

China-Japan Collaborative Site Testing in West China - A report by Japanese group -

Toshiyuki Sasaki (NAOJ)

on behalf of Site Survey Team

Prof. Yongqiang Yao (NAOC/China),

M. Yoshida(Hiroshima-u), N. Ohshima, Y. Mikami, N. Okada, H. Koyanao,

S. Nagayama, K. Sekiguchi , H. Ando (NAOJ/Japan),

L. Liu (NAOC) and Chinese collaborators

Contents

- Background and monitoring instruments
- Site monitor showing good conditions in winter at Oma/Tibet
 - Clear Sky ratio observed with CloudMon
 - image deterioration measured with micro-thermal (C_T^2) sensors

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- Site monitor showing good conditions in winter at Oma/Tibet
- Telescope Plan near Ali and possible 4m telescope in future for Asian astronomers

Collaborative Site Testing in West China

Summary

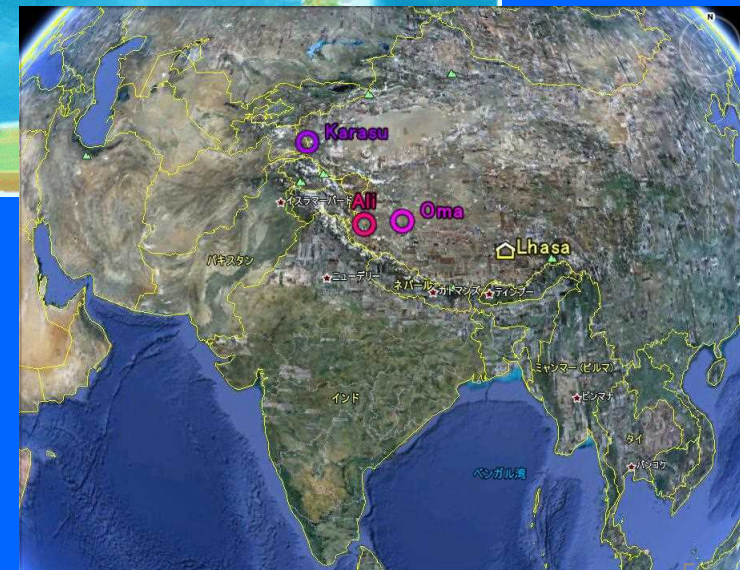
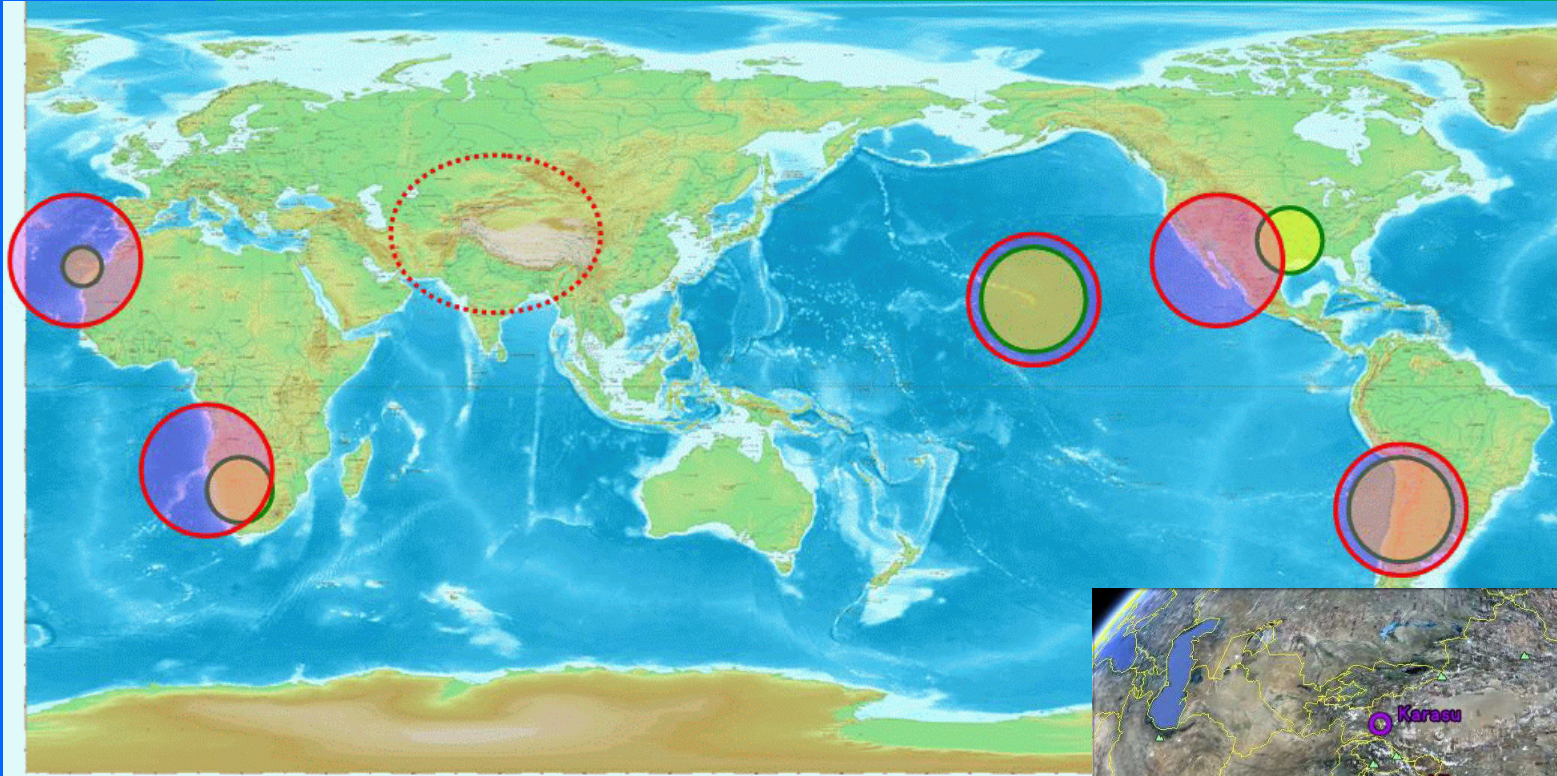
- 1) **Site Survey and testing** has been conducted since 2003, led by Prof. Y. Yao, and two weather-monitoring stations have been settled at **Karasu** (Xinjiang) and **Oma** (Tibet).
- 2) Japanese team has joined the site survey project after the workshop at Lhasa, 2004. We introduced **MIR cloud monitor** cameras, atmospheric micro-turbulent C_T^2 sensors, and weather stations at both sites.
- 3) At **Oma** site, **cloud monitor camera** revealed excellent sky conditions in winter, but not good in summer.
- 4) Nominal seeing measured with C_T^2 was less than 0.1 arcsec up to 36m height in Nov. 2008. We must conduct seeing measurement through whole atmosphere w/ DIMM/MASS/(SNODAR) to evaluate seeing condition at the site soon.
- 5) Strong winds have been observed at **Oma** in winter season, which may affects seeing seriously.
- 6) We are settling site survey instruments at possibly best site near **Ali** in west Tibet.

Collaborative Site Testing in West China

Summary

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- 5) Strong winds have been observed at **Oma** in winter season, which may affects seeing seriously.
- 6) We are settling site survey instruments at possibly best site near **Ali** in west Tibet.
- 7) We are discussing to deploy a small telescope w/some observation instruments and negotiating to introduce a possible 4m telescope near **Ali**.

A site in west Tibet is in an important location for global astronomical observation network



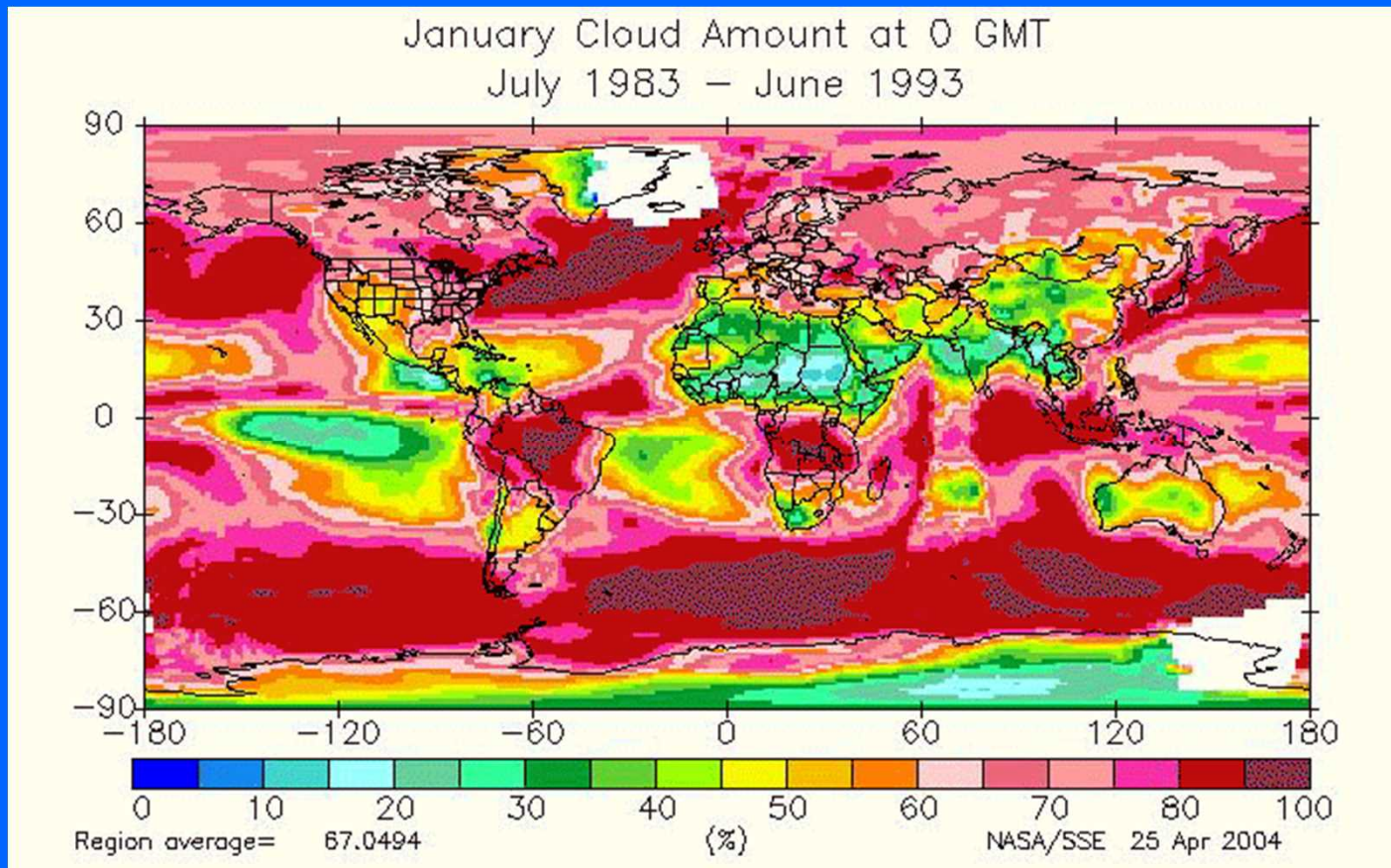
sites in west China; Karasu, Oma, and Ali

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 .

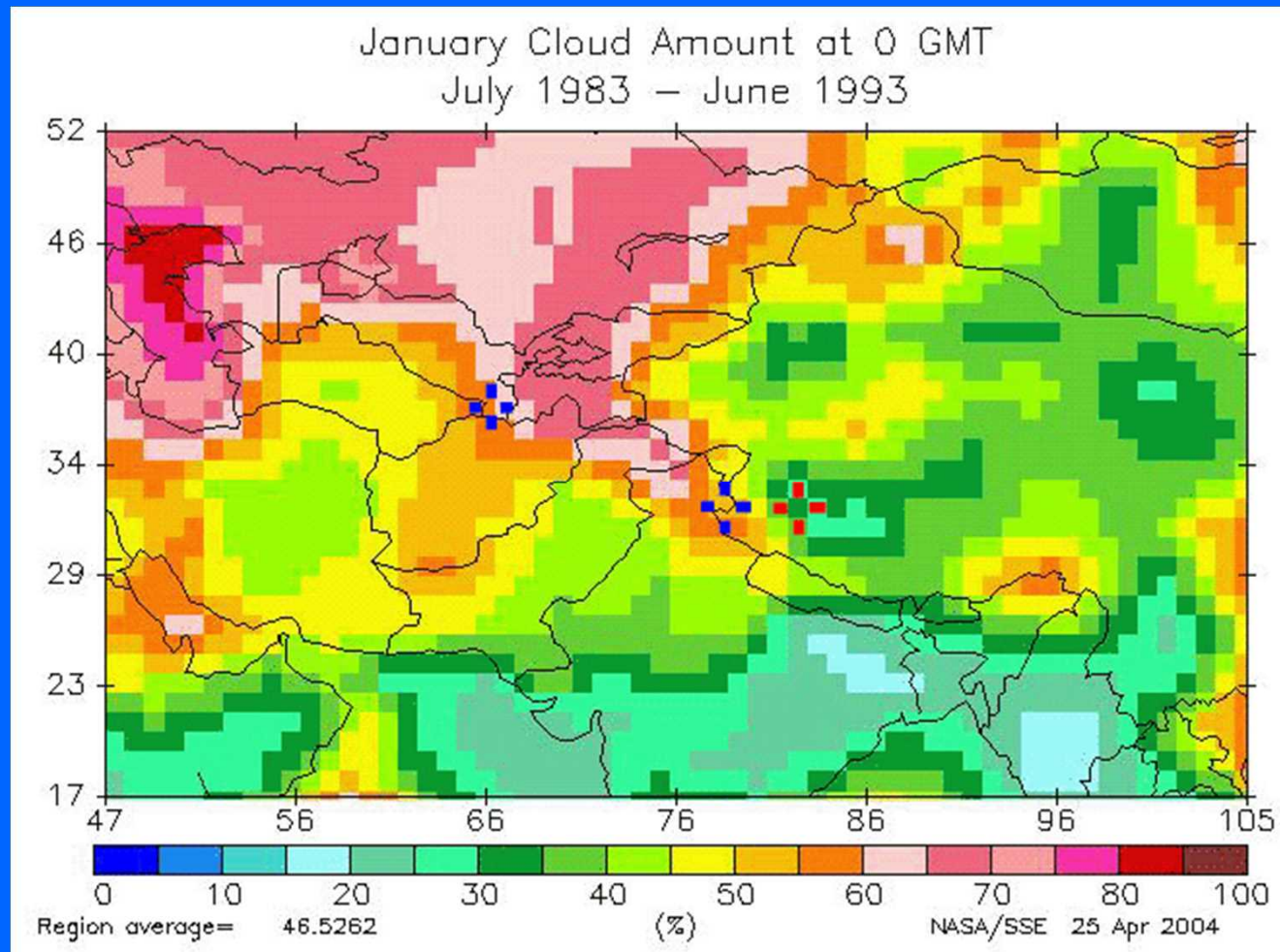
Refer to <http://eosweb.larc.nasa.gov/sse/>
Meteorology and Solar Energy
Global/Regional Plots

Global Cloud Distribution



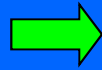
Cloud map around west China

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



Wind Speed at Tibet and Mauna Kea at 200mb

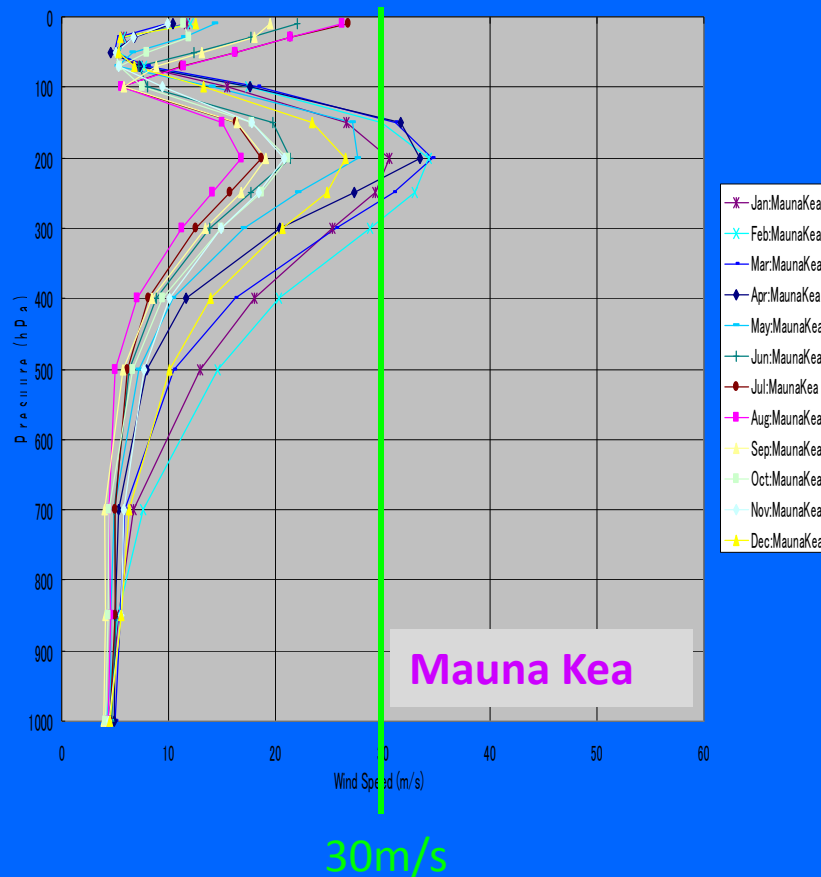
Wind speed at 200mb (altitude ~12000m) shows correlation with seeing size



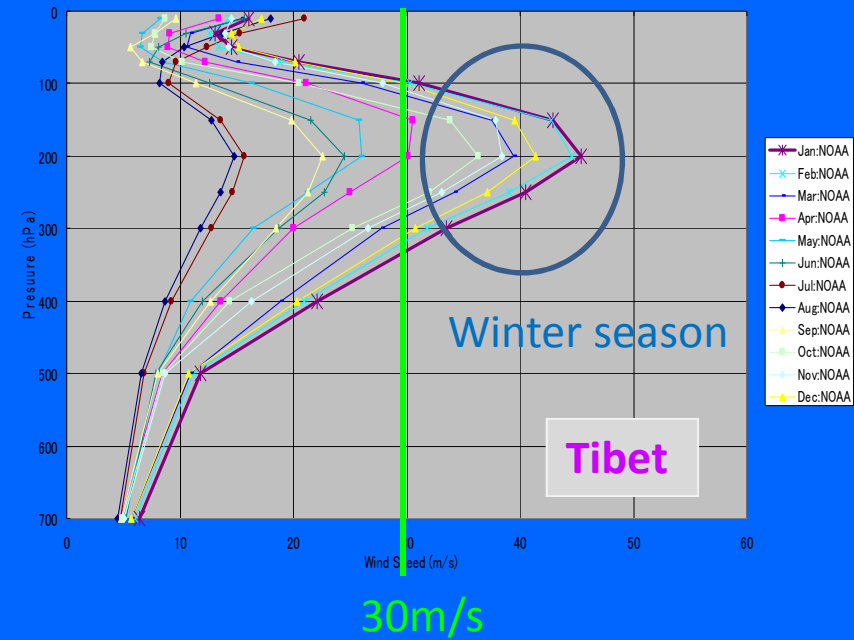
Does it mean bad seeing during winter at Tibet?

(Vernin 1986 SPIE 628,142)

Scalar Wind Speed at MaunaKea from NOAA

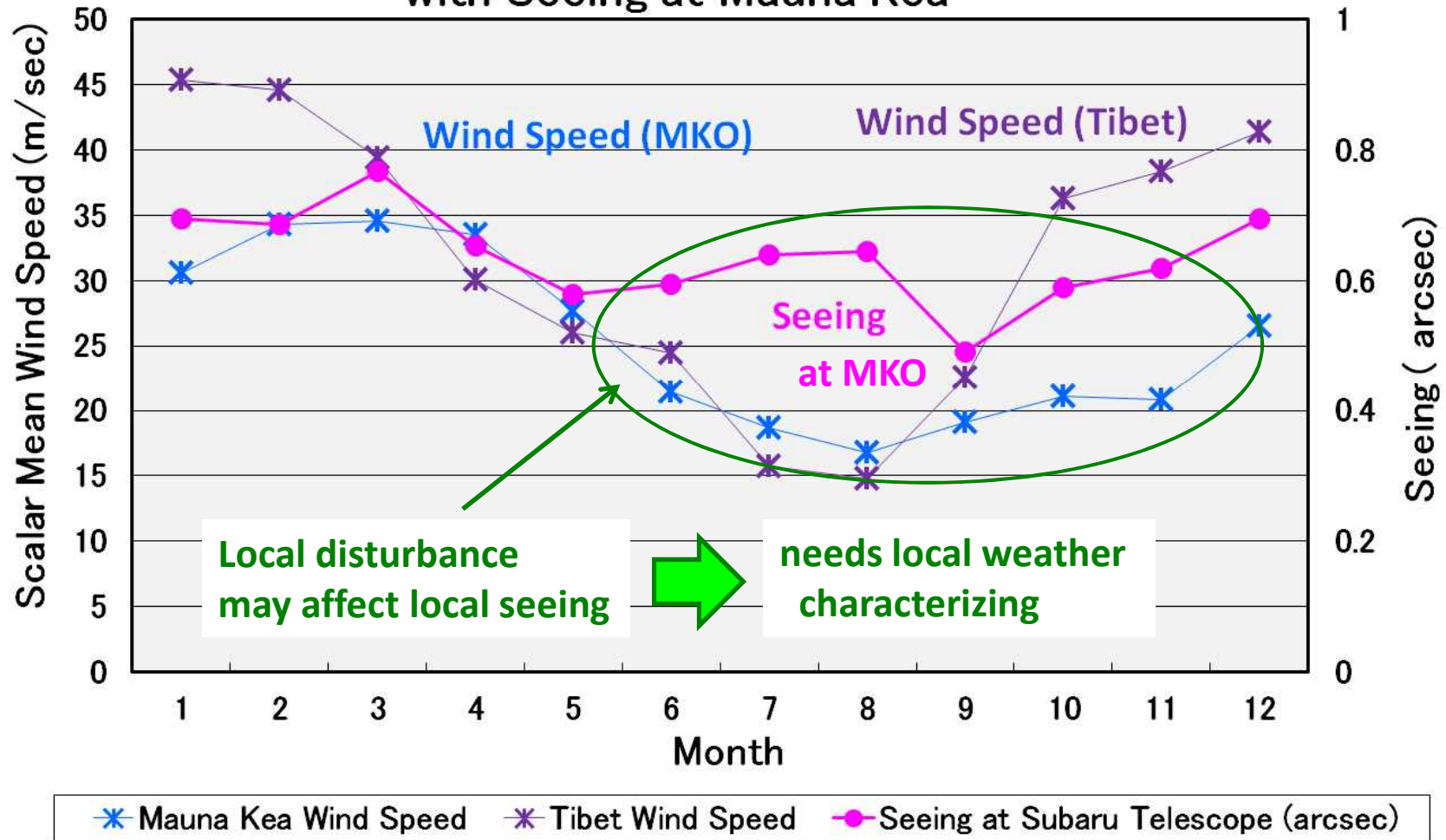


Scalar Wind Speed at Tibet from NOAA

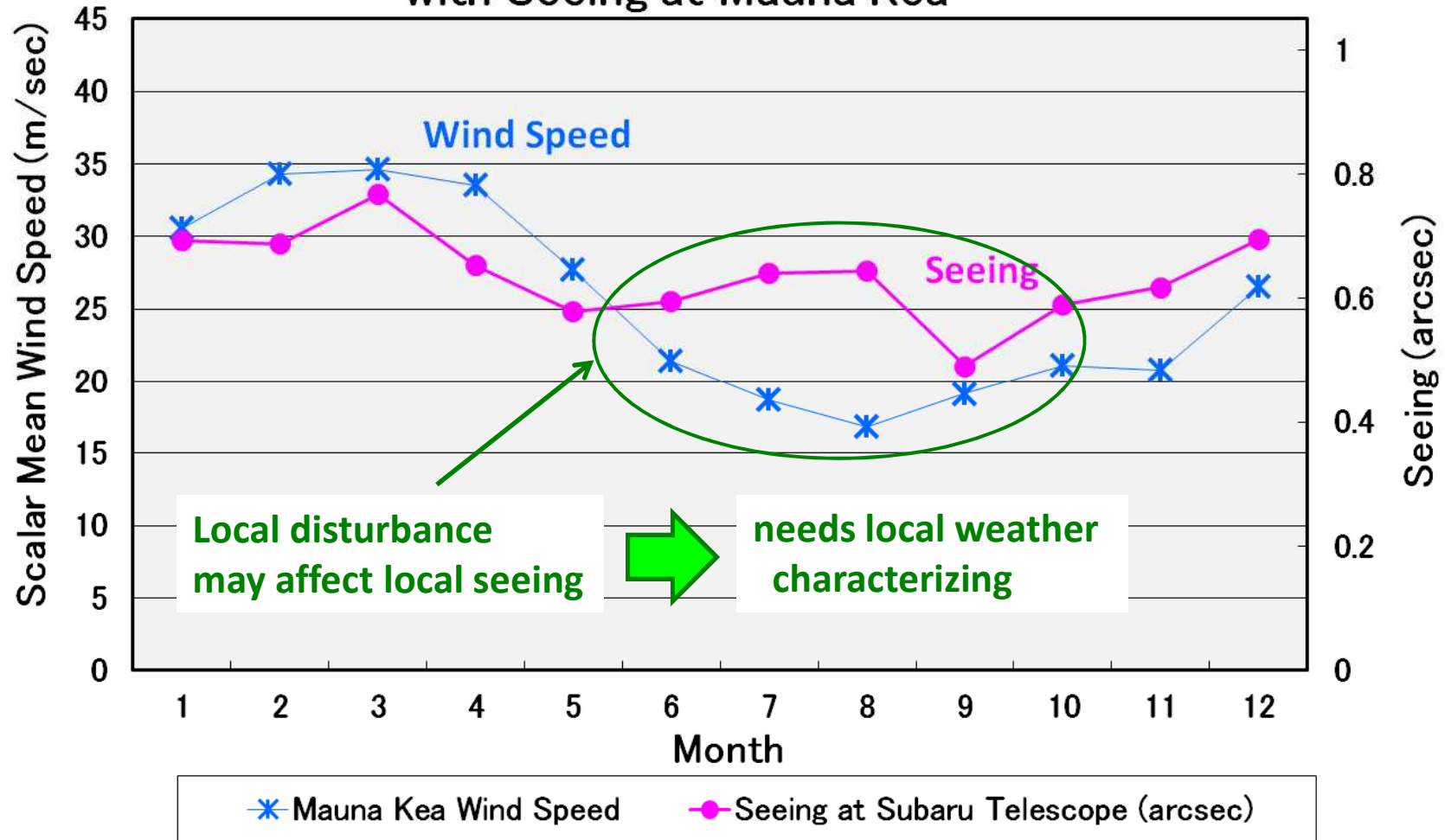


From ¥01SatelliteData¥NOAAData¥AstronomicalSites¥AllSites200mb.xls

Comparison of 200mb Wind Speed with Seeing at Mauna Kea



Comparison of 200mb Wind Speed with Seeing at Mauna Kea



Site Surevy Project in west China

中国西部選址的協力

Future telescope plan is considered on base of
Science, Telescope, Instruments and Site.

Site is one of the very important factors for future telescopes.

