Generating an InSAR DEM using ASF software tools

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Outline

- AKDEM production system

- SAR interferometric processing chain

  - general setup

  - examples

InSAR DEM generation

AKDEM production system

- driver program runs processing chain from data ingest until geocoded digital elevation model

- allows STF, RAW and SLC data

- runs from configuration file

- allows definition of default values

InSAR DEM generation

Configuration file

AKDEM project: Configuration file

[General]
reference dem = /3dsar2/tlogan/dem/alaska_dem.img
base name = 57_23592_3919
log file = 1
quiet = 1
processors = 8
data type = STF
lat begin = 63.500
lat end = 64.500
coregistration = AUTOMATIC
maximum offset = 3
default values = /3dsar2/tlogan/default_values2
status = new

[Master image]
path = /3dsar2/akdem/tracks/57_tape1
data file = e2_3919.000
metadata file = e2_3919.000.par

[Slave image]
path = /3dsar2/akdem/tracks/57_other
data file = e1_23592.000
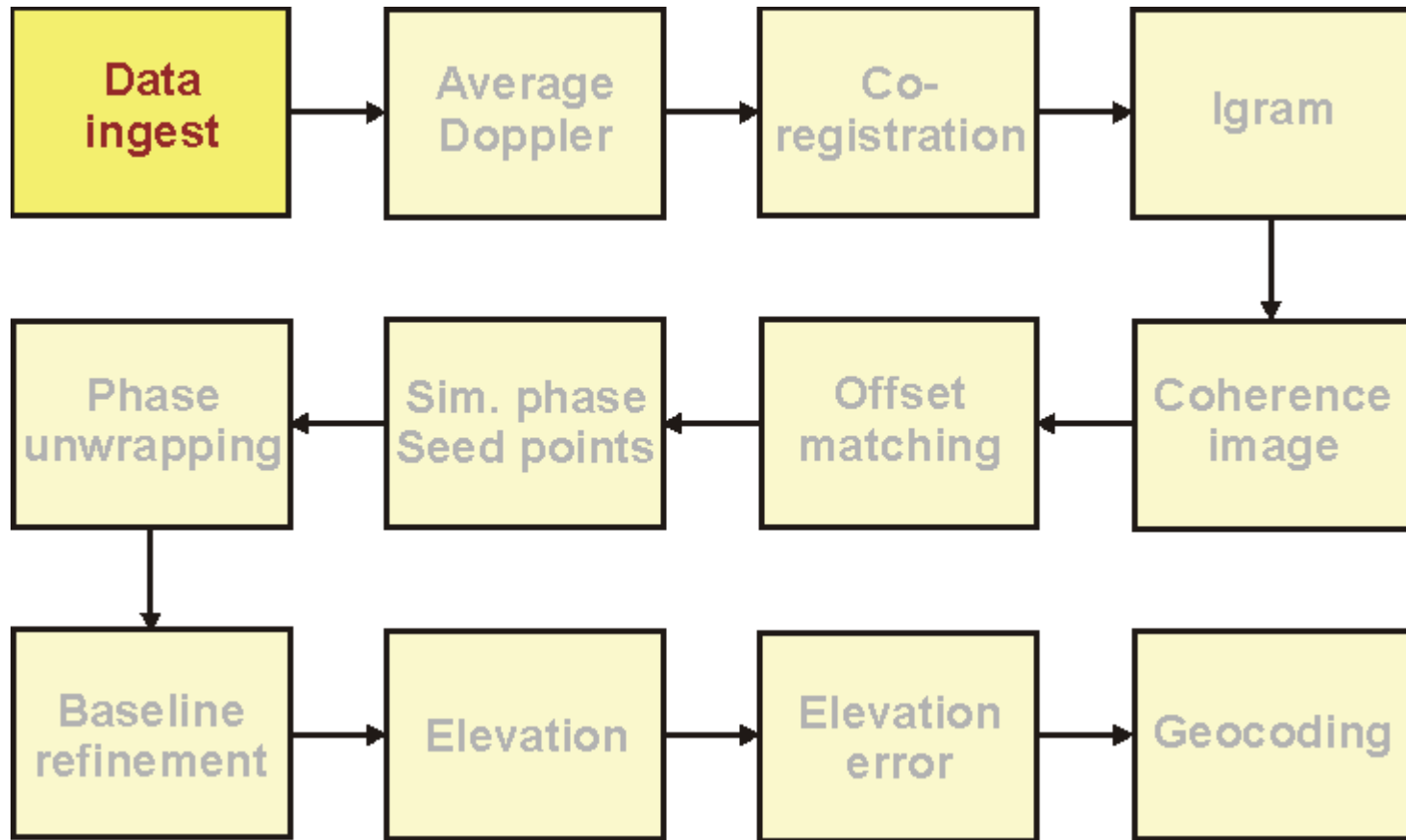**metadata file = e1_23592.000.par**

Default values

reference dem = /3dsar2/tlogan/dem/alaska_fixed.img
log = 1
quiet = 1
processors = 8
data type = STF
coregistration = AUTOMATIC
maximum offset = 3
precise master = /3dsar2/tlogan/PRC/ERS2
precise slave = /3dsar2/tlogan/PRC/ERS1
minimum coherence = 0.3
phase unwrapping = snaphu_v2
projection file = /3dsar2/tlogan/albers.proj
projection key = albers
pixel spacing = 20
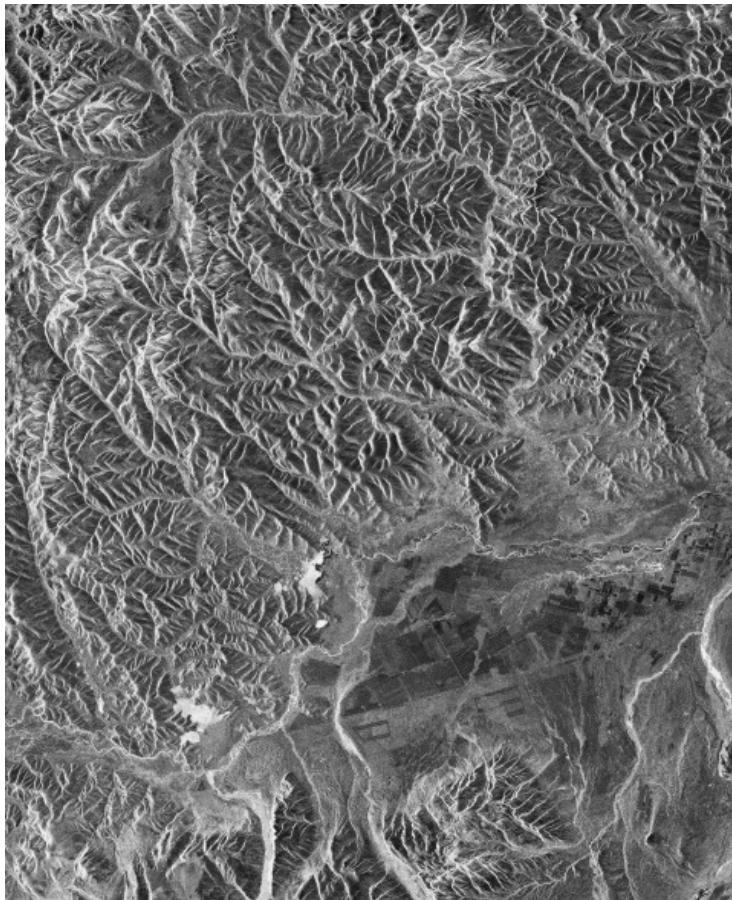
InSAR DEM generation

