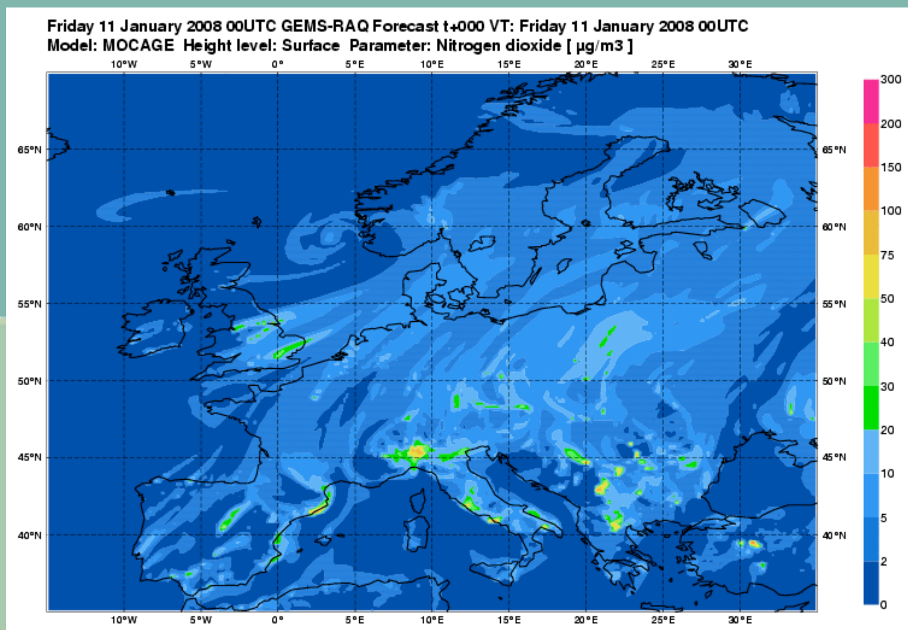
International Workshop on Air Quality Forecasting Research



Chemical data assimilation for AQ prognoses over Europe in GEMS/MACC

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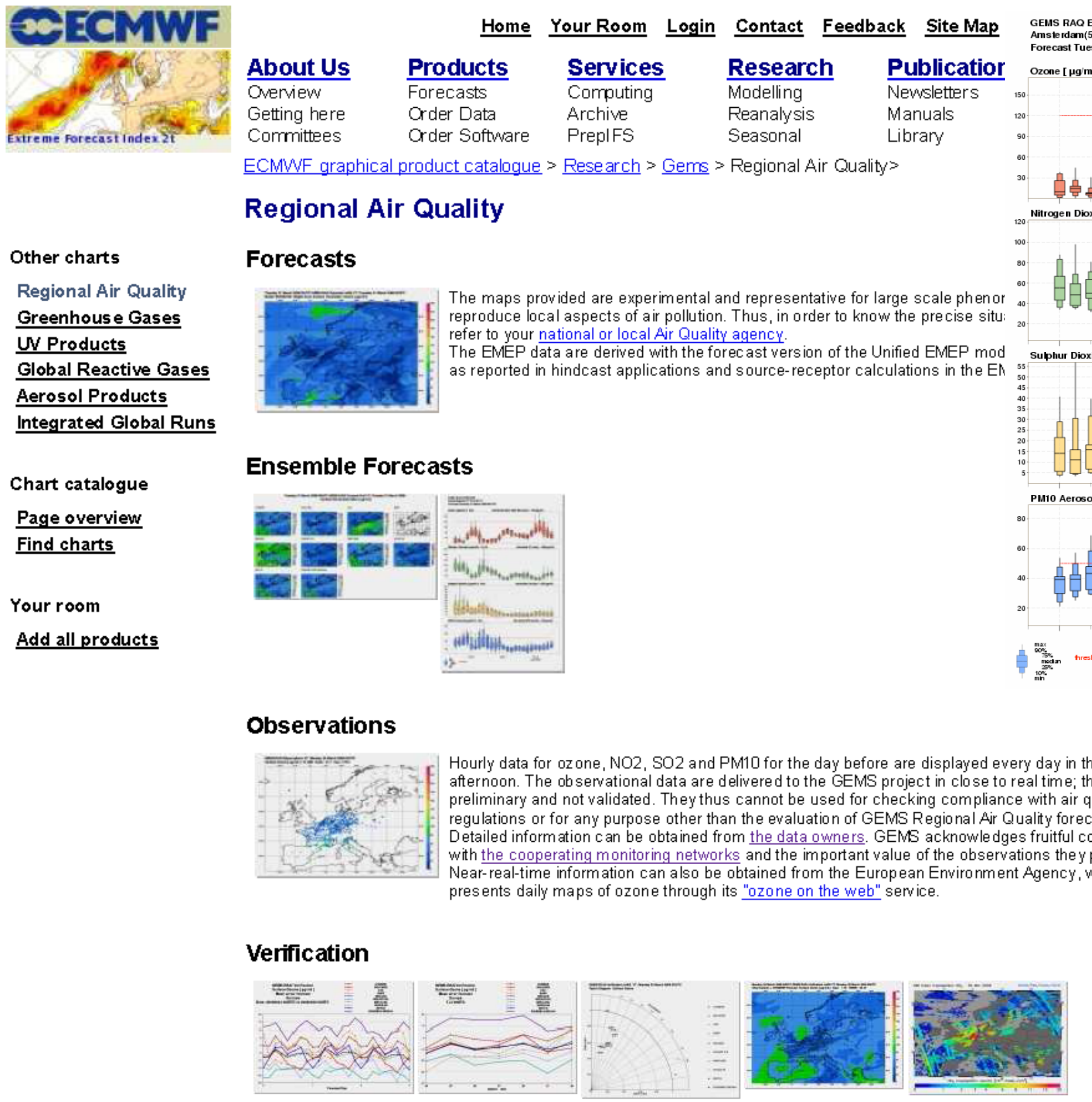
H. Elbern (RIU, Köln University)

Acknowledgements : Adrian Simmons (ECMWF) and the GEMS/MACC regional air quality teams

METEO FRANCE
Toujours un temps d'avance

http://gmes-atmosphere.eu/



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Forecasts

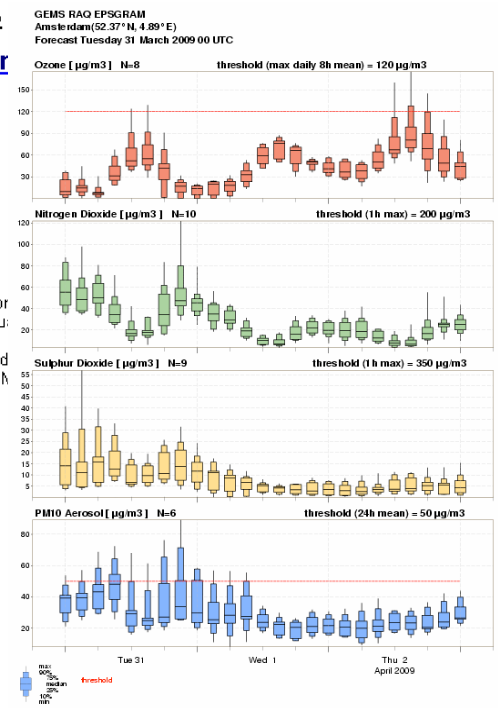
The maps provided are experimental and representative for large scale phenor
reproduce local aspects of air pollution. Thus, in order to know the precise situ
refer to your national or local Air Quality agency.
The EMEP data are derived with the forecast version of the Unified EMEP mod
as reported in hindcast applications and source-receptor calculations in the EM

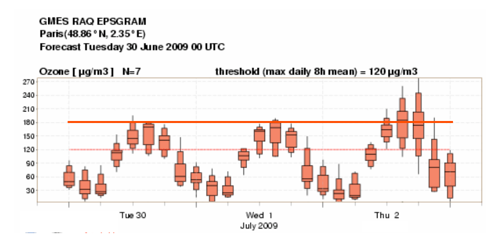
Ensemble Forecasts

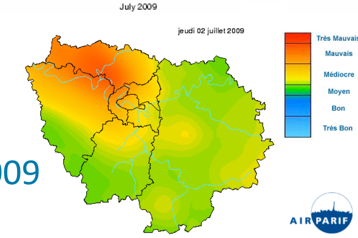
Observations

Hourly data for ozone, NO2, SO2 and PM10 for the day before are displayed every day in th
afternoon. The observational data are delivered to the GEMS project in close to real time; th
preliminary and not validated. They thus cannot be used for checking compliance with air q
regulations or for any purpose other than the evaluation of GEMS Regional Air Quality forec
Detailed information can be obtained from the data owners. GEMS acknowledges fruitful cc
with the cooperating monitoring networks and the important value of the observations they p
Near-real-time information can also be obtained from the European Environment Agency, v
presents daily maps of ozone through its "ozone on the web" service.

