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Case studies on aerosol feedback effects in online coupled chemistry-meteorology models during the 2010 Russian fire event

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Introduction

Integrated or online coupled meteorology-chemistry models permit the simulation of

- aerosol radiative effects (direct aerosol effect)
- aerosol cloud interactions and resulting effects on radiation (indirect aerosol effect)
- feedback effects to meteorology

→ Different online coupled meteorology-chemistry models may respond differently to the same aerosol emissions

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COST ES1004 (EuMetChem) Case Studies

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Simulations for prescribed episodes with identical emissions and boundary conditions

- Base case: no interactions with simulated aerosol
- Only direct aerosol effect based on simulated aerosol
- Direct and indirect aerosol based on simulated aerosol effect

Two episodes in the year 2010

- The Russian heat wave and wildfires episode in
- A period in October 2010 (rainy, later a dust event)

cost

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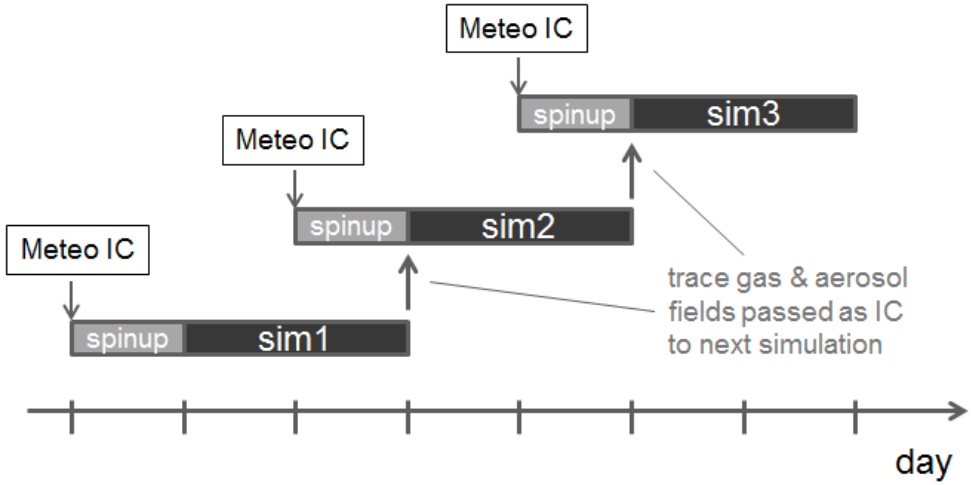
COST ES1004 Case Studies: Setup

General setup following (AQMEII model intercomparison):

- 1-day meteo-only spin-up + 2-days simulations with chemistry
- Chemistry restarted from previous 2-day run

Long enough to allow feedback ↔ short enough for suppressing semi-direct effects?



Modelling domain covers entire Europe + NA (with one exception)

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Contributions to the case studies

Modeling protocol:
Distributed to EuMetChem WG2/WG4 mailing list members + 5 additional possible participants on June 24th.

Response:

- Mostly none
- 9 positive (four of them for a joint effort, participation of one - until Oct. 2014 - non-member)
- 3 „perhaps, if time“
- 2 negative

Some of the positive responses were withdrawn later

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Contributions to the case Studies

	Lead Institution	Model	Episode	Runs	Resolution
CS1	Univ. Lubljana, KIT/IMK-IFU *	WRF-Chem (a)	Fire, dust	Base, direct, dir&indir	23 km
CS2	Univ. Lubljana, KIT/IMK-IFU *	WRF-Chem (b)	Fire	Base, direct, dir&indir	9.9 km
ES1	Univ. Murcia	WRF-Chem (c)	Fire, dust	Base, direct, dir&indir	23 km
DE3	IFT Leipzig	COSMO Muskat	Fire, dust	Base, direct	0.25°
ES3	UPM-ESMG	WRF-Chem (d)	Fire, dust	Base, direct, dir&indir	23 km
CH1	EMPA	COSMO-ART	Fire, dust	Base, direct	0.22°
ES2	BSC	NMMB/BSC-CTM	Fire, dust	Base, direct	0.22°

(a) RADM2/MADE-SORGAM
(b) same as (c), but with higher resolution
(c) RADM2/MADE-SORGAM, Lin microphysics
(d) CBMZ/MOSAIC

*: Joint effort, also including ZAMG, RSE, UPM-ESMG

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Results overview

Results shown for

- CS1 (WRF-Chem with RADM2-MADE)
- CS2 (WRF-Chem with better resolution)
- DE3 (COSMO-MUSCAT)
- ES3 (WRF-Chem with CBMZ-MOSAIC)

ES1 discussed in more detail in Rocío Baro‘s talk:

→ Quite similar to CS1 contribution

→ Not shown here

Comparison with observations near Moscow

Courtesy of Dr. Natalia Chubarova, Moscow State University for providing surface measurement data from the national network (Mosecomonitoring) operated by the Meteorological Observatory of Moscow

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Baseline PM10

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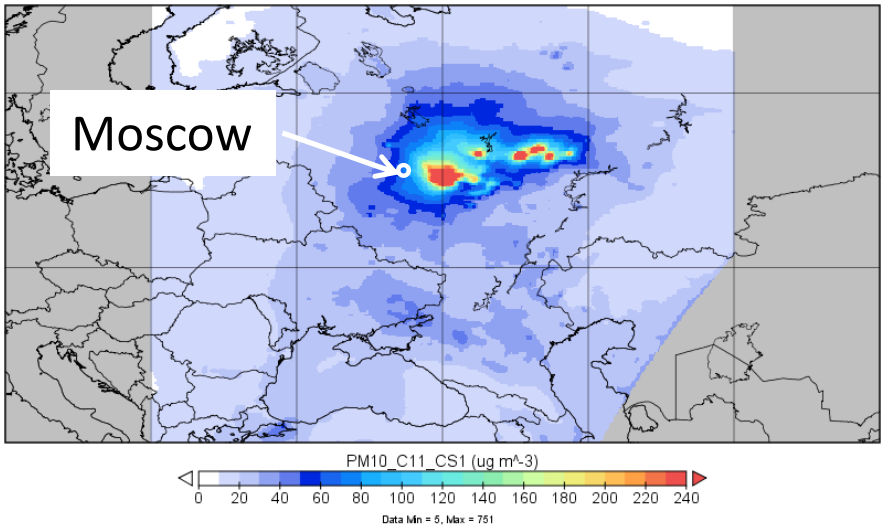
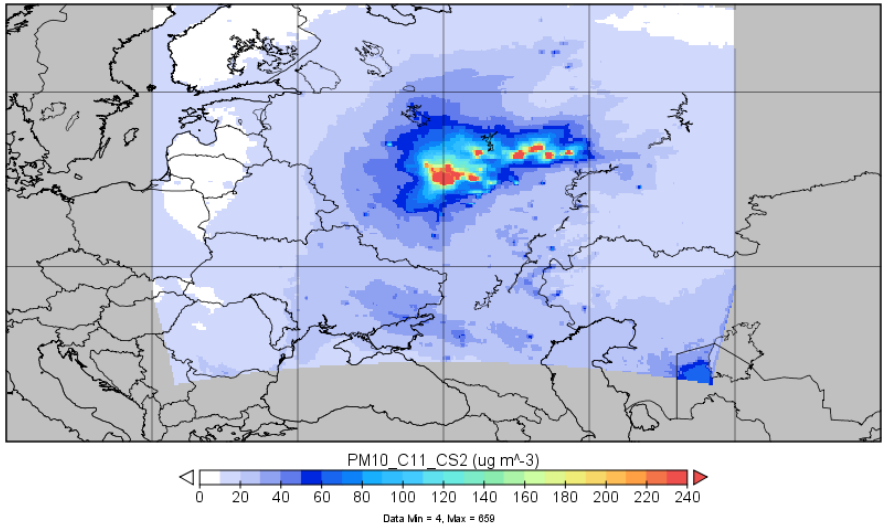
Episode mean PM10 (µg m^{-3})

