AROME sensitivity to cloud and EDMF schemes

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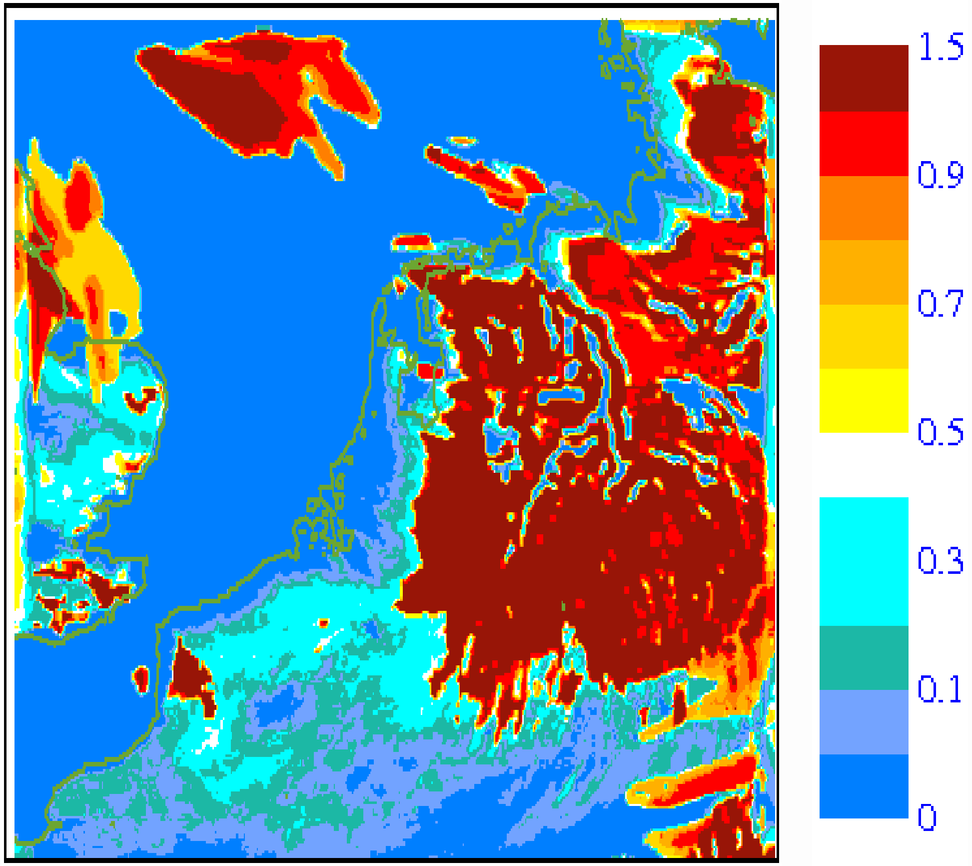
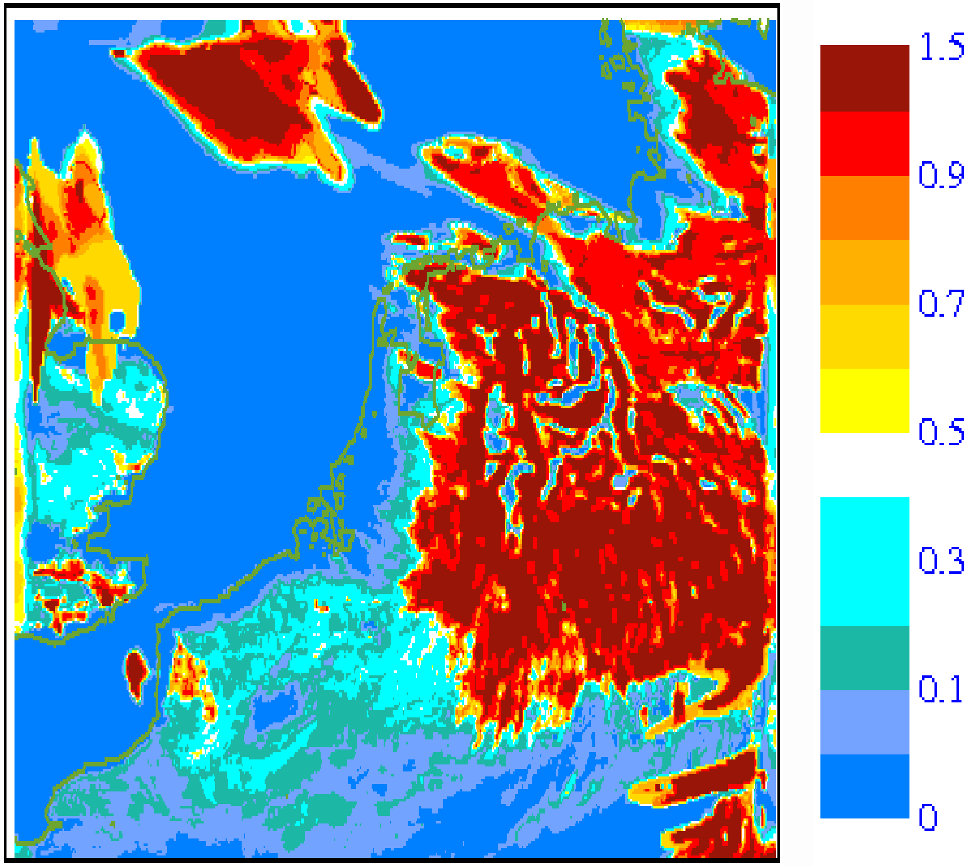
Problematic (9 April 2010 at 12h)



AROME has a too much “all-or-nothing” behaviour

Problematic (9 April 2010 at 12h)



With the additional variance term suggested by Wim de Rooy (based on humidity) we reduced this problem but we still have a too much “all-or-nothing” behaviour in shallow convection area.

