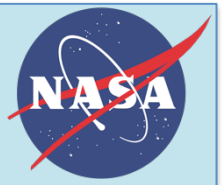
California Institute of Technology



National Aeronautics and Space Administration

Comparison between model and satellite observations using GEOS-Chem and TES ozone products over the Arctic region

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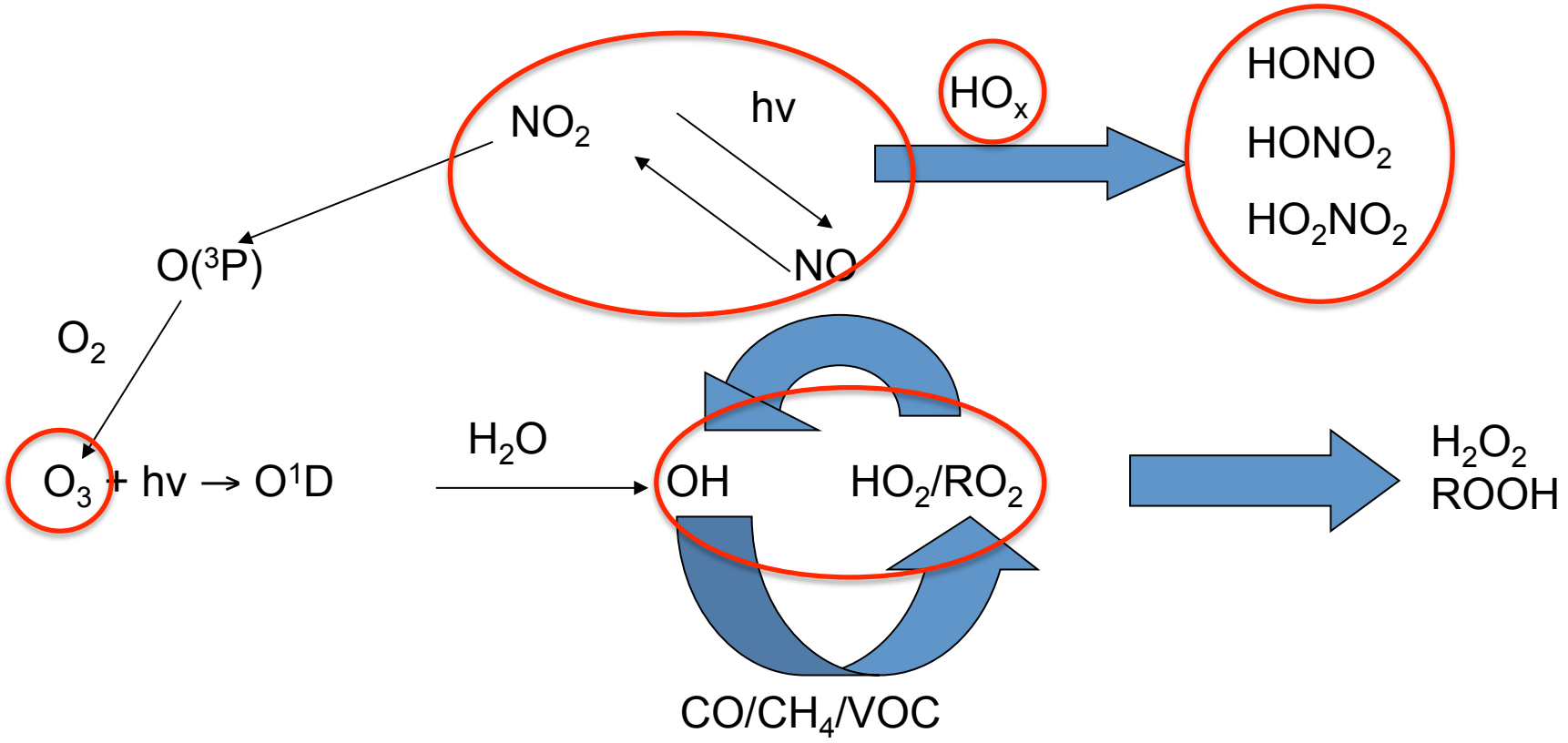
Ozone (O_3)



An important source of hydroxyl radicals (**HO_x**), the "detergent" of the atmosphere;

The third most important **greenhouse gas** in the atmosphere (IPCC, 2007).

