Karlsruhe Institute of Technology

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A multi-model case study on aerosol feedbacks in online coupled chemistry-meteorology models within the COST Action ES1004 EuMetChem

R. Forkel, D. Brunner, A. Baklanov, A. Balzarini, R. Baró, M. Hirtl, L. Honzak, P. Jiménez-Guerrero, O. Jorba, J. L. Pérez, G. Pirovano, R. San José, W. Schröder, G. Tsegas, J. Werhahn, R. Wolke, R. Žabkar

Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Objective

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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Objective

AQMEII phase2 evaluation of online coupled models:

- Only some groups were able to perform multiple model simulations for AQMEII phase2 which is necessary for the investigation of aerosol feedback effects.
- For Europe, all of these studies were made with WRF-Chem.

→ **Further case studies with different models are necessary**

→ **COST ES1004 Case Studies are performed for shorter episodes with high aerosol concentrations**

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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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

cost

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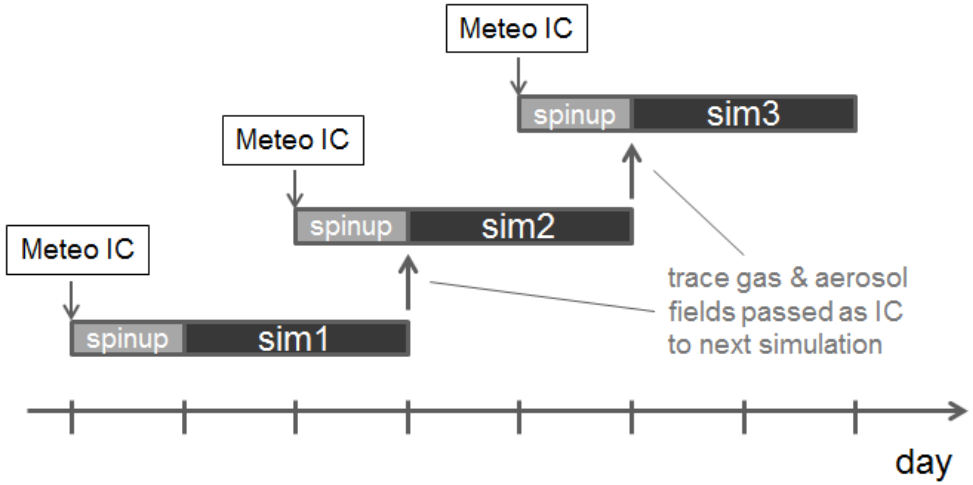
Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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)

cost
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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Russian heat wave and fire episode

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 (like CS1, but with different cloud micropysics) is 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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Baseline PM10

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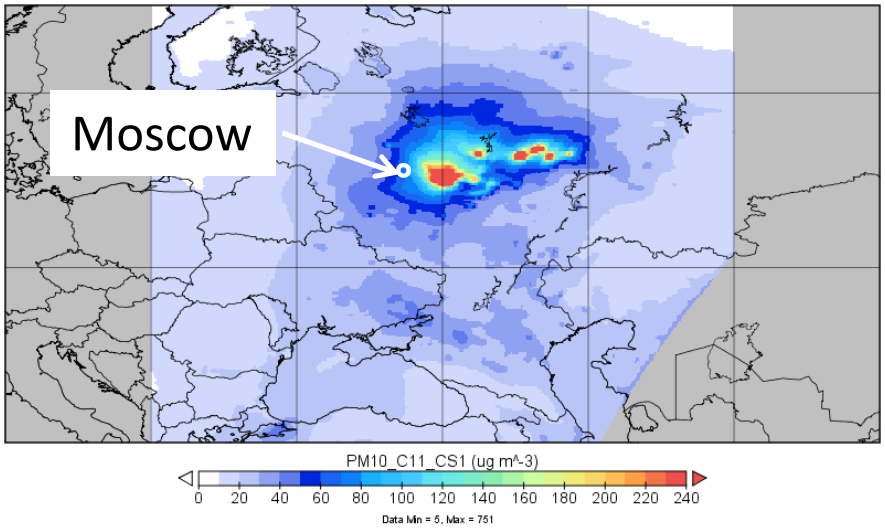
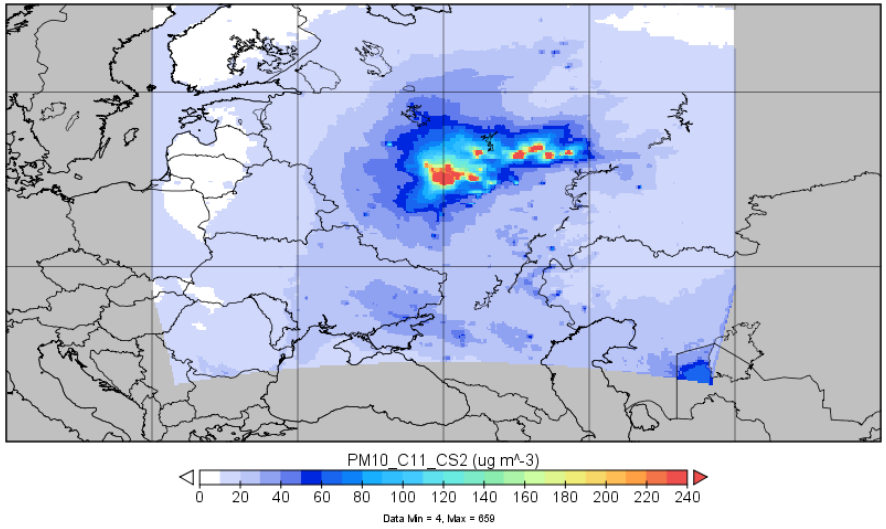
Episode mean PM10 (µg m^{-3})

