Site Testing, Equipment's and programs at Oukaimeden Observatory

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In the beginning, some times ago …

Site Testing and helisysmology

- IRIS Network: 11 year Solar Cycle (1988-1999)
- Site testing with Photometric diurnal monitoring followed by the Seeing and Meteorological measurements.
- Several Scientifics works and publications in this two fields (Articles, Communications, PHD thesis, …)
- The Oukaimeden Observatory has a median seeing of about 0.9 arcsec with frequent peaks at 0.5-0.6 arcsec. It has very good climate statistics especially in terms of the number of good photometrical night (260-300 per year confirmed by MOSS project).

Confirmation and expertise

Our Group continues to work in this subject area, especially with models and forecasting and with the new instruments development for site testing measurements. We could also lead the Aklim qualification campaign in the context of ELT-Site testing, despite the very challenging conditions.

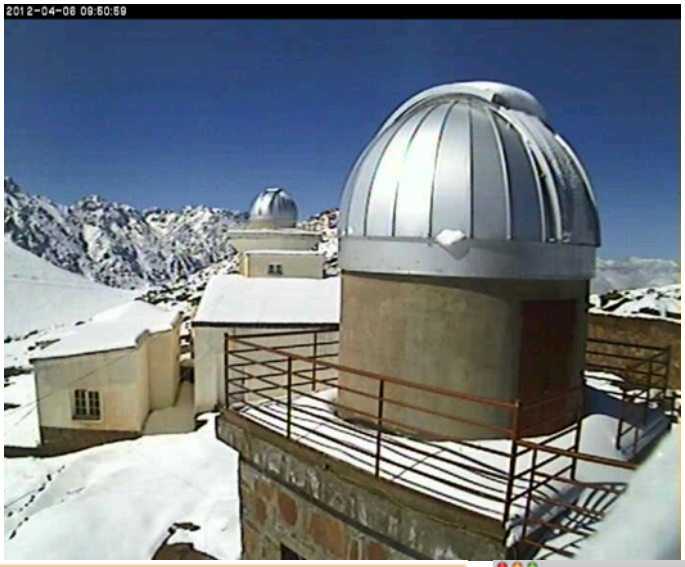
See the posters presented at this respect in this session:

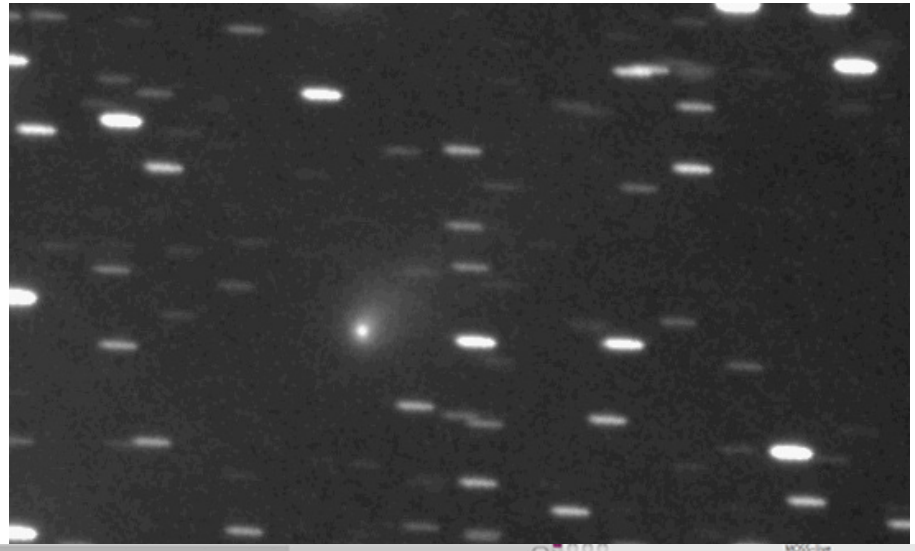
- Modeling (Mraini K. Phd student)
- Climatology and Aklim campaign (Sabil M.)
- ISM, new concept of seeing monitor (Habib A.)

THE MOROCCO OUKAIMEDEN SKY SURVEY THE MOSS TELESCOP

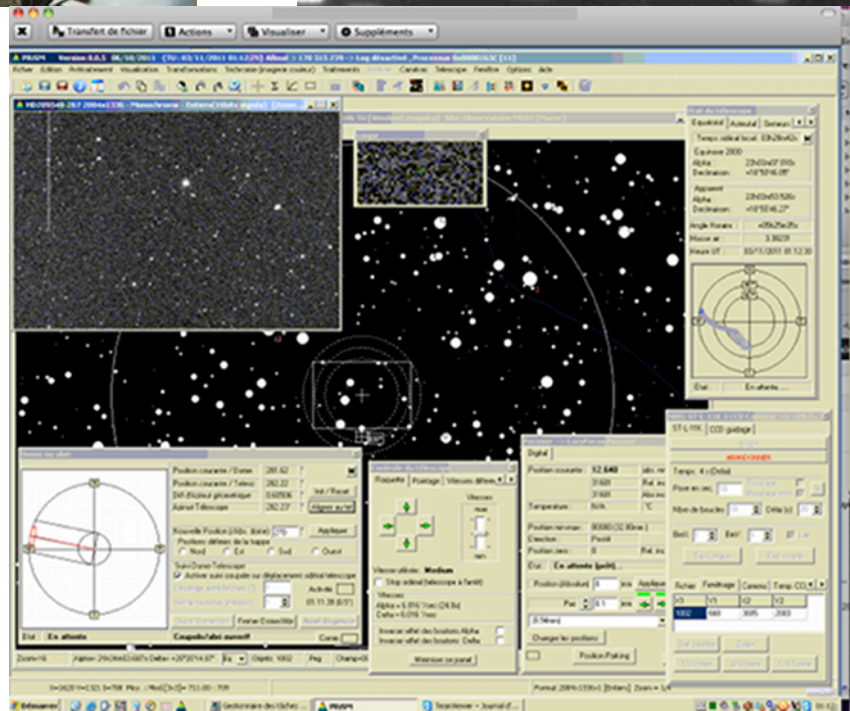
Installed, October 2011

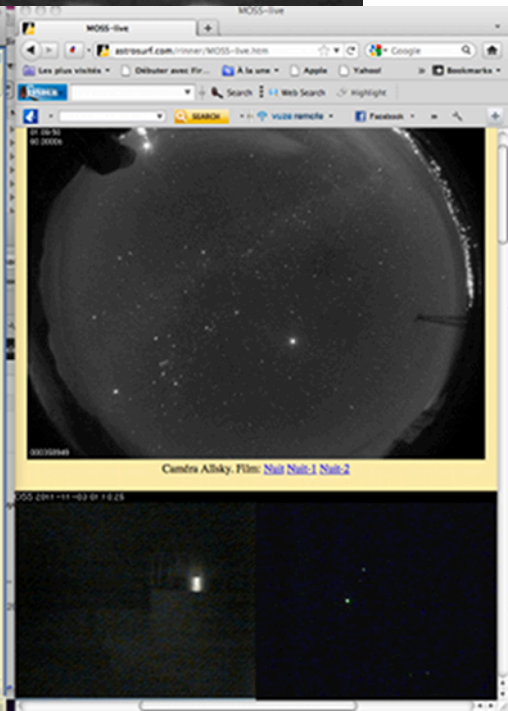
http://moss-observatory.org





Discoveries at J43 - MOSS (05.06.2015)	
Comets	**4**
C/2013 V5 (Oukaimeden)	
P/2013 CE31 (MOSS)	
C/2012 CH17 (MOSS)	
P/2011 W2 (RINNER)	
NEO	**3**
2013 YL2	
2012 RM2	
2011 VP12	
Minor Planets	
Named objects	0
Numbered objects	0
Designations found	2180
Supernovae	**0**

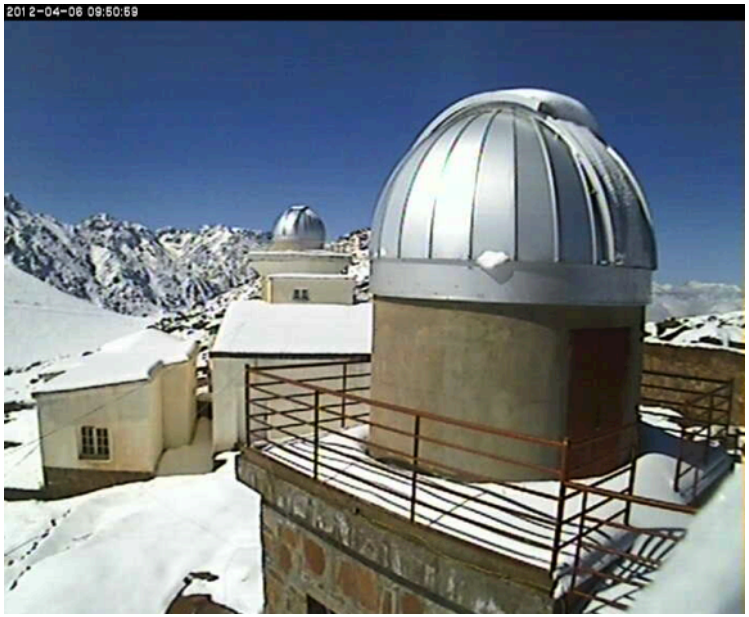




THE MOROCCO OUKAIMEDEN SKY SURVEY THE MOSS TELESCOP

MOSS Instrument :

The telescope has a 500mm primary mirror and is used at prime focus with a Wynne corrector (F/D=3,0). The detector is a SBIG STL11000 based on a Kodak KAF 11000 chip. The pixel size is of 1,2 arcsec; the field of view is of 1,5 degree.
The telescope is used in remote control, it is operated by three teams in Marrakech Cadi Ayyad University, in France and in Switzerland. Observing time is also shared between observation of exoplanet transits and asteroid search.



Starting from October 2011 5th, the Oukaimeden observatory (UAI code : J43) got **2180** new designations, so about 50 new designations per month. MOSS send more than 30 000 astrometric measurements to the MPC and is eighth among minor planets observatories.
The Oukaimeden recently integrated the top 50 best Observatories among the world

This project shows that it is still possible to find new asteroids and comets with a small telescope, the success of MOSS come from the good seeing conditions prevailing at the observatory of the Oukaimeden and also from the efficiency of the team who run the telescope.

OUKAIMEDEN IN THE TOP 50

Minor Planet Discovery Sites:

The following table lists the total number of discoveries made at each of the most prolific discovery sites, arranged in decreasing order of number of discoveries. This list was last updated on **2015 June 3**.

