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A multi-model case study on aerosol-meteorology interactions with regional online coupled chemistry-meteorology models

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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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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 sim. aerosol
- Direct and indirect aerosol based on simulated aerosol effect

Two episodes in the year 2010

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

cost

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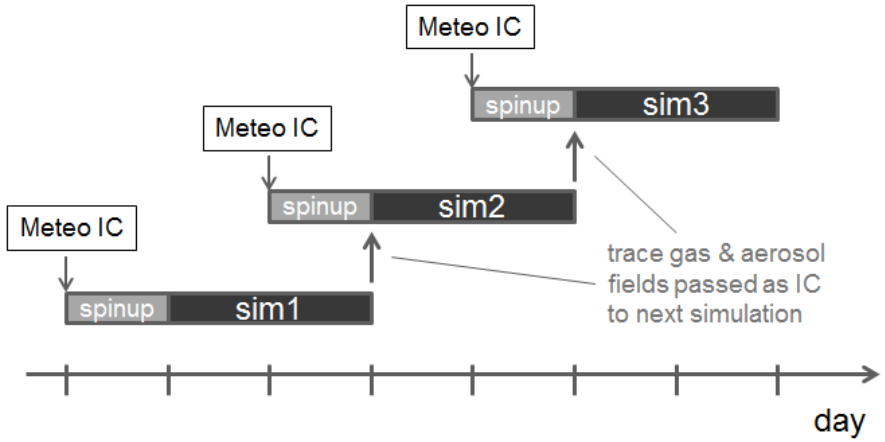
COST ES1004 Case Studies: Setup

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?



- Most modelling domains cover entire Europe + North Atlantic
- Smaller domain for DE3 and CS2

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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
ES3	UPM-ESMG	WRF-Chem (d)	Fire, dust	Base, direct, dir&indir	23 km
DE3	IFT Leipzig	COSMO-MUSCAT	Fire, dust	Base, direct	0.15°
CH1	EMPA	COSMO-ART	Fire (3 days missing)	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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Russian heat wave and fire episode

Concentrate on

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

ES1 (like CS1, but with different cloud micropysics)
Quite similar to CS1 contribution. See talks by **Rocío Baró** (this afternoon) and **Palacios Peña Laura** (tomorrow)

CH1: (COSMO-ART with MADE-Soot [not complete])

Comparison with observations near Moscow courtesy of Dr. Natalia Chubarova, Moscow State University . Surface measurement data from Mosecomonitoring, Meteorological Observatory of Moscow

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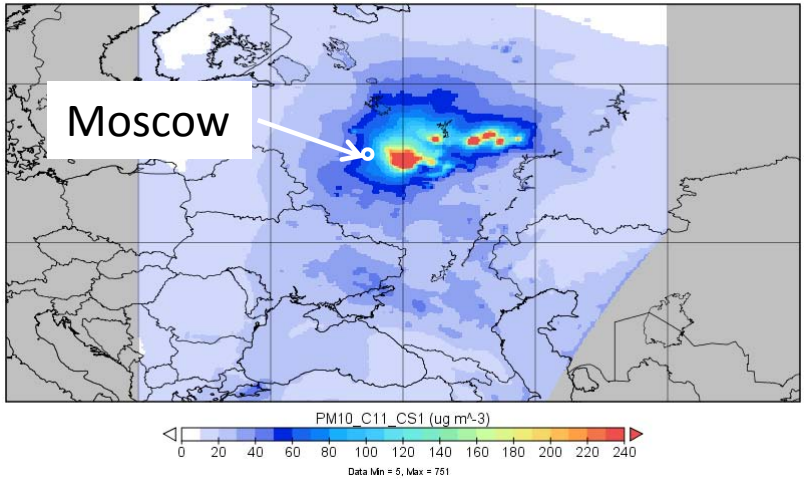
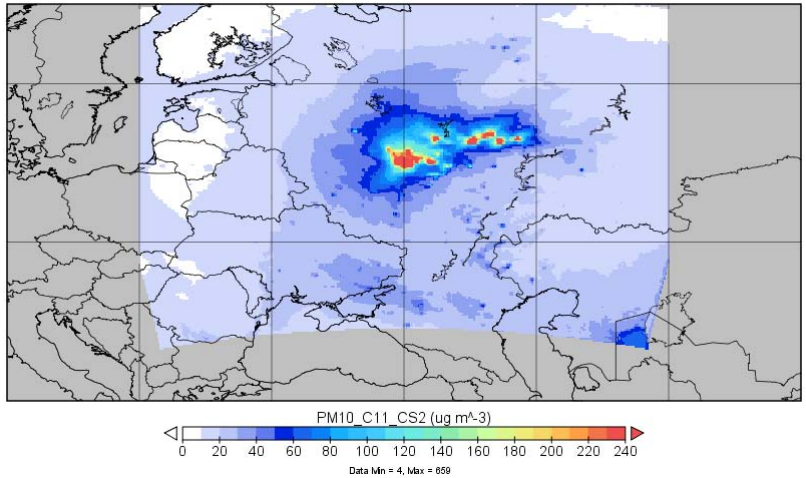
Baseline PM10

Episode mean PM10 (µg m^{-3})

