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Dry deposition perspectives in EMEP & CAMS

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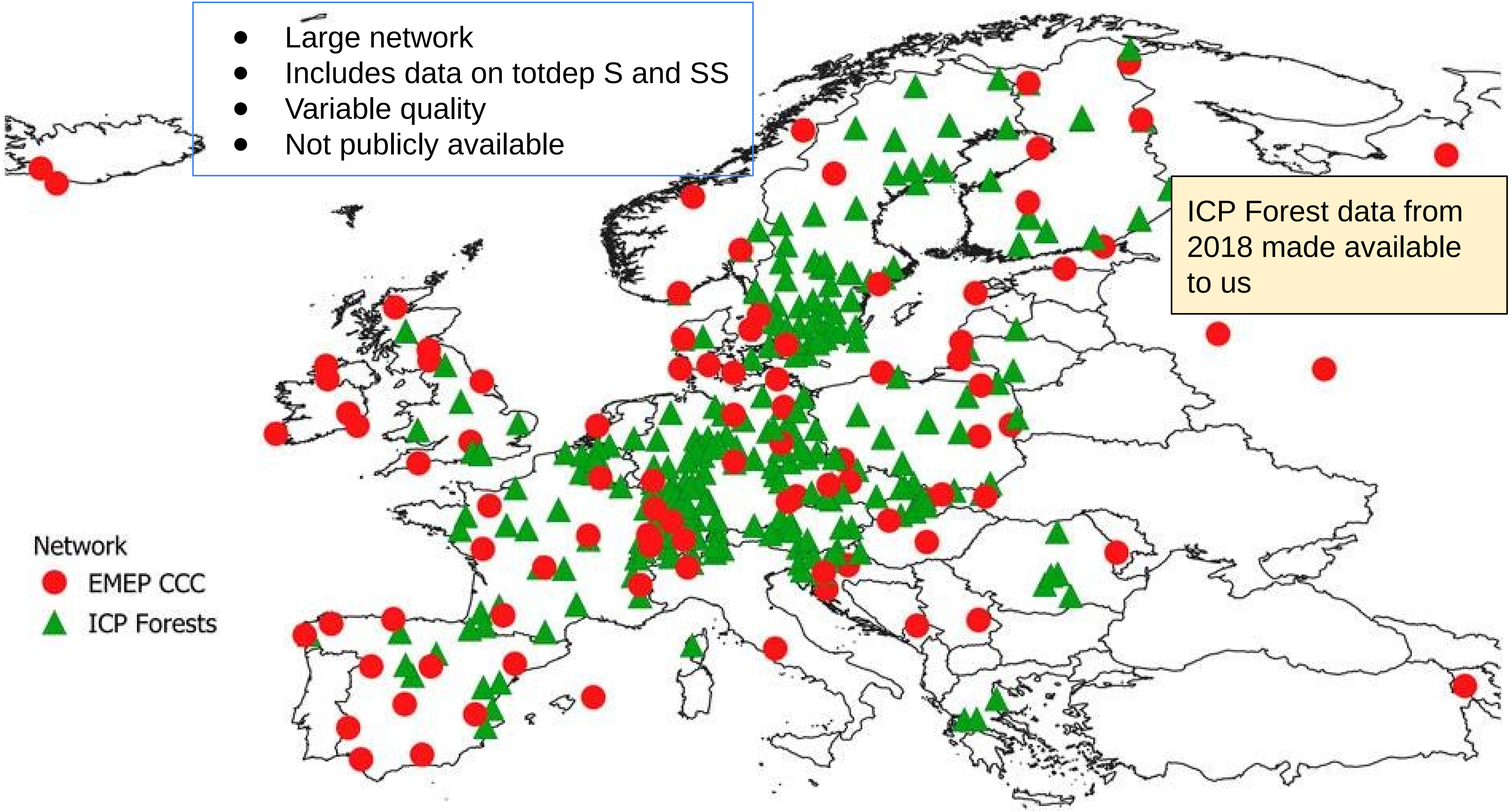
Overview

1. CAMS2_40: Task 4041: Evaluation of deposition modelled by regional and CAMS-global (3 versions).
2. Dry deposition - experiences and lessons from EMEP modelling
3. Links to satellites and SEEDS

CAMS2_40: **Task 4041 Deposition** (Lead: MET Norway, HF)

- Timeline: 01.05.2022 --> 31.10.2023 (18 months)
- Dedicated study to **evaluate the deposition fluxes** for key pollutants from the Regional Systems, (*as well as from the global CAMS data assimilation and forecasting system*).
- 1-year model run for a historical year where most observations are available. 2018 chosen due to ICP Forest data
- Compare to observational data on **wet deposition** of **sulphur, oxidized nitrogen, reduced nitrogen and sea salt** from different networks: EMEP, OSPAR, HELCOM, national data (when available), ICP Forest
- Comparison to surface observation included for explanatory reasons (EMEP, OSPAR, HELCOM observations)
- Inter compare dry deposition fluxes
- Participating models: **EMEP**, **CHIMERE**, **DEHM**, **LOTOS-EUROS**, **MOCAGE**, **MONARCH**, **SILAM** + *CAMS48, CAMS49 and CAMSRA*