Rank	Discoveries	Between	Site name
1	143594	1960-2011	Lincoln Laboratory ETS, New Mexico
2	95247	1960-2014	Steward Observatory, Kitt Peak-Spacewatch
3	36671	1960-2013	Mt. Lemmon Survey
4	32176	1960-2012	Palomar Mountain/NEAT
5	22623	1973-2013	Catalina Sky Survey
6	20267	1993-2008	Lowell Observatory-LONEOS
7	8472	1960-2013	Pan-STARRS 1, Haleakala
8	7562	1993-2010	Haleakala-AMOS
9	6814	1949-2008	Palomar Mountain
10	5655	1976-2010	European Southern Observatory, La Silla
.....			
46	481	1995-2011	iTelescope Observatory, Mayhill
47	459	1992-2012	Mauna Kea
48	422	1978-2011	Cerro Tololo Observatory, La Serena
49	420	1993-2009	Lulin Observatory
50	**391**	**2011-2013**	**Oukaimeden Observatory, Marrakech**

Credit: MPC

Discoverys 2015 Ranking

Year	Code	Obs	NumMPs	UnnumMPs	Comets	Sats	NumMPs	UnnumMPs	Comets	Sats	Country
2015	G45	3271823	110922	5914	41	6	3196310	74216	1075	222	US
2015	F51	2711036	191571	67678	80	18	2147404	562626	833	173	US
2015	G96	860864	103520	15863	25	5	768358	92260	202	44	US
2015	703	833455	80325	2591	48	1	817655	15373	423	4	US
2015	D29	671565	76259	3059	25	7	658790	12478	192	105	CN
2015	691	316748	45978	5443	11	0	291989	24696	63	0	US
2015	I41	110897	10011	436	6	3	106324	4465	27	81	US
2015	C51	107534	4922	97	18	1	104258	2734	510	32	--
2015	F52	82064	16744	1342	3	2	76743	5299	14	8	US
2015	K95	59186	13303	38	8	0	58905	201	80	0	ZA
2015	**J43**	**47880**	**7586**	**313**	**3**	**0**	**45764**	**2096**	**20**	**0**	**MA**
2015	H15	46793	13559	158	9	0	46265	501	27	0	US
2015	C41	42881	10186	21	4	2	42799	64	12	6	RU
2015	W95	42378	8842	78	10	0	42006	320	52	0	CL

http://www.minorplanetcenter.net/iau/special/CountObsByYear.txt

Last update 20.01.2014

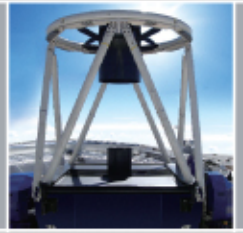
NEO summary

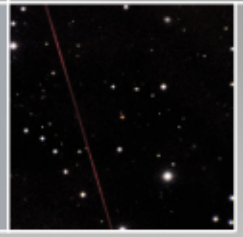
Designation	Emoid [AU]	q [UA]	a [UA]	e	i [deg]	H	Discov.	Type
2013 YL2	0.008	0.404	1.166	0.659	5.87	23.1	MO	Apollo
2012 RM2	0.060	0.991	2.058	0.519	4.85	22.8	MO	Apollo
2011 VP12	0.104	1.086	1.980	0.450	8.34	21.0	CR	Amor

Comets summary

Designation	Emoid [AU]	q [UA]	a [UA]	e	i [deg]	P [year]	Discov.	Type
C/2013 V5 (Oukaimeden)	0.188	0.627	---	1.0	154.95	---	MO	---
P/2013 CE31 (MOSS)	---	4.015	4.853	0.173	4.72	10.7	CR	---
C/2012 CH17 (MOSS)	0.378	1.296	---	0.999	27.70	---	CR	---
P/2011 W2 (Rinner)	---	2.303	3.780	0.394	13.77	7.4	CR	Jupiter-Family

OWL



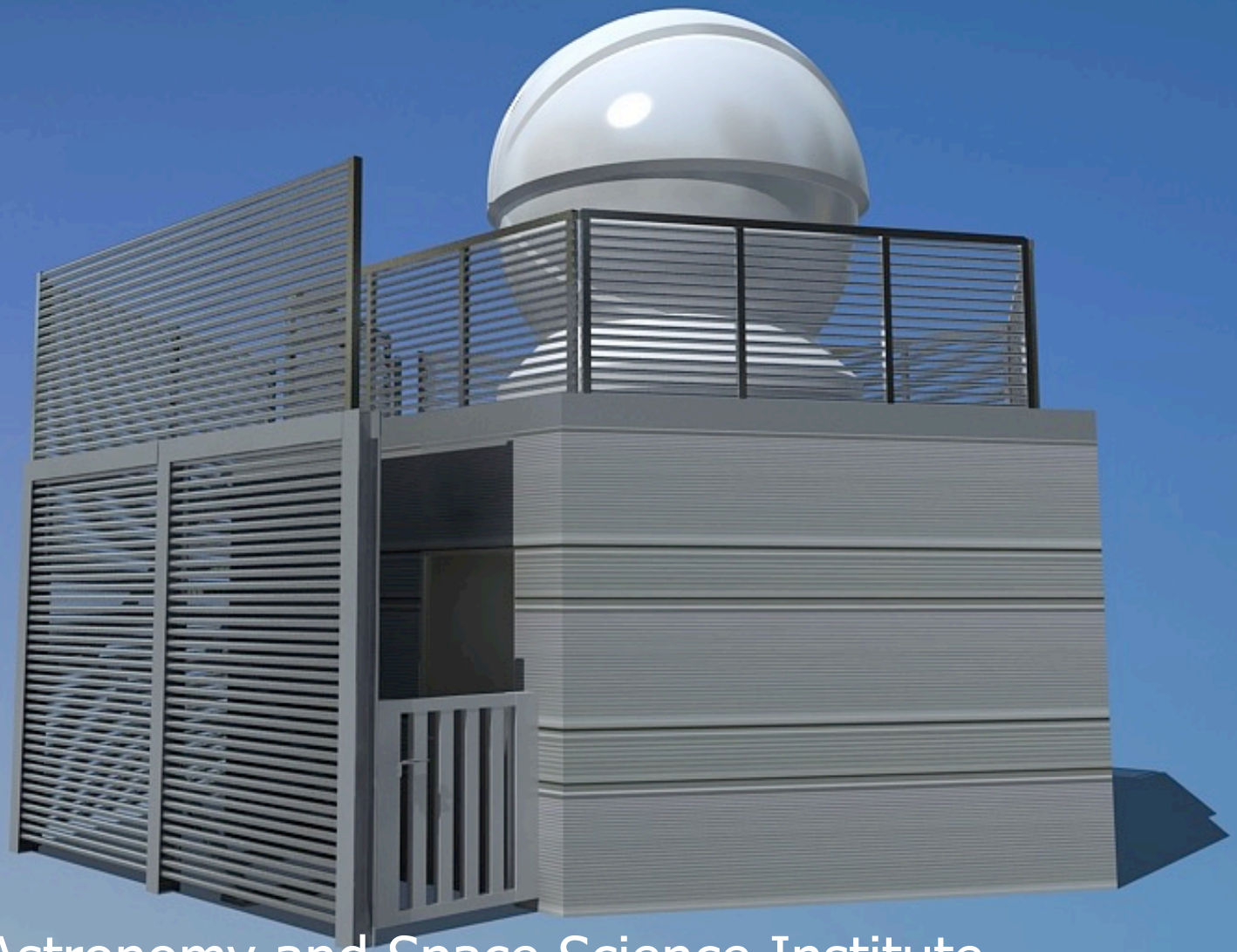


감사합니다

KASI 한국천문연구원
Korea Astronomy & Space Science Institute

OWL : Optical Wide-field patroL

Installed at Oukaimeden Observatory on January 2015



Korea Astronomy and Space Science Institute

System Overview

- OWL-Net is a planned system of wide-field telescopes which will track and monitor domestic satellites and space debris. The five identical telescopes, cameras, and site operating systems will be constructed and deployed to five astronomical sites with excellent weather conditions and infrastructures. They will be longitudinally well-separated so that the network will provide near-24-hour monitoring of the sky for astronomical- and practical- purposes.

- The primary mission of the OWL Project is to monitor and protect space-based assets. In addition, either wide-field imaging- or fast data acquisition- capability would enable the facilities to undertake observational program to catalog and follow-up various transient events in the night sky.

Our agreement

Scientific cooperation

For the scientific benefit of astronomers in Morocco, individuals from the science community will be allowed access to database which KASI intends to maintain under conditions subject to mutual agreement between Oukaimeden Observatory of Cadi Ayyad University and KASI.

Oukaimeden Observatory may also retain a right to access the telescope time under the agreement. Both institutes may encourage collaboration on the interpretation of the sky survey data; promote and explore appropriate joint projects.

