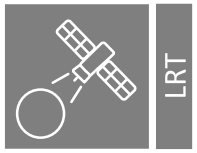
Qualitative Investigation of the Usability of SAR Altimetry Data for Characterizing Land Cover in Central and Northern Africa

Maximilian Eitel, Florian Rüdele

University of the Bundeswehr Munich
Department of Aerospace Engineering
Chait of Earth Observation



Universität der Bundeswehr München
Professur für
Erdbeobachtung

der Bundeswehr
Universität München

Research Focus

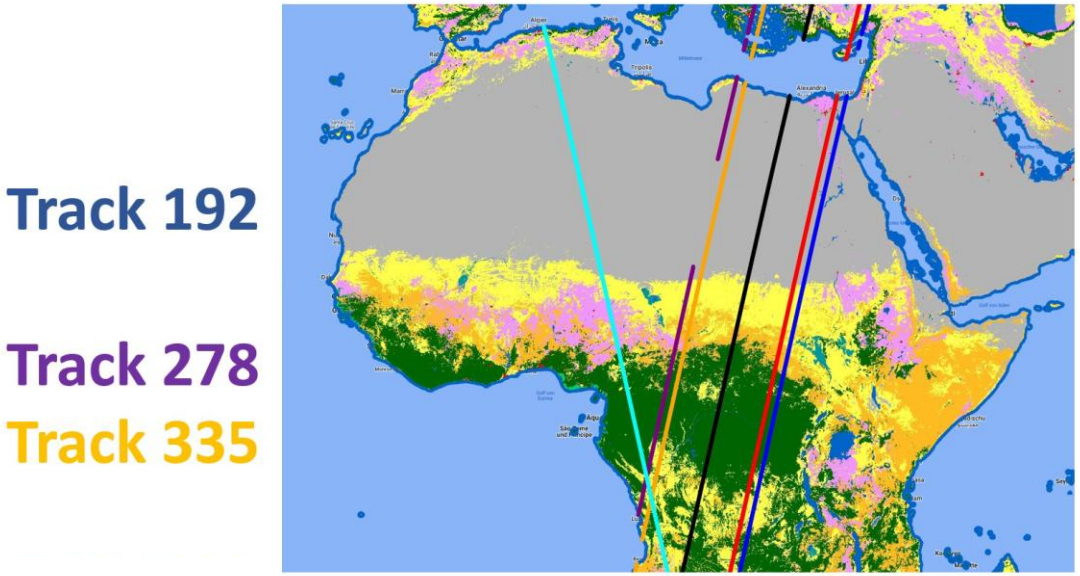
- **Objective**: Investigate the usability of SAR altimetry waveforms for characterizing land cover.
- **Key Question**: Do specific land cover types produce consistent waveform patterns?
- **Scope**: Analyze SAR altimetry data over Central and Northern Africa using two different processing methods.
- **Evaluation**: Determine the most suitable dataset and assess the qualitative value of waveforms for land surface analysis.
- **Tool Assessment**: Evaluate the benefits of advanced reprocessing with SARvatore.

Methodology

- **Study Region Selection**: Central and Northern Africa were chosen due to their diverse but homogeneous land cover types, ranging from dense rainforest to desert.
- **Data Processing Tools**: Two processing methods were used:
  - **Copernicus SciHub**: Provides standard datasets.
  - **SARvatore Tool**: Allows customized reprocessing for higher resolution and precision.
- **Waveform Generation**:
  - Extracted from Sentinel-3 Level 2 enhanced measurement datasets in netCDF format.
  - Python scripts were used to visualize the waveforms for selected tracks and latitudes.
- **Analysis**:
  - Compared waveforms across various land cover types and tracks.
  - Assessed differences in waveform quality and consistency between Copernicus SciHub and SARvatore-processed datasets.
- **Evaluation Metrics**:
  - Homogeneity of land cover.
  - Clarity of waveform features, especially the "leading edge slope."
  - Usability of waveforms for identifying consistent patterns across land cover classes.

