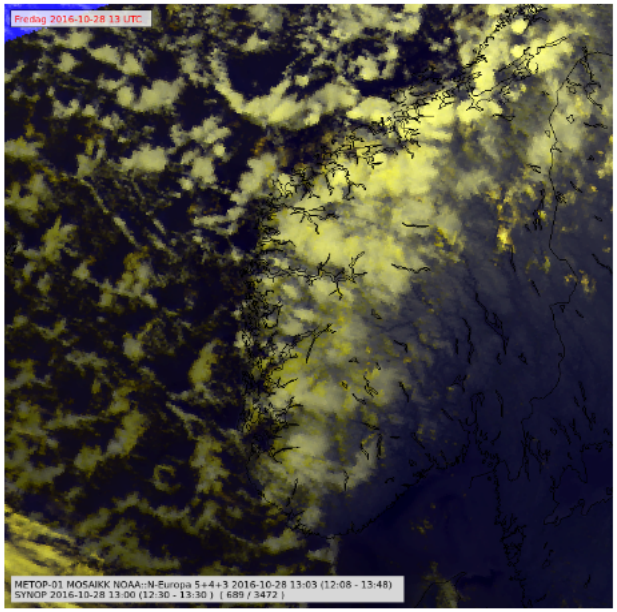
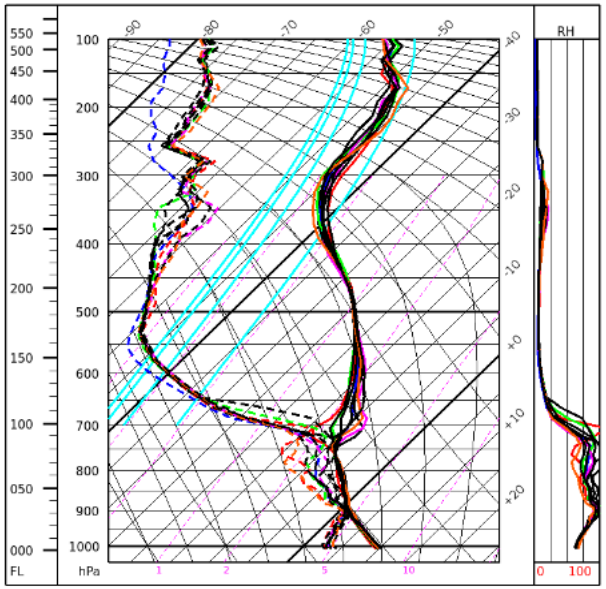
Snow showers and shallow convection

Lisa Bengtsson, SMHI

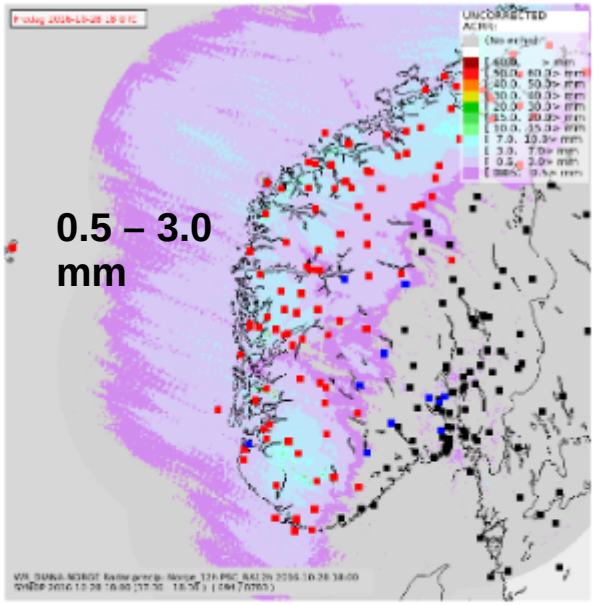
Workshop on clouds in the ALADIN-HIRLAM NWP system, Toulouse 16-18 January, 2017

Snow showers from shallow convective clouds are common over the relatively warm north sea when a cold air advection is from north/north-west.





Oseberg MEPS-profiles 13UTC

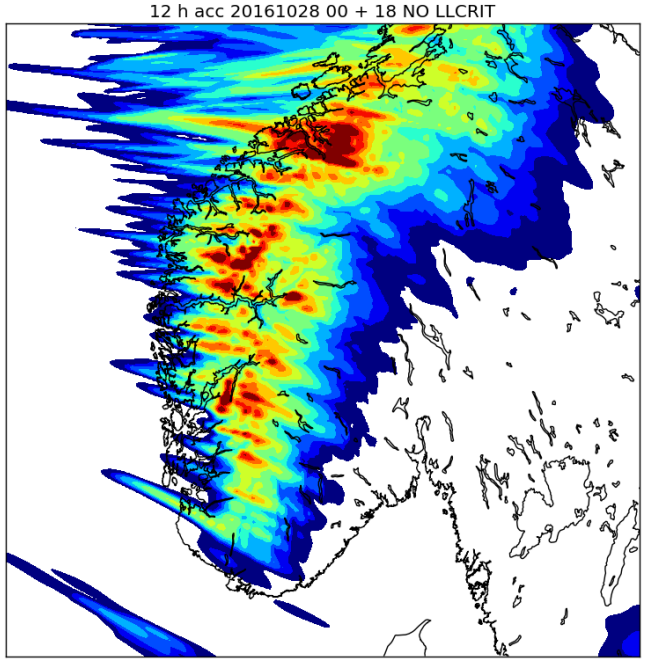


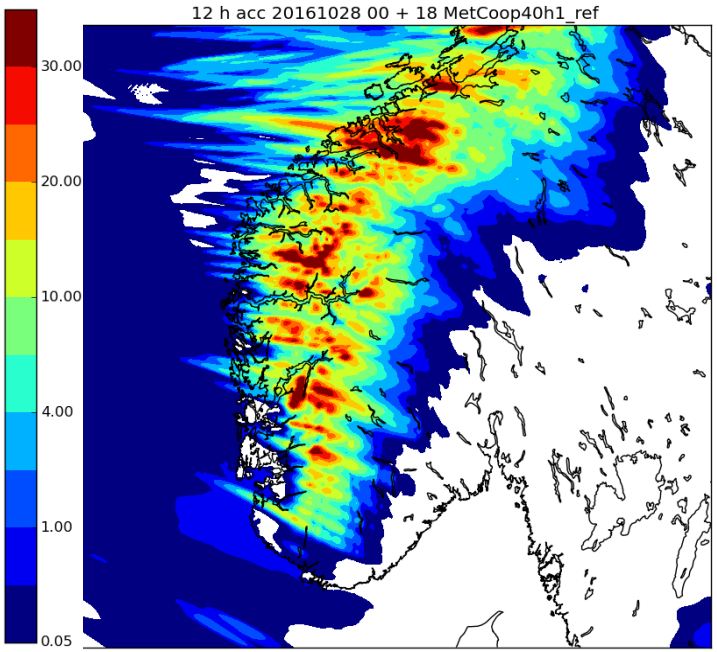
Radar + synop

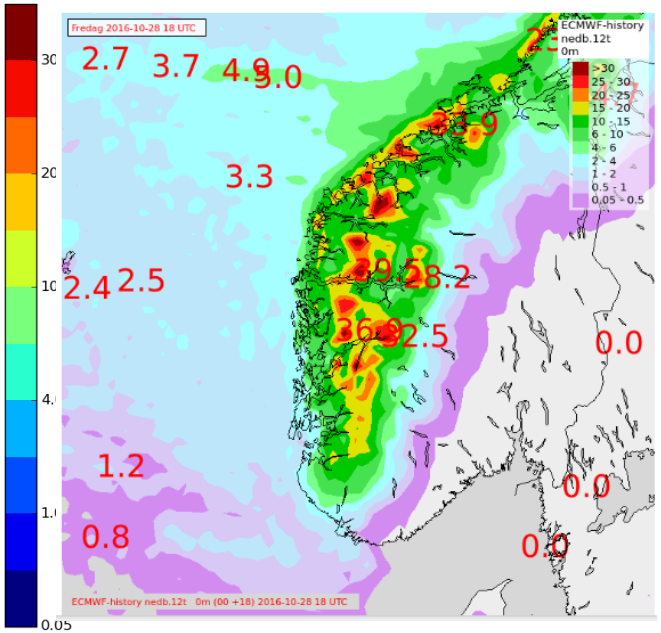
black = 0mm
blue = 0.1 - 0.4mm
red >= 0.5mm

Morten Køltzow, Met-Norway

The model underestimates precipitation from convection over sea in Scandinavian fall/winter/spring.







