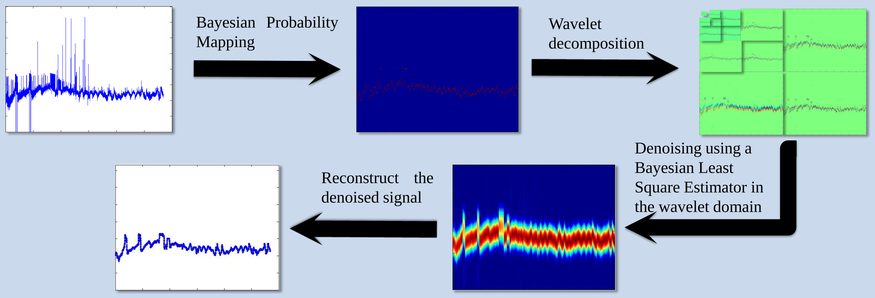
Gaussian Noise Removal for Wet Chemistry Data from the Phoenix Mars Mission

Yang Mu[1], Wei Ding[1], Xiang Ren[1], Elizabeth Oberlin[2], Samuel Kounaves[2]
[1]Department of Computer Science, University of Massachusetts Boston, 100 Morrissey Blvd., Boston, MA 02125
[2]Department of Chemistry, Tufts University, 62 Talbot Avenue, Medford, MA 02155

Method: The signal data is first transformed into a 2D matrix, and then the matrix is decomposed into pyramid subbands at difference scales in the Wavelet domain. De-noising is performed at each subband. Finally, we invert the pyramid transformation and obtain the de-noised signal.

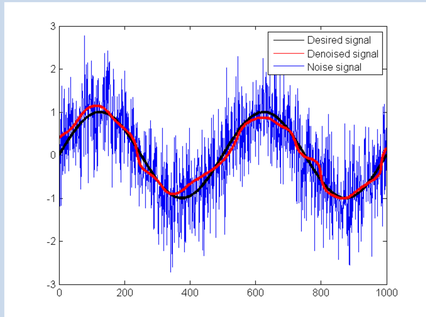


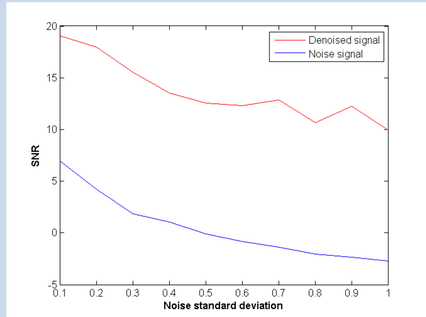
Our technical de-noising approach is Bayesian white noise removal. For the WCL data, we propose to model local clusters of wavelet coefficients of a pyramid subband using Gaussian Scale Mixtures $x = \sqrt{\lambda}\vec{u}$, where $\vec{u}$ is a zero-mean Gaussian vector, λ is an independent positive scalar random variable, we then calculate the local neighborhood noise covariance Cw and the observed signal in Wavelet domain local neighborhood covariance Cy.

$$
\begin{aligned}
&E\{x|y,\lambda\} \\
&= \int E\{x|y,\lambda\}\, p(\lambda|y)\, d\lambda \\
&= \lambda(Cy - Cw)(\lambda(Cy - Cw) + Cw)^{-1} y
\end{aligned}
$$

where $E\{x|y, \lambda\}$ is the estimated Wavelet coefficients of the de-noised signal. The last step is invert the pyramid subbands to produce the de-noised sensor data.

Result: To evaluate our method, we first performed simulations with white Gaussian noises with a standard deviation of 0.5 added to the standard Sine function.





We then applied our algorithm to this noise signal. Then, we used this algorithm on Li^+, pH A, Ir pH, and Na^+ of the WCL data for sol.

