Computing influence function values for 28-years of western North America tropospheric ozone observations using FLEXPART-ERA5

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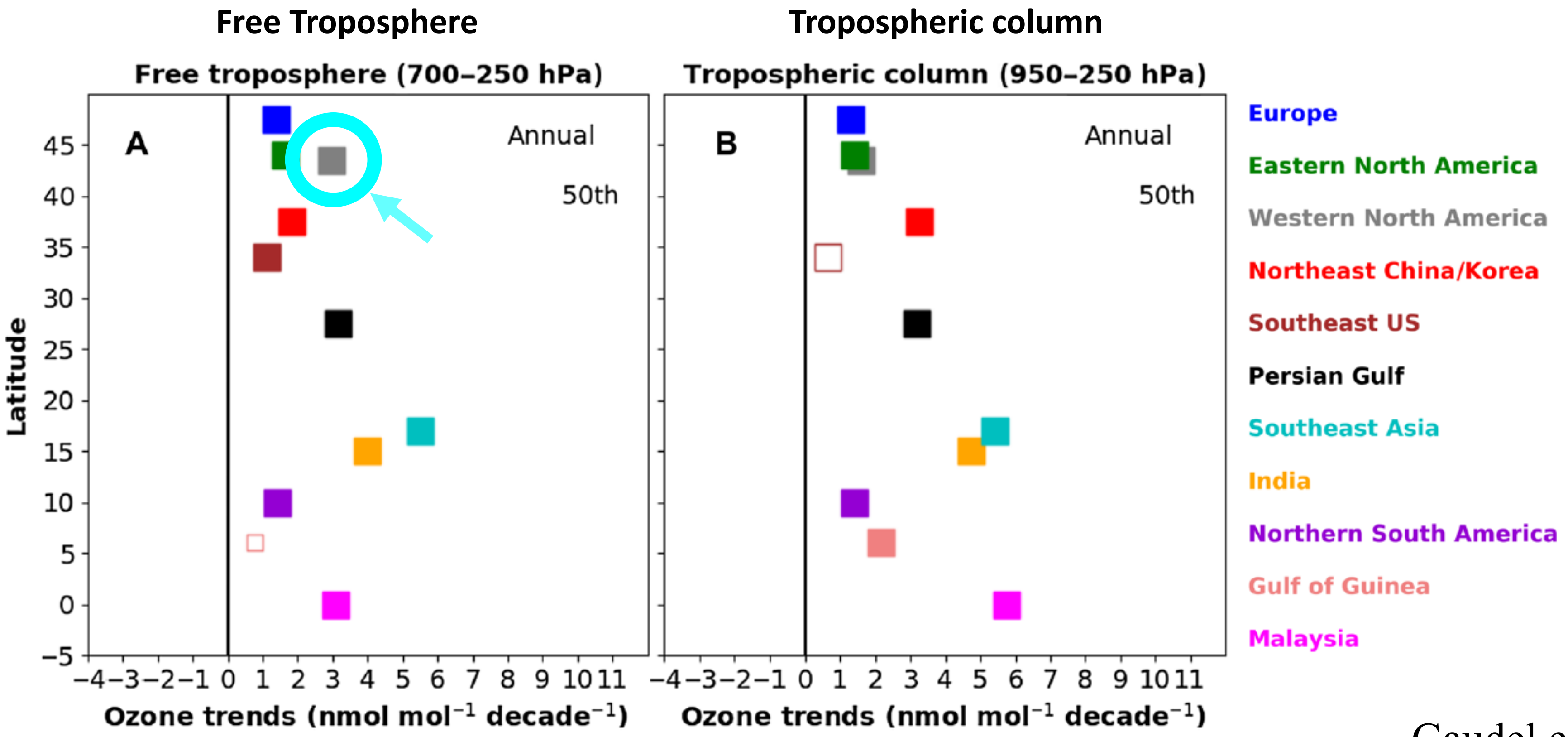
Outline

