The Mocage-accident transport and dispersion tool in support of Toulouse VAAC operations

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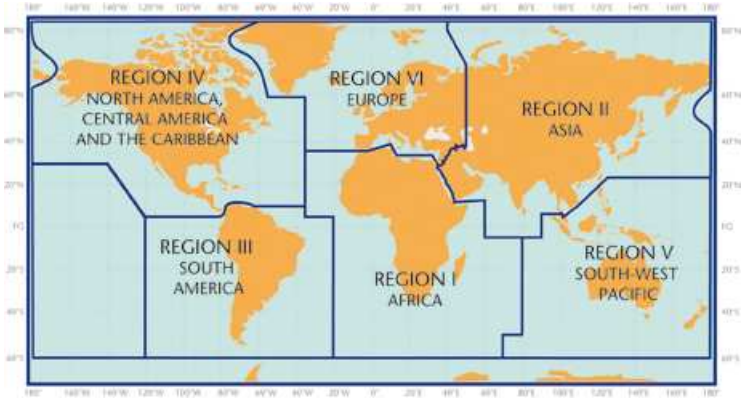
Overview

- Météo-France's responsibilities
  - at international level
  - at national level in France
- The atmospheric transport model « MOCAGE-accident »
  - the MOCAGE 3d chemistry and transport model platform
  - the « MOCAGE-accident » configuration
  - MOCAGE-accident operational set up
  - examples

Context

- **Responsibilities at international level**

  - Météo-France/Toulouse is one of the 8 WMO Regional Specialised Meteorological Centres (RSMC) for Environmental Emergencies.



➢ In a framework established by international conventions, RSMCs can be requested 24/7 for support by the International Atomic Energy Agency (IAEA) in the event of a nuclear accident or radiological emergency. They provide atmospheric transport model outputs, such as atmospheric concentrations and deposition fields.

➢ RSMCs can also be requested by the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) in case of detection of anomalous radionuclide levels. RSMCs provide “backtracking” (inverse modelling) results, which are used by CTBTO to infer source characteristics.

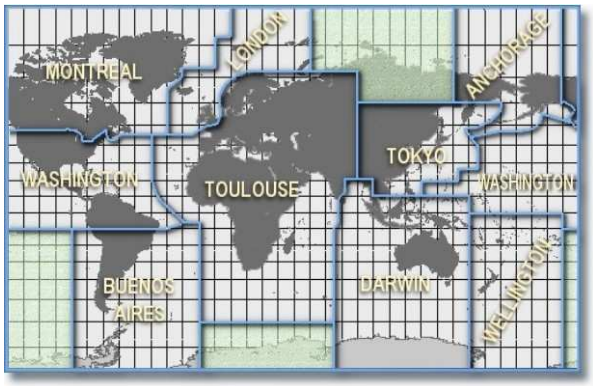
➢ Upon request, RSMCs can also provide assistance in case of non-nuclear environmental emergencies (chemical, forest fire…).

Context

- **Responsibilities at international level** (cont.)

  - Météo-France/Toulouse is one of the 9 Volcanic Ash Advisory Centres (VAAC).

    In the framework of a convention between WMO and the International Civil Aviation Organization (ICAO), each VAAC monitors volcanic ashes in a pre-defined area of responsibility.



- **Responsibilities over France**

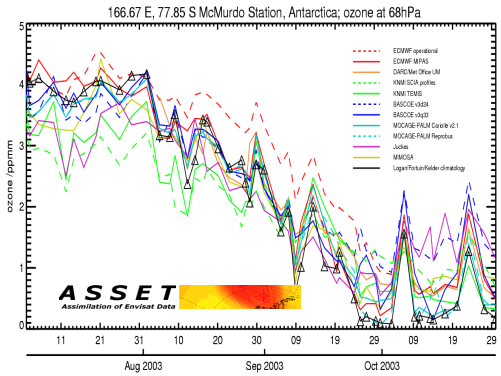
  Provision 24/7 of an assistance to the local and national authorities in case of environmental emergencies, in the context of Météo-France institutional mission of securing people and belongings.

  ➢ Conventions with IRSN (national agency for the monitoring of nuclear activity) and EDF (national electricity company operating nuclear power plants) in the case of a nuclear alert.

  ➢ Convention with INERIS (national agency in charge of industrial risks) in the case of a chemical alert.

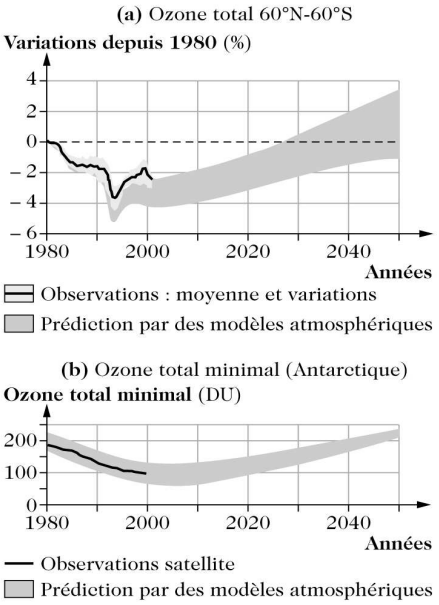
MOCAGE: science themes and applications

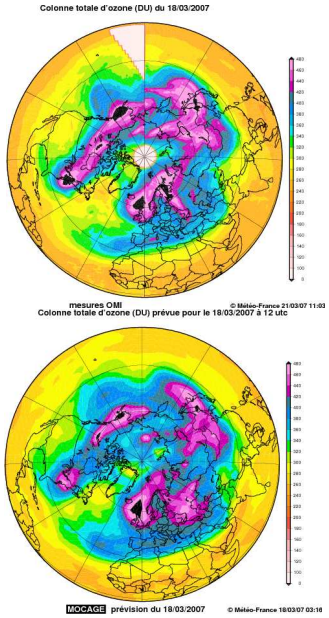
MOCAGE-accident is based upon the MOCAGE 3D Chemistry and Transport Model of Météo-France, used for both research on atmospheric composition (over 50 publications in the international literature) and operations in Météo-France and at several collaborating institutes.



