Asian Summer Monsoon Chemical and Climate Impact Project (ACCLIP) Part I

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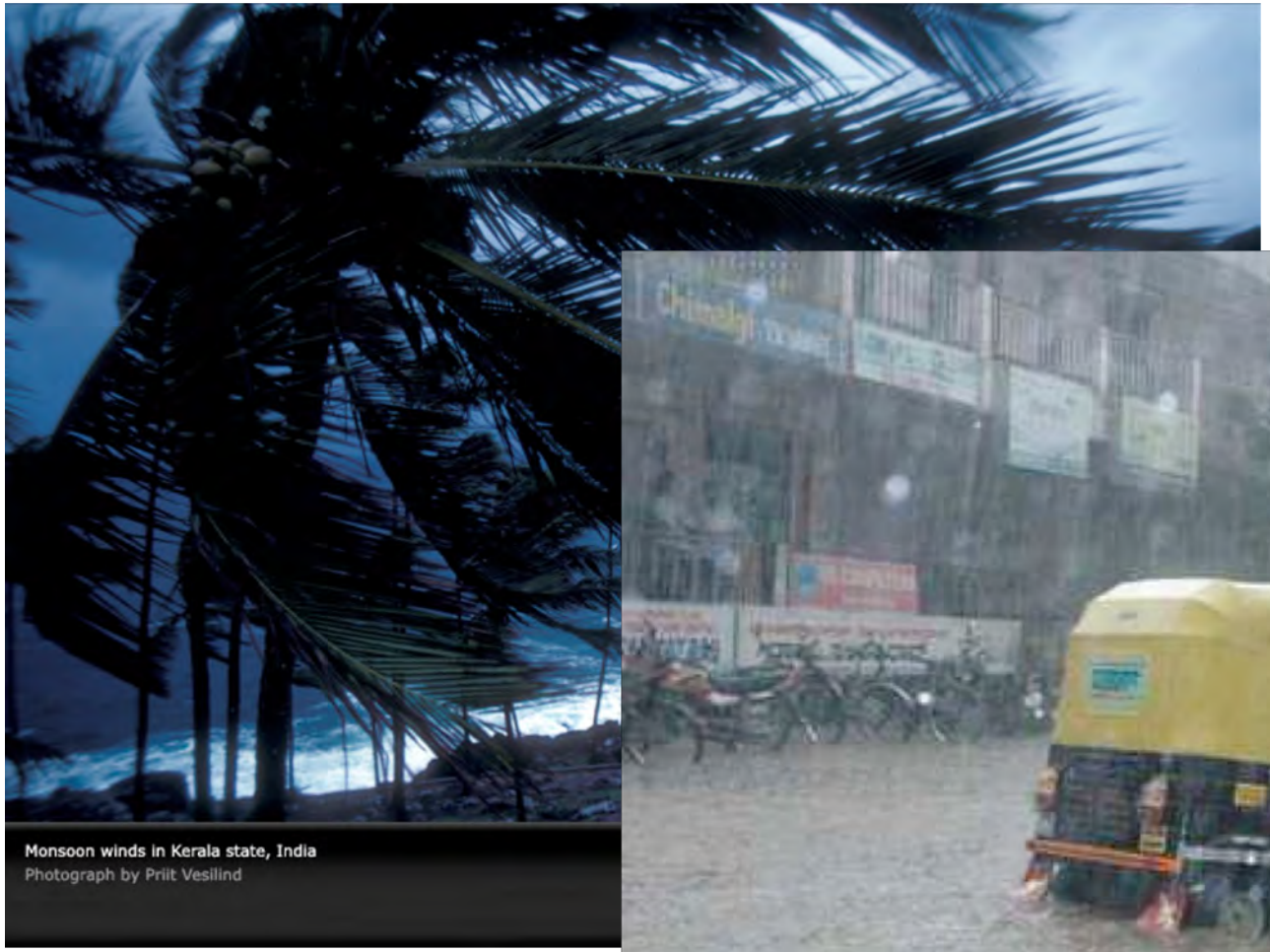
DCOTSS Science Team Meeting, October 2019

The Asian Summer Monsoon
A regional weather-climate pattern



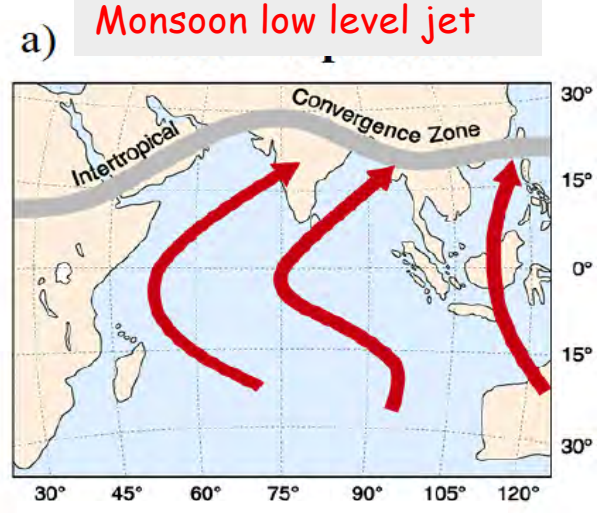
Monsoon winds in Kerala state, India
Photograph by Priit Vesilind

An emerging chemical composition problem in monsoon research

Asian Emissions, Air Quality ↔ Monsoon ↔ Climate

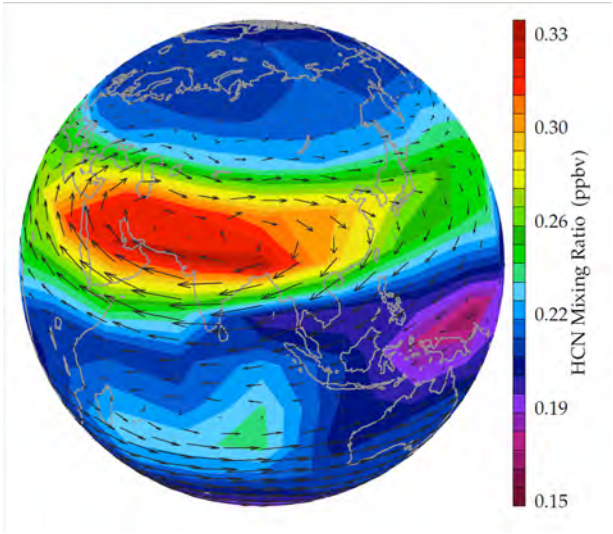
Asian Summer Monsoon transport: a **"perfect storm"**

