UNCERTAINTY FACTORS IN MODELLING DISPERSION OF SMOKE FROM WILD FIRES IN A MEDITERRANEAN AREA

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summary

- ✓ **motivation**
- ✓ **fire preprocessor description**
- ✓ **atmospheric dynamic and composition model**
- ✓ **case study**
- ✓ **discussion and conclusion**

motivation

- ✓ **the Mediterranean Area is often affected by air pollution events;**
- ✓ **the Mediterranean Area is often affected by fires which burn thousand hectares of vegetation;**
- ✓ **gas and particulate emitted by forest fires can be transported over long distances, thus affecting both air quality and climate, from local to regional and global scales;**

MODIS image, Algeria 29/08/07

➢ **importance to include forest fire emissions in chemistry-transport model.**

wildfire emissions

$$E_i = A * B * CE * e_i$$

(Seiler and Crutzen, 1980)

E_i (kg) is the total emission of specie i

A (m^2) is the burnt area

B ($kg\ m^{-2}$) is the fuel load (biomass per surface unit)

CE (adimensional) is the combustion efficiency

e_i is the emission factor of specie i ($g\ kg^{-1}$)

wildfire emissions

- ✓**satellite data for spatial and temporal fires identification**

- ✓**land cover classification map: B, e_i , CE depend on vegetation type (*Whyedinmier et al. 2006)***

Vegetation classes of UMD Global Land Cover Classification map

1	Evergreen Needleleaf Forest
2	Evergreen Broadleaf Forest
3	Deciduous Needleleaf Forest
4	Deciduous Broadleaf Forest
5	Mixed Forest
6	Woodland
7	Wooded Grassland
8	Closed Shrubland
9	Open Shrubland
10	Grassland
11	Cropland
12	Bare Ground
13	Urban and Built
14	Water

wildfire emissions

✓**emitted species**:

gas: CO_2, CO, NOx, NH_3, SO_2 , NMHCs, CH_4 **aerosol:** PM_{10}, $PM_{2.5}$

✓**emissions are supposed to not be constant during the day**

hour	% per hour	hour	% per hour
1	0.57	**13**	10
2	0.57	**14**	13
3	0.57	**15**	16
4	0.57	**16**	17
5	0.57	**17**	12
6	0.57	**18**	7
7	0.57	**19**	4
8	0.57	**20**	0.57
9	0.57	**21**	0.57
10	2	**22**	0.57
11	4	**23**	0.57
12	7	**24**	0.57

Diurnal profile used to distribuite wildfire emissions.
Source WRAP, 2005

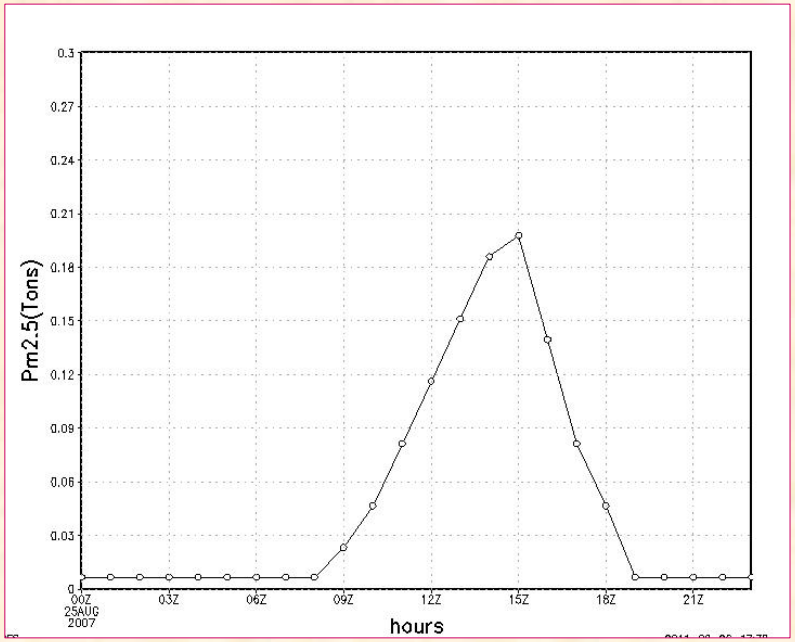
emissions height

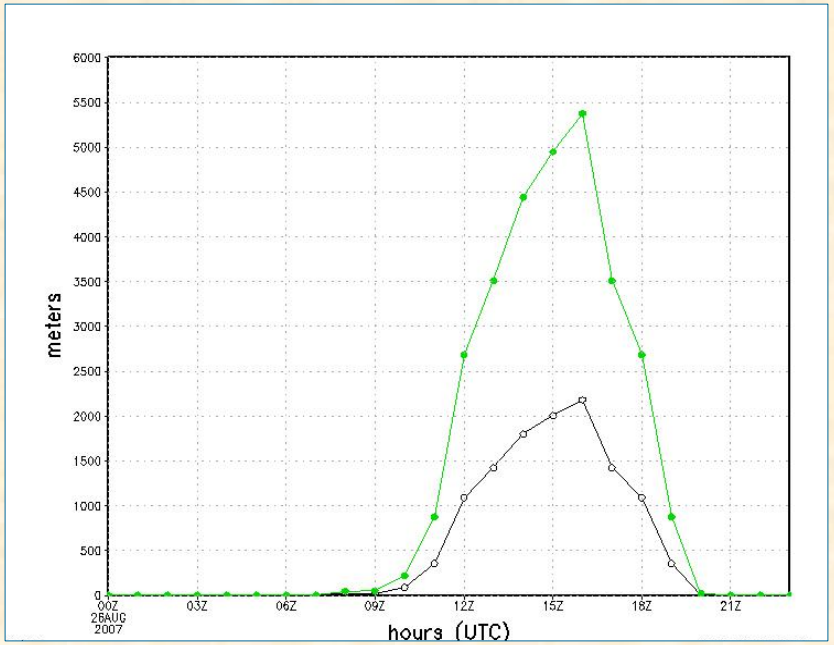
- ✓ **the injection height is related to the flaming intensity of the fire and it is estimated on the base of fire characteristics (such as the fire size and fuel loading);**
- ✓ **five plume classes are defined (WRAP, 2005);**
- ✓ **the bottom (Pbotmax) and top (Ptopmax) altitudes of the fire plume are calculated as a function of plume class;**
- ✓ **a diurnal modulation, as function of the bouyant efficiency from the size class and the hourly bouyant efficiency, is then used.**

