



Comparative Assessment of NISAR L-Band and Sentinel-1 C-Band SAR for Flood Inundation and Surface Water Dynamics

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Abstract

The NASA–ISRO SAR (NISAR) mission, launched in July 2025 and releasing calibrated L-band products since July 2026, complements Sentinel-1 C-band SAR for flood monitoring. This review compares both systems for monsoon floodplains of South Asia, synthesising scattering physics, mission characteristics, processing methods and accuracy metrics. C-band remains effective for open-water floods and rapid mapping, whereas L-band is decisive for water beneath vegetation, wind-roughened water and long-baseline coherence; a multi-frequency framework is proposed.

Introduction

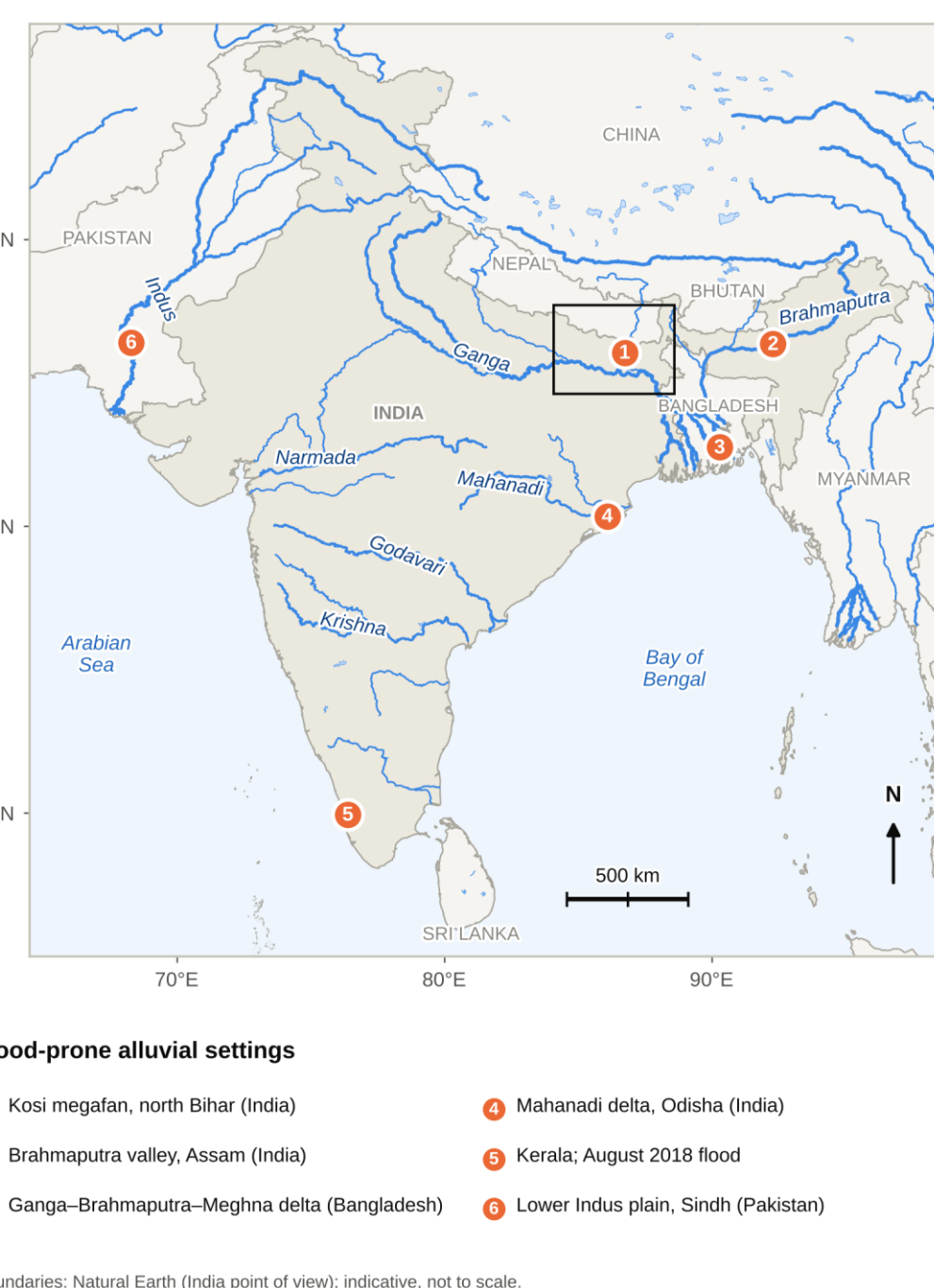
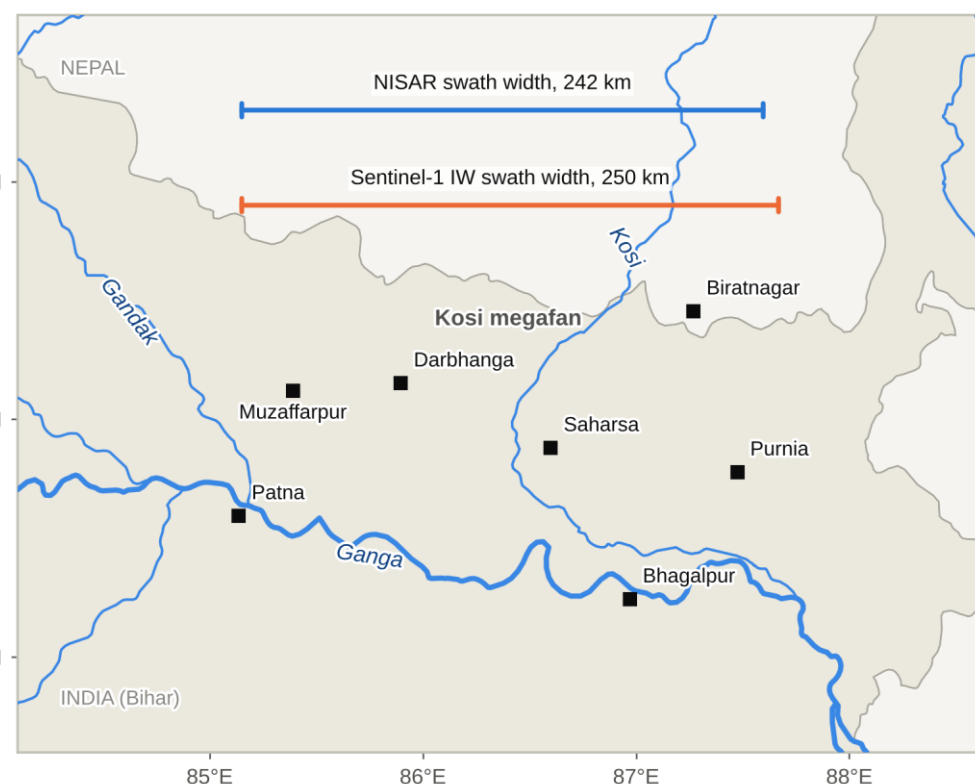
Floods affect more people than any other natural hazard: large floods directly affected **255–290 million** people in 2000–2018, and the share of the world's population living in flood-exposed areas rose by **20–24%** in 2000–2015 (Tellman et al., 2021). In monsoon South Asia, persistent cloud defeats optical sensors when observations matter most, so synthetic aperture radar (SAR) has become the backbone of flood mapping. Since **2014**, Sentinel-1 C-band SAR ($\lambda \approx 5.6$ cm) has been the operational standard, but its short wavelength interacts mainly with vegetation canopies, so floodwater beneath forests and tall crops is under-detected. The NASA–ISRO SAR (NISAR) mission, launched on **30 July 2025**, adds free and open L-band ($\lambda \approx 24$ cm) data with a 242-km swath and a 12-day repeat. This review therefore compares both systems for mapping flood inundation and surface-water dynamics in monsoon-dominated floodplains.

