High resolution modeling of CO spatial & temporal variations in Europe

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Our most recent studies with GEOS-Chem:

- **Nested-Grid model's configuration in Europe:**

  full-chemistry + tagged CO simulations (1^{o}x1^{o}) (following Wang et al., 2004)

  Acknowledgement: Philippe Le Sager

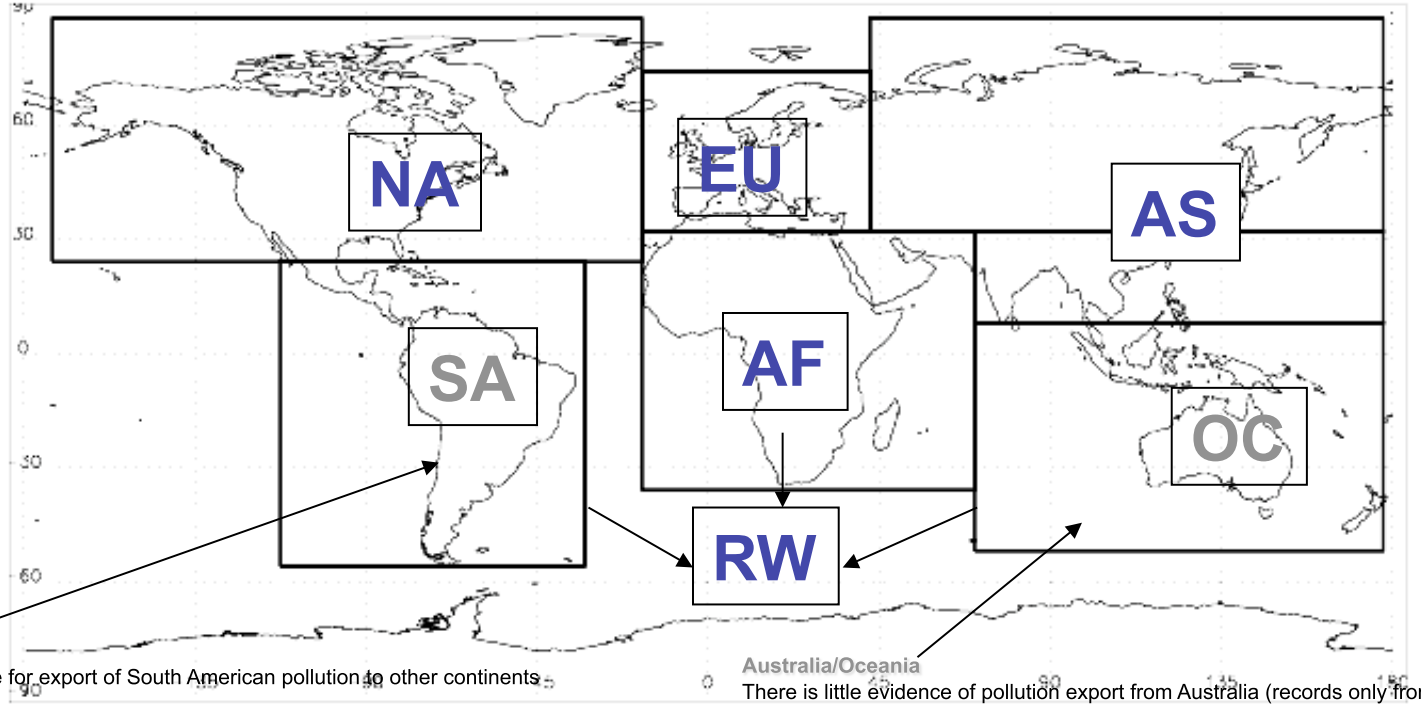
- **Coupling GEOS-Chem with a regional air pollution model for Greece**

  In press: ATMENV-D-08-00734R3

Outline of the presented work: Tagged CO simulations with nested-grid over Europe (v7-01-02)

- **Motivation: study CO budget in Europe**
- Set up the geographical regions
- Investigate differences between the results of the global and the nested-grid simulations in Europe
- Check differences for cold and warm periods for CO in several levels in LT, MT, UT
- Study the global CO Fluxes
- Estimate fractions over several contribution in European CO budget

Determine the geographical source regions:



South America
There is little evidence for export of South American pollution to other continents

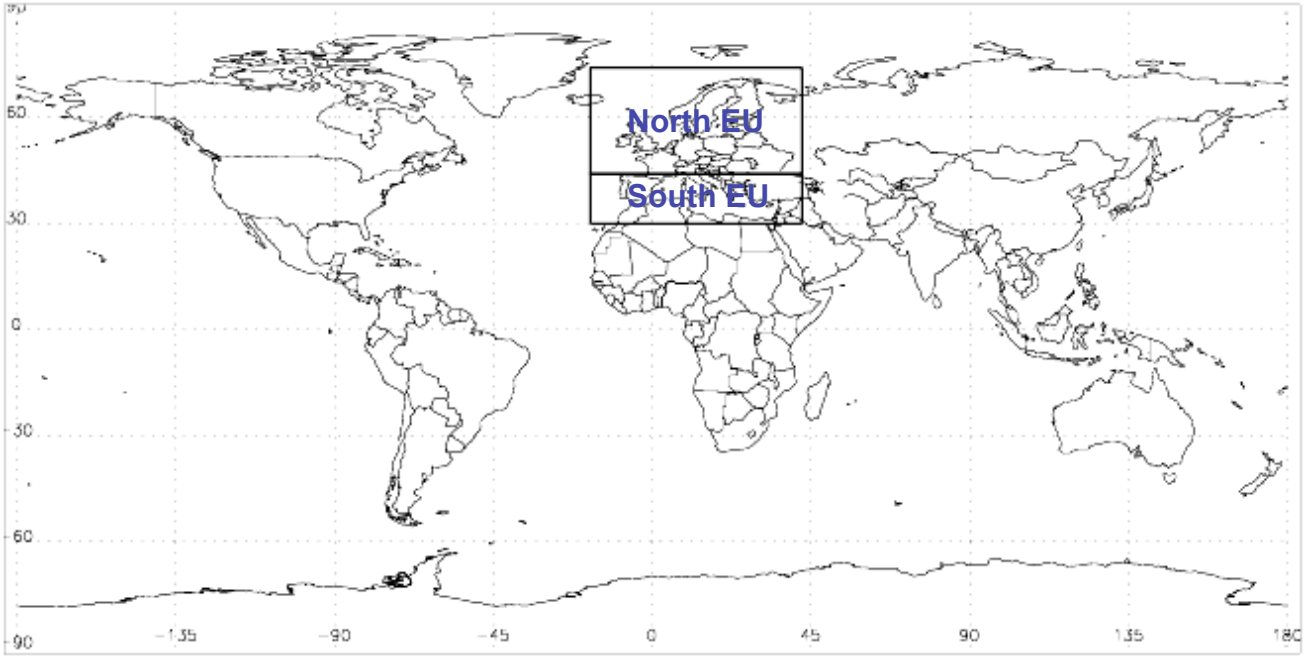
Australia/Oceania
There is little evidence of pollution export from Australia (records only from Australia to N.Zealand).

We focus on fossil fuel (FF), biofuel and biomass burning (BB) contribution in CO budget:

"European FF" = FF EU
"North American FF" = FF NA
"Asian FF " = FF AS
"Rest of World FF" = FF RW

"European BB " = BB EU
"North American BB" = BB NA
"Asian BB " = BB AS
"Rest of World BB" = BB RW

Nested-grid "North" and "South" inner tags in Europe for CO



We focus on fossil fuel (FF), biofuel and biomass burning (BB) contribution in CO budget:

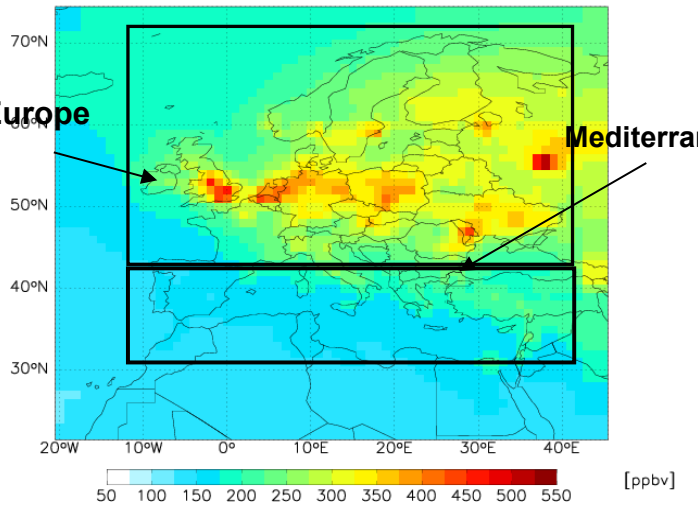
"FF of North Europe" = NEU
"FF of South Europe" = SEU

"BB of North Europe " = BB NEU
"BB of South Europe " = BB SEU

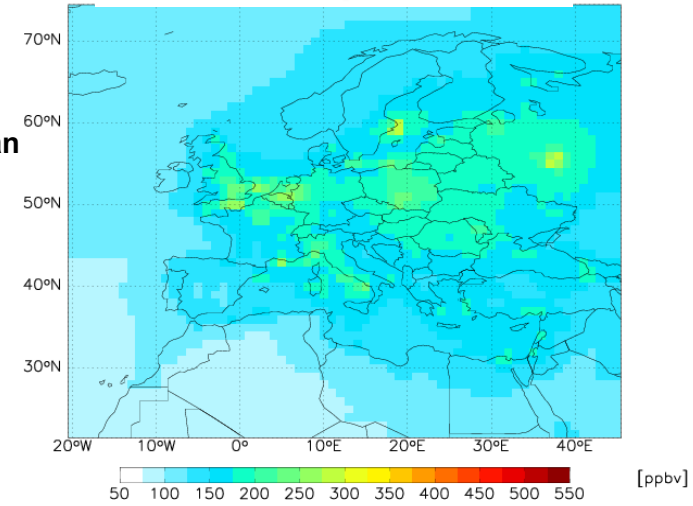
Examples to show differences between nested-grid (S_2) and global (S_1) model full-chemistry simulations