LLCRIT = FALSE

REFERENCE 40h1.1

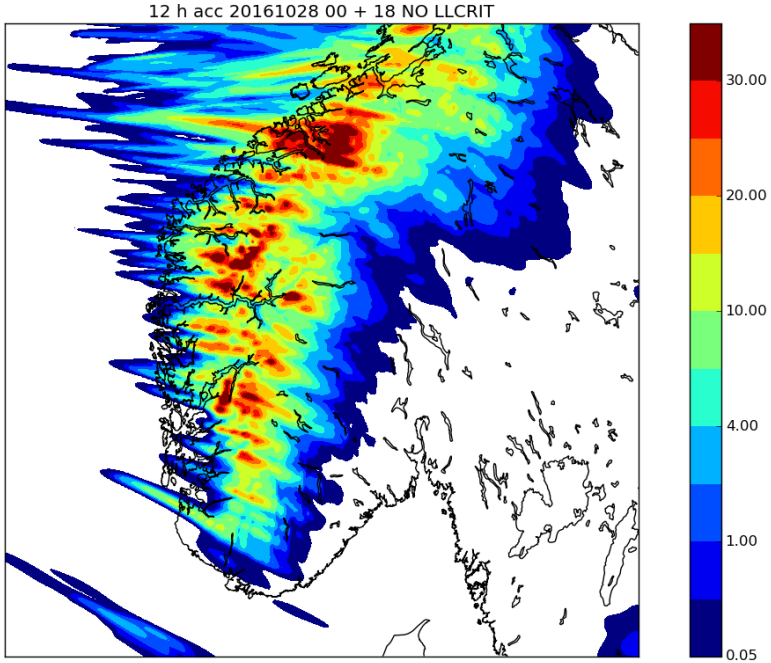
ECMWF ~9 km

In cycle 40h1.1 we introduced a solution which made it easier to generate precipitation if the temperature at LCL was below 0 C. (**LLCRIT**). For lower temperatures the critical threshold for precp. generation is lower as it was reasoned that precipitation production is likely to be favored by active ice-phase processes, so that when cloud-base temperature is close to freezing point, precipitation is possible with relatively shallow convective clouds (Kain and Fritsch, 1990)

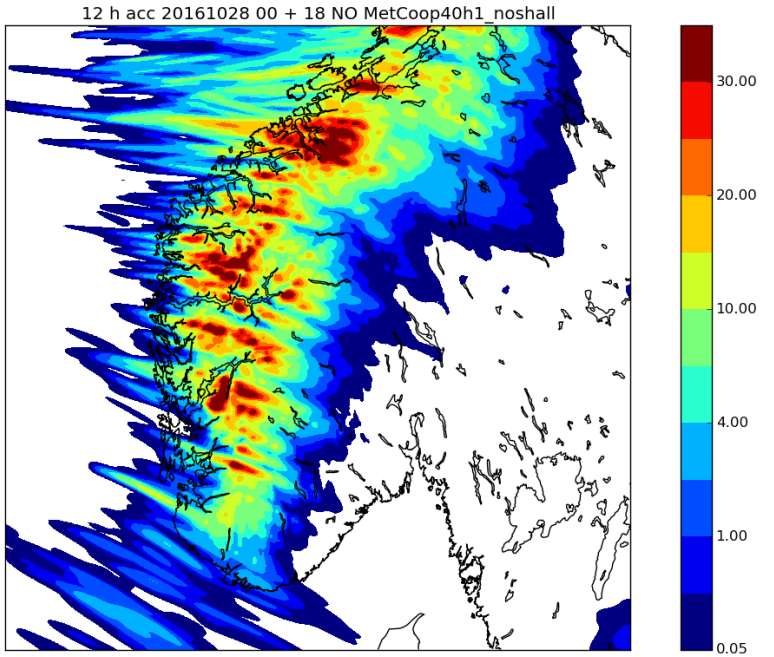
This case, 2016 10 28 is a typical case, and we can demonstrate many others with similar behaviour.

Possible solutions

LLCRIT=FALSE



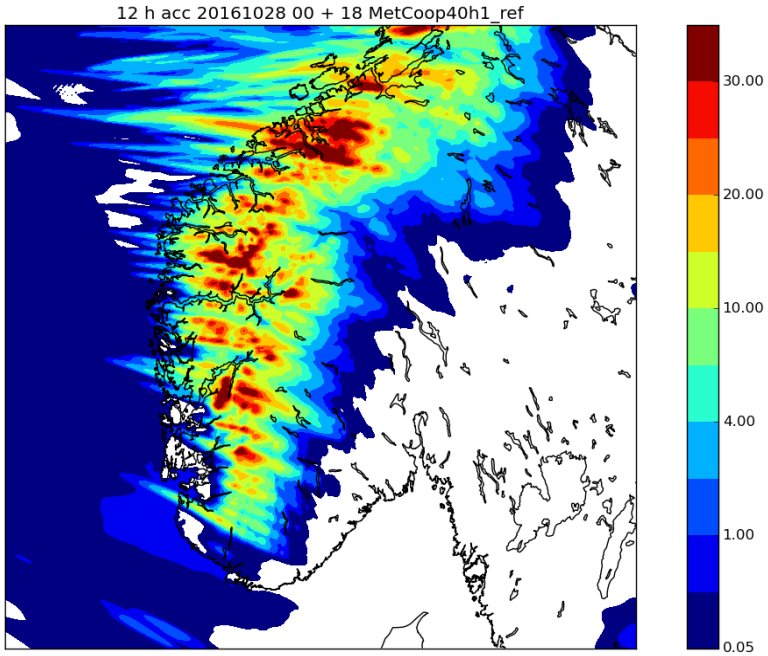
- If we turn off the shallow convection scheme, the model treats the convection explicitly, and the precipitation forecast gets slightly improved along the coast – but not over sea.
- One possibility would be to limit the cloud depth hight used for the decision of deep/shallow convection.
- This could be lower in case of cold temperatures (right now this depth is 4000 m). A similar solution has been done in the Kain-Fritch scheme for the (at the time) ETA model.



Shallow conv off

Possible solutions

- However, we discussed that if the clouds are in fact shallow, we should treat them as such and improve the precipitation generation, instead of treating the clouds as deep convection.
- Currently the surface diagnosed precipitation from the shallow convection scheme is scaled by the constant updraft mesh-fraction at cloud base (0.03). This is quite an arbitrary choice, and we could try to generate more precipitation locally by scaling with for instance the total cloud-fraction.