Objectives

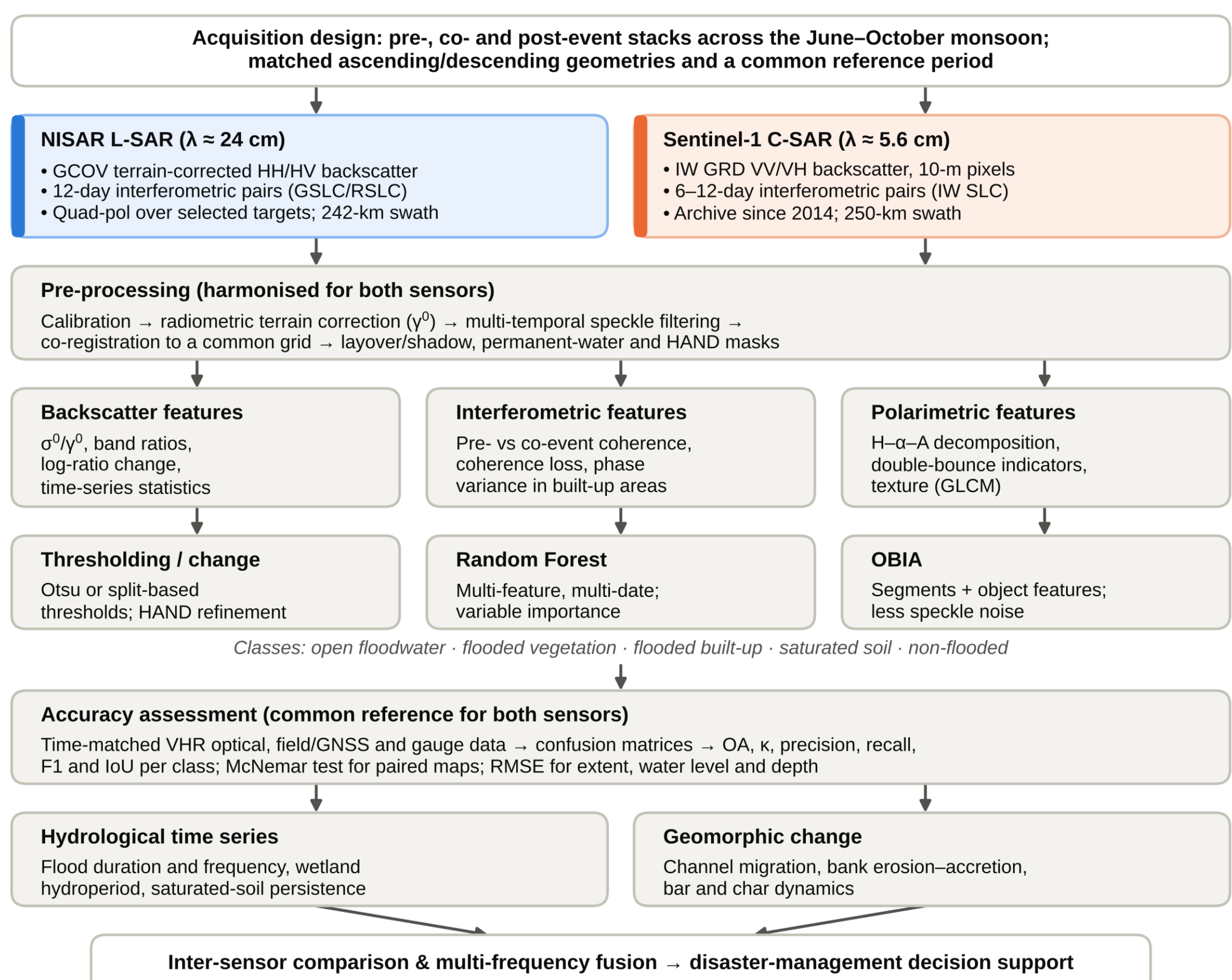
- To compare the scattering physics, roughness sensitivity and interferometric coherence of L-band and C-band SAR over flooded surfaces.
- To review mission characteristics, processing methods and accuracy metrics (OA, Kappa, F1, IoU and RMSE).
- To propose a multi-frequency framework for flood extent, wetland persistence and channel change.

Study Area

The review focuses on the monsoon-dominated alluvial floodplains of South Asia, especially the Kosi megafan and Ganga plain of north Bihar, where floods recur almost every year.