InSAR processing

InSAR DEM generation

Data ingest → Average Doppler → Co-registration → Igram
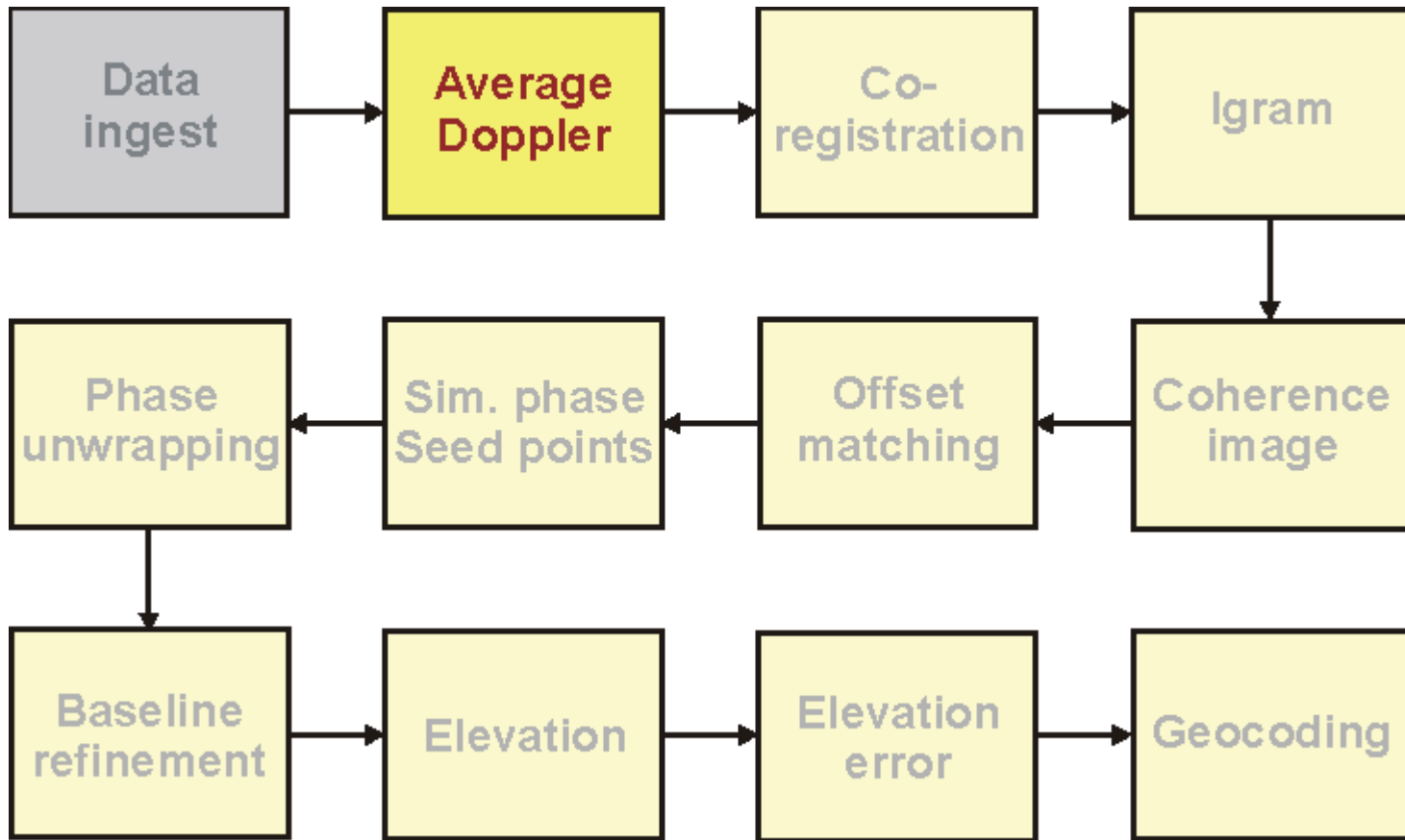
Phase unwrapping ← Sim. phase Seed points ← Offset matching ← Coherence image

Baseline refinement → Elevation → Elevation error → Geocoding

Data ingest

64.5°

InSAR DEM generation

63.5°

- ingest of STF data
- can handle precision state vectors for ERS data
- allows latitude constraint

InSAR processing

Data ingest	Average Doppler	Co-registration	Igram

Phase unwrapping	Sim. phase Seed points	Offset matching	Coherence image

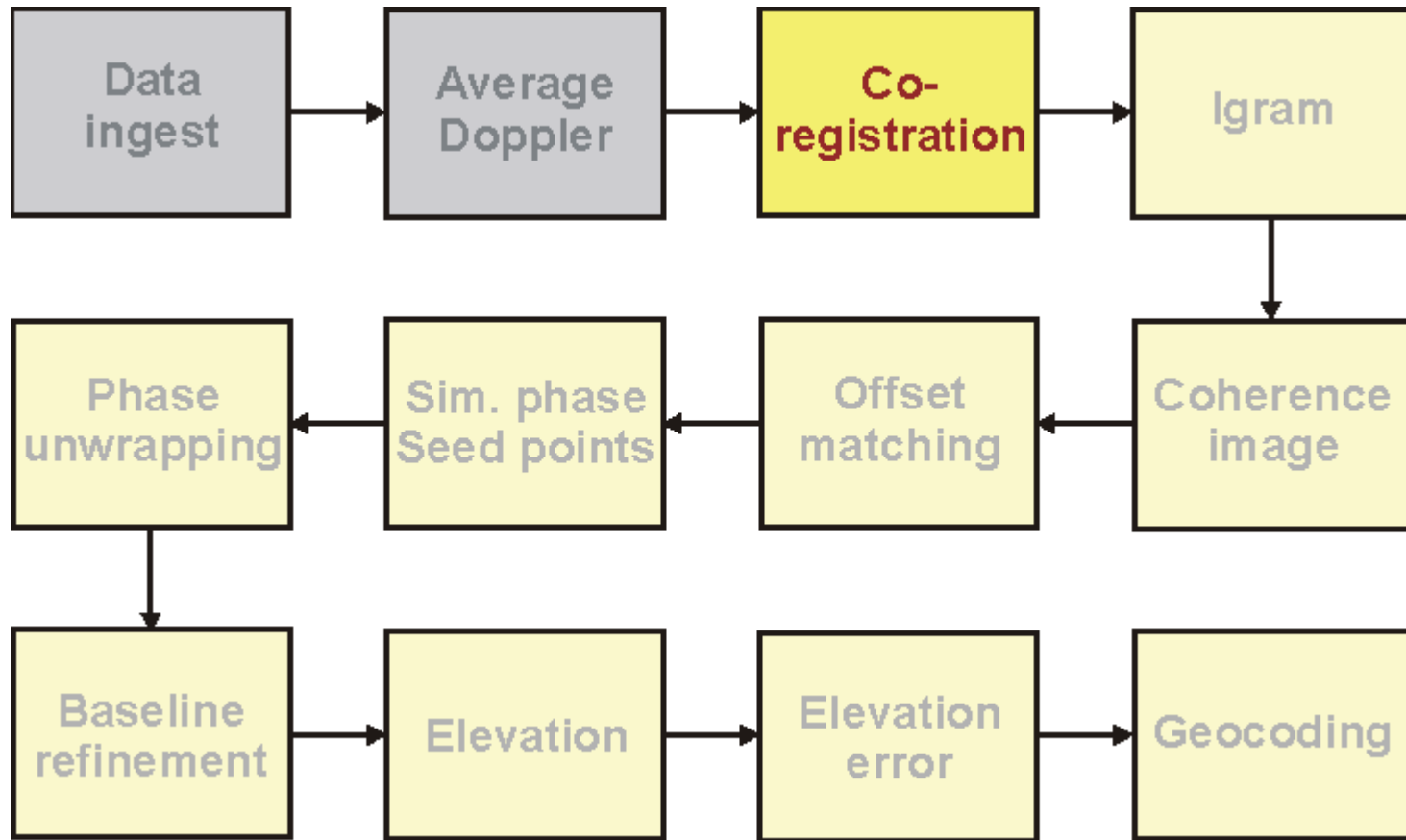| Baseline refinement	Elevation	Elevation error	Geocoding

