RMI

CSU and convergence towards the ‘all-resolved’ solution

Luc Gerard

13 June 2012

Updraught initiation

When/how and at which level to trigger the updraught ?

Bougeault Ascent:

- progressive, one way
  → very cheap
- quite realistic results
- no control on triggering

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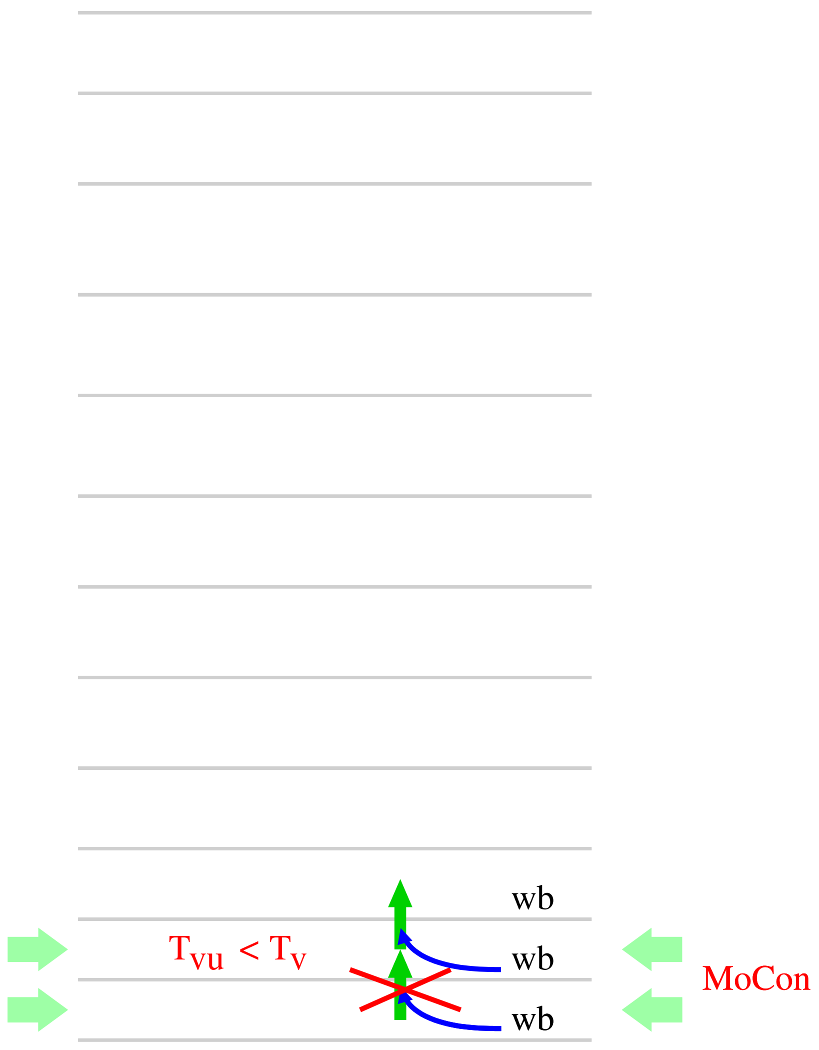

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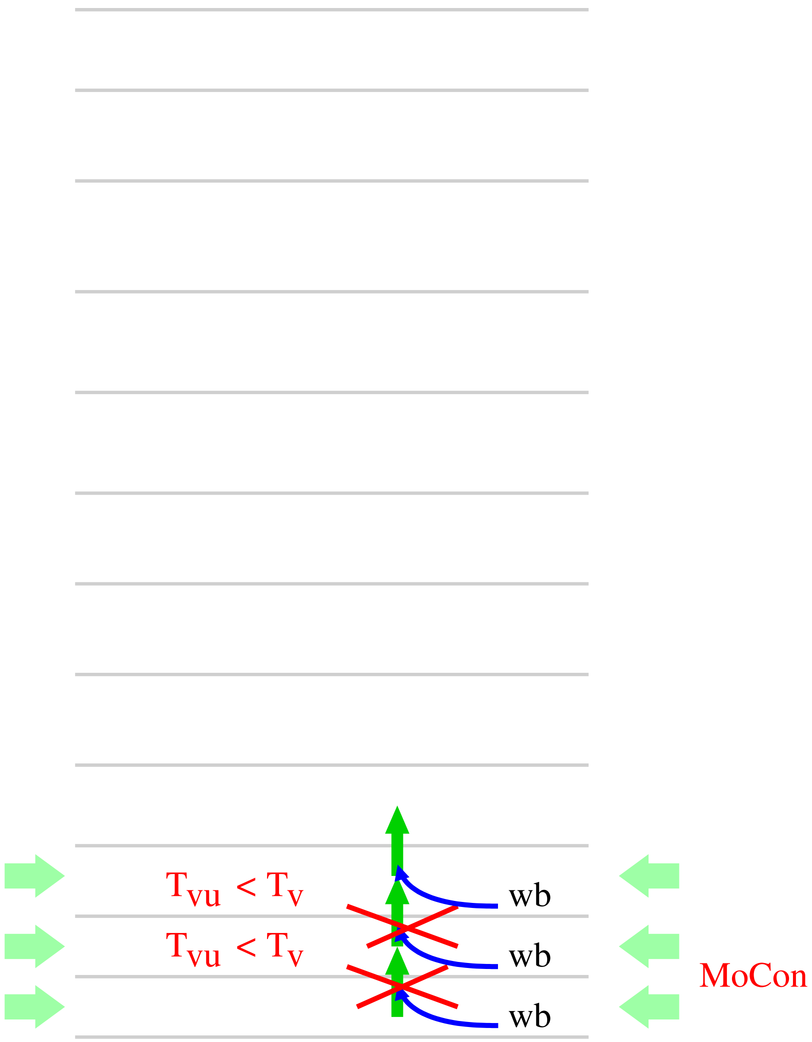

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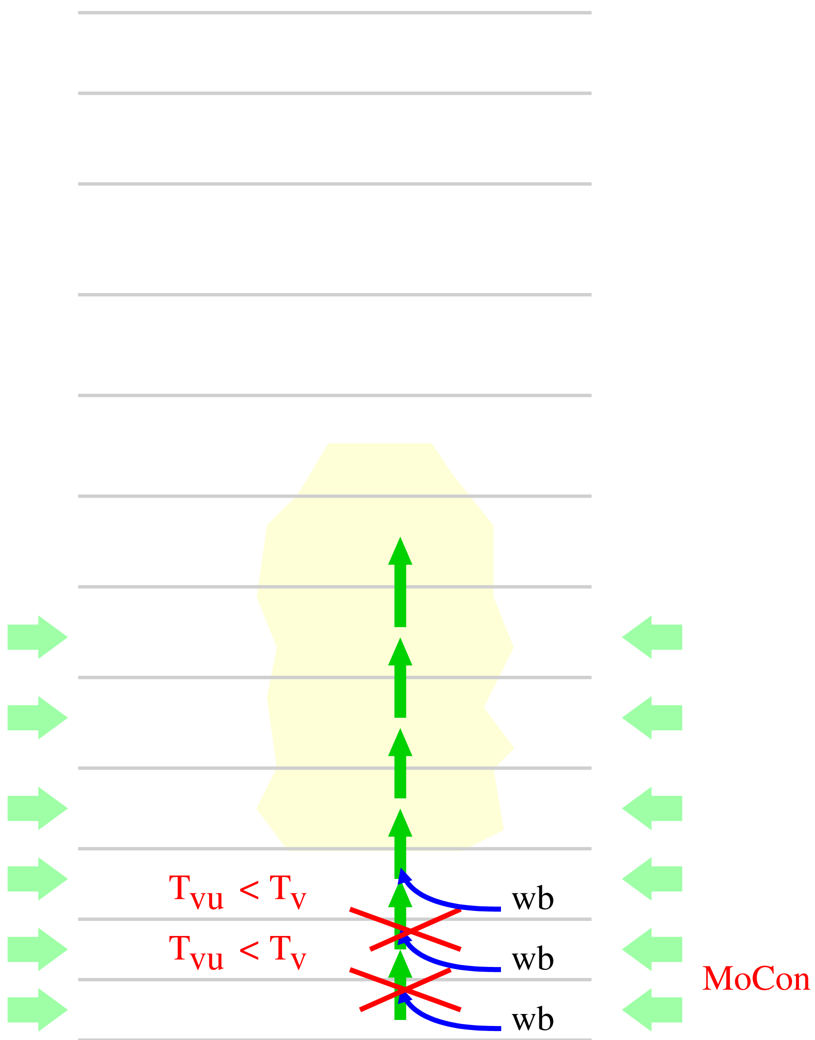

