Danube area: Geographic origin of pollutants using FLEXPART

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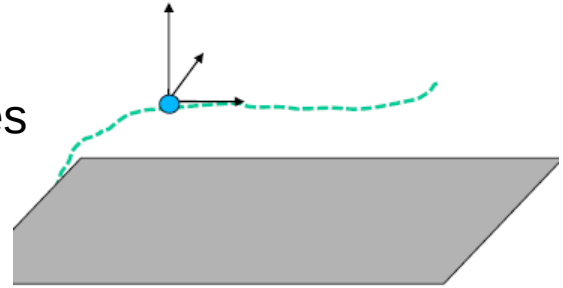
What is FLEXPART?

Lagrangian

Lagrangian particle dispersion model (LPDM)

- Particles released with a certain amount of mass – species
- Mean wind and turbulence move particles
- Particles follow the eddies and are not deformed
- Many particles are needed to properly represent a plume



$$\frac{\partial c_i}{\partial t} + u_x \frac{\partial c_i}{\partial x} + u_y \frac{\partial c_i}{\partial y} + u_z \frac{\partial c_i}{\partial z} = \frac{\partial}{\partial x}\left(K_{xx}\frac{\partial c_i}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_{yy}\frac{\partial c_i}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_{zz}\frac{\partial c_i}{\partial z}\right) + R_i(c_1, c_2 \cdots, c_n) + E_i(x,y,z,t) - S_i(x,y,z,t)$$