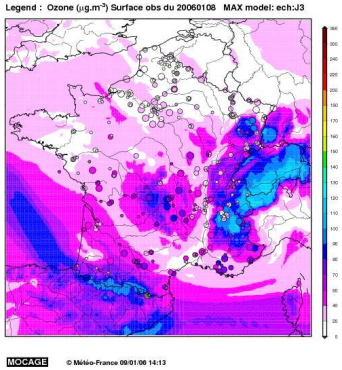
Chemical data assimilation

Chemistry and climate interactions

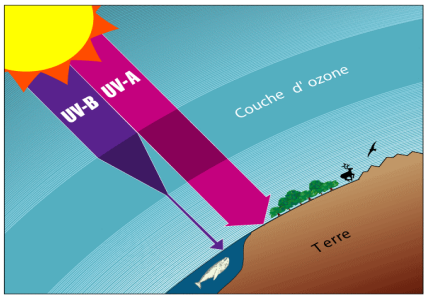




Stratospheric and tropospheric chemistry at the global scale and « chemical weather » forecasting



Regional Air Quality

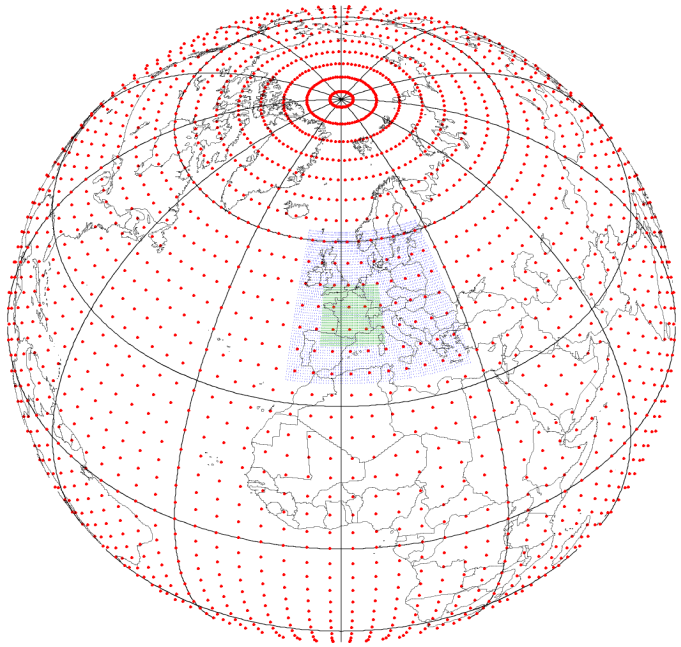


UV radiation, pollens and health impacts

… and accidental and volcanic atmospheric transport and dispersion

MOCAGE: model grid geometry

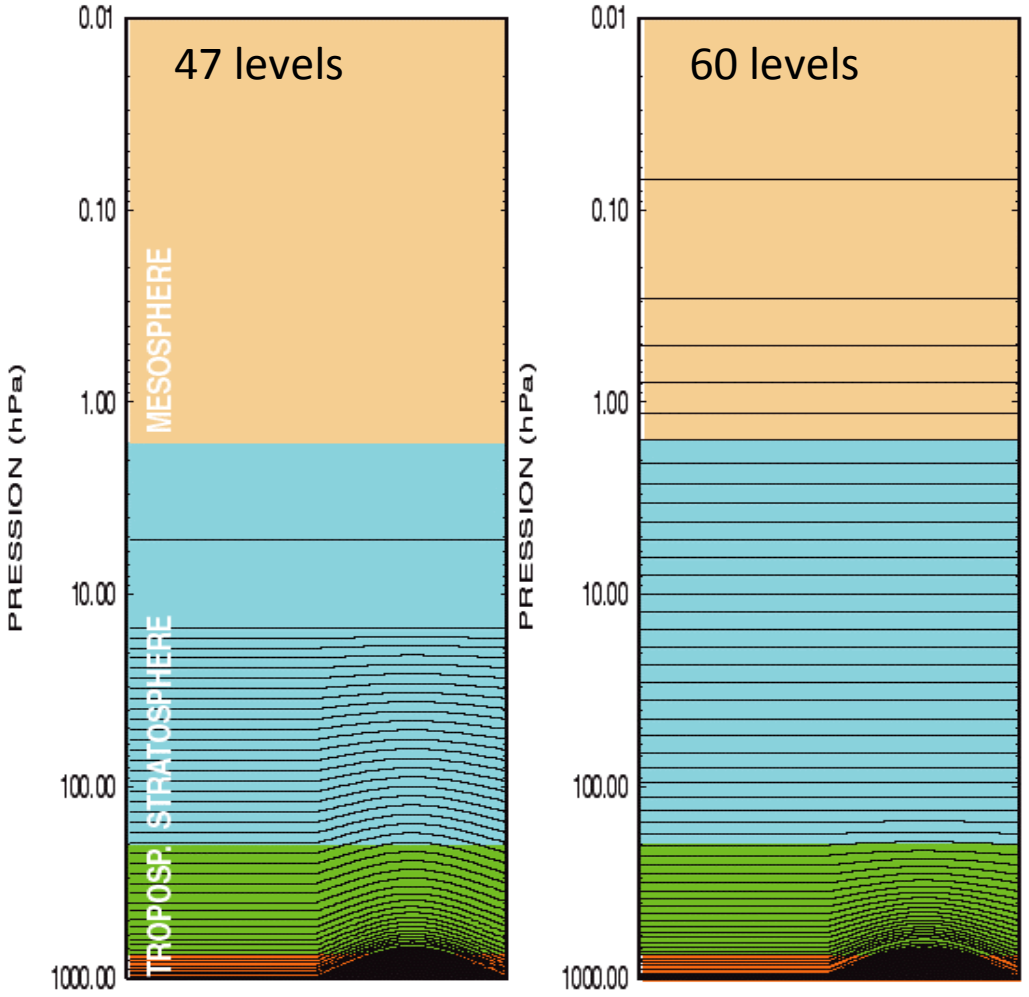
Horizontal geometry



Two options are available:

- gaussian (possibly reduced) grids: global domain only
- lat-lon: up to 3 subdomains (two-ways nested), located by the user for high-resolution simulations or forecasts.

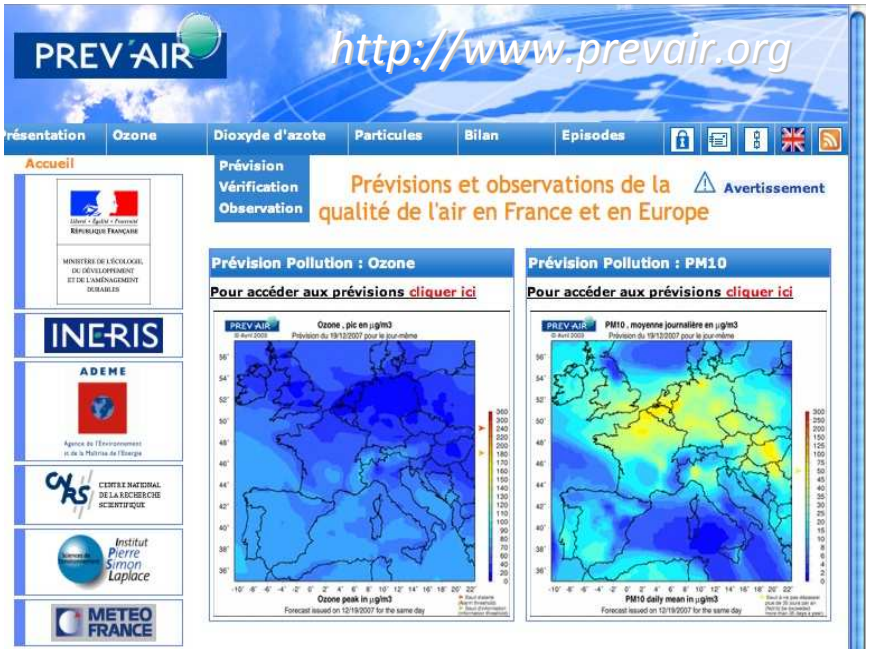
Vertical geometry (σ-P levels)

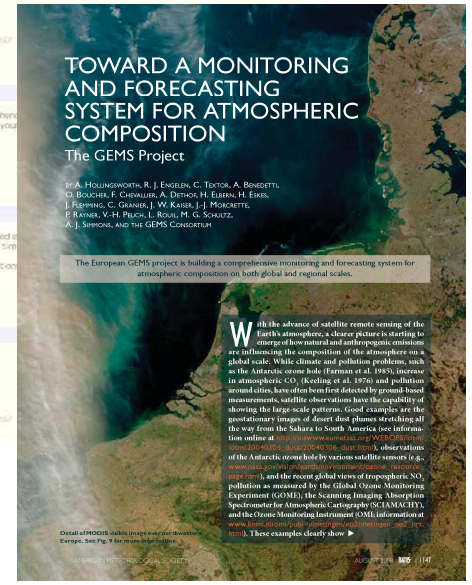


MOCAGE for operational air quality

In particular, MOCAGE is used:

- for the French operational Air Quality platform Prév'Air (http://www.prevair.org);
- in the context of the development of Global Monitoring for Environment and Security (GMES) Atmospheric services (currently FP7 "MACC", http://www.gmes-atmosphere.eu). Météo-France coordinates regional (Europe) NRT products: analyses and forecasts of Air Quality.





GMES
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SEVENTH FRAMEWORK PROGRAMME

The MOCAGE-accident configuration

- MOCAGE-accident is a dedicated version of MOCAGE for the transport and diffusion of atmospheric releases of gases and particles, from the regional to the global scale. Only dynamical and physical processes are taken into account, excluding (in general) chemistry.

