Cloud reunification in the CSD context

Luc Gerard

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Smith 1990 Cloud scheme

Symmetric pdf of s, departure from mean saturation excess

Q_c: $s = \breve{q}_c - Q_c \equiv (q_t - q_s) - (\overline{q_t} - \overline{q_s})$:

width $b = \sigma\sqrt{6} = \overline{q_s}(1 - U_c)$, ($U_c$ is critical relative humidity).

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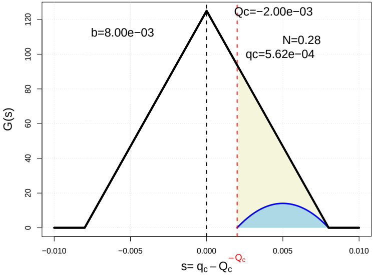

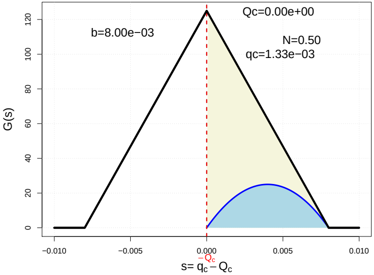

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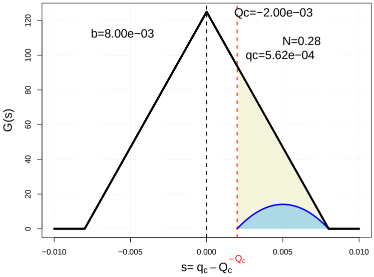
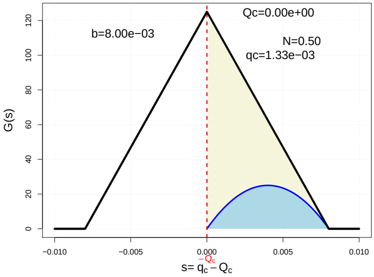


$Q_c < 0$: unsaturated grid-box



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$\iff \overline{q_t} = \overline{q_s}$, $N = 0.5$.

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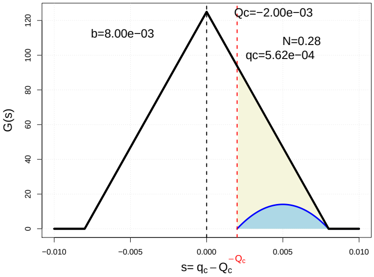

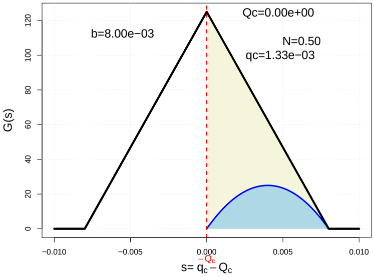

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$\iff \overline{q_t} = \overline{q_s}$, $N = 0.5$.

more cloud at $\overline{RH}_t = \overline{RH} + \frac{\overline{q_c}}{\overline{q_s}} = 1$ *requires a skewed pdf !*

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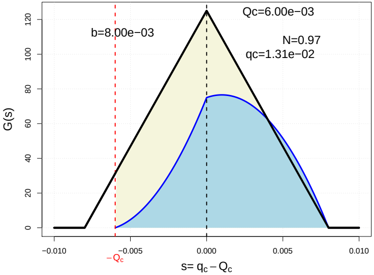

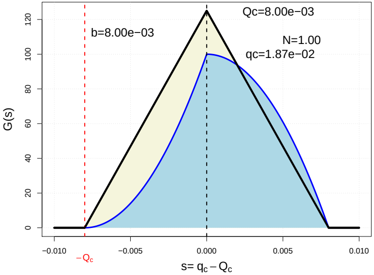

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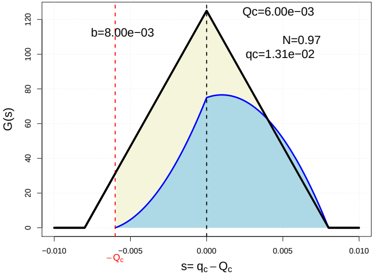

