Burnt area assessment using Sentinel 1A/B SAR and high resolution Planetscope data over South/Southeast Asia

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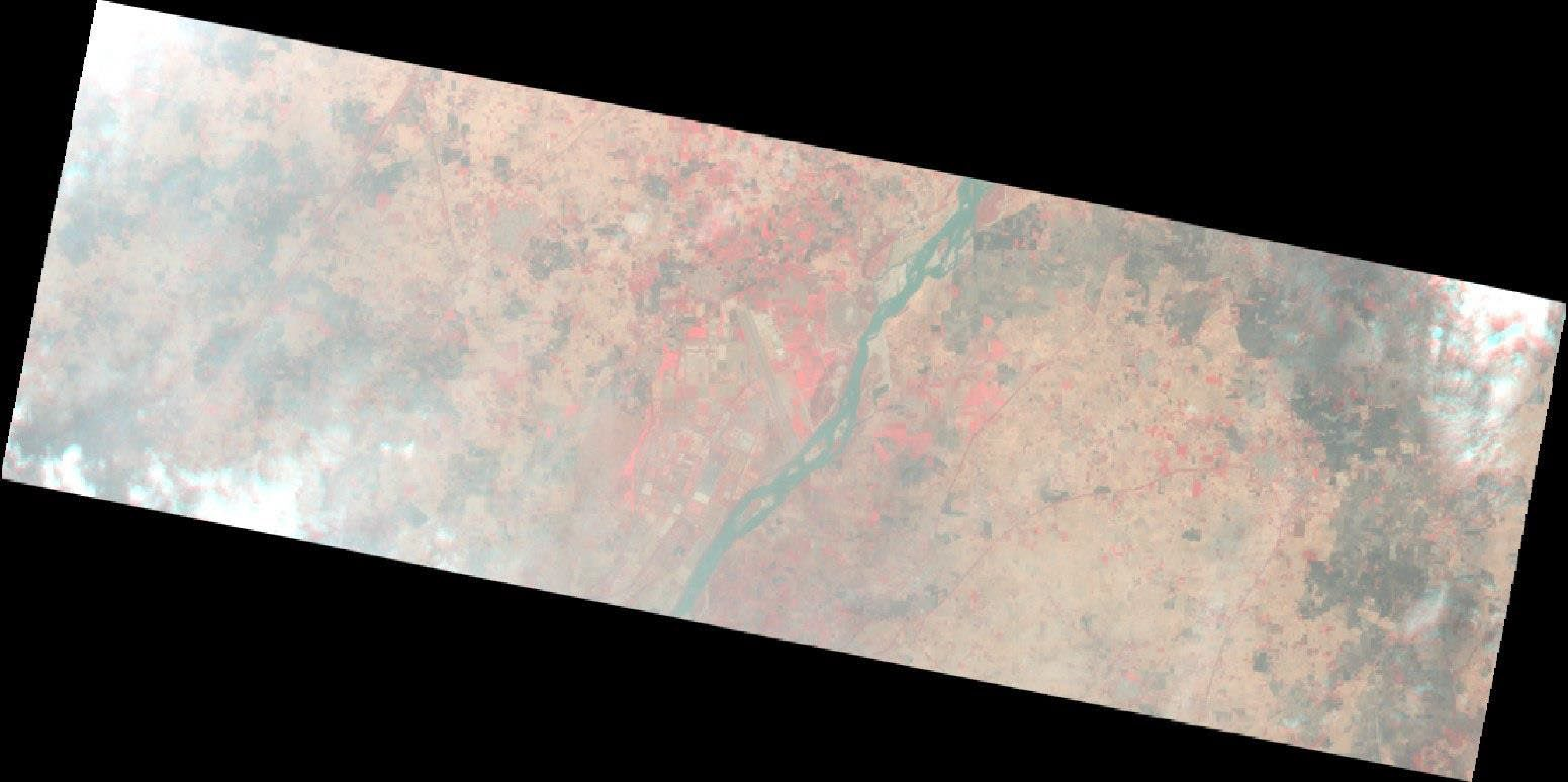
Presentation Summary

- Planetscope data and burnt areas
- SAR data and burnt areas
  - Backscatter variations
  - Incident angle variations
  - BA processing steps and BA’s



Planetscope 2018-05-12 (RGB) Surface Reflectance (RGB)

First step – Image Correction

$$h(v) = \mathrm{round}\left(\frac{cdf(v) - cdf_{min}}{(M \times N) - cdf_{min}} \times (L - 1)\right)$$

Image normalized based on the cumulative distribution function

MXN = image pixels width and height

L = grey levels

This simple approach was OK for some scenes, but not all others. They needed robust atmospheric correction

Planetscope Surface Reflectance Products - Scope for improvement

https://assets.planet.com/marketing/PDF/Planet_Surface_Reflectance_Technical_White_Paper.pdf

Search

160%

average of the AOD values within that region. When looking up reflectance values from the LUTs, tables with the closest matching values of water vapor and ozone concentrations are used. Tables built with the two closest solar zenith angles are interpolated between and a linear interpolation is performed for AOD and TOA reflectance. Since Planet satellites are nadir pointing, zenith angle is fixed at 0 degrees.

PRODUCT LIMITATIONS

The Planet Surface Reflectance V1 product corrects for the effects of the Earth's atmosphere, accounting for the molecular composition and variation with altitude along with aerosol content. Combining the use of standard atmospheric models with the use of MODIS water vapor, ozone and aerosol data, this provides reliable and consistent surface reflectance scenes over Planet's varied constellation of satellites as part of our normal, on-demand data pipeline. However, there are some limitations to the corrections performed:

- In some instances there is no MODIS data overlapping a Planet scene or the area nearby. In those cases, AOD is set to a value of 0.226 which corresponds to a "clear sky" visibility of 23km, the `aot_quality` is set to the MODIS "no data" value of 127, and `aot_status` is set to 'Missing Data - Using Default AOT'. If there is no overlapping water vapor or ozone data, the correction falls back to a predefined 6SV internal model.
- The effects of haze and thin cirrus clouds are not corrected for.
- Aerosol type is limited to a single, global model.
- All scenes are assumed to be at sea level and the surfaces are assumed to exhibit Lambertian scattering - no BRDF effects are accounted for.
- Stray light and adjacency effects are not corrected for.

