



Jet Propulsion Laboratory
California Institute of Technology

Trace Gas Atmospheric Rivers: Remote Drivers of Air Pollutants

Mukesh Rai, Kazuyuki Miyazaki, Vivienne Payne, Bin Guan, Duane Waliser

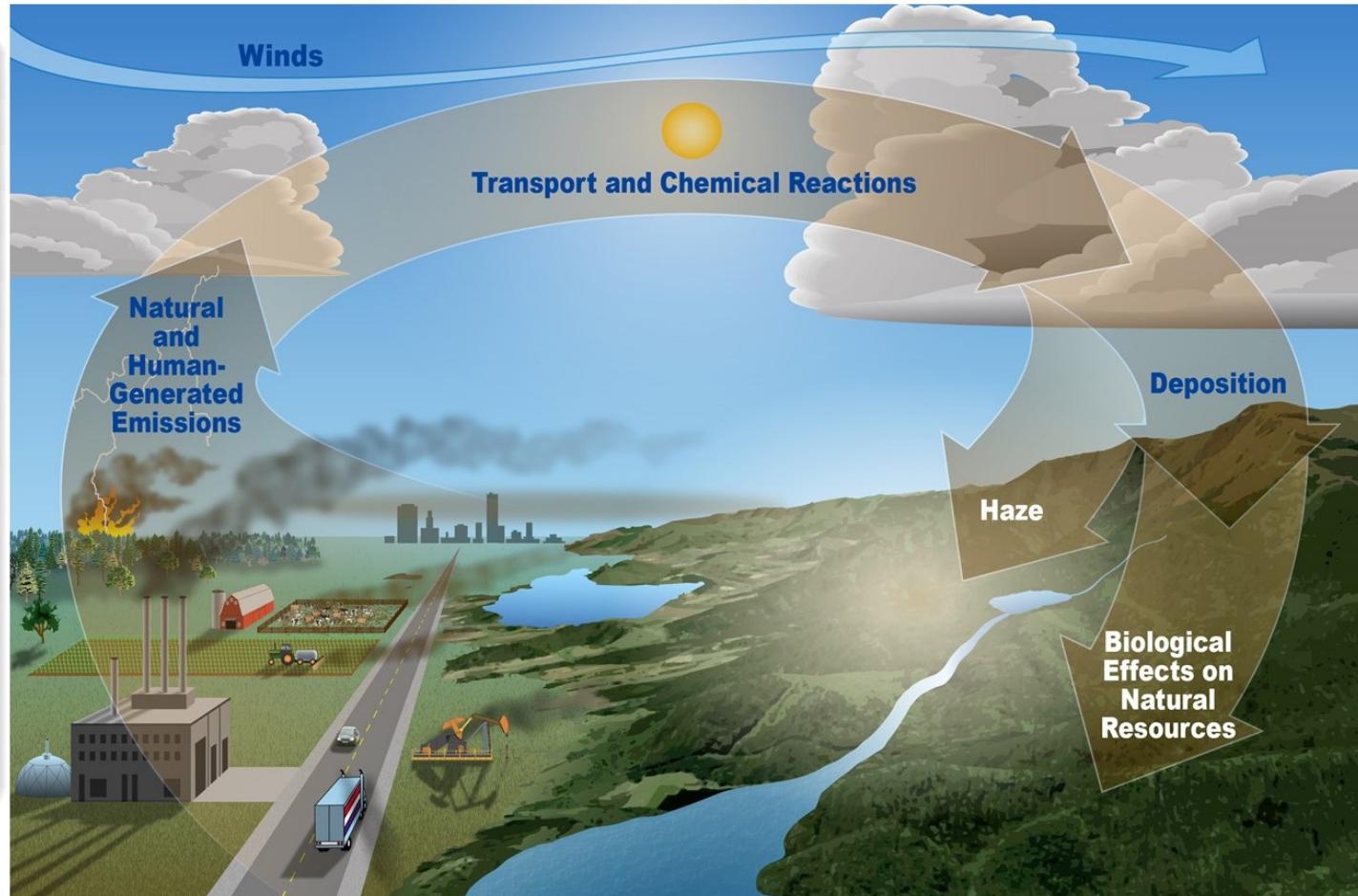
NASA Joint AIRS/Sounder Science Team Meeting
College Park, Maryland

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Context

Raising concern on degrading air quality

- Potential increasing threat due to air pollution hazards amplified by extreme air pollution
- However, the contributions from long-range transport during extreme events are not well understood

