User Guide for
RO-CLIM
Radio Occultation Climate Data Records

Version 1.0

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RO-CLIM Project Team

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1. INTRODUCTION

1.1 Purpose of the document

This document provides a brief guide to the Radio Occultation (RO) Climate Data Records (CDRs) generated within the RO-CLIM project. It provides a description of the contents of the data sets, the file formats, and where to find the data. It also provides references to more detailed descriptions of the algorithms used, to the processing methods adopted, and to validation of the climate data records. The data provided by RO-CLIM consist of *ensembles* of six independently generated monthly-mean CDRs, each provided by one of the RO processing centres participating in the RO-CLIM collaboration. URLs to the web sites of the individual RO centres, offering additional RO data, can be found in the last section of this document.

RO-CLIM is one of (currently) 10 pilot projects coordinated by SCOPE-CM with the purpose of supporting the generation of high-quality CDRs, in response to requirements stated by GCOS. SCOPE-CM can be described as a coordination activity under WMO auspices.

1.2 Acronyms and abbreviations

CDR	Climate Data Record, (Fundamental CDR, Thematic CDR)
CHAMP	Challenging Minisatellite Payload
DMI	Danish Meteorological Institute, Copenhagen, Denmark
EUM	EUMETSAT, Darmstadt, Germany
JPL	Jet Propulsion Laboratory, Pasadena, CA, USA
GCOS	Global Climate Observing System
GFZ	GeoForschungsZentrum Potsdam, Germany
GNSS	Global Navigation Satellite System
GPS	Global Positioning System (US)
L1, L2	GPS carrier frequencies: 1575.42 MHz and 1227.6 MHz
LC	(Ionosphere-corrected) neutral atmosphere bending angle
LEO	Low Earth Orbit
MSL	Mean Sea Level
netCDF	Network Common Data Format
MMC	Monthly-Mean Climatology
PPC	Profile-to-Profile Comparison
RO	Radio Occultation
RO-CLIM	RO-based gridded climate data sets (a SCOPE-CM project)
ROM SAF	RO Meteorology Satellite Application Facility
SCOPE-CM	Sustained Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring
UCAR	University Corporation for Atmospheric Research
WEGC	Wegener Center, University of Graz, Graz, Austria
WMO	World Meteorological Organization

2. GNSS Radio Occultation Measurements

2.1 The radio occultation technique

The RO technique is based on measuring small phase shifts (excess phase) of radio signals propagating through the atmosphere along horizontal paths (see Fig 1). The signals are emitted from GNSS (Global Navigation Satellite System) satellites orbiting some 20,000 km above the Earth's surface and received by an RO instrument onboard a satellite in low-Earth orbit (LEO), e.g. the IGOR instrument onboard the FORMOSAT-3/COSMIC satellites, or the GRAS instrument onboard the Metop satellites. The GPS radio signals scan the atmosphere during 1 to 2 minutes until they are occulted by the Earth (setting occultation) or from the moment they appear behind the Earth (rising occultation).

The first step in the processing is to compute the *bending angle* of the signal as an integrated measure along the entire signal path. The refractive index, or *refractivity*, at a given *tangent point* is then derived through an inversion of the bending angle. In general, the profile is not a straight, vertical line but rather a slightly curved, skewed line such that the deviation of the topmost point relative to the point closest to the Earth (the so-called tangent point drift) can be more than 100 km. The occultations are distributed relatively even across the Earth, but the locations of the individual profiles vary in a non-repeatable, quasi-random, way. The profiles are generated at random times (i.e. not at synoptic times), in common with most polar orbiting satellite data.

For more details on the RO technique and its applications see, e.g., *Kursinski et al.* (1997) and *Anthes* (2011).

