Trace gas atmospheric rivers: remote drivers of air pollutants

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BACKGROUND

- Air quality in a given location can be influenced by local emissions or by pollution that has been transported from afar.

- Mandate of task force Hemispheric Transport of Air Pollution (HTAP) to improve the scientific understanding of intercontinental air pollution transport
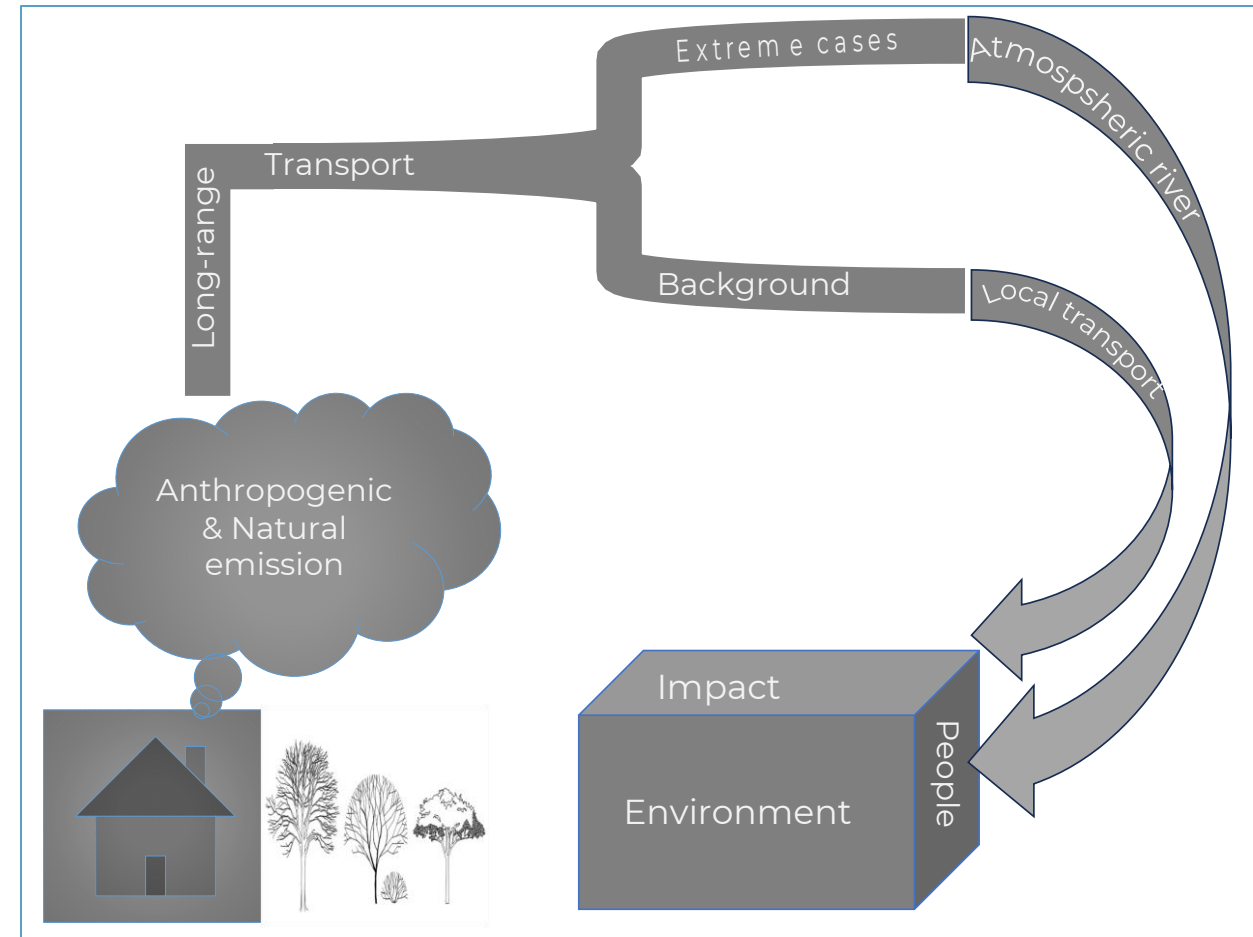
Schematic diagram showing emission and transport of pollutants (local and remote)
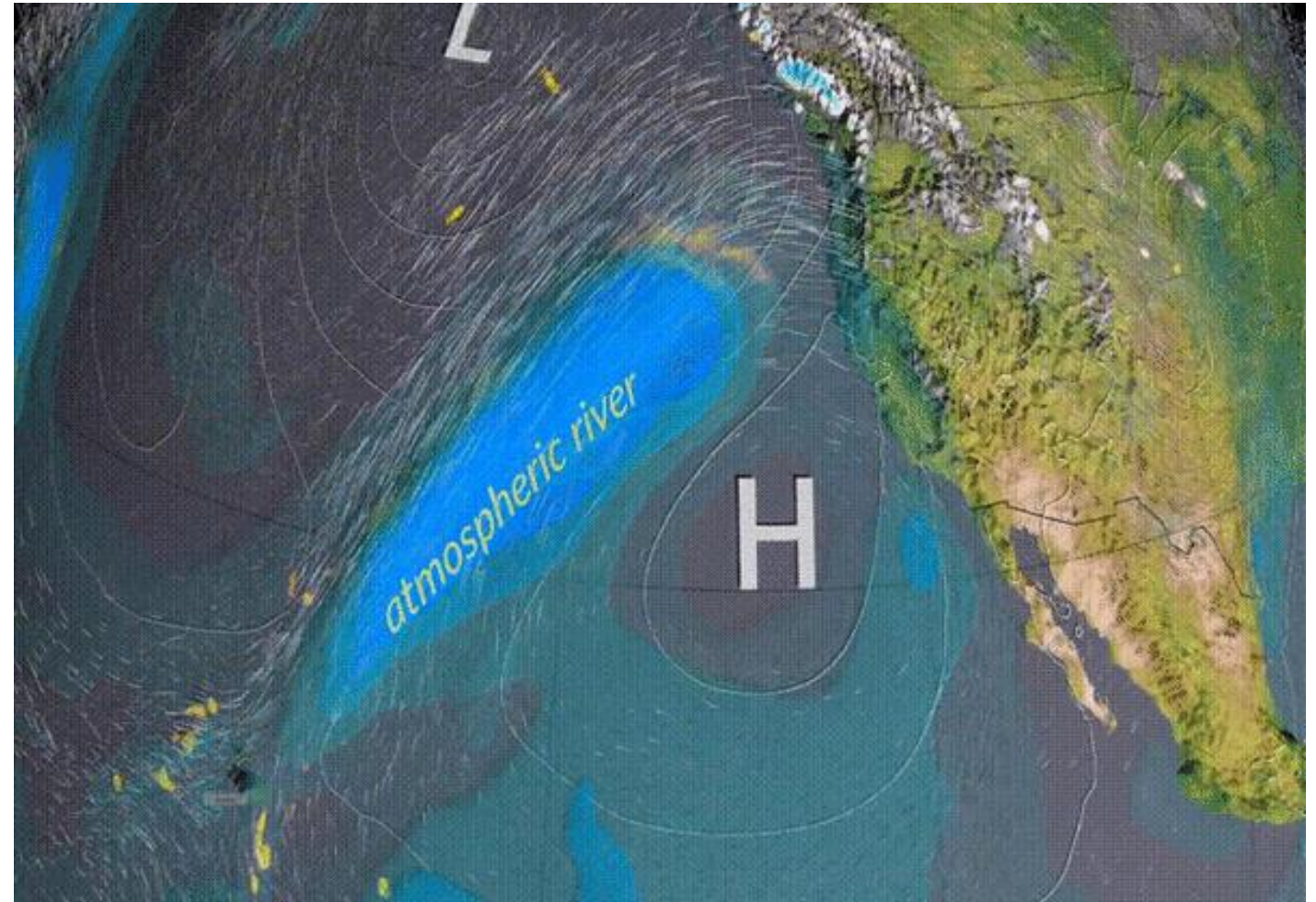
ATMOSPHERIC RIVER ?

