



Toward a Moroccan Optical and Radio Observatory

for Time-Domain and Multi-Messenger Astronomy

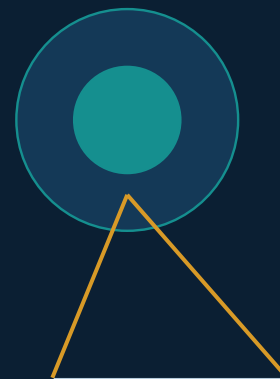
A platform-building pathway from regional reconnaissance to international follow-up capability

Kavli-IAU Global Coordination Workshop (GCW) 22-26 June 2026 in
Görlitz, Germany

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June 2026 • Online contribution

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A strategic gap — and a concrete opportunity

Time-domain and multi-messenger astronomy depends on geographically distributed, operationally reliable nodes — not only on flagship facilities.

GLOBAL NEED

International follow-up requires:

- longitudinal and geographic complementarity
- rapid optical / radio response capacity
- trained local teams, resilient operations, and open coordination

MOROCCAN OPPORTUNITY

A future North-African optical/radio node

- **Existing foundation**
A longstanding national astronomy base at Oukaimeden
- **Promising terrain**
Mountain plateaus around 3,000–3,200 m in Beni Mellal–Khenifra
- **Platform vision**
Optical + radio capability, research training, regional outreach

~3,200 m

High-altitude finalist plateau elevation

Optical + radio

Dual-domain design from the outset

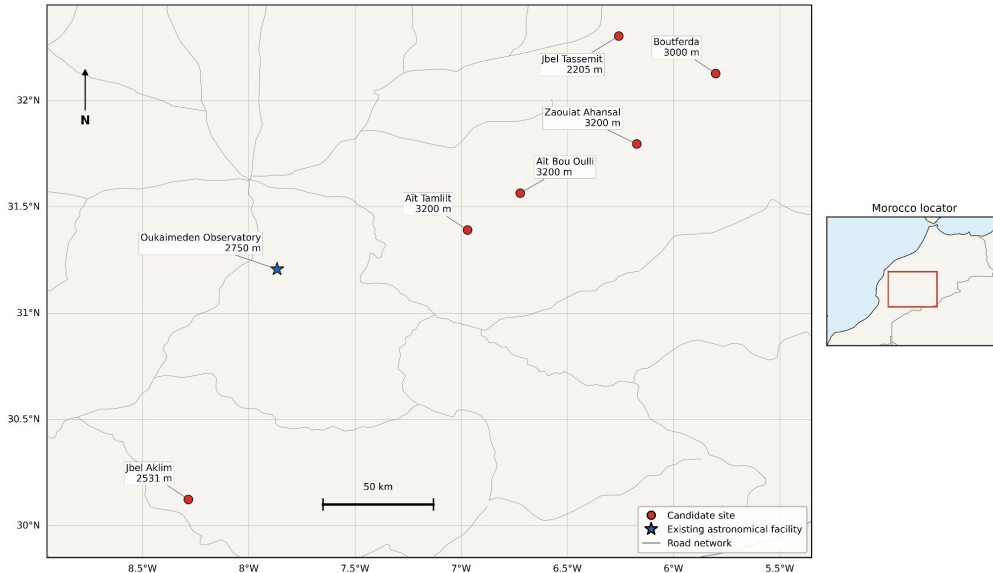
North Africa

New capacity for global coordination

From candidate terrain to an observatory platform

The project is being anchored simultaneously in science, territory, administration, and training.

Candidate sites and existing astronomical infrastructure in the Béni Mellal-Khénifra region