Average Doppler

- getting both images into the same geometry

- works fine for ERS imagery

- Radarsat imagery requires zero Doppler processing (currently under development)
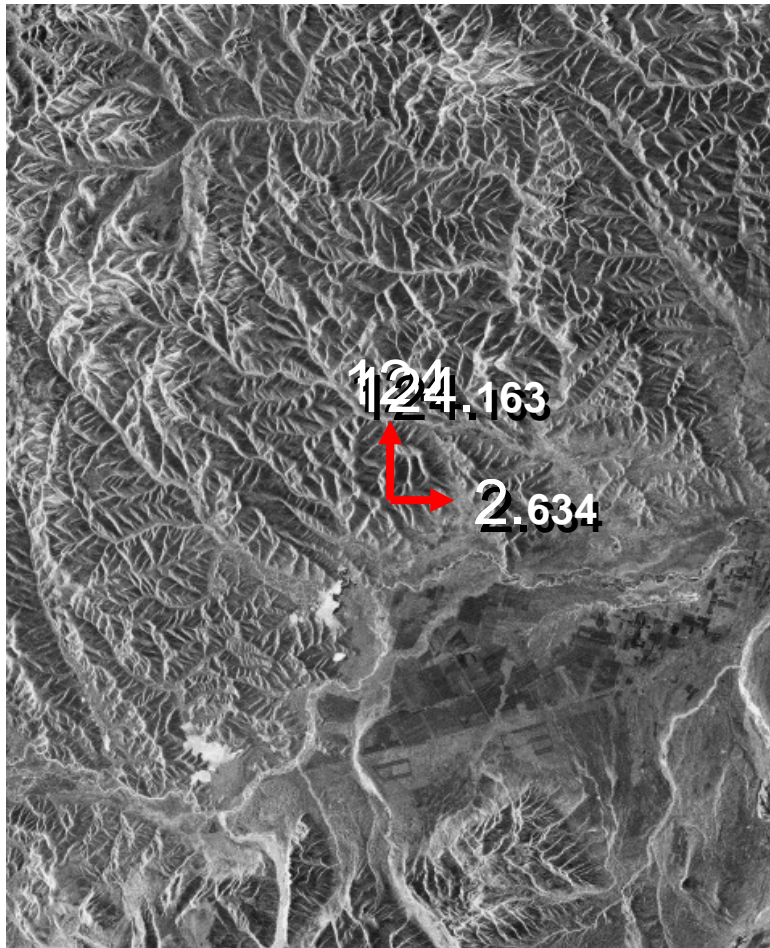
InSAR DEM generation

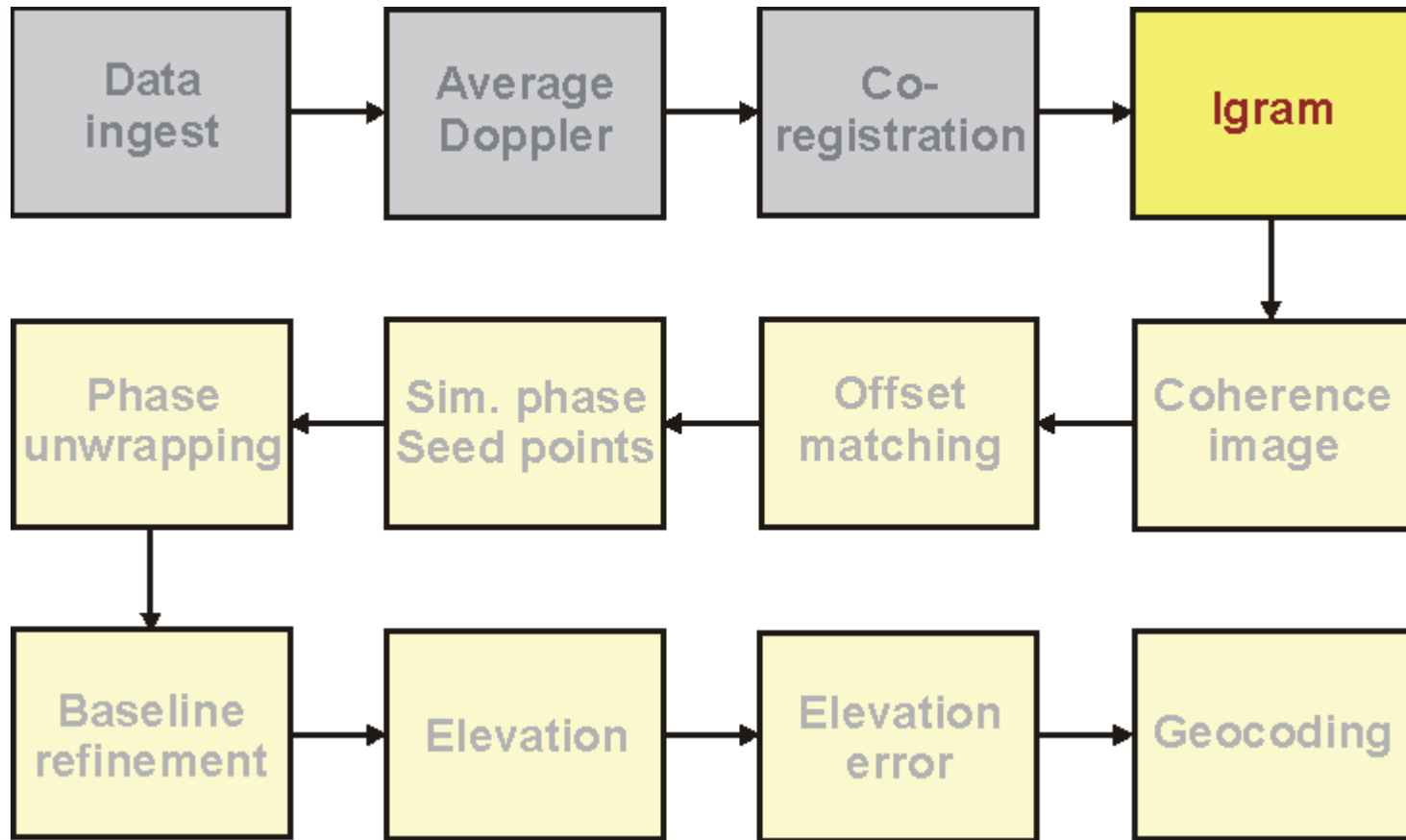# InSAR processing

Co-registration

InSAR DEM generation

- initial offset estimated from state vectors (pixels)
- fine co-registration for sub-pixel accuracy
- baseline estimate as side product
  Bn = -61.829628
  Bp = 19.505440
- exit condition with maximum offset (default 3 pixels)

