Improved Cloud-Radiation Coupling for the COSMO-Model

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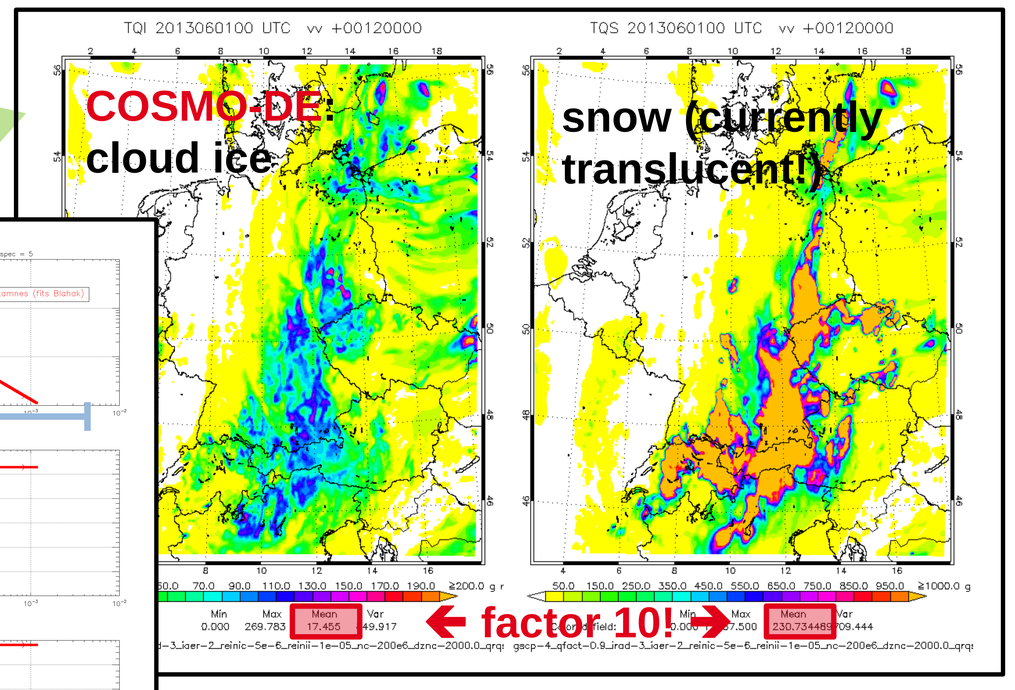
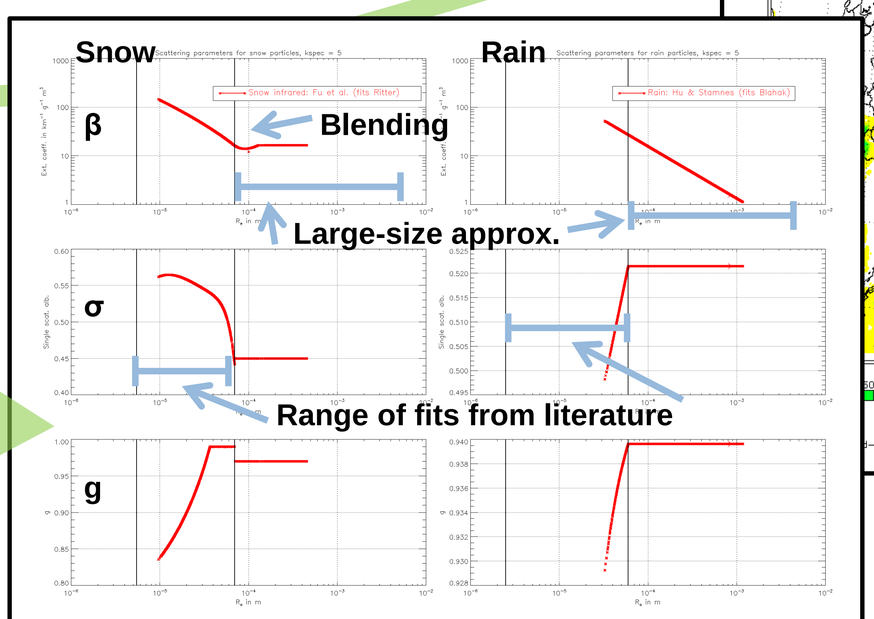
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

