FACING THE CHALLENGES OF OUR TIME

An Interpretable AI Framework for Clear-Sky Detection in Photovoltaics Monitoring

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Summary

- Introduction of an interpretable AI framework for clear-sky detection (CSD) addressing the critical "black-box" problem in modern ML-based PV monitoring by integrating a SHAP-based diagnostic workflow.
- Final model achieves 97.3% accuracy with 1.99% FP rate, with reduced false alarms improving PLR calculation uncertainty.
- Identified error patterns used to develop real-time confidence metrics, allowing the system to flag ambiguous sky conditions where the CSD prediction may be less certain.

Context and Methods

- **Problem:** Clear-sky detection (CSD) often fails under haze or cloud enhancement, limiting PV data accuracy.
- **Solution:** use interpretable AI not as a "black box," but as a diagnostic tool to understand the physical reasons for model failure.

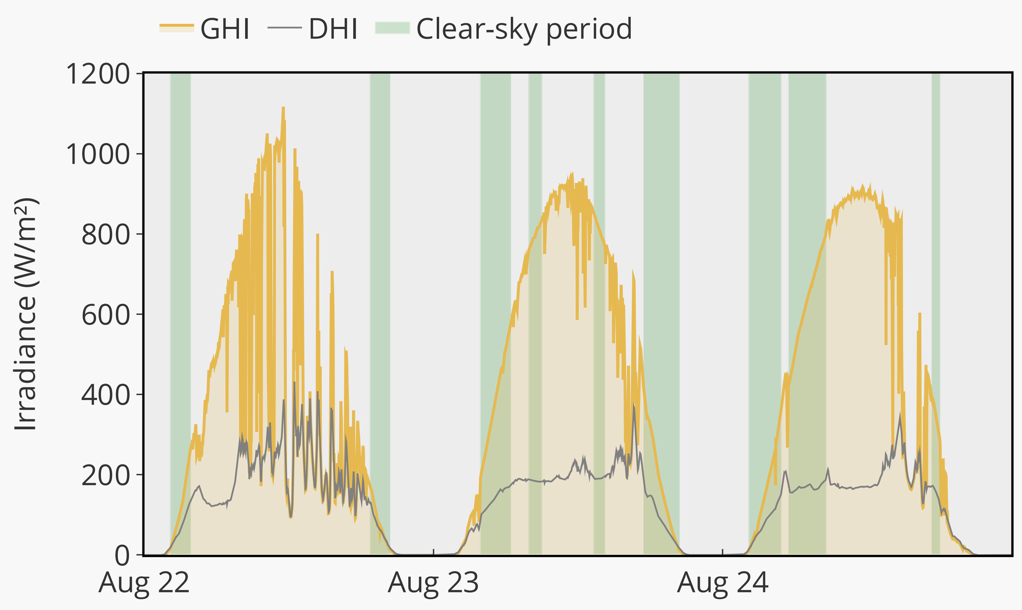

Fig. 1 | Example of Clear-Sky Detection (CSD).

Impact:
Enables a *diagnose – refine* cycle: trace errors to physical causes and apply targeted, physics-based fixes.

Labelled dataset from Jordan & Hansen (2023)

"Diagnose-and-Refine" Framework

Workflow: Diagnose physical root-cause of errors
Refine model with physics-based insights
iterative