Divergence of the advected flux

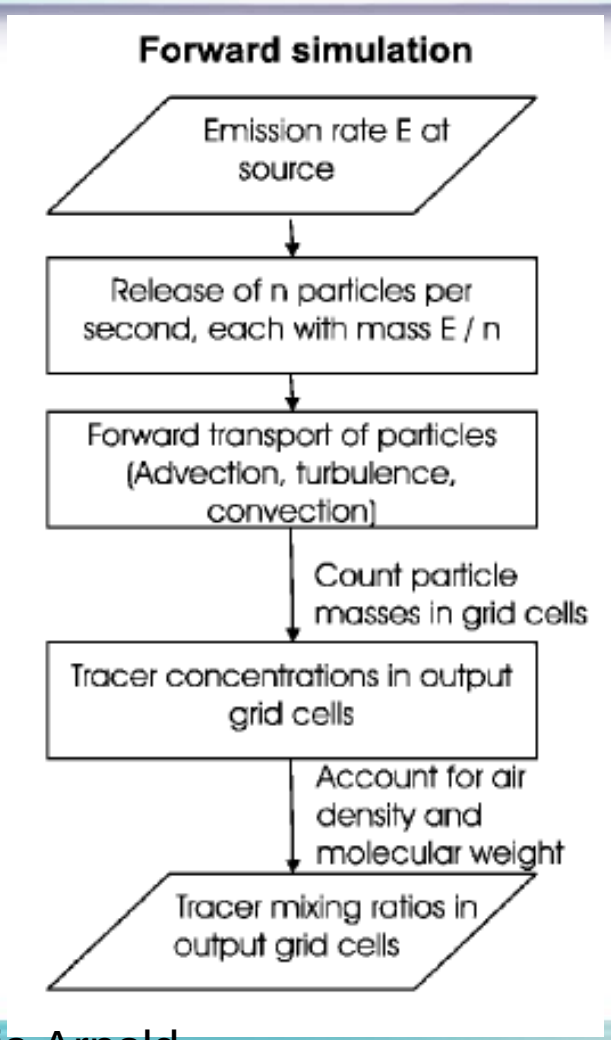
Divergence of the turbulent fluxes

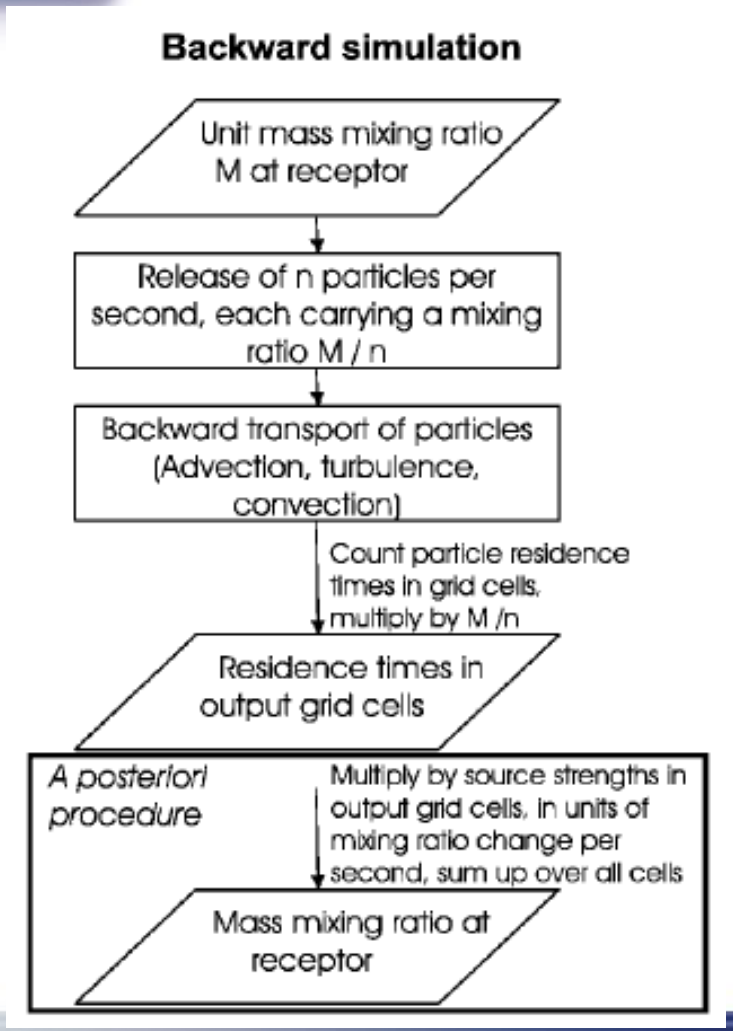
Chemical reactions

Emissions

Sinks

How does it work?





Athens Footprint Examples

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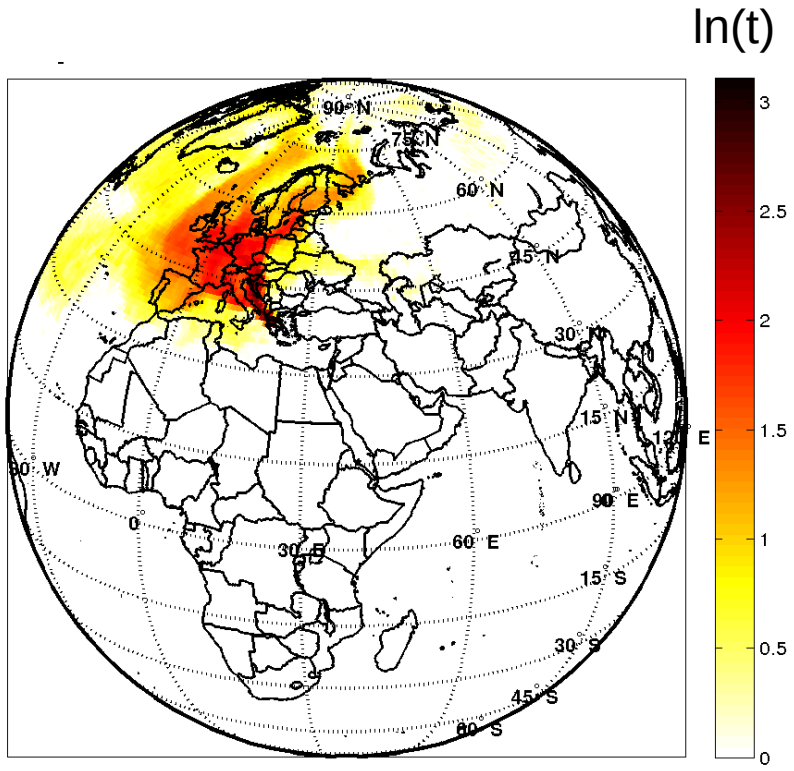
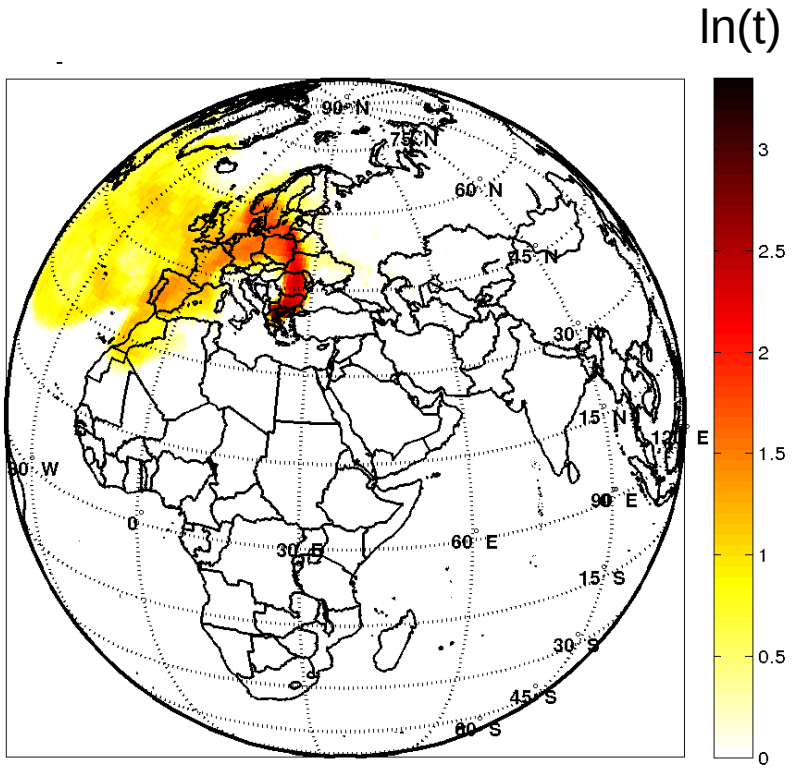
Athens