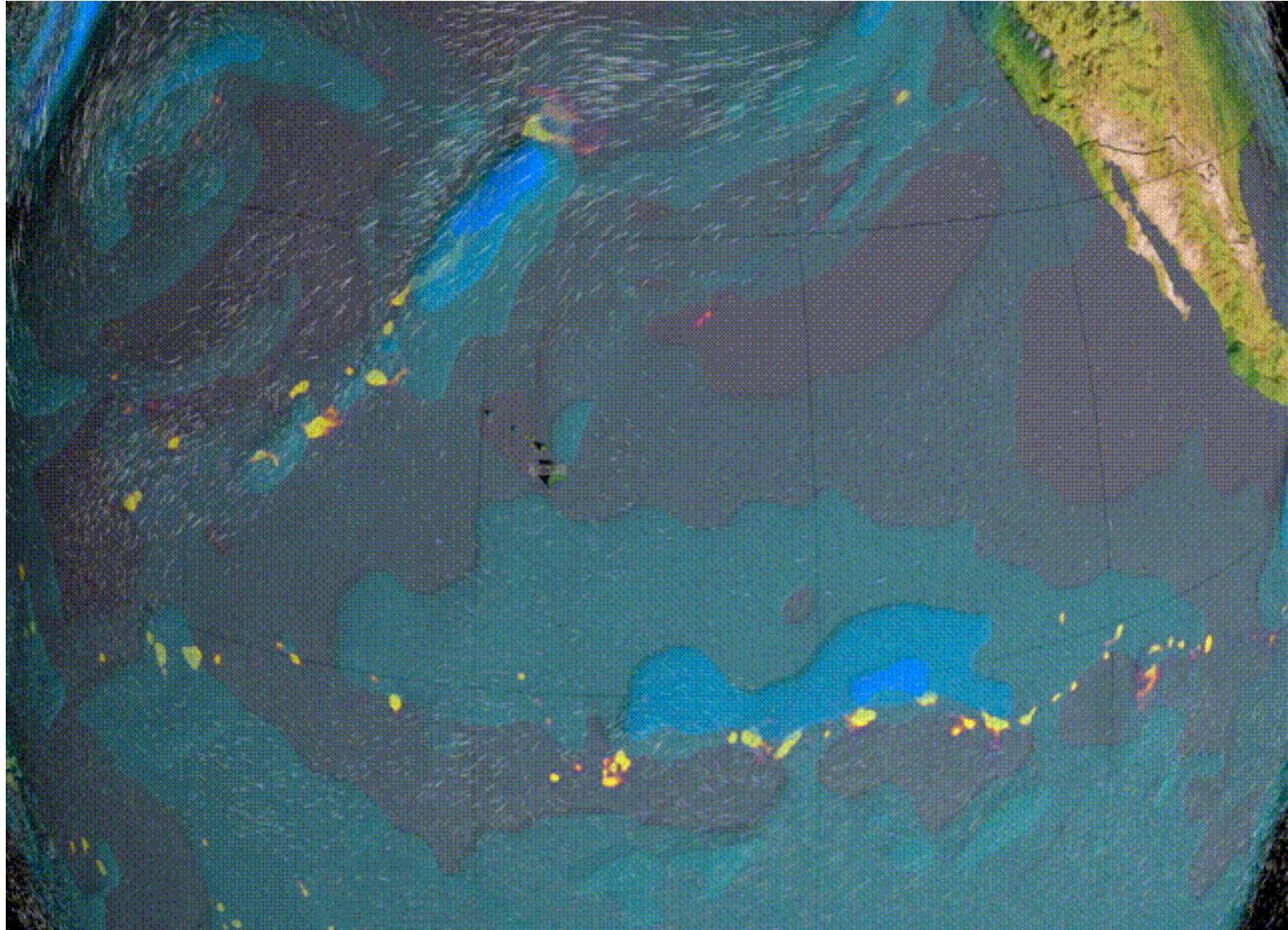


Source:- NPS

Motivation

Extending AR to air pollution

- Extend the concept of atmospheric river (AR) to trace gas atmospheric river (TGAR)
- AR - Narrow, long band of water vapor that transports large amount moisture from one region to another



A 3D View of an Atmospheric River from an Earth System Model (NASA SVS)

TROPESS CrIS products

TRopospheric Ozone and its Precursors
from Earth System Sounding
(TROPESS)

- O₃ and other trace gas by processing data from multiple satellites through a common retrieval algorithm
- It incorporates a range of activities (including data dissemination, validation, and data analysis)

Cross-Track Infared Sounder [CrIS]

- A nadir-viewing Fourier transform spectrometer (FTS) which on board the Suomi National Polar-orbiting Partnership (S-NPP)
- Specification:- Spatial resolution [14 km x 14 km], Temporal [6 min, Daily], Vertical: 1 km vertical layer
- Application: High spatiotemporal resolution, air quality study, emission from wildfire plumes and transport