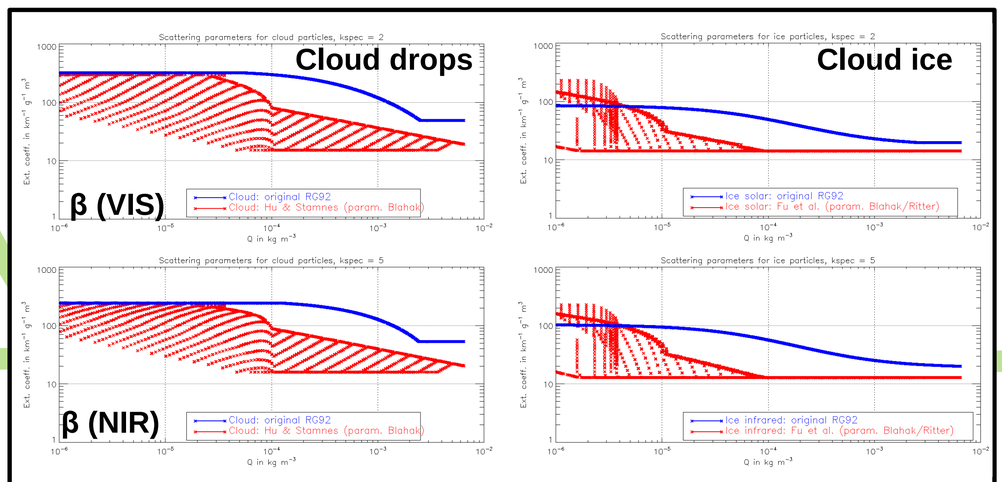
Revision of Ritter & Geleyn (RG92) radiation scheme with respect to the following points:

- RG92 includes only cloud drops and cloud ice. Other species (snow, graupel, rain, hail) translucent.
  - ➔ Include all grid scale species
- Extinction coeff. β, single scatt. albedo σ, asym. parameter g of hydrometeors only depending on their density, not their size (eff. radius R_e).
  - ➔ Switch to newer parametr. based on R_e:
    Hu & Stamnes (1993) – drops (D < 130 µm)
    Fu et al. (1996, 1998) – hex. needles (D < 140 µm)
    Spectral remapping to the 8 RG92 bands
  - ➔ Large-size-approx. for snow, graupel, rain, hail
  - ➔ R_e = fct (spectral mean mass) = fct (qx/nx)
- Revision of effective factor for subgrid variability of gridscale clouds (previously: qx_rad = 0.5 qx !)
  - ➔ Theoretical analysis, new tuning parameters „radqc_fact“, „radqi_fact“ instead of „0.5“
- Subgrid scale water/ice clouds: qc, qi, R_e?
  - ➔ New tuning parameters P1, P2, P3:
    qc = P1 * qvsat_mix * (1-f_ice)
    qi = P1 * qvsat_mix * f_ice
    P2 = $R_{e,w}$ P3 = $R_{e,i}$
- Tuning of other uncertain parameters (ongoing):
  - ➔ Number densities of cloud drops, cloud ice
    nc = fct(qc,z) ni = fct(qi,T)
    needed for R_e in case of 1-moment micrphysics
  - ➔ Sometimes very high LWPs in COSMO associated with very low SWD fluxes, which are not observed. Clipping of TQC, TQI, TQS to max. allowed values (new tuning parameters)
- Re-tuning of model system, using new Tegen aerosols (ongoing, but still long way to go!)
  - ➔ Extensive sensitivity studies, longer experiments
  - ➔ References: currently CMSAF surface SWD fluxes, but also pyranometer data (soon to come)





Examples of **new R_e-based scattering parameters**, spectral band No. 5, NIR (near infrared).

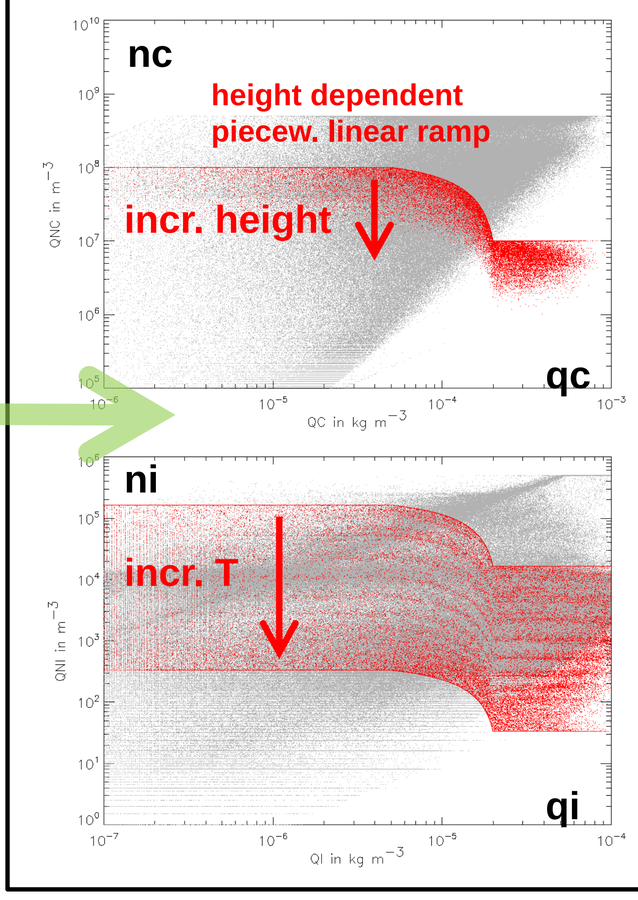


Comparison: new (red) and old (blue) β as function of q for cloud drops (left) and cloud ice (right), band 2 (top, VIS) and band 5 (bottom, NIR).