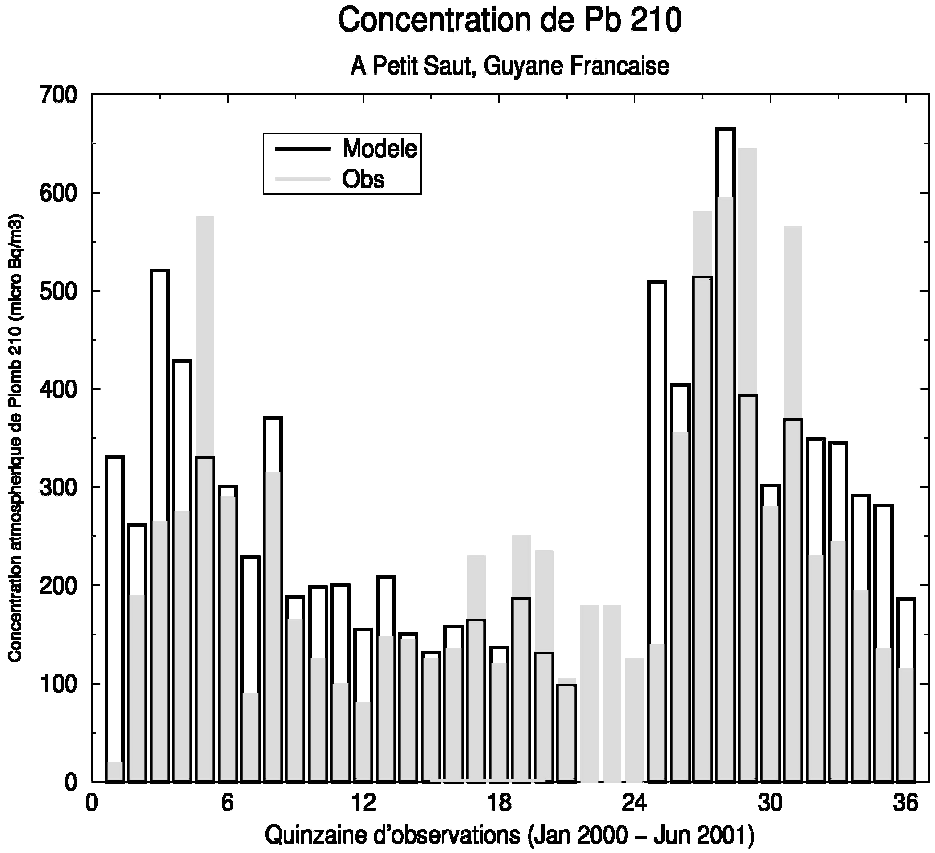
- It accounts for the following processes:
    - advection by means of a semi-lagrangian transport scheme [Williamson and Rasch, 1989];
    - convection [Bechtold et al., 2000];
    - turbulent mixing [Louis, 1979];
    - dry deposition;
    - wet deposition, treated with a detailed 3D scheme [Mari et al., 2000; Liu et al., 2001];
    - radioactive decay in case of radionuclides;
    - sedimentation for particles.

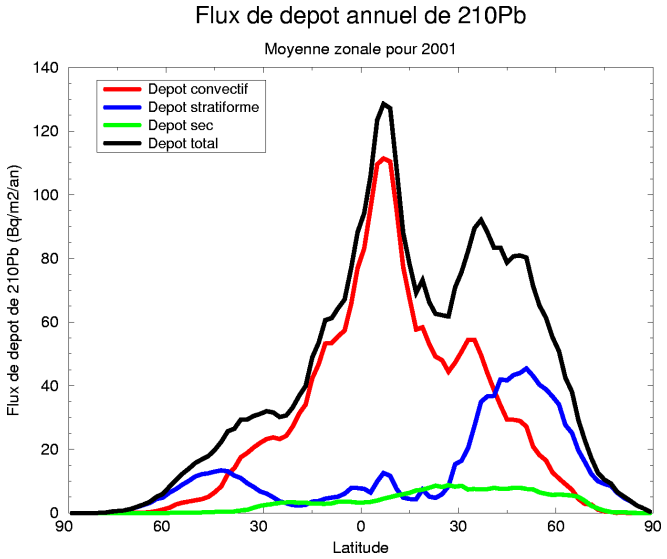
See [Josse et al., Tellus, 2004] for details and validation of transport at resolved and parameterized scales.

Evaluation of transport/deposition in convective areas

The use of MOCAGE in different configurations allows extensive validation of all aspects of the code (advection, parameterizations of transport and of chemical processes, sources and sinks representation…).

210-Pb (from radioactive decay of natural 222-Rn) is well-suited to evaluate the representation of transport and wet deposition (highly soluble) in models.





Above: wet deposition within convective systems (red) is an important sink, even in mid-latitudes.