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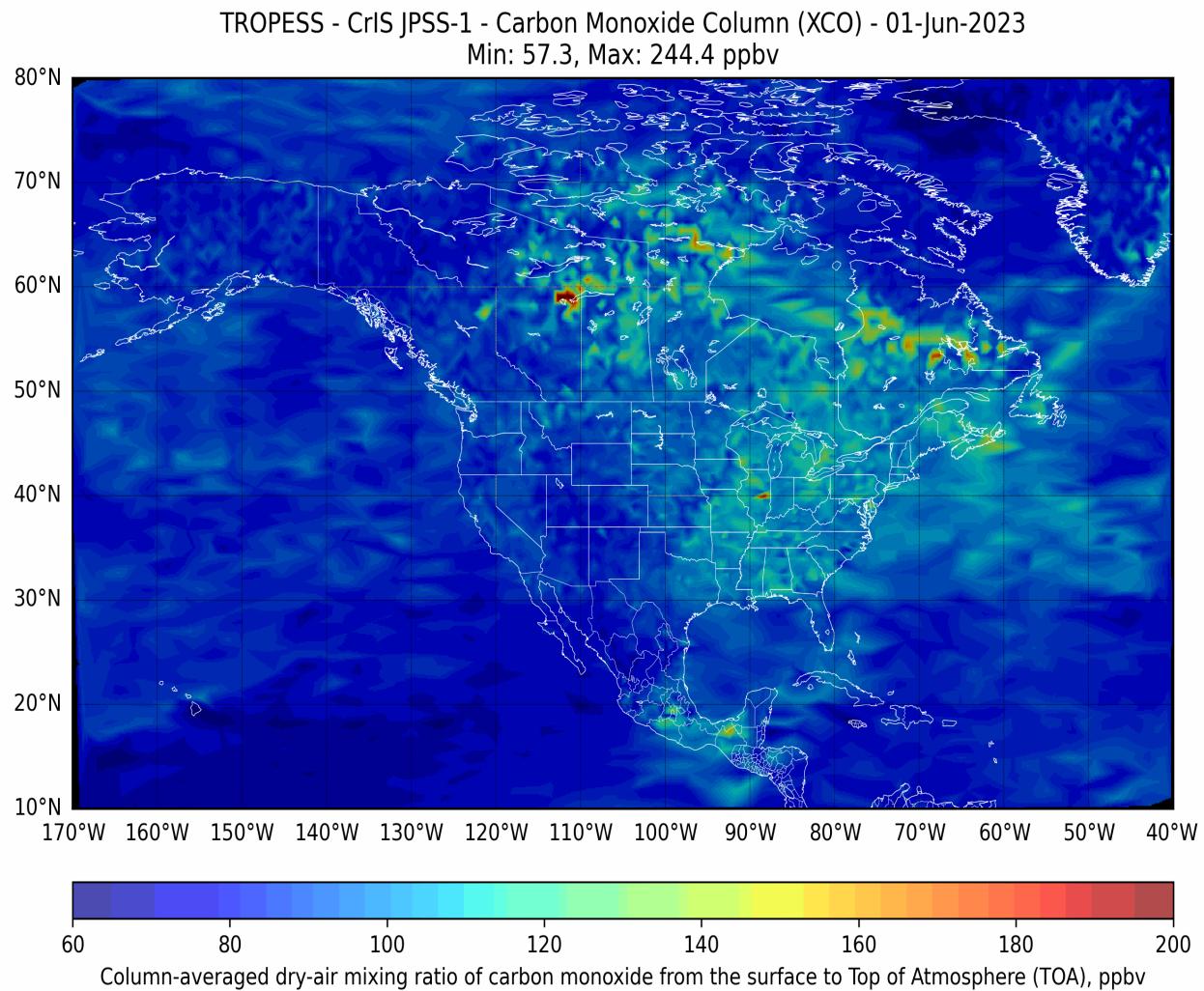
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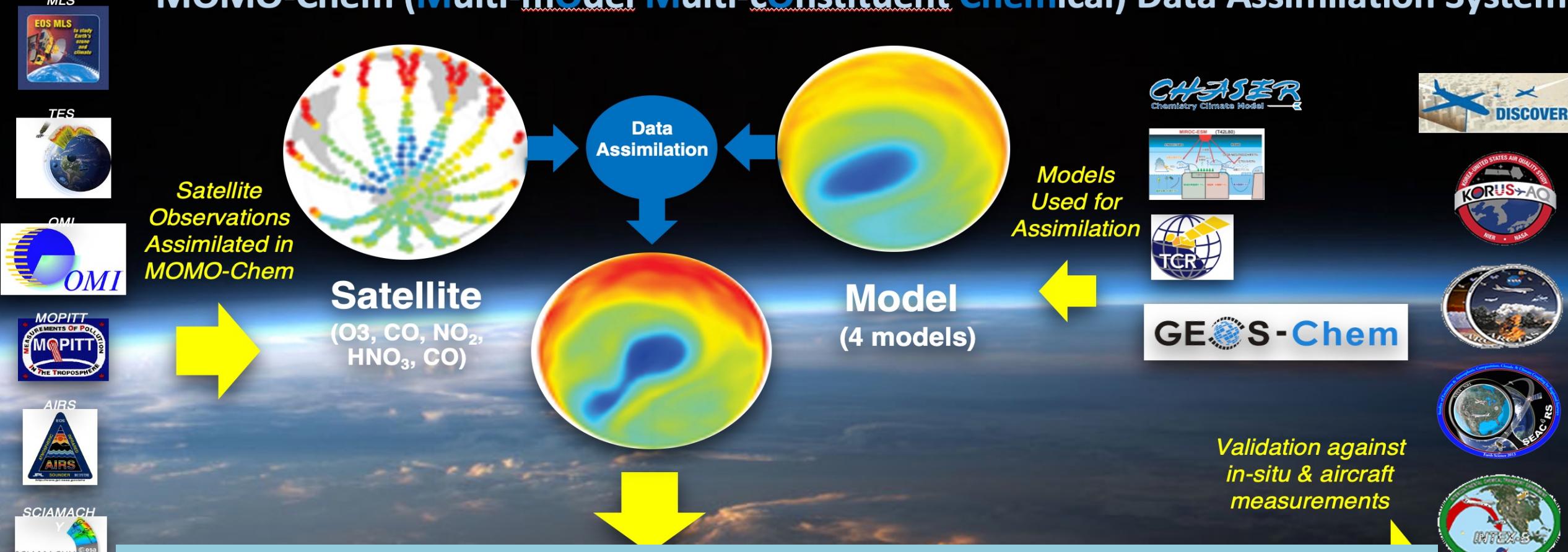
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2023 Canadian wildfires. Source: JPL

