Unsharp Masking: Map results are jointly dependent on transform configuration

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Unsharp Masking Background

1. Transform identified as a deconvolution technique in several papers related to Lunar Prospector neutron flux rate mapping as enhancing spatial resolution.

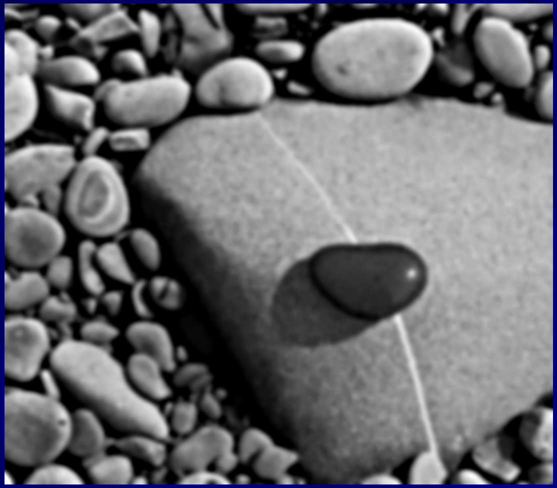
2. Transform identified as an Image Sharpening Transform called Unsharp Masking.

Objectives:

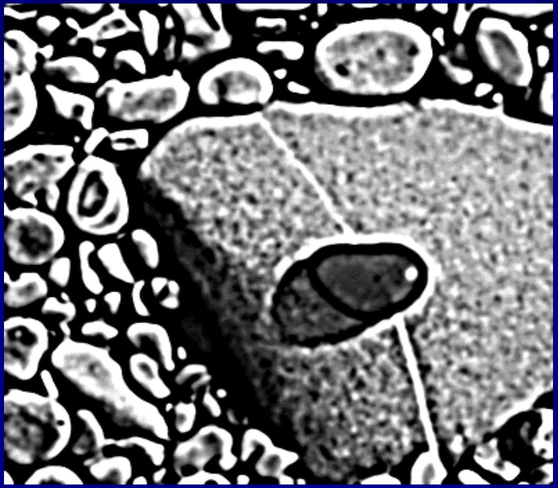
To investigate possible use of Unsharp Masking process on HEND and LEND data analysis. Also, to identify Any dependencies in several key transform parameters.

Unsharp Masking in Imagery

Blurred Image, O



Unsharp Masking, $k = 1$
Kernel p =gaussian, (5x5)



