<#_overview>1.4. Overview
##Para 9

Once the variables containing coordinate data are identified, further
conventions are required to determine the type of coordinate represented
by each of these variables. Latitude, longitude, and time coordinates
are identified solely by the value of their *|units|* attribute.
Vertical coordinates with units of pressure may also be identified by
the *|units|* attribute. Other vertical coordinates must use the
attribute *|positive|* which determines whether the direction of
increasing coordinate value is up or down. Because identification of a
coordinate type by its units involves the use of an external software
package [UDUNITS] <#UDUNITS> , we provide the optional attribute
|axis| for a direct identification of coordinates that correspond to
latitude, longitude, vertical, or time axes.

<#units>3.1. Units

The *|units|* attribute is required for all variables that represent
dimensional quantities (except for boundary variables defined in Section
7.1, "Cell Boundaries" <#cell-boundaries> and climatology variables
defined in Section 7.4, "Climatological Statistics"
<#climatological-statistics>). The value of the *|units|* attribute is
a string that can be recognized by UNIDATA's Udunits package [UDUNITS]
<#UDUNITS>, with a few exceptions that are given below. The Udunits
package <http://www.unidata.ucar.edu/software/udunits/> includes a file
|udunits.dat|, which lists its supported unit names. Note that case is
significant in the *|units|* strings.

The COARDS convention prohibits the unit |degrees| altogether, but this
unit is not forbidden by the CF convention because it may in fact be
appropriate for a variable containing, say, solar zenith angle. The unit
|degrees| is also allowed on coordinate variables such as the latitude
and longitude coordinates of a transformed grid. In this case the
coordinate values are not true latitudes and longitudes which must
always be identified using the more specific forms of |degrees| as
described in Section 4.1, "Latitude Coordinate" <#latitude-coordinate>
and Section 4.2, "Longitude Coordinate" <#longitude-coordinate>.

Units are not required for dimensionless quantities. A variable with no
units attribute is assumed to be dimensionless. However, a units
attribute specifying a dimensionless unit may optionally be included.
The Udunits package defines a few dimensionless units, such as
|percent|, but is lacking commonly used units such as ppm (parts per
million). This convention does not support the addition of new
dimensionless units that are not udunits compatible. The conforming unit
for quantities that represent fractions, or parts of a whole, is "1".
The conforming unit for parts per million is "1e-6". Descriptive
information about dimensionless quantities, such as sea-ice
concentration, cloud fraction, probability, etc., should be given in the
|long_name| or *|standard_name|* attributes (see below) rather than
the *|units|* .

The units |level|, |layer|, and |sigma_level| are allowed for
dimensionless vertical coordinates to maintain backwards compatibility
with COARDS. These units are not compatible with Udunits and are

---

Margin comments:

General:

Change "UDUNITS" to UDUNITS2?

Always spell UDUNITS in uppercase letters?
Unknown Author
08/09/2022 17:23

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1) How exactly is this achieved – i.e. iIf we feed the units string to UDUNITS what will we get back that [helps to] identify the coordinate type?
2) Do we actually require UDUNITS here ?
3) Can we instead describe what exactly is needed to identify the coordinate type?
4) Suggest to [strongly] recommend using the `axis` attribute
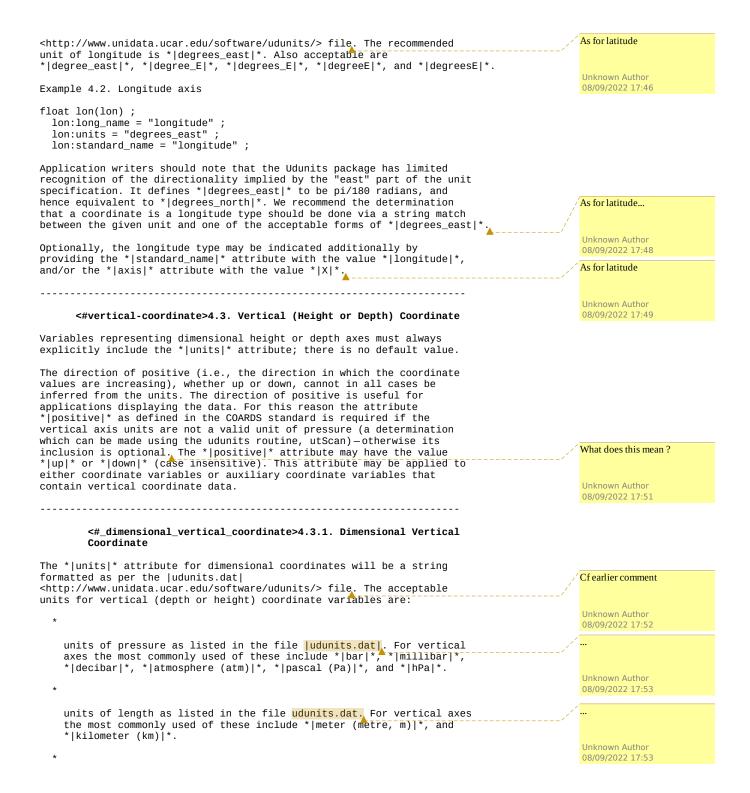Unknown Author
08/09/2022 17:02