Monsoon low level jet



Lawrence and Lelieveld, 2010

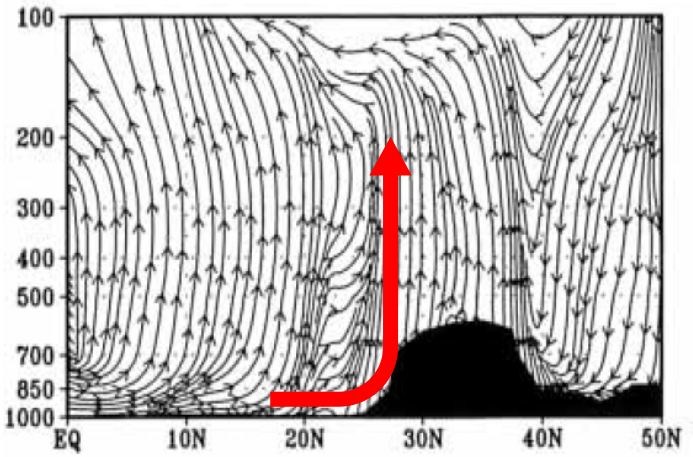
HCN from Space



Randel, et al. 2010, Science

Widespread pollution in Asia

Rising branch of the Hadley cell



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

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

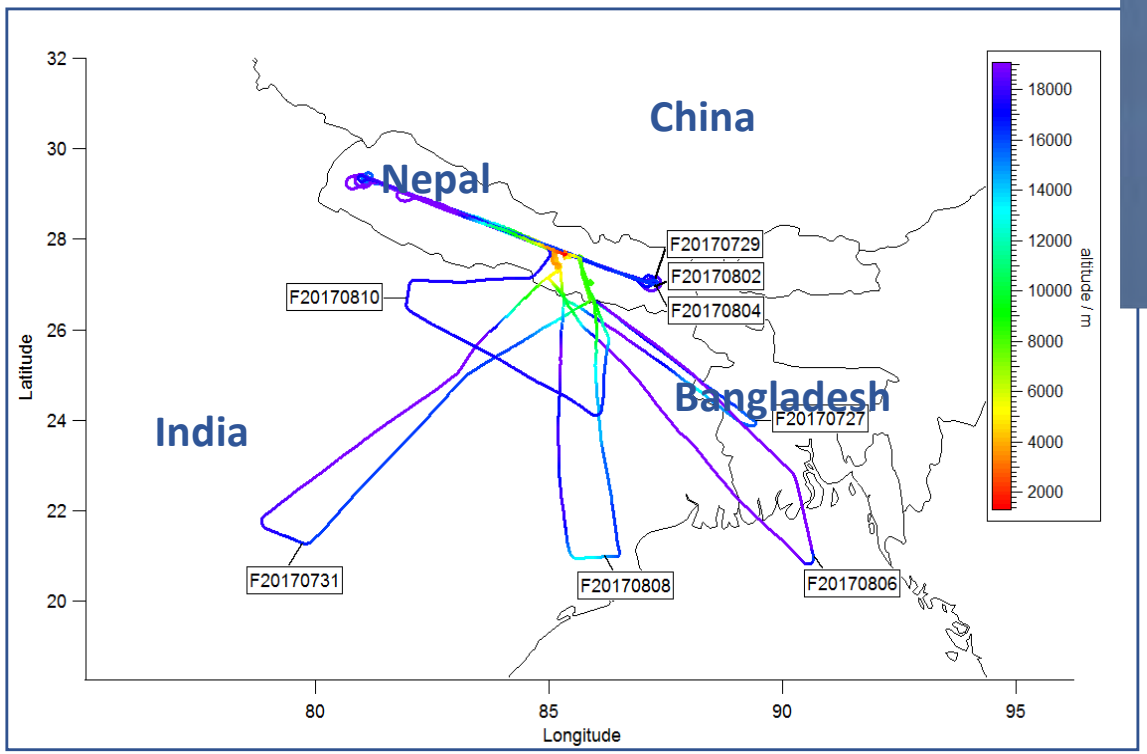
Scientific Objectives: Obtain a comprehensive suite of dynamical, chemical and microphysical measurements in the region of ASM anticyclone to address:

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

The First Successful Field Campaign focus on the ACAM Core UTLS Science Issues

StratoClim



8 Research flights, Jul-Aug 2017. Exciting data on water vapor, reactive gas species, and aerosol composition

Höpfner et al., 2019

Ammonium Nitrate particles

Ammonia

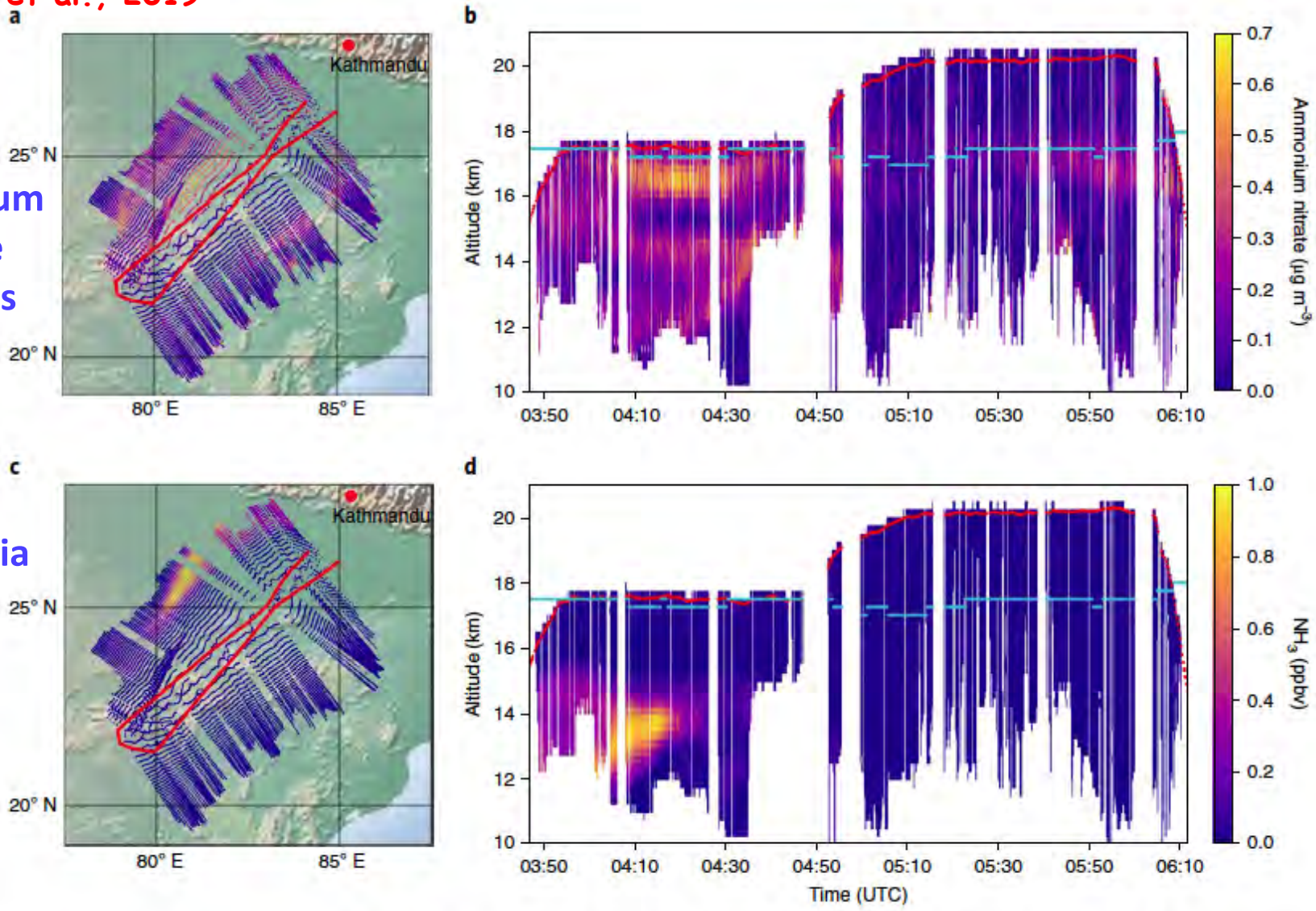
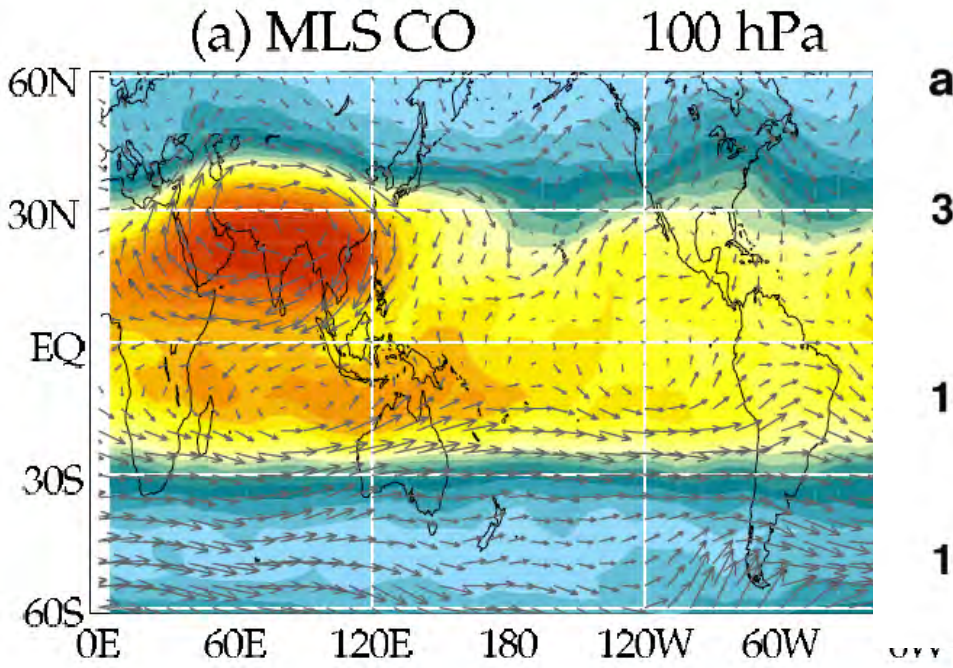


FIg. 3 | Airborne limb-imaging observations of AN and NH_3 in the UT above India during the 2017 Asian monsoon season. a–d, Altitude–time horizontal projections of AN mass densities (**a**,**b**) and NH_3 VMRs (**c**,**d**), derived from GLORIA measurements during the Geophysica flight on 31 July 2017. 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.

