

# 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 ( $\omega_u^\diamond$ ,  $\sigma_u$ ,  $\sigma_D$ , 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,

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

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

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

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

( $\sigma_{CA}$  is mesh fraction from cellular automaton).

## Triggering methods (II)

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

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

- Relative Humidity (Narita & Ohmori 2007)

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

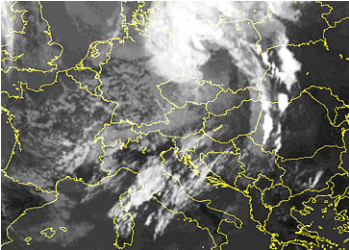
## Interaction with mean grid box

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

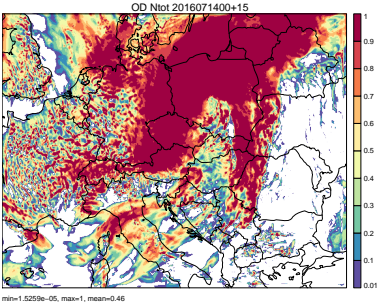
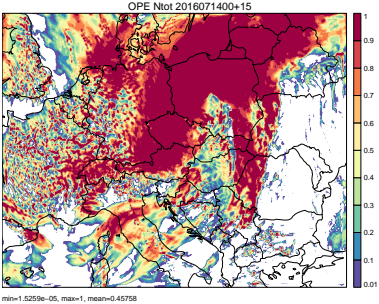
$$\xi = \max\left[0, \frac{(-\bar{\omega} - \sigma_u \omega_u^\diamond - \omega_n)}{\omega_r}\right]$$

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

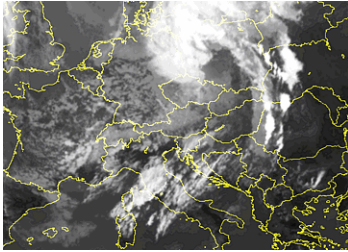
# Summer 2016



+ Non Saturated Downdraught

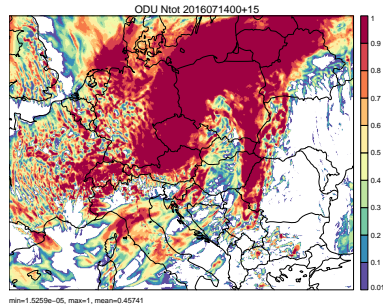
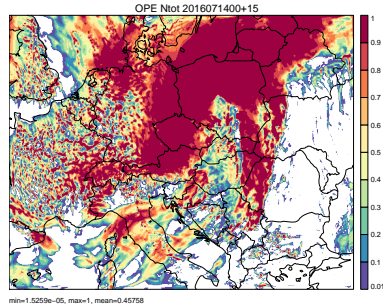


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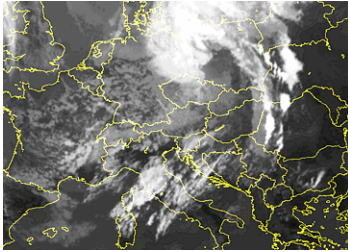


+ Non Saturated Downdraught

+ CSD

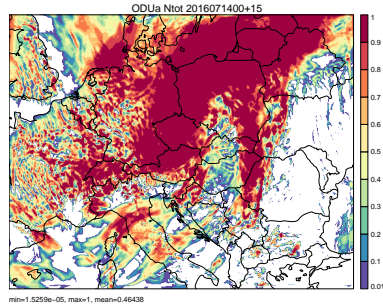
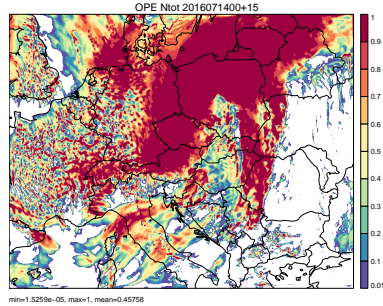


# Summer 2016



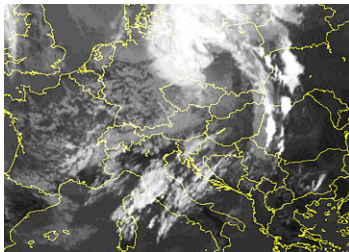
+ Non Saturated Downdraught

+ CSD, RWBF1=100

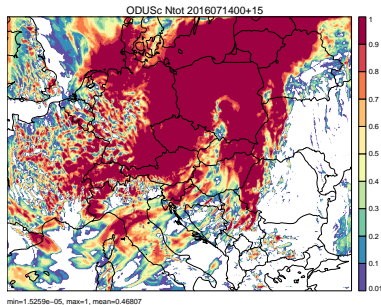
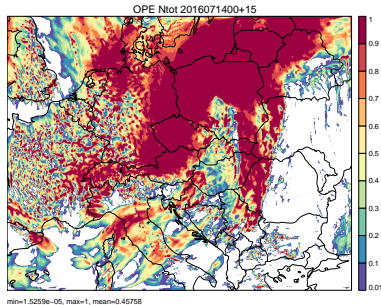




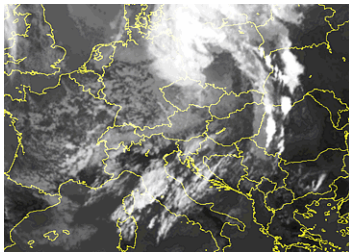
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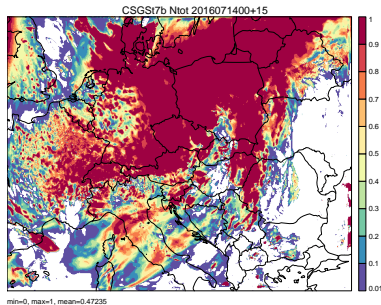
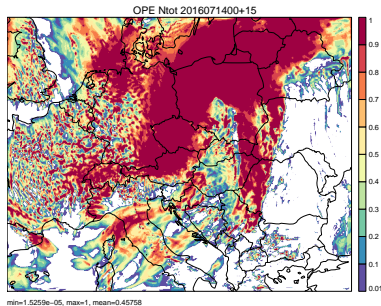
- + Non Saturated Downdraught
- + CSD, RWBF1=100
- +LSMGCDEV +  $N_{sc}$ +RPHI0



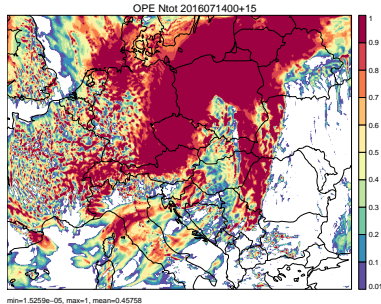
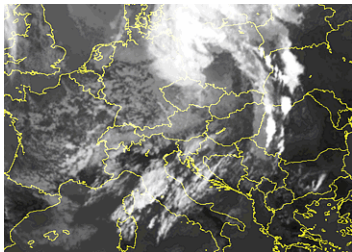
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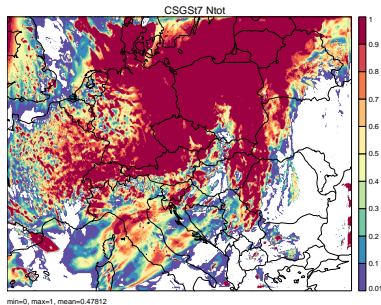
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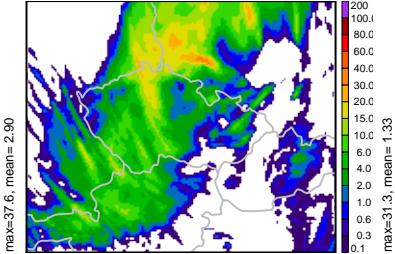


