Ozone Hindcast

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AC&C meeting, Washington DC, June 2008

Major factors driving changes in tropospheric ozone:

- trends in precursor emissions, especially NO_x
  - increases in Asia, increases then decreases in Europe, U.S.
- trends in methane
- interannual variability in biomass burning
- changes in ozone in the lower stratosphere (LS)
- dynamical variability, e.g., AO, ENSO, STE, ..
- climate change, temp. trends etc

Time periods for hindcast:

- **1980 – present**
  - **consistent with other hindcasts**
- **1990 – present**
  - **large changes in lower strat. ozone**
- **2000 – present**
  - **satellite data for CO, aerosols, trop. NO_2**
  - **Aura data from 2004 on**
- **Three periods to accommodate groups with different resources, interests**

Model Issues:

- **assimilated or reanalyzed met. data best for comparisons to observations, GEOS-4, 5; ECMWF, ..**
- **GCM met. data also useful (these will be used for future scenarios)**
  - **sometimes nudged to met. data**
  - **can look at effects of ENSO, AO, changes in strat. ozone, etc**
- **realistic treatment of changes in ozone in the lower stratosphere is essential – changes in 1990s**
- **"complete" treatment of stratospheric and tropospheric processes is ideal**
- **coupled aerosol-gas phase chemistry - some models**

Some issues with emissions:

- Use best regional emissions in areas where global inventories have known problems, e.g., China
  - Need to use provincial energy statistics for China (Zhang, Streets et al, JGR; Ohara, Akimoto et al., ACP)

- Incorporate latest info. on NO_x decreases in US, Europe

- are aerosol emissions consistent with gas-phase emissions?
  - e.g., is the same biomass burning inventory used?

- GFED2 for biomass burning after 1996
- TOMS AI scaling before 1996?
- RETRO used a fire-model in many regions

Simulations

- **HC – ozone**
  - **Groups choose emissions**

- **HC.ACC – ozone**
  - **Groups use recommended set**
  - **HTAP looks promising, but need to go back to 1980**
  - **IPCC does not look promising, but goes back to 1980**
  - **Discuss tomorrow**

- **HCC-ozone-sens**
  - **Sensitivity studies to isolate causes of trends and IAV**

Learn from previous intercomparisons and hindcasts:

- ACCENT
- AEROCOM
- RETRO
- HTAP
- CCMVal
- Hindcasts with GEOS-Chem
- Others?

Discuss in break-out group this afternoon

Data for model evaluation

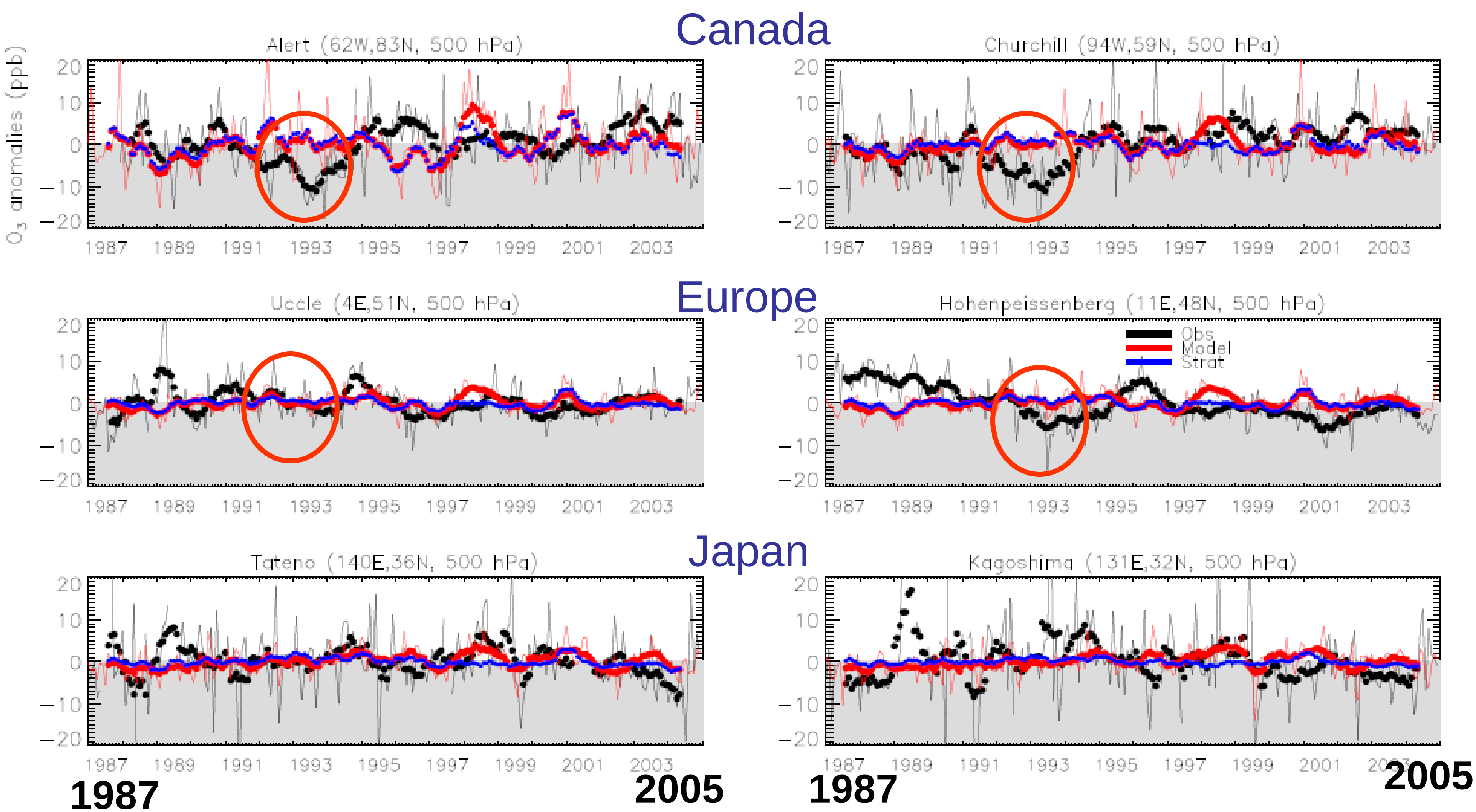
- CO - NOAA/GMD surface stations, MOZAIC aircraft data, MOPITT, …..
- NO_2 – GOME, SCIAMACHY, OMI columns – issues with different retrieved products
- Ozone – surface stations, sondes, MOZAIC, TCO products, satellite data for the LS (SAGE, Aura MLS)