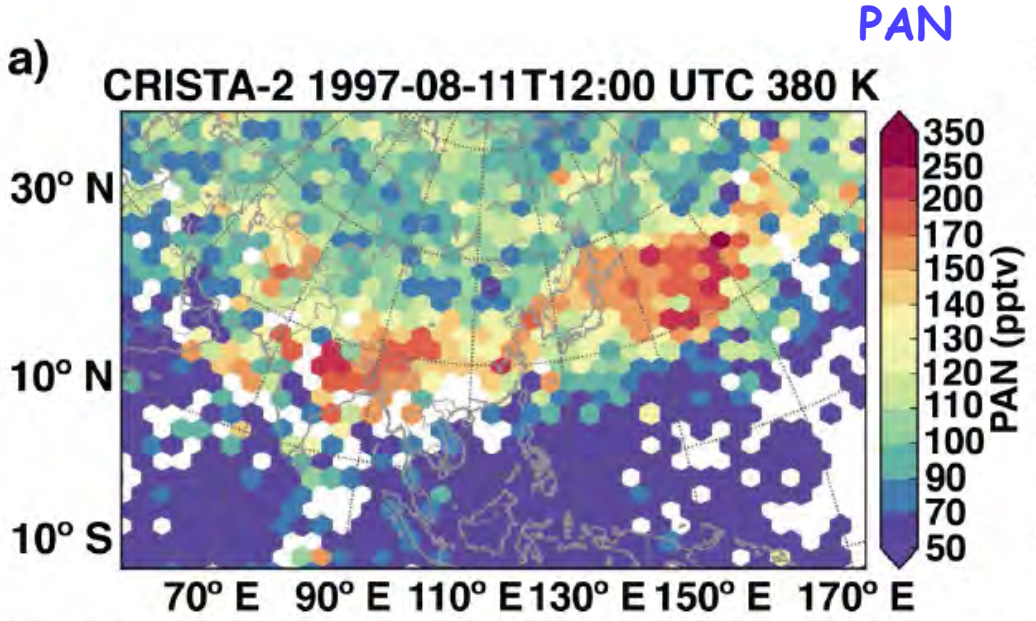
UTLS chemical composition signature of Asian monsoon from Space:
Seasonal average vs. daily structure



Park and Randel, 2007, 2008

Space shuttle

PAN



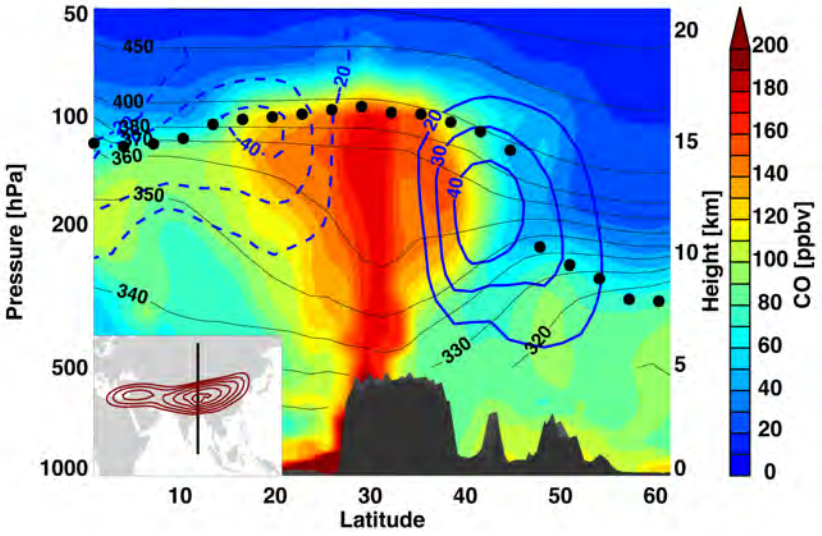
Ungermann et al., 2015

Sub-seasonal scale dynamics and transport

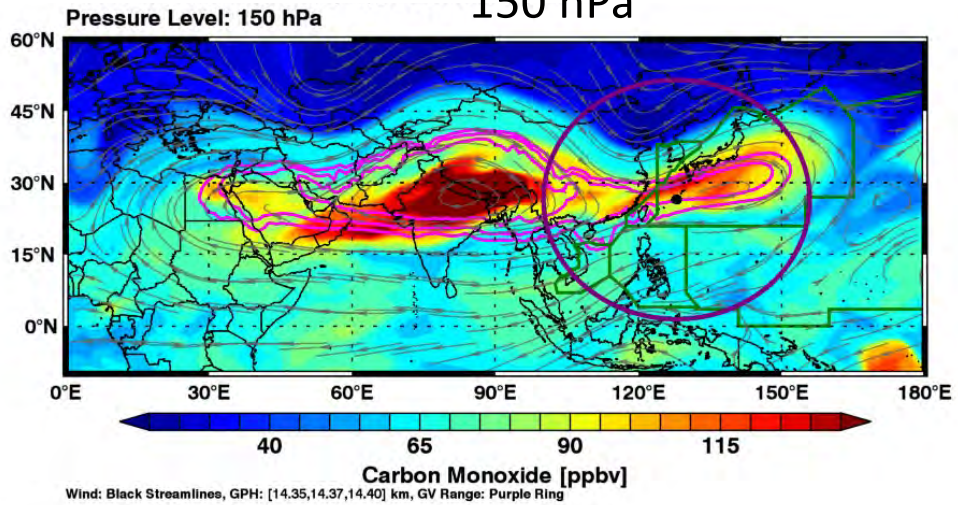
Asian monsoon transport: Two main components

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

Carbon Monoxide, from WACCM model



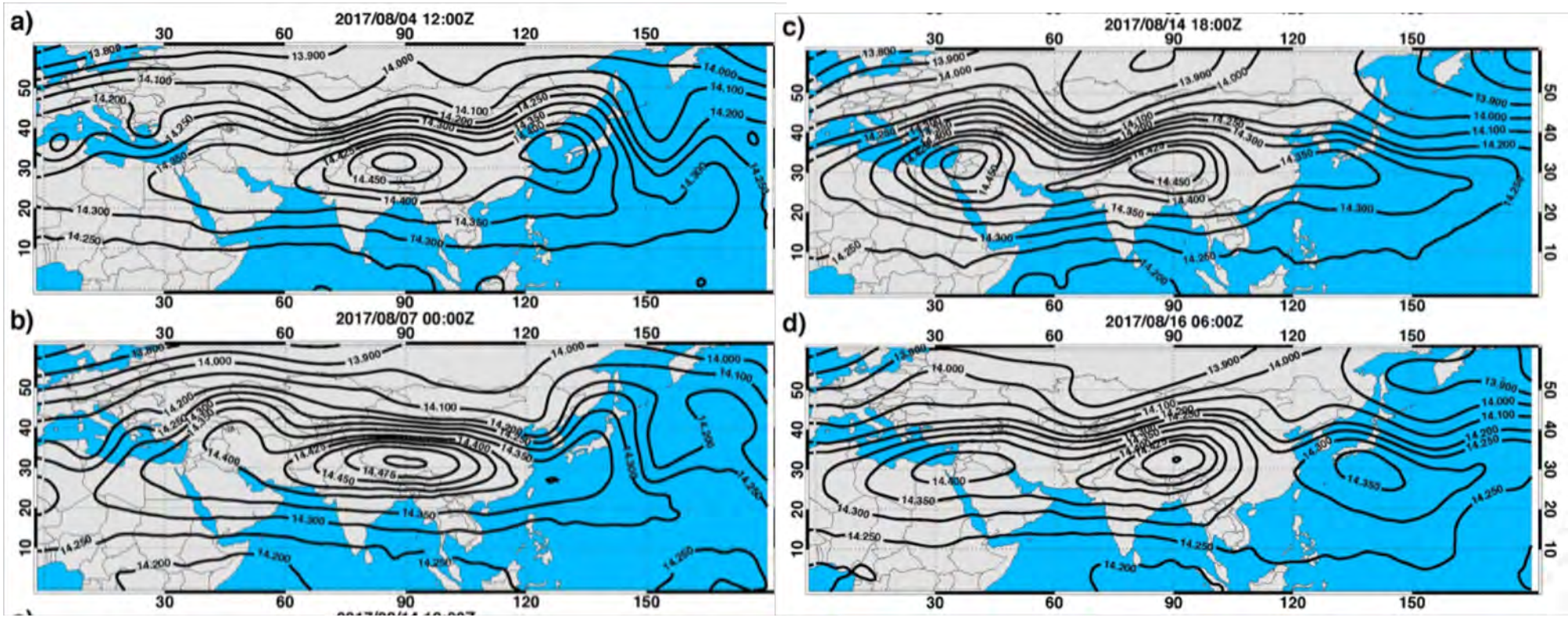
150 hPa



Pan et al., 2016

Sub-seasonal scale dynamical variability of the anticyclone & the western Pacific Mode