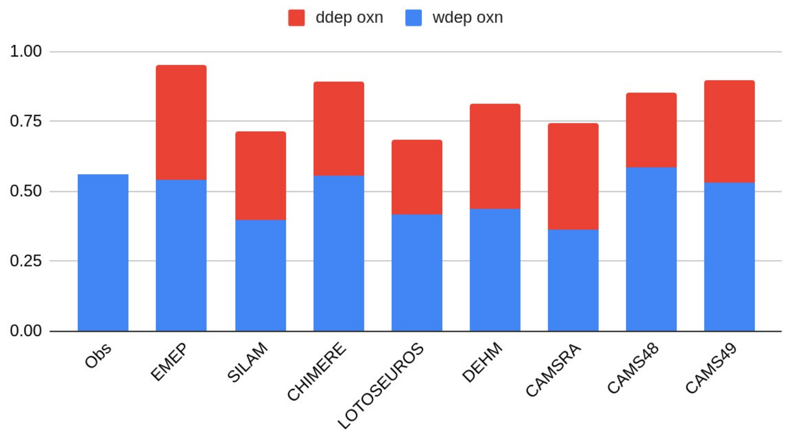
- Large network
- Includes data on totdep S and SS
- Variable quality
- Not publicly available

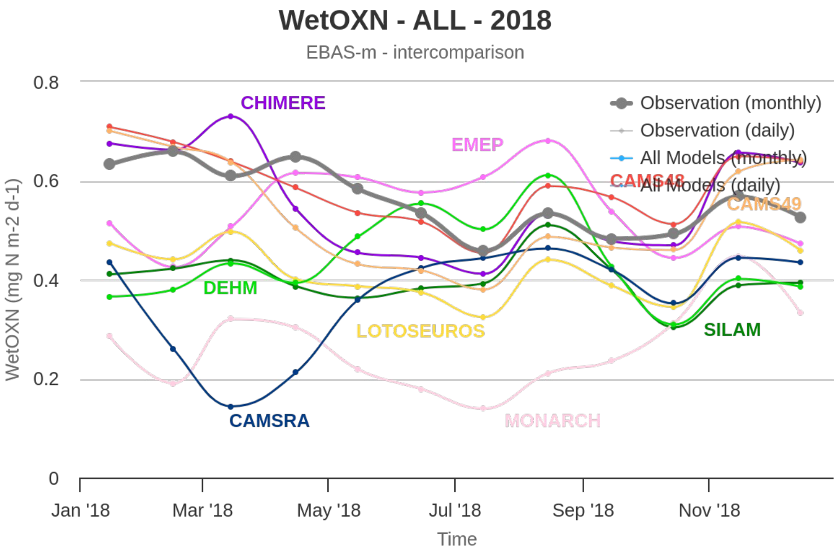


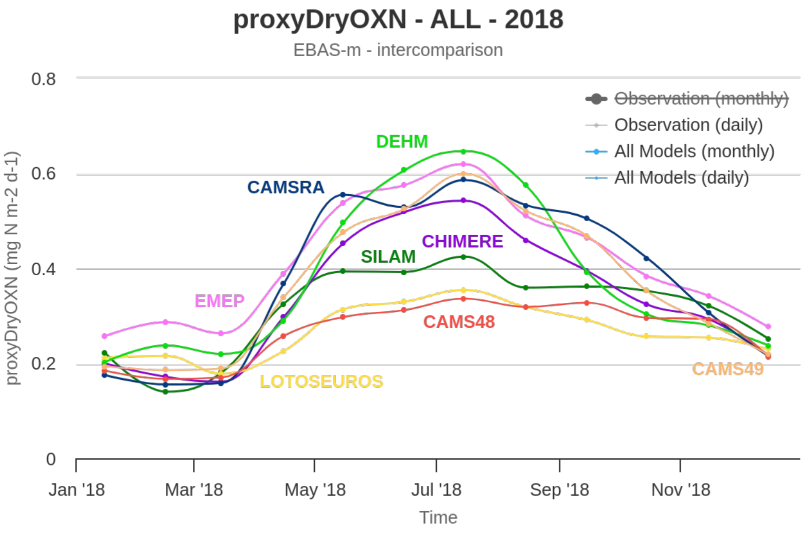
ICP Forest data from 2018 made available to us

