Estimating the ASCAT spatial response function for enhanced resolution processing

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Introduction

The Advanced Scatterometer (ASCAT) is a scatterometer orbiting the Earth. A scatterometer is a type of radar that measures the normalized radar cross-section, $\sigma^o$. ASCAT measures $\sigma^o$ of the Earth surface on a global scale.

Each ground measurement has an associated spatial response function (SRF),

$$\sigma^o_{\text{model}} = \int \sigma^o(x, y) b(x, y) \, dx \, dy,$$

where $b(x, y)$ is the SRF and $\sigma^o(x, y)$ is the radar backscatter from the Earth surface.

Enhanced resolution processing effectively inverts this equation using the $\sigma^o$ measurements in conjunction with their associated SRFs to produce a high resolution image of $\sigma^o(x, y)$. Lacking enough information to accurately represent the ASCAT SRF, we estimate the ASCAT SRF in order to produce enhanced resolution $\sigma^o$ data.

Estimating the SRF

Each ASCAT antenna beam is subdivided into adjacent measurements. Each measurement SRF is dominated by the antenna beam response in the cross-beam direction, and the response imposed by range-Doppler processing in the along-beam direction. The cross-beam antenna response is known, but the along-beam equivalent response is estimated from SZF (full resolution) ASCAT data.

ASCAT beams that overlap a land/ocean transition are used to estimate the along-beam response. A noncausal FIR filter is used to model the equivalent along-beam processing.

$$t[n] \quad g[n] \quad x[n]$$

The land/ocean transition measurement model. The transition is $t[n]$, the along-beam response is $g[n]$, noise is $\eta[n]$, and the measured ASCAT beam is $x[n]$. $n$ indexes along the beam.

The filter $\hat{g}[n]$ is estimated using least squares estimation. Multiple land/ocean transitions are used to jointly estimate the filter coefficients.

$$x[n] \quad \sum t[n] \quad \hat{g}[n] \quad \eta[n] \quad \hat{g}[n] \quad x[n]$$

Estimating the along-beam filter $\hat{g}[n]$. From the ASCAT data $x[n]$ the transition $t[n]$ is created (this is not a linear operation). The data $x[n]$ is expressed as the convolution of $t[n]$ with the unknown system $g[n]$ with $\eta[n]$ representing remaining additive noise. $\hat{g}[n]$ is found such that the error $\epsilon[n]$ is minimized.

Estimation Results

30 days of ASCAT data are used to find over 110,000 land/ocean transitions.

An ASCAT beam overlapping land and ocean in California, USA. The $\sigma^o$ measurements $x[n]$ are plotted along with the transition function $t[n]$. The estimated values for $\hat{g}[m]$ are shown with a quadratic fit.

An ASCAT beam overlapping land and ocean in Brazil. The $\sigma^o$ measurements $x[n]$ are plotted along with the transition function $t[n]$. The estimated values for $\hat{g}[m]$ are shown with a quadratic fit.

With the filter estimated, the full spatial response function is computable.

Enhanced Resolution Results

The estimated SRF is used for enhanced resolution processing.

Standard and high resolution $\sigma^o$ images for North America.

Standard and high resolution $\sigma^o$ images for Antarctica.

Conclusion

The SRF is estimated from ASCAT data using transitions between land and ocean. The estimated SRF is used for enhanced resolution $\sigma^o$ data. Work is ongoing to determine the sensitivity of the high resolution processing to approximations made to the SRF. The ASCAT dataset has been processed and is available at http://scp.byu.edu.

References