Data

MOMO-Chem (Multi-mOdel Multi-cOnstituent Chemical) Data Assimilation System



Tropospheric Chemical Reanalysis version-2 (TCR-2) was produced under the TROPESS project using the JPL MOMO-Chem system that ingests many NASA's satellite data using a data assimilation technique (Miyazaki et.al 2015, 2017, 2019, 2020).

- Ozone, PAN, CO
- 2005-2019 @ $1.1^\circ \times 1.1^\circ$ [Global], 6 hourly]
- 1000-60 hpa, 27 levels

Trace Gas Atmospheric River (TGAR)

TGAR framework

- Numerous AR detection algorithm: Atmospheric River Tracking method Intercomparison Project (ARTMIP)
- Adopted Guan and Waliser et.al (2015) AR detection algorithm BUT also mirroring Chakraborty et.al (2021) study
- Introduction of TGARs algorithm

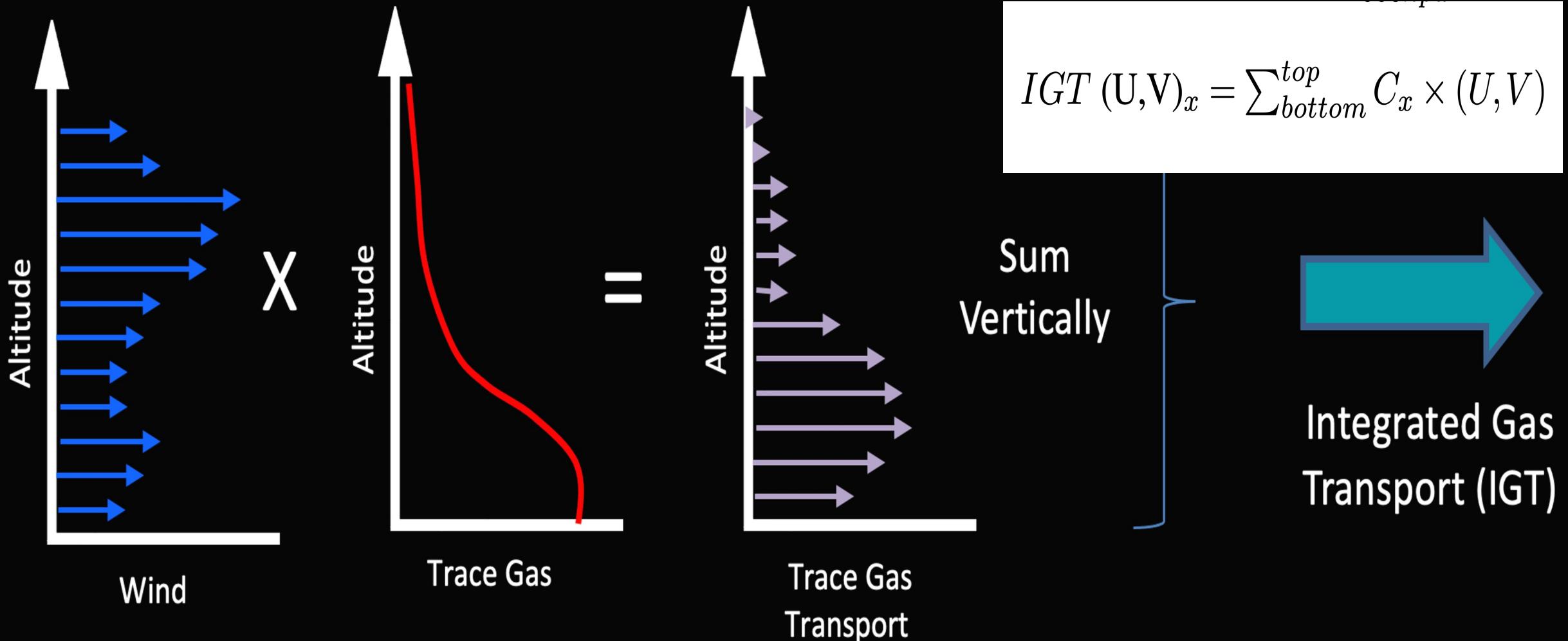
