

# MOCAGE Accident : description and operational use

Météo-France

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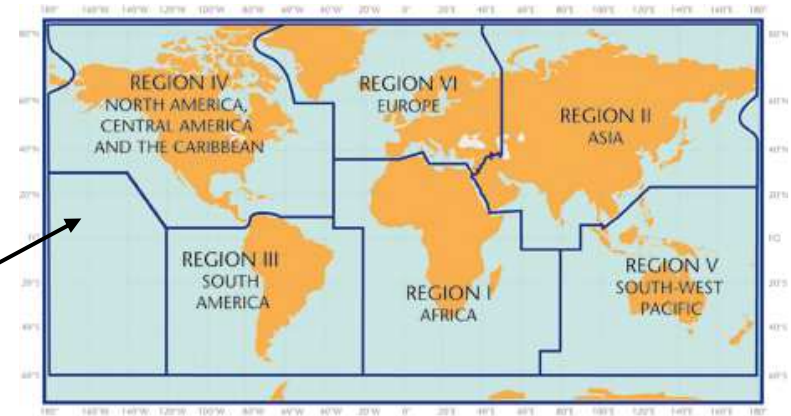
November 2013

# OUTLINE

- Meteo-France responsibilities
- MOCAGE-accident real-time context
- Use for volcanic eruptions :
  - Web-Interface
  - Validations
- New evolutions experiments
- VAACTRAJ tool

## Responsibilities of Meteo-France in case of accidental release

- International :
- **RSMC** (Regional Specialised Meteorological Center) (6 regions) for WMO/IAEA (Exeter, Toulouse, Melbourne, Montreal, Washington, Beijing, Tokio, Obninsk) : **NUCLEAR**
- **VAAC** (Volcanic Ash Advisory Center) (9) for ICAO (Anchorage, Buenos Aires, Darwin, London, Montreal, Tokyo, Toulouse, Washington, Wellington): to track **AIRBORNE ASHES** in near real-time after an eruption

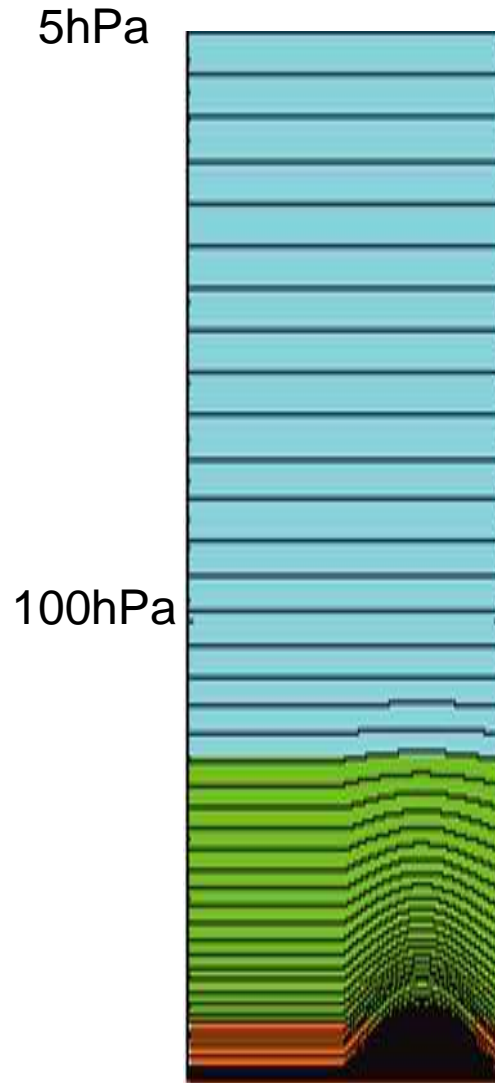


- **National : Nuclear or chemical:**  
Intervention Particular Plan : an emergency meteorological cell is activated in order to provide the authority with information about pollutant transport.