Footprint 2014-06-01 at 500 m agl, Air tracer



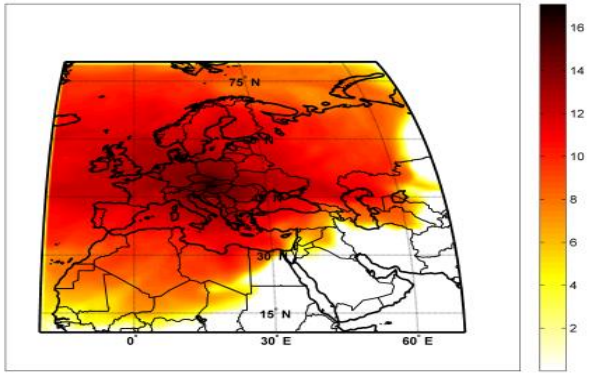
Footprint 2014-06-12 at 500 m agl, Air tracer

PSCF Description

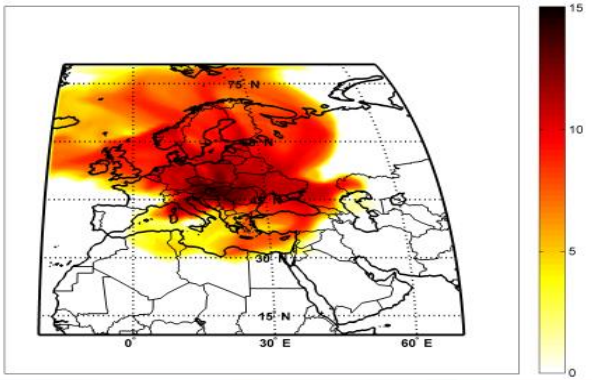
- 5-day backward simulation by FLEXPART model at hourly intervals (Draxler and Rolph, 2003)
- Air parcels (particles) below 3000 m included
- $PSCF_{ij}=m_{ij}/n_{ij}$
- m_{ij}=residence time in a cell that has equivalent concentration >90th percentile of the mean concentration observed
- n_{ij}=residence time in a cell

A Binomial distribution is applied in order to distinguish the cells with very low residence time

Natural logarithm of residence time in cells for PMF Budapest dataset (n_{ij}).



Natural logarithm of residence time in cells for Nitrate Rich source above the 90th percentile (m_{ij}).



Input data for analysis

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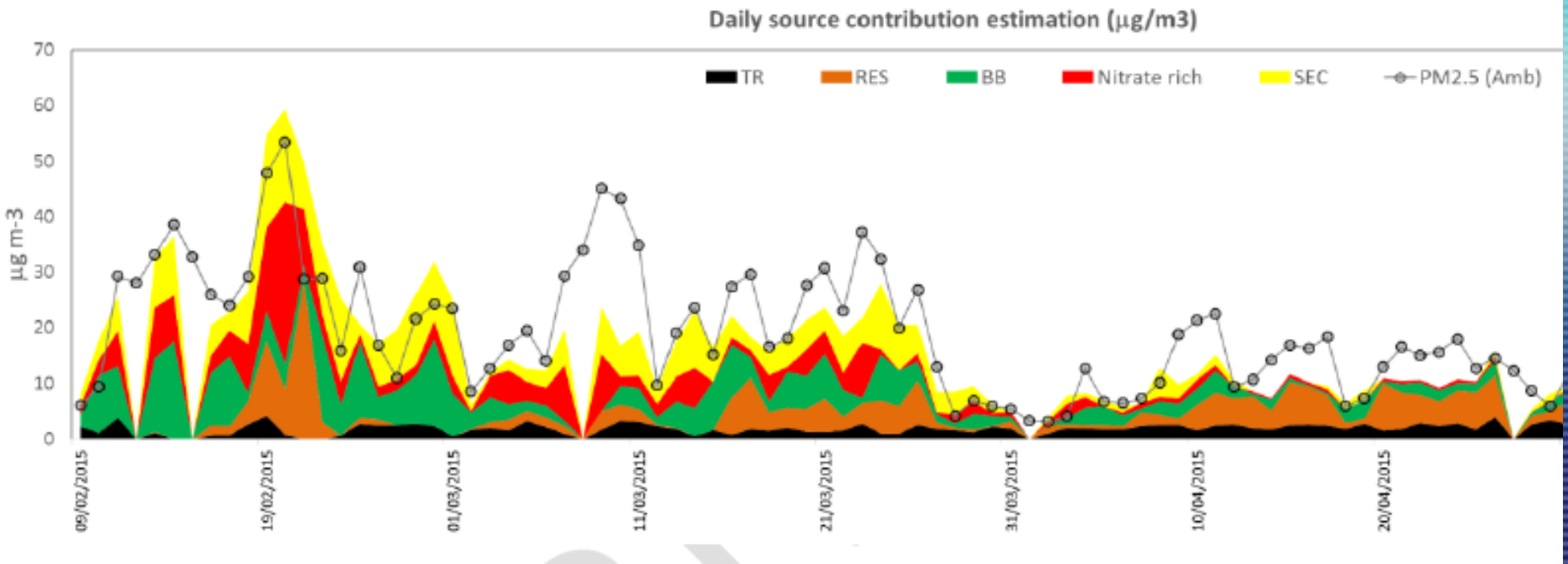
- Positive Matrix Factorization has been employed (Model EPA PMF5.0).
- The most relevant source with respect to long-range transport is secondary aerosol, while sea salt, heavy oil combustion and soil dust (during African dust events) may be also associated with long-distance sources.
- Biomass Burning and Traffic are considered mainly local.
- Sources with similar profiles could be distinguished if we know whether they are transported or not. Air mass origin provides us with additional information.