Wet vs dry deposition of OXN

- Large spread in wdep



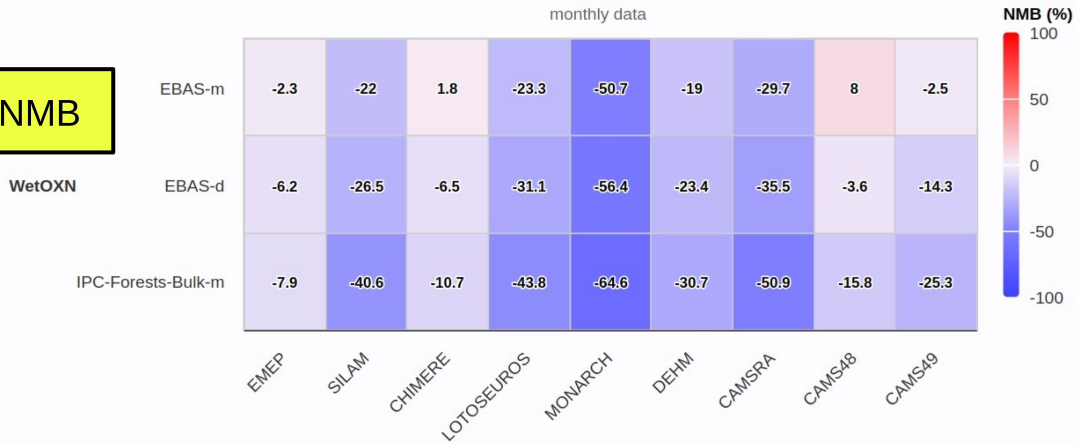




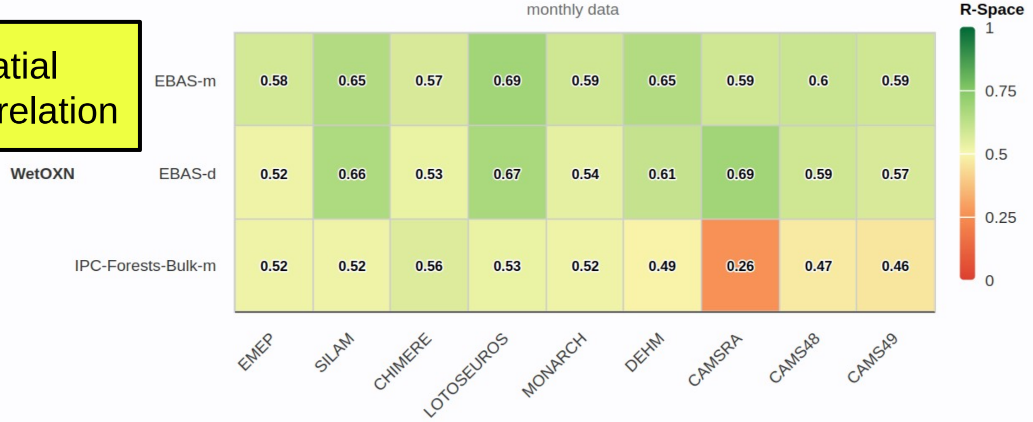
Wet deposition of oxidized nitrogen

- All models are lower compared to ICP Forest than EMEP observations, as expected
- MONARCH underestimate WetOXN substantially
- SILAM, LE, DEHM, CAMSRA underestimate WetOXS somewhat (~20-30%)
- CHIMERE and EMEP (CAMS48, CAMS49) around zero bias
- MOCAGE results not available

