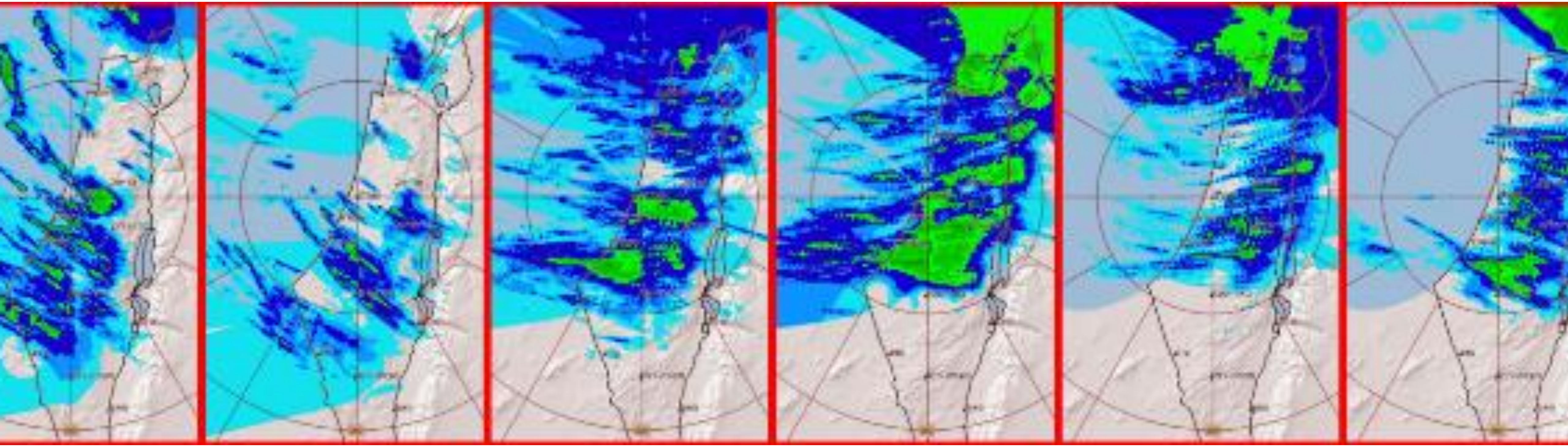
Deutscher Wetterdienst
Wetter und Klima aus einer Hand



Effect of shallow convection parametrization on cloud resolving precipitation forecasts over the Mediterranean

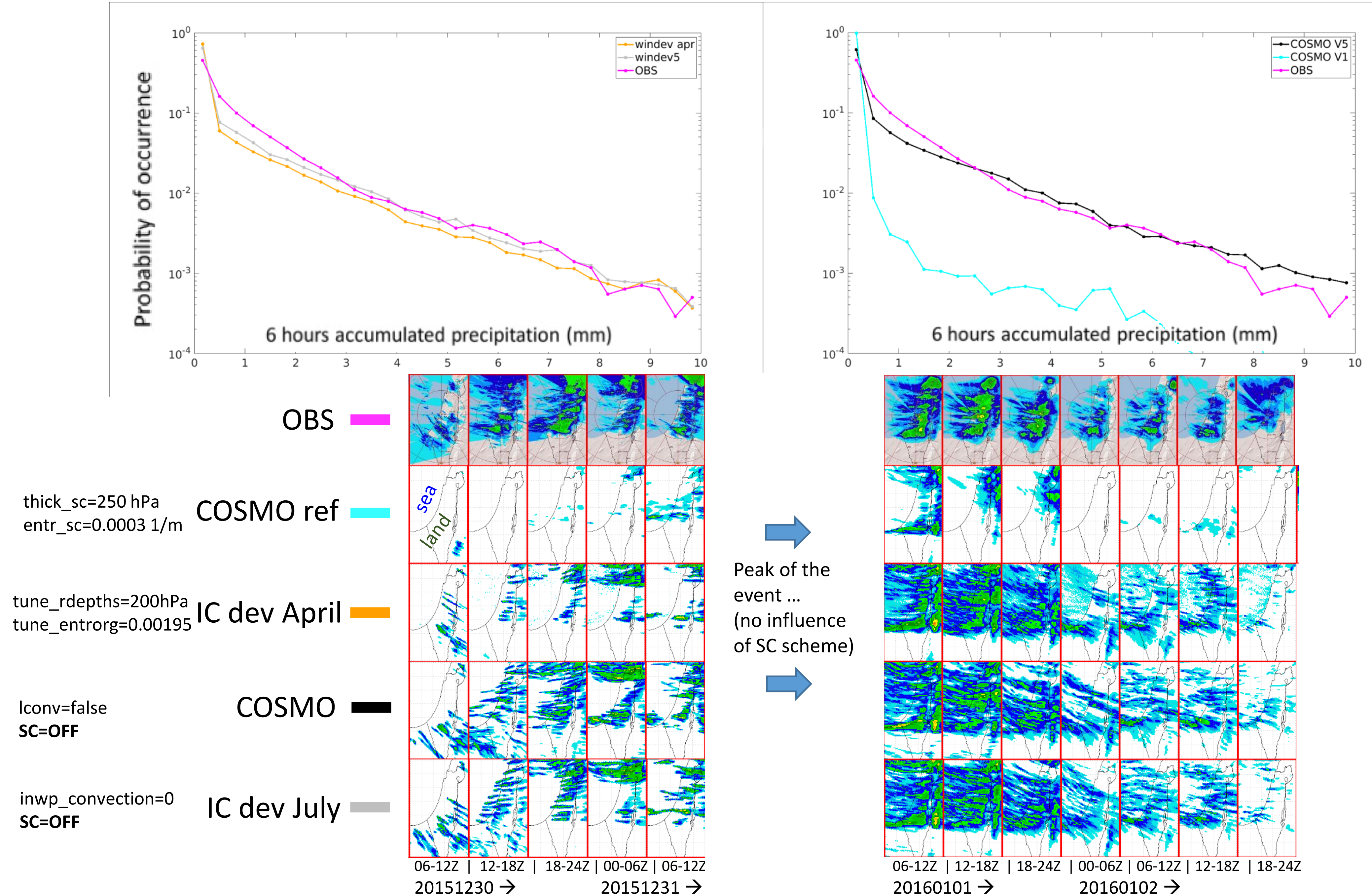
Pavel Khain (Israeli Met Service), Maike Ahlgrimm (DWD) and colleagues

Goals:

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- Finding the optimal ICON setup for the Eastern Mediterranean/Israel
- Considerations:
  - Different challenges in different seasons
  - Parameter settings – summer/winter
  - Diagnostic cloud cover scheme – “allow_overcast” switch
- Focus today: **Precip for wintertime advective rain events**
  - Which shallow convection option? (“Old” default, grayzone tuning, stochastic?)
  - How does shallow convection scheme impact grid-scale precipitation?
- Previously in COSMO:
  - Separate parameter tuning for summer/winter seasons
  - Reduced activity of the parameterized shallow convection - > all precipitation resolved (winter)

Baseline Situation:



1. Default convection settings in COSMO suppress grid scale precip ->very poor forecast

2. Default (old) convection scheme in ICON produces much better results, but also suppresses grid scale precip in the onset phase

3. Switching off convection in both COSMO and ICON leads to more grid-scale precip in the onset phase (better)

Standard convection vs. stochastic convection

default

- Convective activity limited by mass flux limiter
- parameterization switches off if clouds get deeper than ~130hPa (at 2km resolution) **rdepths=200hPa corresponds to about 130hPa after resolution-dependent tuning is applied**
- different thresholds for onset of precip over land/ocean

stochastic

- Mass flux not limited, may reach larger values
- clouds may grow up to 200hPa
- different thresholds for onset of precip over land/ocean
- stochastic process perturbs convective activity randomly in space, single grid point has some memory

Two approaches:

Reduce convective activity, resolve all precip (old COSMO strategy)

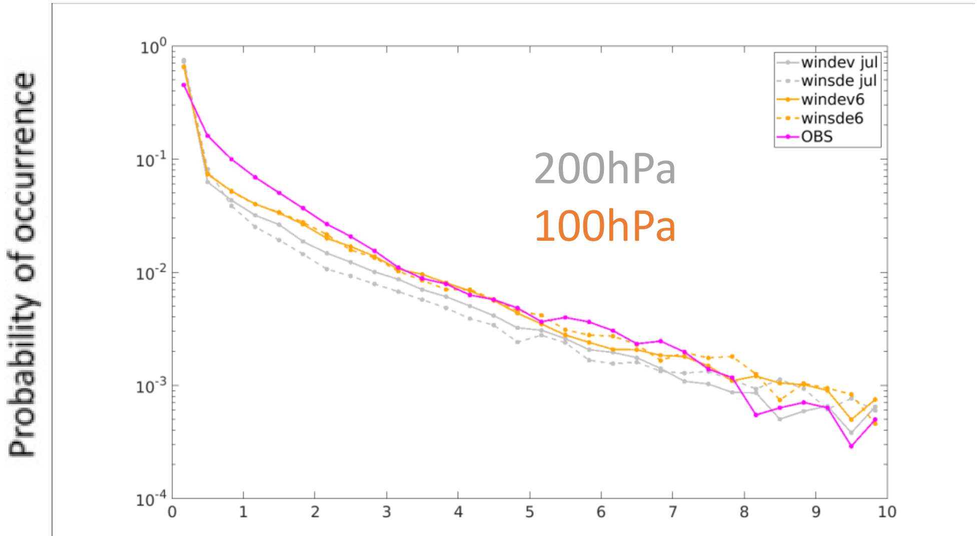
- Reduce rdepths
- Increase lateral entrainment to dilute plume

Allow convection to produce precipitation, complement resolved convection

- Increase rdepths (to allow clouds to exceed critical LWP)
- Reduce critical condensate threshold
- Try stochastic scheme (which allows more intense mass flux -> potentially more intense precip)

Does the same approach work for ICON?

