Models and satellite observations of air pollution in the Netherlands and Europe

Henk Eskes and Suzanne Jongen

Royal Netherlands Meteorological Institute (KNMI), Netherlands

- Air Quality forecasts for the Netherlands: projects and plans
- European context: GEMS and PROMOTE
- OMI and SCIAMACHY data and data assimilation
- Some results

Air quality forecasts for the Netherlands

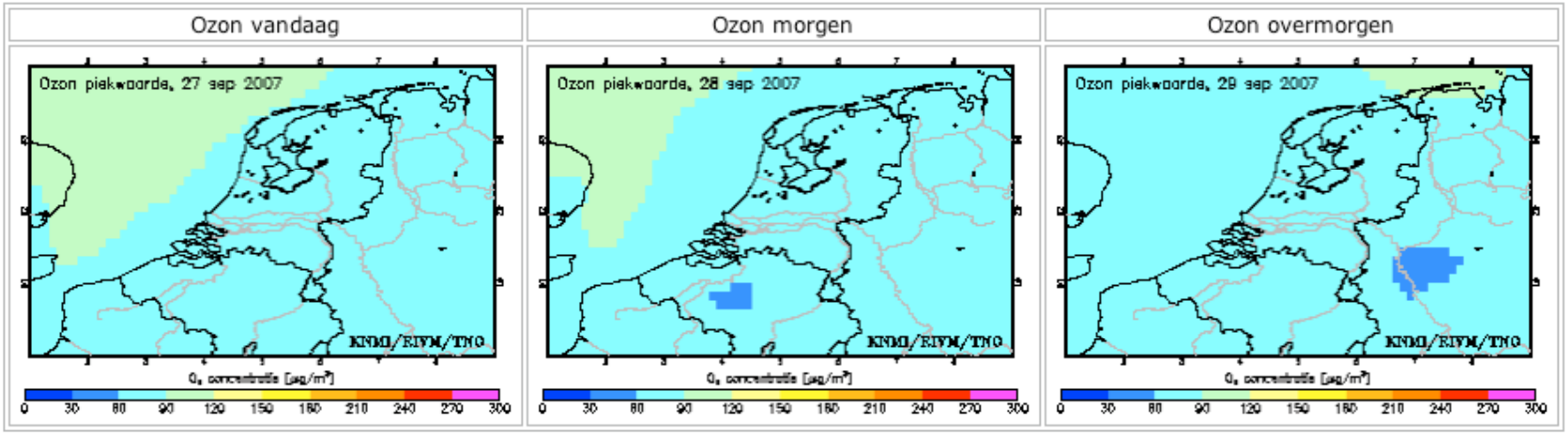
Dutch SmogProg project, User Support Programme, NIVR, 2007-2008

- Aim: To replace the (simple) statistical AQ forecast now issued by RIVM
- Collaboration of three Dutch institutes
  RIVM, KNMI, TNO
- Based on Dutch LOTOS-EUROS model, and French CHIMERE model
- Region covering the Netherlands and surroundings (about 10 km resol)
  Use high-resolution meteorological input, i.e. KNMI - HIRLAM
- Assimilation of surface and satellite data
  NO2 from OMI on EOS-Aura
- First focus on ozone and precursors
- Project started beginning 2007

Air quality forecasts for the Netherlands

- Two-day ozone forecast available on the web (demo service)

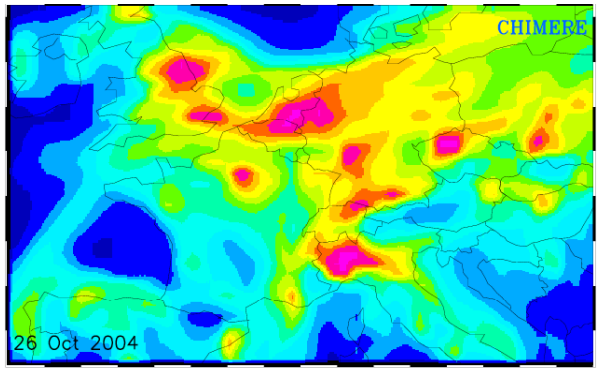
  http://www.lml.rivm.nl



- Plan: become operational in spring 2008

- ozone forecasts during summer

Chimère model

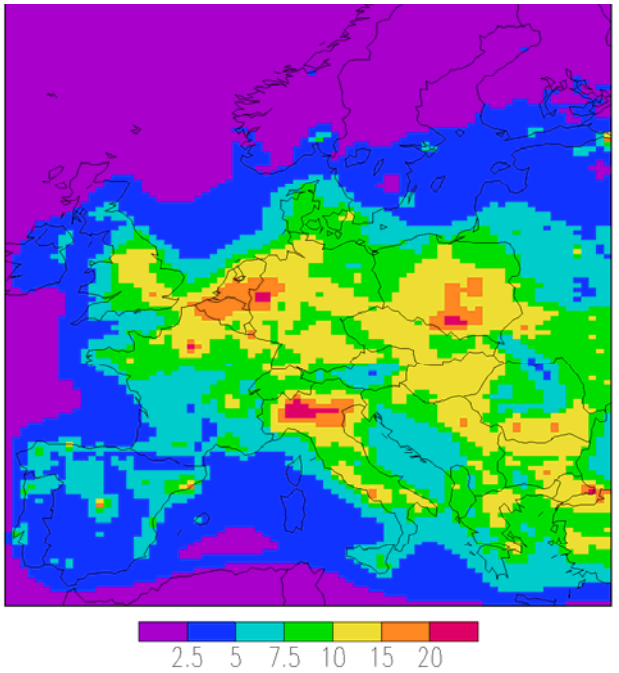


Developed in France
R. Vautard, H. Schmidt, L. Menut, M. Beekman, N. Blond, ...
Operational air-quality forecasts: http://www.prevair.org/

Model ingredients:
- MELCHIOR-2 chemistry (44 species, 120 reactions)
- EMEP emissions (TNO-GEMS)

Version running at KNMI:
- V200606A including aerosols
- CONT3 domain, 8 vertical layers, surface - 500 hPa
- Boundary conditions from LMDZ-INCA monthly-mean climatology
- ECMWF and HIRLAM (10km res) meteorological analyses

Lotos-Euros model



Developed in the Netherlands
- LOTOS developed by TNO
- EUROS developed by RIVM

Model ingredients:
- Ozone and precursors, PM (aerosol), heavy metals, POP
- European domain with 0.5x0.25 degree (lon-lat)
- Dynamical boundary layer approach (4 layers, top at 3.5 km)
- ECMWF meteorological analyses (FU Berlin, HIRLAM/RACMO)
- Wet/dry deposition, emissions, transport, vertical exchange
- Gas-phase: CBM-IV or CB99
- Aerosol: fine/course, SO4, NO3, NH4, EC, OC, salt

QuickTime™ en een
TIFF (ongecomprimeerd)-decompressor
zijn vereist om deze afbeelding weer te geven.

Europe and air quality

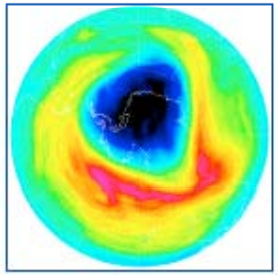
Global Monitoring for Environment and Sequrity (GMES)

http://www.gmes.info/

Atmosphere projects: PROMOTE en GEMS
KNMI contributes to both on Air Quality

GMES Atmosphere Service: (2009 onward)

Ensemble air quality forecast Europa
with Dutch contribution (TNO-KNMI)



Ozone Service

UV Service

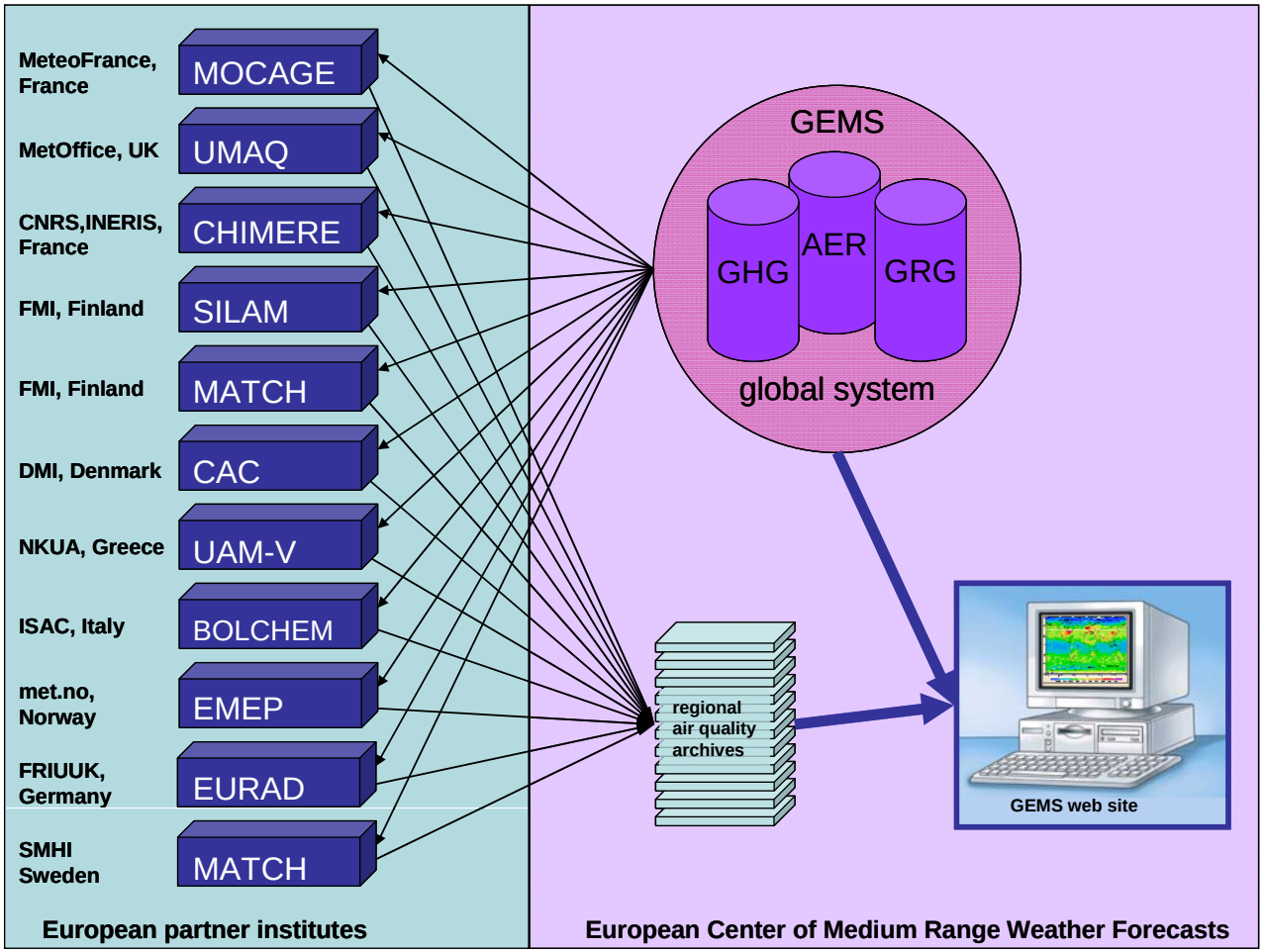
Air Quality Service

Greenhouse Gas and Aerosol Service

Special Services

GEMS subproject: Regional Air Quality

- Production of regional forecasts of chemical species and air quality indices based on an ensemble of air-quality models on the European scale



GEMS: Reactive gas subproject

KNMI

Aspects:

- Two way coupling of ECMWF model with three CTMs: Mozart, Mocage, TM5, coupling via OASIS-4
- Assimilation for ozone, CO, NO_2, SO_2, CH_2O, methane based on 4D-Var system of ECMWF
- Delivery of boundary conditions for RAQ
- Initial focus on troposphere

OMI and GEMS (GRG+RAQ):

- OMI NO2, CH2O, SO2 will be considered for / included in the first and second GEMS reanalysis
- OMI NO2 comparison with regional ensemble analysis

PROMOTE

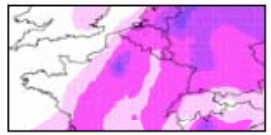
- Home
- Background
- Validation
- Partnership
- User Federation
- Gallery
- News
- Documents
- Contact us
- Internal

