A new path to cloud and condenation reunification in Alaro

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Reunification ?

Current state:

1. $\overline{q_v^-}, \overline{q_i^-}, \overline{q_\ell^-}, N_c^- \rightarrow$ ACNEBCOND Resolved condensation $\rightarrow q_c^{(1)}, N_s$
2. ACNEBN Radiative cloud $\rightarrow \mathbf{N}_{\mathrm{rad}}, q_{i,\mathrm{rad}}, q_{\ell,\mathrm{rad}}$

   re-estimates $\overline{q_{cs\mathrm{rad}}}$ from $\overline{q_t}$ with other HU$_c$ profile and $\overline{q_{cc\mathrm{rad}}}$ from N_c^-, then N_{rad} xith Xu-Randall formula.

   - $N_{\mathrm{rad}}, N_c \rightarrow$ ACNPART classified cloud $\rightarrow \mathbf{N_t}, \mathbf{B_H}, \mathbf{N_M}, \mathbf{N_L}$
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3. *Turbulent transport*, *depp convection* $\rightarrow \mathbf{N_c^+}$

4. $q_v * -, q_i * -, q_\ell^*, N_c^+ \rightarrow$ ACNEBCOND $\rightarrow q_c^{(2)}, \mathbf{N_s}$

   $\rightarrow$ ACCDEV $\rightarrow F_{csi}, F_{cs\ell}$

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5. $(+F_{cci}, F_{cc\ell}) + N_{eq} \rightarrow$ microphysics $\rightarrow$ *iautoconversion, collection, evaporation...*
   $(+$ *turbulent fluxes*$)\rightarrow$ *cptend, dynamics* $\Rightarrow \overline{\mathbf{q_v^+}}, \overline{\mathbf{q_i^+}}, \overline{\mathbf{q_\ell^+}}, q_s^+, q_r^+$

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$\Rightarrow$ use 'liquid (and ice)' temperature

$$Q_c \equiv q_t - q_{\mathrm{sat}}(T, p) = a_L \left[q_t - q_{\mathrm{sat}}(T_L, p) \right]$$

$$T_L = T - (L_v q_\ell + L_s q_i)/c_p, \qquad a_L = \frac{1}{1 + \frac{L}{c_p} \frac{\partial q_{\mathrm{sat}}}{\partial T}\Big|_{T=T_L}}$$

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Principle: assume some distribution of Q_c aroud $\overline{Q_c}$

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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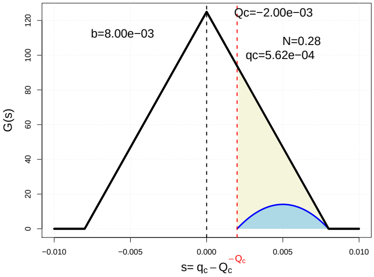

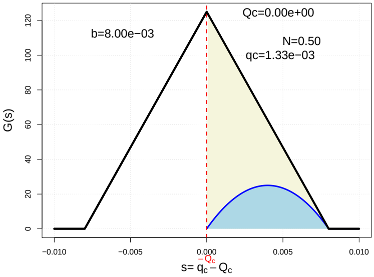

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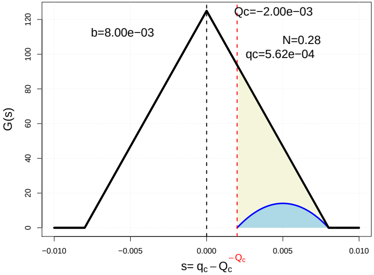
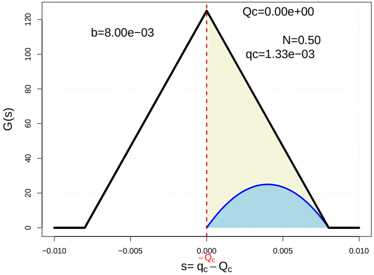


$Q_c < 0$: unsaturated grid-box



$Q_c = 0$: just saturated mean grid-box

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

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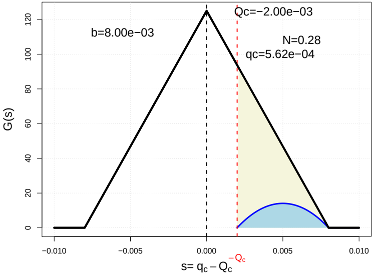

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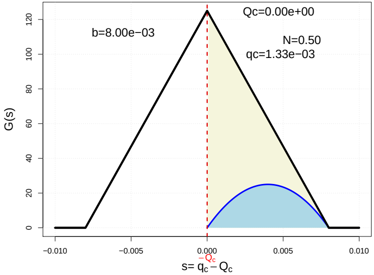
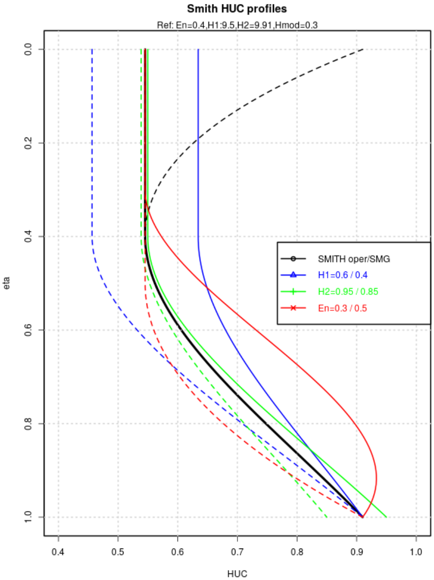


$Q_c = 0$: just saturated mean grid-box

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

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

Smith 1990 triangular pdf width



$$b = \sigma\sqrt{6} = \overline{q_{\text{sat}}}(1 - HU_c)$$

where HU_c is
critical mean grid box relative humidity

$=$ at twhich first cloud appears

$En \equiv$ RETAMIN $\sim$ 0.4

$H_1 \equiv$ RHCRIT1 $\sim$ 0.5

$H_2 \equiv$ RHCRIT2 $\sim$ 0.91

$+\triangle x dependency$

Drawbacks and high resolution issues

- the triangular Q_c distribution lacks realism.
- at mean grid box saturation, $\overline{q_t} \sim \overline{q_{\mathrm{sat}}} \iff \overline{Q_c} = 0 \Rightarrow N = 0.5$
- In the presence of convective ascents, the pdf should have more than 1 mode.
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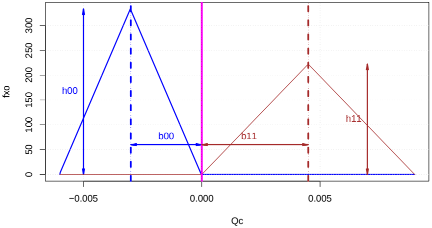
$\Rightarrow$ *Define a bimodal PDF, with distinct clear and cloudy modes*

$\Rightarrow$ *Resolved vertical velocity should avffect the relative widths of the 2 modes*

$\Rightarrow$ *Use physical reasoning to get a more or less realistic representation.*

Making a bimodal PDF (1)

- two triangular modes: **clear** and **cloudy**, with a horizontal transition at a fraction α of the *minor* mode height.



