Incertainties in ash clouds with MOCAGE (CTM) and MOCAGE Accident

Workshop on expert judgment for volcanic ash clouds
22-23 september 2015 in Reykjavik

Mathieu Deslandes (Météo-France)

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Introduction

Incertainties with volcanic eruption

Input	Current level of readiness/ suitability
Eruptive plume height	depends on monotoring level of volcano
Meteorological forcings	less accurate in tropics
Mass eruption rate	high Incertainty + significant knowledge gap
Onset and duration	depends on monotoring level of volcano
Vertical and horizontal distribution of eruptive plume	high incertainty + significant knowledge gap
Particle size distibution (aggregation)	high incertainty + significant knowledge gap

From VAAC 'Inputs and Outputs' (Ins and Outs),

dispersion Modelling Workshop in Washington

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Mocage

Mocage

MOCAGE (CTM)

Chemical Transport Model used in Météo-France

Mocage

MOCAGE (CTM)

Chemical Transport Model used in Météo-France

MOCAGE Accident

Mocage

MOCAGE (CTM)

Chemical Transport Model used in Météo-France

MOCAGE Accident

- All charts must be available within less than 20 minutes for forecasters

Expensive processes have been switched off or replaced by simpler ones

=> **Particles don't interract with each other**

Mocage

MOCAGE (CTM)

Chemical Transport Model used in Météo-France

MOCAGE Accident

- All charts must be available within less than 20 minutes for forecasters

Expensive processes have been switched off or replaced by simpler ones

$=>$ **Particles don't interract with each other**

- Long range dispersion tracking (national and global scale)
  - spatial scale : L $\geq$ 300km
  - temporal scale : from 6-12h up to several days

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Variations of source parameters on a fictive situation

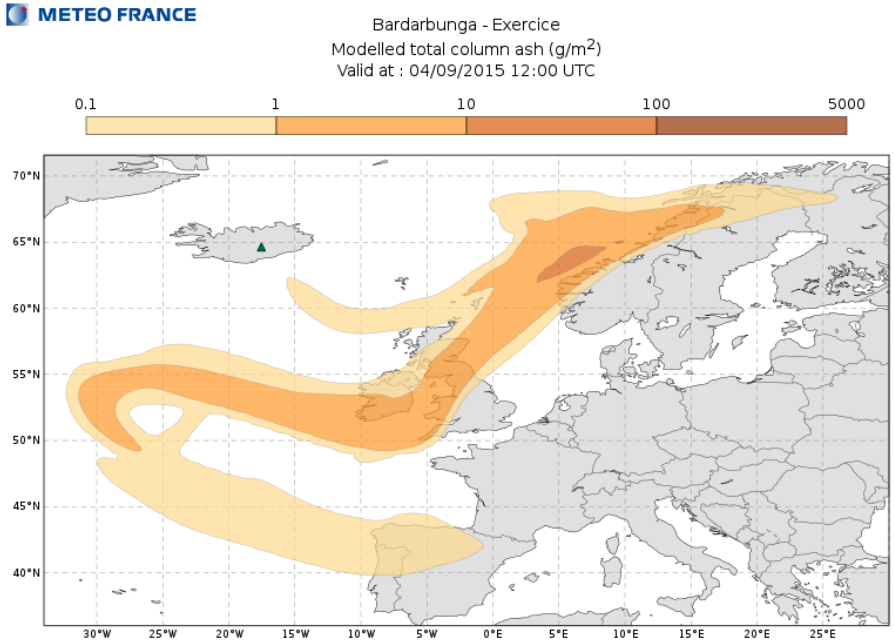
Reference experiment

- place : Bardarbunga
- start : 2 september 2015 at 9h UTC
- duration : 24 hours
- mass emission rate : Mastin's relationship
- mass fraction of fine ash : 5%
- vertical distribution : uniforme
- size distribution : distribution
- top (abs) : 12000 meters

Impact of mass eruption rate

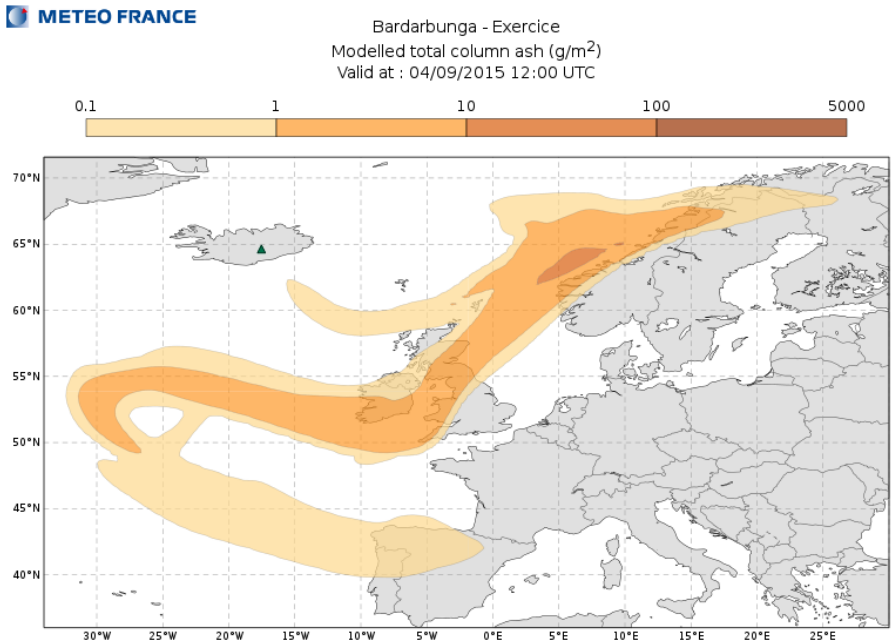
Impact of mass eruption rate

Mastin's relationship

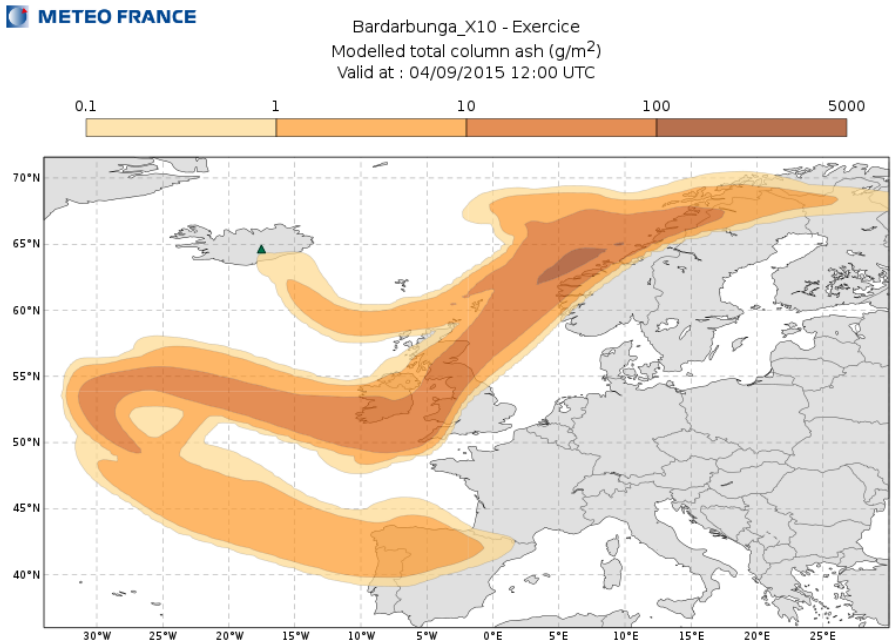


Impact of mass eruption rate

Mastin's relationship



Mastin's relationship X 10



Impact of mass eruption rate

Impact of mass eruption rate

Change isolines

Impact of mass eruption rate

Change isolines

Roughly, intructions for forecasters for concentration charts :

Impact of mass eruption rate

Change isolines

Roughly, intructions for forecasters for concentration charts :

- first run of MOCAGE Accident

Impact of mass eruption rate

Change isolines

Roughly, intructions for forecasters for concentration charts :

- first run of MOCAGE Accident
- find isolign that match with observations

Impact of mass eruption rate

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Roughly, intructions for forecasters for concentration charts :

- first run of MOCAGE Accident
- find isolign that match with observations
- apply a coefficient to mass emission rate

Impact of mass eruption rate

Change isolines

Roughly, intructions for forecasters for concentration charts :

- first run of MOCAGE Accident
- find isolign that match with observations
- apply a coefficient to mass emission rate
- new run of MOCAGE Accident