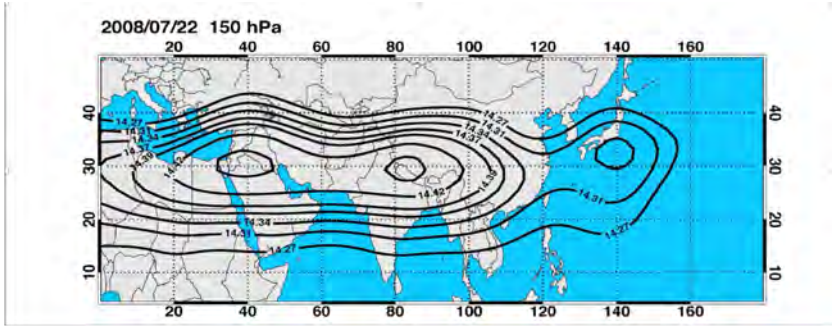
GPH



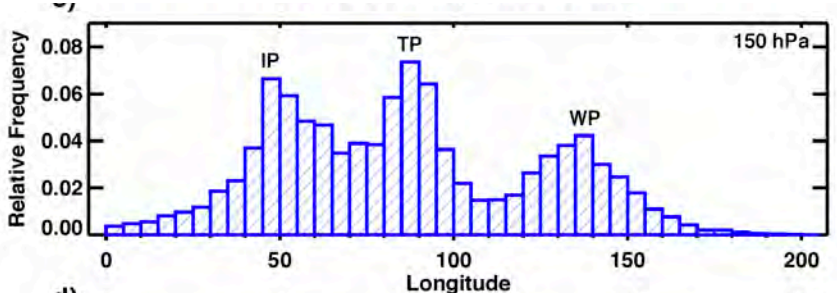
(Selected frame of an animation)

Honomichl and Pan, to be submitted

Tri-modal structure of the AMA



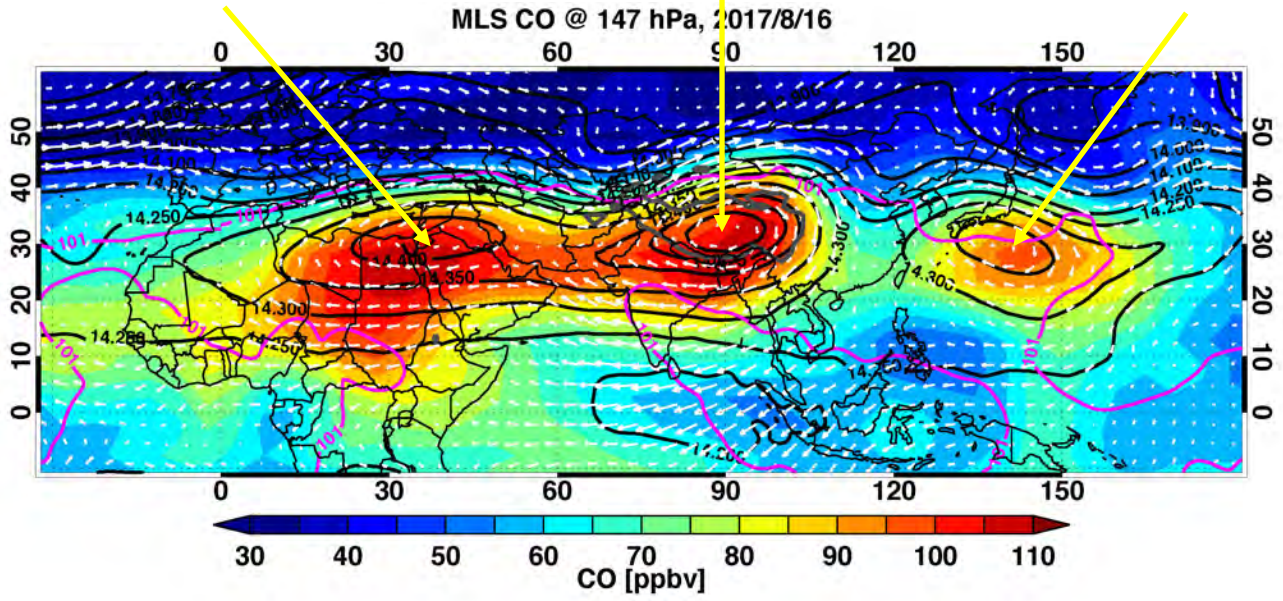
ERAi GPH anticyclone center JA, 1979-2017