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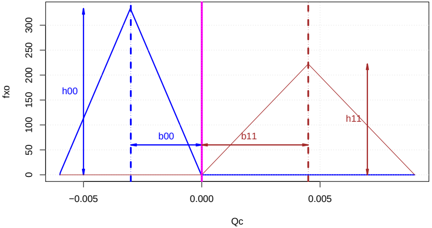

The extreme widths b_{00}: clear sky and b_{11}:overcast determined from mean grid-box state:

$$\mathbf{b}_{00} = (1 - HU_c)q_{\mathrm{sat}}(\overline{T}, p), \qquad \text{as in Smith}$$

$$\mathbf{b}_{11} = \mathbf{br} \cdot \mathbf{b}_{00} \qquad \mathbf{br} \text{ tunable, depending on the phase}$$

...and **br** affected by the *resolved vertical velocity* $\overline{\omega}$

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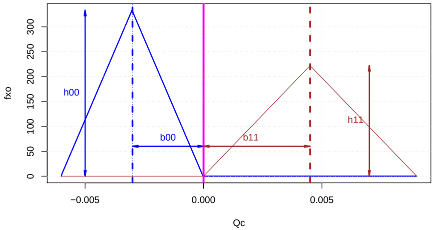

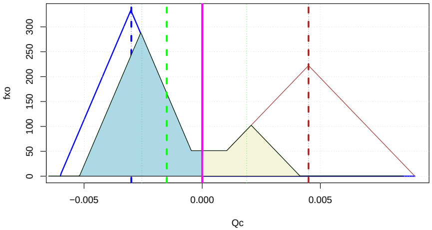

Actual mode widths

- **b0** $\Rightarrow$ variability of q_v in the **clear** part: $0 \leq \mathbf{b0} \leq \mathbf{b}_{00}$
- $\mathbf{b}_1$ $\Rightarrow$ variability of q_c *or oversaturation* in **cloudy** part. $0 \leq \mathbf{b1} \leq \mathbf{b}_{11}$

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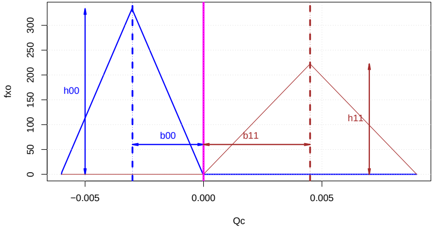

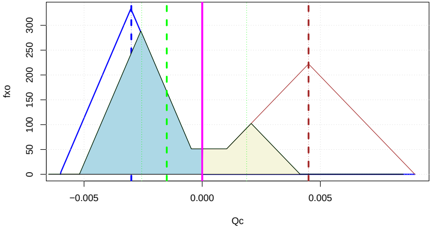

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- When $N = 0 \Rightarrow b_0 = b_{00}$ and $b_1 = 0$: limit of first cloud;
- When $N = 1 \Rightarrow b_0 = 0$ and $b_1 = b_{11}$: limit of first hole in clouds.

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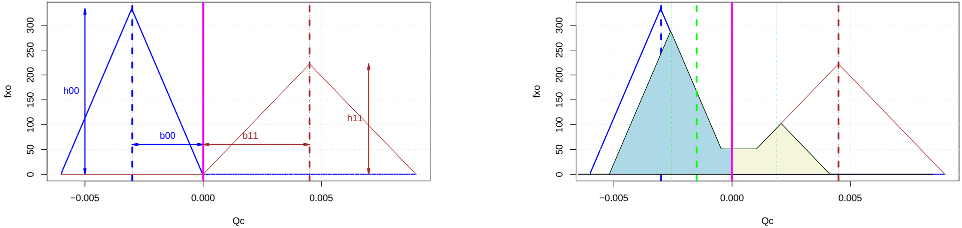

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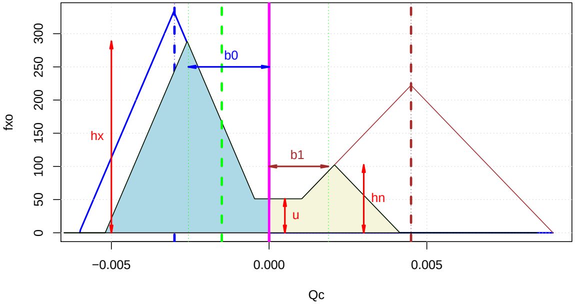
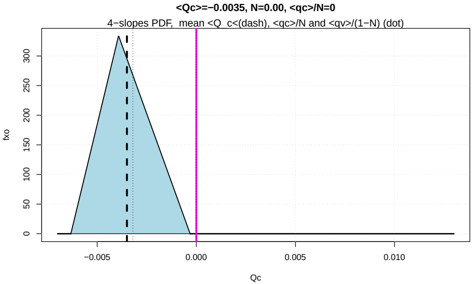
- Otherwise bothe mode are present, α makes the transition

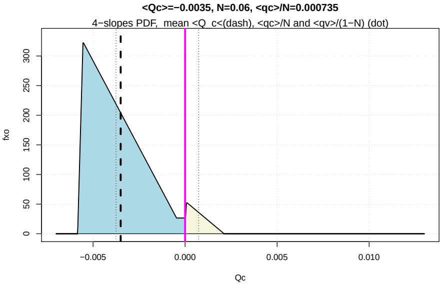
Making a bimodal PDF (2)

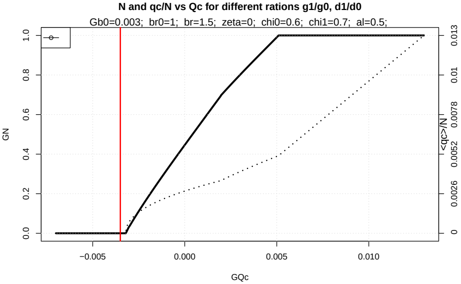


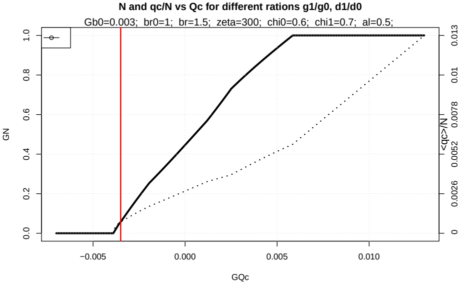
- The variation of the modes width and height is obtained by pre-determining the slopes, from b_{00} and b_{11}: $S = 1 = b_{00} \cdot (\gamma_0 \cdot b_{00})$ etc. for isocele case.
- gliding from 2 isocele triangles (2 slopes) to a 4-slopes represntation: $0 < \chi 0 < 1$, relative abscisse of the summit.
- The slopes may vary with $\overline{Q_c}$.
- **br** depends on $\overline{\omega}$: see below.