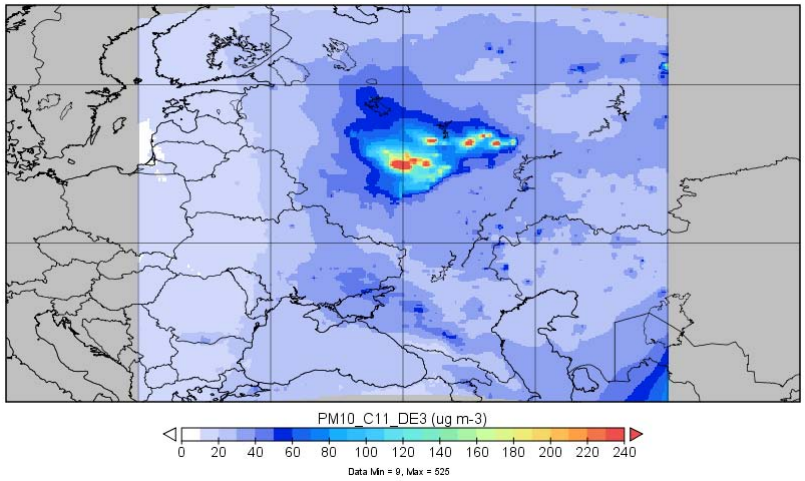
WRF-Chem modal PM10_C11_CS1



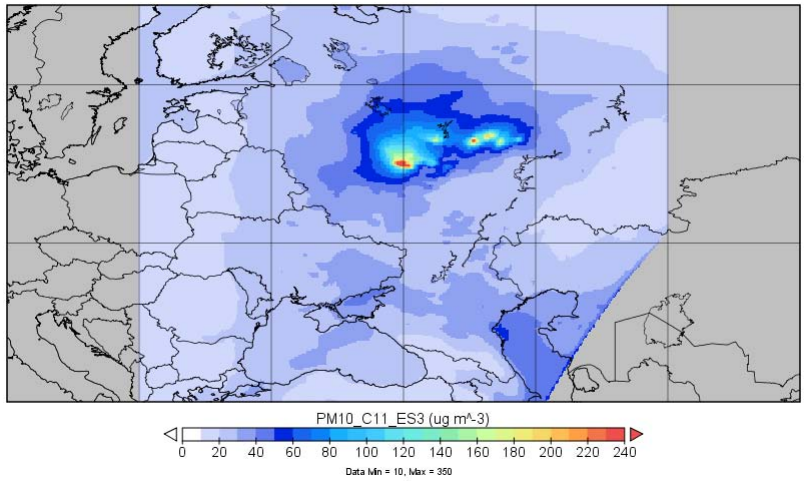
WRF-Chem modal PM10_C11_CS2



COSMO-MUSCAT PM10_C11_DE3



WRF-Chem sectional PM10_C11_ES3



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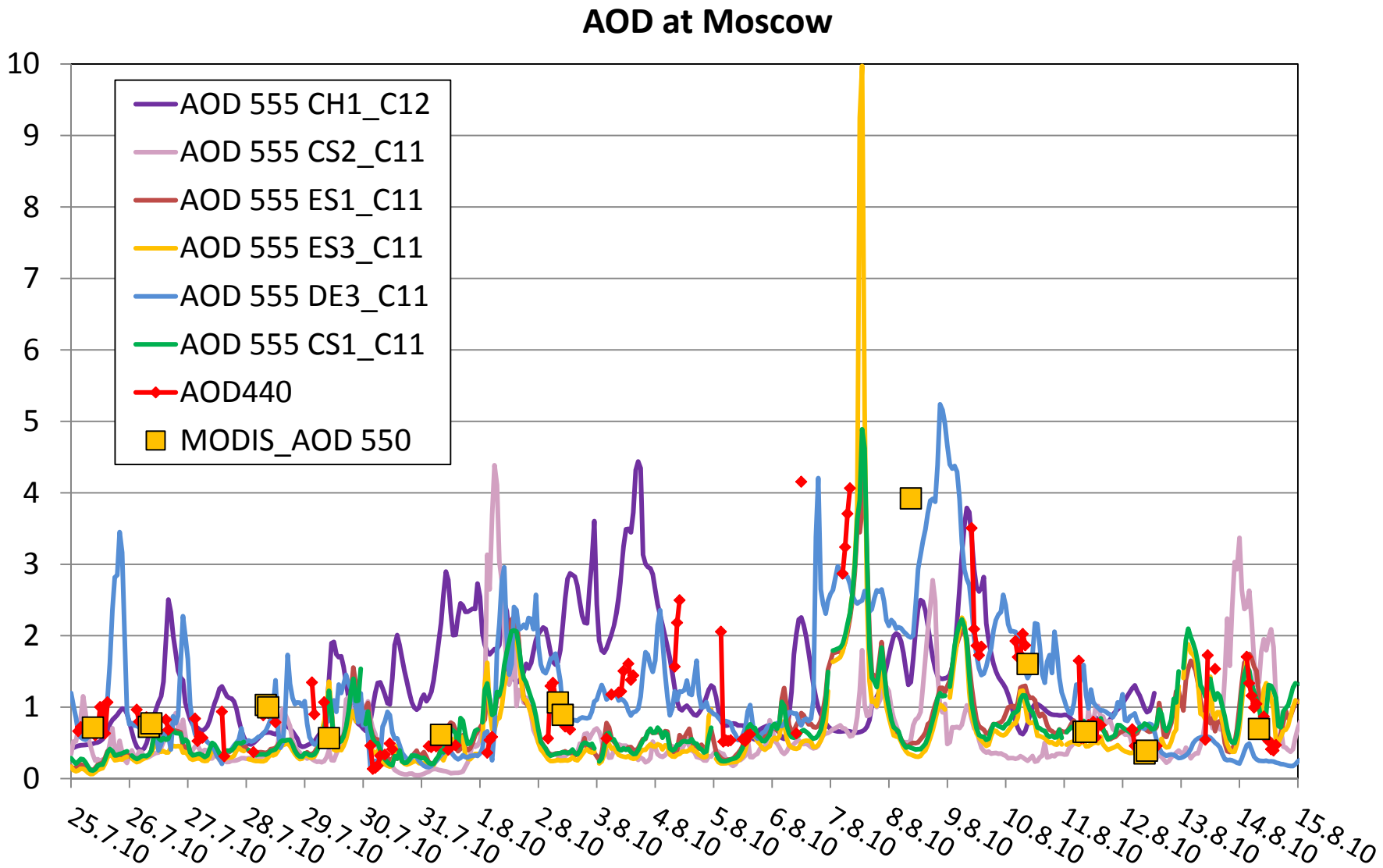
Baseline AOD at Moscow



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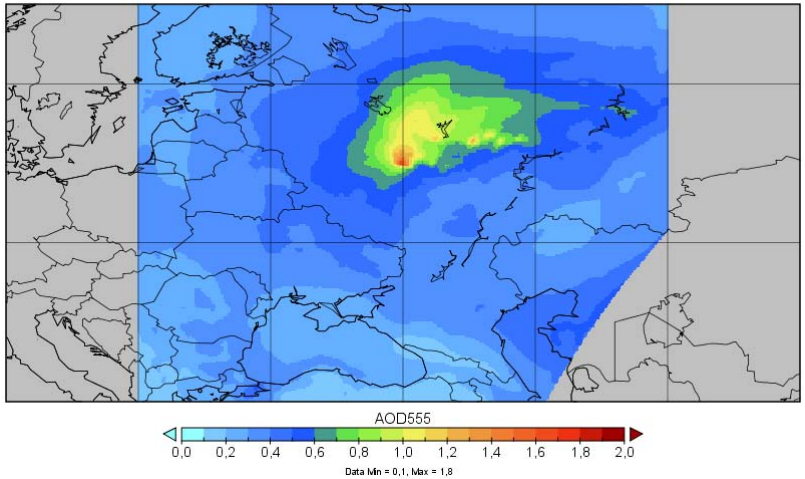
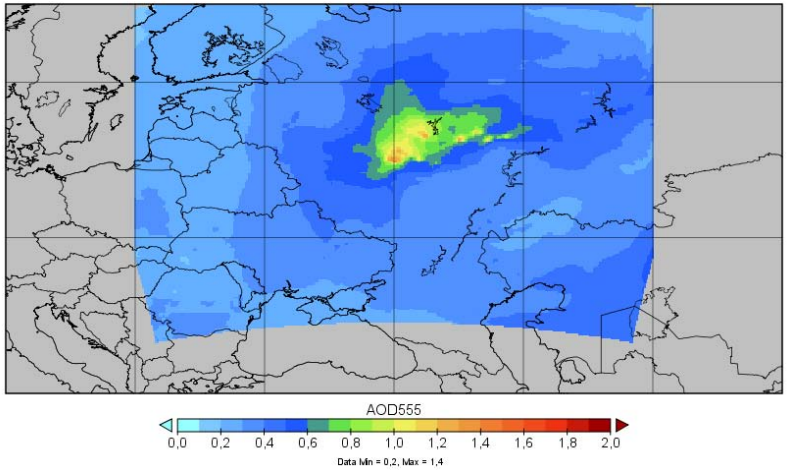
Baseline AOD at 555nm