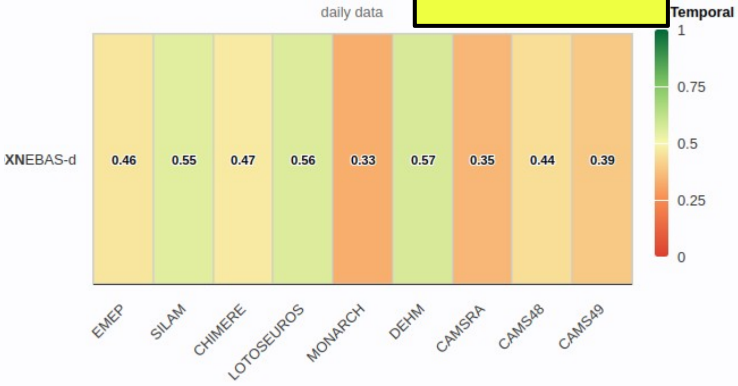
NMB



Spatial correlation

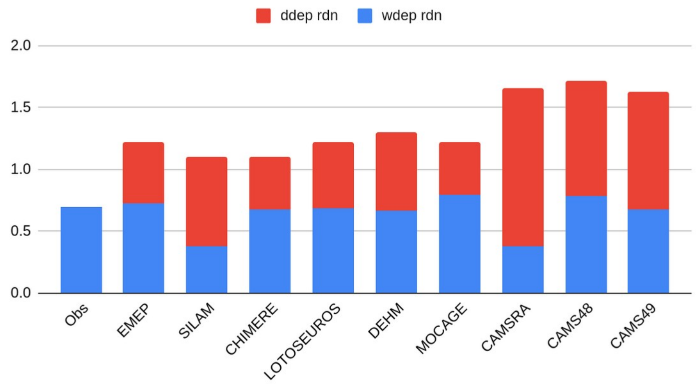


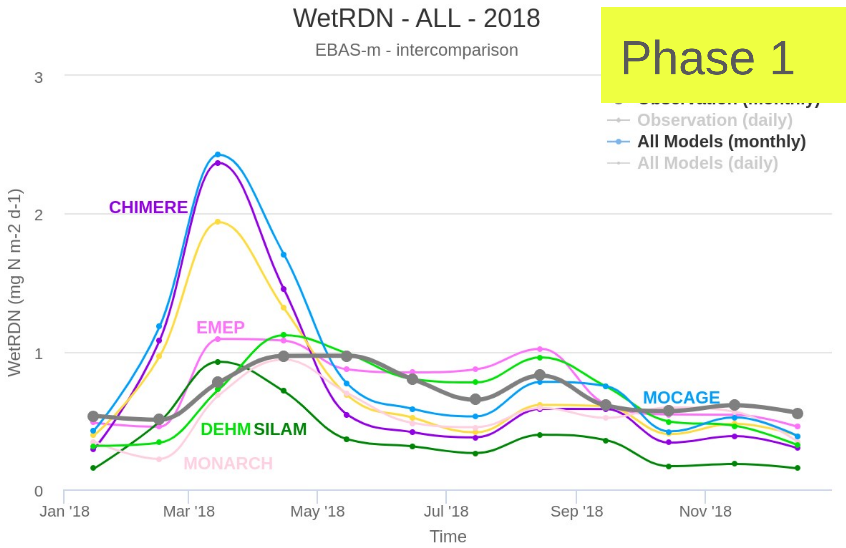
Temporal (d) correlation

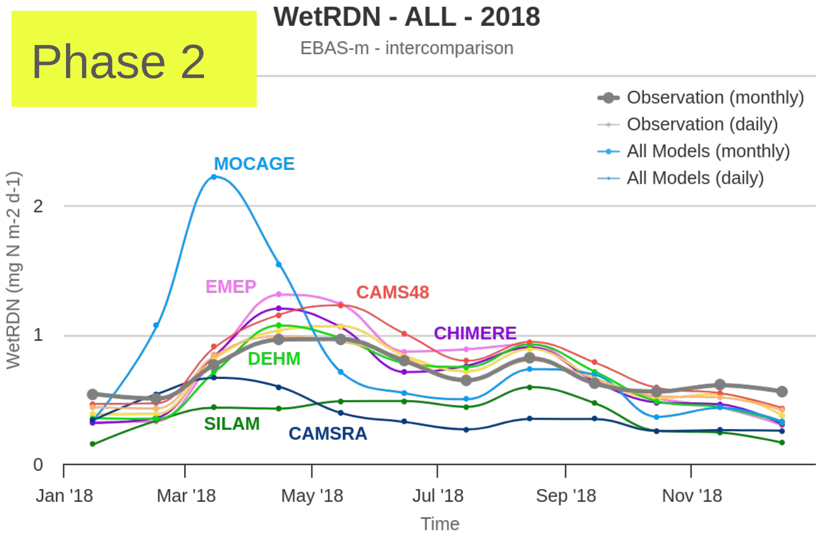


Wet deposition of RDN

- Similar total wet dep (except SILAM) but very different seasonal variation
- MOCAGE, CHIMERE, LE, (SILAM) had large March peak, now only MOCAGE (SILAM)



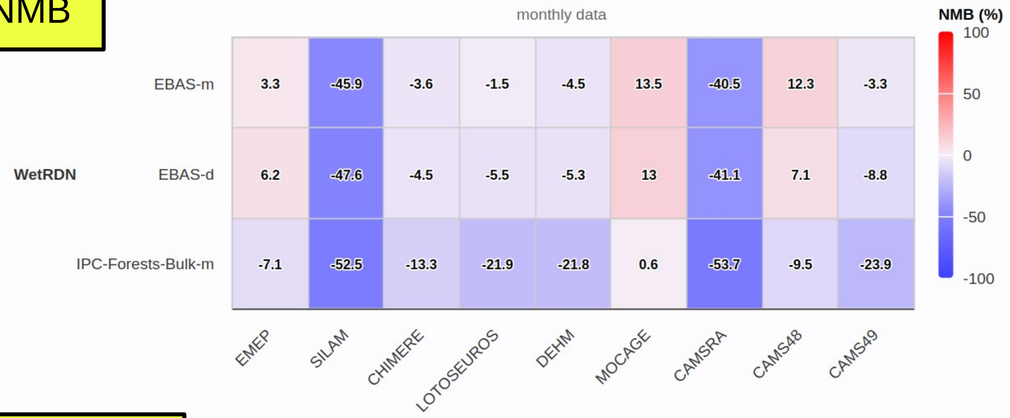




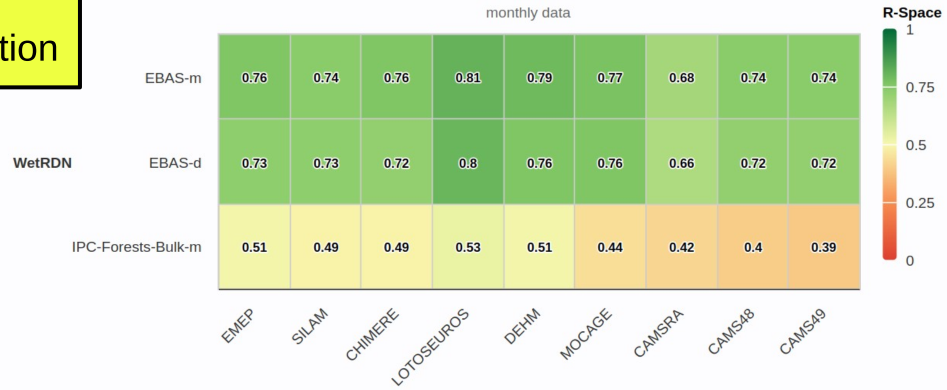
Wet deposition of reduced nitrogen

- SILAM and CAMSRA substantially underestimate wdep RDN (~50%)
- EMEP, CHIMERE, LE and DEHM around 0 bias
- MOCAGE overestimate somewhat
- Higher spatial correlation than for OXS

