A Model Intercomparison Study: EMEP MSC-W and EMEP4UK-WRF Application Over the UK (June-July 2022)

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UKRI Natural Environment Research Council

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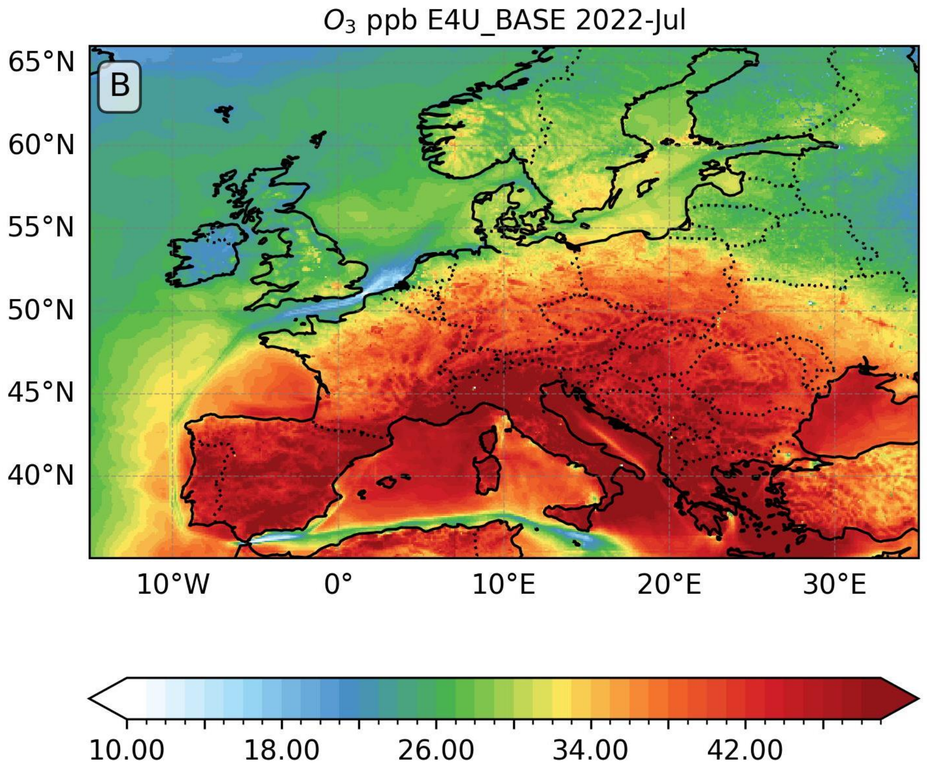
The EMEP4UK and WRF model – TFMM model intercomparison domain and setup



- The EMEP MSC-W model rv5.5 as downloaded from GitHub (www.emep.int)
- Weather Research & Forecasting model (www.wrf-model.org) – ERA5
- Domain as specified for the TFMM - 0.1°×0.1° horizontal resolution
- The emissions are derived from NAEI v2025 (UK), EMEP (EU) v2025
- The FINN biomass burning (FINN - Fire INventory from NCAR)
- The "common" input files are for the rv5.5 as downloaded from GitHub
- The landcover is an ad-hoc landcover with UK specific data
- The vertical column is divided into 21 layers (~50m up to ~16km)

EMEP4UK specific papers
ACP Vieno et. al, 2010, 2014, 2016, ERL Vieno et. al, 2016, GMD Ge et. al, 2021, ACP Ge et. 2022, Science Gu et al. 2021

EMEP MSC-W model
(ACP Simpson et al., 2012) and EMEP reports

WRF
(Skamarock, W. C. wt al., 2019)

EMEP MSC-W model
www.emep.int - https://github.com/metno/emep-ctm

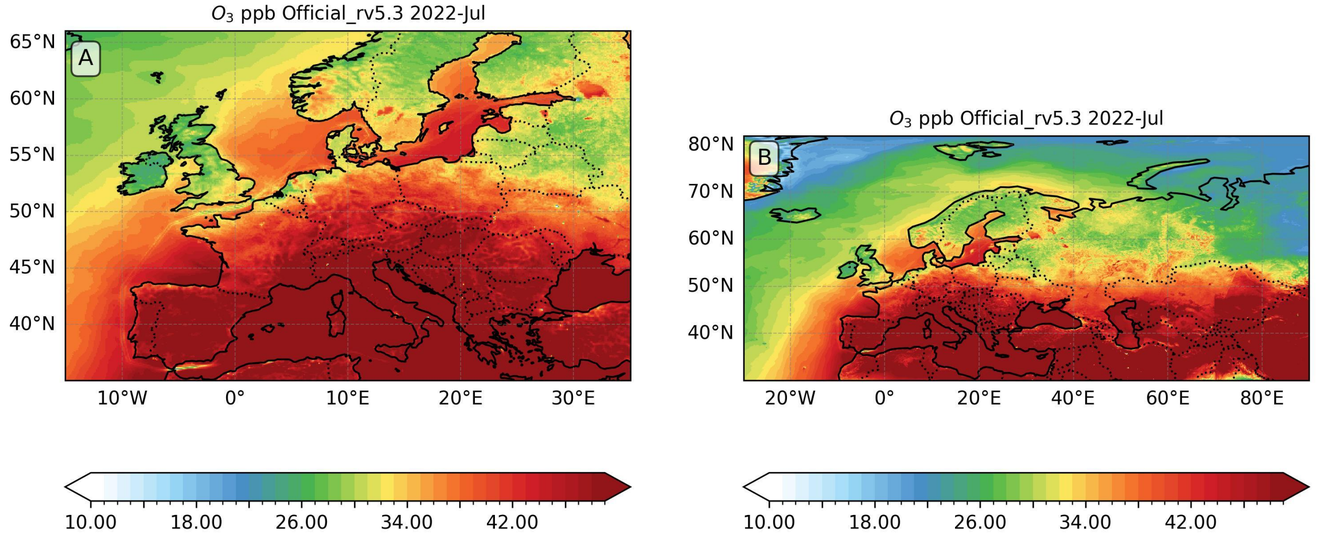
EMEP4UK model
www.emep4uk.ceh.ac.uk

NAEI emissions:
https://naei.beis.gov.uk/data/mapping

EMEP emissions:
https://www.ceip.at/webdab-emission-database/emissions-as-used-in-emep-models

WRF model:
https://www2.mmm.ucar.edu/wrf/users/

The EMEP MSC-W model used for this comparison (referred here as "Official EMEP")



