# Climatologies and long-term evolution of $O_3$ and CO over northern midlatitudes in the UTLS as seen by IAGOS

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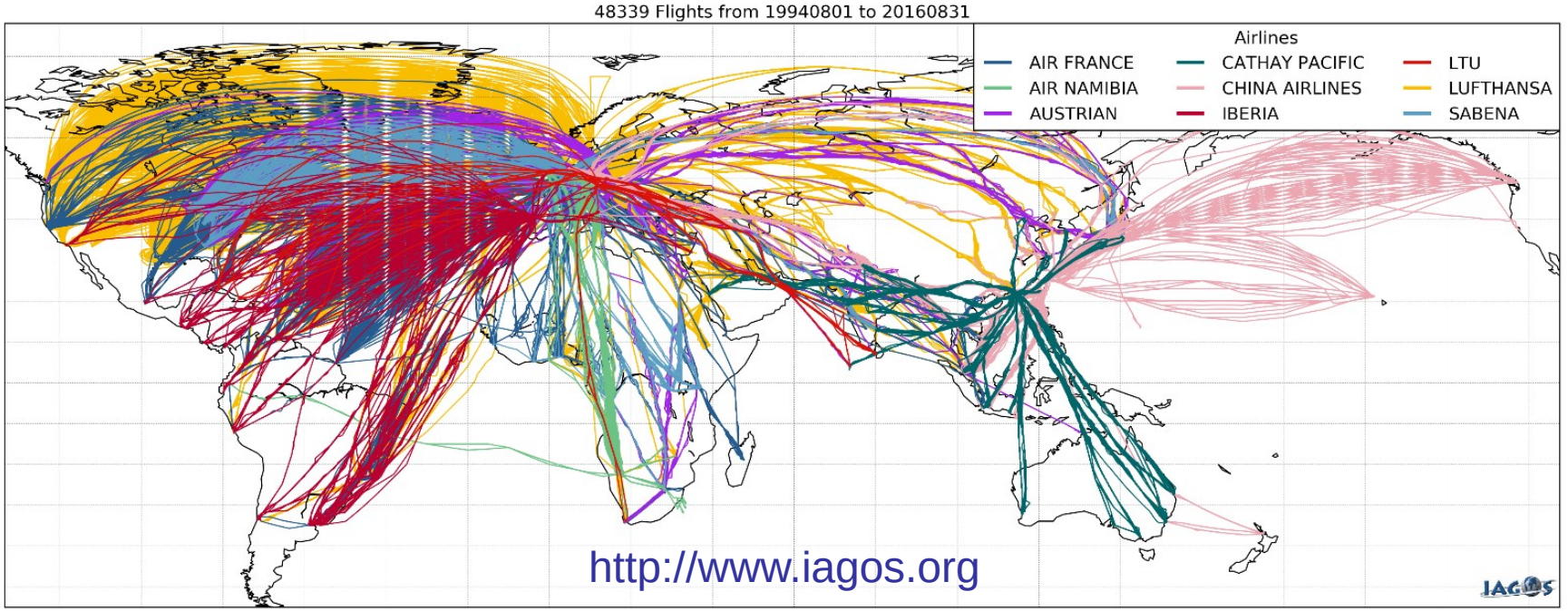
(2) Centre National de Recherches Météorologiques, Toulouse, France

# IAGOS database

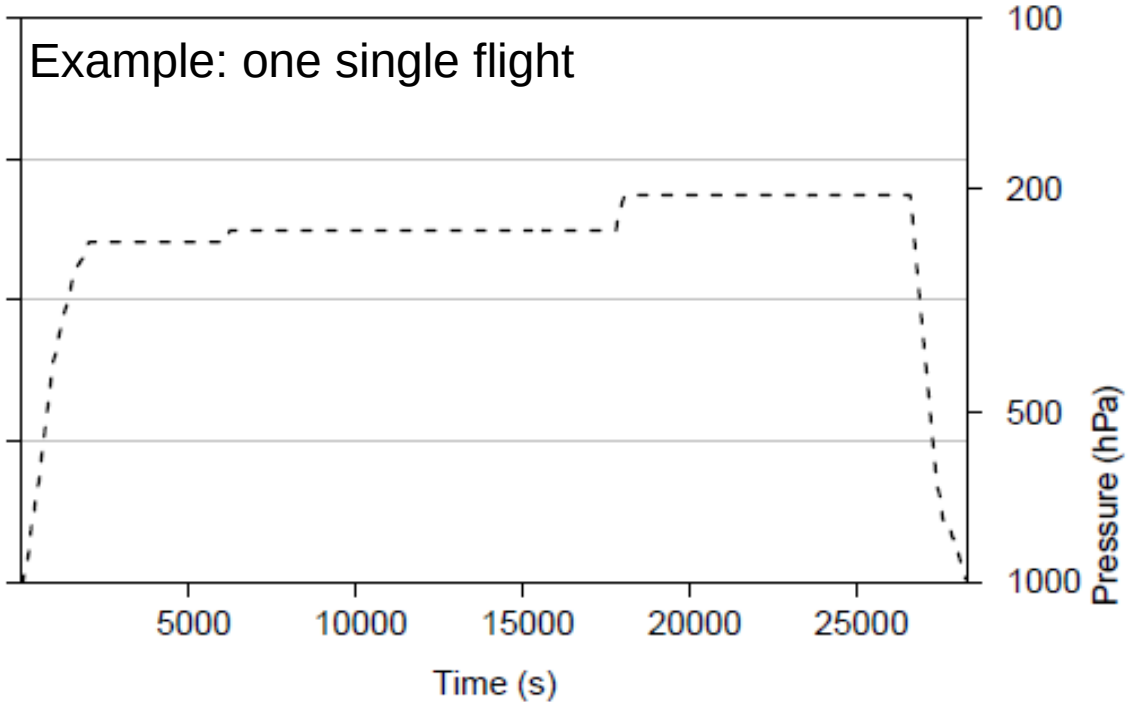



- $O_3$ since 1994; CO since 2001
- This study: cruise data (9 – 12 km)
- ~48,000 flights (~121 million observations)

# Objective:

# Climatologies of $O_3$ and CO in the UT and in the LS

⇒ Discrimination UT – LS




- $O_3$ mixing ratio: both tropospheric and stratospheric air masses. ⇒ How to separate ?
- Dynamical tropopause: 2 pvu isosurface from ECMWF operational analysis

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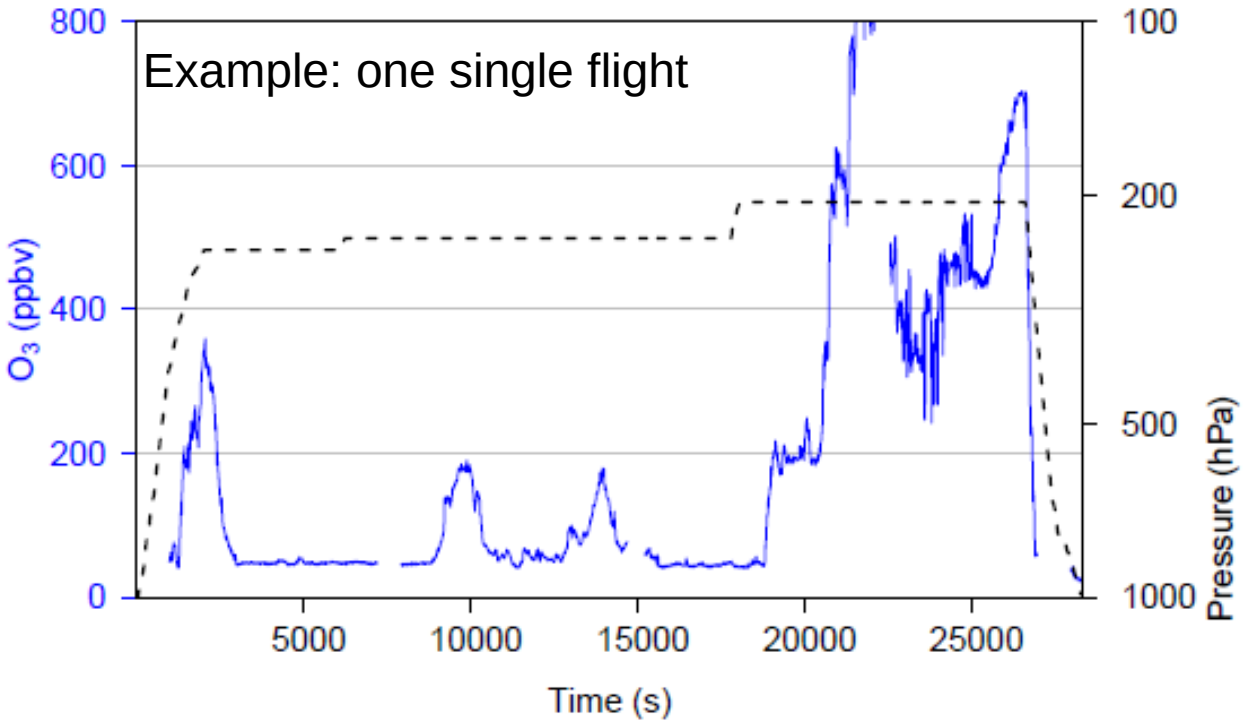