PSCF: Source regions for Secondary Aerosol up to 3000 m and Emission regions for SO_2

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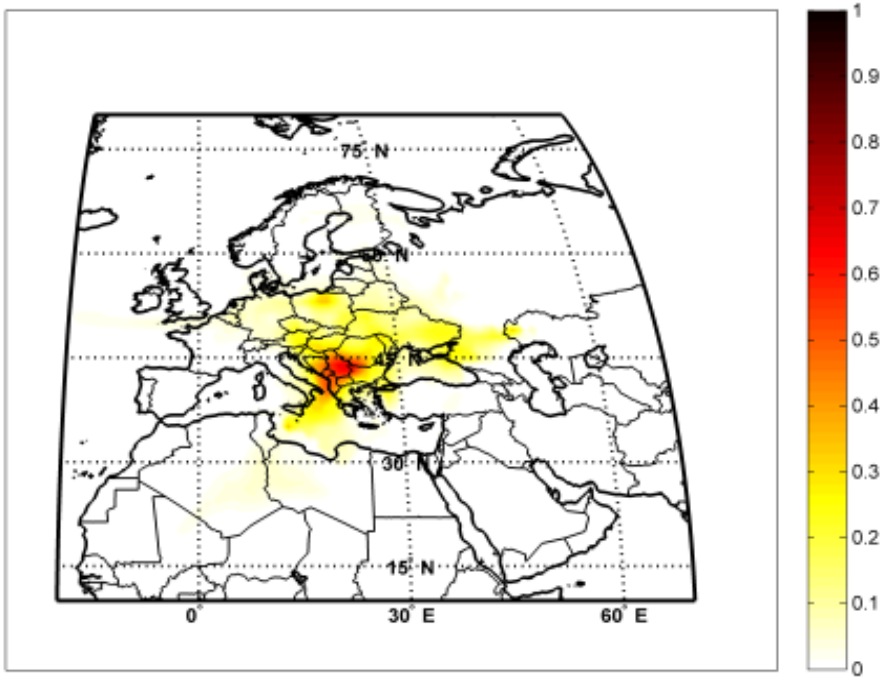
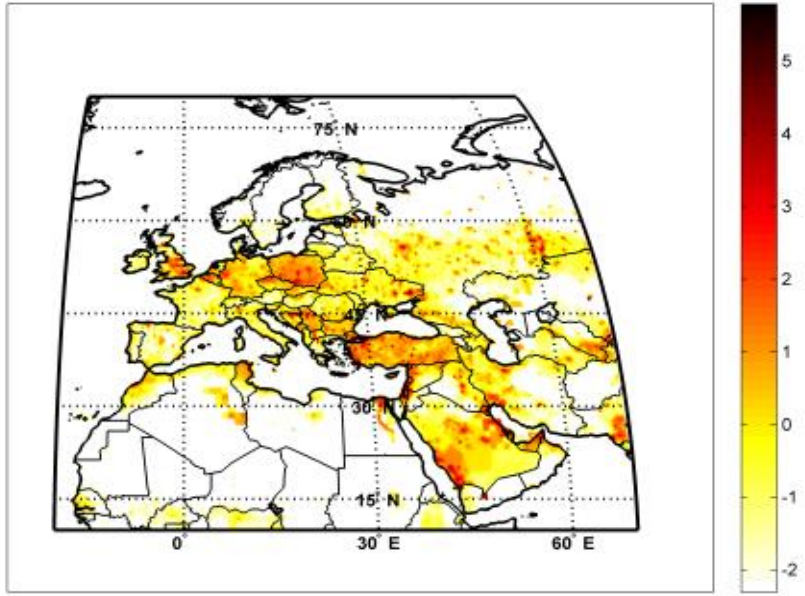
Budapest-PM2.5



Budapest Secondary aerosol PSCF Analysis – 5 days backward run – up to 3000 m



Natural logarithm of SO_2 Emissions (kt/year) for 2015 from ECLIPSE DATABASE (http://eclipse.nilu.no/, forecast). Anthropogenic sources are included, excluding shipping and aviation.

