Notes on analyses of FriOWL and CLAUS weather database

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ABSTRTACT

Using FriOWL and CLAUS weather database, China mainland is investigated to search for areas with good astronomical conditions. Five sites (Karsu, Oma, Hami, Xinglong, and Yunnan) are studied and compared; Oma area is relatively better in Tibet where diurnal variations of weather conditions should be investigated. Karasu shows not so good conditions. An area around Hami shows possibility for astronomical observations in China.

1. What are FriOWL database and CLAUS database

FriOWL is a tool dedicated to tracking climatic trends and has been developed for ESO by the Department of Geogra-phy of the University of Fribourg, Switzerland (Graham et al. 2005). FriOWL (current version 2.1, *http://archive.eso.org/friowl*) is a geographical information system with a spatial resolution of 2.5 degrees (ca. 300 km), It is composed of many different climatic layers containing a minimum of 15 years of data stored as monthly averages (see table 1). FriOWL is created using Reanalyses data which come from two main centres, namely the joint National Centers for Environmental Prediction/National Center for Atmospheric Research in the USA (NCEP/NCAR) and the European Reanalysis products from the European Centre for Medium Range Weather Forecasting (ERA). Additional data, such as Out-going Longwave Radiation (OLR) from NOAA, and the Aerosol Index from the Total Ozone Mapping Spectrometer (TOMS) satellite, are also included in the FriOWL database.

Table 1. FriOWL weather data availability

Topography	-	meters
Outgoing Longwave Radiation (OLR)	1974 - 2001	Watt/m^2
2m Air Temperature	1948 - 2001	K deg
Precipitable Water Vapor (Surface)	1948 - 2002	Kg/m^2 (= mm depth)
Total Cloud Cover	1979 - 1993	Fraction
Surface Wind direction	1979 - 1993	days/month (8 directions)
Surface Wind Velocity	1979 - 1993	m/sec (8 directions)
850hPa Wind Direction	1979 - 1993	days/month (8 directions)
850 hPa Wind Velocity	1979 - 1993	m/sec (8 directions)
200 hPa Wind Direction	1979 - 1993	days/month (8 directions)
200 hPa Wind Speed	1979 - 1993	m/sec (8 directions)
Surface Average Wind Speed	1979 - 1993	m/sec
200 hPa Average Wind Speed	1979 - 1993	m/sec
850 hPa Average Wind Speed	1979 - 1993	m/sec
Aerosol	1980 - 2002	Areosol index[1] x 10

A FriOWL user guide is available on the Web[2]. For use of FriOWL, a permission to access FriOWL is necessary by

[1] dimensionless real number, dependent on the optical depth or transmissivity of the atmosphere. An aerosol index of 4.0 would mean that sun is completely obscured by haze.

sending a request to FriOWL administrator using Contact-Us web page.

Figure 1. FriOWL web page for login.

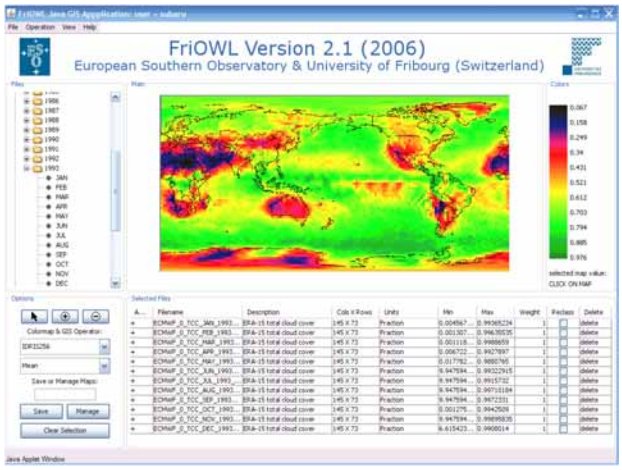

Figure 2. FriOWL retrieval windows.

CLAUS is Cloud Archive User Service Data, serviced by The British Atmospheric Data Centre (BADC) to produce a long time-series of global thermal infrared window (10.5-12.5 μm; Satellite channel 2) imagery of the Earth. The CLAUS archive is produced from channel 2 which is processed to create a uniform latitude-longitude gridded dataset (or image) of Brightness Temperature (TB) values at spatial resolutions of one-half degree (the original resolution) and one-third degree (recently released) and temporal resolution of three hours. The CLAUS archive currently spans the period Jan1985 to June 2005 for high-resolution data and Jul 1983 to Dec 1994 for movie. At first when you access to CLAUS web page to get their data, you must ask *BADC support* to get permission for data access. Permission may be easily obtained for researchers worldwide.

2. Analysis with FriOWL database

2.1 Cloudiness comparison among several sites in China

Cloudiness at five sites in China is investigated using total cloud cover on FriOWL database (Figure 3). Investigated sites and their results are shown briefly in Table 2. For each sites, cloudiness at surrounding areas are compared to find a relatively good area among them.

As shown in Figure 4 and monthly cloudiness distributions attached in appendices, Karasu area shows relatively cloudy through year, especially in summer. As clear sky is one of the most important factors to select astronomical sites, Karasu area may be abandoned for more astronomical site survey after finishing currently-progressing measurements with microthermal sensors and cloud monitor camera in a year.

Oma area shows a relatively good site in Tibet, but cloudiness in summer is too bad. Cloud map movies on CLAUS database, described in section 3, show diurnal variations in Tibet is so strong. Sasaki (2004) showed that Oma area is better at night using original NOAA weather data, which hourly data are available every 3 hour, on the other hand hourly data are averaged on FriOWL database. It should be investigated on weather conditions at night at Oma with continuous observations day and night through year.

On the base of less cloudiness, Hami around longituide(L)=92, Latitude(b)=45 appears having better conditions among those five sites. It must be noted that Hami is a little bit cloudy compared with Paranal, Chile where cloudiness is less than 20% through year, shown in Figure 4.

Monthly Cloudiness distributions at 5 sites are attached in Appendix A with CLAUS data for some sites.

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[2] http://archive.eso.org/friowl/documentation/users_guides/FriOWL_Version_2.1_User_Guide_c.pdf

Table 2. Cloudiness comparison among five sites in China using FriOWL database on total cloud

Site	Longitude Latitude	Investigated areas	results
Karasu	L=74.8 b=38.2	L=72.0, 74.5, 77.0, 79.4 b=42.2, 39.7, 37.2, 34.8, 32.3	more cloudy (80%) in summer cloudy (50%) in winter
Oma	L=83.0 b=32.5	L=72.0, 74.5, 77.0, 79.5, 81.9, 84.4, 86.9 b=37.2, 34.8, 32.3, 29.8, 27.3	less cloudy (20%) in winter more cloudy (80%) in summer
Hami	L=92 b=45	L=86.9, 89.4, 91.9, 94.3, 96.8, 99.3, 101.8, b=47.2, 44.7, 42.2, 39.7 , 37.2	less cloudy (less than 30%) through year
Xinglong	L=117.6 b=40.4	L=109.2, 111,7, 114.2, 116.7, 119.2, 121.7 b=44.7, 42.2, 39.7, 37.2, 34.8	less cloudy (less than 30%) in winter cloudy (50%) in summer
Yunnan	L=100.0 b=26.7	L=96.8, 99.3, 101.8, 104.3 b=29.8, 27.3, 24.8	less cloudy (30%-50%) in winter more cloudy (90%) in summer

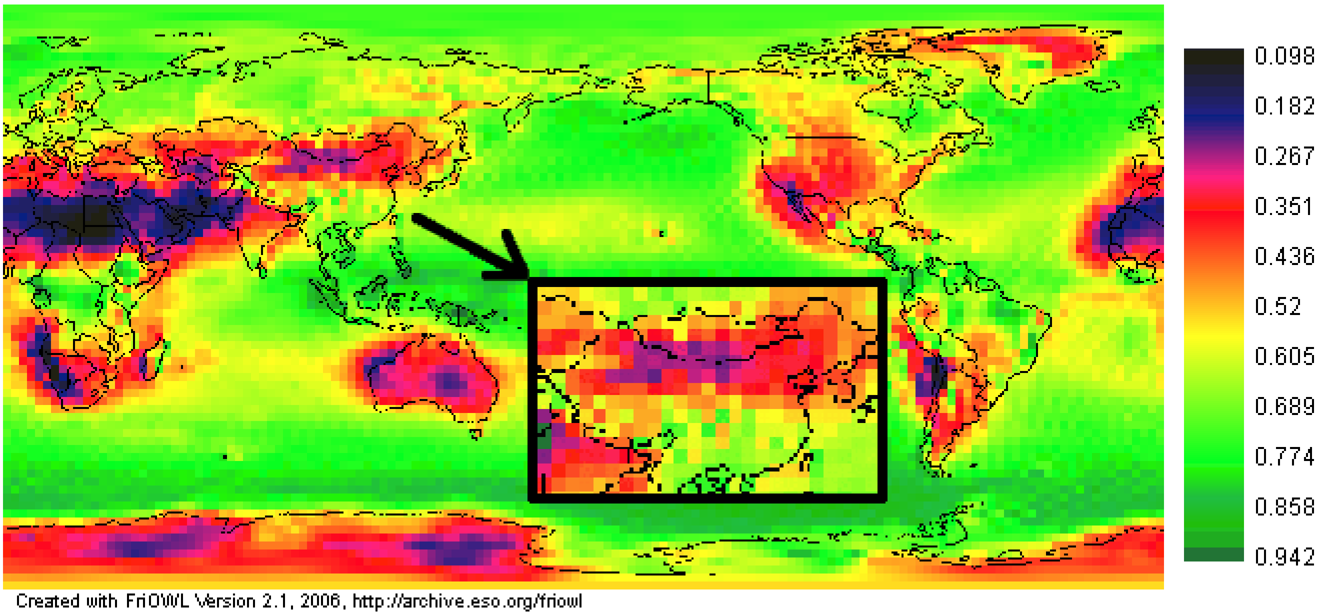

Figure 3. Total cloud cover map from FriOWL database, averaged through 1979 and 1993. In China, an area close to Hami shows less cloudy conditions except desert areas and an area around Oma shows relatively better conditions in Tibet.

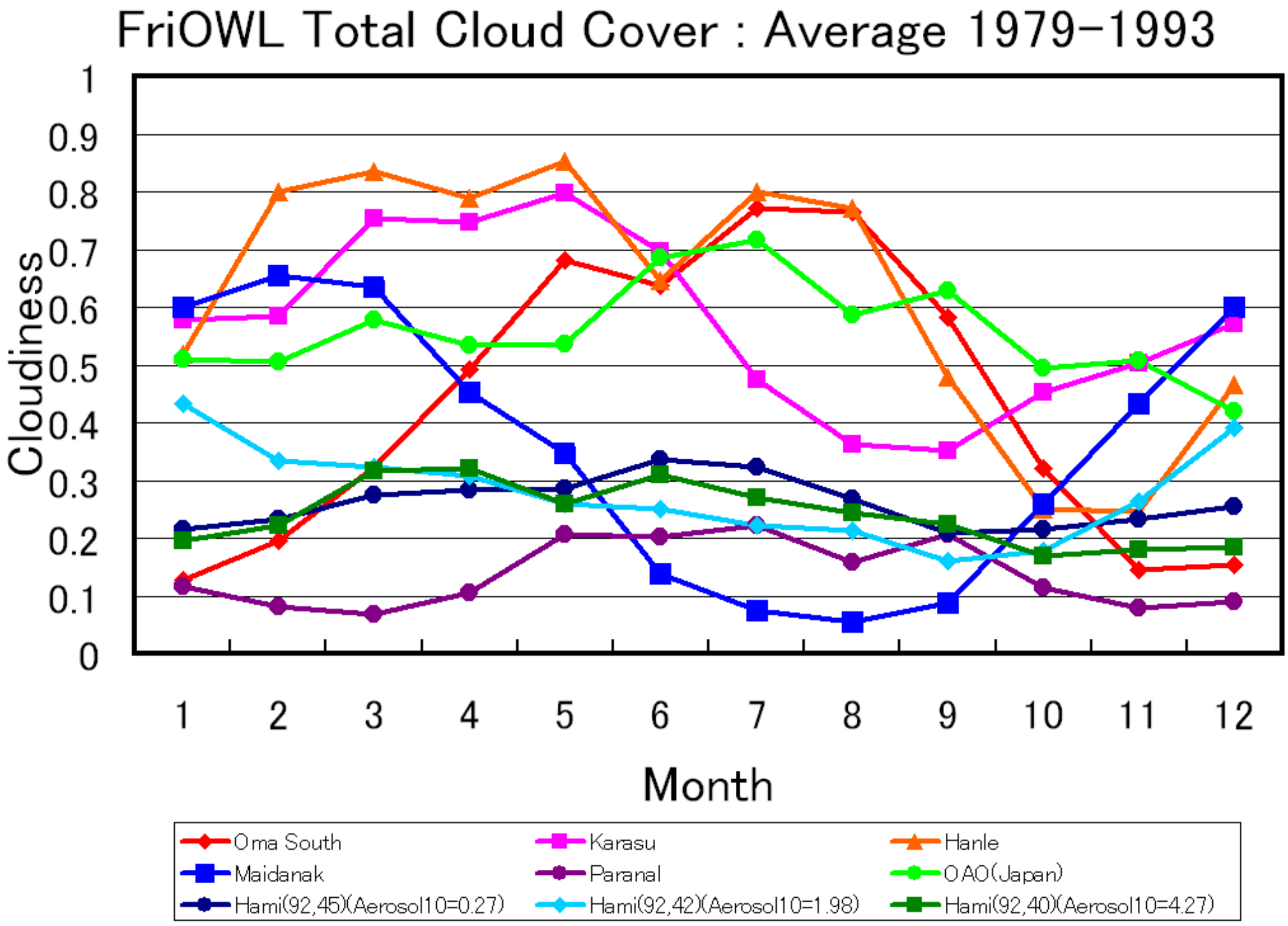

Figure 4. Comparison of cloudiness at several astronomical sites and candidates in China using FriOWL total cloud cover database. Combined with aerosol data, an area at L=92 and b=45 close to Hami may reveal a better site in China. Cloudiness data is an average of whole day through month. Note that diurnal variation manifests strongly at Oma in Tibet.

2.2. Aerosol and surface wind velocity

As expected from the fact that Hami area is close to desert, aerosol may affects much about astronomical observations. Hami area at L=92 and b=45 is aerosol level of maximum of 0.1 around April to June, other seasons lower levels are observed (Figure 5). Surface wind velocity around the area is less than 4 m/sec in summer and 2.5m/sec in winter, comparable to Paranal (Figure 6).

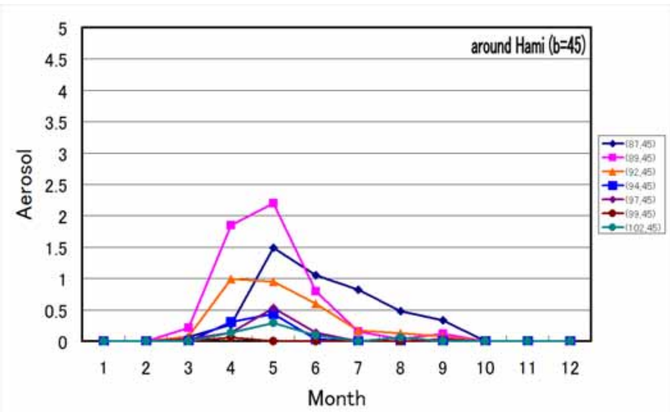

Figure 5. Aerosol around Hami area at b=45.

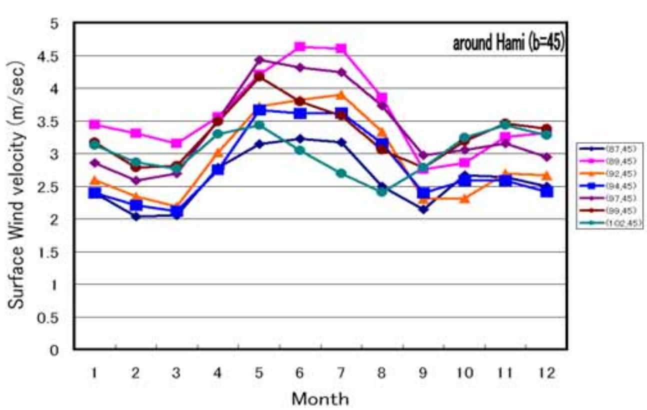

Figure 6. Surface Wind Velocity around Hami area at b=45.

2.3. What high latitude affects observability of astronomical objects

Observability is calculated by spherical trigonometry. An observable surface area is defined as

$$\Omega(\mathrm{sr}) = 2\pi(1 - \cos\theta)$$, where θ is a half of a viewing angle.

Then observability is defined as surface area devided by total surface area 4π、

$$\text{Observability} = \Omega(\mathrm{sr}) / 4\pi = (1 - \cos\theta) / 2.$$

At the site at latitude of 45 deg, a half of viewing angle of 135 yield observavility of 85% of total sky. If the lowest observable elevation of 10 or 15 deg above the horizon, θ of 125 or 120 , instead of 135, is used to get observability of 79% or 75%. The lowest declination can be -35 or -30 deg, respectively.

3. Cloud movie and high resolution cloud data available on CLAUS database

On CLAUS database, cloud movies are available in 1983 to 1994 (Figure 7). Cloud movies are useful to get a glance about cloudiness through a year.

High resolution (spatial resolution of 0.3°) data are also available in digital form on CLAUS database during 1985 to 2005. A part of cloud brightness data are extracted to investigate precisely about cloudiness distribution around particular sites. Cloud brightness distributions are compared through 1985 to 2005 using whole day data (0h, 3h, …, 21h) at Karasu, Oma, and Hami (Figures 8, 9, and 10; All data in Appendix A). Diurnal variations look as spikes in distribution maps of cloud brightness temperature as surface temperature can be observed under clear atmosphere. Existence of high-altitude low-temperature cloud over the site can be recognized as downward spikes in these maps. Upward spikes and downward ones are counted as cloudiness indicators in Table 3. Compared to FriOWL data (Figure 4), our estimates of cloudiness using CLAUS data look too coarse for Karasu and Hami. It is noted that Karasu is located near observation boundaries of satellites which may cause worse quality around Karasu on CLAUS database.