InSAR processing

Interferogram

- single-look interferogram
- color-coded multilooked interferogram
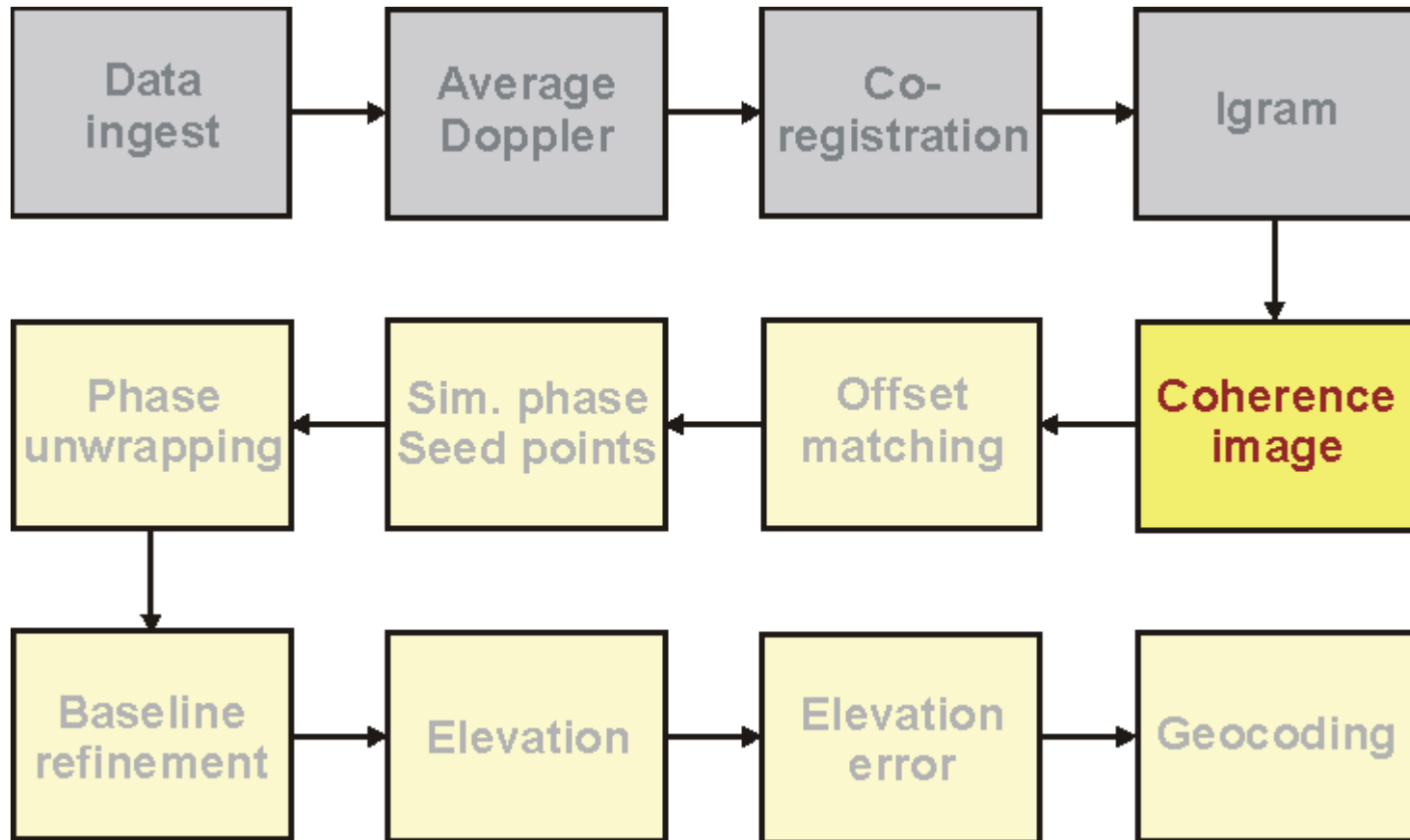
InSAR DEM generation

InSAR processing

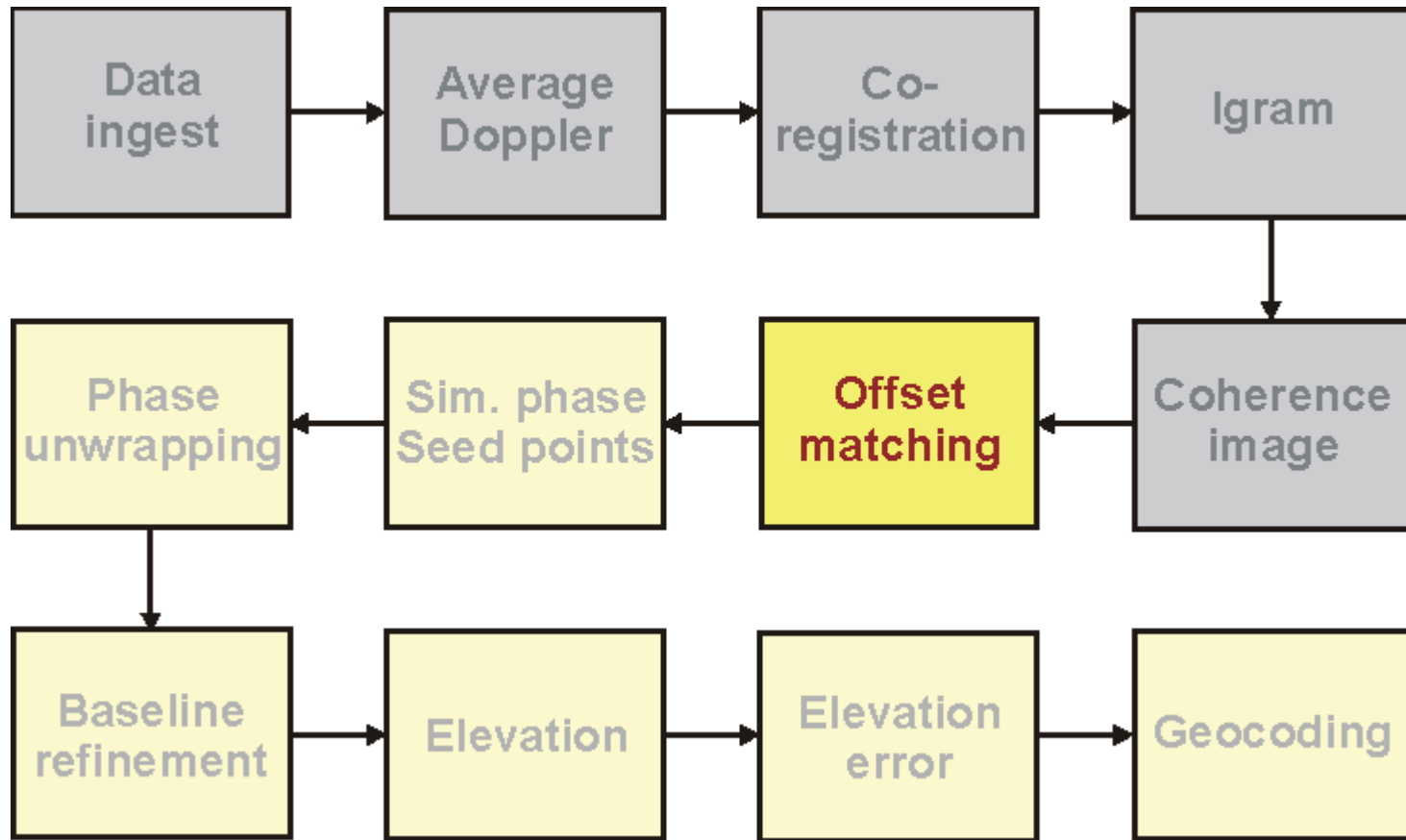# Coherence image

InSAR DEM generation

- exit condition with minimum coherence level
  (default value: 0.3)

- statistics
  - maximum: 0.975
  - average: 0.747

InSAR processing

InSAR DEM generation

```
[Data ingest] → [Average Doppler] → [Co-registration] → [Igram]
                                                            ↓
[Phase unwrapping] ← [Sim. phase Seed points] ← [Offset matching] ← [Coherence image]
        ↓
[Baseline refinement] → [Elevation] → [Elevation error] → [Geocoding]
```
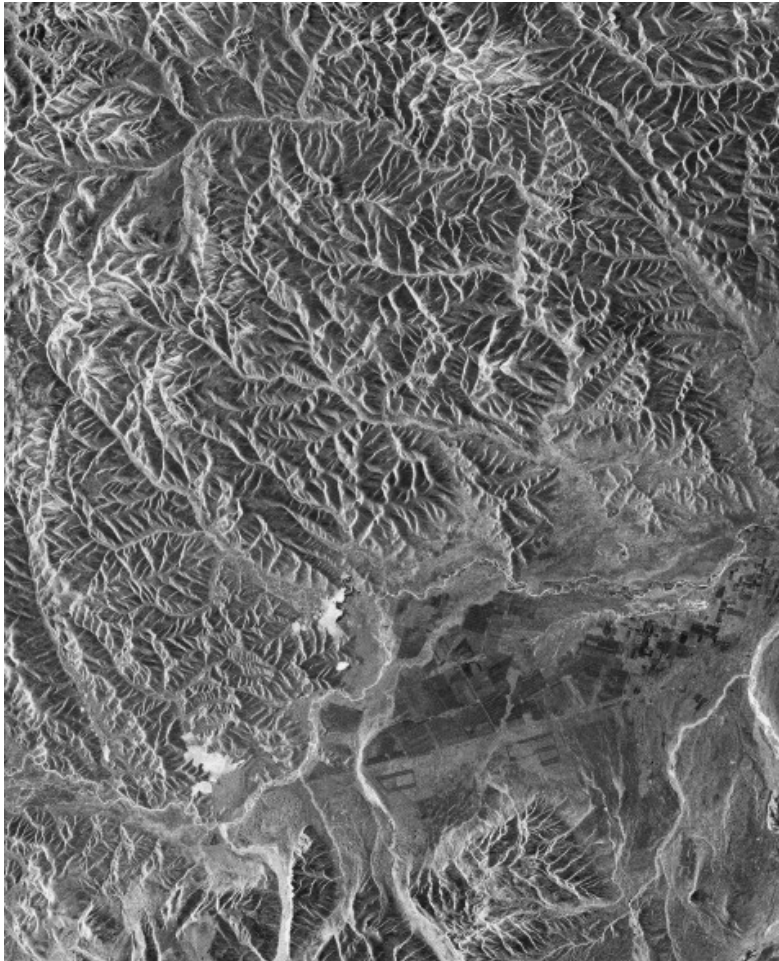
Offset matching