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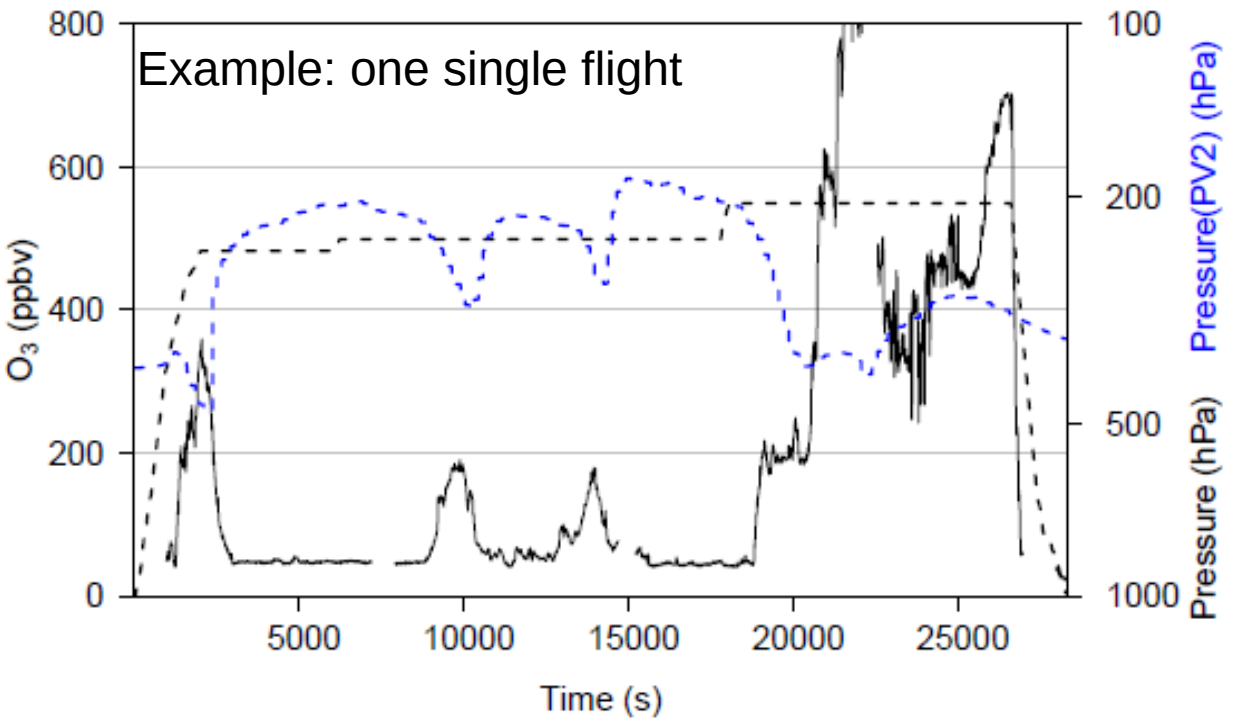
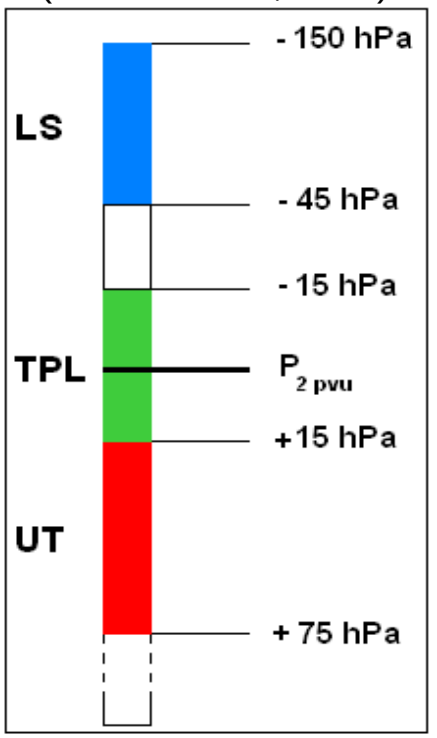



(Thouret et al., 2006)

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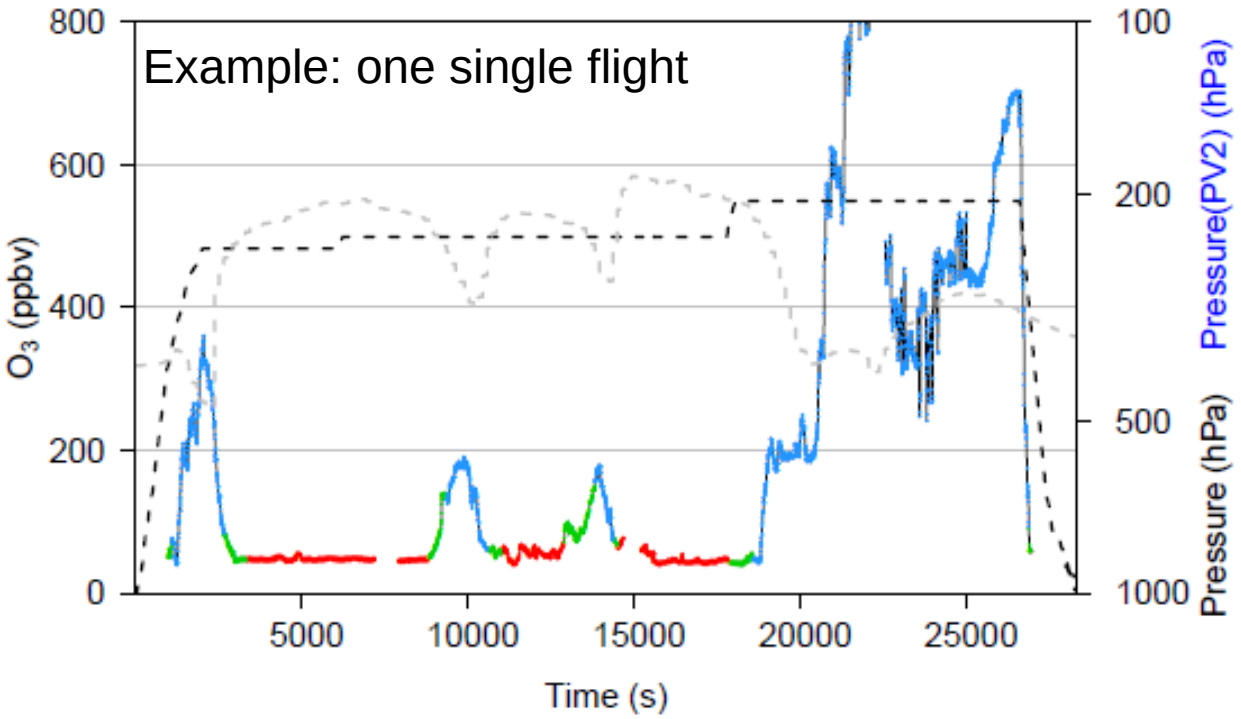


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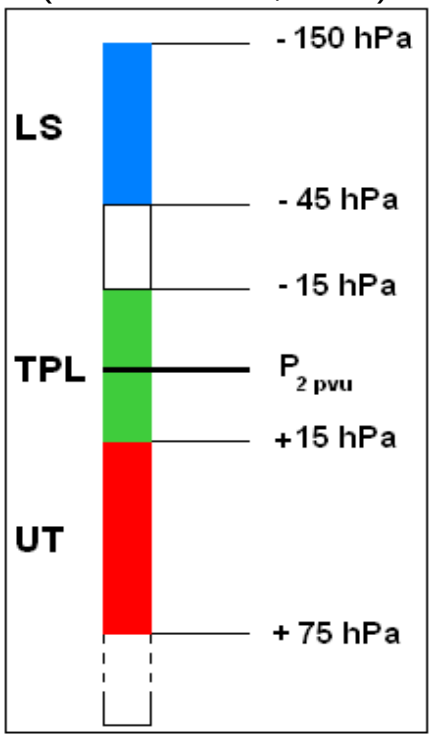


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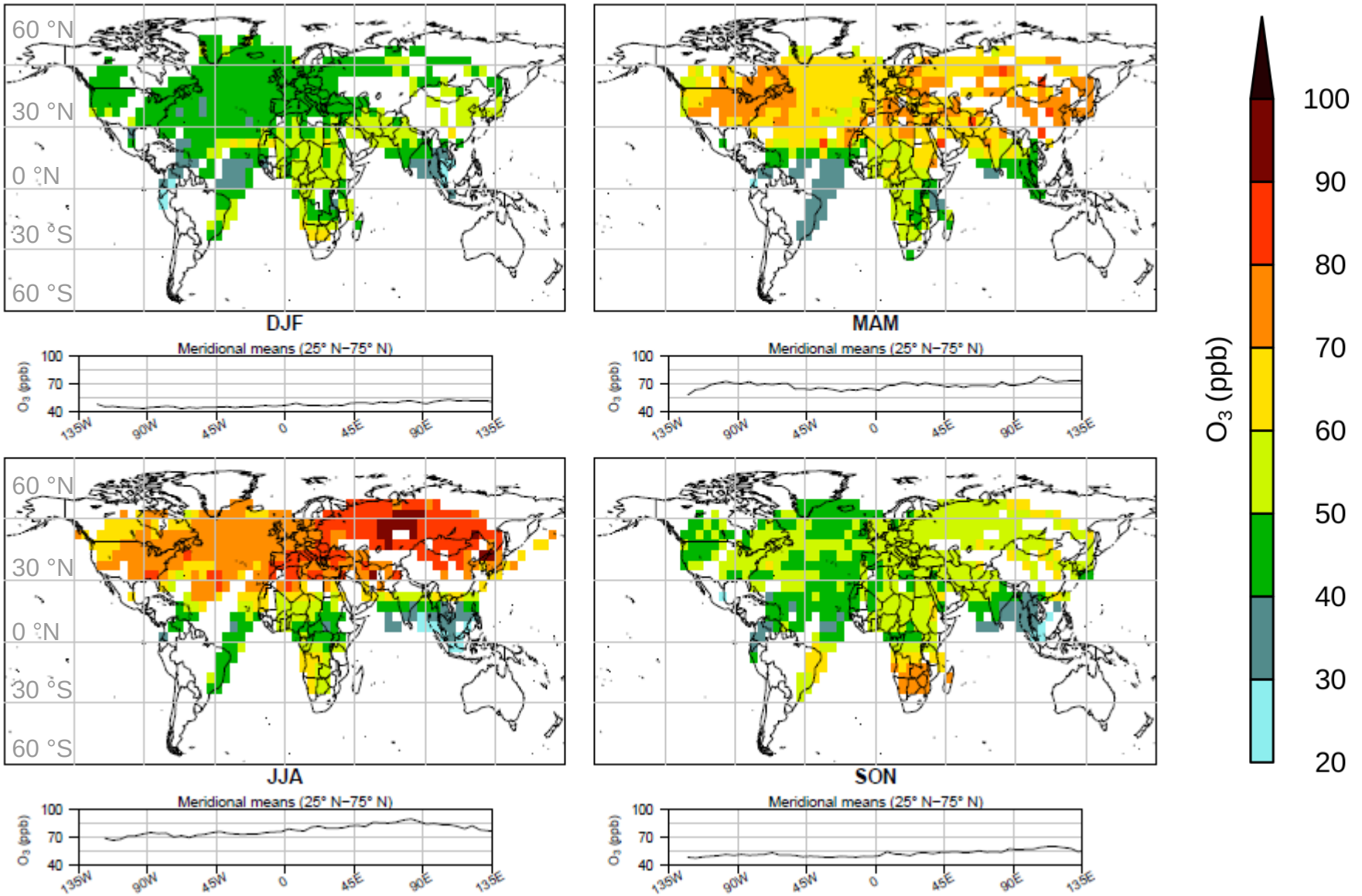
# $O_3$ seasonal climatology (1994 – 2013)

