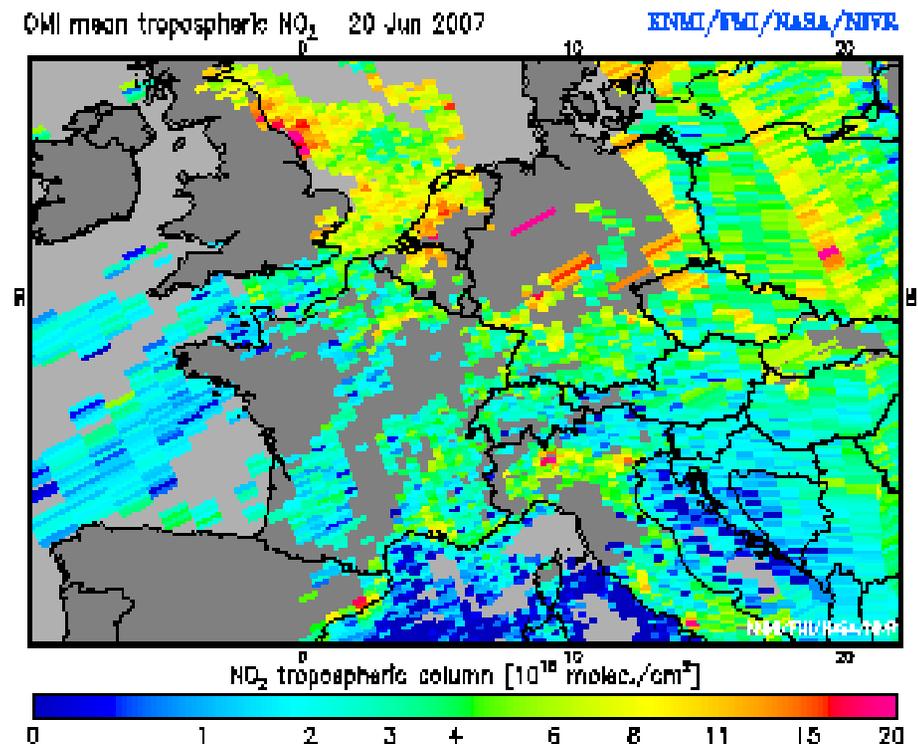
A world map showing air quality data with a color scale from blue (low) to red (high). A black box highlights Europe, which is shown in a larger inset at the bottom left. The text is overlaid on the map.

**Developments on
air quality modeling,
satellite observations and services in Europe**

**Prof. Dr. Hennie Kelder
Royal Netherlands Meteorological Institute
KNMI
University of Technology, Eindhoven**

GMES: Global Monitoring of the Environment and Security

- European contribution to GEO
- Integrated approach (satellite and ground-based data, models and assimilation):
 - Infra structure and use of data for Atmospheric Service
EU: GEMS and GAS
ESA: GSE, PROMOTE
EUMETSAT: Ozone SAF
 - Provision of future satellite data for operational monitoring of the atmosphere



OMI NRT NO₂ June 20, 2007



Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft



Global and regional Earth-System (atmosphere) Monitoring using Satellite and in-situ data (GEMS)

- Integrated Project of the 6th EC Framework Programme
- part of the GMES (EC&ESA) Atmosphere theme
- 31 consortium members
- 4 years (started in March 2005)
- coordinated by the European Centre for Medium-Range Weather Forecasts
ECMWF