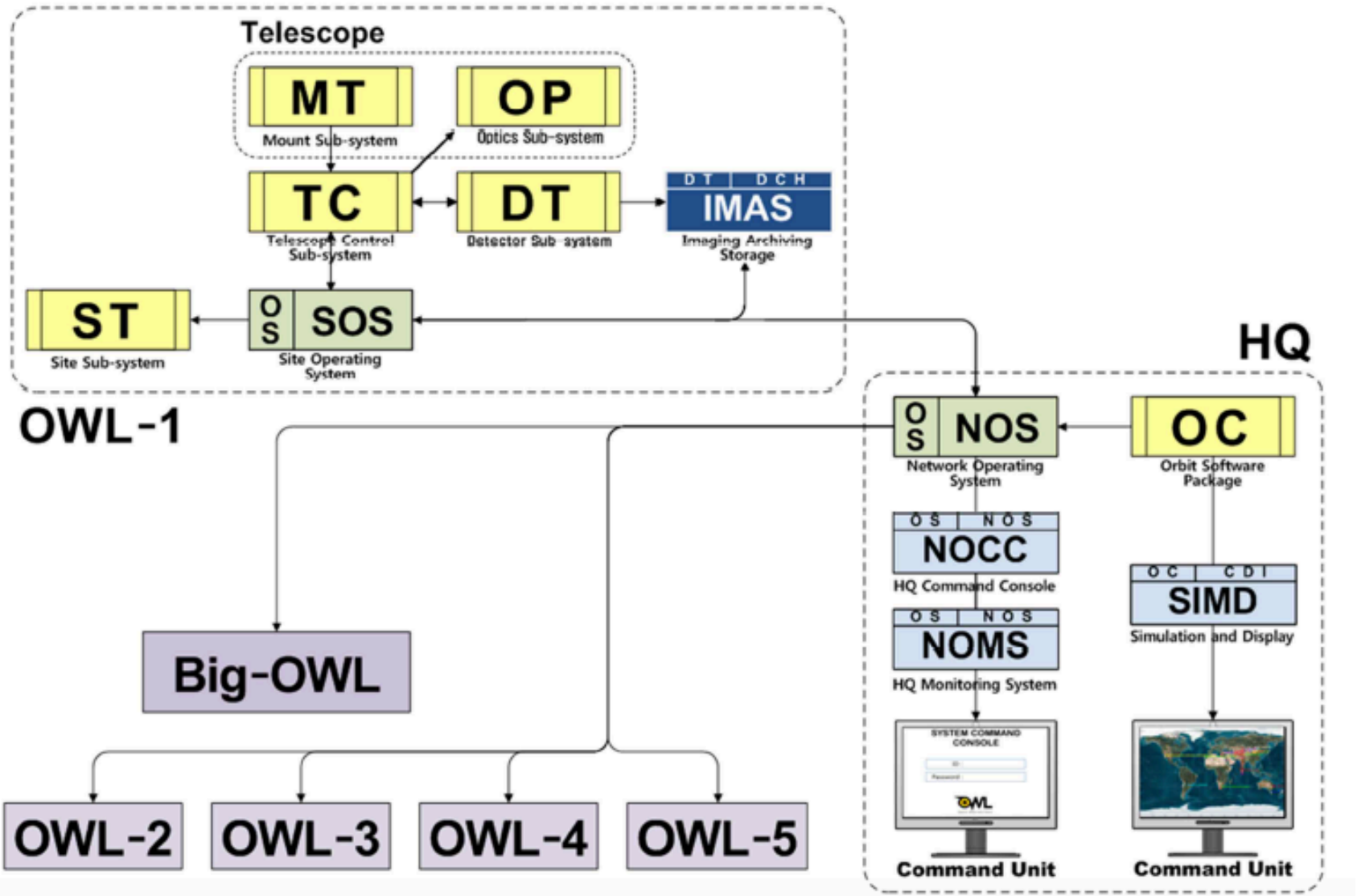
Education and training

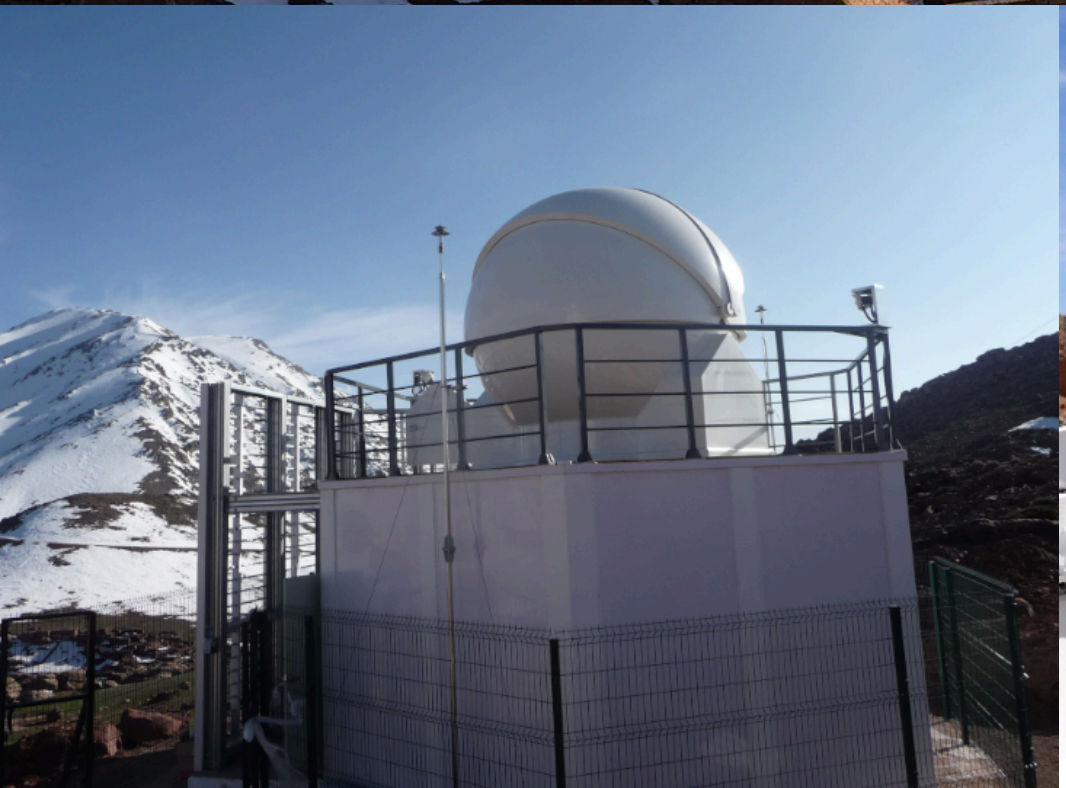
Oukaimeden Observatory and KASI may exchange personnel (scientists, engineers and students) to participate in collaborative activities (research projects, conferences and seminars, or joint publications). They may collaborate on the development of training and exchange programs for staff and students. In order to facilitate collaboration, they may seek to provide office accommodation and internet connections for visitors.

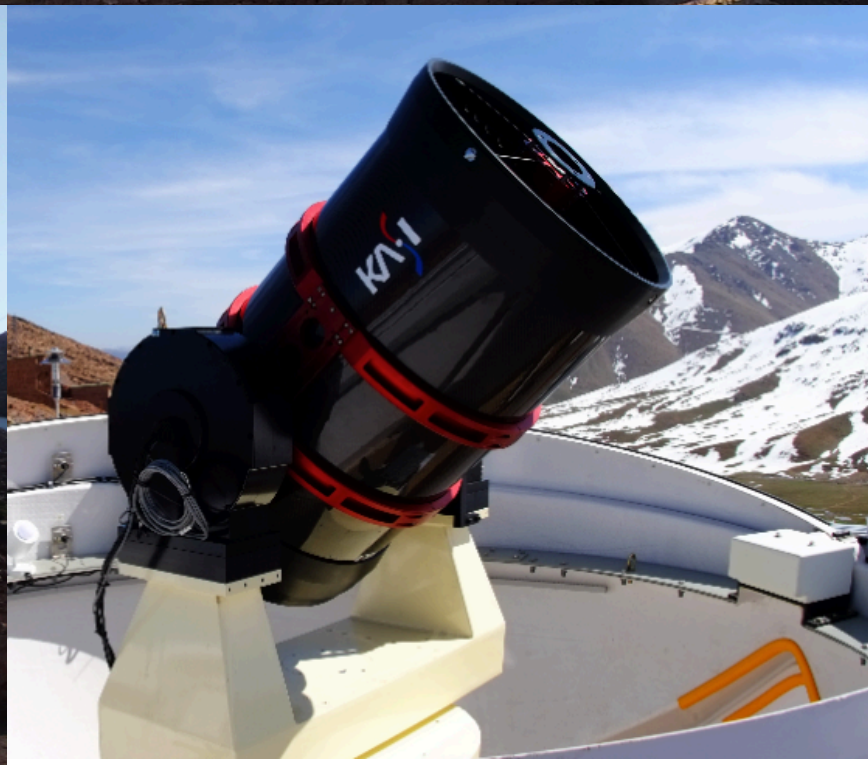
The candidates for OWL science program is:

- Follow-up astrometry of bright Near-earth objects
- Target of opportunity observations of small bodies in the Solar System
- Target observations of bright variable stars with improperly-determined periods
- Emission-line survey of the Galactic plane
- Follow-up observations of GRB afterglow

OWL-Net Overview






KAI

International Space Weather Initiative: RENOIR

The Remote Equatorial Nighttime Observatory of Ionospheric Regions (RENOIR) project studies interactions between ionospheric and thermospheric dynamics that can impact modern satellite-based communication systems. RENOIR uses a variety of different systems to determine coupling effects between ionospheric and thermospheric dynamics.

This experiment is conducting by Illinois University under NSF financing.

Background and Rational

International Space Weather Initiative (ISWI) sponsored by the United Nations is a multi-national program.

For understanding of the Earth's near-space environment, ISWI develop the scientific insight necessary to understand the science, and to reconstruct and forecast near-Earth space weather. Furthermore, international cooperation in research and development activities in the field of solar-terrestrial physics is important to all nations, in particular developing nations, owing to the high cost of such activities and the increasing involvement of all nations in the use of outer space for peaceful purposes.

Although the specific effects of space weather – power grid failures, communication outages, and navigation errors – are local in nature, understanding and predicting their occurrence requires a global view of the environment.

RENOIR Scientific Goals:

The Remote Equatorial Nighttime Observatory of Ionospheric Regions (RENOIR) experiment uses a variety of different systems to determine coupling effects between ionospheric and thermospheric dynamics. The principals goals are:

- Measure quiet-time neutral winds
  - The neutral wind dynamo plays a large role in the electrodynamics of the nighttime ionosphere
- Quantify the effects of neutral winds on equatorial instability processes
  - The development of ionospheric irregularities may be affected by the background neutral winds and perturbations therein
- Study the thermosphere/ionosphere response to geomagnetic storms
  - The background neutral winds can be greatly perturbed during geomagnetic storms, affecting low-latitude electrodynamics

Instruments: Installed at Oukaimden on October 2013

The instruments included in a RENOIR station allow for the study of the background thermospheric conditions (winds and temperatures) as well as the space weather effects in the ionosphere (e.g., equatorial plasma bubbles, medium-scale traveling ionospheric disturbances). Two instruments are deployed at Oukaimeden Observatory: a Fabry-Perot interferometer (FPI) and a wide-angle imaging system. The FPI will provide measurements of the thermospheric winds and temperatures made in four different look directions. Data analyze use routines developed at the University of Illinois (J. J. Makela et al., 2011).

