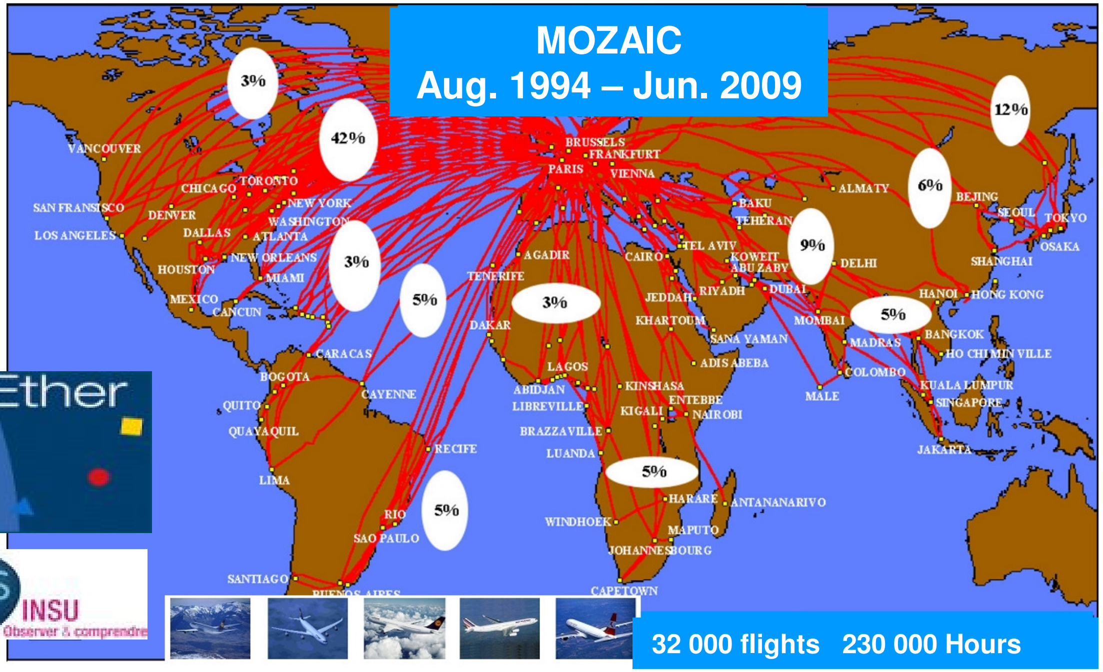
MOZAIC-IAGOS :
Its role in the satellite validation and in assessing the ozone “trends”.



http://mozaic.aero.obs-mip.fr http://www.iagos.org

V. Thouret, J-P. Cammas, B. Barret, B. Sauvage,
G. Athier, D. Boulanger, J.M. Cousin, E. Le Flochmoën, P. Nédélec,
Laboratoire d’Aérologie, CNRS, Université de Toulouse, France

MOZAIC in a few words :

- So far = up to 5 aircraft, 15 years of O3 (8 of CO), in situ measurements with the same instruments.
- Vertical profiles up to 12 km altitude over ~50 airports, large scale northern mid-latitudes UTLS sampling (9-12 km)
- IAGOS keeps going on = up to 20 aircraft for 20 more years, new sampled routes (Pacific, Asia, Middle East, etc…), new measurements (Cloud droplets, NOx, NOy, CO_2, CH_4, Aerosols)

➔ Unique data set to observe and understand the troposphere and lower stratosphere (up to 12 km) gaseous composition and its long-term changes.

http://mozaic.aero.obs-mip.fr http://www.iagos.org

Use of MOZAIC data for satellite products validation

Species	Satellite	Publication
Ozone	**POAM III**	**Prados et al., 2003**
	TOMS	**Kim et al., 2005**
	GOME	**Kunhikrishnan et al., 2006**
		Liu et al., 2006
		Sauvage et al., 2007
	MLS/AURA	**Livesey et al., 2008**
	UARS **IASI**	**Oikonomou et al., 2006** **Barret et al., submitted**
Carbon Monoxide	**MOPITT**	**Edwards et al., 2003**
	MOPITT	**Kim et al., 2005**
	MOPITT	**Emmons et al., 2007**
	MLS/AURA	**Livesey et al., 2008**
	MLS/AURA	**Barret et al., 2008**
	ACE/FTS	**Clerbeaux et al., 2008**
	SCIAMACHY	**Tangborn et al., 2008**
	MOPITT, SCIAMACHY, ACE-FTS **MOPITT**	**Turquety et al., 2008** **Emmons et al., JGR, 2007; ACP, 2009**
Water Vapour	**POAM III**	**Nedoluha et al., 2002**
	MLS	**Spichtinger et al., 2003**
	TOVS	**Gierens et al., 2004**
	ODIN/SMR	**Ekstrom et al., 2007**
	CHAMP	**Heise et al., 2007**
	UARS/MLS, ODIN/SMR, AURA/MLS	**Ekstrom et al., 2008**

IASI-SOFRID (activities at LA-CNRS)

SOFRID: SOftware for a Fast Retrieval of IASI Data

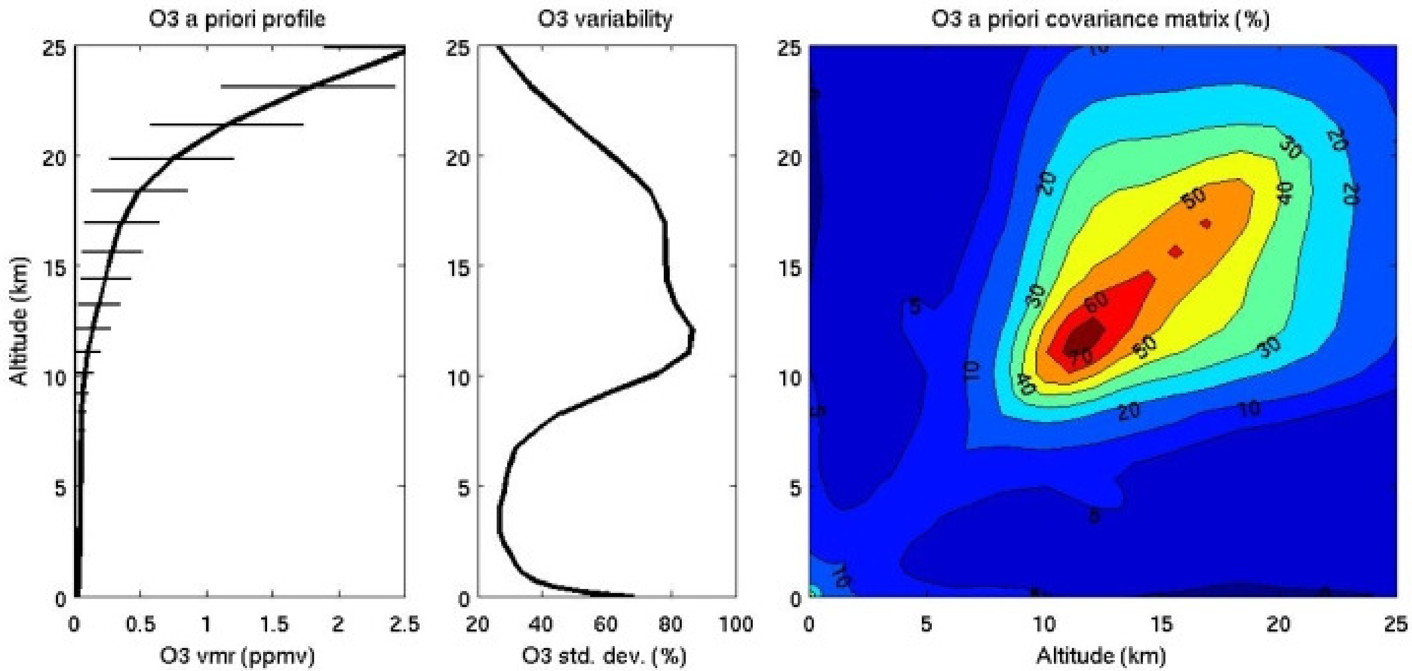
Aim at fast retrieval of global O_3/CO profiles from Metop/IASI