Six candidate sites • three $\approx 3,200$ m finalists

Ait Tamllit, Ait Bou Oulli, Zaouiat Ahansal

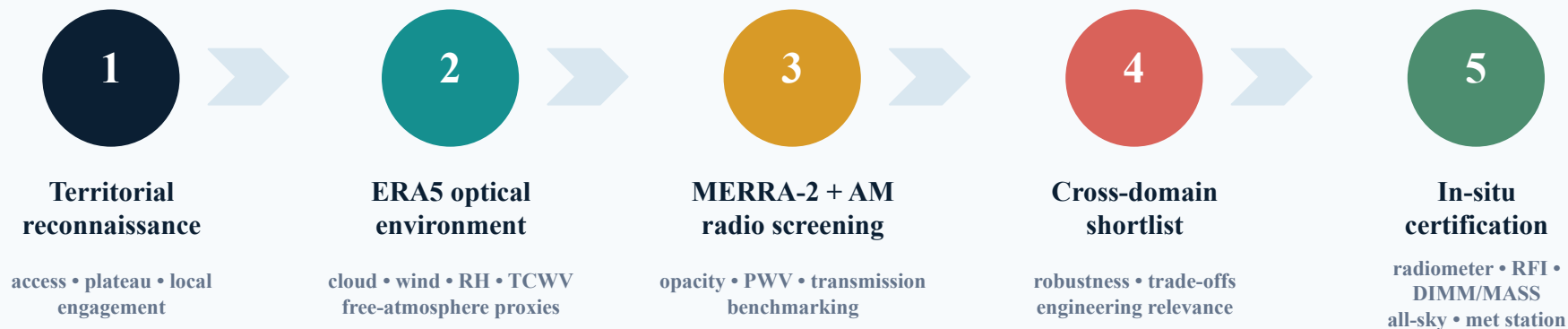
Work already underway

- Agreements and engagement with regional actors, including education, development, tourism and Geopark stakeholders.
- Official outreach to local authorities to enable exploration, qualification instruments, and a future land pathway.
- Field reconnaissance with regional representatives: broad plateaus, practical access, and potential electrical connection.

Project candidate-site mapping and field reconnaissance. Exact final location remains subject to on-site qualification and administrative authorization.

A staged prequalification workflow

Two complementary reanalysis workflows prioritise sites before any final field campaign.



Interpretation rule ERA5 and MERRA-2/AM provide screening and prioritisation indicators. They do not replace in-situ optical, atmospheric, meteorological, or RFI qualification.

2016–2025

Ten-year atmospheric screening window

6 + 3

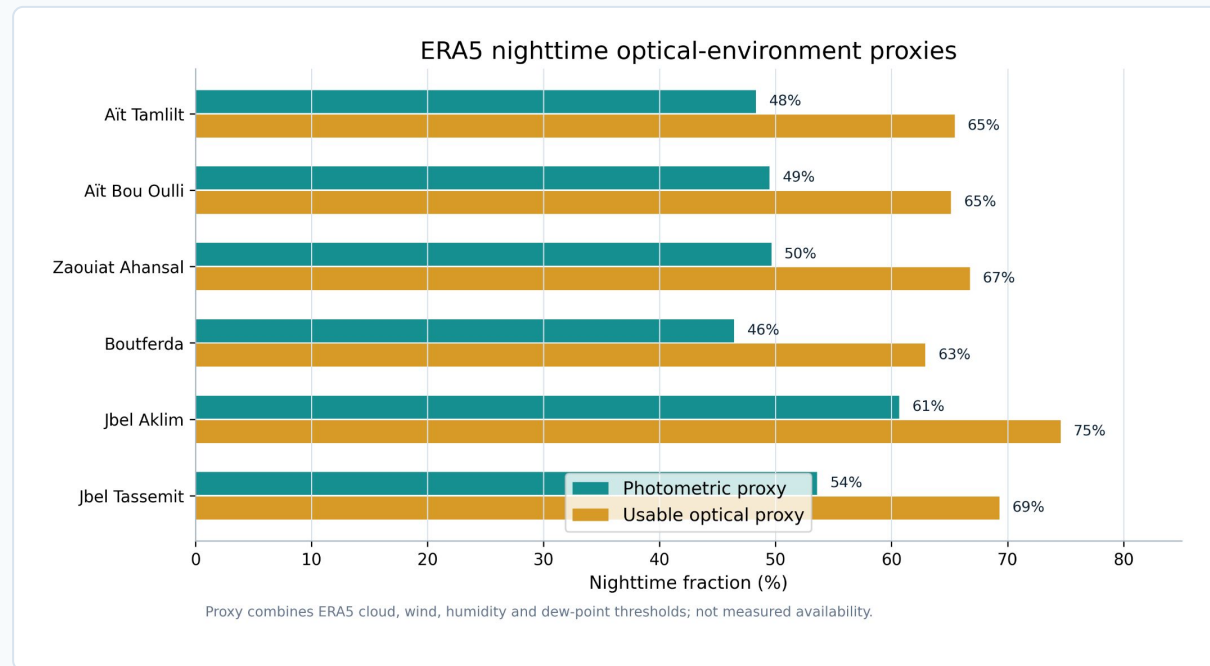
Moroccan candidates + historical radio benchmarks

No final site yet

Prequalification precedes certification

Optical-environment screening: first encouraging indicators

Nighttime cloud, wind, humidity and dew-point thresholds were combined into conservative operational proxies.