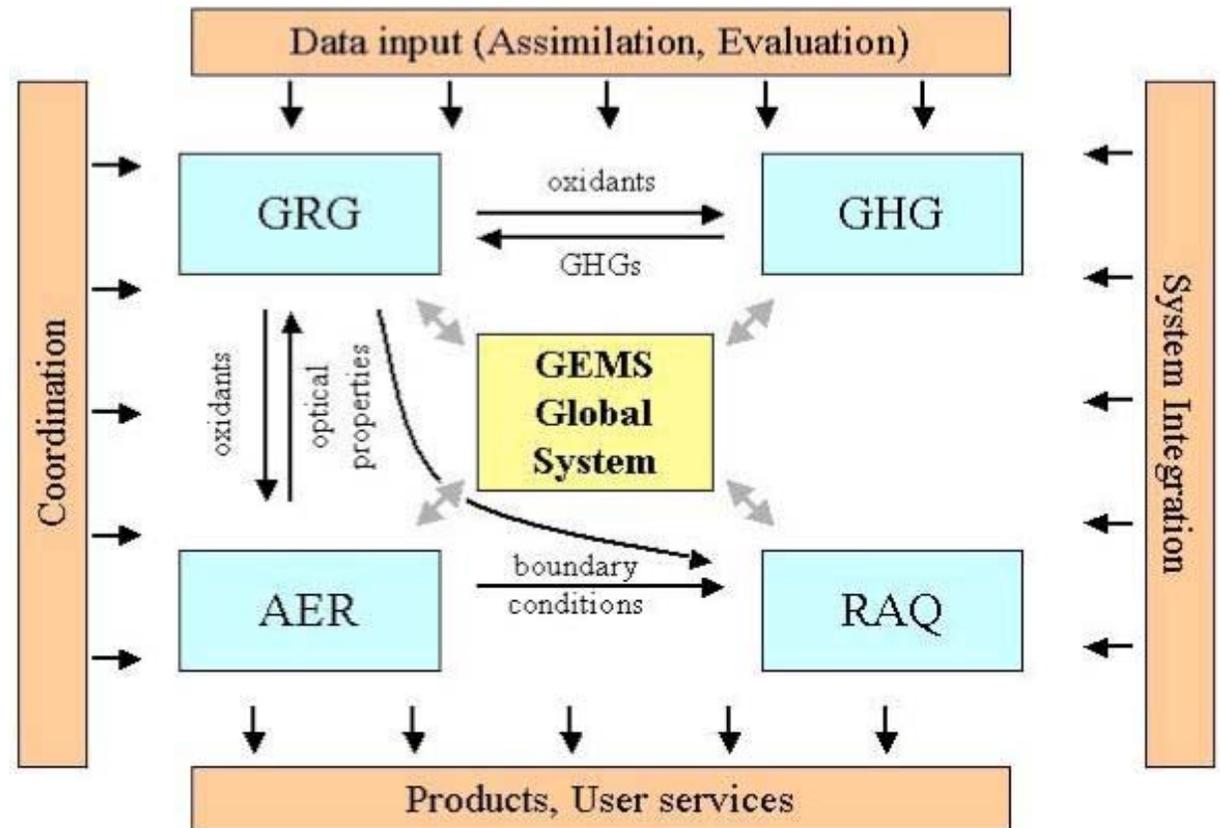
The GEMS Project

Global & regional Earth-system Monitoring using Satellite and in-situ data

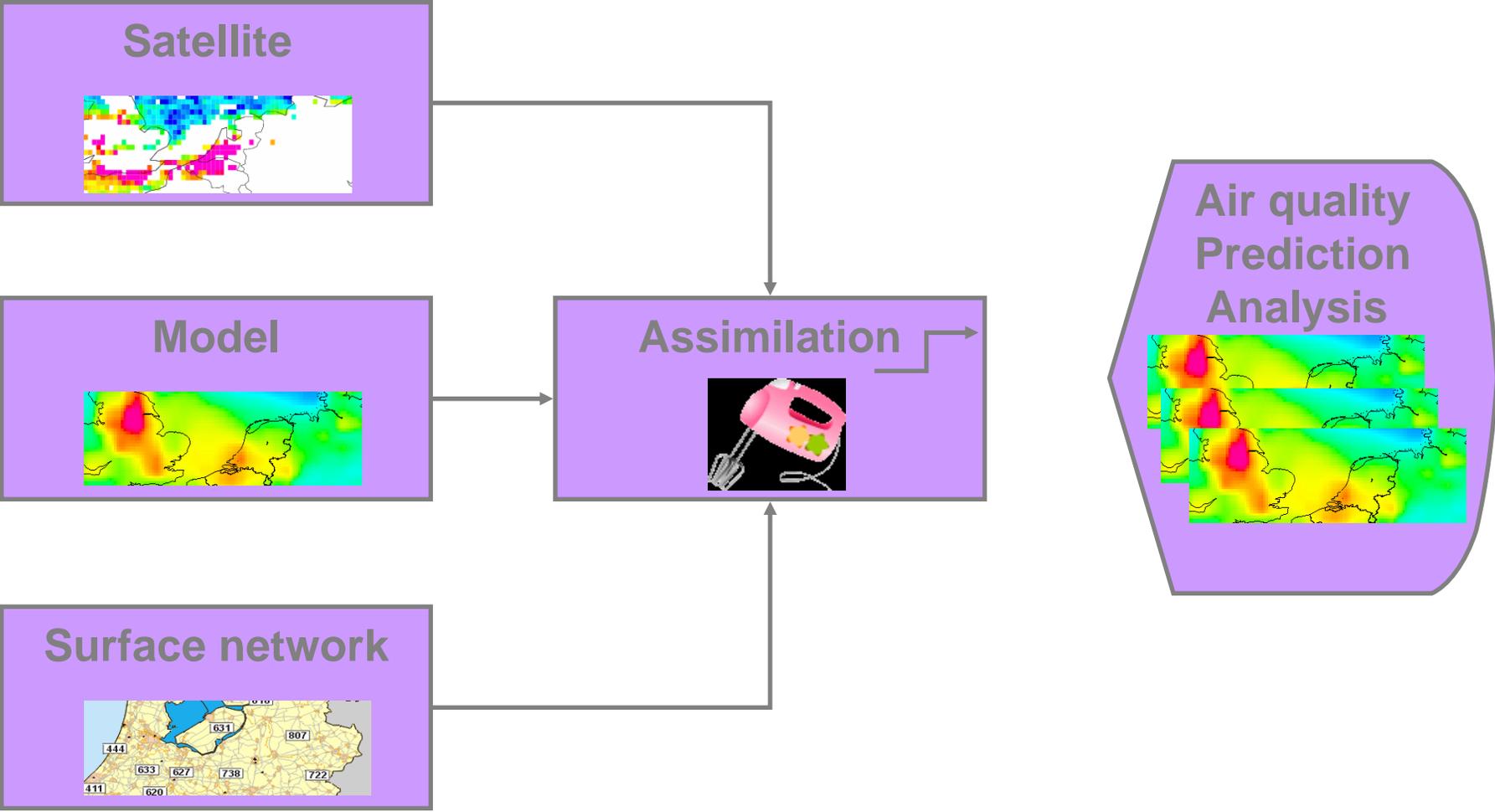
Subprojects:

- Greenhouse gases
- Reactive gases
- Aerosols
- Regional air quality

First (trial) reanalysis
(period 2003/2004)



The aim



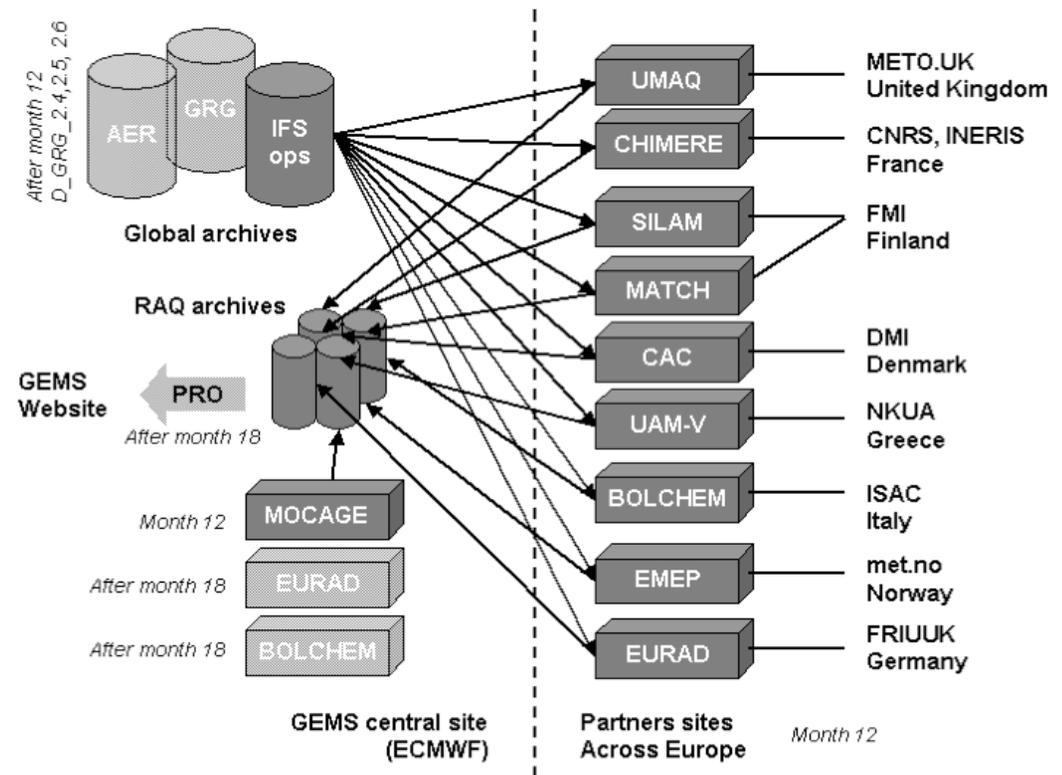
GEMS: Regional air quality subproject

Aspects:

- Many of the European regional AQ modelling groups involved
- Intercomparison of 11 European RAQ models on GEMS website
- Chemical assimilation at regional scale(surface observations)
- NRT access to surface data
- Ensemble forecasts

Satellite data of SCIAMACHY, GOME, OMI and GEMS-RAQ:

- nrt NO_2 etc. will be included in intercomparison

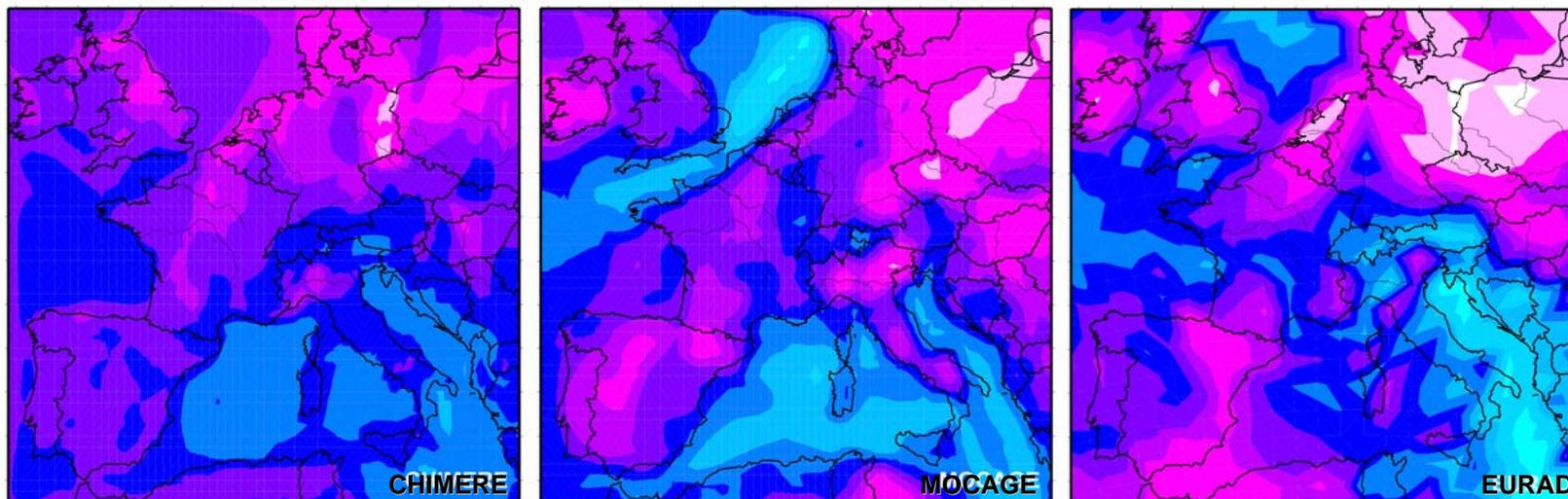




Forecast from three European air quality model systems



daily maxima of surface ozone [$\mu\text{g}/\text{m}^3$] for 20/10/2006



CHIMERE (CNRS-INSU and INERIS)

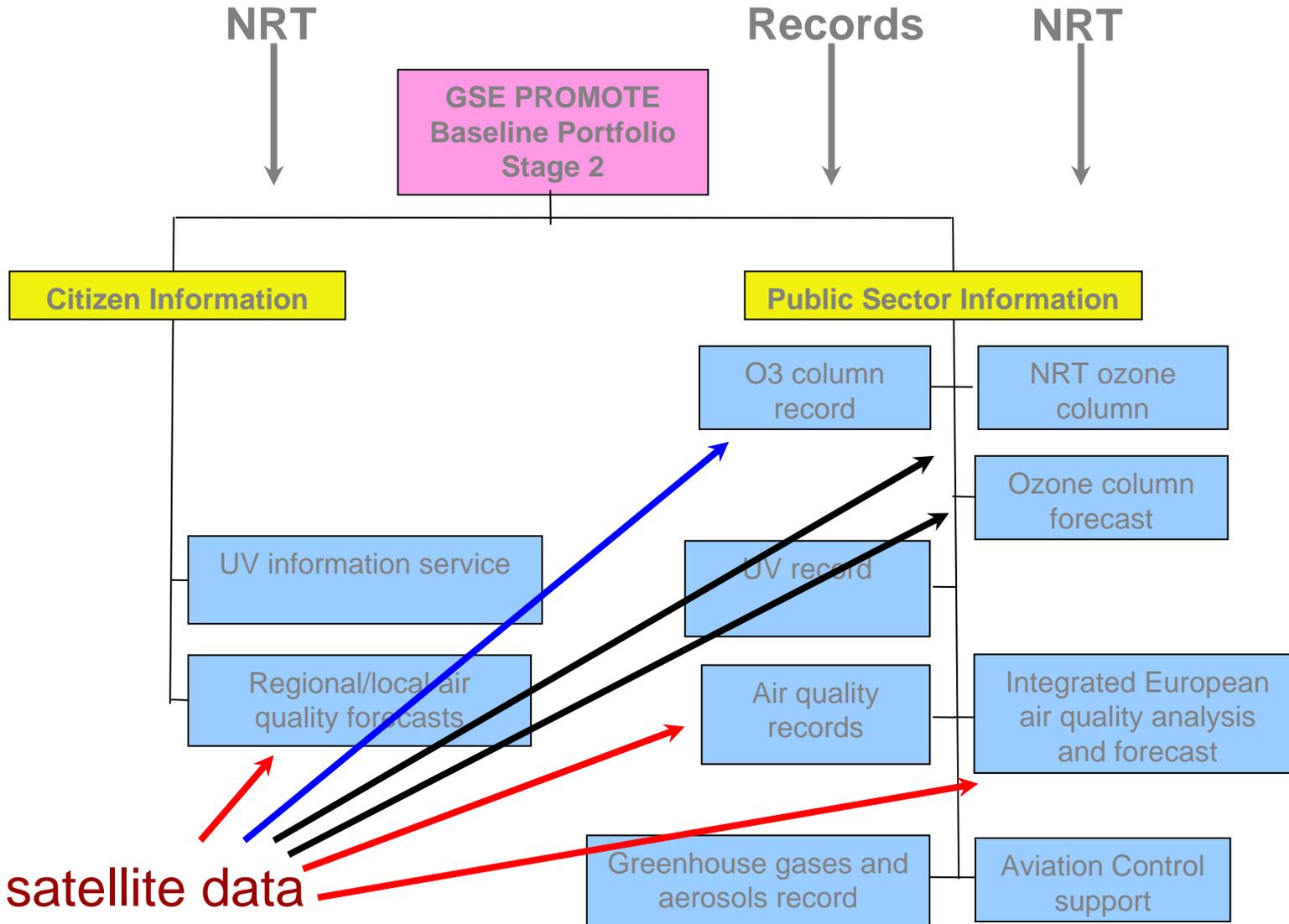


MOCAGE (Météo-France)



