Determining human judgements of visibility using webcam images

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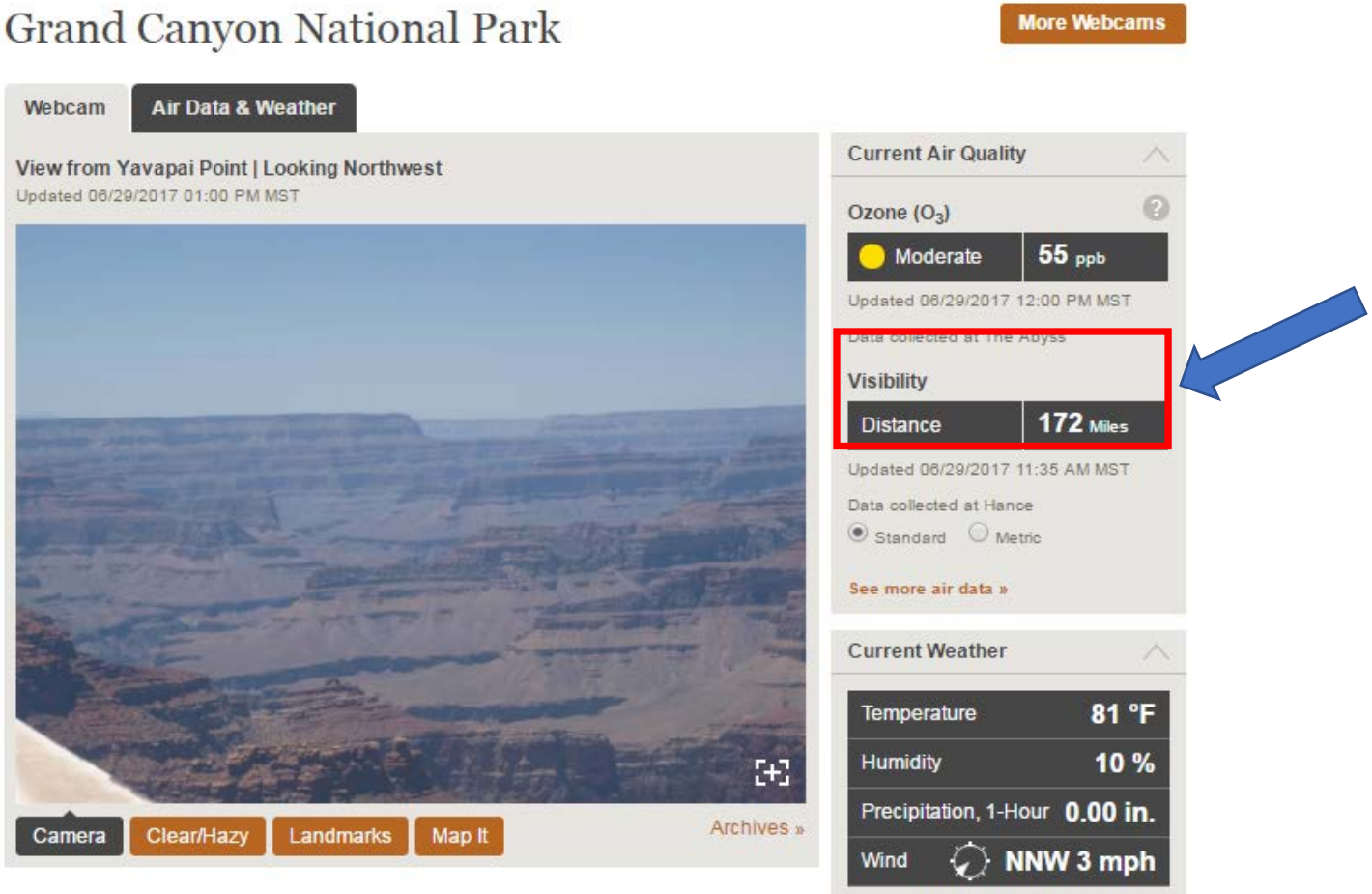
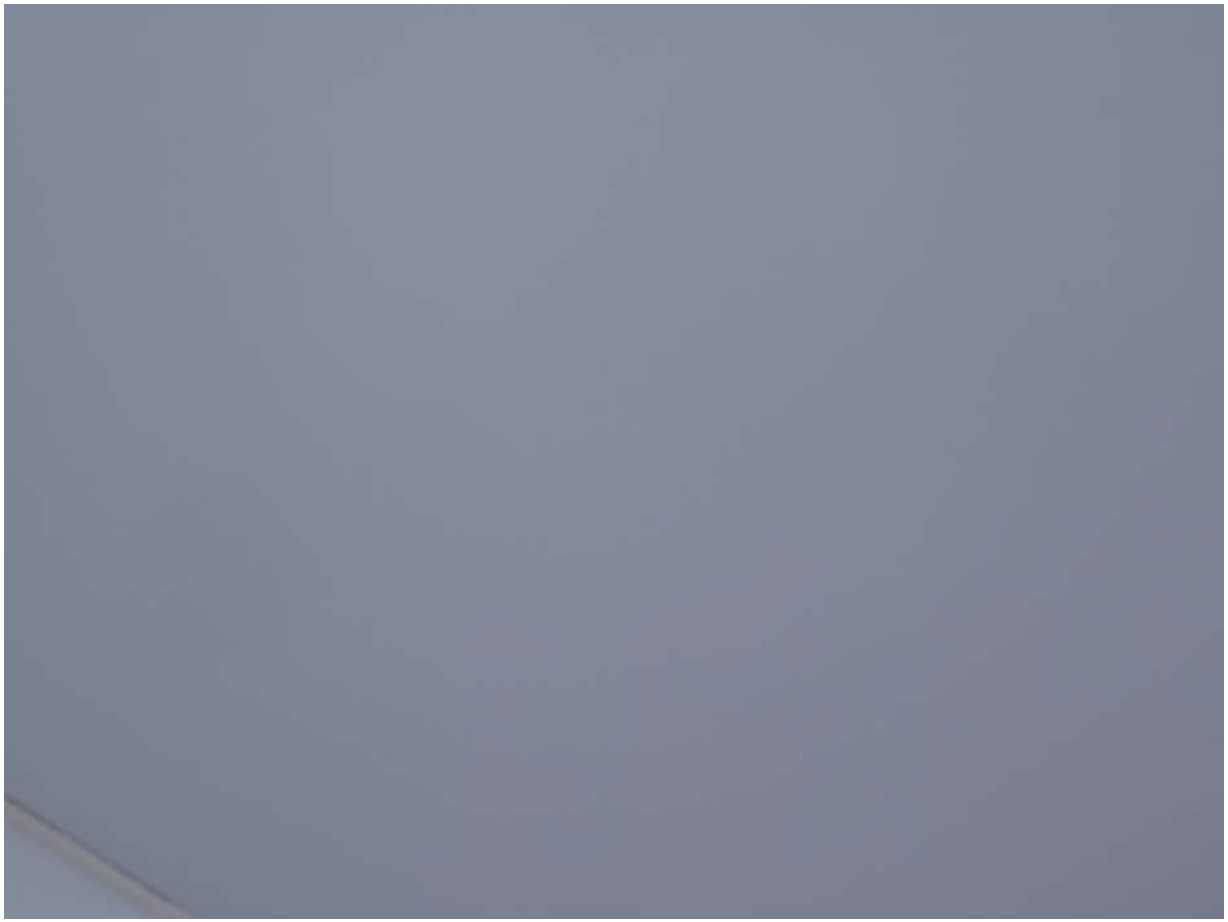
HOW ARE WEBCAM IMAGES CURRENTLY BEING USED?

- Public browsing – inform public of landscape features in the park.
- In some park images are used to inform public of current visibility conditions, in the form of visual range, without reference to what might or should be expected



But is visual range the most appropriated index to represent “visibility” of scenic landscape features? A picture where calculated visual range is in excess of 300 km.



Images capture the effects meteorological and varied lighting conditions as well as haze.