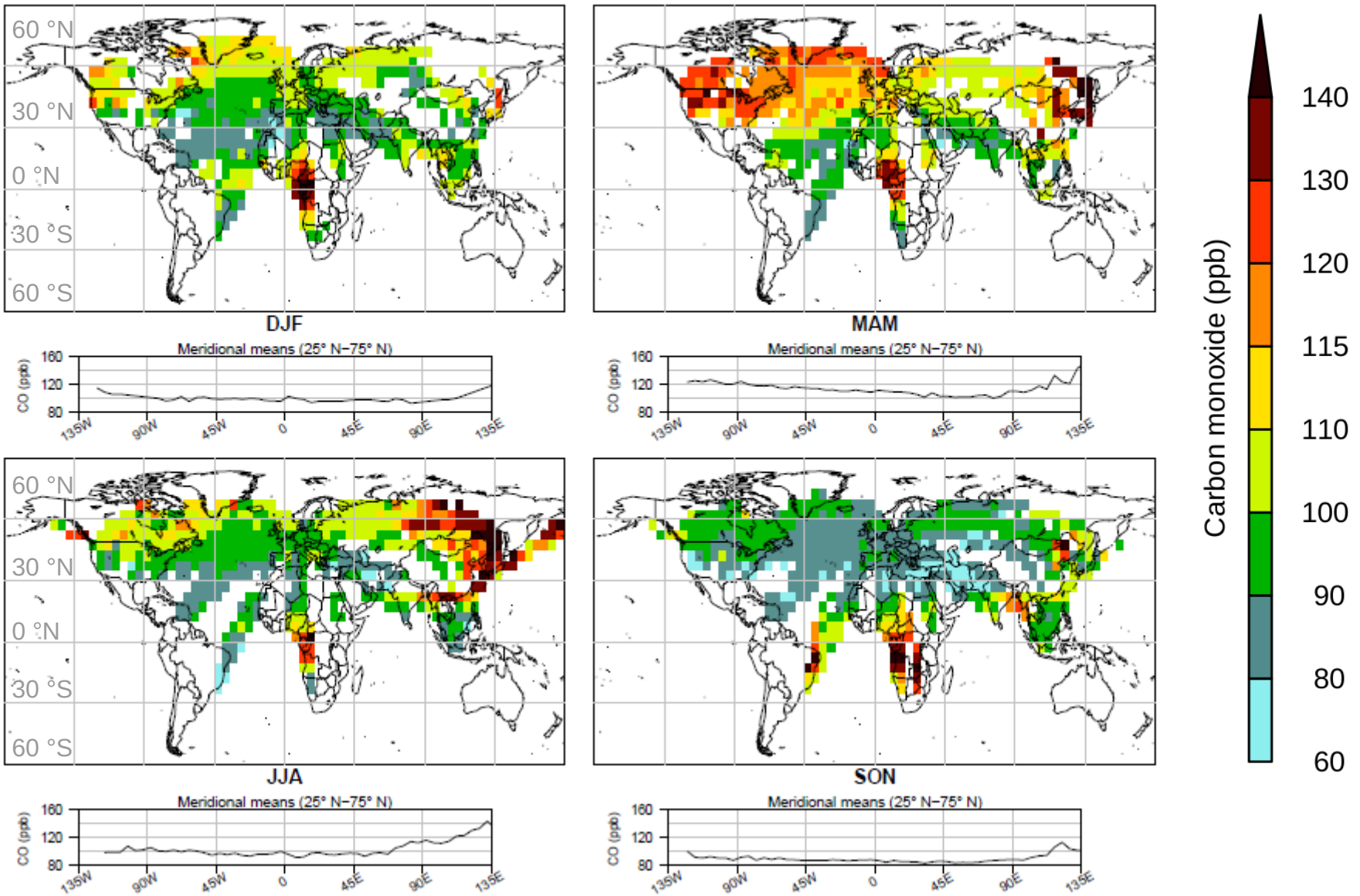
## - Upper Troposphere -




- Northern extratropics: 40 – 100 ppb
- Ozone increases from west to east

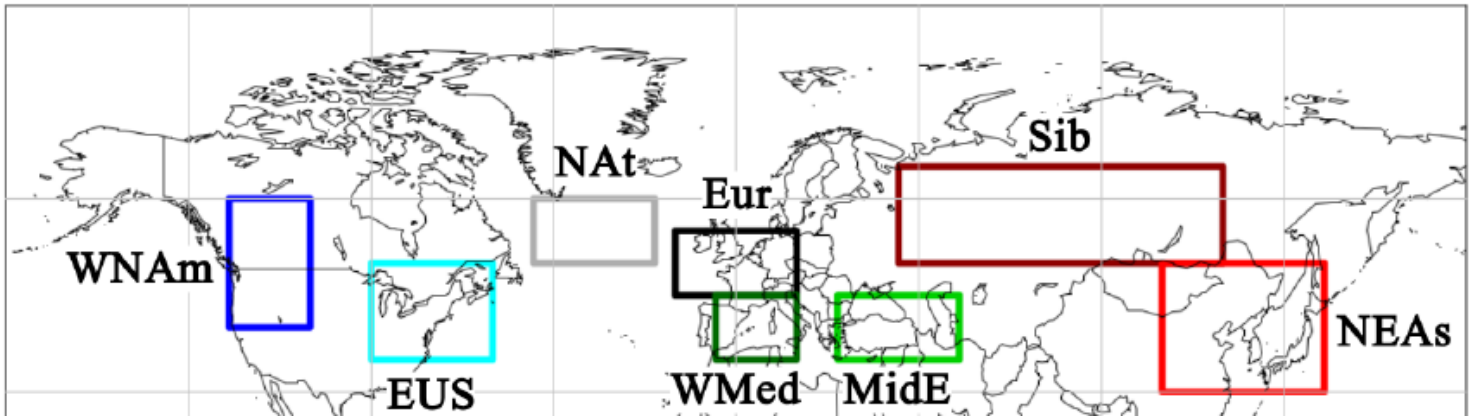
# CO seasonal climatology (2001 – 2013)

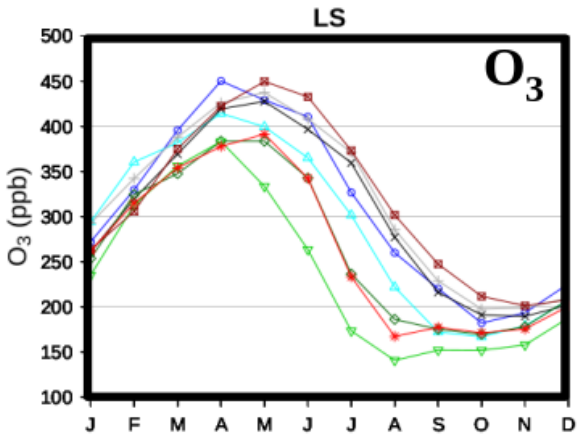
## - Upper Troposphere -

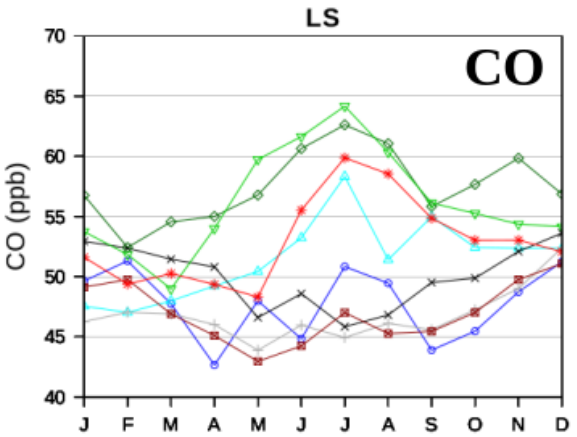


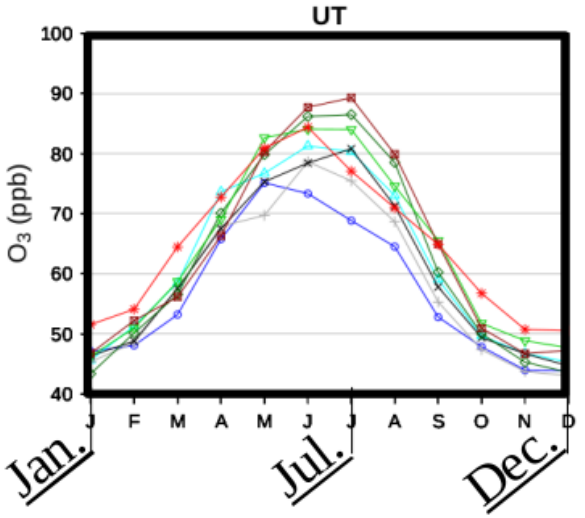

- Northern extratropics: 80 – 140 ppb
- Hot spots above eastern Asia and North America