The EMEP MSC-W for the year 2022

I downloaded the files from the EMEP web site:

https://thredds.met.no/thredds/catalog/data/EMEP/2024_Reporting/catalog.html

1) EMEP01_rv5.3_month.2022met_2022emis.nc

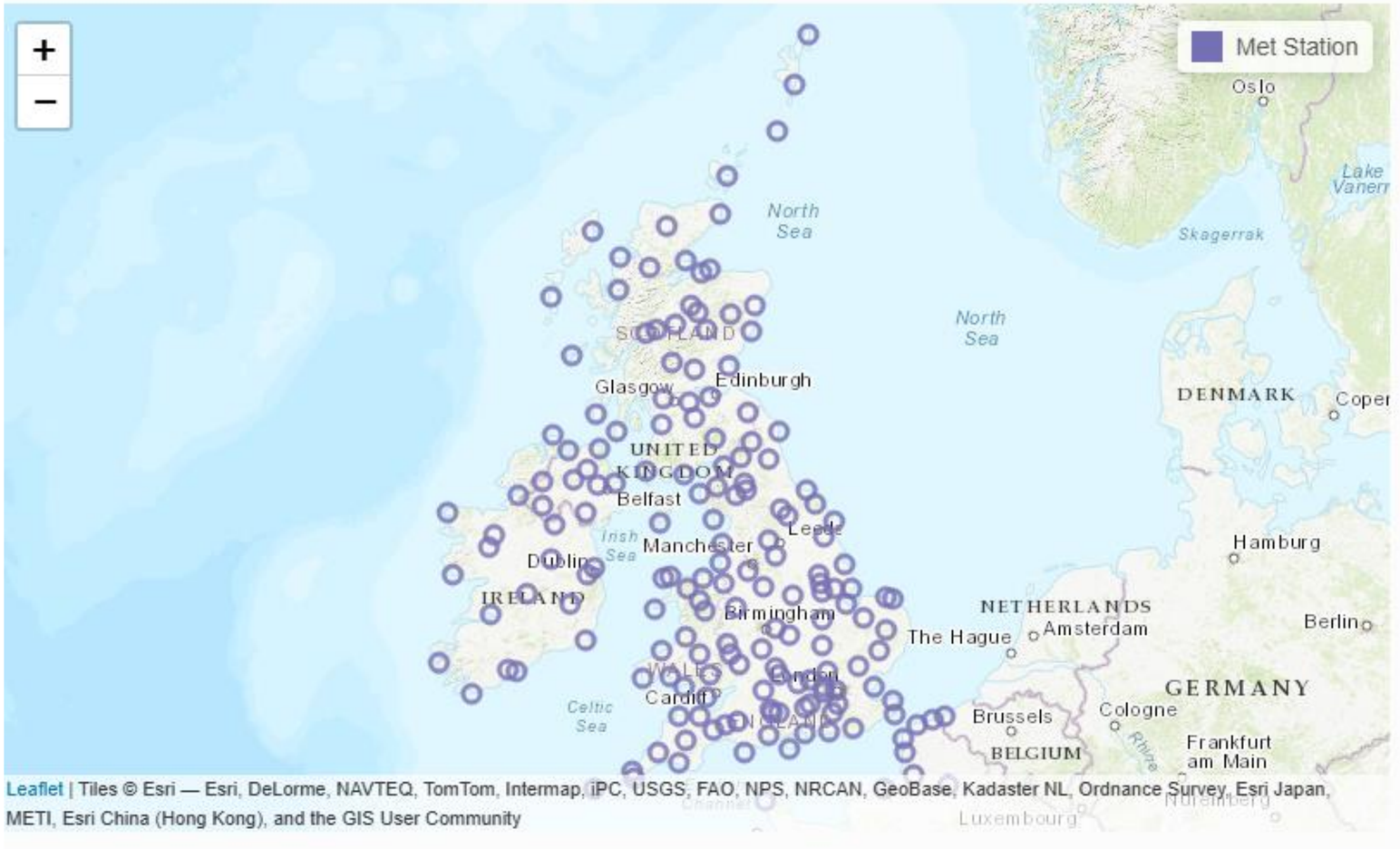
2) EMEP01_rv5.3_hour.2022met_2022emis.nc

The downloaded EMEP MSC-W dataset have been processed using CDO

"cdo remapbil,EMEP4UK.nc EMEP01_rv5.3_month.2022met_2022emis_regridded.nc"

CDO Map the EMEP model output from B to A (TFMM domain)

UK Evaluation of the hourly WRF 4.6.1 model for June and July

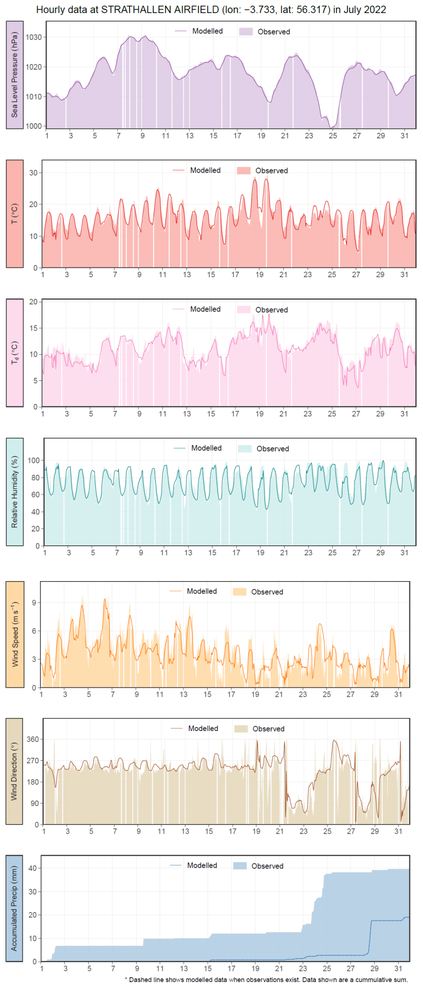


Hourly modelled concentrations have been compared with observations from the NOAA Integrated Surface Database.

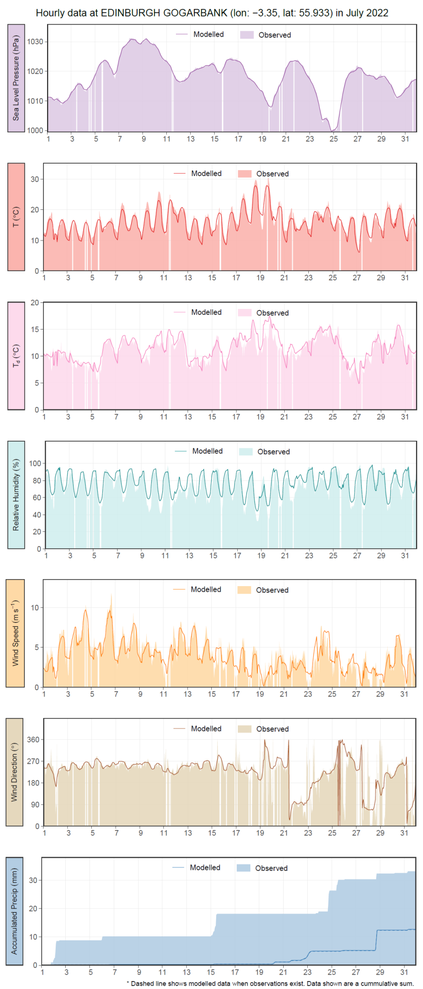
- Temperature
- Rainfall
- Relative humidity
- Wind speed
- Wind directions

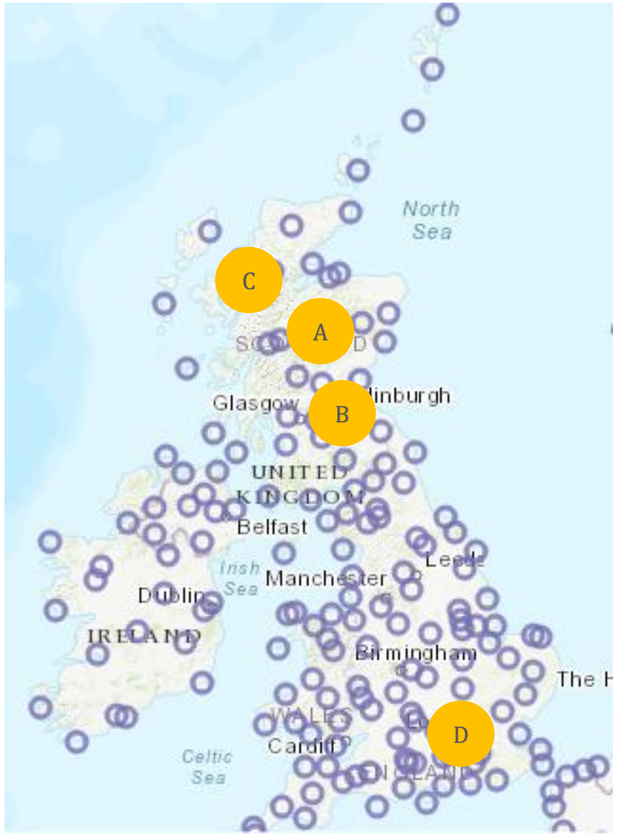
UK Evaluation of the hourly WRF 4.6.1 model for June and July (only July here)