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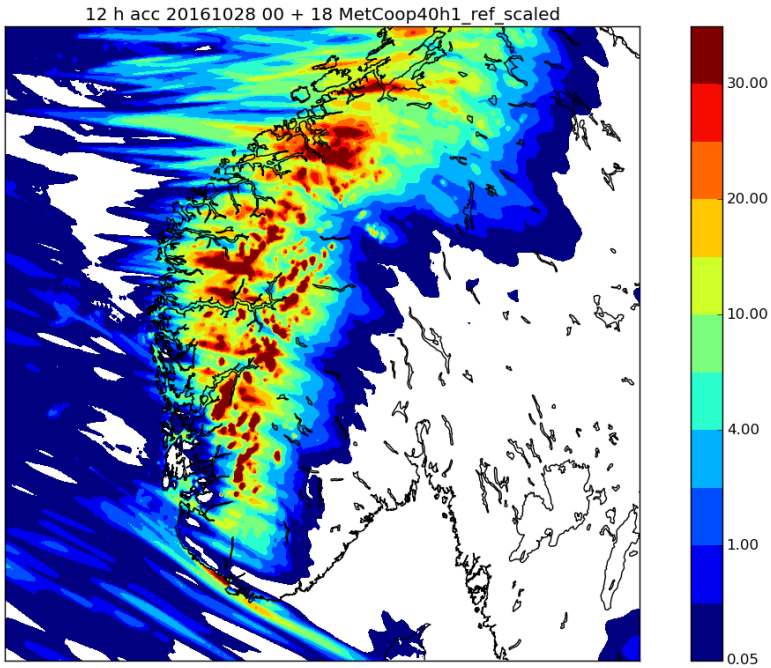
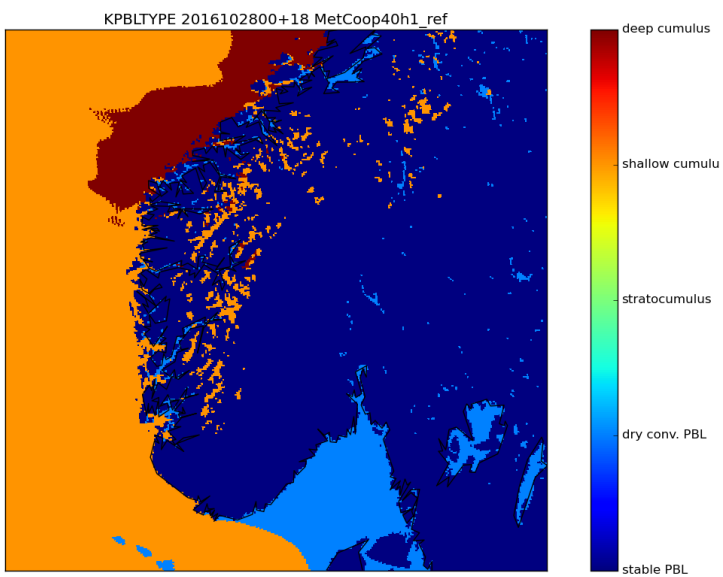


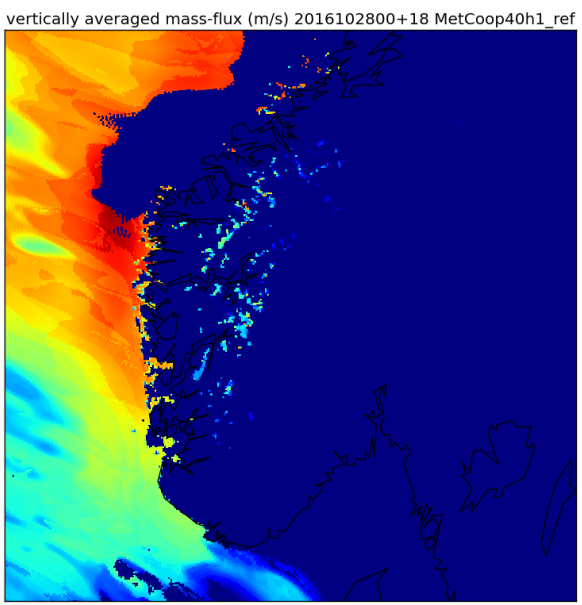
LLCRIT scaled with cloud fraction

Convection parameterization

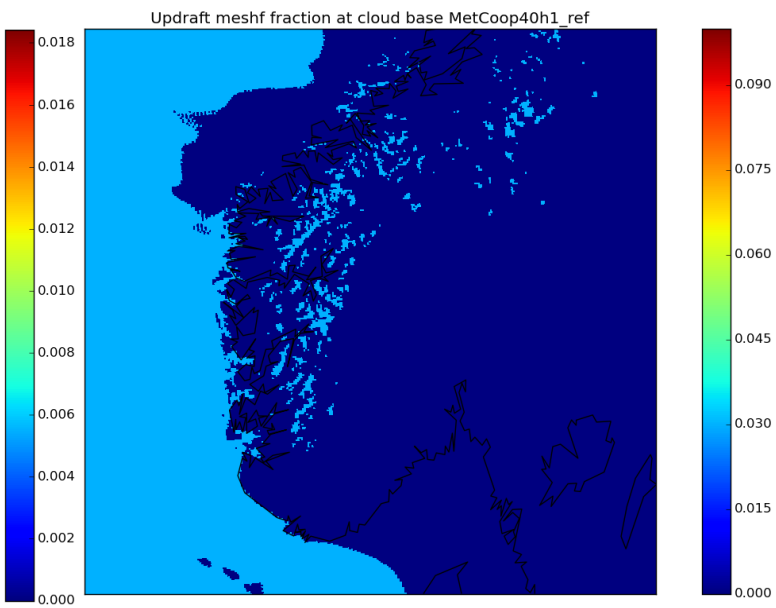
There is a general problem with diagnostic convection in a 1D column, we don't get the desired advection in over the coast. Fields strictly follow the coast line due to the warmer sea surface temperatures.



Type of boundary layer



Vertically averaged mass-flxu (m/s)