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- +LNEB\_FP + DC adaptation
- + Reinforced triggering

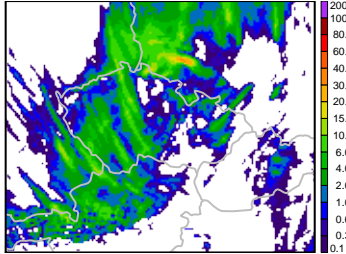


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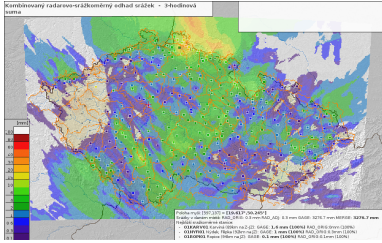
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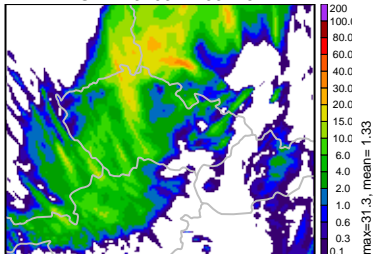


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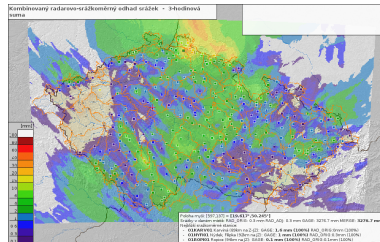
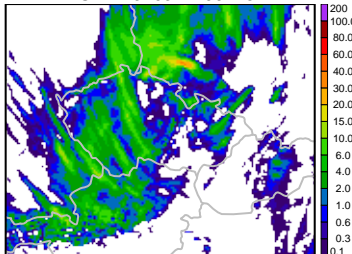
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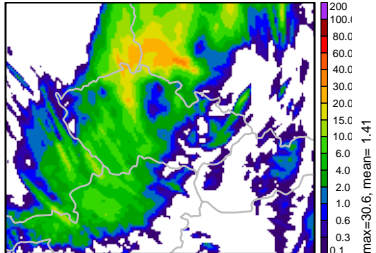


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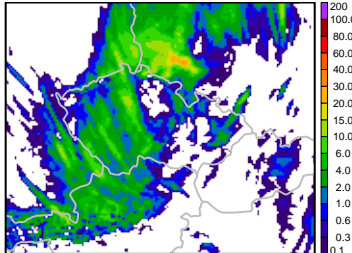


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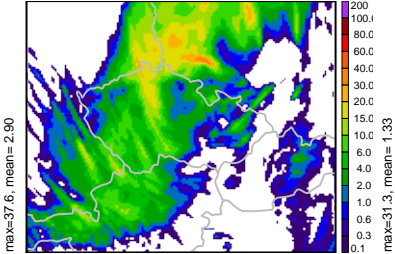
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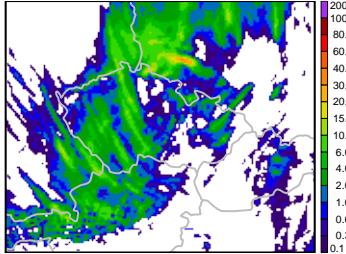
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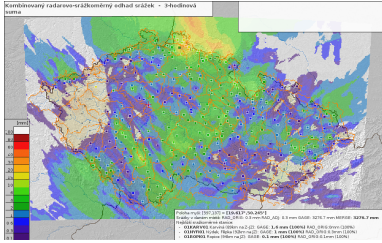


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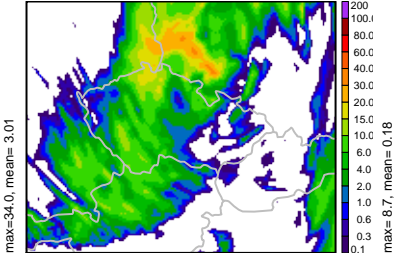
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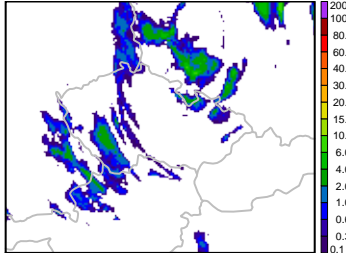


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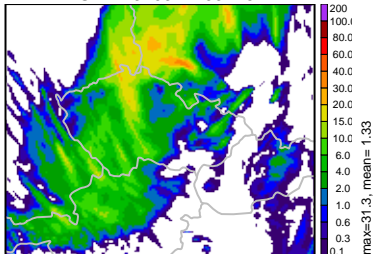


SURF PREC.EAU.CON+NEI.CON, 12 to 15

+ Non Saturated Downdraught  
+ CSD

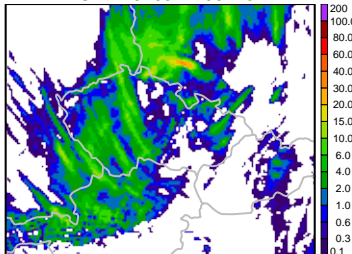
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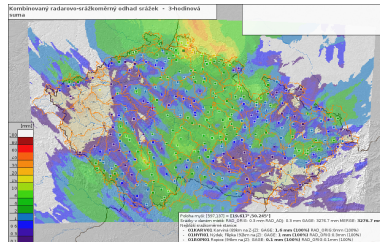


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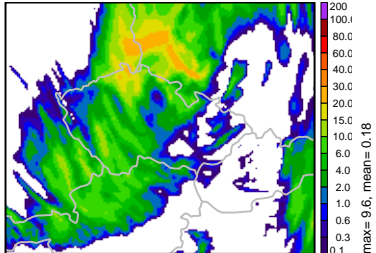
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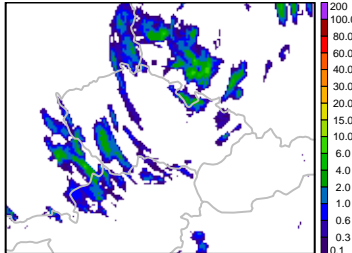


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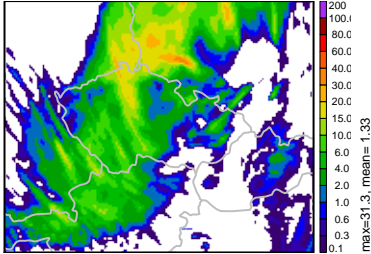
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+ Non Saturated Downdraught