Why studying Arctic O_3 is important?

The Arctic region is a region particularly sensitive to **climate change** and **a receptor of pollution** from the northern mid-latitudes;

Arctic tropospheric O_3 has been increasing since the early 1990s (Oltmans et al., 2006; Tarasick et al., 2005; Kivi et al., 2007) and could be responsible for **up to 30%** of the observed Arctic warming trend in the 20th century (Shindell et al., 2006).

Uncertainties

- **Ozone tropospheric chemistry**: budget and cycling of PAN and other NO_x reservoirs (e.g. Stroud et al., 2003), local sources;
- **Long-range transport**: position of the Arctic front
  Timescales and pathways (Stohl et al., 2006);
- **Stratospheric-Tropospheric exchange**: not quantified in the Arctic
  15% to 25% of total O_3 in the middle and lower troposphere (Browell et al., 2003b; Liang et al., 2009), **dominant contributor** in the upper troposphere (Singh et al., 2010).

GOALS

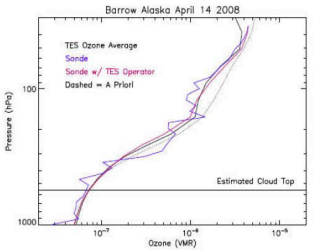
Improve **model estimation** of tropospheric O_3 in the Arctic;

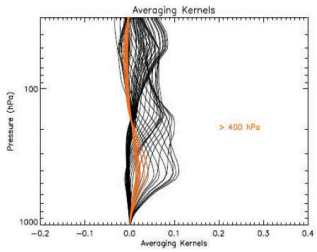
Investigate **the processes** that determine Arctic tropospheric O_3 abundance;

Quantify the amount of Arctic O_3 that is of **biomass burning, anthropogenic and stratospheric origin**;

Investigate ideas for **short-term mitigation** of Arctic warming by reducing tropospheric O_3 sources.

TES





TES = infrared Fourier Transform Spectrometer
Spectral range = 650-2250 cm^{-1}
Nadir footprint = 5.3 km (across-track) × 8.5 km (along track) (Beer et al., 2001)
O_3 vertical resolution = about 6 km
Main sensitivity = middle troposphere