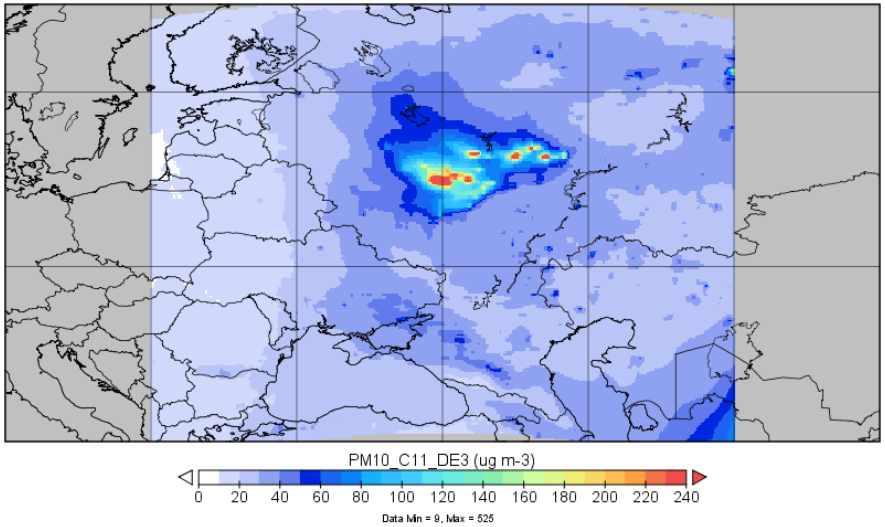
PM10_C11_CS1



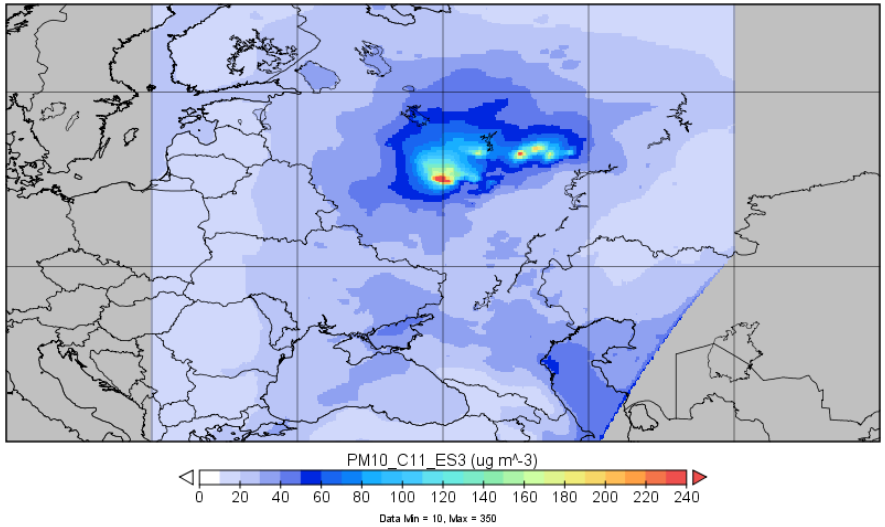
PM10_C11_CS2



PM10_C11_DE3



PM10_C11_ES3



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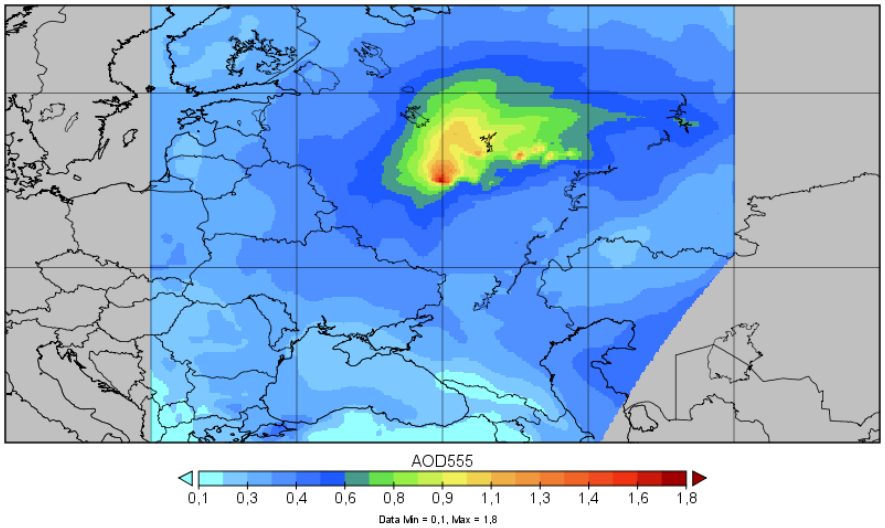
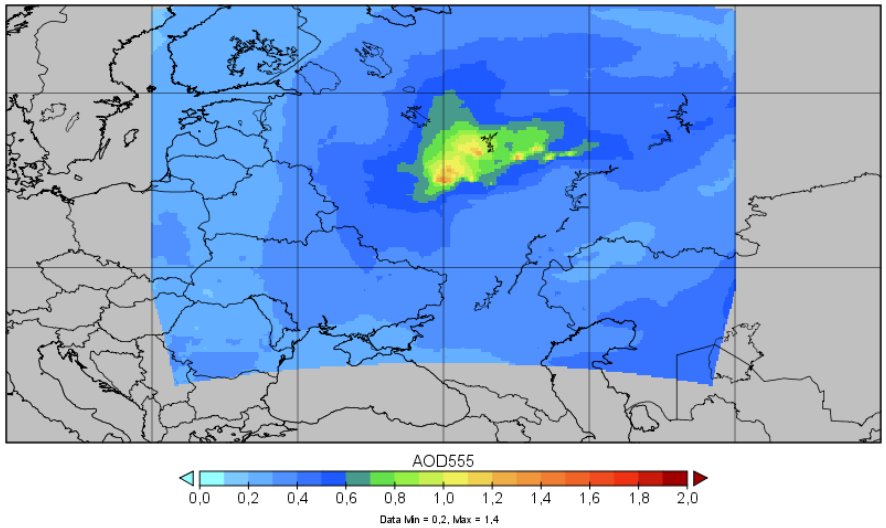
Baseline AOD at 555nm

AOD555_C11_CS1



AOD555_C11_CS2



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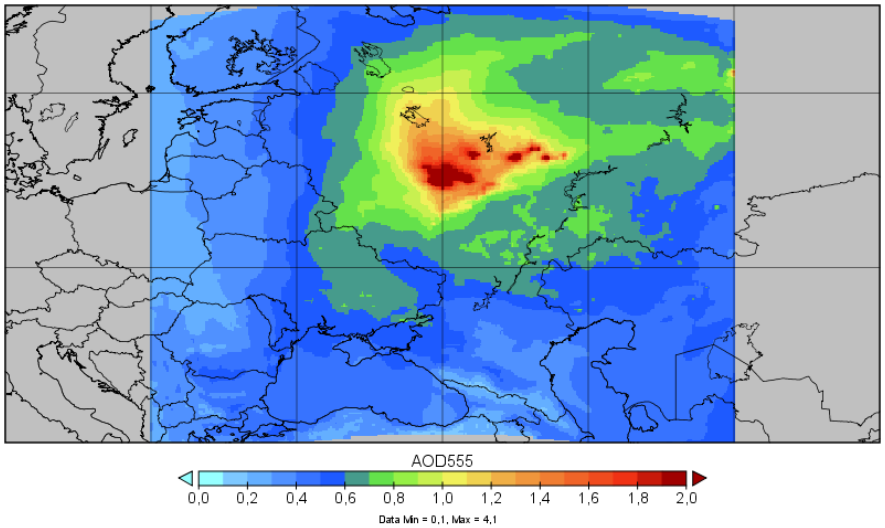
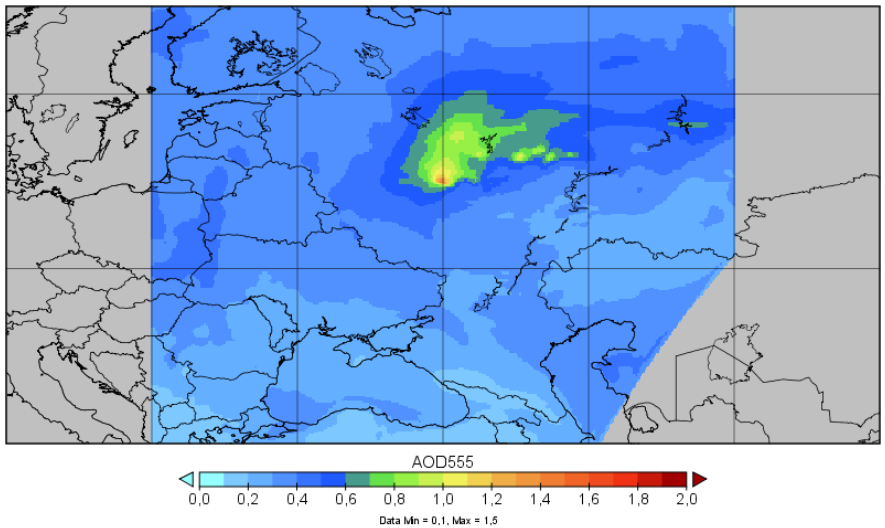


