Diurnal Differences in Global ERS Scatterometer Backscatter Observations of the Land Surface

Jan Friesen¹, Susan C. Steele-Dunne², and Nick van de Giesen²

Introduction
Soil moisture estimates from the European Remote Sensing Satellite (ERS)-1, ERS-2, and Metop scatterometer instruments are available as time series starting in 1991. To better understand the satellite signal backscatter data and the corresponding soil moisture estimates, differences between different overpass times are analyzed. Analysis of more than 15 years of ERS scatterometer data has shown distinct patterns in backscatter between different overpass times. Differences between backscatter data from descending (morning overpass) and ascending (evening overpass) tracks show spatial and temporal patterns that cannot be attributed to soil moisture. Based on regional studies, we highlight the main processes causing the diurnal differences in backscatter data. Data used for this study are based on preprocessed normalized backscatter, \( \sigma_0(40) \), and slope, \( \sigma(40) \), data from a modified TUWien WARP 5.0 algorithm. Results show that the diurnal differences in \( \sigma_0(40) \) between descending and ascending data are systematic and are not artifacts from previous processing steps. Statistically significant diurnal differences, \( \Delta \sigma_0(40) \), are detected over about 30% of the land area, underscoring the potential significance for hydrologic remote sensing on a global scale.

Methods

\[ \Delta \sigma_0(40) = \frac{1}{N} \sum_{i=1}^{N} \sigma_0(40)_{\text{descending}} - \frac{1}{M} \sum_{j=1}^{M} \sigma_0(40)_{\text{ascending}} \]

where \( N \) and \( M \) are the numbers of descending and ascending overpasses for a selected time period. For this study, a monthly time period was selected. A similar methodology was applied for slope data. For analysis only points with significant differences between descending and ascending data were taken (Student’s t-test, \( \alpha=0.01 \)).

Excluding slope and overpass pattern effects

Conclusions
• Systematic and statistically significant differences between descending and ascending tracks of ERS-1/-2 wind scatterometer data
  • Differences are in the order of 1-2 dB
  • Significant differences affect about 30% of the land cover
• Causes may differ depending on actual overpass times and region
  • Azimuthal anisotropy due to uniform microrelief \( \rightarrow \) e.g. sand dunes or water bodies
  • Freeze/thaw cycles in higher latitudes
  • Diurnal variations in dew accumulation
  • Diurnal variations in vegetation water status \( \rightarrow \) e.g. West Africa or South America
• Existing climatologies of ERS data or upcoming missions such as SMAP might be useful for vegetation water status estimates in forested regions

References

Figure 1 Monthly averaged \( \Delta \sigma_0(40) \) against monthly averaged \( \Delta \sigma_0 \). Blue dots are all points over land, and red dots are points with significantly different backscatter from descending and ascending tracks.

Figure 2 Difference in average number of observations between descending and ascending overpasses.

Figure 3 Monthly averaged \( \Delta \sigma_0(40) \). Positive numbers correspond to higher moisture in the morning (descending track; 9:30 A.M.–12:00 P.M.), and negative numbers correspond to higher values in the evening (ascending track; 9:30 P.M.–12:00 A.M.). Gray indicates no significant differences to data from descending tracks (\( \sigma = 0.01 \), based on Student’s t-tests of \( \sigma_0(40) \) descending against \( \sigma_0(40) \) ascending).

Figure 4 Monthly averaged \( \Delta \sigma_0(40) \) for (a) West Africa (JJA and DJF) and (b) South America (JJA and DJF). Positive numbers correspond to higher moisture in the morning (descending track; about 10:00 A.M.), and negative numbers correspond to higher values in the evening (ascending track; about 10:30 P.M.)