

- 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)

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

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

The slide features a background image of a cityscape and a river. A yellow text box contains a list of projected future trends. Below the list, there are two sections: 'Biomass burning emission sources' and 'Industrial and traffic emission sources', each with a corresponding courtesy credit.

Tropospheric composition and its effect on climate

OMI AAI (EOS Aura)

Figure: OMI Aerosol Index : Dust event Gobi desert, OMI aerosol index measurements, China

Source: O. Torres & P.K. Bhartia, NASA GSFC, ATMOS

Climate

Change in tropospheric composition is an important cause of climate change

Climate change and air pollution are linked :

climate change will lead to other pollution levels;

other pollution levels will lead to climate change

Climate forcing on a regional scale: much more complex and influenced by air quality (UNEP)

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Prof. dr. P.F. Levelt, KNMI, TUE, Copenhagen, December 2009

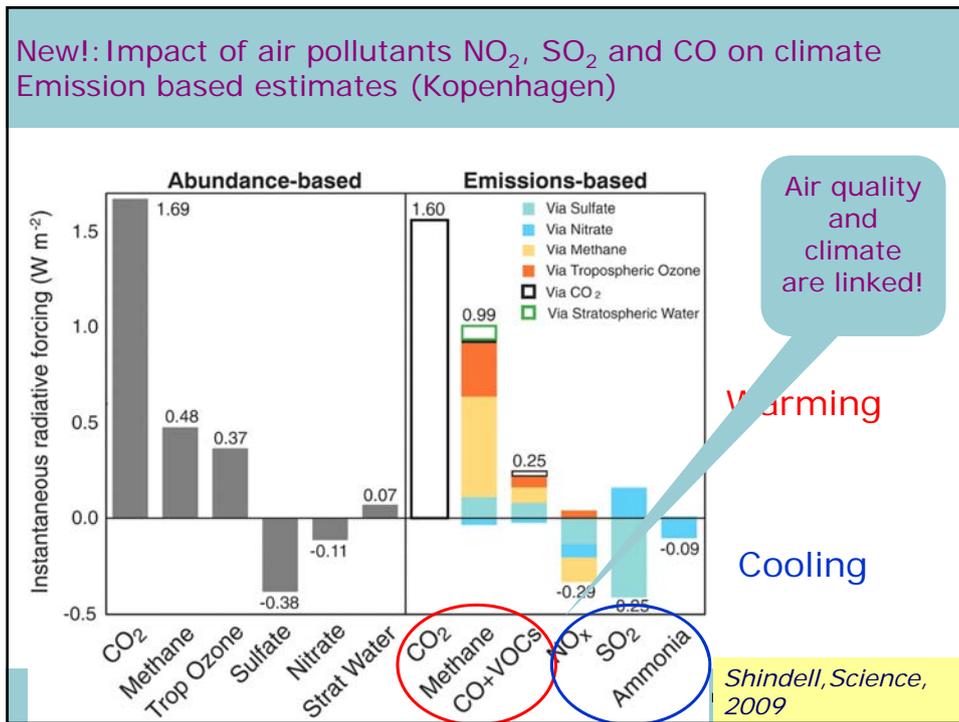
Radiation forcing recent IPCC: warming or cooling due to atmospheric composition changes

Radiative Forcing Terms	RF values	Spatial scale	LOSU
Long-lived greenhouse gases			
CO ₂	1.66 [1.49 to 1.83]	Global	High
CH ₄	0.48 [0.43 to 0.53]	Global	High
HFCs	0.16 [0.14 to 0.18]		
PFCs	0.34 [0.31 to 0.37]		
SF ₆			
Ozone			
Stratospheric	-0.05 [-0.15 to 0.05]	Continental to global	Med
Tropospheric	0.35 [0.25 to 0.65]		
Stratospheric water vapour from CH ₄	0.07 [0.02 to 0.12]	Global	Low
Surface albedo			
Land use	-0.20 [-0.40 to 0.00]	Local to continental	Med - Low
Black carbon on snow	0.10 [0.00 to 0.20]		
Total Aerosol			
Direct effect	-0.5 [-0.9 to -0.1]	Continental to global	Med - Low
Cloud albedo effect	-0.70 [-1.80 to -0.30]	Continental to global	Low
Contrail cirrus	0.01 [0.003 to 0.03]	Continental	Low
Natural			
Solar irradiance	0.12 [0.06 to 0.30]	Global	Low

