A China-Japan Collaborative Site Survey in west Tibet - Sky clearness at Gar/Ali, Tibet -

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on behalf of Site Survey Team

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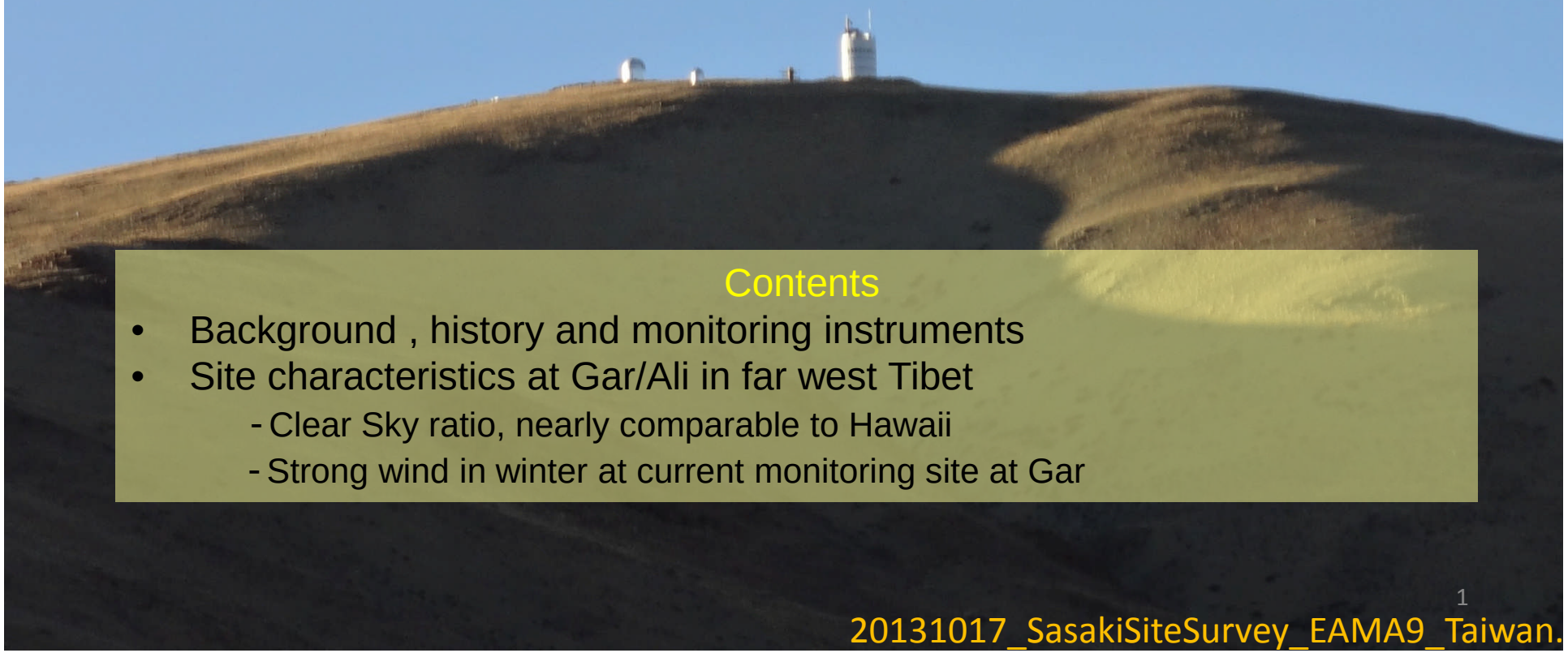


Contents

- Background , history and monitoring instruments
- Site characteristics at Gar/Ali in far west Tibet
  - Clear Sky ratio, nearly comparable to Hawaii
  - Strong wind in winter at current monitoring site at Gar

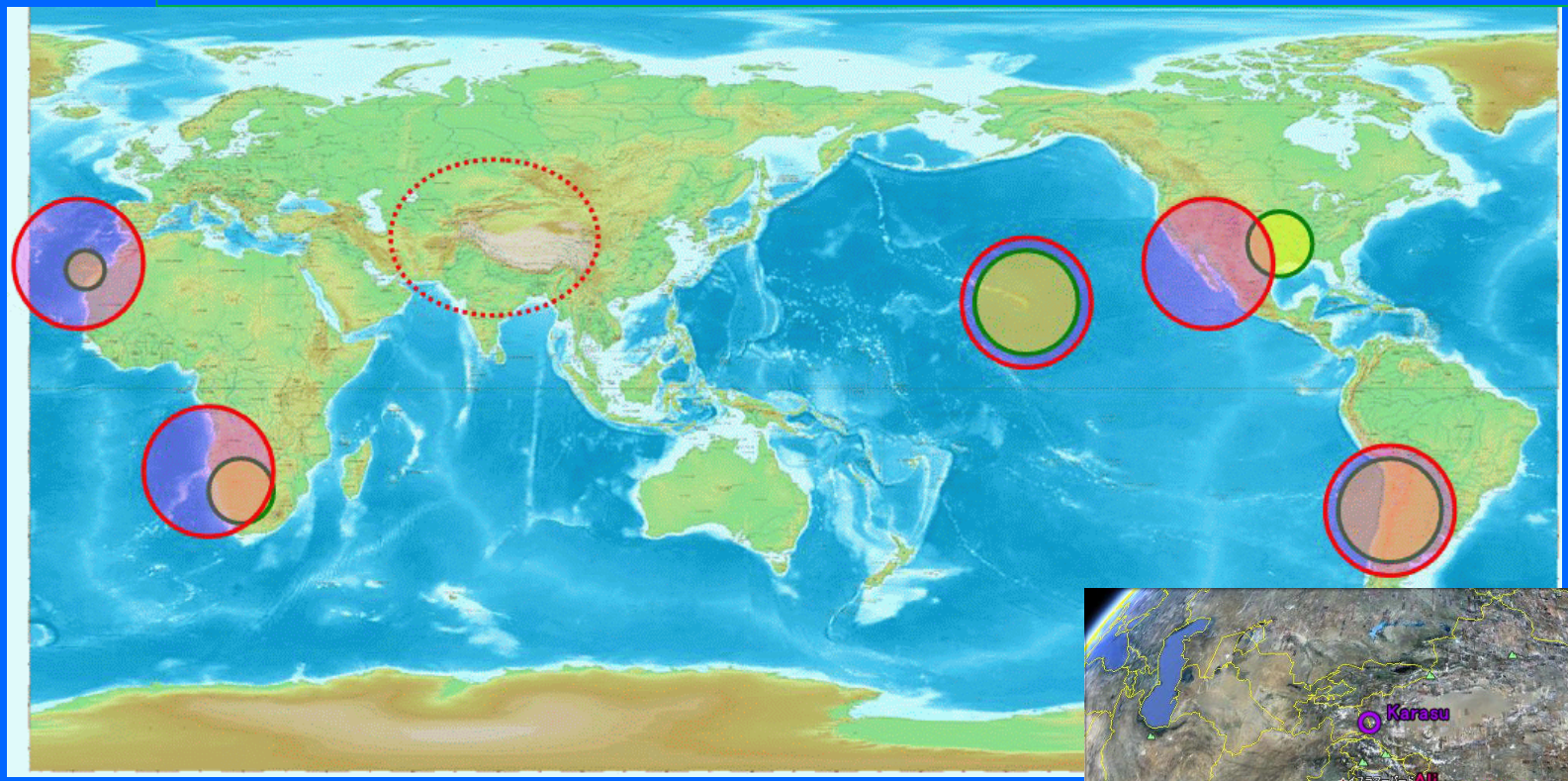
Collaborative Site Testing in West China

Short Summary

1) **Site Survey and testing** has been conducted since 2003, led by Prof. Y. Yao (NAOC), and three weather-monitoring stations have been settled at **Karasu** (Xinjiang), at **Oma** (Tibet), and currently at **Gar** (Tibet).
2) Japanese team has joined the site survey project after the workshop at Lhasa, 2004. We introduced **MIR cloud monitor** cameras , atmospheric micro-turbulent $\mathbf{C_T^2}$ sensors, and weather stations at the sites.
3) At **Oma and Gar** site, **cloud monitor camera** has revealed excellent sky conditions, especially in winter. **Gar** has shown better weather conditions than **Oma**.
4) Strong winds have been observed at current site, **Gar,** in winter season, which may affects observable nights seriously.
5) We are now searching for another better site(s) near **Ali** with more calm wind condition.

Why do we need a new observing site in west Tibet?

