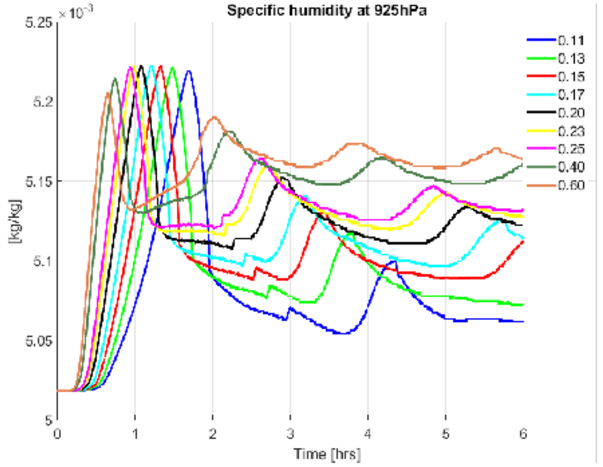
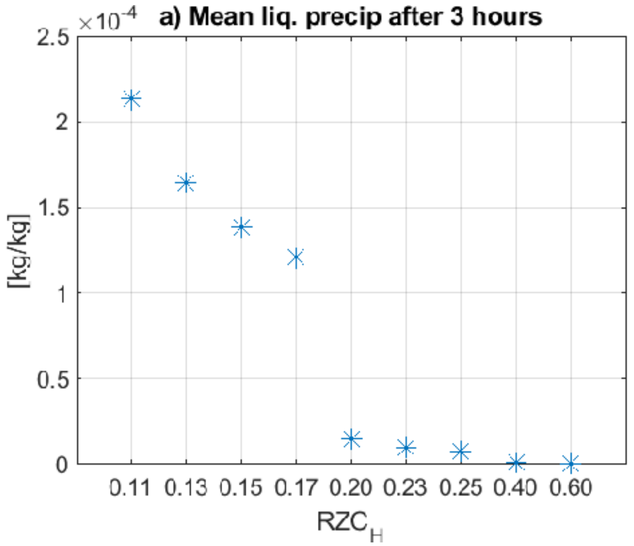
Potential of accumulated AROME-Arctic parameterisation tendency for stochastic parameterisation perturbation patterns

Harald Sodemann[1], Marvin Kähnert[1], Teresa Maaria Valkonen[2], Petter Ekrem[1,2], and Inger-Lise Frogner[2]
Geophysical Institute and Bjerknes Centre for Climate Change, Bergen, Norway; Met Norway

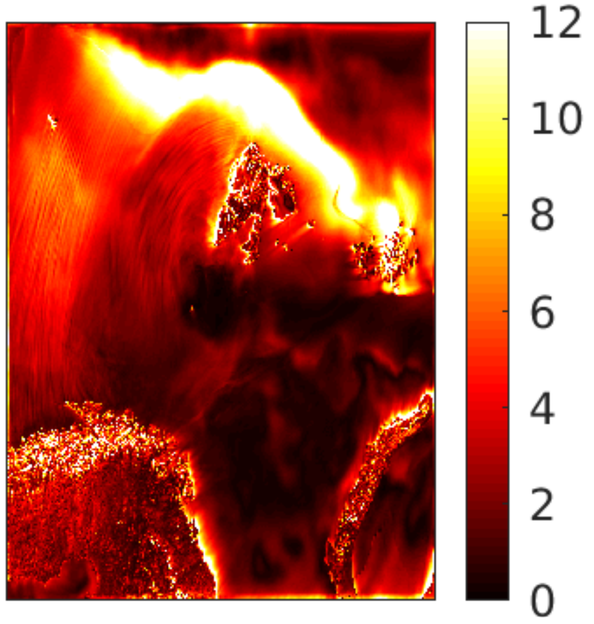
1. Sensitivity studies of microphysics parameters in single-column model MUSC



