UFOOrbitV2 Users Manual

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1.Introduction

UFOOrbit is a software for computing and visualizing orbits of meteors that were observed by multi-stations. It provides you with these features:

- Detect simultaneous observed meteors from multi-stations observation data (M*.csv for UFOAnalyzer output data) and compute radiant point, trail on the ground and the orbit.
- Draw the radiant point map.
- Draw the trail map that shows relation between observed trail and radiant point on the star map.
- Draw the trail map on the ground.
- Draw the orbit map in the solar system.
- Output U2_*.csv for meteor information data base, UFORadiant.

General notation used in UFOOrbit

- all angle values are expressed in the format of decimal degree
- abbreviations
  - Ra : right ascension J2000 (0.0 .. 360.0)
  - Dec,dc: celestial declination J2000 (-90.0 .. 90.0)
  - Az: azimuth direction (0.0 .. 360.0)
    - 0.0 for North, 90.0 for East, 180.0 for South, 270.0 for West
    - exception
      - in input CSV files , South oriented directions are used
  - Alt,Ev : elevation angle from ground (0.0(G) .. 90.0(Z))
  - Long,lng : geographical longitude (-180.0(W) .. 180.0(E))
  - Lat : geographical latitude (-90.0(S) .. 90.0(N))
  - Alt,H : altitude of the station (m), height of meteor position (km)

2. Setup

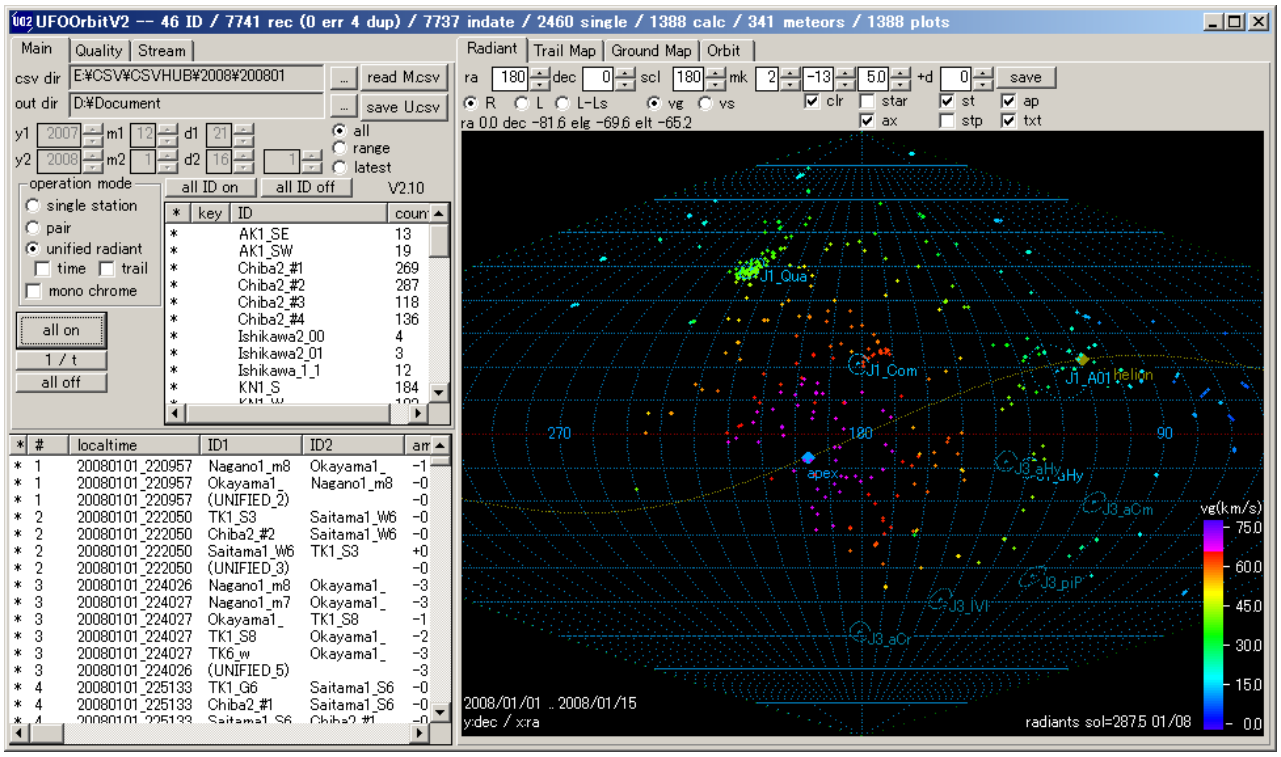
- Windows 2000/Xp/Vista is required.
- Download UO2xx.zip (or .lzh) from SonotaCo.com.
- Expand it into appropriate directory (e.g. c:\Program Files\UO2).
  - Invoke UO2.exe in UO2 directory to start the program.
- If you want to uninstall, delete UO2 directory.
- Japan map is included in UO2xx.zip (or .lzh).
  - If you need another map;
    - download map data GM*.zip from SonotaCo.com and expand it into UO2 directory.
    - specify it as Base Map in Ground Map sheet.
    - if you don't find your region's map, please contact SonotaCo.

3. Basic procedure

1. Gather multi-stations observation data (M*.csv of UFOAnalyzer output data) and save into a certain directory.
2. Specify the directory into "csv dir" on Main sheet.
3. Specify the date range with all/range/latest and click "read M.csv" to read M*.csv.
4. After reading files, it starts detecting of simultaneous meteors and analyzing.
5. You can brows by using functions for each sheet. Click "save" button for each sheet to output the figure if needed.
6. Click "save U.csv" on Main sheet to output U2_*.csv for UFORadiant if needed.
7. You can select the records by their quality on Quality sheet or streams on Stream sheet.

4. Operation guide

4.1 Base window



Base window consists of 4 parts, title bar, left sheets, right sheets, and record lists.

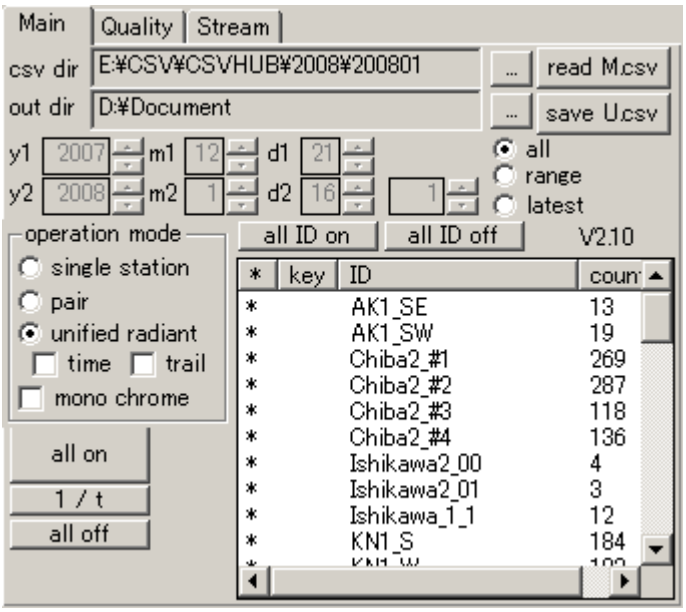
- title bar
  - There are 3 buttons, which are minimize, maximize and terminate button, at the upper right corner. Click **x** button to terminate the program.
  - After reading M.csv, the following items are displayed at the title bar.
    - ID : number of IDs.
    - rec : number of all records.
    - err : number of error records.
      - They are number of incomplete, inconsistent, and ignored records.
      - The ignored records are saved as ErrRec.csv in UO2 directory.
    - dup : number of duplicated records
      - The records, which have the same localtime and ID, are counted as the duplicated records.
      - Either one in duplicated records may be used for calculation.
      - The status of duplicated record is saved as DupRec.csv in UO2 directory.
      - If displayed other than 0, check the csv not to include duplicated records.
    - indate : number of records within specified period.
    - single : number of records satisfied with conditions in Single on Quality sheet.
    - orbit, paired orbit, UNIFIED orbit : number of orbits calculated as possible simultaneous meteors. (not displayed if single site mode)
    - meteors : number of meteors. (not displayed if single site mode)
    - plots : number of plots. (not displayed if single site mode)

- Left sheets : There are 3 sheets, **Main**, **Quality**, **Stream** sheet. Click tab to change the sheet.

- Right sheets : There are 4 sheets, **Radiant**, **Trail map**, **Ground map**, **Orbit** sheet.