West Tibet is at an important *longitudinal* location for global astronomical observation network



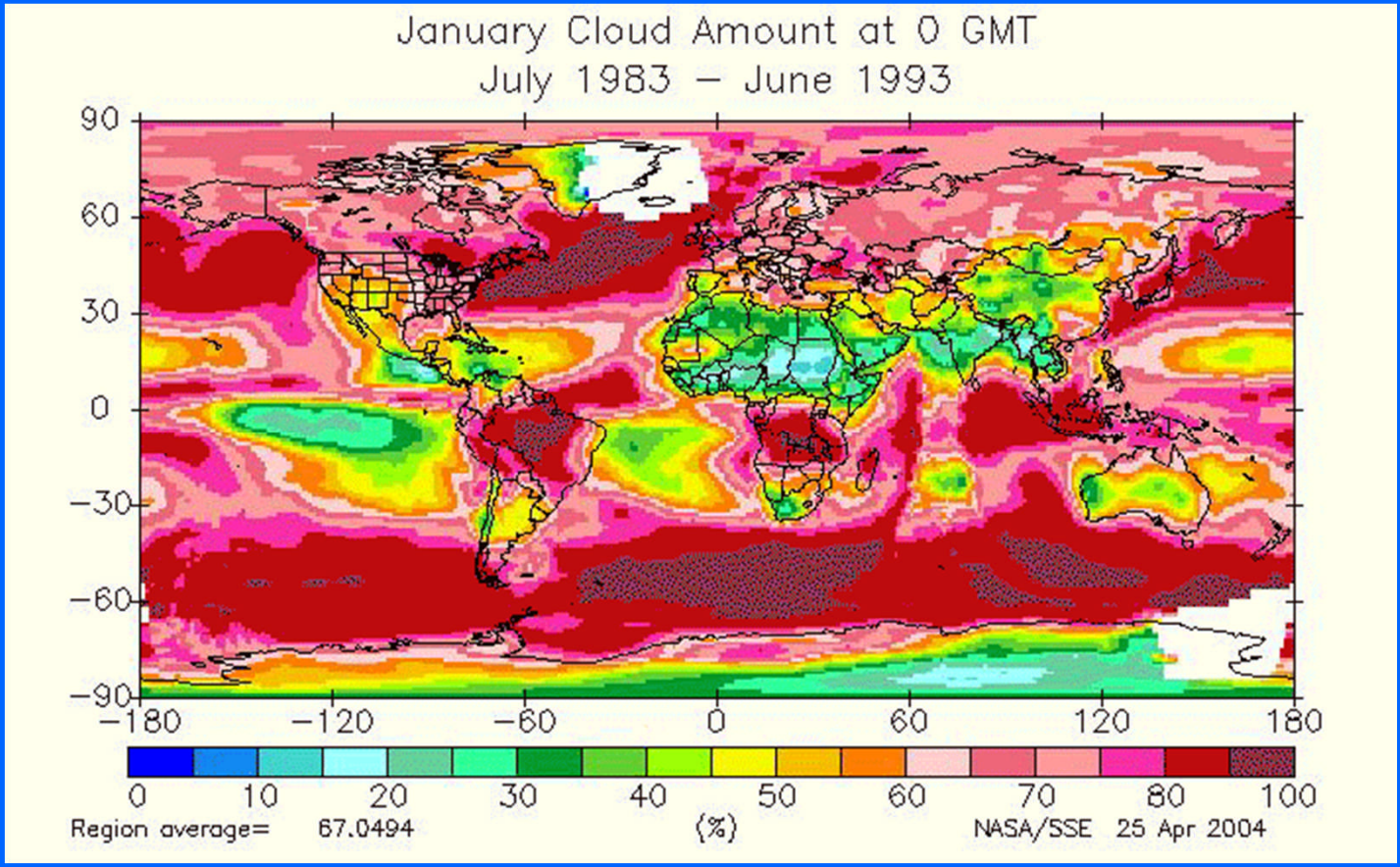
sites in west China; Karasu, Oma, and Gar/Ali

In Planning phase of ELT, west China is one of candidate sites

Dr. Sarazin (ESO) showed a global weather map at SPIE at Kona, 2002 .

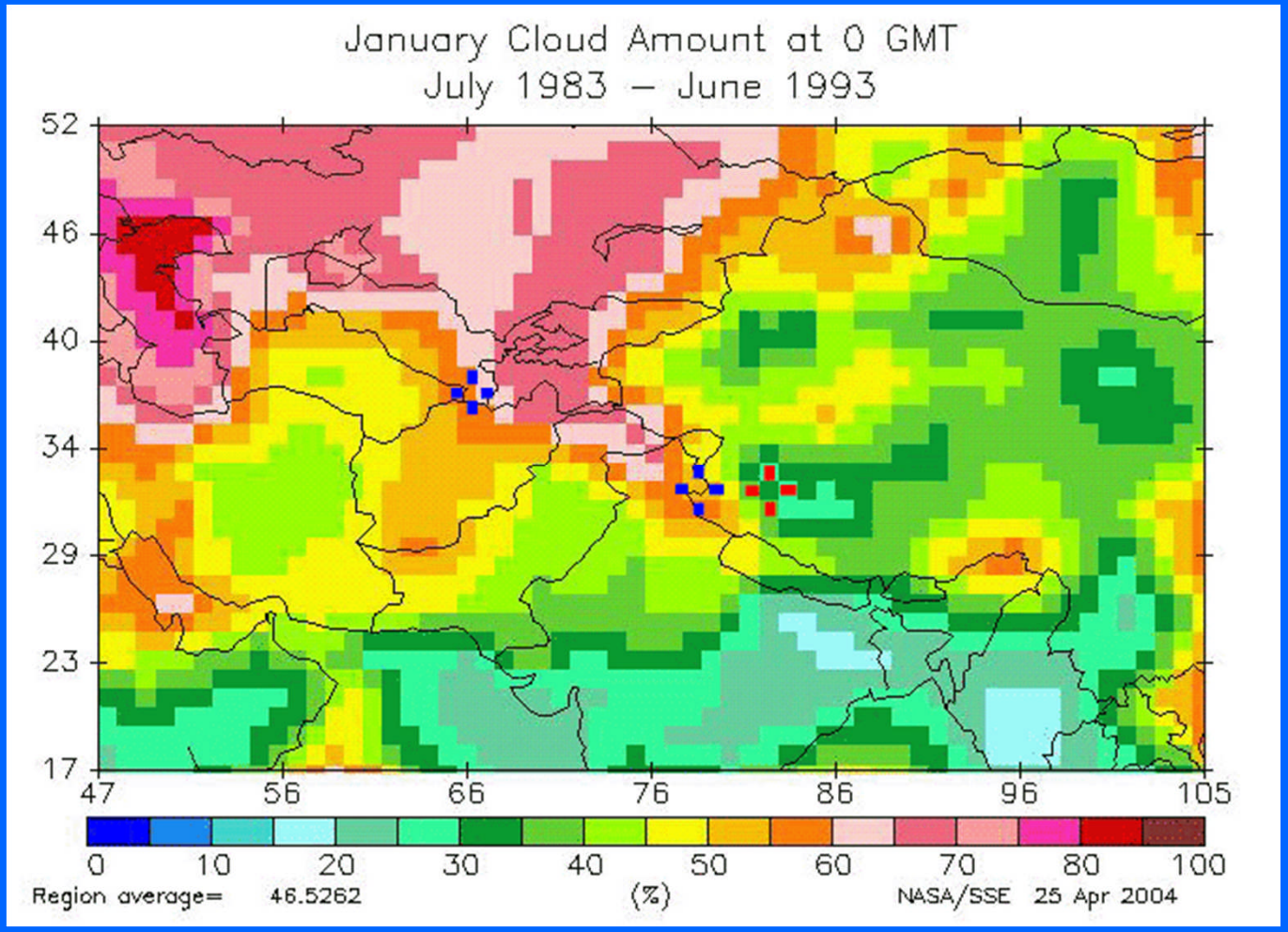
Global Cloud Distribution

Refer to **http://eosweb.larc.nasa.gov/sse/**
Meteorology and Solar Energy
Global/Regional Plots



Cloud map around west China

Arranged only for night data.
Two blue crosses show ***Hanle*** (India) and ***Maidanak*** (Uzbekistan). Red cross shows candidate site in **Tibet**.



Site monitoring instruments available and/or planned

Instrument	Method	Measured value	Height range
Weather Station	Temperature, Humidity, Wind, Pressure Rain, (Sunshine, IR radiation)	Meteorological data	at several m
Dust counter	Particle counter	Dust particle	at several m
Visible whole-sky camera	visible CCD camera	Night sky	through atmosphere
IR Cloud monitor	10μm-band MIR camera	Cloudiness	through atmosphere
DIMM	Differential Image Motion Monitor	Seeing	through atmosphere
MASS	Multi-Aperture Scintillation Sensor	Scintillation	1km to several 10km
SCIDAR	Scintillation Detection and Ranging	Scintillation	1km to several 10km
CT2 sensor	Micro-thermal Turbulence in Surface Layer	Turbulence	0 m to several 10 m

Cloud Monitor Weather Station

(at *Gar*)

CT2 sensors on 40m tower

(at *Karasu*)

Site Monitoring Instruments at Gar (Japan group)

