
Probabilistic Line of Sight (PLOS)

Ed Wright

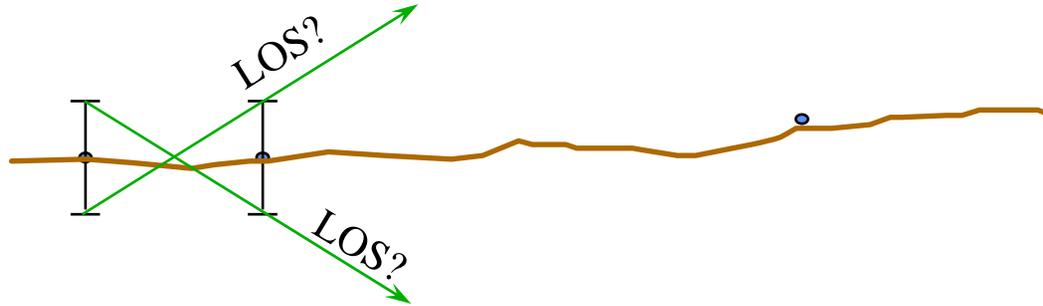
ewright@iet.com

Information Extraction and Transport (IET), Inc.

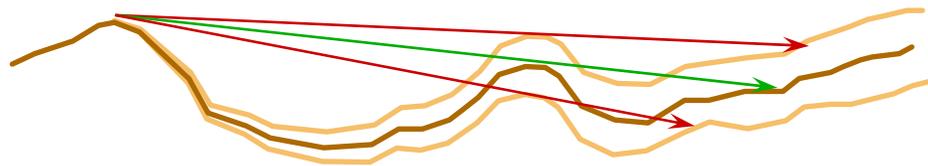
(703)284-0609

Accuracy of LOS?

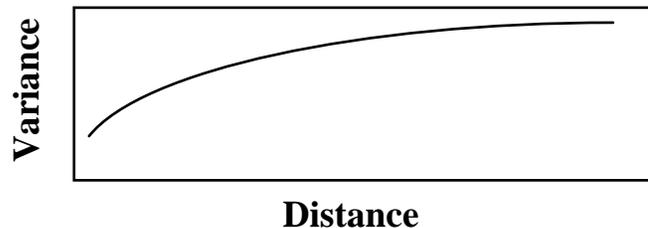
DEM Absolute Accuracy:



DEM Relative Accuracy
– as a function of distance!

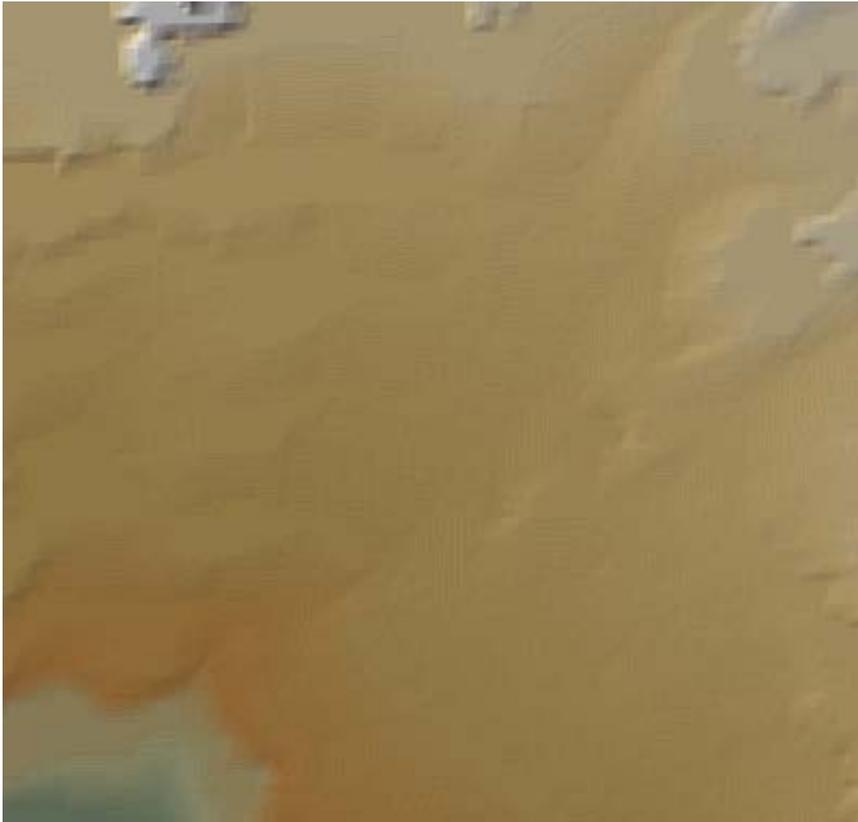


Geostatistics: Variogram is used to estimate correlation based on the distances between points.