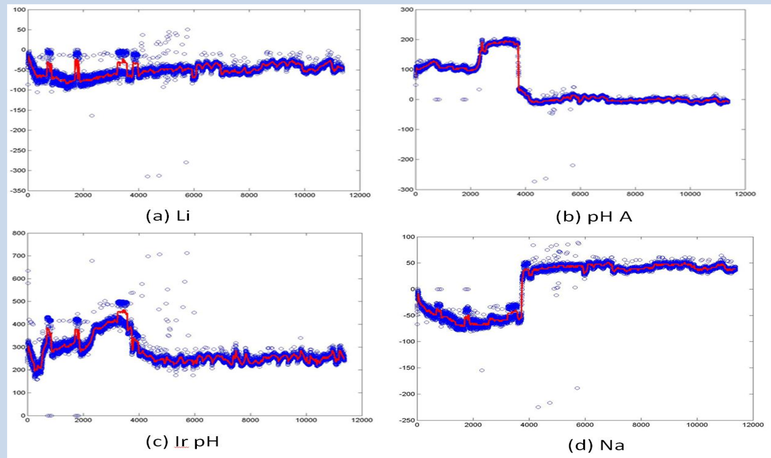
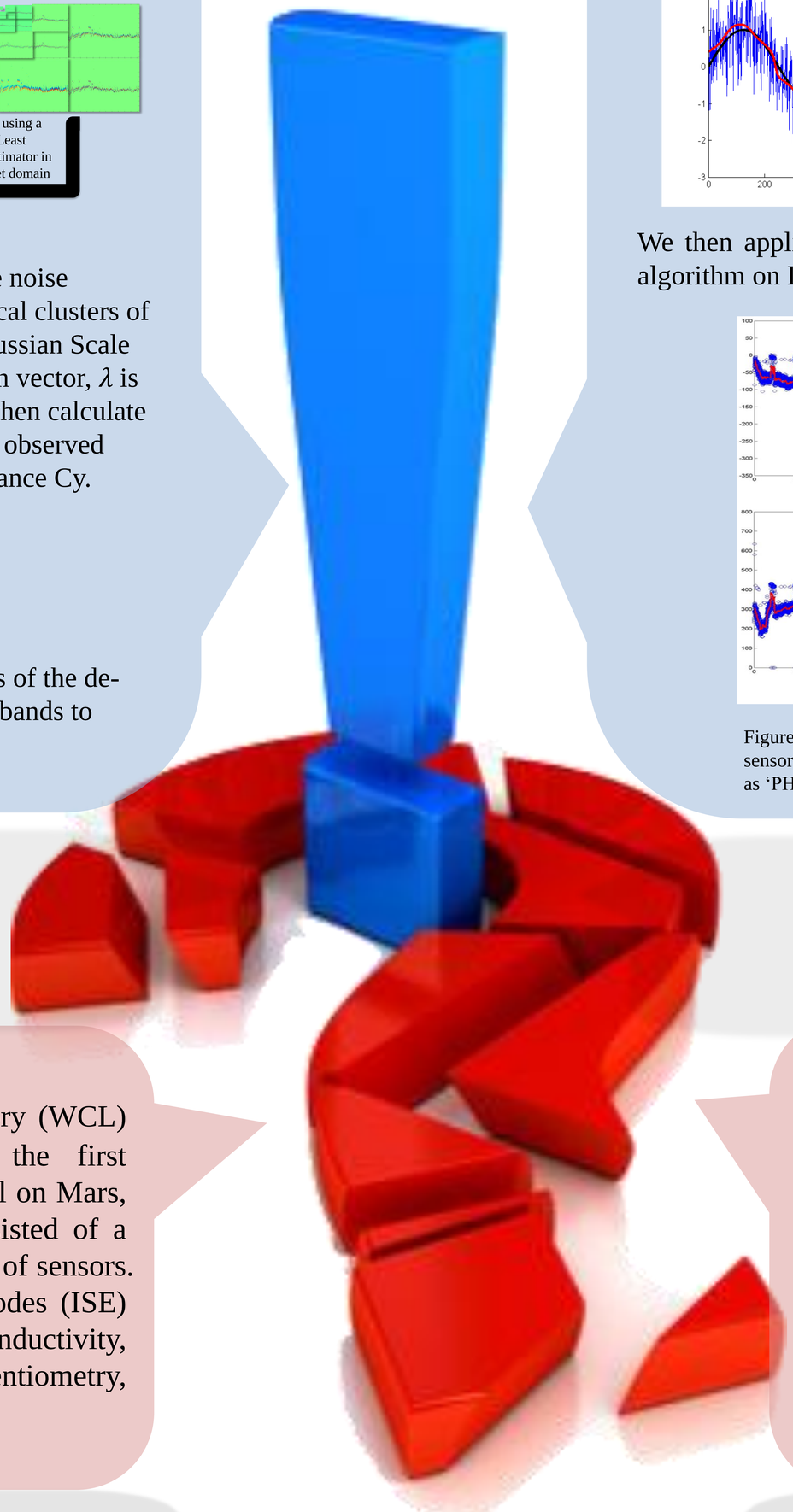


Figure: Li and Na refer to the ISE sensor of Li^+ and Na^+, there are three PH sensors included in the WCL design, we picked one of the ISE PH sensor labeled as 'PH A' and Iridium oxide PH sensor labeled as 'Ir PH'.



Introduction: The Wet Chemistry Laboratory (WCL) on board the Phoenix lander performed the first comprehensive wet chemical analysis of the soil on Mars, during the summer of 2008. Each WCL consisted of a lower cell whose walls were lined with an array of sensors. The sensor array included ion selective electrodes (ISE) for K^+, Na^+, Mg^+, Ca^+, etc. and electrodes for conductivity, redox potential, cyclic voltammetry, chronopotentiometry, and an PH electrode.

Problem: While the result has become clearly evident that the analyses were complicated by an un-planned titration of the soil/water mixture with barium chloride, the presence of chemical species whose signal was convoluted into other sensor readings, and the effects of temperature and noise. Use of such incorrect values in conjunction with chemical speciation modeling programs could result in misinterpretation of the minerals and parent salts present in the soil analyzed by the Phoenix WCL.

Acknowledgements: This work was supported by NASA under Grant NNX13AJ69G