Reconstruction of flux and altitude of volcanic SO_2 emissions from IASI satellite observations: implications for volcanological and atmospherical studies

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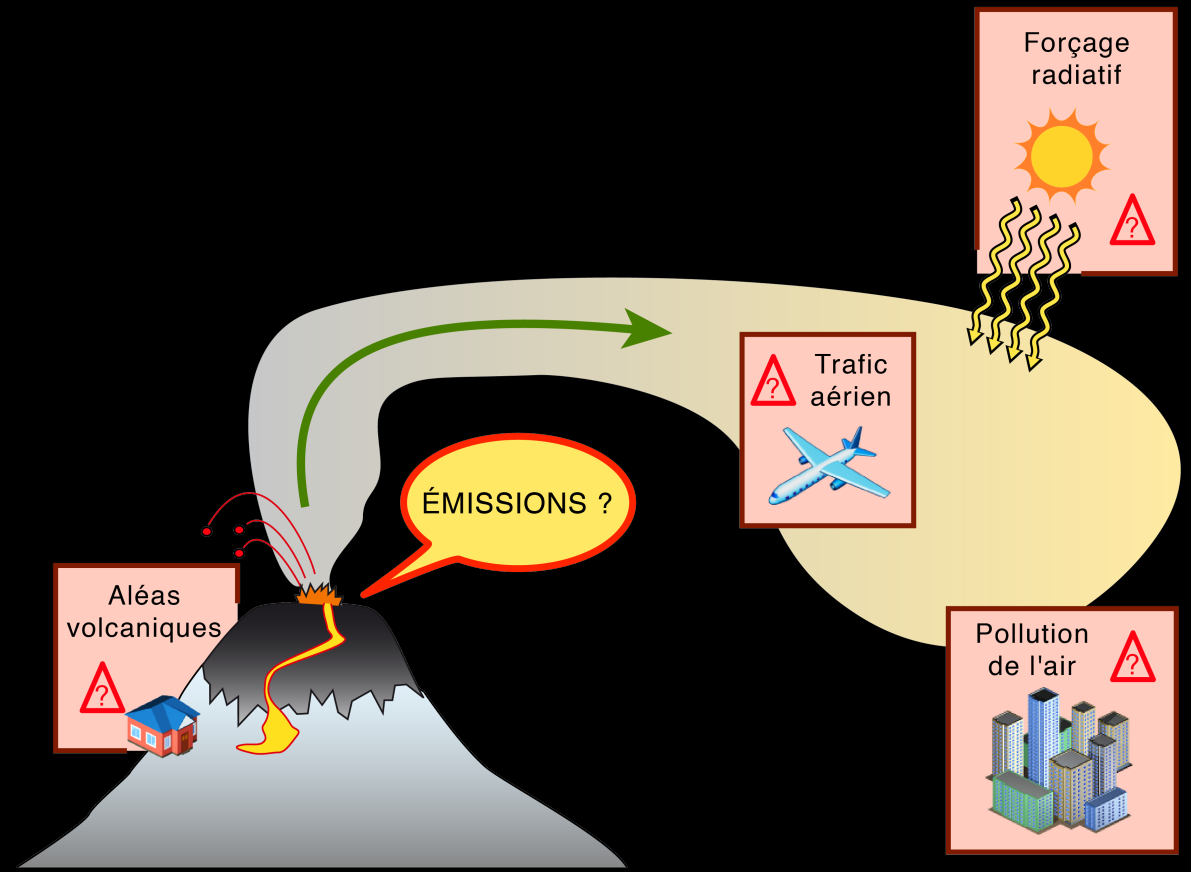
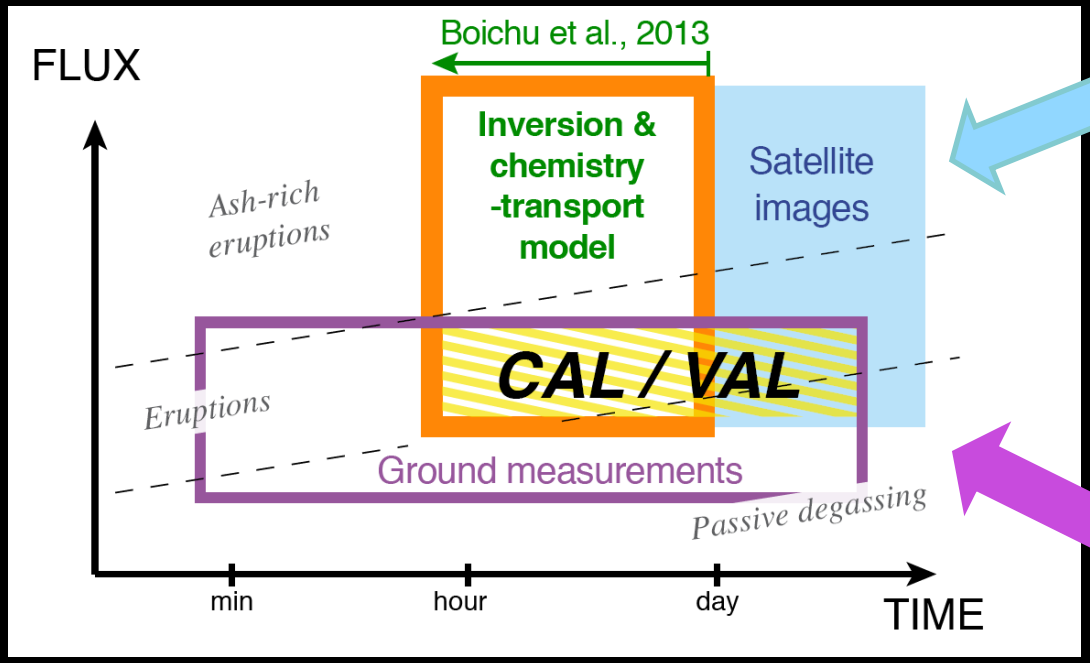


1 – Flux of SO_2 emissions

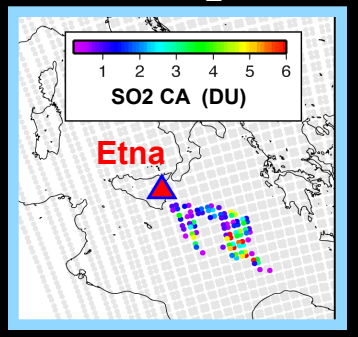
2 – Altitude of SO_2 emissions

IASI conference, April 2016

Presently, what do we know about volcanic SO_2 flux emissions ?