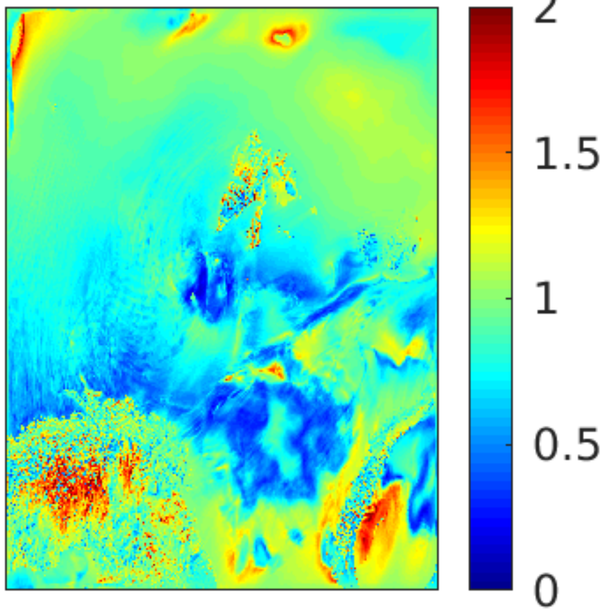


Example: response of specific humidity and liquid precipitation for parameter RZC_H (Stable conditions length scale)

2. Patterns for perturbing statistical parameterisations



Temperature tendency accumulated for 48h at surface level (K)



Ratio of physical over dynamical tendencies (1)

3. The way forward: Exploring different options:

- variable/model level/time interval
- ratio of physical/dynamical tendency
- scaling/normalisation
- local accumulation or advection

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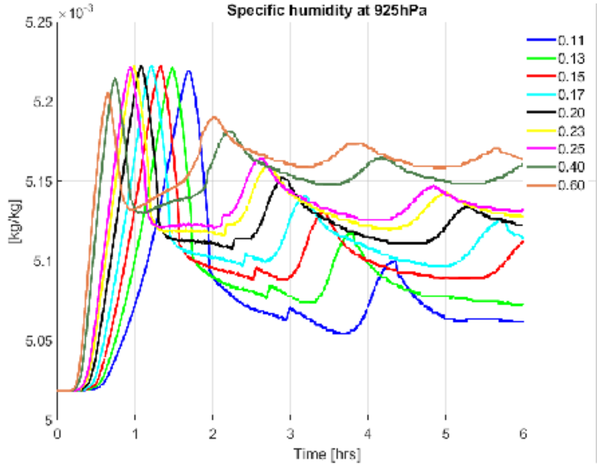

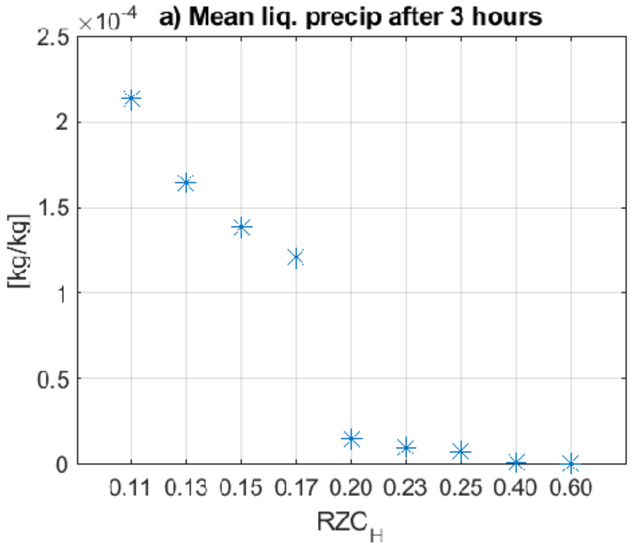

Example: response of specific humidity and liquid precipitation for parameter RZC_H (Stable conditions length scale)

Long-lasting fog episodes are an important case of high-impact weather in the Arctic. Current EPS forecasts show limited variation in cloud cover.

We explore the sensitivity of different parameters within the cloud microphysics scheme of the AROME-Arctic forecast system to provide targeted perturbations of the EPS.

During perturbations, we also use values outside the range considered physically meaningful to obtain clearer indications of the parameter sensitivity.

Many parameters and parameter values are evaluated efficiently using the single-column model MUSC (Cy43).

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1. Sensitivity studies of microphysics parameters in single-column model MUSC

Table 1: Parameters that have been perturbed, with default value, accepted range, and tested range.