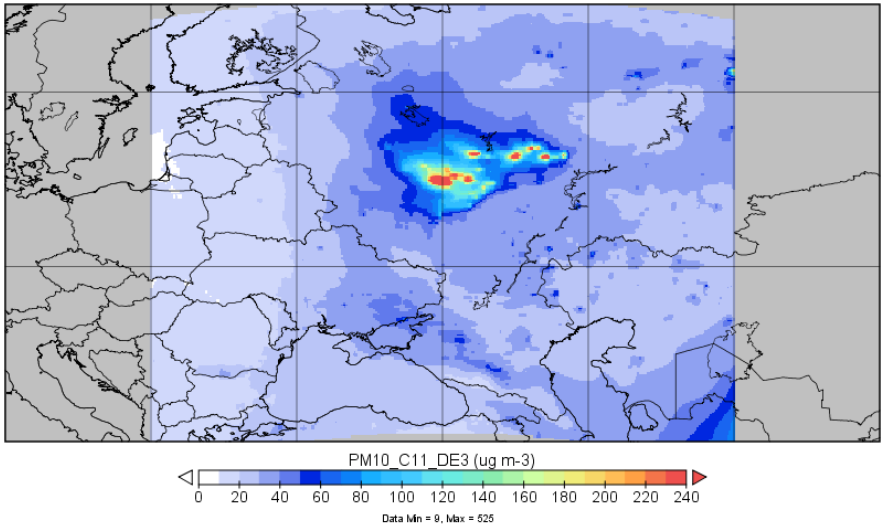
PM10_C11_CS1



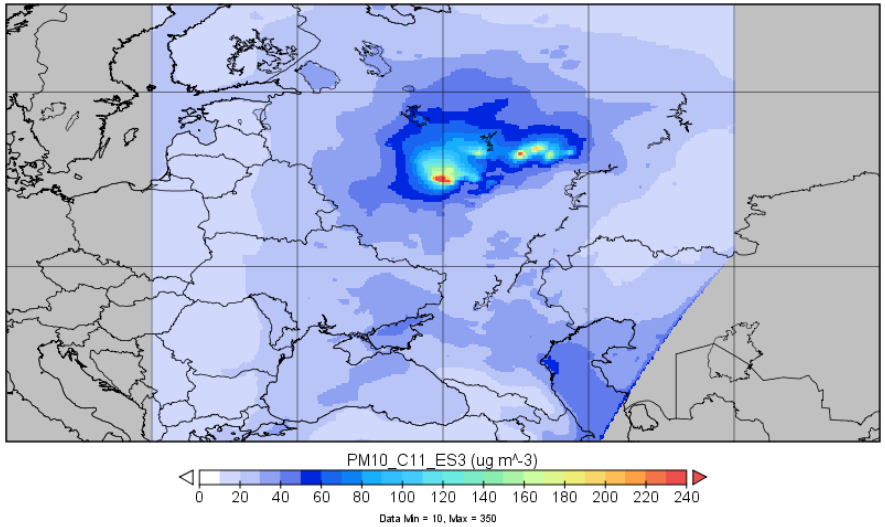
PM10_C11_CS2



PM10_C11_DE3



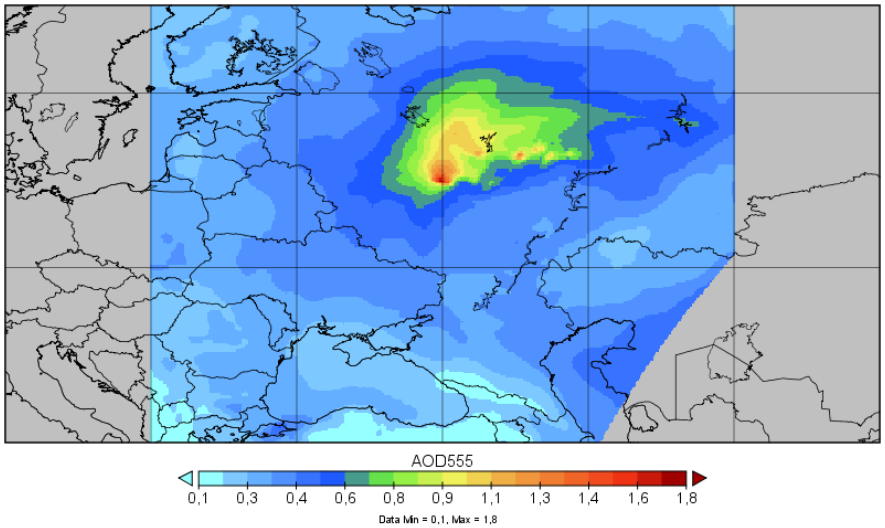
PM10_C11_ES3



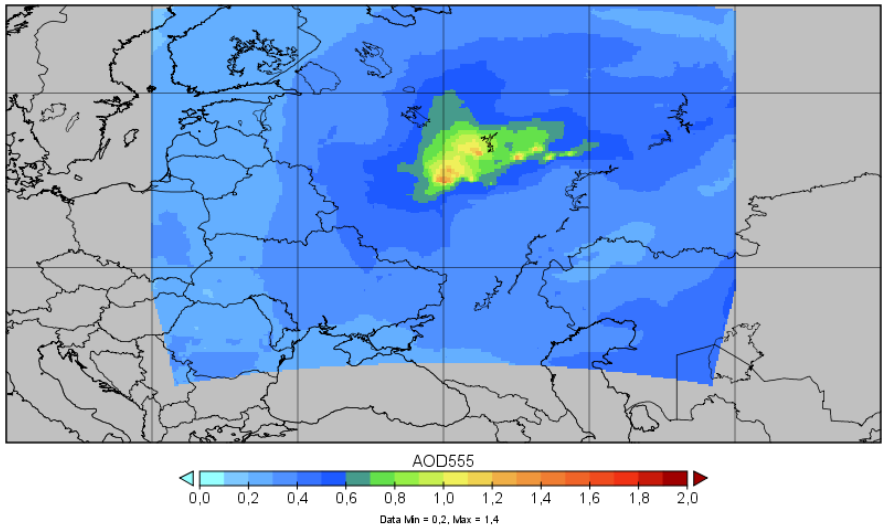
Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Baseline AOD at 555nm

AOD555_C11_CS1



AOD555_C11_CS2



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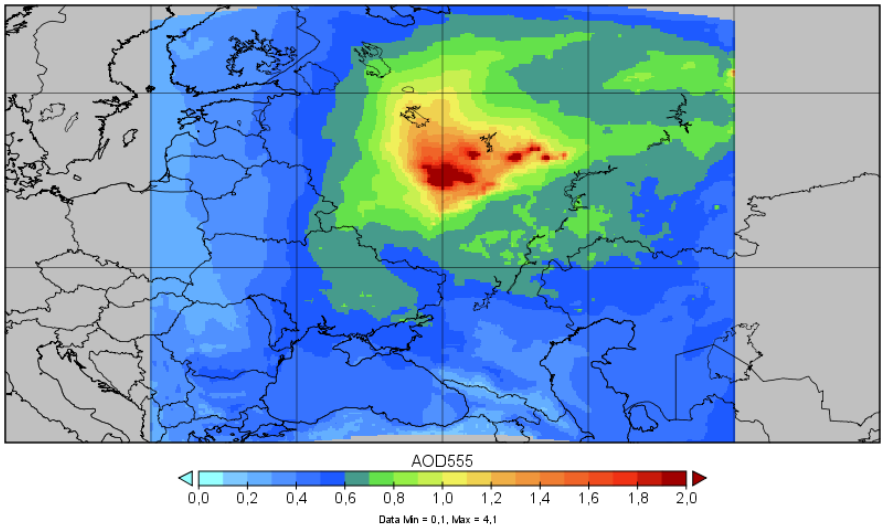

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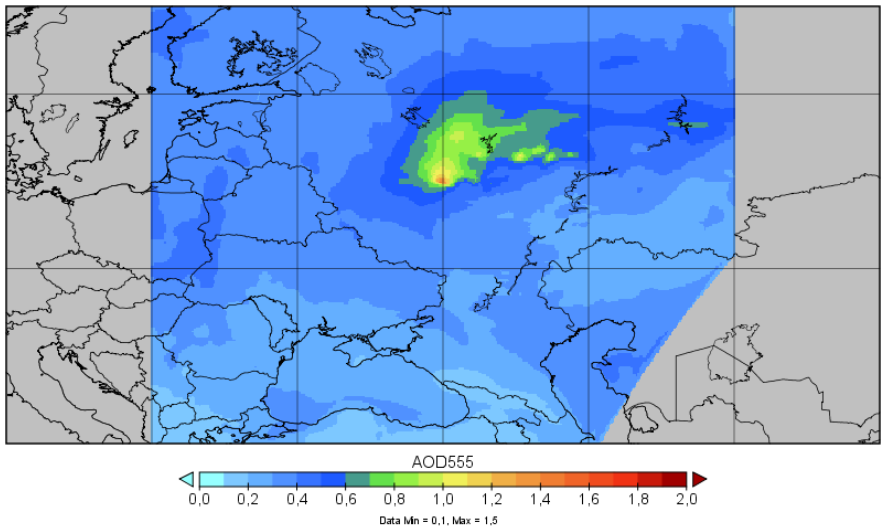
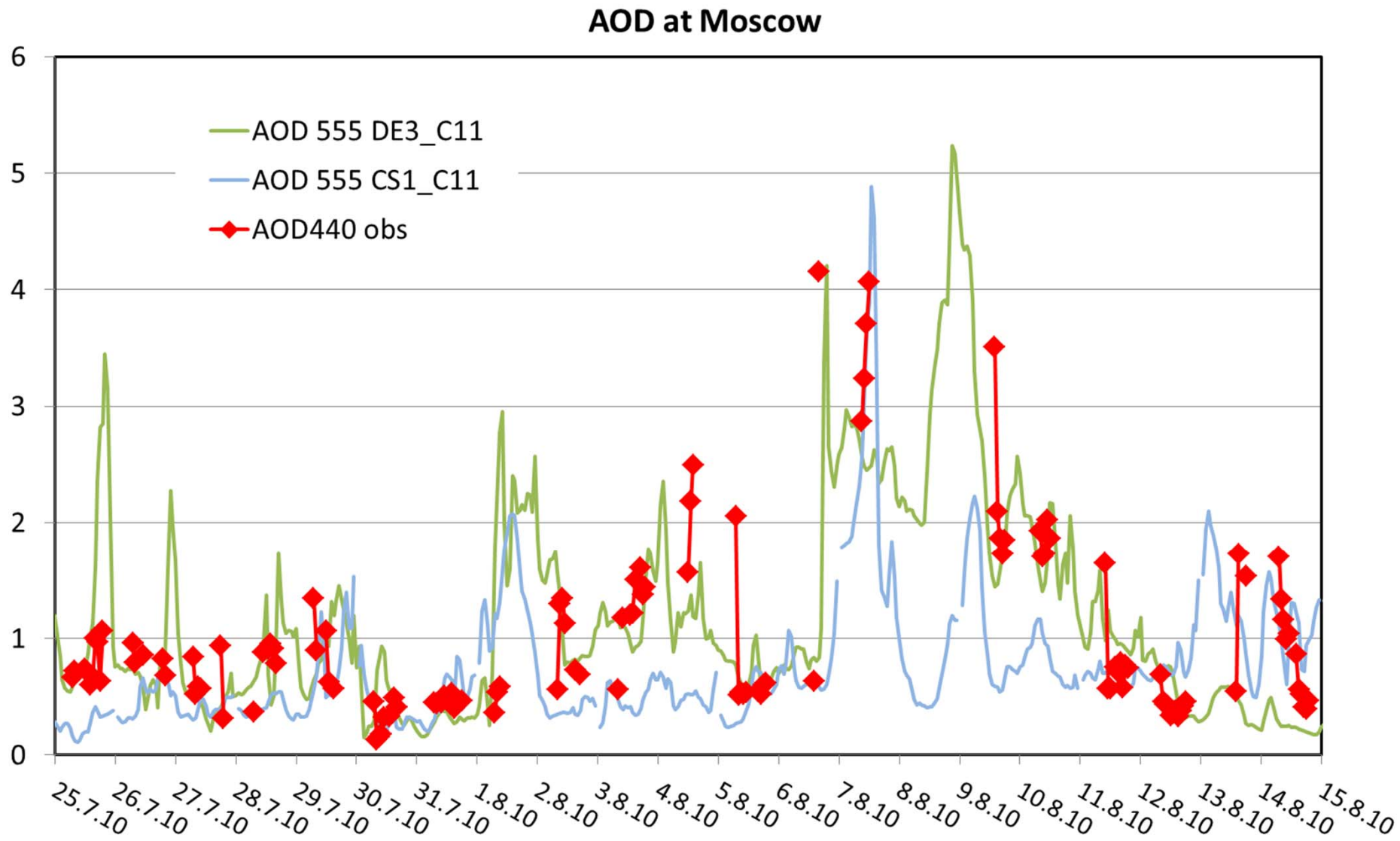


Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Baseline AOD at Moscow

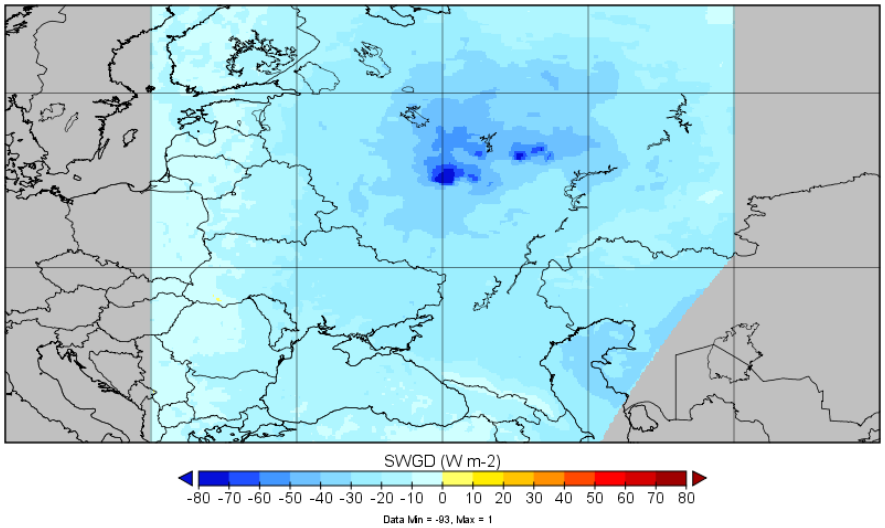


Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

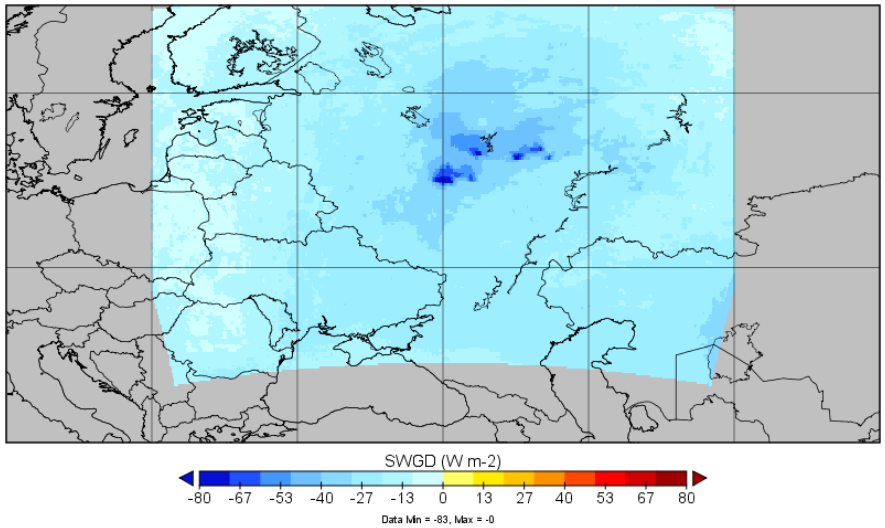
Effect on solar radiation

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

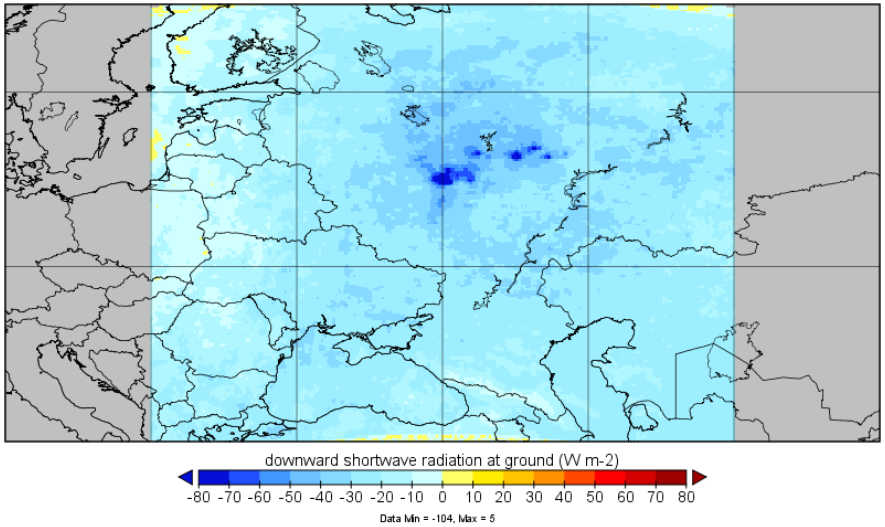
SWGD C12-C11 CS1



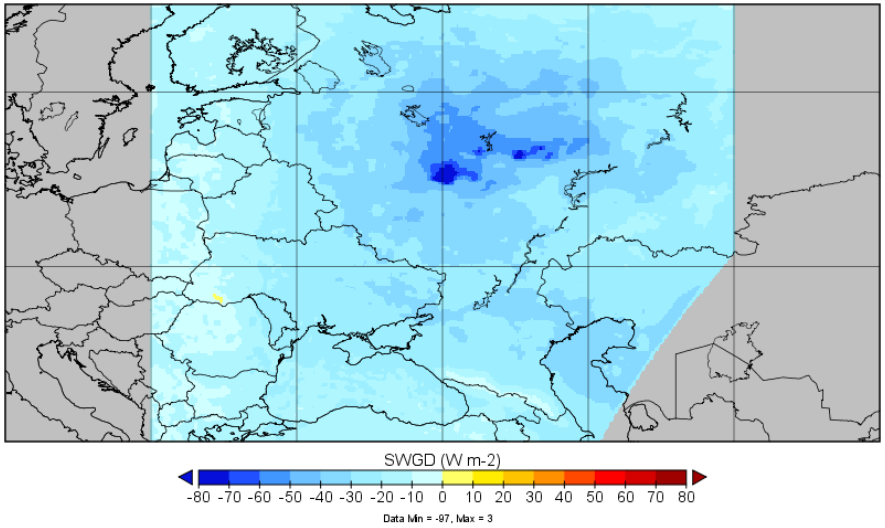
SWGD C12-C11 CS2



SWGD C12-C11 DE3



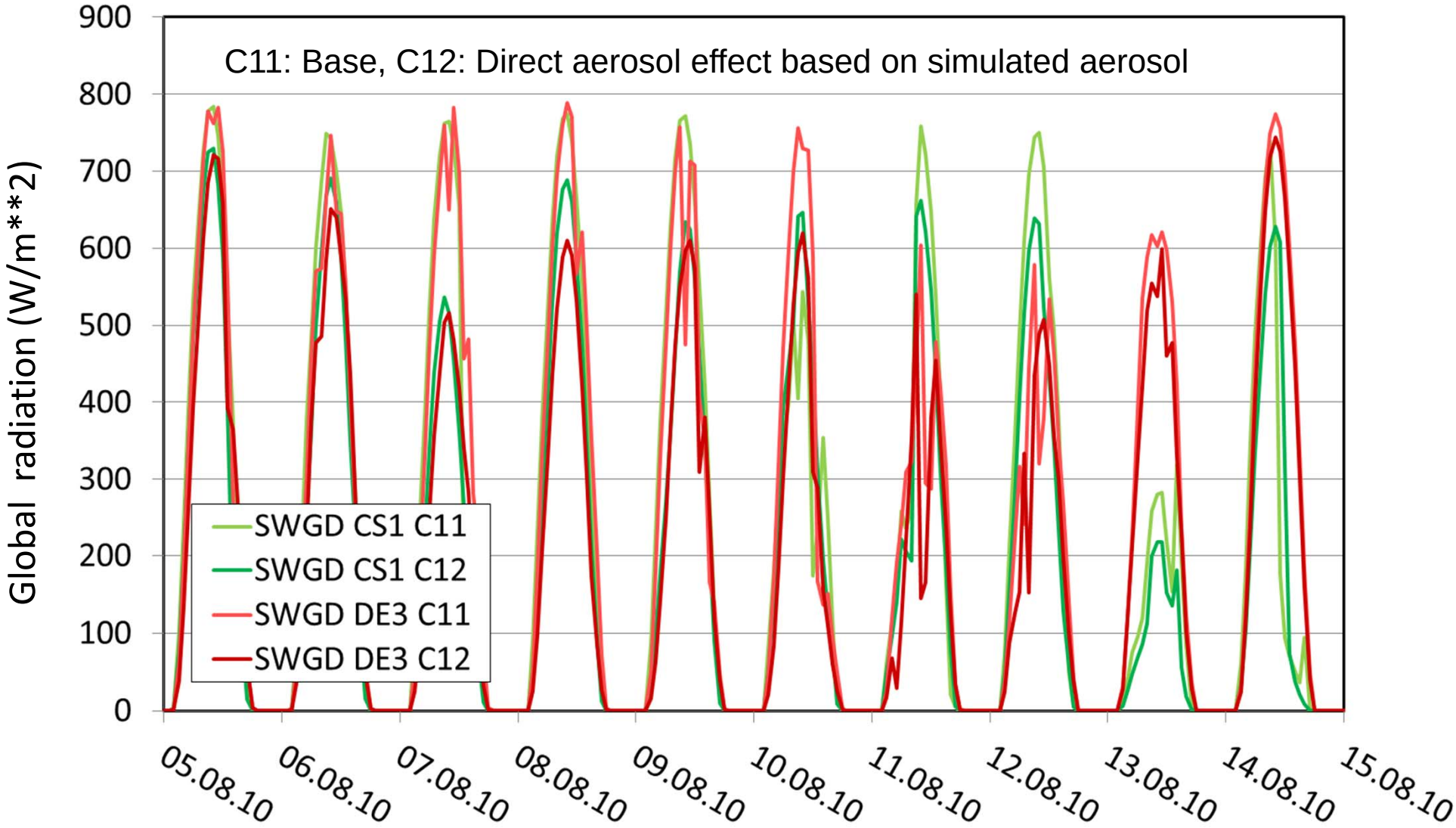
SWGD C12-C11 ES3



Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Solar radiation at Moscow

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



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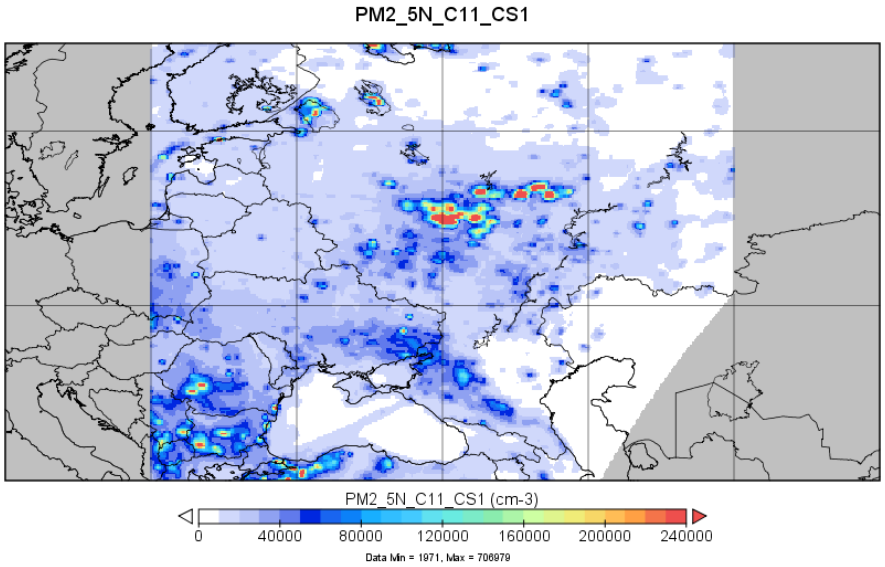
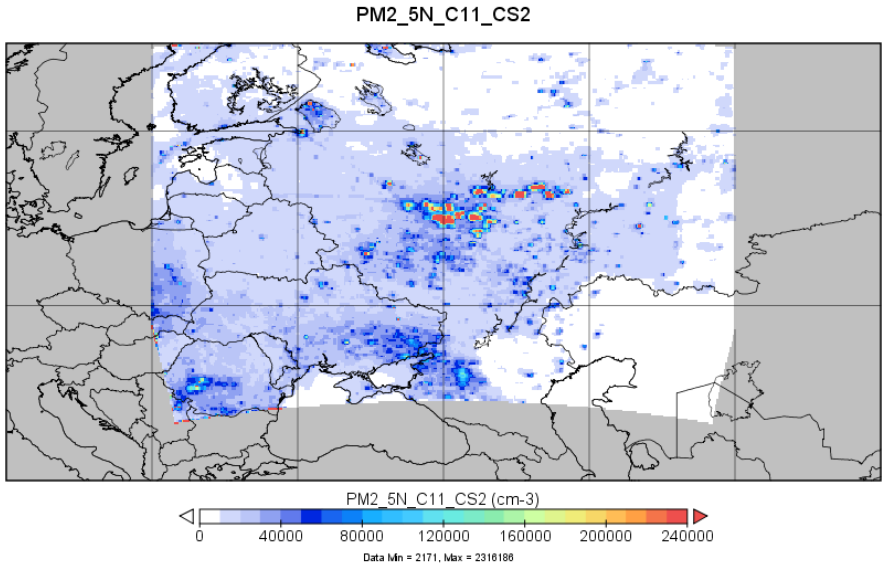
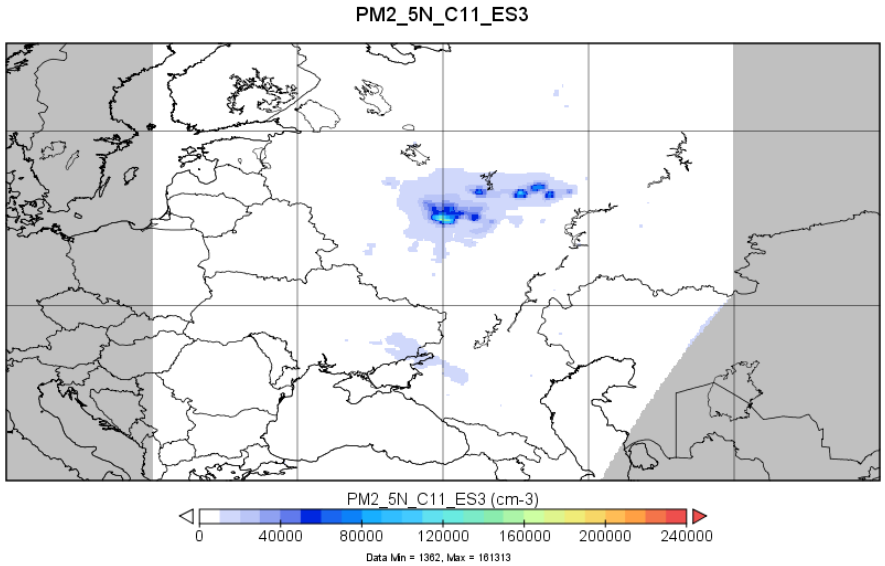
renate.forkel@kit.edu