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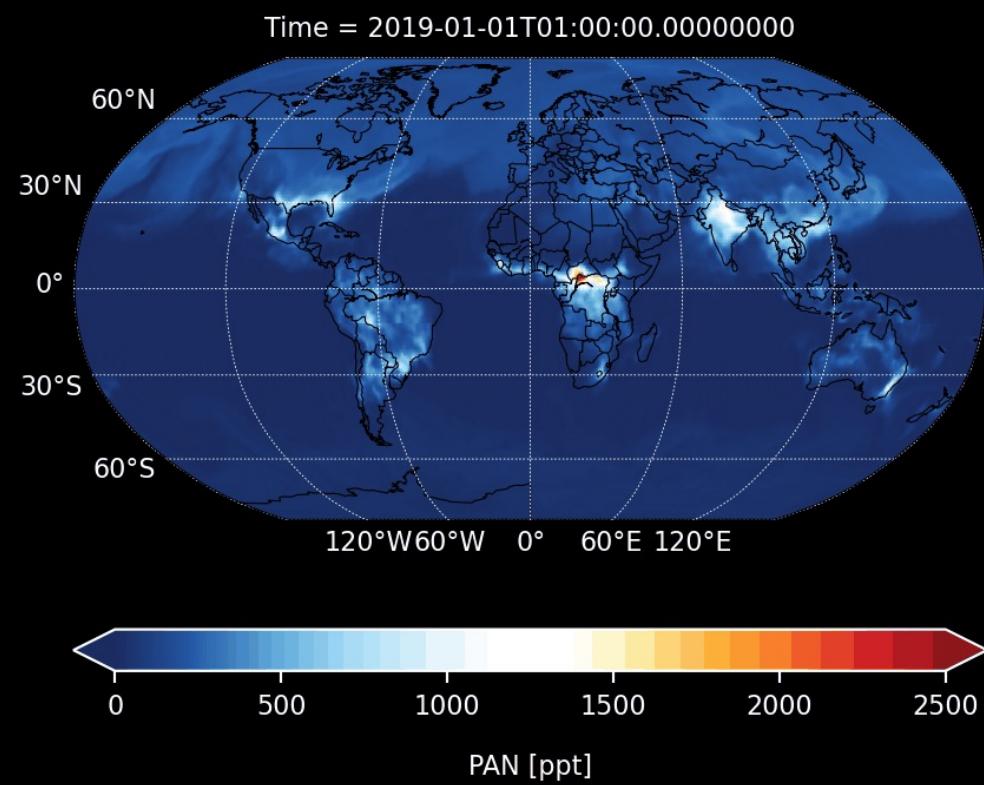
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Trace Gas Atmospheric River (TGAR)

TGAR framework



Multi-pollutant AR transport analysis



source: combustion and biogenic [🔥🔥🔥]

important ozone precursor

long: 1-2 month = ideal atmospheric tracer

Secondary pollutant produced by various sources

Greenhouse gas

Impact human and environmental health

Secondary pollutant formed by NOx and VOCs

Temporary reservoir for NOx

source ozone remotely after long-range transport

Validation of TCR-2 and CrIS data

Tropospheric Chemistry Reanalysis (TCR-2) - CO and O₃

- *Miyazaki et.al (2020)* performed a comprehensive evaluation of TCR-2 data:
 - CO against WDCGG, IAGOS, AToM, NASA's aircrafts
 - O₃ against WOUDC, IAGOS, AToM, NASA's aircrafts

