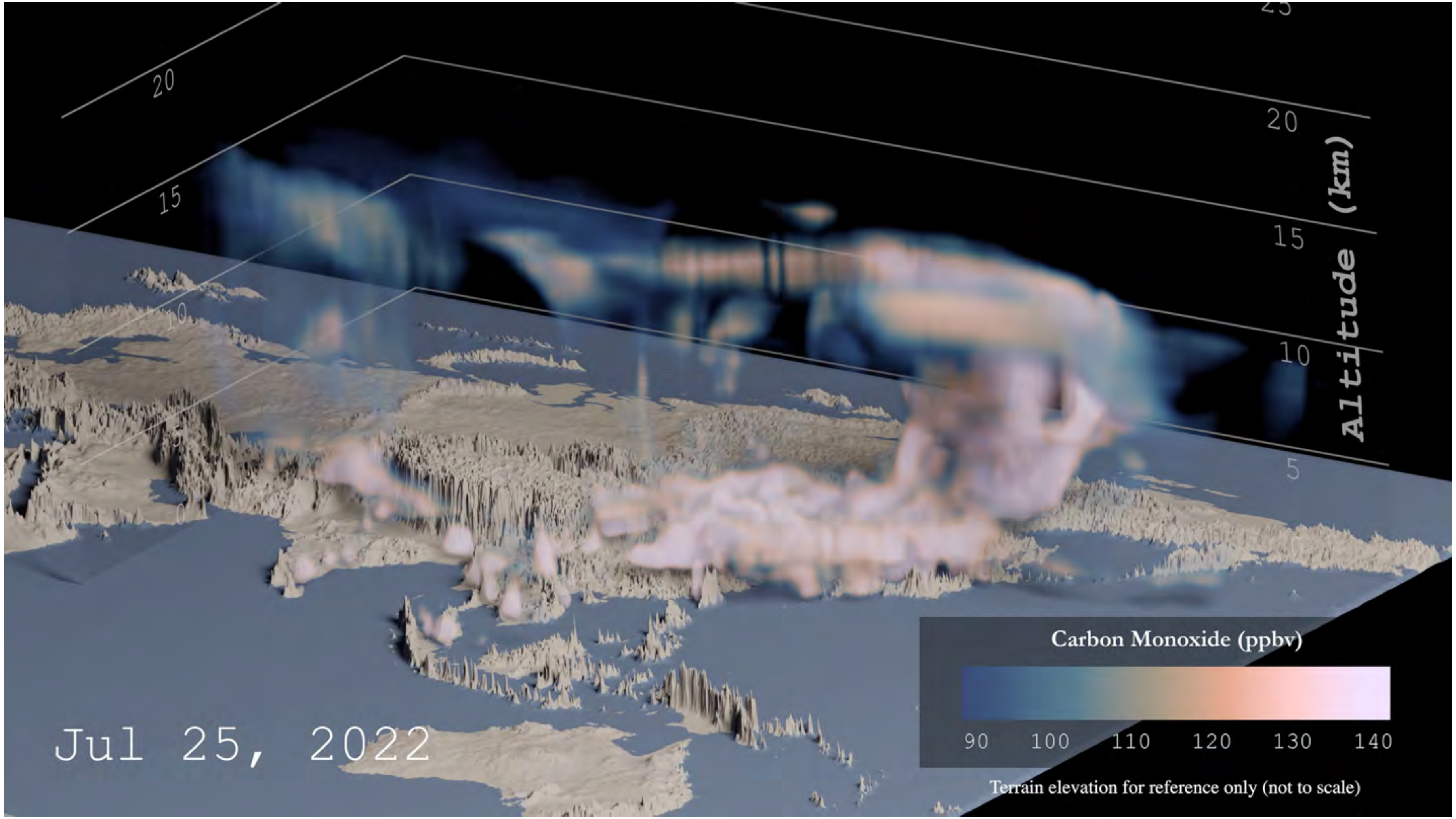
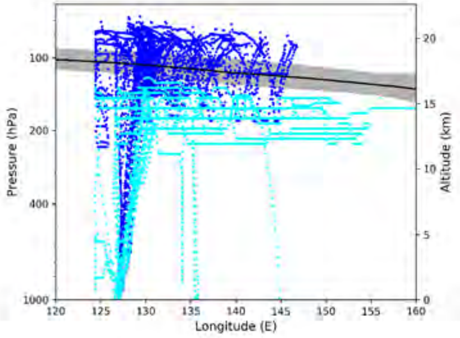
Characterizing convective sources for ACCLIP is essential for understanding our observations



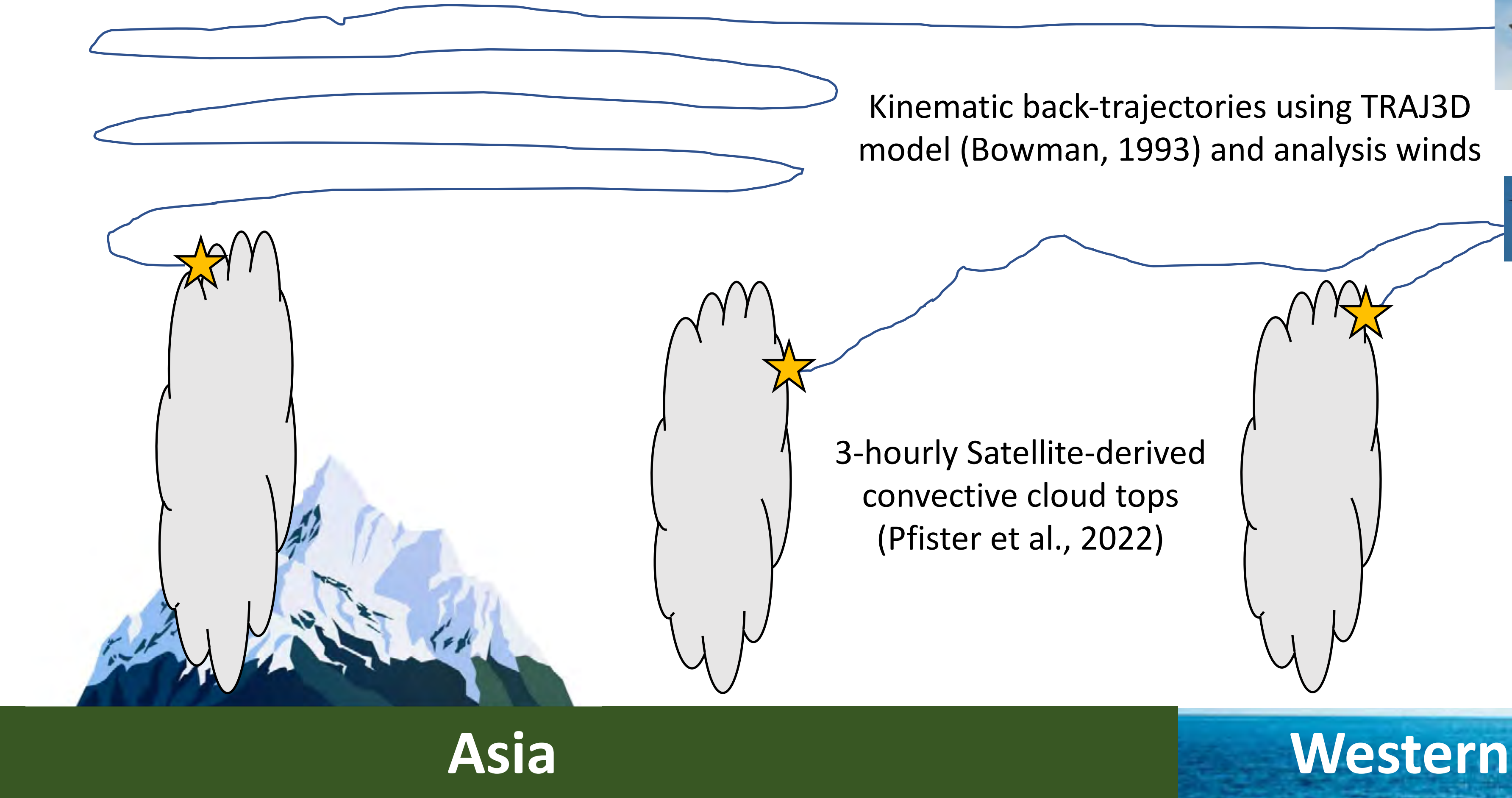
3D MUSICA rendering by Matt Rehme, NSF NCAR/CISL

