# Unsaturated downdraught in Alaro-1

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13 May 2014

# Which downdraught

Knupp & Cotton 1985:

- Penetrative downdraught (non precipitating convection, width $<$1km, depth $\sim$ 500m to 5km, w$\sim$ 1-15 m/s)
- Cloud-edge downdraught (width $<$ 5km, depth $\sim$ 1-5 km, w$<$5m/s)
- Overshooting downdraught (cloud top, width $\sim$ 500m to 5km, depth $\sim$ 1 to 3km, w $\sim$ 1-40 m/s))
- Precipitation-driven downdraught (Low level, width $\sim$ 1 to 10 km, depth $\sim$ 1-5 km , w$<$15 to 20 m/s).

# Subsaturation

Air parcel in precipitation: Evaporation of condensate

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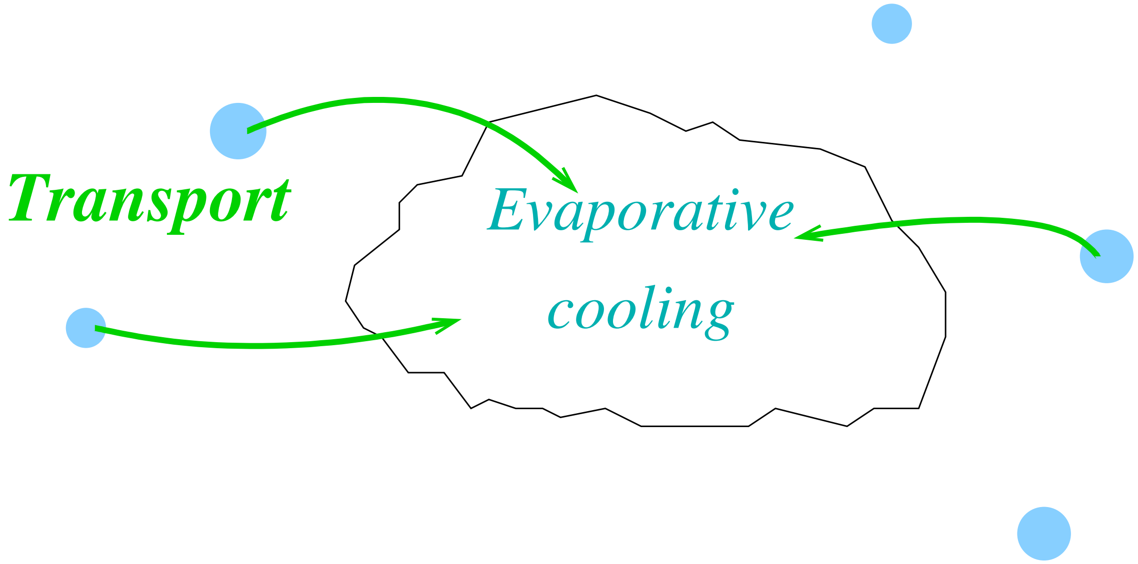