Plan

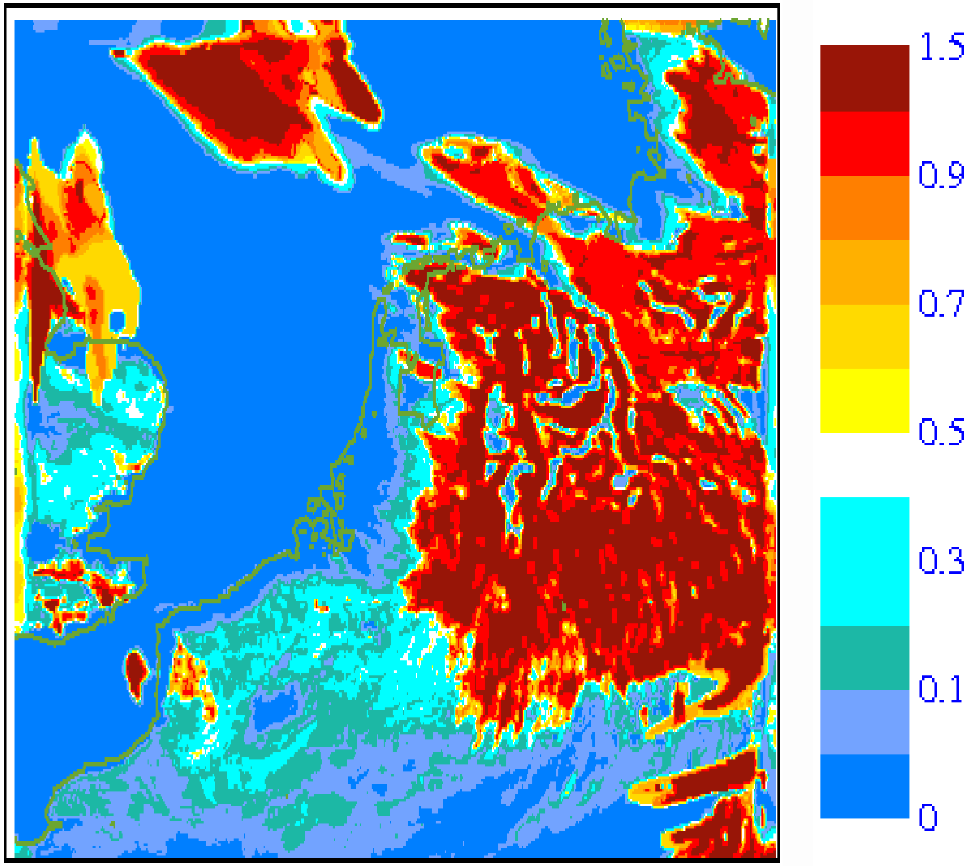
1. EDKF corrections
2. New cloud scheme
3. Cloud schemes comparisons with EDKF
4. EDMF schemes comparisons
5. Scores over 1 month
6. Perspectives

EDKF corrections

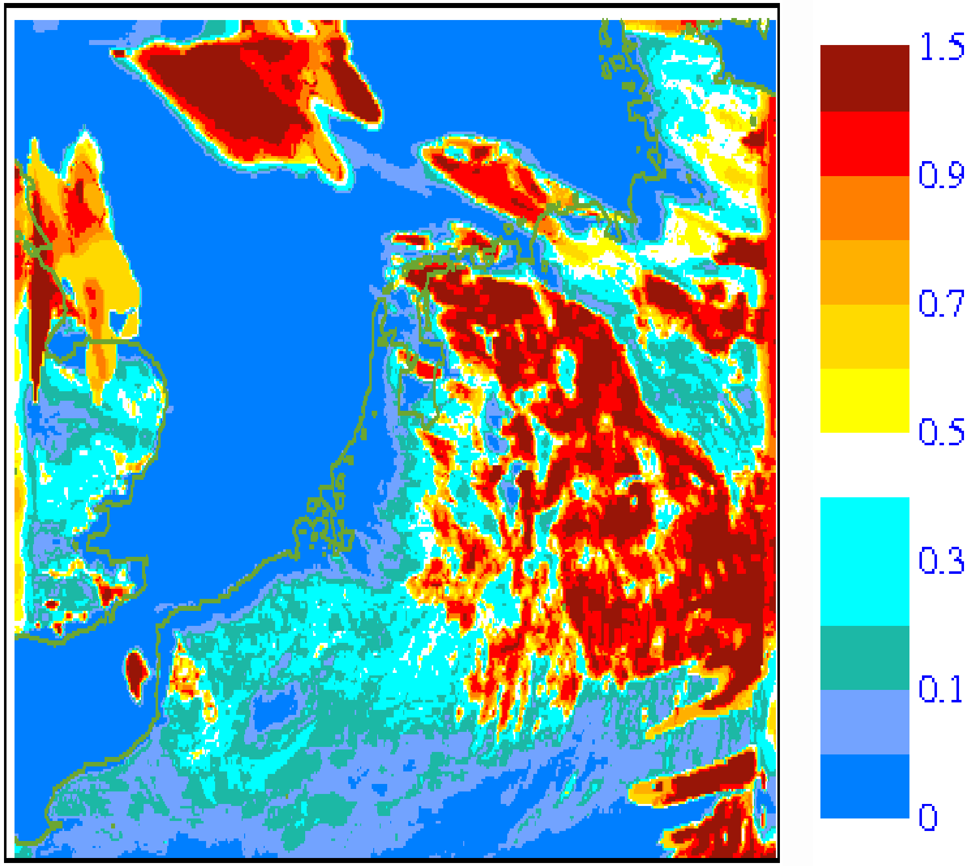
Rt and θ_l are the variables used in EDKF but we need to calculate θ in order to compute the buoyancy:

- It's an iterative process (because it uses Rv_{sat} which depends on θ) that must converge,
- To accelerate computation, we use a guess of Rc/Ri. This guess can be too small or too big,
- Clouds can be warm, cold or mixed

9 April 2010 at 12h simulated with operational version of θ_l to θ conversion



9 April 2010 at 12h simulated with ice correction



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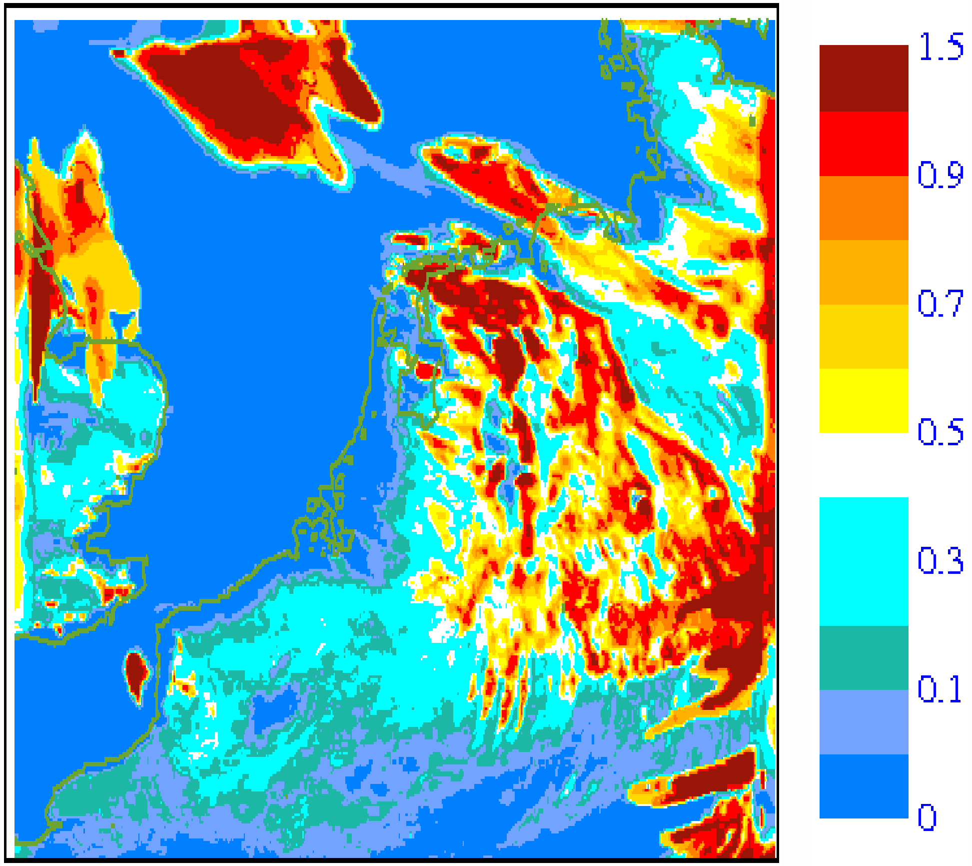
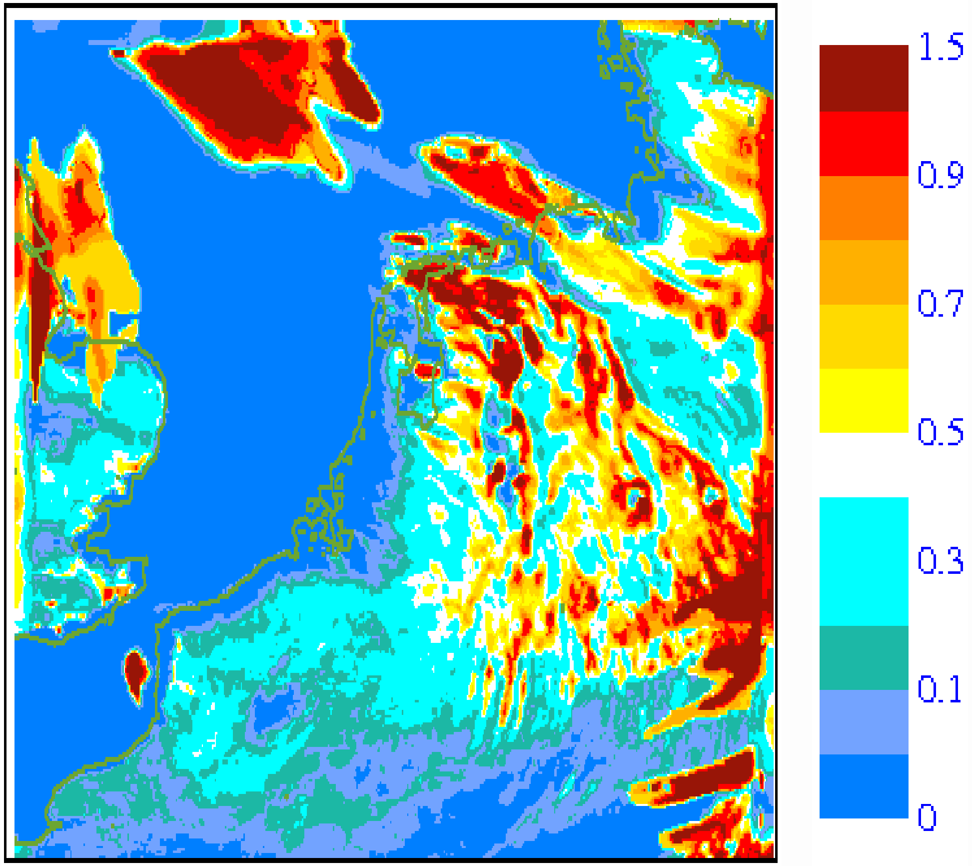
9 April 2010 at 12h simulated with ice correction and allowing guess to be over or under estimating