GEOS-Chem hindcast (Koumoutsaris et al.,2008)

- GEOS-4 met. data for 1987-2005
- Temporal scaling of a base inventory for fossil fuel emissions (1985-1998, constant after 1998)
- Scaling of a biomass burning inventory using TOMS AI and ATSR data (update of Duncan et al., 2003)
- Aerosols did not change
- Same flux of ozone from the stratosphere every year (SYNOZ method)

- Focus here on ozone results (CO matches data fairly well, and is better understood, see also Duncan et al., 2007, 2008)

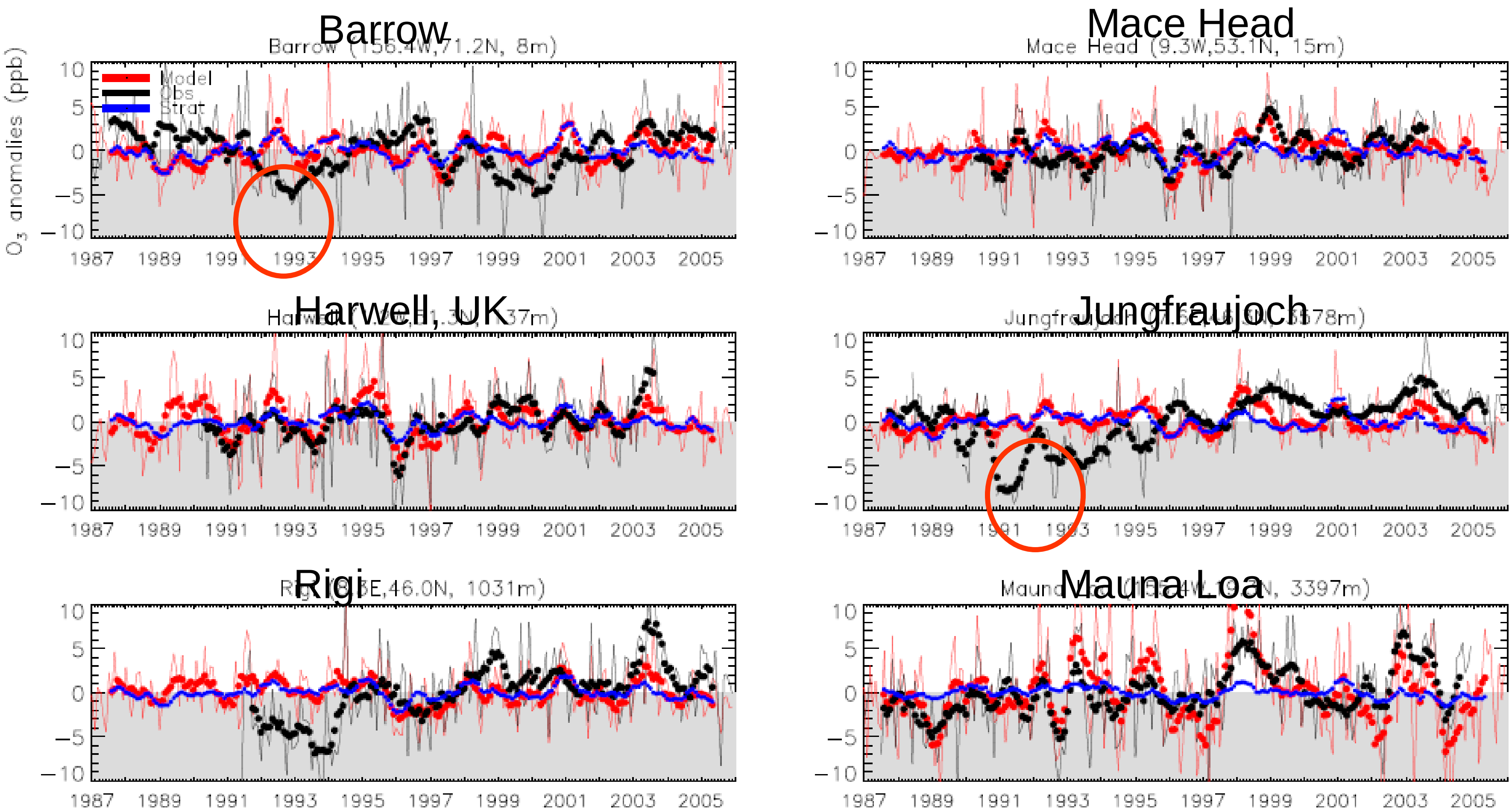
Ozone anomalies (500 hPa)



(Koumoutsaris, Bey, Generoso, and Thouret, in review, JGR).