- Record list : List of results.
    - Click column name to display the following menu. (This function is common for all tables.)
        - **Hide** : Hide the row.
        - **Row Select** : Select the row to display.
        - **Sort +** : Sort the row in ascending order.
        - **Sort -** : Sort the row in descending order.
    - Drug the boundary line to change the row width.
    - The following operation is available for each row.
        - Click the row to select the row (map display N/OFF).
        - Click the row with pressing ctrl key to additionally select the row ON/OFF.
        - Right click in *****column or **#**column to select lines that have same # (same meteor).
        - Right click in other columns to display table of all the values of one row.
    - Click **all on** / **all off** button to select all rows ON/OFF.

4.2 **Main** sheet



csv dir : Click "..." button to enter the input directory, which contains M*.csv. All M*.csv files under the specified directory and its lower level directories are read into.

out dir : Click "..." button to enter the output directory, which outputs maps and U.csv.

read M.csv : Read all csv in specified input directory.
save U.csv : Save records, which marked * in lower list, to out dir as csv format.

all : All records in input directory will be are processed.
range : Records from y1/m1/d1 to y2/m2/d2 (UTC) will be processed.
latest : Records within specified days from current day will be processed.

ID list : All IDs in inputted CSV files are listed. Following options are available.

- * column: Only * marked IDs are processing.
  - Double click the column to toggle ON/OFF.
  - Click "**all ID on**" button to set all ID ON.
  - Click "**all ID off**" button to set all ID OFF.
- key column : Only * marked IDs combinations are processing.
  - Double click the column to toggle ON/OFF.
- count column : Number of records to be read.

single station : Set operation mode to handle inputted single station records.

- Single station mode is used to confirm the inputs.
- Trail map and Stream selection can be valid in single station mode.
- Radiant , Ground map and Orbit are not available.

pair : Set operation mode to compute all possible combination of two records.

- Max n*(n-1) orbits for n observations per a meteor (2 orbits per pair) will be reduced.

unified radiant : Set operation mode to compute one unified radiant and one average velocity from possible simultaneous records.

- Firstly, same computation and qualification process as pair mode will be done, and the valid simultaneous observations are decided.
- Using simultaneous observations, one unified radiant will be computed.
- Using the unified radiant, n results are computed from n valid simultaneous observations.
- One record per a meteor that is named “UNIFIED_n” will be added.
- “UNIFIED_n” record has combined trajectory information.
- UO2_Unify.log will be created if the log checkbox of Quality sheet is on.
- Two additional mode below can be assigned.

    - **time** : Force to use same time in computation.
        - Error will be reduced when observation time error exists.
        - Error will be added when observed sections were different.

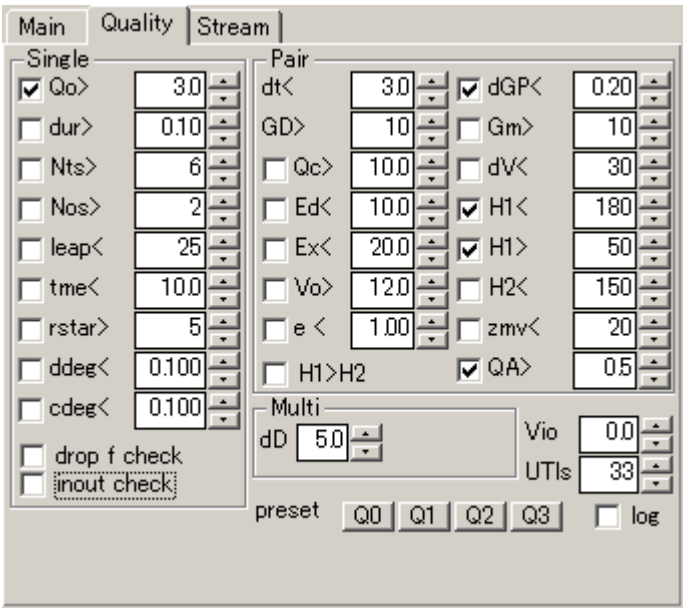
    - **trail** : Make an unified trajectory if possible.

mono chrome : Set display mode to monochrome.

all on: Set select of all records ON.
all off: Set select of all records OFF.
1/t :

- in pair mode : Only one record, which has most high total quality (QA) in the simultaneous meteors, is set select ON.
- in unified radiant mode : Only “UNIFIED” record that a is set select ON.

4.3 **Quality** sheet



In Quality sheet, set the selection conditions of records to be used to compute the orbit.

- Only records satisfied with the checked conditions in Single column are used to detect simultaneous meteors.
- Only results satisfied with the checked conditions in Pair column are listed in the record list.
- Records that are permitted by the condition in Multi column are treated as one acctual meteor and will be given same #.
- **Q0**,**Q1**,**Q2**,**Q3** sets the preset conditions.
    - **Q0**: all combinations that is permitted by the condition of time difference (dt) and ground distance of two stations (GD) will be processed. In this case, there contains many inappropriate combinations or incorrect results.
    - **Q1** : minimum conditions for normal radiant computation.
    - **Q2** : standard conditions for radiant and velocity computation.
    - **Q3** : conditions for high precision computation.
    - You can add or modify conditions at ant time.
        - Normally, conditions of **Qo**,**Qc**, and **QA** are effective to reject poor quality observations.
        - If you need precise radiant coordinates, **Ed** is effective condition.
        - If you need precise velocity or orbital radius, **Ex** is effective condition.
        - If you narrow records down to the precise observations in Single column, it might raise processing speed to reduce combinations to calculate.
- **log** : Check “log” to output UO2_Group.log and UO2_Quality.log.
- **Vio** : Specify the deceleration by the atmosphere (Vinf - Vo) to calculate the orbit. Usually 0.0 is used.
- **UTls** : Specify accumulated leap seconds between UT1 and UTC. In 2007, it is 33 seconds.

Single selection condition

name	unit	explanation
Qo	deg	minimum observed trajectory angle
dur	sec	minimum duration time
Nts	sample	minimum total samples in duration time
Nos	sample	minimum detected object samples
leap	%	(Nts - Nos)/Nts*100.0
tme	sec	maximum recorded time error (value in the input file is checked)
rstar	-	minimum reference stars in analyzing
ddeg	deg	maximum average positioning error in analyzing
cdeg	deg	maximum linearity error in analyzing
drop f check	-	reject if frame drop detected
inout check	-	reject if start or end point is out of view

Pair selection condition
(They are selected only if combination of records, which conform simultaneous observation, satisfied with the pair selection conditions simultaneously.)

name	unit	explanation
dt	sec	maximum time difference between 2 stations (*1)
GD	km	minmun ground distance between 2 stations
Qc	deg	minimum cross angle of two observed plane
Ed	deg	maximum quality assessment of radiant position(*2)
Ex	deg	maximum quality assessment of trajectory positioning(*3)
Vo	km/s	minimum observed velocity
e	-	maximum eccentricity (equivalent to upper limit of velocity)
dGP	deg	maximum difference of 2 pole of ground trajectory
Gm	%	minimum overlap percentage of 2 observed trajectory
dV	%	maximum difference of 2 velocity
H1	km	maximum and minimum height of start point
H2	km	maximum height of end point
zmv	deg	maximum distance between modified radiant and observed radiant
QA	-	total quality assessment (*4)
H1>H2	-	reject if H1 is lower than H2

Multi condition (acctual meteor determination condition)

name	unit	explanation
dD	deg	maximum angle difference of radiant and ground pole (*5)

*1 : The criteria for simultaneity of time are used meteor duration time and tme as well as dt. For this reason, there may contain records that have bigger time difference than dt.

*2 : Ed is added assessment of trail length, radiant point elongation and observed plane crossing angle to observed position error.

- It is calculated on the following formula. (Qr2 is an elongation between end point and radiant point.)
- Ed = (cdeg/sqrt(Nts) + ddeg) / Qo * Qr2 / sin(Qc)

*3 : Ex is added assessment of perpendicular angle at the end of the trail to Ed. It is used to assess calculated position error on the trail.

- It is calculated on the following formula. (Qd2 is the perpendicular angle at the end of the trail, which is different the angle between perpendicular to the other observed plane and the direction of the end of the trail from 90 degree.)
- Ex = Ed / sin (Qd2)

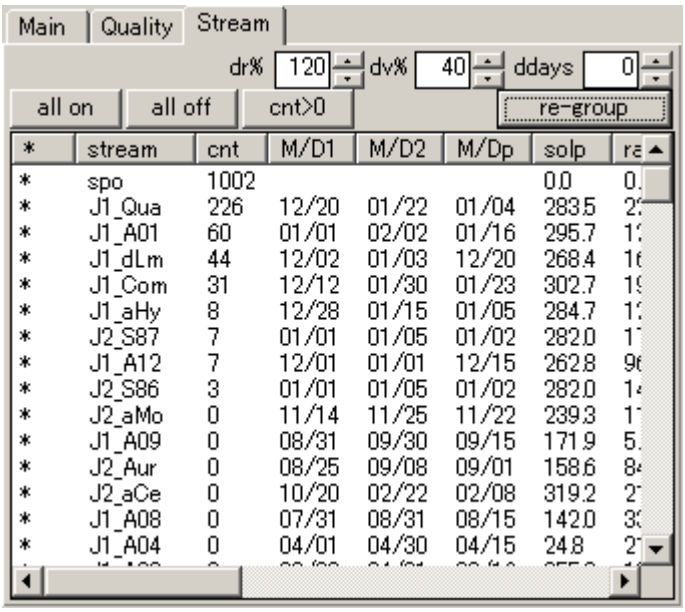
*4 : QA is total quality assessment (from 0.0 to 1.0) mainly based on Qo and Ex. This means the nearer 1.0, the more reliable.