The file udunits.dat is since long gone.

Delete sentence ?
Or something else ?
How to inform about formatting requirements ?
Unknown Author
08/09/2022 17:11

Actually UDUNITS2 now accepts ppm, ppmv, ppb, ppbv, ppt, pptv, ppq, ppqv
Unknown Author
08/09/2022 17:12

deprecated by this standard because conventions for more precisely
identifying dimensionless vertical coordinates are introduced (see
Section 4.3.2, "Dimensionless Vertical Coordinate"
<#dimensionless-vertical-coordinate>).

The Udunits syntax that allows scale factors and offsets to be applied
to a unit is not supported by this standard. The application of any
scale factors or offsets to data should be indicated by the
|scale_factor| and *|add_offset|* attributes. Use of these attributes
for data packing, which is their most important application, is
discussed in detail in Section 8.1, "Packed Data" <#packed-data>.

<#coordinate-types>4. Coordinate Types
Para 3

Because identification of a coordinate type by its units is complicated
by requiring the use of an external software package [UDUNITS]
<#UDUNITS> , we provide two optional methods that yield a direct
identification. The attribute *|axis|* may be attached to a coordinate
variable and given one of the values *|X|*, *|Y|*, *|Z|* or *|T|* which
stand for a longitude, latitude, vertical, or time axis respectively.
Alternatively the *|standard_name|* attribute may be used for direct
identification. But note that these optional attributes are in addition
to the required COARDS metadata.

<#latitude-coordinate>4.1. Latitude Coordinate

Variables representing latitude must always explicitly include the
|units| attribute; there is no default value. The *|units|* attribute
will be a string formatted as per the |udunits.dat|
<http://www.unidata.ucar.edu/software/udunits/> file. The recommended
unit of latitude is *|degrees_north|*. Also acceptable are
|degree_north|, *|degree_N|*, *|degrees_N|*, *|degreeN|*, and
|degreesN|.

Example 4.1. Latitude axis

float lat(lat) ;
  lat:long_name = "latitude" ;
  lat:units = "degrees_north" ;
  lat:standard_name = "latitude" ;

Application writers should note that the Udunits package does not
recognize the directionality implied by the "north" part of the unit
specification. It only recognizes its size, i.e., 1 degree is defined to
be pi/180 radians. Hence, determination that a coordinate is a latitude
type should be done via a string match between the given unit and one of
the acceptable forms of *|degrees_north|*.

Optionally, the latitude type may be indicated additionally by providing
the *|standard_name|* attribute with the value *|latitude|*, and/or the
|axis| attribute with the value *|Y|*.

<#longitude-coordinate>4.2. Longitude Coordinate

Variables representing longitude must always explicitly include the
|units| attribute; there is no default value. The units *|attribute|*
will be a string formatted as per the |udunits.dat|

```
<http://www.unidata.ucar.edu/software/udunits/> file. The recommended
unit of longitude is *|degrees_east|*. Also acceptable are
*|degree_east|*, *|degree_E|*, *|degrees_E|*, *|degreeE|*, and *|degreesE|*.
```

Example 4.2. Longitude axis

```
float lon(lon) ;
  lon:long_name = "longitude" ;
  lon:units = "degrees_east" ;
  lon:standard_name = "longitude" ;
```

Application writers should note that the Udunits package has limited
recognition of the directionality implied by the "east" part of the unit
specification. It defines *|degrees_east|* to be pi/180 radians, and
hence equivalent to *|degrees_north|*. We recommend the determination
that a coordinate is a longitude type should be done via a string match
between the given unit and one of the acceptable forms of *|degrees_east|*.

