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The World's Largest Magnetometer Array.

G. Maeda, K. Yumoto
International Center for Space Weather Science and Education

Presented at
2012 ISWI and MAGDAS School
17-26 September 2012.
LAPAN, Bandung, Indonesia.

during the MAGDAS Session

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The MAGDAS Strategy

So far, ICSWSE has deployed 67 MAGDAS magnetometers all over the world.

However, they are not placed randomly. Locations are selected with a strategy.

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The 3 Chains of MAGDAS

210 Magnetic Meridian Chain

- Runs north and south of Japan, in Asia.

Dip Equator Chain

- Runs around the globe (magnetic equator)

96 Magnetic Meridian Chain

- Runs north and south in Africa, from Hermanus up to Egypt.

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Topics covered in this talk

1. Overview of the early years of MAGDAS
2. Overview of MAGDAS in Africa
3. Summary of the Horizontal Chain and Vertical Chain.
4. Ambient Noise: Best Six Stations … but *Proper Observatories* are needed !!!!
5. Data transmission performance of the African stations
6. Temperature Drift Problem of MAGDAS
7. Installation this year at Ica, Peru.
8. Installation this year at Canberra, Australia.
9. Installation this year at Khovd, Mongolia.
10. List of all 57 MAGDAS stations now in operation.

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1st overseas MAGDAS

Hualien, Taiwan (May of 2005)

Sensor

Hut of
Data Logger

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Year 2005

Installations concentrated along
210 Magnetic Meridian
(average latitude spacing of 500 km)

Most northern MAGDAS: Cape Schmidt
Most southern MAGDAS: Tasmania

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Year 2006

Installations concentrated along the dip equator (Africa and South America)

Most southern MAGDAS became MacQuarie Island (this photo)

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Year 2007

The most southern installation became the MAGDAS unit at Davis Station (of the Australian Antarctic Division)

This is a photo of the Davis sensor house; courtesy of AAD

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MAGDAS Northern Front

The most northern MAGDAS is at Cape Schmidt

West side of Alaska

Kamchatka Peninsula

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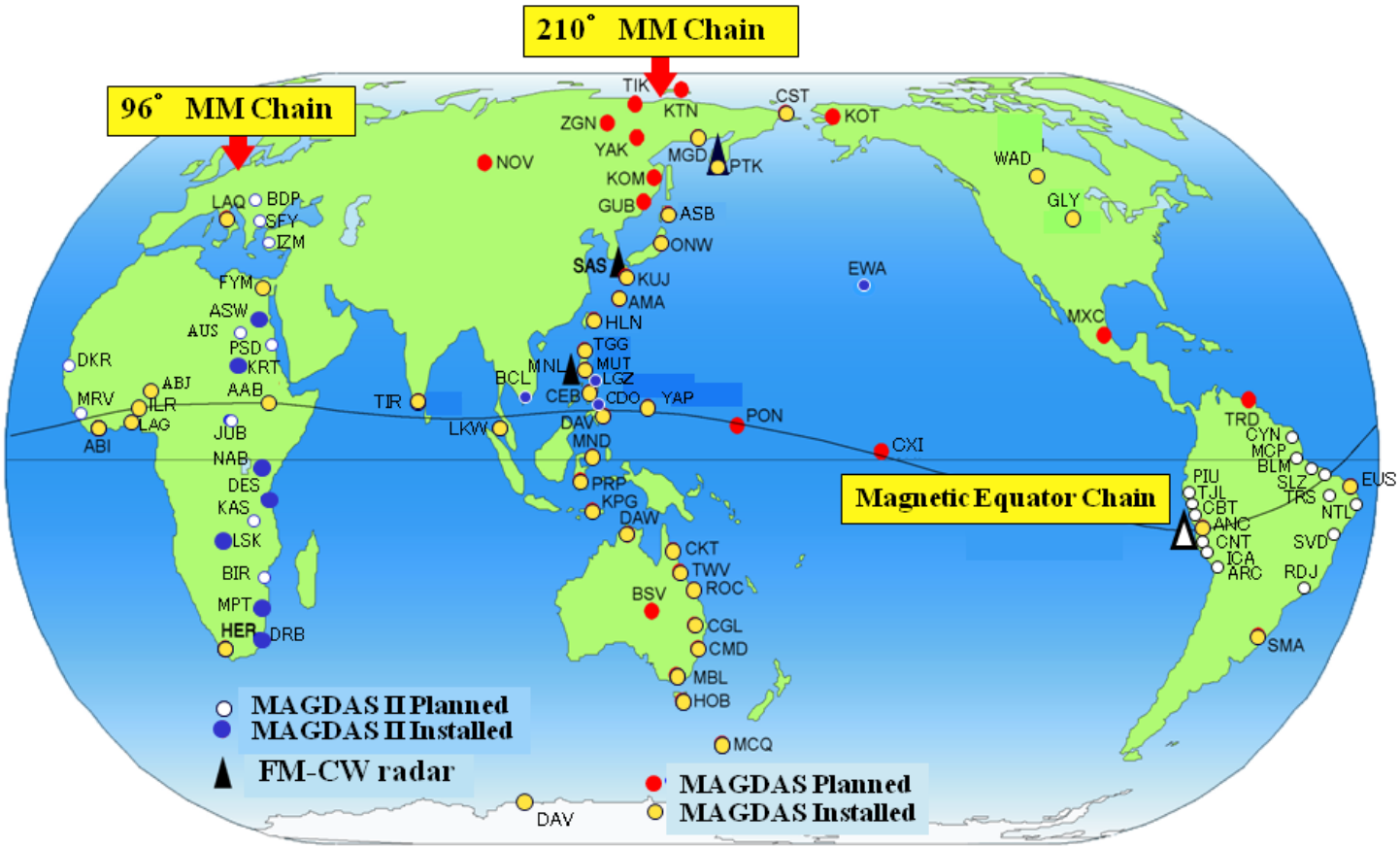
Motivation for MAGDAS in Africa

The three chains of MAGDAS



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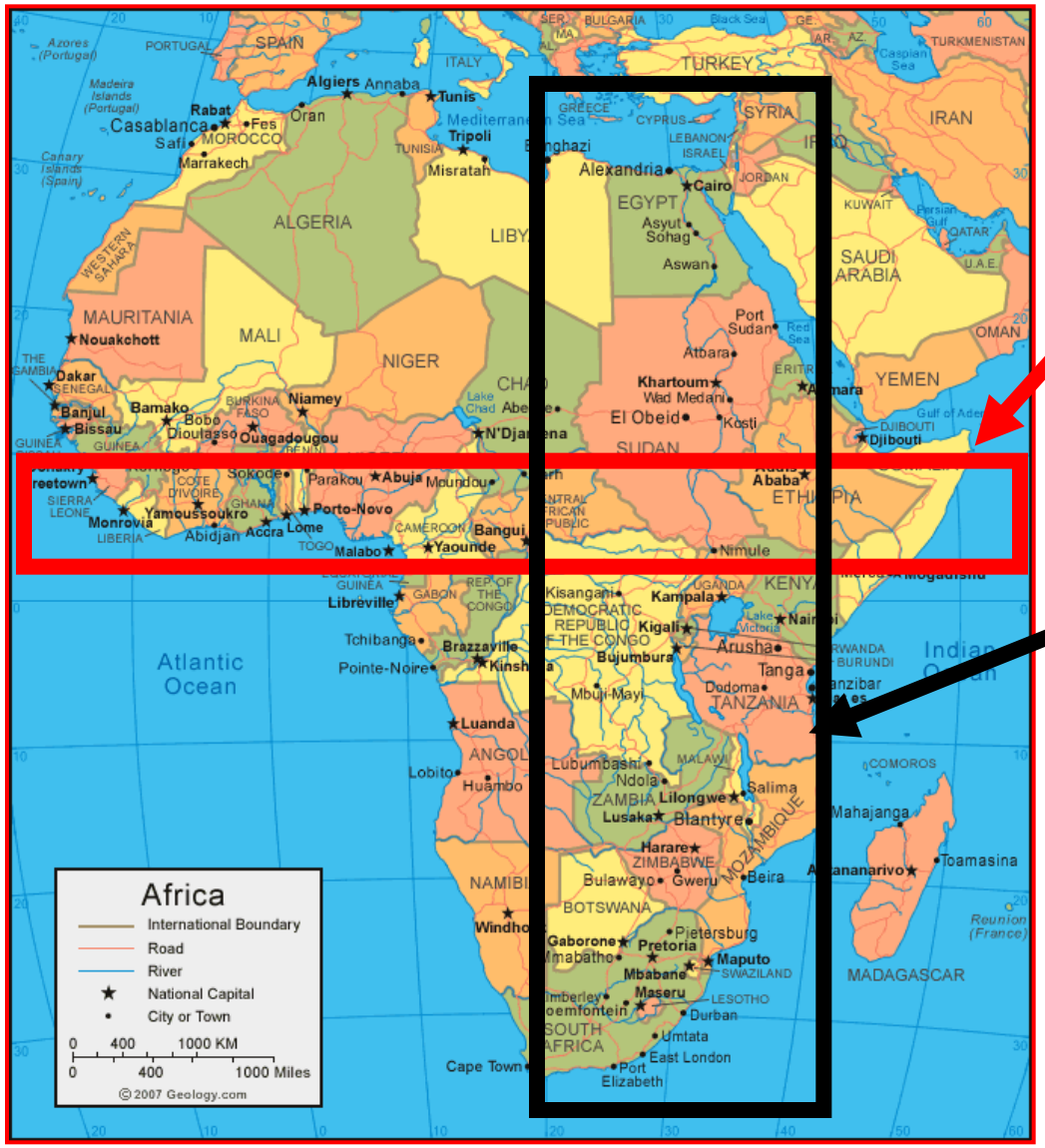
History of MAGDAS in Africa



Phase 1 (Summer 2006)
Three MAG-1 installed along Dip Equator.