+ CSD, RWBF1=100

# Summer 2016

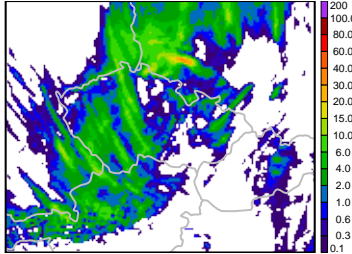
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max=37.6, mean=2.90

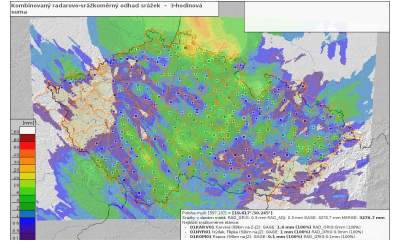
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max=31.3, mean=1.33

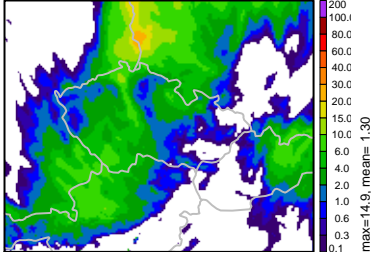
SURF PREC.EAU.CON+NEI.CON, 12 to 15



Kartákový radarový odhad srážek - 3 hodnota  
maxima

Podoba vyhledání: 14.07.2016 11:04:37 (24.08.2016)  
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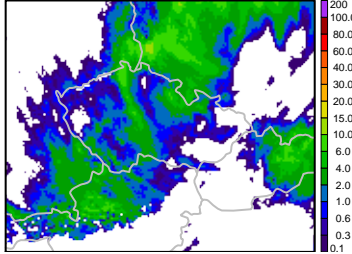
ODUSc 2016071400+15



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ODUSc 2016071400+15



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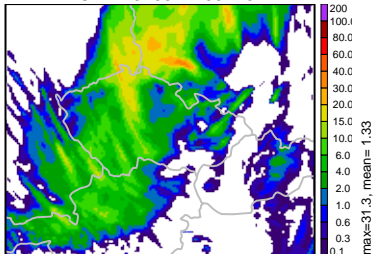
SURF PREC.EAU.CON+NEI.CON, 12 to 15

- + Non Saturated Downdraught
- + CSD, RWBF1=100
- + LSMGCDEV +  $N_{sc}$  + RPH10



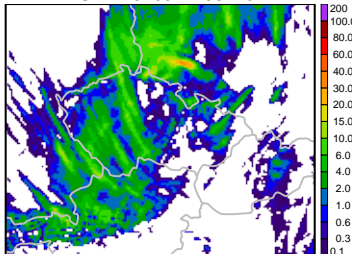
# Summer 2016

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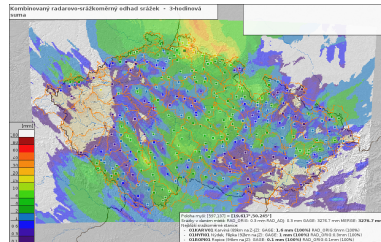


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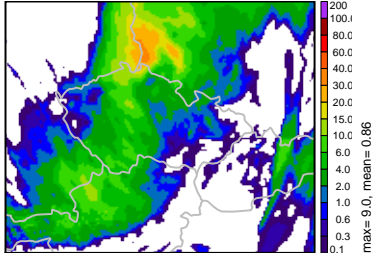
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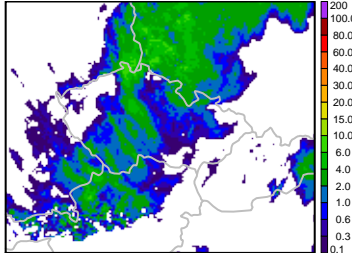


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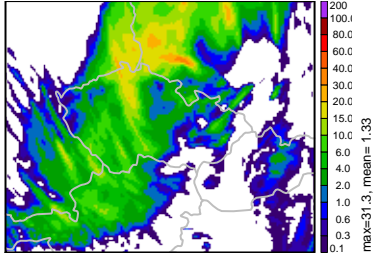


SURF PREC.EAU.CON+NEI.CON, 12 to 15

- + Non Saturated Downdraught
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- +LSMGCDEV +  $N_{sc}$ +RPHI0
- +LNEB\_FP + DC adaptation

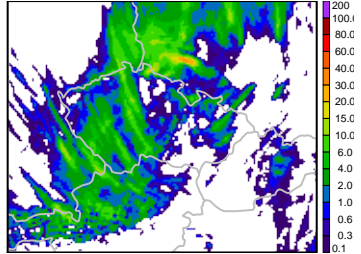
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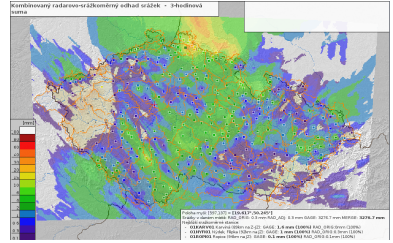


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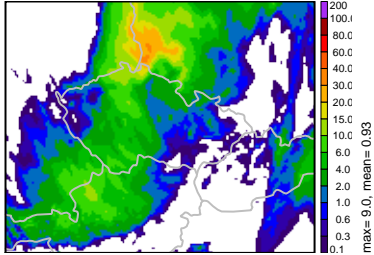
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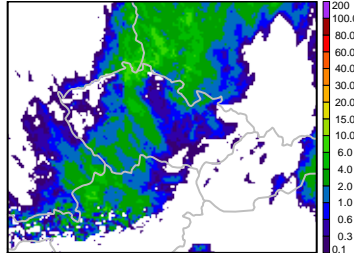


CSGS7 : 2016/07/14 z00:00 +15h



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CSGS7 : 2016/07/14 z00:00 +15h

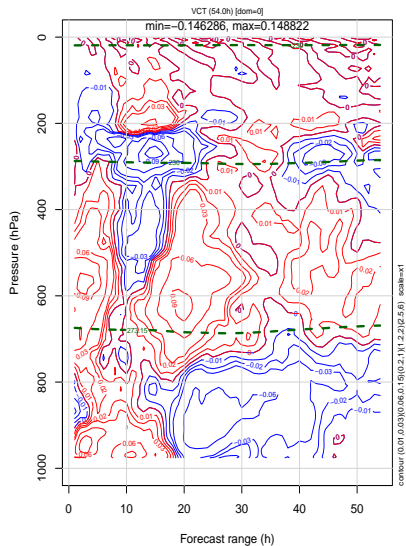


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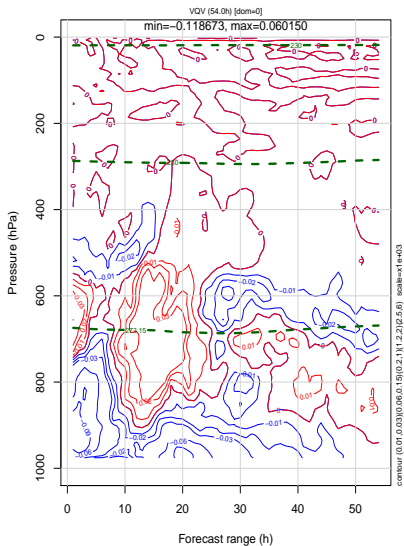
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- + Reinforced triggering