Nested-grid of G-C full-chemistry → CO in Europe at surface

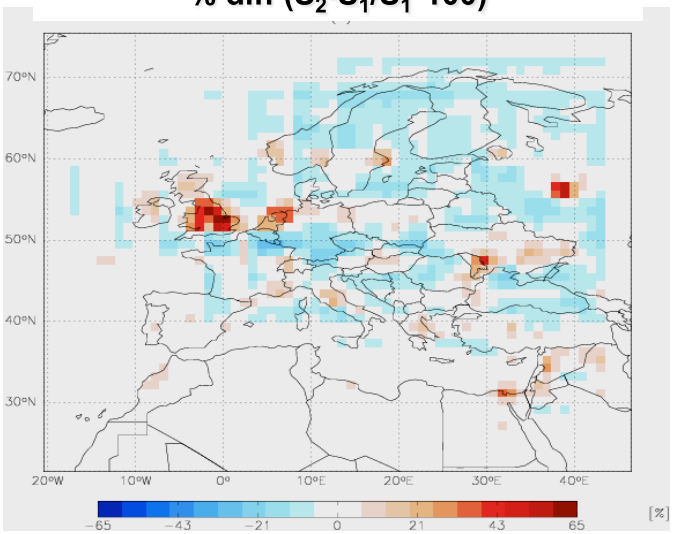
Cold period



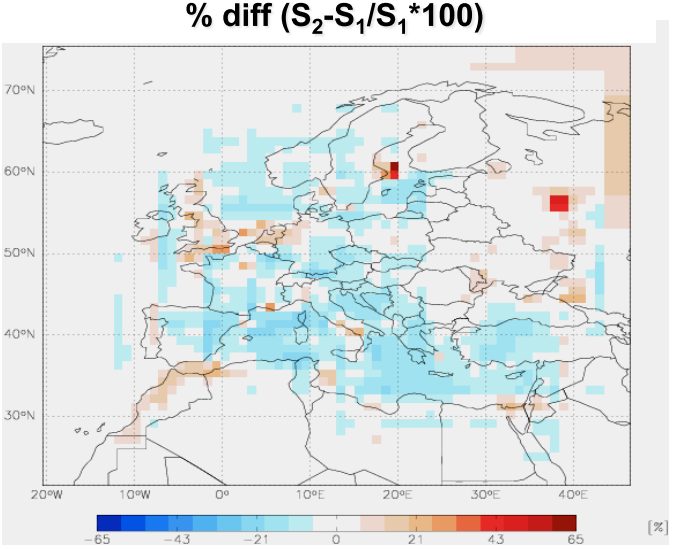
Warm period



% diff (S_2-S_1/S_1*100)



% diff (S_2-S_1/S_1*100)

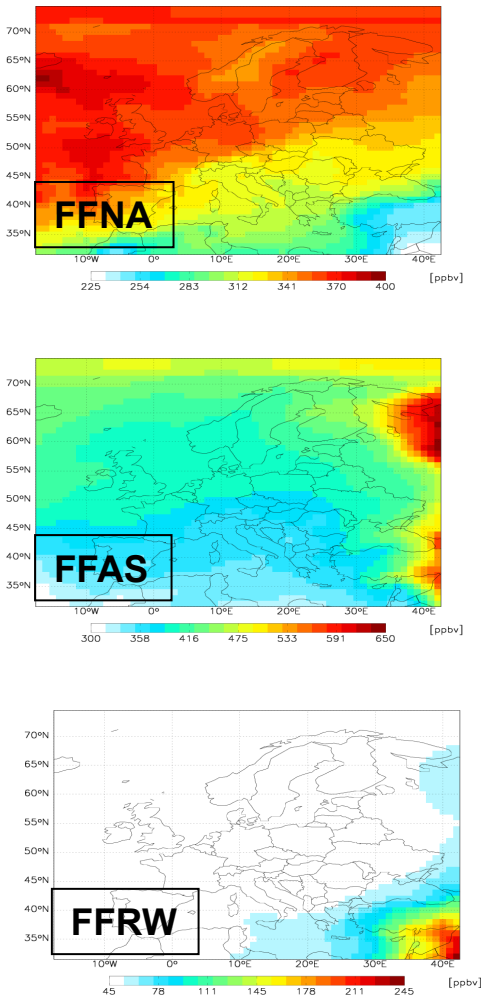


Examples to show the differences ….

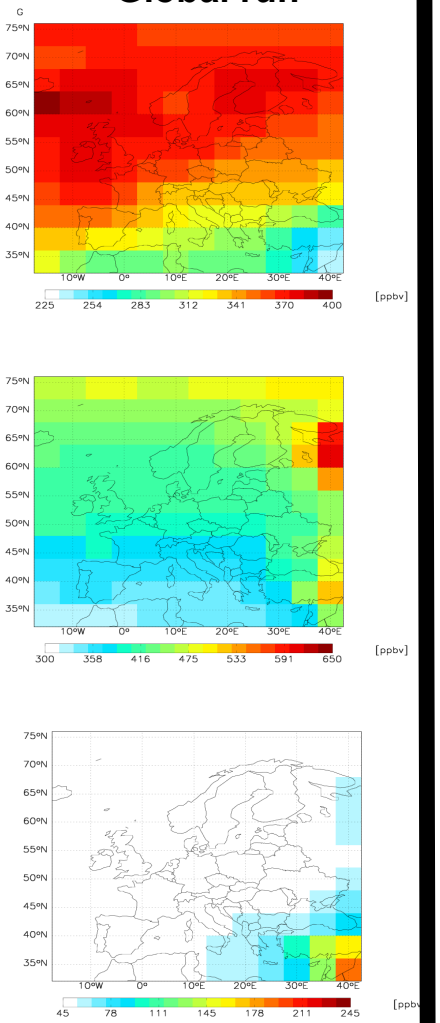
Contribution from other continents in CO European budget within the Troposphere

