DRD
Surface Inundation

PRODUCT SPECIFICATIONS

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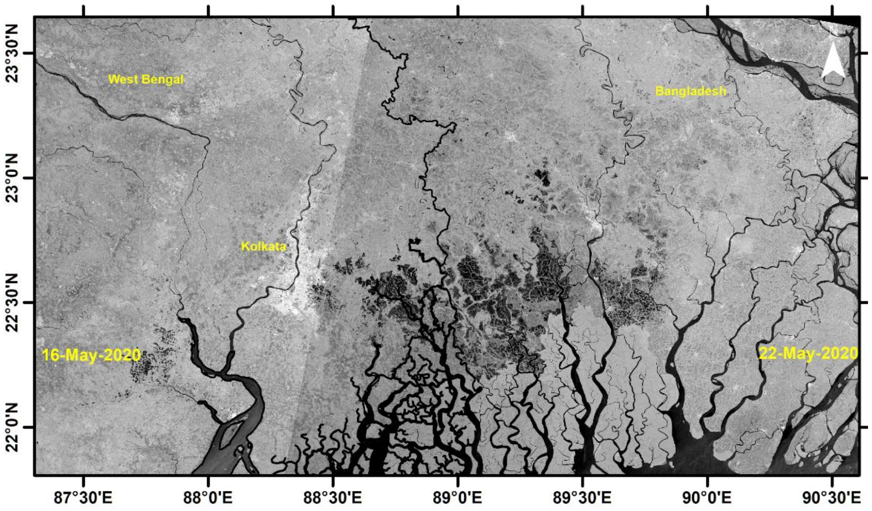
CEOS
Committee on
Earth Observation Satellites

Analysis Ready to Decision Ready



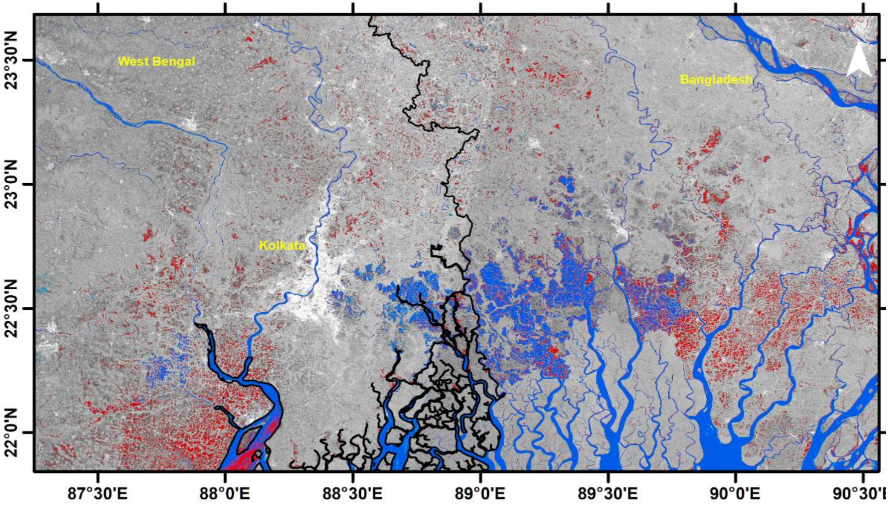
Sentinel-1A / 1B Mosaic
Pre-Cyclone: 16-May-2020
Post-Cyclone: 22-May-2020

0 20 40 80 km

ARD

DRD

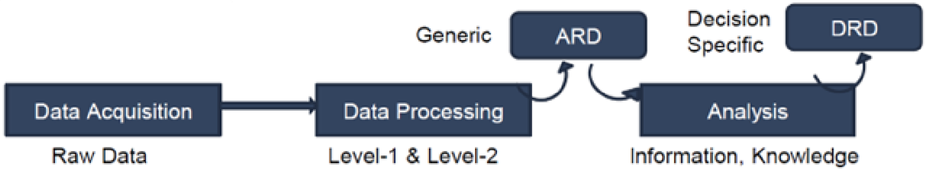
- Pre-processing
- Flood Layer
- QA Flag