A 3D view of an AR from an Earth System Model

Narrow, long band of water vapor that transport large amount of moisture
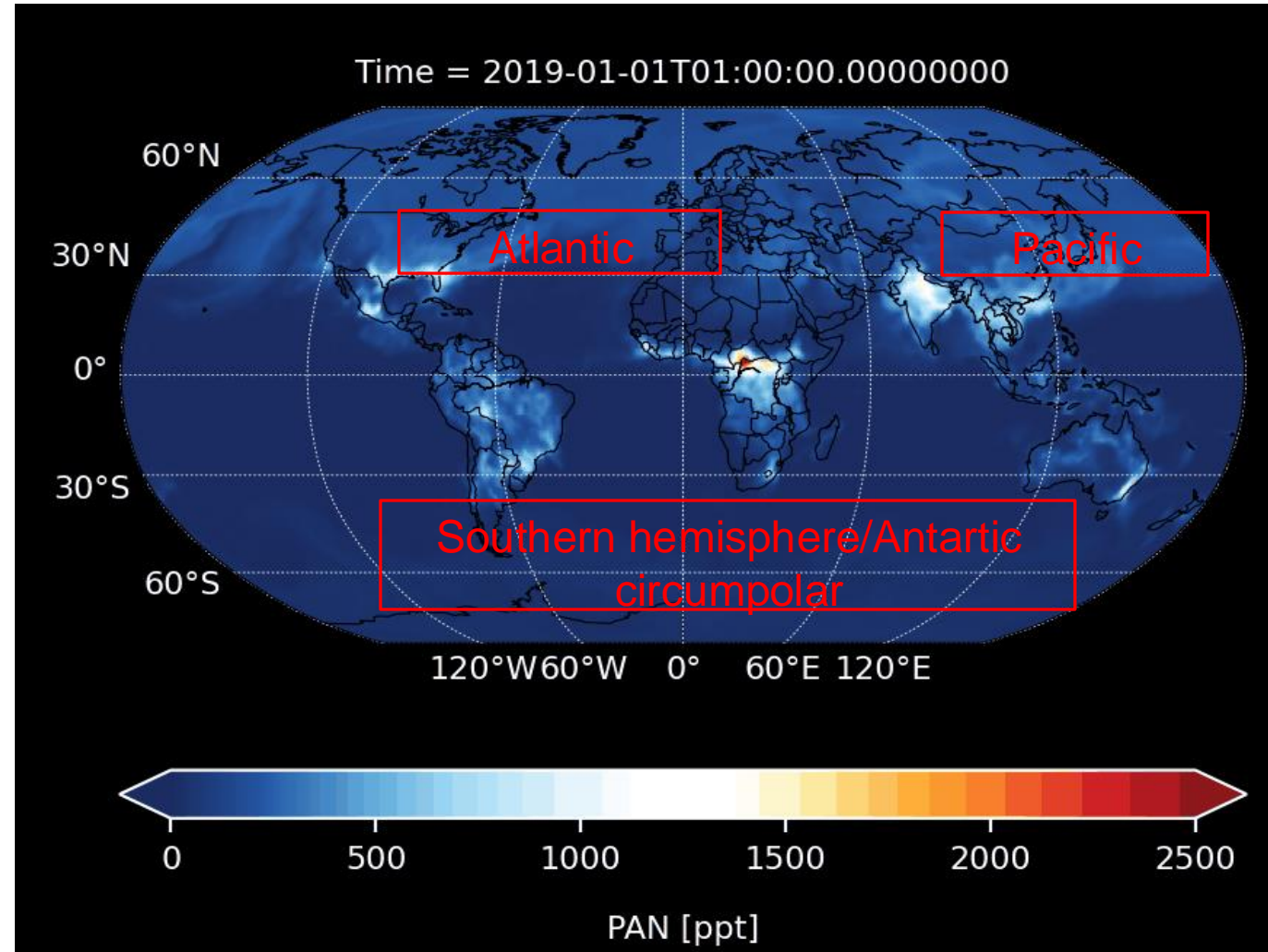
Guan and Waliser et.al (2015)