- improves geolocation by refining shifts in time and range

- iterative process

- matches real and simulated amplitude (derived from reference DEM) until no offset can be measured

Offset matching
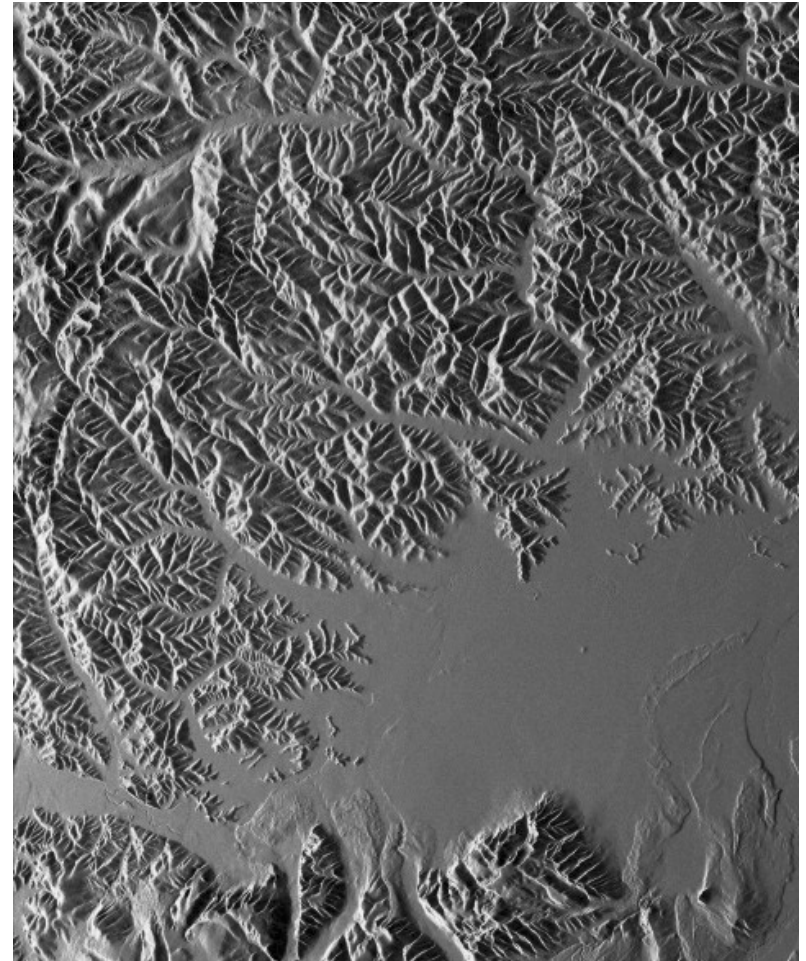

InSAR DEM generation

real amplitude   simulated amplitude
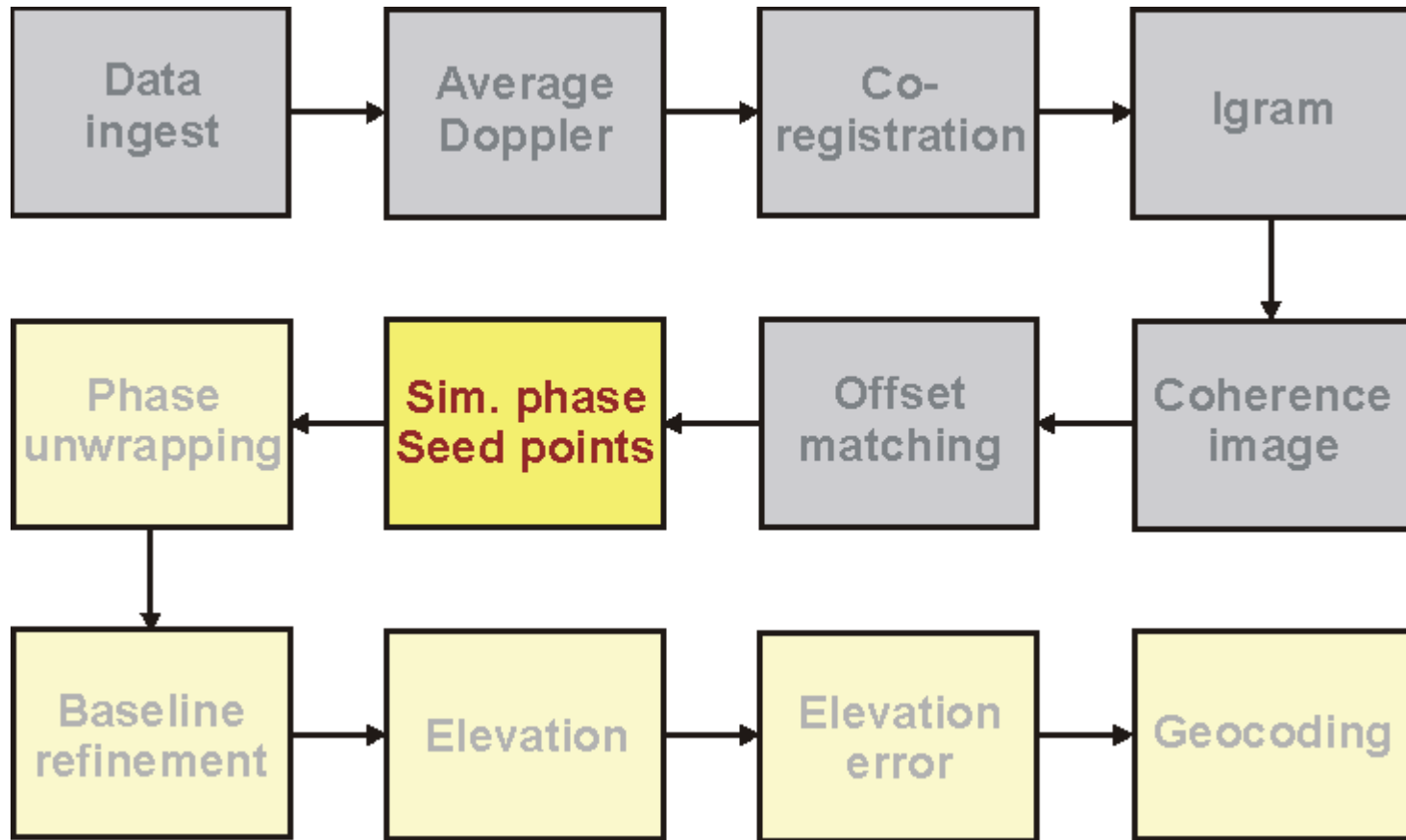
InSAR processing

InSAR DEM generation

Data ingest → Average Doppler → Co-registration → Igram

Phase unwrapping ← Sim. phase Seed points ← Offset matching ← Coherence image

Baseline refinement → Elevation → Elevation error → Geocoding

Simulated phase / seeds points

- derived from reference DEM

- simulated phase
  - used for removal of topographic phase (optional)

- seed points
  - equally distributed
  - selection criteria: minimum slope in reference DEM
  - potential seed points: 10000
  - final number of seed points: 2321

