HFRNet National Network
WERA Radial LonLatUV (LLUV) file format
1.0 Jan 10, 2008

This document describes the basic structure of WERA radial files formatted for the HF radar national network. The file uses a layout with columnar tabular data consisting of a minimum of Longitude, Latitude, Northward (u) velocity, and Eastward (v) velocity for each radial current vector. Additional fields supported by the file structure include range, bearing, error and other data associated with each radial current measurement.

File Naming:
Filename should be used for archiving the data, not as a software determination of whether the file is a valid LLUV file.

The filenames follow the time-stamped naming convention
RDL_XXX_yyyy_mm_dd_HHMMSS.ruv'

'XXX' is the three character site code.
'yyyy' is the year
'mm' is the two character month from 01 to 12
'dd' is the two character day from 01 to 31
'HH' is the two character 24 hour from 00 to 23
'MM' is the two character minute from 00 to 59
'SS' is the two character second from 00 to 59
 '.ruv' is the file type extension for radial files.

Keywords:
Metadata associated with the radial current data is contained within the file using a set of keywords. Keywords are prefaced with the '%' symbol. This allows the file to be easily imported into data analysis programs like MATLAB.

Identification of the file:
The first keyword of the file will typically be '%CTF: <version>' describing the version of the CTF file.

%CTF: 1.00
Identifies the file as a Column Table Format. The 1.00 version will change in the future if any changes are needed in reading the format.

%FileType: LLUV <subtype>
Identifies the file as a LonLatUV file. The <subtype> is rdls for Radials.

%Manufacturer: Helzel Messtechnik GmbH, WERA.
Identifies that the file came from WERA.

%LLUVSpec: 1.00 2007 12 06
LLUV File specification version followed by date year, month, day.
This version will change when the fundamental LLUV data changes meaning or to point resolved problems.
The LLUV 1.00 version has each vector of longitude, latitude, u,v, vector flag where u,v is the current velocity towards North and East at the location of each vector.

%Site: XXX "KNS"
Contains the three-character site code followed by an optional user-friendly site name/info.

%TimeStamp: 1999 08 16 13 00 00
Identifies the start time in year, month, day, hour, minute, second of the data collected in the file.

%TimeZone: "UTC" +0.00 0
Identifies the time zone of the TimeStamp. The first parameter is the timezone abbreviation in quotes. The second is the hours from UTC to the timezone. The third is an indicator, if not zero, indicates that daylight savings is in effect. Timezone should be UTC for participation in HFRNet.

%TimeCoverage: 266.23999023 Seconds
Identifies the coverage time in seconds of the data collected in the file. The time the LLUV data covers is represented by

the timestamp minus half the coverage time to timestamp plus half the coverage time

%Origin: 28.033333 -90.016667
Is the <latitude> <longitude> in fractional degrees (positive East and North) of where all Easting Distance(x), NorthingDistance(y), Range, and Bearing data is relative to.

%GreatCircle: "WGS84" 6378137.000 298.257223562997
Identifies the model used to represent the Earth's surface as an ellipsoid. WGS84 is the world geodetic since 1984.6378137 meters is the equator circumference, and the 298.2572 ratio is the 1/f roundness factor.

%GeodVersion: "NGS-Vincenty" 2.0 2002 10 01
Identifies the distance calculation for geo-location used. The first parameter is the name of the method. The second is the version number, followed by year, month, day time stamp. The CGEO method makes use of Vincenty's Great Circle calculation based upon NOAA Aug 9, 2002 source. This calculation measures the distance and bearings from/to any two points on the Earth using a great circle between the two points. A great circle is a circle on the globe, centered at the globe's center, and is the minimum distance between any two points. Because the HF Radar currents are surface based (follows the curvature of the Earth) the radial bearings also follow a great circle.

%RangeResolutionKMeters: 1.500
This key is the range resolution in km of a Radial Site.

%TransmitCenterFreqMHz: 16.0640
Is the center transmit frequency used in megahertz.

%DopplerResolutionHzPerBin: 0.000976563
Is the Doppler bin resolution of the cross spectra used. It is used to determine current velocity. It is a calculation of the waveform sweep rate divided by number of Doppler cells used.

%CurrentVelocityLimit: 100.0
Is the maximum allowed current velocity cm/s in processing the cross spectra or combining into a total vector. You will not find any LLUV vector in this file with a larger velocity.

%MergedCount: 1
Is the number of radials averaged into the given output.

%TransmitSweepRateHz: 1.00000
Sweep rate used.

%TransmitBandwidthKHz: -124.914
Bandwidth used. A negative value indicates a down sweep.

%SpectraDopplerCells: 1024
The number of doppler cells.

%End:
Marks the end of the file.

%TableType: LLUV <subtype>
<type> must be 'LLUV' which indicates that the first four columns are always lon,lat,u,v
<subtype> helps to identify the extra columns for the various current maps.
The current subtypes are
 'RDL1' for radial data of Longitude, Latitude, U, V, Variance, Accuracy, X Distance, Y Distance, Range, Bearing, Velocity, Direction, Spectra Cell

A LLUV type will always contain a minimal of the first four columns of lon, lat, u, v. If there is no subtype then the data contains only lon, lat, U, V.