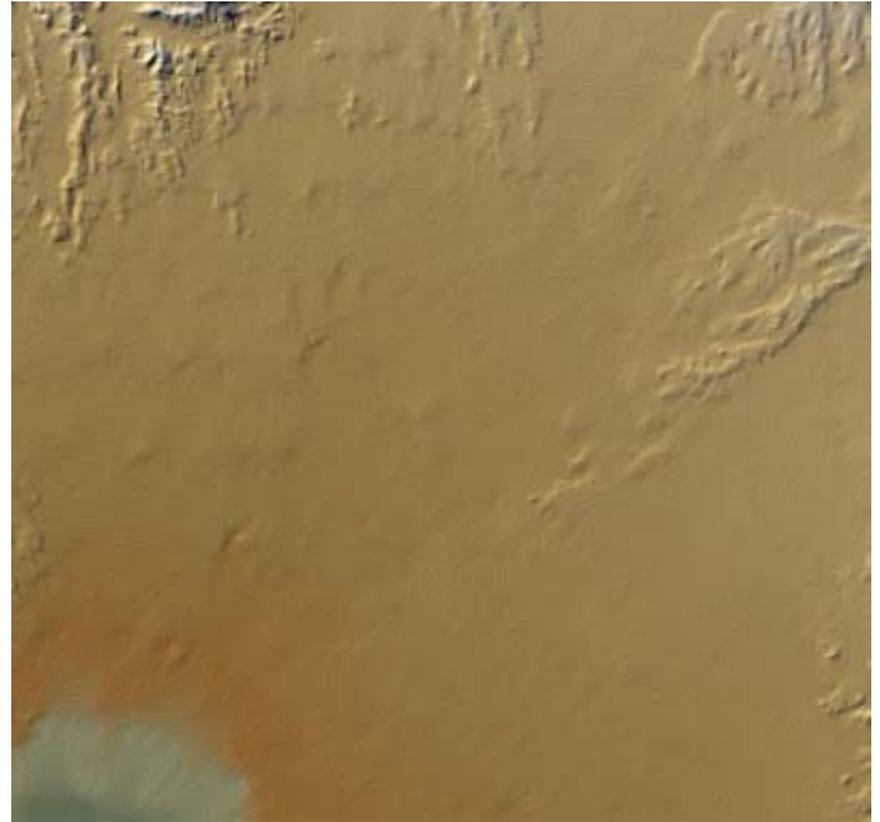


Standard DTED Data

DTED Level 1



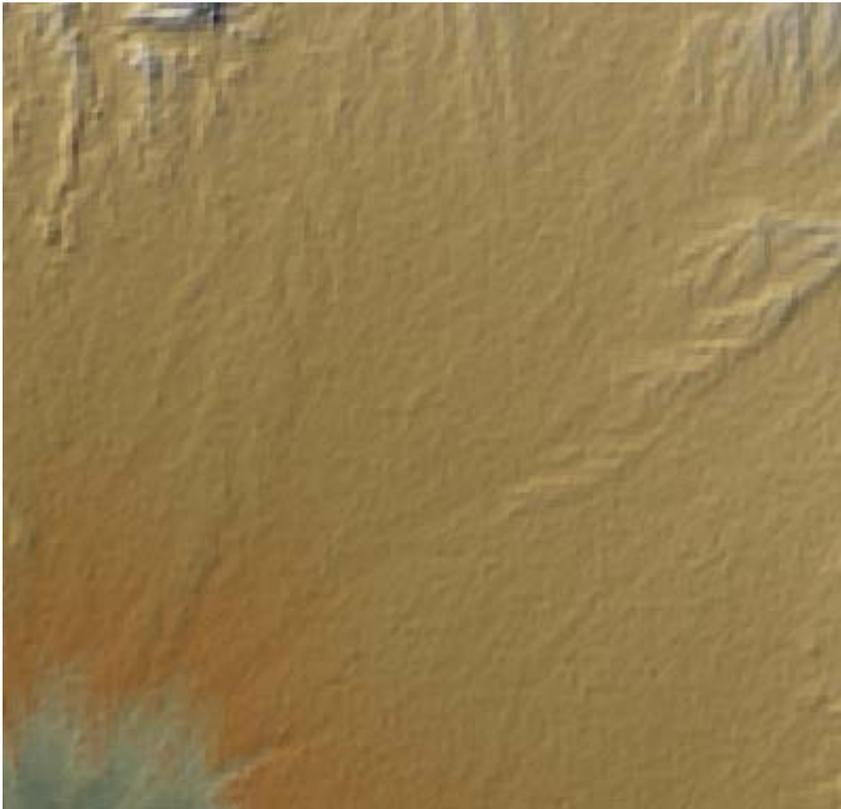
DTED Level 2



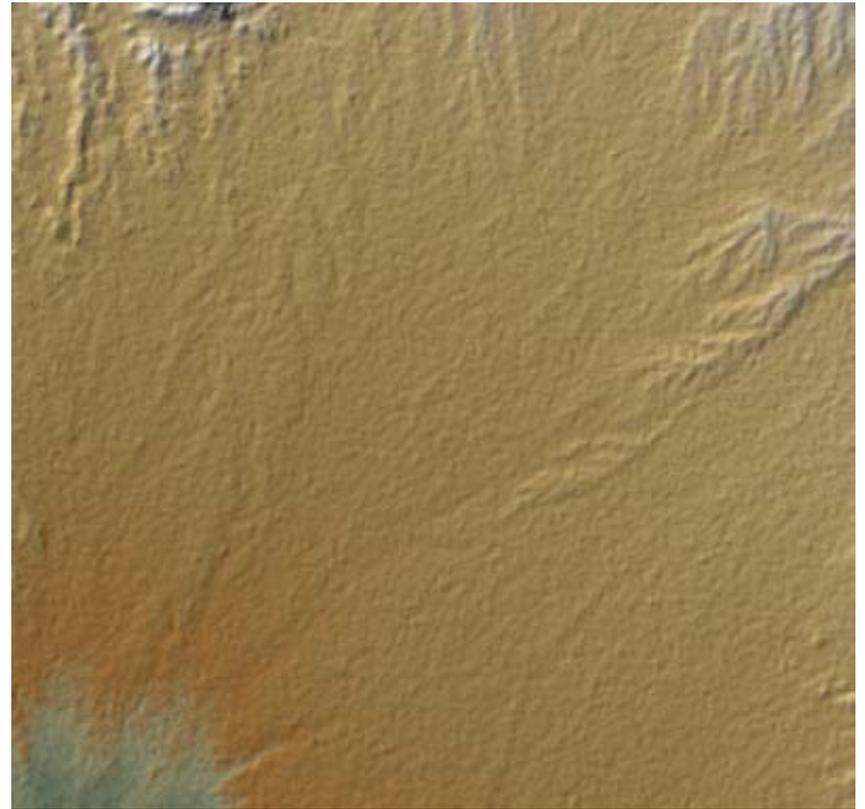
SRTM Data Sources

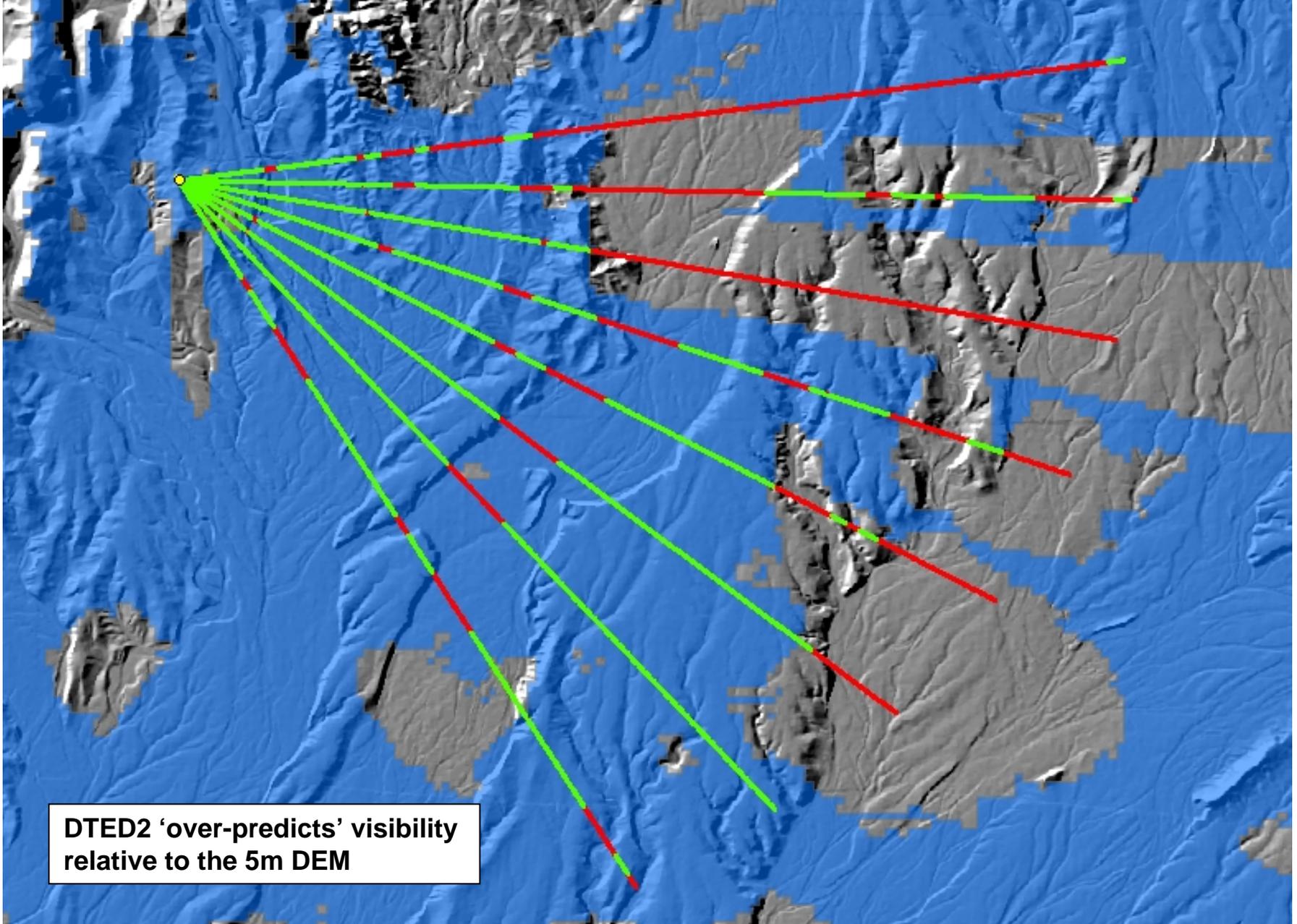