Based on NWP-SAF tools:

- RTTOV operational radiative transfer model taking into account the land surface emissivity
- 1D-Var retrieval scheme

1-) O3 a priori profile

In order to have the best database to represent the O3 variability from the surface to the upper stratosphere : combination of MOZAIC, WOUDC-SHADOZ and coincident profiles from the assimilation of Aura/MLS O3 data in the Valentina system.



The database currently covers year 2008 with :
- 700 profiles from WOUDC-SHADOZ
-1600 from MOZAIC-IAGOS.

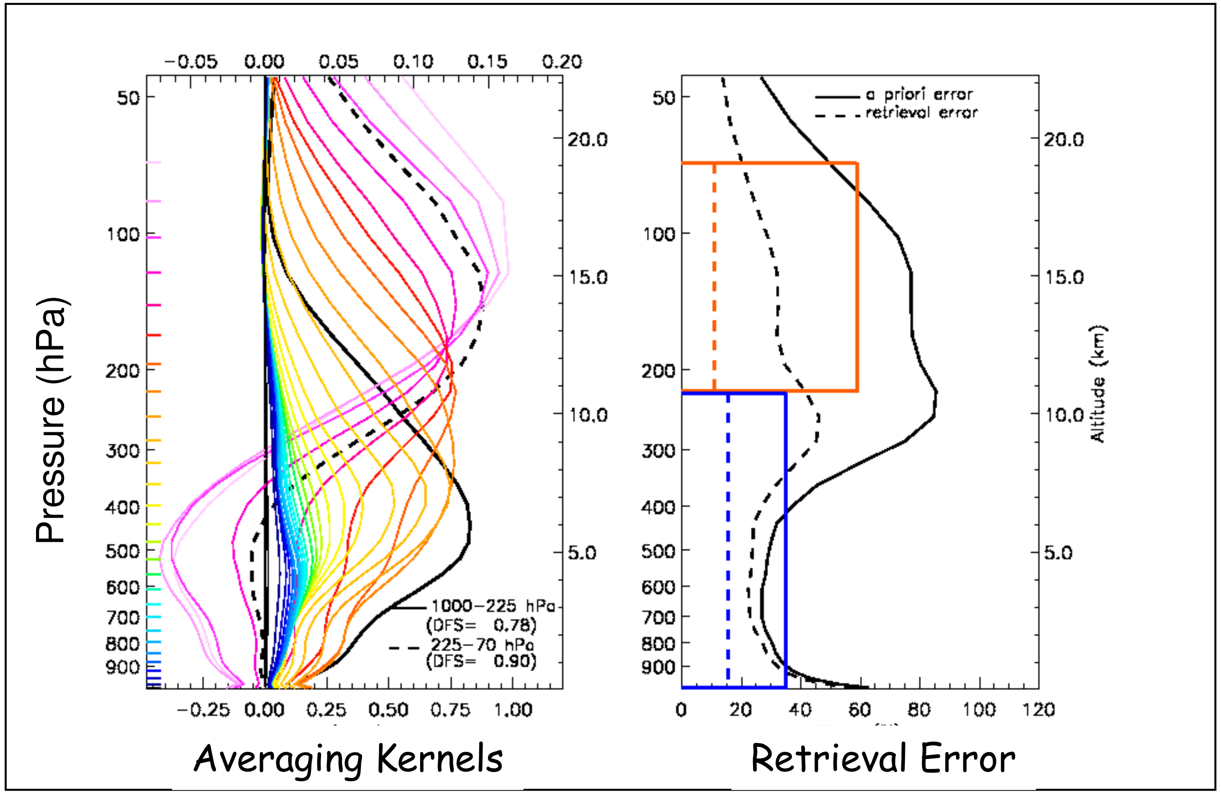
IASI-SOFRID

2-) Retrieval of O3 profiles

~ 2 independent pieces of information from lower troposphere to lower stratospher

UTLS
(225-70 hPa)
max. 150 hPa
10% error

Troposphere
(1013-225 hPa)
max. 500 hPa
15% error



Case study :Tropospheric O3 in south Asia

Context: India post-monsoon
- Emissions of O_3 precursors
- High insolation

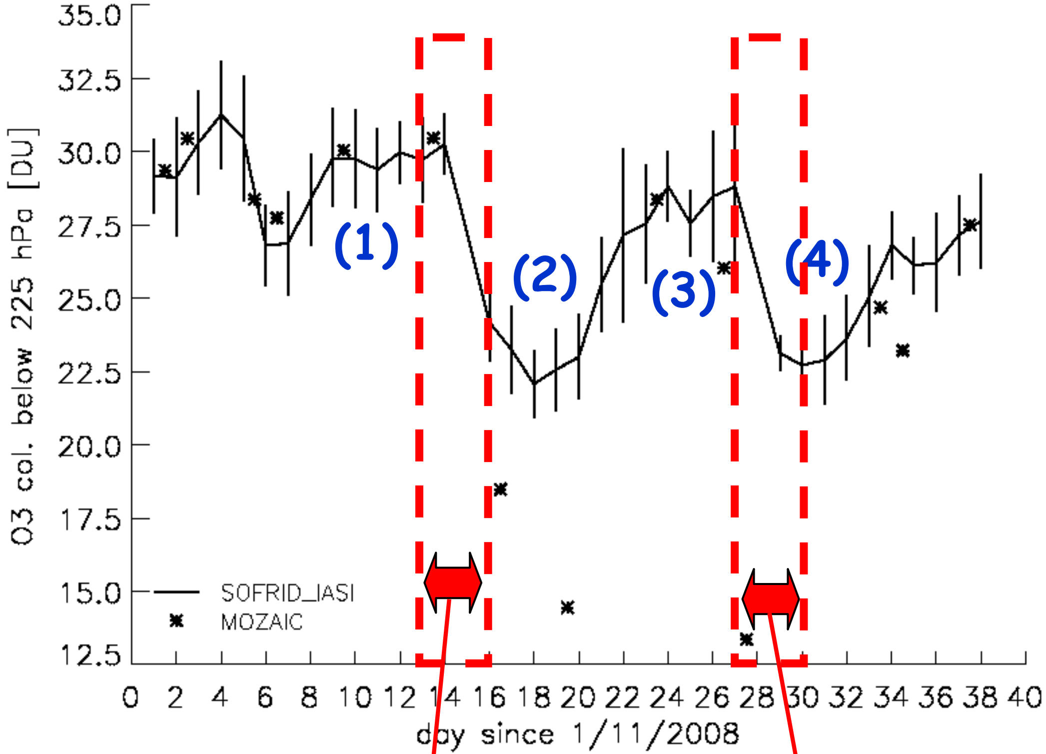
➔ High tropospheric O_3

MOZAIC vs. IASI in central India
- Elevated "tropo." O_3 columns
- High variability

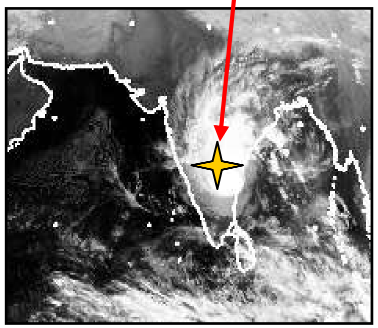
Clouds from satellites
➔ Tropo. O_3 drops correlated with the crossing of tropical storms.