InSAR DEM generation

Seed point distribution

```
X  XXX    X  XXX  XX
   X  XXXXX        XXX
   XX         XXX    XX
   X X            XX  X  X
          X     XX        XX
          X     X    XX  XX
                XXXXXXXXX
   X  XX          XXXXXXX
   XXXXXXXXXXXXXX
   X    XXXXXXXXXXXX
   XXX  XXXXXXXXXX
   XXXXXXXXXXXXXXX
   XXXXXXXXXXXXXXX
   XX  XXXXXX    XXXX
   XX  XXXXXX  XXXXX
```
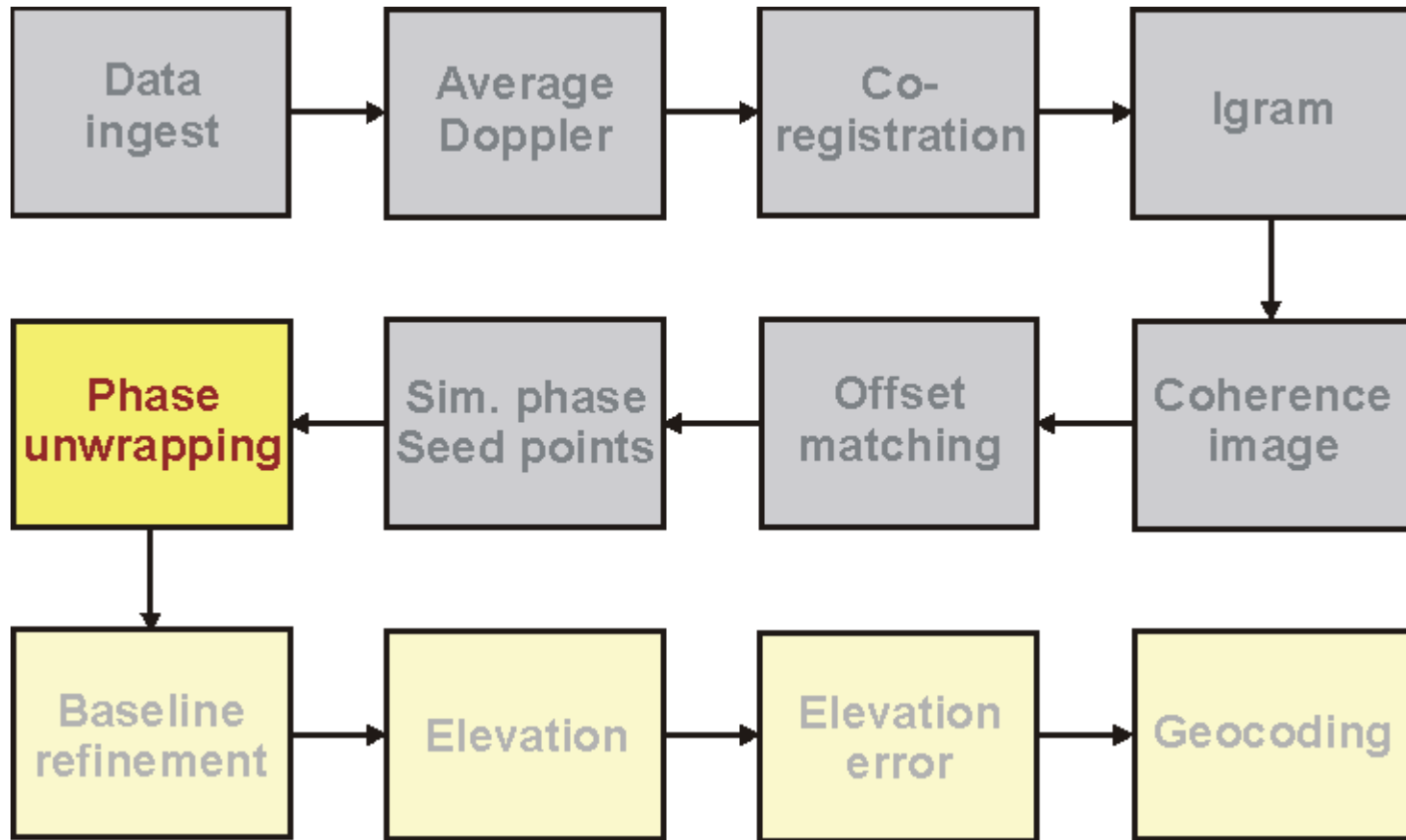
InSAR DEM generation
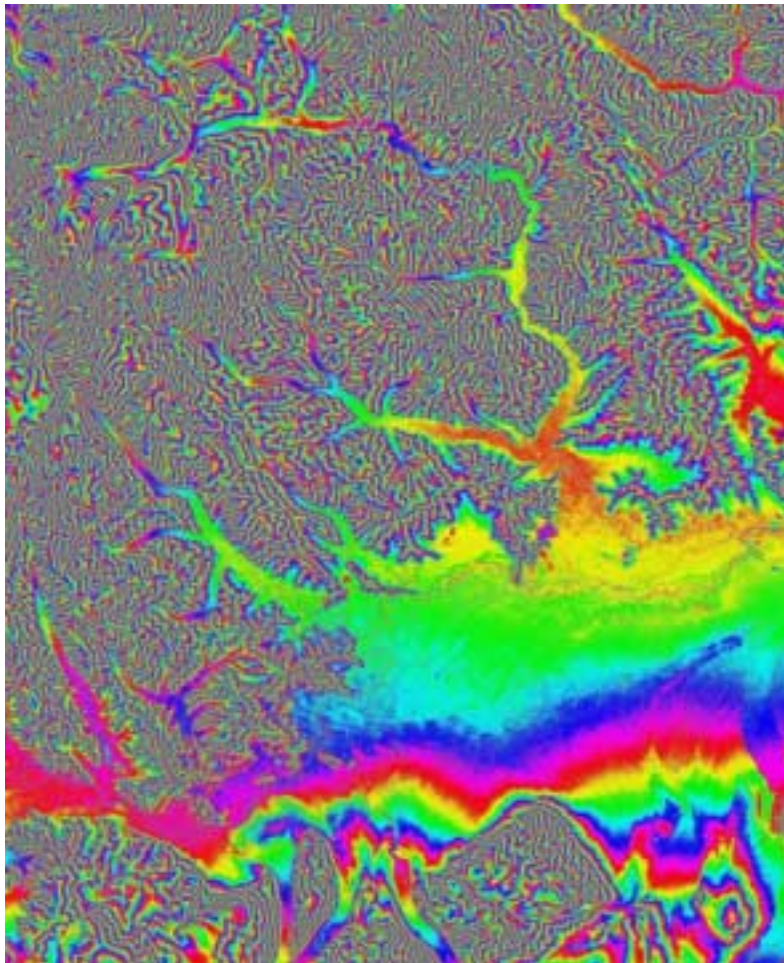
InSAR processing

Phase unwrapping

- multilooking of interferogram

- unwrapping with
  - snaphu (minimum cost flow algorithm)
  - escher (branch cut algorithm)