- QA is calculated on the empiric formula and used in 1/t processing for selecting the best result.
- If you need clear criteria for selecting the orbit, set the individual conditions.
- QA is calculated by the following elements.
    - assessment of single record
        - drop,inout,tme,leap,Qo
    - assessment of pair records
        - vo,e,Ex

*5 : dD is used in the determination of one actual meteor by following conditions.

- time difference is less than 60 seconds.
- difference of radiant direction is less than dD.
- difference of ground pole direction is less than dD.

4.4 **Strea**m sheet



In stream sheet, you can set parameters for grouping the stream and select the stream to be listed.

dr%: Specify upper tolerant percentage of angular separation (dr) between modified radiant point (ra t, dc t) and catalog radiant point by catalog radius (R).

- If catalog R is 3 degree and you specify 120 in dr%, it can tolerate within 3.6 degree.

dv%: Specify upper tolerant percentage of velocity difference (dv) between calculated geocentric velocity (vg) and catalog vg by catalog vg.

- If catalog vg is 40km/s and you specify 40 in dv%, it can tolerate error within +/- 16km/s.

ddays : Specify +/- ddays to extend appearance period from M/D1 to M/D2 in catalog.

It can classify the stream that has the smallest dr if dr, dv, ddays are all tolerated.

all on: Set all stream ON.

all off: Set all stream OFF.

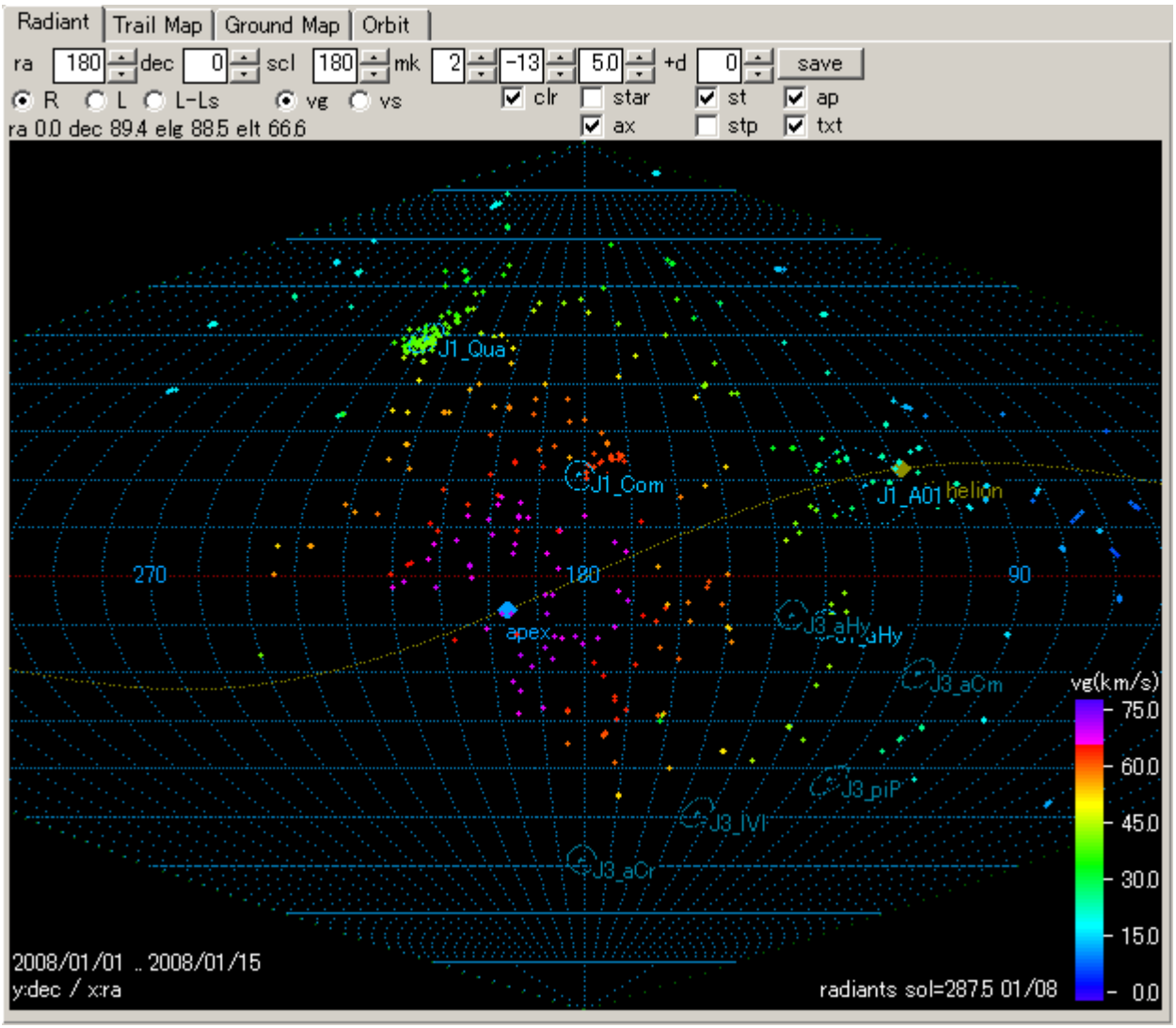
cnt > 0: Set ON only if the number of meteors classified (cnt) is positive.

In cnt column in the table, number of records that are classified to the stream are listed. Click 1/t button in Main sheet to list number of records without duplications.
Click the row in table to display only the classified records on each map. If displayed for 1/t, cancel it. Operate again in Main sheet.

Click the row with pressing ctrl key to additionally select the row.

re-goup : Classify again under current conditions. It is effective for single site mode.

