RECURRING SLOPE LINEAE ON MARS ARE NOT FED BY SUBSURFACE WATER.

J. T. Wilson[1], V. R. Eke[1], R. J. Massey[1], R. C. Elphic[2], W. C. Feldman[3], S. Maurice[4] and L. F. A. Teodoro[5], [1]Institute for Computational Cosmology, Durham University, South Road, Durham. DH1 3LE, UK (j.t.wilson@durham.ac.uk), [2]Planetary Systems Branch, NASA Ames Research Center, MS 245-3, Moffett Field, CA,94035-1000, USA, [3]Planetary Science Institute, Tucson, AZ 85719, USA,[4]IRAP-OMP, Toulouse, France, [5]BAER, NASA Ames Research Center, MS 245-3, Moffett Field, CA 94035, USA.

Introduction: Recurring slope lineae (RSL) are narrow, dark markings that appear on Martian steep slopes during warm seasons and fade in cold seasons. They were first identified in the southern midlatitudes using HiRISE images [1]. Contemporary liquid water activity on the surface of Mars has recently been confirmed at sites of RSL, using spectral data from the Compact Reconnaissance Imaging Spectrometer for Mars onboard the Mars Reconnaissance Orbiter [2].

The origin and recharge mechanism of these liquid brines detected in RSL, which may vary across the surface, remains poorly understood. Possible scenarios include recharge by shallow briny aquifers, melting of shallow ice and absorption of atmospheric water vapour. To distinguish between these hypotheses, we use the results of the Mars Odyssey Neutron Spectrometer (MONS) to obtain knowledge of the near-surface water abundance.

Here we present a map of the near subsurface hydrogen distribution on Mars, based on the Mars Odyssey Neutron Spectrometer epithermal data but with much improved resolution. Via the first global Bayesian reconstruction of a remotely sensed planetary data set this map achieves a near doubling in linear spatial resolution over the instruments that make up the Mars Odyssey Gamma Ray Spectrometer suite, including the Neutron Spectrometer, Gamma Subsystem and High Energy Neutron Detector.

Neutron Spectroscopy: Neutron spectroscopy detects the products of nuclear interactions to characterize the composition of a planet's surface. In the case of passive spectroscopy, as used in orbital remote sensing, the nuclear reactions are the result of interactions of the top metre of the surface with high energy cosmic rays. The conversion of neutron count rates to abundances of hydrogen (conventionally given as weight per cent water equivalent hydrogen, wt. % WEH) relies on knowledge of the composition of the surface and detector, plus detailed simulations of the nuclear interactions and transport. Here we adopt the calibration of Feldman et al. [3].

Maps of hydrogen from remotely sensed neutron data have previously had poor resolution. For example, the MONS detector's 520 km FWHM footprint was unable to resolve variation across features a few hundred km in size, such as the Valles Marineris. However, using image reconstruction we can improve upon the resolution of the data and suppress noise so examine the water abundances in more detail in the regions containing RSL.

Pixon Reconstruction: To create our improved resolution map of the WEH distribution we have used the pixon method, a spatially adaptive image reconstruction technique that removes blurring caused by convolution with the point spread function (PSF) and suppresses noise. Other versions of the pixon method have been used to reconstruct remotely sensed data from regions of the Moon and Mars sufficiently small that they can be considered locally flat [4,5]. However, by modifying the technique to work on the surface of a sphere we have carried out the first global Bayesian reconstruction of a remotely sensed planetary data set, the result of which is shown in Fig. 1. Our reconstructed data set is available for the entire surface of Mars with a characteristic global scale of 290 km, as determined by the two-point angular correlation function.