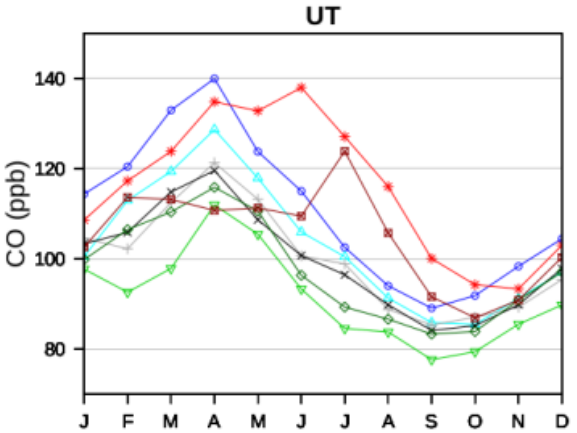
# Mean seasonal cycles




- From UT to LS: max shifted from summer to spring
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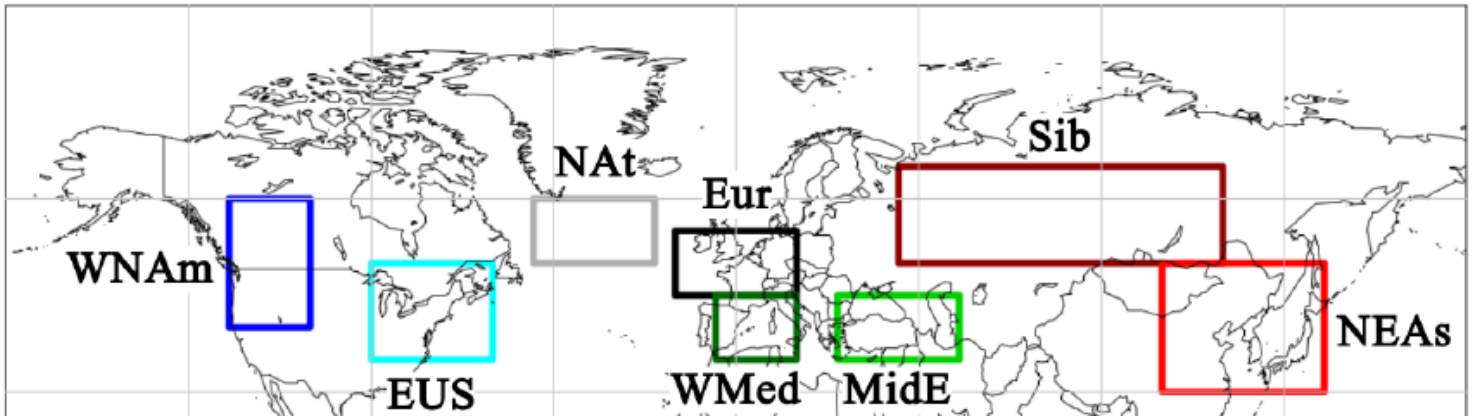


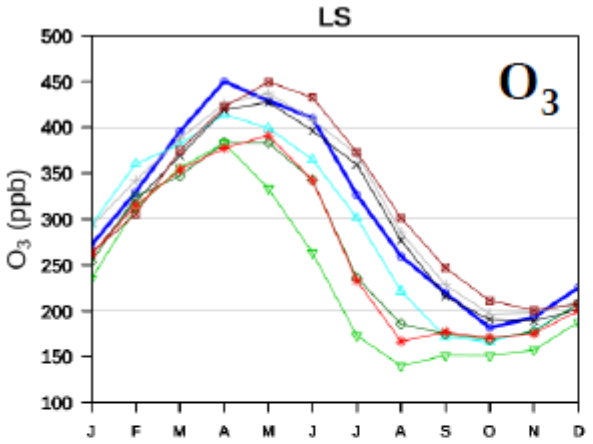


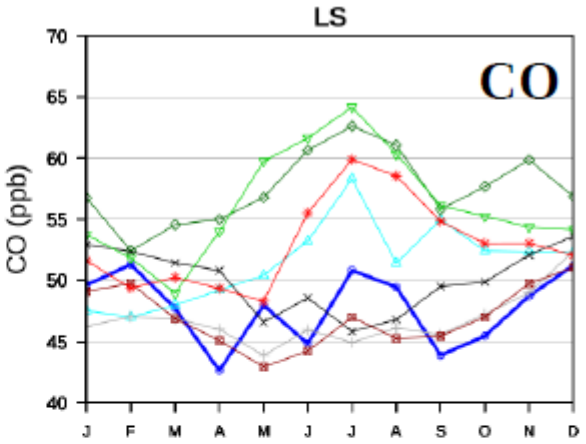


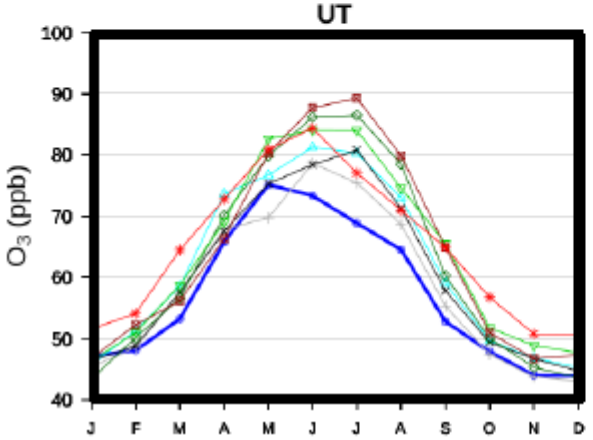


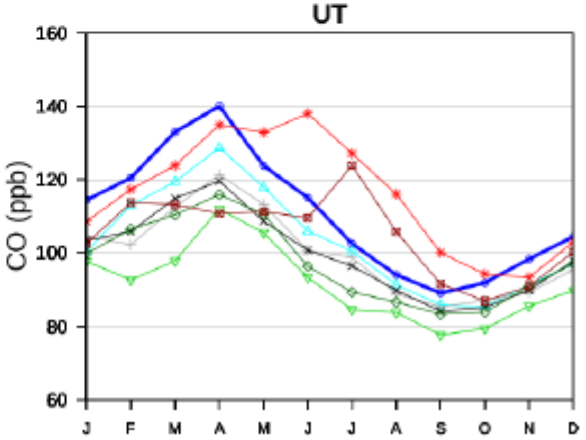


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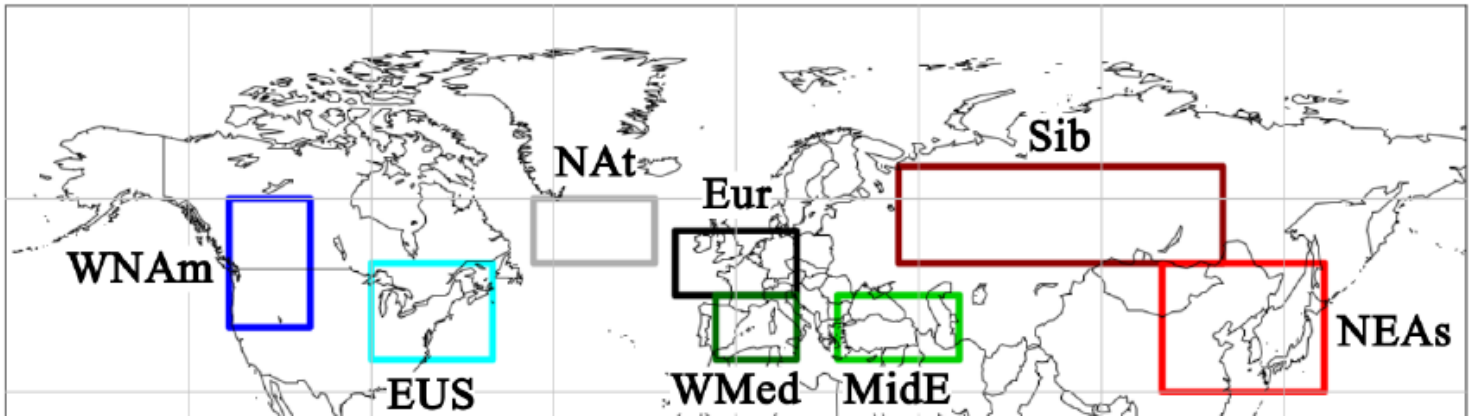