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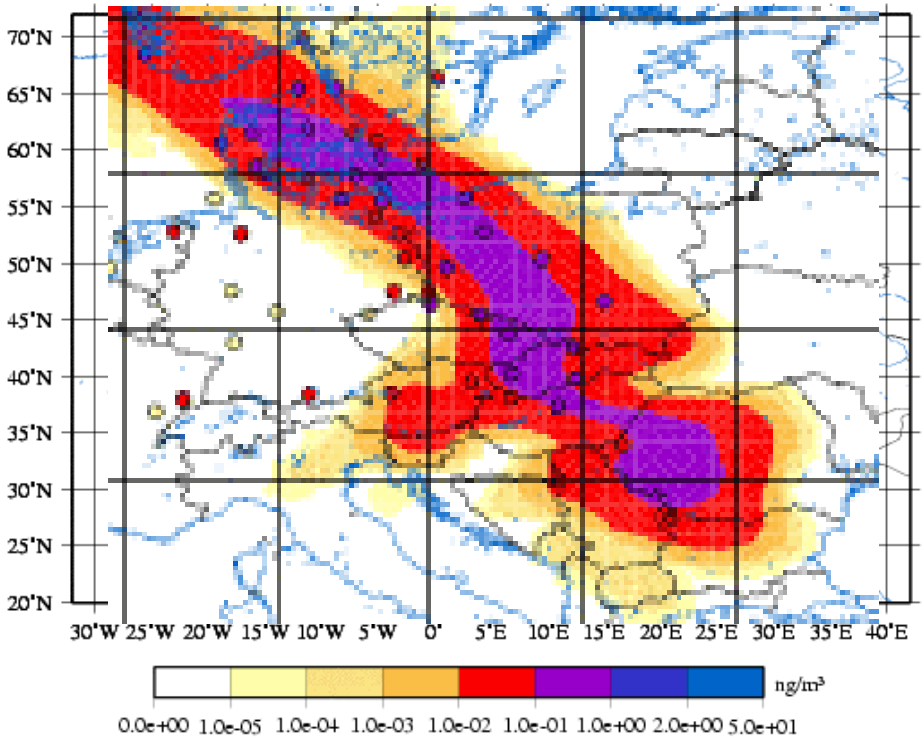
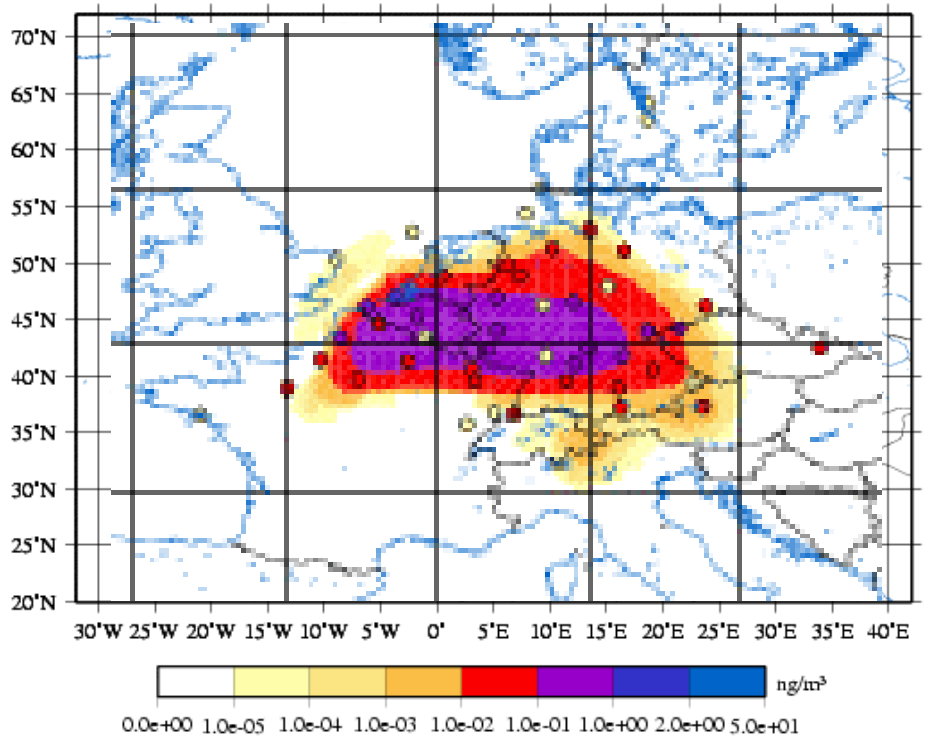
Another example of validation: ETEX-1 case

Evaluation by inter-comparison with other models (about 20 in the ENSEMBLE project) and evaluation against measurements databases.





Comparison to the measurements of the ETEX1 field campaign (1994) - emission of a gas during 12h in Monterfil (Brittany, France); 168 measurement sites in Europe.

Forecast: release + 30h (top)

Forecast: release + 60h (left)

Operational set-up for Toulouse VAAC

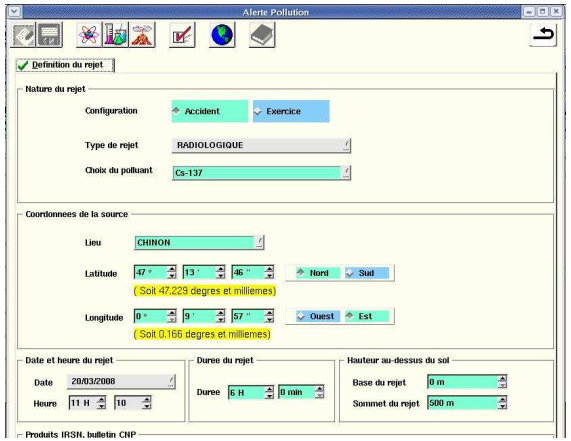
MOCAGE-accident is used in operations at Météo-France since February 2010 with the following characteristics:

- 2 options for global NWP forcings, sampled at 0.5° resolution (choice by forecasters on duty depending on their evaluation on the situation):
  - ARPEGE (Météo-France)
  - or IFS (ECMWF).

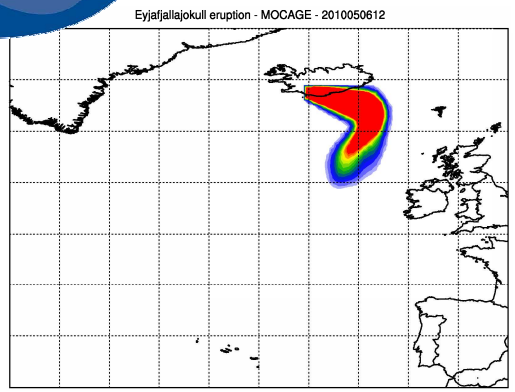
  NWP analyses are used over past periods.