Verification



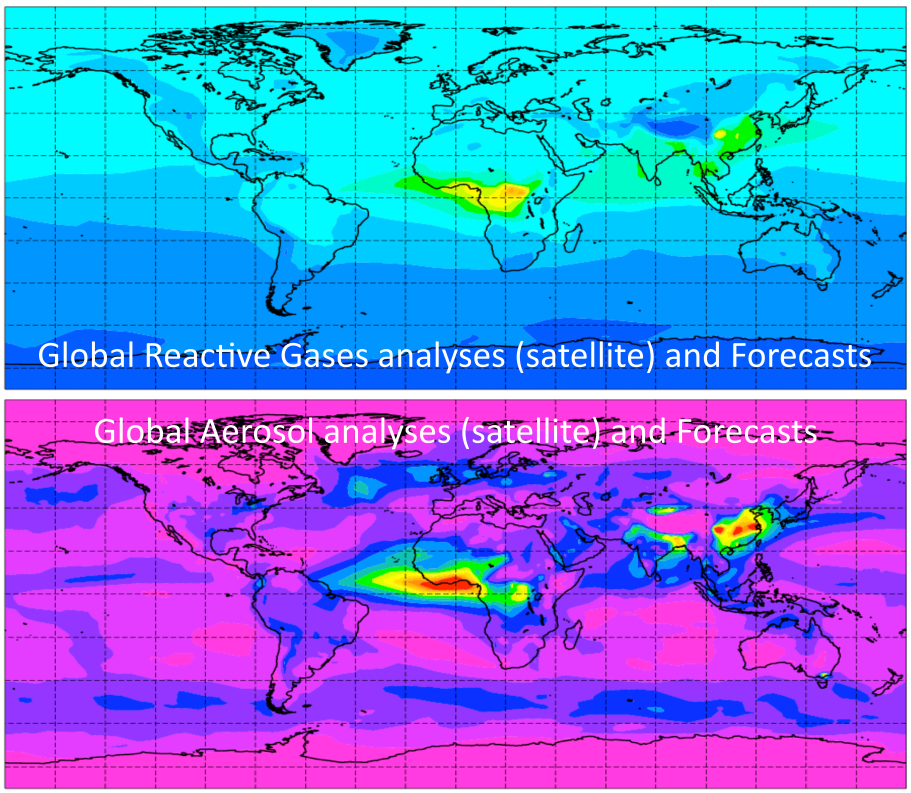




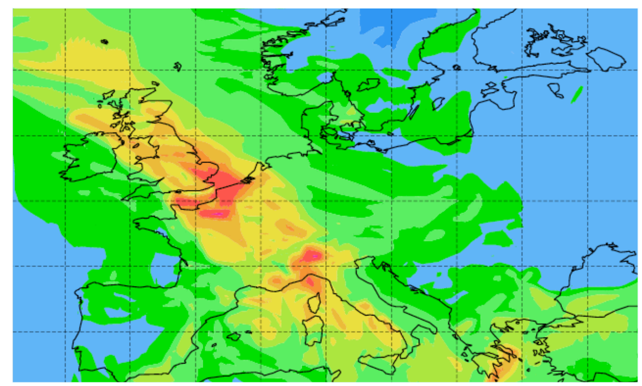
Paris
02/07/2009

From chemical DA research to pre-operations

- In the precursor project GEMS, chemical data activities have been performed « off-line ». In the MACC phase, a data assimilation step will be included in 7 pre-operational regional Air Quality forecasting suites, with NRT analyses and a posteriori analyses (based upon validated data) as new services.
- At this stage, no attempt at modifying dynamical fields using tracer information.



BC



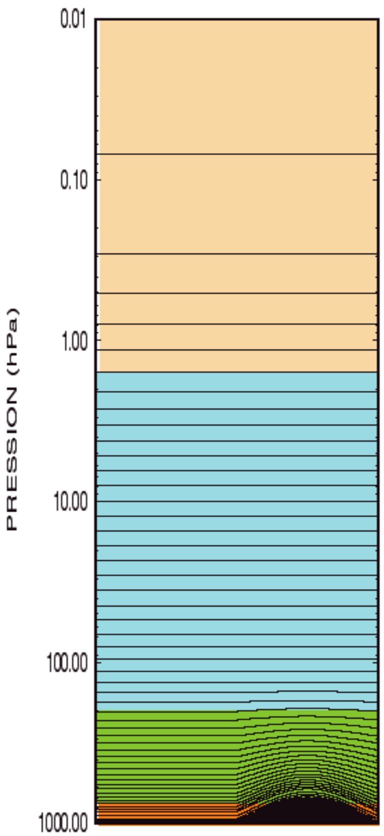
Surface, satellite and/or profile data assimilation at higher resolution (target 0.1°). Impact on AQ reanalyses over Europe and forecasts?

Asset : seven AQ assimilation and forecast suites

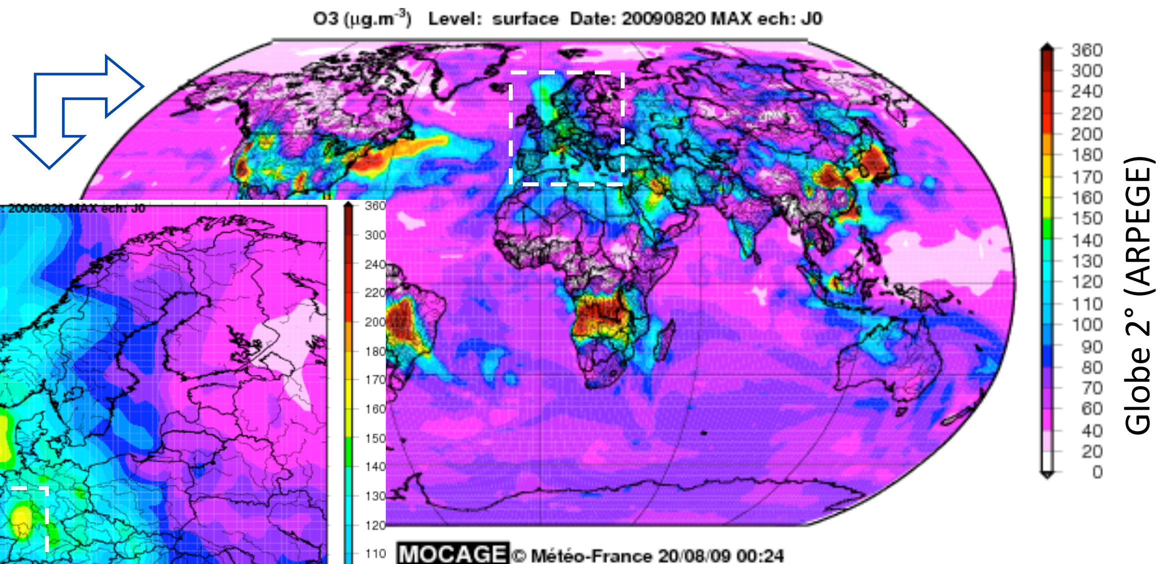
	Current resolution	Assimilation method
CHIMERE Foret et al., CNRS	0.5°, L8, top : 500hpa	Optimal Interpolation, EnKF
EMEP Gauss et al., met.no	0.25°, L20, top : 100hpa	Variational, 3d-var
EURAD Elbern et al., RIU	15km, L23, top : 100hpa	Variational, 3d-/4d-var
LOTOS-EUROS Schaap et al., TNO	25km, L4, top : 3.5km	Optimal Interpolation, EnKF
MATCH Roberston et al., SMHI	0.5°, L30, top : 100hpa	Variational, 3d-var (ongoing)
MOCAGE Peuch et al., MF	0.2°, L47, top : 5hpa	Variational, 3d-fgat
SILAM Sofiev et al., FMI	0.2°, L46, top : 100hpa	Variational, 4d-var

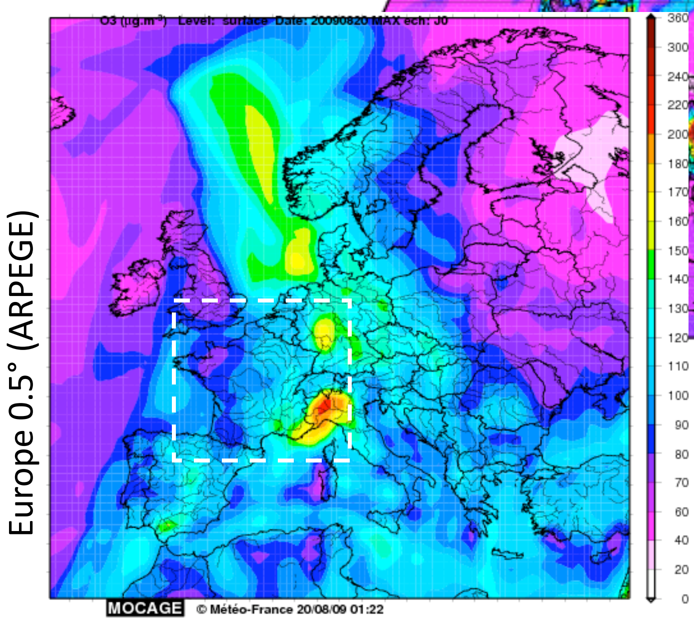
AQ forecasting with the MOCAGE model

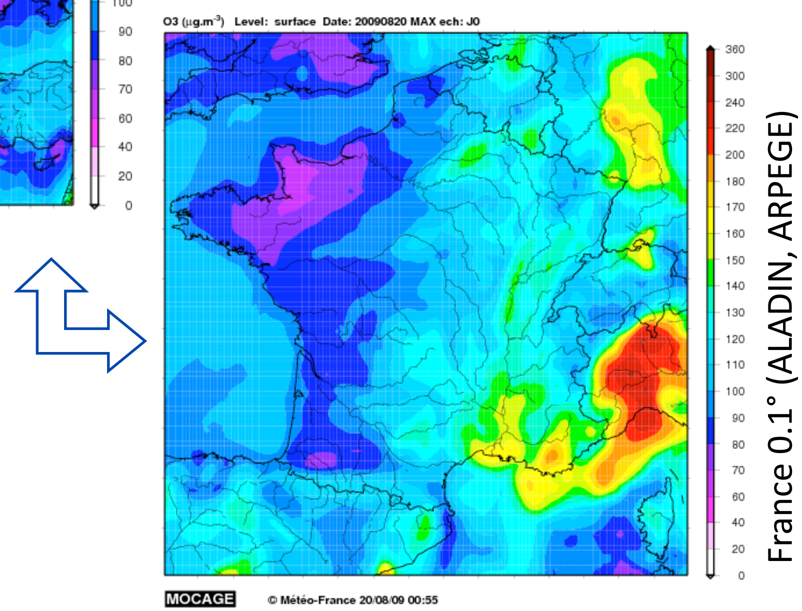
Operational configuration at Météo-France