Weather Station
↓ ***Vaisala WXT510***

↓ ***Himalaya*** *is over these mountains*

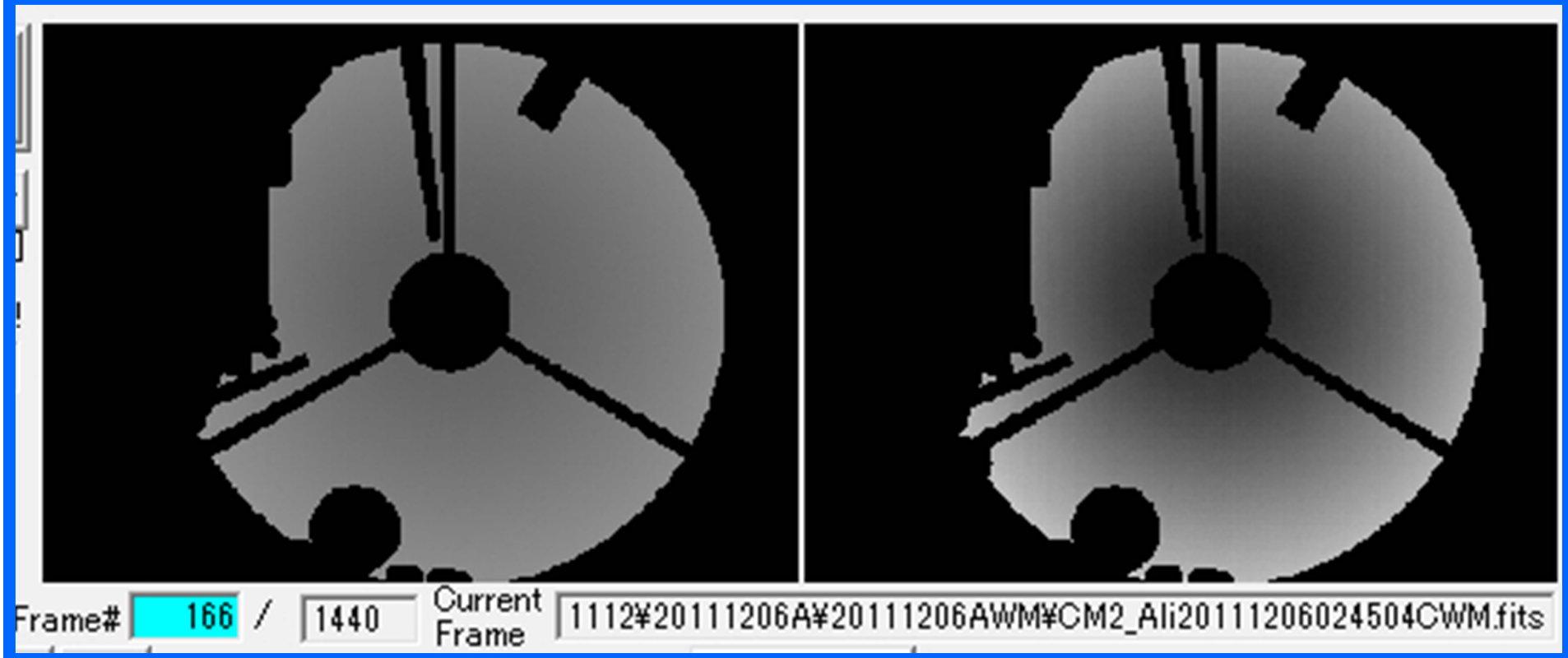
↑ **Dust Counter**
DustTrak 8520

CloudMonitor →
w/ ***FLIR A40M*** MIR camera

Sample Images of CloudMon at *Gar* on 2011/12/06

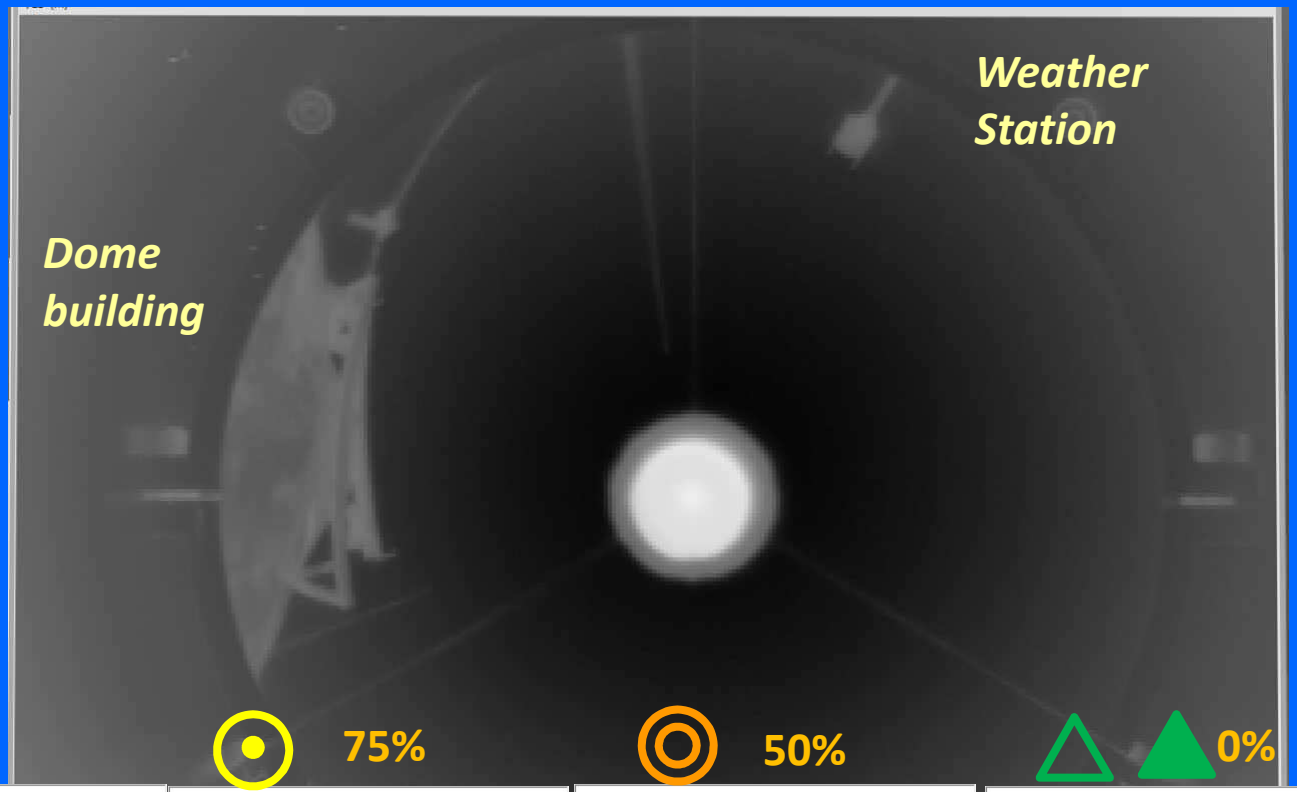
All-sky images, every 6min, taken w/Cloud Monitor at Gar on 2011-12-06

- Original Images were taken every 1 min
- Ground-based MIR images (Thermal-Eye 2000B Camera, 7-14 μm (320x240 pixel array), 1 frame/ 1 min)

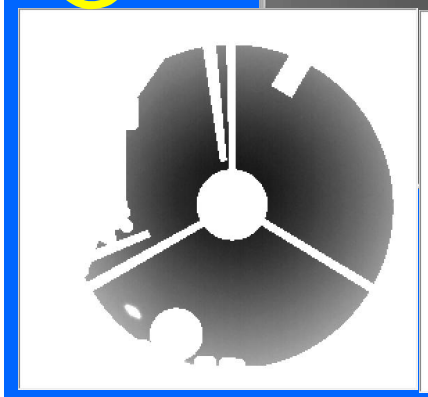


(↑ Red circles ◯ are marked to show Solar/Lunar images occasionally.)

