Ozone trends in the UTLS over northern mid-latitudes as seen by MOZAIC-IAGOS

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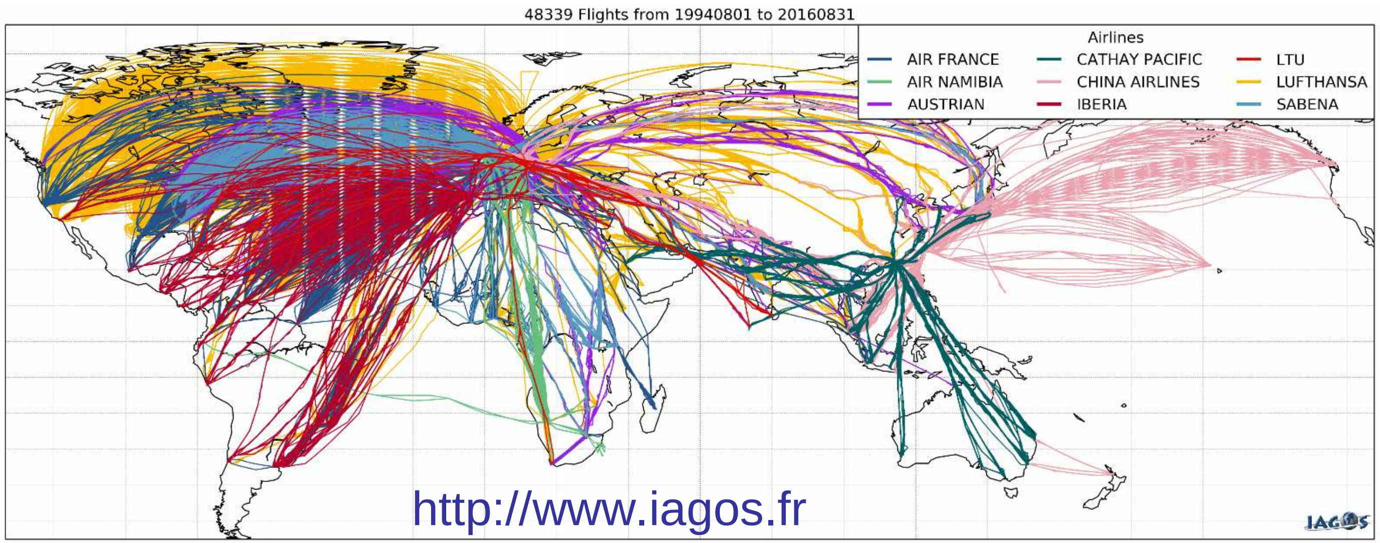
MOZAIC-IAGOS data

http://www.iagos.org

MOZAIC : Measurement of OZone and water vapour by Airbus In-service airCraft (1994 – 2014)
IAGOS : In-service Aircraft for a Global Observing System (from 2011)
Aim : establish a sustainable research infrastructure for the global observation of the atmosphere, based on in-service aircraft measurements
➔ **UTLS** (9-12 km) and **vertical profiles** nearby airports