After the TableType key is the '%TableColumnTypes:' key which describes the data in each column. The %TableColumnTypes: contains a list of four charcodes describing each column of the table data in order. The known column codes are:

LOND is the current vector longitude in fractional degrees with positive East
LATD is the current vector latitude in fractional degrees with positive North.
VELU is the current vector velocity eastern component in cm/s
VELV is the current vector velocity northern component in cm/s
EVAR is a radial variance of current velocity over coverage period.
EACC is a radial accuracy of current velocity over coverage period.
XDST is the current vector easting distance in km from the origin key.
YDST is the current vector northing distance in km from the origin key.
RNGE is the current vector range in km from the origin key.
BEAR is the current vector bearing in degrees clockwise from true North from the origin key.
VELO is the current vector velocity in cm/s. (Negative velocity implies 180deg direction change)
HEAD is the current vector direction in degrees clockwise from true North
SPRC is the current vector range cell.
MAXV is the maximum current velocity found over the coverage time.
MINV is the minimum current velocity found over the coverage time.

Example:
%TableColumnTypes: LOND LATD VELU VELV EVAR EACC XDST YDST RNGE BEAR VELO HEAD SPRC

%TableRows: <count>
tells reader software how many vectors to expect. Typically you should not count on this number being exact as the file
might have been hand edited after its creation.

%TableColumns: <count>
can be used with the table type and subtype to determine if all the expected columns are in the file. This will always match
the number of columns but you should rely on the TableColumnTypes key for column content.
The table data should then be preceded by a

%TableStart: <tablenumber> <tablenumber> will be missing for the first table. Currently, the LLUV files contain only one
table.

Followed by a line for each Table Row of data. Each line is preceded by a space. Spaces (no Tabs) are used between
columns.

Followed by a
%TableEnd:
key after the data.

A table might look like this:

```
%TableType: LLUV RDL1
%TableColumns: 13
%TableColumnTypes: LOND LATD VELU VELV EVAR EACC XDST YDST RNGE BEAR VELO HEAD SPRC
%TableRows: 5
%TableStart:
%%   Longitude   Latitude   U comp  V comp  Variance  Accuracy  X Distance  Y Distance  Range   Bearing   Velocity  Direction  Spectra
%%     (deg)       (deg)    (cm/s)  (cm/s)   (cm/s)    (cm/s)      (km)        (km)       (km)   (deg NCW)  (cm/s)    (deg NCW)  RngCell
    -80.1641693  25.3614120  3.031  88.047   26.890    4.612     -1.3423    -38.9861    39.009    2.0      -88.10     182.0       33
    -80.1641693  25.3524113  2.986  88.928   26.739    4.586     -1.3424    -39.9832    40.006    1.9      -88.98     181.9       34
    -80.1641693  25.3434124  2.907  88.747   27.063    4.641     -1.3425    -40.9801    41.002    1.9      -88.79     181.9       35
    -80.1641693  25.3344135  2.712  84.783   29.677    5.090     -1.3426    -41.9770    41.998    1.8      -84.83     181.8       35
    -80.1641693  25.3254147  2.654  84.951   28.922    4.960     -1.3427    -42.9738    42.995    1.8      -84.99     181.8       36
%TableEnd:
```

Vector Description:

Each line in the LLUV table describes a single current vector. The main component of the vector is the Lon,Lat,U,V data.
Additionally, x, y, range, bearing, velocity, and direction data should be included as redundant reference information about
the vector that helps to provide diagnostics when examining the data.

Longitude, Latitude.
The first two columns are the geo location in fractional degrees of each current vector. This is the data that should be used
to plot the current vector with. A positive longitude is East and a positive latitude is North.

U, V Components.

The third and fourth columns show the ocean current vector's velocity and direction. These are in a x,y style in which U is the Easting velocity component and the V is the Northward velocity component in centimeters per second. These components are always oriented from True North at the location of each vector. For Total LLUV files this is the actual ocean current vector. For Radial LLUV files this is a radial component of the actual ocean current vector

X, Y Distance.
The x,y distances are given as a reference from the %Origin: keyword. They are the cos/sin of the range and bearing great circle distance from the %Origin location. This makes x an Easting distance and y a Northing distance. The x,y coordinate can be thought of as a tangential plane to the earth at the location of the %Origin:. You should not compare or add x,y distances from different origins as orientation of their planar data will be different.

Range, Bearing
Range and Bearing is a reference location of the vector from the %Origin: keyword. The location is found by navigating a great circle from the %Origin starting with Bearing direction degrees clockwise from True North and traveling the Range in kilometers.

Velocity, Direction
Velocity and Direction is the ocean current vector. This is the same info as the U, V data except that it is in magnitude of centimeters per second and direction degrees clockwise from True North at the location of the vector. For radials, the Direction will be close to 180 degrees from the Bearing but will vary depending on the latitude and the difference in the longitude from the %Origin. Also for radials the sign of the velocity indicate whether the velocity is towards(positive) or away (negative) from the site.

Quality Factors
There are four columns for quality factors.
For Radials, there are 4 columns: Variance, Accuracy, Velocity Maximum, and Velocity Minimum.
Velocity Maximum is the maximum detected velocity at the same range and bearing across the radial coverage time.
Velocity Minimum is the minimum detected velocity at the same range and bearing across the radial coverage time.

Known Table subtypes and their data column types:
RDL1: LOND LATD VELU VELV EVAR EACC XDST YDST RNGE BEAR VELO HEAD SPRC

Revision Notes:
2008/12/06   LLUVSpec 1.00, RDL1 radial file format defined as prototype WERA LLUV radial file format