Making a bimodal PDF (illustration)









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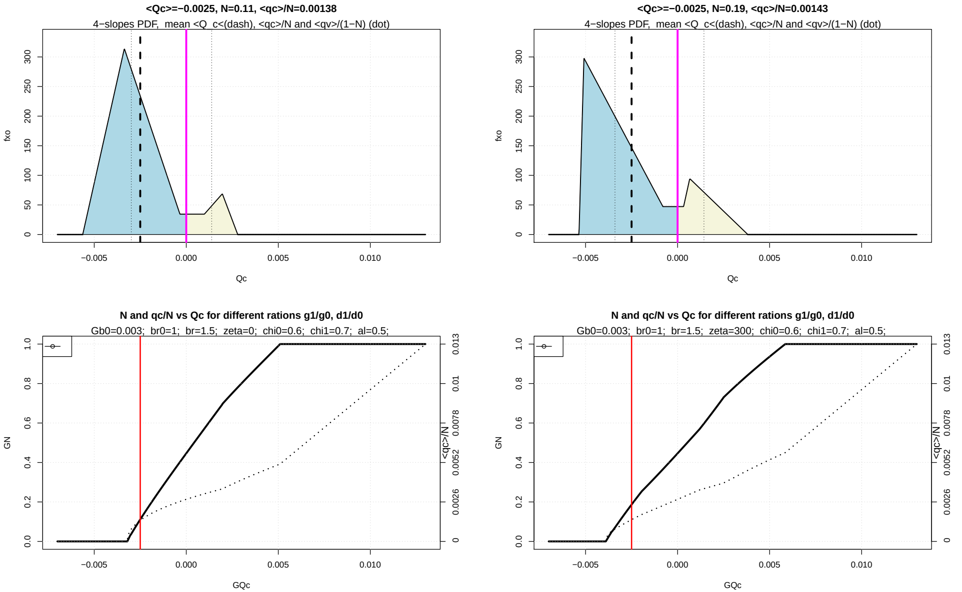

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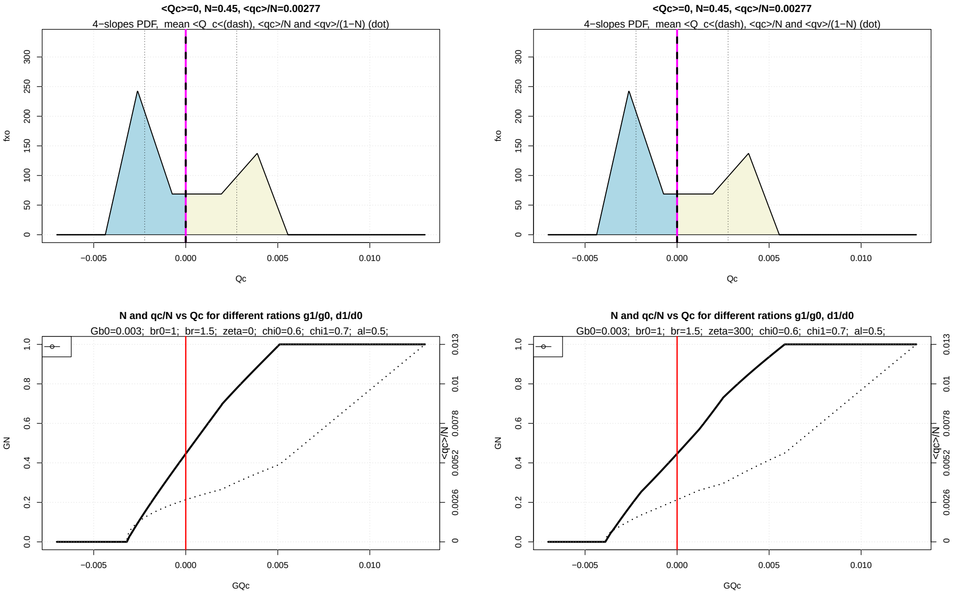

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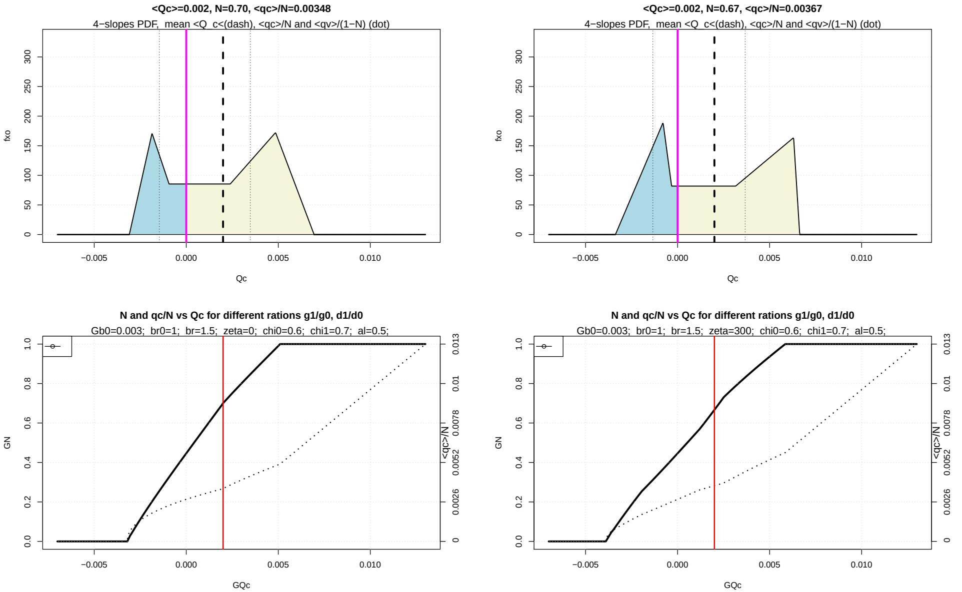

