HARMONIE-AROME CAR* experiences

Laura RONTU

with thanks to:
Daniel MARTÍN Ján MAŠEK Karl-Ivar Ivarsson
Piotr SEKULA Ana ŠLJIVIĆ Panu MAALAMPI

FMI Finland
AEMET Spain CHMI Czechia SMHI Sweden
IMGW Poland DHMZ Croatia

ACCORD All-staff workshop
27-31.3.2023 Tallinn

* Cloud-Aerosol-Radiation

Contents

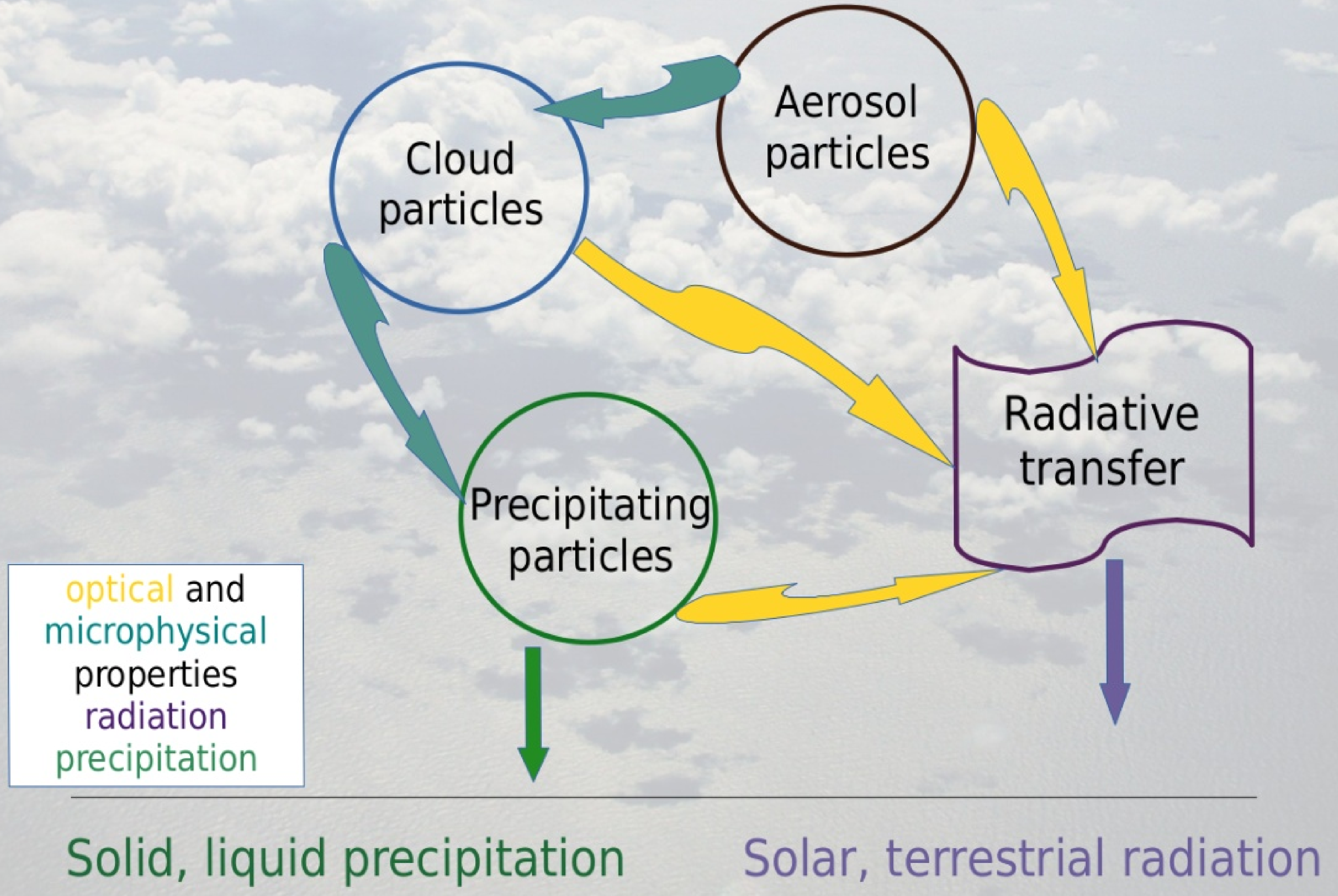
Where are we?

In HARMONIE-AROME CY46h1 we now have tools to introduce and use climatological aerosol concentration with new optical properties for radiation (RAY,RAYFM) and near-real-time aerosol concentration for radiation + cloud microphysics (ICE3/OCND2).

We have learned that the largest impact on radiation and precipitation is due to n.r.t. aerosol via clouds.

Introduction of n.r.t. aerosols into cloud microphysics means introduction of new CAR interactions and uncertainties into the model.

Parametrization of microphysics and optical properties



Based on CY46h1

Aerosol input

Aerosol mass mixing ratios (MMRs)
- from CAMS reanalysis via m-climate files (2D)
- CAMS near-real-time (n.r.t.) data imported via boundary files (3D)

Radiation

- MMRs converted to Tegen AOD550 for the default IFS radiation
- Run-time optical properties of aerosol mixture derived from MMRs and AIOPs for the single-band acraneb2 and hlradia

Cloud microphysics

- cloud droplet and ice generation for default rain-ice scheme from nuclei based on n.r.t. MMRs
- possible use of cloud droplet number in IFS radiation for droplet size parametrization

Contents

Where are we?

