Status overview of the CSD adaptive convection scheme

Luc Gerard

Royal Meteorological Institute of Belgium

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CSD features

- Provide a subgrid complement to the resolved part of the convective updraughts.
- Resolved signal adaptive scheme, more than simply scale-aware.
- Perturbation plume
- Prognostic evolution ($\omega_u^\diamond$, σ_u σ_D, cloud top)
- Physically based mixed closure (CAPE + Moisture convergence)
- Specific triggering, based on resolved condensation.

Triggering methods

A mixed source parcel is lifted up to its LCL
where a buoyancy kick is added, allowing or not to reach the LFC.

Referring to the initial source parcel,

$$\triangle T_v = \max\{-\triangle T_{vx}, \min[(\triangle T_{v,LCL} + \underbrace{\triangle T_{v,rc} + \triangle T_{v,...}}_{\text{kicks}}), \underbrace{\triangle T_{v,cin}}_{\text{barrier}}, \triangle T_{vx}]\}$$

- Main kick: resolved condensation over a thickness GTRTHCK$\sim$ 700hpa:

$$\triangle T_{Fcs} = \max[0, g\triangle t \frac{\sum_{l=L}^{k} \frac{L^l}{c_p^l} \triangle F_{cs}^l}{\sum_{l=L}^{k} \triangle p^l}],$$

$$\triangle T_{v,rc} = \gamma_{rc}(1 + \gamma_{CA}\sigma_{CA})\left[\triangle T_{Fcs}(1 + \gamma_{CA}\sigma_{CA}) - T_{0,rc}\right]$$

(σ_{CA} is mesh fraction from cellular automaton).

Triggering methods (II)

- Possibe complementary kicks:
  - TKE (Kuell & Bott 2008):

$$\triangle T_{v,tke} = \gamma_k \max[0, (2\sqrt{\langle TKE \rangle})^{\frac{1}{3}} - 1]$$

  - Relative Humidity (Narita & Ohmori 2007)

$$\triangle T_{v,RH} = \gamma_{RH} \langle q_v \rangle_{usl} \underbrace{\frac{RT^2}{\frac{R_a}{R_v} L(T, \alpha_i) \overline{q_s}}}_{1/\frac{\partial q_s}{\partial T}} \begin{cases} 0 & \text{if } RH \leq 0.75 \\ \frac{RH - 0.75}{4} & \text{if } 0.75 < RH < 0.95 \\ \frac{1}{RH} - 1 & \text{if } RH \geq 0.95 \end{cases}$$

Interaction with mean grid box

- subgrid transport fluxes $\neq$ production fluxes: $M_{tr} = M_u / \max[\mathrm{GCVFXM}, (1 - \sigma_u)]$
- subgrid condensation flux added to resolved flux
- $N_c = \sigma_u + \sigma_D$ (detrained fraction), now with max overlap in cloud scheme (LSMGCDEV) and radiation (LNEB_FP)
- Compute convective activity index (resolved and subgrid)

$$\xi = \max[0, \frac{(-\overline{\omega} - \sigma_u \omega_u^{\diamond} - \omega_n)}{\omega_r}]$$

that can be used in microphysics to affect auto-conversion thresholds and efficiencies.

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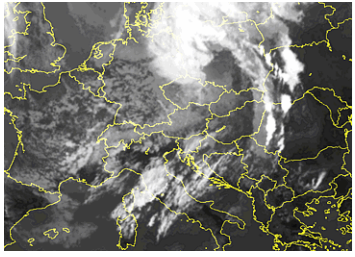

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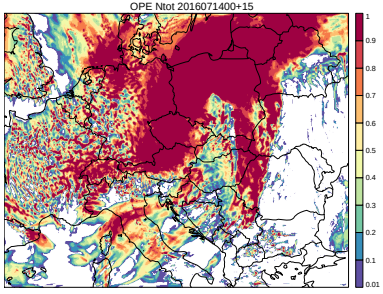

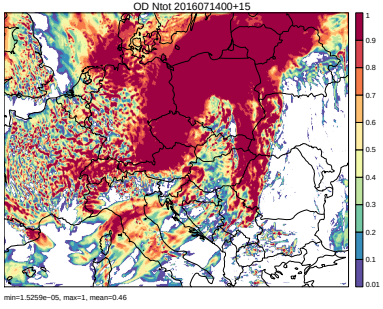

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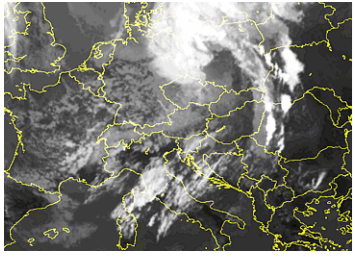

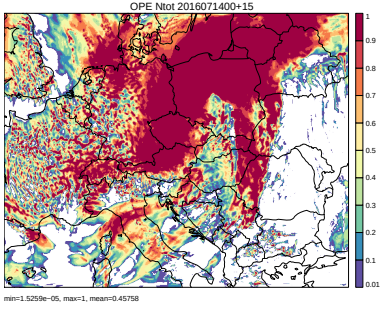

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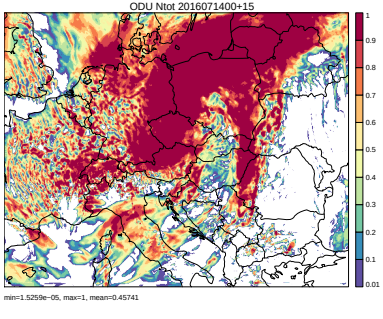

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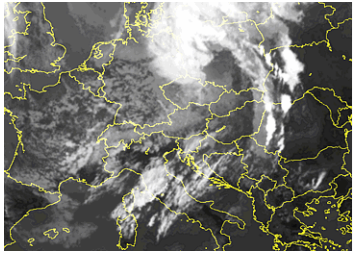

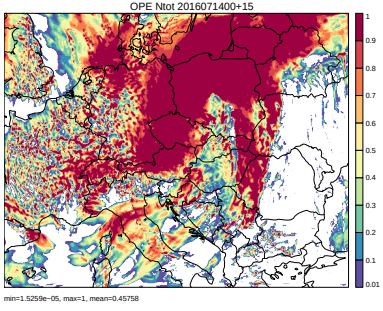

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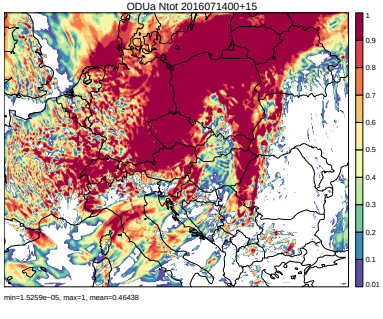

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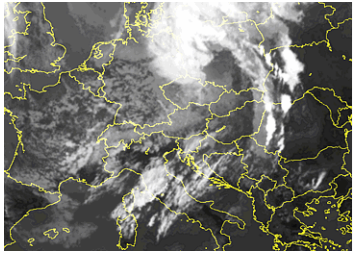

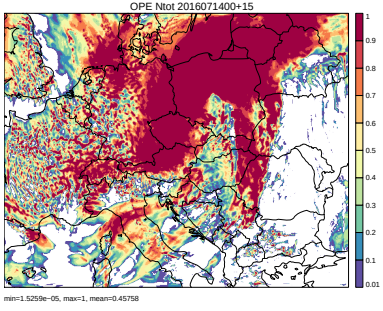

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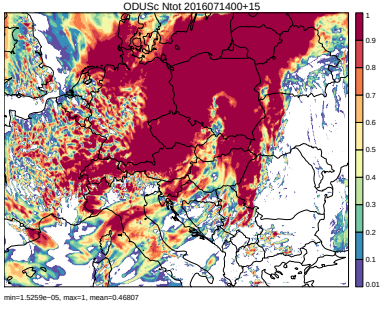