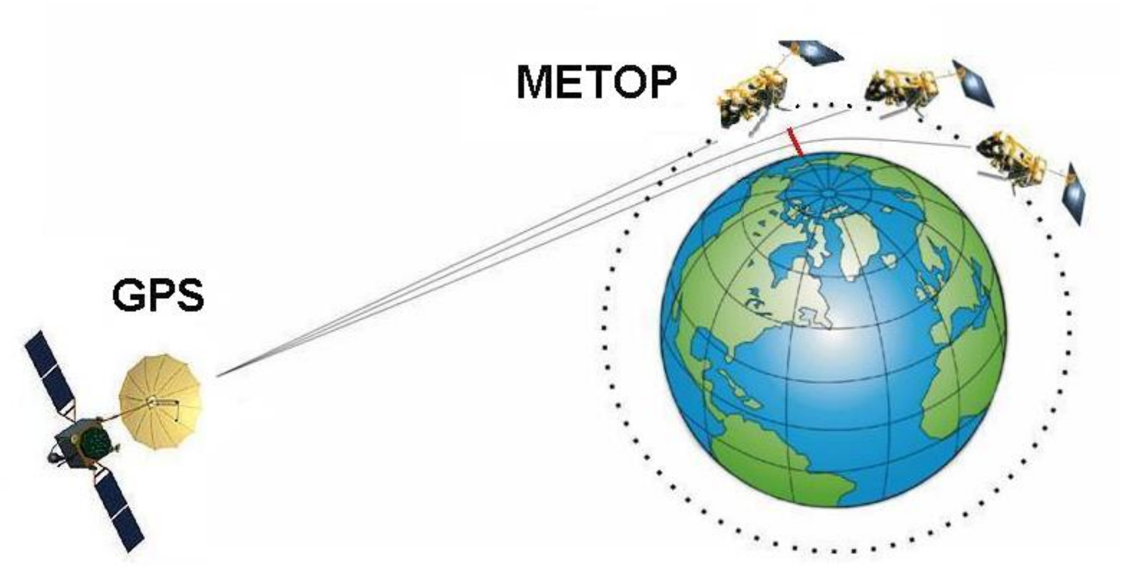

Figure 1. *Schematic representation of the RO observing geometry during an occultation. It is shown how the GRAS instrument onboard Metop receives radio signals from a GPS satellite.*

Despite a limited horizontal sampling of RO data from a single RO instrument, and the inherent horizontal resolution of around 250 km, the RO technique has several very significant benefits:

- High stability – both in time for one instrument and inter-instrument, leading to very stable long-term data for climate applications;
- High accuracy – better than 1K from mid-troposphere to lower stratosphere (5-30 km);
- High vertical resolution – from around 200 m in the lower troposphere, to 1-1.5 km in the stratosphere – comparable to radiosondes and superior to vertical passive sounders;
- All weather capability – GNSS signals are virtually unaffected by clouds and precipitation;
- Global coverage

The general characteristics of the RO technique make it a quite complementary observing system within the WMO's World Weather Watch programme.

2.2 Atmospheric profile data

An RO instrument onboard a LEO satellite receives GNSS radio signals at two frequencies, e.g. the L1 and L2 frequencies used by the GPS system. The signals are characterised by their amplitude and phase values, and bending angle profiles are obtained using the positions and velocities of the GNSS and LEO satellites. The L1 and L2 bending angle profiles are first subject to a correction in order to eliminate the effect of the ionosphere on the signals (*ionospheric correction*), leading to the neutral-atmosphere (LC) bending angle. In the case of single ray propagation, the phase contains all the necessary information in order to derive the bending angle, whereas in the case of multiple ray propagation (multipath), caused by strong vertical gradients in the atmosphere, both the amplitude and the phase are needed to obtain a bending angle profile free of multipath artefacts.

The raw, observed LC bending angle profile is smoothed and extended to infinity by merging it with a background bending-angle profile taken from an atmospheric model or a climatology. This merging with an *a priori* bending angle background (sometimes referred to as statistical optimization) is necessary in order to process the observed, noisy bending angles to a near-vertical refractivity profile. The inversion from bending angle to refractivity is done using the Abel transform.

Refractivity is a relatively simple function of pressure, temperature, and humidity, and where humidity is negligible (normally from the upper troposphere and up) we can obtain the pressure and temperature of the atmosphere with only the additional assumption of hydrostatic equilibrium. These are referred to as dry pressure and dry temperature.

To retrieve temperature, pressure and humidity where the humidity is not negligable, ancillary data are needed. These data can be obtained, e.g., from ECMWF forecasts or reanalysed forecasts, appropriate to the time and location of the occultation. In combination with the observed refractivity, the *a priori* model data is used in a 1D variational algorithm to simultaneously estimate the temperature, humidity and pressure profiles. Note that unique humidity profiles cannot be obtained from RO measurements without using some source of ancillary information on temperature. This problem is referred to as the "water vapour ambiguity".

The starting point for the processing into monthly mean data is thus vertical profiles of *bending angle* (α) as a function of *impact altitude* (H_a), microwave *refractivity* (N) as a function of *mean sea level (MSL) altitude* (H; geometric height above the geoid), and *temperature* (T), *pressure* (p), and *specific humidity* (q) as functions of *MSL altitude* (H). The impact altitude and the MSL altitude are referenced to the Earth's geoid. The *geopotential height* (Z) as a function of pressure or *pressure altitude* (H_p) is an alternative formulation of the pressure profile. Pressure altitude is simply a logarithmic measure of pressure ($H_p(p) = H_s \times \ln(p_0/p)$, with scale height H_s=7000 m and standard surface pressure p_0=1013.25 hPa). The various height scales are described in more detail in *Kursinski et al.* (1997).

2.3 Gridded monthly-mean data

The zonally gridded monthly mean data are generated from the RO profile data through rather straight-forward *binning and averaging*. A set of equal-angle latitudinal bands are defined, and all quality-controlled observations that fall within a latitude band and calendar month undergo averaging to form a zonal mean for that latitude and month. The generation of zonal monthly-mean data may be followed by further averaging into seasonal and annual means, and into regional, hemispheric, and global means.

The error in the mean can be estimated as a combination of the statistical measurement error and the error due to under-sampling of the atmosphere (*Scherllin-Pirscher et al.*, 2011a,b). The statistical *measurement uncertainty* of the monthly mean is an estimate based on the measurement uncertainties of the underlying individual profiles (*Scherllin-Pirscher et al.*, 2011a). The *sampling error* of the monthly mean is due to under-sampling of the atmospheric variability within the bins. This error can be estimated by sampling an atmospheric model – e.g., ERA-Interim reanalyses – at the same times and locations as the actual observations. Correction for sampling errors (through subtraction) leaves a remaining *residual sampling error* (*Scherllin-Pirscher et al.*, 2011b) which is considerably smaller than the original sampling error.