- Reducing rdepths or switching convection off increases GSP, but sensitivity not as extreme as in COSMO. Convection suppresses precip particularly in the onset phase, weak convective precip over ocean with boundary along coast line
- Litte impact of tuning lateral entrainment parameter
- Adding vertical velocity criterion is also negligible



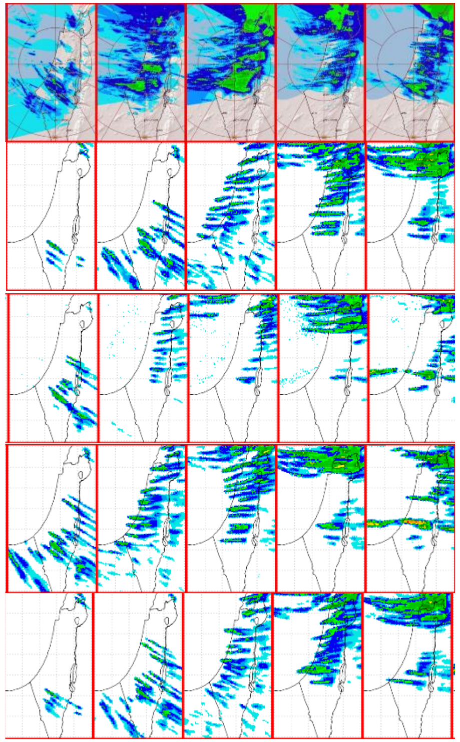
OBS

inwp_convection=0
SC=OFF
IC dev July

tune_rdepths=200hPa
tune_entrorg=0.00195
IC dev July

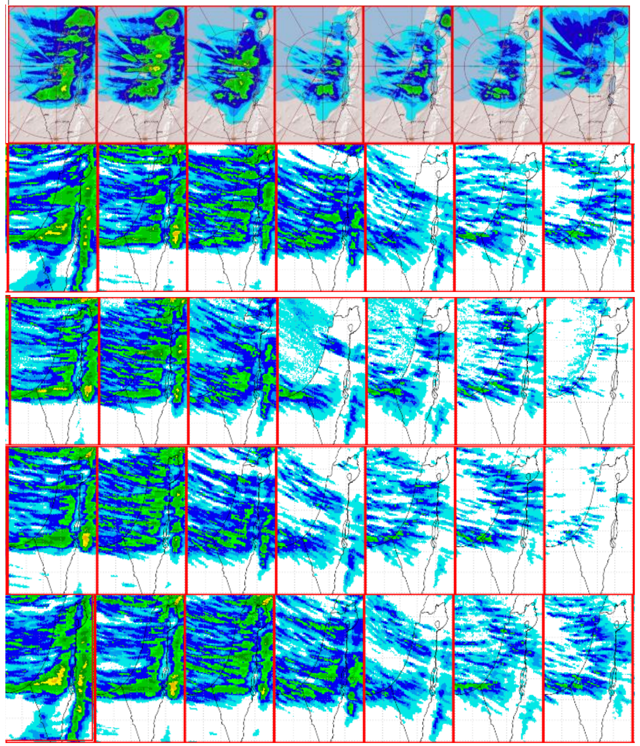
tune_rdepths=**100**hPa
tune_entrorg=0.00195
IC dev July

tune_rdepths=100hPa
tune_entrorg=**0.01**
IC dev July

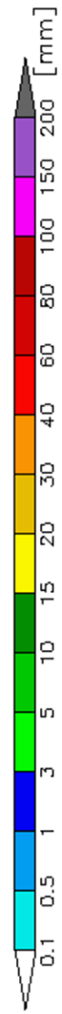


06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z
20151230 → 20151231 →

Peak of the event …
(no influence of SC scheme)

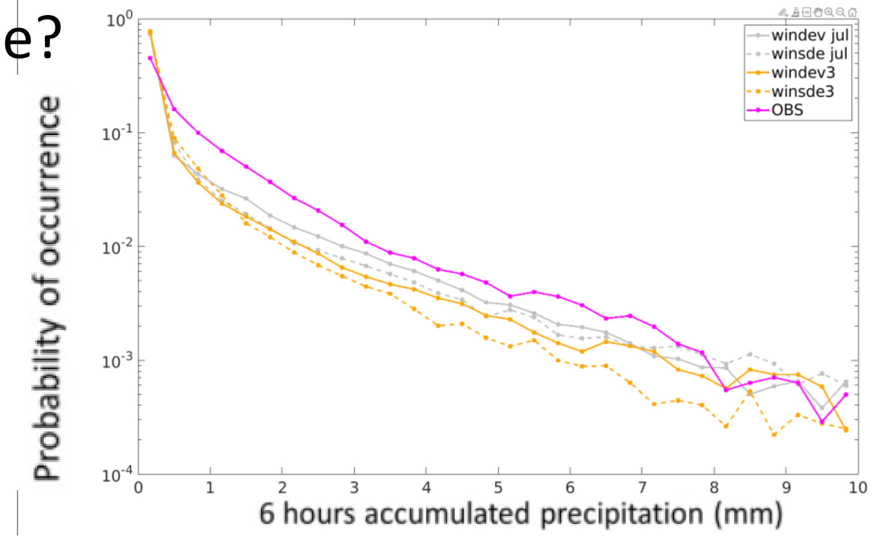


06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z | 12-18Z | 18-24Z
20160101 → 20160102 →



What additional benefit does the stochastic scheme provide?

- More conv precip over ocean (generally weak), but higher intensities with SDE vs. default
- Reduced (higher intensity) GSP
- Land/sea contrast becomes more visible
- Less structure



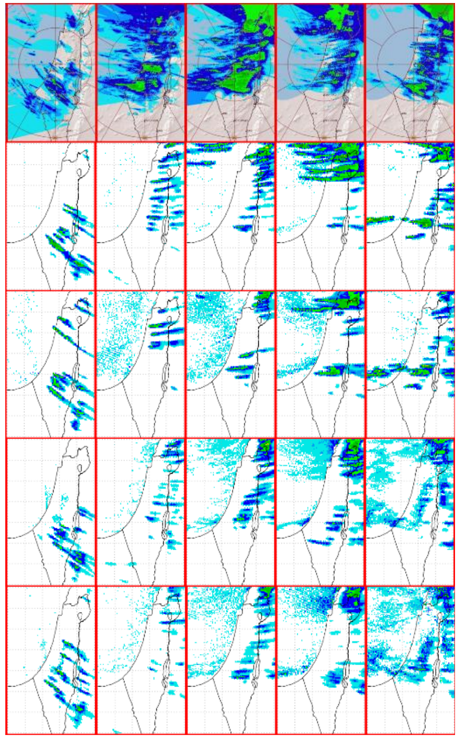
OBS

tune_rdepths=200hPa
tune_entrorg=0.00195 IC dev July

tune_rdepths=200hPa
tune_entrorg=0.00195 IC sde July

tune_rdepths=**600**hPa
tune_entrorg=0.00195 IC dev July

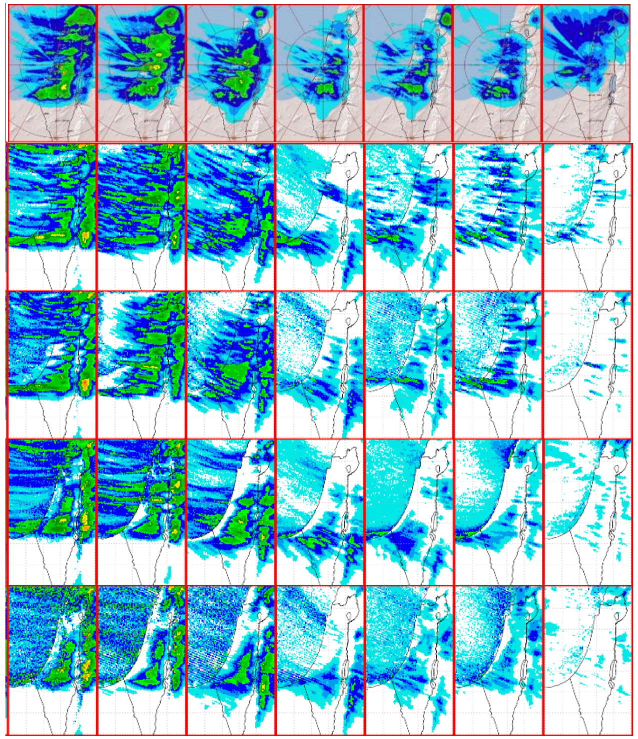
tune_rdepths=**600**hPa
tune_entrorg=0.00195 IC sde July



06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z

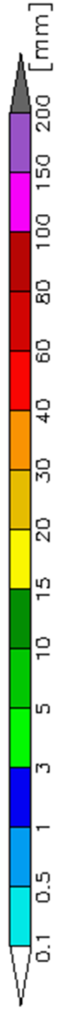
20151230 → 20151231 →

Peak of the event … (no influence of SC scheme)



06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z | 12-18Z | 18-24Z

20160101 → 20160102 →



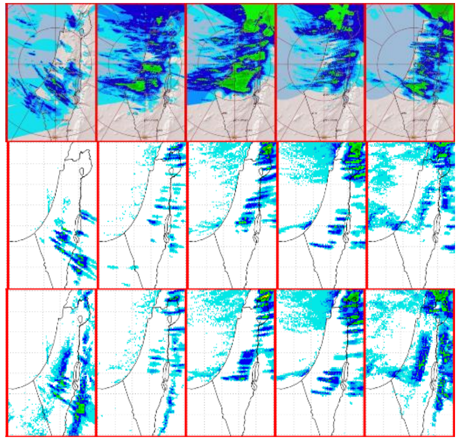
Land-sea contrast:

- Based on assumed higher CCN concentration over land vs ocean – is this applicable here?
- Using same, more permissive settings over land/ocean decreases coastline effect during the day, but has little effect at night

OBS

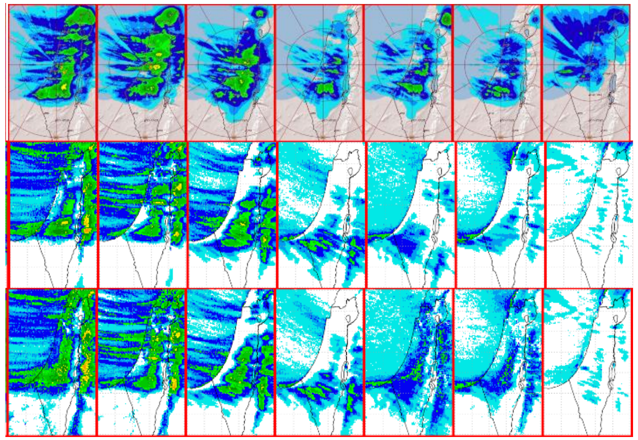
tune_rdepths=**600**hPa
tune_entrorg=0.00195 IC dev July

tune_rdepths=**600**hPa
tune_entrorg=0.00195 IC dev July
autoconversion over land = over sea, i.e.
icpl_aero_conv=0, zdnoprc=3.e-4