60 vertical levels
Top at 0,1hPa







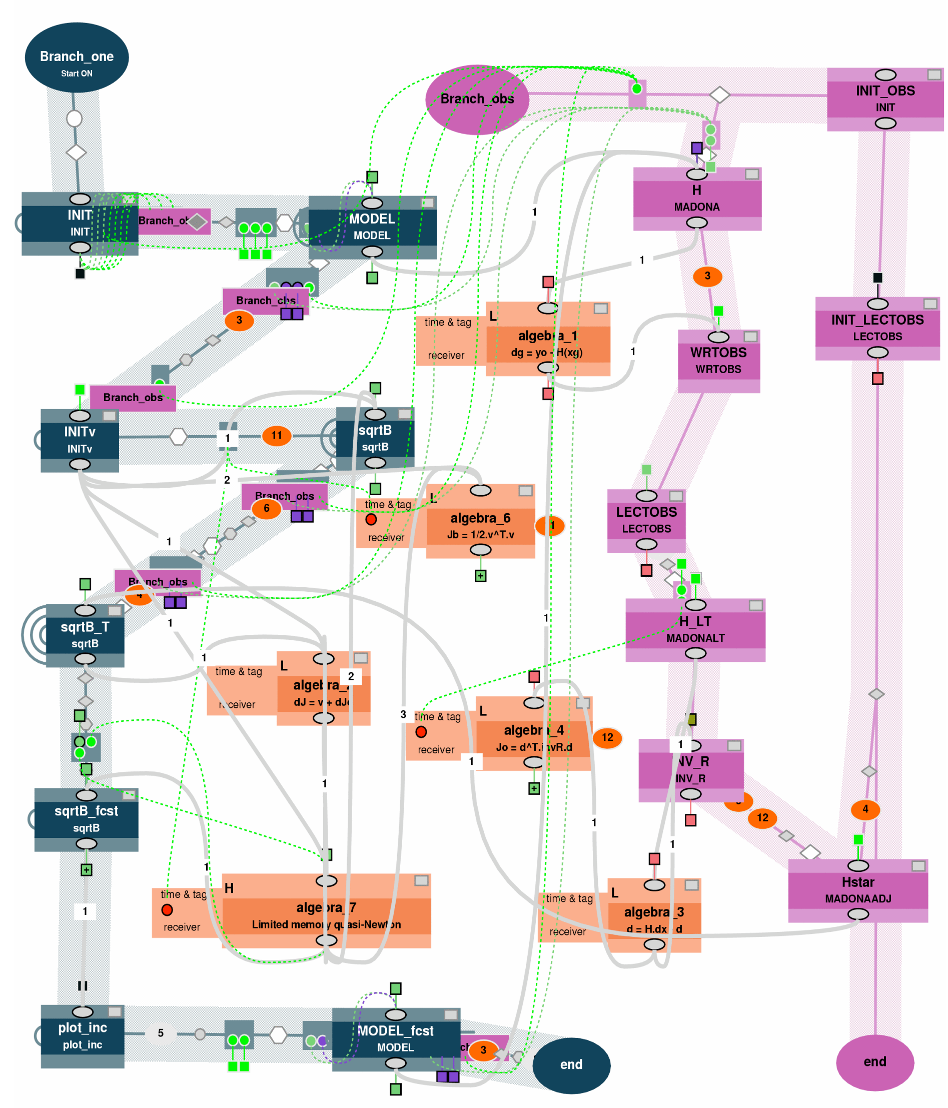
The MACC version has only 2 domains, increased resolution over Europe (0.2°), L47/5hPa, nudging of the global domain towards MACC global chemical BCs, and ECMWF/IFS forcings

Assimilation module: PALM

Method : Variational (3D-FGAT)

Minimisation of the cost function (observations + model). PALM offers full flexibility : all the parameters of the assimilation system can be tuned by the user). Several diagnostics are available.

http://www.cerfacs.fr/~palm



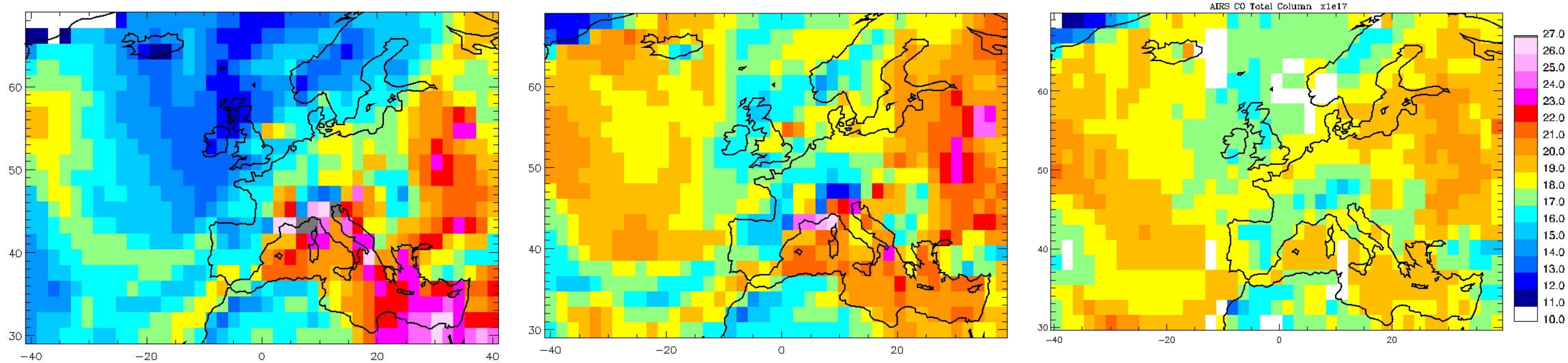
Asset : initial condition assimilation

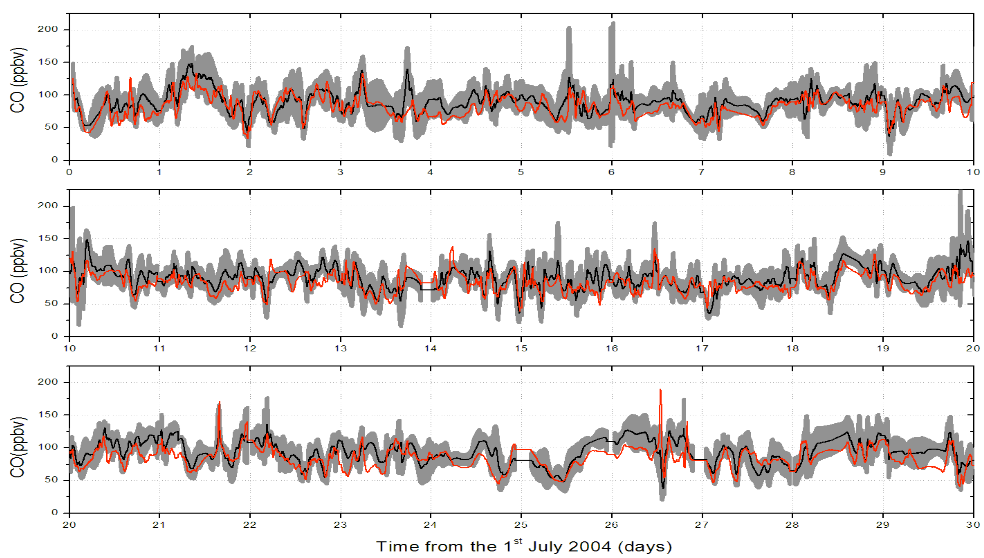
MOCAGE CO data assimilation (MF, El Amraoui, Attié, Claeyman, Peuch)

Method : 3D-fgat

Data assimilated : MOPITT CO (NCAR)

MOCAGE **ASSIM. MOPITT** **AIRS**





Evaluation against independant MOZAIC in-situ data (flight level, July 2004).