Saharan dust case, February 2021

Further questions

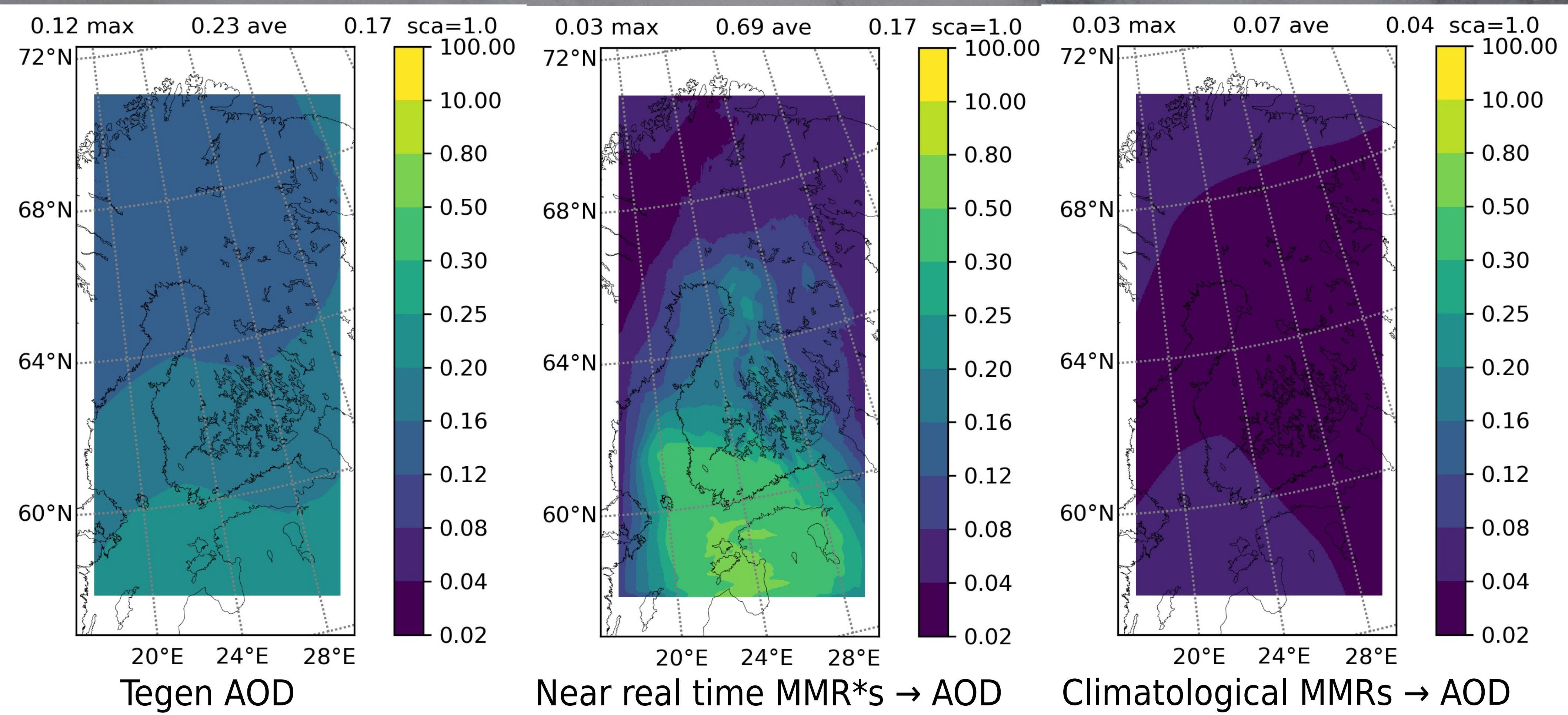
From Sahara to Helsinki, February 2021

Murcia 19 Feb 2021 towards south. Photo Jakob Lödjquist

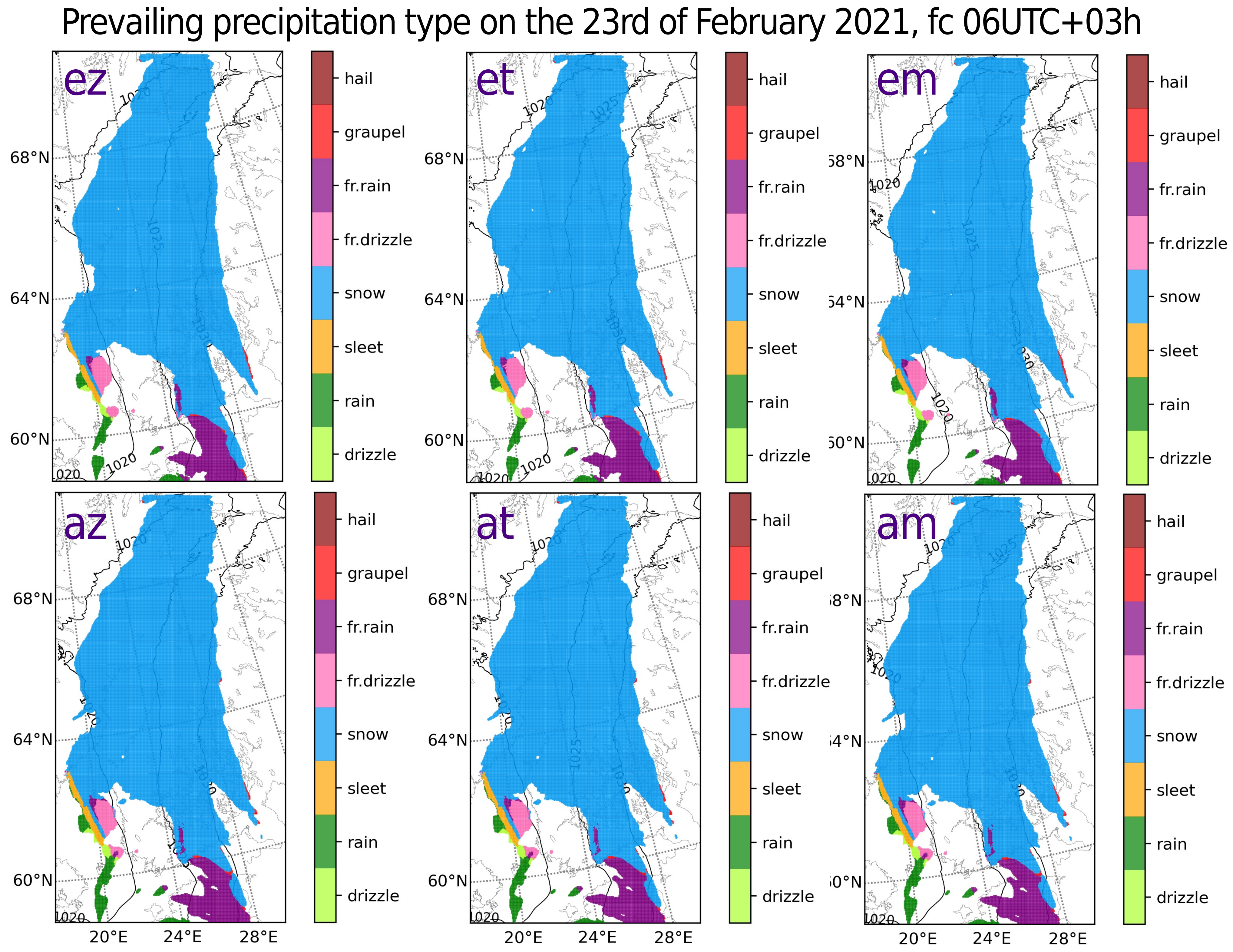
Helsinki sea ice on 23 Feb 2021 10 UTC
Photo Laura Rontu

Helsinki sea ice on 15 UTC 25 Feb 2021 Photo Laura Rontu

Diagnostic AOD550* 23 Feb 2021 06 UTC+03h



*AOD550 = aerosol optical depth @ 550nm *MMR = mass mixing ratio


Prevailing precipitation type on the 23rd of February 2021, fc 06UTC+03h
ez
et
em
az
at
am
hail
graupel
fr.rain
fr.drizzle
snow
sleet
rain
drizzle
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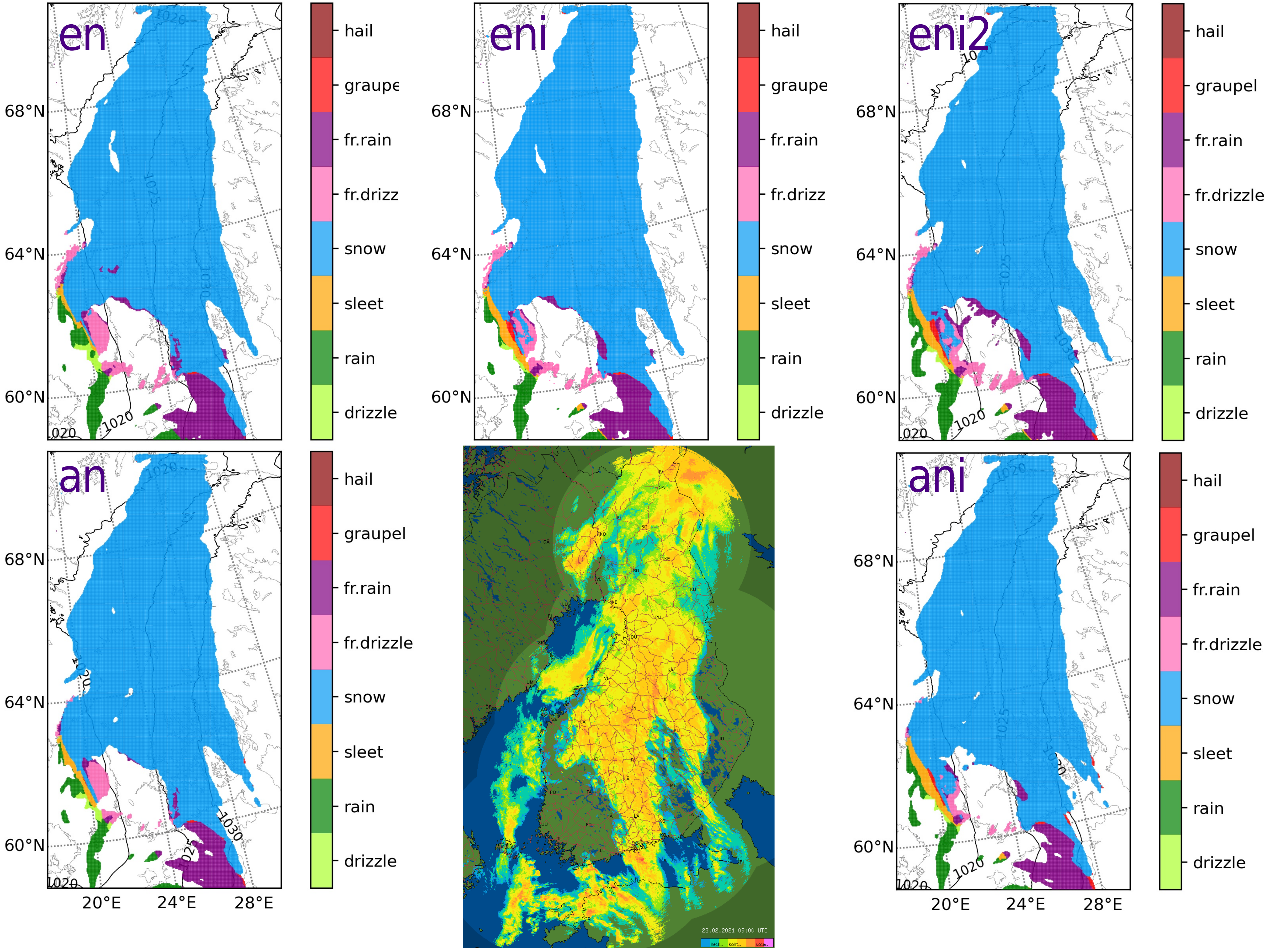
24°E
28°E
1020
1025
1030


en
eni
eni2
an
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hail
graupe
graupel
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sleet
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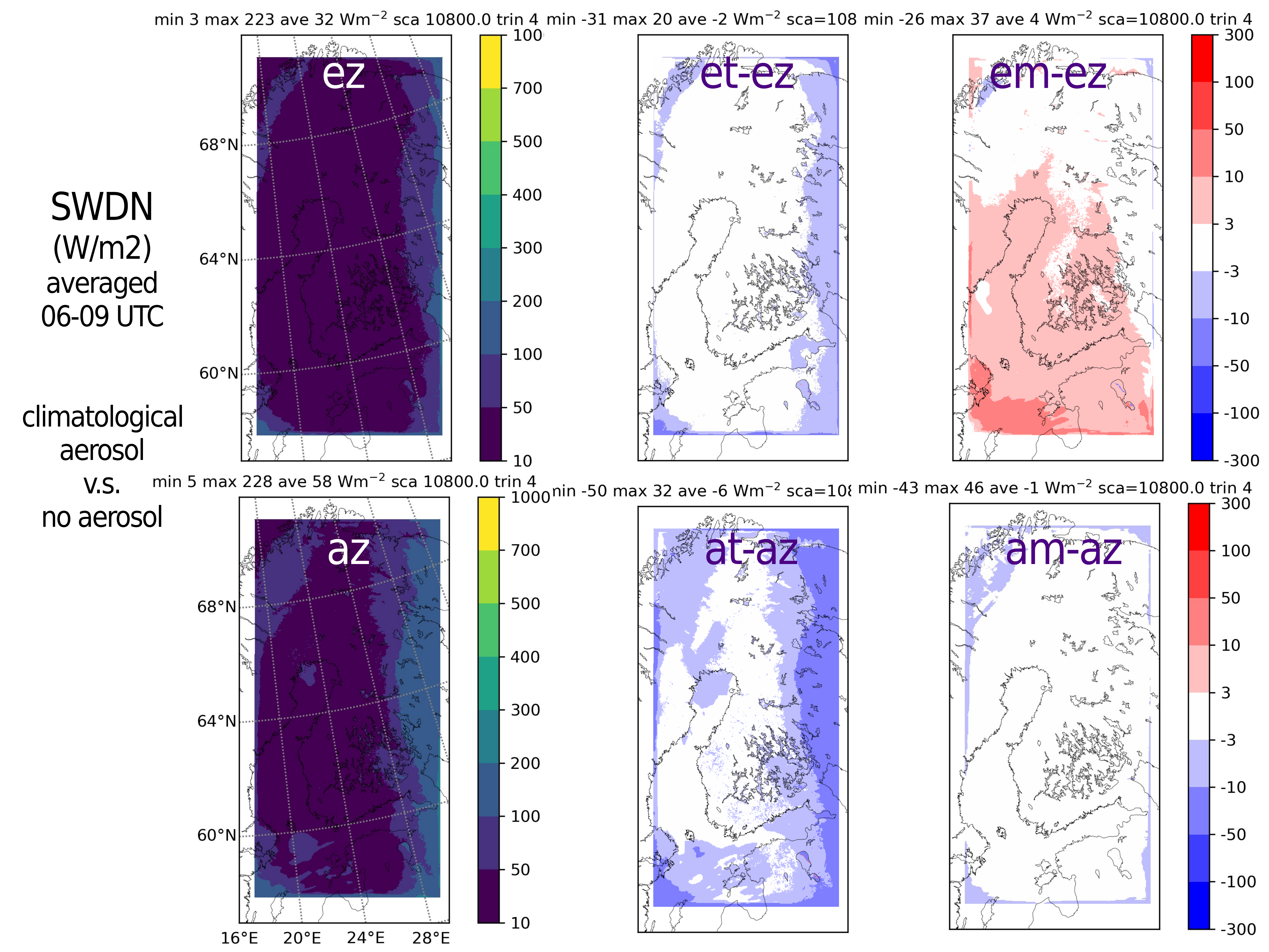
23.02.2021 09:00 UTC