3. The RO-CLIM Climate Data Records

3.1 Overview of RO-CLIM CDRs

The CDRs provided by RO-CLIM consist of *ensembles* of six independently generated monthly-mean CDRs, each provided by one of the RO processing centers participating in the SCOPE-CM RO-CLIM project [*P01*, *R04*]. These processing centres are currently ROM SAF, EUMETSAT, GFZ, JPL, UCAR, and WEGC, and the RO-CLIM CDRs cover the following geophysical variables:

- Bending angle as a function of impact altitude (H_a)
- Refractivity as a function of MSL altitude (H)
- Dry pressure as a function of MSL altitude (H)
- Dry temperature as a function of MSL altitude (H)
- Dry geopotential height as a function of pressure altitude (H_p), i.e., geopotential height of dry pressure altitude

These variables are provided as zonal monthly means on 2D latitude-height grids with a resolution of 5° x 200 m. The gridded monthly means have been sampling error corrected (except for bending angle) and are provided together with the number of data used in the averaging. Future versions of the RO-CLIM CDRs will also include uncertainty estimates.

The data are stored in netCDF files, further described in Section 4.

In the RO-CLIM data records, the refractivity and the dry retrieved atmospheric profiles are influenced by the *a priori* data used in the statistical-optimization procedures (see Section 2.2), while the bending-angle data are based on raw observed bending angles that are less influenced *a priori* assumptions. Due to this weaker dependence on underlying assumptions, bending-angle data have some important advantages compared to more processed data types (*Ringer and Healy*, 2008; *Steiner et al.*, 2013).

Climate Data Record	RO mission	Length of time series	Time resol.	Spatial resol.	Vertical grid variable	RO-CLIM data set version
Bending angle	CHAMP	Sep 2001 – Sep 2008	month	5° x 200 m	H_a	1
Refractivity	CHAMP	Sep 2001 – Sep 2008	month	5° x 200 m	H	1
Dry pressure	CHAMP	Sep 2001 – Sep 2008	month	5° x 200 m	H	1
Dry temperature	CHAMP	Sep 2001 – Sep 2008	month	5° x 200 m	H	1
Dry geopotential	CHAMP	Sep 2001 – Sep 2008	month	5° x 200 m	H_p	1

Table 1. Overview of RO-CLIM climate data records, showing length of time series, temporal and spatial resolution, and type of vertical grid. Here, H denotes mean-sea level *altitude*, whereas H_a denotes *impact altitude* and H_p *pressure height*. Note that the *impact altitude* is referenced to the geoid, rather than to the ellipsoid (in which case it would be referred to as *impact height*). More details on the various height scales are found in *Kursinski et al.* (1997).

3.2 FCDRs and TCDRs

GCOS makes a distinction between Fundamental Climate Data Records (FCDRs) and Thematic Climate Data Records (TCDRs). According to the definitions stated in the relevant documents [*R01*, *R02*], FCDRs are well-characterized, long-term data records, usually involving a series of instruments, but with overlaps and calibrations sufficient to allow the generation of products that are accurate and long-term stable in both space and time. FCDRs are typically calibrated radiances, but for RO measurements, bending angles are considered FCDRs. TCDRs are the counterpart of the FCDRs in geophysical space, e.g., temperatures, and for RO measurements also refractivities.

3.3 CDR short descriptions

3.3.1 Bending angle zonal monthly mean

This climate variable is derived from "raw" (i.e., not statistically optimized) LC bending-angle profiles. Of the five climate variables described in this document, this is the variable that is least influenced by processing or by *a priori* assumptions. For this, and other, reasons it has been pointed out as particularly useful for long-term climate monitoring and for use in climate-change detection studies (*Ringer and Healy*, 2008). An example of a 5° zonal-mean monthly-mean bending angle field is shown in Fig. 2.

Table 2. RO bending angle zonal monthly-mean grid

Quantity	Values	Remarks
Units	radians (rad)	
Valid range	-1 mrad to 100 mrad	
Domain, latitude	90˚S to 90˚N	global coverage
Domain, altitude	8 to 30 km	impact altitude
Resolution, spatial	5 deg x 200 m	latitude x impact altitude
Resolution, temporal	month	