Credit: NASA,GSFC
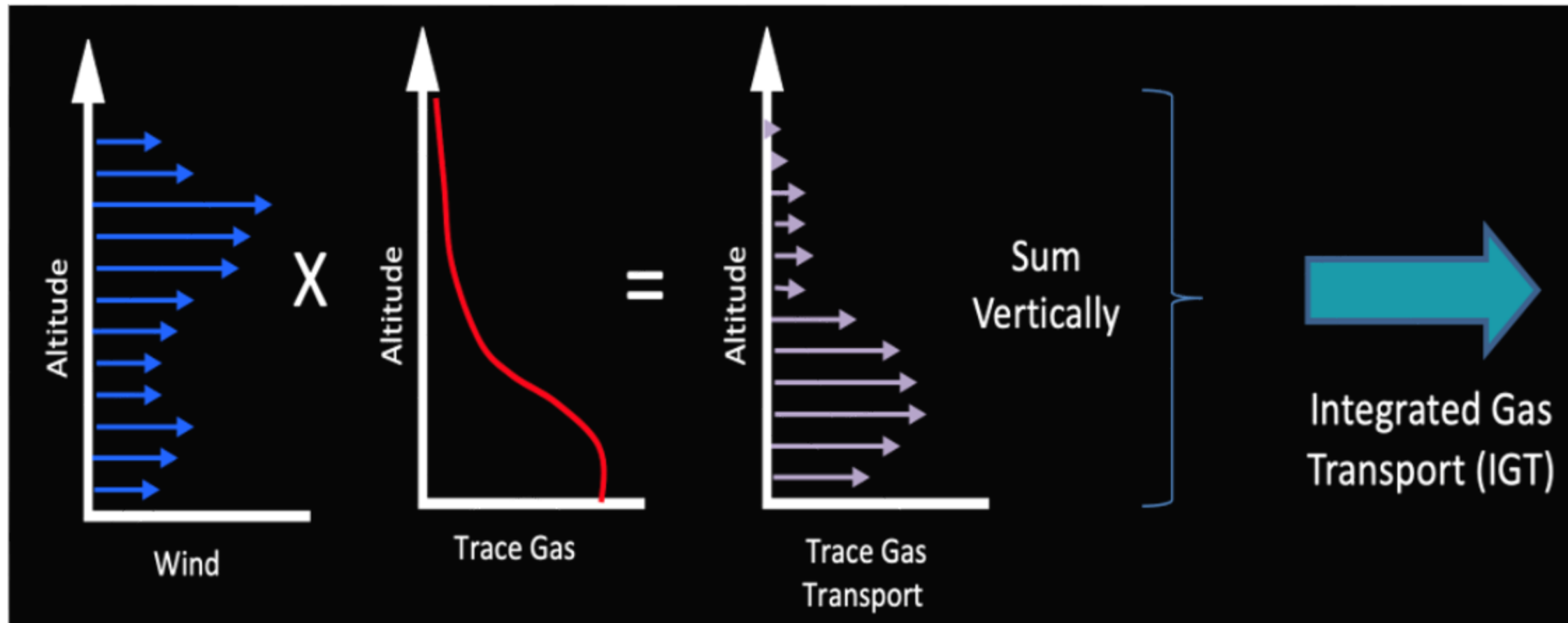Visualizers: Greg Shirah, Cindy Starr, Horace Mitchell, Kel Elkins

MOTIVATIONS

- Extend the concept of atmospheric river (AR) to trace gas atmospheric river (TGAR)