4.5 **Radiant** sheet

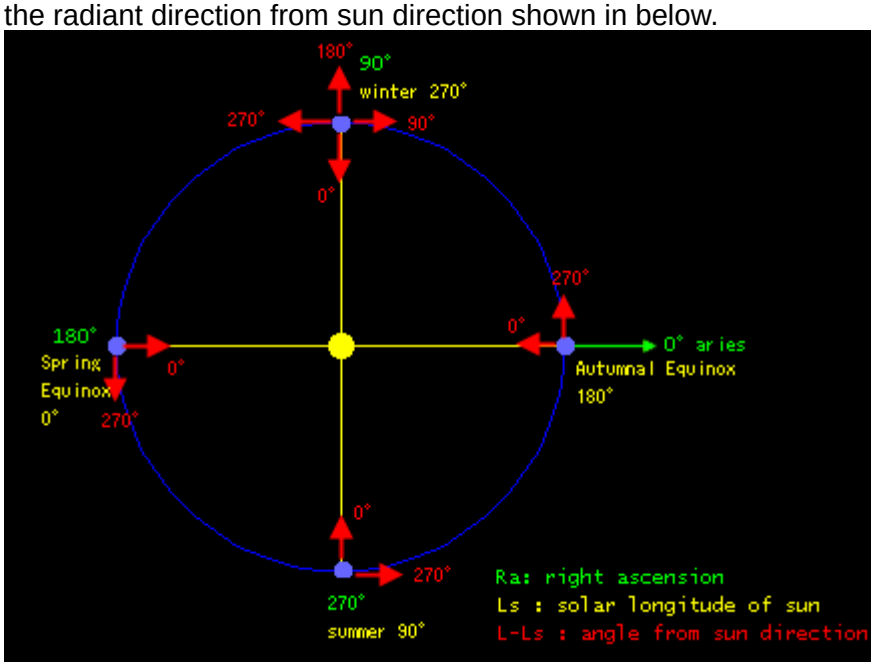


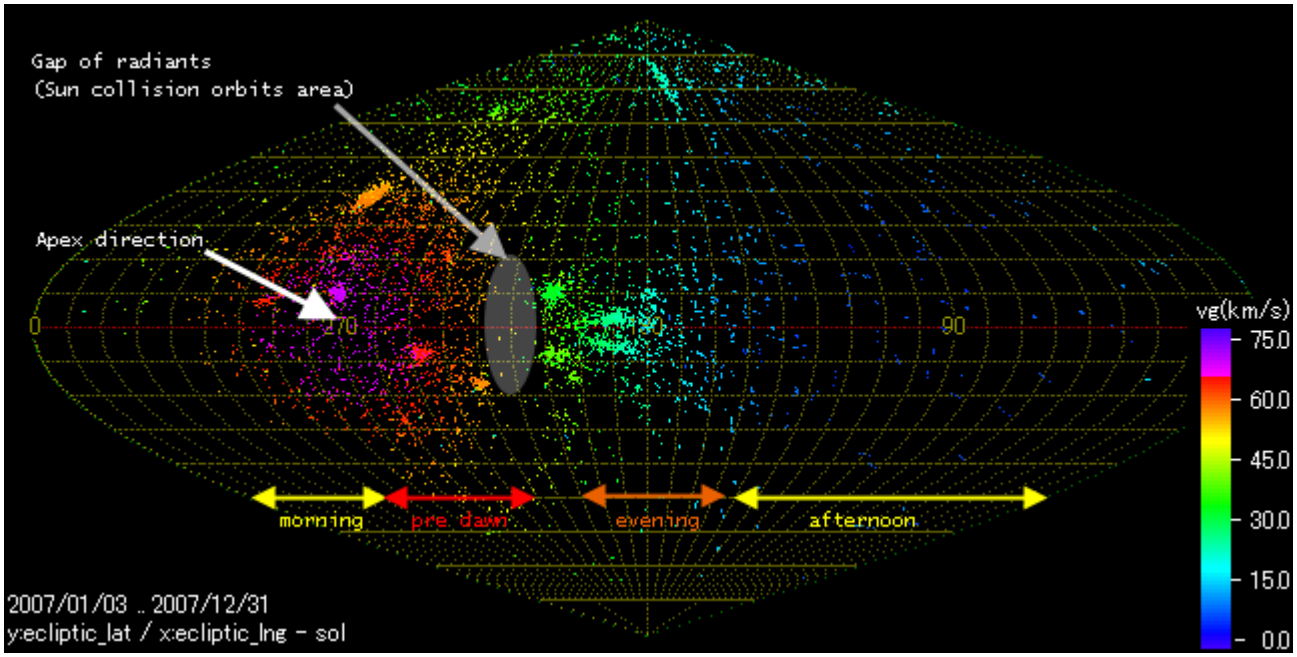
Radiant map is plotted the radiant points on Sanson projection (sinusoidal projection) map. The following options are available.
Click the radiant point to select and highlight the records.

- **ra/elg**: Specify Ra or ecliptic longitude in degree at the center position.
- **dec/elt**: Specify Dec or ecliptic latitude in degree at the center position.
- **scl** : Specify angle in degree for vertical size of window.
- **mk** : Specify 1 to 4 for the size of the radiant point mark.
- **clr** : If checked, radiant points are displayed with color corresponding to their speed. Set -79 to 79 in clr for velocity 0.0km/s. If minus, gradation is inverted.
- **star** : Specify the limit magnitude of stars to display.
- +d : Specify the increase or decrease days to calculate the date of radiant point, apex, anti-helion
- **st**: Display the radiant point in catalog.
- **stp**: Display the radiant point at maximum time's position.
- **ax** : Draw Ra, Dec line or ecliptic longitude, ecliptic latitude line.
- **ap** : Draw ecliptic, apex and anti-helion.

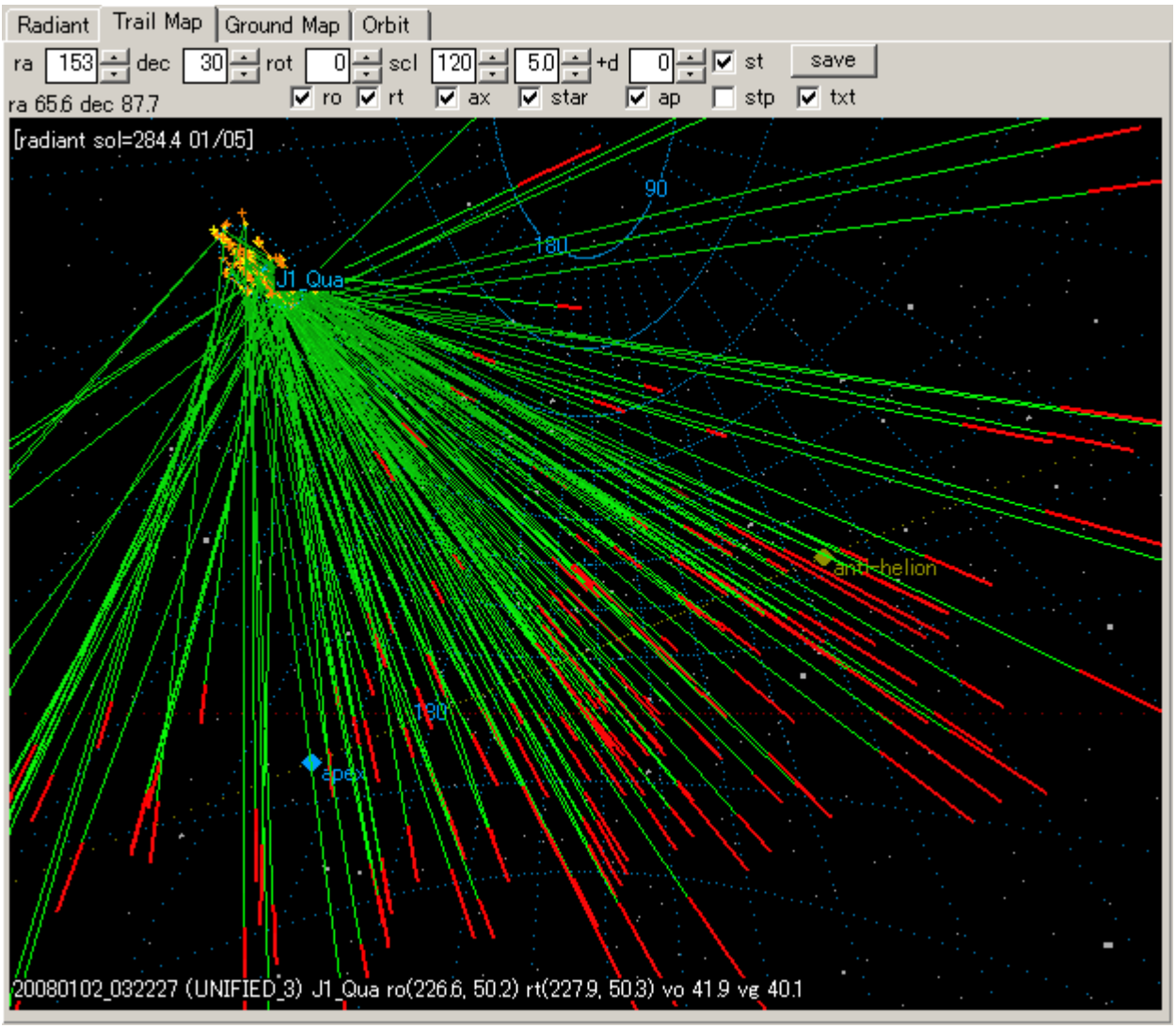
- **txt** : Display text information.
- **R**: Equatorial coordinate system mode
- **L**: Ecliptic coordinate system mode
- **L-Ls**: The ecliptic longitude is used ecliptic longitude - ecliptic longitude of the sun.*
- **vg** : Display with color corresponding to geocentric velocity.
- **vs** : Display with color corresponding to heliocentric velocity.
- **save** : Save the map as bmp format.

***L-Ls** almost cancels the typical radiant movement of showers (1 deg/day of Ra). Also it means the radiant direction from sun direction shown in below.





