Impact of the Eyjafjallajökull's eruption on surface air quality in France

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Fast Facts

- 24/7 lidars showed the continuous advection of a thin layer of volcanic material in altitude over the Paris area until its ultimate injection in the boundary layer. The following days several fractioned layers were detected in the lowermost troposphere.
- Eulerian and Lagrangian transport models proved to be able to reproduce the timing of the event, estimate the extent of the footprint and provide a quantitative assessment of tracer concentration at the surface.
- Surface measurements showed a significant impact of the volcanic plume on particulate matter concentration in some Northern French regions and allowed to discriminate the respective contribution of local pollution and Eyjafjallajökull's emissions.

Perspectives

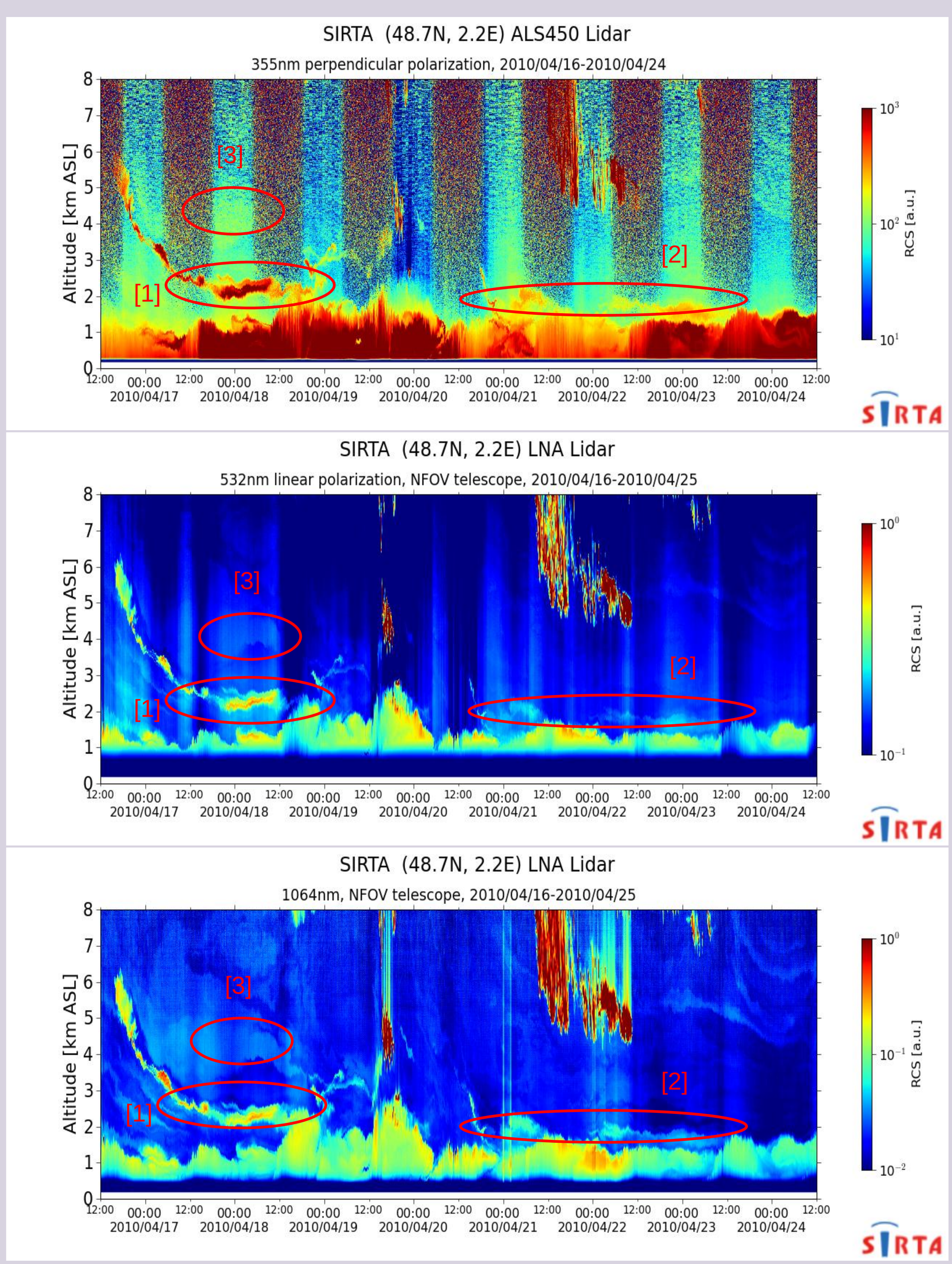
- In depth analysis of collected samples may provide insight into the chemical processes taking place in the plume
- Improvements of the deposition in the models will allow a more realistic representation of the decay
- Further processing of the all lidar signals will yield a wealth of information on optical characteristics of the the aerosols in the ash plume