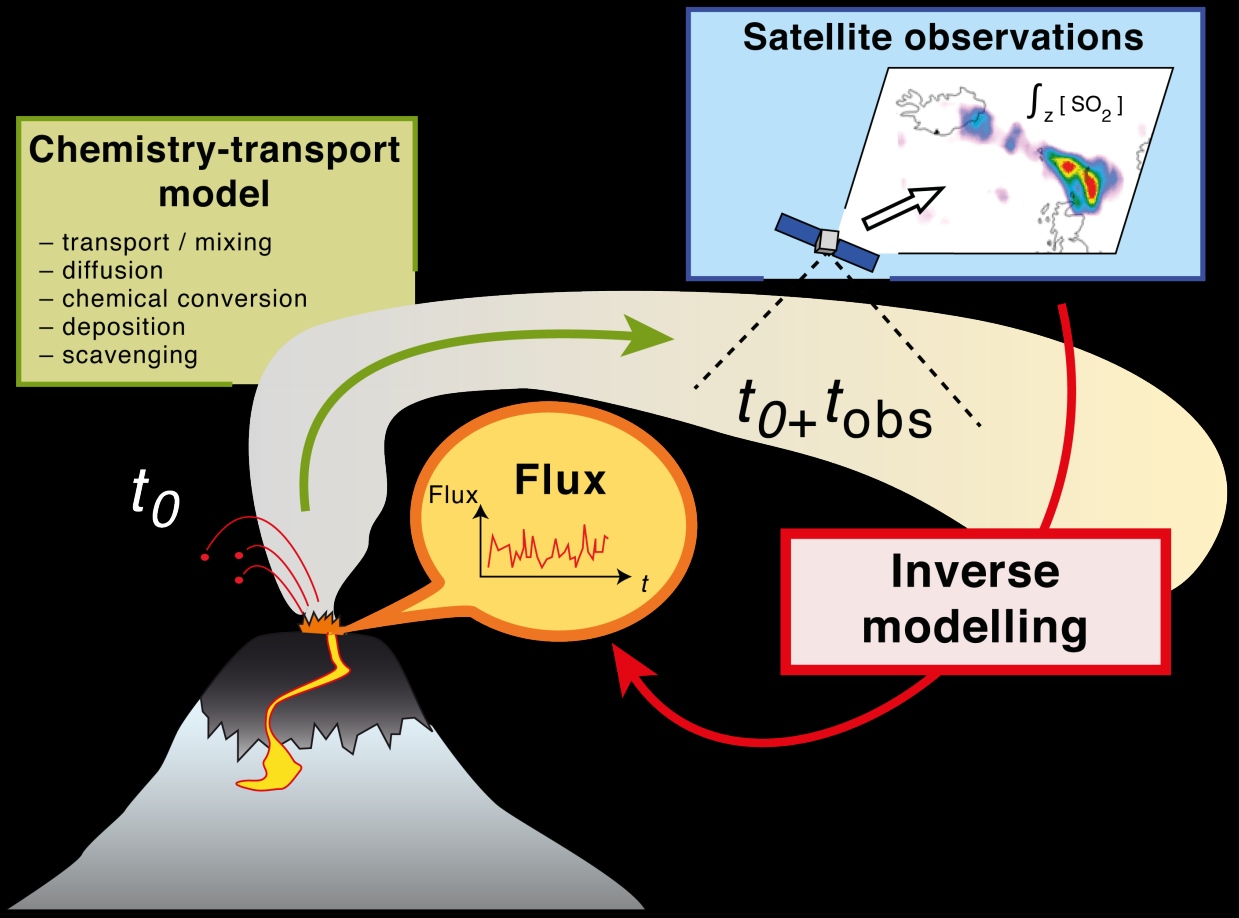
IASI SO_2 load



Every ~ 12 hours

Ground-network of UV-DOAS scanning spectrometers (Etna)

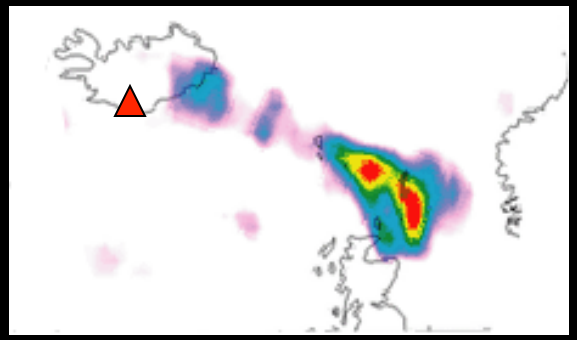
How to characterise volcanic gas emissions at high temporal resolution from satellite imagery?



Boichu et al., ACP, 2013
Boichu et al., GRL, 2014

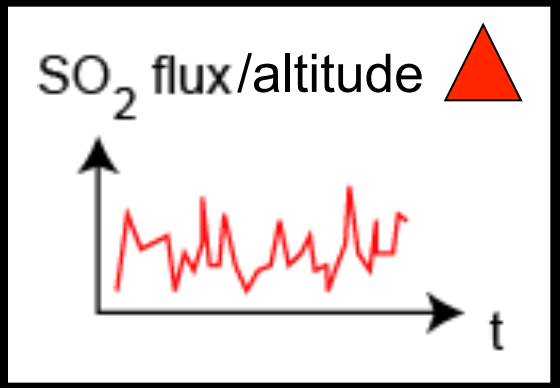
Reconstructing volcanic emissions by inverse modelling

d = G m



d for data

Needs a description of :
- Transport/mixing
- Diffusion
- Deposition
- Wet scavenging
- Chemistry…



m for model

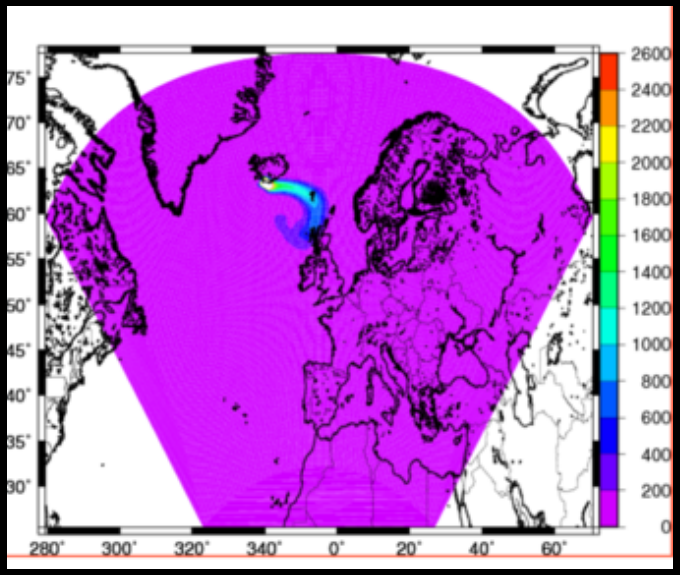
… from the volcano to the observation point !