EURAD (Rhenish Institute for Environ. Research, Univ. Köln)

ESA PROMOTE



Use of satellite data

GMES Atmospheric Service

December 5/6, 2006, EU workshop on GAS in Brussels

Results:

- European contribution to Atmospheric services
- Implementation team to be installed
- Issue a space call including GAS

- Subject: Activity 9.1.2 GMES Atmospheric Services
 - **Developing pre-operational service capabilities in new application field **Atmosphere****

– **pre-operational service capabilities in application field Atmosphere**

- **GEMS** and **PROMOTE** prepared **MACC** proposal, lead ECMWF
- infrastructure for atmospheric services,
- submitted to EU on 19 June 19th, 2007
- Budget 15 M€

GMES Atmospheric Service (GAS-Pilot Service)

- Implementation team installed in 2007

Working group of 5 European experts on satellite data

First meeting sept 20, 2007

- Analysis of present and future needs for data and corresponding requirements on satellite missions
- Analysis of needs for infrastructure for provision and use of data
- Workshops on user requirements
- Recommendations

Overview recent European satellite instruments for tropospheric measurements

GOME

Launched April 1995 (ESA ERS-2)

*First total ozone data, 11 Jan 07
courtesy Eumetsat / DLR*

SCIAMACHY

Launched February 2002 (ESA ENVISAT)

OMI

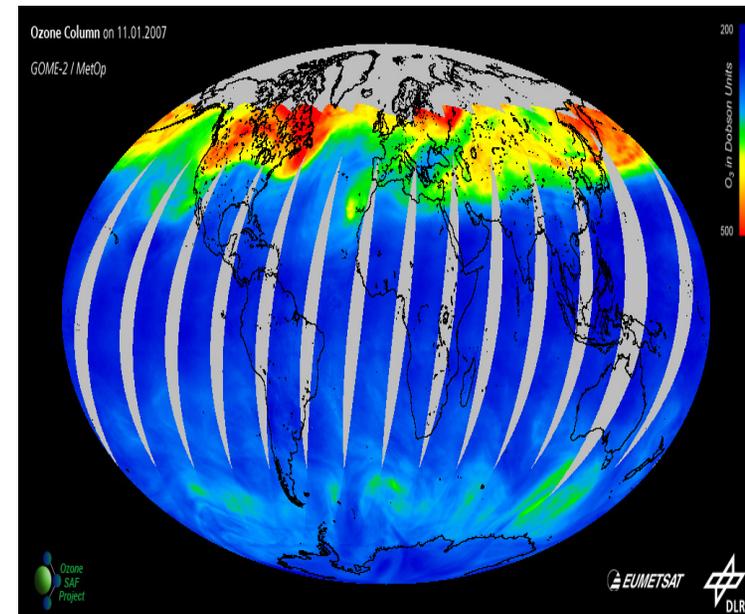
Launched July 2004 (NASA EOS-Aura)

