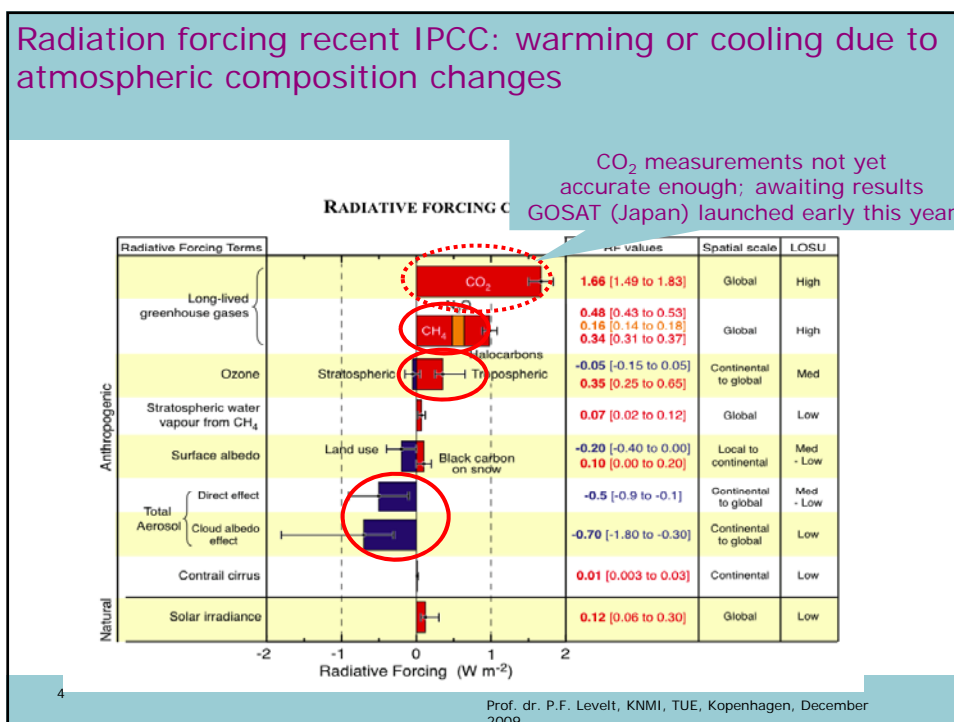
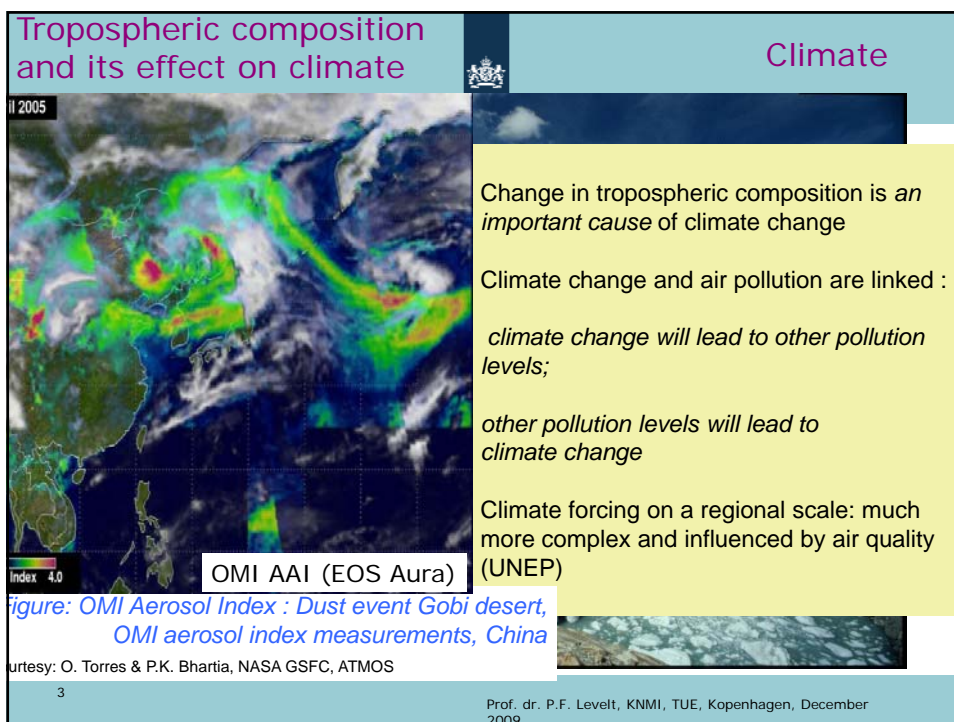


