FALL3D:
An Eulerian model for transport and deposition of volcanic ash

Antonio Costa[1], Arnau Folch[2] and Giovanni Macedonio[1]

(1) Istituto Nazionale di Geofisica e Vulcanologia (INGV), Napoli, Italy.
(2) Barcelona Supercomputing Center (BSC-CNS), Barcelona, Spain.

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FALL3D: Model Overview

A model for **atmospheric transport** of particles and gases.

Based on an **Eulerian** approach.

The model solves the advection–diffusion–sedimentation (**ADS**) equation on a structured terrain-following grid using a second-order **FD** explicit scheme.

Different parameterizations for each term of the ADS equation are possible:

- Vertical and horizontal diffusion.
- Terminal settling velocity models.
- Dry deposition mechanism (needed for the finest granulometric components only).
- It incorporates a model for **wet aggregation** of fine ash.
- Magmatic water is transported in the plume.

Multipurpose model:

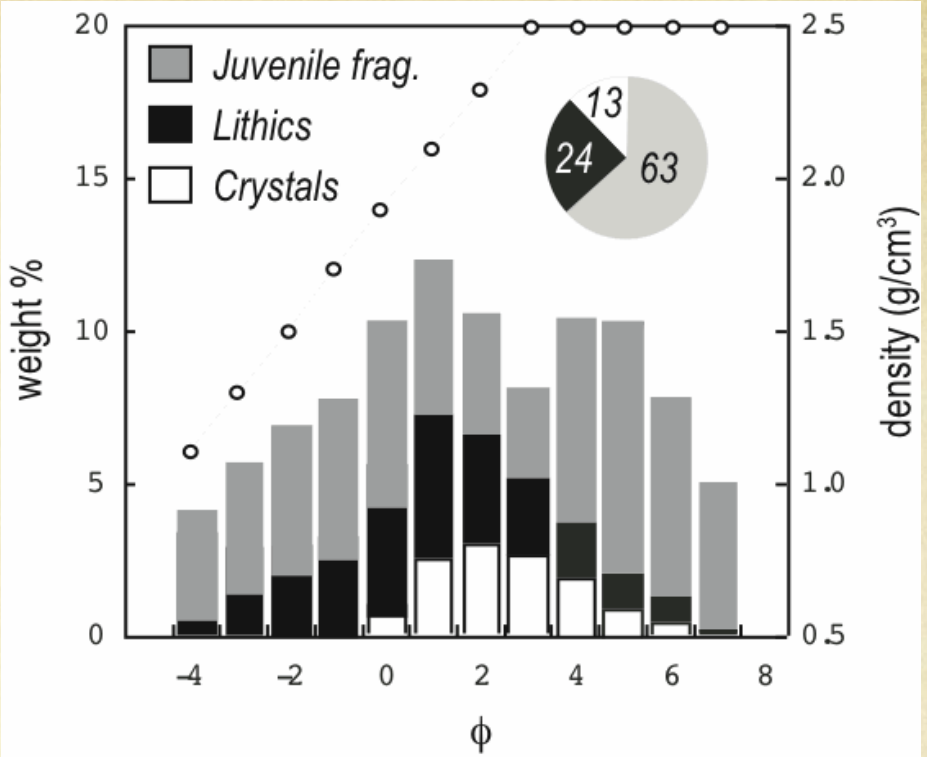
- It computes the **deposit** (ash fallout forecasting, elaboration of hazard maps, etc).
- It computes **airborne concentration** (ash cloud tracking and quantification).
- It can be used to **forecast** or to **study past events (analysis)**.

FALL3D: Model Overview

It handles **multiple classes** of particles

A particle class (bin) is characterized by

- **Size**
- **Density**
- **Shape factor**



d(mm)=2$^{-\Phi}$

Aggregates

Remote Sensing

Φ	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
d	16 mm	8 mm	4 mm	2 mm	1 mm	0.5 mm	250 μm	125 μm	64 μm	32 μm	16 μm	8 μm	4 μm

