Evaluation of Two Methods for Determining Surface Soil Moisture from Radar Imagery

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Introduction:

Large area monitoring of surface soil moisture (to depths of 5 cm) may be possible with radar remote sensing techniques. Two methods for predicting surface soil moisture from radar satellite imagery were tested in AZ, GA and OK. Close attention was paid to issues of roughness (L_c, rms) and speckle which both limit the scale and accuracy of soil moisture prediction using radar techniques.

Methods:

Field: Surface soil moisture measurements were made commensurate with satellite overpass either gravimetrically, or with capacitance probes. Roughness measurements were made with a 1-meter pin board.

Imagery:

Type	Resolution	Polariz.	Band	Inc. Angle
Radarsat	7 m	HH	C	46
ERS-2	25 m	VV	C	23

Image pixels were either median filtered, then averaged (Radarsat), or simply averaged (ERS-2) over the ground locations where soil moisture was measured.

Models:

1) The Integral Equation Method (IEM) model was inverted using a a Look-up-Table (LUT) to estimate soil moisture from backscatter and roughness input variables.

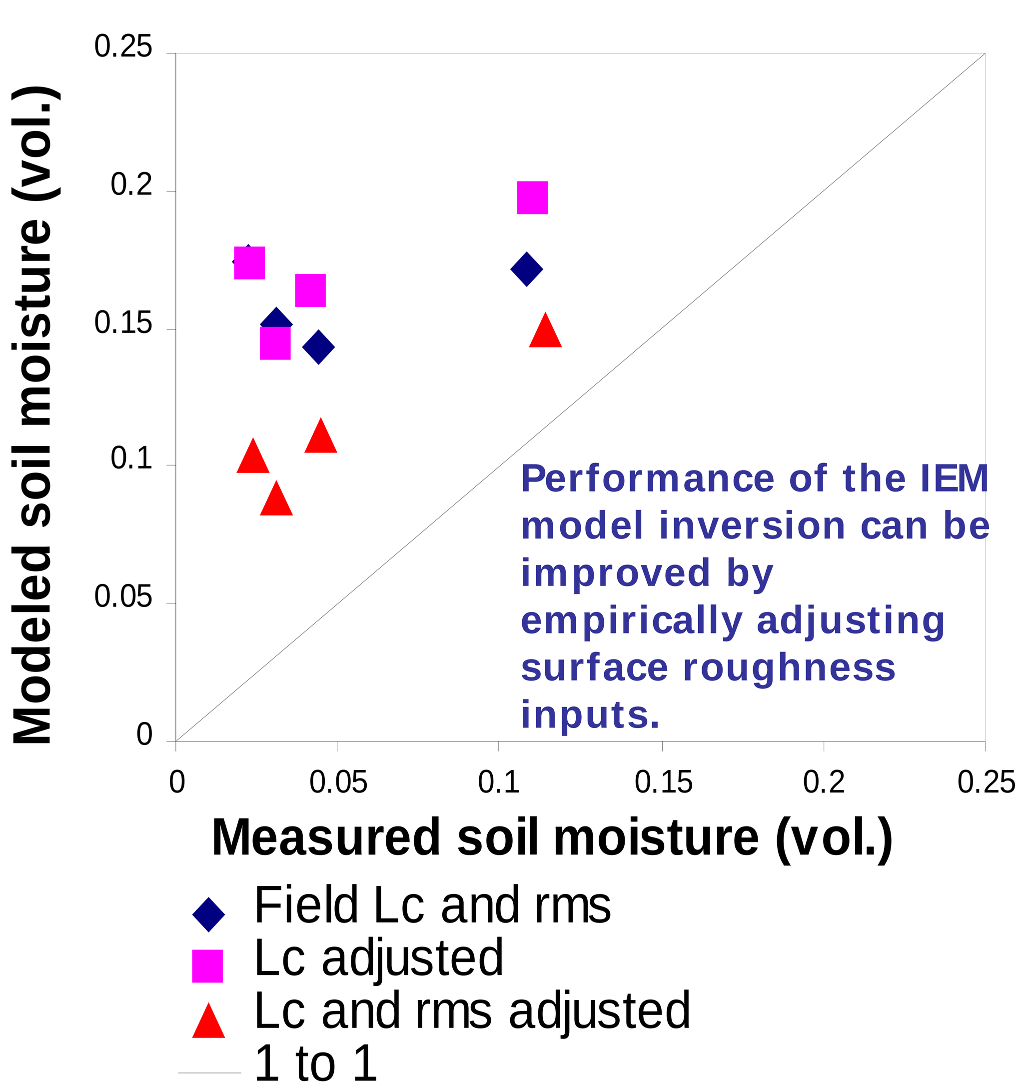
2)The Delta index was defined as,

$$\Delta\text{-index} = \text{abs}[(\sigma_{wet} - \sigma_{dry}) / \sigma_{dry})],$$