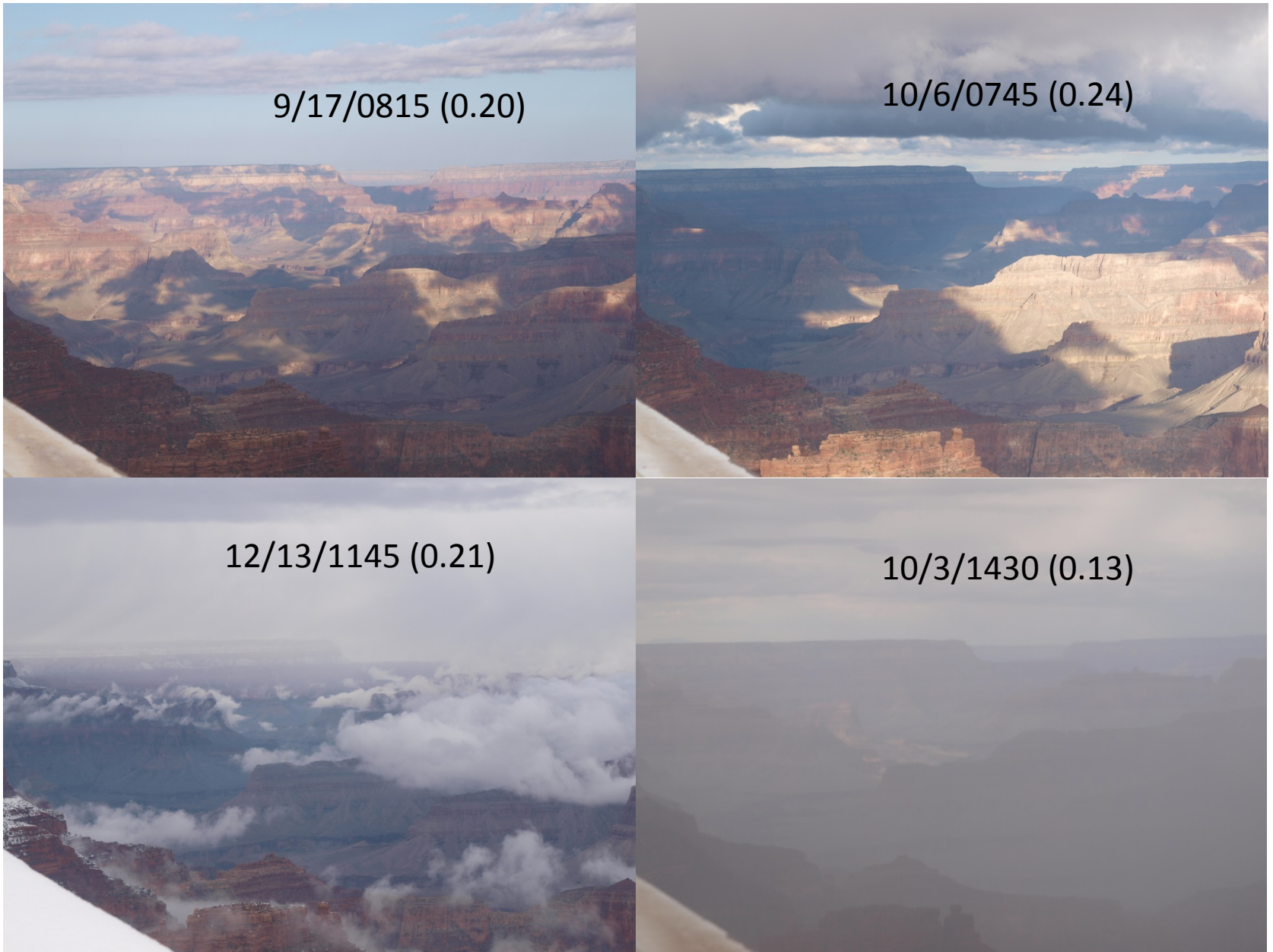
Varying lighting conditions?

8 AM

5 PM

Images from the same day with similar visual range values (slightly greater in 5 PM photo).

Varied meteorological conditions

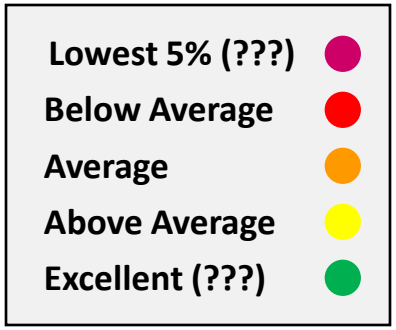


Next series of slides:

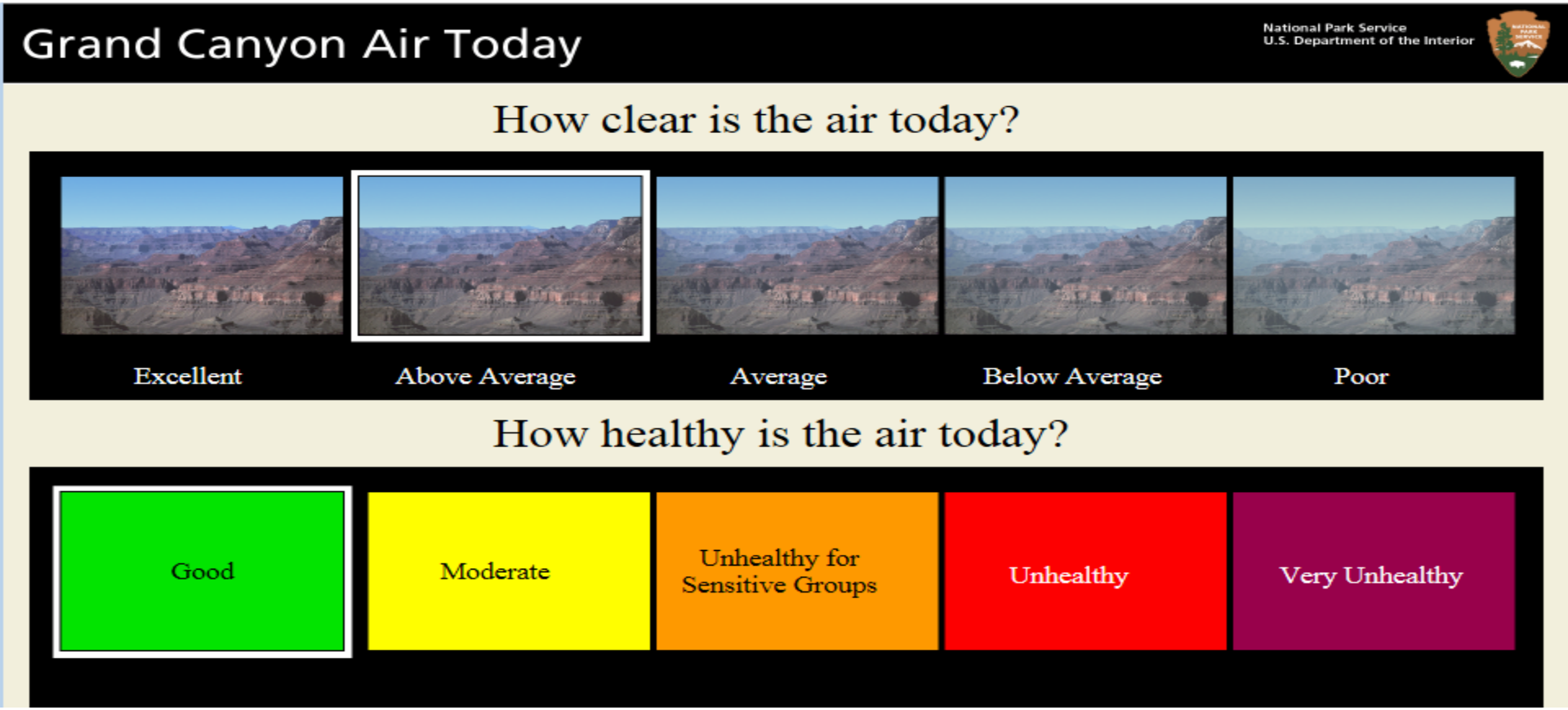
Time lapse of the appearance of landscape features for one day at Grand Canyon National Park. Notice the effects of sun angle change and meteorological conditions. Extinction and visual range levels are about the same for the whole day!

Project Goal

- Develop a quantitative method for assessing human judgements of visibility conditions using the webcam images themselves with the goal of using this metric to reflect perceived visibility on the webcam page.
- Quantify the distribution of perceived visibility conditions for the webcam image of interest.



Something like ----

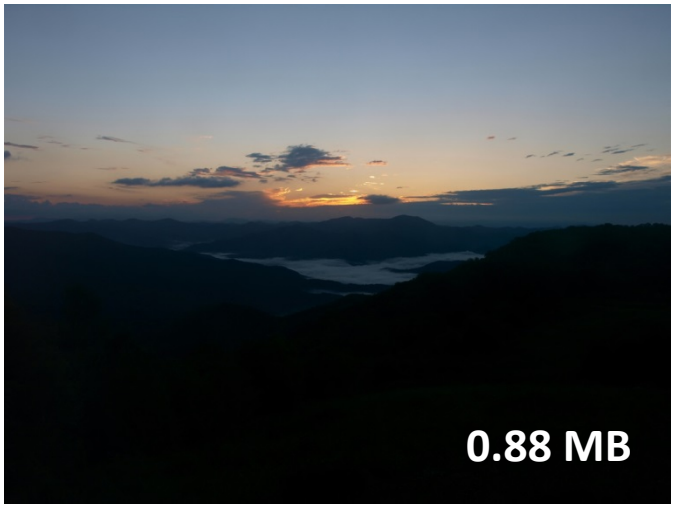


Three Indexes explored as possible indicators of judged visual air quality.

- JPEG size
- Average Contrast
- Edge or gradient estimators.

JPEG file size

- Easy to extract this information
- File size is proportional to information content in the image.