Link to animation

Backward trajectories are initiated from the ACCLIP flight tracks to study convective history



Kinematic back-trajectories using TRAJ3D model (Bowman, 1993) and analysis winds

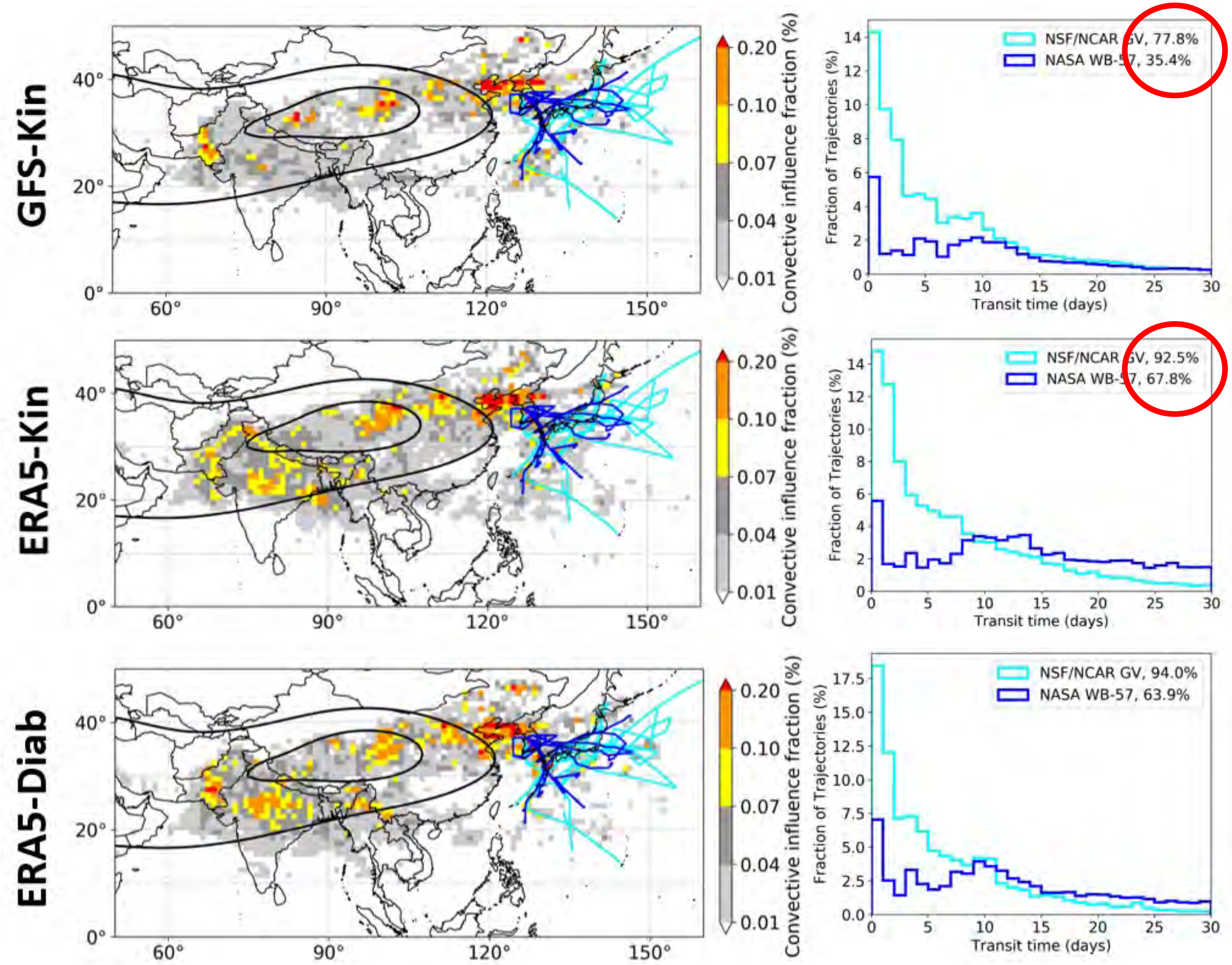


3-hourly Satellite-derived convective cloud tops (Pfister et al., 2022)

This product is available in the ACCLIP data archive to support science applications!

https://doi.org/10.26023/DP1P-C32K-YJ05

Analysis winds used for trajectories give *qualitatively* similar, but *quantitatively* different solutions



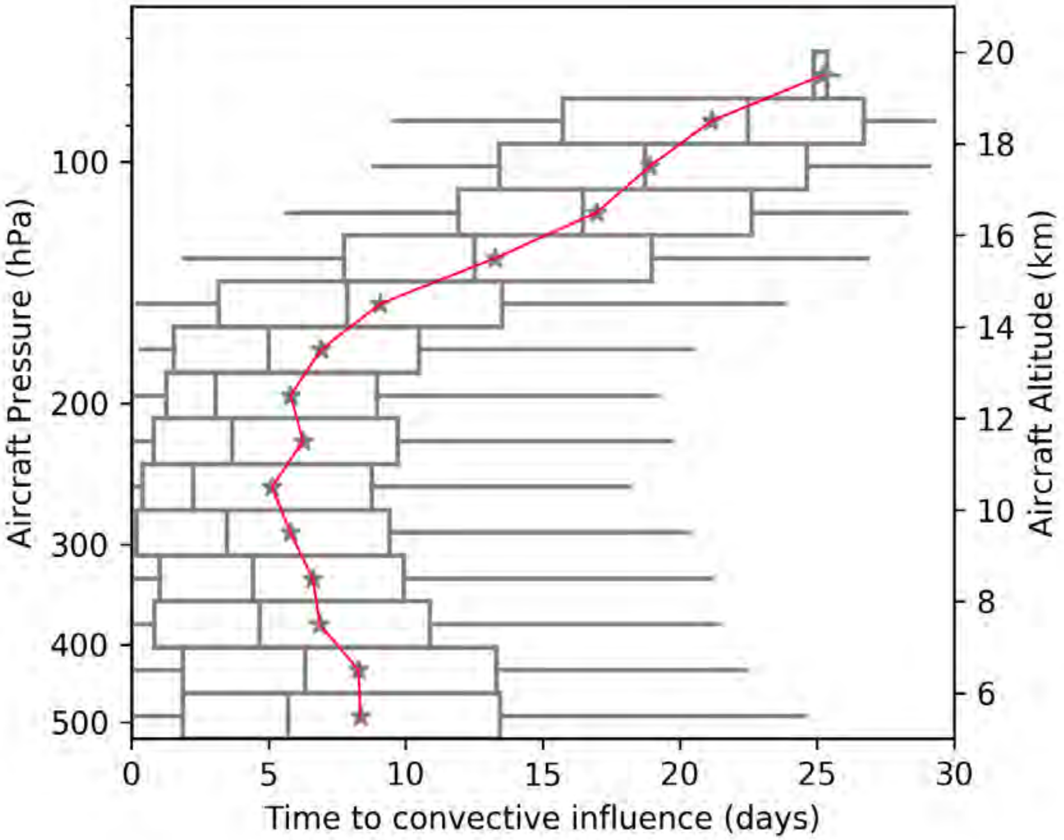
There are two primary regions of convective contribution to ACCLIP sampling: (1) southern Asia / northern India and (2) along the east Asian subtropical front

The GV had considerably enhanced convective contribution and faster transport from convection compared to the WB-57, due to primary sampling altitudes

