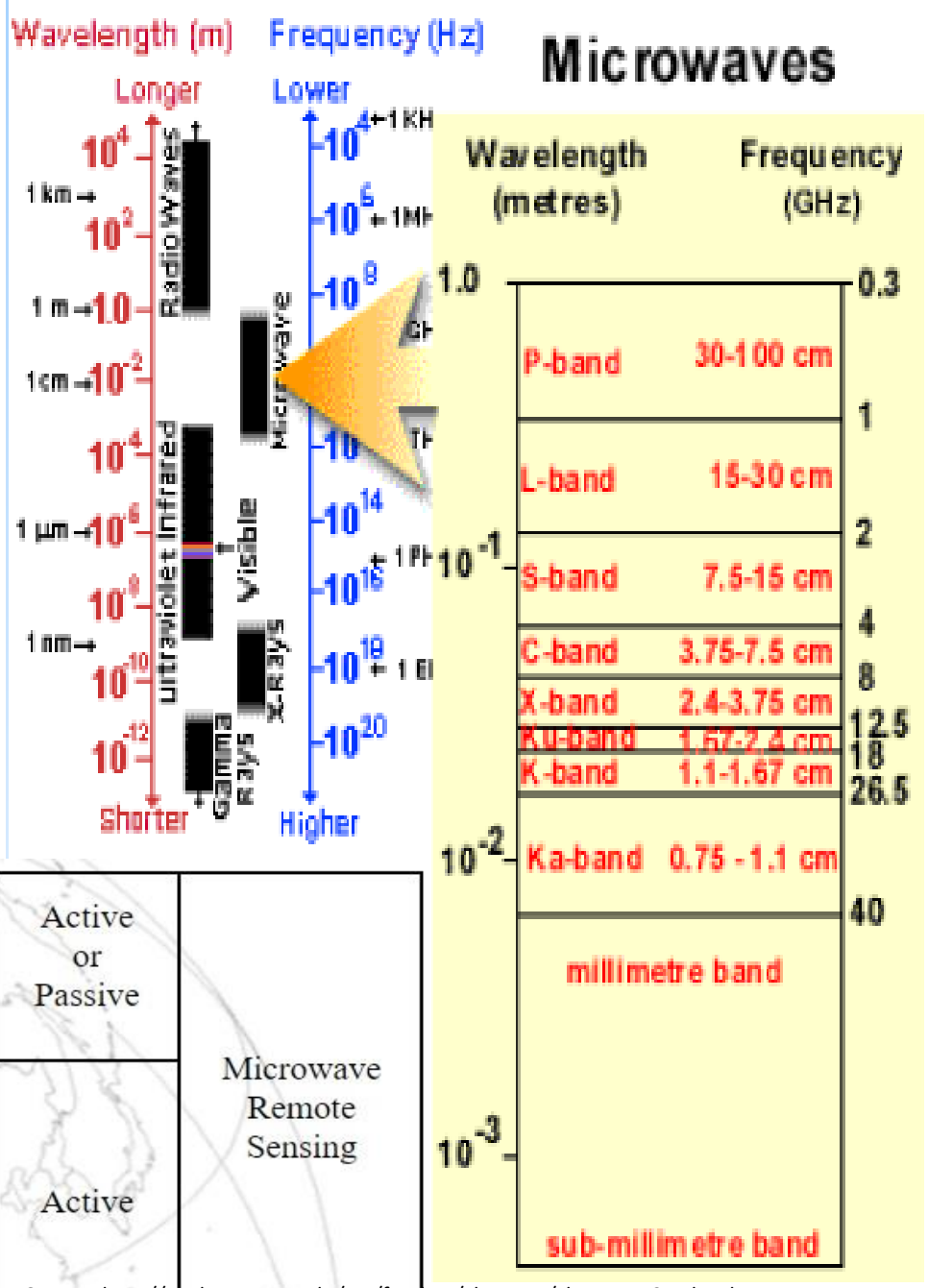
# Deriving velocity of the Polar Record Glacier, east Antarctica using SAR interferometry

Prashant H. Pandit

# Introduction

Synthetic Aperture Radar interferometry (InSAR) is the dominant practice for the measurement of topography of the earth surface. It is an active microwave radar imaging system, which works on Doppler motion principle.




| | | | | |
|---|---|---|---|---|
| Microwave | 0.1 to 30 cm | Longer wavelengths can penetrate clouds, fog, and rain. Images may be acquired in the active or passive mode. | Active or Passive | Microwave Remote Sensing |
| Radar | 0.1 to 30 cm | Active form of microwave remote sensing. Radar images are acquired at various wavelength bands. | Active | |
| Radio | > 30 cm | Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelength operate in this region. | | |