Table 3. Coarse estimates of Cloudiness (%) in 2000 to 2004 using CLASU high-resolution Brightness Temperature data

%	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
Karasu	40	65	47	47
Oma	40	60	63	25
Hami	42	59	52	42

As meteorological investigation (Fujinami & Yasunari 2001, Fujinami, et al. 2004, Fujinami, et al. 2005), diurnal variations over Tibetan plateau has been investigated regarding monsoon mechanism. Diurnal variations are observed strongly at Oma area in Tibet as noticed by watching the cloud movies of CLAUS. It is necessary to obtain exact cloudiness data by observing cloud at the site continuously day and night with the CloudMon (Sasaki et al. 2008).

High-altitude cirrus is usually easier to detect as its low temperature with satellite data. Clouds at low altitude above the ground are hard to detect as temperature diffrenece from ground is so small. It shows ground observations of cloudiness are crucial to characterize the site.

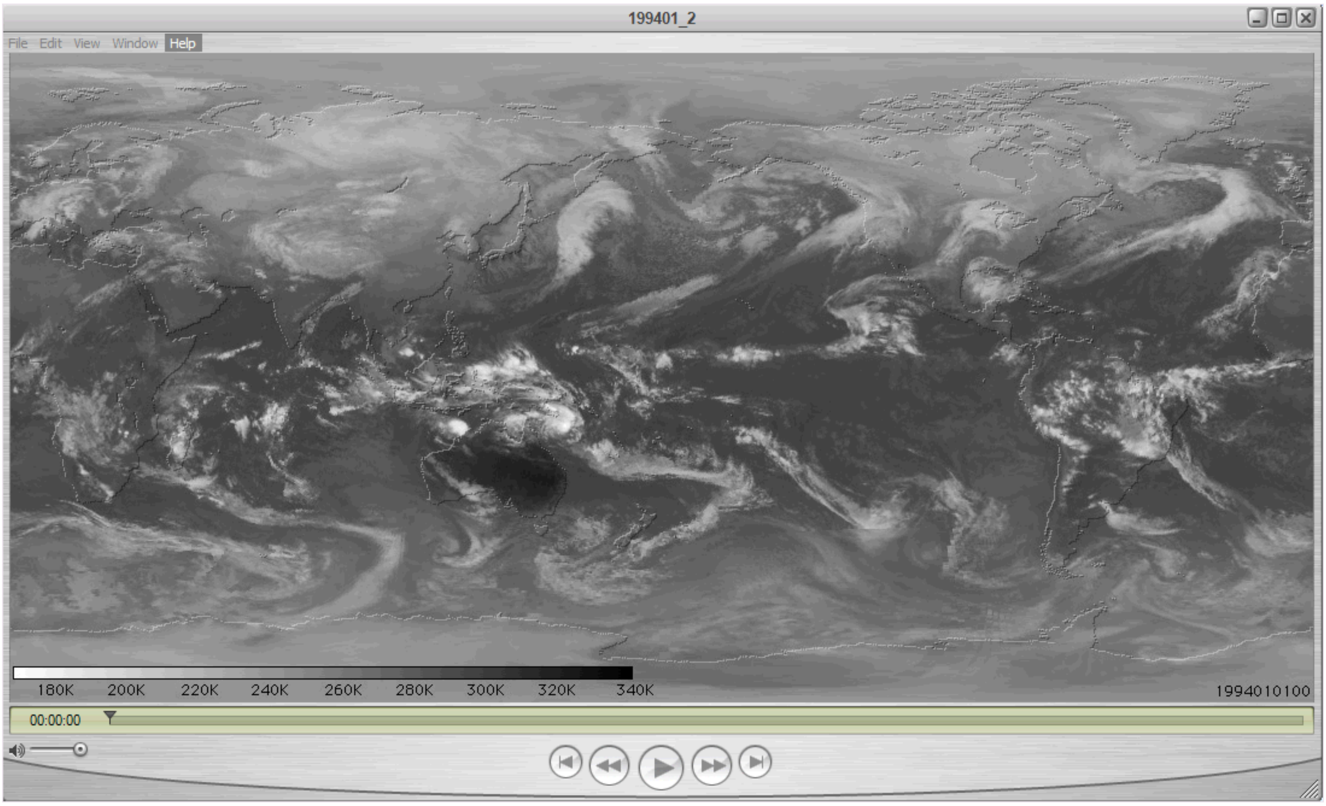

Figure 7. A snapshot of cloud map movie on Jan 2004 on CLAUS data base.

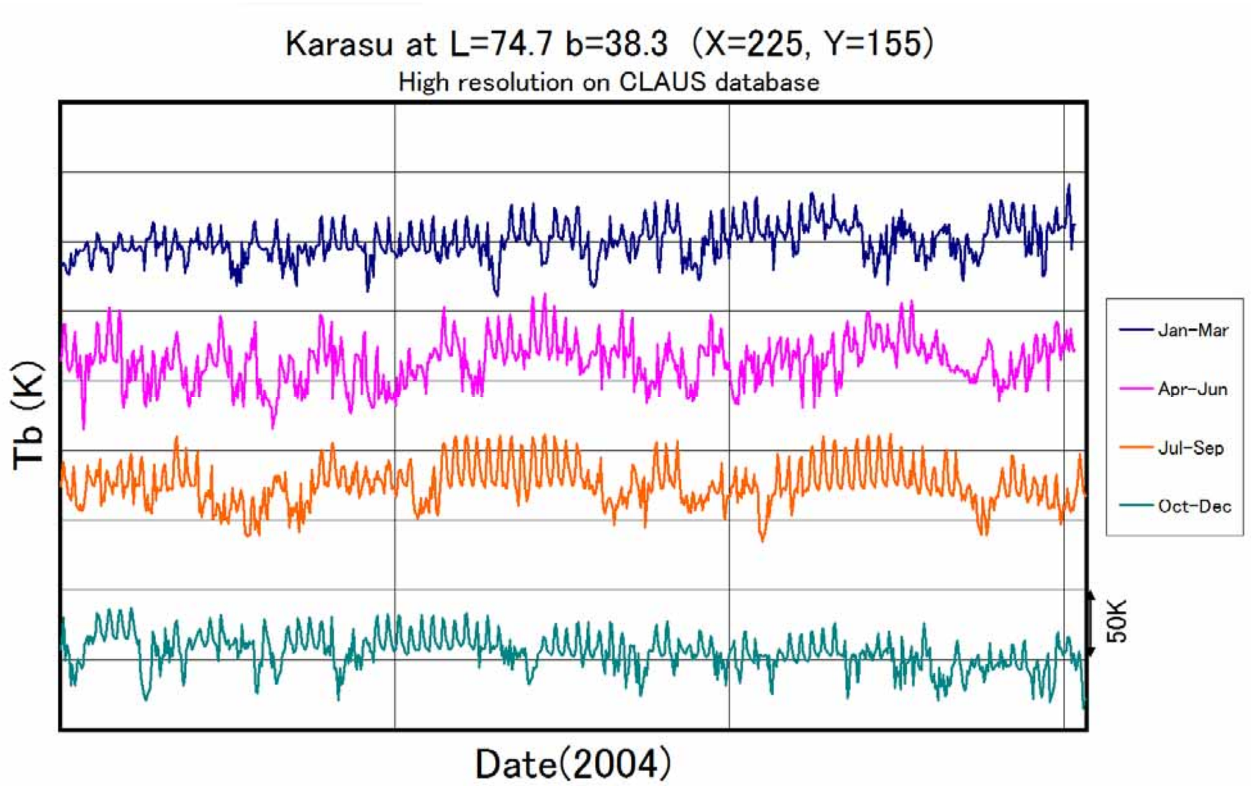

Figure 8. Cloud brightness Temperature at Karasu (L=74.7°, b=38.3°) in 2004 extracted from High resolution data on CLAUS database. Diurnal variations look as spikes as surface temperature can be observed under clear atmosphere. Downward spikes show existence of high-altitude low-temperature cloud over the site.

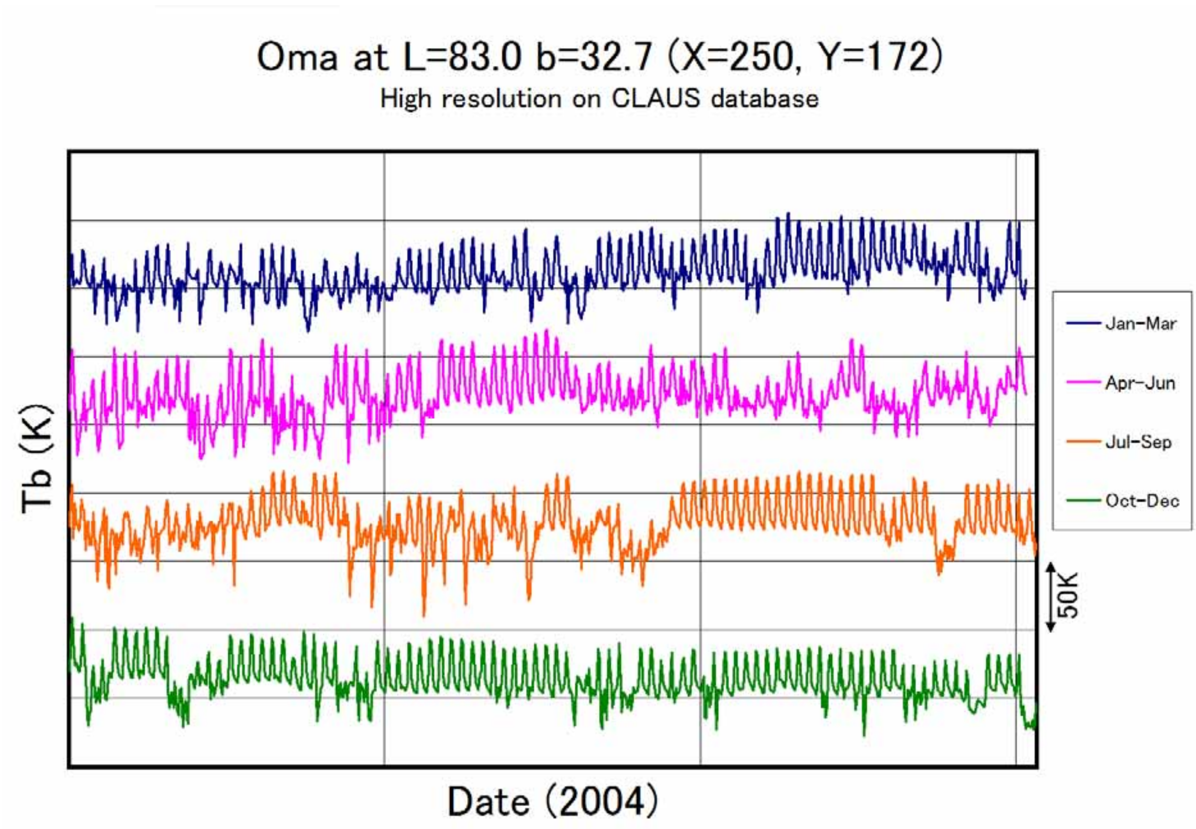

Figure 9. Cloud brightness Temperature at Oma (L=83.0°, b=32.7°) in 2004.

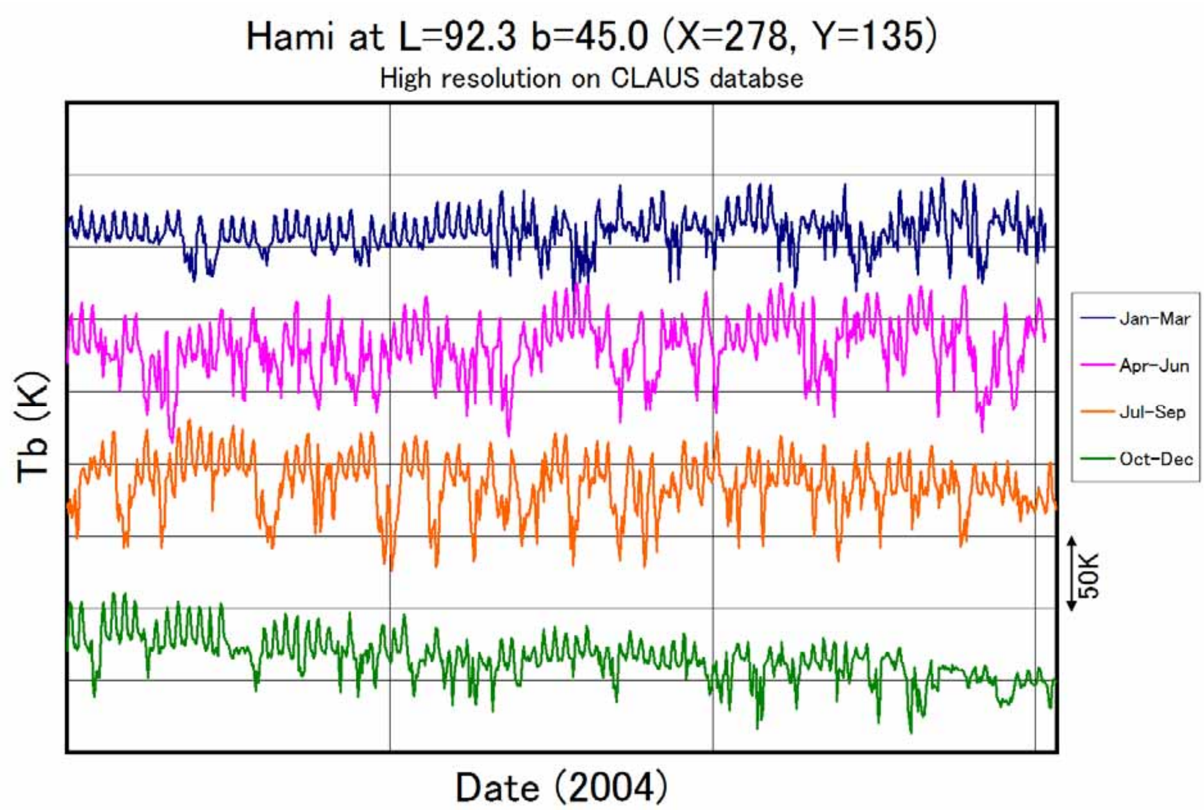

Figure 10. Cloud brightness Temperature at Hami (L=92.3°, b=45.0°) in 2004.

4. New candidate sites around Hami

After several trial to find a good site in China, Hami area around L=92 and b=45 may be an attractive site as new target for site survey in China. From GoogleEarth, small mountains with 2800m high are located surrounding flat, low Mongolian plateau about 700m – 1400m high (Fig.8 and Fig.9). Those locations are noted as Hami site#1 of L=92.3435, b=45.0132, 2893m high and Hami site#2 of L=92.3986, b=44.9596, 2809m high (shown in Appendix D).

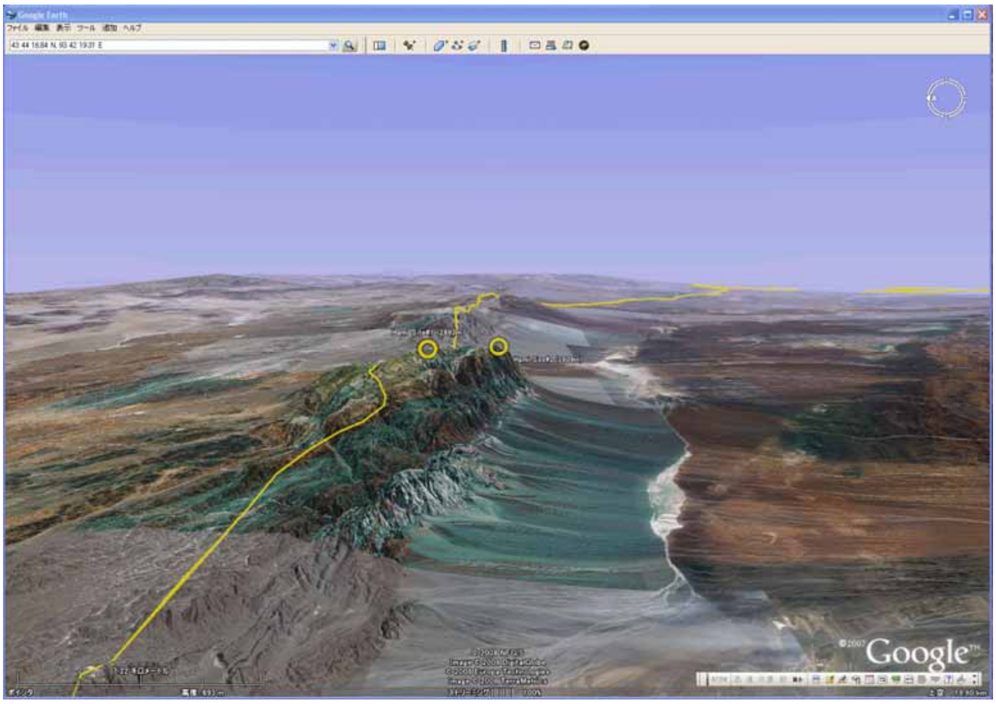

Figure 8. A possible candidate site around Hami (aerial view from west on Google). Yellow line is border to Mongolia. Two circles show mountains, steeply standing on flat plateau.