MOZAIC

Assim. MOPITT

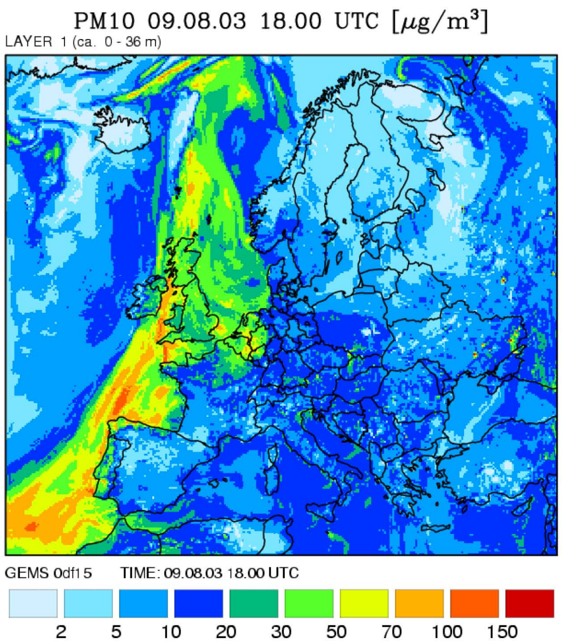
Sigma of assim.

Asset : Inititial condition assimilation

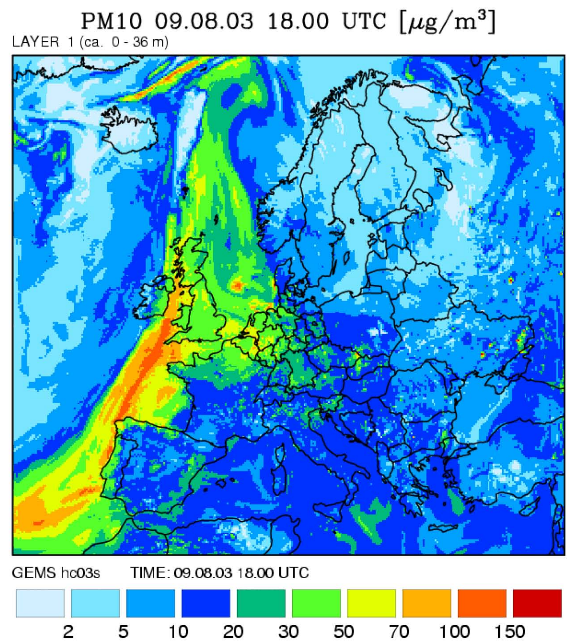
EURAD-IM aerosol data assimilation (RIU, Elbern et al.)
Method : 3D-var
Data assimilated : insitu PM10 + SYNAER DLR retrievals

9.8.2003 18:00 UTC

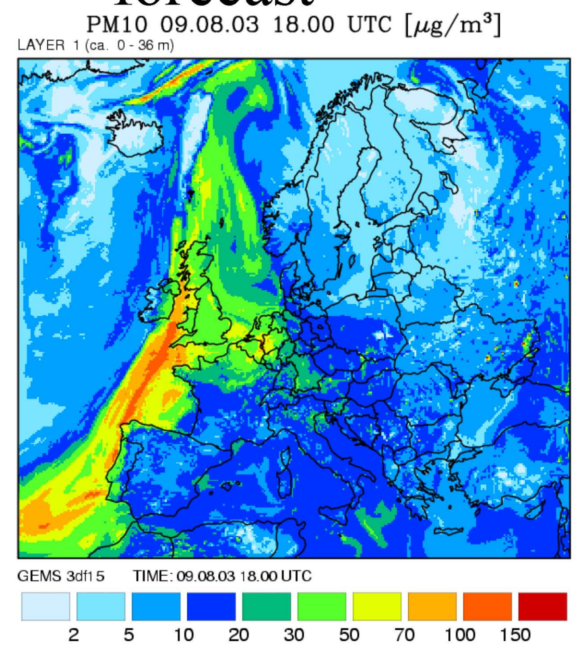
control



analysis



assimilation based forecast



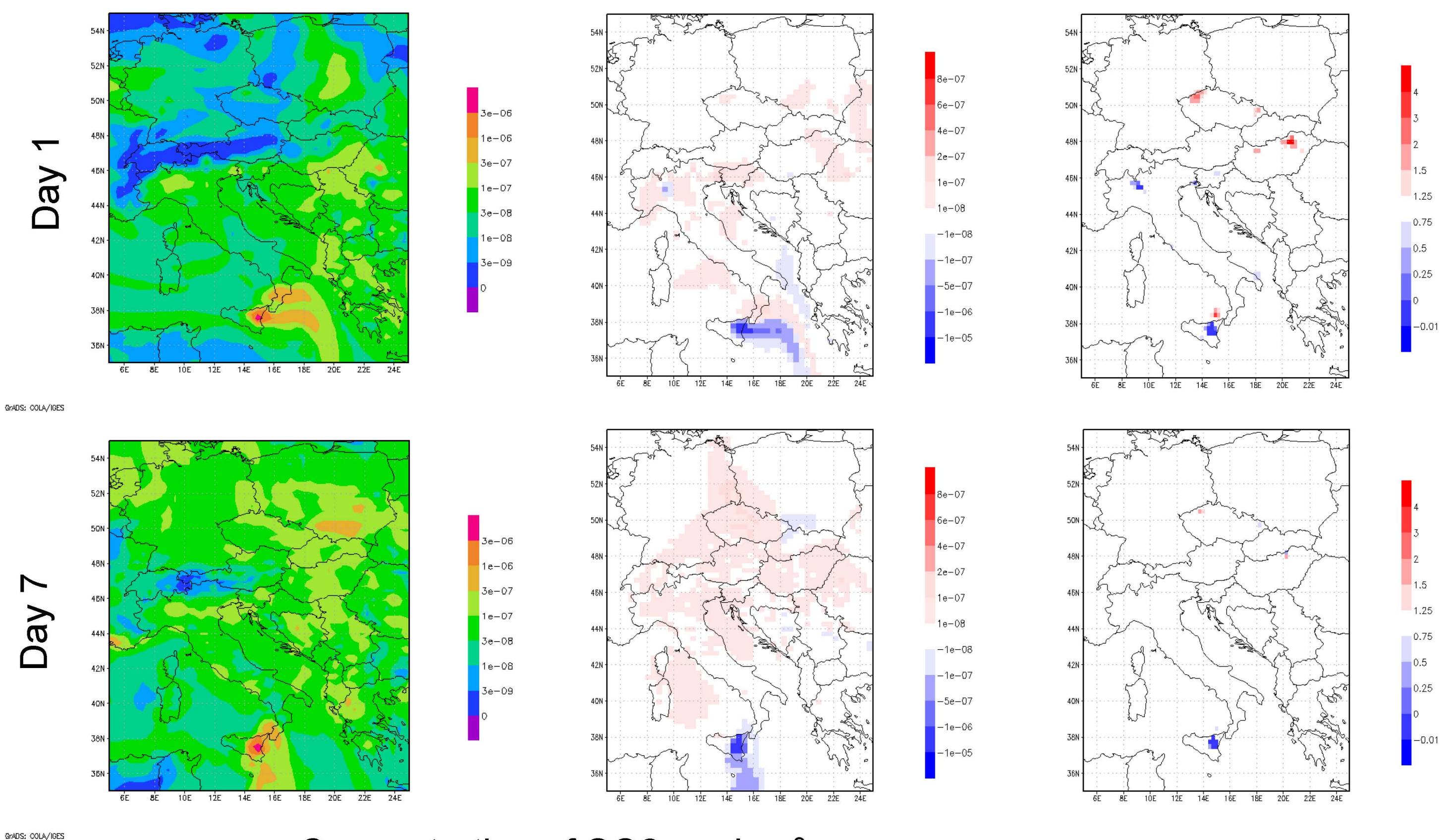
Asset : Joint emissions and initial condition optimization

SILAM SO2 data assimilation (FMI, Sofiev, Vira)

Method : 4D-var

Data assimilated : surface SO_2

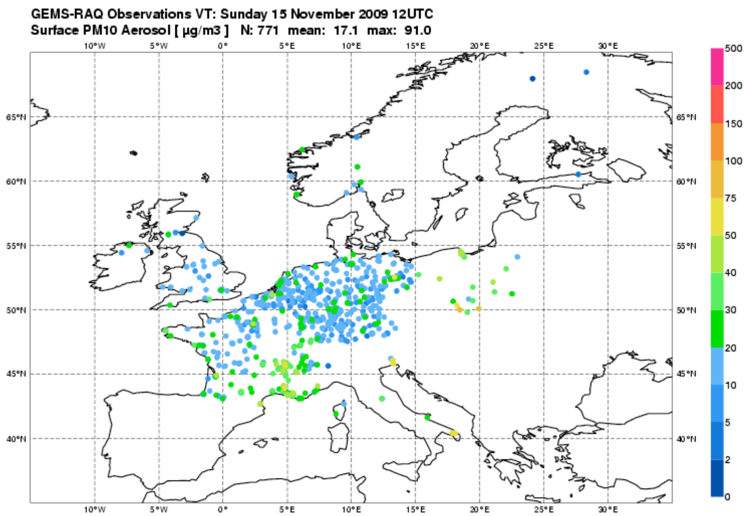
Reference | Optimised-Ref | Emissions factor update