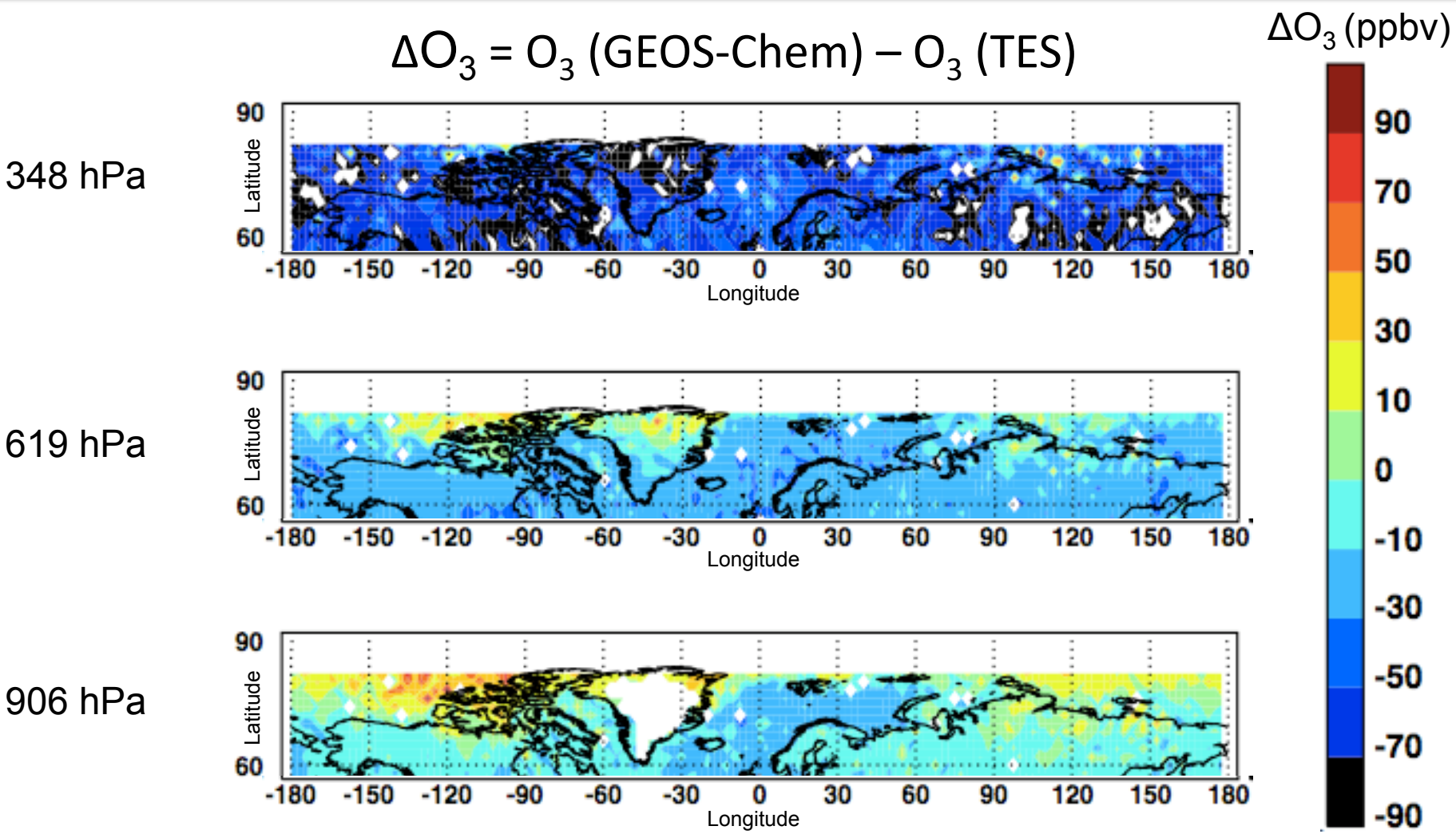
GEOS-Chem

GEOS-Chem = **global 3-D chemical transport model** (CTM)
Spatial/temporal resolutions: 2°×2.5° and 30 vertical levels / every 1 hour
Meteorological fields: GEOS-5 dataproducts (2°×2.5°)
Anthropogenic invetories: EDGAR, EMEP, STREETS, CAC, EPA_NEI99
Biogenic inventory: MEGAN v2.01
Biomass burning inventory: GFED_2
Stratospheric–tropospheric exchange: LINOZ (Hsu and Prather, 2009)

Recent validation of TES tropospheric O_3 (Boxe et al., 2010) will allow us to constrain Geos-Chem O_3 and improve its distribution and concentration.

Bias between TES and Geos-Chem O_3 without assimilation

$\Delta O_3 = O_3$ (GEOS-Chem) – O_3 (TES)