Optionally, the longitude type may be indicated additionally by
providing the *|standard_name|* attribute with the value *|longitude|*,
and/or the *|axis|* attribute with the value *|X|*.

    <#vertical-coordinate>4.3. Vertical (Height or Depth) Coordinate

Variables representing dimensional height or depth axes must always
explicitly include the *|units|* attribute; there is no default value.

The direction of positive (i.e., the direction in which the coordinate
values are increasing), whether up or down, cannot in all cases be
inferred from the units. The direction of positive is useful for
applications displaying the data. For this reason the attribute
|positive| as defined in the COARDS standard is required if the
vertical axis units are not a valid unit of pressure (a determination
which can be made using the udunits routine, utScan)—otherwise its
inclusion is optional. The *|positive|* attribute may have the value
|up| or *|down|* (case insensitive). This attribute may be applied to
either coordinate variables or auxiliary coordinate variables that
contain vertical coordinate data.

    <#_dimensional_vertical_coordinate>4.3.1. Dimensional Vertical
    Coordinate

The *|units|* attribute for dimensional coordinates will be a string
formatted as per the |udunits.dat|
<http://www.unidata.ucar.edu/software/udunits/> file. The acceptable
units for vertical (depth or height) coordinate variables are:

  *

    units of pressure as listed in the file |udunits.dat|. For vertical
    axes the most commonly used of these include *|bar|*, *|millibar|*,
    |decibar|, *|atmosphere (atm)|*, *|pascal (Pa)|*, and *|hPa|*.
  *

    units of length as listed in the file udunits.dat. For vertical axes
    the most commonly used of these include *|meter (metre, m)|*, and
    |kilometer (km)|.
  *

other units listed in the file udunits.dat that may under certain
circumstances reference vertical position such as units of density
or temperature.

Plural forms are also acceptable.

<#time-coordinate>4.4. Time Coordinate

Variables representing time must always explicitly include the *|units|*
attribute; there is no default value. The *|units|* attribute takes a
string value formatted as per the recommendations in the [UDUNITS]
<#UDUNITS> package. The following excerpt from the UDUNITS documentation
explains the time unit encoding by example:

"The specification |seconds since 1992-10-8 15:15:42.5 -6:00| indicates
seconds since October 8th, 1992 at 3 hours, 15 minutes and 42.5 seconds
in the afternoon in the time zone which is six hours to the west of
Coordinated Universal Time (i.e. Mountain Daylight Time). The time zone
specification can also be written without a colon using one or two
digits (indicating hours) or three or four digits (indicating hours and
minutes)."

The acceptable units for time are listed in the UDUNITS database. The
most commonly used of these strings (and their abbreviations) includes
|day| (*|d|*), *|hour|* (*|hr|*, *|h|*), *|minute|* (*|min|*) and
|second| (*|sec|*, *|s|*). Plural forms are also acceptable.

The reference date/time string (appearing after the identifier
|since|) is required. It may include date alone, or date and time, or
date, time and time zone. If the time zone is omitted the default is
UTC, and if both time and time zone are omitted the default is 00:00:00 UTC.

UDUNITS defines a *|year|* to be exactly 365.242198781 days (the
interval between 2 successive passages of the sun through vernal
equinox). /It is not a calendar year./ UDUNITS defines a *|month|* to be
exactly *|year/12|*, which is /not a calendar month/. The CF standard
follows UDUNITS in the definition of units, but we recommend that
|year| and *|month|* should not be used, because of the potential for
mistakes and confusion.

Example 4.4. Time axis

double time(time) ;
  time:long_name = "time" ;
  time:units = "days since 1990-1-1 0:0:0" ;

A time coordinate is identifiable from its units string alone. The
Udunits routines *|utScan()|* and *|utIsTime()|* can be used to make
this determination.

Optionally, the time coordinate may be indicated additionally by
providing the *|standard_name|* attribute with an appropriate value,
and/or the *|axis|* attribute with the value *|T|*.