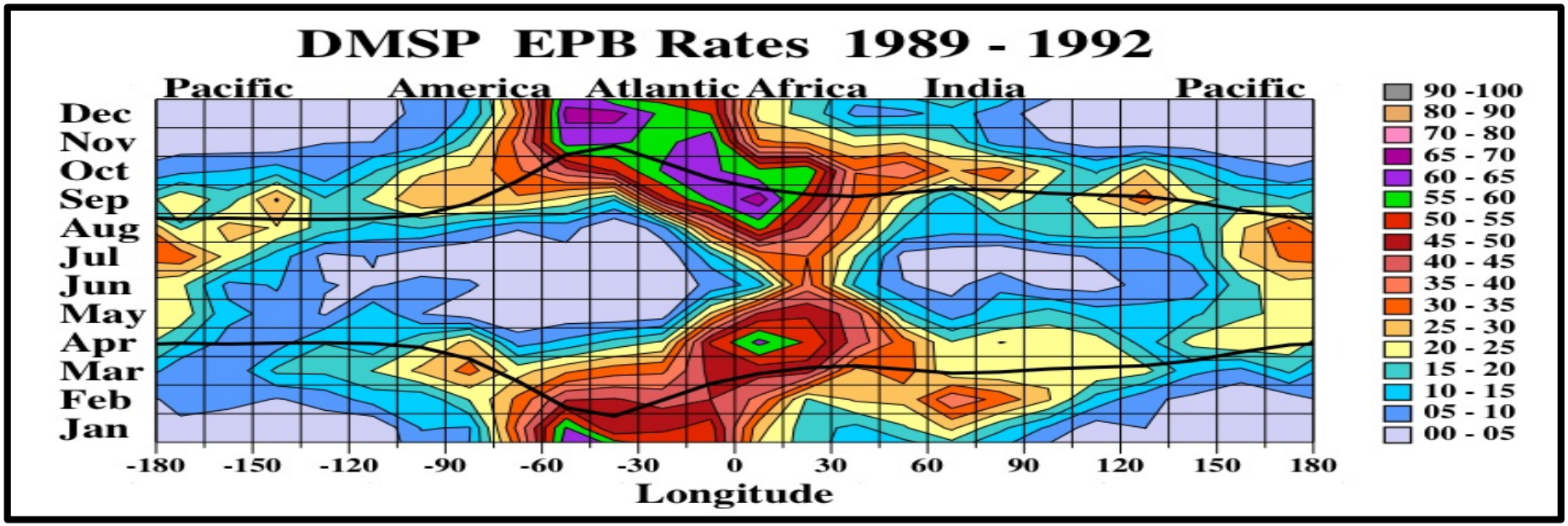
The wide-angle imaging system provide measurements of structures in the thermosphere/ionosphere occurring in an approximately 1000×1000 km^2 region above the observing site. Similar systems previously deployed in other parts of the world have demonstrated their utility for elucidating the physics of space weather processes (e.g., J. J. Makela and Miller, 2011; J. J. Makela et al., 2010, Meriwether et al, 2011).

Wide-angle imaging system and Miniaturized Nightglow Interferometer for Monitoring Emissions (FPI)

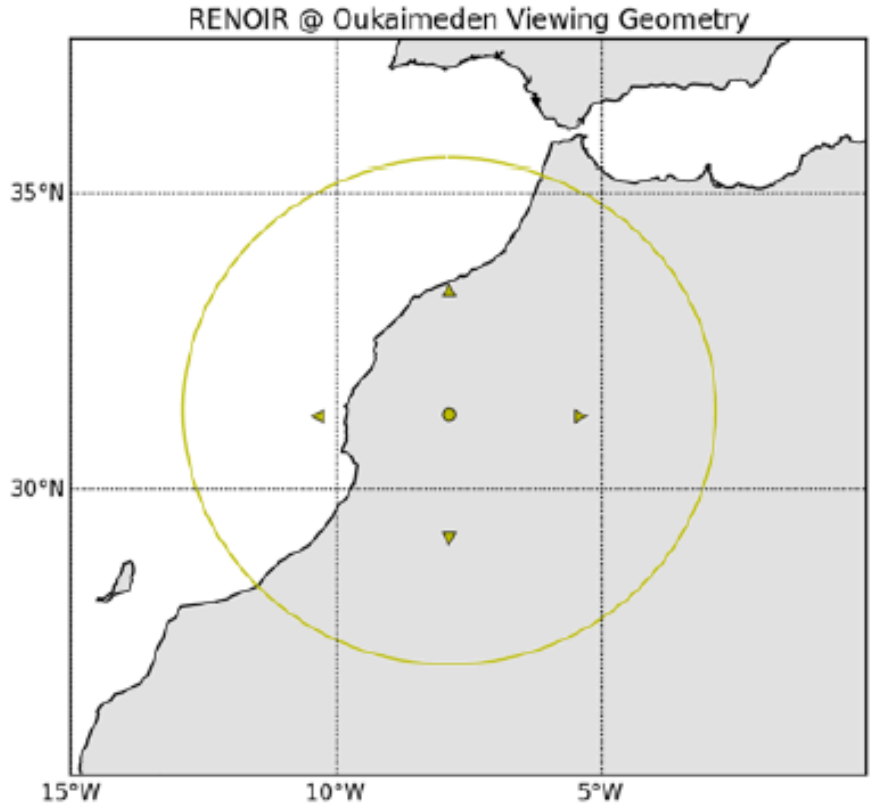
Left: MiniME2 CCD and optical system. Right: SkyScanner optical pointing head. The MiniME CCD barrel attaches underneath the SkyScanner to enable omnidirectional observations

Why Morocco

- Recent satellite measurements indicate that the structuring in the African region is unlike other regions.
- Africa shows an extended season for equatorial plasma bubbles, as compared to other longitude sectors.
- Wind measurements are severely lacking in this region of the world. Any measurements will enhance our understanding of the global thermospheric wind system.



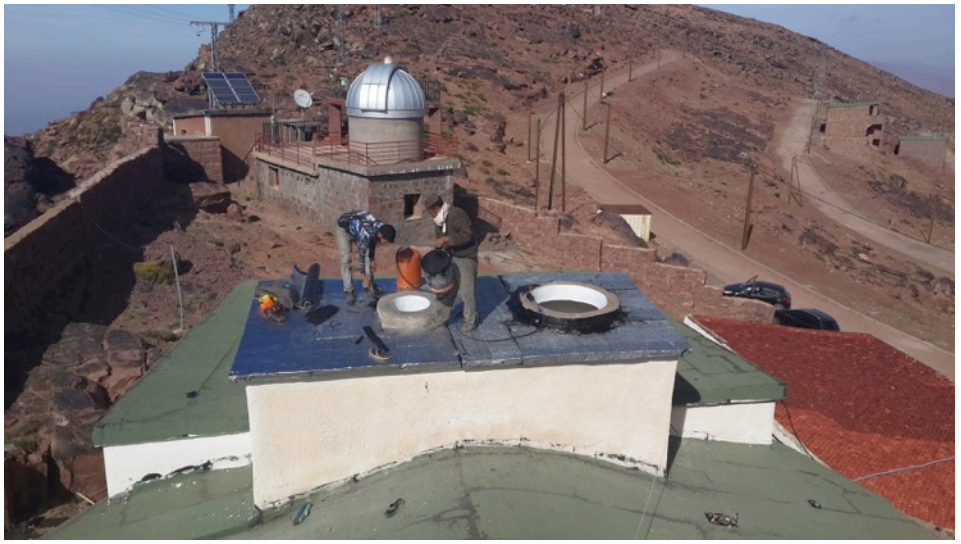
Gentile et al., AG, 2006

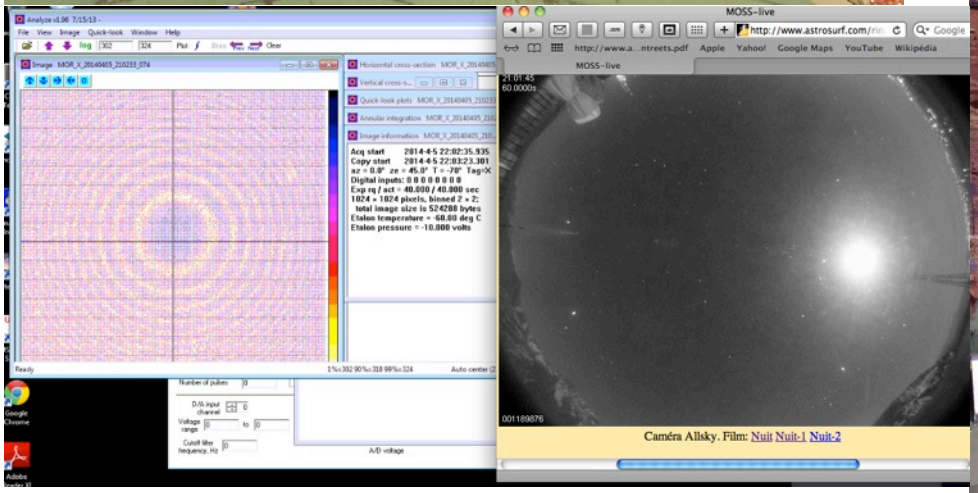


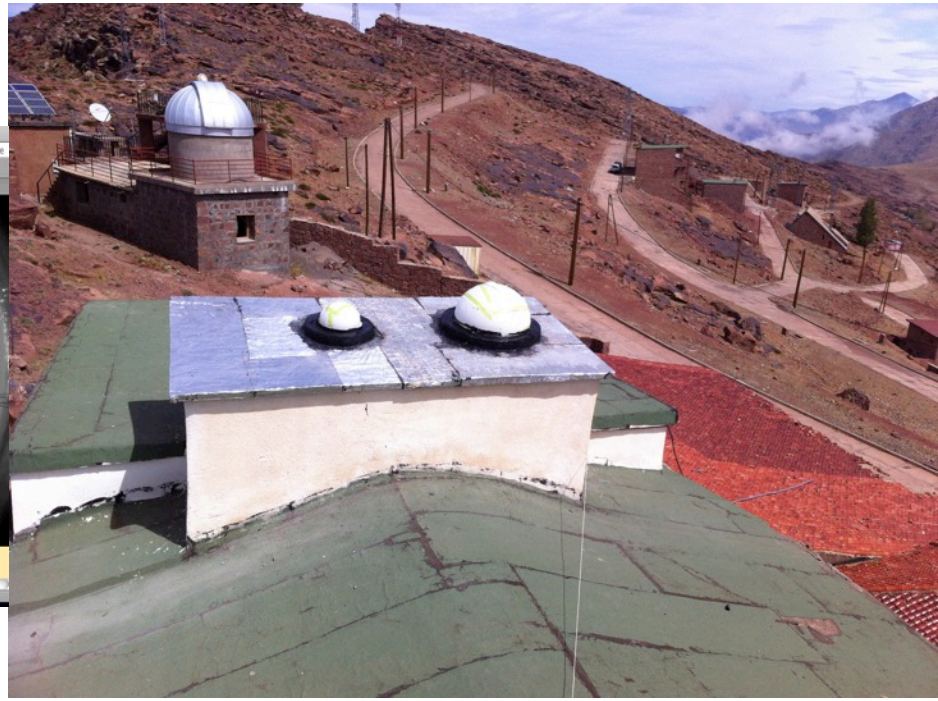
- installation of an FPI and PICASSO took place from 4-9 Nov 2013 at the Oukaimeden Observatory
- wind and temperature data along with imaging will be useful as a stand alone observing station as well as a collaborative experiment with other sites around the world