- Quantify the contribution of atmospheric rivers to long range transport of pollution
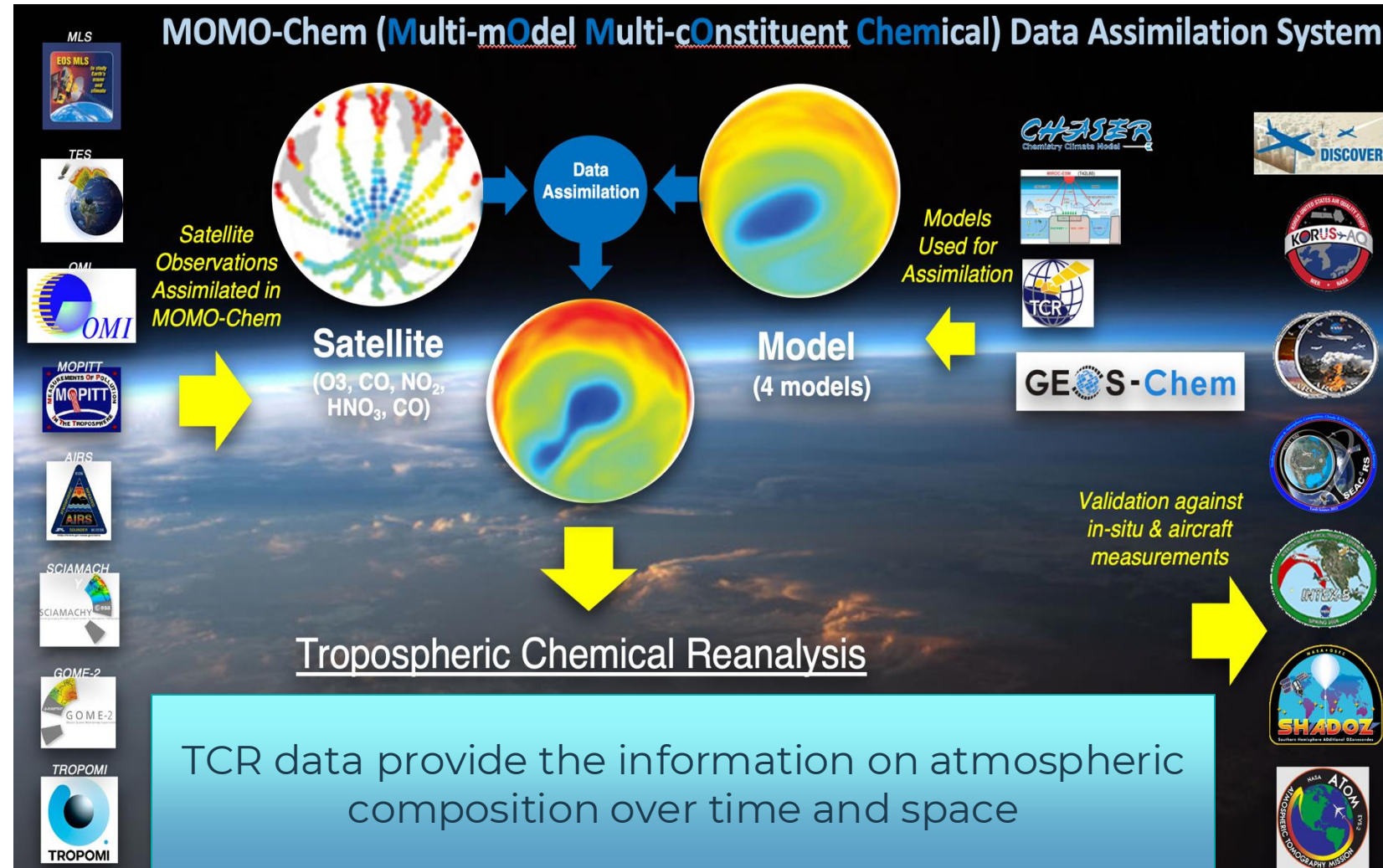
METHODS