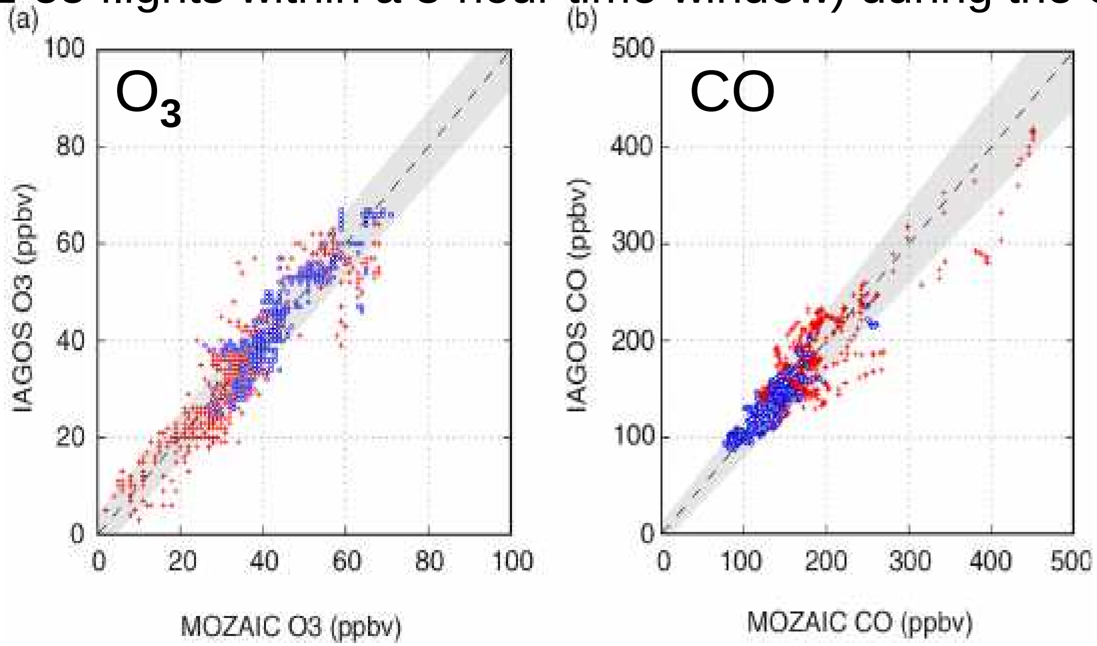
Ozone : since 1994
CO : since 2001

Thouret et al., 1998
Nédélec et al., 2003, 2015

→ Until today : ~ 48.000 flights (~ 81 million observations in the UTLS)

From MOZAIC to IAGOS

Comparison between vertical profiles from MOZAIC and IAGOS over Frankfurt (32-55 flights within a 3-hour time window) during the **overlap period: 2011-2013**



Measurement points taken :

- Above 1 km altitude
- Below 1 km altitude
- Instr. uncertainty range

(Nédélec et al., 2015)

93 % (ozone) and 81 % (CO) of the points are within the uncertainty range of the instrument

➔ **Consistency demonstrated between the two datasets (important for trend analysis)**

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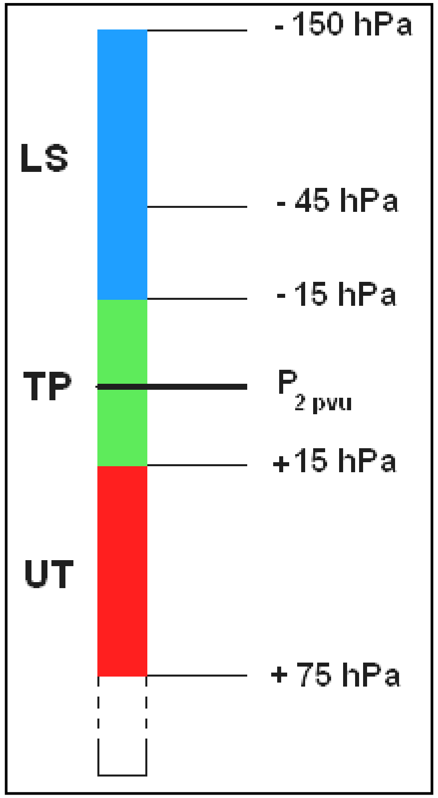
Climatology and trends

- Methodology -

Cruise altitude : 9-12 km
- Close to the tropopause
- Tropospheric and stratospheric air masses



Extratropics :

- Discrimination between UT and LS
- Dynamical tropopause : 2 pvu-isosurface of potential vorticity from ECMWF

Thouret et al., 2006

Tropics (25°S-25°N):