# Model for long range dispersion tracking at CMC MOCAGE-Accident

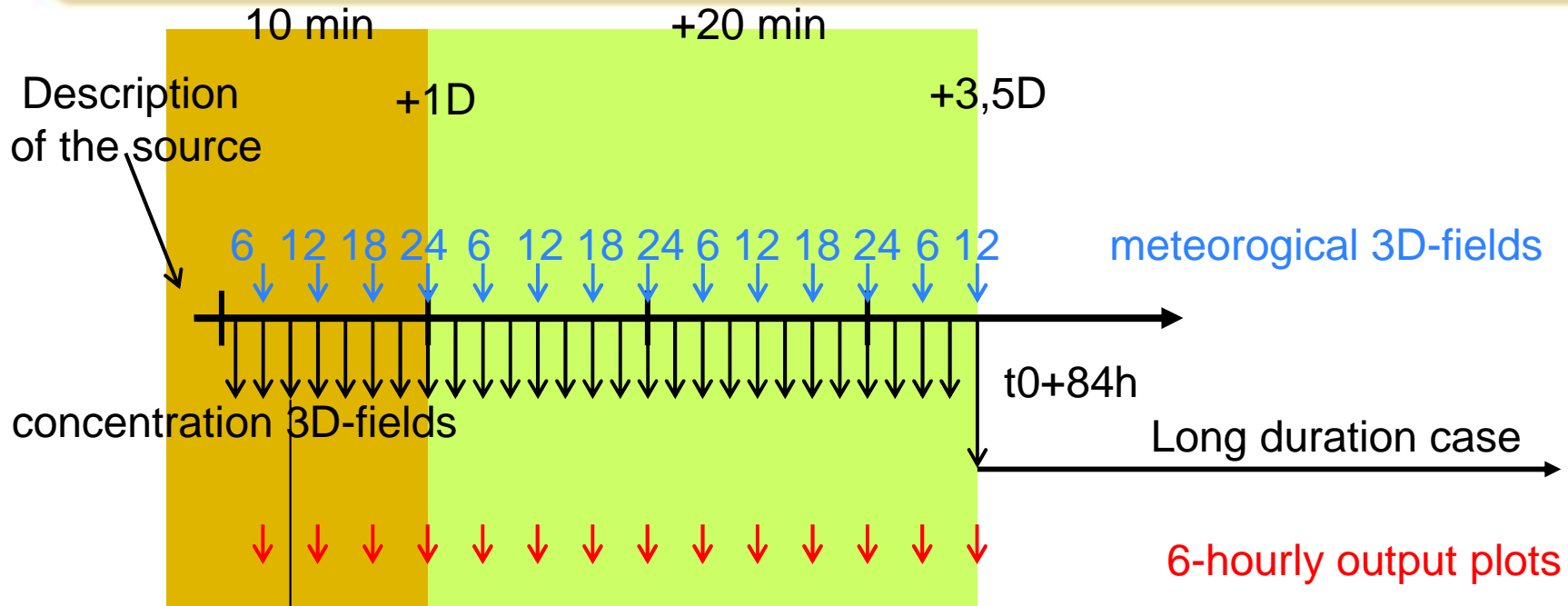
- **MOCAGE-Accident is a version of MOCAGE model**
  - ✓ MOCAGE is a global 3D Chemical-Transport Model (CTM) developed at CNRM (Meteorological Research National Center). Dynamic core with physical and chemical optional parametrizations
  - ✓ Initialisation and coupling : ARPEGE(Meteo-France), ECMWF
  - ✓ Several versions of MOCAGE : operational uses « air quality »(2005), « accident » (2010), « backward-trajectories »(2012) and research uses « climate » , « chemical assimilation » ,...
  - ✓ MOCAGE-Accident allows to specify several point sources anywhere over the world and takes into account deposits (dry and wet). Chemical parametrizations have been switched off. Polluants are considered as **passive tracers**.

## MOCAGE-Accident operational configuration

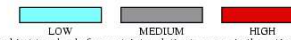


- Horizontal resolution :  $0.5^\circ$
- Vertical resolution : 47 levels from surface to 35km height (5hPa)
- Initialisation and 6-hourly coupling on 20 levels from surface to 10hPa
  - ARPEGE (Météo-France)
  - or IFS (CEPMMT).
- Parametrizations :
  - advection by a semi-lagrangien transport scheme de[Williamson and Rasch, 1989];
  - convection [Bechtold et al., 2000];
  - turbulence [Louis, 1979];
  - dry deposit (constant deposit velocities near the ground)
  - wet deposit (detailed 3D-scheme[Mari et al., 2000; Liu et al., 2001];
  - sedimentation for ashes  $f$  (size , density);
  - radioactive disintegration if radionuclides emission.

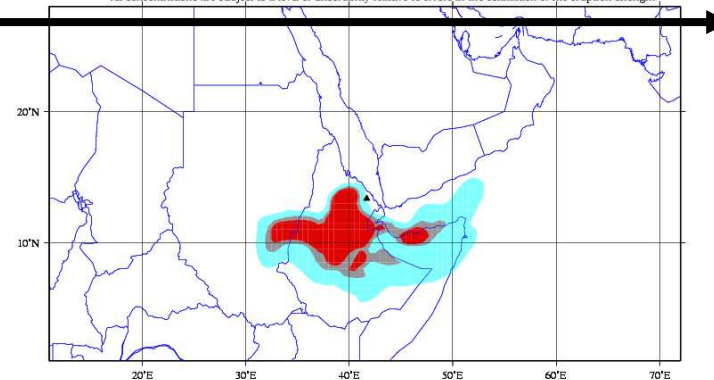
# Real-time operations context



NABRO Accident  
 Modelled Ash Concentration from SFC to FL200  
 14/06/2011 18h00 UTC  
 This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.  
 Issue time: 2011081412



All concentrations are subject to a level of uncertainty relative to errors in the estimation of the eruption strength



# Source description 1/2

Applications Raccourcis Système

Alerte pollution, le site WEB... - Mozilla Firefox

ven 8 avr, 14:35 27 °C

Fichier Édition Affichage Historique Marque-pages Outils Aide


http://localhost:8185/alerte\_pollution/

Alerte pollution, le site WEB...