Sky Clearness is judged by eye inspection on MIR whole-sky images

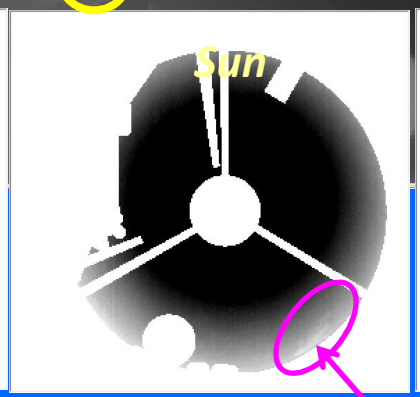


100%



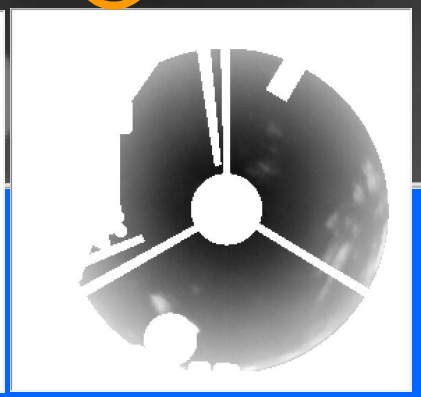
Clear Sky

75%



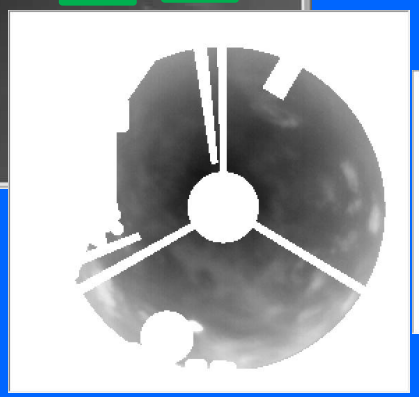
Fine SKy

50%



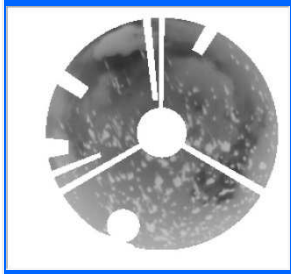
Fair Sky

0%



Cloudy SKy

0%



Rainy

Monthly lists of Weather Conditions at Gar, Oma and Karasu,

which are now open to public

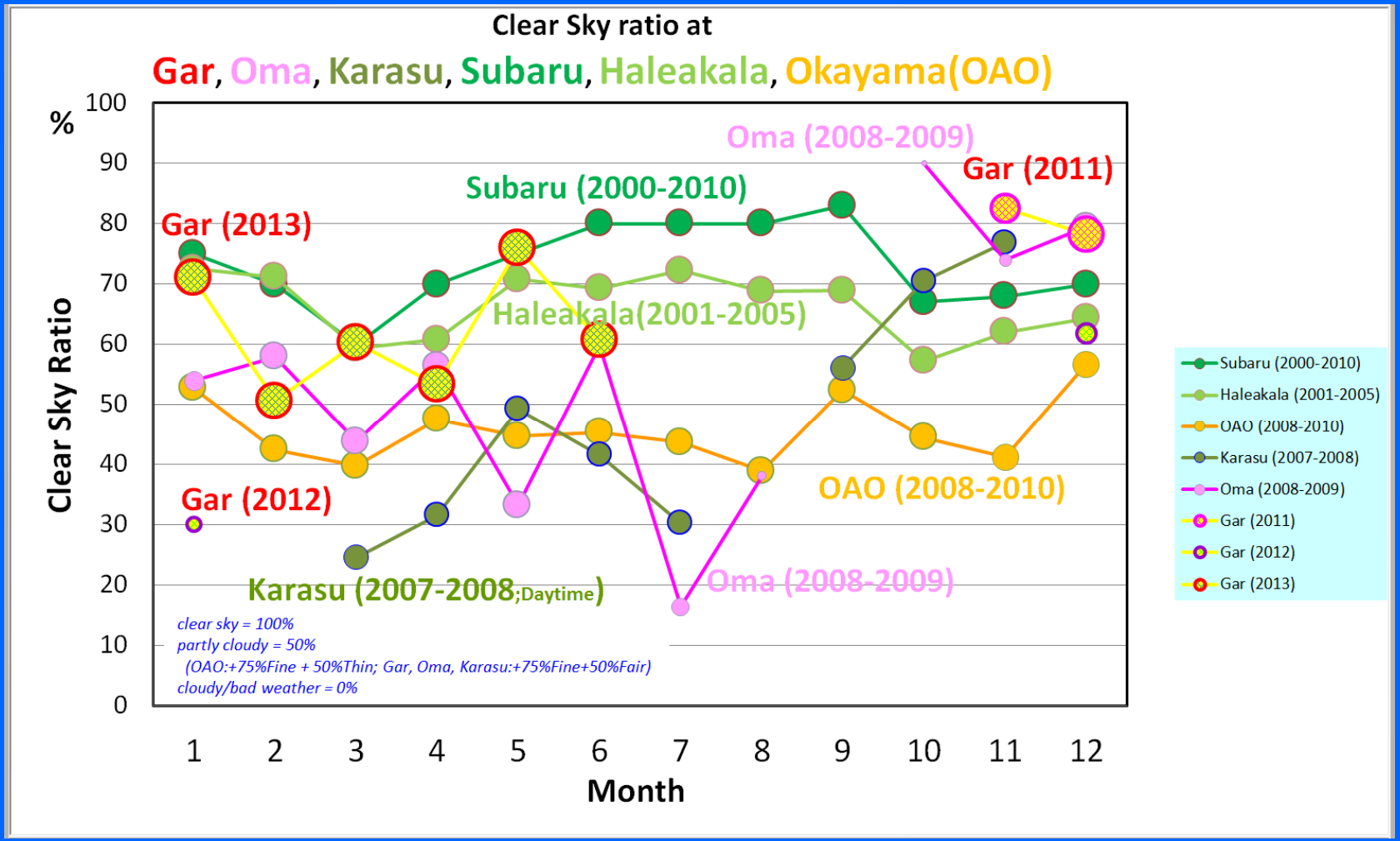
http://sasakihome.info/~sasaki/TibetSiteSurvey/index.html

Sky Condition 天候概況判断: ○ Clear 快晴 | ⊙ Fine 若干雲 | ◎ Fair 雲あり | △ Cloudy かなり雲 | ▲ Heavily Cloudy 厚い雲 | ■ Rainy 降雨

