



A holistic evaluation of remote sensing datasets used in lunar resource identification

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1. INTRODUCTION

- Four datasets used to indicate the presence of water-ice are compared and evaluated on a polar scale.
- By combining multiple datasets over extensive areas, we can understand how water-ice indications correlate with the presence of permanently shadowed regions (PSRs).

2. DATASETS

Instrument	Value measured	Orbiter	Type of dataset used
Diviner ¹	Bolometric temperature	LRO	Gridded
LOLA ¹	Reflectance	LRO	RDR
M ³ ¹	Albedo	Chandrayaan-1	RDR
Mini-RF ¹	Radar backscatter	LRO	Gridded

3. DATA PROCESSING

- Diviner was interpolated using maximum radial method to ensure highest temperatures were kept.
- All others were interpolated using inverse distance weighting.
- Once on a common grid, the points were labelled.

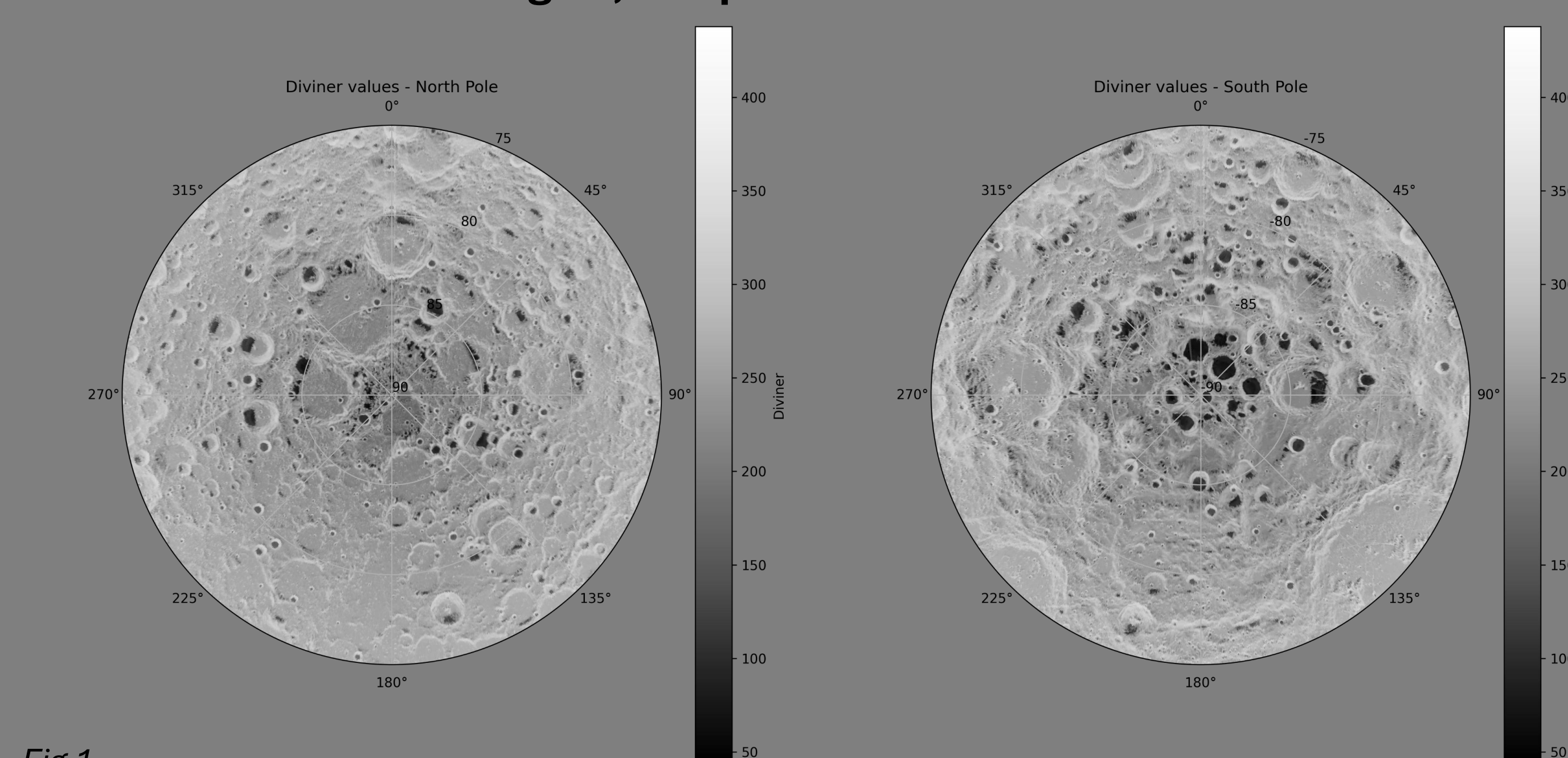


Fig 1 Interpolated Diviner data weighted to maximum temperature to identify cold traps.

4. LABELING

For every point, each dataset contributes a score of 0, 1 or 2 based on certain criteria².

K	Not consistent 0	Slightly consistent 1	Highly Consistent 2
Diviner criteria	T > 110K	n/a	T < 110K
LOLA Albedo criteria	Below $\mu + 2\sigma$	Above thresh, PSR area < 2.4km ²	Above thresh, PSR area > 2.4m ²
M3 criteria	Above $\mu - 2\sigma$	Below thresh, PSR area < 3m ²	Below thresh, PSR area > 3m ²
Mini-RF criteria	Below $\mu + 2\sigma$	Above $\mu + 2\sigma$	n/a