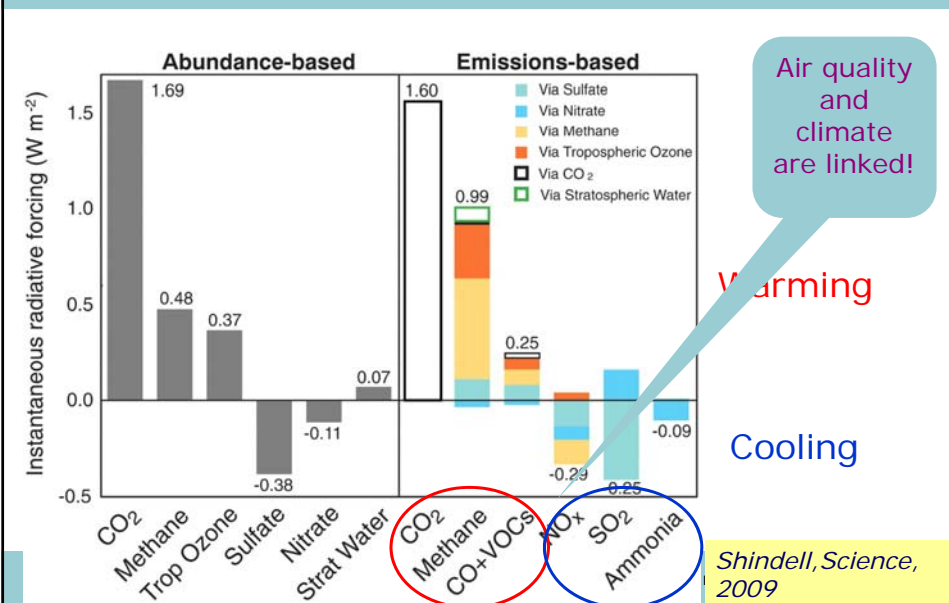
- Human population growth (9 billion in 2050)
- Growth in use of Energy, especially by the developing world
- Fossil fuel needs will increase
- Increase of air pollution
- Increase of greenhouse effect (climate)

Industrial and traffic emission sources
Courtesy: David G. Streets *Atmospheric Environment* 41 (2007) 480–492

Biomass burning emission sources
Courtesy: R. Noordhoek (KNMI)



New!: Impact of air pollutants NO₂, SO₂ and CO on climate Emission based estimates (Kopenhagen)



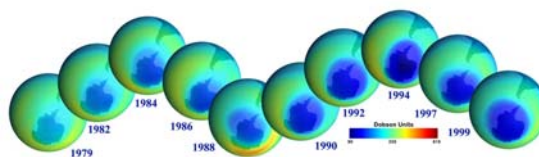
Satellite measurements of the tropospheric emissions are essential for understanding Climate Change