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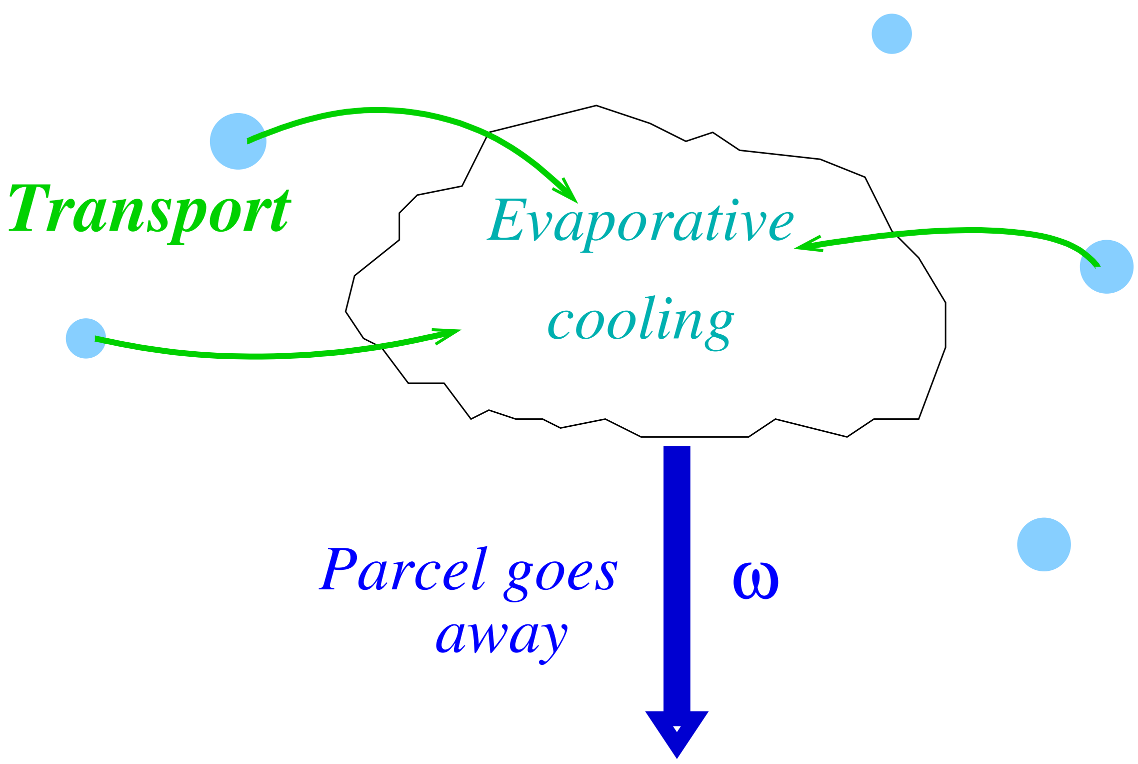

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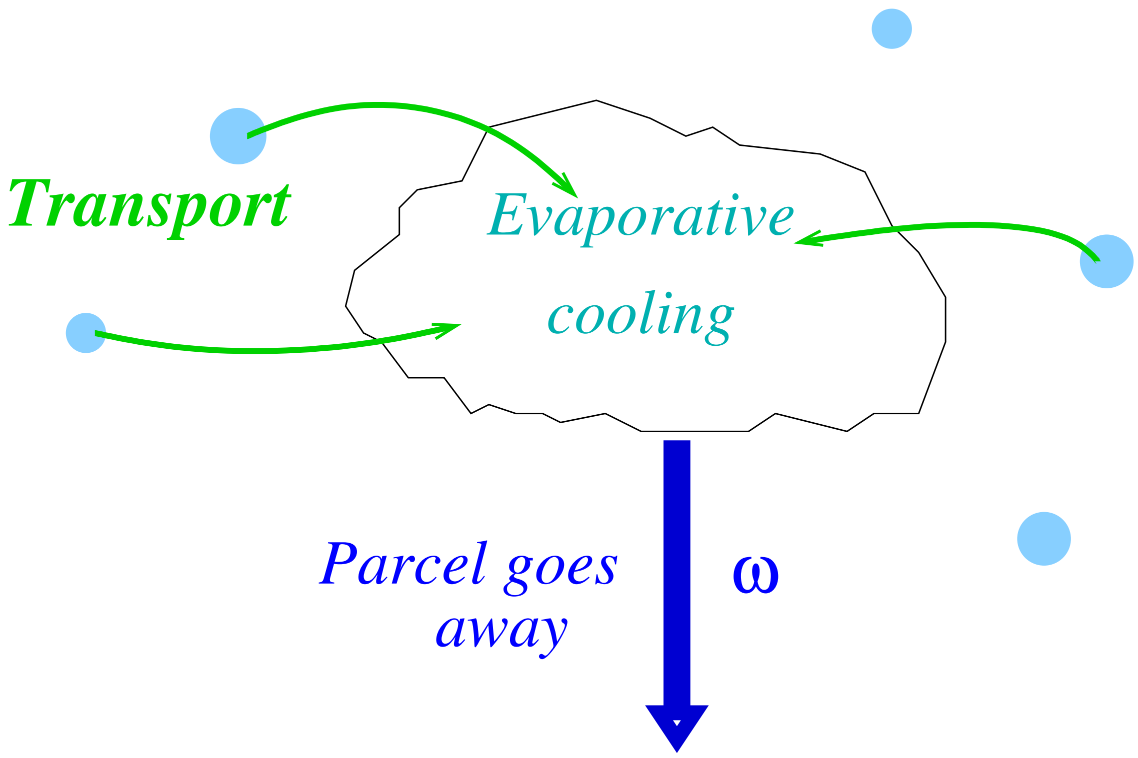


