Representation of SGS clouds in COSMO radiation scheme

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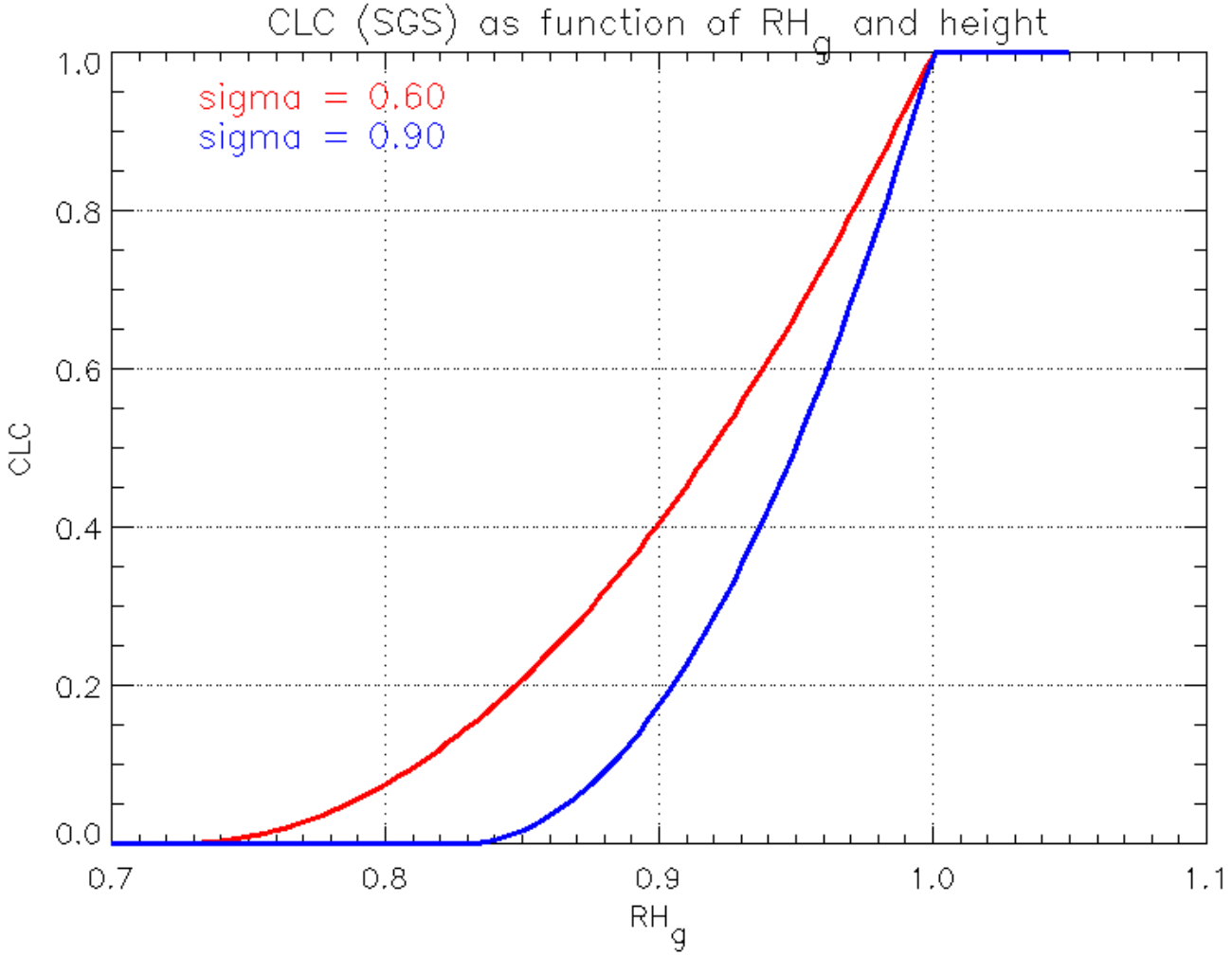
COSMO subgrid scale clouds default radiation scheme