Source:-http://sar.kangwon.ac.kr/etc/fundam/chapter1/chapter1_3_e.html

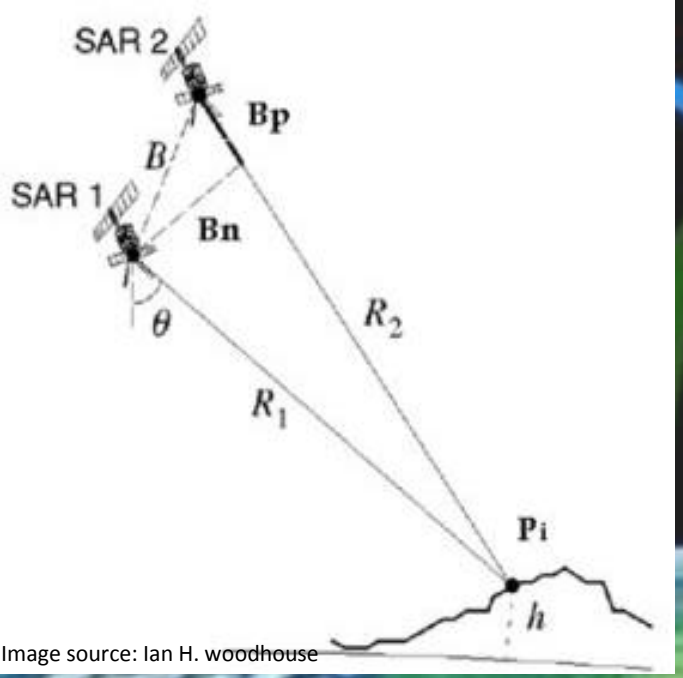
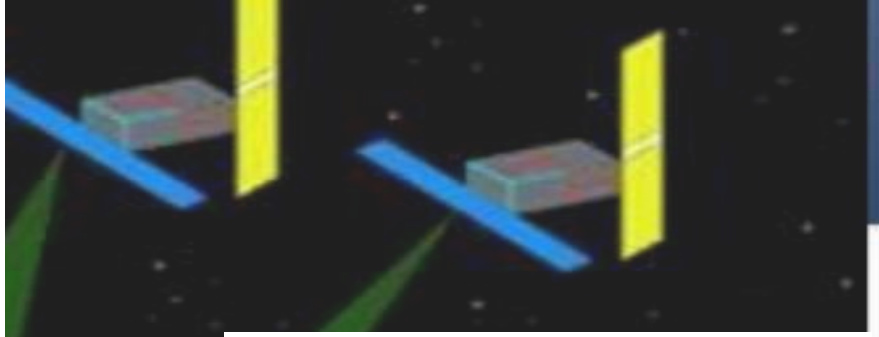



Image source: Ian H. woodhouse



# Interferometric SAR (InSAR)

Two SAR images are required
Both the images should be collected with same SAR geometry