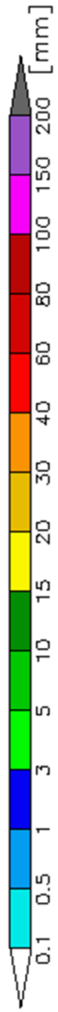


06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z
20151230 → 20151231 →

Peak of the event …
(no influence of SC scheme)



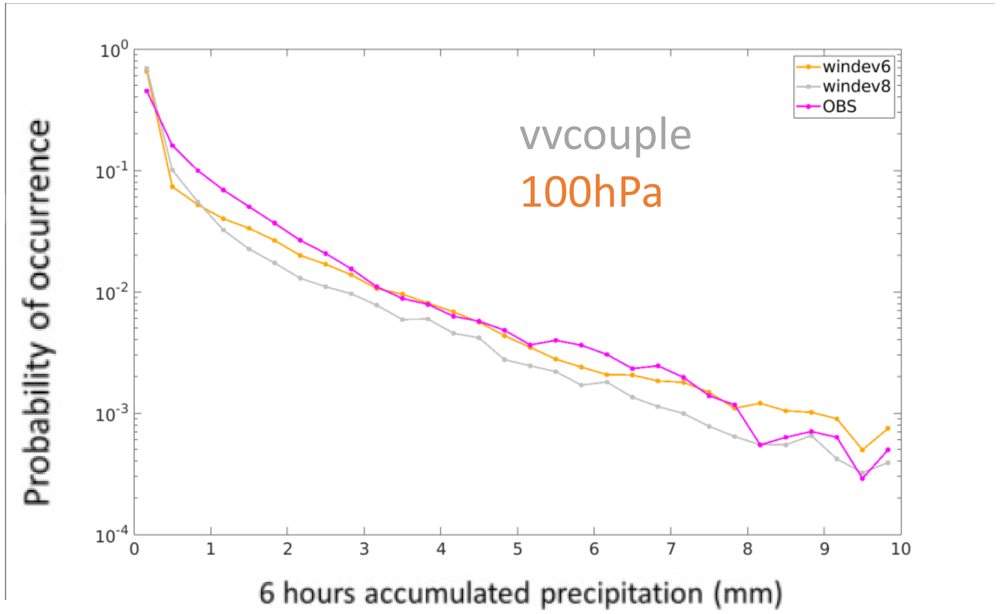
06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z | 12-18Z | 18-24Z
20160101 → 20160102 →



20151230-20160102

Vertical velocity limiter:

- Instead of using rdepths to decide whether grid point is parameterized or not, use vertical velocity at 650hPa (ascending motion -> resolved)
- No great improvement

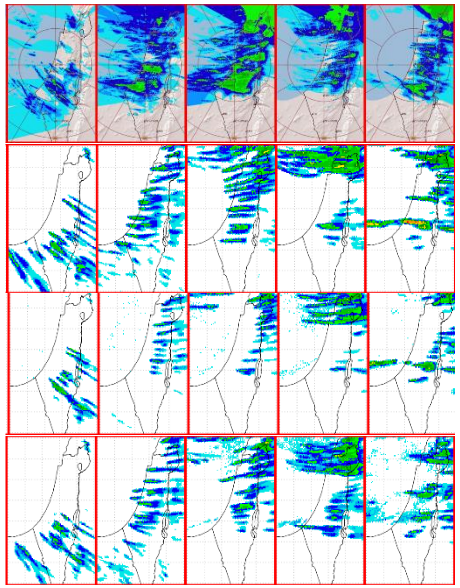


OBS

tune_rdepths=100hPa
tune_entrorg=0.00195
IC dev July

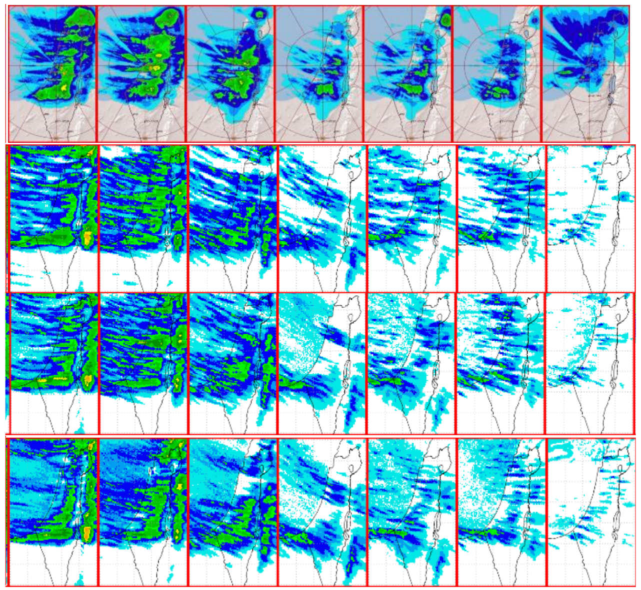
tune_rdepths=200hPa
tune_entrorg=0.00195
IC dev July

tune_rdepths=200hPa
tune_entrorg=0.00195
lvvcouple=T
lvv_shallow_deep=T
IC dev July

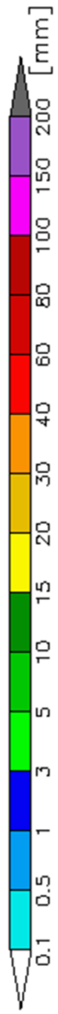


06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z
20151230 → 20151231 →

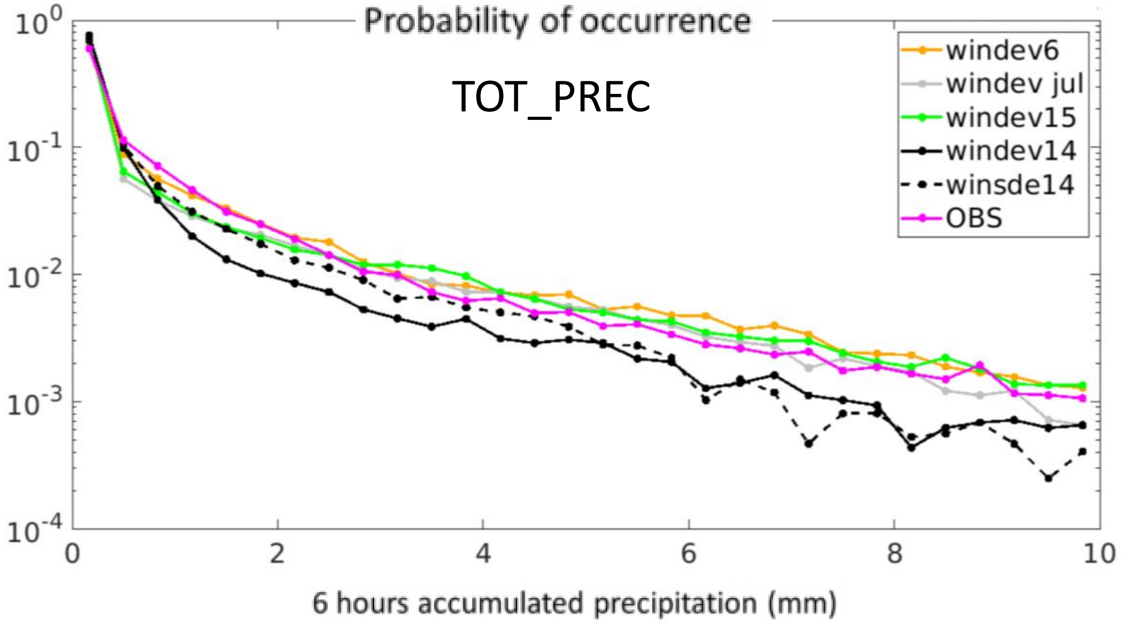
Peak of the event ...
(no influence of SC scheme)



06-12Z | 12-18Z | 18-24Z | 00-06Z | 06-12Z | 12-18Z | 18-24Z
20160101 → 20160102 →

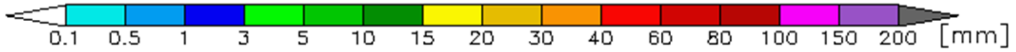


Different (more recent) case!



Conclusions:

1. Reduction of maximum depth is a good solution for weak precipitation (still not enough as seen on previous test cases. However, it “kills” SC which may have negative effect on other fields.
2. Increase of maximum depth increases SC precip but strongly decreases GS precip, leading to underestimation.
3. SDE improves the situation, still underestimating precipitation
4. Strange land-sea contrast in SC precipitation