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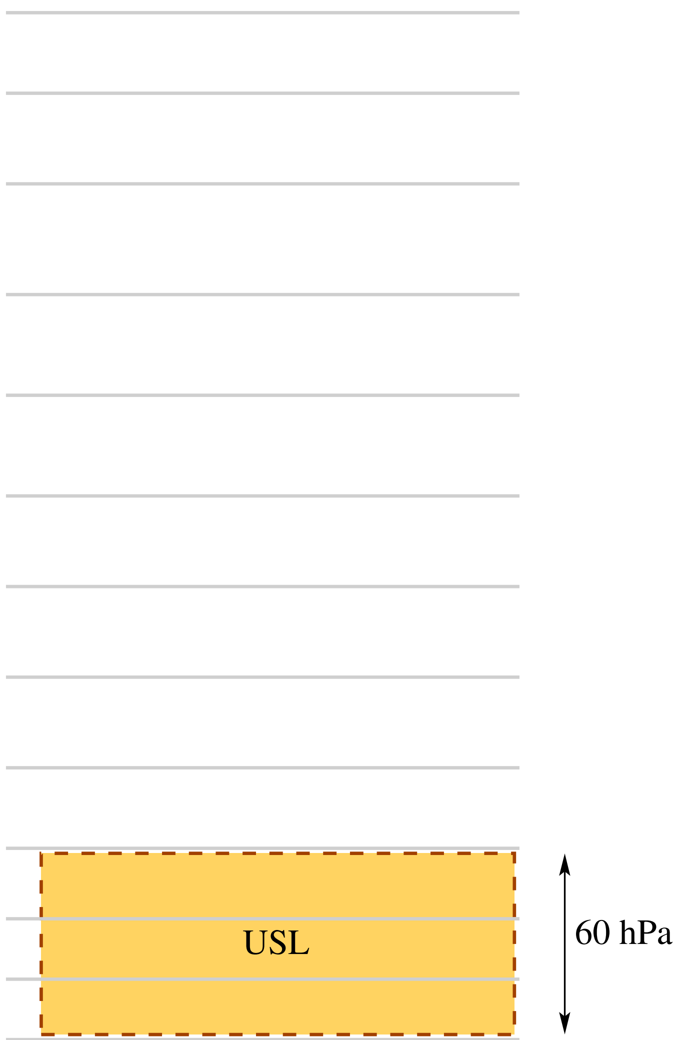

USL Ascent:

- more physical;
- independent of vertical discretization;
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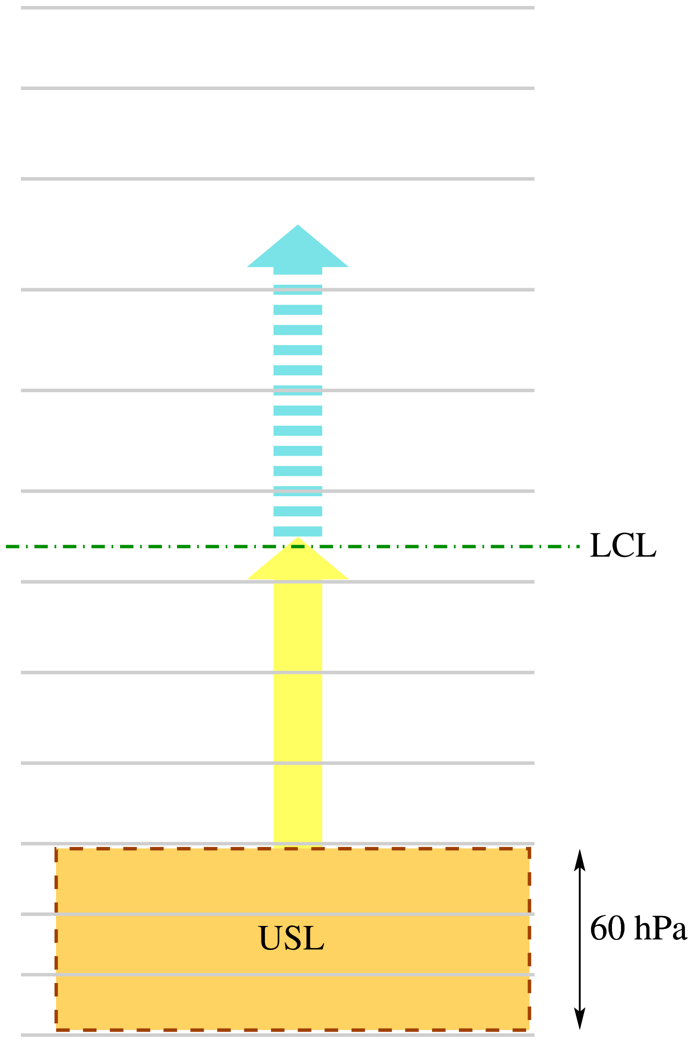

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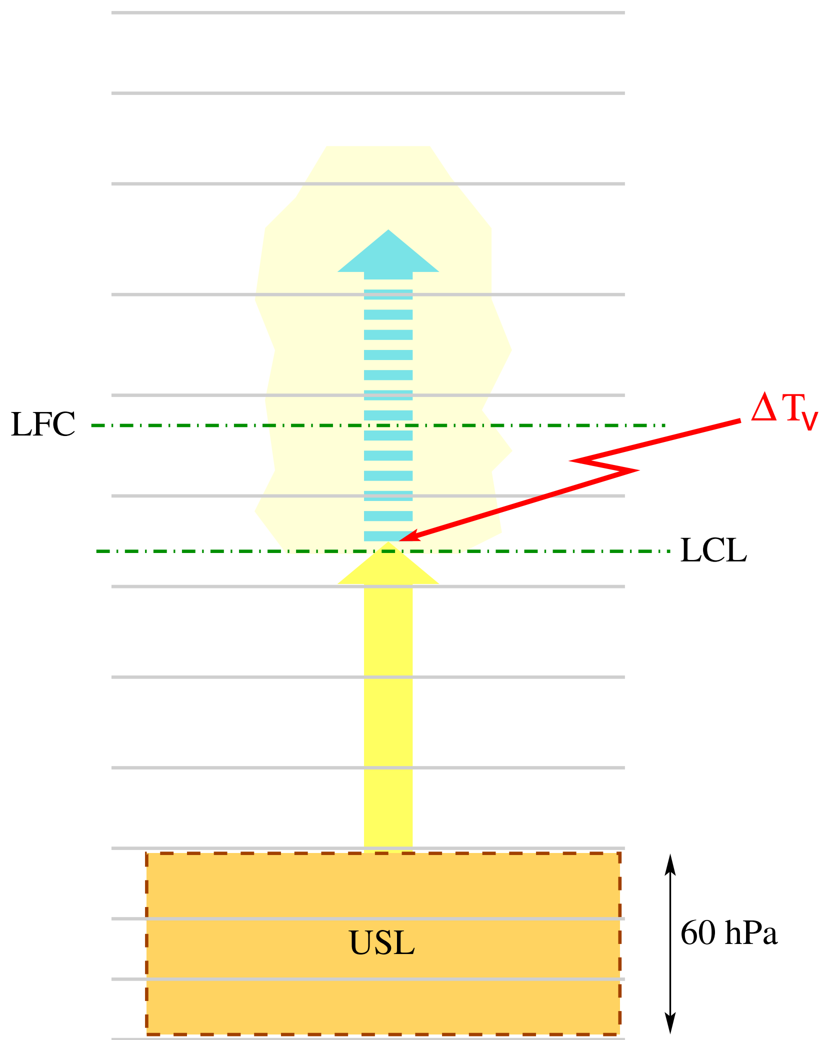

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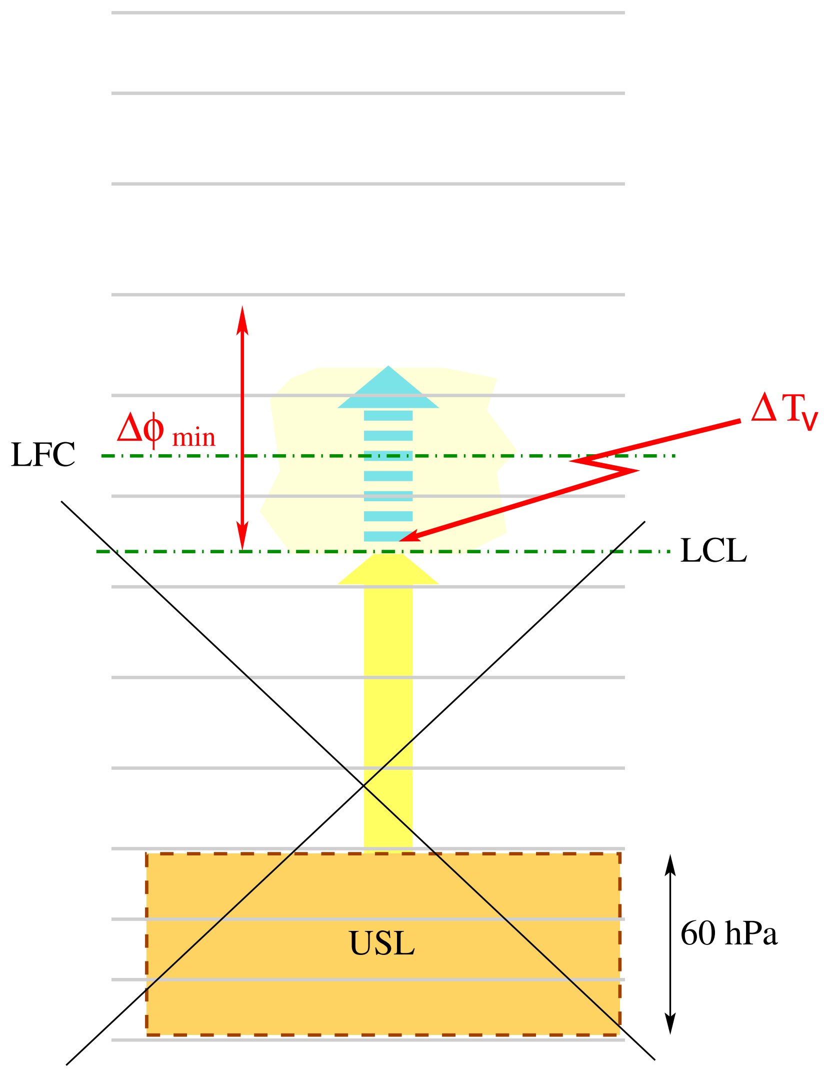