- Motivation
- Data & Method
- Results
- Summary

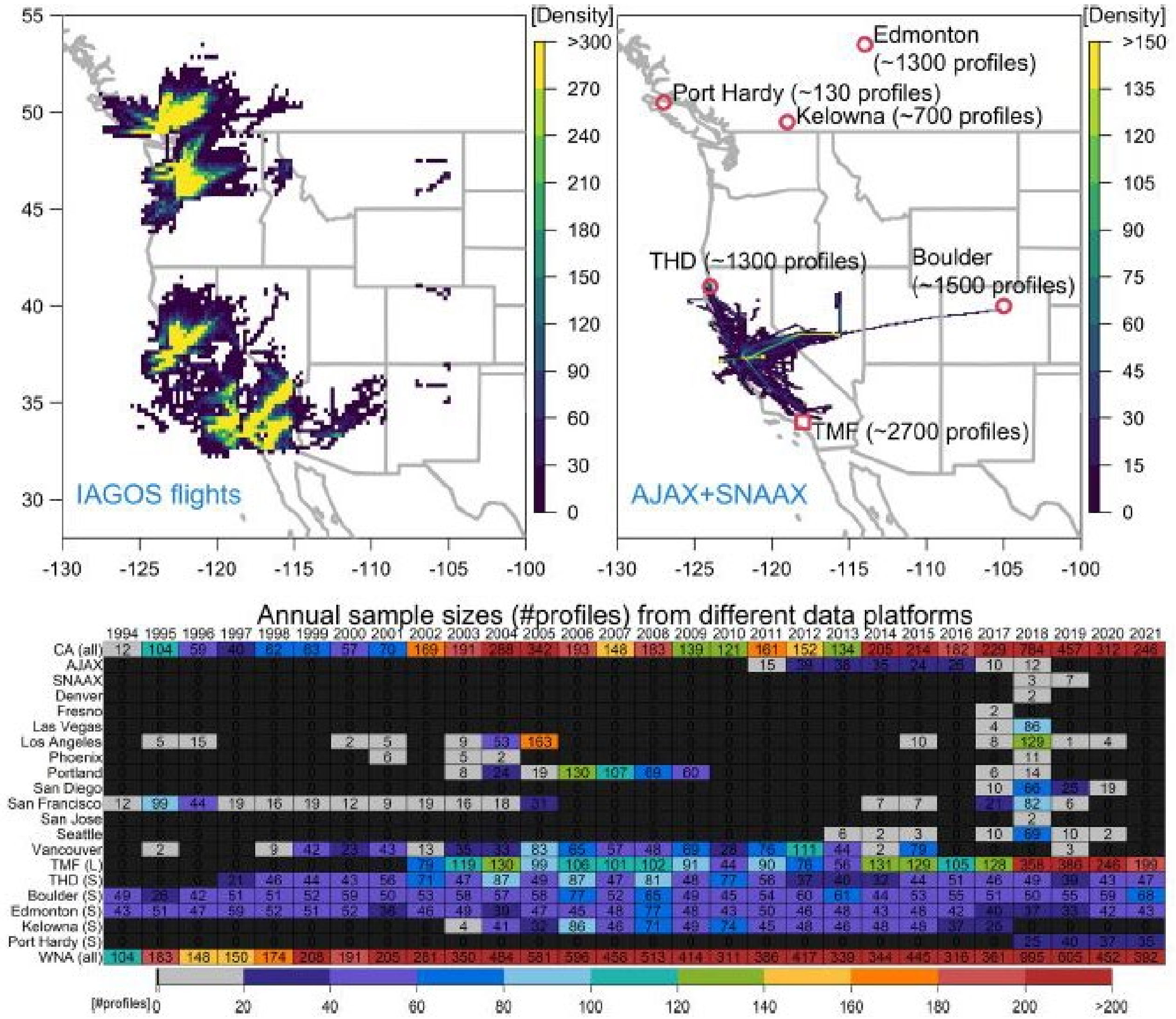
Ozone in free troposphere is increasing across the Northern Hemisphere



Gaudel et al.,
Science Advance (2020)

- Recent observations spanning the past few decades have indicated a decline in the occurrence of the lowest tropospheric ozone levels (< 20 ppb) across the northern hemisphere. This trend has raised concerns regarding the increased transport of ozone to surface levels in the western United States.