Site Characteristics:

Clear night, less Cloudiness ← **most important !**
Seeing
precipitable water vapor
Wind strength
Scale height of ground-layer turbulence
coherence time
wavefront outer scale
dust
Earthquake
Accessibility

Infrastructure at Site:

Access road
Housing / Rest room
Electric Power
Water supply
Lab house
Internet connection

Food, Bed
O₂ supply for people at high mou

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
SNODAR (planned)	Surface layer Non-Doppler Acoustic Radar	Scintillation	8m~200m
SODAR (NOT exists)	Sound detection and ranging	Scintillation	15m~1-2km

^{\$} * Currently available instruments (^{\$}China 🇨🇳 , *Japan 🇯🇵)



Cloud Monitor

Weather Station

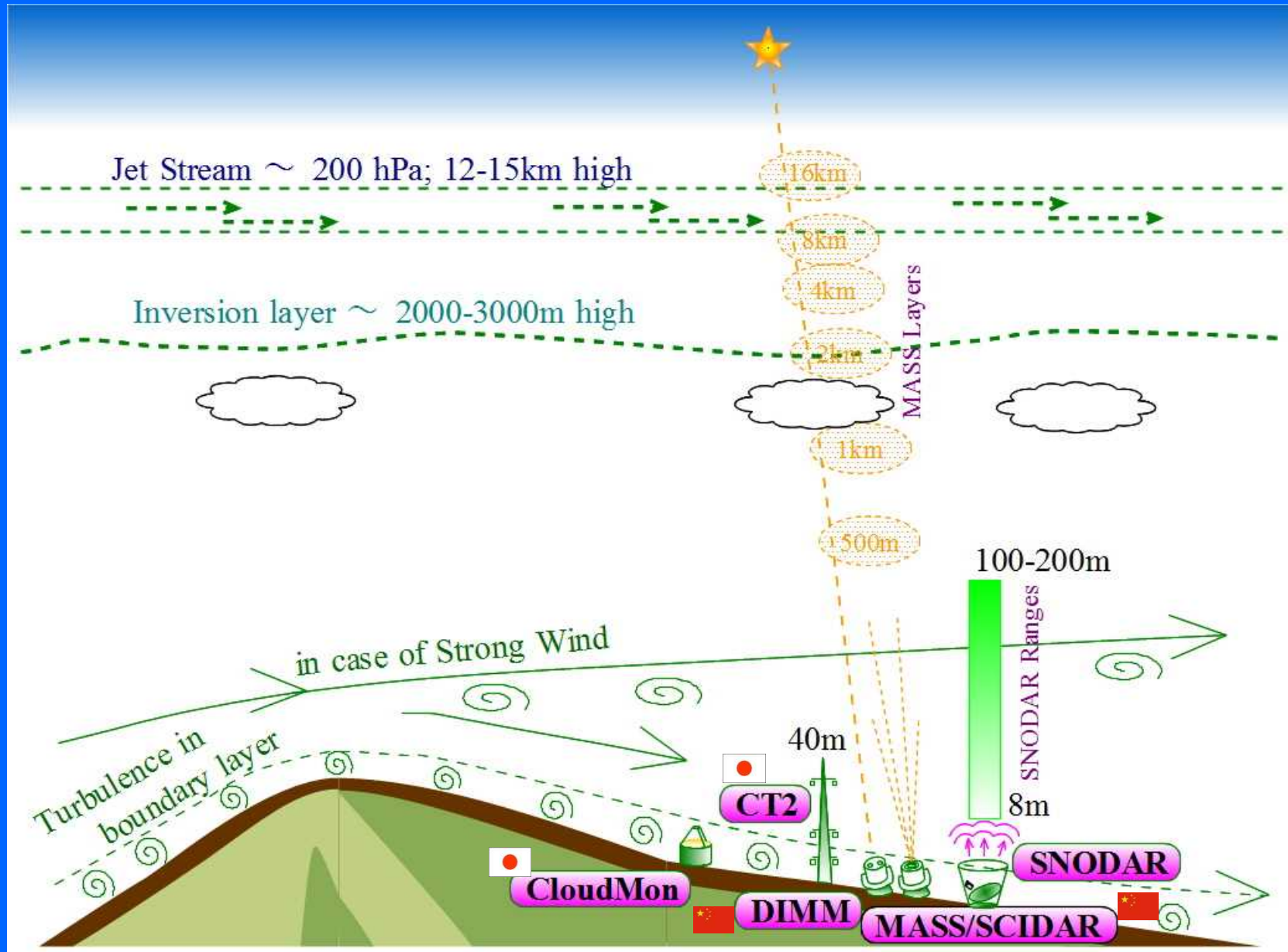
(at Ali)

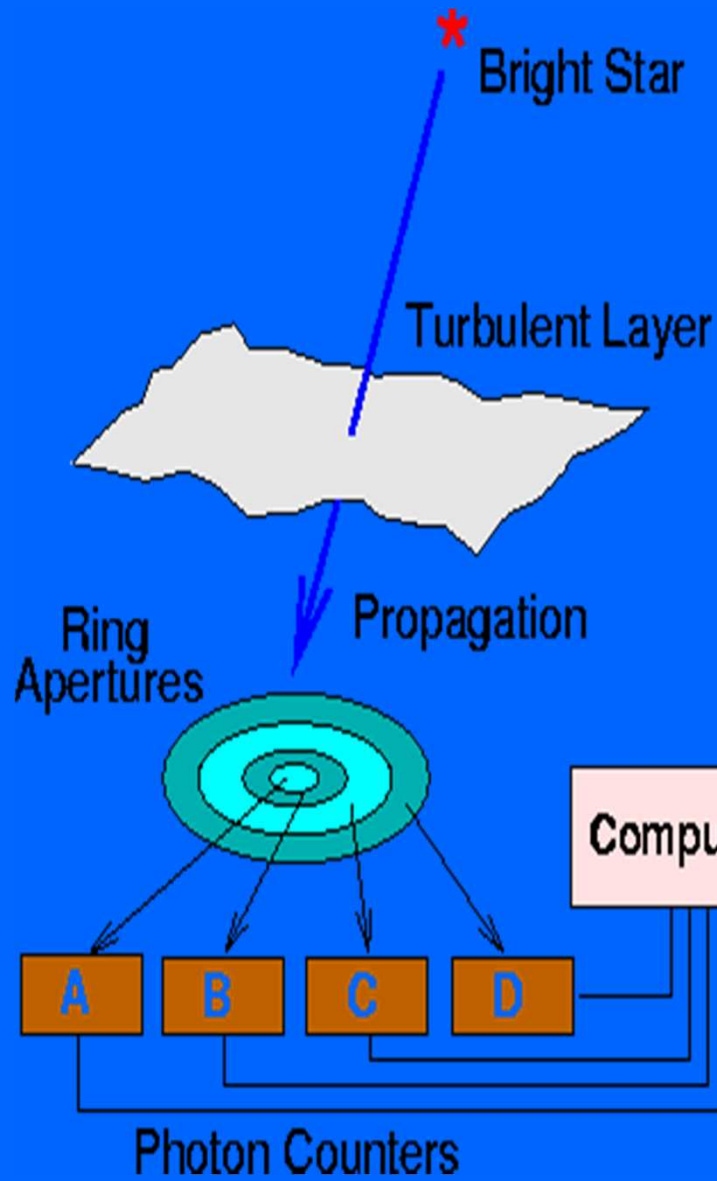


CT2 sensors on
40m tower

(at Karasu)

12

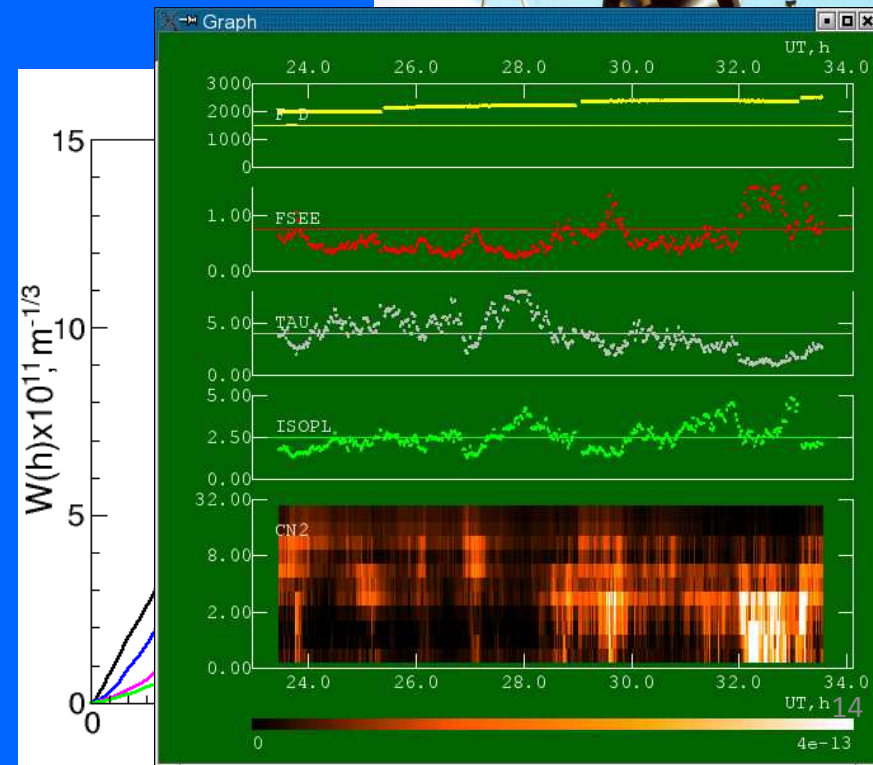
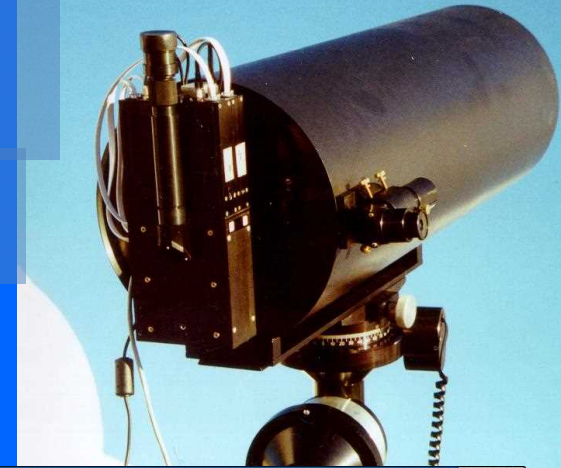




MASS

(Multi-Aperture Scintillation Sensor)
 Figures from V.Kornilov,
 A.Tokovinin,2004

6 fixed layers model
 (0.5, 1, 2, 4, 8, 16 km)

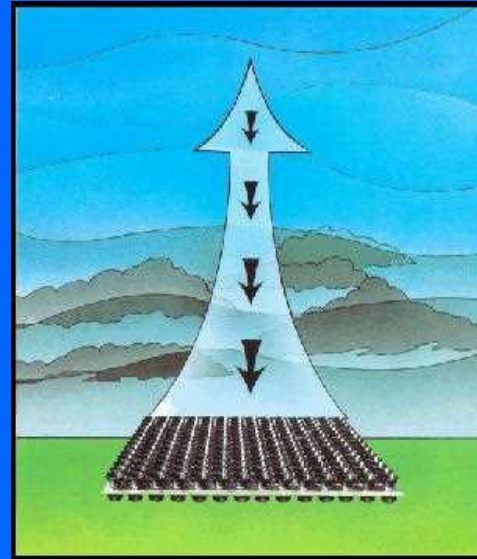


SODAR

(Sound detection and ranging)

Figures from
<http://www.remtechinc.com/sodar.htm>

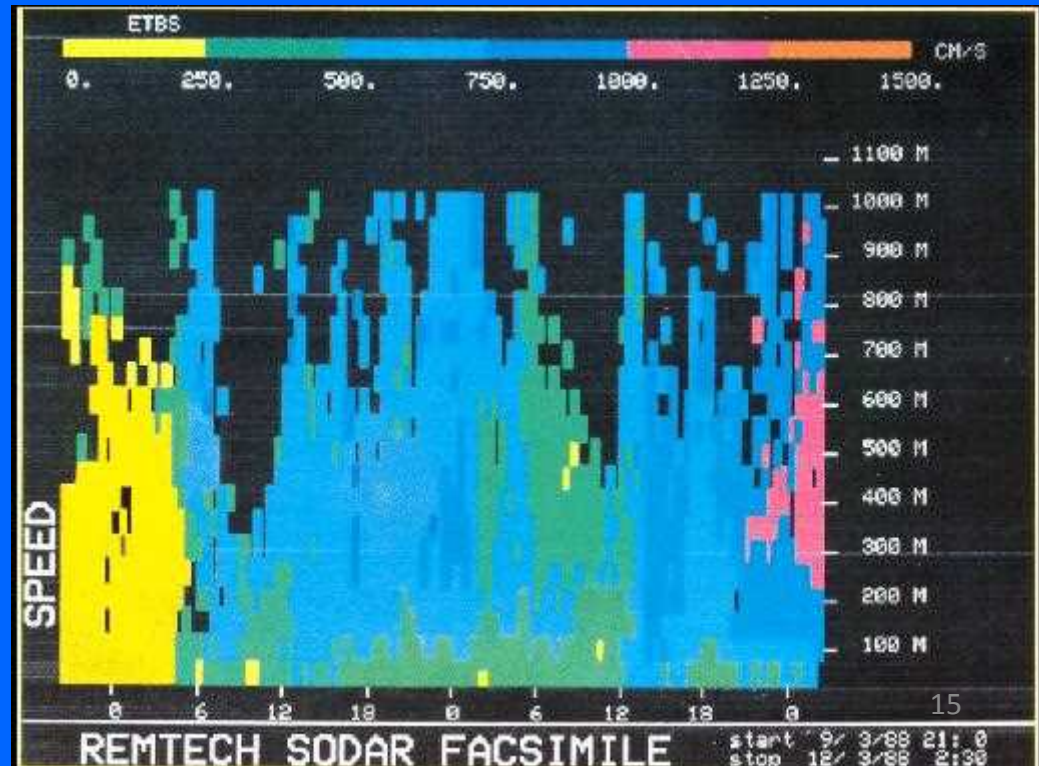
52 elements
 40 cm x 40 cm x 15 cm in size
 weight less than 20 kg



- An **acoustic pulse** into the atmosphere
- **Frequency shift** of the echo varies according to the **wind speed** (DOPPLER effect)
- **Echo intensity** varies according to **thermal turbulence and structure**.



SODAR for TMT site survey at MKO(2006)





DIMM/OAO (Yoshida 2004)

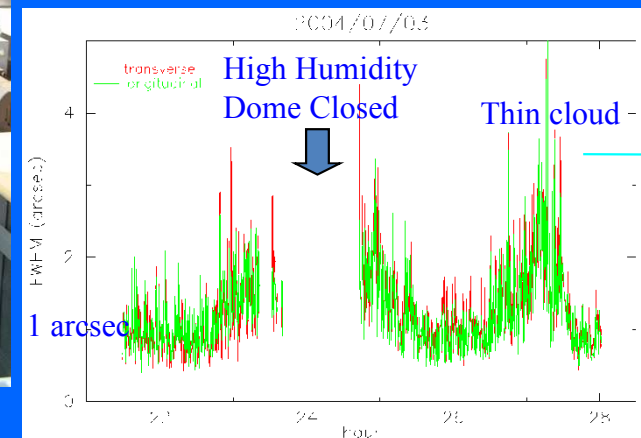
Meade 20 cm telescope

Two 4cm ϕ apertures with a separation of 15 cm

Image-Intensified CCD

Exposure time = 2 – 6.7 msec

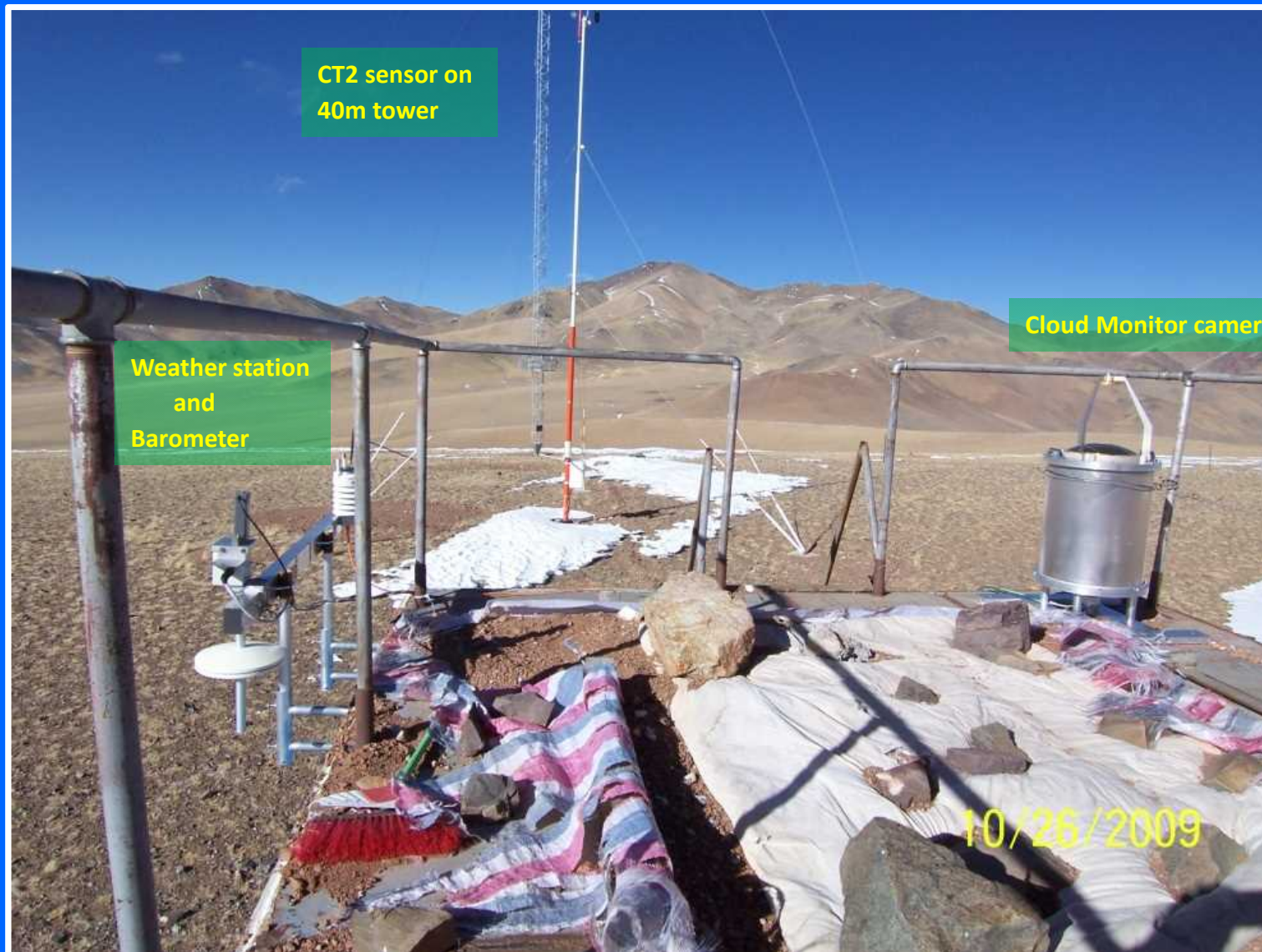
Data sampling interval = 1/30 sec



History of Site Survey in West China (Japanese group)

2004 Jul	Lhasa WS on Site Survey and Negotiation starts
2006 Mar	MOU between NAOC and NAOJ
2007 Mar	Install CloudMon w/ MIR camera at Karasu/Pamir
2007 Oct	Install CT2 system at Karasu/Pamir
2008 Jul	Relocate CT2 sensors at higher positions Car accident from Kashi to Hotan Visit Hami area. Total eclipse
2008 Nov	Install CloudMon, CT2 at Oma/Tibet Install WeatherStation WXT510 at Karasu
2009 Oct	Repair CT2 sensor system and replace RAID for data at Oma Extend MOU
2010 Dec	Move instruments at Oma to Ali Sasaki got " High altitude sickness " for 3 days in hospital
2011 Sep	Install CloudMonitor, Barometer, T-sensors and UPS at Ali
2011 Nov	Install WeatherStation WXT510, DustCounter at Ali
2012 Apr	Review Site survey project shall extend MOU

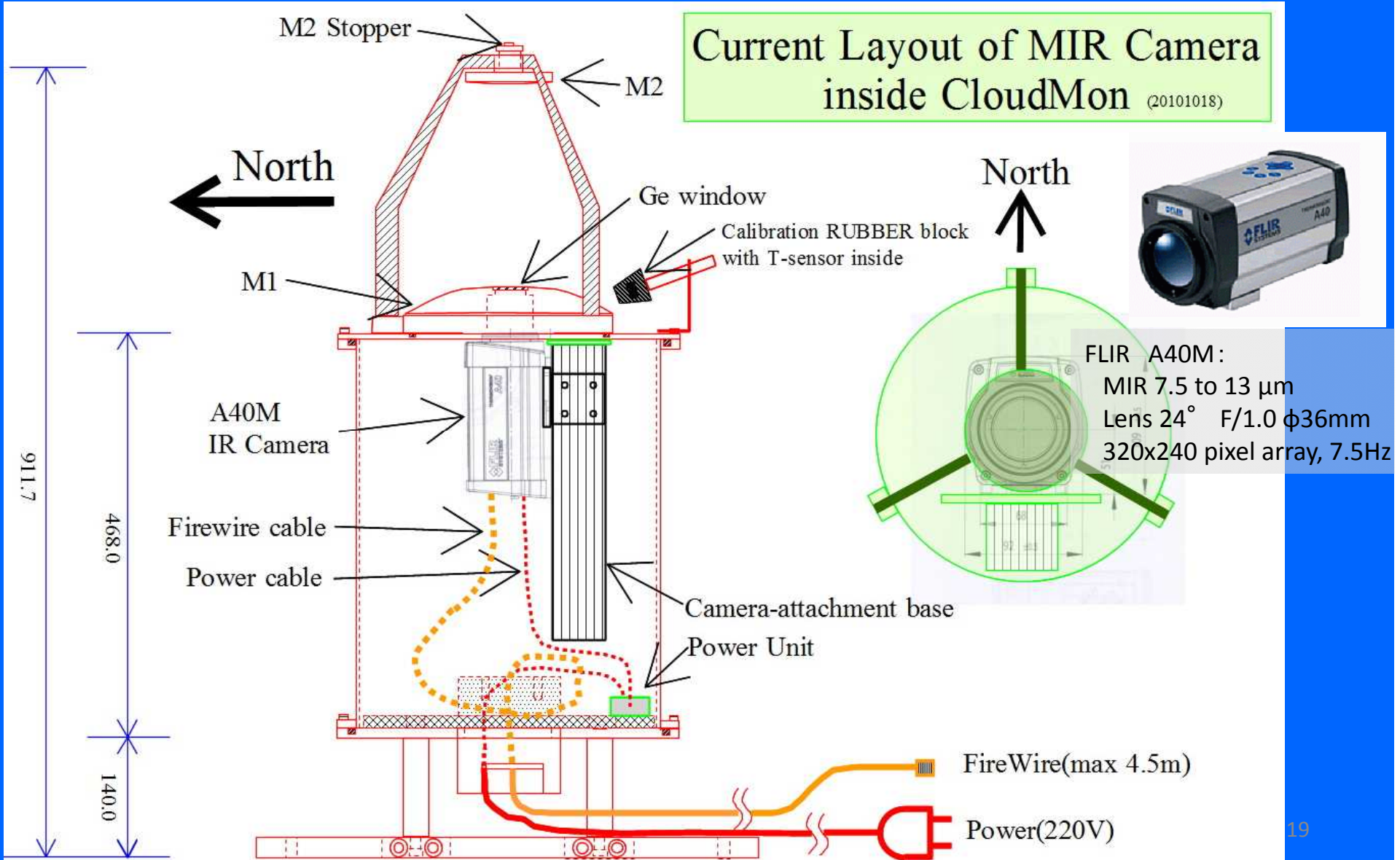
Site Monitoring Instruments at Oma (Japanese group)



CloudMonitor at Karasu and at Oma

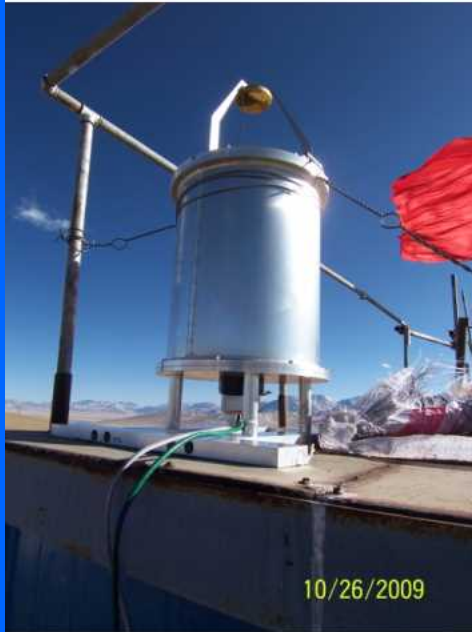
With mid-infrared camera (7.5 to 13 μm) to detect cloud distribution with MIR emission of water vapor

Current Layout of MIR Camera inside CloudMon (20101018)

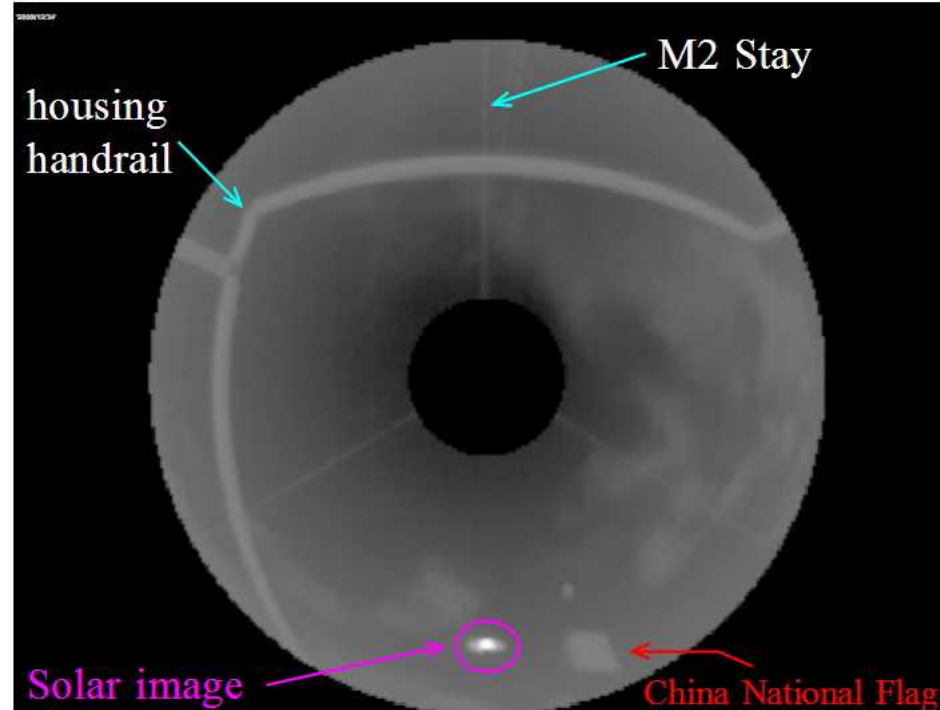


Cloudiness observed w/ CloudMon at Oma in 2008 and 2009

FOV of Cloud Monitor



A Cloud Monitor on housing roof at Oma, Tibet



Sample Images of CloudMon at Oma on 2008/12/24

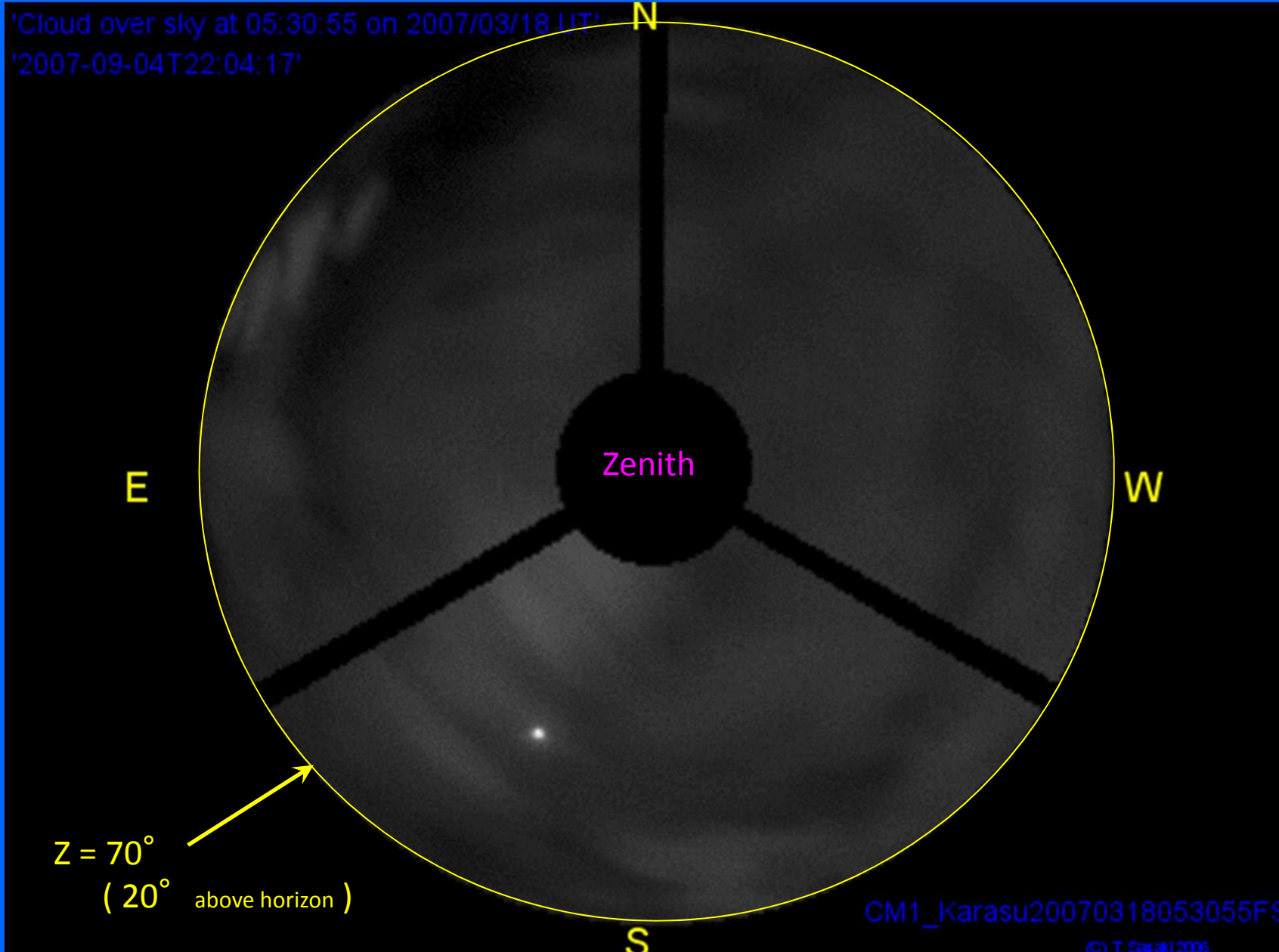
All-sky images, every 1 hour, taken w/Cloud Monitor at Oma on 2008-12-24

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



CloudMonitor Image

2007 March 18 at Karasu



Error estimate of cloudiness with Cloud Monitor

Data Analysis

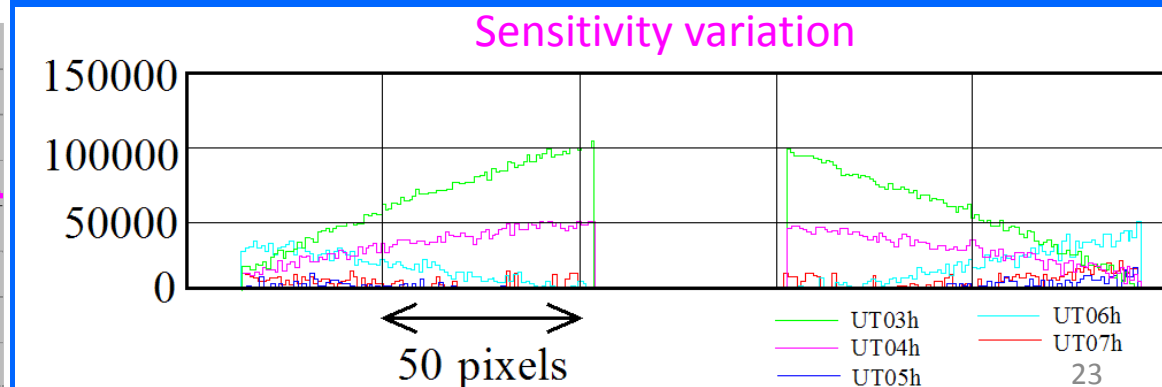
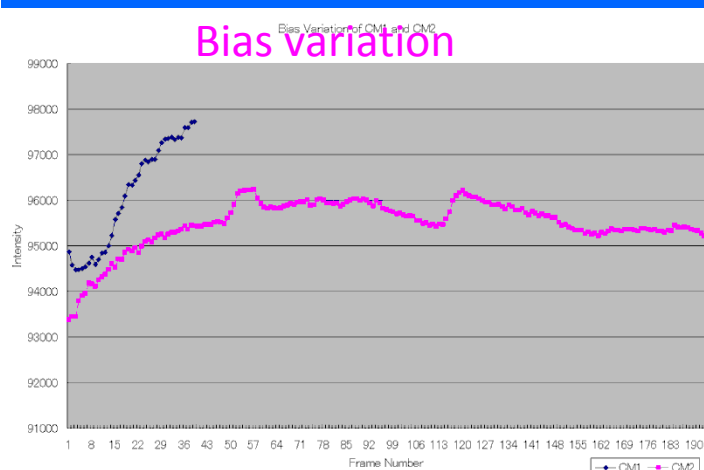
1) Flat-Fielding, 2) sky subtraction, and 3) masking

Estimated Errors

- 1) Flat-Fielding image with covered-wth-cap camera with variation of 3.4%.
- 2) Background intensity variation of 7.7% of flat-fielded images; a part of variation are due to solar radiation, but other might be sensitivity variation of the MIR camera.
- 3) time-dependent variation of sensitivity across the image of 10 - 12%

In total, intensity error might be of 14%.

Due to this large error, we use CloudMonitor images only for qualitative evaluation of cloudiness so far.