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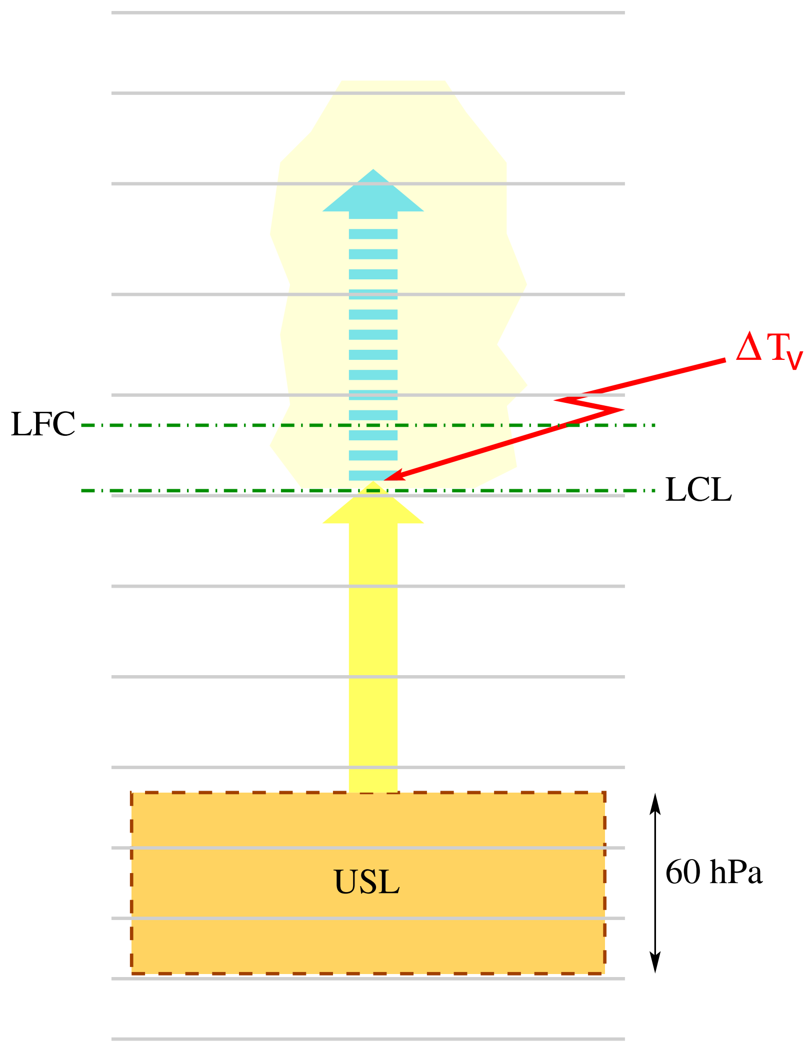

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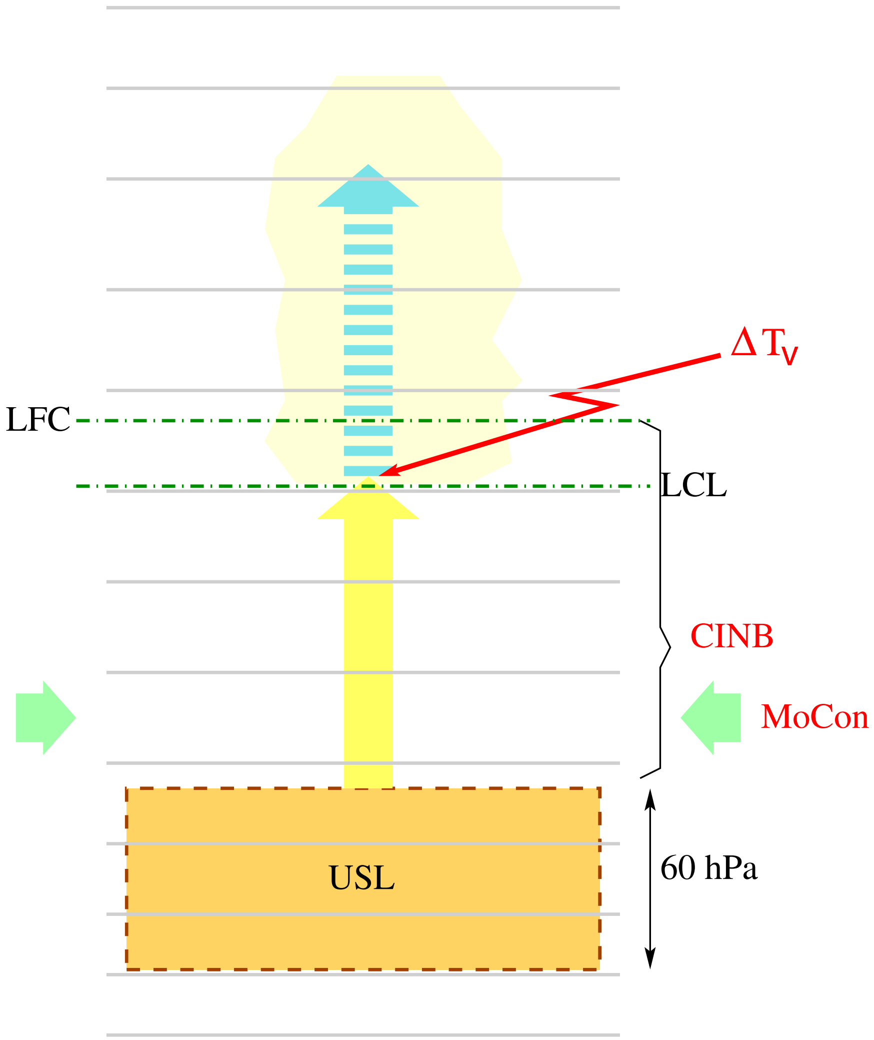

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USL computation parameters

New routine acusltrig: lusl=T

- gcvpuslmin=30000. maximum $p_{\rm surf} - p_{\rm usl}$.
- gcvdpmix=6000. : mix properties over 60hPa for usl
- gcvdphimin=29430. : min cloud elevation $\triangle\phi$ for viability

Outputs of acusltrig:

- KNND (triggered);
- p^{LCL}, T^{LCL} (updraft base)
- l^{usl}: medium usl level, q^{usl}, T^{usl}, used to compute downdraft effect in closure.
- $\delta_{\rm asc} = 1$ starting from LCL
- $\omega_u^\diamond$ between USL And LFC for energy-based triggering methods
- the perturbations $s_u^\diamond$, $q_u^\diamond$, $q_{cu}^\diamond$, $T_u^\diamond$ and $T_{vu}^\diamond$ at the LCL

Kicking triggering methods (1)

- Kain-Fritsch (2004):

$$\triangle T_{v,KF} = \left[\gamma(\overline{w}_{LCL} - w_0 \min(1, \frac{z_{LCL}}{z_0})\right]^{1/3}, \quad \frac{1}{\gamma} \sim 0.01 \mathrm{m\,s^{-1}K^{-3}}, \quad z_0 = 2\mathrm{km},$$

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  - $w_0 \sim 0.02 m/s$: threshold resolved w
    between positive and negative kick

    $\Rightarrow$ resolution dependent ?... ...how ?

  - mass-convergence criterion ?

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- additional TKE kick (Kuell & Bott 2008)

$$\triangle T_{v,\mathrm{TKE}} = \min(3, 5[\frac{\sqrt{2TKE}}{w_1}]^{1/3} - 1), \qquad w_1 = 100\,\mathrm{m\,s^{-1}}$$

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- Narita & Ohmori (2007): additional kick based on Relative Humidity (weak forcing in wet low atmosphere)

$$\triangle T_{v,RH} = \begin{cases} 0 & \text{if } RH^{LCL} < 0.75 \\ 0.25(RH^{LCL} - 0.75) q^{USL} / \frac{\partial q_{\mathrm{sat}}}{\partial T}^{LCL} & \text{if } RH^{LCL} \leq 0.95 \\ (\frac{1}{RH^{LCL}} - 1) q^{USL} / \frac{\partial q_{\mathrm{sat}}}{\partial T}^{LCL} & \text{if } RH^{LCL} > 0.95 \end{cases}$$

Kicking triggering methods (2)

- Ma& Tan (2009): local temperature anomaly scaled by normalized moisture convergence to compute a kick.

$$\delta T_{vv} = R_h \delta T_{vvh} + R_v \delta T_{vvv}$$

$$R_{h,v} = \frac{\mathbf{u} \cdot \nabla q - \min(\mathbf{u} \cdot \nabla q)_{h,v}}{\max(\mathbf{u} \cdot \nabla q)_{h,v} - \min(\mathbf{u} \cdot \nabla q)_{h,v}}, \qquad \delta T_{vvh,v} = T_v - < T_v >_{h,v}$$

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$\rightarrow$ computation of horizontal and vertical anomalies wrt neighbouring grid boxes:

– scan2m surgery
– extents vs grid spacing dependency ?