CO₂ measurements not yet accurate enough; awaiting results GOSAT (Japan) launched early this year

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

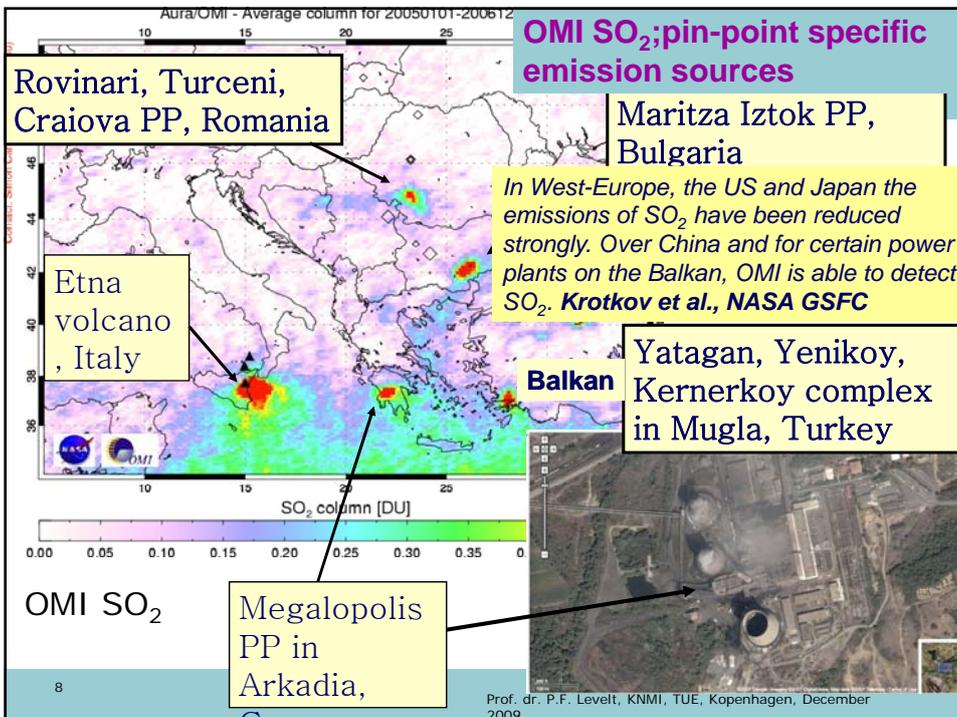
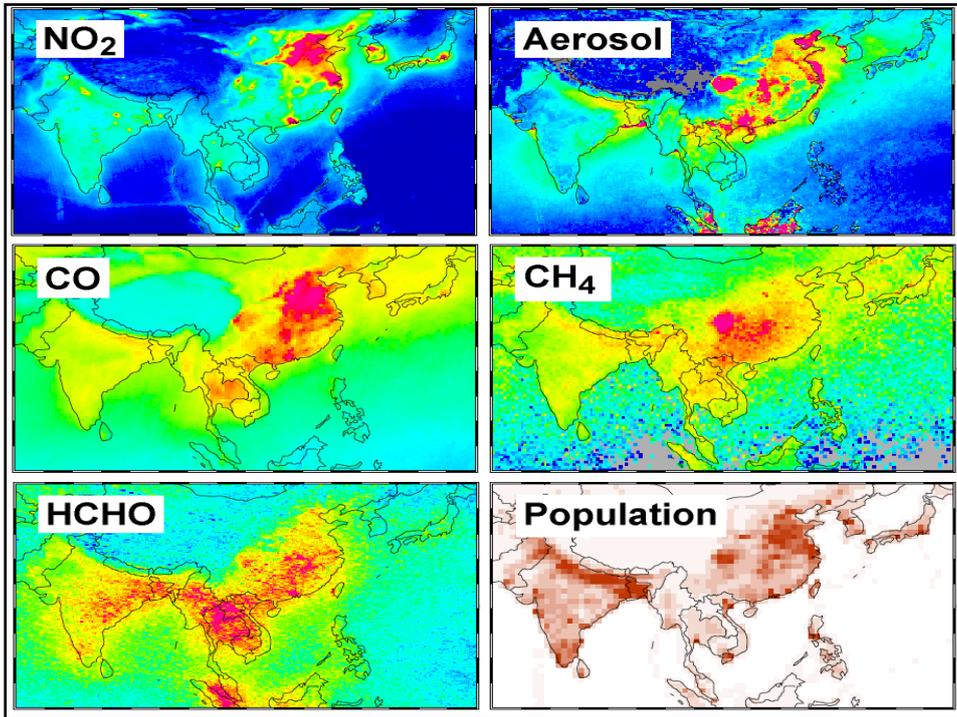
- Satellite based emission estimates are essential
 - To improve climate model prediction
 - To validate climate models
 - To control emissions (Kopenhagen)
- Satellite data provide global coverage
- For climate long satellite based data
- records are needed