Top and bottom emission height as function of fire classes

Class	1	2	3	4	5
$Ptop_{max}$(m)	160	2400	6400	7200	8000
$Ptop_{min}$(m)	0	900	2200	3000	3000

diurnal modulation WRAP2005 es.

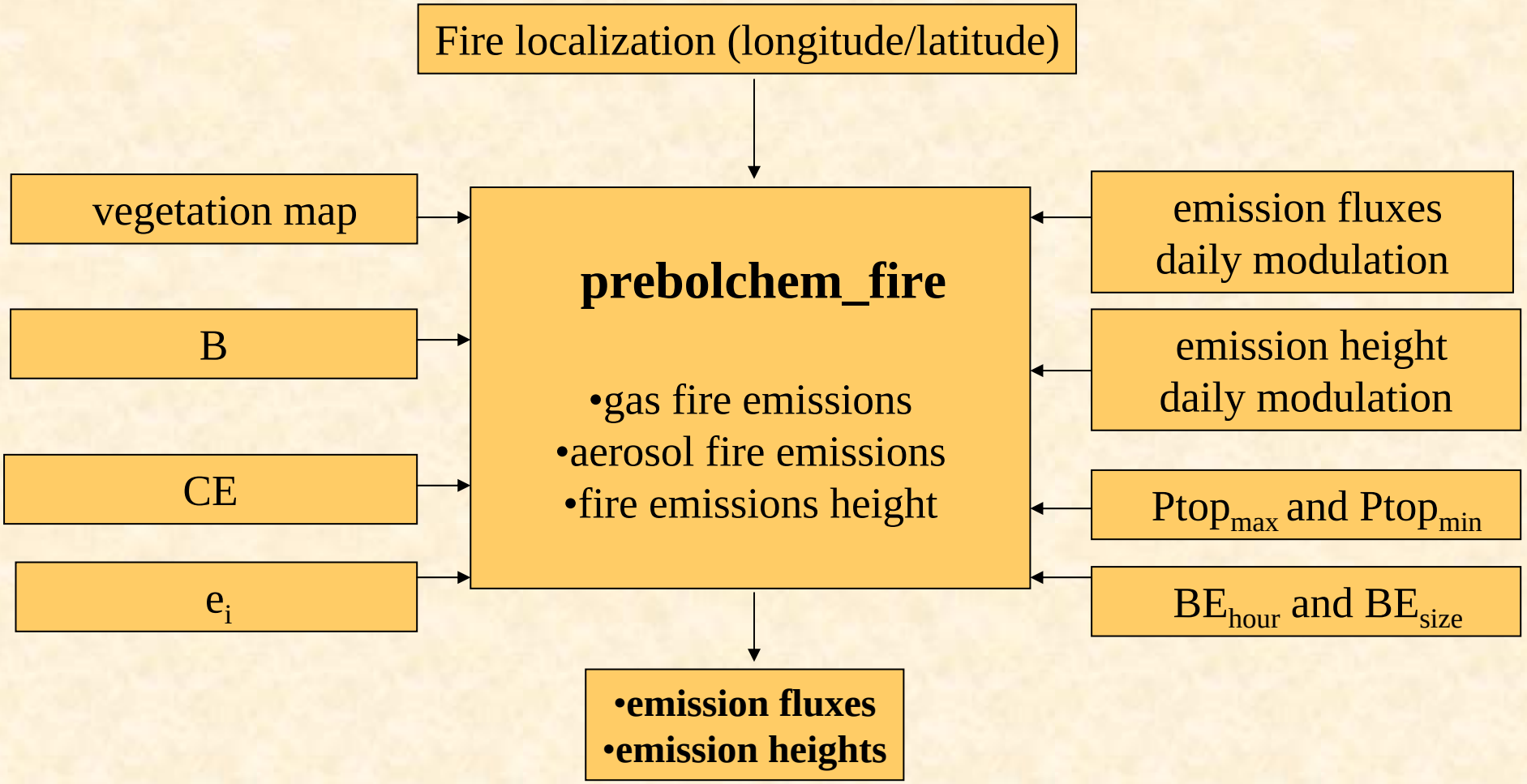




- ***example of diurnal cycle of $PM_{2.5}$ emission***

- ***corresponding diurnal cycle of maximum (in green) and minimum (in black) emission height***

fire preprocessor



uncertainity factors

- ✓**fire spatial identification (burned area)**
- ✓**fire temporal identification (time duration)**
- ✓**fire evolution (temporal emission distribution)**
- ✓**emission height**
- ✓**vegetation database**

The model: BOLCHEM

online coupled

Meteorological module: BOLAM

Photochemistry scheme: SAPRAC90 (lumped-molecular condensed mechanism)