All the points above 8 km are attributed to the UT

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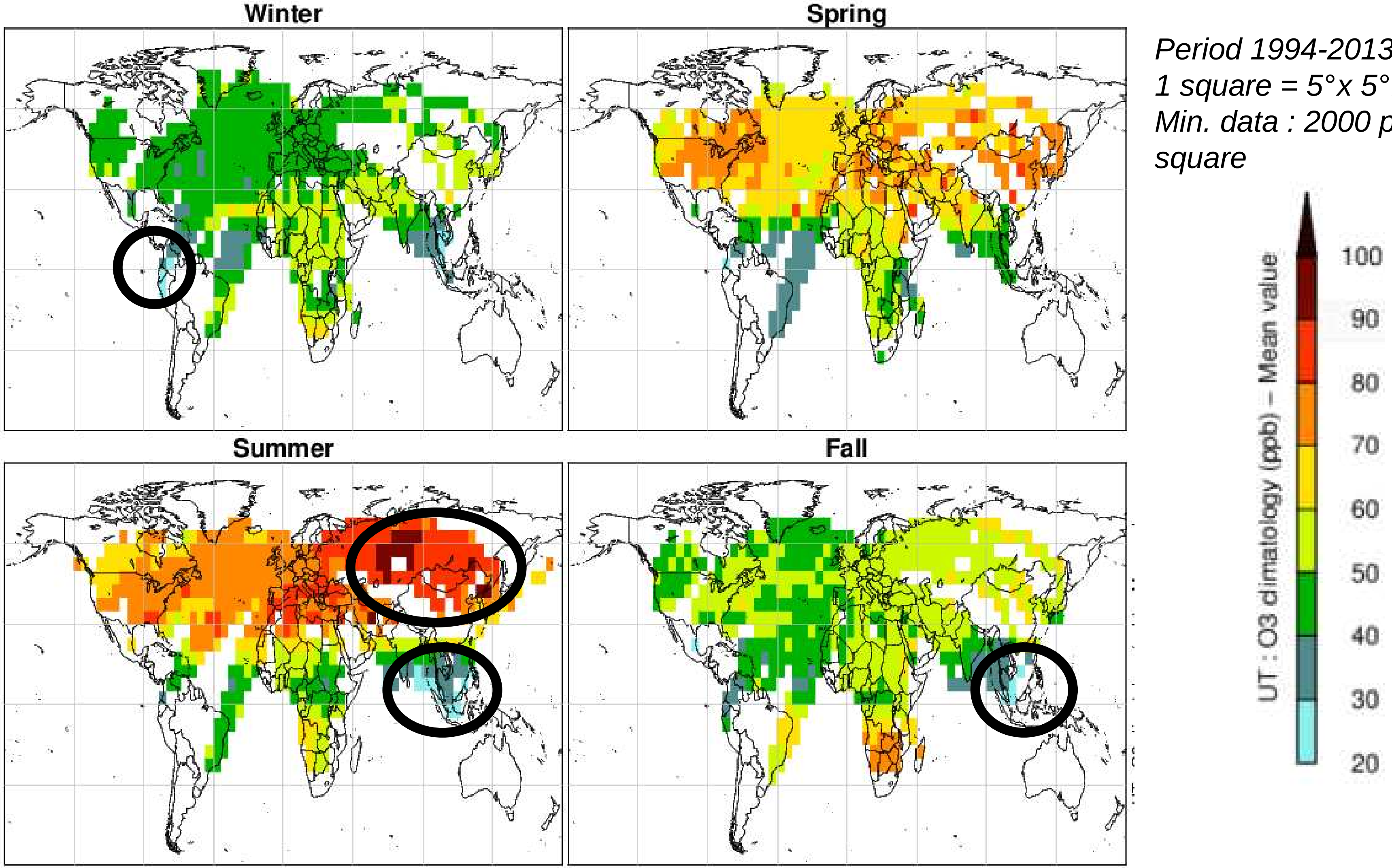
Ozone mean seasonal distribution in the UT



Period 1994-2013
1 square = 5°x 5°mean
Min. data : 2000 per square

Minimum O_3 (20-30 ppb) : southeast Asia in summer/fall, northwest South America in winter

Maximum O_3 (90-110 ppb) : Siberia and northeast Asia in summer

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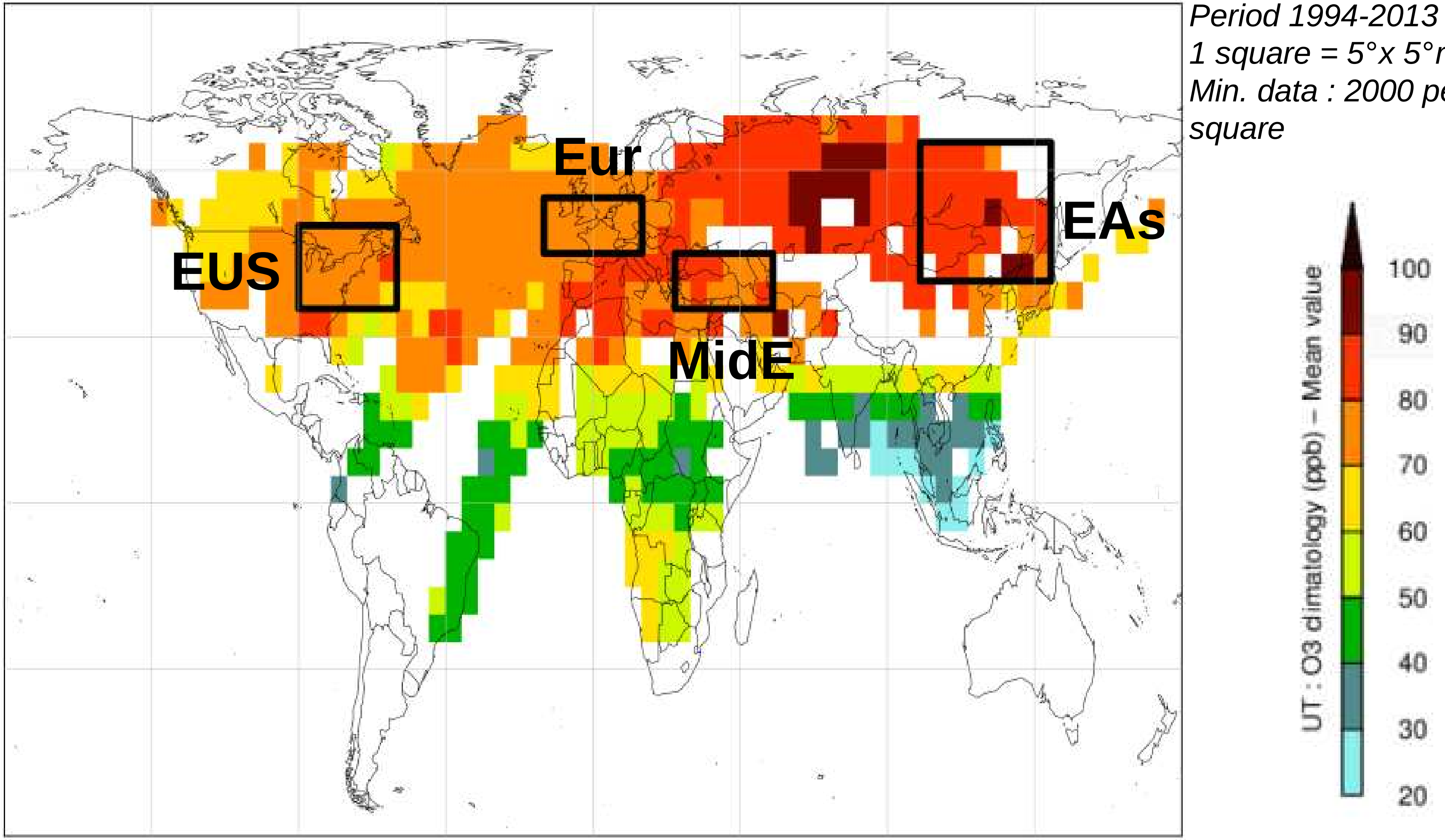
Ozone mean seasonal distribution in the UT