Cold period

Nested-grid run

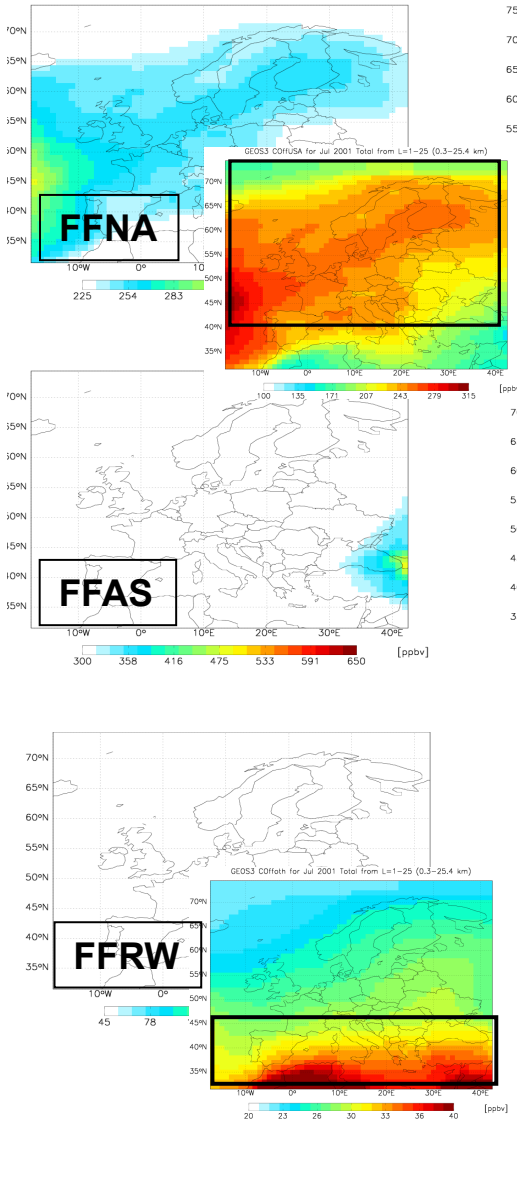


Global run

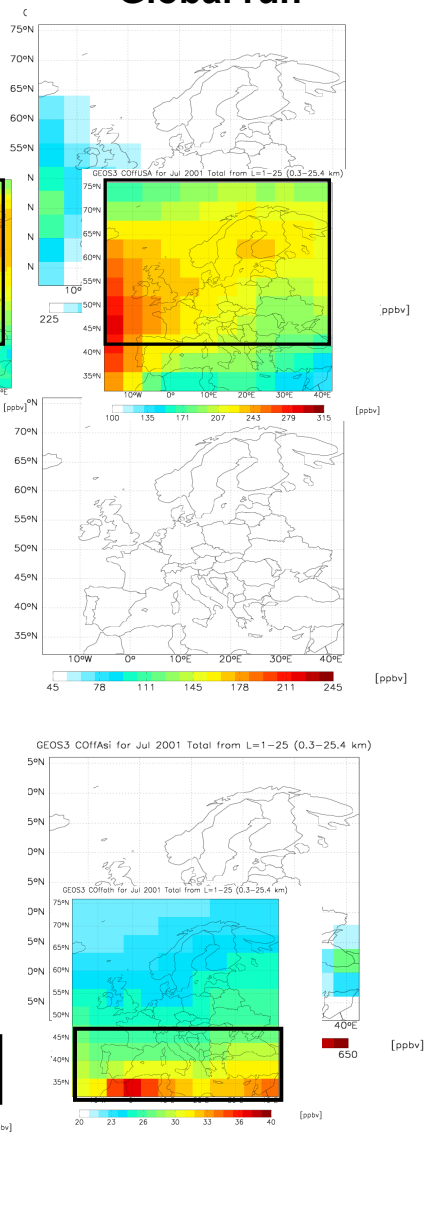


Warm period

Nested-grid run



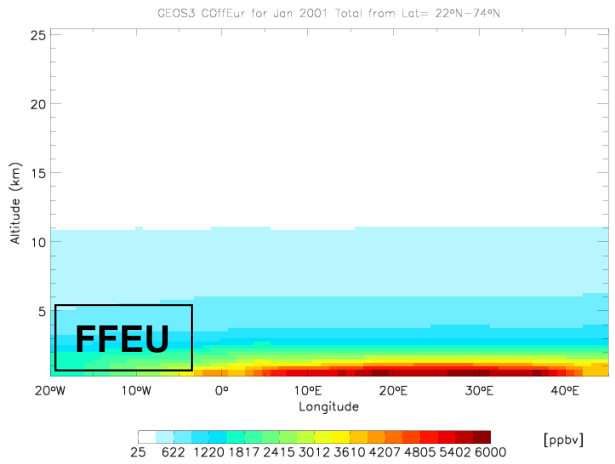
Global run



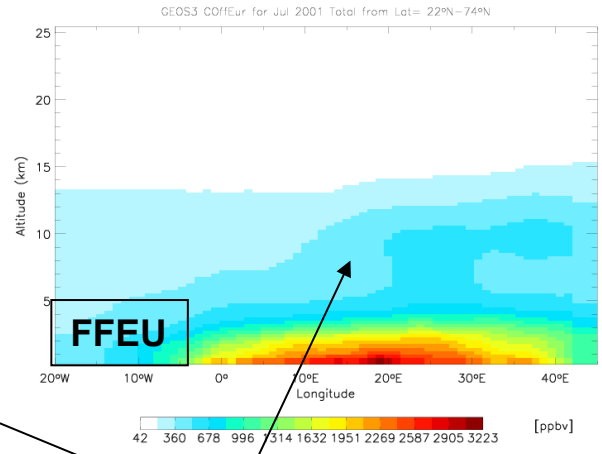
"European Fossil Fuel CO"

Vertical/longitudinal distribution within the European Troposphere

Cold period



Warm period



With increasing altitude in the atmosphere:

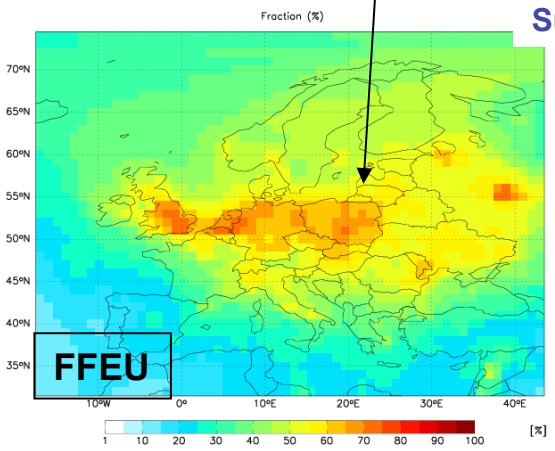
The impact of European sources strongly weakens with height.

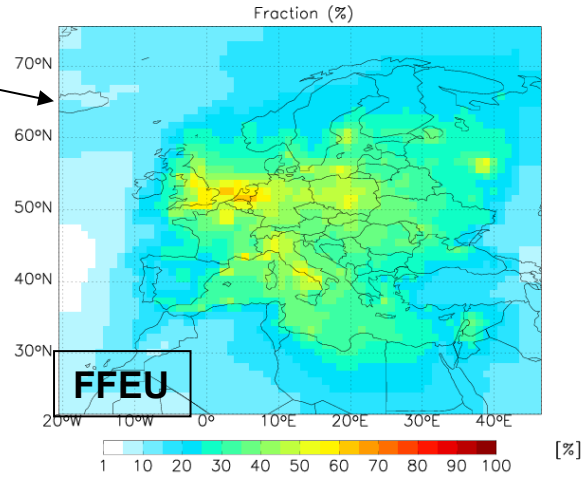
50% at 800m!

Near the surface:

the strongest contribution to the anthropogenic CO fields is attributed to European sources

Surface Fraction up to 74.6 %

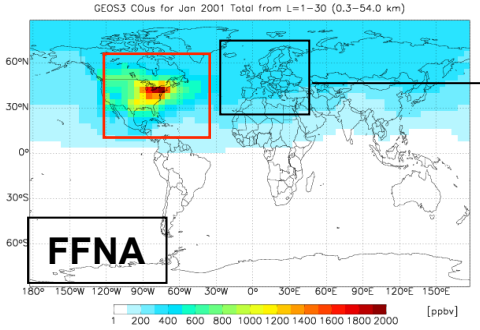




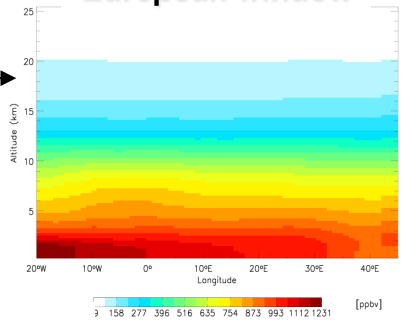
Contribution from LRT within the Troposphere