Evaporative cooling

- increases $\omega_d$
- reduced by $\omega_d >$

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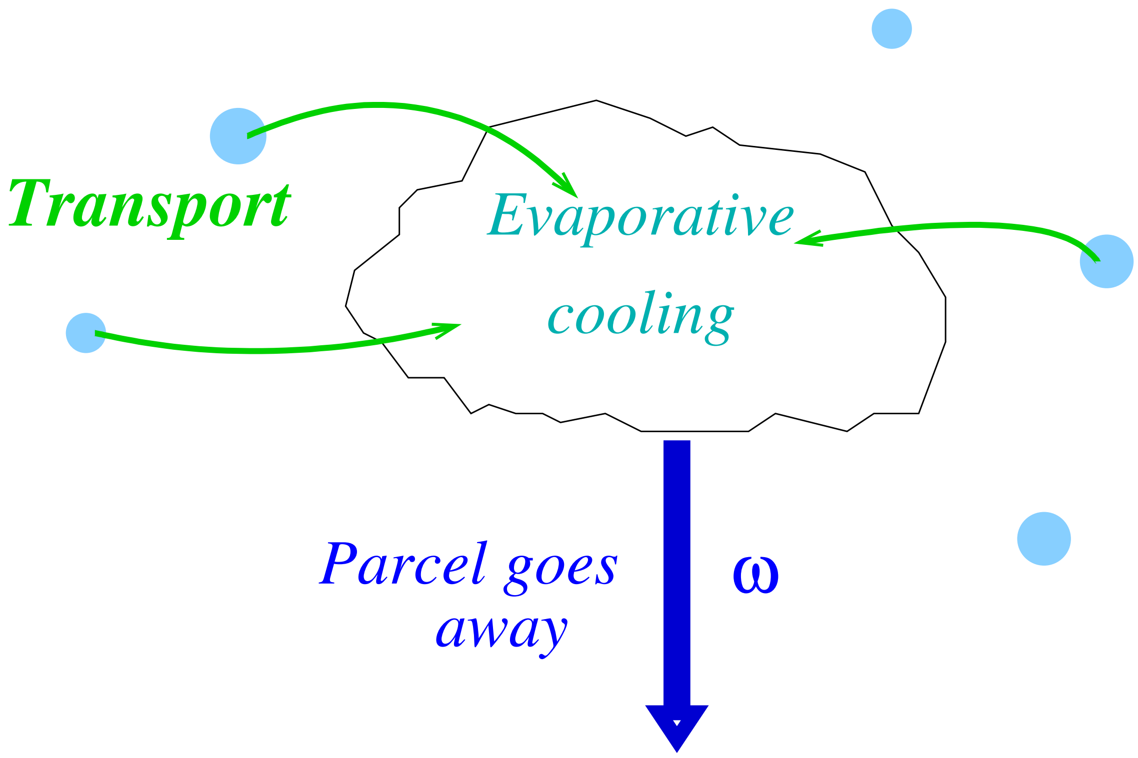