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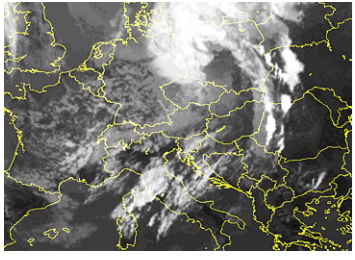

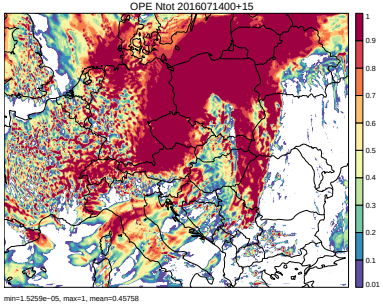

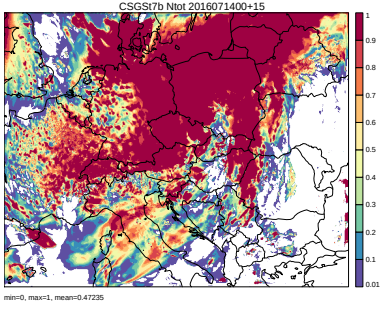

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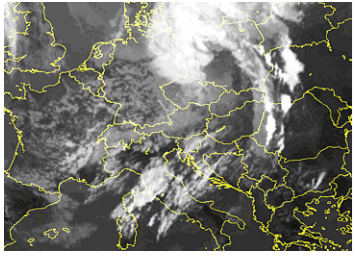

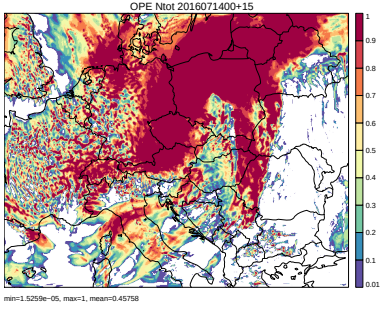

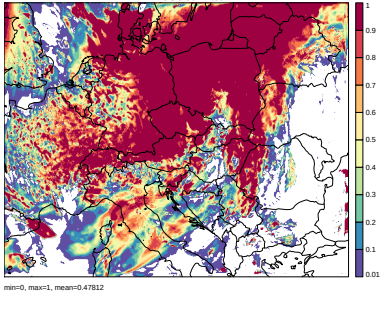

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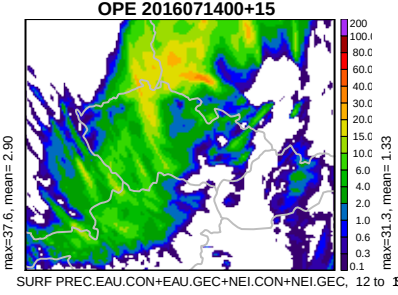
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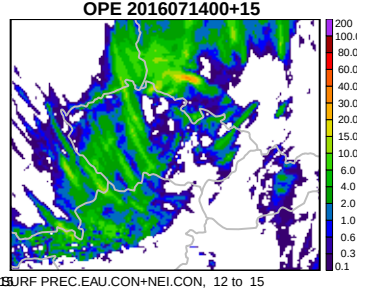
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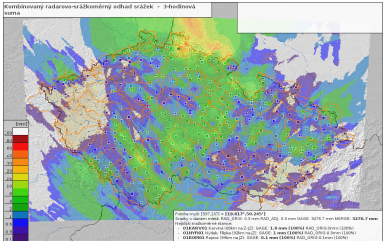
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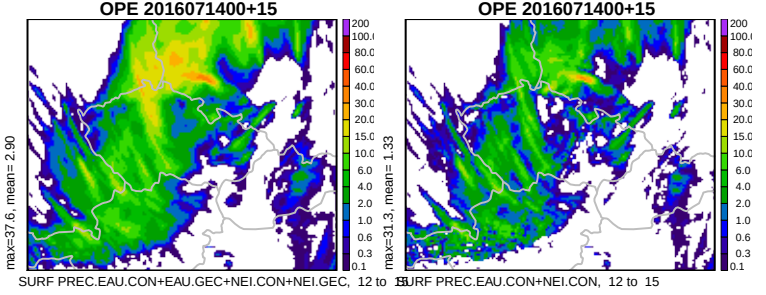

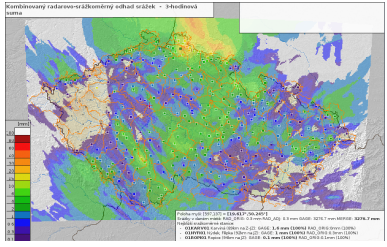

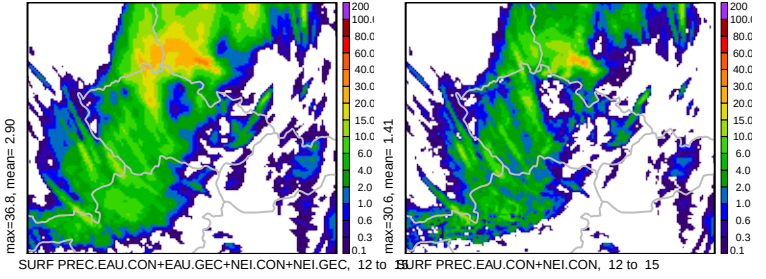

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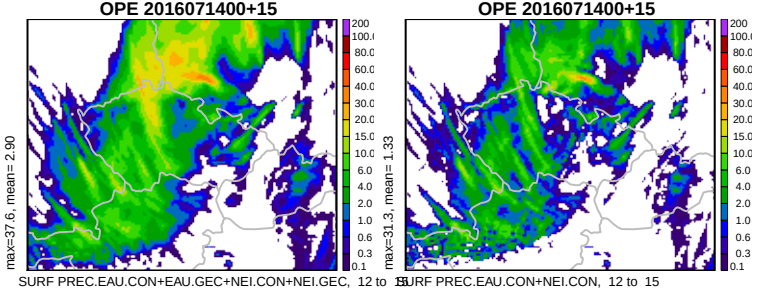

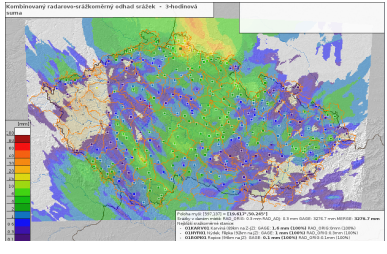

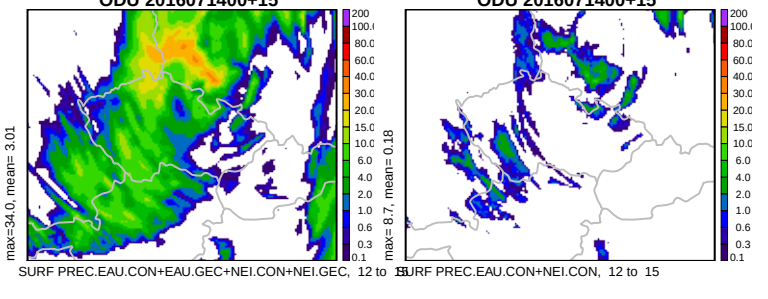

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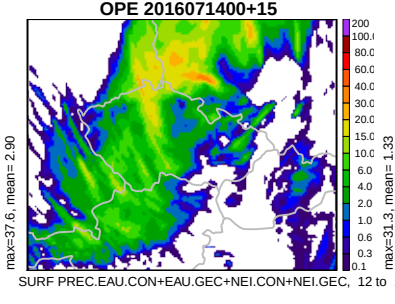