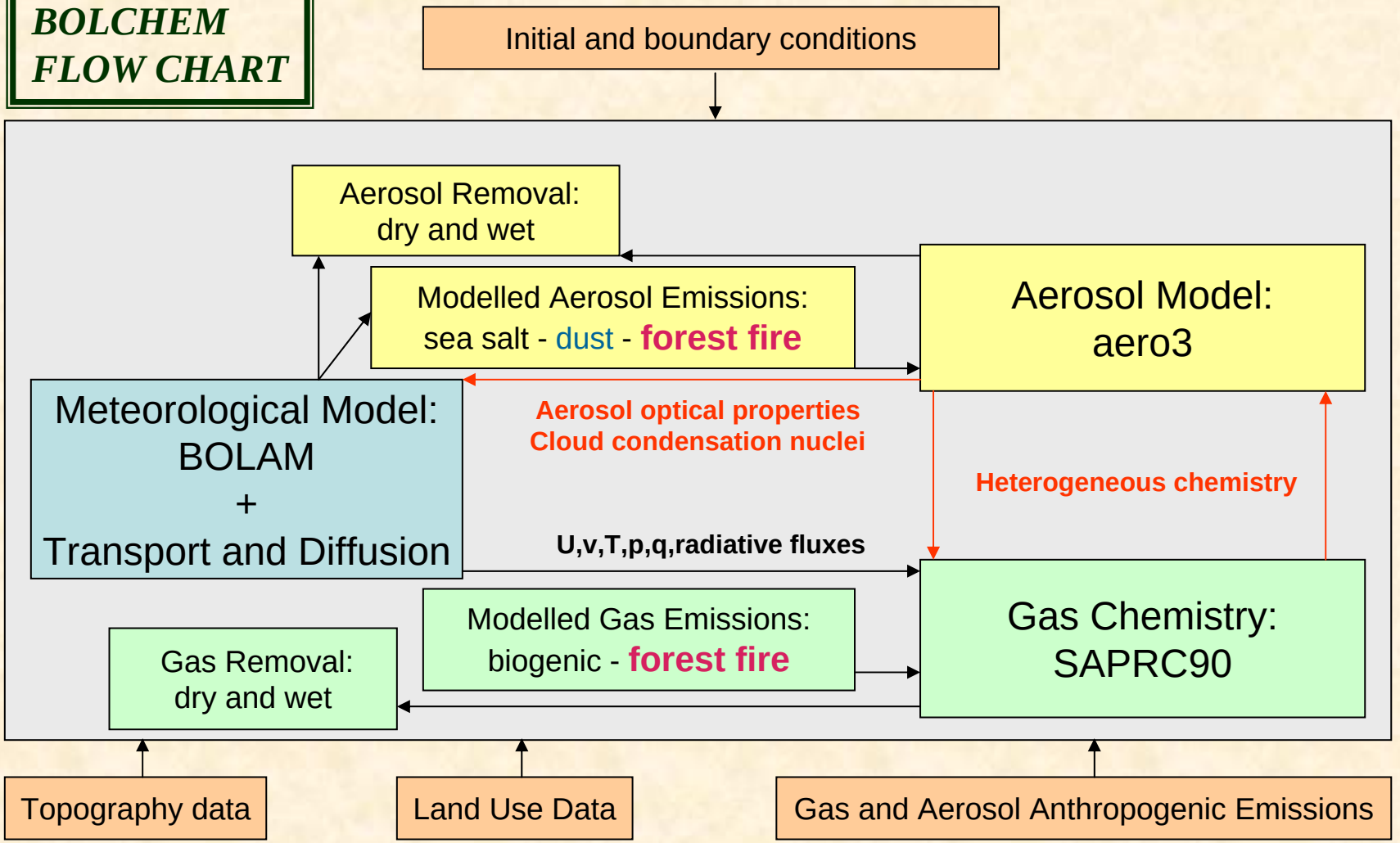
Aerosol processes: AERO3 (modal approach three lognormal subdistributions) – secondary aerosols