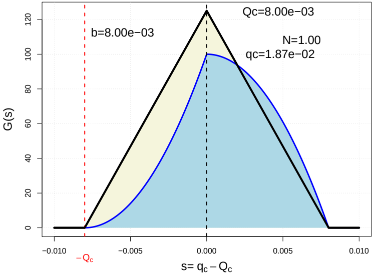

$Q_c > 0$: saturated mean grid-box $Q_c \geq b$: overcast, $N = 1$.

$$\overline{q_t} - \overline{q_s} = b \iff \overline{RH_t} = 1 + b = 1 + \overline{q_s}(1 - U_c) = 2 - U_c$$

e.g. U_c=0.7 *and* $\overline{RH} = 1$ *requires* $\overline{q_c} = 0.3\ \overline{q_s}$ *for* $N = 1$

Xu-Randall cloud diagnostic formula

Xu-Randall 1996: N→1 as soon as $\overline{RH} \rightarrow 1$, *whatever be* $\overline{q_c}$

$$N = (\overline{RH})^r \left[1 - \exp\{ - \frac{\alpha \, \overline{q_c}}{\left(\overline{q_s}(1 - \overline{RH}) \right)^{\delta}} \right] \qquad \text{with } \overline{RH} = \frac{\overline{q_v}}{\overline{q_s}}$$

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...and consider $\overline{q_{\mathrm{csus}}}$ a maximum *mean grid-box* condensate, e.g.

$$\overline{q_{\mathrm{csus}}} = N \cdot \widehat{q_{\mathrm{csus}}}(\overline{\omega}, \alpha_i, ...)$$

More about cloud scheme

- Both XR and Smith schemes valid *exclusively for stratiform* clouds: others where excluded from the datasets.
- Any cloud produced from elsewhere should have associated condensation taken into account, e.g.
  - Shallow convection
  - Sub-inversion enhanced condensation
  - Deep convective cloud, *parameterized or not*

The problem of shallow cloud condensate

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The problem of shallow cloud condensate(II)

- Solution: protect this shallow cloud condensate against auto-conversion ?

... but only if there is no deep convection above !

- In practice:
  - In columns where shallow cloud must be protected, increase autoconversion thresholds and reduce autoconversion efficiencies
  - For this pass an array to acacon containing

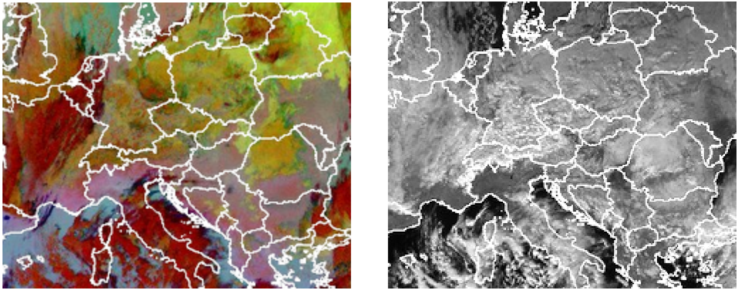
$$\xi = \begin{cases} -N_{sc} & \text{where it must be protected} \\ \to 0 & \text{where } \overset{above}{\max} \left(\overline{-\omega}\right) > \omega_n > 0 \end{cases}$$

and

$$q'_{i|\ell cr} = q_{i|\ell cr} \cdot (1 - A \cdot \xi), \qquad \text{zautef}' = \text{zautef} \cdot (1 + B \cdot \xi)$$

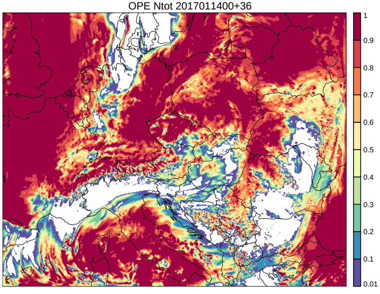
parameters $A \equiv \text{ginvqcr} \sim 10$, $B \equiv \text{ginvaut} \sim 0.99$,