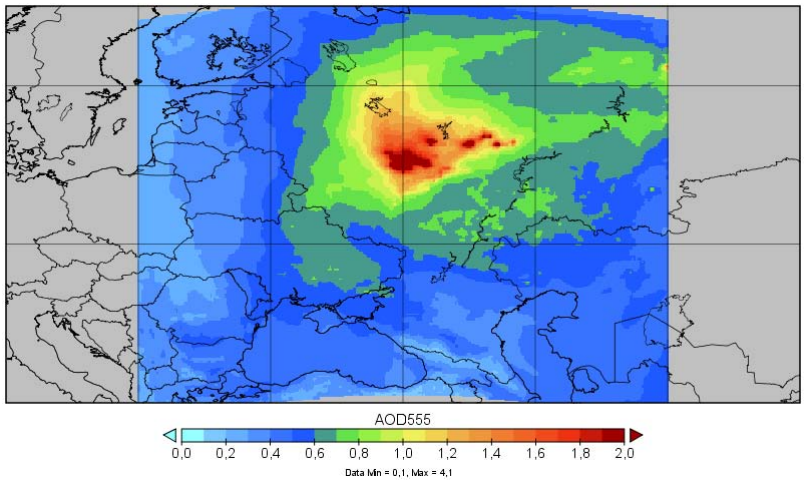
WRF-Chem modal AOD555_C11_CS1



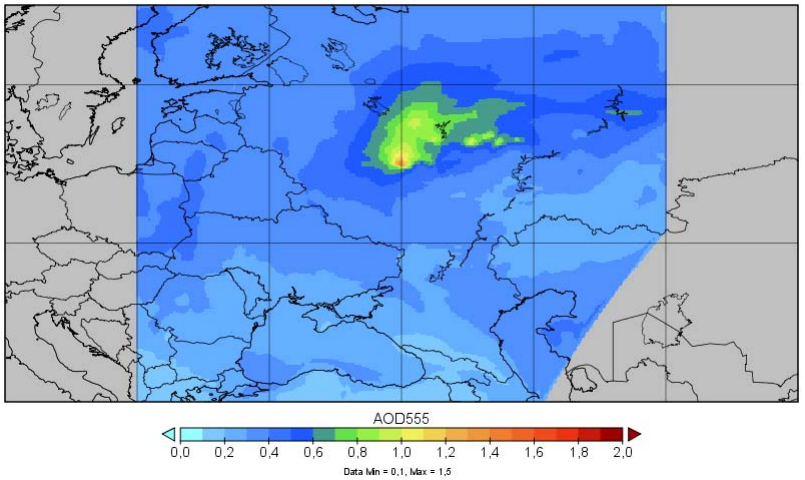
WRF-Chem modal AOD555_C11_CS2



COSMO-MUSCAT AOD555_C11_DE3



WRF-Chem sectional AOD555_C11_ES3



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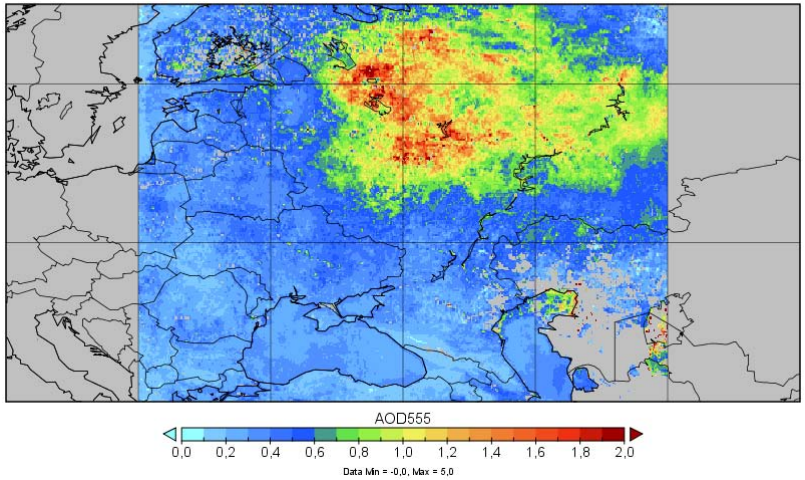
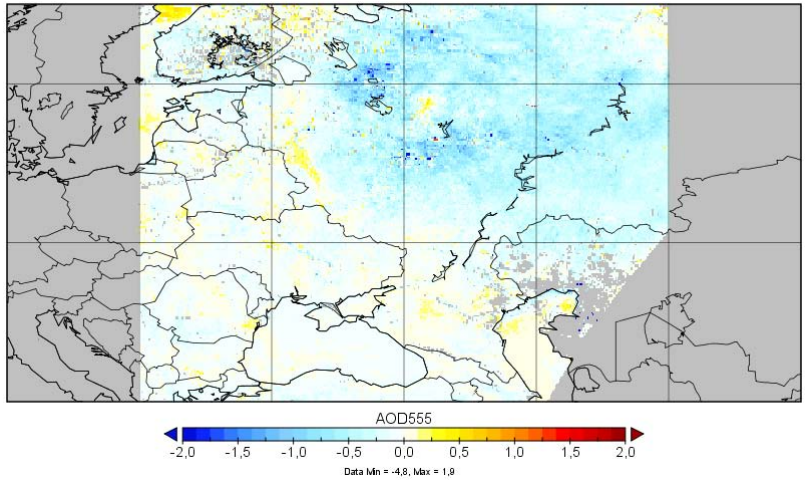
Baseline AOD at 555nm

Comparison with MODIS (overpass time: morning)

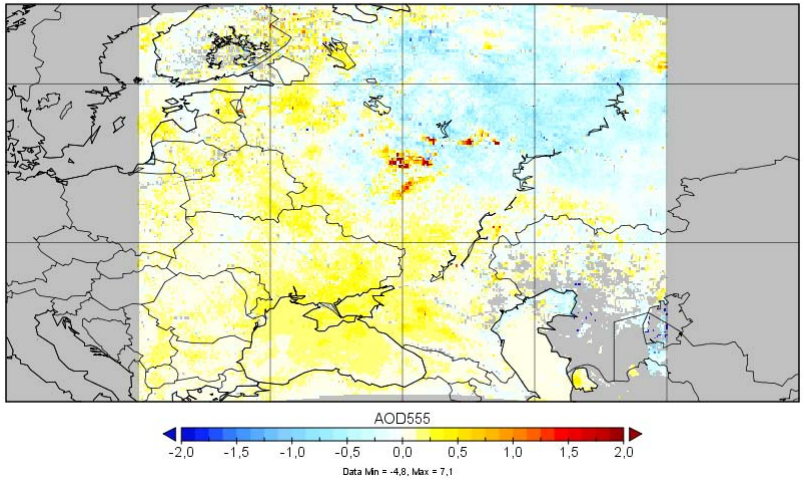
AOD555 MODIS



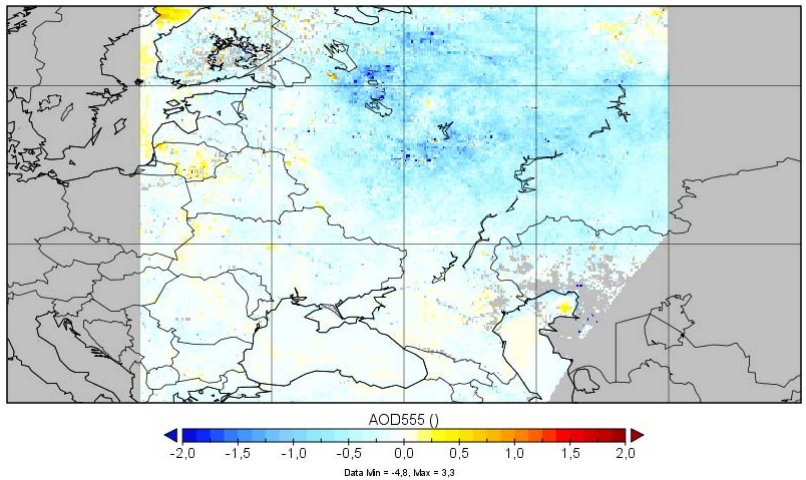
WRF-Chem modal AOD555: CS1_C11 - MODIS



COSMO-MUSCAT AOD555: DE3_C11 - MODIS



WRF-Chem sect. AOD555: ES3_C11 - MODIS



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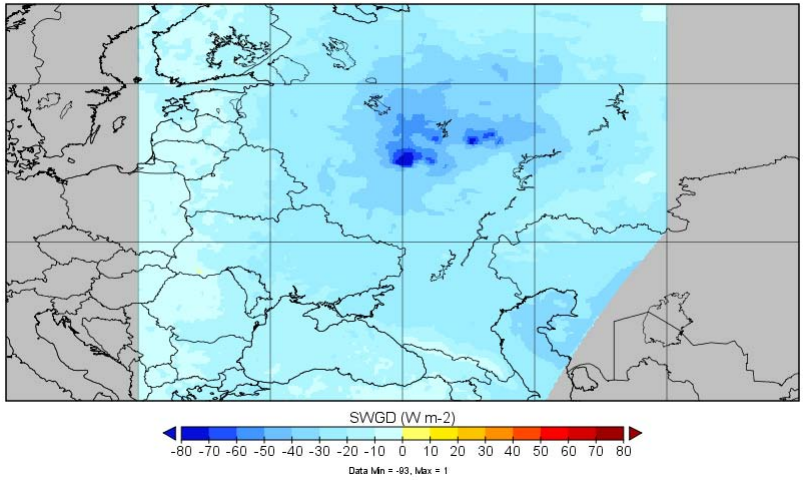
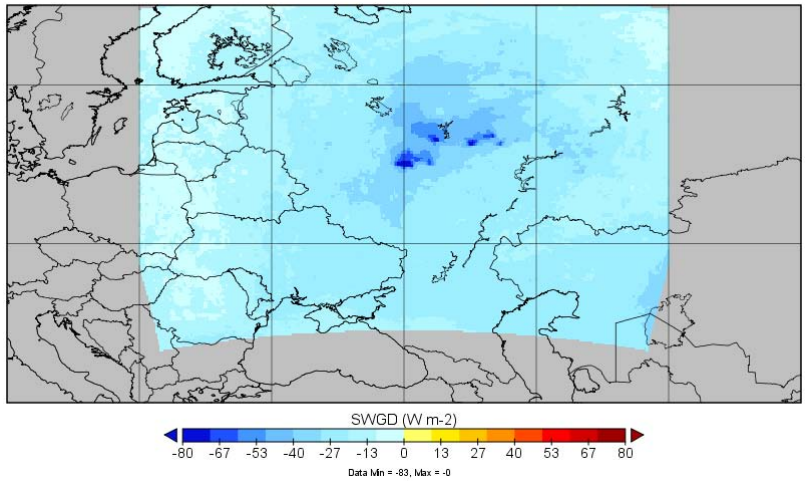
Effect on solar radiation