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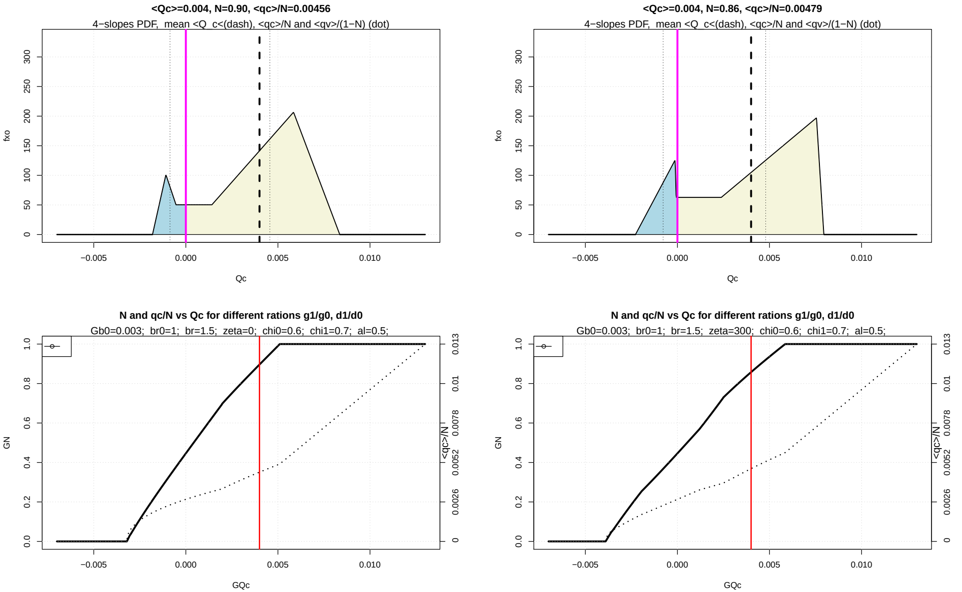

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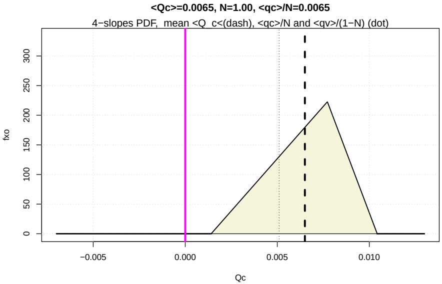
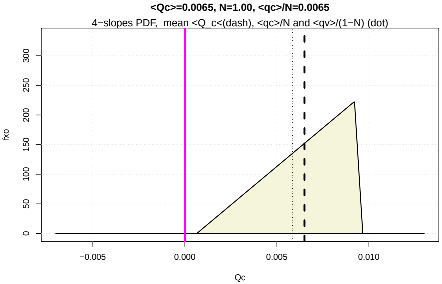
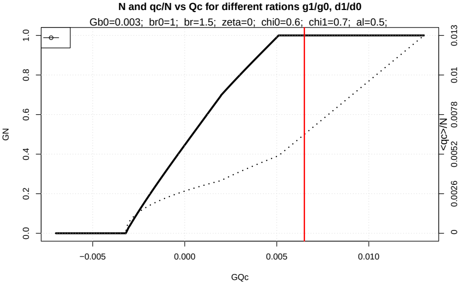
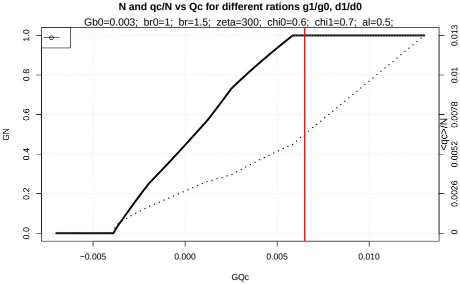
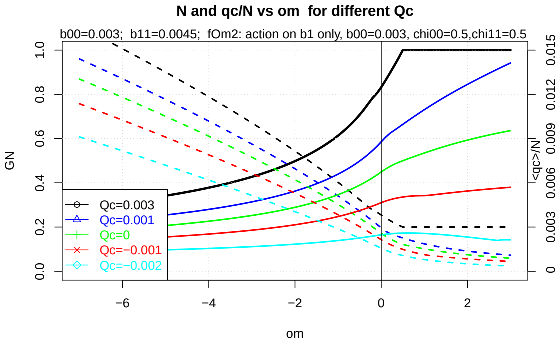








Effect of the vertical velocity



$$b_{11} = br \cdot b_{HUC} \cdot \frac{1 - \min(0, \omega_r)}{1 + \max(0, \omega_r)}, \qquad \omega_r = \frac{\overline{\omega}}{\omega_0}$$

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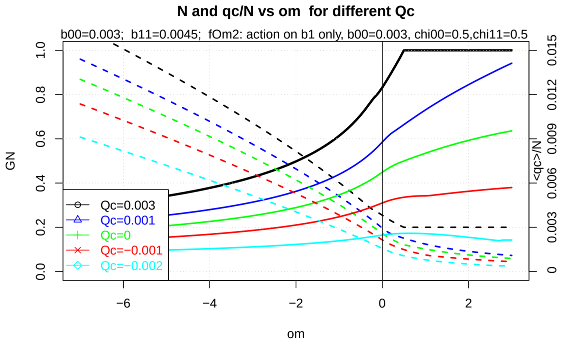

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$\Rightarrow$ *resolved upwards motion increases b_{11}, which in turn*

- *reduces N*
- *increses cloud water concentration $\overline{q_c}/N$.*

Other aspects of unified scheme

- Correction of saturation (local T) below real T inversion:
  - earlier only in radiative cloud
  - here moved to cloud condensation scheme $\Rightarrow$ thermal effect of enhanced condensation.

- Shallow convection :TOUCANS $\rightarrow$ only transport,

  $\Rightarrow$ assume condensation covered by resolved scheme.