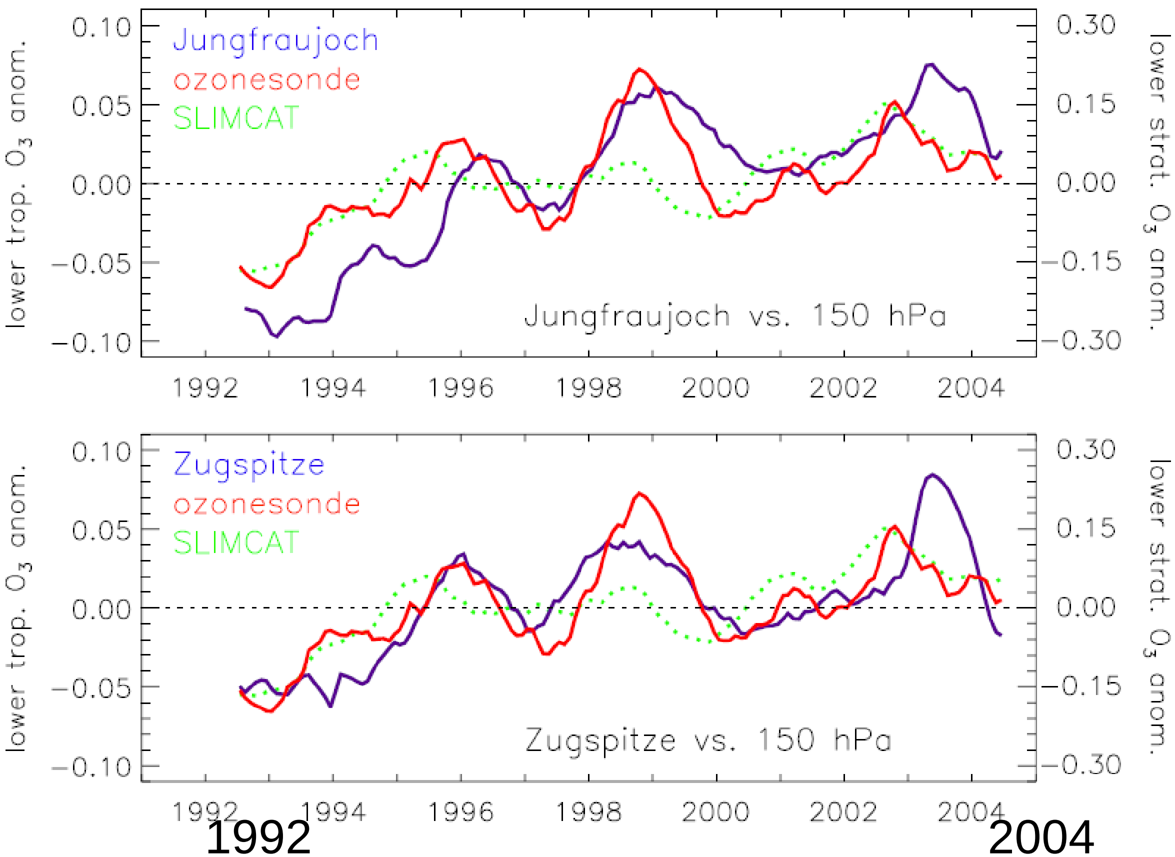
Observations (12 mon. means)
Model (GEOS-Chem)
model stratospheric ozone