# ...Summer 2016

OD\_0714-OPE\_0714, 2016-07-14 00:00



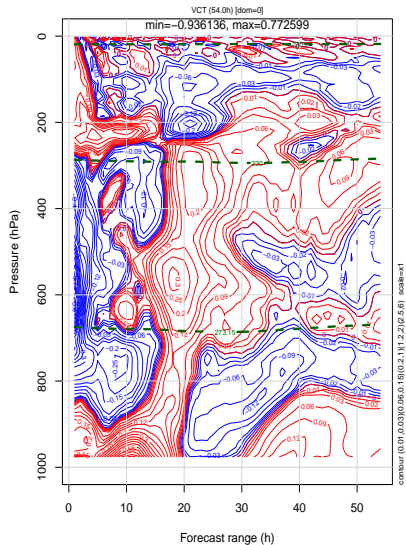
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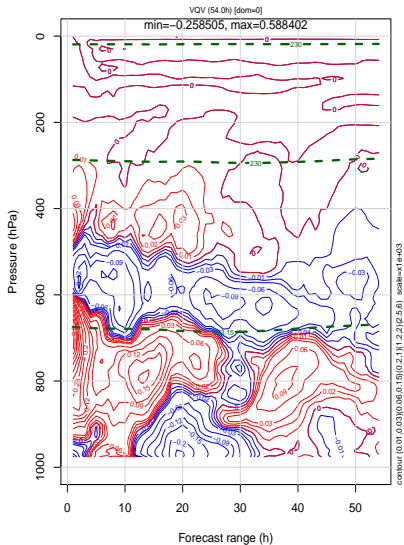
+ Non Saturated Downdraught

# ...Summer 2016

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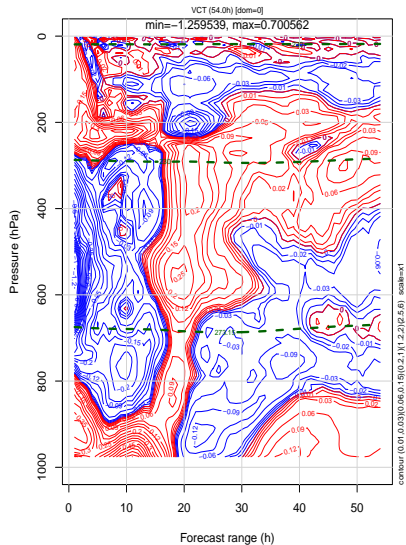
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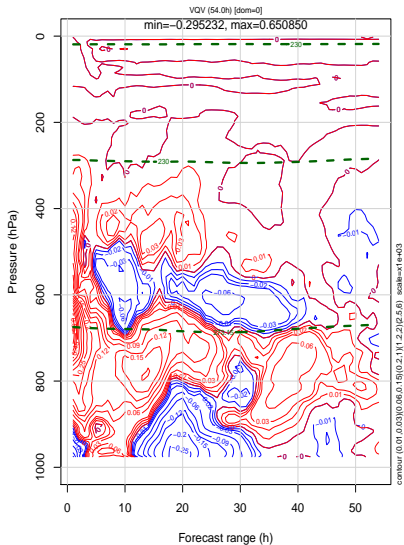
+ Non Saturated Downdraught  
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# ...Summer 2016

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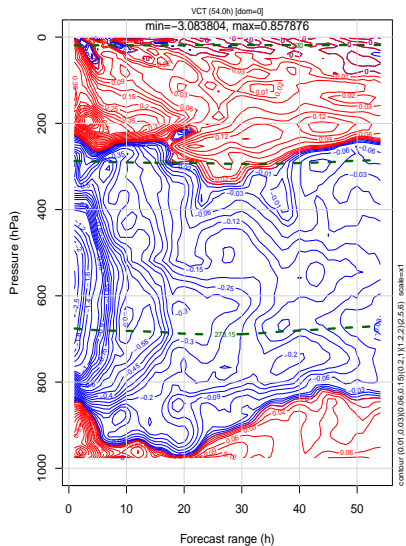
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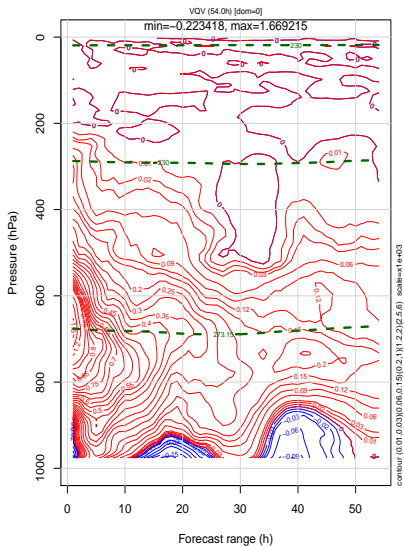
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# ...Summer 2016

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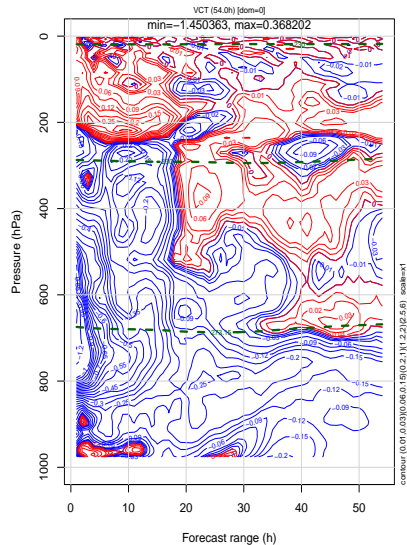


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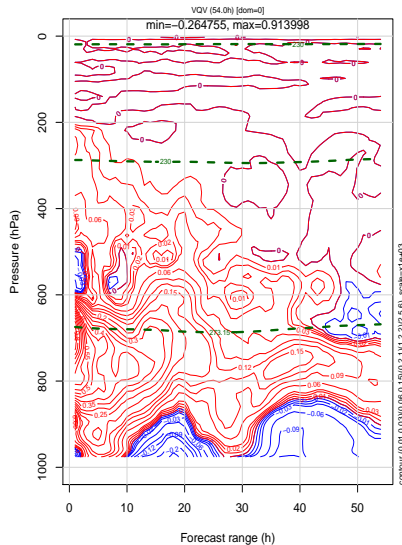


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CSGSt7b\_0714-OPE\_0714, 2016-07-14 00:00