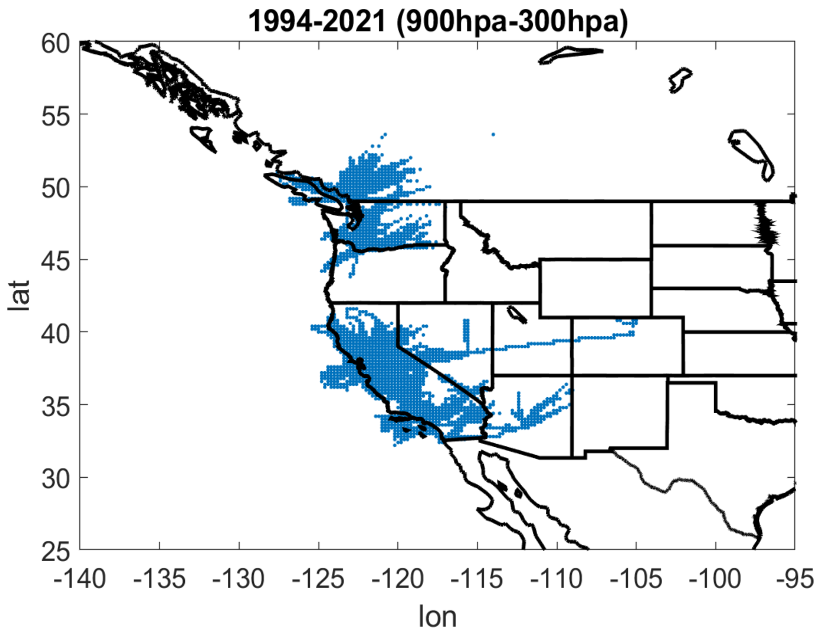
Regional observation-based study confirmed the positive trends of free tropospheric ozone over western North America



- Integrated various measurement platforms of ozone with differing sampling frequencies at 700-300hpa over the period of 1994-2021 and western North America.
- Free tropospheric ozone above western North America has increased since the mid-1990s. The overall free tropospheric ozone trends have not been offset by COVID-19 and continued to increase over 1995–2021, mainly driven by strong positive trends in winter and summer.

Chang et al., JGR, (2023)

Generating Retroplume (influence function) values for the 28-year data



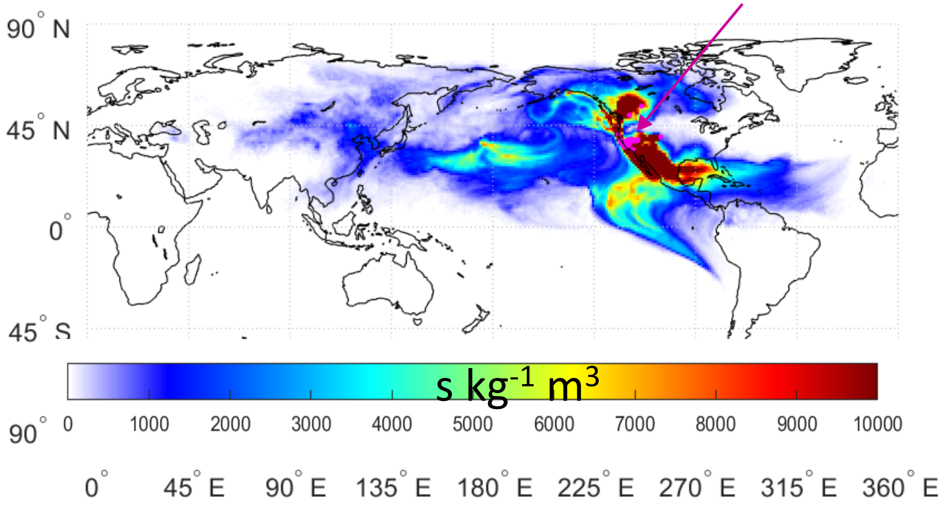
- We focused on data from ozone observing platforms used in Chang et al., (2023) and extend the data from 900hPa to 300hPa pressure levels instead of 700-300hpa.
- We employed a Lagrangian particle dispersion model (FLEXPART v10.4-ERA5) to calculate the retroplume on a global scale affiliated with these observations.
- We released 10,000 particles for each receptor and simulated their backward transports up to 15 days. Total 553608 receptors.