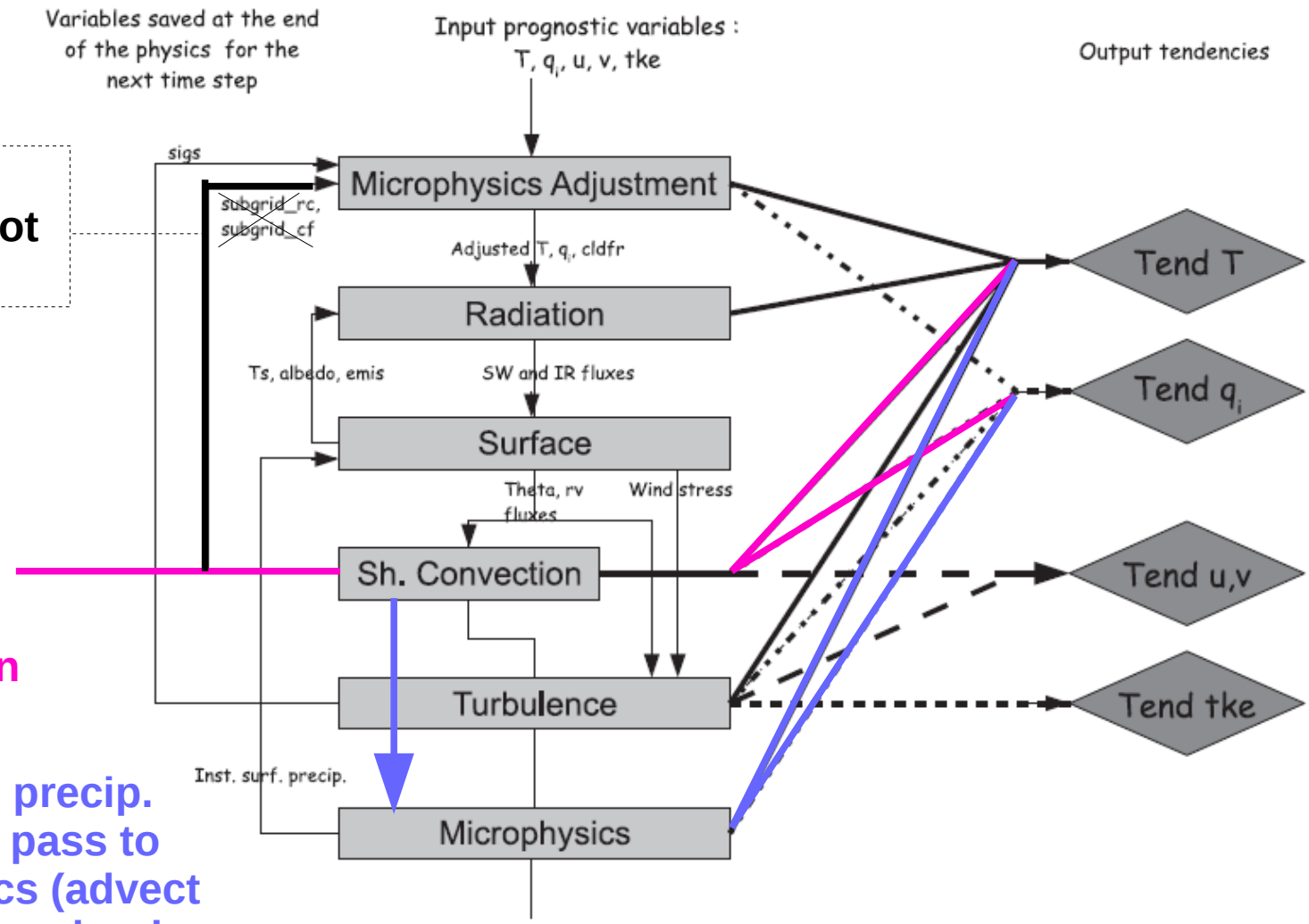


Updraft mesh fraction at cloud base, ZFRACB

Also, the precipitation fields gets very uniform, some small amounts everywhere, which is not very realistic.

Adding precipitation tendencies and pass to microphysics.

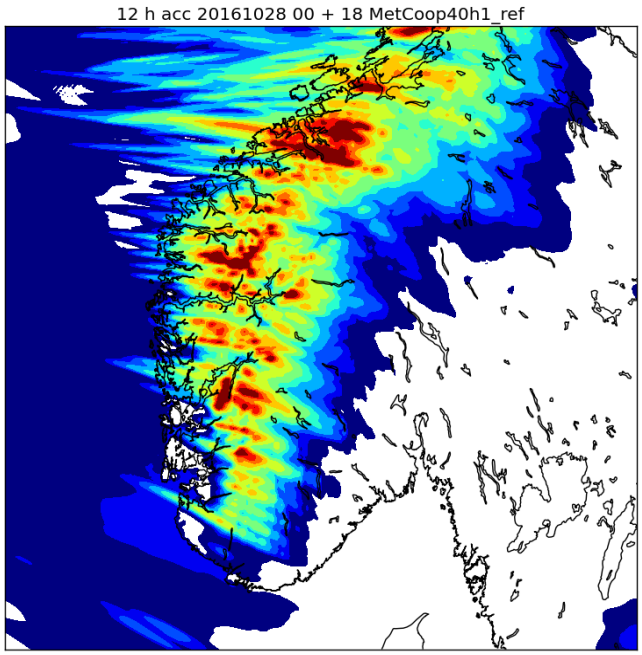
Sigs
subgrid_r_tot



Currently: Diagnostic surf. precipitation

New test: Add to total precip. tendencies, pass to microphysics (advect etc). Scale by cloud-fraction

Adding precipitation tendencies and pass to microphysics. 12 h acc precip.



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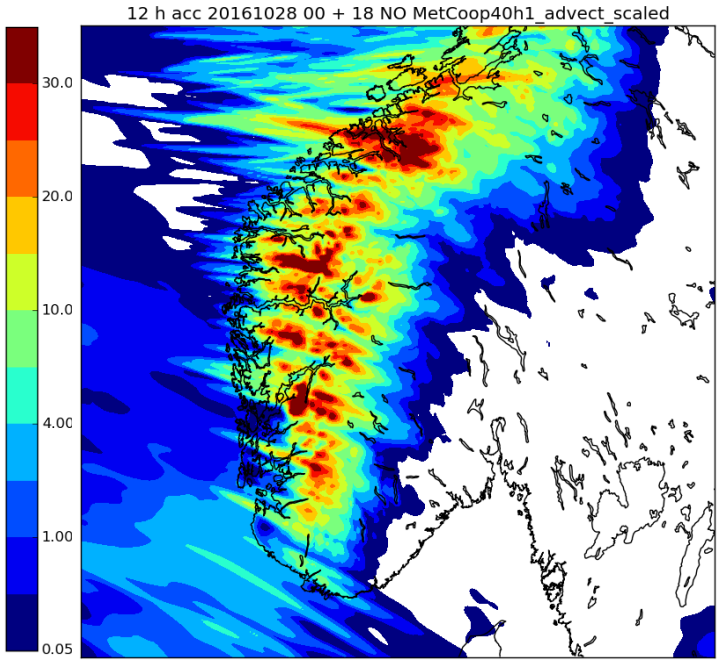
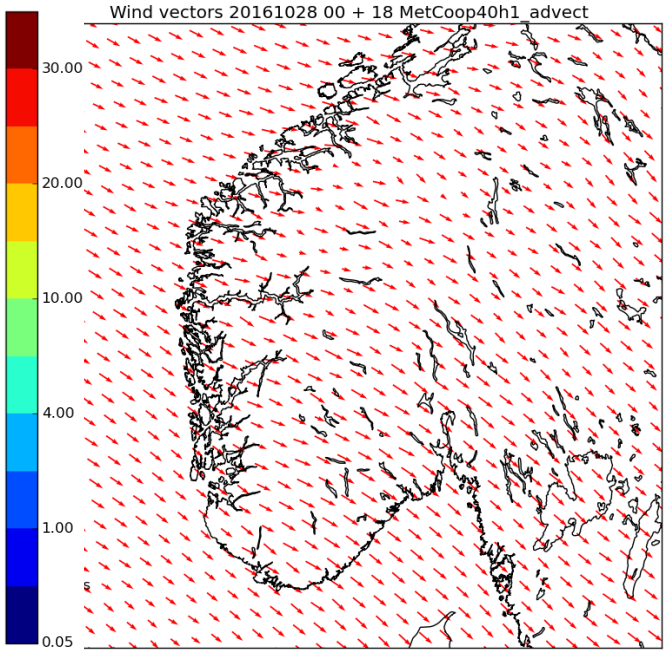


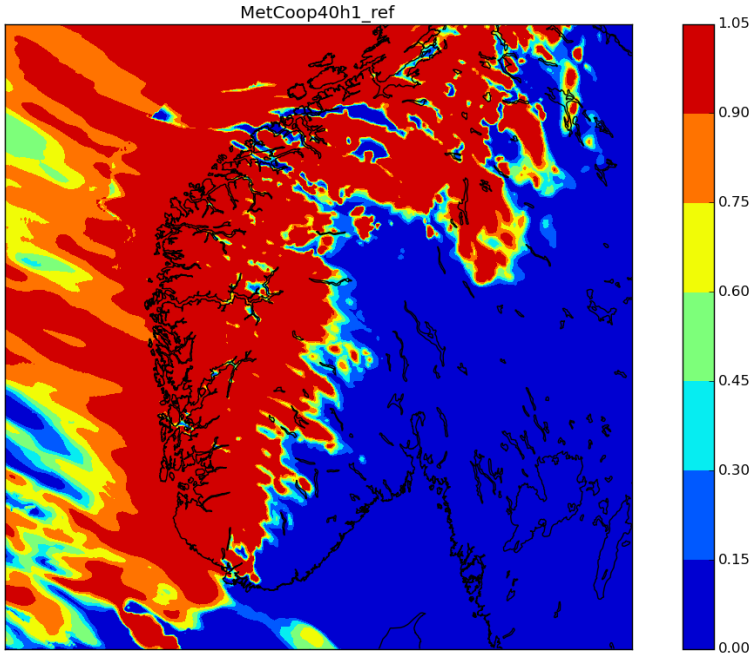
Sub-grid generated precip. passed to micro.