Iranian Plateau mode

Tibetan Plateau mode

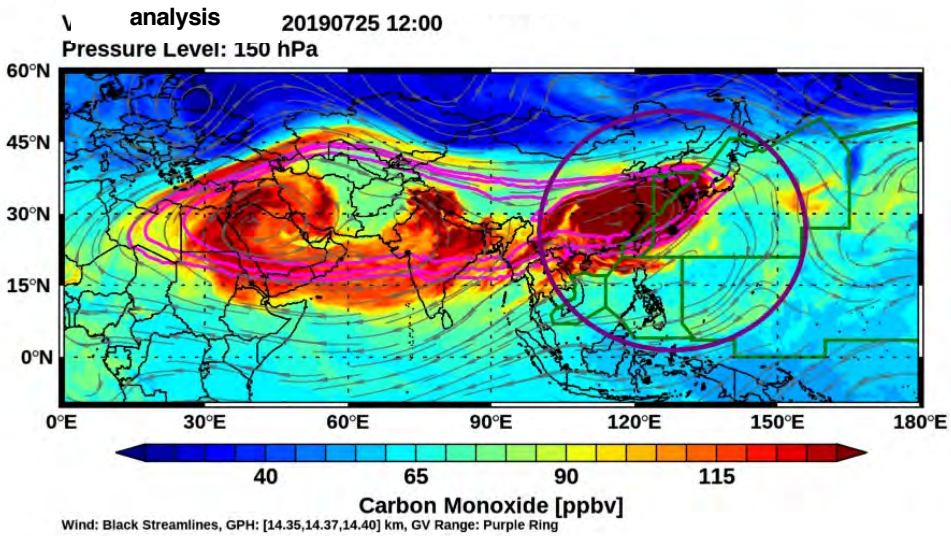
Western Pacific mode

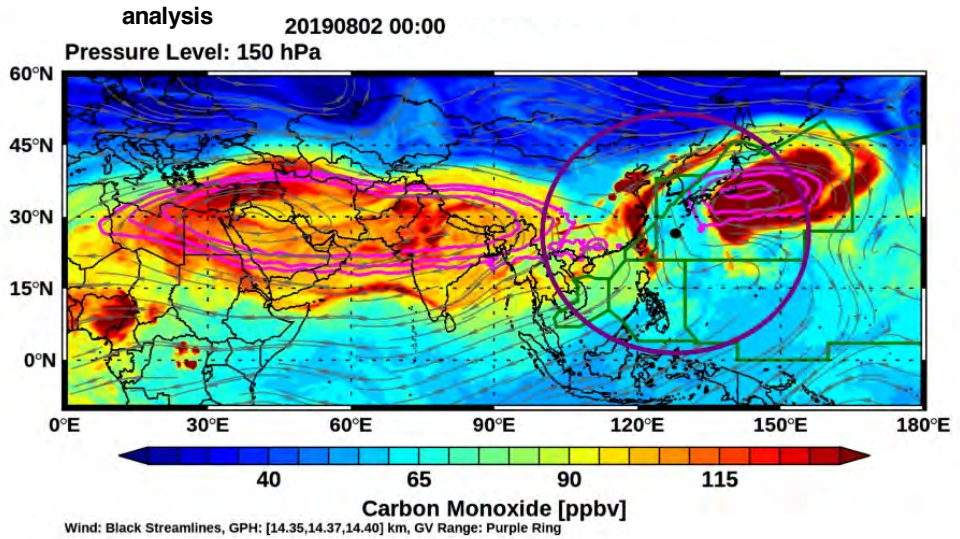


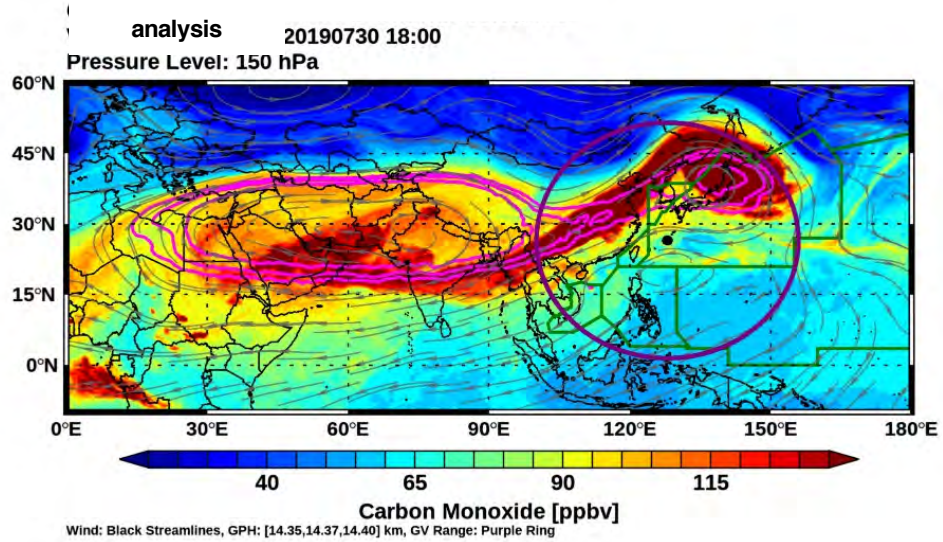
Honomichl and Pan, to be submitted

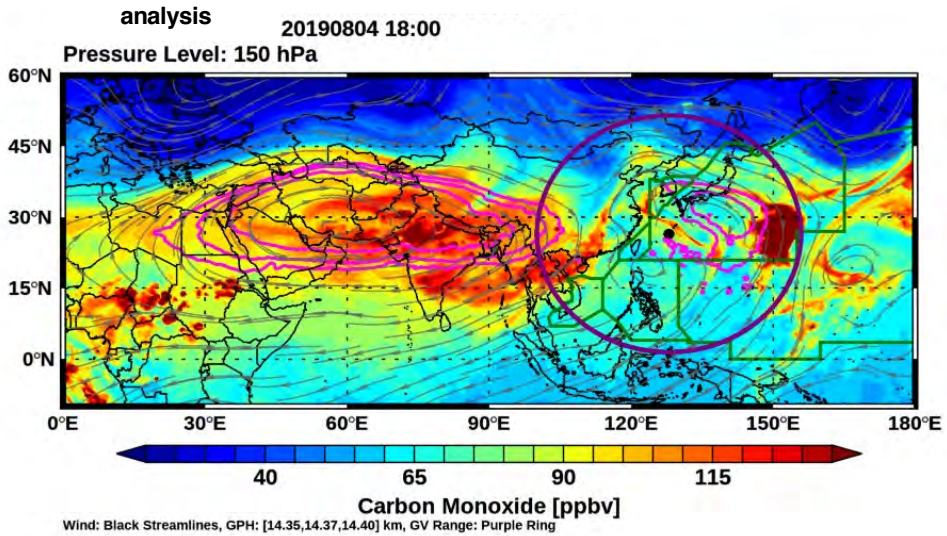
Eastward eddy shedding – a mechanism for ASM to impact global UTLS

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







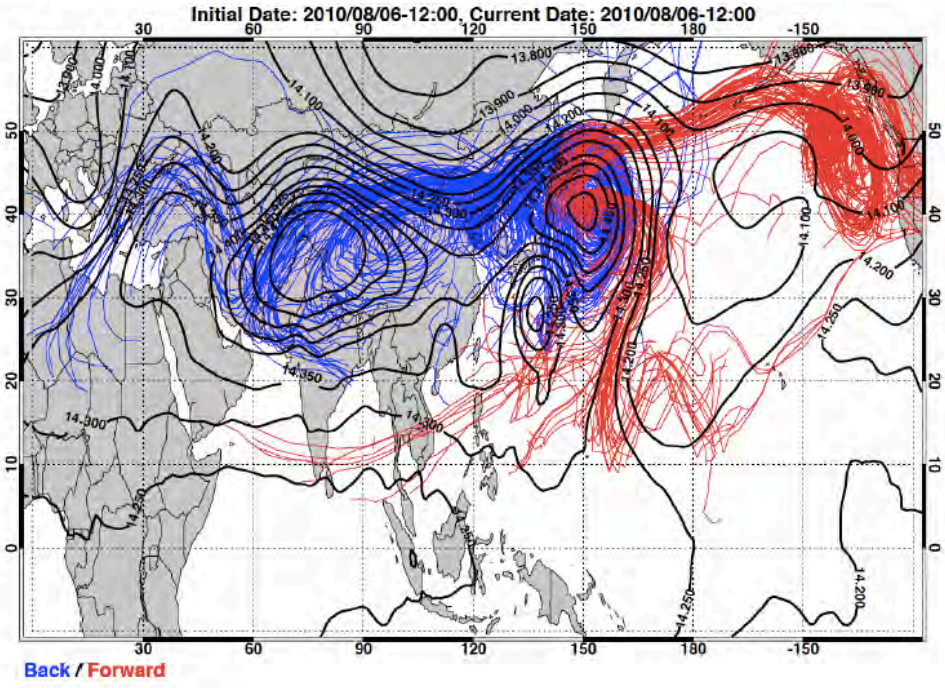


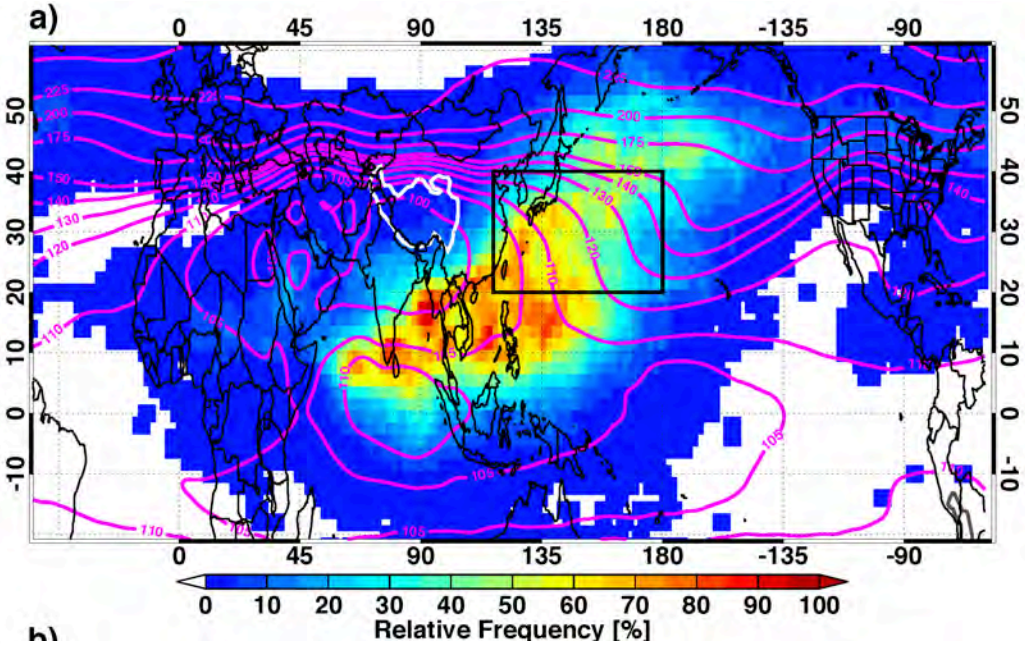
(Selected frame of an animation)

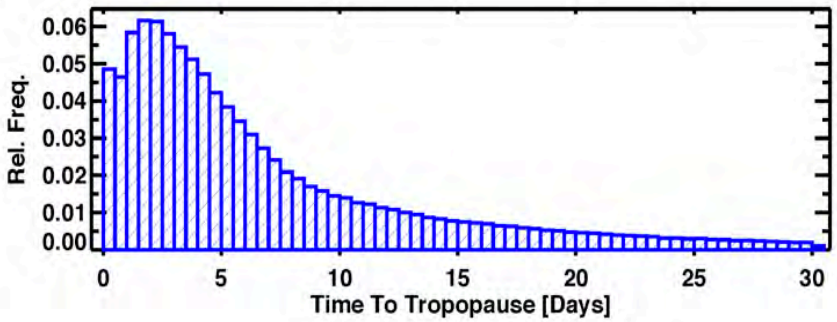
Origins and fate of the air mass we target over the Western Pacific Anticyclone:

Pre-study using trajectory analysis

Distribution of airmass after exiting the western Pacific anticyclone

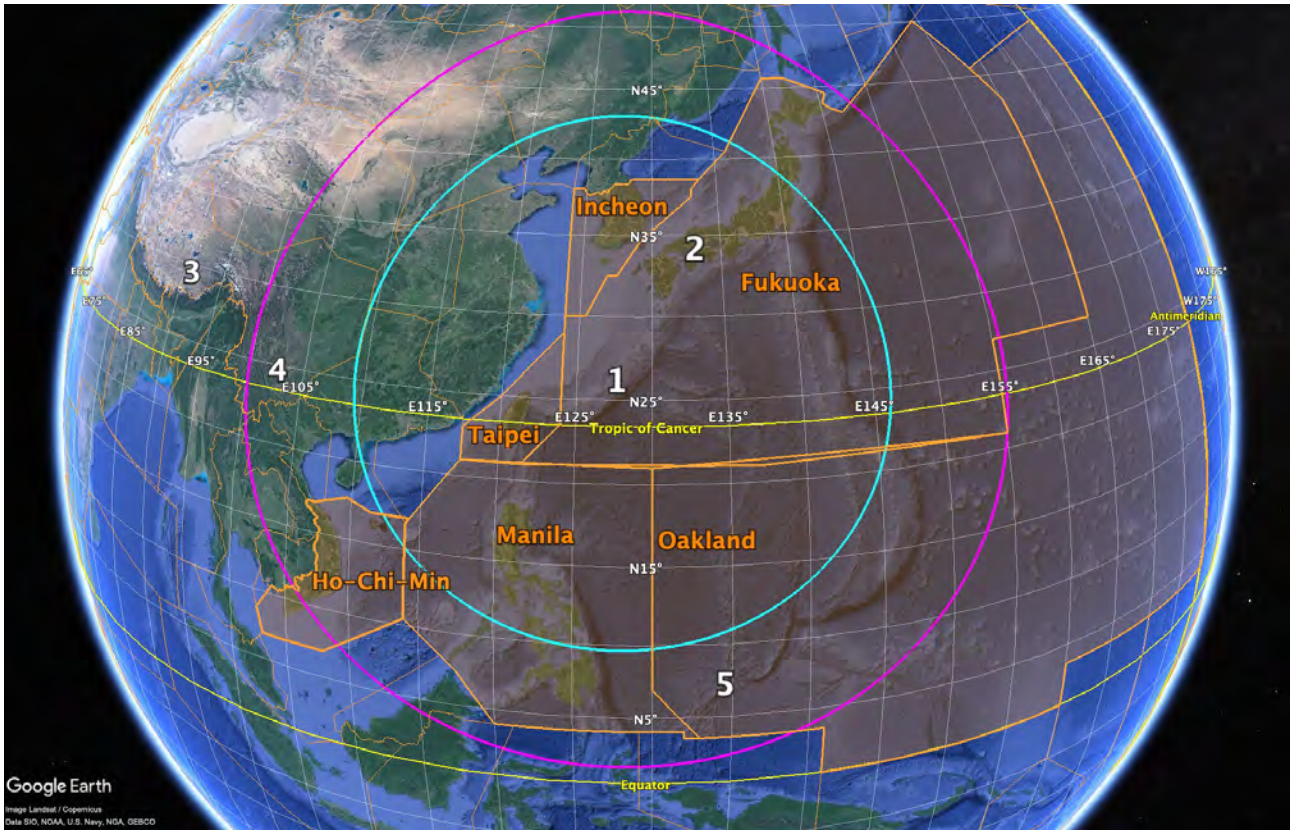






Honomichl and Pan, to be submitted

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

Radiation

HARP (actinic flux)	**Hall**, ACOM

Aerosol

Size:

NMASS	**Williamson/Brock**, NOAA
UHSAS (cabin)	(3-60 nm)
	(60 nm – 1 μm)
UHSAS (wing)	RAF

Composition:

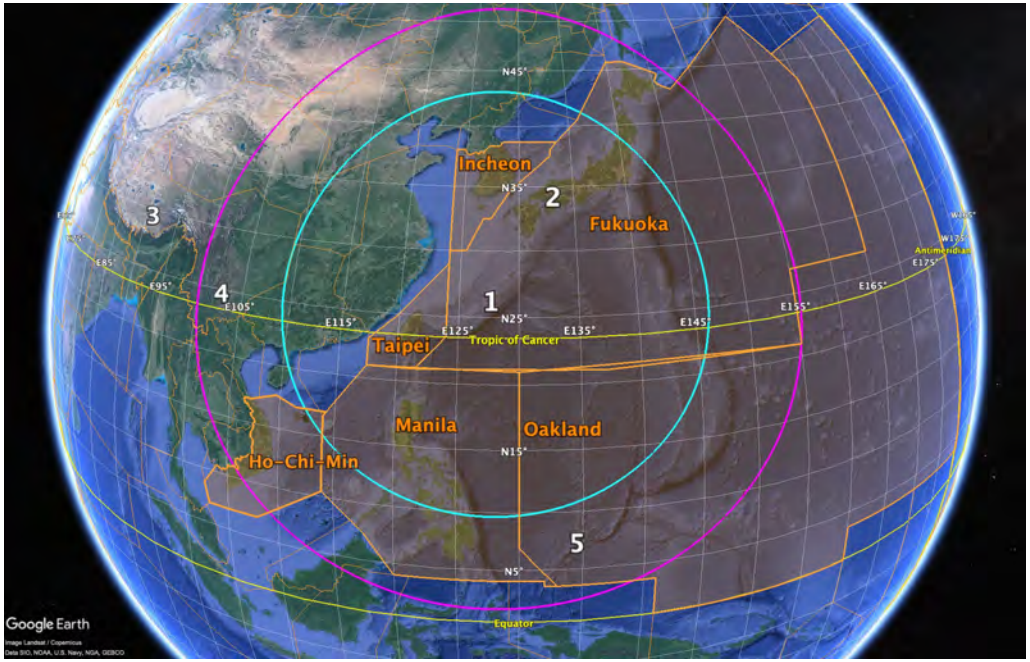
SP2 (BC)	**Schwarz**, NOAA
ERICA (particle types and elemental composition)	**Borrmann**, MPIC
	RAF
	RAF

Cloud

CDP	**2DC**	RAF
MTP (Temperature profile)		

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)

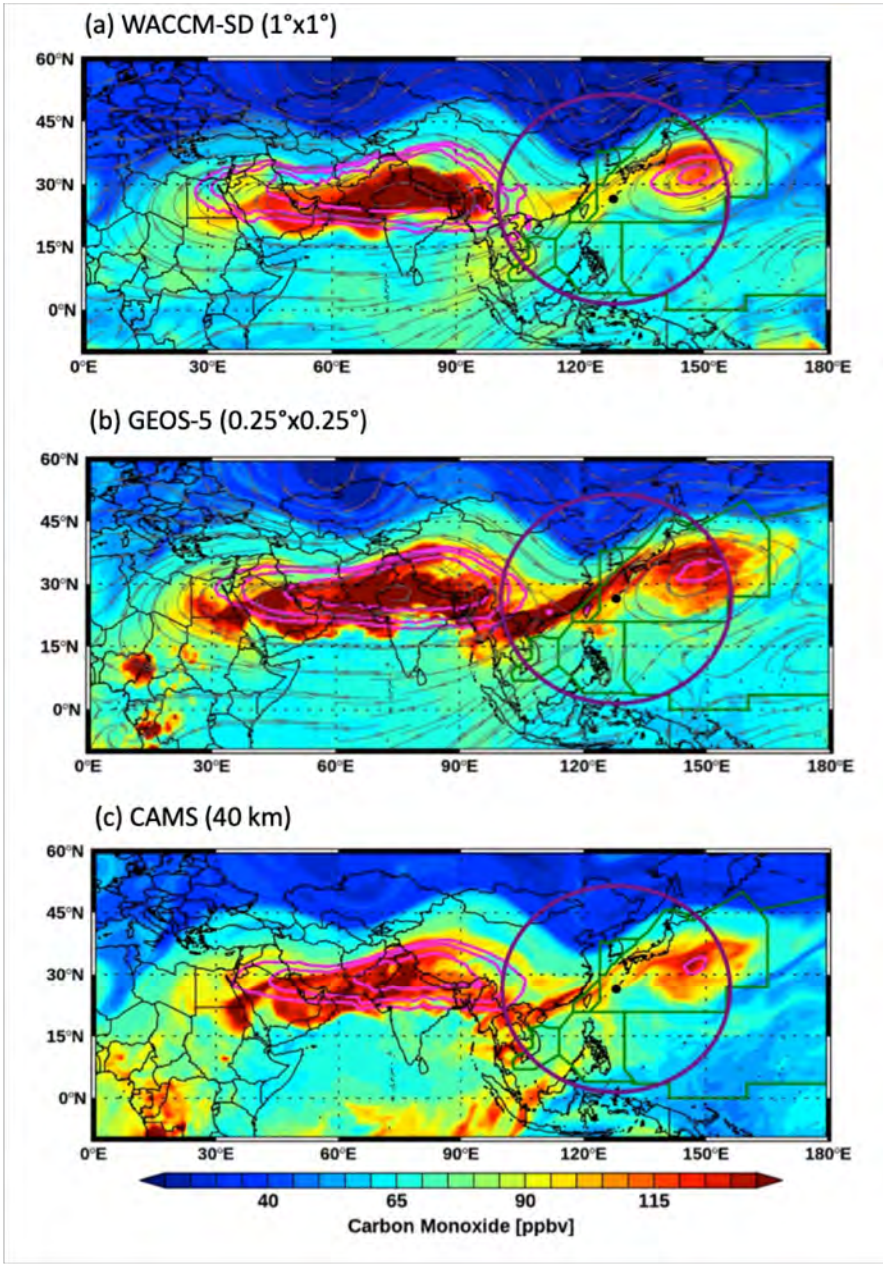
ECMWF/CAMS: Chemical forecast products (Johannes Flemming, et al.)