A) STRATHALLEN AIRFIELD

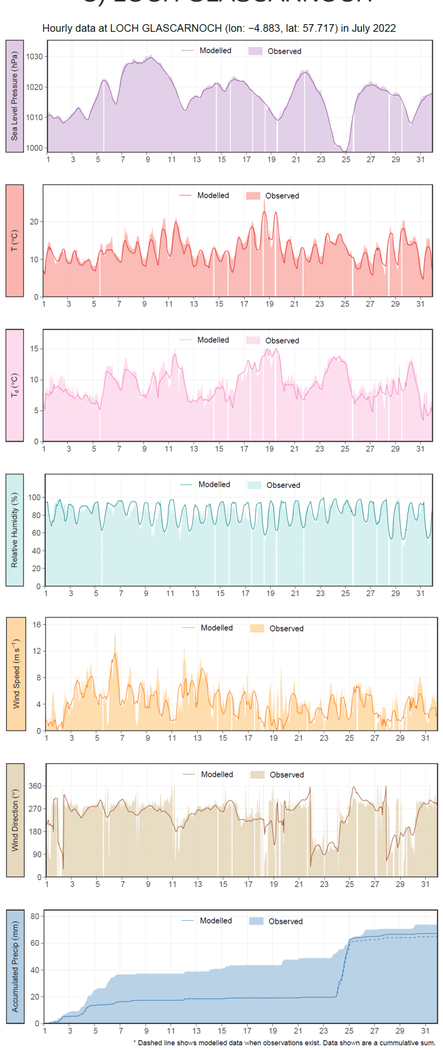


B) EDINBURGH

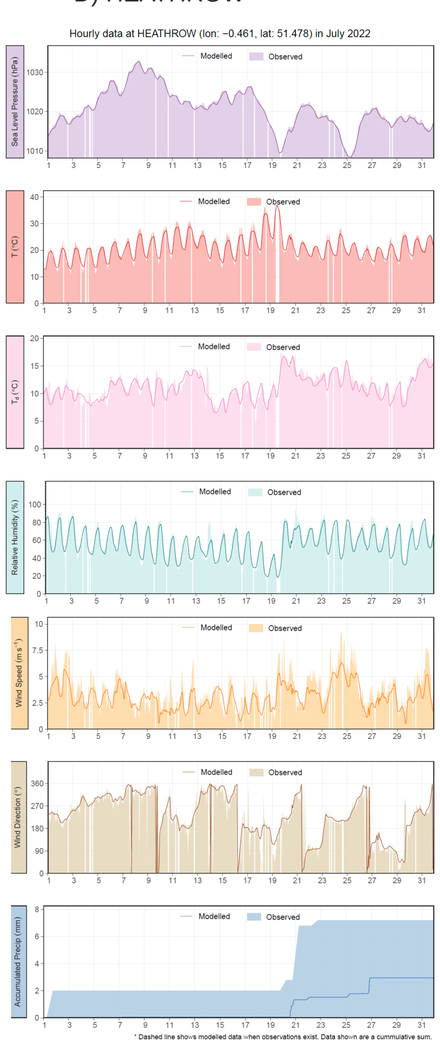




C) LOCH GLASCARNOCH

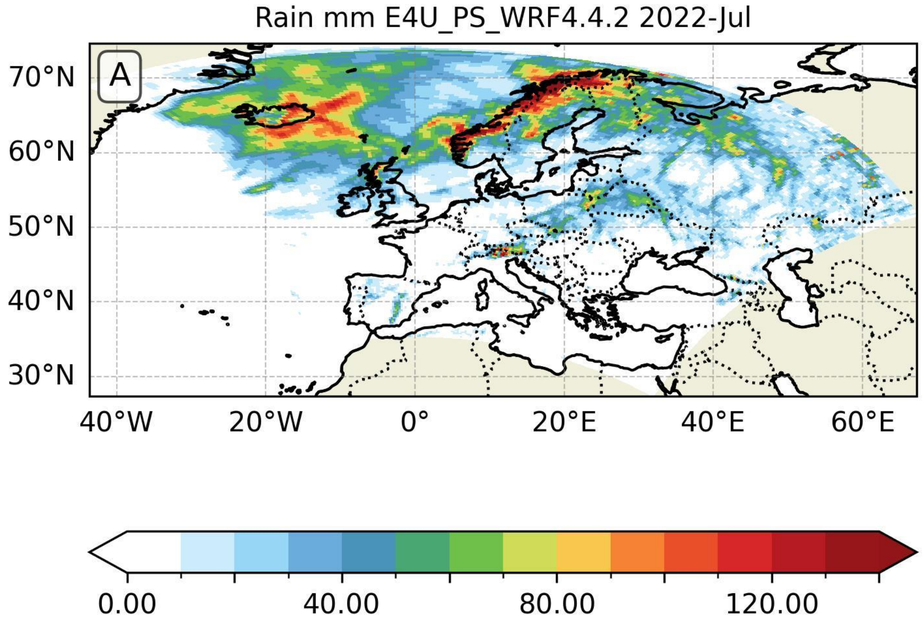


D) HEATHROW

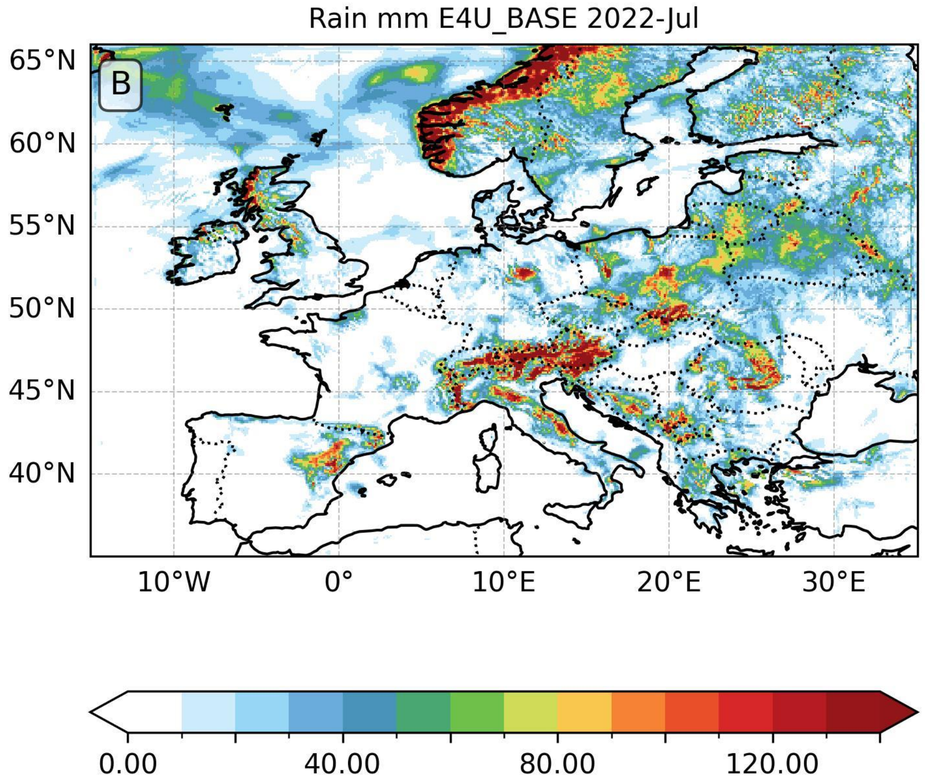


WRF micro-physics schemes (although different version of WRF)