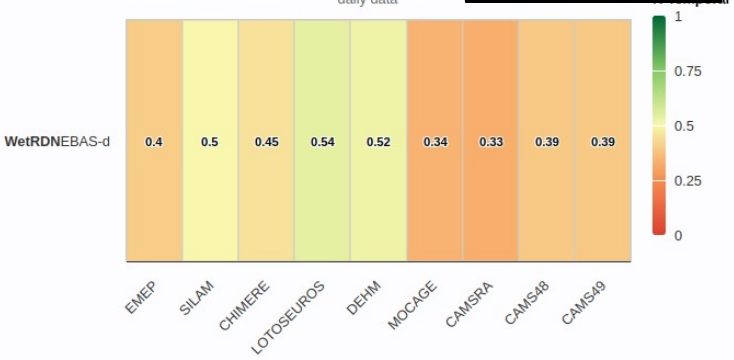
NMB



Spatial correlation



Temporal (d) correlation

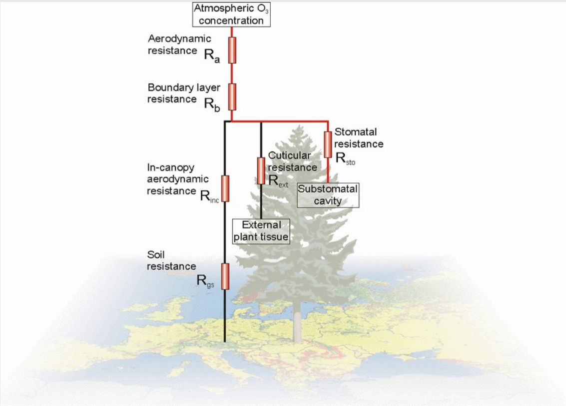


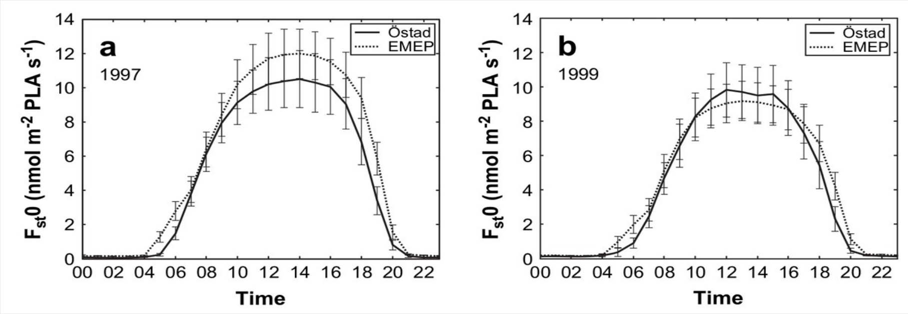
CAMS2_40: some conclusions (very brief!)

- Total dep (dry + wet) are relatively similar across regional models for RDN and OXS but not for OXN. Global CAMS has higher total dep for all the species. (As CAMS uses MACCity emissions?)
- The importance of dry vs wet deposition varies across models, and by species
- Some issues found in some models (e.g. older time profile for NH_3 emissions).
- There are substantial differences in aerosol deposition (factor 10)
- Report completed and sent to ECMWF. (ie not yet available.)

EMEP – Biosphere-atmosphere exchange

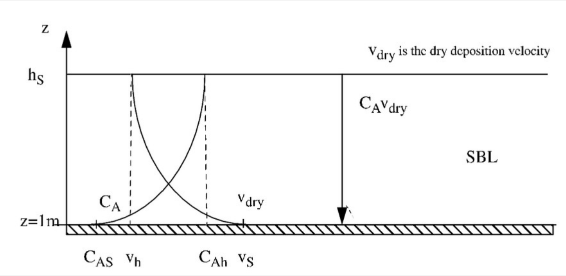
- BVOC emissions
  - O3
  - SOA
- NOx/NHy emissions from vegetation and soils
- NOy/NHy/PM deposition
- O3 fluxes to ecosystems



