

Data description - band albedo reduction of snow contain black carbon (Broadband and RRTM narrowband)

The datasets described in this file provide coefficients and constants to calculate the broadband and RRTM narrowband **albedo reduction** caused by adding black carbon in pure snow. The albedo reduction is function of snow grain radius r and black carbon mass fractions C . Part of these data is published in Table 2 of paper *Dang et al., 2015, JGR*. Please refer to this paper for the development of parameterization and relevant figures.

1. Description of variables and functions:

- Variables:
 - r = snow grain radius (μm)
 - reference snow grain radius $r_0 = 100 \mu\text{m}$
 - C = black-carbon mass fraction
 - Reference black carbon mass fraction $C_0 = 10^{-6}$
 - $r_n = \log_{10}(r/r_0)$
 - $C_n = \log_{10}(C/C_0)$
 - $\Delta\alpha$ = band albedo reduction from the band albedo of pure snow
 - $\Delta\alpha_n = \log_{10}[\Delta\alpha(r/C)]$
- The parameterizations for snow contains black carbon are developed separately for different domains. These domains of broadband albedo parameterizations are defined by illumination wavelength band and mass fraction C of black carbon:

Band boundaries (μm)	Range 1 $1 \times 10^{-7} < C < 10^{-5}$	Range 2 $C_{\text{low}} \leq C < 3 \times 10^{-7}$	Range 3 $0 < C \leq C_{\text{low}}$
Allwave(0.3-4.0)	Cubic Functions: $\Delta\alpha_n = f(C_n)$		Linear function $\Delta\alpha = f(C)$
Visible (0.3-0.7)	Coefficients are quadratic functions of r_n		
Near -IR (0.7-4.0)	Quadratic Functions: $\Delta\alpha_n = f(C_n)$ Coefficients are quadratic functions of r_n		

- Functions

- For Ranges 1 and 2 the parameterization is

$$\Delta\alpha_n = \log_{10}\Delta\alpha = q_0 + q_1 C_n + q_2 C_n^2$$

where the q_i are quadratic/cubic functions of r :

$$q_2 = p_{4,1} + p_{3,1} r_n + p_{2,1} r_n^2 + p_{1,1} r_n^3$$

$$q_1 = p_{4,2} + p_{3,2} r_n + p_{2,2} r_n^2 + p_{1,2} r_n^3$$

$$q_0 = p_{4,3} + p_{3,3} r_n + p_{2,3} r_n^2 + p_{1,3} r_n^3$$

For the near-IR a quadratic function is sufficient, so $p_{1,i} = 0$.

- A minimum value of C , called C_{low} , is determined for Range 2, below which a linear function is used (Range 3); C_{low} is a quadratic function of r_n :

$$C_{\text{low}} = j_1 + j_2 r_n + j_3 r_n^2.$$

For BC mixing ratio lower than C_{low} , $\Delta\alpha$ is calculated by linear interpolation between $C = C_{\text{low}}$ and $C = 0$:

$$\Delta\alpha = t C / C_{\text{low}},$$

where the t is the albedo reduction produced by C_{low} .

2. Folder, files, and data

- Name of folder: XXXX_yyyPoly
 - XXXX:
 - Broad: broadband albedo reduction caused by black carbon
 - RRTM: RRTM narrowband albedo reduction caused by black carbon
 - yyy:
 - 2nd: functions used to calculate coefficients q are second order polynomials of r_n
 - 3rd: functions used to calculate coefficients q are third order polynomials of r_n

Note: to calculate allwave and visible broadband, and RRTM narrowband albedo reductions, please use 3rd order polynomial functions of $p_{row,column}$ to calculate coefficients q_0 , q_1 , and q_2 . To calculate near-IR broadband albedo reduction, you can use either 2nd order polynomial or 3rd order polynomial functions, both of these functions are accurate for near-IR band.

- Name of files: SootSnow_xxx_YY.txt
 - xxx:
 - all - allwave
 - nir - near-IR
 - vis - visible
 - YY:
 - CS - clear sky
 - OC - overcast cloud

For example

SootSnow_all_OC.txt: coefficients to calculate all-wave broadband albedo reduction caused by adding black carbon in pure snow

- Data in txt file:
 - 3rd order polynomial functions, files in folder XXXX_3rdPoly

Row 1-4: Coefficients p used for band (broadband or RRTM) in **Range 1** ($1 \times 10^{-7} < C < 10^{-5}$). Column 1, 2 and 3 contain coefficients $p_{row,column}$ to calculate q_2 , q_1 and q_0 respectively, where q_2 , q_1 and q_0 are coefficients of C_n^2 , C_n and constant. From row 1 to row 4, $p_{row,column}$ are coefficients in front of r_n^3 , r_n^2 , r_n and constant.

Row 5-8: Coefficients p used for band (broadband or RRTM) in **Range 2** ($C_{low} \leq C < 3 \times 10^{-7}$). Column 1, 2 and 3 contain coefficients $p_{row-4,column}$ to calculate q_2 , q_1 and q_0 respectively, where q_2 , q_1 and q_0 are coefficients of C_n^2 , C_n and constant. From row 5 to row 8, $p_{row-4,column}$ are coefficients in front of r_n^3 , r_n^2 , r_n and constant.

Row 9 : The coefficients to calculate band ((broadband or RRTM) albedo reduction in **Range 3** ($0 < C \leq C_{low}$). Column 1, 2, and 3 are j_1 , j_2 , and j_3 respectively.

- 2nd order polynomial functions, files in folder XXXX_2ndPoly

Row 1-3: Coefficients p used for band (broadband) in **Range 1** ($1 \times 10^{-7} < C < 10^{-5}$).
Column 1, 2 and 3 contain coefficients $p_{\text{row},\text{column}}$ to calculate q_2, q_1 and q_0 respectively,
where q_2, q_1 and q_0 are coefficients of C_n^2, C_n and constant. From row 1 to row 3,
 $p_{\text{row},\text{column}}$ are coefficients in front of r_n^2, r_n and constant.

Row 4-6: Coefficients p used for band (broadband) in **Range 2** ($C_{\text{low}} \leq C < 3 \times 10^{-7}$).
Column 1, 2 and 3 contain coefficients $p_{\text{row}-3,\text{column}}$ to calculate q_2, q_1 and q_0 respectively,
where q_2, q_1 and q_0 are coefficients of C_n^2, C_n and constant. From row 4 to row 6, $p_{\text{row}-3,\text{column}}$
are coefficients in front of r_n^2, r_n and constant.

Row 7: The coefficients to calculate band ((broadband) albedo reduction in **Range 3** ($0 < C \leq C_{\text{low}}$). Column 1, 2, and 3 are $j_1, j_2,$ and j_3 respectively.

- Constant not giving in the file but is necessary for band albedo reduction calculation

t: allwave and visible: $t = 0.001$
near-IR and RRTM: $t = 0.0001$