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

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• European contribution to GEO

• Integrated approach (satellite and ground-based data, models and assimilation):
  – Infrastructure 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
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

Satellite

Model

Surface network

Assimilation

Air quality Prediction Analysis
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(surfaces observations)
• NRT access to surface data
• Ensemble forecasts

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

• nrt NO\textsubscript{2} etc. will be included in intercomparison
Forecast from three European air quality model systems

daily maxima of surface ozone [ug/m3] for 20/10/2006

CHIMERE (CNRS-INSU and INERIS)
MOCAGE (Météo-France)
EURAD (Rhenish Institute for Environ. Research, Univ. Köln)
Use of satellite data

http://www.gse-promote.org
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€
- 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)

**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

*First total ozone data, 11 Jan 07 courtesy Eumetsat / DLR*
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
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?
TROPOMI: Backscatter instrument (trop) columns of O$_3$, NO$_2$, SO$_2$, HCHO, aerosols & CO and CH$_4$. Swath 2600, 10 x 10 km$^2$
Heritage: Aura-OMI, Envisat

SIFTI (FTIR): O$_3$, CO, CH$_4$: trop columns and profiles with intelligent pointing for cloud free pixels. Swath 2000 km, 10 x 10 km$^2$
Heritage: IASI

OCAPI: POLDER type of instrument: AOD, single scattering albedo ($\omega_0$), Air quality index (AQI), aerosol sizes and aerosol type. Swath 2000 km, 5 x 5 km$^2$
Heritage: POLDER, PARASOL

ESA explorer mission candidate TRAQ Payload
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.
• **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
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
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
- 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
Successor of OMI and 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
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.
- **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 - ?**