Forward model:	$d = G\ m$
Inverse problem:	$m^* = G^{-g}\ d$
A posteriori prediction:	$d^* = G\ m^*$

Inverse modelling
combining SO_2 spaceborne imagery with chemistry-transport modelling

G: CHIMERE regional chemistry-transport model

- Eulerian model
- Grid: dx = dy = 20 km horizontal resolution
- 29 vertical layers up to 150 hPa (~ 14 km)
- Forced with WRF meteorological fields

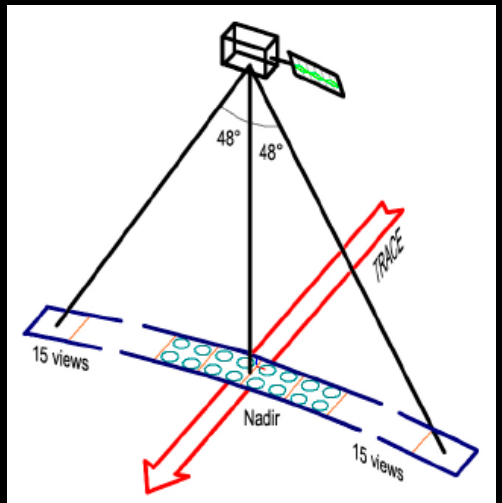


d: IASI (Infrared Atmospheric Sounding Interferometer)

- Abord the polar-orbiting MetOp-A
- Infrared (645 cm−1 to 2760 cm −1)

⇒ 2 overpasses per day at Equator (9h30; 21h30 LT)

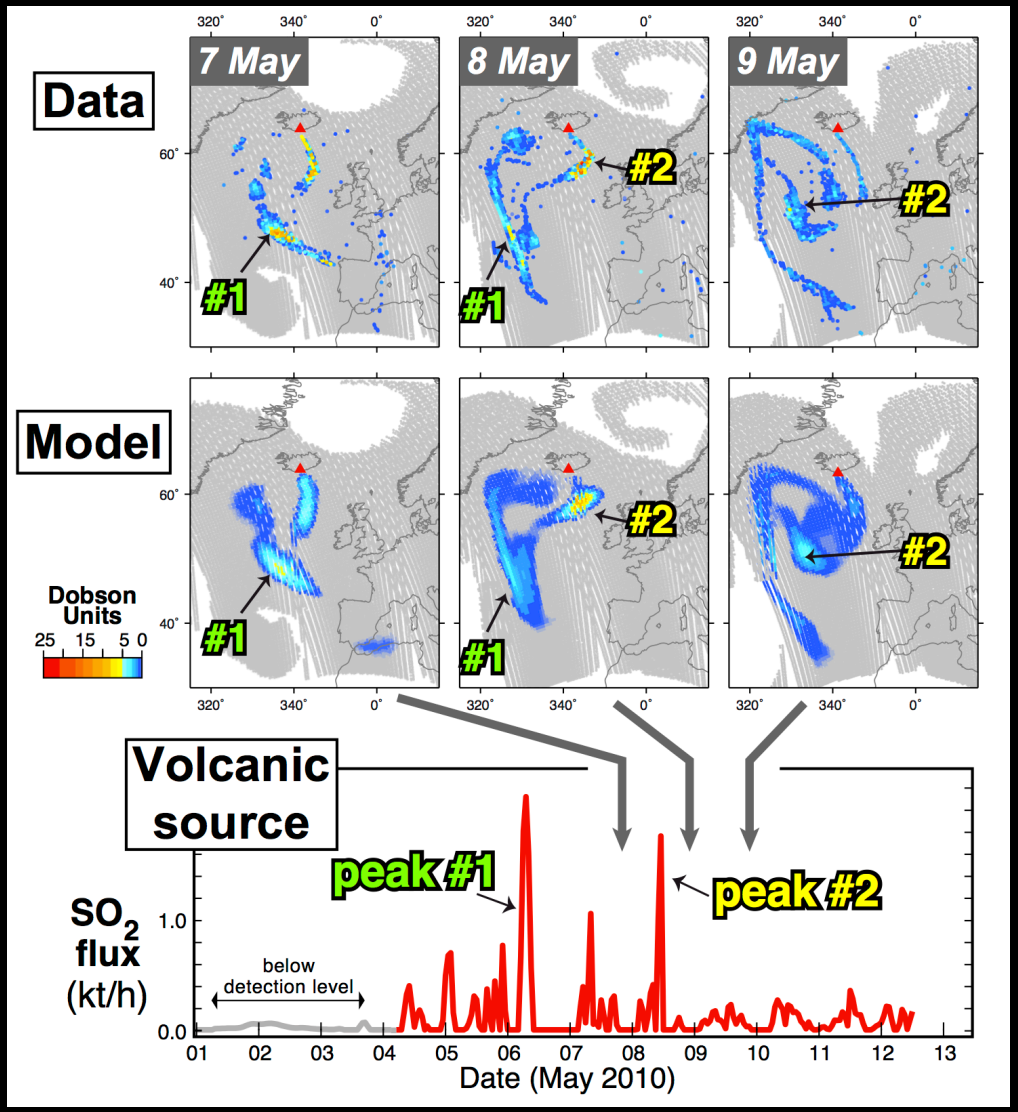
- Spatial resolution : (12 km x 12 km) pixel at nadir



