Can radar see a burn through the smoke?

A pre-registered test on the Frijoles Fire, New Mexico, August 2026

FIRE	BURNING FROM	WINDOW TESTED	PRE-REGISTERED	DECIDED
Frijoles, New Mexico	Aug 5, 2026	Aug 13–22, 2026	Sep 4, 2026	Sep 6, 2026

We asked whether radar from NISAR (L-band) and Sentinel-1 (C-band) could see the burn through smoke and cloud while the fire was still burning. Before looking at any result we wrote down the pass marks. Neither radar passed. Over burned ground, L-band changed by +0.17 dB against a noise floor of 1.22 dB, and C-band by +0.06 dB. We stopped the work there.

1. The question

Optical satellites measure burn severity well, but smoke and cloud block them while a fire burns. Radar sees through both.

So we asked one thing: while the fire is still burning, does the burn change the radar signal by more than the radar's own noise? If it does, radar could start a debris-flow screen before the skies clear. If it doesn't, radar can't do that job, at least not this way.

2. What we wrote down first

Every mark is judged on the low end of its 95% range, never on a single best guess. All of them had to pass.

SIZE	Over burned ground, compared with matched unburned ground, the radar signal had to drop by more than 1.22 dB. That is three times the scatter we measured between dry, same-angle passes before the fire (0.41 dB).
SEPARATION	The score for telling burned ground from unburned ground (AUC) had to reach 0.65. A coin flip scores 0.5.
DIRECTION	At least three of the four NISAR passes had to move the same way.
RAIN	The headline number could not come from a pass with more than 5 mm of rain on its day or the three days before.
PLACEMENT	On every usable pass, the drop had to beat the gap between two patches of unburned ground (p of 0.05 or less).
STOP RULE	If these checks failed with the confounds controlled, we would stop, not tune the method until it passed.

3. Data

One post-fire pass per radar track inside the window, each compared with a pre-fire baseline built from passes in the 45 days before the fire, screened the same way for rain.

Radar	Track	Pass (UTC)	Rain check	Fire covered
NISAR L-band	19	Aug 14, 12:10	Clean	98.2%
NISAR L-band	27	Aug 15, 01:58	Clean	99.2%
NISAR L-band	99	Aug 20, 01:50	Clean	82.5%
NISAR L-band	120	Aug 21, 12:19	Flagged: 7.2 mm on Aug 20	96.5%
Sentinel-1 C-band	56	Aug 14, 13:10	Clean	Not measured
Sentinel-1 C-band	151	Aug 15, 01:00	Clean	Not measured

- Burned ground: VIIRS 375 m heat detections up to each pass date (Suomi NPP, NOAA-20, NOAA-21).
- Unburned comparison ground: matched for elevation and ESA WorldCover land cover.
- NISAR product: L2 GCOV v1.0.11, still provisional. Sentinel-1: terrain-corrected (RTC). All on one 60 m grid, UTM zone 13N.

4. Method, in plain terms

- For every pass we measured the change in radar brightness (HV for NISAR, VH for Sentinel-1) between the pre-fire baseline and the mid-fire pass.
- We compared that change over burned ground with the change over the matched unburned ground.
- The 95% ranges come from a spatial block bootstrap: 1,000 resamples of blocks big enough that neighbouring pixels cannot fake precision.
- The headline combines the three rain-clean NISAR passes. The rain-flagged pass is reported but never counted.
- We ran the same steps on Sentinel-1 for the same days, and on NISAR again after the fire was contained, as a control.

5. Results

	Drop (dB)	95% range	AUC	95% range	Passed?
NISAR L-band, 3 rain-clean passes	+0.17	0.11 to 0.23	0.61	0.57 to 0.65	No
Sentinel-1 C-band, 2 passes	+0.06	0.01 to 0.10	0.53	0.51 to 0.54	No
Pass mark	*above 1.22*		*0.65 or more*		

Pass	Drop (dB)	95% range	AUC	95% range	Placement p
NISAR 19, Aug 14	+0.24	0.10 to 0.39	0.60	0.55 to 0.67	0.005
NISAR 27, Aug 15	+0.18	0.07 to 0.28	0.59	0.54 to 0.63	0.02
NISAR 99, Aug 20	+0.15	−0.06 to 0.36	0.55	0.47 to 0.63	0.56
NISAR 120, Aug 21 (rain-flagged)	+0.19	−0.08 to 0.51	0.56	0.48 to 0.65	0.87
Sentinel-1 56, Aug 14	+0.04	−0.02 to 0.10	0.51	0.50 to 0.53	0.47
Sentinel-1 151, Aug 15	+0.12	0.07 to 0.17	0.54	0.52 to 0.55	0.51

- Every pass moved in the burn direction, and two NISAR passes beat the placement check. The burn left a real, consistent mark on L-band. It was about a seventh the size of the noise floor.
- Control, after containment (passes Aug 26 to Sep 2): NISAR found +0.03 dB (95% range −0.04 to 0.10), AUC 0.53. Nothing above the noise there either.

6. Verdict

Didn't clear the bar.

The size and separation marks failed on both radars. We stopped the radar burn-severity work at this point, as the stop rule required. What we kept is the rule that marks what radar can't tell, so a map never guesses.

7. Limits

- One fire, in mixed-conifer forest during the New Mexico monsoon. The result sets a direction; it does not settle radar for every fire. A dry-season fire, or a different measurement (coherence instead of brightness), would need its own pre-registered test.
- NISAR's product is still provisional. A calibration update would mean re-measuring the noise floor.
- Heat detections count a whole day, so some burned ground may come from after a pass. Trimming each mask to its pass time changed the result by 0.009 dB at most.
- We did not test timing. NISAR comes back every 12 days, which may be too slow even for a real signal.

8. What isn't in this report

- The test's sub-basin ranking part compared radar with an optical burn map that turned out to have a processing error. It stays out until the map is rebuilt and the ranking re-run. Nothing above uses that map.
- A planned map-skill check could not be computed at the rigor we set: too few independent blocks of burned ground. The method refused rather than guess, as designed.

Sources

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