Oversharpened, $k = 5$

Unsharp Masking Transform: $I_{k+1} = I_k + r^*(O - p \otimes I_k)$

High Pass Filter

O = Starting Image

I_k = Present Image at iteration, k

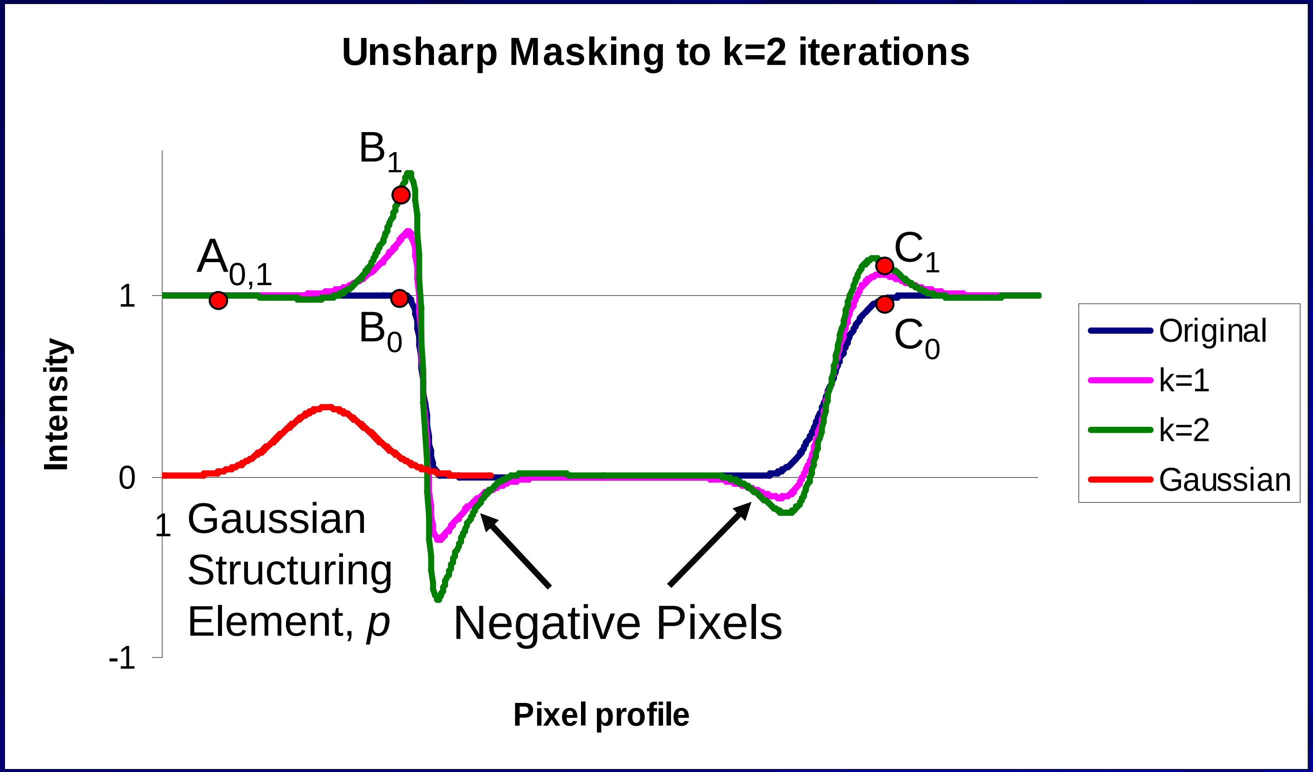
r = scalar: fraction of high pass filter

p = 2-d structuring element, Gaussian: 5x5 pixels

$\otimes$= convolution operator

* Note: amplified high frequencies oversharpened rock

Unsharp Masking: Pixel Profile, k = 0,1,2 iterations