Clerbaux et al., 09

Reconstruction of volcanic SO_2 flux emissions at high temporal resolution

Eyjafjallajökull 2010



IASI SO_2

WRF/CHIMERE SO_2

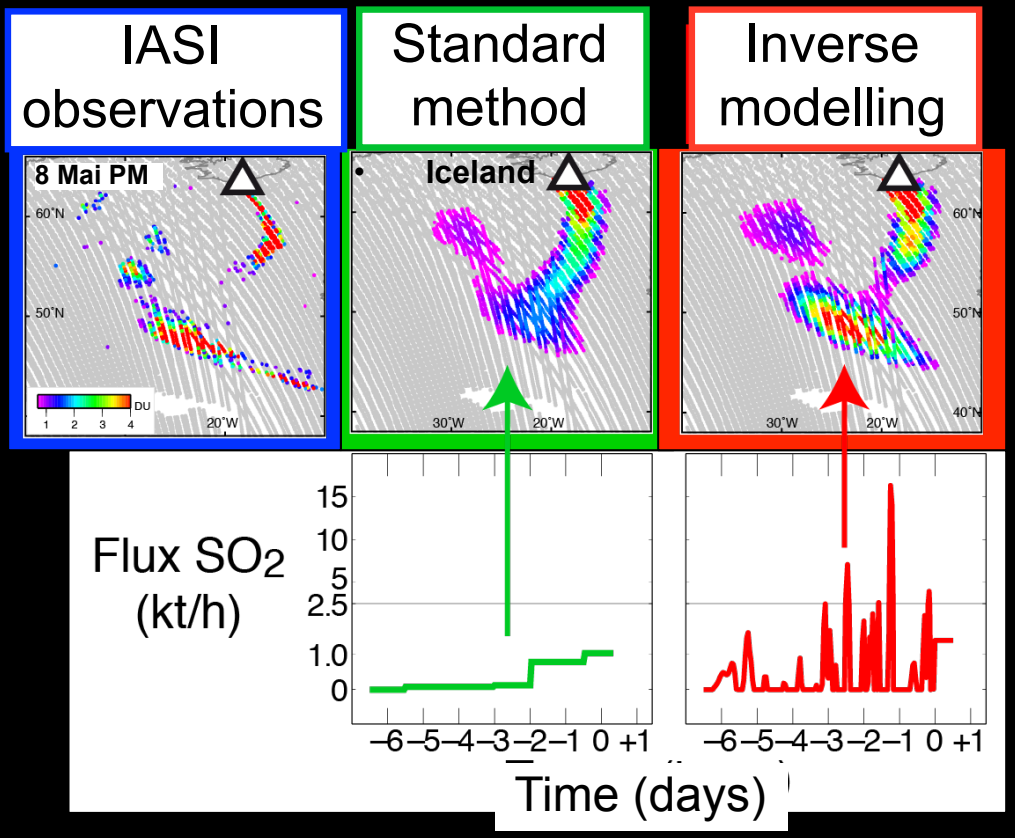
Inverse modelling

Boichu et al., ACP, 2013; GRL, 2014

Forecast of the SO_2 cloud dispersal

Eyjafjallajökull 2010

Forecast at + 12h

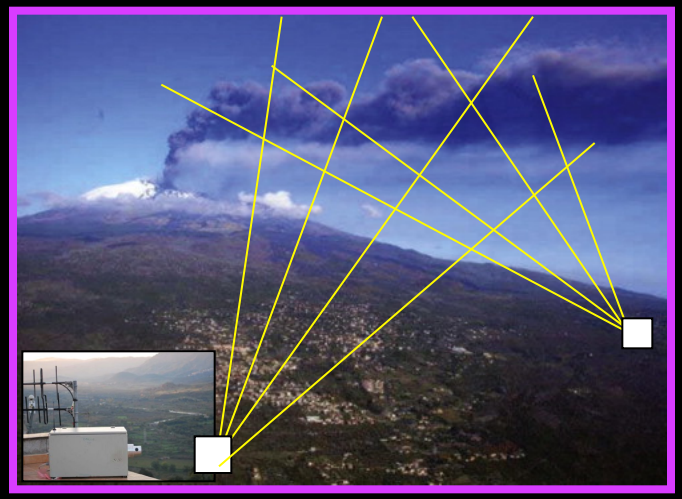


Boichu et al., GRL, 2014

WRF/CHIMERE chemistry-transport model

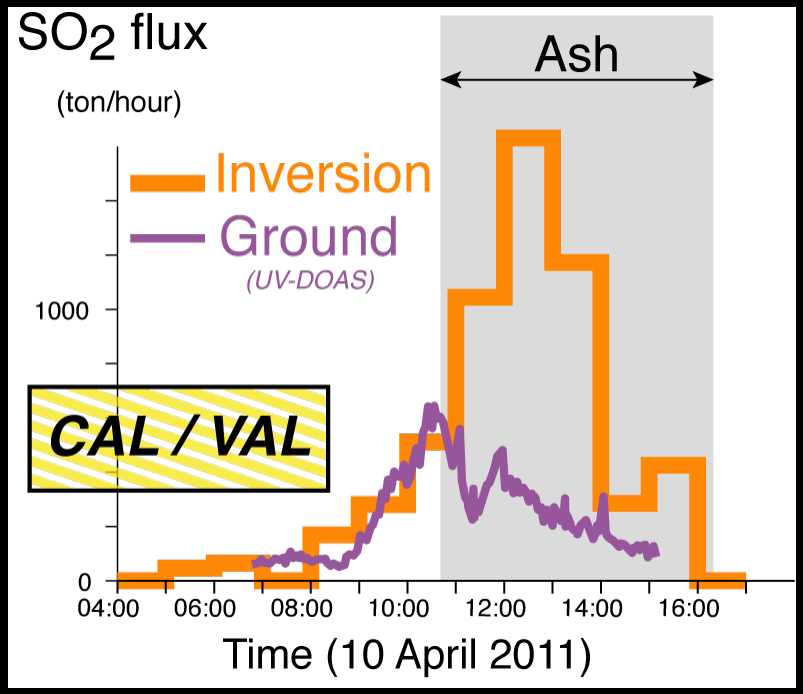
Calibration/Validation with ground UV observations

Ground-network of 9 UV-DOAS scanning spectrometers

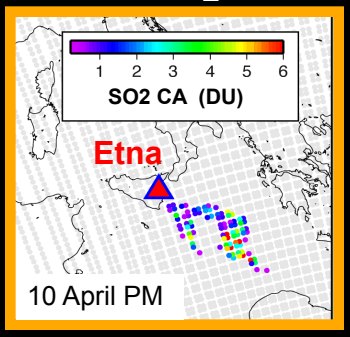


Salerno et al., 2008

Etna, April 2011



IASI SO_2 load



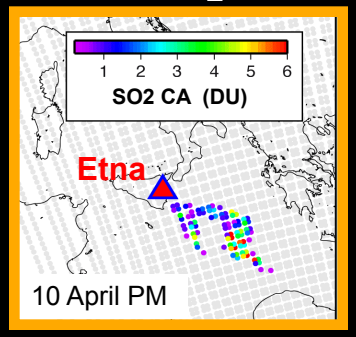
Boichu et al., ACP 2015

Volcano monitoring: precautions to take in the interpretation of ground-based UV-observations for hazard assessment

Atmosphere: Re-assessment of the global budget of volcanic emissions (SO_2, CO_2, H_2S, HCl, HF, etc…) ?

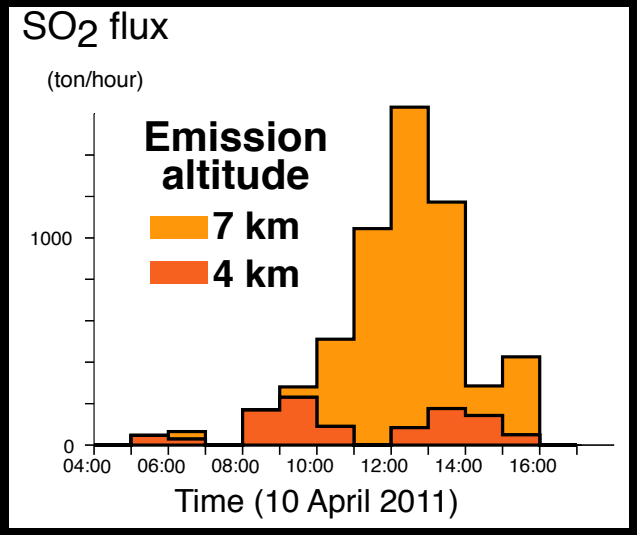
Reconstructing the altitude of SO_2 emissions under wind shear conditions