**Alerte Pollution**

Simulation Sites Polluants

Longitude: 19°11'38"W Latitude: 63°38'24"N



Nom du site: EYJAFJOLL

Coordonnées: Latitude 63°37'48"N Longitude 19°03'00"W

63.630 -19.050

**Fiche Récapitulative**

Nature: EXERCICE VOLCAN

site: EYJAFJOLL

Lieu: longitude -19.05 (19°03'00"W) latitude 63.63 (63°37'48"N)

nom: CENDRE

Polluant: quantité auto (2.3282922e+11) g débit auto (3.8804871e+10)

début: le 08/04/2011 à 00:00 TU

durée: 6:00 heures

Rejet: base 0 m sommet 3000 m

MOCAGE ARPEGE VOLCAN 84H

Réseau du 08/04/2011 à 00 TU

LANCER

conception Frédéric Duret, Météo-France 2011

Terminé

Alerte pollution, le site WEB... - Mozilla Firefox

**METEO FRANCE**  
Toujours un temps d'avance

Volcan name  
Longitude  
Latitude  
Ash emission  
Total Mass  
Mass rate  
Duration (start-end)  
Bottom of the plume  
Top of the plume

## Source description 2/2

- mass eruption rate (constant through the simulation) possibly calculated from eruption height
- the vertical distribution (bottom->top) is uniform
- one size of particle (chosen by the forecaster) or a distribution of sizes

Mass fraction	Diameter $\mu\text{m}$
0.1%	0.2
0.5%	0.7
5%	2
20%	7
70%	20
4.4%	70

The screenshot shows a web browser window with the title 'Alerte pollution, le site WEB...'. The application header is 'Alerte Pollution'. Below the header are three tabs: 'Simulations', 'Sites', and 'Polluants'. The 'Polluants' tab is active, and an 'ENTER' button is visible. The main content area is titled 'Caractéristiques du polluant' and contains a table with the following data:

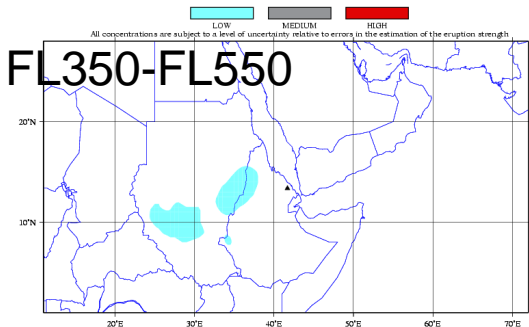
Paramètre	Valeur	info
codename	CENDRE	nom du polluant
quantite	auto (2.3282922e+11)	quantité = débit * durée du rejet
debit	auto (3.8804871e+10)	débit
unite	g	Unité associée au polluant
diametre	distribution	Diamètre des particules (micron)
densite	1000.0	Densité (kg/m3)
depot	0.001	Vitesse de dépôt (m/s)
lessivage	5e-05 1000.0	Coefficient de lessivage (s-1)
ejection	0.0	Vitesse d'éjection (m/s)
demie-vie	0.0	Demie-vie du polluant (s)
henry1	1e+14	1ère constante de Henry
henry2	8650.0	2ème constante de Henry
mol	1.0	Concentration molaire



# 6-hourly output products

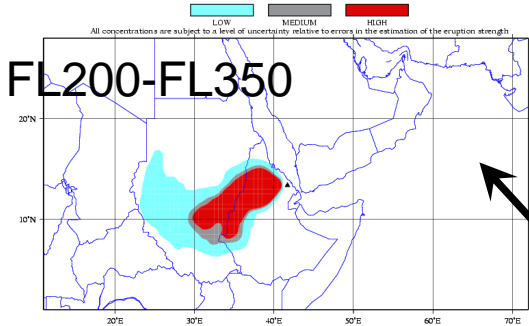
**METEO FRANCE**  
VAAC TOULOUSE

**NABRO Accident**  
Modelled Ash Concentration from FL350 to FL550  
14/06/2011 18h00 UTC  
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.  
Issue time: 2011061412