SWDN
(W/m2)
averaged
06-09 UTC
climatological
aerosol
v.s.
no aerosol
min 3 max 223 ave 32 Wm^{-2} sca 10800.0 trin 4
ez
min -31 max 20 ave -2 Wm^{-2} sca=108
et-ez
min -26 max 37 ave 4 Wm^{-2} sca=10800.0 trin 4
em-ez
min 5 max 228 ave 58 Wm^{-2} sca 10800.0 trin 4
az
min -50 max 32 ave -6 Wm^{-2} sca=108
at-az
min -43 max 46 ave -1 Wm^{-2} sca=10800.0 trin 4
am-az
68°N
64°N
60°N
16°E
20°E
24°E
28°E
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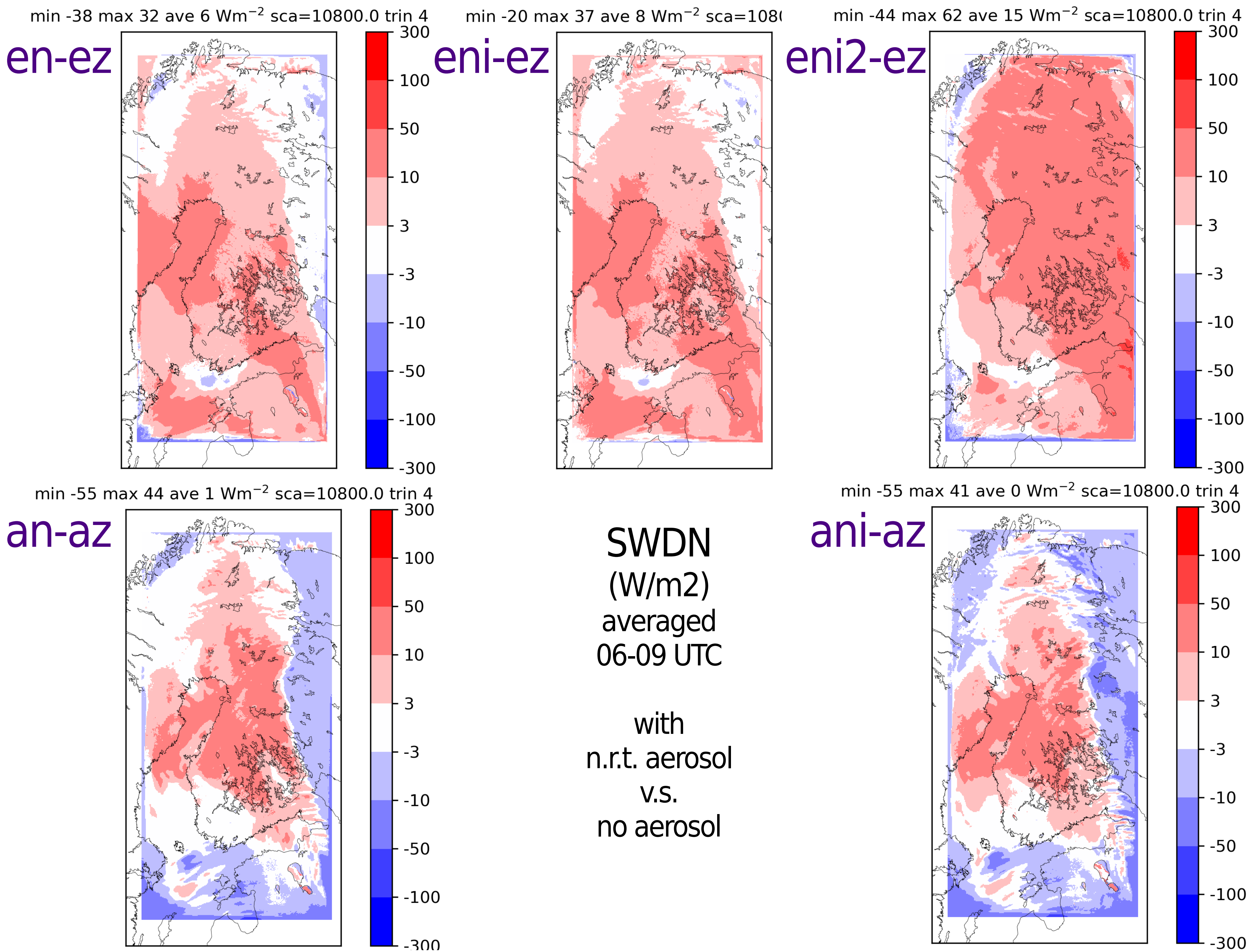
min -38 max 32 ave 6 Wm^{-2} sca=10800.0 trin 4
en-ez
min -20 max 37 ave 8 Wm^{-2} sca=1080
eni-ez
min -44 max 62 ave 15 Wm^{-2} sca=10800.0 trin 4
eni2-ez
min -55 max 44 ave 1 Wm^{-2} sca=10800.0 trin 4
an-az
min -55 max 41 ave 0 Wm^{-2} sca=10800.0 trin 4
ani-az
300
100
50
10
3
-3
-10
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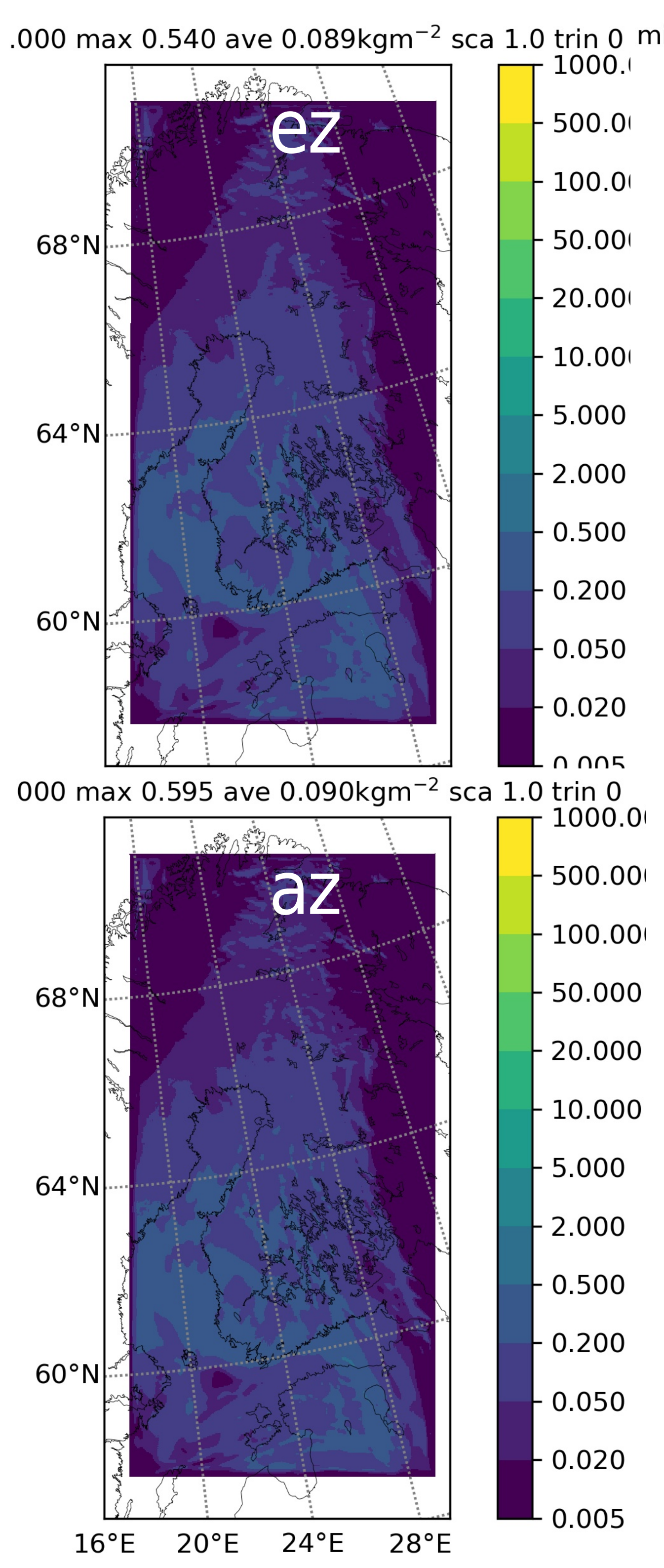
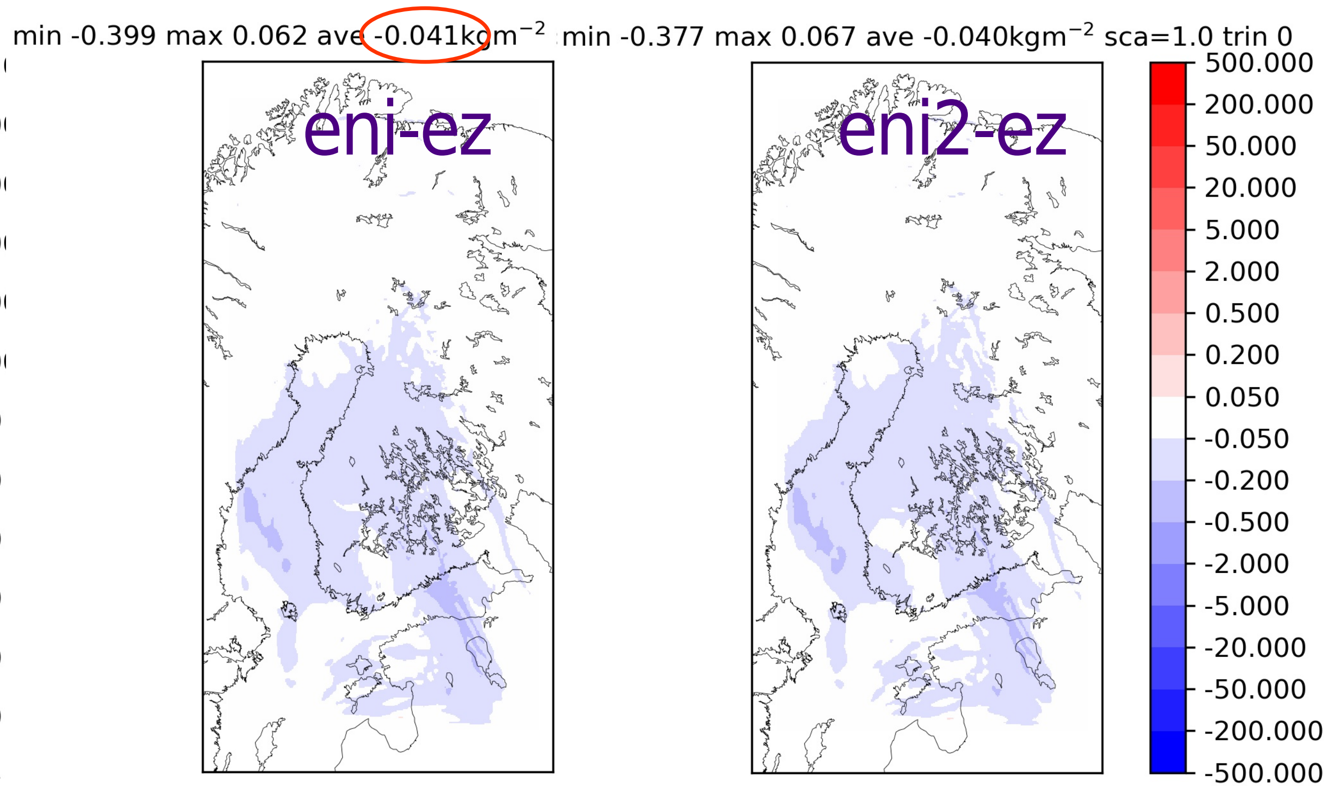
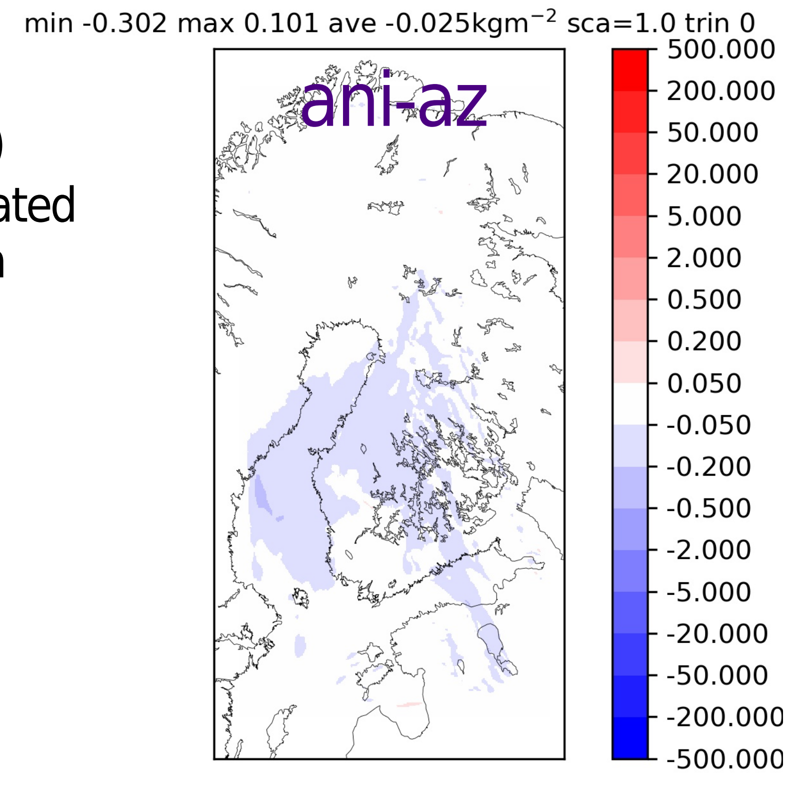
-100
-300
SWDN
(W/m2)
averaged
06-09 UTC
with
n.r.t. aerosol
v.s.
no aerosol