IASI SO_2 load



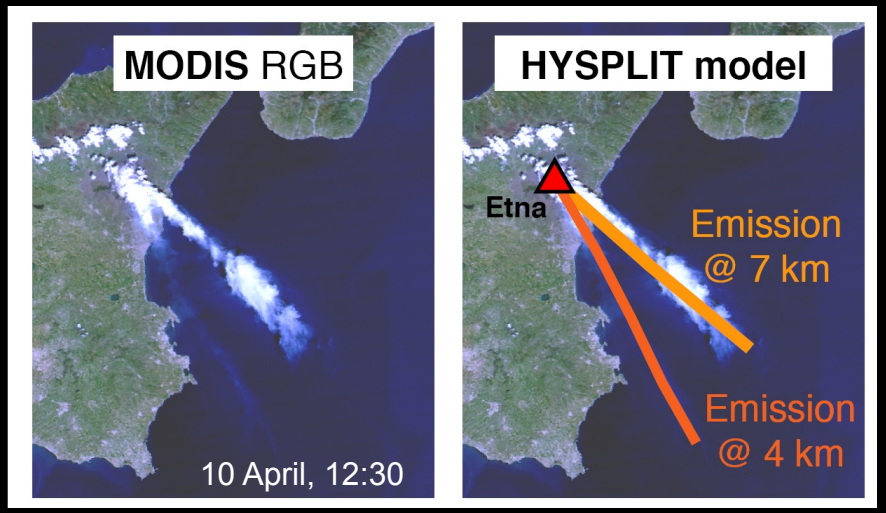
Inversion

Wind shear prerequisite



Direct model

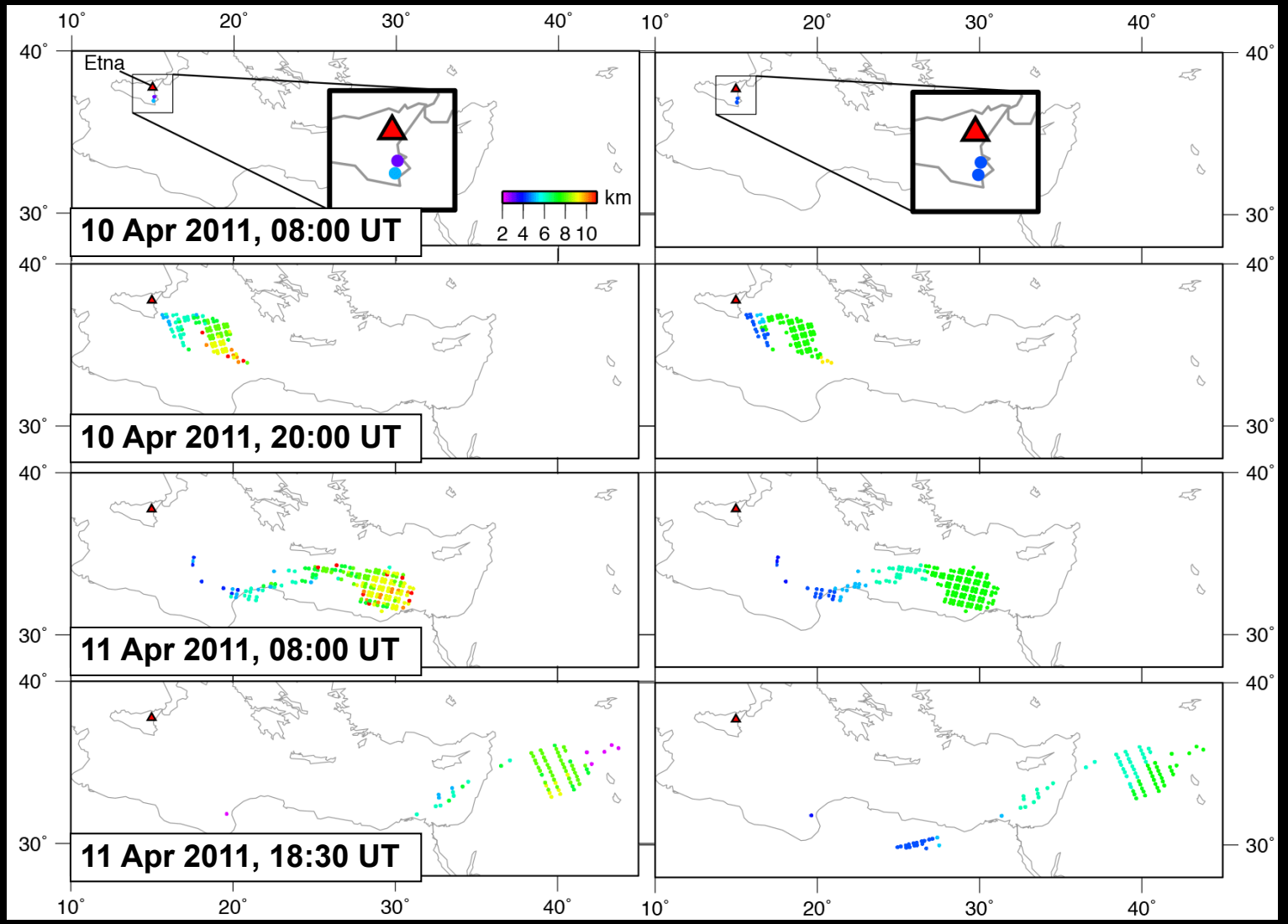
Etna 2011



Boichu et al., ACP, 2015

High variability of far-range altitude of SO_2

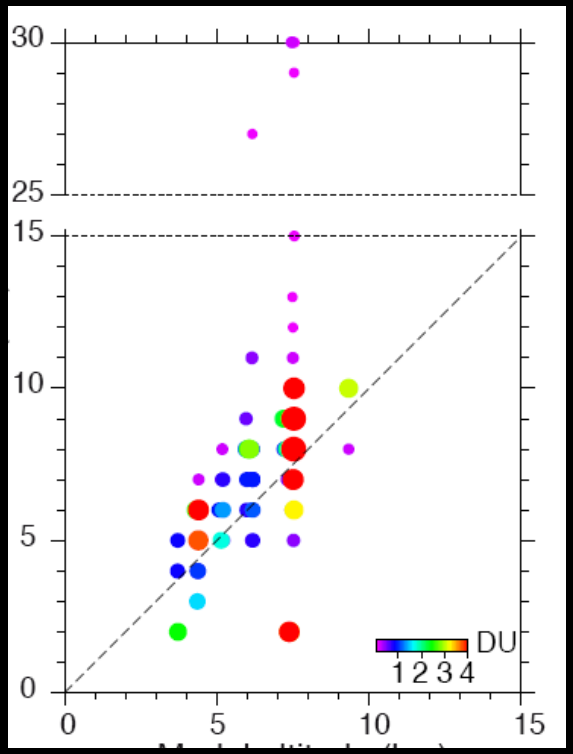
Etna 2011



Boichu et al., ACP, 2015

Toward the assimilation of IASI SO_2 altitude

IASI SO_2 altitude (km)