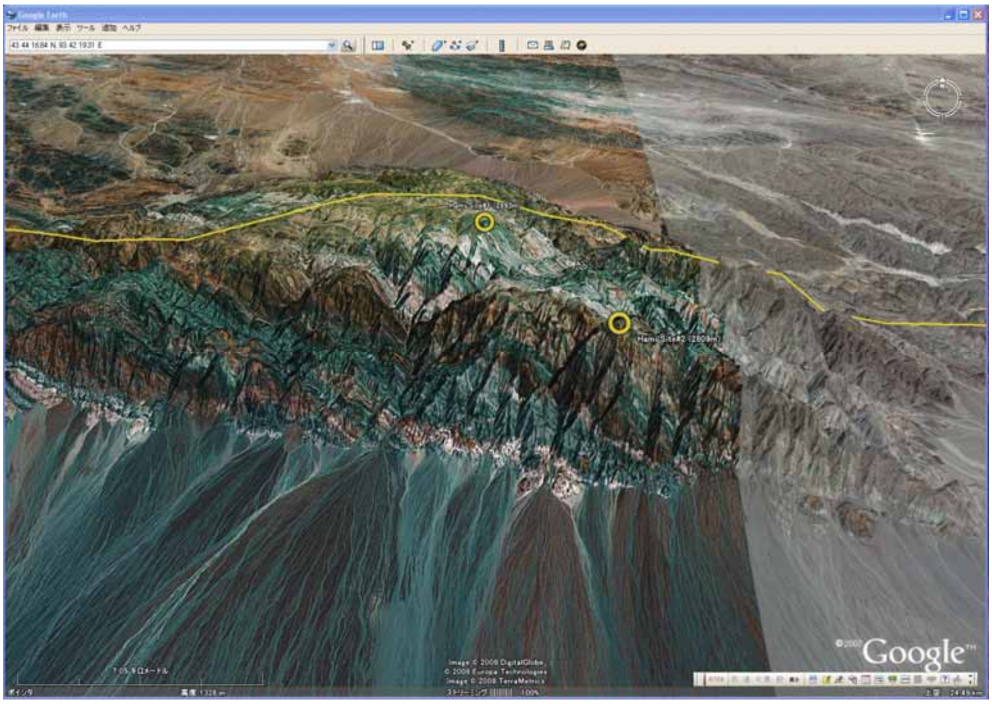

Figure 9. Another look of a possible candidate site around Hami (aerial view from south on Google). Yellow line is border to Mongolia. Two circles show mountains.

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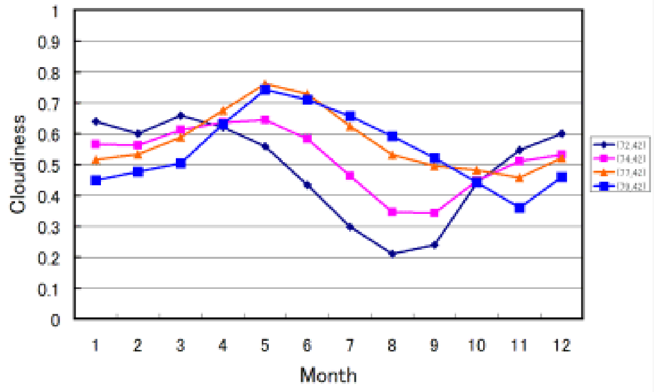
Appendes:

Apendix A: Cloud distribution of 5 astronomical sites/candidates in China

A-1: Cloudiness around Karasu from FriOWL database



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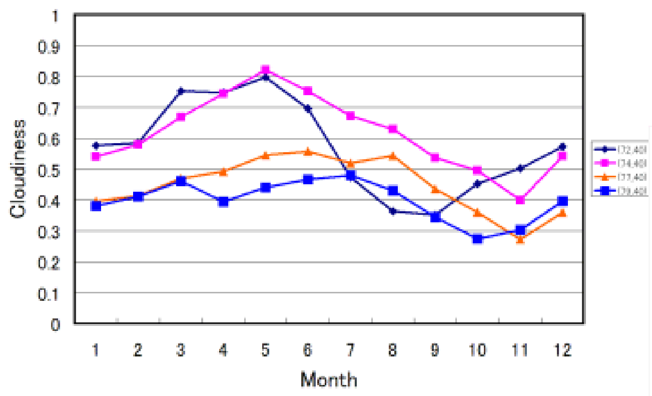

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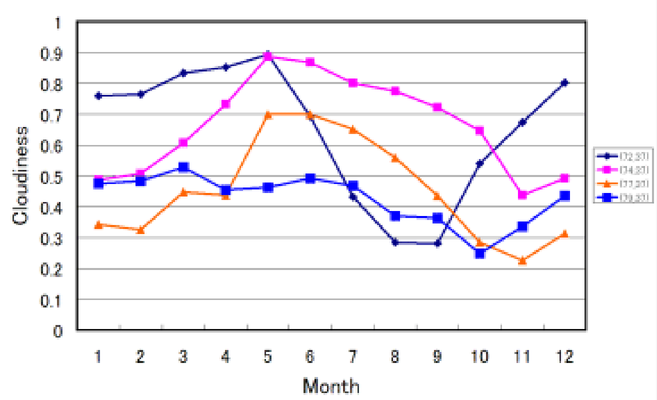
b=37.241377



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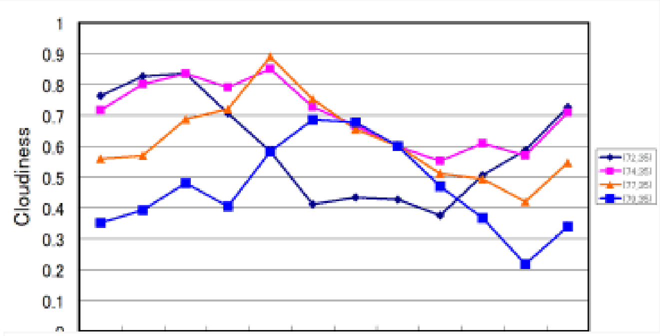
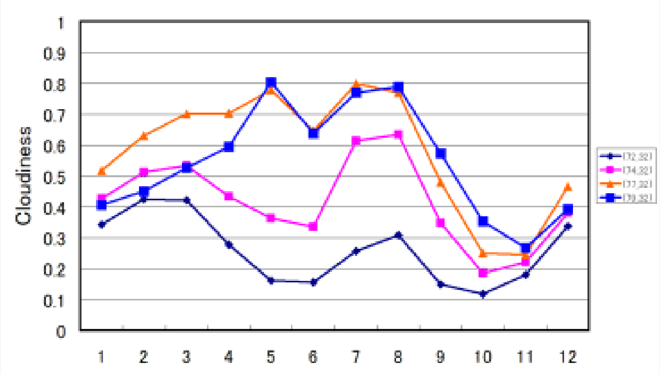


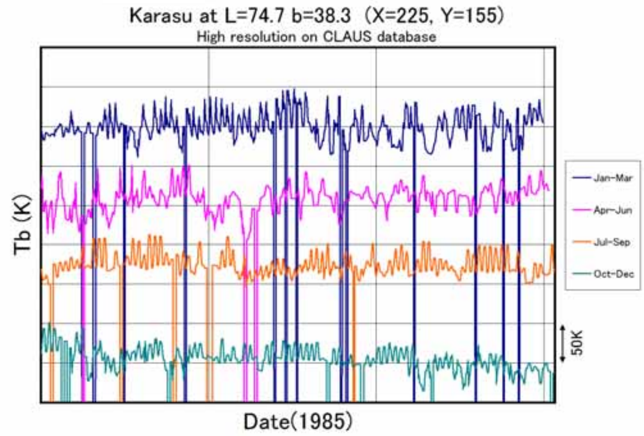
Karasu

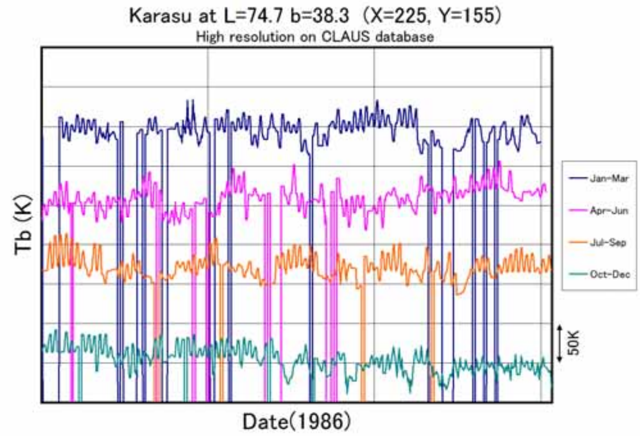
L= 71.999997
74.482755
76.965514
79.448272

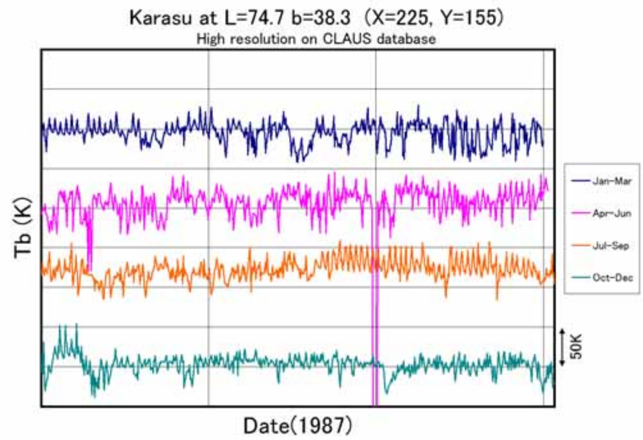
b=32.275861

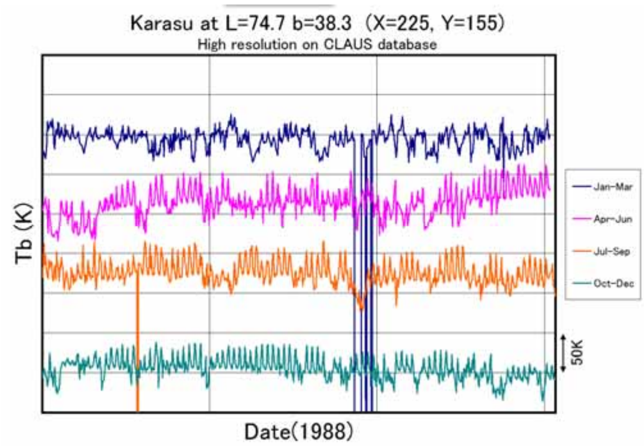


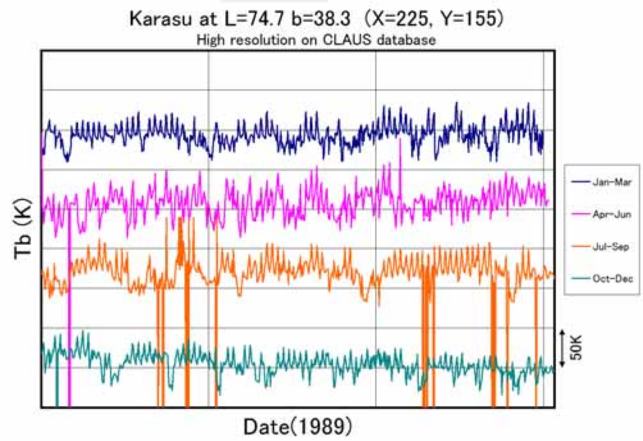
Data from CLAUS high-resolution (0.3°) data of cloud brightness temperature at Karasu