installation of RENOIR @ Oukaimeden

Installation @ Oukaimeden







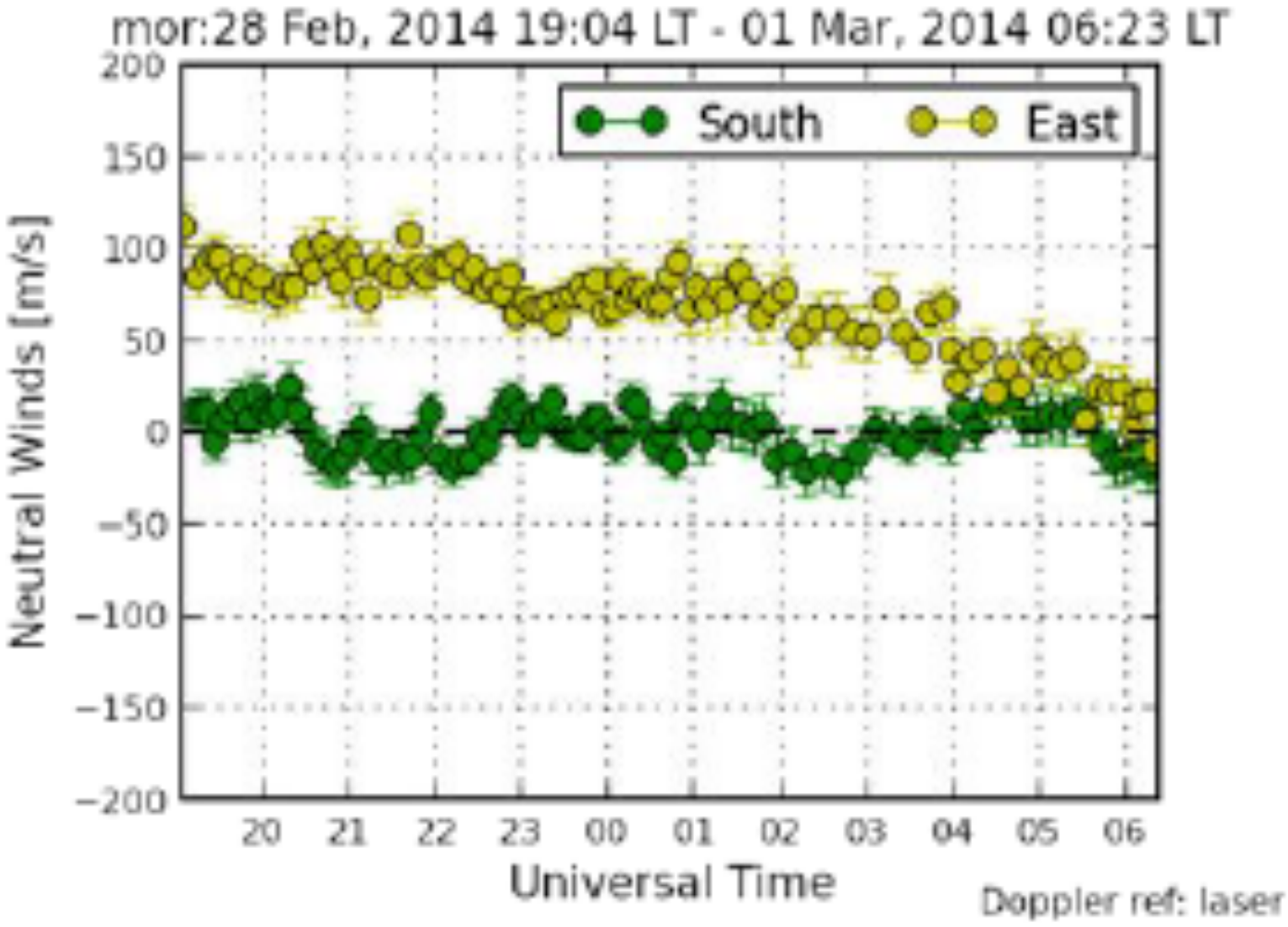


Figure 2. Example neutral winds obtained by the FPI on the night of 28 Feb-01 Mar 2014. The zonal (yellow) and meridional (green) winds are shown.

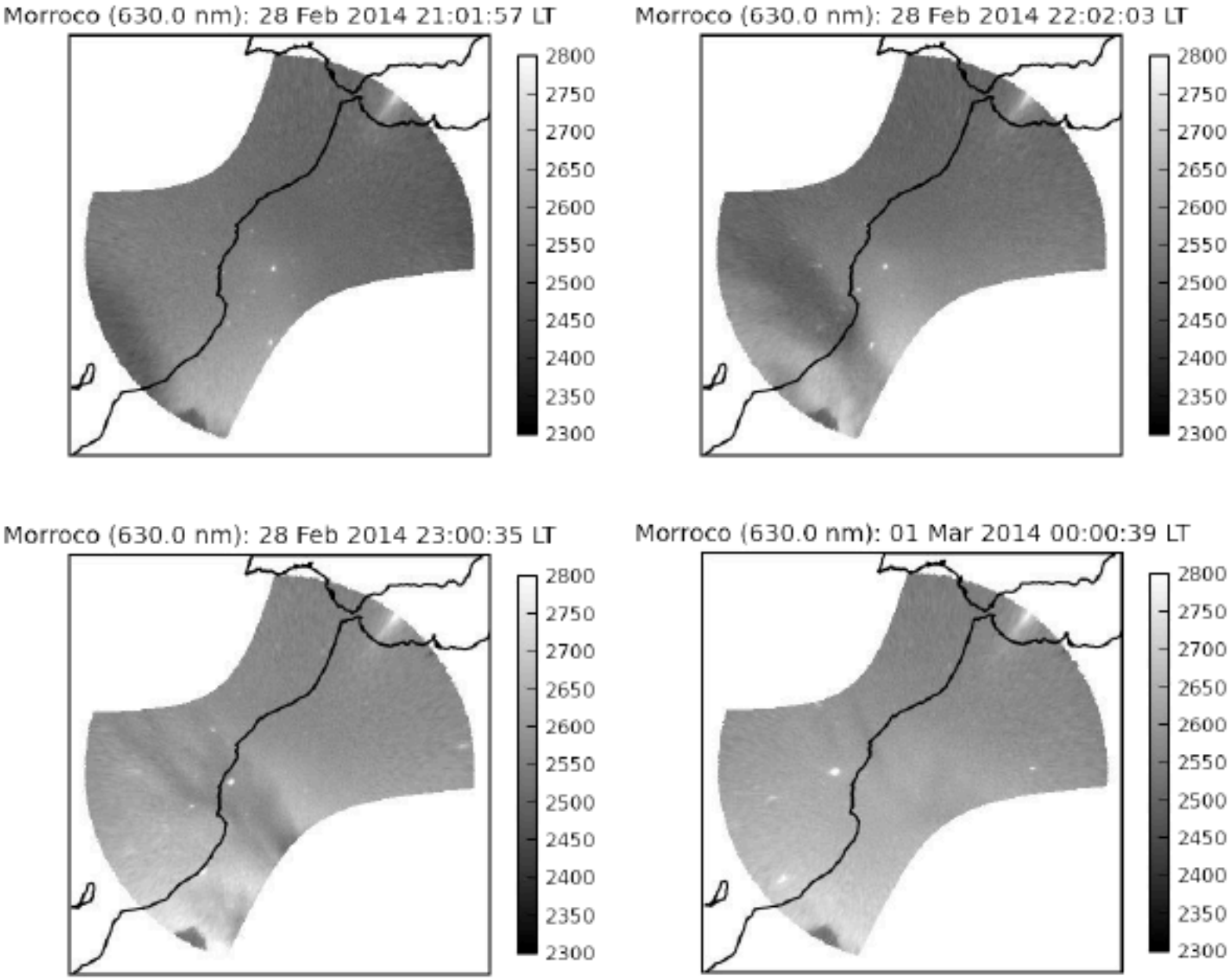


Figure 3. Sequence of the 630.0-nm images showing the propagation of an equatorial plasma bubble from west to east.

TRAPPIST: TOWARDS EXOPLANETS DISCOVERY FROM OUKAIMEDEN

TRAnsiting Planets and PlanetesImals Small Telescope

60cm ASTELCO robotic telescope
Back-illuminated 2048 x 2048 CCD camera
FOV = 22' x 22'
ESO La Silla Observatory, Chile
Operated from Liege
Collaboration ULg – Geneva
Funding: F.R.S.-FNRS with participation of
Swiss National Science Foundation
In operation in Chile since 2010

<u>Scientific program:</u>
75% exoplanets (PI M. Gillon)
25% comets (PI E. Jehin)

Credit E. Jehin & M. Gillon

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Exoplanet program: follow-up of WASP candidates

WASP: Wide Angle Search for Planets

- UK consortium of 8 academic institutions
- 2 robotic observatories: La Palma & South Africa
- 11.1cm aperture, FOV=488 deg
- World leading survey in the discovery of transiting Jupiter-size planets (>130).

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Exoplanet program: follow-up of WASP candidates

WASP

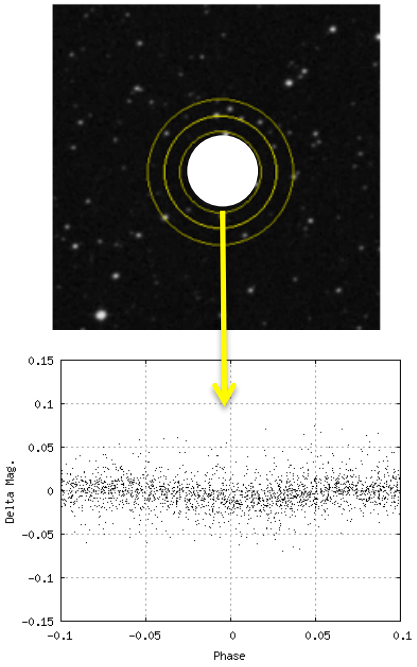
Pixel scale = 13.7’’