Services

- Ozone
- UV
- Air Quality
- GHG-Aerosol
- Special

esa

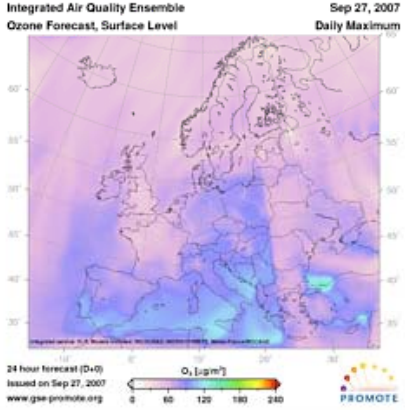
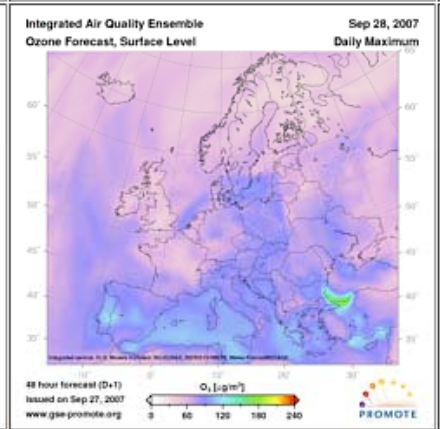
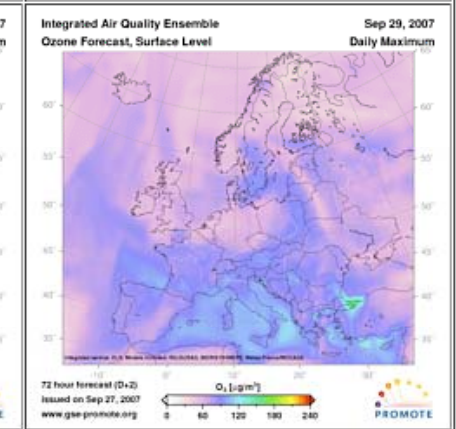
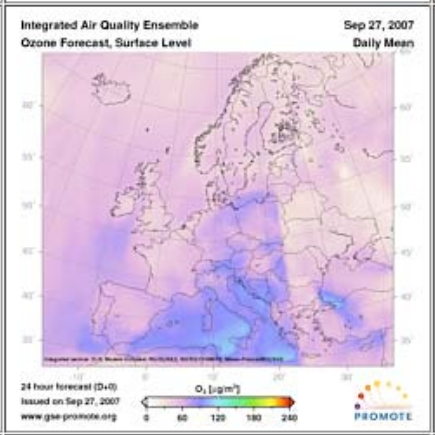
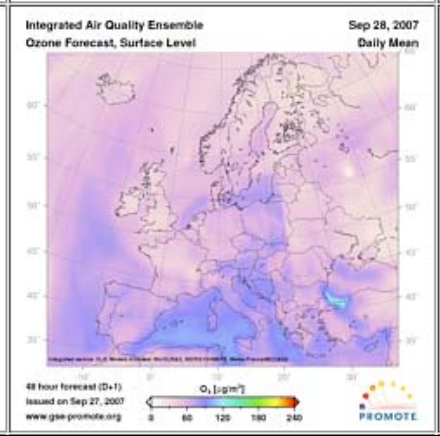
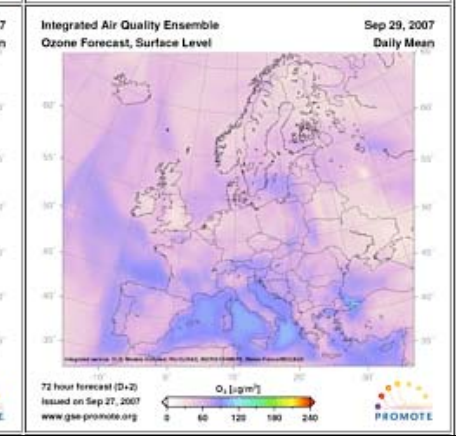
Integrated Air Quality platform



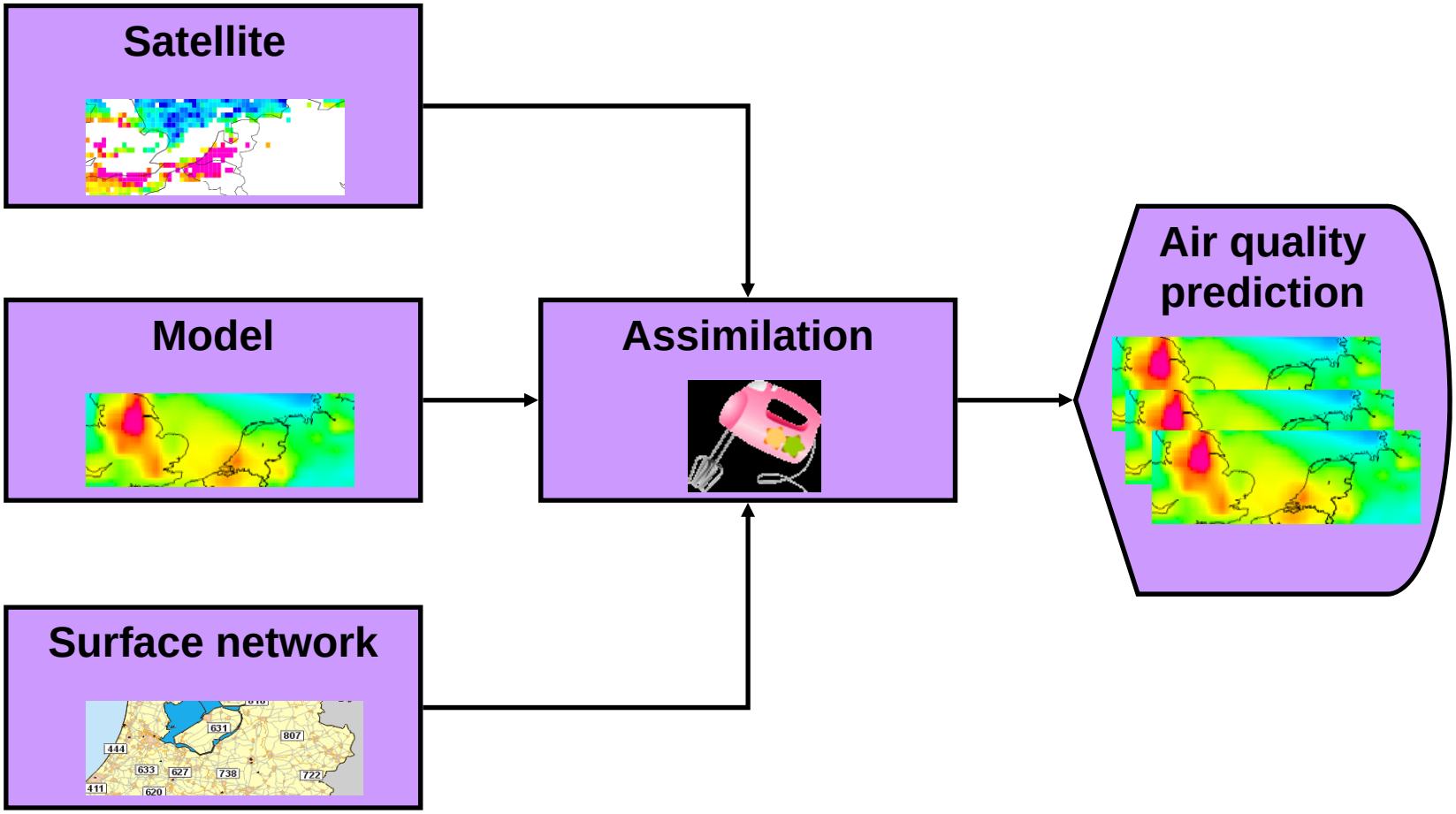
Integrated air quality platform

This service provides an ensemble forecast of air pollutant concentrations for all of Europe. Ground level concentrations of ozone, nitrogen dioxide and particulate matter derived from several well established and validated chemistry-transport models are integrated. The final product is based on an ensemble approach in order to get the best result from a combination of different models. Forecasts up to two days (72 hours) are provided at a resolution of ~50km*50km. In the near future analysed maps will be available, too. They will be issued from simulations including assimilated in-situ observations. All products are availbale daily using near-real-time observational data from satellite and ground.

Latest Forecasts (preliminary results)

Pollutant	Latest Forecast Day+0	Latest Forecast Day+1	Latest Forecast Day+2
O_3 Daily Maximum			
O_3 Daily Mean			

The aim


Satellite
Model
Assimilation
Air quality prediction
Surface network
631
807
444
633
627
738
722
411
620

Assimilation of satellite and surface data

- LOTOS-EUROS + Ensemble Kalman Filter

Used in several studies, e.g.

- Hanea et al, JGR 2004
- EUMETSAT OSSE study on impact of aerosol space obs, Timmermans et al, preprint
- Aerosol AOD assimilation: M. Schaap

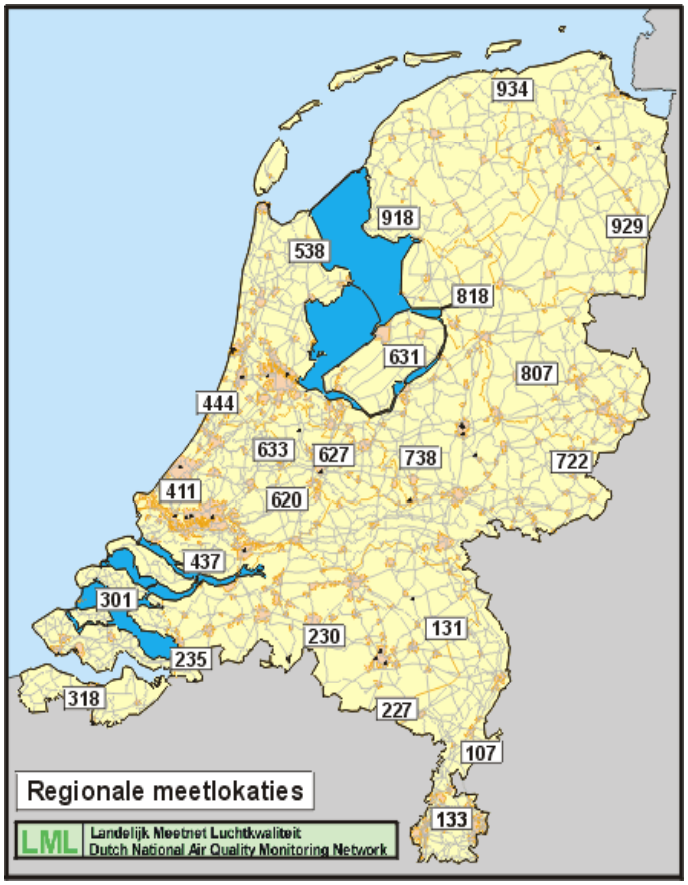
- An interface between LE / Kalman and OMI-NO2 data has been built

First experiments are starting

- Collaboration with the Chimère team envisaged

Monitor air pollution at surface

rivm



RIVM LML surface network

Properties:

Hourly averages

Continuous (24/7)

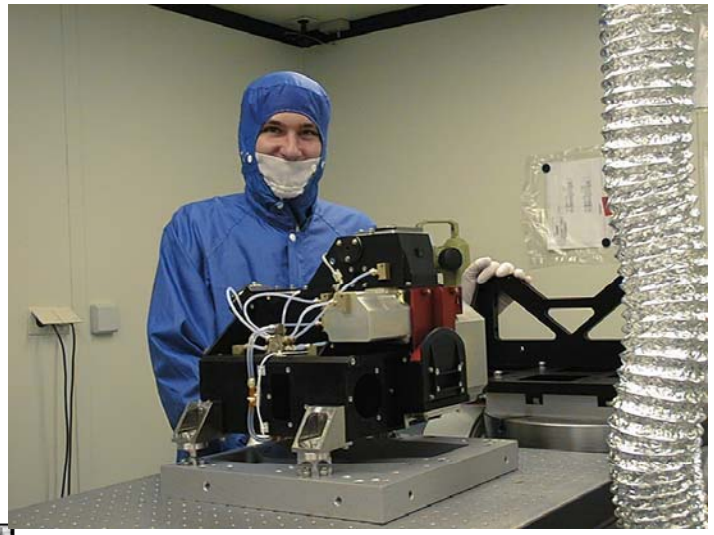
Constituents:

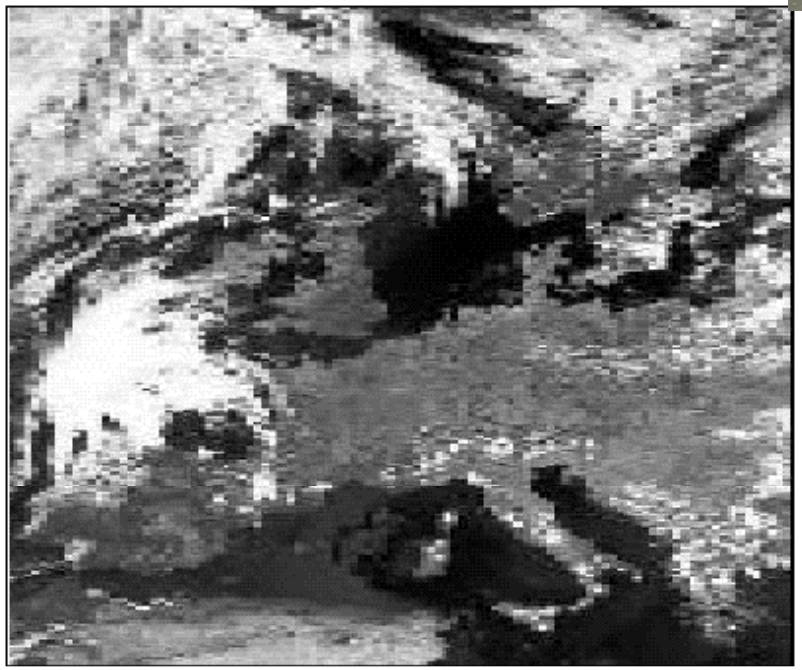
O3, NO, NO2, PM, SO2, CO, NH3, PM10

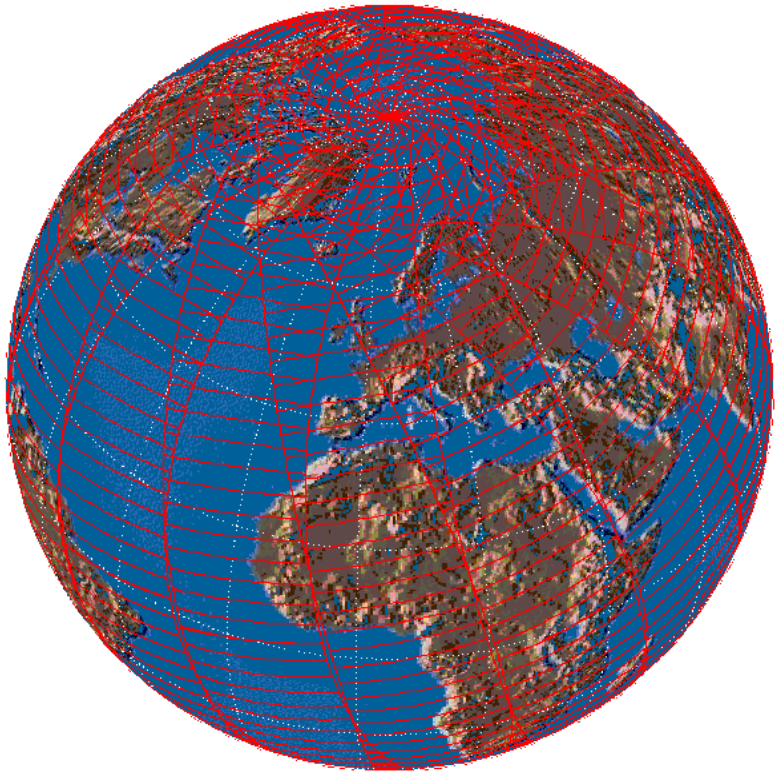
About 20 regional stations

OMI: unique instrument

EOS-AURA satellite
July 2004 - present

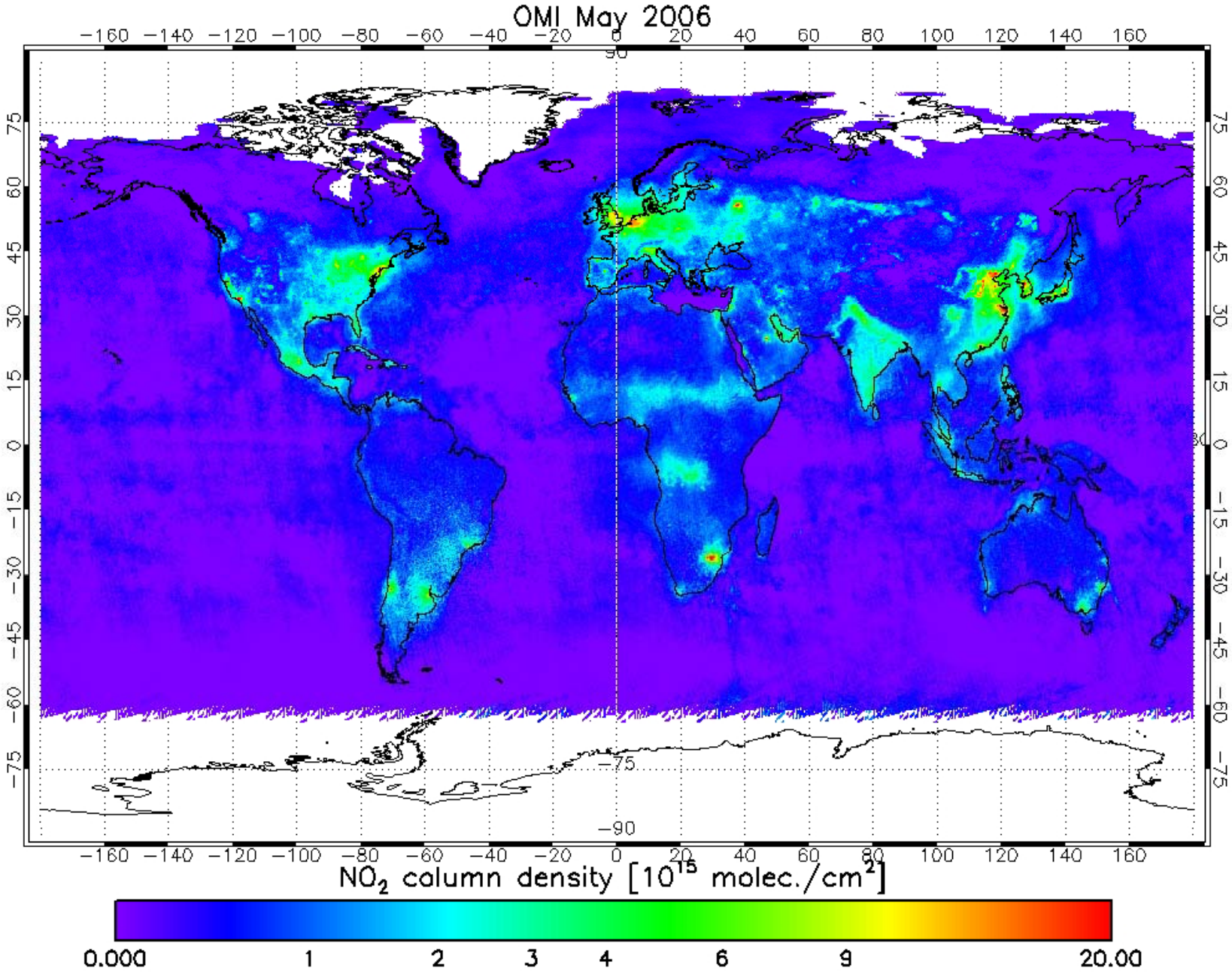




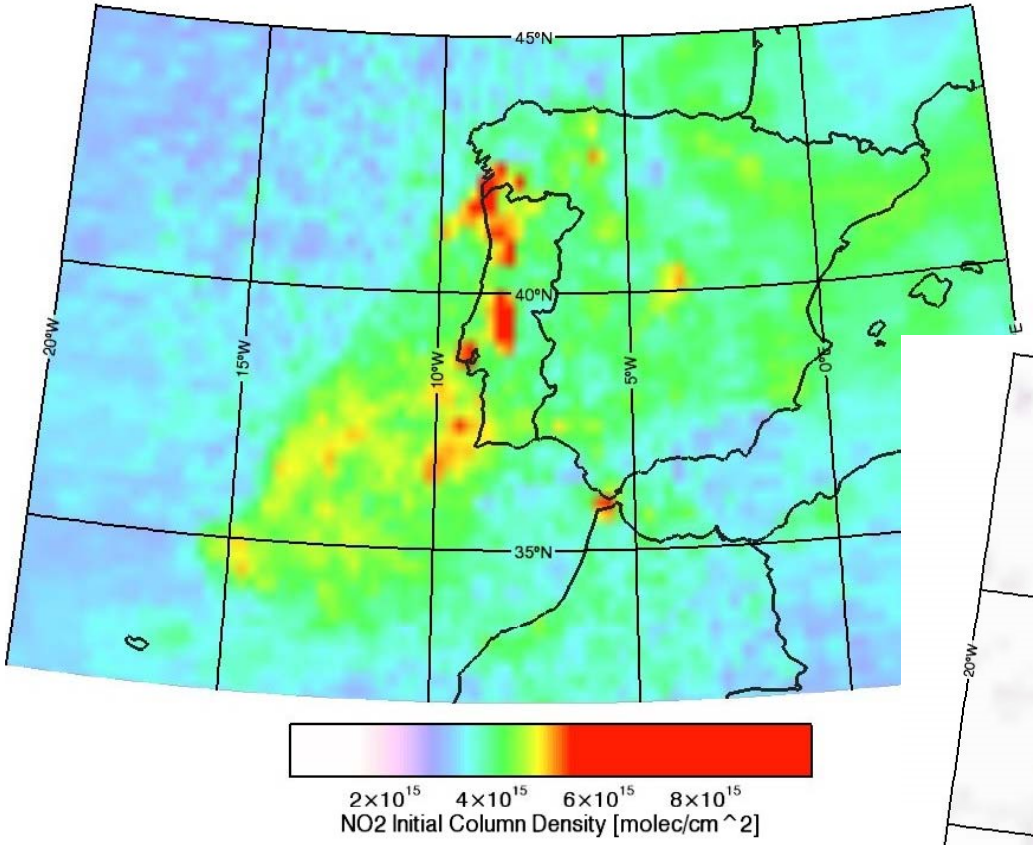


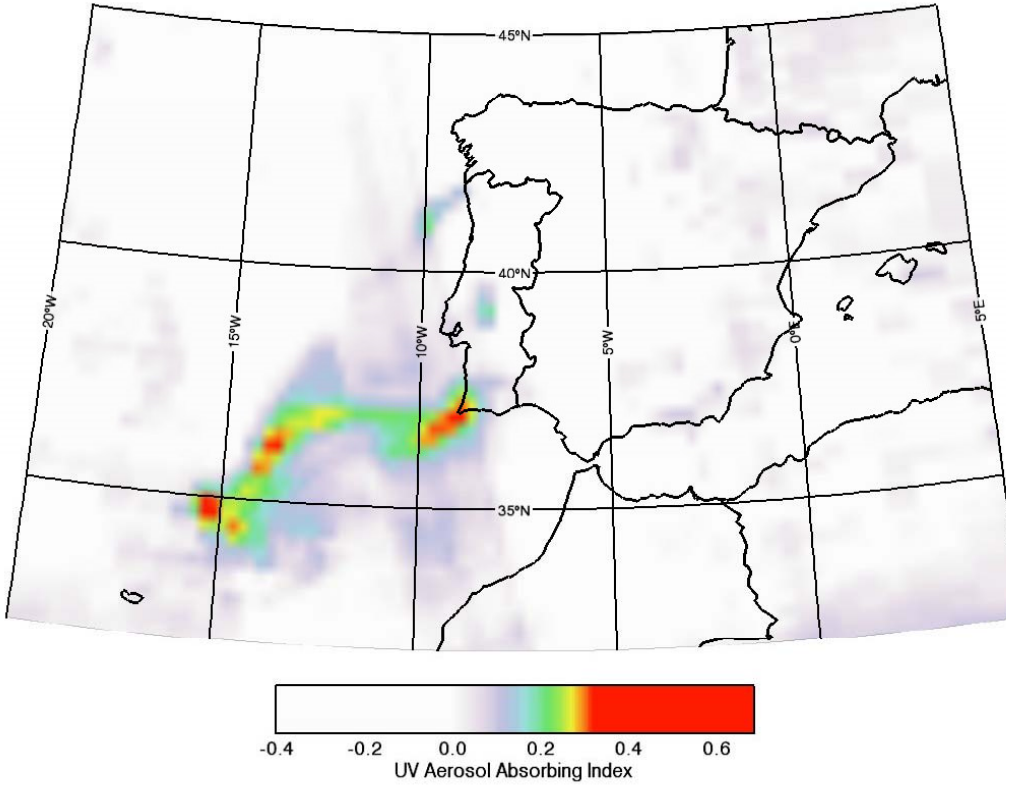
- - - -

Tropospheric NO_2 by OMI, May 2006

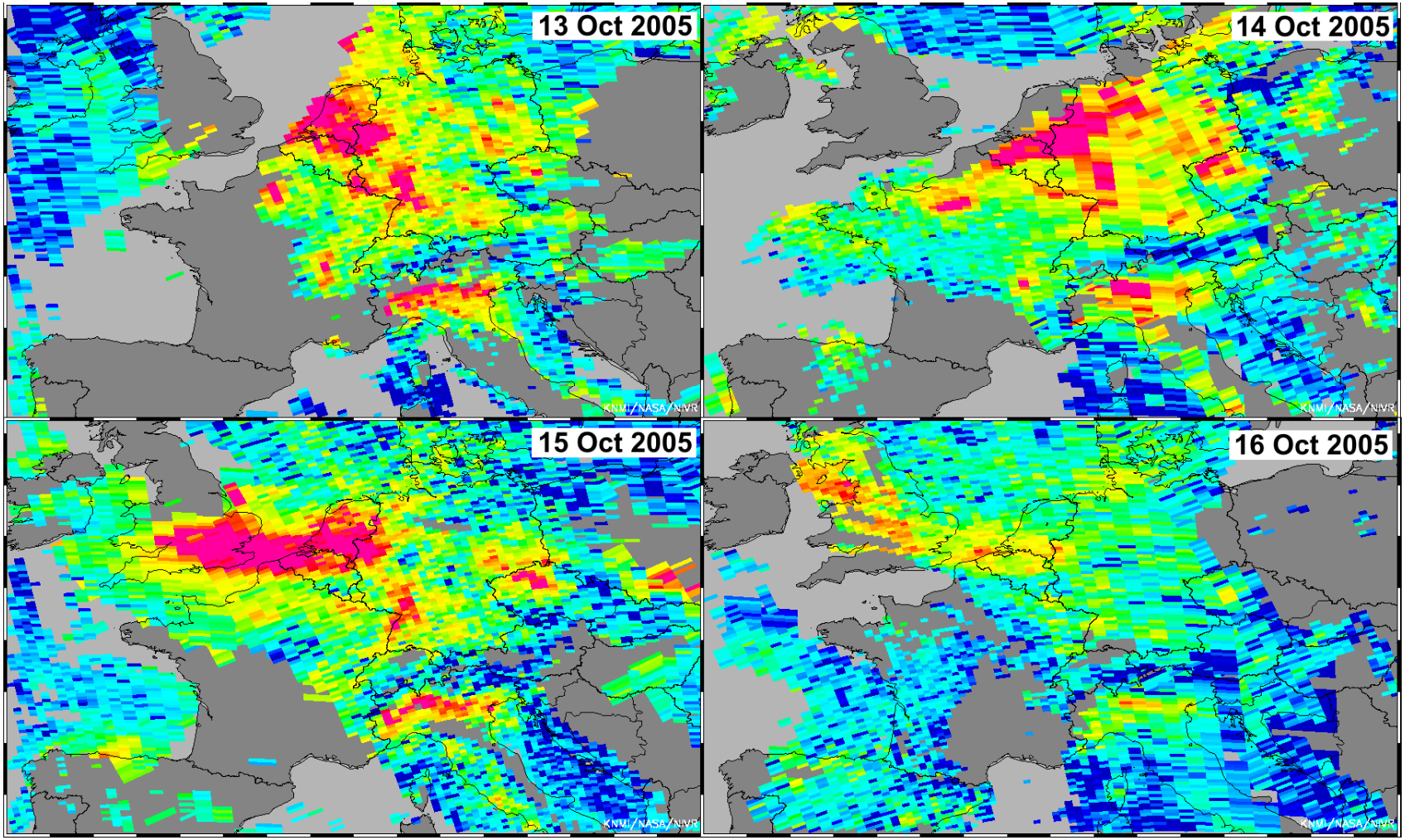


Fire events seen by OMI

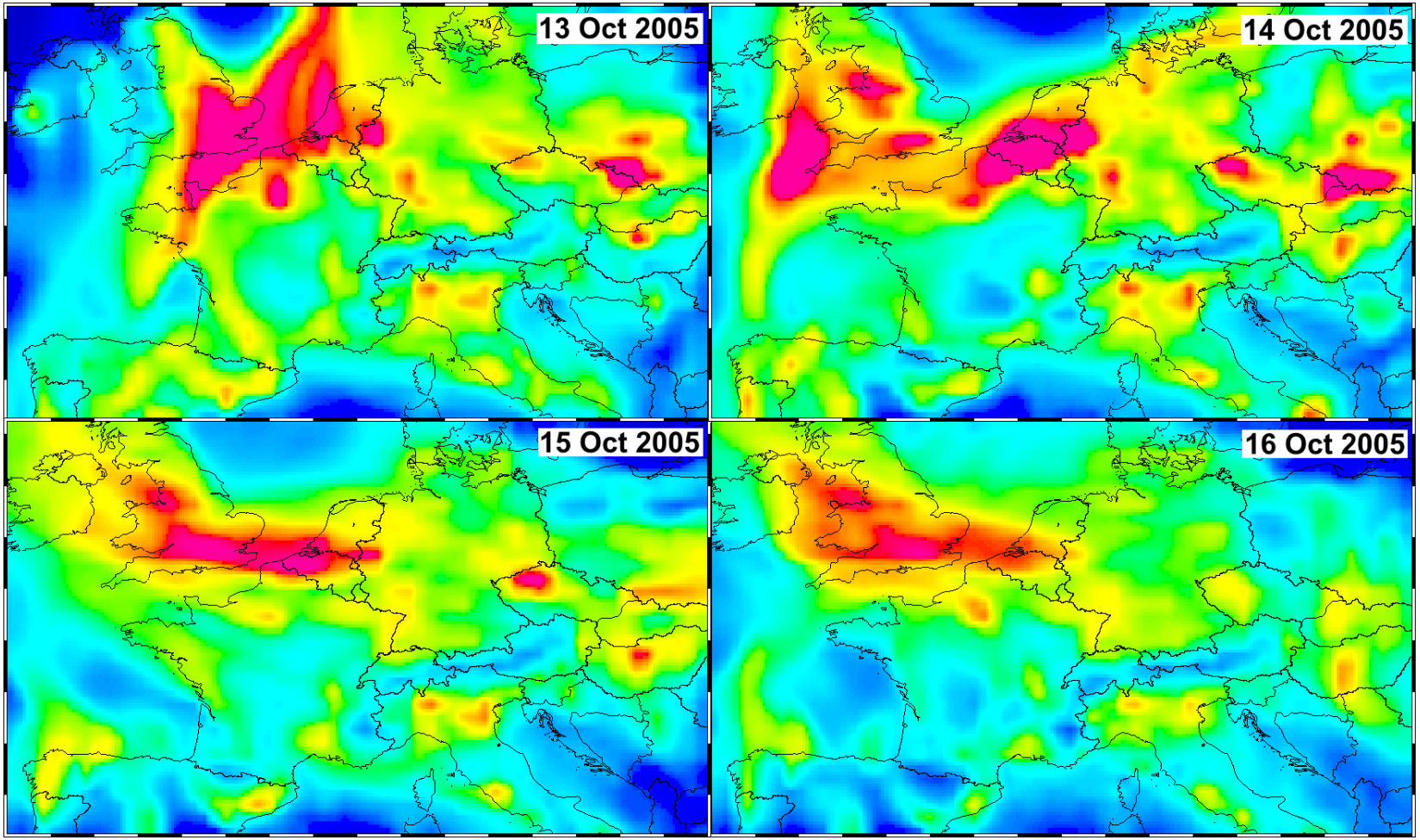


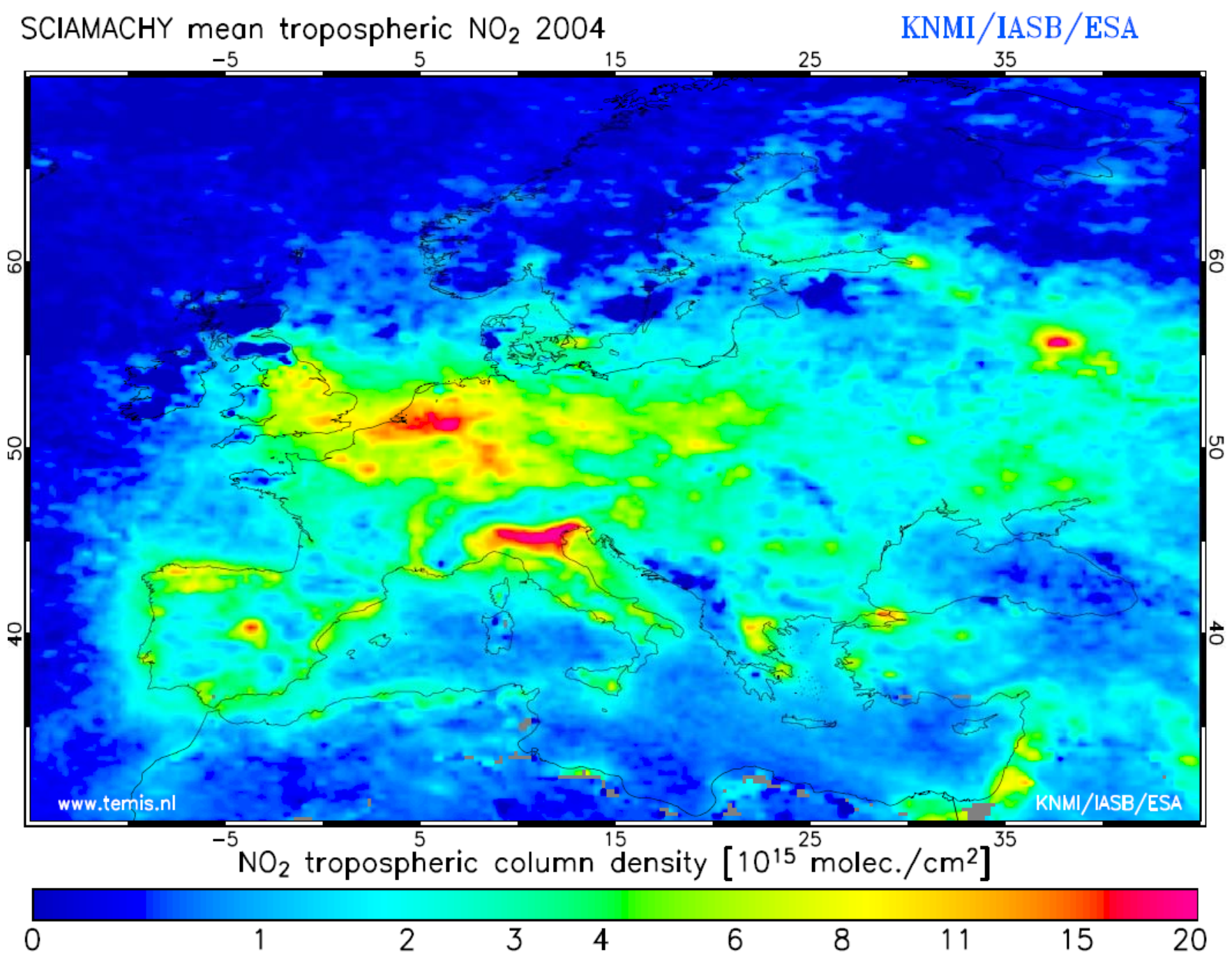