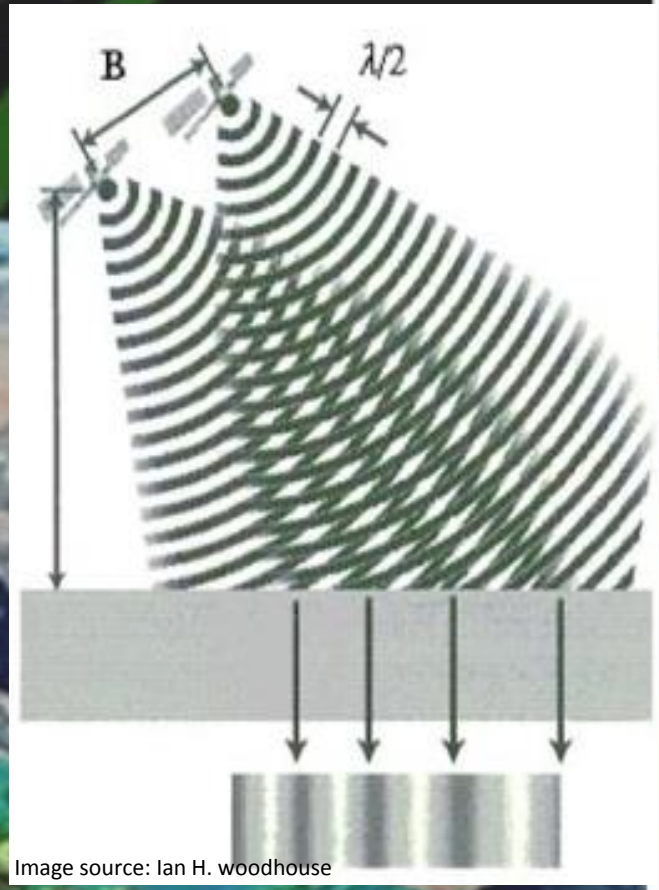



Image source: Ian H. woodhouse

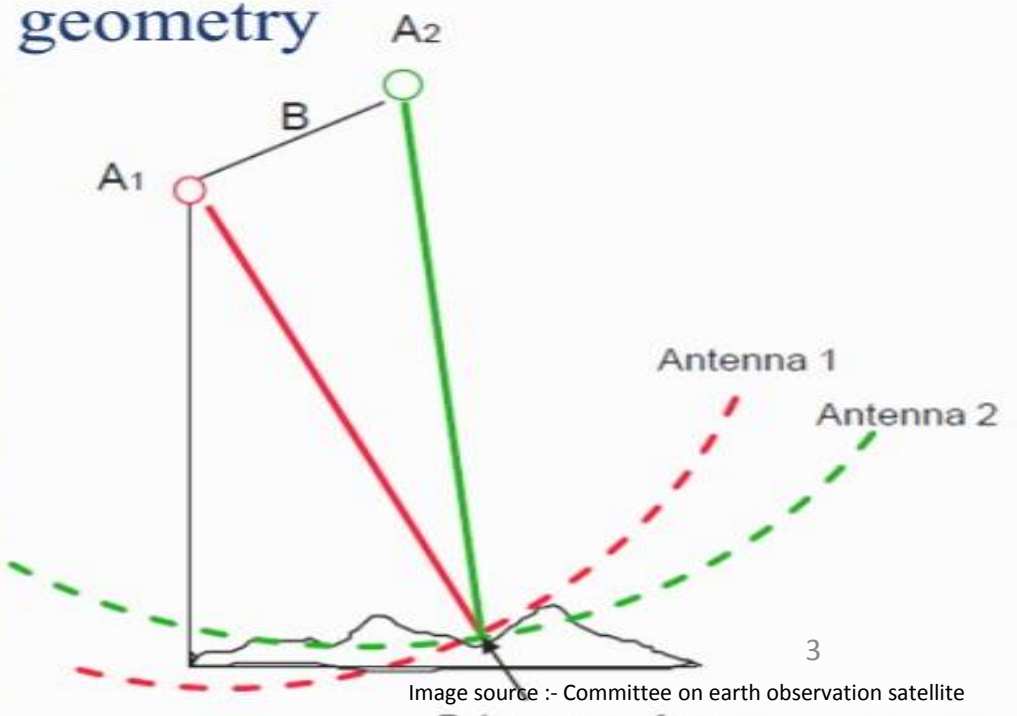
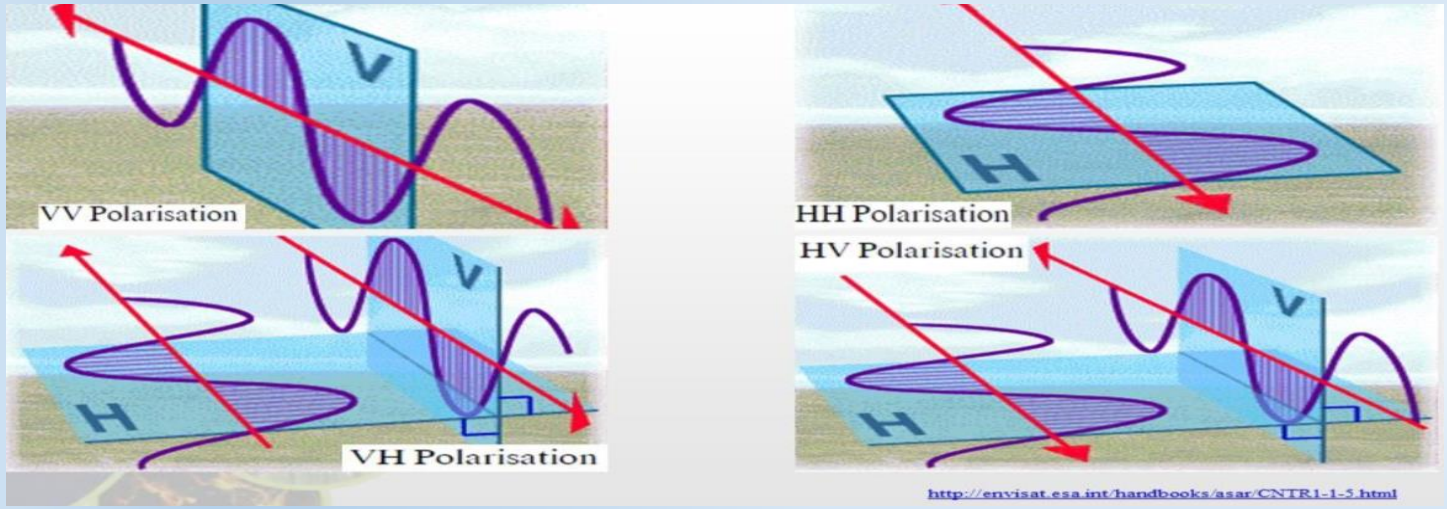


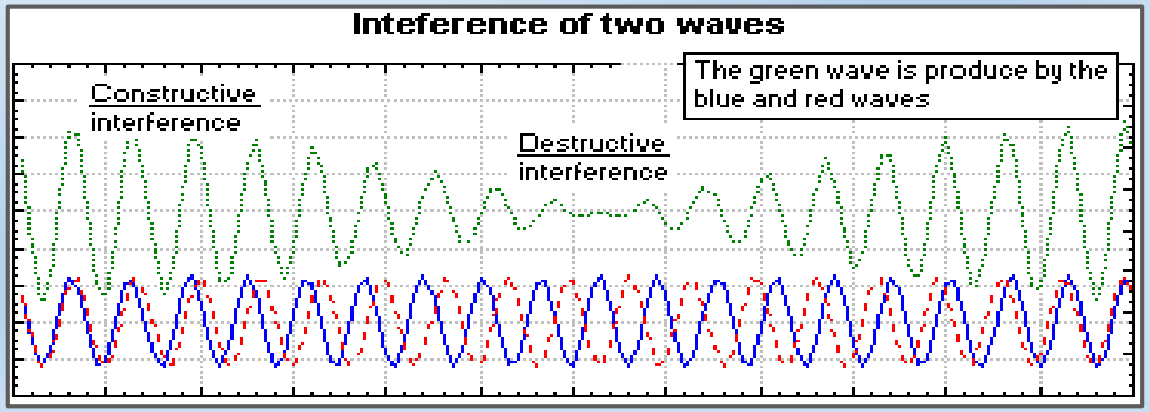

Image source :- Committee on earth observation satellite

**Coherence** : - A prerequisite for waves to interfere is that they are *coherent*. Two waves with a phase difference that remains constant over time, are said to be coherent.

**Polarization**:- A parameter that describes the direction in which the oscillations are taking place. The pulse of the energy is filtered so that its electrical wave vibrations are only in single plane  that is perpendicular to direction of travel.