Study Area I

- **Tracks and Temporal Scope**:
- Data collected for three tracks (Track 192, 278, 335) over Central and Northern Africa.
- Timeframe includes 25 satellite overpasses from September 2020 to December 2022.
- **Latitudes Analyzed:**
- Waveforms were extracted for specific latitudes: 4.7°N, 5.9°N, 7.0°N, 15.2°N, and 20.0°N.
- These cover diverse land cover types, from rainforest to desert.
- **Key Features Analyzed:**
- Waveforms with 128 bins per measurement for each track's position.
- Geographic coordinates (latitude, longitude) used to map waveforms to land cover types.

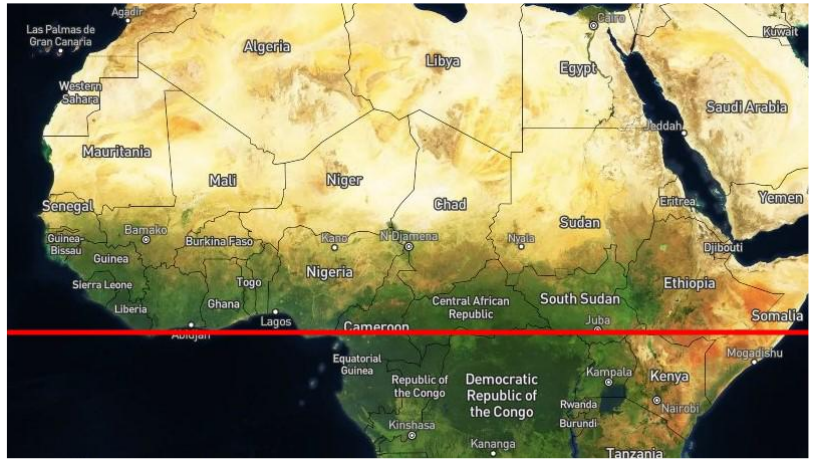


Study Area II

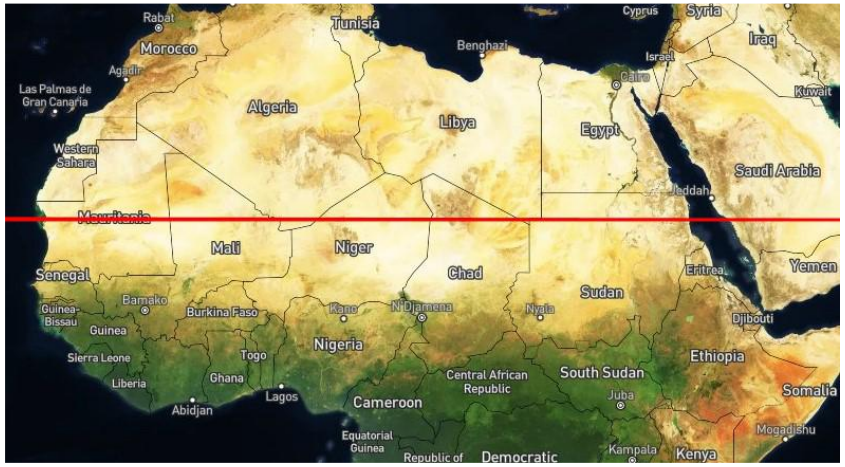
5.9°N

7°N

15.2°N

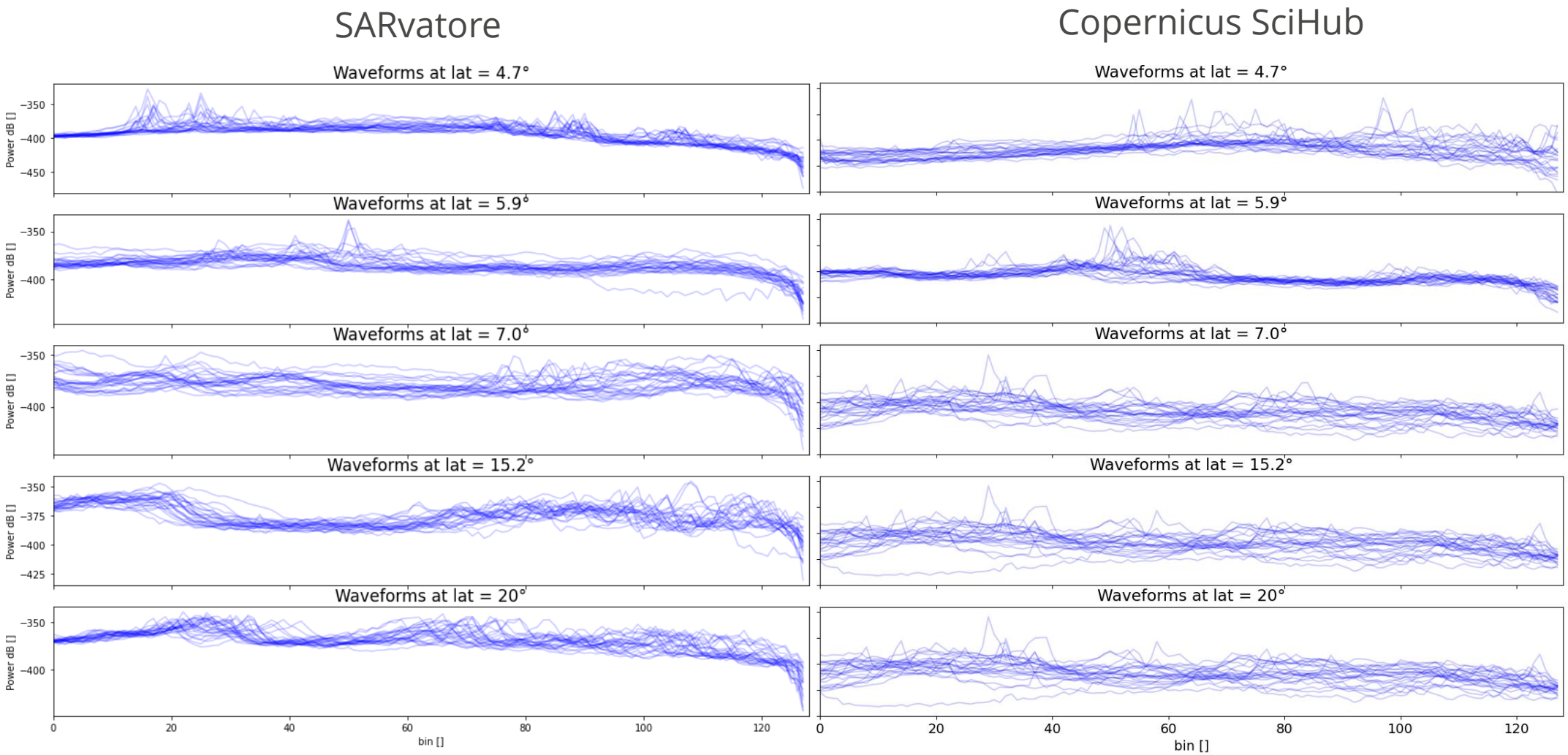


4.7°N

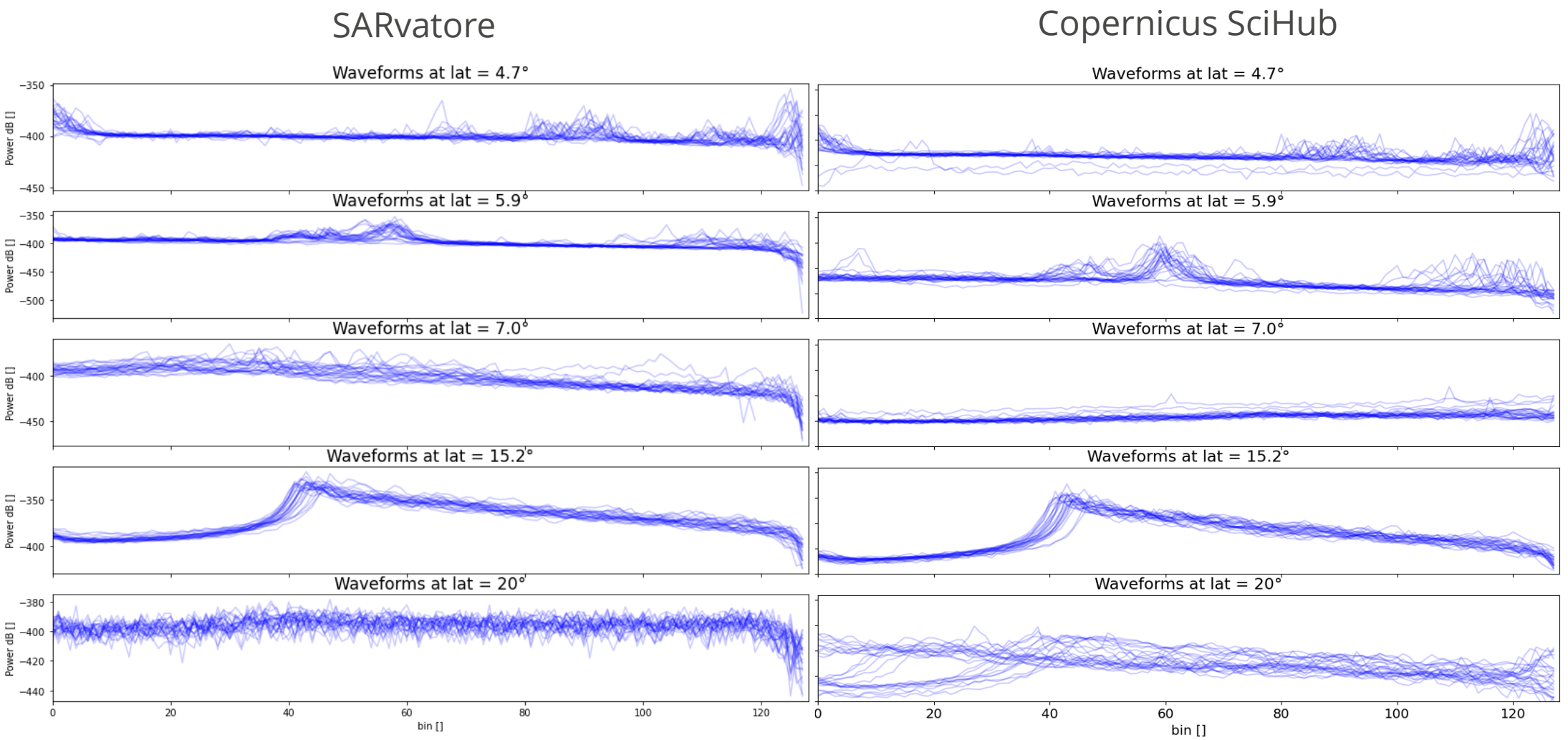


20°N

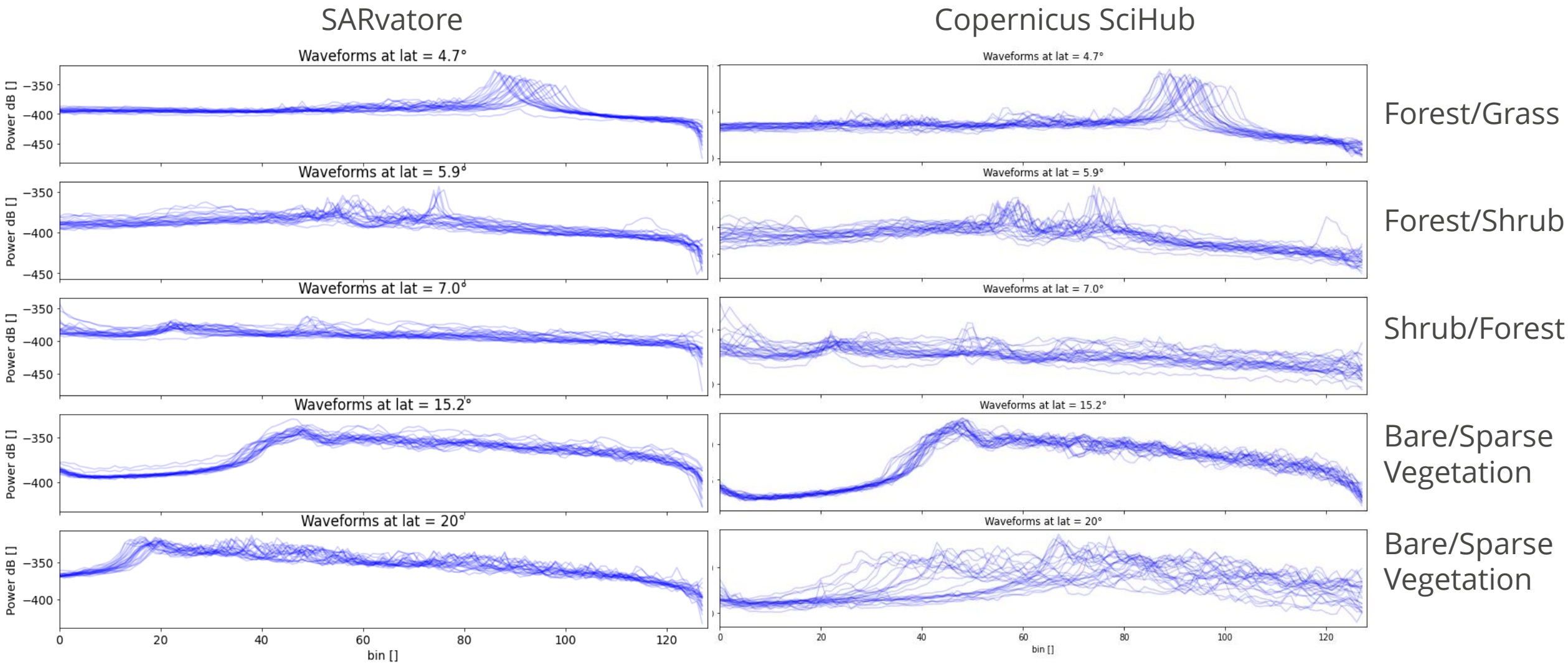
