Diagnosing factors in parameterised and resolved convection: A CAO example with AROME-Arctic tendencies

Marvin Kähnert[1], Harald Sodemann[1], Wim de Rooy[2], Teresa Valkonen[3]

(1) Geophysical Institute, University of Bergen and Bjerknes Centre for Climate Research, Bergen, Norway
(2) Royal Netherlands Meteorological Institute (KNMI), Utrecht, Netherlands
(3) Norwegian Meteorological Institute, Oslo, Norway

Lead questions:

- **What** determines the activity of physical parameterisation schemes during a CAO in AROME-Arctic?
- **How** does the sub grid scale react to a change in parameterisation schemes?
- **What** is the impact of resolved and parameterised convection during the event?

YOPP YEAR OF POLAR PREDICTION

Contact: marvin.kahnert@uib.no

Alertness

BJERKNES CENTRE for Climate Research

Method:

new implemented **physical tendency output** in AROME-Arctic
Variables: temperature, all cloud condensates, u-/v-wind

$$\frac{\partial X}{\partial t} = D + K + \sum_{i=1}^{6} P_i$$

$\frac{\partial X}{\partial t}$: Total tendency

D : Dynamics

K: h. diffusion

P_i: ith Physics scheme

Examination of tendencies for a major CAO event [1]

Sensitivity experiments:

cy40_ref: the control, using the operational physics setting

cy40_nosh: running without shallow convection

cy40_KNMI: running with *enhanced* shallow convection* [2]

***Also Incorporates: new statistical cloud scheme, better ventilation into cloud layer by turbulence scheme**

[1] **Papritz, L.** and **Sodemann, H.**, 2018: Characterising the local and intense water cycle during a cold air outbreak in the Nordic Seas, Mon. Wea. Rev. 146: 3567-3588, doi: 10.1175/MWR-D-18-0172.1.

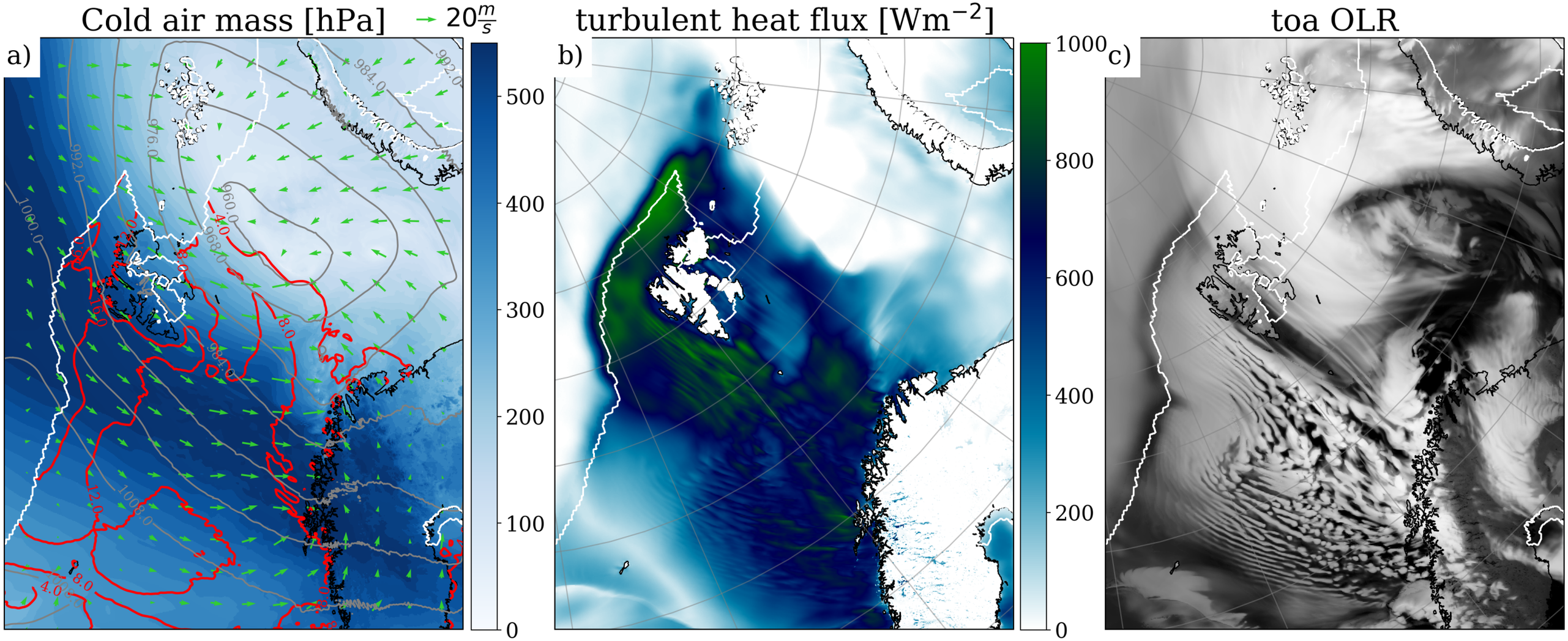
[2] **de Rooy, W.** et al., in prep.: Improved parametrization of the boundary layer in Harmonie-Arome