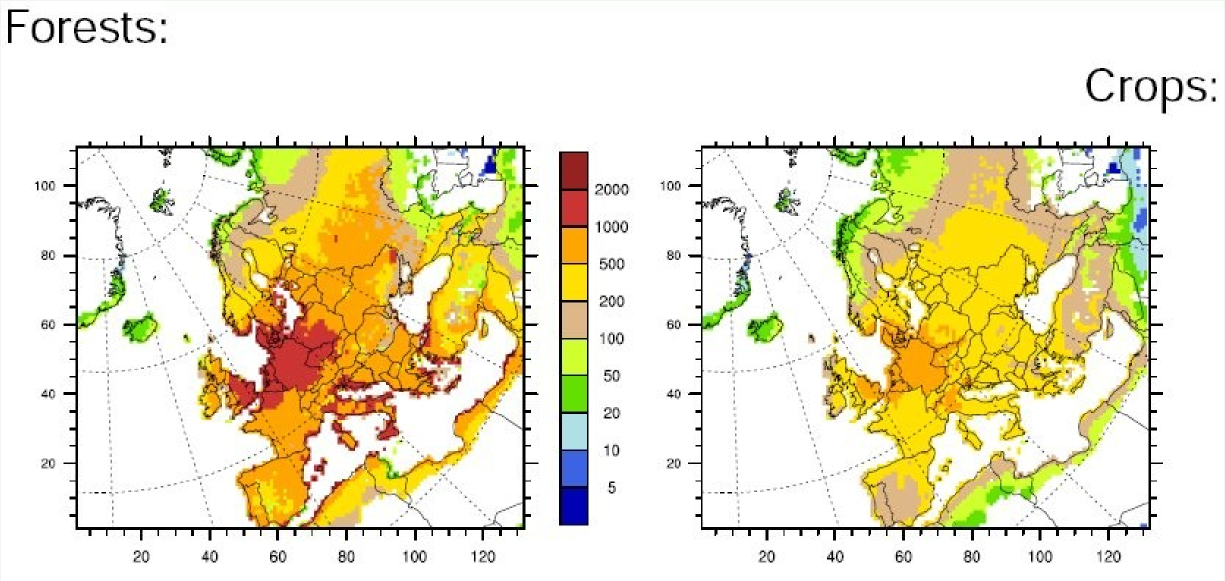


O3 fluxes, Klingberg et al., Env.Poll. 2008

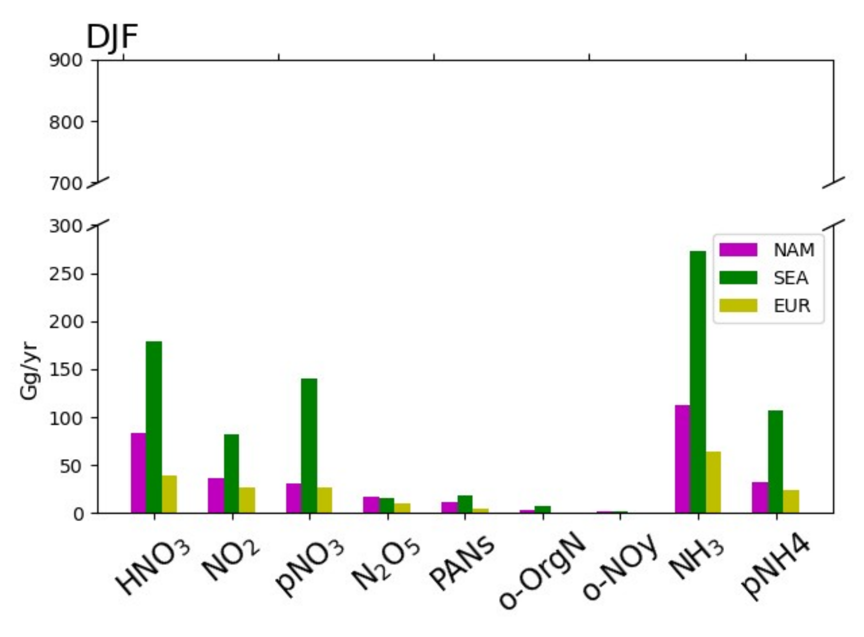
EMEP approach to dep: mosaic

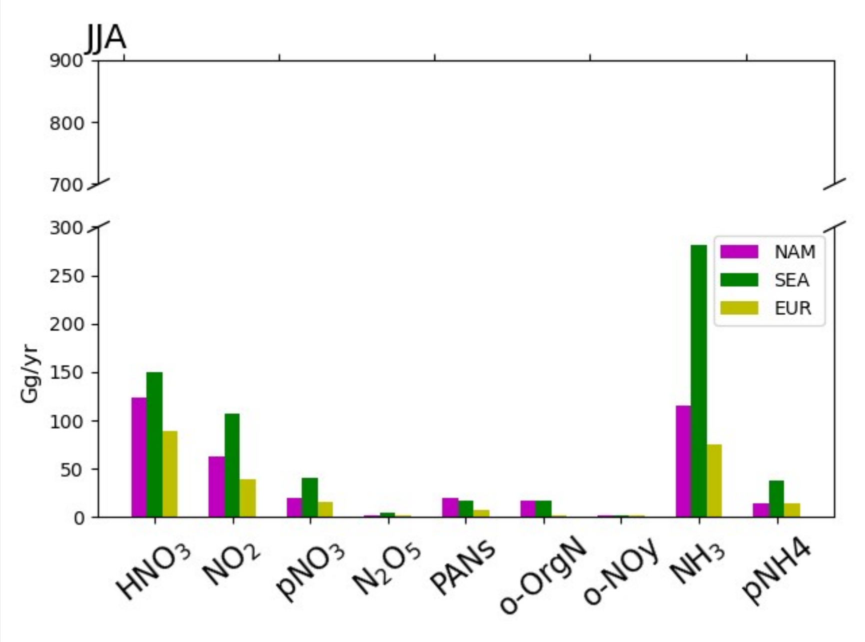


- e.g. NOy depn:



EMEP dry N_r deposition by compound – around the globe





NAM = North America; SEA = South & East Asia; EUR = Europe

Schwede, DB, Simpson, D, et al., Modelling nitrogen deposition in global forests, https://doi.org/https://doi.org/10.1016/C2021-0-00011-0, 2023.