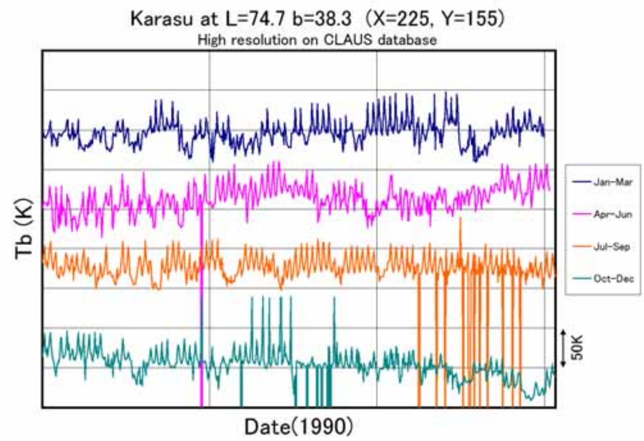


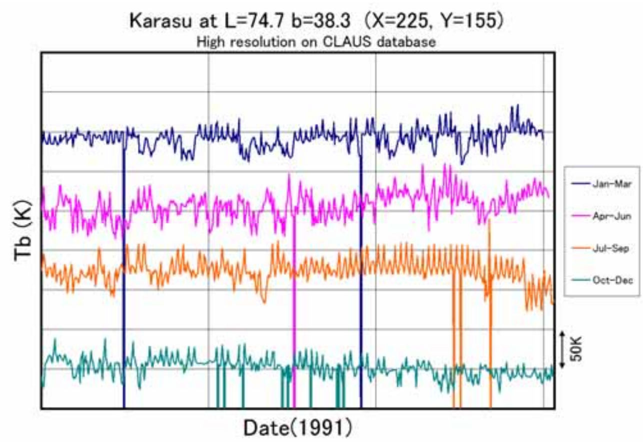


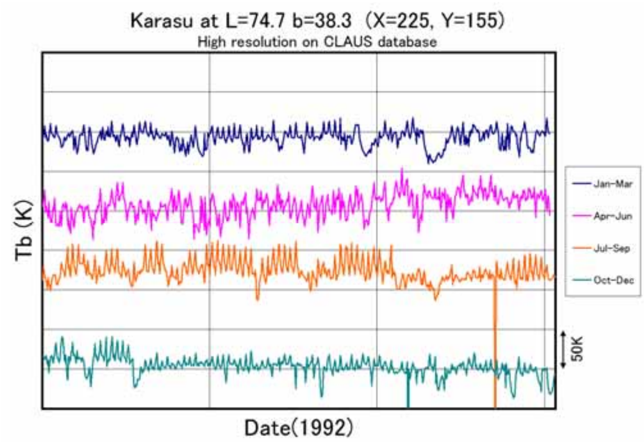


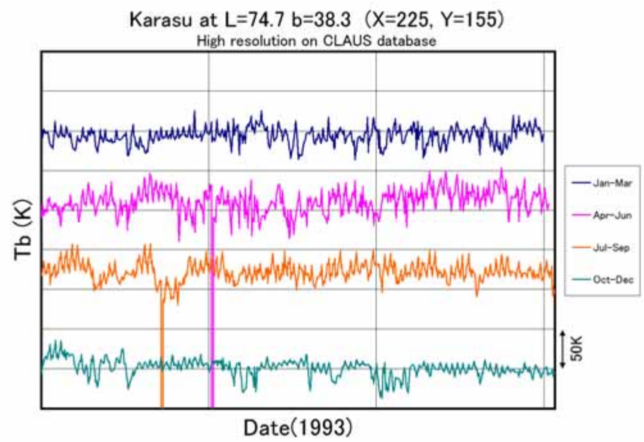


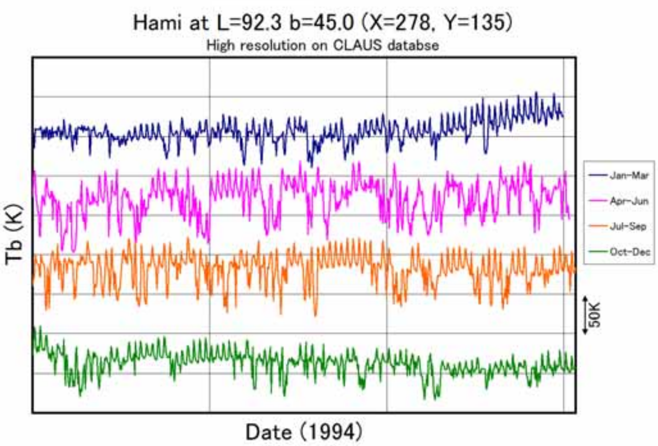









Karasu at L=74.7 b=38.3 (X=225, Y=155)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(1993)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Jan-Mar
Apr-Jun
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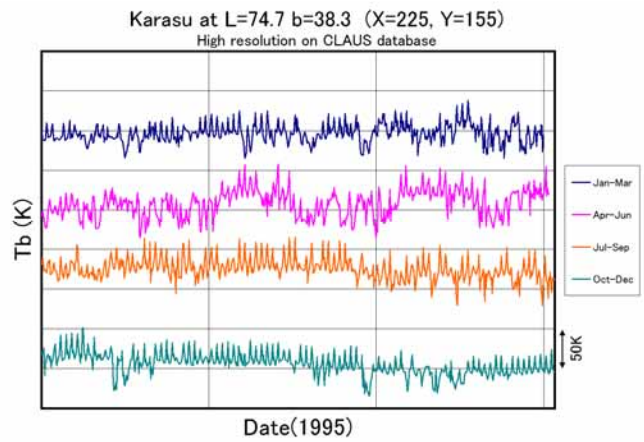
Oct-Dec
50K
Date (1994)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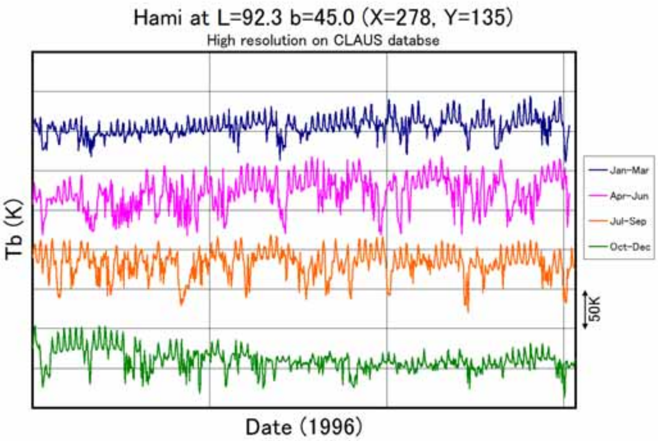
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(1995)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Oct-Dec
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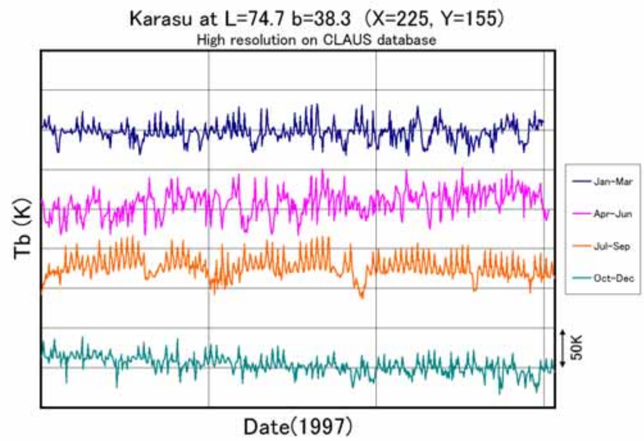
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Apr-Jun
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50K
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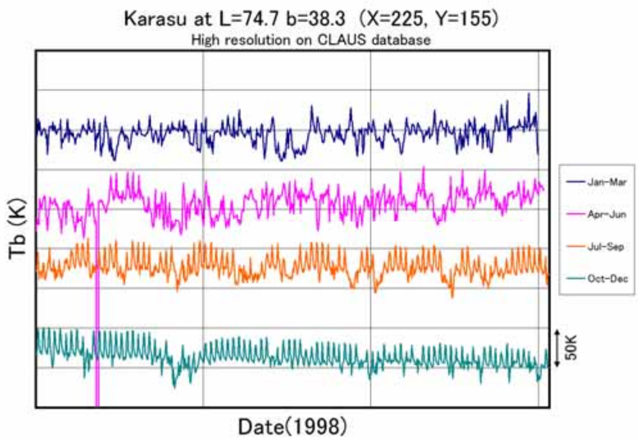
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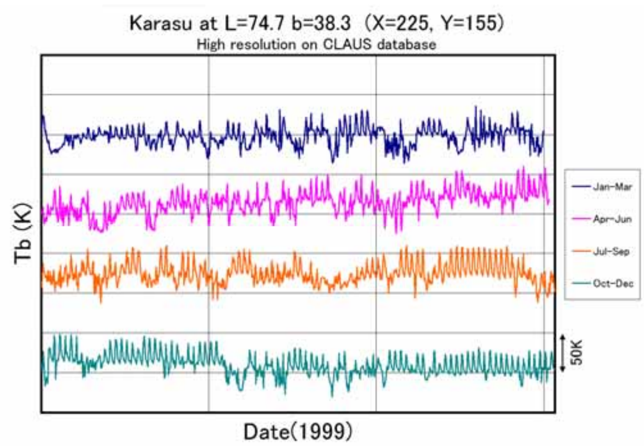
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High resolution on CLAUS database
Tb (K)
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Apr-Jun
Jul-Sep
Oct-Dec
50K
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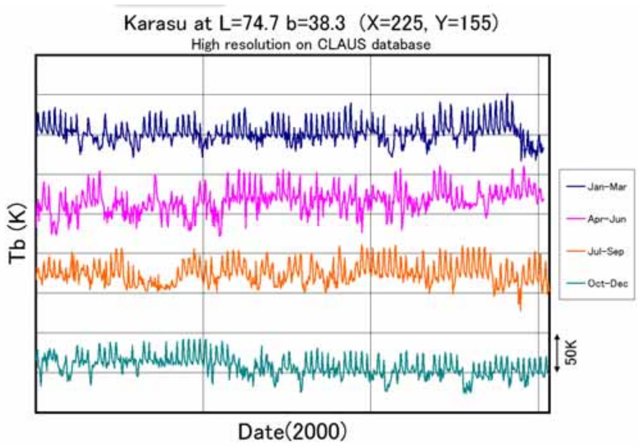
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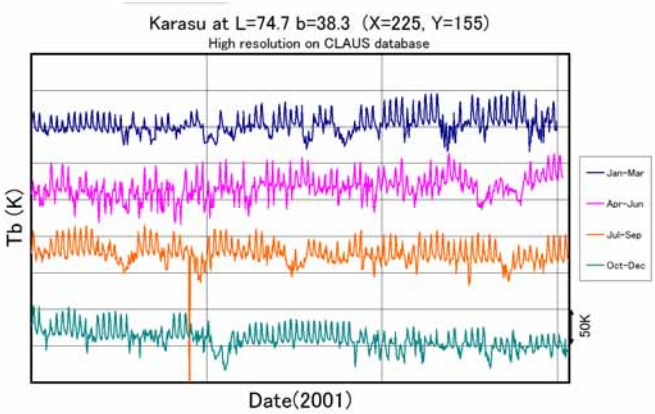
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(2000)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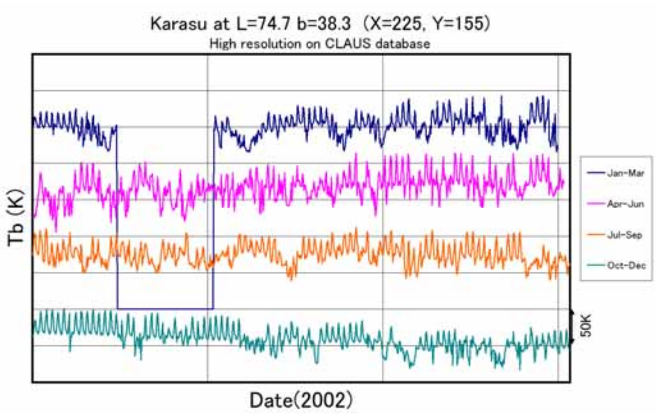
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(2001)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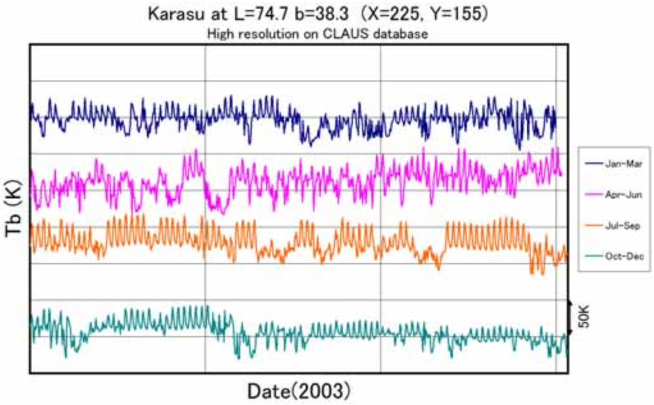
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(2002)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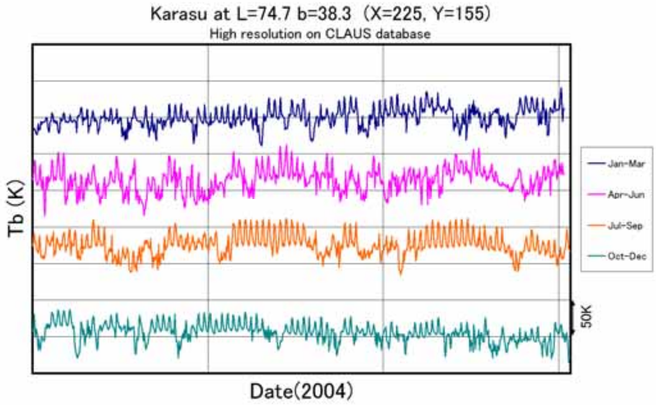
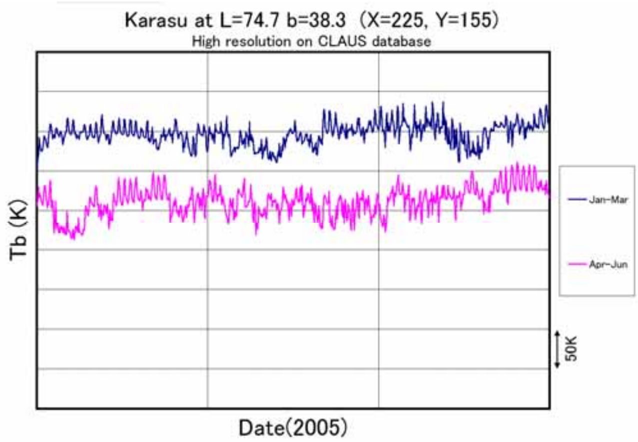
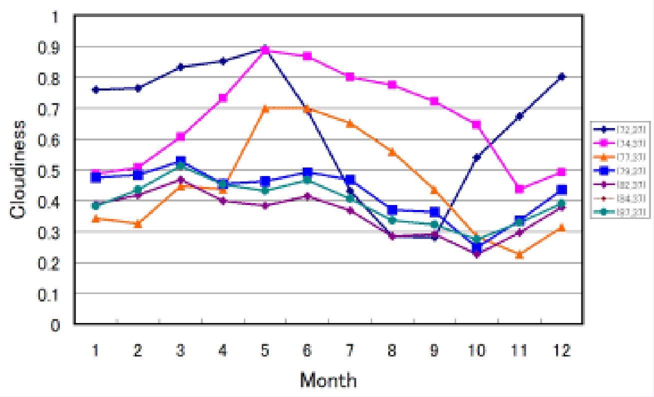
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(2003)


Karasu at L=74.7 b=38.3 (X=225, Y=155)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date(2004)

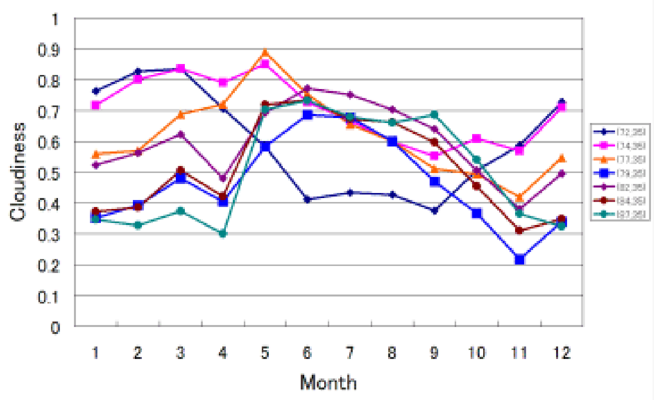

Karasu at L=74.7 b=38.3 (X=225, Y=155)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
50K
Date(2005)

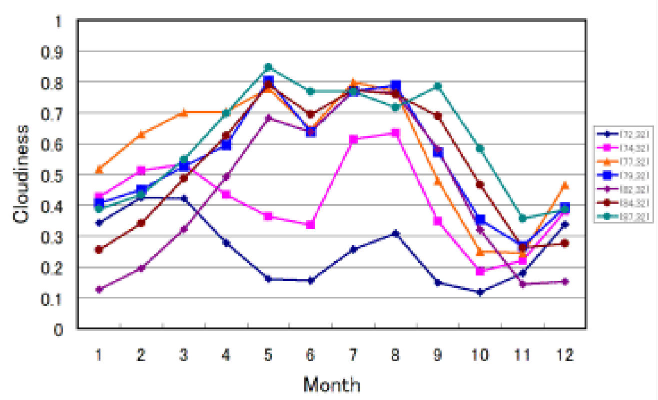
A-2: Cloudiness around Oma from FriOWL database



b=37.241377

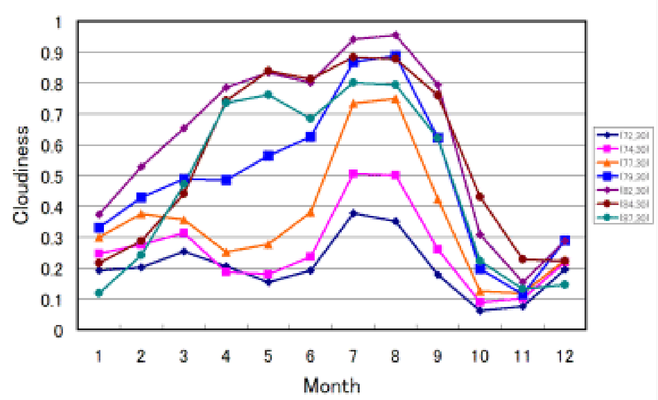
b=34.758619





b=32.275861

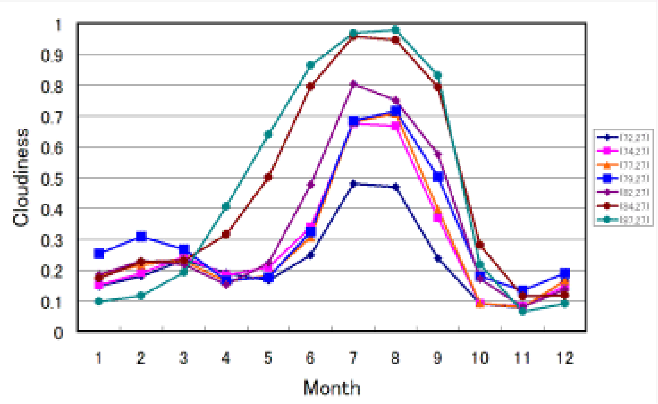
b=29.793102



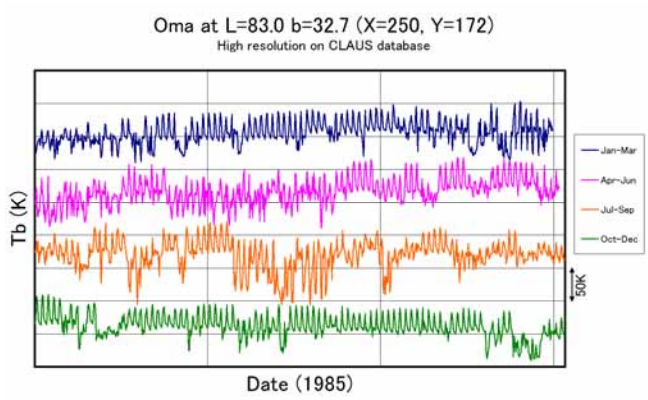
Oma

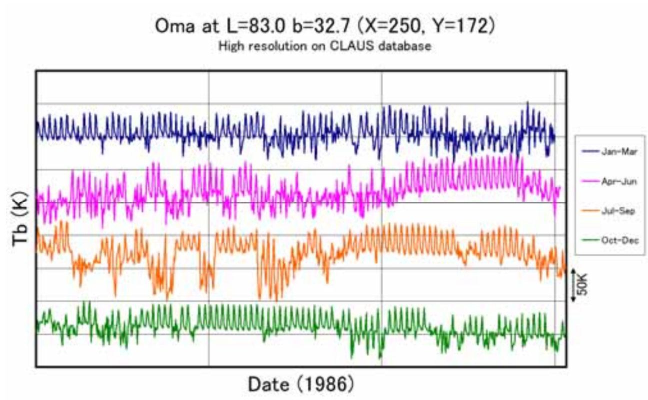
L= 71.999997
74.482755
76.965514
79.448272
81.931031
84.413789
86.896547

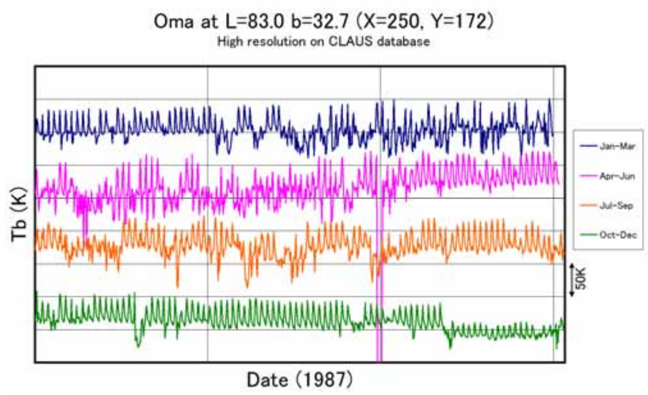
b=27.310343

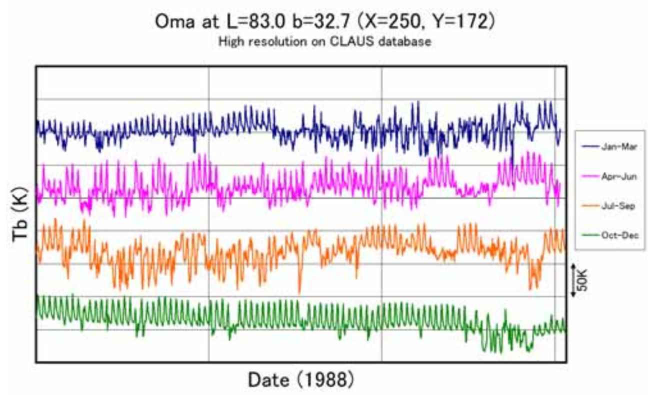


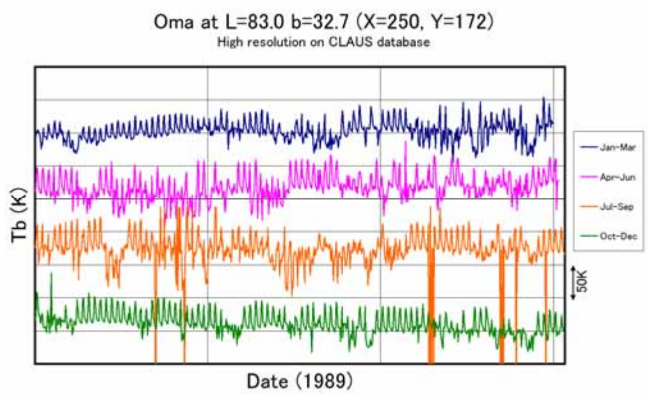
Data from CLAUS high-resolution (0.3°) data of cloud brightness temperature at Oma

