Realtime ground measurement of atmospheric parameters critical to Free Space Optical communication

35th Space Symposium
Tech Track

8 April 2019
Colorado Springs, CO

Miratlas

Metering the Sky

Statement and Facts

To provide continuous monitoring of the sky and atmospheric conditions from a network of ground based passive optical sensors

- Incorporation May 2018
- Design and manufacturing in France

Frederic Jabet, Président, founder, fjabet@miratlas.com

Former telecom market consultant and CTO at Alcatel Lucent, founder & CEO of Airylab, astronomical instrument manufacturering.

Jean-Edouard Communal, founder, jecommunal@miratlas.com

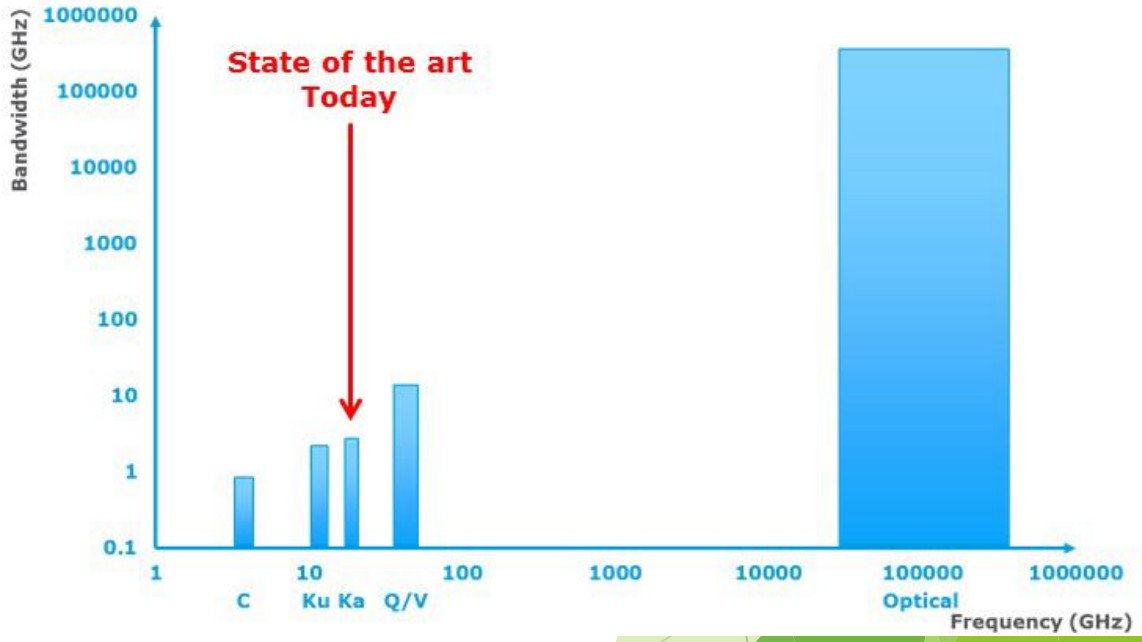
Director Strategy & Business Development, Ph.D in laser physics for telecommunications and 15 years' experience as a sales manager in photonics for research and industrial applications.

Karine Chevalier, Ph.D, founder, kchevalier@Miratlas.com

Data machine learning

FSO Satcom: Advantages

- **Fast**, over 100Gbps per wavelength, broad spectrum
- **Unregulated**, no licence needed,
- **Secure**, very narrow beam, line of sight, quantum key distribution
- **Reduced SWaP** for onboard and ground terminals.



Source: ESA Scylight

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FSO Satcom: Weaknesses

Challenges inherent to the transmission of laser light through the atmosphere:

- Cloud cover
- Turbulence
- Absorption

Survey of local atmospherics conditions in real time is critical.