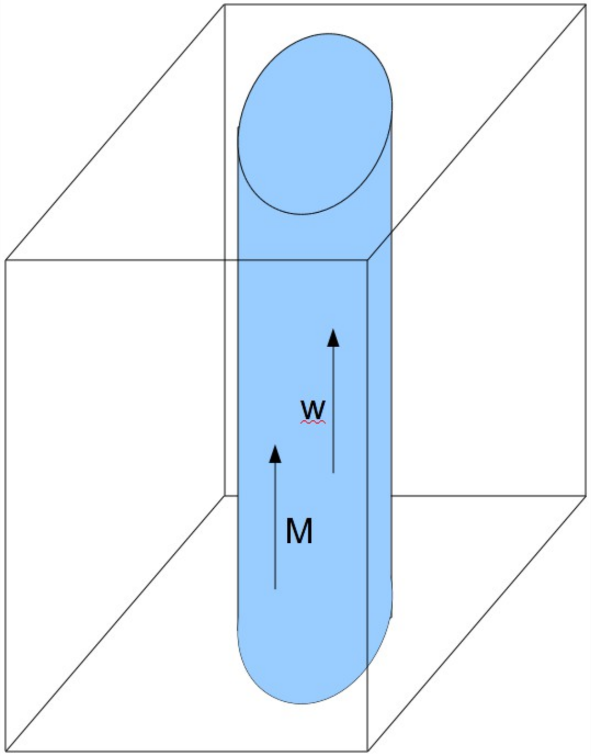
9 April 2010 at 12h simulated with ice correction, allowing guess to be over or under estimating and total convergence



Different cloud schemes

Different cloud schemes are implemented in AROME:

- 'DIRE': Cloud fraction and Rc/Ri are diagnosed directly from updraft variables. (Pergaud et al, 2009)



$$CF = 2.75 \times \frac{M}{\rho w}$$

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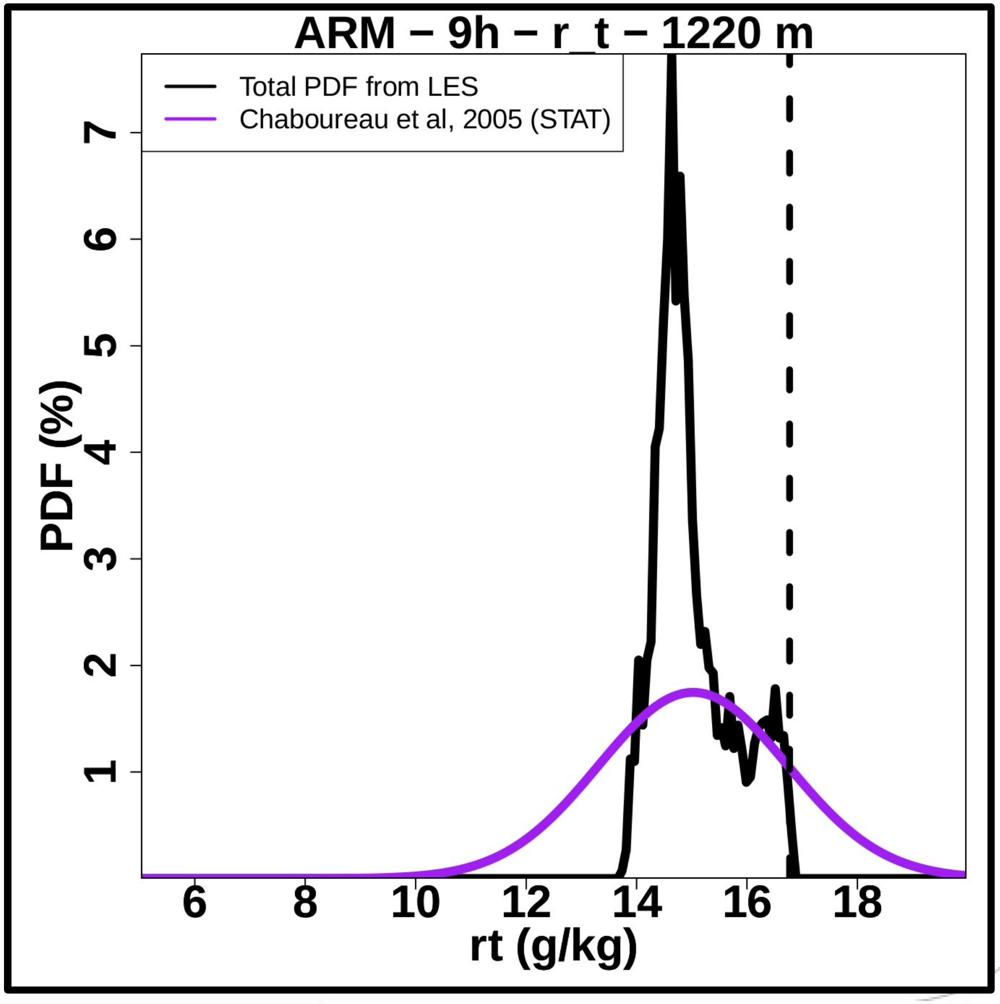
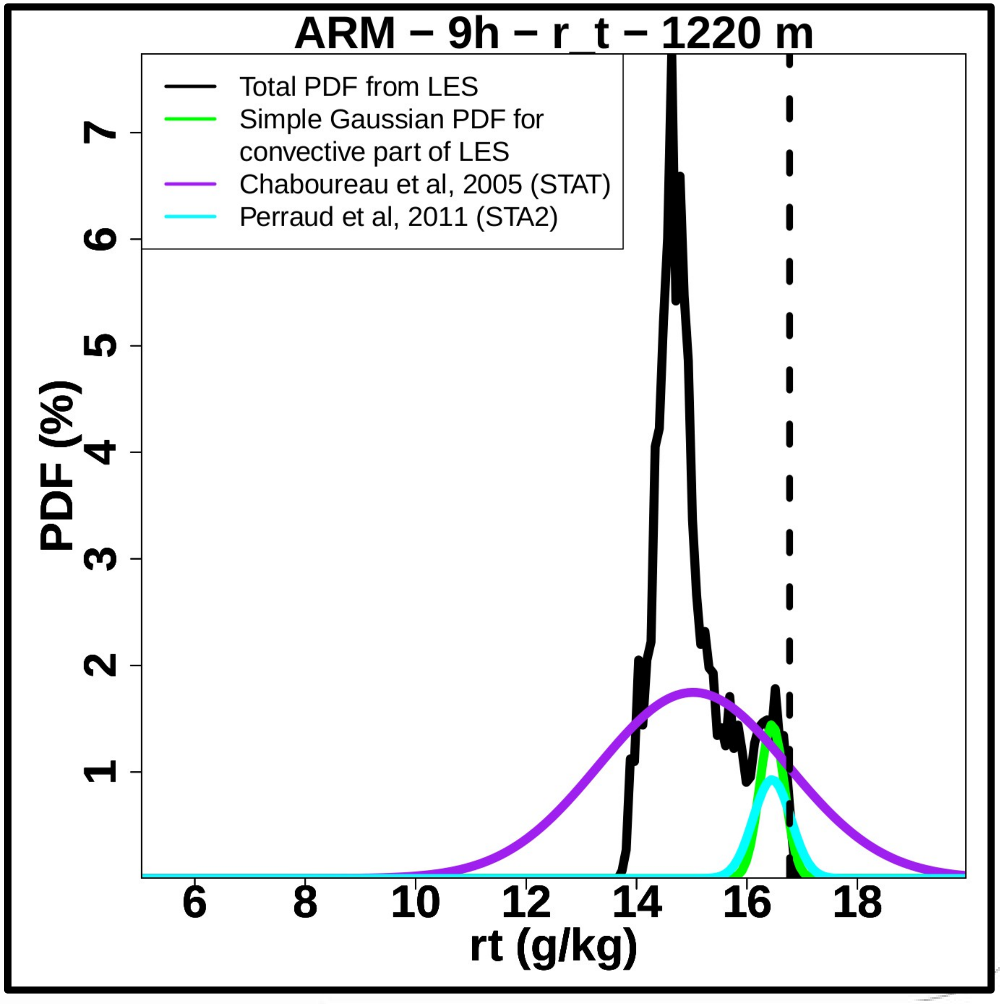
Different cloud schemes