OMI near-real time NO2, 13-16 October 2005

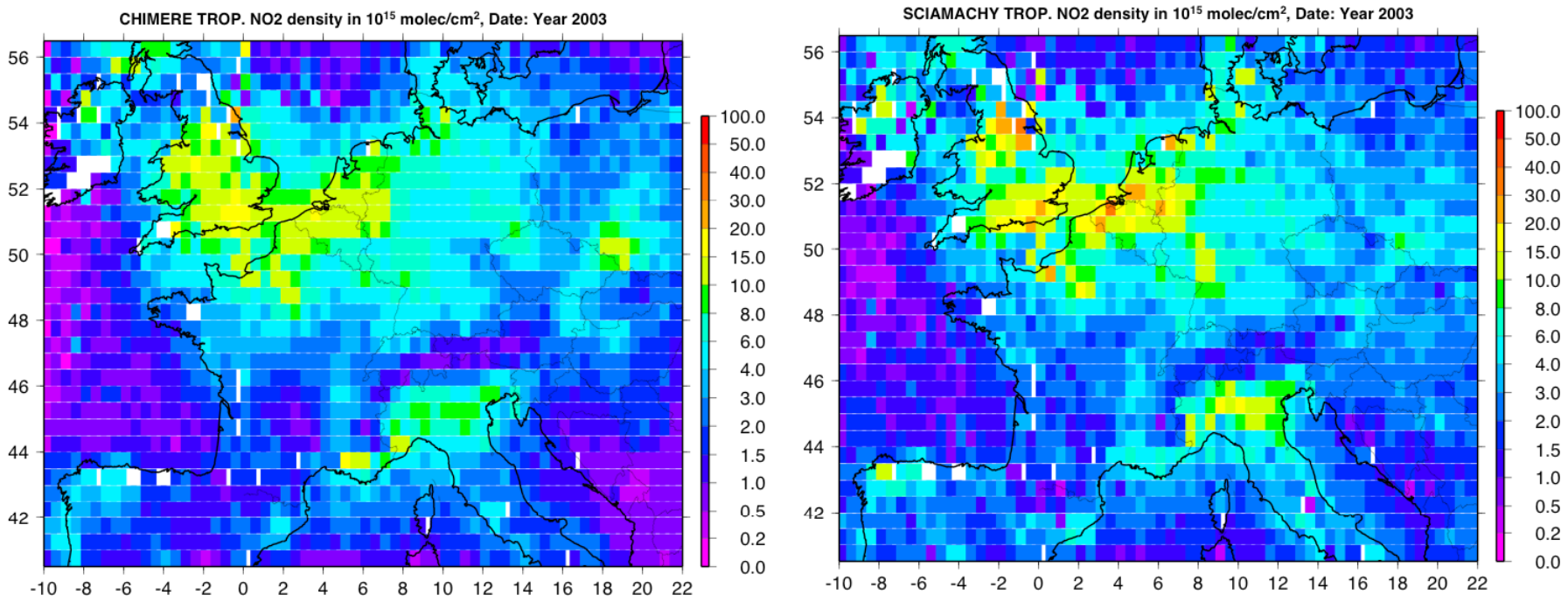


Chimere @ OMI overpass time, 13-16 Oct 2005



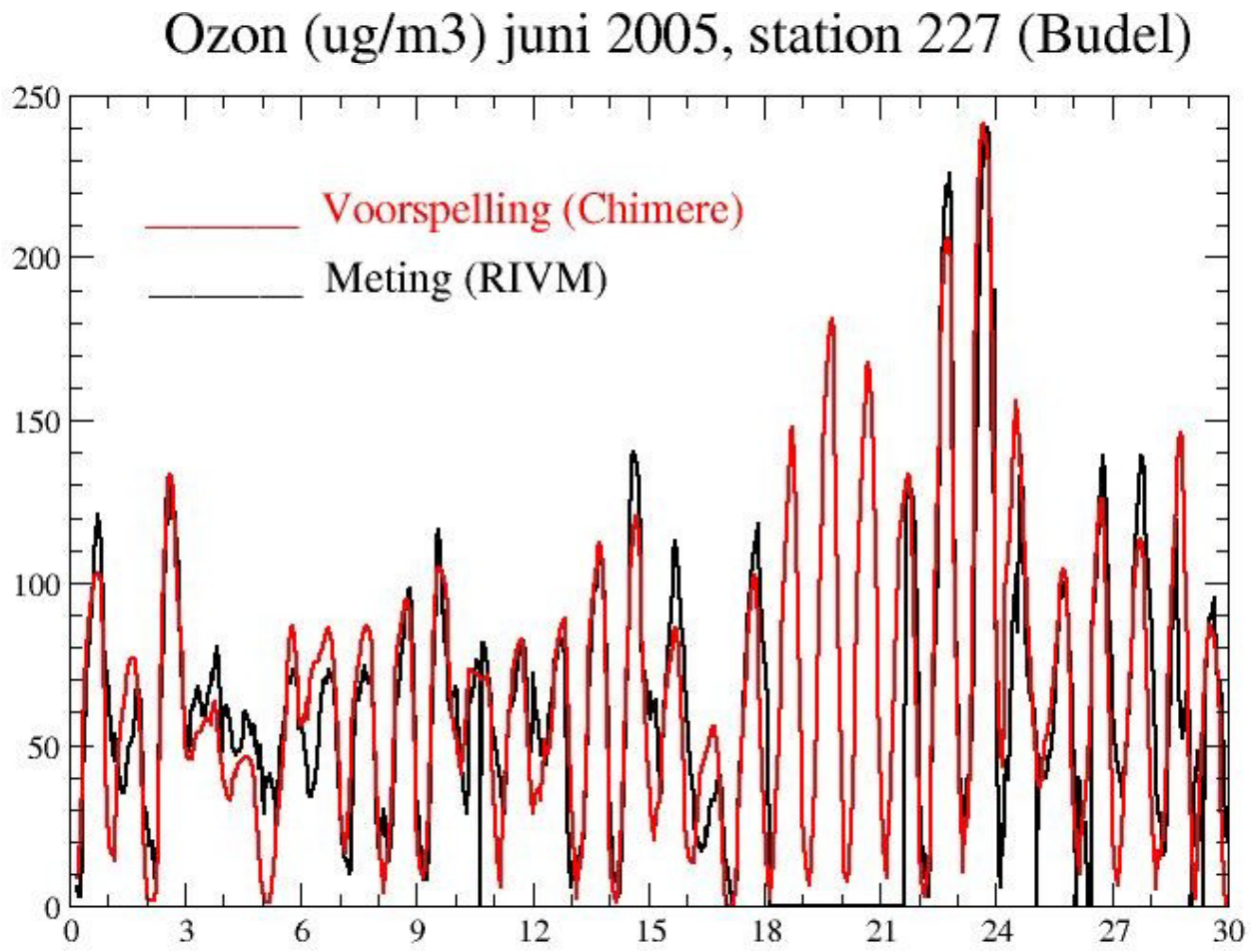

SCIAMACHY mean tropospheric NO2 2004
KNMI/IASB/ESA
−5
5
15
25
35
60
50
40
www.temis.nl
KNMI/IASB/ESA
NO2 tropospheric column density [10^15 molec./cm^2]
0
1
2
3
4
6
8
11
15
20

SCIAMACHY vs. Chimère: yearly mean

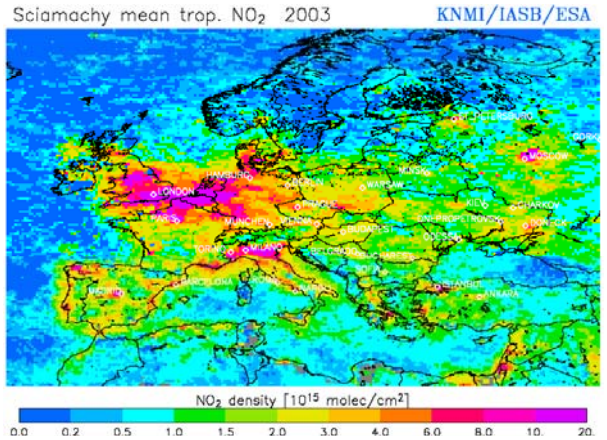


Yearly-mean bias = 0.2 10^{15} molec cm^{-2}, RMS 2.9, correl.coeff. 0.73
Cloud-free pixels
Nadege Blond - JGR 2007