Impact of height

3 differents heights with same MER

- 12 kms (reference)
- 10 kms
- 8 kms

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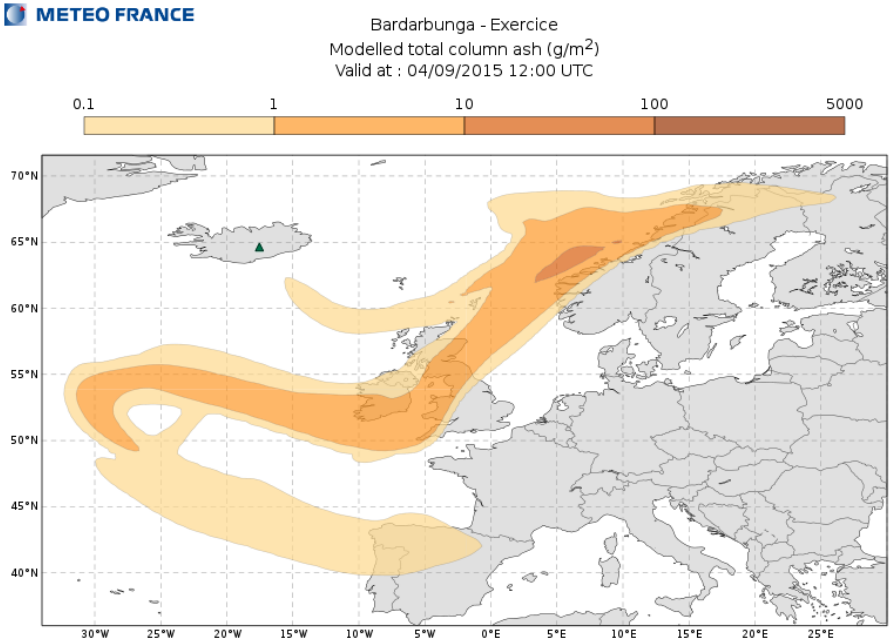

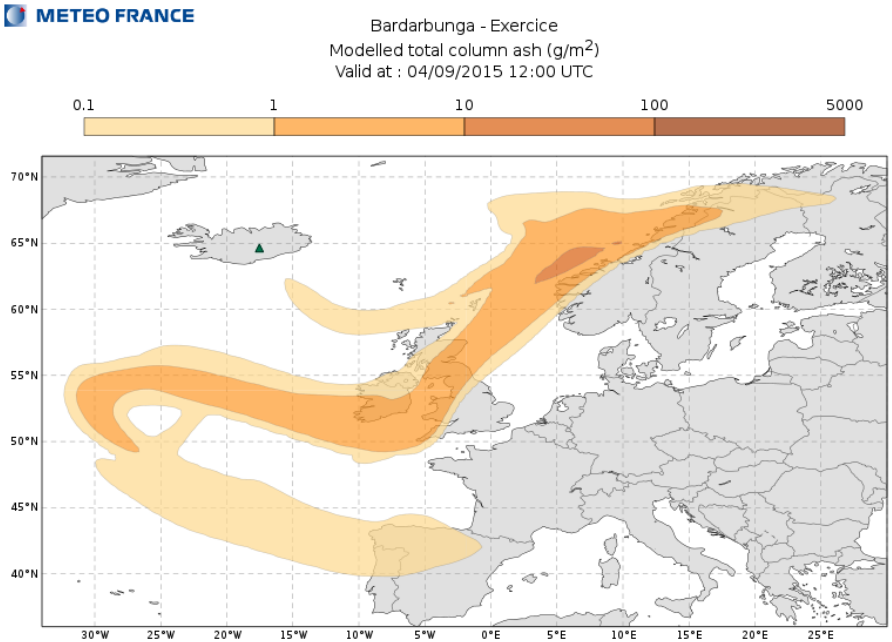
METEO FRANCE
Bardarbunga - Exercice
Modelled total column ash (g/m2)
Valid at : 04/09/2015 12:00 UTC
0.1
1
10
100
5000
70°N
65°N
60°N
55°N
50°N
45°N
40°N
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20°E
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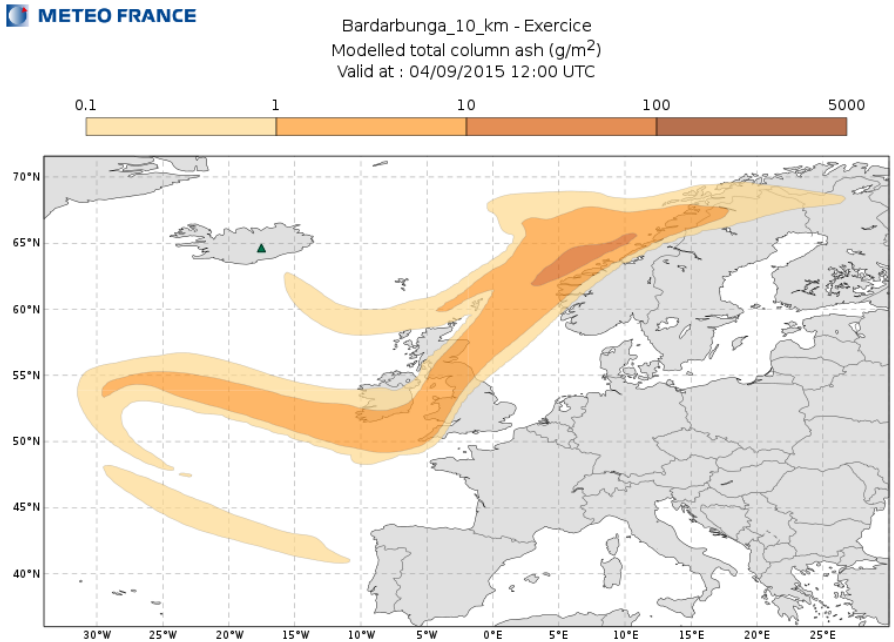
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Bardarbunga_10_km - Exercice
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0.1
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10
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70°N
65°N
60°N
55°N
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45°N
40°N
30°W
25°W
20°W
15°W
10°W
5°W
0°E
5°E
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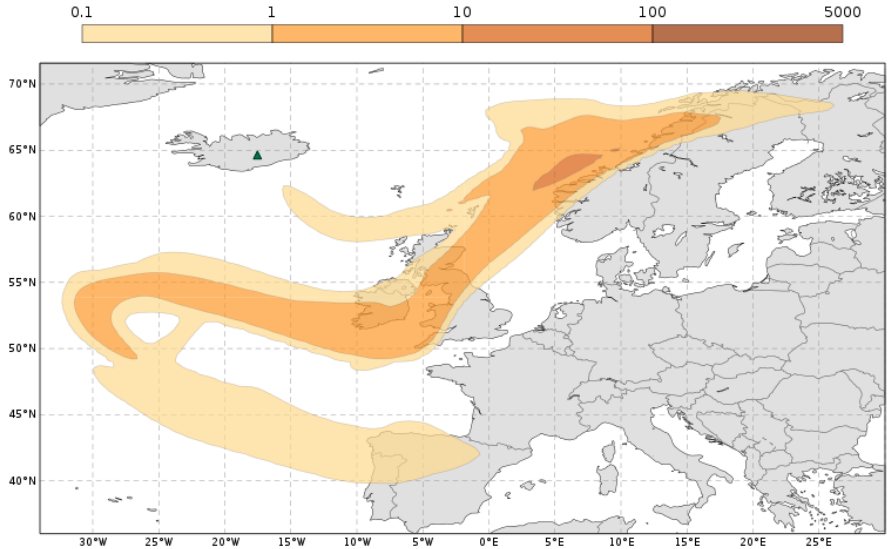

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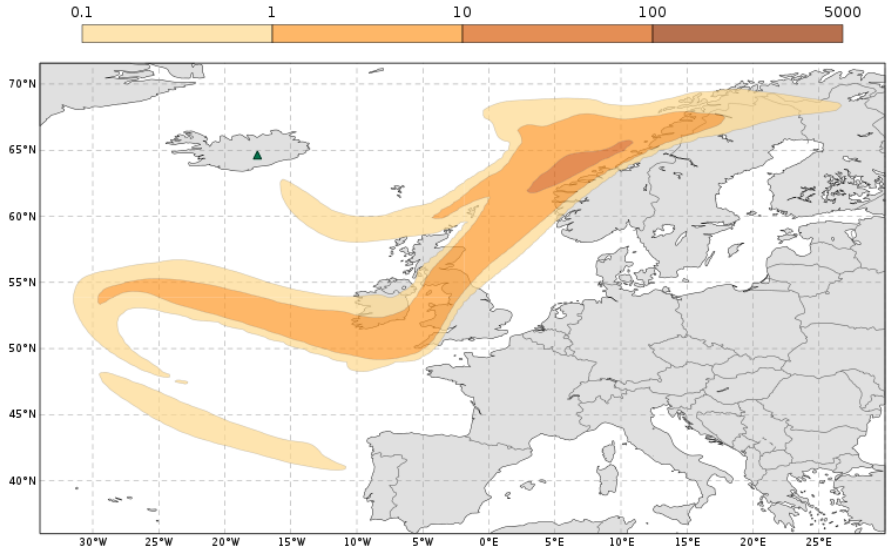

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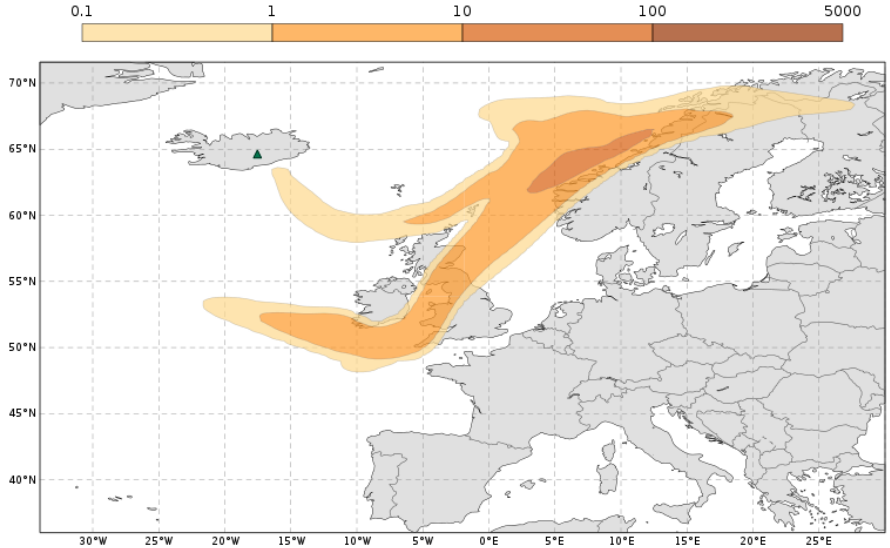