TROPESS CrIS validation against NASA's aircrafts

- *Payne et.al (2022)* validated CrIS PAN against aircraft campaign (ATom)
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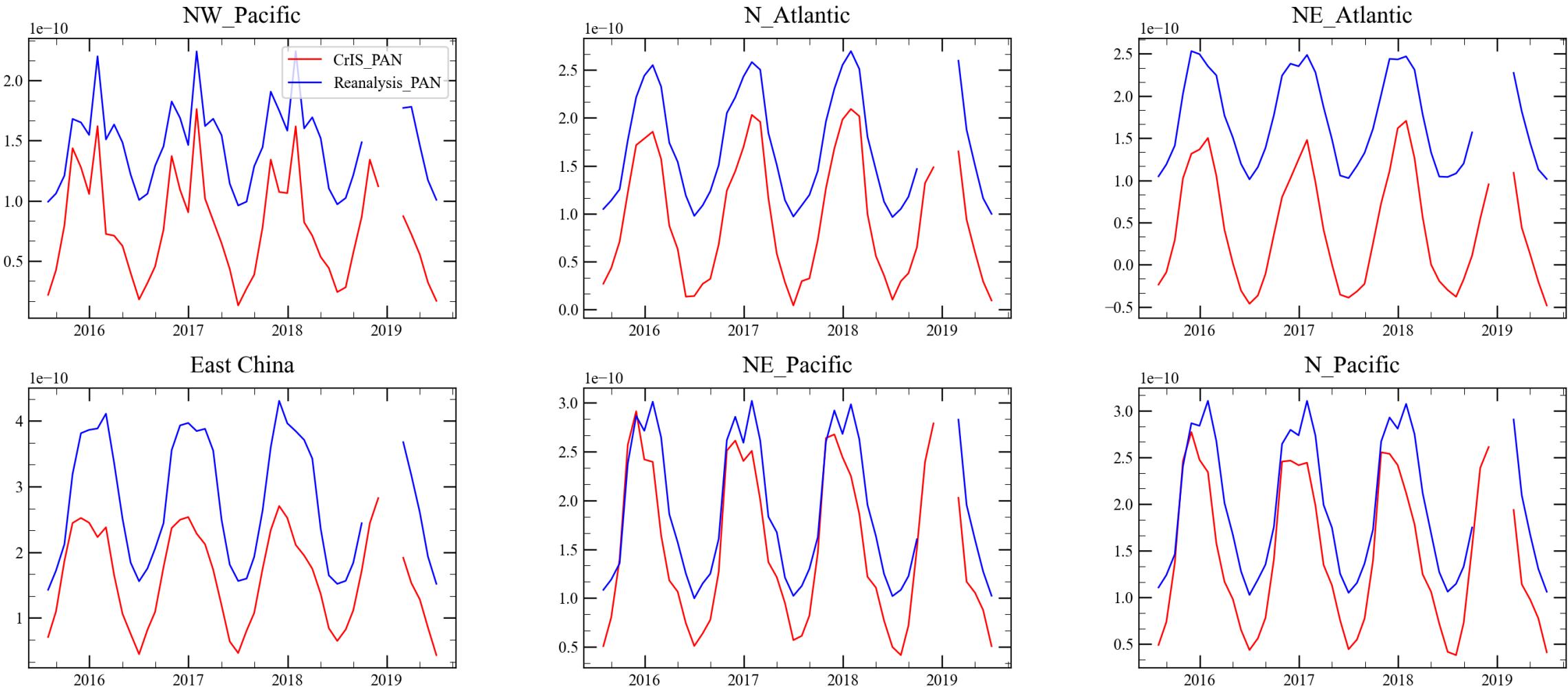
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Validation [PAN validation: TROPESS CrIS against TCR-2]