CCSDS Members Agencies

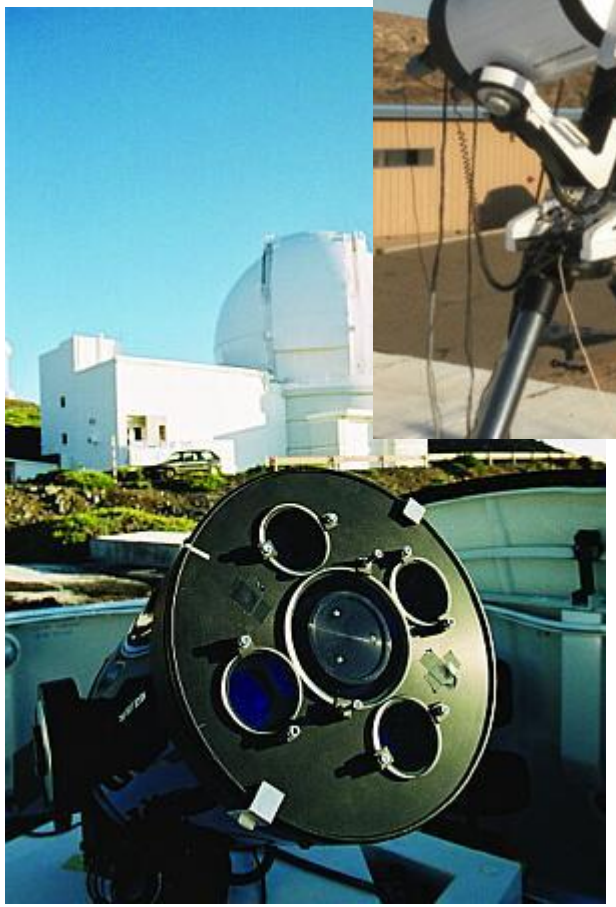
- Agenzia Spaziale Italiana (ASI)/Italy.
- Canadian Space Agency (CSA)/Canada.
- Centre National d'Etudes Spatiales (CNES)/France.
- China National Space Administration (CNSA)/People's Republic of China.
- Deutsches Zentrum für Luft- und Raumfahrt (DLR)/Germany.
- European Space Agency (ESA)/Europe.
- Federal Space Agency (FSA)/Russian Federation.
- Instituto Nacional de Pesquisas Espaciais (INPE)/Brazil.
- Japan Aerospace Exploration Agency (JAXA)/Japan.
- National Aeronautics and Space Administration (NASA)/USA.
- UK Space Agency/United Kingdom.