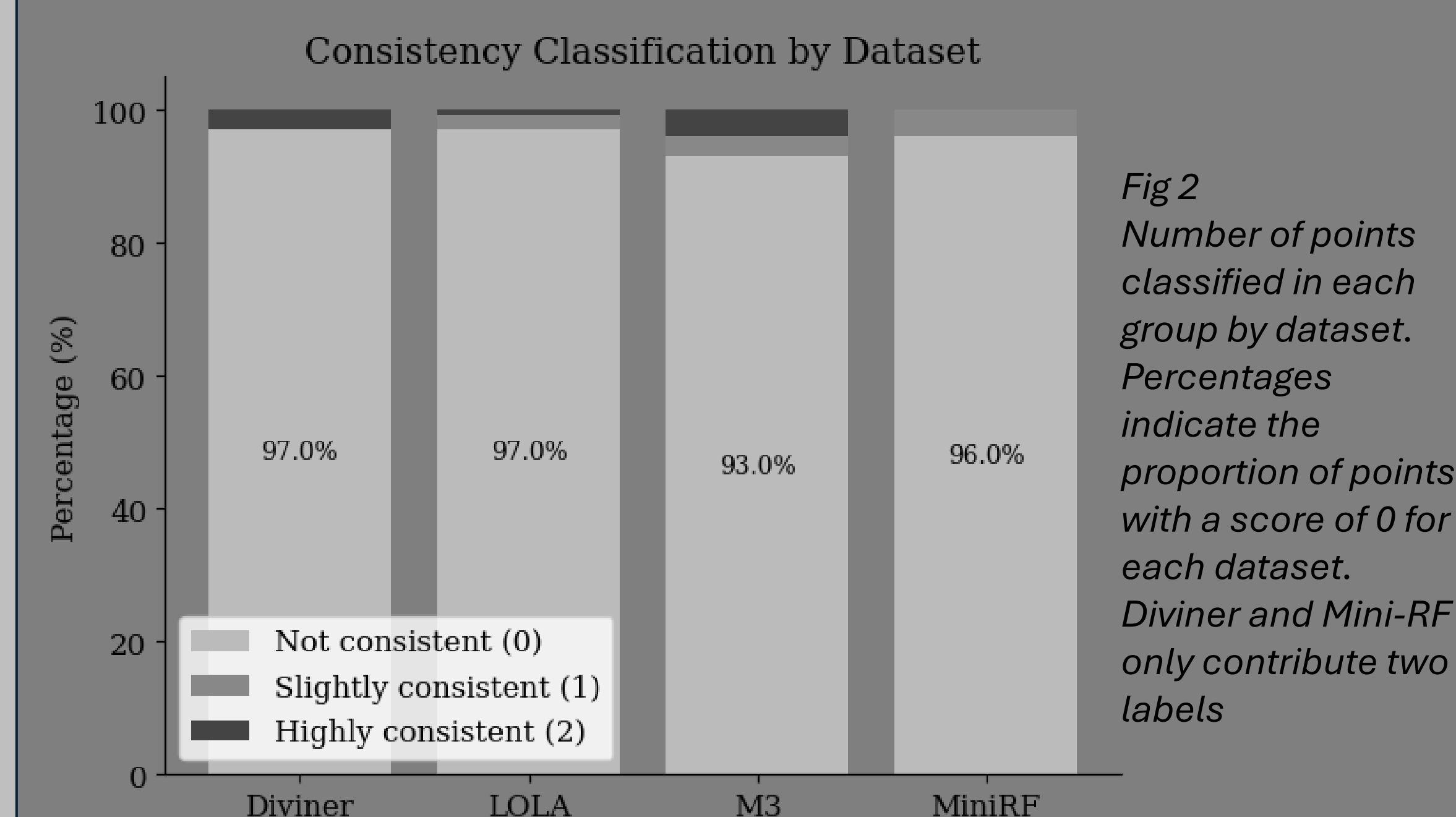


Fig 2 Number of points classified in each group by dataset. Percentages indicate the proportion of points with a score of 0 for each dataset. Diviner and Mini-RF only contribute two labels