OBS

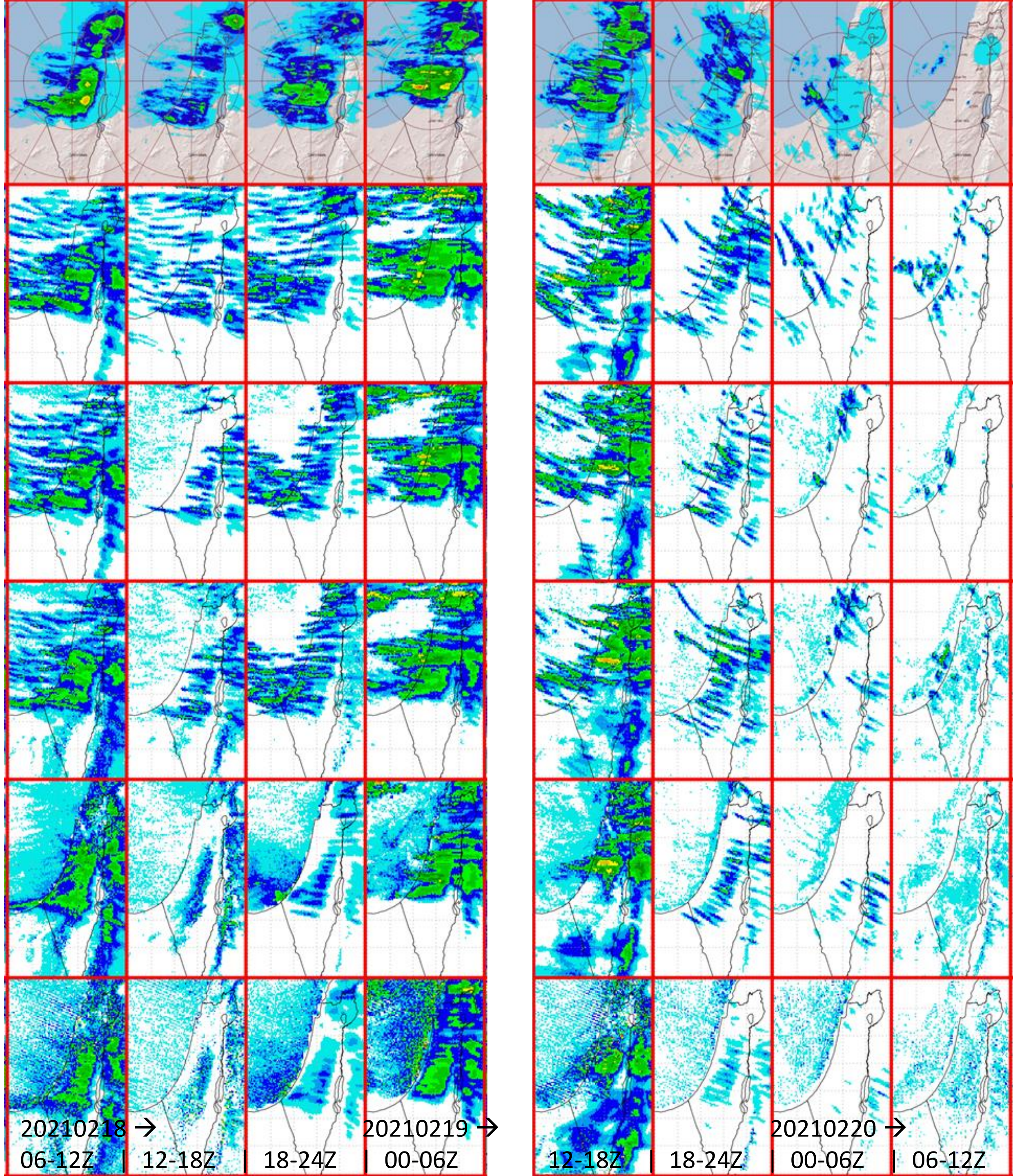
tune_rdepths=**100**hPa tune_entrorg=0.00195

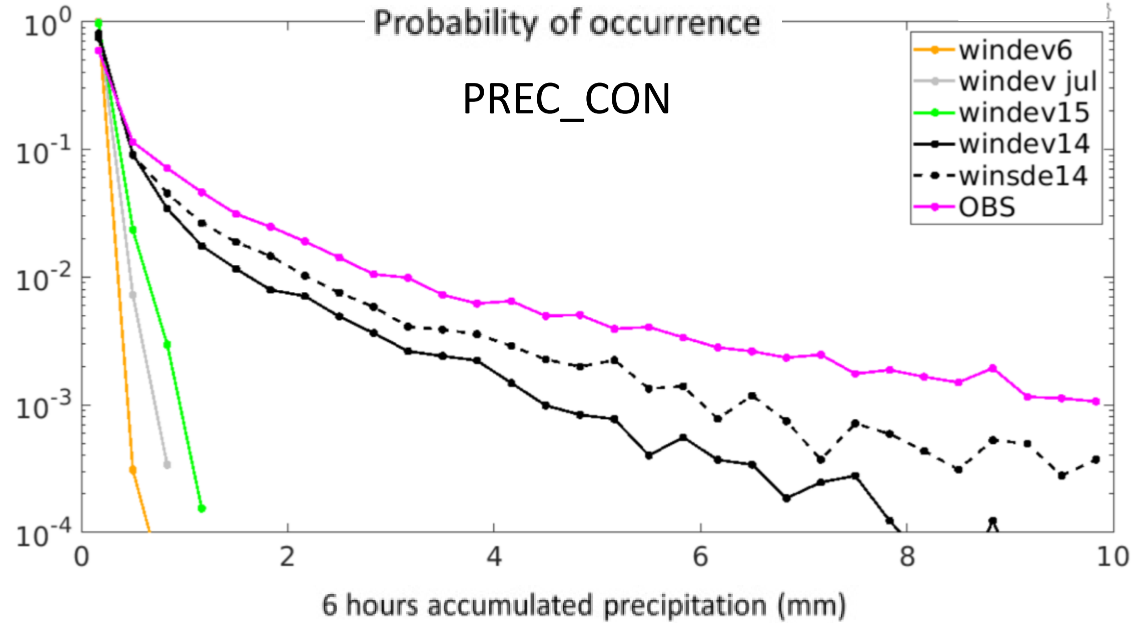
tune_rdepths=**200**hPa tune_entrorg=0.00195

tune_rdepths=**200**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land

tune_rdepths=**600**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land

SDE+ tune_rdepths=**600**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land





OBS

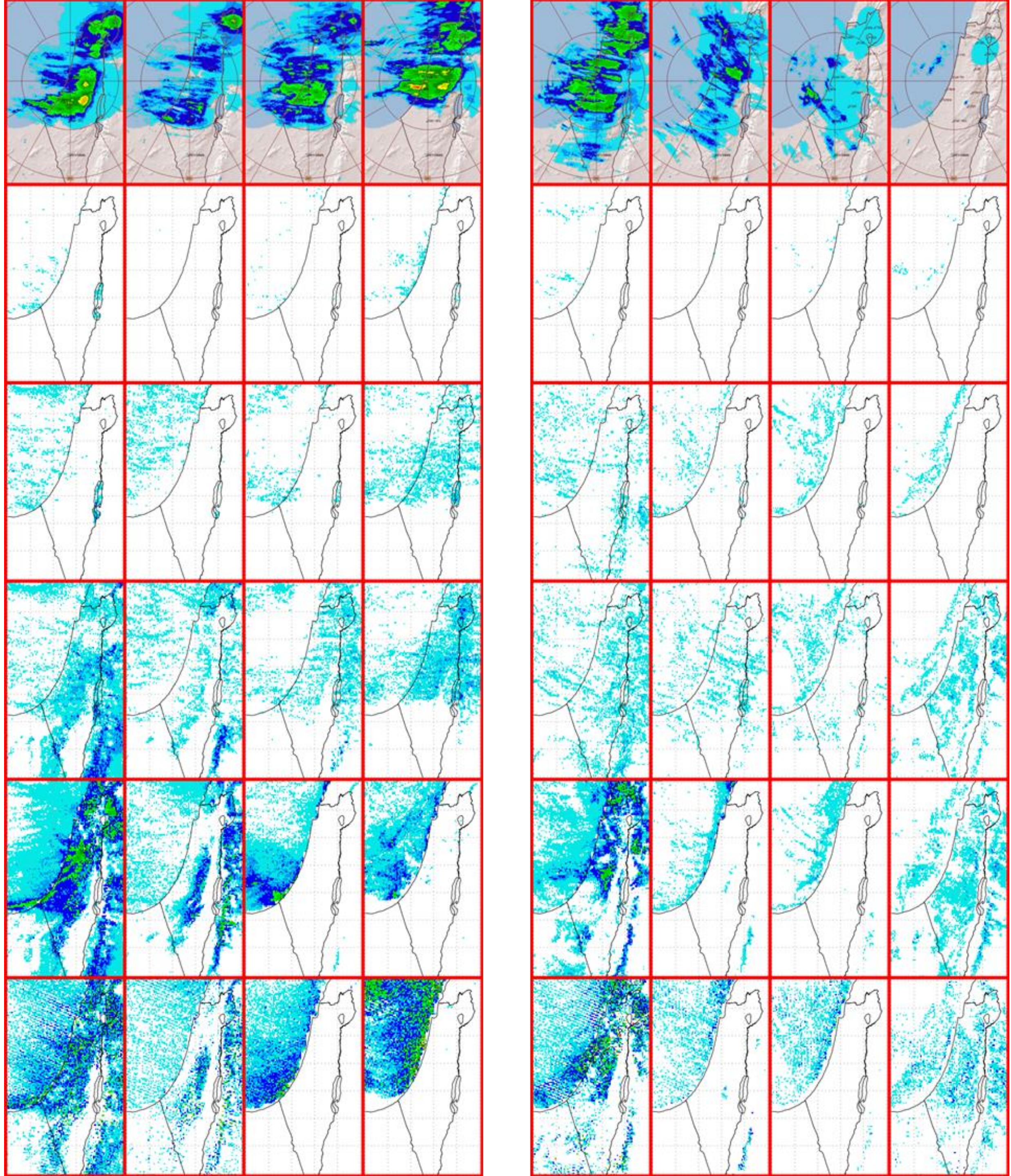
tune_rdepths=**100**hPa
tune_entrorg=0.00195

tune_rdepths=**200**hPa
tune_entrorg=0.00195

tune_rdepths=**200**hPa
tune_entrorg=0.00195
zdnoprc=3.e-4
both sea&land

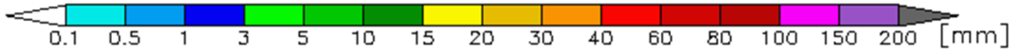
tune_rdepths=**600**hPa
tune_entrorg=0.00195
zdnoprc=3.e-4
both sea&land

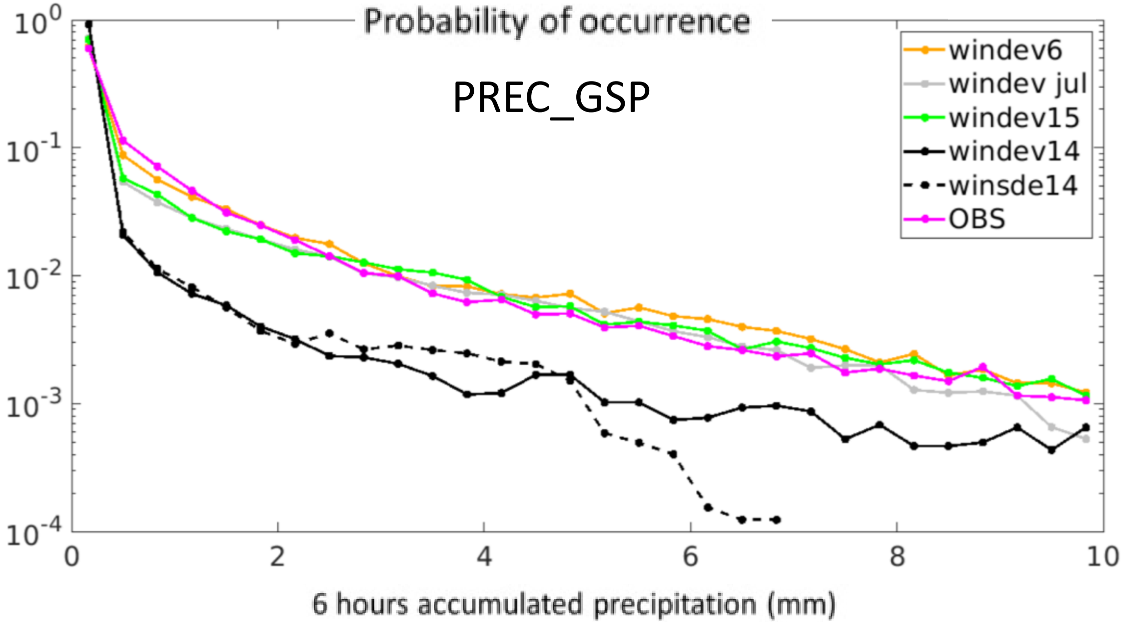
SDE+
tune_rdepths=**600**hPa
tune_entrorg=0.00195
zdnoprc=3.e-4
both sea&land



