Insights into Carbonyl Sulfide (OCS) Distribution and Sources in the Asian Summer Monsoon (ASM) Region: Evidence from Elevated Levels Observed in the UTLS during the ACCLIP Campaign (A43P-2982)

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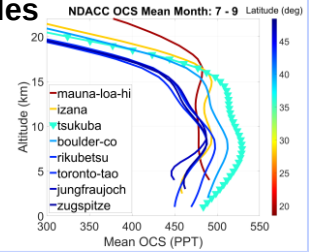
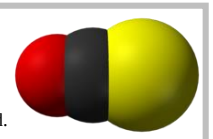
Troposphere OCS Profiles

- Global NDACC Network provides vertical OCS profiles
- In the Summer Season (July-August), the Tsukuba Japan site reports the most free tropospheric OCS globally
- Minimal observational record of tropospheric OCS in the Asian region limits OCS inventory validation



Carbonyl Sulfide: OCS or COS



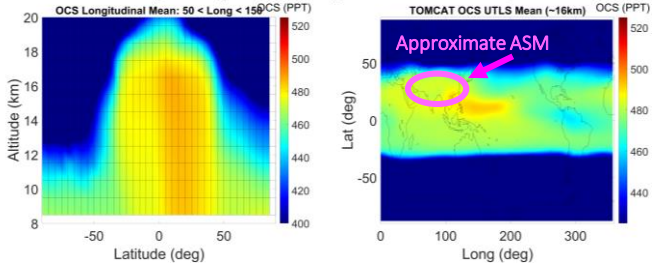
- OCS has low water solubility, resulting ineffective vertical transport in large convective systems
- Poorly Constrained Sources: Ocean Surface Production, Biomass Burning, Anthropogenic Pollution
- Primary Sinks: Boundary Layer: Plant Uptake (Photosynthesis proxy), Stratospheric conversion to Sulfuric Acid.
- New data for ACCLIP, SABRE & AEROMMA campaigns with the Airborne Carbonic Oxides Spectrometer (ACOS)
- OCS is the most abundant Sulfur species in atmosphere with long lifetime (>1 year in Troposphere, ~50 years in Stratosphere)
- Understanding the Stratospheric OCS flux is critical to determine the sulfur budget and stratospheric aerosol evolution

OCS serves as the primary Sulfur reservoir in Stratosphere for Sulfate Aerosol formation (Forcing~ -0.4 W/m^2)

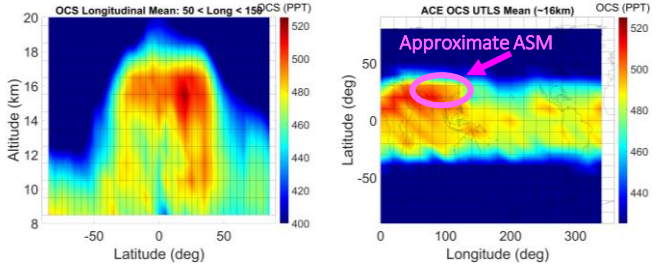
Asian Summer Monsoon (ASM) Region Model vs Satellite Observations: Spatial Variations of OCS in the UTLS

- A comparison of the mean OCS profile from the TOMCAT Model output and ACE-FTS-V5.2 for the summer season (July-September, 2004-2018). *Seasonal averaging is required to build up sufficient statistics for sparse ACE-FTS data*

TOMCAT Data (Cartwright et al 2023), Years: 2004 - 2018, Months: 7 - 9



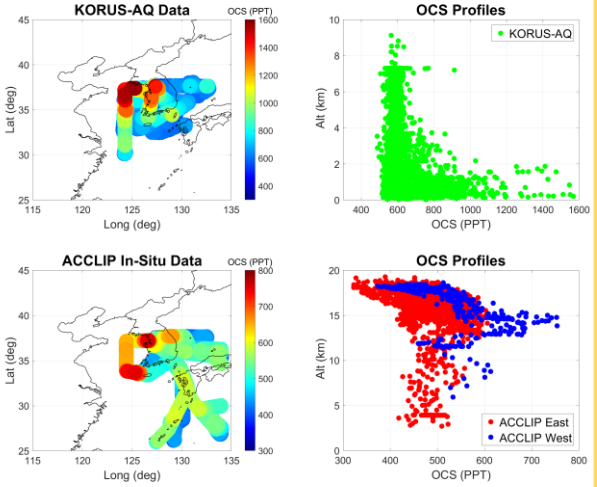
ACE-FTS V5.2 Data, Years: 2004 - 2018, Months: 7 - 9



- Cartwright et al 2023 model predicts summer max UTLS OCS over Western Pacific resulting in transportation to the tropical pipe while ACE-FTS observational data suggests summer max UTLS OCS further Northwest with potential for northern lower stratosphere, and cross hemisphere transport. The difference may result in underestimate of OCS in the ASM southwest outflow.