Model vs surface observations (LML, RIVM)

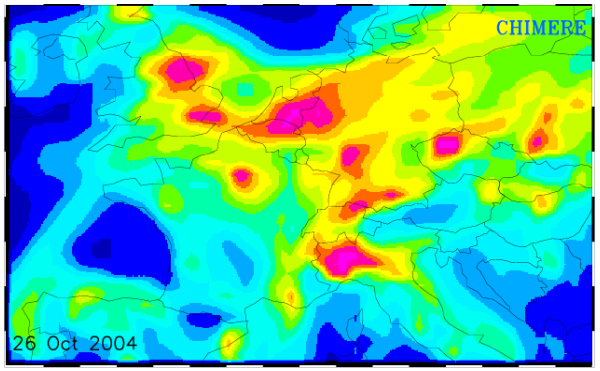


SCIAMACHY vs. Chimère: conclusions



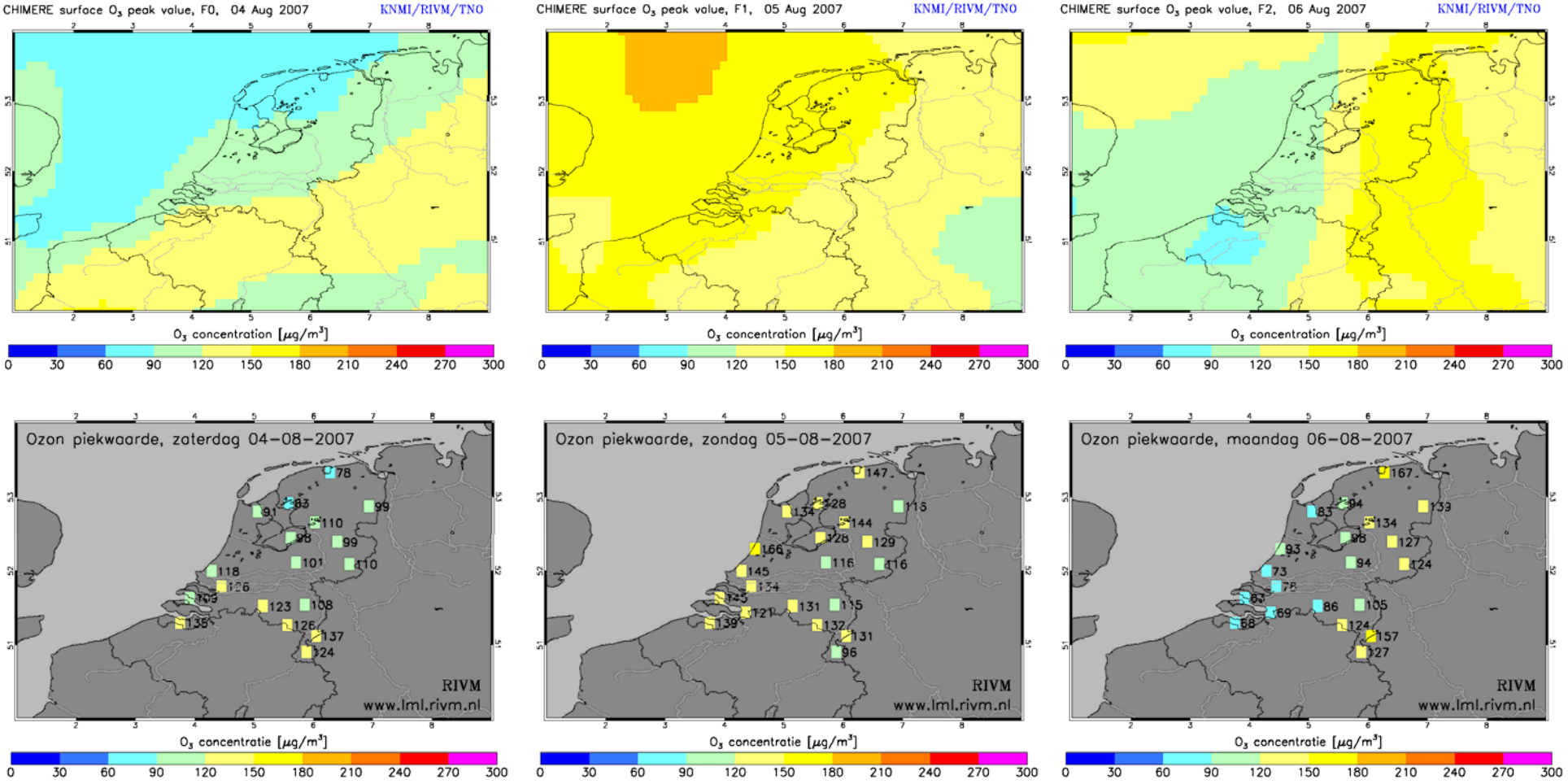
SCIAMACHY - Chimère - surface

- Yearly mean:
  - small bias SCIA - Chimère and Chimère - surface
  - Correlation coefficients 0.7 typically
- SCIA and Chimère resolution comparable
- Extended NO_2 plumes compare well
- Details show differences:
  - Seasonality (winter Chimère higher)
  - Sunday reduction effect smaller in Chimere
  - Individual days
  - Distribution
  - Amount of detail