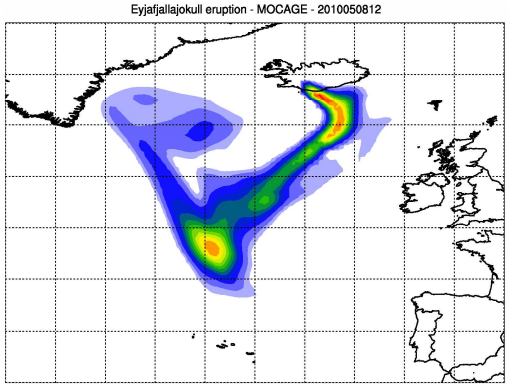
- 0.5° resolution over the globe and 47 vertical levels up to 25km of altitude (Planetary Boundary Layer has ~7 levels, and resolution in the free troposphere ranges from 500m to 800m approximately at the tropopause).

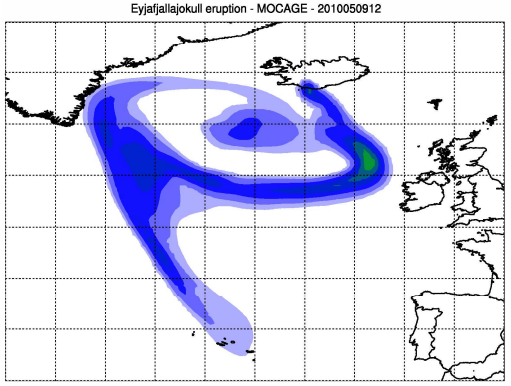
- Emission sources can be prescribed anywhere in the world. For a single run of the model, the source term is prescribed simply with:
  - location
  - beginning and duration of the release
  - base and top of the column (fixed for the simulation)
  - emission rate (fixed for the simulation)
  - uniform vertical distribution

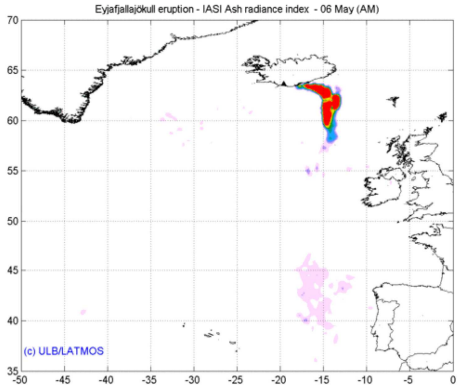


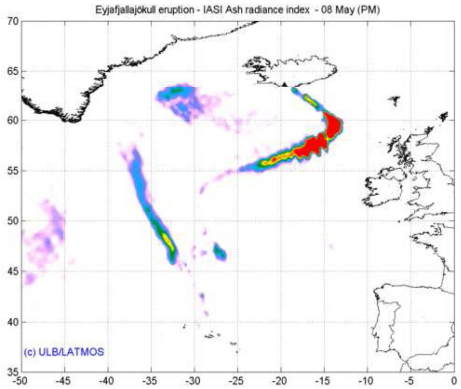
The Eyjafjöll case with MOCAGE-accident

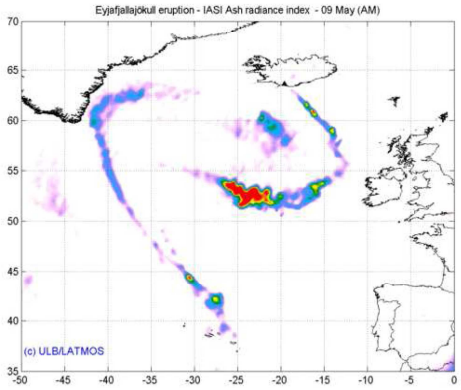


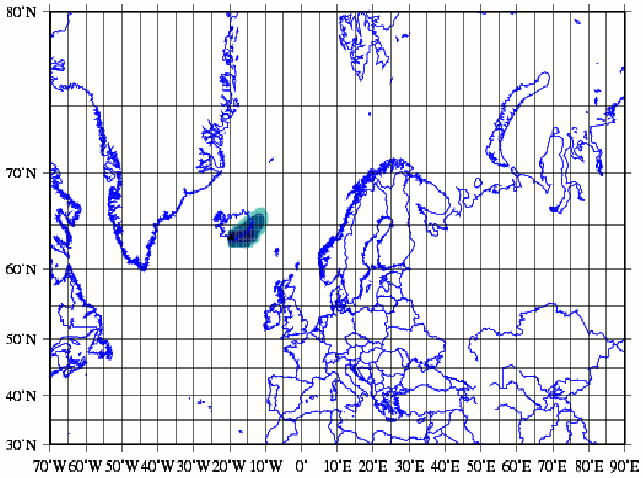












Top : animation of a simulation (April eruption)

Left : comparison of a simulation for the May eruption with IASI observations (LATMOS/ULB).