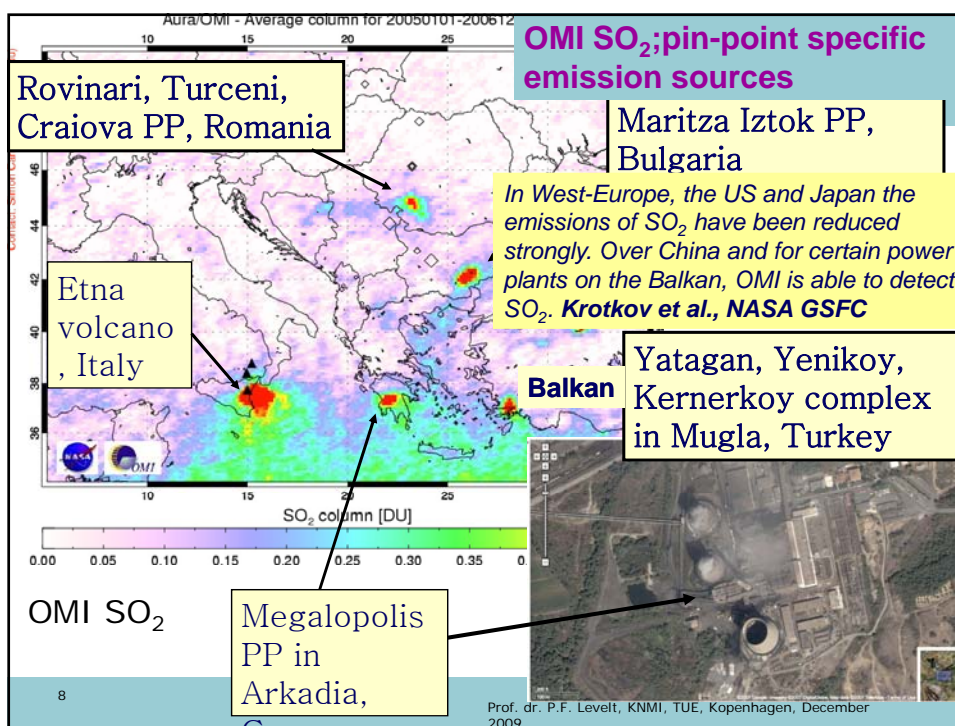
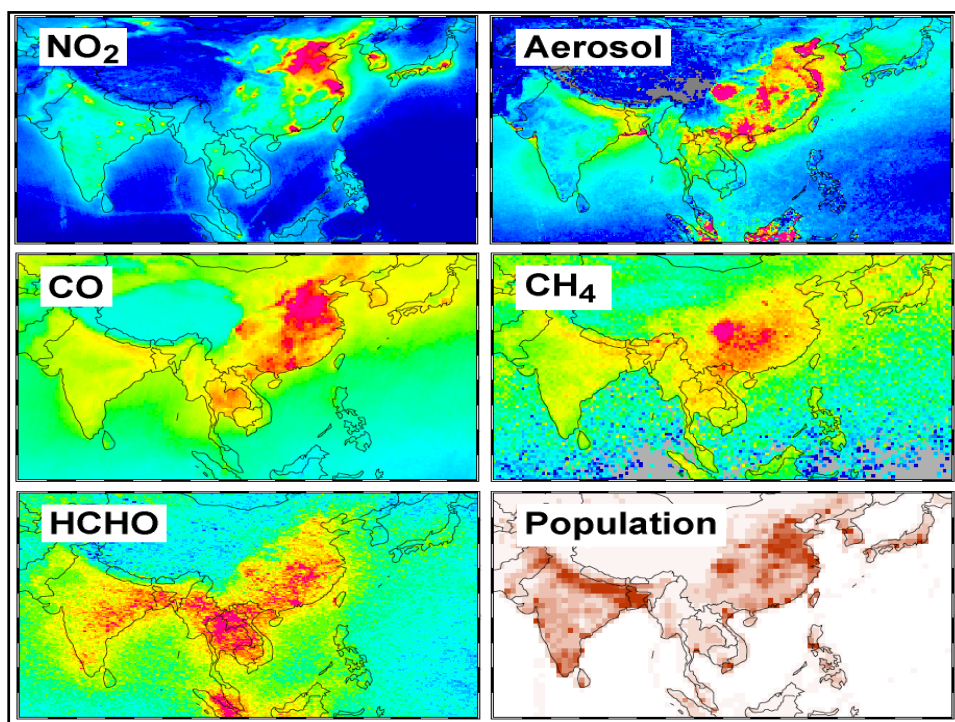
- Satellite based emission estimates are essential
 - To improve climate model prediction
 - To validate climate models
 - To control emissions (Kopenhagen)
- Satellite data provide global coverage
- For climate long satellite based data
- records are needed

Aerosols have a large impact on climate change

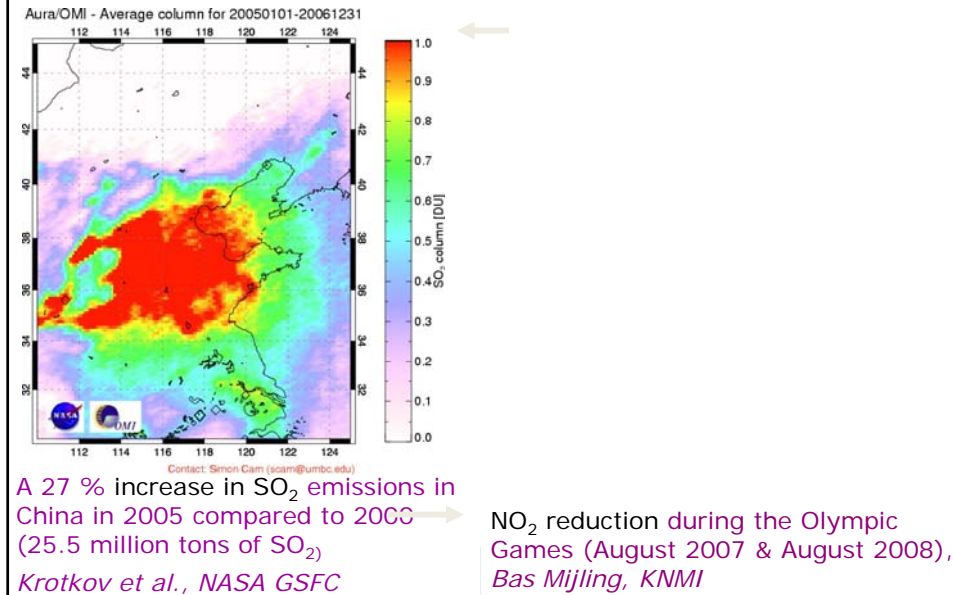


*30 year ozone record
Based a.o. OMI data
Montreal & Kyoto Protocol*





Can we control emissions and measure these changes from satellites?