PSCF: Source regions for Nitrate Rich-BB up to 3000 m

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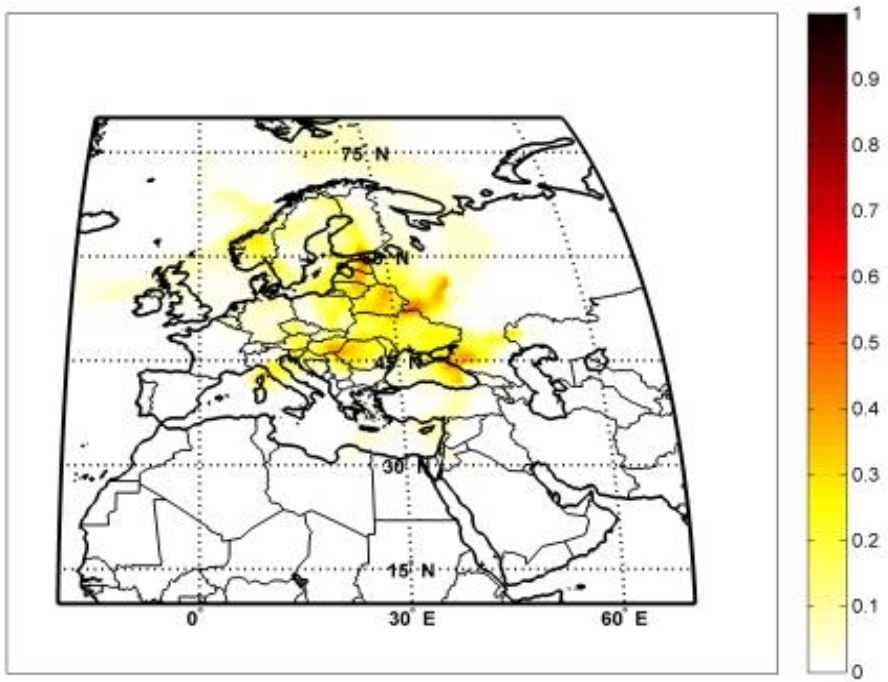
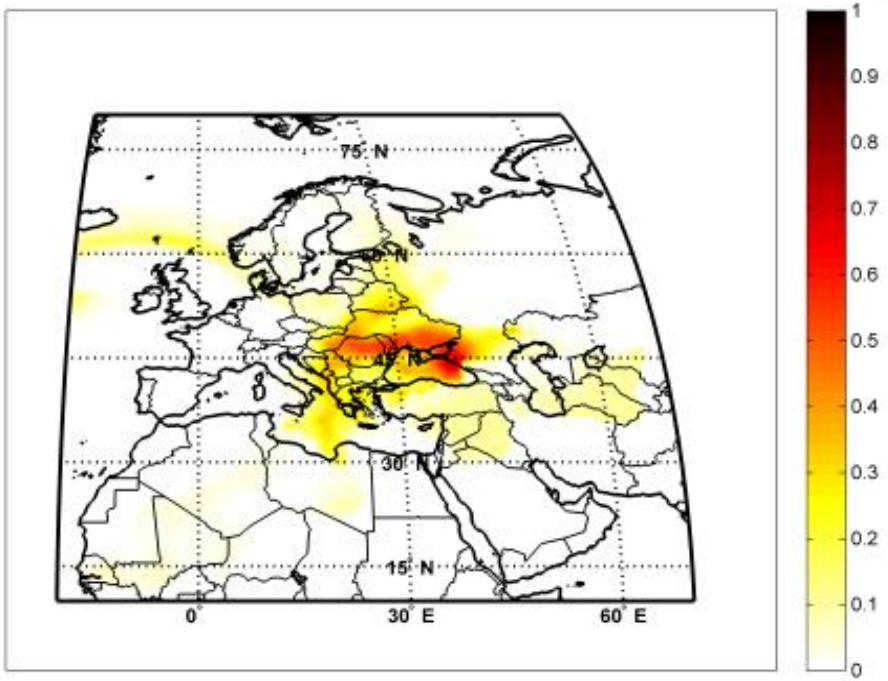
Budapest-PM2.5



