

## CF-compliant NetCDF metadata minimum requirements:

Define dimensions as needed:

- time
- lat
- lon
- nbnds

All variables should have attributes:

- units: units compatible with the UDUNITS-2 format are recommended
- long\_name

In addition, lat/lon variables should have attributes:

- standard\_name = "latitude" or "longitude"
- units = "degrees\_north" or "degrees\_east"
- Values of longitude variable shall go from west (-180) to east (180). For global data, avoid longitude values going from 0 to 360.
- Values of latitude variable shall go from south (-90) to north (90)

Values of latitude and longitude variables shall represent center of each grid cell.

In addition, time variables should have attributes:

- standard\_name = "time"
- units: should follow CF conventions specifying the unit of measure and start date, such as "days since 2000-01-01 00:00:00" (see <http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.html-time-coordinate>). The time units should represent the middle time point of each measurement.
- calendar (see <http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.html-calendar> for details)
- bounds = "time\_bnds". "time\_bnds" is a separate 2-dimensional variable that defines the start and end time points of each measurement. Variable "time\_bnds" has the same attributes "units" and "calendar" as variable "time".

It's highly recommended to use values of time variable represented in UTC.

In addition, data variables should have attributes:

- \_Fill\_Value (denotes missing or blank data. Should be outside the valid range of the data.)

If multiple missing data values are presented, use the attribute below instead:

- valid\_range: values outside of valid range will be treated as missing values

In addition, data variables are highly recommended to include the attribute below:

- cell\_methods: Purpose of this attribute is to describe the characteristic of a field that is represented by cell values. For example, assume variable "pressure" is an hourly time series and it has attribute pressure:cell\_methods = "time: point". This means the pressure values represent the pressure measured at certain time points every hour. But

if it has attribute `pressure:cell_methods = "time: mean"`, the pressure values represent the average pressure during each hour. See <http://cfconventions.org/Data/cf-conventions/cf-conventions-1.6/build/cf-conventions.html#cell-methods> for details.

Each file should also include the following global attributes:

- `institution` (can be "Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC)", or the PI's institution)
- `references` (any paper citation that the data is based on)
- `title` (title of the data set)
- `source` (some info about the source or provenance of the data set)

Any abbreviations, such as DAAC, should be spelled out in the attribute descriptions.

**Example:**

`dimensions:`

```
time = 506 ;
lat = 360 ;
lon = 720 ;
nbnds = 2 ;
```

`variables:`

```
double lon(lon=720);
:units = "degrees_east";
:long_name = "Longitude";
:standard_name = "longitude";
:_ChunkSize = 720; // int
```

```
double lat(lat=360);
:units = "degrees_north";
:long_name = "Latitude";
:standard_name = "latitude";
:_ChunkSize = 360; // int
```

```
float prop_secnd(time=506, lat=360, lon=720);
:_FillValue = -9999.0f; // float
:long_name = "Proportion of landcover in secondary landcover";
:missing_value = -9999.0f; // float
:units = "percent";
:cell_methods = 'time: mean area: mean';
:_ChunkSize = 1, 360, 720; // int
```

```
double time(time=506);
:long_name = "Time";
:standard_name = "time";
:calendar = "proleptic_gregorian";
:units = "years since 1500-01-01 00:00:00";
:bounds = 'time_bnds';
:_ChunkSize = 1; // int
```

```

double time_bnds(time=506, nbnds=2);
    :long_name = 'start and end points of each time step';
    :calendar = 'proleptic_gregorian';
    :units = 'years since 1500-01-01 00:00:00';

// global attributes:
:institution = "Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC)";
:references = "Hurtt, G C, L P. Chiri, S Fridking, R A Betts, J. Fedde ma, G Fischer, J. P. Fisk, K Hbbard, R A Houghton, A Janet os, C. D Jones, G Kinder mann, T. Kinoshita, Kees Klein Gdewijk, K Rahi, E Shevliakova, S Smith, E Shefest, A Thomson, P Thornton, D P. van Vuuren, Y. P. Wang (2011) Harmonization of land-use scenarios for the period 1500- 2100: 600 years of global gridded annual land-use transitions, wood harvest, and resulting secondary lands. Climatic change, 109: 117- 161. DOI 10.1007/s10584-011-0153-2";
:title = "Land Use Harmonization version 1, including urban land (LUHa_u2.v1)";
:source = "Version 1 of Land-Use History A product, including land-use changes and transitions from r to urban land";

```