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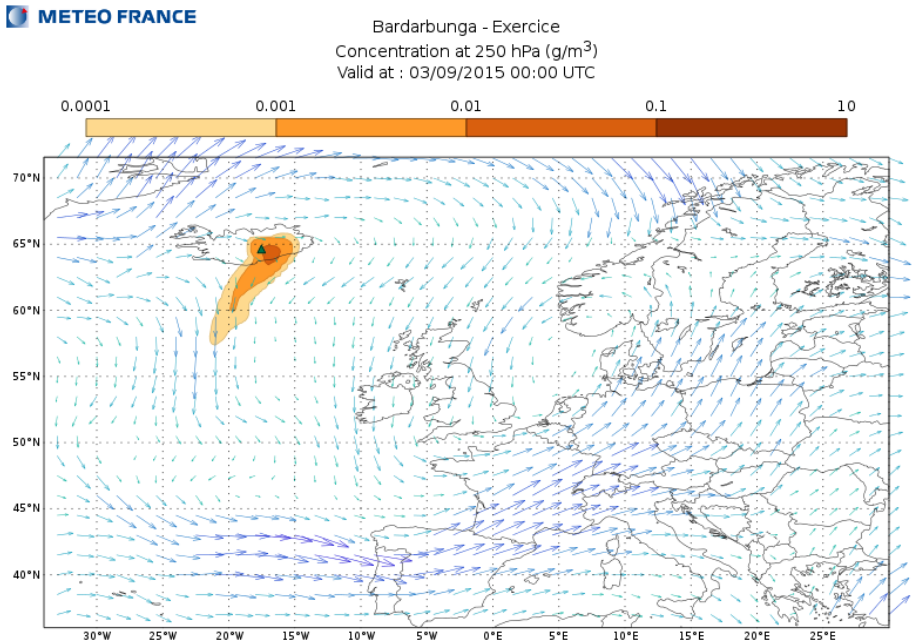

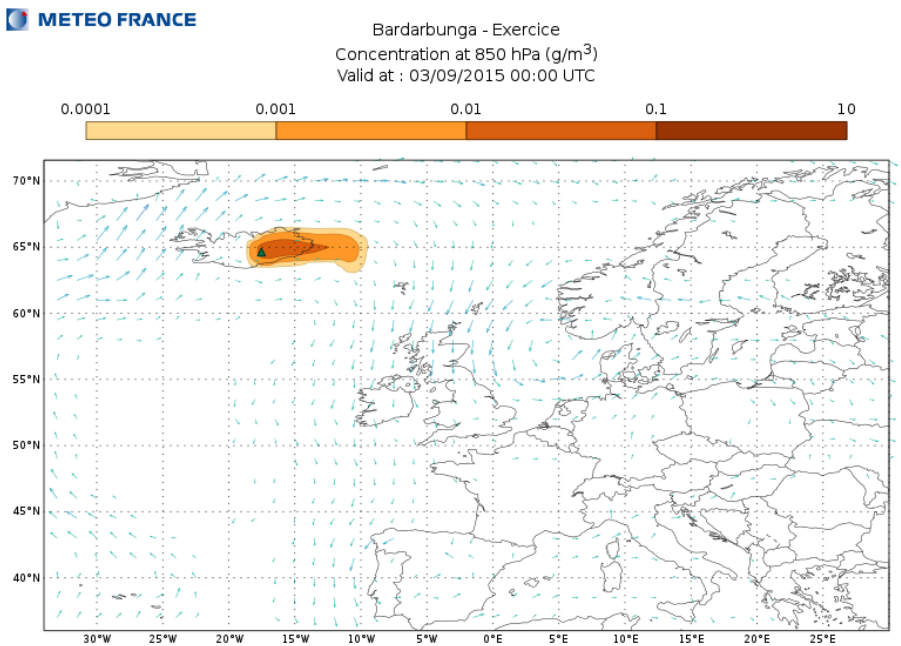

Concentrations of reference run

- 03/09/2015 00 :00 UTC
- 250 hPa (top)
- 850 hPa (bottom)

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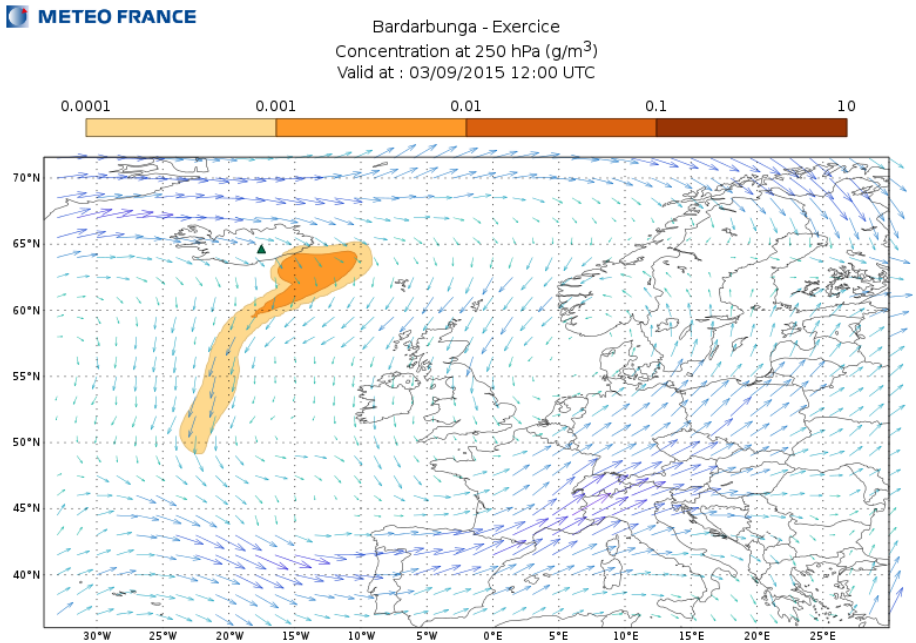

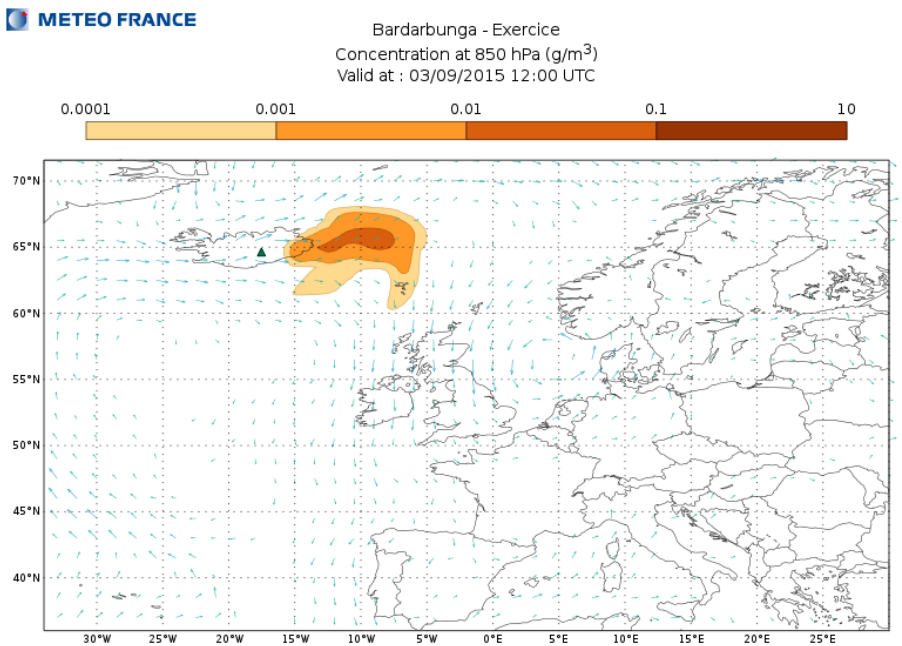

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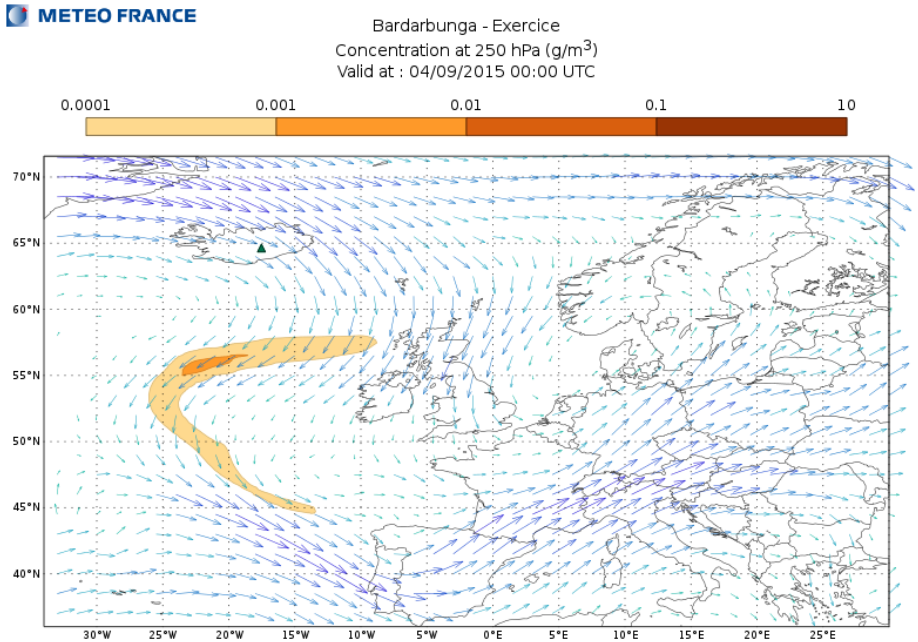