PRODUCT ASSESSMENT

With Planet's constellation of satellites, farming regions can be revisited on a nearly daily basis enabling real time monitoring of crop health and insights on day to day changes in the fields. Combined with the physics-based atmospheric correction methodology used to produce the Planet SR product, crops can be monitored with a high degree of precision. The following section details an assessment of the SR Product for temporal monitoring of crops and an assessment of the correction on derived indices and band reflectances as compared to the Landsat

Planet Scope – Surface Reflectance Products

Scope for improvement

-**Aerosol model used by Planet:** Continental Type (uniform across the world) –

Urban type preferred when close to N.Delhi

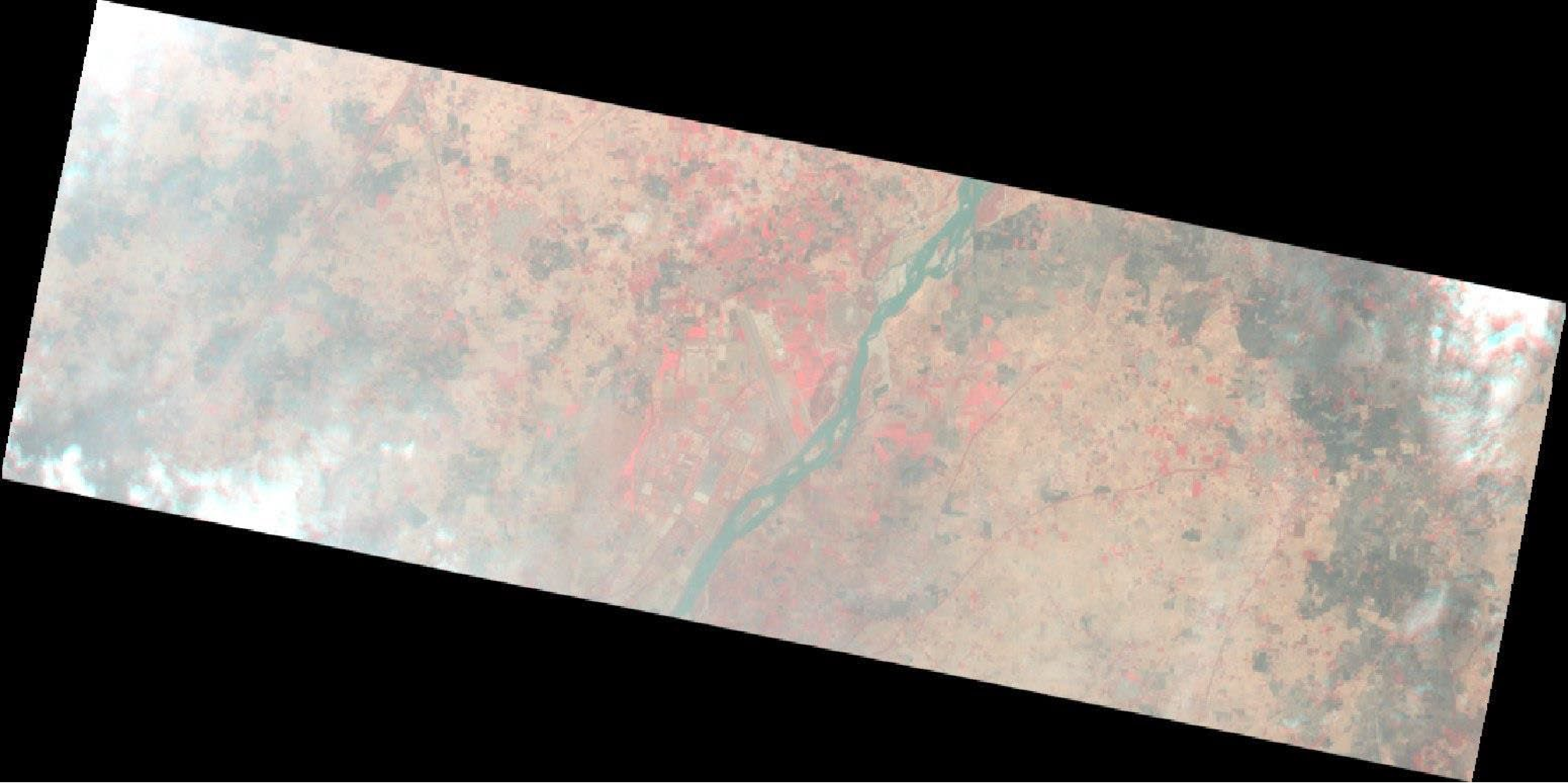
-**Effects of Haze and thin cirrus clouds not corrected in the Planet Surface Reflectance**

-**Also, adjacency effects not corrected for**

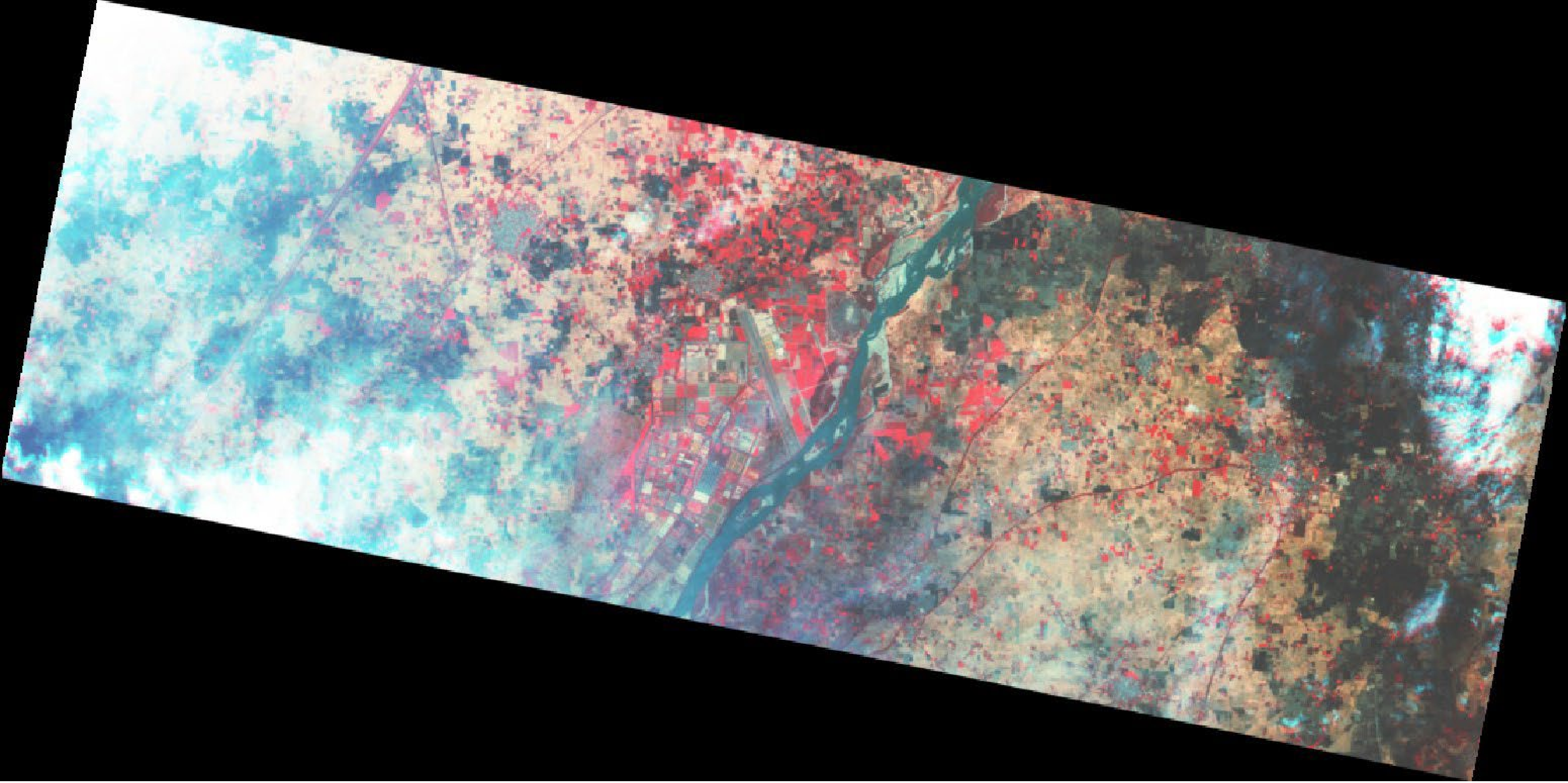
Atmospheric Correction - 6SV Improved Parameterization