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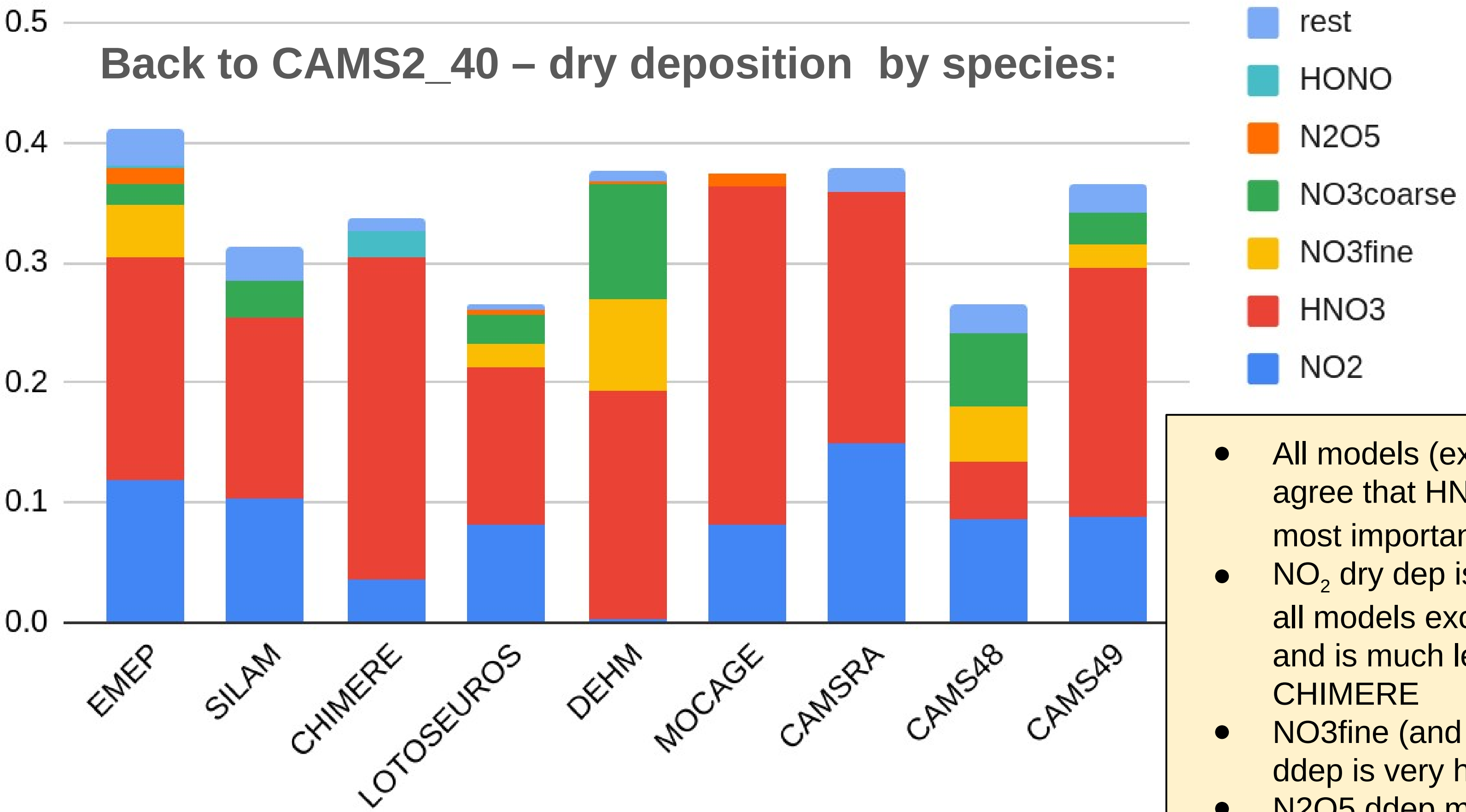
Back to CAMS2_40 – dry deposition by species:



- All models (except CAMS48) agree that HNO_3 ddep is most important
- NO_2 dry dep is important in all models except DEHM, and is much less important in CHIMERE
- NO3fine (and NO3coarse) ddep is very high in DEHM
- N2O5 ddep much more important in EMEP and MOCAGE and LE than other models

Deposition - general problems

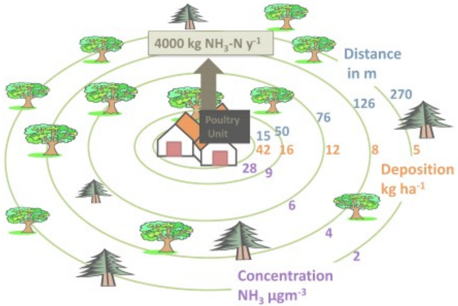
Dry deposition fluxes depend on:

1. Emissions & concentrations of NO_2, NH_3, ….
2. LAI (leaf area)
3. Phenology
4. Canopy density
5. Humidity
6. Soil moisture
7. Non-stomatal uptake
8. Temperature

Problem: we have poor data on (1), (2), (3), (4), (6) and (7)!