Surface ozone



Observations (12 mon. means)
Model (GEOS-Chem)
model stratospheric ozone

Red: sondes at 150 hPa
Blue: mountain sites in Europe



12-mon means

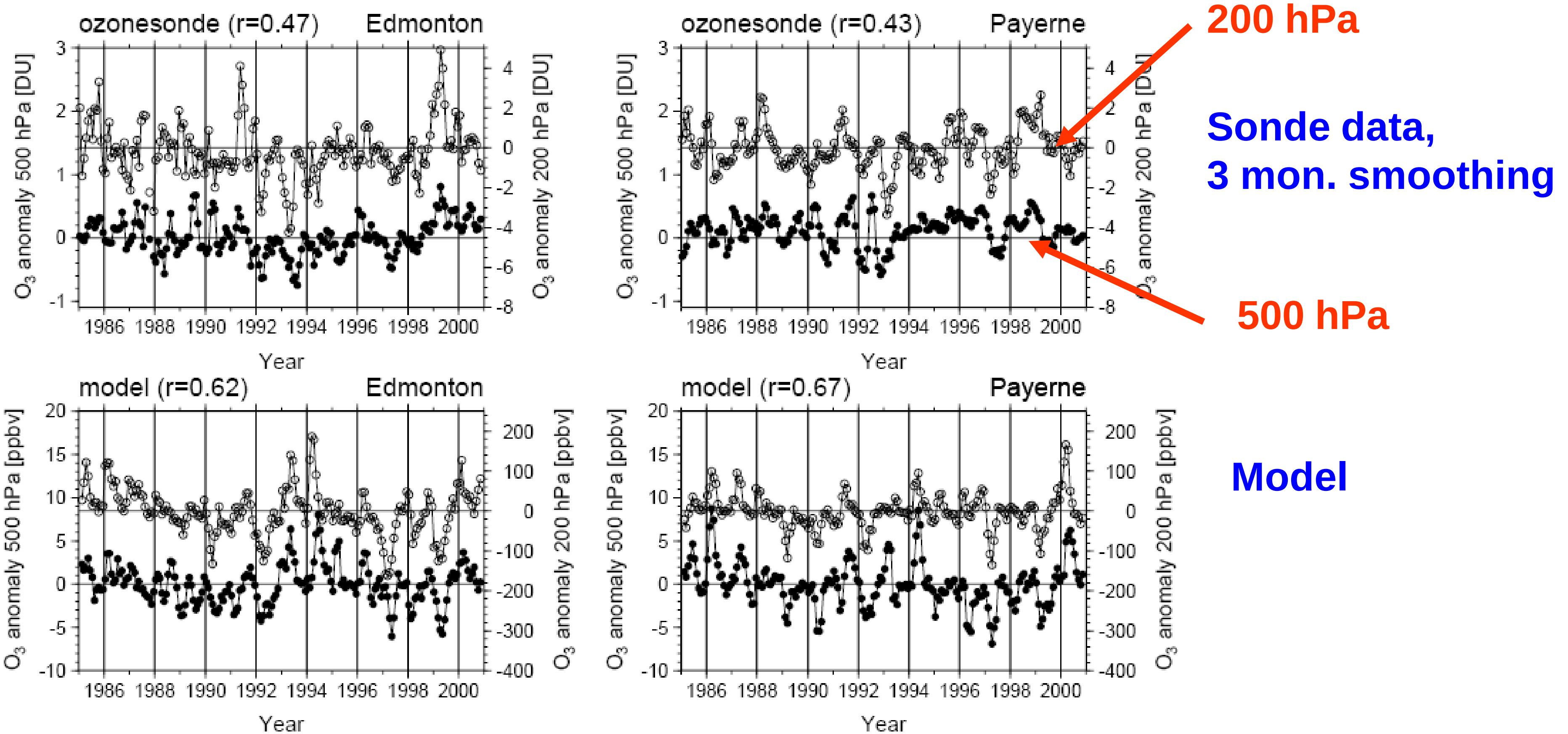
Tropospheric ozone appeared to respond to changes in ozone in the lower strat. after the Pinatubo eruption in 1991 – low trop. ozone in 1992-93: e.g.,

Fusco and Logan (2003), sonde stations

Tarasick et al., JGR (2005) for Canadian sonde stations

Ordonzes et al., GRL (2007) for Europe

Ozone for 1985-2000



Goddard CTM, GCM met. data, 50 year run of stratospheric chemistry, simple P and L for trop. ozone, the same every year (from GEOS-Chem) [Terao et al., in press, JGR)