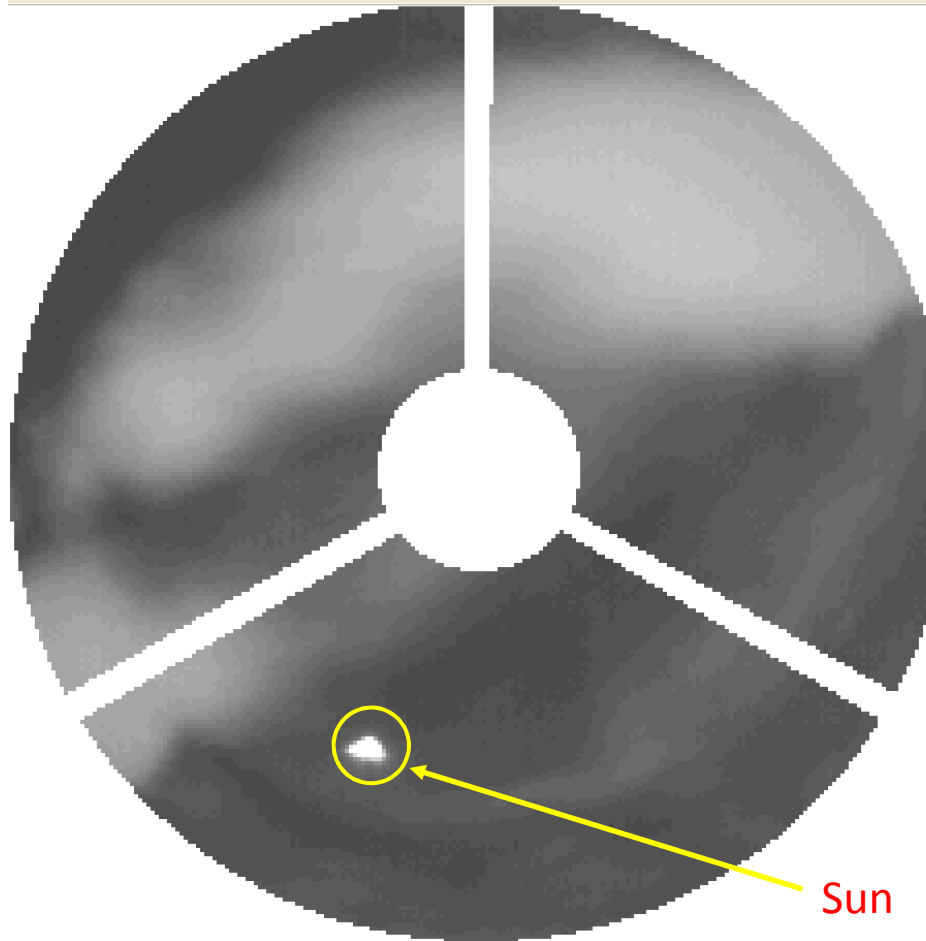
Comparison between CloudMon (MIR) image and Visible image

on 2007 March 17 05:35:55UT

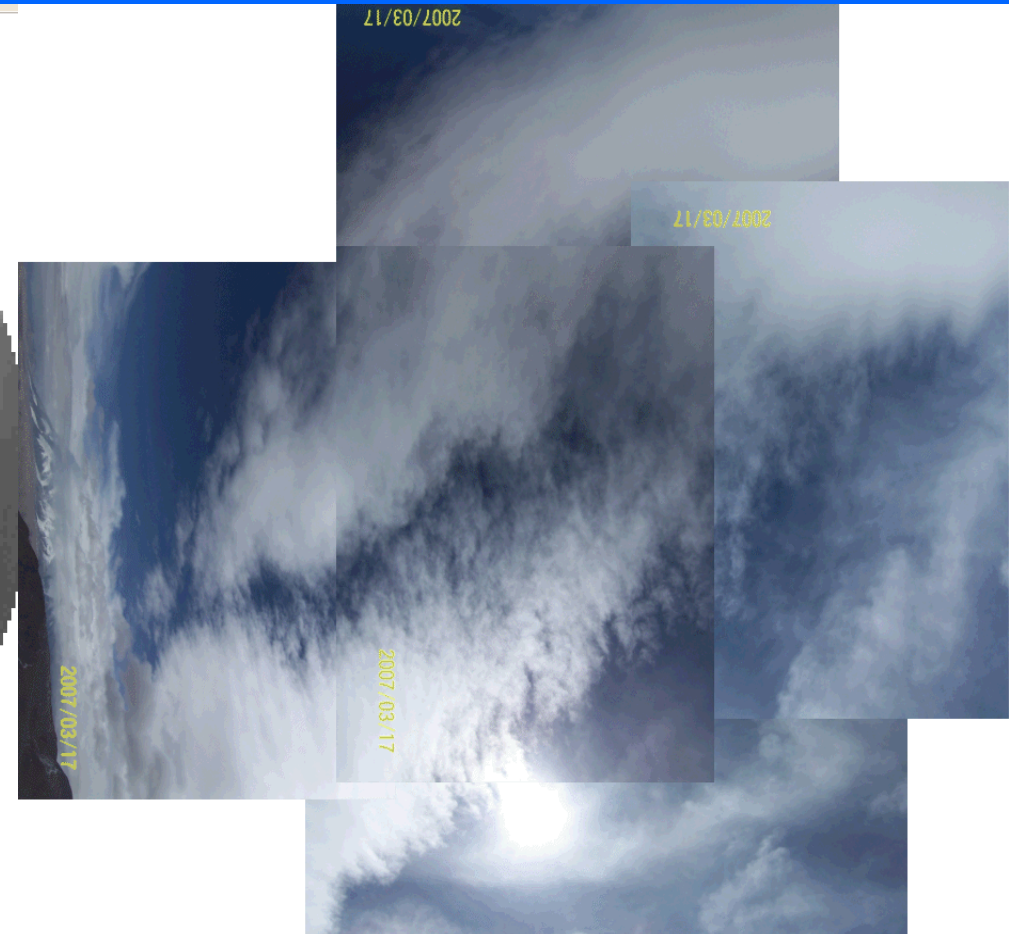
Using intensity of solar image



CloudMon detection limit of Cloud w/ 5 % extinction



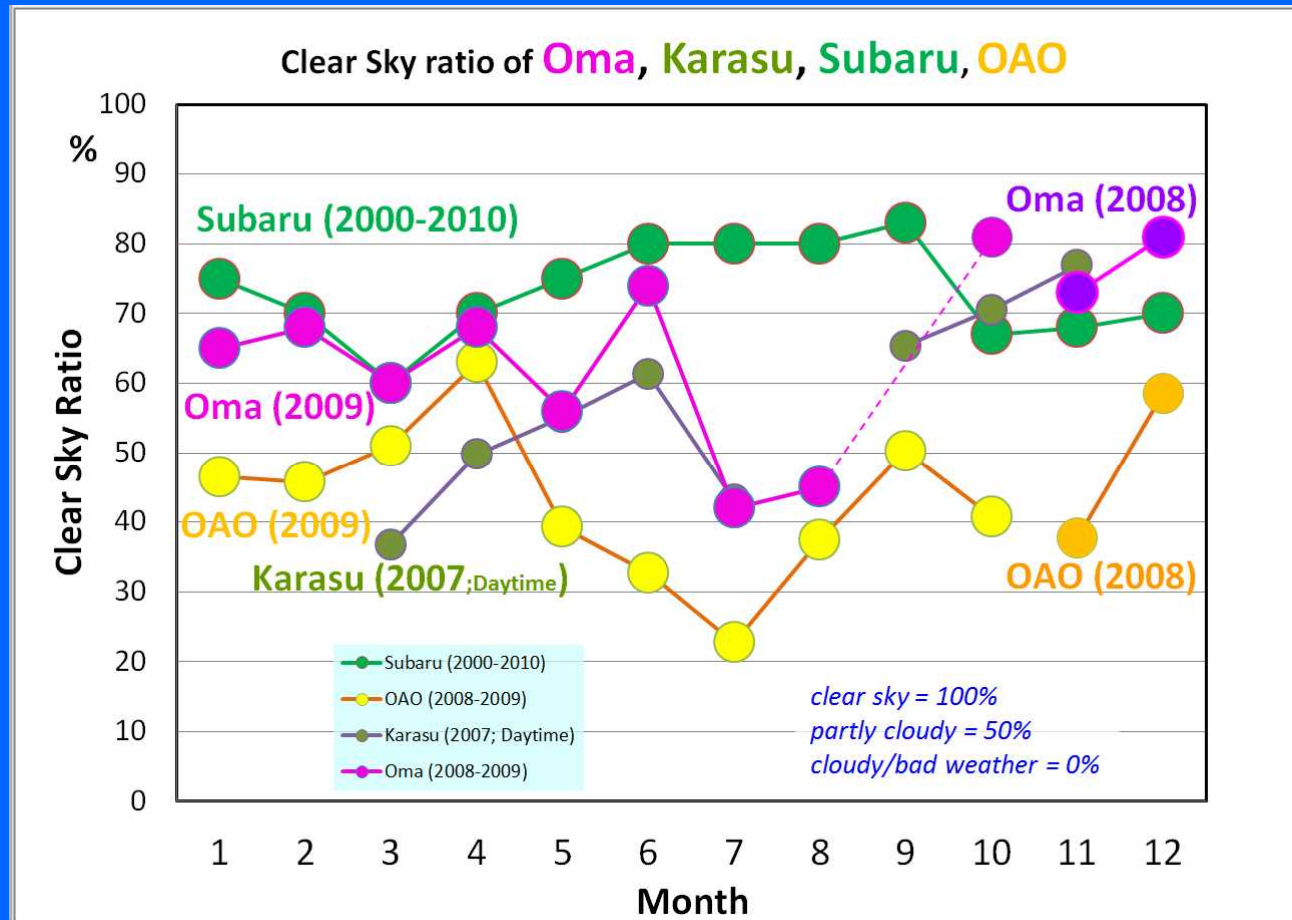
CloudMonitor image
(MIR)



Digital camera
(Visible)

Cloudiness judged w/ CloudMon Images at Oma in 2008 Dec.

Oma	天候概況判断		○		△		×		快晴		Clear		雲あり		Fine/fair/partly cloudy		降雨		Cloudy/rainy																			
	昼間	夜間																																				
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														
2008/12/1	△	△	△	△	△	△	△	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		
2008/12/2	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/3	○	○	△	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/4	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/5	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/6	○	○	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/7	○	○	○	△	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/8	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/9	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/10	○	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
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2008/12/12	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
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2008/12/25	○	○	○	○	○	△	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/26	○	○	○	○	○	△	△	△	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/27	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	
2008/12/28	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△
2008/12/29	○	○	○	○	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/30	○	○	△	△	○	○	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
2008/12/31	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	△	
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														



Clear sky ratios at Oma, except summer monsoon season, are around 70%, which are comparable to at Mauna Kea, Hawaii, and much better than at Okayama, Japan.

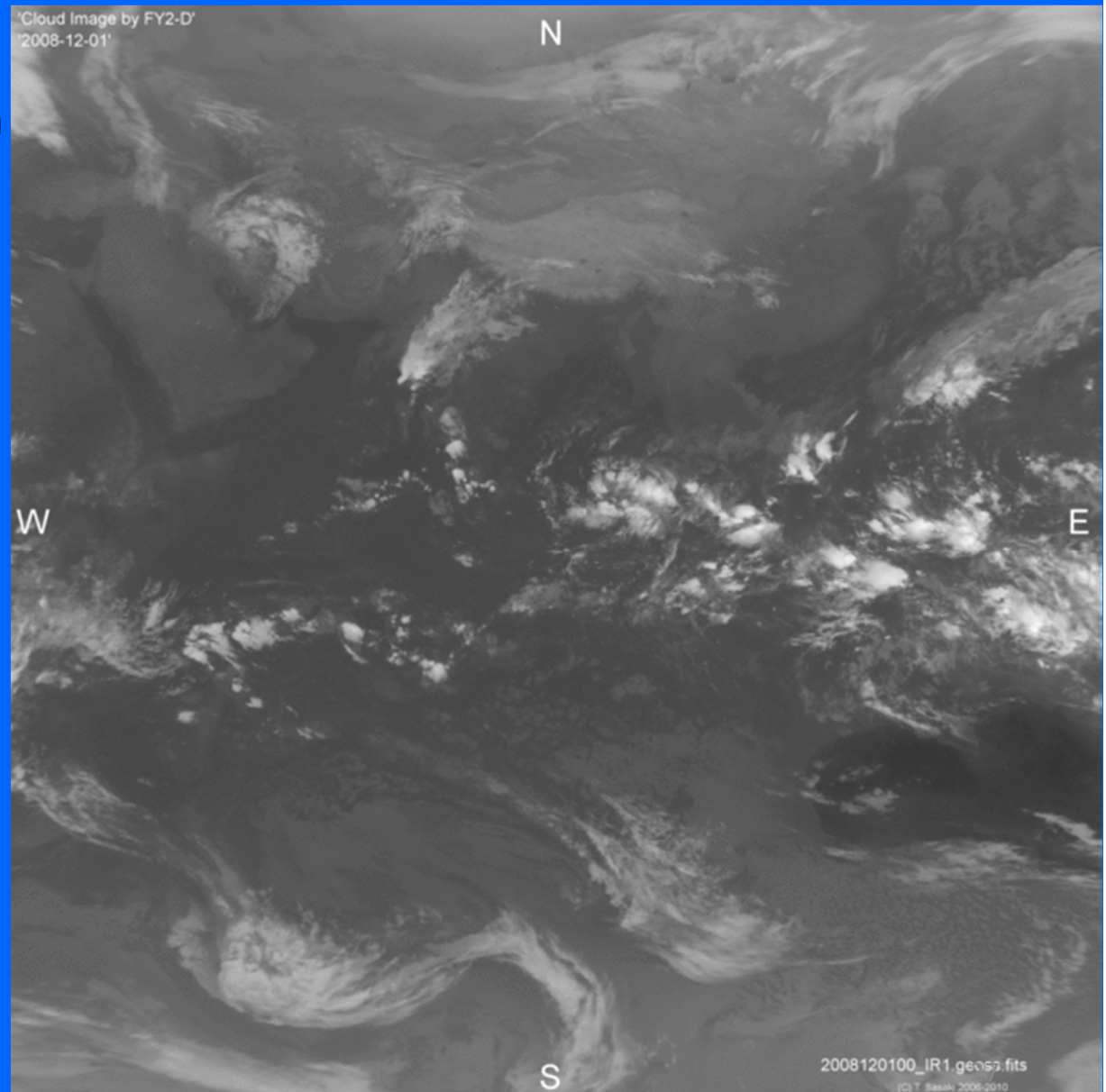
Subaru : statistics during 2000-2010
 OAO: summary report during 2008-2009

Weather Satellite, FY2-D, Image

Chinese Weather Satellite, FY2-D,
is currently working and their data
are available at Chiba-U, Japan
on Web site,

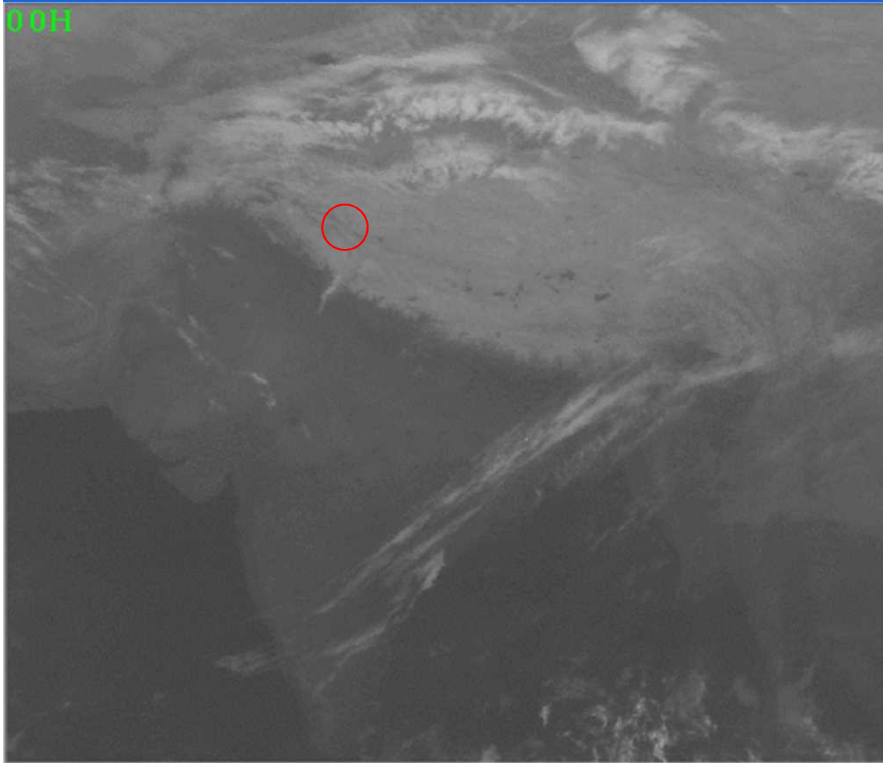
<ftp://fy.cr.chiba-u.ac.jp/>

(Resolution = $0.04^\circ \sim 4\text{km}$)

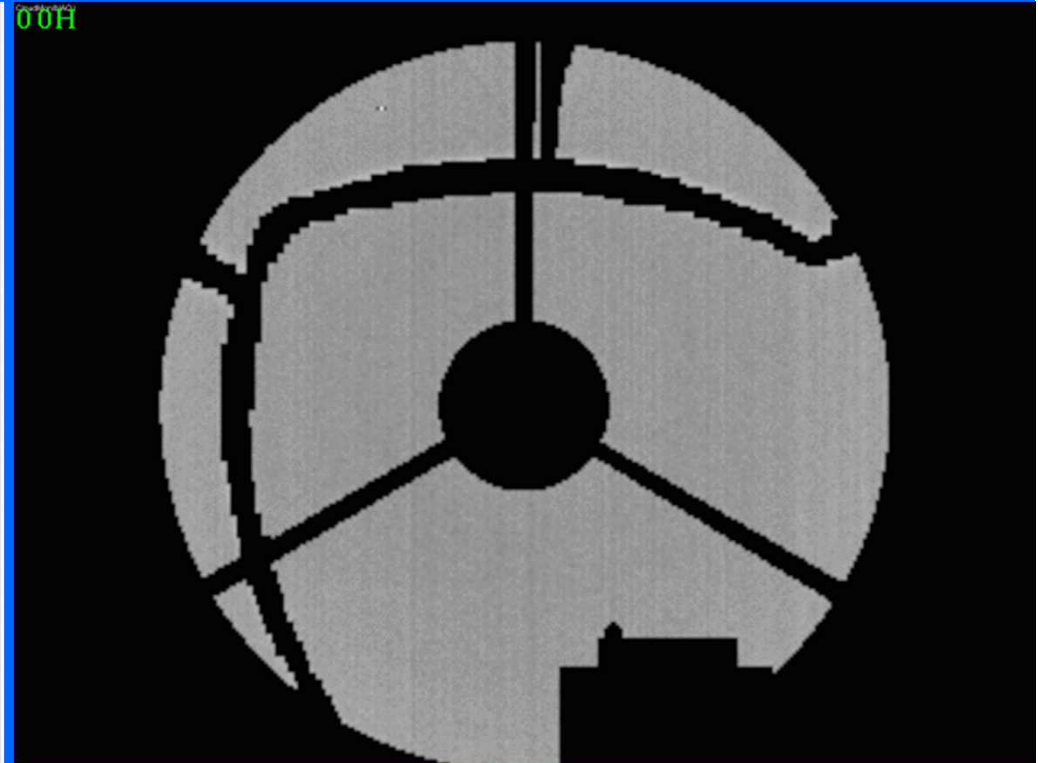


Clouds observed w/Weather Satellite and ground-based CloudMon

Weather Satellite, FY2-D in IR(10 μ m)

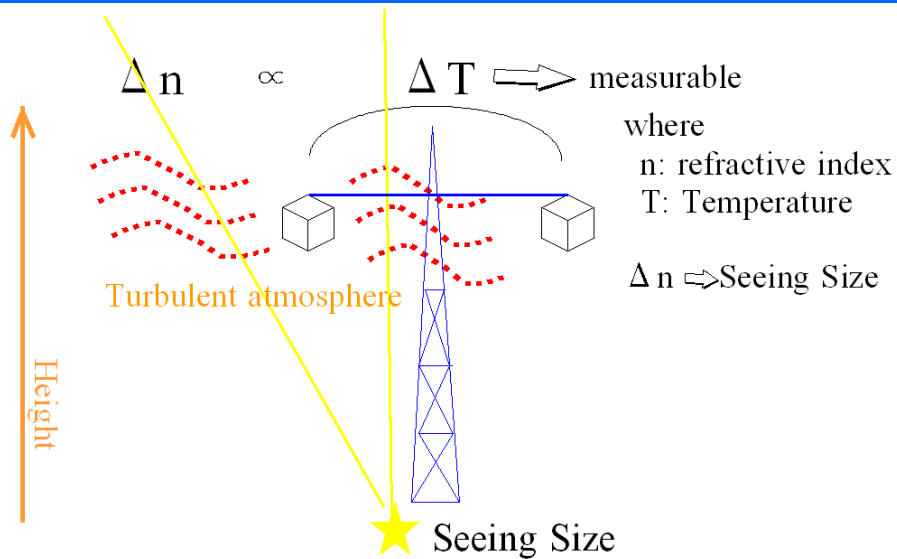


MIR Cloud Monitor Camera (7-14 μ m)



Ground-based Monitoring of Clouds in the sky is very useful to evaluate the site, as weather satellite data is difficult to clarify localized cloud behaviors.

Micro-thermal turbulence detected with C_T^2 sensors



$$C_T^2 = \left\langle |T(r_1) - T(r_2)|^2 \right\rangle r^{-2/3}$$

C_T^2 : temperature structure coefficient

$$C_n^2 \propto P^2 T^{-4} C_T^2$$

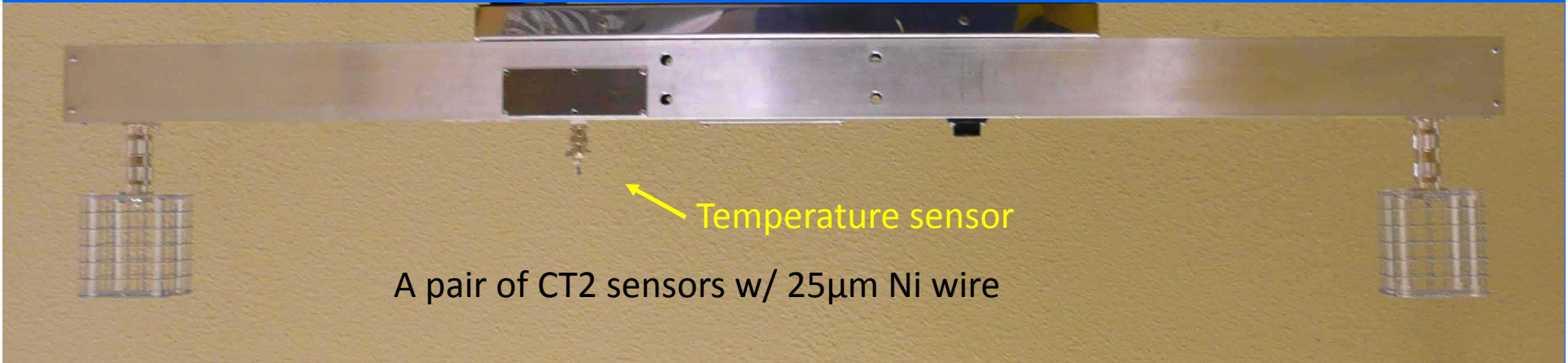
C_n^2 : refractive index structure coefficient

29

Related Site testing instruments

- **DIMM**: Differential Image Motion Monitor
- **MASS/SCIDAR**: Multi Aperture Scintillation Sensor
- **C_T^2 sensor**: Micro-thermal turbulence in surface layer to measure height variation
- **SNODAR**: Surface layer Non-Doppler Acoustic Radar to measure Scintillation
- **SODAR**: Sound detection and ranging to measure Scintillation

CT2 measurements at Karasu and at Oma



Temperature Structure Coefficient

$$C_T^2(z) = C_T^2(z_0) \exp(-(z-z_0)/z_h)$$

$$C_T^2 = \left\langle \left| T(r_1) - T(r_2) \right|^2 \right\rangle r^{-2/3}$$

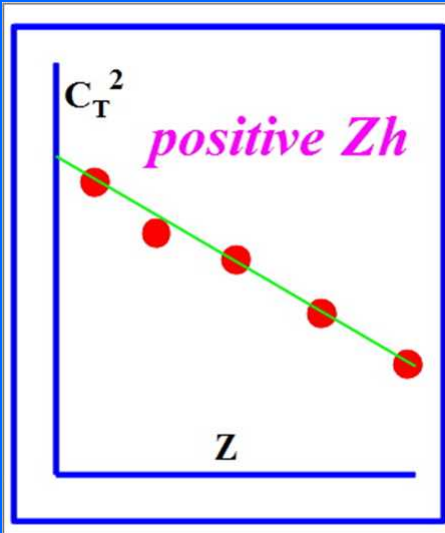


Image deterioration estimated from C_T^2

$$\theta(z) = 5.3 \lambda^{-1/5} \left(\frac{7.9 \times 10^{-5} P}{T^2} \right)^{6/5} \left[C_T^2(z) z_h \right]^{3/5}$$

C_T^2 measurements at Karasu and at Oma

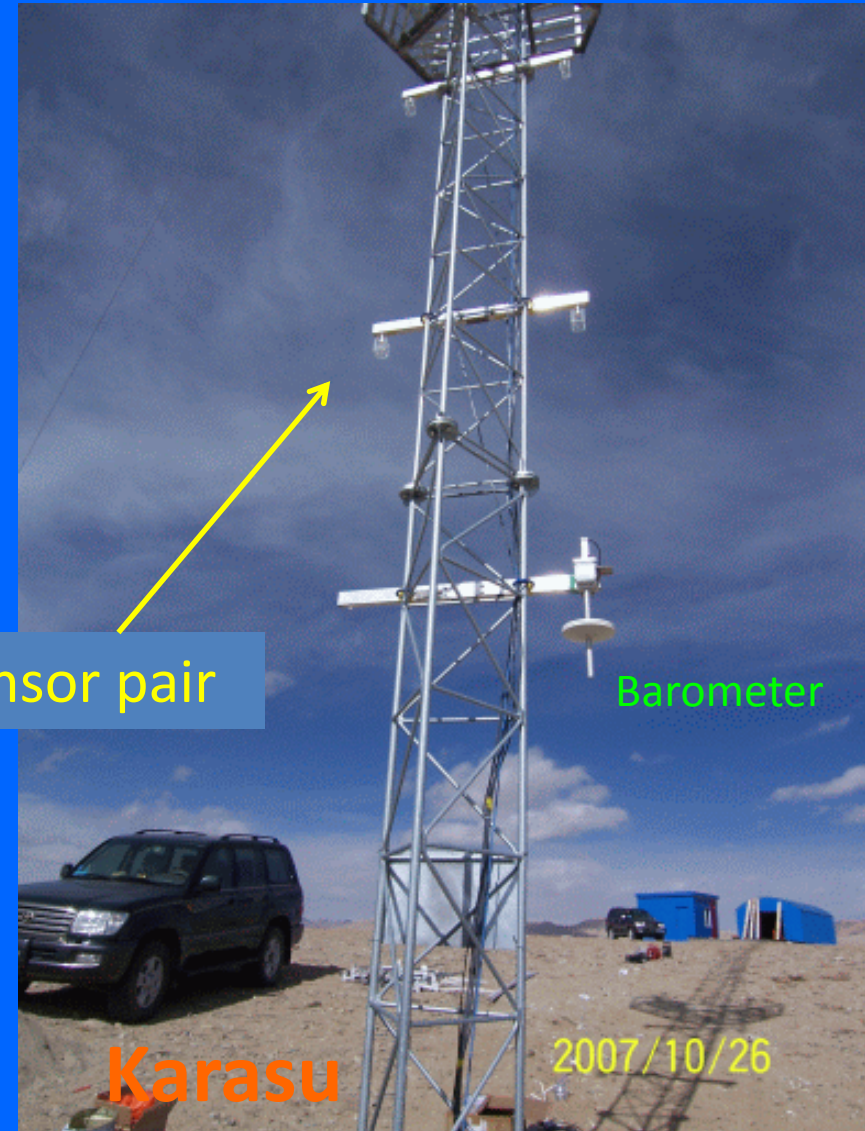


5 Layers of a C_T^2 sensor pair



Barometer

Controller and Digital Multimeter

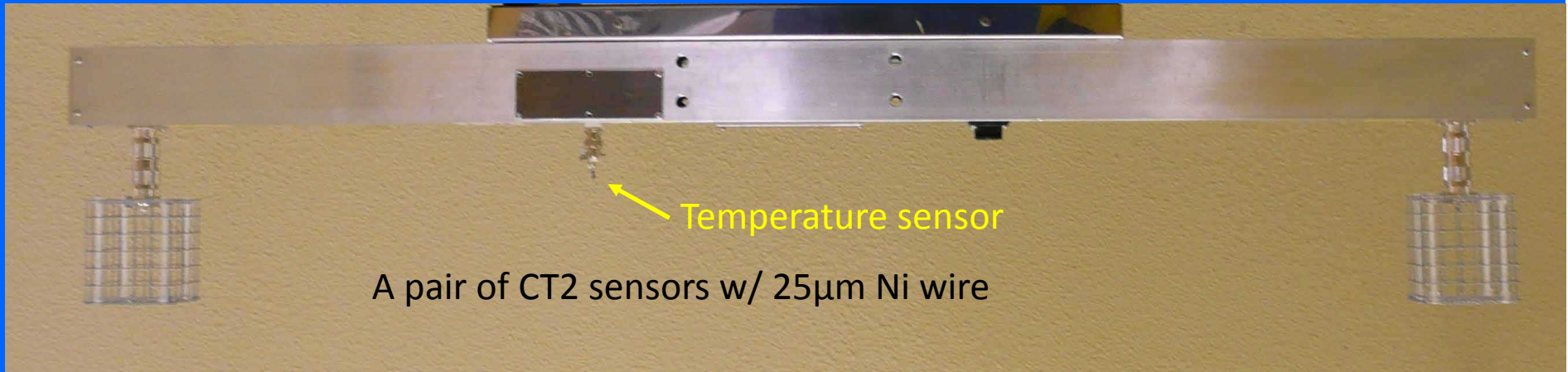


Barometer

Karasu

2007/10/26

CT2 measurements at Karasu and at Oma



Temperature Structure Coefficient

Diagram of

$$C_T^2 = \left\langle |T(r_1) - T(r_2)|^2 \right\rangle r^{-2/3}$$

A pair of CT2 sensors

Seeing estimated from C_T^2

$$\theta(z) = 5.3 \lambda^{-1/5} \left(\frac{7.9 \times 10^{-5} P}{T^2} \right)^{6/5} [C_T^2(z) z_h]^{3/5}$$