Budapest Nitrate rich PSCF Analysis – 5 days backward run – up to 3000 m

Budapest-PM2.5



Budapest BB PSCF Analysis – 5 days backward run – up to 3000 m

PSCF: Source regions for Nitrate Rich-BB up to 3000 m

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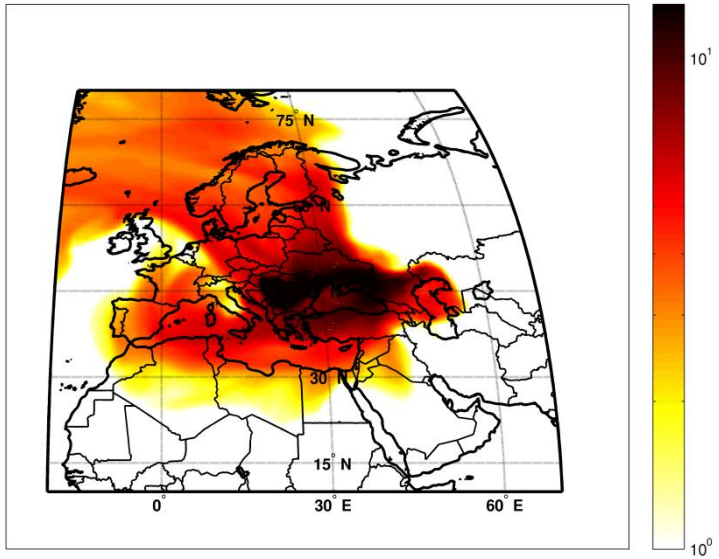
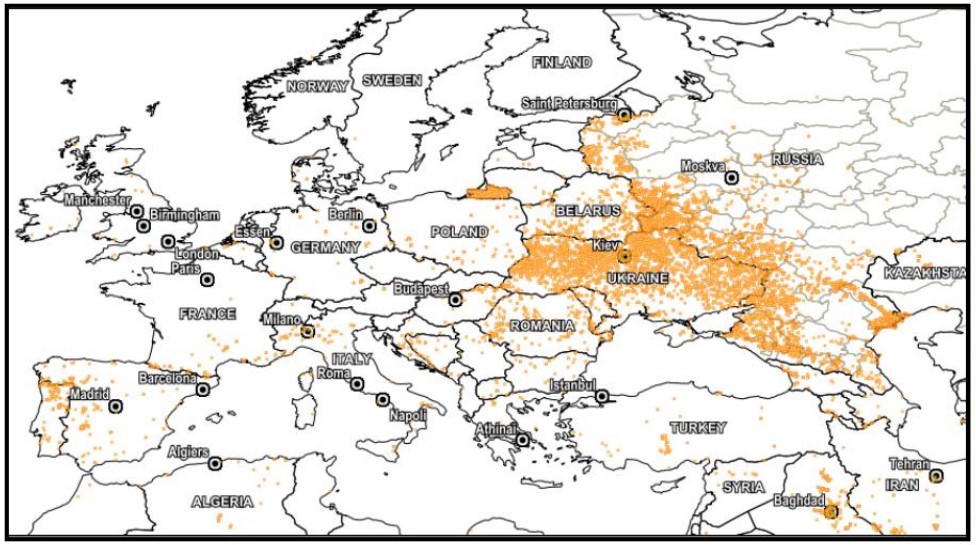
Budapest-PM2.5

Footprint 20150214, Air tracer



Budapest air mass origin on the 14th of February 2015 – 5 days backward run – up to 3000 m

Budapest-PM2.5



Agricultural fires on February – March 2015, MODIS satellite.

Sofia: Source regions for Secondary Sulfate up to 3000 m

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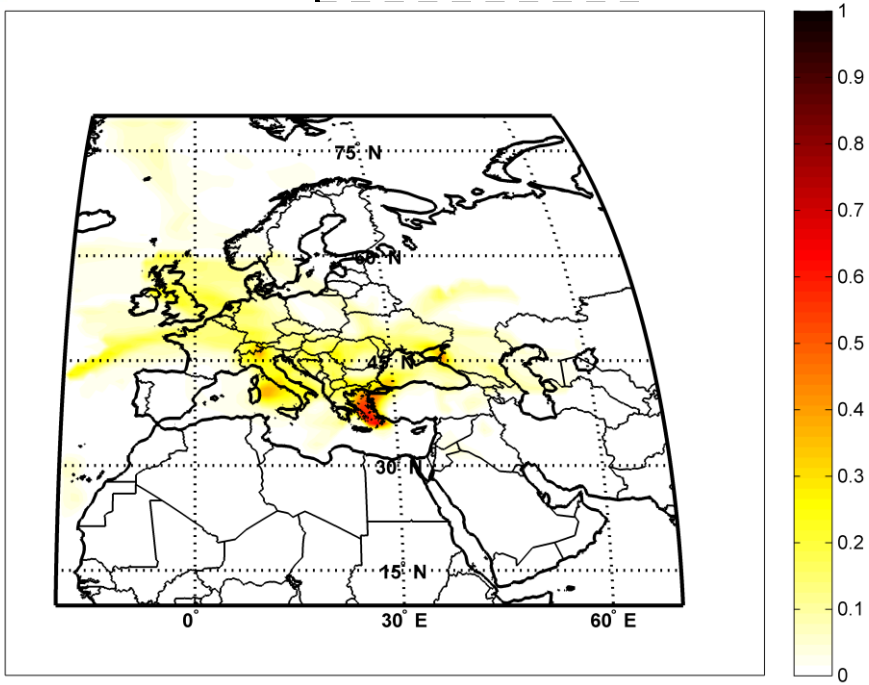
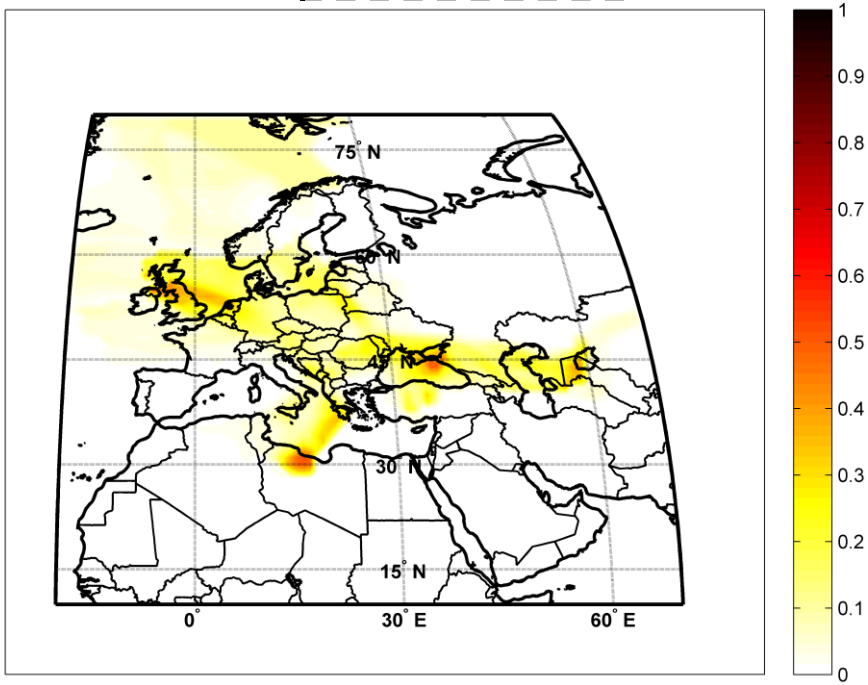
SOFIA-PM10