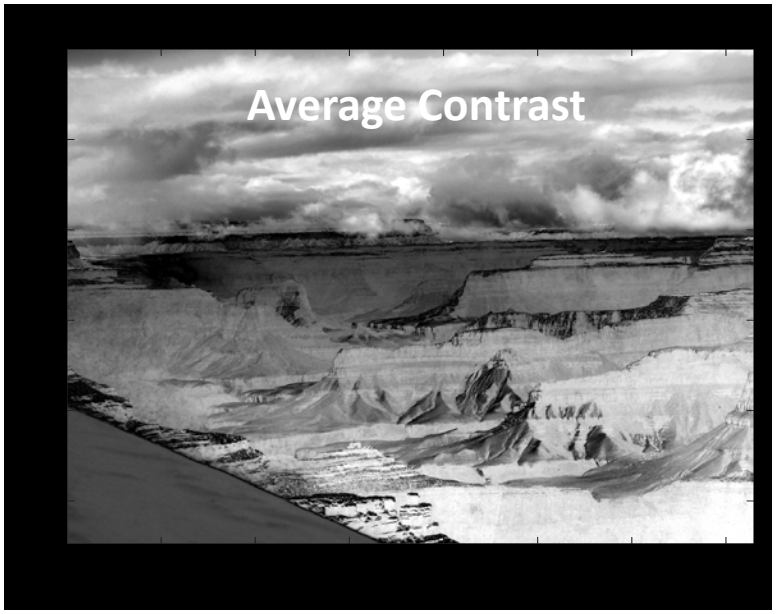
- BUT…JPEG compression algorithm is a little bit of a black box and should not necessarily be correlated with visual clarity.

$$Index = \bar{C} = \frac{\sum_i \left|(\bar{N}_r - N_{r,i})\right| / N'}{\bar{N}_r}$$

$$\left|(\bar{N}_r - N_{r,i})\right|$$

$$\left(\overline{N_r} - N_{r,i}\right)^2$$

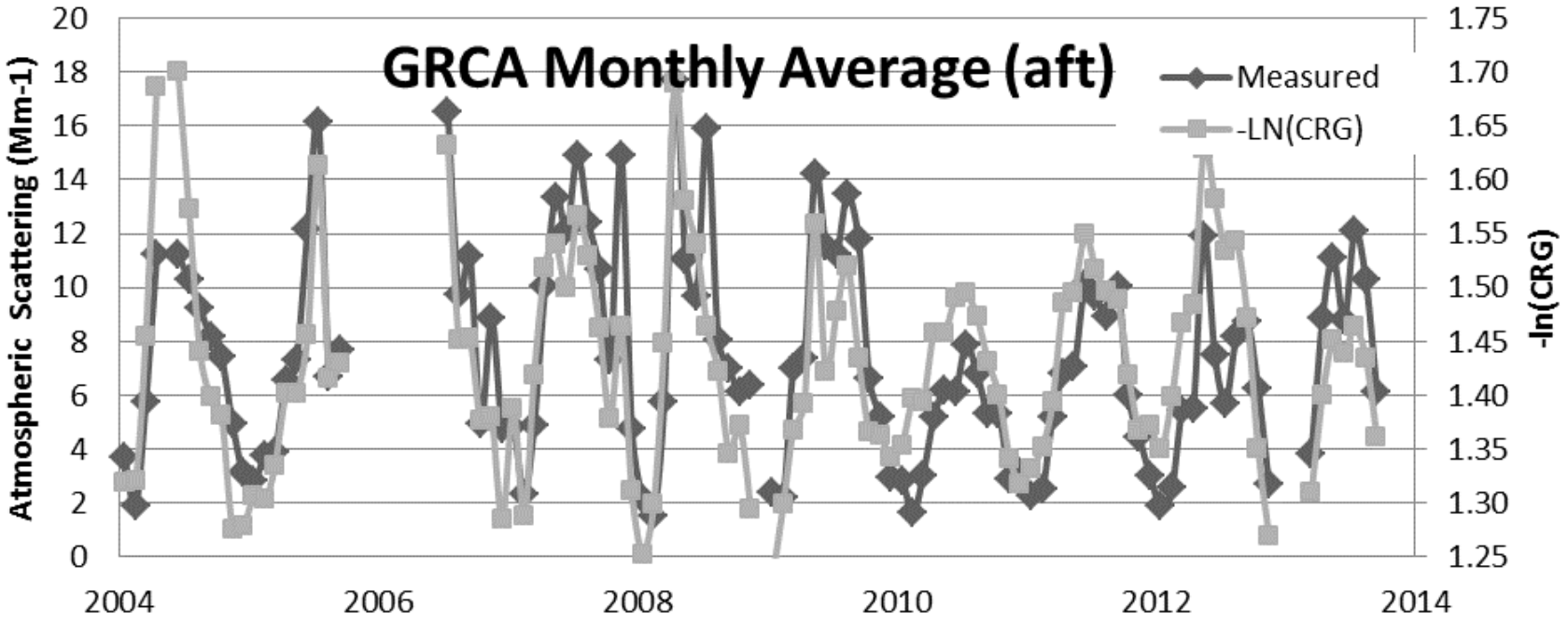
$$Index = \overline{C_{eq}} = \frac{\sum_i \left(\overline{N_r} - N_{r,i}\right)^2 / N'}{\bar{N}_r}$$




This image has high average contrast.

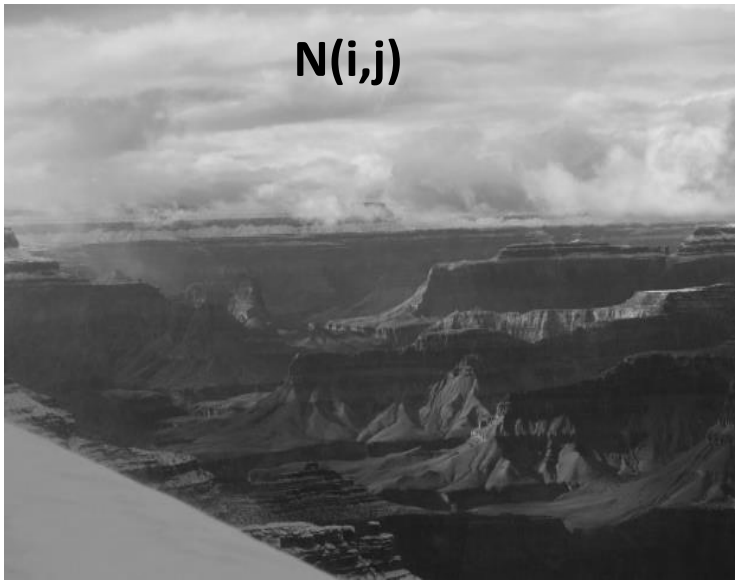
But so does this one. Is the “visibility” the same in these two images?

Average contrast good predictor of extinction

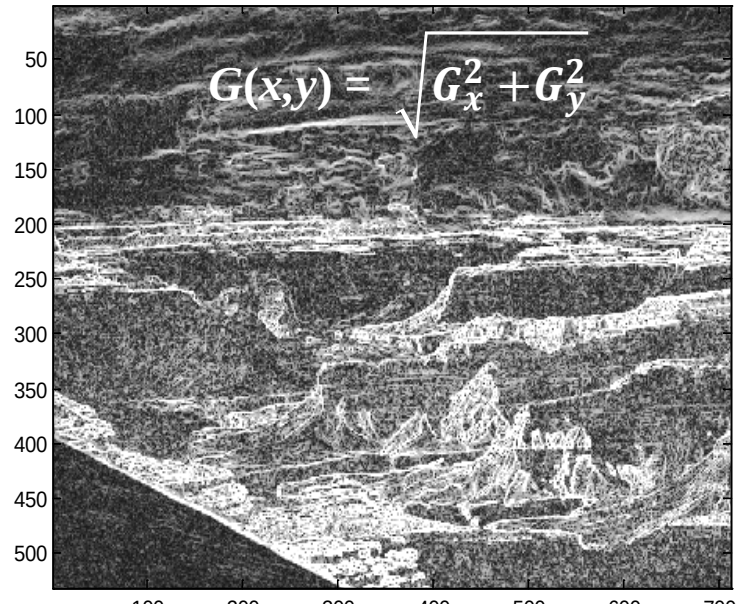


Sobel Filter

$$S_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \text{ and } S_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$$



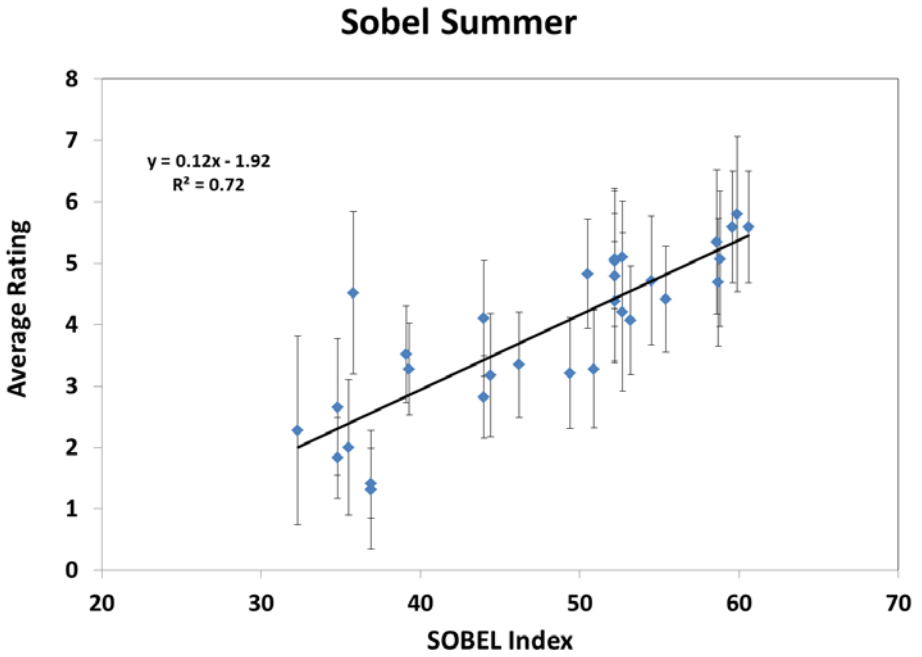
N(i,j)*S (x,y)