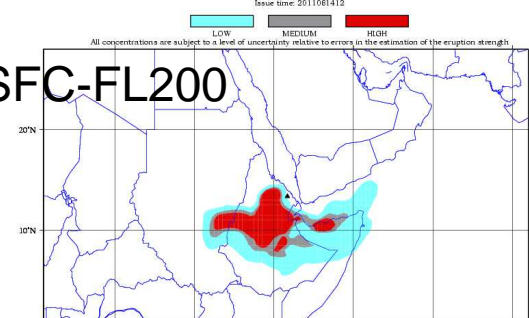
**METEO FRANCE**  
VAAC TOULOUSE

**NABRO Accident**  
Modelled Ash Concentration from SFC to FL200  
14/06/2011 18h00 UTC  
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.  
Issue time: 2011061412



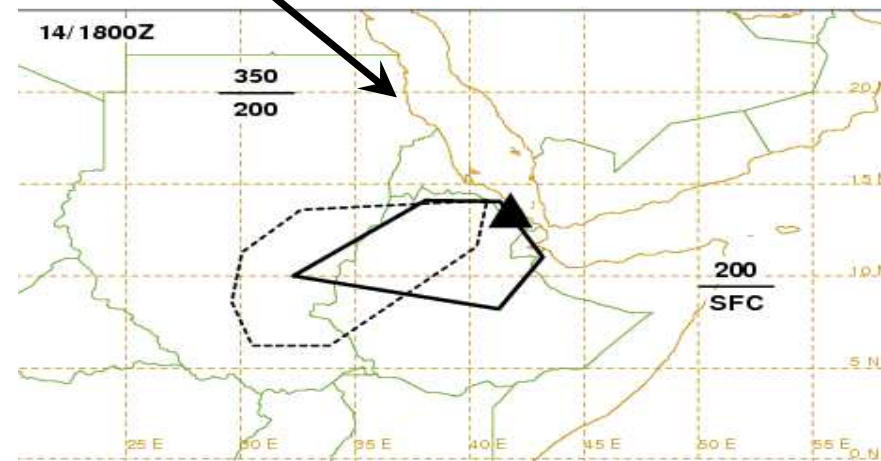
**METEO FRANCE**  
VAAC TOULOUSE

**NABRO Accident**  
Modelled Ash Concentration from SFC to FL200  
14/06/2011 18h00 UTC  
This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.  
Issue time: 2011061412



18GG\_WMO WORKSHOP-Geneva2013

- Instantaneous concentrations for synoptic hours on each standard pressure level to support the forecasters expertise in official ICAO VAA and VAG productions :



- + mean concentration integrated on 3 layers Surface → FL200, FL200 → FL350, FL350 → FL550
- Corresponding to 3 contamination levels : 

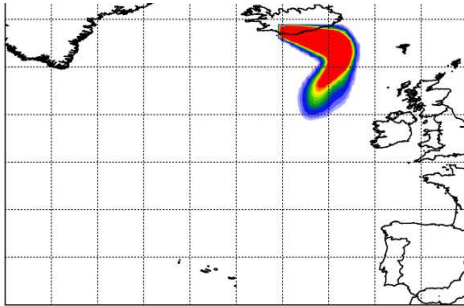
Low	Medium	High
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 based on 3 thresholds

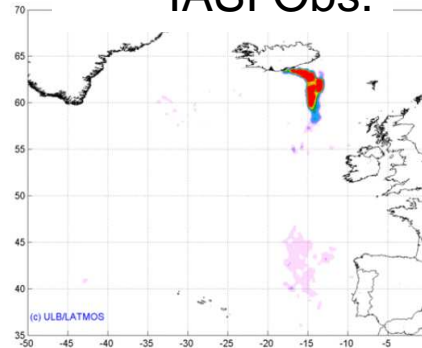
provided during the Eyjafjöll crisis (200µg/m<sup>3</sup>, 2mg/m<sup>3</sup> and 4mg/m<sup>3</sup>)

# EYJAFJÖLL eruption by MOCAGE-ACCIDENT

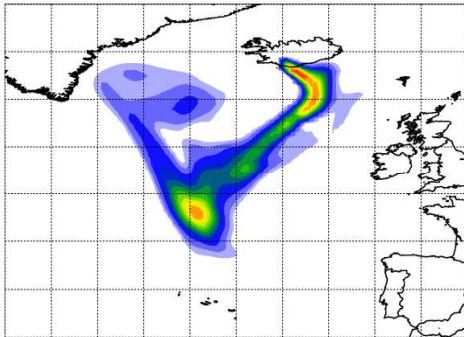
Mocage-acc simul.



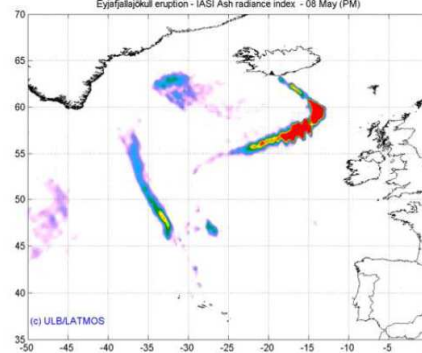
IASI Obs.