Gar/Ali

Z:¥00SiteSurveyData¥00Params¥Param_WS¥WS.AvailablePeriod_Ali.txt

	UT	0h	1h	2h	3h	4h	5h	6h	7h	8h	9h	10h	11h	12h	13h	14h	15h	16h	17h	18h	19h	20h	21h	22h	23h
2011/12/1	CloudMon	△	△	△	△	△	△	△	△	◎	⊙	◎	◎	⊙	⊙	⊙	○	○	○	○	○	○	○	○	○
	T_WS (K)	270.7	269.2	268.9	269.5	270	272	271.5	272.5	272.9	274.4	275.9	275.1	274.4	273.8	273.9	273.2	272.9	272.7	272.2	271.6	271.5	270.9	270.5	270.3
	Wind (m/sec)	1.1	1.6	1.4	1.7	2	1.4	5.6	1.6	3	4.4	4.8	10.7	14.8	12.9	18.7	13.4	14.1	10.5	8.2	10.7	6.8	7.8	11.3	11.8
2011/12/2	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	270.5	270.4	270.3	270.7	271.5	272.4	273.2	273.9	274.4	275.1	275.1	274.5	273.8	273.1	272.9	271.6	270.8	270.6	270	270.5	269.4	269.5	269	268.9
	Wind (m/sec)	18.9	13.4	9.8	11.5	10.6	12.1	8.2	13.6	13.6	22.7	16.1	16.9	18.5	18.2	12.6	14.7	15.4	12.7	11.3	14.4	13.7	6.5	9.4	10.7
2011/12/3	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	269.1	268.9	269.4	269.4	270.5	271.5	272.5	273.7	273.6	273.8	274.2	274.1	272.9	272.3	271.7	271.4	270.8	270.6	269.6	269.3	268.9	269.1	269.7	269.5
	Wind (m/sec)	6.4	1.4	10.7	23	14.3	17.3	20.9	11.4	14.3	14.7	14.6	8.6	8.4	9.7	12.7	13.6	11.3	12.2	11	14.7	14.7	17.6	12.8	15.8
2011/12/4	CloudMon	○	○	○	○	○	○	○	○	⊙	⊙	⊙	⊙	⊙	○	○	○	○	○	○	○	○	○	⊙	○
	T_WS (K)	269.7	269.3	269.7	270.1	270.5	271.5	272	272.9	273.4	274	274.3	273.8	272.9	271.8	271.6	270.9	270.5	270.5	270.5	270	269.5	269.3	268.8	268.4
	Wind (m/sec)	16.6	19.6	16.5	11.1	18.9	15.9	13.2	17.9	22.9	17.1	14.4	18.5	18.6	14.3	14.1	17	15.7	17.5	14	18.7	17.5	19	30.2	13.6
2011/12/5	CloudMon	○	○	○	○	⊙	⊙	◎	◎	◎	◎	△	△	△	△	△	△	◎	◎	△	△	△	△	△	△
	T_WS (K)	268.4	268.4	267.9	268.3	269.1	270	270.6	270.9	271.3	271	270.6	269.7	268.9	268.7	268.2	268	267.6	267.3	266.8	266.2	266	265.8	265.5	265.5
	Wind (m/sec)	19.2	22.3	26.4	31.2	25.3	27.7	28.3	28.3	28.2	31.8	36.4	37.7	28.8	20.6	34.6	33.9	24.9	30.8	34.4	26.5	30.9	31.3	27.9	26.3
2011/12/6	CloudMon	△	⊙	⊙	⊙	○	◎	△	△	◎	⊙	⊙	⊙	⊙	○	○	○	○	○	⊙	○	⊙	◎	◎	△
	T_WS (K)	265.3	265.1	264.8	265	265.1	265.3	265.3	265.8	265.8	266	266.1	265.2	264.2	263.6	263.2	262.9	262.6	262.8	263.3	263	262.7	263.1	261.8	261.8
	Wind (m/sec)	20.9	27.7	19.5	18.5	23.1	27.6	28.9	27.6	23.9	24.7	21.9	23.9	18	18	21.6	17.1	16.4	16.5	16.2	13.7	15.4	13.8	7.2	7.8
2011/12/7	CloudMon	△	△	△	△	△	△	△	△	△	△	△	◎	⊙	⊙	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	262.6	262.2	262.6	262.8	264.2	265.3	266.2	266.4	266.7	266.5	266.6	266.7	265.2	264.6	264.6	263.6	263.7	264	264	262.2	263.4	262.5	263	262
	Wind (m/sec)	20.9	27.7	19.5	18.5	23.1	27.6	28.9	27.6	23.9	24.7	21.9	23.9	18	18	21.6	17.1	16.4	16.5	16.2	13.7	15.4	13.8	7.2	7.8
2011/12/8	CloudMon	○	○	○	○	○	⊙	△	△	△	△	△	△	△	△	△	△	◎	◎	△	△	△	△	△	△
	T_WS (K)	261.4	262	262.2	262.9	264	265.3	266.7	267.3	267.5	268.2	267.9	267.7	267.1	266.9	266.6	266.1	265.8	265.5	264.5	264.9	264	264.2	263.7	263.6
	Wind (m/sec)	10.2	10.2	13.5	16.4	17.3	18.2	17.7	20.4	23.9	22	23.6	23.3	20.1	20	22.8	21	22.5	18.1	10.9	33.5	29.5	27.4	27.4	24.7
2011/12/9	CloudMon	△	▲	▲	△	△	△	△	△	△	△	◎	⊙	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	263.3	262.7	262.6	262.3	263.6	263.7	264.4	264.8	265.3	265.1	265.2	264.7	263.6	262.9	262.3	262.1	262	261.9	261.3	261.1	261.2	260.8	259.3	259.7
	Wind (m/sec)	18.9	18.6	10.5	10.3	16.2	20.5	14.8	20	15	21.5	21	19.2	15.8	11.6	9.6	8.6	6.7	6	4.2	7.4	7.6	7.7	4.7	3.4
2011/12/10	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	259.1	257.9	257.6	257.6	258.2	261.4	261.8	263.5	263.5	263.9	263.6	263.8	263	262.6	262.1	261.6	261.4	261.4	261.2	260.9	260.6	259.4	259.3	259.1
	Wind (m/sec)	2.5	3.3	2.3	7.5	9.6	1.8	4.6	7.1	6.7	10.2	12.1	11.8	7.1	7.3	8.7	7.6	8.3	5.2	5.4	2.3	1.2	1.2	2	1.9
2011/12/11	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	259.2	258.8	258.4	258.8	259	260.1	261.6	263.2	263.8	266.2	266.4	265.7	265.1	264.6	264.4	263.9	263.4	262.9	262.5	262.5	262.2	261.7	261.3	260.8
	Wind (m/sec)	4.6	4.6	1.8	1.9	3.8	2.5	2.7	5.3	1.3	6	9.9	11.8	13.3	10.3	10.3	7	5.5	7.7	10.8	5.3	3.7	4.6	4.1	4.8
2011/12/12	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	260.2	259.8	259.7	261.9	261.9	263.2	264.5	265.3	265.4	265.6	265.6	265.6	264.7	263.9	263.2	262	261.7	261.7	260.9	260.8	260.9	260.7	260.4	259.6
	Wind (m/sec)	5.3	3.3	5.2	6.3	4.7	6.5	8	14.8	11.5	20.6	20.8	16.2	16.7	13.2	14.8	16.1	17.5	18.8	17.3	21.6	18.5	19.3	17.6	13.6
2011/12/13	CloudMon	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	T_WS (K)	259.9	260.2	259.7	260.4	261.6	263	264.1	264.9	265.3	266	265.9	265.5	264.6	263.5	263.2	262.4	262.3	262.3	262.3	262.2	262.5	262.4	262.4	262.4
	Wind (m/sec)	11.9	18.8	18.8	17	14.5	19.3	17.2	21.7	22.2	24.2	24	22	19.4	21	7.1	13.2	17.6	17.4	18.4	22	17.2	15.9	10.9	7
2011/12/14	CloudMon	○	○	○	○	○	○	○	○	⊙	○	○	○	○	○	○	○	⊙	◎	◎	△	△	△	△	◎
	T_WS (K)	261.6	261.9	261.3	261.7	262.5	263.3	264.3	265	265.4	265.5	265.9	265.7	264.7	263.6	263.3	262.8	262.8	262.4	262	261.5	261.4	261.3	260.8	260.4
	Wind (m/sec)	12.5	12.3	17	15.2	14.3	19.5	15.3	16.3	12.2	20.7	21	23.2	17.8	16.7	18.8	20	18.7	11.5	9.9	18.6	14	13	16	14.5
2011/12/15	CloudMon	◎	◎	⊙	⊙	⊙	⊙	○	◎	◎	◎	◎	◎	⊙	○	○	○	○	○	○	⊙	⊙	△	△	○
	T_WS (K)	260	259.9	259.7	260.2	260.9	261.8	262.7	263.1	264.1	264.5	264.6	263.9	263	262.3	261.7	261.1	260.6	260.3	259.8	259.7	259.8	259.8	260.2	260
	Wind (m/sec)	26.2	22.3	22.6	22.8	25.9	22.9	20.1	21.7	18.9	25.3	29	19.7	24	21	21.2	18.6	20.2	18.6	10.8	12.2	15.4	12.8	14.7	11.1
2011/12/16	CloudMon	○	○	○	○	○	○	○	○	○	⊙	◎	◎	△	◎	◎	⊙	⊙	⊙	◎	◎	△	⊙	⊙	○
	T_WS (K)	260.7	260.5	260.2	260.5	261.3	262.7	263.2	263.6	264.5	265.1	265.8	265.6	264.6	263.5	263.2	262.7	262.4	262.3	262.1	262.5	262.5	262.3	262.1	262.1
	Wind (m/sec)	10.8	7.9	14	15.5	21.5	23.4	16.3	19.4	17.5	22.1	23.7	19	23.1	15	15.9	13.5	14.4	12.1	9.1	14.1	12.6	10.8	11.2	7.9
2011/12/17	CloudMon	○	○	⊙	○	⊙	△	△	◎	◎	◎	△	△	◎	◎	△	◎	⊙	⊙	⊙	◎	△	△	△	△
	T_WS (K)	262.3	261.9	262	262.3	263.2	264.2	264.6	264.8	265.7	266	266.2	266	265	264.2	263.6	263	262.7	262.6	262.3	261.6	261.4	261.6	261.5	261.4
	Wind (m/sec)	10	14	12.6	8	6.3	8.9	6.9	13.2	15.5	16.8	15.9	16.1	19.6	15.1	17.7	16.3	17.2	12.4	14.7	12.8	17.3	19	13.9	11.9
2011/12/18	CloudMon	△	△	△	⊙	◎	◎	◎	△	△	△	◎	○	○	○	○	○	○	○	○	○	○	○	○	○

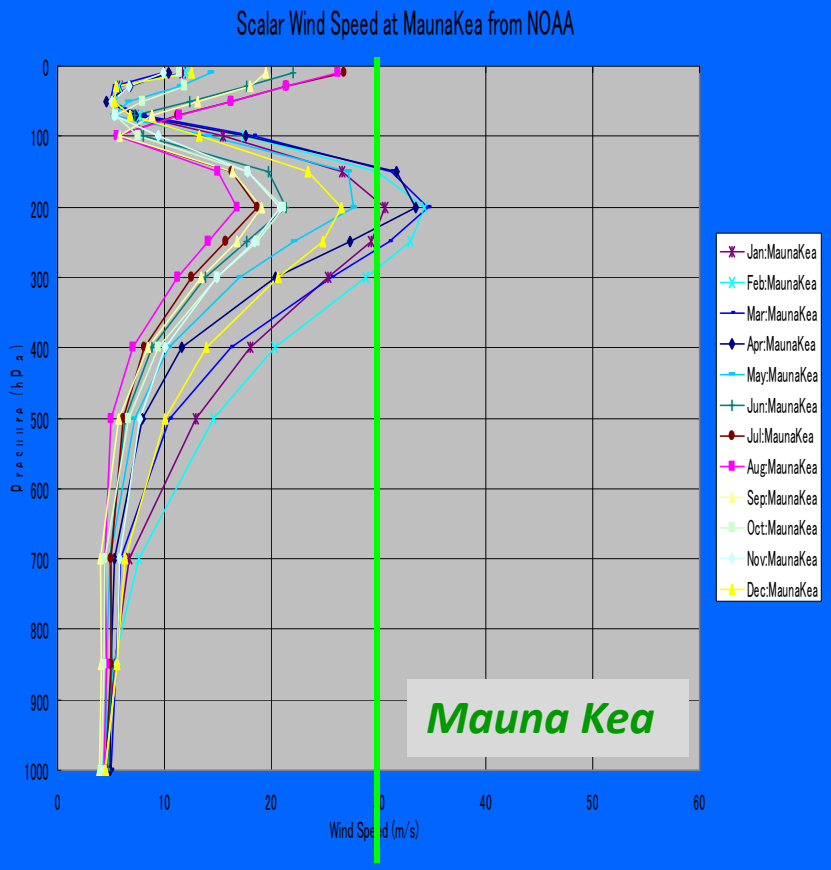


Clear sky ratios at ***Gar***, except unknown summer season, are around 65%, which are nearly comparable to at Mauna Kea and Haleakala, Hawaii.