Phase 2 (Summer 2008)
Six MAG-II installed along 96 Deg. MM.

Phase 3 (Summer 2010)
Major upgrade of existing stations.

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Phase 1 – Year 2006 – Dip Equator Installations

Abidjan (ABJ)

Cote 'Ivoire

Ilorin (ILR)

Nigeria

Addis Ababa (AAB)

Ethiopia

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Phase 2 – Year 2008 – 96 Deg MM (A Team)

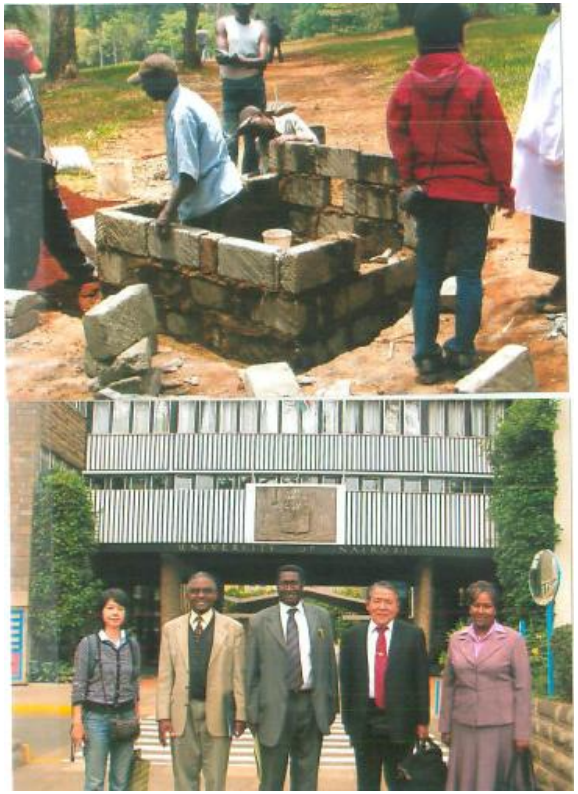
Dar Es Salaam (DES)

Tanzania

Khartoum (KRT)

Sudan

Nairobi (NAB)



Kenya

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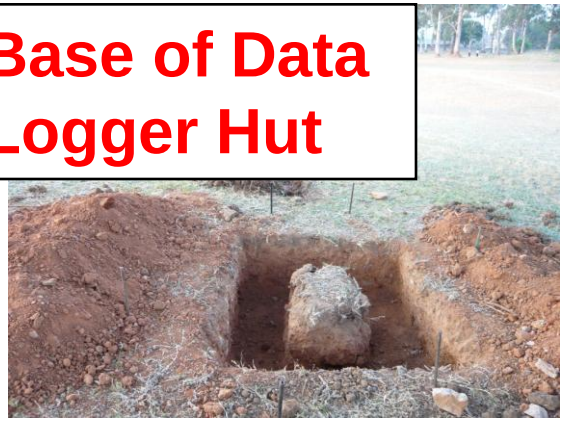
Phase 2 – Year 2008 – 96 Deg MM (B Team)

Lusaka (LSK)

Base of Data Logger Hut



Base of sensor.

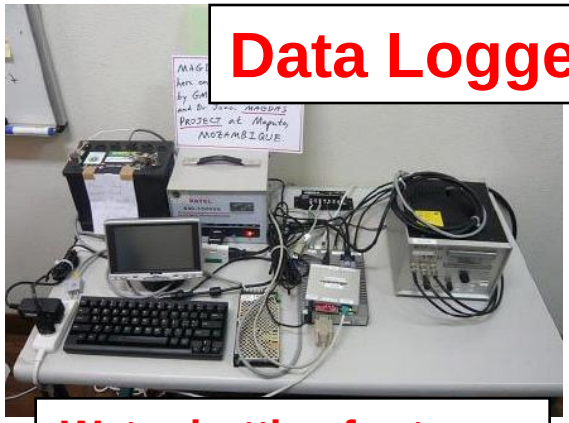
Zambia

Durban (DRB)

South Africa

Maputo (MPT)

Data Logger



Water bottles for temp. stabilization.

Mozambique

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Phase 3 – Year 2010 – Upgrade of Stations in Africa

A u g u s t

Equatorial Team

- G. Maeda
- M. Sakai
- N. Etoh

ABJ (Abidjan)

MAG-1 to MAG-9

LAG (Lagos)

MAG-II to MAG-9

ABU (Abuja)

MAG-9 (new)

AAB (Addis Ababa)

MAG-1 to MAG-9

A Team

- Prof. K. Yumoto
- Y. Yamazaki
- Y. Fujita

DES (Dar Es Salaam)

Upgrade of MAG-II

NAB (Nairobi)

Upgrade of MAG-II

KRT (Khartoum)

Upgrade of MAG-II

B Team

- G. Maeda
- A. Ikeda
- K. Matsuyama

DRB (Durban)

Upgrade of MAG-II

MPT (Maputo)

Upgrade of MAG-II

LSK (Lusaka)

MAG-II to MAG-9

← S e p t e m b e r →

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Summary of MAGDAS Equatorial Stations in Africa

FROM WEST TO EAST

Station Code	Country	Year of Installation	MAG-DAS type	Institute	Person of Highest Authority
ABJ	Cote D'Ivoire	2006	MAG-9	University de Cocody	Dr Vafi
LAG	Nigeria	2008	MAG-9	Redeemer's University (RUN)	Prof. Kolawole
ILR	Nigeria	2006	MAG-9	University of Ilorin	Dr Adimula
ABU	Nigeria	2010	MAG-9	National Space Research and Dev. Agency (NASRDA, the space agency of Nigeria)	Dr Rabiu
AAB	Ethiopia	2006	MAG-9	Addis Ababa University	Dr Gizaw

Note: All are MAGDAS-9

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Summary of MAGDAS Stations in Africa along 96 Deg MM

FROM NORTH TO SOUTH

Station Code	Country	Year of Installation	MAG-DAS type	Institute	Person of Highest Authority
FYM	Egypt	2008	MAG-II	Fayoum University	Dr Mahrous (Helwan Univ.)
ASW	Egypt	2008	MAG-II	South Valley University.	Dr Mahrous (Helwan Univ.)
KRT	Sudan	2008	MAG-II	Sudan University of Science and Technology (SUST)	Prof. Badi
NAB	Kenya	2008	MAG-II	University of Nairobi	Dr Baki
DES	Tanzania	2008	MAG-II	Univ. of Dar es Salaam	Prof. Magingo
LSK	Zambia	2008	MAG-9	University of Zambia	Dr Mweene
MPT	Mozambique	2008	MAG-II	Eduardo Mondlane University (EMU)	Dr Macamo
DRB	South Africa	2008	MAG-II	Univ. of Kwazulu-Natal (UKZN)	Prof. Afullo
HER	South Africa	2007	MAG-I	Hermanus Magnetic Observatory	Dr Lee-Anne McKinnell

These 2 recently restored.

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Local Ambient Noise

Very roughly, these are the Best Six Stations in terms of noise:

1. ABJ (Abidjan, the best performer)
2. ILR (Ilorin, Nigeria)
3. LSK (Lusaka, Zambia)
4. MPT (Maputo, Mozambique)
5. NAB (Nairobi, Kenya)
6. DES (Dar es Salaam, Tanzania)

BUT ALL ARE NOT GOOD ENOUGH FOR SERIOUS SCIENCE !

So proper observatories are needed in Africa.

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Data Transmission Performance

ABJ	**Temporarily not operational**
LAG	**Usually OK**
ILR	**Usually OK**
ABU	**Usually OK**
AAB	**Usually OK**
FYM	**Recently changed to cellular modem; now good.**
ASW	**Recently changed to cellular modem; now good.**
KRT	**Usually OK**
NAB	**Usually OK**
DES	**Usually OK**
LSK	**Usually OK**
MPT	**Usually OK**
DRB	**Not responding to our requests.**
HER	**Usually OK**

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Temp. Drift Problem

Magnetometer should be sensitive to changes in the magnetic field – and nothing else. But some MAGDAS sensors are sensitive to changes in temperature. Luckily, we have solved this problem. We have two countermeasures. See the following slides.

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Countermeasure #1

During field installation, MAGDAS sensor houses are heavily insulated with layers of styrofoam, scores of water bottles, concrete blocks, cement, and so on. In this way, we attempt to keep the day-to-day temperature variation down to one or two degrees.