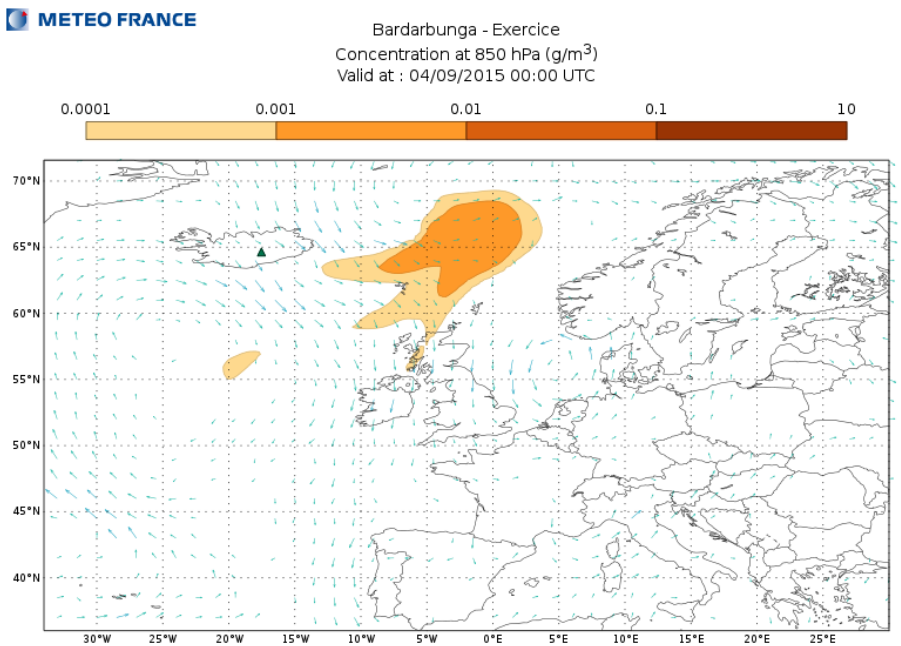

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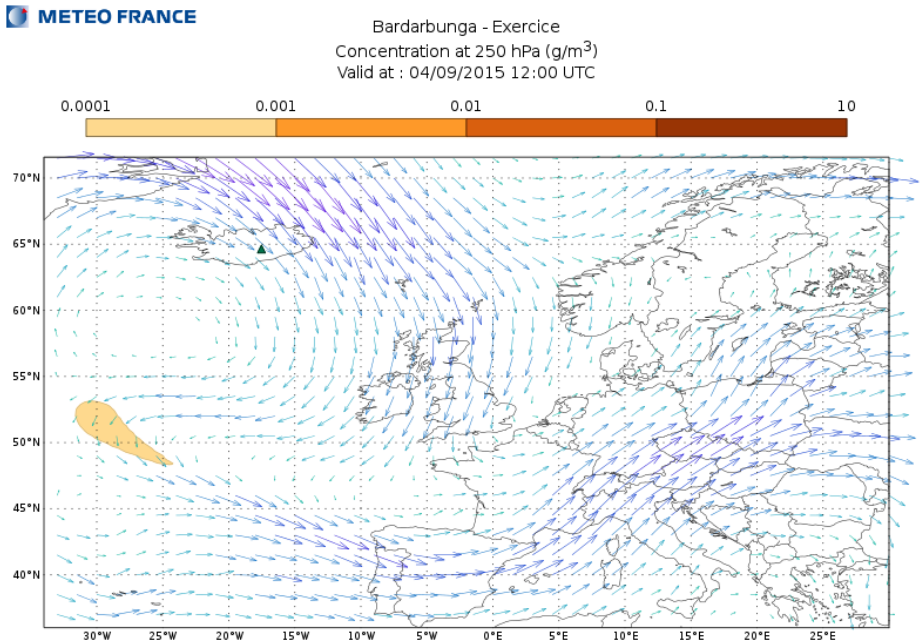

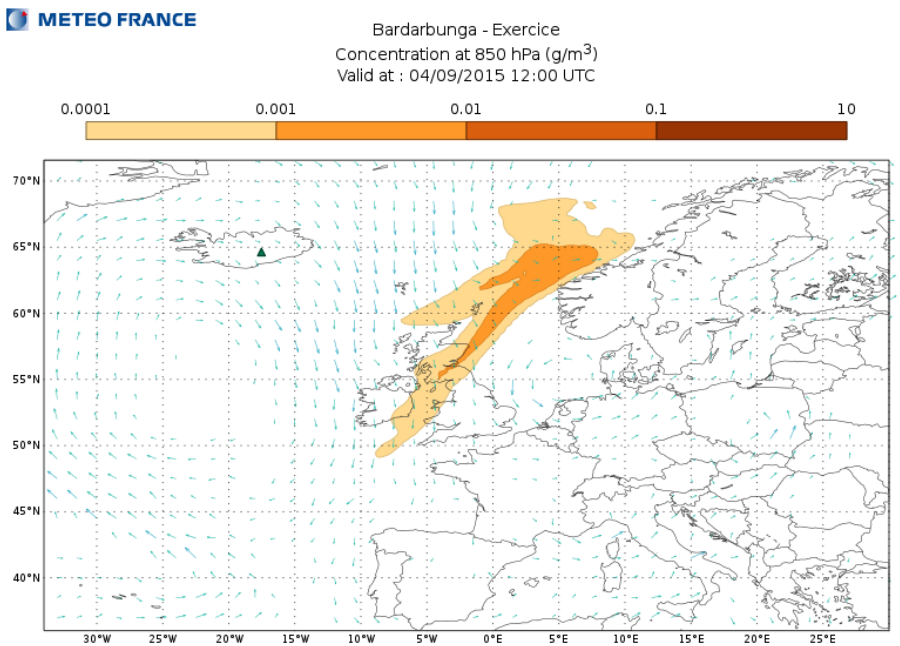

Concentrations of reference run

- 04/09/2015 12 :00 UTC
- 250 hPa (top)
- 850 hPa (bottom)

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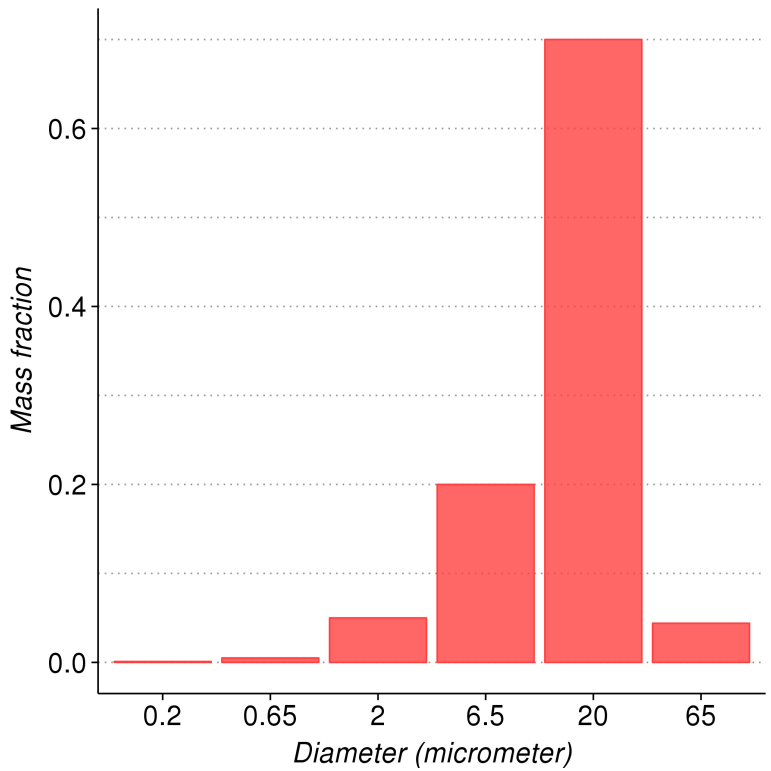
Impact of particules size distribution

3 different sizes :