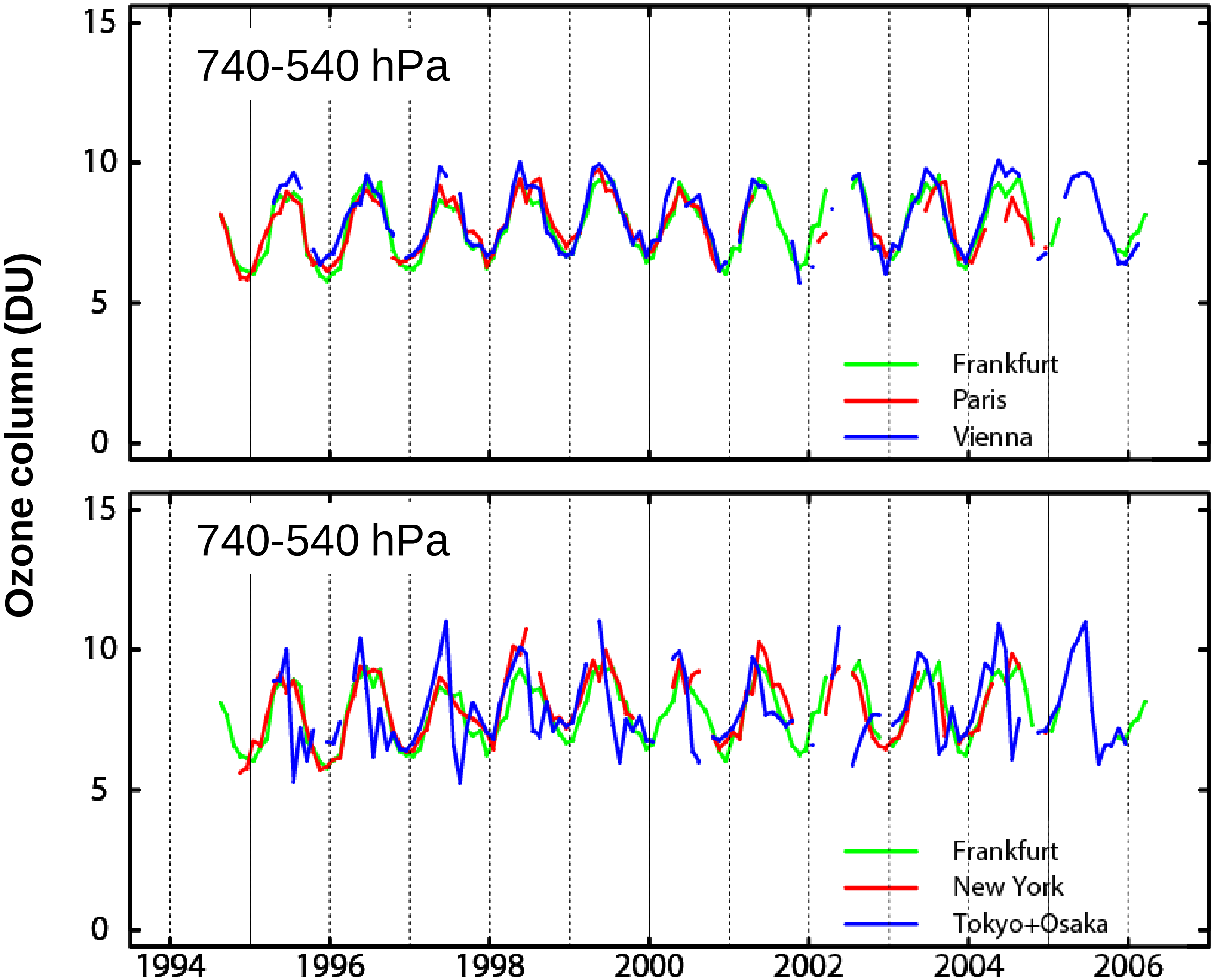
Some data issues

- Focus here on data above the surface (not that there are no issues with surface data)

- Europe has the most long-term records from sondes
- 3 profiles/week at 3 sites, two since 1960s
- Weekly data at several other sites
- Also frequent ascents and descent of MOZAIC aircraft, since late 1994

MOZAIC ozone data, 1994-2006

(Zbinden et al., Thouret et al., ACP, 2006)