Protecting shallow clouds: effect of protection

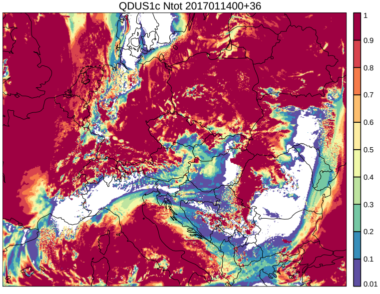


(Satellite)
15 Jan 2017 12:00utc

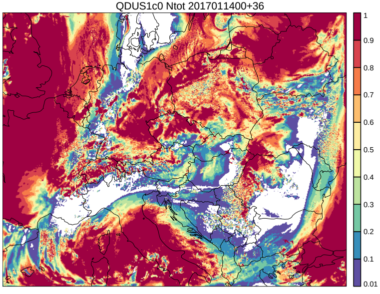
vs 36h forecast



OPER

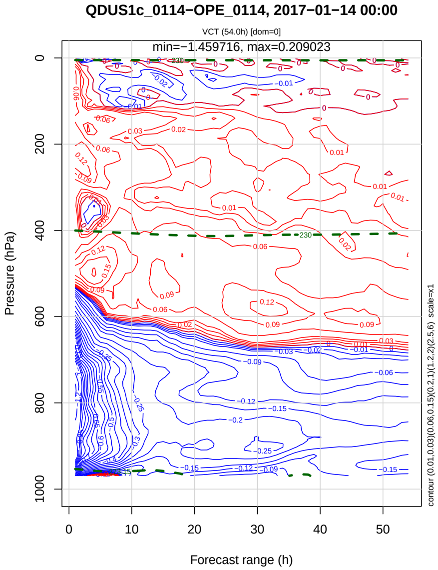


PROTECTED

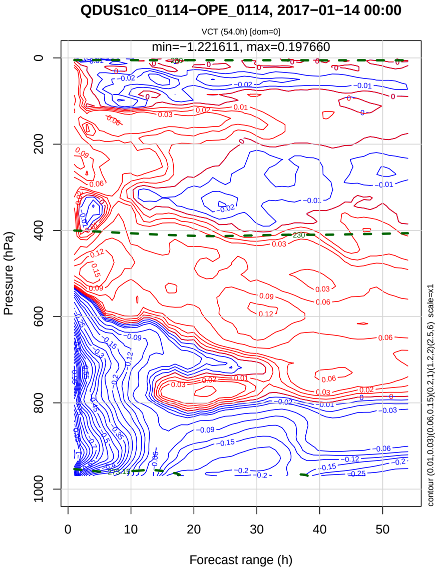


NOT PROTECTED

Protecting shallow clouds: thermodynamics



PROTECTED



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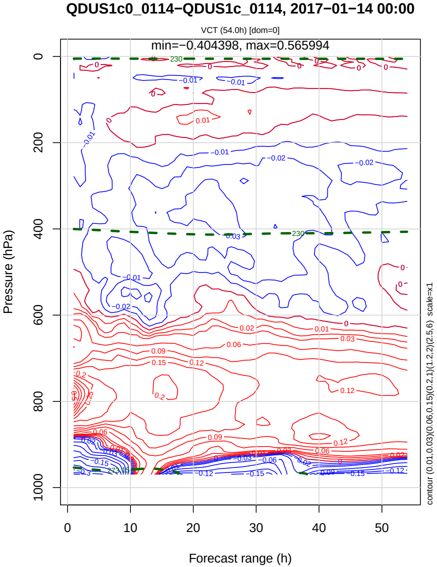
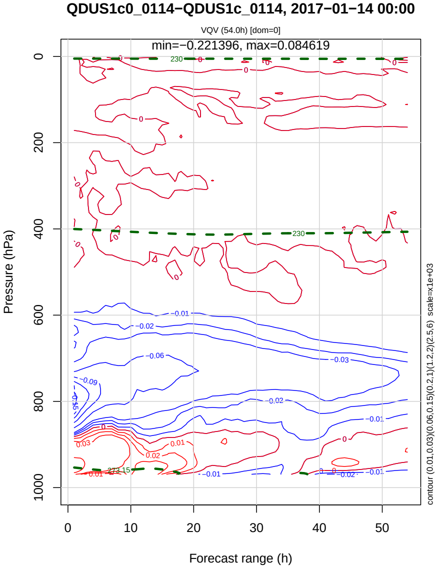