Thermal Insulation

This is a photo of the MAGDAS sensor house at Hermanus – it has over 350 kg of water to hold down changes in ambient temperature. The method is very effective. There is also styrofoam insulation in the walls and ceiling.

MAGDAS sensor at Hermanus

(South Africa)

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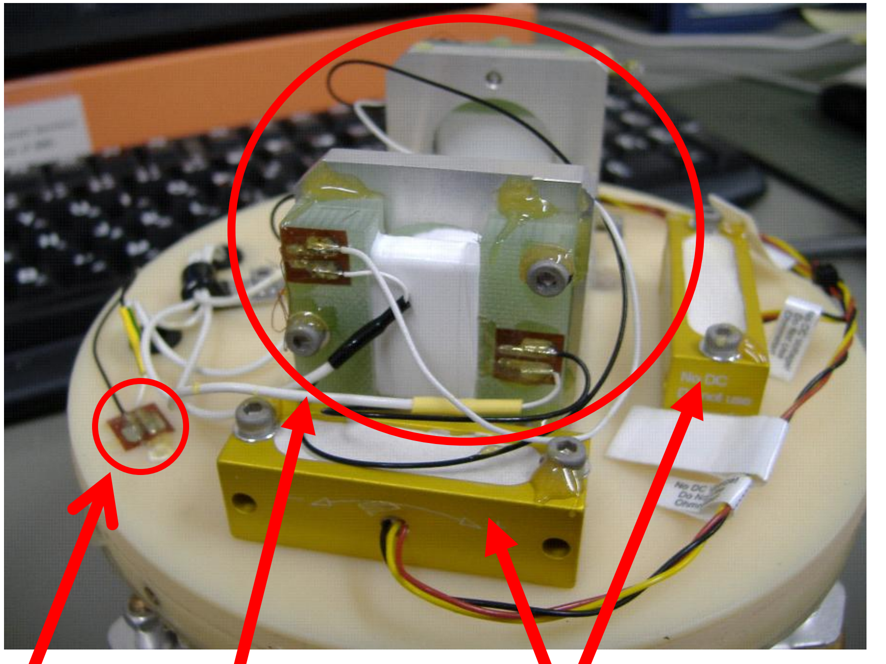
Countermeasure #2

The other counter-measure is to correct the data --- by taking out the effect of temperature variation. This is possible because we can calculate the temperature sensitivity of each sensor, and each sensor is equipped with a high-resolution thermometer.



Fluxgate sensors

Orthogonal tilt-meters

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Installation of MAGDAS II System at Ica, Peru. 11-15 July 2011.

Done by two grad students under Prof. Yumoto with the generous help of people in Peru.

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Location of Ica, Peru.

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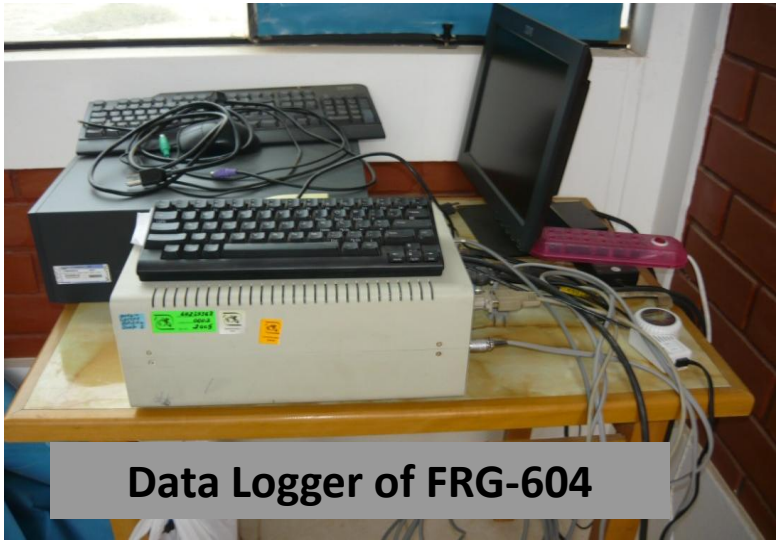
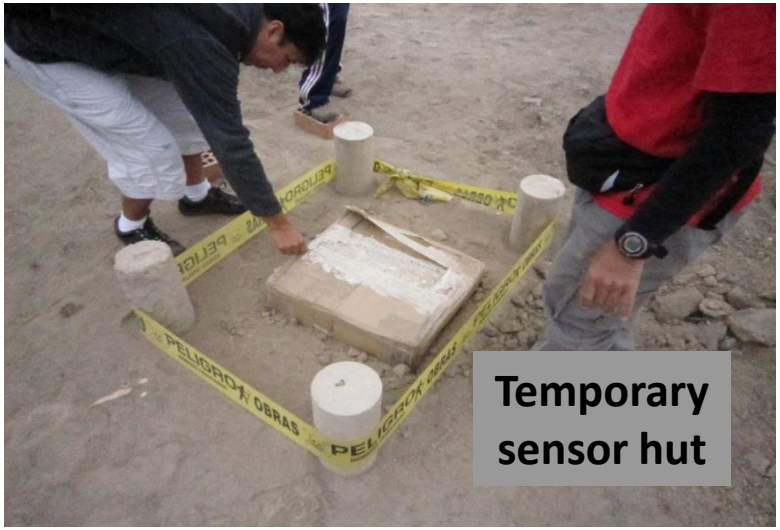
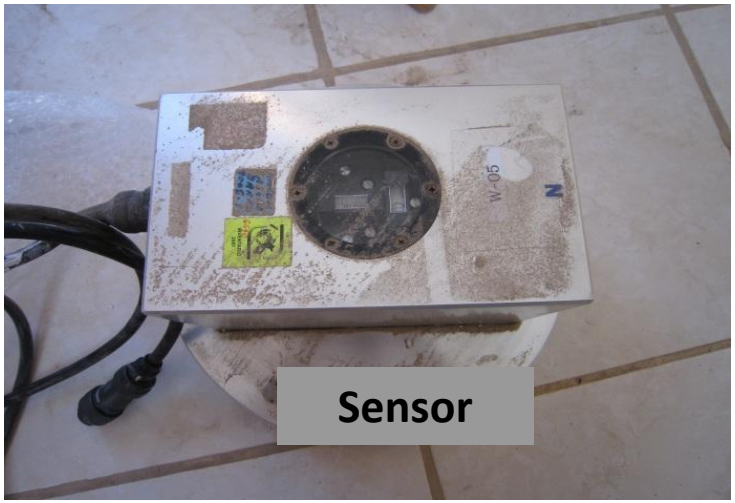
Initial condition of magnetometer at Ica Station


Data Logger of FRG-604



Temporary sensor hut

Inside temporary sensor hut


Sensor

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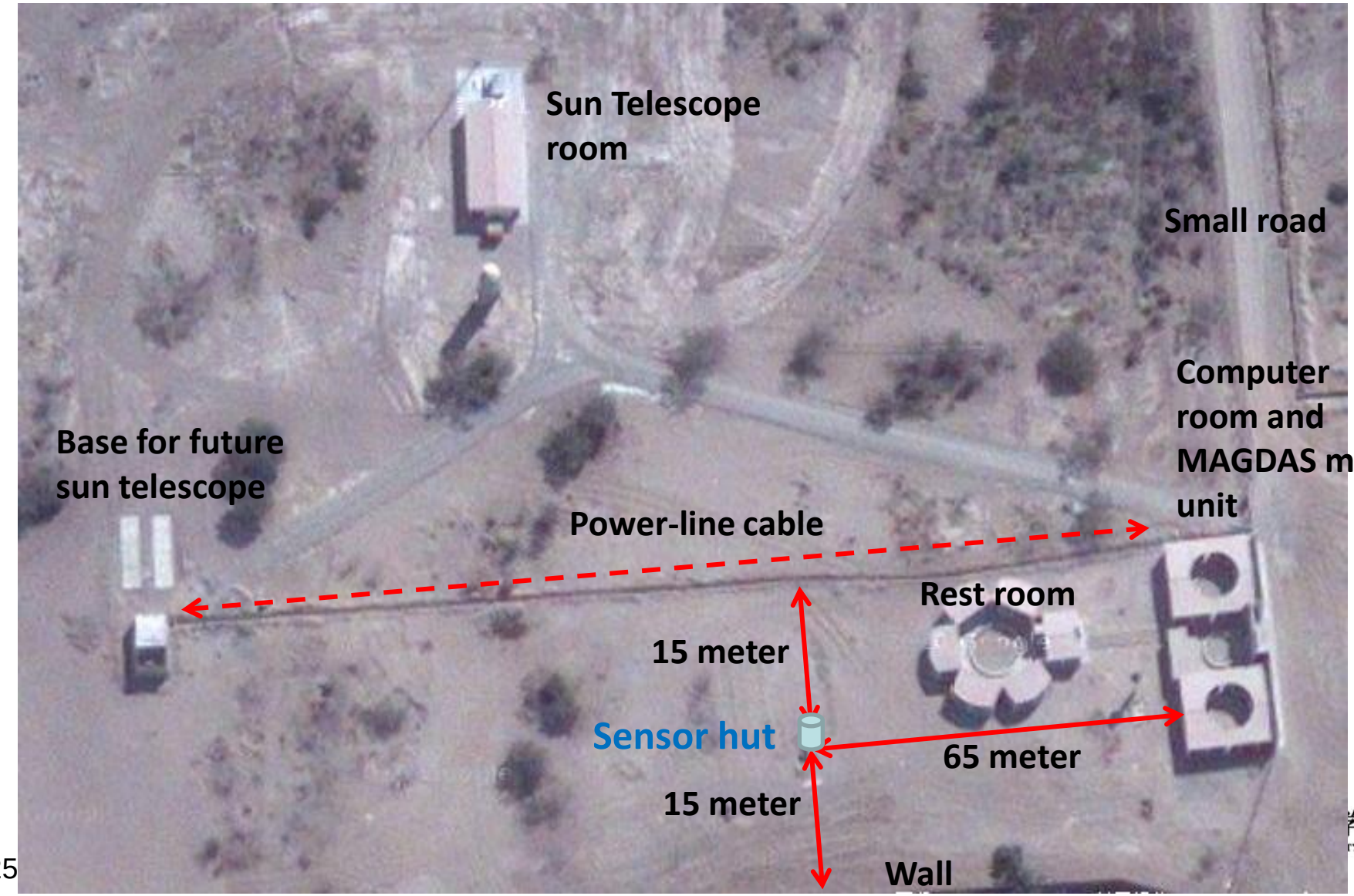
Location of sensor hut