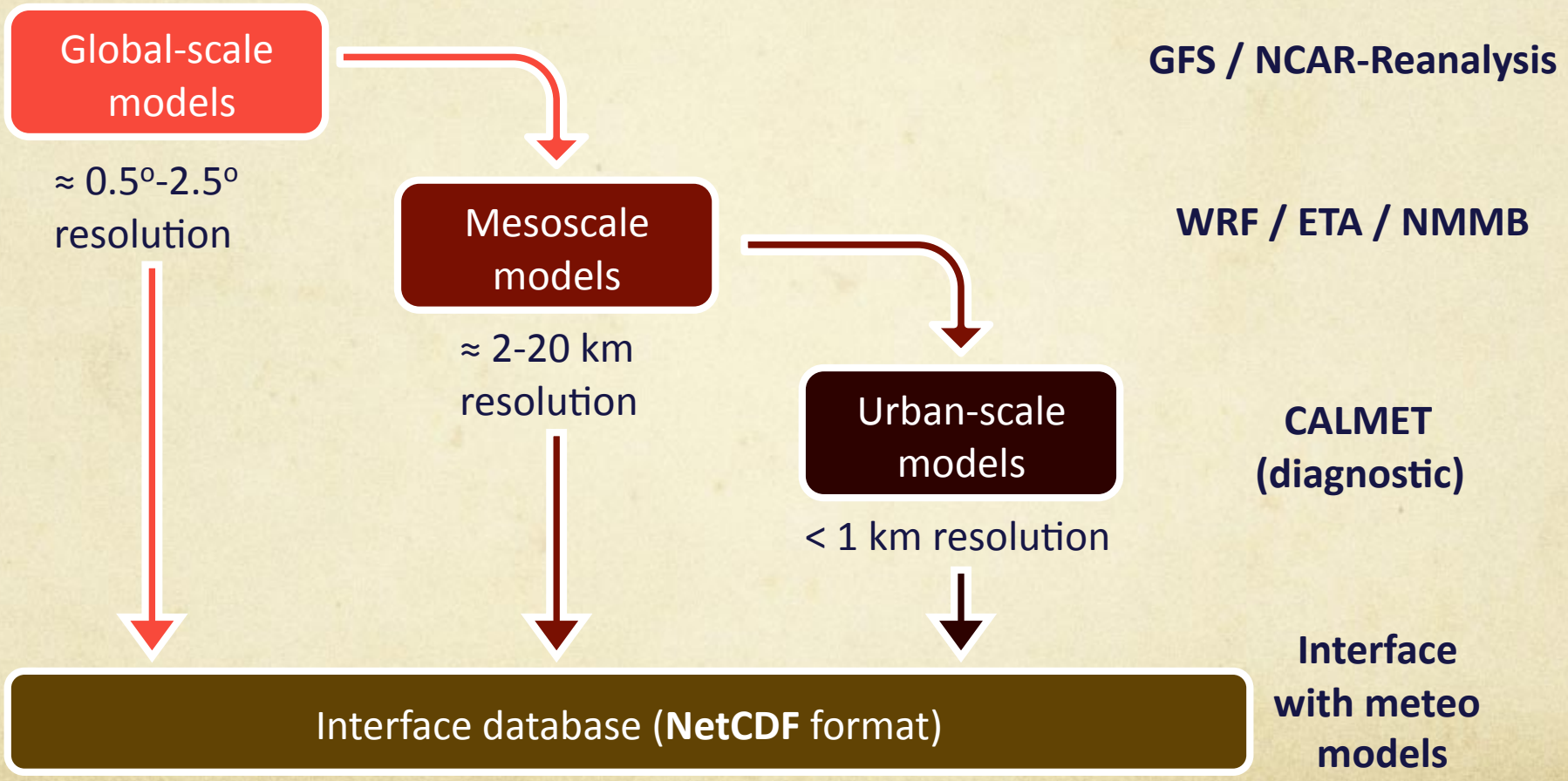
Lapilli
10s km

Coarse ash
100s km

Fine ash
1000s km

FALL3D: Model Overview

Multiscale model: it can run at scales from **synoptic** (≈1000s km) to **very local** (≈few km) following an *off-line* strategy with prognostic or diagnostic meteorological models.



FALL3D: Model Overview

Model inputs:

1. Vent location
2. Meteorological data (wind field, temperature, mixing ratio, etc)
3. Volcanological input (**source term**)
    - Column Height
    - Vertical distribution of mass
    - Total MER
    - Granulometry (i.e. MER for each bin)

Source term is difficult to be assessed, especially on real-time:

- It can be estimated using the Buoyant Plume Theory or empirical parameterizations.
- Pulsating columns are a serious “problem”.
- A key aspect for simulations is the “**mass issue**”. Important considerations:
    * Mass Eruption Rate (MER) versus column height.
    * Granulometric mass fraction. How does the total mass distribute among bins?
    * For long-range modelling, which is the fraction of fine ash?

FALL3D: Model Overview

Download and further information: www.bsc.es/projects/earthscience/fall3d/
http://datasim.ov.ingv.it/Fall3d.html

Currently, there are two code versions: **Public** (PUB) and **Professional** (PROF).

PUB version:

- General distribution and open source.
- **Serial code** version only.
- Limited pre and post-process functionalities.

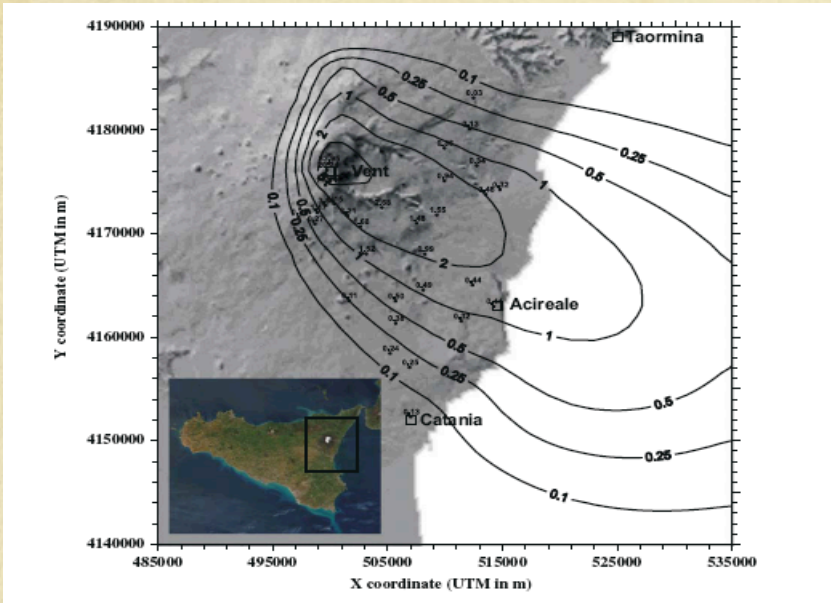
PROF version:

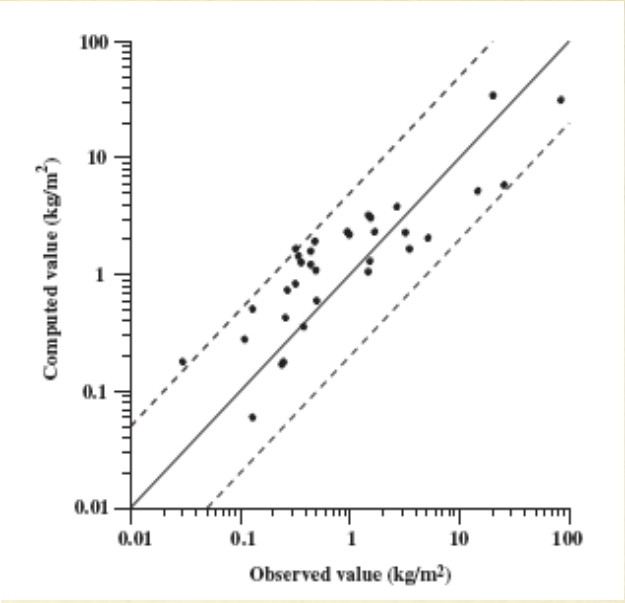
- **Serial and parallel** code versions.
- Available only via research project of memorandum of understanding with BSC.

Some **PROF users**:

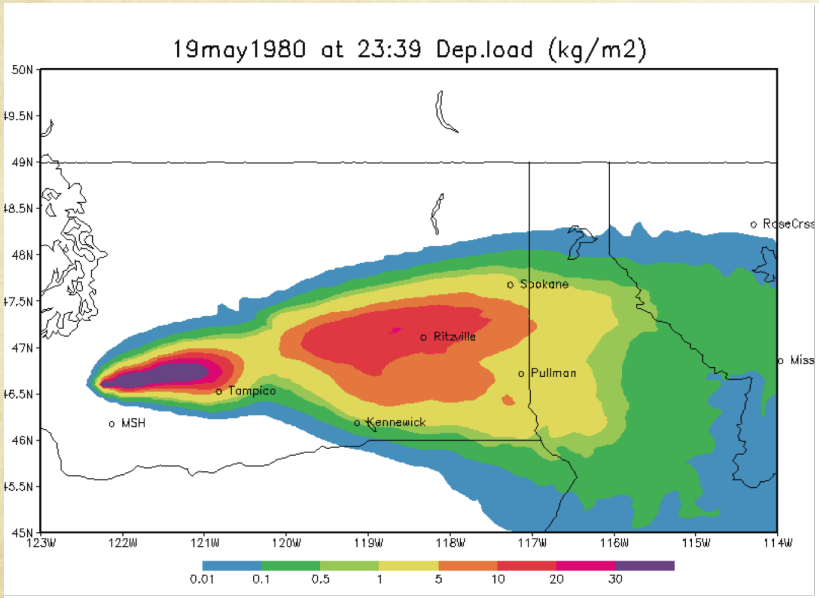
- INGV (Italy).
- Buenos Aires VAAC (Argentina).
- CORPAIRE. Quito municipality agency for air quality (Ecuador).
- Instituto Geográfico Nacional (Spain).
- Australia Geoscience (Australia), at AIFDR (for Indonesia and Philippines).

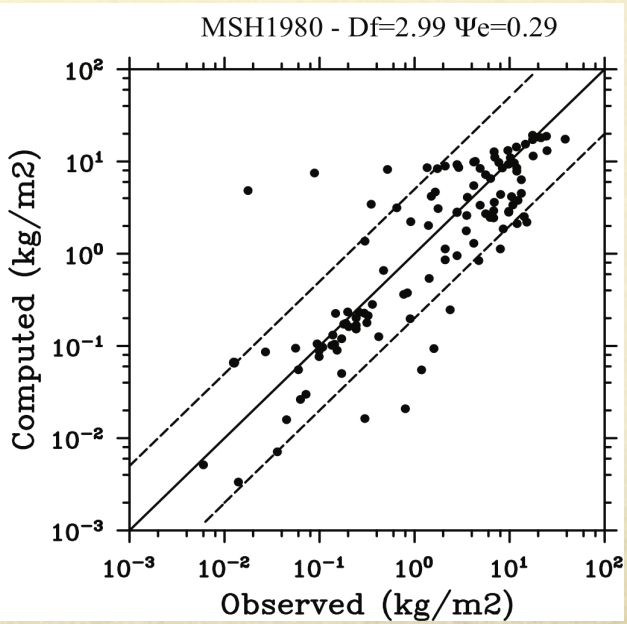
FALL3D: Model Validation vs Observed Tephra Deposits





Etna 1998
(short scale)



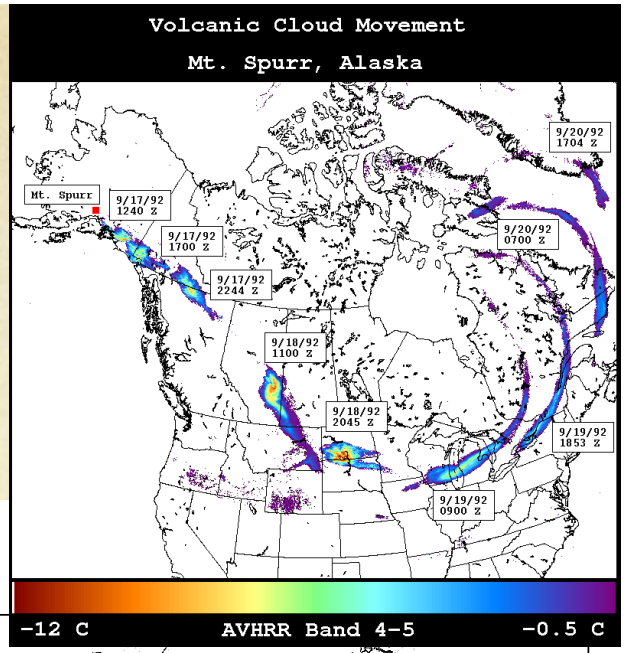


MSH 1980
(large scale)