Period 1994-2013
1 square = 5°x 5°mean
Min. data : 2000 per square

This talk : 4 regions of interest with a sufficient sampling frequency to derive trends over the period 1994-2013

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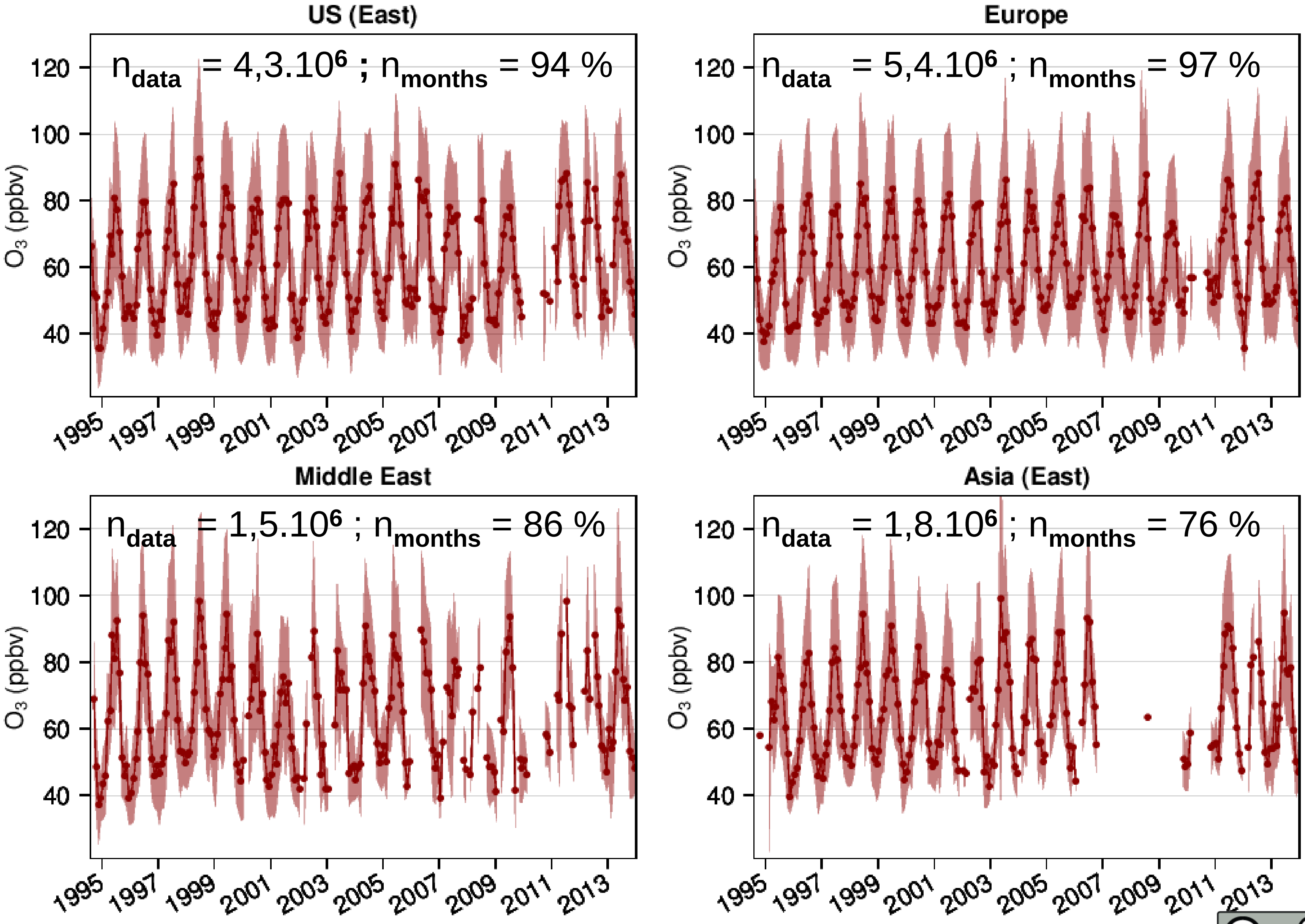
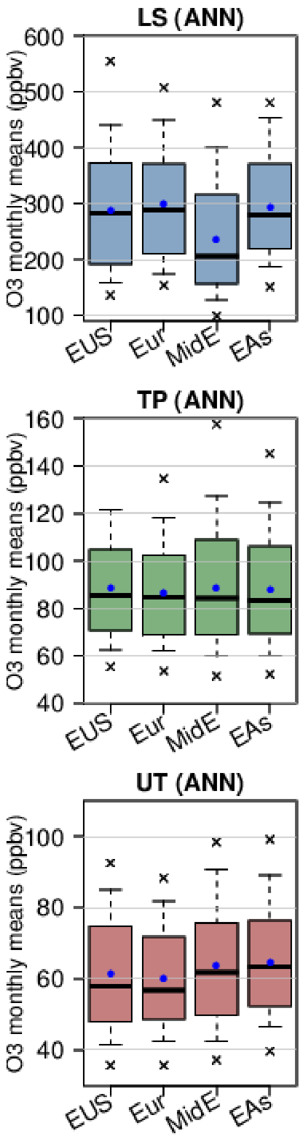
Time series : ozone monthly means in the UT