- 'STAT': A variance is diagnosed from updraft variables to be used with the same PDF as the one used in the adjustment process. (Chaboureau et al, 2005)



Different cloud schemes

- 'STA2': New parametrisation. A variance is diagnosed from updraft variables to be used with an other (new) PDF. This way we use a double-Gaussian PDF with one mode for the environment and one for shallow convection. (Perraud et al, 2011)



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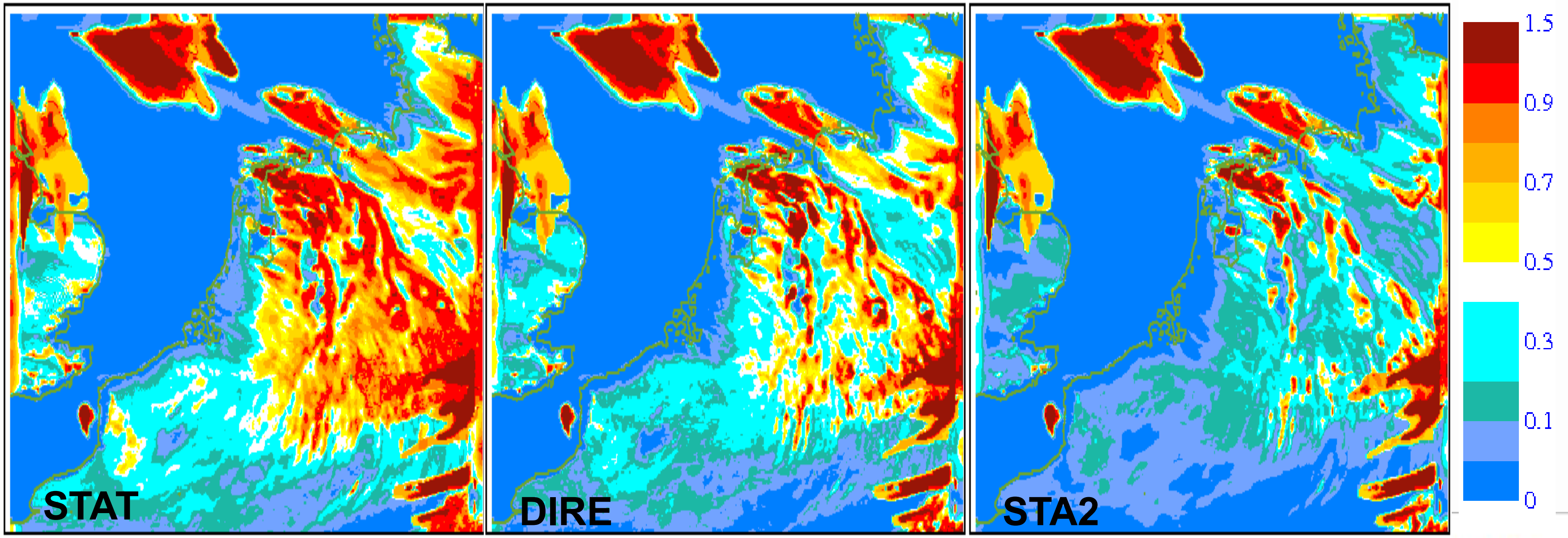
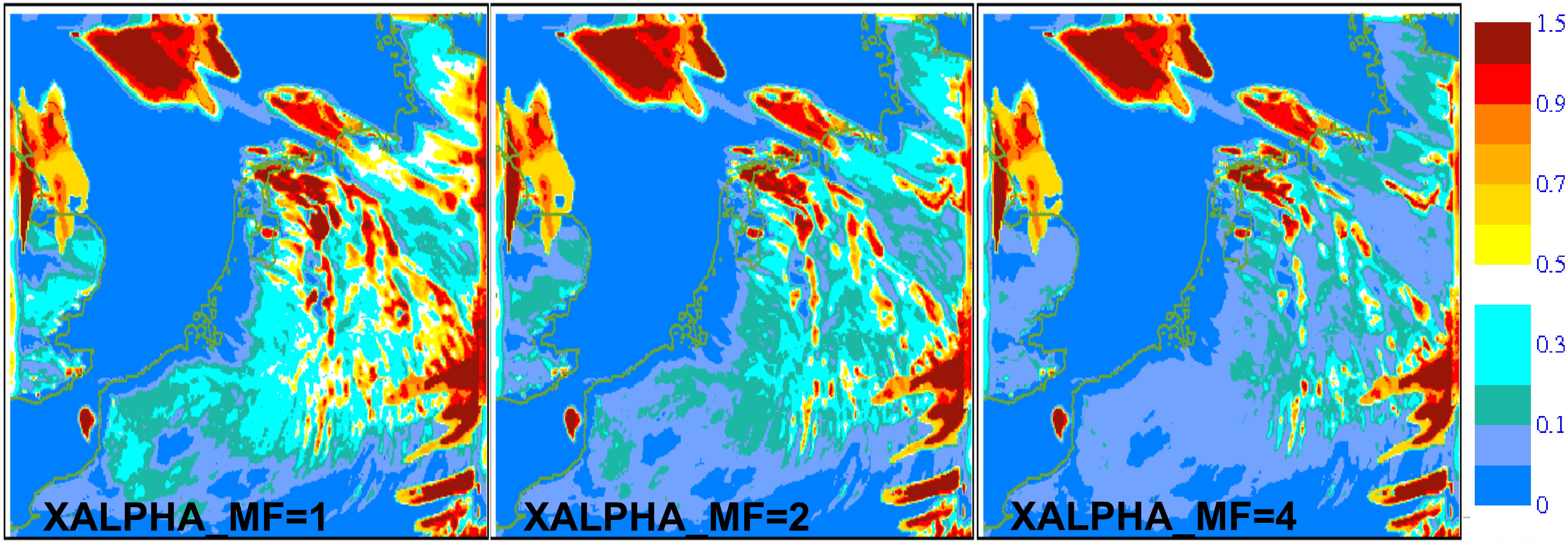
Cloud scheme comparisons



STA2 cloud scheme
XALPHA_MF sensitivity



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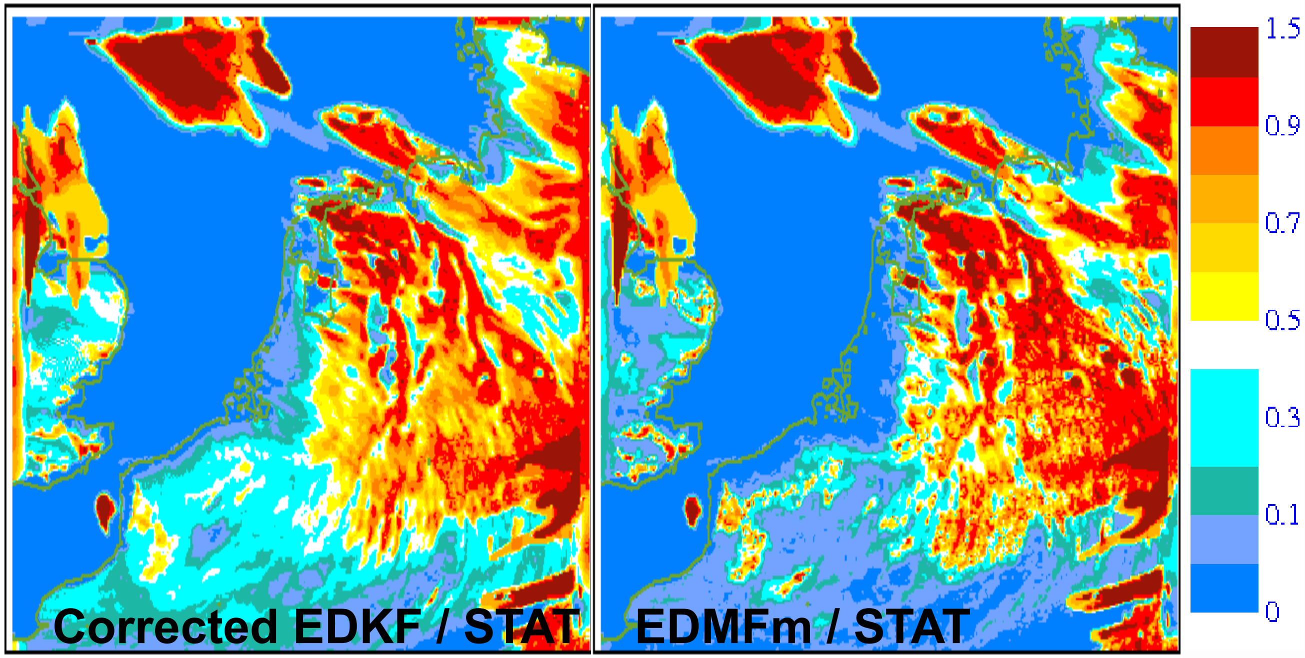
EDMF and entrainment / detrainment schemes