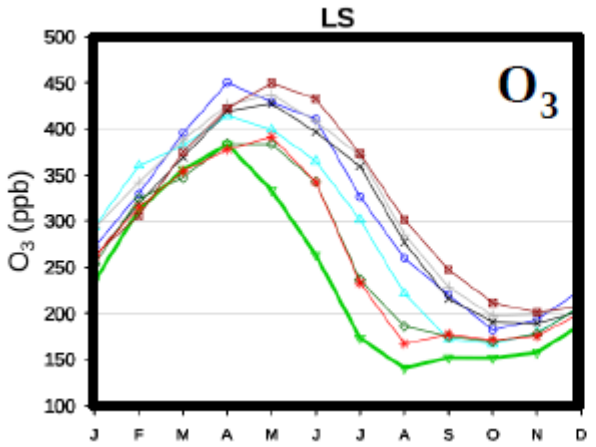


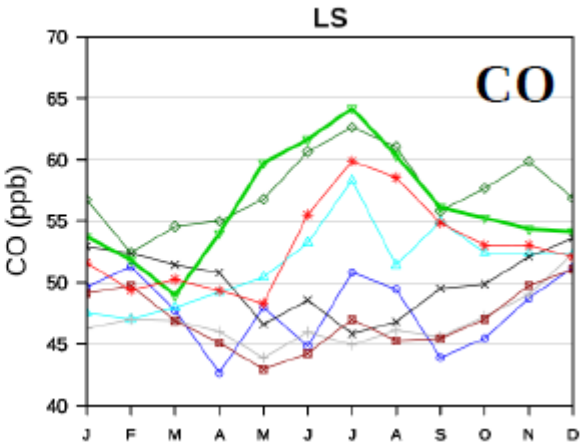


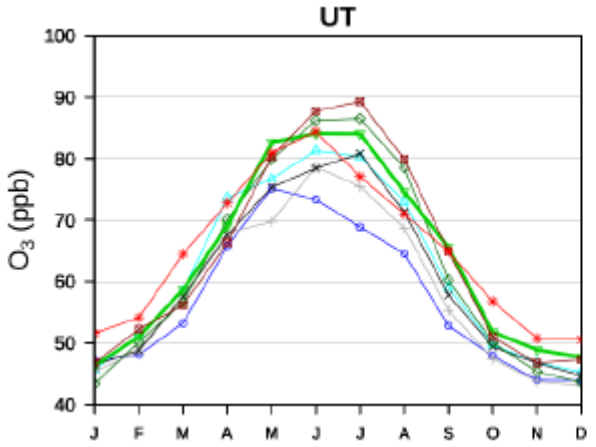


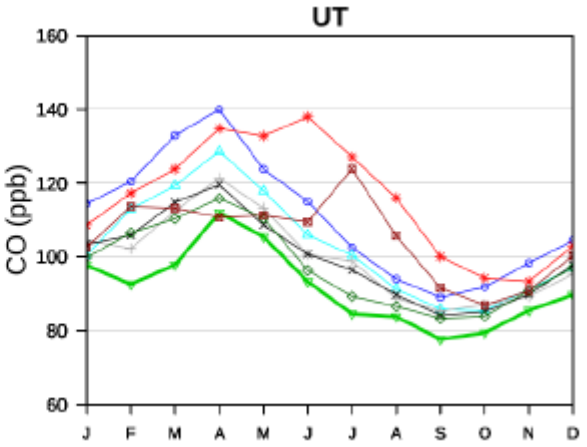


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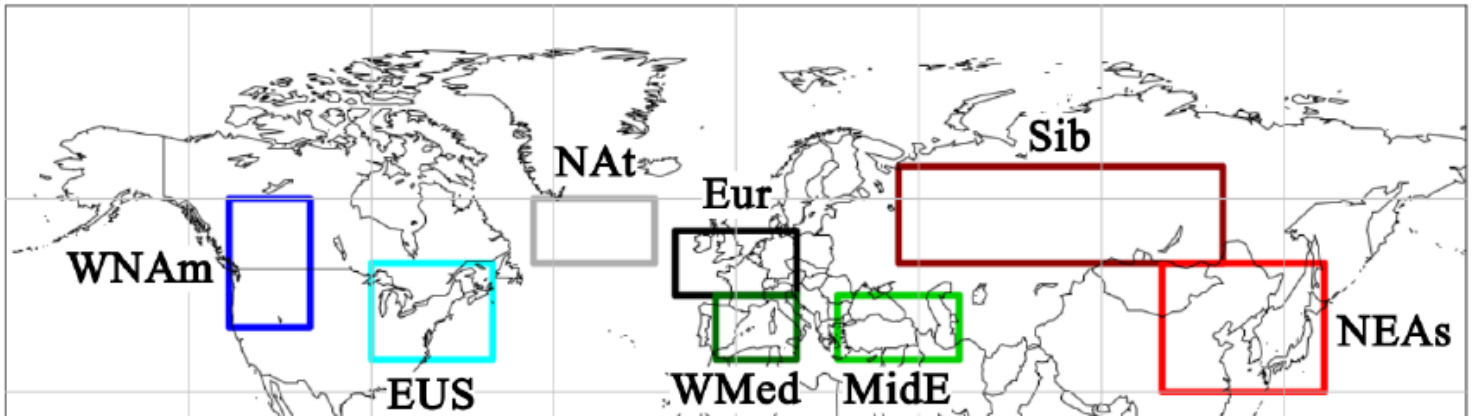