30-day convective influence percentages from GFS-kin are diminished compared to ERA5-kin, likely due to spatial and temporal resolution

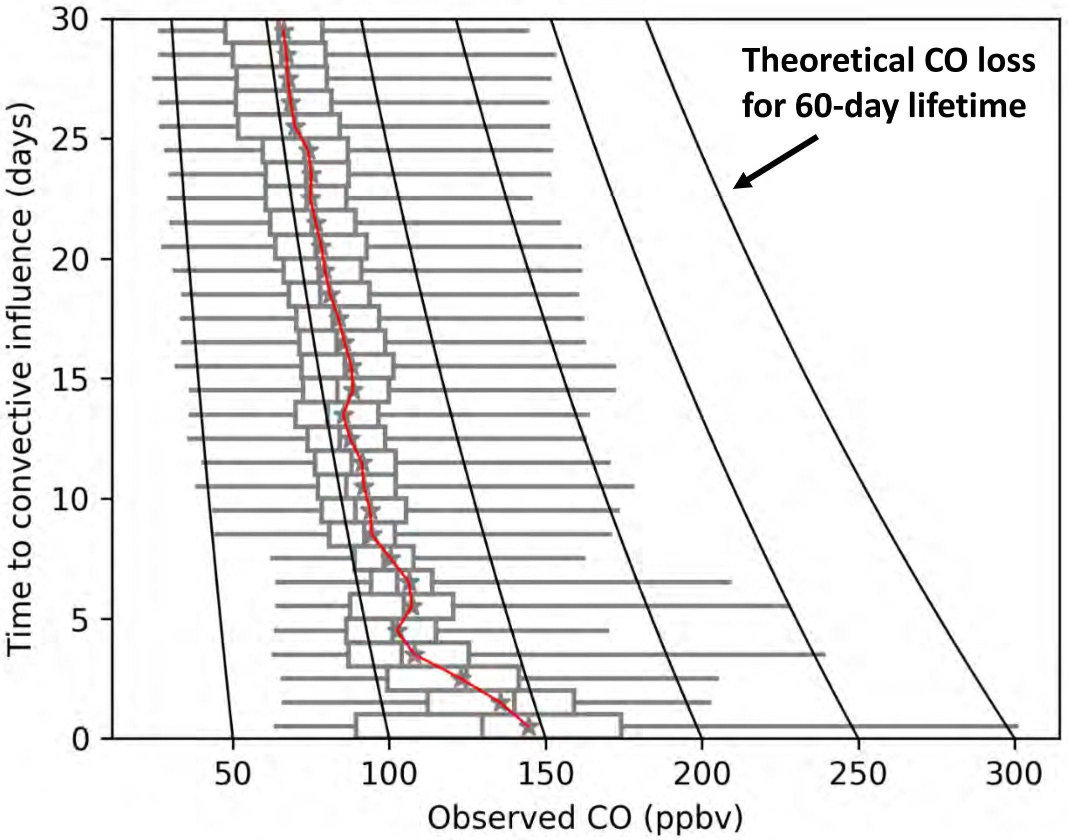
ERA5-kin and ERA5-diab are similar, likely because we consider transport _to_ convection but not *_through_* convection

ERA5-kin configuration is used hereafter



Mean time since convective influence is ~one week throughout the free troposphere (~5-14 km), suggesting convection dominates in this layer. Above ~15 km, mean time increases by ~5 days / km

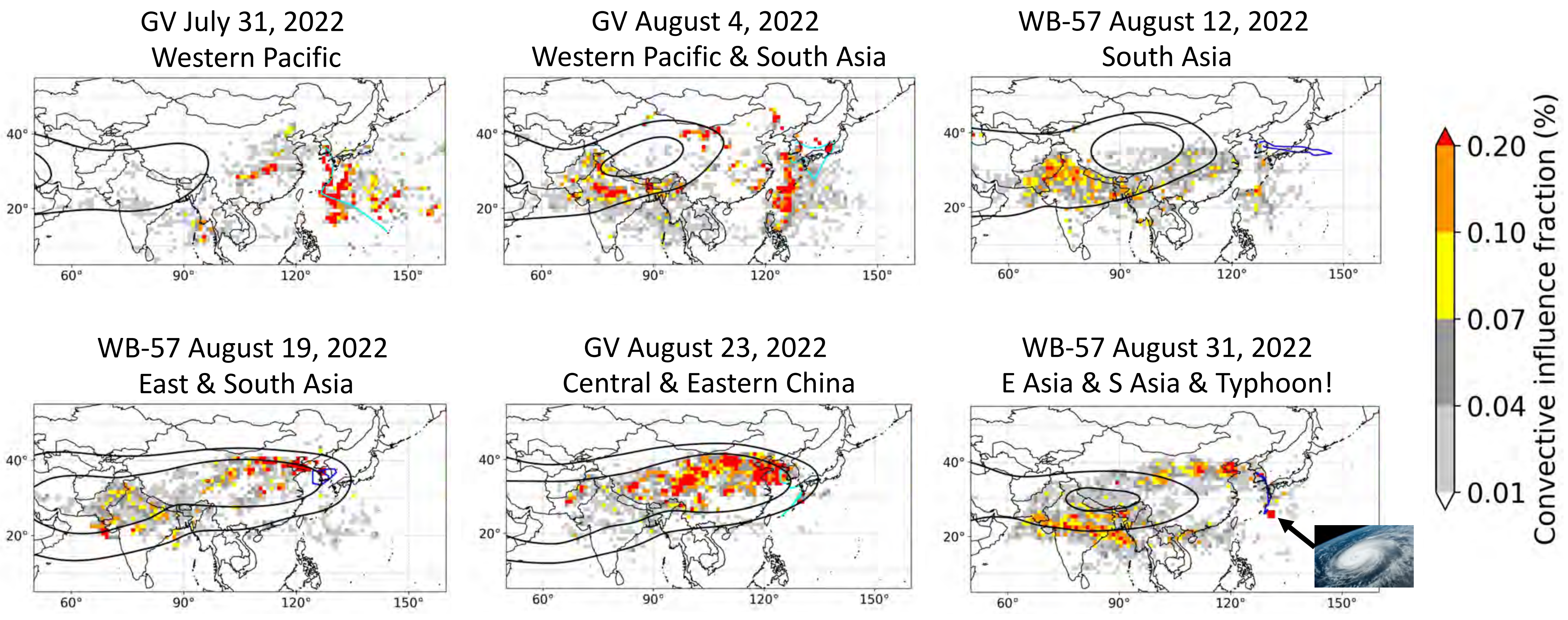
GV CO data provided by T. Campos, WB-57 CO data provided by S. Viciani and the COLD2 instrument team