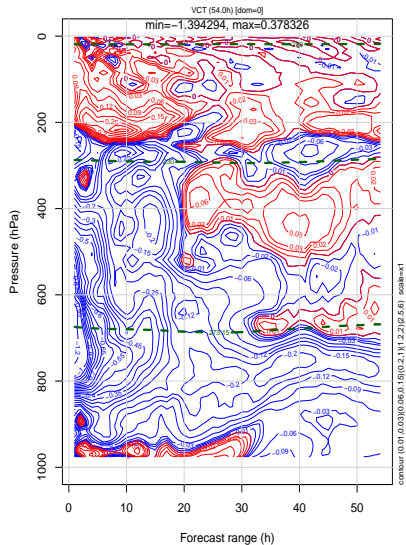
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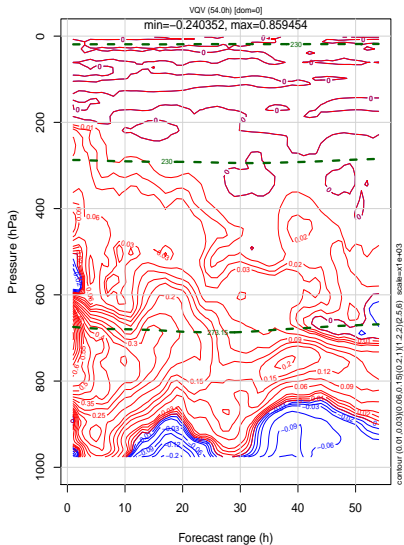
- + Non Saturated Downdraught
- + CSD, RWBF1=100
- +LSMGCDEV +  $N_{sc}$ +RPH10
- +LNEB\_FP + DC adaptation

# ...Summer 2016

CSGSt7\_0714-OPER\_0714, 2016-07-14 00:00



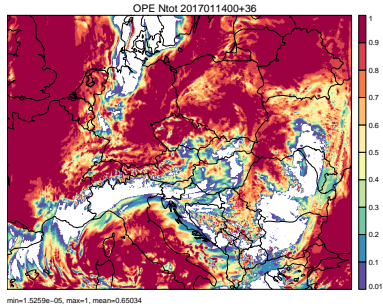
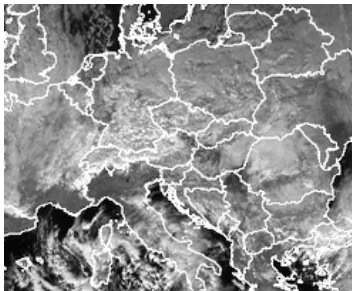
CSGSt7\_0714-OPER\_0714, 2016-07-14 00:00



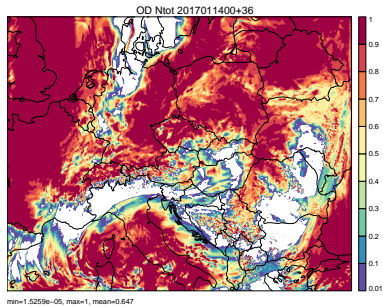
- + Non Saturated Downdraught
- + CSD, RWBF1=100
- + LSMGCDEV +  $N_{sc}$  + RPH10
- + LNEB\_FP + DC adaptation
- + Reinforced triggering



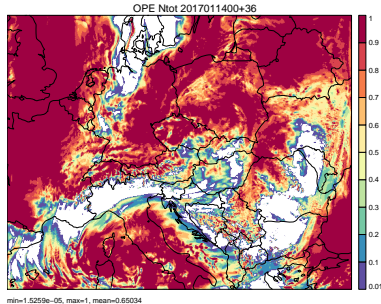
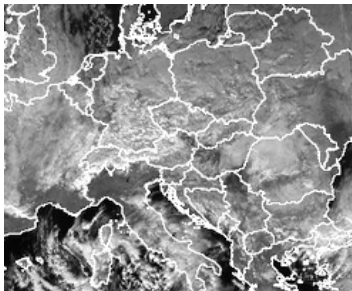
# Winter 2017



+ Non Saturated Downdraught

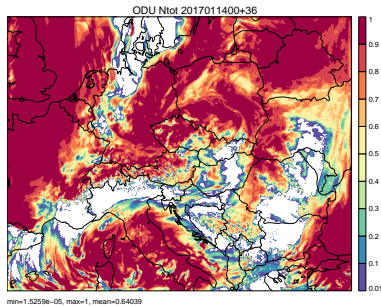


# Winter 2017

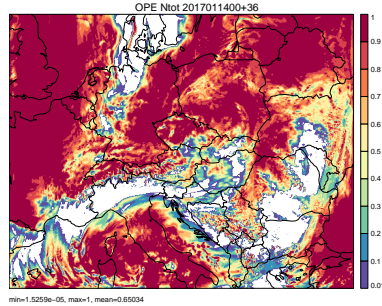


+ Non Saturated Downdraught

+ CSD

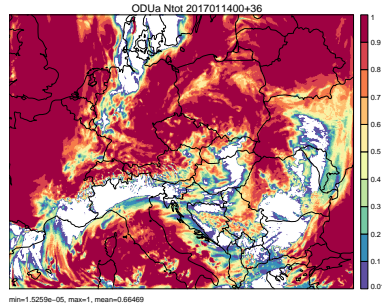


# Winter 2017

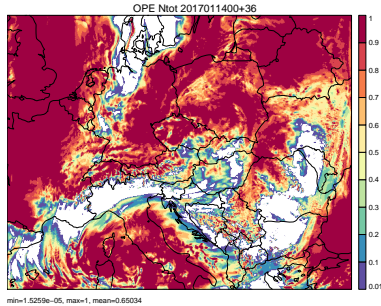
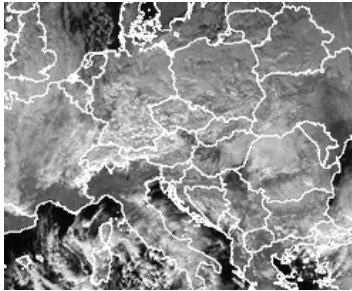


+ Non Saturated Downdraught

+ CSD, RWBF1=100



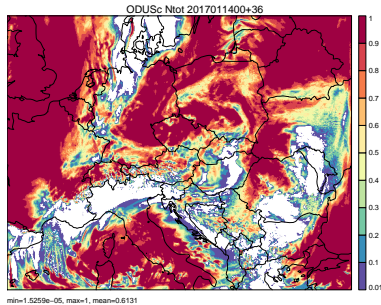
# Winter 2017



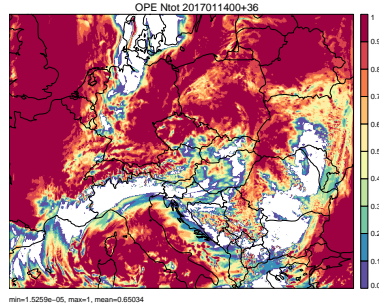
+ Non Saturated Downdraught

+ CSD, RWBF1=100

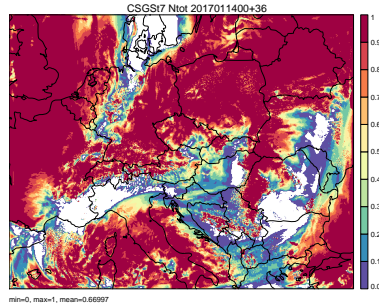
+LSMGCDEV +  $N_{sc}$ +RPHI0



# Winter 2017

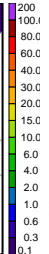
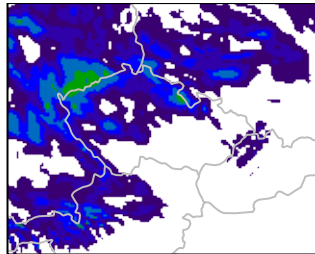