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

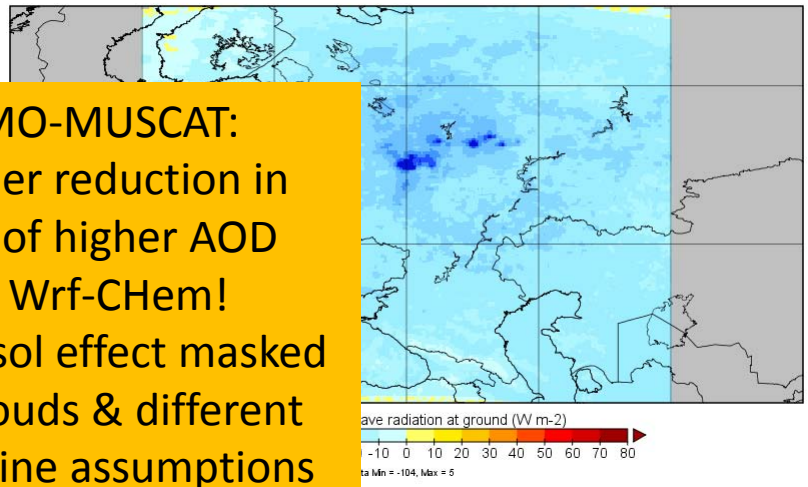
WRF-Chem modal SWGD C12-C11 CS1



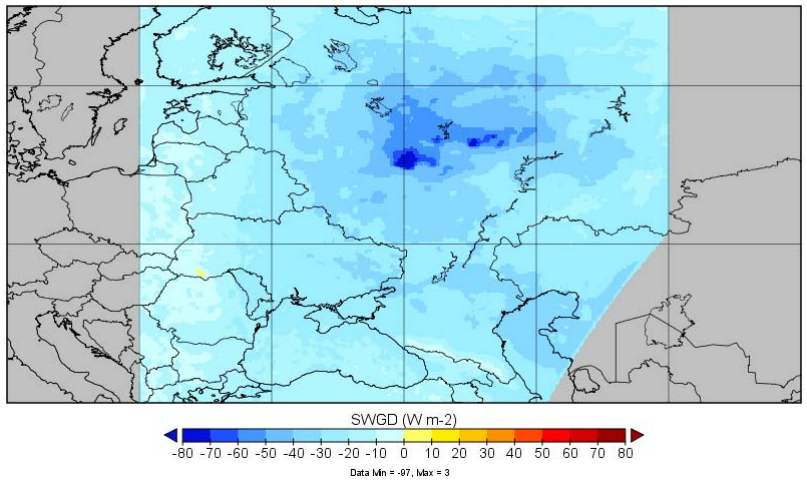
WRF-Chem modal SWGD C12-C11 CS2



COSMO-MUSCAT SWGD C12-C11 DE3



WRF-Chem sectional SWGD C12-C11 ES3



COSMO-MUSCAT: Smaller reduction in spite of higher AOD than Wrf-CHem! Aerosol effect masked by clouds & different baseline assumptions

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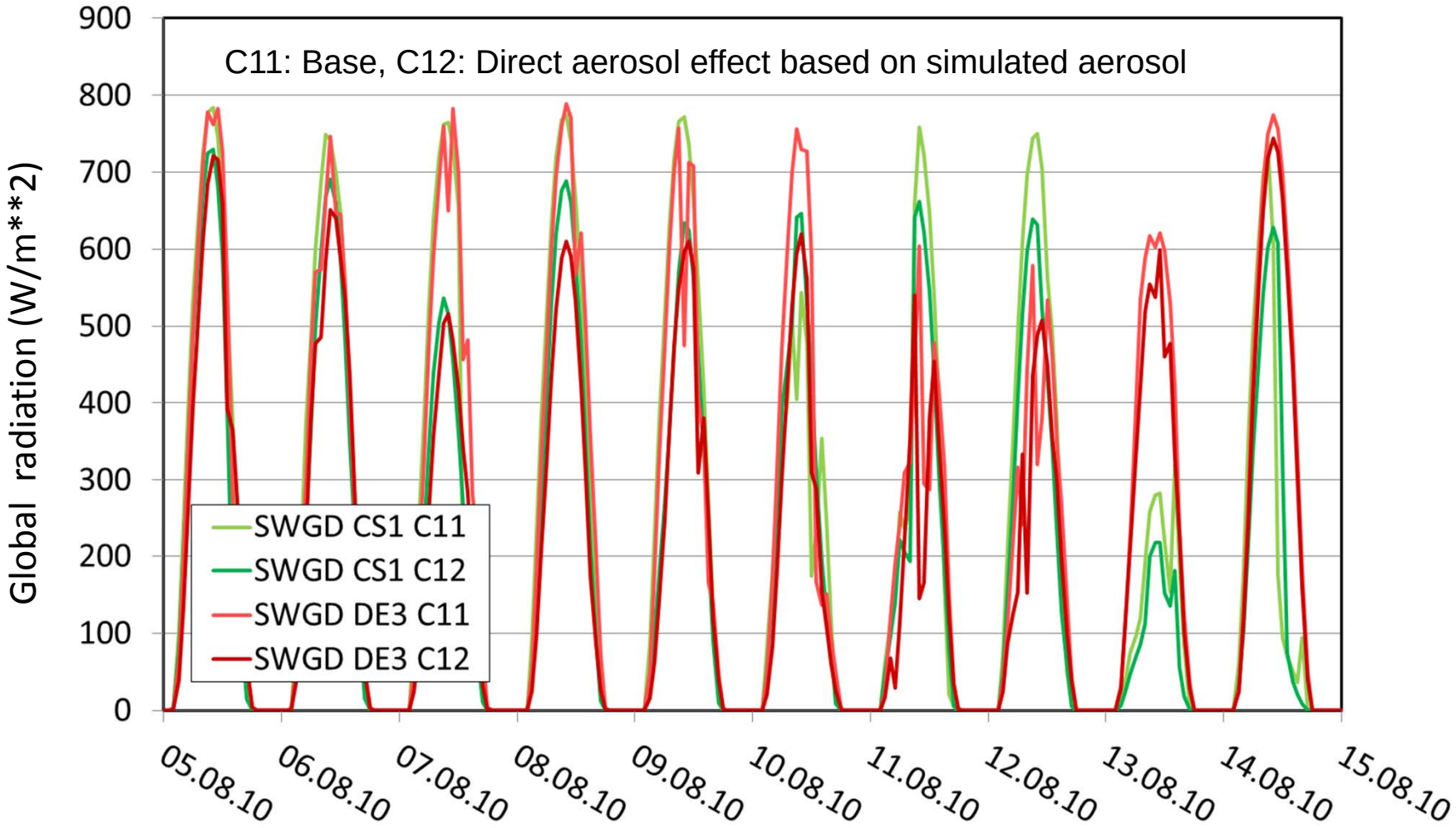
Solar radiation at Moscow

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



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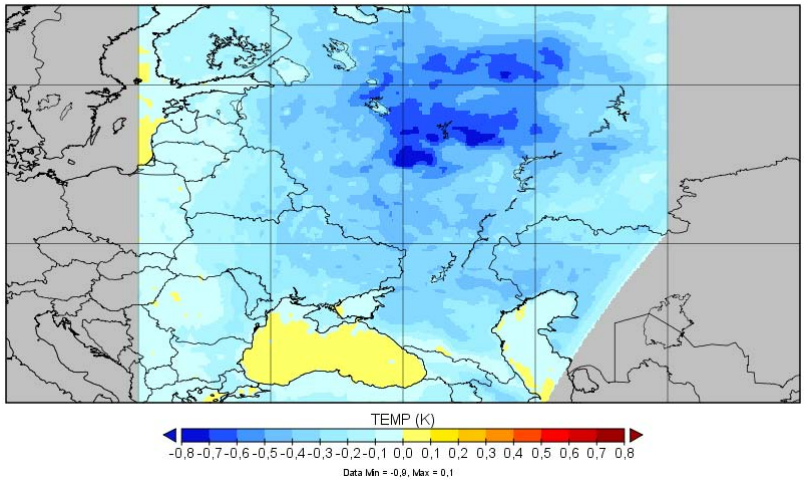
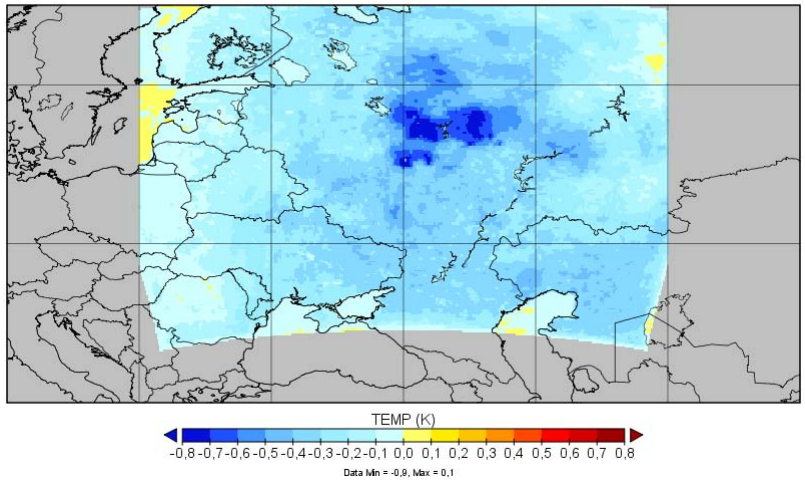
Effect on Temperature