- ◆ The terrain features are better defined, but there is random noise.

SRTM Level 1

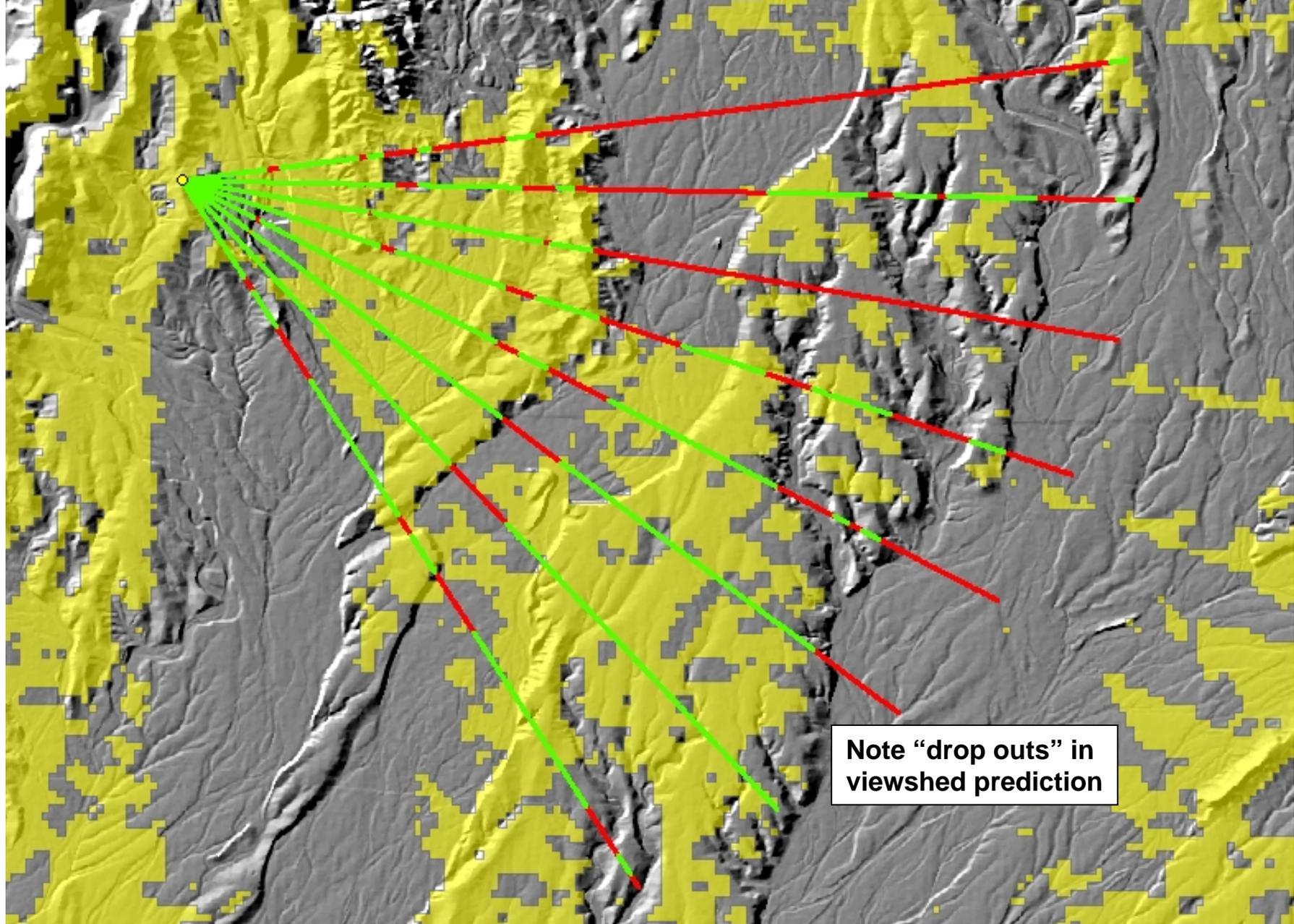


SRTM Level 2





**Yuma Area 6 Line-of-Sight Field Data – DTED2 Viewshed (3.6 KM x 4.4 KM)
Over 5 m Photogrammetric DEM Shaded Relief – Blue Represents Visible Area**