Energy-based triggering criteria

$E_k + \text{CIN} = \frac{1}{2}\rho w^2 \qquad \Longrightarrow \qquad$ impose ω_u from LCL to LFC

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- Rogers& Fritsch (1996): perturbation velocity and convergence:

$$w' = w_p(1 + c_3\left(\frac{\partial\overline{\omega}}{\partial p}\right)^{\frac{1}{3}}), w_p = w_i(\triangle x, \mathrm{surf})(1 - \frac{h^{usl}}{H}) + \begin{cases} w^* \\ w^* e^{\left[-c_1(\triangle z)^2 - \frac{c_2}{\theta_v}\frac{\partial\theta_v}{\partial z}\right]} \end{cases}$$

w^* =convective scaling velocity (CBL)

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- Resolution dependency: with decreasing $\triangle x$, how
  - not to trigger more ?
  - or to trigger less ?

  resolved TKE, $\overline{w}$, convegence are locally enhanced at higher resolution

CSU Triggering criterion

- Criterion based on resolved condensation:

$$\triangle T_{v,RC} = \min(T_1, \left[\gamma(F_{cs} - F_{cs0})\right]^{1/3}), \qquad \frac{1}{\gamma} \sim 0.005\,\mathrm{kg\,m^{-1}s^{-1}K^{-3}}$$

F_{cs0} resolution-dependent threshold

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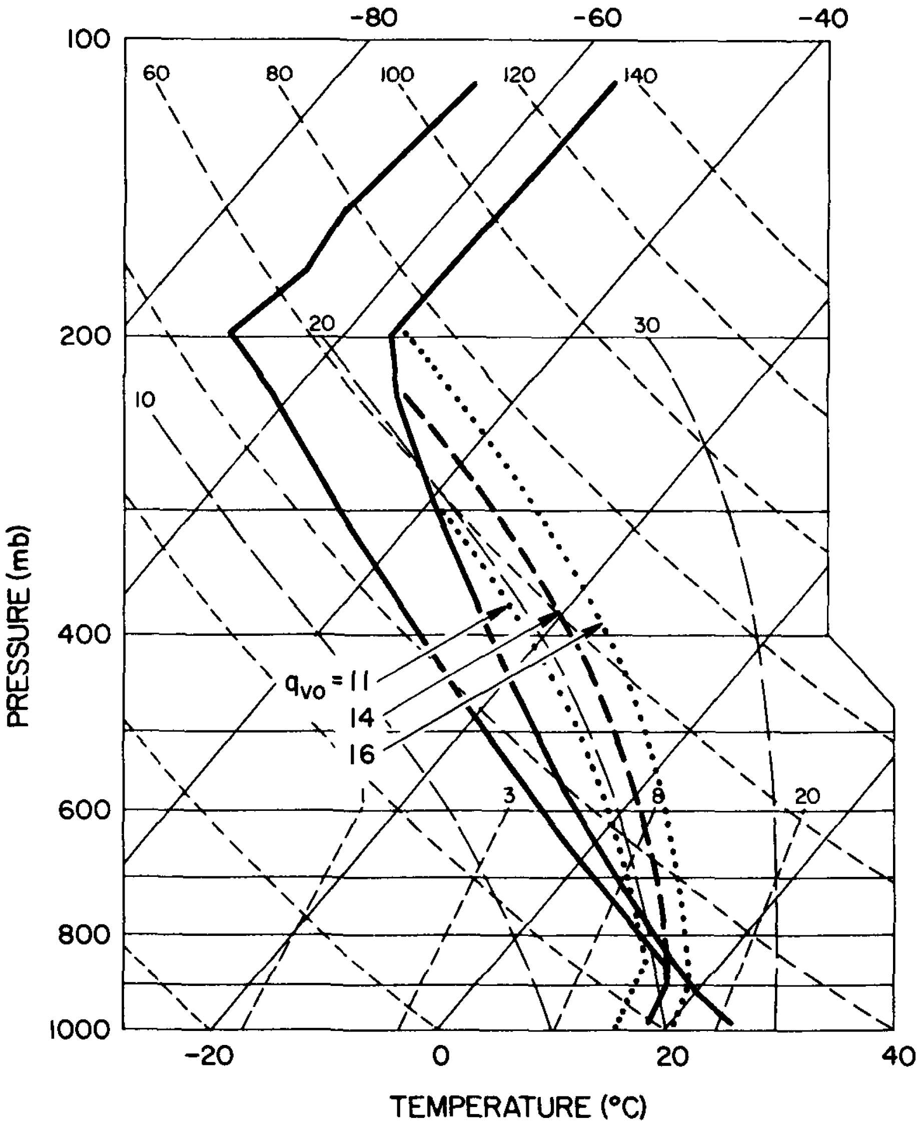
- test behaviour in stratiform as well as convective situations

Academic test bench

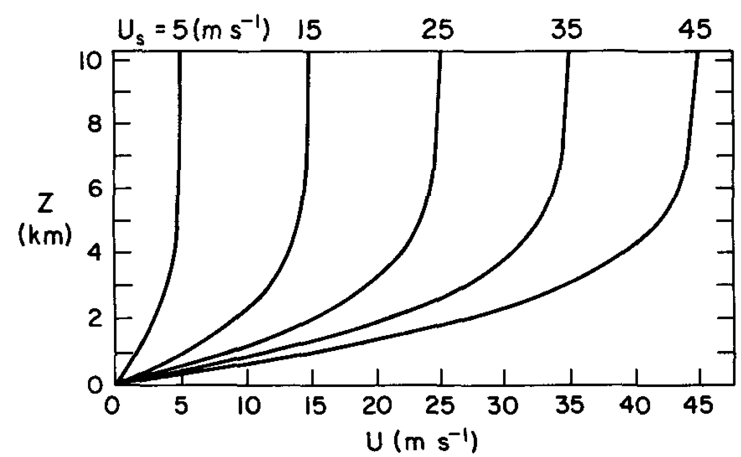


Weisman & Klemp 1982: single profile with CAPE

Zonal wind with vertical shear

Imposed pbl moisture

Ellipsoïdal Bubble of θ perturbation



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take r_h=3km, r_v=1400m=z_0, $\triangle\theta_0$=2K
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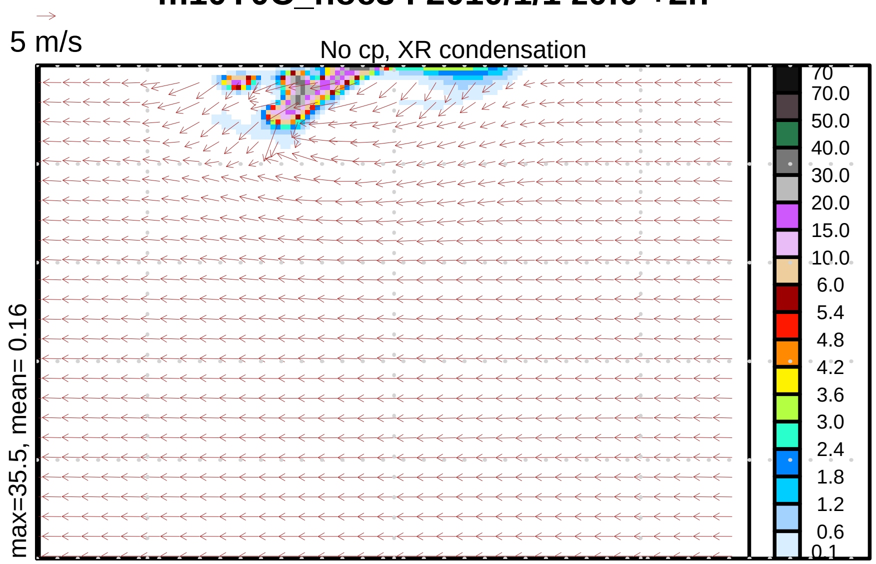
- Initial field computation: prevent aliasing error by averaging a bubble computed with $\triangle x = 200m$ at each resolution.
- Avoid horizontal mean motion by adding a negative offset to the zonal wind.

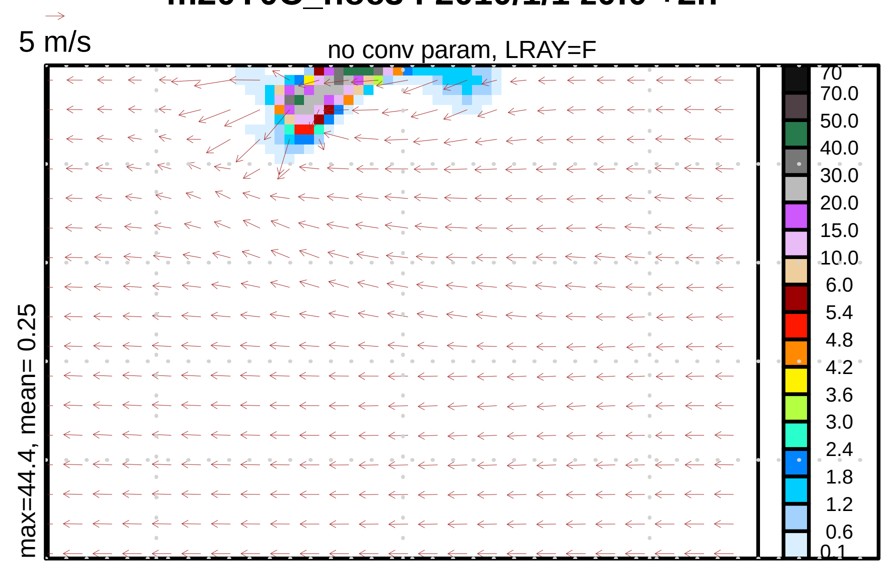
noCP: 2-h total precipitation

m10Y0C_noc3 : 2010/1/1 z0:0 +2h



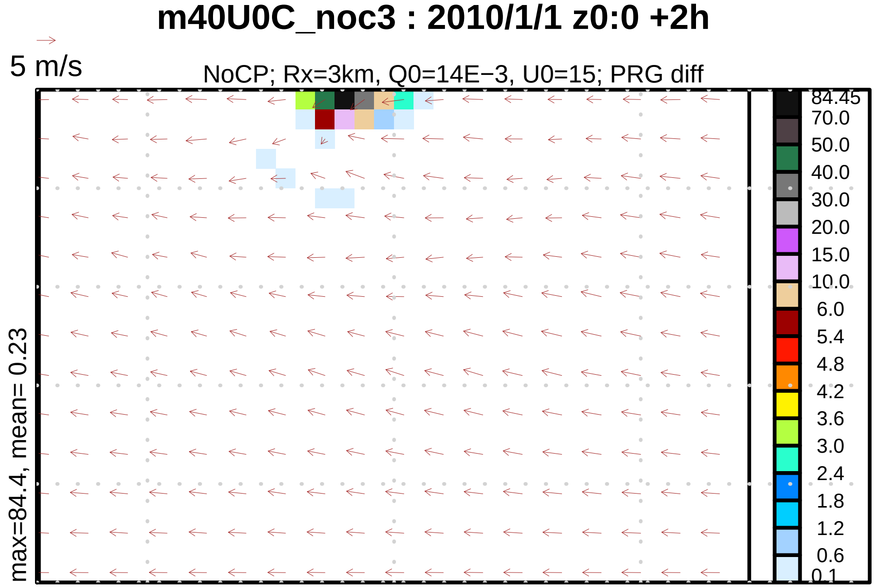
BOT t+0240 PREC EAU.CON+EAU.GEC+NEI.CON+NEI.GEC