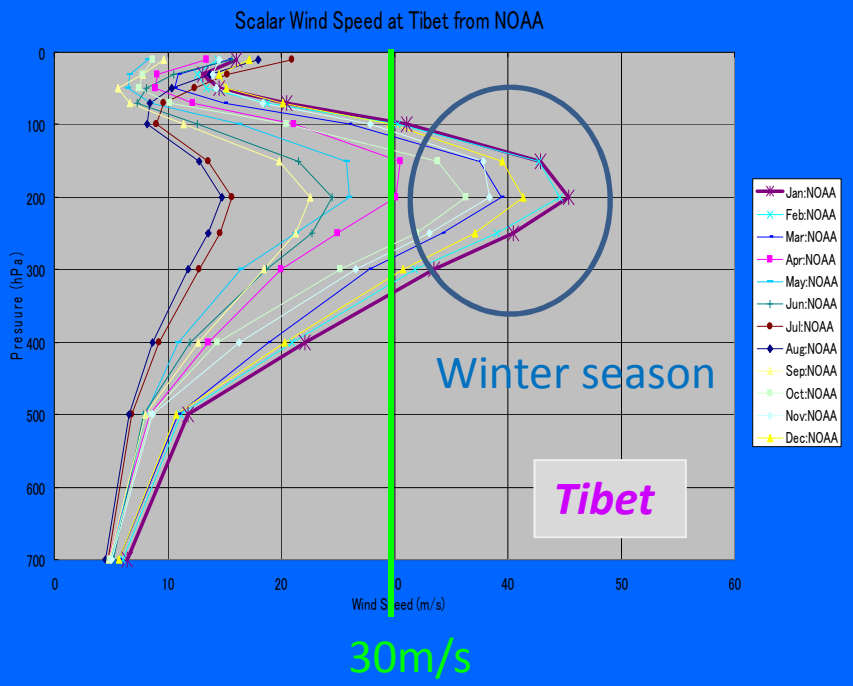
Subaru : statistics during 2000-2010
Haleakala: after Suganuma et al. 2007, *PASP*, 119, 567.
OAO: summary report during 2008-2010

Wind Speed at Tibet and Mauna Kea at 200mb

➡ Stronger wind in winter in ***Tibet*** than over ***Mauna Kea***



30m/s



30m/s

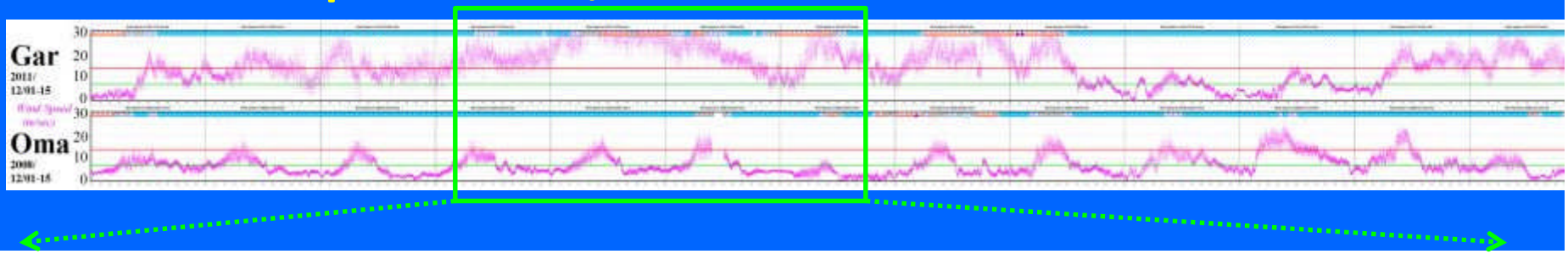
[200mb around altitude～12,000 m]

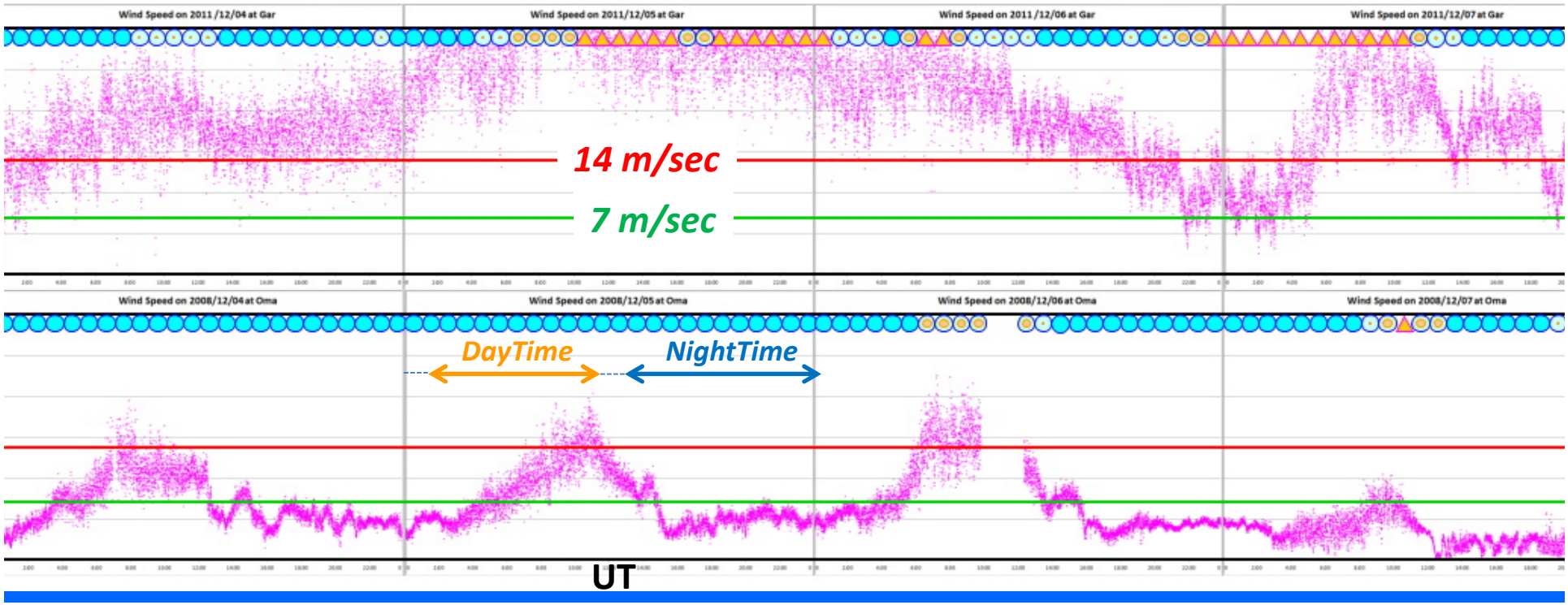
From ¥01SatelliteData¥NOAAData¥AstronomicalSites¥AllSites200mb.xls

Gar/Ali Evaluation matters

(2) Strongly Windy condition in winter season,

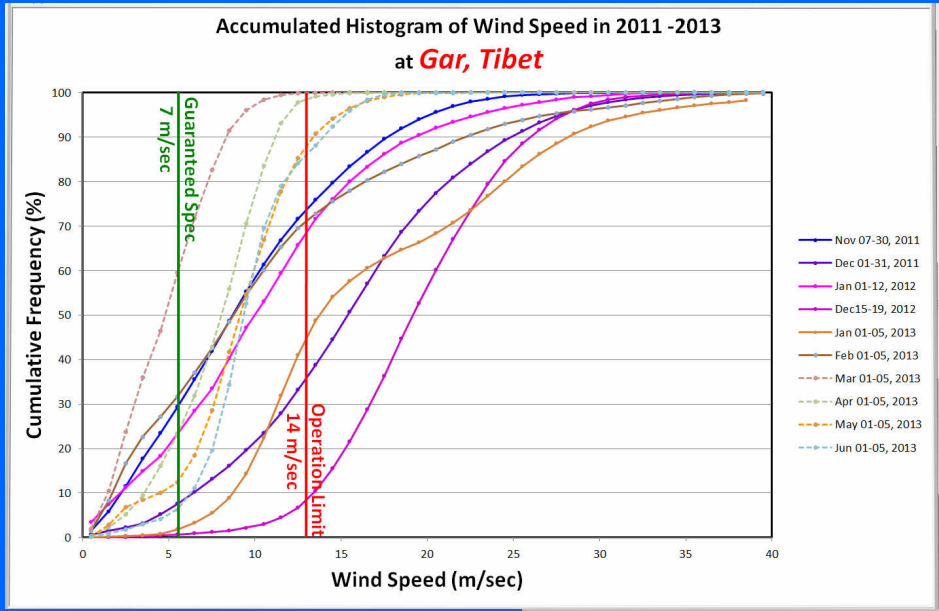
- Wind Speed in Dec, 2011 at *Gar* and 2008 at *Oma*