Baseline PM 2.5 number density





Not available

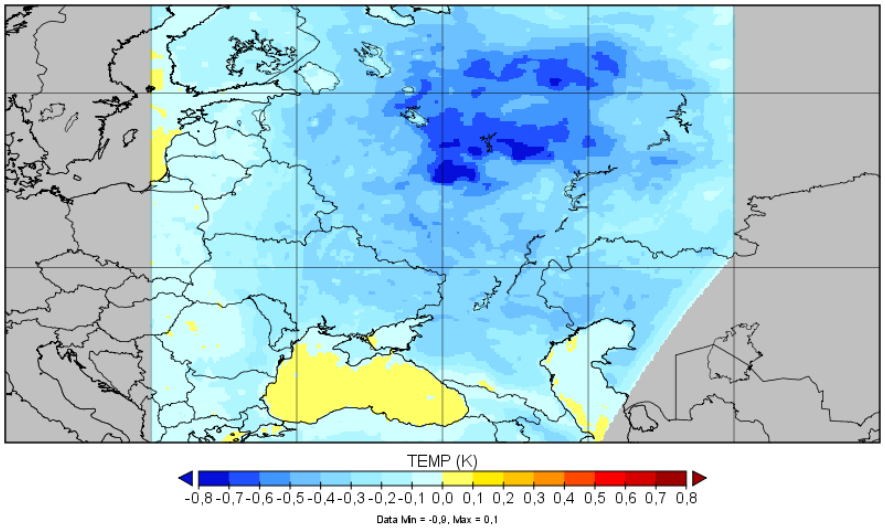


Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

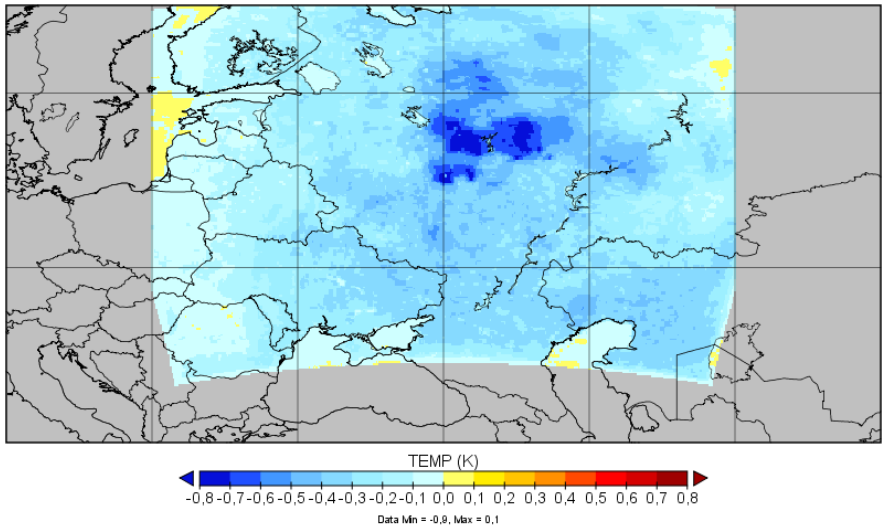
Effect on Temperature

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

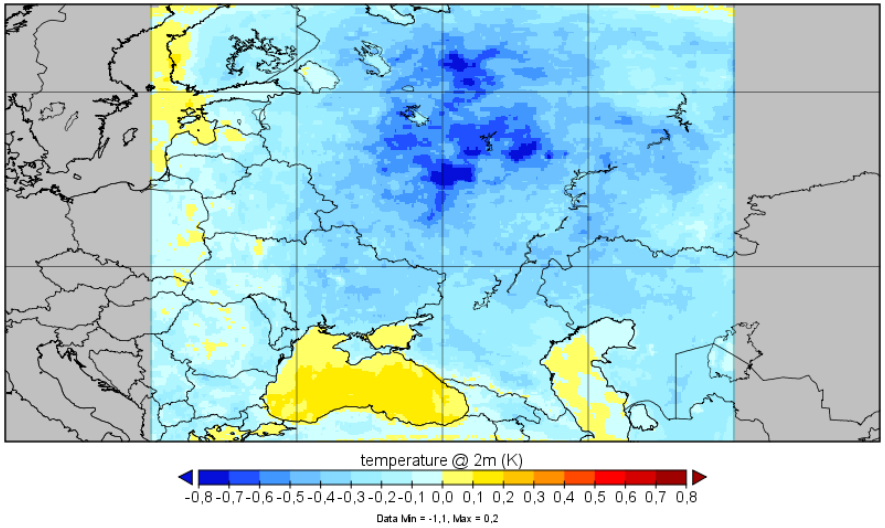
TEMP C12-C11 CS1



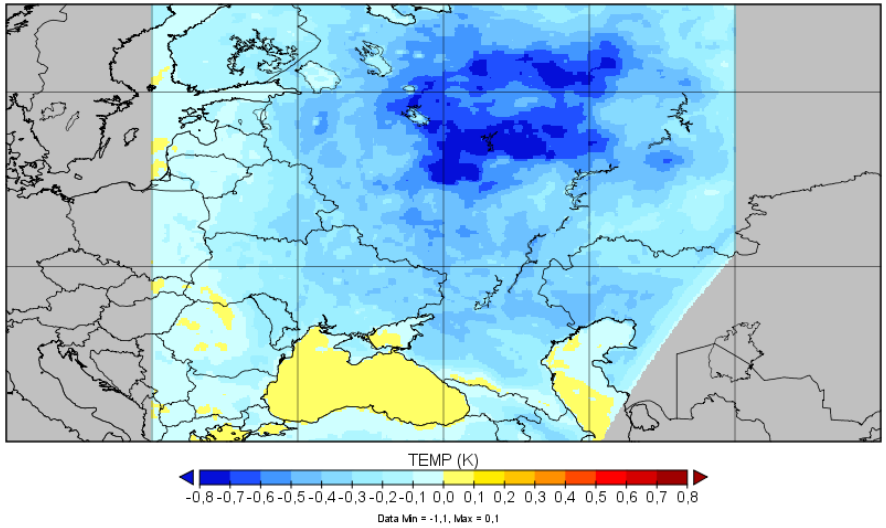
TEMP C12-C11 CS2



TEMP C12-C11 DE3



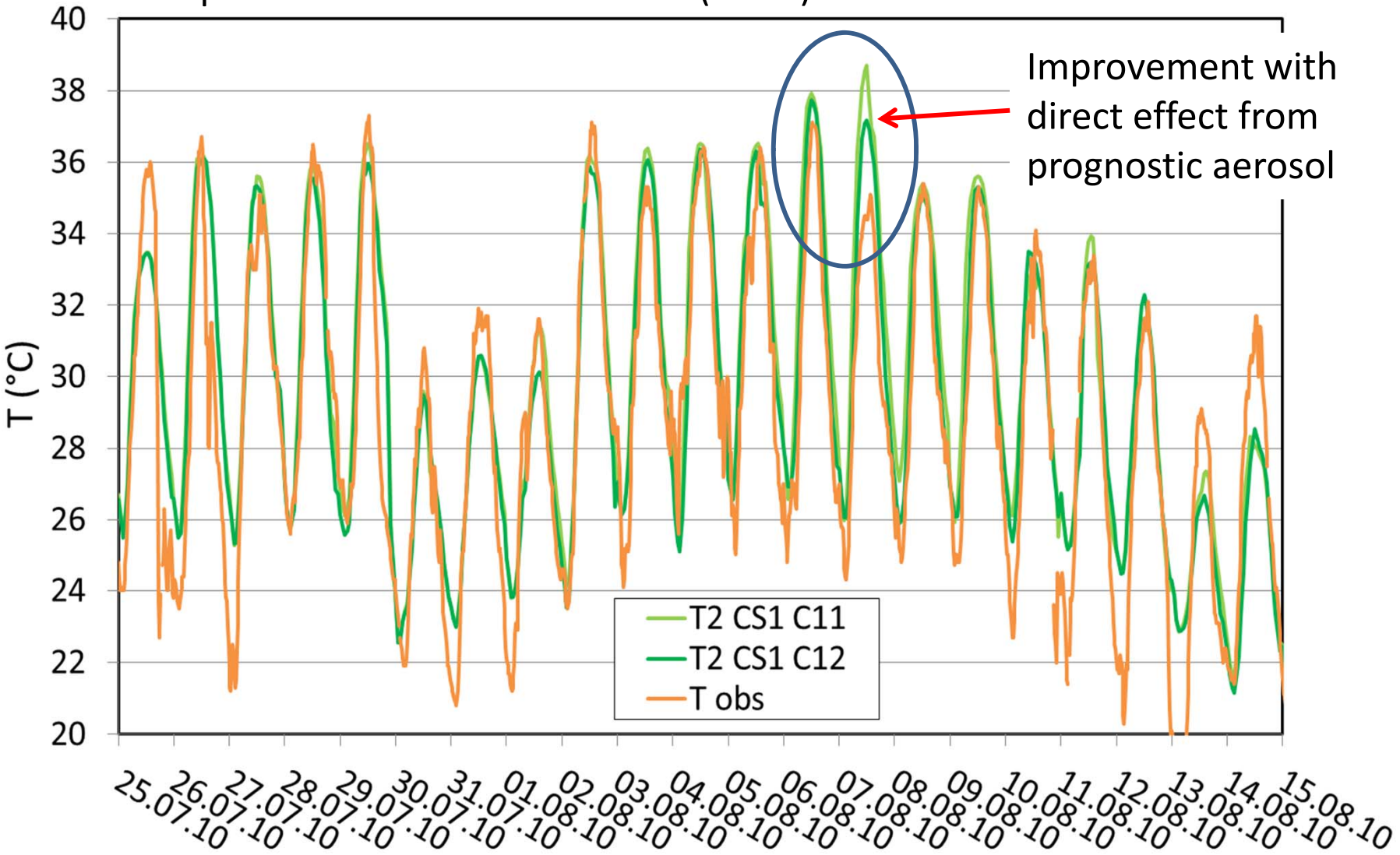