- Variable Pixel Enhancement, Pixel $[A_0,B_0,C_0] = 1$, $A_1 < C_1 < B_1$
  - *f*(Local Spatial Gradient) and *p* (size)
- Special handling of Negative Physical Values < 0. (Threshold)
- Pixel intensity transition = *f(p, k, r)* (User Defined), Convergence?

Pre-Transform: HEND Variable initial smoothing, O_A, O_B

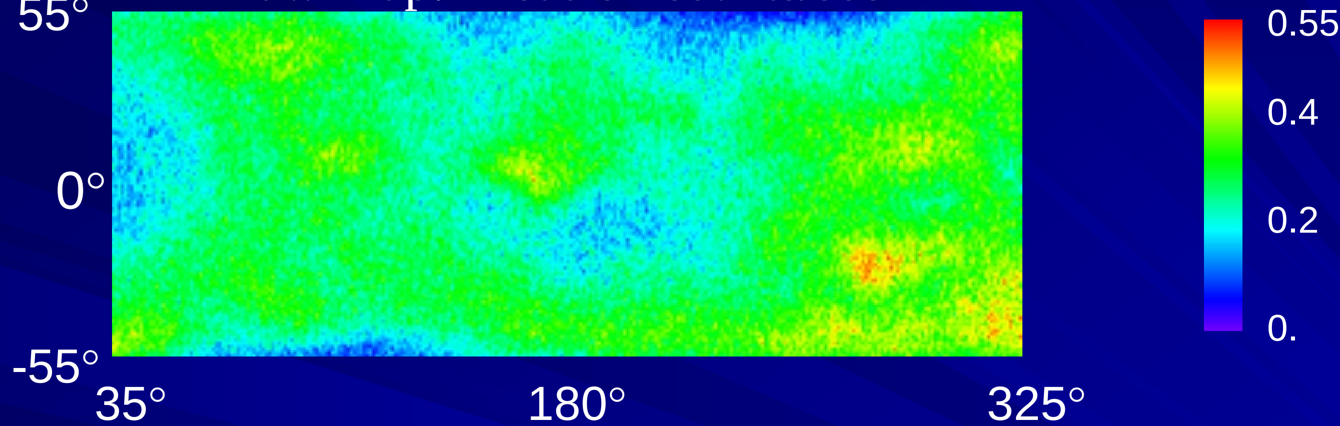
- Incremental Smoothing of Raw Map: 1 and 2 gauss conv.