$\neq \dot{T}$ Unprotected – Protected



$\neq \dot{q}_v$ Unprotected – Protected

Cloud enhancement under a steep inversion (RPHI0)

- Under a steep inversion, the T^l is overestimated, $\Rightarrow$ q_{sat} as well.

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- Fixed by estimating a temperature gradient over a reference height below the inversion top (JFG's method).
- $\triangle T$ can be as large as 5K !
- Using $q_{\mathrm{sat}}(\overline{T^l} - \triangle T)$ in the cloud scheme allows to compute directly the associated condensation.

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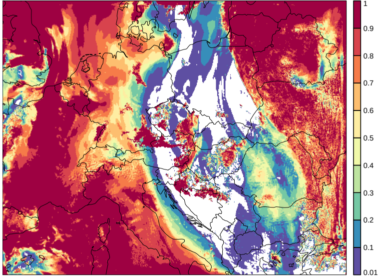
- *More physical method possible with Smith scheme:*
  use the mixing length from TOUCANS and build a multimodal local pdf
  (K. Van Weverberg, UKMO)

Cloud enhancement under a steep inversion: clouds

CSGS8j0l Ntot



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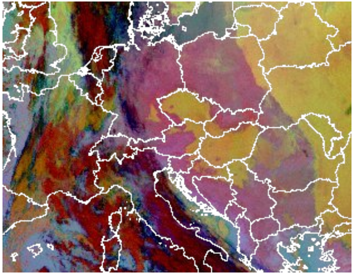
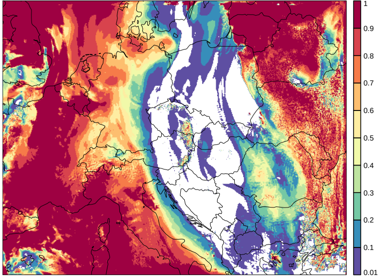


Satellite 28/1/2017 12:00utc

CSGS8j0j Ntot



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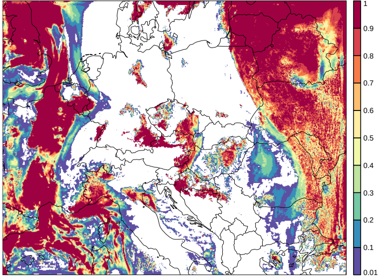
CSGS8j0l Nlow



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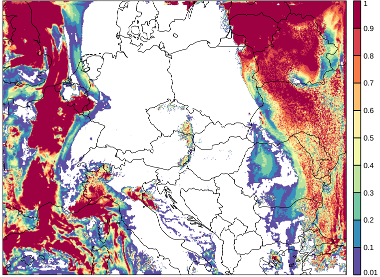
← Low cloud →