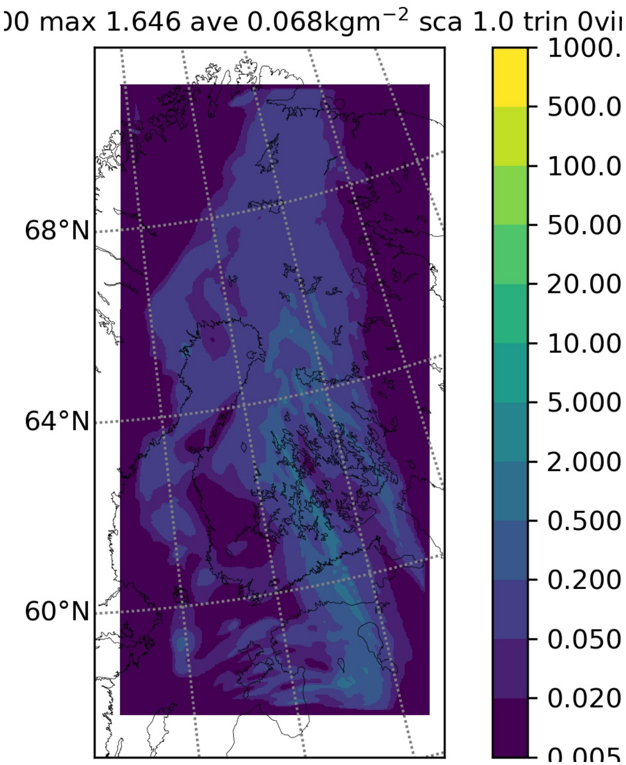


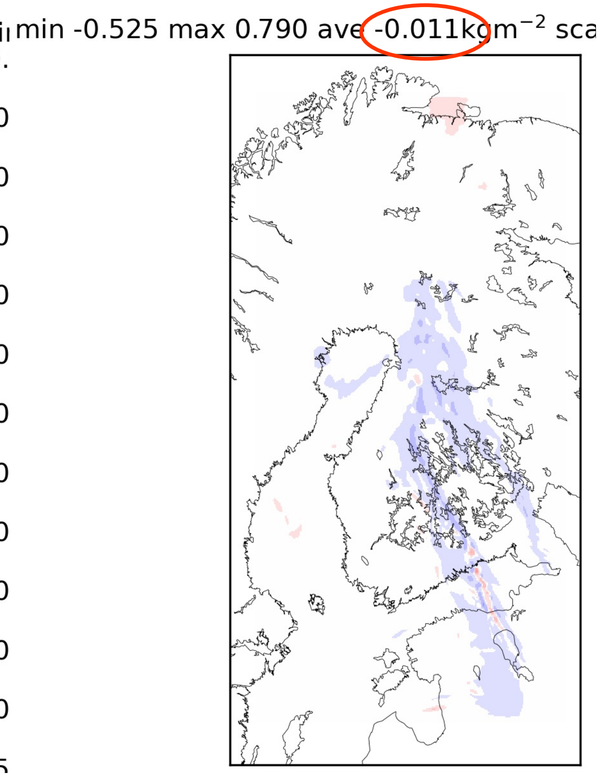


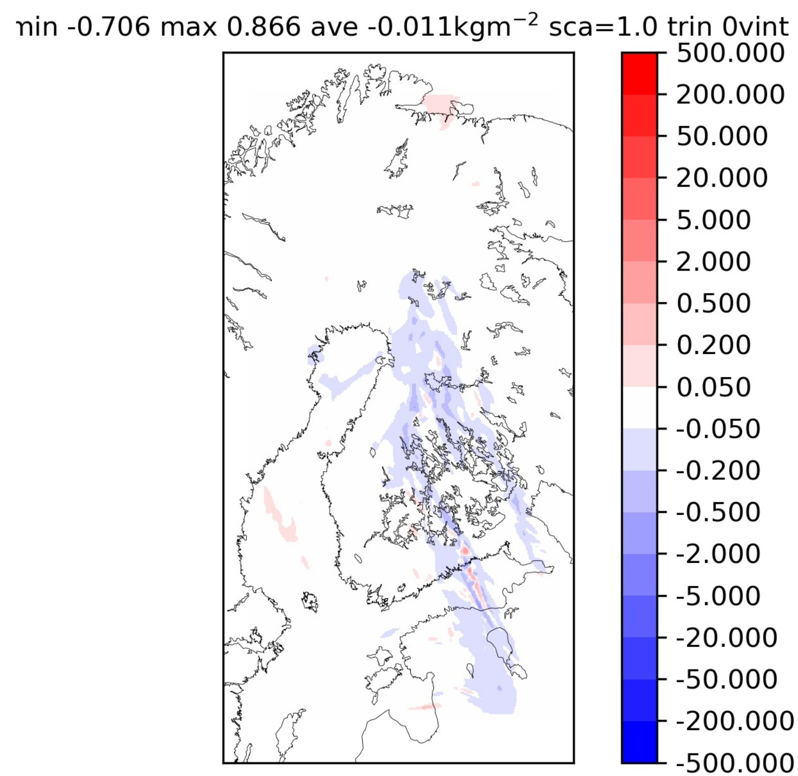
q_{liq} (kg/m2)
vertically integrated
06 UTC+03h