Time coverage	Receptor set-up	Output	Met driver
1994-2021	All data were averaged over a 0.2° x 0.2° grid, at 10 mb vertical resolution between the surface and 20 km, backward in time for 15-day	Retroplume distributions were output as hourly on 1° x 1° grids globally. Five vertical layers: 0-0.3 km, 0.3-3 km, 3-8 km, 8-13 km, and 13-20 km	ERA5 provides the global Met variables in the hourly ~30x 30km^2 resolution.

Model operational framework and product formats

July, 2016

Pink dots are receptors



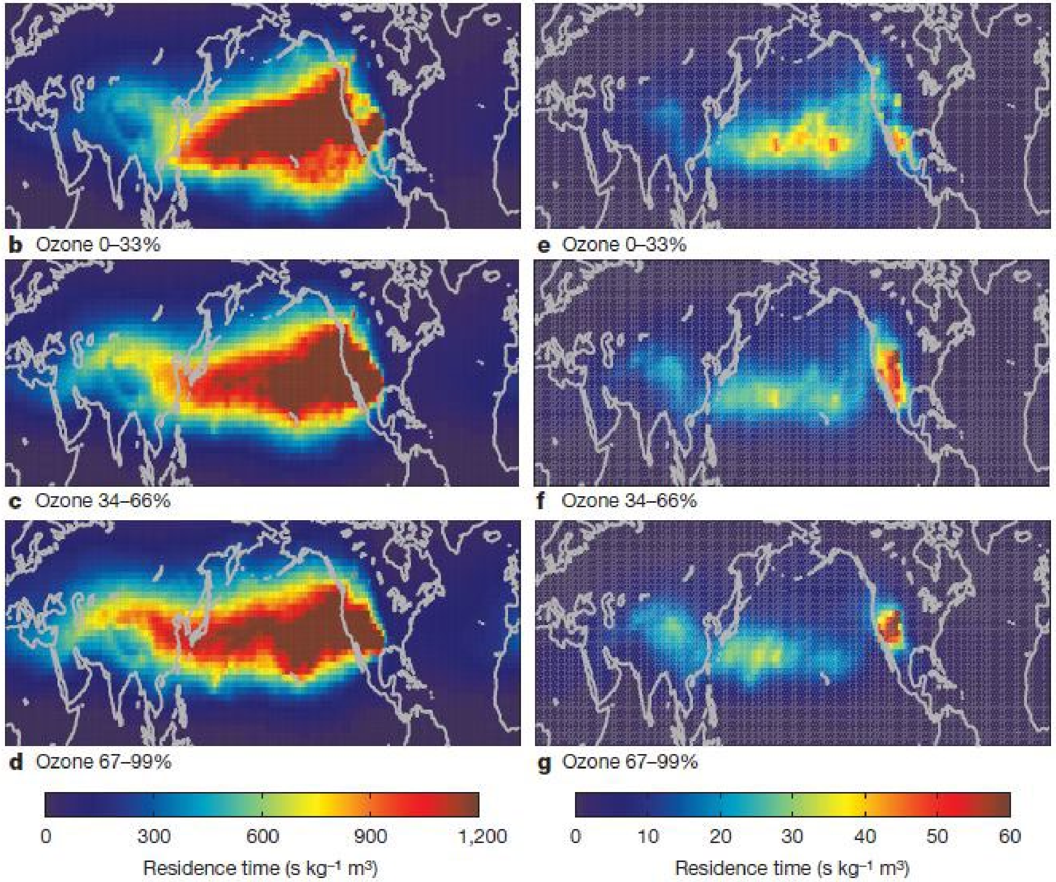
A batch is defined by the month, such as in the case of 201606. Receptors within that specific month are included, and retroplume simulations are conducted backward for up to 15 days.