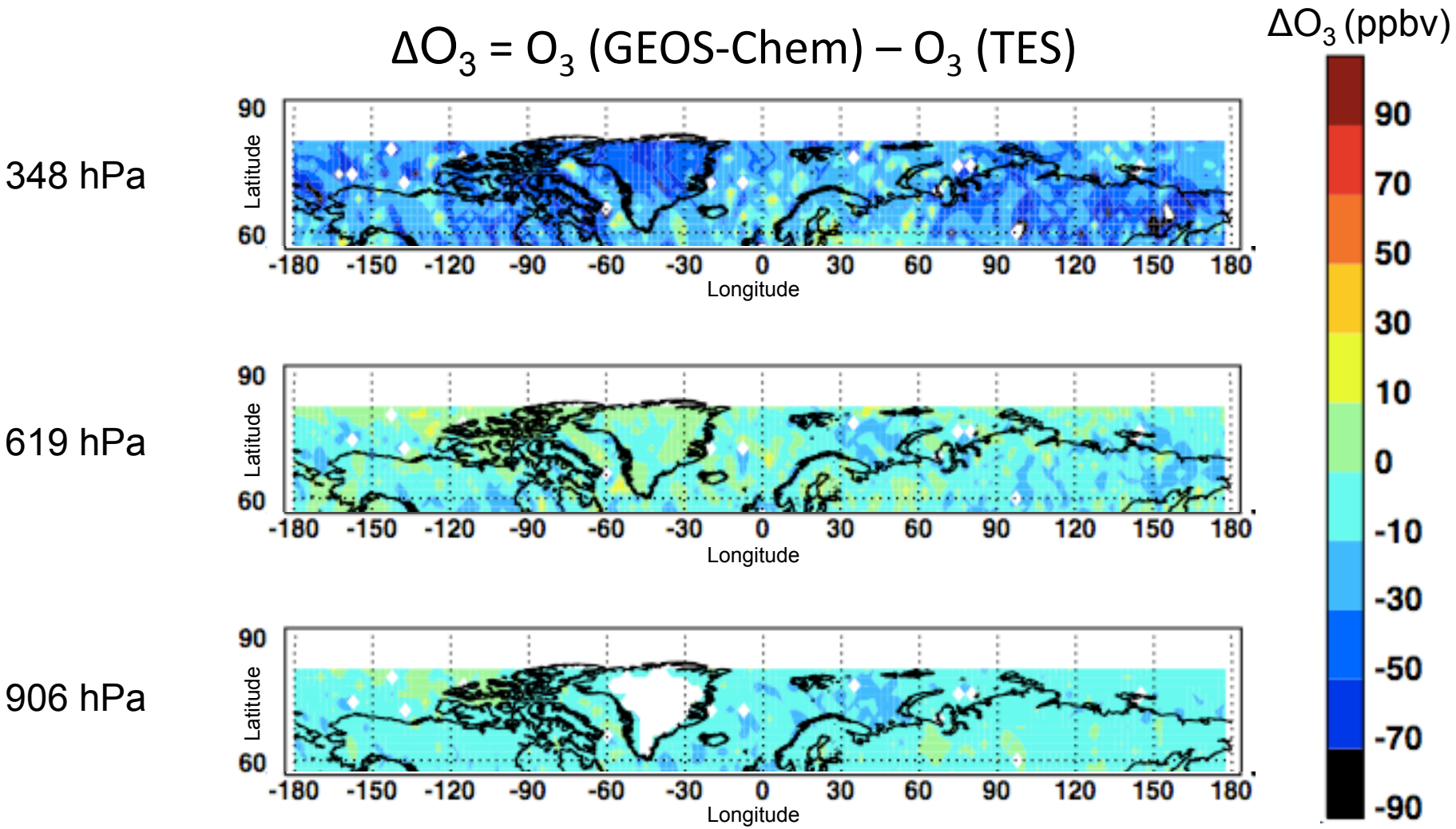


Large negative bias in the upper troposphere;

Large gradient and positive bias in the lower troposphere.

Bias between TES and Geos-Chem O_3 constrained by TES O_3

$\Delta O_3 = O_3$ (GEOS-Chem) – O_3 (TES)