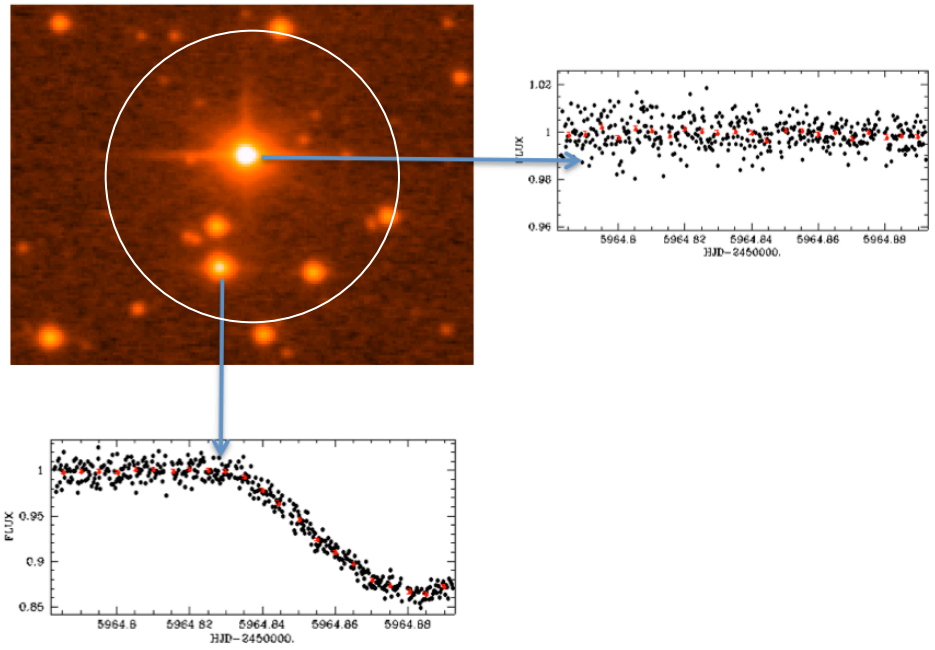
Typical precision ~ 1%

TRAPPIST

Pixel scale = 0.65’’

Typical precision ~0.1%





Example: a « blend » easily spotted by TRAPPIST

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Exoplanet program: results summary

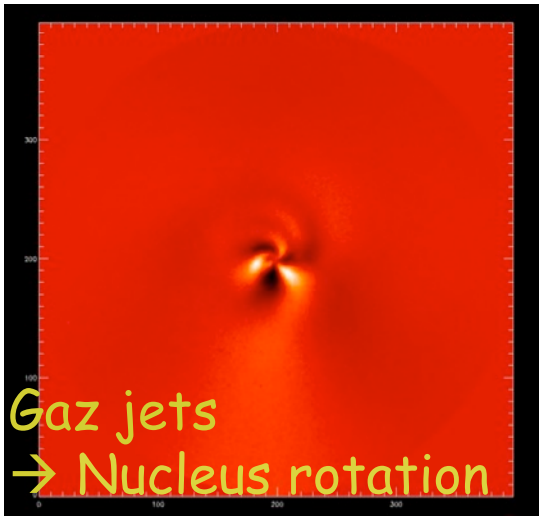
TRAPPIST contribution in a few numbers:

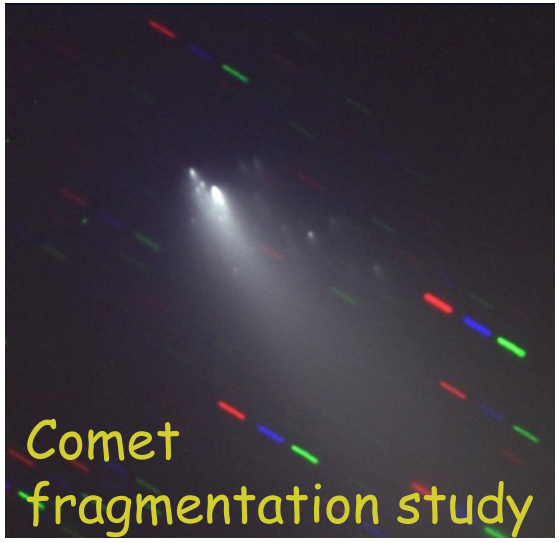
- 452 WASP & 5 CoRoT candidates monitored
- 251 WASP & 2 CoRoT candidates rejected thanks to TRAPPIST data
- Participation to the detection of 92 transiting planets (WASP: 89, CoRoT:2, HARPS: 1)
- Transiting planets detection papers: 26 published, 2 submitted, 7 in prep.
- Participation to the characterization of 30 transiting planets
- 472 eclipse for 117 planets
- First firm demonstration of fast-evolving weathers on L-T transiting brow dwarfs

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Comet program





TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Comet program: ISON

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

TRAPPIST-North: extending the TRAPPIST project to the North

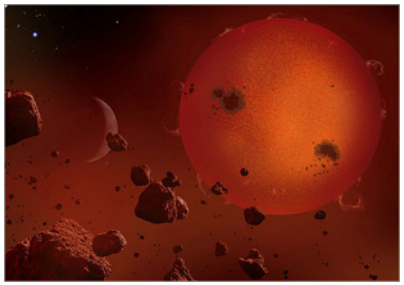
Oukaïmeden Observatory, Morroco 2750m
>260 clear nights/yr
Collaboration with Cadi Ayad University of Marrakech
ULg: M. Gillon (PI), E. Jehin (co-PI)
Cadi Ayad: Z. Benkhaldoun (co-PI)
Funding: ULg
Status: call for tenders open, installation planned for Autun 2015

TRAPPIST

TRAnsiting Planets and PlanetesImals Small Telescope

Main objective of TRAPPIST-North: extending SPECULOOS to the North

- There are in the sky 1000 ultra-cool dwarfs for which a transiting Earth-size planet is amenable for atmospheric characterization
- From Chile, the SPECULOOS facility + TRAPPIST have access to ~600 of them
- **It could be that THE Earth-size planet hosting life waiting to be caught in transit is among the 400 remaining ones**
- TRAPPIST-North will be able to explore 100 northern targets, the brightest ones
- To cover the 300 remaining ones within 5-10 years, **two dedicated 1m robotic telescopes operating from a good northern site are still needed.**



Flux of impactors on the Earth-Moon environment

The flux of Kilogram-sized meteoroids is relatively low. Meteoroids are too small to be detected directly by ground-based or space telescope. By monitoring Earth atmosphere for large meteoroids penetrations (Fireballs), the volume monitored is limited to $10^3 km^2$ (for All-sky camera).

The influx rate of objects hitting the Earth and the Moon is most uncertain at centimeter and meter-sizes.

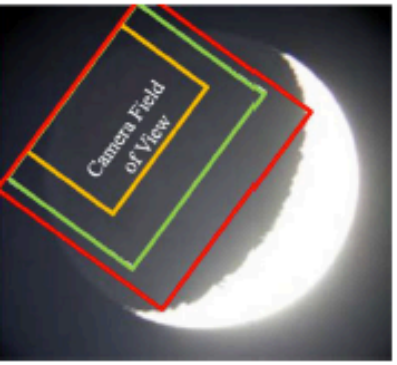
Solution : Moon allows to monitor a larger surface 2-8 10^6 km^2 (~2000 All sky area). Monitoring lunar meteoroids impact suitable for the study of the flux of interplanetary matter impacting the Earth-Moon system and enhance hazard from small impactors.

Meteoroids impacting the Moon give rise to a variety of different phenomena.

- Optical flashes
- Seismic waves
- Studying lunar atmosphere
- Cratering

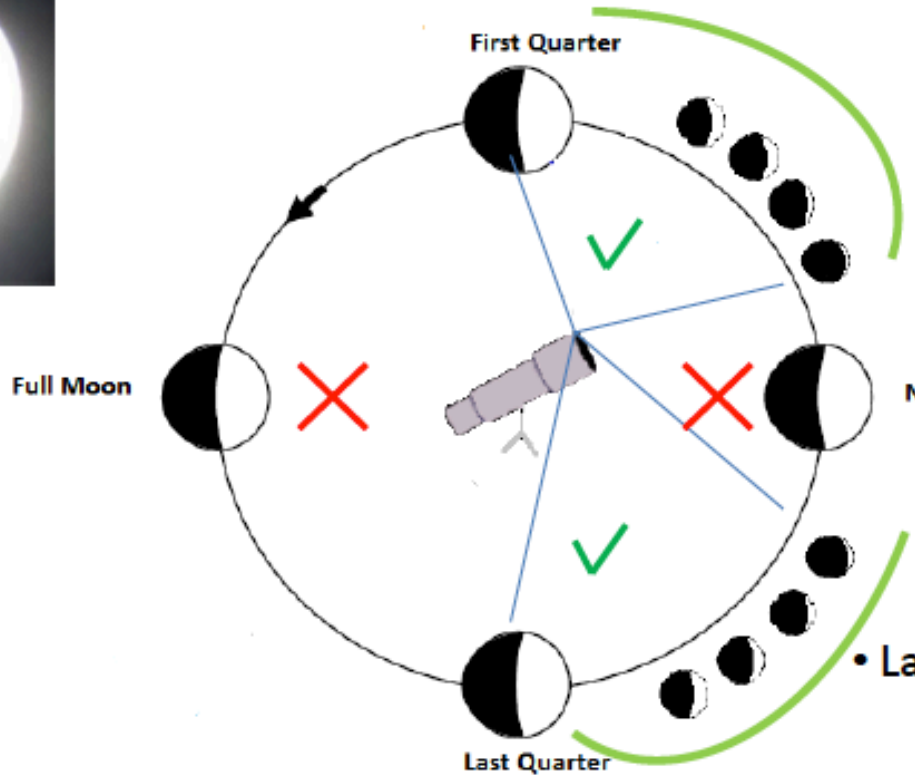
Lunar Flashes Observation : Period of Observation