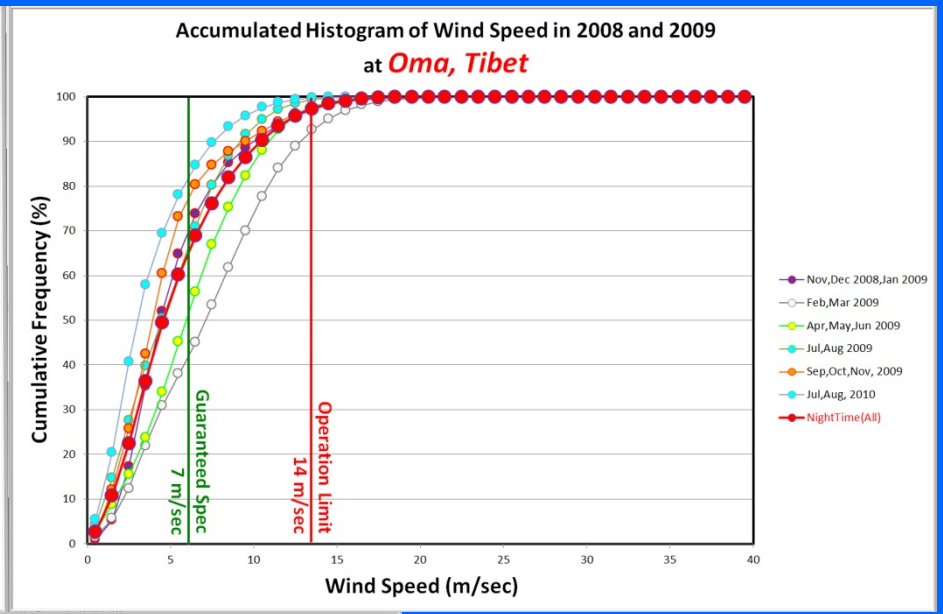


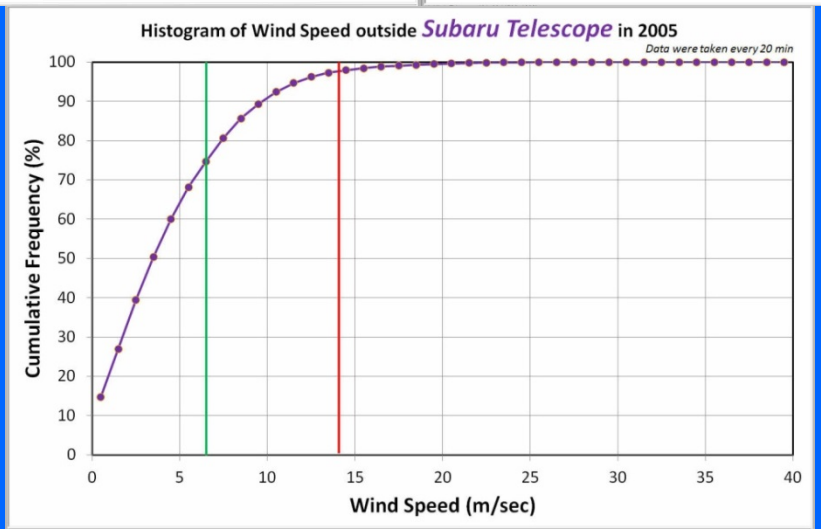


Gar/Ali Evaluation matters

(2) Strongly Windy condition in winter season,
- detected in Nov-Jan, 2012 and Dec-Jan, 2013







Gar/Ali Evaluation matters

(2) Strongly Windy condition in winter season,
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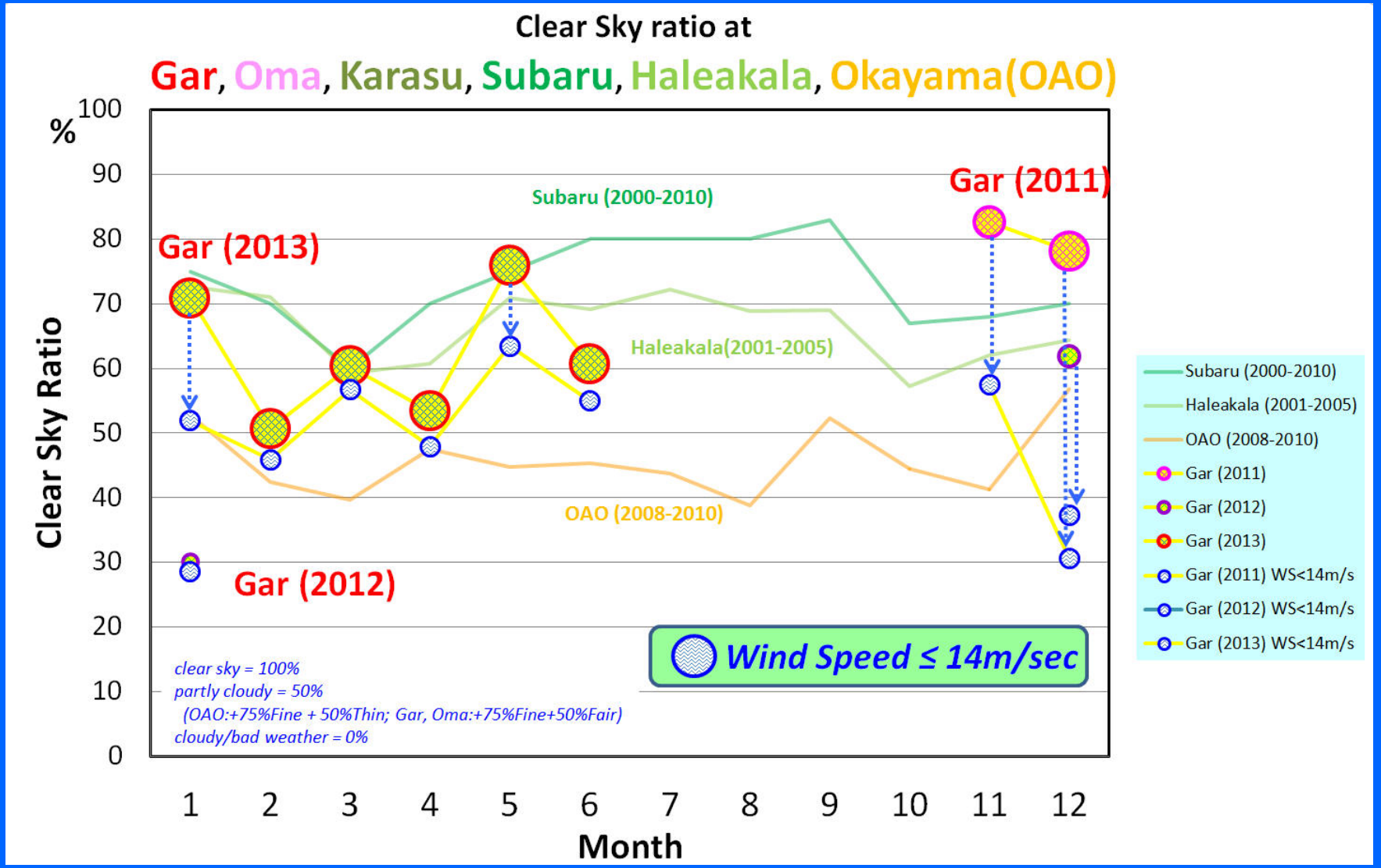


Other Candidate Sites in Ali area?

Weather Research and Forecasting (WRF) Model

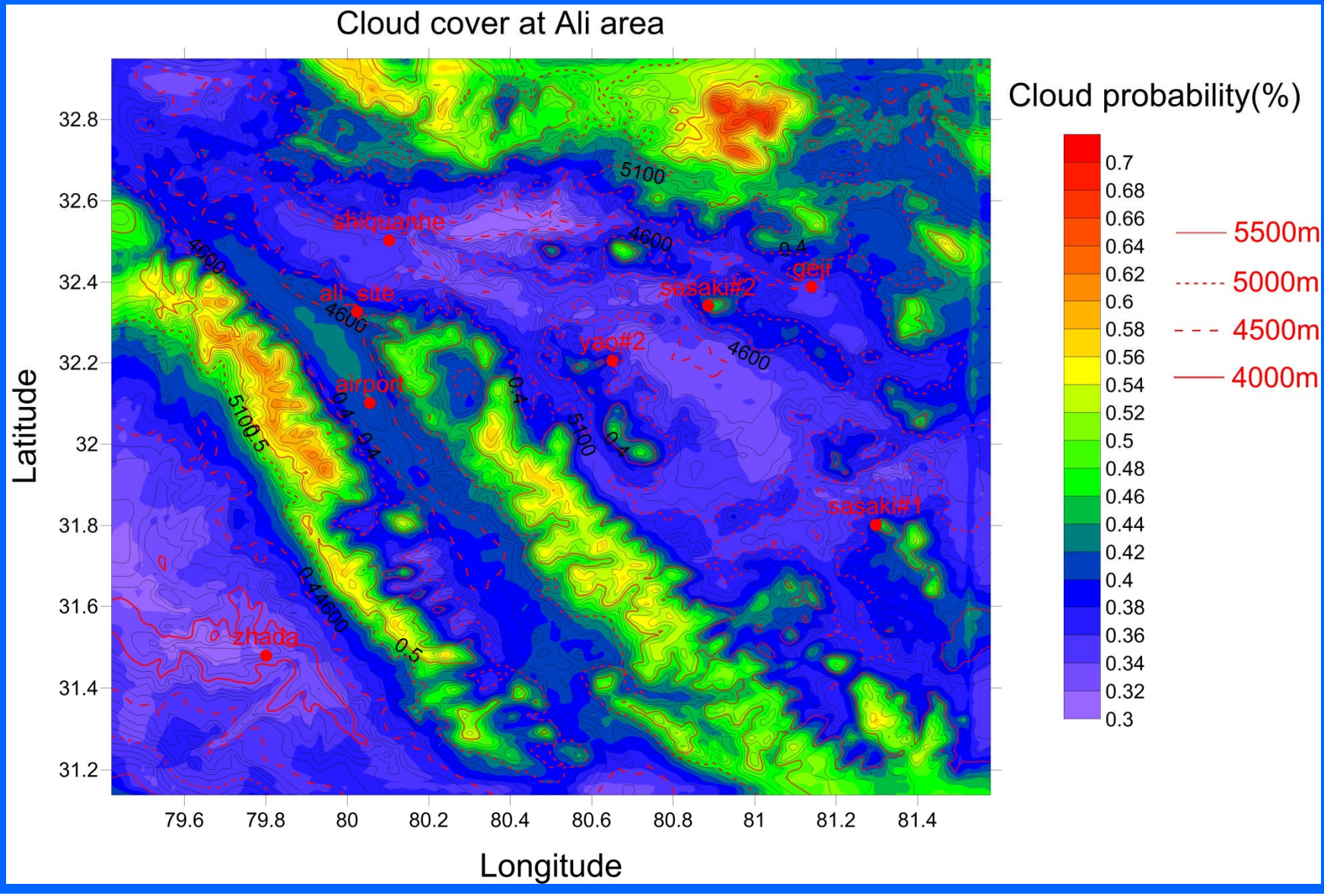
NCAR(National Center for Atmosphere Research) and NCEP(National Centers for Environmental Prediction).