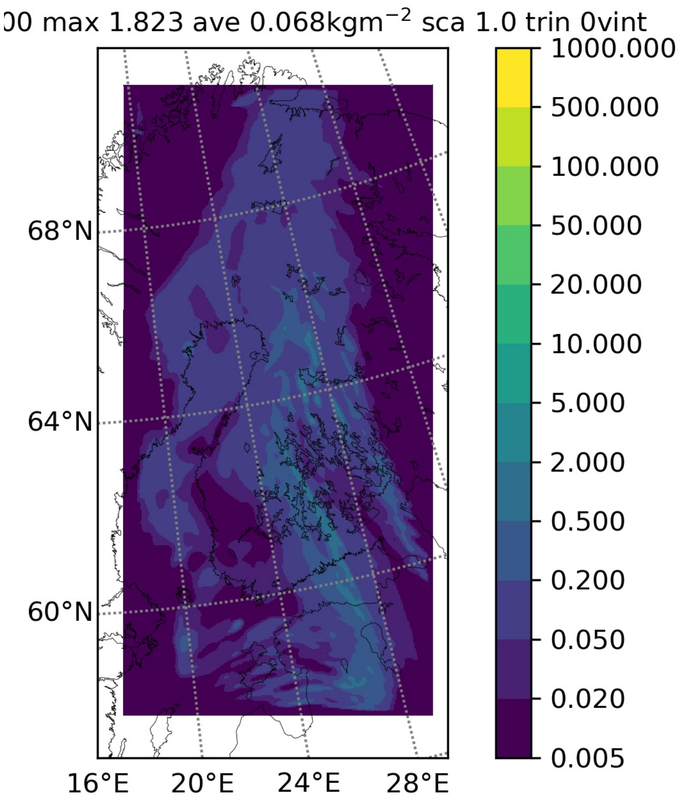
with
n.r.t. aerosol
v.s.
no aerosol





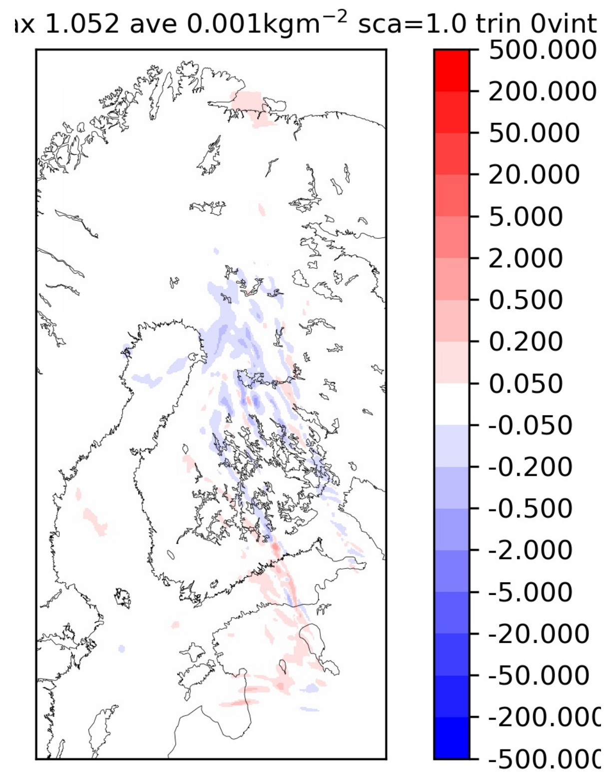


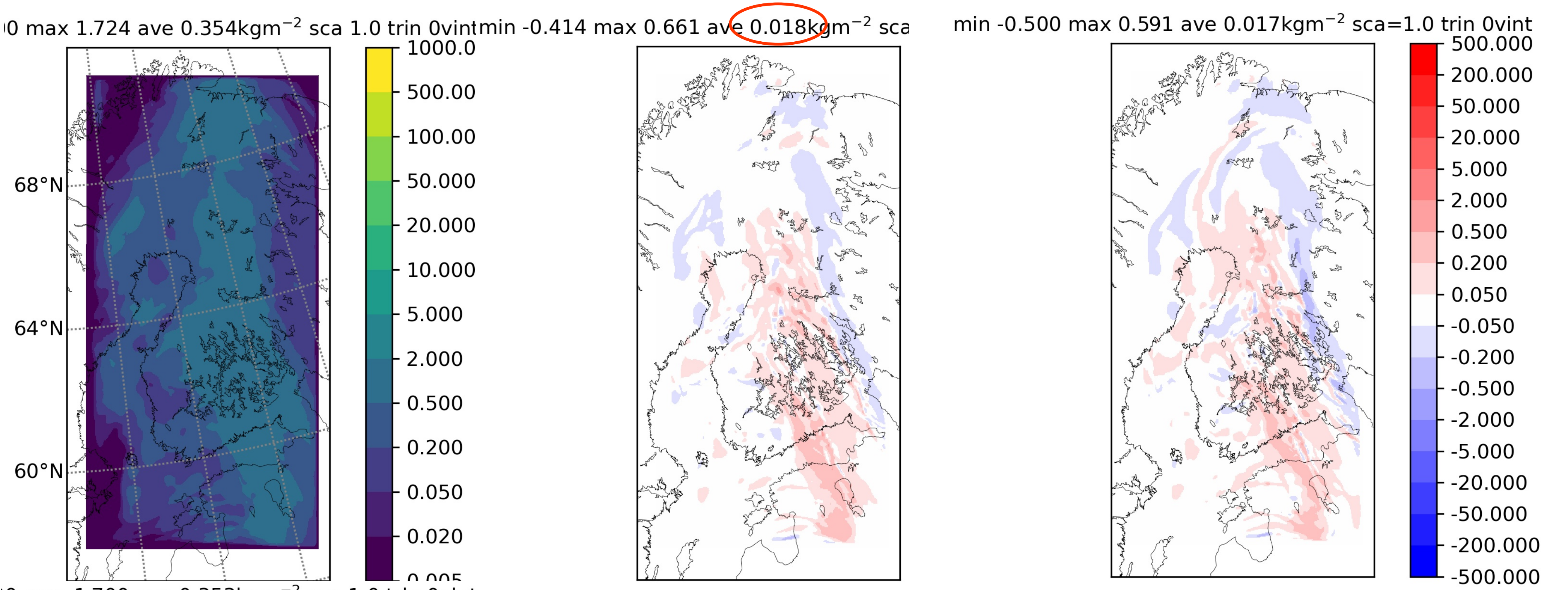


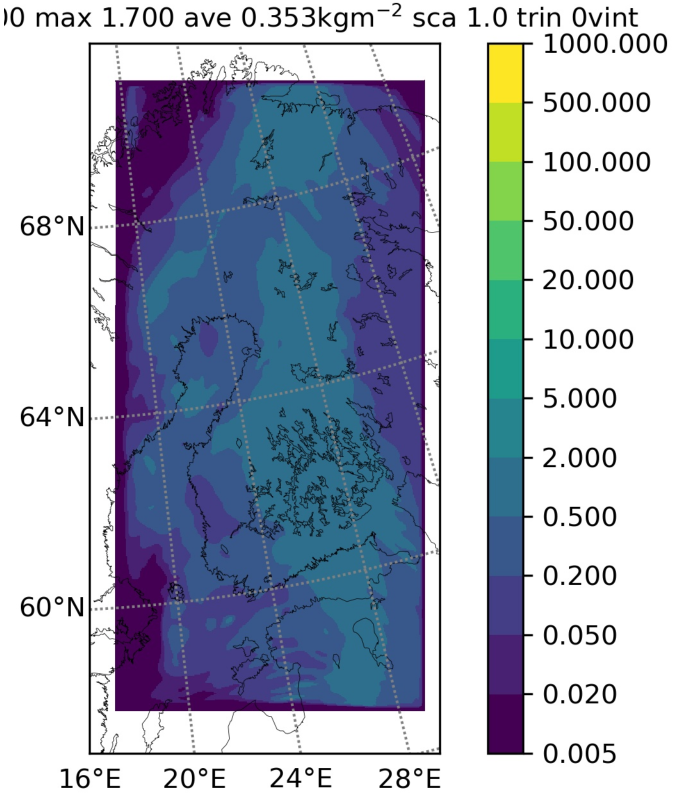


q_{grpl} (kg/m2)
vertically integrated
06 UTC + 03h

with
n.r.t. aerosol
v.s.
no aerosol

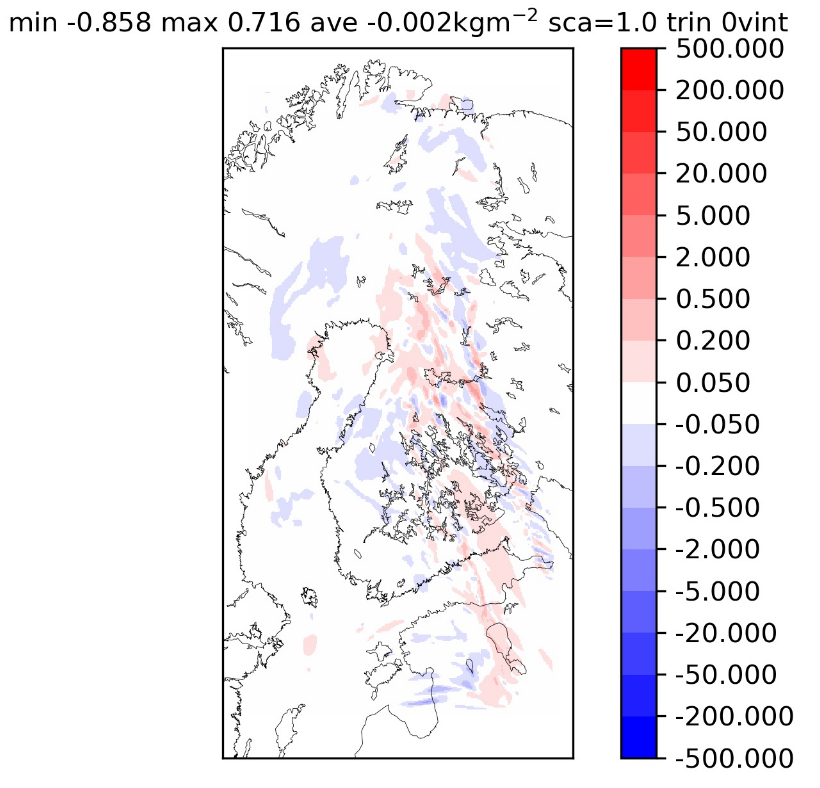






q_{snow} (kg/m2)
vertically integrated
06 UTC + 03h

with
n.r.t. aerosol
v.s.
no aerosol



Summary of HARMONIE-AROME experiments

Climatological aerosol for radiation only

ez, et, em for default RAYFM with zero, tegen AOD, CAMS cmr aero
az, at, am for acraneb2 RAY with zero, tegen AOD, CAMS cmr aero