This study adopted Guan and Waliser et. al (2015) and Chakraborty et. al (2021) approach
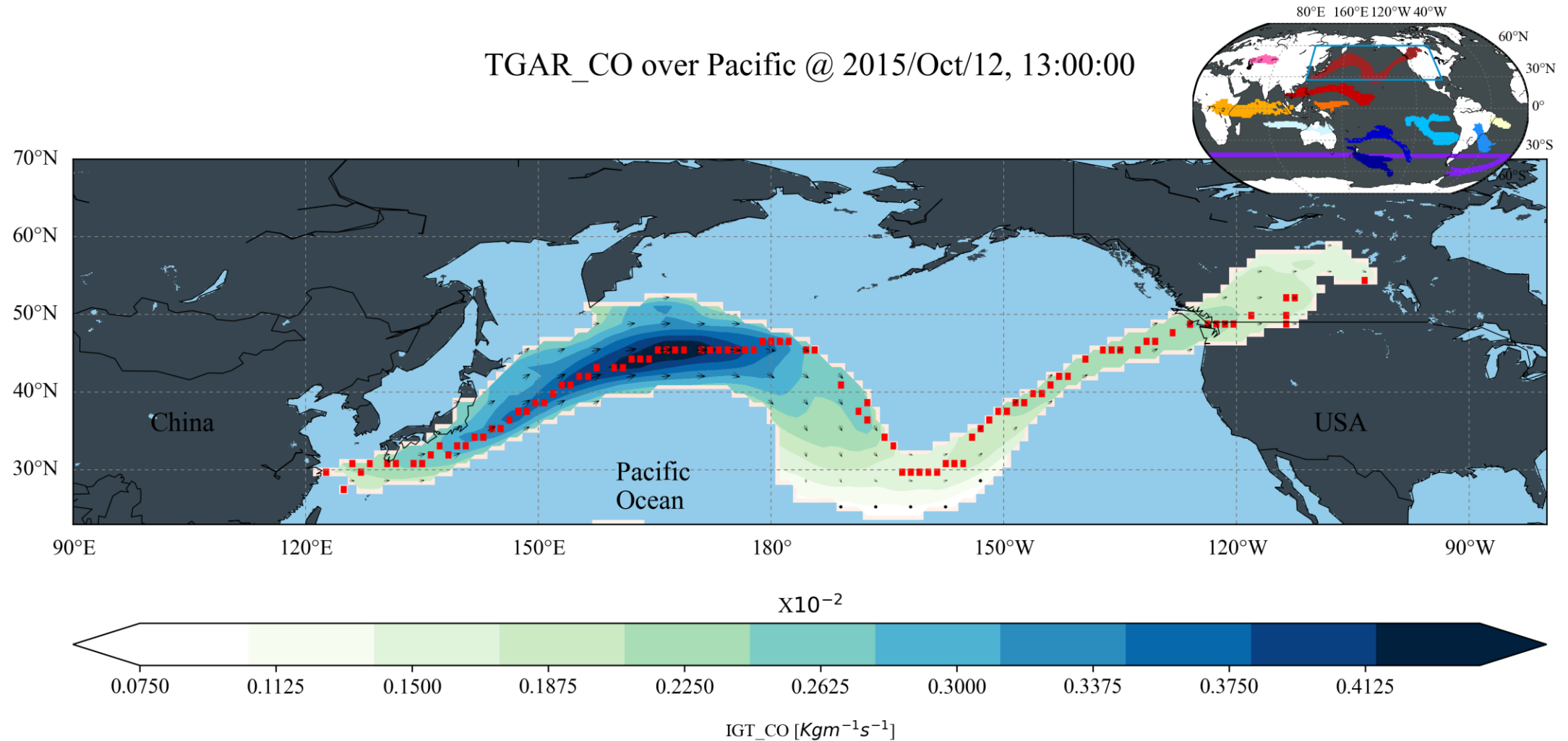
TCR-2 DATA

Tropospheric Chemical Reanalysis (TCR-2) produced under the TROPESS project using the JPL MOMO-Chem system that ingests many NASA's satellite data using MOMO-Chem System (Miyazaki et. al 2020).

- TCR-2 data 👇
 https://tes.jpl.nasa.gov/tes/chemical-reanalysis/
- TROPESS 👇
  https://tes.jpl.nasa.gov/tropess/

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

MLS

TES

OMI

MOPITT

AIRS

SCIAMACHY

GOME-2

TROPOMI

Satellite Observations Assimilated in MOMO-Chem

Data Assimilation

Satellite (O3, CO, NO2, HNO3, CO)

Model (4 models)