- particles size distribution (6 bins)
- 20 micrometers
- 0.65 micrometers



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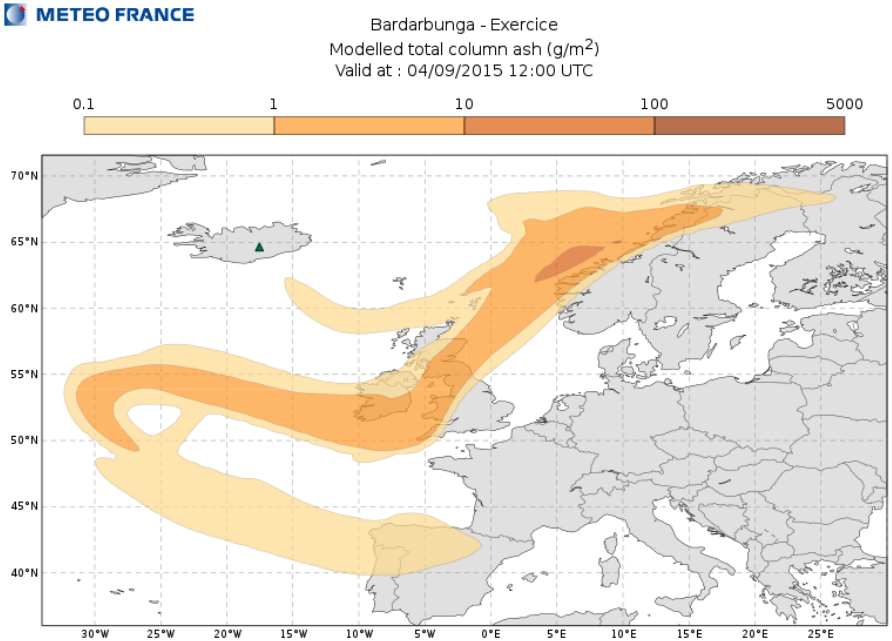

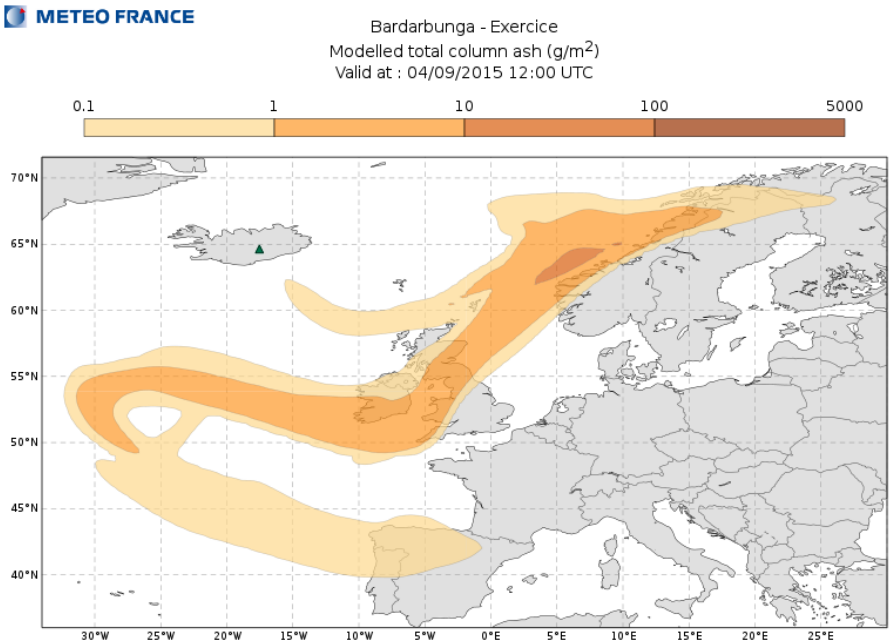
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50°N
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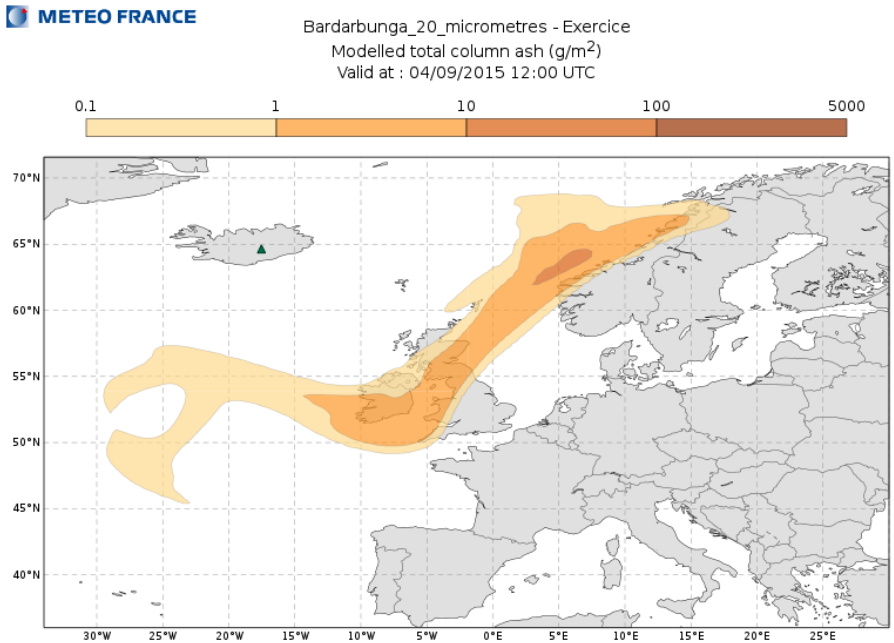
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Bardarbunga_20_micrometres - Exercice
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Valid at : 04/09/2015 12:00 UTC
0.1
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70°N
65°N
60°N
55°N
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METEO FRANCE

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Modelled total column ash (g/m^2)
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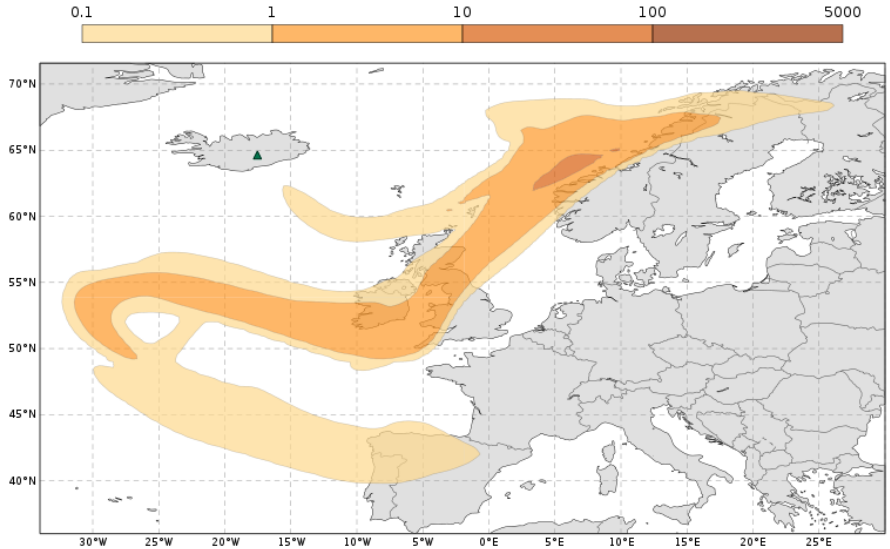

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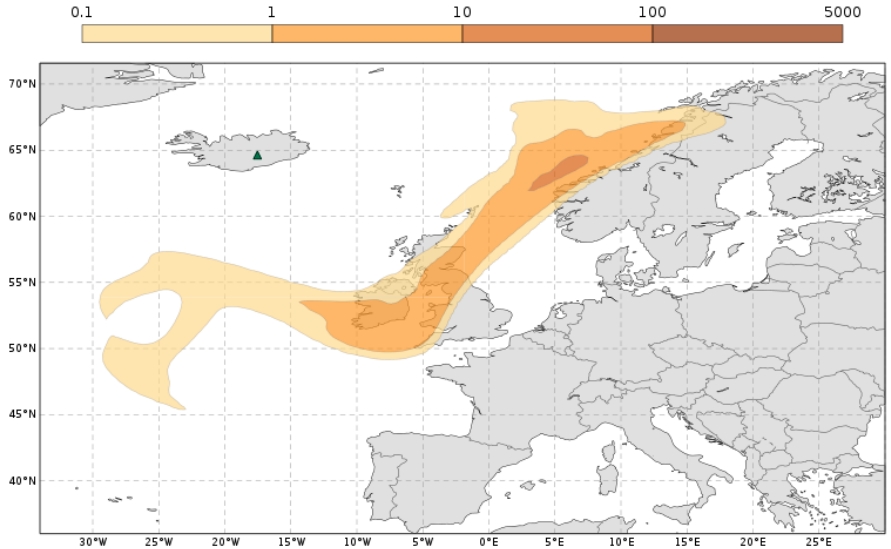

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Bardarbunga_0_65_micrometres - Exercice
Modelled total column ash (g/m^2)
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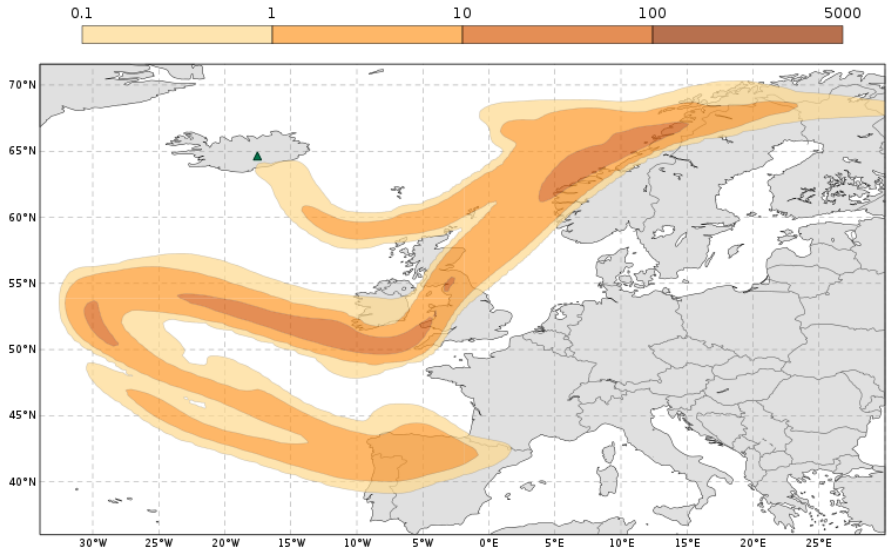