- Context of grey zone, maximum overlap of convective and 'resolved' cloud

Other aspects of unified scheme

- Protection of convective condensate

$$N_t = \max(N^\diamond, N_c) \qquad \overline{q_{c0}}^c = \overline{q_{c0}} \cdot \frac{N_c}{N_t} \qquad \overline{q_{c1}} = \max(\overline{q_c}^\diamond, \overline{q_{c0}}^c)$$

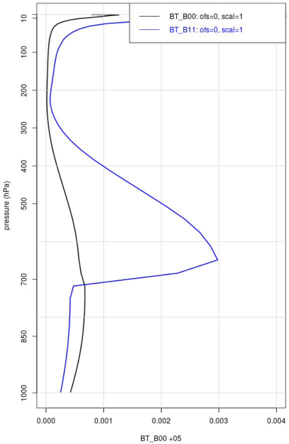
- "radiative' condensates: suspended part of gross condensate after acnebcond, with effect of vertical velocity.

$$\omega_1 = \alpha_i\,\omega_{\rm ice} + (1-\alpha_i)\,\omega_{\rm liq}, \qquad \mathsf{zsusx} = \mathsf{qsusxs}\frac{1+\max(0,\frac{-\overline{\omega}}{\omega_1})}{1+\max(0,\frac{\overline{\omega}}{\omega_1})}$$

$$\overline{q_{c,rad}} = \mathsf{zsusx}[1-\exp(\frac{-\overline{q_{c1}}}{\mathsf{zsusx}})]$$

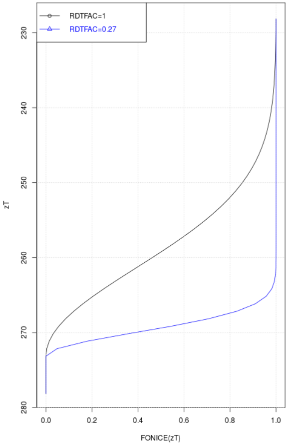
Other aspects of unified scheme

-
  - Chosen HUC profile, consideration of oversaturation below the tropopause.
  - Effect of phase on b_{00} and b_{11}:
    $\Rightarrow$ phase partition $\alpha_i(T)$ vs step transition



Peculiar things from operational 3MT

- RDTFAC=1 making a mixed phase zone up to -40^{o}C: litterature suggests -8^{o}C or RDTFAC=0.27
- XR scheme assumes $\overline{q_w}$ in clouds, *computed with a step transition from liquid to ice at 0^{o} C*: source of large departures when qorking with $\alpha_i(T) \equiv$ fonice.
- RWBF1=1600 $\leftrightarrow$ 300.



Preliminary results: Precipitation

BITRI unified cloud/condensation

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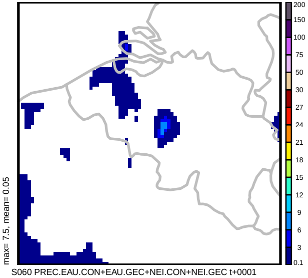

XR 3MT operational

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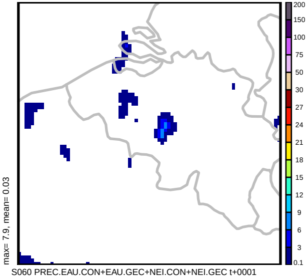

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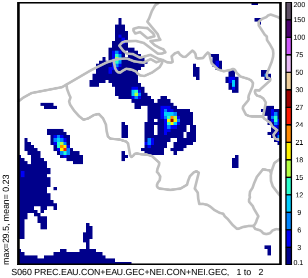

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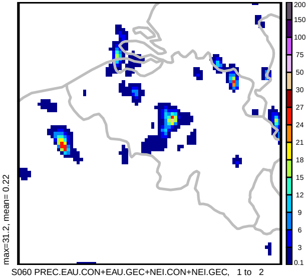
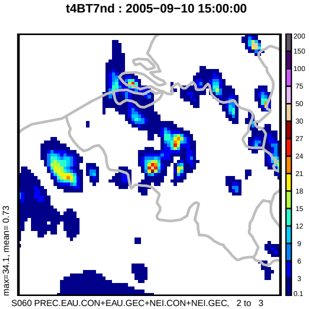