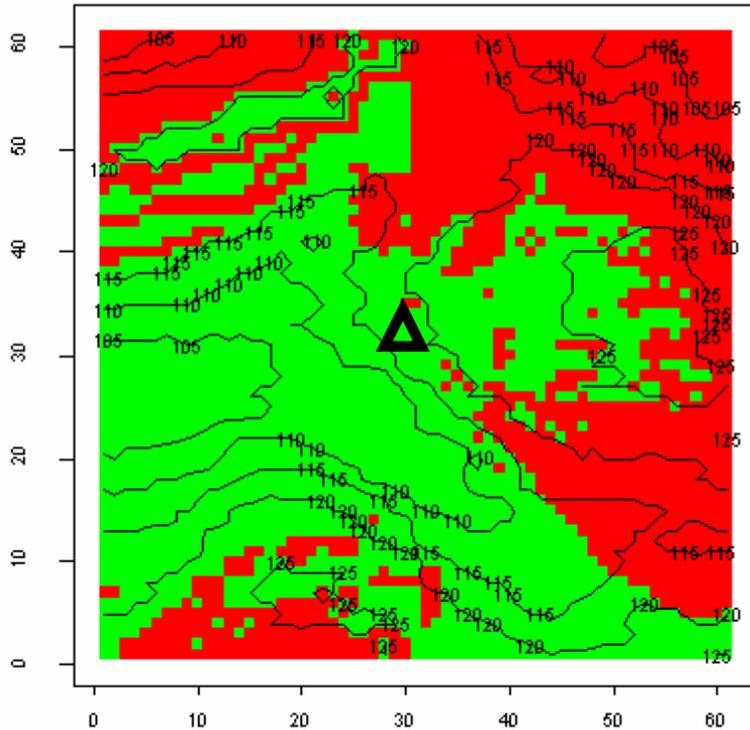
Note "drop outs" in viewshed prediction

**Yuma Area 6 Line-of-Sight Field Data – SRT2 Viewshed (3.6 KM x 4.4 KM)
Over 5 m Photogrammetric DEM Shaded Relief – Yellow Represents Visible Area**

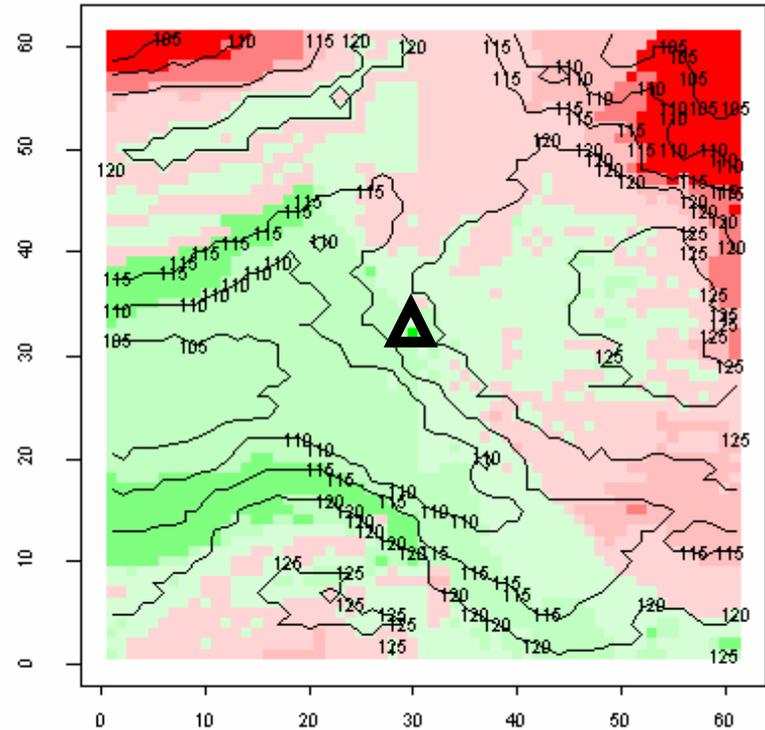
Impact of SRTM data on LOS

- Impact of the Shuttle Radar Topography Mission (SRTM) Data on Geospatial Support to United States Army Operations, TRAC-WSMR-TR-05-020(R), April 2005
 - ◆ SRTM2 data contains details about the terrain not available in DTED Level 2.
 - ◆ SRTM2 data also contains random data noise that remains after processing (radar characteristic).
 - ◆ The noise-induced anomalies create erroneous results in LOS and related visualization applications especially at the low grazing angles required for most Army operations.
 - ◆ Inherent characteristics of SRTM2 and DTED Level 2 mitigates utility for LOS
 - SRTM2 underestimates LOS due to unfiltered random data noise
 - DTED Level 2 overestimates LOS due to excessive smoothing in production process