m20Y0C_noc3 : 2010/1/1 z0:0 +2h



BOT t+0120 PREC EAU.CON+EAU.GEC+NEI.CON+NEI.GEC

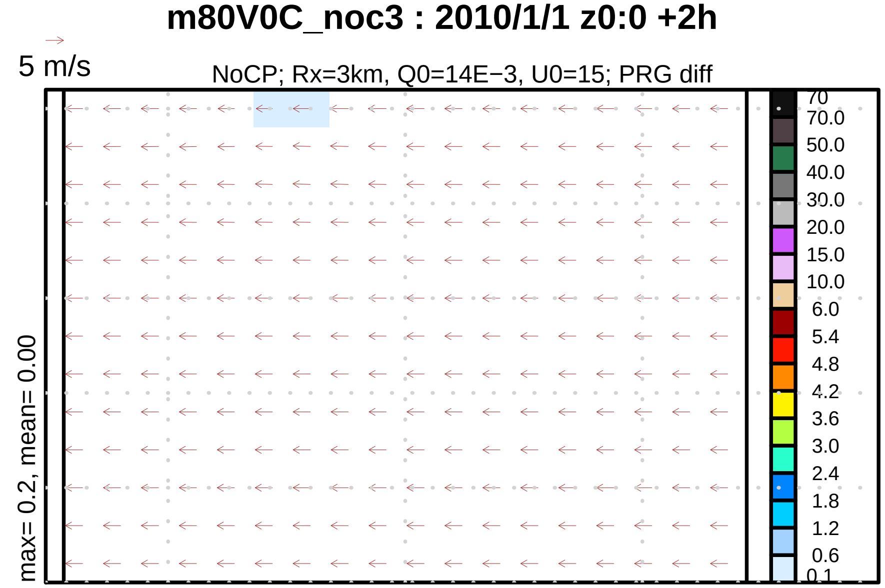
m40U0C_noc3 : 2010/1/1 z0:0 +2h



BOT t+0060 PREC EAU.CON+EAU.GEC+NEI.CON+NEI.GEC

S081WIND: −6.3<u<−0.9, −3.6<v< 2.5; ff< 6.5

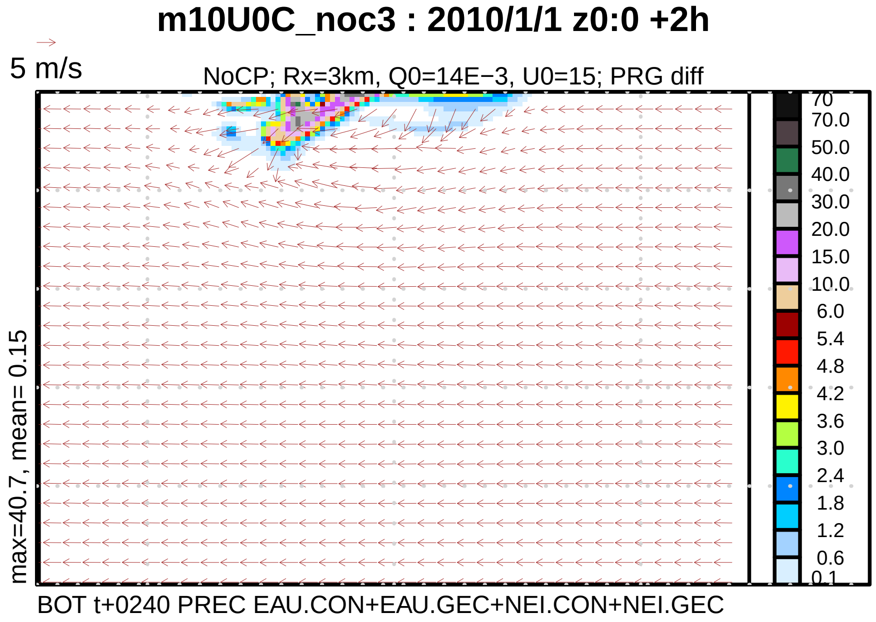
m80V0C_noc3 : 2010/1/1 z0:0 +2h

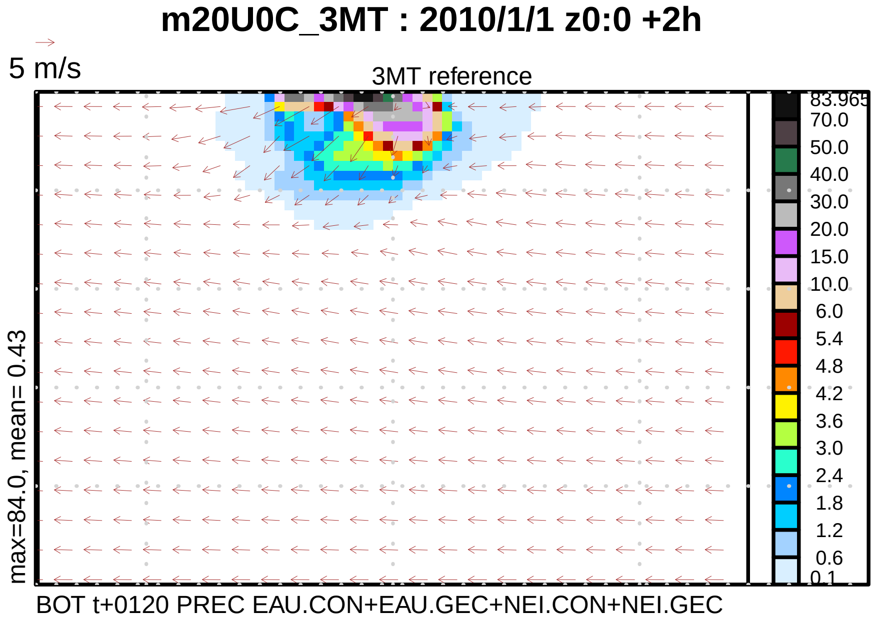


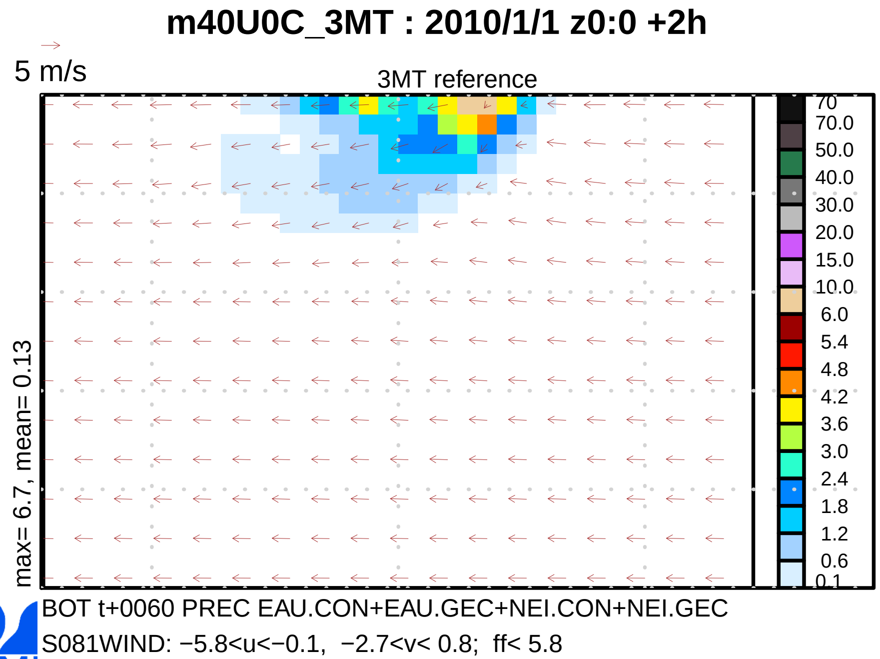
BOT t+0030 PREC EAU.CON+EAU.GEC+NEI.CON+NEI.GEC

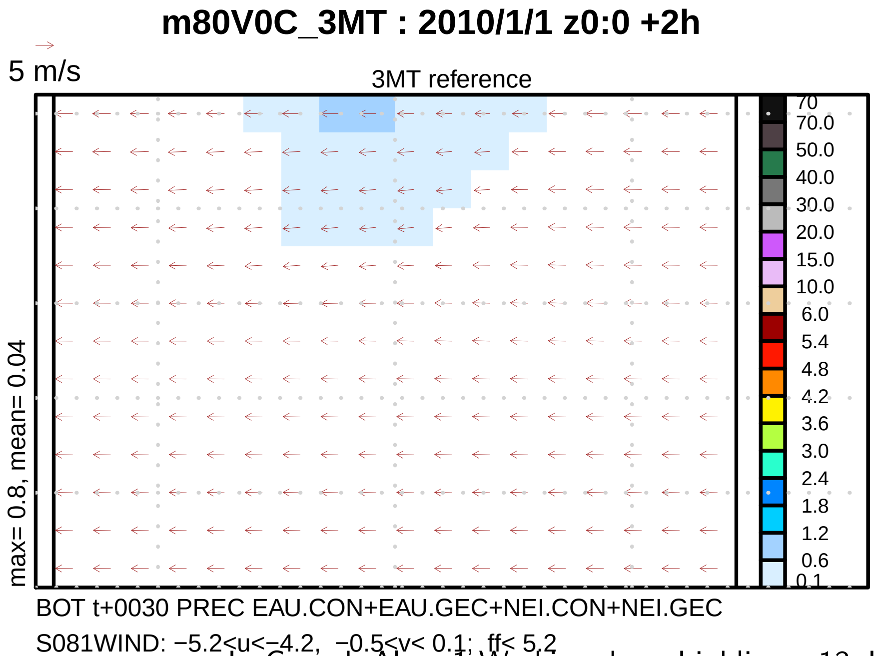
S081WIND: −5.0<u<−4.6, −0.1<v< 0.2; ff< 5.0