Models Used for Assimilation

Validation against in-situ & aircraft measurements

Tropospheric Chemical Reanalysis

TCR data provide the information on atmospheric composition over time and space

RESULTS – TGAR DETECTED OVER PACIFIC AND ATLANTIC

TGAR_CO over Pacific @ 2015/Oct/12, 13:00:00

$X10^{-2}$

IGT_CO $[Kgm^{-1}s^{-1}]$

RESULTS - DYNAMIC EVOLUTION OF TGAR
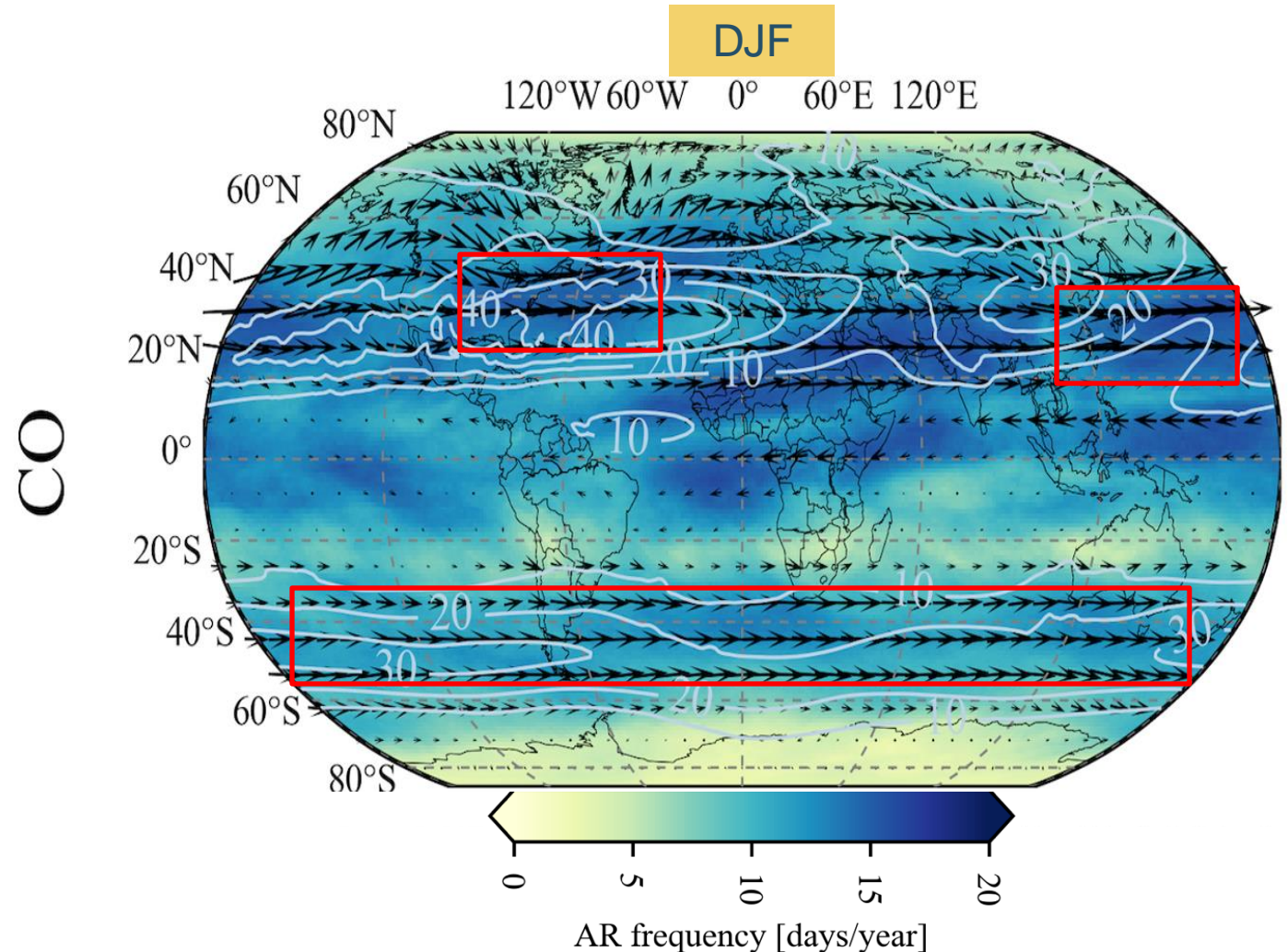

CO TGARs
Time=2007/Jan/0
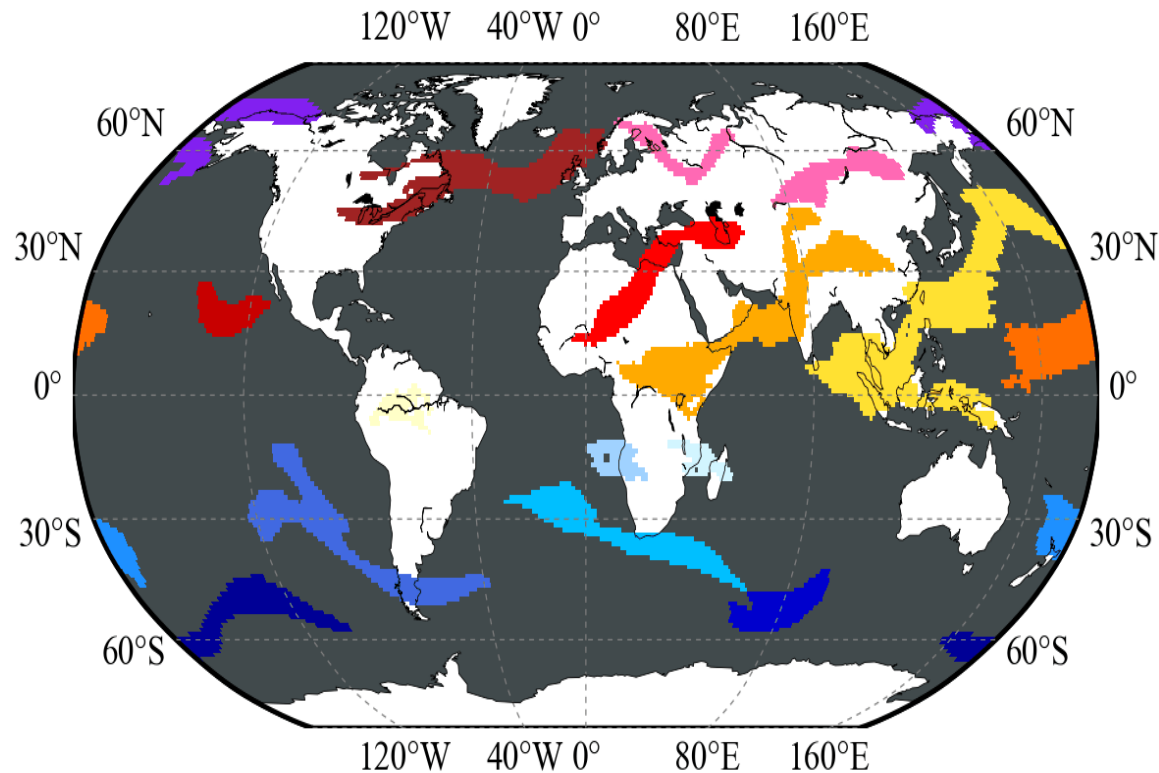
- TGAR detected AR objectives
- Westerlies dominants
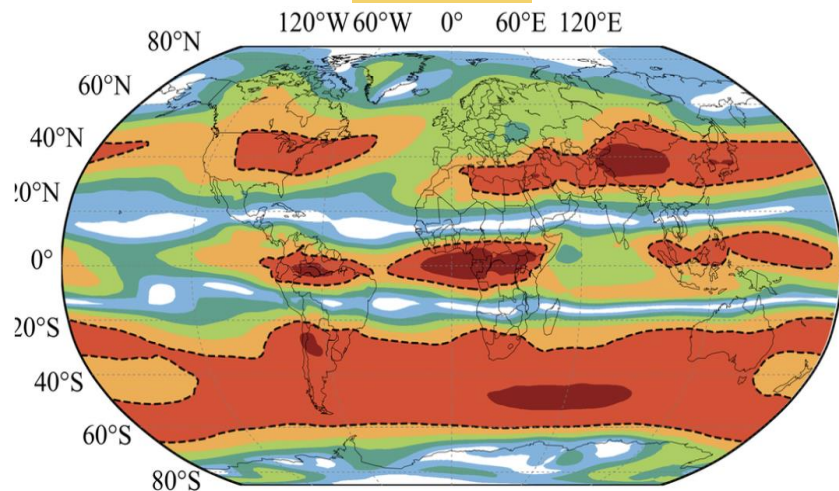- Move all directions