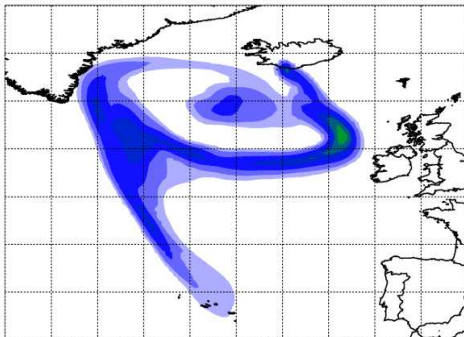
Eyjafjallajökull eruption - MOCAGE - 2010050812



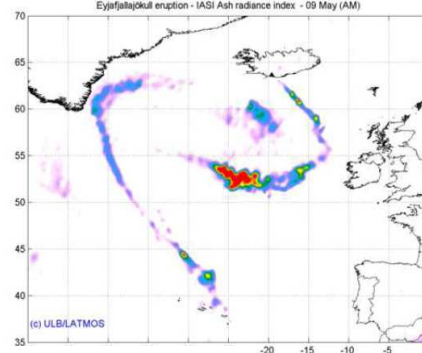
Eyjafjallajökull eruption - IASI Ash radiance index - 08 May (PM)



Eyjafjallajökull eruption - MOCAGE - 2010050912



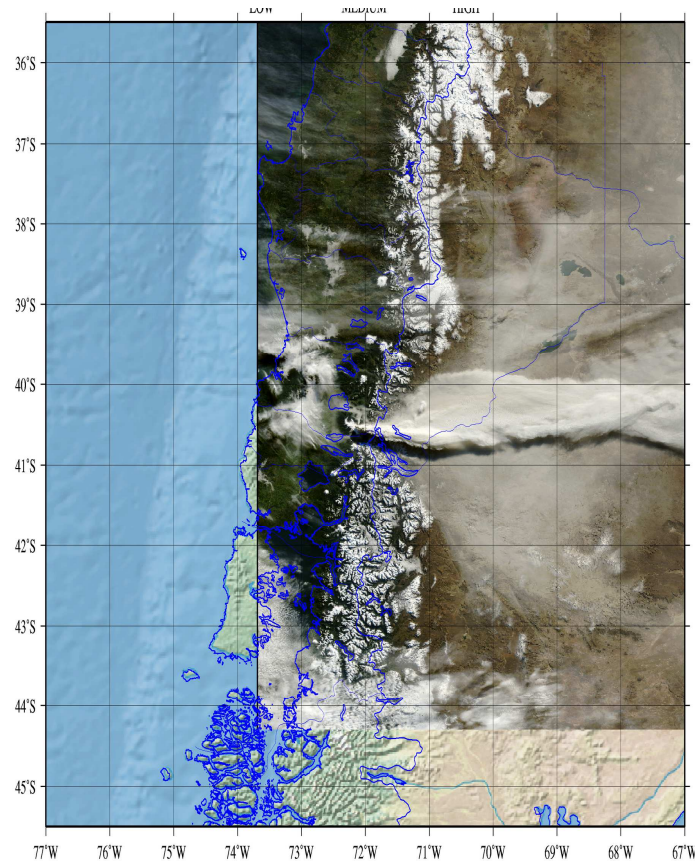
Eyjafjallajökull eruption - IASI Ash radiance index - 09 May (AM)



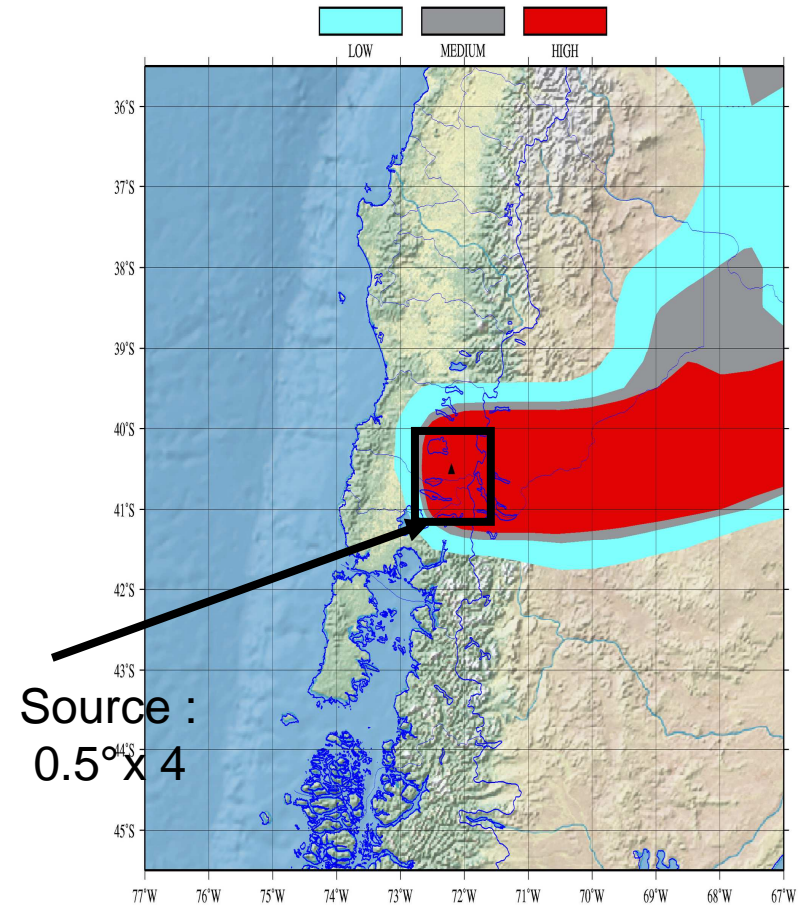
May 2010 eruption, comparison between Mocage-Accident simulation (total column ash) and IASI (radiance indice) (LATMOS/ULB).