↖ RPHI0=1250

↗ RPHI0=0

CSGS8j0j Nlow



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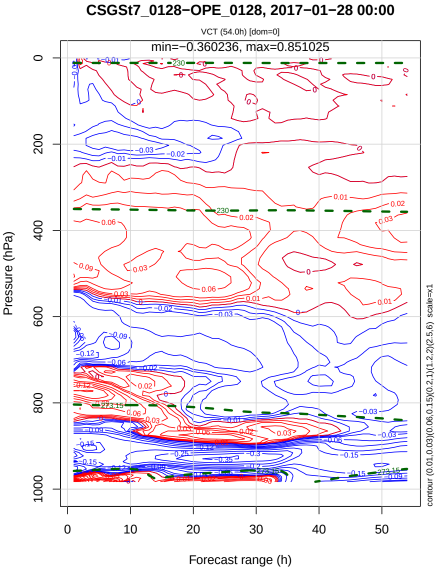
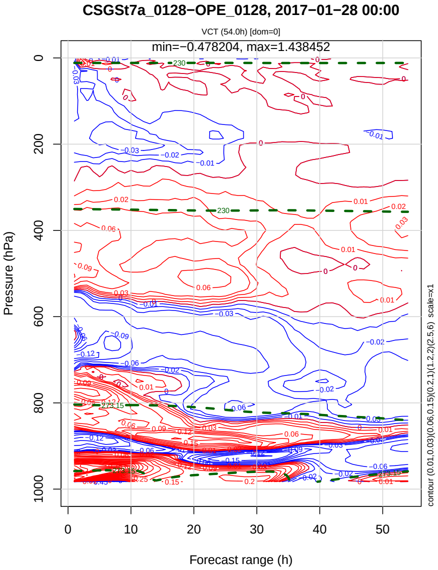
Cloud enhancement under a steep inversion: thermodynamics



RPHI0=1250



RPHI0=0

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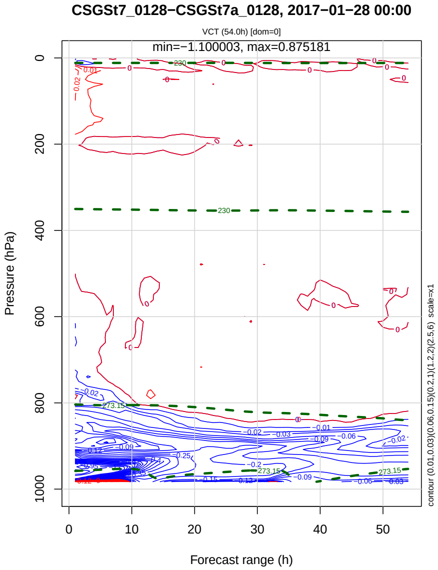
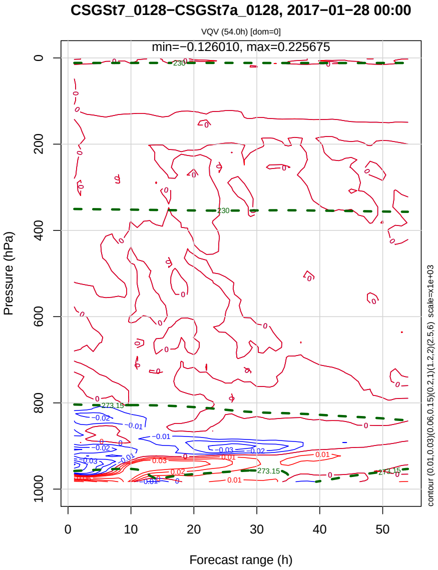


$\neq \dot{T}$ Corrected − not corrected



$\neq \dot{q}_v$ Corrected − not corrected

Deep convection and the cloud scheme

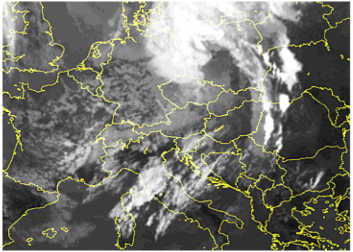
- Deep convection yields more intensive cloud condensate and smaller mesh fractions.
- The parameterization already provides q_{cc}, N_c

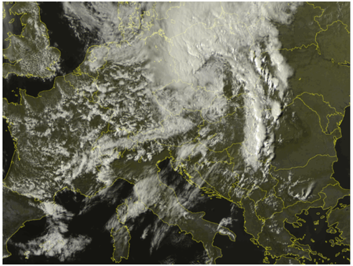
… but the resolved signal is not included !