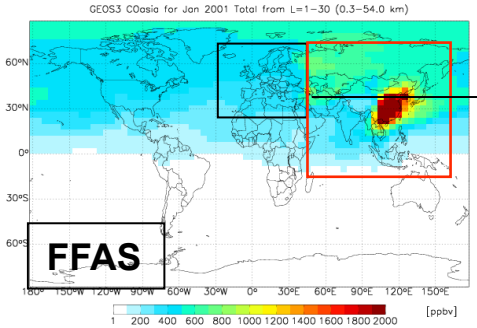
Cold period

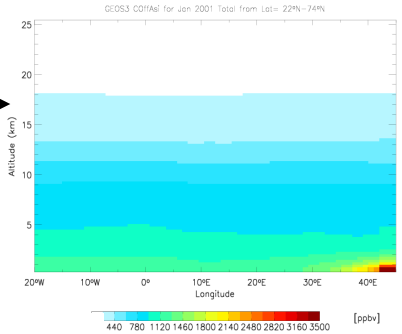
Global simulation Global map

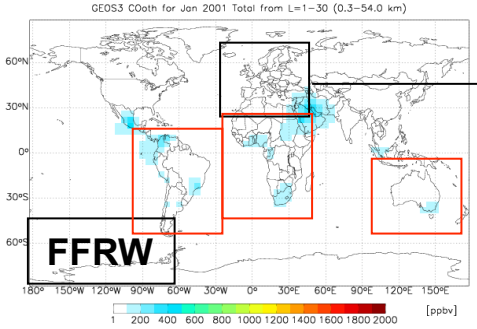


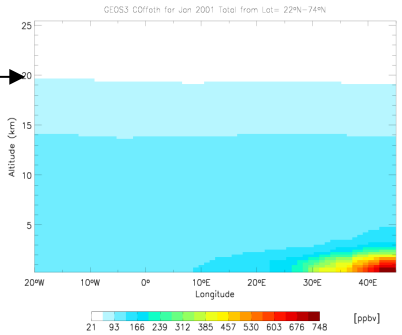
Nested-grid simulation European window





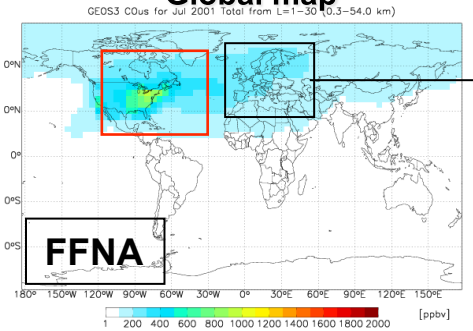




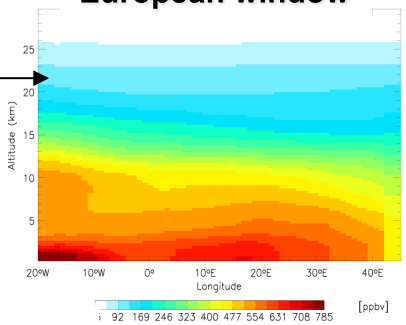


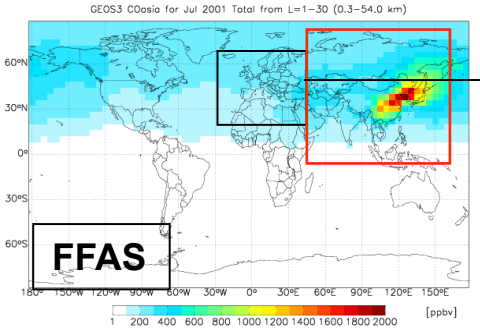
Warm period

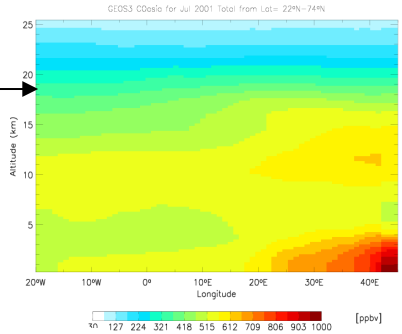
Global simulation Global map

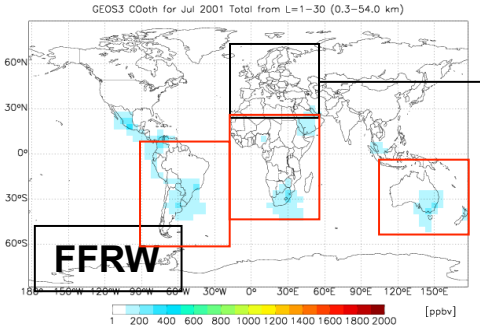


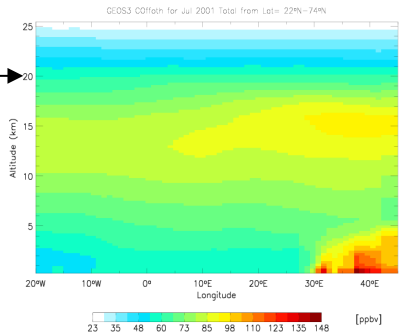
Nested-grid simulation European window









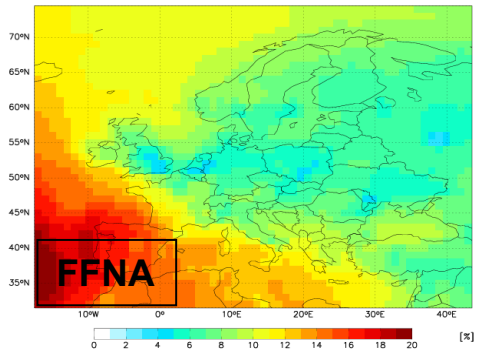


Cold period

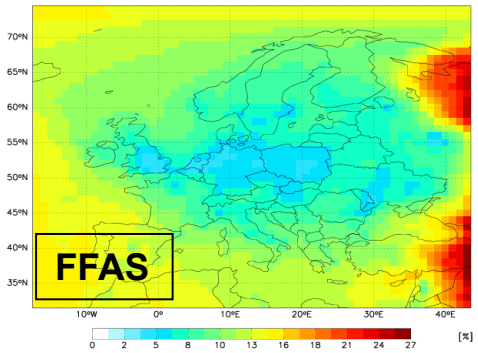
% Contribution from other regions at European CO (surface)

Fossil Fuels

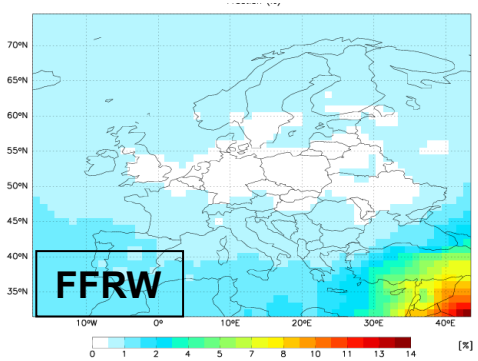
Fraction up to ~ 15 %



Fraction up to ~ 16 %

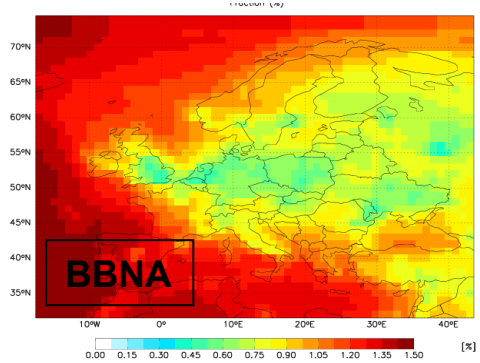


Fraction up to ~ 3%

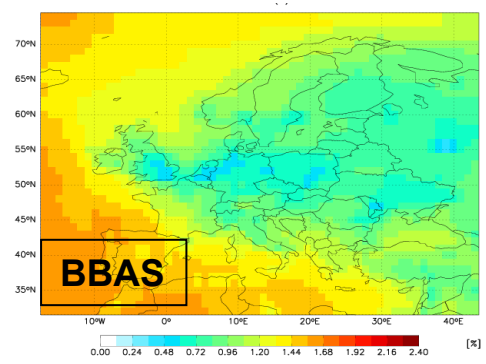


Biomass burning

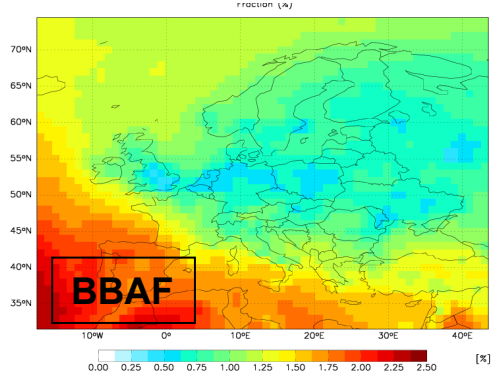
Fraction up to <1 %



Fraction up to <1 %



Fraction up to <2 %



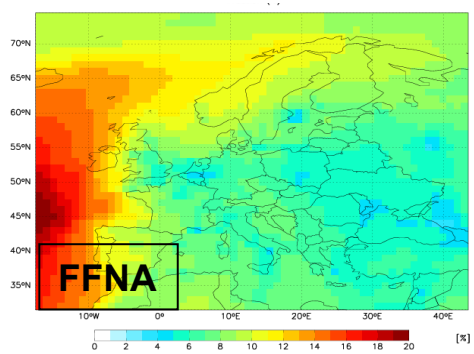
Warm period

% Contribution from other regions at European CO (surface)

Fossil Fuels

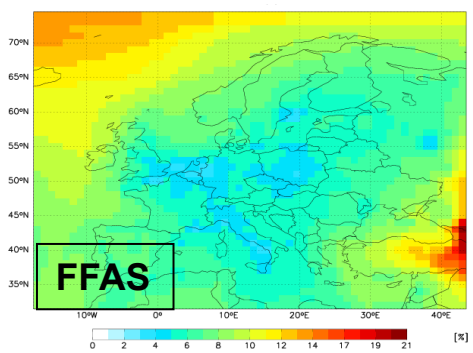
Weaker than cold period

Fraction up to ~ 8-10%



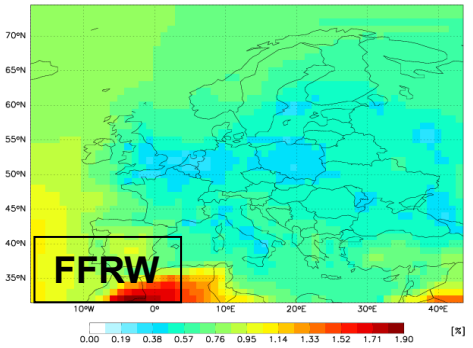
Weaker than cold period

Fraction up to ~ 8-10 %



Smaller than cold period

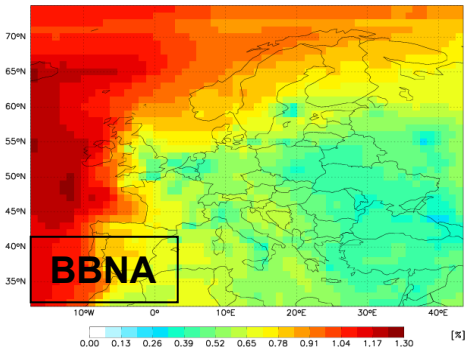
Fraction up to <1 %



Biomass burning

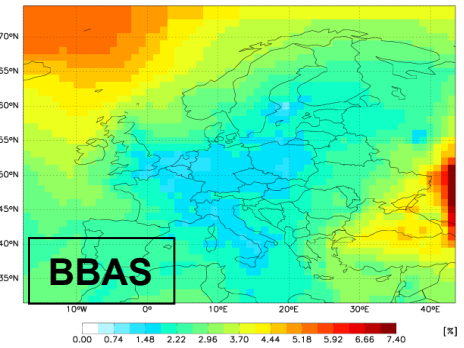
Weaker than cold period

Fraction up to <1%



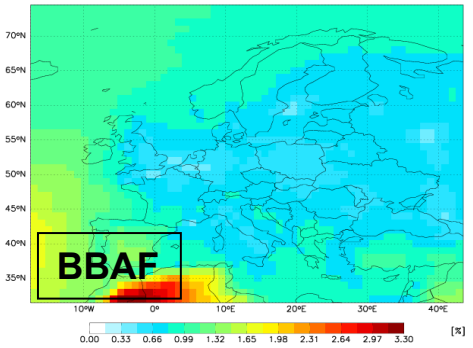
Higher than cold period

Fraction up to <3 %



Smaller than cold period

Fraction up to <1 %



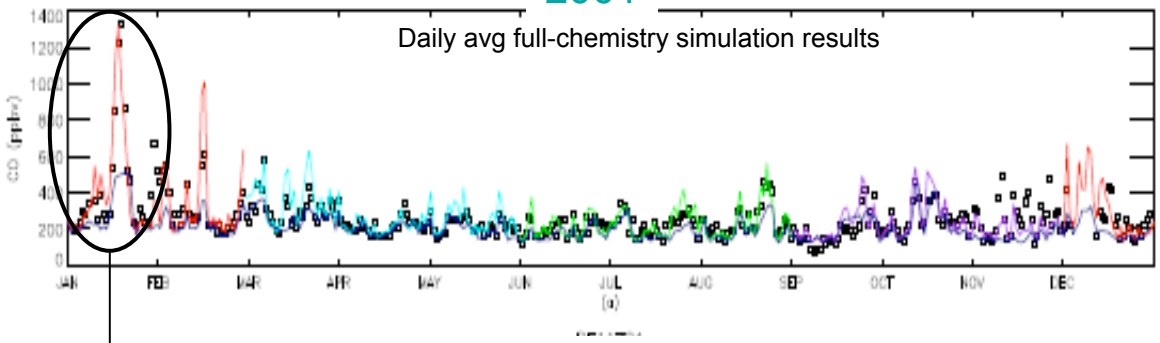
NL0229A

A station in the Netherlands at O m a.s.l., close at coast & to major anthropogenic sources

R^2: On annual basis the correlation between the model and the observation is strong (0.9)