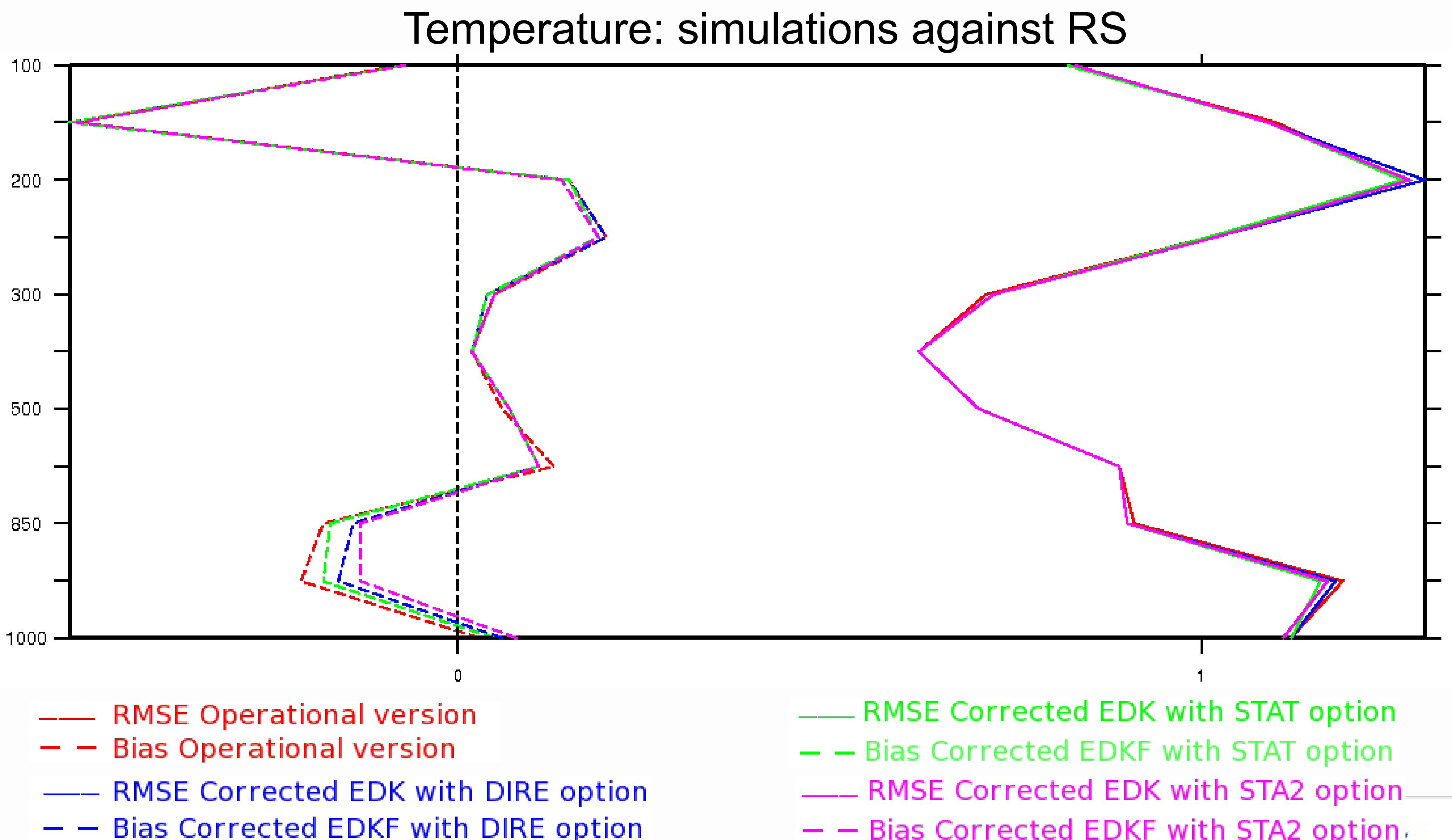
Different schemes are or will be implemented in AROME:

- EDKF as used in operations but corrected (Pergaud et al, 2009)
- EDKF with entrainment/detrainment scheme by Rio et al, 2010 (implementation in progress by R. Honnert).
- EDMFm scheme as used at KNMI

Entrainment / detrainment scheme comparisons



Scores over a 40 days-period (April-May)



Scores over a 40 days-period (April-May)

Same kind of impact is seen on humidity,

but scores show a very weak impact on screen-level parameters.

=> We need other diagnostics to evaluate EDKF and the cloud scheme used.

Perspectives

- Test of Rio et al entrainment/detrainment scheme
- Choice of entrainment/detrainment and cloud schemes to use
- Development or use of existing cloud scores with CALIPSO, CLOUDSAT, SIRTA and/or Cabauw...
- Tuning of the cloud scheme using 3D experiments
- Study of transition with resolved convection
- Homogenisation (computation of ice fraction, temperature to use to compute Rv_{sat}, iterations...) during
  - adjustment process
  - θ_l to θ conversion in EDKF
  - computation of shallow convection clouds

  which all compute cloud fraction and cloud content from θ_l.