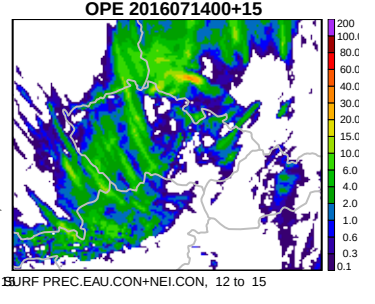

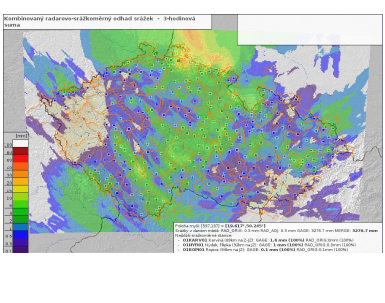

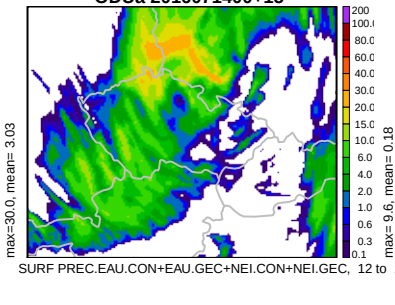

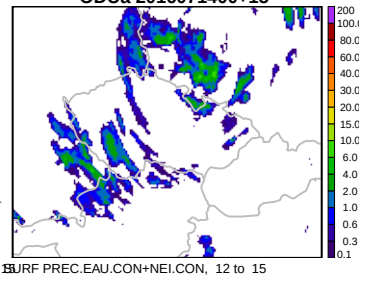

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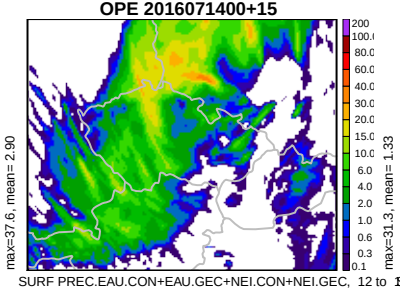

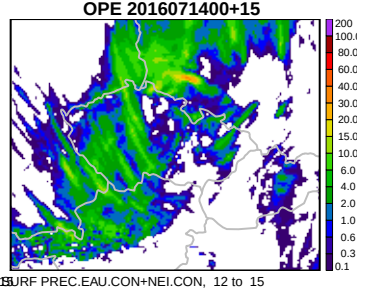

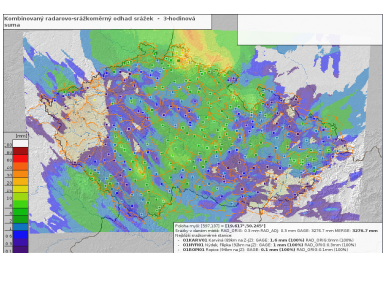

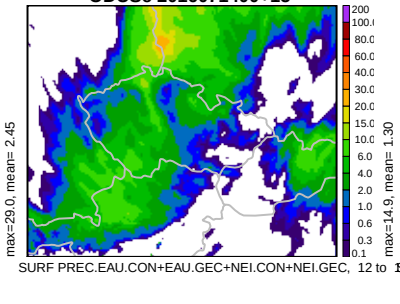

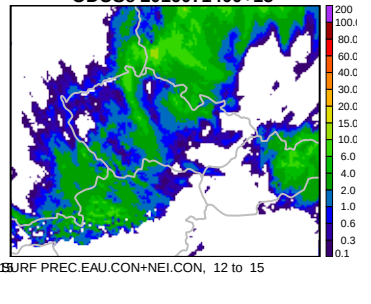

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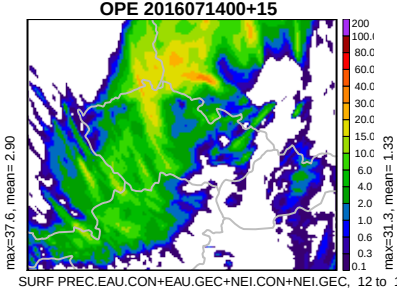

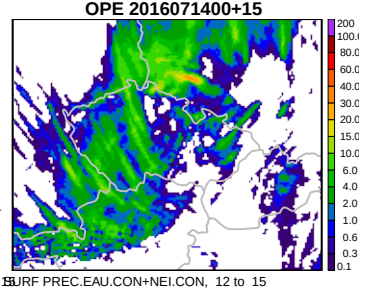

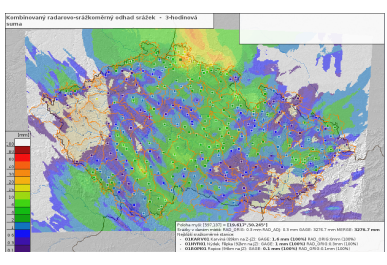

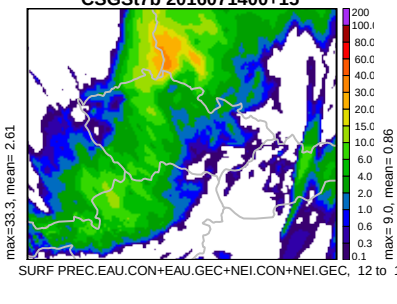

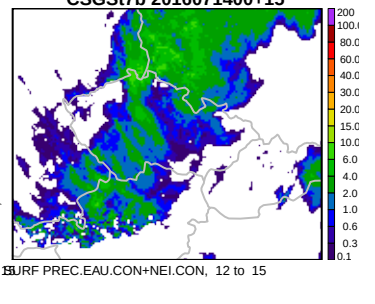

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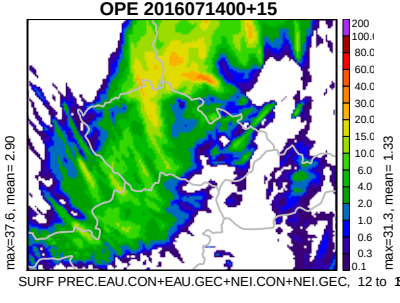

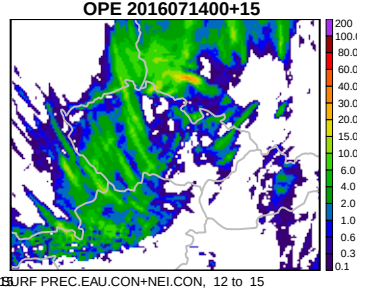

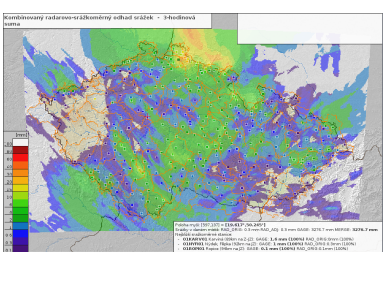

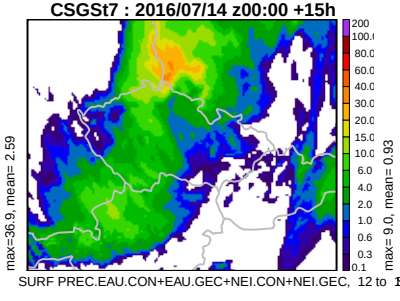

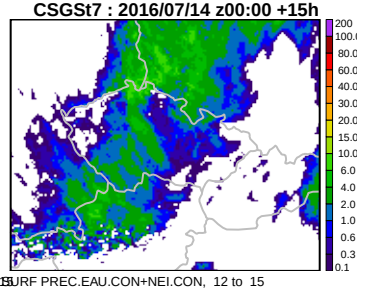

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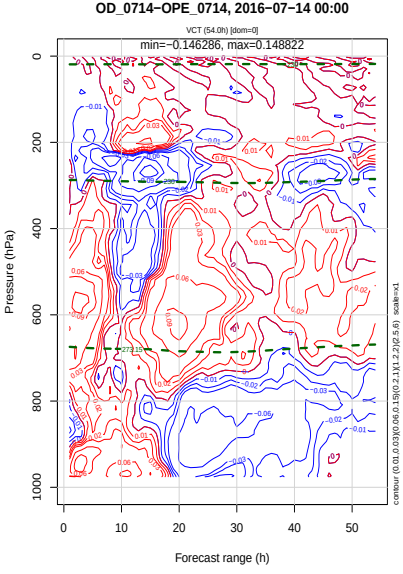