- This product is implemented on NASA HEC Pleiades Broadwell Nodes.
- The operational framework is set up on a monthly batch configuration, processing all receptors within a given month in one FLEXPART-ERA5 run using a single processor.
- Most individual runs require less than 120 hours to complete. Excluding the time required for downloading ERA5 data, we took approximately one month to generate this comprehensive set of products.
- The original high-resolution outcomes for each batch are stored in a designated folder in binary format. To facilitate further analysis, the next step involves post-processing the outputs into NetCDF formats.

LPDM is used to identify the source region and altered pathway

April-May, 1995-2008

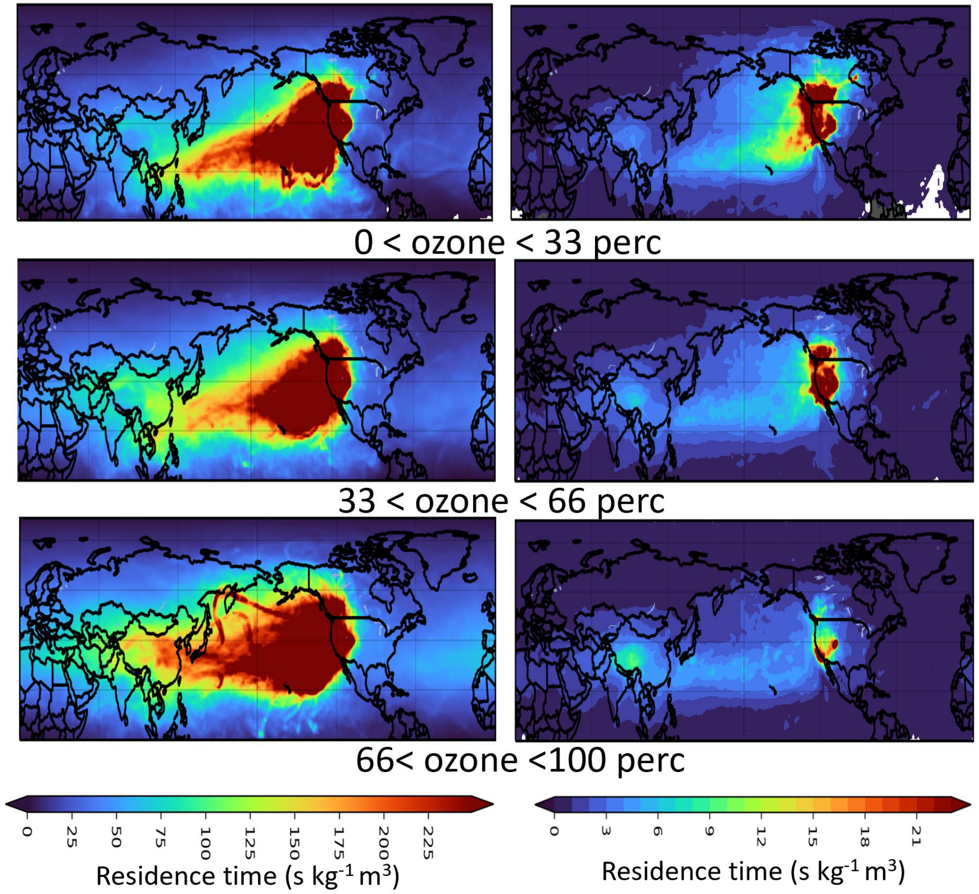
the column | the lowest 300m



Cooper et al., Nature, (2010)