Modelled SO_2 altitude (km)

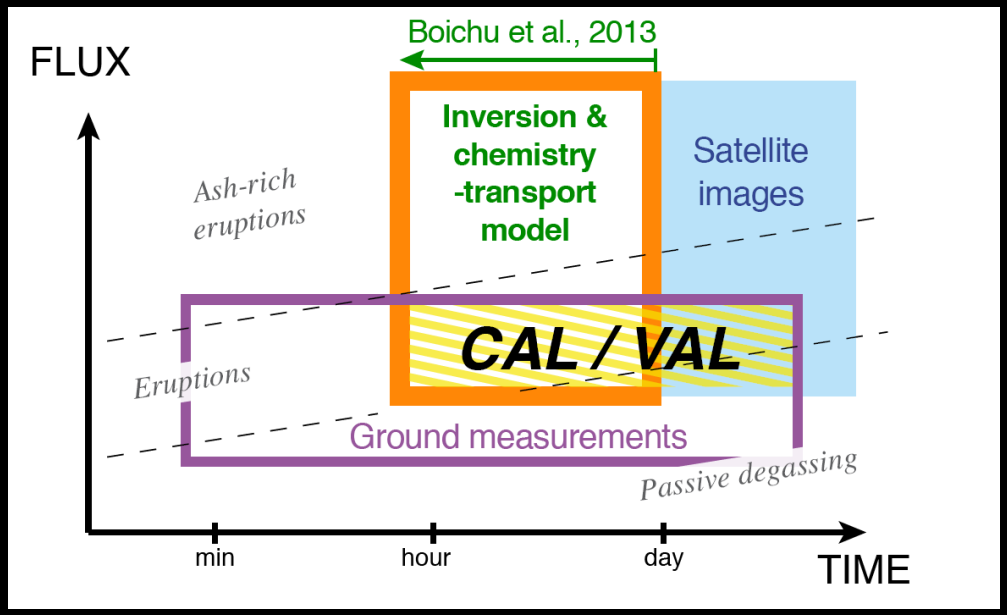
Boichu et al., ACP, 2015

Next step:
Assimilation of IASI SO_2 altitude to reconstruct the altitude of SO_2 emissions
In any meteorological conditions (no more wind shear pre-requisite)

Conclusions regarding SO_2 emissions

1- FLUX:

Tools at hand to describe the whole range of volcanic SO_2 degassing behaviours with a high temporal resolution
(ground/satellite synergy is possible using inverse modelling schemes)



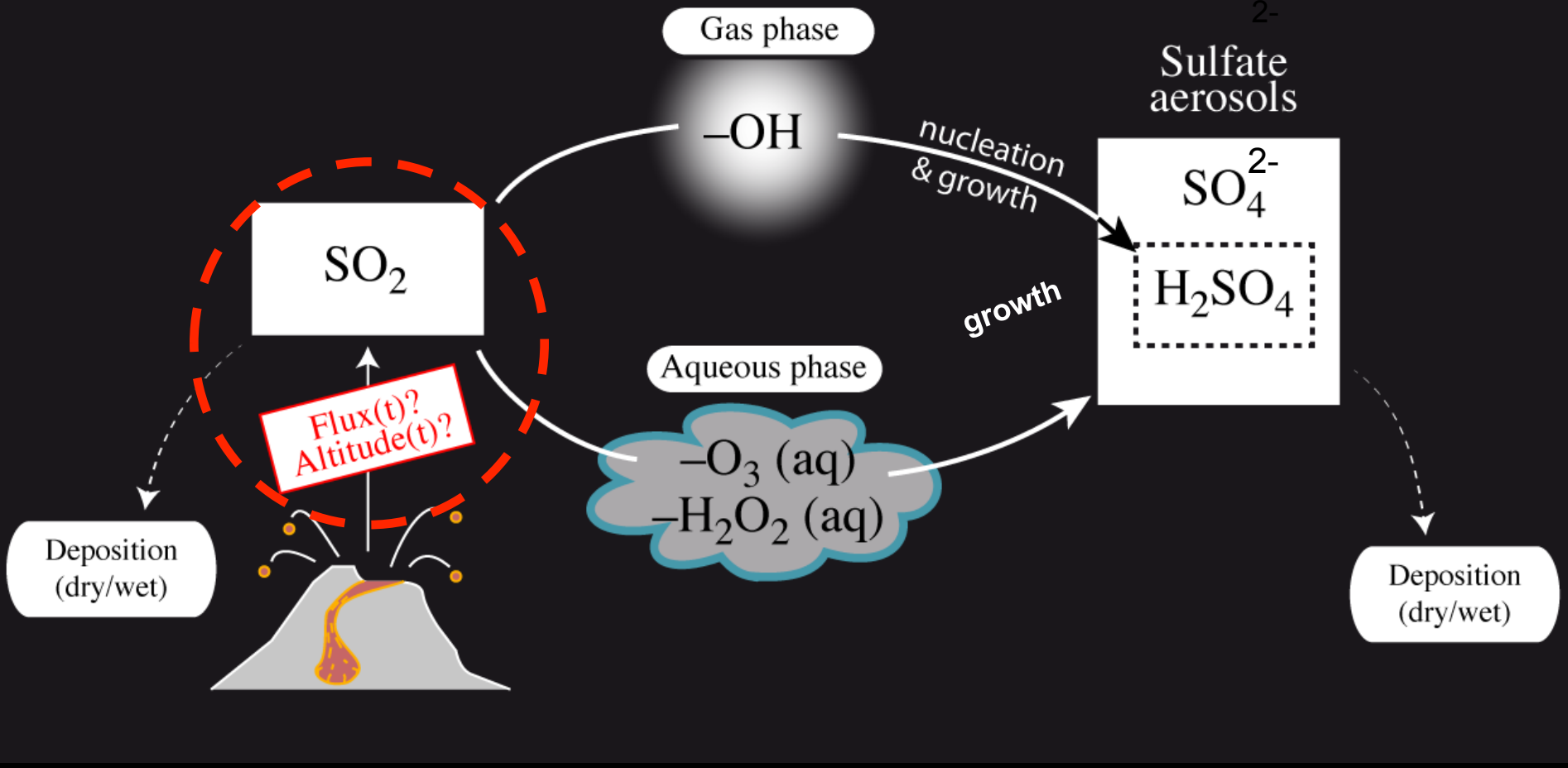
2- ALTITUDE of INJECTION:

Reconstruction of the altitude of SO_2 emissions by inverse modelling under wind shear conditions, but soon in any meteorological conditions!
(thanks to the assimilation of recently-developed IASI SO2 altitude products)

Perspective: formation and lifecycle of sulfate aerosols

High temporal variability of volcanic SO_2 emissions (flux and altitude): toward a better modelling of sulfate aerosol production and lifecycle