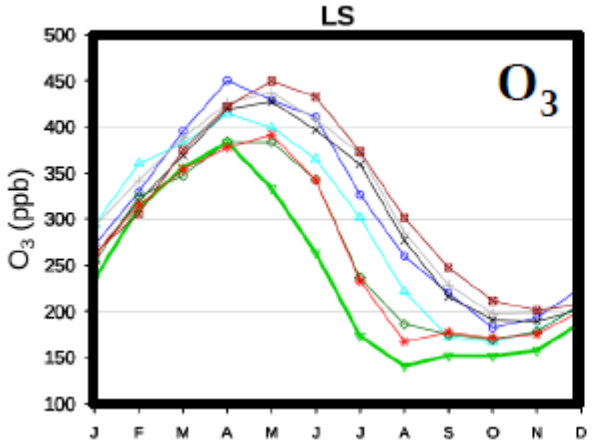


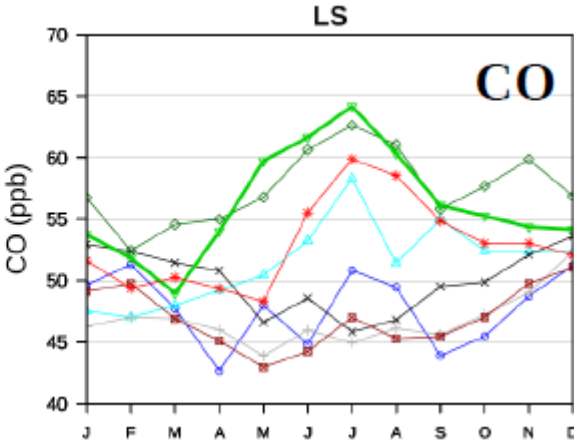


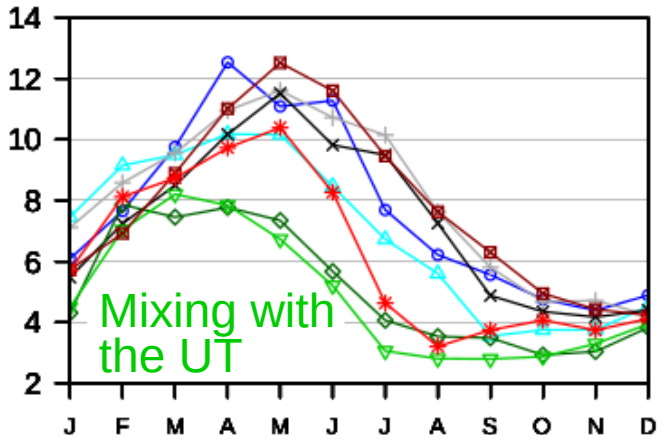


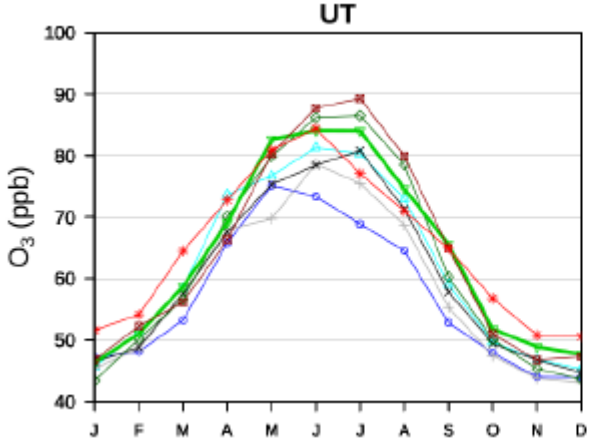


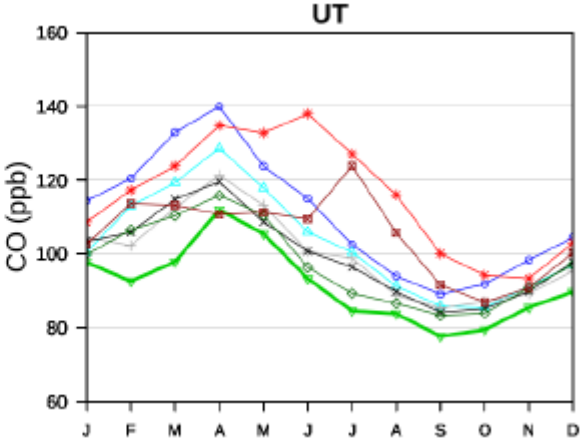


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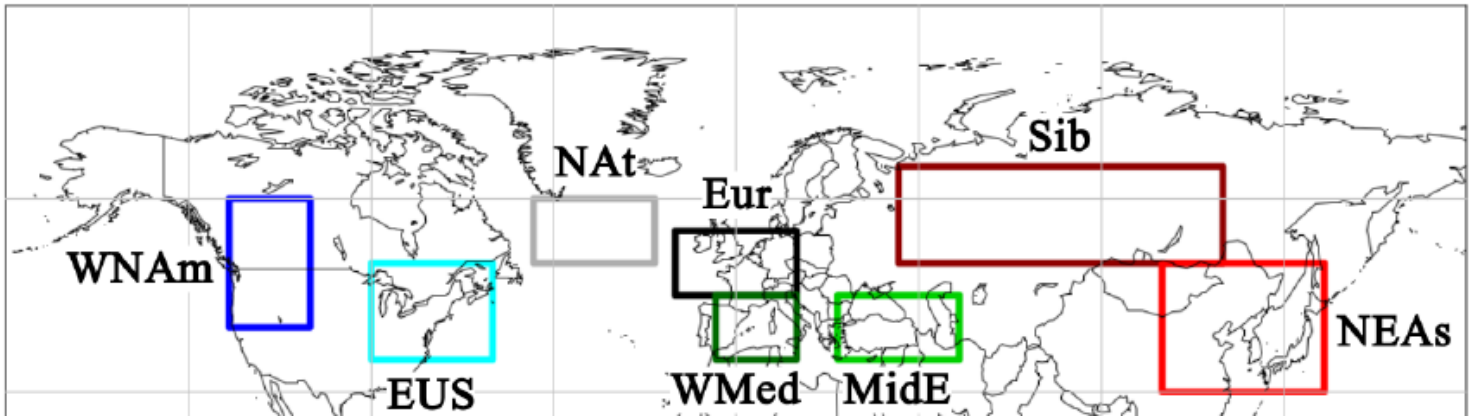


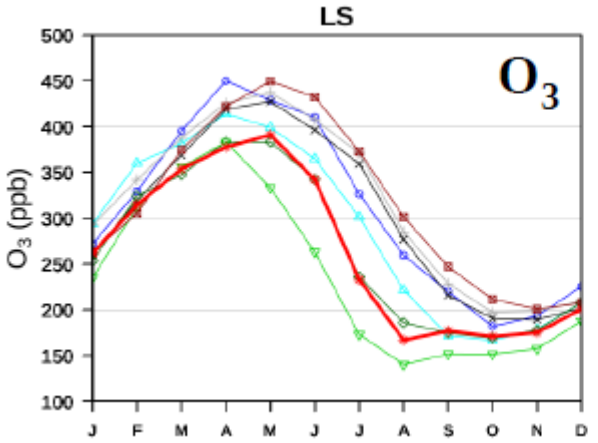


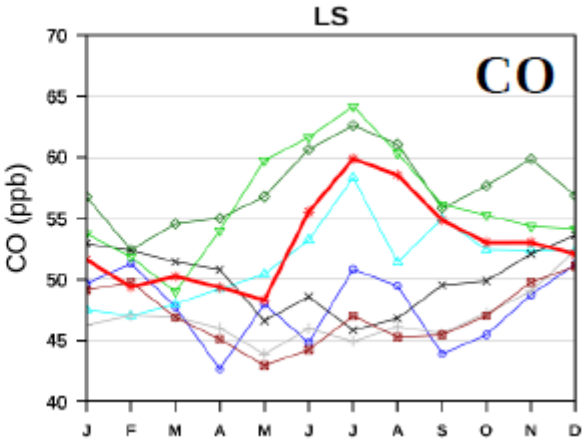


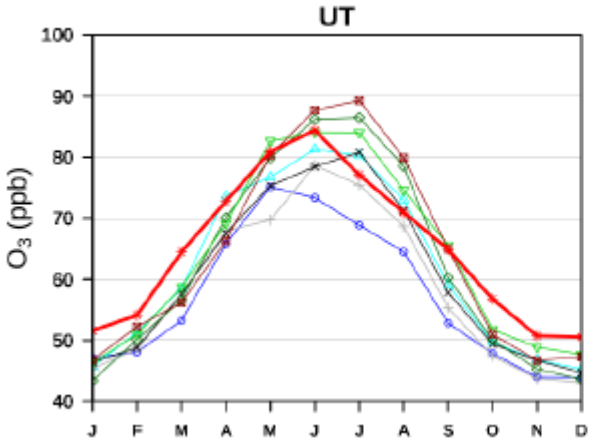


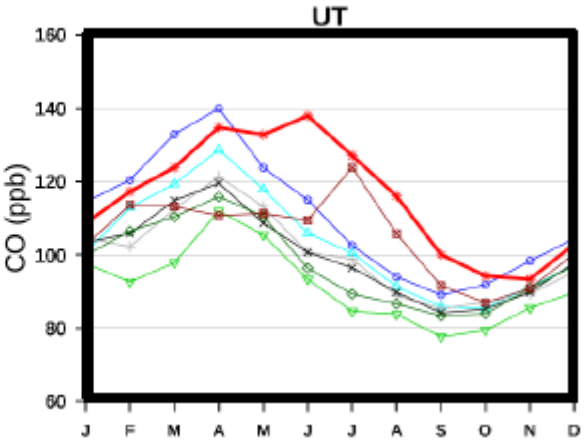


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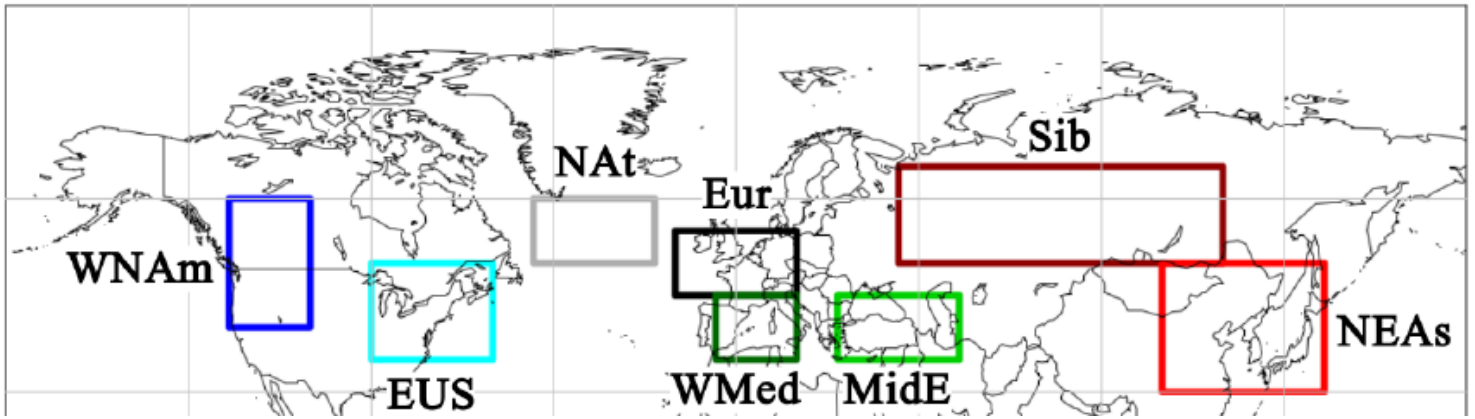
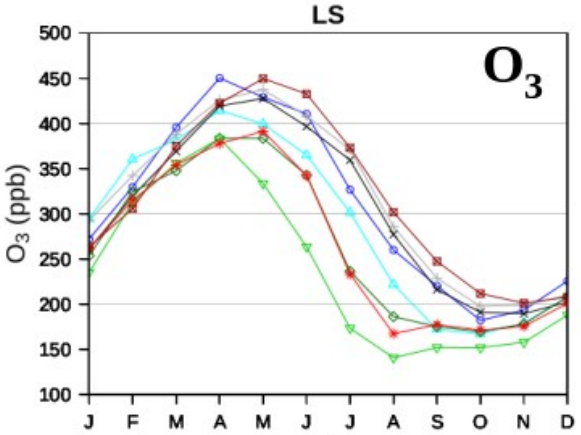
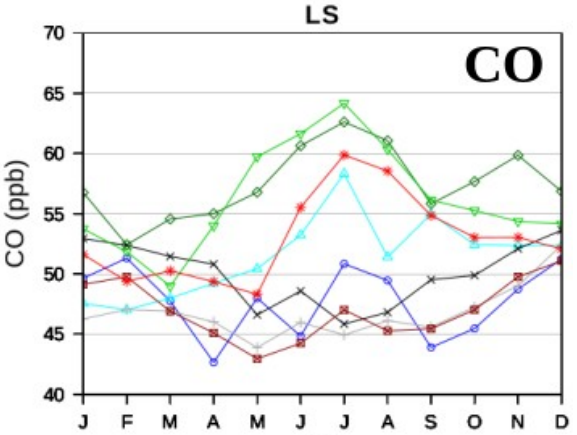
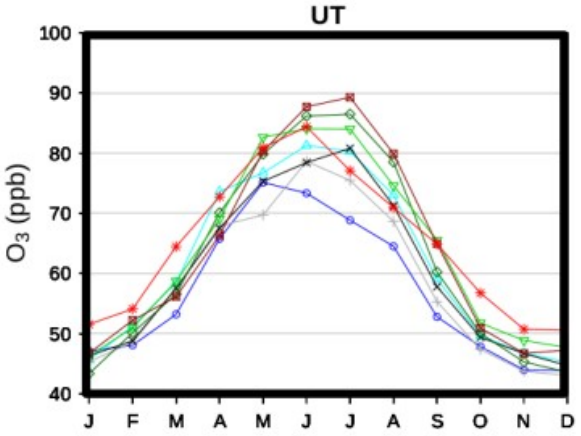
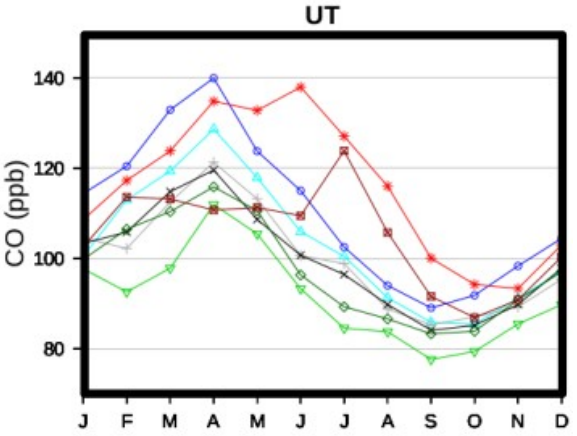