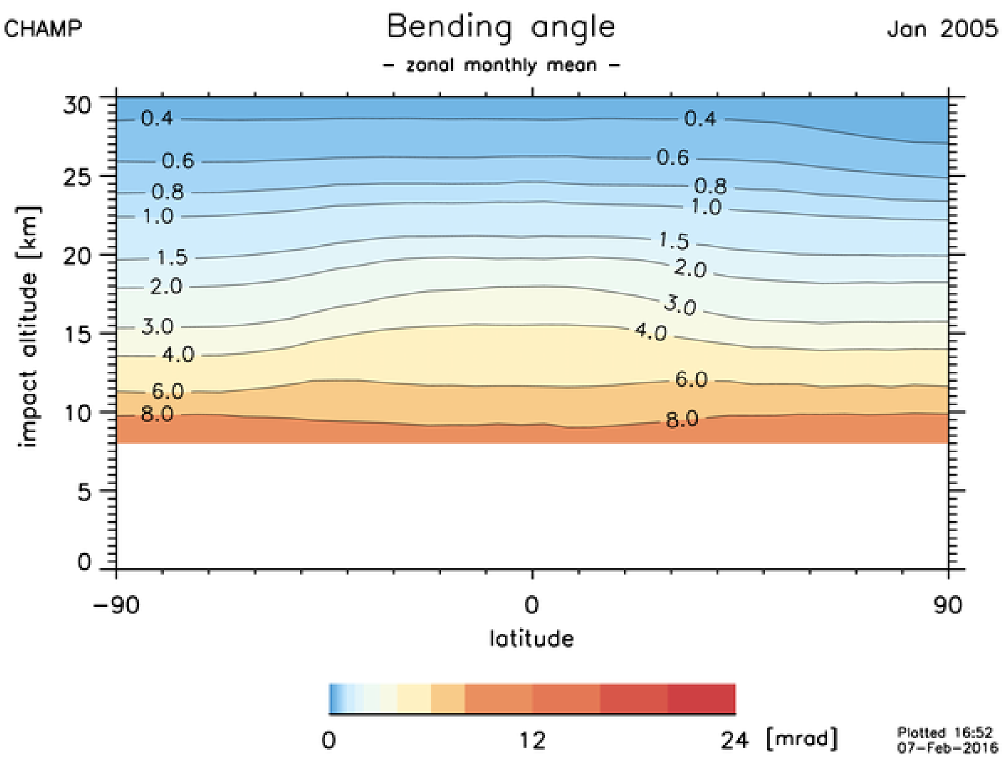

Figure 2: *Bending angle zonal monthly means for January 2005, based on data from the CHAMP mission.*

3.3.2 Refractivity zonal monthly mean

This climate variable is derived from refractivity profiles that are retrieved from optimized bending-angle profiles. Hence, it is slightly influenced by *a priori* data at high altitudes. An example of a 5° zonal-mean monthly-mean refractivity field is shown in Fig. 3.

Table 3. RO refractivity zonal monthly-mean grid

Quantity	Values	Remarks
Units	refractivity units (N)	
Valid range	0 N-units to 500 N-units	
Domain, latitude	90˚S to 90˚N	global coverage
Domain, altitude	8 km to 30 km	MSL altitude
Resolution, spatial	5 deg x 200 m	latitude x MSL altitude
Resolution, temporal	month	

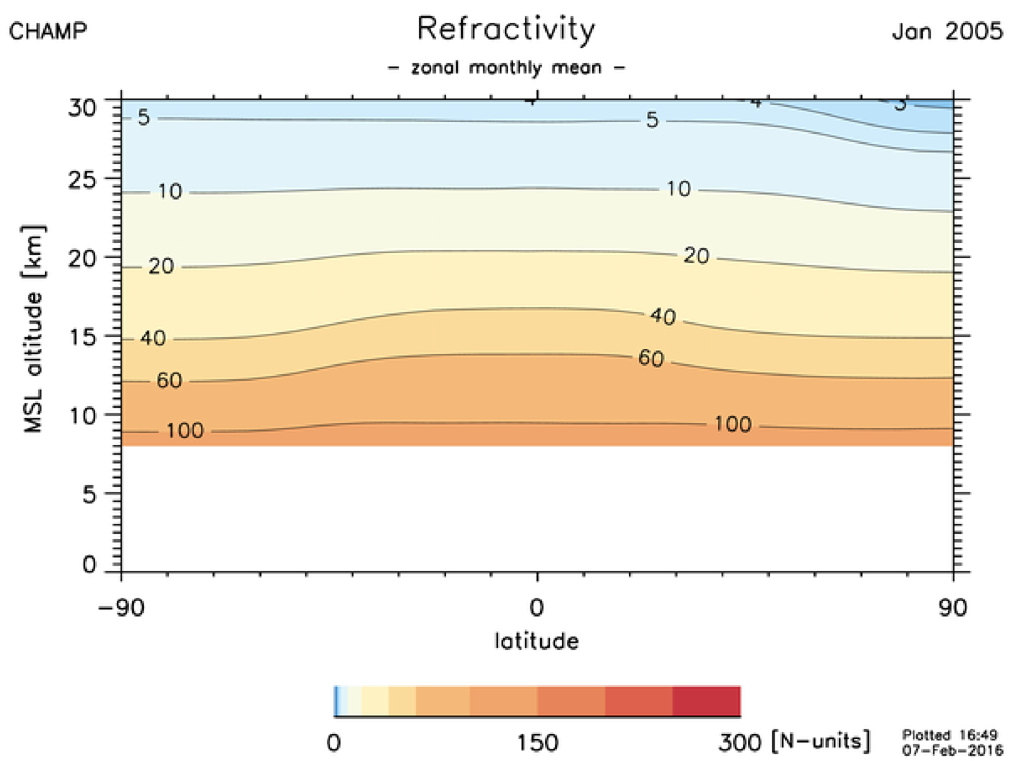

Figure 3: *Refractivity zonal monthly means for January 2005, based on data from the CHAMP mission.*

3.3.3 Dry pressure zonal monthly mean

The dry pressure climatologies are derived from RO refractivity profiles, assuming hydrostatic equilibrium. Dry pressure is identical to physical pressure if water vapour is negligible. An example of a 5° zonal-mean monthly-mean dry pressure field is shown in Fig. 4.