**Interference**:- The superposition of waves in called interference.



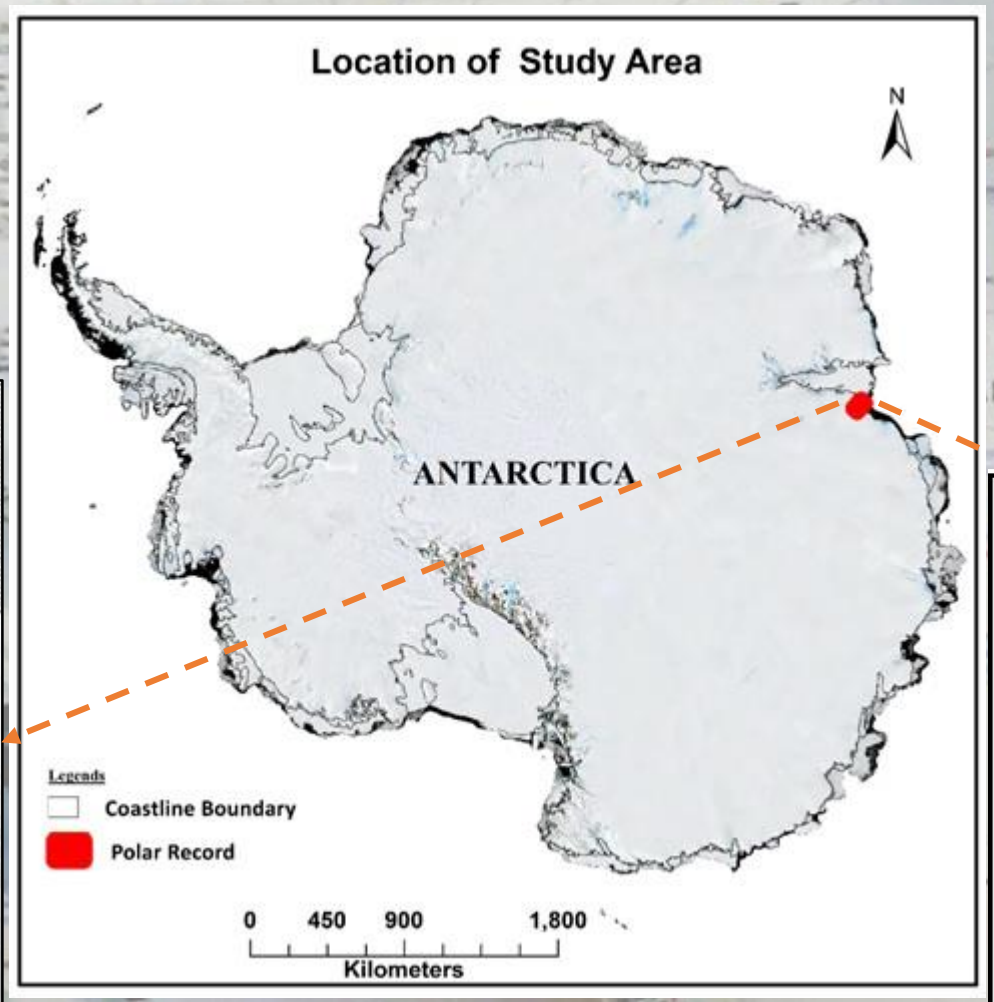
# Objectives

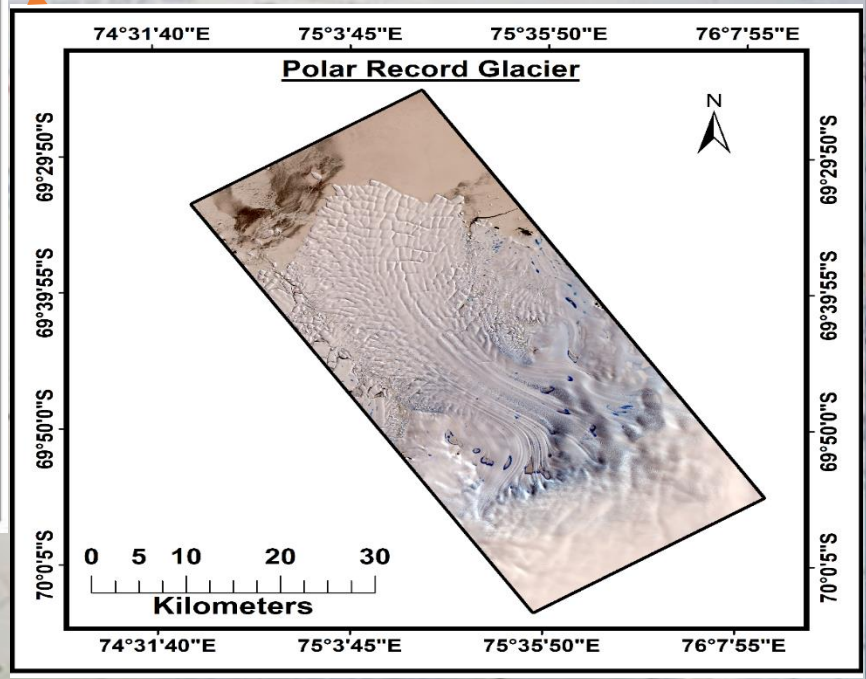
To Estimate the glacier velocity of Polar record glacier.

- Secondary- Objectives
  - To study temporal velocity changes.
  - To quantify the changes occurred within the region.