Improved Atmospheric Correction - Ran 6SV with following parameterization

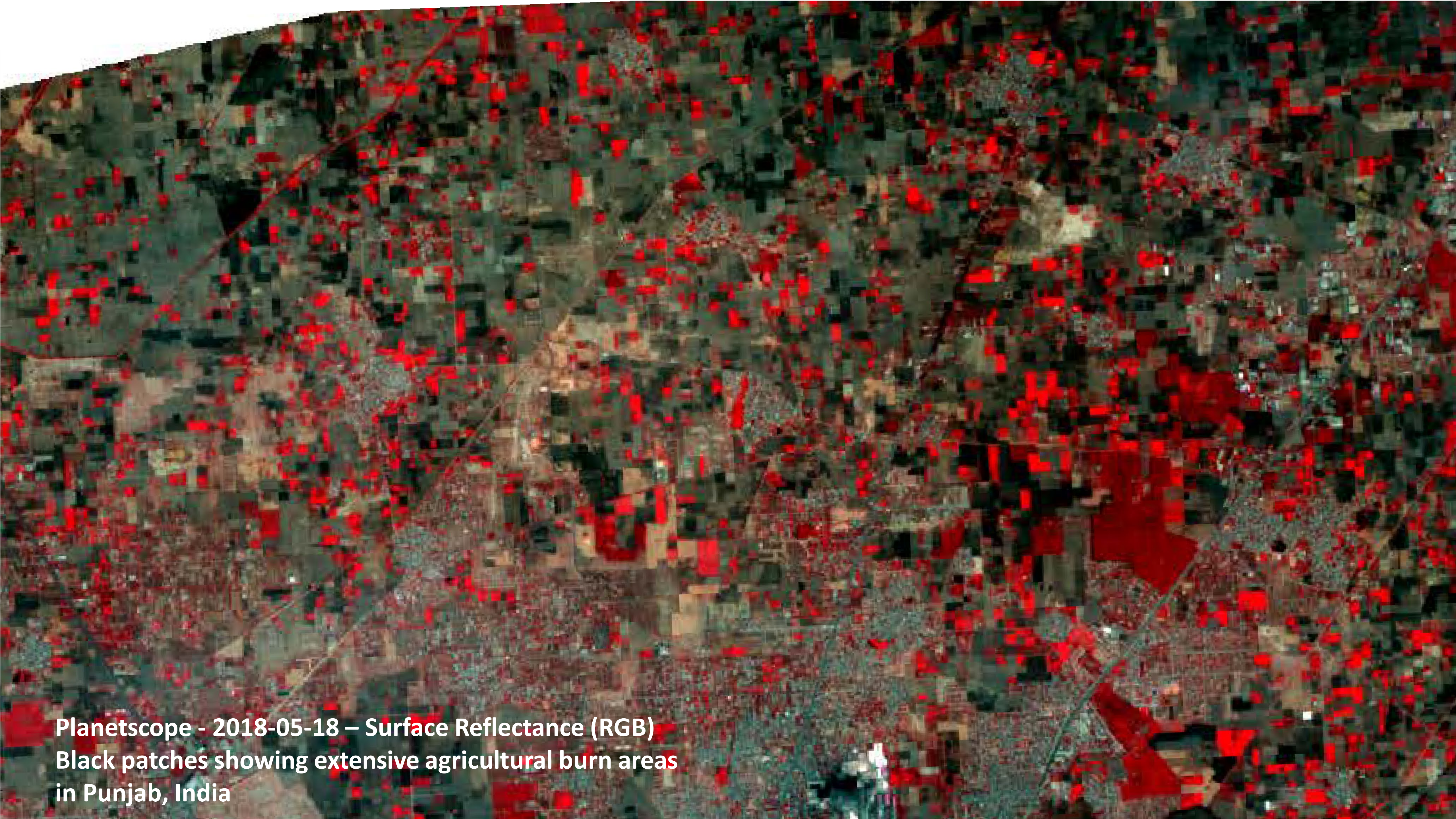
- Separate Aerosols for Rural and Urban
- 2-different atmospheres – summer and winter
- Different types of ozone concentration – summer and winter
- Different amounts of water vapor column – summer and winter