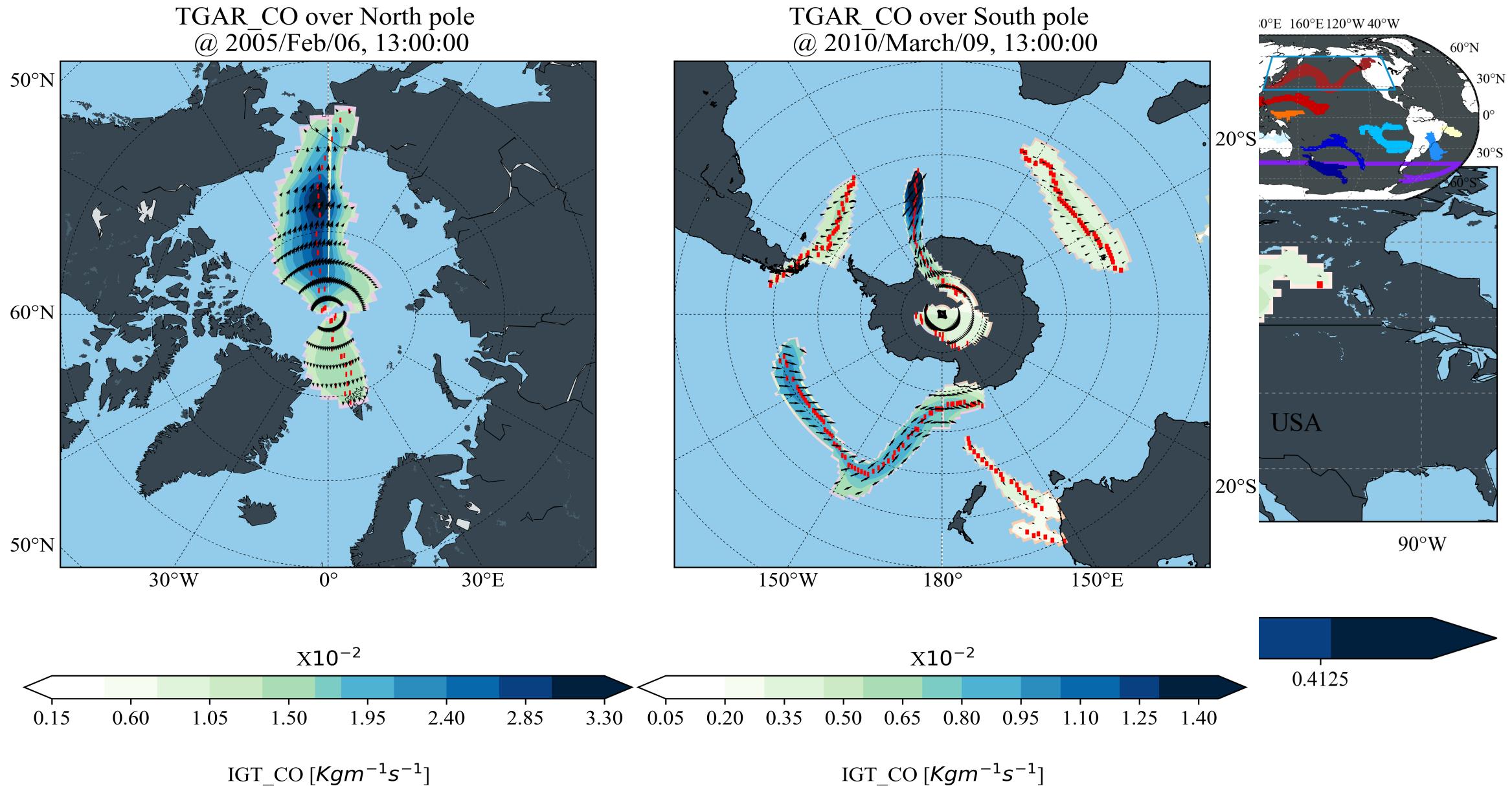
Past validation of TCR-2

- Here, we performed the evaluation of TCR-2 PAN data against Cross Track Infrared Sounder (CrIS), which essentially provides the level of confidence using reanalysis data
- In this study, CrIS was used to validate TCR-2 PAN, in future these CrIS will be assimilated into future reanalysis products

PAN validation: TROPESSE CrIS against TCR-2

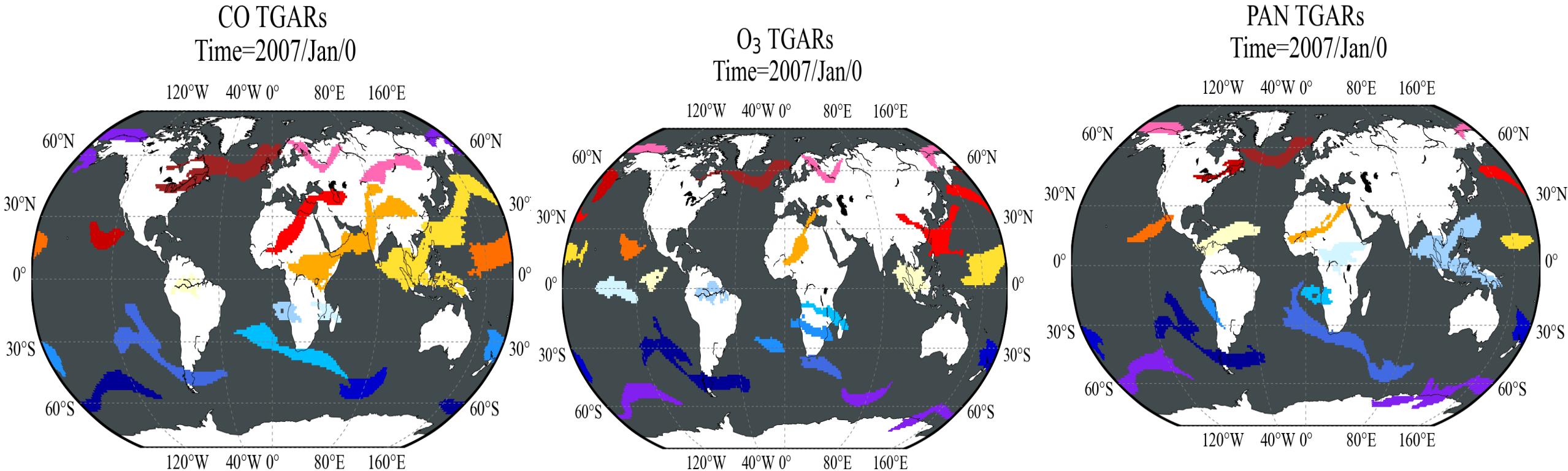


Results [Snapshot of AR detected by TGARs]