4.6 **Trail map** sheet

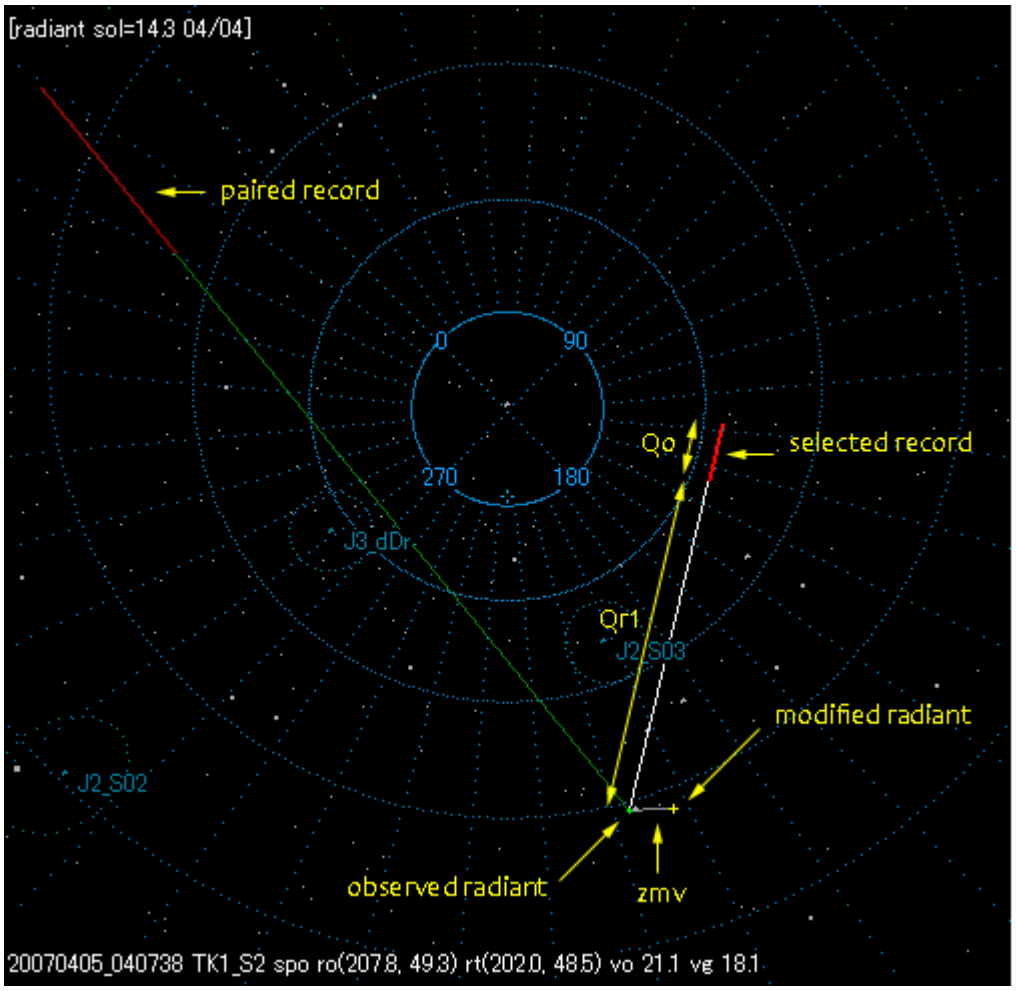


Trail map is plotted the observed trails, direction for radiant point, observed radiant point and modified radiant point on gnomonic projection map. The following options are available.

- **ra** : Specify Ra in degree at the center on the map.
- **dec** : Specify Dec or ecliptic latitude in degree at the center on the map.
- **rot** : Specify rotation angle in degree at the center on the map.
- **scl** : Specify angle in degree for horizontal size of window.
- **star** : Specify the limit magnitude of stars to display.
- **+d** : Specify the increase or decrease days to calculate the date of radiant point, apex, anti-helion.
- **st** : Display the radiant point in catalog
- **stp** : Display the radiant point at maximum time's position.
- **ro** : Display observed trajectory(red),coming direction(green), and observed radiant(yellow).
- **rt** : Display modified radiant and zmv line (observed radiant to modified radiant line).
- **ax** : Draw Ra, Dec line.
- **ap** : Draw ecliptic, apex and anti-helion.

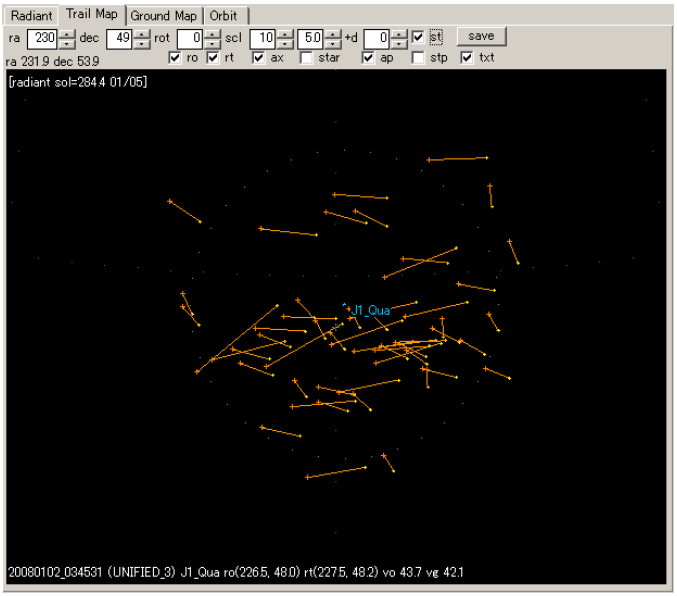
- **txt** : Display text information.
- **save** : Save the map as bmp format.

Click a green line on trail map to select the record.
The selected record is highlighted in record list and on map.
On trail map, the observed radiant point and modified radiant point are shown as below.

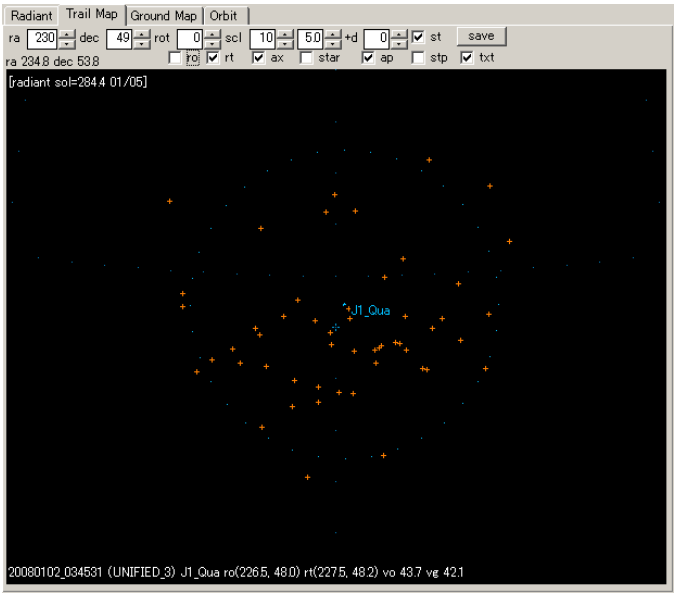


“UNIFIED” records inn unified radiant mode, trajectories and coming directions are not displayed. The zmv line and modified radiant is displayed in orange color.

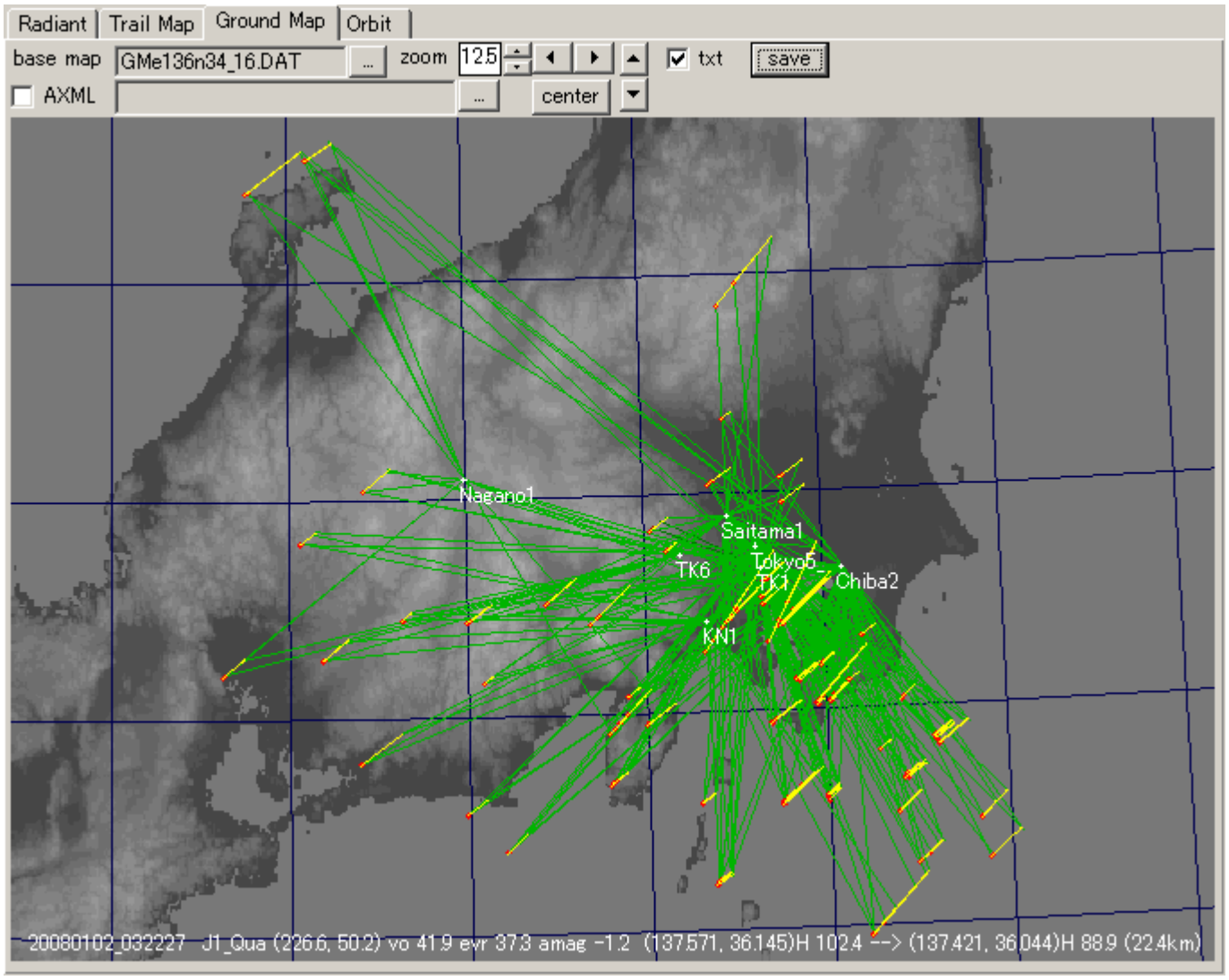
“UNIFIED” recored when ro and rt are both ON.