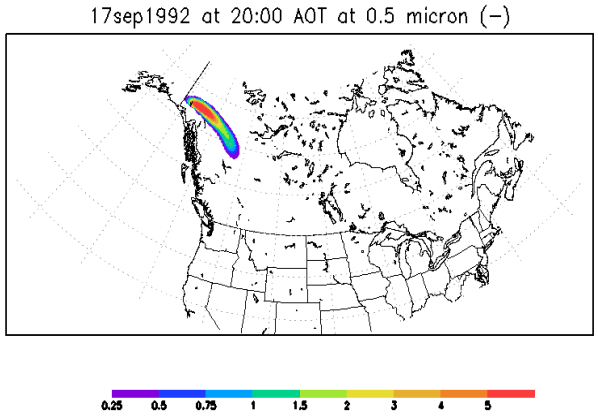
FALL3D: Validation vs Plume Observations

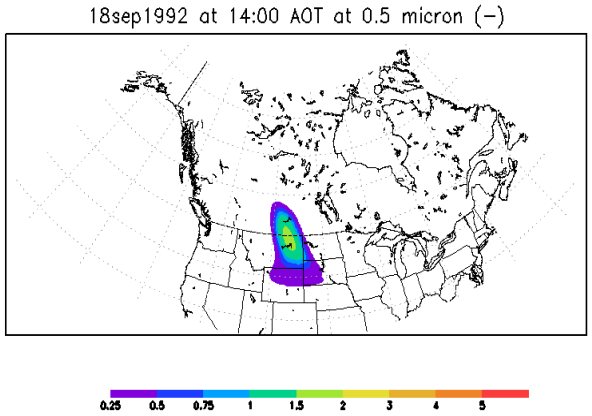
Example: Tracking and quantification of ash clouds

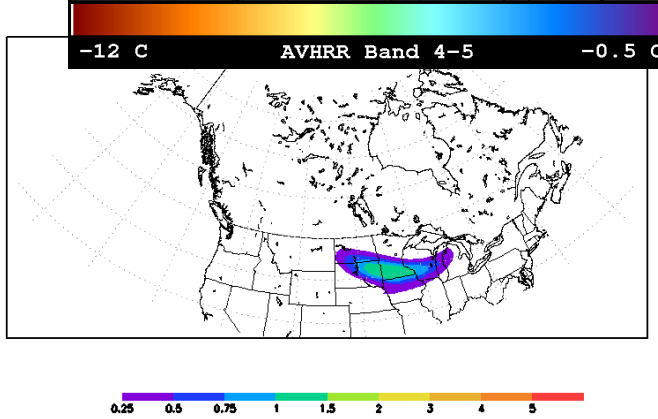
- Cloud trajectory.
- Cloud concentration.
- Cloud mass and AOD.

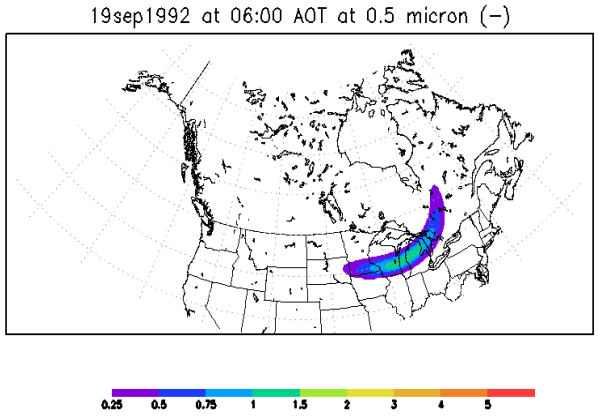


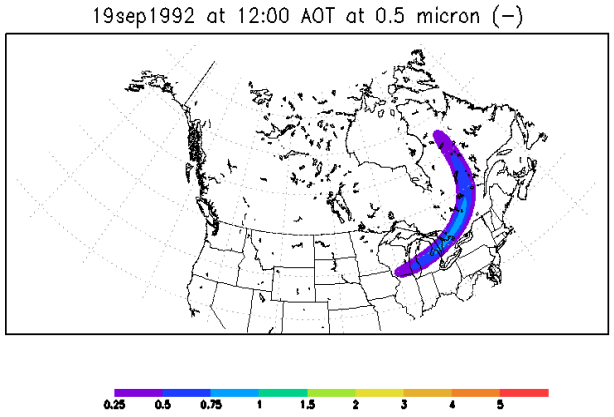
Mt. Spurr SET 1992 ash cloud: BTD versus FALL3D AOD