April-May, 1994-2021

the column | the lowest 300m



This study

LPDM is used to identify the source region and altered pathway

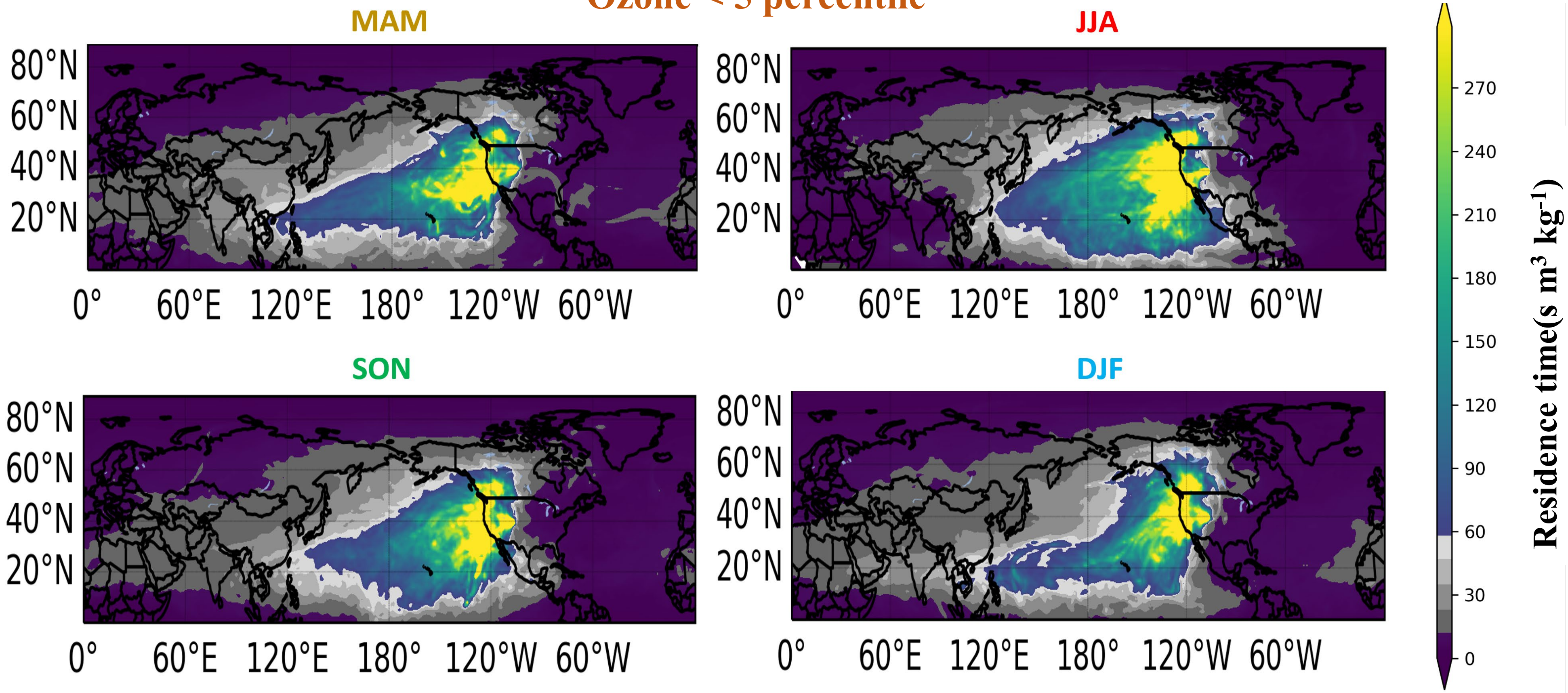
1994-2021

Whole column

Seasonal patterns

Cleanest ozone concentrations (<5 percentile) are primarily influenced by sources emanating from the tropical Pacific Ocean, and other remote regions such as SE Asia, NE Asia, and other mid-latitude regions.