Table 4. RO dry pressure zonal monthly-mean grid

Quantity	Values	Remarks
Units	hekto-pascal (hPa)	
Valid range	0 hPa to 1100 hPa	
Domain, latitude	90˚S to 90˚N	global coverage
Domain, altitude	8 km to 30 km	MSL altitude
Resolution, spatial	5 deg x 200 m	latitude x MSL altitude
Resolution, temporal	Month	

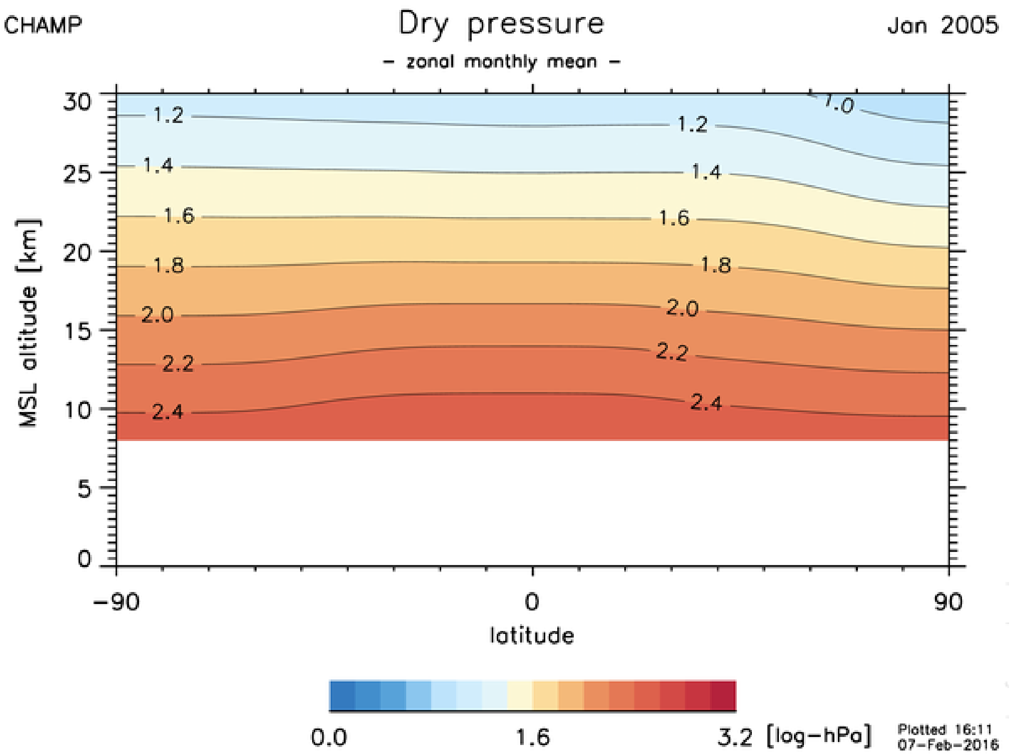

Figure 4: Dry pressure zonal monthly means for January 2005, based on data for the CHAMP mission.

3.3.4 Dry temperature zonal monthly mean

The dry temperature climatologies are derived from RO refractivity profiles, assuming hydrostatic equilibrium. Dry temperature is identical to physical temperature if water vapour is negligible. An example of a 5° zonal-mean monthly-mean dry temperature field is shown in Fig. 5.

Table 5. RO dry temperature zonal monthly-mean grid

Quantity	Values	Remarks
Units	kelvin (K)	
Valid range	150 K to 350 K	
Domain, latitude	90˚S to 90˚N	global coverage
Domain, altitude	8 km to 30 km	MSL altitude
Resolution, spatial	5 deg x 200 m	latitude x MSL altitude
Resolution, temporal	month	