=> impact of volcanism on climate and air quality

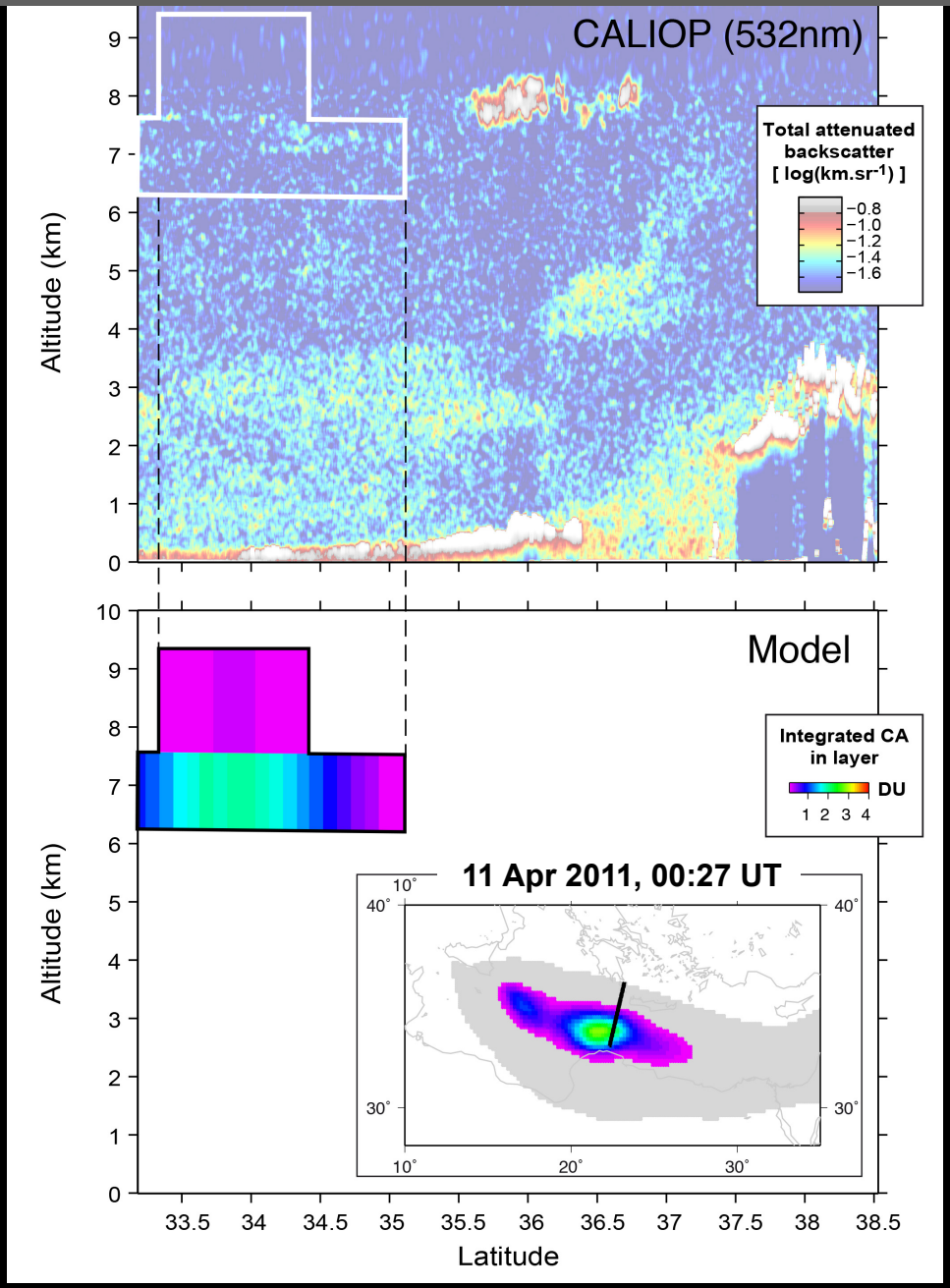


Remote sensing of volcanic sulfate aerosols using spaceborne LIDAR observations

Etna 2011

CALIOP lidar

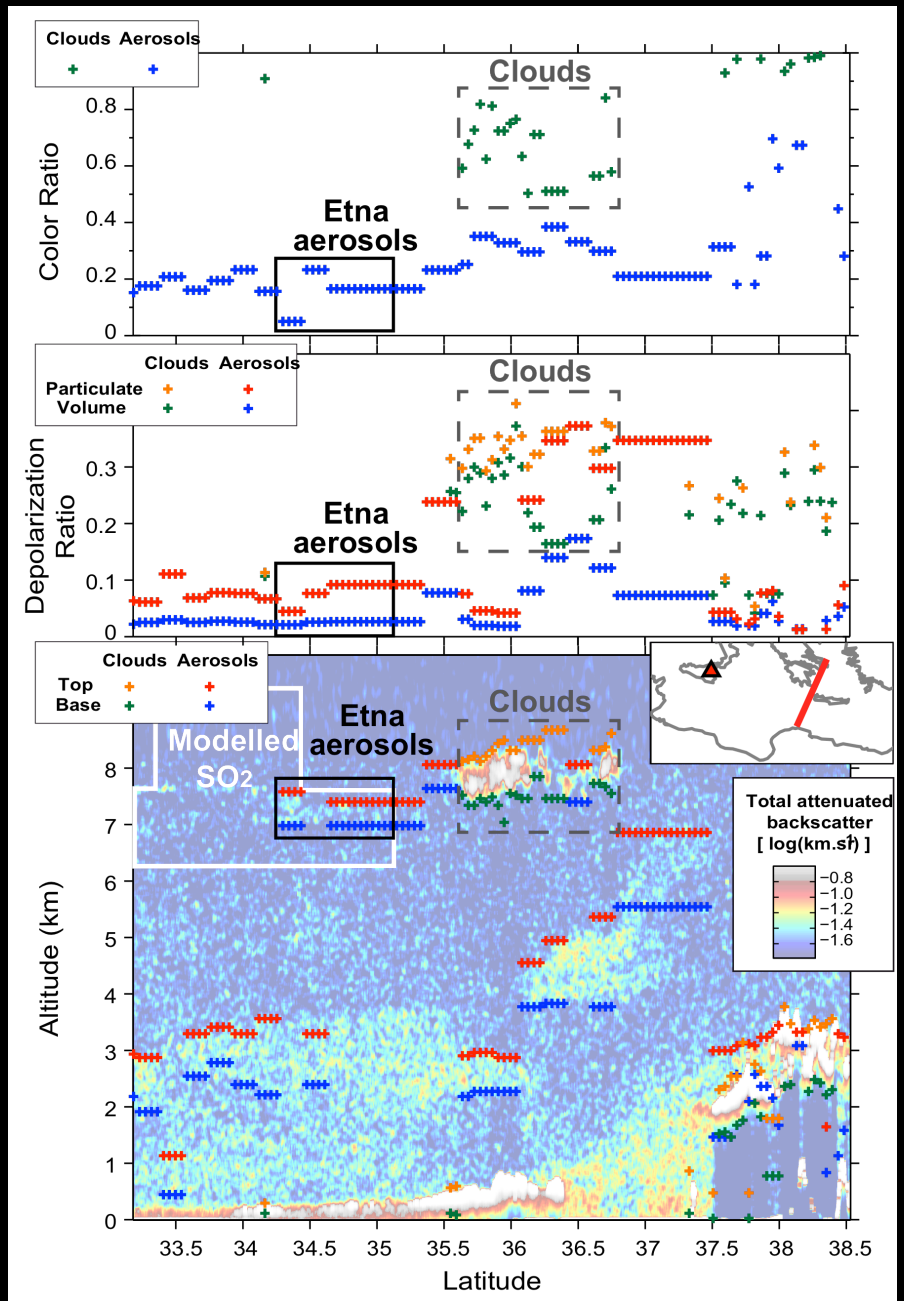
Modelled SO2 using WRF/CHIMERE chemistry-transport model initialised with reconstructed emissions