Barret et al., ACP, submitted

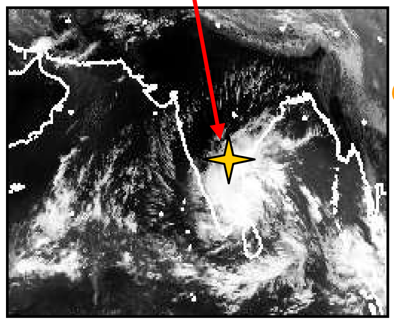
Tropospheric O_3 over Hyderabad
columns Ground-225 hPa



Cyclonic storm Khai-Muk



2008/11/15/18UT



2008/11/27/06UT

Cyclonic storm Nisha

IASI-UTLS Validation with MOZAIC

UTLS

-IASI: high sensitivity

-MOZAIC: most of the observations

➔ interpretation of comparison results to be made carefully (no complete profiles…) !

Preleminary results

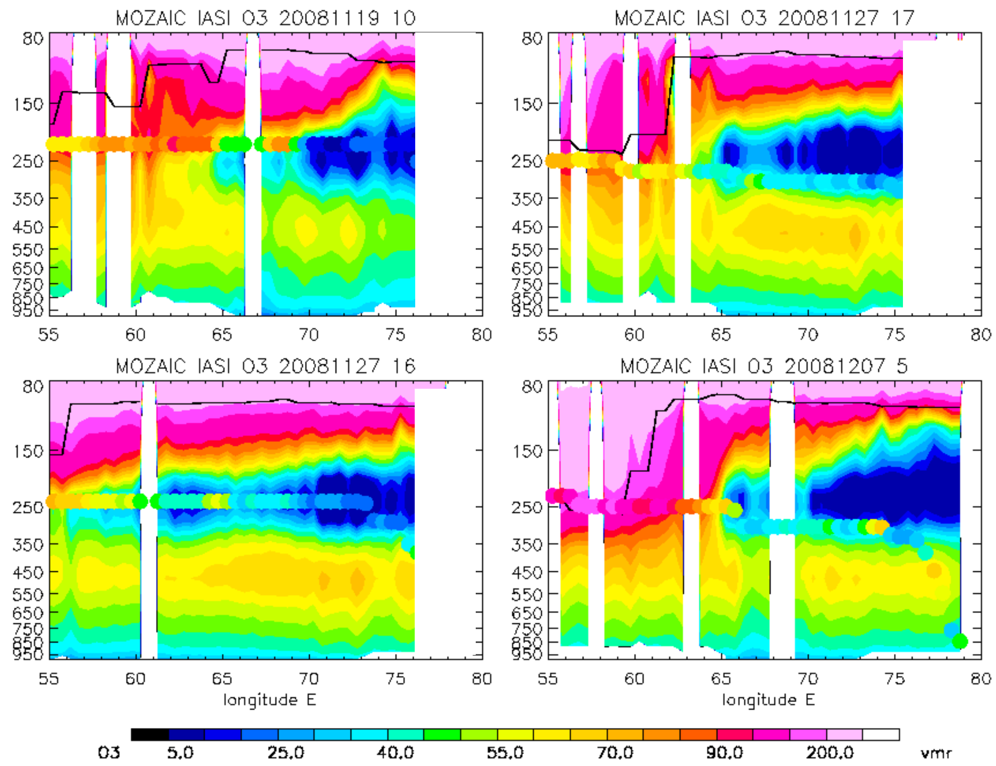
-tropical UT O_3 minimum in good agreement

-very good detection of the sharp transition from tropical UT (low O_3) to mid.-lat. LS (high O_3)

IASI O_3 profiles versus MOZAIC in-flight O_3

4 days in Nov-Dec 2008

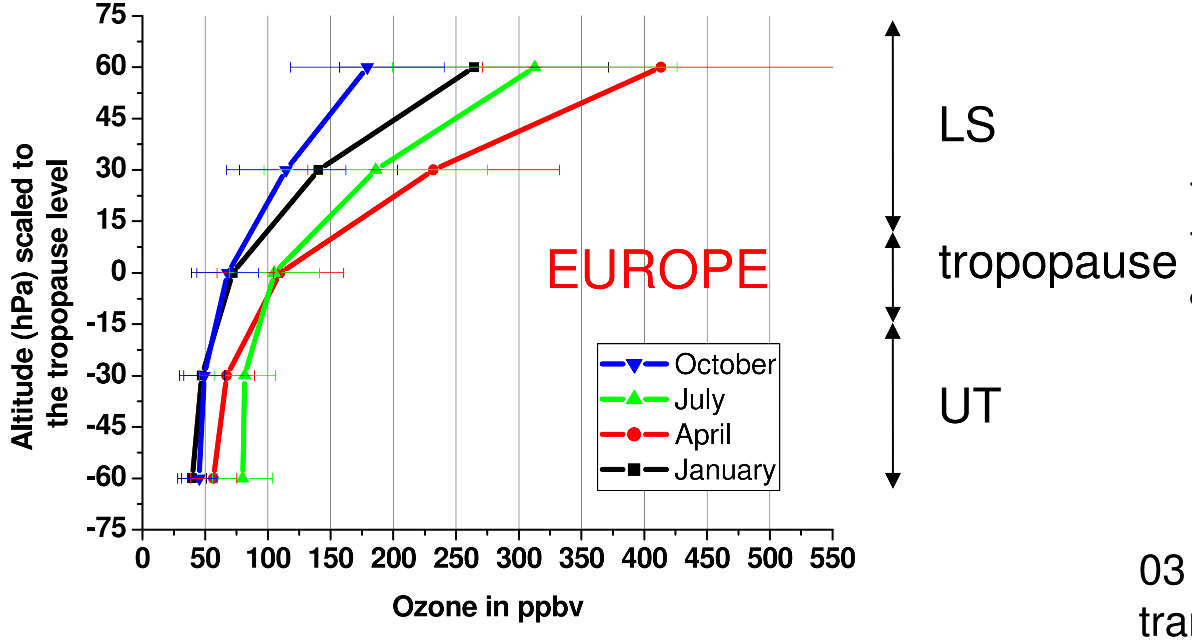
Hyderabad-Frankfurt

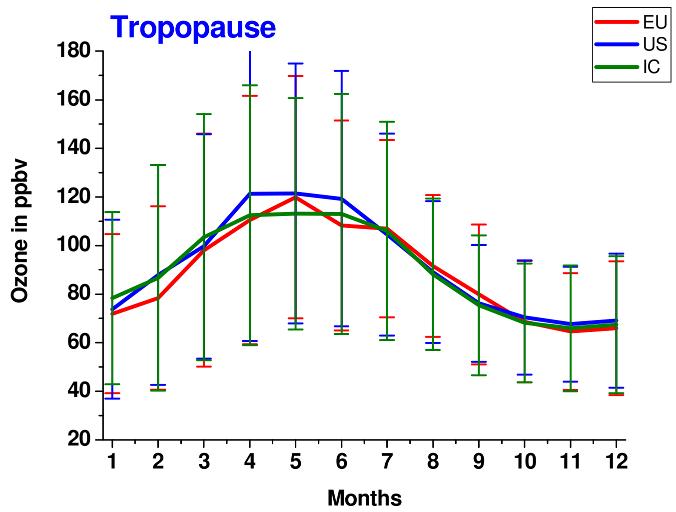


UTLS as seen by MOZAIC

(90 % of the data base, most critical region of the atmosphere)

- Commercial aircraft are flying mostly between 180 and 300 hPa ➔
  - Tropopause = a 30 hPa thick layer centered around PV=2pvu
  - UT = a 60 hPa thick layer below the tropopause
  - LS1 = a 30 hPa thick layer above the tropopause
  - LS2 = all the remaining measurements above LS1.