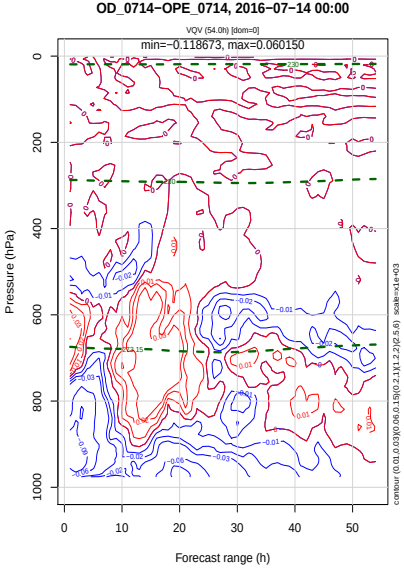

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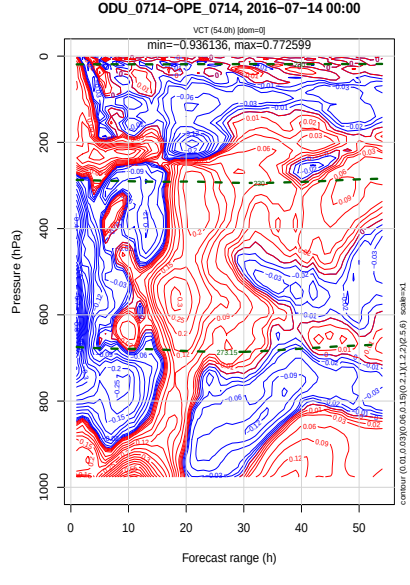

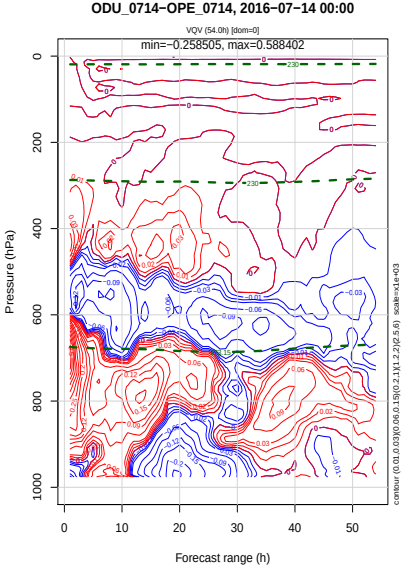

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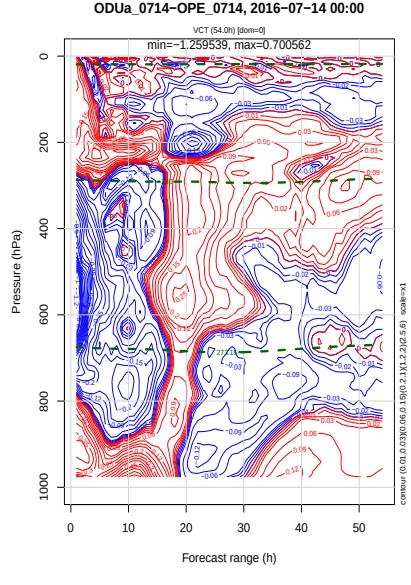
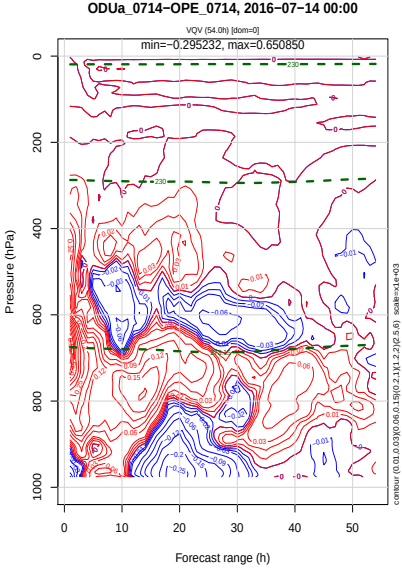
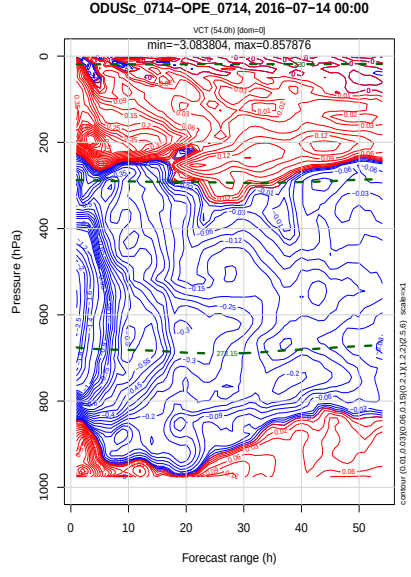