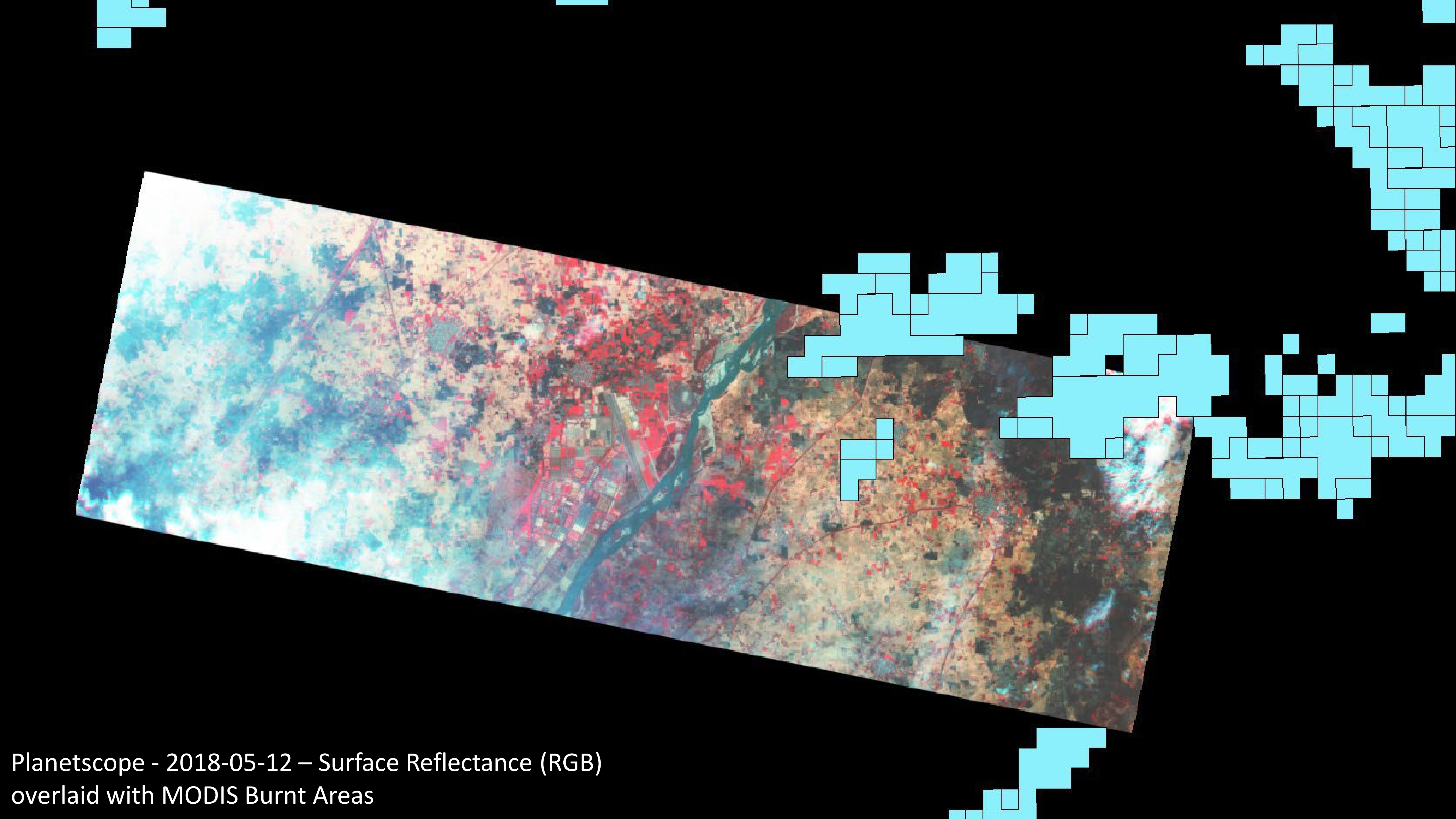
Planetscope 2018-05-12 (RGB) Surface Reflectance (RGB)



Planetscope 2018-05-12 (RGB) Surface Reflectance (RGB) - After Atmsopheric Correction improvement in SR : (B=28%; G=23.6; R=21%; NIR=26%)

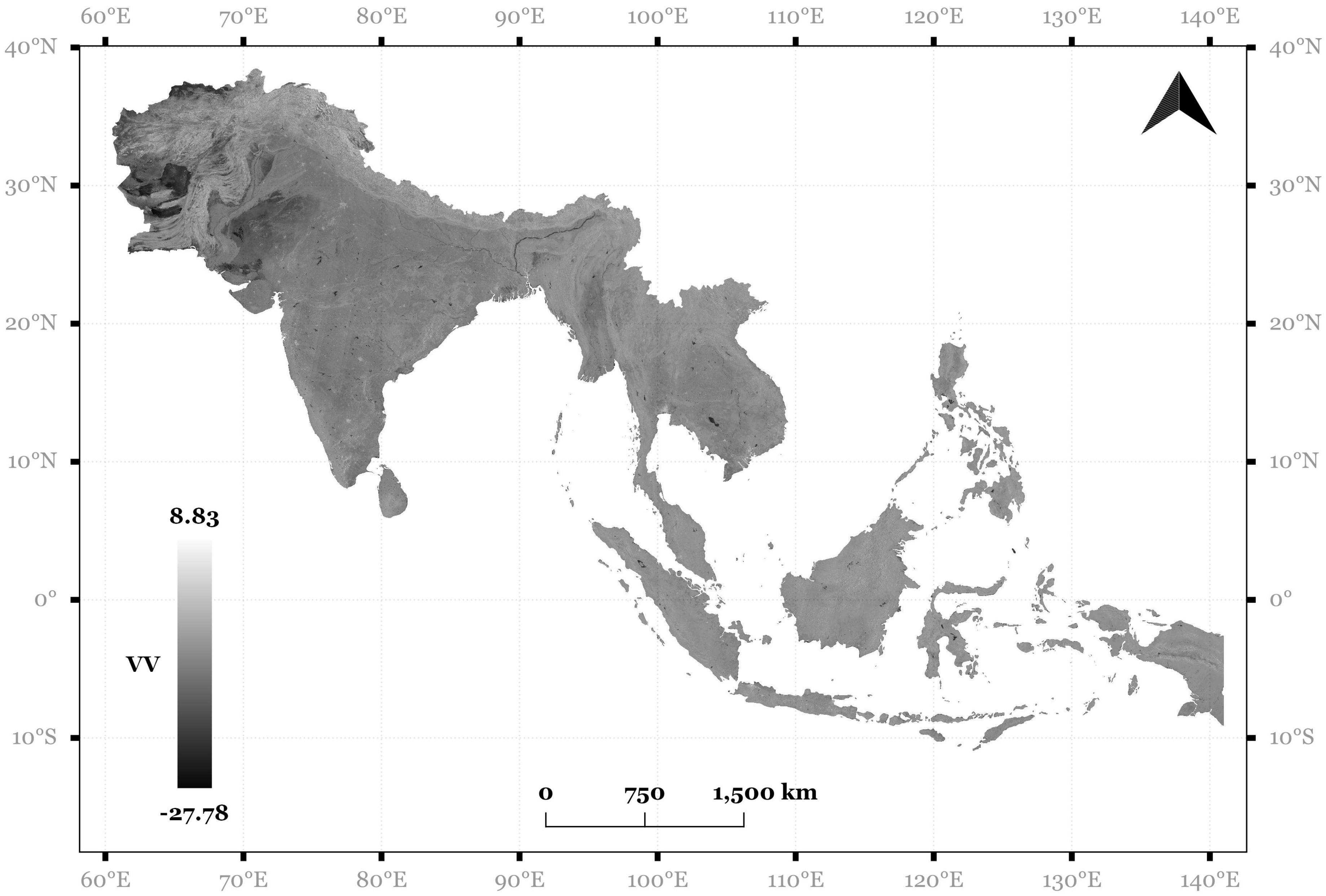


Planetscope - 2018-05-18 – Surface Reflectance (RGB)
Black patches showing extensive agricultural burn areas
in Punjab, India