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

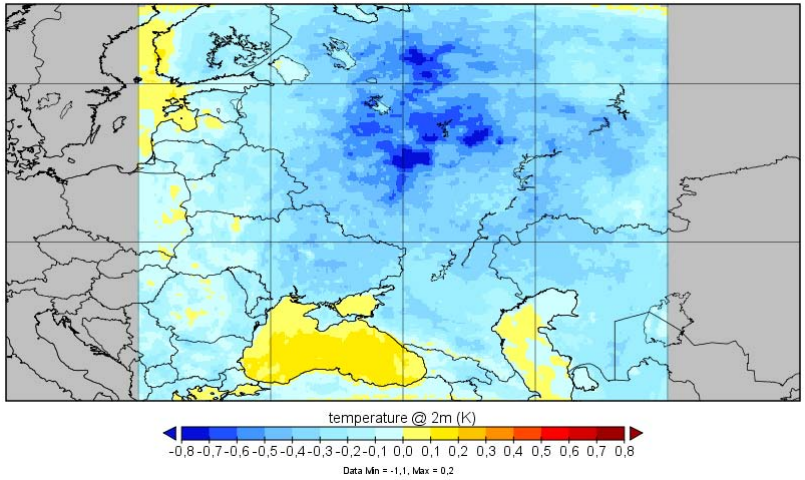
WRF-Chem modal TEMP C12-C11 CS1



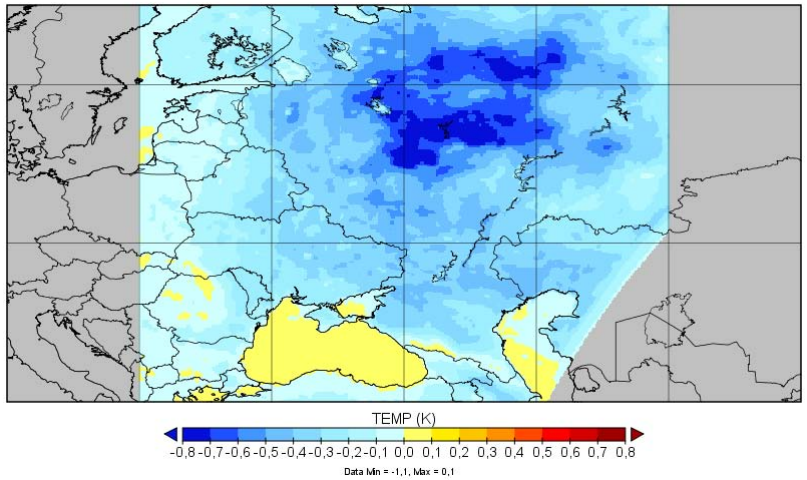
WRF-Chem modal TEMP C12-C11 CS2



COSMO-MUSCAT TEMP C12-C11 DE3



WRF-Chem sectional TEMP C12-C11 ES3



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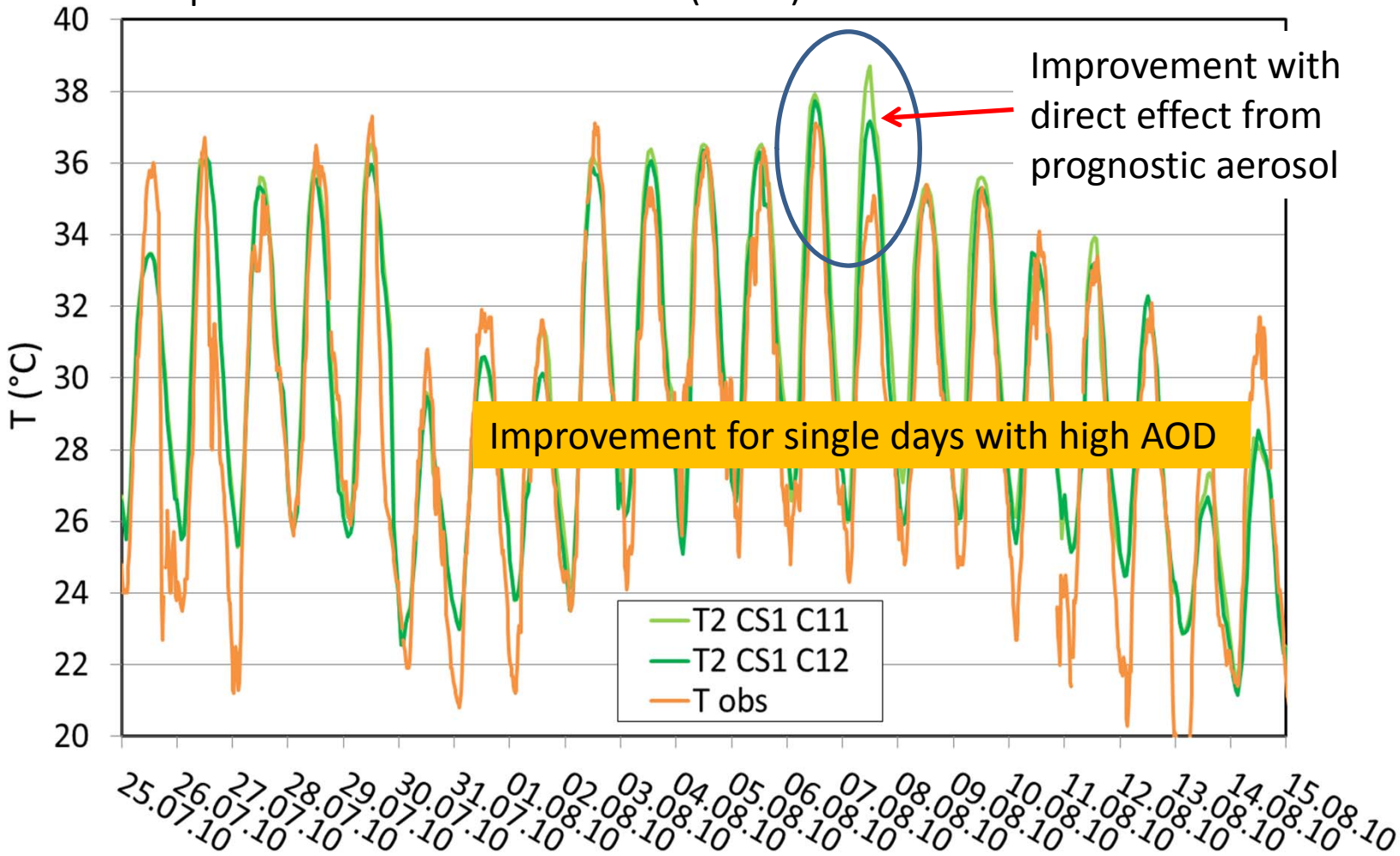
Local effect on Temperature: CS1 vs. obs