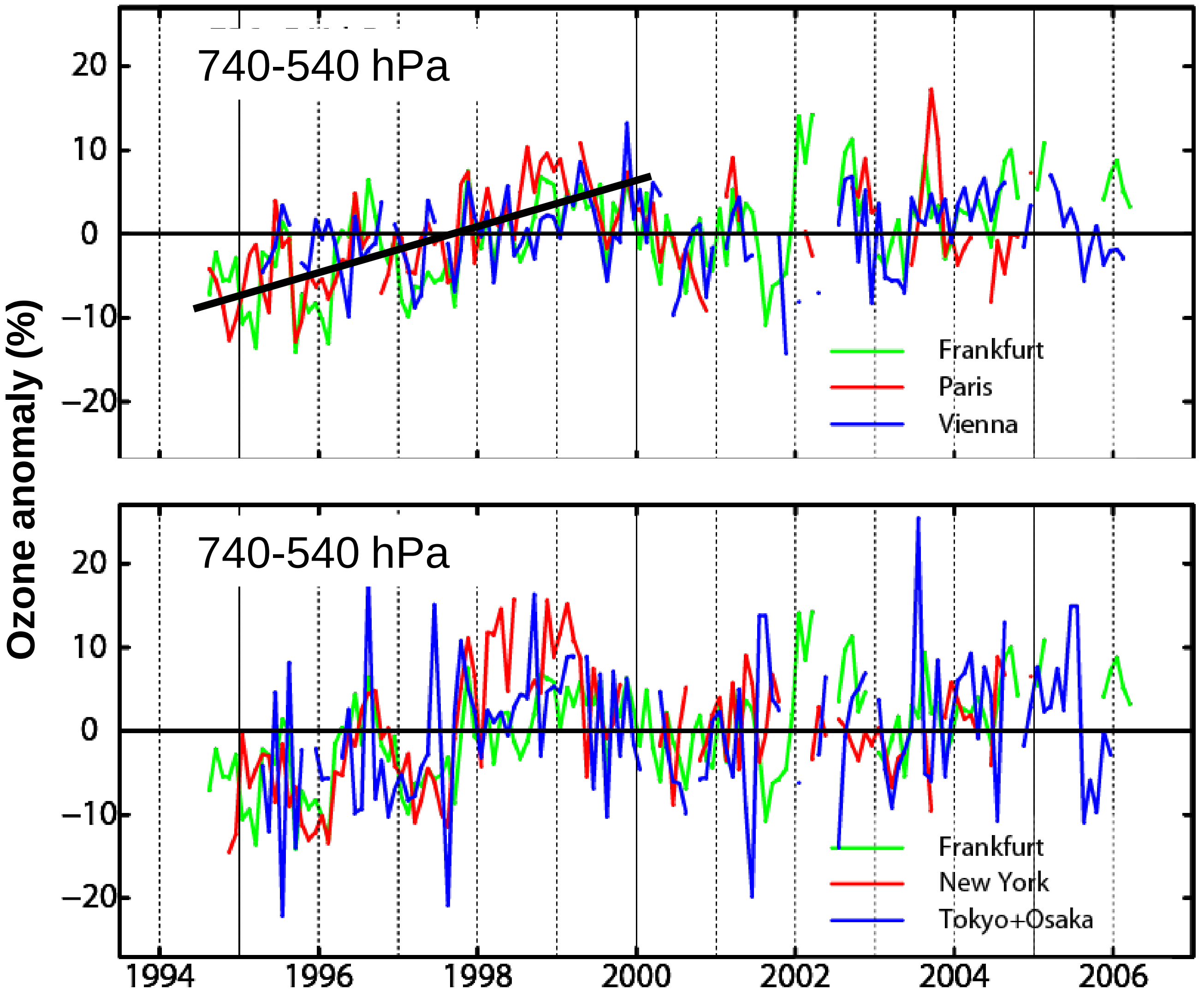


3 airports in Europe – very alike

N>10 per month

Europe
East US
Japan

MOZAIC ozone anomalies, 1994-2006

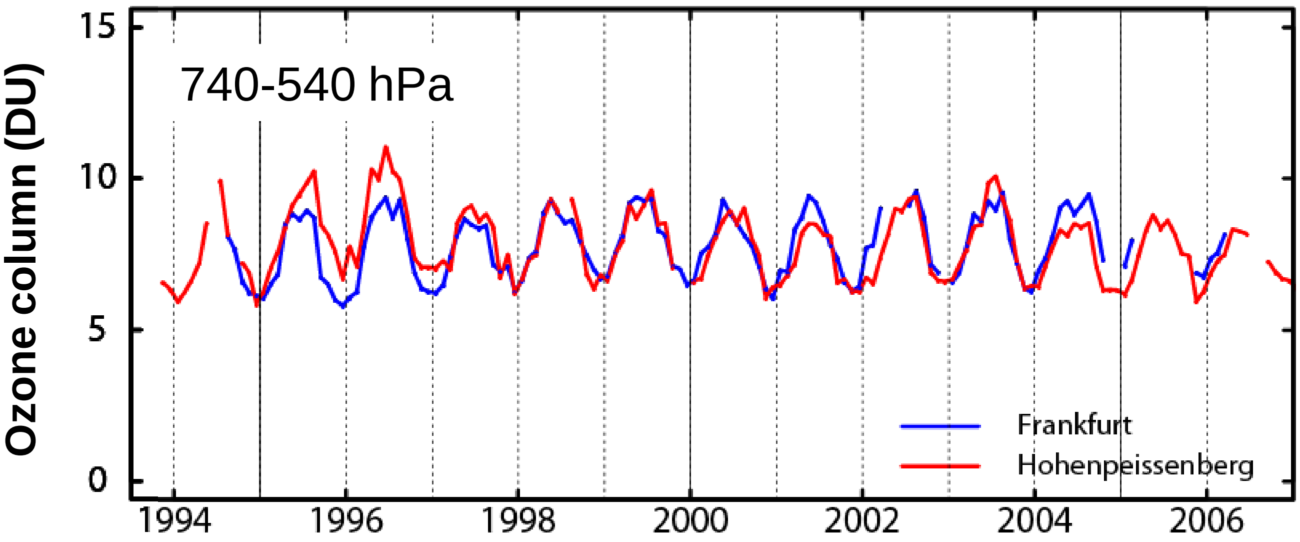


3 airports in Europe

Europe
East US
Japan

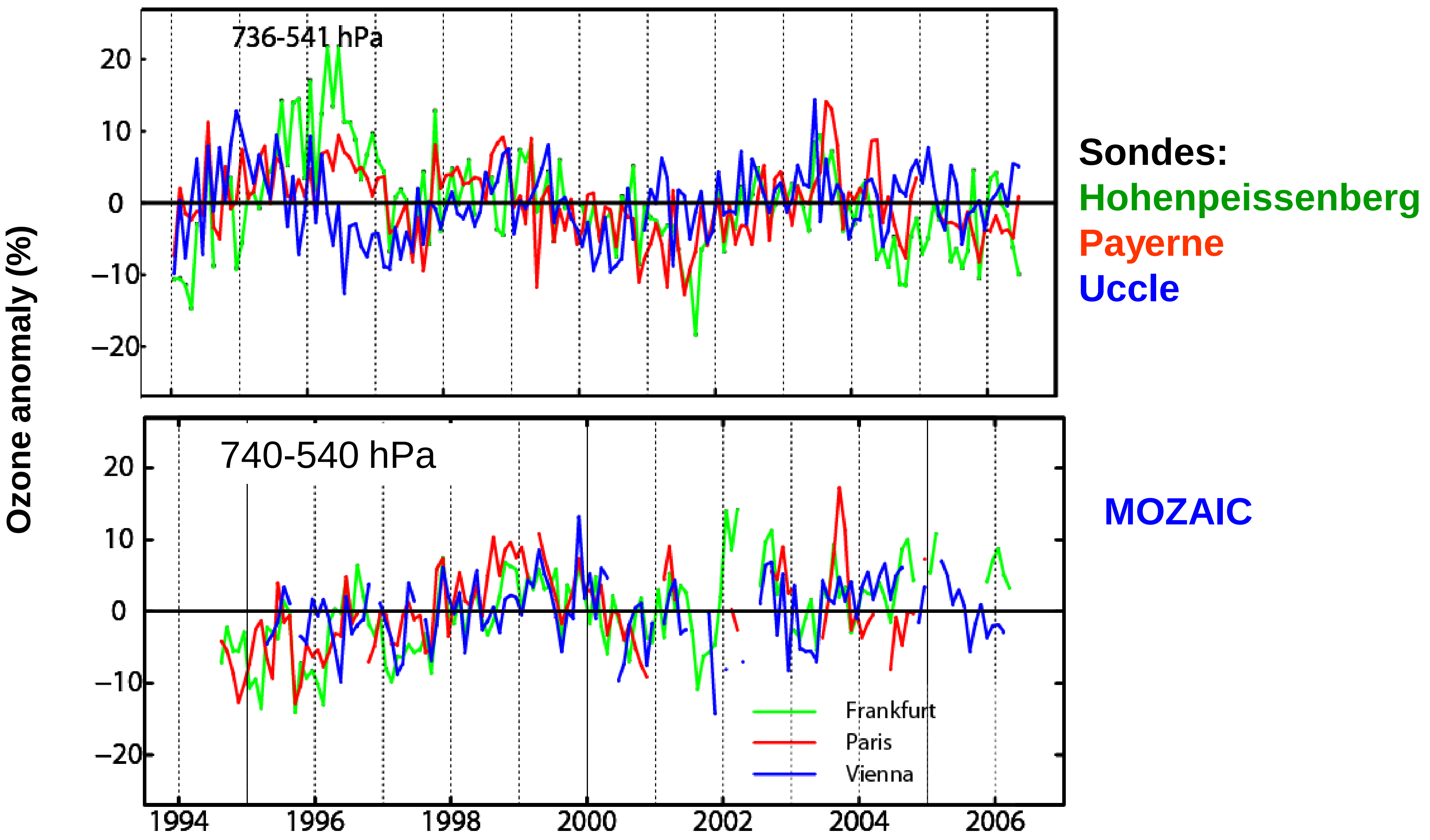
Consistent time dependence in Europe, Eastern US and Japan