Planetscope - 2018-05-12 – Surface Reflectance (RGB)
overlaid with MODIS Burnt Areas

S/SEA Sentinel-1 VV Polarization – 2021 mean composite image



- Black and White images;
- Pixels with Digital Numbers;
- Images affected by speckle noise

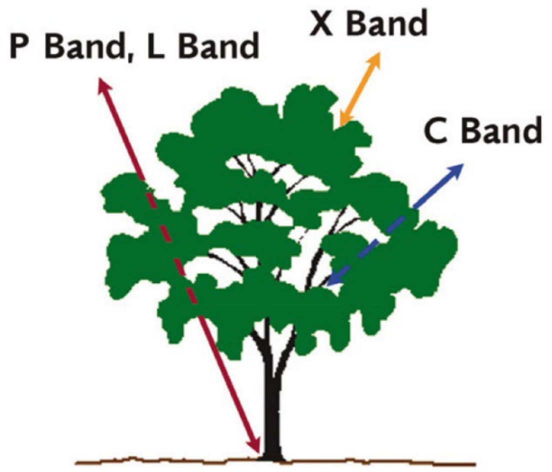
Radar frequency bands

Penetration Depth

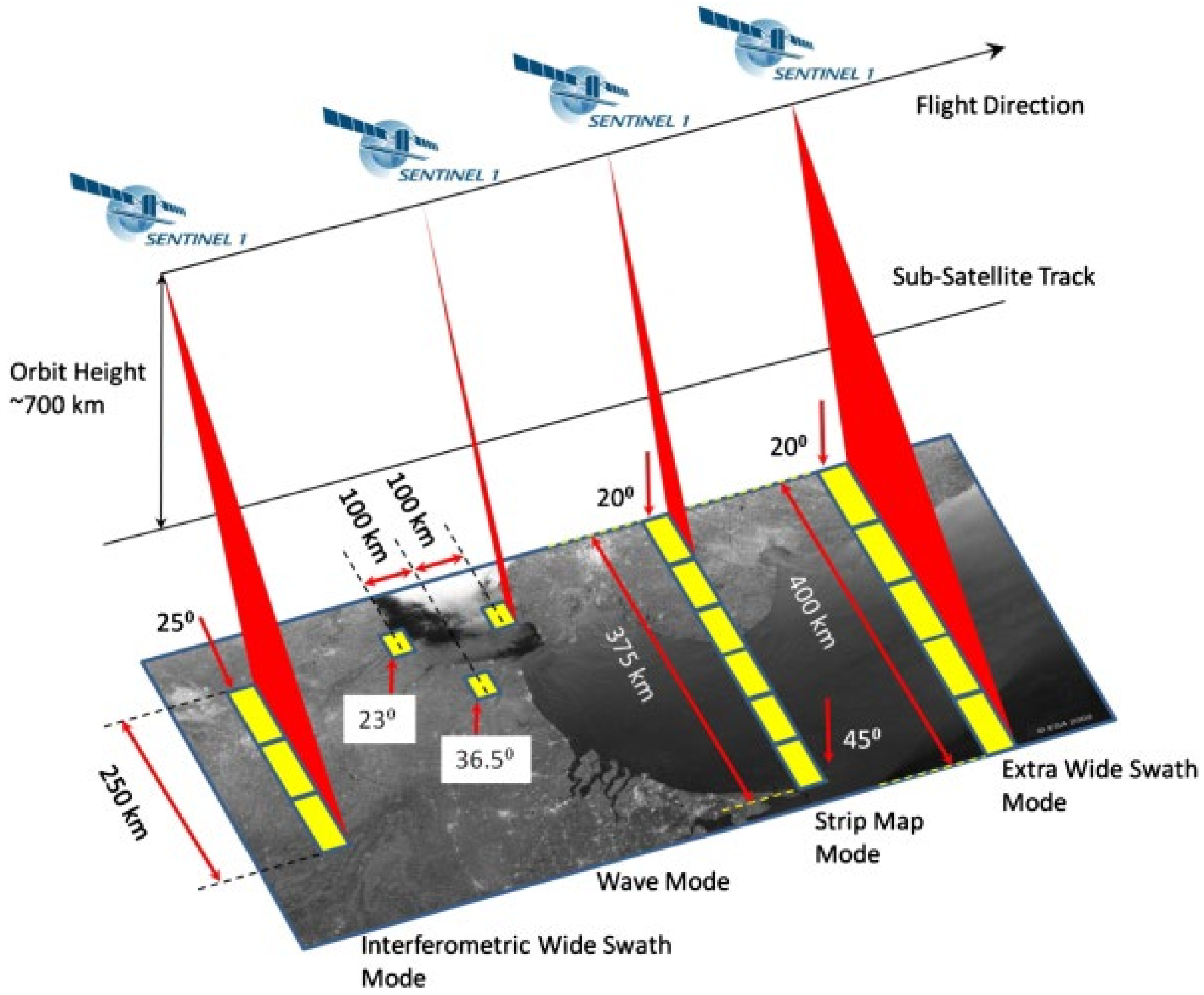
Increases at longer Wavelength

Frequency and Wavelength of Commonly Used Radar Remote Sensing Bands

Band	Frequency	Wavelength	Key Characteristics
X Band	12.5-8 GHz	2.4-3.75 cm	Widely used for military reconnaissance, mapping and surveillance (TerraSAR-X, TanDEM-X, COSMO-SkyMed)
C Band	8-4 GHz	3.75-7.5 cm	Penetration capability of vegetation or solids is limited and restricted to the top layers. Useful for sea-ice surveillance (RADARSAT, ERS-1).
S Band	4-2 GHz	7.5-15 cm	Used for medium-range meteorological applications—e.g., rainfall measurement, airport surveillance
L Band	2-1 GHz	15-30 cm	Penetrates vegetation to support observation applications over vegetated surfaces and for monitoring ice sheet and glacier dynamics (ALOS PALSAR)
P Band	1-0.3 GHz	30-100 cm	To date only used for research and experimental applications. Significant penetration capabilities regarding vegetation canopy (key element for estimating vegetation biomass), sea ice, soil, glaciers.