850 hPa wind field

Precipitation fields get better, larger amounts and more precipitation over the coast. Sub-grid precip not so uniform, but larger where cloud fraction is larger.

Adding precipitation tendencies and pass to microphysics. Total cloud cover.



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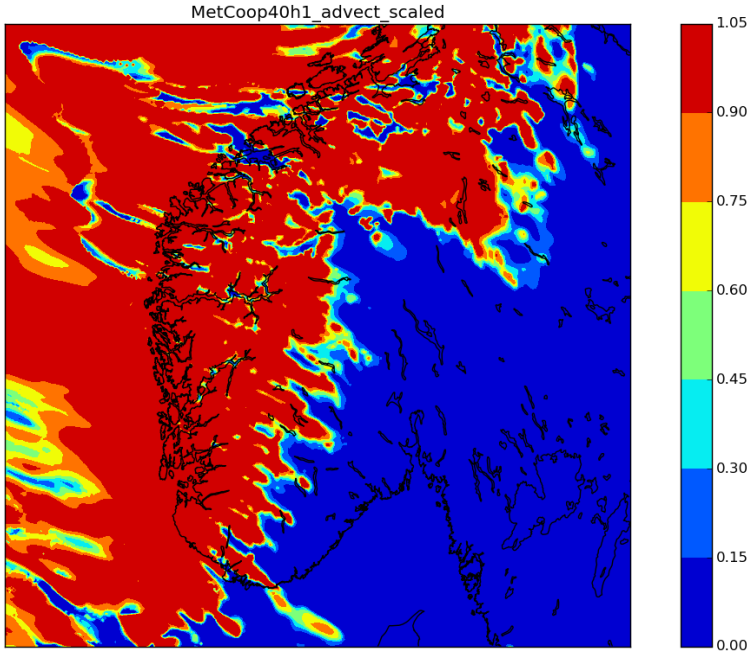


Sub-grid generated precip. passed to micro.

Total cloud cover increases slightly, probably should be more broken up. Could be due to feed-back from the total specific humidity passed in to the adjustment scheme at the next time-step. Need to do some longer evaluation.

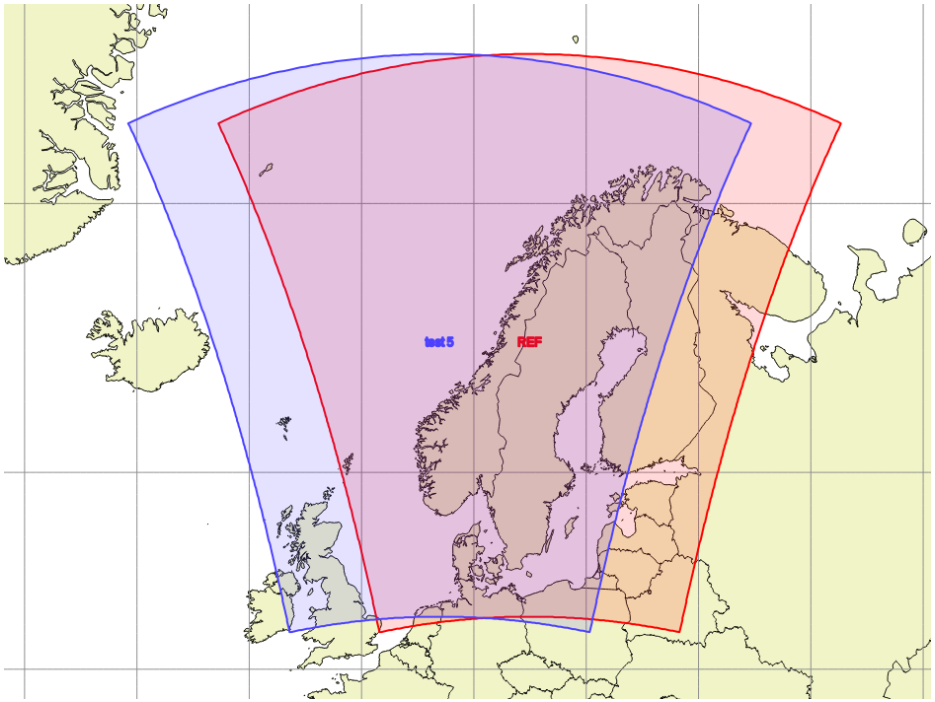
Other relevant tests

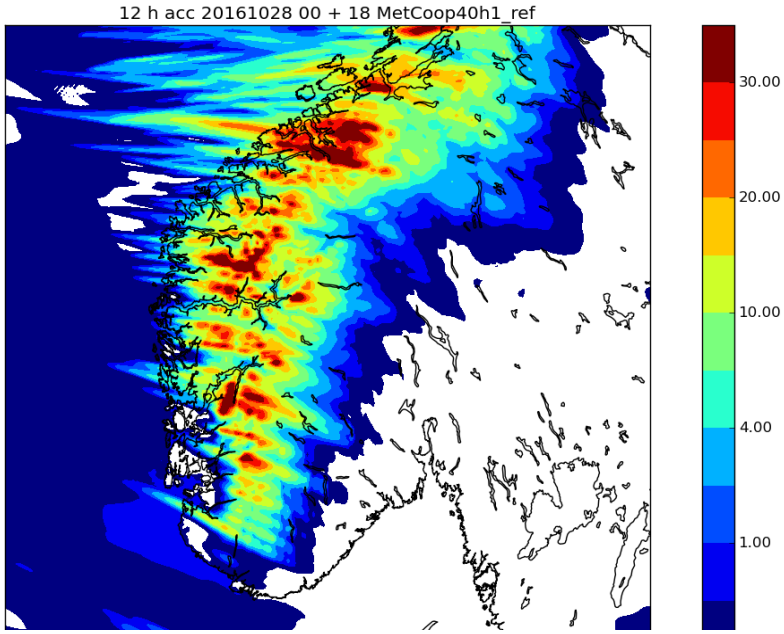
- If we turn off the precipitation generation from the shallow convection scheme, can precipitation be generated by the microphysics scheme? (e.g LPREC = FALSE). **(Removes all precipitation – does not work for this case)**
- In HARMONIE-AROME it was found that we smooth orography twice, once in SURFEX and once in the dynamics. If we switch off the smoothing of orography in SURFEX does it generate more precip along the coast? **(Very small impact, should be investigated further for other fields)**
- Test with moving the domain westward, Norway too close to the boundary? **(This results in more precipitation and a better forecast – see next slide)**
- Coupling also rain, snow, cloud water and ice crystals at the lateral boundaries (instead of setting them to 0 which is currently done)?