Big Tank for Sensor

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Preparation of tank for sensor hut


Transportation to mechanical workshop


At mechanical workshop, Ica University


Drilling process of the tank


Holes for air ventilation

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Preparation of sensor hut and cable-trench

Pouring very fine sand into sensor hut hole to stabilize the sensor hut tank

Silica type cement for base of sensor; to stabilize and as a coolant

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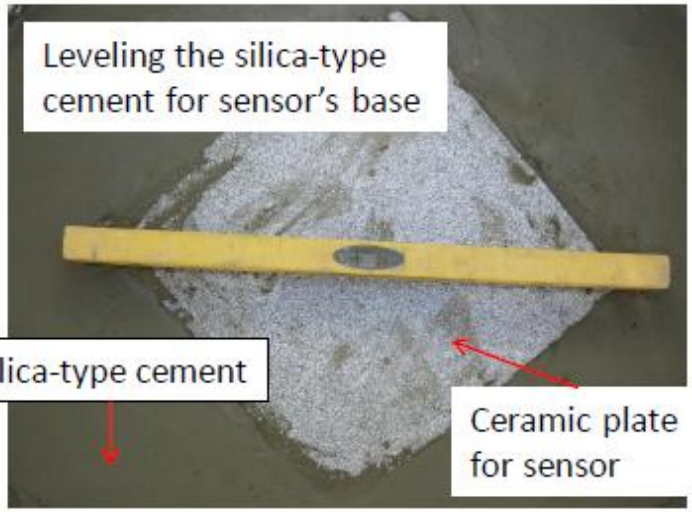
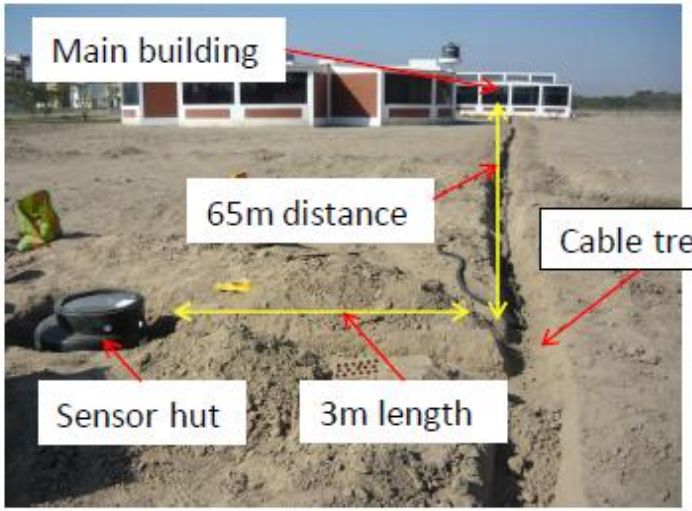
Preparation of sensor hut and cable-trench (cont..)

Preparing the silica-type cement





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Cable laying process

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Water for temperature stabilization

First row – 30 bottles of 500 ml water

Water bottles are secured with cable ties to prevent the bottles from falling down and disturbing the sensor.

Second row – 24 bottles of 500 ml water

Final view inside of sensor casing

Preparation of sensor casing ventilation

This air ventilation system was designed to allow air flow for cooling system and to avoid dust to enter sensor casing.

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Final work on sensor hut

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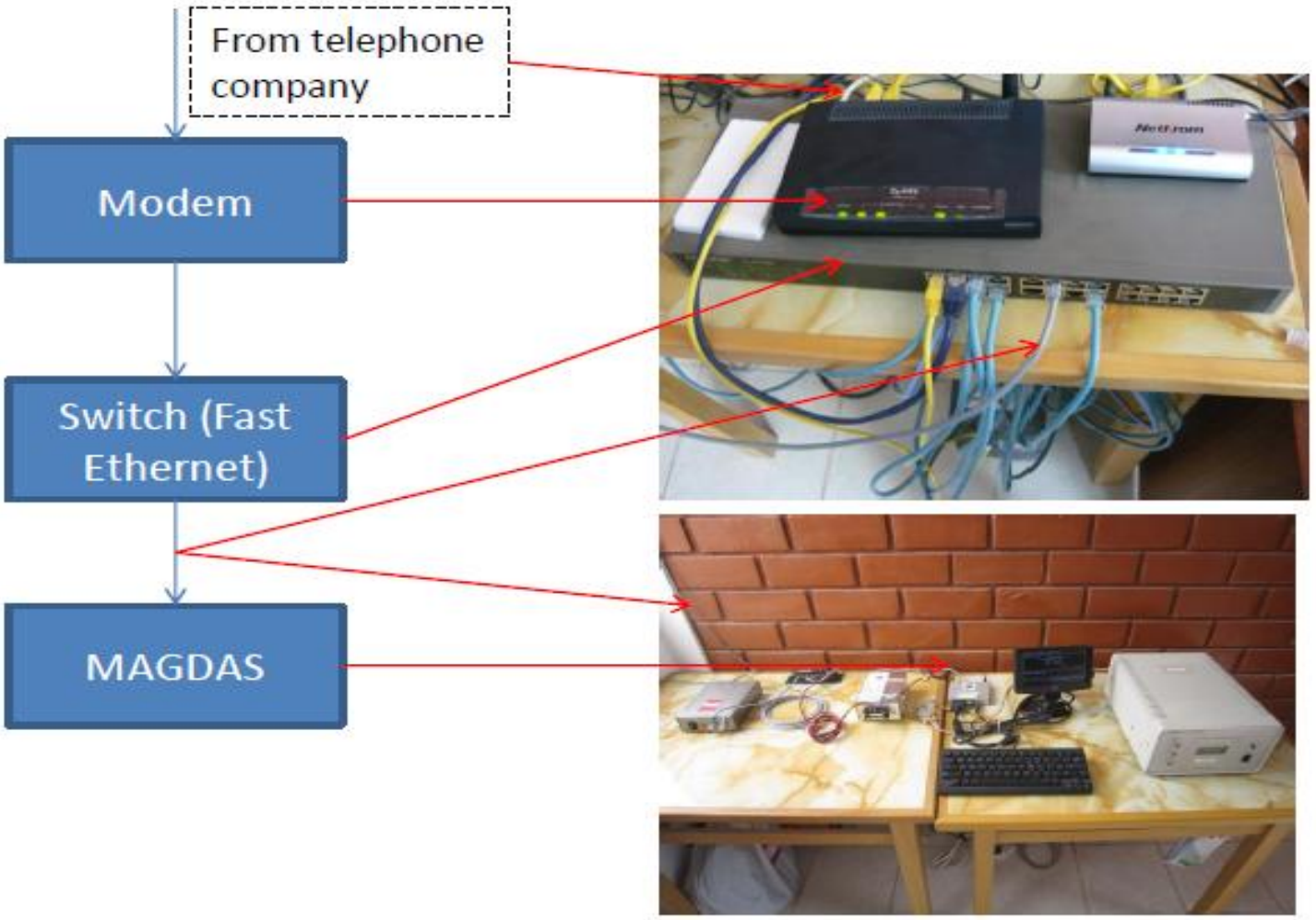
Final work on sensor hut (cont..)

Internet layout of Ica station



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MAGDAS Certificate presented to the Ica Host.