GOME-2

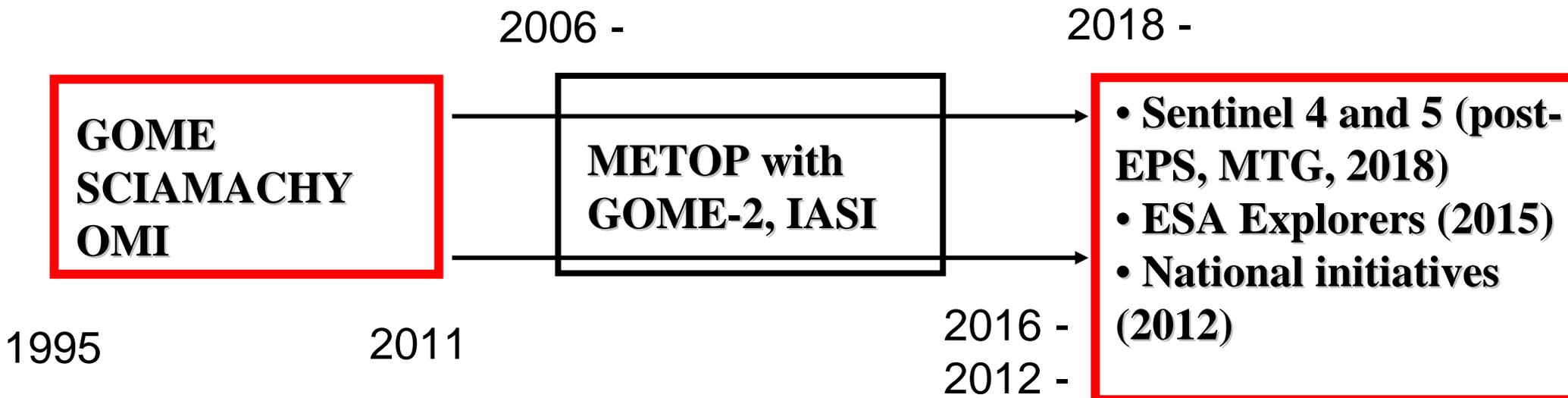
Launched October 2006, EUMETSAT METOP 1

IASI

Launched October 2006, EUMETSAT's METOP 1



European satellite instruments for air quality



Red = present or planned European missions with air quality data

**Black = European atmospheric composition missions
not optimal for air quality and greenhouse gases**

Initiatives and plans for air quality/climate exploring and monitoring satellite missions

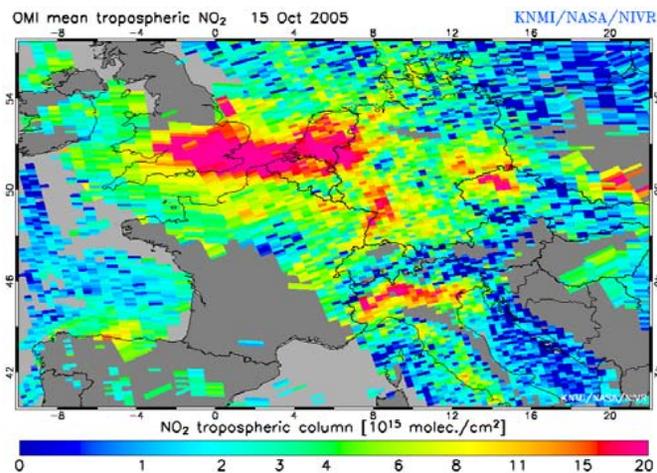
- **ESA**
 - Earth Explorer program
 - Sentinels 4 and 5: Capacity study 1 and 2, operational monitoring atmospheric chemistry based on user requirements.
- **EUMETSAT**
 - Post EPS and MTG
- **National initiatives**
 - Air quality and climate monitoring : NL, Fi, Belgium, UK, etc.
 - **TROPOMI/TROPI (Dutch led initiative):**
Nadir looking UV/VIS/NIR/SWIR instrument on small platform

ESA EOEP Program (EE7, estimated Launch 2014/2015): Six Candidate Core Missions for phase 0 study

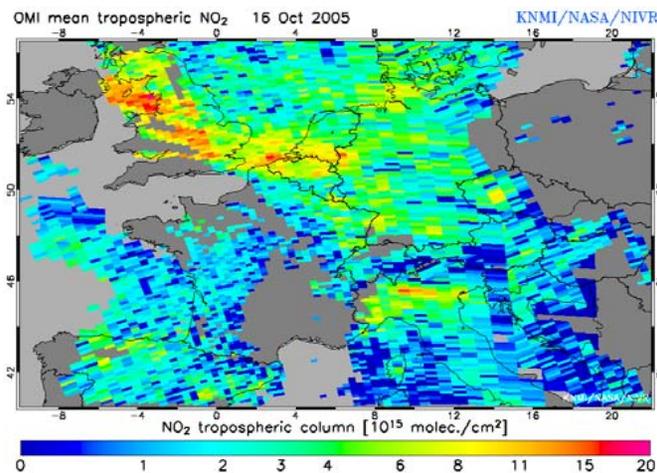
- **BIOMASS: A BIOMASS Monitoring Mission for Carbon Assessment**
- **TRAQ: TRopospheric composition and Air Quality**
- **PREMIER: PRocess Exploration through Measurements of Infrared and millimetre-wave Emitted Radiation,**
- **FLEX: FLuorescence Explorer**
- **A-SCOPE: Advanced Space Carbon and Climate Observation of Planet Earth**
- **Core-H2O: Cold Regions Hydrology High-resolution Observatory**

TRAQ Science Questions

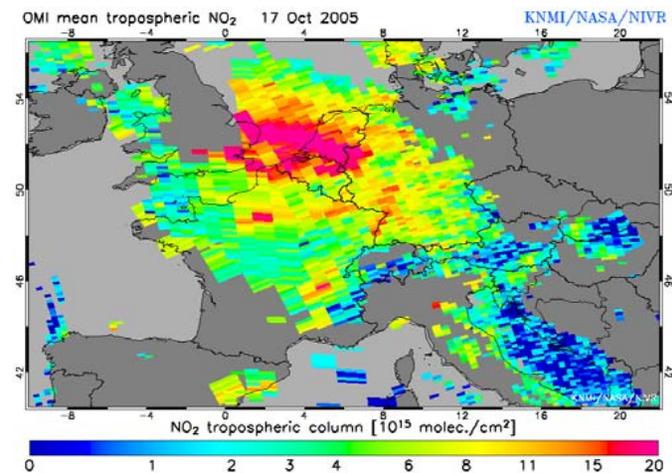
- How fast is air quality changing on a global and regional scale?
- What are strengths and distributions of sources and sinks of trace gases and aerosols influencing air quality and climate?
- What is the role of tropospheric composition in global change?