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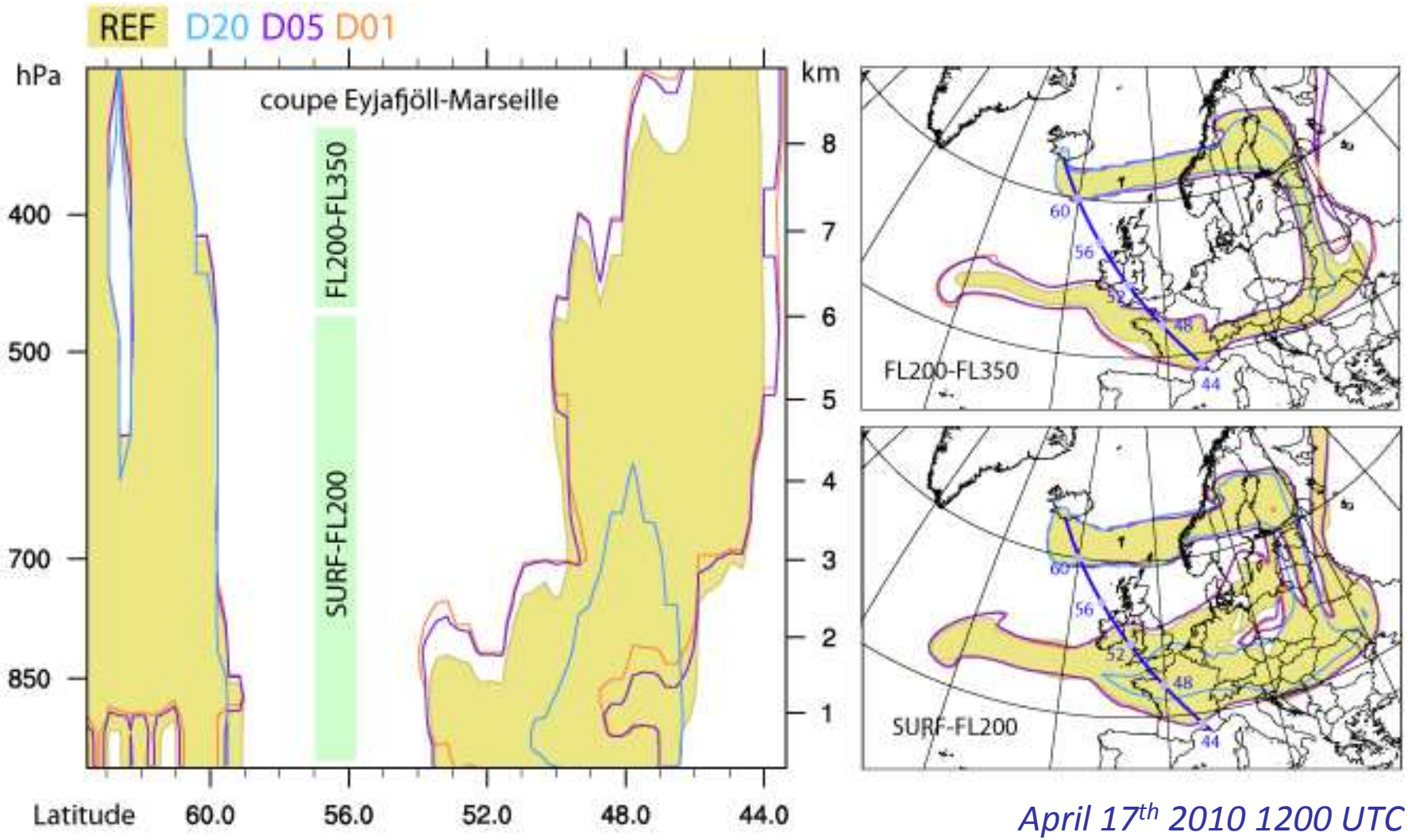
Sensitivity studies (particle size) for the Eyjafjöll case

Currently, the operational version of MOCAGE-accident considers one size of particle (at a time), but the development version allows to see effects of particle size on the simulated plumes.