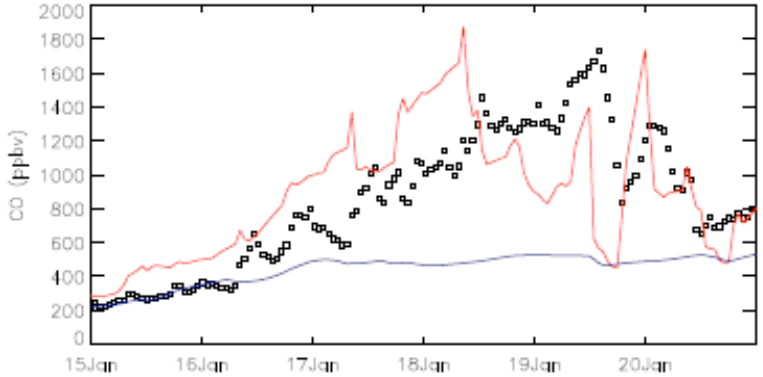
2001

Daily avg full-chemistry simulation results



15-21 January

Hourly full-chemistry simulation results



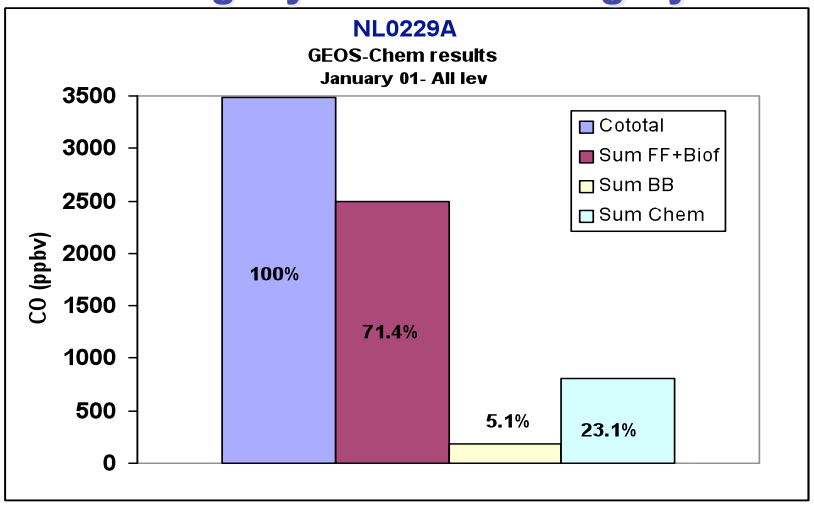
Black boxes: obseravtions
Red line: nested-grid run
Blue line: global run

Tagged CO nested-grid simulation results

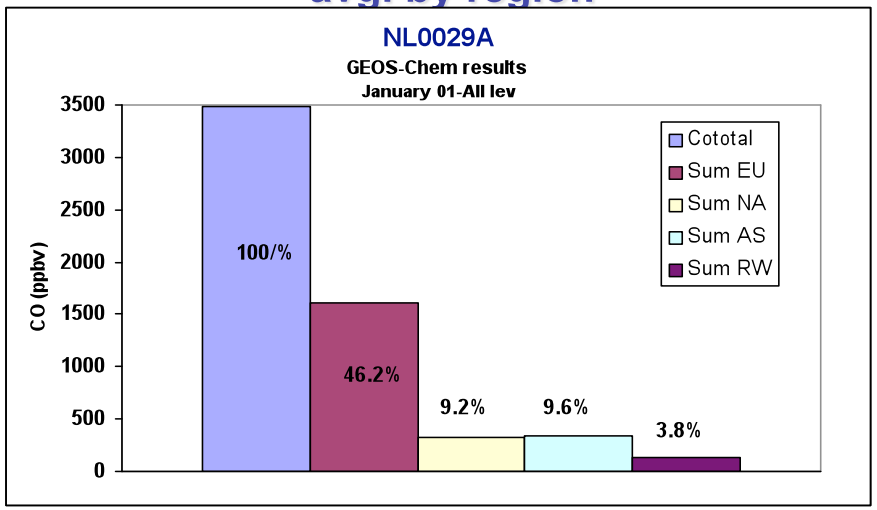
NL0229A

January 2001

Mean monthly CO within the troposphere avg. by emission category



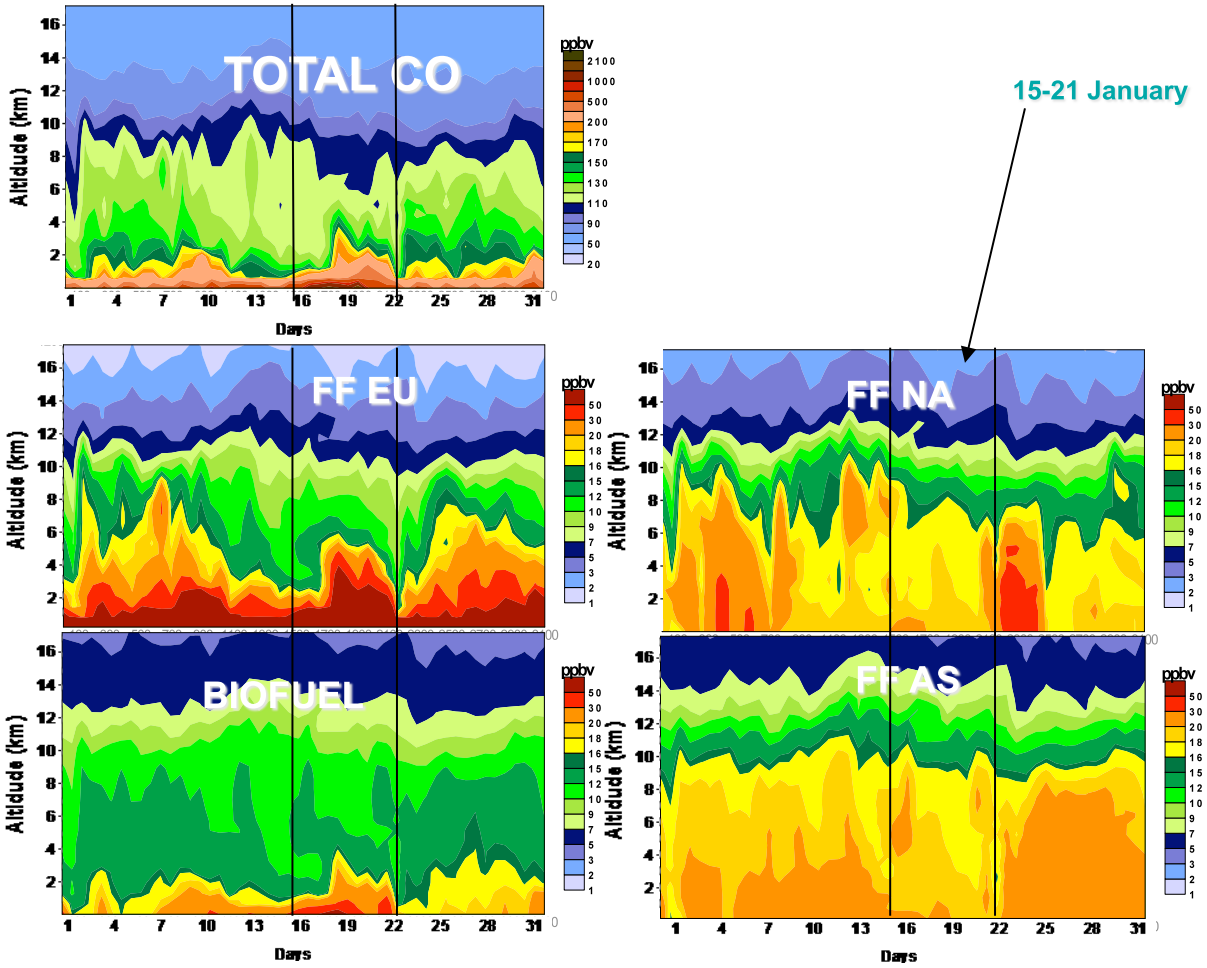
Mean monthly CO within the Troposphere avg. by region