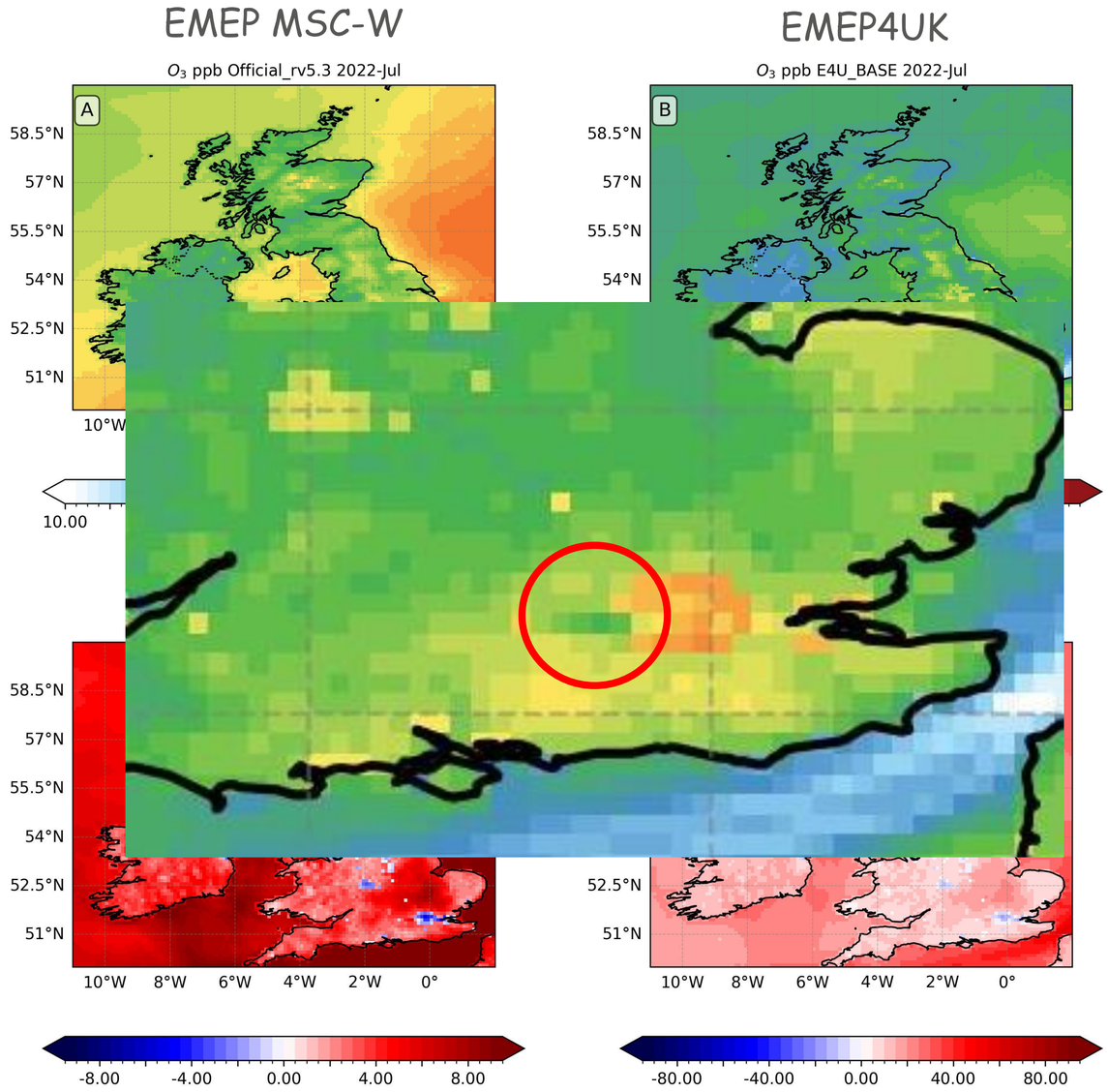
Purdue Lin Scheme:
Chen, S.-H. and W.-Y. Sun, 2002: A one-dimensional time dependent cloud model. J. Meteor. Soc. Japan., 80(1), 99–118. doi:10.2151/jmsj.80.99



WRF Single-moment 3-class and 5-class Schemes
Hong, Song-You, Jimy Dudhia, and Shu-Hua Chen, 2004: A revised approach to ice microphysical processes for the bulk parameterization of clouds and precipitation. Mon. Wea. Rev., 132, 103–120. doi:10.1175/1520-0493(2004)