- Dark (not sunlit) side only



- Crescent to First quarter – 0.1 to 0.5

5 nights waxing (evening), weather dependent



- Last quarter to Crescent – 0.5 to 0.1

5 nights waning (morning), weather dependent

Last quarter

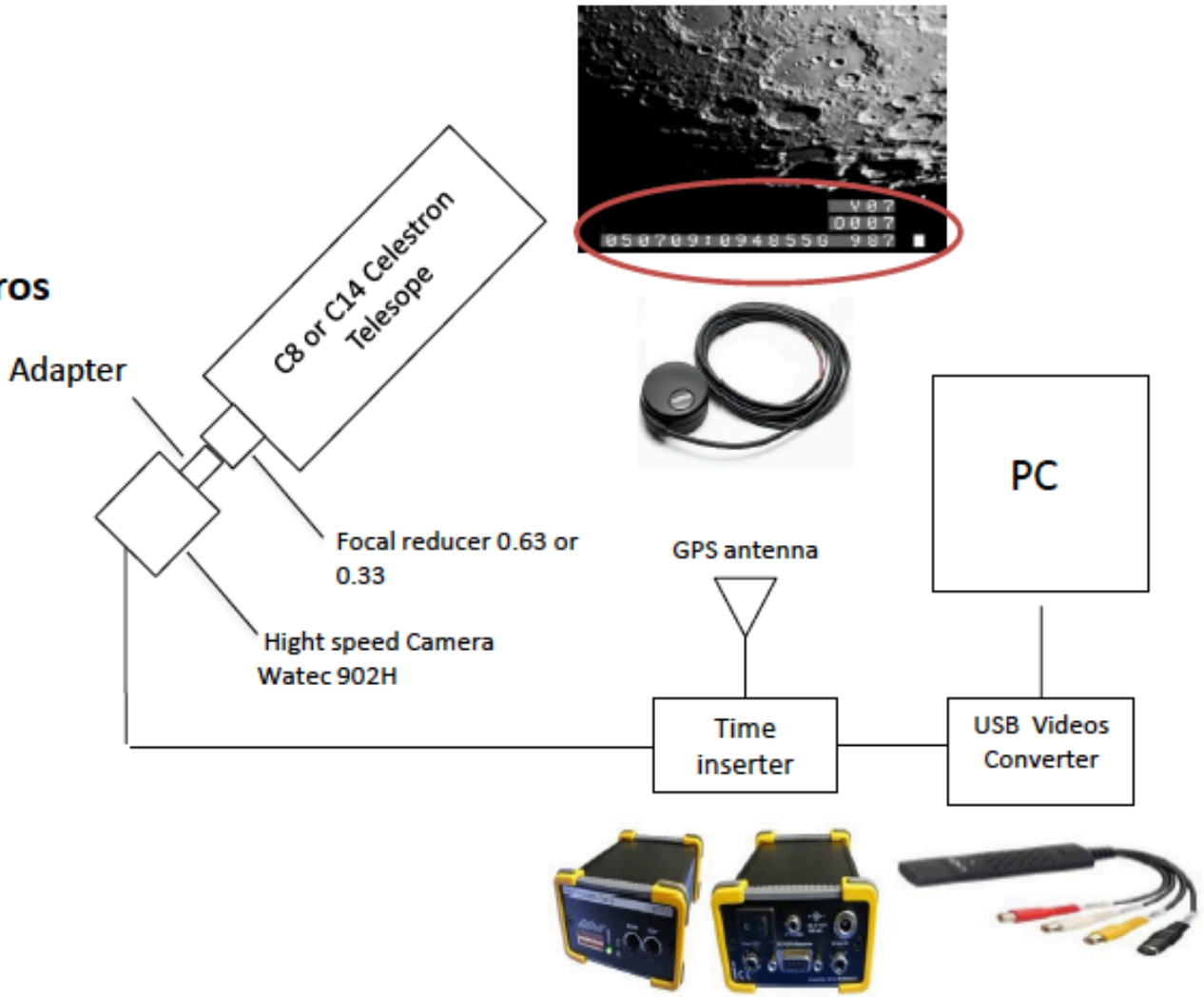
First quarter

Lunar Flashes Observation : Observation equipments

Costs :

- 20 cm telescope : **1200 Euros**
- Watec video camera : **600 Euros**
- Focal reducer : **125 Euros**
- Time inserter + GPS
  + Grabber : **250 Euros**

Total : ≈ 2175 Euros

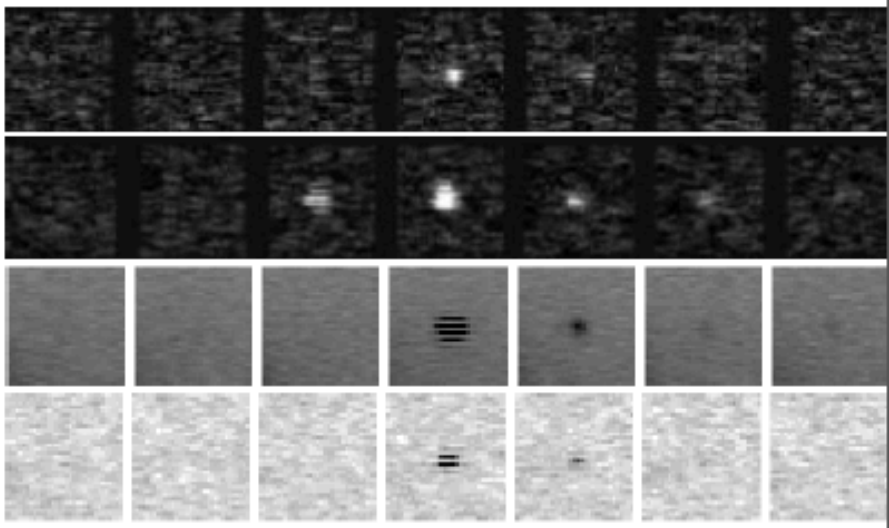


Detections from Morocco :

Detections :

- From February, 2013 to December, 2014 : (56±3) hours of data recorded.

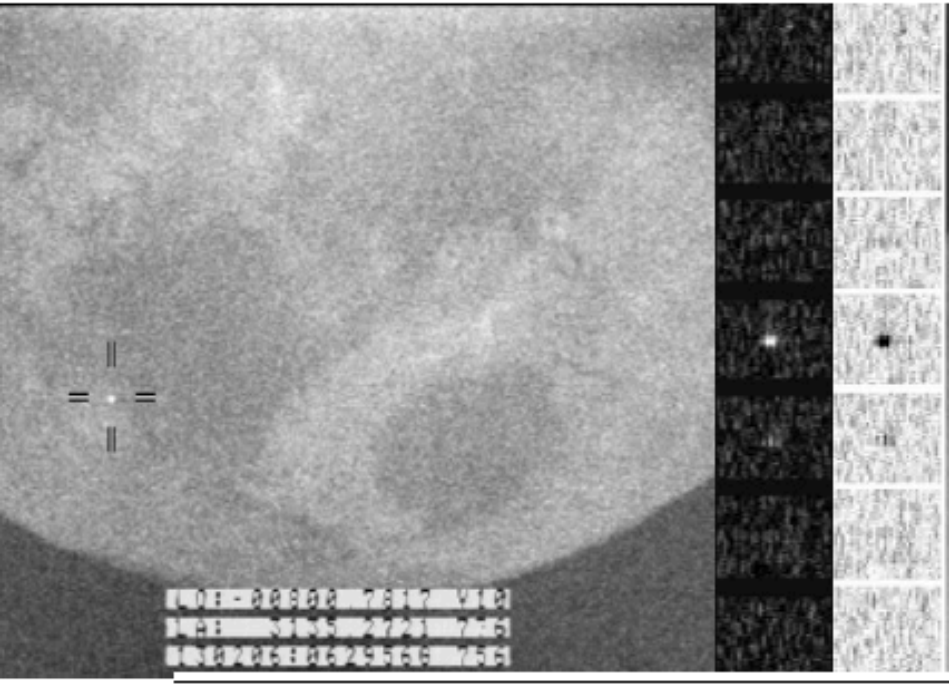
→Four flashes detected :

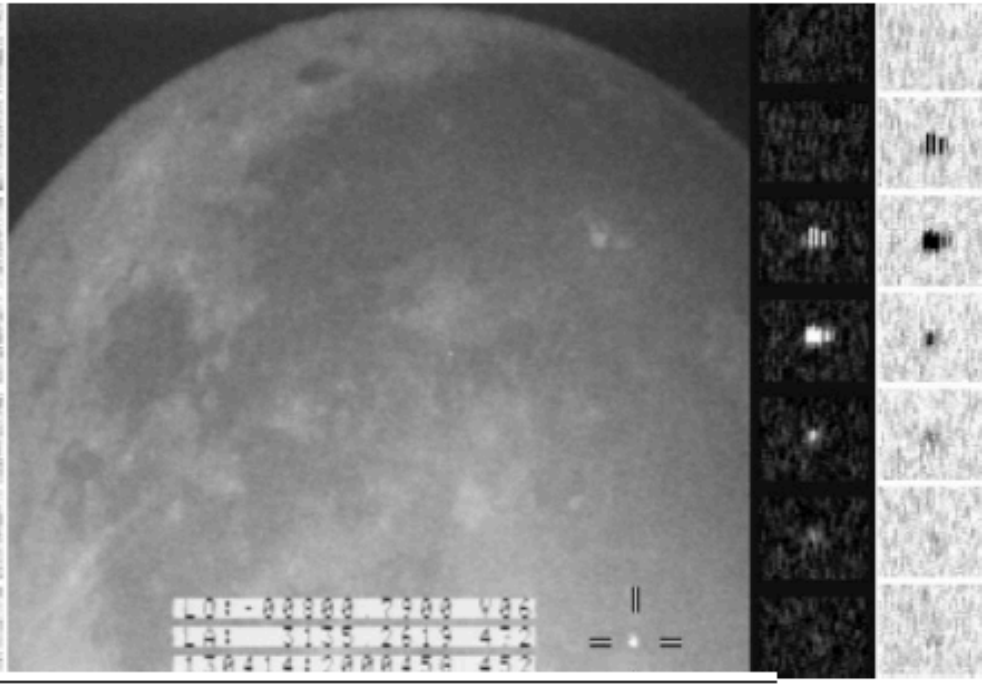


Publications :

- European Planetary Sciences Congress (September 2013).
- American Geophysical Union Fall Meeting (December 2013).
- Earth Moon and Planets journal, Manuscript accepted with minor revisions

Detections from Morocco : Two published detections



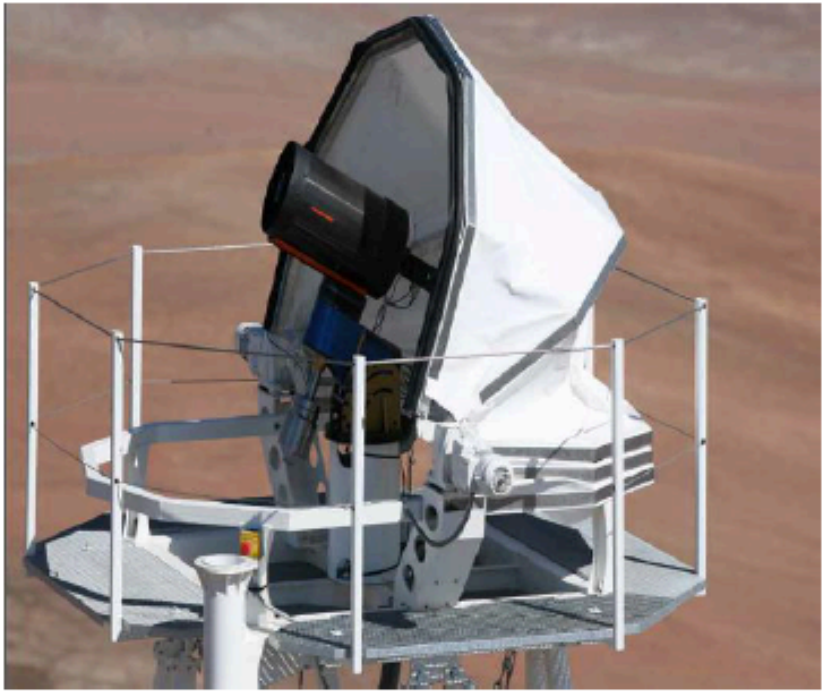


	Flash 1	Flash 2
Duration (ms)	80	240
Estimated Peak magnitude	9.4 ± 0.2	7.7 ± 0.2
Luminous Energy of impact(in visible)	$(5.7 \pm 0.6) \times 10^4 J$	$(34.1 \pm 8.1) \times 10^4 J$
Kinetic Energy of impactor	$(3.8 \pm 0.4) \times 10^7 J$	$(23.1 \pm 5.9) \times 10^7 J$
Estimated mass of impactor	0.3 ± 0.05 kg	1.8 ± 0.3 kg
Estimated diameter of impactor	7-8 cm	14-15 cm
Estimated crater diameter	2.6 ± 0.3 m	4.4 ± 0.3 m
impact coordinates	$08.15^o \pm 0.15$ S $59.1^o \pm 0.15$ E	$26.81^o \pm 0.15$ N $09.10^o \pm 0.15$ W