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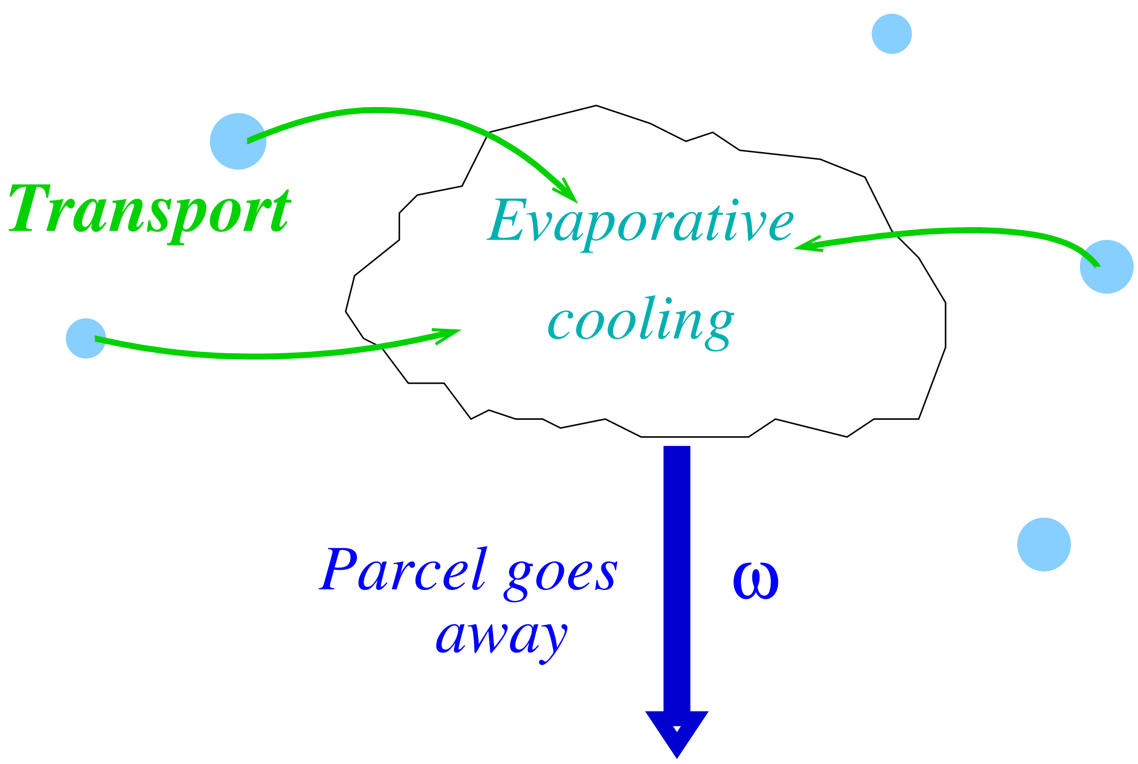


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The downdraught buoyancy results from a balance between evaporative cooling limited by $\omega_d$ and adiabatic heating increased by $\omega_d$.
Saturation requires the parcel to move very slowly ($\omega_d \sim 0$).

# Precipitation-driven downdraught parametrization

Betts and Silva Dias 1979
$\psi_d$ follows a path of constant $\theta_e$ while remaining unsaturated.

$$\frac{dq_d}{dp} = \frac{q_w - q_d}{\Pi_E} + \frac{q_e - q_d}{\mathcal{L}_e}, \qquad \Pi_e = \frac{\omega_d}{\mathcal{F}(\mathcal{P})}$$

Water transfer: parameters derived from Marshall-Palmer's distribution (Kessler 1969) + fitting a curve :

$$\mathcal{F}(\mathcal{P}) = k_F \mathcal{P}^{\beta_F}, \qquad k_F = \text{gddfp}[1] = 4.398 \cdot 10^{-2}, \qquad \beta_f = \text{gddfp}[2] = 0.75$$

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$$\frac{1}{\mathcal{L}_e} = \frac{1}{M_d}\frac{dM_d}{dp}\bigg|_e = \lambda_d \frac{d\phi}{dp}, \qquad \lambda_d = \text{tentrd} \qquad + \text{tddfr in } \omega \text{ equation}$$

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$q_d$, $T_d$ directly affected by $\omega_d$:
*vertical motion equation must be solved at the same time as downdraught profile.*

RMI

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- Control arrival level:
- not saturated
- remaining precipitation
- $k\widetilde{\omega_d} > 1.E - 12$

$$\delta q_{ev}^{\overline{l-1}} = \frac{q_w - q_d}{\Pi_e} \triangle p^{\overline{l-1}}$$

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| $I_d$ | 0 | 0.40 | 2.6 | 11.25 | 18 |
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*maybe $\sigma_{\mathcal{P}}$ presently quite crudely estimated*