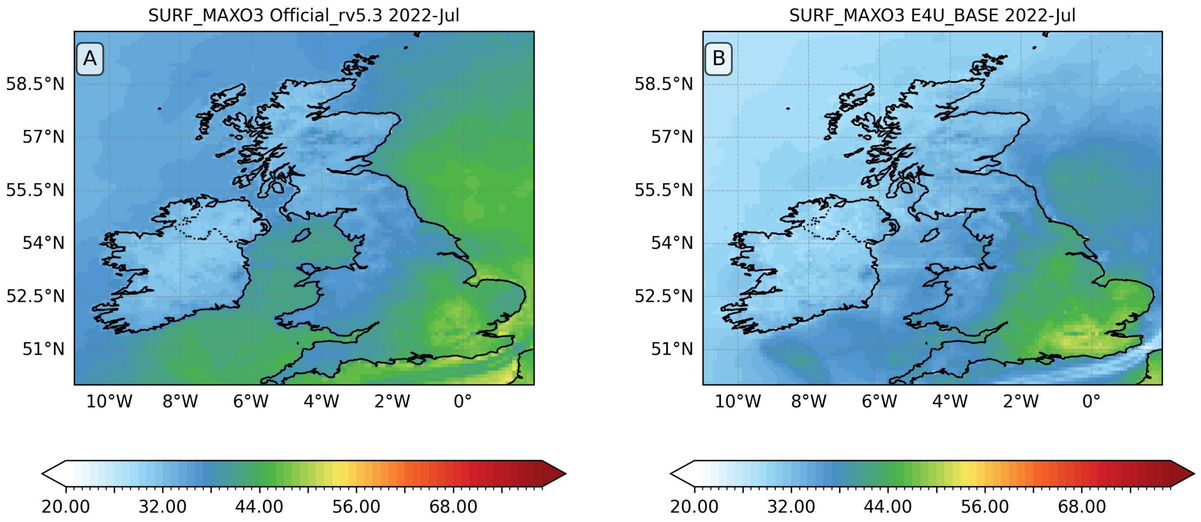
Surface ozone July 2022



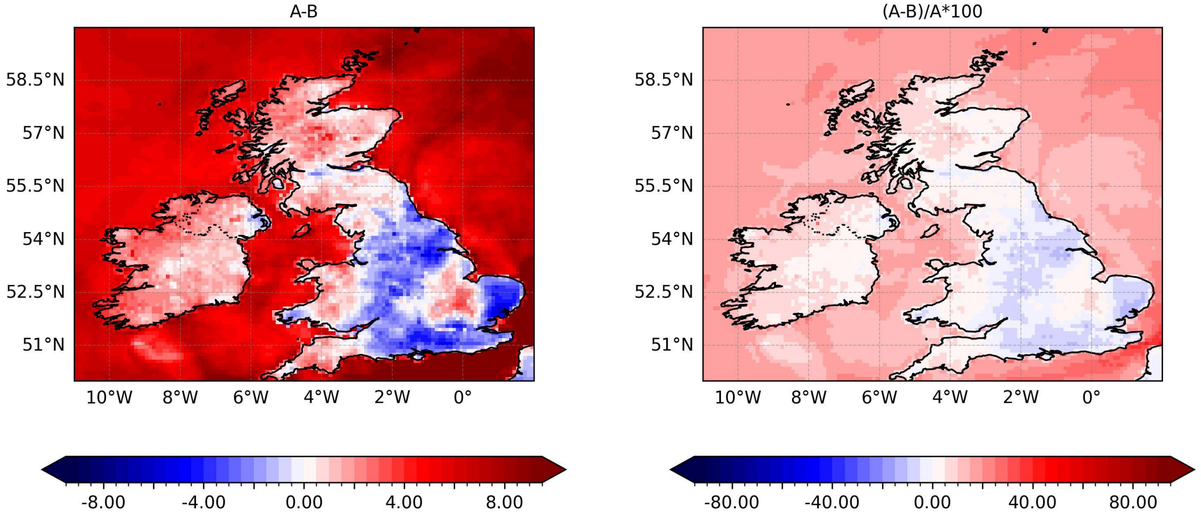
- The EMEP4UK-WRF broadly match the EMEP MSC-W rv5.3 model
- The near surface ozone concertation is lower in the EMEP4UK model in rural areas and higher in the cities
- Over the UK this is +/-4 ppb
- The same Mace Head correction is used for July (26 ppb – for July 2022)
- U* comes from WRF
- The vertical velocity is calculated by the EMEP model from the U and V
- The size of the Official EMEP domain extend further west and east
- Same forest fires input
- Wind speed-direction, temperature, humidity are well represented at the surface by WRF
- Rainfall should not affect ozone too much (also low rainfall in July 2022)
- We use the NAEI v2025 emissions and EMEP v2025 emissions