- Smoothly skewing the pdf would increase or decrease both N and q_c.
- Instead and much easier, reduce and increase q_c in function of $\overset{above}{\max}(-\overline{\omega} - \omega_n)$

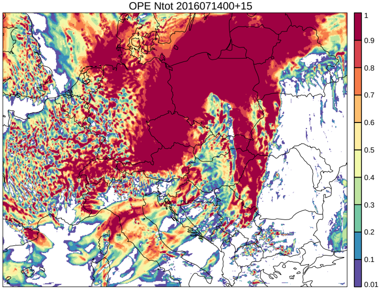
Summer 2016 situation

IR→





←VIS



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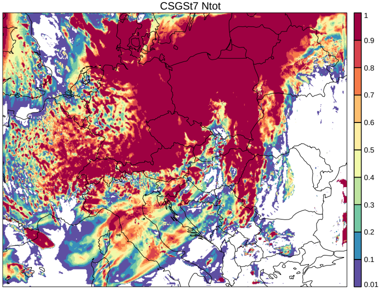
←OPER

Unified+CSD→



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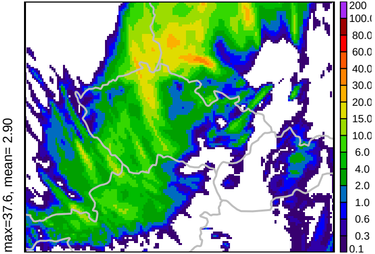
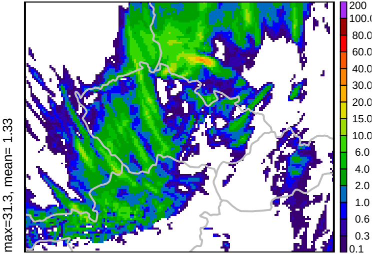
Summer 2016 situation

OPE 2016071400+15

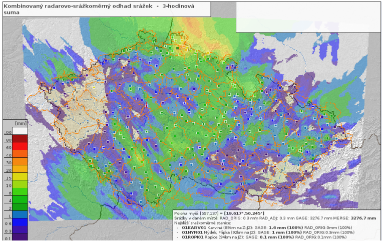


SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 12 to 15

OPE 2016071400+15

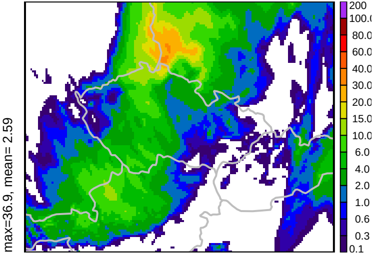


SURF PREC.EAU.CON+NEI.CON, 12 to 15


Kombinovaný radarovo-srážkoměrný odhad srážek - 3-hodinová suma

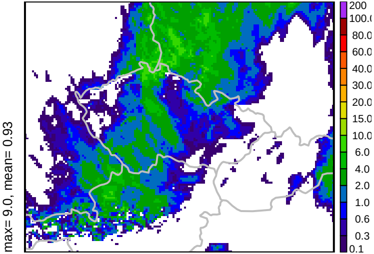
Poloha myši: [597,137] = **[19.617°,50.245°]**
Srážky v daném místě: RAD_ORIG: 0.3 mm RAD_ADJ: 0.3 mm GAGE: 3276.7 mm MERGE: **3276.7 mm**
Nejbližší srážkoměrné stanice:
- **01KARV01** Karviná (89km na Z-JZ): GAGE: **1.6 mm (100%)** RAD_ORIG:0mm (100%)
- **01NYFI01** Nýdek, Filipka (92km na JZ): GAGE: **1 mm (100%)** RAD_ORIG:0.3mm (100%)
- **01ROPI01** Ropice (94km na JZ): GAGE: **0.1 mm (100%)** RAD_ORIG:0.1mm (100%)