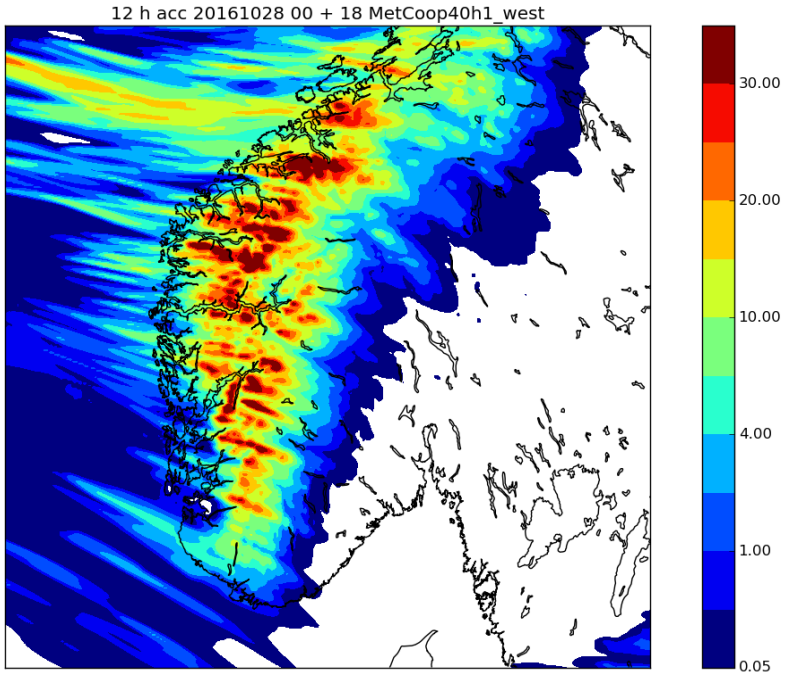
  (Small impact, in some areas precipitation was reduced)

Moving the domain westward

REFERENCE
40h1.1



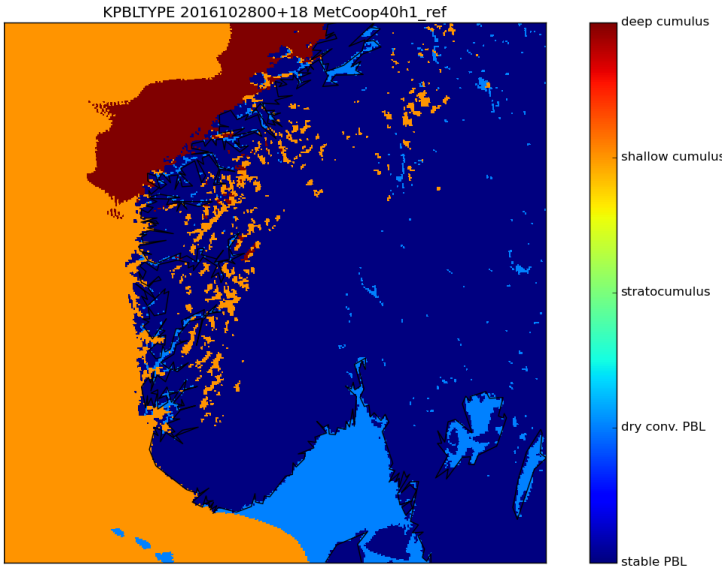


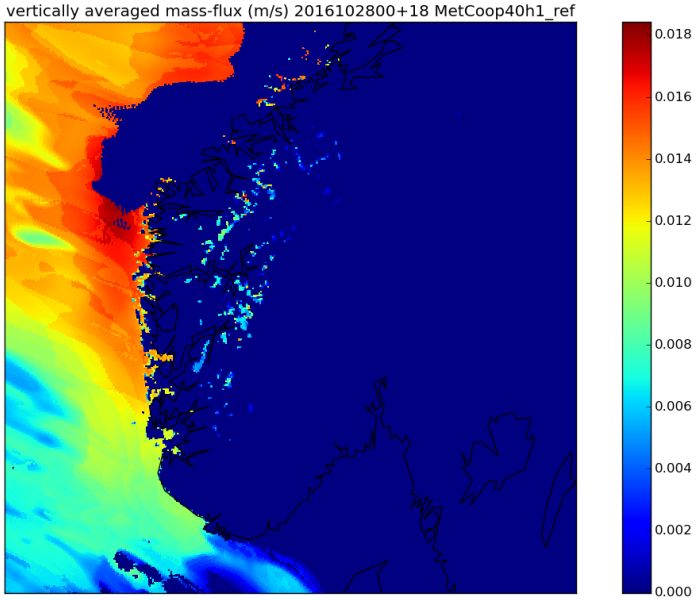


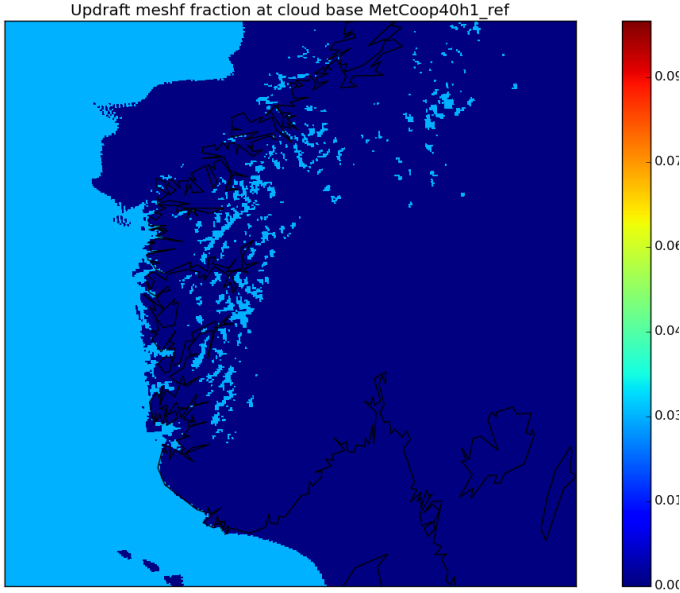
More convection is treated as deep conv.

Moving the domain westward

Back to the problem of diagnosed convection.





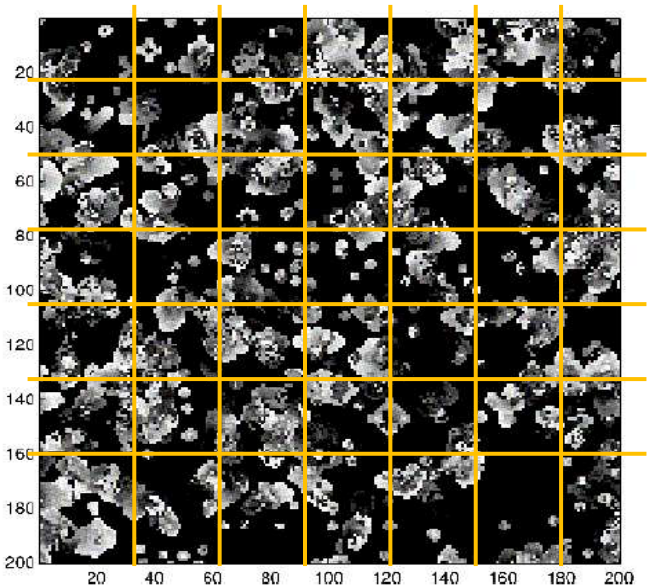


Type of boundary layer

Vertically averaged mass-flxu (m/s)

Updraft mesh fraction at cloud base, ZFRACB

Diagnostic convection and cellular automata.



- Cellular automata (CA) is a mathematical model where cells on a lattice grid given a set of rules, depending on the state of neighbouring cells, can self-organize into clusters.