Saturday 15 October 2005



Sunday 16 October 2005



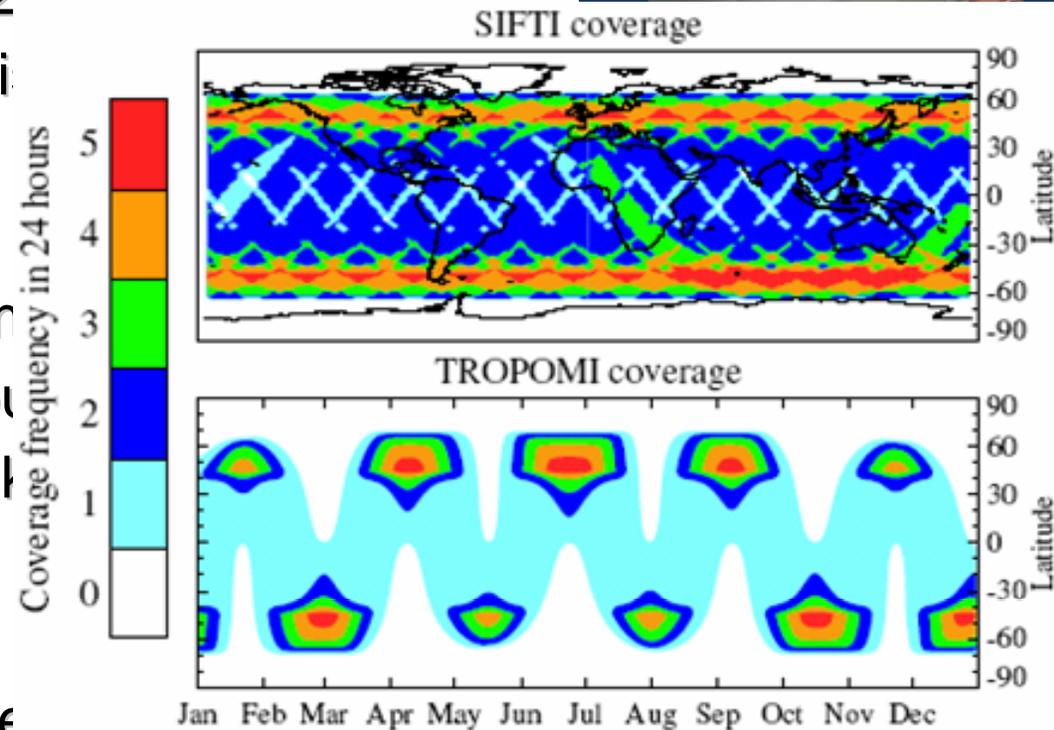
Monday 17 October 2005

ESA explorer mission candidate TRAQ Payload

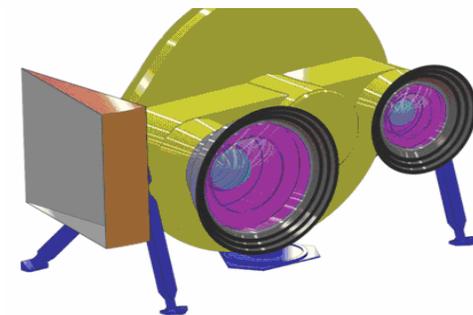
TROPOMI: Backscatter instrument (trop) columns of O_3 , NO_2 , SO_2 , HCHO, aerosols & CO and CH_4 .
Swath 2600, 10 x 10 km²
Heritage: Aura-OMI, Envi



SIFTI (FTIR): O_3 , CO, CH_4 : trop column
intelligent pointing for cloud
Swath 2000 km, 10 x 10 km²
Heritage: IASI



OCAPI: POLDER type of instrument
AOD, single scattering albedo (ω_0), Air quality
index (AQI), aerosol sizes and aerosol type.
Swath 2000 km, 5 x 5 km²
Heritage: POLDER, PARASOL



GMES Sentinels 4&5

Eumetsat

Meteosat Third Generation

- Detailed UV-VIS instrument studies during phase 0
- Instrument not considered at system level
- Will not be followed in phase A

Post-EPS

- Several atmospheric composition instruments considered
- Highest priority : UV-VIS-NIR-SWIR and TIR spectrometers

Eumetsat – ESA cooperation

- It is planned to merge Sentinels 4&5 with Eumetsat atmospheric composition programme.
- Funding is open.