Distribution and seasonal variations of O_3



Mean Distribution

Average mixing ratios :

200-300 ppb in LS
80-90 ppb in TP
55-70 ppb in UT

Seasonal variations

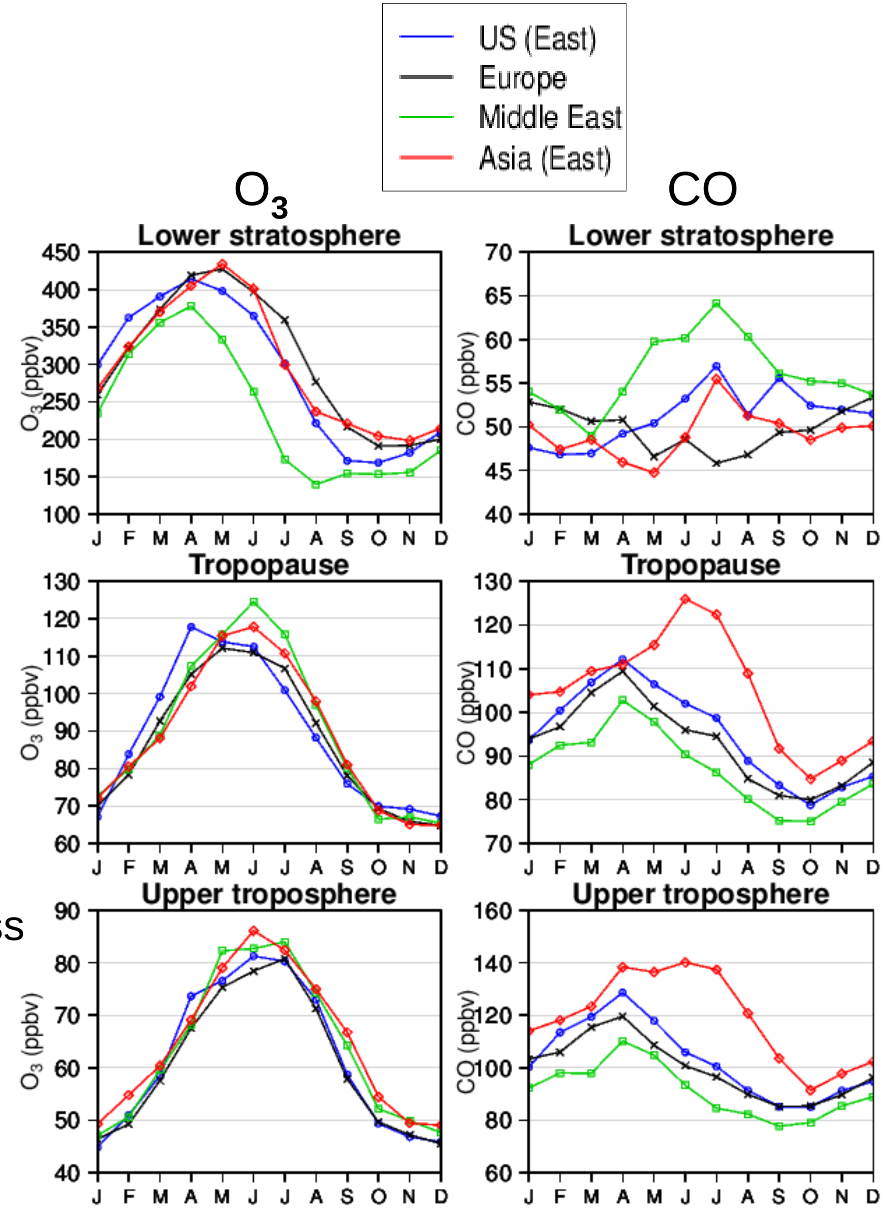
Ozone

- similar seasonality among the regions whatever the layer

CO

- high inter-regional variability