Dry deposition

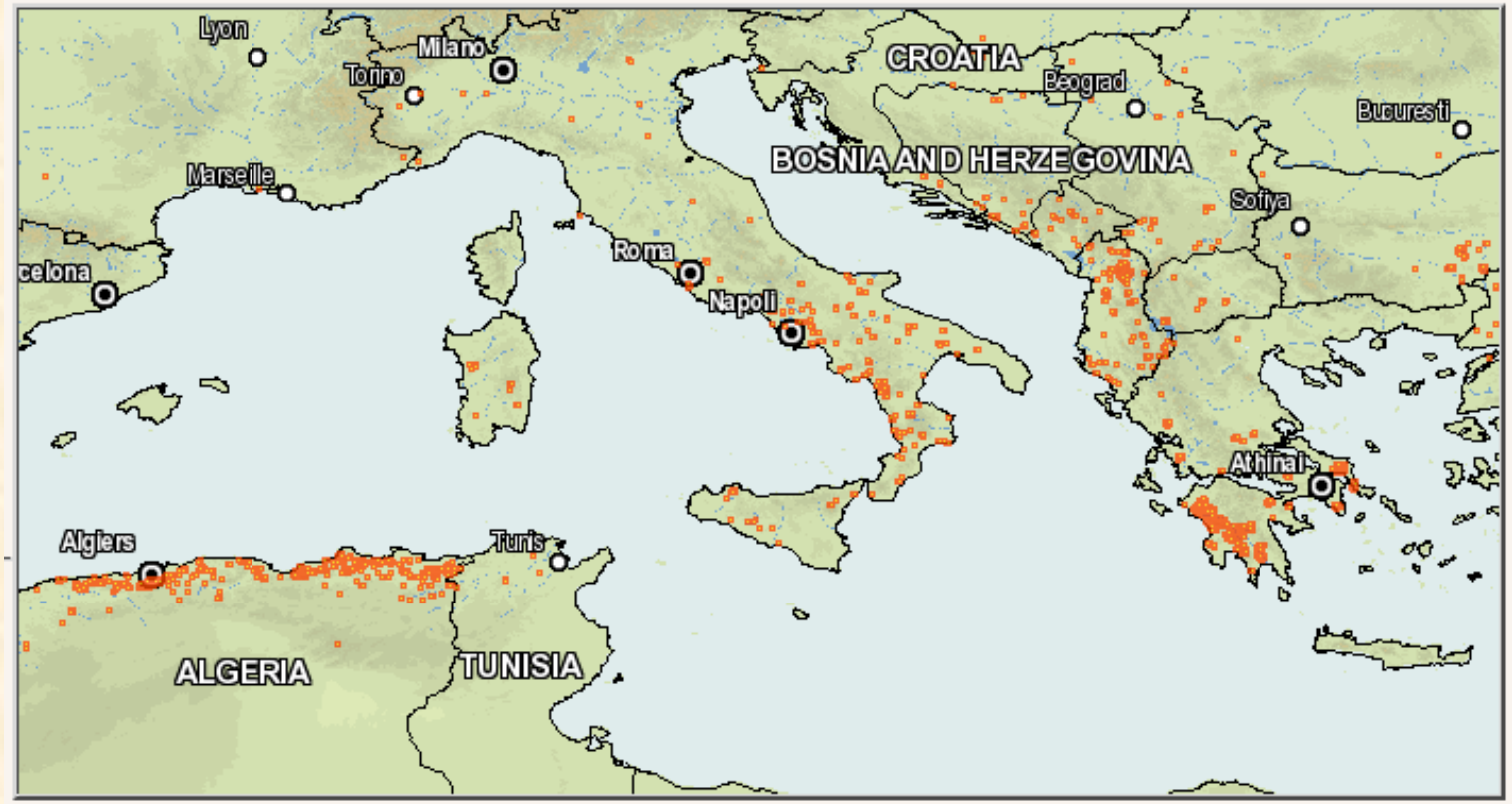
Wet deposition

BOLCHEM flow chart

BOLCHEM FLOW CHART



case study: summer 2007
fires in Greece, Albania, Algeria

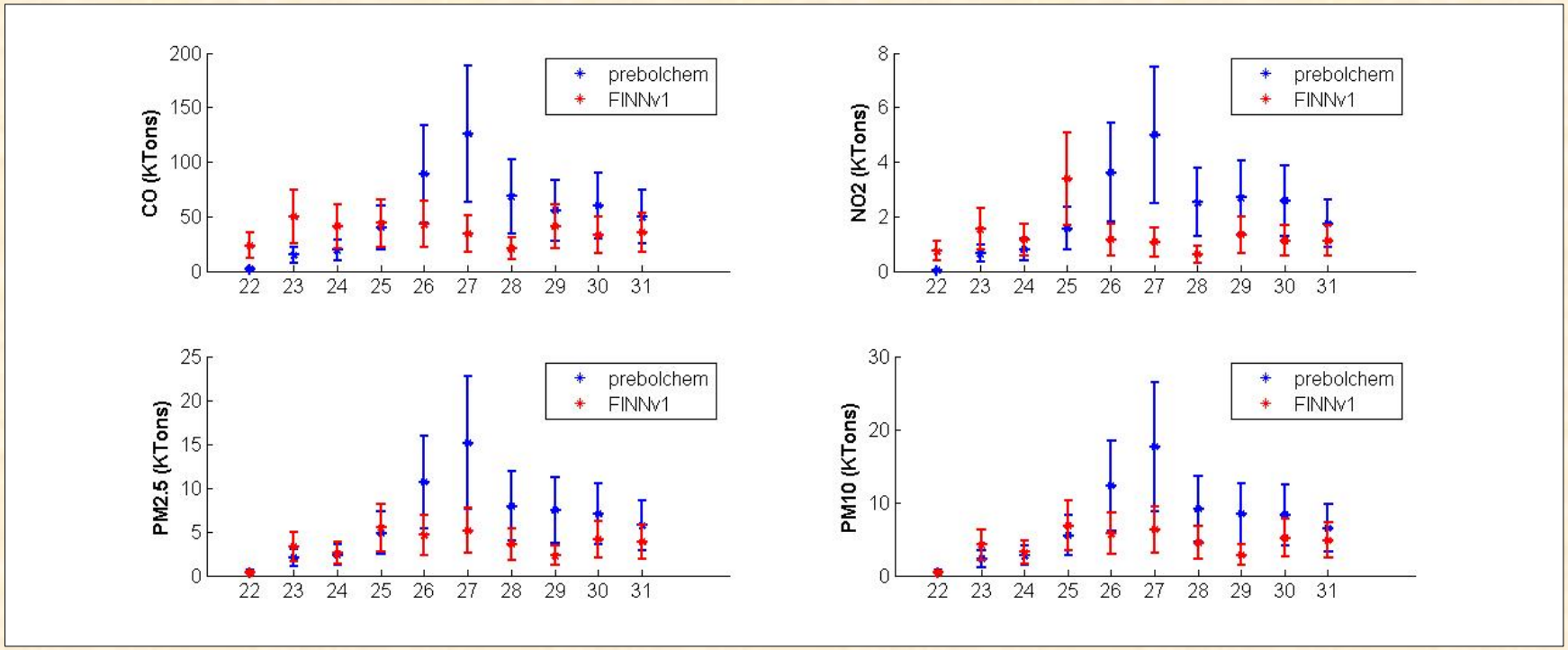


Active fires map 22 - 31 August 2007

estimated emissions

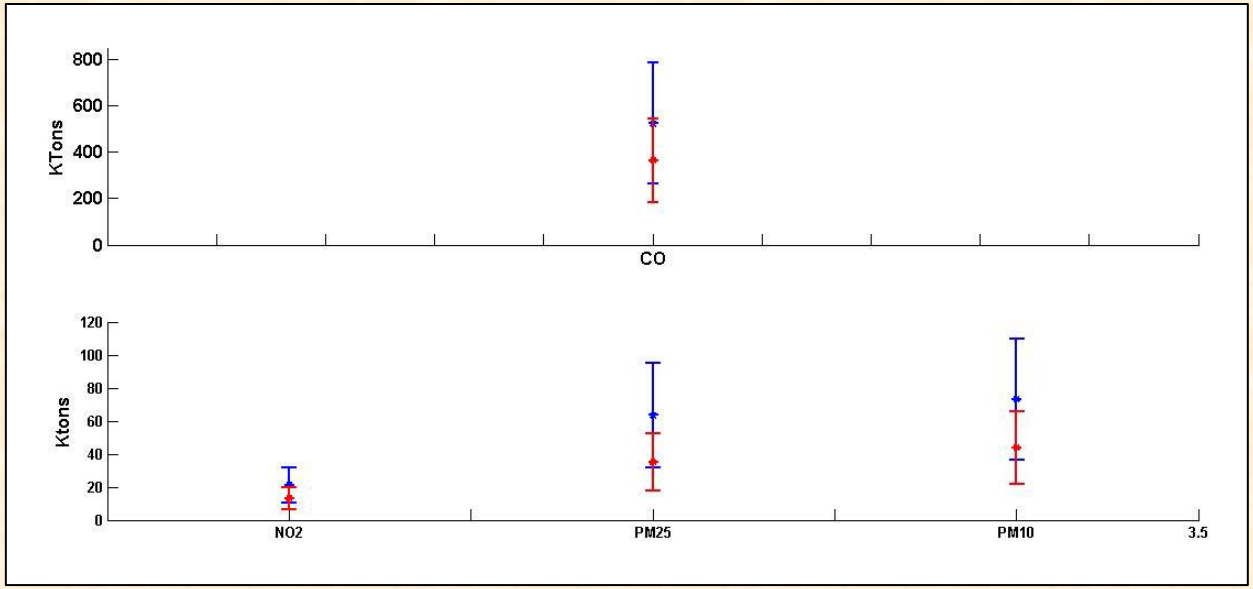
prebolchem_fire
based on
MODIS "Burned Area Product"

***FINNv1** (Fire INventory from NCAR version 1.0)*
based on
"Fire Radiative Power operational MODIS product "



- ***daily emissions (KTons) of CO, NO2, PM2.5 and PM10 estimated by means of prebolchem-fire (blue) and FINNv1 model (red).***

estimated emissions



* *FINNv1*
* *prebolchem_fire*

- ***total emissions (KTons) of CO, NO2, PM2.5 and PM10 estimated by means of prebolchem-fire (blue) and FINNv1 model (red) for the period 22-30 august 2007.***