Inundated Regions
22-May-2020
16-May-2020
Both Dates

Sentinel-1A / 1B Mosaic
Pre-Cyclone: 16-May-2020
Post-Cyclone: 22-May-2020

0 20 40 80 km



Presentation Roadmap

Agenda & Roadmap
Requirements → Workflow → Delivery

CEOS

→ **Context**
→ **Requirements**
→ **Implementation**
→ **Distribution**

QA & Traceability
Bitmask + DOI

Delivery
GeoTIFF/COG

● CONTEXT	● REQUIREMENTS	● IMPLEMENTATION
1 Overview & Use Cases Who uses DRD-SI & why	**2 The DRD Concept** Raw → processed → ready	**3 Data Sources** Optical vs SAR
4 Key Definitions SI, QA, DRD, etc.	**5 Framework** Threshold vs Goal	**6 General Metadata** Traceability → sensor
7 General Metadata Resolution → lineage	**8 Per-Pixel & QA** Bitmask + flags	**9 Processing Workflow** End-to-end flow
10 Uncertainty & Validation Mixed pixels, in-situ	**11 Access & Distribution** DOI, GeoTIFF/COG	**12 Accuracy & Performance** RMSE/CEP90, QA
13 Compliance Self-Assessment Checklist & gaps	**14 Summary** Key takeaways	**15 References** STAC, ISO 19115-2

Product Overview & Use Cases

DRD-SI provides a **surface inundation land–water mask** derived from **optical** or **SAR** imagery to support rapid decisions and long-term assessment.

Emergency Response

Minutes–Hours

Operations • situational awareness

- Rapid flood extent mapping to support incident response.
- Situational awareness for impacted infrastructure and communities.
- Resource allocation and prioritization for field deployment.

Key need

Clear QA flags (cloud/shadow/no-data) for confident action.

Hydrologists & Climatologists

Seasons–Years

Science • monitoring • trends

- Long-term flood monitoring and hydroclimate analysis.
- Risk assessment: frequency, persistence, and spatial patterns.
- Trend analysis across sensors and resolutions (intercomparability).

Key need

Uncertainty & validation reporting (mixed pixels, in-situ stats).

Government Agencies

Planning–Response

Preparedness • coordination

- Disaster preparedness and scenario planning using consistent products.
- Inter-agency response coordination with common geospatial references.
- Public communication and reporting backed by traceable metadata.

Key need

Traceability via DOI landing page + versioning/lineage for audits.

Core Product Idea

A consistent inundation mask plus machine-readable metadata enables rapid integration into operational and scientific workflows.

Why It Matters

Enables consistent flood mapping across sensors with clear quality signaling and metadata for rapid integration.

The DRD Concept

A concise processing pipeline that transforms **raw satellite observations** into **Decision Ready Data** for fast flood decisions—while preserving **quality signaling** and **provenance**.

DRD design intent

Operationally usable + reproducible

The pipeline is modular to support multiple sensors (optical/SAR) and resolutions.

DRD-SI processing pipeline (conceptual)

From inputs to decision-ready output, with explicit QA + metadata packaging

Output is machine-readable

QA supports confident use

Input — Raw satellite data
Optical or SAR imagery + acquisition context
- All resolutions / GSDs

→

Prep — Calibrated/corrected
Sensor calibration + geometric correction
- CRS/projection documented

→

Model — Masking/classification
Cloud/shadow + land–water inference
- Inundation mask generated

→

QA — QA bitmask
Per-pixel quality encoding (machine-readable)
- Flags: no-data, cloud/shadow

→

Meta — Packaged metadata
STAC (threshold) or ISO 19115 (goal)
- Version + lineage captured

→

DRD — Decision Ready Data
GeoTIFF/COG + DOI-accessed assets
- Ready for operations & science

Speed
Minimize time-to-action for emergency response workflows.

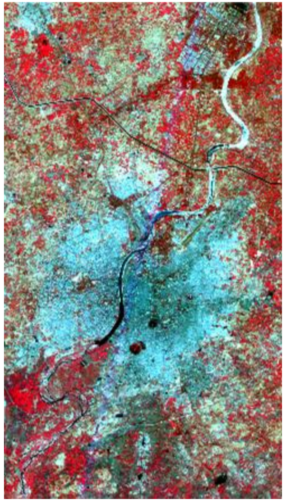
Interoperability
Standard CRS + machine-readable metadata enables easy fusion.

Traceability
DOI landing page + versioning + lineage supports audits.

Data Sources: Optical vs SAR

DRD-SI can be derived from **optical** or **Synthetic Aperture Radar (SAR)** imagery across all resolutions/GSDs. Use the modality best suited to cloud conditions, latency needs, and local terrain.

Optical



SAR

BEST PRACTICE

Fuse modalities when available; flag QA.

Optical Imagery

Spectral reflectance-based water mapping

High interpretability

Strengths

- Intuitive visual interpretation and mapping products.
- Supports spectral indices (e.g., NDWI) for water detection.
- Strong for mapping open water under clear conditions.