Near-real-time aerosol for radiation and cloud microphysics

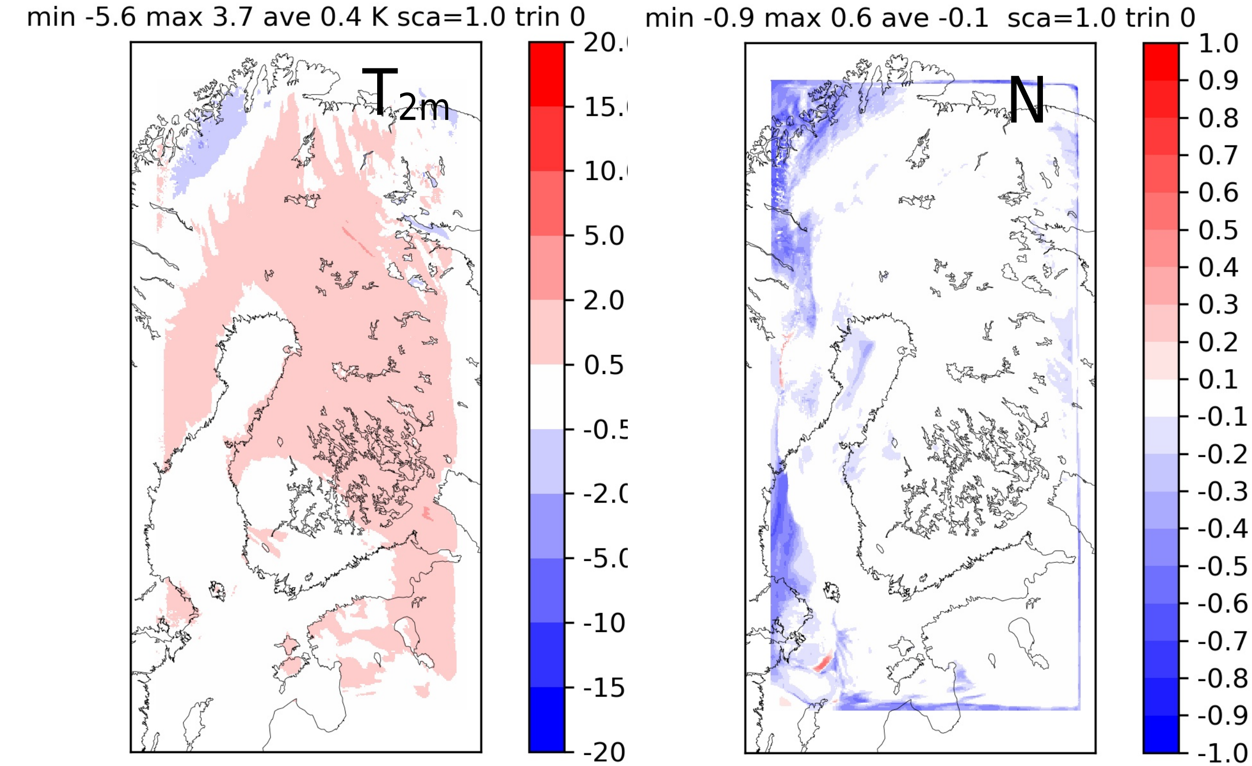
en, eni, eni2 for default RAYFM and mpa/micro OCND2 with CAMS n.r.t. aero
an, ani for acraneb2 RAY and mpa/micro OCND2 with CAMS n.r.t. aero

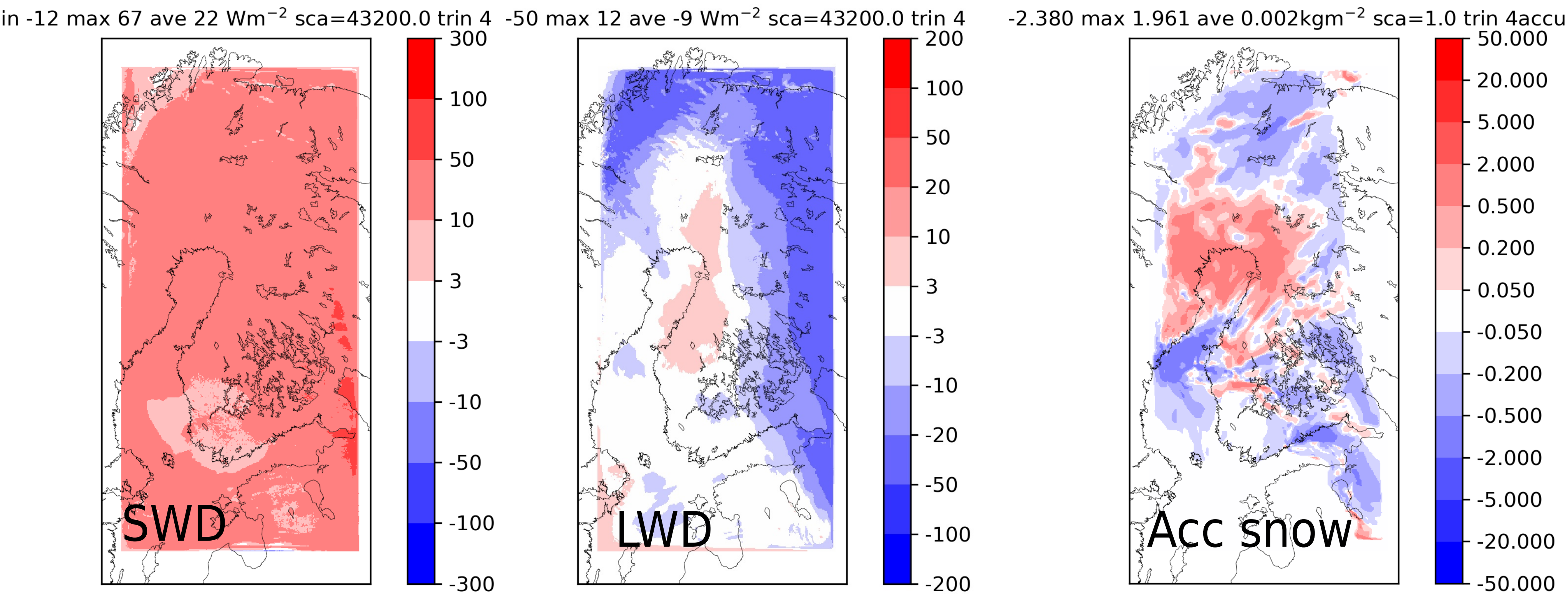
Aerosol n.r.t. usage for microphysics

Feature	en	eni	eni2	an	ani
liquid droplet number concentration based on n.r.t. aerosol	yes	yes	yes	yes	yes
cloud ice mass concentration based on n.r.t. aerosol	no	yes	yes	no	yes
liquid droplet number concentration passed to radiation for r_{eff} and optical properties	yes	yes	no	no	no
0.5*graupel and 1.0*snow mass concentration added to cloud ice for radiation ($\rightarrow r_{eq}$ and optical properties)	yes	yes	no	no	no
NB: also for ez,et,em but not az,at,am!					

23 Feb 2021 00 UTC+12h

Differences between experiments (n.r.t. with acraneb2) - (Tegen with default IFS)





What did we learn from the experiments?

Introduction of aerosols to cloud microphysics influences both radiation and precipitation. Direct radiation impacts are smaller but possibly more systematic (not discussed today).

We have more alternatives and uncertainties than previously expected: options and choices in cloud microphysics and CAR-interactions – besides they are different in HARMONIE and Toulouse cycles

There is room for improvements with respect to aerosols: consistent cloud particle size (effective/equivalent radius), ice and snow formulations, fog and stratus...

We have just started – many things need to be carefully tested, analysed, streamlined, simplified for application

We need good diagnostics and tools to analyse differences

Contents

Further questions

Should climatological aerosol mass concentrations also influence cloud microphysics?

Main impacts seem to be not due to exact content of aerosols but due to the fact that aerosols in general were included in cloud microphysics parametrizations

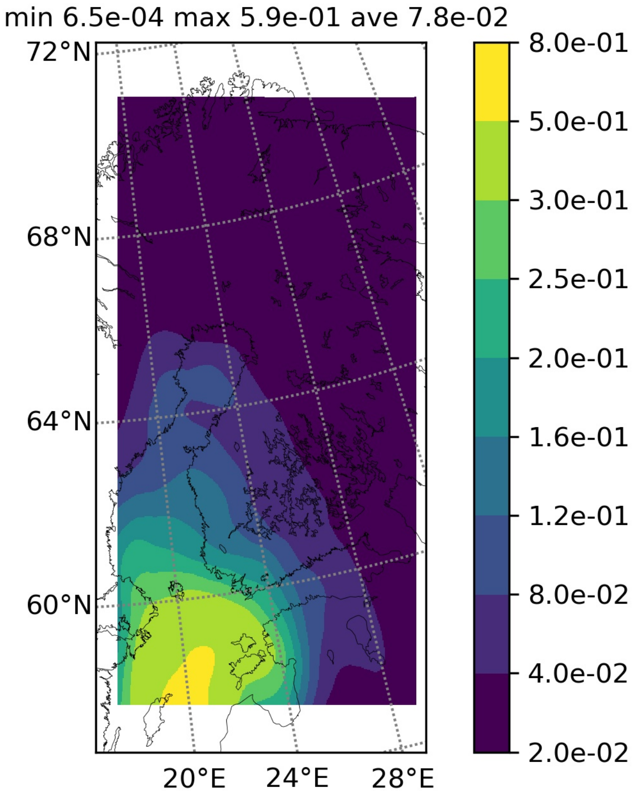
Impact of old indirect sulfates via clouds to radiation was seen when using climatological MMRs