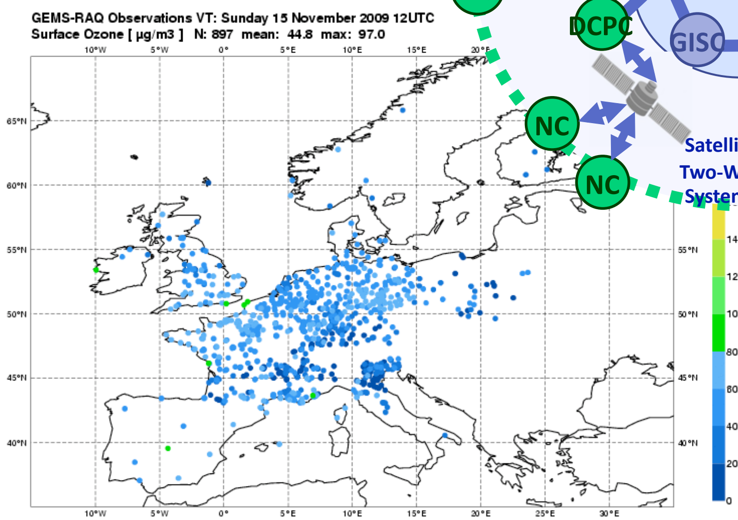


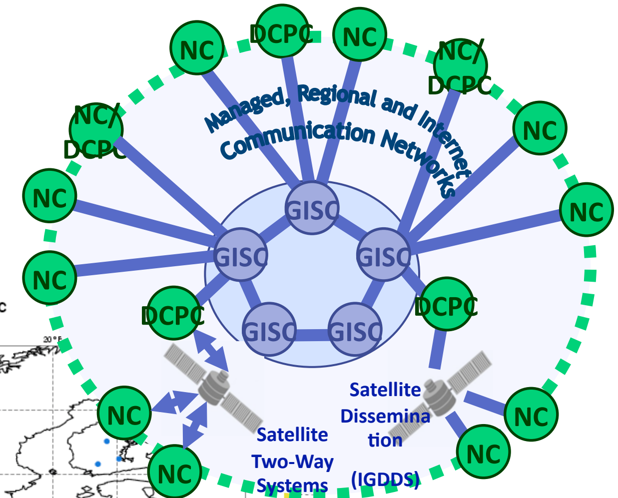
Concentration of SO2, mol m^{-3}

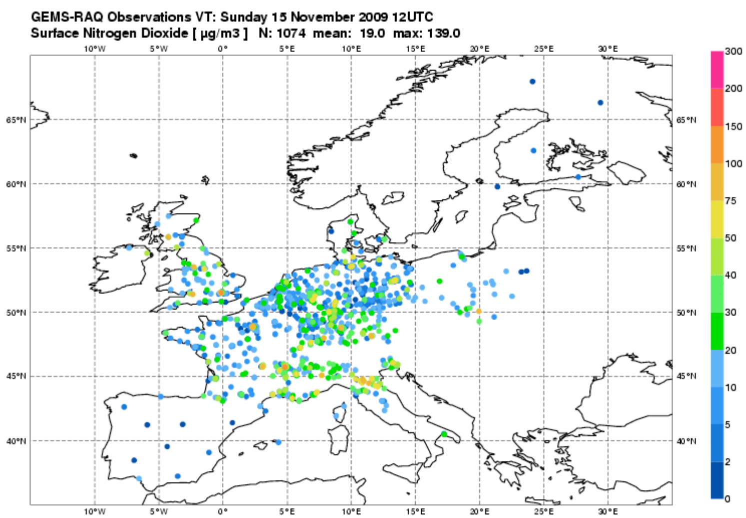
Asset : NRT surface observations

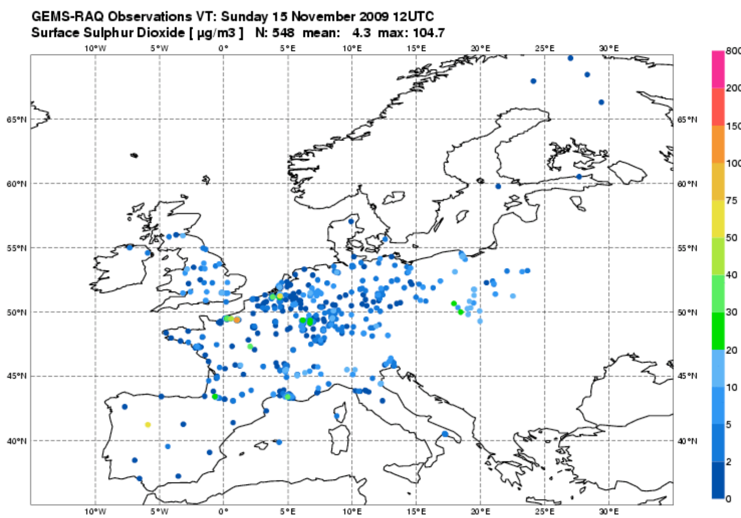
Access in NRT of surface data in BUFR from 14 countries (900 sites for ozone and PM10, 1200 sites for NO2, 550 for SO2, 300 for CO). Ahead : use of the WIS.