# Study Area


Image Source:- Mellor et.al



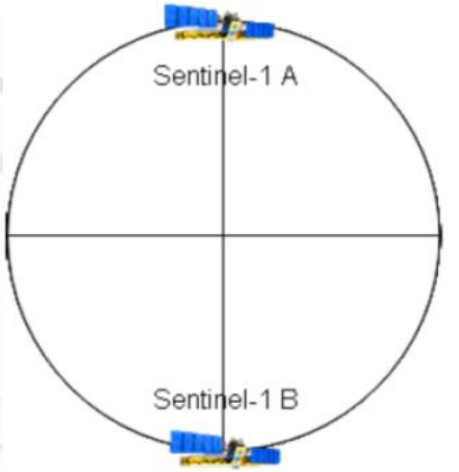
# Data

Different Missions

| Mission | Agency | Band | Polarization |
|---|---|---|---|
| **SEASAT** | JAXA | L(23.5 cm, 1.275 GHZ) | HH |
| **JERS-1** | JAXA | L(23.5 cm, 1.275 GHZ) | HH |
| **ERS-1** | ESA | C(5.7 cm, 5.25 GHZ) | VV |
| **ERS-2** | ESA | C(5.7 cm, 5.25 GHZ) | VV |
| **ENVISAT** | ESA | C(5.7 cm, 5.25 GHZ) | Multiple |
| **RADARSAT** | CSA | C(5.7 cm, 5.35 GHZ) | HH |
| **RISAT-2** | ISRO | X(3.1cm, 9.59GHz) | HH, HV, VH, VV |
| **ALOS PALSAR** | JAXA | L(22.9cm,1.2GHz) | Multiple |
| **RISAT-1** | ISRO | C(5.35GHz) | Multiple |
| **SENTINEL-1** | ESA | C(5.5 cm, 5.405GHZ) | Multiple |

Sentinel-1 Specification

| Parameters | Specification |
|---|---|
| **Central Frequency** | 5.405 GHz |
| **Wavelength** | 5.6cm |
| **Look Direction** | Right |
| **Temporal** | 12 days |
| **Incident Angle** | 20º-46º |
| **Antenna Size** | 12.3 m x 0.821 m |
| **Interferometric Wide Mode** | |
| **Polarization** | HH+HV, VV+HV, **HH**, VV |
| **Azimuth Resolution** | 20m |
| **Ground range resolution** | 5m |
| **Azimuth and Rang look** | Single |
| **Swath** | 250km |




Sentinel-1 is European Radar Satellite, representing the first new space component of the Copernicus programme (earlier it was known as GMES- Global Monitoring for Environment and Security) launched by European Space Agency.

# Images used for Polar Record Glacier

| Mission | Acquisition date | Orbit no | Id | Unique identifier | Flight Direction |
|---|---|---|---|---|---|
| S1A | 07-08-2016 | 012500 | 0138DA | DA1D | Descending |
| S1A | 19-08-2016 | 012675 | 013E9C | 7FB2 | Descending |
| S1A | 31-08-2016 | 012850 | 01448E | 27DE | Descending |
| S1A | 12-09-2016 | 013025 | 014A22 | 2258 | Descending |
| S1A | 18-10-2016 | 013550 | 015B08 | 93BF | Descending |
| S1A | 11-11-2016 | 013900 | 0165F4 | 9EDC | Descending |
| S1A | 05-12-2016 | 014250 | 0170BC | 4526 | Descending |
| S1A | 29-12-2016 | 14600 | 017BB9 | C3E0 | Descending |
| S1A | 22-01-2017 | 014950 | 018671 | 6B79 | Descending |
| S1B | 30-09-2016 | 002304 | 003E57 | 540C | Descending |
| S1B | 24-10-2016 | 002654 | 0047CC | A1F8 | Descending |
| S1B | 05-11-2016 | 002829 | 004CA8 | F585 | Descending |
| S1B | 17-11-2016 | 003004 | 0051B4 | 7BAB | Descending |
| S1B | 11-12-2016 | 003354 | 005BA9 | C91B | Descending |
| S1B | 04-01-2017 | 003704 | 0065D5 | 6C7B | Descending |
| S1B | 21-02-2016 | 004404 | 007A9F | C99D | Descending |