End

Cloud scheme: DIRE (Pergaud et al, 2009)

$$CF = XKCF * CF^{up}$$
$$Rc = CF * Rc^{up}$$
$$Ri = CF * Ri^{up}$$

$$XKCF = 2.75$$

Cloud scheme: STA2 (Perraud et al, 2011)

$$PDF(x,\mu,\sigma) \equiv \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

$$CF^{up}(r_{sat}(T^{up}), r_t^{up}, \sigma) \equiv \int_{x=r_{sat}(T^{up})}^{x=+\infty} PDF(x, r_t^{up}, \sigma)\, dx \qquad CF = CF^{up} \times \alpha^{up}$$

$$\overline{r_c}^{up}(r_{sat}(T^{up}), r_t^{up}, \sigma) \equiv \int_{x=r_{sat}(T^{up})}^{x=+\infty} (x - r_{sat}(T^{up}))\, PDF(x, r_t^{up}, \sigma)\, dx \qquad Rc = \overline{r_c}^{up} \times \alpha^{up}$$

Lenderink et Siebesma, 2000

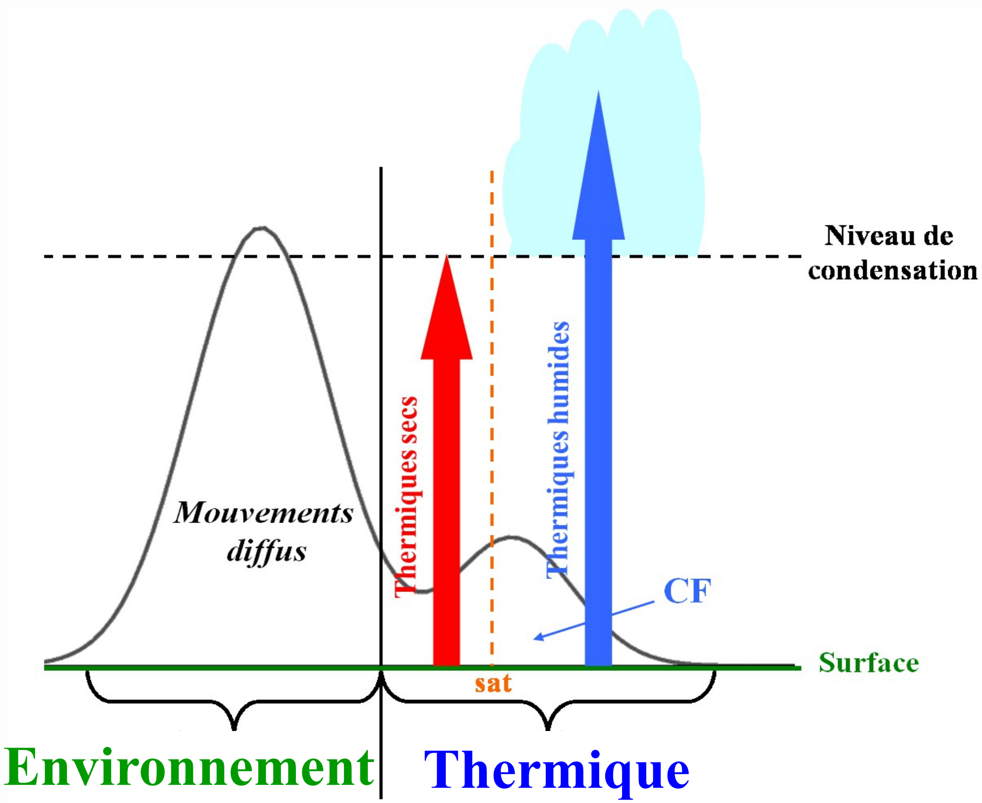
$$\omega_*^{up} = \left(\int_{cloud} \frac{g\, M (\theta_v^{up} - \theta_v^{env})}{\theta^{env} \rho} dz \right)^{1/3}$$

$$\alpha^{up} = \frac{M}{XALPHA\, \rho\, \omega_*^{up}}$$

$$\sigma^2 = \left| \frac{M (r_t^{up} - r_t^{env})}{XSIGMA\, \rho\, \omega_*^{up}} l_{cloud} \frac{\partial r_t^{env}}{\partial z} \right|$$

$$XALPHA = 2$$
$$XSIGMA = 20$$

Double-gaussian PDF



$$\mathrm{PDF} = (1-a^{up}) \cdot G_{env} + a^{up} \cdot G_{up}$$

References

- Pergaud J, Masson V, Malardel S, Couvreux F, 2009: A parameterization of dry thermals and shallow cumuli for mesoscale numerical weather prediction. Boundary-Layer Meteorol 132: 83–106
- Chaboureau JP, Bechtold P, 2005: Statistical representation of clouds in a regional model and the impact on the diurnal cycle of convection during tropical convection, cirrus and nitrogen oxides (troccinox). J Geophys Res 110: D17103
- Perraud, E., F. Couvreux, S. Malardel, C. Lac, V. Masson, and O. Thouron, 2011: Evaluation of statistical distributions for the parametrization of subgrid boundary-layer clouds, Boundary Layer Meteorology
- Rio, C., F. Hourdin, F. Couvreux and A. Jam, 2010: Resolved versus parametrized boundary-layer plumes. Part II : Continuous formulation of mixing rates for mass-flux schemes, Boundary Layer Meteorology
- G. Lenderink et P. Siebesma, 2000: Combining the mass ux approach with a statistical cloud schemes. In Proc. of 14th Symposium on Boundary Layers and Turbulence, p. 6669. American Meteorological Society