Dr. Hongshuai **Wang** (王紅師) and Prof. **Yao** has simulated weather conditions for 72 days over 2010 around Ali area(200km × 200km) with ***1km*** horizontal resolution and vertical resolution is 65 levels from ground to 30km(1000Pa).

- Cloud Cover at Ali area
- Wind Speed and Direction
- PWV at Ali area
- Seeing distribution over Ali area

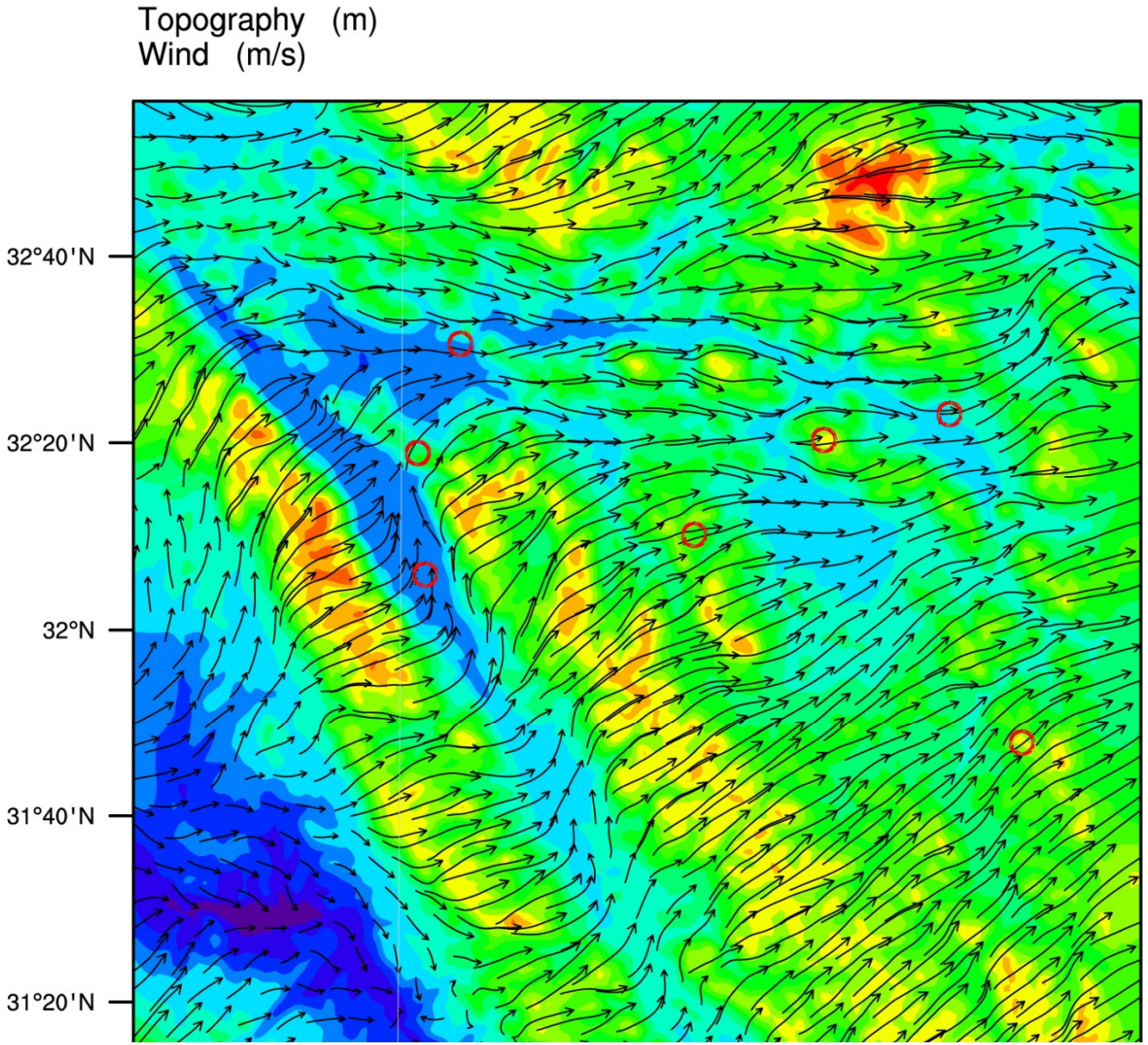
Other Candidate Sites in Ali area?

Weather Research and Forecasting (WRF) Model



Other Candidate Sites in Ali area?

➔ ***Weather Research and Forecasting (WRF) Model with higher spatial resolution***



Other Candidate Sites in Ali area?

Weather Research and Forecasting (WRF) Model

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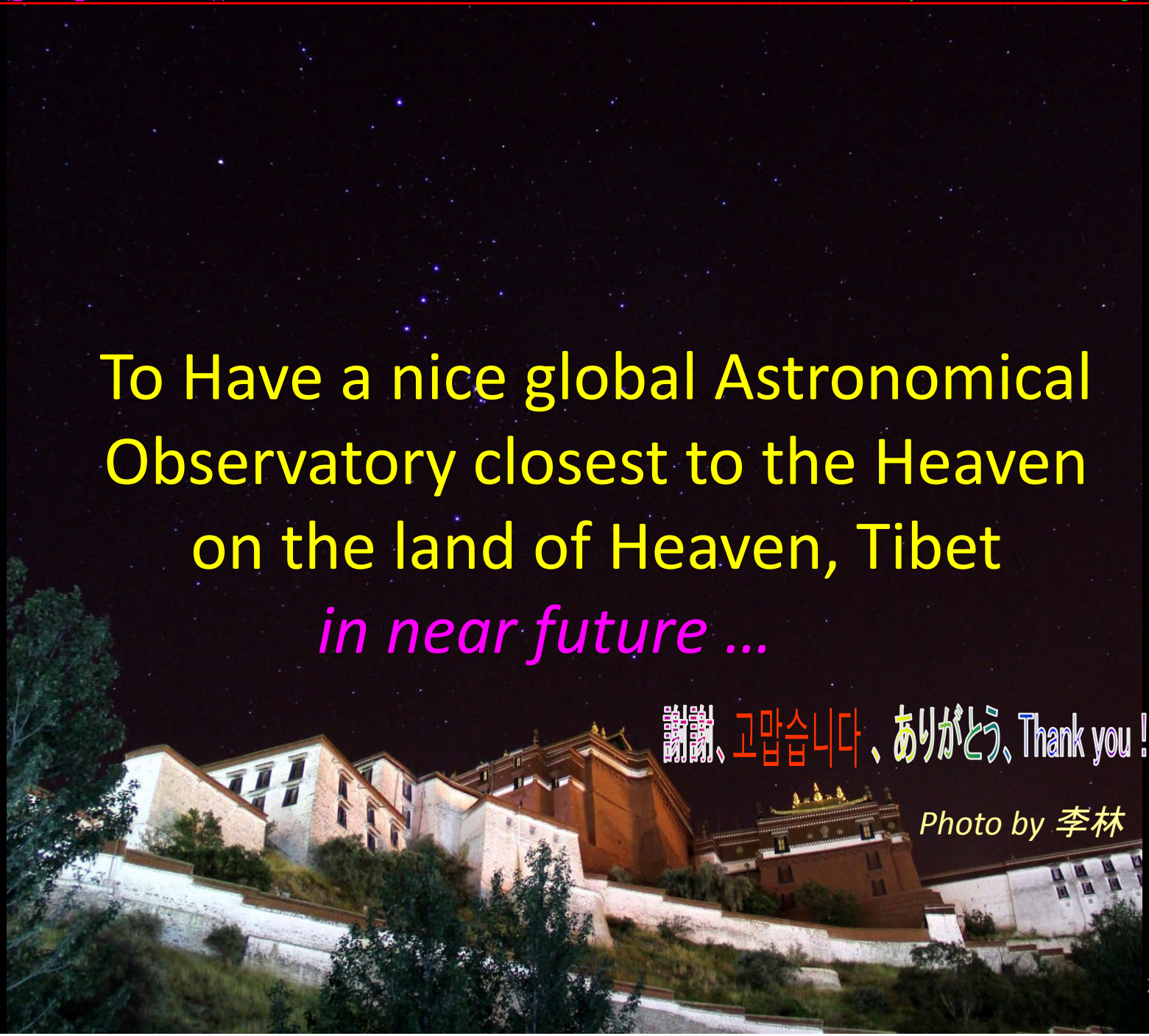
- Cloud Cover at Ali area
- Wind Speed and Direction
- PWV at Ali area
- Seeing distribution over Ali area

➔ ***to find more suitable site(s) around Ali ,***
WRF Model with higher spatial resolution of ～100m resolution
in an special area of several km


To Have a nice global Astronomical Observatory closest to the Heaven on the land of Heaven, Tibet
in near future …
謝謝、고맙습니다 、ありがとう、Thank you !
Photo by 李林

http://sasakihome.info/~sasaki/TibetSiteSurvey/index.html