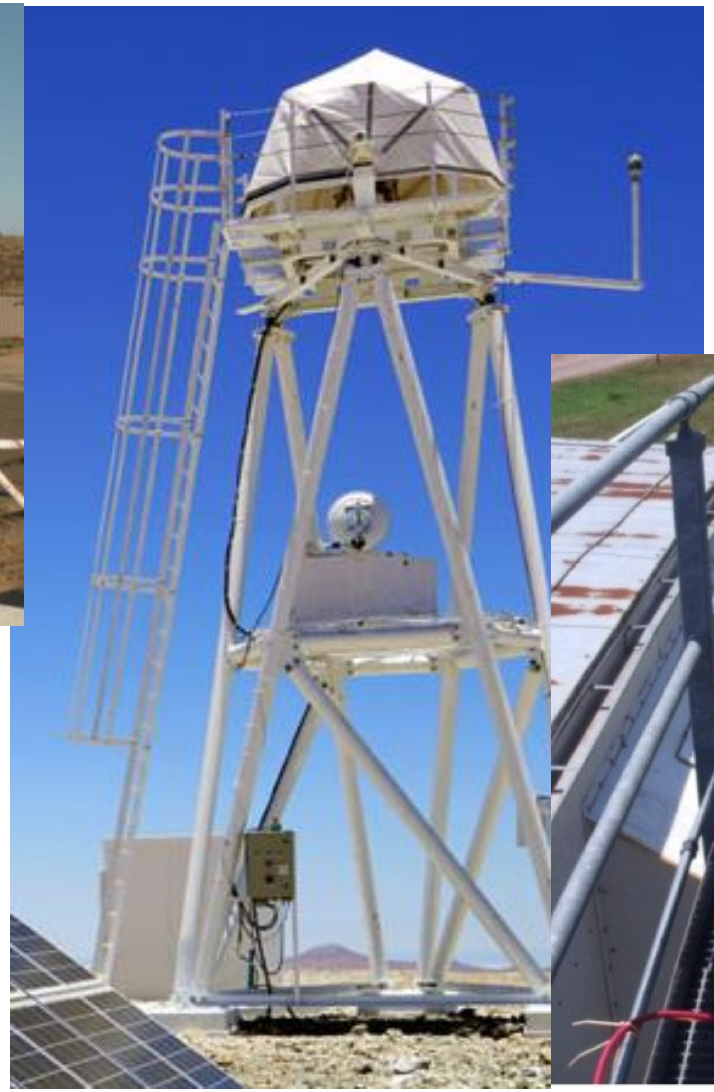
Atmospheric parameters & instruments

Quantity	Characteristics	Instrument
Clouds	Coverage Base height Attenuation	Whole sky imager Ceilometer
Optical Turbulence	Fried parameter Isoplanatic angle	**DIMM, night**
Aerosols	Aerosol attenuation Sky radiance	Sun Photometer
Standard Meteorological Quantities	Temperature Wind Pressure Relative Humidity	Thermometer Anemometer Barometer Hygrometer

Source: CCSDS 140.1-G-1

Current instruments:





All sky cameras

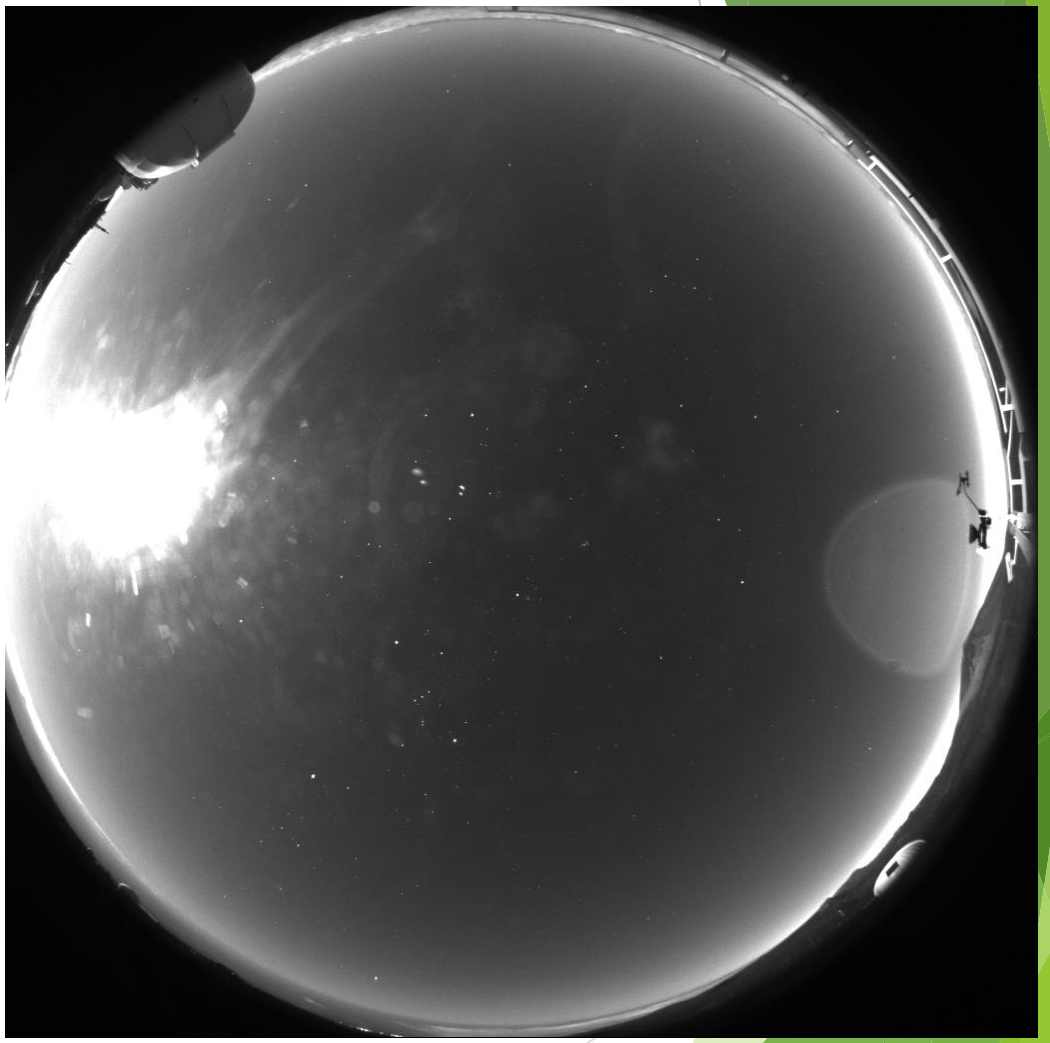
Visible, 380-1000nm

- 2048x2048, 180°FOV, 60Hz, black & white
- Magnitude 6-7

LWIR, 8-14µm

- 640x480, 180° FOV, 30Hz,
- -40°to +120°C range
- Radiometric calibration 2°K or 2%
- upgradable to 1280x960

SWIR compatible, 800-1700nm



Night Seeing Monitor

The NSM analyses star position jitter with subpixel precision.

- High-speed CMOS, 100-800Hz with RoI using 500-580nm filter by default
- Designed to keep the Polaris in the RoI without mechanical tracking
- Compute the star image barycenter with a sub pixel precision

Every 20 to 60 seconds, the RMS motion of the star is used to calculate:

- Stellar seeing in ArcSec
- Fried parameter r0
- Stellar scintillation
- Atmospheric transmission

3 years qualification with the LAM in Observatoire de Haute Provence to qualify the system for a long period of time through all seasons and conditions against 60cm Ritchey Chretien telescope.

Sun Seeing Monitor

The SSM measures the solar light scintillation at very high frequency using a single high signal to noise photodiode.