- MidE : most southern region
- EAsia (CO) : impact of biomass burning + anthropogenic emissions + strong convection



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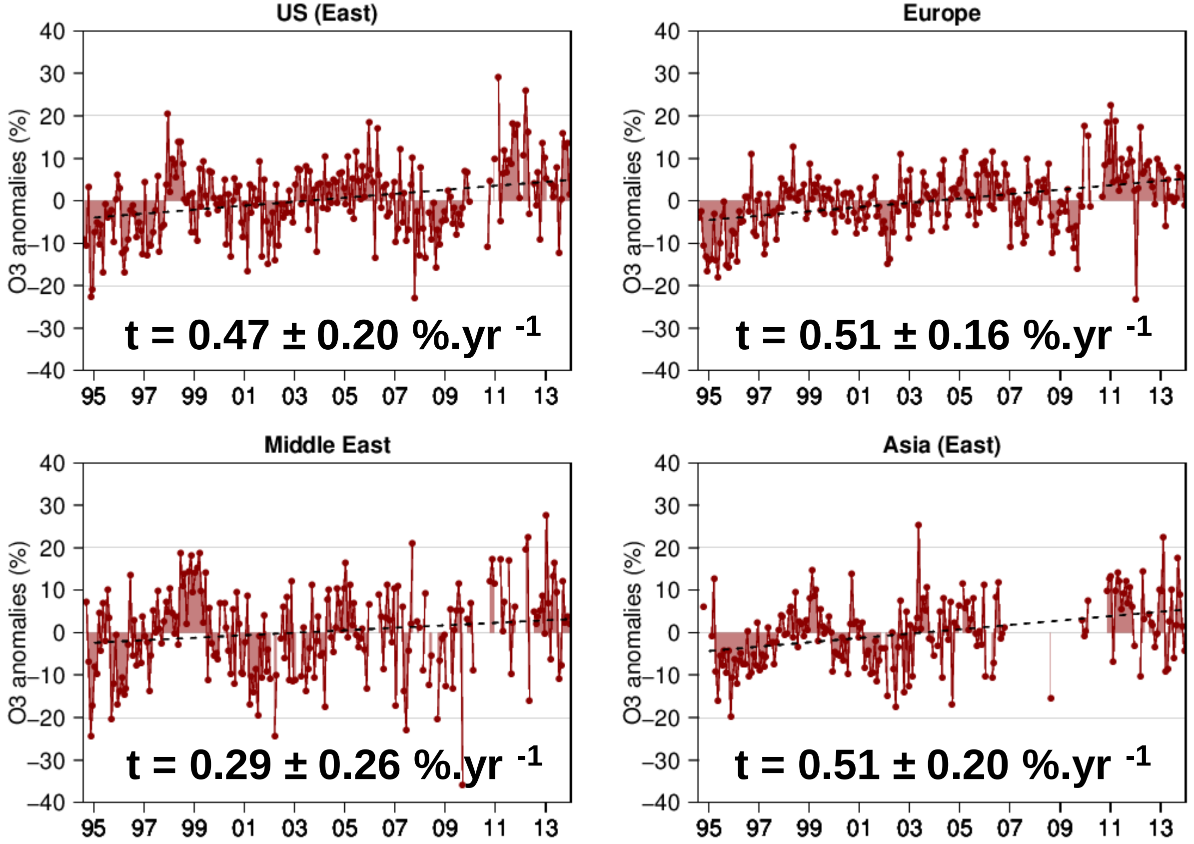
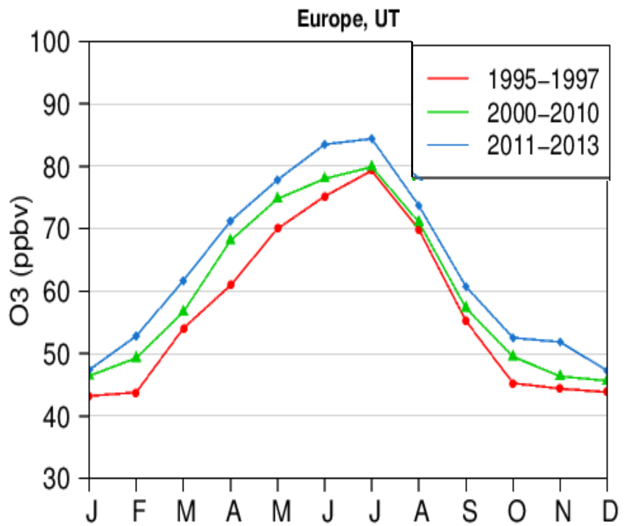
Ozone monthly anomalies in the UT

