Arctic cirrus particle size distributions and their parametrizations depending on the cloud origin

SND-ID: snd1126-1. **Version**: 1.0. **DOI**: https://doi.org/10.5878/qh1n-4466

Download data

SND1126-001_V1.0.zip *(160.91 KB)*

Citation

Kuhn, T., & Wolf, V. (2019) Arctic cirrus particle size distributions and their parametrizations depending on the cloud origin (Version 1.0) [Data set]. Luleå University of Technology. Available at: https://doi.org/10.5878/qh1n-4466

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Description

Particle size distributions (PSDs) for cirrus clouds are important for both climate models and many remote sensing retrieval methods. It is necessary to parametrize PSDs for different cloud types.

Arctic cirrus particle size distributions (PSD) are presented depending on the cloud origin, either in situ or liquid. The data set used originate from balloon-borne measurements above Kiruna (north of Sweden, 67.8N, 20.4E) during winter. The observed PSDs are represented by gamma functions. The gamma coefficients exhibit large differences with regard to cloud origin. Thus, two new PSD parametrizations for Arctic cirrus of in situ and liquid origin are presented. These functions for Arctic cirrus confirm established parametrizations for continental cirrus sorted by two particle size modes, but differ from others depending only on temperature. We suppose that the agreement between the parametrizations of the geographically different cirrus is because in situ and liquid origin cirrus also distinguish by particle size modes. Since cloud sorting by their origin is based on physical processes which are independent of geographical region, we further hypothesise that these cloud-type-based parametrizations might be generally valid for use in global models and satellite retrievals, given the distribution of the cloud types is known.

The dataset consists primarily of measured particle size distributions (PSD).
Then, coefficients of the fitted gamma functions are reported.
Also, PSD data calculated from the new parametrizations at various temperatures are provided for typical conditions.

The dataset is the basis of Wolf, V., T. Kuhn, and M. Krämer (2019), On the dependence of cirrus parametrizations on the cloud origin, Geophys. Res. Lett., 46(21), 12,565- 12,571, doi: 10.1029/2019GL083841.

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The particle size distributions (PSDs) that are used in the MS are sorted according to cloud origin, 'in situ' origin or 'liquid origin.
The clouds on the following measurement days are of in situ origin:
2012-04-04
2013-02-20
2016-03-15
2016-12-15
The clouds on the following measurement days are of liquid origin:
2013-12-18 (no PSD with more than 75 particles)
2014-03-20
2015-04-01
2016-02-12
2017-12-07
2018-02-28

PSD data in individual data files, one for each PSD:
YYYYMMDD_psd_xxx.txt
The columns contain:
1 bin_centre/um Bin centre size (micrometre).
2 psd/m-4 Bin particle concentration normalized to width of bin.
3 stdev/m-4 Standard deviation of bin particle concentration normalized to width of bin based on Poisson statistics of counts N: N/sqrt(N)/sample_volume/bin_width.
4 mean_dmax/um Bin average maximum dimension D_max (micrometre).
5 mean_area/m2 Bin average particle cross-sectional area A.
6 mean_Ar Bin average particle area ratio Ar (Ar=A/(pi/4*D_max^2)).
7 stdev_Ar Standard deviation of area ratios in bin.
8 mean_m09/kg Bin average of particle mass based on Schmitt and Heymsfield (2009), Eq.2.
9 N_trop_F07 Tropical PSD based on Field et al. (2007): bin particle concentration normalized to width of bin calculated from the second and third moment of the measured PSD (column 2).
10 N_mid_F07 Mid-latitude PSD based on Field et al. (2007): bin particle concentration normalized to width of bin calculated from the second and third moment of the measured PSD (column 2).
11 Tot.num.conc/m-3 Total number concentration of PSD
12 Min_alt/m Minimum altitude at which particles were collected for PSD
13 Max_alt/m Maximum altitude at which particles were collected for PSD
14 mean_m_fromAfract/kg Bin average of particle mass based on Kuhn and Heymsfield (2016), Eq.8a+8b.
Before the data, some metadata is stored in comments (lines 1-21).