Parameter	Default	Range	Tested	Description
VSIGQSAT	0.02	0-0.06	0.01-0.18	Saturation limit sensitivity
RADGR	0.5	0-1	0.1-3.0	Graupel impact on radiation
RZC_H	0.11	0.1-0.25	0.11-0.6	Stable conditions length scale
RZL_INF			20-500	Asymptotic free atmospheric length scale
RFRMIN(21)	1	0-2		Cloud ice content impact on cloud thickness
RFRMIN(10)			1-100	Kogan autoconversion speed
RFRMIN(11)			0.01-2	Kogan subgrid scale(cloud fraction) sensitivity
XCCR	8e6		8e5-8e9	rain intercept parameter, shifts the distribution from larger to smaller raindrops

The single-column approach with MUSC (here using Cy43) allows to quickly scan a wide range of parameter values.

Several parameters have been implemented such that they can be accessed from namelist input.

Impacts can be distinguished into more gradual changes, and non-linear changes, the latter in particular related to precipitation formation.

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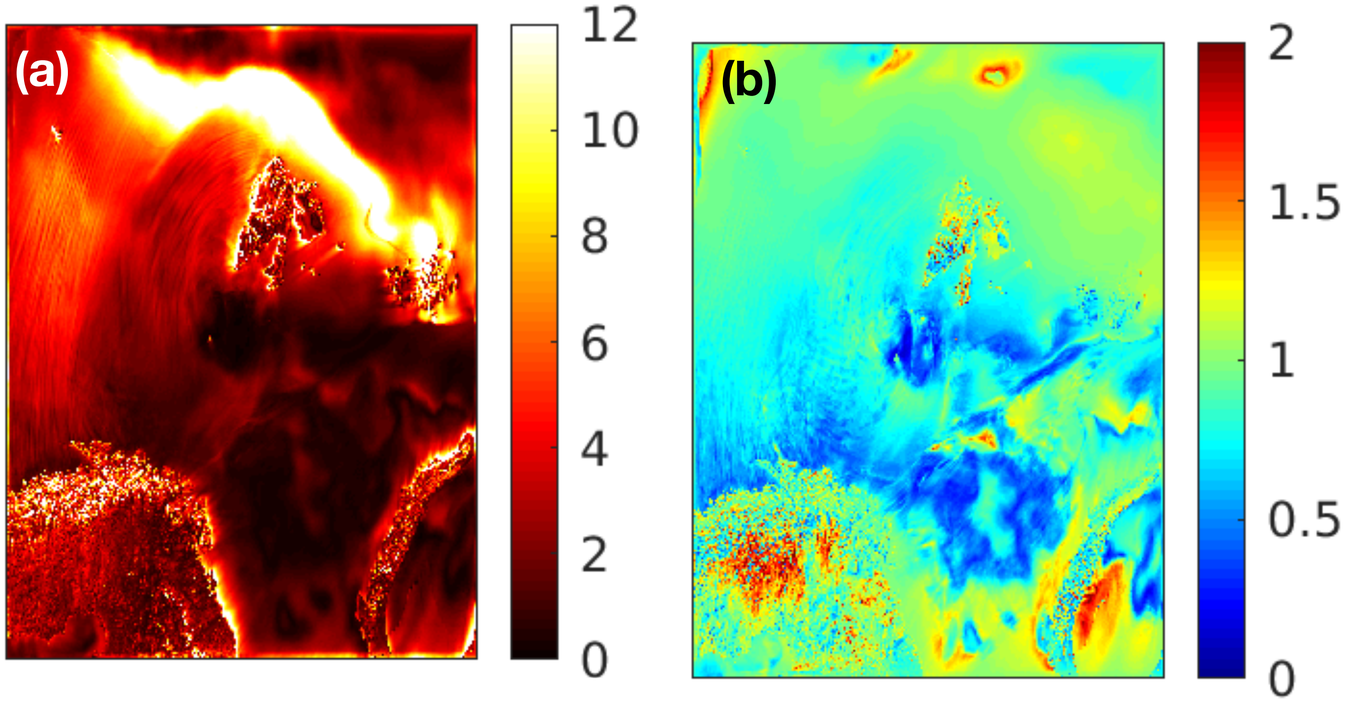

Temperature tendency accumulated for 48h at surface level (K)

Ratio of physical over dynamical tendencies (1)

Once appropriate target variables have been identified, suitable perturbation patterns need to be chosen.