LOS Uncertainty Example

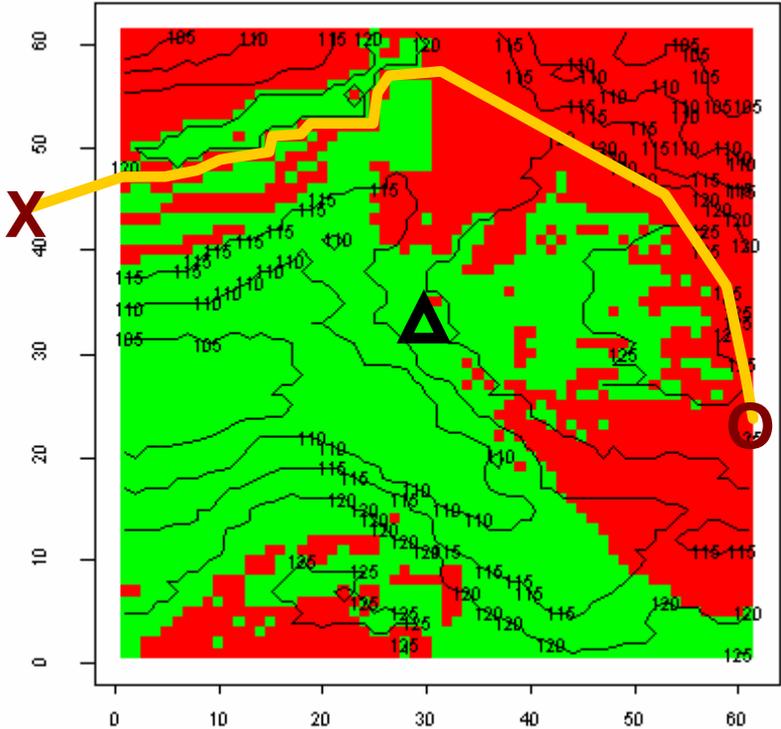


Traditional LOS Product
Green: Visible - Red: Not Visible

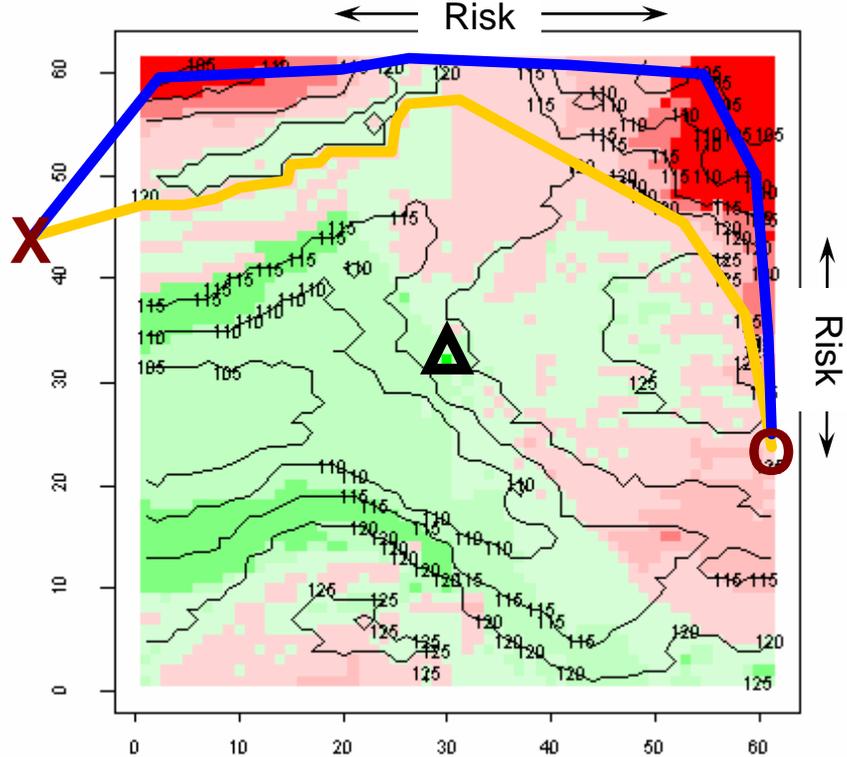


Uncertainty in LOS Product
Green: Visible - Red: Not Visible
Intensity: Certainty of the Result

Value of Understanding Uncertainty



Shortest Concealed Path to Goal

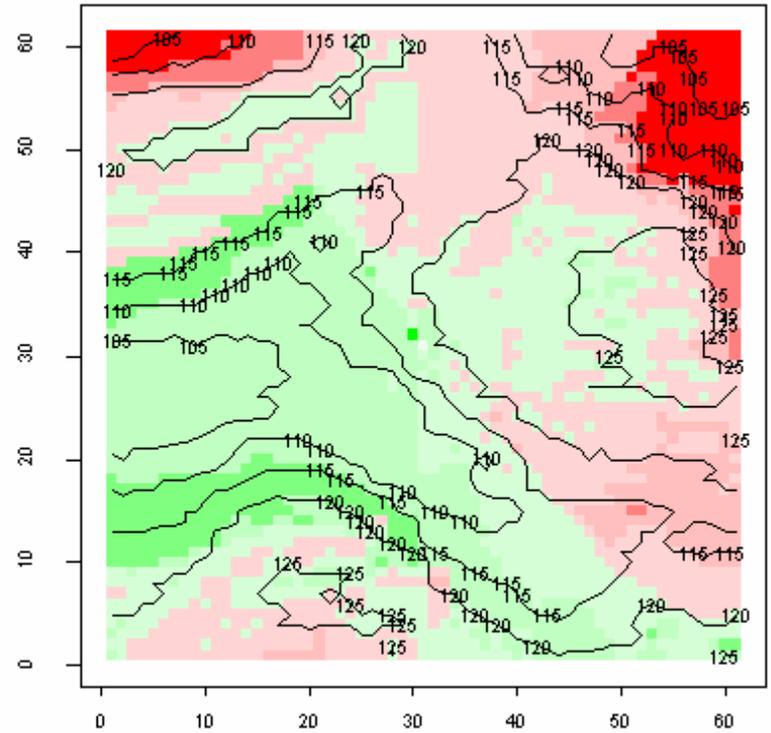
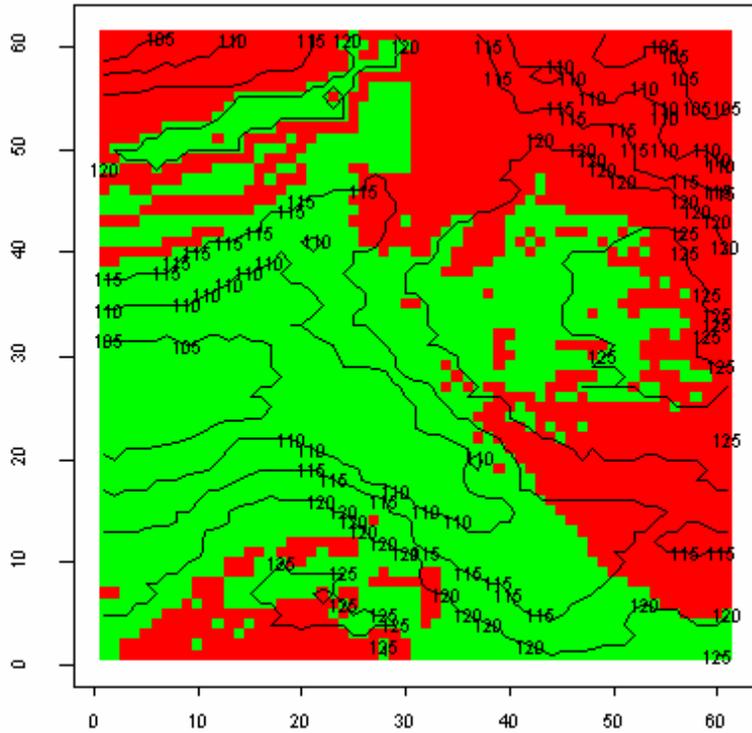