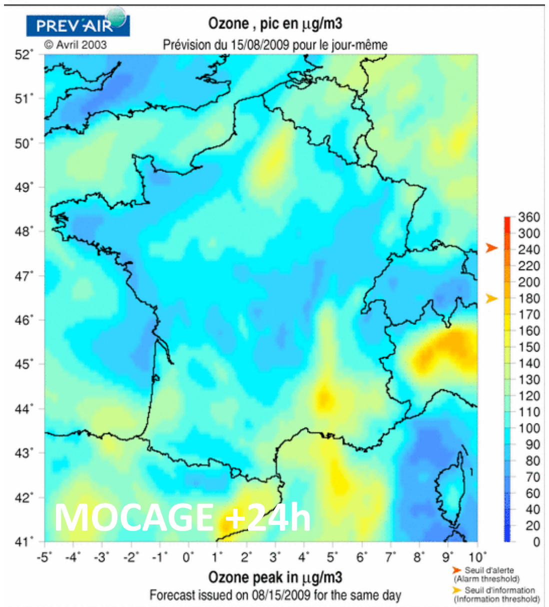


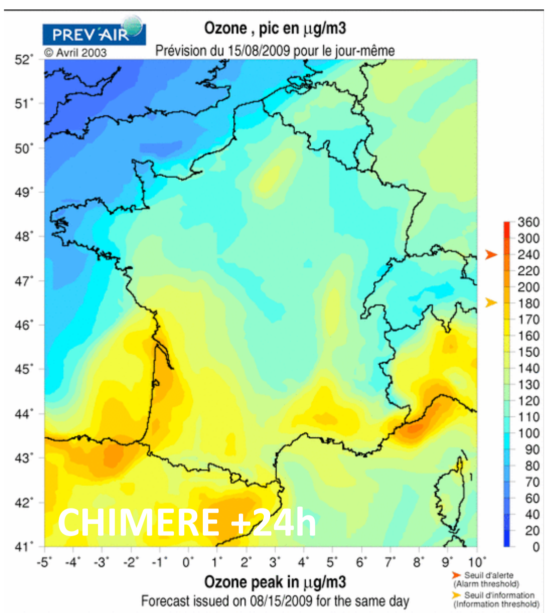


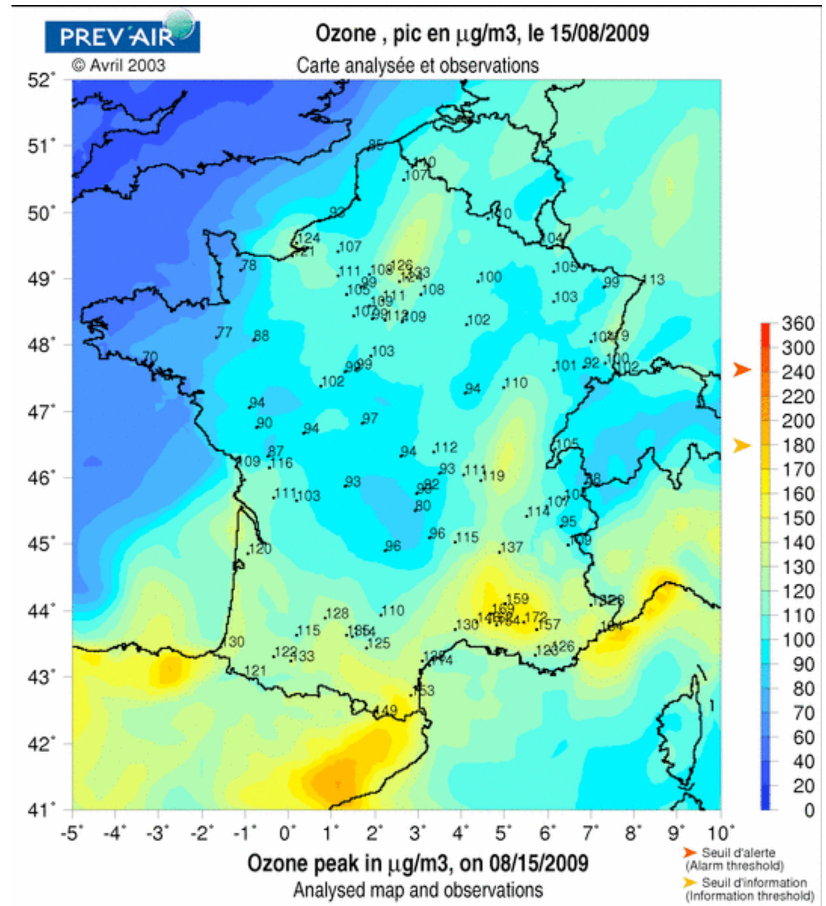




Monitoring surface Air Quality : surface analyses



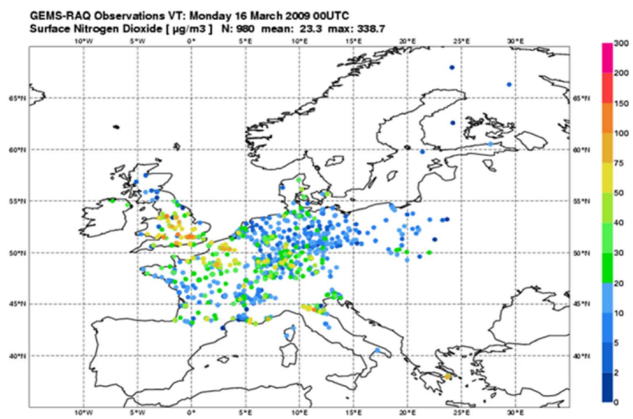




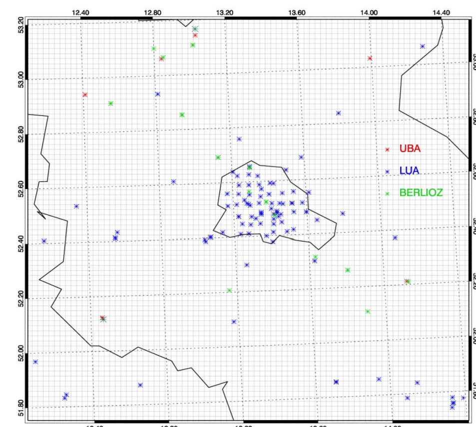
A first important application are surface analyses, both for the information of the public and authorities (EEA, …) and for model verification. Example from the French operational AQ platform Prev'Air (http://www.prevair.org)

Some issues with surface chemical data assimilation

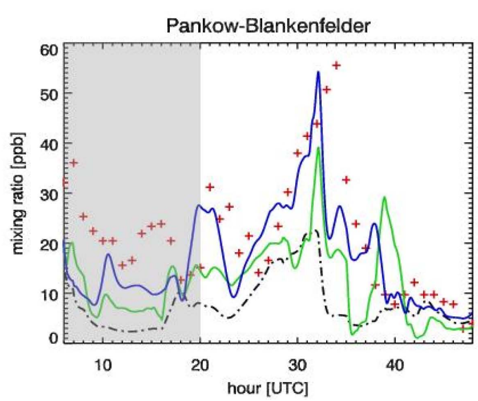
- Surface network deployment bias toward populated locations
- Observations density and representativity problems
- Manyfold surface processes challenge initial value dominance
- Computational burden for advanced (eg. 4d-var) assimilation algorithm…

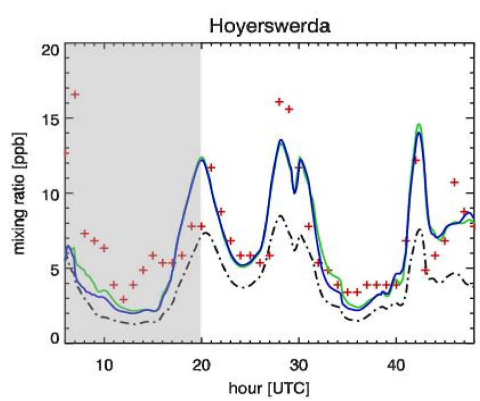


EURAD-IM



Workaround: spatio-temporal data assimilation:

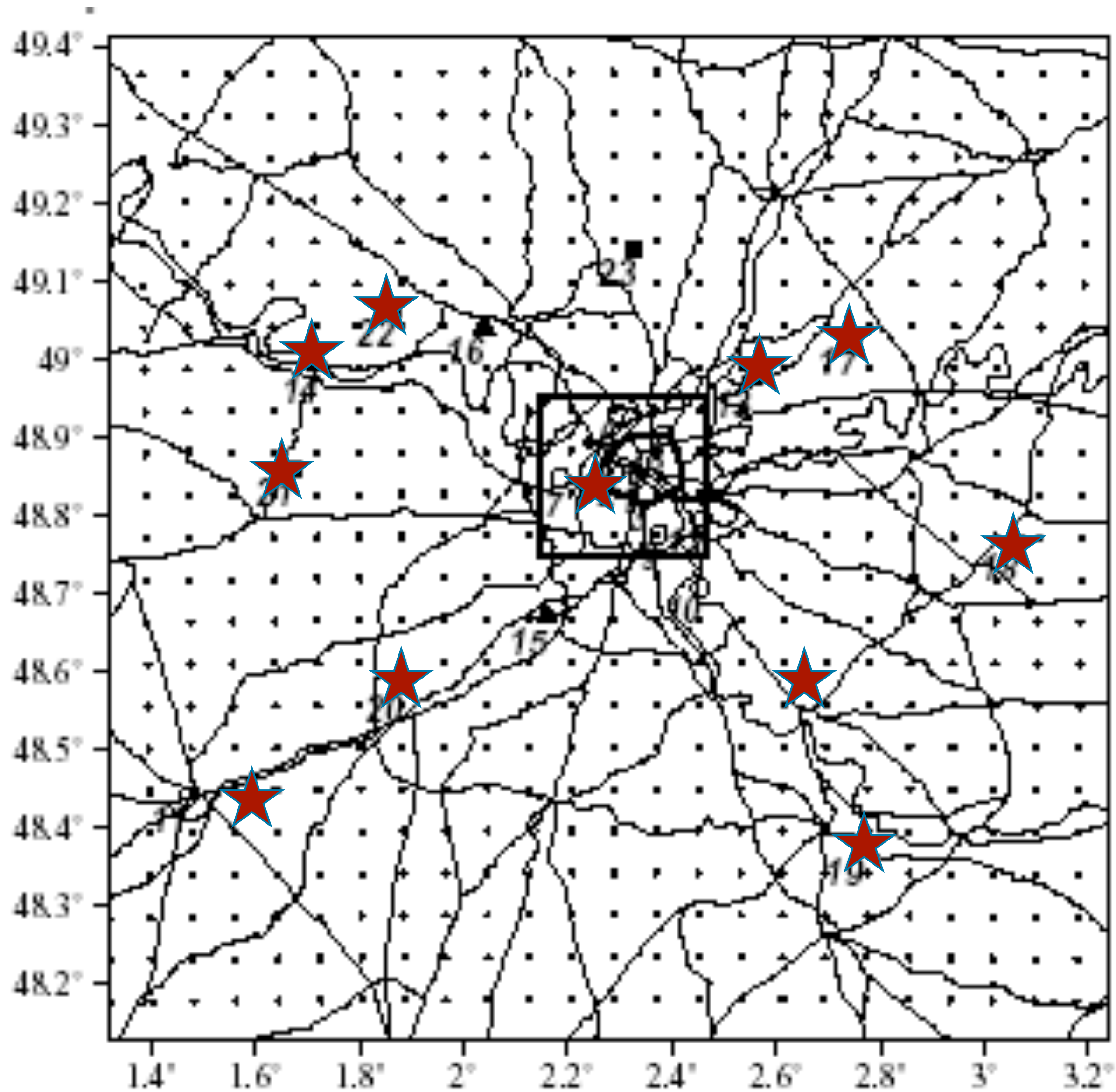




Time series for selected NOx stations on nest 2.
\+ observations,
-- - no assimilation,
-_____ N1 assimilation (**18 km**),
-_____N2 assimilation.(**6 km**),
-grey shading: assimilated observations, others forecasted.

Can surface assimilation improve forecast skill?