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **CLC = fct(QC, QI, generalized RH_g, convective CLC_CON)**
  - RH_g: blending in mixed-phase region between water and ice saturation, using prescribed ice fraction
    f_{ice} = linear ramp function of T between 0 (-5˚C) and 1 (-25˚C) (Deardorff?)
    $RH_g := (QV+QC+QI) / QV_{sat,g} = (QV+QC+QI) / (QV_{sat,water} *(1-f_{ice}) + QV_{sat,ice}*f_{ice})$
  - $CLC\_SGS = MAX (0, MIN (1, (RH_g - \xi) / (c_L - \xi)))^2$
    with: $\xi = 0.95 - c_1 * \sigma * (1-\sigma) * (1 + c_2*(\sigma-0.5))$,
    $c_1 = 0.8$ (tunen) , $c_2 = sqrt(3)$, $c_L = 1.0$
    $\sigma = p / p_s$ (height parameter)
  - But CLC_SGS = 1 for gridscale clouds (QC and/or QI > 0) !
    (dep. on RH_g see next slide)
  - CLC_CON = 0.35*(TOP_CON-BAS_CON) / 5000.0
    (for both „shallow“ and „full“ convection parameterization)
  - Finally weighted average: $CLC = CLC\_SGS + CLC\_CON * (1 – CLC\_SGS)$
- **Water contents of SGS clouds:**
  - of SGS clouds: $QC\_SGS = 0.005 * QV_{sat,g} * (1-f_{ice})$ (0.005 = 0.01 * subgr. variab. fact. 0.5)
    $QI\_SGS = 0.005 * QV_{sat,g} * f_{ice}$
  - of convective clouds: $QC\_CON = 0.01 * QV_{sat,g} * (1-f_{ice})$ (= 2.0 x 0.005 * $QV_{sat,g} * (1-f_{ice})$)
    $QI\_CON = 0.01 * QV_{sat,g} * f_{ice}$
- **Finally: combined water contents as input for radiation:**
  - $QX\_RAD = QX\_CON * CLC\_CON + max[QX\_SGS, 0.5*QX] * CLC\_SGS * (1 – CLC\_CON)$
    with $X \in \{C,I\}$

COSMO subgrid scale clouds



sigma = P / PS

COSMO subgrid scale clouds alternative RH_g-based scheme

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **icldm_rad = 2, itype_wcld = 1**
- **CLC = fct(QC, QI, QV, generalized RH_g, convective CLC_CON)**
  - $RH_g := (QV+QC) / QV_{sat,water}$
  - $CLC\_SGS = MAX (0, MIN (1, 0.5 * (RH_g - \xi) / (c_L - \xi)))^2$ $c_1 = 0.8$ (tunen) , $c_2 = sqrt(3)$, $c_L = 1.0$
    with: $\xi = 0.95 - c_1 * \sigma * (1-\sigma) * (1 + c_2*(\sigma-0.5))$, $\sigma = p / p_s$ (height parameter)
  - But CLC_SGS = 1.0 if QI > 0.0
  - CLC_CON = 0.35*(TOP_CON-BAS_CON) / 5000.0
    (for both „shallow“ and „full“ convection parameterization)
  - Finally weighted average: $CLC = CLC\_SGS + CLC\_CON * (1 – CLC\_SGS)$
- **Water contents of SGS clouds:**
  - $QC\_SGS = 0.005 * QV_{sat,water} + (GAM*DQ - 0.005*QV_{sat,water}) * (CLC\_SGS-CLC_1) / (1-CLC_1)$
    $GAM = 1 / (1 + L_{wd}/c_p * dQV_{sat,water}/dT)$
    $DQ = QV + QC - QV_{sat,water}$
    $CLC_1 = 0.5 * ((1- \xi) / (c_L-1))^2$ (0.005 = 0.01 * subgr. variab. fact. 0.5)
  - of convective clouds: $QCI\_CON = 0.01 * QV_{sat,water}$ if T > 0°C
    $QCI\_CON = 0.01 * QV_{sat,ice}$ if T < 0°C
- **Finally: combined water contents as input for radiation:**
  - $QC\_RAD = QCI\_CON * CLC\_CON + QC\_SGS * CLC\_SGS * (1 – CLC\_CON)$

COSMO subgrid scale clouds alternative statistical scheme

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

- **icldm_rad = 2, itype_wcld = 2**
- **CLC = fct(QC, QI, QV, DQ, σ_{DQ}, convective CLC_CON)**
  - DQ = QV + QC - $QV_{sat,water}$ (saturation deficit) σ_{DQ} = MIN [stdev. of DQ from turb. , 0.001]
  - CLC_SGS = MAX (0, MIN (1, 0.5 * (1 + ξ / q_{crit}))) with: ξ = DQ / σ_{DQ} 0.5 = clc_diag
  - But CLC_SGS = 1.0 if QI > 0.0
  - CLC_CON = 0.35*(TOP_CON-BAS_CON) / 5000.0
    (for both „shallow“ and „full“ convection parameterization)
  - Finally weighted average: CLC = CLC_SGS + CLC_CON * (1 – CLC_SGS)
- **Water contents of SGS clouds:**
  - QC_SGS = GAM * DQ if $\xi > Q_{MAX}$
    QC_SGS = 0.0 if $\xi < -q_{crit}$
    $QC\_SGS = GAM * \sigma_{DQ} * Q_{MAX} * ((\xi + q_{crit}) / (Q_{MAX} + q_{crit}))^2$ else
    $GAM = 1 / (1 + L_{wd}/c_p * dQV_{sat,water}/dT)$
    $Q_{MAX} = q_{crit} * (1 / 0.5 – 1)$
  - of convective clouds: QCI_CON = 0.01 * $QV_{sat,water}$ if T > 0°C
    QCI_CON = 0.01 * $QV_{sat,ice}$ if T < 0°C
- **Finally: combined water contents as input for radiation:**
  - QC_RAD = QCI_CON * CLC_CON + QC_SGS * CLC_SGS * (1 – CLC_CON)

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