TEMP C12-C11 ES3



Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Effect on Temperature: CS1 vs. obs

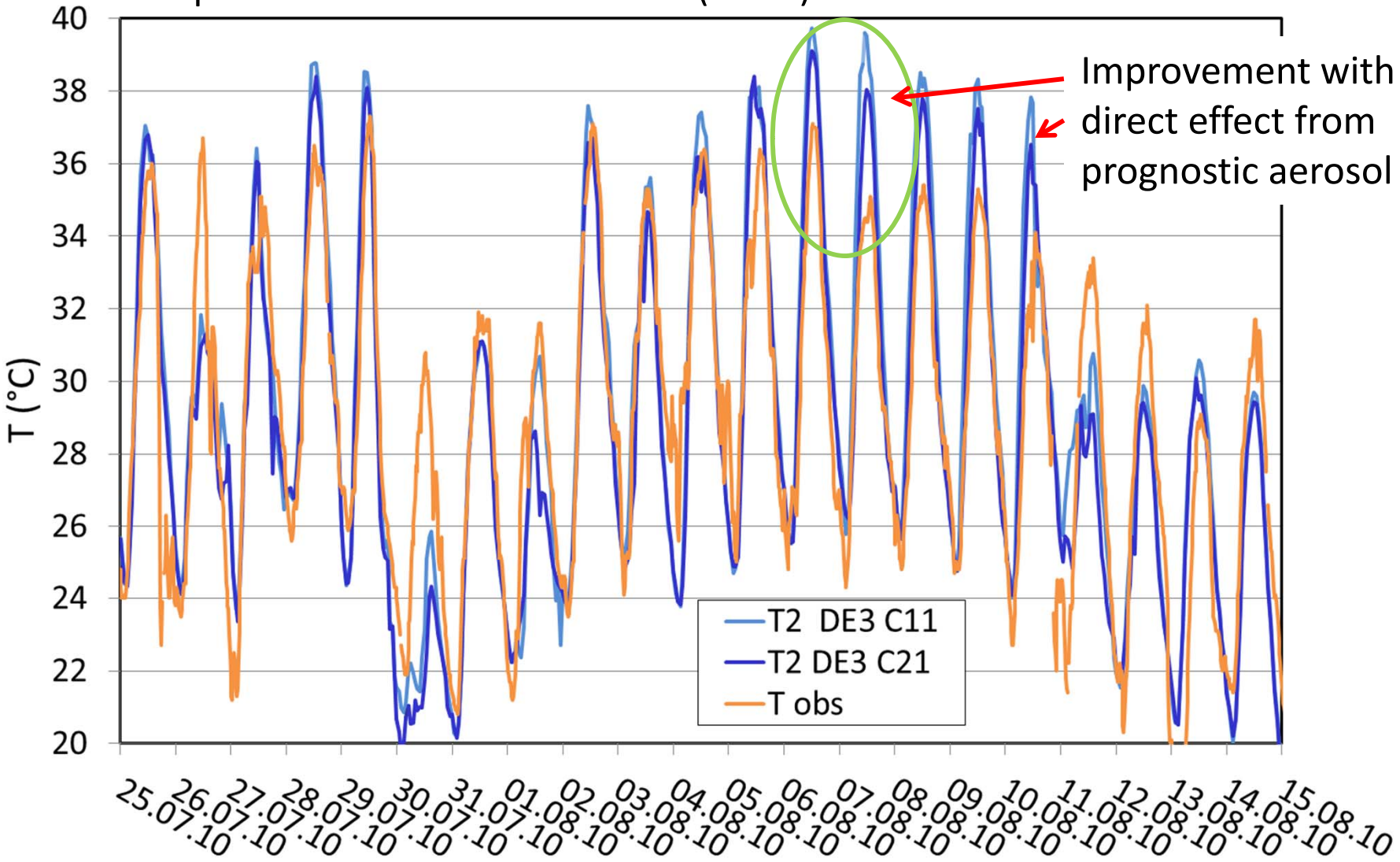
WRF-Chem baseline (CS1 C11) and „direct aerosol effect“ (CS1 C12) compared to T at Moscow station (T obs)



Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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)



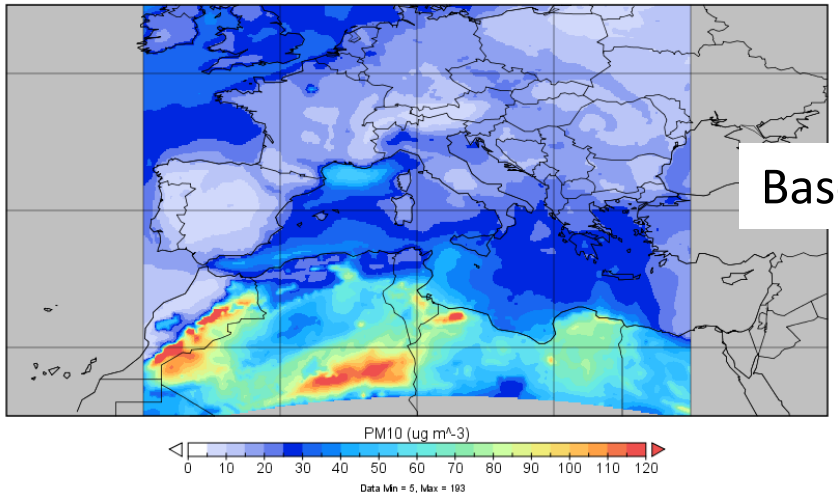
Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