Inside photo (from left):
Mr Edwin (IGP), Hasegawa san (SERC),
Teacher Loayzea (Lecturer of Ica University)
and Dr Ishitsuka (IGP)

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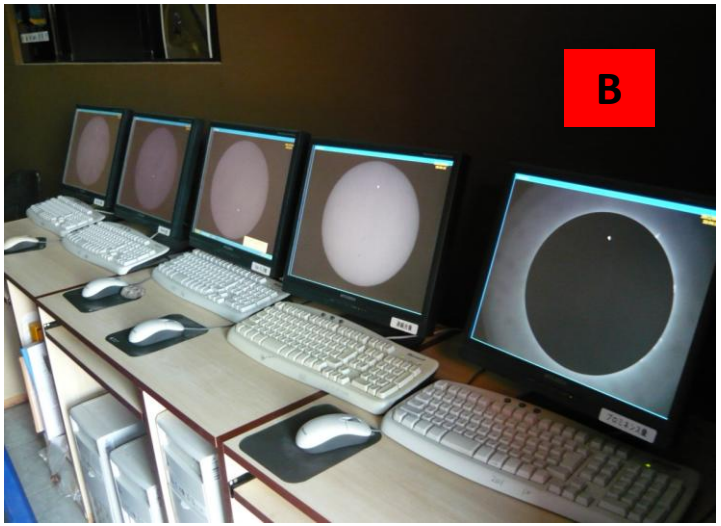
Short visit to IGP's Sun Telescope

A: Sun Telescope

B: 5 monitoring computers for each lens of telescope

C: Photo of the technical staff of IGP and Dr. Ishitsuka after short briefing



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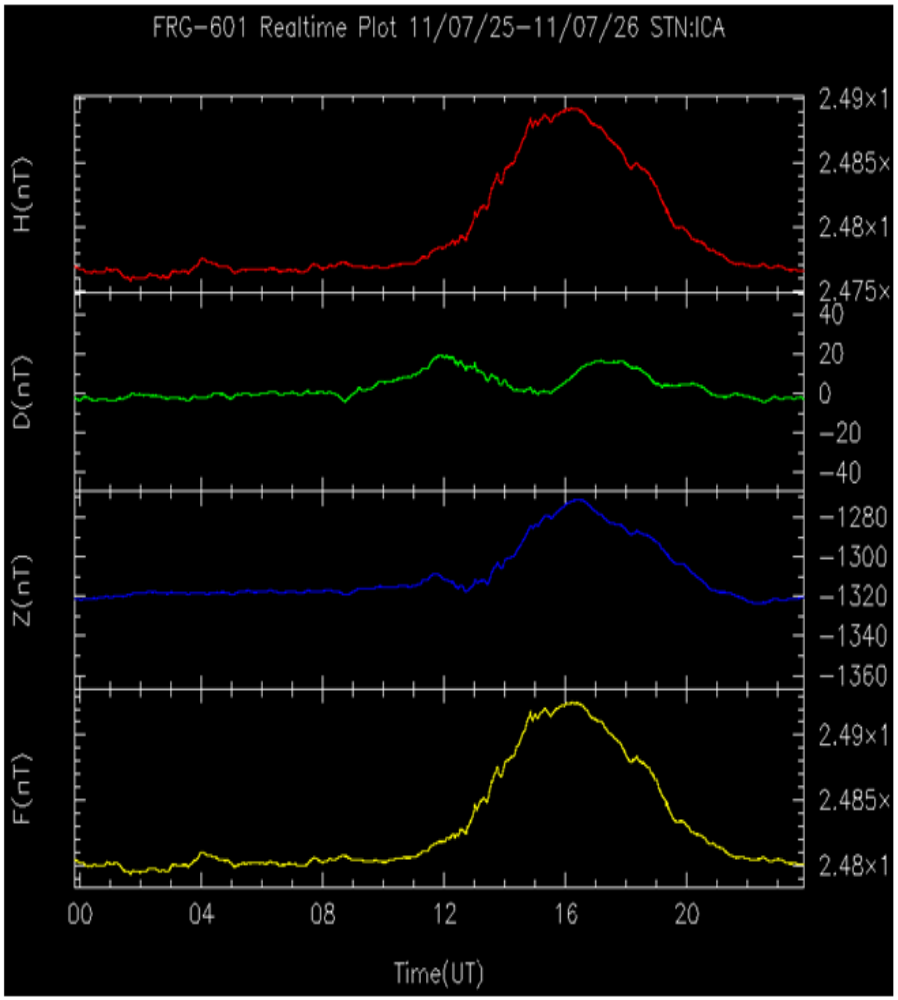
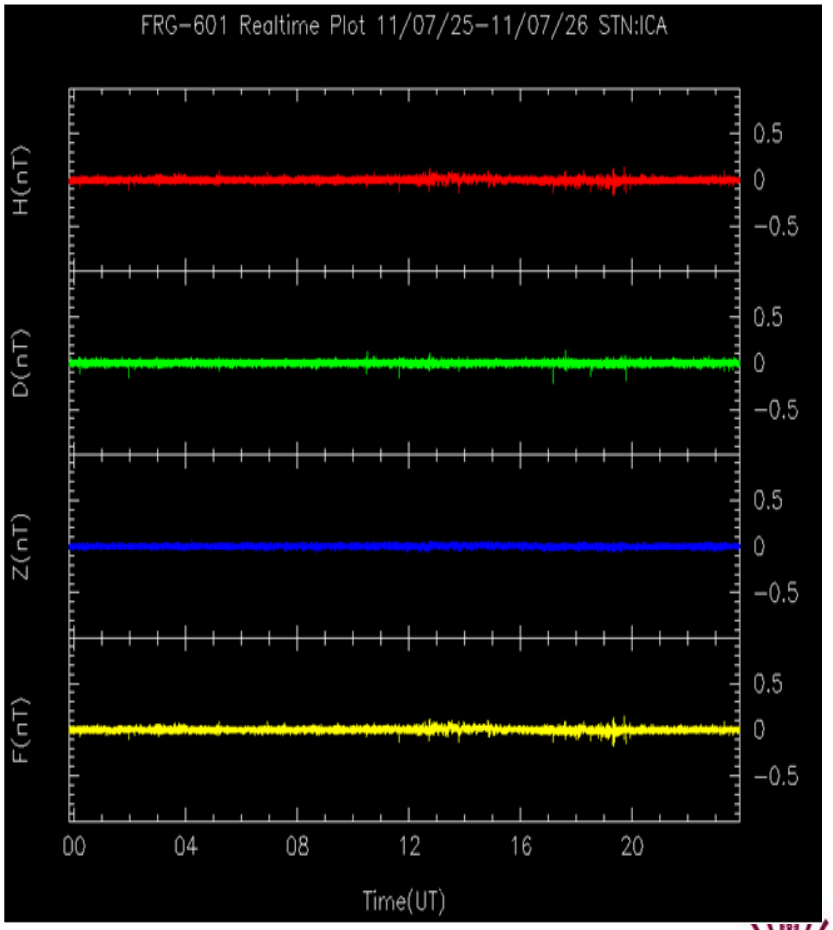
MAGDAS data from Ica station (25-26 July 2011)





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Installation of MAGDAS II System at Canberra, Australia. February 2011.

by G. Maeda and A. Ikeda.

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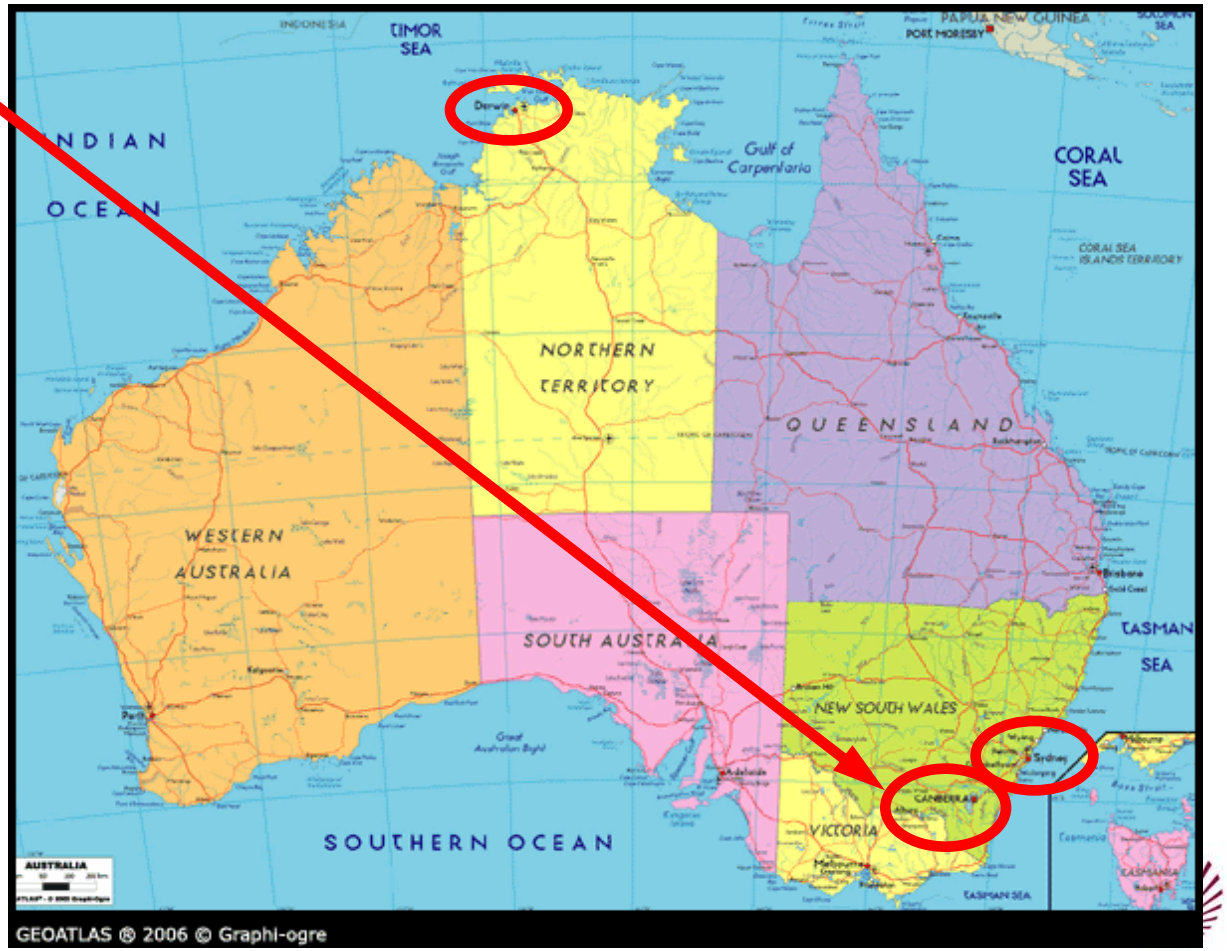
Places visited