3MT: 2-h total precipitation vs ref









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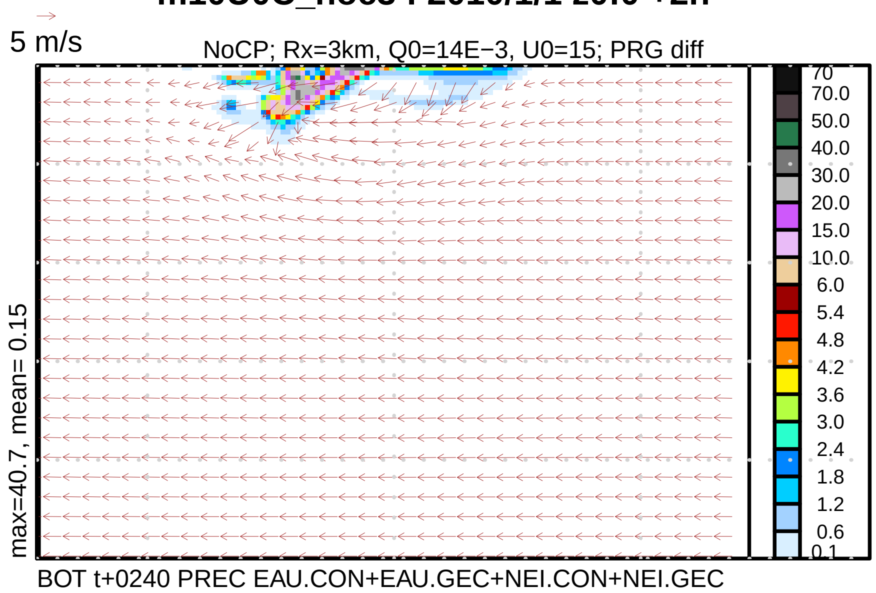
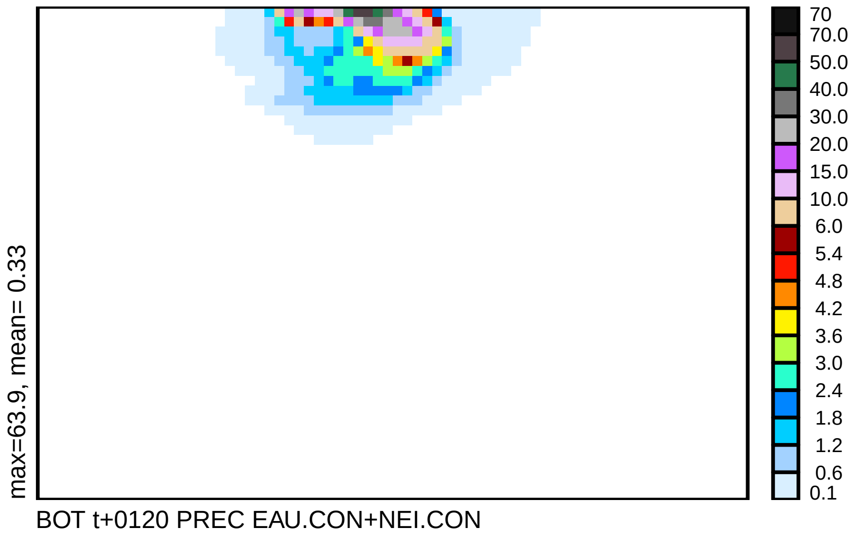
3MT: 2-h subgrid precipitation vs ref