- + Non Saturated Downdraught
- + CSD, RWBF1=100
- +LSMGCDEV +  $N_{sc}$ +RPHI0
  
- +LNEB\_FP + DC adaptation
- + Reinforced triggering

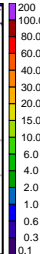
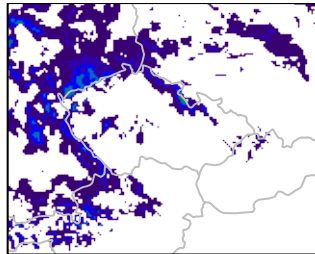


# Winter 2017

OPE 2017011400+36



OPE 2017011400+36



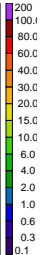
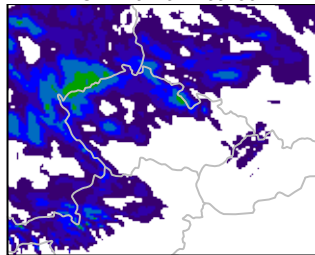
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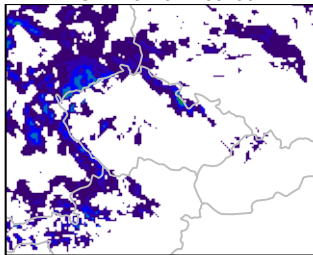
SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 33 SURF PREC.EAU.CON+NEI.CON, 33 to 36

# Winter 2017

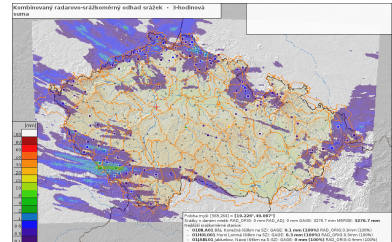
OPE 2017011400+36



OPE 2017011400+36

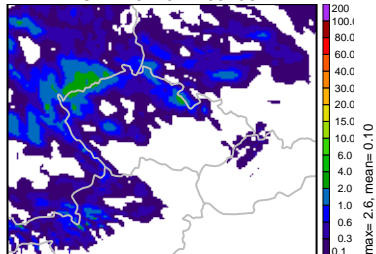


SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36 SURF PREC.EAU.CON+NEI.CON, 33 to 36



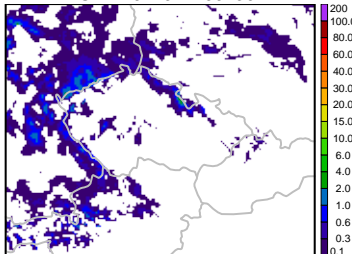
# Winter 2017

**OPE 2017011400+36**

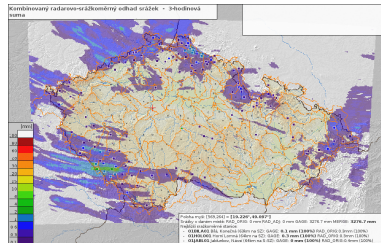


SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36

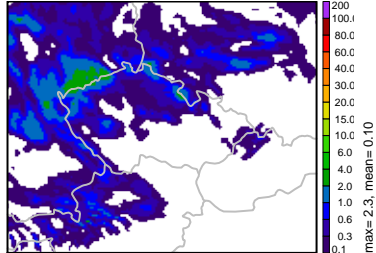
**OPE 2017011400+36**



SURF PREC.EAU.CON+NEI.CON, 33 to 36

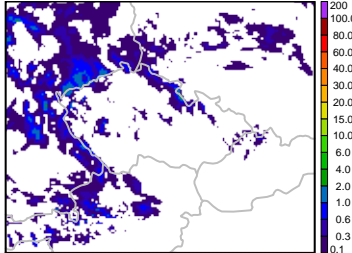


**OD 2017011400+36**



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

**OD 2017011400+36**



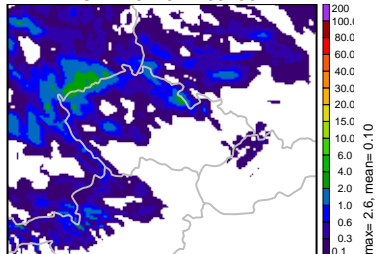
SURF PREC.EAU.CON+NEI.CON, 33 to 36

+ Non Saturated Dnwdraught

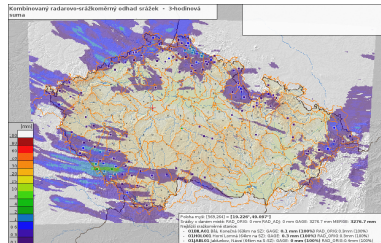
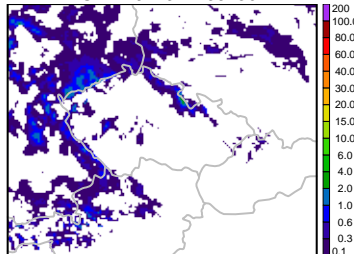


# Winter 2017

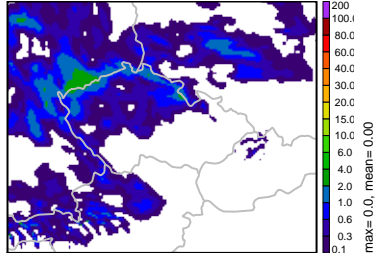
OPE 2017011400+36



OPE 2017011400+36



ODU 2017011400+36



ODU 2017011400+36

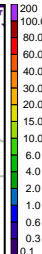
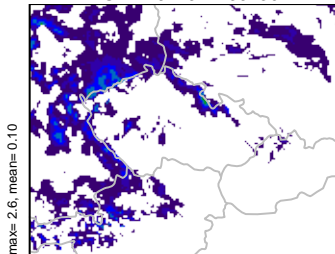
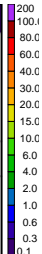
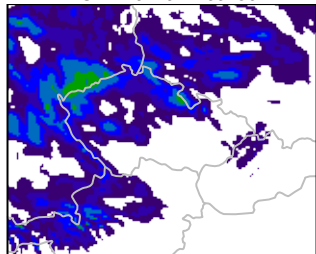


+ Non Saturated Dnwdraught

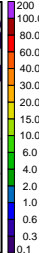
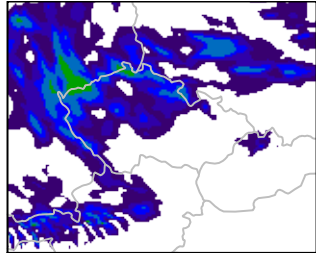
+ CSD