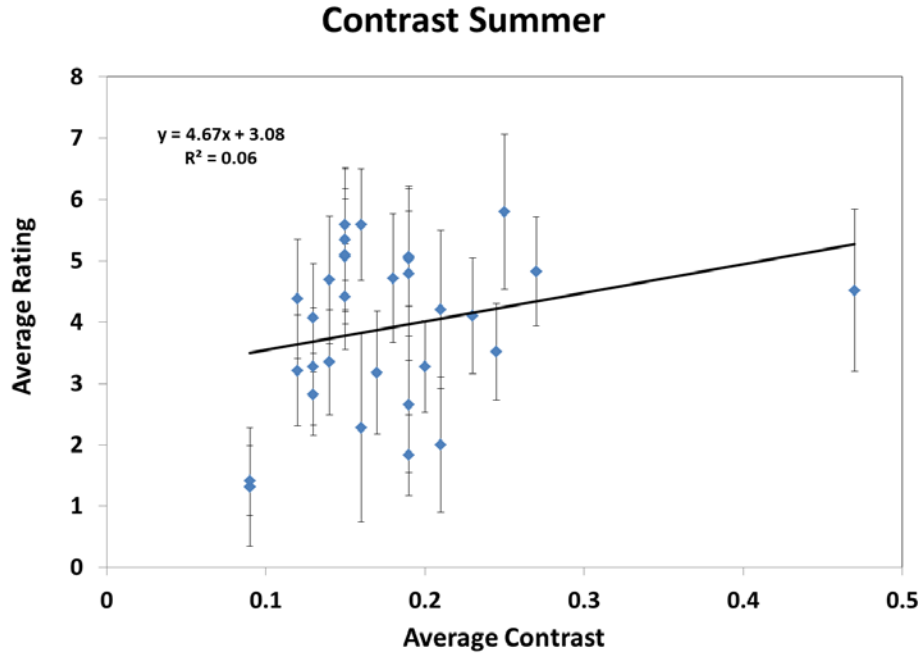


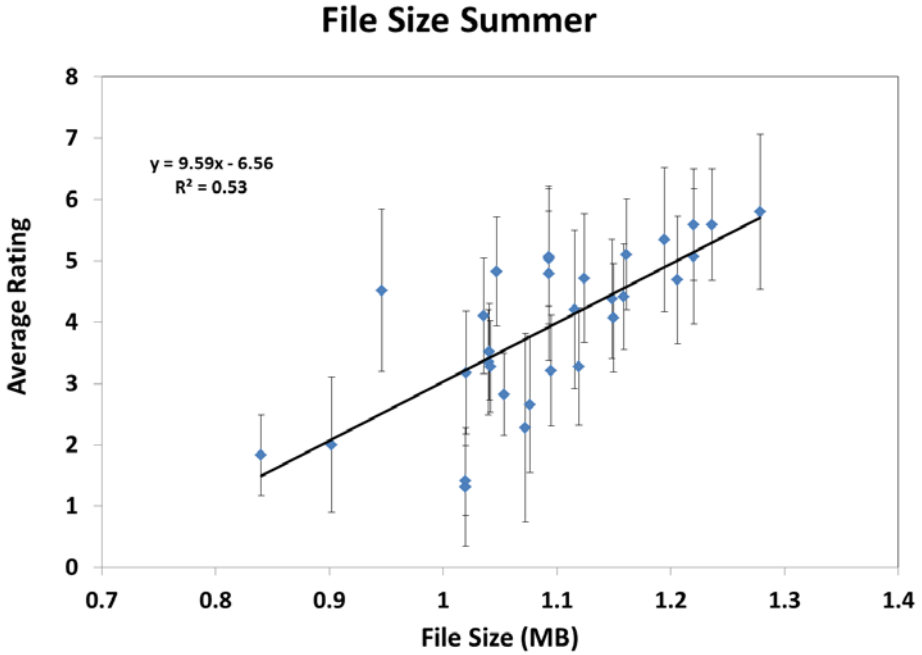
SOB index = $\sum_{i,j}(G(x,y))/N'$

So which metric relates best to judgements of visual air quality (visibility)