Remote Sensing

The Sirta observatory hosts several atmospheric remote sensing instruments in a suburban environment 20 km south of Paris including two lidars that were operated 24/7 during the episode:

- The clouds and aerosols (LNA) lidar operates between 0.1 km and 15 km. Two wavelengths are emitted (532 nm & 1064 nm) and the detection system is capable of measuring the signal at 532 nm (linear and cross-polarized), 1064 nm, and 607 nm from the Raman diffusion of N2.
- A commercial automated ALS450 lidar operating at 355nm between the surface and 12km and measuring the backscatter of the linear and cross-polarized signals.

Raw lidar backscattering ratios at 355, 532 and 1064nm measured continuously at the SIRTA observatory between the 16th and the 24th of April



Several layers presenting a high aerosol load are advected above the observatory:

- The most outstanding event occurs between April 16th and 18th and terminates with the injection of a thin layer (labelled [1]) inside the planetary boundary layer.
- During the same period a deeper layer (labelled [2]) with a weaker backscatter at all wavelengths is observed at higher altitude.
- The following days, the presence of several thin layers above the boundary layer could indicate the remains of the first layer of ash or residual planetary boundary layers.

Acknowledgements

We are grateful to the technical teams for their dedication during the April 2010 episode particularly the SIRTA and the French air quality monitoring associations (AASQA) which, as part of the CARA network provided the PM samples and real time concentration data: AIR NORMAND, ASPA, ARPAM, AIR LOR, Atmo Champagne Ardennes, Atmo Nord - Pas de Calais, Atmo Rhone Alpes, AIRAQ, Atmo Loraine Nord. Andreas Stohl is also acknowledged for providing the Flexpart model and helpful assistance. Mathieu Gouhier from Observatoire de Physique du Globe de Clermont-Ferrand provided the estimate of source terms through the Hotvolc Service: http://wwwobs.univ-bpclermont.fr/SO/televolc/hotvolc/Islande_Avril2010/

Modelling the Eyjafjallajökull's plume

INERIS is responsible for air quality forecasts at the national level in France. In that context the Institute operates a suite of models in an operational forecasting mode. In the hours following the onset of the Eyjafjallajökull's eruption an emergency forecasting strategy was designed to better anticipate any potential impact on air quality in France:

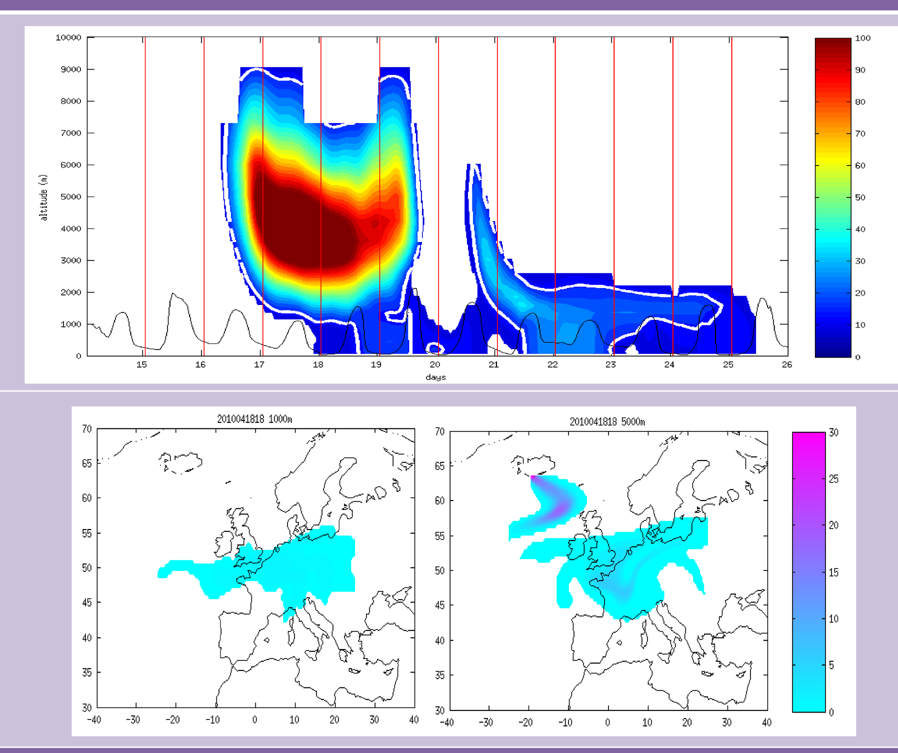
- The Chemistry and Transport Model Chimere was adapted to cover a larger domain and include Iceland so that a passive particulate tracer could be released at the location of the Volcano. The forecast are driven with ECMWF/IFS fields.
- The Lagrangian Particle Dispersion Model Flexpart was implemented in forecast mode driven by NCEP/GFS fields

In both models the ash emissions of the Eyjafjallajökull were estimated on the basis of the Hotvolc Service's reports and the altitude of the plume was obtained from the Icelandic Institute of Earth Sciences' Nordic Volcanologic Center:

Source of volcanic ash	14/04	15/04	16/04	17/04	18/04	19/04	20/04	21/04 and beyond
Total mass (kt)	1.6	20	4	5.2	3.2	34	8	0.4
Altitude (km asl)	4-8	4-8	3-7	3-6	2-6	2-5	2-4	2-4

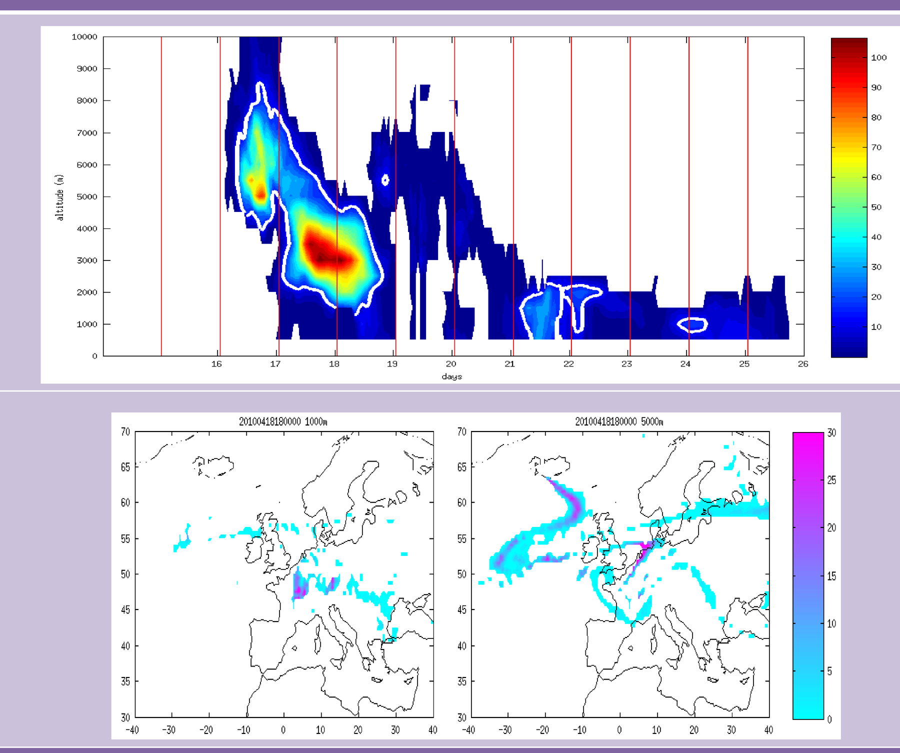
Chimere Eulerian Model:

- **Top panel: time slice above the SIRTA observatory of modelled tracer concentrations (colour shading, the 10µg contour is highlighted in white) and temporal evolution of the modelled PBL depth (black)**
- **Bottom panel : geographical extent of the plume on 20100418 at 18UT at the surface (left) and 5000m (right).**



Flexpart Lagrangian Model:

- **Top panel: time slice above the SIRTA observatory of modelled tracer concentrations (colour shading, the 10µg contour is highlighted in white)**
- **Bottom panel : geographical extent of the plume on 20100418 at 18UT at the surface (left) and 5000m (right).**



A number of features are captured similarly by both models even though they rely on very different modelling framework and distinct meteorological forcing:

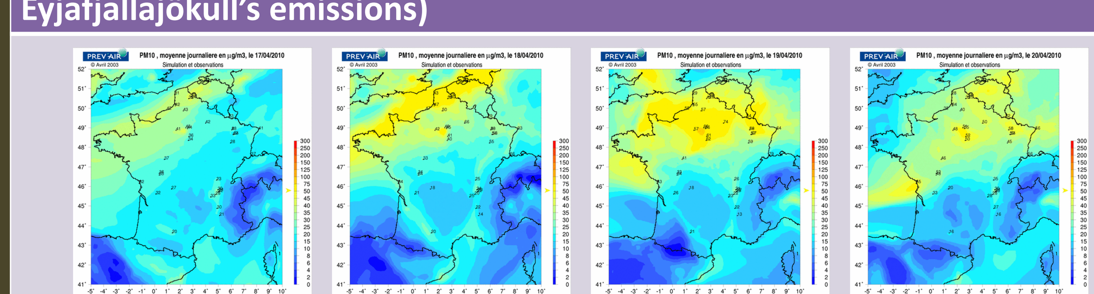
- A layer of tracers arrives above the observation site on the 16th and is injected into the planetary boundary layer on the 18th.
- This layer is much thicker than the feature labelled [1] on the lidar data. It could be related to the conjunction of layers [1] and [3] seen as a single event by the models
- Several features appear on both models in the vicinity of the PBL the following days and could be related to the series of layers labelled [2] on the lidar. These layers could also be related to a spurious effect of the lack of deposition in the models yielding a too weak decay of the tracer.
- The estimated concentrations at the surface are in-line with the order of magnitude derived from surface observations (right panel): 10~30µgm/3

Amongst the differences between the two models we can note that the higher vertical resolution in the Flexpart's results is inherent to the nature of the Lagrangian framework