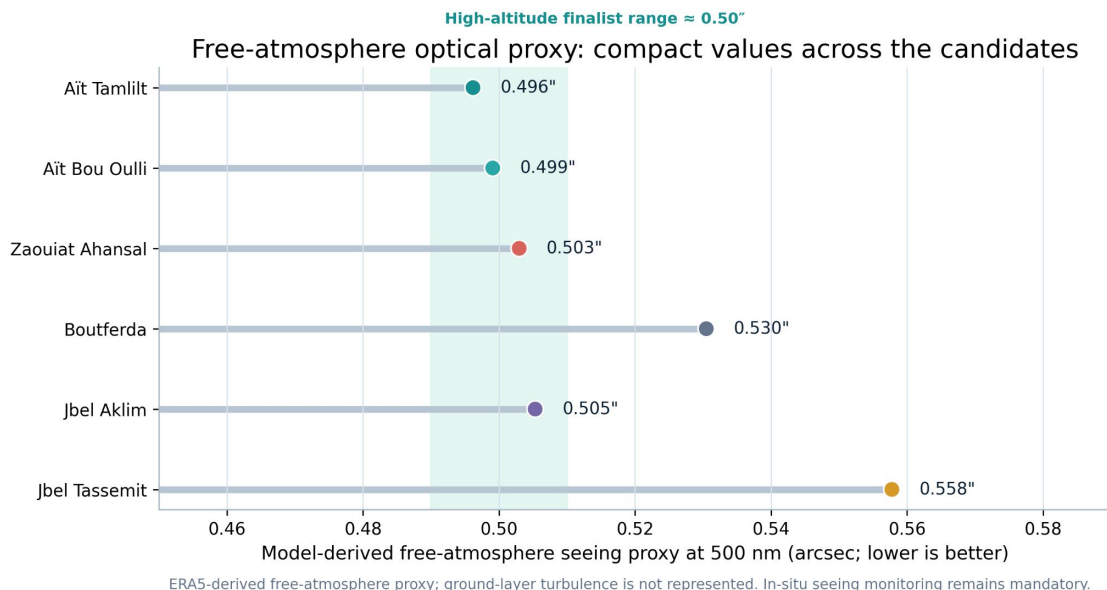


Read the result carefully

- The high-altitude trio has photometric proxies near 48–50% and usable proxies near 65–67%. Aklm is optically attractive in the
- ERA5 proxies, but the dual-domain shortlist must also account for radio atmosphere and altitude.
- These are model-based environmental proxies, not telescope duty-cycle measurements.

Free-atmosphere optical proxy: promising, but not a seeing certificate

Pressure-layer diagnostics yield a first model-derived free-atmosphere proxy; ground-layer turbulence remains unmeasured.