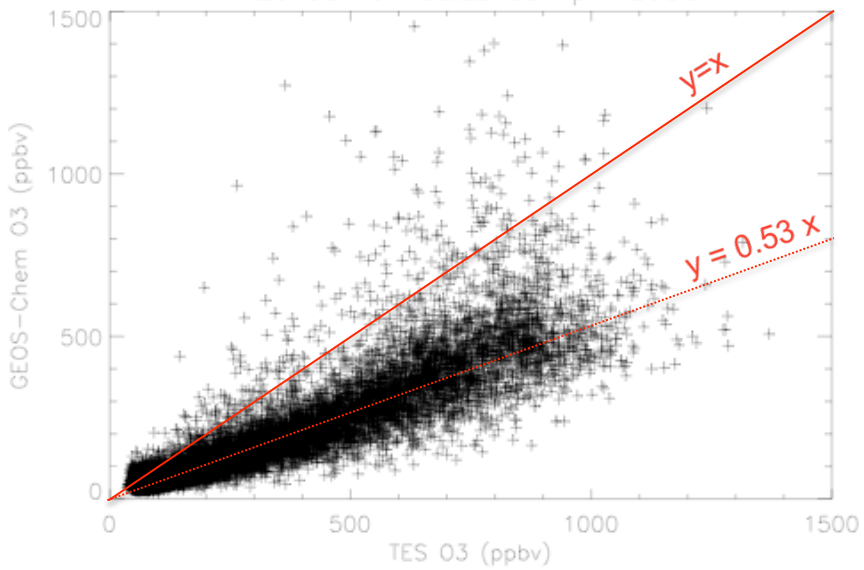


Reduction of the bias and gradient in the upper, middle and lower troposphere

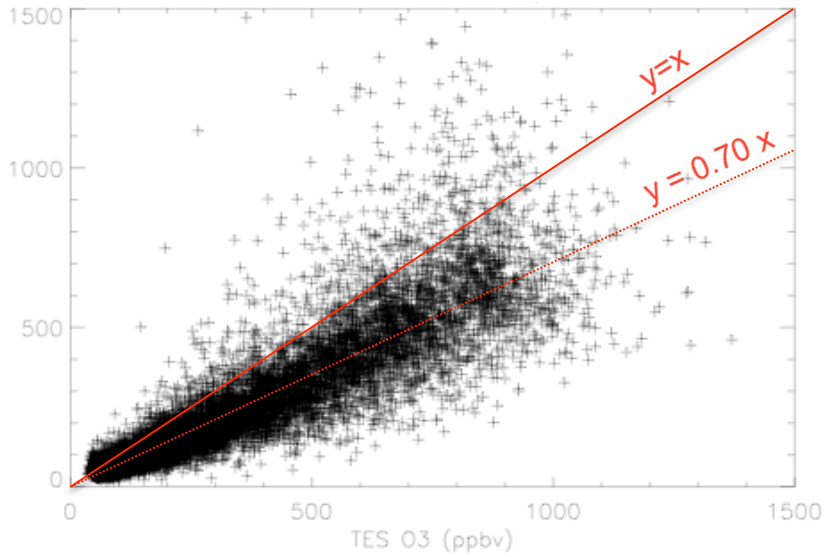
TES O_3 brings significant information on stratospheric O_3, transport and production

TES and GEOS-Chem O_3 comparison over the ARCTIC

GEOS-Chem without TES O_3 assimilation



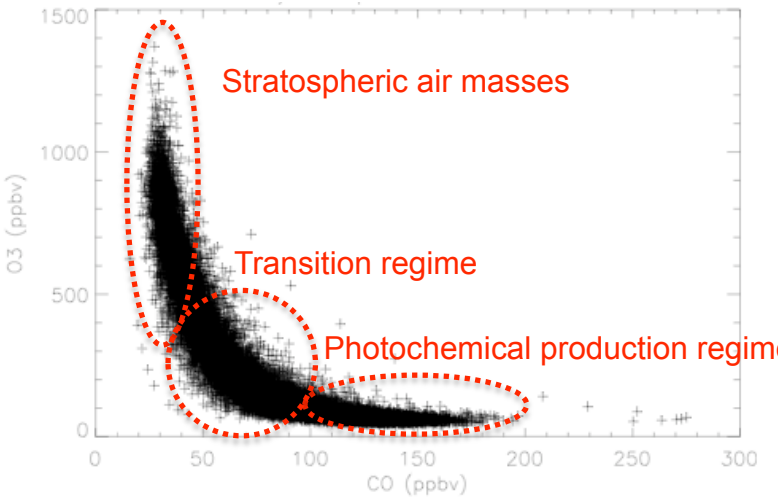
GEOS-Chem with TES O_3 assimilation



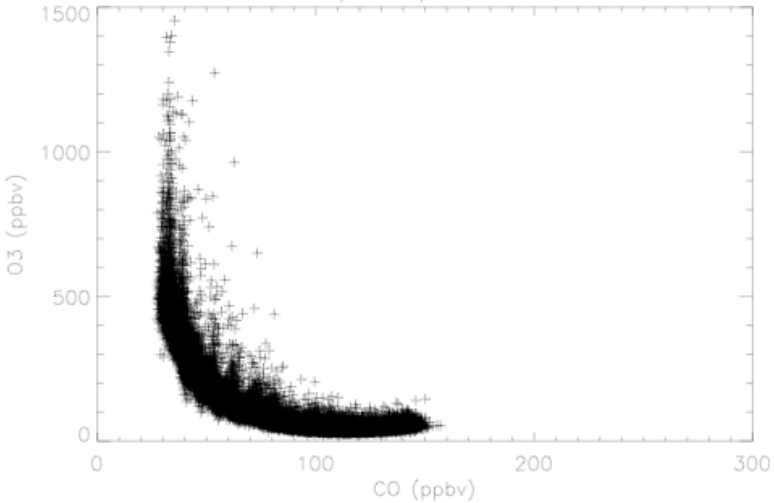
Improvement in the overall representation of GEOS-Chem O_3 representation