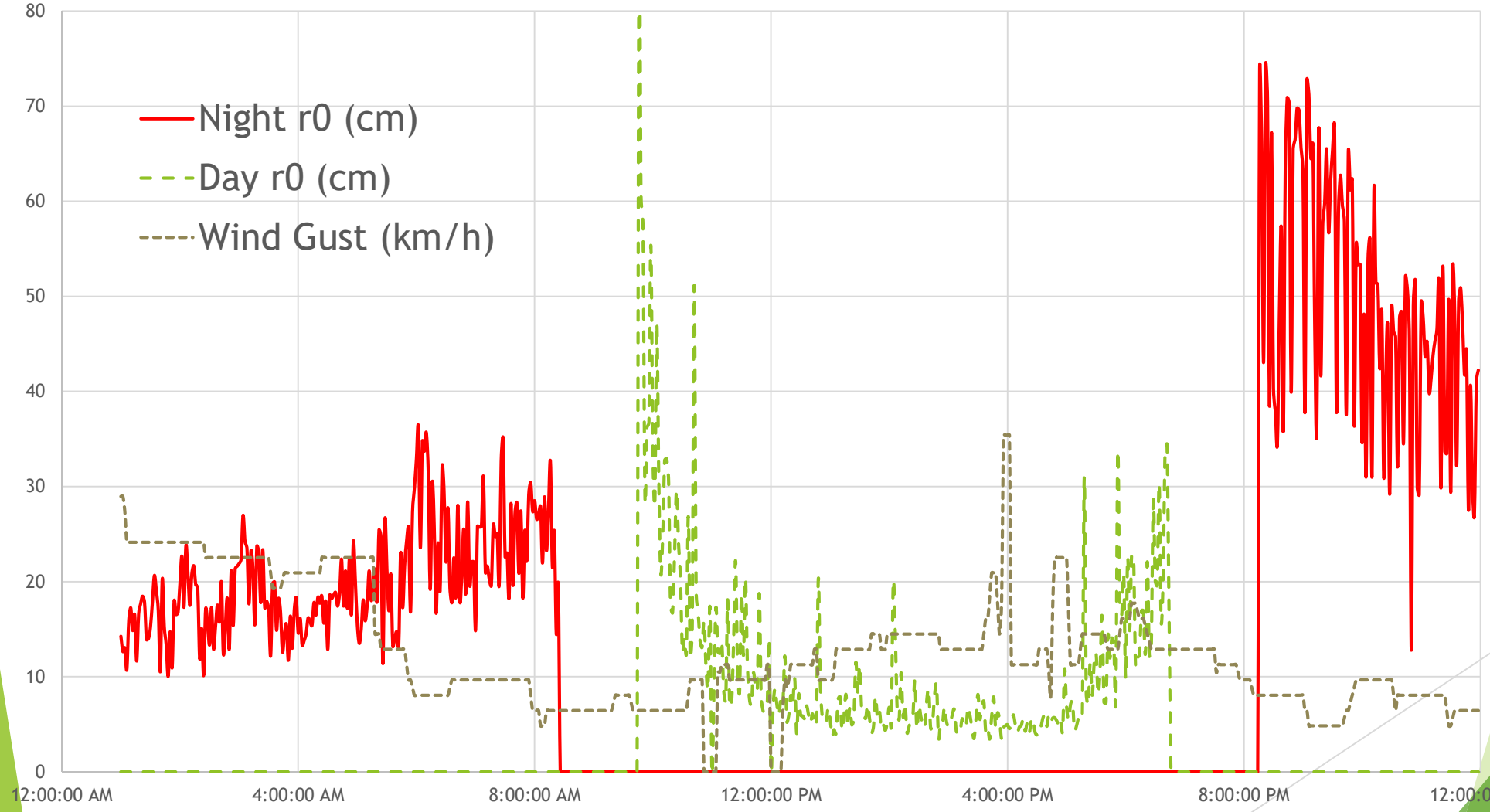
- Scintillation from an extended object, such as the Sun ~0.01rad, is mainly caused by the lower layers of the atmosphere because turbulences are averaged over an area which increases with altitude.
- Daytime turbulence are dominated by low layer effects.

Tested and developed at the NASA JPL/Caltech requests during 2017, it relies on the SHABAR (SHAdow Band Ranger) scintillator developments.

- Stellar seeing in ArcSec
- Fried parameter r0

The SSM has been used in professional observatories around the world, and its reading have been correlated with high resolution solar images (up to 40cm apertures).