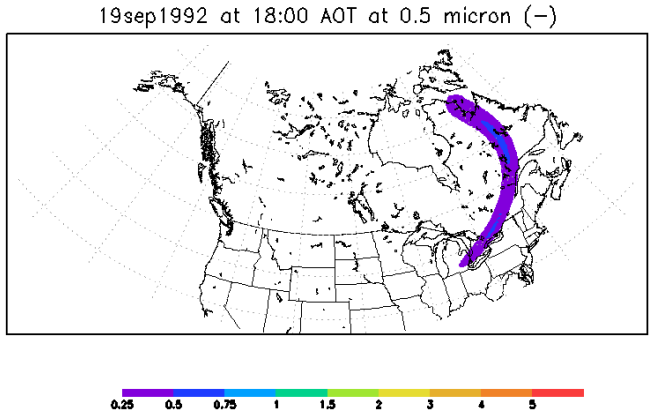












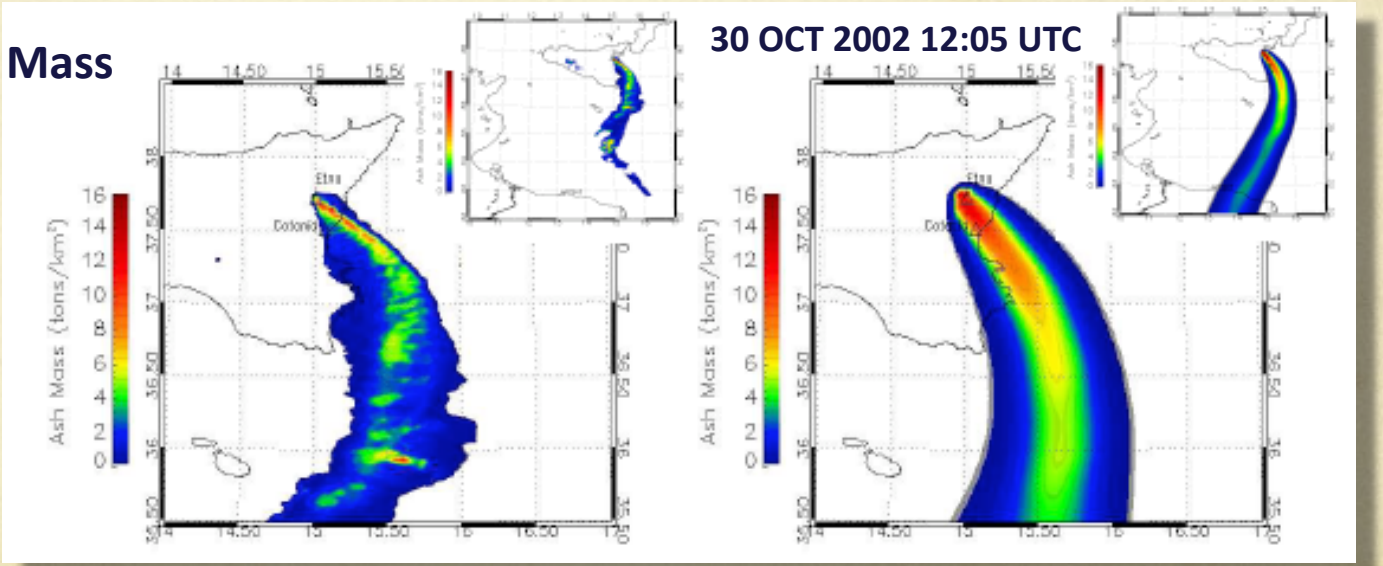
FALL3D: Validation vs Plume Observations

3D comparison FALL3D/MISR

Scollo S., A. Folch, M. Coltelli, V.J. Realmuto (2010).3D Volcanic aerosol dispersal: a comparison between MISR data and numerical simulations, J. Geophys. Res.

Quantitative comparison FALL3D/MODIS

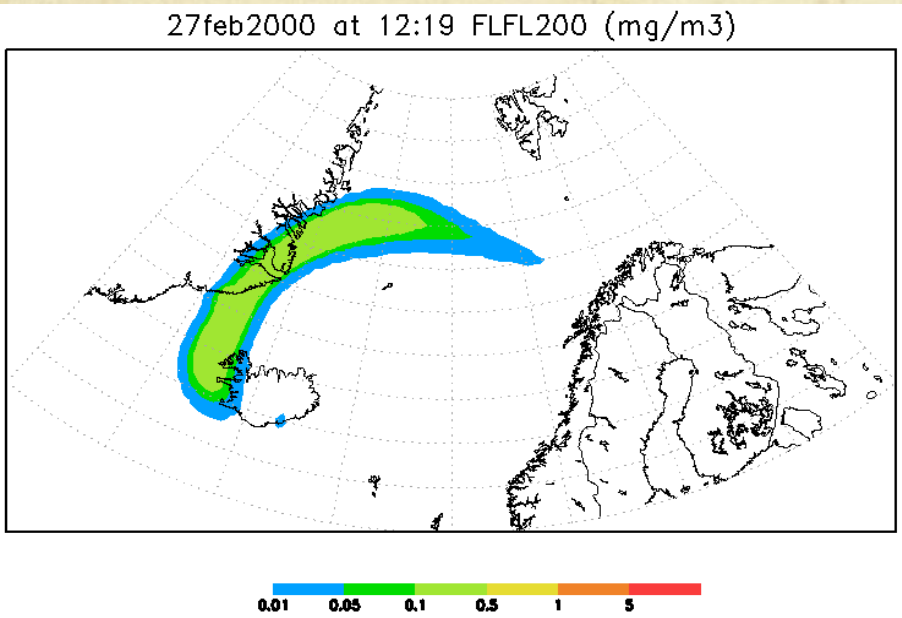
Corradini, S., L. Merucci, A. Folch (2010). Comparison between MODIS satellite retrievals and FALL3D transport model, IEEE Geoscience and Remote Sensing Letters, in press.