Conclusions:

1. Reduction of maximum depth is a good solution for weak precipitation (still not enough as seen on previous test cases. However, it “kills” SC which may have negative effect on other fields.
2. Increase of maximum depth increases SC precip but strongly decreases GS precip, leading to underestimation.
3. SDE improves the situation, still underestimating precipitation
4. Strange land-sea contrast in SC precipitation





OBS

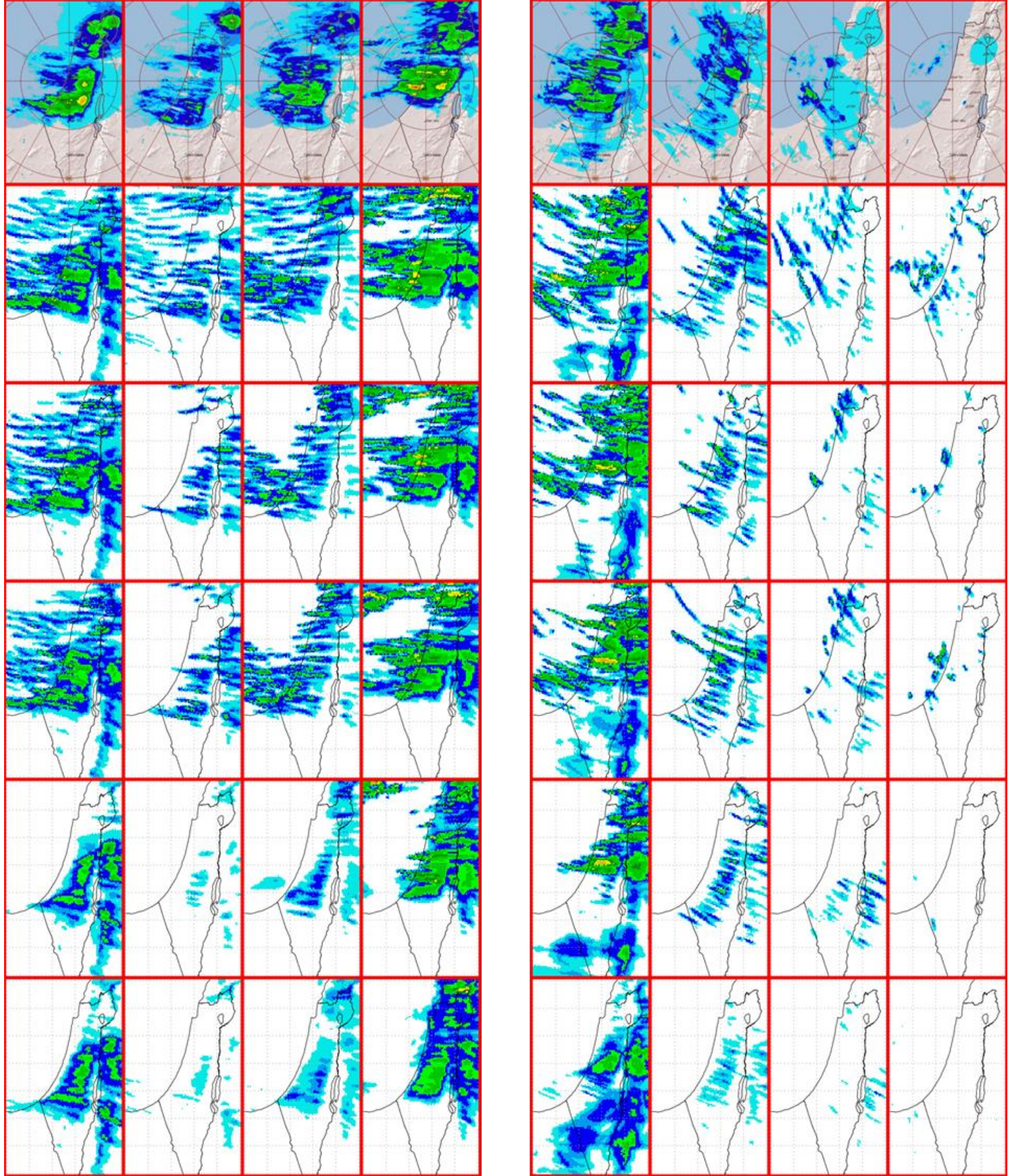
tune_rdepths=**100**hPa tune_entrorg=0.00195

tune_rdepths=**200**hPa tune_entrorg=0.00195

tune_rdepths=**200**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land

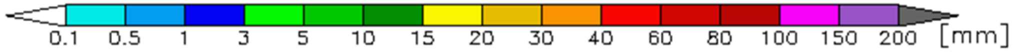
tune_rdepths=**600**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land

SDE+ tune_rdepths=**600**hPa tune_entrorg=0.00195 zdnoprc=3.e-4 both sea&land



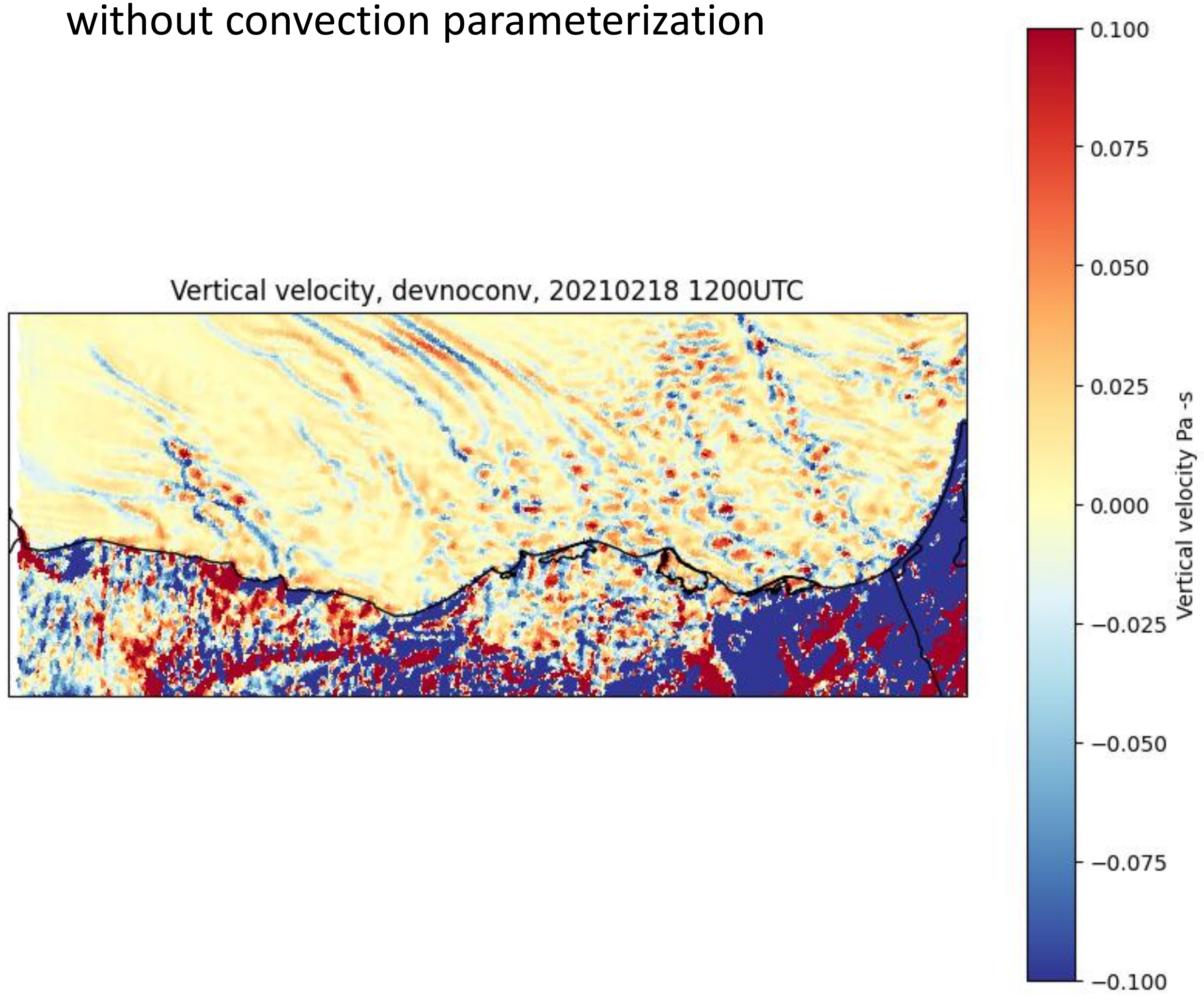
Conclusions:

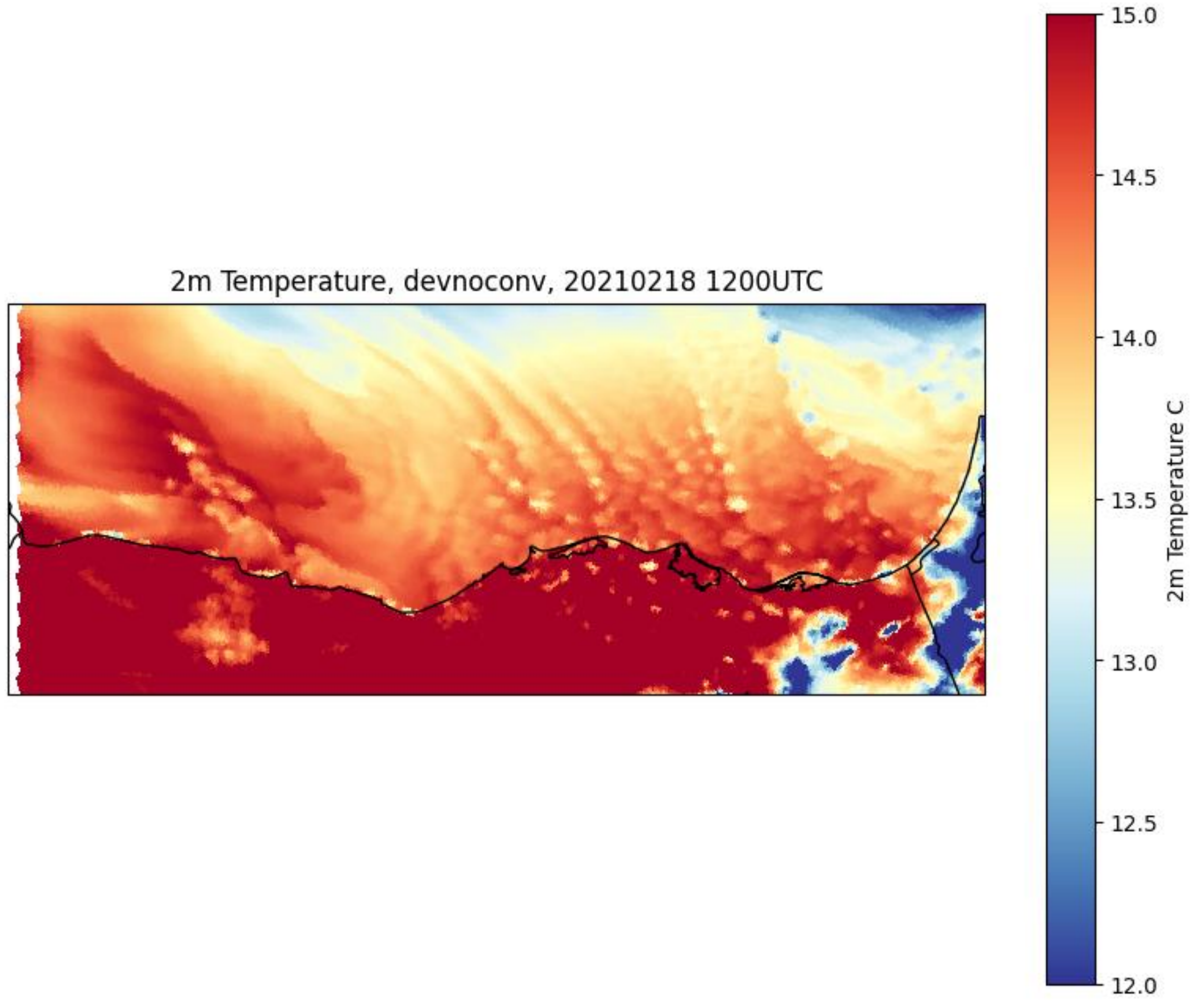
1. Reduction of maximum depth is a good solution for weak precipitation (still not enough as seen on previous test cases. However, it “kills” SC which may have negative effect on other fields.
2. Increase of maximum depth increases SC precip but strongly decreases GS precip, leading to underestimation.
3. SDE improves the situation, still underestimating precipitation
4. Strange land-sea contrast in SC precipitation