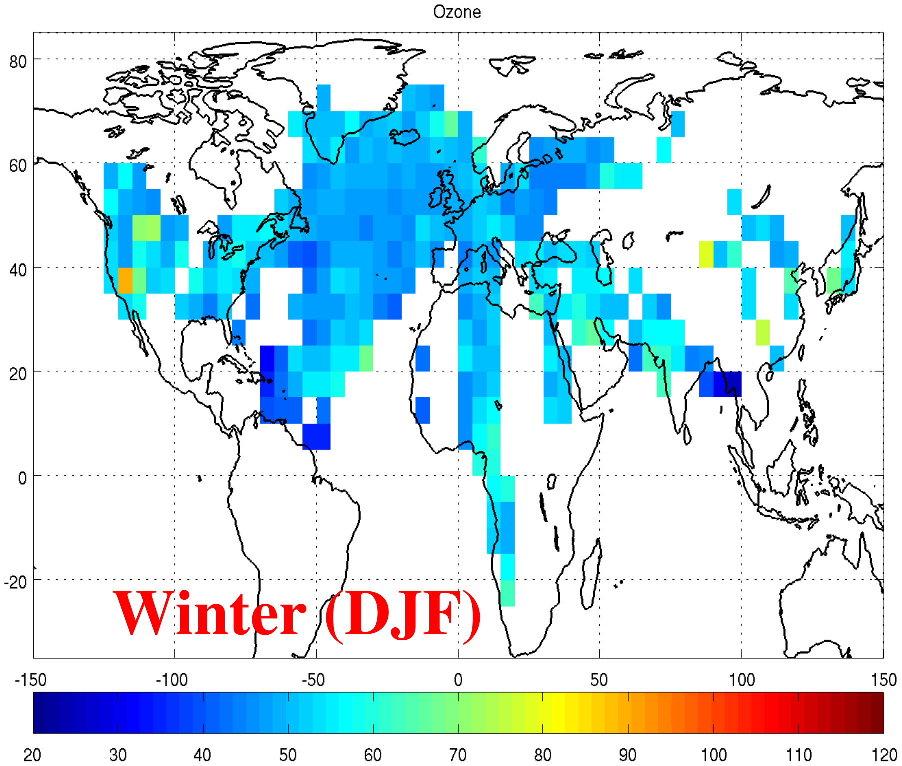


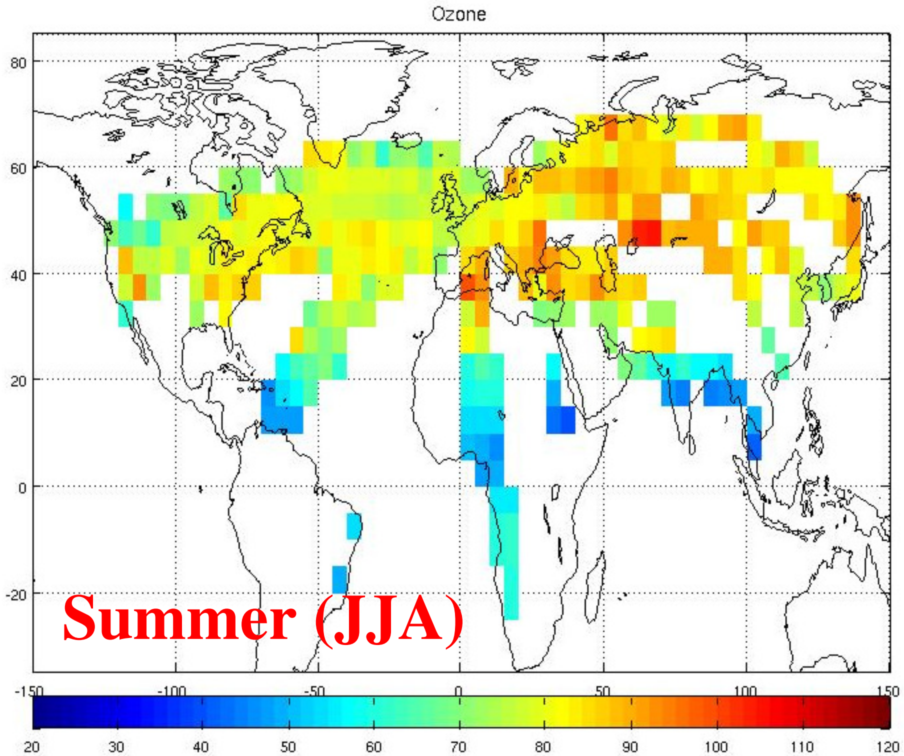
03 monthly means and seasonal cycle : transition between tropo and strato