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RESULTS – NUMBER OF GLOBAL AR OCCURRENCE

- Global TGAR frequency of trace gas species are similar

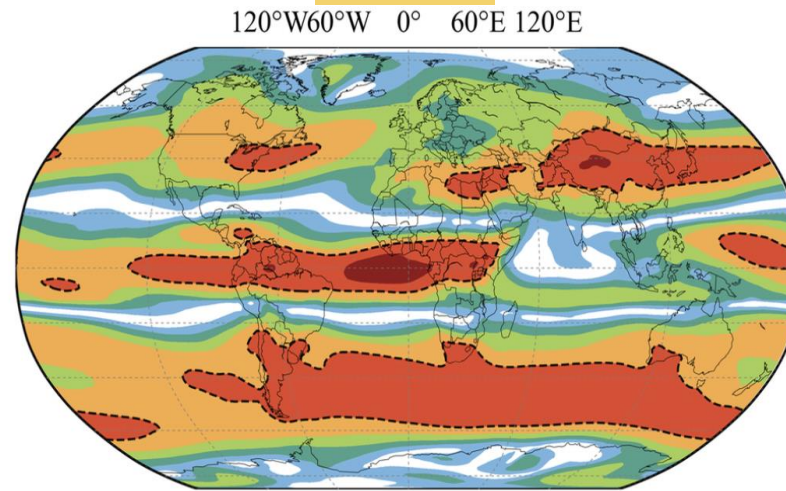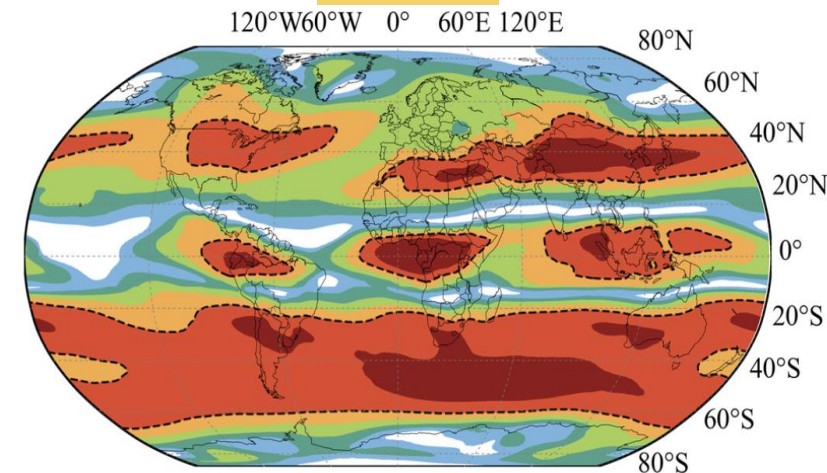- CO, an ideal passive tracer in atmosphere

RESULTS – TOTAL TRANSPORT ATTRIBUTION

- Overall climatological patterns are similar but some difference likely due to difference in vertical distribution of three different pollutants

- TGAR responsible for ~ 50 - 60% of total annual transport over NAO, South temperate zone, central Asia, Africa, and Pacific ocean
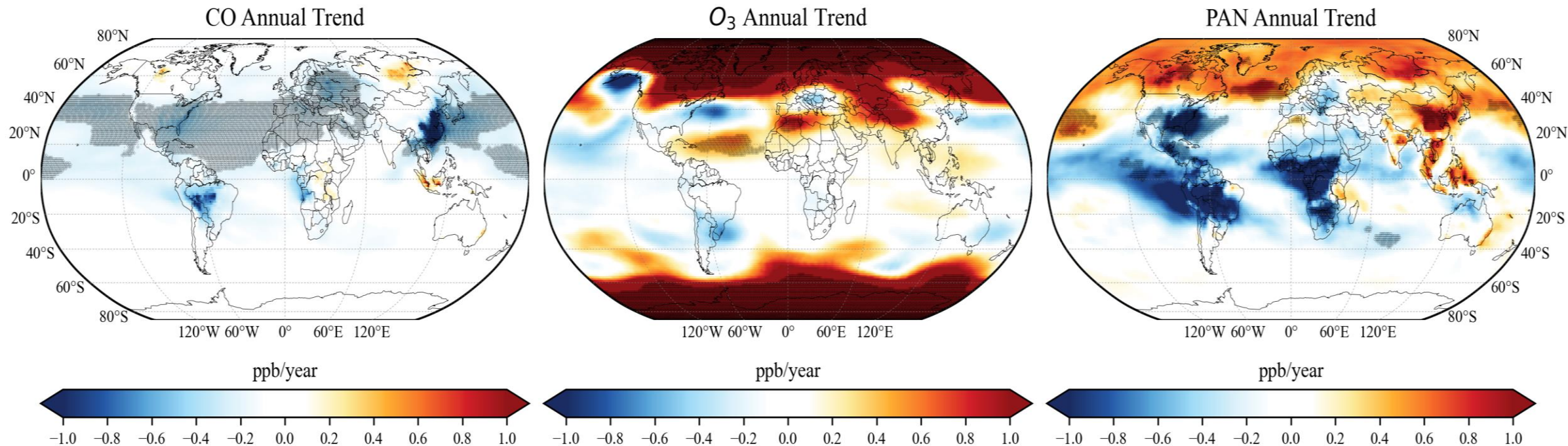
RESULTS – INTER-ANNUAL TREND