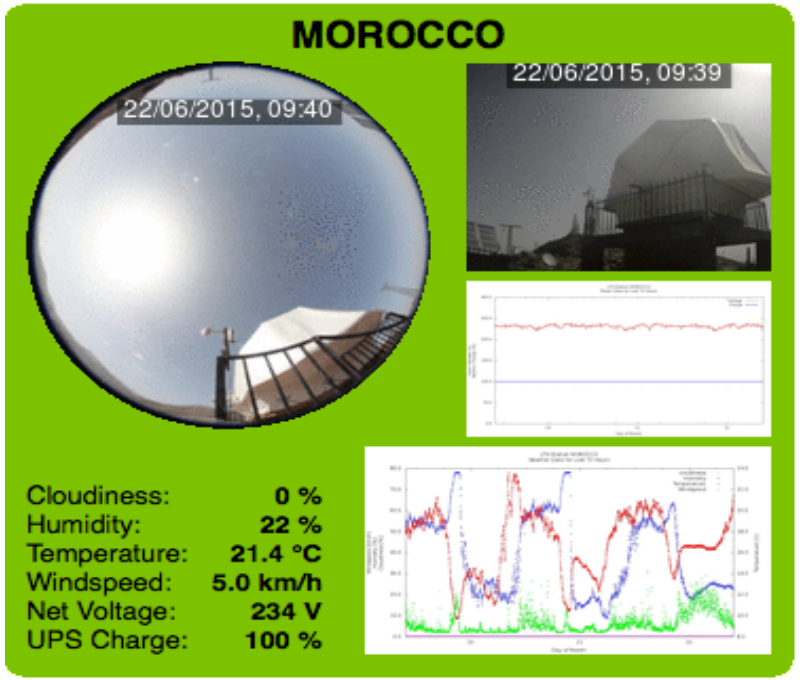
How to get better from lunar flashes

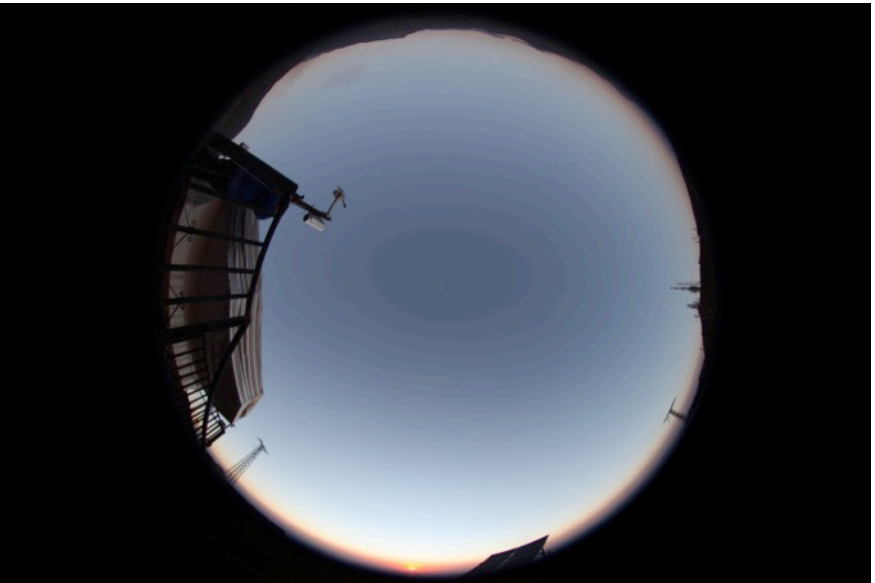
- Increase the number of detections :

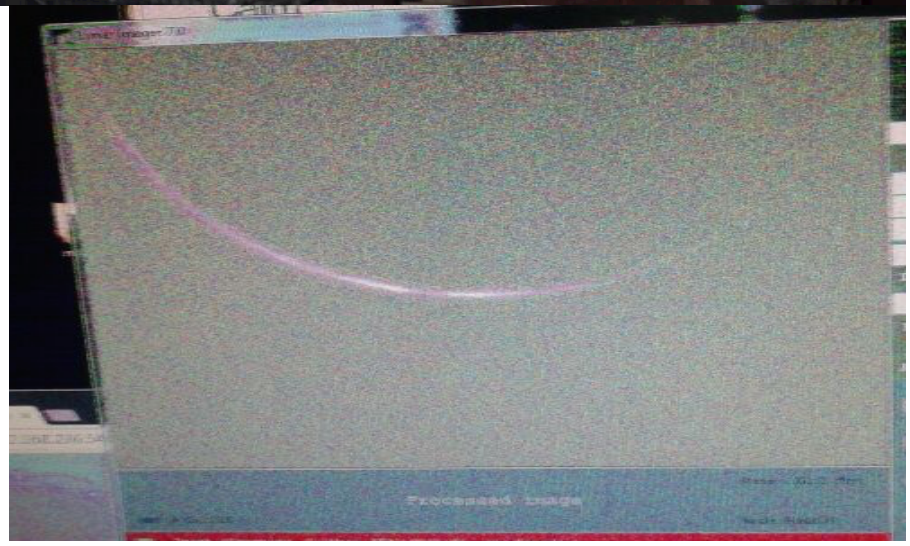
✓ Increase the observation time and reduce the time-consuming workload, by using permanent and automated monitoring stations



KACCOLR: for Lunar flashes







Publications (Articles): Frome 2012

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2. *A. Daassou, Z Benkhaldoun, Y Elazhari and Ait Moulay M Larbi. Article: An analytical model for the 0.33 - 7.85 micron transmission spectrum of HD189733b : Effect of stellar spots. International Journal of Computer Applications 107(10):1-8, December* ***2014****.*
3. *Varela, Antonia M.; and ELT-Site-Testing Team,, « European Extremely Large Telescope Site Characterization III: Ground Meteorology », Publications of the Astronomical Society of the Pacific, Volume 126, issue 938, pp.412-431,* ***2014****.*
4. *Jonathan J. Makela, Benkhaldoun Zouhair, « Installation of RENOIR at the Oukaïmeden Observatory, Morocco », VarSITI. 07/****2014****; 2:3-4.*
5. *T Elhalkouj, M Sabil, A Habib, Z Benkhaldoun, My.y. Elazhari, M Lazrek, O Azagrouze, European Extremely Large Telescope: Isopistonic Angle Measurements at Aklim Site , International Journal of Computer Applications. 08/****2014****; 99(5):1-4. DOI: 10.5120/17366-7889.*
6. *Habib Abdelfetah, Benkhaldoun Zouhair, El Azhari Youssef, « Numerical simulations of a new approach for seeing measurement », Monthly Notices of the Royal Astronomical Society, Advance Access. 6 pp,* ***2013***
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9. *S. Bouley, D. Baratoux, J. Vaubaillon, A. Mocquet, M. Le Feuvre, F. Colas, Z. Benkhaldoun, A. Daassou, M. Sabil, P. Lognonné, « Power and duration of impact flashes on the Moon: Implication for the cause of radiation », Icarus, Volume 218, Issue 1, Pages 115-124.,* ***2012****.*
10. *Hach, Y.; Jabiri, A.; Ziad, A.; Bounhir, A.; Sabil, M.; Abahamid, A.; Benkhaldoun, Z. « Meteorological profiles and optical turbulence in the free atmosphere with NCEP/NCAR data at Oukaïmeden Monthly Notices of the Royal Astronomical Society, Volume 420, Issue 1, pp. 637-650,* ***2012****.*

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1. Zouhair Benkhaldoun (**2012**). A project of a two meter telescope in North Africa. Proceedings of the International Astronomical Union, 10, pp 558-558. doi:10.1017/S1743921314012137.
2. Meryem Guennoun, Zouhair Benkhaldoun, Jérémie Vaubaillon, « Meteor observations from double station in Morocco », Proceedings of the IMC, Giron, **2014**; 11/2014
3. Romain G. Petrov, Thami Elhalkouj, Abdelkarim Boskri, Jean-Pierre Folcher, Stéphane Lagarde, Yves Bresson, Zouhair Benkhaldoun, Mohamed Lazrek, Suvendu Rakshit, « Hierarchical fringe tracking », SPIE 9146, Optical and Infrared Interferometry, Montréal, Quebec, Canada; 06/**2014**.
4. Mraini, Kamilia; Jabiri, Abdelhadi; Benkhaldoun, Zouhair; Bounhir, Aziza; Hach, Youssef; Sabil, Mohammed; Habib, Abdelfettah, « The OTP-model applied to the Aklim site database », Proceedings of the SPIE, Volume 9150, id. 91501X 6 pp. (**2014**).
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Conclusion

- The site testing and scientific results that it generated, have played a leading role of the Oukaimeden Observatory attractiveness.
- Thanks to its very good seeing and recent discoveries of comets and Near-Earth object, Oukaimeden Observatory has aroused the interest of several scientific institutes who selected it for their programs.
- We have taken advantage of this infatuation to develop research training in our small group that continues to grow up and diversify. So much is that Morocco holds now a prominent place in the region (Africa and Middle East) in terms of scientific publications related to astronomy and astrophysics.
- Moreover, thanks to Oukaimeden observatory success story, we can clearly state that we still need to invest in small ground observatories, especially for the sites located in the third world regions.
- Besides their undeniable scientific importance as a relay and complements of big terrestrial and space projects, the role on the training through research and outreach must be considered and encouraged.