Norwegian Meteorological Institute

Impacts on Norwegian coastal precipitation by aerosol forcing

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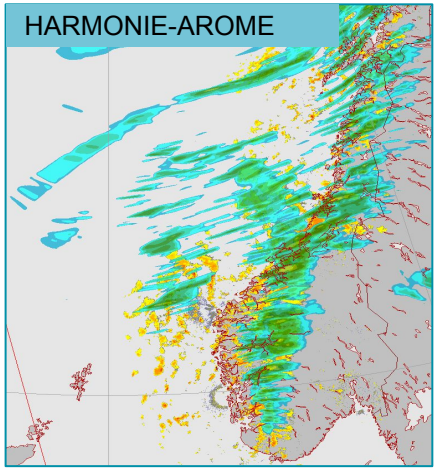
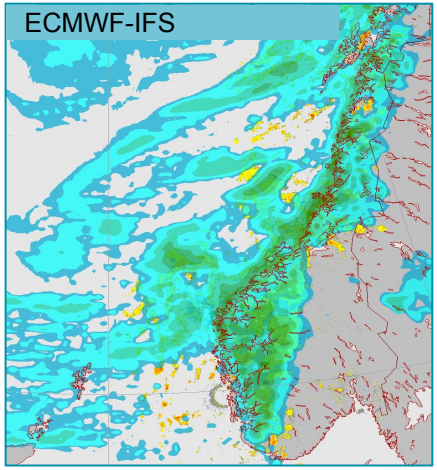
Based on CAMS setup by Daniel Martin (AEMET)

Precipitation bias examples



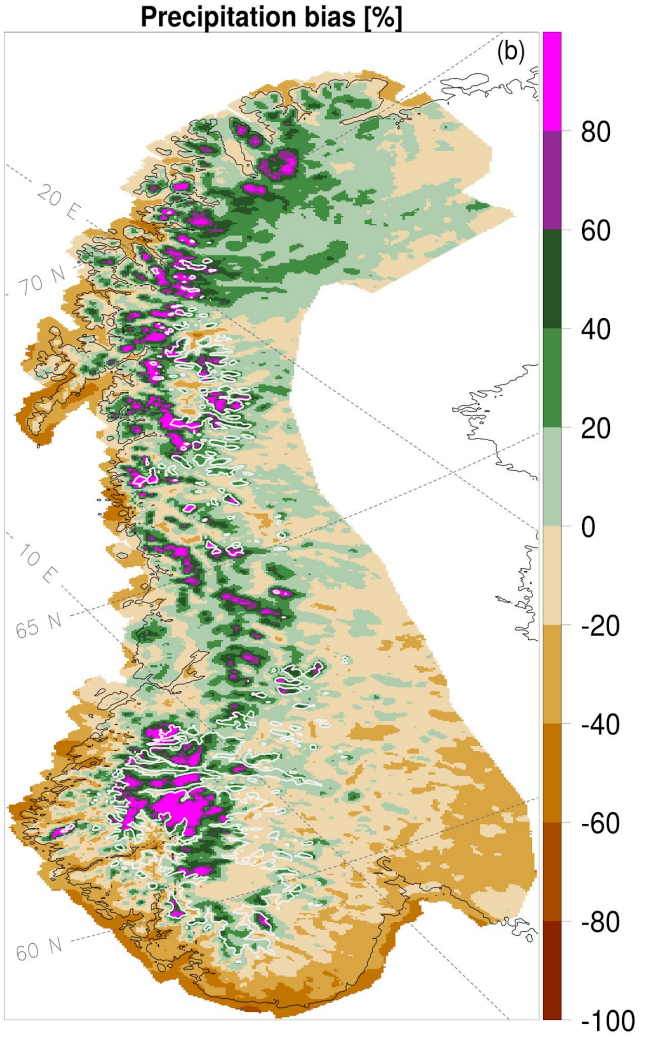


Left: 2018-10-22 +24h

Right: 13-year HCLIM-AROME compared to gridded observation dataset seNorge2

Dry bias along the coast

Wet bias in the mountains



Backdrop / History / Standing on the shoulders of giants

Precipitation bias along the coast (previous slide)

Lisa Bengtsson's investigations in 2017 (shallow convection, moving western boundary etc.)

Bjørg Jenny Engdahl (PhD student at MET Norway, supervised by Lisa) suggested to look at default CCN concentrations