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

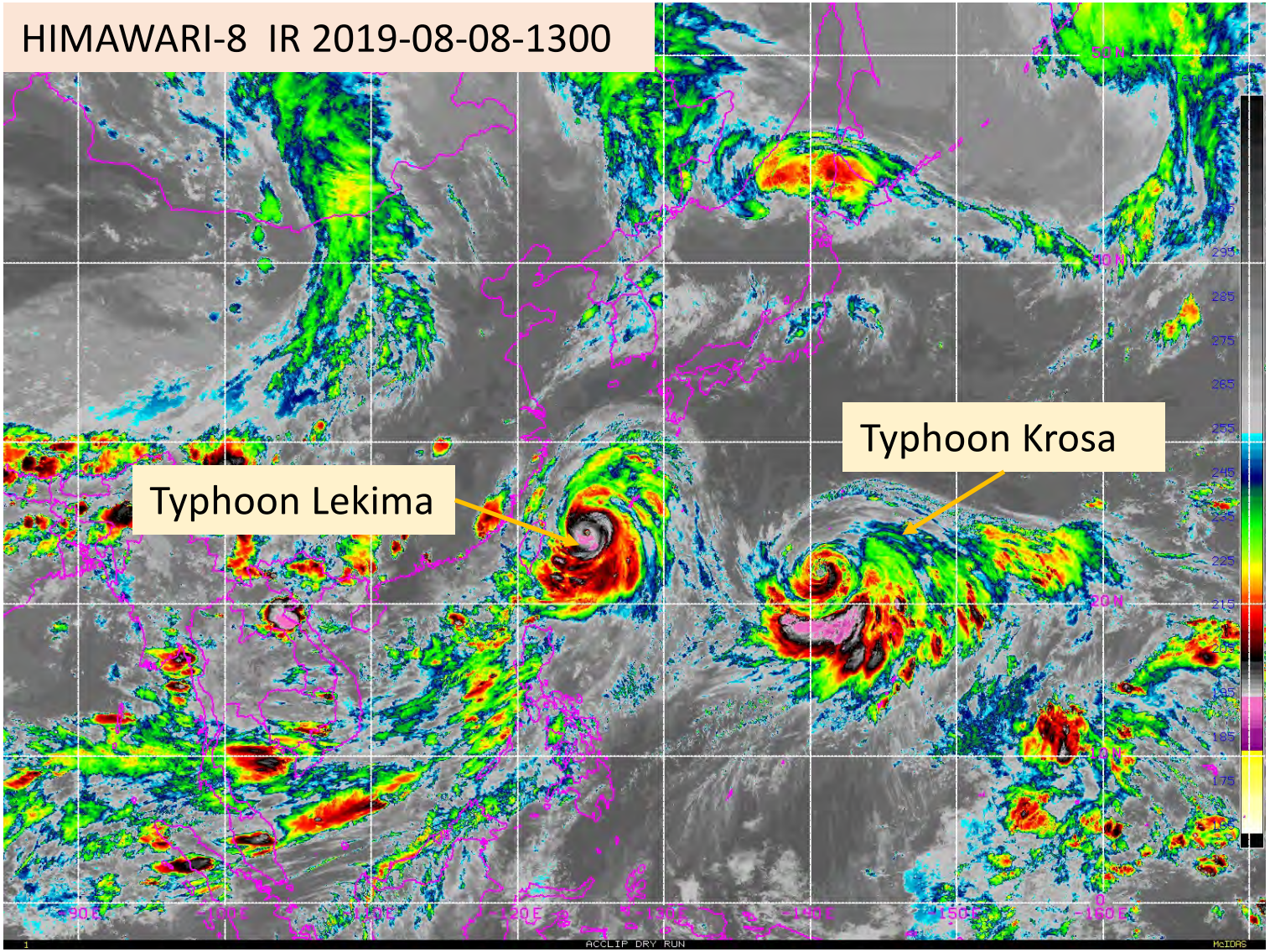
SO_2 @150 hPa

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

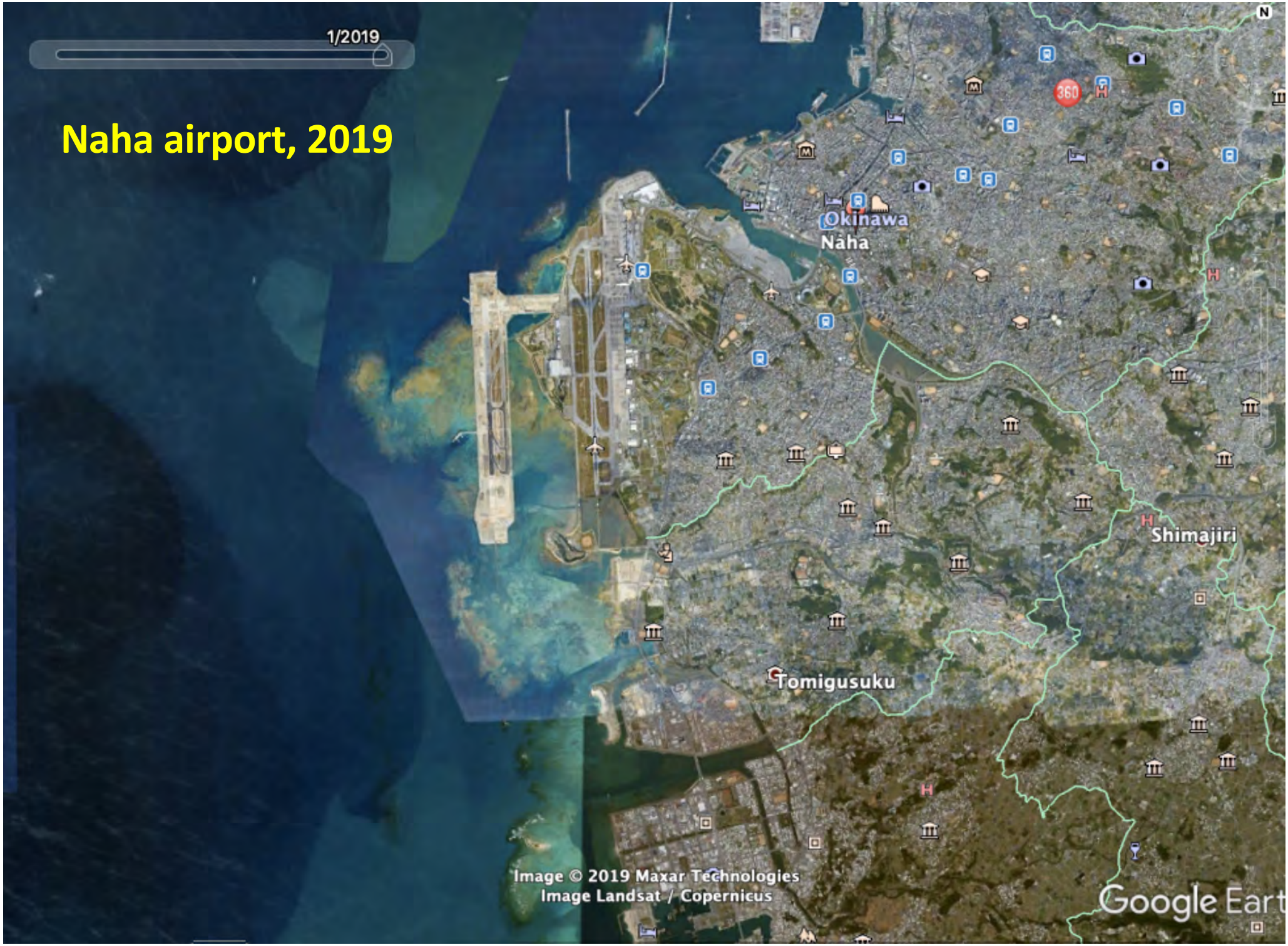
C_3H_8 @150 hPa

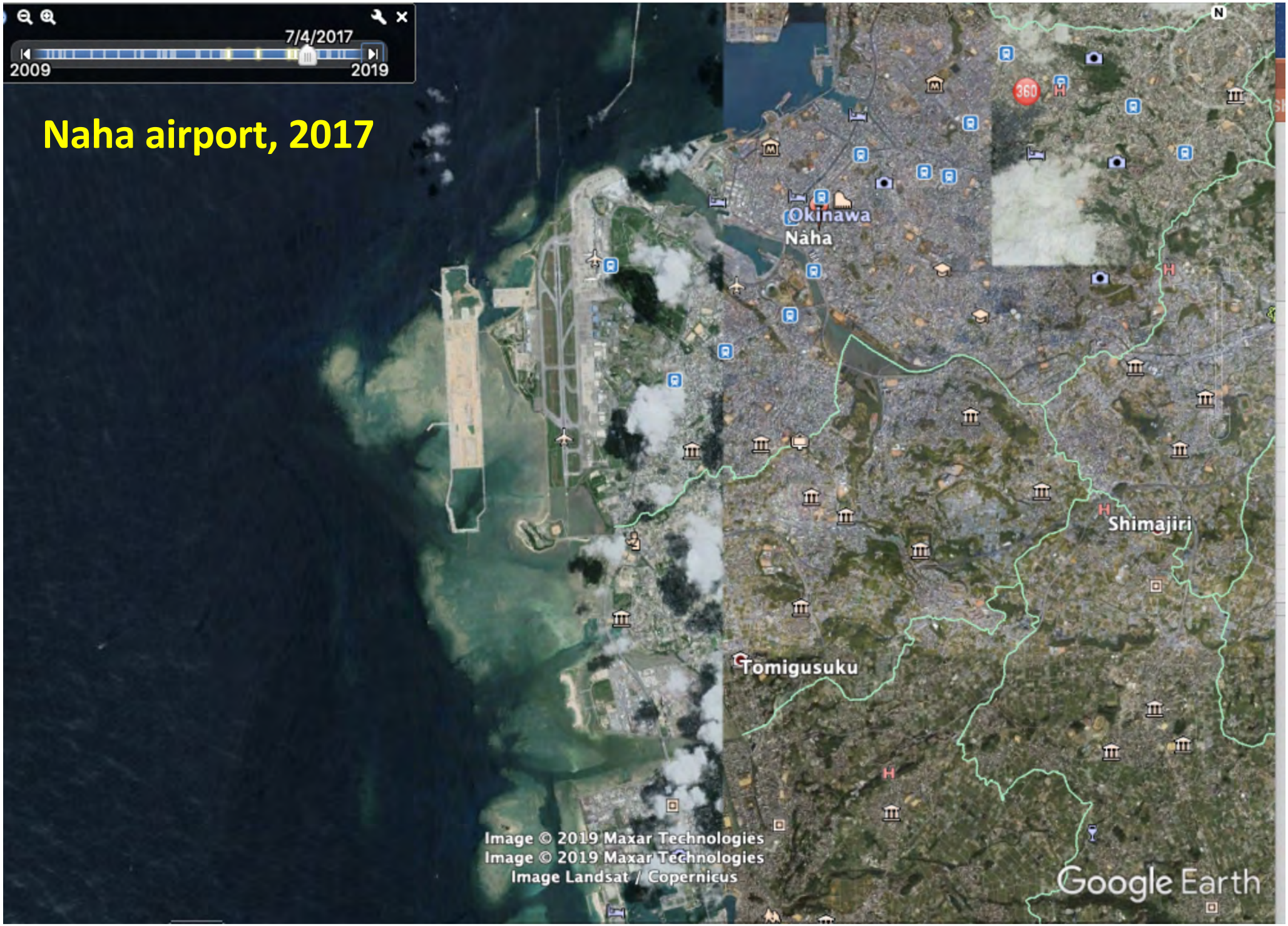
http://catalog.eol.ucar.edu/acclip_2019/model/cams_ecmwf_40km/150mb_C3H8/20190730/0000/000

Significant concerns: Typhoon Influence in the domain




Thank you !
Naha airport new runway expected to be operational March 2020


1/2019
Naha airport, 2019