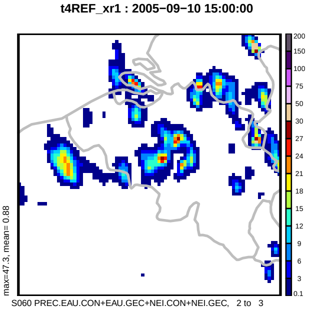
Preliminary results: Precipitation

BITRI unified cloud/condensation



t4BT7nd : 2005−09−10 15:00:00

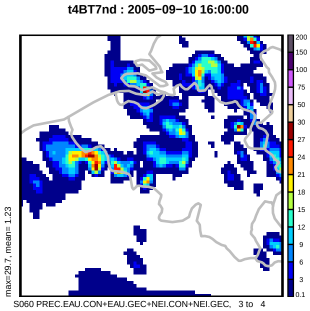
XR 3MT operational



t4REF_xr1 : 2005−09−10 15:00:00

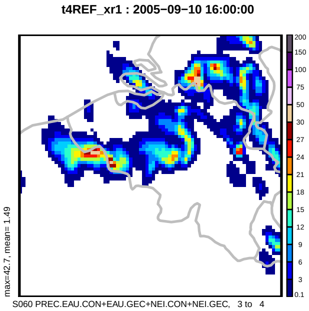
Preliminary results: Precipitation

BITRI unified cloud/condensation



t4BT7nd : 2005−09−10 16:00:00

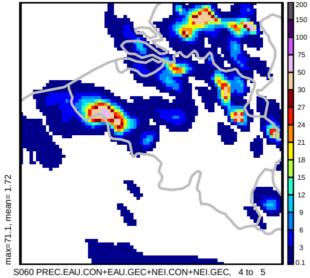
XR 3MT operational



t4REF_xr1 : 2005−09−10 16:00:00

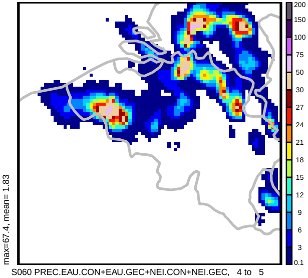
Preliminary results: Precipitation

BITRI unified cloud/condensation



t4BT7nd : 2005−09−10 17:00:00

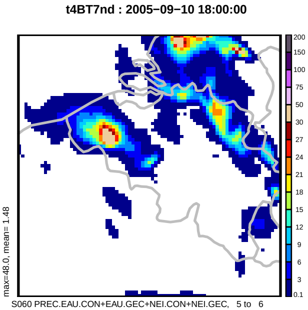
XR 3MT operational



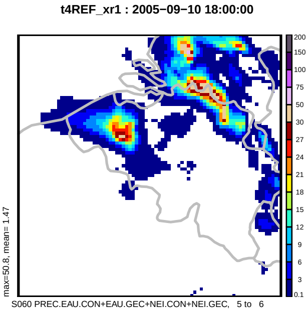
t4REF_xr1 : 2005−09−10 17:00:00

Preliminary results: Precipitation

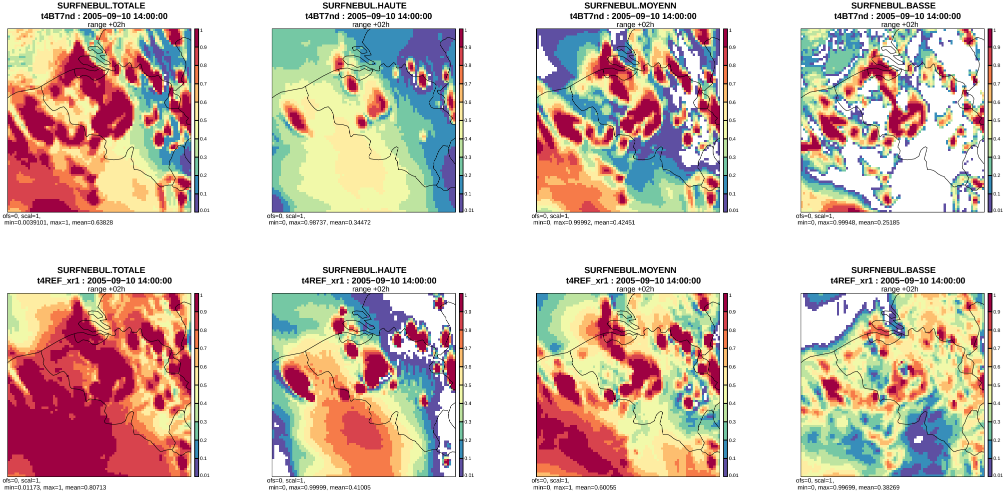
BITRI unified cloud/condensation



XR 3MT operational

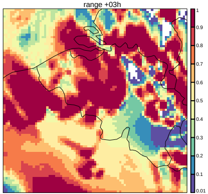


Preliminary results: classified cloud



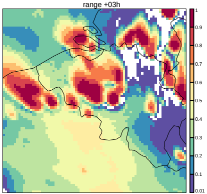
Preliminary results: classified cloud

SURFNEBUL.TOTALE
t4BT7nd : 2005−09−10 15:00:00
range +03h



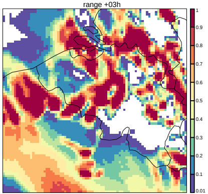
ofs=0, scal=1,
min=0, max=1, mean=0.66104

SURFNEBUL.HAUTE
t4BT7nd : 2005−09−10 15:00:00
range +03h



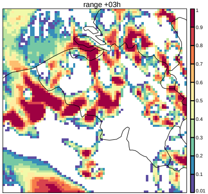
ofs=0, scal=1,
min=0, max=0.99783, mean=0.38418

SURFNEBUL.MOYENN
t4BT7nd : 2005−09−10 15:00:00
range +03h



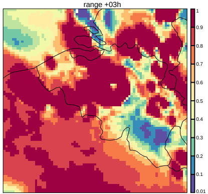
ofs=0, scal=1,
min=0, max=0.99993, mean=0.43652

SURFNEBUL.BASSE
t4BT7nd : 2005−09−10 15:00:00
range +03h



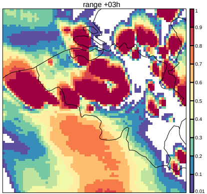
ofs=0, scal=1,
min=0, max=0.99954, mean=0.28242

SURFNEBUL.TOTALE
t4REF_xr1 : 2005−09−10 15:00:00
range +03h



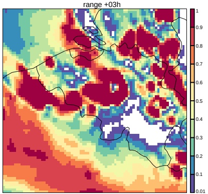
ofs=0, scal=1,
min=0.00097752, max=1, mean=0.74335

SURFNEBUL.HAUTE
t4REF_xr1 : 2005−09−10 15:00:00
range +03h



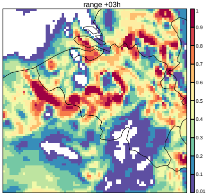
ofs=0, scal=1,
min=0, max=0.99999, mean=0.43785

SURFNEBUL.MOYENN
t4REF_xr1 : 2005−09−10 15:00:00
range +03h



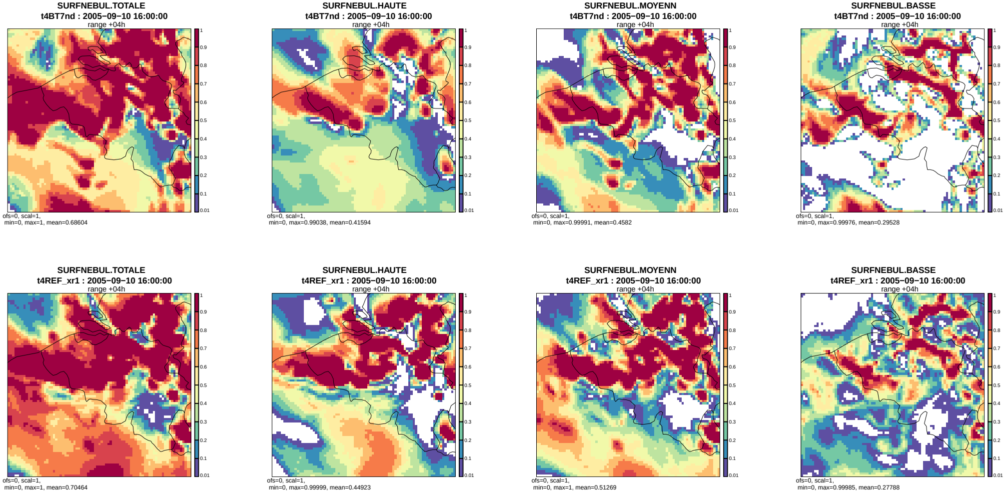
ofs=0, scal=1,
min=0, max=1, mean=0.53579

SURFNEBUL.BASSE
t4REF_xr1 : 2005−09−10 15:00:00
range +03h

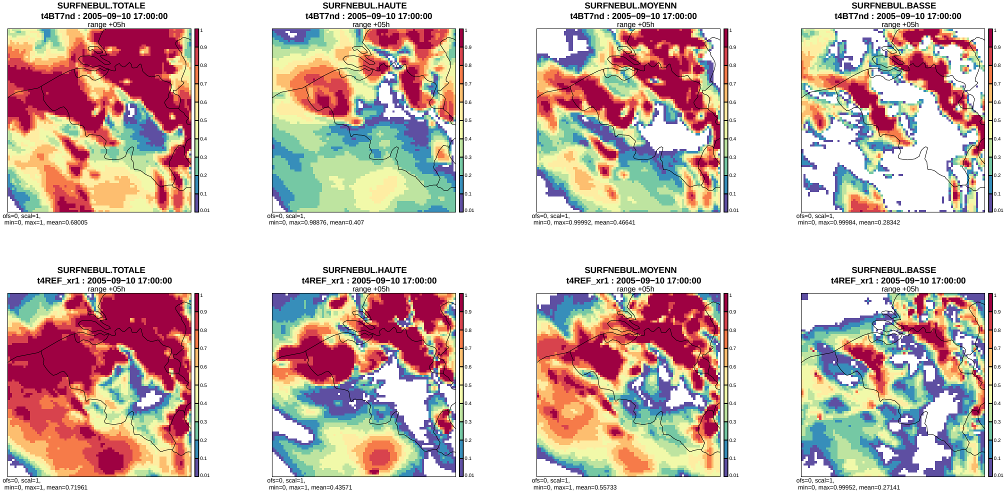


ofs=0, scal=1,
min=0, max=0.9967, mean=0.32353

Preliminary results: classified cloud



Preliminary results: classified cloud



SURFNEBUL.TOTALE
t4BT7nd : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=1, mean=0.68005