# Real case : Cordon Caulle eruption ( June 2011)

Visible satellite Image

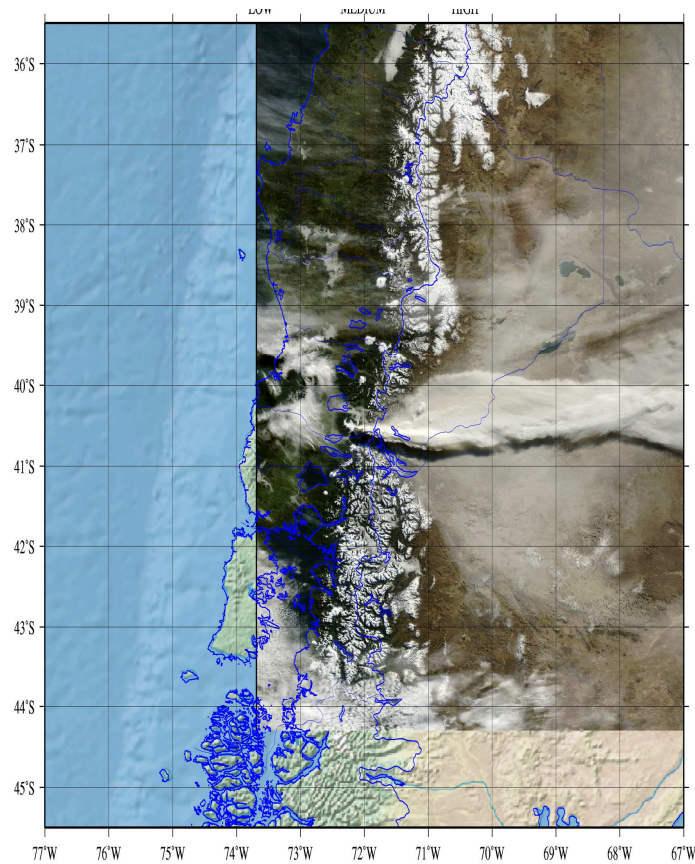


MOCAGE-ACC 0.5°  
total column concentration

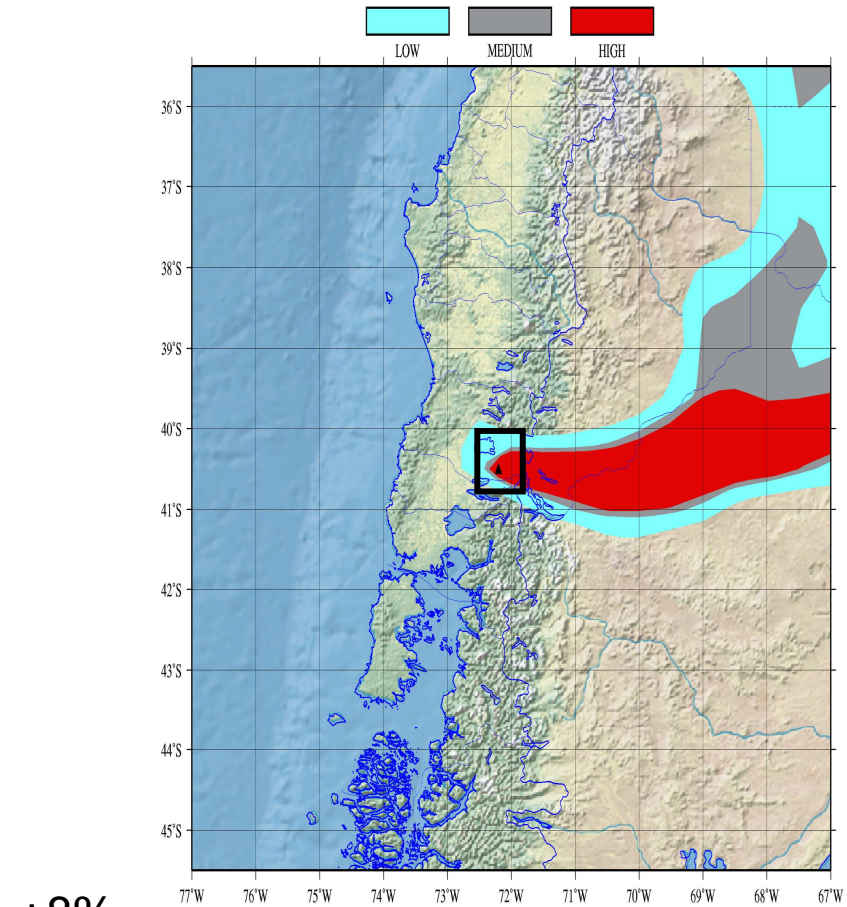


# Perspectives for MOCAGE Accident : increase the horizontal resolution near the source

Visible satellite Image



MOCAGE-ACC 0.1°  
total column concentration



+8%

computer cost

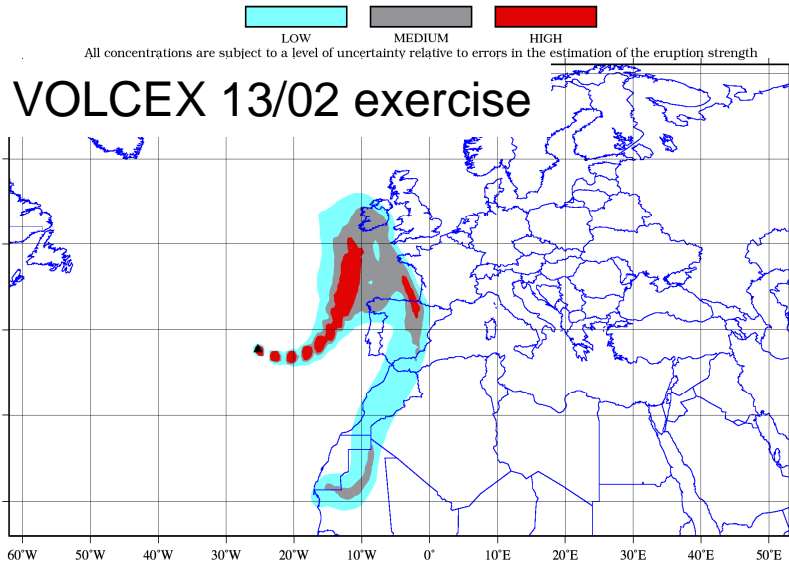
source : M. Martet