differences between the two emissions are mainly due to:

✓**different vegetation map,**

✓**different feature of used MODIS product**

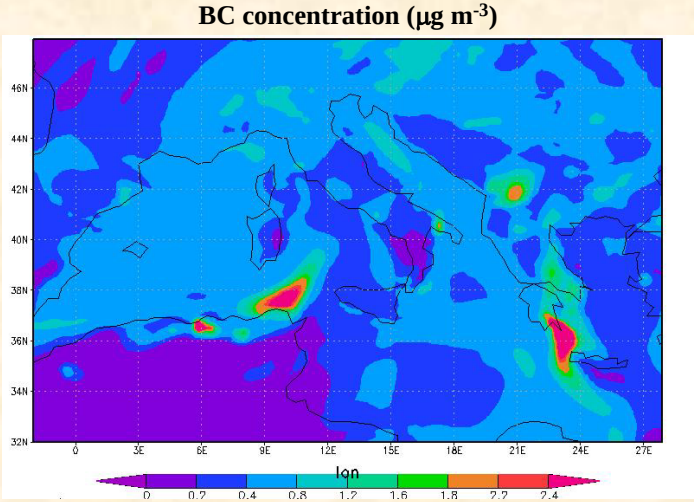
BOLCHEM set up

- **simulation period** → 22-31 August 2007
- **simulation domain** → Europe and North Africa
- **horizontal resolution** → 0.25° X 0.25°
- **vertical resolution** → 40 vertical level in signa coordinates for meteorology, 20 for chemistry
- **temporal step** → 200 s
- **initial and boundary METEOROLOGICAL condition** → meteorological fields from ECMWF (analysis) every 6 hours
- **initial and boundary CHEMICAL condition** → chemical fields from ECMWF (GEMS project) every 6 hours
- **antropogenic emissions** → data set TNO *(TNO 2007)*
- **biogenic emissions** → on line calculation (fluxes GEMS/NKUA *(Symeonidis et al,2007))*