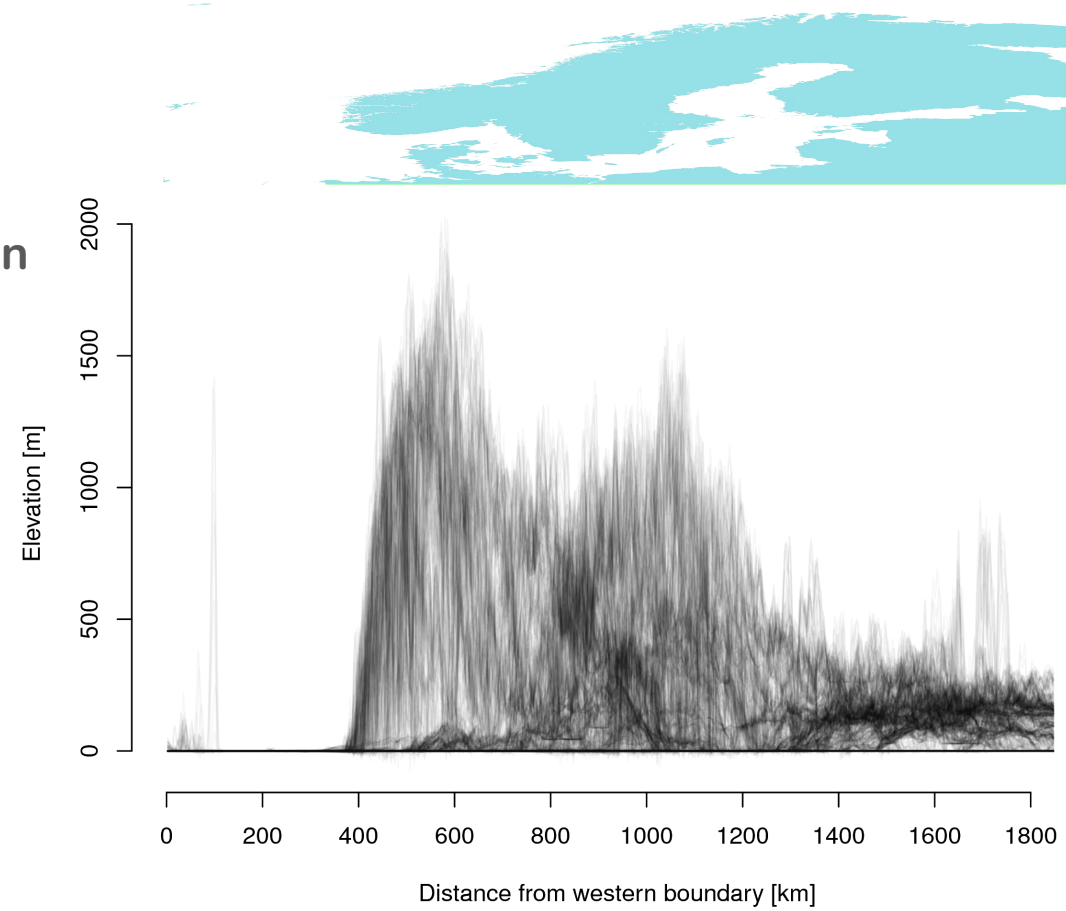
EMS2019: talking to Emily Gleeson (Met Éireann), Karl-Ivar Ivarsson (SMHI), Laura Rontu (FMI) about their aerosol harmonization efforts

Daniel Martin (AEMET), implementation of CAMS aerosols

Note to self: Talk to people!

Elevation of MetCoOp domain (from east to west)

- High mountains, close to the coast.
- Strong orographic precipitation.



Default concentrations of cloud condensation nuclei

(in src/mpa/micro/internals/ini_rain_ice.F90)

