

Unsupervised Continuous Flood Mapping from Multi-temporal, Multi-view and Multi-sensor SAR Sequences

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COSMO-SkyMed data under ASI licence — Project COSMO-FLOOD (ID 3969)

Session: Floods & Drought · 14:30 CEST

Continuous flood monitoring breaks on three operational gaps

HAZARD

Fluvial / pluvial flood

fast-onset — Emilia-Romagna 2023

persistent, recurrent — La Mojana 2021–24

DRM PHASE

Emergency response → daily extent
Recovery & preparedness →
persistence

1

On-demand tasking = mixed geometries

ascending / descending, different incidence angles, different sensors — classical change detection breaks

2

No usable pre-flood reference

missing, too old, or the floodplain is already wet

3

Operational chains are heavy

response needs minutes from Level-1, not hours of preprocessing

User requirement one automated workflow · any SAR Level-1 product · with or without reference · daily continuity

pre-event reference (COSMO-SkyMed)

... 31 days ...

one COSMO-SkyMed scene per day, mixed orbit / incidence → daily flood maps

16 Apr

17

18

19

20

21

22 May

Two flood regimes, two sensors, Level-1 products as delivered

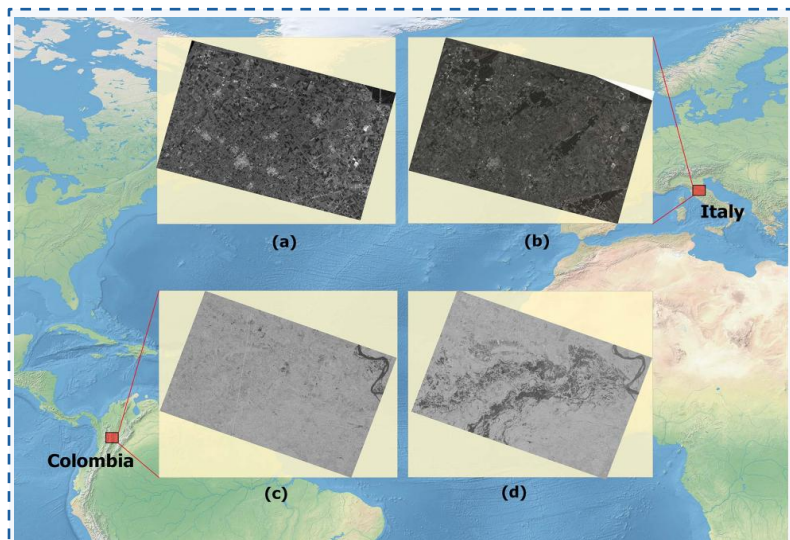


Fig. 1. Locations of the study areas in Italy and Colombia.

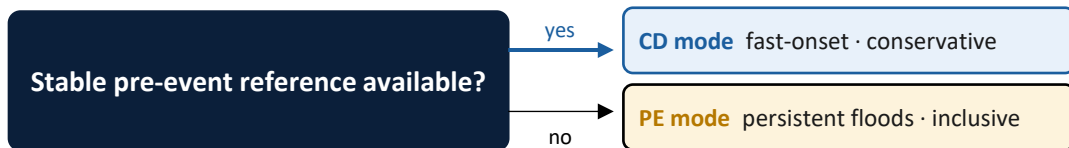
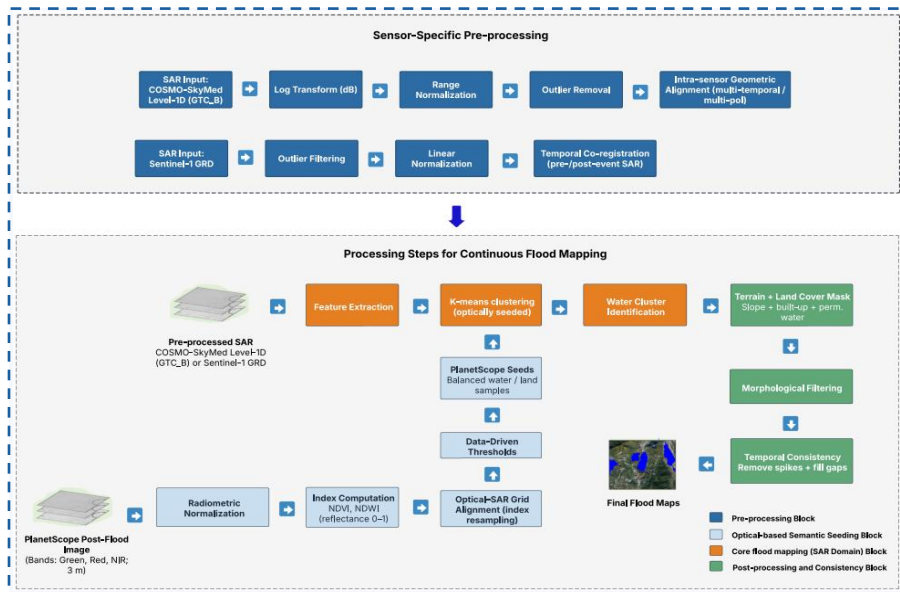
Emilia-Romagna, Italy — May 2023

- COSMO-SkyMed CSK + CSG, Level-1D GTC_B, one scene/day 17–22 May, mixed geometries; reference 16 April;
- PlanetScope SuperDove, 21 May — seeding only, never validation;
- TINITALY DEM 10 m · benchmark: CEMS EMSR664 (17 & 21 May).