October episode

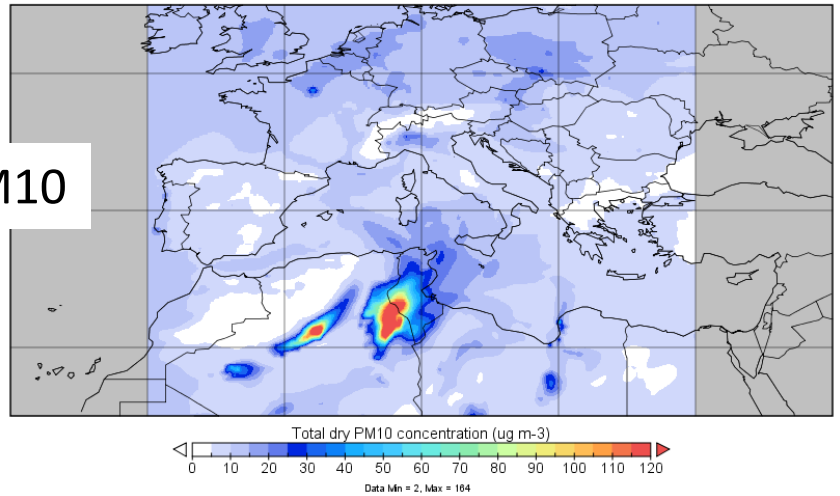
Wet and ‚Dust' Episode, 2.-15. Oct. 2010:

More pronounced PM10 variablity among models for direct effect

CS1 C21 PM10

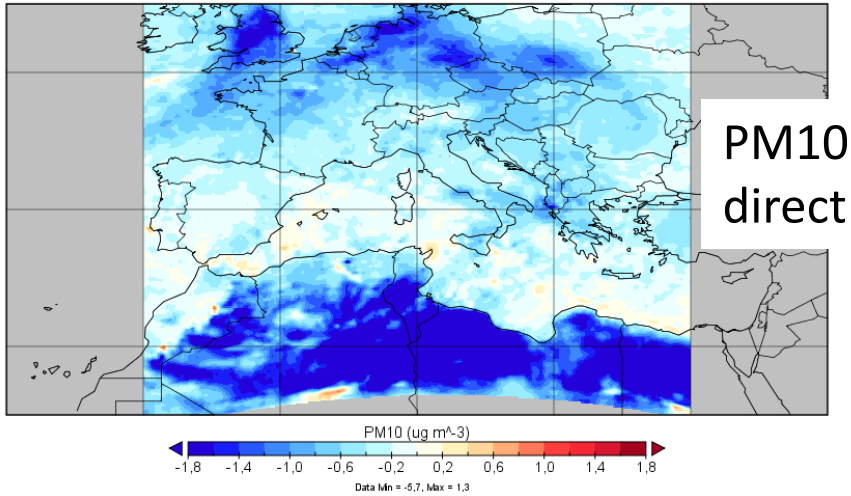


DE3 C21 PM10

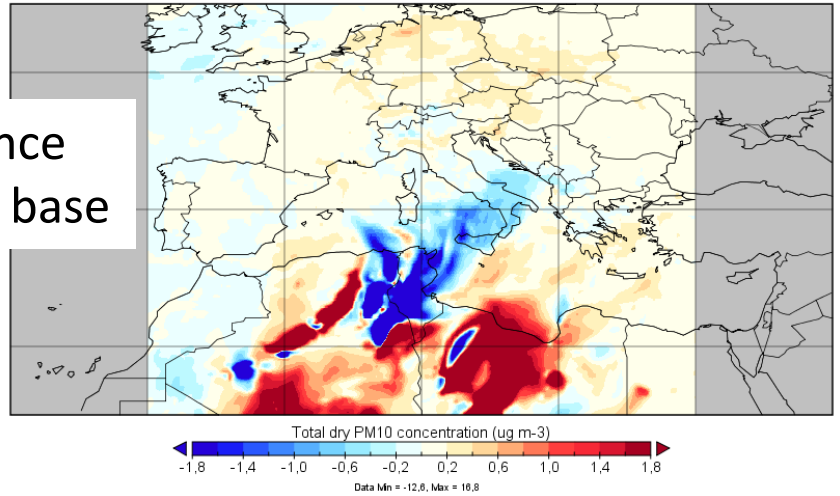


Baseline PM10

ES1 C22-C21 PM10



DE3 C22-C21 PM10



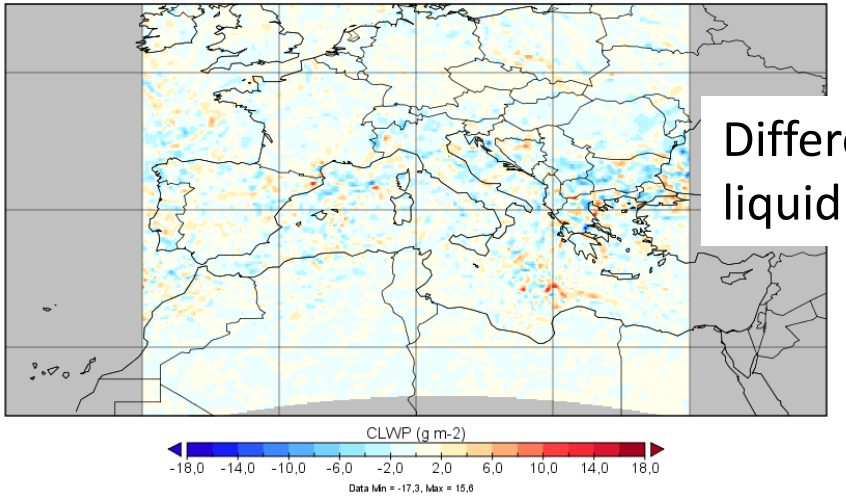
PM10 difference
direct effect - base

Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

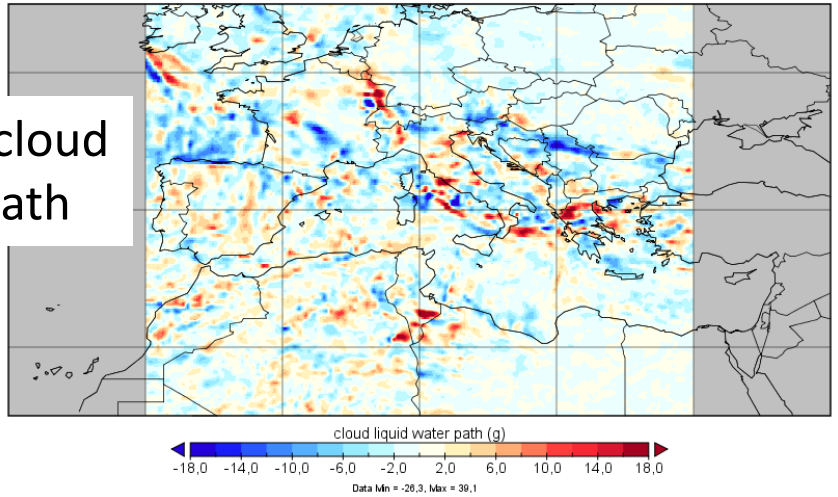
October episode

Direct effect

CS1 C22-C21 Cloud liquid water path

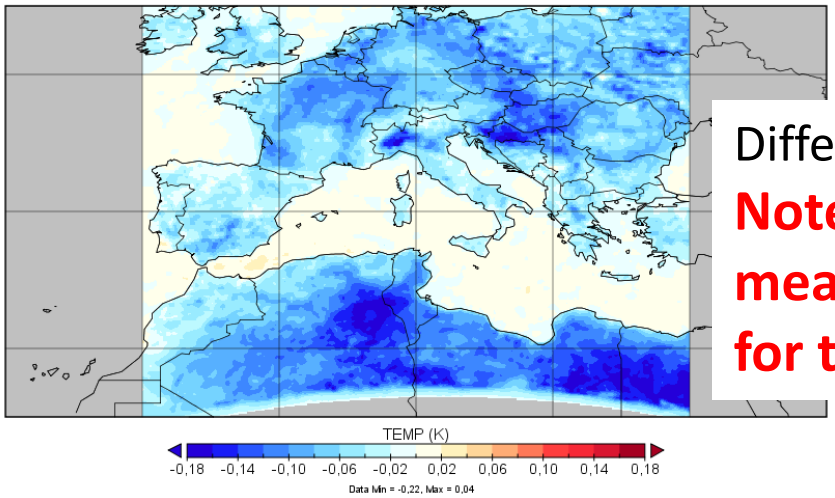


DE3 C22-C21 Cloud liquid water path

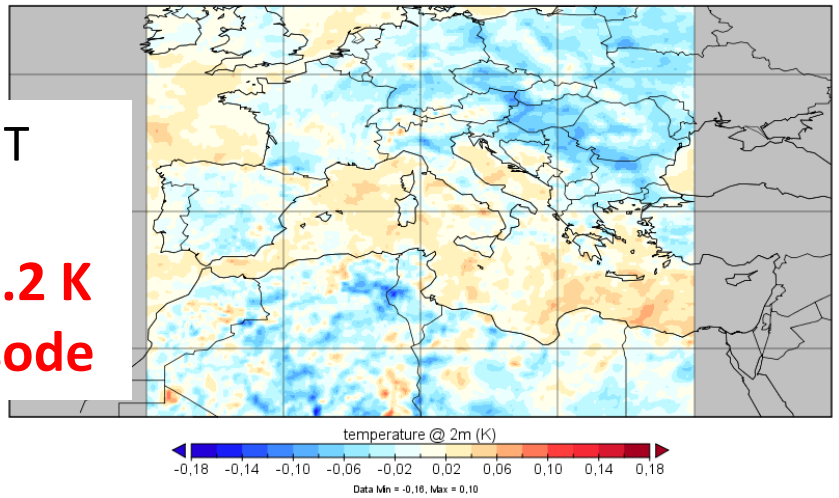


Difference in cloud liquid water path

CS1 C22-C21 T @ 2m



DE3 C22-C21 T @ 2m



Difference in T

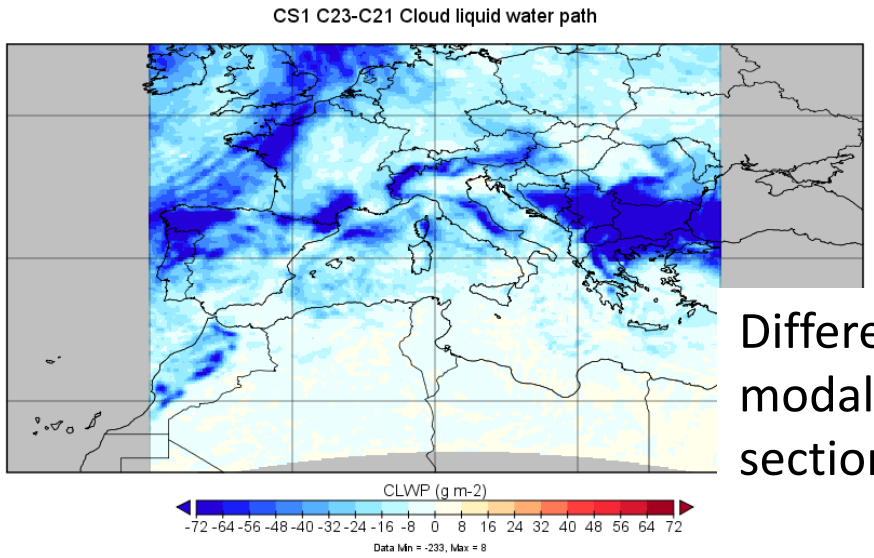
Note:

mean dT< 0.2 K for this episode

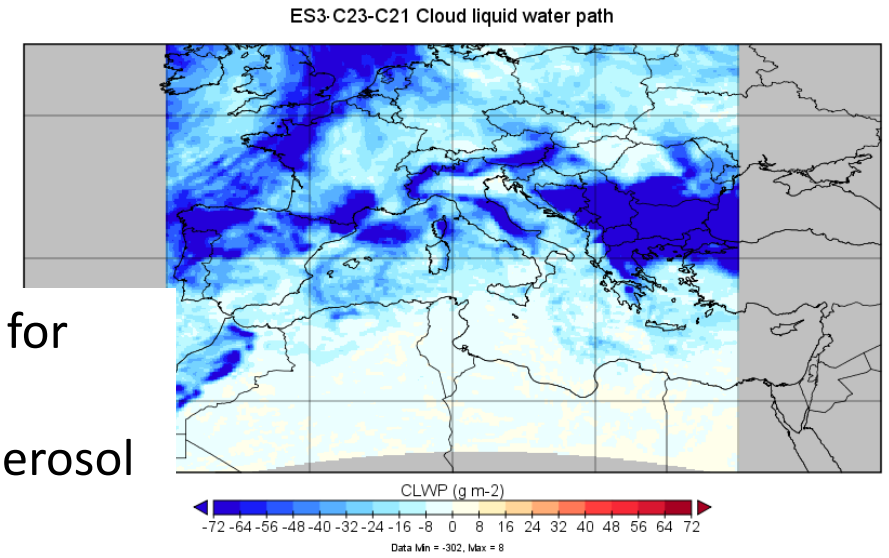
Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

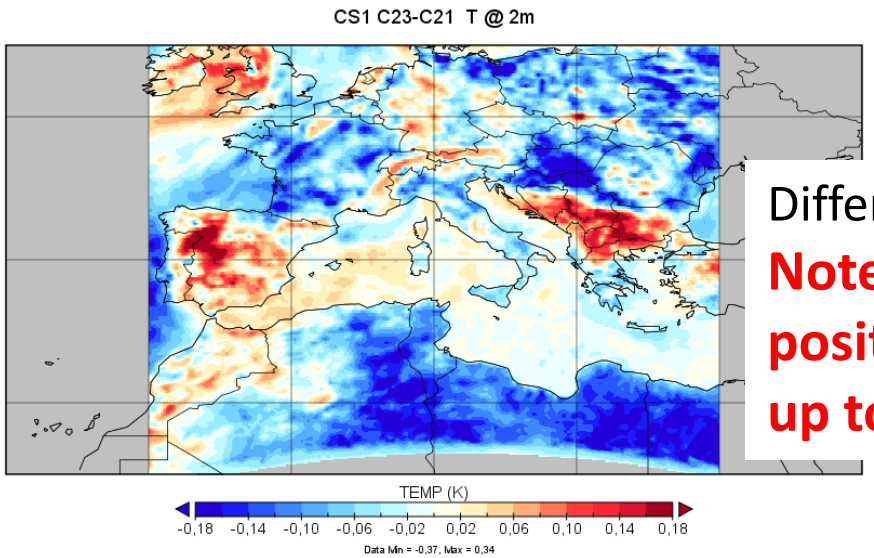
October episode

Indirect effect



Difference for modal and sectional aerosol

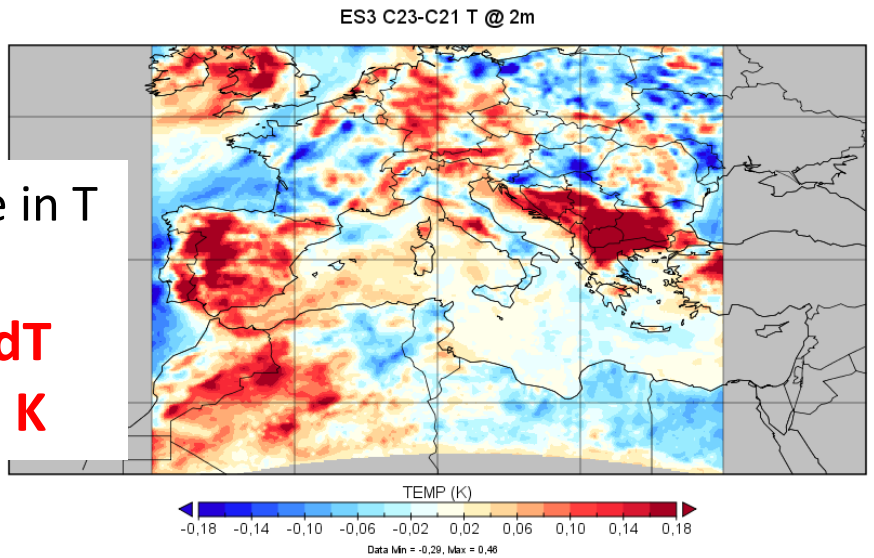




Difference in T

Note:

positive dT up to 0.5 K



Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

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
- Indirect effect: increased solar radiation due to decreased cloud water content (for WRF-Chem)
- For indirect effect different baseline assumptions can strongly affect the model response to feedback
  ⇒ 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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu

Acknowledgments:

- 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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Renate Forkel, KIT, IMK-IFU
renate.forkel@kit.edu