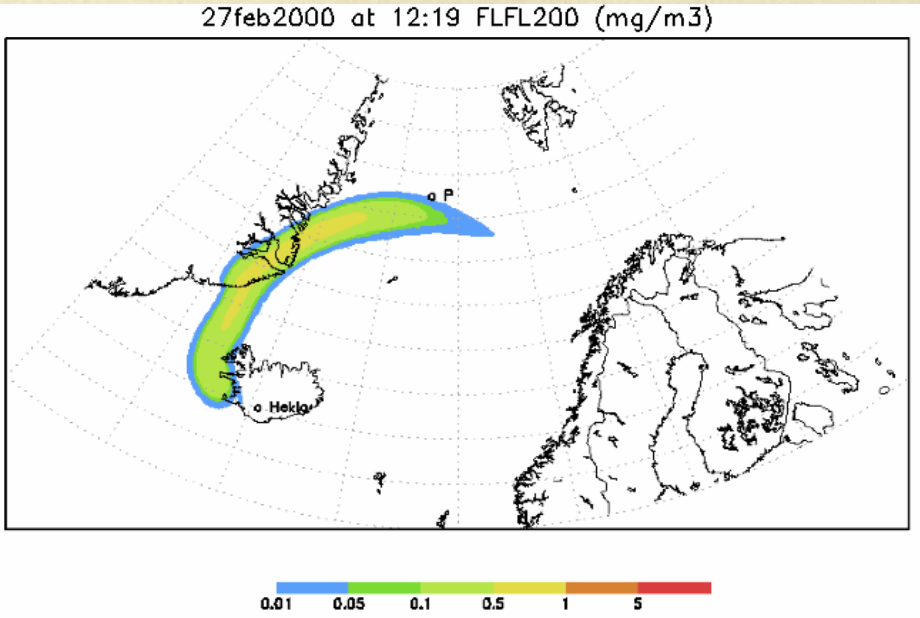
- Some other validations: Vesuvio 1944, Mt Spurr 1992, Etna 2001, 2002, Chaitén 2008...

Hekla Benchmark: issues for discussion (1)