Max ozone July 2022

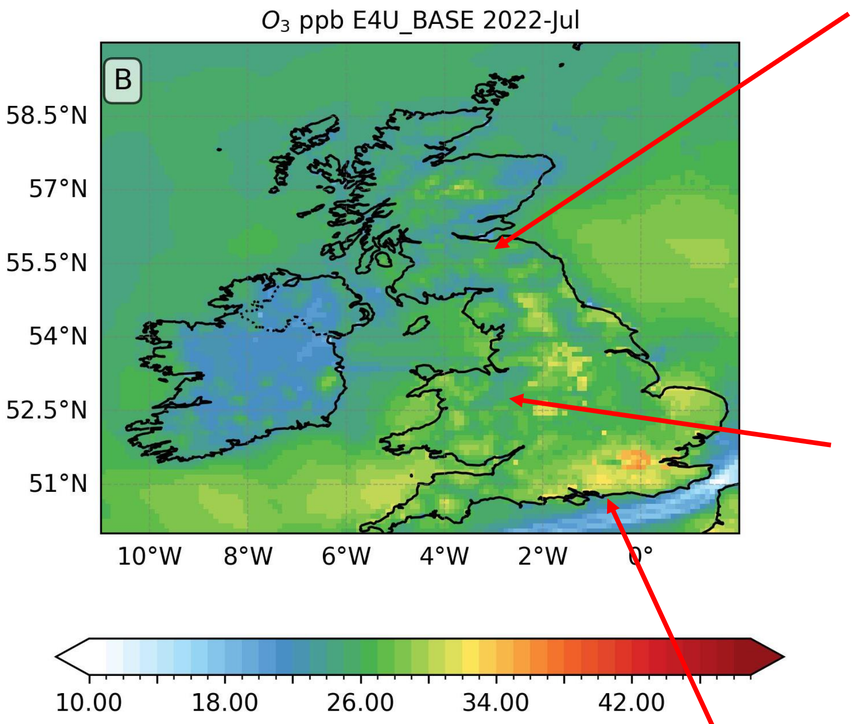
EMEP MSC-W

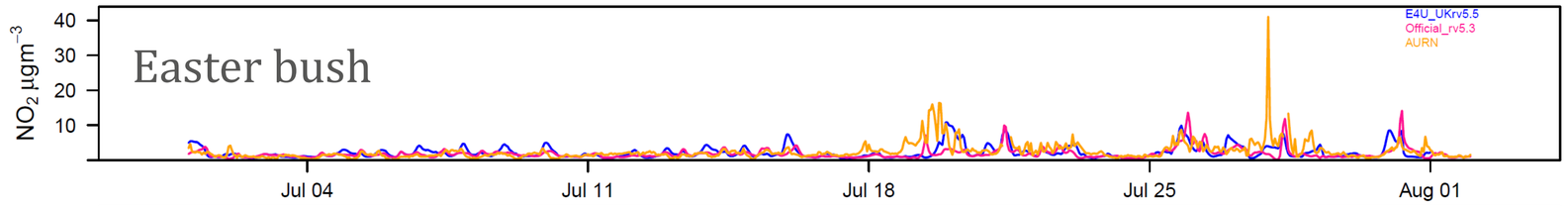


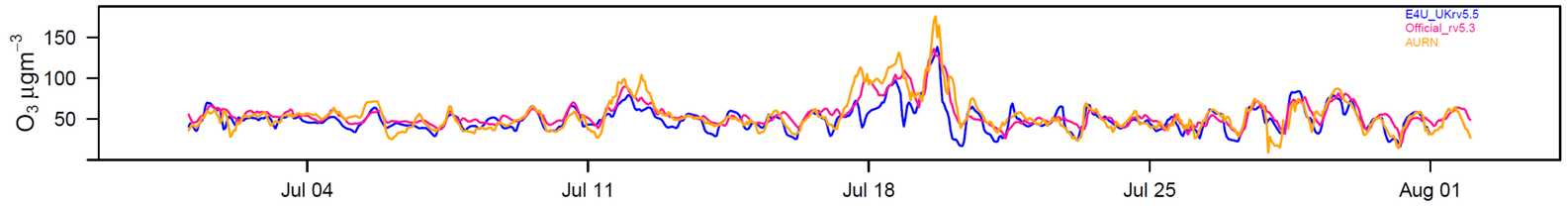
EMEP4UK

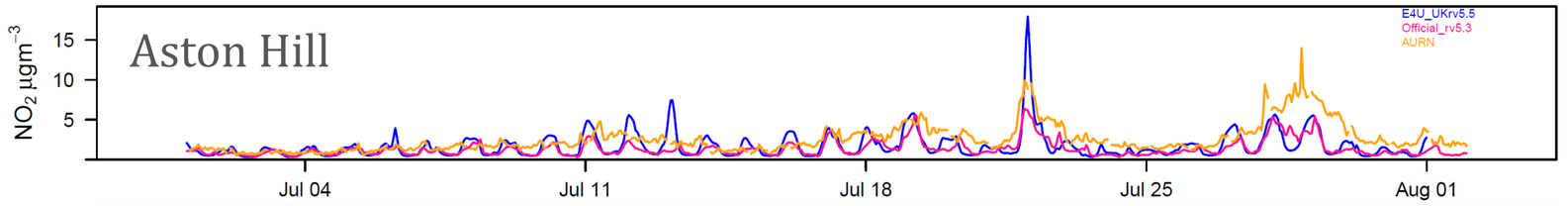


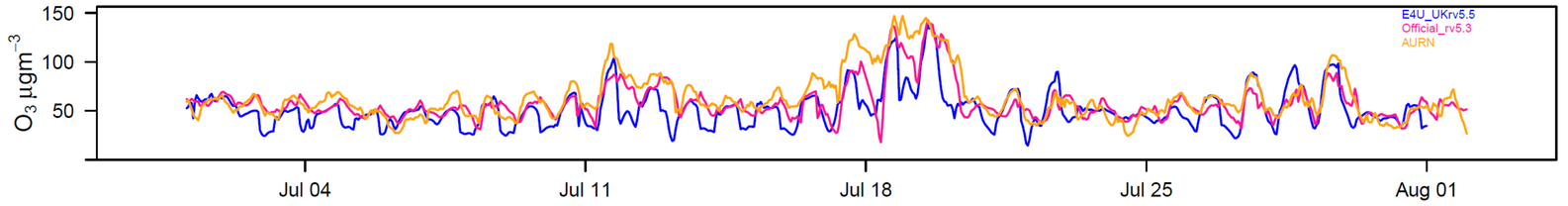
- The EMEP4UK-WRF broadly match the EMEP MSC-W rv5.3 model
- The near surface max ozone concertation is higher England away from London and lower in Scotland and Ireland
- Over the UK this is ~4 +/- ppb
- The EMEP4UK seems to have higher peak of ozone compared to the Official EMEP MSC_W
- Max ozone as calculated by the EMEP model

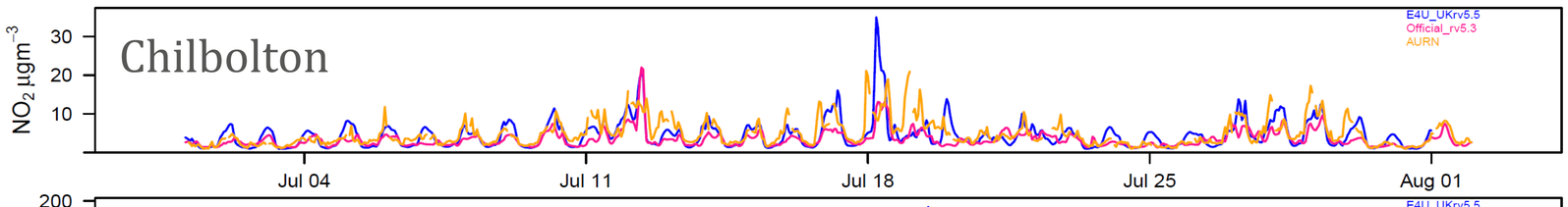


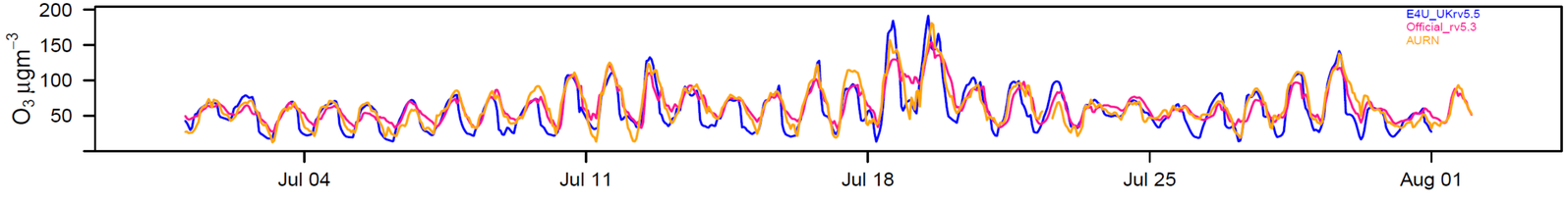












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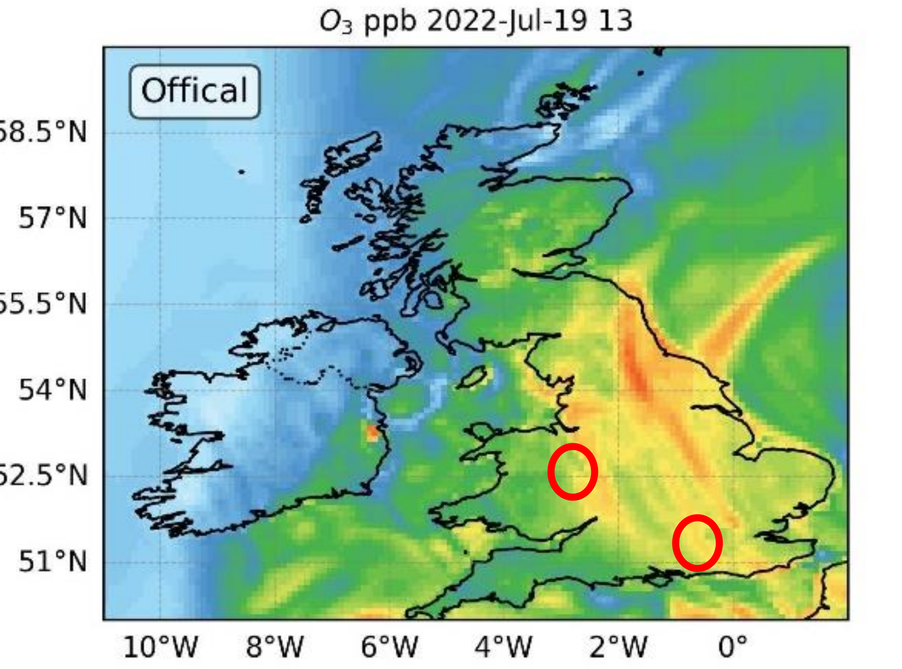
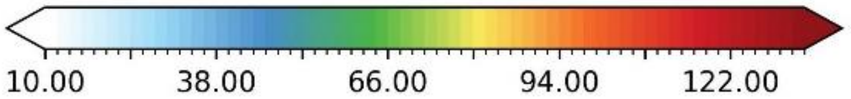
19th July 2022 - 08:00 – 19:00