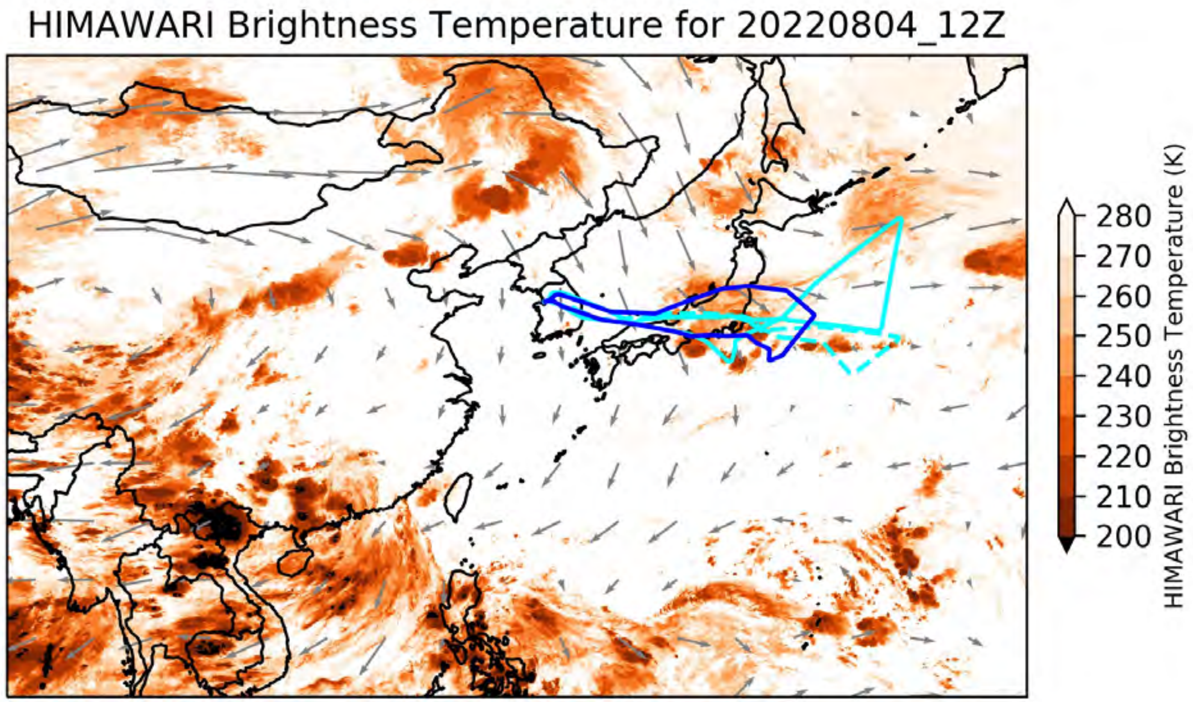
Within ~one week since convection, CO loss is much faster than expected from chemical loss alone.

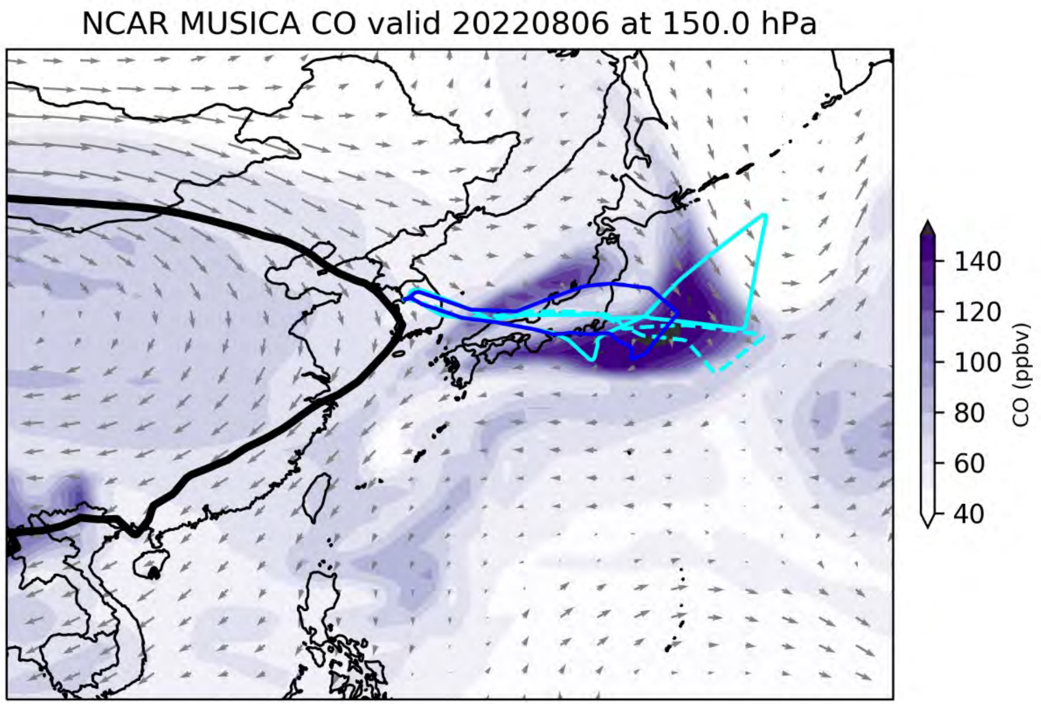
This suggests that convection carries localized "bursts" of pollution to the UTLS, which gradually reduce to "ambient anticyclone" levels within ~one week

Individual ACCLIP research flights offer unique convective transport histories



Flights on Aug 6-7, 2022 sampled horizontal, vertical and temporal gradients





Wind vector level: 150 hPa

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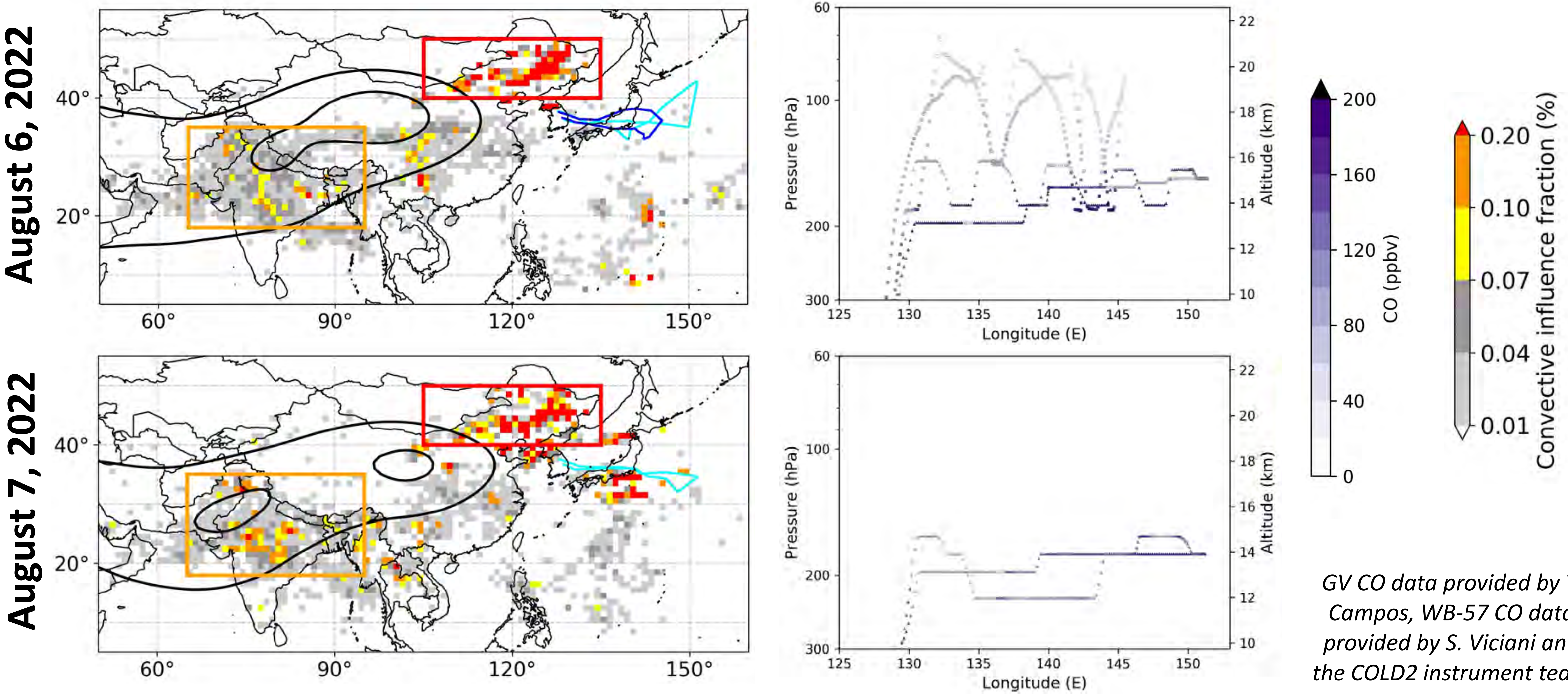