# Mocage-ACC & transport scheme



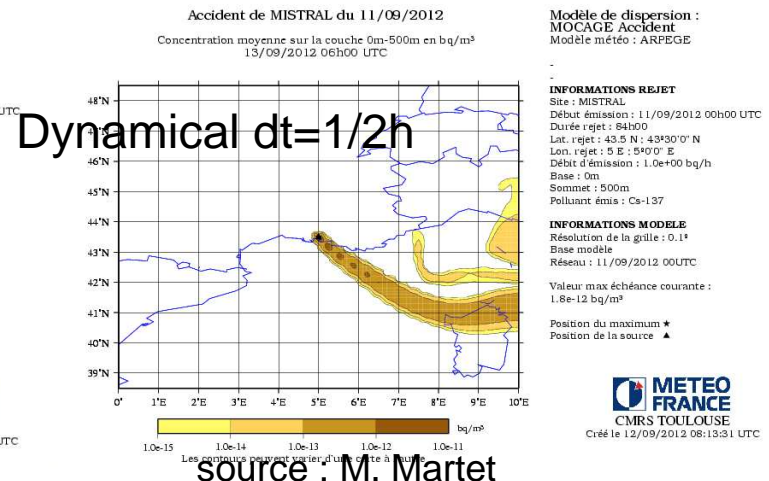
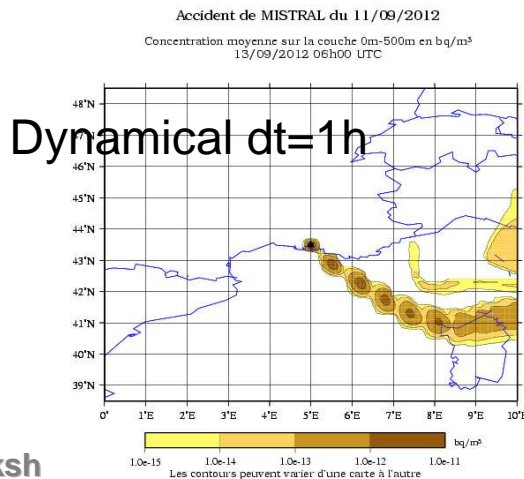
Furnas VOLCEX 13/02 Exercise  
 Modelled Ash Concentration from FL200 to FL350  
 23/10/2013 18h00 UTC

This is a guidance product, supplemental to the official VAAC Toulouse Volcanic Ash Advisory and Volcanic Ash Graphic products.  
 Issue time: YYYYMMDDHHMM



- The 1 hour time step for the advection with a strong mean wind could lead to a «strange» plume. This will be emphasized at higher resolution.