Foret, Beekmann et al., CNRS (CHIMERE)



Grid characteristics

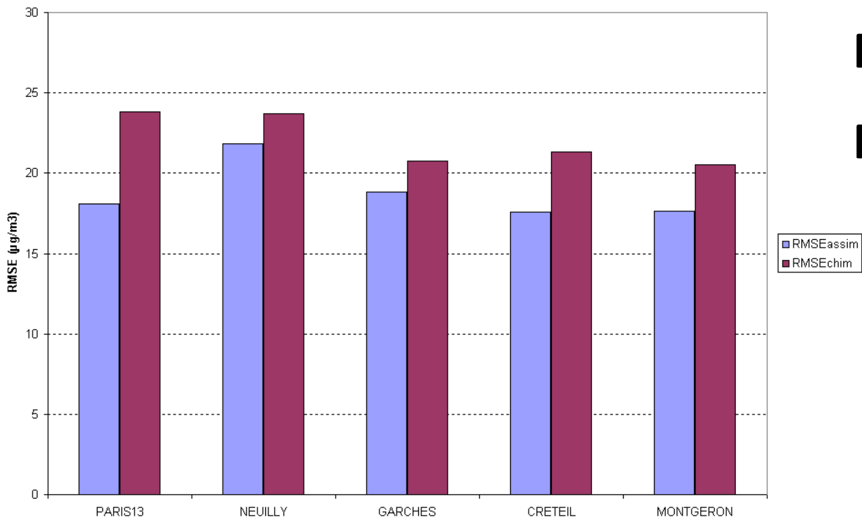
- *25×25 cells*
- *resolution 6 km×6 km*
- *vertical stratification: 8 levels*
- *44 species*
- *assimilation period: 11-21 July 1999*

Measurements (AIRPARIF)

- *11 background stations used for assimilation*
- *5 stations used for validation*

Very promising first results for ozone

RMSE FOR VALIDATION STATIONS



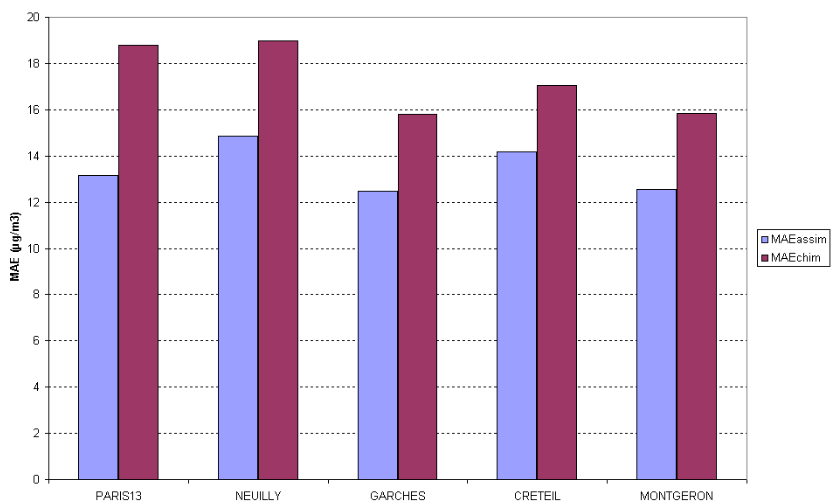
RMSE CHIMERE : 21-24 µg/m^3

RMSE CHIMERE/ENKF: 18-22 µg/m^3

RMSE IMPROVEMENT:

8%-24%

MAE FOR VALIDATION STATIONS **(MAE : Mean Absolute error)**



MAE CHIMERE : 16-19 µg/m^3

MAE CHIMERE/ENKF: 12-15 µg/m^3

MAE IMPROVEMENT:

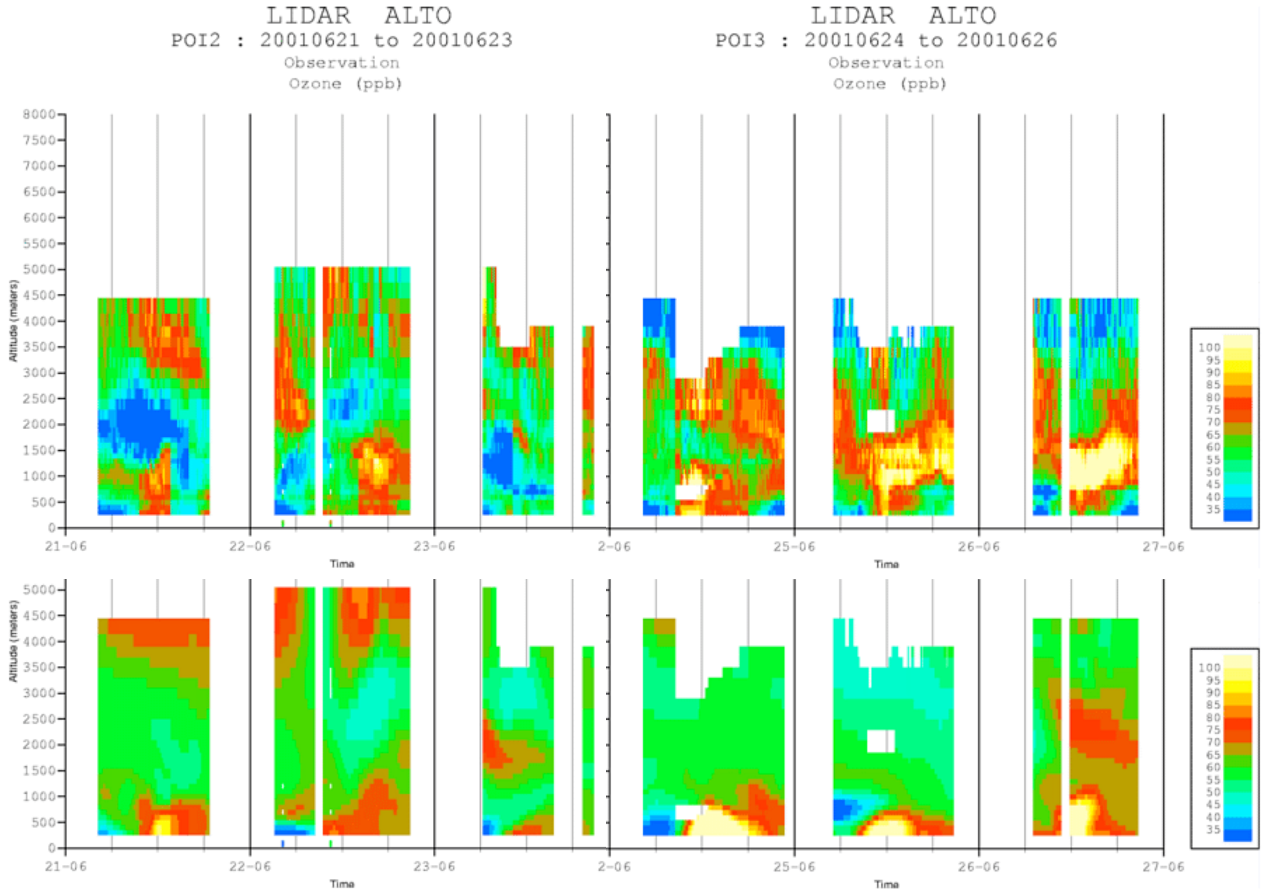
17%-30%

Now another challenge : what satellite information would we need « ideally » in addition to surface data?

What variables to target? (TBD)

1) PM and ozone : complex chemical/physical/transport processes. Errors in models can accumulate over a couple days before « memory » is lost.
2) NO2 and CO : characterisation of emissions and their variations (essentially in time for the anthropogenic contribution).

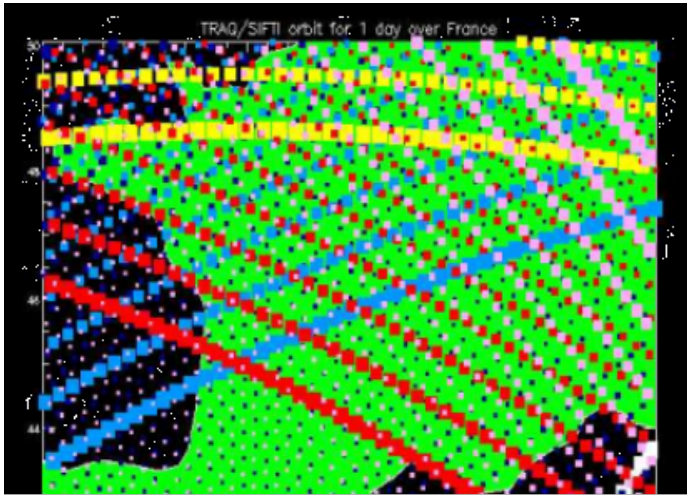
How do models on the vertical?



Lidar (CNRS) during ESCOMPTE 2001

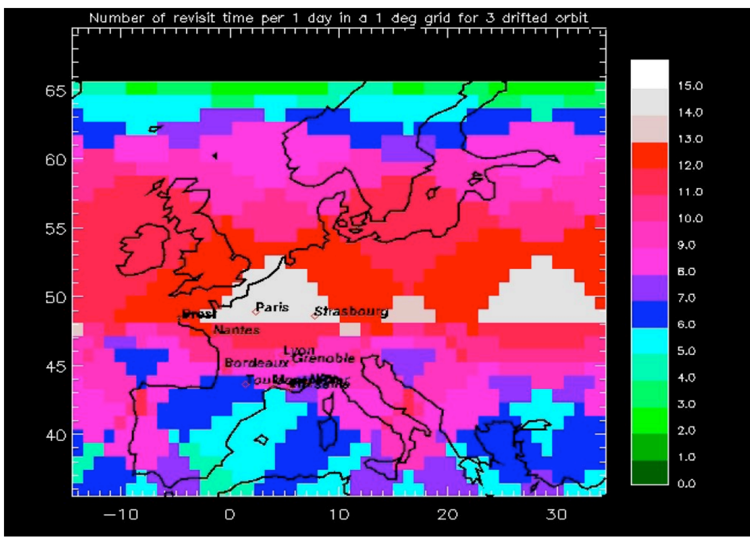
MOCAGE equivalent

Is it possible to monitor AQ with a constellation of 3 LEOs?