NL0229A

Tagged CO nested-grid simulation results

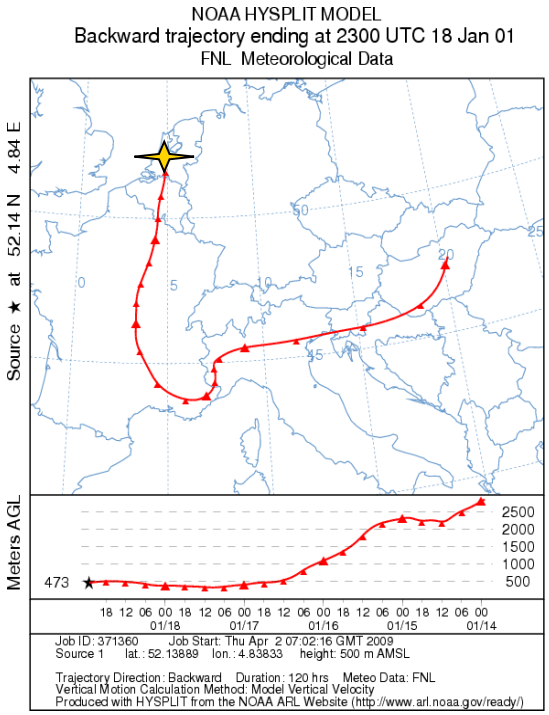
January 2001



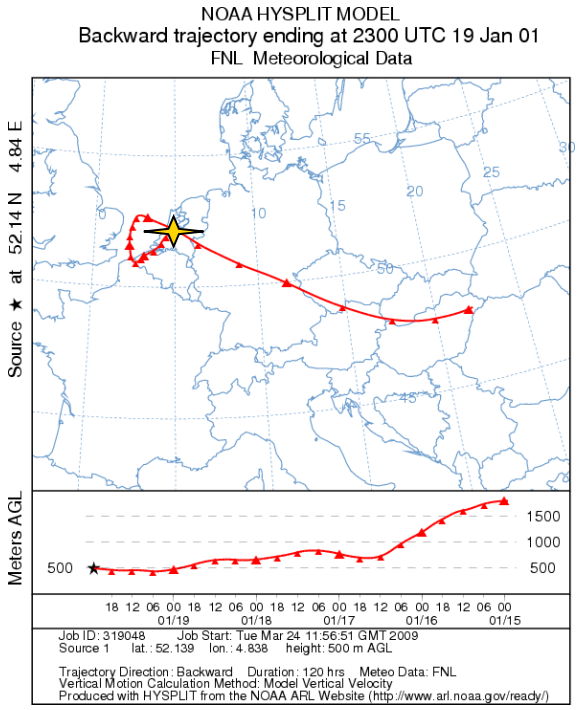
NL0229A

Trajectories HYSPLIT

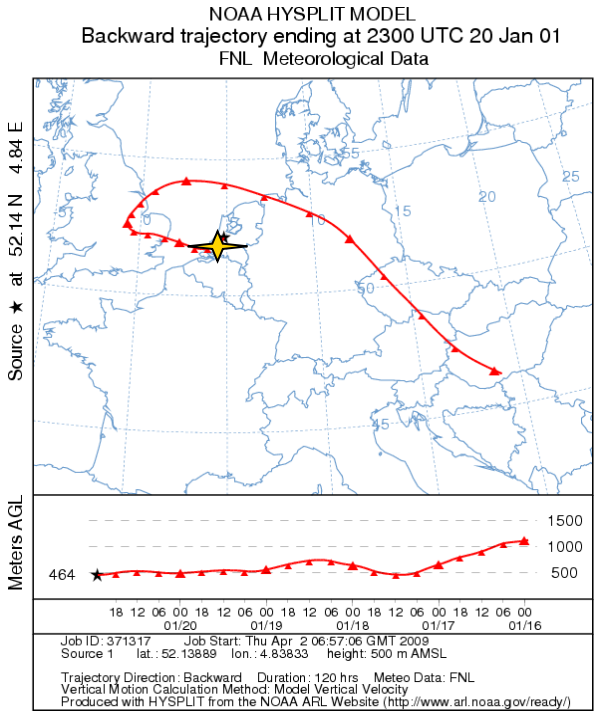
18 Jan



19 Jan



20 Jan

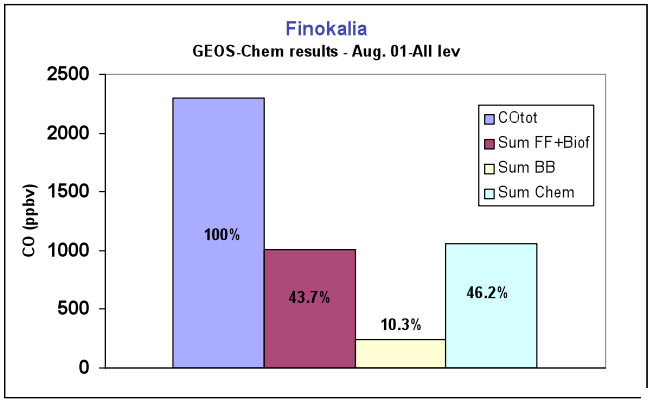


Finokalia – different approach ➔ Inner tags in Europe

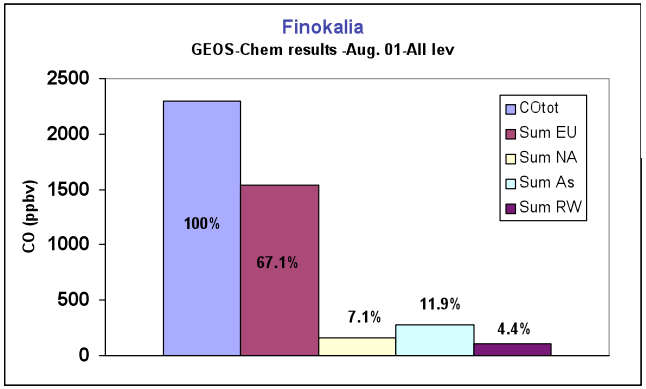
A station in Greece at 130 m a.s.l., close at coast, downwind from LRT, remote from major anthropogenic emissions – south border

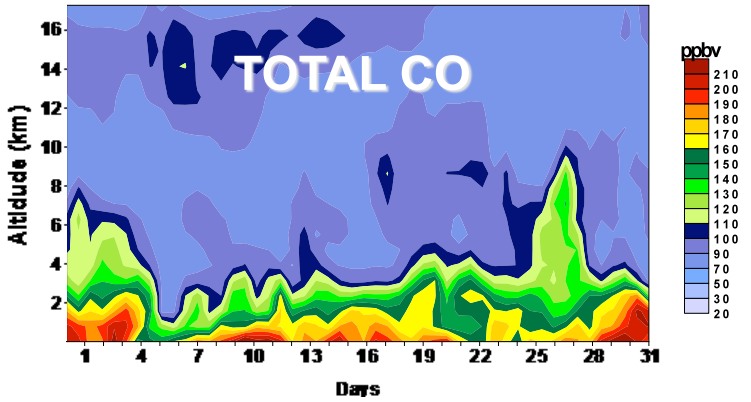
August 2001

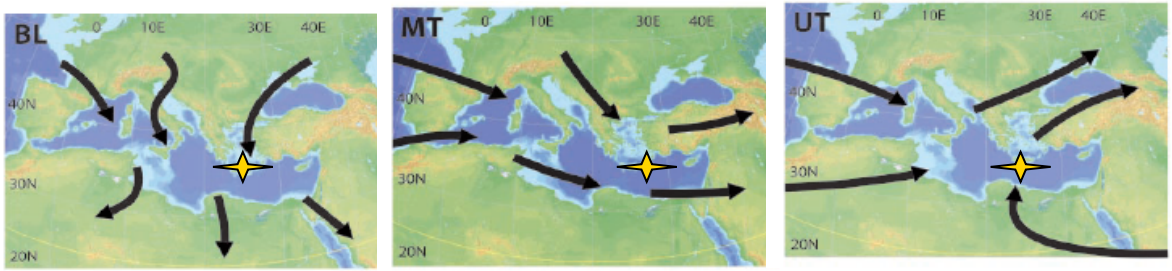
Avg. by emission category



Avg. by region





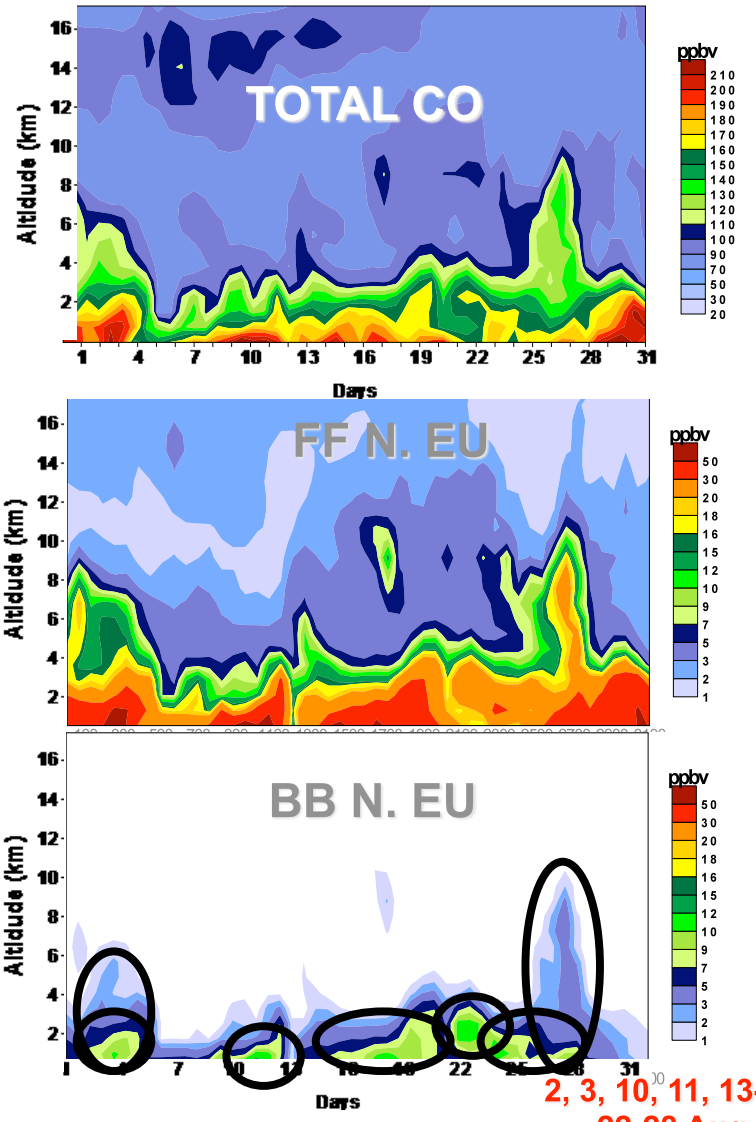


[Lelieveld et al., 2002]