Limitations

- Clouds and shadows can obscure water signal.
- Lower reliability during storms (exactly when floods occur).
- Requires robust cloud/shadow QA flagging.

Best-fit use cases

- Post-event mapping when skies clear.
- Long-term analyses where cloud seasonality is manageable.

SAR Imagery

Microwave backscatter-based water mapping

All-weather capability

Strengths

- Day/night acquisition with reduced cloud sensitivity.
- Operationally valuable during active storm response.
- Useful for mapping inundation beneath light vegetation

Limitations

- Speckle noise and radiometric variability require careful processing.
- Terrain effects (layover/shadow) can complicate interpretation.
- ATBD is critical for reproducibility.

Best-fit use cases

- Near-real-time monitoring during cloudy events.
- Emergency response operations needing consistent coverage.
- Complement optical products for cross-validation and completeness.

Key Definitions Glossary

Glossary cards (definitions aligned to specification)

Teal = product/data · **Orange** = QA/trace

SI — Product
Surface Inundation (product family: land–water masks)

QA — QA
Quality flag bitmask encoding algorithm assessment per pixel

Satellite Data — Input
Original satellite observations used to generate DRD

Ancillary Data — Input
Instrument/satellite-origin data: orbit, attitude, time, calibration

Auxiliary Data — Input
External processing inputs (e.g., DEMs, ground segment data)

Metadata — Meta
Structured information describing data and services for understanding & use

Spatial Resolution — Data
Highest magnification of the sensor at the ground surface (pixel size)

DRD — Output
Decision Ready Data: processed and packaged for immediate use

SAR — Sensor
Synthetic Aperture Radar imagery used for all-weather flood mapping

ATBD — Doc
Algorithm Theoretical Basis Document describing methods and assumptions

RMSE / CEP90 — Metric
Geometric accuracy metrics used to report positional performance

WGS84 — CRS
World Geodetic System 1984 reference for geographic coordinates

GeoTIFF / COG — Format
Raster delivery formats; COG optimizes cloud-based access

STAC / ISO 19115 — Meta
Metadata standards for cataloging and machine-readability

DOI — Trace
Digital Object Identifier used for persistent access to products and documentation

→ **NOTE:** “Ancillary” vs “Auxiliary” are separated to clarify instrument-provided vs external processing inputs.

Tip: keep terms consistent in metadata

General Metadata Requirements

(traceability • timing • geometry • sensors)

Metadata Matrix — Part I

Threshold (minimum operational usability) and
Goal (optimal interoperability, traceability, and reproducibility).

ITEM	REQUIREMENT	THRESHOLD (MINIMUM)	GOAL (DESIRED)
I.1	Traceability	Not mandatory for SI reference standards.	Traceable via a single DOI landing page.
I.2	Machine Readability	Structured for automated extraction.	Follows community standards (e.g., ISO 19115-2).
I.3	Data Collection Time	Start/stop times to the second (with UTC offset).	Per-pixel acquisition time in UTC.
I.4	Geographical Area	Coordinates in WGS84.	Per-pixel identification; projection/datum specified.
I.5	Geometric Accuracy	Not required for basic products.	Metrics included (e.g., RMSE or CEP90).
I.6	Coordinate Reference System (CRS)	Must list the CRS used.	Parameters allow transformation to WGS84/EPSG.
I.7	Map Projection	Must provide projection and parameters.	Supports consistent gridding with other datasets.
I.8	Geometric Correction	Not required.	Describe approach (e.g. DEM, GCPs, ortho-method).
I.9	Instrument / Sensor	Sensor name and mission must be specified.	—

→ Metadata enables consistent cross-sensor comparisons and audit-ready flood products.

Tip: keep wording identical across products for automation

General Metadata Requirements

Spatial resolution • algorithms • provenance • versioning • lineage

Metadata Matrix — Part 2

Threshold (minimum operational usability) and **Goal** (optimal interoperability, traceability, and reproducibility).

ITEM	REQUIREMENT	THRESHOLD (MINIMUM)	GOAL (DESIRED)
1.10	**Spatial Resolution**	Pixel size must be reported.	Effective resolution and resampling documented.
1.11	**Sensor Calibration**	Not required.	Documented and traceable parameters.
1.12	**Radiometric Accuracy**	Not required.	Accuracy estimates must be provided.
1.13	**Algorithms**	All algorithms must be documented.	Published or described in an **ATBD**.
1.14	**Auxiliary Data**	Sources must be identified.	Accessible via **DOI**.
1.15	**Processing Chain**	Not required.	Full workflow description + software versions.
1.16	**Product Version**	Version identifier required.	Version history maintained.
1.17	**Product Lineage**	Source datasets must be identified.	Processing lineage must be traceable.