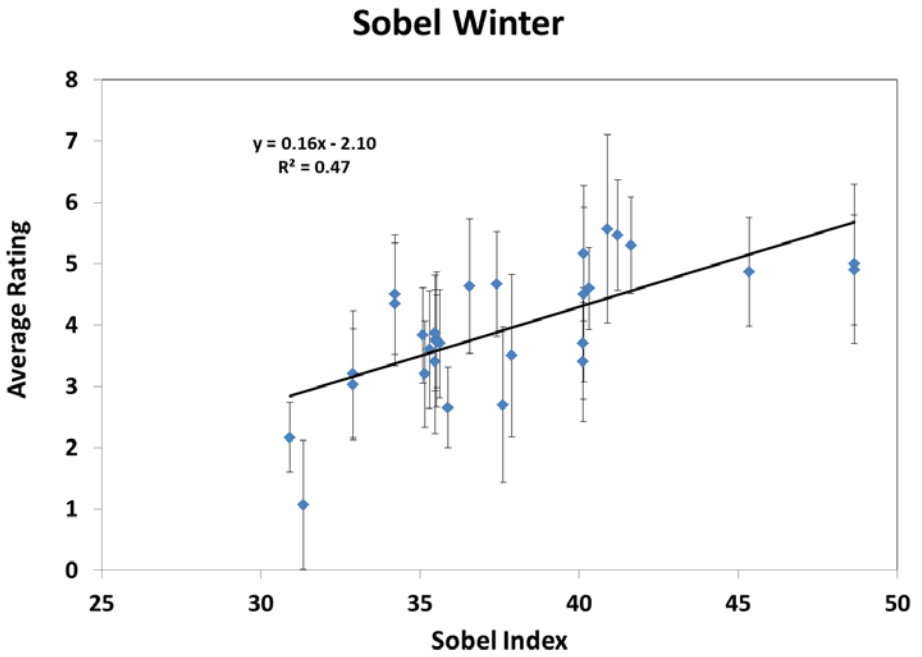
Summer Noon GRCA Results

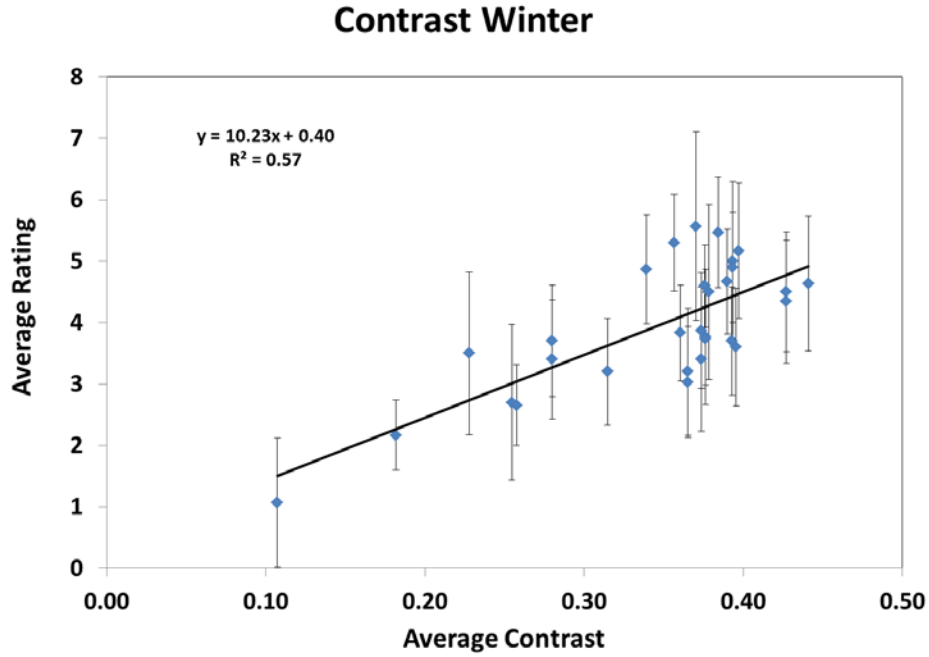


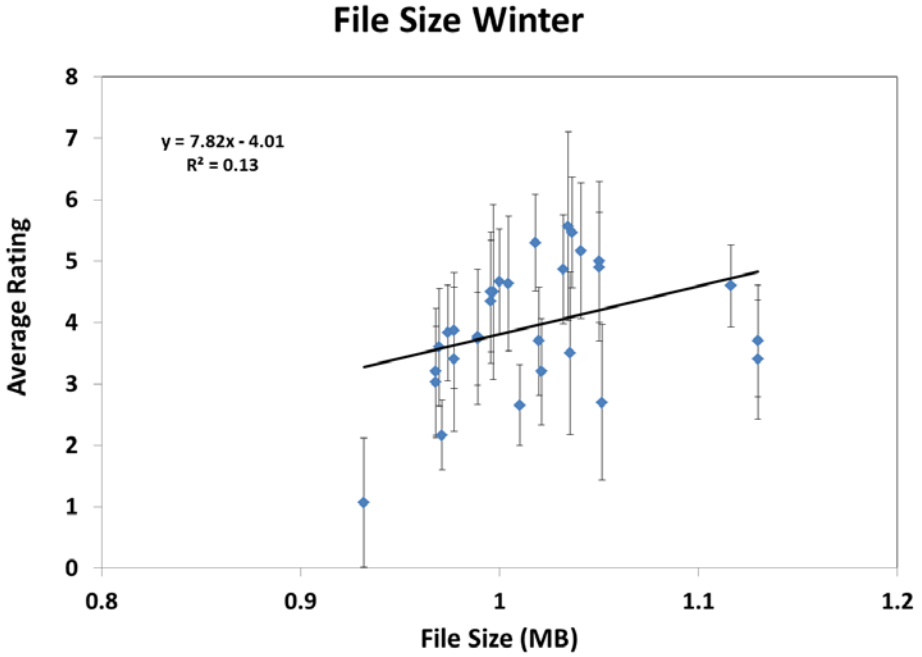




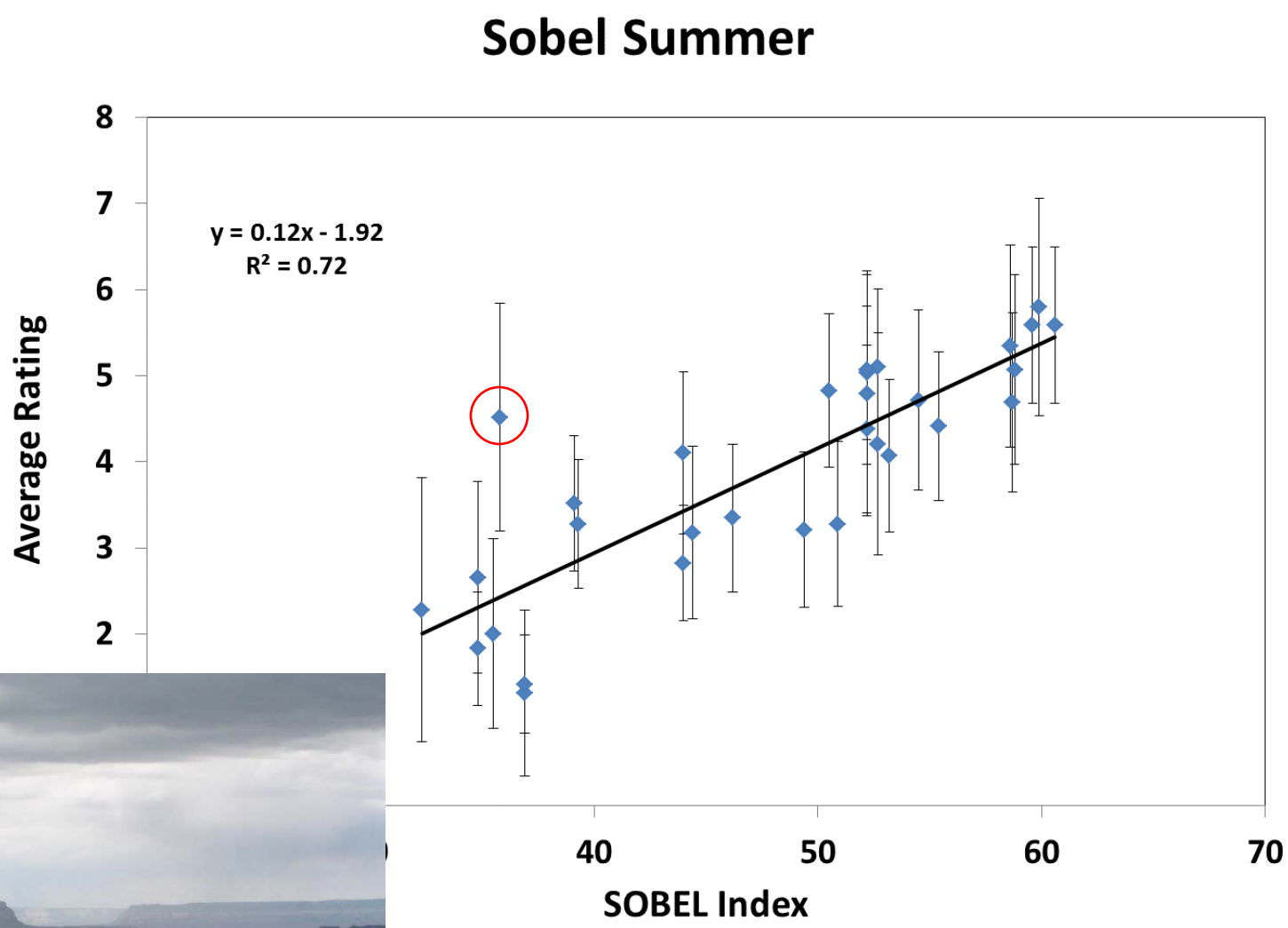
Winter Morning GRCA Results





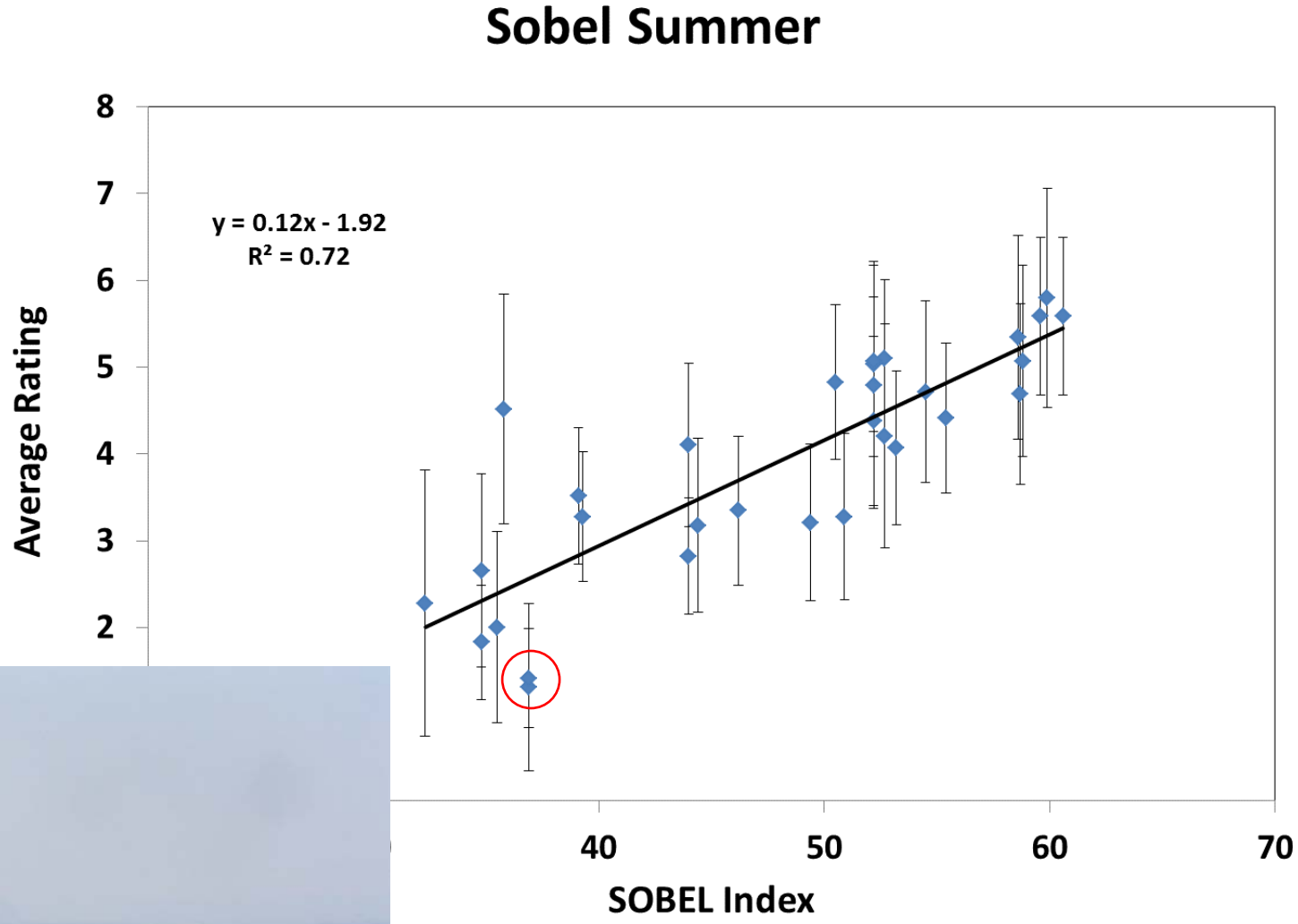


Outliers



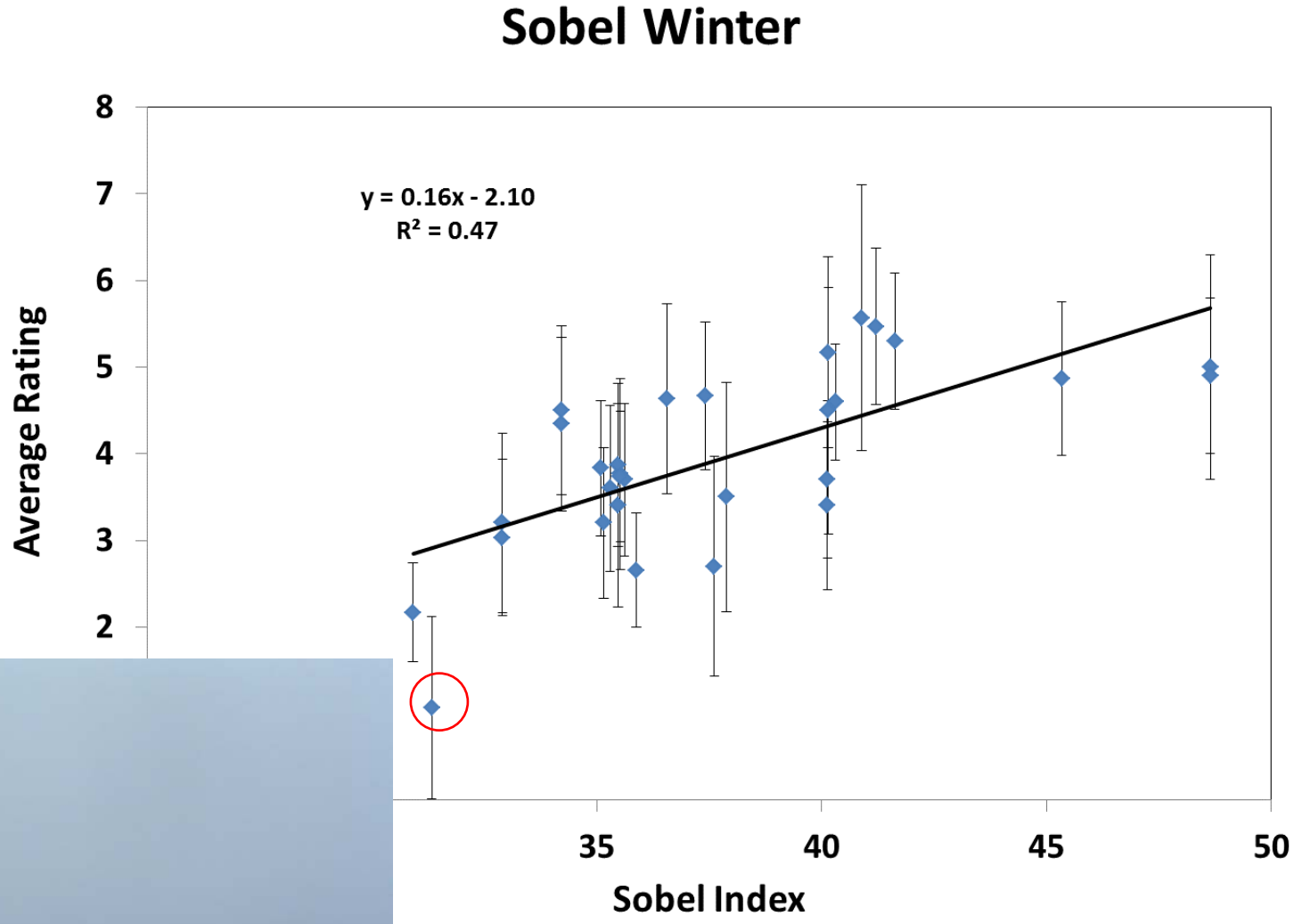
Dark Image with reasonably good visibility.

Outliers



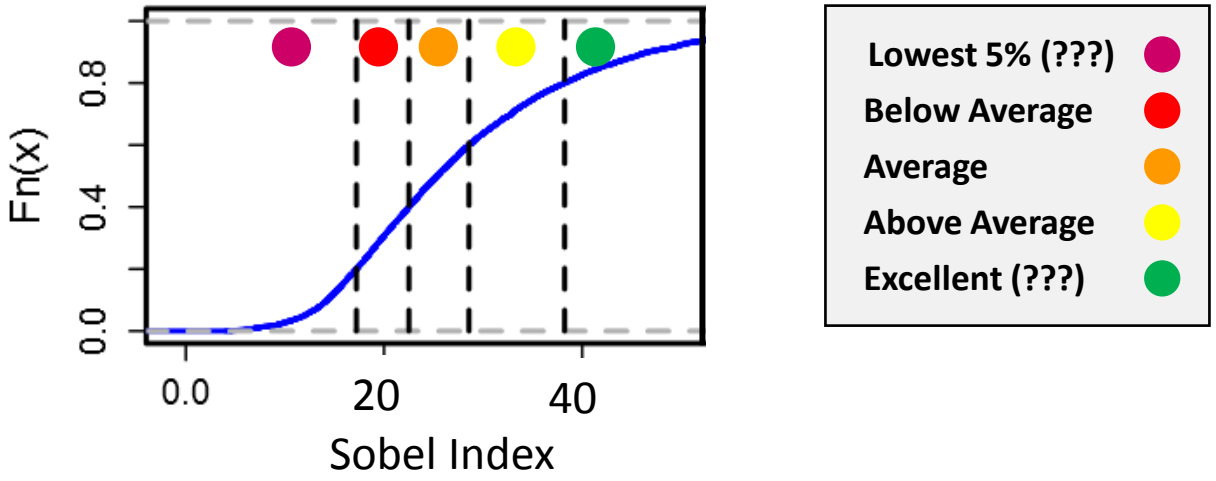
A repeated slide in the study (very reproducible!) with poor visibility.

Outliers