Coefficients from gamma fits to measured PSDs:
Fig2_coeffs_gamma_HF_direct_io.txt
Fig2_coeffs_gamma_HF_direct_lo.txt

The gamma coefficients have been calculated by using the first, second, and sixth moments (Heymsfield et al., 2002, Eqs 3-7) using directly the particle maximum dimensions.
The resulting coefficients are listed in two files:
In situ origin PSDs: Fig2_coeffs_gamma_HF_direct_io.txt
Liquid origin PSDs: Fig2_coeffs_gamma_HF_direct_lo.txt
The data is arranged in columns, and the columns contain:
1 PSD file name
2 Slope lambda (cm)
3 Intercept Ntot (cm^-4)
4 Dispersion mu

PSD data obtained from new parametrization:
NMio.txt (Insitu origin)
NMlo.txt (Liquid origin)
The columns contain:
1 Maximum dimension (cm)
2 PSD for 0 degree Celsius
3 PSD for -10 degree Celsius
4 PSD for -20 degree Celsius
5 PSD for -30 degree Celsius
6 PSD for -40 degree Celsius
7 PSD for -50 degree Celsius
8 PSD for -60 degree Celsius
9 PSD for -70 degree Celsius
10 PSD for -80 degree Celsius
The PSD values in columns 2-10 are N/N0 calculated using Eq 1., the coefficients are parametrized according to the fits slope vs temperature on Fig. 2 together with dispersion from MB14 Small or Large for in situ origin or liquid origin respectively:
In situ origin:
λ/cm-1=exp(-0.06837*T/degC+3.492)
MB14 Small: μ=0.009·λ^0.85

Liquid origin:
slope/cm-1=4.937*exp(-0.001846*T/degC)
MB14 Large: μ=0.104·λ^0.71-1.7

For plotting N in Fig. 3, the intercept values N0 have been chosen to yield typical total number concentrations:
In situ origin:
T/degC N0/cm-4 total_number_conc/L-1
-50 2.55e9 7
-60 1.9e17 12
-70 3.8e31 49
Liquid origin:
T/degC N0/cm-4 total_number_conc/L-1
-40 2.6e6 10
-50 1.8e7 10
-60 1.6e8 10

Language

English

Time period(s) investigated

2012-04-04 – 2018-02-28

Data format / data structure

Numeric

Geographic spread

Geographic location: Sweden, Norrbotten County, Kiruna Municipality

Responsible department/unit

Department of Computer Science, Electrical and Space Engineering

Contributor(s)

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Research area

Earth and related environmental sciences (Standard för svensk indelning av forskningsämnen 2011)

Natural sciences (Standard för svensk indelning av forskningsämnen 2011)

Climatology / meteorology / atmosphere (INSPIRE topic categories)

Keywords

Particle size distribution, Atmospheric conditions, Parametrization, Cloud origin, Cirrus, Ice particles, Arctic

Publications

Kuhn, T., & Heymsfield, A. J. (2016). In Situ Balloon-Borne Ice Particle Imaging in High-Latitude Cirrus. Pure and Applied Geophysics, 173(9), 3065–3084. https://doi.org/10.1007/s00024-016-1324-x
Link to article
DOI: https://doi.org/10.1007/s00024-016-1324-x
URN: urn:nbn:se:ltu:diva-7503

Wolf, V., Kuhn, T., Milz, M., Völger, P., Krämer, M., & Rolf, C. (2018). Arctic ice clouds over northern Sweden : microphysical properties studied with the Balloon-borne Ice Cloud particle Imager B-ICI. Atmospheric Chemistry And Physics, 18(23), 17371–17386.
https://doi.org/10.5194/acp-18-17371-2018
Link to article
URN: urn:nbn:se:ltu:diva-72316
DOI: https://doi.org/10.5194/acp-18-17371-2018

Wolf, V., Kuhn, T., & Krämer, M. (2019). On the Dependence of Cirrus Parametrizations on the Cloud

Origin. Geophysical Research Letters, 46(21), 12565–12571. https://doi.org/10.1029/2019GL083841
Link to article
DOI: https://doi.org/10.1029/2019GL083841
URN: urn:nbn:se:ltu:diva-73538

Polygon (Lon/Lat)

20.01091706032, 68.179723798329

20.01091706032, 67.127290449095

23.360040425145, 67.127290449095

23.360040425145, 68.179723798329

20.01091706032, 68.179723798329

Accessibility level

Access to data through SND
Data are freely accessible

Use of data

Things to consider when using data shared through SND

Versions

Version 1.0. 2019-10-08

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DataCite

DDI 2.5

DDI 3.3

DCAT-AP-SE 2.0

JSON-LD

PDF

Citation (CSL)

File overview (CSV)

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