Sentinel 1A&B – C-Band SAR Data



Strip Map (SM): 80 km swath, 5 x 5 m spatial resolution

Interferometric Wide Swath (IW): 250 km swath, 5 x 20 m spatial resolution

Extra-Wide Swath (EW): 400 km swath, 20 x 40 m spatial resolution

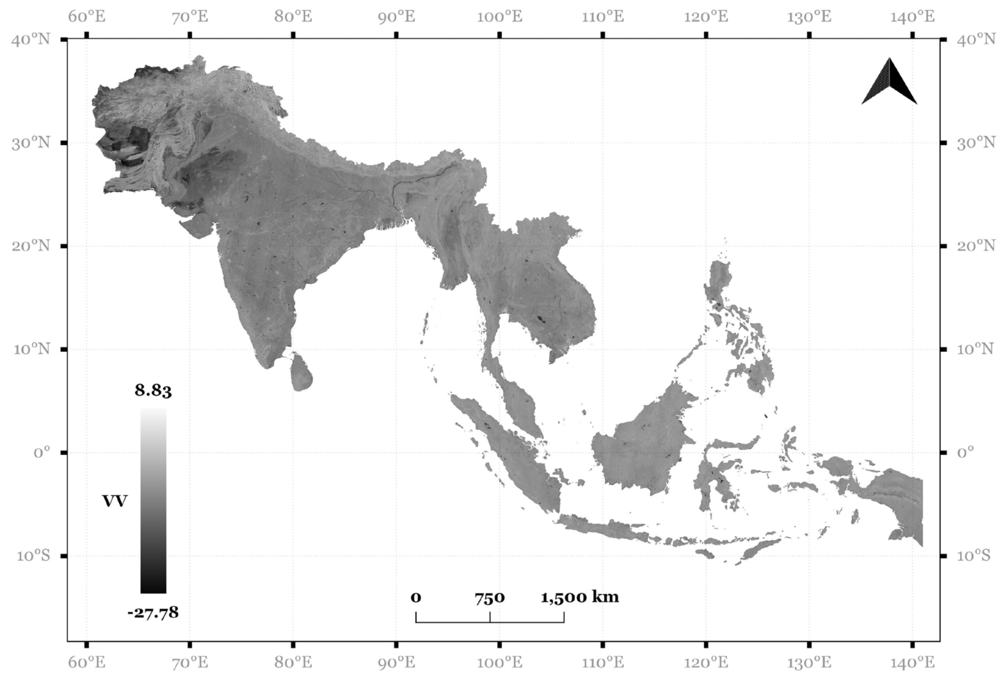
Wave (WV): 20 x 20 km, 5 x 5 m spatial resolution

Interferometric Wide Swath

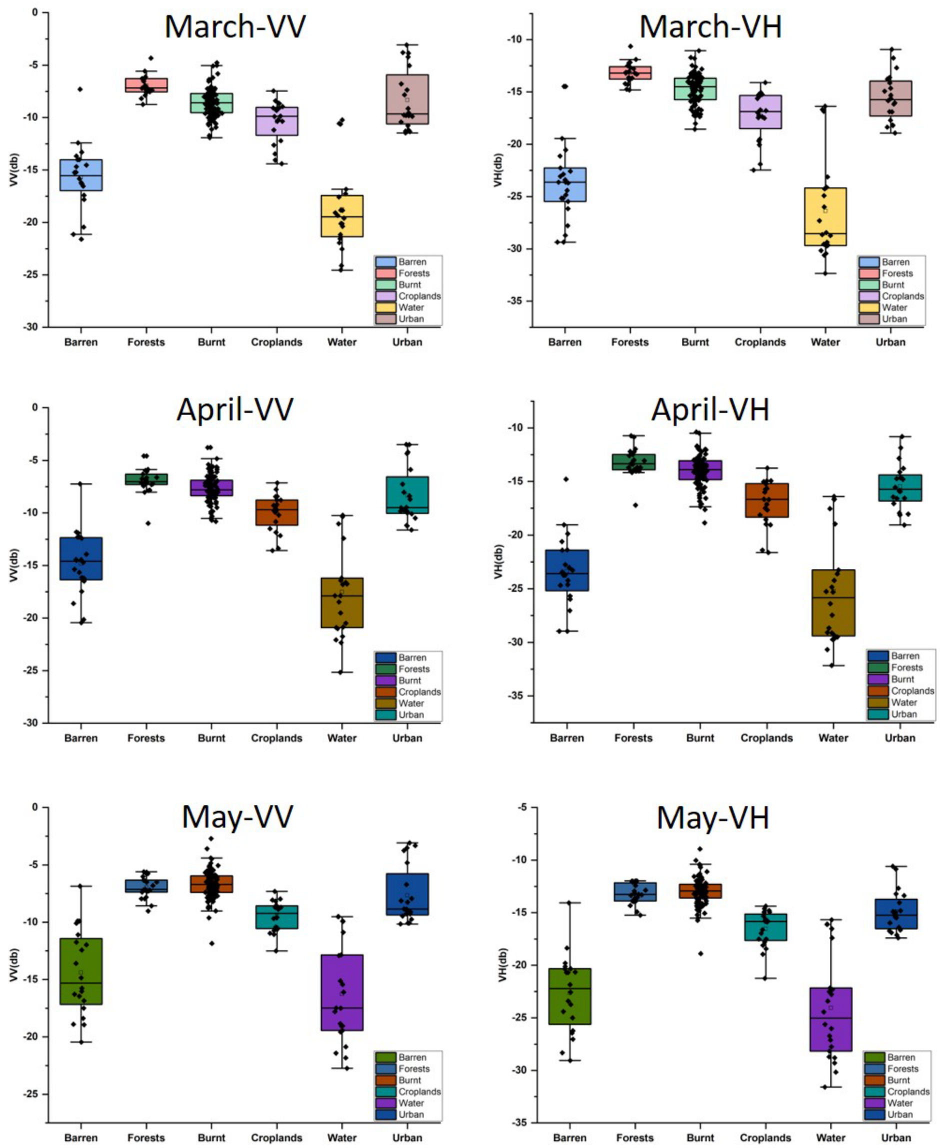
Characteristic	Value
Swath width	250 km
Incidence angle range	29.1° - 46.0°
Sub-swaths	3
Azmiuth steering angle	± 0.6°
Azmiuth and range looks	Single
Polarisation options	Dual HH+HV, VV+VH Single HH, VV
Maximum Noise Equivalent Sigma Zero (NESZ)	-22 dB
Radiometric stability	0.5 dB (3σ)
Radiometric accuracy	1 dB (3σ)
Phase error	5°

Burnt area assessment using SAR Data – What literature says

- Most of the studies on SAR derived BA mapping done in Mediterranean regions. Differences mainly attributed to changes in the dielectric constant of the scattering surfaces due to the moisture content (French et al., 1996).
- Gimeno and Ayanz (2004), using RADARSAT data, highlighted topography influences influencing backscatter in BA. Areas affected by forest fires on front facing-slopes present a higher backscatter coefficient than those back-slopes.
- Donezar et al., (2019) used the Sentinel-1 data highlighted the importance of the incidence angle, with lower angles resulting in higher accuracies. Also, they conclude that VH performed slightly better than VV polarization; however, those differences are not significant. Incident angles are also strongly related to topographic impacts.
- ***Increase or Decrease in Backscatter pre-versus post fires is highly varied in different landscapes***