Model domain and case study, CAO in 2015

CAO index ($\theta_{SST} - \theta_{900}$)

P_surf

Model: AROME-Arctic, operational NWP model
resolution: 2.5 km, 65 hybrid-sigma levels

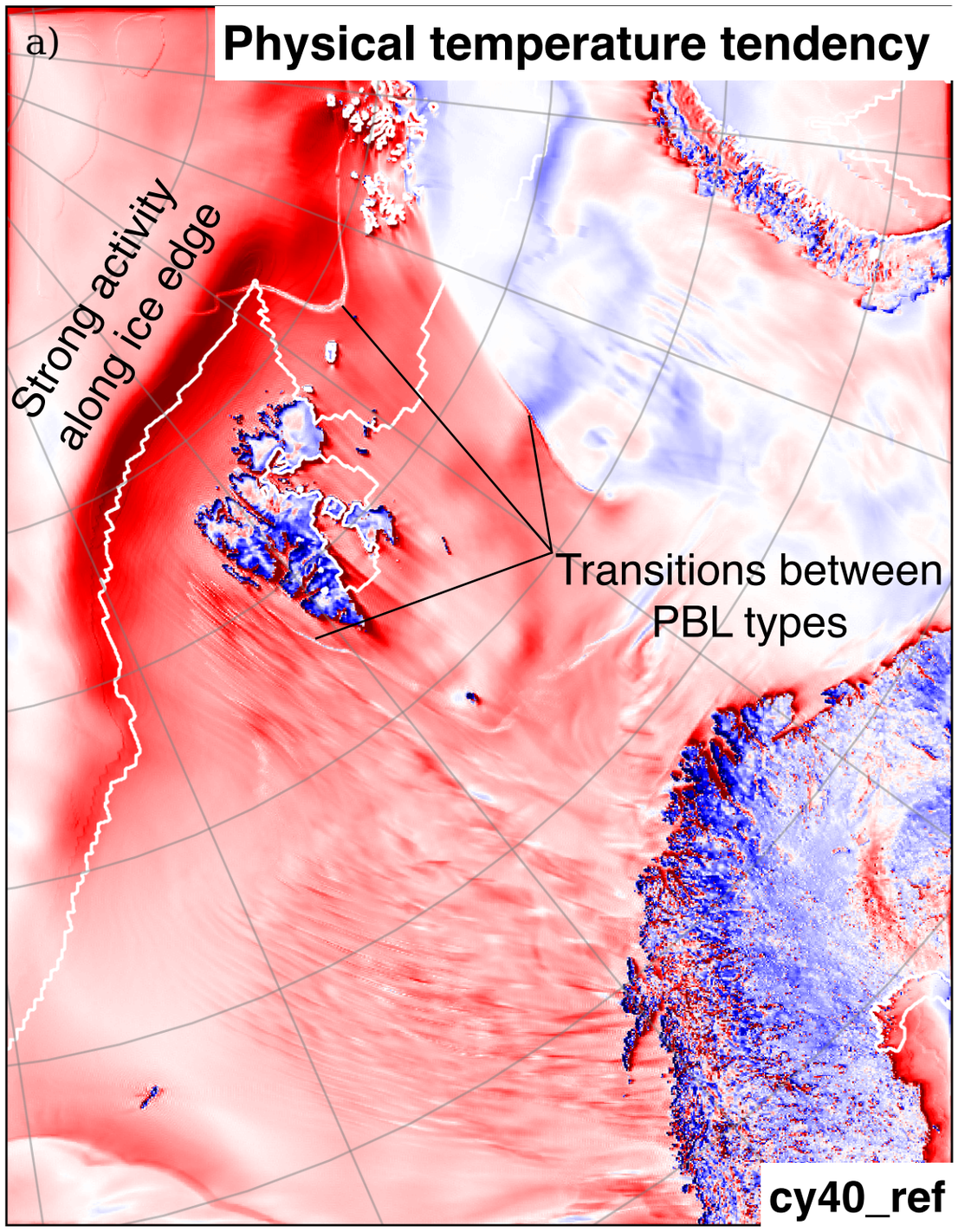


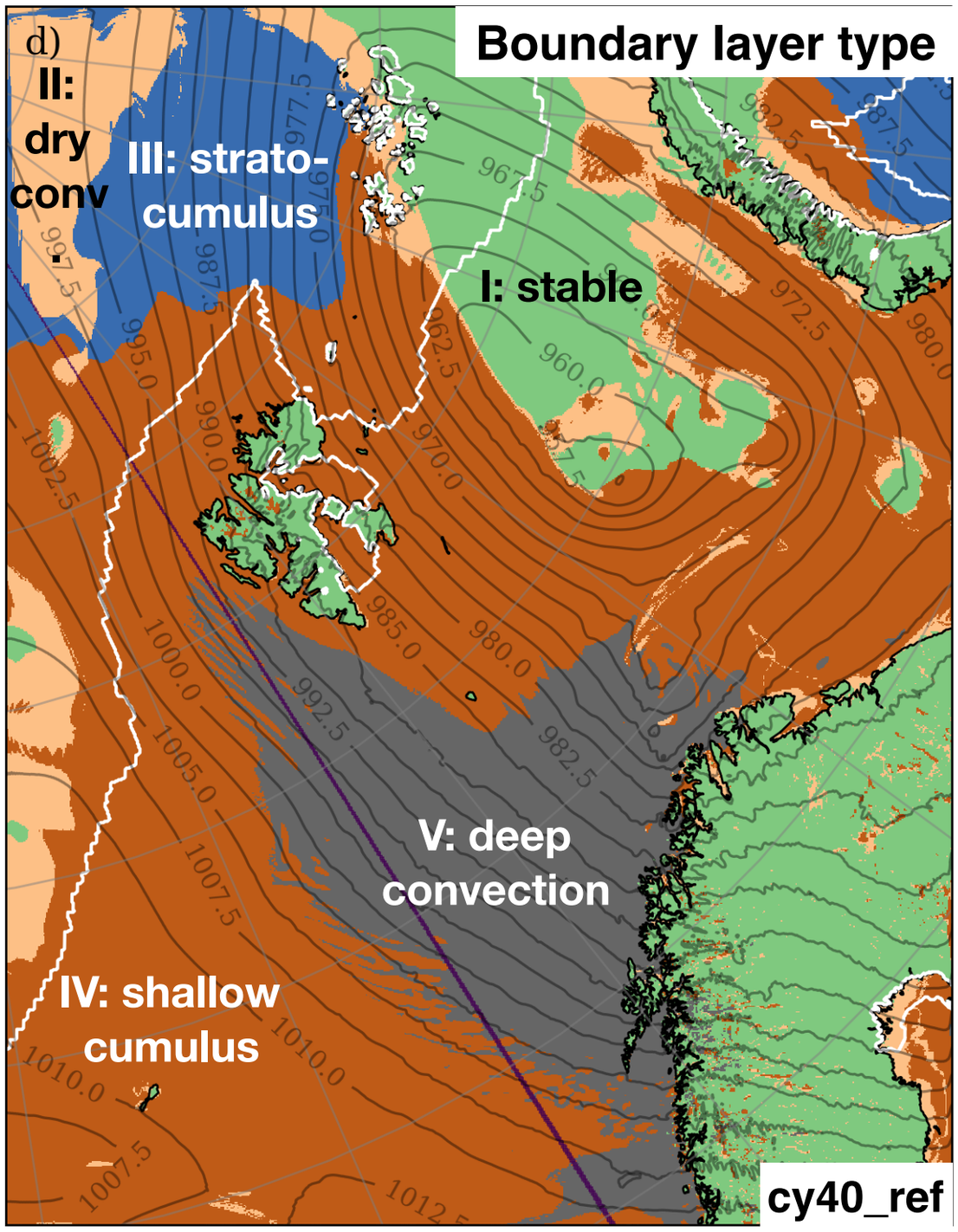
Massive CAO event that affected a large fraction of the nordic seas at once