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



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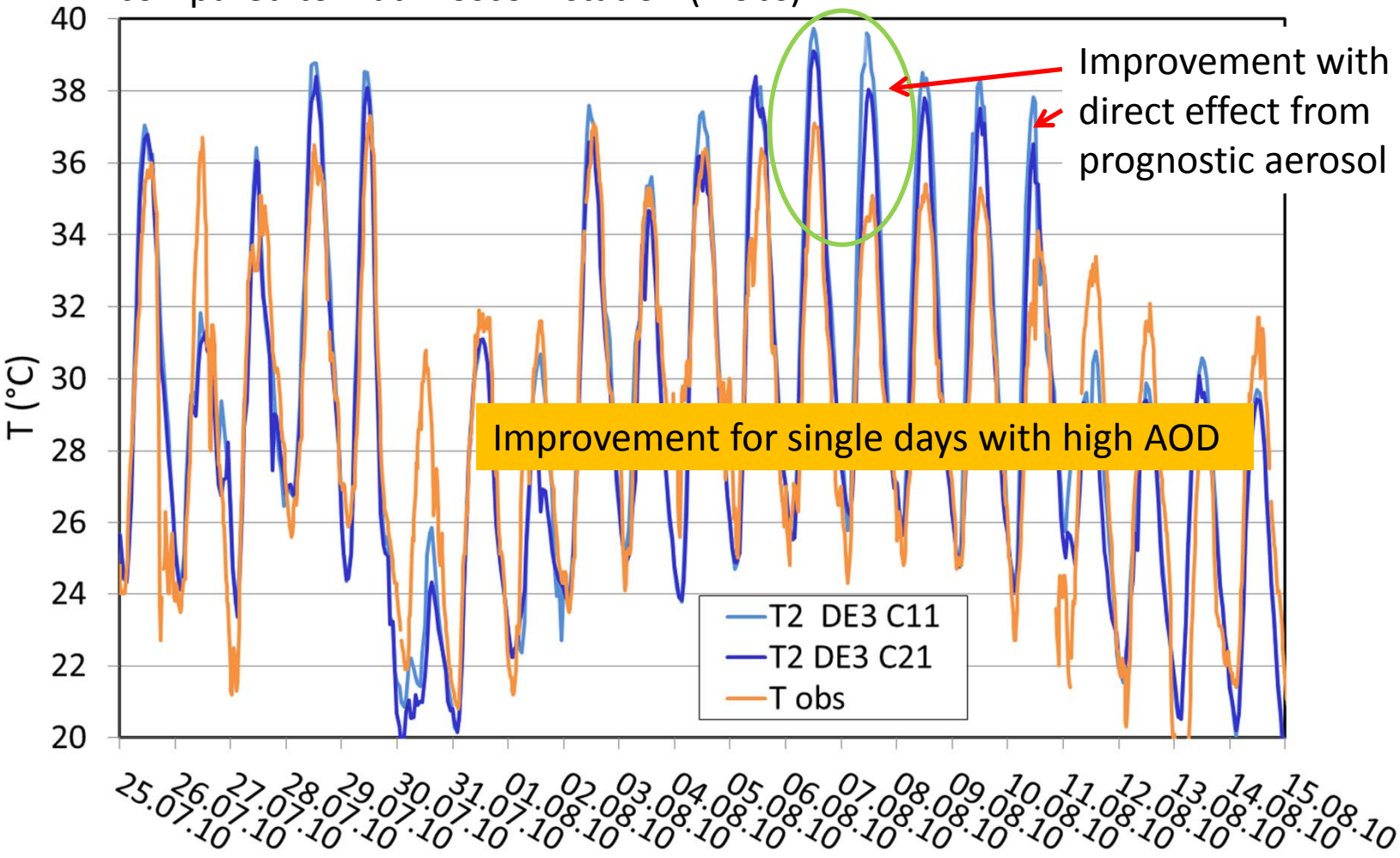
Local effect on Temperature: DE3 vs. obs

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



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Effect on Temperature = Improvement?

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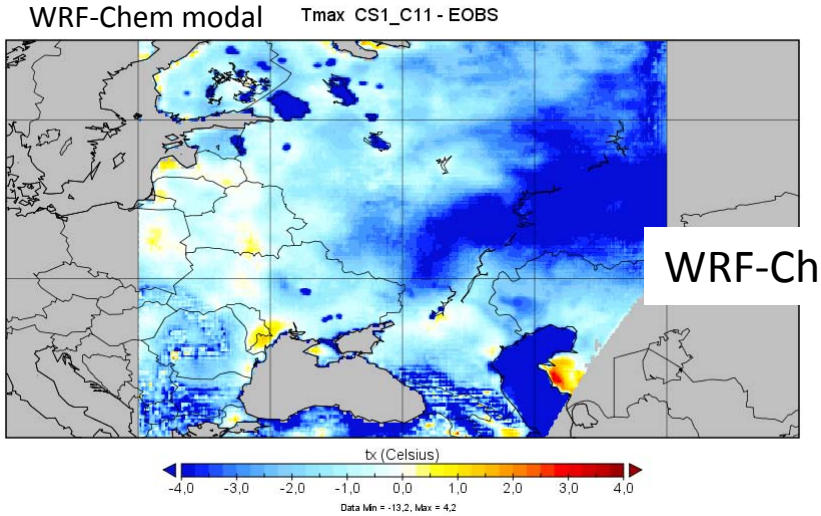
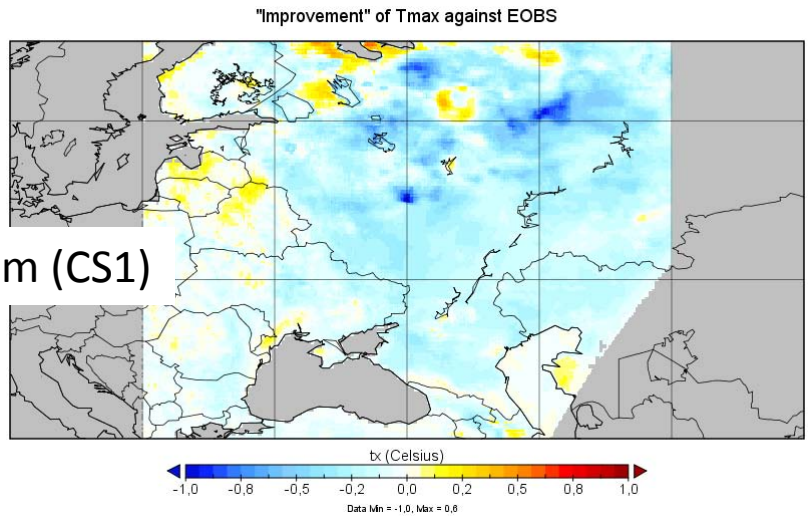
Difference to EOBS

„Improvement“ (red=yes, blue=no)

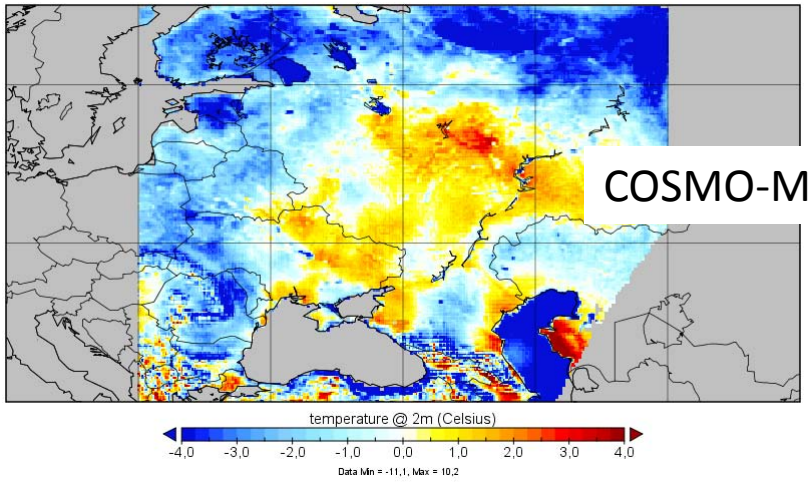
WRF-Chem modal

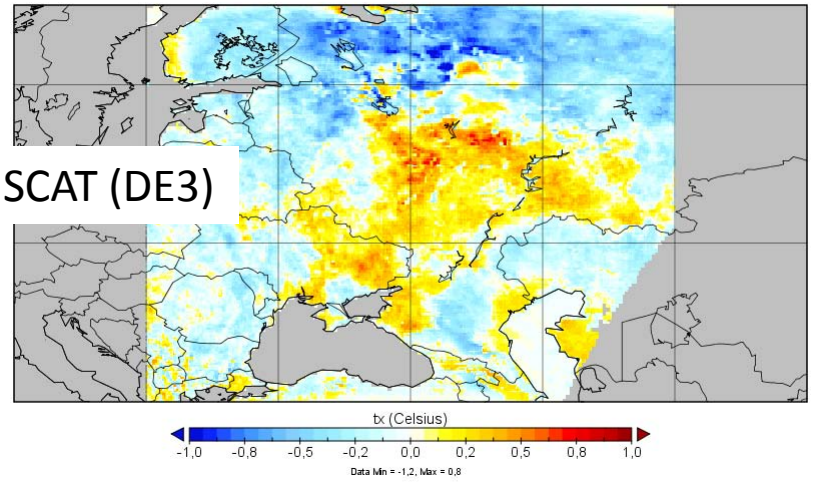




WRF-Chem (CS1)

COSMO-MUSCAT





COSMO-MUSCAT (DE3)