Night and day r0 and wind data over 24h



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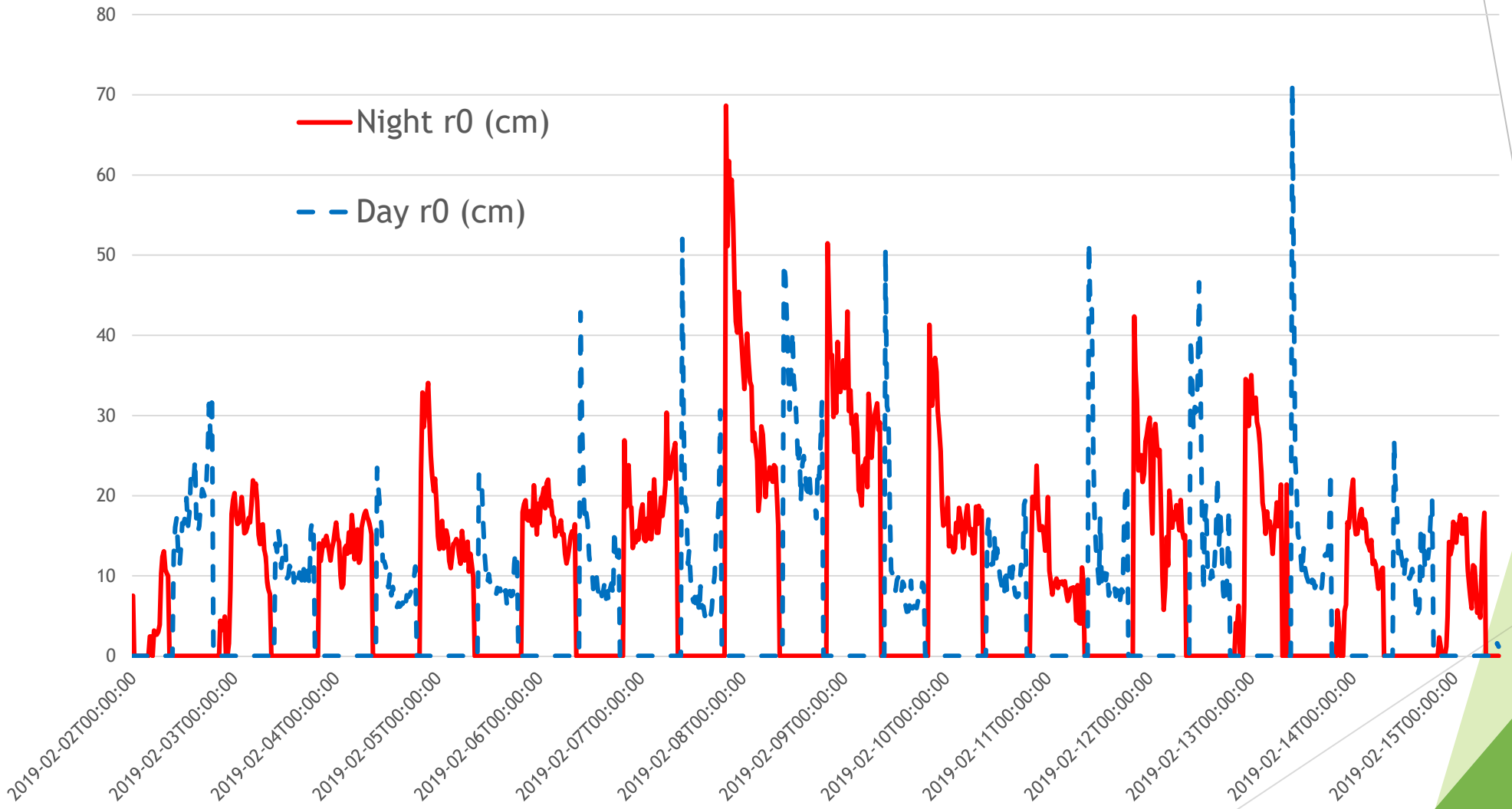
Night and day r0 over two weeks



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All in one: Integrated Sky Monitor




- **ISM main unit**: *all sky camera, day time seeing monitor, LWIR sensors and CPU. 15x17x17cm, 5kg, <40W*

  Intel iCore, Linux, partially open source, over 80% CPU available for data processing.
- **Night Seeing Monitor**: *pointing polaris. 32x16cm, 2.5Kg, <300mW in PoE*
- **All Sky Thermal camera**: *-40°c to +120°C, 24/7 Cloud cover mapping*
- **Weather Station**

Measurements provided by the ISM

Quantity	Data	Unit	Availability
Clouds	Allsky visible	ADU	Always
	Allsky thermal	°C	
Optical Turbulence	Seeing night	ArcSec	Night
	Night r0	cm	
	Scintillation	ADU	
	Transparency	ADU	
	Seeing day	ArcSec	**Day**
	Day r0	cm	
Aerosols	Pyrgeometer	Wm^{-2}	Always
	Sky Temp	°C	Always
	Total Water Column	Cm	Clear Day
	Irradiance	$Mag/ArcSec^2$	Day
Standard Meteorological Quantities	Ext Temp	°C	Always
	Pressure	hPa	
	Humidity	%	
	Wind	ms^{-1}	
	Rain/Rain rate	mm	