Monthly mean anomalies, relatively to the mean seasonal cycle

Trends : linear fit, using the least-squares method





Common features : « wave-pattern »

- Before 1998 : negative anomaly
- 2000 - 2010 : leveling off
- 2011 - 2013 : positive anomaly for most of the months (up to 5 ppb on seasonal average)

➔ **1994-2013 : Similar, significant, positive trends** around **0.3-0.5 %.yr $^{-1}$ for all the regions**

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1) Ozone in the UT : seasonal trends

Can the trends be explained by a seasonal feature ?

Minimum of data: 4000/season

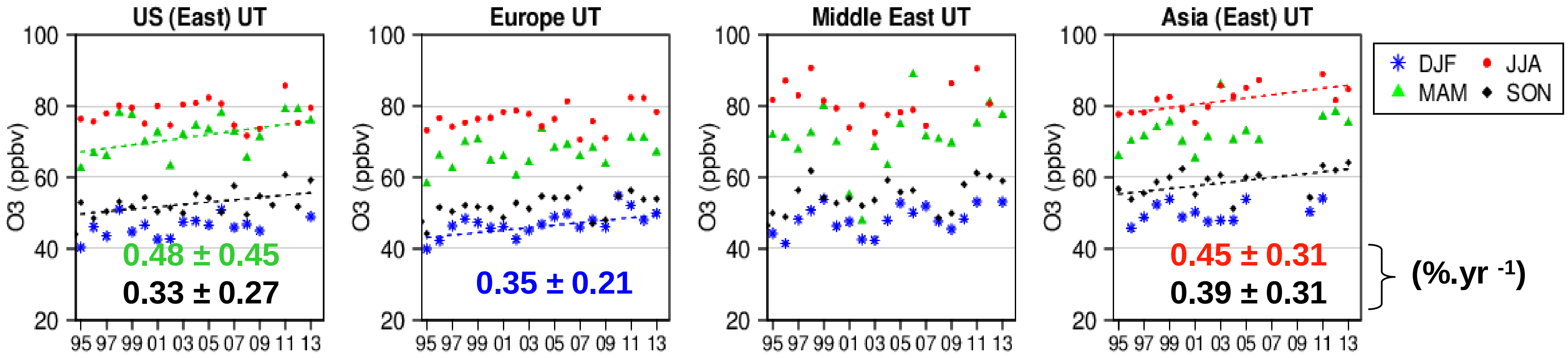

Fig. : Seasonal means, with the corresponding trends if significant

- Significant trends are positive
- Differences between seasons are not statistically significant