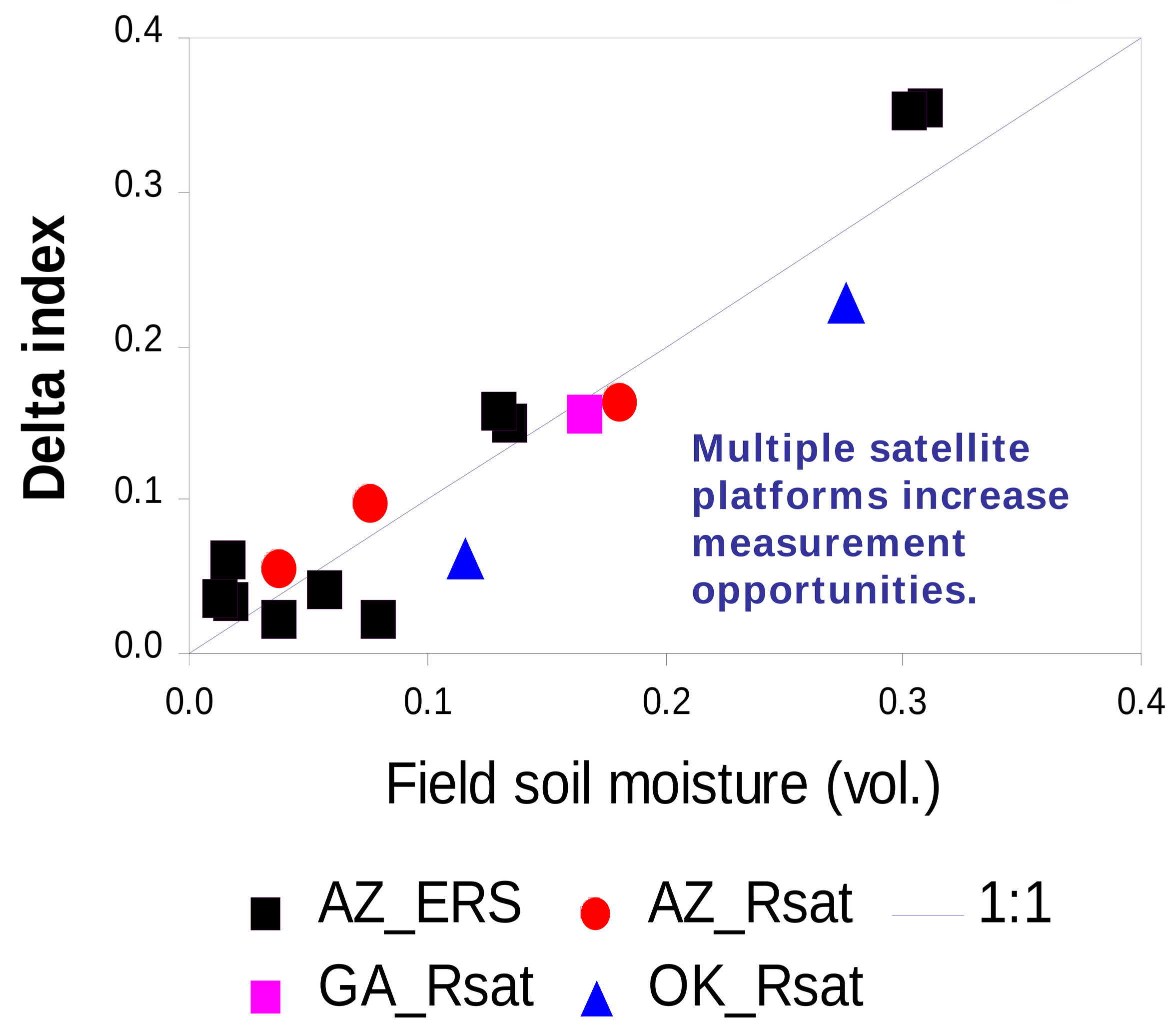
where σ_{dry} = backscatter of dry soil,
and σ_{wet} = backscatter of wet soil.

Results from both methods were validated against in situ measurements of surface soil moisture.