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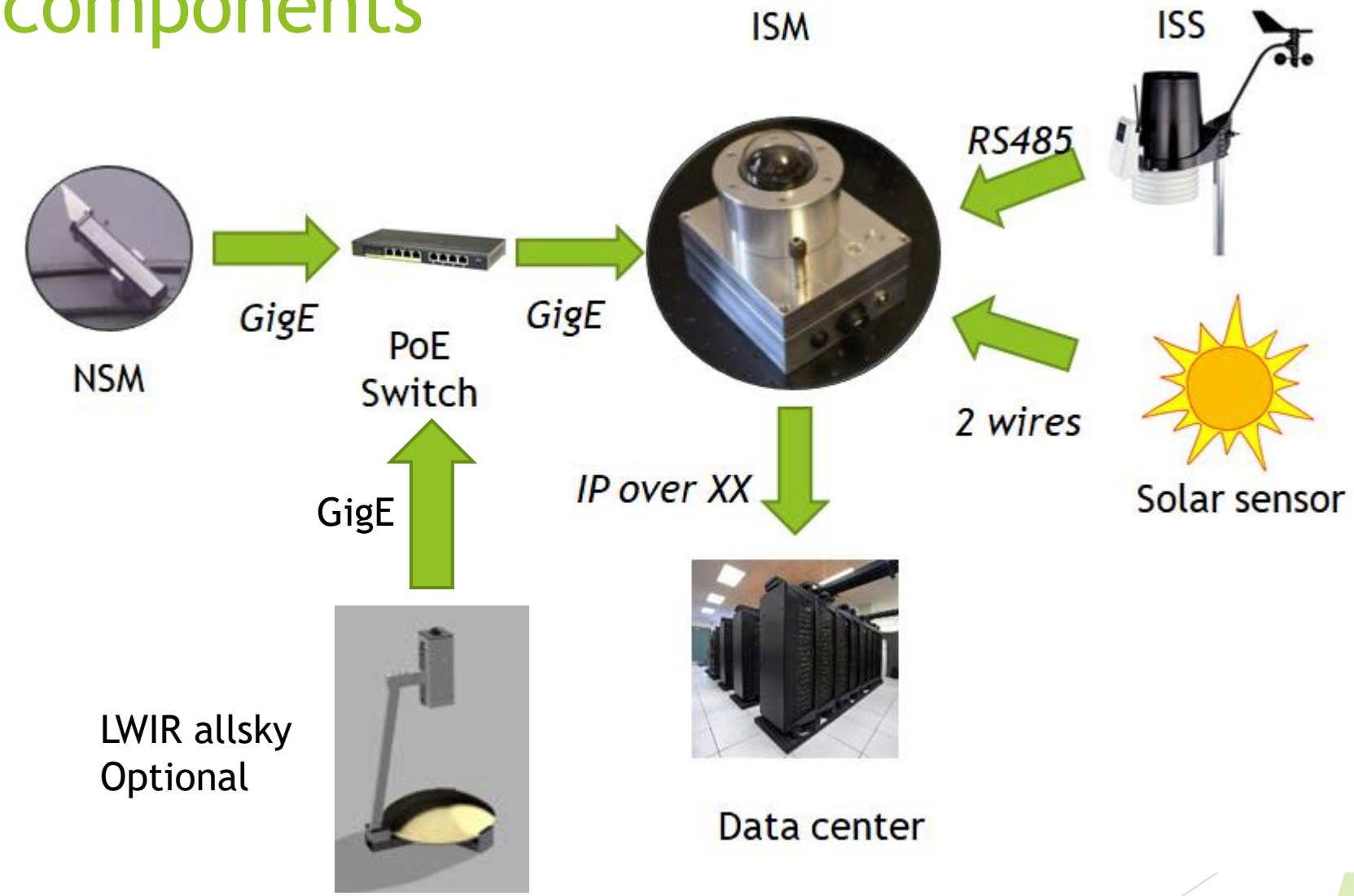
ISM components