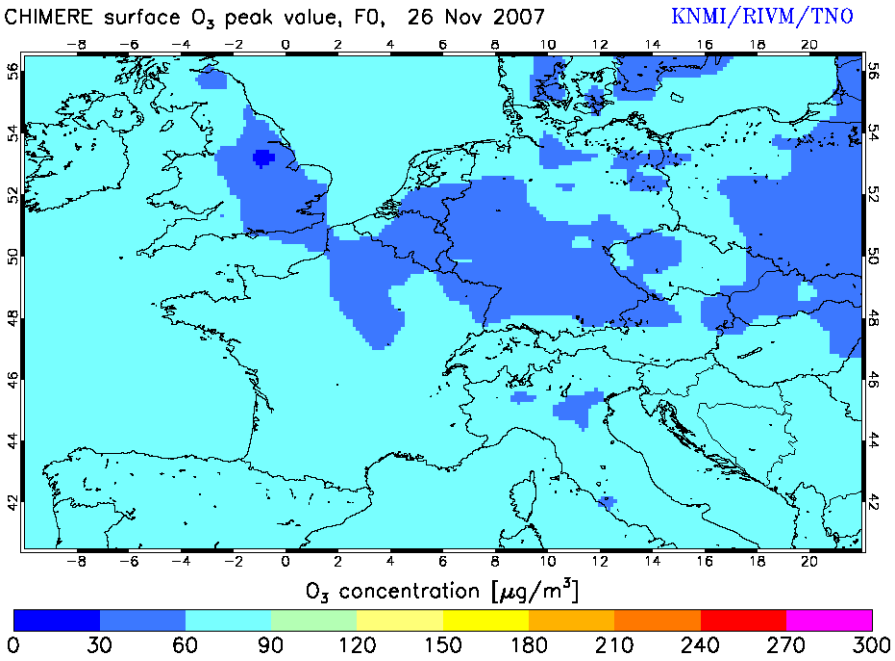
N. Blond et al, JGR 2007

Daily variation in ozone: Chimère vs surface

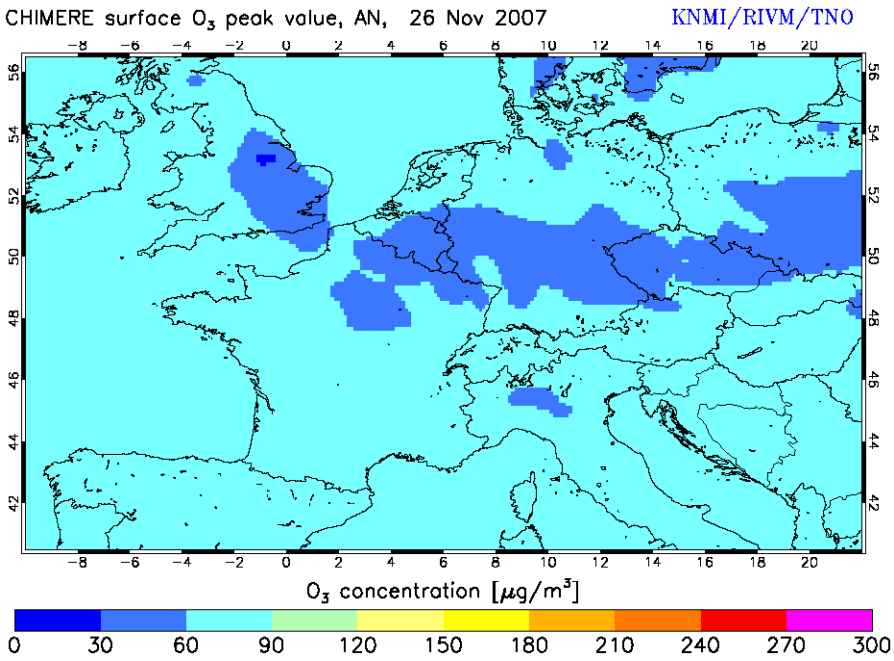


4 Aug 2007 | 5 Aug 2007 | 6 Aug 2007

Chimere: ECMWF vs HIRLAM meteo - Ozone

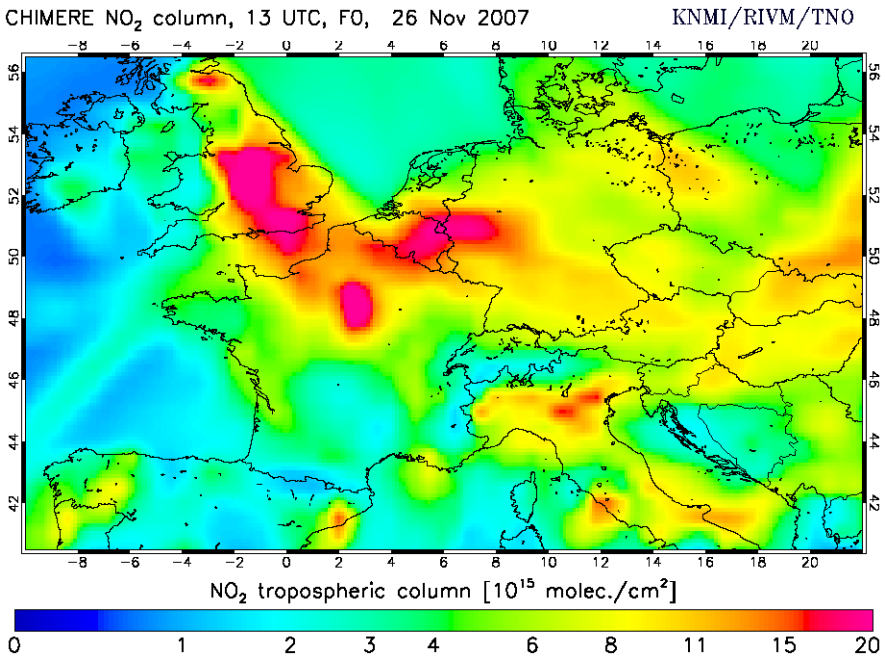


CHIMERE-ECMWF
26 Nov 2007

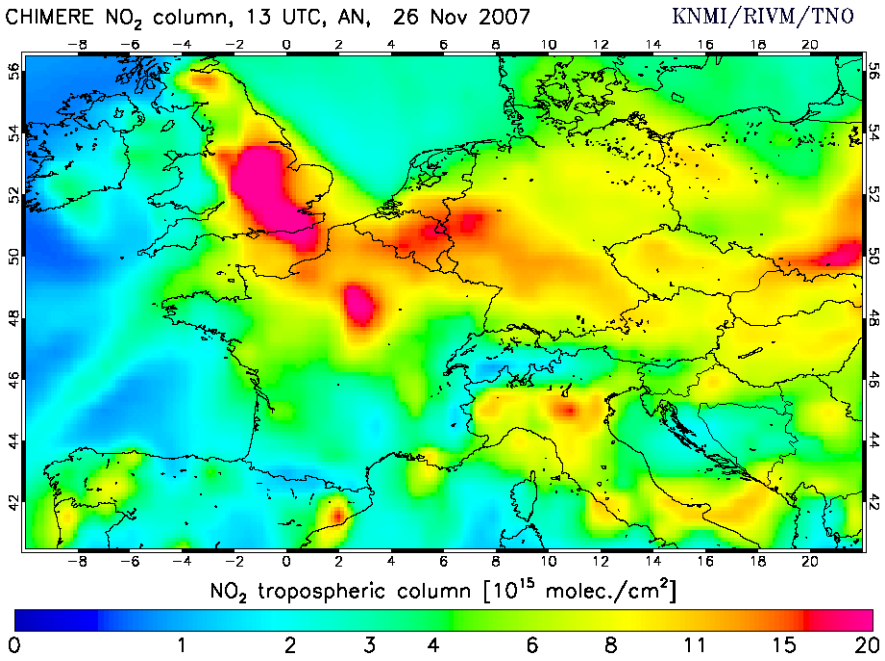


CHIMERE-HIRLAM
26 Nov 2007

Chimere: ECMWF vs HIRLAM meteo - NO2

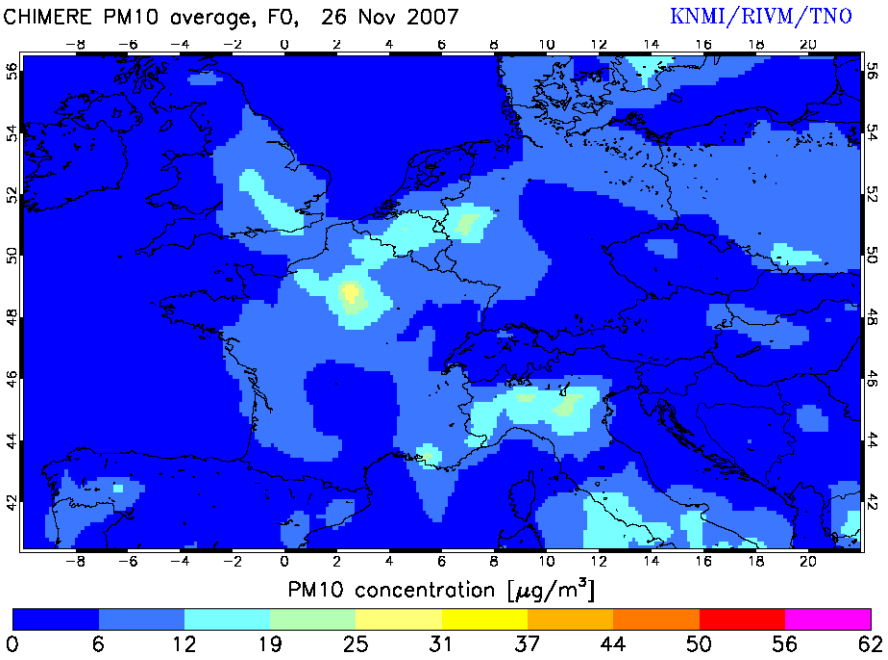


CHIMERE-ECMWF
26 Nov 2007

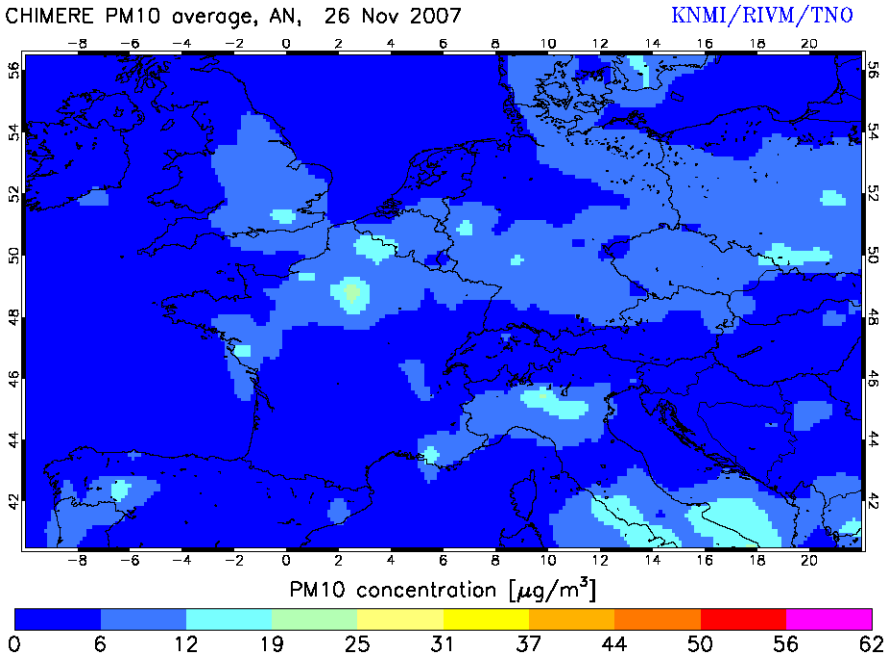


CHIMERE-HIRLAM
26 Nov 2007

Chimere: ECMWF vs HIRLAM meteo - PM10



CHIMERE-ECMWF
26 Nov 2007



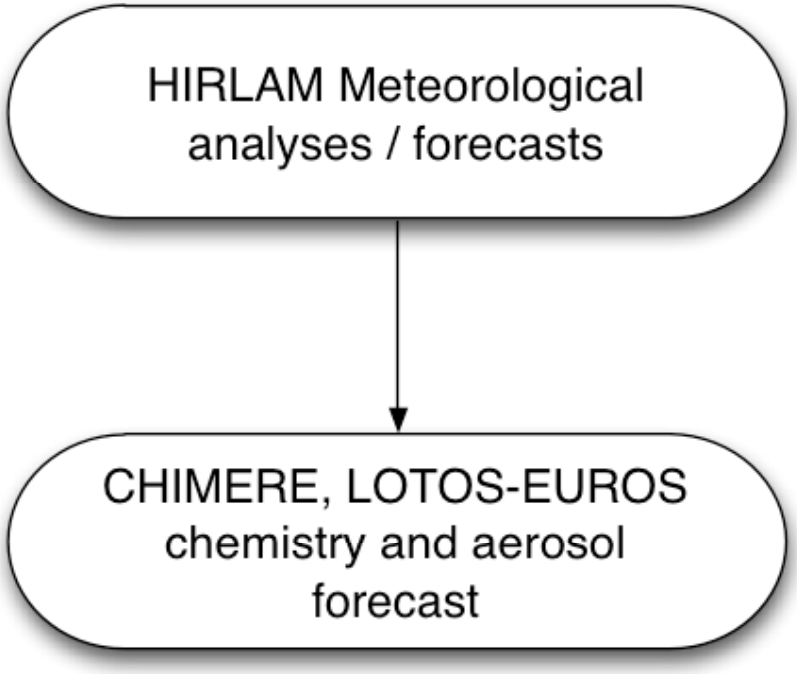
CHIMERE-HIRLAM
26 Nov 2007

That's all

Air-quality forecasts for the Netherlands

Status:
- Project started summer 2006
- Demo forecast on European grid, models driven by ECMWF meteo

Plans:
- High-resolution forecast for the Netherlands
- Coupling to HIRLAM
- Summer 2007 - Performance tests
  Summer 2008 - operational ...
- Assimilation