We hypothesize that parameterisation tendencies provide guidance in where model errors from parameterisation are located, as well giving indications about their magnitude.

Panel a shows the AROME-Arctic model domain whereby the bright area stands out due to strong fluxes near the sea ice edge.

Panel b shows the ratio between tendencies from parameterisations and from dynamics (calculated as residual). Several areas stand out as dominated by physics parameterisations (yellow and red shading).

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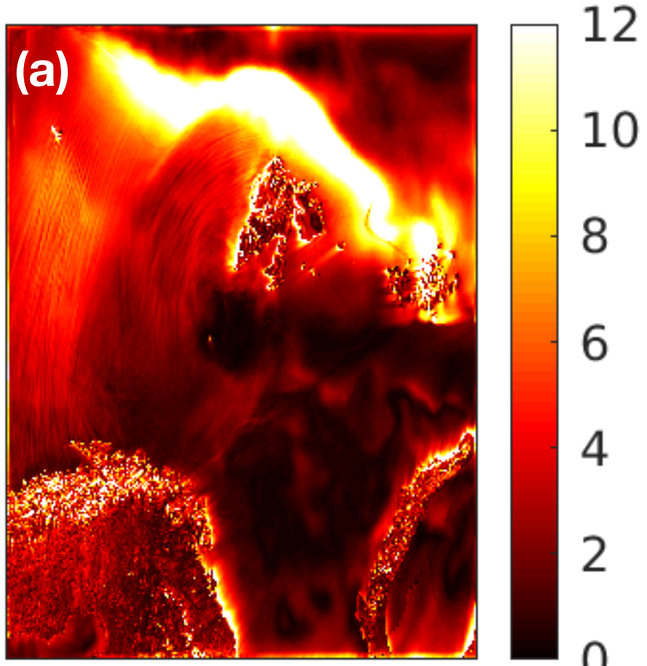
3. The way forward: exploring different options



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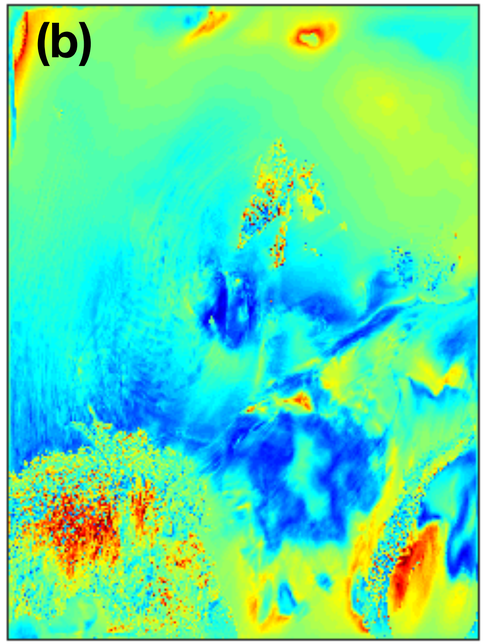

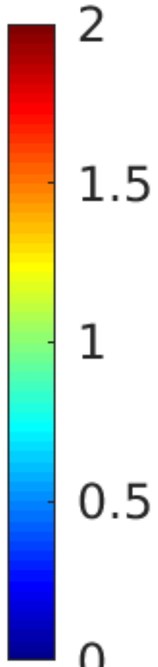

Ratio of physical over dynamical tendencies (1)

We continue to explore some of the many different options that are available to perturb the cloud microphysics parameterisations.

Options include the choice of
- variable (T, u, v, w, q),
- model level,
- averaging time interval,
- ratio of physical/dynamical tendency,
- scaling/normalisation,
- local accumulation or advection.

We particularly welcome your comments and feedback regarding the sensitivity tests, perturbation patterns and the interpretation of accumulated parameterisation tendencies!

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