Understanding Uncertainty

Better Path

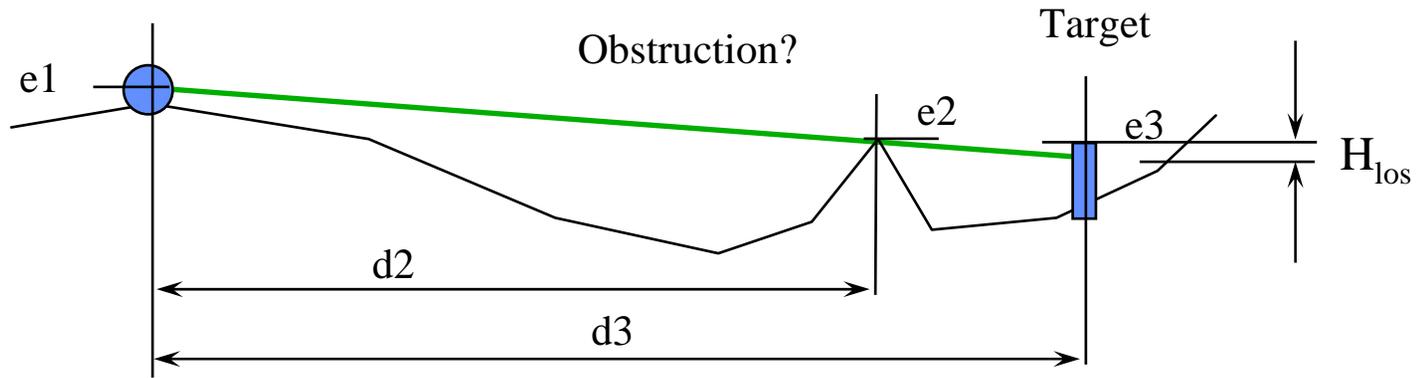
Plan for Risk Risk





Line of Sight Algorithm

Observer

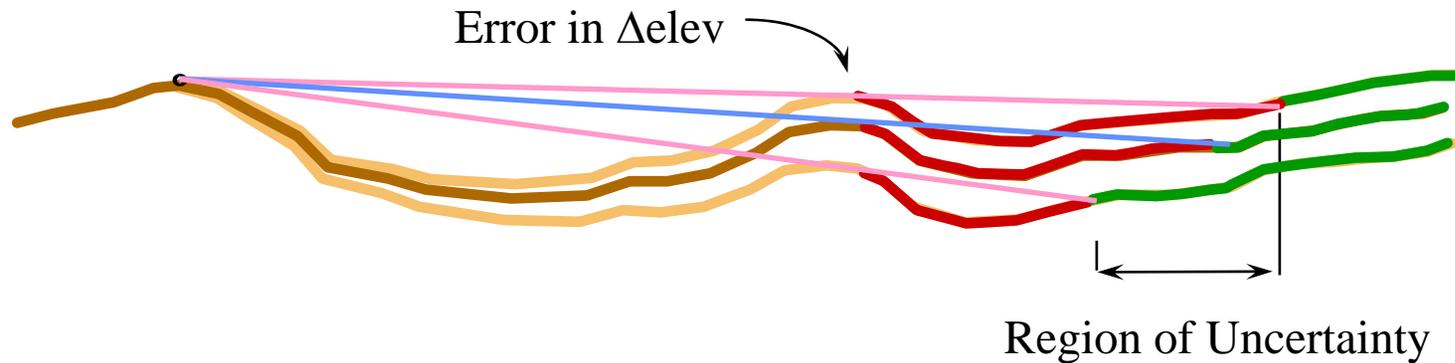


LOS Algorithm:

$$H_{los} = ((e_1 - e_2)/d_2)d_3 - (e_3 - e_1)$$

If ($H_{los} > 0$) then LOS is blocked, else LOS is OK

Propagation of Uncertainty



$$Y = F(X)$$

$$\Sigma_{YY} = C \Sigma_{XX} C^T$$

$$C = J_{XY} = \frac{\partial F(X)}{\partial X}$$

$$X = [e_1, e_2, e_3]; \quad Y = [H_{\text{los}}]$$

$$H_{\text{los}} = ((e_1 - e_2)/d_2)d_3 - (e_3 - e_1)$$

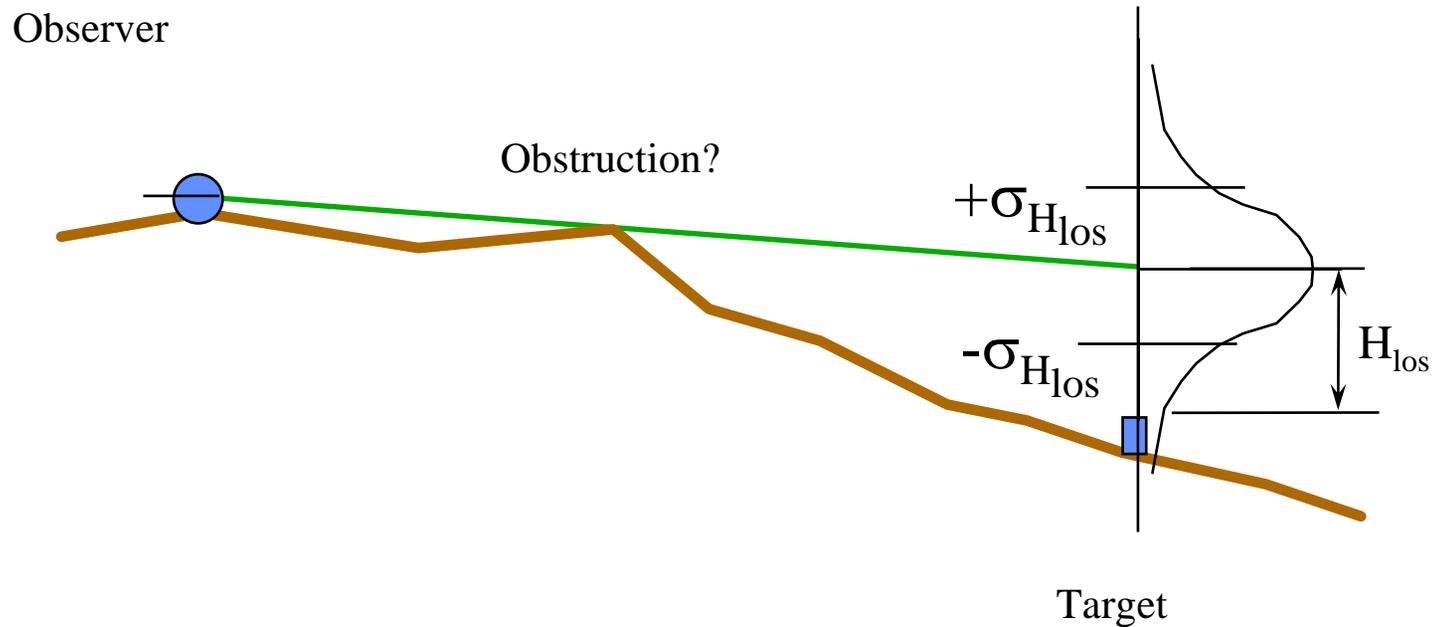
$$C = [1 - d_3/d_2, d_3/d_2, -1]$$

$$\Sigma_{XX}; \quad \text{Cov}(e_i) = 2.0 \text{ meters}$$

$$\text{Cov}(e_i, e_j) = f(\text{distance } ij)$$

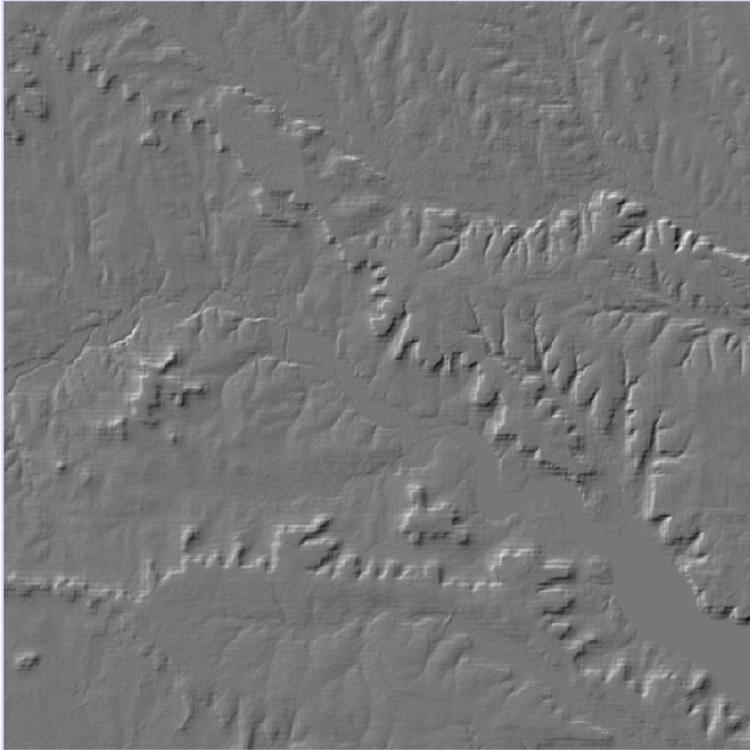
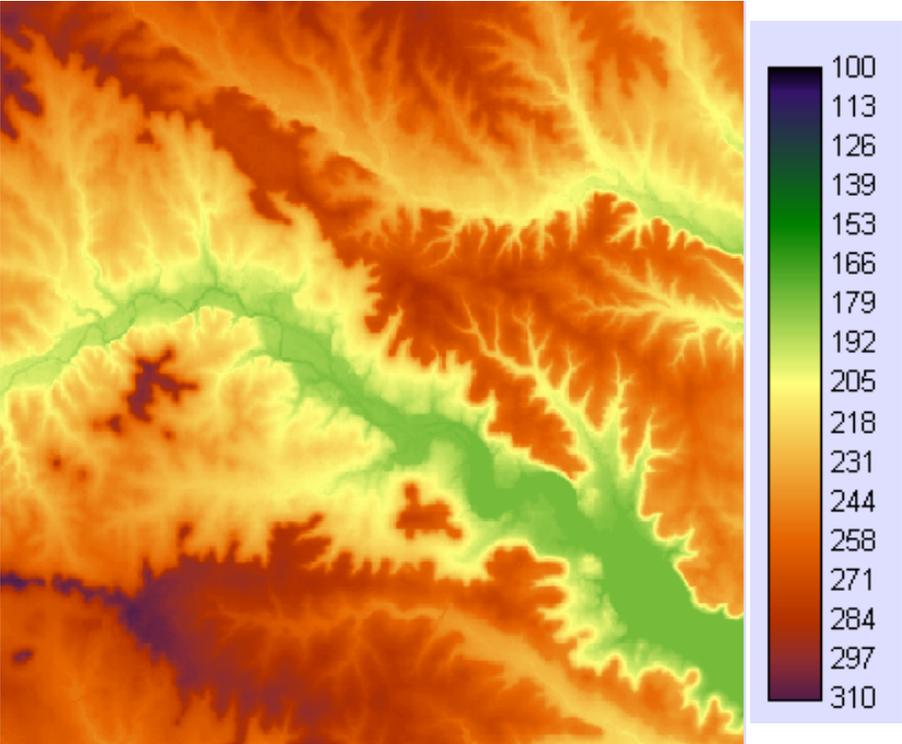
as defined by Variogram

Probability of LOS

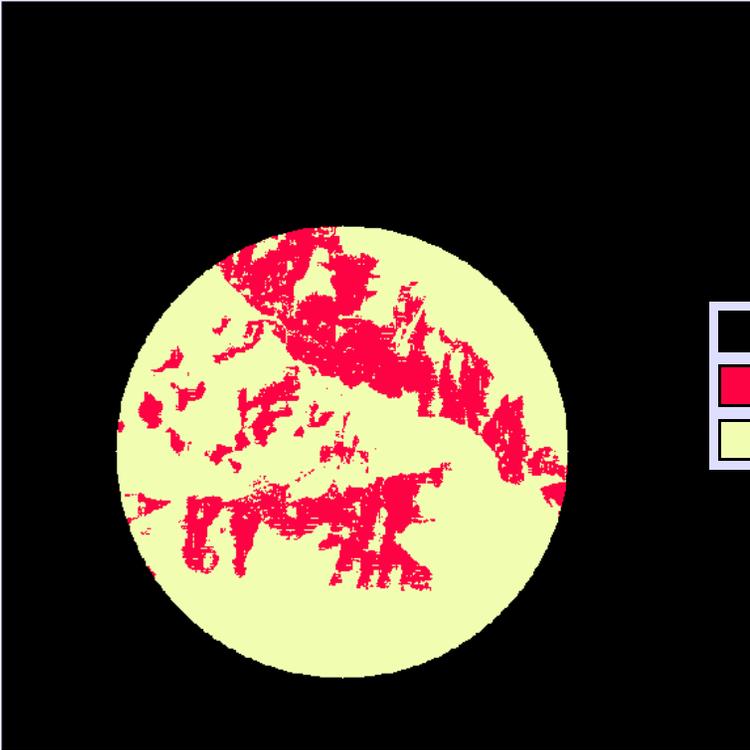
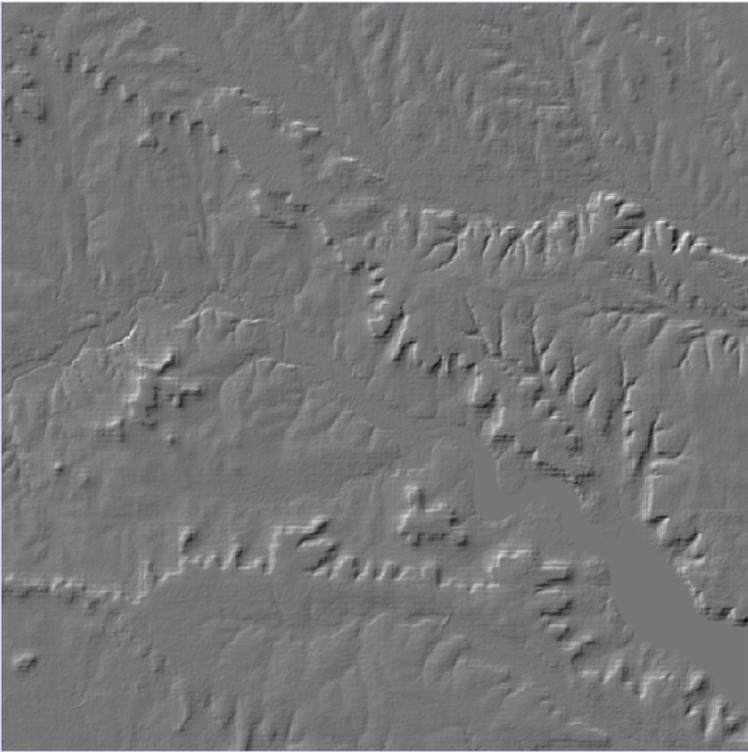


$$\text{Probability of LOS} = P(x > H_{los} \mid x \sim N[0, \sigma^2_{H_{los}}])$$