How do sondes and MOZAIC compare?
Frankfurt (blue) and Hohenpeissenberg (red)

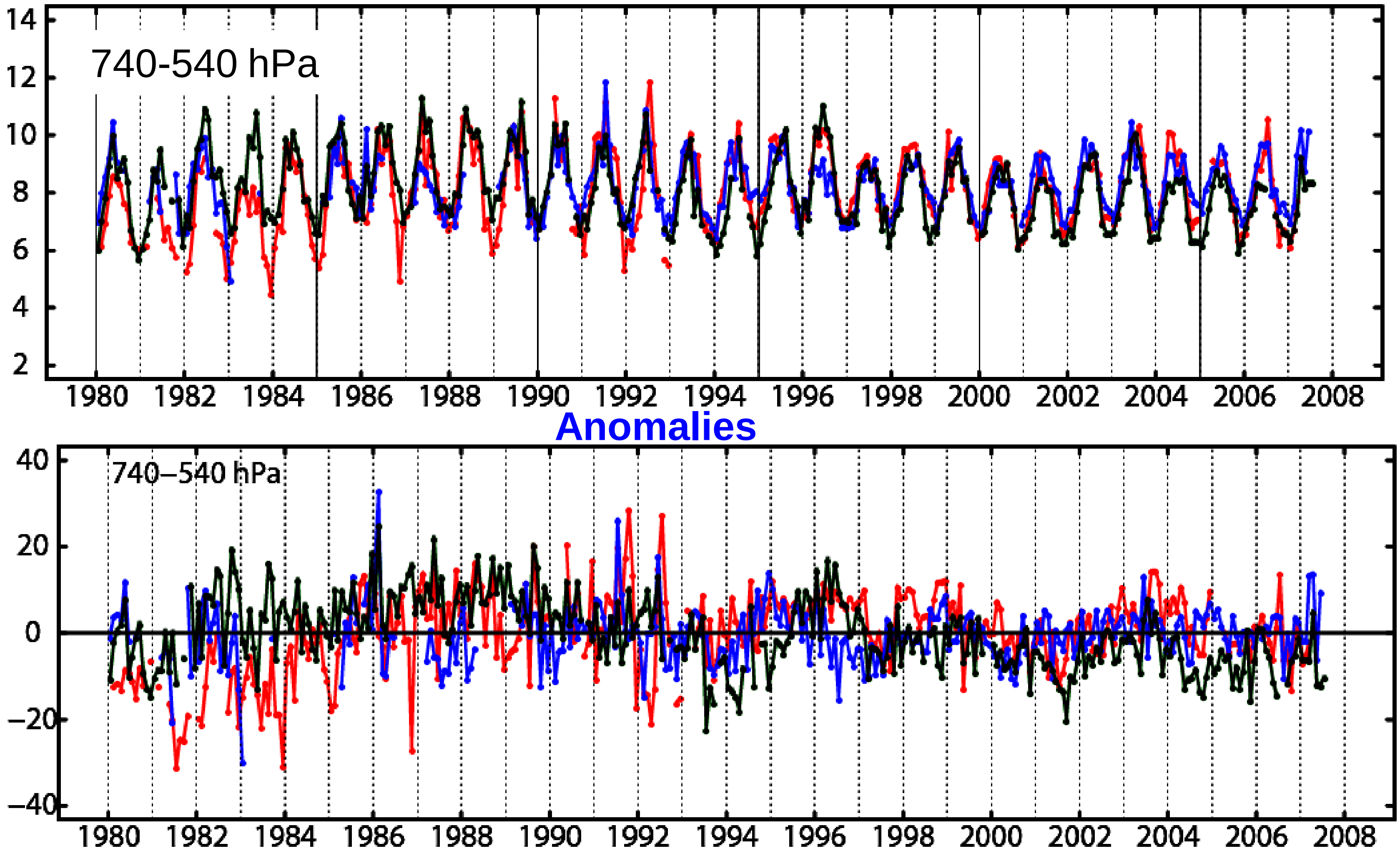


Sondes > MOZAIC in 1995-96 (as in Thouret et al., 1998)
Similar in 1997-2004.