Amp

MM

Micro-thermal turbulence detected with C_T^2 sensors

at Karasu

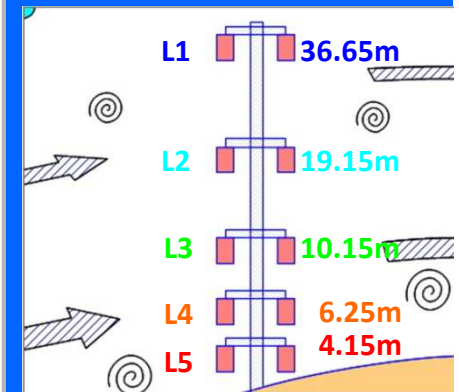
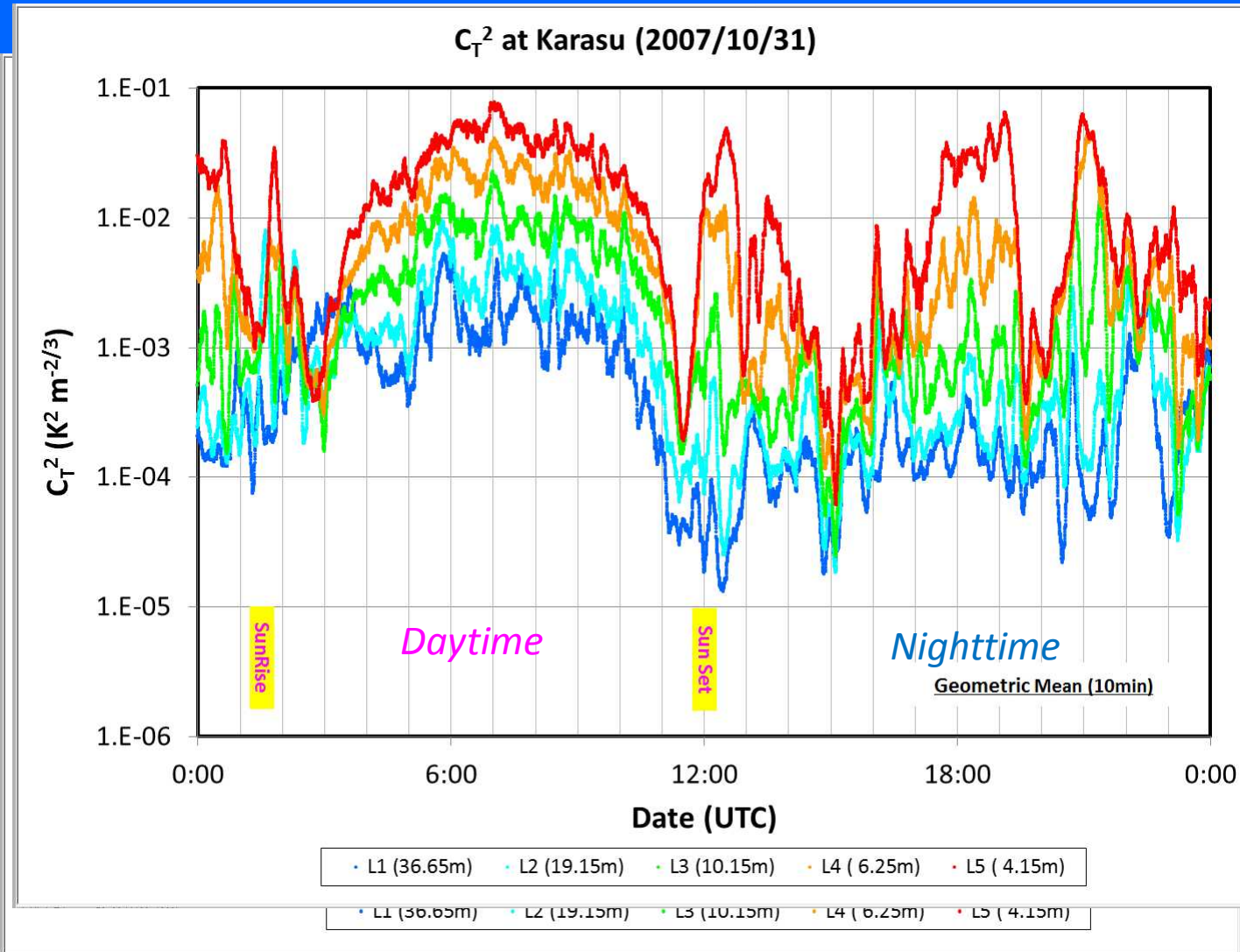
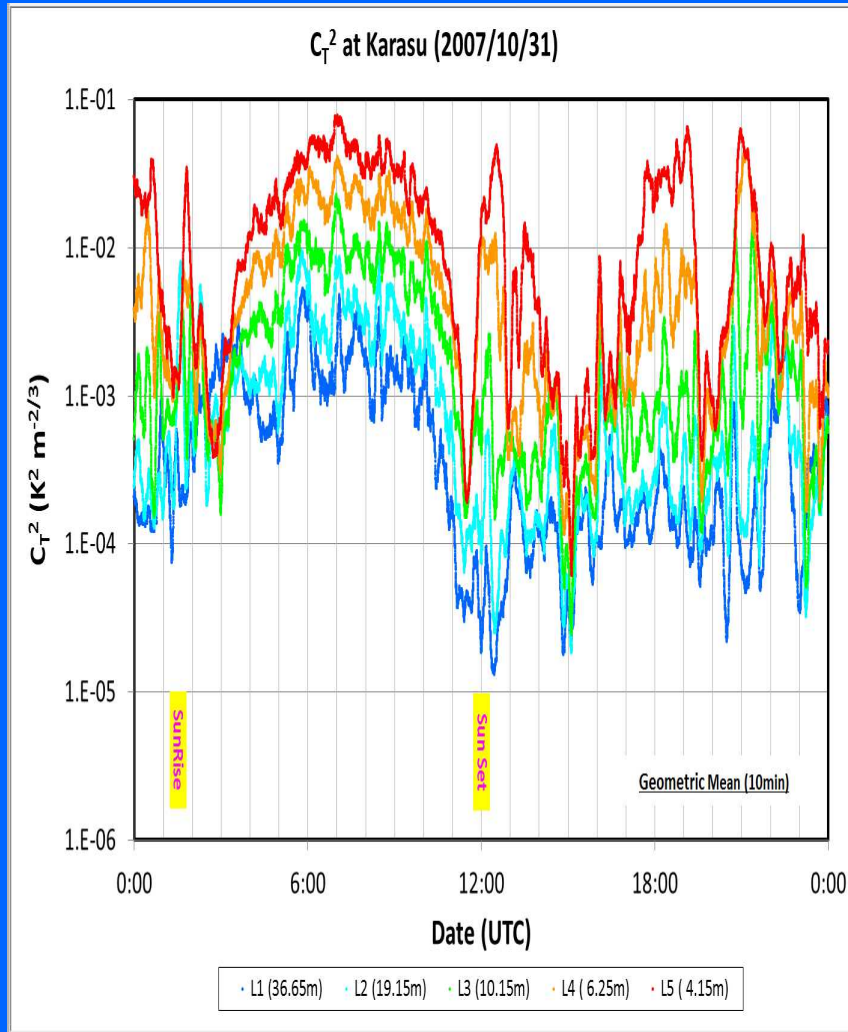


Image deterioration estimated with C_T^2 data



C_T^2 distribution

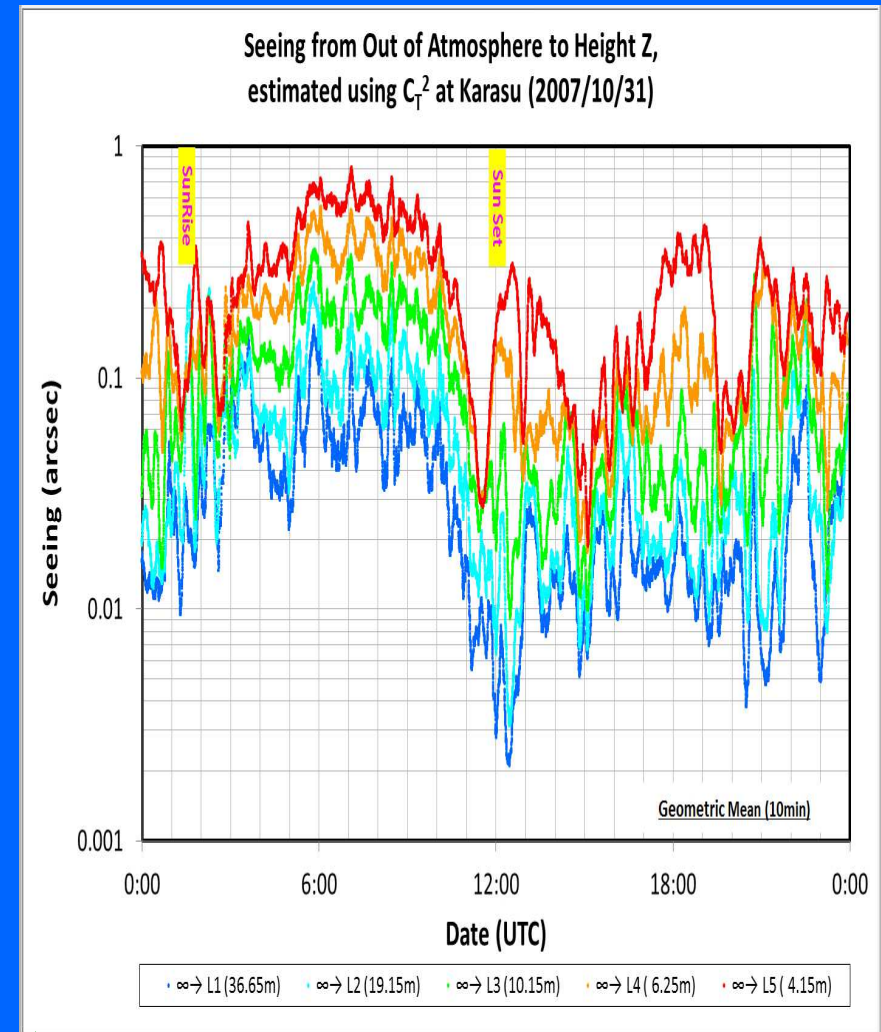
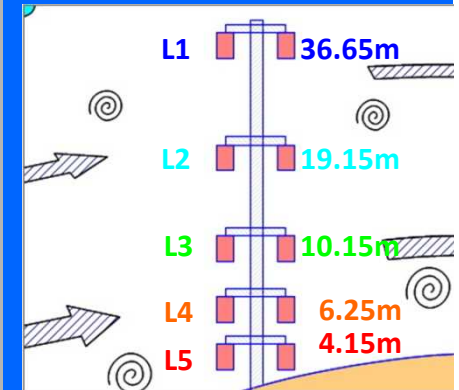
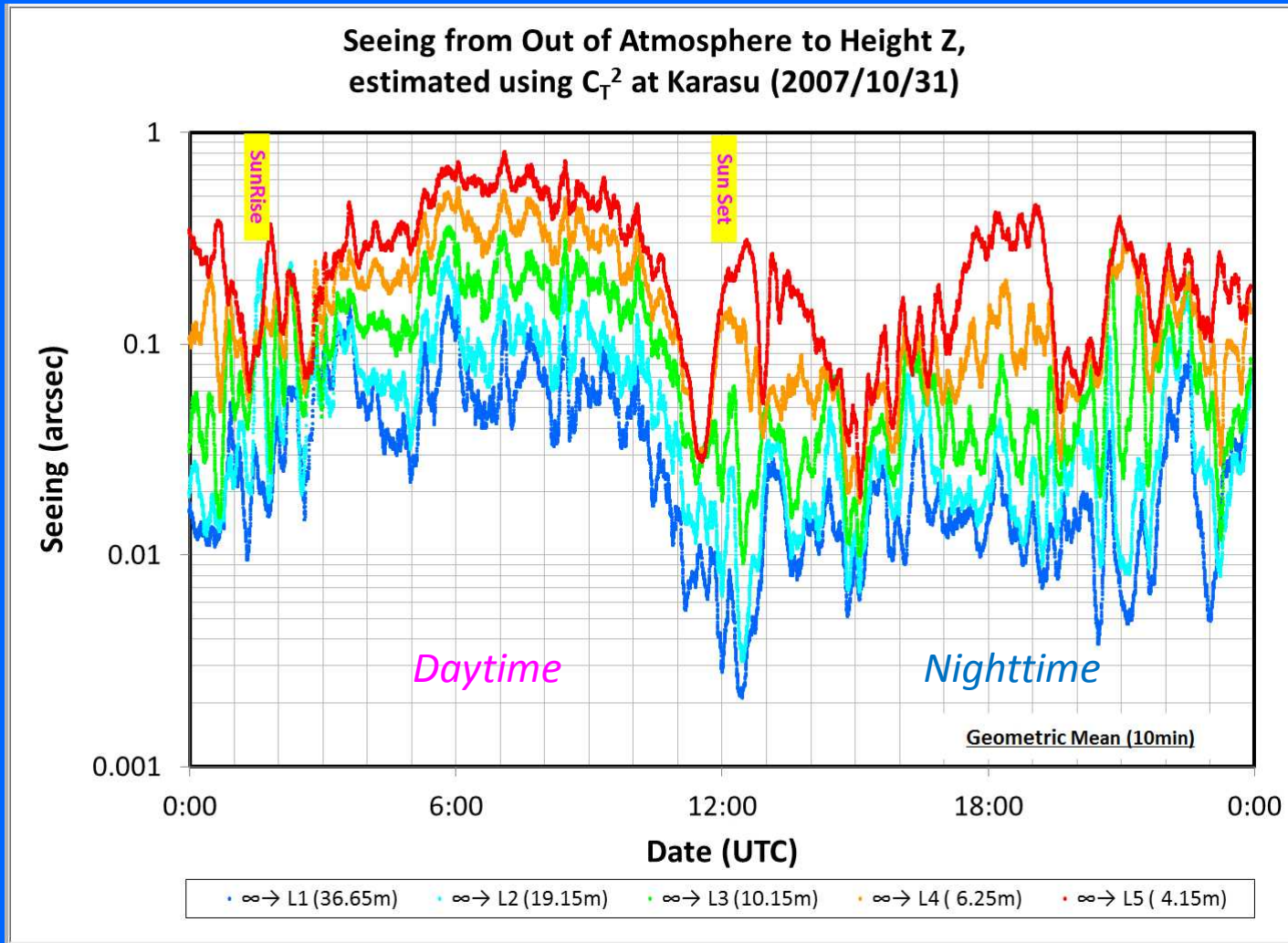


Image deterioration derived from C_T^2 distribution

$$\theta(z) = 5.3 \lambda^{-1/5} \left(\frac{7.9 \times 10^{-5} P}{T^2} \right)^{6/5} [C_T^2(z) z_h]^{3/5}$$

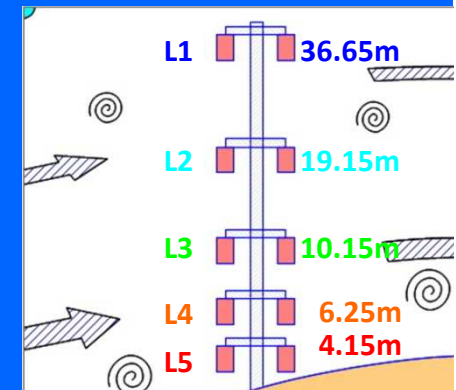
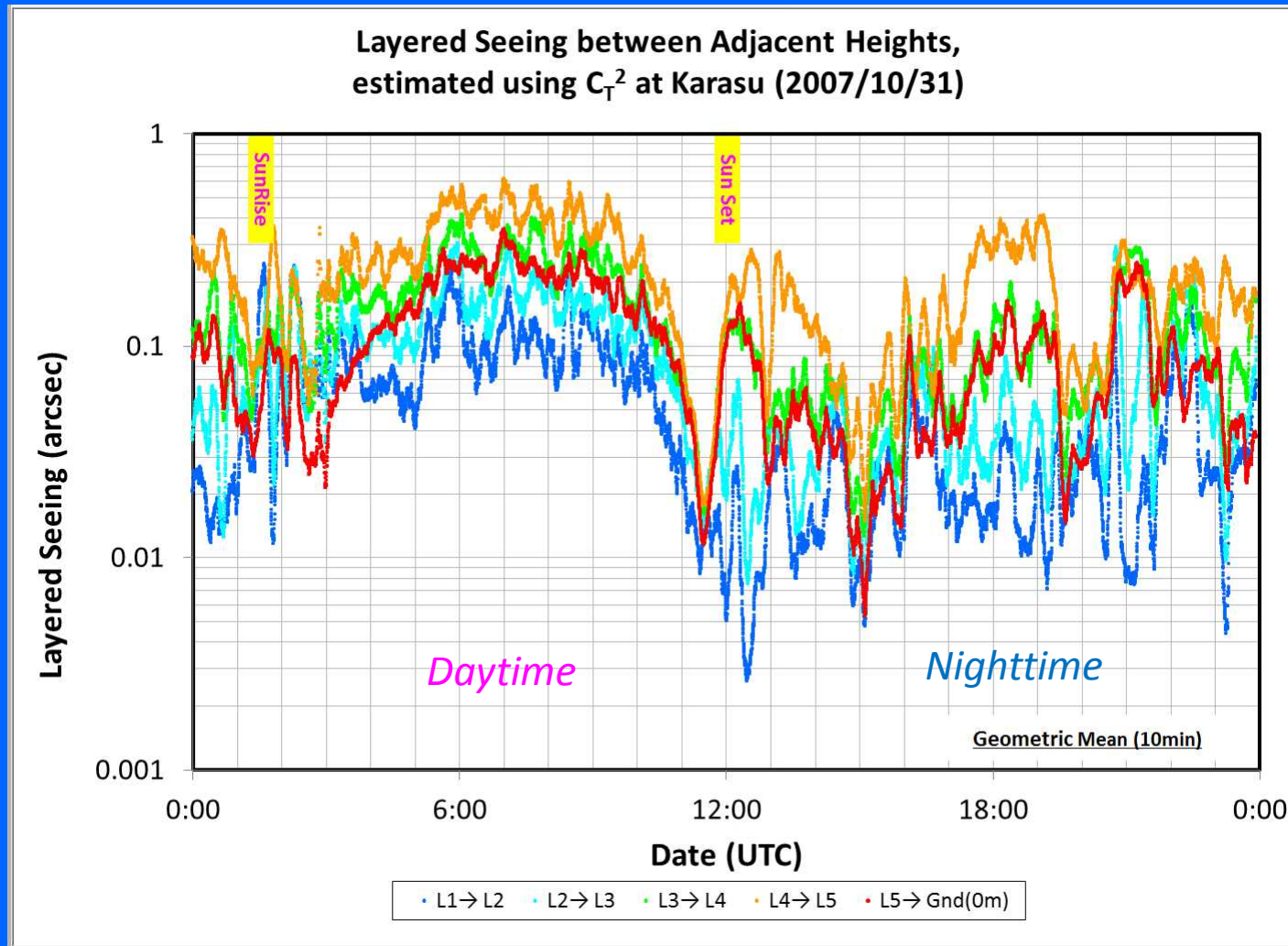
Image deterioration estimated with C_T^2 data

at Karasu



Layered Image deterioration estimated with C_T^2 data

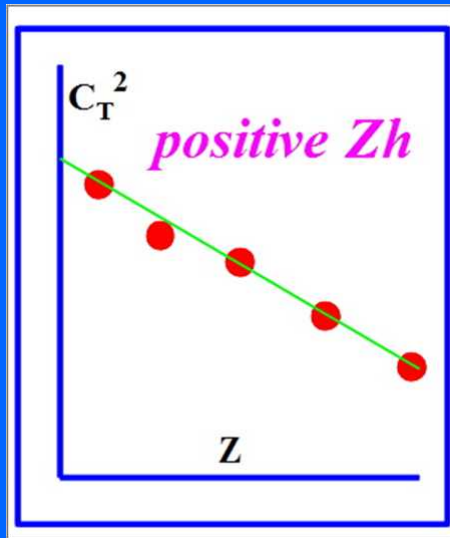
at Karasu



Local Image deterioration between heights of z_1 and z_0

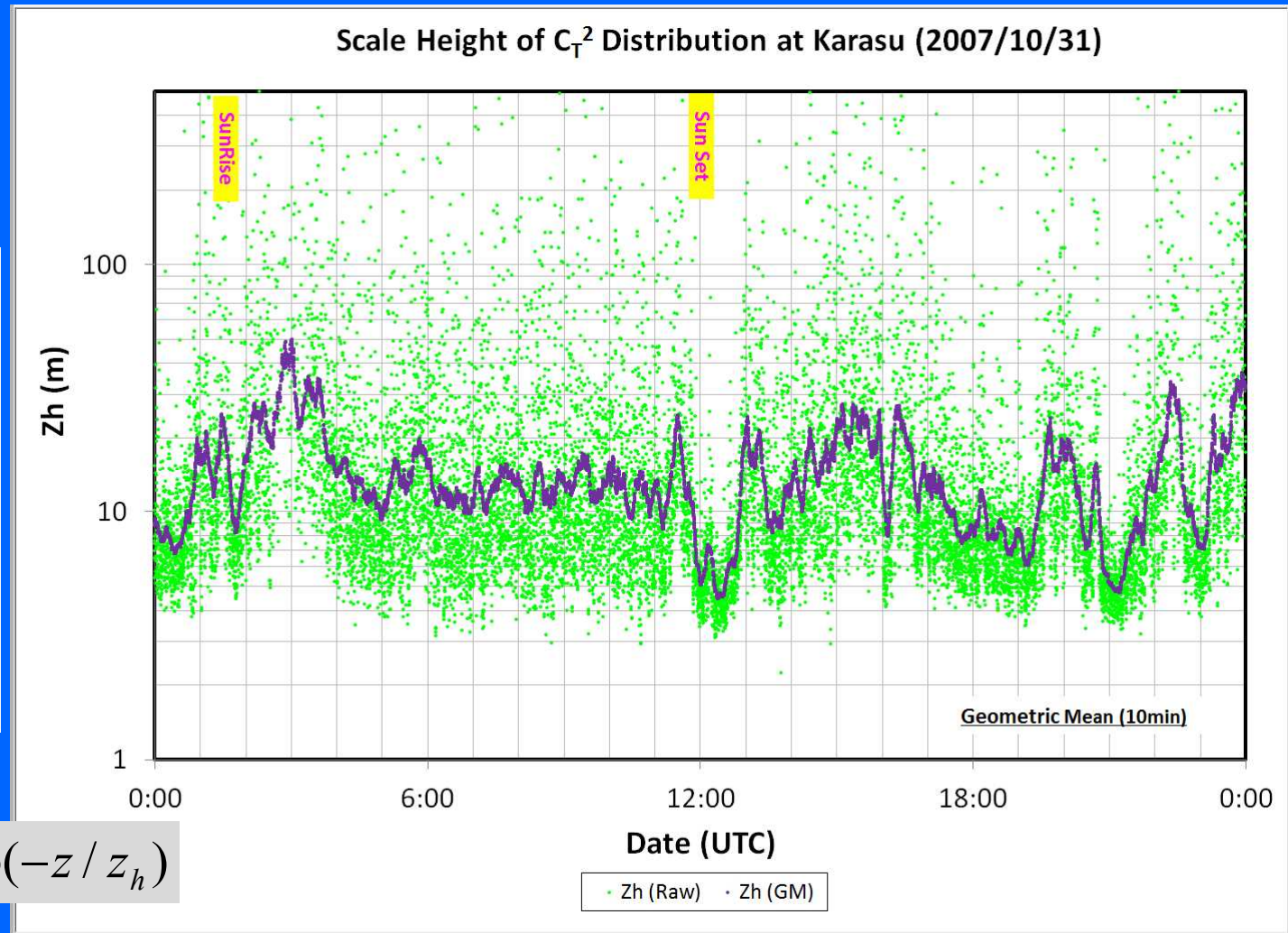
$$\theta(z_1 : z_0) = \left(\theta(z_1)^{5/3} - \theta(z_0)^{5/3} \right)^{3/5}$$

Scale Height of vertical distribution of C_T^2 data



$$C_T^2(z) = C_T^2(0) \exp(-z / z_h)$$

➔ derive z_h



Micro-thermal turbulence detected with C_T^2 sensors

at Oma

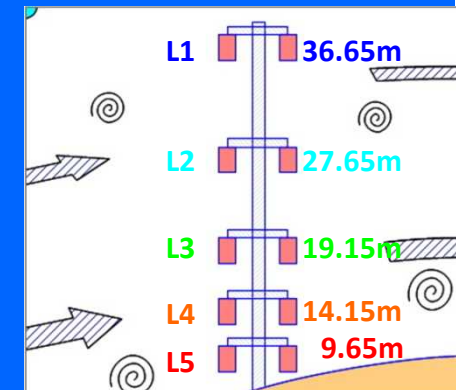
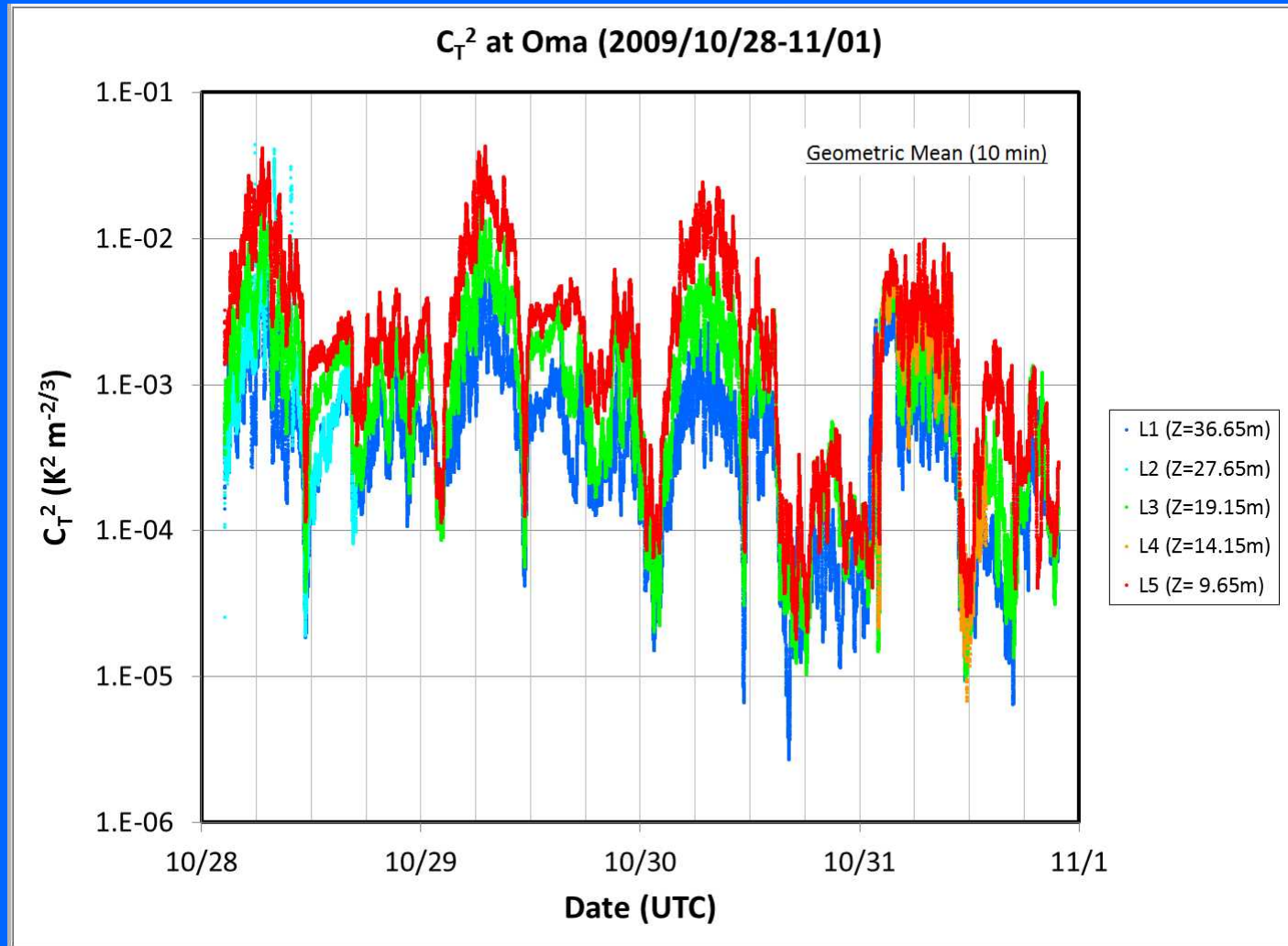
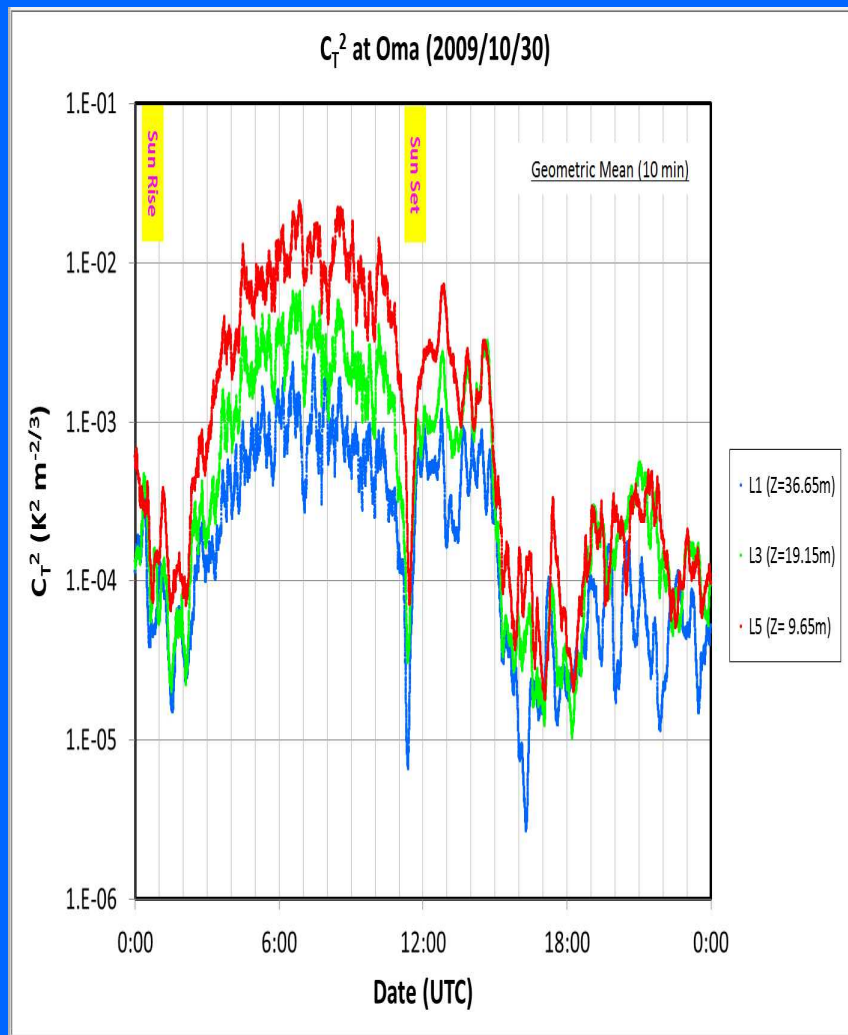