5 day FLEXPART PSCF: Sofia Secondary aerosol PSCF Analysis – 5 days backward run – up to 3000 m

SOFIA-PM10



5 day FLEXPART PSCF: Sofia Fuel-Oil PSCF Analysis – 5 days backward run – up to 3000 m

Sofia: Source regions for Resuspension up to 3000 m

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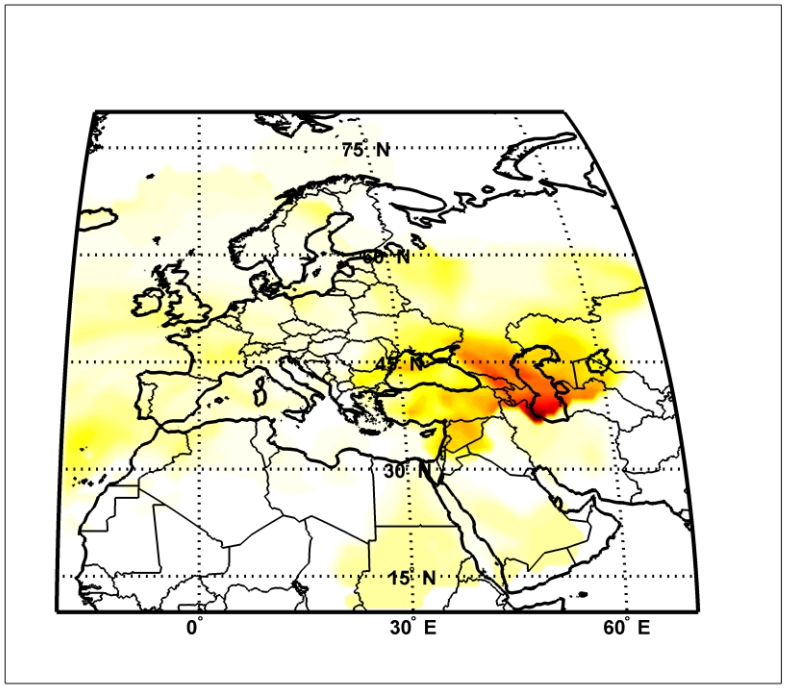
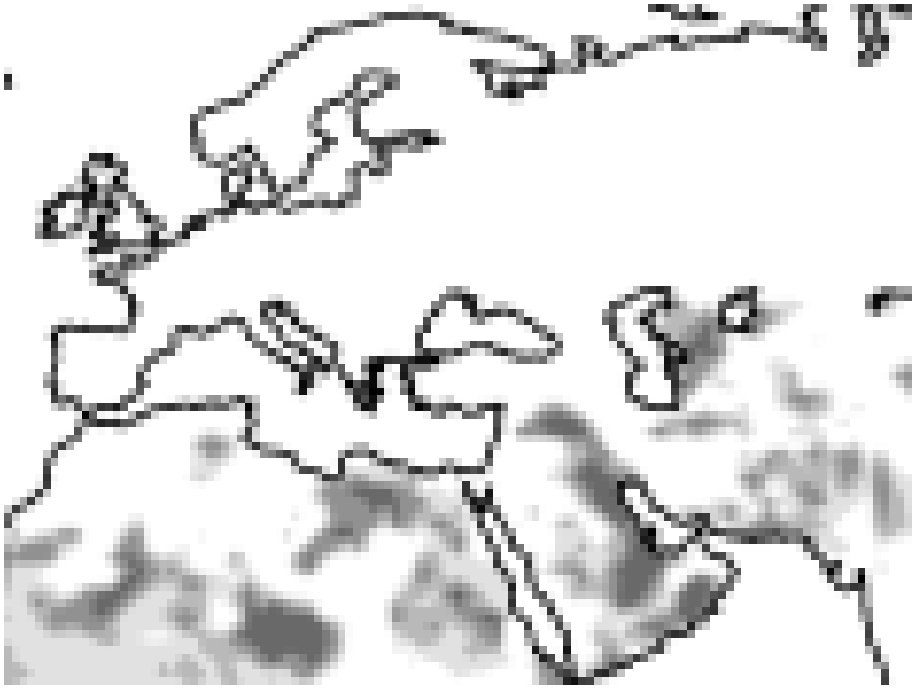
SOFIA-PM10



Sofia Resuspension PSCF Analysis – 10 days backward run – up to 3000 m



The global distribution of TOMS (Total Ozone Mapping Spectrometer) dust sources.