Dominated by clouds.

Differences in lighting conditions due to time of day and season primarily result from changes in sun angle. Therefore select poor, below average, average, above average, and good visual air quality for each increment of 10 degrees in azimuth or zenith sun angles.

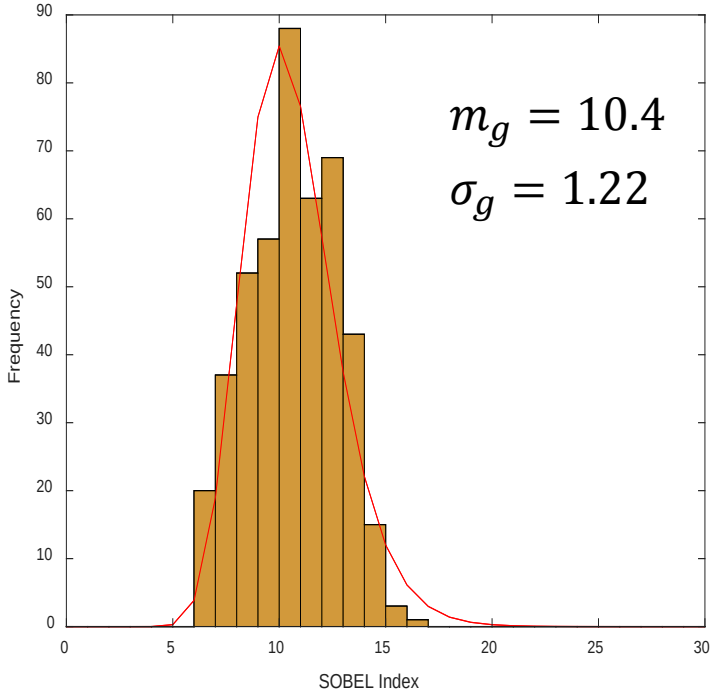


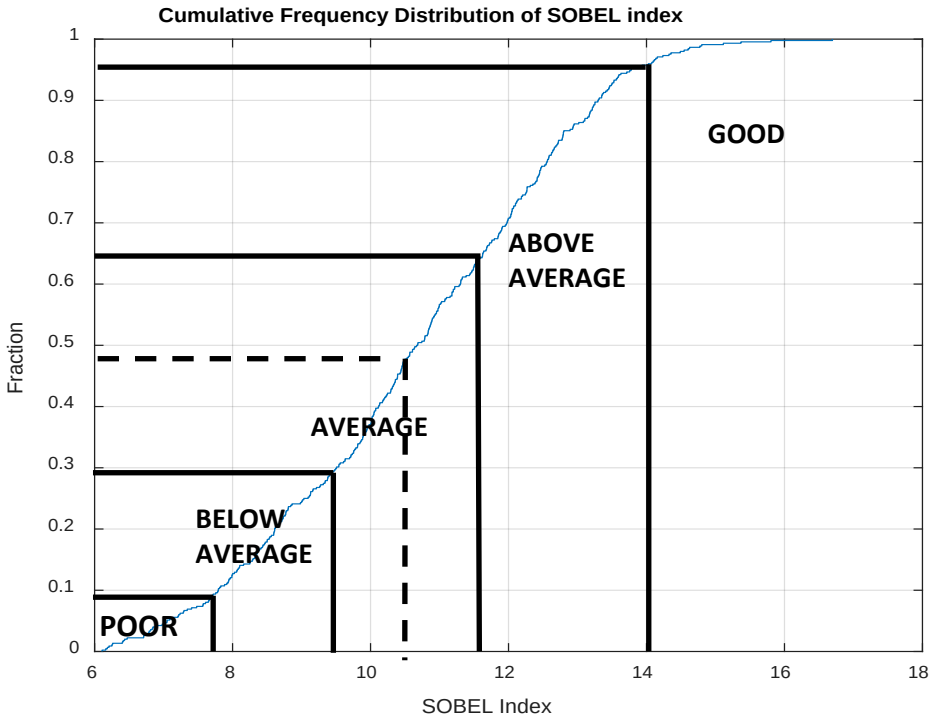
Distribution of SOBEL index for one time of day (one zenith and azimuth angle) when the distribution is approximately log normal.