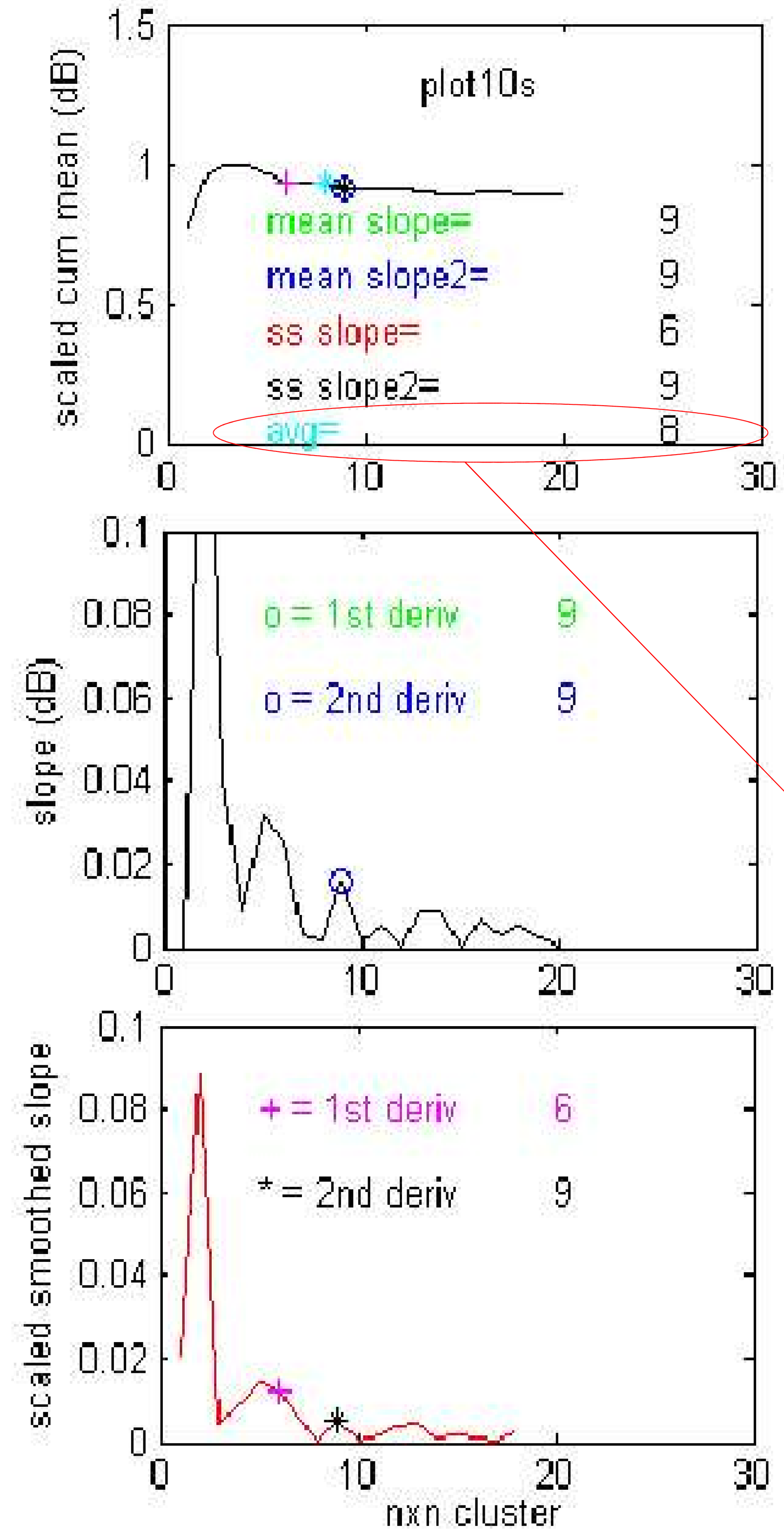
Results: IEM



Results: Δ-index



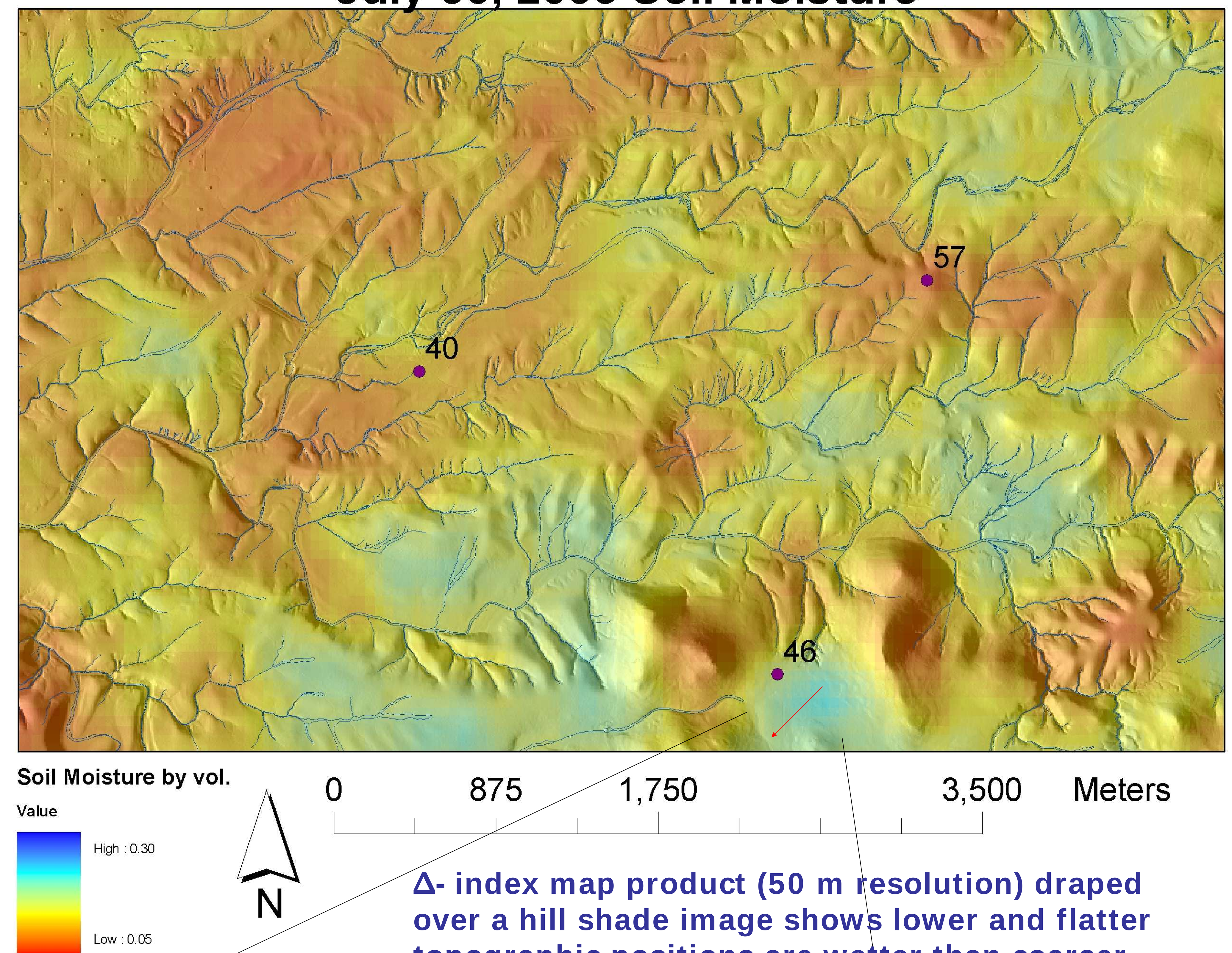
Minimizing speckle:



Metrics used to determine optimum size pixel cluster that retains information for soil moisture estimates, but minimizes influence of speckle. Metrics include stability of cumulative mean and derivatives of cumulative mean function.

A 9 by 9 pixel cluster at 7m image resolution optimized the tradeoff between scale and information for all field sites in the Walnut Gulch study area.

July 30, 2003 Soil Moisture



Δ-index map product (50 m resolution) draped over a hill shade image shows lower and flatter topographic positions are wetter than coarser textured hill sides hours after a monsoon storm in Walnut Gulch, AZ. Red arrow indicates view direction in photograph.

Discussion:

IEM:

Inadequacies of IEM, or difficulties characterizing surface roughness limit its potential without first making empirical adjustments to roughness parameters.

Δ-index:

The stronger relation between the **Δ**-index and soil moisture is due to inherent accounting of factors that dramatically affect IEM such as surface roughness and topographic effects. As with the IEM model, speckle confounds results on a site by site basis, but this effect can be minimized by averaging many pixels to reduce the effects of speckle and natural soil moisture variability over 50 by 50 meter areas.

Conclusions:

1) IEM model with Look-Up-Table may be useful for estimating soil moisture at watershed scales if excellent ancillary information about surface roughness is known and can be empirically adjusted.

1)The **Δ**-index performed better than the un-calibrated IEM model. Advantages of the **Δ**-index include its simplicity and ability to minimize effects of surface roughness as long as roughness is unchanged between image acquisition dates.

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