La Mojana, Colombia — 2021–2024

- Sentinel-1 GRD 2021–23 + COSMO-SkyMed 2023–24;
- PlanetScope, 2 Sept 2021 · SRTM · ESA WorldCover;
- Benchmark: independent, field-validated flood maps (multi-temporal S1 + ML + in-situ).

One workflow: seeded, not trained — nothing to tune at run time



1 Sensor-specific normalisation only
dB + percentile clip (CSK) · z-score (S1) → common grid

2 Two modes
CD: [Cnid, Clogr, Cpost, texture], 2 clusters · PE: stacked post-event intensities, 4 clusters

3 K-means seeded by one post-event VHR optical scene
NDVI/NDWI, Otsu + percentile · flood = lowest-mean-backscatter cluster

4 Physics masks + temporal logic
slope ≥ 8°, built-up, permanent water · morphology · gap-fill / spike removal

Clustering stays fully unsupervised in SAR feature space; optical only anchors cluster semantics.

Emilia-Romagna: six daily maps, mixed geometries, one reference

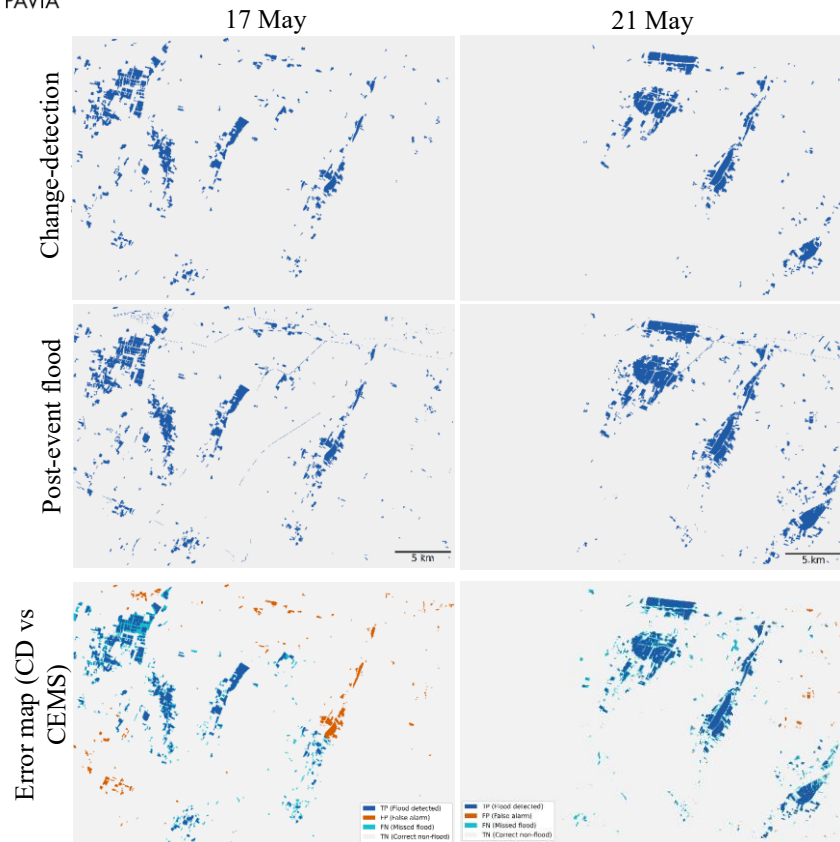


Fig. 2. validation heat-map, 17 & 21 May

Otsu and log-ratio thresholds under identical conditions: far lower precision.

Trade-off is stable across all dates → an operational choice, not a case-specific accident

97.5–98.8 %

overall accuracy vs CEMS,
both modes, both dates

86.4 %

F1-score — PE mode, 21 May

92 %

precision — CD mode:
conservative outline

86 %

recall — PE mode: complete
extent

Reading the errors

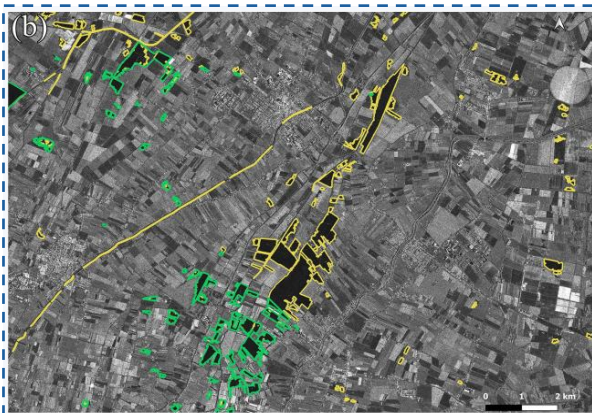


Fig. 3. post-event SAR · green = CEMS · yellow = additional extent detected

- 1 **Part of “commission” is real water absent from the reference**
newly activated channels and ponded fields visible in the post-event image
- 2 **Omission = flooded vegetation with no open-water signature**
intrinsic to intensity-driven SAR mapping; canopy scattering hides shallow water
- 3 **Temporal consistency alters 8 % of mapped area**
fills one-day gaps, removes one-day spikes