Modelling the April 2010 nitrate pollution episode

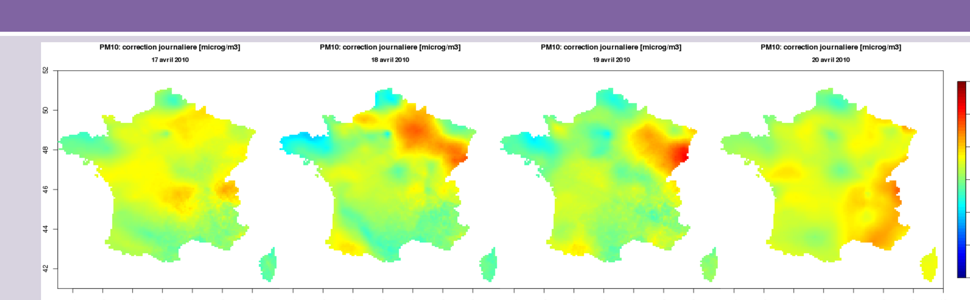
Ineris provides daily operation air quality over France based on the Prev'Air system (www.prevair.org) that includes the Chimere CTM (amongst others). For the period covering 18-20th April a classical springtime pollution episode was forecasted in Northern France independently from the occurrence of the Eyjafjallajökull 's eruption.

PM10 forecasts with the Prev'Air system (*not* accounting for the Eyjafjallajökull's emissions)



A PM10 pollution event was forecasted to occur on 18-19 April in Northern France as a result of a conjunction between an adverse meteorological context and spreading of nitrate-rich agricultural fertilizers leading to the formation of ammonium nitrate particulate matter.

Bias between forecasted and observed (krigged) PM10 concentration.