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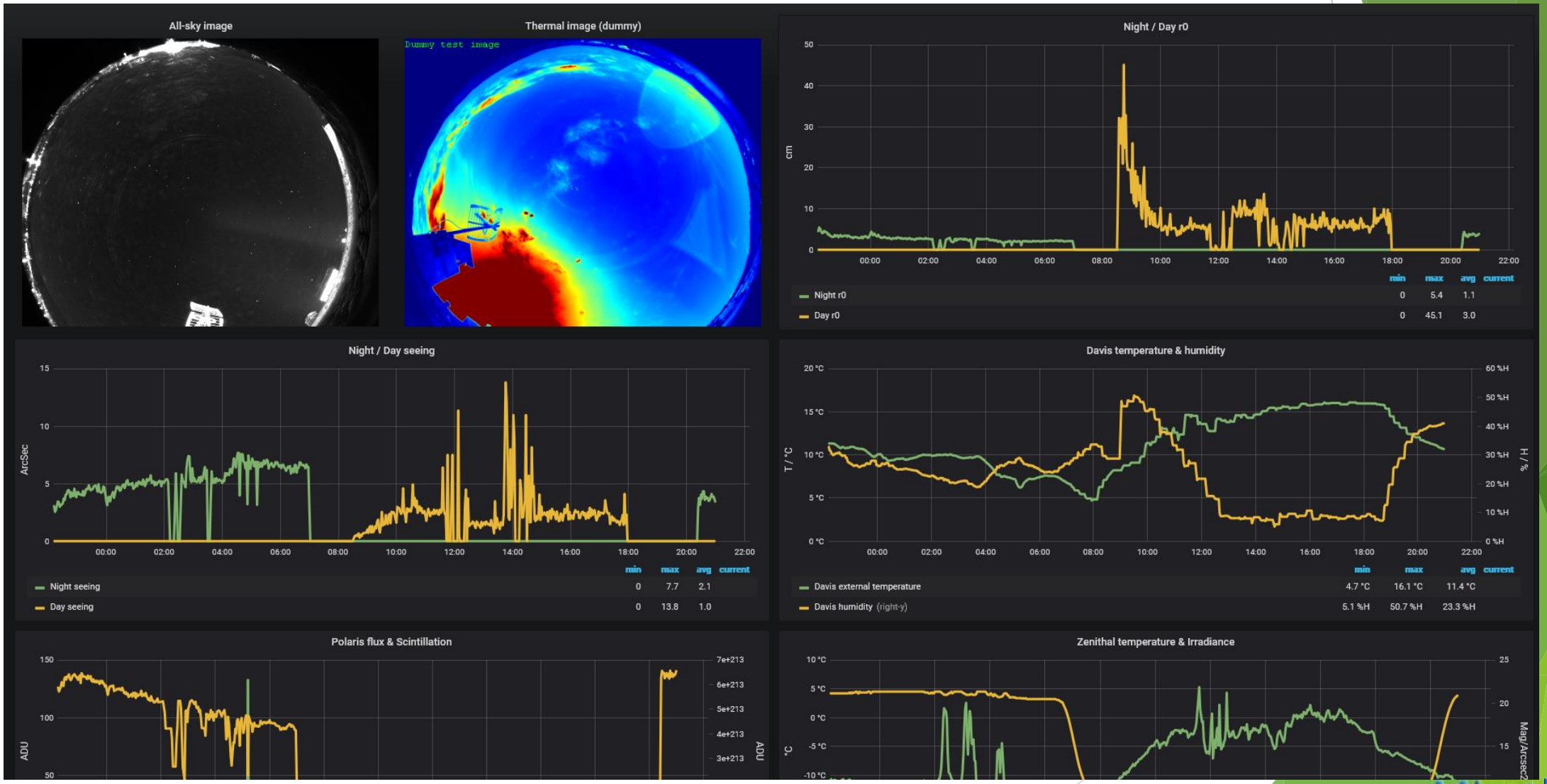
https://dashboard.miratlas.com



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Conclusion

The Integrated Sky Monitor provides:

- All atmospheric metrics for FSO satcom,
- Real time 24/7 data including seeing,
- Turn key solution including dashboard of database
- Partially open source for custom data processing.
- Minimal red tape,
- Overnight installation.

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