Image deterioration estimated with C_T^2 data



CT2 distribution

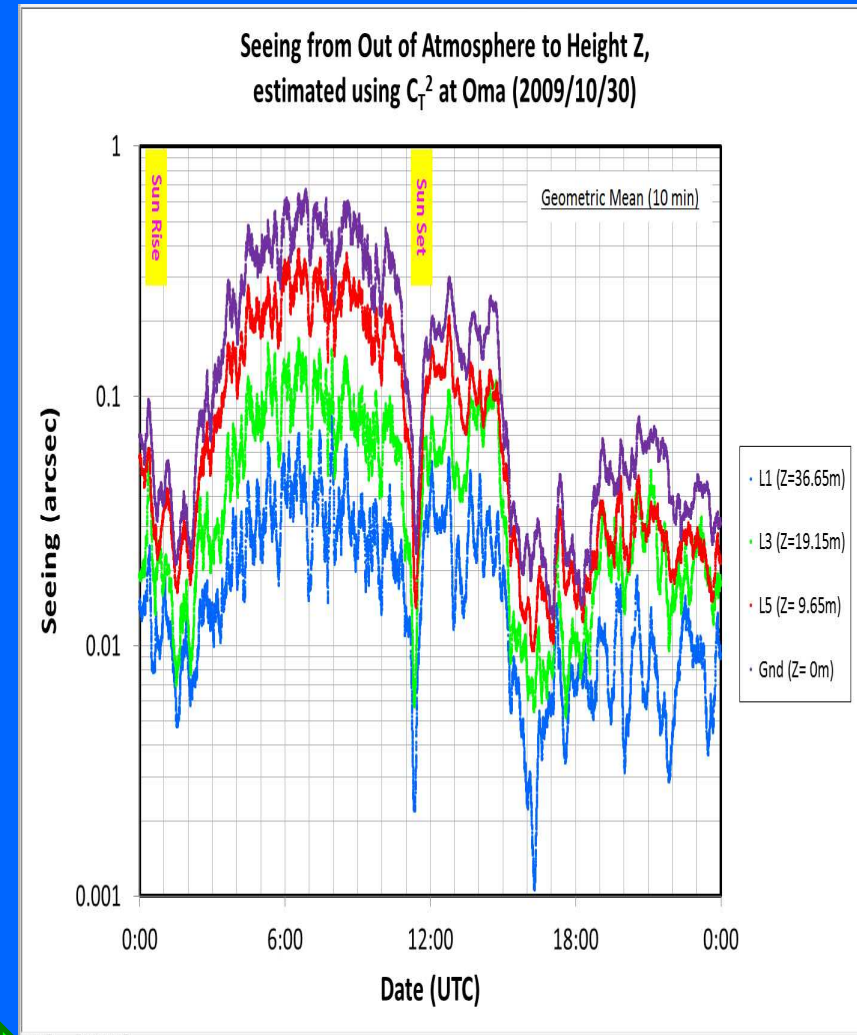


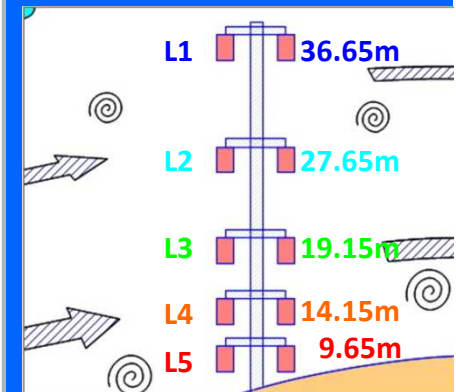
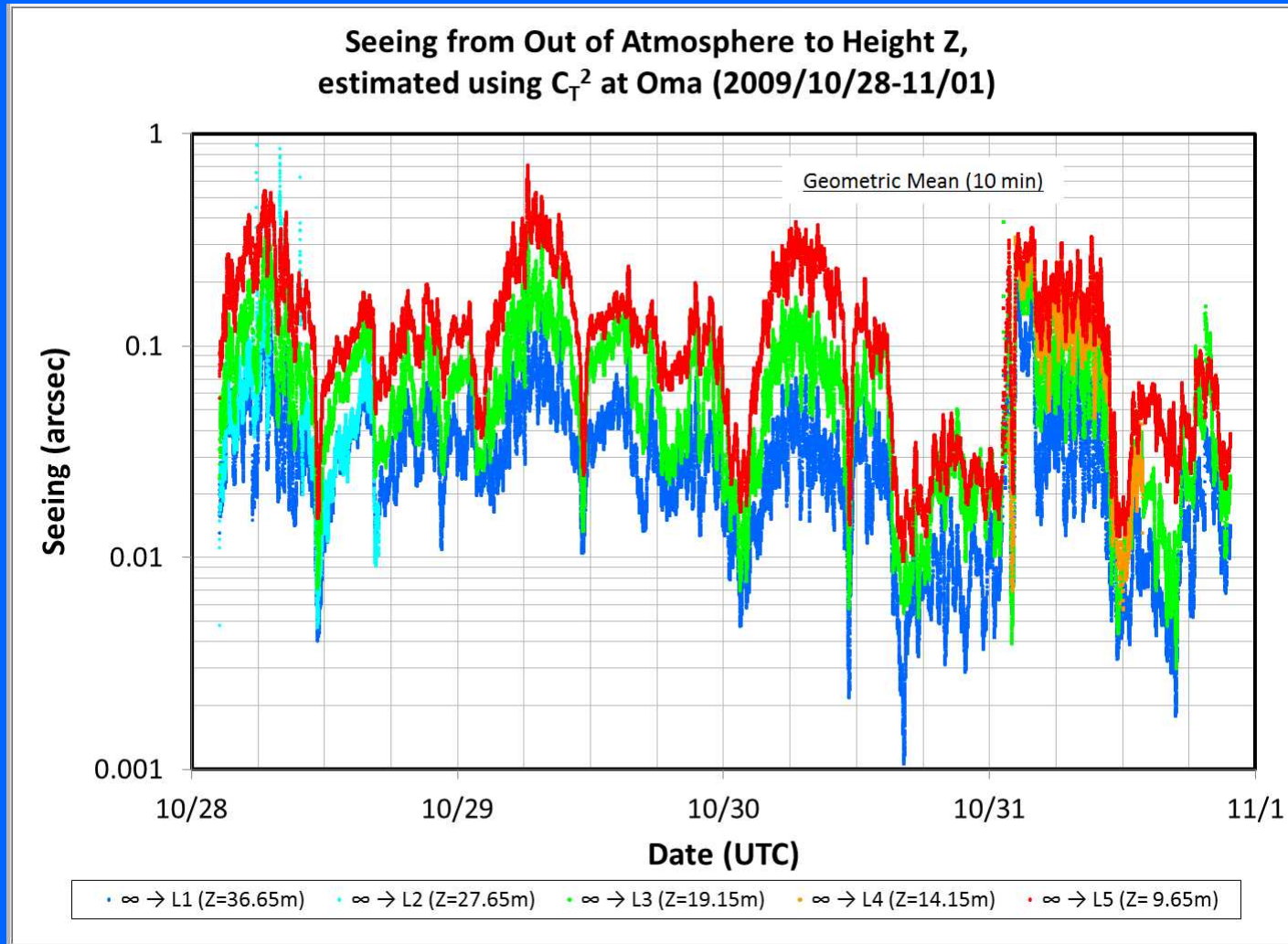
Image deterioration derived from CT2 distribution

$$\theta(z) = 5.3 \lambda^{-1/5} \left(\frac{7.9 \times 10^{-5} P}{T^2} \right)^{6/5} [C_T^2(z) z_h]^{3/5}$$

at Oma

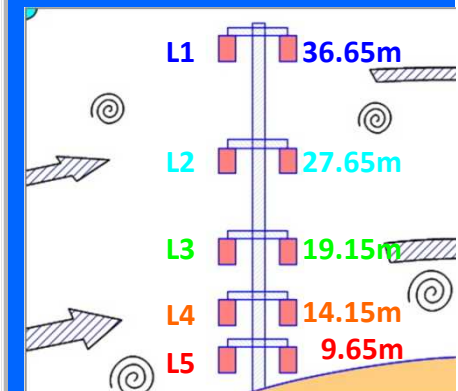
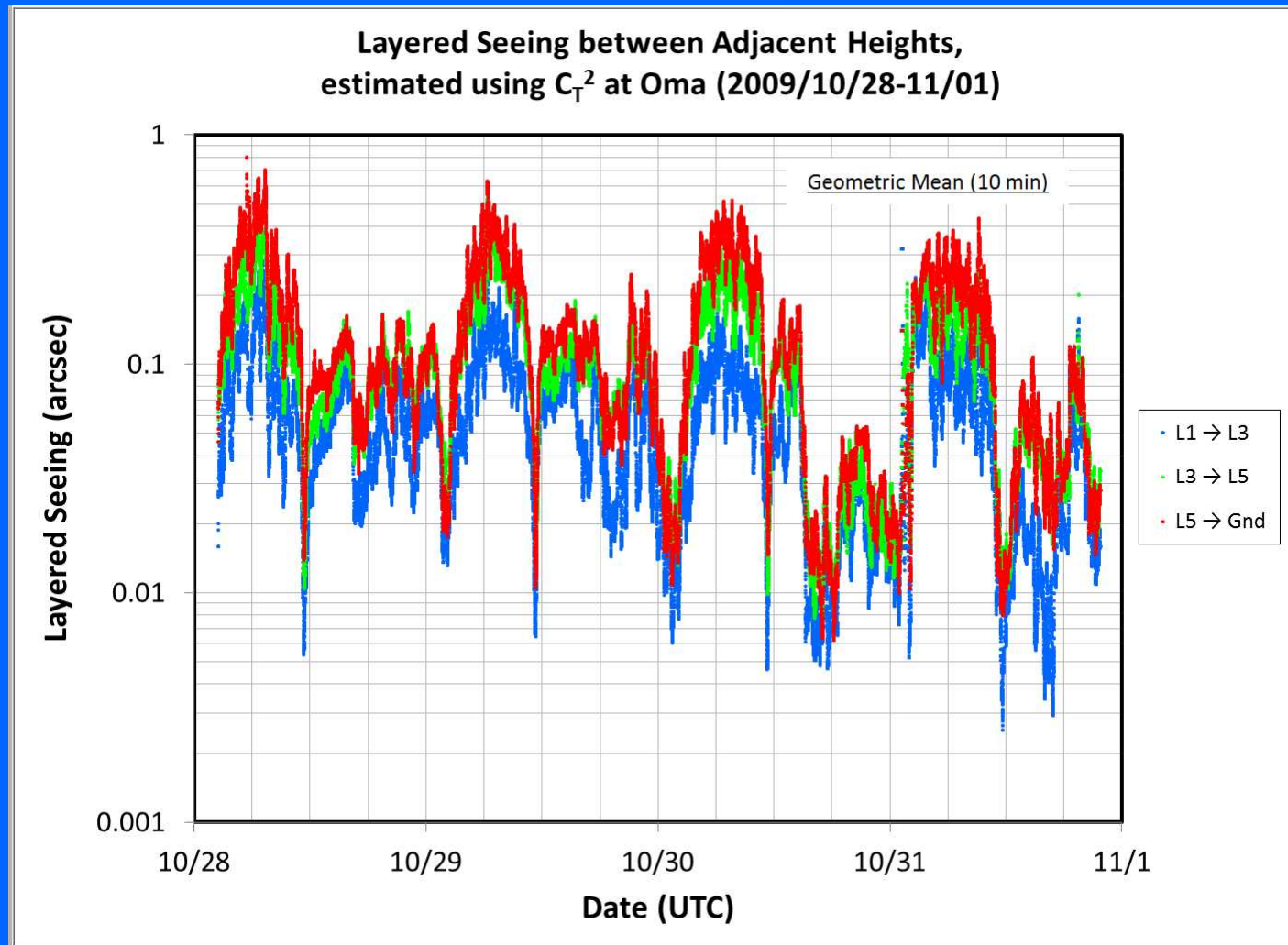
Image deterioration estimated with C_T^2 data

at Oma

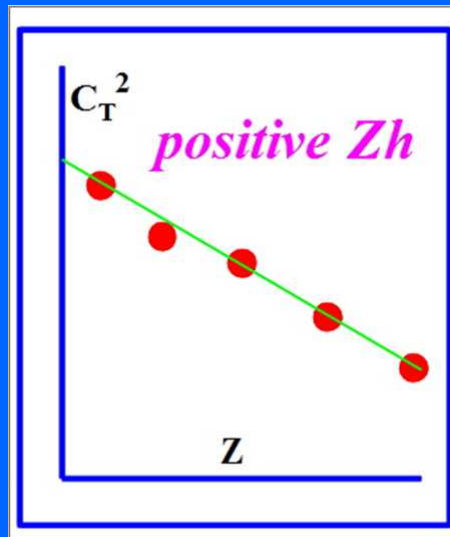


Layered Image deterioration estimated with C_T^2 data

at Oma

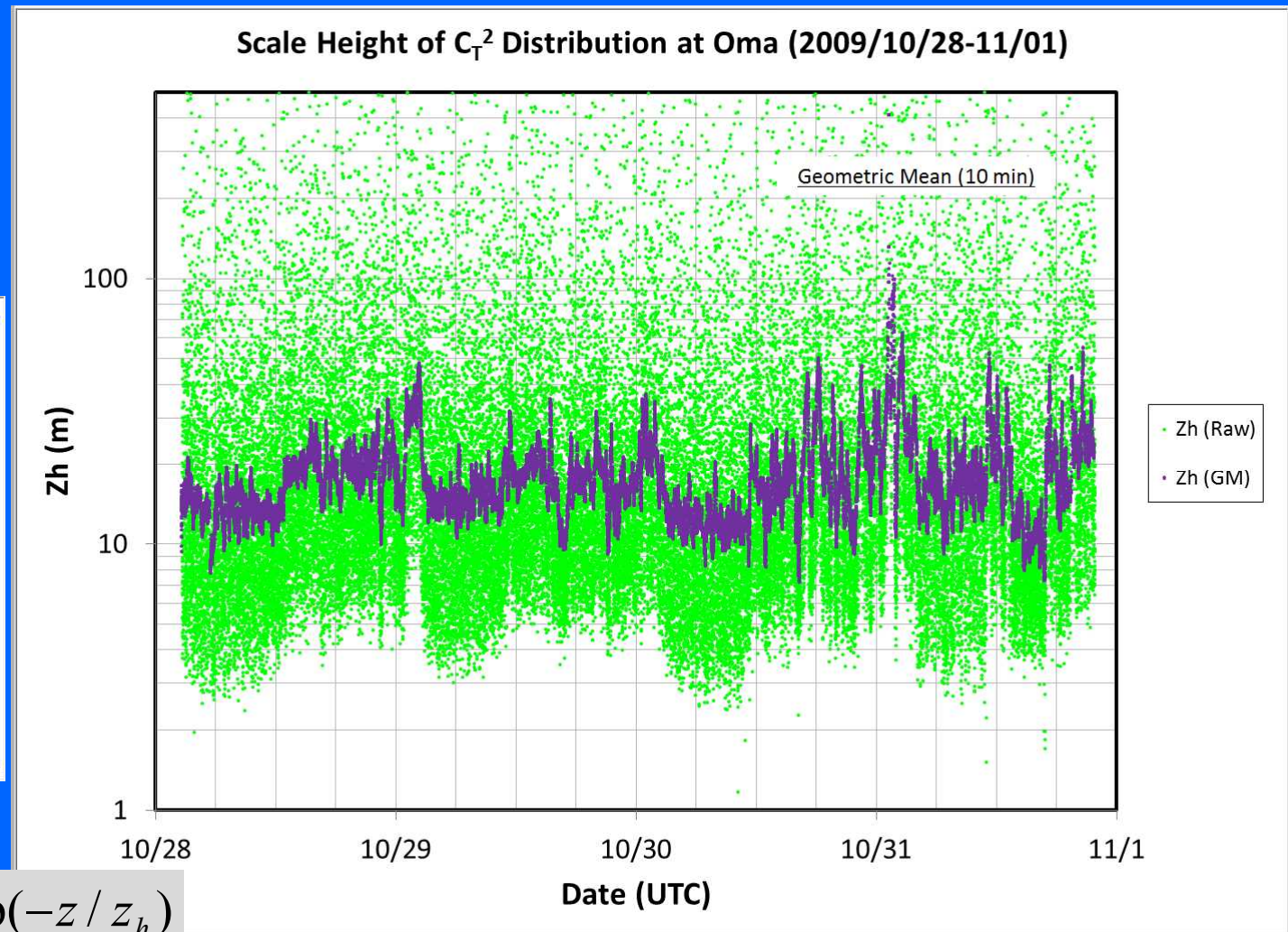


Scale Height of vertical distribution of C_T^2 data



$$C_T^2(z) = C_T^2(0) \exp(-z / z_h)$$

➔ derive Z_h



at Oma

Micro-thermal turbulence detected with C_T^2 sensors

at OAO (Japan)

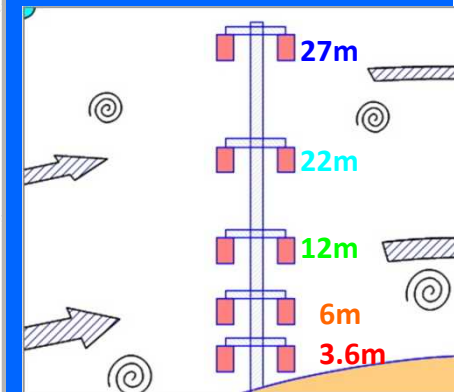
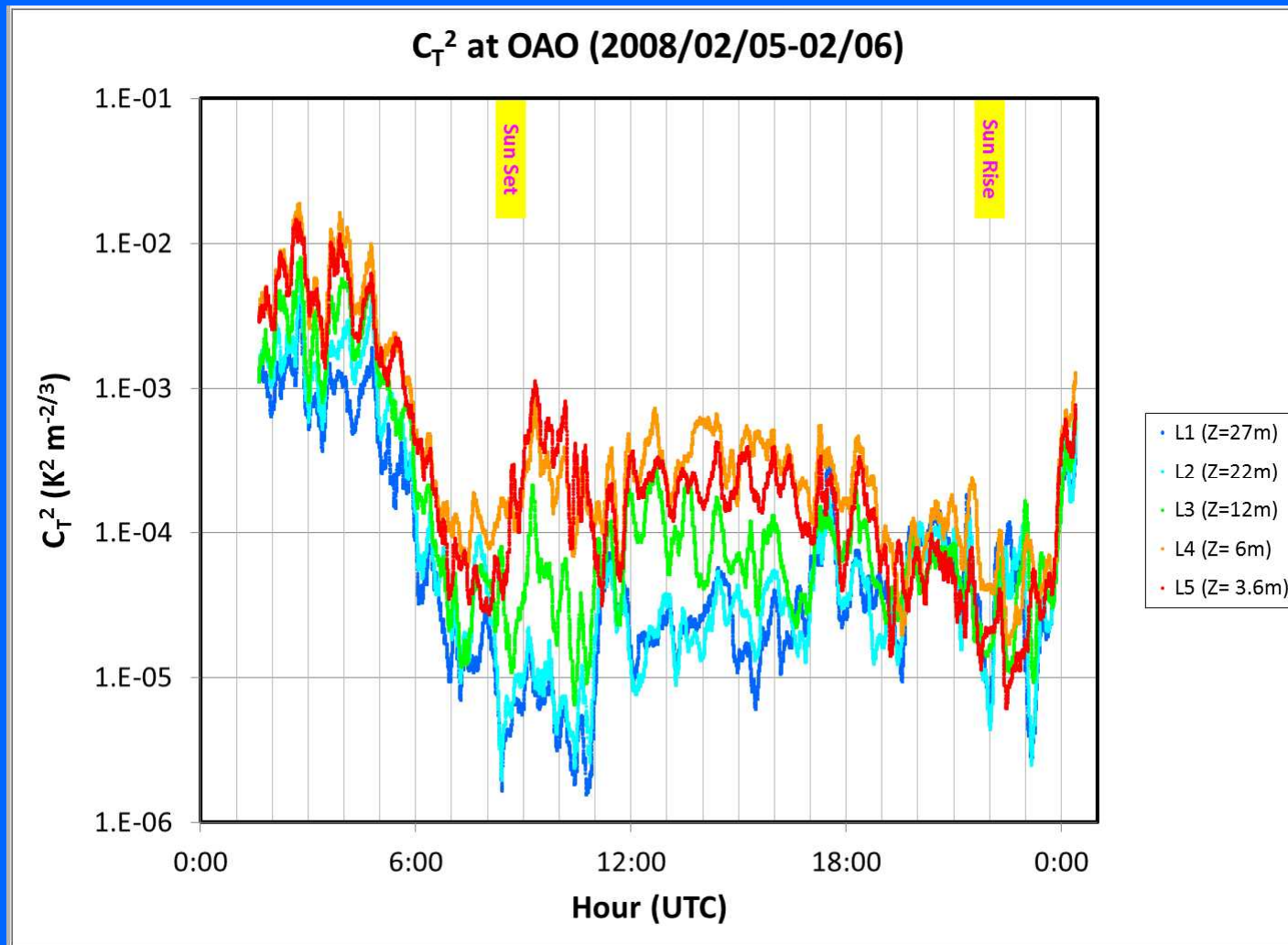
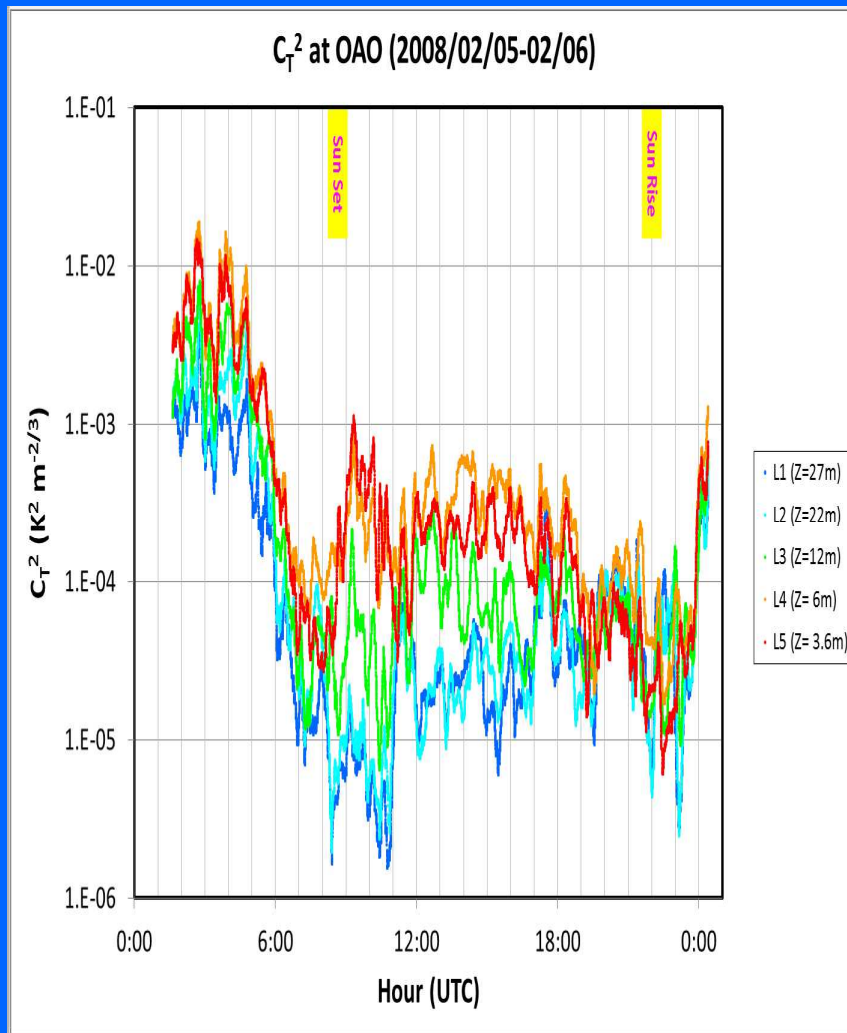


Image deterioration estimated with C_T^2 data



CT2 distribution

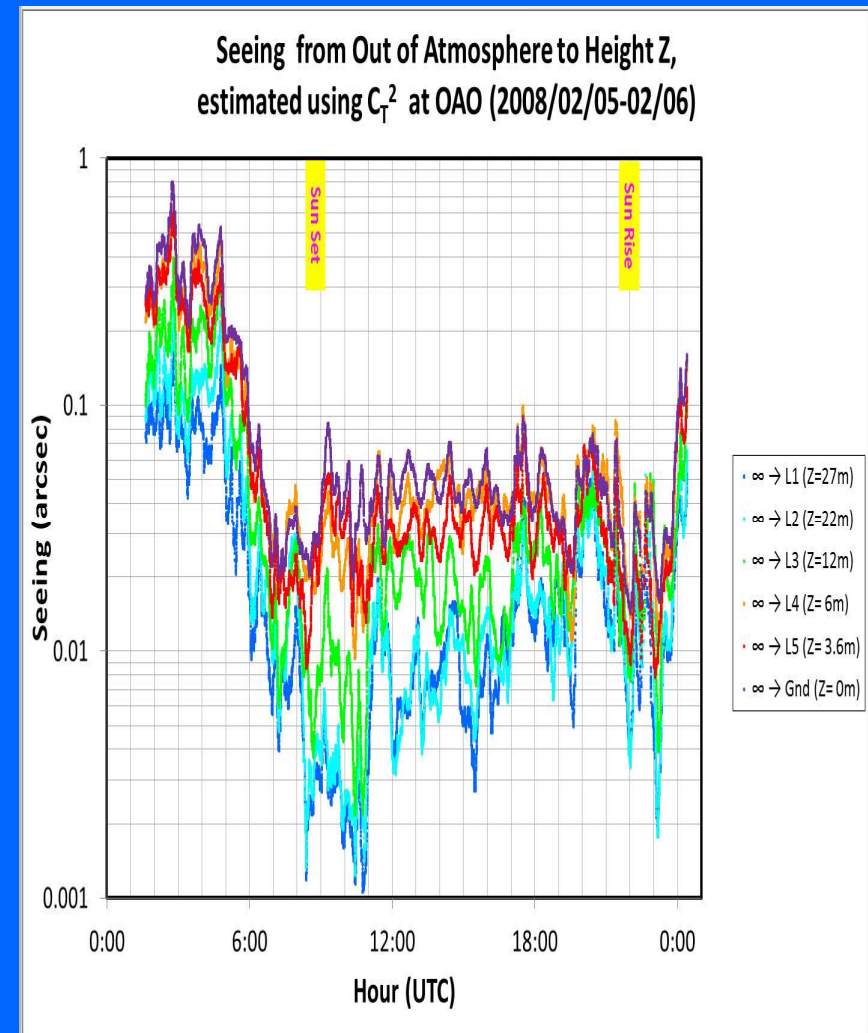
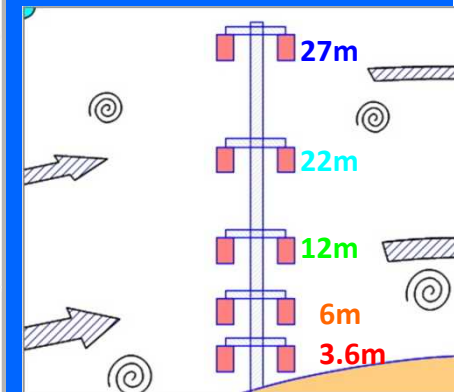
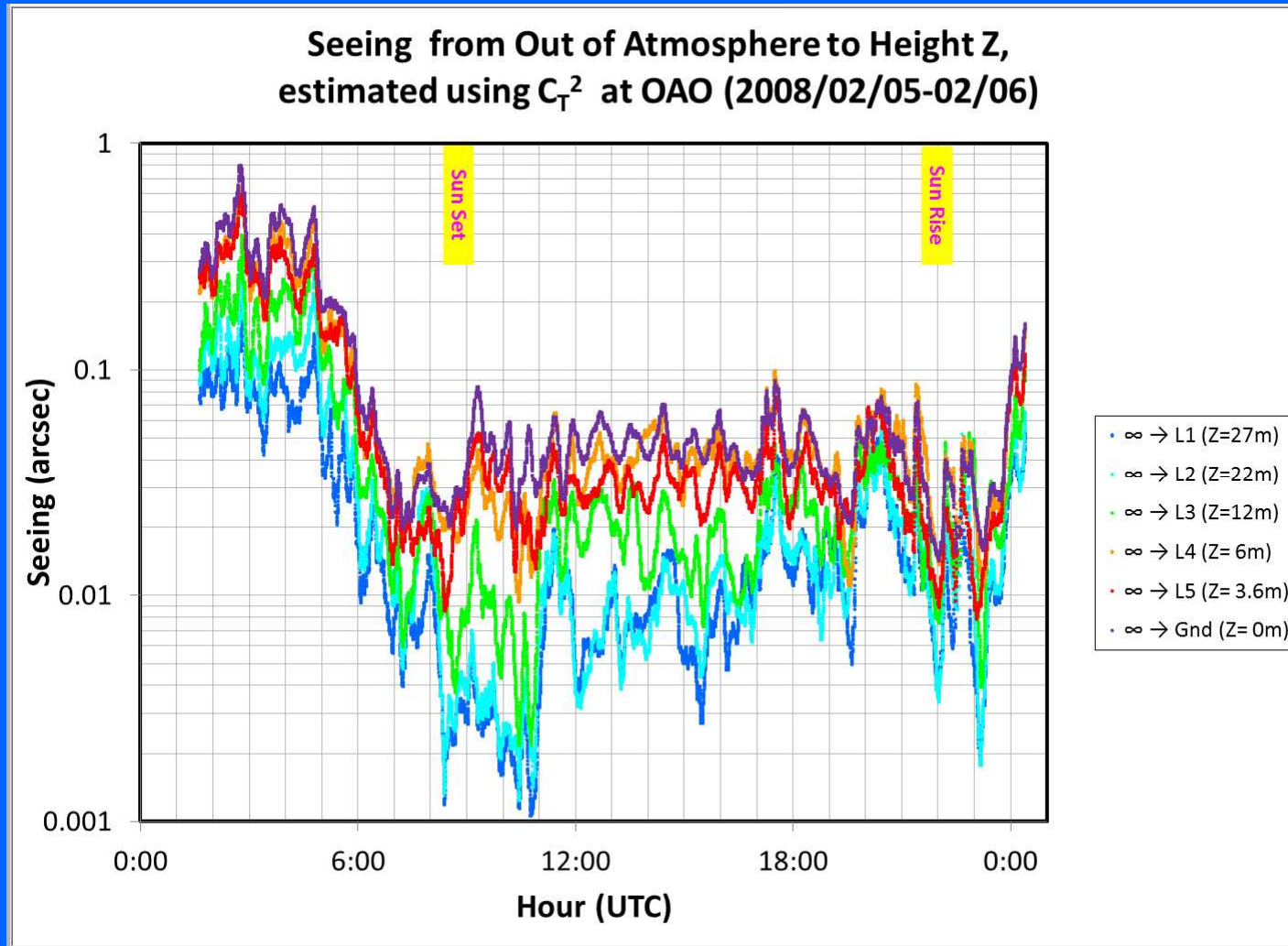


Image deterioration derived from CT2 distribution

$$\theta(z) = 5.3 \lambda^{-1/5} \left(\frac{7.9 \times 10^{-5} P}{T^2} \right)^{6/5} \left[C_T^2(z) z_h \right]^{3/5}$$