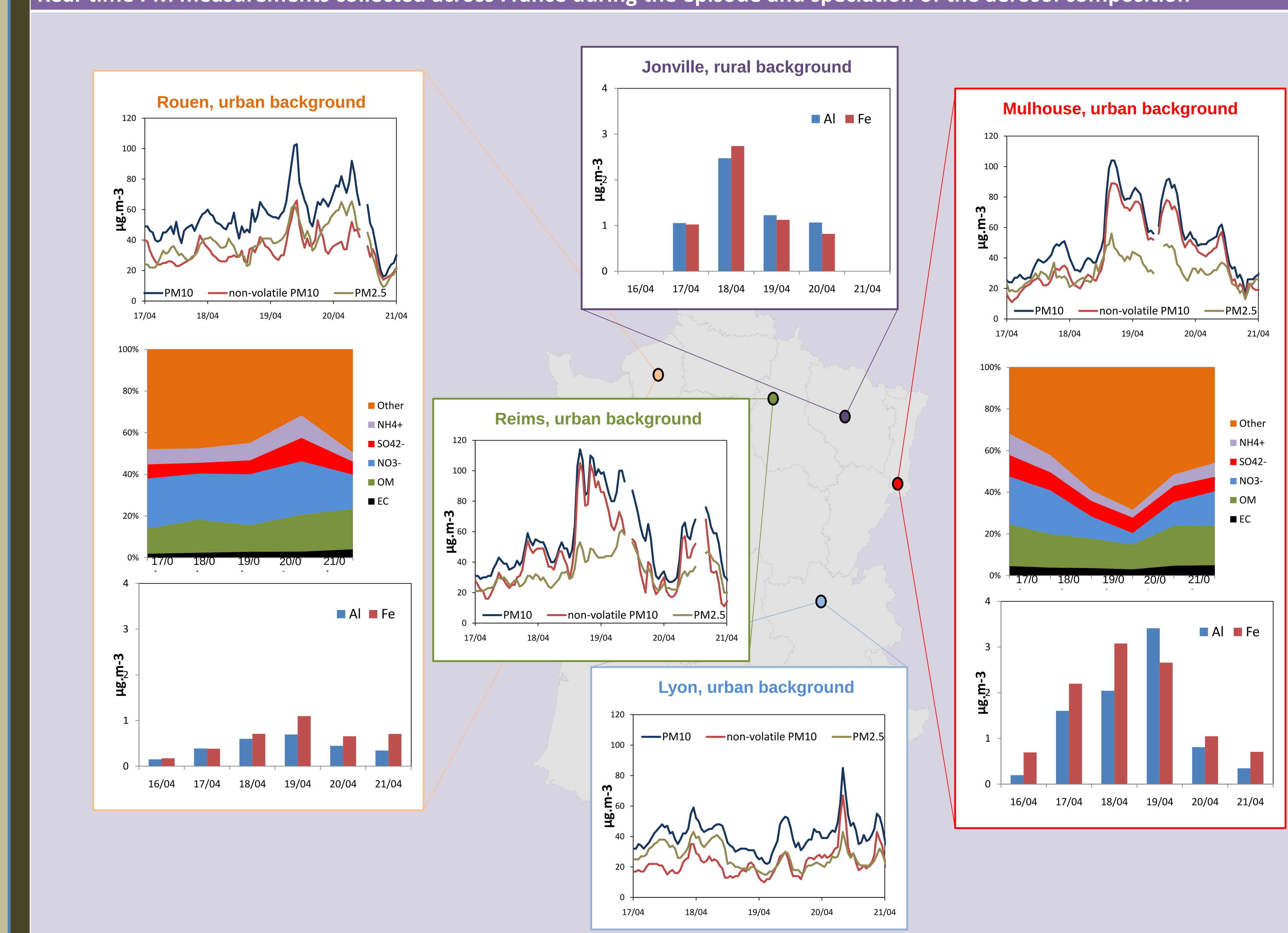


An unusual bias was found between the forecast and optimum interpolation of real-time observations in North-Eastern France on the 18th and 19th of April as a result of injection of the boundary layer of volcanic material that was not included in the forecast - neither in the boundary conditions nor in the emission inventory.

Surface Data

As part of the French reference laboratory for air quality monitoring (LCSQA), the INERIS has designed and implemented a comprehensive air quality assessment procedure (named CARA) since 2007. The aim of this procedure is to sample and analyse airborne particles at several background sites in order to investigate important aerosol sources and chemical processes, particularly during heavily polluted episodes. Owing to the anticipated impacts of the eruption on air quality, the emergency mode of the CARA procedure has been activated on April 16th 2010. Some preliminary results of on-going sample analyses are presented below.

Real-time PM measurements collected across France during the episode and speciation of the aerosol composition



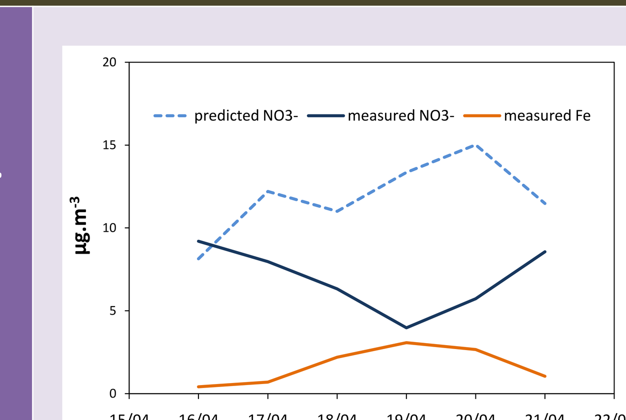
In a large part of France, real-time measurements showed an increase of PM10 concentrations during the April 18-19th episode, the main factor for this anomaly being related to anthropogenic sources (spreading of nitrate-rich fertilizers).

However a detailed investigation allowed for the identification of an unambiguous signal in the North-Eastern part of France that can be attributed to the volcanic ash plume:

- unusual non-volatile and coarse PM fractions
- dramatic increases of non-carbonaceous and insoluble materials
- significant levels of aluminium, iron and titanium in PM10.

The investigation of mineral dust constituents in Mulhouse suggests a contribution of volcanic emissions to total PM10 of about 30% the 19th of April.

Comparison: Observations versus Prev'air (CTM *not* accounting for the Eyjafjallajökull's emissions).



It is worth noting that the presence of volcanic emissions seems to disfavour the formation of NH_4NO_3, whereas the model forecasted a classical PM10 pollution episode for this period with an increase of Nitrates. Hypotheses for this phenomenon include the scavenging of gaseous precursors by mineral aerosols, as well as the photo-sensitized uptake of NO_x, e.g. onto titanium and iron oxides.

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