XCONC_SEA = 1E8 # 100 cm^{-3}
XCONC_LAND = 3E8 # 300 cm^{-3}
XCONC_URBAN = 5E8 # 500 cm^{-3}

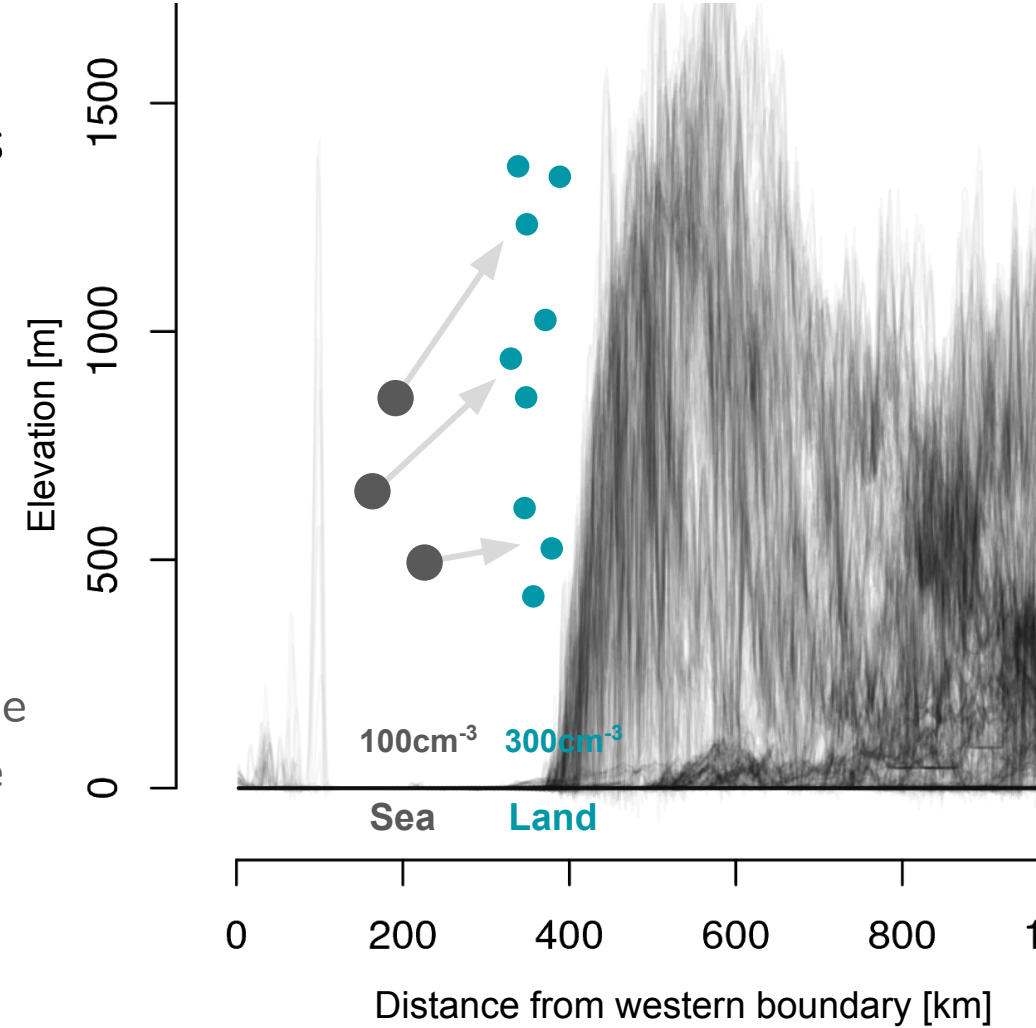
Reality:

It's complicated

Hypothesis in layman's terms

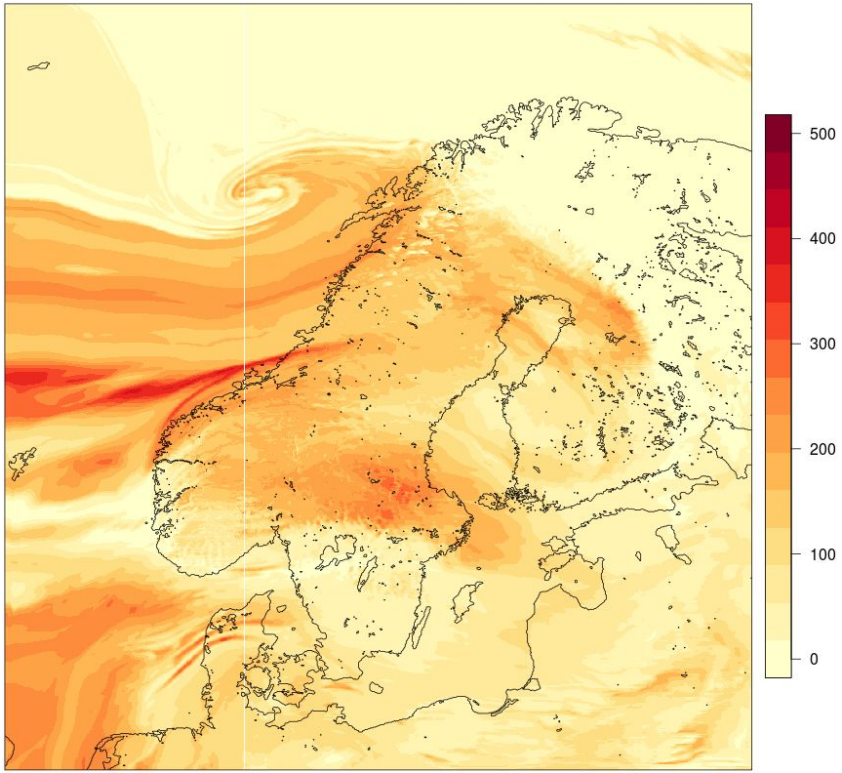
Once a maritime air mass makes landfall, particle concentrations are tripled, dividing the water into more, smaller droplets, less likely to precipitate.

Result:
Dry bias on the coast. Model retains the humidity too long, carried inland to the mountains.



More physically realistic aerosols

- Spatial distribution (avoids sudden change for airmass making landfall)
- Temporal evolution
- Often much lower numbers than default → Fewer, larger droplets (?)