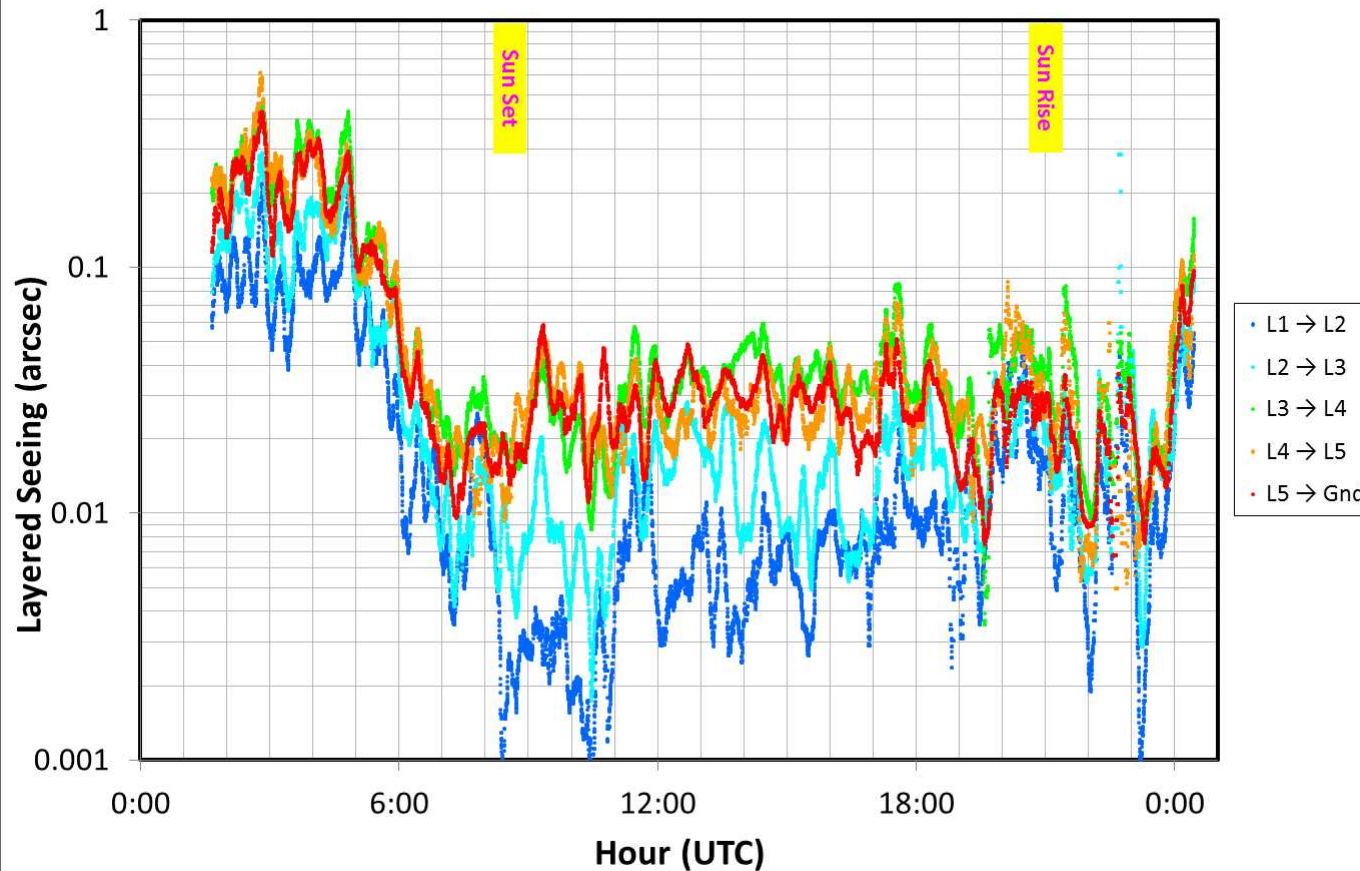
Image deterioration estimated with C_T^2 data

at OAO (Japan)

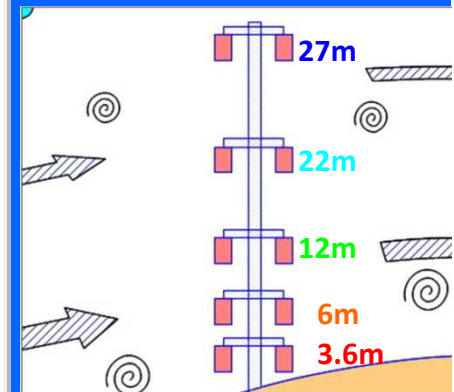


Layered Image deterioration estimated with C_T^2 data

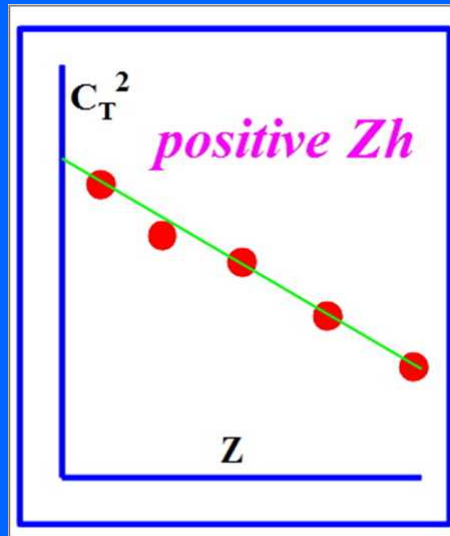
Layered Seeing between Adjacent Heights,
estimated using C_T^2 at OAO (2008/02/05-02/06)



at OAO (Japan)

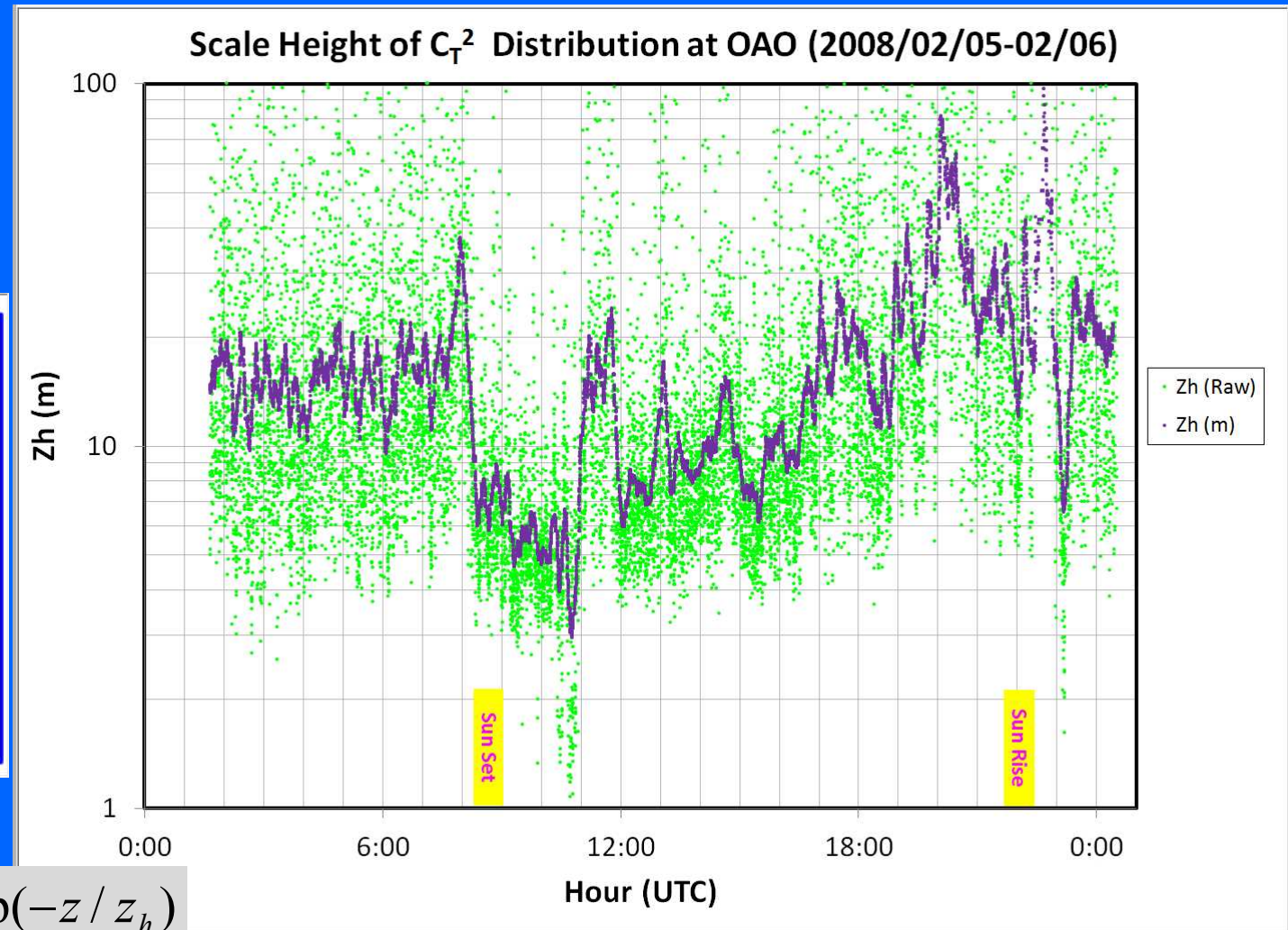


Scale Height of vertical distribution of C_T^2 data



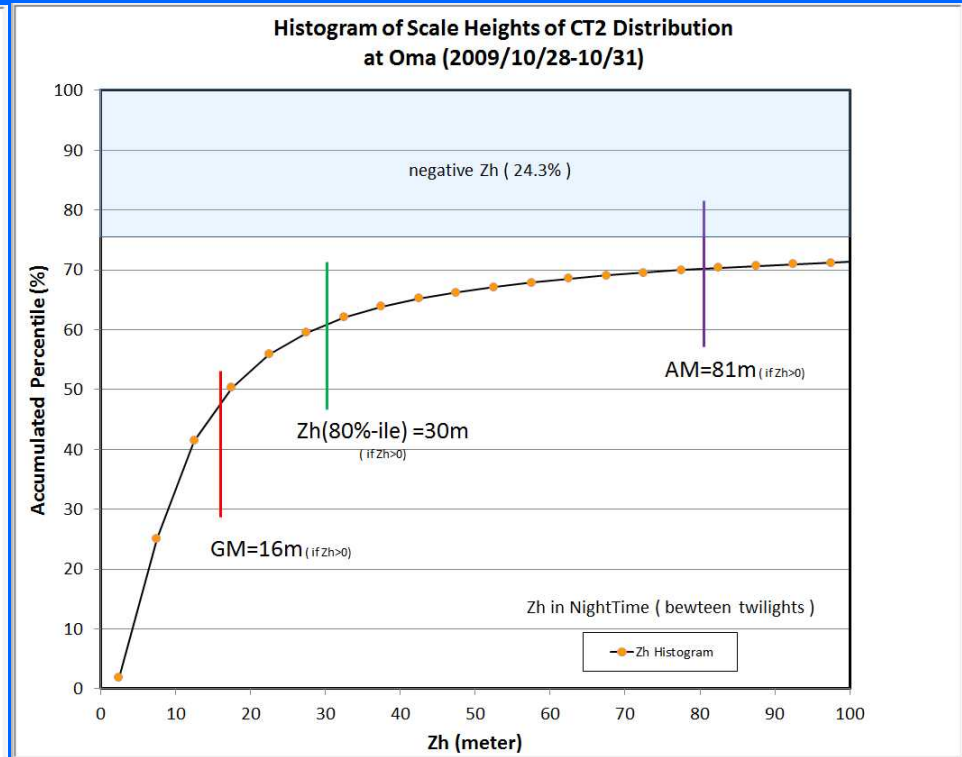
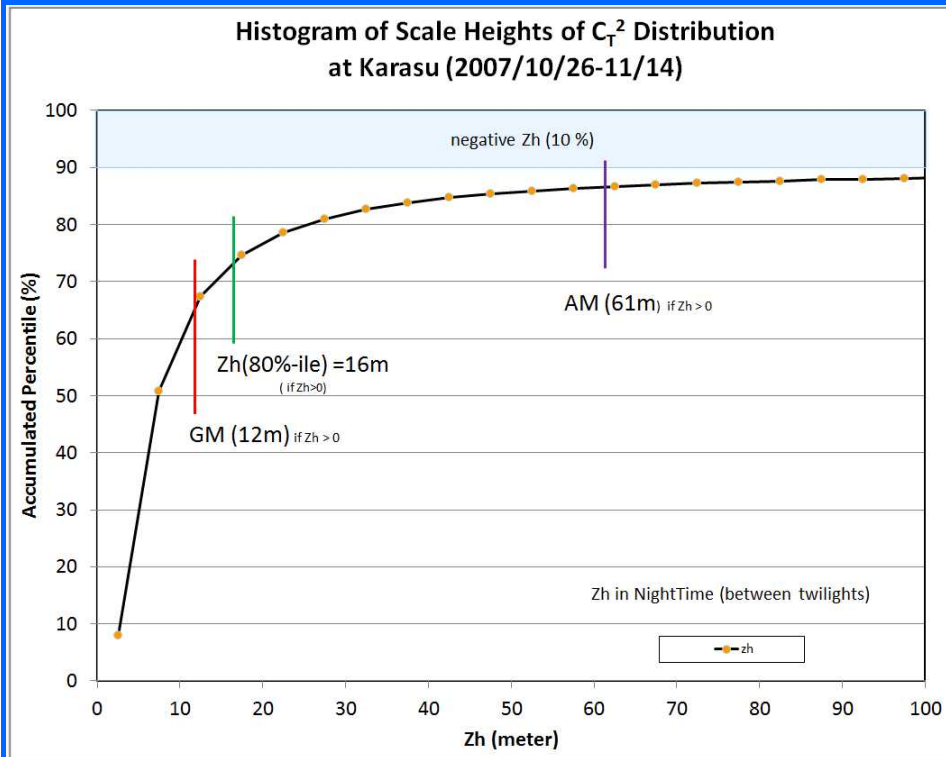
$$C_T^2(z) = C_T^2(0) \exp(-z / z_h)$$

➔ derive Z_h



at OAO (Japan)

Histogram of scale height, Z_h , of vertical C_T^2 distribution



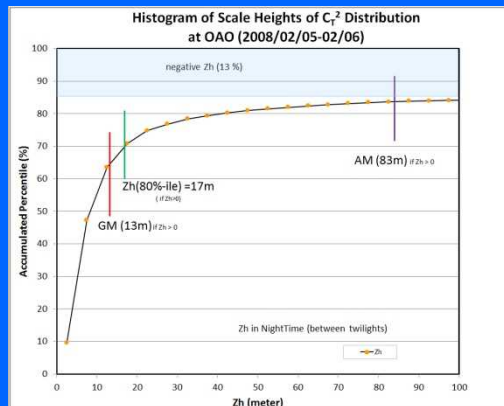
at Karasu

CT2Karasu_20071026UT07H_20071115UT01_Seeing_10min_1.xlsx

CT2Okayama_20080205UT01H_20080206UT00H_Seeing_10min_1.xlsx

at Oma

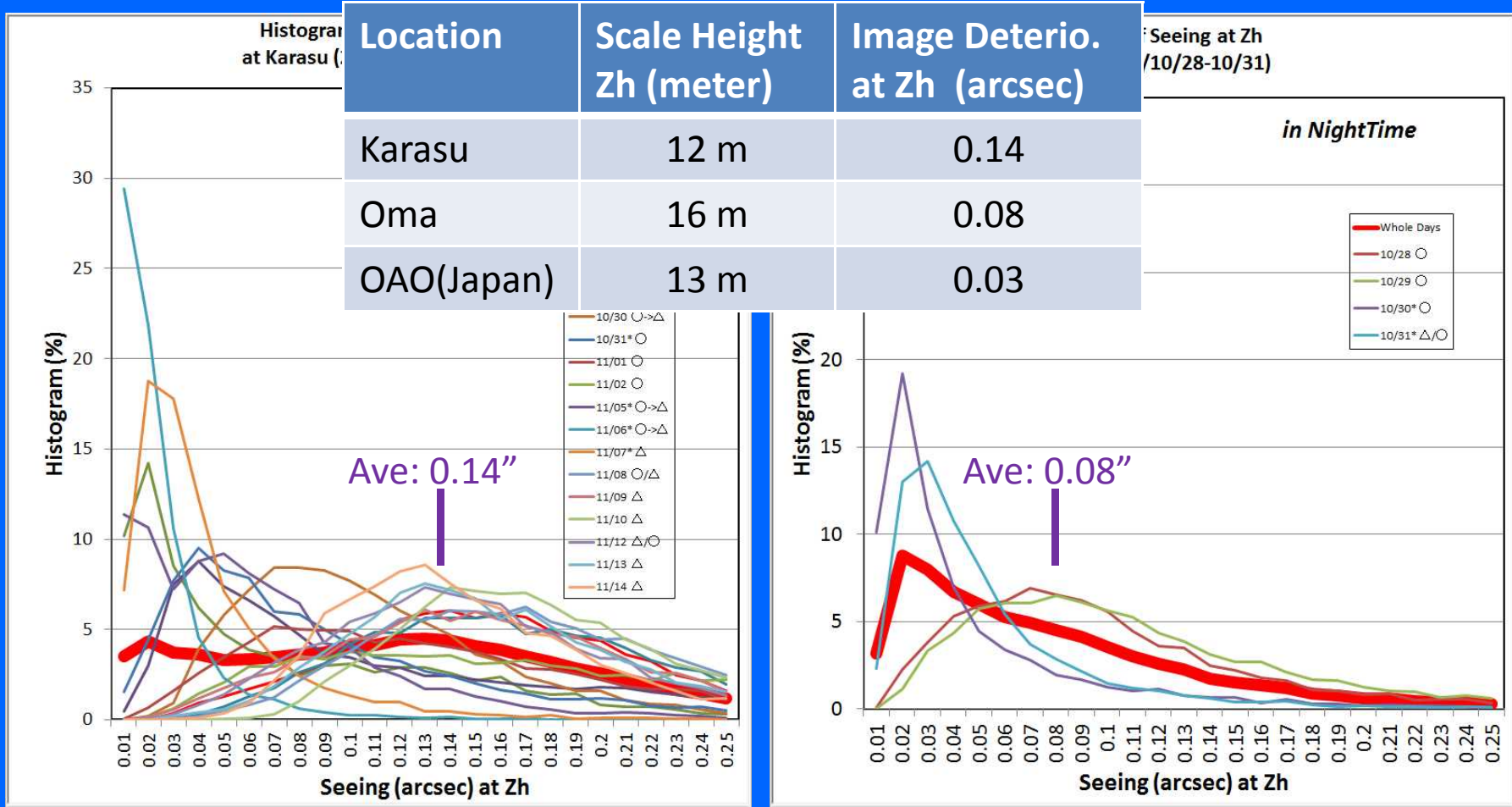
CT2Oma_20091028UT02H_20091111UT10H_Seeing_10min_1.xlsx



at OAO
(Japan)

Location	GM of Scale Height Z_h (meter)	Z of 80%-ile (for $Z_h > 0$)
Karasu	12 m	16m (@72%)
Oma	16 m	30m (@61%)
OAO (Japan)	13 m	17m (@70%) ⁴⁸

Histogram of image deterioration at Z_h estimated from C_T^2



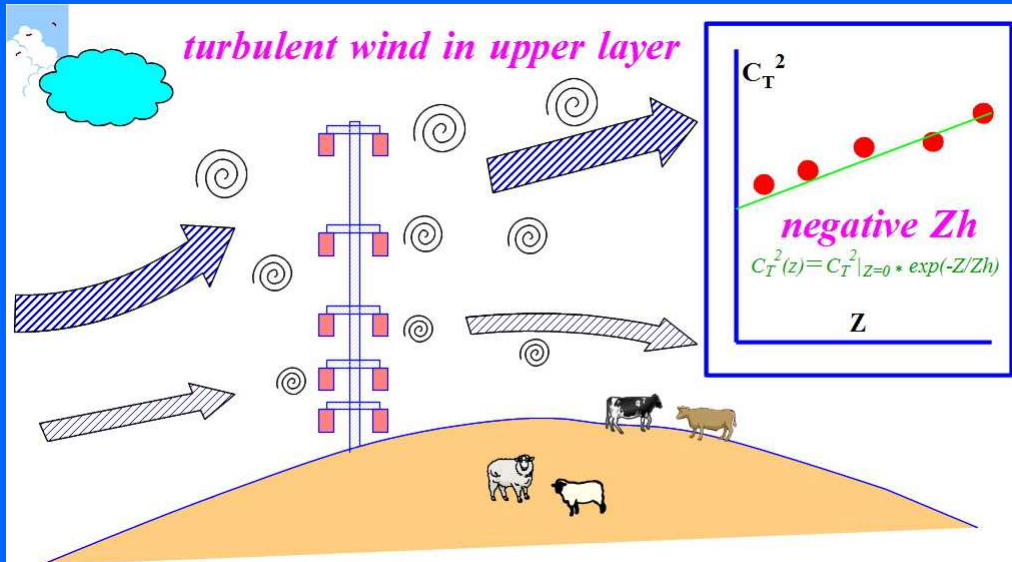
at Karasu

CT2Karasu_20071026UT07H_20071115UT01_Seeing_10min_1.xlsx

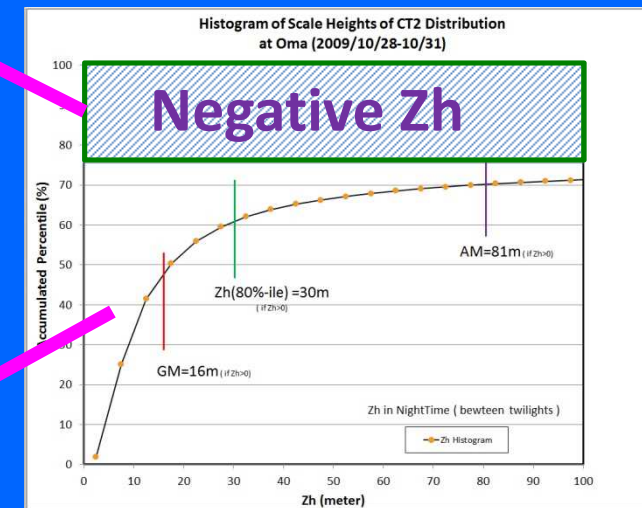
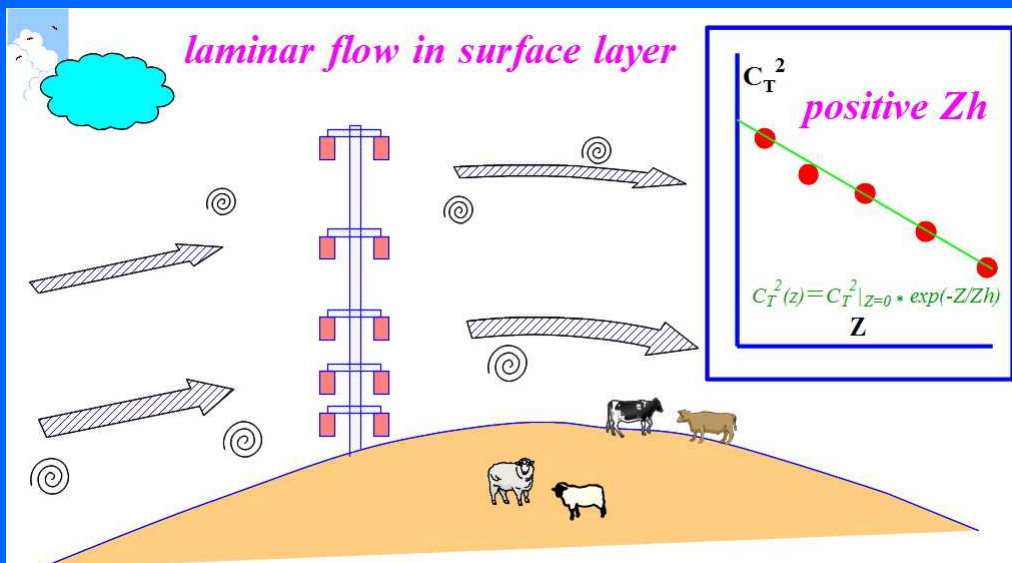
at Oma

CT2Oma_20091028UT02H_20091111UT10H_Seeing_10min_1.xlsx

Negative Zh means higher turbulent atmosphere caused by strong wind

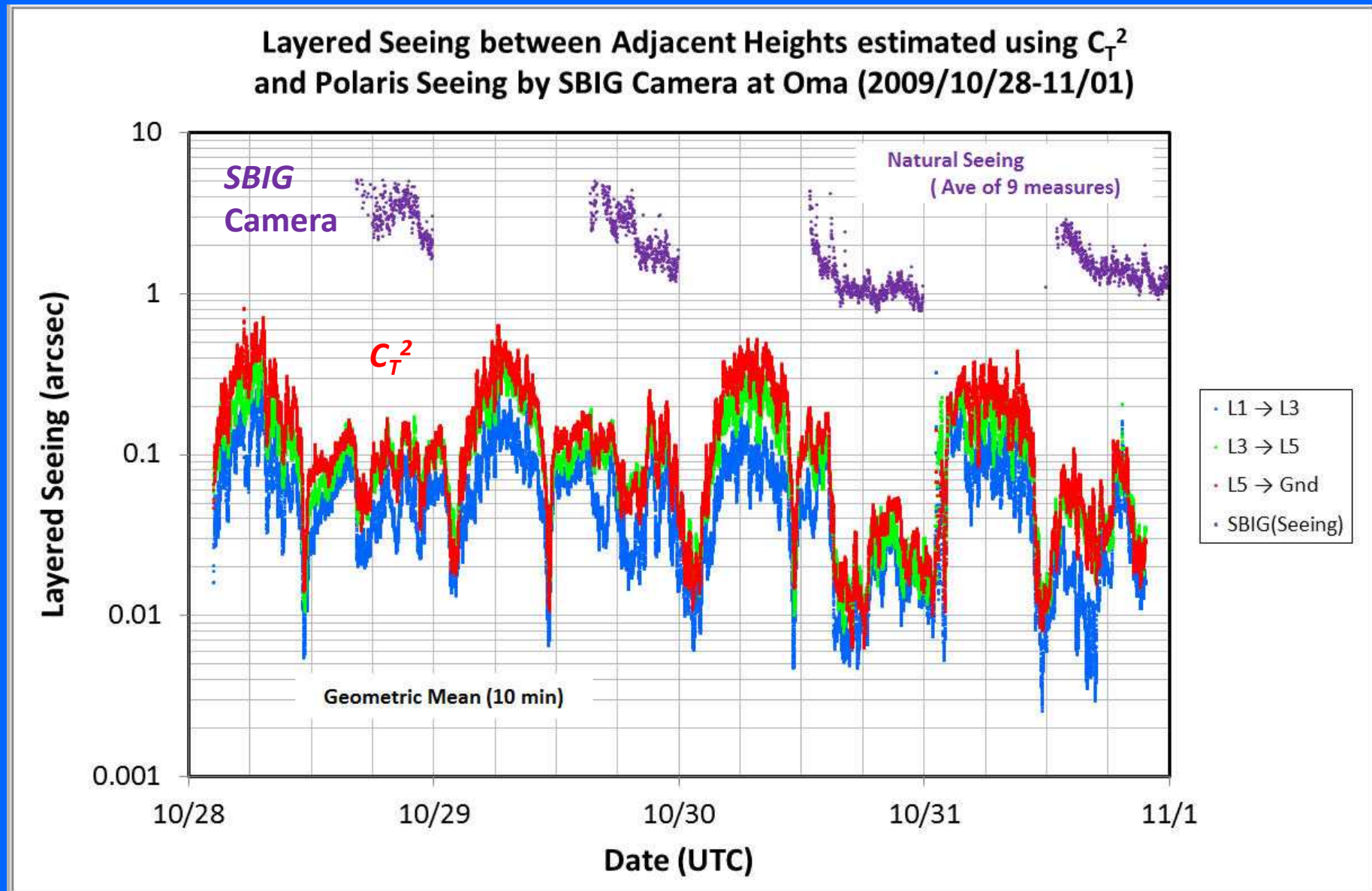


at Oma



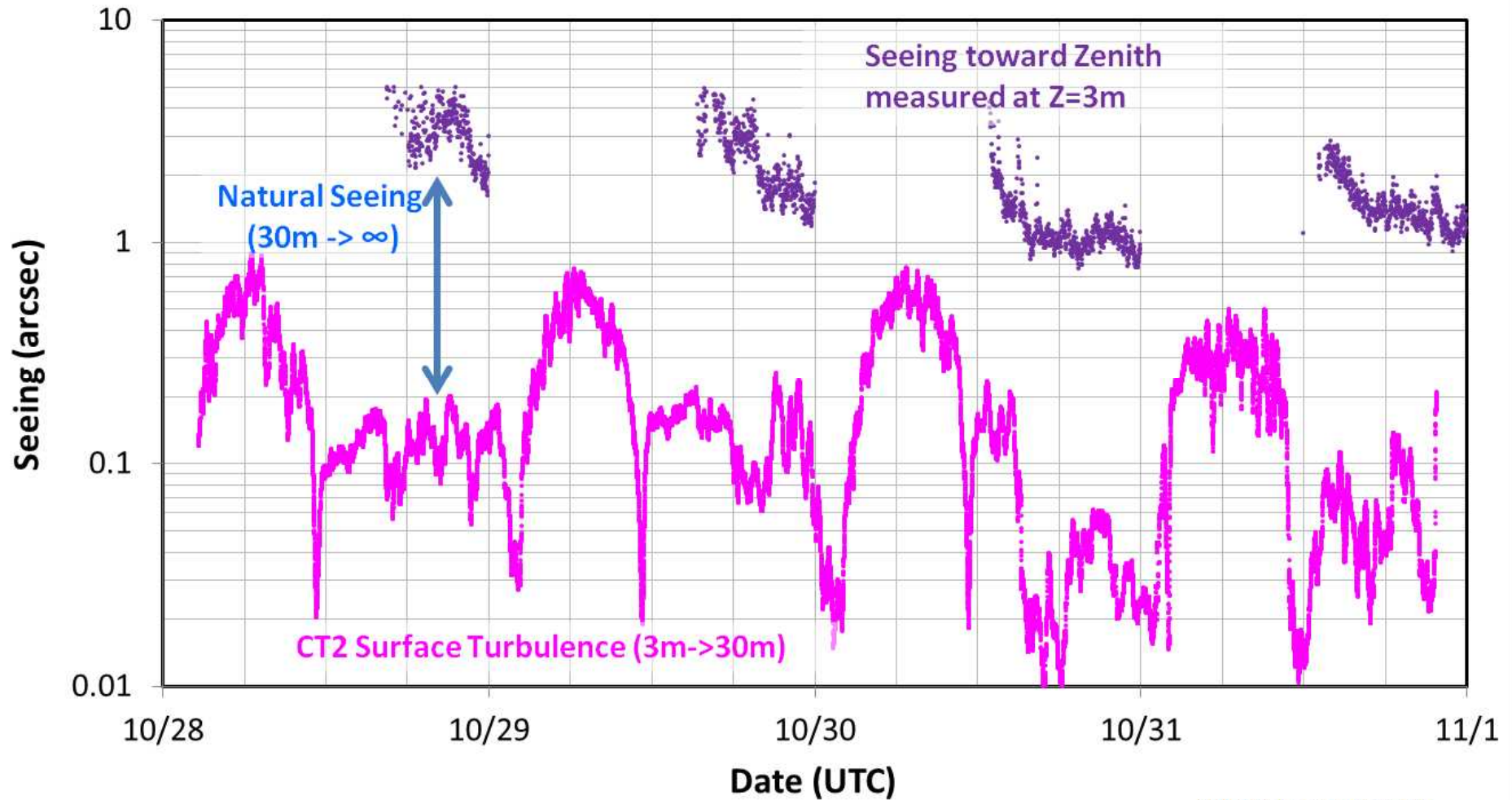
CT2Oma_20091028UT02H_20091111UT10H_Seeing_10min_1.xlsx

Upper atmosphere should be measured on turbulent motions with SNODAR (planned).