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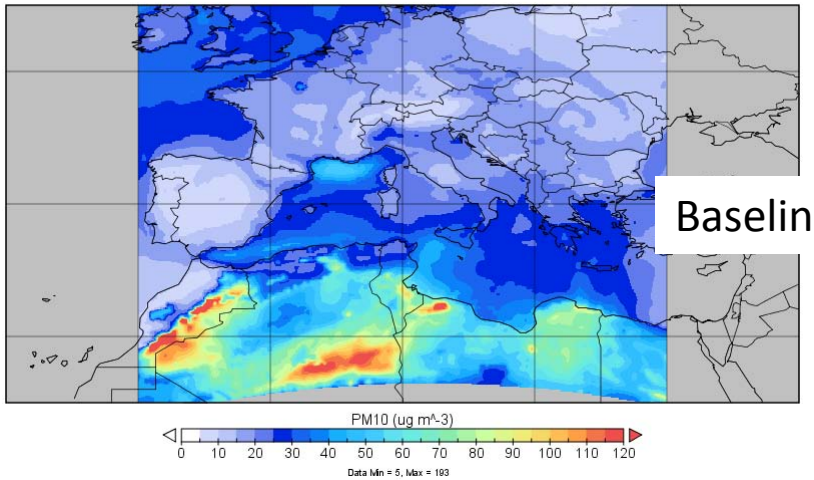
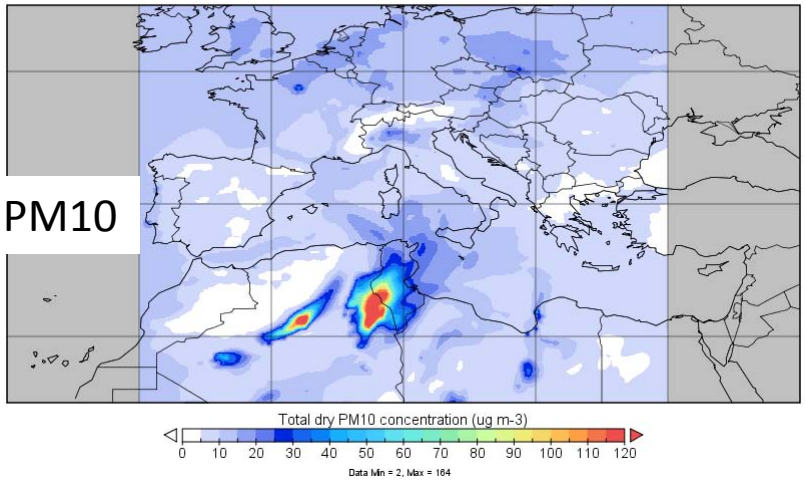
Wet and ‚Dust' October episode

Pronounced PM10 variablity among models for direct effect

WRF-Chem modal CS1 C21 PM10

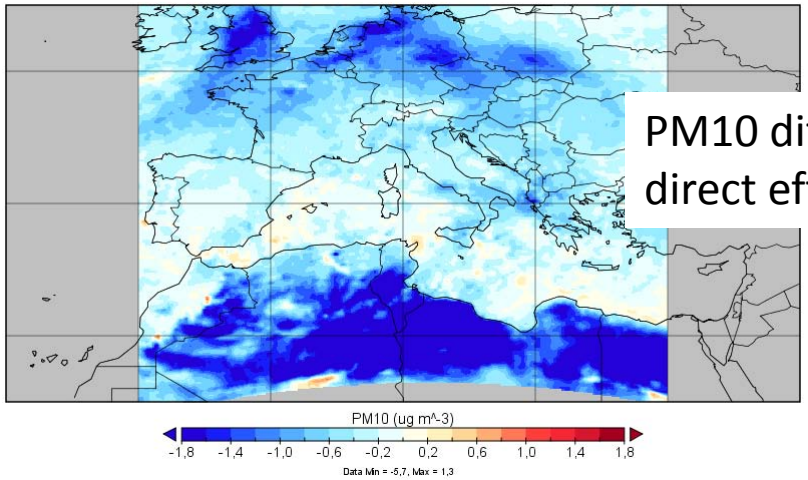


COSMO-MUSCAT DE3 C21 PM10

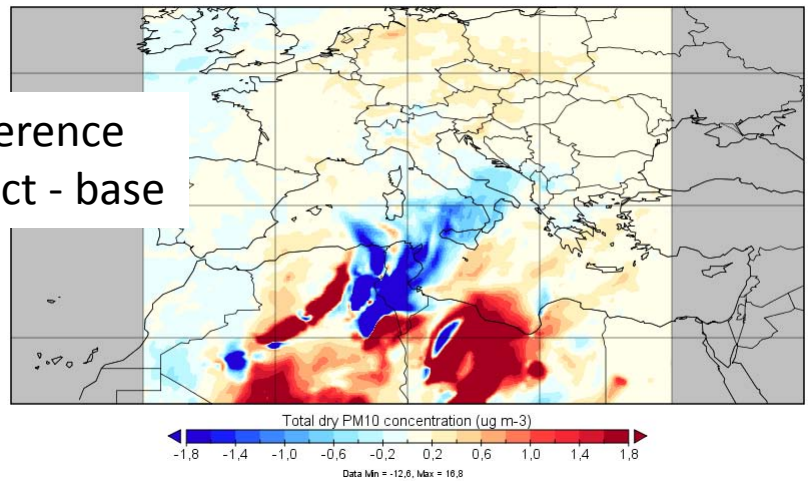


Baseline PM10

WRF-Chem modal CS1 C22-C21 PM10



COSMO-MUSCAT DE3 C22-C21 PM10



PM10 difference
direct effect - base

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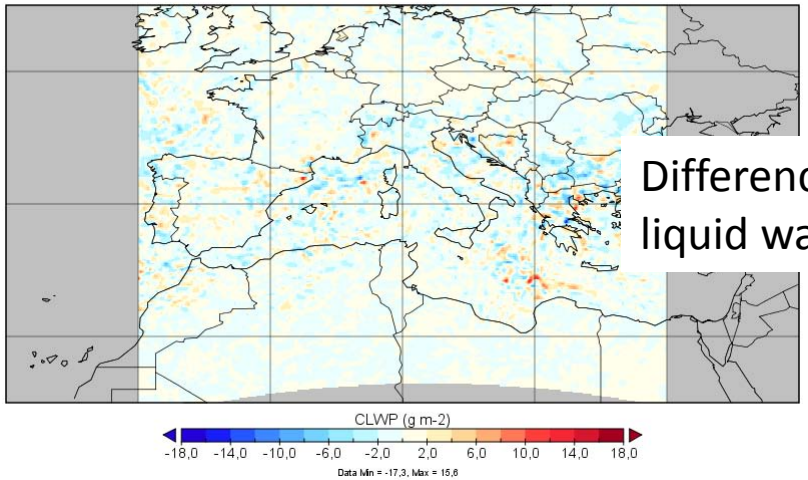
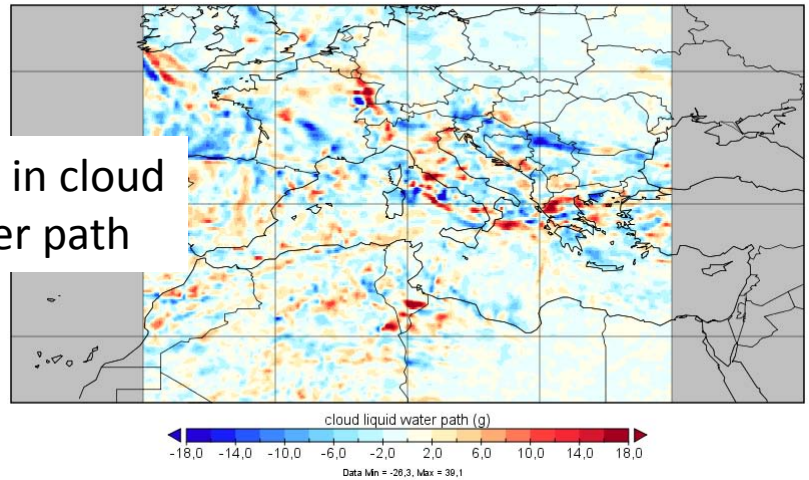
Wet and ‚Dust' October episode