Example: CN.TOT at 2020-01-01 18:00

Sensitivity experiments

Name	Version	XCONC_SEA	XCONC_LAND	XCONC_URBAN
Exp1 (CTR)	40h111	100/cm^3	300/cm^3	500/cm^3
Exp2	40h111	100/cm^3	**100/cm^3**	500/cm^3
Exp3	40h111	**300/cm^3**	300/cm^3	500/cm^3
CAMS	40h11_cams, using CAMS aerosols			

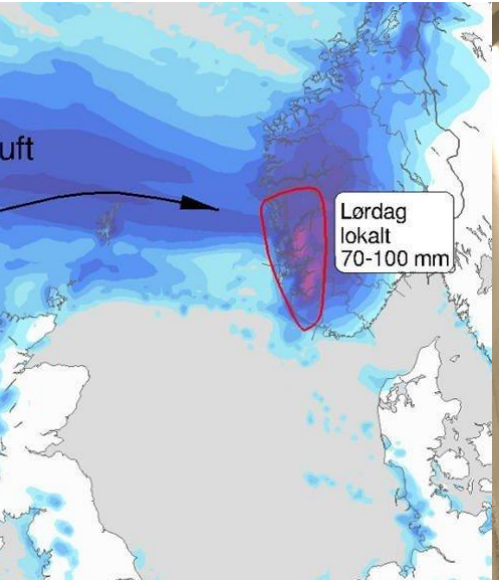
Ran for a handful of cases + 1-month run with CTR and CAMS.

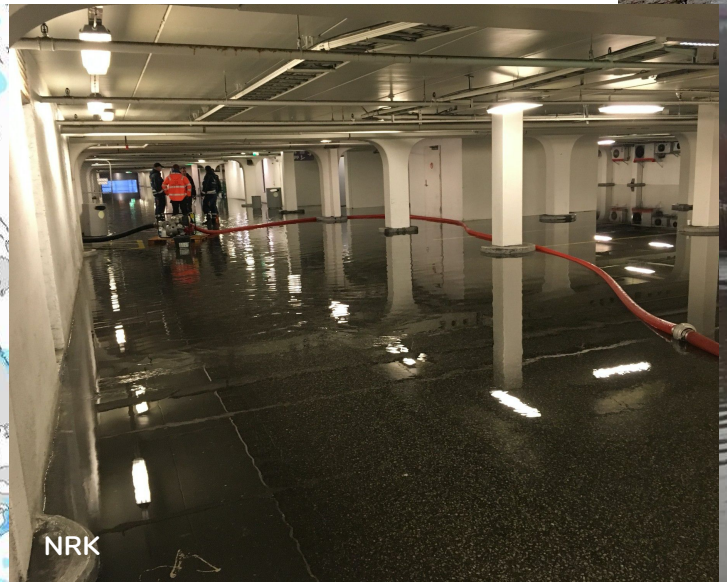
Case 2017-12-23: Extreme weather "Birk"

Strong precipitation on the west coast.

New record in Bergen: 93.9 mm/24h.

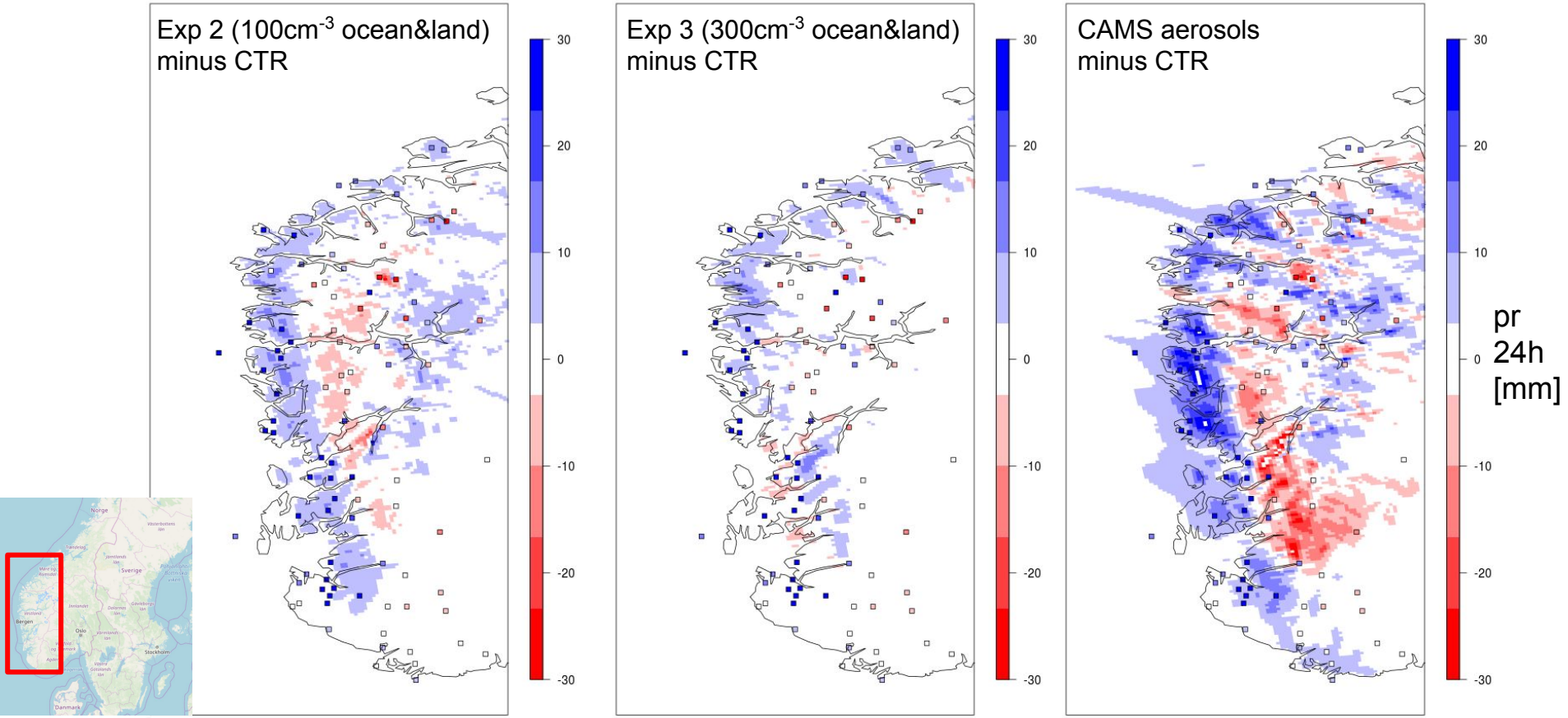
Forecast underestimated precipitation on the coast, overestimated in the mountains.