Operational implication: Part 2 drives reproducibility: algorithms, provenance, and version-controlled releases.

Per-Pixel Metadata & QA Bitmask

DRD-SI delivers a flood **inundation mask** plus pixel-level flags that encode observation integrity and limitations. The **QA bitmask** enables fast filtering and automation at scale.

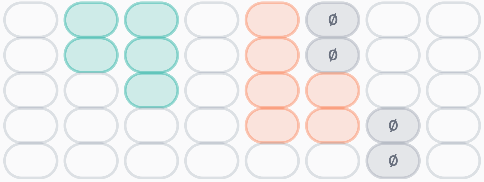
Example pixel tile (conceptual)

Mask + QA

Each pixel carries an inundation value + QA flags

PIXEL FLAGS OVERLAY

- Inundated
- Cloud/Shadow
- No Data



Inundation mask
Binary water presence flag

Cloud/ Shadow
Mask unreliable observations

No
Empty pixels flagged

Operational filtering

Exclude clouds / no-data before analytics

THRESHOLD
Provide flags per pixel

GOAL
Link algorithms via DOI

Machine-readable QA

Bitmasks support fast queries (bitwise operations) and compact storage.

Goal: algorithm traceability

Cloud/shadow detection method should be discoverable via DOI landing pages.

QA bitmask (conceptual layout)

A compact integer encoding multiple flags

BIT POSITIONS

1 value / pixel

b0	b1	b2	b3	b4	b5	b6	b7
Inundation	No Data	Cloud	Shadow	Reserved	Reserved	Reserved	Reserved

ENCODING EXAMPLE

illustrative

qa = 0b00001101 → inundation + cloud + shadow

Use a documented scheme so downstream systems interpret flags consistently.

Threshold

- Inundation mask present
- No-data + cloud/shadow flagged
- Machine-readable QA layer

Goal

- DOI links to detection algorithms
- Transparent QA interpretation
- Supports audit-ready workflows

Processing Workflow

A reproducible chain from **raw observations** to **inundation masks** with **QA + standards-aligned metadata** for distribution and decision support.

Workflow flowchart (conceptual)

Process stages | **Delivery** stages

1. **Input collection** — Optical/SAR + ancillary + auxiliary
2. **Sensor calibration** — Apply documented calibration parameters
3. **Geometric correction** — DEM + GCPs + ortho-rectification
4. **Resampling** — To target GSD / grid
5. **Cloud/Shadow masking** — Flag obscured pixels
6. **Inundation mapping** — Generate land–water mask
7. **Mixed pixels** — Fractional inundation (Goal)
8. **Quality assessment** — Generate QA bitmask
9. **Metadata packaging** — STAC (Thr.) / ISO 19115 (Goal)
10. **Output + publication** — GeoTIFF/COG + DOI landing page

Traceability endpoint

A single DOI landing page should connect product, metadata, and referenced algorithms.

Uncertainty & Validation Framework

CEOS

Threshold supports operational interpretation; Goal adds richer uncertainty characterization and validation reporting.

Threshold: minimum uncertainty reporting

Basic metrics to interpret the inundation mask

Operational

Cloud cover extent

Land/water classification

IMPLICATION

fast to deliver

Supports rapid use during response when deeper validation may be unavailable.

Goal: advanced uncertainty & validation

Quantitative metrics to support comparisons and auditing

Audit-ready

Valid observation proportion
Report share of pixels not impacted by non-target phenomena.

Fractional inundation (mixed pixels)
Represent sub-pixel water fractions or uncertainty values.

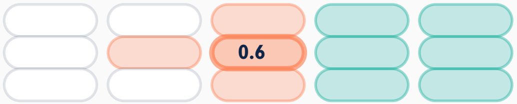
In-situ validation (with statistics)
Include validation results and summary stats in metadata.

Mixed pixel → fractional inundation

binary → fractional

PIXEL NEIGHBORHOOD

Water Land Mixed



Binary mask
Water/land decision

Fractional
e.g., 0–1 water fraction

Uncertainty
Confidence / ambiguity

Why mixed pixels matter

Flood boundaries often fall inside a pixel footprint; fraction reduces edge artifacts in area estimates.