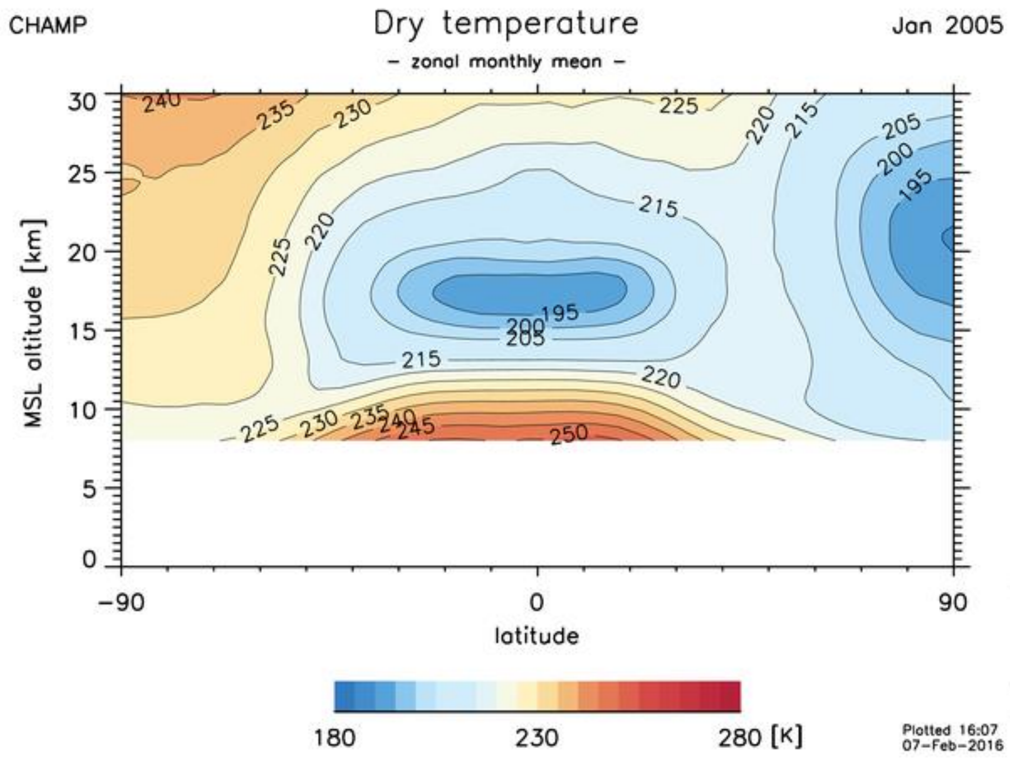

Figure 5: *Dry temperature zonal monthly means for January 2005, based on data from the CHAMP mission.*

3.3.5 Dry geopotential height zonal monthly mean

The dry geopotential height climatologies are derived from RO refractivity profiles, assuming hydrostatic equilibrium. Geopotential height of dry pressure surfaces is identical to geopotential height of pressure surfaces if water vapour is negligible. It is essentially an inversion of the pressure altitude profile, after conversion of altitude to geopotential height. An example of a 5° zonal-mean monthly-mean dry pressure field is shown in Fig. 6.

Table 6. RO dry geopotential height zonal monthly-mean grid

Quantity	Values	Remarks
Units	meters	
Valid range	0 m to 100000 m	
Domain, latitude	90˚S to 90˚N	global coverage
Domain, altitude	8 km to 30 km	dry pressure altitude
Resolution, spatial	5 deg x 200 m	latitude x dry pressure altitude
Resolution, temporal	month	

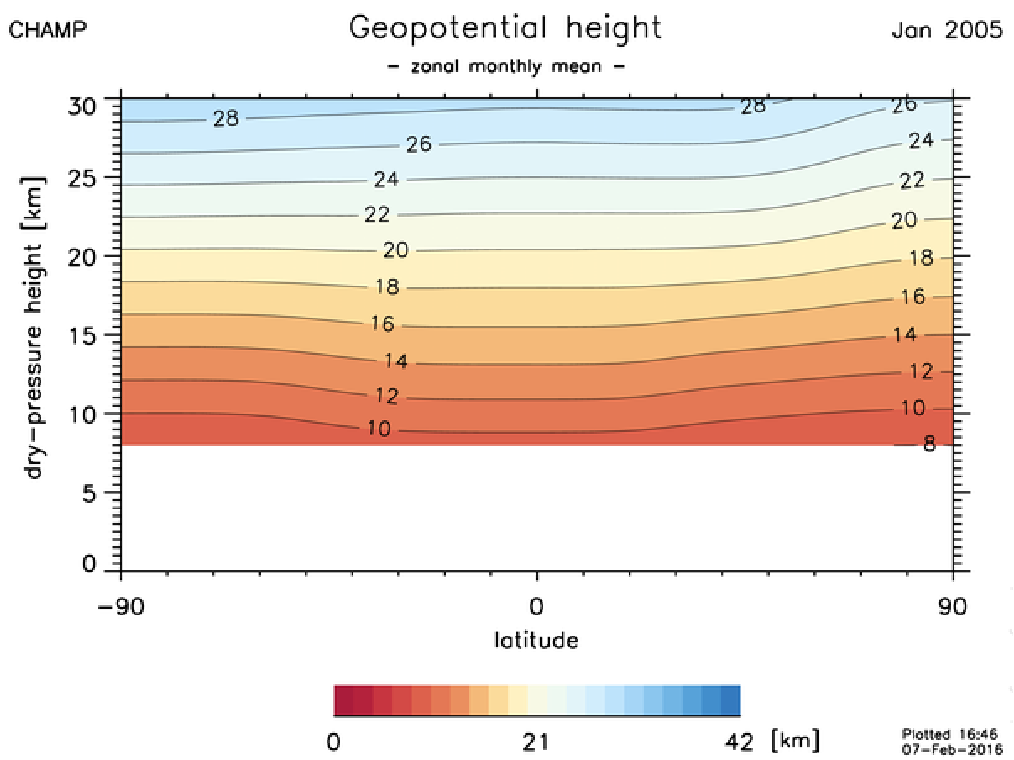

Figure 6: Dry geopotential height zonal monthly means for January 2005, based on data from the CHAMP mission.