Case 2017-12-23

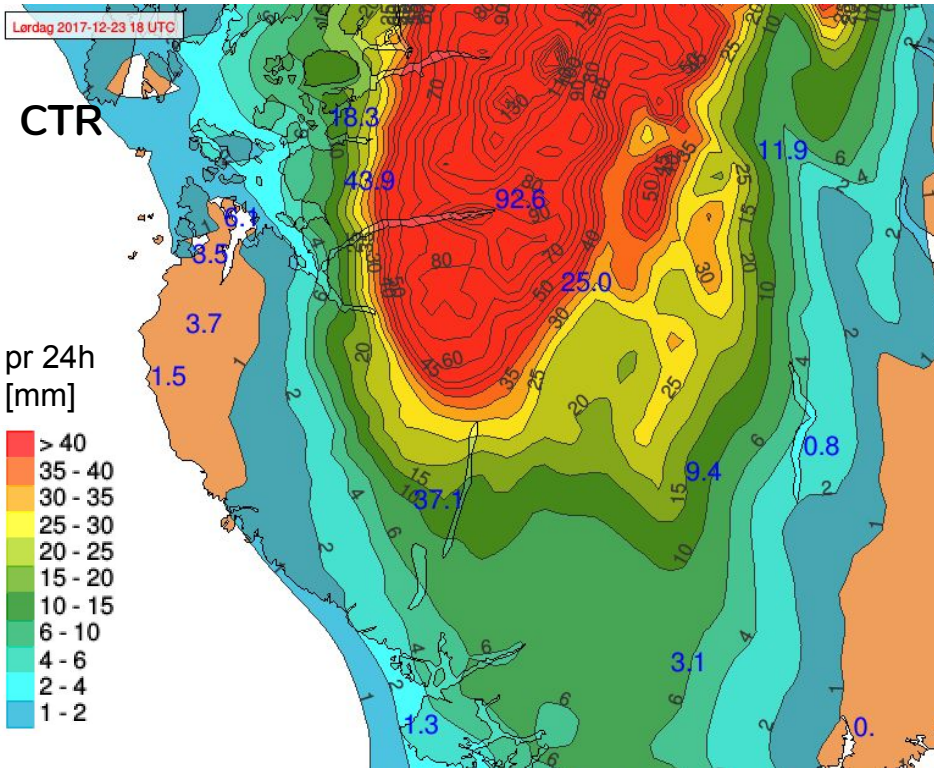
Difference relative to CTR [mm]. (Color agreement of obs point and field = good.)