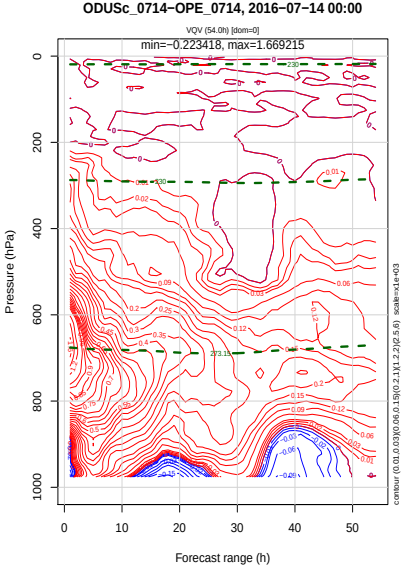


+ Non Saturated Downdraught

+ CSD, RWBF1=100

...Summer 2016



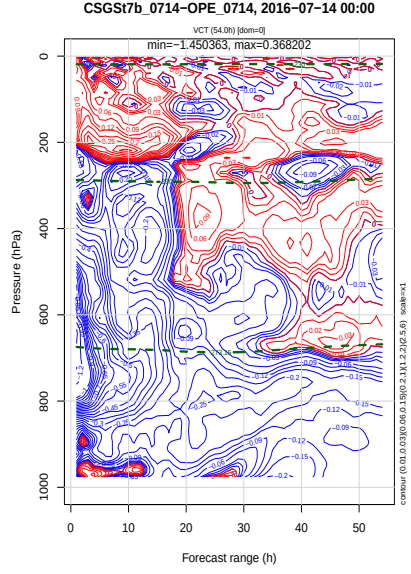


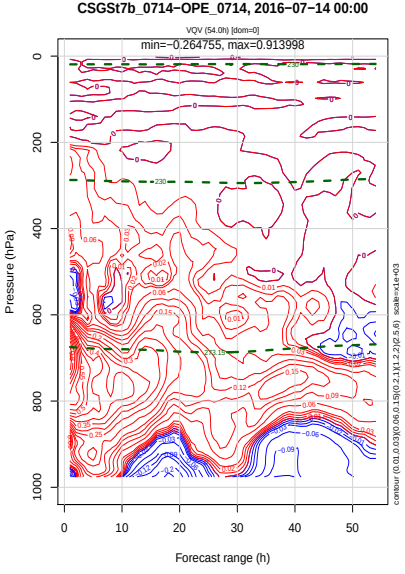
+ Non Saturated Downdraught

+ CSD, RWBF1=100

+LSMGCDEV + N_{sc}+RPHI0

...Summer 2016





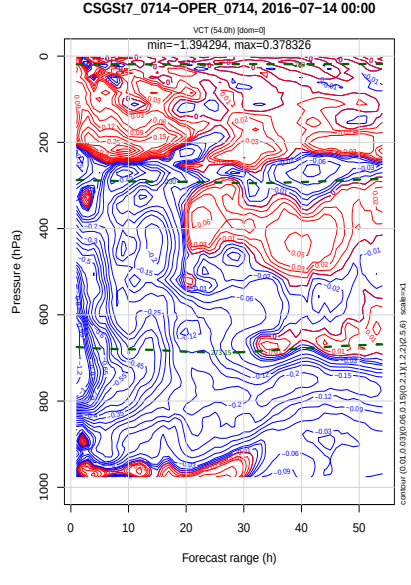
+ Non Saturated Downdraught

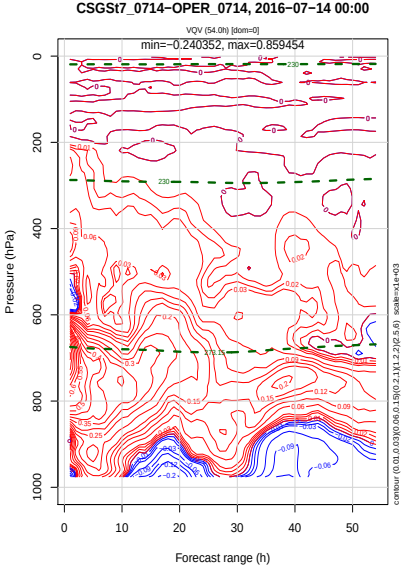
+ CSD, RWBF1=100

+LSMGCDEV + N_{sc}+RPHI0

+LNEB_FP + DC adaptation

...Summer 2016





+ Non Saturated Downdraught

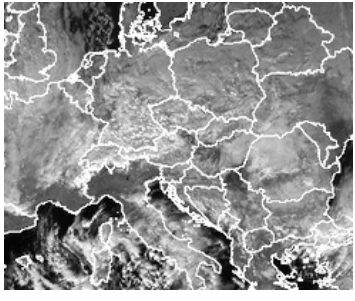
+ CSD, RWBF1=100

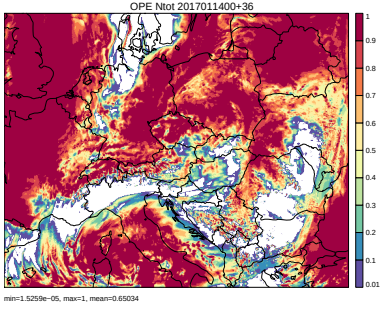
+LSMGCDEV + N_{sc}+RPHI0

+LNEB_FP + DC adaptation

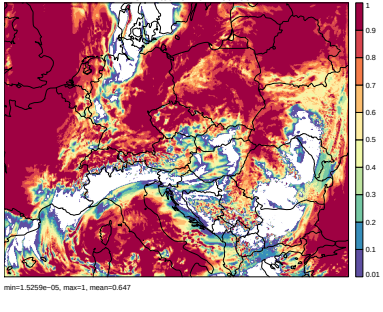
+ Reinforced triggering

Winter 2017

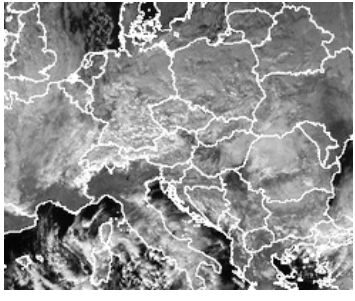


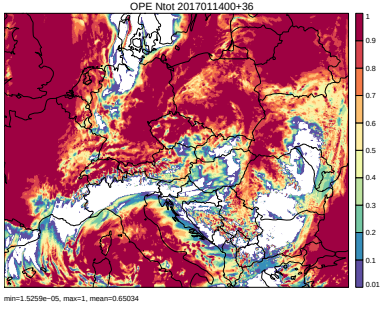


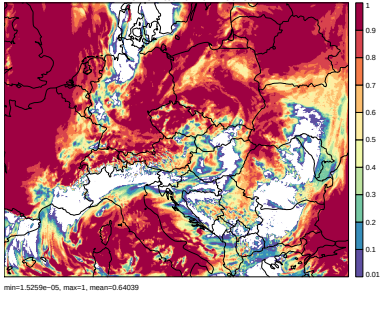
+ Non Saturated Downdraught



Winter 2017



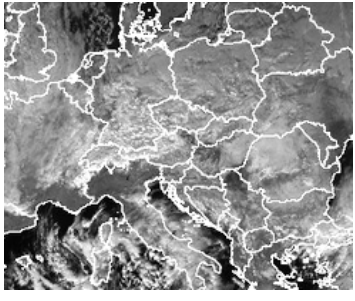


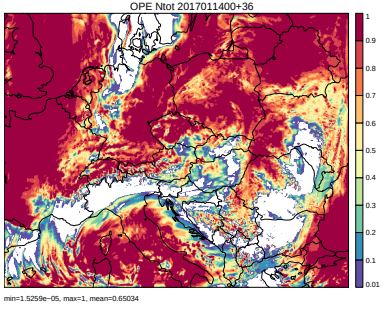


+ Non Saturated Downdraught

+ CSD

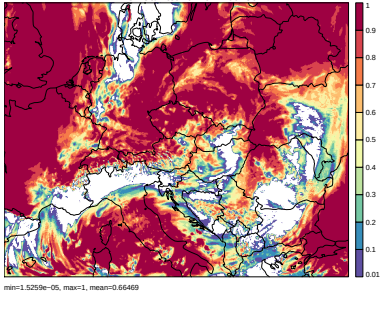
Winter 2017



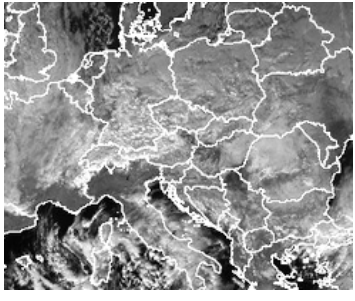


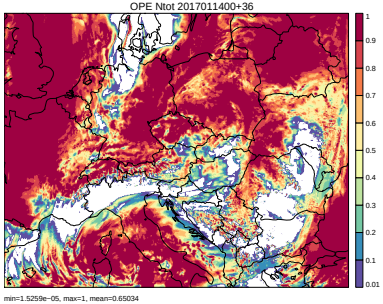
+ Non Saturated Downdraught