AOD555_C11_ES3



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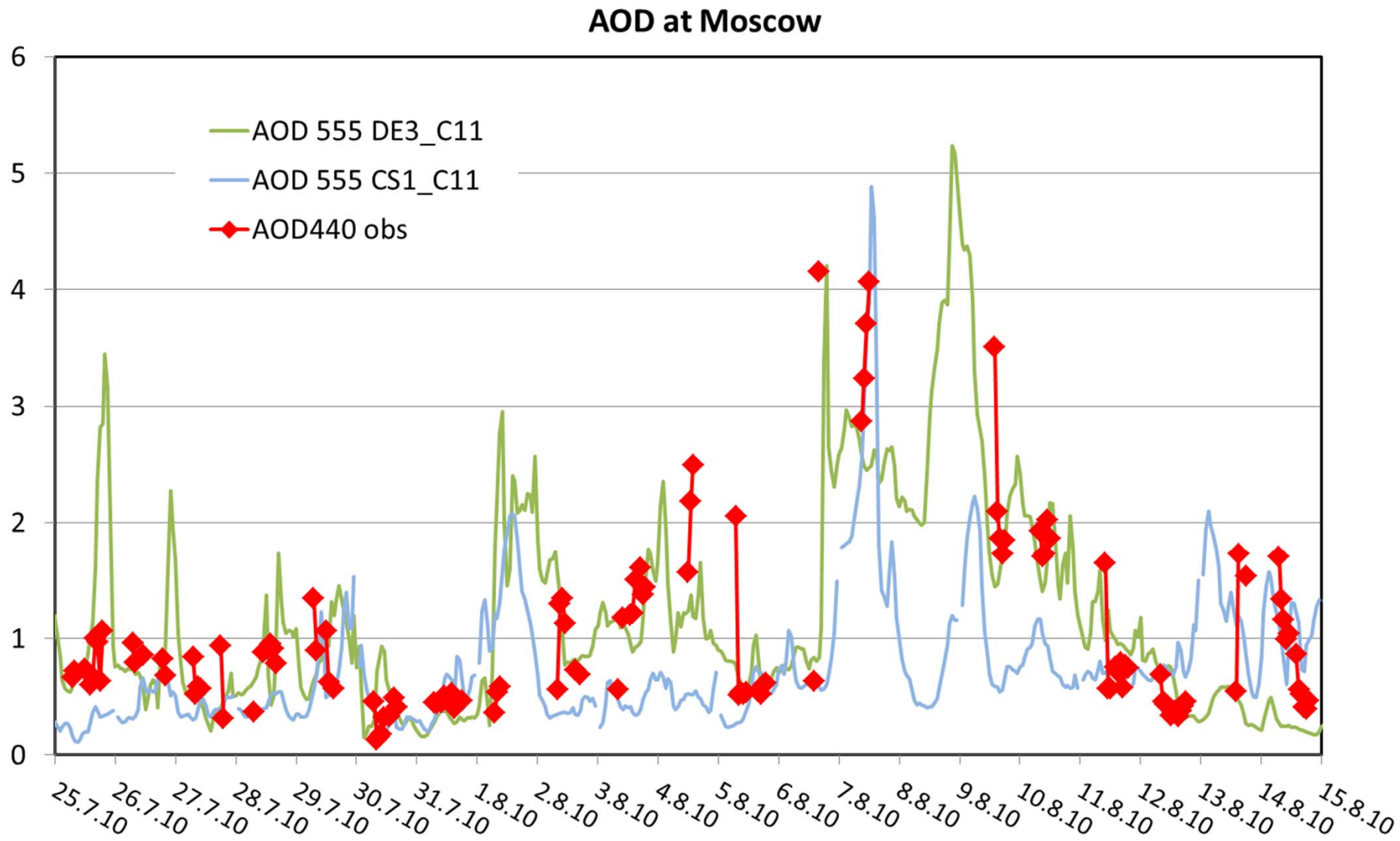
Baseline AOD at Moscow



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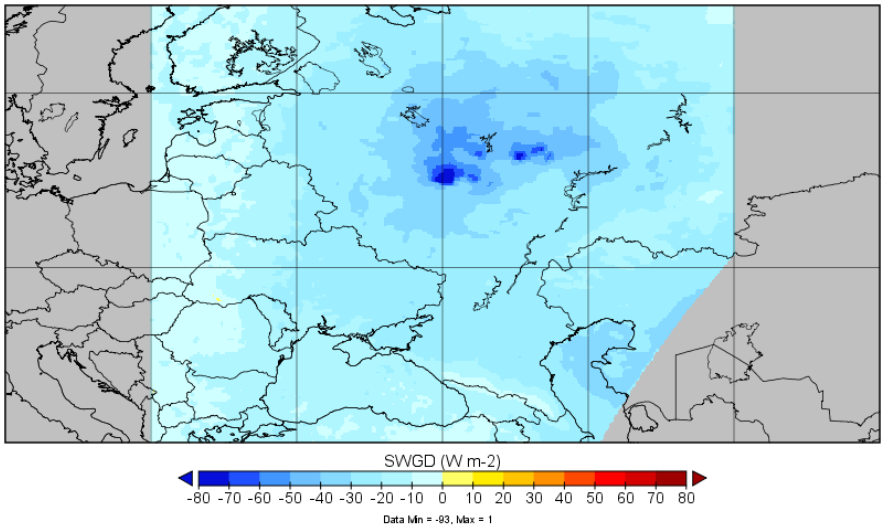
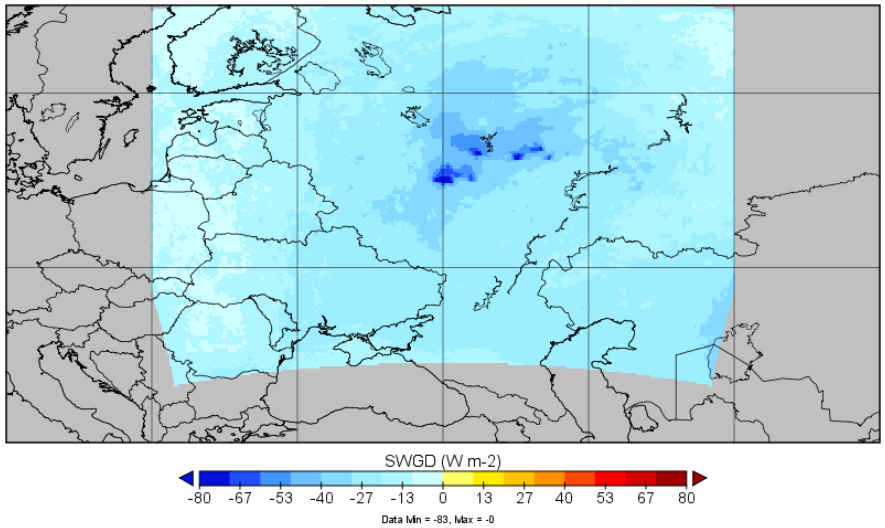
Effect on solar radiation

Episode mean global radiation difference between ‚direct effect' and baseline (W m^{-2})