Results

The TGAR algorithm detected about 300,000 events globally



Results

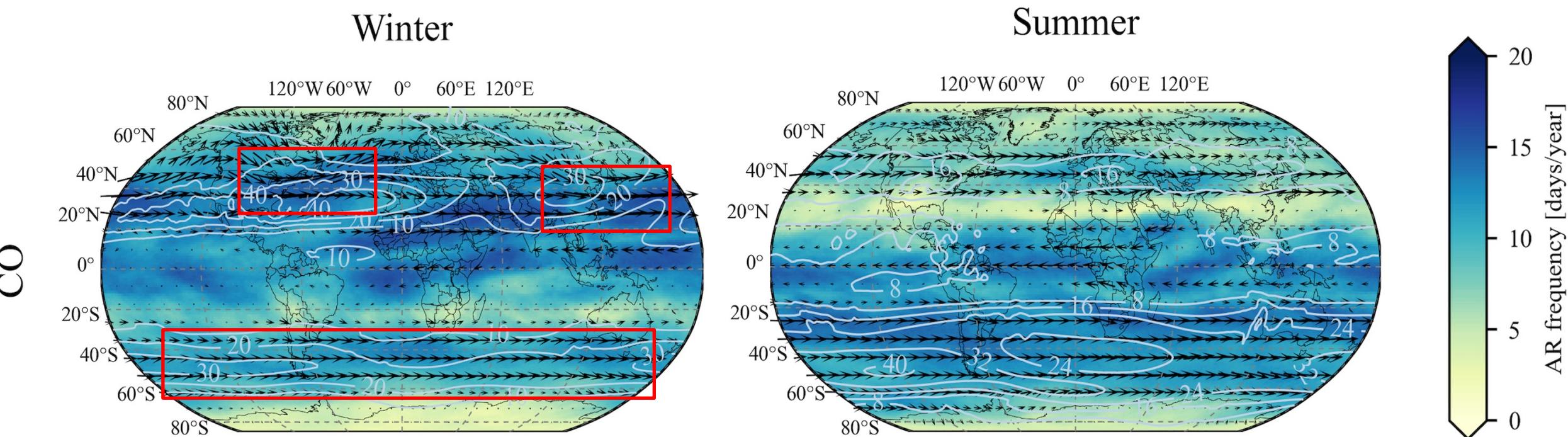
TGAR frequency [days per year]

- On an average, 20 days in a year considered as extreme events (i.e AR events)
- The highest over Pacific, Atlantic, Antarctic circumpolar

Results

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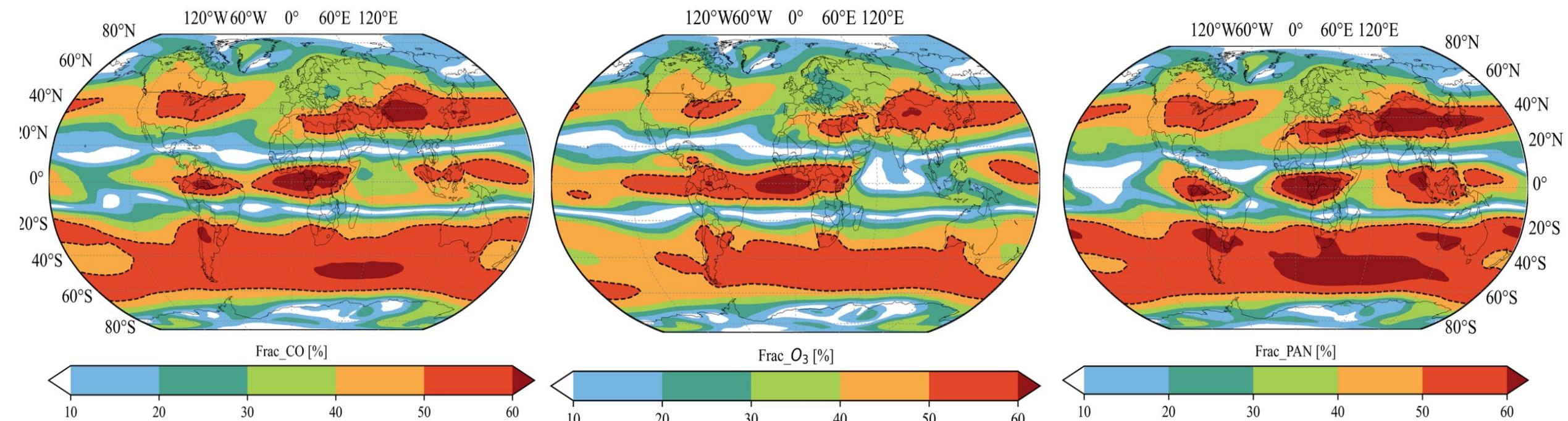
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Results

Attribution to total transport by TGAR events

AR events responsible greater than **60 %** of the annual total transport over North Atlantic Ocean, South temperate zone, central Asia, Africa, Pacific Ocean



Conclusions

- Globally, TGAR detected about 300,000 events, corresponded to up to 20 days per year (extreme events AR), and was responsible for greater than 60 % of the annual total transport over the North Atlantic Ocean, South temperate zone, central Asia, Africa, Pacific Ocean
- This study shed light on drivers of extreme air pollution (trace gas) events and identified the potentially hazardous regions in terms of air quality

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Way forward

- This framework could be useful for studying the extreme air pollution driver for addressing a wide range of societal and environmental challenges including AR patterns and strengths on global atmospheric composition
- Further comparisons between TCR-2 and TROPESS CrIS products for a better understanding of agreement and differences
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Thank You

Teleconnection with Jet stream ?