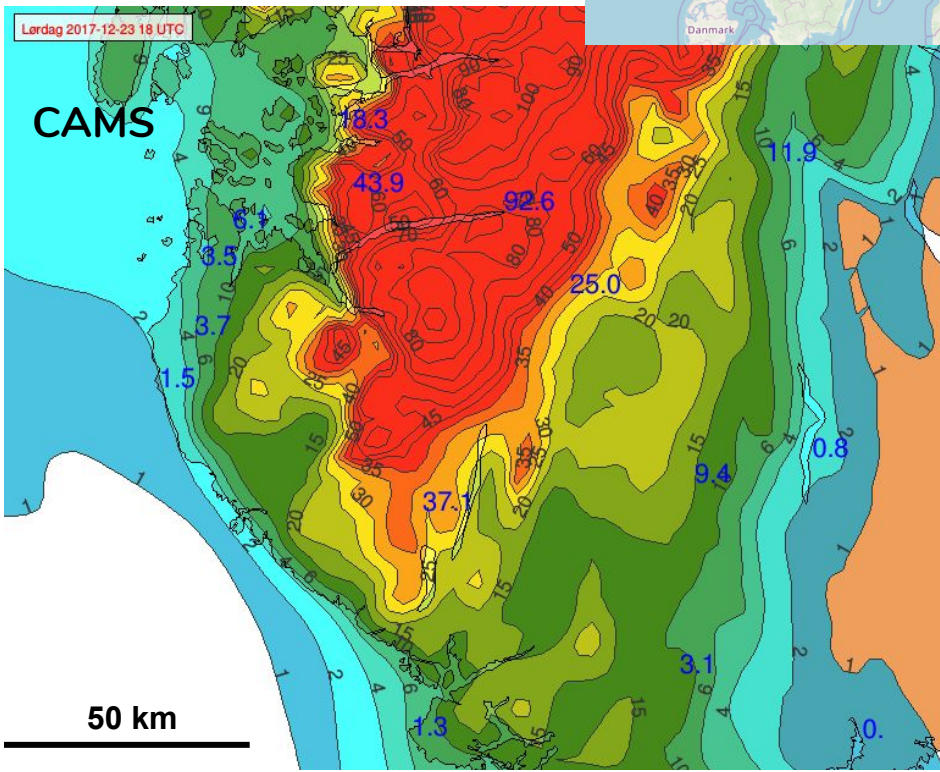


Improvement in Exp2 and 4, with better spatial structure (but note that the scale is capped at 30 mm, while obs are much above this). CAMS shows largest improvement, but still does not capture southwestern part.