# Winter 2017

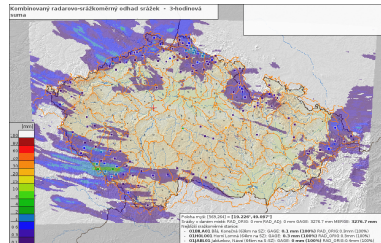
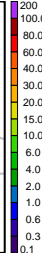
### OPE 2017011400+36



### ODUa 2017011400+36



### ODUa 2017011400+36



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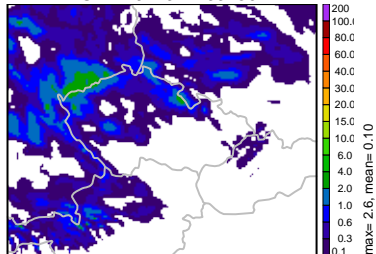
SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36 SURF PREC.EAU.CON+NEI.CON, 33 to 36

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

- + Non Saturated Dnwdraught
- + CSD, RWBF1=100

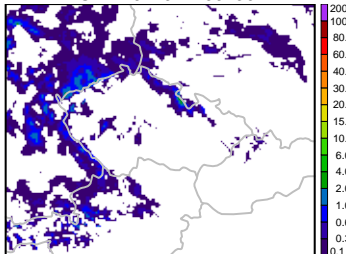
# Winter 2017

OPE 2017011400+36

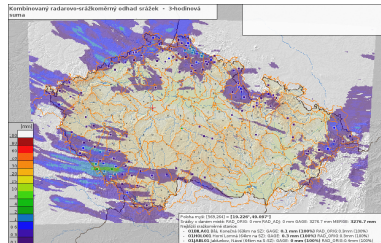


SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36

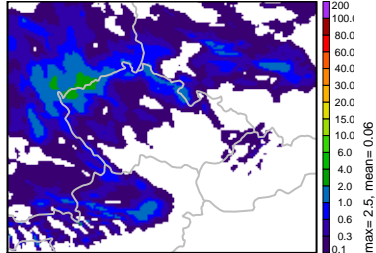
OPE 2017011400+36



SURF PREC.EAU.CON+NEI.CON, 33 to 36

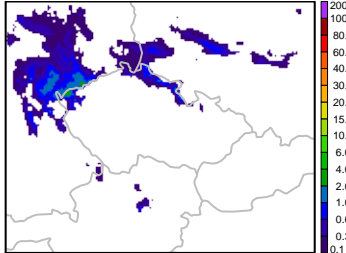


ODUSc 2017011400+36



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

ODUSc 2017011400+36

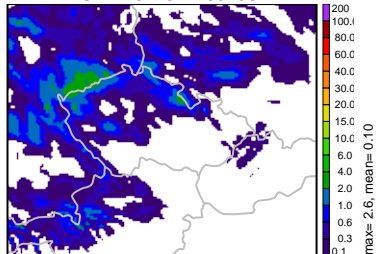


SURF PREC.EAU.CON+NEI.CON, 33 to 36

- + Non Saturated Dnwdraught
- + CSD, RWBF1=100
- + LSMGCDEV +  $N_{sc}$  + RPH10

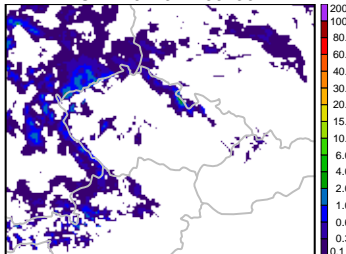
# Winter 2017

OPE 2017011400+36

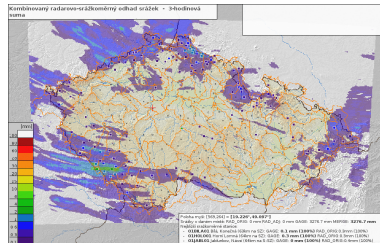


SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 33 to 36

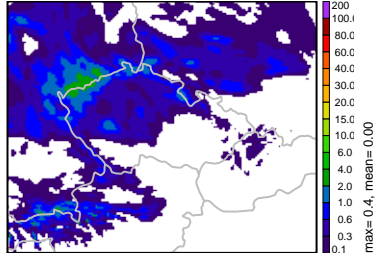
OPE 2017011400+36



SURF PREC.EAU.CON+NEI.CON, 33 to 36

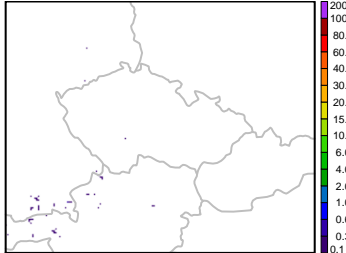


CSGS<sub>t7</sub> 2017011400+36



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

CSGS<sub>t7</sub> 2017011400+36

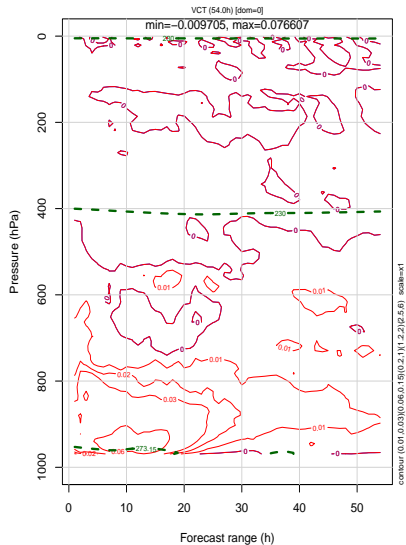


SURF PREC.EAU.CON+NEI.CON, 33 to 36

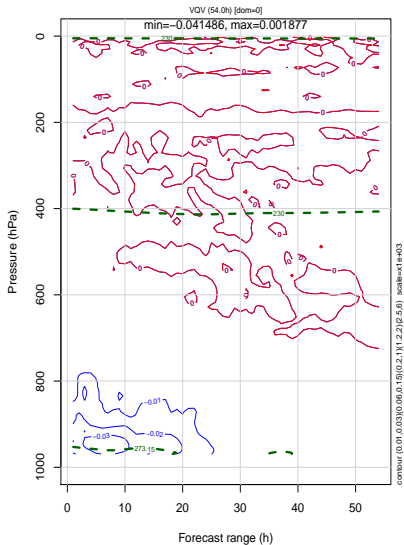
- + Non Saturated Dnwdraught
- + CSD, RWBF1=100
- + LSMGCDEV +  $N_{sc}$  + RPH10
- + LNEB\_FP + DC adaptation
- + Reinforced triggering