Effect of numerical discretization

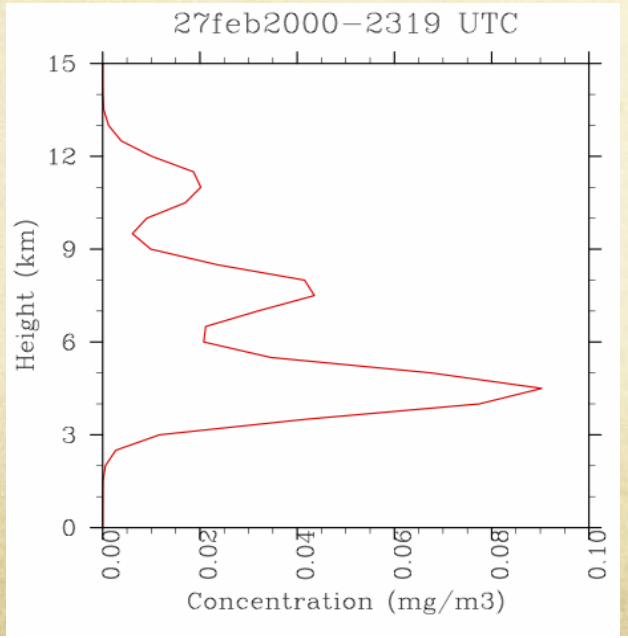


Coarser Grid: 0.50°x0.50°x500m

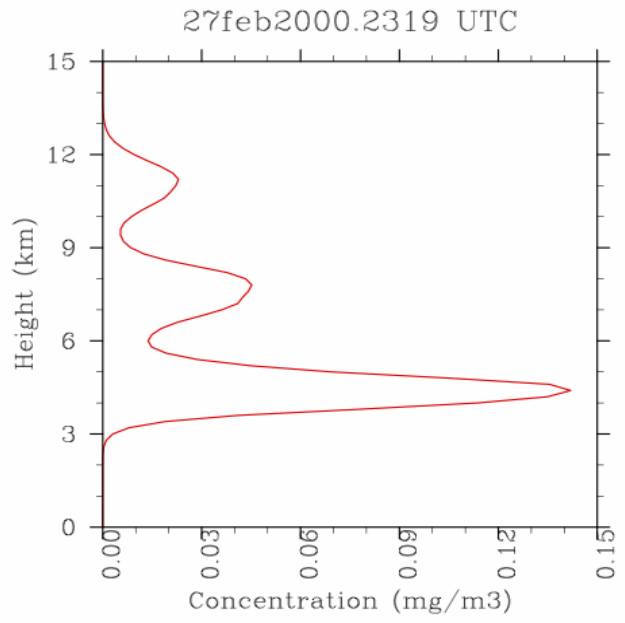


Finer Grid: 0.25°x0.25°x500m

Vertical discretization: 500m

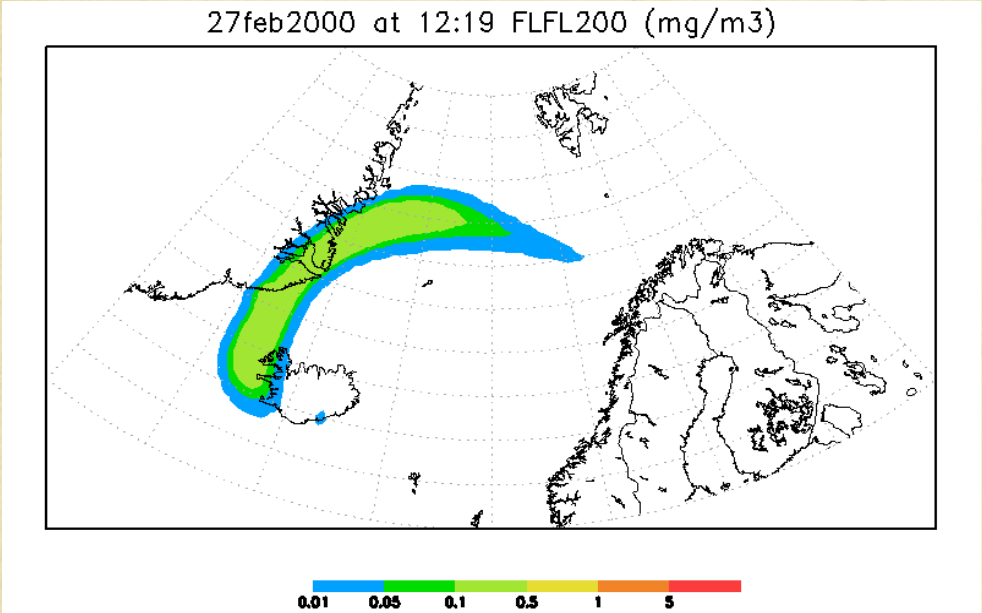


Vertical discretization: 200m

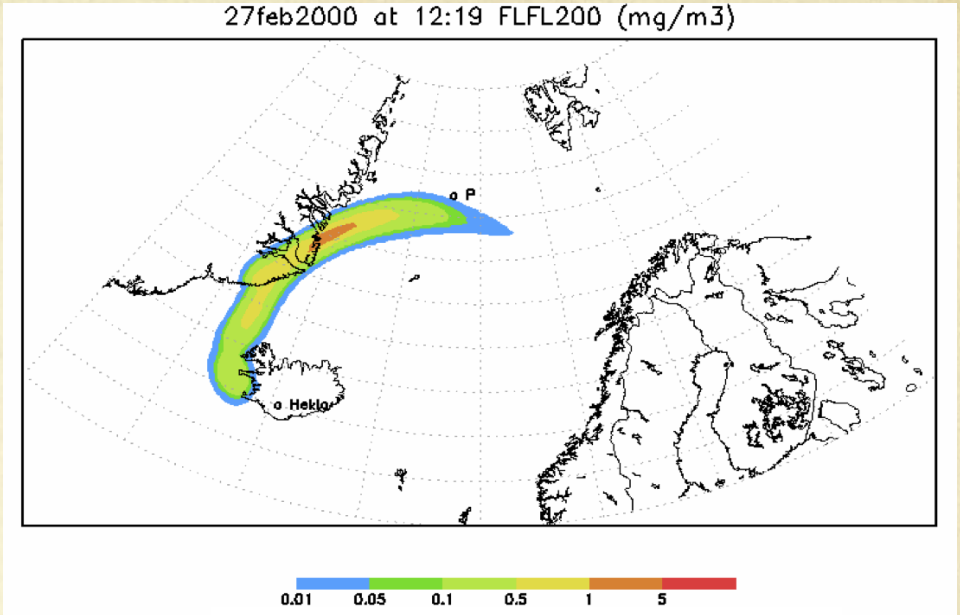


Hekla Benchmark: issues for discussion (1)