Case 2017-12-23

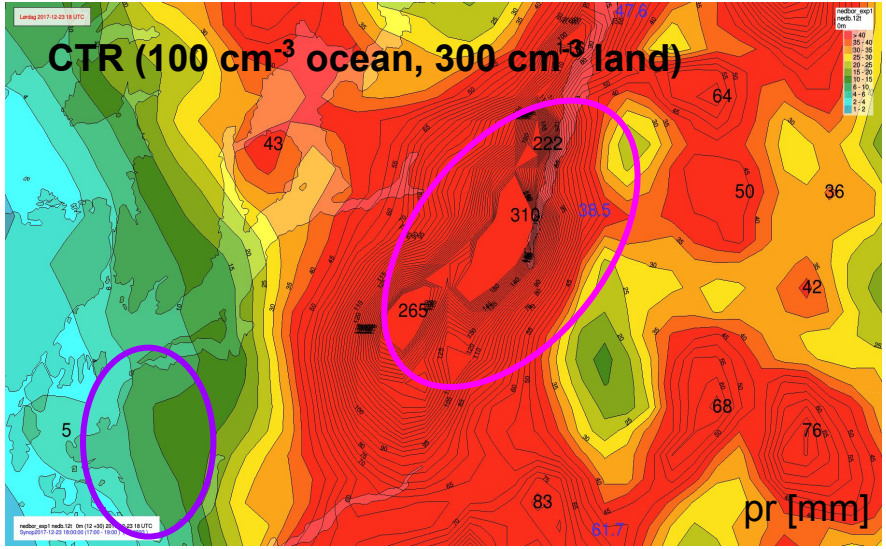
Improved spatial representation

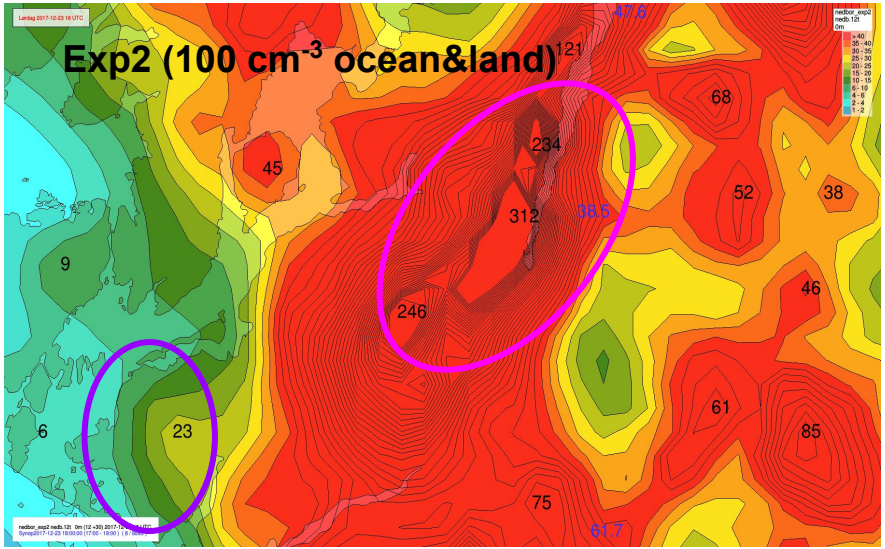


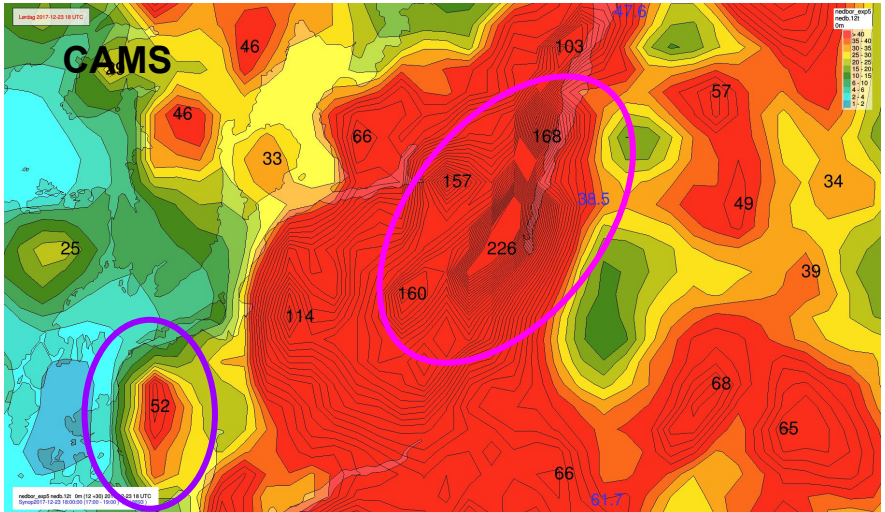


Observations in blue

Case 2017-12-23







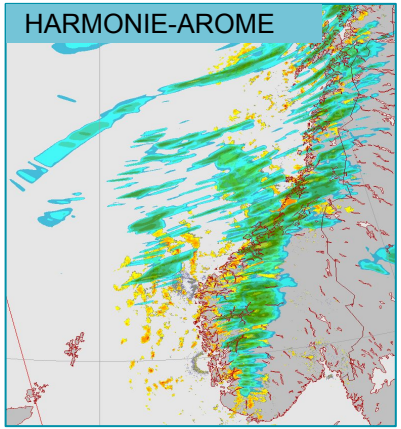
Reduction in local maxima (black numbers) by ~100 mm. Shifting some precip closer to the coast.

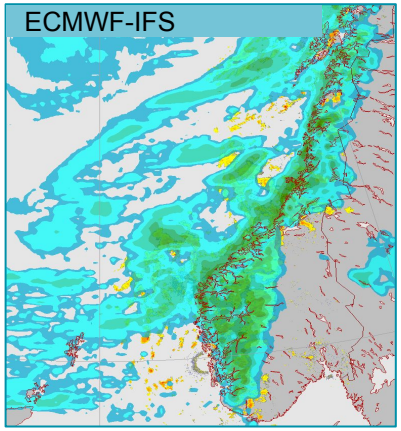
Even Exp2 sees improvement, indicating that ocean-land CCN gradient in CTR is important.

Note spatial variability. → Importance of high resolution.

Case 2018-10-22

Another case

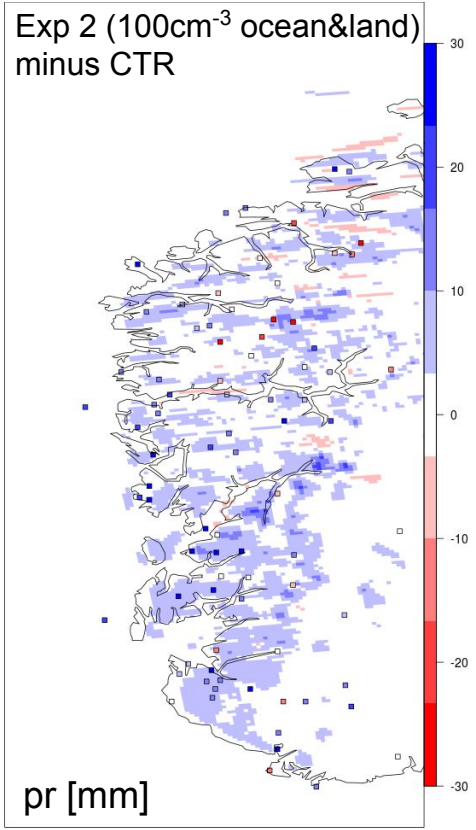


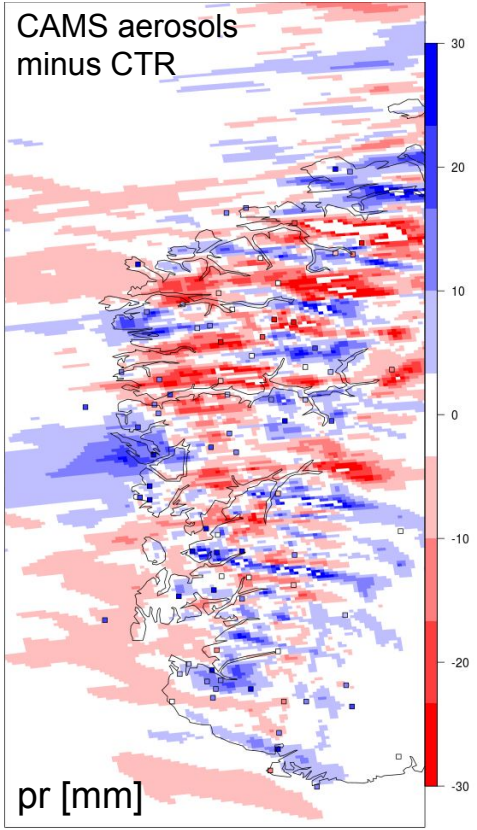


More precip in Exp 2. Largest difference with CAMS, but no systematic pattern.