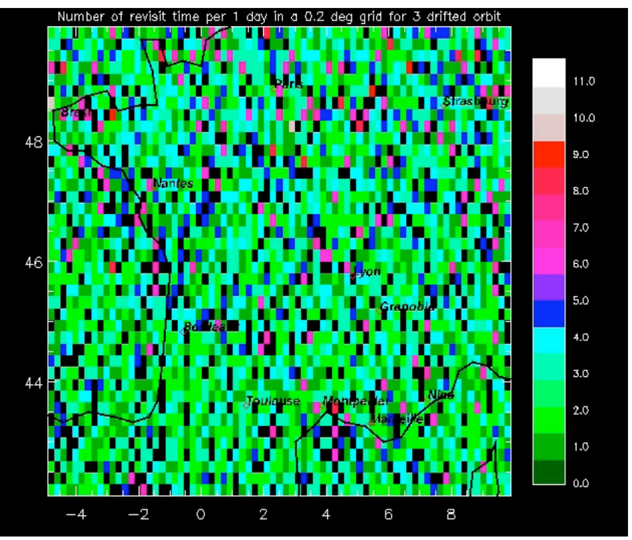


LEO with optimised drifting orbit (TRAQ/SIFTI). Issue : varying pixel size across track.

Heterogeneous coverage in time and space :
Between 2 and 15 revisit /day at 1°x1°
Between 0 and 10 revisit /day at 0.2°x0.2°



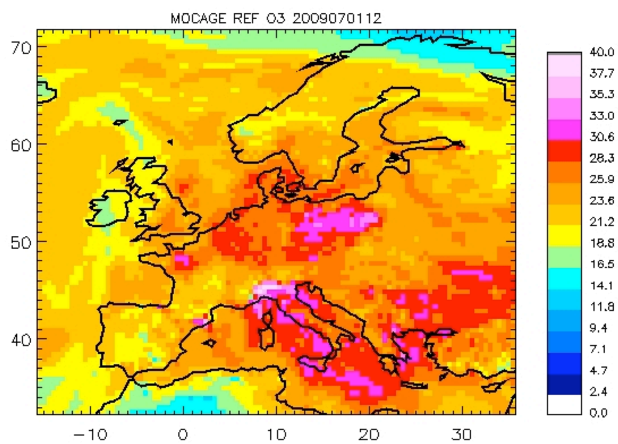
Number of revisit time over Europe in boxes of 1°x1°



Number of revisit time over France in boxes of 0.2°x0.2°

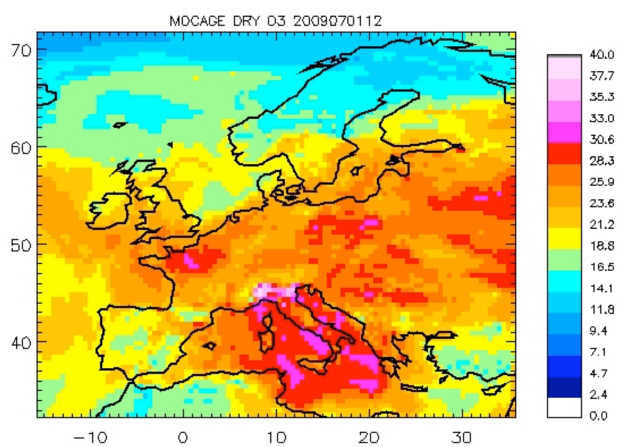
The GEO orbit is needed for QA!

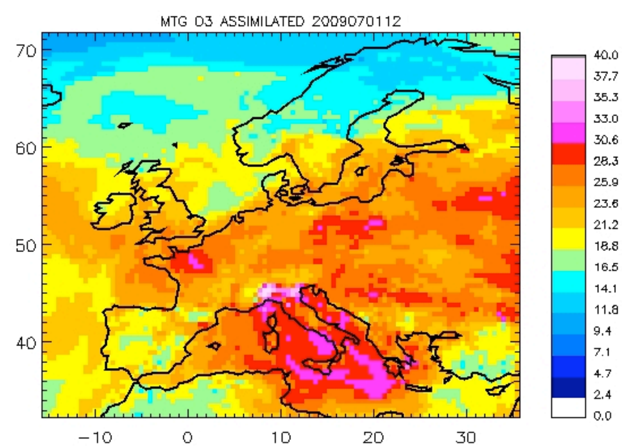
EUMETSAT and ESA have initiated joint preparatory activities for the MTG definition to be available in the 2016-2018 timeframe. In particular, MTG-IRS specifications result from a compromise between meteorology and chemistry needs, with a priority on Numerical Weather Prediction. We show here results from OSSEs (MOCAGE-PALM and KOPRA/KOPRAfit).



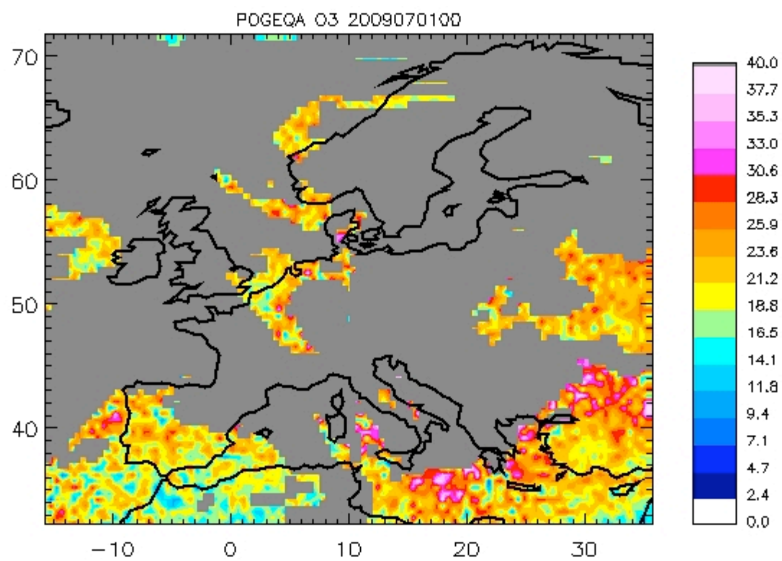
Impact on initial conditions after 12 hours of MTG assimilation

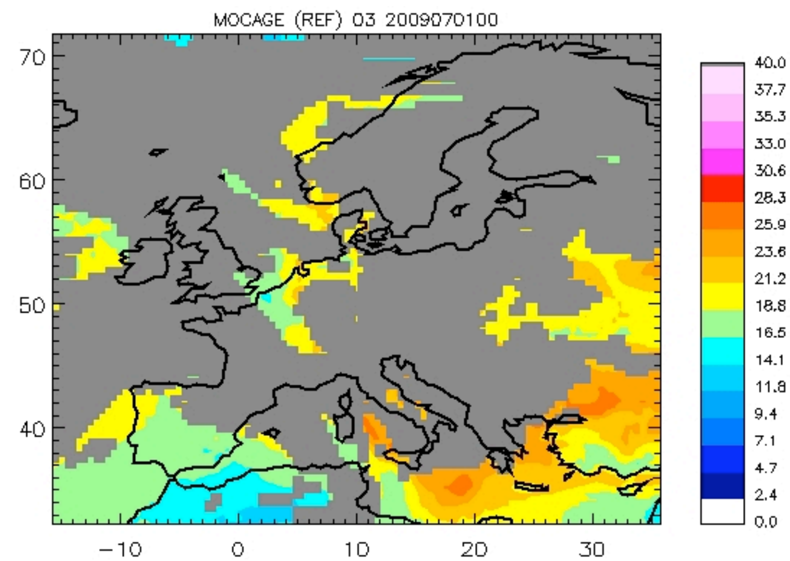
Limited impact of the assimilation in the partial column 0-6km.





Dedicated mid- to low tropospheric sensor on-board GEO





Error on temperature profile : 1K (white noise)

Error on H_2O profile: 10% (white noise)

➡ O_3 concentrations are captured but

High contamination from H_2O and temperature error (to be improved)

MAGEAQ

Monitoring the Atmosphere from Geostationnary orbit for European Air Quality. LoI submitted to ESA EE8 call, Dec 1st.

Observation requirements and geometry	
Domain covered	(15°W-35°E, 35°N-65°N)
Space resolution	10km x 10km at 45° (target) ; 15km x 15km (threshold)
Time resolution	1h (target); 2h (threshold)
Duty cycle	Higher than 90% of observational time
Ozone sensor	
Objectives	2 (target) to 3 (goal) pieces of information in the troposphere. Accuracy: 10% (target) for 0-6 km column, 25% (threshold).
Channel 1	Centered 1060 cm^{-1}, 40 cm^{-1} wide
Spectral resolution	0.1 cm^{-1} (target), 0.2 cm^{-1} (threshold)
Signal to Noise Ratio	2000 (target), 1000 (threshold). Re
Channels 2 to 9	8 broadband channels from 450 to
Signal to Noise Ratio	2500 (target), 1500 (threshold)
CO sensor	
Objectives	2 pieces of information in the trop 6 km column, 15% (threshold).
Channel 10 and 11	Centered 2130 cm^{-1} and 4230 cm
Signal to Noise Ratio	500 (target), 250 (threshold). Refe

PI

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Underlined: "Lead Scientist"
Bold: "Core Team"

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Interested to join in?
Vincent-Henri.Peuch@meteo.fr

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