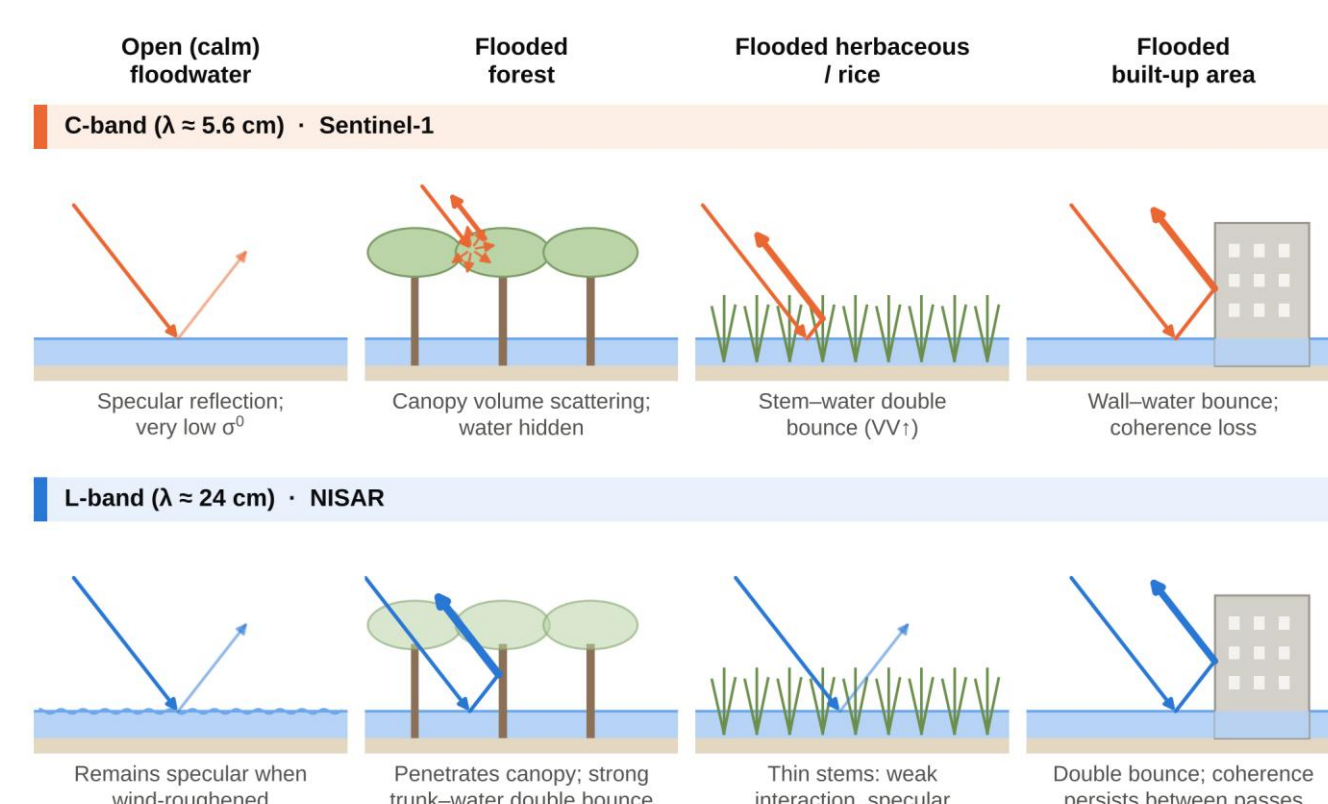
Methodology



- Systematic review of SAR flood-mapping studies and NISAR and Sentinel-1 mission documents (20 key references).
- Physics-based computation of Rayleigh roughness limits and coherence decorrelation for L-, S- and C-band.
- Synthetic floodplain test of both bands with identical change-detection rules, scored by F1-score and Kappa (κ).

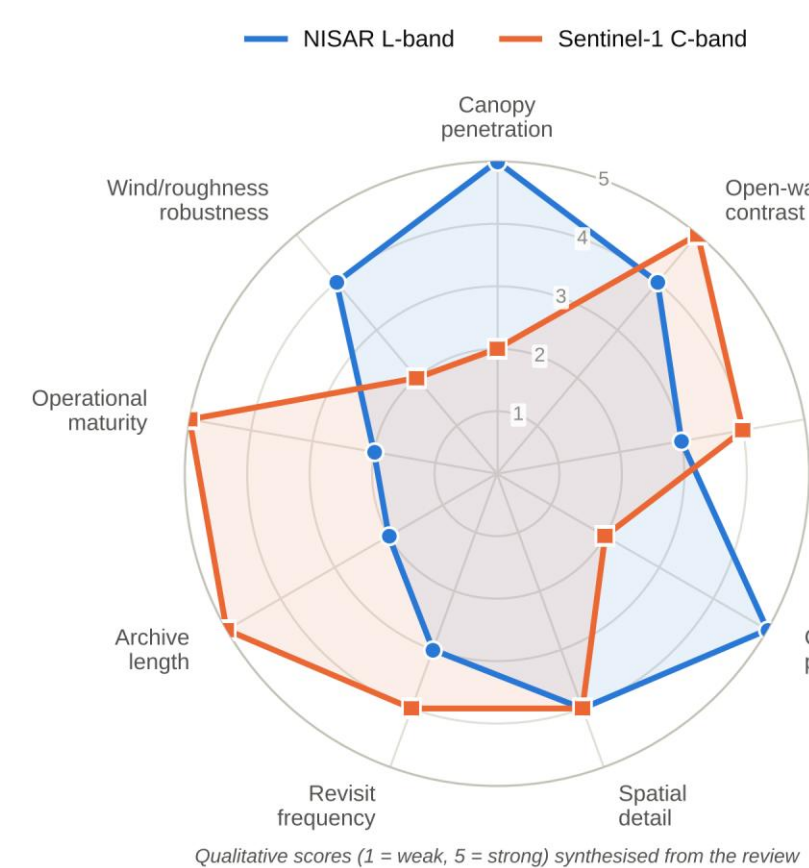
Result and Discussion

Floodwater scattering mechanisms at C-band (Sentinel-1) and L-band (NISAR)