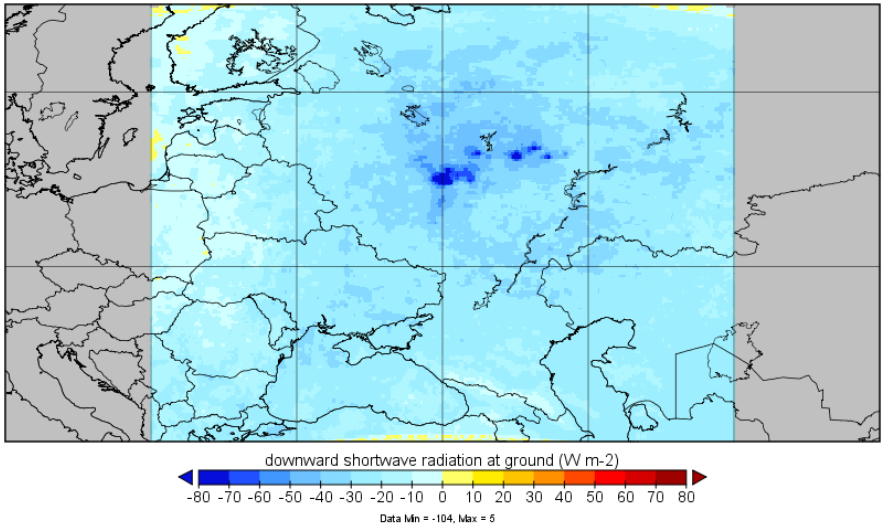
SWGD C12-C11 CS1



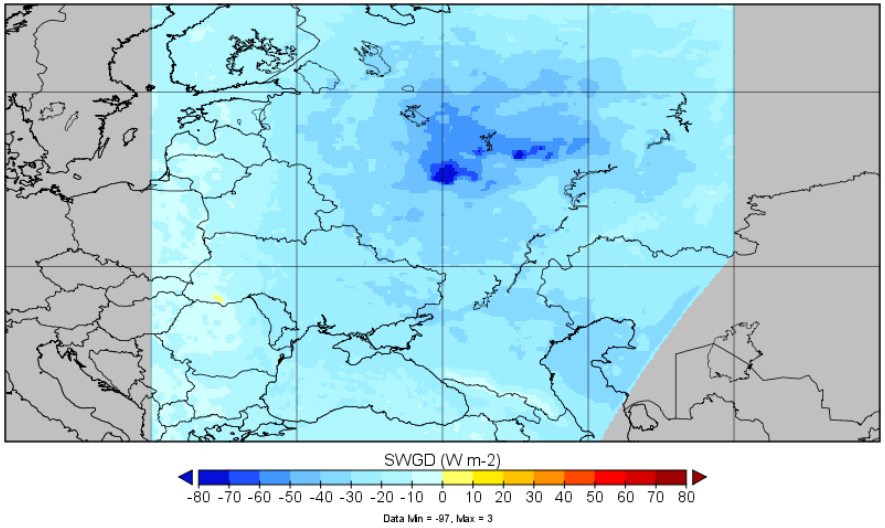
SWGD C12-C11 CS2



SWGD C12-C11 DE3



SWGD C12-C11 ES3



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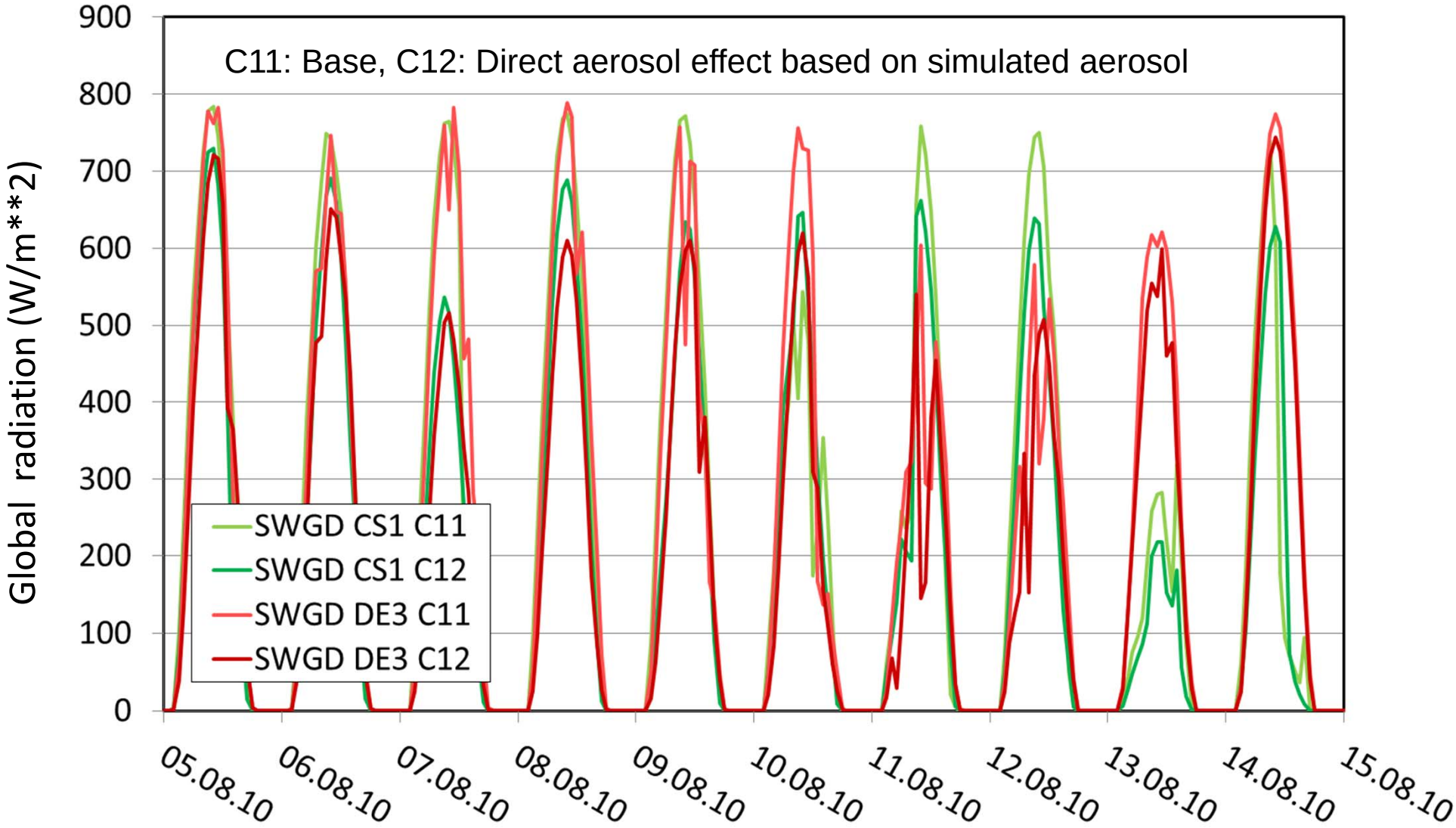
Solar radiation at Moscow

Global radiation: CS1 WRF-Chem (green) / DE3 (COSMO-MUSCAT /red)



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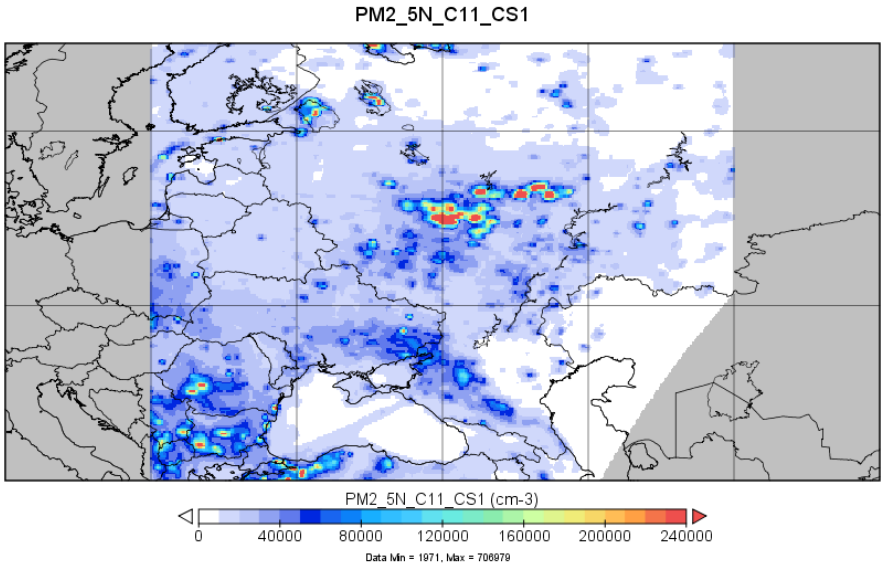
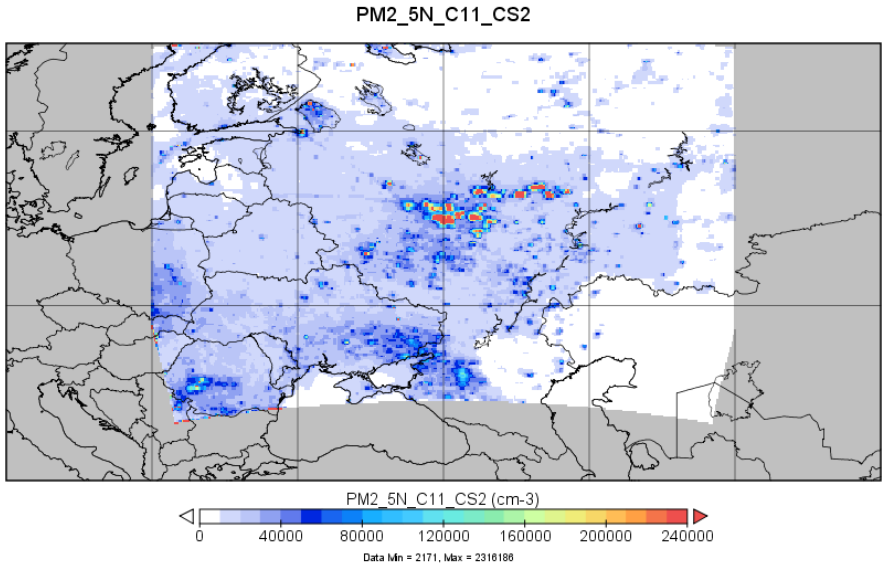
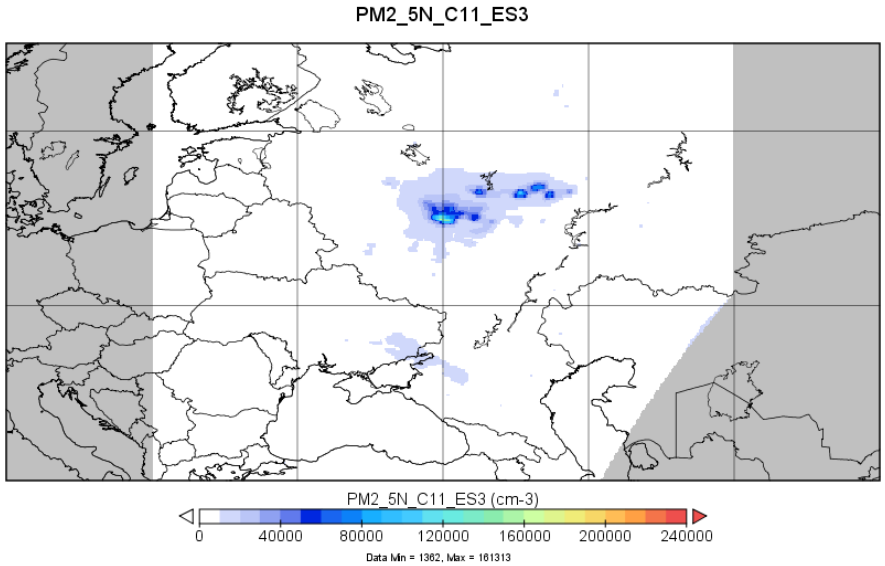
Baseline PM 2.5 number density