Thouret et al., ACP 2006

UT seasonal climatologies

O3 : 2002-2008

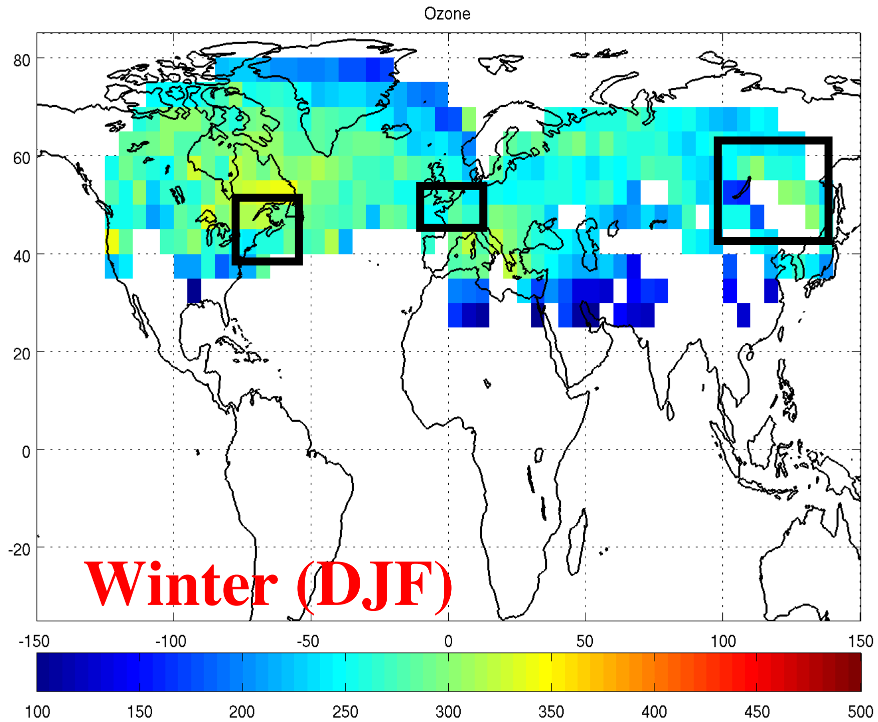


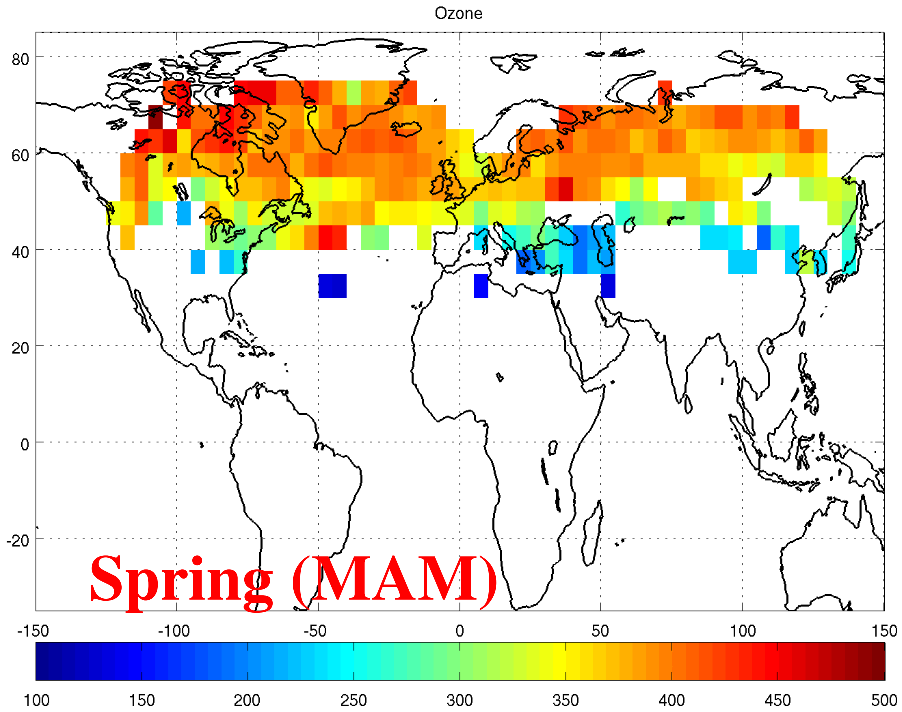


- O3 : summer maximum in the UT
- Higher concentrations of O3 in the eastern hemisphere in summer
- The Black Sea region is characterized by an O3 maximum and a CO minimum in summer (strong stratospheric influence ?)

LS seasonal climatologies

O3 : 2002-2008

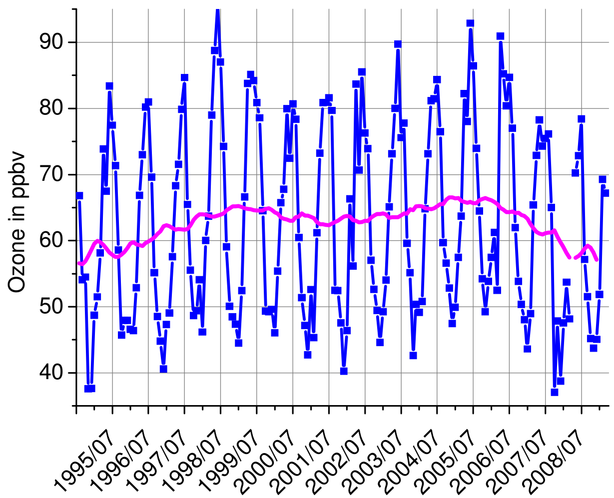




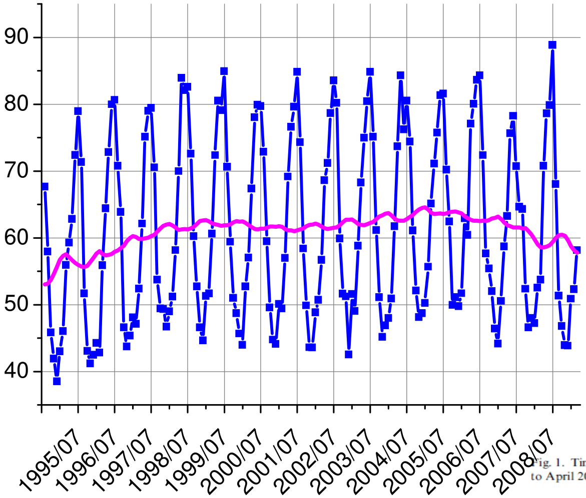
- Spring maximum in the LS
- Tropical influence south of 40°N

O3 in the UT since August 1994 - Atlantic

US East



EU West



Mace Head Ozone data
(From Derwent et al., 2007)

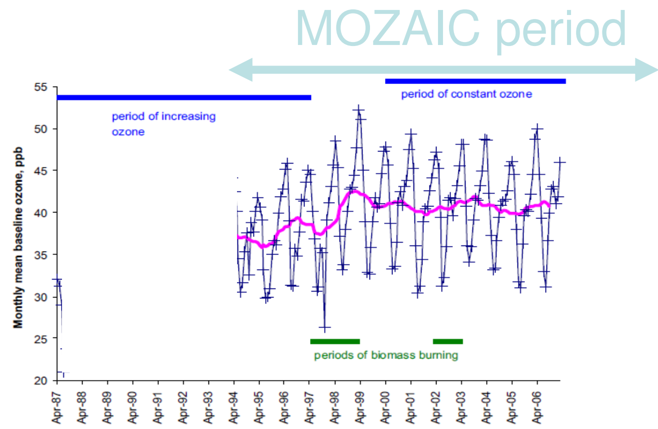
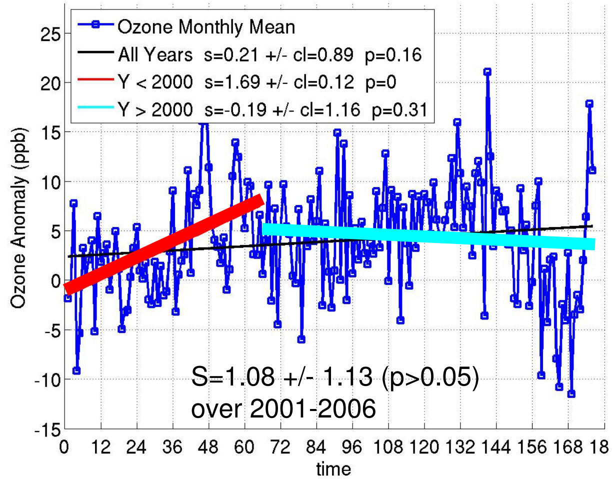
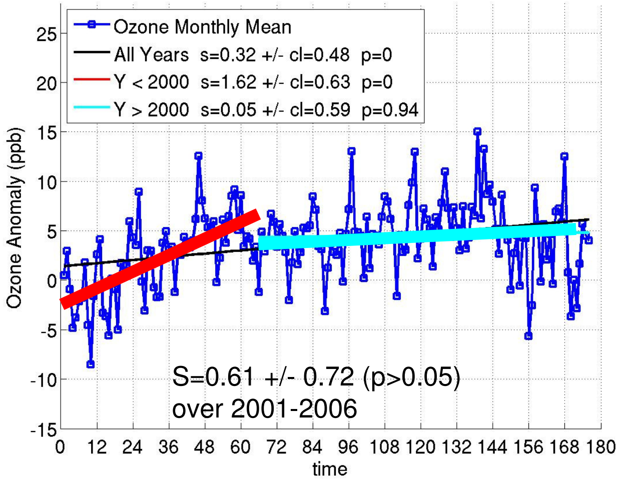


Fig. 1. Time development of the monthly mean (+) and 12-month running mean (solid line) baseline ozone mixing ratios from April 1987 to April 2007.