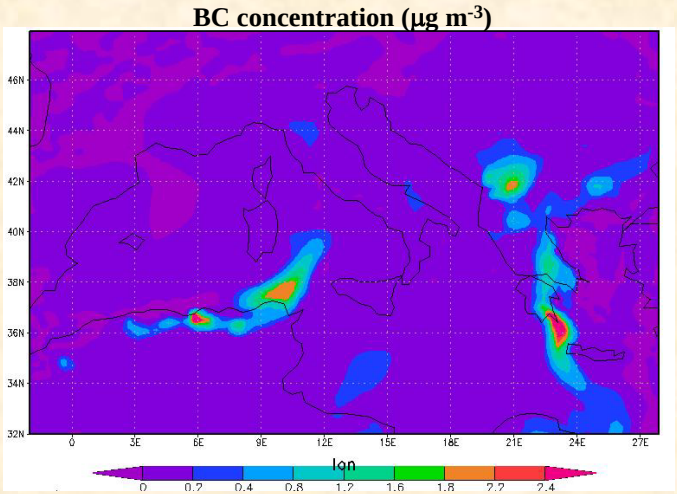
- **Fire emissions → prebolchem_fire preprocessor**
- **NOx = 95%NO_2 + 5% NO**
- **$PM_{2.5}$ = 6% BC + 84% OC + 6% S**
- **SIMULATIONS: ant+bio / ant+bio+fire (different emission height set up)**
  → fire (diff)

BOLCHEM simulations

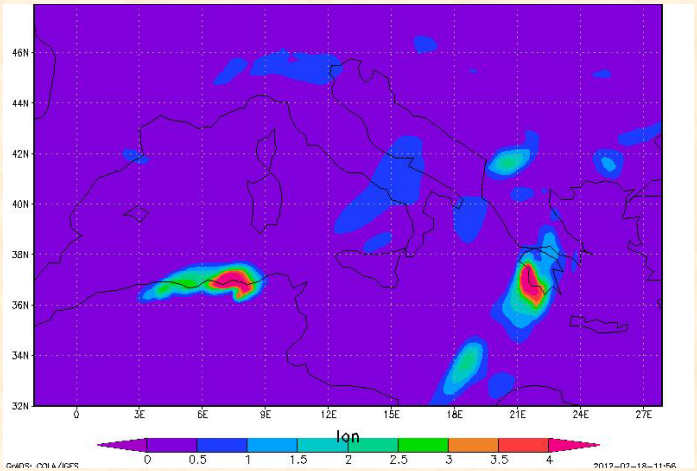
a)



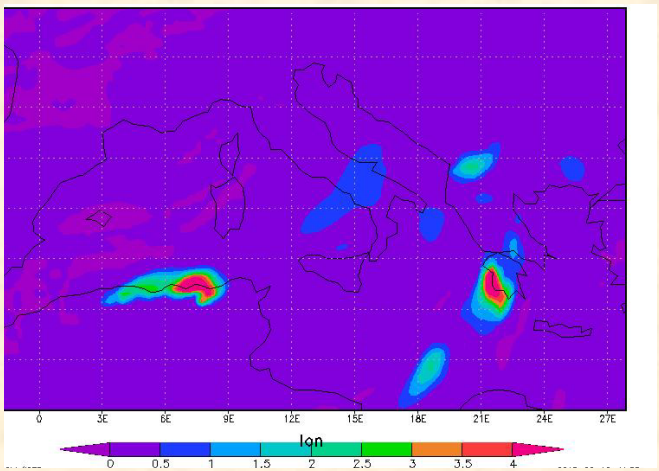
c)



b)

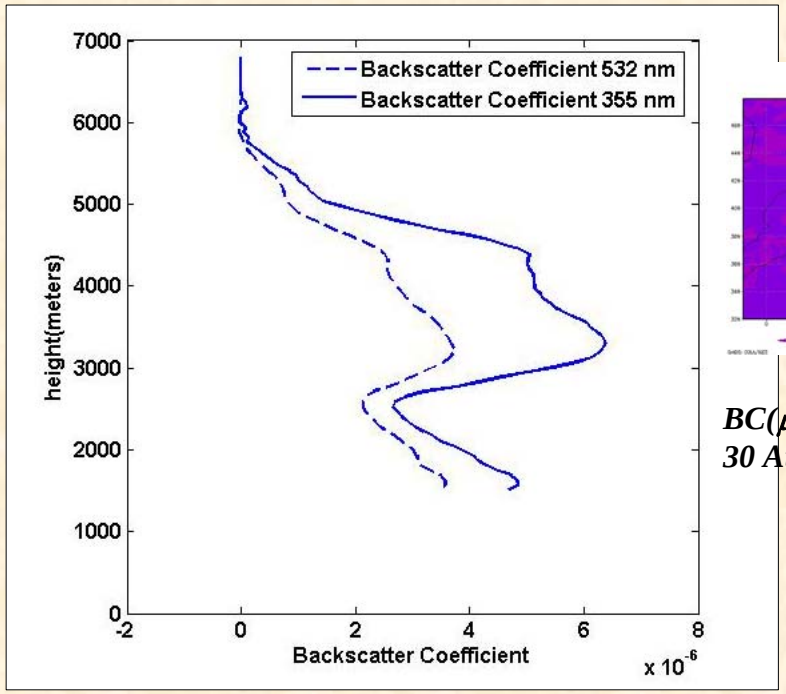


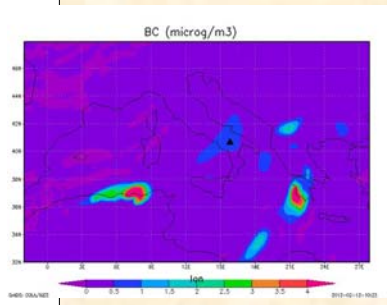
d)



- ***concentration field of BC (µg/m³) for the 30th August 2007 17UTC:***
  (a) sim bio-ant-fire and (c) fire at ground; (b) sim bio-ant-fire and (d) fire at 850Hp