# **High resolution:** LCSD=T

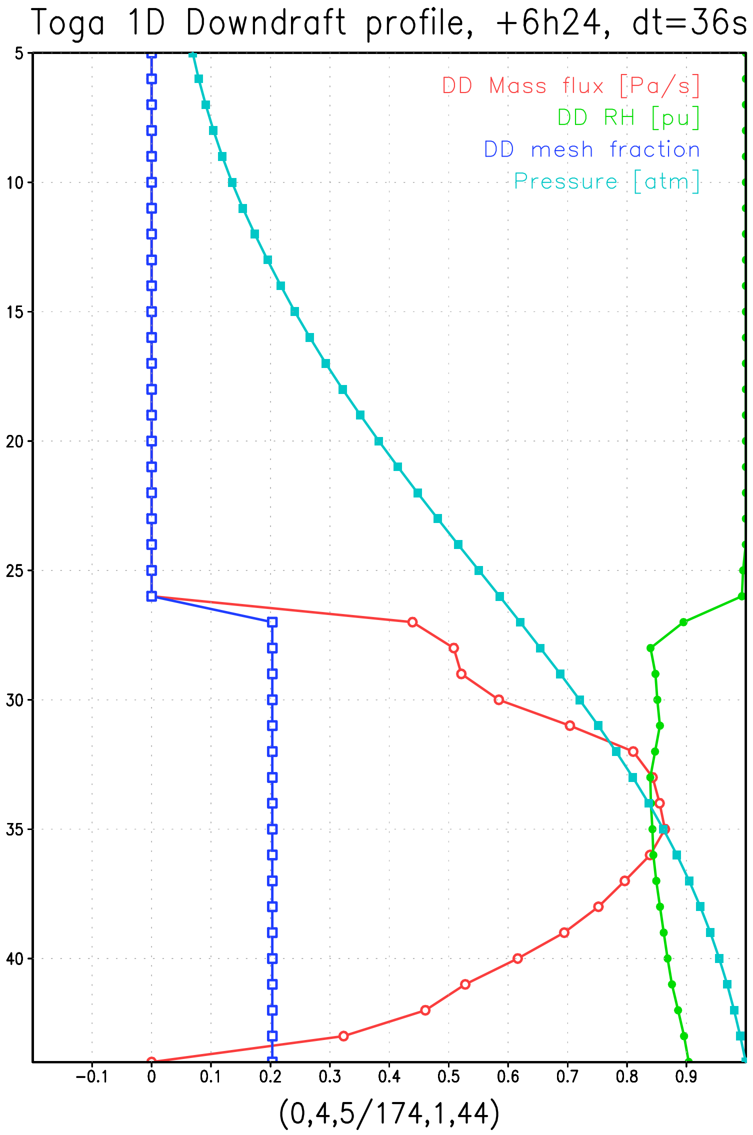
- Environment vertical velocity does matter: geometrical $\omega_e \neq 0$, i.e.
  - $\omega_e < 0$: resolved part of the updraughts in the grid box
  - $\omega_e > 0$: resolved downdraught: then $\sigma_d$ no longer limited to $\frac{1}{3}$.
- Representation of a complement to the resolved part of the downdraught;
- Separation of organized entrainment vs turbulent mixing;
- Accounting for mesh fraction on the estimation of downdraught vs environment properties.
- parameters:
  - gddalbu=0.9 buoyancy coefficient csd motion equation (instead of tddbu$\sim$0.5);
  - gddendymx=$10^{-4}$ limitation of organized entrainment.
  - tentrd represents only turbulent entrainment.

# Other tunings

- braking towards the surface:
$$\frac{\text{gdddp}}{(p^{\overline{L}} - p^{l})^{\text{gddbeta}}},$$
now $(\text{gddbeta}, \text{gdddp}) = (3, \quad 8 \cdot 10^7)$ instead of $(2, \quad 10^4)$ in acmodo.