Parameterizations nc = fct(qc,z), ni = fct(qi,T)

Grey: 2-moment microphysics reference run

Red: corresponding parameterized values



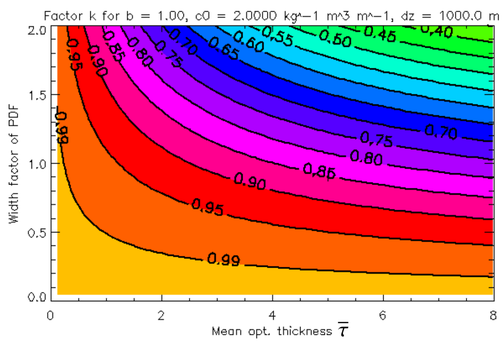
Effective factor k („radqc_fact“, „radqi_fact“) to take into account subgrid variability in clouds for β (here c_0). Simple theory based on boxcar PDF:

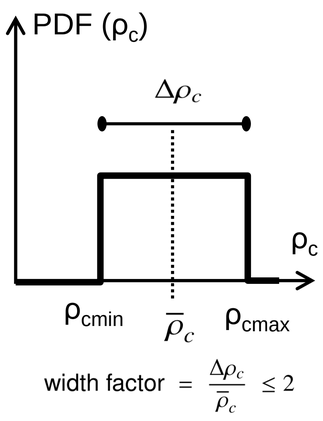
$$e^{(-k\,c_0\,\bar{\rho}_c\,\Delta z)} \stackrel{!}{=} \int_0^\infty PDF(\rho_c)\, e^{(-c_0\,\rho_c\,\Delta z)}\, d\rho_c$$

$$k = \frac{1}{c_0\,\bar{\rho}_c\,\Delta z}\,\ln\left[\frac{\Delta\rho_c\, c_0\,\Delta z}{\exp(-c_0\,\rho_{cmin}\,\Delta z) - \exp(-c_0\,\rho_{cmax}\,\Delta z)}\right]$$

$$\bar{\tau}$$

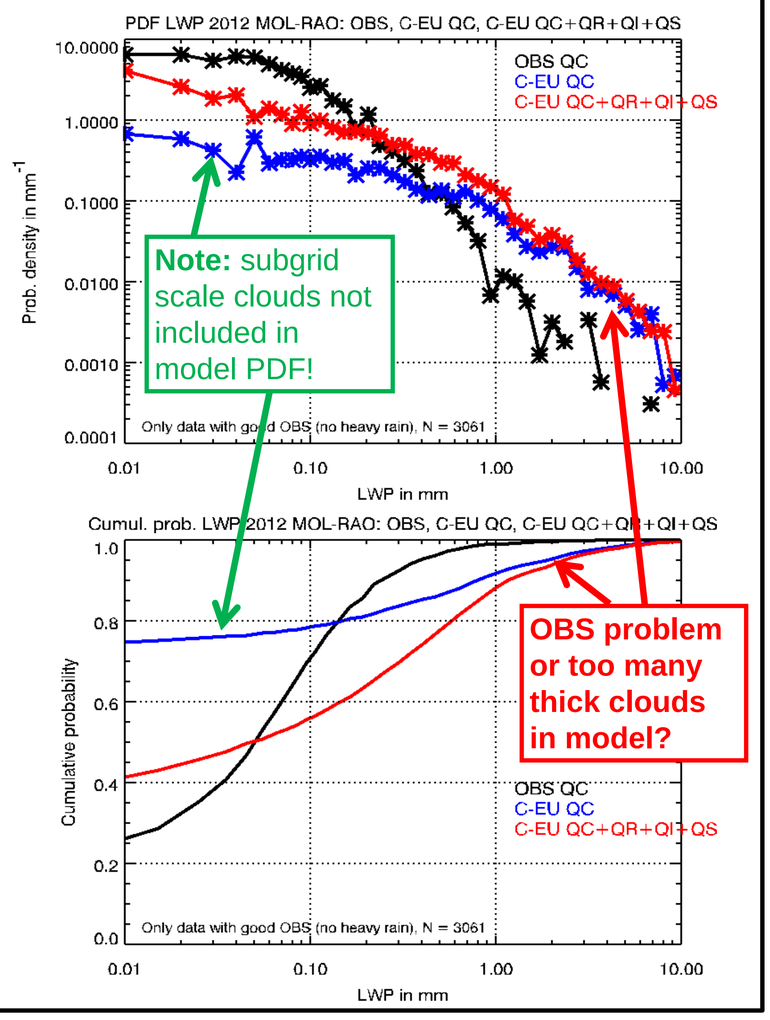
cloudy grid box ρ_c





For higher resolution (lower width factor!), k = 0.5 seems too low!