Canberra
Camden
Darwin



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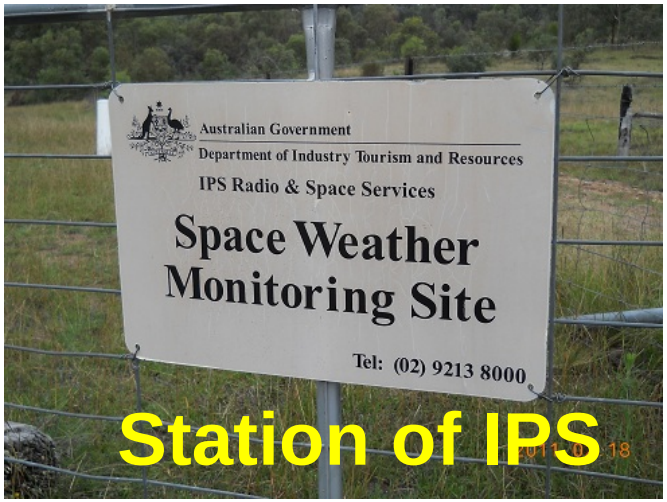
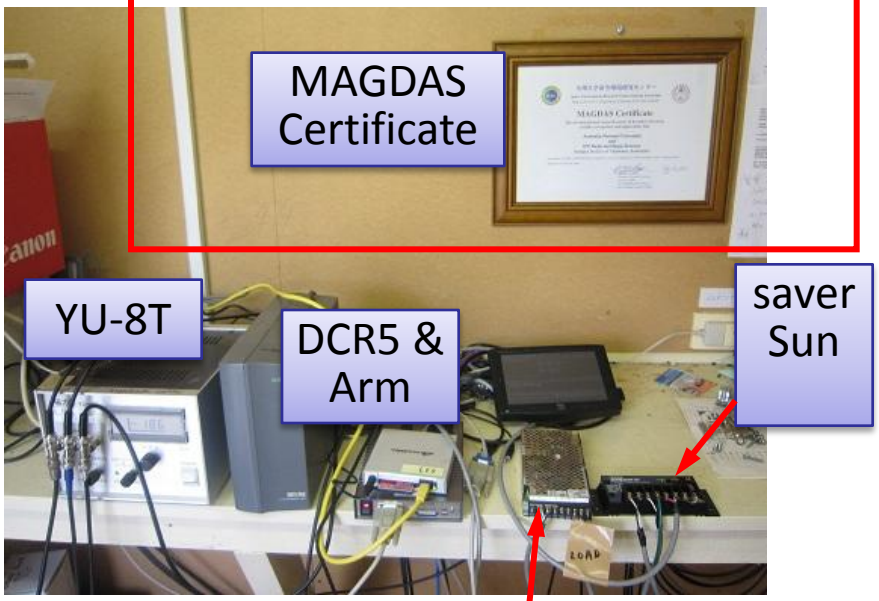
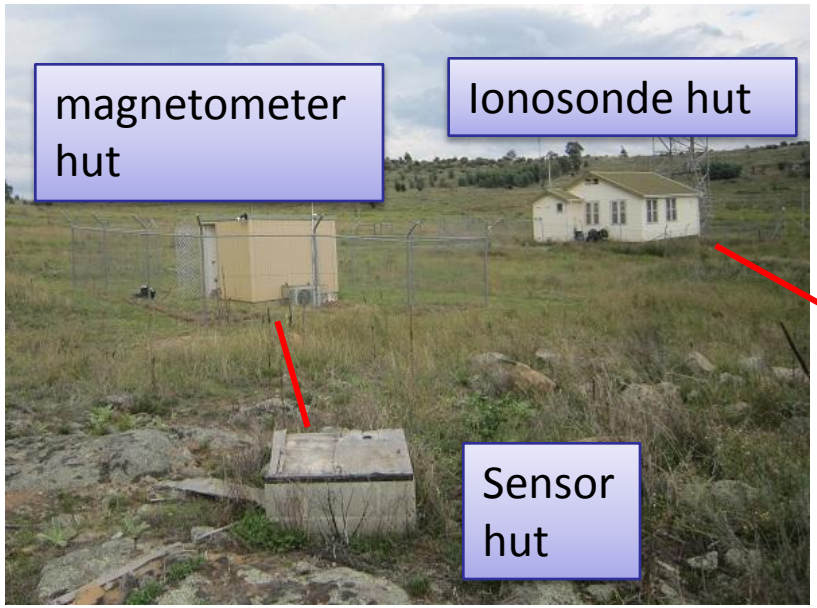
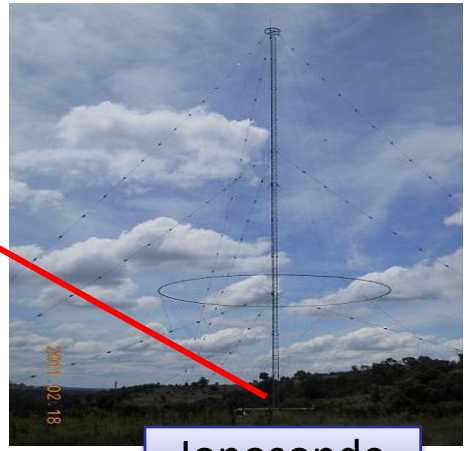
Canberra Station of MAGDAS









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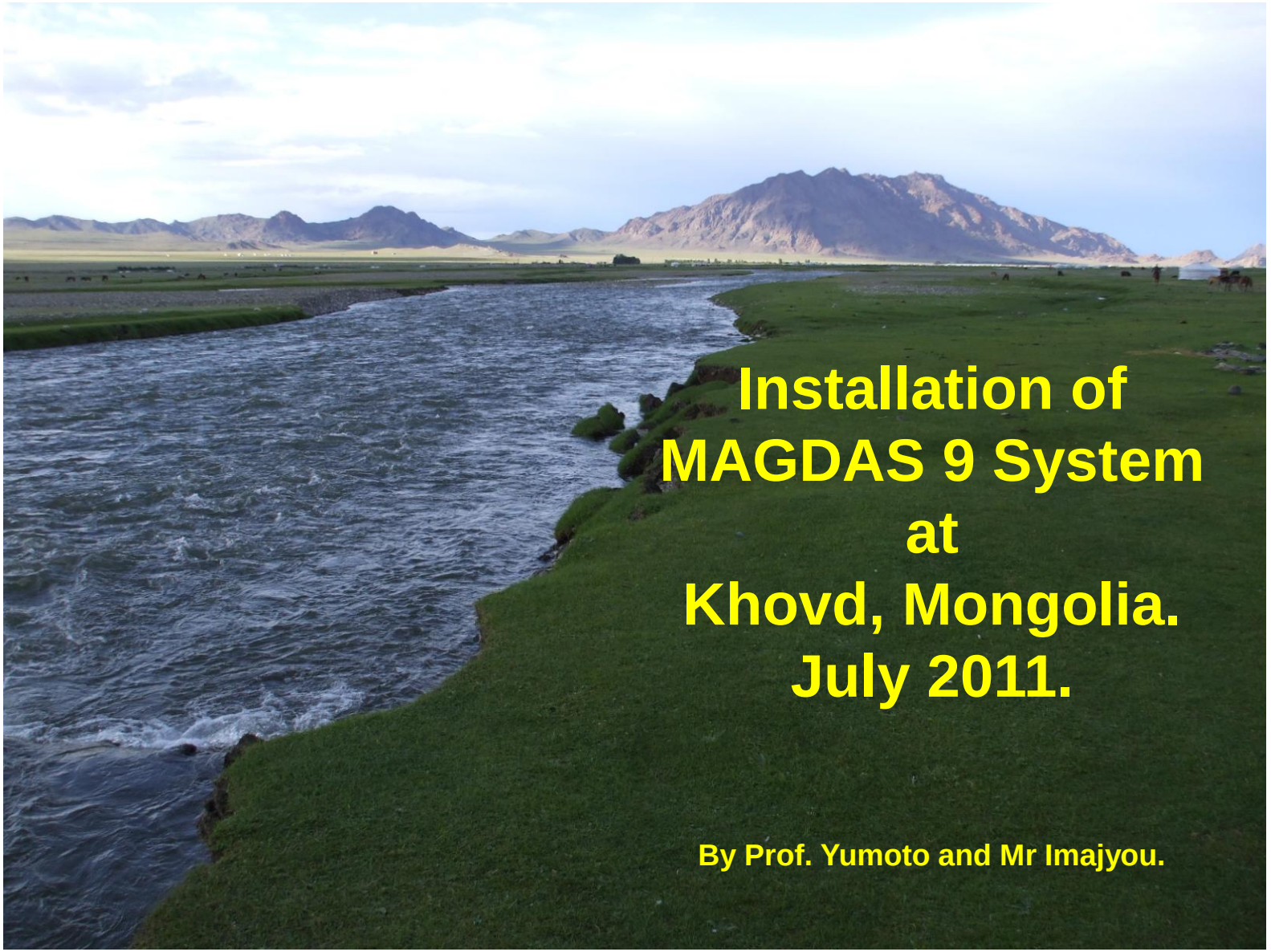