In-situ validation concept

Field observations support QA statistics

In-situ

FIELD SITES (ILLUSTRATIVE)

site IDs

S01	S02	S03	S04
Gauge A	**Survey B**	**Imagery C**	**Archive D**
Water level / presence observation	Transect / photo evidence	Drone / aerial snapshots	Historical flood marks
Used for validation stats	Summarize in metadata	Cross-check boundaries	Contextual checks

Accuracy & Performance Metrics

DRD-SI uses tiered requirements to communicate what's required for operational use (Threshold) and what improves intercomparability and auditability (Goal). Key metrics span **resolution**, **calibration/corrections**, and **accuracy & quality evidence**.

Metrics matrix

What to report for accuracy, resolution, and data quality

Threshold view | Goal view

METRIC AREA	THRESHOLD (MINIMUM)	GOLD (OPTIMAL)
Spatial resolution GSD & gridding context	• Pixel size reported	• Effective resolution documented • Resampling method reported
Sensor calibration Calibration parameters	• Not required	• Documented & traceable parameters
Radiometric accuracy Signal fidelity	• Not required	• Accuracy estimates provided
Geometric accuracy Positioning precision	• Not required (basic products)	• Report RMSE or CEP90
Data quality Usability indicators	• Cloud cover extent • Land/water classification provided	• Proportion of valid observations • Fractional inundation (mixed pixels)

Why this matters

Consistent reporting enables cross-sensor comparisons and supports automated filtering for response operations.

Coverage by tier (conceptual)

More metrics become available at Goal illustrative

Visualization indicates relative breadth of reporting. It does not represent measured performance values.

References & Standards

DRD-SI interoperability relies on community standards

Core standards & conventions

ISO 19115-2
Goal tier machine-readable packaging

STAC
Threshold tier metadata delivery

WGS84 / EPSG
Report CRS & enable transformation

GeoTIFF / COG
THRESHOLD: GeoTIFF
GOAL: COG

ATBD best practices

Workflow
Describe calibration, correction, masking, QA, packaging steps.

Inputs & params
List satellite/ancillary/auxiliary data and key parameter choices.

Validation
Summarize uncertainty handling and in-situ validation approach.

Include software versions and processing lineage in documentation and metadata to support repeatability across releases.

DOI LANDING PAGE (GUIDELINE)

- Single entry point for download, provenance, and version history
- Links to ATBD, algorithms, auxiliary data sources, and QA definitions

CONTACT
{Name / Team} • {Email} • {Org URL}

Optional: add QR code pointing to DOI landing page.

Suggested missions (eg.)

Use: optical + SAR

Sentinel-1/NISAR
Sentinel-2/ Landsat

Acknowledgements

Project team
{List core contributors / group name}

Partners
{Agencies / universities / NGOs}

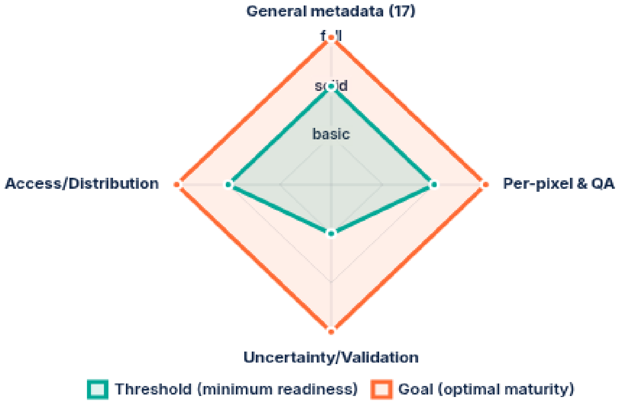
Keep acknowledgements and funding notes on the DOI landing page for persistent attribution across versions.

Summary & Key Takeaways

The DRD-SI specification defines a **repeatable, auditable** approach to generate **surface inundation masks** with **tiered requirements** for operational response and scientific comparability.

CORE OUTPUT

A land–water inundation mask packaged as **Decision Ready Data** with traceable metadata.



The Goal tier strengthens provenance with software versions, lineage, and ATBD-referenced algorithms.

DRD-SI delivers interoperable, traceable inundation masks

Built for multi-agency operations and scientific reuse: consistent metadata, QA flags, and provenance hooks.

Robust, reproducible workflow

Designed for repeatability across sensors

Calibration → Correction → Masking → QA

Distribution: formats + metadata + DOI

Enable discovery and access at scale

Discovery path

Data → DOI → Catalog → User

DOI landing page links to: **product files**, **metadata**, **ATBD**, and **version/lineage records**.

Provide satellite data in the form of actionable data to make decisions

Thanks

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