➔ Tests with a timestep = 1/2h on a chemical accident run



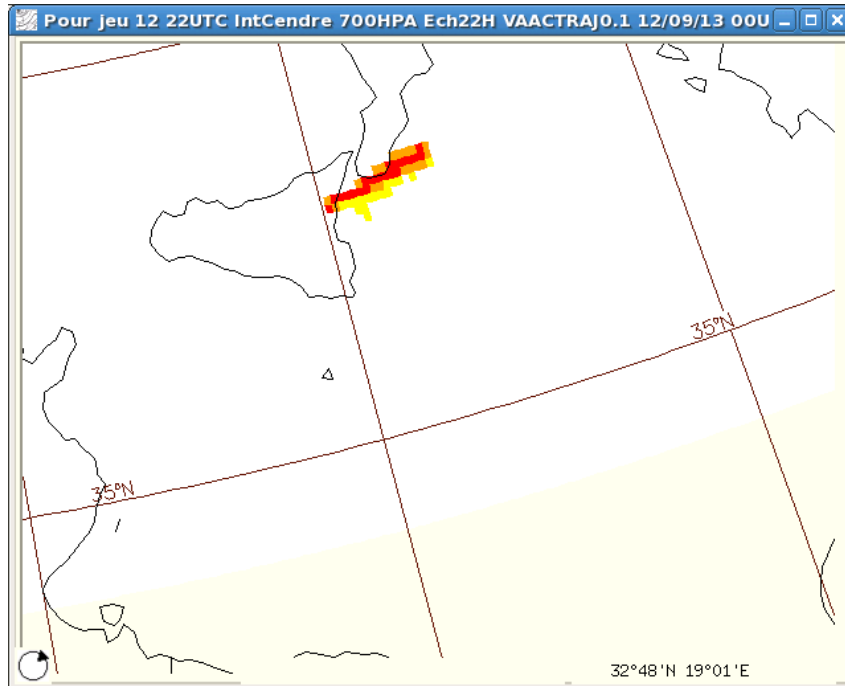
# Evolutions summary

- **Higher horizontal resolution near the source :**
  - With a source represented by a square of 4 x 4 grid, better capture of the plume for the first time steps.
- **Dynamical time step : higher frequency**
  - Better representation of the plume but the puff-shape still remains
- **Meteorological fields**
  - The frequency of meteorological fields would be increased as well to 3-hourly  
This high frequency could help in capturing wind shift and the mid-afternoon convection (15UTC). Wet deposition improvement is expected
- **But ....**
  - Computing time increases of 8% for higher horizontal resolution
  - Computing time increases of 20% for increasing dynamical time step
  - Computing time increases again for higher frequency of meteorological fields

The new computer will allow to apply the two last evolutions within the operational time constraints

Nevertheless the forecast close to the source will be not enough accurate → New tool : VAACTRAJ

## Local scale : tool VAACTRAJ



- Quartile 30 / total in the whole domain
- Between 30 and 70
- Quartile 70 / total in the whole domain

source : M. Bouzom

- Trajectories off-line tool based on ARPEGE / ECMWF 6-hourly meteorological fields
- 8000 trajectories/min at the location of the eruption
- Parameterizations :
  - Dynamical time step along the mean wind = 5 minutes
  - Sedimentation is applied
  - No convection, no turbulence, no wet scavenging
- Source description :
  - Volcano, localisation,
  - Start and duration of the eruption
  - Bottom and top of the plume
  - 4 particles size classes
  - Vertical distribution : homogeneous from bottom to top / 2 layers one with 10% and a second with 90%
- Available within 15min
- Area covered : <150km-300km around the source
- Hourly outputs on one day
- 3 scales (not quantitative)

## CONCLUSIONS

- The performances of MOCAGE-ACCIDENT model must include the real-time operations constraints.
- This model has been validated on several cases (real cases and international exercises) : the regional ( > 300km from the source) to global scale is better represented.
- Some improvements have been experimented.
- The new computer in Meteo-France will allow new evolutions within the real-time operations time constraints.
- The local scale is covered with the new VAACTRAJ tool.



**THE END**