Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP)

Laura Pan
National Center for Atmospheric Research
Atmospheric Chemistry Observations & Modeling Lab

DCOTSS Science Team Meeting, October 2019
The Asian Summer Monsoon
A regional weather-climate pattern
An emerging chemical composition problem in monsoon research

Asian Emissions, Air Quality ↔ Monsoon ↔ Climate

Asian Summer Monsoon transport: a “perfect storm”

Widespread pollution in Asia

New Dehli,

Monsoon low level jet

HCN from Space

Rodel, et al. 2010, Science

Lawrence and Lelieveld, 2010

HCN mixing ratio (ppbv)

Rising branch of the Hadley cell

Zhang et al., 2002

Zhang et al., 2002
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
**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

[https://www2.acom.ucar.edu/acclip](https://www2.acom.ucar.edu/acclip)
The First Successful Field Campaign focuses on the ACAM Core UTLS Science Issues:

Fig. 3 | Airborne limb-imaging observations of AN and NH$_3$ in the UT above India during the 2017 Asian monsoon season. a–d, Altitude–time horizontal projections of AN mass densities (a,b) and NH$_3$ VMRs (c,d), derived from GLORIA measurements during the Geophysica flight on 31 July 2017. The horizontal projections at the tangent points are given in a and c and the vertical projections in b and d. The vertical resolution and estimated uncertainty (precision, accuracy) are: AN, 0.8 km, ±0.03 μg m$^{-3}$ ±30%; NH$_3$, 0.8 km, ±8 pptv ±20%. Red lines, aircraft position (a and c) and altitude (b and d); light blue lines, lapse rate tropopause (b and d). UTC, coordinated universal time.
UTLS chemical composition signature of Asian monsoon from Space:
Seasonal average vs. daily structure

Ungermann et al., 2015
Sub-seasonal scale dynamics and transport

Asian monsoon transport: Two main components

Vertical – Convective transport ("chimney")
Horizontal – East–West Eddy shedding ("blower")

Carbon Monoxide, from WACCM model

Pan et al., 2016
Sub-seasonal scale dynamical variability of the anticyclone & the western Pacific Mode

GPH

(Selected frame of an animation)

Honomichl and Pan, to be submitted
Tri-modal structure of the AMA

Honomichl and Pan, to be submitted
Eastward eddy shedding – a mechanism for ASM to impact global UTLS

Example from GEOS5 run (A) (Lait, Liang)

(Selected frame of an animation)
Origins and fate of the air mass we target over the Western Pacific Anticyclone:

Pre-study using trajectory analysis
Distribution of airmass after exiting the western Pacific anticyclone

Honomichl and Pan, to be submitted
Map of Flight Operations

- Base of the flight operation: Okinawa
- Aim to operate in 6 FIRs
- Nominal flight ranges of the GV (purple) and WB-57 (cyan)
The GV payload and investigators

Trace gas measurements

**FASTO$_3$ + NO, NO$_x$$_y$**  
Floke, ACOM

**Aerodyne CO (CO, N$_2$O)**  
Campos/Flocke, ACOM

**Picarro (CO$_2$, CH$_4$)**  
Campos, ACOM

**GT-CIMS (SO$_2$, HCl, HNO$_3$, HO$_2$NO$_2$, CH$_3$COOH, HCOOH)**  
Huey, GT

**TOGA**  
Apel, ACOM

**AWAS**  
Atlas, U Miami

**VCSEL (H$_2$O)**  
RAF

Aerosol

**Size:**

**NMASS**  
Williamson/Brock, NOAA

**UHSAS (cabin)**  
(3-60 nm)

**UHSAS (wing)**  
(60 nm – 1 µm)

**Composition:**

**SP2 (BC)**  
Schwarz, NOAA

**ERICA (particle types and elemental composition)**  
Borrmann, MPIC

Cloud

**CDP 2DC**  
RAF

**MTP (Temperature profile)**  
RAF

Test flights are scheduled end of Jan 2020
Ground-based measurements

1) Lars Kalnajs & Doug Gontz (CU): Funded by ACCLIP NSF proposal

2) Masatomo Fujiwara (Japan PI): A large team collaboration

3,4) Jianchun Bian (IAP/CAS): Balloonborne measurements on the Tibetan plateau

5) Katrin Mueller/Markus Rex (AWI/Germany): Ground based station Palau, TWP
Chemistry modeling including forecast

NCAR CESM/WACCM:
   Doug Kinnison, Lead chemical forecast and model investigation
   Michael Mills,
   Simone Tilmes

NCAR WRF:
   Jim Bresch (Lead Meteorologist)

NASA GEOS-5:
   Qing Liang (NASA/GSFC)
   Peter Colarco (NASA/GSFC)
   Mian Chin (NASA/GSFC)

ECMWF/CAMS: Chemical forecast products (Johannes Flemming, et al.)

Additional modeling of aerosol and radiative forcing:
   CARMA/CESM2: Brian Toon (CU), Pengfei Yu (JNU), Yunqian Zhu (CU), Cenlin He (NCAR)
Forecast Dry Run 2019 – a few examples

CO mixing ratios at the 150 hPa level for 2019-08-30 0Z from 3 models:

Examples of other species from CAMS

SO₂ @150 hPa

http://catalog.eol.ucar.edu/acclip_2019/model/cams_ecmwf_40km/150mb_SO2/20190730/0000

C₃H₈ @150 hPa

http://catalog.eol.ucar.edu/acclip_2019/model/cams_ecmwf_40km/150mb_C3H8/20190730/0000/000
Significant concerns: Typhoon Influence in the domain

Typhoon Lekima

Typhoon Krosa
Thank you!

Naha airport new runway expected to be operational March 2020
Naha airport, 2019
Naha airport, 2017
Naha airport, 2012