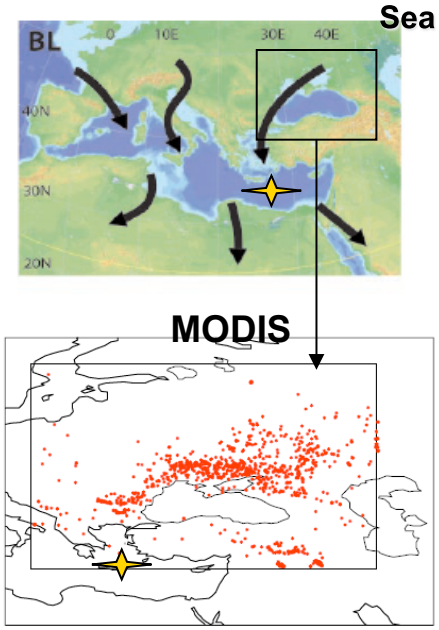
North Europe Tags for CO

Finokalia

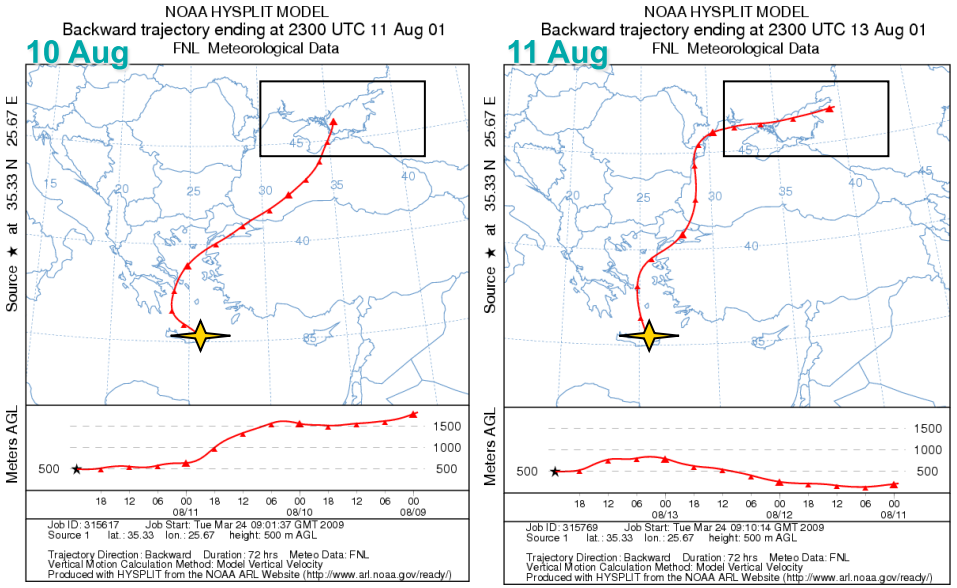
August 2001



Sea of Azov



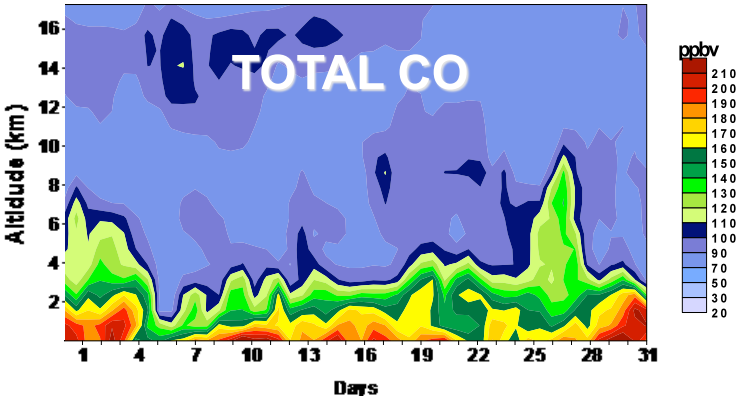
Trajectories HYSPLIT
Finokalia @ Greece



South Europe Tags for CO

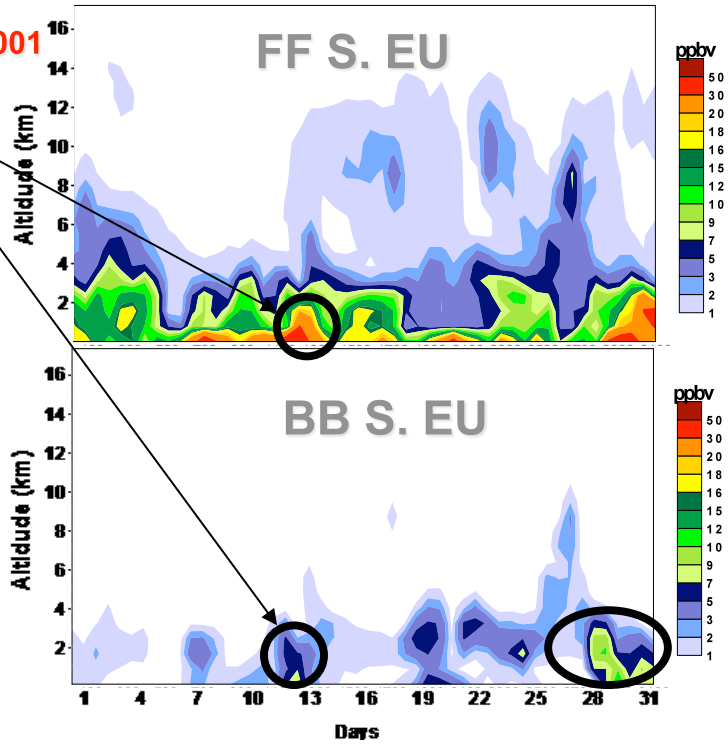
Finokalia

August 2001

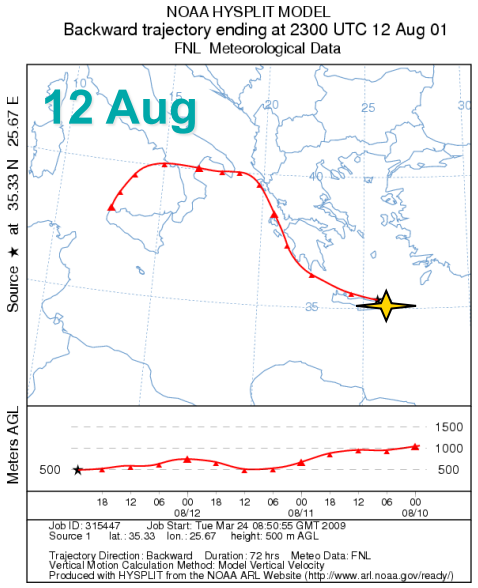


12 Aug 2001

Italy



Trajectories HYSPLIT
Finokalia @ Greece



Conclusions

- Nested-grid configuration of GEOS-Chem to study air pollution in Europe is efficient. Differences between the global and the nested-grid simulations both in full-chemistry and tagged CO simulations

- On average, the largest contribution (up to 75%) to CO budget in Europe originates from regional anthropogenic sources. Their predominant impact is near the surface and it strongly weakens with increasing altitude (8% at MT).

- With increasing altitude, anthropogenic CO from Asia and North America gains in importance, reaching maximum contributions for North American CO at MT and for Asian CO at UT.

- 2 pollution episodes examined, where high CO levels originated from different sources

On going and future work

- Poster session: Climate change in the Eastern Mediterranean-Links with air quality by Kostas Varotsos
- Running GEOS-Chem with GISS data under the future emission scenario A1B of the IPCC for the Eastern Mediterranean

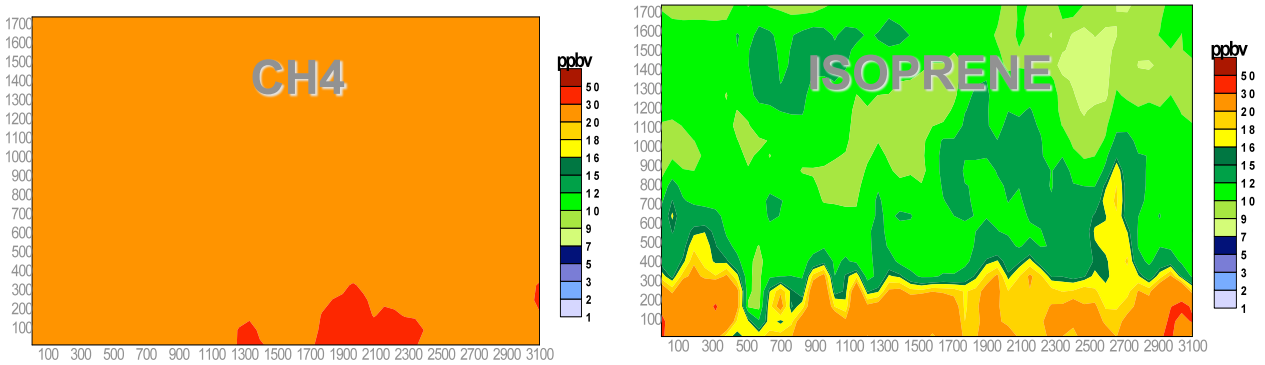
Thank You!!

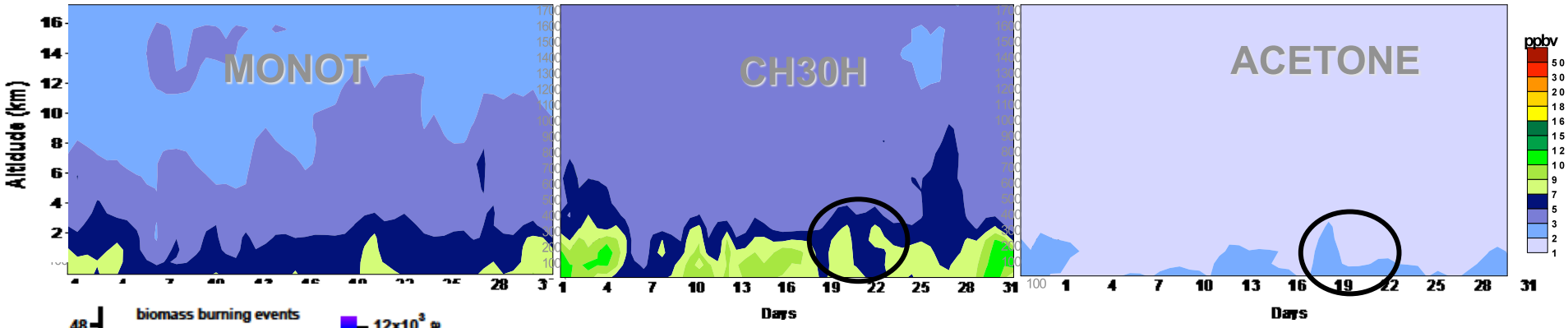
Additional slides

Finokalia, Greece

August 2001

Chemical contribution to CO budget





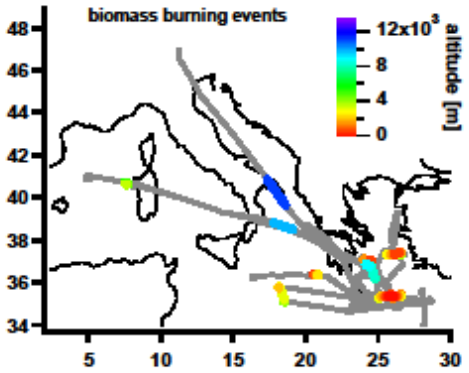


Fig. 1. Flight tracks and location of biomass burning plumes.