- Given >50 % contribution and 20 days/year AR frequency is essential to understand the impact of AR on regional and global pattern of atmosphere composition
- However, temporal changes shows the strong species dependences (wildfires, local vs. imported pollution)
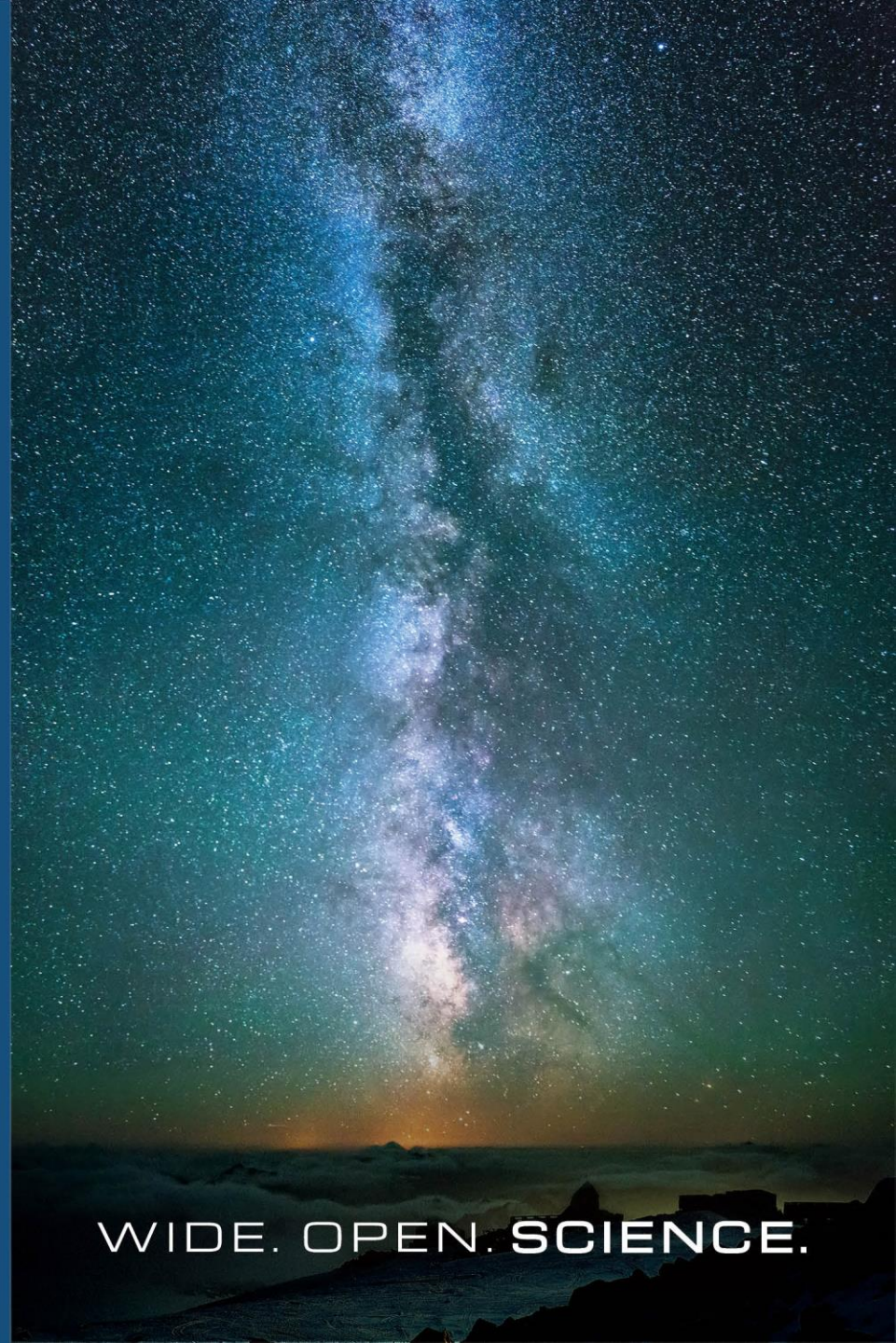
CONCLUSIONS

- Study find >300,000 TGAR events that corresponds TGAR frequency of occurrence ~20 days/year which responsible for >50 – 60 % of total annual transport

- This study provide the insight into extreme cases of air pollution events and identified the potentially hazardous regions in the context of air quality

- Future work will be focused on the regional scale assessment of of air quality during extreme cases focusing on these species

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THANK YOU

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BACKUP

Bias

X10⁻¹⁰

Correlation [Jet stream Vs. CO]

8-day mean

no jet   jet occurence   jet center

8-day counts

2-sigma Gaussian filter of jet centers