- We can run a CA model in IFS on finer resolution than the NWP model resolution and couple to ARPEGE/ALADIN/ALARO/AROME/ECMWF physics.

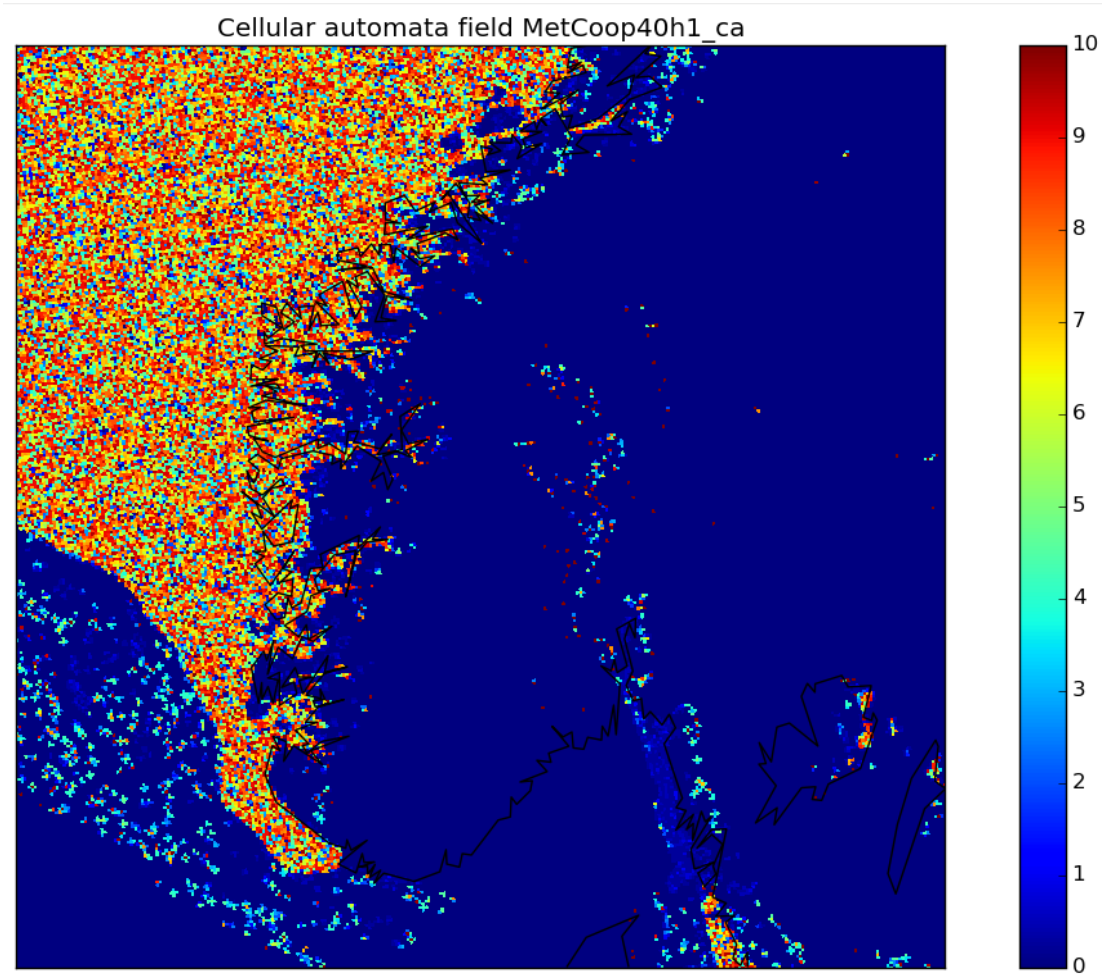
- Example in: Bengtsson et al. 2011, 2013 and 2016 in connection with 3MT in ALARO.

- The self organizational properties of the CA makes it interesting for this type of questions, where we want the convection to organzie and trigger also in over land.

- The CA can be initialized randomly (and fed each time-step with random information) which makes it interesting for Ensemble prediction to account for sub-grid variability.

A first test to couple the scheme with shallow convection in EDMFm

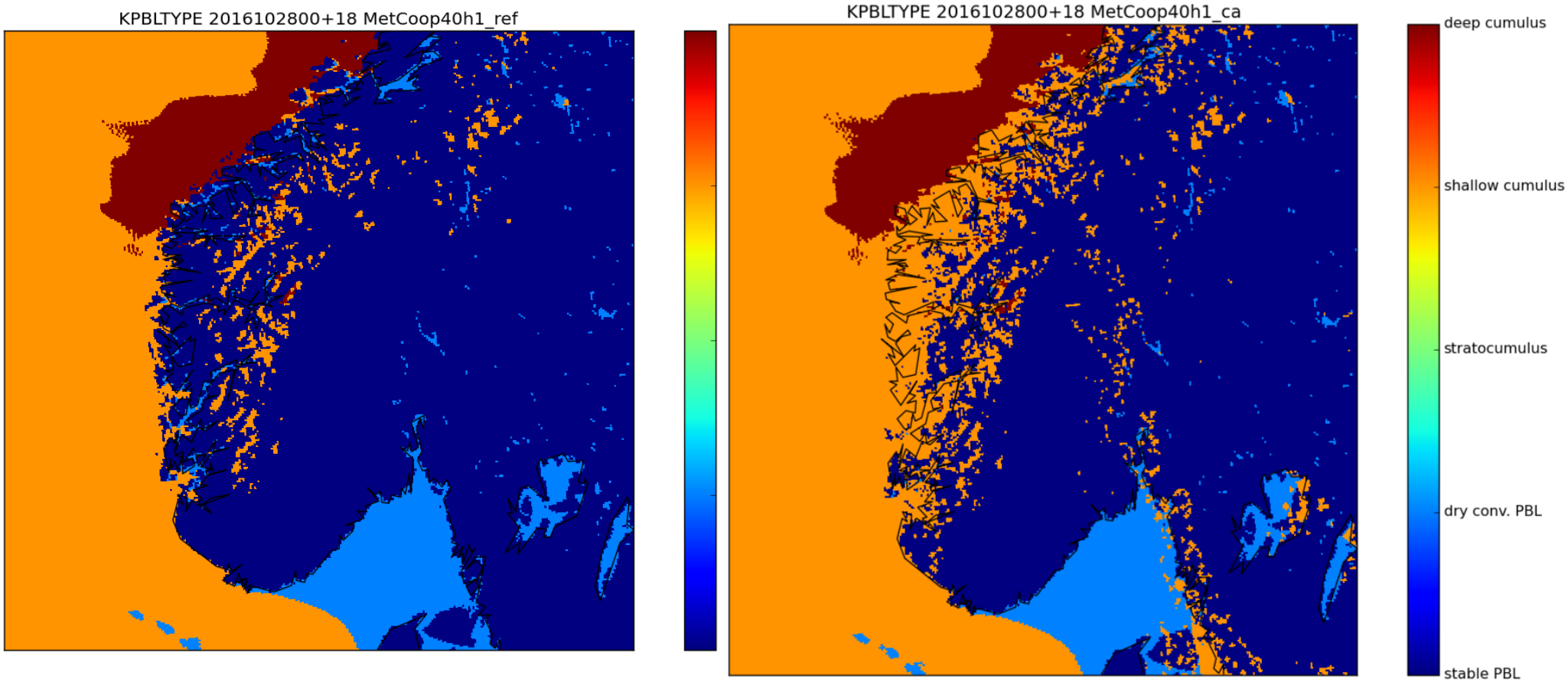
- Initialize CA-cells where CAPE > 100 J/kg (and random number fraction > 0.85) on a grid with 2x2 cells in one NWP grid-box, with a lifetime = 10 time-steps.
- Evolve the CA based on the state of it's neighbouring cells, with increased probability in direction of the wind. If rules are not met, the CA looses a life.