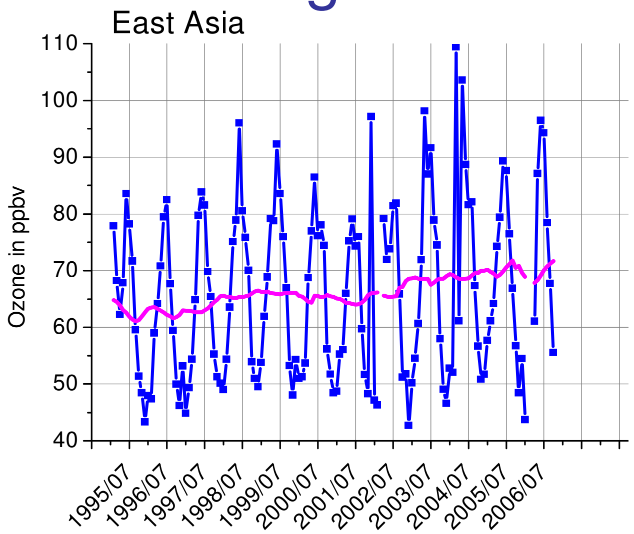


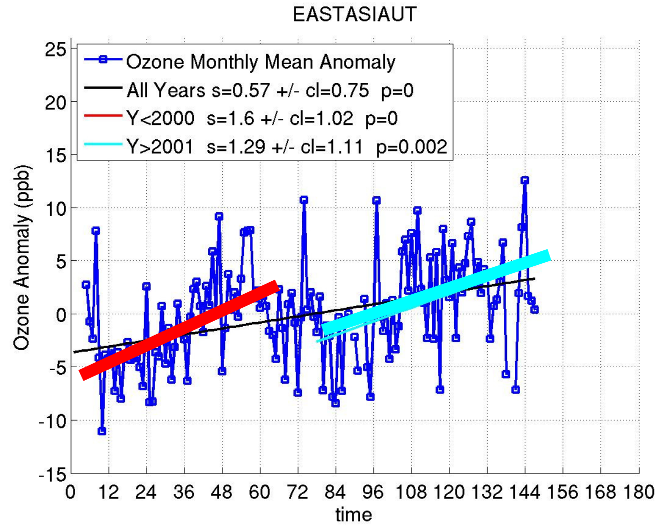
➔Same behaviour from surface to tropopause.
➔Impact of emissions reduction in EU and US ?
➔Impact of Asian emissions ? (not as global as expected)

- Meaningless linear regression ! (running mean better)
- Same behaviour between US East and EU West (Years<2002); Good agreement with surface data (remote area, i.e. background concentrations).
- Significant increase before year 2000 (1.6 ppb/year), levelling off after 2000.
- Difficult to get significant « trends ». Too short time serie ? strong anomaly in 1998-1999.

O3 in the UT since August 1994 – North East Asia

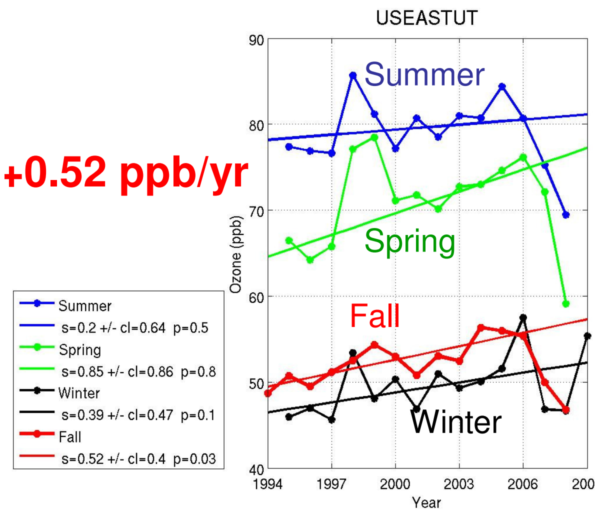
-Increase before 2000
(1.6 ppb/year)
-Increase after 2001
(1.3 ppb/year)
-Significant in both cases