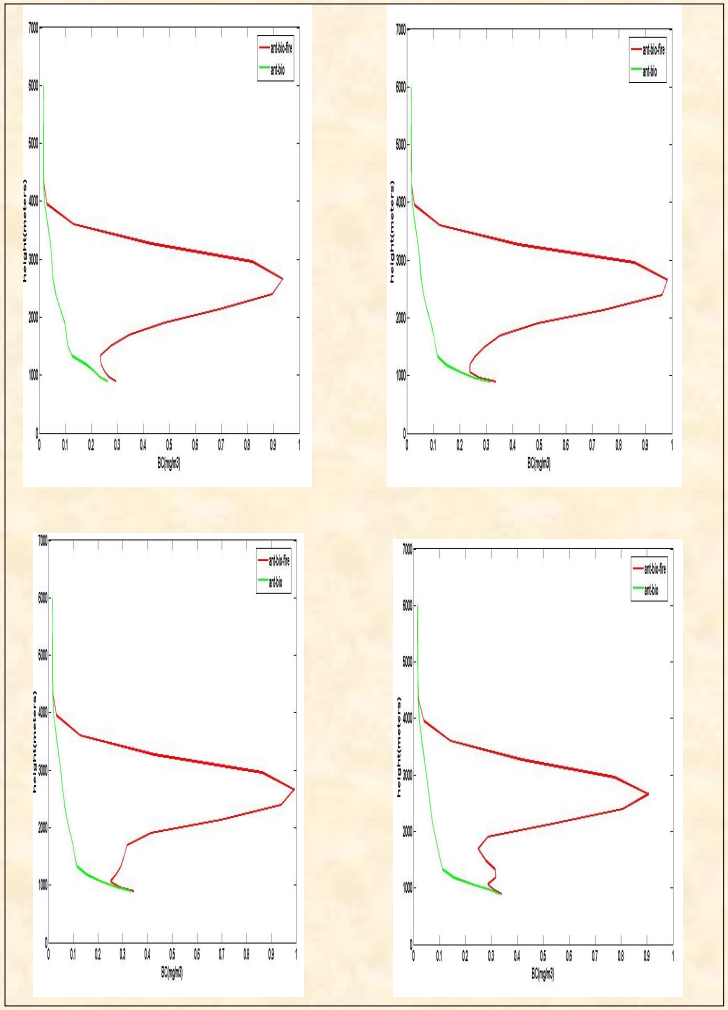
BOLCHEM simulations





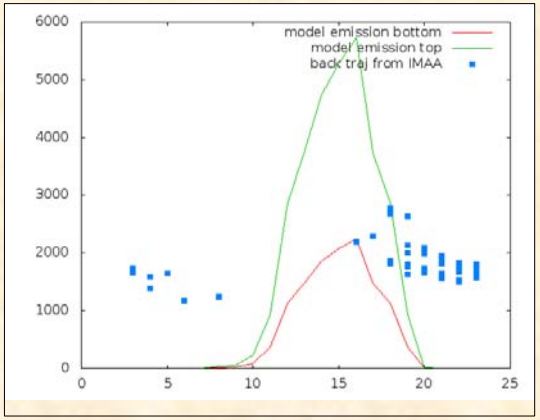
BC(μg/m³) at 850Hp sim fire 30 August 2007 at 18 UTC

- ***Backscatter profiles in PEARL station (Tito Scalo, Potenza (40,63 N, 15,80 E, 760 a.s.l.)) for the 30 August 2007 at 18UTC***



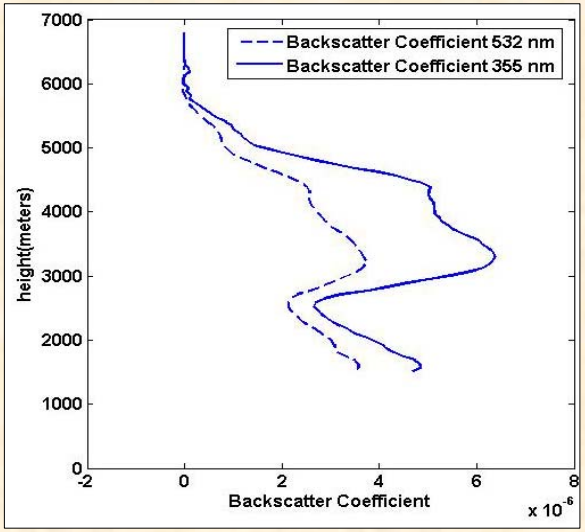
- ***simulated BC concentration (μg m^{-3}) profile at Tito Scalo at 18 UTC (a), 19 UTC (b), 20 UTC (c) and 21UTC***