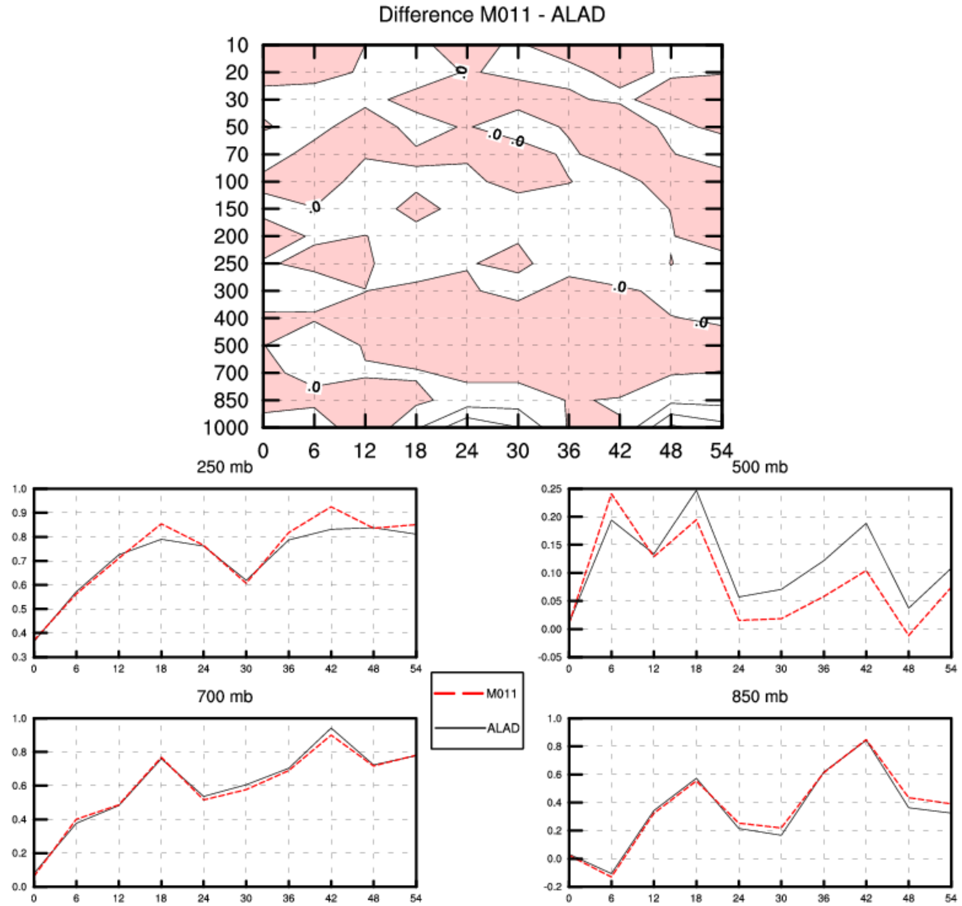
- Fixing some other aspects: $n_{\text{eq}}$, wrongly interpreted the stratiform fraction in Alaro-0 – could require a re-tuning of updraught / microphysics.