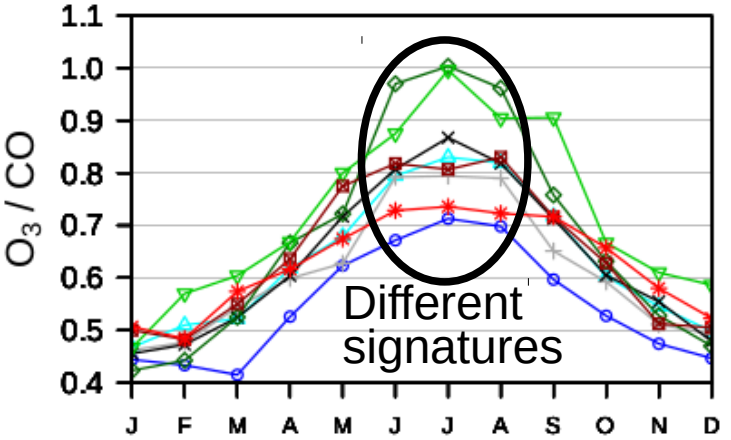



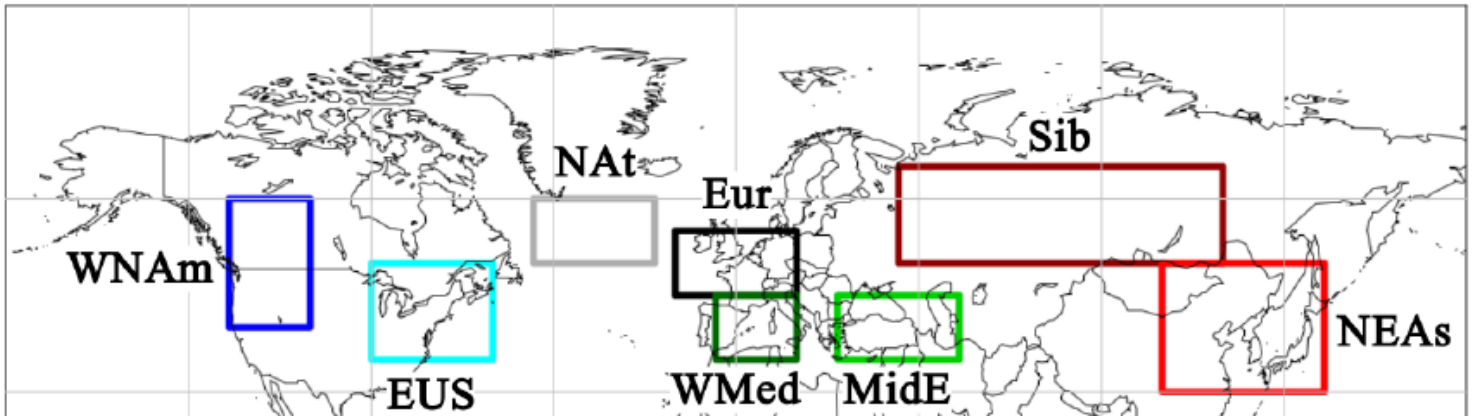



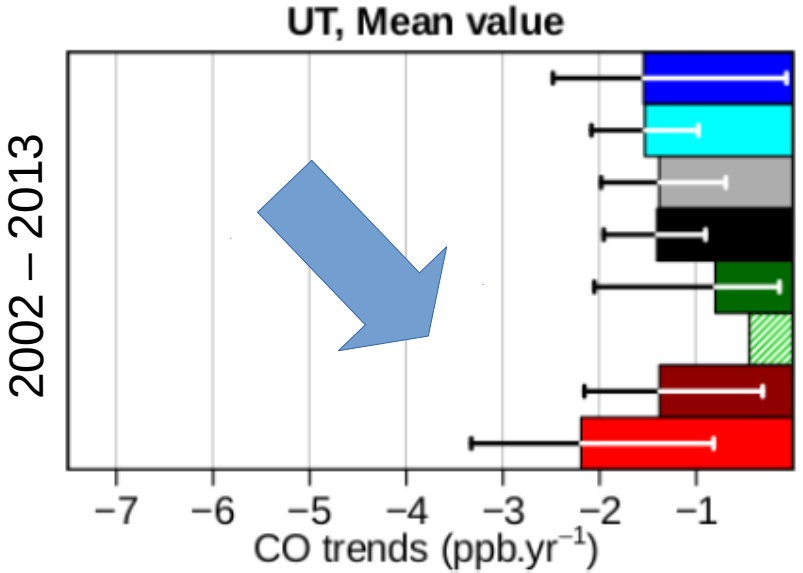

<u>Upper troposphere in summer:</u>

Stratospheric influence in the Mediterranean regions



# Trends in CO (UT)



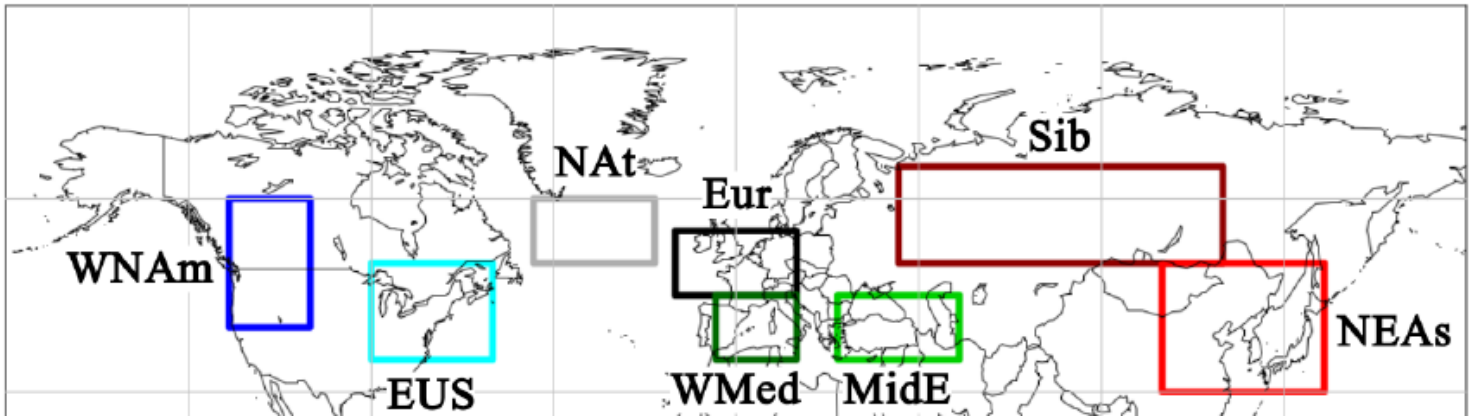



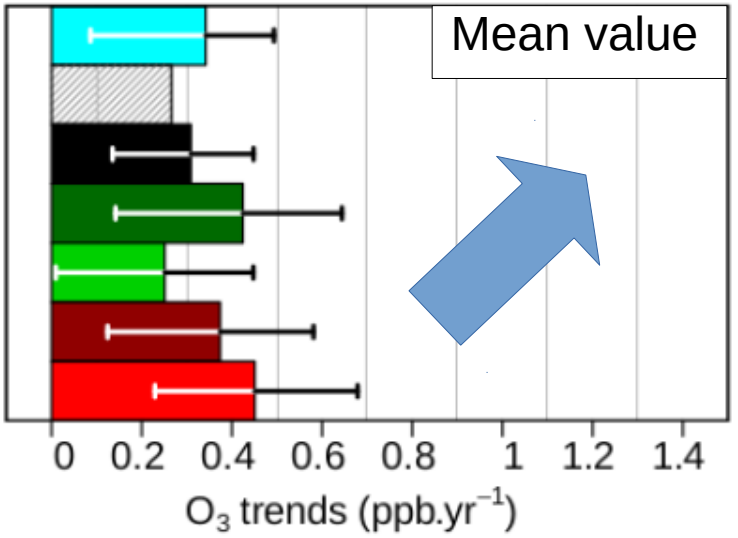

- Global decrease

  [-0.8; -2.2] ppb.yr$^{-1}$
- Insignificant in **MidE**

  ⇒ less influence of surface emissions ?