CSGSt7 : 2016/07/14 z00:00 +15h



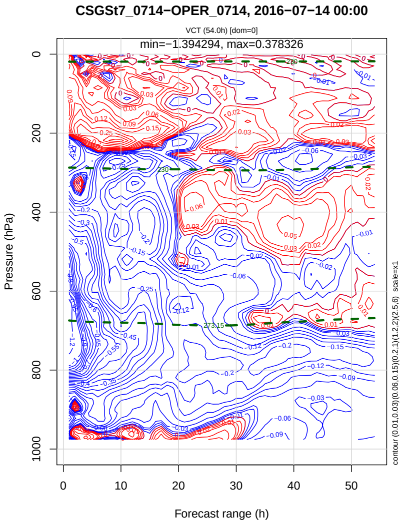
SURF PREC.EAU.CON+EAU.GEC+NEI.CON+NEI.GEC, 12 to 15

CSGSt7 : 2016/07/14 z00:00 +15h

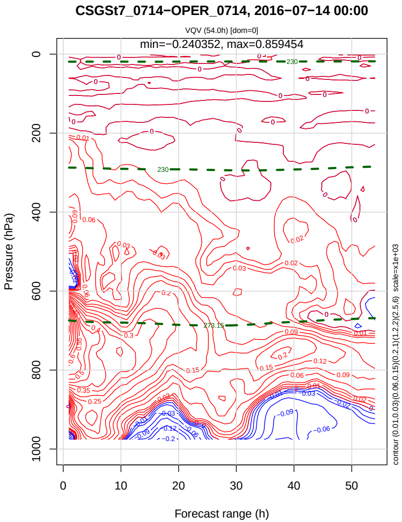


SURF PREC.EAU.CON+NEI.CON, 12 to 15

Summer 2016



≠ $\dot{T}$ vs OPER

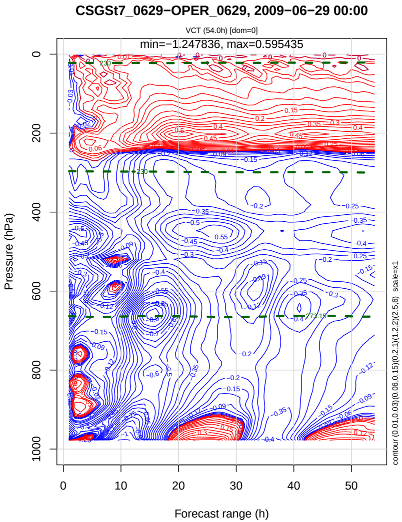


≠ $\dot{q}_v$ vs OPER

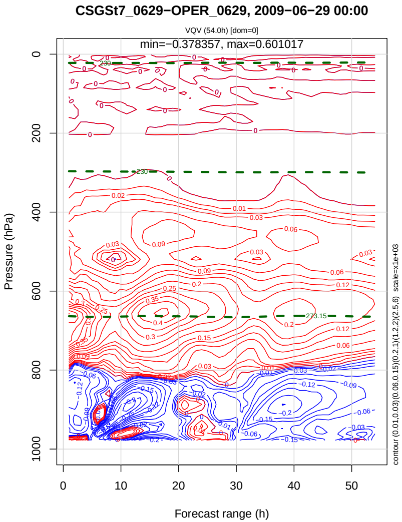
Moderate convection appears to work

See other talk

2009 strong convection disaster



$\neq \dot{T}$ vs OPER



$\neq \dot{q}_v$ vs OPER

Strong convection fails:

Unsufficient precipitation

Excess cloud fraction

Should further adapt the CSD signal ?

Further on

- Resolved transport $\neq$ subgrid transport: how to further enhance CSD subgrid transport.
- Other impacts of strong upwards velocity
  - Mixed phase / subgrid variability (Uc)
  - Autoconversion
  - Collection
  - Sedimentation
- Reduce the arbitrariness
  - Use turbulent mixing length for enhancing cloud under inversion top
  - Estimate directly the Smith pdf width using subgrid variances derived from TOUCANS.
- Why is it so difficult ?
  - CRMs use a binary cloudiness
  - cloud scheme prognostic character based on an evolving diagnostic rather than on tendencies
  - Most models recognize they stay with a schizoïd representation of clouds between thermodynamics ad radiation