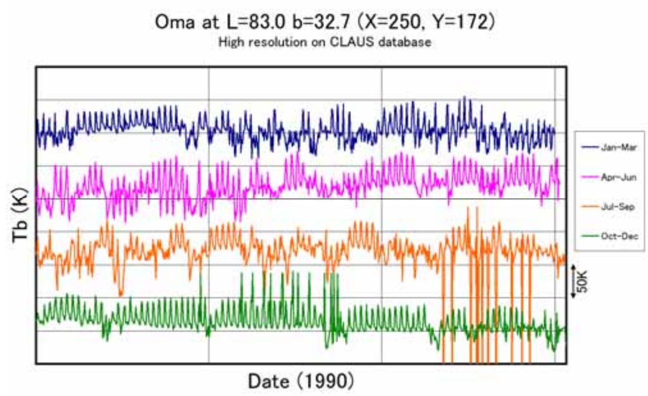


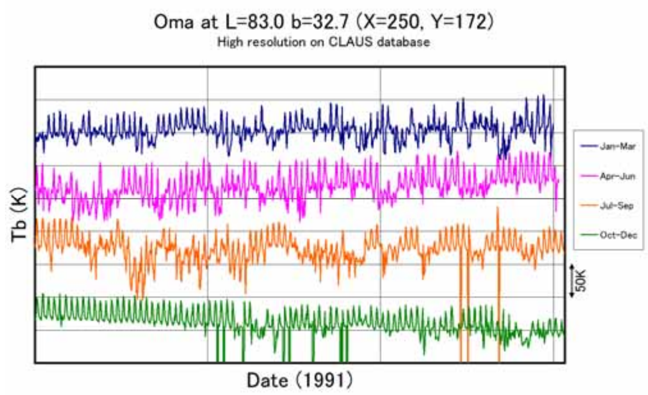


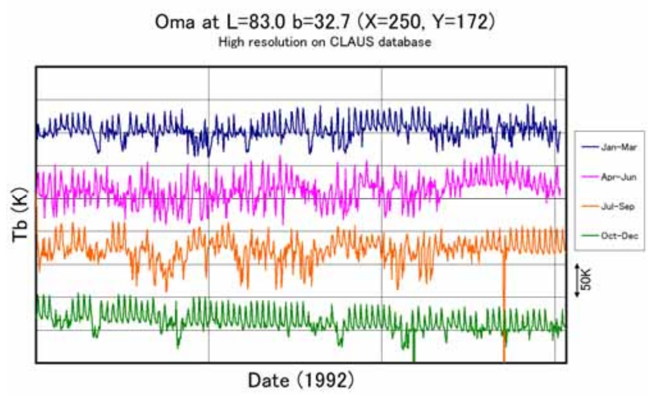


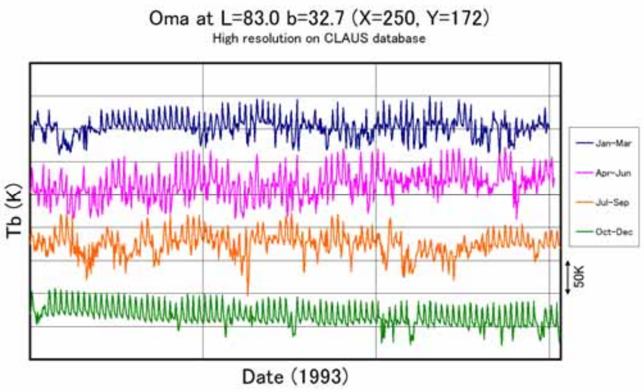


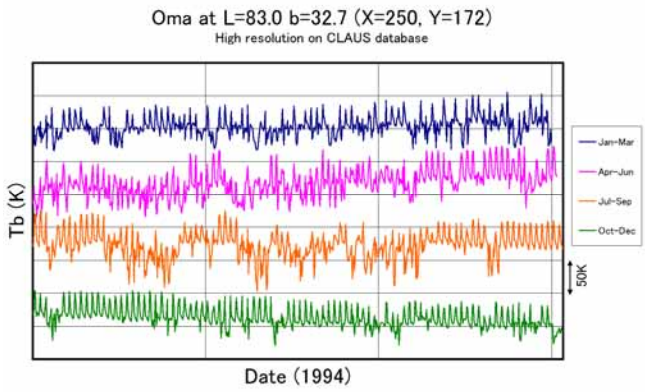


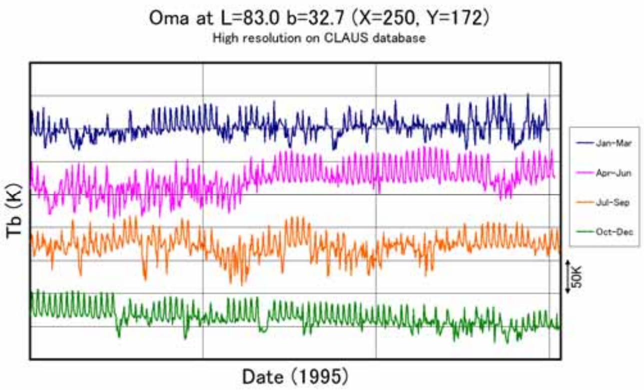


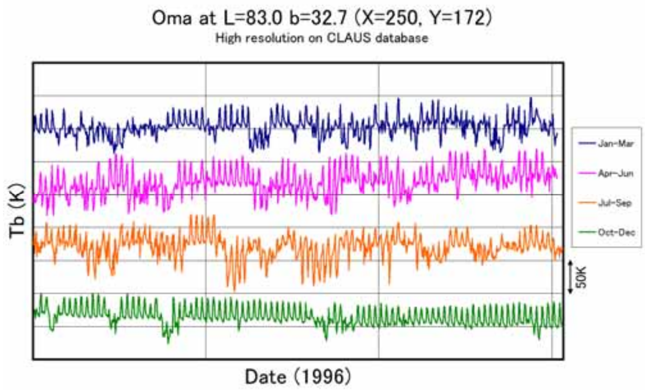


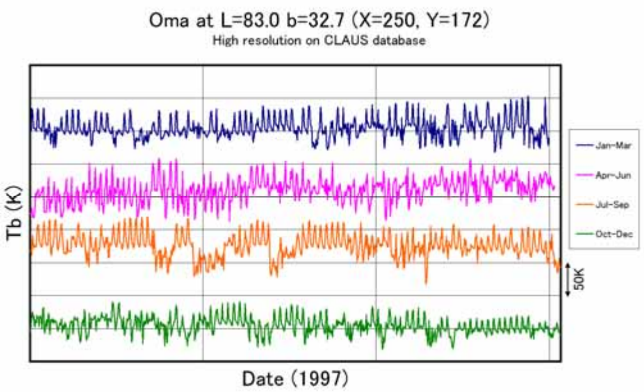


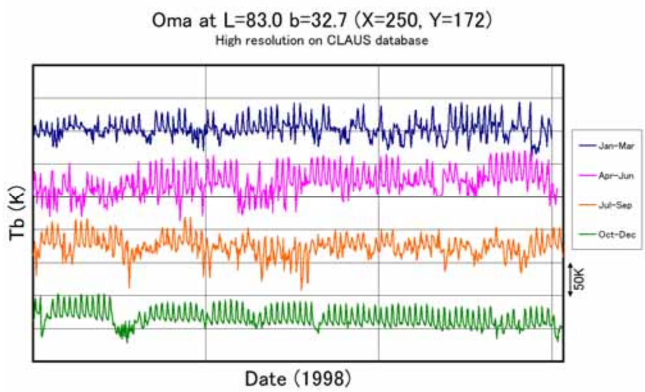

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1993)

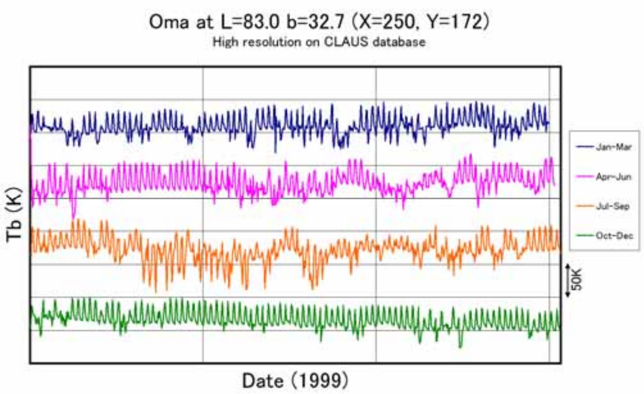

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1994)

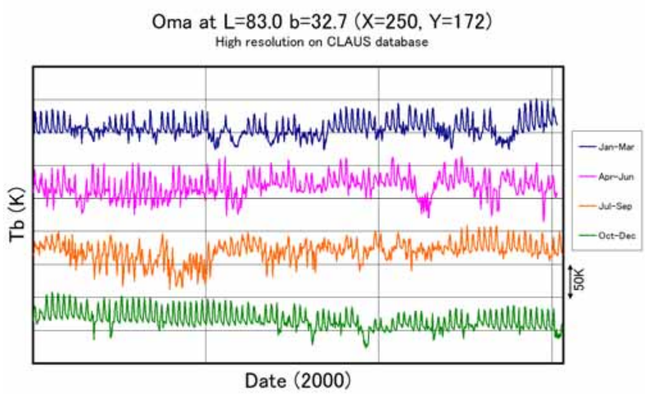

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1995)

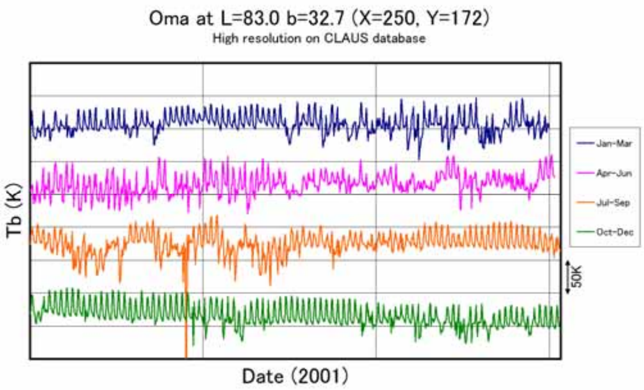

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1996)

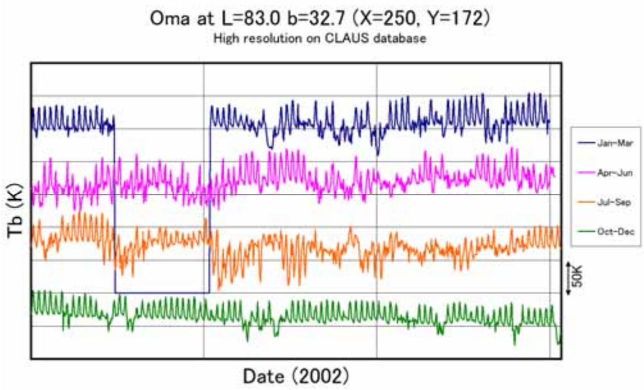

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1997)

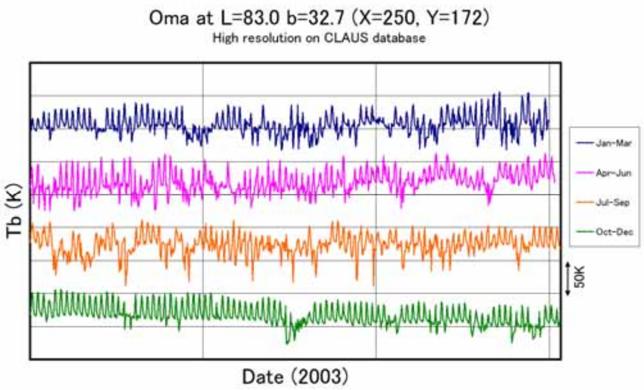

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1998)

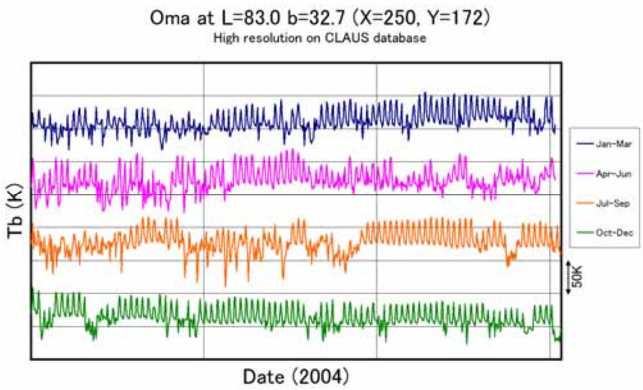

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (1999)

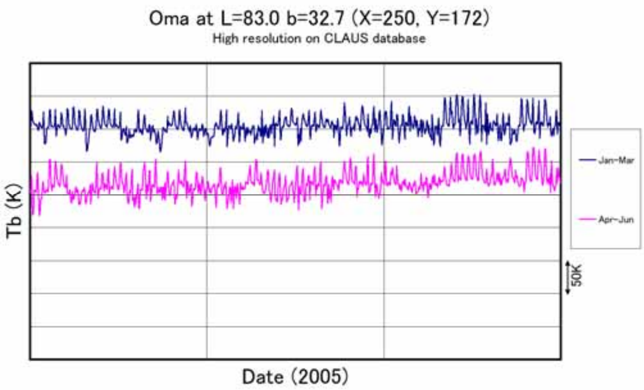

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2000)


Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2001)

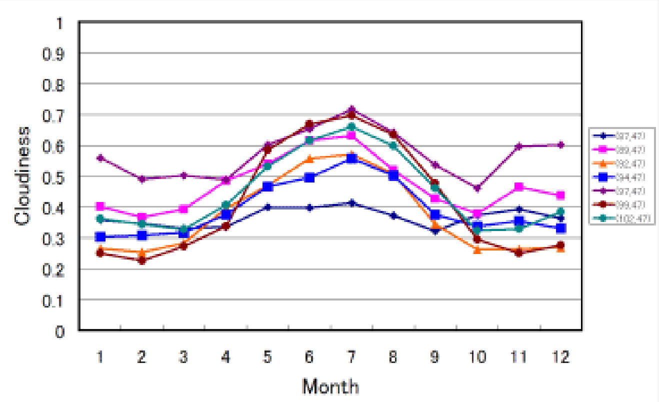

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2002)


Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2003)

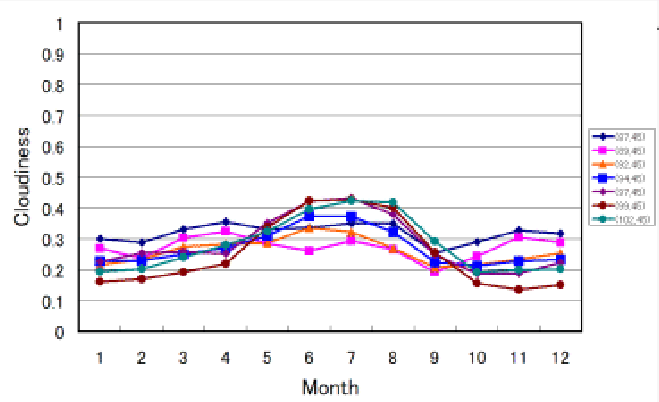

Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2004)


Oma at L=83.0 b=32.7 (X=250, Y=172)
High resolution on CLAUS database
Tb (K)
Jan-Mar
Apr-Jun
50K
Date (2005)

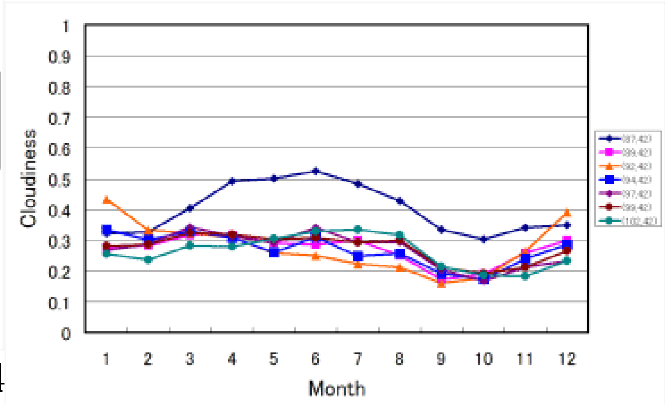
A-3: Cloudiness around Hami from FriOWL database



b=47.172411

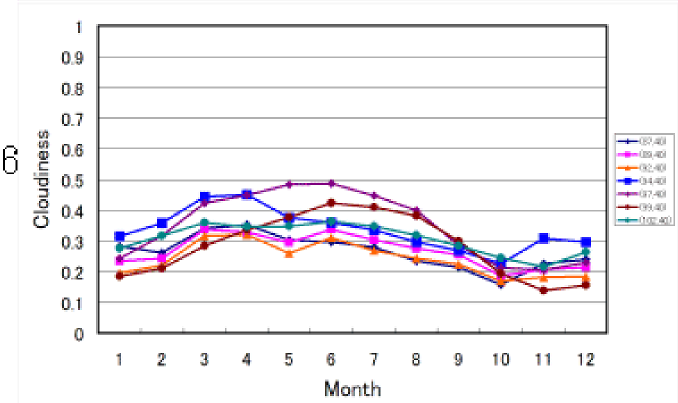


b=44.689653



b=42.206894

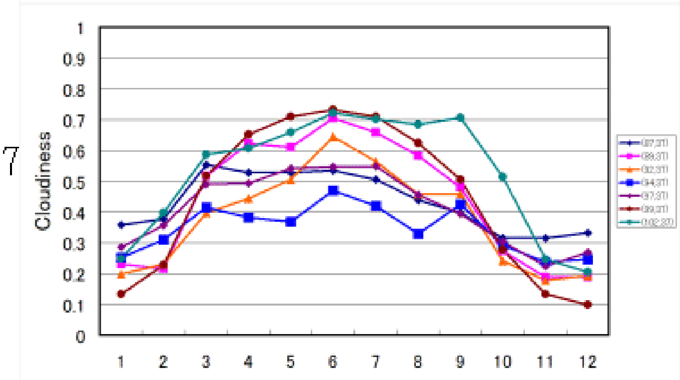
b=39.724136



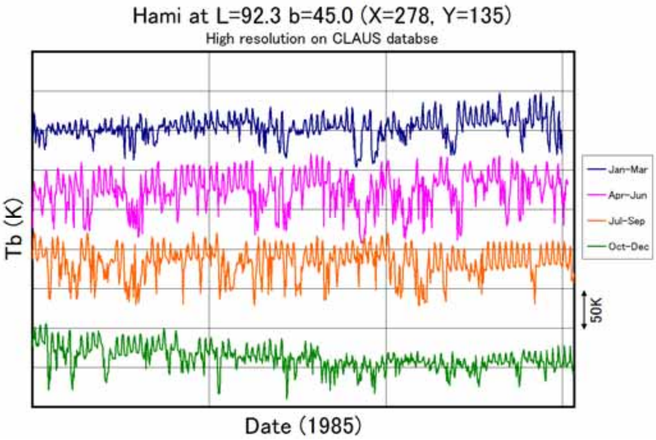
Hami

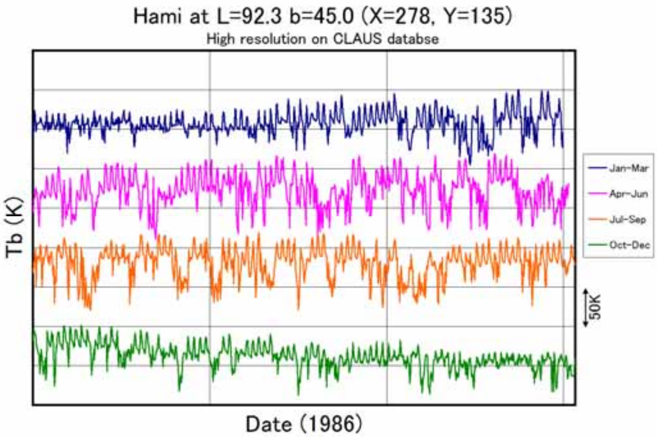
L= 86.896547
89.379306
91.862065
94.344823
96.827582
99.31034
101.793099