Aerosols have a large impact on climate change

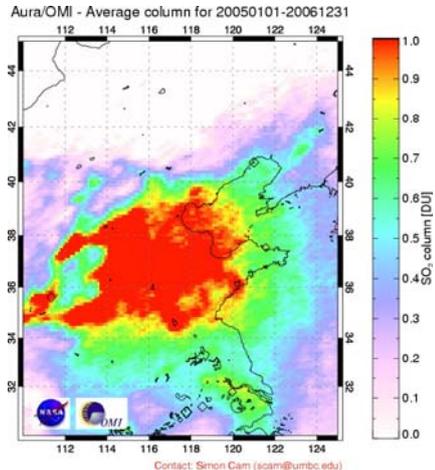
30 year ozone record
Based a.o. OMI data
Montreal & Kyoto Protocol

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Can we control emissions and measure these changes from satellites?



A 27 % increase in SO₂ emissions in China in 2005 compared to 2000 (25.5 million tons of SO₂)
 Krotkov et al., NASA GSFC

NO₂ reduction during the Olympic Games (August 2007 & August 2008),
 Bas Mijling, KNMI

Dutch & KNMI involvements in satellite measurements

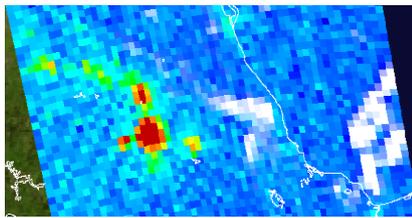
- GOME (ESA)**
 Launched April 1995 (ESA's ERS-2)
- SCIAMACHY (Germ-Neth-Belg)**
 Launched February 2002 (ESA's ENVISAT)
- OMI (Neth-Finl) (KNMI, PI)**
 Launched July 2004 (NASA's EOS-Aura)
- GOME-2 (ESA)**
 Launched October 2006 (EUMETSAT's METOP-1)
- TROPOMI (Neth, ESA) (KNMI, PI)**
 New instrument; cooperation ESA, 2013/2014



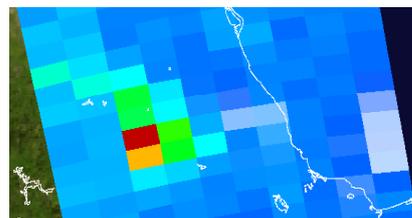
TROPOMI



- 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

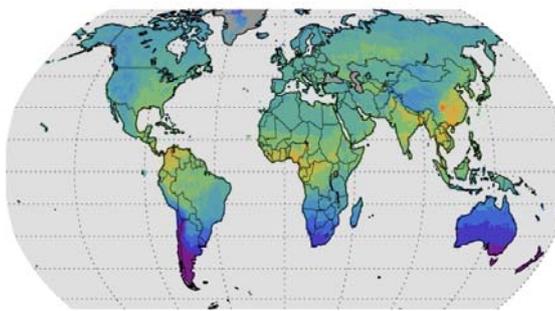


Approx. GOME-2 72x39 km²

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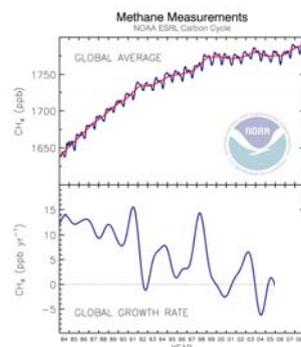
Mexico City January 20, 2005

SCIAMACHY methane measurements



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

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



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

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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