First test, couple to convection scheme

Simply condition the “type of boundary layer” decision on where the CA is (or has been in the last N time-steps) active.

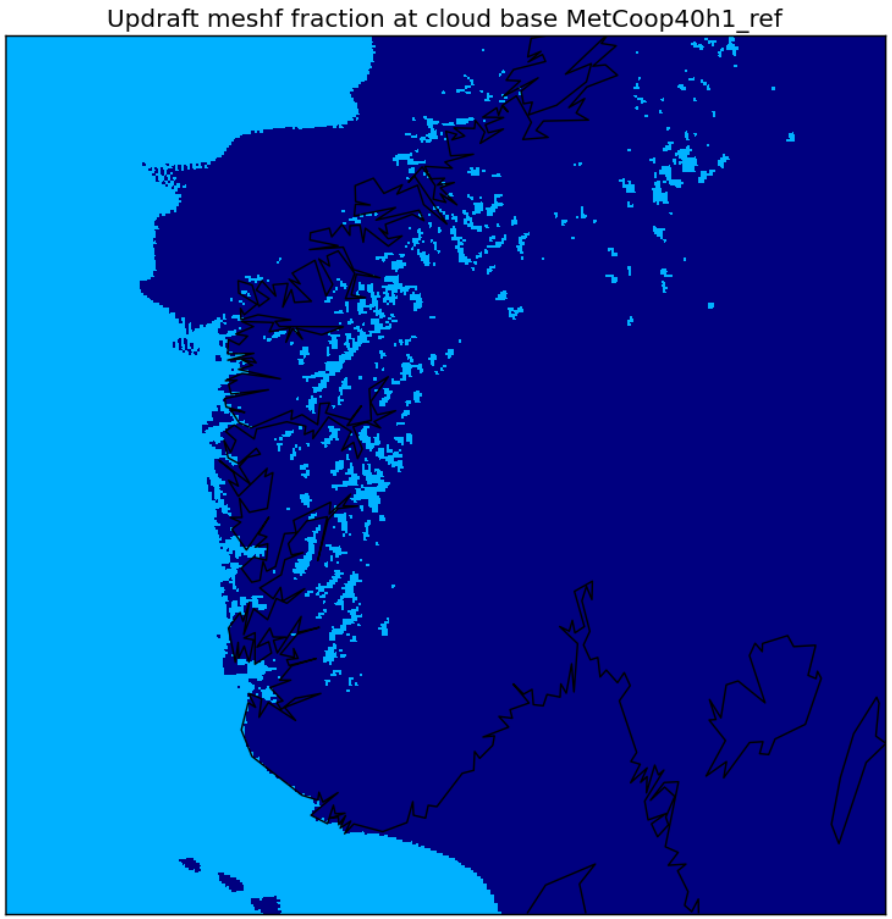
KPBLTYPE:

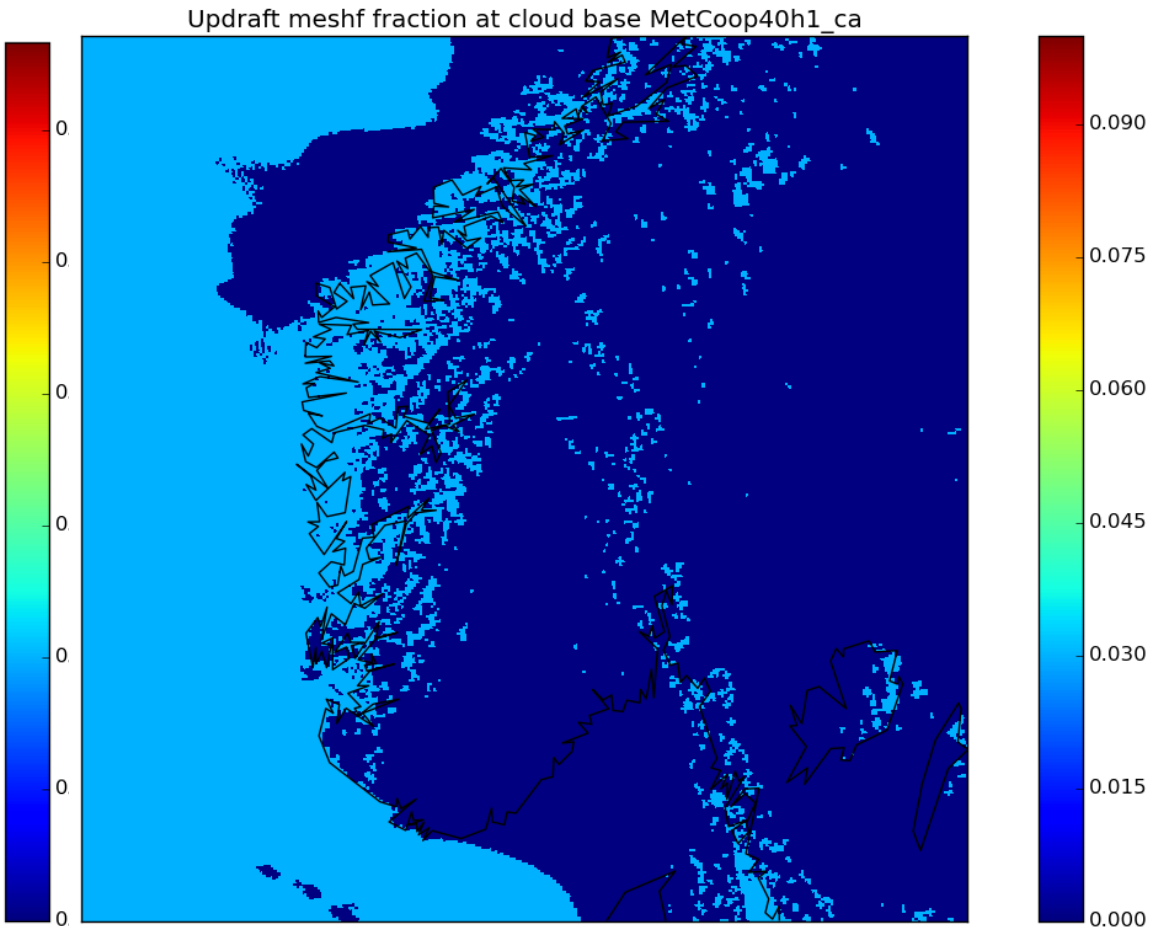


First test, couple to convection scheme

Simply condition the “type of boundary layer” decision on where the CA is (or has been in the last N time-steps) active.

ZFRACB:





Conclusions

- The solution to add precipitation to total tendencies gives better results for this case in terms of precipitation, could yield slightly increased cloud cover. Try longer evaluation with this modification, potentially in combination with more variance in the cloud cover computations.
- Simply scaling the current sub-grid precipitation with a higher value gives higher amounts, but only where it is diagnosed over sea.
- Moving the domain westward helps generating more precipitation (which looks like deep convection – more/less realistic?)
- Turning off sub-grid precip generation, or reducing the smoothing of orography, or coupling with all hydrometeors at the lbc's all had little impact on this type of weather situation.
- Use of cellular automata has potential of propagating convection in over land. In the first attempt the mass-flux was not altered, probably better to couple the fraction of CA directly to the updraft vertical velocity or the column updraft mesh-fraction. Currently also a problem that the scheme crashes depending on the number of processors (related to the SL-halo and MPI) which I had not seen before in ALARO.