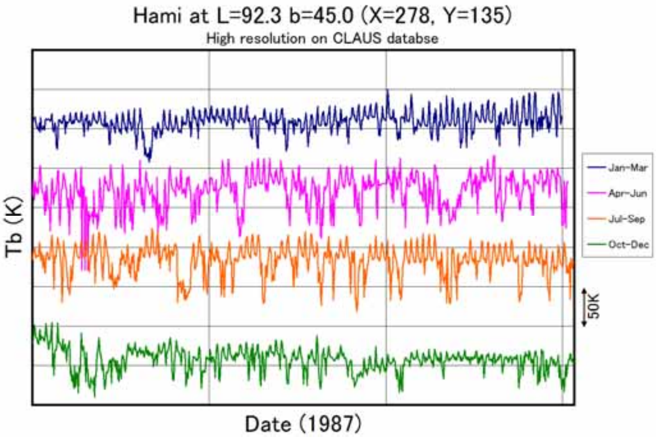
b=37.241377

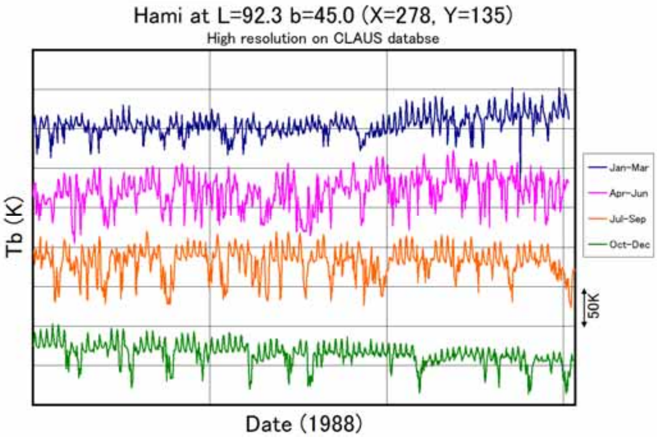


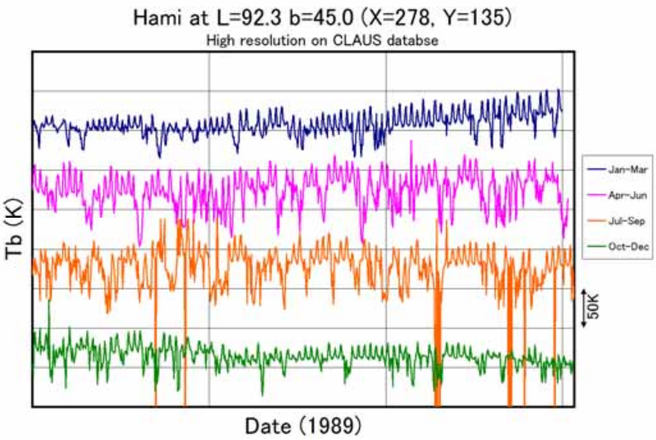
Data from CLAUS high-resolution (0.3°) data of cloud brightness temperature at Hami

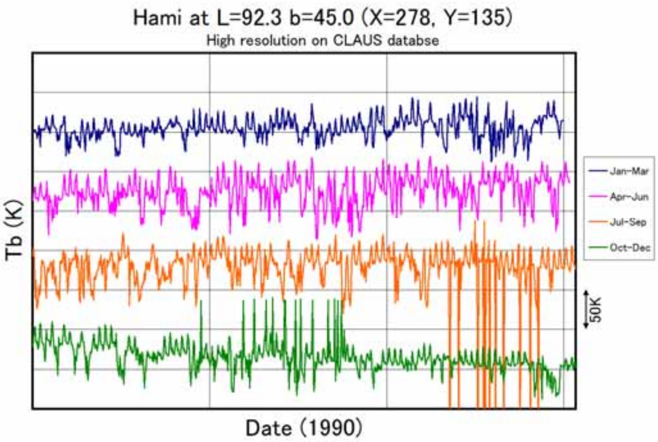


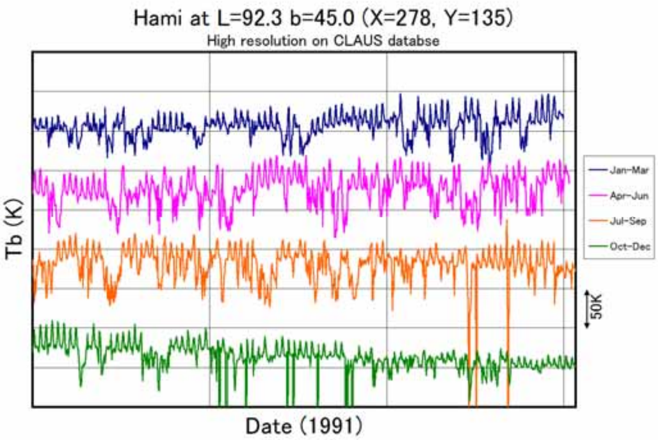


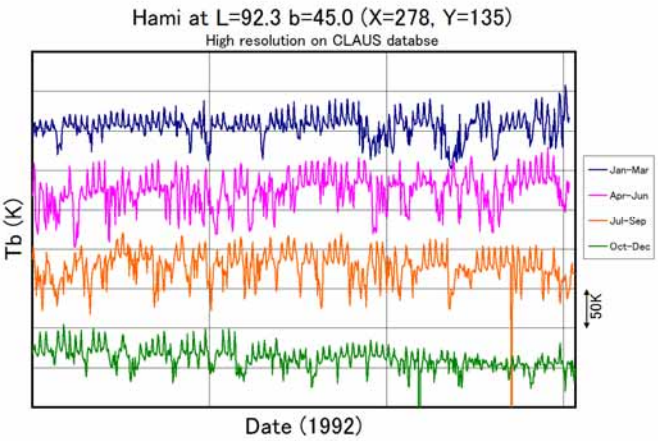




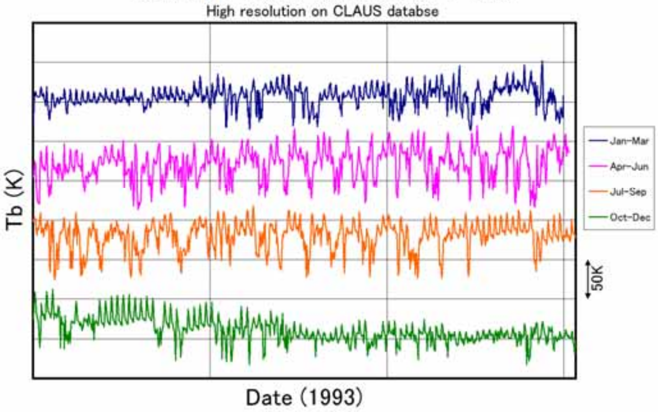




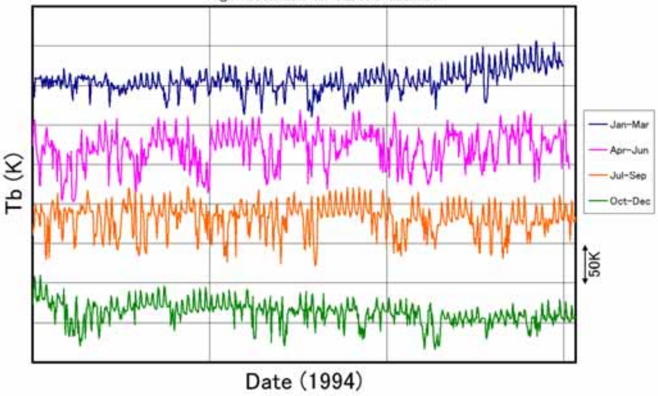




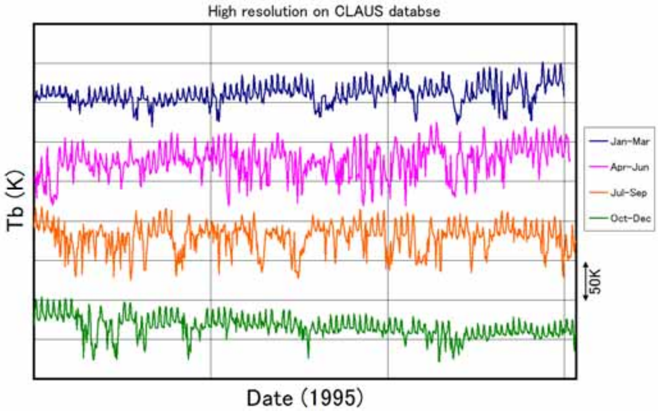
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse



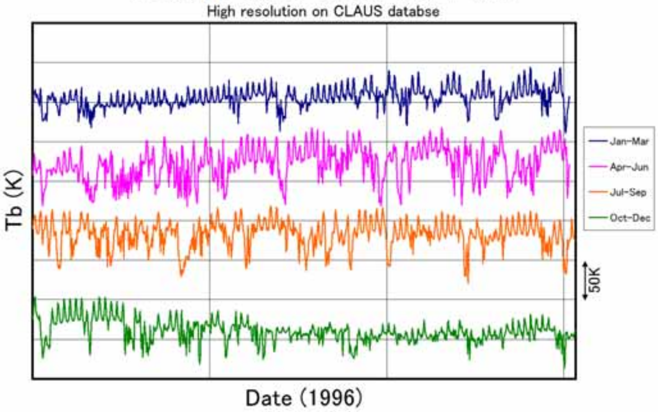
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse



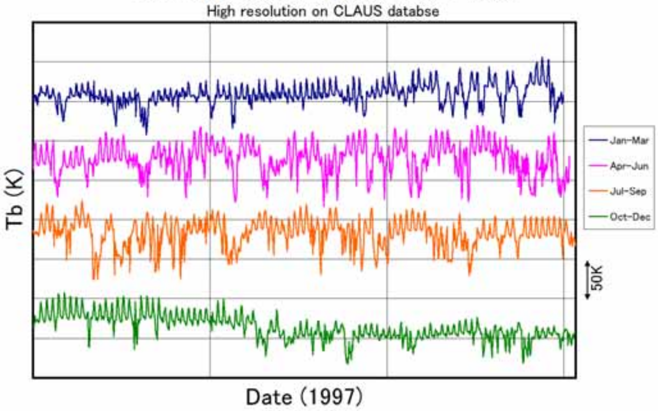
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse



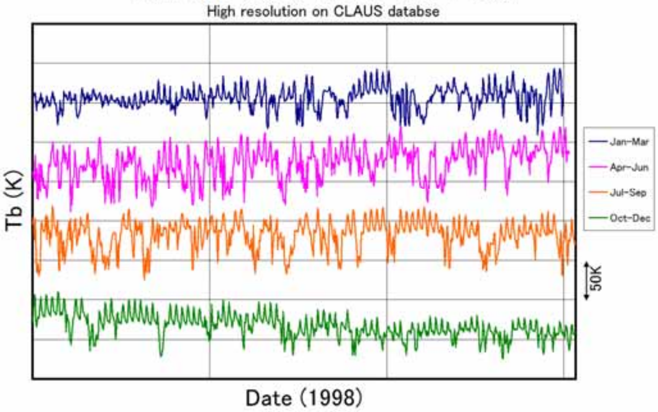
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse



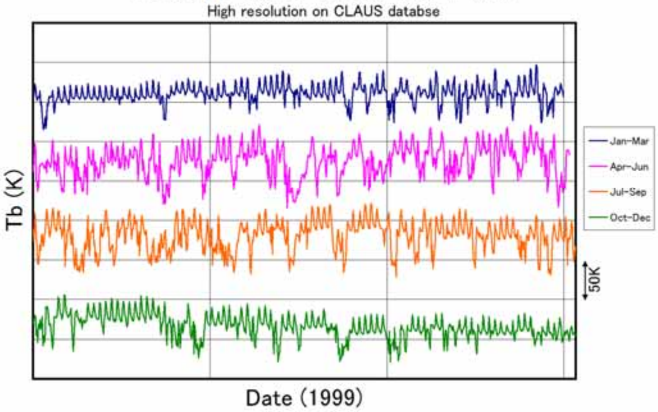
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse



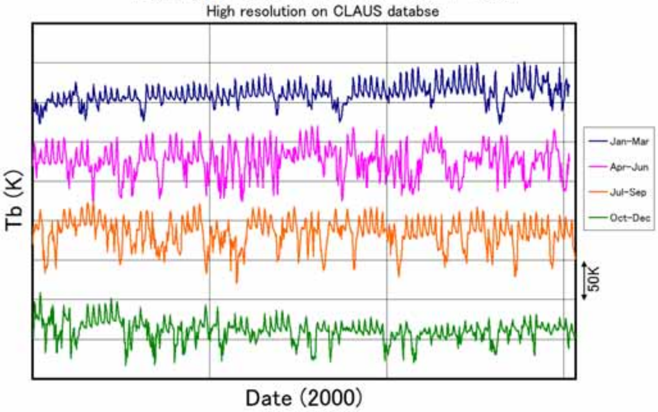
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse

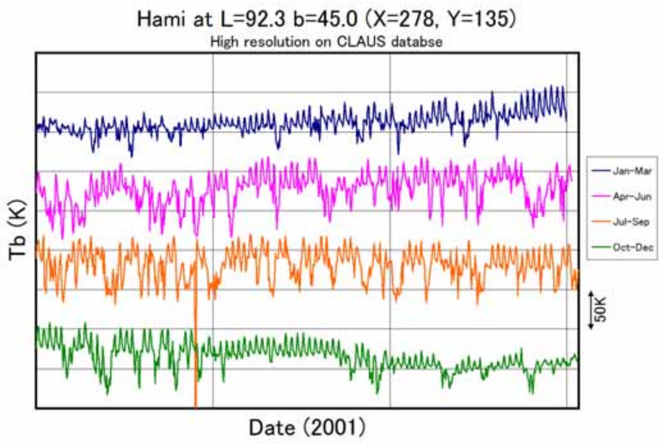


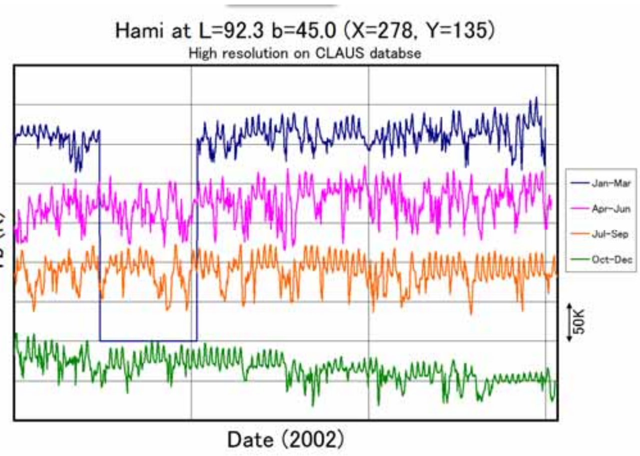
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse

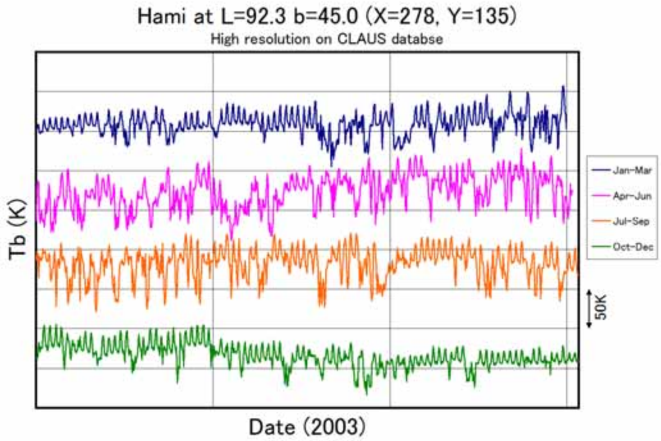


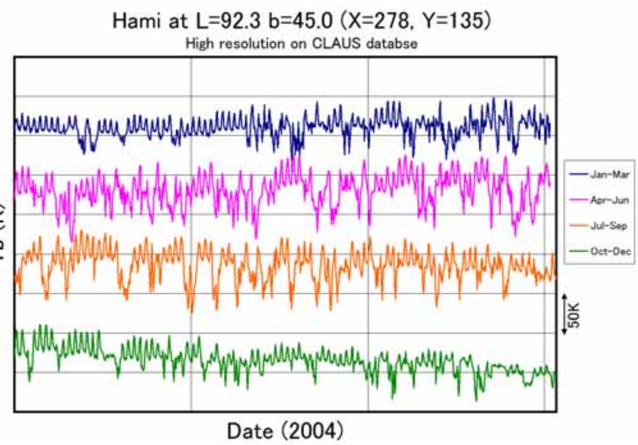
Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse

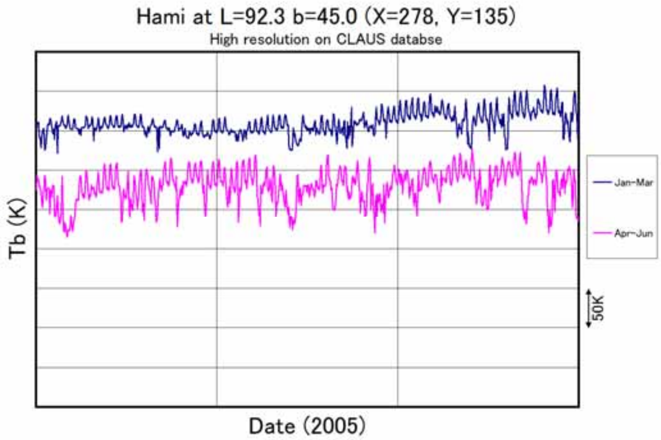



Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2001)

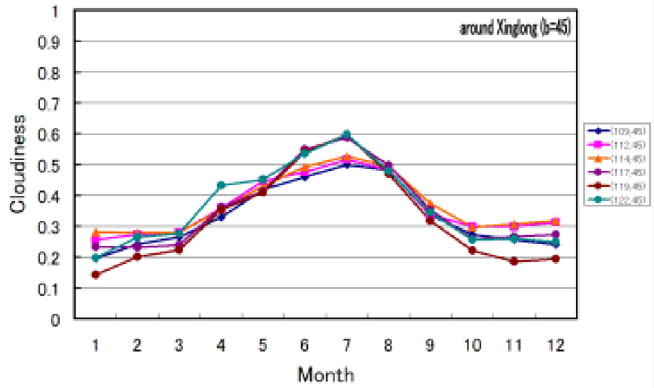

Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2002)


Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2003)

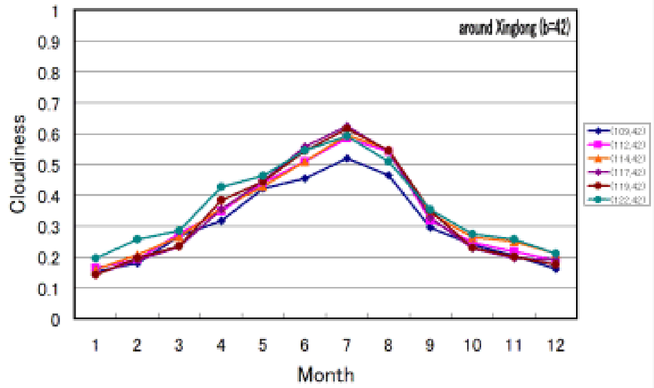

Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse
Tb (K)
Jan-Mar
Apr-Jun
Jul-Sep
Oct-Dec
50K
Date (2004)


Hami at L=92.3 b=45.0 (X=278, Y=135)
High resolution on CLAUS databse
Tb (K)
Jan-Mar
Apr-Jun
50K
Date (2005)

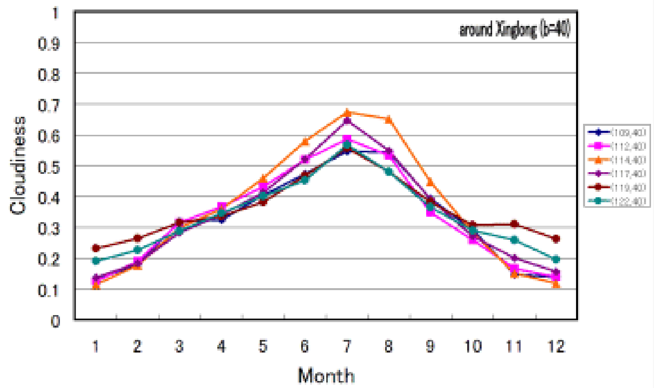
A-4: Cloudiness around Xinglong from FriOWL database



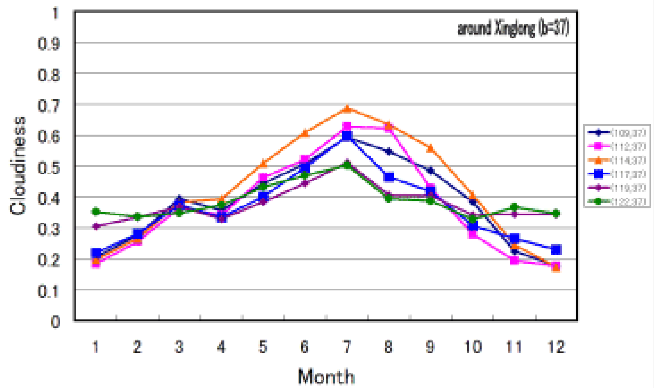
b=44.689653



b=42.206894



b=39.724136



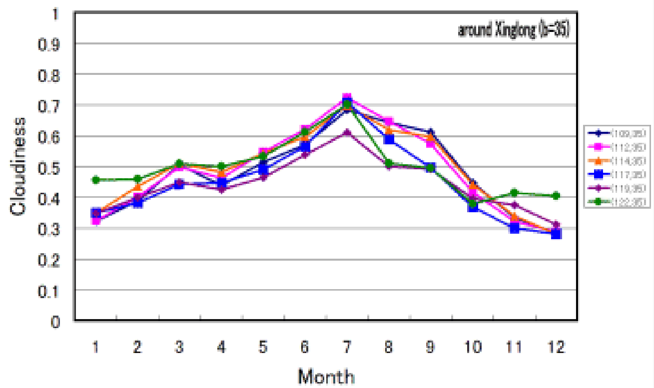
b=37.241377

Xinglong

@ L=117.576 b=40.3934

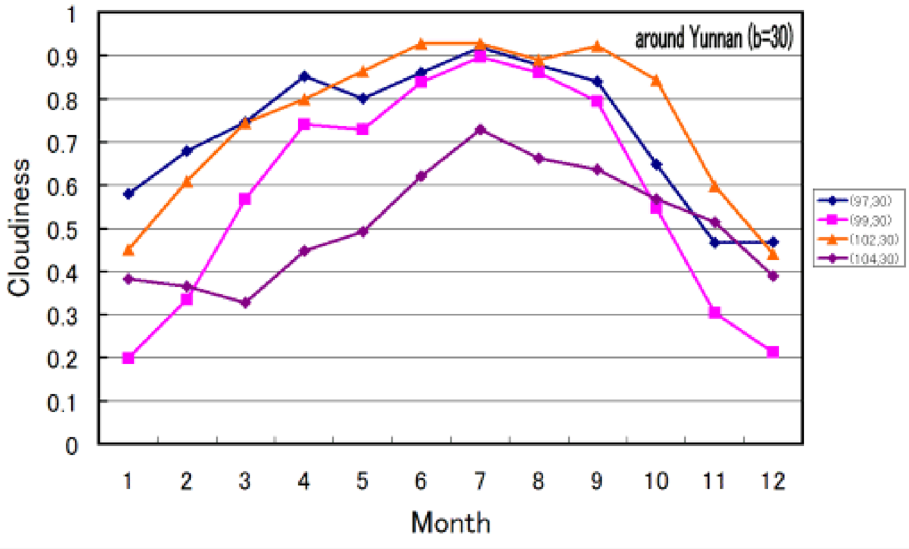
L= 109.241374
111.724133
114.206891
116.68965
119.172408
121.655167

b=34.758619

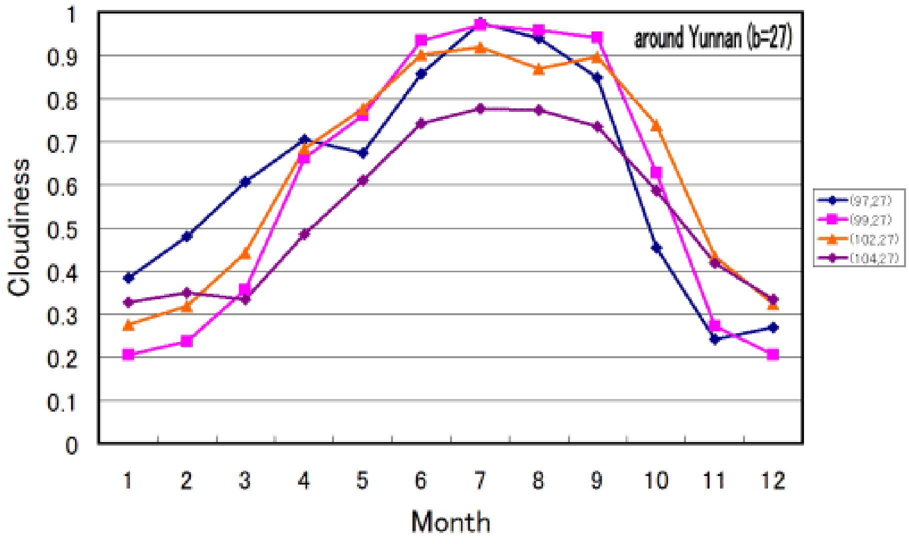


A-5: Cloudiness around Yunnan from FriOWL database

b=29.793102



b=27.310343

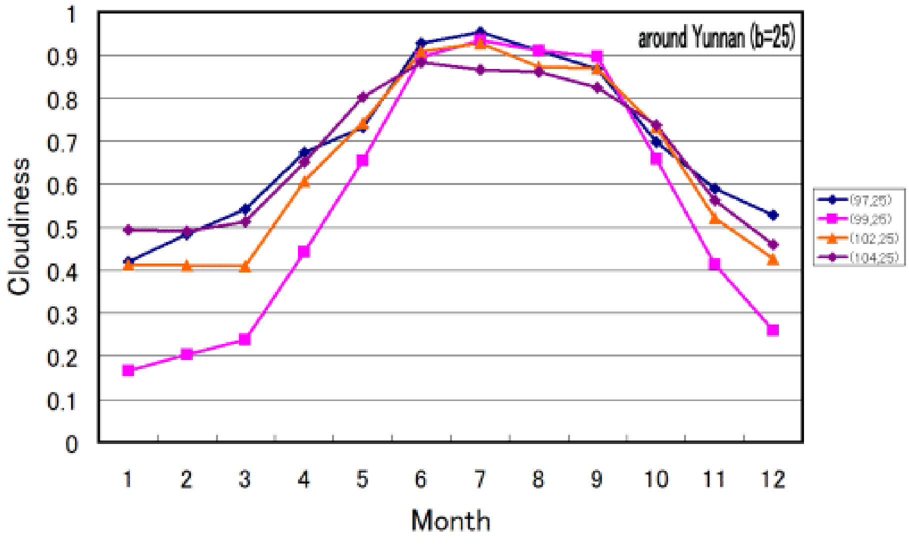


b=24.827585

Yunnan

@ L=100.0 b=26.7

L= 96.827582
99.31034
101.793099
104.275857

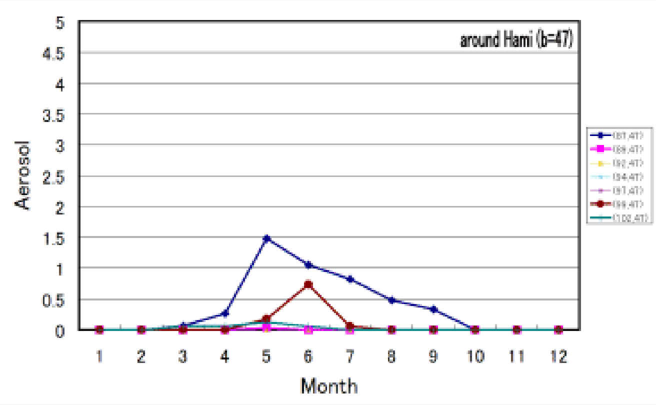


Appendix B: Aerosol around Hami from FriOWL database

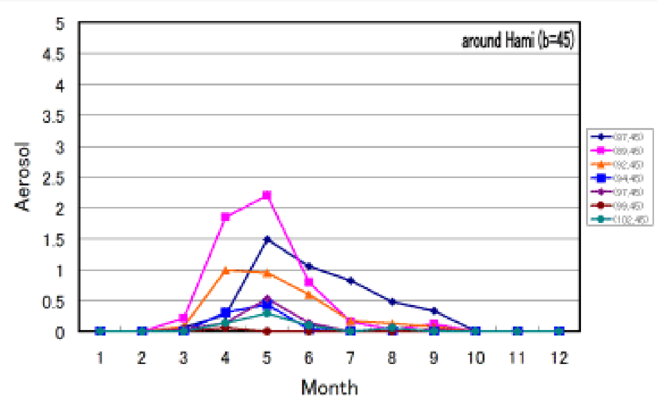
Hami Aerosol

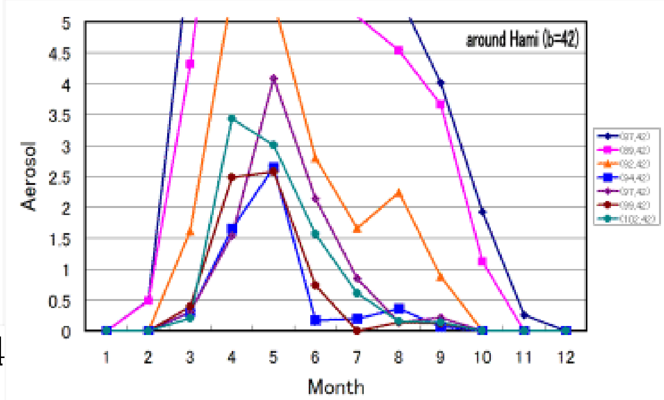
L= 86.896547
89.379306
91.862065
94.344823
96.827582
99.31034
101.793099

b=47.172411



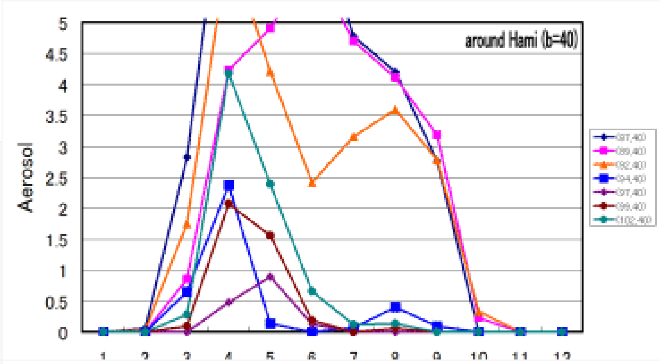
b=44.689653



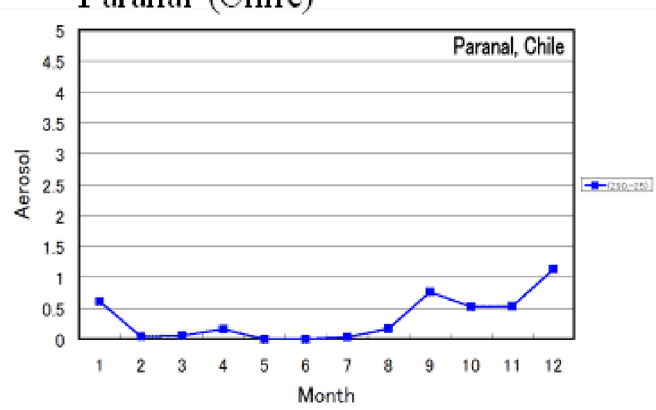


b=42.206894

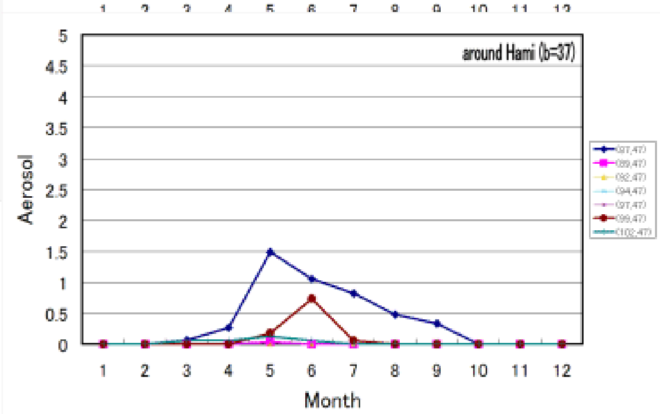
b=39.724136



Paranal (Chile)