Dutch & KNMI involvements in satellite measurements

GOME (ESA)

Launched April 1995 (ESA's ERS-2)

SCIAMACHY (Germ-Neth-Belg)

Launched February 2002 (ESA's ENVISAT)

OMI (Neth-Finl) (KNMI, PI)

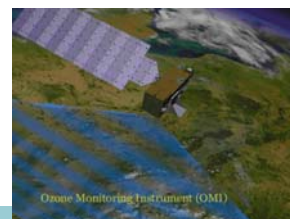
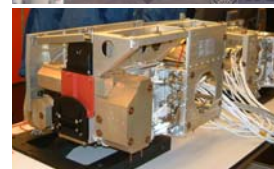
Launched July 2004 (NASA's EOS-Aura)

GOME-2 (ESA)

Launched October 2006 (EUMETSAT's METOP-1)

TROPOMI (Neth, ESA) (KNMI, PI)

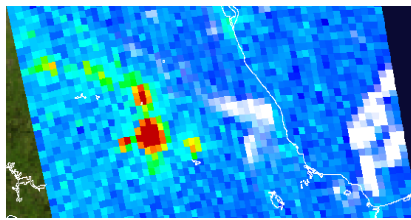
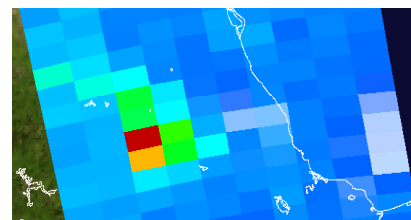
New instrument; cooperation ESA, 2013/2014



TROPOMI



- Will continue data records ozone, aerosols, clouds and precursors (NO₂, SO₂, HCHO, CO) of ozone and aerosols
- Will continue methane (CH₄) measurements of SCIAMACHY
- Will provide more accurate tropospheric data products
- Will provide daily sub-urban scale (7 x 7 km²) measurements and daily global coverage

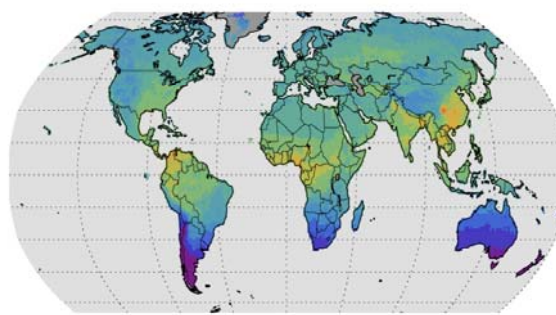
OMI Zoom 12x13 km²

Approx. GOME-2 72x39 km²

11

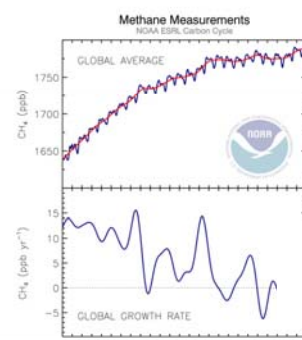
Mexico City January 20, 2005

SCIAMACHY methane measurements



1640. 1655. 1670. 1685. 1700. 1715. 1730. 1745. 1760. 1775. 1790. 1805. 1820.

Satellite observations of distribution
(SCIAMACHY; Years 2003-2005)



Top: Global average atmospheric methane mixing ratio (blue line) determined using measurements from the Carbon Cycle cooperative air sampling network. The red line represents the long-term trend. Bottom: Global average growth rate for methane. Contact: Dr. Ed Dlugokencky, NOAA ES&R, Carbon Cycle, Boulder, Colorado 80507-6120, ed.dlugokencky@noaa.gov, <http://www.es&r.noaa.gov/ccsd/ccscr/>

Surface observations
of declining trend:
Could be connected
with increased
pollution

12

Kennismaken met
Levelt, KNMI, TUE

Conclusions



- Satellite measurements of the troposphere play an important role in understanding climate change
- Air quality monitoring is important for climate monitoring
- TROPOMI will extend current record of GOME, SCIAMACHY and OMI measurements and will fill the gap to sentinel-5: long term records
- Satellite measurements are available and suited for controlling emissions and validate climate models.

Emission control in Beijing
for the Olympic games
Mijling et al, 2008