3.4 Supporting data

3.4.1 ERA-Interim reanalysis

Sampling-error estimation is based on sampling an atmospheric model at the same times and locations as the instrumental record. For this purpose, we currently use ERA Interim reanalysis fields at a relatively coarse 2.5˚x2.5˚ horizontal resolution. This grid has been interpolated from an ERA-Interim spectral model truncated to T63, which has a horizontal resolution comparable to the observation resolution of an RO measurement.

Each occultation has a reference latitude, longitude, and time associated with it. To retrieve co-located reanalysis profiles, the reanalysis field at the nearest 6-hourly time step (i.e. at UTC 0, 6, 12, or 18) was selected and then interpolated bi-linearly from the model grid to the nominal latitude and longitude of the occultation. Hence, there is no interpolation in time.

The collocated reanalysis data include the same set of variables as the observed data and are similarly formatted. In addition, they also contain some metadata identifying the source of the reanalysis data, information on model resolution, etc.

4. File format and conventions

4.1 File names

The name of an RO-CLIM CDR file consists of a string with six fields separated by underscores:

```
<DATATYPE>_<CENTER>_<MISSION>_<DATE>_<VARS>_<VER>.nc
```

where:

- `<DATATYPE>` is either 'mmc' (gridded monthly means) or 'ppc' (profiles);
- `<CENTER>` is an acronym for one of the members, or 'roclim' for the ensemble;
- `<MISSION>` is the name of a satellite mission, e.g. 'cosmic' or 'champ';
- `<DATE>` is a date or date-interval string, e.g. '201107' or '201103–201108';
- `<VARS>` describes the geophysical variables stored in the files, e.g., 'refrac';
- `<VER>` is 'v' followed by the data set version (e.g. 'v2').

An example of the name of a file containing CHAMP gridded monthly mean bending angles from September 2001 to September 2008, provided by the RO-CLIM consortium as an ensemble, can be:

mmc_roclim_champ_200109-200809_bendangle_v2.nc

while a file containing CHAMP gridded monthly means derived from refractivity profiles (including the related dry variables) processed by GFZ, can be:

mmc_gfz_champ_200109-200809_refrac_dry_v2.nc

For files containing climate data derived from ERA-Interim profiles, co-located with CHAMP data, the `<MISSION>` string can, for example, be "eraint@champ".

4.2 File format and conventions

The data format for the RO-CLIM climate data records is netCDF-3. The data files comply with the CF-1.4 convention.

4.3 File structure

The RO-CLIM data files have a simple structure, here described by two examples.

Example 1

An *ncdump* from the file

mmc_roclim_champ_200109-200809_refrac_dry_v1.nc

holding CHAMP zonal monthly-mean refractivity, dry pressure, dry temperature, and dry geopotential heights for the full RO-CLIM ensemble:

```
netcdf mmc_roclim_champ_200109-200809_refrac_dry_v1 {

dimensions:
        c4 = 4 ;
        c6 = 6 ;
        lon = 1 ;
        lat = 36 ;
        altitude = 111 ;
        time = 85 ;
        member = UNLIMITED ; // (5 currently)

variables:
        char mission(member, c6) ;
                mission:long_name = “RO mission” ;
        char center(member, c4) ;
                center:long_name = “RO processing center” ;
        float lon(lon) ;
                lon:positive = "east" ;
                lon:_FillValue = 999999.f ;
                lon:delta_lambda = 360.f ;
                lon:valid_range = -180.f, 180.f ;
                lon:units = "degrees_east" ;
                lon:long_name = "longitude" ;
        float lat(lat) ;
                lat:long_name = "latitude" ;
                lat:positive = "north" ;
                lat:_FillValue = 999999.f ;
                lat:valid_range = -90.f, 90.f ;
                lat:units = "degrees_north" ;
                lat:delta_phi = 5.f ;
        float altitude(altitude) ;
                altitude:valid_range = 8000.f, 30000.f ;
                altitude:units = "meters" ;
                altitude:long_name = "Altitude: Mean sea level altitude for refractivity, dry temperature .....
                altitude:_FillValue = 999999.f ;
                altitude:delta_h = 200.f ;
        float time(time) ;
                time:delta_t_1 = "month" ;
                time:_FillValue = 999999.f ;
                time:units = "julian date" ;
                time:long_name = "time" ;
                time:averaging_period = "month" ;
        float refractivity(member, time, altitude, lat, lon) ;
                refractivity:long_name = "Refractivity" ;
                refractivity:_FillValue = 999999.f ;
                refractivity:units = "N-units" ;
```

```
	short N_refractivity(member, time, altitude, lat, lon) ;
		N_refractivity:units = "unitless" ;
		N_refractivity:_FillValue = -1s ;
		N_refractivity:long_name = "Number of averaged refractivity values" ;
	float dry_temperature(member, time, altitude, lat, lon) ;
		dry_temperature:_FillValue = 999999.f ;
		dry_temperature:long_name = "Dry Temperature" ;
		dry_temperature:units = "K" ;
	short N_dry_temperature(member, time, altitude, lat, lon) ;
		N_dry_temperature:long_name = "Number of averaged dry temperature values" ;
		N_dry_temperature:units = "unitless" ;
		N_dry_temperature:_FillValue = -1s ;
	float dry_pressure(member, time, altitude, lat, lon) ;
		dry_pressure:units = "hPa" ;
		dry_pressure:long_name = "Dry Pressure" ;
		dry_pressure:_FillValue = 999999.f ;
	short N_dry_pressure(member, time, altitude, lat, lon) ;
		N_dry_pressure:long_name = "Number of averaged dry pressure values" ;
		N_dry_pressure:units = "unitless" ;
		N_dry_pressure:_FillValue = -1s ;
	float geopotential(member, time, altitude, lat, lon) ;
		geopotential:long_name = "Geopotential height" ;
		geopotential:units = "meters" ;
		geopotential:_FillValue = 999999.f ;
	short N_geopotential(member, time, altitude, lat, lon) ;
		N_geopotential:units = "unitless" ;
		N_geopotential:_FillValue = -1s ;
		N_geopotential:long_name = "Number of averaged geopotential height values" ;

// global attributes:
		:Title = "RO-CLIM Radio Occultation Climatologies: refractivity & dry properties" ;
		:Version = "RO-CLIM CDR v1.0" ;
		:Description = "CHAMP mission: MMCs computed by UCAR, based on PPCs computed …..
		:Conventions = "CF-1.4" ;

data:
```