Not available



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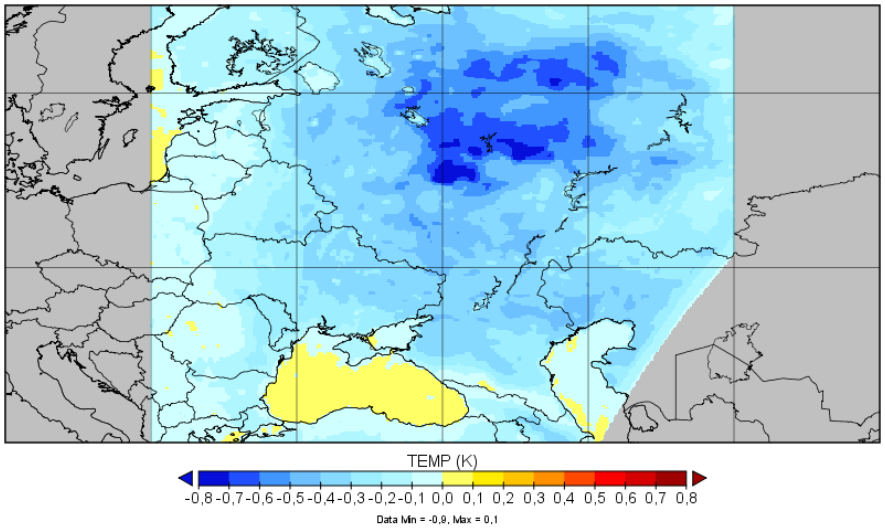
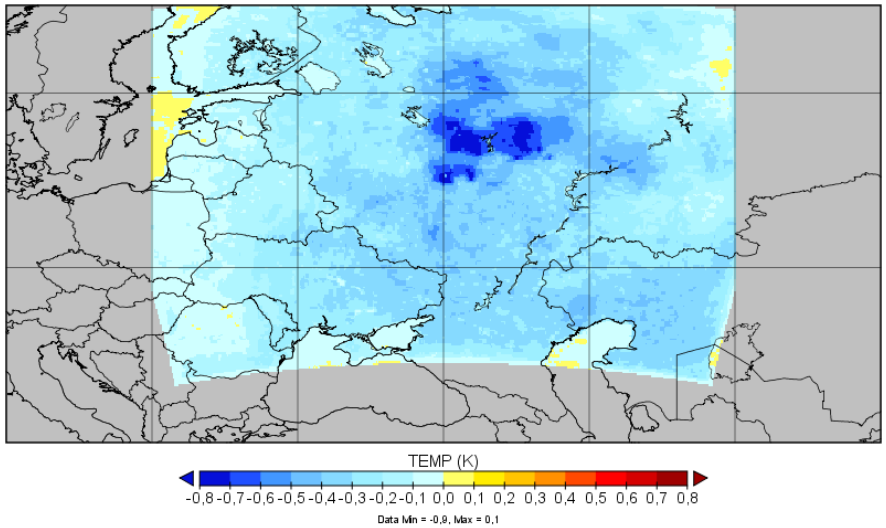
Effect on Temperature

Episode mean temperature difference between ‚direct effect' (C12) and baseline (C11)