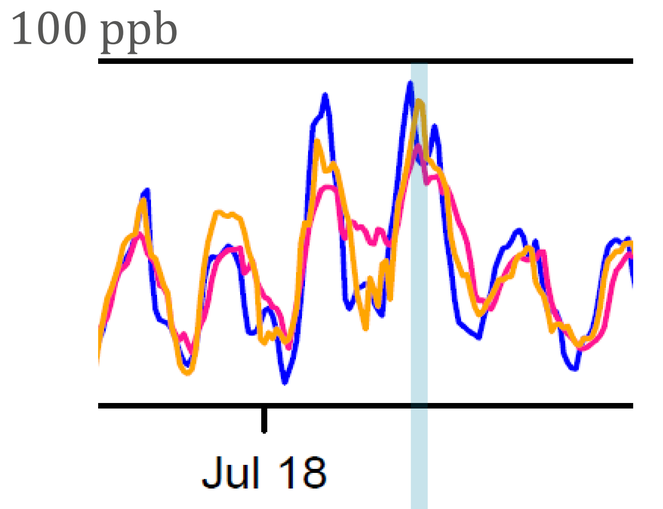
EMEP MSC-W



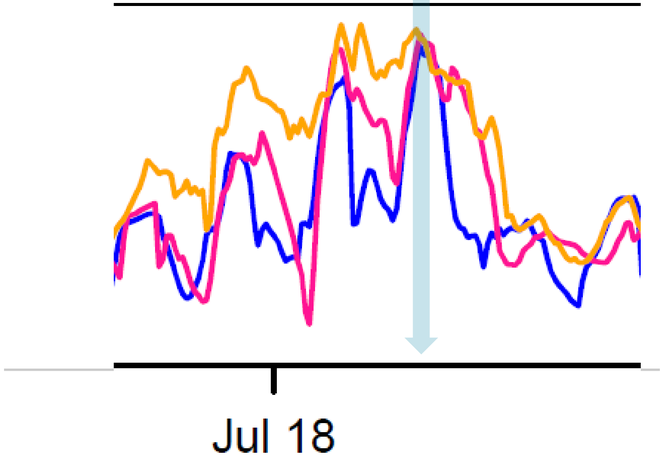


19:00

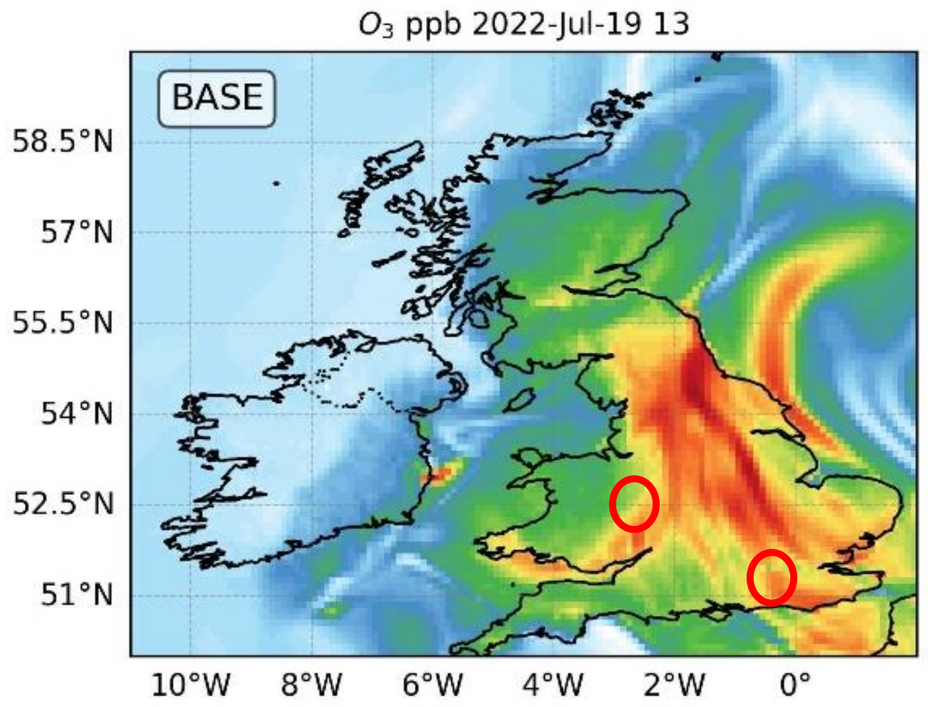
Chilbolton

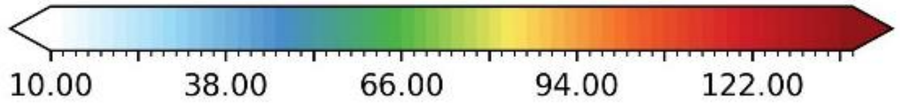


Aston Hill



EMEP4UK





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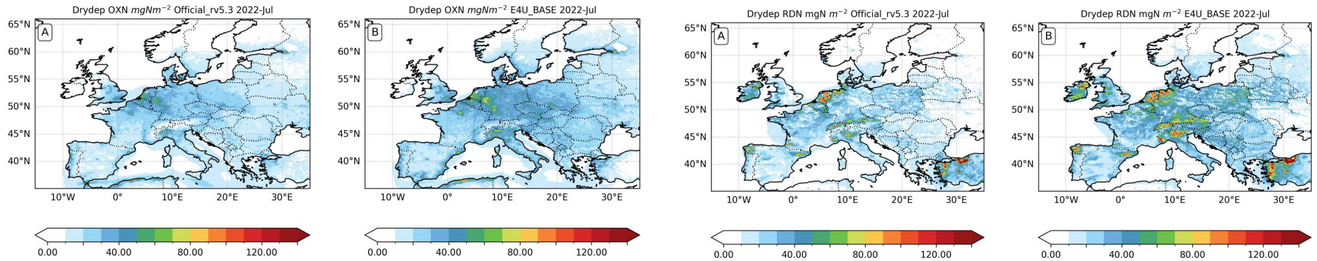
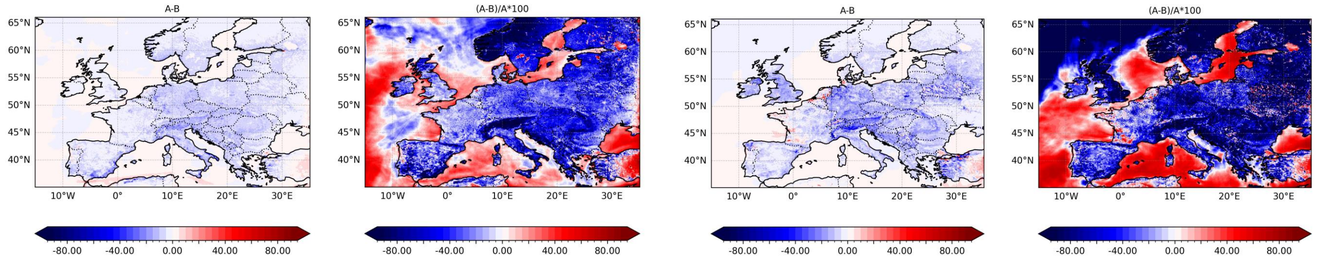
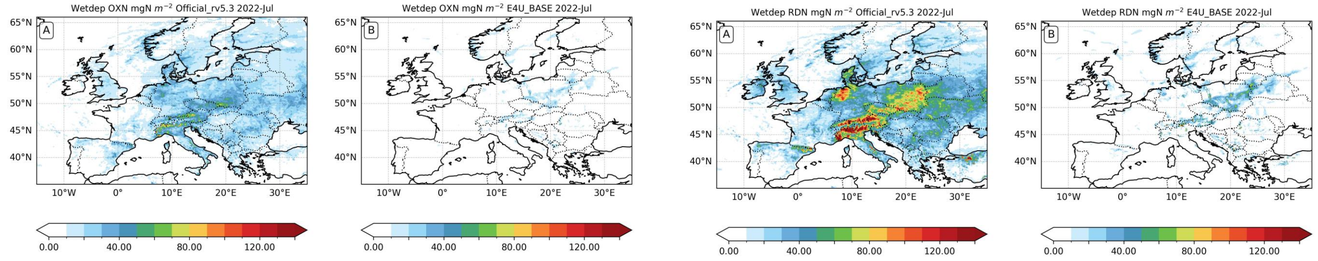
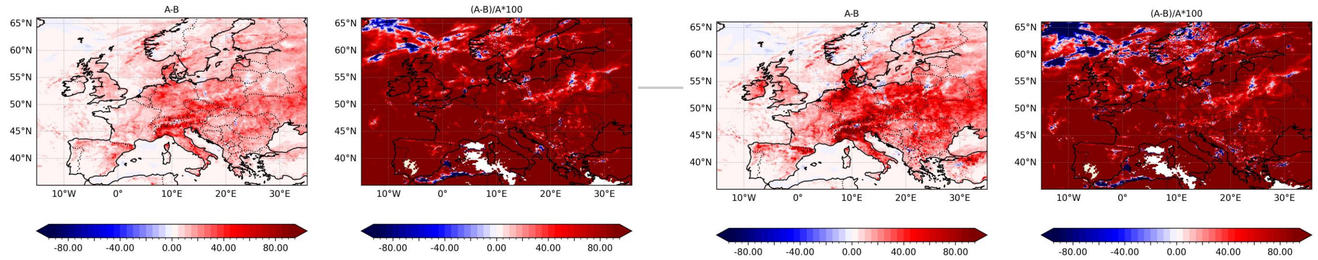
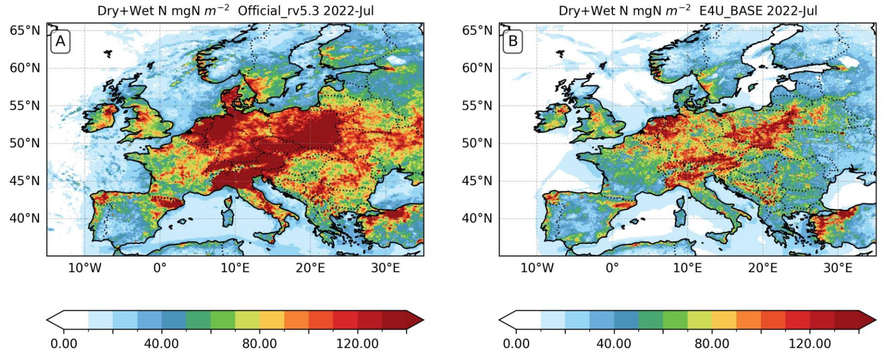
Dry and Wet deposition of N