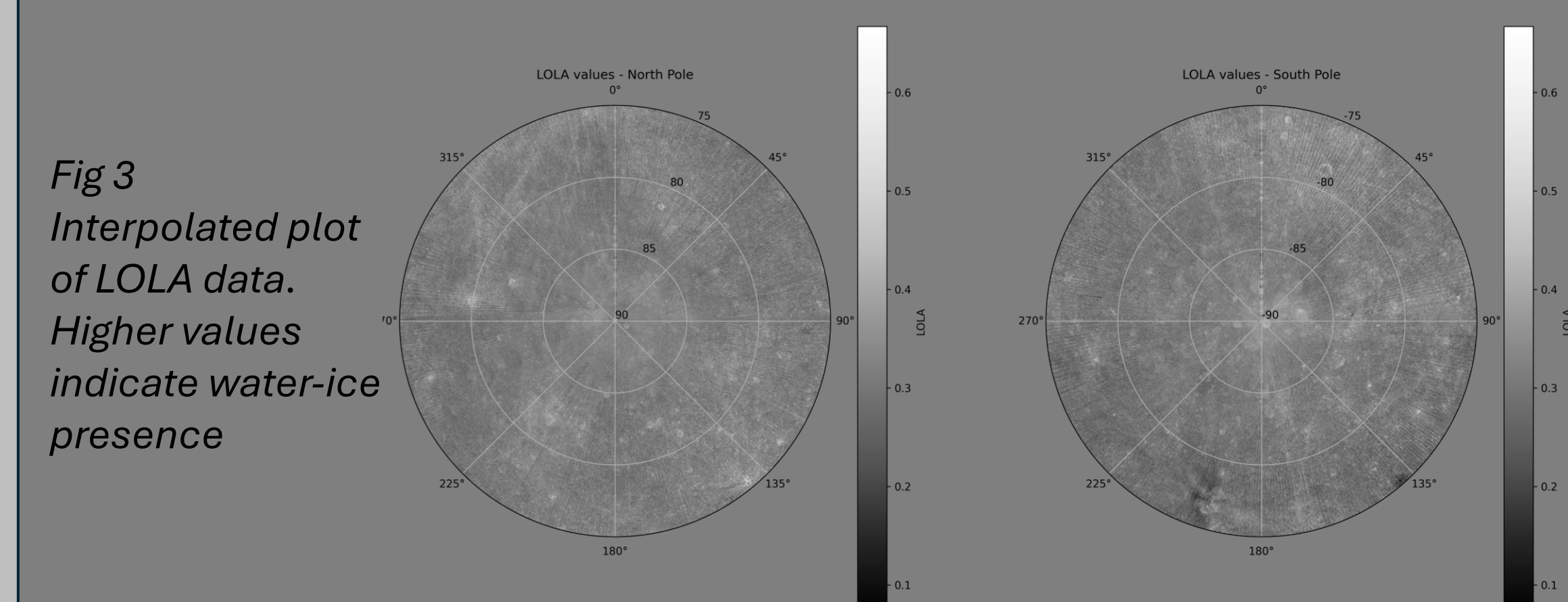


Fig 3 Interpolated plot of LOLA data. Higher values indicate water-ice presence

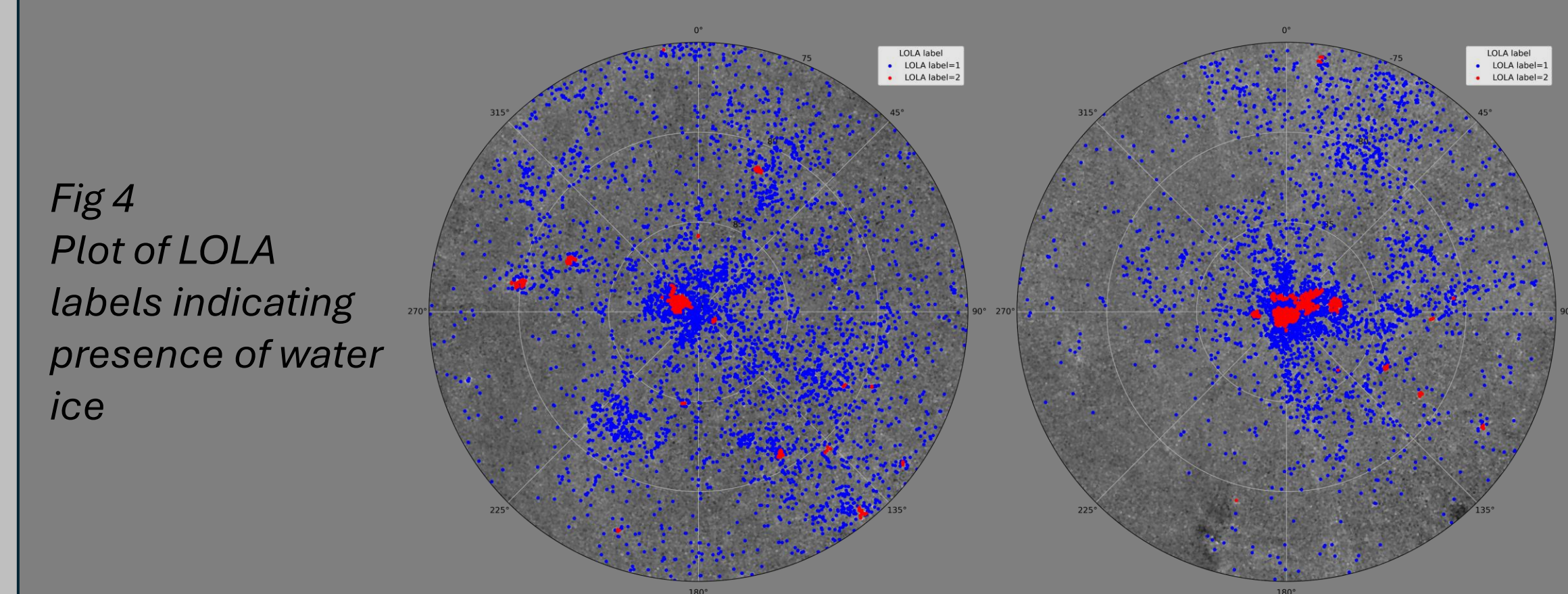


Fig 4 Plot of LOLA labels indicating presence of water ice

5. RESULTS

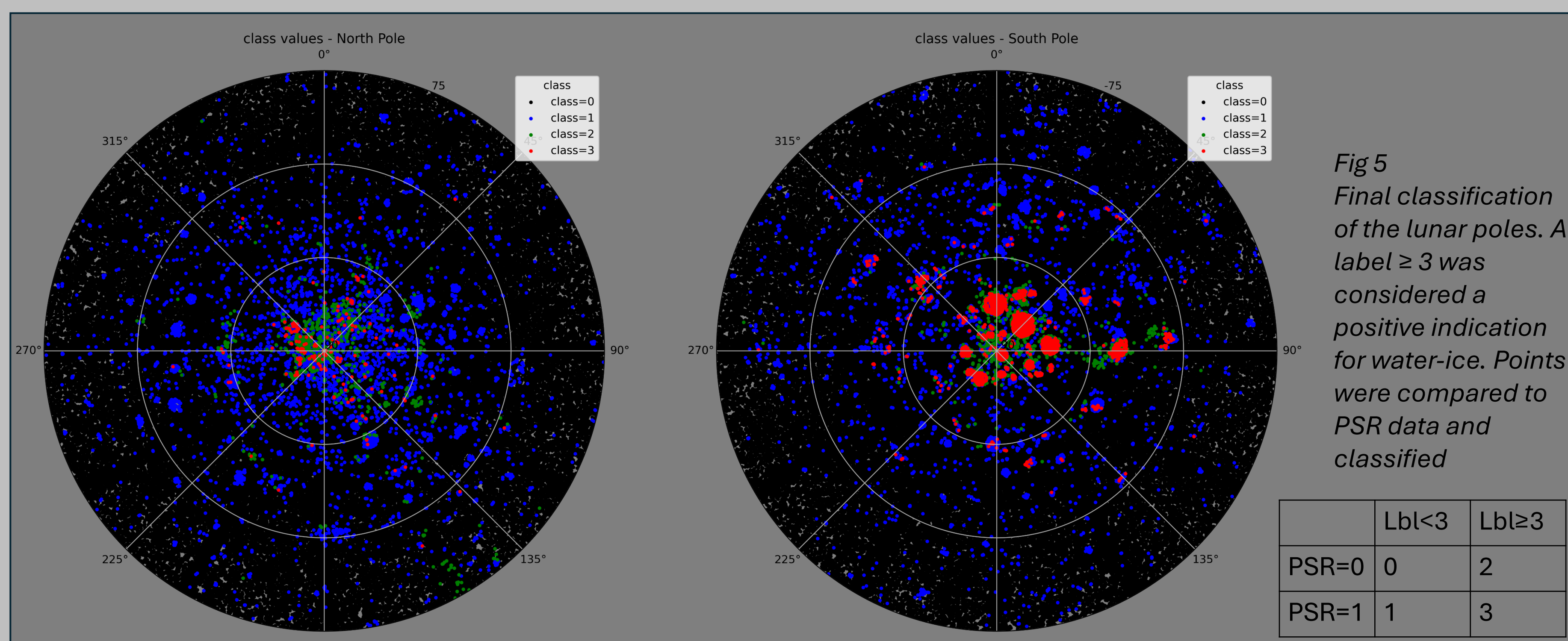


Fig 5 Final classification of the lunar poles. A label ≥ 3 was considered a positive indication for water-ice. Points were compared to PSR data and classified

Metric	Value	Meaning	Significance / takeaway for lunar-ice work
Precision	0.7979	How trustworthy is a positive detection?	High confidence targets. ~80% of the pixels the remote-sensing layer flags truly lie in PSRs, so field missions that sample only these positives will waste little time on false alarms.
Recall	0.5776	Proportion of PSR area with positive detections	Many PSRs stay silent. Only ~58% of the permanently shadowed terrain shows a detectable ice signature; the rest may be genuinely dry or hold ice below the instruments' sensing depth.
F1	0.6148	Single-number trade-off between precision and recall	Moderate overall effectiveness. The balance of good precision and limited recall yields a middling F1, signaling that the dataset is useful but cannot be the sole basis for resource-assessment decisions.
Matthews corr. coeff.	0.3040	Correlation coeff. between PSR and detections	Modest map-to-map agreement. A value well above 0 (random) but far from 1 indicates the sensor product and PSR mask correlate, yet substantial spatial disagreement remains—highlighting the need for complementary data.
Intersection-over-Union (IoU)	0.1475	Fraction of the union of "detected-ice" and "PSR" pixels common to both maps	Sparse overlap. Only ~15% of the combined 'ice OR PSR' area is shared, underscoring the patchy nature of water ice inside PSRs and reinforcing that positive detections are reliable but incomplete.

6. TAKEAWAY

- 80% of signals indicating water-ice reside in PSRs
- Only 58% of total PSR area showed detectable ice signatures
- While PSRs and ice signatures correlate, there are large areas of PSRs where no water-ice is detected