DTED 2 Elevation Data (Ft Hood)



Line of Sight (LOS)



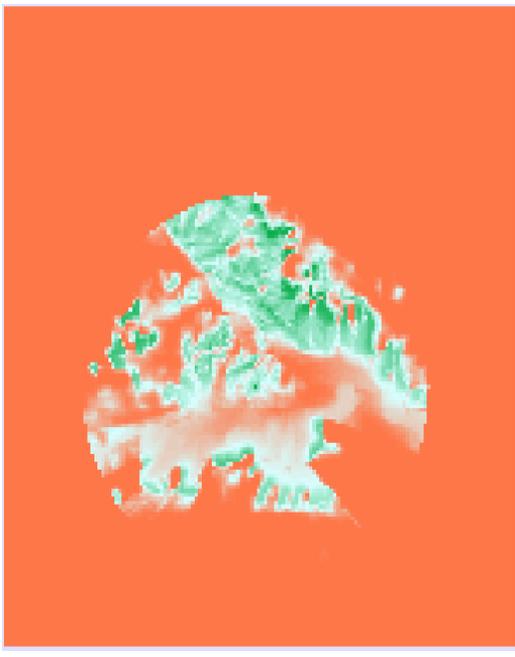
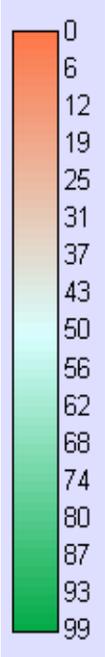
- Black: Beyond Range
- Red: LOS
- Yellow: No LOS

Analytical Hill Shading (DTED 2)

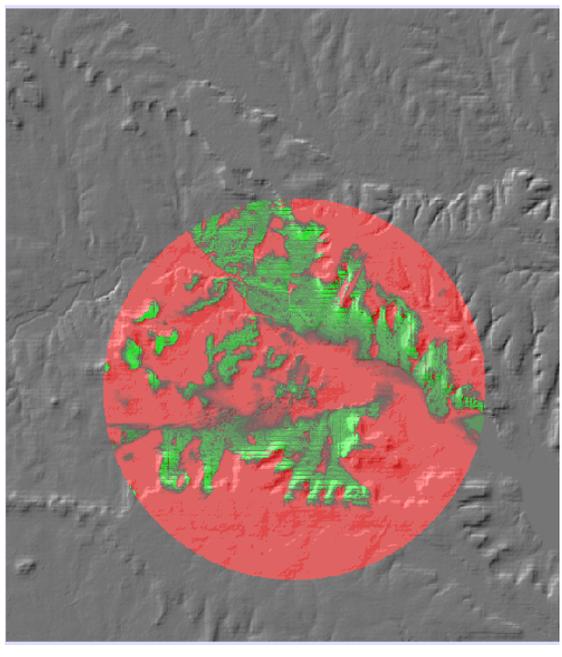
Probabilistic LOS Examples



Accurate Data (max relative error ~ 2 M)



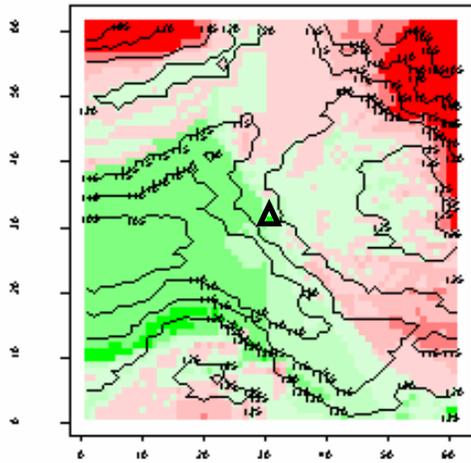
Less Accurate Data (max relative error ~ 15 M)



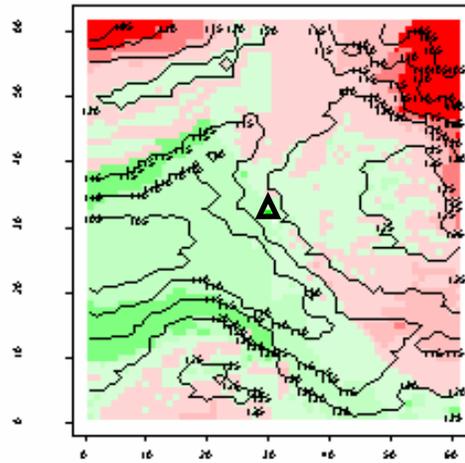
P(LOS) overlaid on Analytical Hill Shading

LOS Results: Tradeoff Analysis

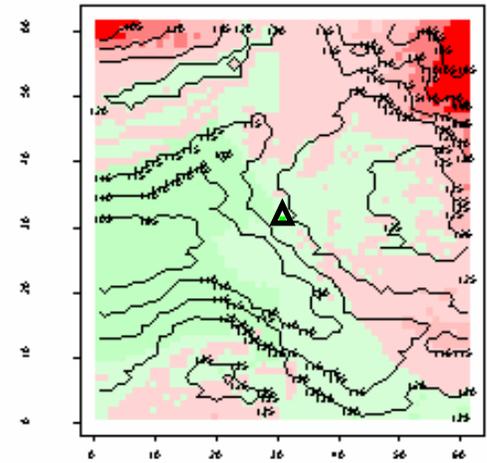
How Good is Good Enough?



Relative Error: 1/2 measured
Time to collect data:
1 month (?)



Relative Error: Original
Time to collect data:
1 Week (?)



Relative Error: 2x measured
Time to collect data:
2 Days (?)

PLOS Summary

- **Method to estimate accuracy of LOS predictions**
 - ◆ Identified as an issue at the TEC Topographic Lessons Learned meeting Sep 2003
 - ◆ Mitigates effects (warns the user) of SRTM random noise
- **Requires estimate of the Covariance model for the elevation data (Relative vertical error as a function of distance)**
- **Allows users to identify & mitigate risks**
- **Supports “trade off” analysis**
 - ◆ Accuracy vs Cost (time)
- **Can be applied to any LOS algorithm**