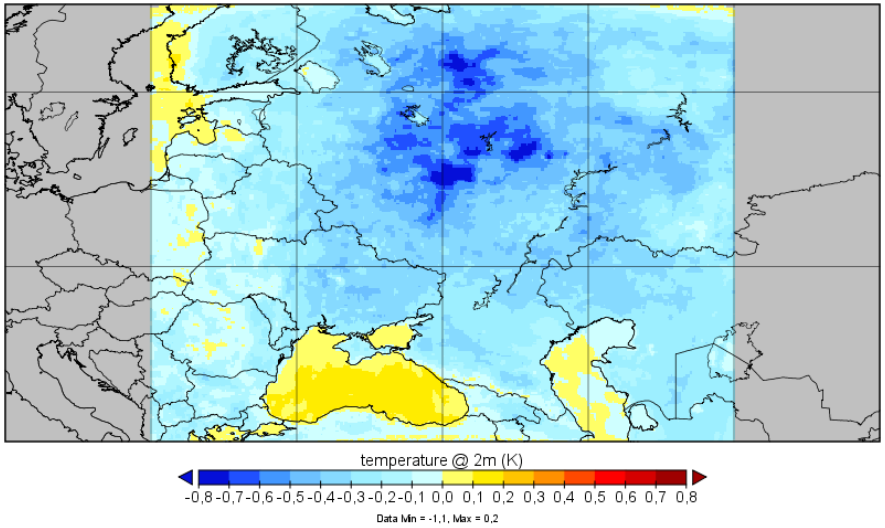
TEMP C12-C11 CS1



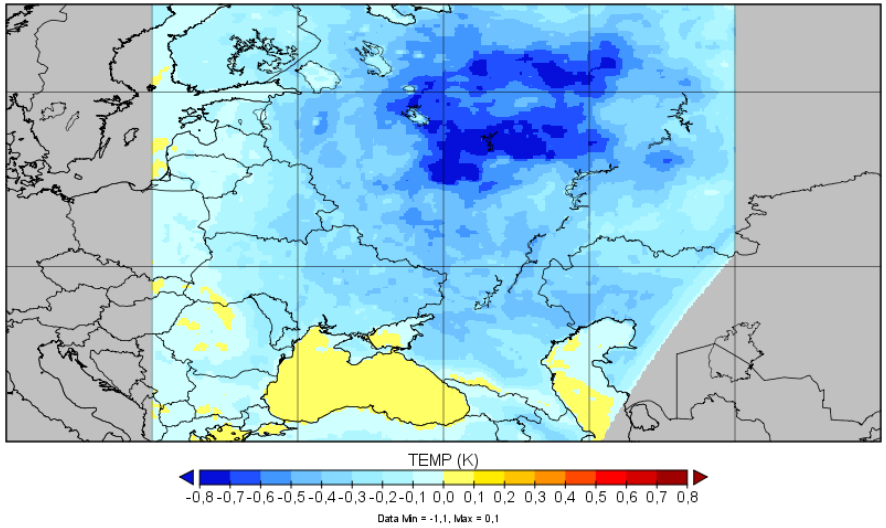
TEMP C12-C11 CS2



TEMP C12-C11 DE3



TEMP C12-C11 ES3



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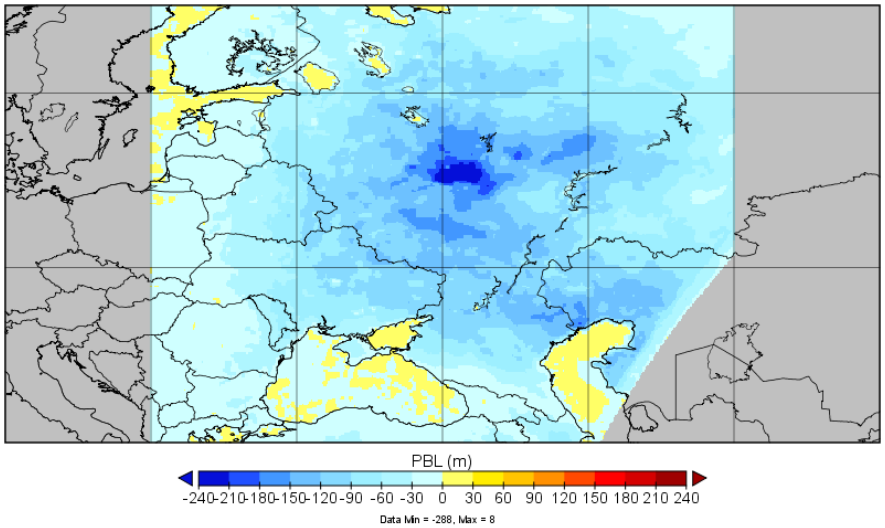
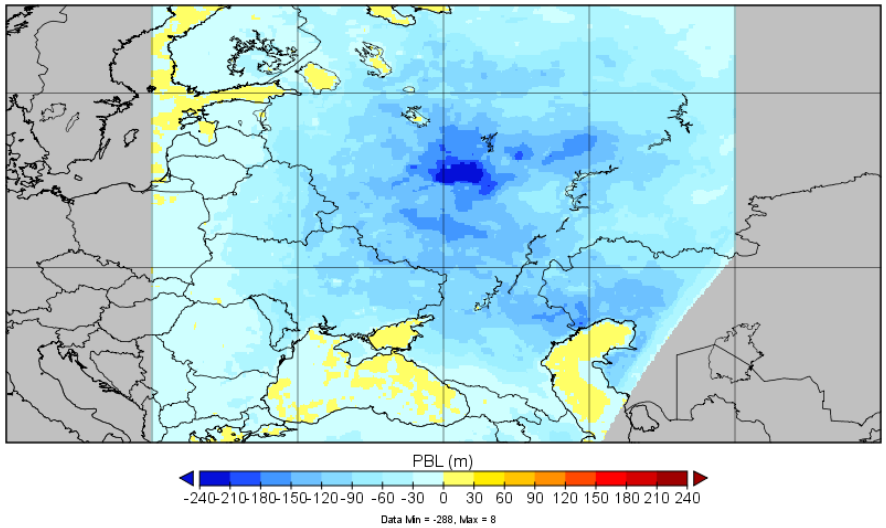
Effect on diagnosed PBL height

Episode mean PBL height difference between ‚direct effect' (C12) and baseline (C11)

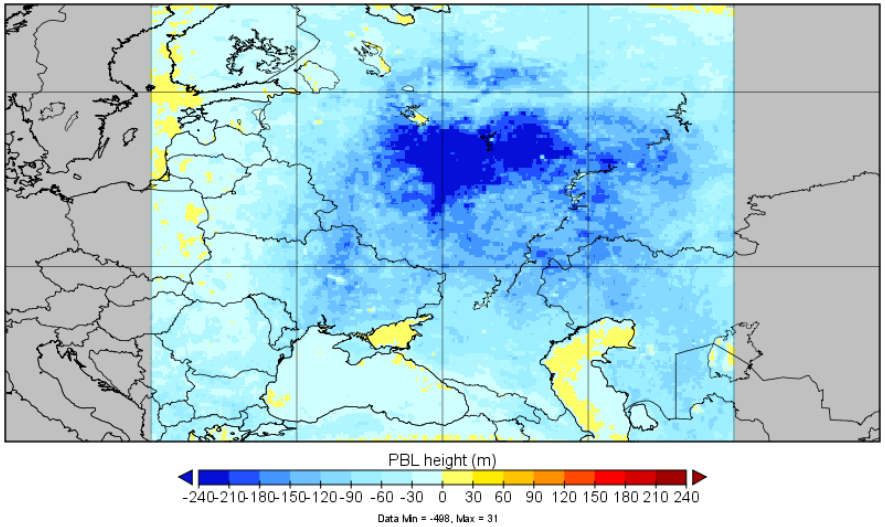
PBL C12-C11 CS1



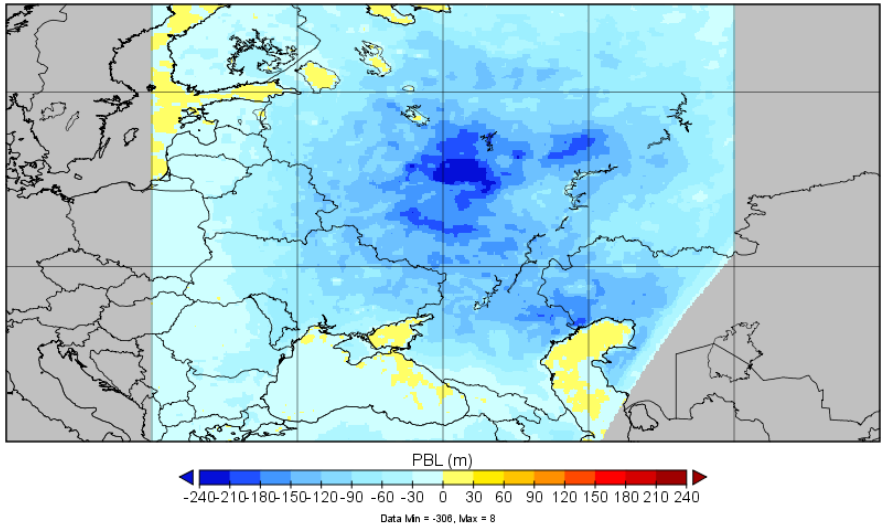
PBL C12-C11 CS1



PBL C12-C11 DE3



PBL C12-C11 ES3



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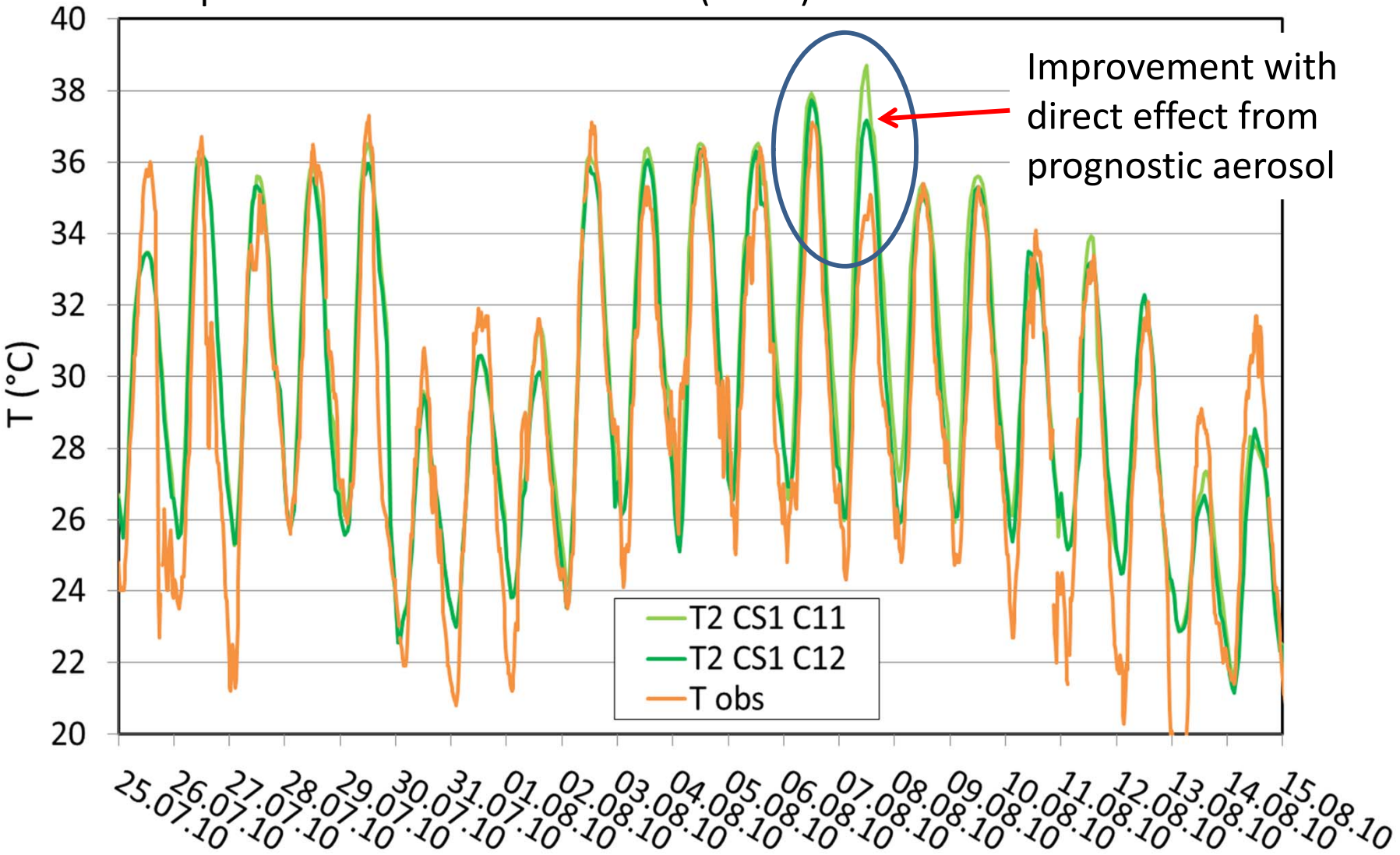
Effect on Temperature: CS1 vs. obs

