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, \( \sigma^0 \). ASCAT measures \( \sigma^0 \) of the Earth surface on a global scale.

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

\[
\sigma^0_{\text{meas}} = \int \sigma^0(x, y) h(x, y) \, dx \, dy,
\]

where \( h(x, y) \) is the SRF and \( \sigma^0(x, y) \) is the radar backscatter from the Earth surface.

Enhanced resolution processing effectively inverts this equation using the \( \sigma^0 \) measurements in conjunction with their associated SRFs to produce a high resolution image of \( \sigma^0(x, y) \). Lacking enough information to accurately represent the ASCAT SRF, we estimate the ASCAT SRF in order to produce enhanced resolution \( \sigma^0 \) 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 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:

\[
x[n] = g[n] * h[n] + \eta[n],
\]

where \( g[n] \) is the filter, \( h[n] \) the along-beam response, \( \eta[n] \) additive noise, and the measured ASCAT beam is \( x[n] \). \( n \) indexes along the beam.

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

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

\[
\epsilon[n] = x[n] - g[n] * h[n] - \eta[n]
\]

Enhanced Resolution Results

30 days of ASCAT data are used to find over 110000 land/ocean transitions.

An ASCAT beam overlapping land and ocean in California, USA. The \( \sigma^0 \) measurements \( x[n] \) are plotted along with the transition function \( \ell[n] \). The estimated values for \( \hat{g}[m] \) are shown with a quadratic fit.

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

Standard and high resolution \( \sigma^0 \) images for North America.

Conclusion

The SRF is estimated from ASCAT data using transitions between land and ocean. The estimated SRF is used for enhanced resolution \( \sigma^0 \) 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