Comparison of image deterioration at Z_h with seeing by SBIG camera at Oma

Comparison of image deterioration at Z_h with seeing w/ SBIG camera at Oma

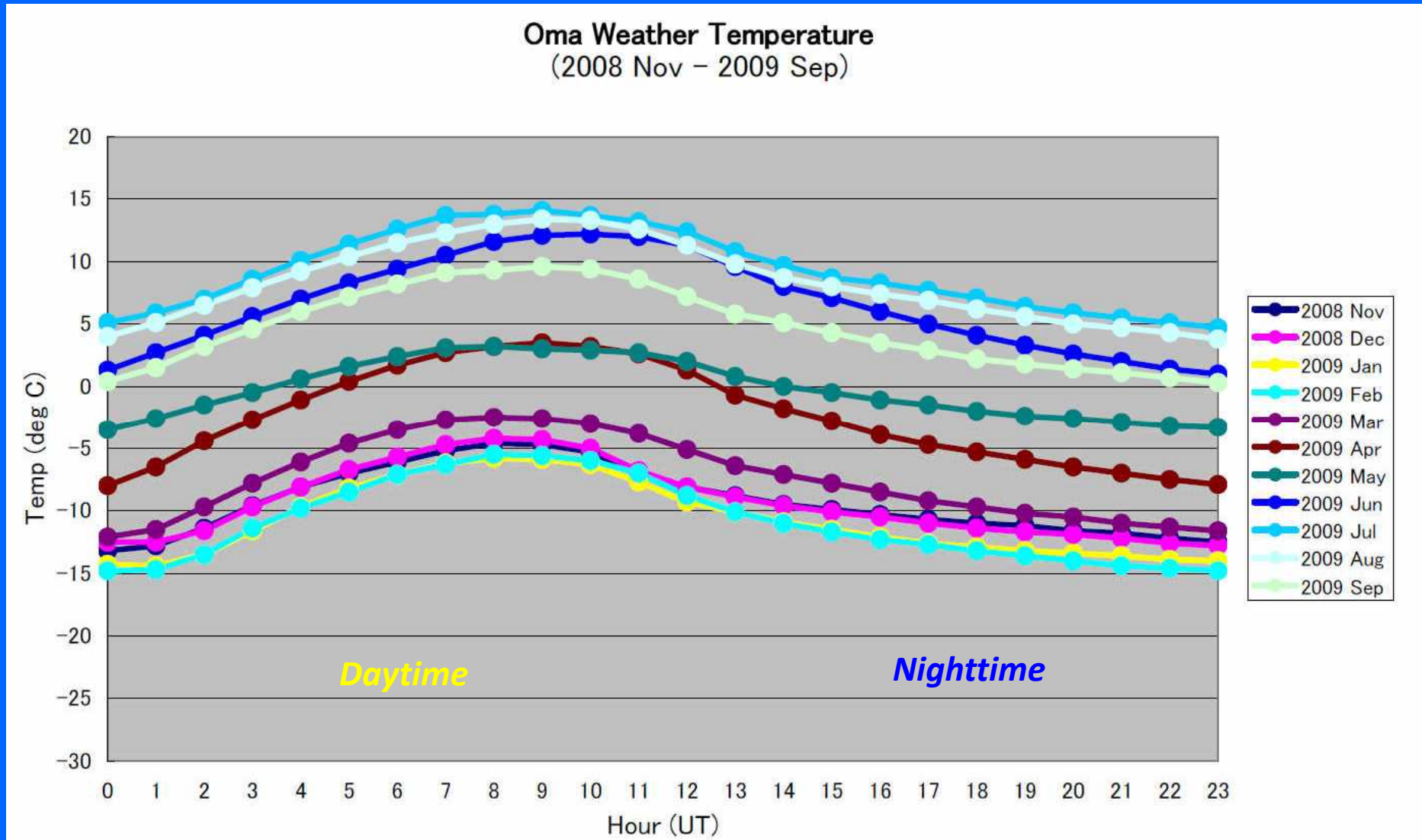
Natural Seeing measured with SBIG camera (Polaris)
at Oma (2009/10/28-11/01)



• CT2 Surface Turbulence (3m->30m: Ave 10min) • Seeing (SBIG)

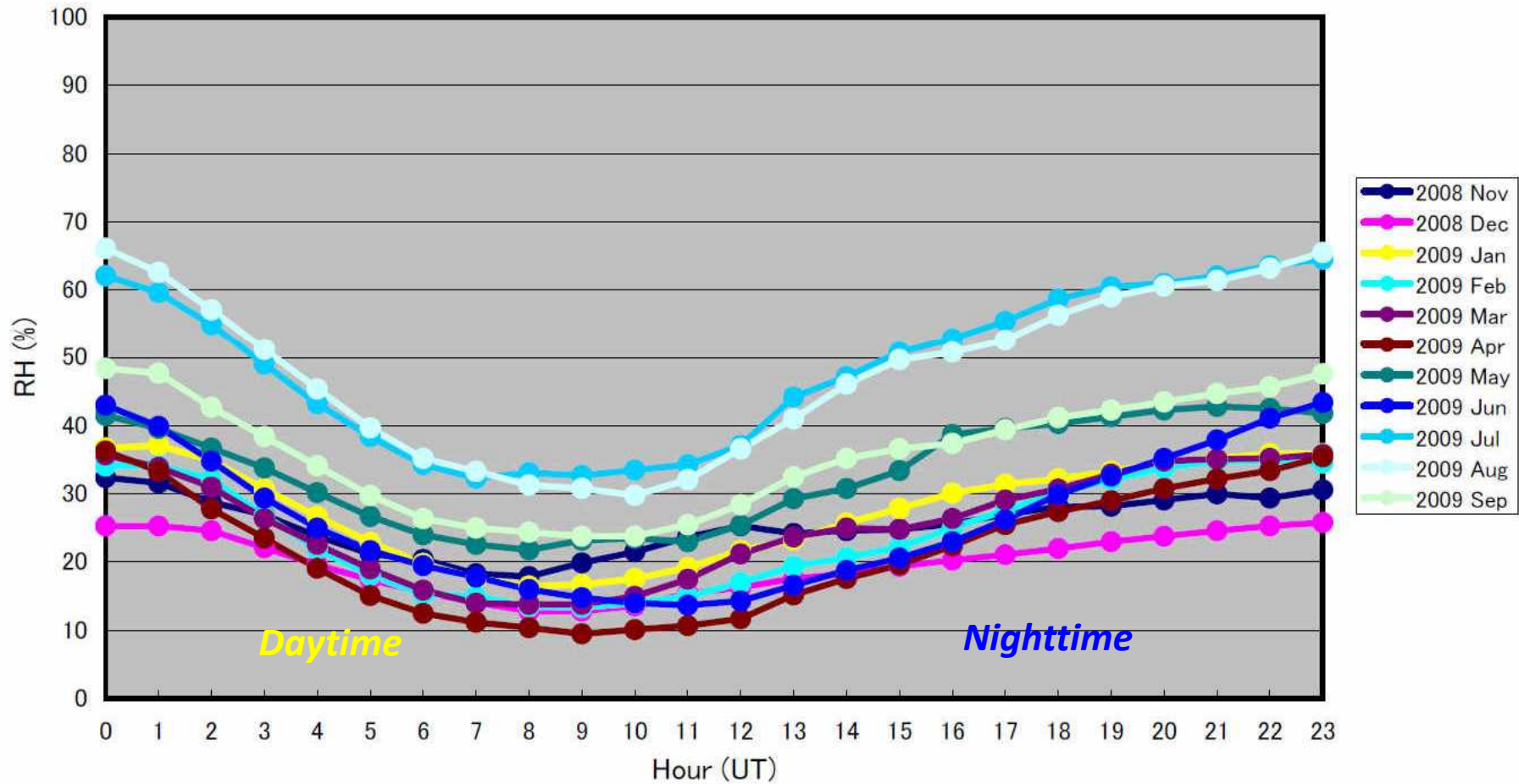
SBIG Camera at Z = 3m
Z_h (80%) of C_T² = 30m

Weather data at Oma in 2008 and 2009

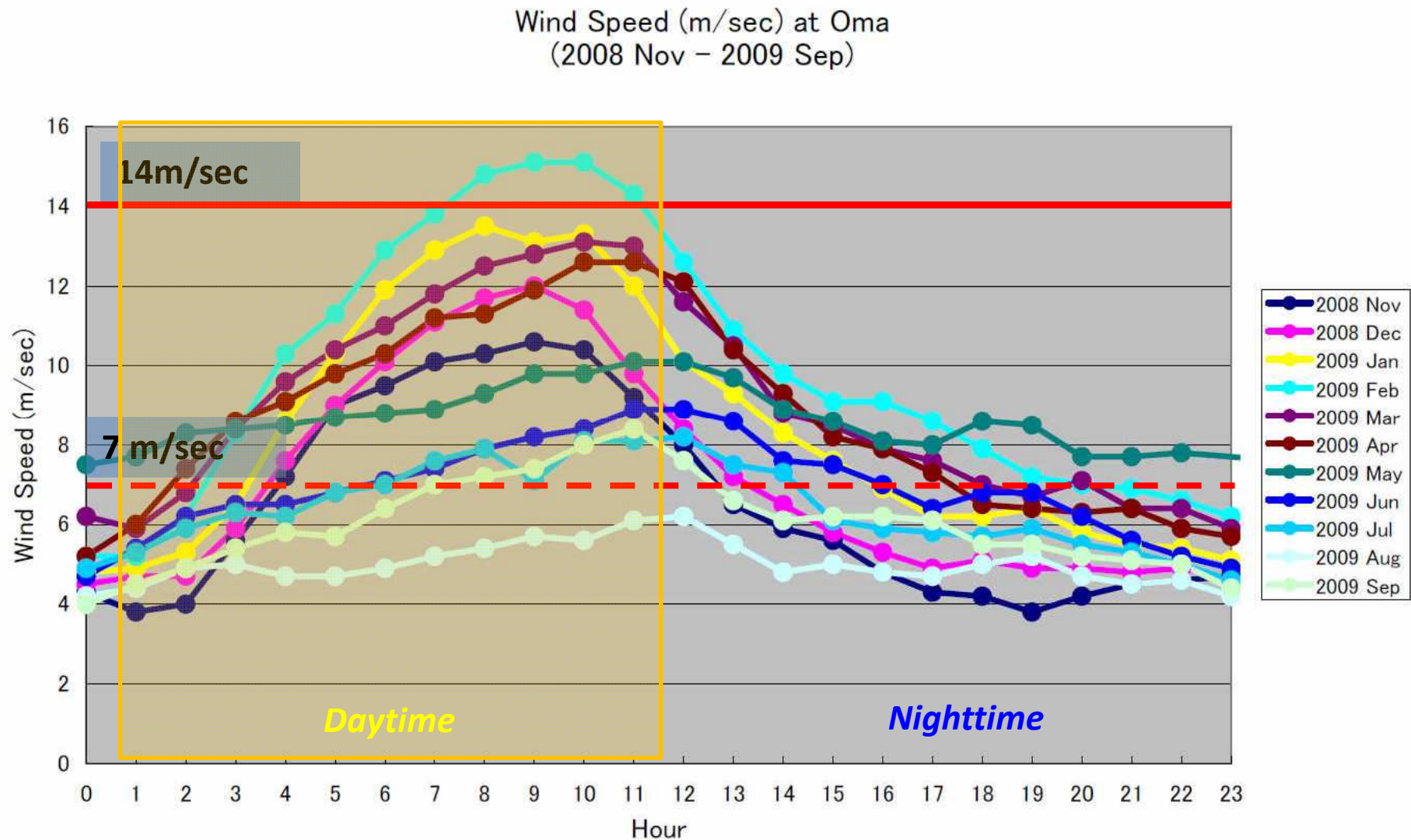


Weather data at Oma in 2008 and 2009

Relative Humidity at Oma
(2008 Nov - 2009 Sep)

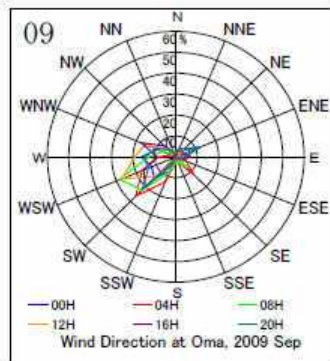
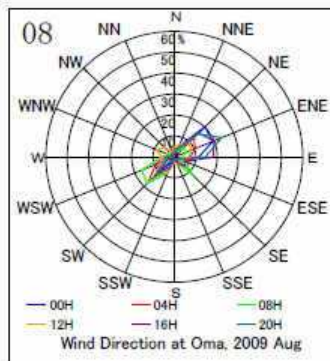
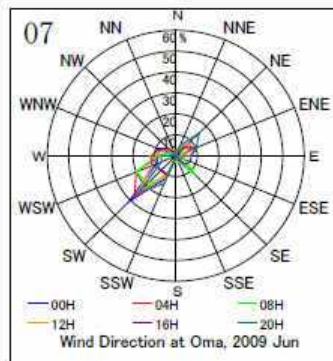
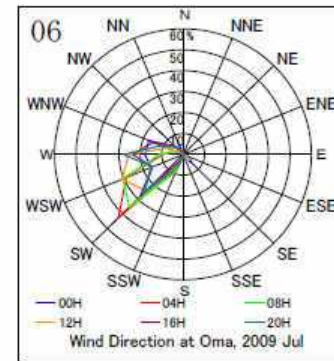
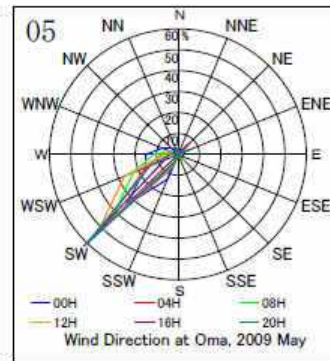
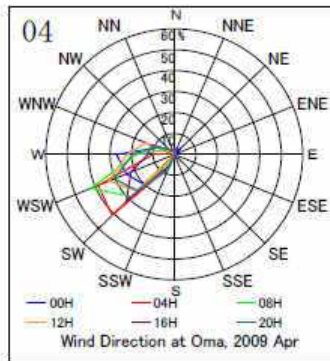
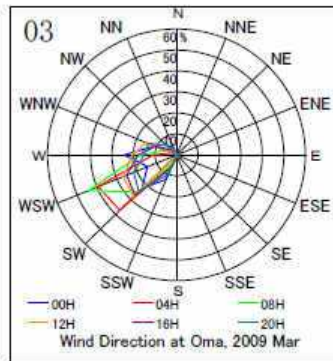
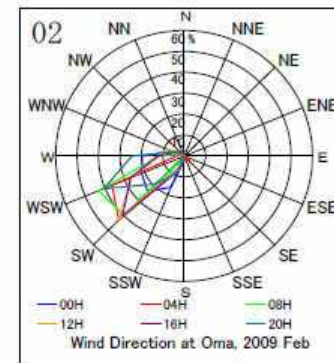
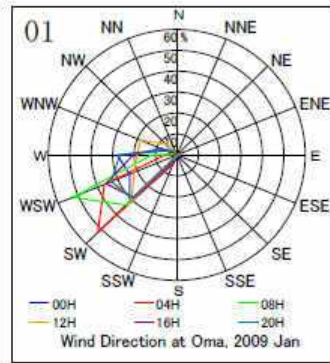
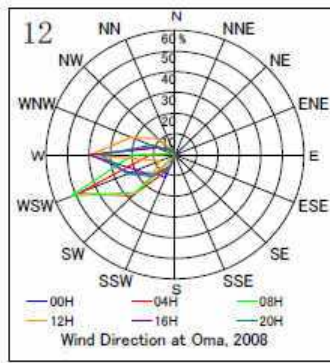
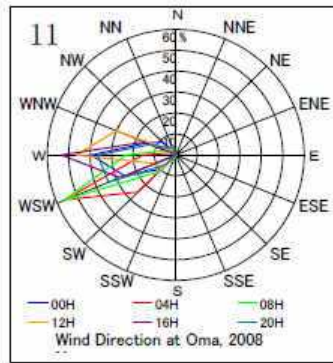


Weather data at Oma in 2008 and 2009



Wind Speed in winter is typically strong at Oma, which affects local seeing. For Subaru telescope, operation is limited under Wind Speed of 14 m/sec and its performance is guaranteed under 7m/sec.

Weather Direction at Oma in 2008 and 2009



Oma Wind Direction
2008 Nov - 2009 Sep

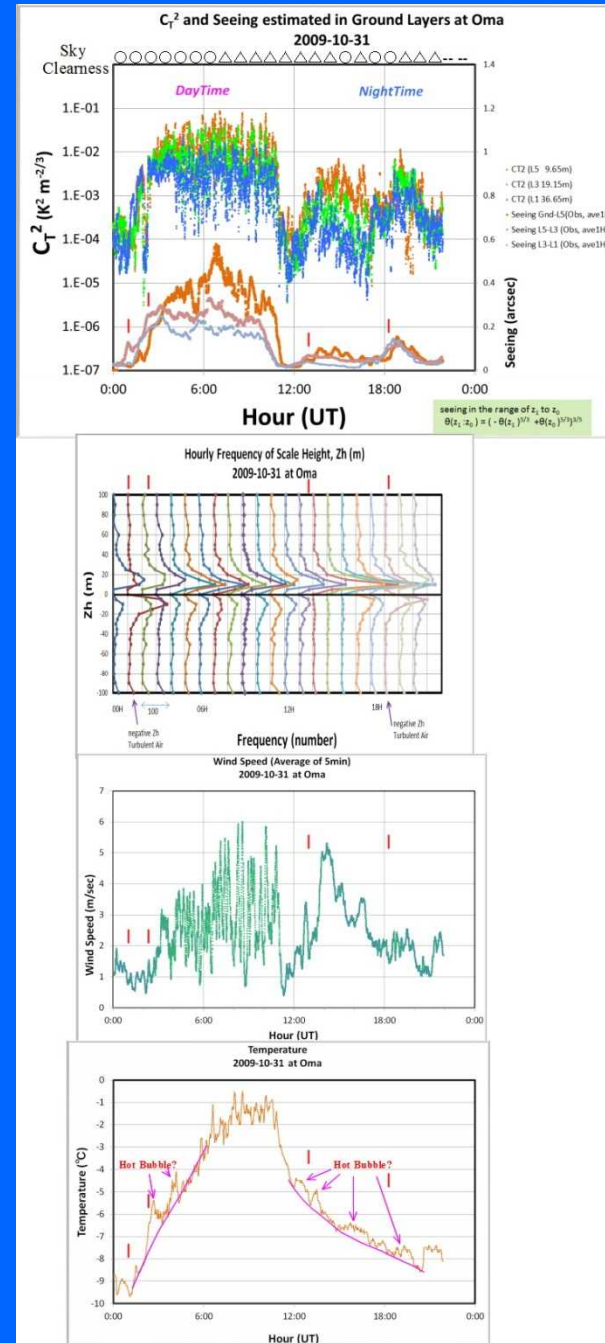
Sky is clear or fine? →

Relation among C_T^2 distribution and Wind Speed

(2009-10-31 at Oma) Zh histogram →

Wind Speed →

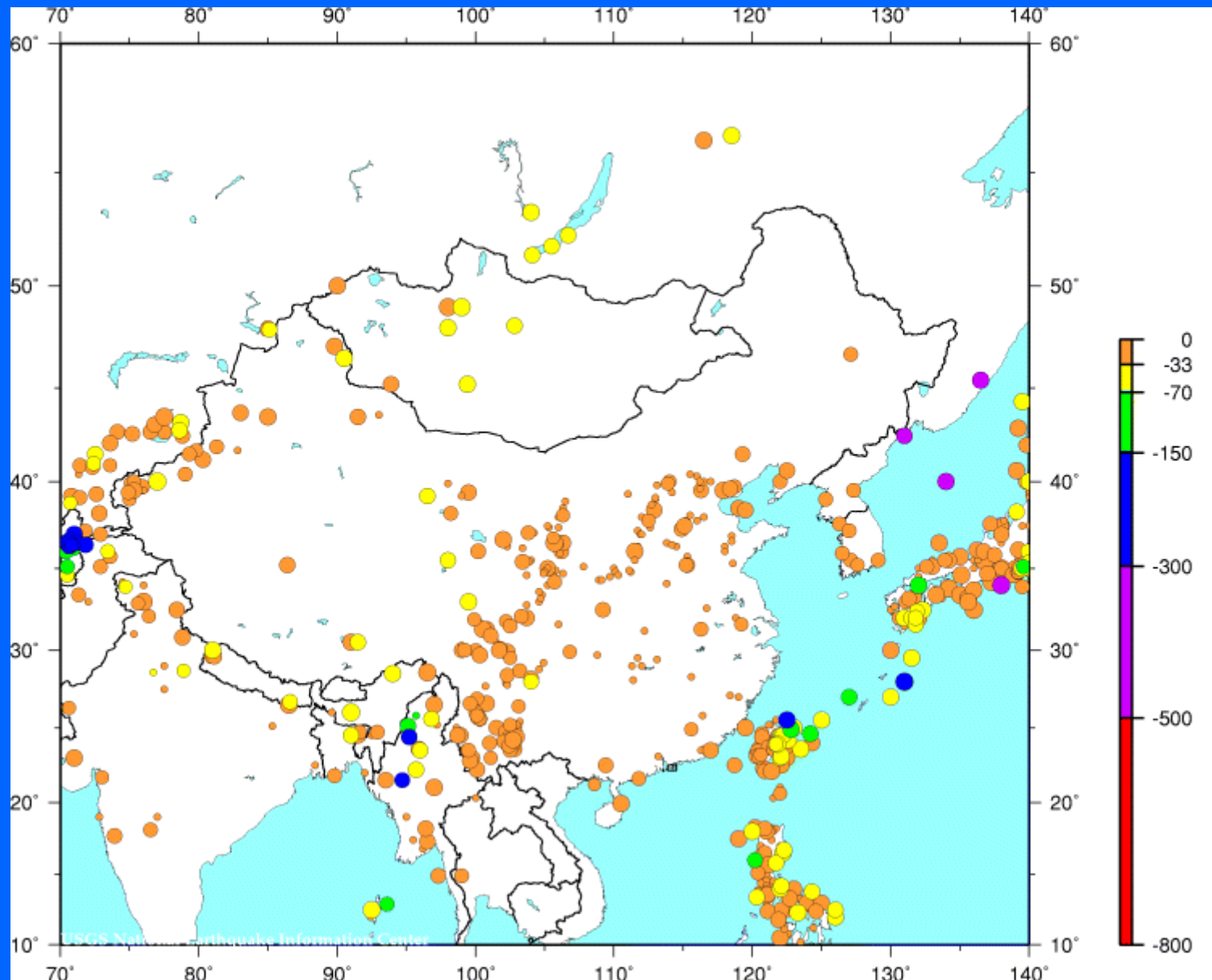
Temperature →



Z:\¥00SiteSurveyData¥000_aSiteSurveySummary¥
 Oma_20091031_CT2_Seeing_WindSpeed_Temp.jpg

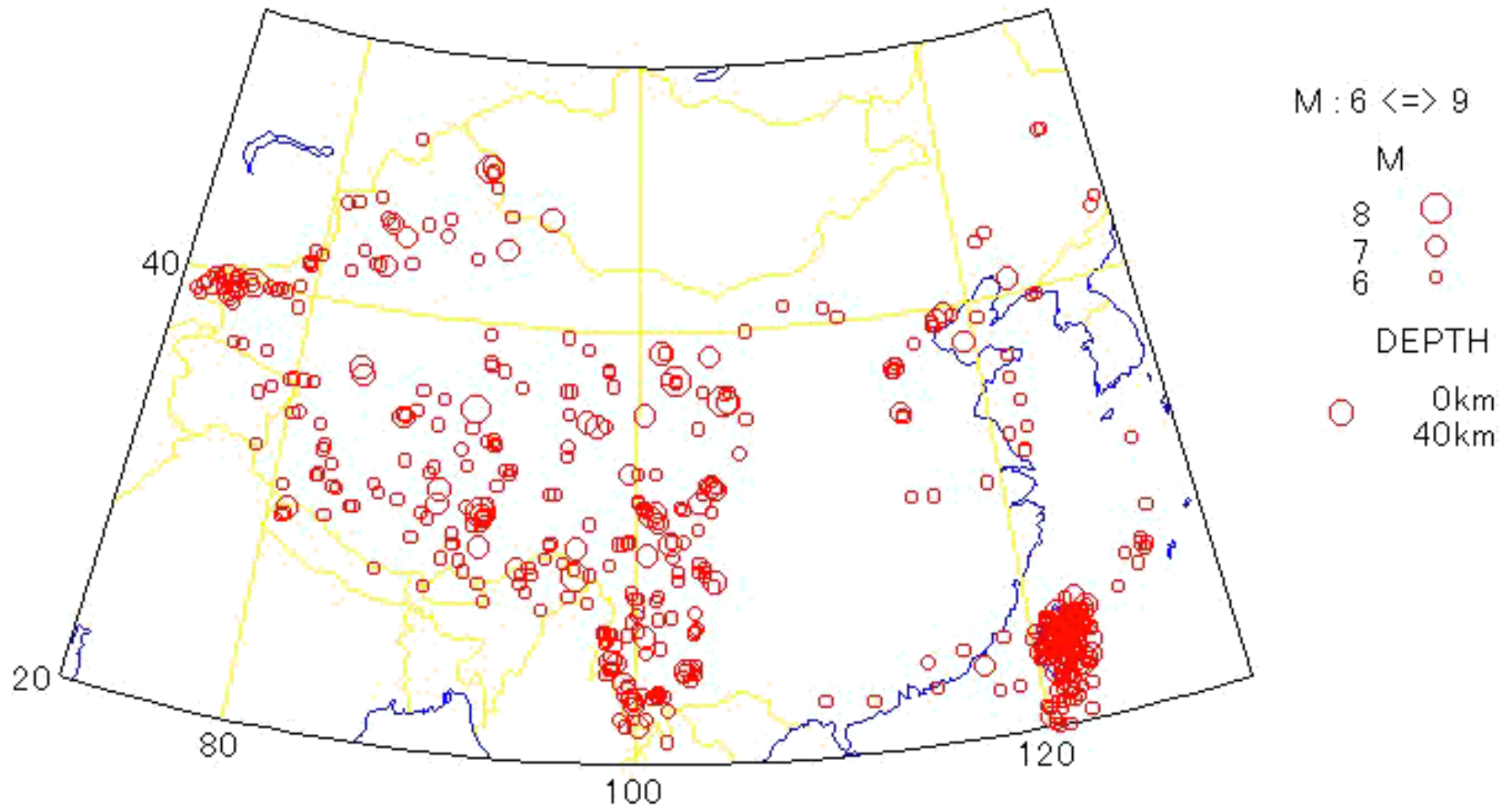
Earthquake in China

SeismicBigMagCentralAsia_USGS.gif



Seismic activity in Tibet

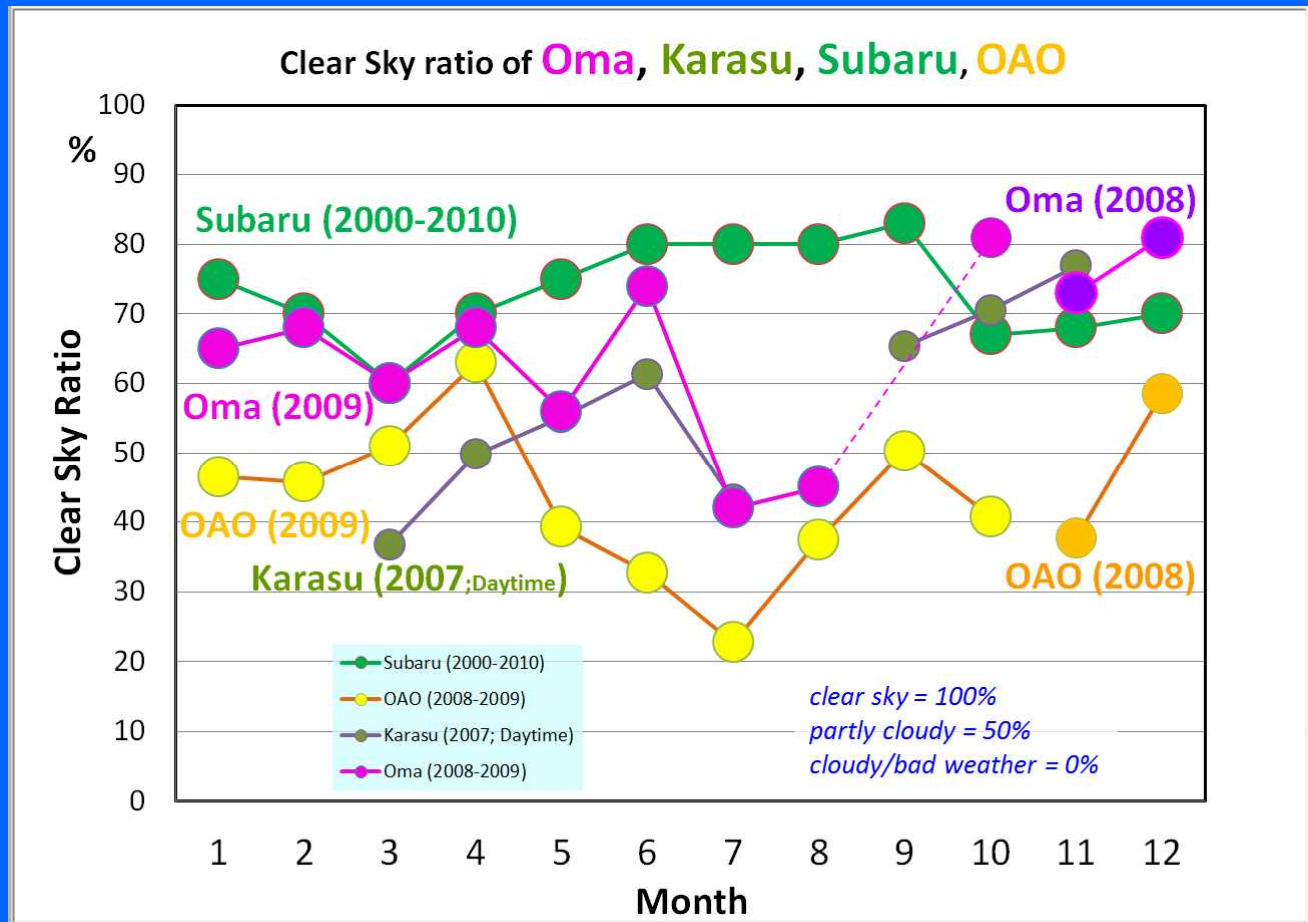
Data from GAME-Tibet project



MIR CloudMonitor

Clear sky ratios at Oma, except summer monsoon season, are around 70%, which are comparable to at Mauna Kea, Hawaii, and much better than at Okayama, Japan.

Subaru : statistics during 2000-2010
 OAO: summary report during 2008-2009


















C_T² measurements

Location	Scale Height Zh (meter)	Image Deterio. at Zh (arcsec)
Karasu	12 m	0.14
Oma	16 m	0.08
OAO (Japan)	13 m	0.03

should evaluate bad effect of **Strong wind** at the sites

On-going Collaborative Site Testing at Ali

Item	Instrument		Status	
Weather condition	Vaisala:WXT510	 	Working at Ali	
Sky condition	MIR Cloud Mon Visible all-sky camera	 	Working at Ali Working at Ali	
Dust	Dust Counter TSI:DustTrak8520		apply site testing instruments with analysis tools to evaluate observational conditions at Ali for years.	
DIMM	(NAOC)			
SCIDAR	(NAOC)			
Surface Layer Turbulence	CT2 sensors on tower	 		Constructed soon this year
Turbulence in upper layer	SNODAR	 		Planning (<i>tomorrow talk</i>)
Housing	w/ electric power		Available at Ali	
	O ₂ supply		Comfortable at 5100m ! 😊	
Road			need 4WD 🚙	
Internet	LAN		Planned (not yet available stably)	

The End

謝謝、ありがとう、Thank you !