PROMOTE

GMES Service Element – Atmosphere

www.gse-promote.org

Providers

Prev'Air
CERC
DLR
DWD
FMI
KNMI
RIU
ACRI
FlyBy
TNO

Deliver a Service on the Ozone layer: past, present and forecast

Deliver a Service on Surface UV: past, present and forecast

Demonstrate a Service on Air Quality: past, present and forecast

Define a future Service on Greenhouse Gases: emissions, concentrations

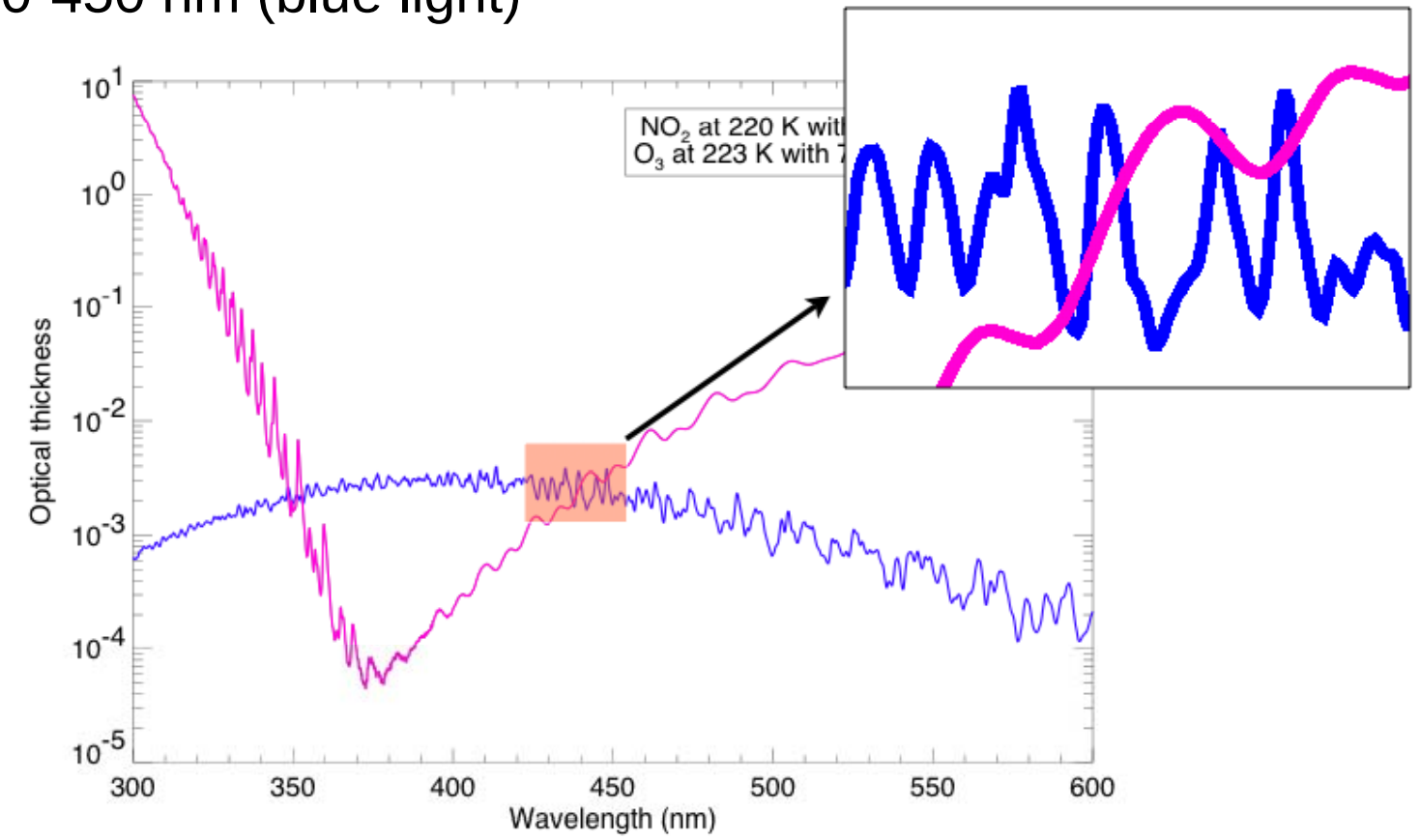
Lead: DLR

Users

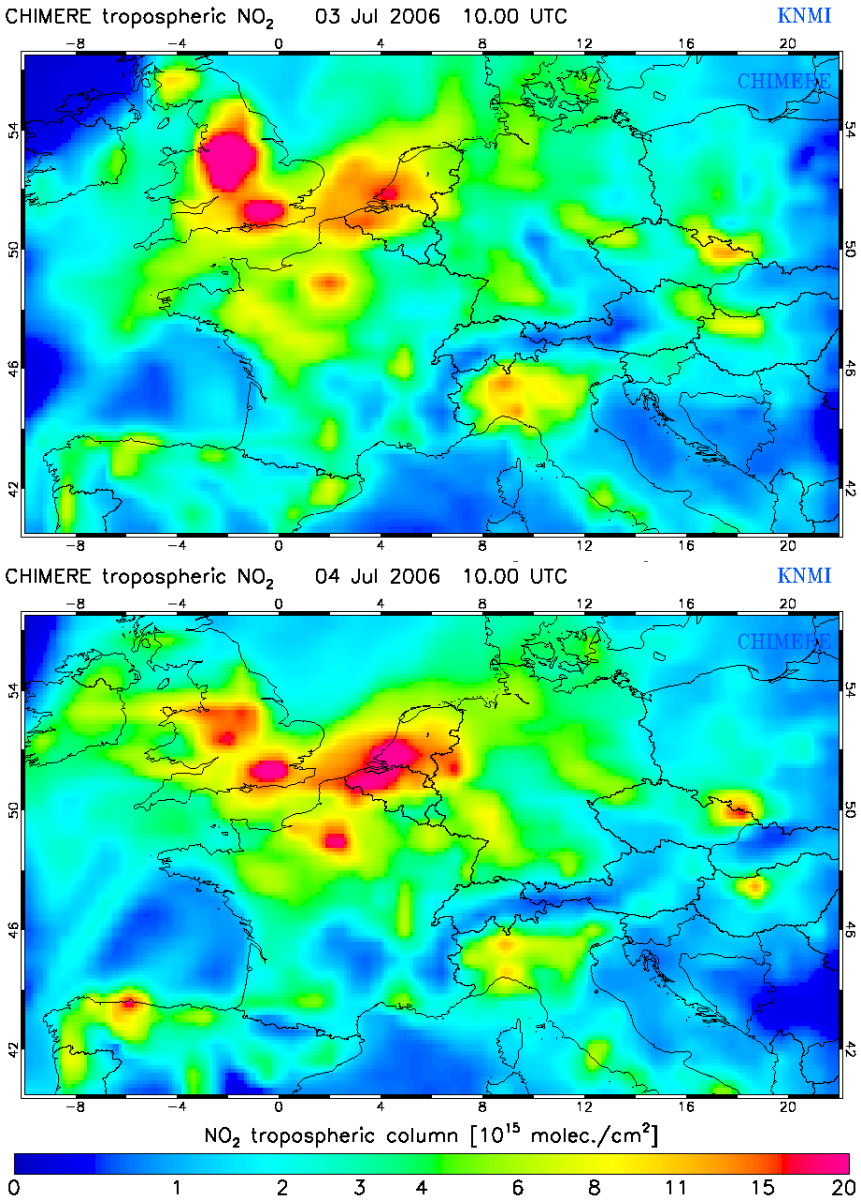
ADEME
INERIS
ARPA
BVDD
ECMWF
EMPA
EPA
JRC
LBC
LUA
NILU
RIVM
SYKE
UBA-A
WMO

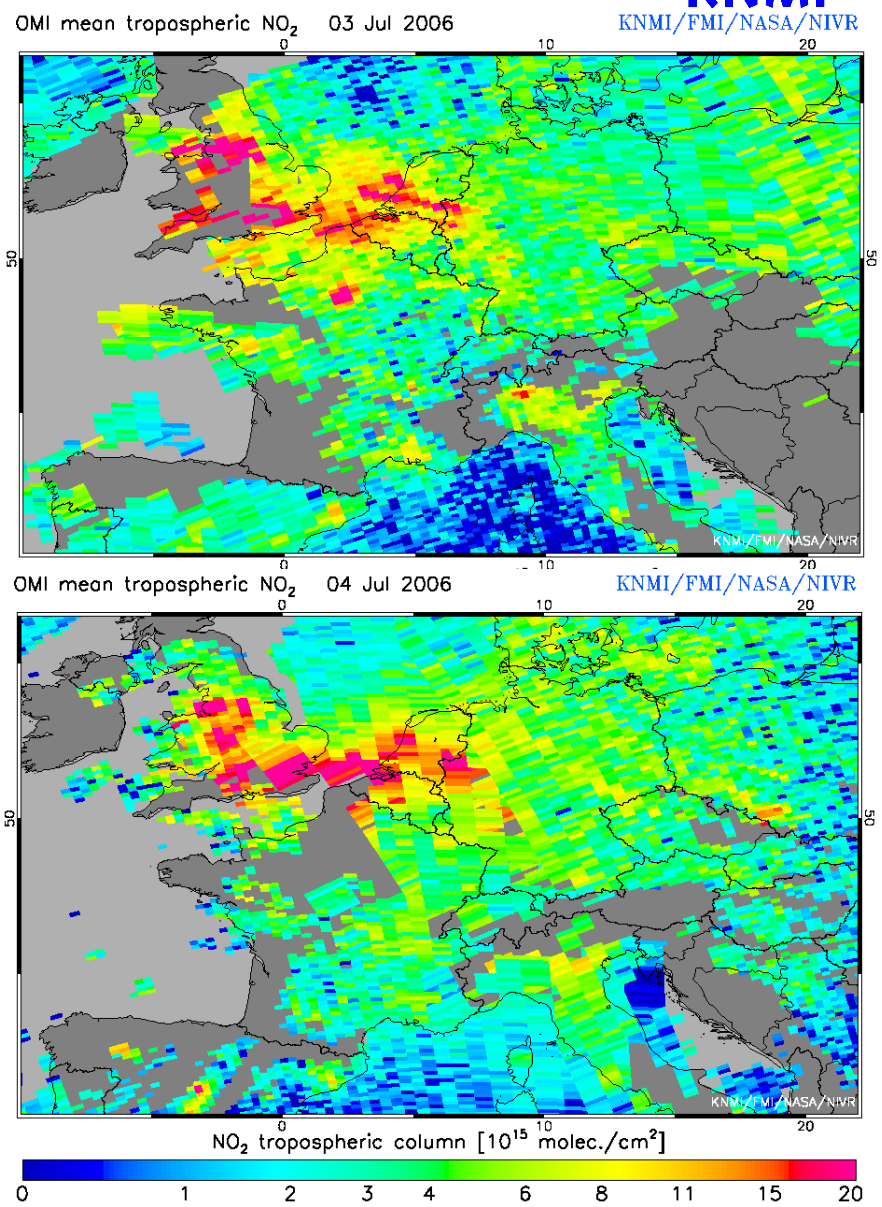
Satellite measurement of NO2

Spectral fingerprint
at 420-450 nm (blue light)