WRF-Chem baseline (CS1 C11) and „direct aerosol effect“ (CS1 C12) compared to T at Moscow station (T obs)



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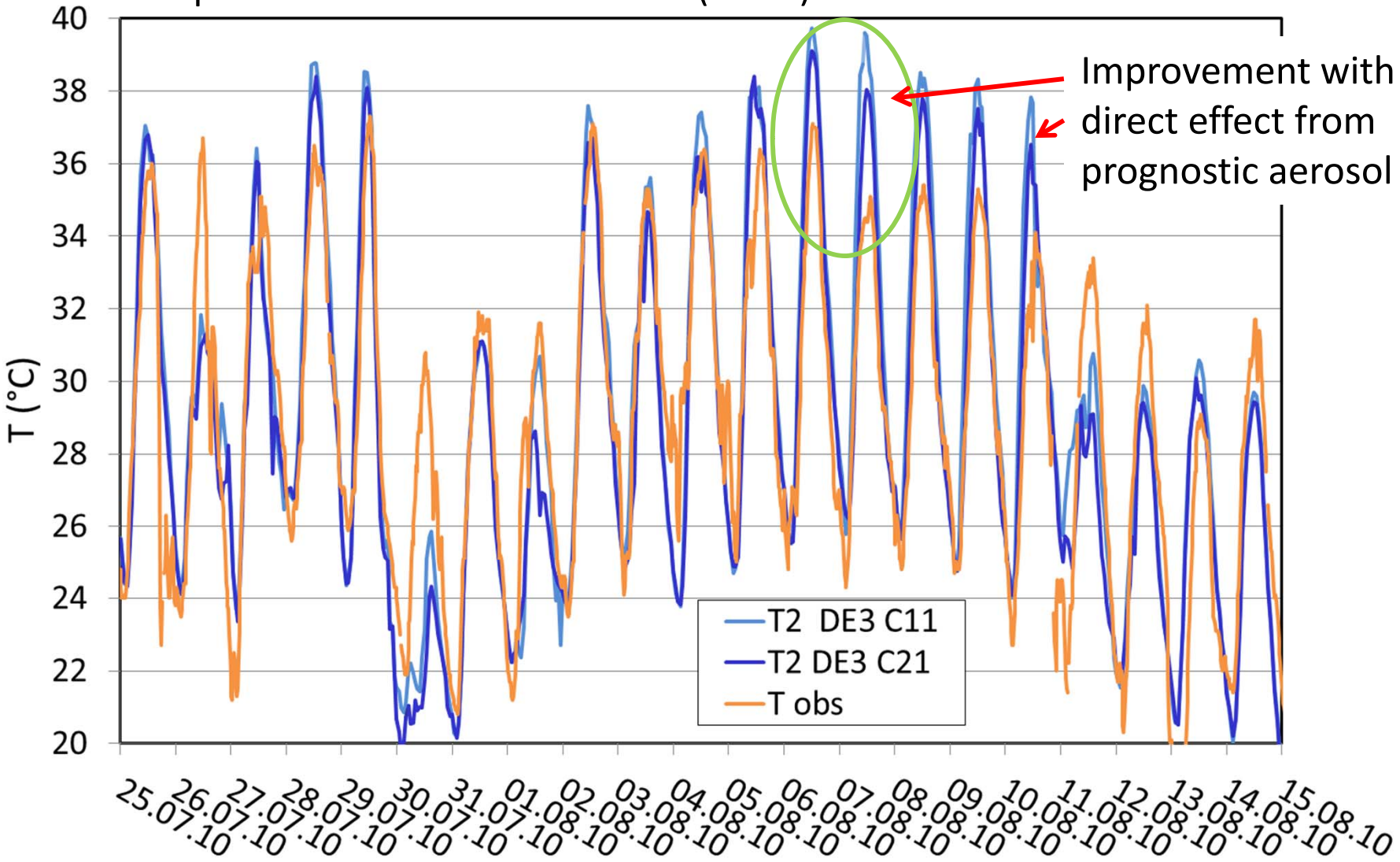
Effect on Temperature: DE3 vs. obs

COSMO MUSCAT baseline (DE3 C11) and „direct aerosol effect“ (DE3 C12) compared to T at Moscow station (T obs)



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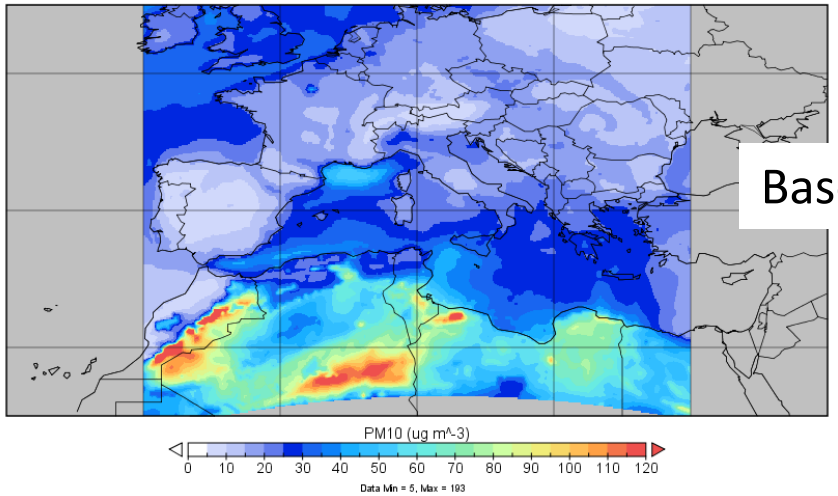
Comparison: Results for October episode

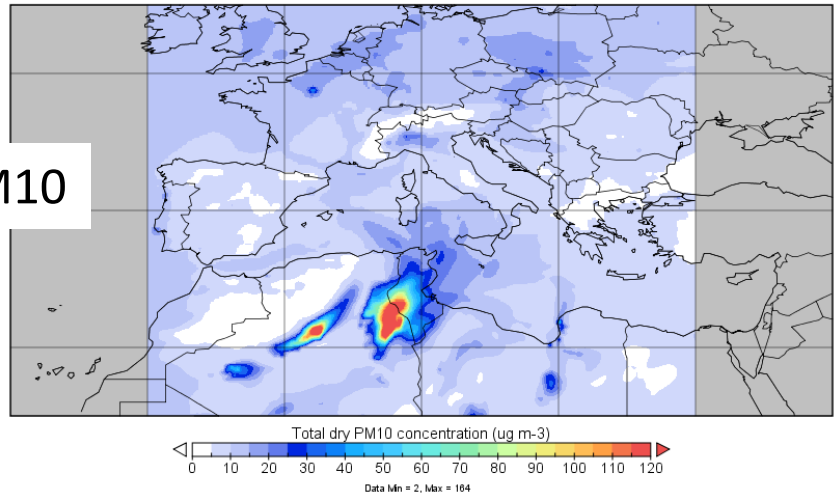
Wet and ‚Dust' Episode, 2.-15. Oct. 2010:

More pronounced PM10 variablity among models for direct effect

CS1 C21 PM10

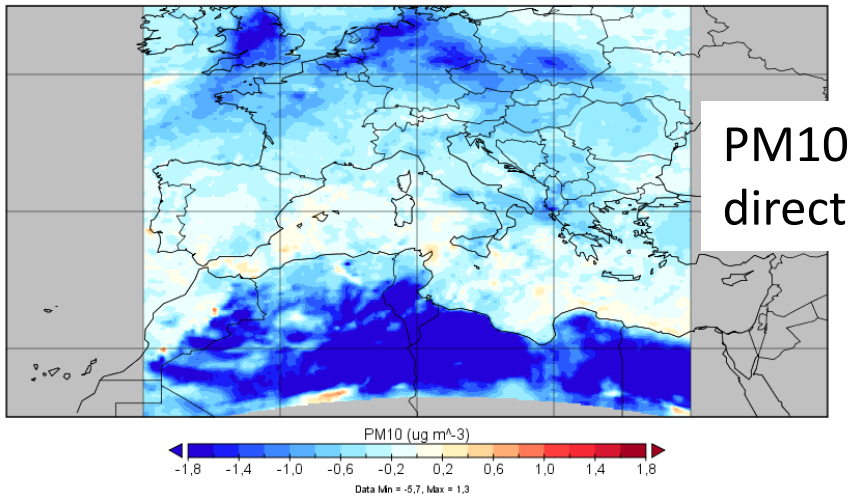


DE3 C21 PM10

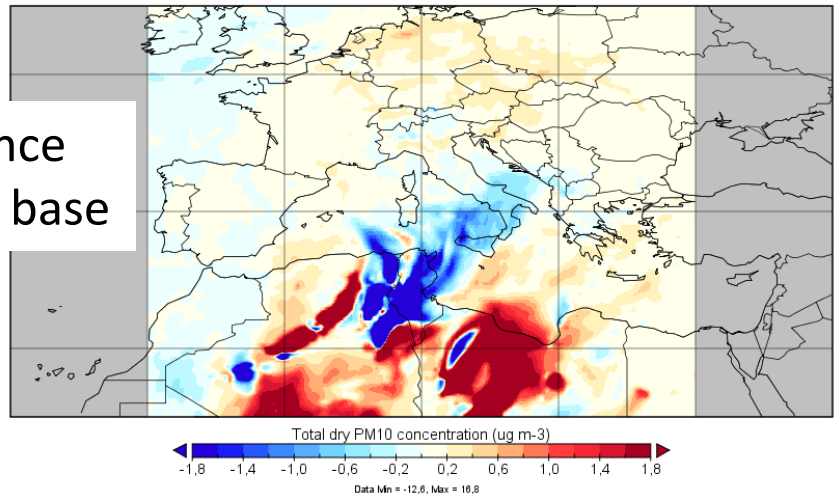


Baseline PM10

ES1 C22-C21 PM10



DE3 C22-C21 PM10



PM10 difference
direct effect - base

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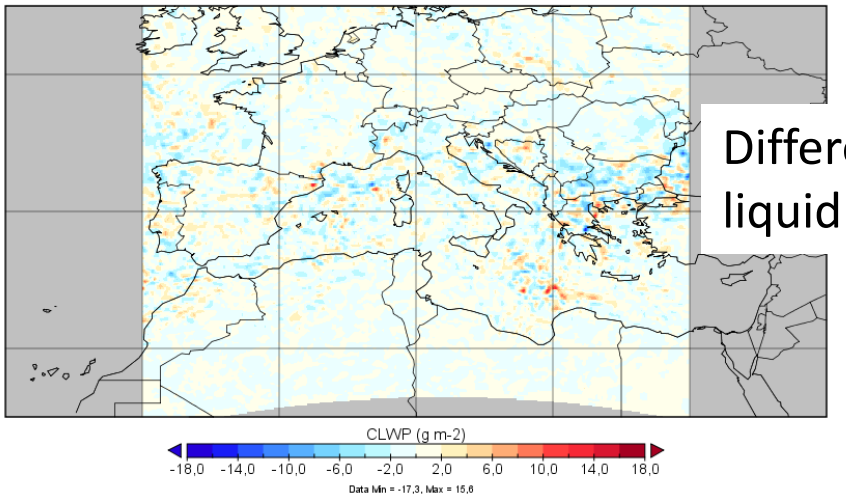
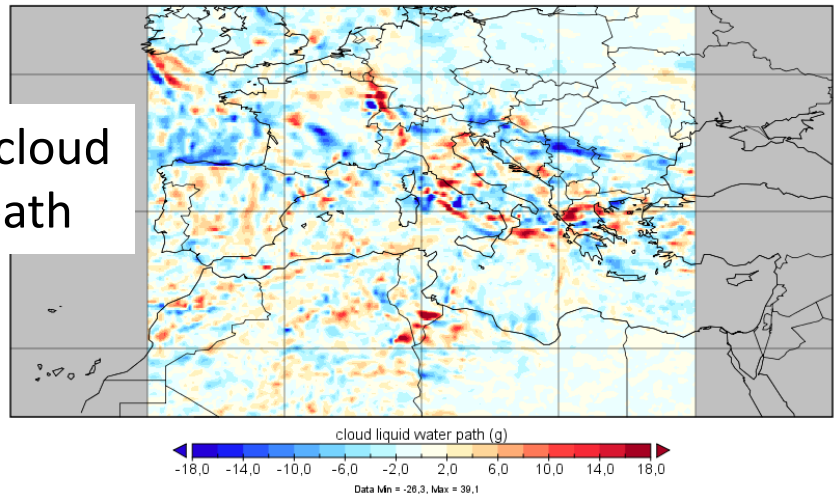
Comparison: Results for October episode

CS1 C22-C21 Cloud liquid water path

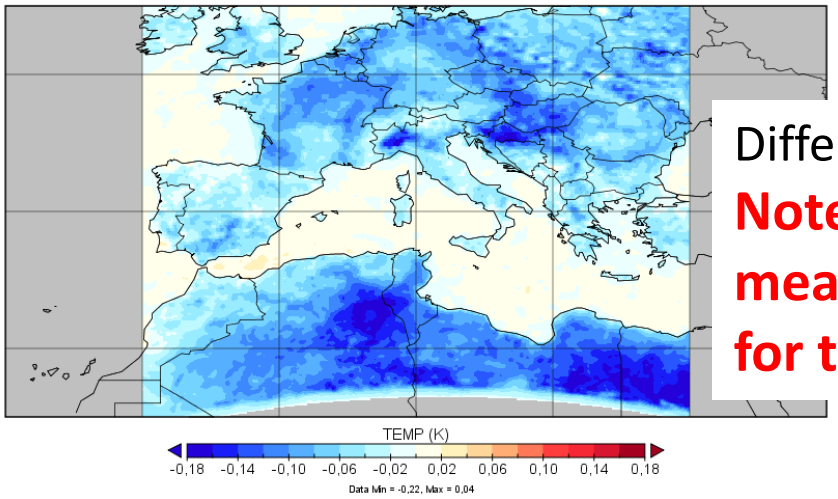


DE3 C22-C21 Cloud liquid water path

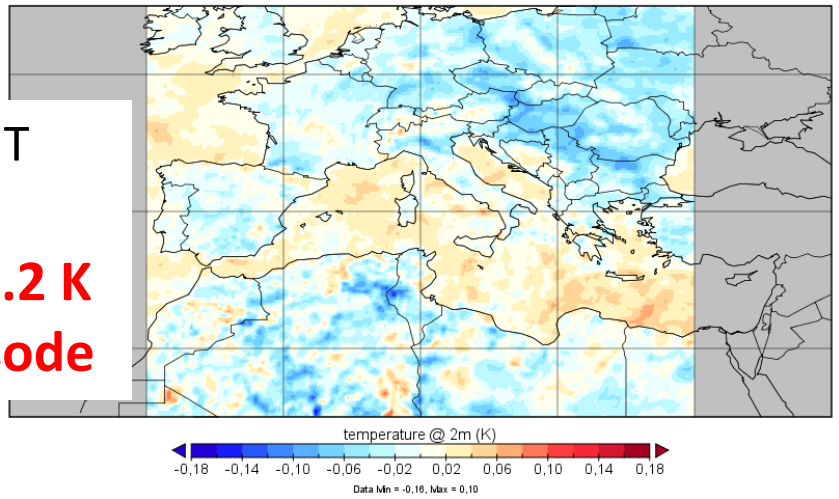


Difference in cloud liquid water path

CS1 C22-C21 T @ 2m



DE3 C22-C21 T @ 2m



Difference in T

Note:

mean dT< 0.2 K for this episode

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Summary and conclusions

- For fire episode quite similar response to direct aerosol effect for WRF-Chem and COSMO-MUSCAT simulations
- Episode mean T decrease of 1 K, up to 2 K for Moscow on single days, up to 3-4 K for PM10 hotspots in the fire areas
- Improved simulated T at Moscow for “direct effect” runs
- For modereate aerosol concentrations different baseline assumptions can strongly affect the model response to feedback (Tandre aerosol climatology for DE3, NCEP aerosol climatorlogy in WRF-Chem) ➡ Simulated „feedback effects“ from case studies with different models are not always comparable unless you know the baseline assumptions.

➡ Further contributions would have been nice to get a more complete picture

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- All groups for doing simulations and contributing their results
- UL and BSC for the space on their FTP server

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- ECMWF/MACC project & Météo-France/CNRM-GAME (chemical boundary conditions)
- FMI (fire emissions)
- Dr. Natalia Chubarova, Moscow State University and AERONET
- Members of the Cost action ES1004 EuMetChem

Thanks to everyone who contributed!

Thank you for your attention

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