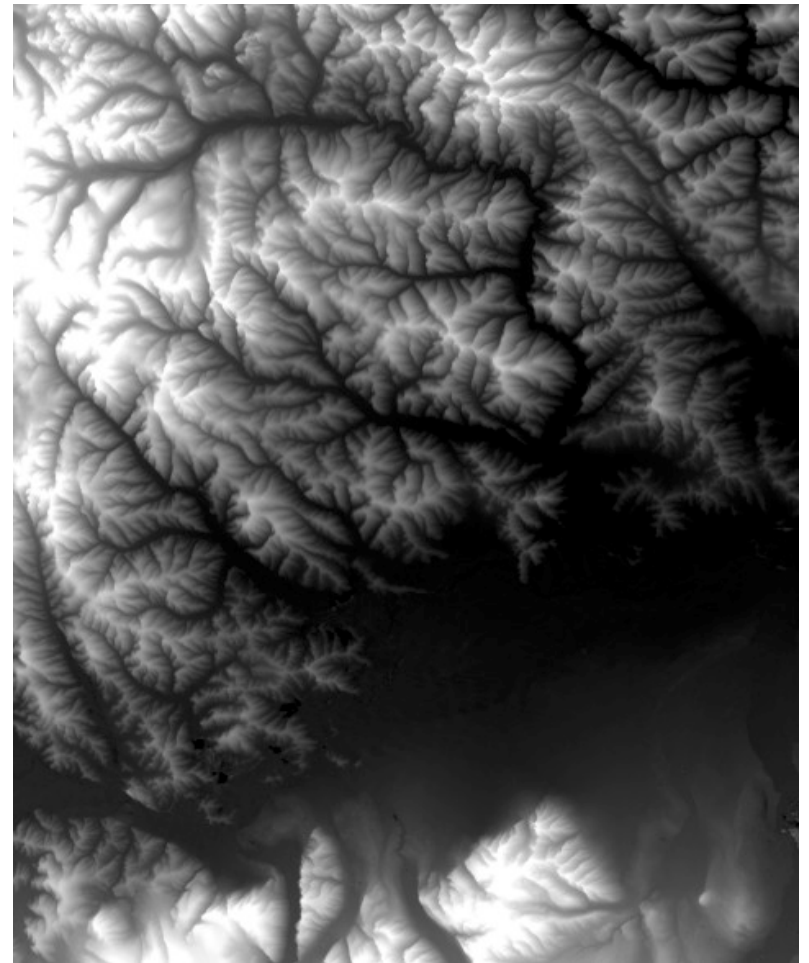- unwrapped phase related to height

InSAR DEM generation

Phase unwrapping

wrapped phase

unwrapped phase

InSAR DEM generation

InSAR processing

InSAR DEM generation

Data ingest	→	Average Doppler	→	Co-registration	→	Igram

Phase unwrapping	←	Sim. phase Seed points	←	Offset matching	←	Coherence image

Baseline refinement	→	Elevation	→	Elevation error	→	Geocoding

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Baseline refinement

- information used
  - unwrapped phase
  - baseline estimate
  - seed points
- iterative process

  Bn: -61.829628, Δ: 5.643837, Bp: 19.505440, Δ: -2.099306

  Bn: -61.527863, Δ: 5.565868, Bp: 19.777119, Δ: -2.117374

  Bn: -61.549664, Δ: 5.693950, Bp: 19.776737, Δ: -2.112025

  Bn: -61.550213, Δ: 5.695910, Bp: 19.776741, Δ: -2.111963

  Bn: -61.550186, Δ: 5.695967, Bp: 19.776741, Δ: -2.111965

InSAR DEM generation

InSAR processing

InSAR DEM generation

Data ingest → Average Doppler → Co-registration → Igram

Phase unwrapping ← Sim. phase Seed points ← Offset matching ← Coherence image

Baseline refinement → **Elevation** → Elevation error → Geocoding
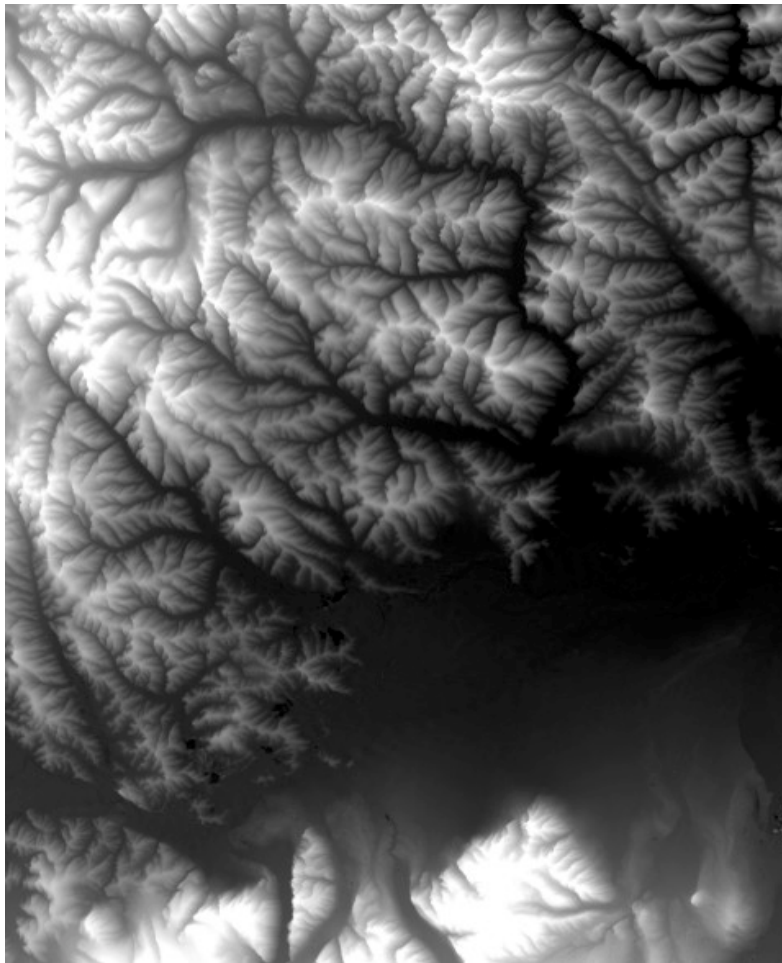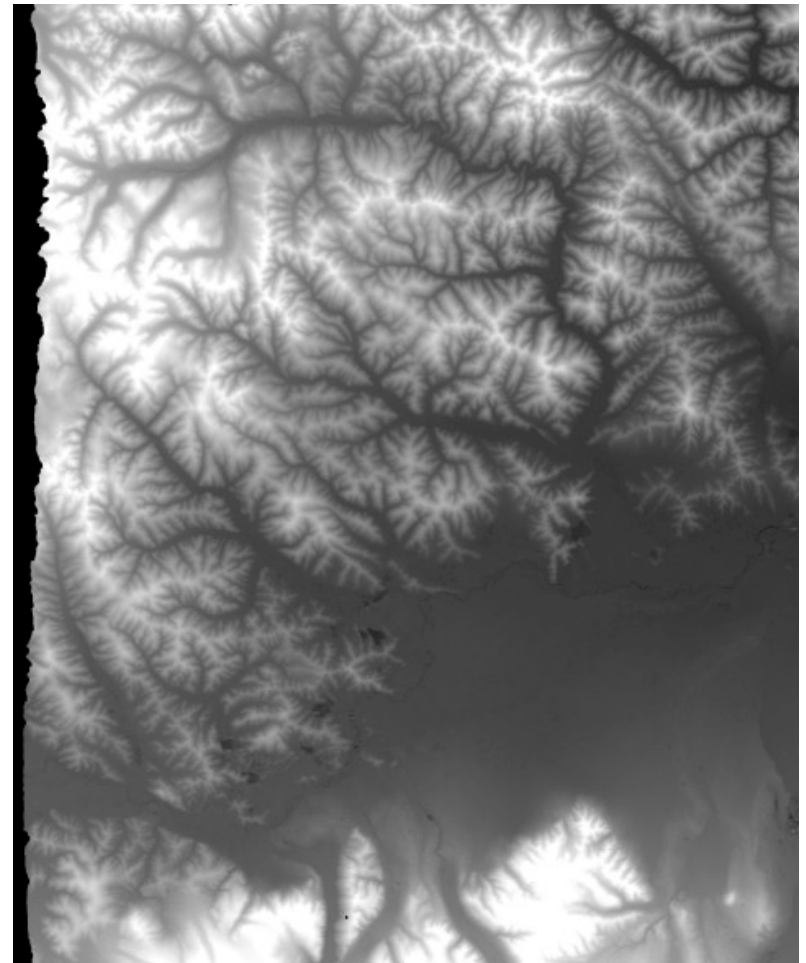
Elevation