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Location of Khovd.

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It is just outside the town.

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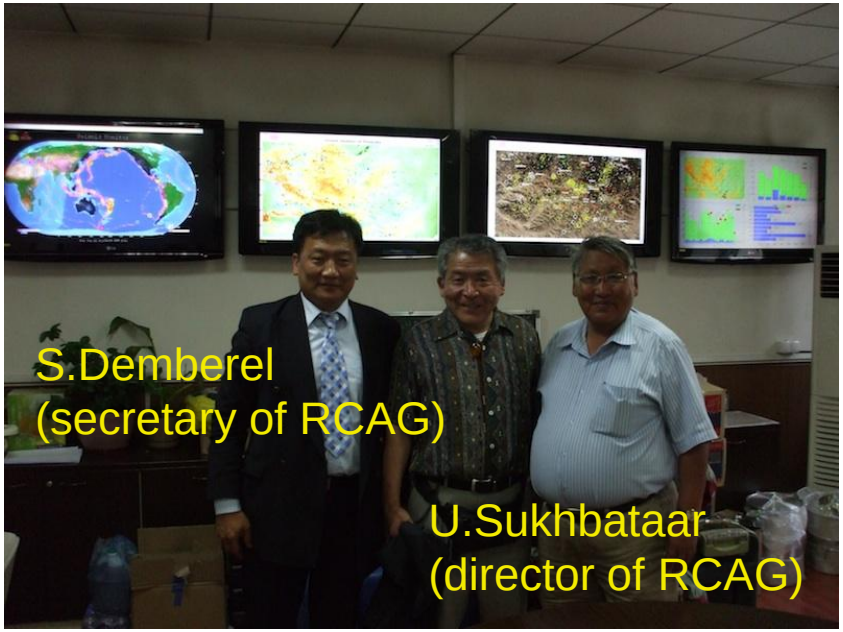
Contact Persons



RCAG=Research Center of Astronomy and Geophysics

(branch of the Mongolian Academy of Sciences)

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Sensor hut was built before the arrival of the SERC Team.

Construction of sensor house
(floor is 1.5m below surface).

Very deep!

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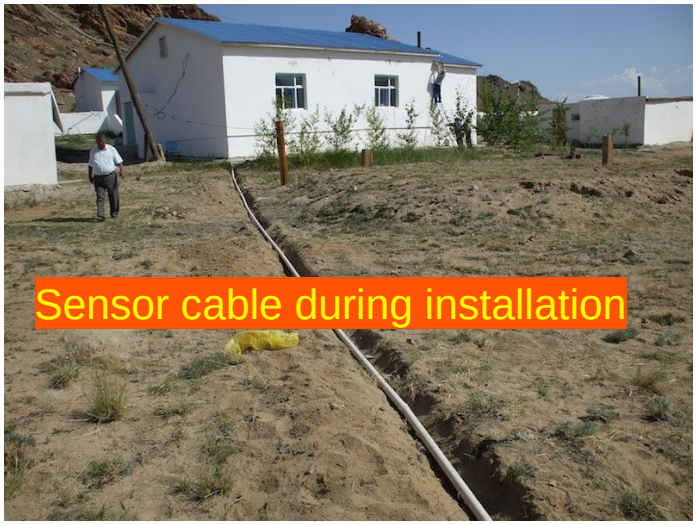
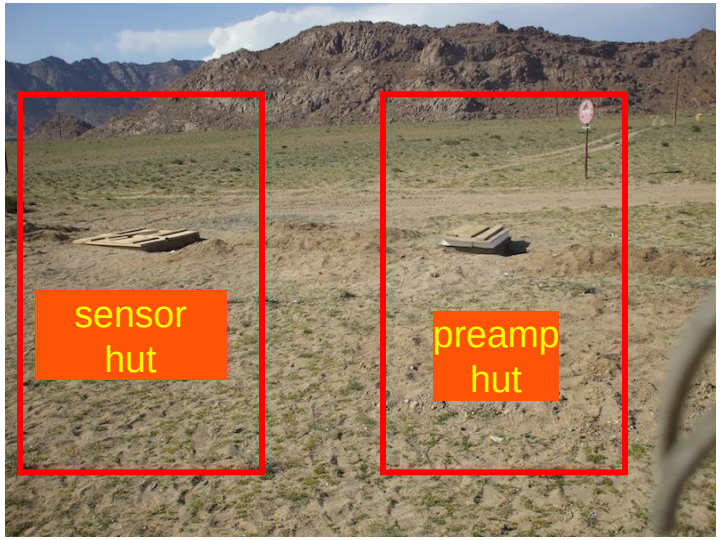
Station Grounds





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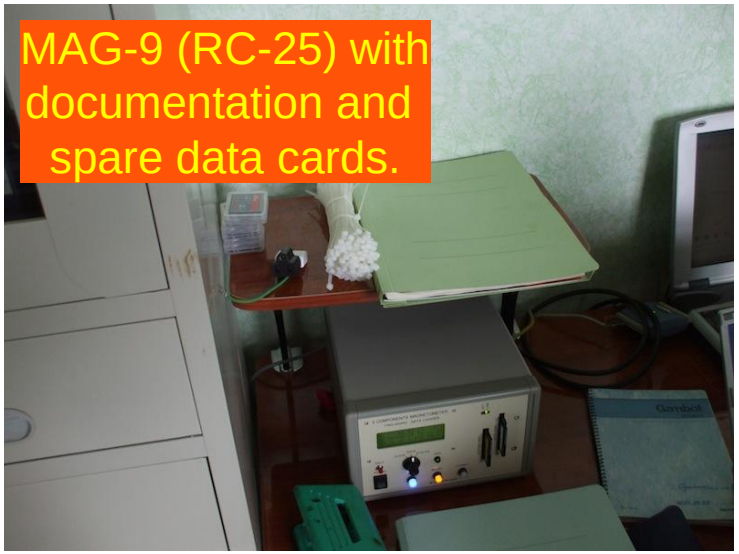
Covering the sensor

Winters are severe in Mongolia!

Sensor and Preamp are basically well buried.