Map Resolution:
1 degree pixels

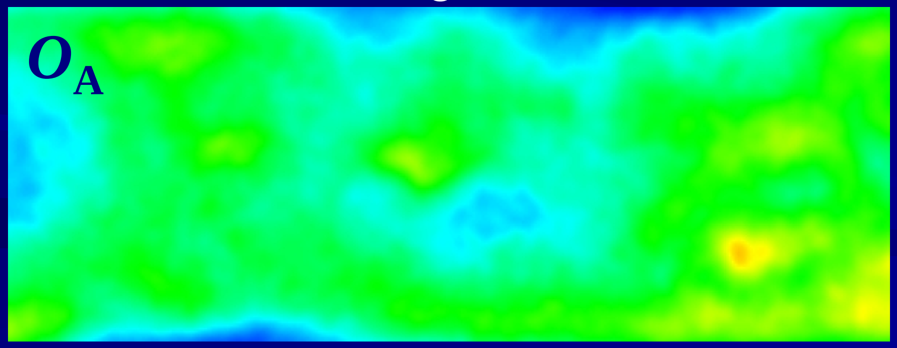
Margins removed due to edge effects

Raw Map: Neutron counts/sec

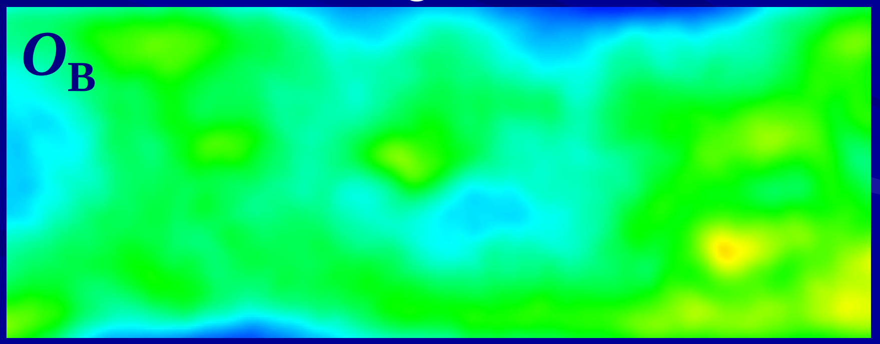
Counts/Sec



Smoothing Iterations = 1

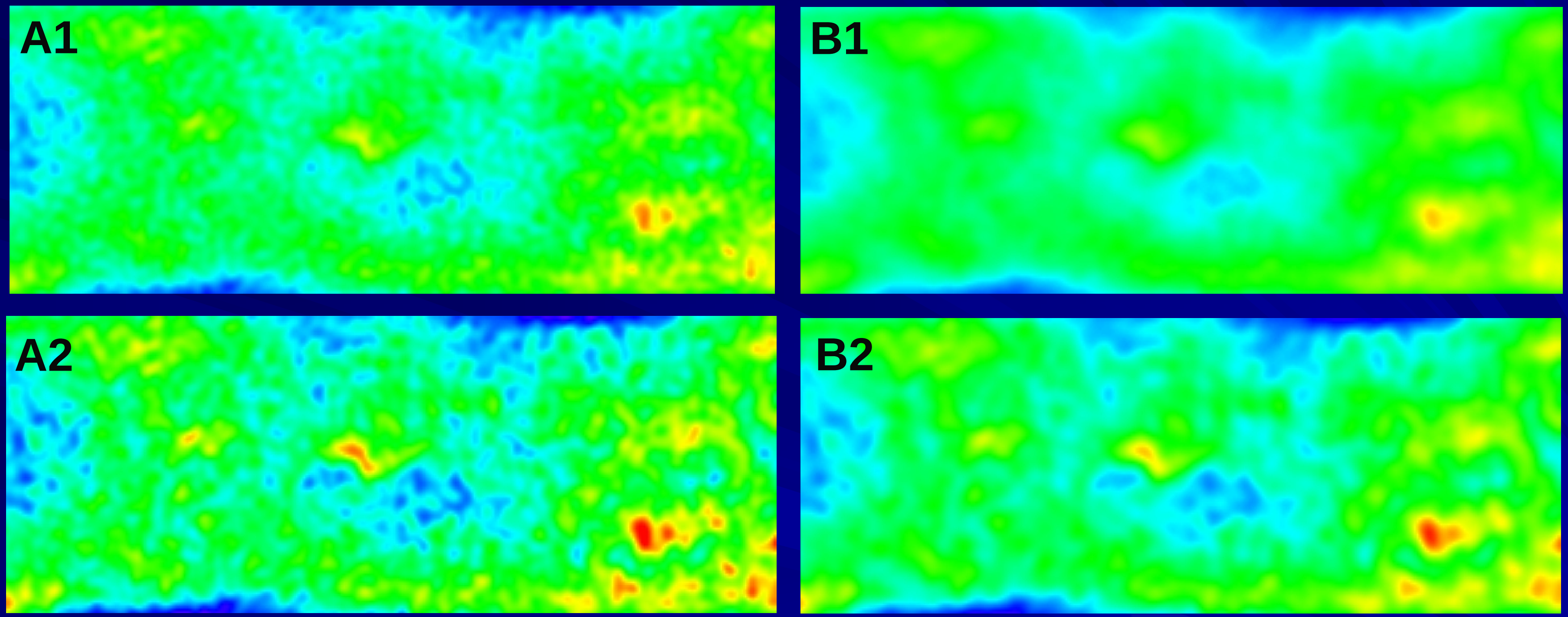


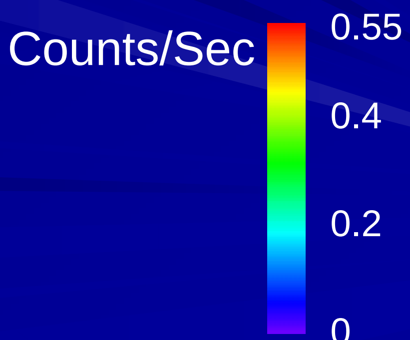
Smoothing Iterations = 2



Unsharp Masking of HEND Neutron flux rates:

- 4 Results for joint smoothing /kernel configurations

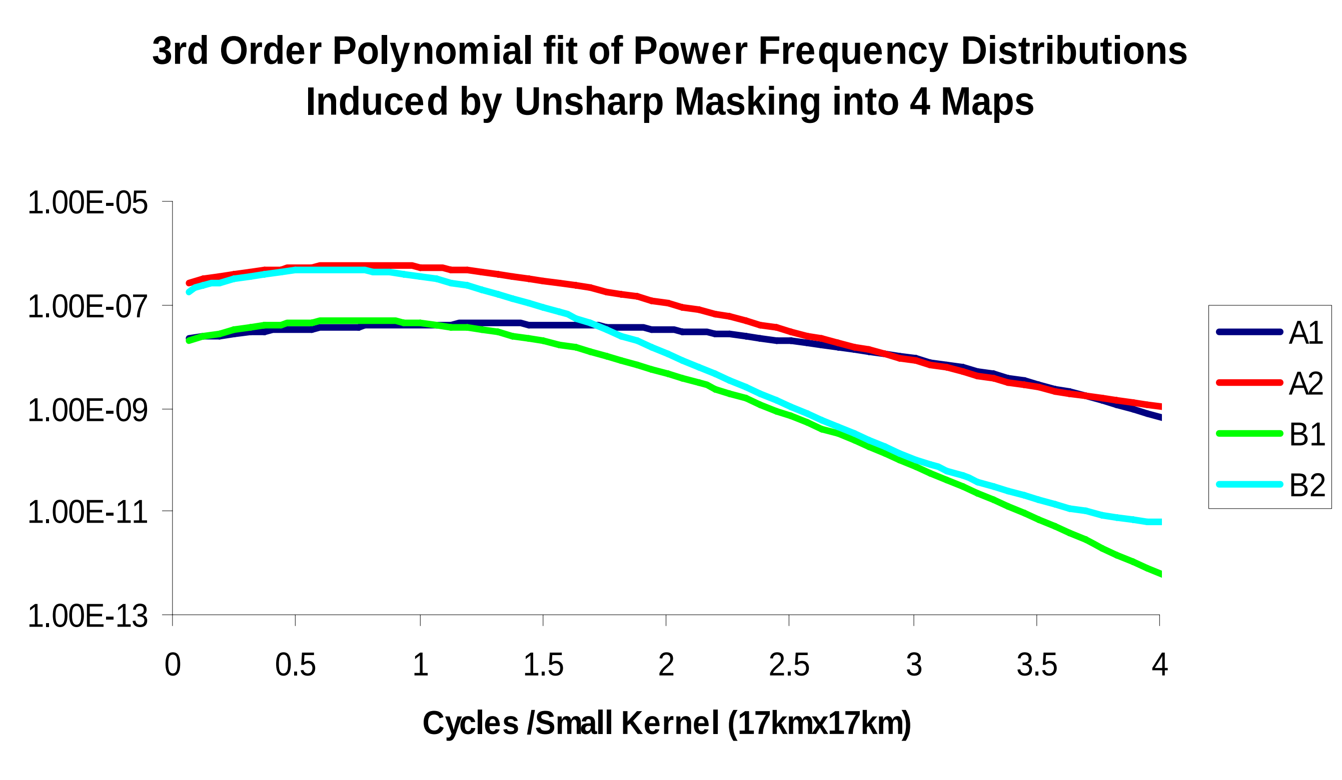




A1 = 1 pass smoothing, *p*= (17x17)km, Gaussian
A2 = 1 pass smoothing, *p*= (31x31)km, Gaussian
B1 = 2 passes smoothing, *p*= (17x17)km
B2 = 2 passes smoothing, *p*= (31x31)km

Fit of Map Power Spectra at Mid Latitudes, (+-35°), 1°

- Subtract Starting Maps, *e.g.* $A2=A2-O_A$ (Isolate Transform Effects)
- Mean Fourier Coeffs. from map mid latitude's (71), Avg (FFT)
- Generate Power Spectra for each map's Avg FFT.
- 3rd Order Polynomial Fit each Power Spectrum (*visualization*)



- Results jointly dependent:

Degree of initial smoothing ***and*** **scale of structuring kernel**

Conclusions:

1. Unsharp Masking is:
   - An Image Processing Operator (Image Sharpening)
   - Enhances local contrast image detail (Noise+signals)
   - Not a deconvolution operator (No signal separation)

2. Pixels are variably promoted as a function of local spatial gradient in original image.

3. Degree of map enhancement is a joint function of several critical user decisions.
   - Degree of initial smoothing
   - Scale of Transform Structuring Element, *p*
   - Transform Iteration count, *k*
   - Scale of additive high pass filter in each iteration, *r*

Conclusions 2:

4. No Convergence Criteria, Possibility Oversharpening

5. Special considerations for negative pixel intensities (Thresholding)

6. Post transform uncertainties at local minima greater than local maxima (as fraction of signal)

7. Distribution of power induced into the map is distributed at frequencies around the scale of the structuring element. (Map Granularity)
   *Biased transform (Actually, a convolution operator!)