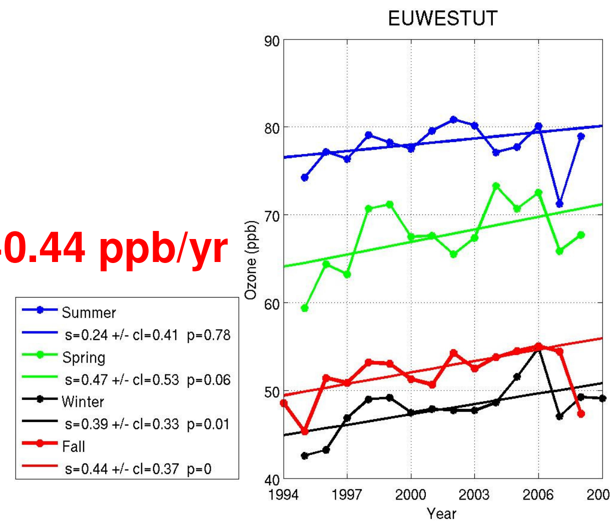


O3 in the UT since August 1994 – Seasonal behavior

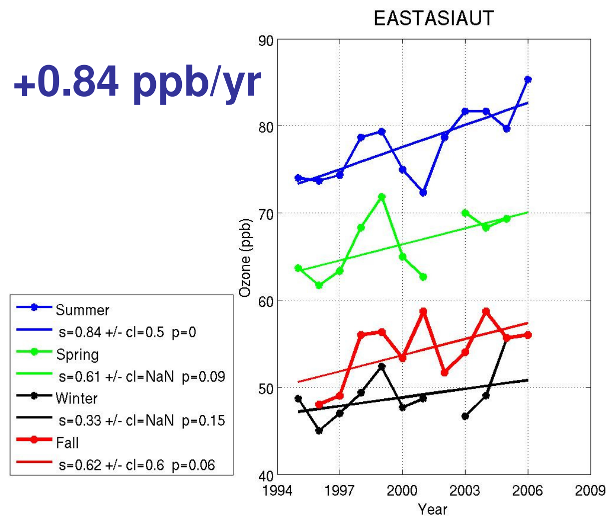
+0.52 ppb/yr



+0.44 ppb/yr

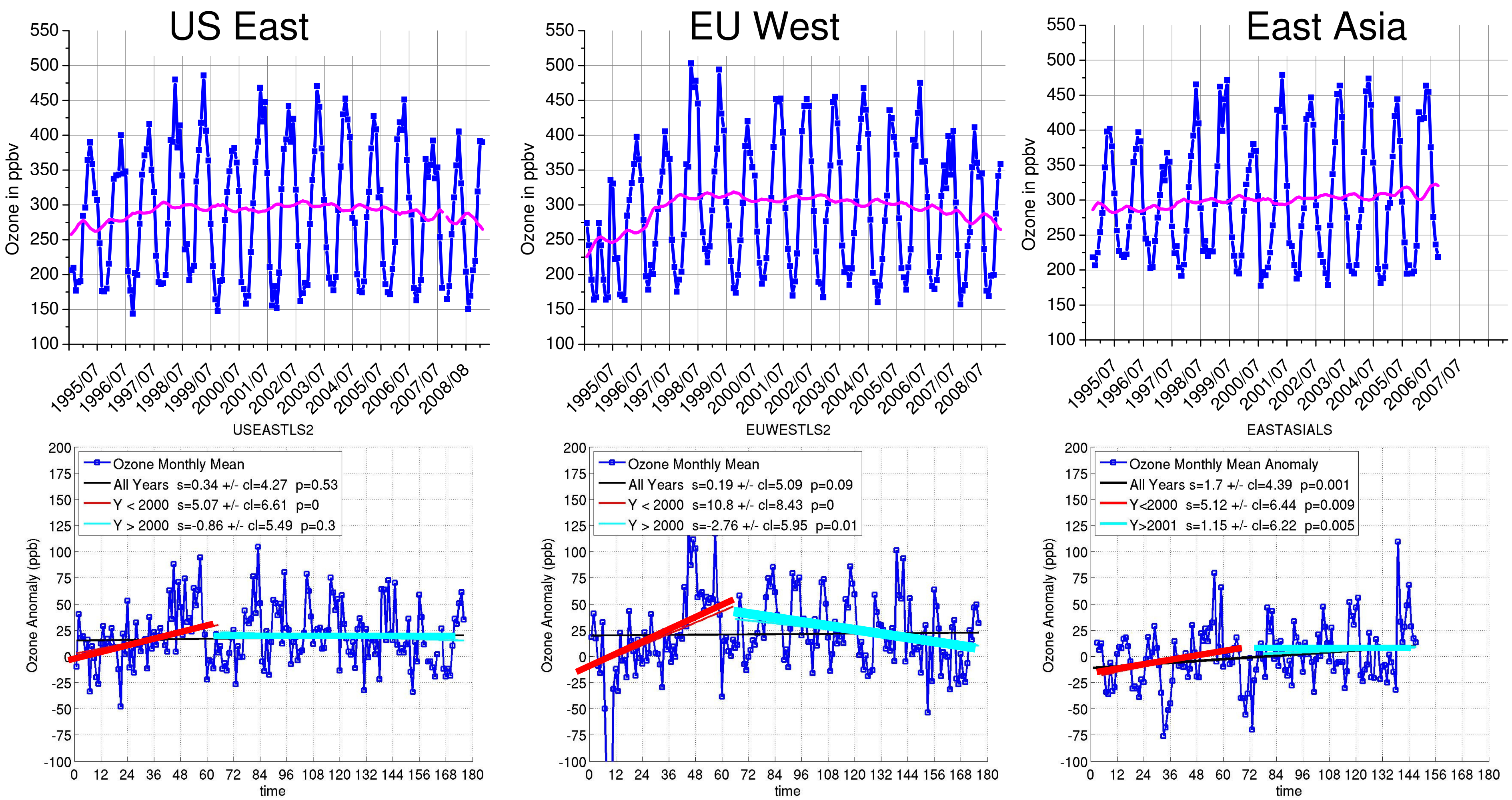


+0.84 ppb/yr



- Over the Atlantic sector : O3 increase in Fall ➔ background increase (large scale)
- Over North East Asia : O3 increase in Summer ➔ probably the effect of growing emissions (regional scale)

O3 in the LS since August 1994



- Same behaviour between US East and EU West, O3 increase before 2000, not after.
- Same behaviour as in the UT
- Strong anomaly in 1998-1999, hemispheric scale, ➔ still difficult to derive significant « trends », too short time serie

Conclusion on the role of MOZAIC-IAGOS:

Satellite validation :

- O_3 profiles are useful, CO even more…
- a few studies using the UTLS data

Trends detections :

- Atlantic sector, UT:
  - **O_3:** Increase before 2000, levelling off after 2000, no significant « trend »
  - Same behaviour as surface data (Mace Head, remote area station)
- East Asia, UT :
  - **O_3:** Increase before and after 2000, the only significant « O_3 trend » !
- Same rate of O_3 increase over 1995-2000 : 1.6 +/- 1.0 ppb/yr : Global feature ?
- LS :
  - No significant trend.
  - Strong coupling with the UT, actually (is our LS « too much UT » ?)
- 1998-1999 anomaly is still the major characteristic of our O_3 time serie (1994-2009) in the UT and in the LS.

Tropospheric O3 in south Asia

Polluted periods

-anticyclonic circulation over Northern India/Arabian sea

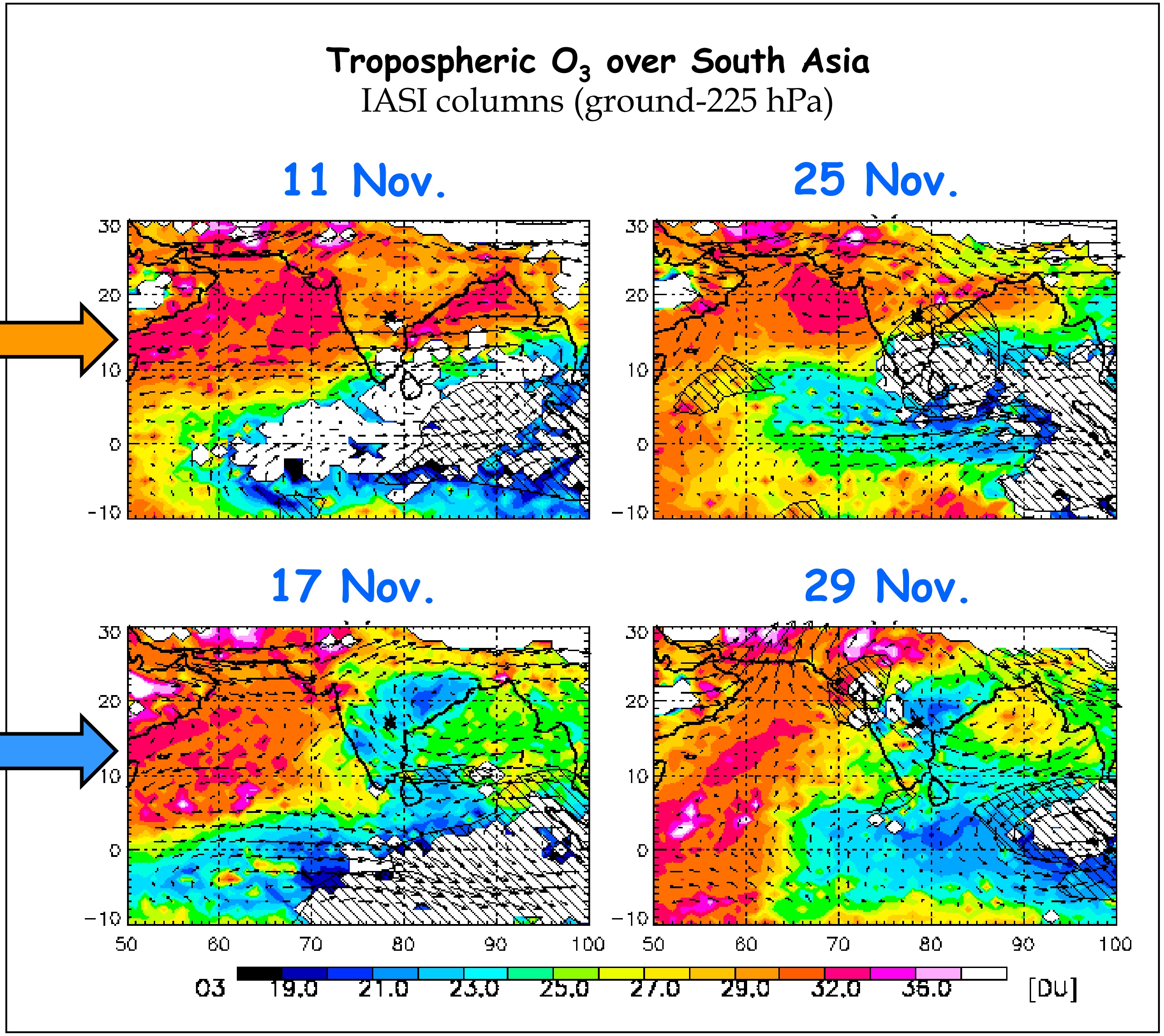
-O_3 accumulation in the free tropo.