Direct effect: Response of WRF-Chem and COSMO-MUSCAT

WRF-Chem modal CS1 C22-C21 Cloud liquid water path

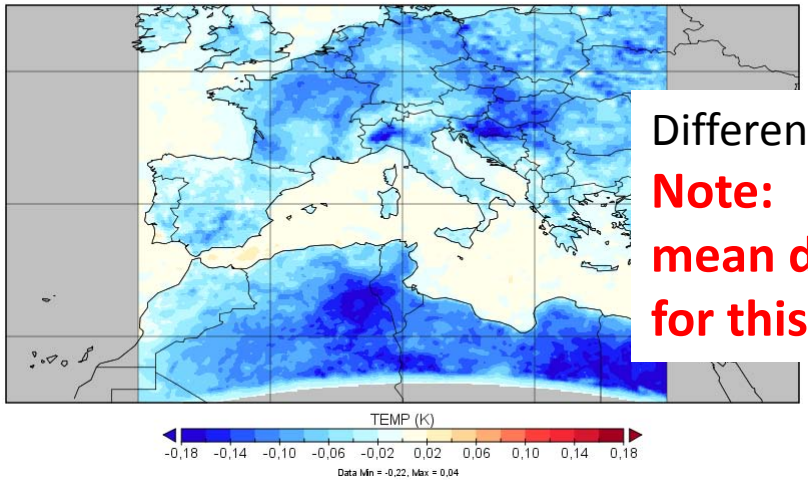


COSMO-MUSCAT DE3 C22-C21 Cloud liquid water path

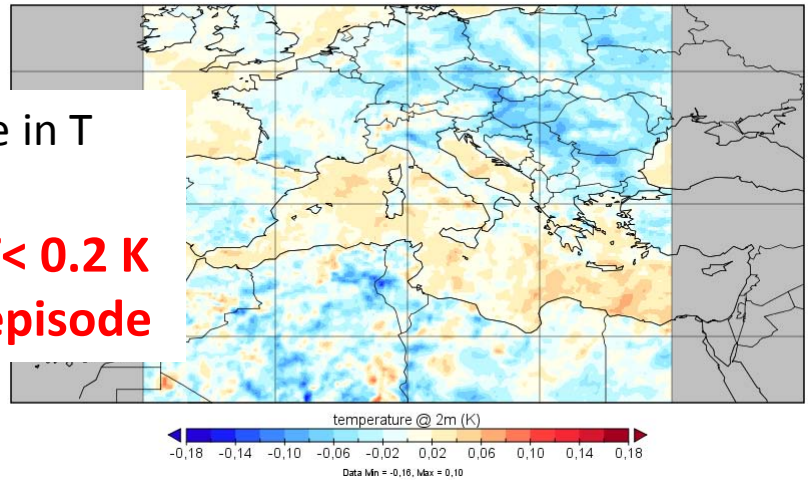


Difference in cloud liquid water path

WRF-Chem modal CS1 C22-C21 T @ 2m



COSMO-MUSCAT DE3 C22-C21 T @ 2m



Difference in T

Note:

mean dT< 0.2 K for this episode

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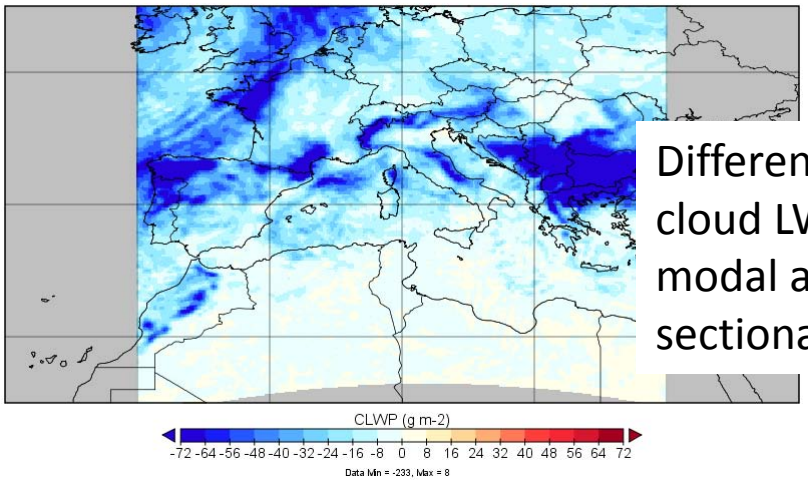
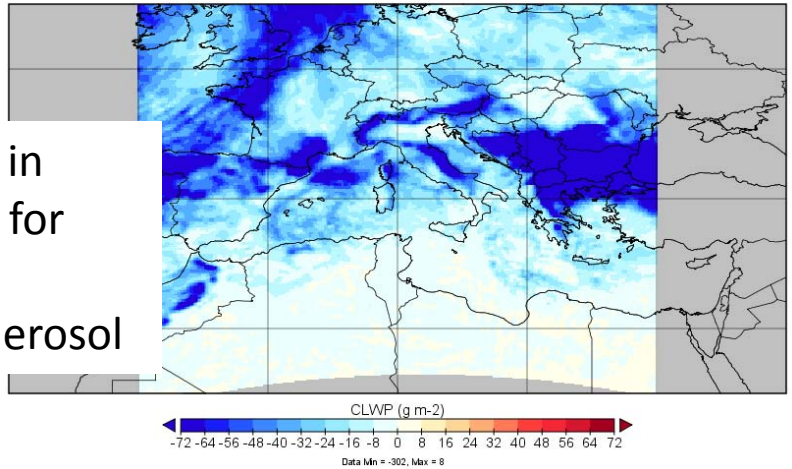
Wet and ‚Dust' October episode

Indirect & dir. effect: WRF-Chem modal and sectional aerosol

Modal

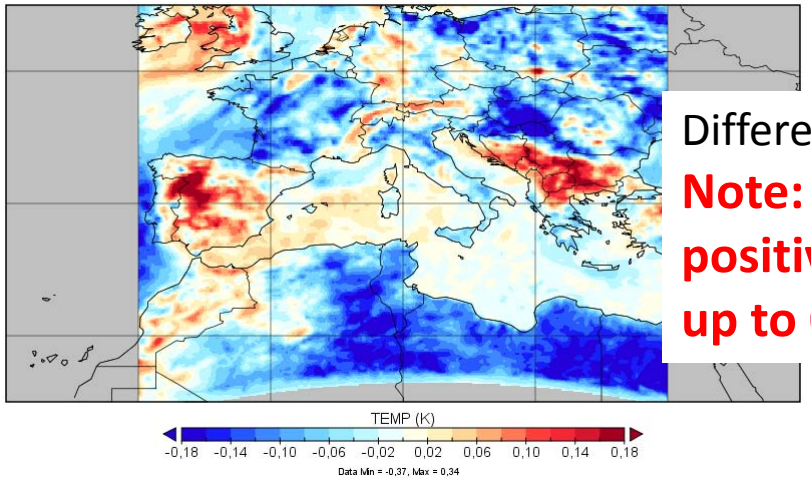


Sectional

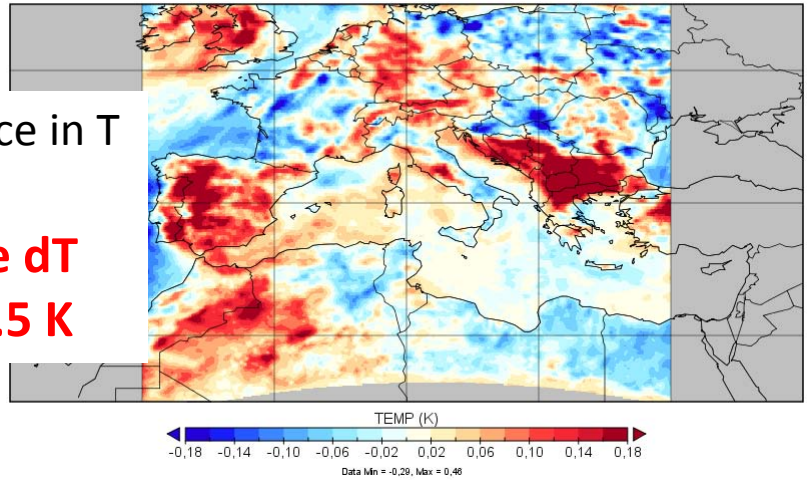


Difference in cloud LWP for modal and sectional aerosol

Modal



Sectional



Difference in T

Note: positive dT up to 0.5 K

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Summary and conclusions

- Generally similar response to direct aerosol effect for different WRF-Chem and the COSMO-MUSCAT simulations for high aerosol concentrations
- Aerosol effect on temperature is only significant for fire hotspot areas with very high AOD during a short episode (and only for a=0.1)
- Different baseline assumptions can strongly affect the model response to aerosol
- Inter-model differences in simulated chemical and meteo variables are often larger than aerosol direct and indirect effects.

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- 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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