Transporting case of MAGDAS 9



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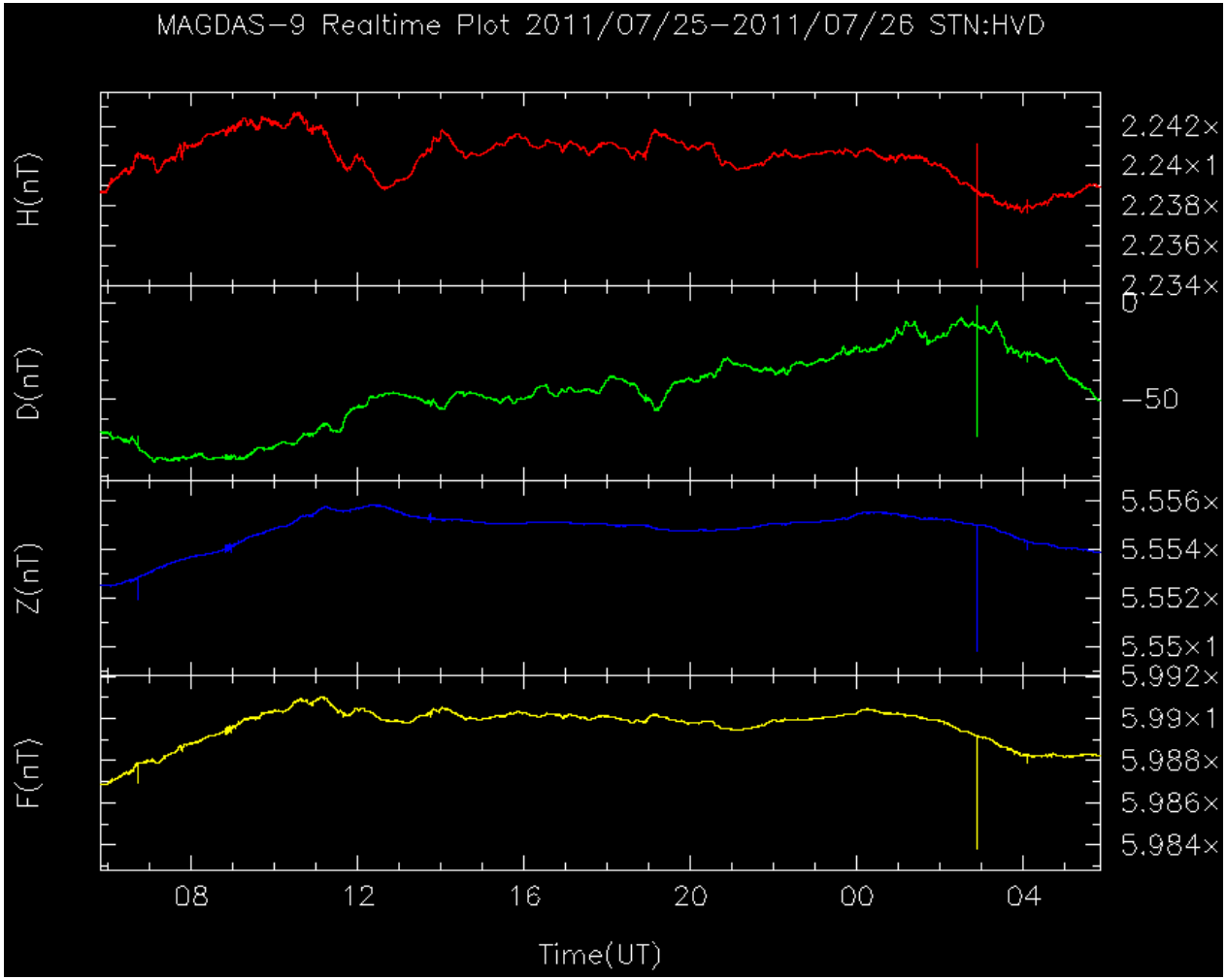
The data is very good here.



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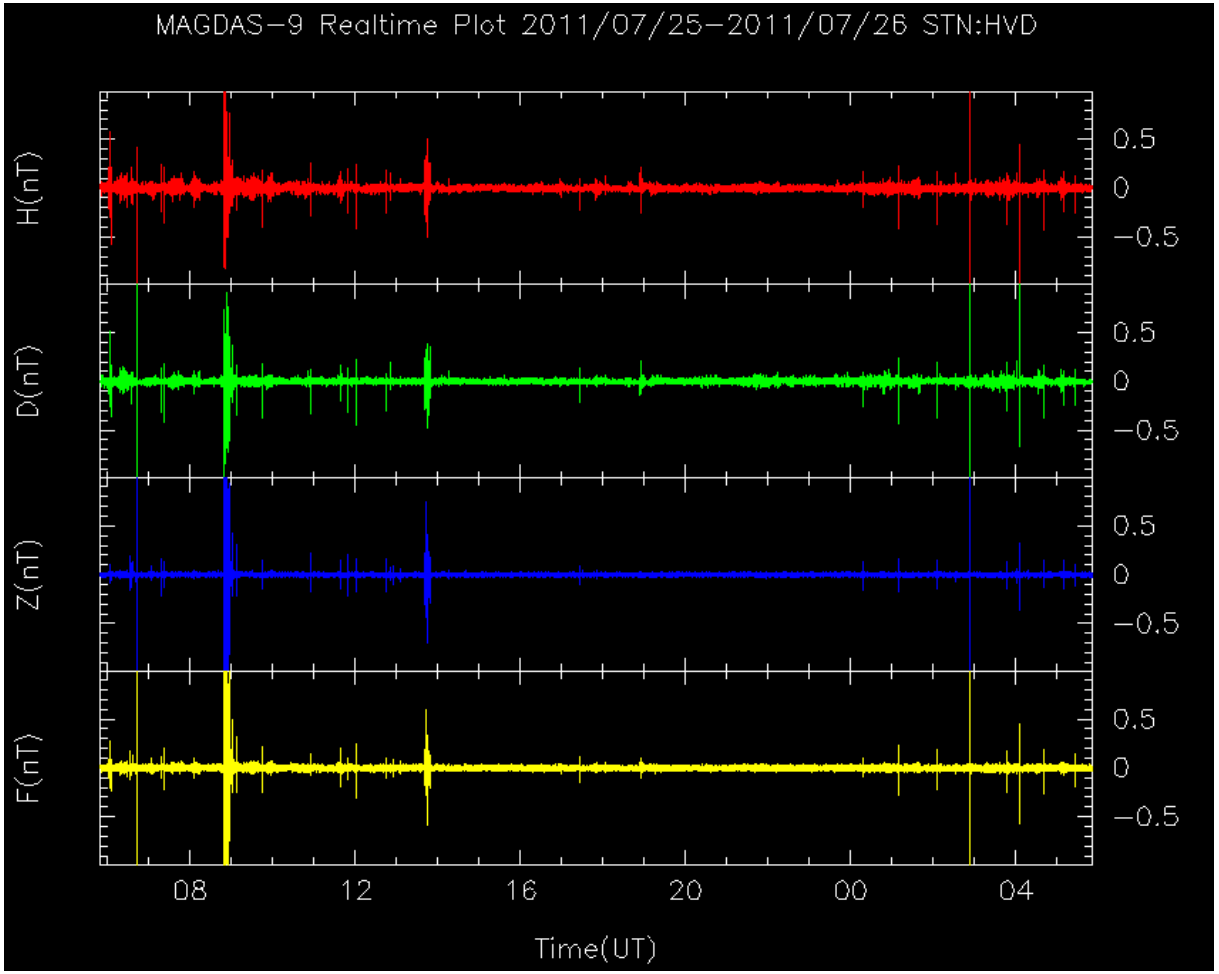
Time Derivative plot – very little noise at Khovd.



Spikes due to cars/trucks.

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The 67 MAGDAS Stations

ABJ	Abidjan, Ivory Coast	**HER**	Hermanus, South Africa	**PRP**	Pare Pare, Indonesia
ABU	Abuja, Nigeria	**HLN**	Hualien, Taiwan	**PTK**	Paratunka, Russia
AMA	Amami Oushima, Japan	**HOB**	Hobart, Australia	**PTN**	Pontianak, Indonesia
ANC	Ancon, Peru	**HVD**	Khovd, Mongolia	**ROC**	Rockhampton, Australia
ASB	Ashibetsu, Japan	**ICA**	Ica, Peru	**SCN**	Sicincin, Indonesia.
ASW	Aswan, Egypt	**ILR**	Ilorin, Nigeria	**SMA**	Santa Maria, Brazil
BCL	Bac Lieu, Vietnam	**KPG**	Kupang, Indonesia	**TGG**	Tuguegarao, Philippines
BKL	Bengkulu, Indonesia	**KRT**	Khartoum, Sudan	**TIR**	Tirunelveli, India
CAN	Canberra, Australia	**KTN**	Kotel' nyy, Russia.	**TIX**	Tixie, Russia
CDO	Cagayan De Oro, Philippines	**KUJ**	Kuju, Japan	**TNO**	Tono, Tohoku, Japan
CEB	Cebu, Philippines	**LAG**	Lagos, Nigeria	**TWV**	Townsville, Australia
CGR	Culgoora, Australia	**LAQ**	L'Aquila, Italy	**WAD**	Wadena, Canada
CHD	Chokurdakh, Russia.	**LGZ**	Legazpi, Philippines	**YAK**	Yakutsk, Russia.
CKT	Cooktown, Australia	**LKW**	Langkawi, Malaysia	**YAP**	Yap Island, Micronesia
CMD	Camden, Australia	**LSK**	Lusaka, Zambia	**ZGN**	Zhignsk, Russia
CST	Cape Schmidt, Russia	**LWA**	Liwa, Indonesia	**ZYK**	Zyryanka, Russia
DAV	Davao, Philippines	**MCQ**	MacQuarie Island, Australia		
DAW	Darwin, Australia	**MGD**	Magadan, Russia		
DES	Dar Es Salaam, Tanzania	**MLB**	Melbourne, Australia		
DRB	Durban, South Africa	**MND**	Manado, Indonesia		
DVS	Davis, Australia	**MPT**	Maputo, Mozambique		
EUS	Eusebio, Brazil	**MUT**	Muntinlupa, Philippines		
EWA	Ewa Beach, Hawaii, USA	**NAB**	Nairobi, Kenya		
FYM	Fayum, Egypt	**OIS**	Oiso, Japan.		

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Thank you !
from all of us at ICSWSE.

Participants of the

Closing Ceremony of

MAGDAS School

at Redeemer's University

near Lagos, Nigeria,

15-20 August 2011.

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