Boichu et al., ACP, 2015

Coexistence of tropospheric SO_2 and sulfate aerosols

CALIOP lidar

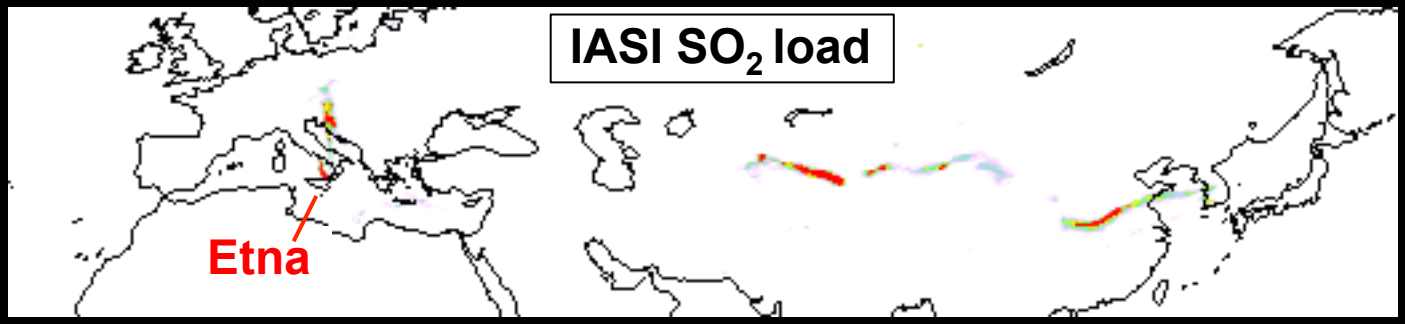


Color ratio

Depolarisation ratio

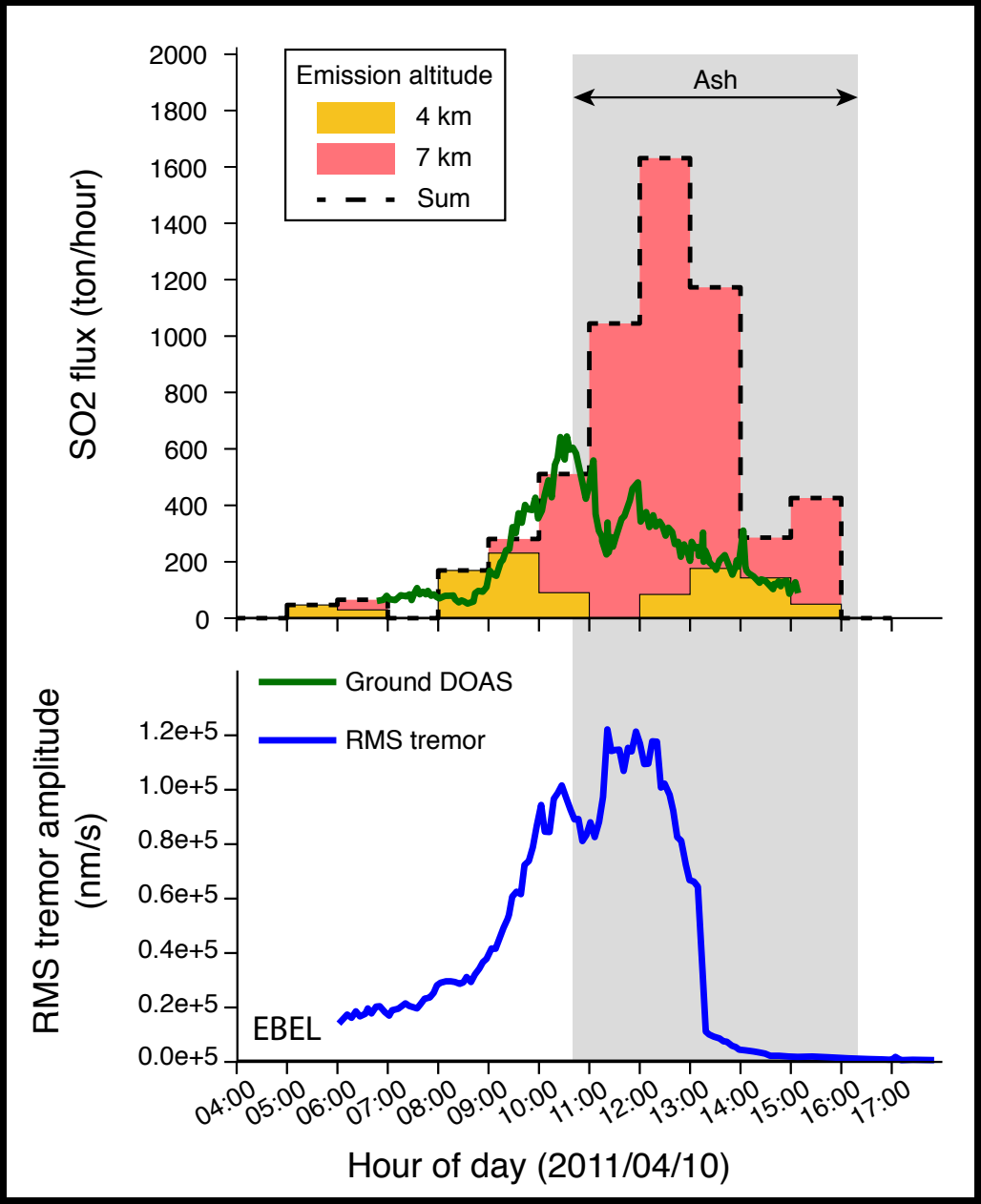
Total attenuated backscatter signal

Boichu et al., ACP, 2015



Major eruption of Mt. Etna, December 2015

Thank you for your attention



Boichu et al.,
ACP 2015