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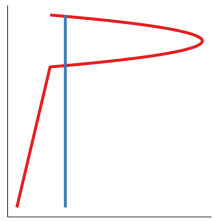
Impact of vertical distribution of particles

Uniform vs umbrella profil



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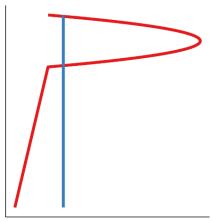

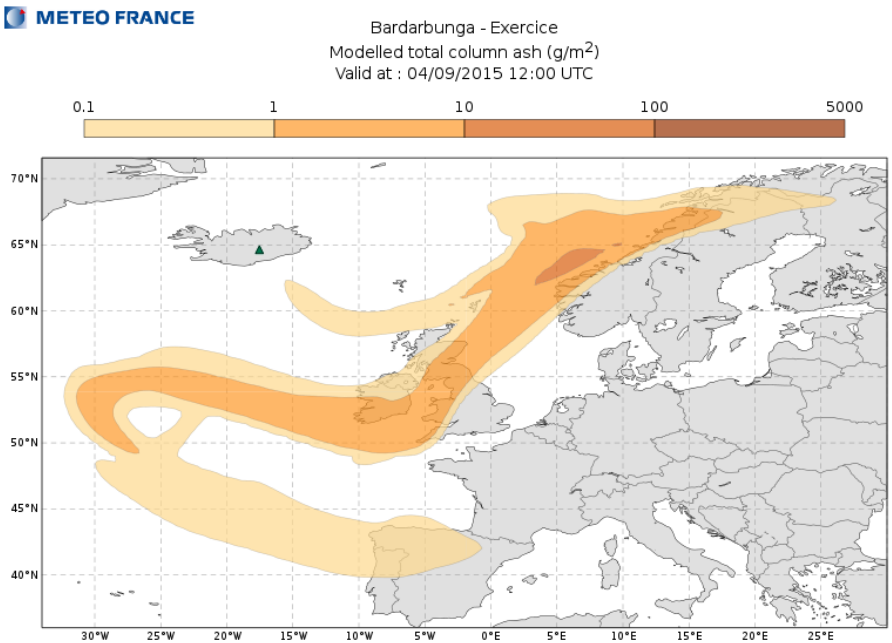

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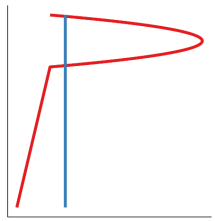

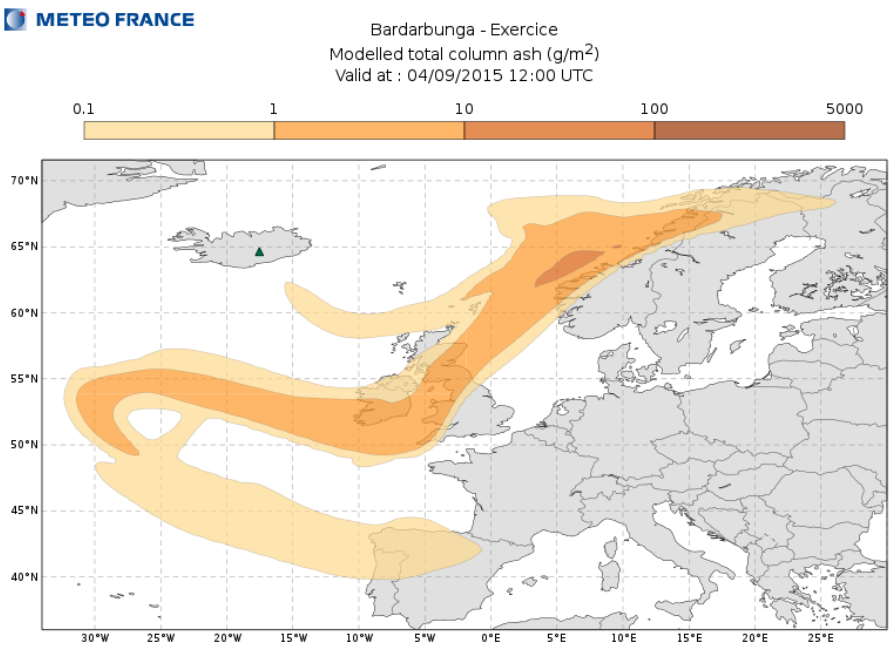

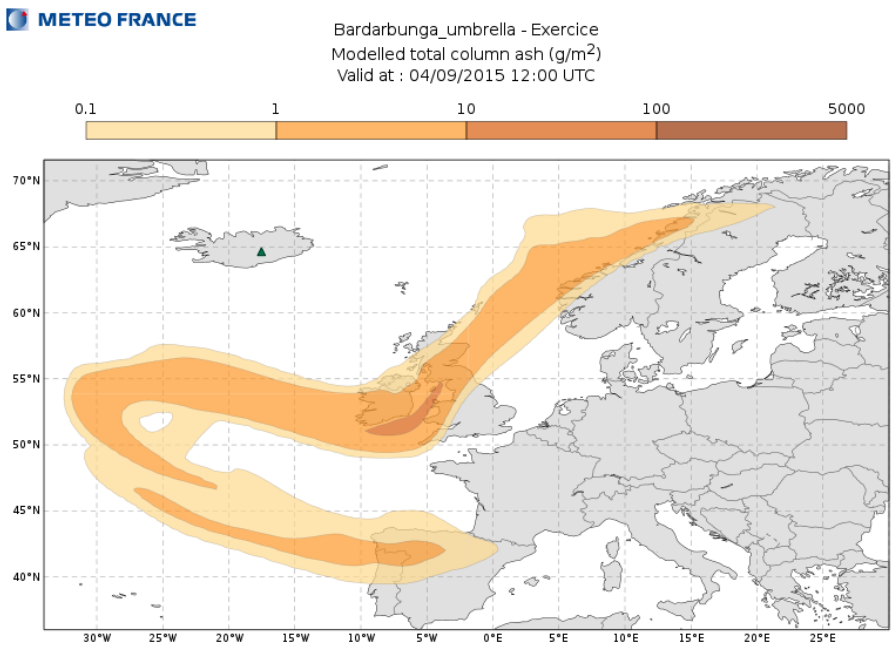

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Other parameters

In these experiments, all these source parameters are constant, but they should be known as a function of time. . .

Many combinations are possible.

Ensemble forecast

Additional tool to help forecaster

Additional tool to help forecaster

Work in progress, not in operation

Additional tool to help forecaster

Work in progress, not in operation

Use different meteorolical data from PEARP (Prévision d'Ensemble ARPEGE)

10 members are extracted from the 35 members of PEARP

Additional tool to help forecaster

Work in progress, not in operation

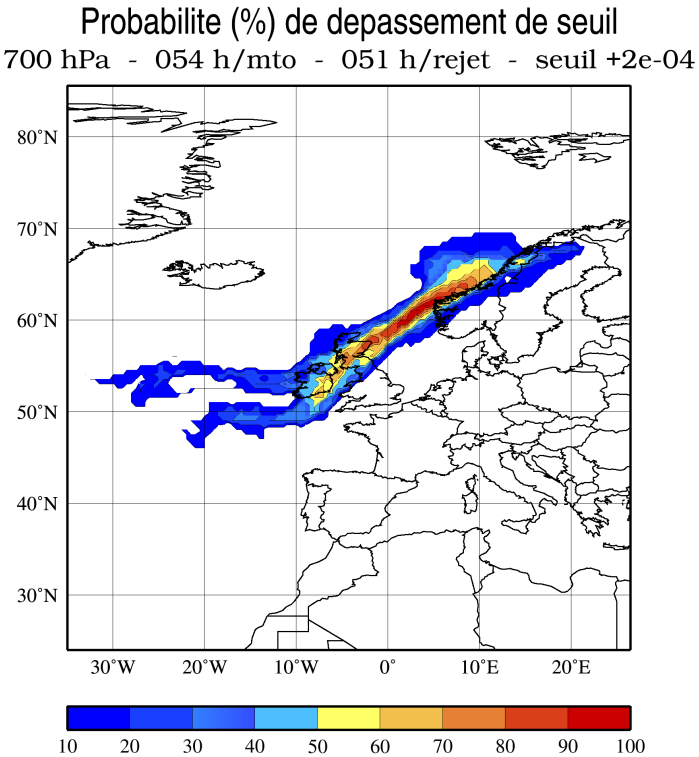
Use different meteorolical data from PEARP (Prévision d'Ensemble ARPEGE)

10 members are extracted from the 35 members of PEARP

No perturbations in eruption source parameters

It is planned... but how to do it ?