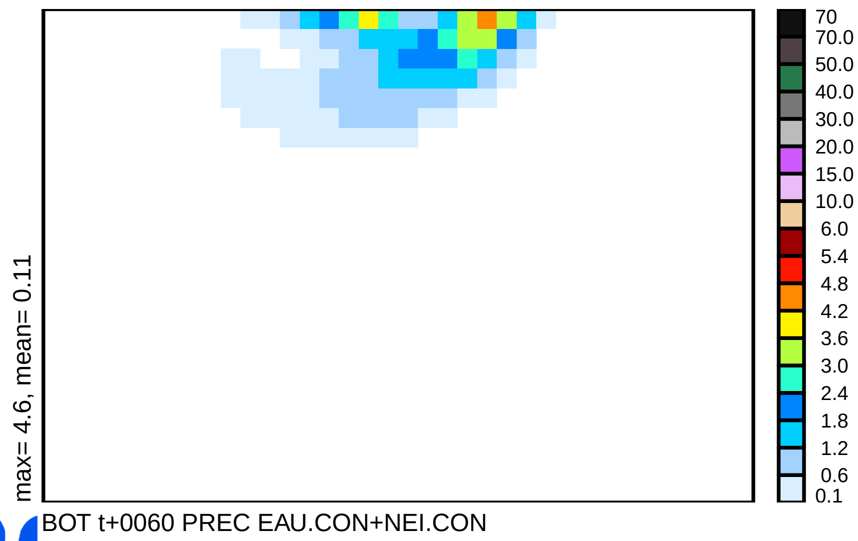
m10U0C_noc3 : 2010/1/1 z0:0 +2h



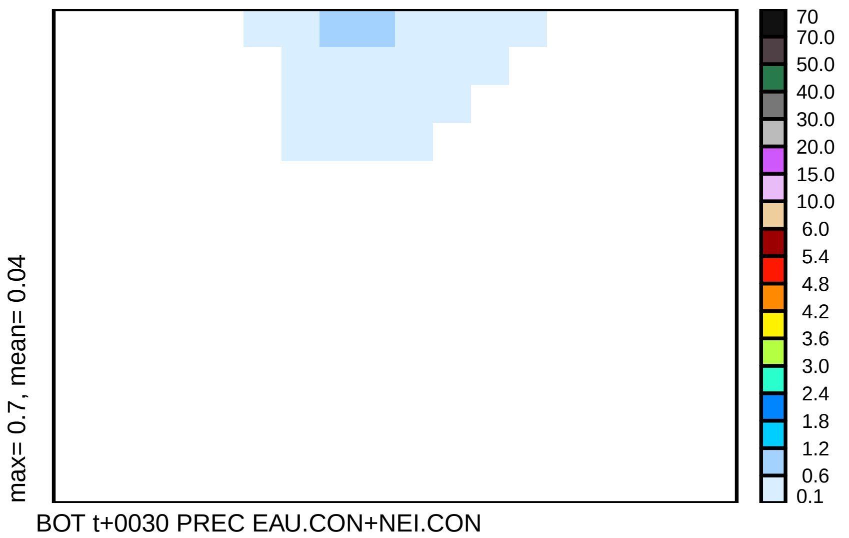
m20U0C_3MT : 2010/1/1 z0:0 +2h



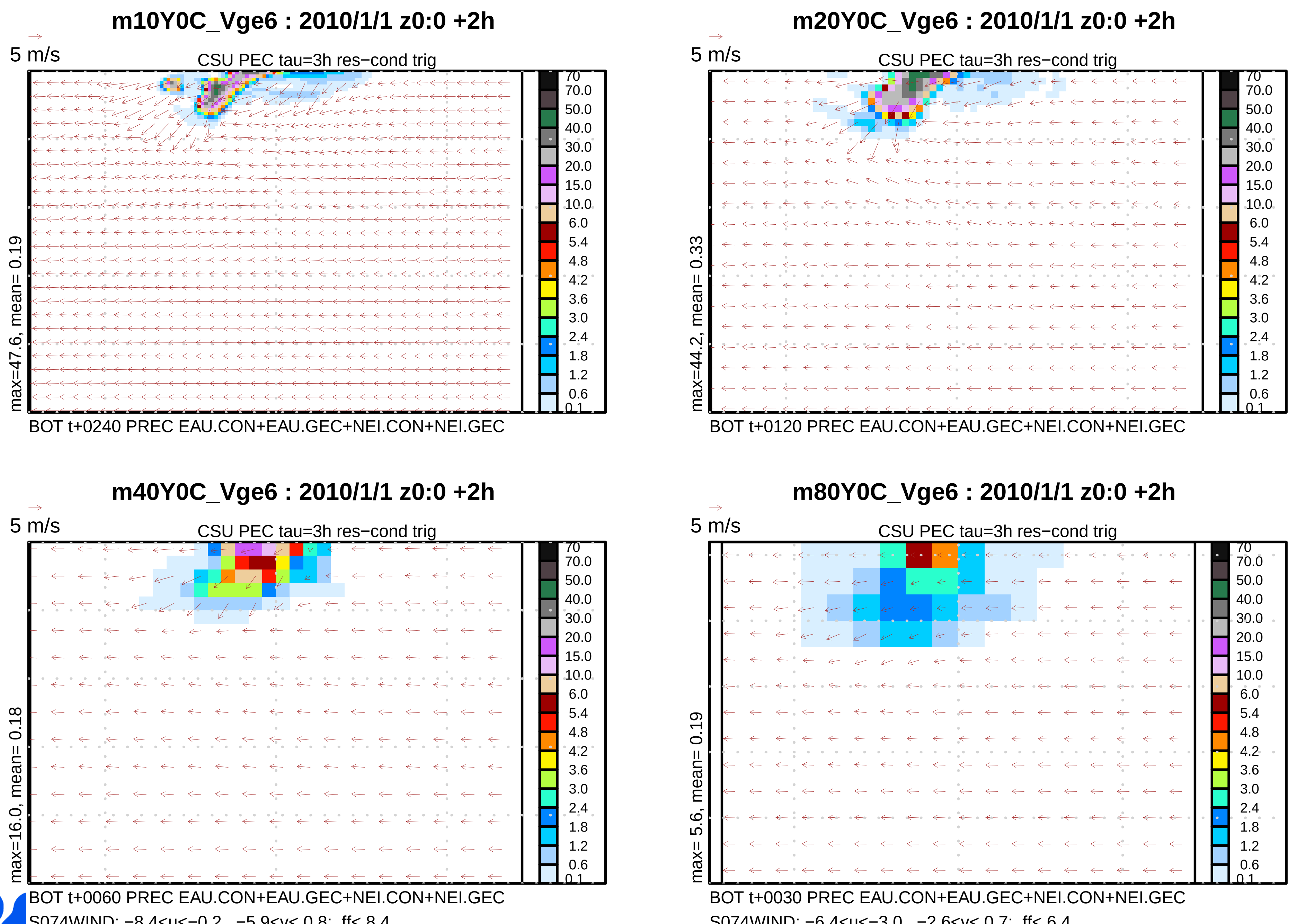
m40U0C_3MT : 2010/1/1 z0:0 +2h



m80V0C_3MT : 2010/1/1 z0:0 +2h

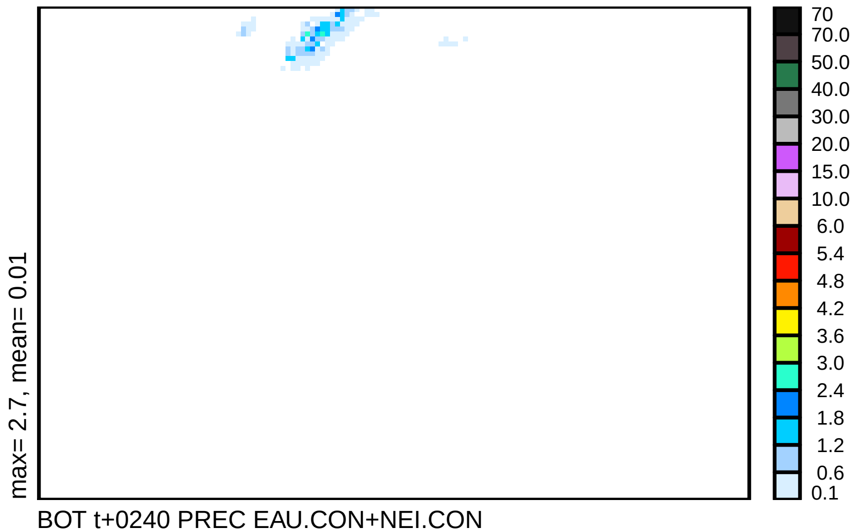


CSU: 2-h total precipitation

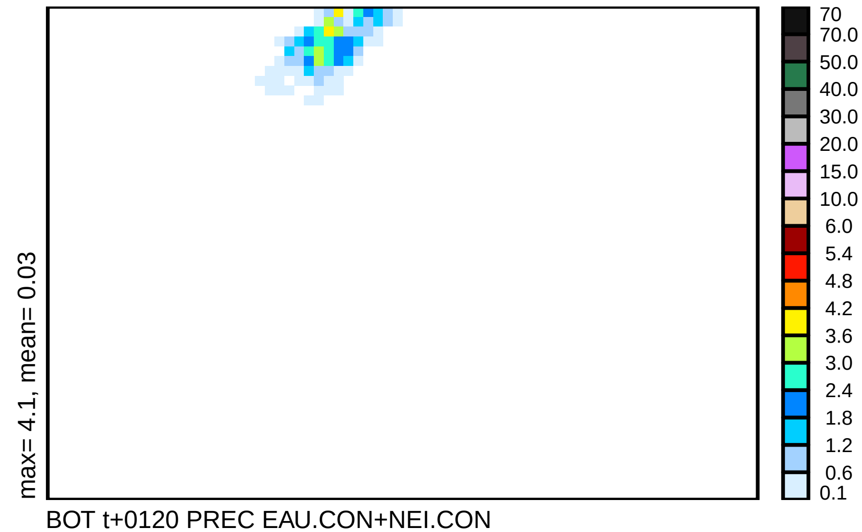


CSU: 2-h subgrid precipitation

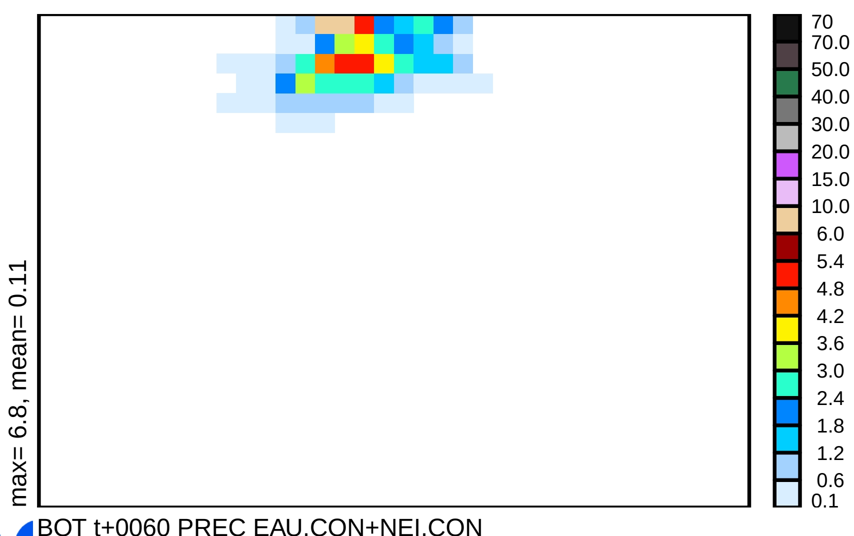
m10Y0C_Vge6 : 2010/1/1 z0:0 +2h



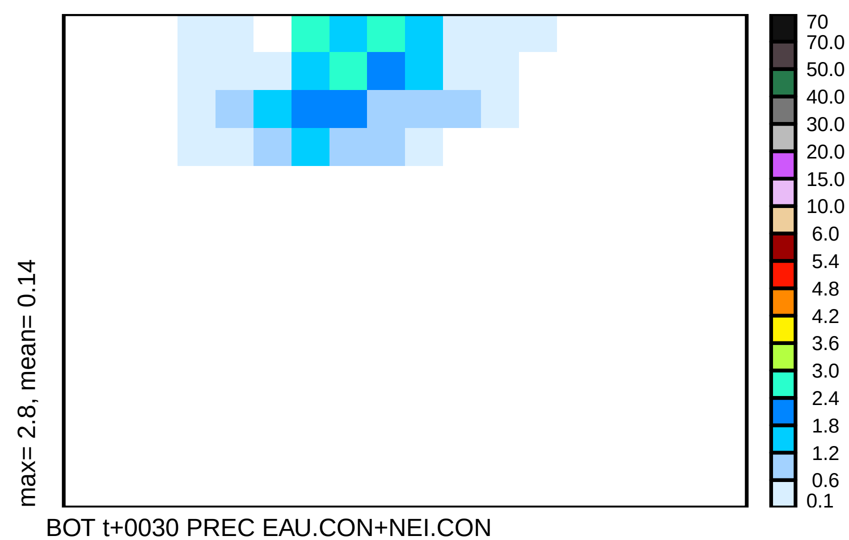
m20Y0C_Vge6 : 2010/1/1 z0:0 +2h