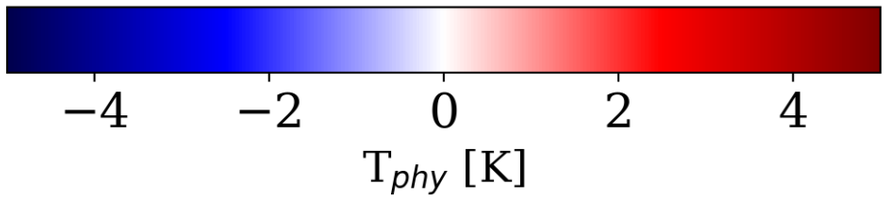
Strong turbulent heat fluxes that propel growth of boundary layer and clouds

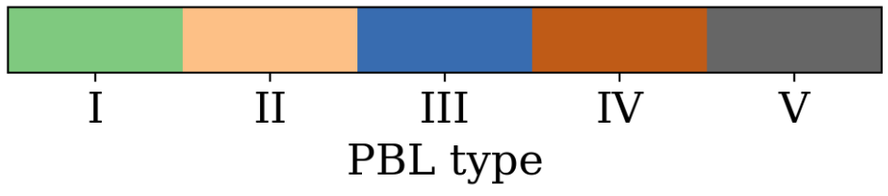
Dense stratocumulus deck breaks up into cellular convection. Cloud streets evident

"Strong heat fluxes and diagnosed PBL type determine the activity of physical schemes (near the surface)!"