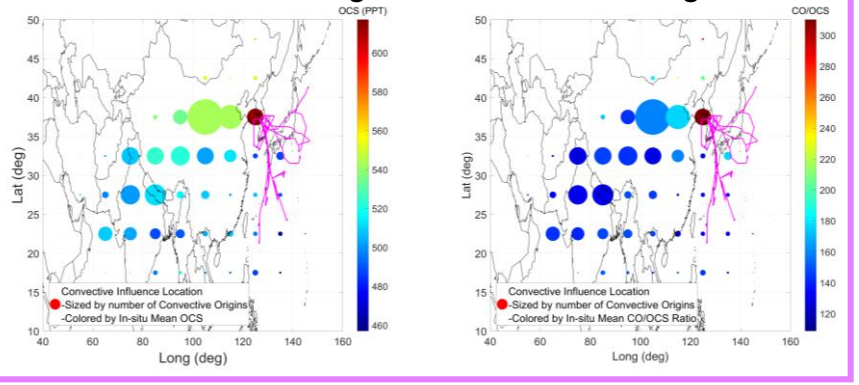
ACCLIP Campaign Observations: Unprecedented OCS observed in UTLS

- 2016 NASA DC8 airborne in-situ observations from the KORUS-AQ campaign indicate extremely high OCS concentrations in the boundary layer over the Yellow Sea
- **2022 NASA WB57 ACCLIP campaign high altitude in-situ aircraft OCS data at the UTLS indicates a similar spatial distribution 2016 Boundary Layer data**
- Transport of Northern China anthropogenic OCS emissions (Simpson et al. 2020) to the upper troposphere is facilitated by deep convection near the coastline in the summer season
- Maximum OCS mixing ratios >200PPT above ambient levels have never before been reported in Upper Troposphere / Lower Stratosphere (UTLS) in-situ sampling

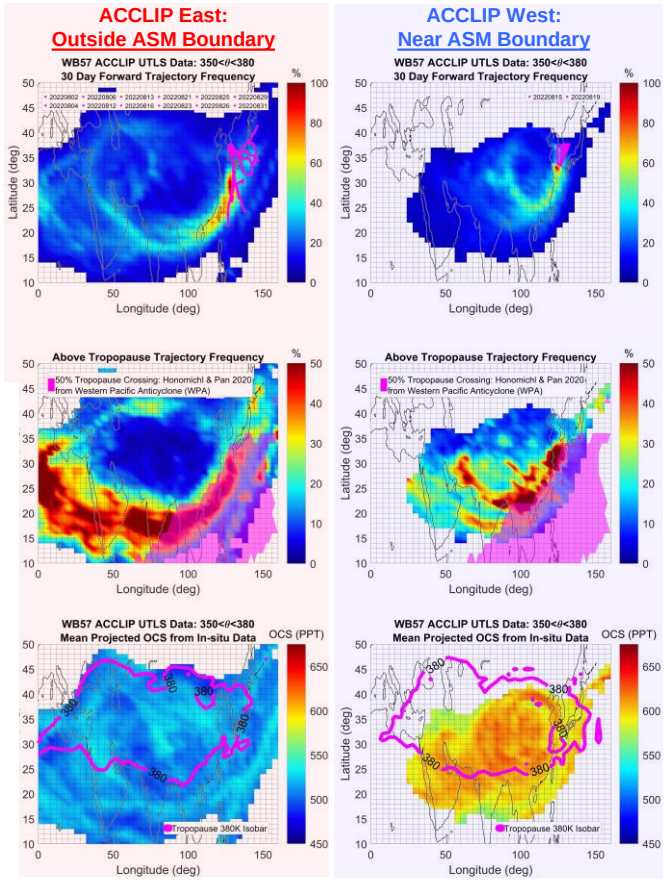


ACCLIP Convective Influence Modeling: Emission Source Regions?

- Convective influence trajectories from the ACCLIP flight tracks are correlated with in-situ measurements to determine approximate source regions for high OCS emissions.
- The largest OCS convective source region for these flights appears to be the Beijing region, which is highly correlated with elevated Carbon Monoxide levels and other tracers, suggesting recent emissions.



ACCLIP Forward Modeling: Implications for OCS Transport into UTLS



- Mean 30 day trajectories distributions of air parcels from research flights east (top), and troposphere crossing trajectories (middle). Mean OCS distribution for in-situ samples projected along the 30day trajectories (bottom).
- The majority of the tropopause crossing occurs in the same region as predicted for air parcels in the Western Pacific Anticyclone (Honomichl & Pan 2020).

Conclusions

- Deep convection is demonstrated to loft parcels with significantly enhanced OCS mixing ratios, presumably a result of anthropogenic emissions
- Chemical signatures and back trajectories suggest that the majority of enhanced OCS parcels originate from the Northern China costal region in agreement with previous studies
- A large proportion of UTLS trajectories in the ACCLIP sample region may cross the tropopause within days outside the southwestern edge of the ASM, providing a pathway for direct stratospheric injection of enhanced OCS parcels.
- Uncertainties in UTLS OCS distributions may result from the incomplete parameterization of the transient convection events like those in ACCLIP.