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

Why are Pakistan’s floods so extreme this year?

Huge swaths of the country are under water, following an intense heatwave and a long monsoon that has dumped a record amount of rain.
The Asian summer monsoon is a dominant component of the Earth’s climate.
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
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

Vertical X-section averaged from 25-40°N

Osan Air Base, ROK

ACCLIP operational region
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.
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

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
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
### ACCLIP observations

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<th>Measurement</th>
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<td>Aircraft, MMS</td>
<td>Aircraft, VCSEL</td>
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<td><strong>Trace Gases</strong></td>
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<td>CO₂</td>
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<td>O₃</td>
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<td>FAST _O3</td>
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<td>CH₂O</td>
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<td>H₂O</td>
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<td>H₂O Isotopes</td>
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<tr>
<td>VOCs (many)</td>
<td>WAS</td>
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<td><strong>Aerosols</strong></td>
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<td>Particle size/mass distributions</td>
<td>NMASS, UHSAS, POPS, CAPS</td>
<td>NMASS, UHSAS</td>
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<td>Chemical composition/size</td>
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<td>Cloud/aerosol distributions above/below aircraft</td>
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<td><strong>Radiation</strong></td>
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<td>Radiative flux/Photolysis frequencies</td>
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# ACCLIP August 2022

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100-year flooding event
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

Low O₃ in the ASMA and tropics (upper troposphere)

High O₃ north of the jet in the stratosphere

WB-57 GV
ACCLIP was able to extensively sample the high CO on the eastern flank of the ASMA

Subtropical jet located to the northern side of the ASMA

High CO in the ASMA (upper troposphere)

Let’s examine a vertical cut at 131°E

Low CO north of the jet in the stratosphere

CO 150 hPa August 2022
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)
The zonal wind in the ACCLIP region was exceptionally strong (as we would have guessed from the climatology).
The CO “high” in the ACCLIP region extended upward from about 500 hPa to the lower stratosphere. The CO max does not extend much into the stratosphere. Large CO “peak” in the UTLS.
The CO “high” in the ACCLIP region extended upward from about 500 hPa to the lower stratosphere.

ACCLIP flights heavily sampled the CO “plume”
Shedding of ASMA into the northern extra-tropics ($\text{H}_2\text{O}$)

ACCLIP was well positioned on the eastern flank of the ASMA to observe shedding.

Hydration events in the ASMA upstream of the ACCLIP region

WB-57 GV
Shedding of ASMA into the northern extra-tropics (CO)

What did the August 15 flight look like?

Shedding events

WB-57 GV

Osan
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!