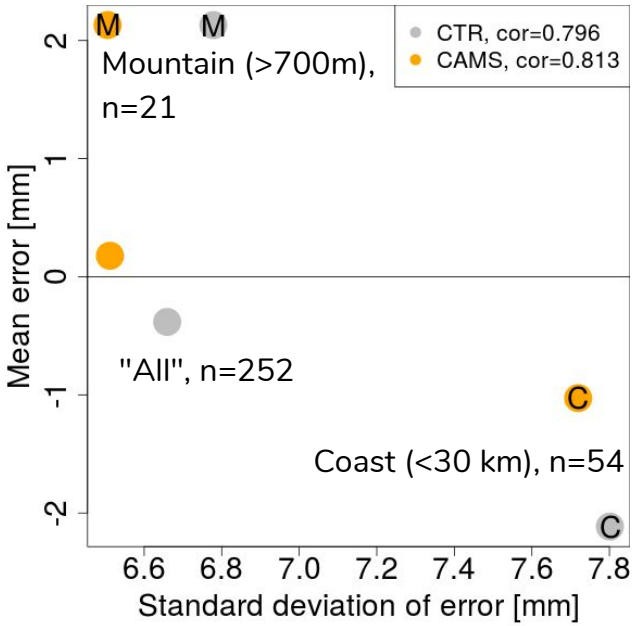
Still, overall correlation improved slightly compared to CTR, but needs longer validation.

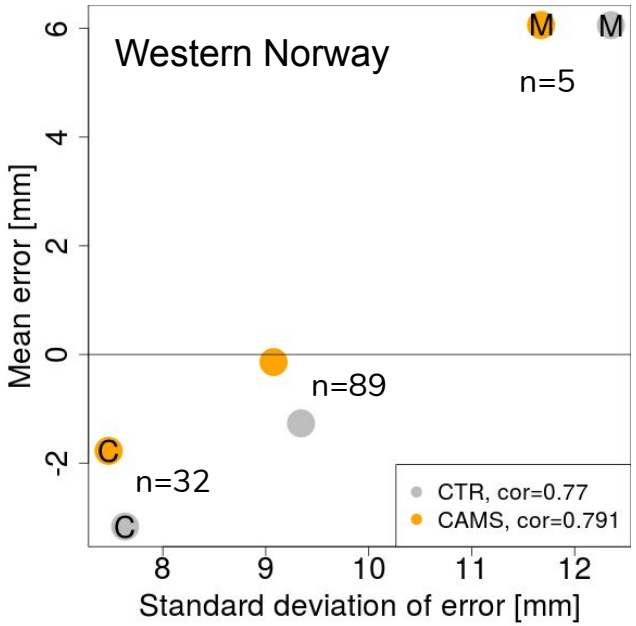
Difference relative to CTR [mm]



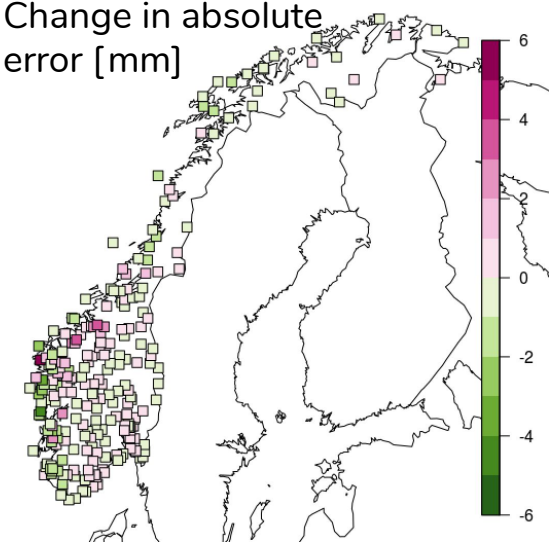


1-month verification (Jan 2020) against stations





Monthly mean:
Change in absolute error [mm]



- Coastal mean error reduction of ~50%!
- Small improvement in correlation 0.796 -> 0.813 (252 stations)
- (Bias in mountains smaller in reality, due to undercatch of snow in obs.)

Summary

- HARMONIE-AROME has a known dry bias on the coast, and wet in the mountains
  - Default use of static aerosol field creates an artificial transition in numbers from sea to land
- Use of prognostic CAMS aerosols impacts precipitation positively
  - More physical spatial distribution
  - Lower droplet number concentration lead to earlier precipitation
- Cases and 1-month results look promising
- Could be part of solution towards lower precip. forecast errors on the coast
  (though maybe shallow convection could matter more for e.g. Northern Norway)

Future work

- Verification of cloud cover, T2m, wind etc.
- Other options: aerosol removal (no significant difference in first tests), ...