Probability of exceeding a particular threhold



Probabiliy of ensemble member

- exceeding 0.0002 g/m^3
- at 700 hPa
- on 2015/09/04 12 :00 UTC

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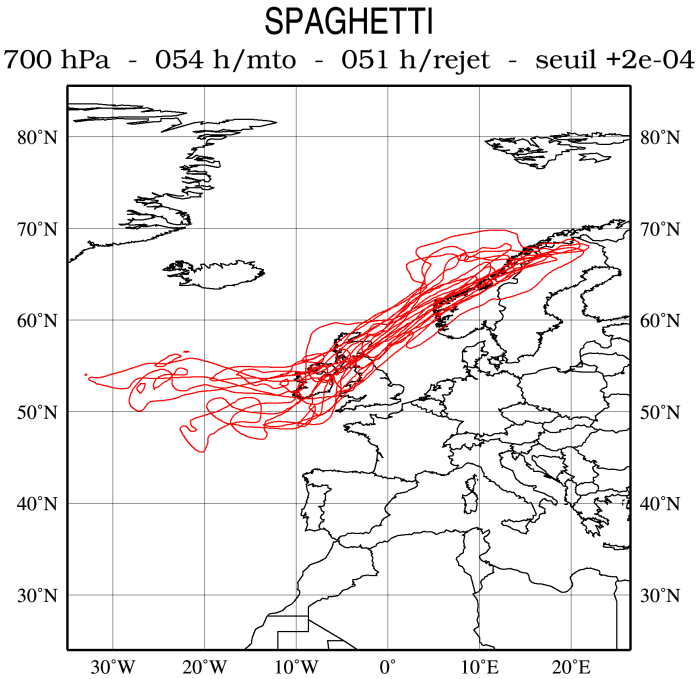
Spaghetti



For all the ensemble members

- Contour level 0.0002 g/m^3
- at 700 hPa
- on 2015/09/04 12 :00 UTC

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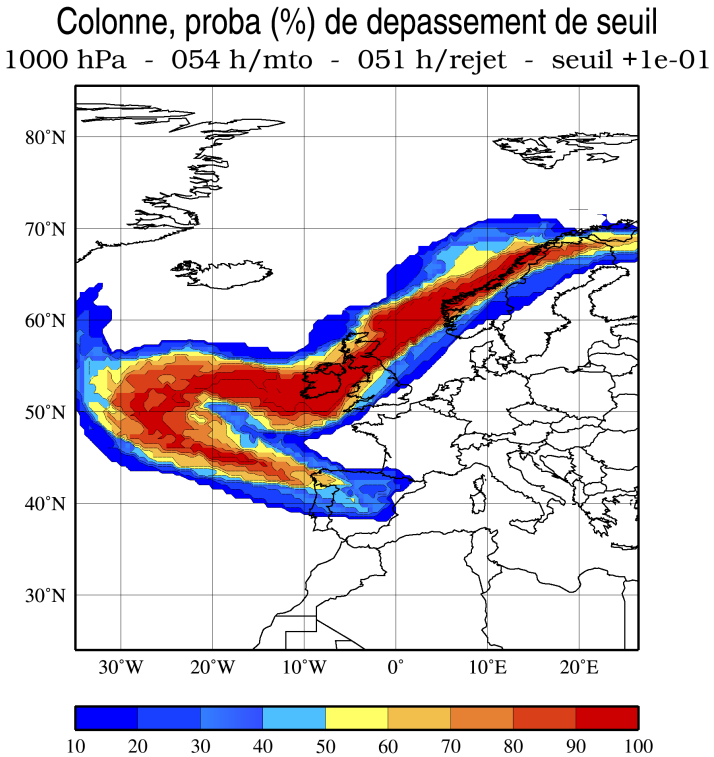
Comparison with previous results



Probability of ensemble member

- exceeding 0.1 g/m^2 total column ash mass loading
- on 2015/09/04 12 :00 UTC

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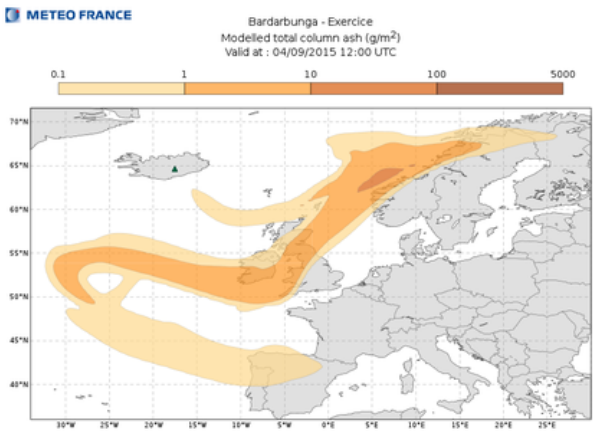
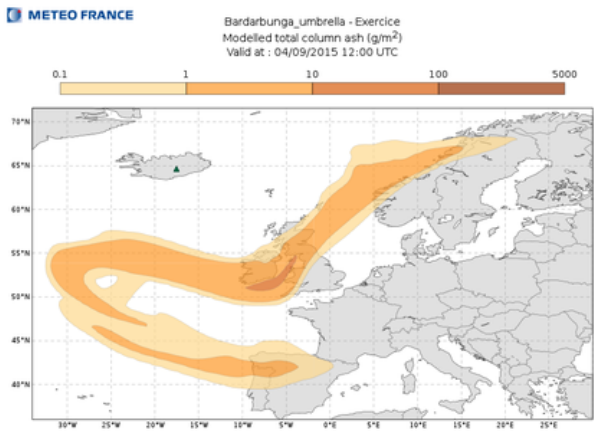
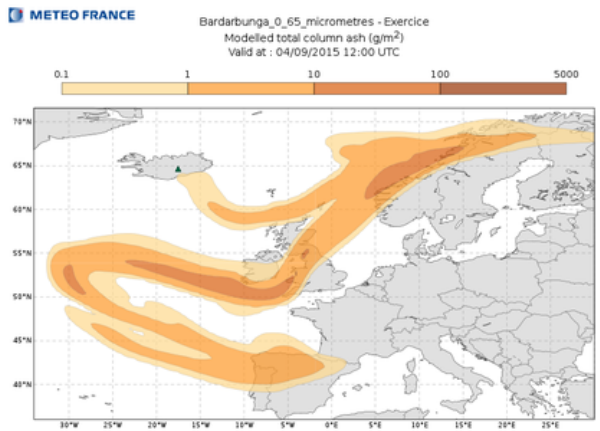
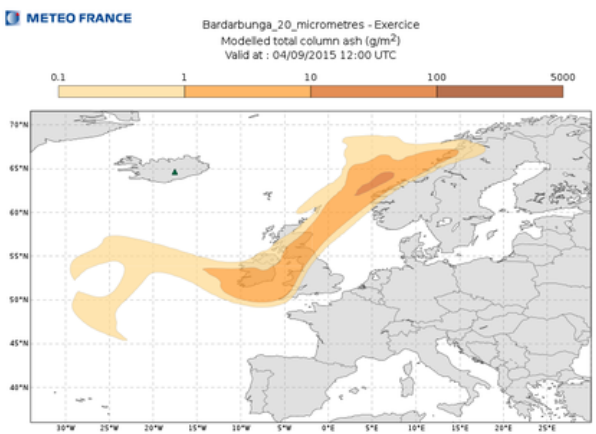
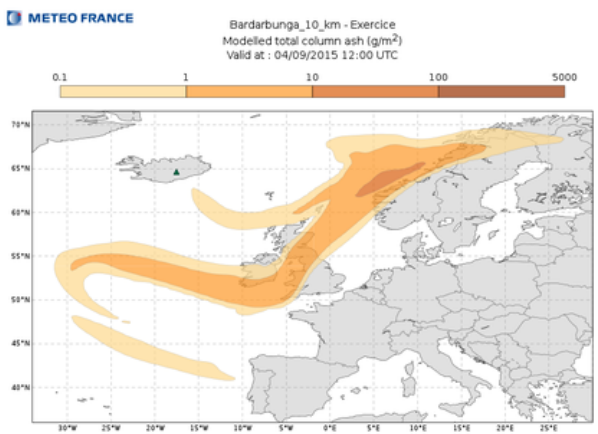
Comparaison with previous runs

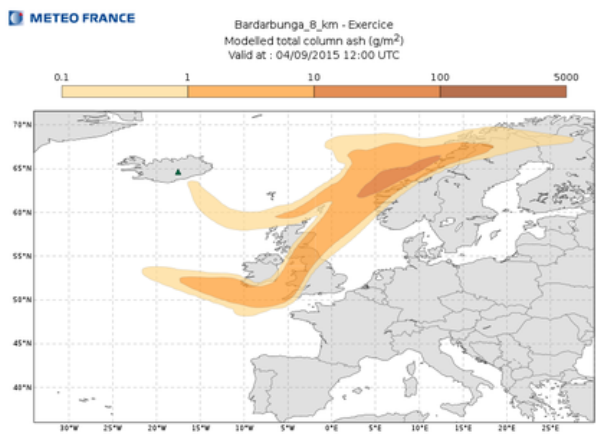












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Adding perturbations to eruption source parameters

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Needs to add perturbations to :

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption
- Bottom and top of ash column

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption
- Bottom and top of ash column
- Vertical distribution of ash

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption
- Bottom and top of ash column
- Vertical distribution of ash
- Particle size distribution

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption
- Bottom and top of ash column
- Vertical distribution of ash
- Particle size distribution
- Mass eruption rate and/or percentage of fine ash

Adding perturbations to eruption source parameters

Needs to add perturbations to :

- Start and end of eruption
- Bottom and top of ash column
- Vertical distribution of ash
- Particle size distribution
- Mass eruption rate and/or percentage of fine ash

Unsanswered questions at present

- How to span the incertainties of these various parameters ?
- Which weight is accorded to the different members ?