Clean periods

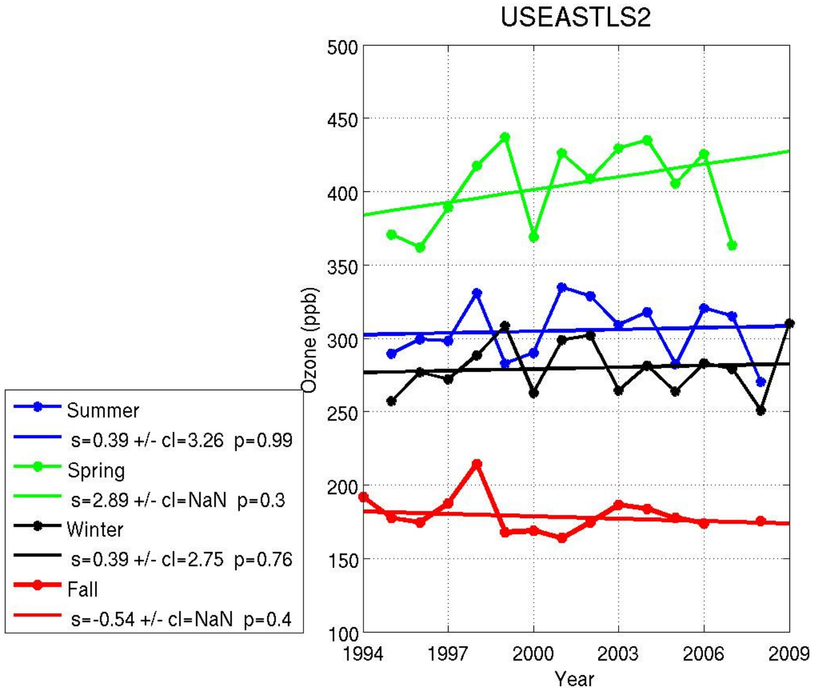
-after storm crossings

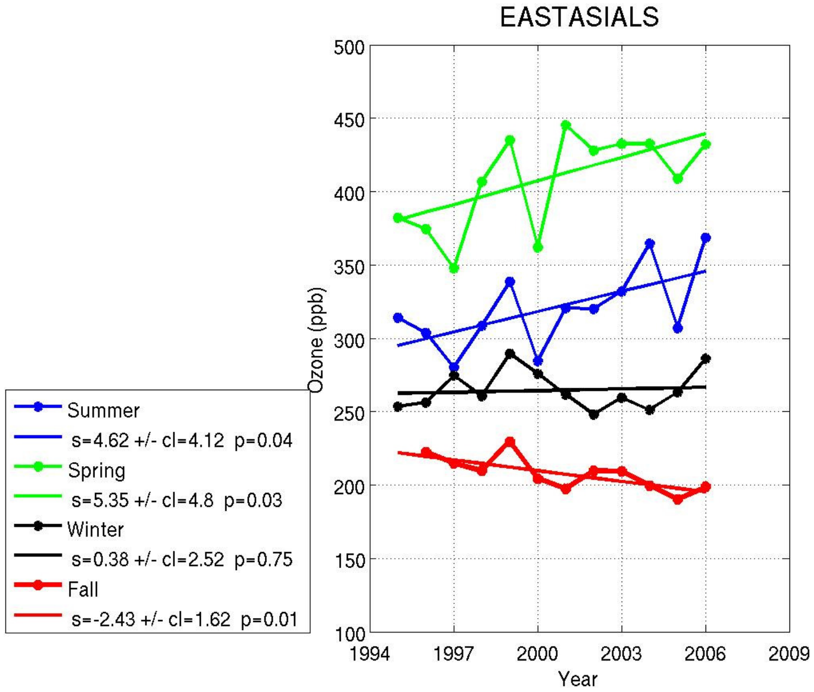
-air masses transport from the Gulf of Bengal MBL to the continental free tropo.

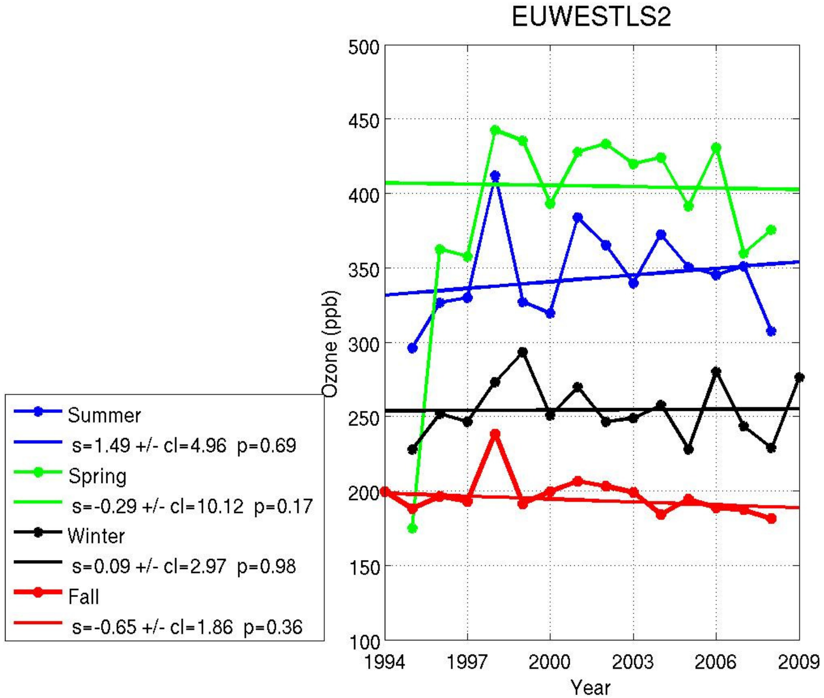
-little impact over the Arabian sea



Barret et al., ACP, submitted







Besides the 1998-1998 anomaly :

The only significant « O3 increase »
is observed over Asia in Spring
and Summer.

Effect of growing emissions as in the UT ?