# 1-D model profiles



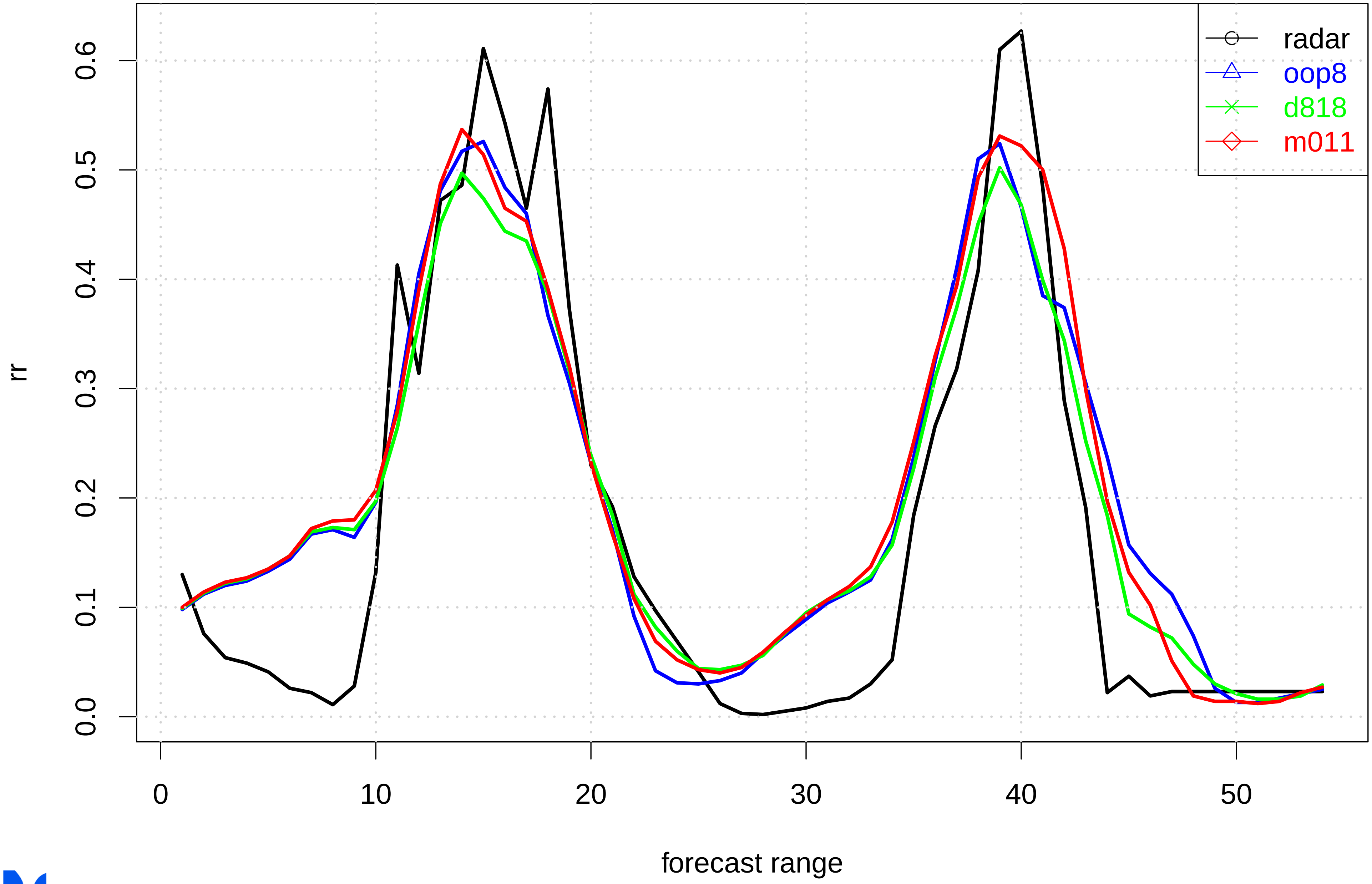
# Main scores

- Scores are sometimes neutral, sometimes it appears that a new fix in $n_{eq}$ and some other aspects may require a wider re-tuning of both microphysics and updraught.