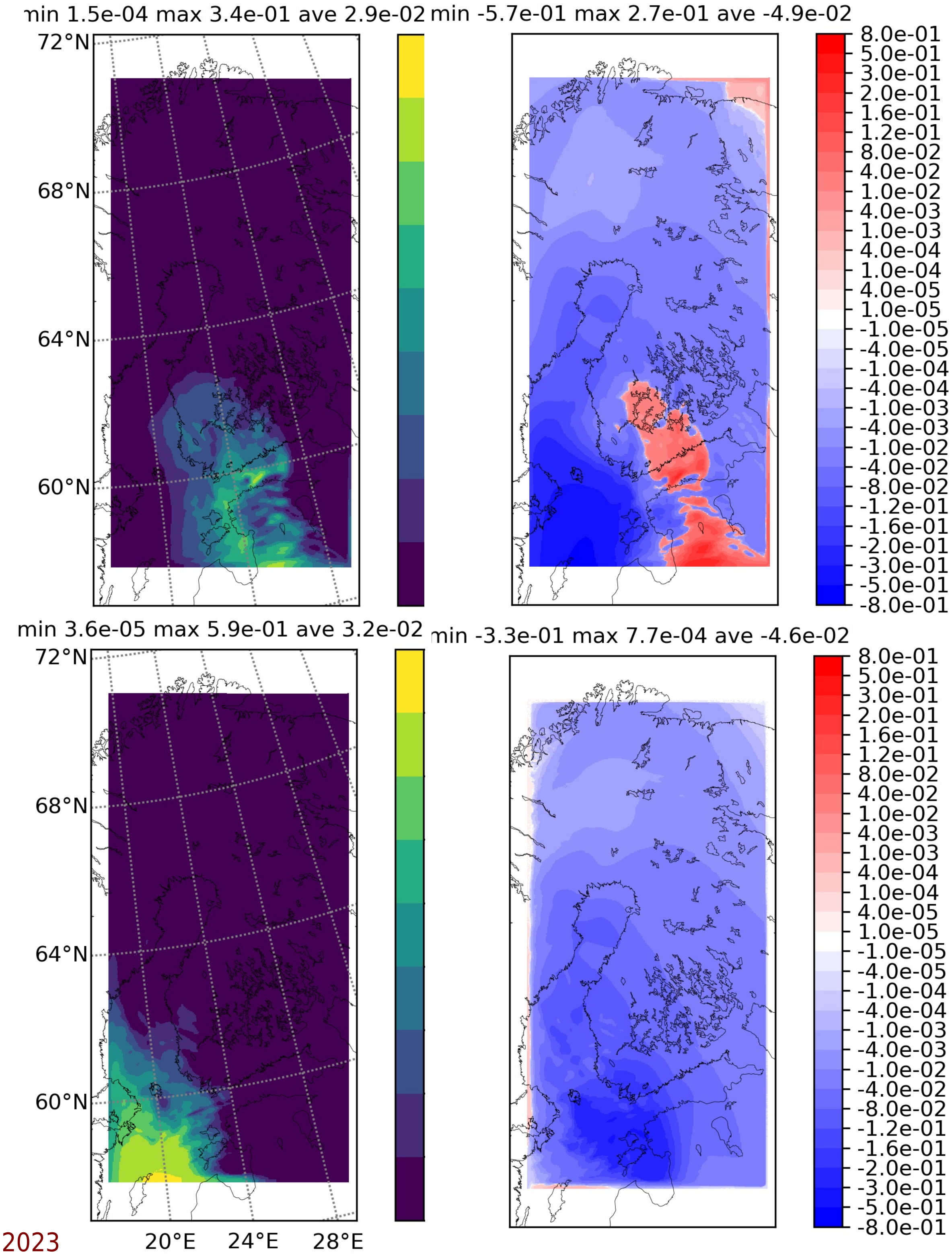
Everything is ready to use CAMS climatological MMRs of 11 species in microphysics and radiation: flat climatologies, vertical extrapolation, microphysics methods developed for n.r.t. MMRs

Climatological aerosols do not evolve during the forecast

How prognostic are the n.r.t. aerosols within HARMONIE-AROME?*

Role of CAMS input, advection and parametrized tendencies?





Total concentration of dust particles > 1 µm (g/m2) 2021023200+00 (left), +06 (middle), diff (right) from CAMS nrt via HARMONIE experiments: full (above) and without advection and coupling (below)

*includes the latest updates by D.Martin 24.3.2023

Further questions

We know very little about the vertical distribution of (near-real-time) aerosols. Should we introduce n.r.t. aerosols as flat fields and extrapolate like climatologies? Could save quite a lot of space and time during (operational) forecast.

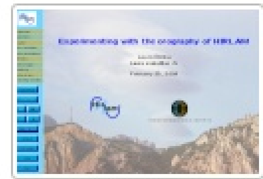
Should we treat more CAR interactions with the help of stochastic physics perturbations instead of searching optimal combinations of microphysics/radiation options?

Some ASM-ASW cover pictures 2001-2023


ASM01.pdf


ASM02.pdf


ASM03.pdf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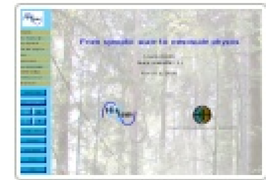
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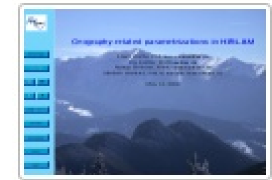
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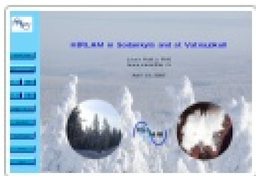
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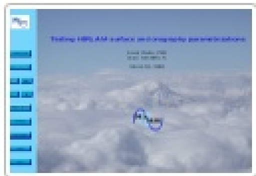
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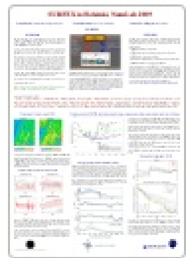
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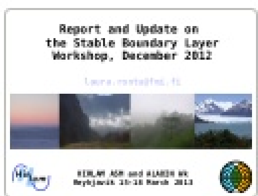
ASM09p2.pdf


ASM10.pdf

ASM11.pdf

ASM12.pdf



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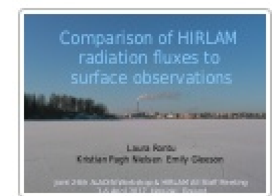

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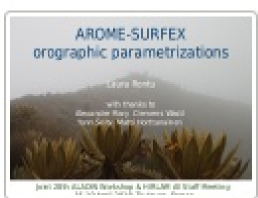

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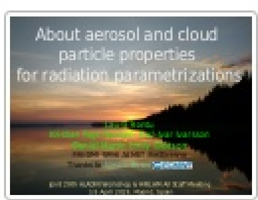

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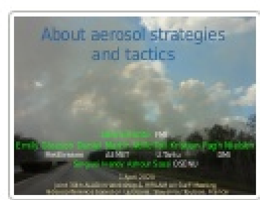

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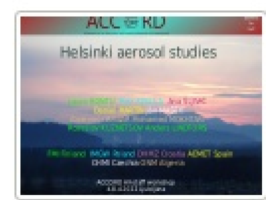

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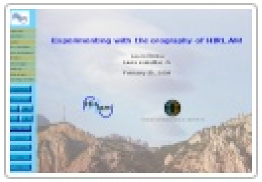
Thank you for listening all these years!


ASM01.pdf


ASM02.pdf


ASM03.pdf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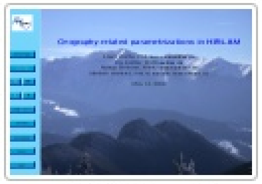
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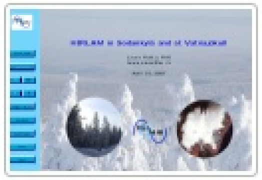
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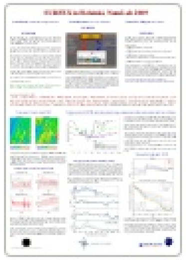
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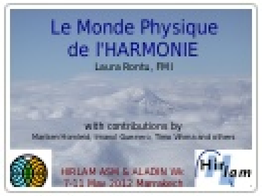

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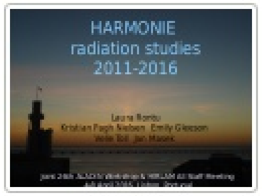

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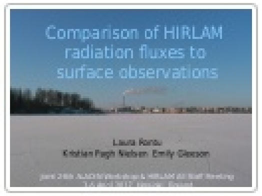

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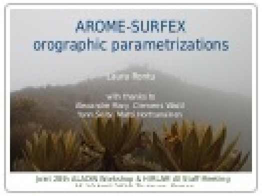

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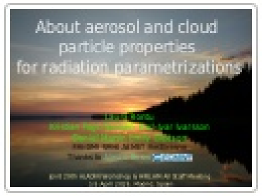

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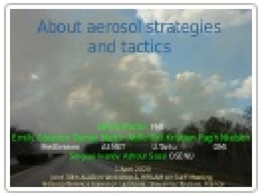

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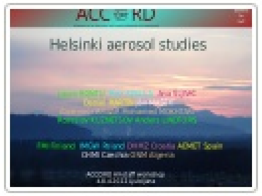

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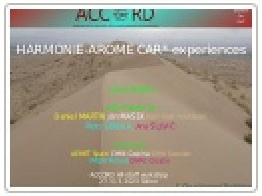