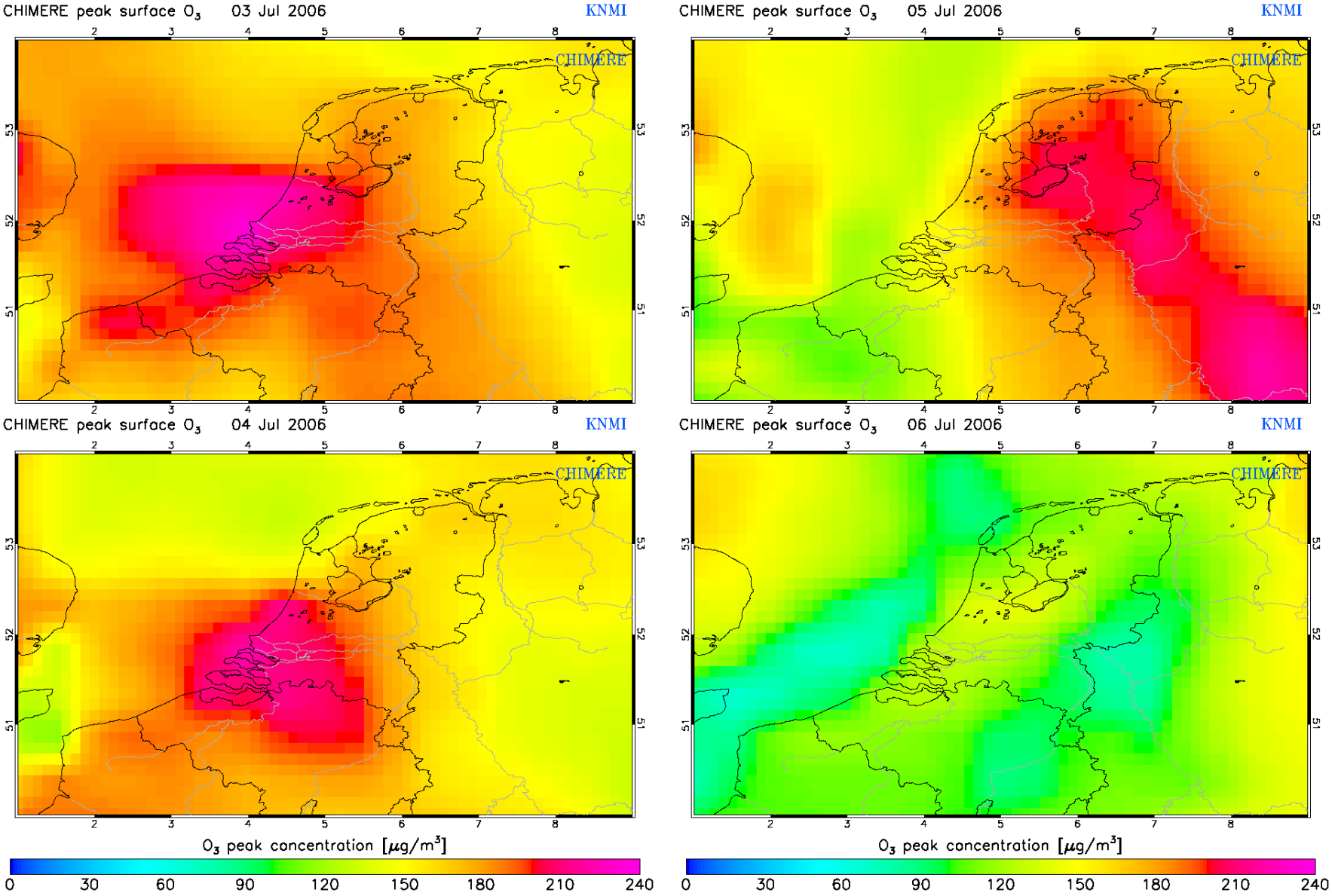


Chimère vs OMI



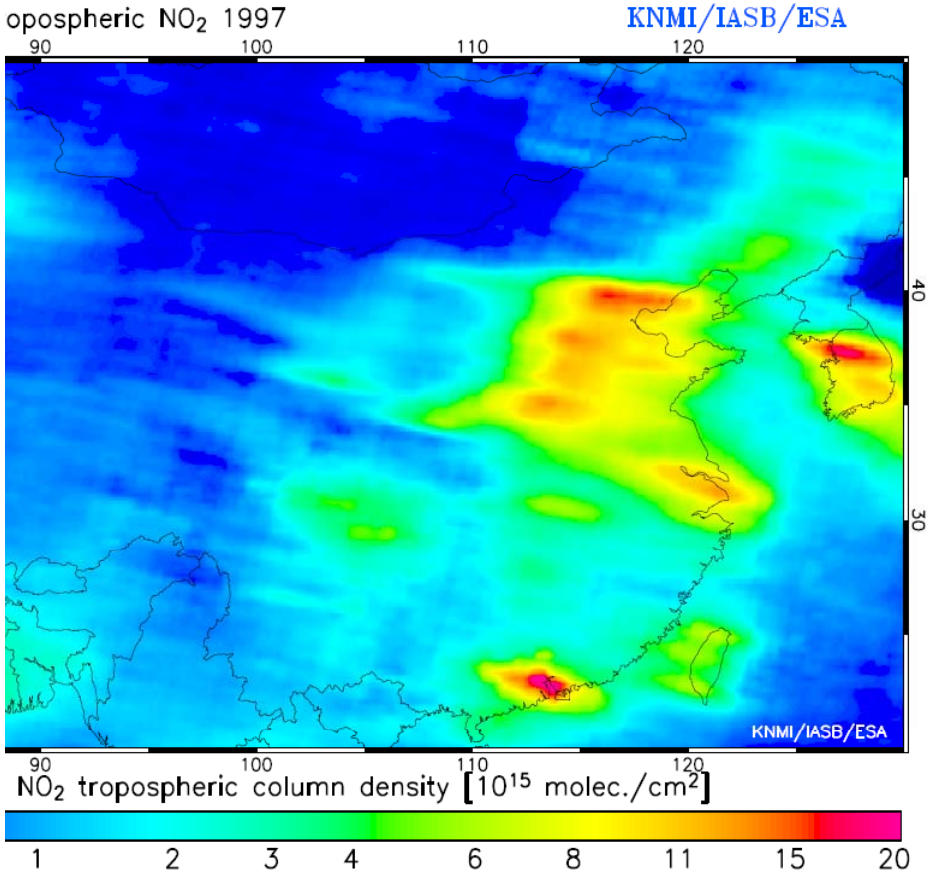


Chimère forecast for 4-6 July 2006

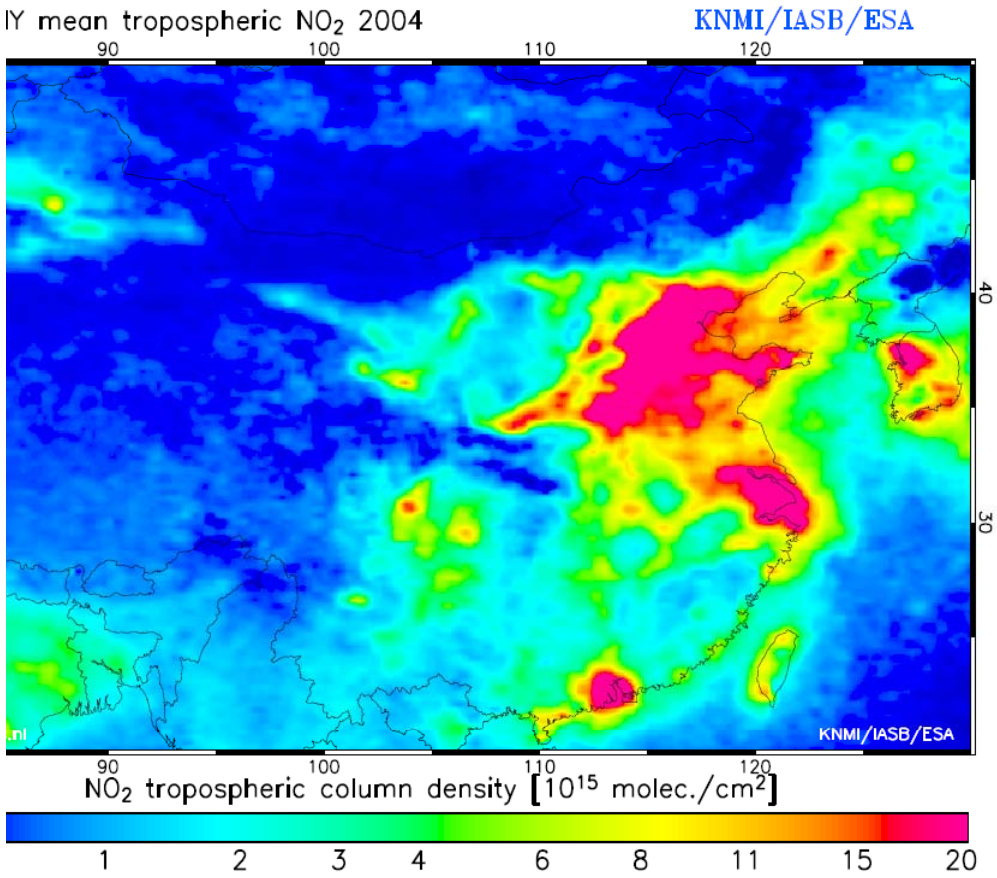


Trend over China

GOME, 1997



SCIA, 2004



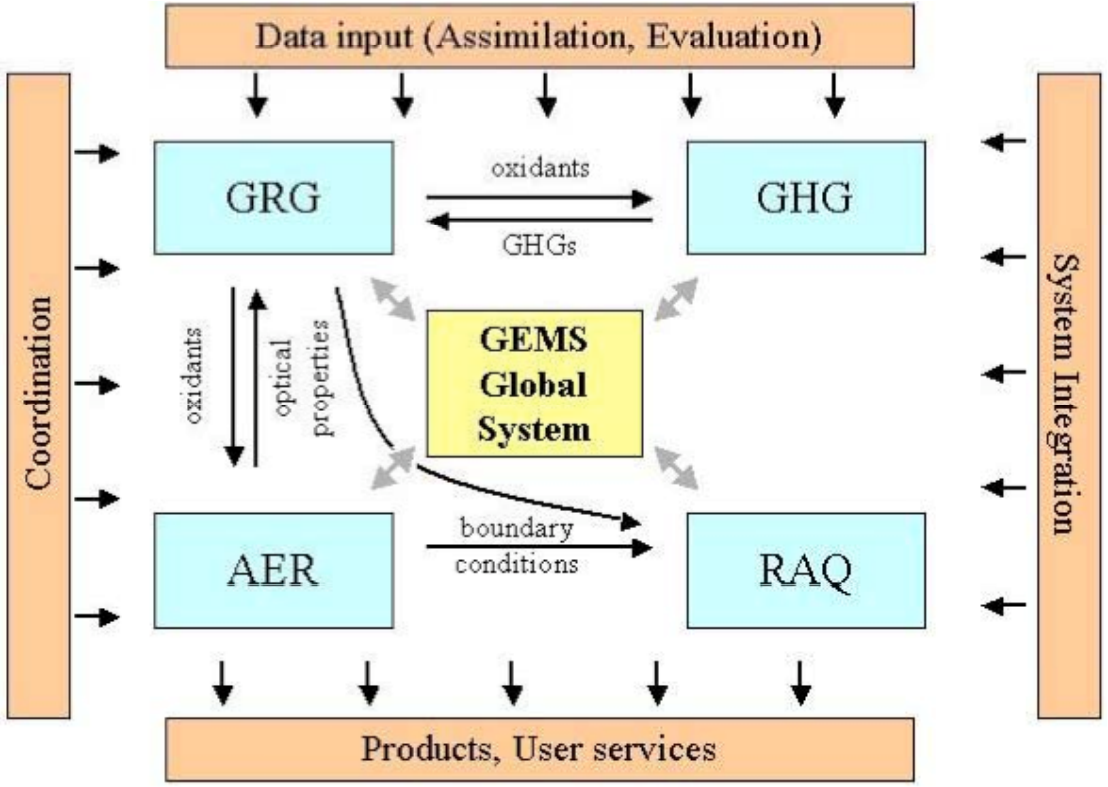
The GEMS Project

Global & regional Earth-system Monitoring using Satellite and in-situ data
EU 6FP, GMES, 2005-2009, 27 partners

Subprojects:

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

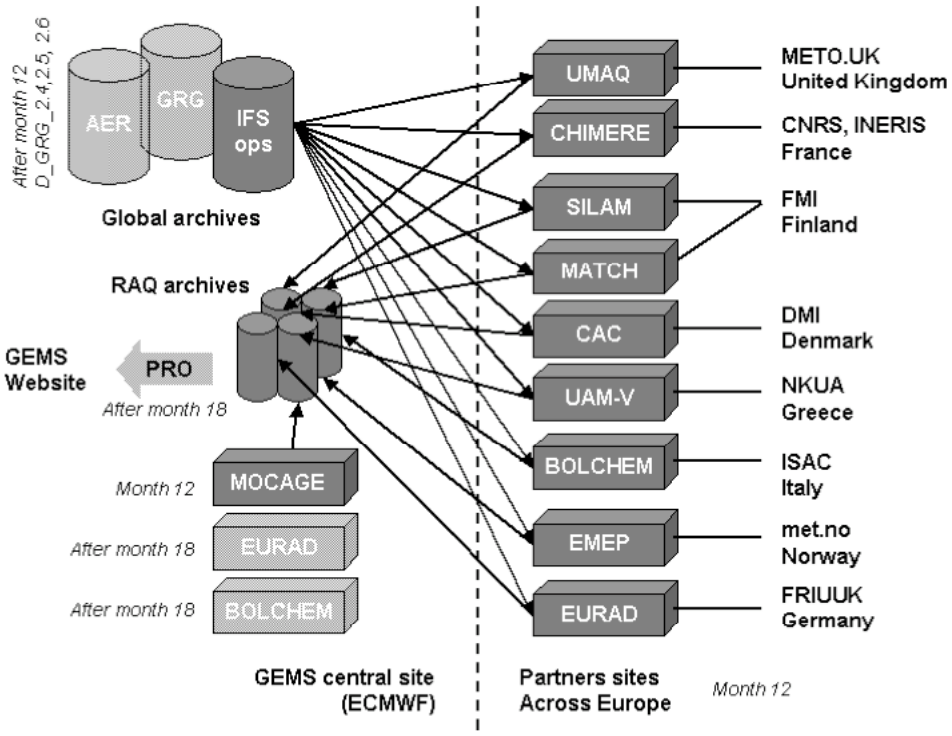
First (trial) reanalysis
(period 2003/2004)
will start at end of 2006



GEMS: Regional air quality subproject

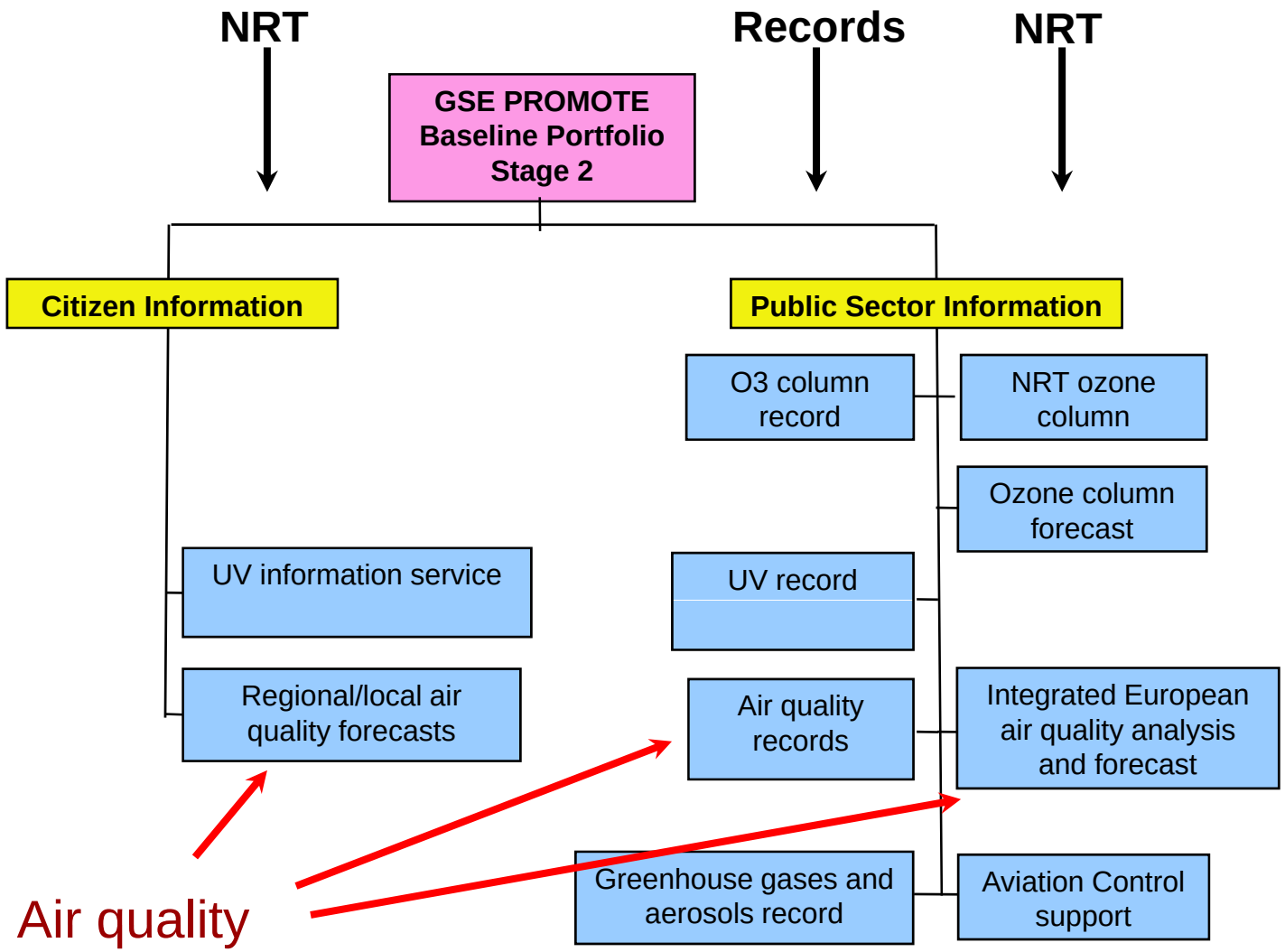
Aspects:

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



PROMOTE

http://www.gse-promote.org



Chimère vs surface observations (LML, RIVM)