b=37.241377

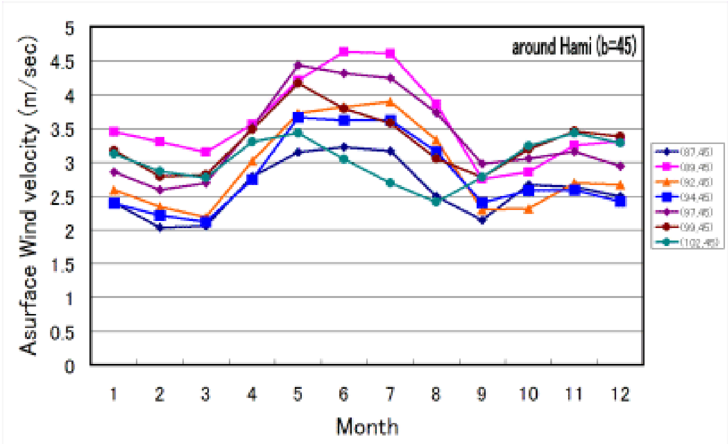


Appendix C: Surface wind velocity around Hami from FriOWL database

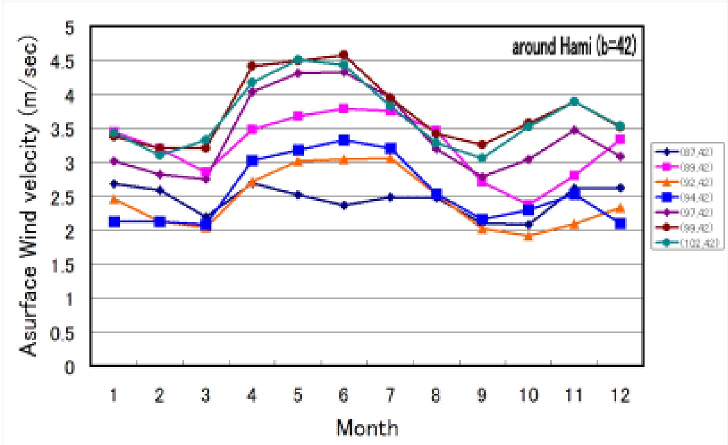
Hami Surface Wind Speed

L= 86.896547
89.379306
91.862065
94.344823
96.827582
99.31034
101.793099

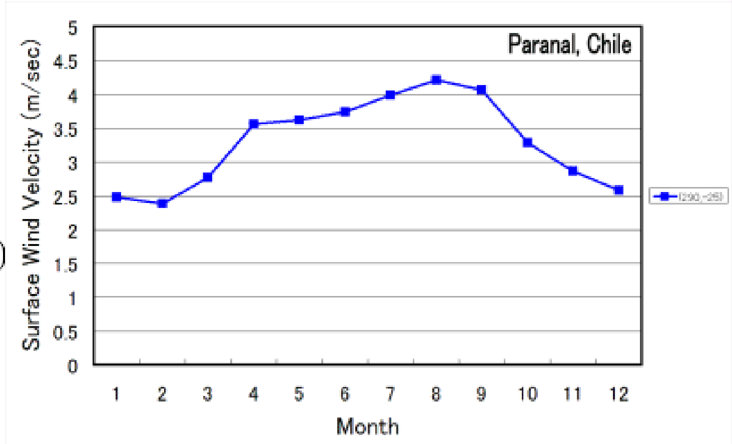
b=44.689653



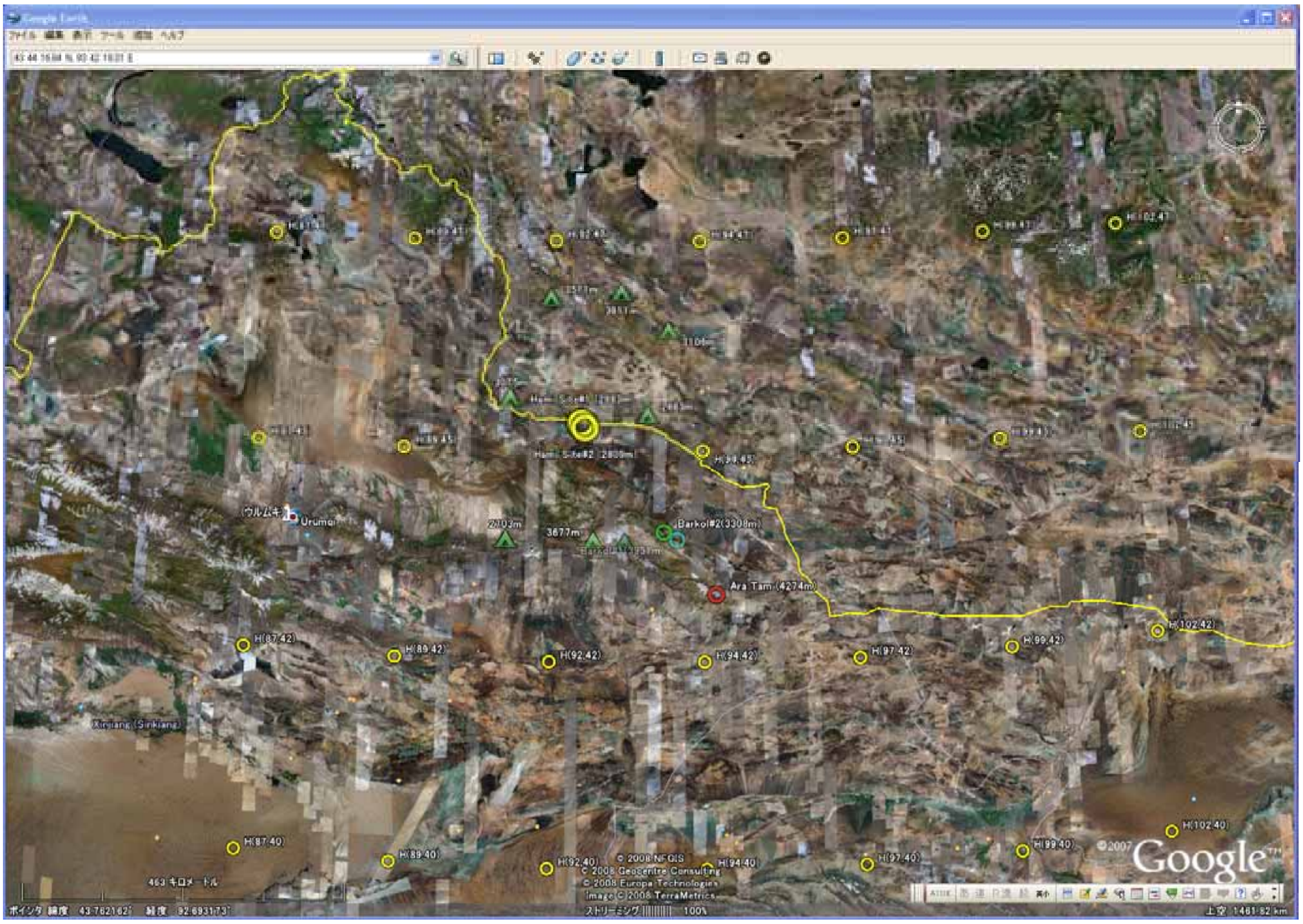
b=42.206894



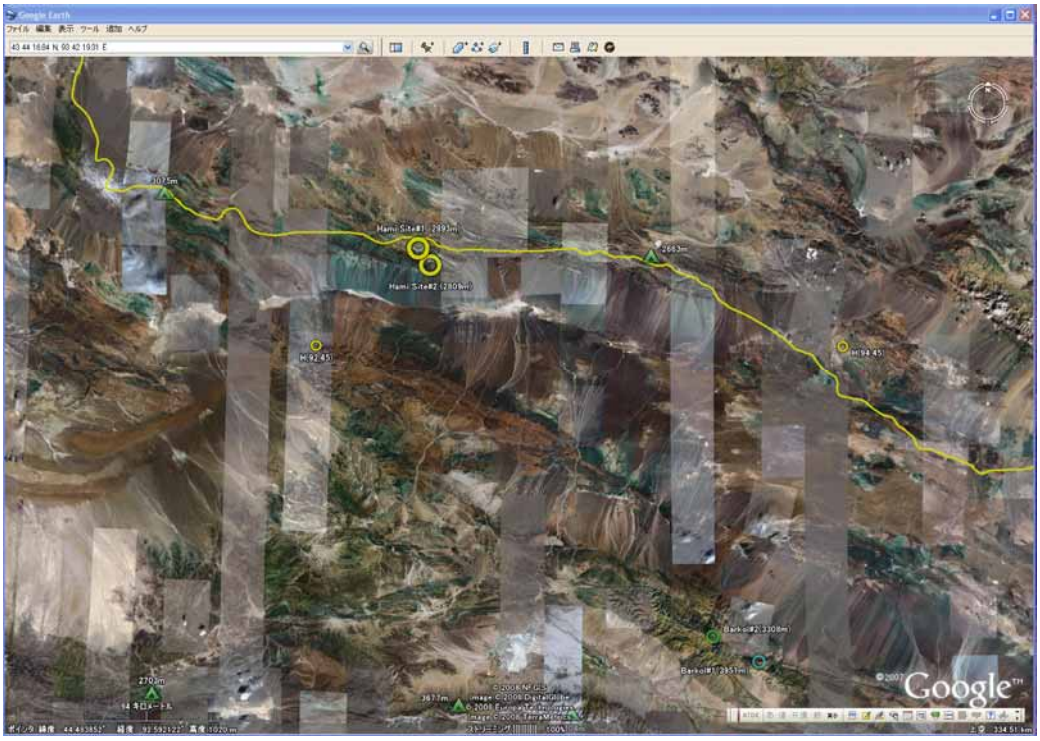
Paranal (Chile)



Appendix D: Aerial view around Hami (GoogleEarth)



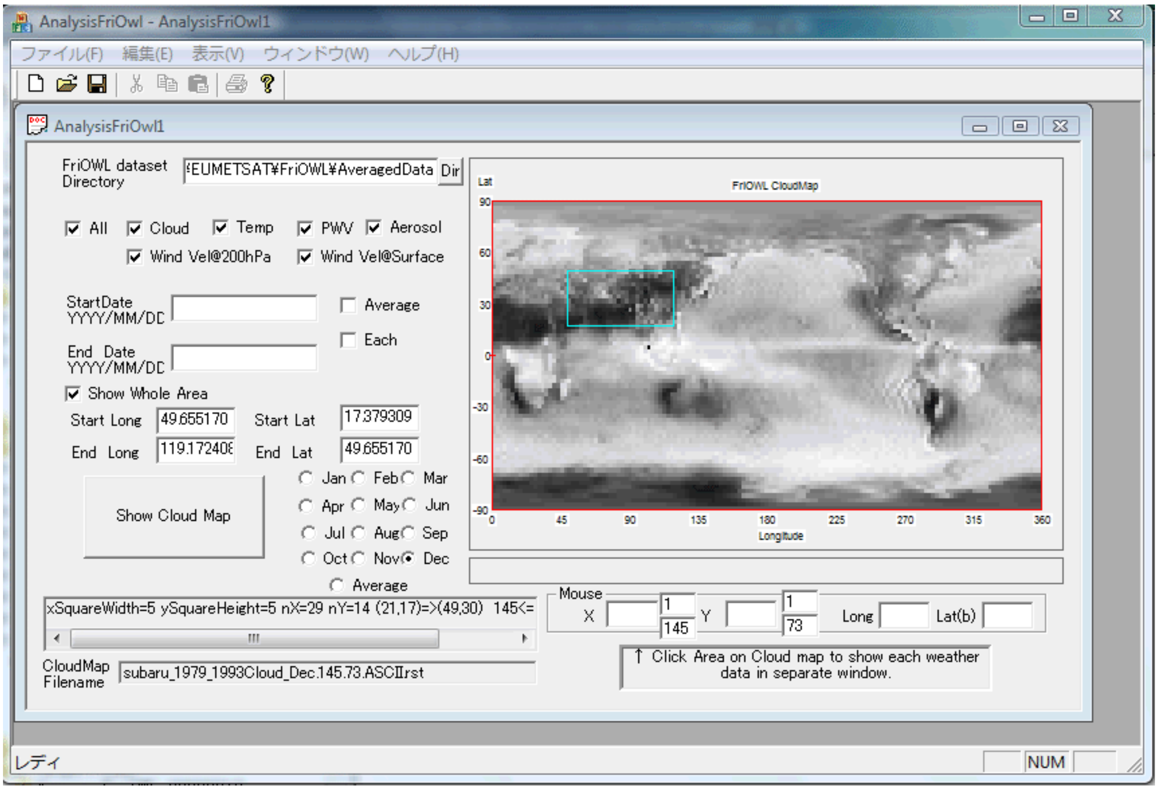
Aerial map around Hami. Two large yellow circles show candidate mountains possibly located in less cloudy area. Small yellow circles show locations where weather data are pointed to. Green triangles show relatively high mountains around candidate mountains, which are separated more than 100 km. That means the candidate mountains are relatively isolated. Close look below.

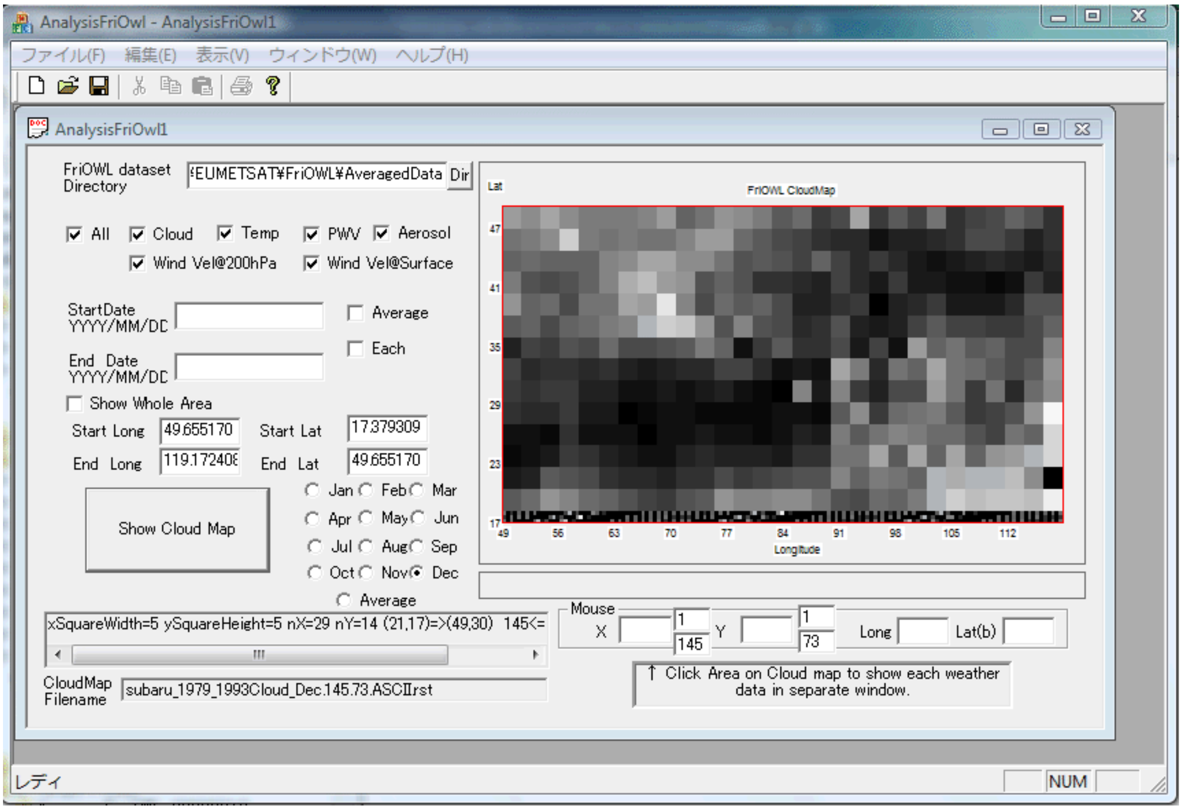


Appendix E: Related software

AnalysisFriOWL (not completed)

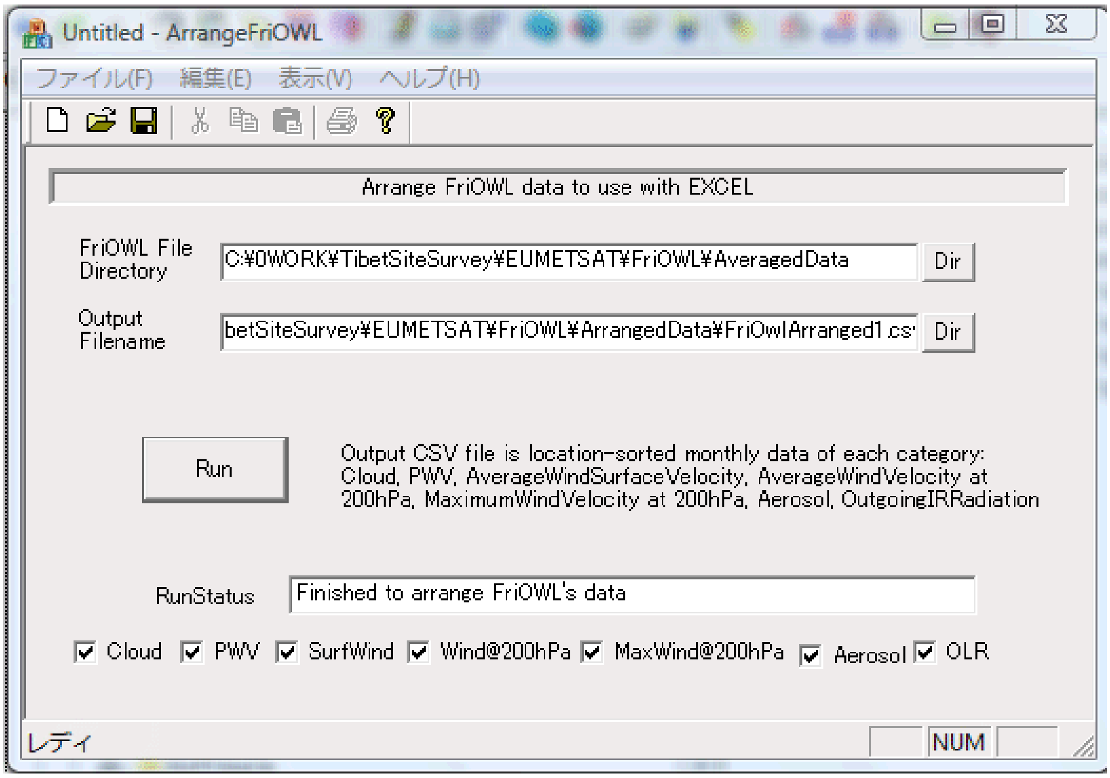
To show cloud map to pick a particular area to display statistical data from FriOWL on one panel easily to take overlook about the area.





ArrangeFriOWL

To arrange original FriOWL data to convert them in CSV format, easily treated with EXCEL.



AnalysisSatelliteCloud

To show CLAUS cloud map data in zoomed format with forth-back function to investigated a particular area precisely using CLAUS high resolution data.

To Extract a part of data in separate file from CLASU high resolution data.