$\approx 0.50''$

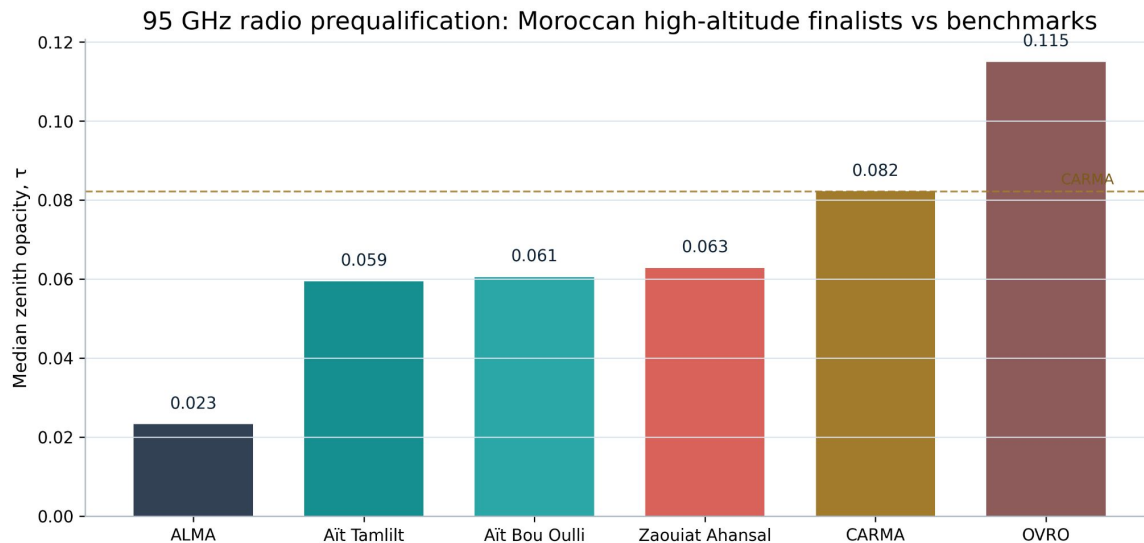
model-derived free-atmosphere seeing proxy
for the high-altitude trio

Scientific interpretation

- The result supports targeted field testing; it does not quantify total site seeing.
- DIMM/MASS or equivalent monitoring is necessary to resolve ground-layer and free-atmosphere contributions.
- The future optical program should also include sky brightness, all-sky imaging, and local meteorology.

Radio prequalification: a stable high-altitude finalist group

At 95 GHz, the three high-altitude Moroccan finalists are modelled to be more transparent than CARMA and OVRO, while ALMA remains the gold-standard benchmark.



MERRA-2 profiles + AM model; 2016–2025. Screening result—not a site certification.

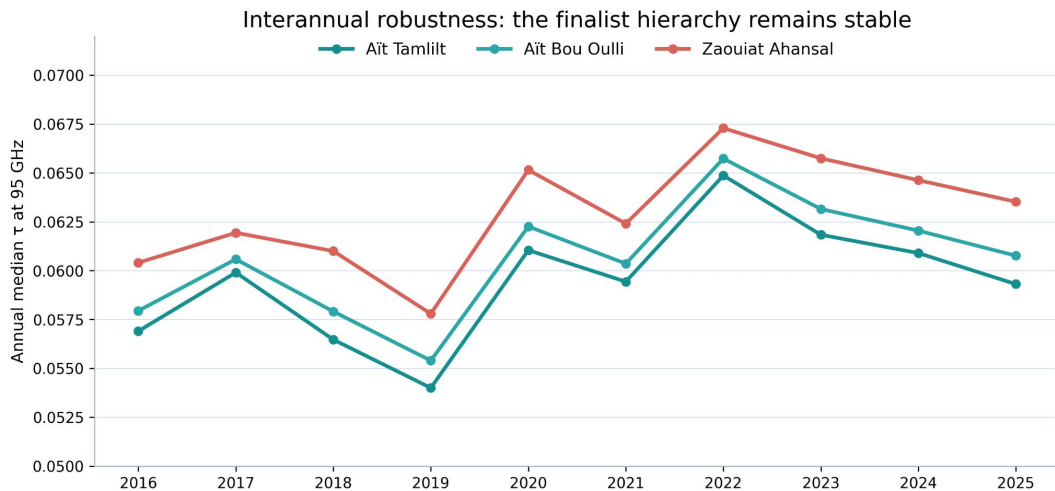
95 GHz finalists

$$\tau \approx 0.059\text{--}0.063$$

What this does — and does not — mean

- The result supports a targeted SZA-class feasibility phase around 95 GHz.
- The comparison is atmospheric modelling, not an operational performance guarantee.
- RFI, on-site radiometry, engineering, and logistics remain mandatory for final qualification.

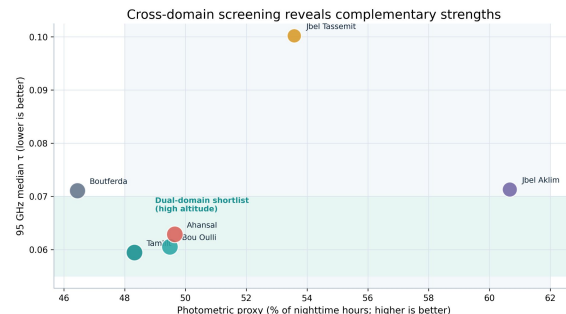
Robustness and cross-domain perspective



Across 2016–2025, the ordering remains Tamlilt → Bou Oulli → Ahansal. Values reflect modelled MERRA-2/AM screening.