TES and GEOS-Chem O_3 / CO relation over the ARCTIC

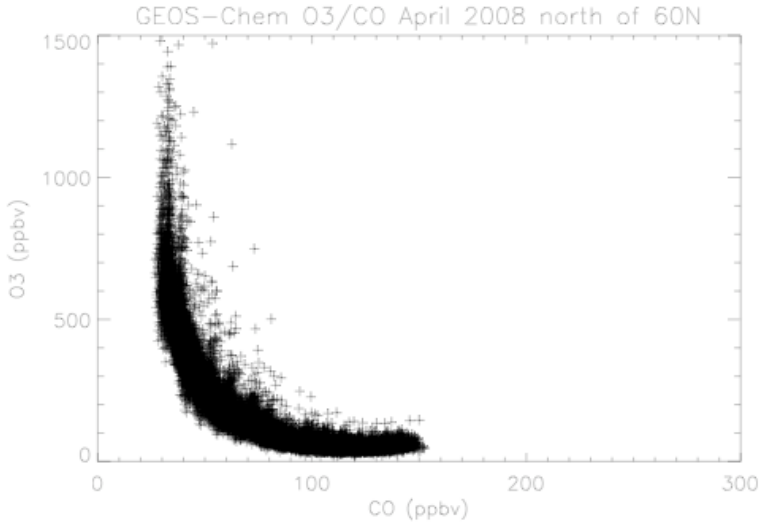
TES



GEOS-Chem without O_3 assimilation



GEOS-Chem with TES O_3 assimilation



Improvement in the representation of the stratospheric influence.

Better representation of the transition regime (mixing and transport)

Conclusion and perspectives

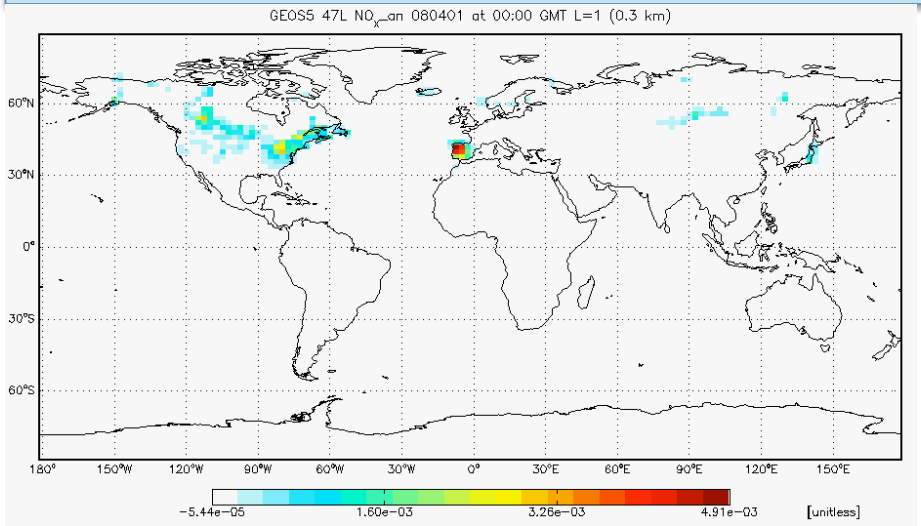
TES tropospheric O_3 profiles, recently validated at Arctic latitude (Boxe et al., 2010), is a **consistent product** for placing constraint on GEOS-Chem O_3 simulations over the Arctic;

Overall improvement of GEOS-Chem tropospheric O_3 representation;