# Trends in $O_3$ (UT)

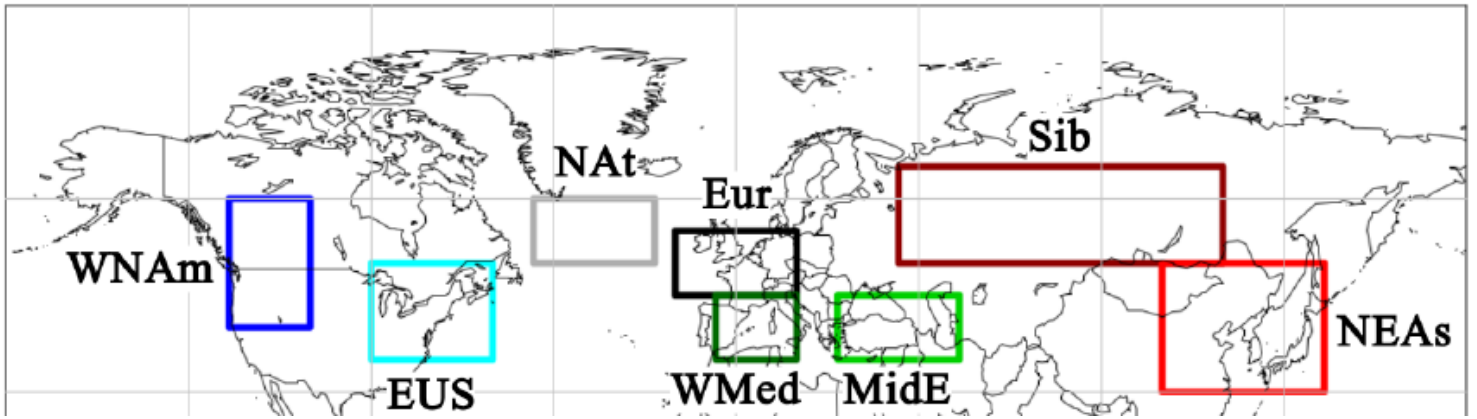


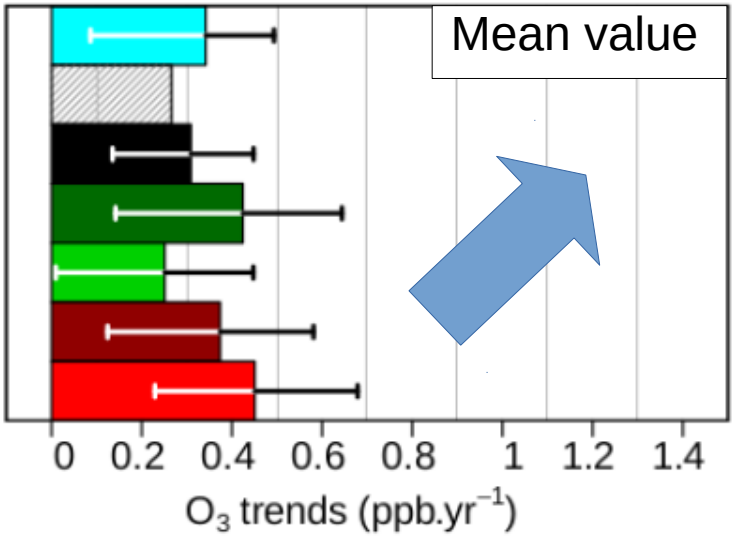




- Global increase

  [0.25; 0.45] ppb.yr$^{-1}$
- Insignificant in **NAt**
- Rather linked with the lowest values

# Trends in $O_3$ (UT)

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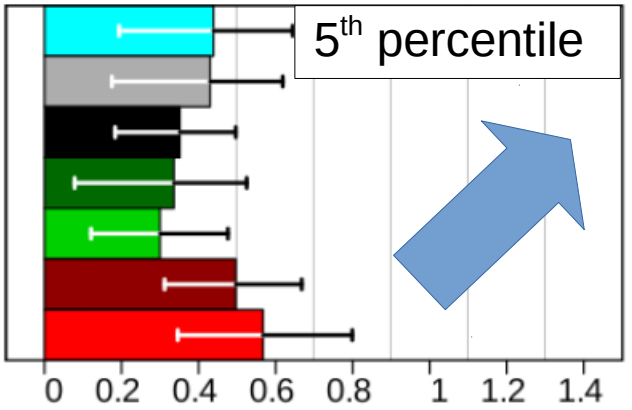
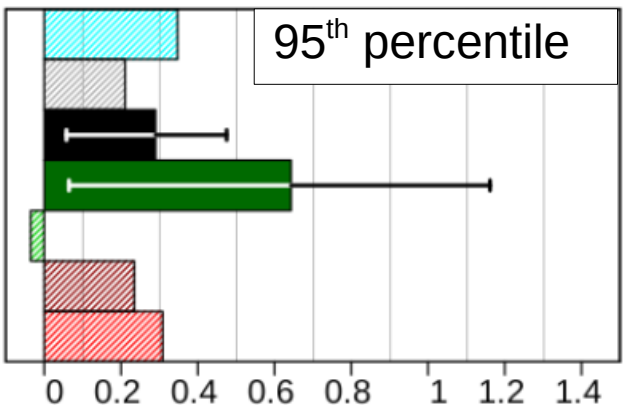
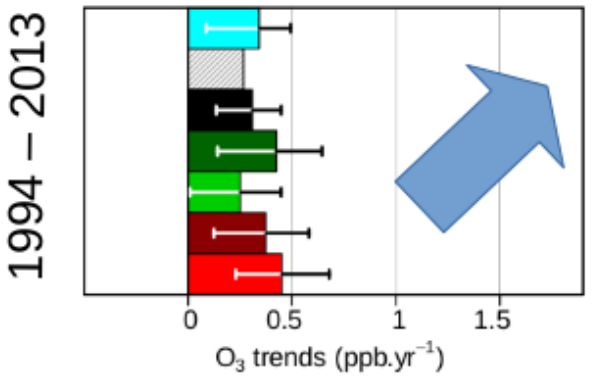
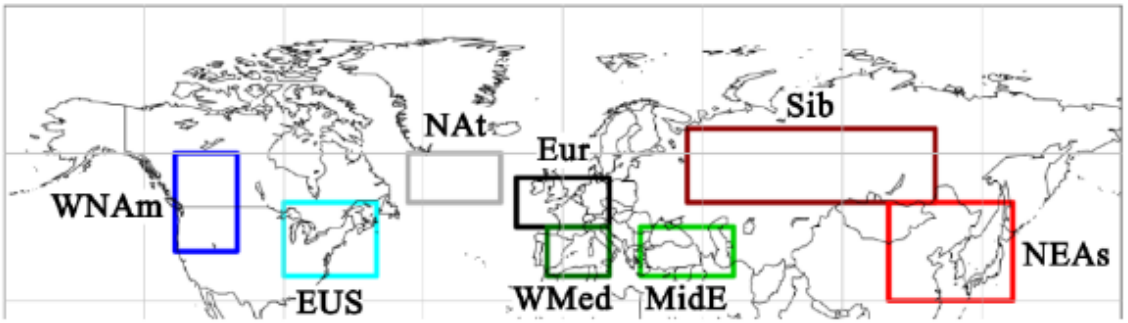


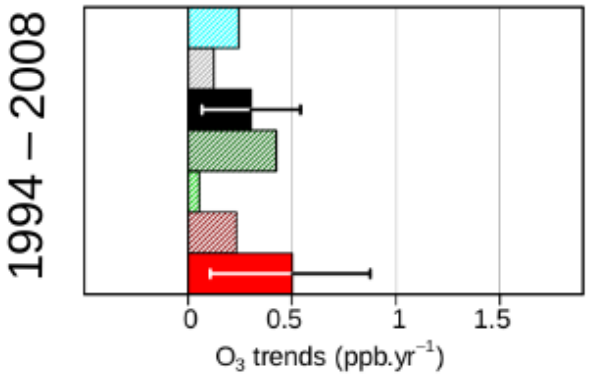



# Trends in $O_3$ (UT): sensitivity analysis to the period

Mean value

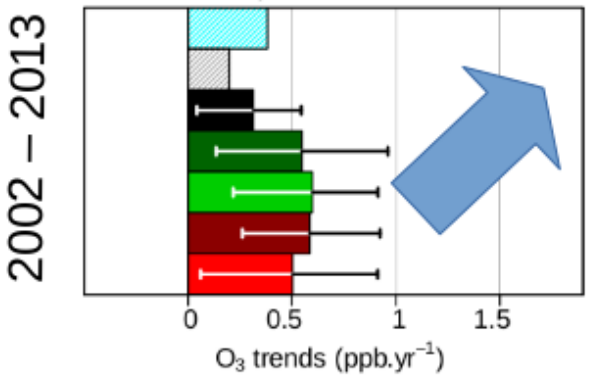


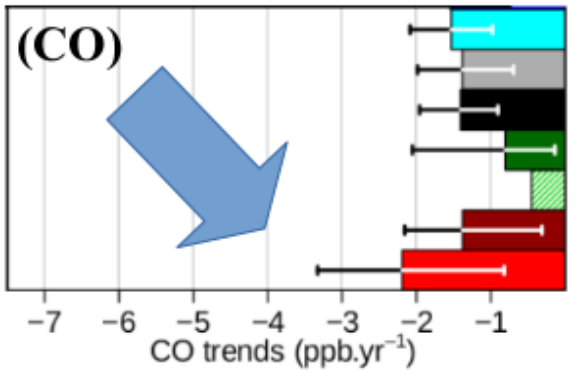




The positive anomalies during 2012 – 2013 seem to drive the positive trends.

⇒ Trends are sensitive to the start and the end of the time series.



# Summary

**What is seen by IAGOS – $O_3$ and CO – so far? (**$O_3$: 1994 – 2013; CO: 2002 – 2013

- Climatologies
  - West – east gradient in $O_3$, UT (up to 15 ppb difference)
  - Summertime tropical air masses (Northwest America)
  - Impact of the Asian Summer Monsoon on the LS (Middle East)
  - Impact of biomass burning emissions (Northeast Asia)

- Trends
  - Significant decrease of CO (-0.8 – -2.2 ppb.yr$^{-1}$)
  - Non-significant trends of $O_3$ in the LS
  - Significant increase of $O_3$ in the UT (0.25 – 0.45 ppb.yr$^{-1}$)

    mostly by the lowest values

*Further details in Cohen et al., ACP, 2018*