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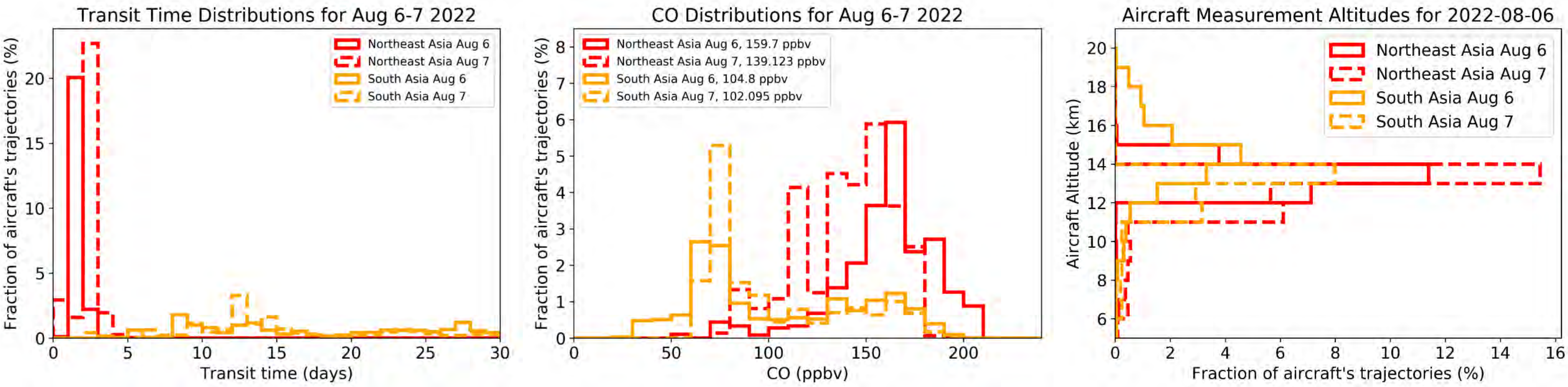


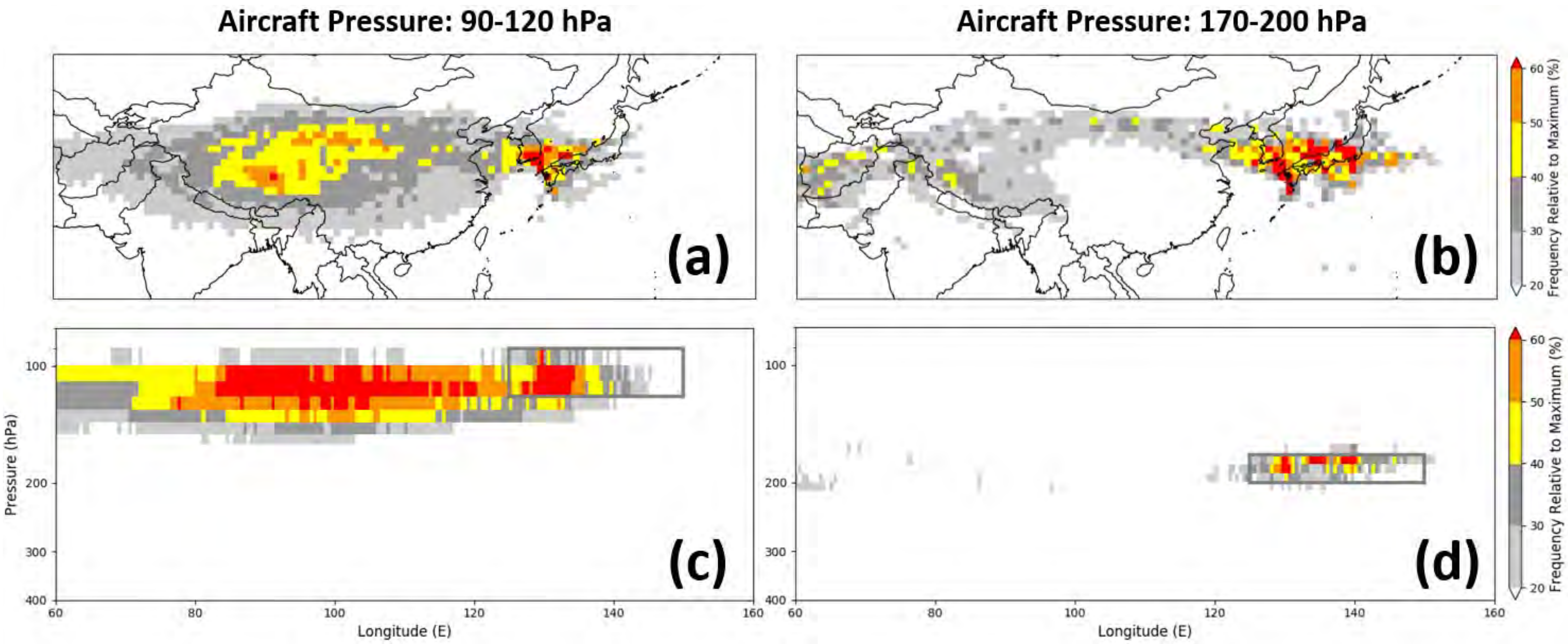
Northeast Asia was observed ~days since convection, while south Asia was ~weeks since convection

CO was considerably elevated in the "fresher" northeast Asia outflow

Northeast Asia CO attenuated considerably from Aug 6 to 7 sampling (~20 ppbv)

The northeast Asia source was only observed from 11-15 km aircraft altitude. Above 15 km, sampling was limited to more distant south Asian outflow

For all ACCLIP sampling, higher-altitude obs generally traveled through the UTLS anticyclone to reach the sampling domain. UT obs were often influenced recently by eastern Asia convection carrying potent pollution



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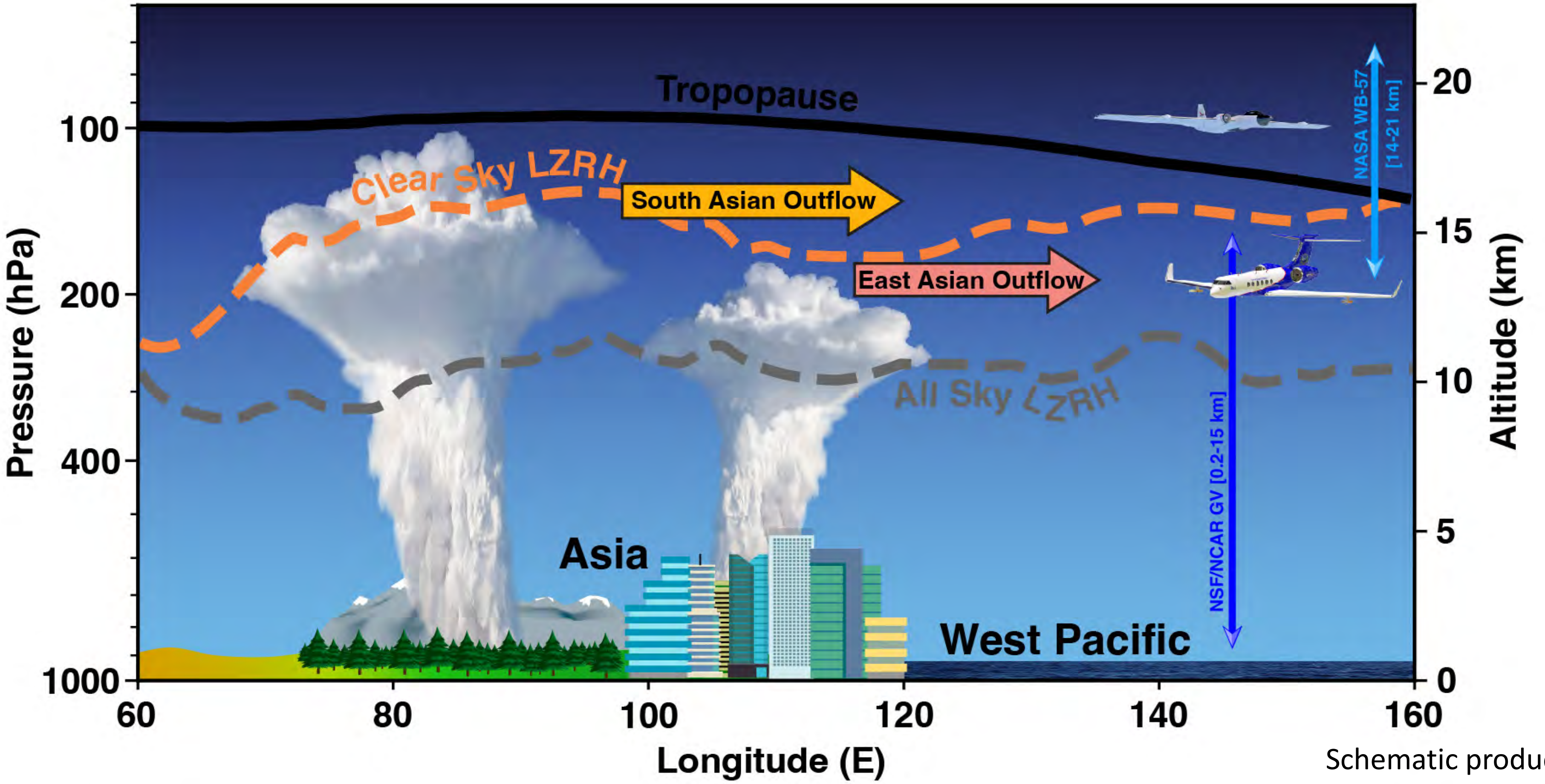