Effect of numerical discretization

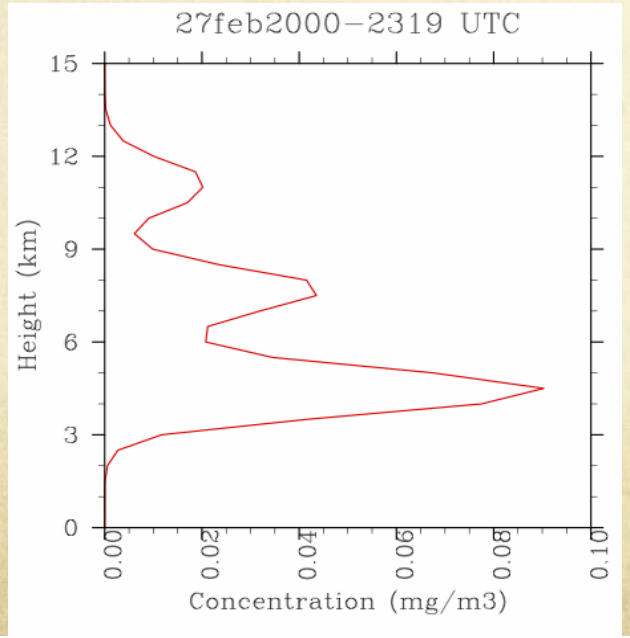


Coarser Grid: 0.50°x0.50°x500m

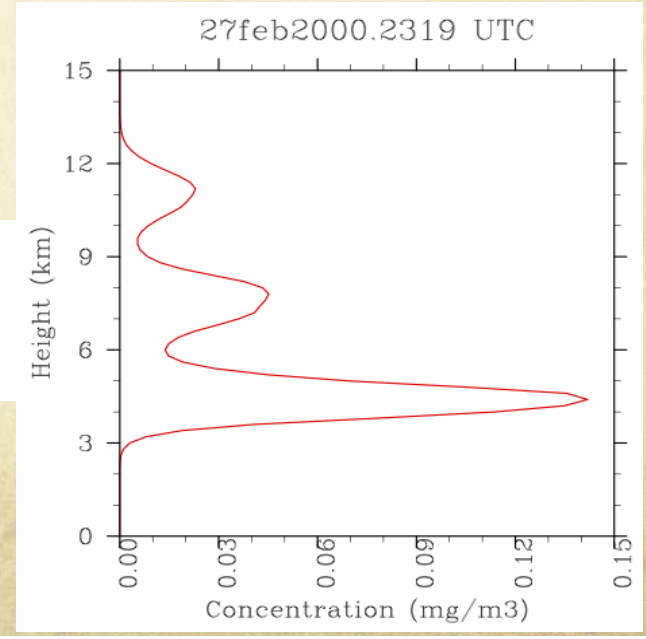


Finer grid: 0.25°x0.25°x200m

Vertical discretization: 500m

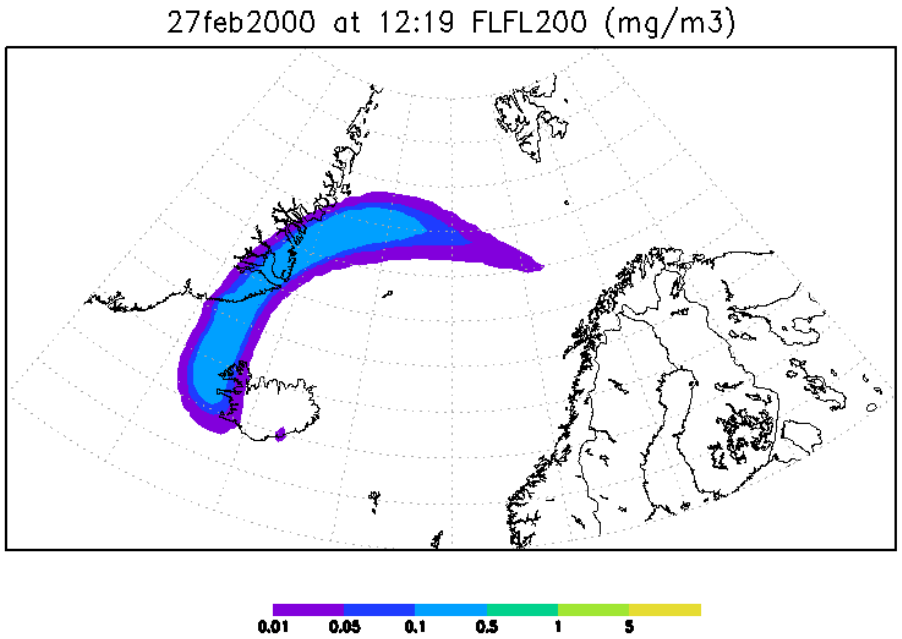


Vertical discretization: 200m

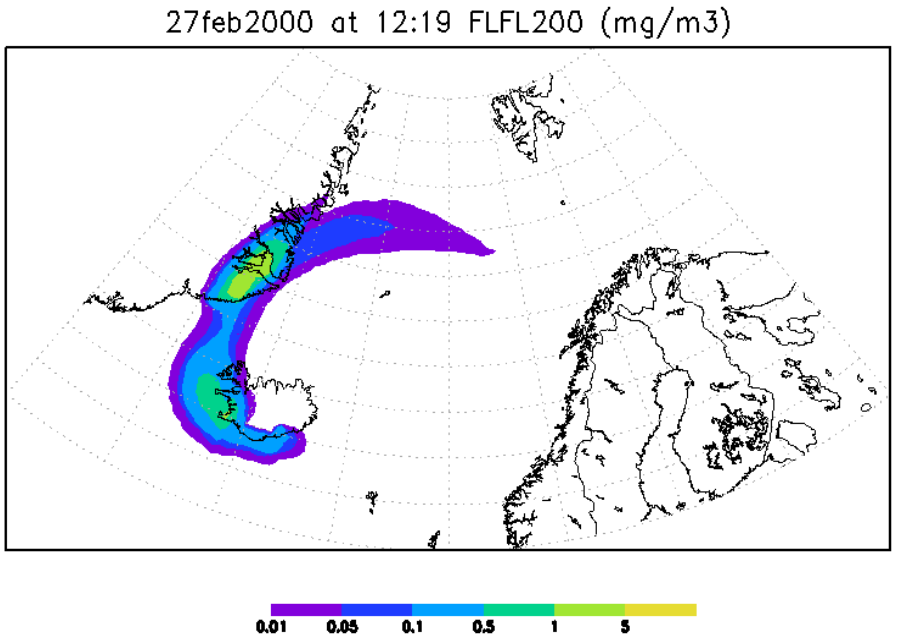


Hekla Benchmark: issues for discussion (2)

Effect of ash aggregation



Without ash aggregation model



With ash aggregation model

Costa A., A. Folch, G. Macedonio (2010), A Model for Wet Aggregation of Ash Particles in Volcanic Plumes and Clouds: I. Theoretical Formulation, J. Geophys. Res.

Folch A.,A. Costa, A. Durant, G. Macedonio (2010), A Model for Wet Aggregation of Ash Particles in Volcanic Plumes and Clouds: II. Model Application, J. Geophys. Res.

THANKS FOR YOUR ATTENTION