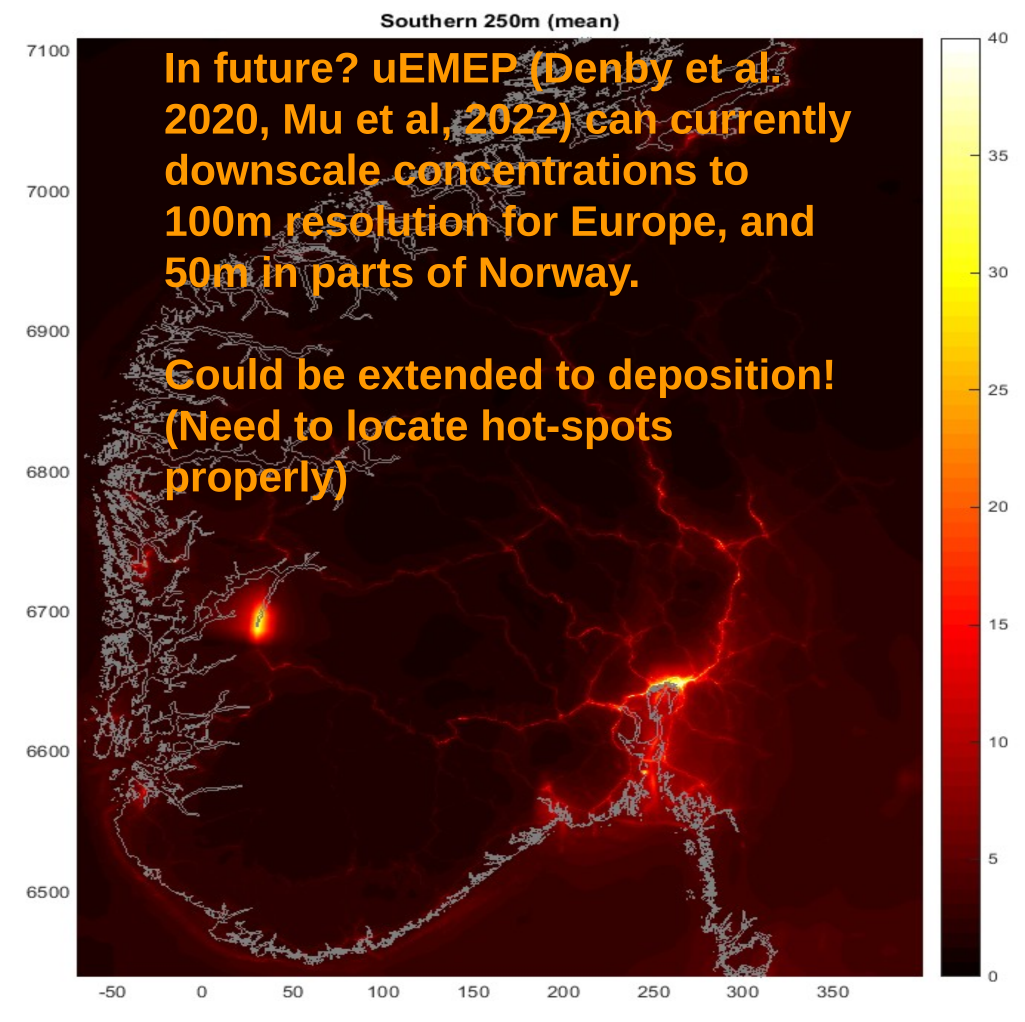
SEEDS can hopefully help with (1), (2), (3), (6)

An unresolved problem. . .



Fowler et al., 1998

- Problem: within-grid variation $>$ grid-to-grid!
- CTMs cannot today resolve local features.
- Need to develop methods to deal with sub-grid. Statistical? Semi-explicit?



In future? uEMEP (Denby et al. 2020, Mu et al, 2022) can currently downscale concentrations to 100m resolution for Europe, and 50m in parts of Norway.

Could be extended to deposition! (Need to locate hot-spots properly)

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Satellite- uses for deposition?

- Pros:
  - Global coverage
  - Spatial location of sources
  - Temporal patterns
  - Quantification of emissions
  - Quantification of concentrations - NO_2, …
  - Vegetation/landcover - e.g. LAI, phenology
- Cons:
  - Lacks data on key deposition components - e.g. HNO_3, pNO_3
  - Uncertainties in concentration/emission/LAI and other estimates
- Summary - satellite data and inversions cannot give independent estimate of deposition, but are good complement to surface stations and models

Acknowledgements

- ICP-Forests and EMEP CCC (incl. data from OSPAR, HELCOM) for data used in CAMS comparisons

- Colleagues from CAMS and EMEP networks