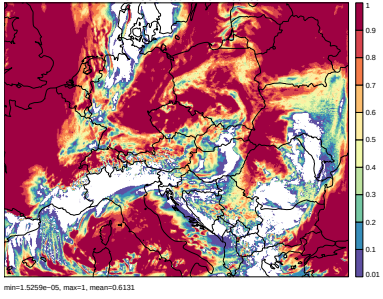
+ CSD, RWBF1=100



Winter 2017





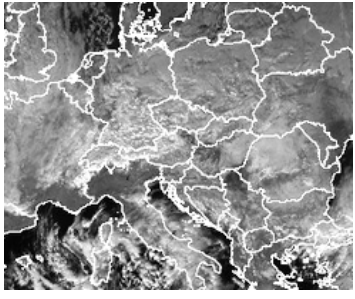


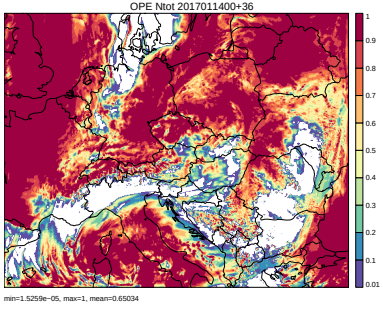
+ Non Saturated Downdraught

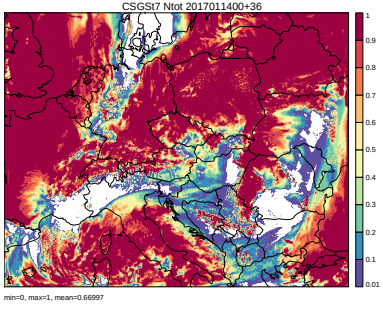
+ CSD, RWBF1=100

+LSMGCDEV + N_{sc}+RPHI0

Winter 2017



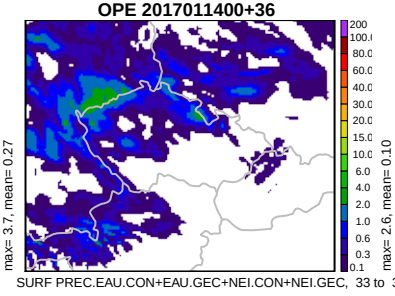




+ Non Saturated Downdraught
+ CSD, RWBF1=100
+LSMGCDEV + N_{sc}+RPHI0

+LNEB_FP + DC adaptation
+ Reinforced triggering

Winter 2017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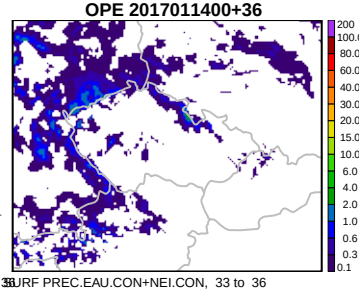
10.0
6.0
4.0
2.0
1.0
0.6
0.3
0.1
max= 3.7, mean= 0.27
SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36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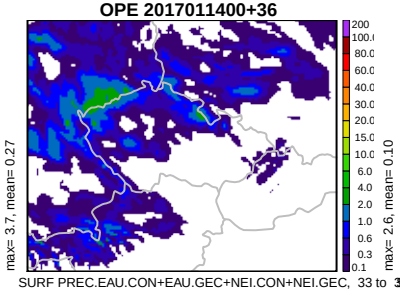
SURF PREC.EAU.CON+NEI.CON, 33 to 36

Winter 2017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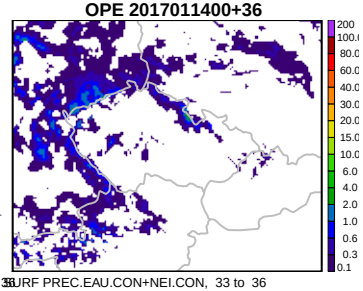
SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36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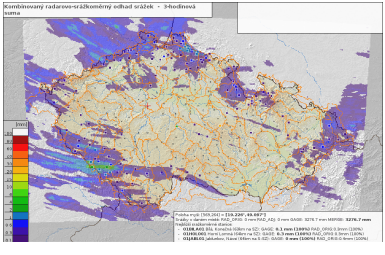
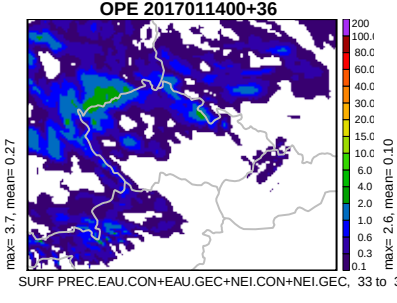
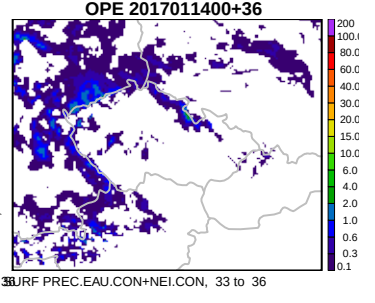
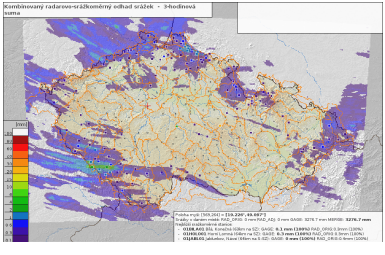
SURF PREC.EAU.CON+NEI.CON, 33 to 36