$$poor < \bar{x} - \frac{3}{2}\sigma, \quad \bar{x} - \frac{3}{2}\sigma \leq below\ avg < \bar{x} - \frac{1}{2}\sigma, \quad \bar{x} - \frac{1}{2}\sigma \leq avg \leq \bar{x} + \frac{1}{2}\sigma$$

$$\bar{x} + \frac{1}{2}\sigma < above\ avg \leq \bar{x} + \frac{3}{2}\sigma, \quad \bar{x} + \frac{3}{2}\sigma < good$$

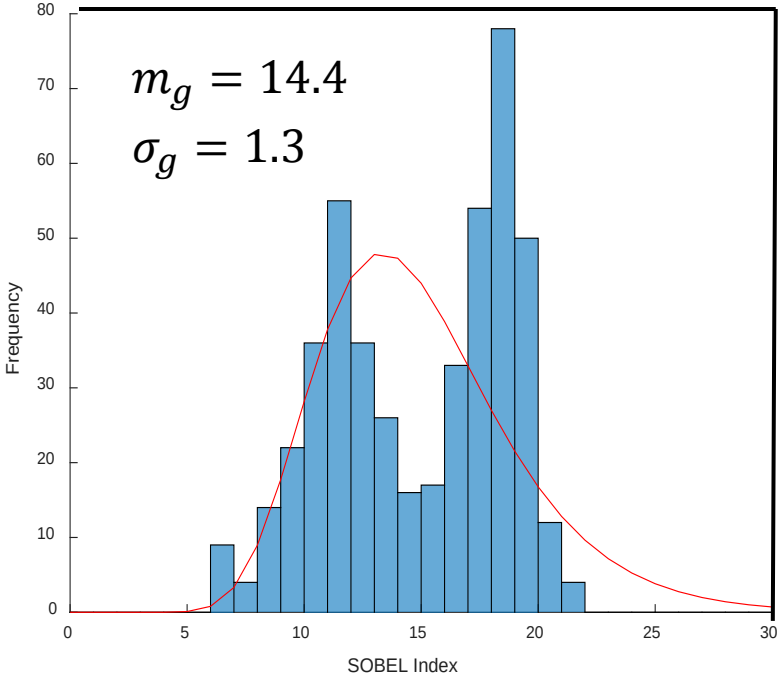
If the index is normally distributed the above cut-points should correspond to Good ≈ 9%, Above average≈22%, Average ≈38%, Below average ≈22%, Poor ≈9%

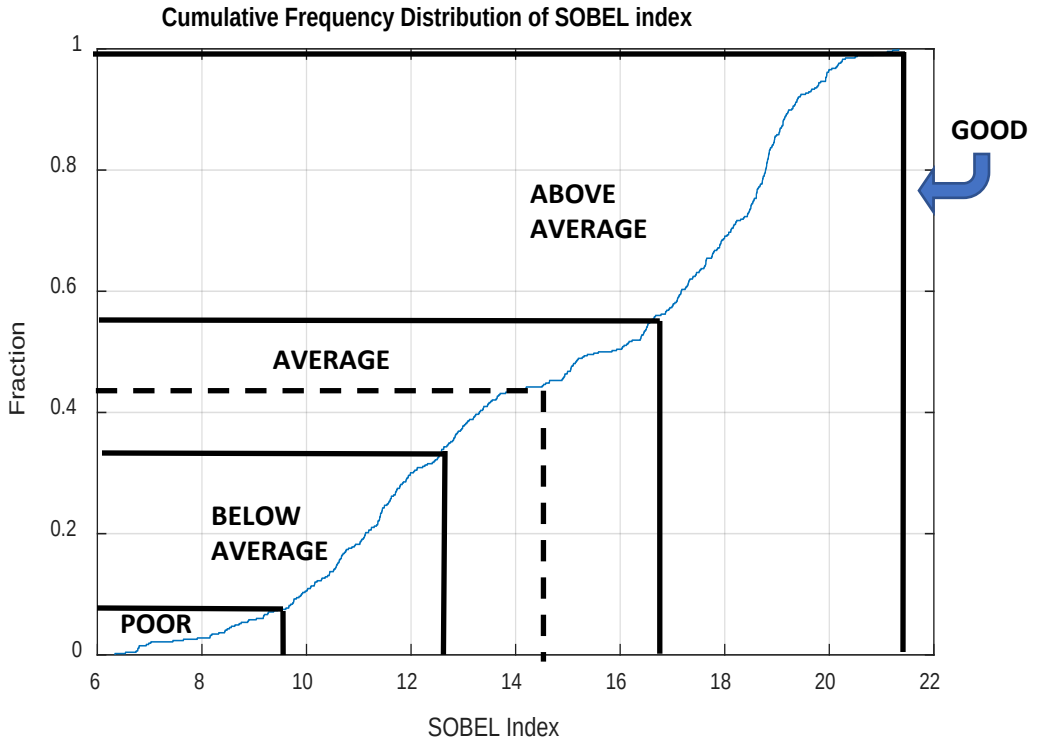




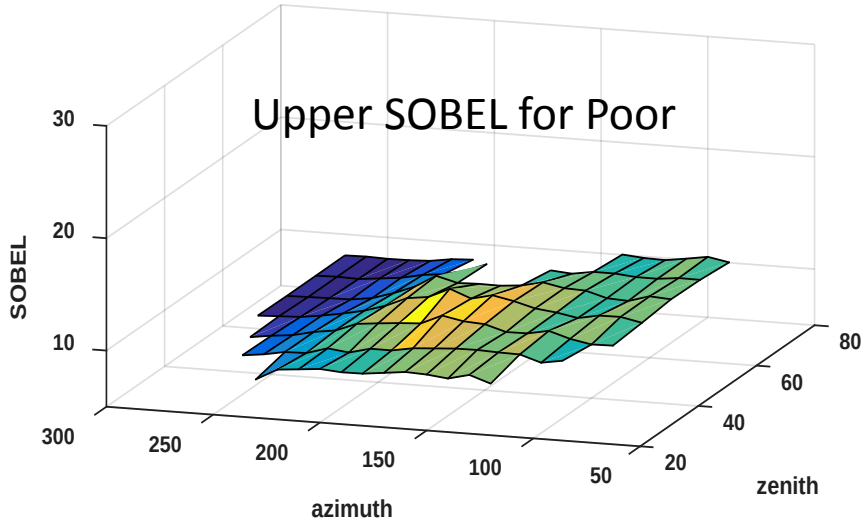
But there are many cases where the distribution is bimodal.

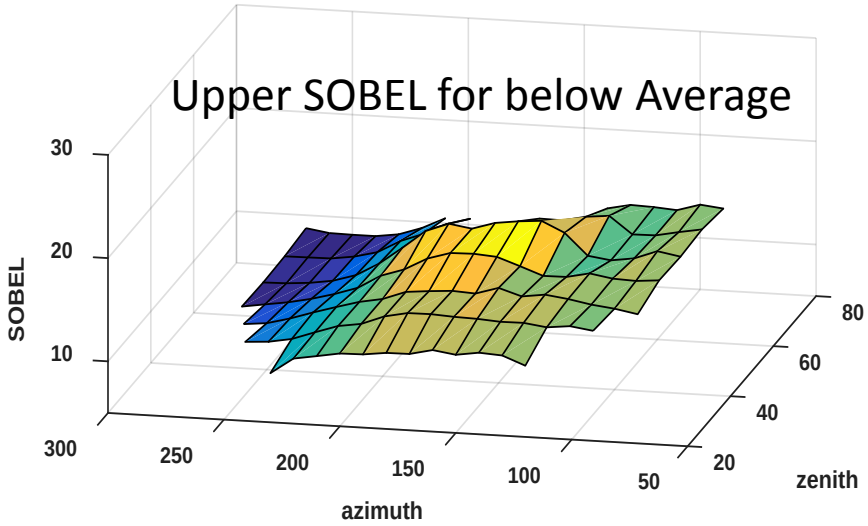
If the index is normally distributed the above cut-points should correspond to Good ≈ 9%, Above average≈22%, Average ≈38%, Below average ≈22%, Poor ≈9%