Example 2

An *ncdump* from the file

mmc_jpl_champ_200109-200809_bendangle_v1.nc

holding CHAMP zonal monthly-mean bending angles generated by NASA/JPL:

```
netcdf mmc_jpl_champ_200109-200809_bendangle_v1 {

dimensions:
	c4 = 4 ;
	c6 = 6 ;
	lon = 1 ;
	lat = 36 ;
	altitude = 111 ;
	time = UNLIMITED ; // (85 currently)

variables:
	char mission(c6) ;
		mission:long_name = “RO mission” ;
	char center(c4) ;
		center:long_name = “RO processing center” ;
```

```
    float lon(lon) ;
        lon:positive = "east" ;
        lon:_FillValue = 999999.f ;
        lon:delta_lambda = 360.f ;
        lon:valid_range = -180.f, 180.f ;
        lon:units = "degrees_east" ;
        lon:long_name = "longitude" ;
    float lat(lat) ;
        lat:long_name = "latitude" ;
        lat:positive = "north" ;
        lat:_FillValue = 999999.f ;
        lat:valid_range = -90.f, 90.f ;
        lat:units = "degrees_north" ;
        lat:delta_phi = 5.f ;
    float altitude(altitude) ;
        altitude:valid_range = 8000.f, 30000.f ;
        altitude:units = "meters" ;
        altitude:long_name = "Altitude: Mean sea level altitude for refractivity, dry temperature .....
        altitude:_FillValue = 999999.f ;
        altitude:delta_h = 200.f ;
    float time(time) ;
        time:delta_t_1 = "month" ;
        time:_FillValue = 999999.f ;
        time:units = "julian date" ;
        time:long_name = "time" ;
        time:averaging_period = "month" ;
    float bending_angle(time, altitude, lat, lon) ;
        refractivity:long_name = "Refractivity" ;
        refractivity:_FillValue = 999999.f ;
        refractivity:units = "N-units" ;
    short N_bending_angle(time, altitude, lat, lon) ;
        N_refractivity:units = "unitless" ;
        N_refractivity:_FillValue = -1s ;
        N_refractivity:long_name = "Number of averaged bending angle values" ;

// global attributes:
        :Title = "RO-CLIM Radio Occultation Climatologies: bending angle" ;
        :Version = "RO-CLIM CDR v1.0" ;
        :Description = "CHAMP mission: MMCs computed by UCAR, based on PPCs computed ….
        :Processing center = “JPL” ;
        :Conventions = "CF-1.4" ;

data:
```

5. Where to find RO data

The RO-CLIM Climate Data Records (CDRs) are available through the SCOPE-CM web site, at the RO-CLIM project page:

http://www.scope-cm.org/projects/scm-08

The RO-CLIM CDRs consist of ensembles of zonally gridded monthly mean data provided by the processing centres participating in the SCOPE-CM RO-CLIM project [*P.01*]. Most of these centres make more data publically available at their own web sites. Reprocessed data in the form of monthly means, and also as data sets consisting of individual RO profiles, can be found through the following URLs:

ROM SAF (DMI):	http://www.romsaf.org
GFZ:	http://isdc.gfz-potsdam.de
JPL:	http://genesis.jpl.nasa.gov
UCAR:	http://www.cosmic.ucar.edu
WEGC:	http://www.wegcenter.at http://www.globclim.org

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6.2 RO-CLIM project documents

[*P01*] RO-CLIM SCOPE-CM (2014), *RO-CLIM Project Description*, 24 March 2014.

[*P02*] RO-CLIM SCOPE-CM (2016), *RO-CLIM Project Plan and Progress Report*, 10 February 2016

6.3 GCOS and SCOPE-CM reference documents

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[*R03*] SCOPE-CM (2009), *Implementation Plan for the Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM)*, Version 1.3, 20 March 2009.

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