“UNIFIED” record when rt is ON.



4.7 **Ground map** sheet

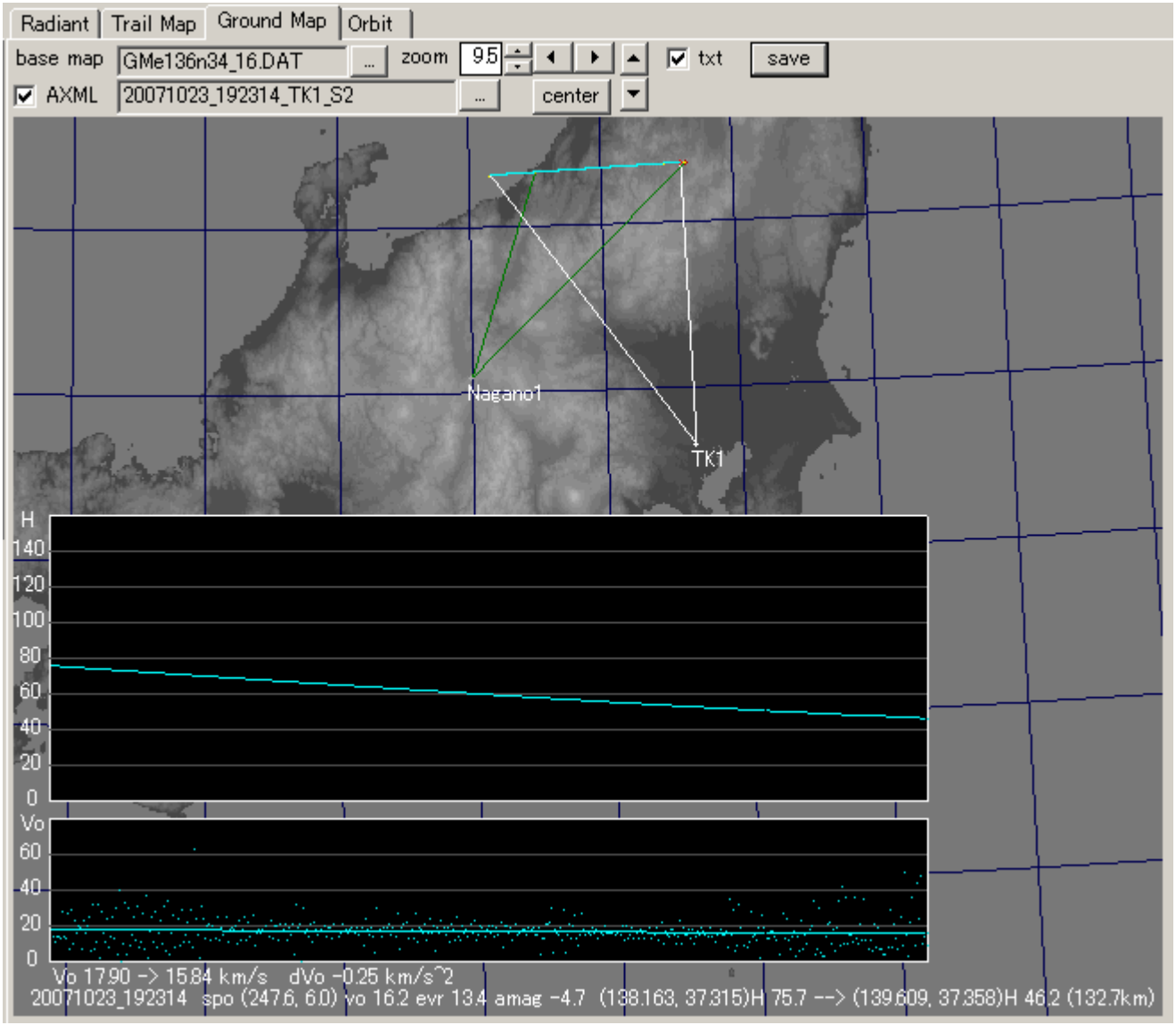


Ground map shows the observed location, observed direction and observed trail on gnomonic projection map. The following options are available.
Click the lines on ground map to select and highlight the record.

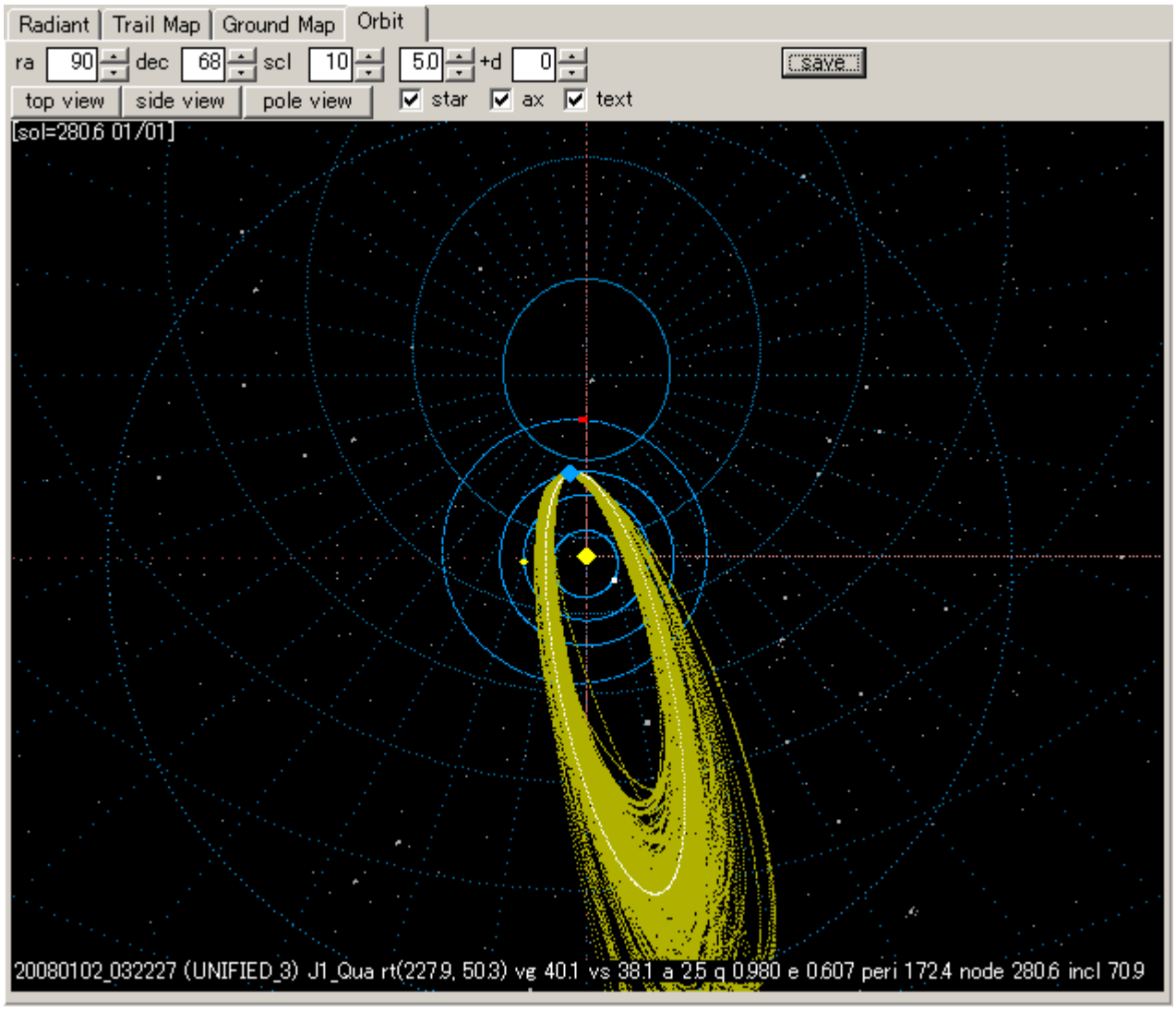
- **base map** : Select the map. Some maps are contained in the package. If you need other map, retrieve from SonotaCo.com.
- **zoom** : Specify zoom rate.
- spin button : Move the viewport.
- **center** : Move the viewport at the center of trails.
- **txt** : Display text information.
- **save** : Save the map as bmp format.