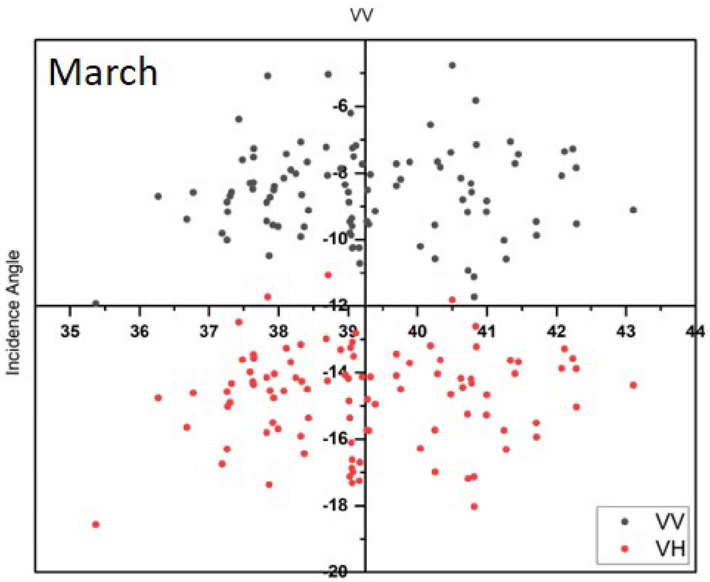


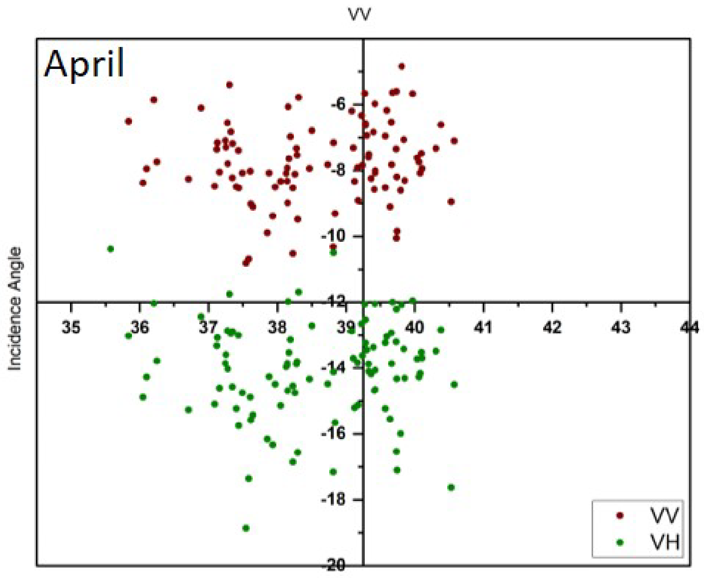
Land Cover Classes and Backscatter Variations - VV versus VH
(Barren, Forests, Agriculture, Croplands, Burnt Areas, Water)

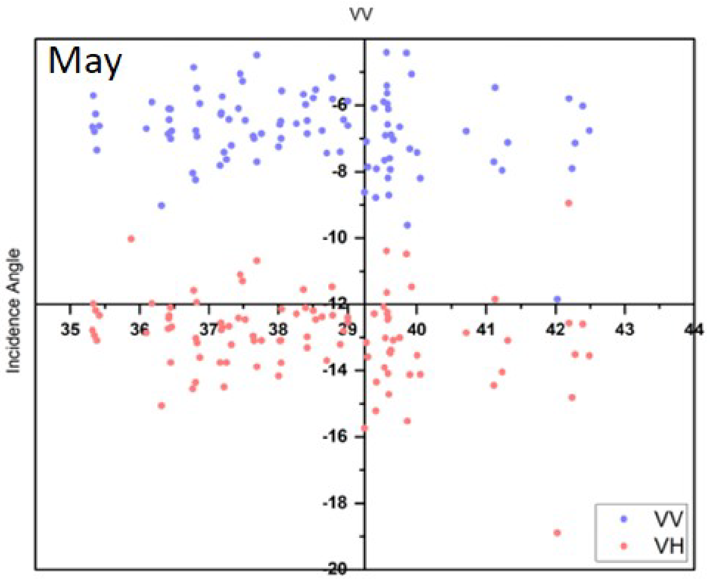


- VH showing more differences in backscatter
- Monthly variations in backscatter are significant
- Urban, water and barren are less problem
- Less variations in BA-Forest-Ag backscatter signal – thus, careful