➔ No particular season seems to drive the trends

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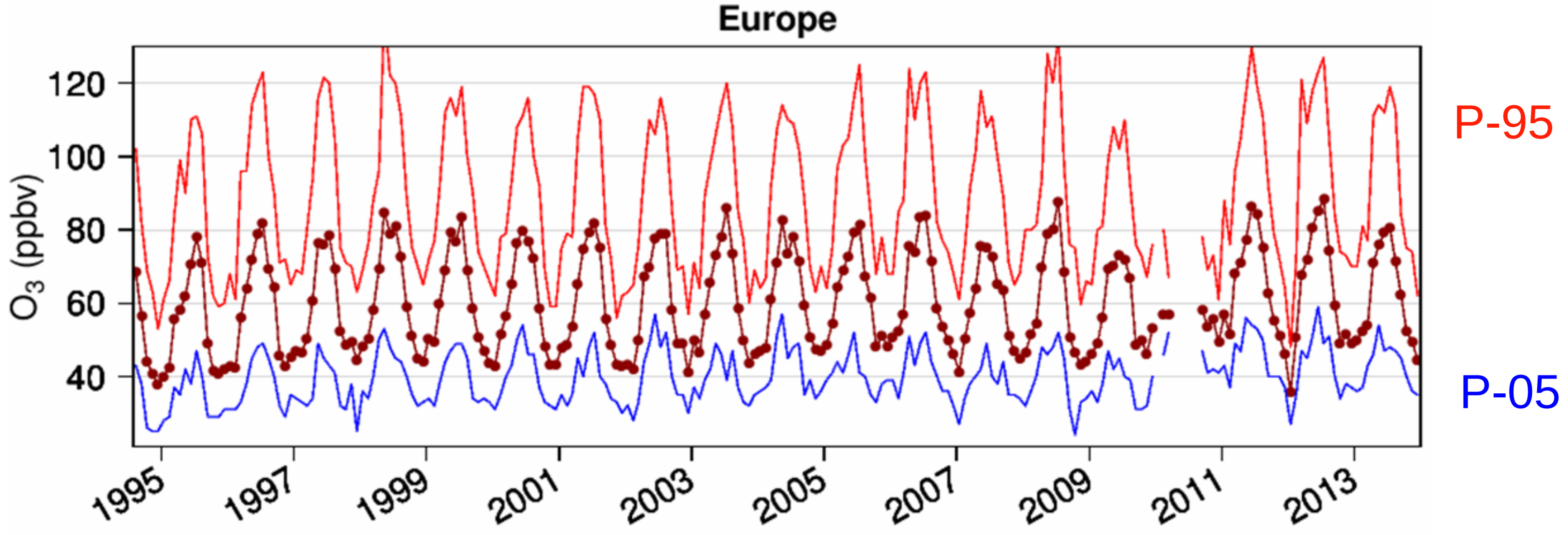
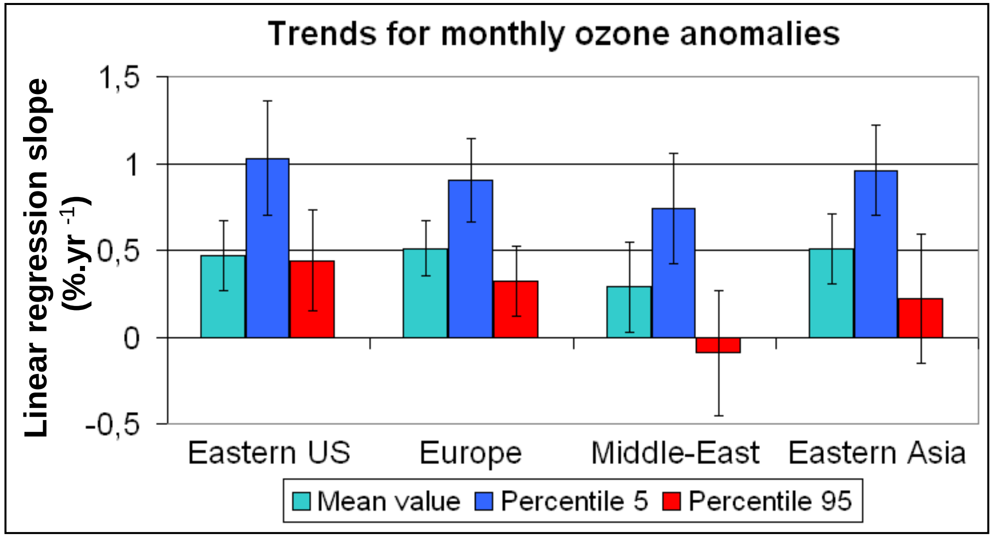
2) Ozone in the UT : extreme monthly values

Other approach : lowest values (percentile 5), and highest values (percentile 95)





➔ The significant positive trends are more likely to be explained by a larger increase of the lowest values.

Conclusions

Field of study :

- 1994-2013
- In-situ measurements of O_3 and CO by MOZAIC-IAGOS
- 4 regions in northern mid-latitudes (East US, EU, Middle-East, NorthEast Asia)

➔ Statistically significant positive trends in the UT

➔ Similar in all the regions : 0.3 - 0.5 %.yr $^{-1}$

Quite unexpected, with regard to CO (2002-2013) :

- Different seasonal distributions between the regions
- Significant negative trends (about -1.3 %.yr $^{-1}$)

Ozone significant increases...

- actually hide a common « wave pattern »
- are not linked to a particular season
- are influenced by the increase of the lowest values

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