BOLCHEM simulations

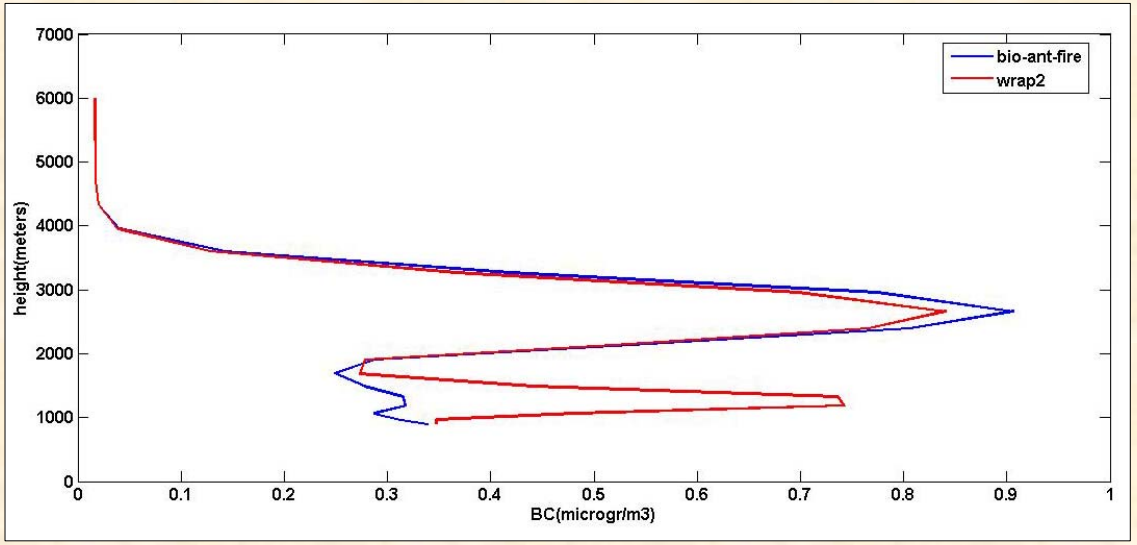


wrap2 setting, referring to wrap, increases the emission height for night time hours, and decreases both minimum and maximum emission height for early afternoon hours.

- ***Back trajectories heights (m) starting from Tito Scalo (30th August 2007 18UTC)***

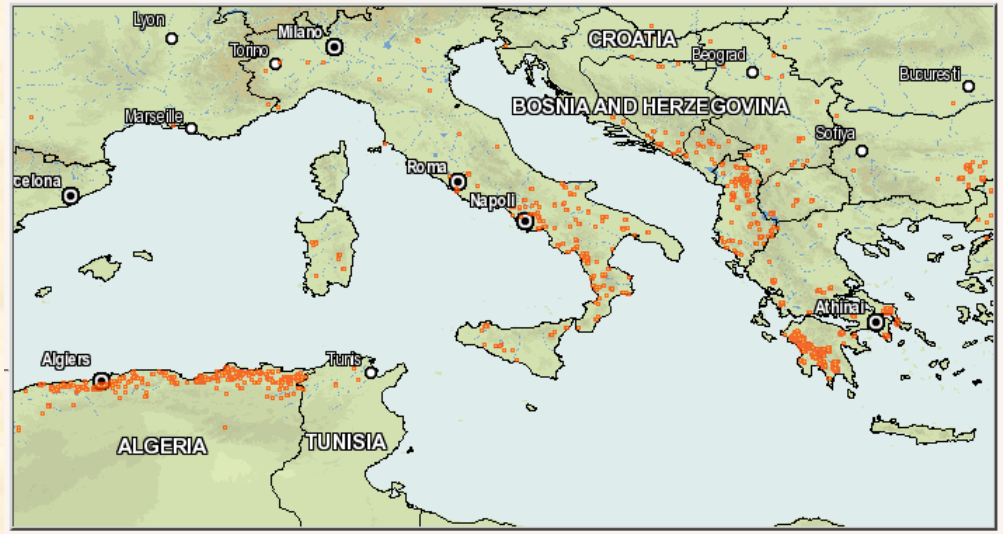


- ***Backscatter profiles in PEARL station for the 30 August 2007 at 18 hour***

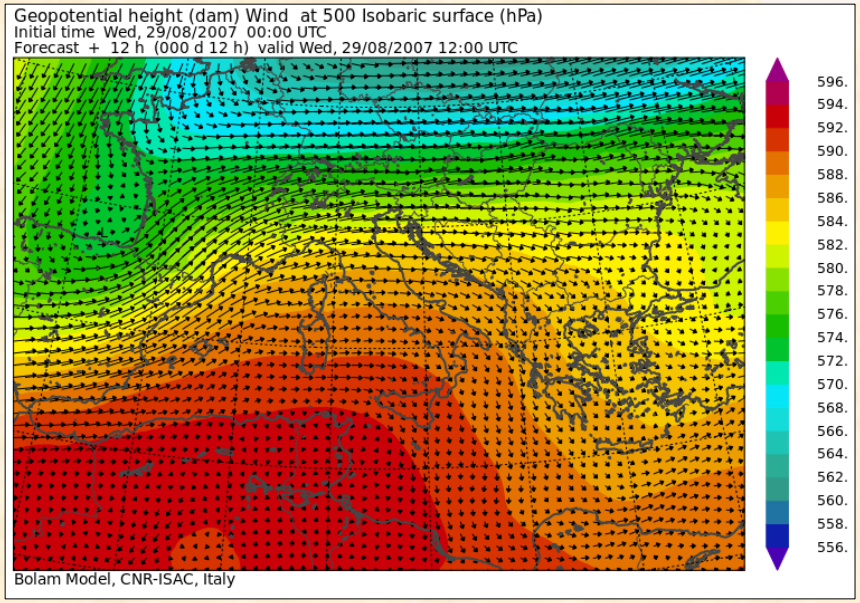


- ***BC concentration profile (μg m-3) from BOLCHEM at 21UTC at Tito Scalo (right).***

BOLCHEM simulation



- ***active fires map 22 - 31 August 2007***



- ***geopotential height and wind field at a 500Hp 29 August 2007 12 UTC***

preliminary conclusion

- ✓ **prebolchem_fire overestimates the wildfires emissions;**
- ✓ **the agreement is better when we consider the total quantity emitted during the whole case study period;**
- ✓ **differences between the two emissions are mainly due to different vegetation maps and due to different feature of used MODIS products.**
- ✓ **the model BOLCHEM captures the formation of aerosol layer, although difference in both vertical distribution and observation time are present;**
- ✓ **they are probably due to the uncertainties related to the estimation of emission fluxes and the adopted daily modulation of fluxes and emission height;**
- ✓ ***wrap2* simulation reproduces BC vertical profile at lower heights.**

- ➢ **further work will be carried out to test *wrap2*, comparing the output model with different measurement stations data;**

- ➢ **inclusion of a plume rise model in BOLCHEM**