SURFNEBUL.HAUTE
t4BT7nd : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=0.98876, mean=0.407

SURFNEBUL.MOYENN
t4BT7nd : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=0.99992, mean=0.46641

SURFNEBUL.BASSE
t4BT7nd : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=0.99984, mean=0.28342

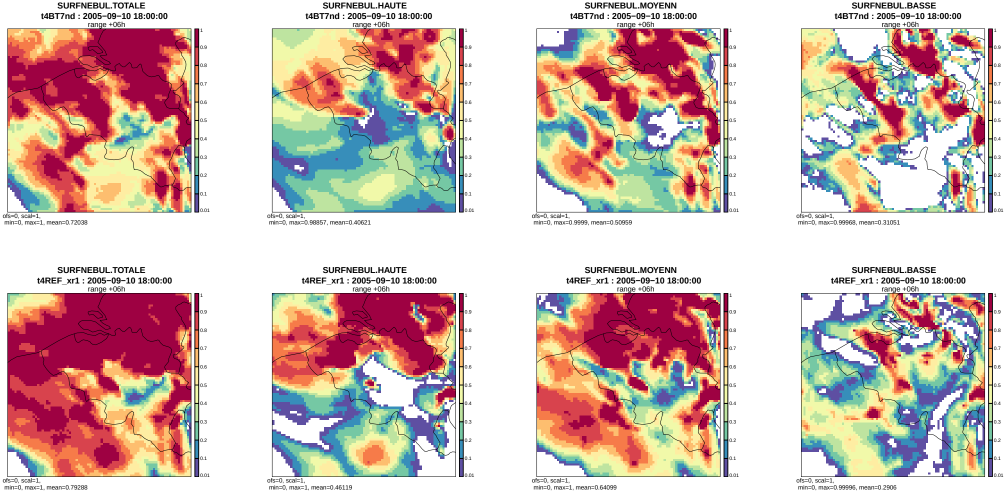
SURFNEBUL.TOTALE
t4REF_xr1 : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=1, mean=0.71961

SURFNEBUL.HAUTE
t4REF_xr1 : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=1, mean=0.43571

SURFNEBUL.MOYENN
t4REF_xr1 : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=1, mean=0.55733

SURFNEBUL.BASSE
t4REF_xr1 : 2005−09−10 17:00:00
range +05h
ofs=0, scal=1,
min=0, max=0.99952, mean=0.27141

Preliminary results: classified cloud



SURFNEBUL.TOTALE
t4BT7nd : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=1, mean=0.72038

SURFNEBUL.HAUTE
t4BT7nd : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=0.98857, mean=0.40621

SURFNEBUL.MOYENN
t4BT7nd : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=0.9999, mean=0.50959

SURFNEBUL.BASSE
t4BT7nd : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=0.99968, mean=0.31051

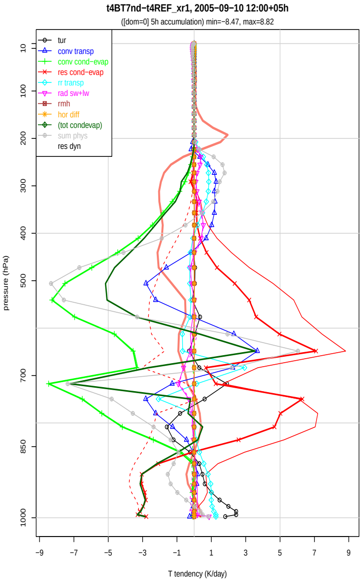
SURFNEBUL.TOTALE
t4REF_xr1 : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=1, mean=0.79288

SURFNEBUL.HAUTE
t4REF_xr1 : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=1, mean=0.46119

SURFNEBUL.MOYENN
t4REF_xr1 : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=1, mean=0.64099

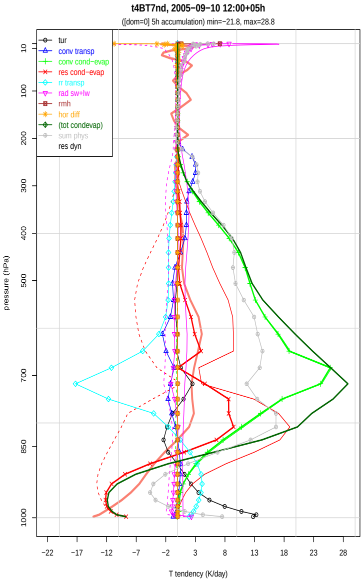
SURFNEBUL.BASSE
t4REF_xr1 : 2005−09−10 18:00:00
range +06h
ofs=0, scal=1,
min=0, max=0.99996, mean=0.2906

Preliminary results: DDH



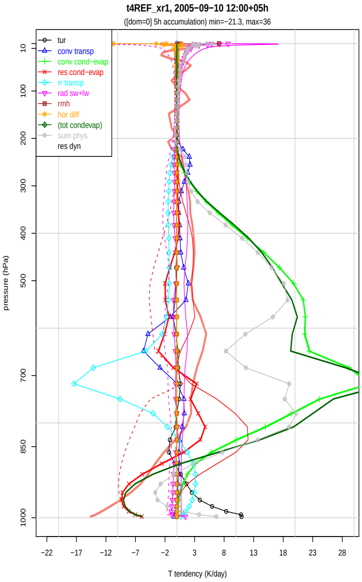
t4BT7nd−t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−8.47, max=8.82