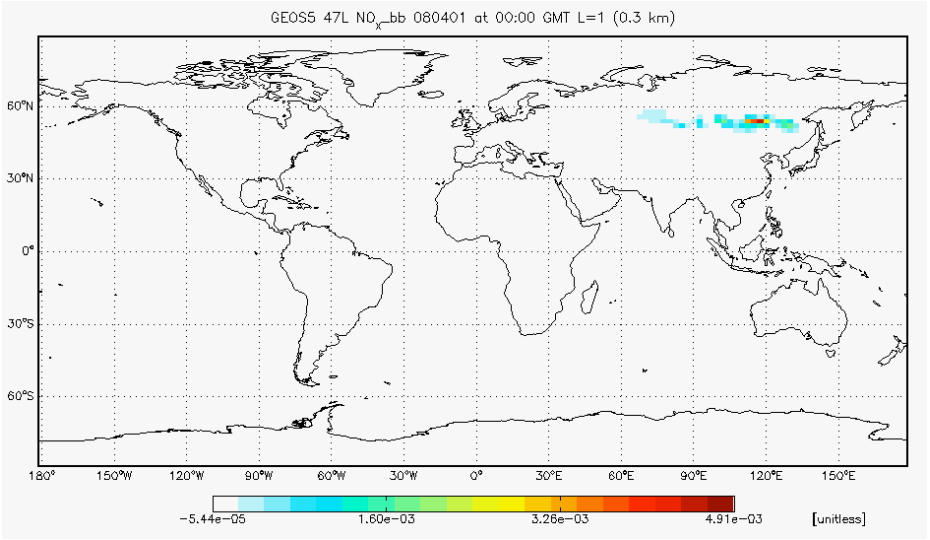
Our approach will identify **pathways for transport** of pollution to the Arctic and quantify the contribution of important **source origin and localisation**, (biomass burning, anthropogenic and stratospheric) to the Arctic O_3 abundance.;

One of the steps would be to constrain **GEOS-Chem adjoint** using TES O_3 to understand sources intensity and the transport pathways that drive O_3 in the Arctic.

Adjoint



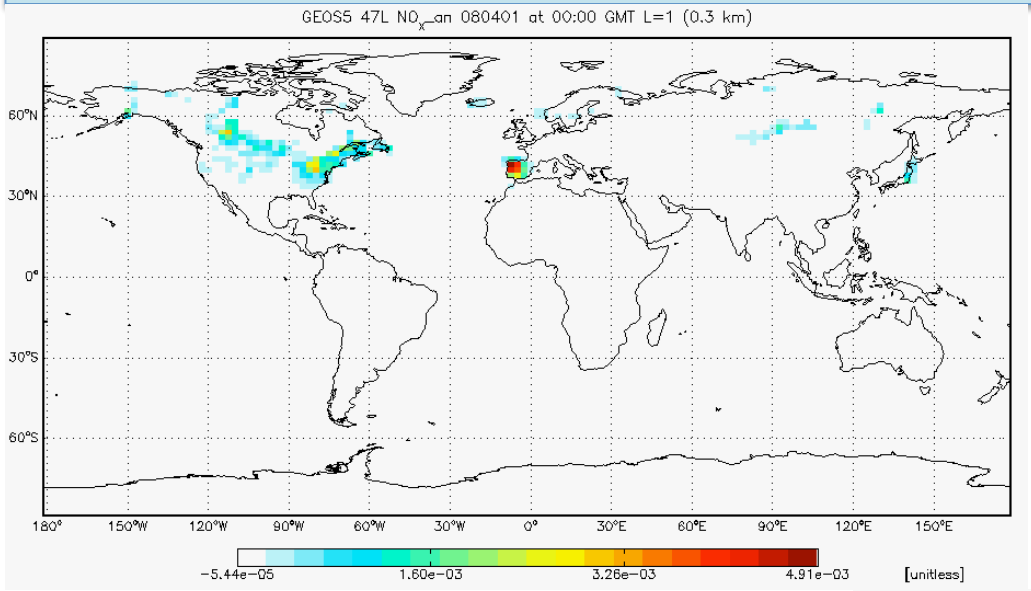
Anthropogenic sources of NO_x



Biomass burning sources of NO_x

Sensitivities with respect to emissions scaling factors

Thanks for your attention!



Anthropogenic sources of NO_x

Biomass burning sources of NO_x