ESA CAPACITY studies 1 and 2

- **Goals:**
 - Operational monitoring of the atmosphere in preparation of Sentinel missions 4 & 5
 - Integrated approach in line with IGACO, ground-based, in situ and satellites
- **CAPACITY 1: 2004 – 3006 (KNMI lead, ESA J. Langen)**
 - Main goal : to identify gaps in current / planned operational system and identify system/instrument requirements

Recommendations from CAPACITY 1

In line with IGACO to implement a system of GEO and LEO satellites:

1. Implement 1 LEO satellite with UV-VIS-SWIR payload for **global air quality and climate protocol monitoring** with small pixel sizes as soon as possible
2. Perform trade-off between GEO + LEO and LEO constellation in inclined orbit, and implement complete air quality & climate protocol monitoring mission
3. Consolidate choice and requirements of instruments for UT/LS mission for climate and ozone NRT and assessment applications, and implement the mission

ESA CAPACITY studies 1 and 2

CAPACITY 2: 2007 - 2009 ESA (J. Langen) KNMI | (H. Kelder) | RAL | U. Leicester | SRON | FMI, BIRA-IASB | CNR-IFAC | Noveltis (LPMAA, ULB) | U. Koeln

Main goal: perform sensitivity and retrieval studies for several operational systems and perform trade-offs, including user's perspective (workshop).

Key issues:

Identification and quantification of **meteorological and possibly other auxiliary data requirements** and their priority compared to chemical data Requirements

Trade-offs between **different observation strategies** (spectral ranges, polarisation, direction etc.) for aerosol and several gaseous species

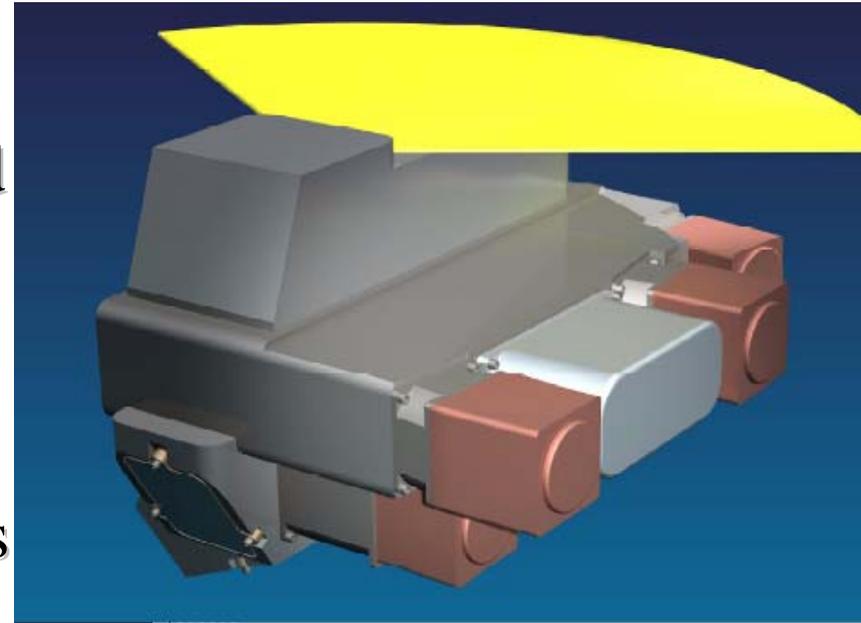
Quantitative mapping of geophysical observation requirements onto instrument performance requirements and a review of the implementation-critical requirements

Quantitative assessment of requirements for **spatio-temporal sampling** taking into account contamination of nadir-viewing observations by clouds

Contribute from **user's perspective** to trade-off between different orbit options

TROPOMI (TROPI)

- Successor of OMI en SCIAMACHY
- Collaboration between KNMI, SRON, TNO and DS.
- Consists of the OMI channels and added to that channels for CO, CH₄ and the O₂-A band (cloud detection and surface albedo)
- Due to TROPOMI's
 - smaller ground pixel size than OMI's and
 - improved correction for clouds the troposphere can be measured with improved accuracy



< 10 x 10 km² ground pixel

- **TROPOMI type of instrument part of TRAQ, Sentinels, National initiative for a precursor mission**
- **TROPOMI also Called TROPI in USA (decadal survey)**

WMO

**Commission on Atmospheric Sciences,
CAS**

**2006, Establishment of a
Joint Scientific Steering Committee(JSSC) on
atmospheric chemistry**

Conclusions

- **European satellite instruments** : key information on ozone/UV, climate and air quality
- **Infrastructure and user services** (ESA Promote, Eumetsat Ozone SAF and EU funded project GEMS, MACC ?, GAS): will result in more users.
- **Next decade: Gome 2 and IASI on METOP, reduction in capacity in Europe compared to present decade.** Better perspectives after 2018. National initiatives for precursor/bridging mission.
- **Shared European responsibility** for GMES/GEO and hence for a mature satellite component & user services - decisions in near future to be taken by ESA, EU, EUMETSAT and national agencies.
- **Cooperation within GEO, across the Atlantic etc - ?**