Example: BL structure for different options

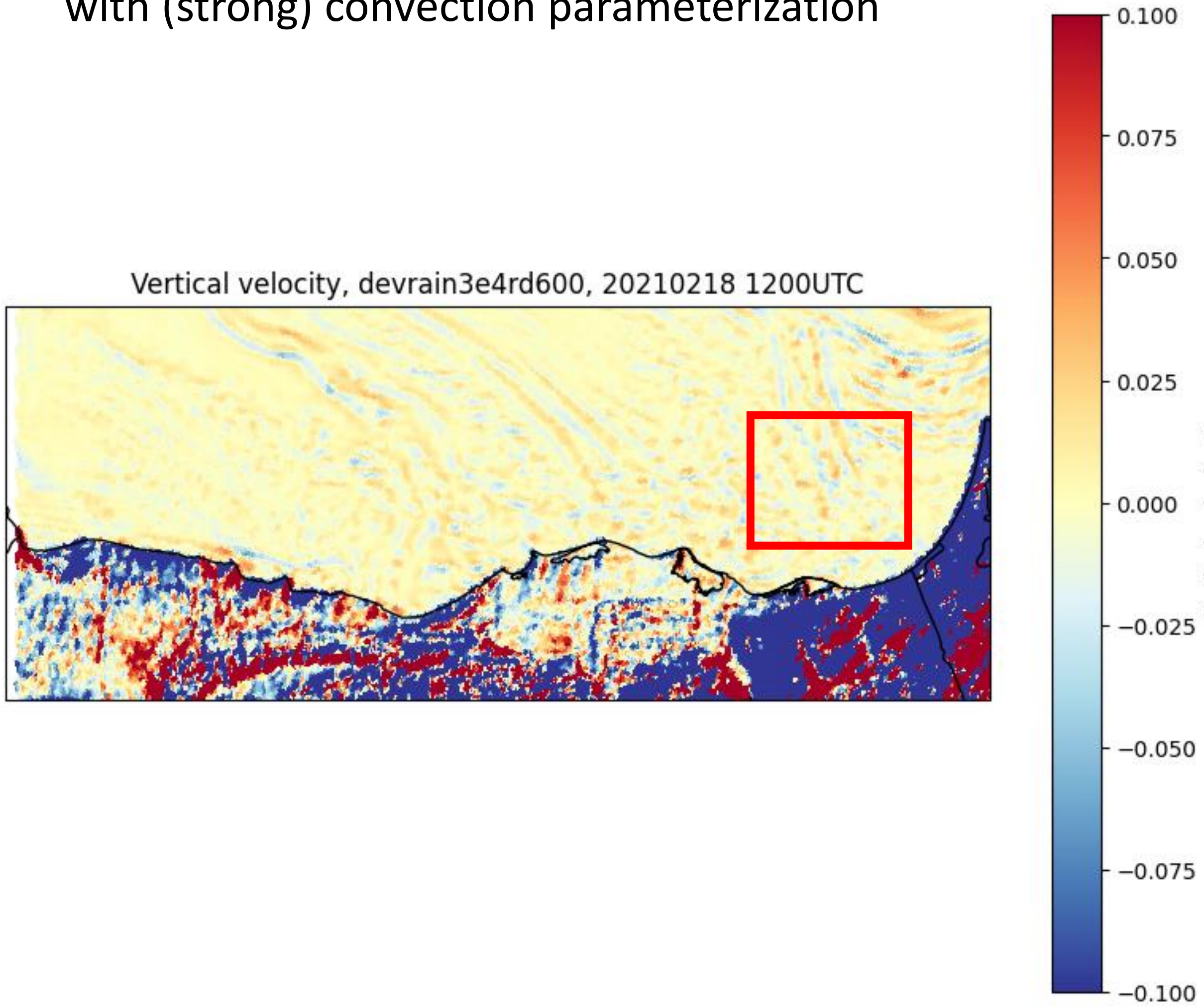
without convection parameterization

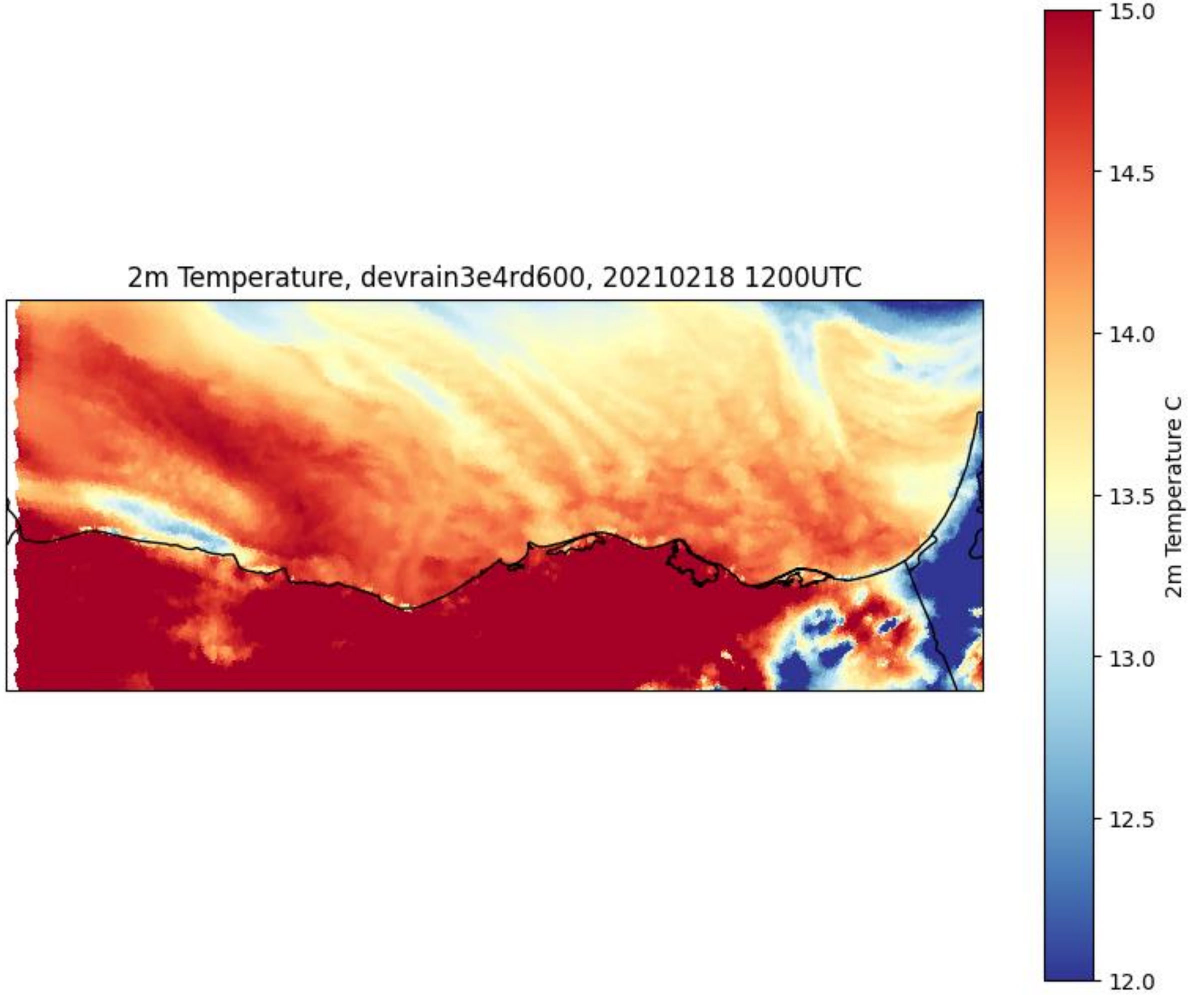




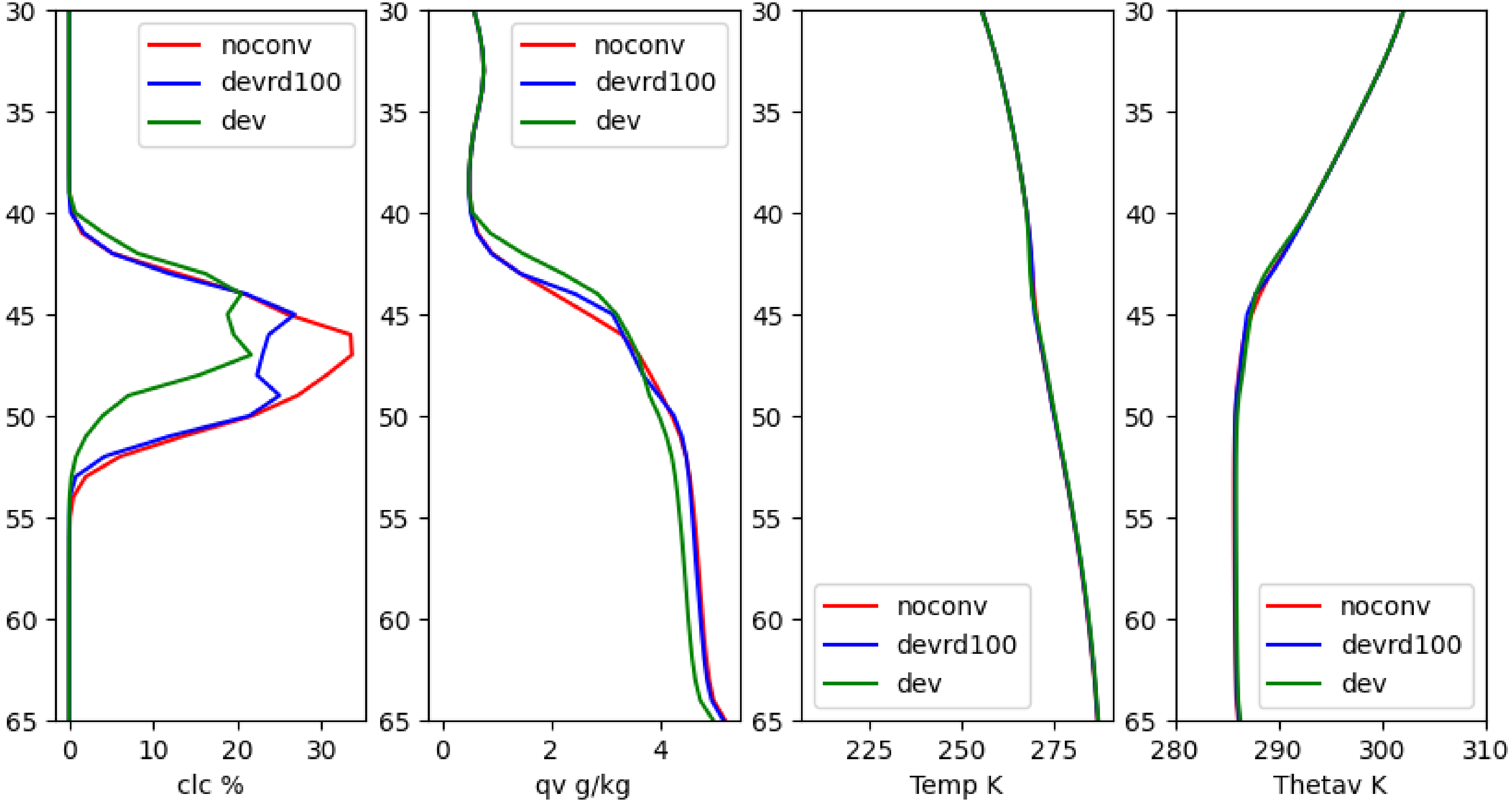
Example: BL structure for different options

with (strong) convection parameterization





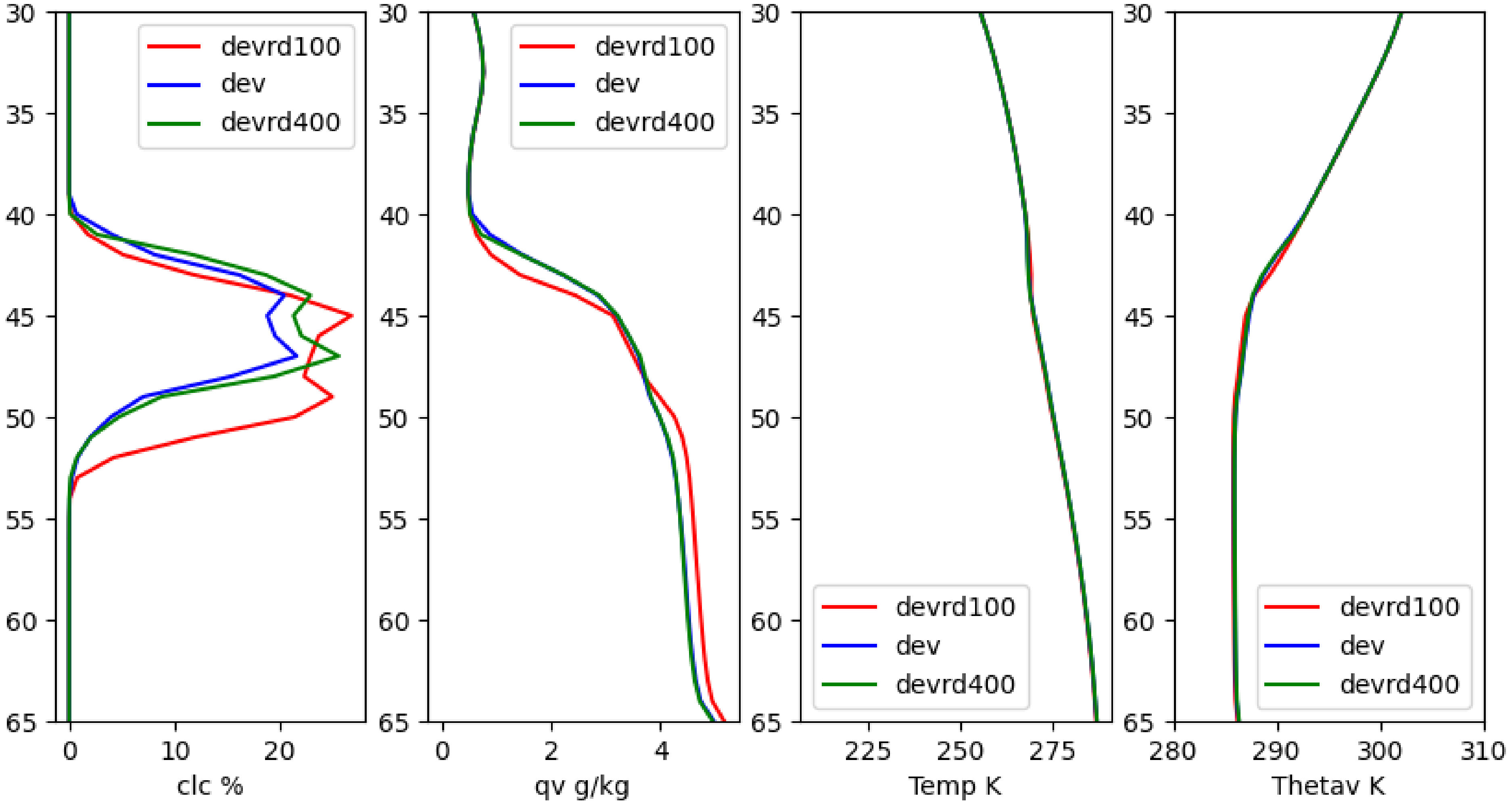
Example: BL structure for different options



More well-mixed, moister subcloud layer, lower cloud base for reduced convection

devrd100: no active convection in area at 12UTC!
dev: about 20% of points convecting