- **AXML** : By following steps, you can plot height(H) and observed velocity(Vo) of every samples on Ground map.

1. Prepare M*A.XML that contains the analysis result of one observation by UFOAnalyzerV2 V2.11 or later.
2. Click "…" button right hand of **AXML** check box and assign the M*A.XML file. On Ground Map sheet.
3. Click one result on the record list that is correspond to M*A.XML.
4. Check **AXML** check box ON



4.8 **Orbit** sheet



Orbit shows the meteor orbits in the solar system. The following options are available.
Click one of the orbits on the map to select and highlight the record.

- **ra** : Specify Ra in degree at the view point.
- **dec** : Specify Dec in degree at the view point.
- **scl** : Specify distance (AU) for horizontal size of window.
- **star** : Specify the limit magnitude of stars to display.
- **+d** : Specify the increase or decrease days to calculate the date of radiant point, apex, anti-helion.
- **ax** : Draw Ra, Dec line.
- **txt** : Display text information.
- **top view** : view from top of ecliptic plane.
- **side view** : view from side of ecliptic plane.
- **pole view** : view from pole of selected orbit pane. (need to select oner orbit.)
- **save** : Save the map as bmp format.

5. Technical information

5.1 Data format

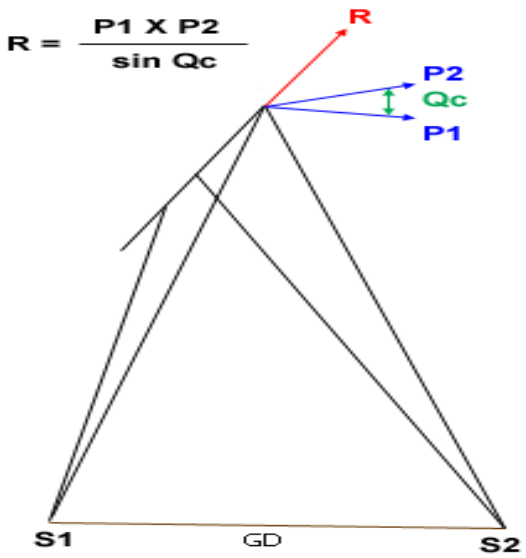
The content of record list is shown below. (They correspond to U2_*.csv. Some of the items are unavailable in single site mode.)

name	type	unit	explanation	remark
*	a1	-	*: displayed	
#	d	-	number of meteor	
localtime	a20	-	YYMMDD_hhmmss	
mjd	f	day	Modified Julian Day（conform to UTC)	
sol	f	deg	solar longitude of observed time	
ID1	a20	-	location ID	
ID2	a20	-	referenced location ID	
amag	f	-	absolute magnitude	
ra_o	f	-	Ra of observed radiant point	
dc_o	f	-	Dec of observed radiant point	
ra_t	f	deg	Ra of modified radiant point	
dc_t	f	deg	Dec of modified radiant point	
elang	f	deg	ecliptic longitude of modified radiant point	
elat	f	deg	ecliptic latitude of modified radiant point	
vo	f	km/s	observed velocity	
vg	f	km/s	geocentric velocity	
vs	f	km/s	heliocentric velocity	
a	f	au	semi-major axis	
q	f	au	perihelion distance	
e	f	-	eccentricity	
p	f	year	period	
peri	f	deg	argument of perihelion	
node	f	deg	longitude of the ascending node	
incl	f	deg	inclination	
stream	a7	-	meteor stream name	
dr	f	deg	distance from radiant point on catalogue	
dv%	f	%	error of geocentric velocity from catalogue value	
dur	f	sec	duration time	
Qo	f	deg	observed trajectory angle	
mag	f	-	observed magnitude	
av	f	deg/sec	dominant angular velocity	
Voa	f	km/s	reserved	
Pra	f	deg	Ra of trajectory pole	*1

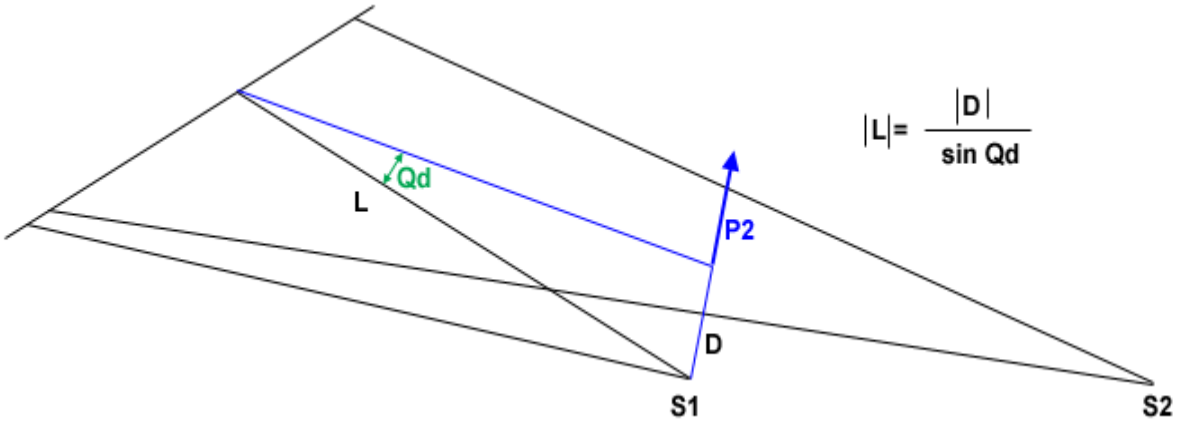
Pdc	f	deg	Dec trajectory pole	*1
GPlng	f	deg	longitude of ground trajectory pole	
GPlat	f	deg	latitude of ground trajectory pole	
ra1	f	deg	Ra of start point	
dc1	f	deg	Dec of start point	
az1	f	deg	Az of start point	
ev1	f	deg	Ev of start point	
lng1	f	deg	longitude of start point	
lat1	f	deg	latitude of start point	
H1	f	km	height of start point	
LD1	f	km	distance between start points and station	
Qr1	f	deg	angle between start point and radiant point	
Qd1	f	deg	angle between start point-station line and its projected line onto the observed trajectory plane of second station	*2
ra2	f	deg	Ra of end point	
dc2	f	deg	Dec of end point	
az2	f	deg	Az of end point	
ev2	f	deg	Ev of end point	
lng2	f	deg	longitude of end point	
lat2	f	deg	latitude of end point	
H2	f	km	height of end point	
LD2	f	km	distance between end point and station	
Qr2	f	deg	angle between end point and radiant point	
Qd2	f	deg	angle between end point-station line and its projected line onto the observed trajectory plane of second station	*2
LD21	f	km	observed trajectory length	
az1r	f	deg	Az of radiant point from start point	
ev1r	f	deg	Ev of radiant point from start point (entry angle)	
evro	f	deg	observed radiant elevation angle	
evrt	f	deg	modified radiant elevation angle	
Nts	d	sample	total samples in duration time	
Nos	d	sample	detected object samples	
leap	f	%	(Nts - Nos)/Nts*100.0	
rstar	d	star	number of reference stars in analyzing	
ddeg	f	deg	average positioning error in analyzing	
cdeg	f	deg	average linearity error in analyzing	
drop	d	0/1	whether drop frame detected	
inout	d	0/1/2/3	position of start and end point 0: both points are out of the field of view	

			1: only start point is in the field of view 2: only end point is in the field of view 3: both points are in the field of view	
tme	f	sec	possible time error	
dt	f	sec	time difference between 2 stations	
GD	f	km	ground distance between 2 stations	*1
Qc	f	deg	cross angle of two observed plane	*1
dGP	f	deg	difference of 2 pole of ground trajectory	
Gm%	f	%	overlap percentage of 2 observed trajectory	
dv12%	f	%	difference of 2 velocity	
zmv	f	deg	distance between modified radiant point and observed radiant point	
Ed	f	deg	quality assessment of radiant position	
Ex	f	deg	quality assessment of trajectory positioning	
QA	f	-	total quality assessment	
Y_ut	d	year	observed year (UT)	V2.02 or later
M_ut	d	month	observed month (UT)	V2.02 or later
D_ut	d	day	observed day (UT)	V2.02 or later
h_ut	d	hour	observed hour (UT)	V2.02 or later
m_ut	d	minute	observed minute	V2.02 or later
s_ut	f	second	observed second	V2.02 or later
No	d	-	simultaneous observation count	V2.10 or later
Qp	f	deg	correction angle of trajectory pole by radiant unification.	V2.10 or later *3

