Cloudiness in the high resolution context

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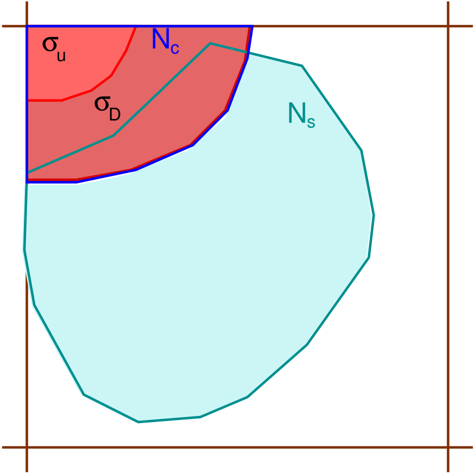
Fractions of the grid box



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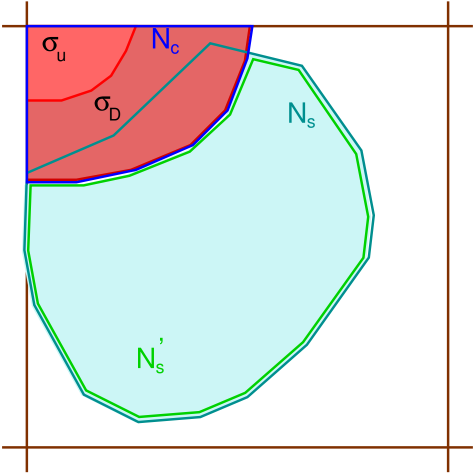

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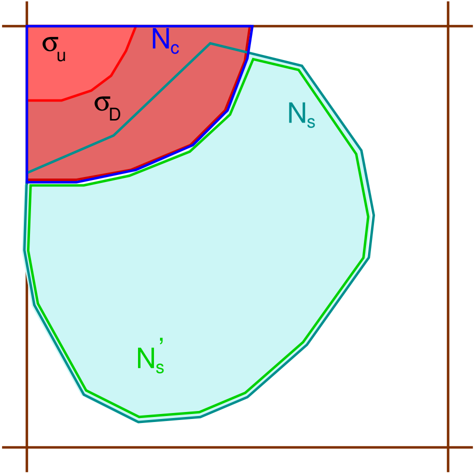

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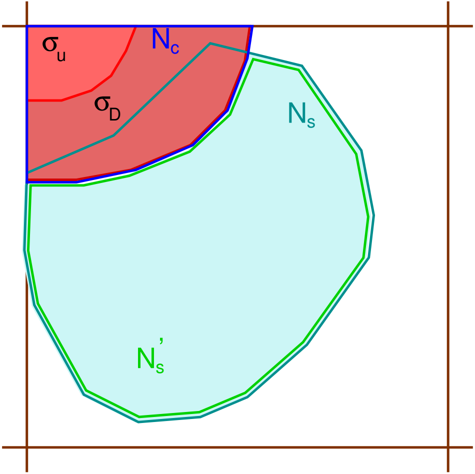

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Deep cloud $\Rightarrow N_c$
Statistical cloud scheme on $e = 1 - N_c$
Shallow convection condensation covered by statistical cloud scheme

The Xu-Randall cloud scheme in Alaro

$$N \approx \left(\frac{q_v}{q_w}\right)^{\frac{1}{4}} \frac{\alpha q_c}{\alpha q_c + (q_w - q_v)^{\frac{1}{2}}}, \qquad \alpha \equiv \text{QXRAL\_ADJ} \sim 150.$$

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Distinguish a convective cloud fraction N_c, and search
N^*= cloudy fraction of $e = 1 - N_c$, q_c^* and q_t^* the mean contents over e.

$$\overline{q_c} = N_c \widehat{q_c}^{\,c} + N_s' \widehat{q_c}^{\,s}, \qquad\qquad N_s' = N^* \cdot e$$

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- *same* condensate in all clouds ? then $\widehat{q_c}^{\,c} = \widehat{q_c}^{\,s} = \frac{q_c^*}{N^*}$ (evaporation over e) $\Rightarrow \overline{q_c} \searrow$ and N_s adjustment does not ensure to maintain $\widehat{q_c}^{\,c}$ constant.

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- *more* concentration in deep clouds: *initial* $\widehat{q_{c0}}^{\,s} = \gamma \widehat{q_c}^{\,c}$, $\gamma = \mathrm{QXRCDIL} \sim 0.5$ then evaporation over e only further modifies $\widehat{q_c}^{\,s} < \widehat{q_{c0}}^{\,s}$.

‘Protection’ of convective cloud

LDREDPR=T in acnebcond: reduced protection of convective fraction. Prevent evaporation over N_c but allow condensation everywhere.