Example: BL structure for different options

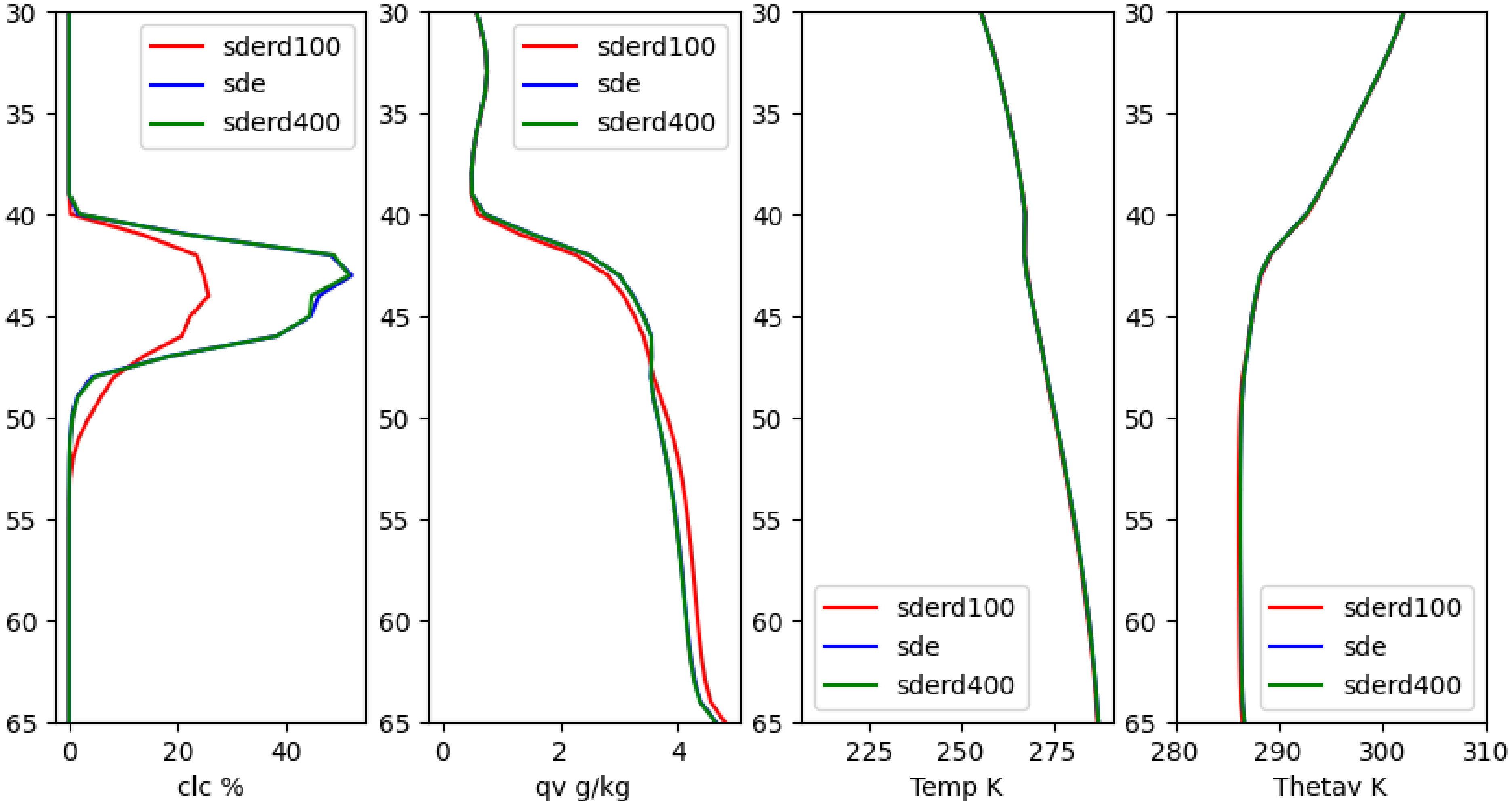


„Free“ convection produces decoupled cloud layer with higher cloud base, drier mixed-layer

rdepths 200-400hPa makes no further difference, shallow clouds don‘t „want“ to grow much beyond 200hPa

0, 20, 71% of convective points

Example: BL structure for different options



SDE produces higher cloud base, drier sub-cloud layer than default scheme (no tuning, no limiters, effectively higher rdepth)
Higher cloud cover

SDE responds similarly to limitation through rdepth (keeping in mind the rdepth set is not further reduced by tuning)

0, 45, 58% convecting points

Conclusion:

- Difficult to achieve better performance (in terms of precip) for advective winter cases than with “suppressed parameterized convection” option
- ICON much less sensitive than COSMO
- Convective trigger tied to surface stability -> land/ocean contrast
- Open question: how does suppressed convection impact other scores? In rare winter rain situations, is accurate precip forecast more important than other parameters?

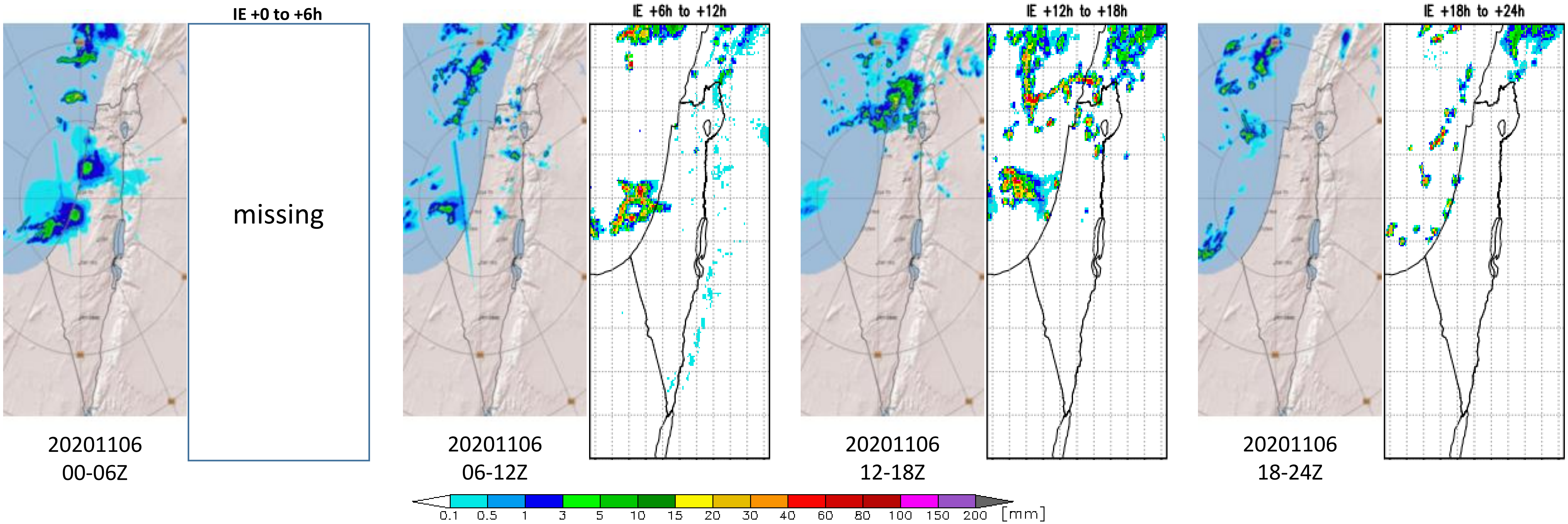
Note: winter-time precip events make up only a fraction of the year!

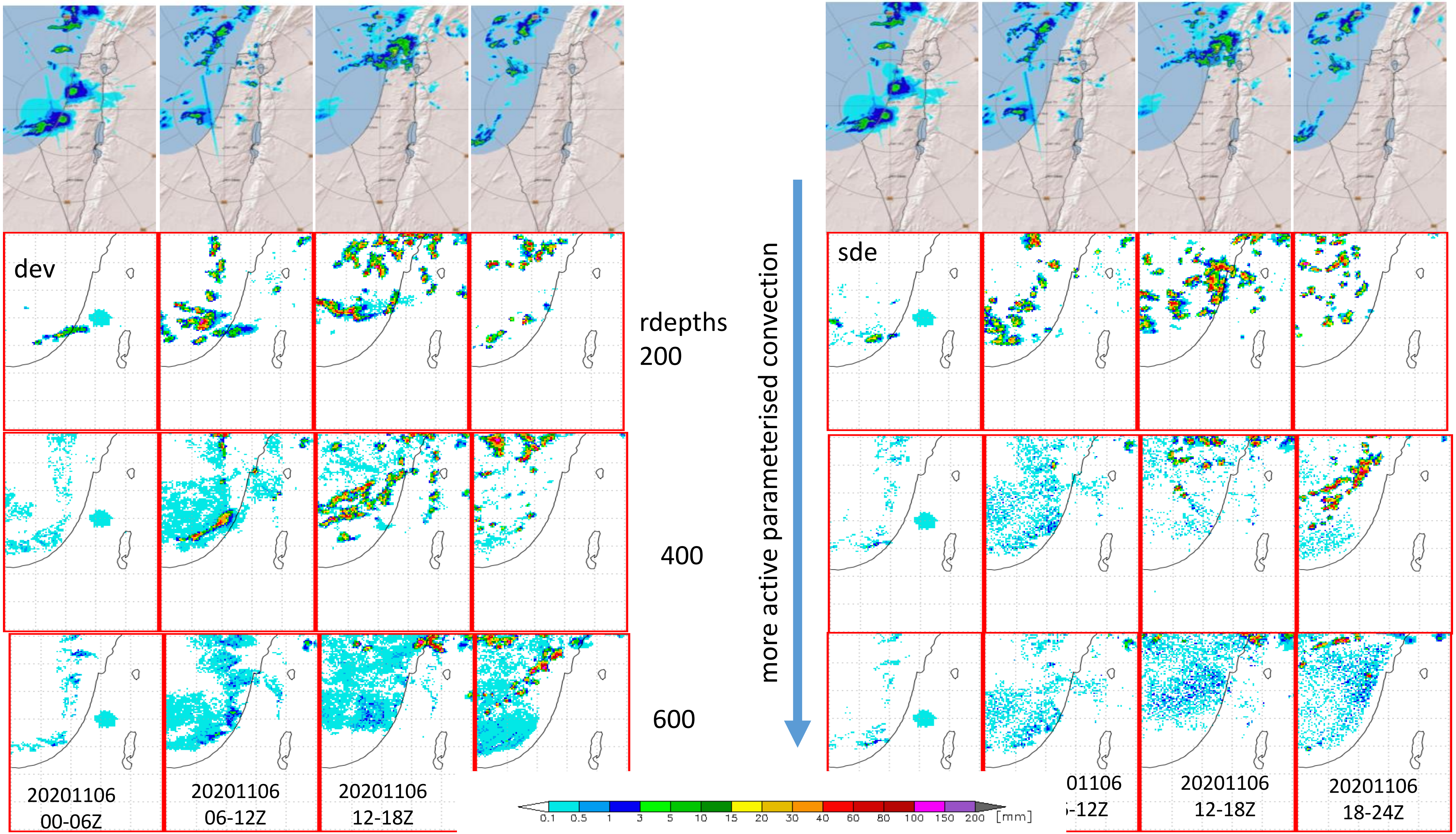
- Summertime shallow convection cases benefit from more active convection scheme and SDE
- Autumn cases with unrealistic high intensity, small-scale resolved rain events
- Other scores (BL state) benefit from parameterized convection

Example: November precip overestimates

- Observed precip on the order of 10-15mm
- Forecast precip up to 100+ mm
- Difficult situation for weather warnings

2020110600Z Precipitation forecast





dev
sde
rdepths
200
400
600
more active parameterised convection
20201106
00-06Z
20201106
06-12Z
20201106
12-18Z
01106
-12Z
20201106
12-18Z
20201106
18-24Z
0.1 0.5 1 3 5 10 15 20 30 40 60 80 100 150 200 [mm]