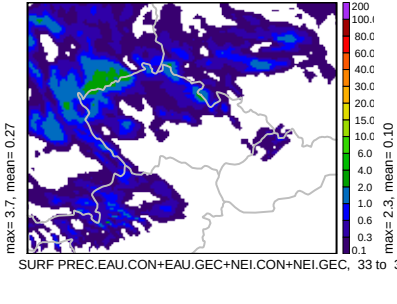

Kombinovaný radarovo-srážkoměrný odhad srážek - 3-hodinová suma

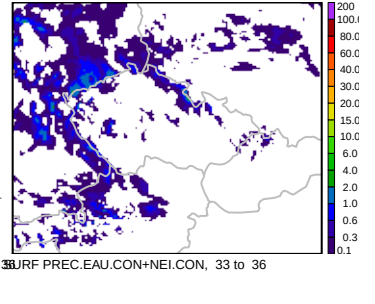
Winter 2017





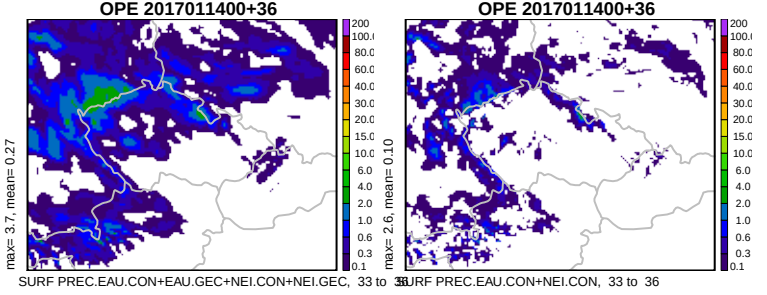


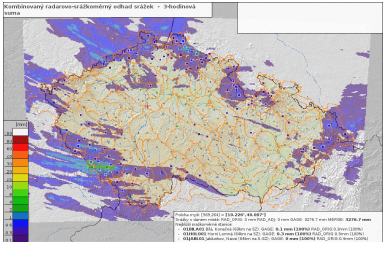


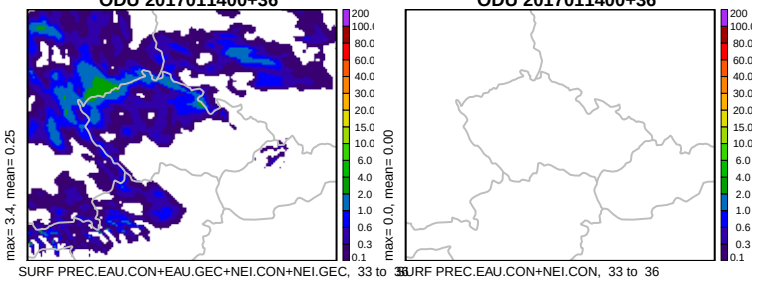


+ Non Saturated Downdraught

Winter 2017



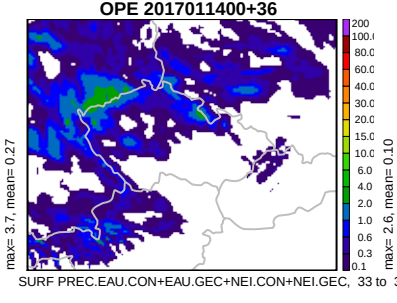


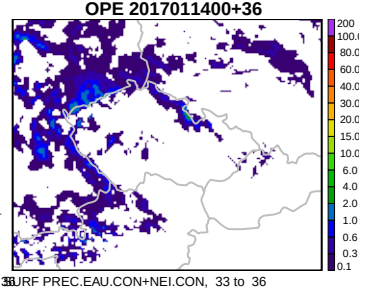


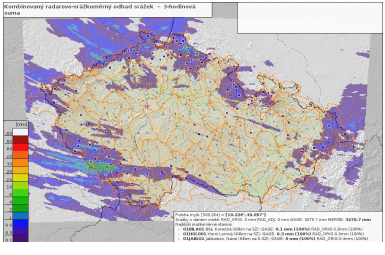
+ Non Saturated Downdraught

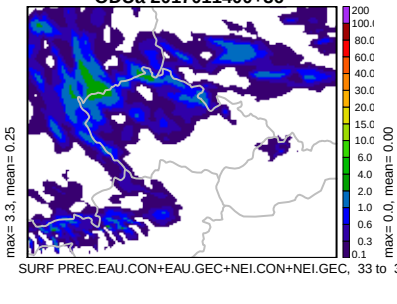
+ CSD

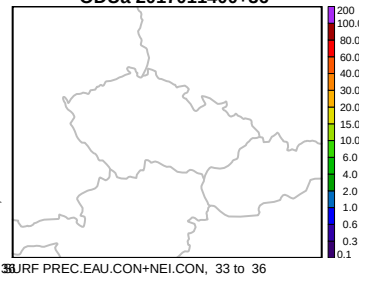
Winter 2017







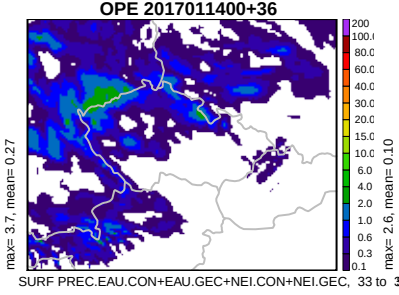


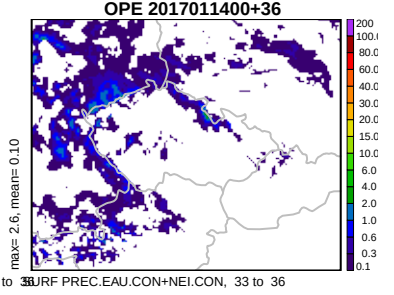


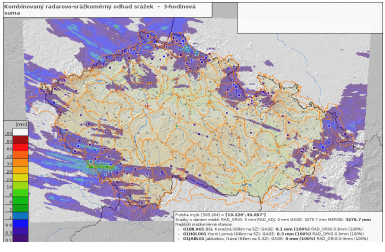
+ Non Saturated Downdraught

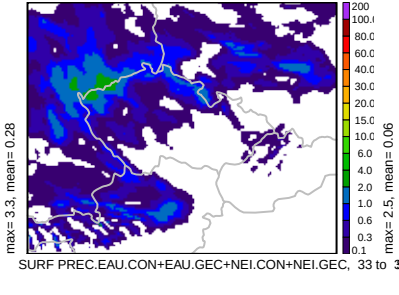
+ CSD, RWBF1=100

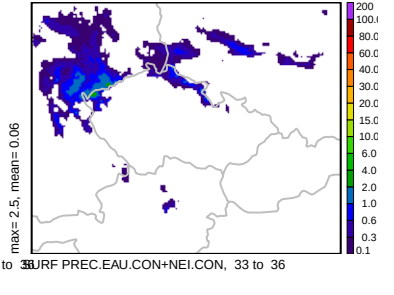
Winter 2017









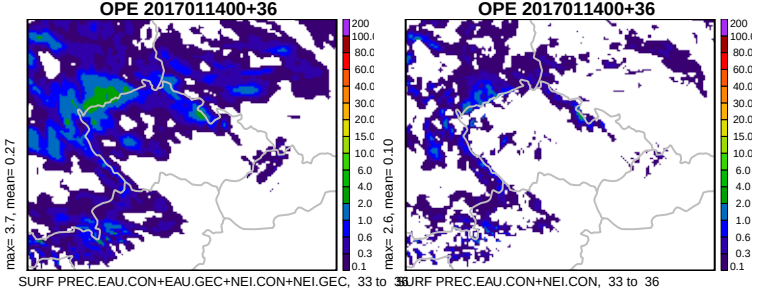


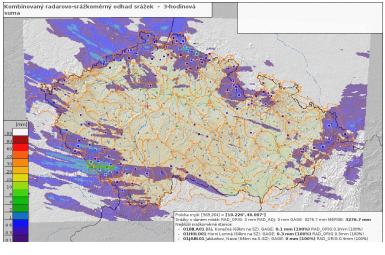
+ Non Saturated Downdraught

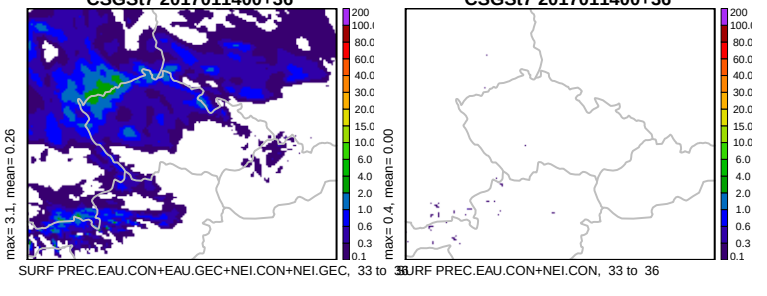
+ CSD, RWBF1=100

+LSMGCDEV + N_{sc}+RPHI0

Winter 2017



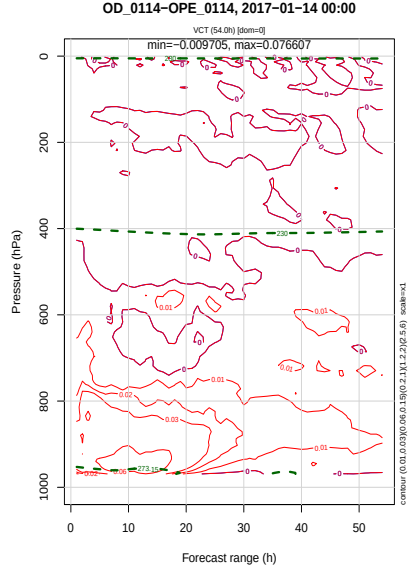