# ...Winter 2017

OD\_0114-OPE\_0114, 2017-01-14 00:00



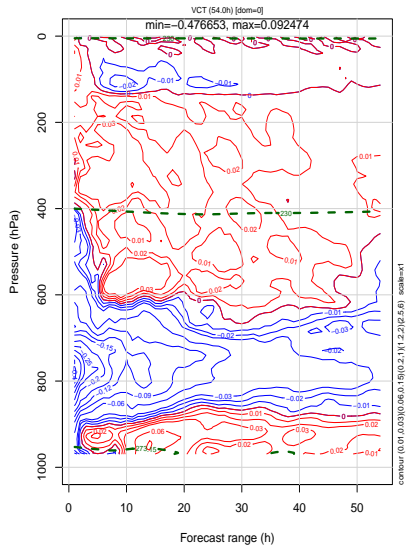
OD\_0114-OPE\_0114, 2017-01-14 00:00



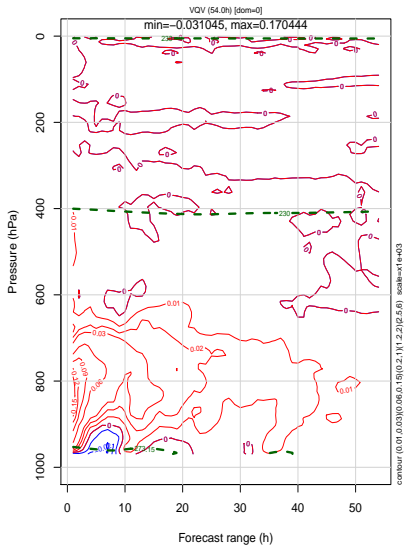
+ Non Saturated Downdraught

# ...Winter 2017

ODU\_0114-OPE\_0114, 2017-01-14 00:00



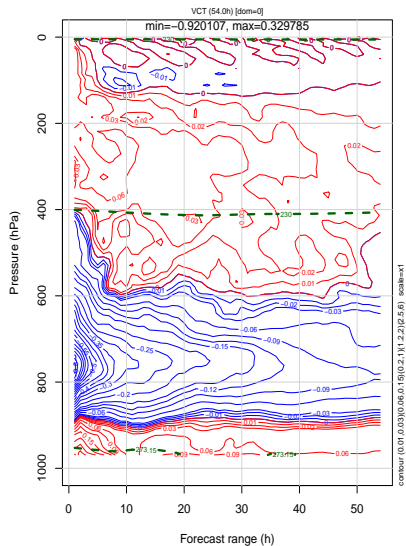
ODU\_0114-OPE\_0114, 2017-01-14 00:00



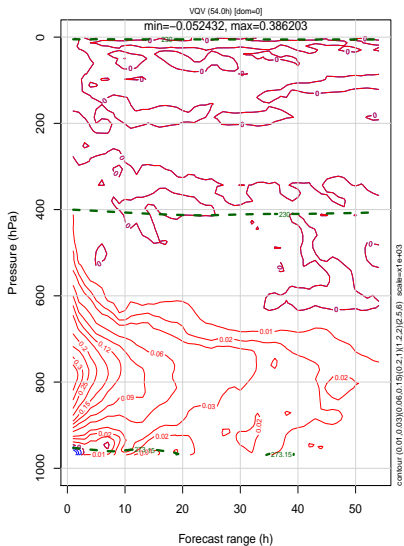
- + Non Saturated Downdraught
- + CSD

# ...Winter 2017

ODUa\_0114-OPE\_0114, 2017-01-14 00:00



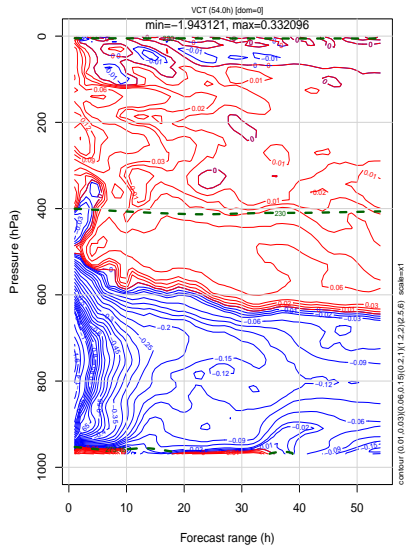
ODUa\_0114-OPE\_0114, 2017-01-14 00:00



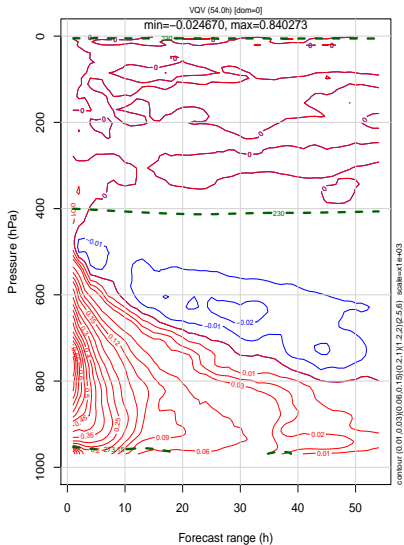
- + Non Saturated Downdraught
- + CSD, RWBF1=100

# ...Winter 2017

ODUSc\_0114-OPE\_0114, 2017-01-14 00:00



ODUSc\_0114-OPE\_0114, 2017-01-14 00:00

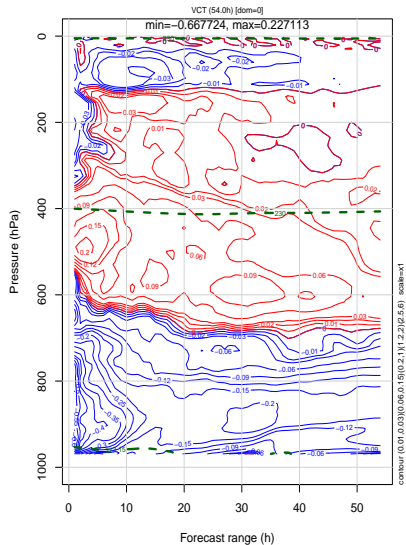


- + Non Saturated Downdraught
- + CSD, RWBF1=100
- +LSMGCDEV +  $N_{sc}$ +RPH10

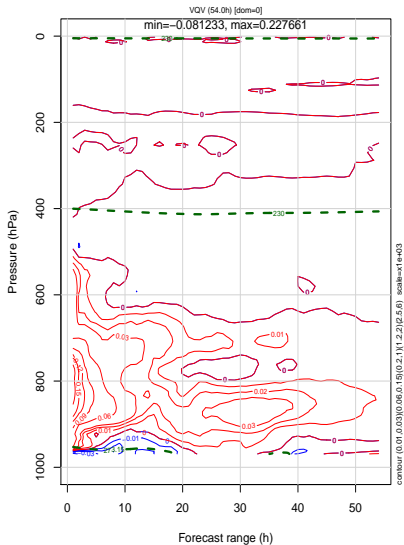


# ...Winter 2017

CSGSt7\_0114-OPER\_0114, 2017-01-14 00:00



CSGSt7\_0114-OPER\_0114, 2017-01-14 00:00



- + Non Saturated Downdraught
- + CSD, RWBF1=100
- + LSMGCDEV +  $N_{sc}$  + RPH10
- + 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