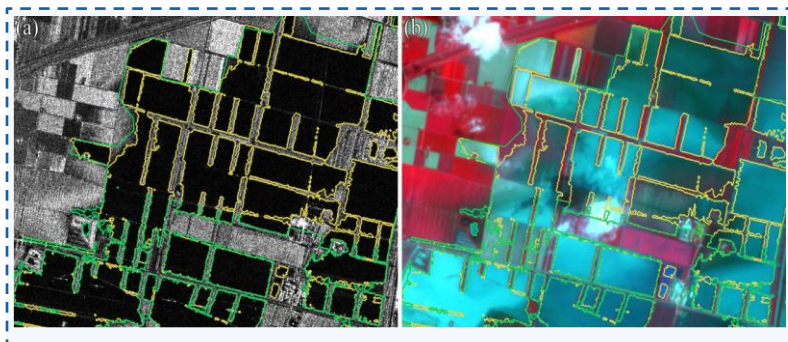


Fig. 4. omission under vegetation — SAR vs PlanetScope

Ablation — PE mode, 21 May (Table V)

	Precision	Recall	F1
With optical seeding	87.2	85.6	86.4
Without seeding	68.2	81.2	74.1

~2 min
PE · per COSMO-SkyMed scene
~4 min
CD · standard workstation

La Mojana: one workflow, C- and X-band, three years

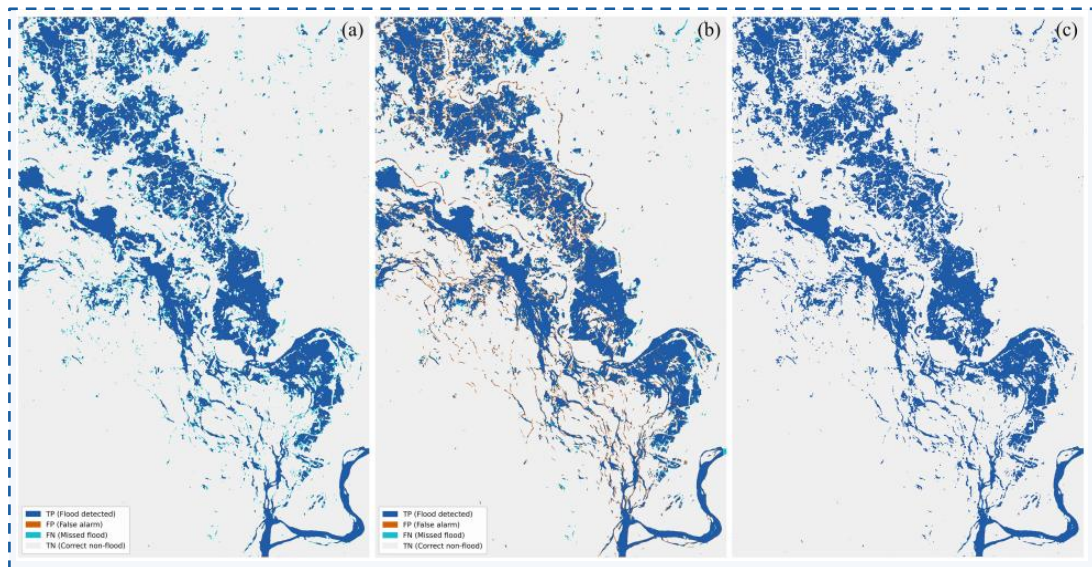


Fig 5. May 2024 — (a) Sentinel-1 · (b) COSMO-SkyMed · (c) reference

87.8 %

F1 · Sept 2021 breach · S1
recall 93 %

91.0 %

F1 · 2023 persistence · S1 stack
COSMO-SkyMed 85.9 %

91.1 %

F1 · May 2024 · COSMO-SkyMed
precision 97 %; S1 same date 87.1 %



Fig 6. Validation heat-map, 2021 / 2023 / 2024

Disagreement between sensors is confined to flood margins and narrow channels, resolution - not method.

Lessons learnt, and three asks of tasking authorities and services

LESSONS LEARNT

1

Geometry-agnostic change detection works

do not wait for same-orbit pairs before mapping

2

The reference-image decision is the critical choice

keep both modes; switch by regime, not by habit

3

Level-1 direct + unsupervised = transferable

minutes per scene, no training data, C- and X-band

4

Benchmarks disagree with each other

report commission and omission, not overall accuracy

RECOMMENDATIONS

1

Tasking pattern

one stable pre-event scene, then mixed-geometry daily post-event acquisitions

2

Interoperability with CEMS / GFM

deliver persistence products, not only snapshot extents

3

Next steps

uncertainty and persistence indicators · new regions in Asia-Pacific · NRT chain

4

Open access

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