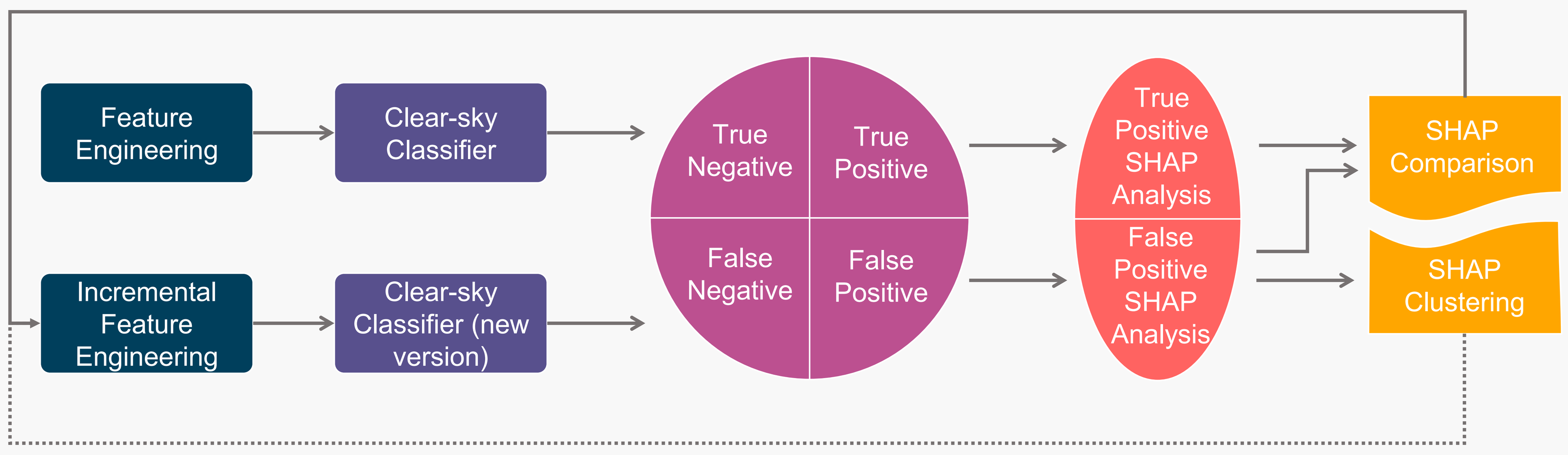

Fig. 2 | Interpretable CSD development framework
SHAP Comparison: Shows why the model failed by ranking feature impacts.
SHAP Clustering: Groups systematic error patterns for targeted fixes.

Interpretable AI for Deeper Insight

Using **Explainable AI (XAI)** to overcome the "black box" problem provides transparent insight into the model's decision-making.

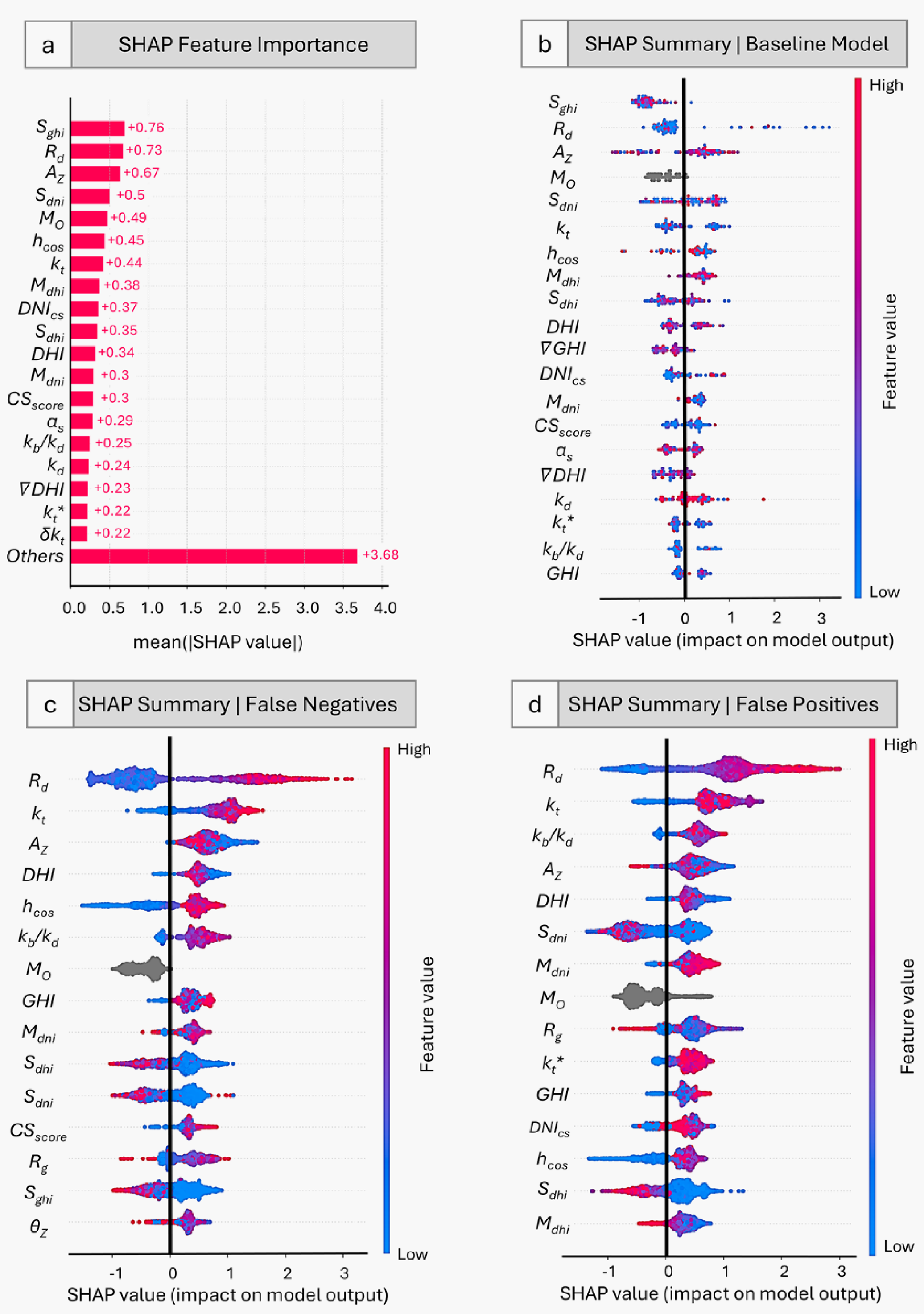

Fig. 3 | SHAP analysis: shows FPs stem from *cloud enhancement*, FNs from *haze*.