Incident Angle Variations - VV versus VH





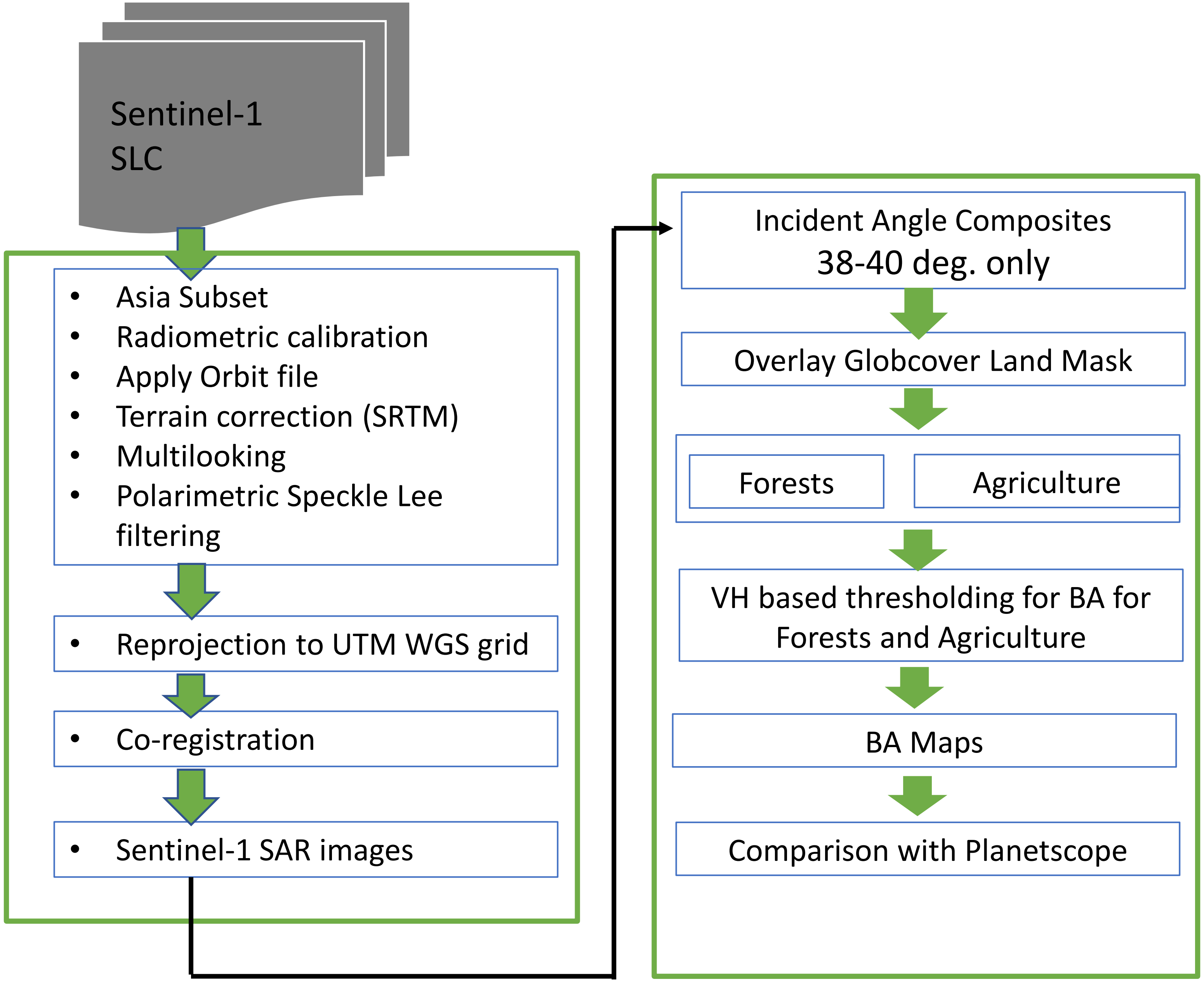


A clear distinction between the VV and VH signal can be seen with the varying incident angles, i.e., VV had a much higher backscatter than VH at all angles.

Further, during the March, the VV signal for burnt areas was in the range of -7 to -10dB whereas, it was -13dB to -16.5dB for VH centered around 37.5-39.5 incident angles.

As the incident angle increased beyond 40 degrees, the data was highly scattered for both VV and VH during March.

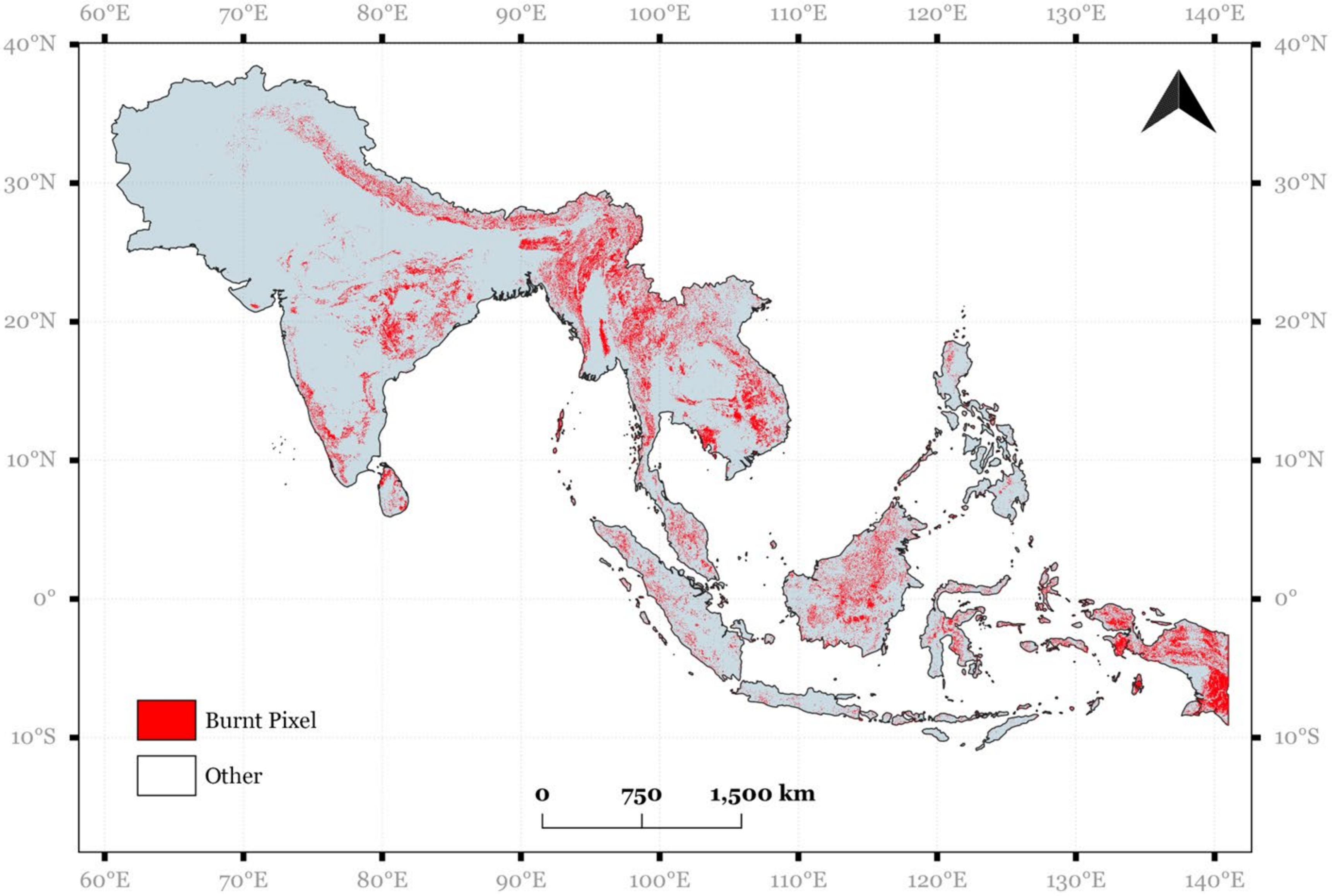
SAR BA Mapping in Asia



- Image compositing based on Incident angles
  - Using only incident angle data from 38-40deg.
  - Eliminate data beyond 40deg.
- Preferred VH based thresholding
  - VV although showing higher backscatter, inter-class differences were small
- For Monthly composites
  - Using varying backscatter thresholds for each month due to backscatter differences
- Separate Agriculture versus Forest BA maps
  - Using Forests and Ag land masks (Globcover) to separate other classes
  - BA backscatter with forests was more closer than agriculture
  - Peatlands not considered as totally mixed signal

AI based learning methods combining optical + SAR being considered

SAR derived Forest BA - VH polarization – March



SAR derived Agriculture BA - VH polarization – March