t4BT7nd, 2005−09−10 12:00+05h

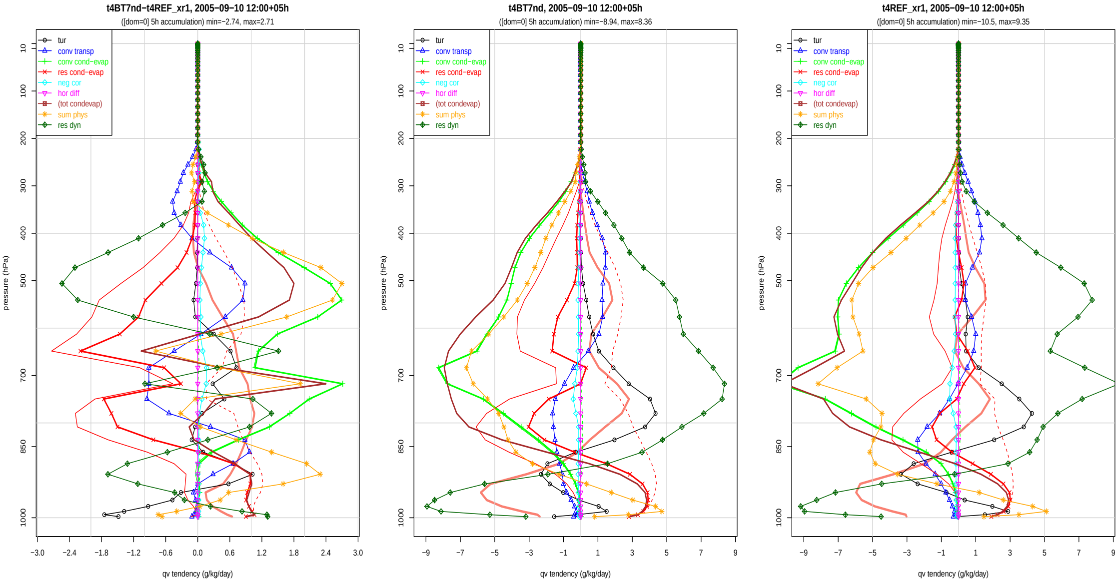
([dom=0] 5h accumulation) min=−21.8, max=28.8



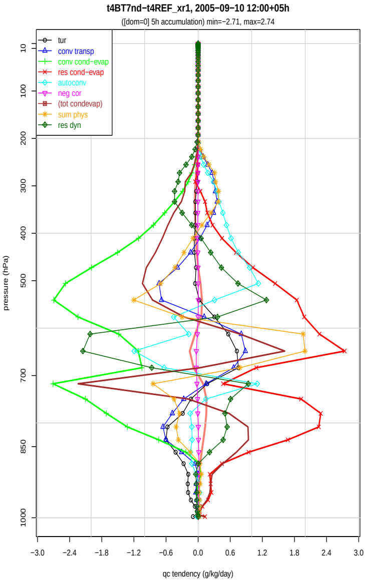
t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−21.3, max=36

Preliminary results: DDH

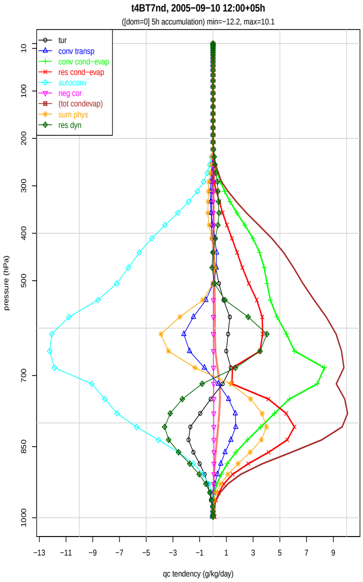


Preliminary results: DDH



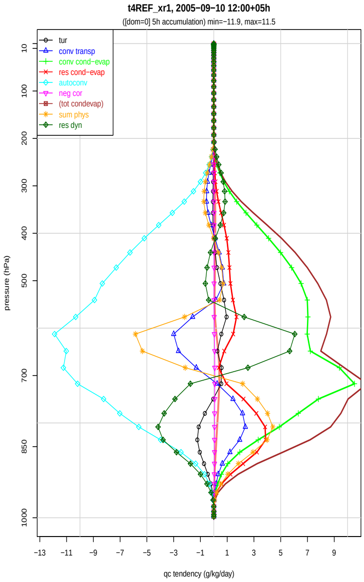
t4BT7nd−t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−2.71, max=2.74



t4BT7nd, 2005−09−10 12:00+05h

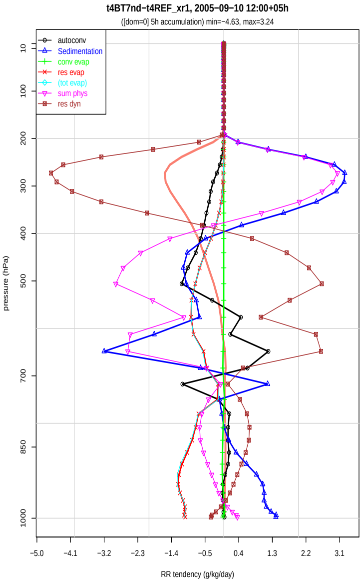
([dom=0] 5h accumulation) min=−12.2, max=10.1



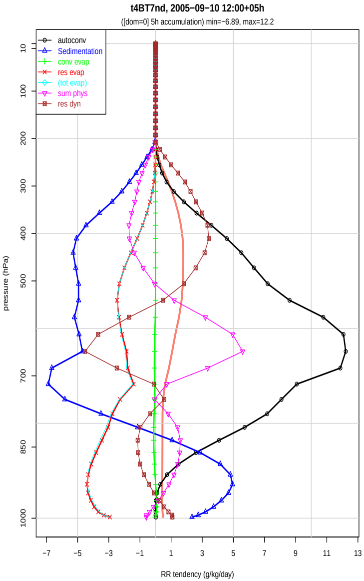
t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−11.9, max=11.5

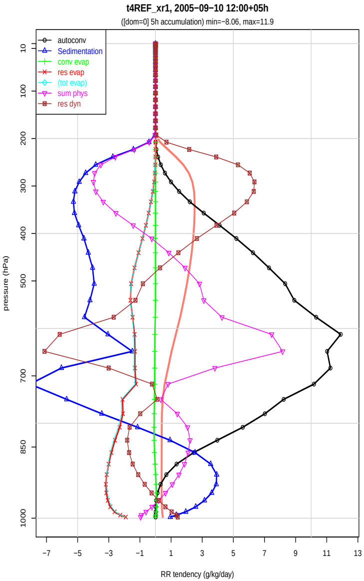
Preliminary results: DDH


t4BT7nd−t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−4.63, max=3.24


t4BT7nd, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−6.89, max=12.2


t4REF_xr1, 2005−09−10 12:00+05h

([dom=0] 5h accumulation) min=−8.06, max=11.9

Work going on...

- getting an effective control of tendencies ⇒ scores
- CSD scheme ⇒ same process.
- Validation over the seasons...
- ...