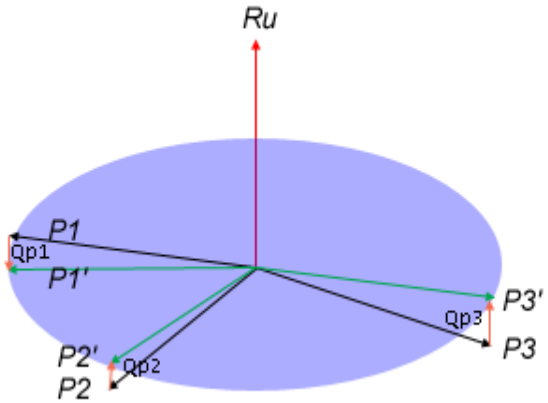
*1 : Relation between radiant R, observed plane , trajectory pole P1.P2, cross angle Qc



*2 : Relation between observed plane, trajectory pole P2, cross angle Qd and line distance L



*3: Radiant unification and pole correction on “unified radiant” mode



$$unit\ vector of\ pole\ direction: Pi = (\lambda_i, \mu_i, \nu_i)$$

$$unit\ vector of\ unified\ radiant\ direction: Ru = (\lambda_r, \mu_r, \nu_r)$$

$$TotalError: E = \sum_i (\lambda_i\lambda_r + \mu_i\mu_r + \nu_i\nu_r)^2$$

$$\frac{dE}{d\lambda_r} = \sum_i \lambda_i^2 + 2\nu_r \sum_i \nu_i\lambda_i + 2\mu_r \sum_i \lambda_i\mu_i = 0$$

$$\frac{dE}{d\mu_r} = \sum_i \mu_i^2 + 2\lambda_r \sum_i \lambda_i\mu_i + 2\nu_r \sum_i \mu_i\nu_i = 0$$

$$\frac{dE}{d\nu_r} = \sum_i \nu_i^2 + 2\mu_r \sum_i \mu_i\nu_i + 2\lambda_r \sum_i \nu_i\lambda_i = 0$$

5.2 Limitation

- UFOOrbitV2 has quantity limit as below.
  - ID : less than 1000
  - total records to be read : less than 400000
- In M*.csv, classified group name beginning with the letter “_” is not read into.
- In M*.csv, dur less than 0.01 second is not read into.
- The record unmatched relation between equatorial coordinate and horizontal coordinate seems to be error and is ignored.
- If there are 2 or more records that have the same localtime, ID, ra1, either one is used and the other is discarded.
- Date earlier than 1970 will cause troubles.

5.3 External data inport

- External data must be comma-delimited (CSV) format that has record version R90 or R80.
- Put R90 or R80 format CSV file in input directory to read as well as M.CSV, you can find simultaneous meteor and calculate its orbit.
- In external data, the longitude , latitude and altitude of observing station must be as accurate as possible.

[R90 format]

- If Ra, Dec of observed meteor is unknown, it calculates Ra, Dec from longitude, latitude of observation location and observed Az, Alt of meteor.
- If Az, Alt of observed meteor is unknown, it calculates Az, Alt from longitude, latitude of observation location and observed Ra, Dec of meteor
- Shown below as sample of R90 format.
  - complete format -> R90-1.csv
  - if Ra and Dec is unknown -> R90-2.csv
  - if Az and Alt is unknown -> R90-3.csv
- Shown below as explanation of record
  - Ver: R90 fixed.
  - Y M D h m s: meteor detected time (**local time**).
  - Mag: magnitude. (this is optional. set 0 if unknown.)
  - Dur: duration time (second) --- it is used to calculate angular velocity. Set as accurate as possible, or 0 if unknown.
  - Az1: Az of start point (degree) that measured from the south toward the west. (**0 for south**, 90 for west, 180 for north, 270 for east) --- If Az, Alt is unknown, set Az1, Alt1, Az2, Alt2 to all 999.9.
  - Alt1: Alt of start point (degree).
  - Az2: Az of end point (degree) that measured from the south toward the west. (**0 for south**, 90 for west, 180 for north, 270 for east)
  - Alt2: Alt of end point (degree).
  - Ra1: Ra of start point (degree) --- If Ra, Dec is unknown, set Ra1, Dec1, Ra2, Dec2 to all 999.9.
  - Dec1: Dec of start point (degree).
  - Ra2: Ra of end point (degree).
  - Dec2: Dec of end point (degree).
  - ID: location ID (up to 16 alpha-numeric characters).
  - Long: longitude of observation location (degree). (plus for east hemisphere, minus for west hemisphere)
  - Lat: latitude of observation location (degree). (plus for north hemisphere, minus for south hemisphere)
  - Alt: height above sea level of observation location (meter).
  - TZ: time zone of observation location (hour). (0 for GMT, 9 for Japan)

[R80 format]

- R80 format is the format which is almost equivalent to MCSV of UFOAnalyzer. It holds the direction of observation plane pole, and error values.
- R80 format can be generated by INF2MCSV. About INF2MCSV, please refer SonotaCo.com.
- Sample of R80 format file
  - R80sample.csv
- Record format of R80
-

name	type	unit	explanation	remark

Ver	a8	-	“R80” fixed string	
SystemID	a16	-	string that identify the camera	
EventName	a20	-	string that identify the event	
samples	d	-	count of frames or fields of the meteor	
Dur	f	second	duration of the meteor	
Mag	f	-	observed magnitude	
Y	d	year	event start time(UT)	
M	d	month		
D	d	day		
H	d	hour		
M	d	minute		
S	f	second		
Az1	f	deg	direction of start point that measured from the south toward the west. (**0 for south**, 90 for west, 180 for north, 270 for east)	
Ev1	f	deg	elevation angle of start point that measured from the ground toward zenith	
Ra1	f	deg	Ra of start point	
Dc1	f	deg	Dec of start point	
Ra2	f	deg	Ra of end point	
Dc2	f	deg	Dec of end point	
PoleRa	f	deg	Ra of pole direction of observed plane	
PoleDc	f	deg	Dec of pole direction of observed plane	
longitude	f	deg	longitude of the station (-180.0 ～180.0 , east plus, west minus)	
latitude	f	deg	latitude of the station (-90.0 ～ 90.0, north plus, south minus)	
altitude	f	m	altitude of the station	
rate	f	Hz	sampling frequency of the system (25.0 for PAL frame processing system, 59.97 for NTSC de-interlacing system)	
inout	d	-	position of start and end point 0: both points are out of the field of view 1: only start point is in the field of view 2: only end point is in the field of view 3: both points are in the field of view	
posErr	f	deg	average error of direction	
lineErr	f	deg	average error of linearity	
refstars	d	-	number of fixed stars that were used for the determination of direction	
magErr	f	-	average error of observed magnitude	
timeErr	f	second	possible maximum time error	

6. Cautions

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You can use it free for personal use. You should not redistribute it.
About figures that UFOOrbit output, you can use it free for non commercial educational or academic usage.
Please contact SonotaCo for other usage.
UFOOrbitV2 package contains data that based on the third party's. Please pay attention to handling.

- Star catalog data : Star catalog data for UFO series, which contains brighter than 6th magnitude, are modified from the following.
  - SKY2000 Star Catalog http://tdc-www.harvard.edu/catalogs/sky2k.html
- Map data : Map data for UFO series are modified from the following.
  - SRTM30 based on the observation of NASA space shuttle ladder.
- Radiant point information : Radiant point information is based on the following information and the observation of SonotaCo Network after 2004.
  - International Meteor Organization http://www.imo.net/
  - http://www.metrec.org/imc06.pdf by Sirko Molau
  - The Nippon Meteor Society http://www.nms.gr.jp/

7. Acknowledgments

Originally, UFOOrbit is made to handle the observation results by the member of SonotaCo Network Japan. UFOOrbit might not exist without the effort of all members who has observed meteors every night for many years and has opened their results.
Algorithms that are used in UFOOrbit are mostly based on the document below.
"Tentai Kidou Ron (Determination of Orbits)" by Ichiro Hasegawa, Koseisya Koseikaku 1983 (ISBN 4-7699-0572-6 C 3044)
This English manual is originally translated by Toshhiro Masuzawa.
I appeal best thanks to the people who concern this product.

9/Feb/2008
SonotaCo