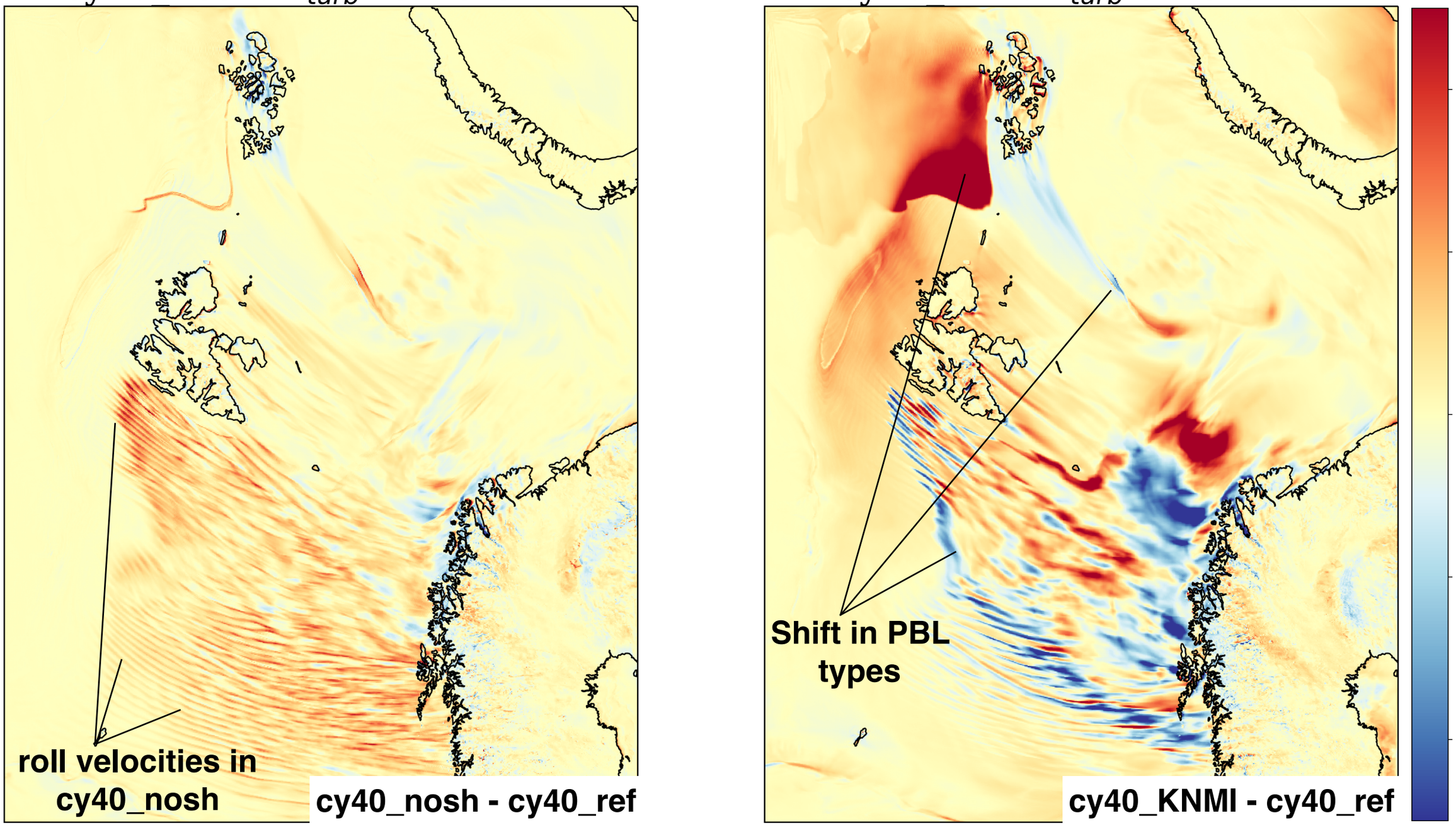




Sensitivity experiments: difference to control run

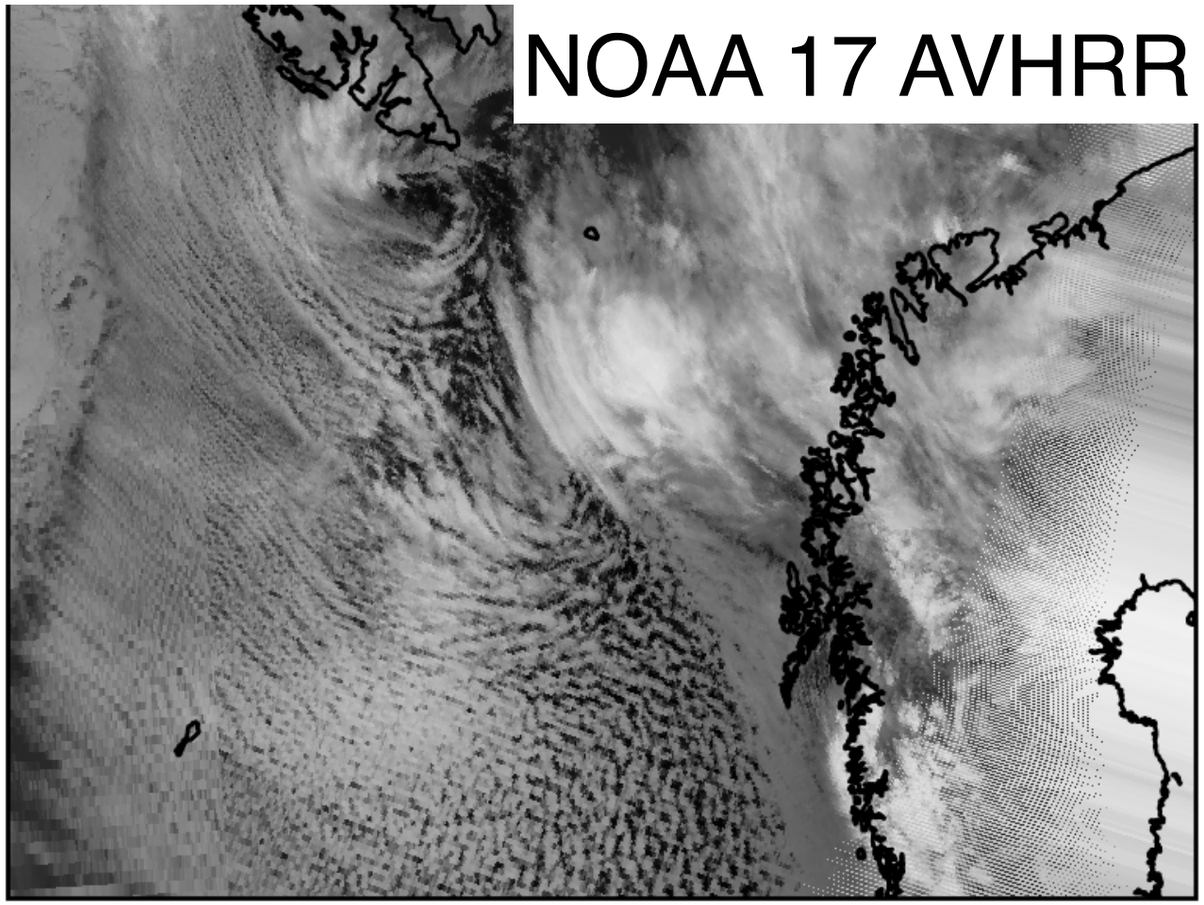
cy40_nosh: T_{turb}* difference

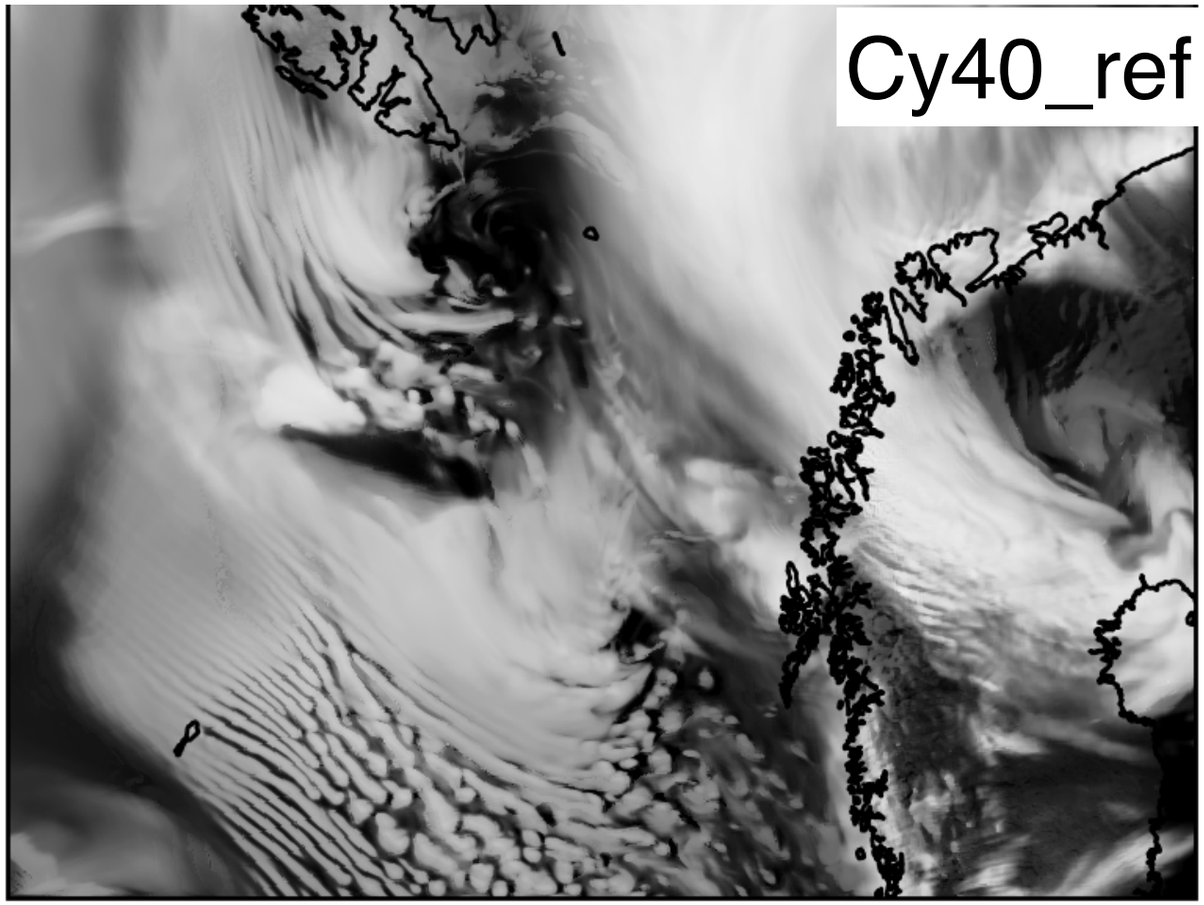
cy40_**KNMI**: T_{turb} difference

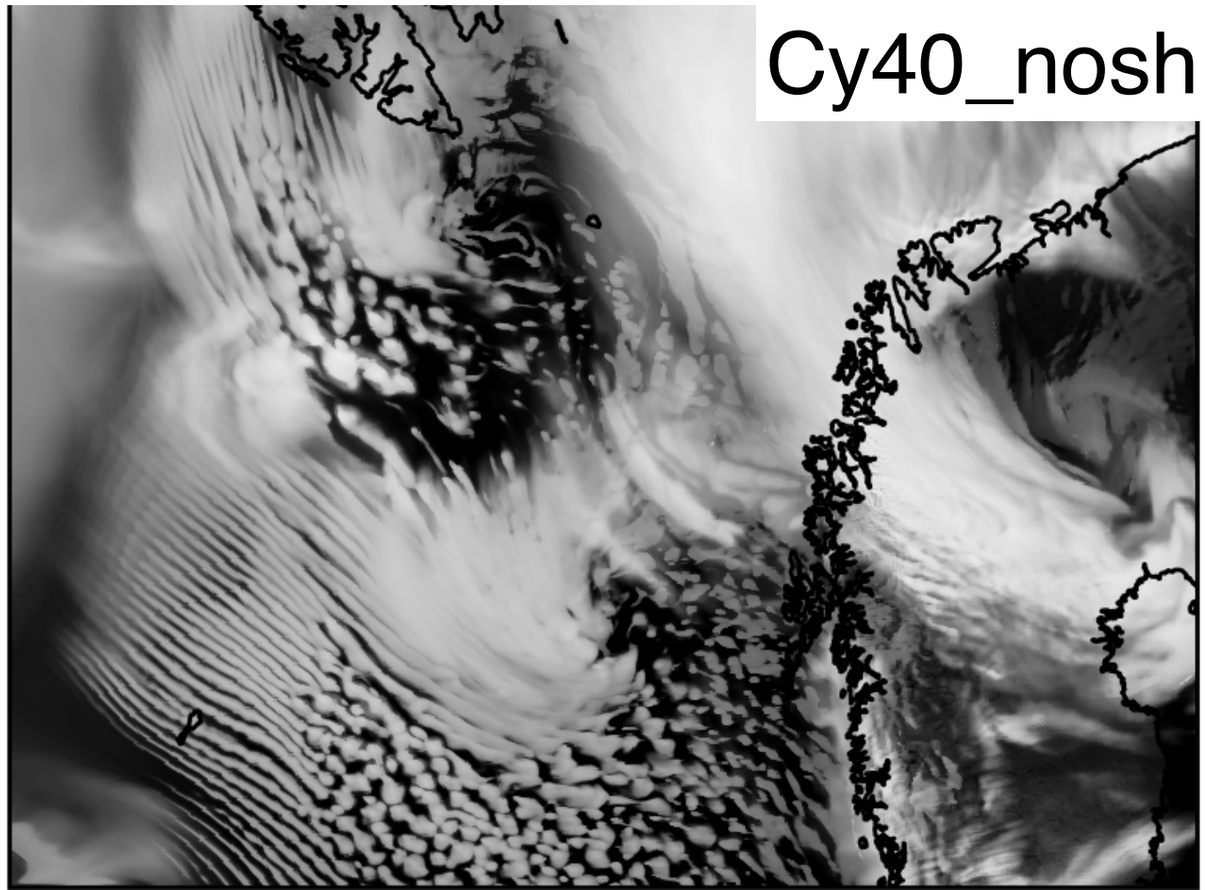


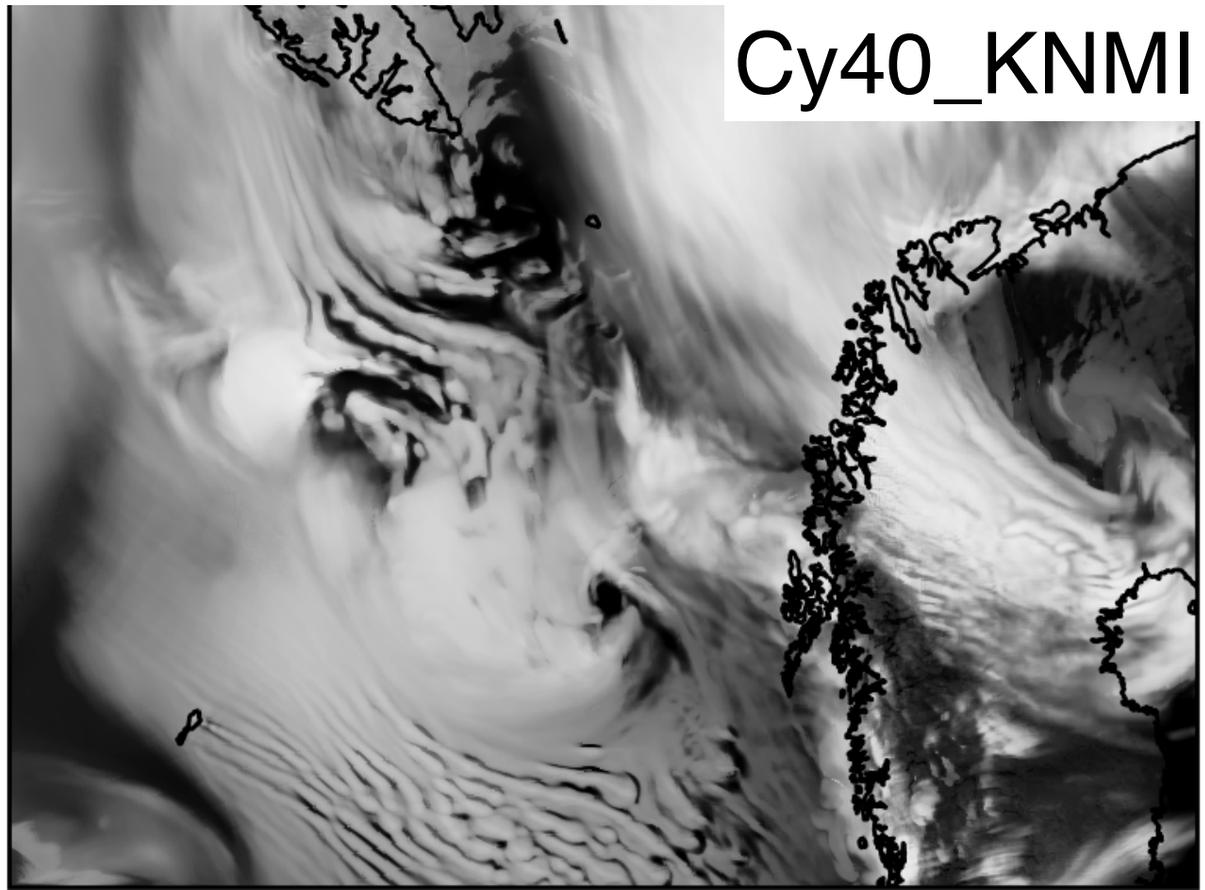
"Tendencies start to show a strongly differing behaviour when changes to the physics impact the dynamics. Here in form of roll velocities (cy40_nosh) or shift in PBL types (cy40_KNMI)."

Contrasting modifications









Conclusions

1. *diagnosed PBL type crucial for the activity of physical schemes*

2. *Strong compensating notion between turbulence and shallow convection*

3. *Tendencies start to show strongly differing behaviour when changes to the physics impact the dynamics Example: roll velocities (cy40_nosh) or shift of boundary layer types (cy40_KNMI)*

4. *Activity of shallow convection scheme has pronounced impact on mesoscale circulations, which can manifest into the presence (cy40_nosh) or absence (cy40_KNMI) of roll velocities in AROME-Arctic.*

Next steps

1. *Optimisation of schemes in cy40_KNMI*

2. *Validation of changes against observations*

3. *Experimenting with removing mass-flux scheme in the deep convective PBL type*