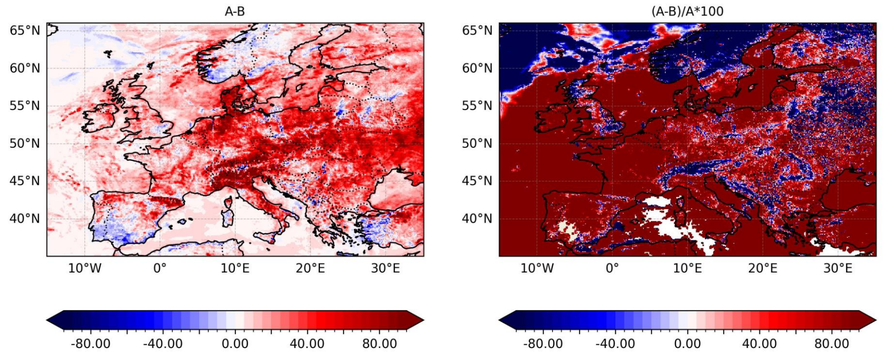




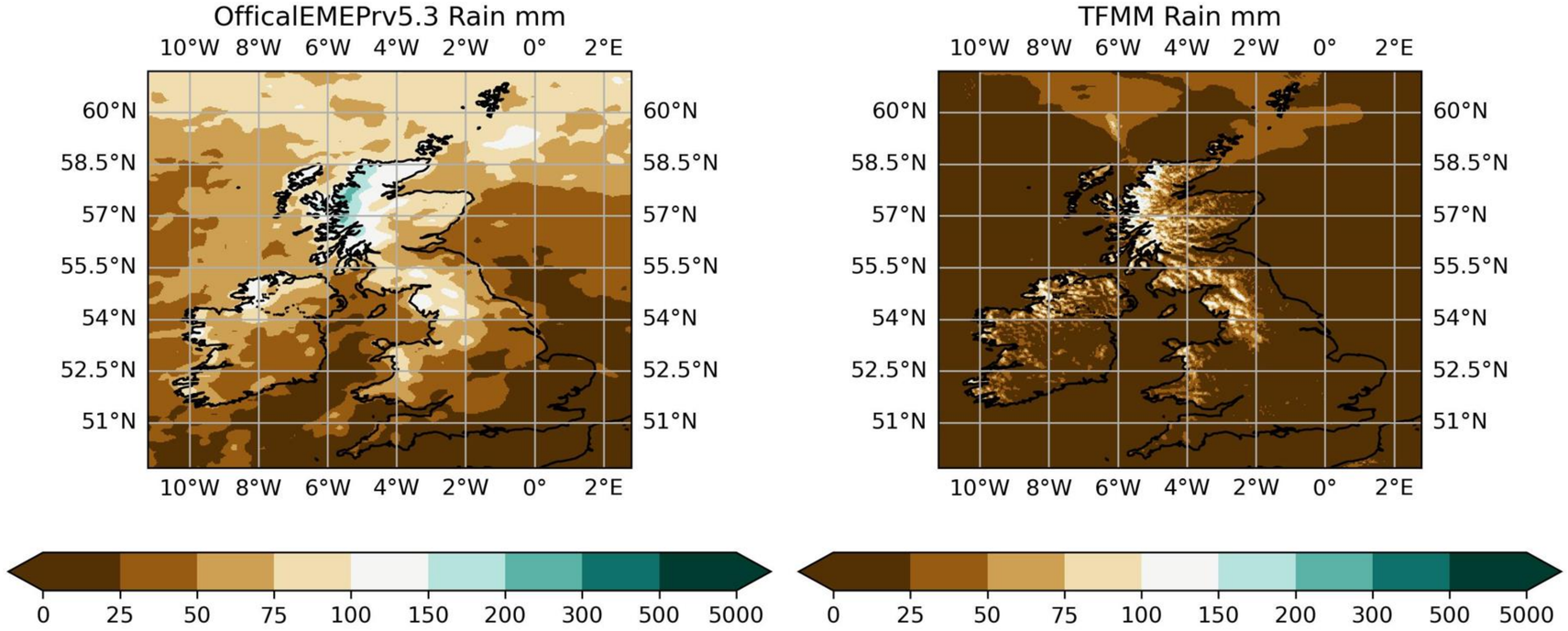








- For July 2022, the EMEP4UK shows a lower removed N compared to the Official EMEP
- This is due to the lower rainfall in the EMEP4UK model compared to the EMEP-MSC W model



- July 2022 had a low rainfall
- Our WRF application underestimate the rainfall
- A smoothing of the rainfall is visible in the EMEP MSC-W (we may need to smooth the rain too)

Conclusions

Ozone as calculated by the EMEP4UK and EMEP MSC-W are similar

The meteorological driver have a big impact especially for wet deposition

WRF setup also influence the rainfall amount

Nudging the rainfall with observed rain either in WRF or as post process

Extend the EMEP4UK domain to match the whole Official domain

Extend the analysis to other periods and other pollutants

Thank You

For more information
please contact:
mvi@ceh.ac.uk

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Ecology & Hydrology