Track 192


SARvatore
Copernicus SciHub
Waveforms at lat = 4.7°
Waveforms at lat = 5.9°
Waveforms at lat = 7.0°
Waveforms at lat = 15.2°
Waveforms at lat = 20°
Power dB []
bin []
Forest
Forest/ Shrubland
Shrub/Grass
Bare/Sparse Vegetation
Bare/Sparse Vegetation

Track 278


SARvatore
Copernicus SciHub
Waveforms at lat = 4.7°
Waveforms at lat = 5.9°
Waveforms at lat = 7.0°
Waveforms at lat = 15.2°
Waveforms at lat = 20°
Power dB []
bin []
Forest
Forest
Shrub/Forest
Bare/Sparse Vegetation
Bare/Sparse Vegetation

Track 335


SARvatore
Copernicus SciHub
Waveforms at lat = 4.7°
Waveforms at lat = 5.9°
Waveforms at lat = 7.0°
Waveforms at lat = 15.2°
Waveforms at lat = 20°
Power dB []
bin []
Forest/Grass
Forest/Shrub
Shrub/Forest
Bare/Sparse Vegetation
Bare/Sparse Vegetation

Analysis

- **Waveform Comparison:**
  - Differences between Copernicus SciHub and SARvatore processed data were observed:
  - SARvatore datasets showed smoother curves, better peak resolution, and fewer outliers.
  - However, these differences are not significant and do not influence the overall appearance or interpretation of the waveforms.
- **Land Cover Insights**:
  - Waveforms differed across various land cover types. Homogeneous regions (e.g., deserts) produced clearer **leading edge slopes**, while heterogeneous areas (e.g., forest-steppe transitions) resulted in noisier waveforms.
  - Similar land cover types showed comparable waveform patterns but with no consistent or definitive relationship.
- **Challenges Identified**:
  - The influence of terrain geometry and environmental factors (e.g., surface relief) could not be isolated from land cover effects.
  - Large SAR altimetry footprints complicate detailed classification of land cover.

Conclusion

- **Waveforms for Land Cover Classification**:
  - SAR altimetry waveforms are unsuitable for reliably classifying land cover types due to overlapping influences of surface geometry and land characteristics.
  - Waveforms reflect surface homogeneity but lack precision for detailed land classification.
- **Tool Assessment**:
  - SARvatore provides superior data quality, enabling better visualization and filtering of measurement errors.
  - While differences between SciHub and SARvatore are minor, SARvatore offers advantages for automated analyses and processing efficiency.
- **Future Directions**:
  - Focus on **Backscatter Coefficients** as an alternative metric for analyzing land cover.
  - Further research could explore reducing footprint sizes or applying fully focused SAR techniques for higher resolution data.