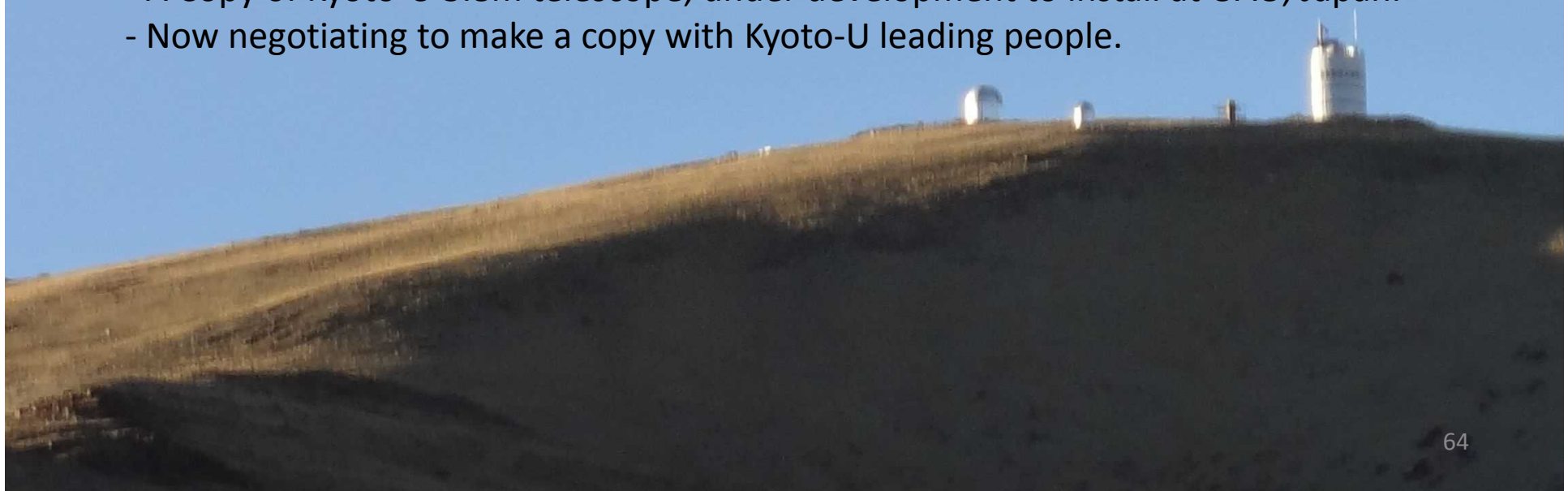
Possible Telescope plan at Ali site

After we evaluate and confirm the good condition around Ali,
We'd like to promote to deploy a **small telescope** w/observation instruments.

- 1m ~2m Telescope, like TAO 1m telescope made by NISHIMURA's.
- Optical Imaging/Spectroscopic/Polarimetric Instrument,
like Hiroshima-U's HOWPol
(HOWPol use two Optical CCDs, which are exported into China easily even now.)

And also we like to introduce a possible **4m telescope** near Ali.

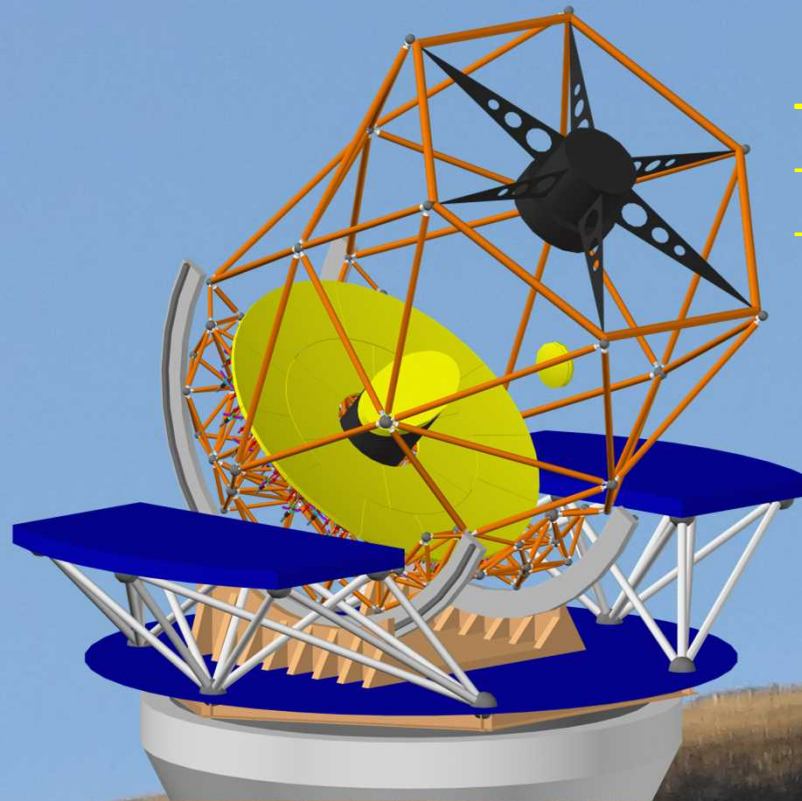
- A Copy of Kyoto-U 3.8m telescope, under development to install at OAO, Japan.
- Now negotiating to make a copy with Kyoto-U leading people.



Kyoto 3.8m telescope, possibly installed in west China

<http://www.kusastro.kyoto-u.ac.jp/~nagata/Kyoto3m>

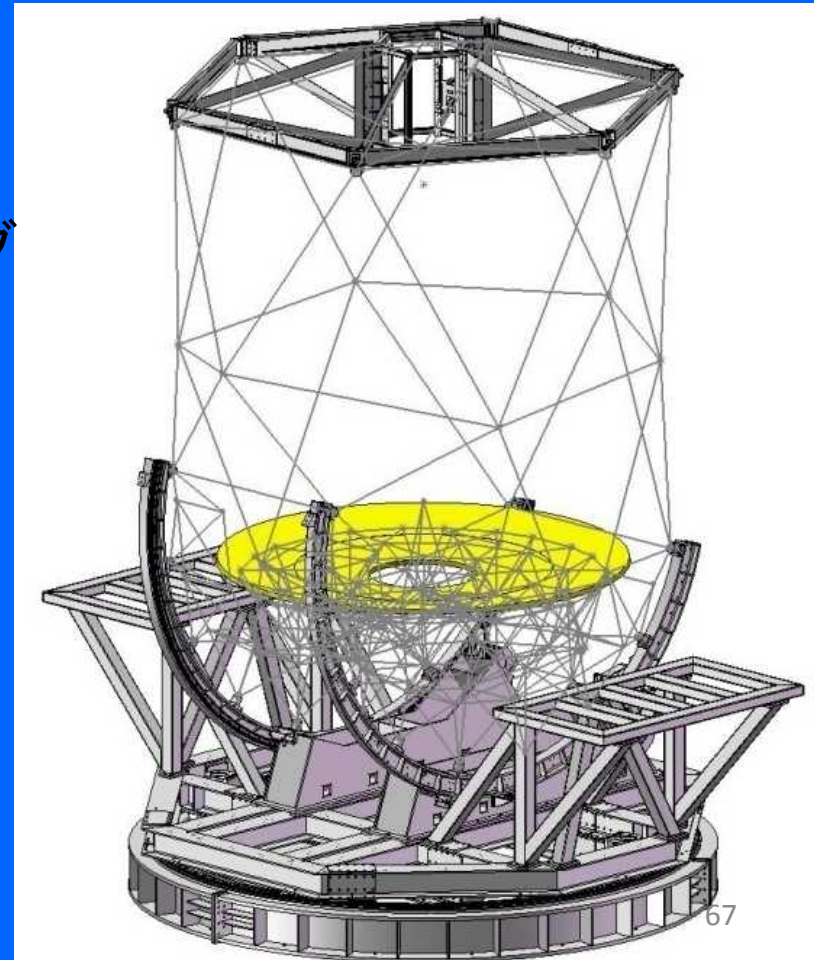
- Fan-shaped segmented 18 mirrors
- light-weighted truss structure
- 1st light in 2014(?)





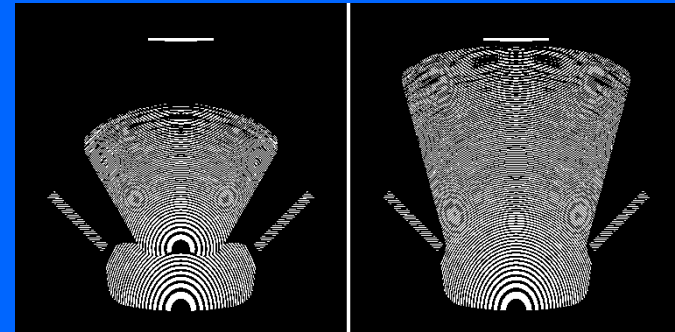
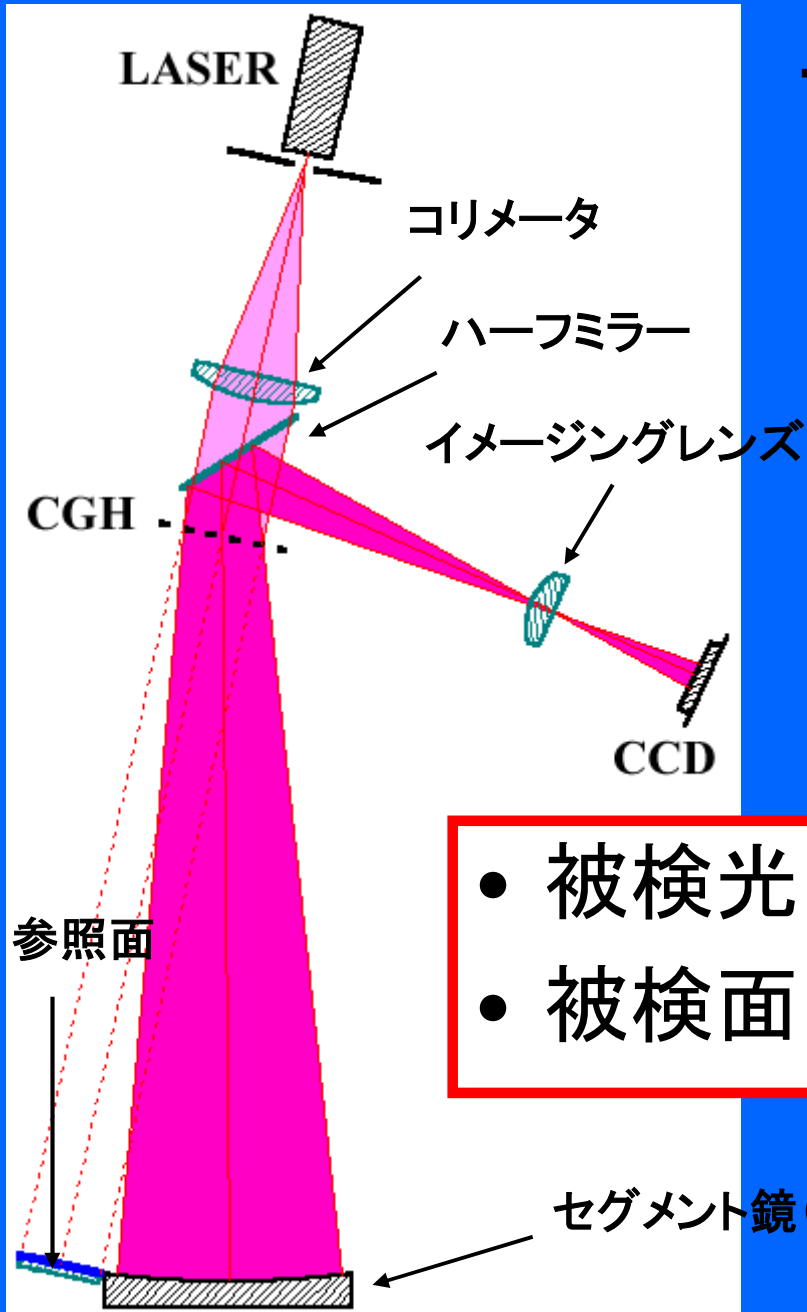
Mount of Kyoto 3.8m Telescope

- 従来の1/5程度の質量
weight ~ 1/5 nominal Telescope
 - 鏡筒質量8トン(うち構造物:4トン)
- 54個の主鏡支持点での相対変形 < 100 μm
relative deformation < 100 μm
- 遺伝的アルゴリズムによる最適化プログラムを開発し、構造の最適化を行った。
Hereditary algorithm
-> Structure optimized (patented)
 - 高速 駆動 High-speed drive
 - 低 熱容量 low thermal capacity
 - 低 熱慣性 low thermal inertia
 - 低 風抵抗 low wind resistance



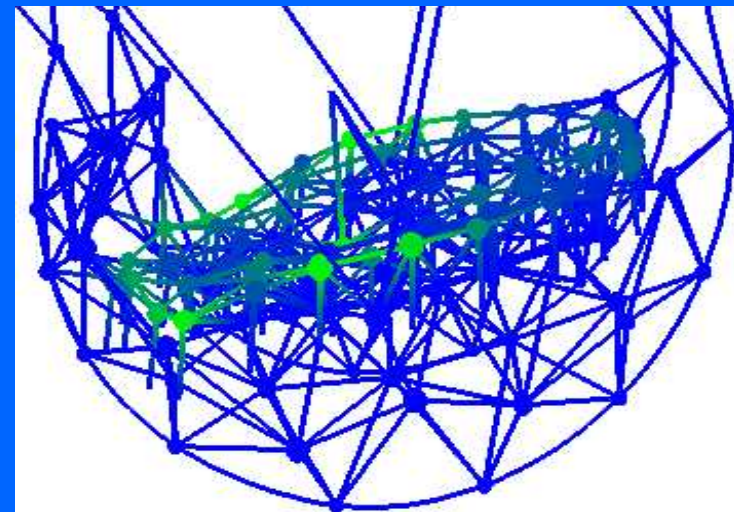
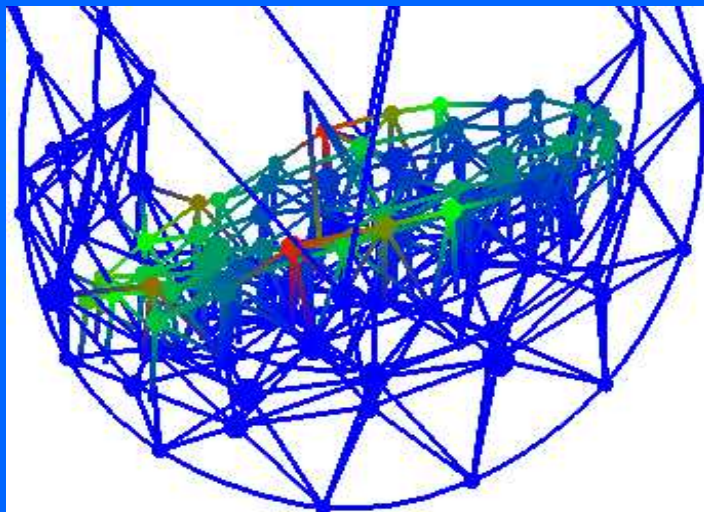
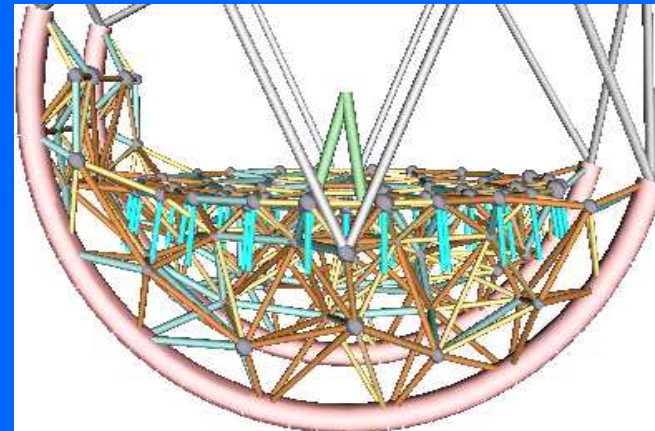
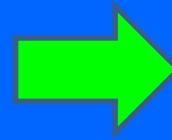
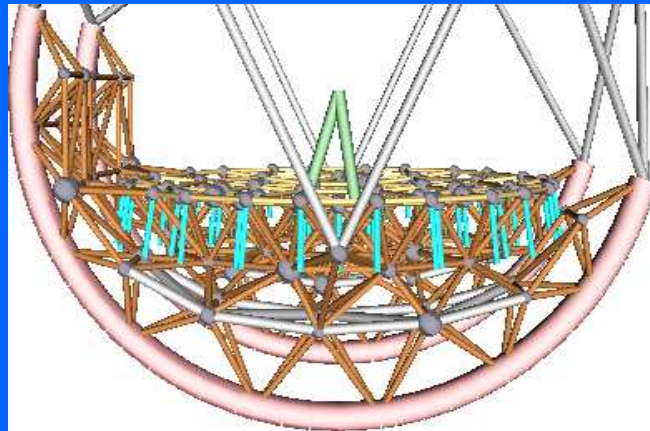
計測 Mirror measurement

非球面波面の生成に
CGHを使用



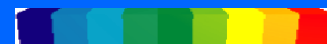
- 被検光と参照光の光路長が等しい
- 被検面と参照面を近接して配置

Structure optimized with Hereditary algorithm and its FEM analysis



0%

200%



許容変形量

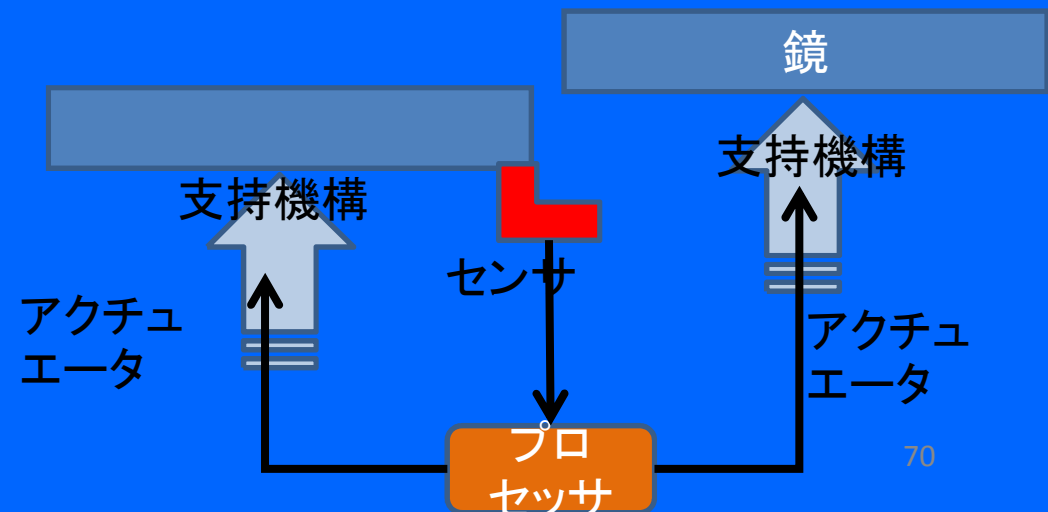
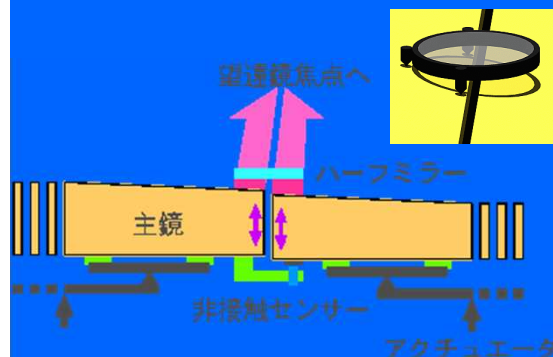


2. 分割鏡の制御

分割鏡制御の要素

Control of segmented mirrors

- 光学センサ: 鏡の向きと段差を計測
Optical sensors
- ギャップセンサ: 鏡の段差を計測
gap sensors
- 支持機構、アクチュエータ: 鏡を支持し駆動
Support and actuators
- プロセッサ: センサ値から指令値を算出
Control Processors



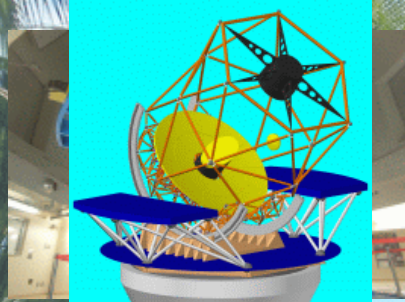
Possible Telescope plan at Ali site

Telescope located covering **global telescope network**

- Follow-up observation of **GRB** to find primordial objects in the early universe and reveal its characteristics
- continuous observations of Blazar, Supernova, nova, X-ray binaries, cataclysmic variables, variable stars, so on.
- Proper astronomical observations for **Asian astronomers**



(**GRB 090423** : Most distant galaxies ever detected : $z=8.2$, 13 b.l.y.)



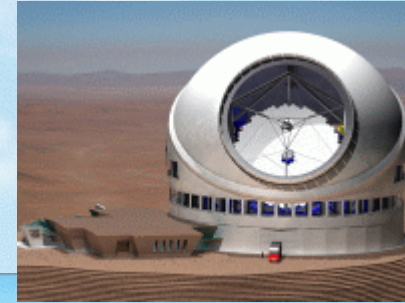
~1m Tel

⇒ ~4m Tel

for Asian Astronomers in coming era

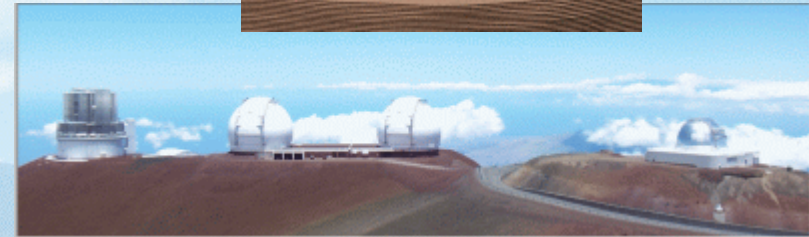


Ali > 5000 m



Mauna Kea

4200 m



謝謝、ありがとう、Thank you !

2008/04/05

Mauna Kea, viewed from Wailoa Park, Hilo

Mauna Kea, viewed from Wailoa Park, Hilo

The End

謝謝、ありがとう、Thank you !



Telescope Array at Oma North

--- Time sequence of Telescope construction



launch Interferometry

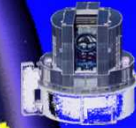
~ 2030?



Coordinated observations between Subaru and Telescopes at Oma



Network connection



Discover New Object

~SN in solar neighborhood!!!

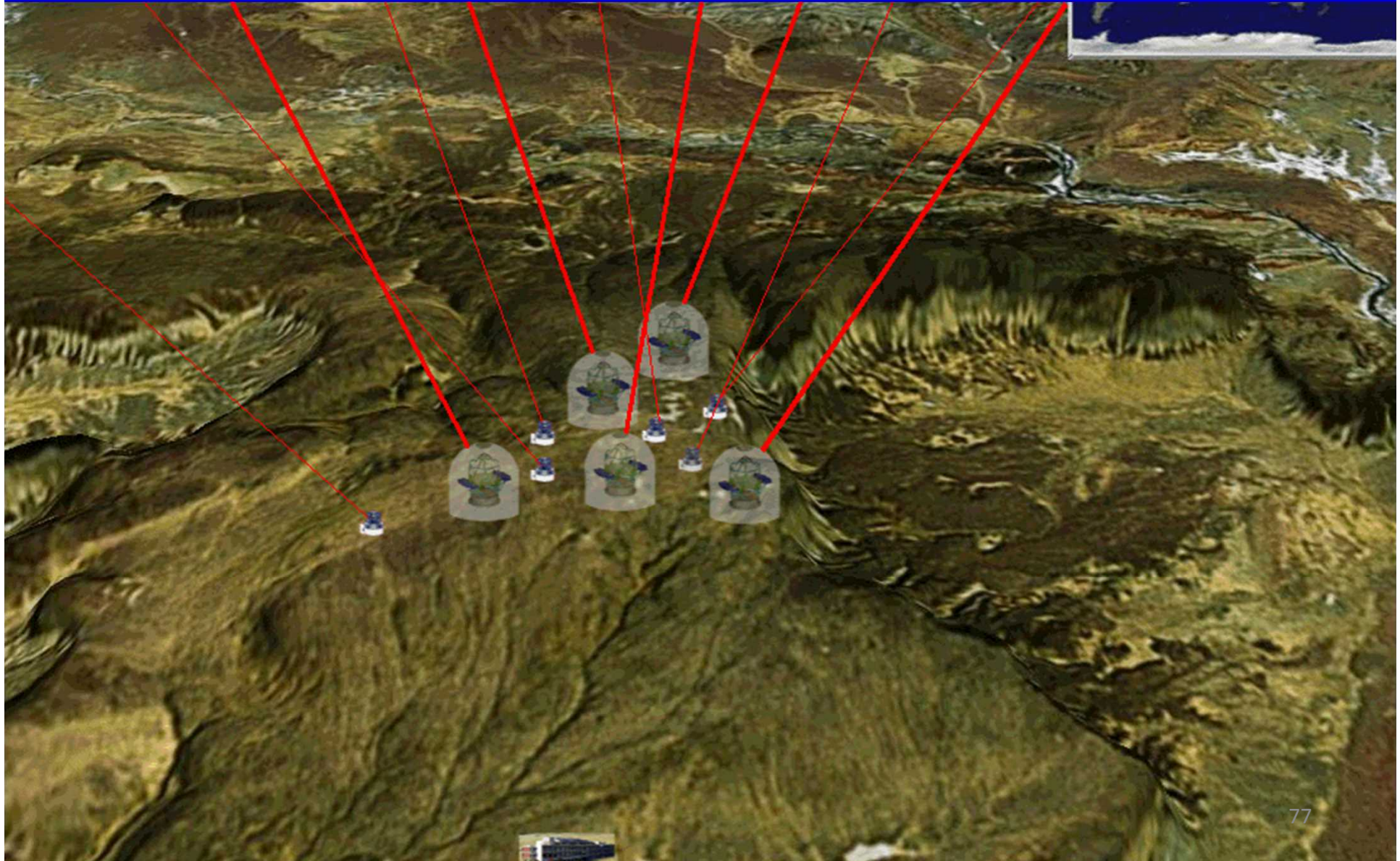
Time Lag about 9h
midnight @ MKO
→ 3pm @Oma



Arrange spectroscopic or Interferometric observations



UTs' random observations and coordinated observation



Merits of Telescope Array

- Each organization possesses **own** telescope
uses own telescope for their science
- Coordinated operation of Telescope Array for **Interferometry**
enable high resolution observation, compared to JWST
more faint objects observable than JWST
- Own(80%) vs coordinated(20%) : need MoU

Optical Interferometry 光干涉計

- 30m Telescopes 5 (10 base lines)
- with help of earth rotation, increases base line data
- Apply mapping method for image reconstruction

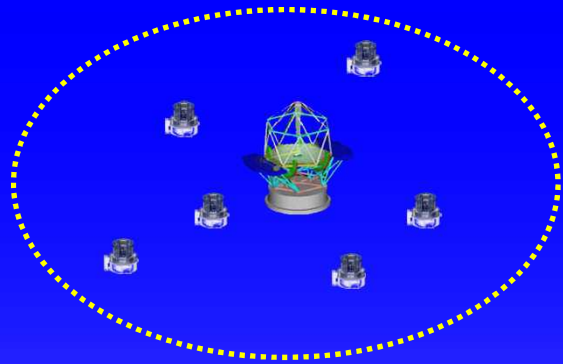
Technical developments

- methods for atmospheric dispersion correction (**ADC**)
- Interferometry with **AO**

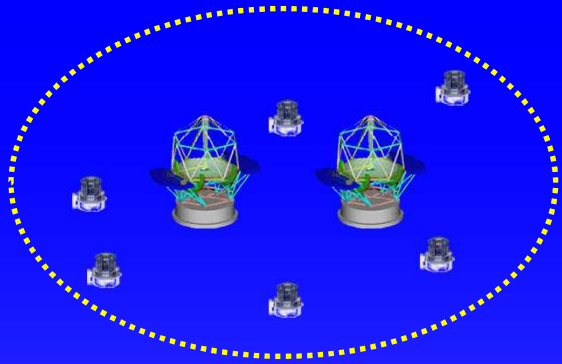
→ Detailed studies are necessary to promote AOTA.



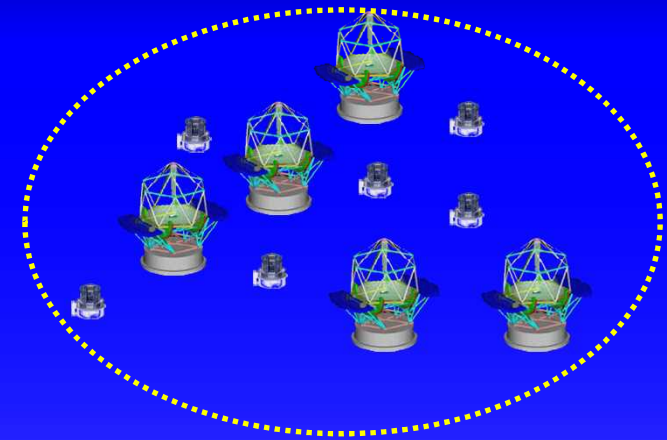
Which configuration we select ?



One 30m + Several 8m



Two 30m + Several 8m

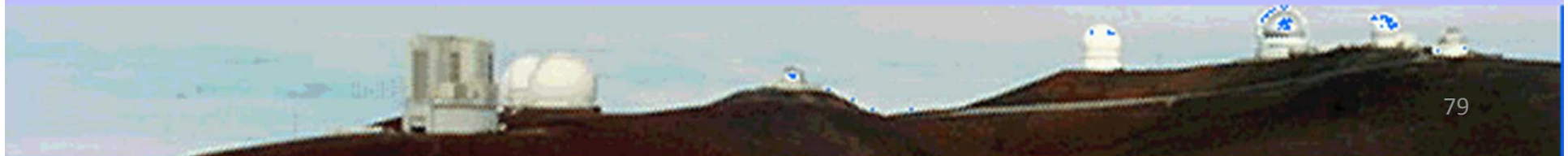


Several 30m + Several 8m

Visibility lower
 Mag(limit) less faint
 Cost high
 Feasibility possible

middle
 faint
 higher
 maybe possible

higher
 more faint
 highest
 difficult ??



Cost Estimation

Site development	US\$ 10M	← MEX budget*
2m telescope	US\$ 5M	← MEX budget*
8m telescope	US\$200M	← fund?
Instruments	US\$100M	← fund?
30m telescope	US\$600M	← fund?
Instruments	US\$300M	← MEX budget*
AOTAI	US\$500M	← fund?
Operation	US\$100M/year	← fund?

*MEX is not so rich, so we find other funds to build AOTA !





The End

謝謝、ありがとう、Thank you !