Ozone < 5 percentile



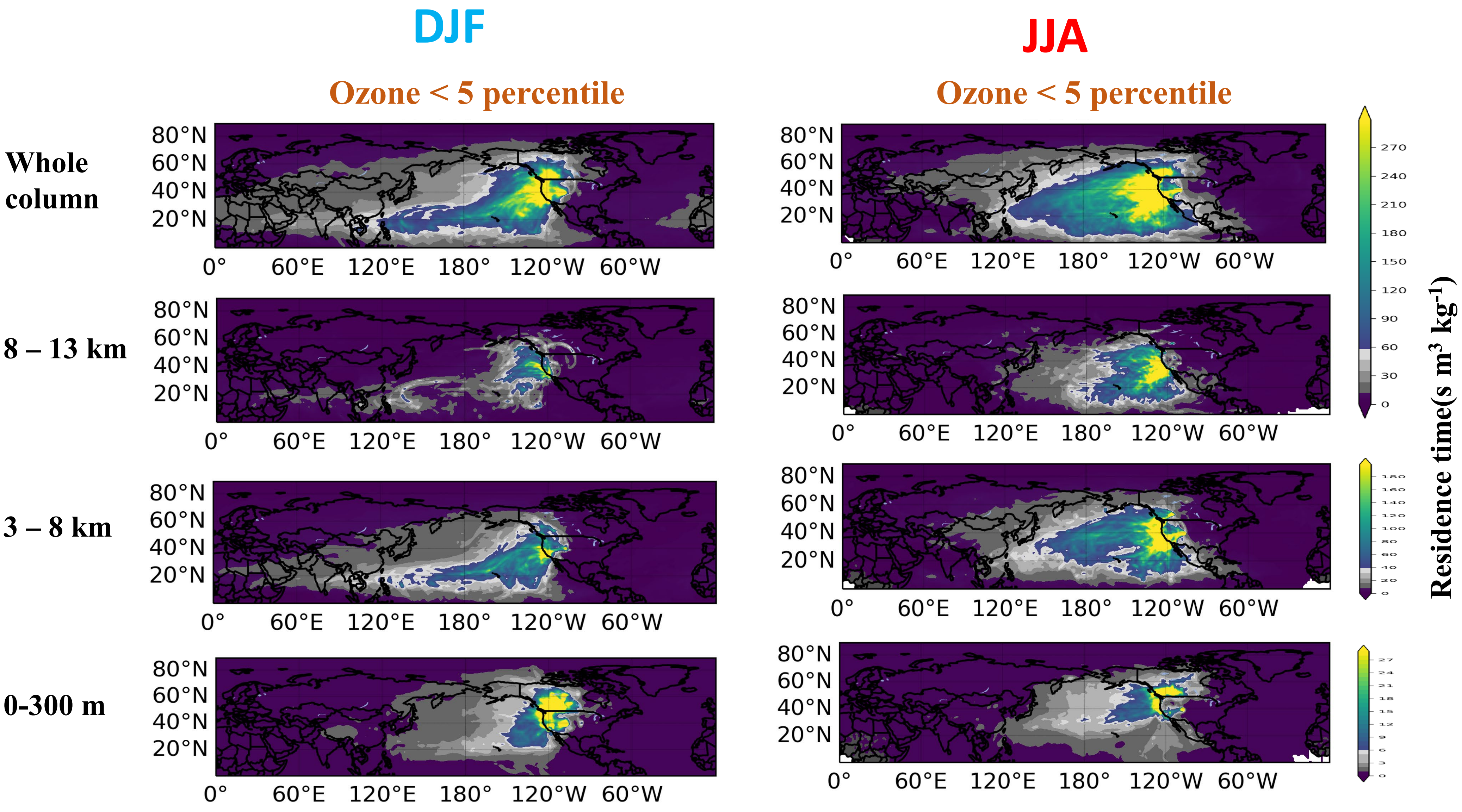
Using baseline (2004-2014) percentile values

LPDM is used to identify the source region and altered pathway

1994-2021

<u>**Vertical layers**</u>

Transport from the tropical Pacific Ocean occurs in winter, and the retroplume shifts northward, extending to cover broader mid-latitude regions during summer.



Using baseline (2004-2014) percentile values

Summary

Preparations

Collect 28-year ozone measurements from different platforms and aggregate them to prepare receptors

Flex-extract v 7.12: processing ECMWF ERA5 Reanalysis Model level data for use in FLEXPART

Operational process

INPUT

4D information of Receptors (time, x, y, z)

4D Meteorological inputs

FLEXPART V10.4

OUTPUT

Retroplume distributions were output as hourly on 1° x 1° grids globally.

Five vertical layers: 0-0.3 km, 0.3-3 km, 3-8 km, 8-13 km, and 13-20 km

Post-processing and applications

Tailoring products for different domains (e.g. Northern Hemisphere)

Retroplume (influence function) analysis (e.g. total column, specific column, surface layer)

Source attribution analysis (e.g. surface influence function values times emission)

Trend analysis of Retropolume (influence function) values

- This component is useful for unraveling transport pathways and emission sources contributing to the declining trend in the cleanest air. Further analysis will be presented during Ryoo's talk in the session.
- We acknowledge the support from the NASA-ACCDAM project and NASA HEC's computational resources.