- First compute N_{t0} from XR scheme with $N_c^* = 0$ (e=1).
- If condensation and $N_{t0} \geq N_c^-$ keep it: $N_s^* = N_{t0}$, $N_c^* = 0$.
  condensation *detected* by $\overline{q_{vn}} = \overline{q_w} N_{t0} + H\overline{q_w}(1 - N_{t0}) < \overline{q_v}$
  if evaporation recompute N_s^* over $e = (1 - N_c^-)$ and keep $N_c^* = N_c^-$.
- Estimation of *total* (rather than stratiform) condensate for radiation:

$$\overline{q_{ct}} = \overline{q_c} + \delta q_c \frac{N_t}{N_s^*}$$

  where initial $\overline{q_c}$ includes unchanged convective condensate and δq_c obtained from XR
- output N_s^* and N_c^* to be used in
  - acnebn : radiative cloud fraction and condensates +*total* condensate $\overline{q_{ct}}$
  - accdev : final XR condensation computation
  - every time a total cloud fraction is to be estimated
- but still use N_c^- in acnpart, and σ_u, σ_D evolve in accsu.

'Equivalent' cloud fraction for microphysics

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- initial formulation (3MT)

$$\frac{1}{N_{eq}} = \frac{\alpha_{\mathrm{co}}^2}{N_c'} + \frac{(1-\alpha_{\mathrm{co}})^2}{N_s'}, \qquad \alpha_{\mathrm{co}} = \frac{\triangle F_{cc}}{\triangle F_{cc} + \triangle F_{cs}}$$

does not work properly at large N_c'/N_t.

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- reviewed formulation (CSD)

$$N_{eq} = N_t[1 - \max(0, \alpha_{\mathrm{co}} - \frac{N_c}{N_t})]$$

  $\Rightarrow N_{eq} = N_t$ as long as $\alpha_{\mathrm{co}} < \frac{N_c}{N_t}$,
  otherwise $N_{eq} < N_t$ (i.e. larger concentration).

acnebn: radiative cloud fraction and condensates

Radiation requires an input of condensates and cloud fraction.

$$N_c^- = \sigma_D^- + \sigma_u^- = \text{zubnebh} \rightarrow \text{znebch} \leftrightarrow \boxed{\text{ACNEBCOND}}$$

$\searrow$ $\downarrow N_s = \text{znebs0}, \overline{q_{cs}} = \text{zqlis0}$

$\overline{q_{cc}}$: how to evaluate ? $\boxed{\text{ACNEBN}}$

$\downarrow \text{pneb}, \text{pqli}, \text{pqice}$

$\boxed{\text{ACRANEB2}}$

- acnebcond prevents evaporation/condensation over N_c^- $\Rightarrow$ yields a stratiform condensate and cloud fraction
- Convective condensate has not been saved $\Rightarrow$ re-evaluate it inside acnebn, based on N_c^-.

...or work differently ?

acnebn: prognostic vs diagnostic radiative condensates

LNEB_FP=F : diagnostic

- ‘Stratiform’ condensate: diagnosed from $\overline{q_t}$, reference critical RH profile and distinct parameters from microphysics; saturation humidity corrected for local temperature inversions.
- Convective condensate: re-estimate condensate from N_c^-:
  - estimate $RH = q_v/q_w$ to put in the formula (qxrtgh).
  - invert XR formula:

$$N \approx (RH)^{\frac{1}{4}}\left[1 - \exp(-\alpha \frac{q_c}{\sqrt{(1-RH)q_{\mathrm{sat}}}})\right], \qquad \alpha \equiv \text{qxral}$$

- Cloudiness: apply XR formula with $\overline{q_c} = \overline{q_{cs}} + \overline{q_{cc}}$. Recompute $N_c = \frac{\overline{q_{cc}}}{\overline{q_c}} \cdot N_t$. *but so called $\overline{q_{cs}}$ does actually include initial convective part.*

LNEB_FP=T : 'prognostic'

- ‘Stratiform’ condensate: use directly value $\overline{q_{cs}}$ (i.e. $\overline{q_{ct}}$) from acnebcond
- Convective condensate: same as LNEB_FP=F
- Cloudiness: same as LNEB_FP=F.

LNEB_FP=T and QXRAL< 0: prognostic

acnebn: prognostic vs diagnostic radiative condensates

LNEB_FP=T and QXRAL< 0: prognostic

- Total condensate: use directly value $\overline{q_{ct}}$ from acnebcond
- Cloudiness: Combine $N_t = Nc^* + N_s^*(1 - N_c^*)$ with $N_c^* = 0$ in case of condensation, N_c^- in case of evaporation.

Practical problems

- Paradox of one of the base formulas: condensation appears to reduce cloudiness $\Rightarrow$ neglecting Temperature effects
- Radiative cloud fractions and condensates:
  - Diagnostic approach has been longly tuned along operational performances but contains more arbitrariness (many parameters, departure from mirophysical values...)
  - Pseudo-prognostic approach challenginf tuning, especially in full Alaro-1 physics context
  - prognostic also requires further tuning study
- Protection of convective condensate had to be reviewed to allow resolved condensation over convective part;
- Need of clarification of everything: the devil is in the details: e.g.
  - what are the actual outputs of acnebcond ? N_s^* and $\overline{q_c t}$, not N_s and $\overline{q_{cs}}$
  - Apparent 'random overlap' vs fraction of non convective area
  - Somehow hidden assumptions: $\overline{q_w}$ unchanged, other approximations in new protection...