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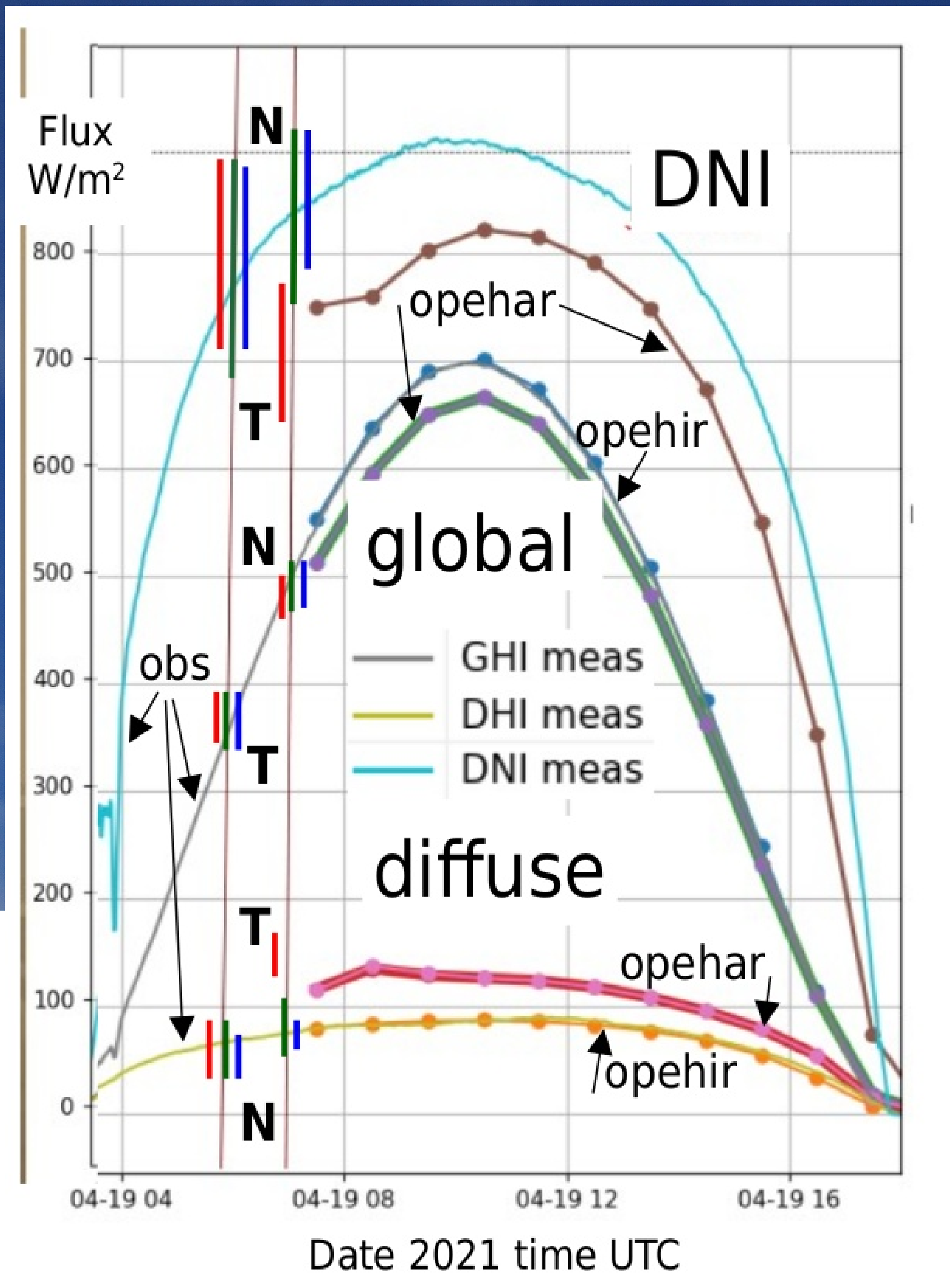
Sallatunturi 13.3.2023

Helsinki 19th of April 2021 case represents clear and clean air conditions

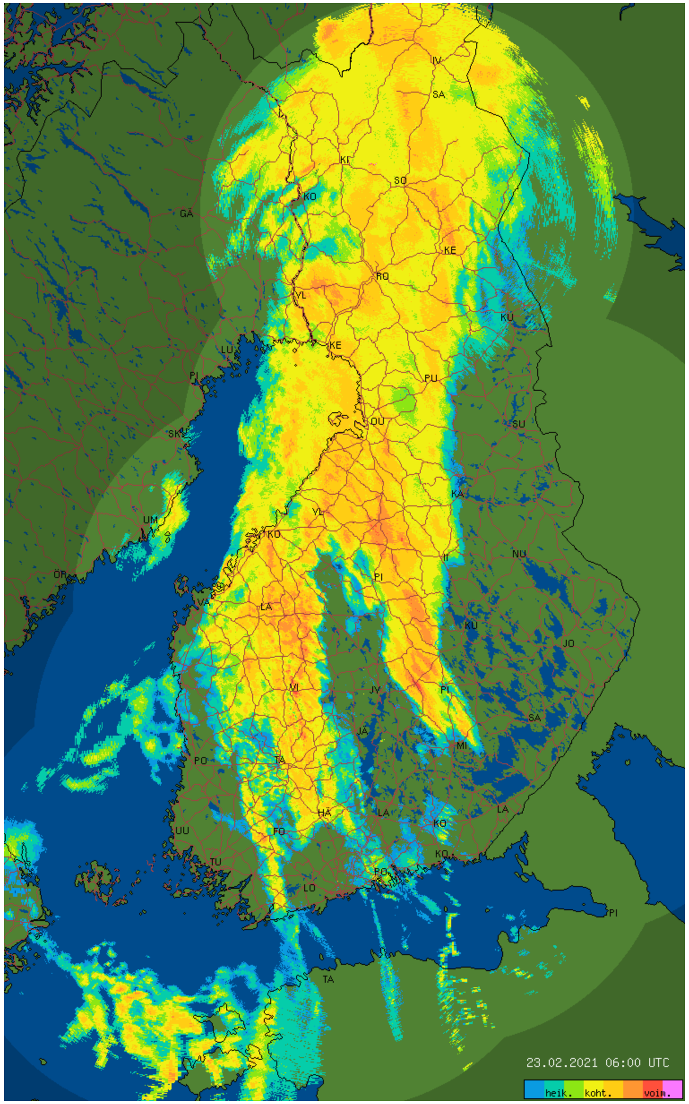


Variables: DNI, GHI, DHI (diffuse!)
Observations (lines)
Operational Hirlam and MetCoOp Harmonie (lines with dots)

In operational Harmonie GHI and DNI seem to be underestimated and DHI overestimated

MUSC experiments
(vertical bars at 06 and 07 UTC)
Radiation schemes: IFS hlradia acraneb2
Aerosols: Tegen, clim. MMR, n.r.t. MMR, none

The largest DHI and smallest DNI are given by all radiation schemes when AOD550 (**T**) is used. Differences in global radiation are smaller between the different radiation schemes and assumed aerosol sources.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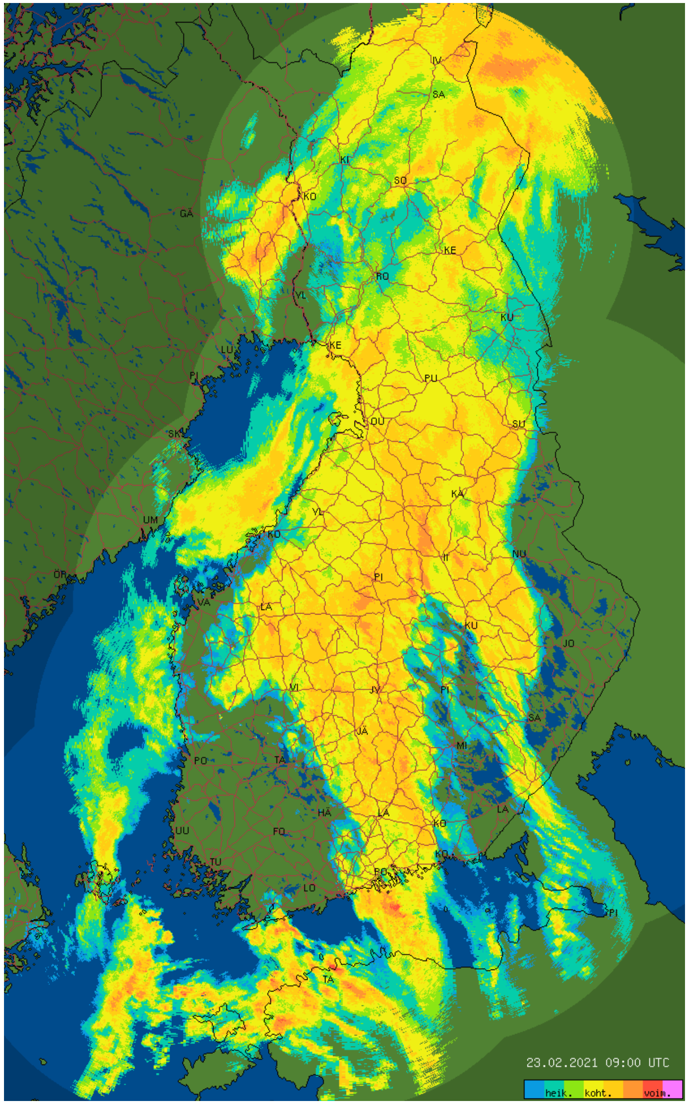
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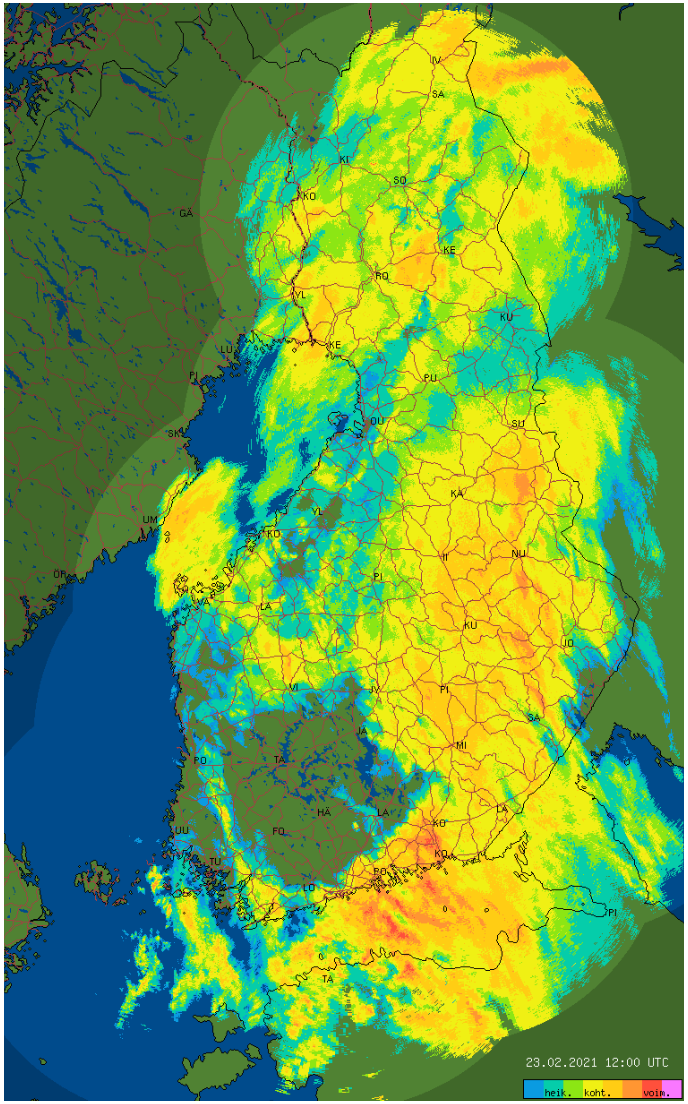
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