# Methodology

**Data selection** → **Data Processing** → **Product validation**

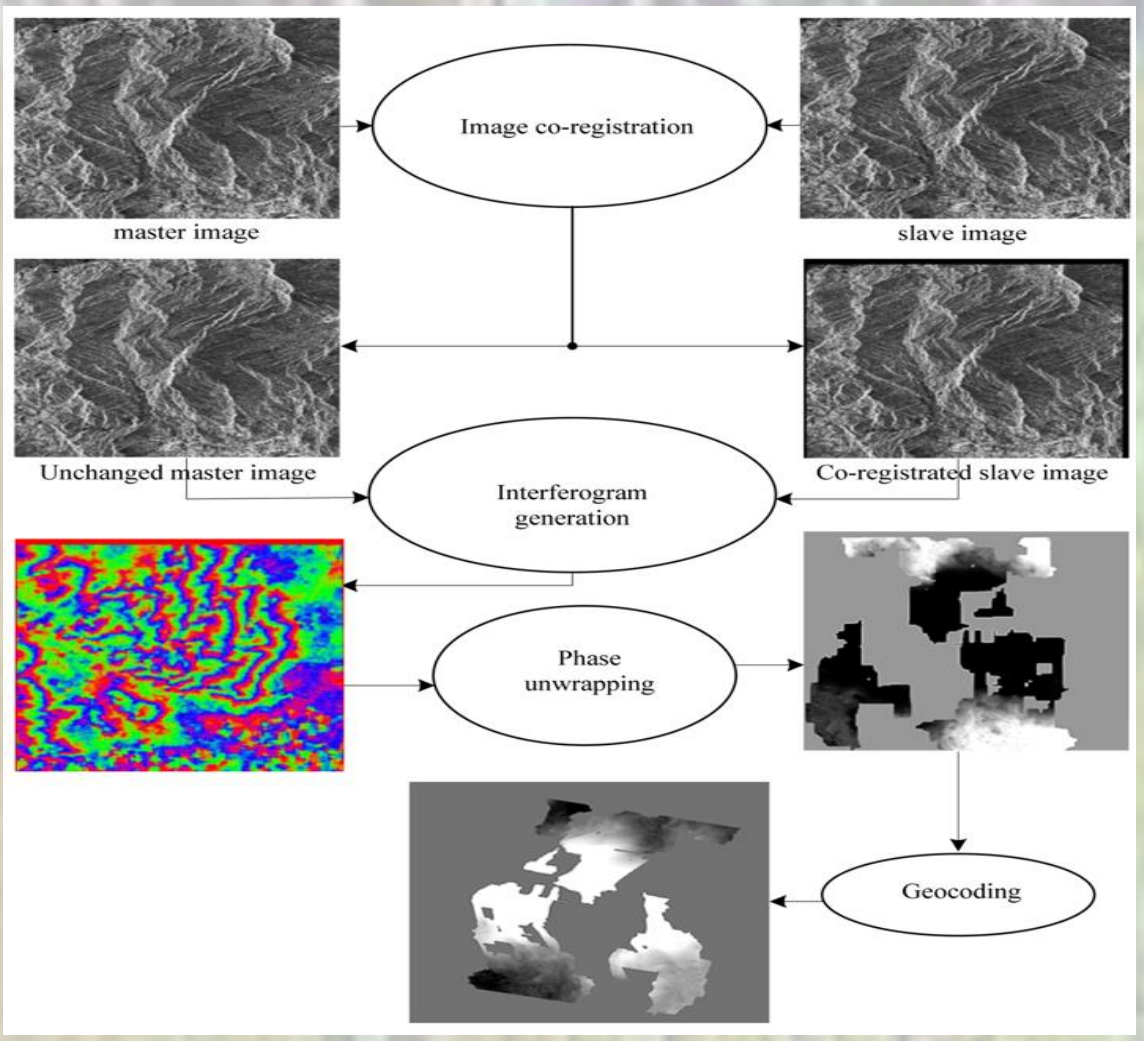



Image Source: Zou et.al 2009

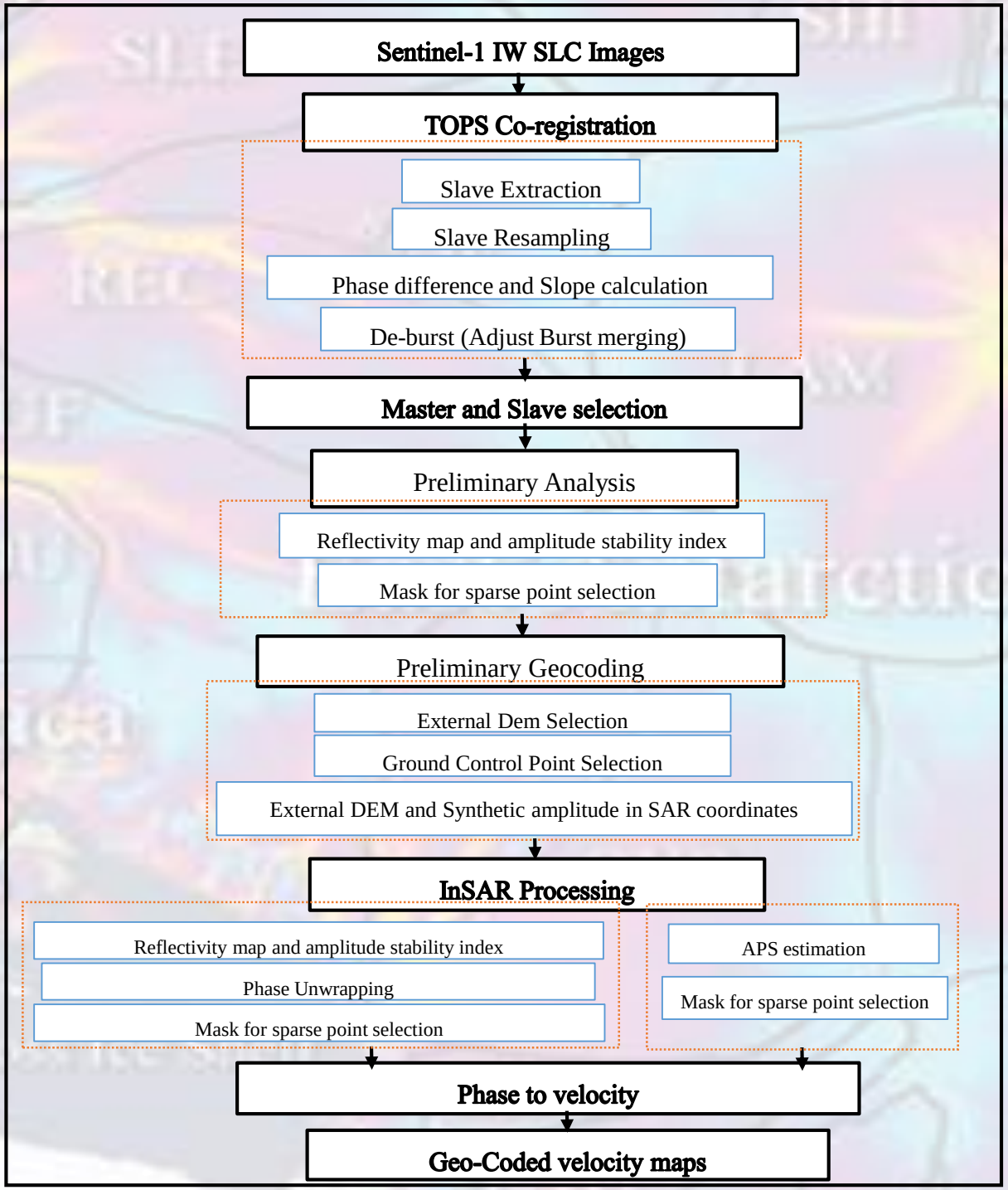
Image Co-Registration

Interferogram Generation

Phase Unwrapping

Phase to Height/Displacement conversion

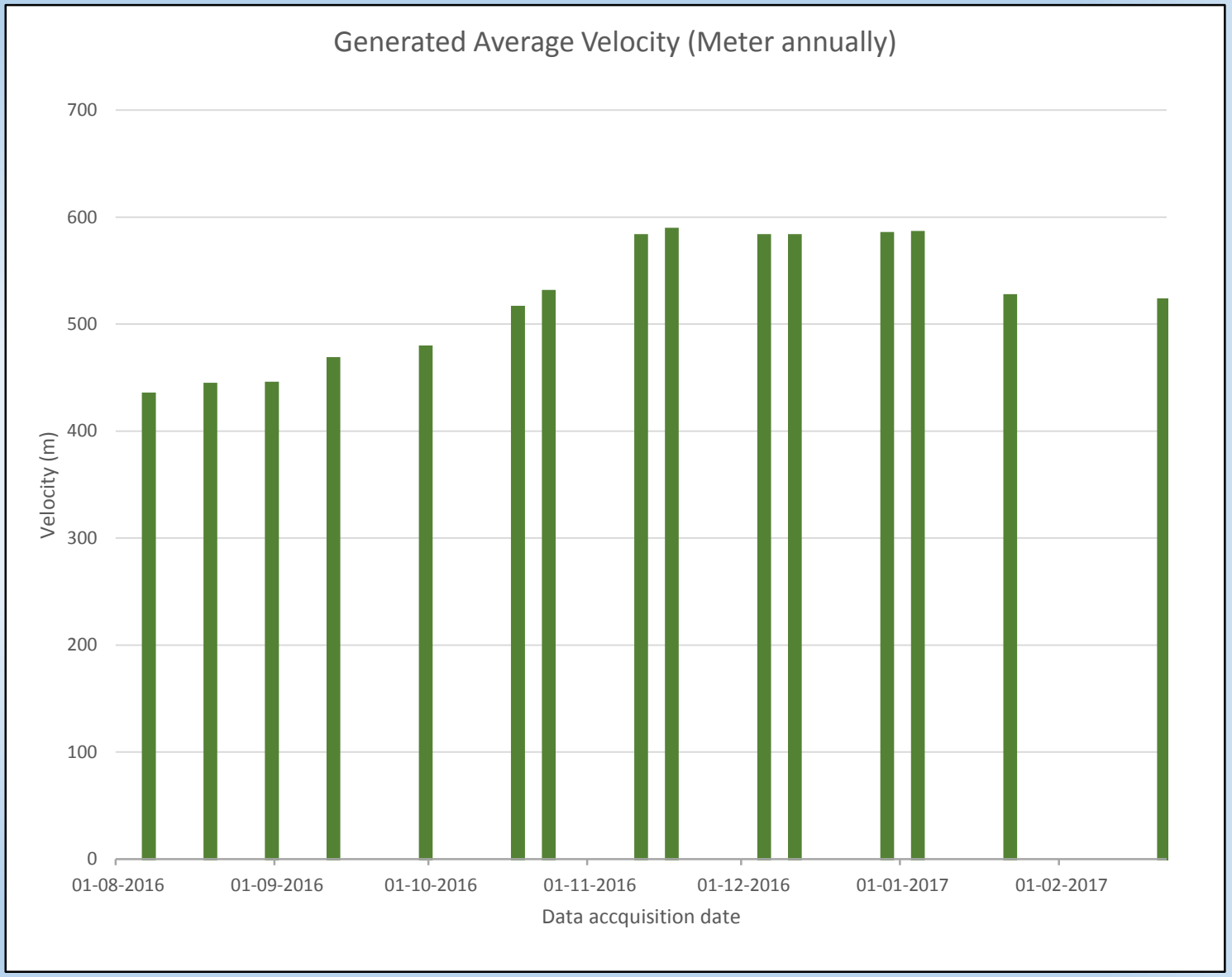
Geocoding


Sentinel-1 IW SLC Images
TOPS Co-registration
Slave Extraction
Slave Resampling
Phase difference and Slope calculation
De-burst (Adjust Burst merging)
Master and Slave selection
Preliminary Analysis
Reflectivity map and amplitude stability index
Mask for sparse point selection
Preliminary Geocoding
External Dem Selection
Ground Control Point Selection
External DEM and Synthetic amplitude in SAR coordinates
InSAR Processing
Reflectivity map and amplitude stability index
Phase Unwrapping
Mask for sparse point selection
APS estimation
Mask for sparse point selection
Phase to velocity
Geo-Coded velocity maps