Schematic produced by Shawn Honomichl

Summary of transport mechanism

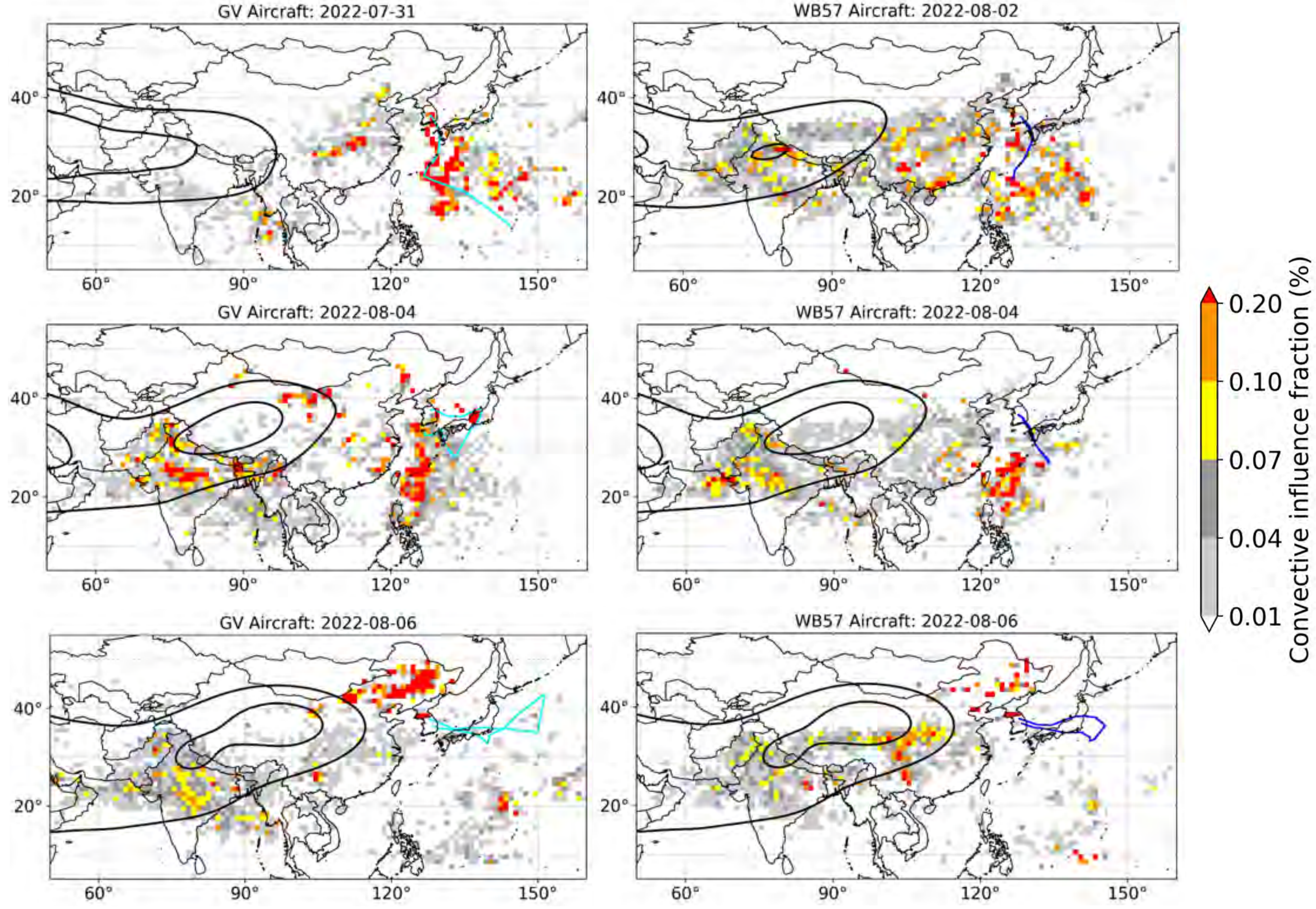
- ACCLIP sampled convective outflow from southern Asia, typically thought to be the primary source region for the ASM UTLS air mass (e.g., Bergman et al., 2013; Legras and Bucci, 2020).
- However, for sampling in the UT the southern Asia source was often "obscured" by comparatively fresh convective outflow along the east Asian subtropical front with enhanced, localized pollution levels (e.g., CO > 200 ppbv).
- It takes about one week for potent, localized pollution lofted by discrete convection to attenuate to "ambient anticyclone" levels. Within this week, pollution may be considerably more intense than estimated from satellite or coarse-grid global models.
  - This underscores the irreplaceable value of targeted in situ airborne observations