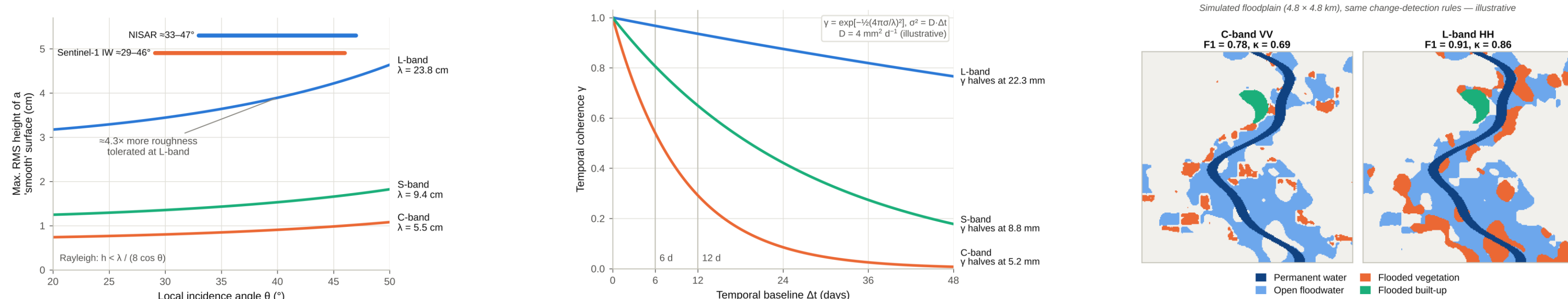
- Calm open water reflects specularly at both bands and appears dark, but C-band brightens when wind roughens the water surface.
- Beneath forest, C-band is scattered by the canopy, whereas L-band penetrates it and returns a strong trunk–water double bounce; over young, sparse rice the stem–water bounce is stronger at C-band.

Comparative suitability of NISAR L-band and Sentinel-1 C-band (1 = weak, 5 = strong)



- NISAR L-band leads in canopy penetration, coherence persistence and robustness to wind-roughened water.
- Sentinel-1 C-band leads in open-water contrast, urban flood detection, revisit, archival length and operational maturity; both offer similar spatial detail.
- Scores are qualitative, synthesised from the reviewed literature and mission documentation.

Roughness, Coherence and Mapping Accuracy



- By the Rayleigh criterion, L-band tolerates surface roughness about **4.3 times** larger than C-band, so wind-roughened floodwater stays dark at L-band but brightens at C-band.
- Temporal coherence halves at about **5 mm** of random motion at C-band but **22 mm** at L-band; the decorrelation time is about **18 times** longer, so 12-day coherence stays near 0.93 at L-band against 0.29 at C-band (illustrative).
- With identical rules, the synthetic floodplain gave **F1 = 0.78 ($\kappa = 0.69$)** for C-band and **F1 = 0.91 ($\kappa = 0.86$)** for L-band; C-band missed flooded forest, while L-band missed shallow paddies.
- Together, NISAR and Sentinel-1C/1D give a mean monsoon revisit of about **3 days**, although short flash peaks can still fall between acquisitions.

Conclusion

- Sentinel-1 C-band remains the workhorse for rapid, frequent mapping of open floodwater, supported by a decade-long archive.
- NISAR L-band adds canopy penetration, robustness to wind-roughened water and coherence that persists over 12-day baselines.
- A harmonised multi-frequency framework with time-matched accuracy assessment offers the most robust path to operational flood monitoring.

References:

1. NISAR. (2018). *NASA-ISRO SAR (NISAR) mission science users' handbook*. NASA Jet Propulsion Laboratory, California Institute of Technology.
2. Torres, R., Snoeij, P., Geudtner, D., Bibby, D., Davidson, M., Attema, E., ... & Rostan, F. (2012). GMES Sentinel-1 mission. *Remote Sensing of Environment*, 120, 9–24.
3. Tellman, B., Sullivan, J. A., Kuhn, C., Kettner, A. J., Doyle, C. S., Brakenridge, G. R., Erickson, T. A., & Slayback, D. A. (2021). Satellite imaging reveals increased proportion of population exposed to floods. *Nature*, 596(7870), 80–86.
4. Tsyganskaya, V., Martinis, S., Marzahn, P., & Ludwig, R. (2018). SAR-based detection of flooded vegetation – a review of characteristics and approaches. *International Journal of Remote Sensing*, 39(8), 2255–2293.