Sonde stations do not show an increase in 1995-2000

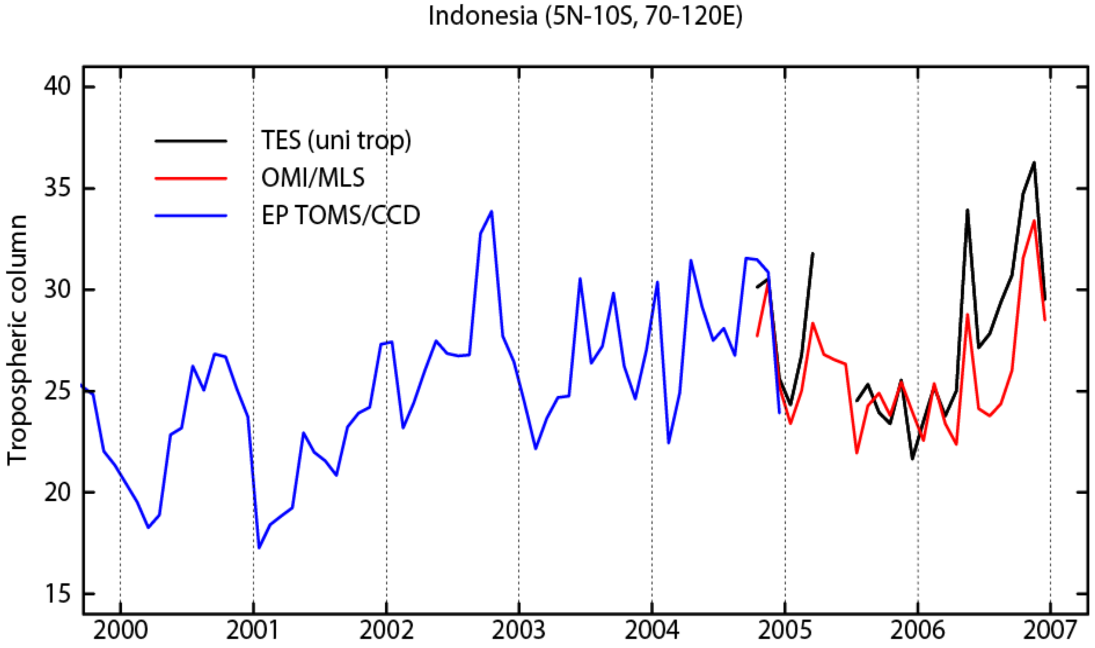


Sonde data over Europe, 1980-2007

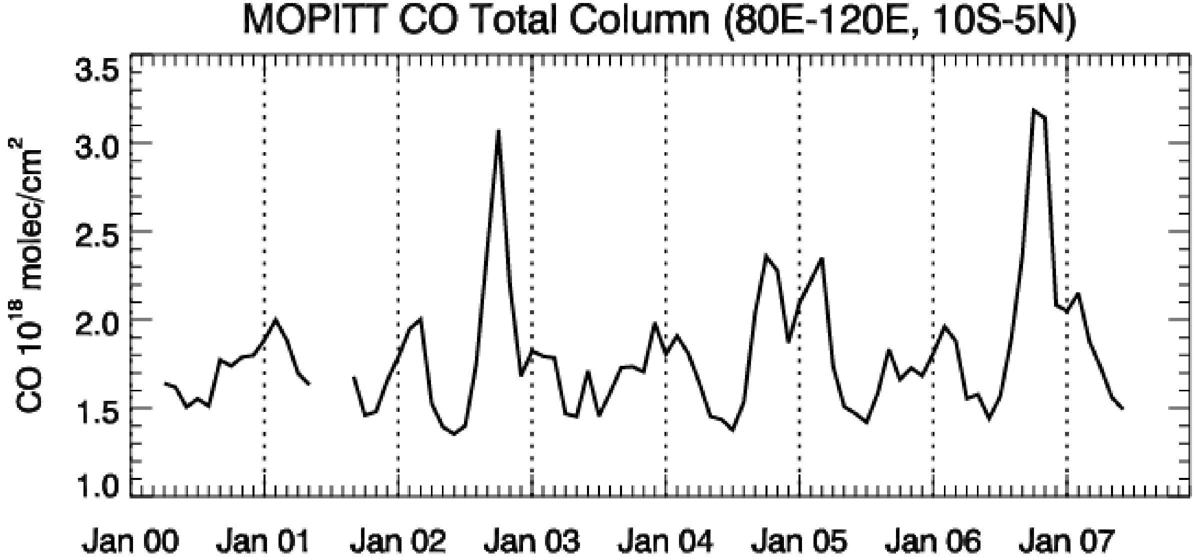


Only Hohenpeissenberg (black) shows a long –term decrease since ~1985. Payerne (blue) and Uccle (blue) do not.

Largest IAV in tropospheric ozone is in the tropics over Indonesia and the eastern Indian Ocean



Ozone – trop. column 2000-2006



CO – trop. column

Summary – main challenges

- EMISSIONS

- What exactly are we trying to hindcast?? Need more data analysis.