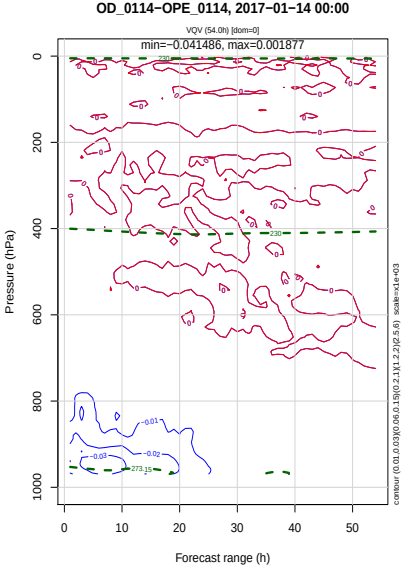


+ Non Saturated Downdraught
+ CSD, RWBF1=100
+LSMGCDEV + N_{sc}+RPHI0

+LNEB_FP + DC adaptation
+ Reinforced triggering

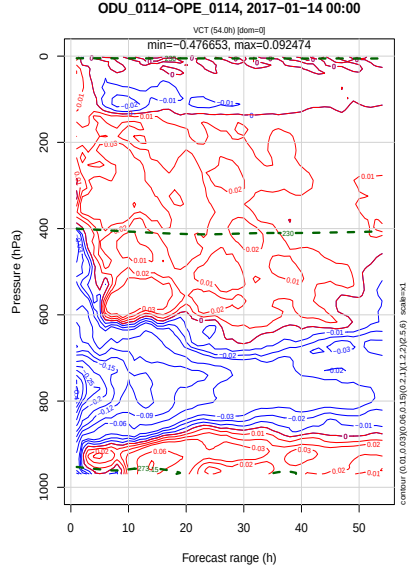
...Winter 2017

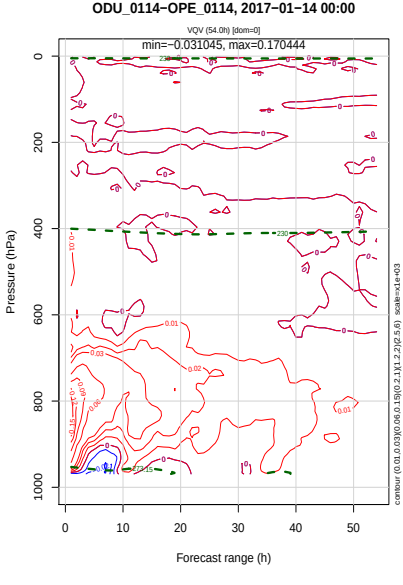




+ Non Saturated Downdraught

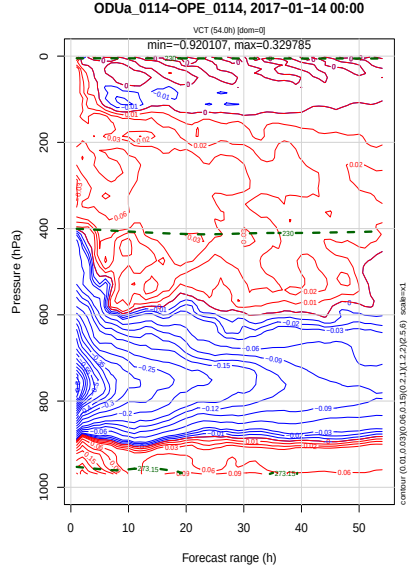
...Winter 2017

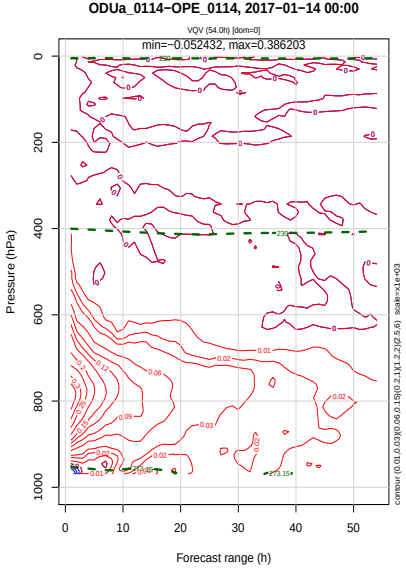




+ Non Saturated Downdraught
+ CSD

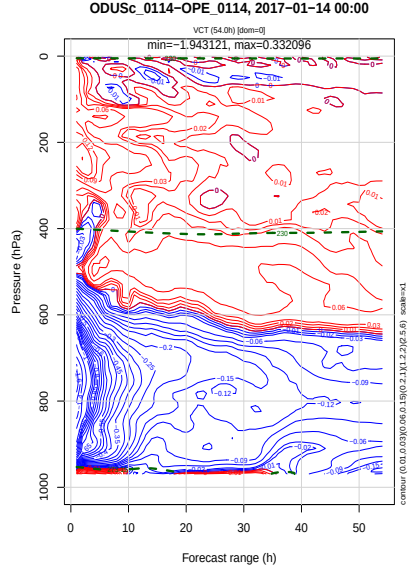
...Winter 2017

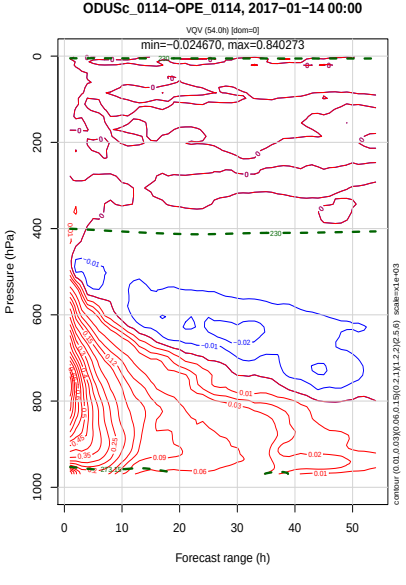




+ Non Saturated Downdraught
+ CSD, RWBF1=100

...Winter 2017



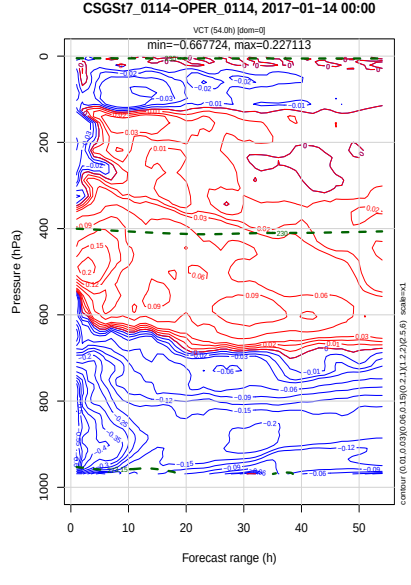


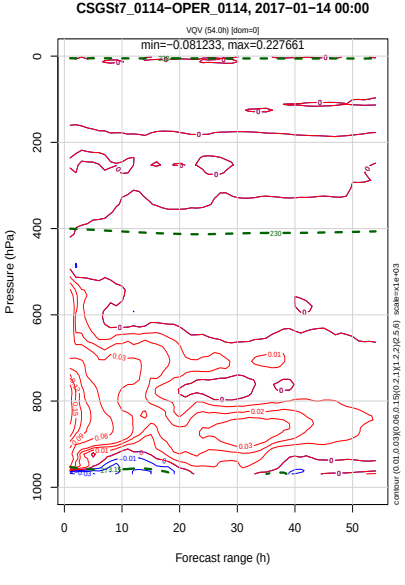
+ Non Saturated Downdraught

+ CSD, RWBF1=100

+LSMGCDEV + N_{sc}+RPHI0

...Winter 2017





+ Non Saturated Downdraught
+ CSD, RWBF1=100
+LSMGCDEV + N_{sc}+RPHI0
+LNEB_FP + DC adaptation
+ Reinforced triggering

Further on...

- CSD revision for strong convection cases:
  - more triggering did seem to improve
  - enhancing other interactions: assessment of subgrid transport
- Deeper insights into the mixed phase
- Further feedbacks on microphysics
- Density currents, cold pools