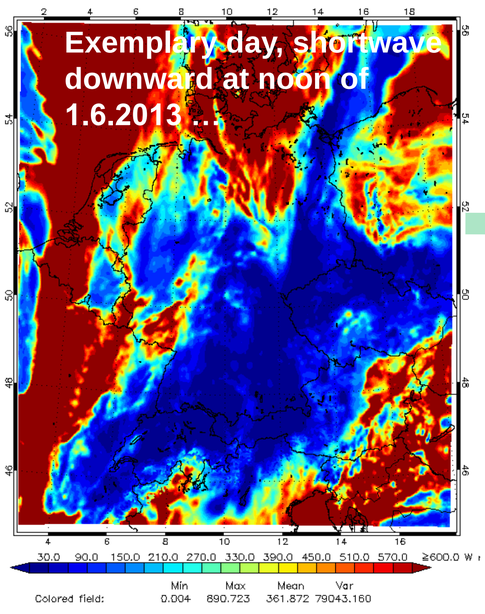
Comparison of TQC (TQT) PDF of COSMO-EU with Lindenberg OBS for 2012-2013 **motivates clipping of TQC, TQI, TQS**, but highlights **necessity to improve incloud microphysics!**

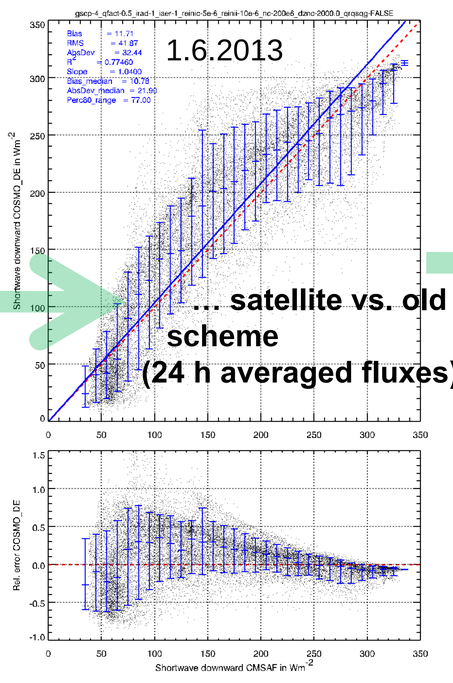


Very large tuning exercise.

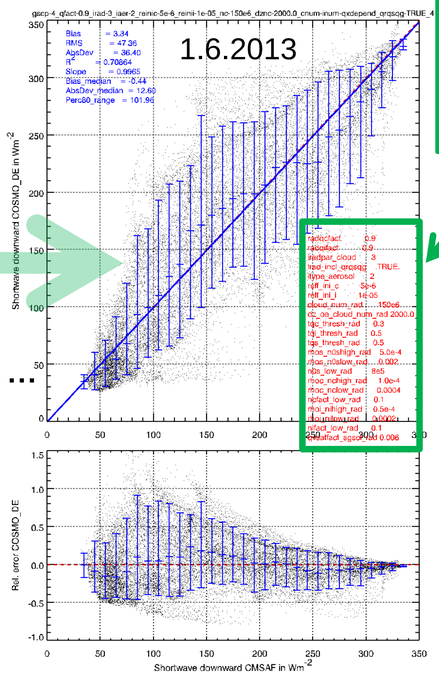
Problem: suitable OBS.

Up to now: CMSAF shortwave downward fluxes as reference.



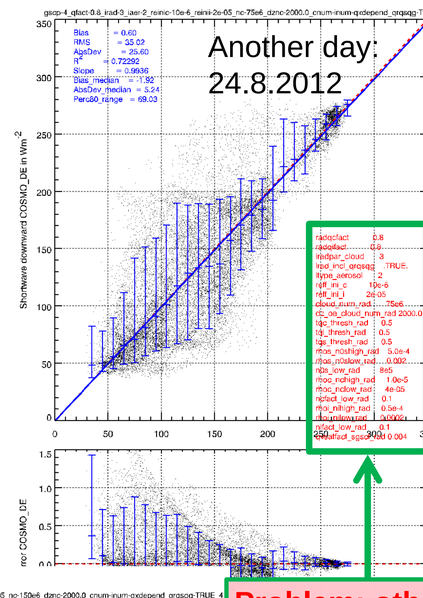


… satellite vs. old scheme (24 h averaged fluxes) …



Problem: other cases lead to other „optimal“ parameters …

… and „optimal“ tuning of the various new tuning parameters to minimize some composite error measure.



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