Broader outlook for this transport work

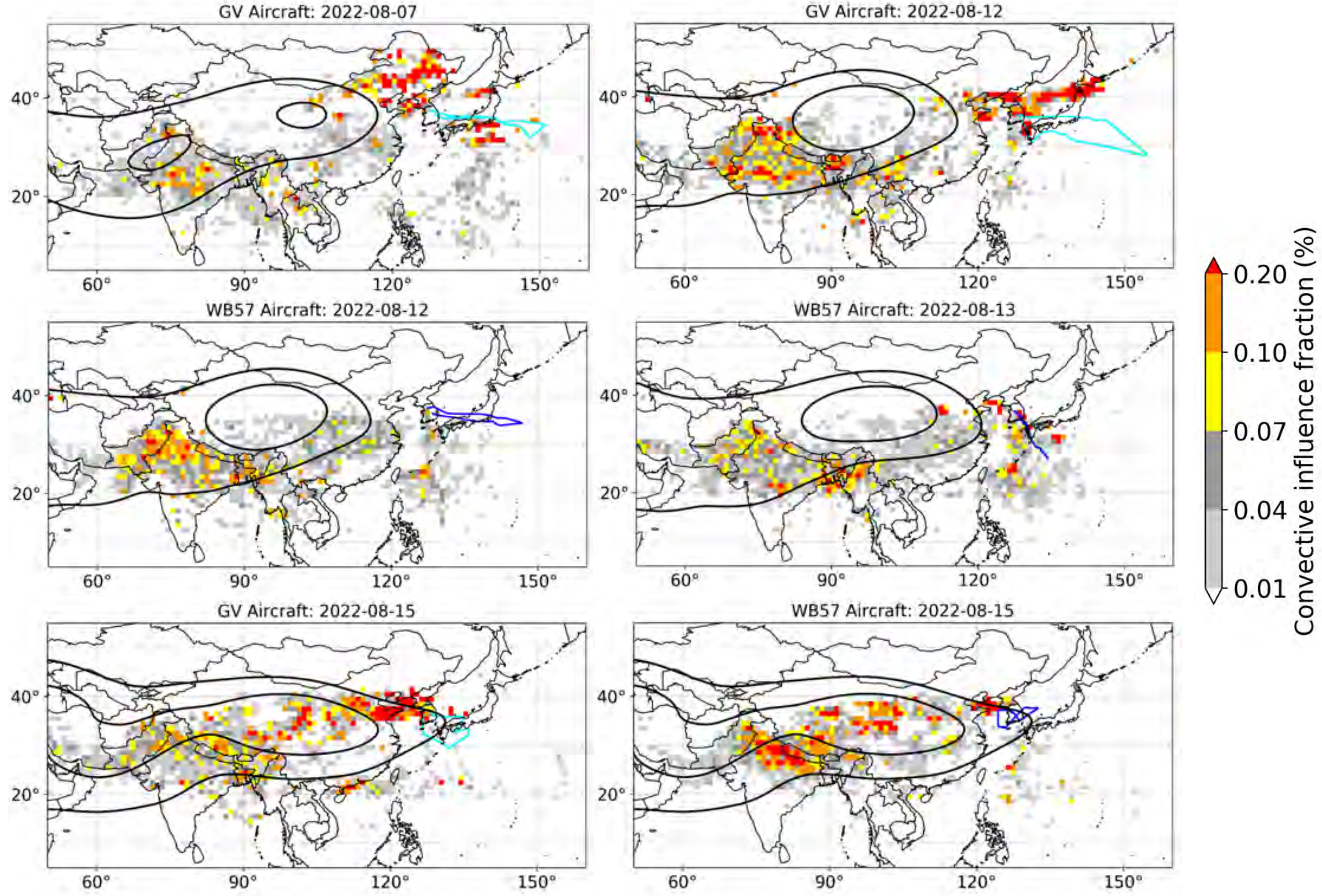
- A publication summarizing these results is in preparation and will be submitted this summer to the ACCLIP special issue
- The trajectory-derived convective influence product is publicly available through the ACCLIP data archive to support community research!
- We are exploring forward trajectories to look at stratospheric impact of ACCLIP sampling (Rei will mention more)
- Longer-term: derive transit time from ACCLIP chemical observations to evaluate trajectory- and CCM-based estimates

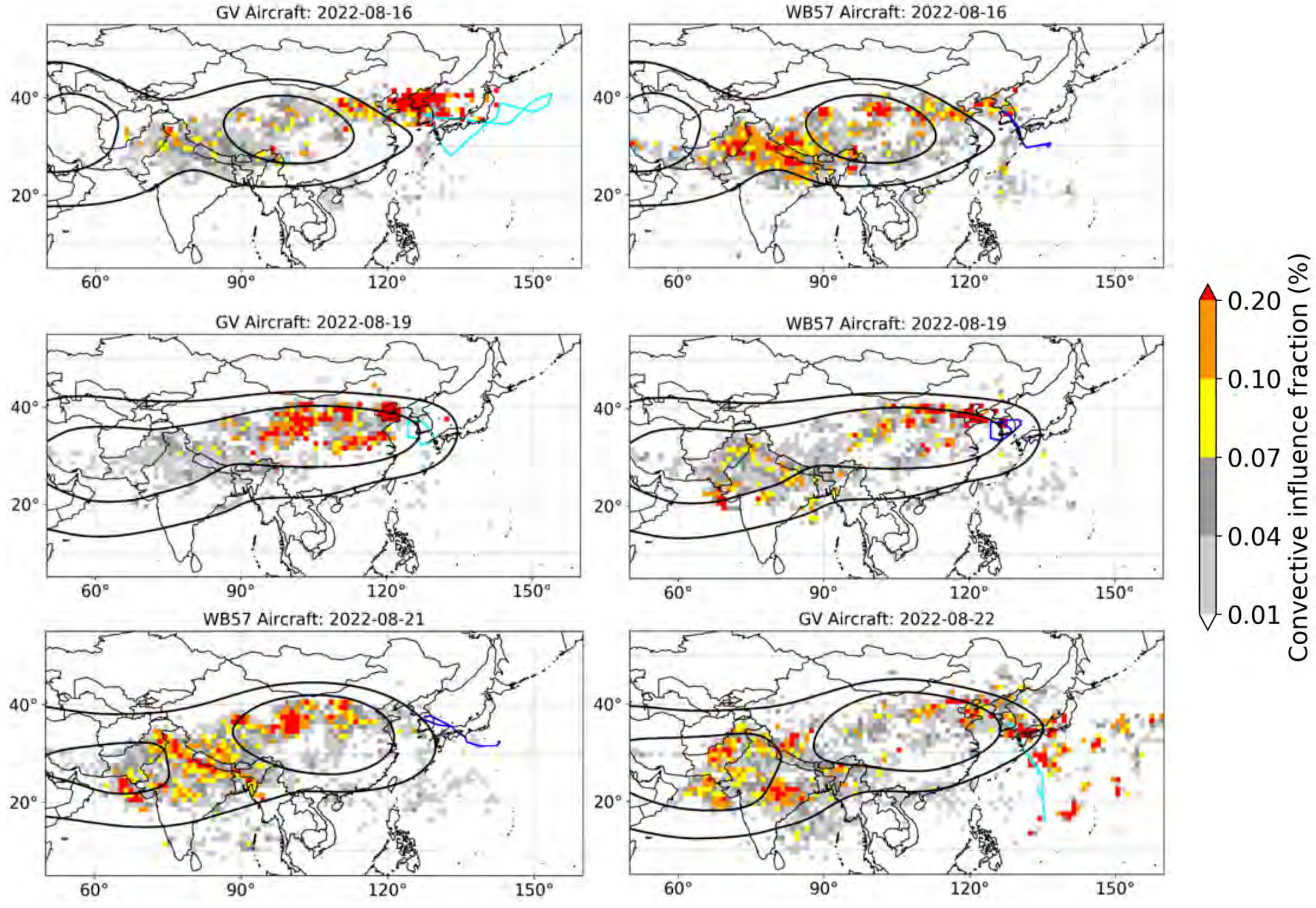
Thank you!