Model limits

For now, it is not possible to take into account incertainties of MOCAGE Accident (no ash aggregation, spherical particles. . .)

Assimilation of the volcanic plume

When eruption last for days

When eruption last for days

- A first MOCAGE Accident is run when the eruption starts

When eruption last for days

- A first MOCAGE Accident is run when the eruption starts
- Several hours later, a second run is started
  - with new source parameters, new meteo. . .
  - with an initial state of concentrations : **ashes already in the atmosphere come from the first run**

When eruption last for days

- A first MOCAGE Accident is run when the eruption starts
- Several hours later, a second run is started
  - with new source parameters, new meteo. . .
  - with an initial state of concentrations : **ashes already in the atmosphere come from the first run**
- and so on . . .

When eruption last for days

- A first MOCAGE Accident is run when the eruption starts
- Several hours later, a second run is started
  - with new source parameters, new meteo...
  - with an initial state of concentrations : **ashes already in the atmosphere come from the first run**
- and so on ...

A present, this initial state of concentration used for successive runs is never corrected...

When eruption last for days

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- Several hours later, a second run is started
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  - with an initial state of concentrations : **ashes already in the atmosphere come from the first run**
- and so on ...

A present, this initial state of concentration used for successive runs is never corrected...

Data Assimilation can be used to bring this initial state closer to observations

Aerosols Optical Depth (AOD) assimilation

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- Thesis work

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- In MOCAGE (CTM), not MOCAGE Accident

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- Thesis work
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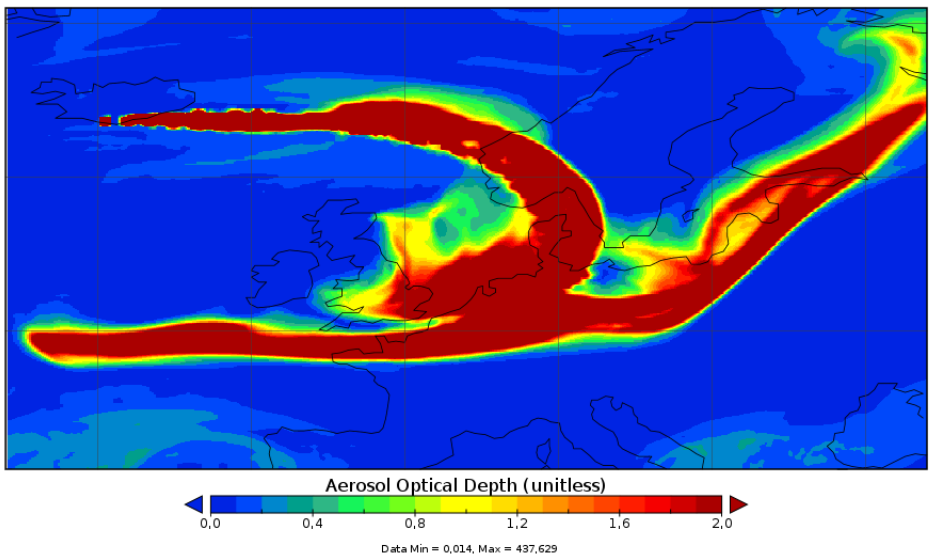
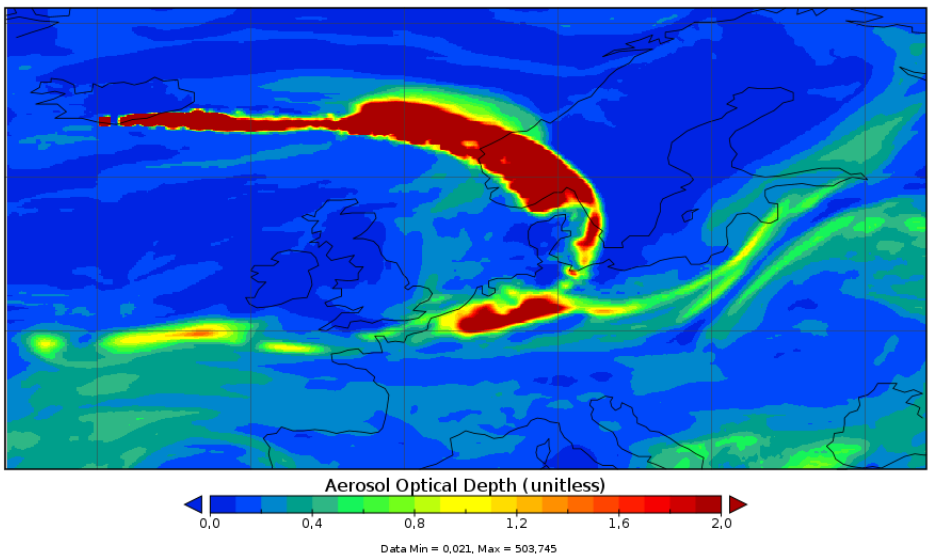
- During Eyjafjöll eruption from 14.04.2010 until 21.05.2010
- Assimilated data from MODIS
- Independant data from SEVIRI
- Two MOCAGE configurations :
  - without assimilation (*direct model run*)
  - with assimilation (*assimilation model run*)

On 16.04.2010 at 14h UTC

MOCAGE Direct - Aerosol Optical Depth

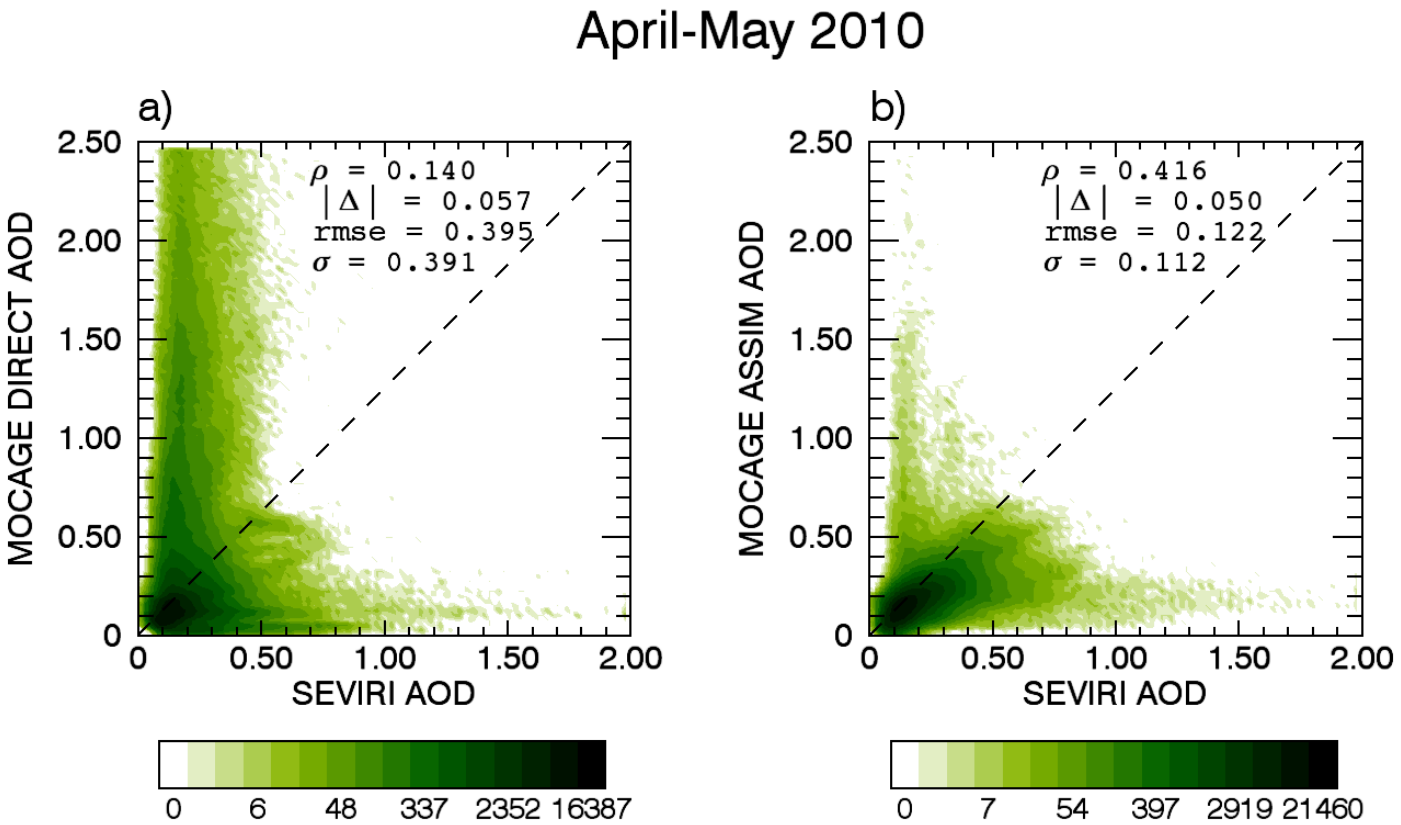


MOCAGE-PALM - Aerosol Optical Depth



METEO FRANCE

Comparison with independant SEVERI data



- Reduce incertainties in quantity and extend of the plume
- Very efficient even in regions or periods with high cloud cover
- Lidars can also be assimilated

What could be done to use it with MOCAGE Accident

A MOCAGE (CTM) run with data assimilation use the same source parameters than MOCAGE Accident :

- It is much slower, and can't be used by forecasters in real time
- But its outputs are available as initial state for the next run of MOCAGE Accident

Questions ?