InSAR DEM generation

Slant range elevation   Ground range elevation

InSAR processing

InSAR DEM generation

```
┌──────────┐    ┌──────────┐    ┌──────────────┐    ┌──────────┐
│  Data    │ →  │ Average  │ →  │    Co-       │ →  │  Igram   │
│  ingest  │    │ Doppler  │    │ registration │    │          │
└──────────┘    └──────────┘    └──────────────┘    └──────────┘
                                                           │
                                                           ↓
┌──────────────┐  ┌──────────────┐  ┌──────────┐    ┌──────────────┐
│   Phase      │← │ Sim. phase   │← │ Offset   │←   │ Coherence    │
│ unwrapping   │  │ Seed points  │  │ matching │    │  image       │
└──────────────┘  └──────────────┘  └──────────┘    └──────────────┘
       │
       ↓
┌──────────────┐  ┌──────────┐    ┌──────────────┐  ┌──────────┐
│  Baseline    │→ │Elevation │ →  │ Elevation    │→ │Geocoding │
│ refinement   │  │          │    │   error      │  │          │
└──────────────┘  └──────────┘    └──────────────┘  └──────────┘
```

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ASF

Elevation error
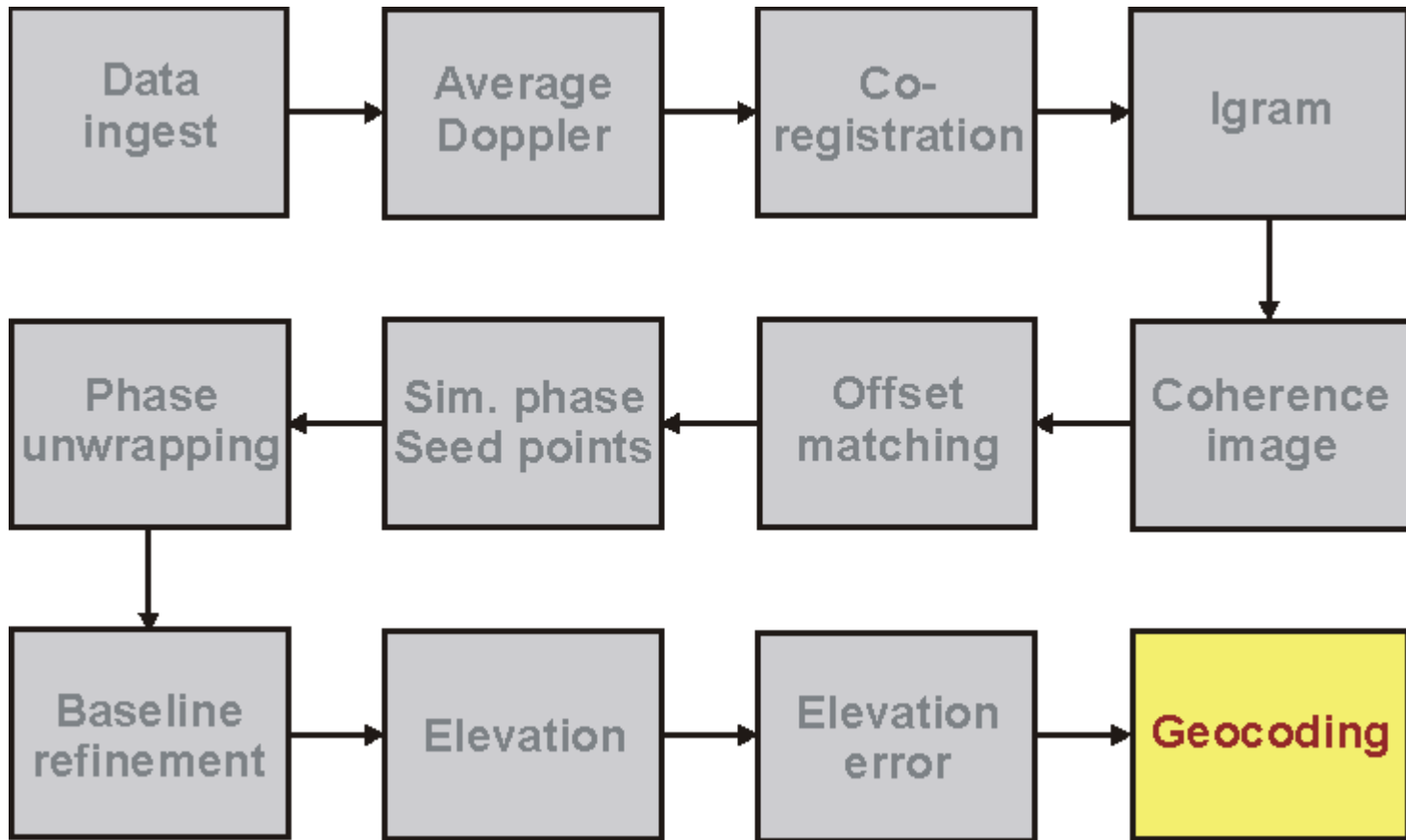

- estimate base on
  - initial height error estimate
  - baseline induced height
  - baseline
  - "flat earth" look deviation
  - coherence

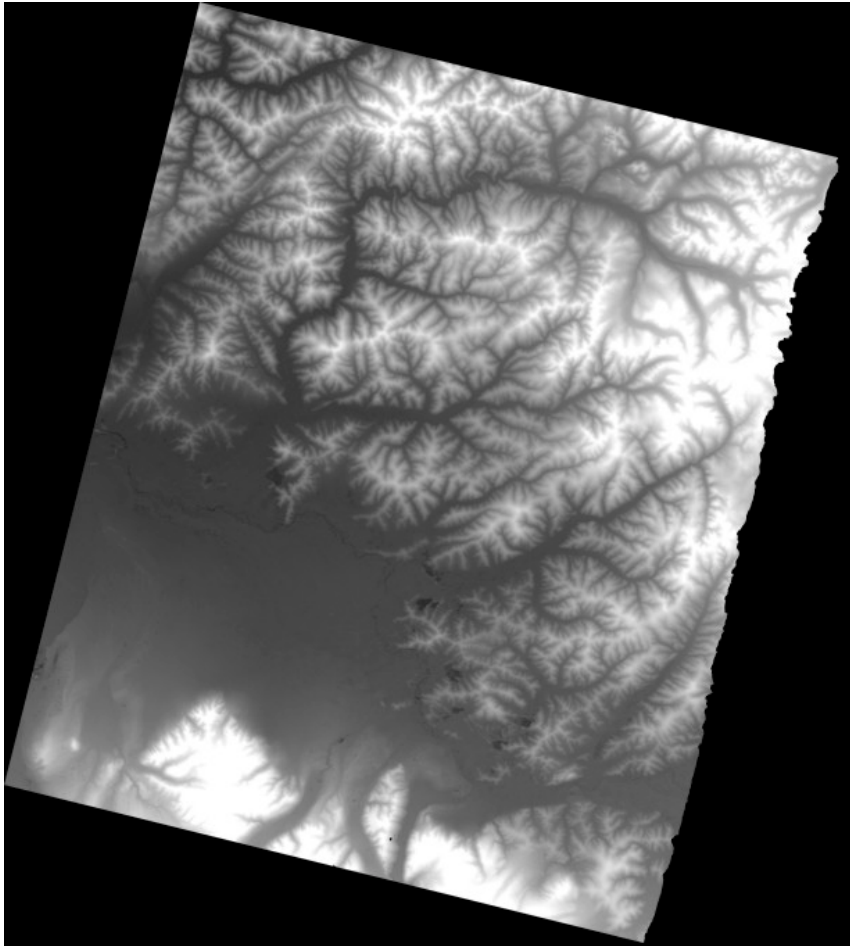InSAR DEM generation

InSAR processing

Geocoding

- final product
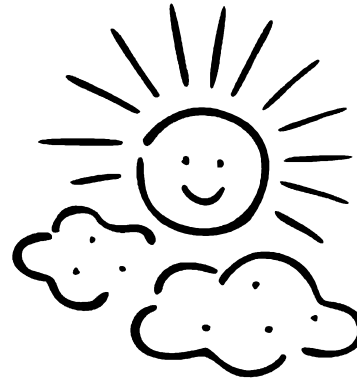
- map projected
  - UTM
  - Albers
  - polar stereo

InSAR DEM generation

Problems?

Talk to Rick !

Questions