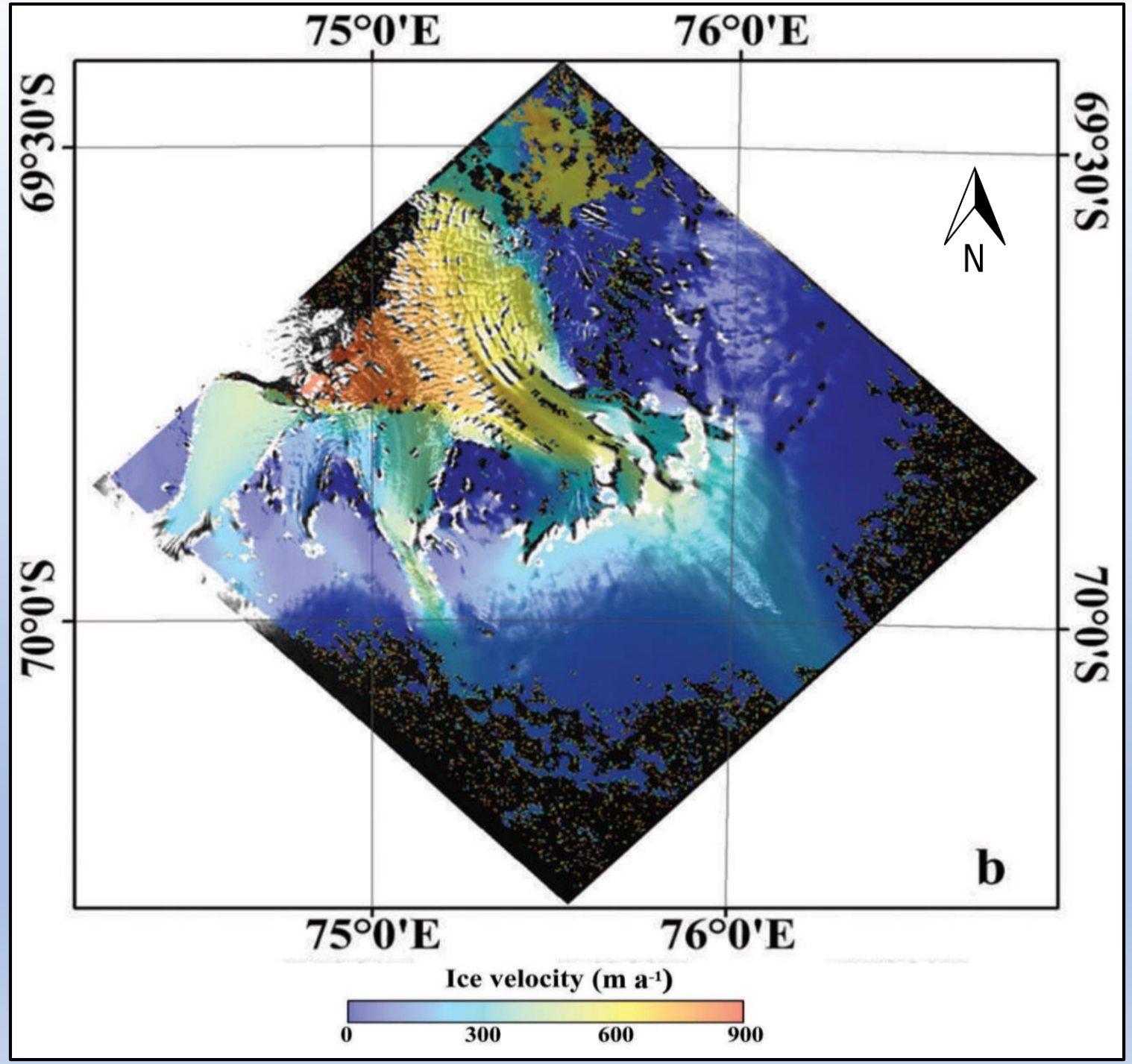
# Results (Velocity)

Velocity result for Polar Record Glacier

| Dates | Generated Average Velocity (Meter annually) |
|---|---|
| 07-08-2016 | 432 |
| 19-08-2016 | 441 |
| 31-08-2016 | 442 |
| 12-09-2016 | 465 |
| 30-09-2016 | 476 |
| 18-10-2016 | 513 |
| 24-10-2016 | 528 |
| 05-11-2016 | 0 |
| 11-11-2016 | 580 |
| 17-11-2016 | 586 |
| 05-12-2016 | 580 |
| 11-12-2016 | 580 |
| 29-12-2016 | 582 |
| 04-01-2017 | 583 |
| 22-01-2017 | 524 |
| 21-02-2017 | 520 |



Velocity result for PRG



# Conclusion

**In case of velocity calculation**

- The velocity of PRG is approx. 3m per day in tongue portion and nearly 1m at upper inland part, eastern part having slower rate than the western part.
- Estimated average velocity of the PRG is approximated to be ≈400 m/year which varies from ≈100 to ≈700 m/year. This study found that PRG moves with a velocity of ≈700m/year in lower parts whereas the upper inland area flows with a velocity of ≈200m/year. The western part of the glacier is moving faster in comparison with the eastern part of the glacier.


धन्यवाद