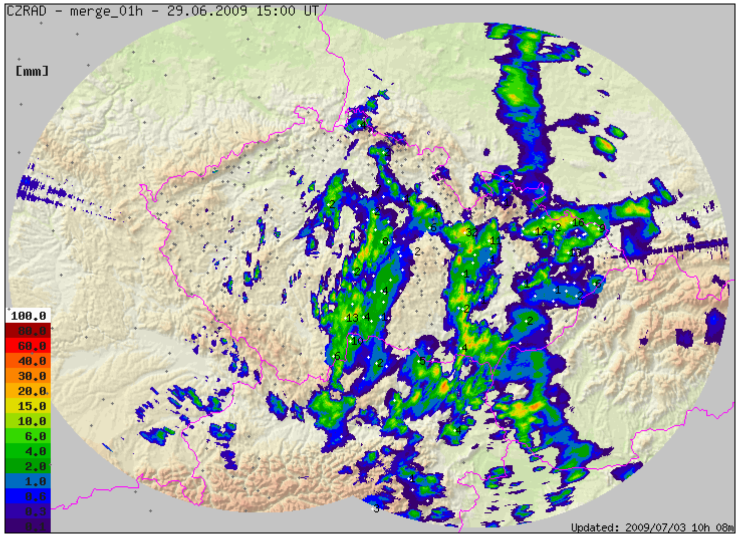


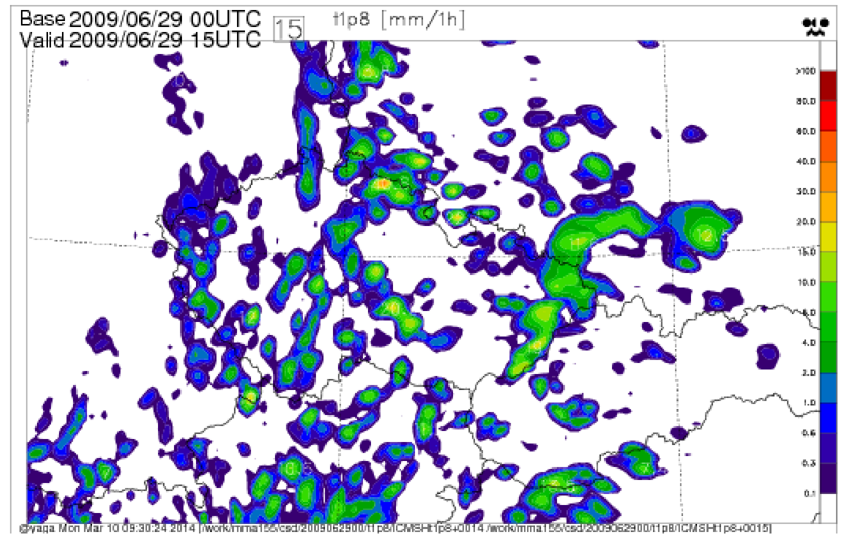

A first tuning of the unsaturated downdraught main parameters, with LCSD=T: GDDDP, TENTRD, TDDFR.

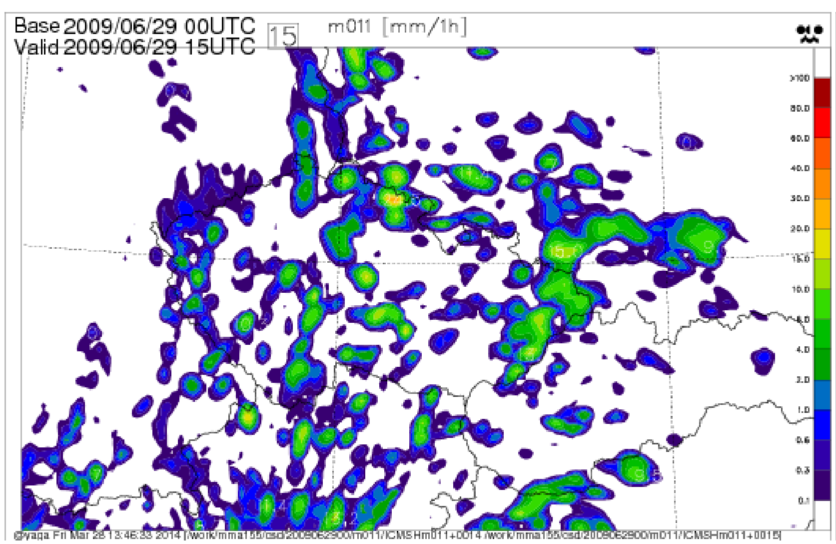
# Diurnal cycle

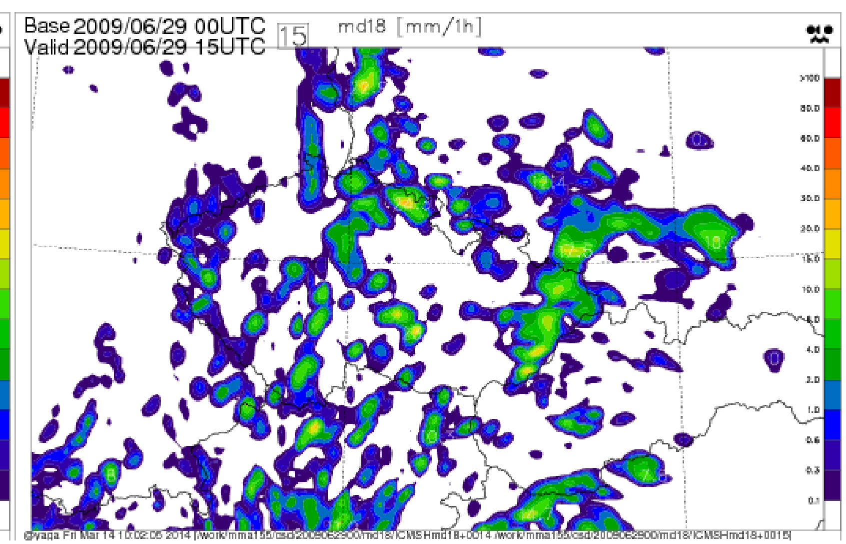


# Travel pictures



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