10-year consistency

Tamlilt → Bou Oulli → Ahansal
across the 95 GHz annual medians



Descriptive cross-domain view; it is not a composite rank or site-certification result.

Cross-domain view: no composite score; a practical trade-off space.

The possible SZA relocation is a catalyst — not the endpoint

A first major radio instrument can accelerate the transition from screening to operational capability, while the broader observatory remains the long-term objective.



Working assumption: SZA is a promising first deployment opportunity, subject to technical, legal, financial, and site-qualification decisions.

From reanalysis to certified infrastructure

The remaining work is well defined — and requires instruments, engineering, administration, and external expertise.

1. In-situ atmosphere

- 22–24 GHz radiometer / PWV monitoring
- RFI survey
- weather station and logging

2. Optical certification

- all-sky camera and sky brightness
- DIMM/MASS or equivalent
- nightly cloud / seeing statistics

3. Engineering readiness

- electrical sizing and backup power
- civil works, shelter and access
- remote monitoring and data link

4. Governance & operations

- authorizations and land pathway
- site protection and local interface
- follow-up and data coordination model

Immediate collaboration ask Funding for a 22–24 GHz radiometer and RFI equipment — or expertise to develop suitable monitoring capability locally — together with optical site-testing and engineering partners.

Research, publications, and training are part of the infrastructure

The observatory is conceived as a long-term academic platform, not as a one-off installation.

PUBLICATION PATHWAY

- 1 Radio prequalification**
MERRA-2 + AM benchmarking and robustness
- 2 Optical prequalification**
ERA5 cloud, free-atmosphere and operational proxies
- 3 In-situ validation**
Radiometry, RFI, weather, cloud and seeing measurements
- 4 Science and operations**
SZA / optical science cases; follow-up workflows and data policy

PEOPLE AND CAPACITY

Proposed PhD themes

- Definitive optical / radio site qualification
- Atmospheric monitoring, radiometry, RFI, and instrumentation
- SZA and optical time-domain science cases
- Data systems, follow-up strategy, and operations

Engineering and Master's pathways will be aligned with this development to train future researchers and technical staff.

From model screening to a durable North-African node

What we need next is expertise, instruments, training, and partnership — to move from promising evidence to measured certification and deployable capability.

Scientific expertise

site testing • atmosphere •
astronomy and astrophysics •
time-domain science cases

Instrumentation & engineering

radiometer / RFI • optical
monitoring • power / civil design
• remote operations

Funding & training pathways

exploration instruments • student
exchanges • PhD co-supervision
• long-term partnerships

For further information or to explore collaboration:

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Thank you.

Appendix — data and interpretation boundaries

Radio workflow

- MERRA-2 atmospheric profiles processed with the AM radiative-transfer model.
- 2016–2025; 3-hour records; 29,224 samples per site and frequency in the radio dataset.
- Benchmarking against ALMA, CARMA, and OVRO.

Optical-environment workflow

- ERA5 single levels: cloud cover, wind, temperature, dew point, relative humidity, TCWV.
- ERA5 pressure levels: free-atmosphere humidity, wind, stability, shear, model-derived optical proxies.
- Optical proxies are labelled as model-derived; they do not replace DIMM/MASS, all-sky, sky-brightness, or local meteorology.

Bottom line

All reanalysis results are screening and prioritisation evidence. The final site and instrument feasibility decision must rest on in-situ measurements, RFI, engineering studies, authorizations, and land access.

Appendix — compact candidate comparison

Site	Altitude (m)	Photometric proxy	FA seeing proxy	τ_{95}
Aït Tamlilt	3200	48%	0.496"	0.059
Aït Bou Oulli	3200	49%	0.499"	0.061
Zaouiat Ahansal	3200	50%	0.503"	0.063
Boutferda	3000	46%	0.530"	0.071
Jbel Aklim	2531	61%	0.505"	0.071
Jbel Tassemmit	2205	54%	0.558"	0.100

The high-altitude trio is the strongest dual-domain starting point; Aklim remains an optically attractive comparison site. No final decision is made from this table alone.