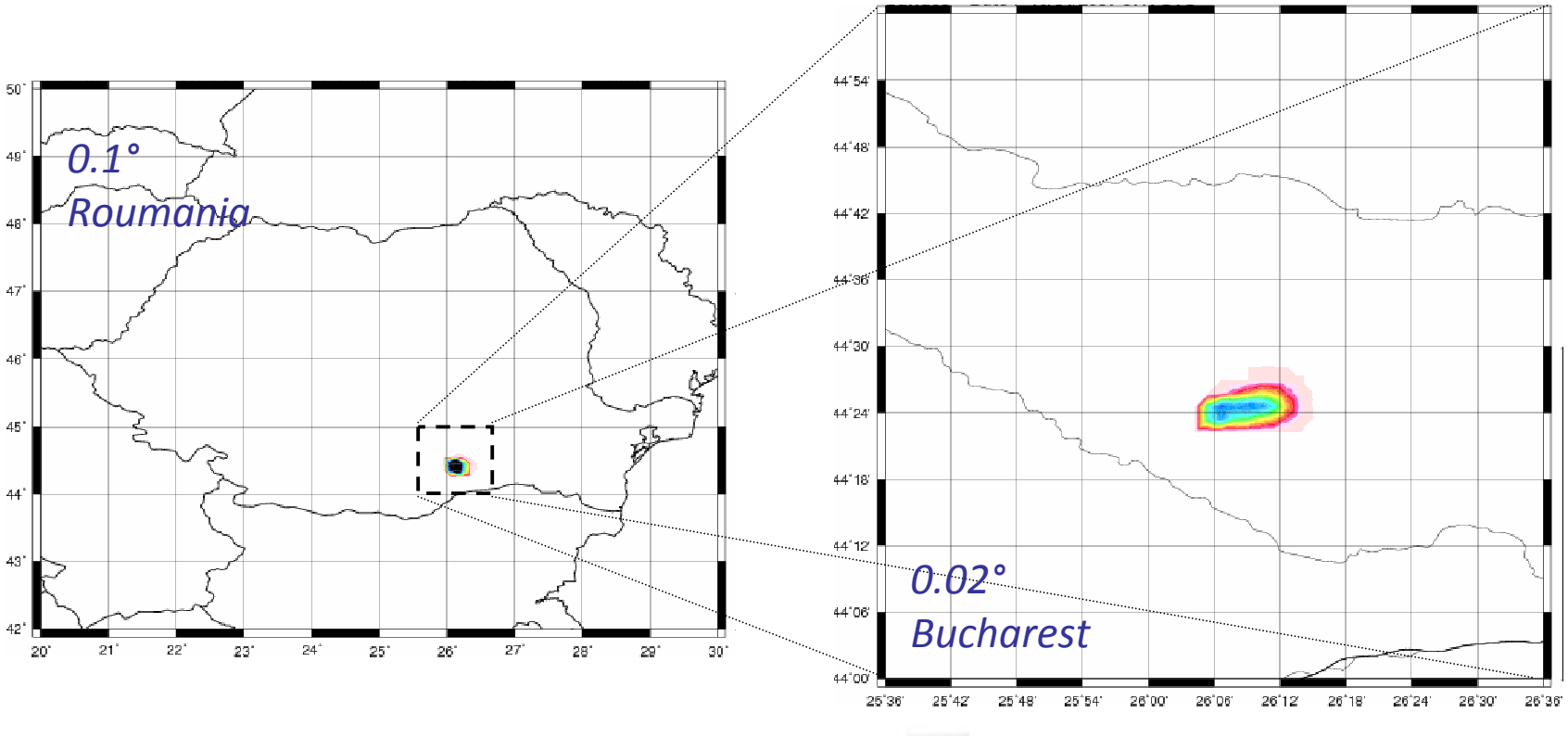


April 17th 2010 1200 UTC

Plans for next version of the operational set-up

Basically, this is transfer to the operations department from what is currently possible with the development version of MOCAGE-accident:

- More flexibility in the description of the geometry of the source (along forecast time)
- Consider automatically a population of particles of different sizes
- A new version with increased resolution for the transport model over a limited area around the release point



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MOCAGE-accident model

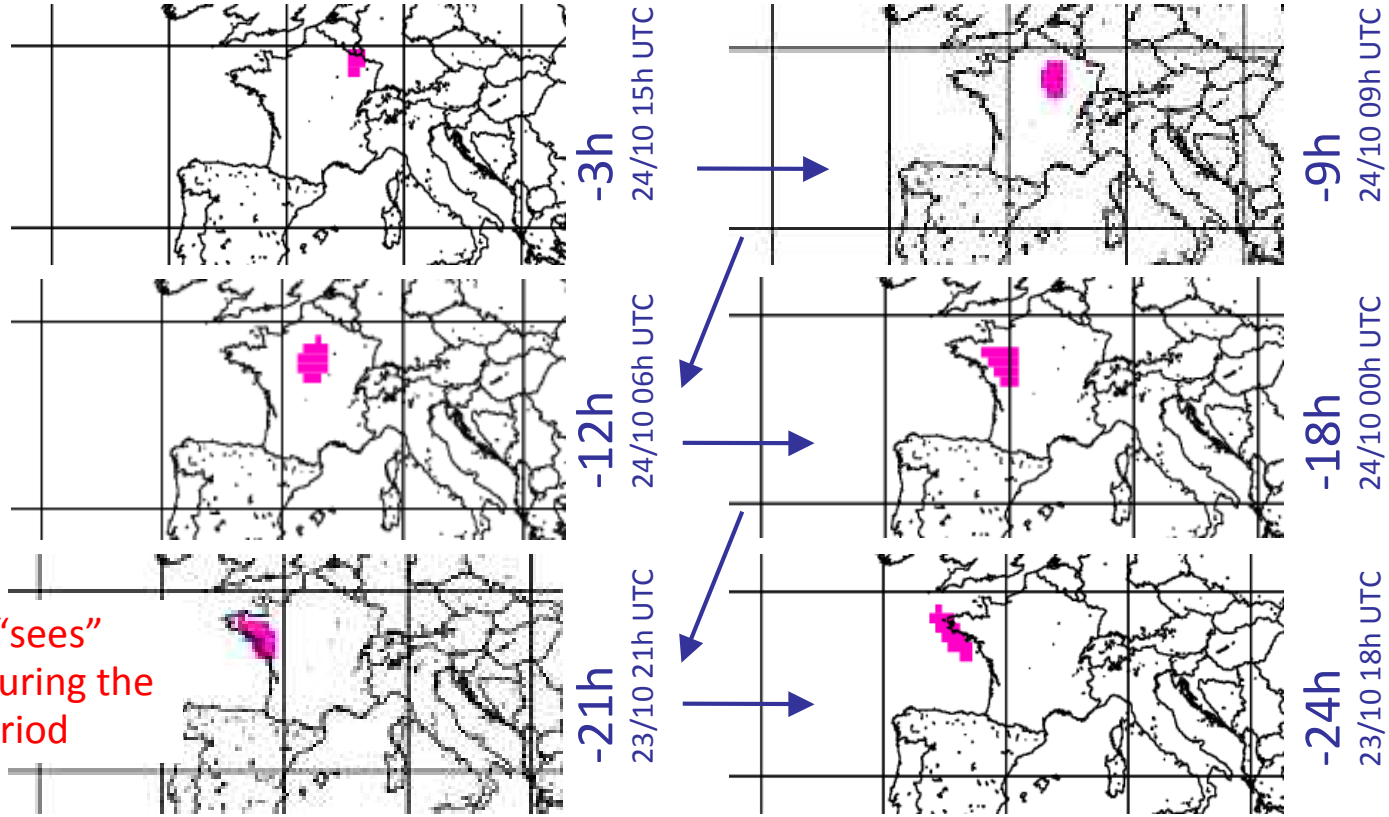
- **Backtracking**

Run in “reverse” mode, MOCAGE-accident can predict the origin of an air-mass arriving at a given point in space and time (ie, its “field of view”).

- Example on ETEX1

- Operational application for response to CTBTO requests

ETEX1: measurement in Offenbach (Germany) - 24/10/1994 at 18hUTC



Offenbach “sees” Monterfil during the emitting period