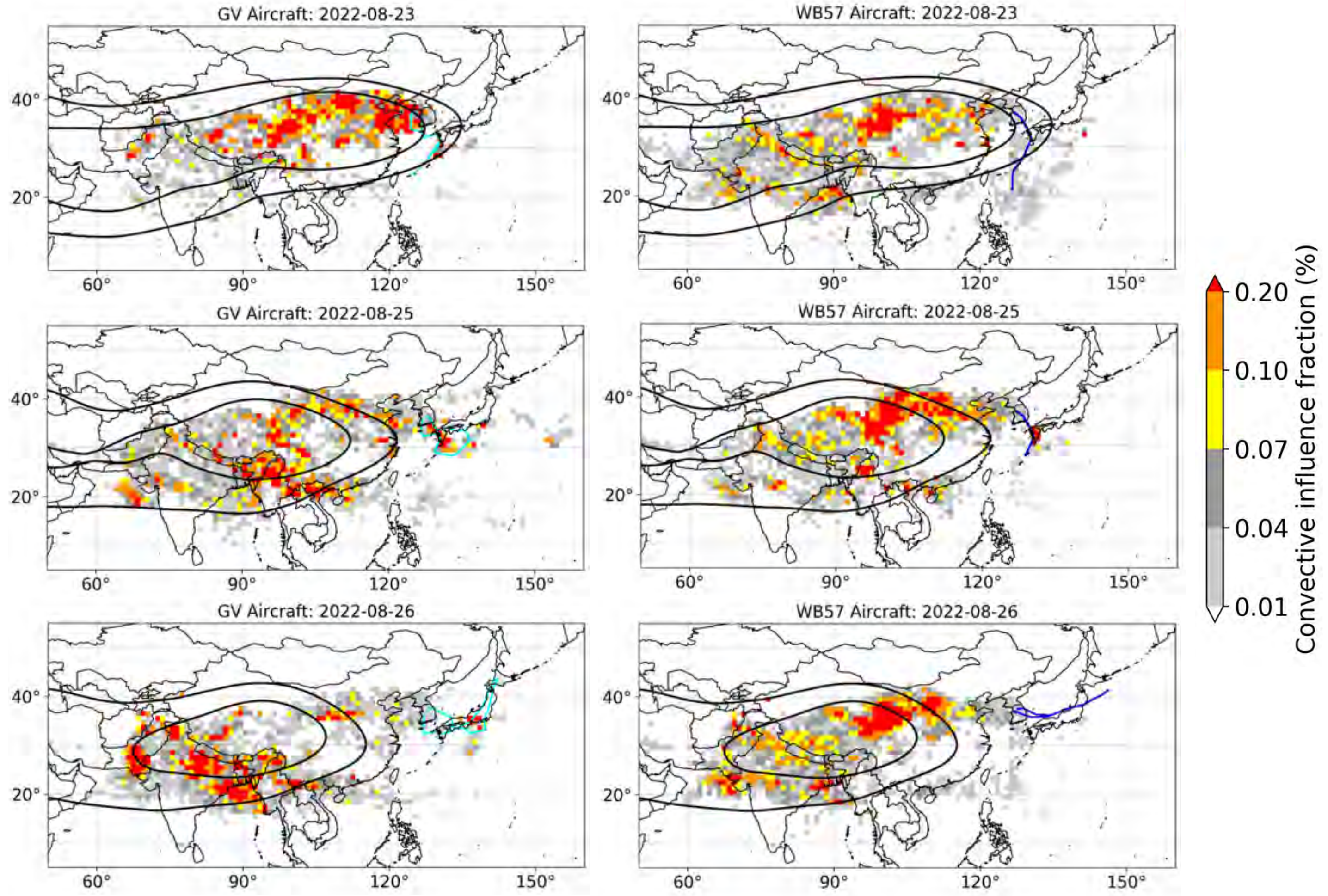
Extra Slides



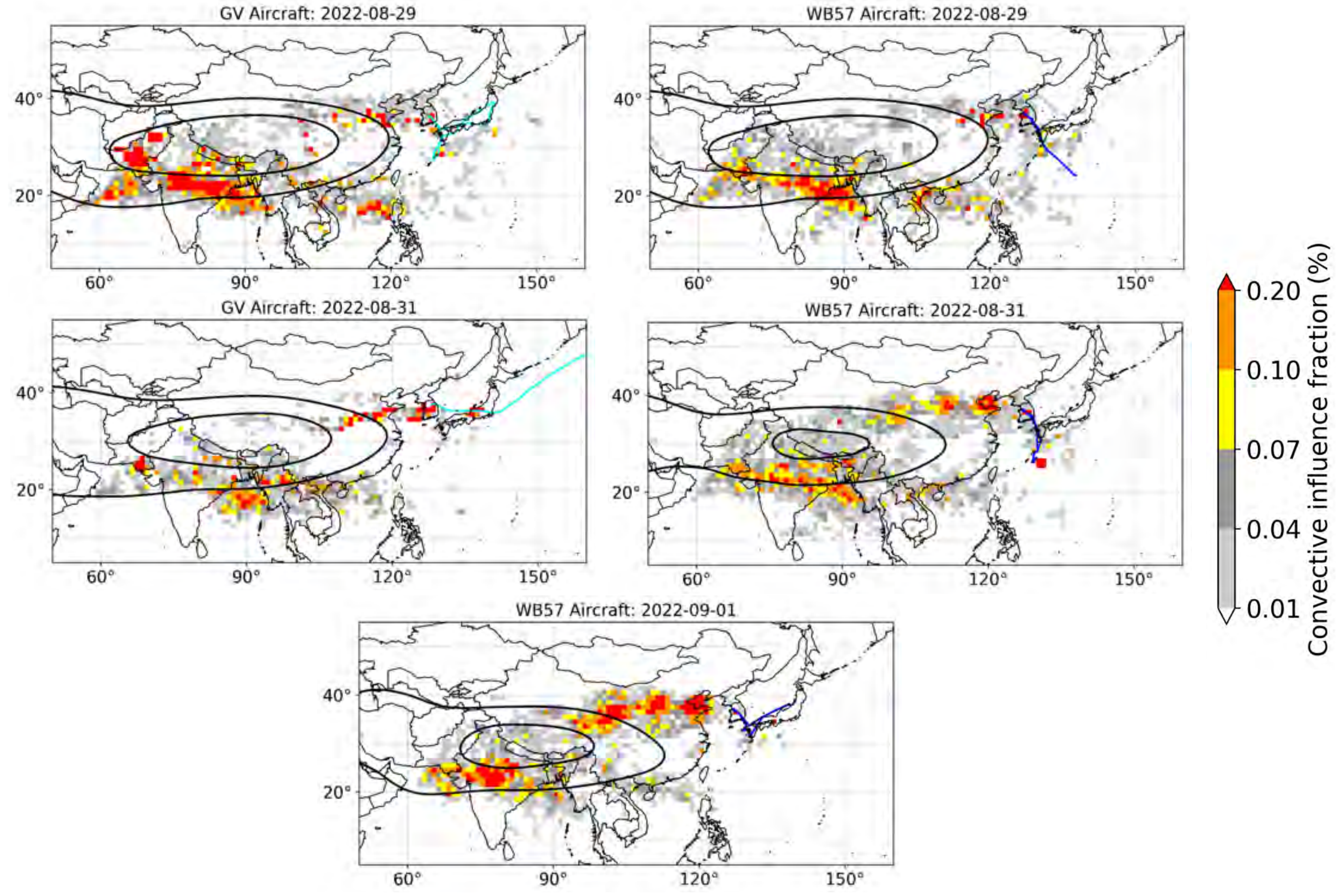
GV Aircraft: 2022-07-31
WB57 Aircraft: 2022-08-02
GV Aircraft: 2022-08-04
WB57 Aircraft: 2022-08-04
GV Aircraft: 2022-08-06
WB57 Aircraft: 2022-08-06
40°
20°
60°
90°
120°
150°
Convective influence fraction (%)
0.20
0.10
0.07
0.04
0.01


GV Aircraft: 2022-08-07
GV Aircraft: 2022-08-12
WB57 Aircraft: 2022-08-12
WB57 Aircraft: 2022-08-13
GV Aircraft: 2022-08-15
WB57 Aircraft: 2022-08-15
40°
20°
60°
90°
120°
150°
Convective influence fraction (%)
0.20
0.10
0.07
0.04
0.01


GV Aircraft: 2022-08-16
WB57 Aircraft: 2022-08-16
GV Aircraft: 2022-08-19
WB57 Aircraft: 2022-08-19
WB57 Aircraft: 2022-08-21
GV Aircraft: 2022-08-22
40°
20°
60°
90°
120°
150°
Convective influence fraction (%)
0.20
0.10
0.07
0.04
0.01



GV Aircraft: 2022-08-23
WB57 Aircraft: 2022-08-23
GV Aircraft: 2022-08-25
WB57 Aircraft: 2022-08-25
GV Aircraft: 2022-08-26
WB57 Aircraft: 2022-08-26
40°
20°
60°
90°
120°
150°
0.20
0.10
0.07
0.04
0.01
Convective influence fraction (%)



GV Aircraft: 2022-08-29
WB57 Aircraft: 2022-08-29
GV Aircraft: 2022-08-31
WB57 Aircraft: 2022-08-31
WB57 Aircraft: 2022-09-01
40°
20°
60°
90°
120°
150°
0.20
0.10
0.07
0.04
0.01
Convective influence fraction (%)