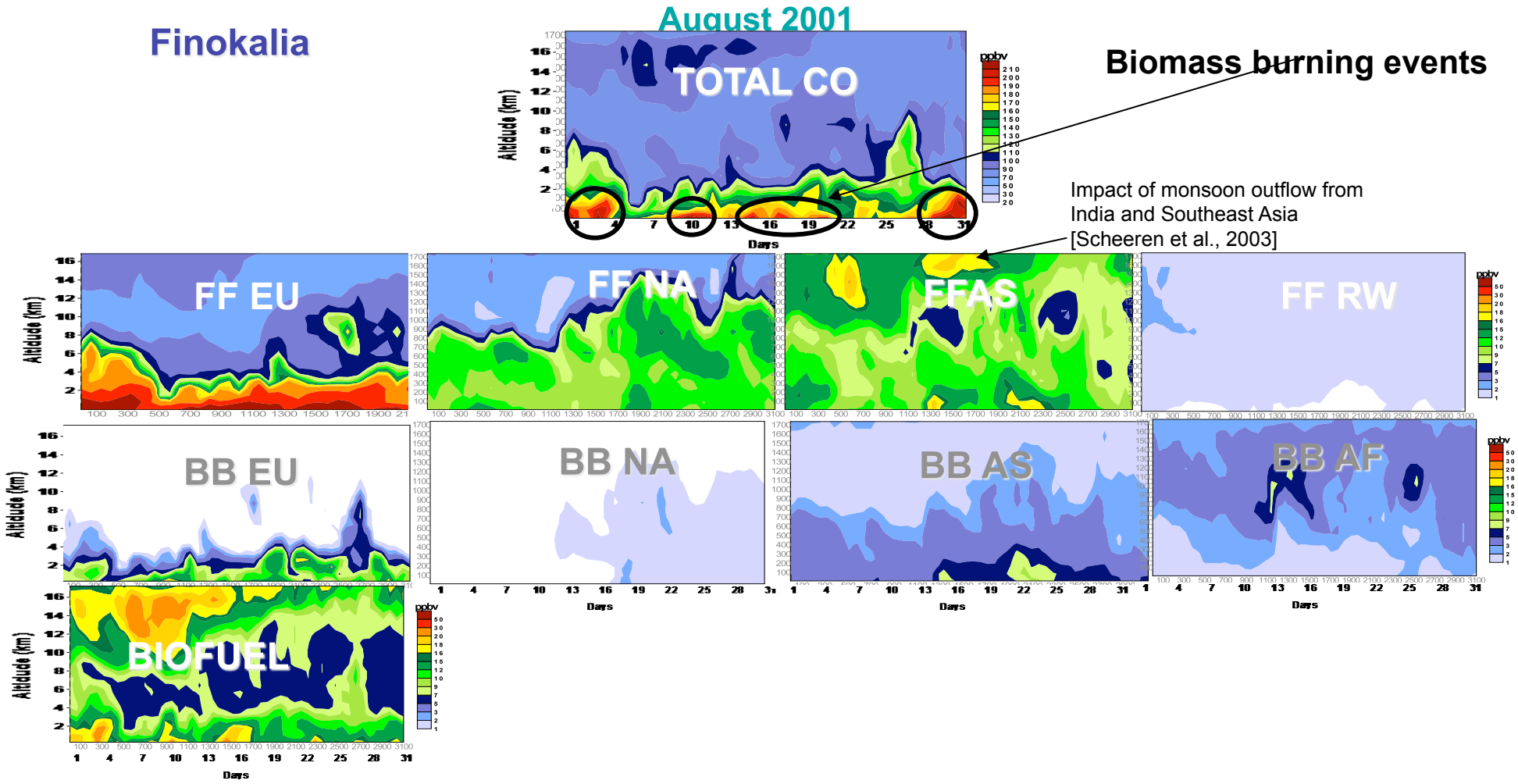
Table 1. Time, position and NEMRs of biomass burning plumes encountered during MINOS.

Time	Position	Alt[a]	acetonitrile[b]	Methanol[c]	acetone[c]	MAN[c]	CO[c]
14.08. 06:21	37.0N, 24.3E	1.9	290	26.4	2.1	−1.1	476
14.08. 12:55	37.3N, 26.2E	3.7	285	24.1	14.1	5.5	753
14.08. 13:14	37.4N, 26.1E	1.7	209	20.7	18.8	6.1	792
17.08. 14:13	35.4N, 26.1E	2.8	192	24.9	19.2	2.8	907
19.08. 10:46	35.3N, 25.9E	1.9	245	18.7	8.6	1.7	477
19.08. 15:44	36.4N, 20.7E	1.3	211	17.2	10.0	6.5	n.m.
19.08. 16:29	35.3N, 25.4E	1.8	237	12.4	4.6	0.8	356
22.08. 05:52	38.7N, 18.4E	9.8	180	13.7	8.7	3.2	380
22.08. 10:33	40.7N, 7.6E	4.6	155	14.3	9.2	5.8	381
24.08. 08:17	40.2N, 18.0E	11.1	214	24.5	12.6	3.4	467
	geometric mean[d]			19.0	9.1	3.2	498

[a] Altitude in km.
[b] Average volume mixing ratio of acetonitrile in the plume in units of pmol/mol.
[c] Normalized excess mixing ratio (NEMR) in units of mol/mol.
[d] Geometric mean of individual NEMRs; negative values have been omitted.

Holzinger et al. [2005]

Finokalia


August 2001
TOTAL CO
Biomass burning events
Impact of monsoon outflow from
India and Southeast Asia
[Scheeren et al., 2003]
FF EU
FF NA
FFAS
FF RW
BB EU
BB NA
BB AS
BB AF
BIOFUEL
Altitude (km)
Days
ppbv

Examples to show the differences ….

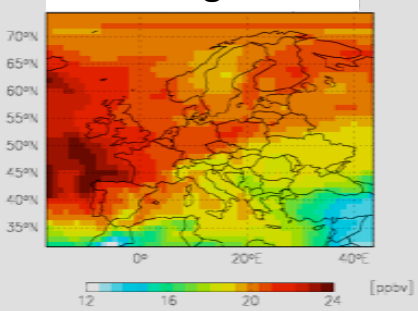
Influence from N. American FF

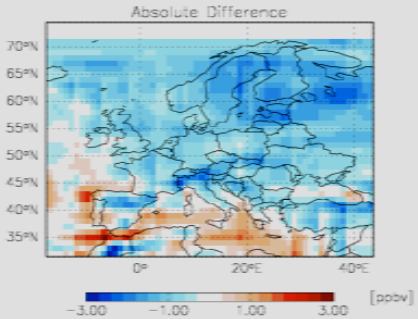
Cold period

Results at 2km

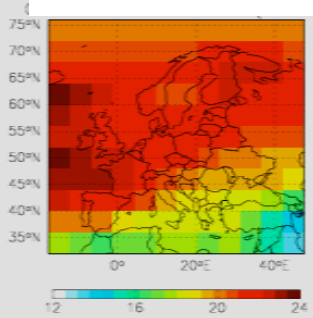
Warm period

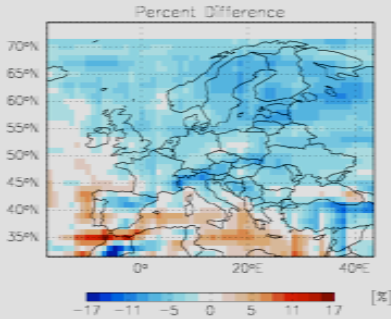
Nested-grid run



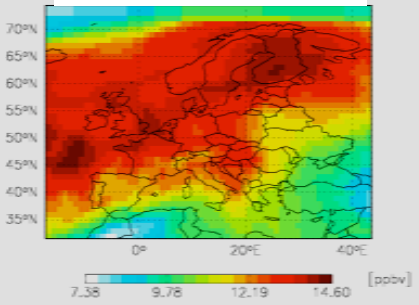


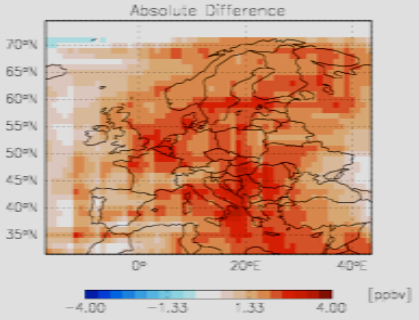
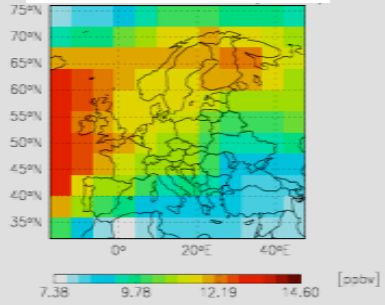
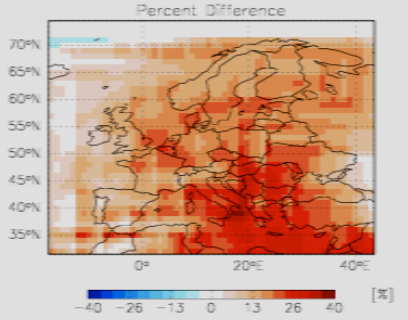
Global run





Nested-grid run





Global run