Pinpointing Failure Modes

Automatically categorise model errors, identifying **"cloud enhancement"** as the cause for >90% of false positives.

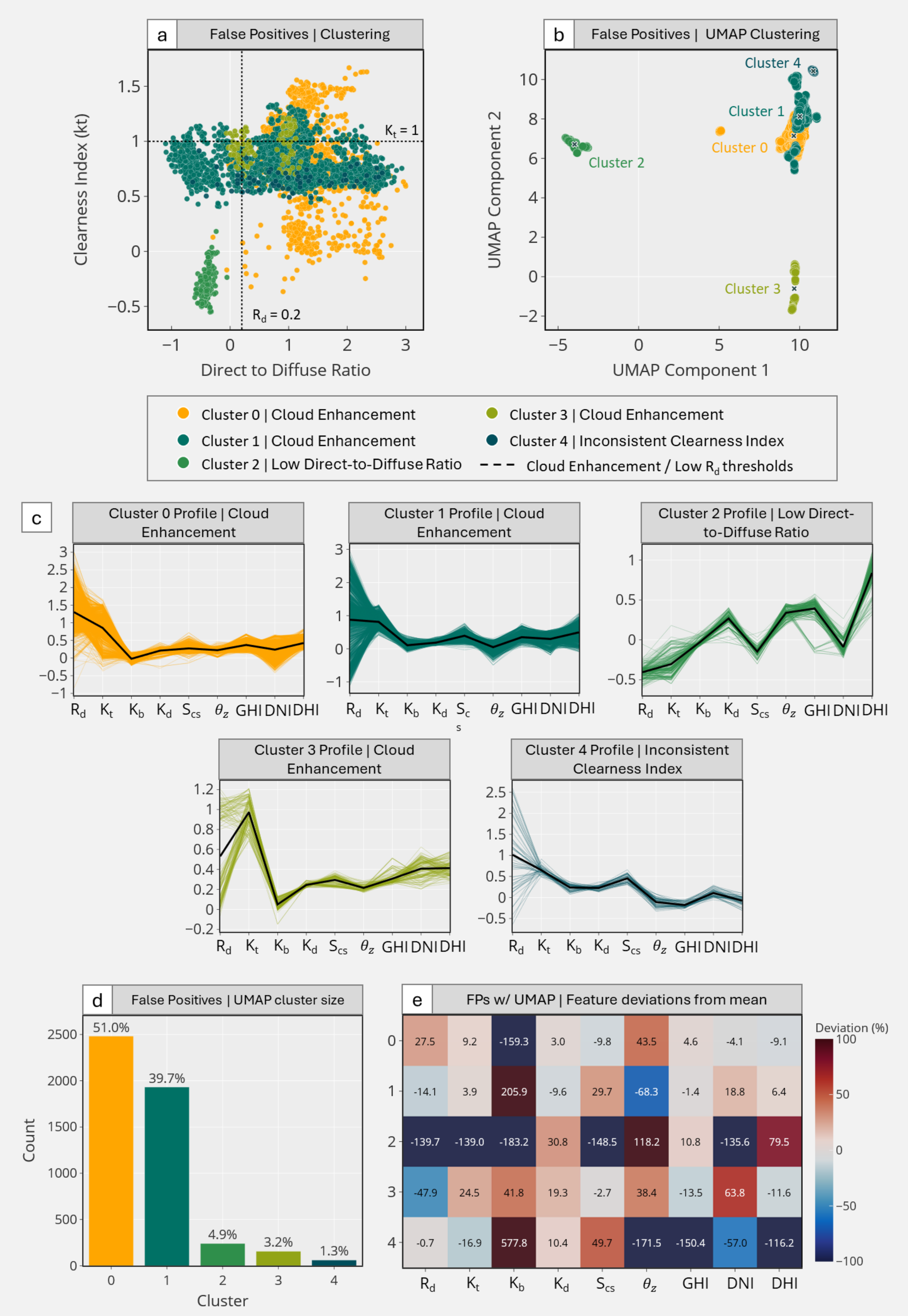

Fig. 4 | FP deep dive: clustering confirms *cloud enhancement* as main failure mode.

High-Impact Results & Application

Refined CSD model achieves **97.3%** accuracy, enabling more reliable fault diagnosis by significantly reducing false alarms.