m40Y0C_Vge6 : 2010/1/1 z0:0 +2h

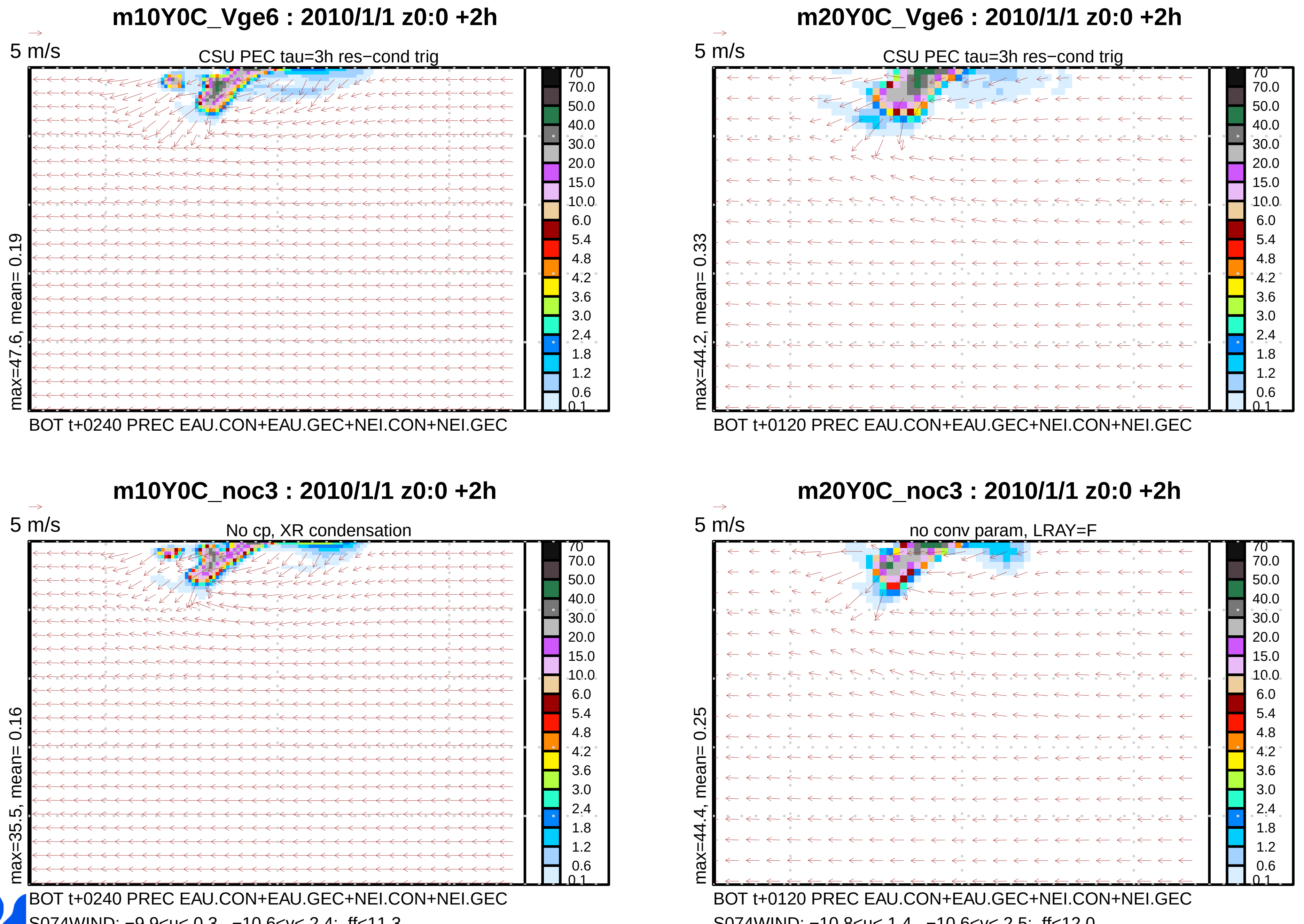


m80Y0C_Vge6 : 2010/1/1 z0:0 +2h

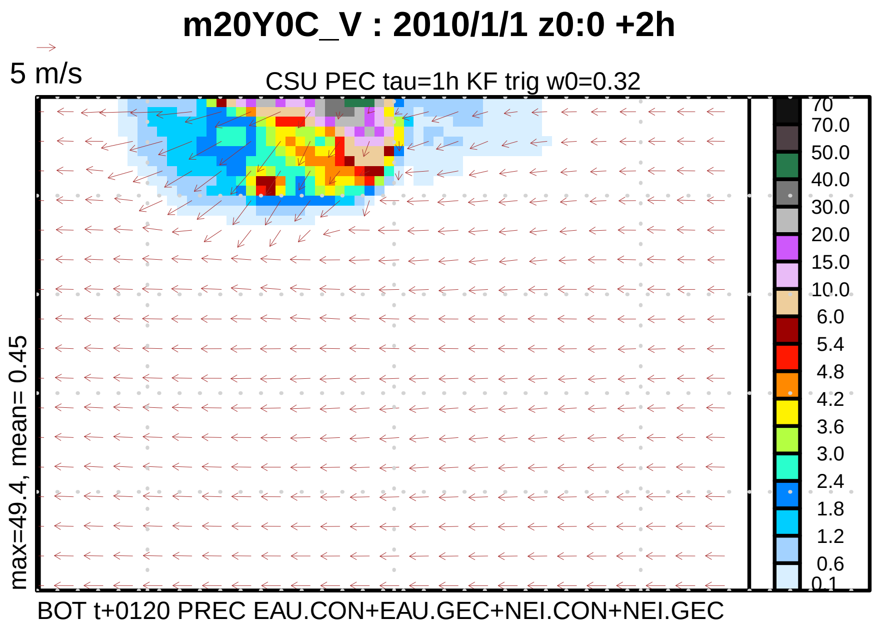


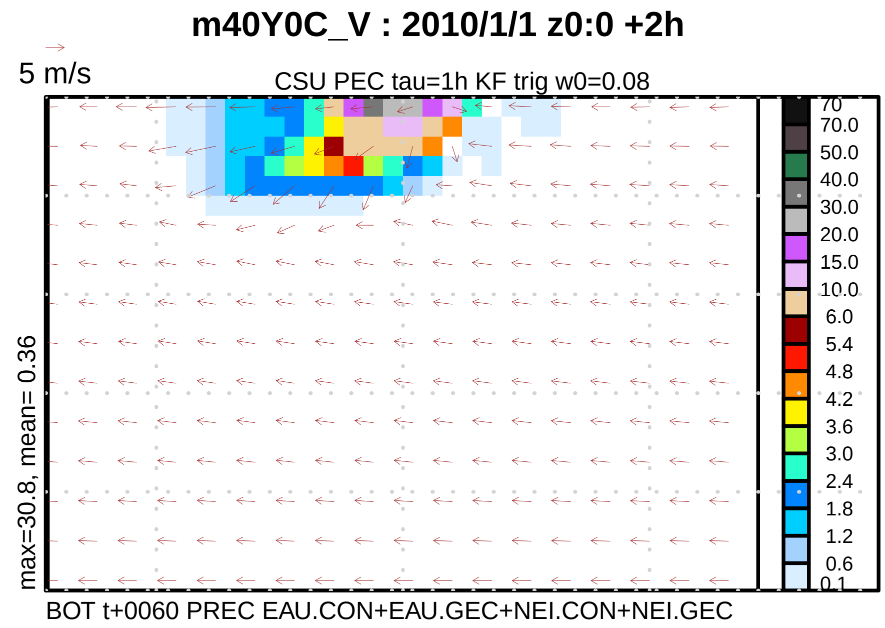
RMI

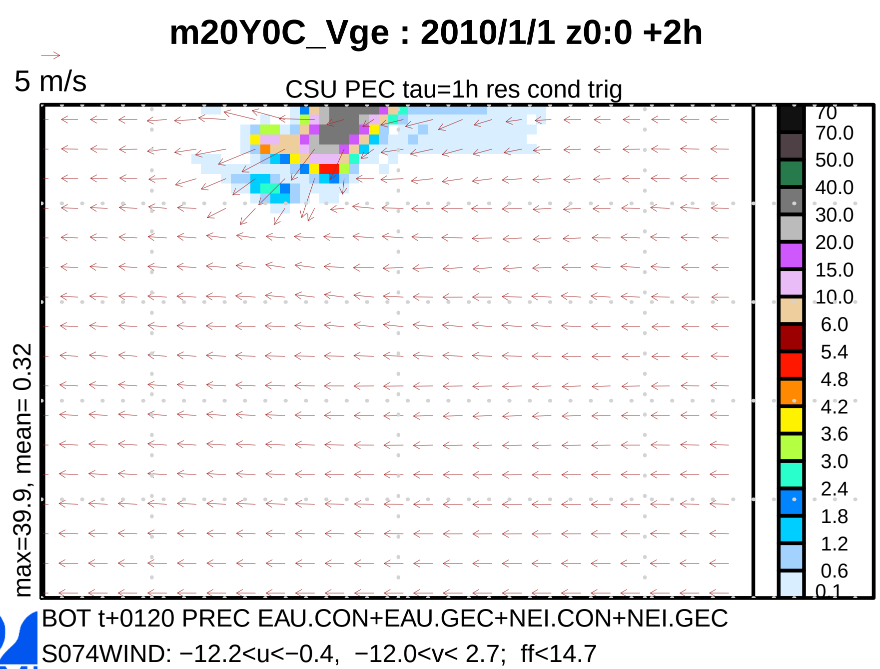
CSU: 2-h total precipitation vs noCP

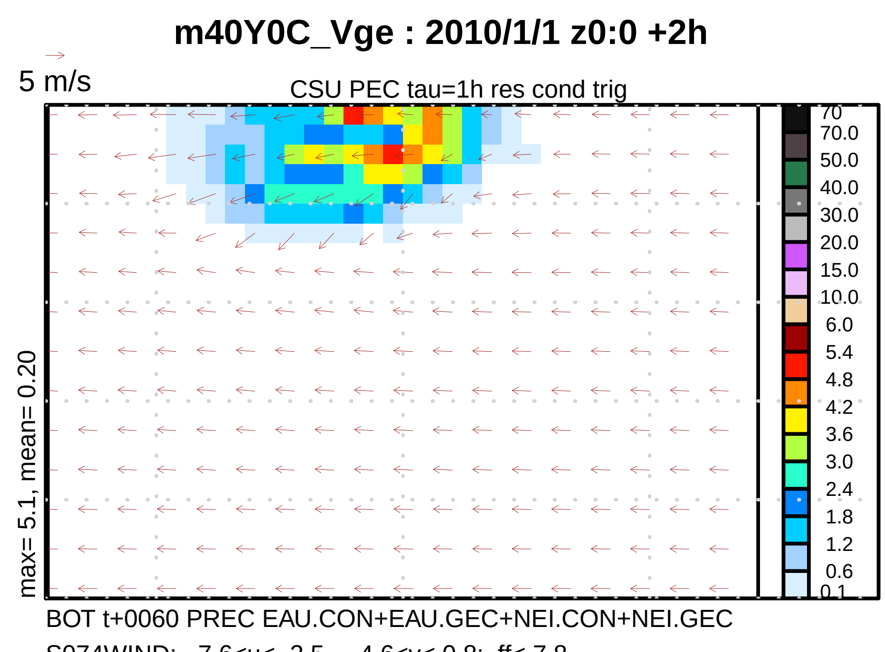


CSU: KF vs resolved condensation trigger. τ=1h









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- Real cases, for multi-scale behaviour, DDH and scores.

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