Zagreb: Source regions for Secondary Inorganic

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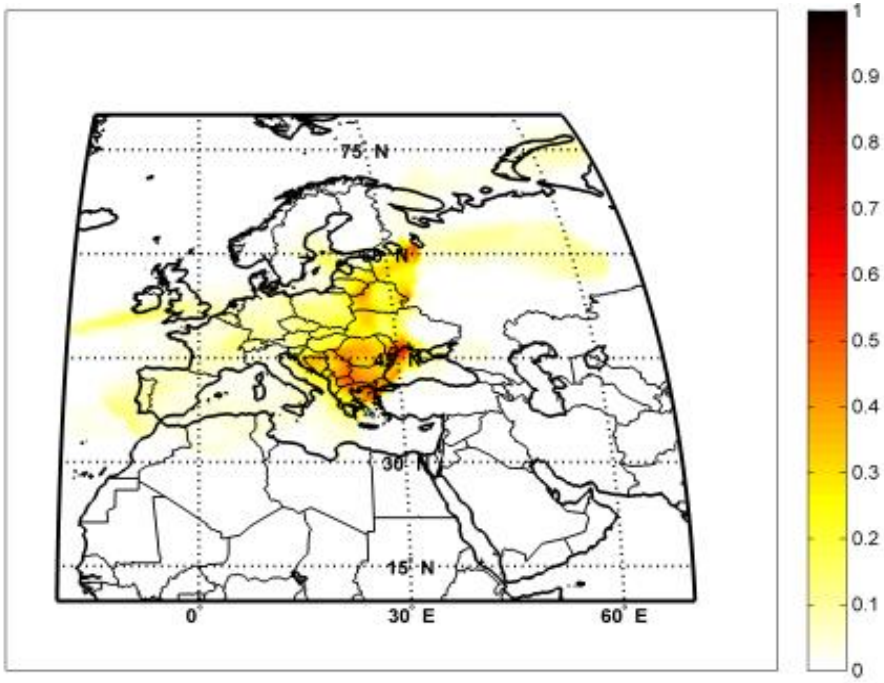
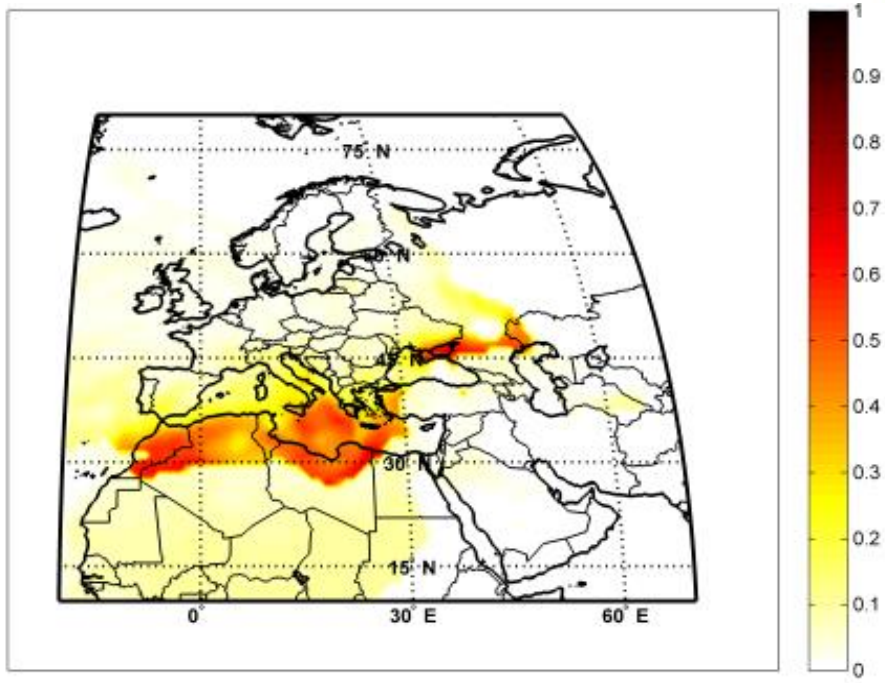
Zagreb-PM2.5



Zagreb Secondary Inorganic PSCF Analysis – 5 days backward run – up to 3000 m

Zagreb-PM2.5



Zagreb Resuspension PSCF Analysis – 10 days backward run – up to 3000 m

Conclusions

- Sofia PM10 Secondary aerosol appears to have a small impact from transported pollution in the mesoscale. There is a path of dust transport from the Caspian Sea and perhaps some shipping influence on the Fuel-Oil source from the Mediterranean Sea and Libya.
- Budapest is influenced from the central Balkans, Turkey, Ukraine, Russia and Poland. There is significant impact from agricultural fires in north-eastern Europe.
- Zagreb dust aerosol appears to originate from Algeria, Tunisia and Libya.
- Zagreb is influenced for sulfates and SO_2 mainly from the central Balkans, Russia, and European part of Turkey.
- FLEXPART can establish source – receptor relationships via sensitivity footprint (residence time) in each cell. Areas with high sensitivity can have a great impact on the receptor site.
- When we use FLEXPART PSCF combined with PMF analysis results, we can obtain an estimate of the geographic regions that affect our measurement site.

Thank you!