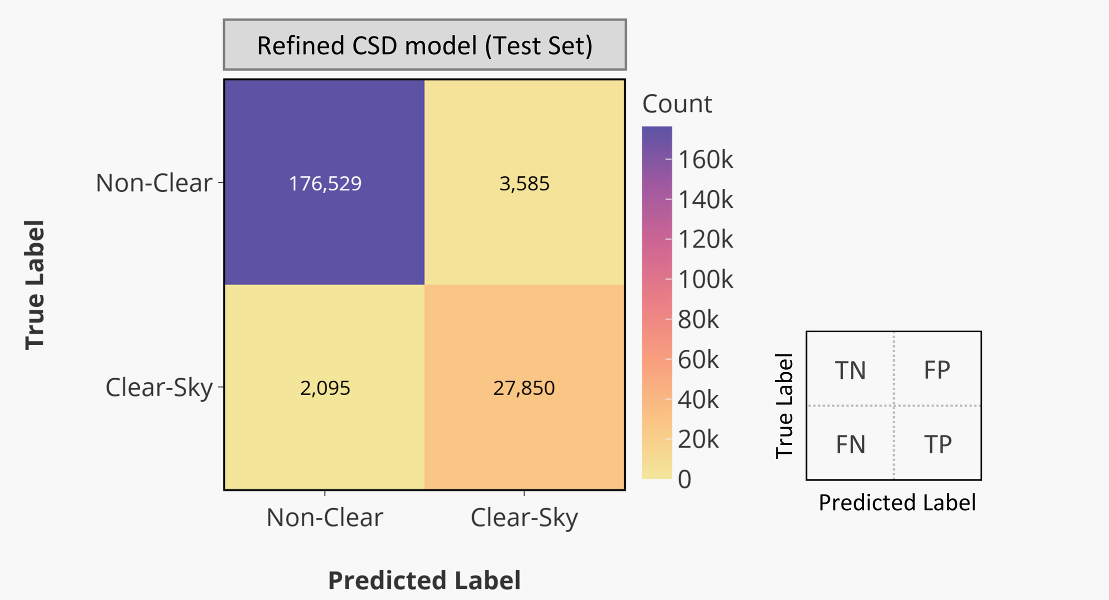

Fig. 5 | Confusion matrix: test performance of the refined CSD model.

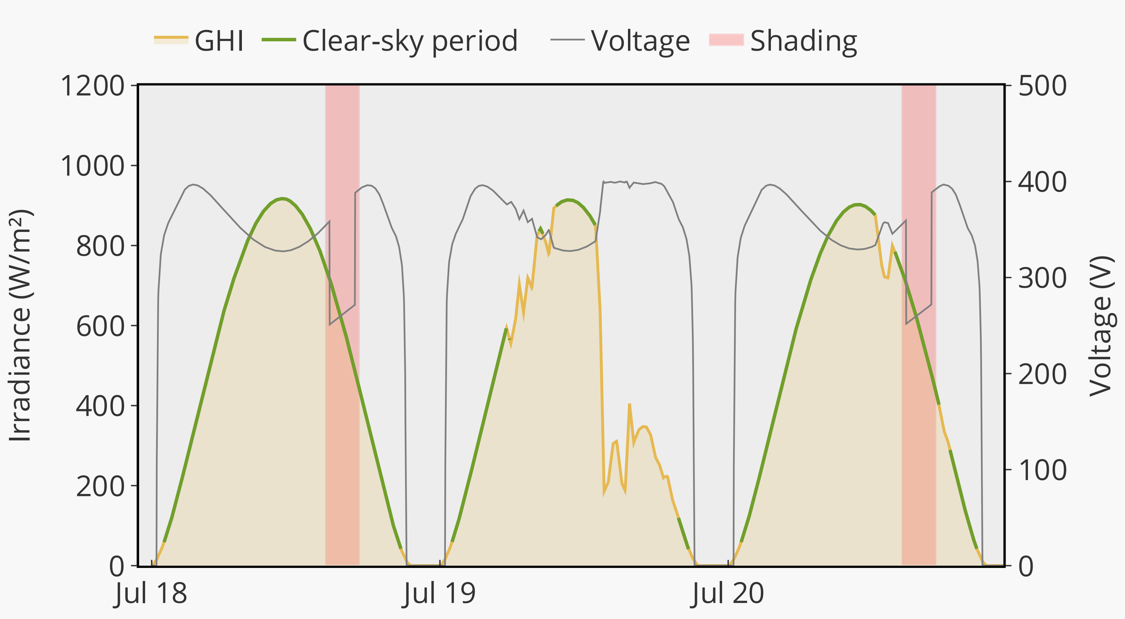

Fig. 6 | CSD for fault diagnosis: reveals voltage drops from bypass diode activation (shading).

Acknowledgements

ASSURed PV
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

References

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