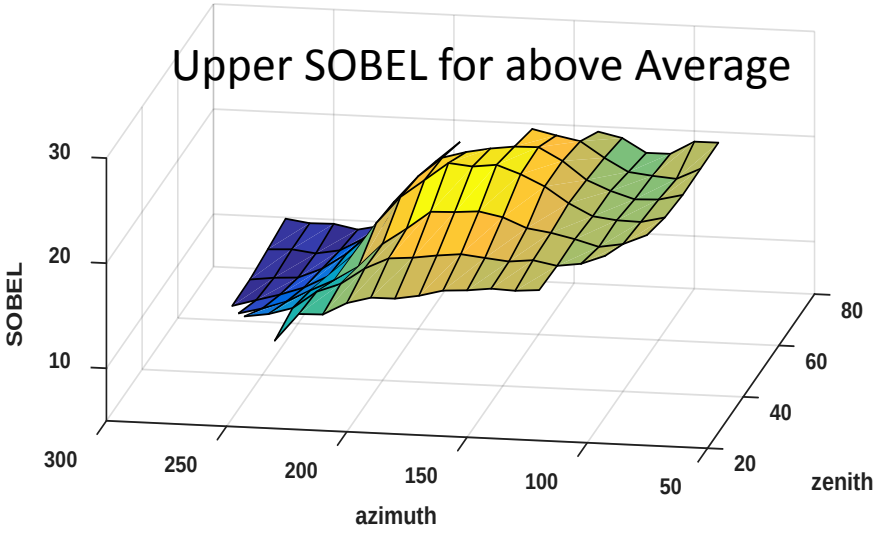


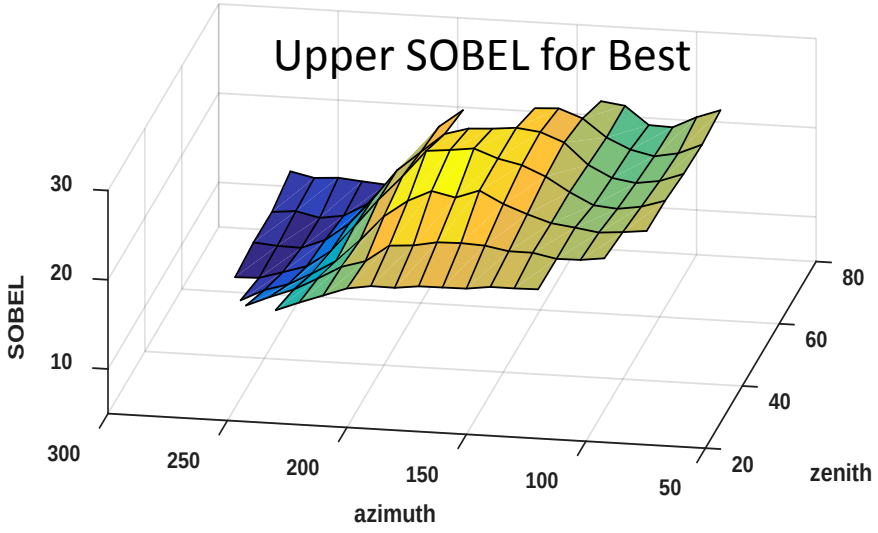


Example of SOBEL index as a function of sun azimuth and zenith angle. All graphs are plotted on the same scale.

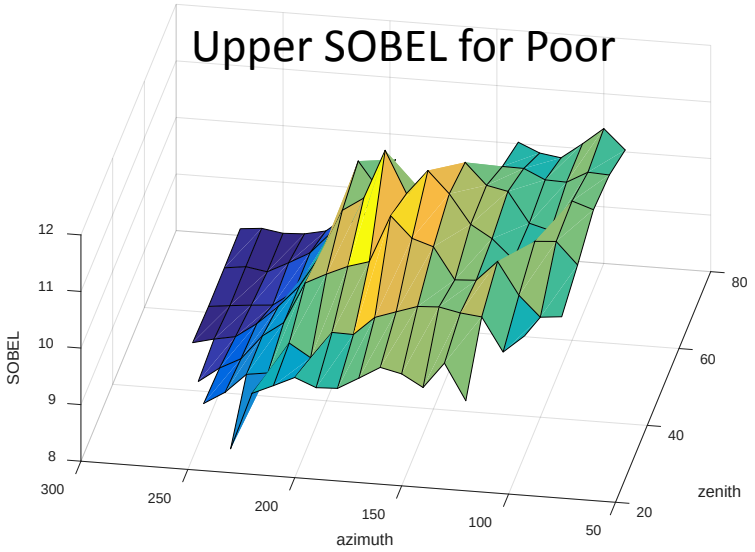


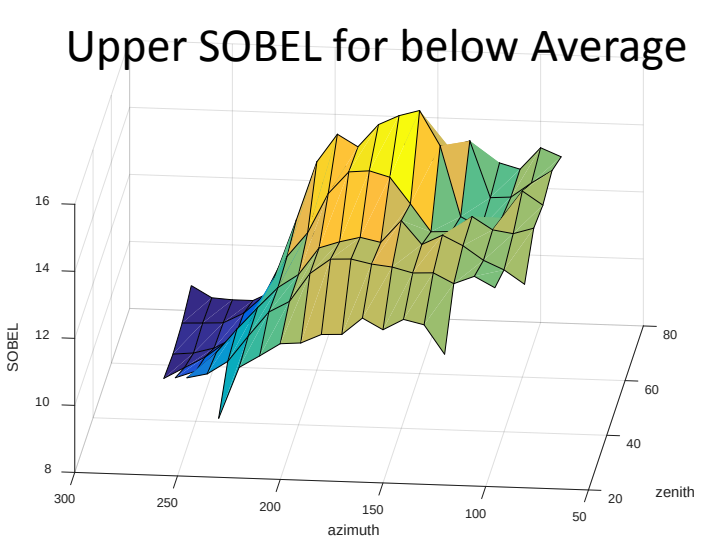


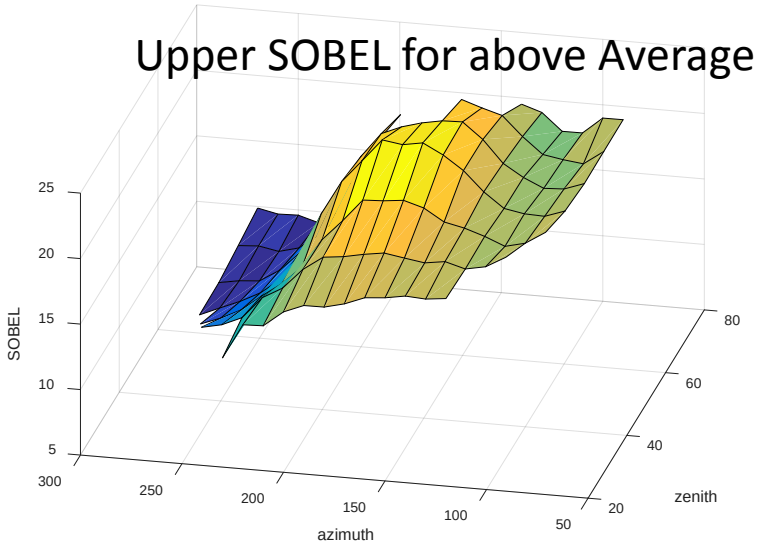


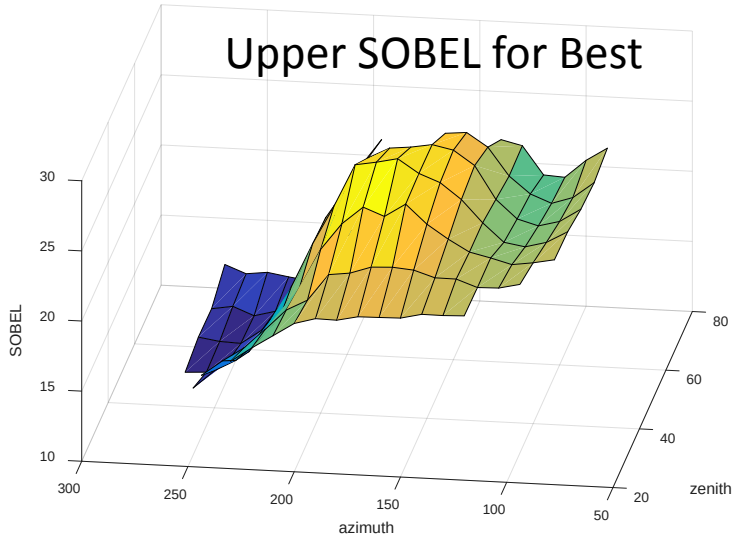


Example of SOBEL index as a function of sun azimuth and zenith angle. Each plot scaled to max and min SOBEL index









NEXT STEPS?

- Use visual AQ survey results to help select the best metric for visibility at the webcam sites.
- Get distributions of the given index for each webcam. and select cut-points for visibility scale for each time day and year? (or use sun angle as indicator of lighting conditions)
- Implement on webcam page.
- Longer term: larger survey as a Citizen Science project?