Okinawa
Naha
Shimajiri
Tomigusuku
Image © 2019 Maxar Technologies
Image Landsat / Copernicus
Google Eart


7/4/2017
2009
2019
Naha airport, 2017
Okinawa
Naha
Shimajiri
Tomigusuku
Image © 2019 Maxar Technologies
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Google Earth

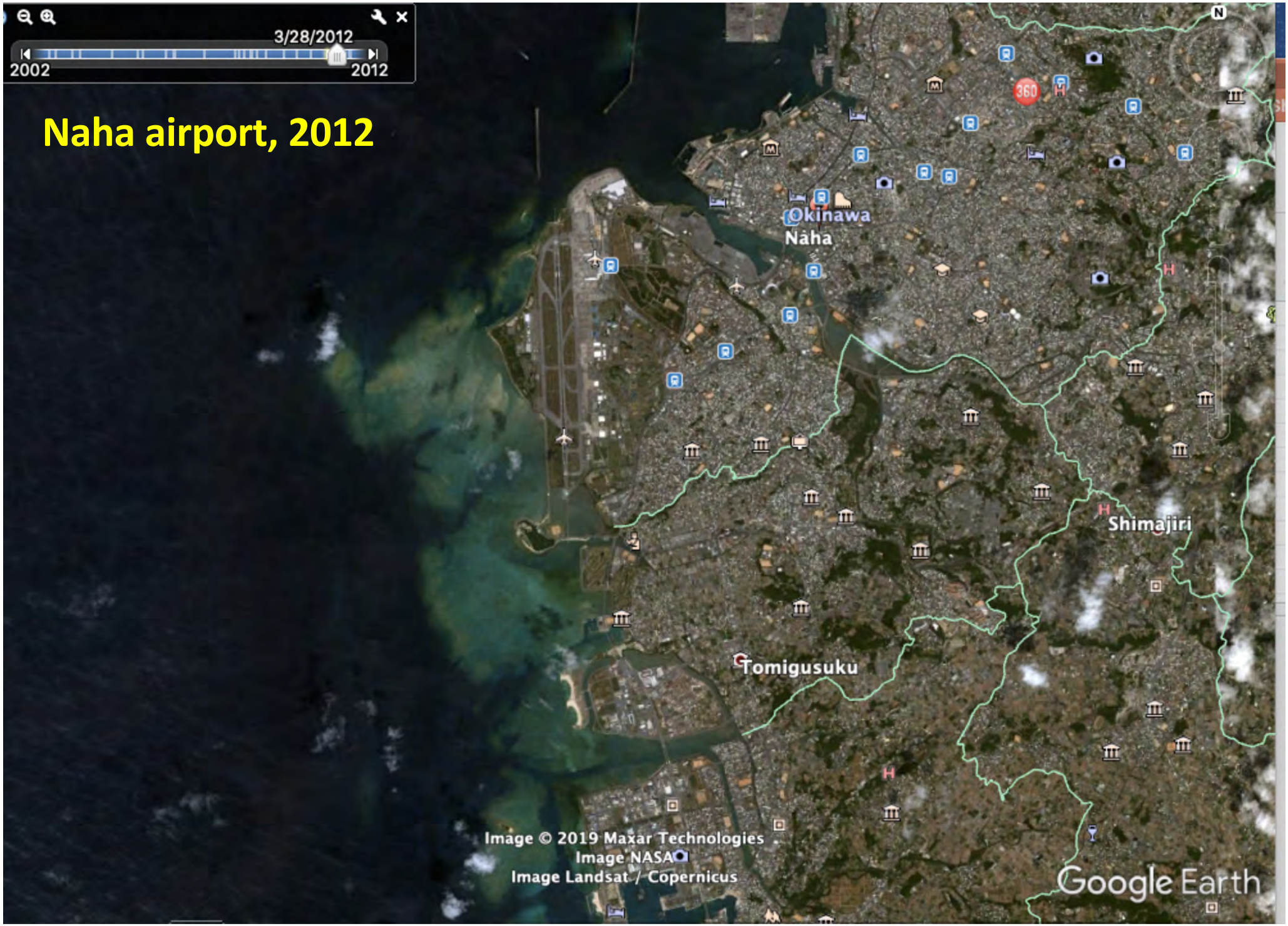
3/28/2012
2002
2012
Naha airport, 2012
Okinawa
Naha
Shimajiri
Tomigusuku
Image © 2019 Maxar Technologies
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Image Landsat / Copernicus
Google Earth