Comparison of this high resolution hydrogen map with the locations of RSL shows no positive correlation (Fig. 1). Fig. 3 shows the probability density function of the reconstructed count rate in the southern mid-latitudes (SML), along with the probability distribution of the count rate restricted to sites within the SML containing RSL. We compared these two distrib-

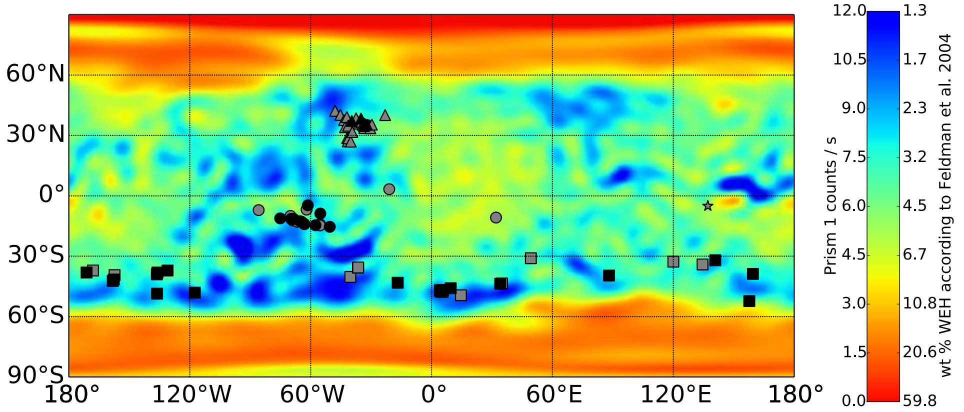

Fig. 1: A global pixon reconstruction of the MONS prism-1 data. The colour bar shows the conversion to wt. % water equivalent hydrogen from Feldman et al. The locations of both confirmed (black) and candidate (grey) RSL are also shown as identified in McEwen et al. (squares) [1], Stillman et al. [6,7] (circles,triangles) and Dundas & McEwen [8] (star).

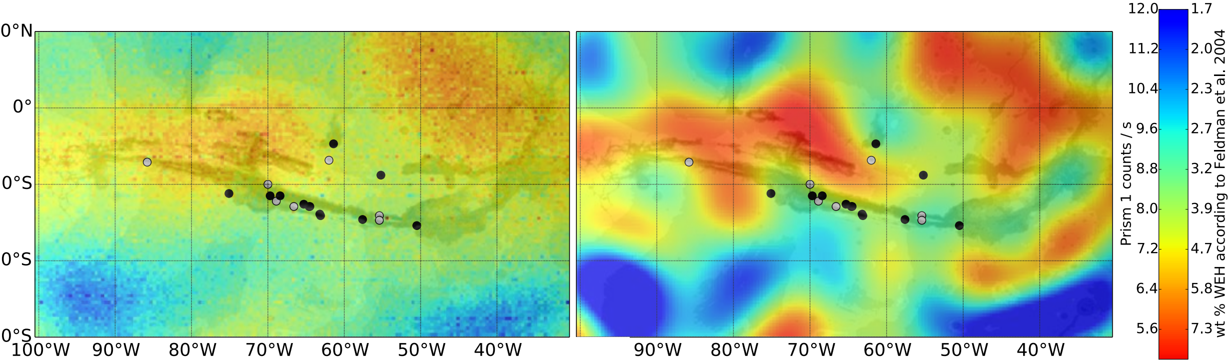

Fig. 2: The MONS data (left) and reconstruction (right) in the area around Valles Marineris. Underlayed is a MOLA shaded relief map. The colour bars also show the conversion to wt. % water equivalent hydrogen from Feldman et al. The locations of both confirmed (black circles) and candidate (grey circles) RSL are also shown as identified in Stillman et al. [6]

utions using a two-sample Kolmogorov-Smirnov test and found a test statistic of 0.19 and corresponding p-value of 0.2 (i.e. test statistics at least this extreme are expected 20% of the time). This is not sufficient to imply that the count-rates (and consequently water abundances) where RSL are present are different from those locations where RSL are absent. In turn this result implies that the occurrence if RSL is statistically independent of the WEH of the top few 10s of cm of soil, on large scales.

That water abundance in the soil is not correlated with RSL activity can be explained either by reference to the resolution of the neutron data, even at 290 km the resolution is too coarse and the regions containing RSL are blurred into those without, or we must conclude that there are no sizeable stores of subsurface water close to the RSL. Thus their formation and renewal is not driven by subsurface aquifers or water ice. Water buried beneath the level accessible to the MONS data (i.e. deeper than about 1 m) could not act as a source for the RSL because thermal inertia prevents ice buried beneath 20 cm from ever being heated above freezing. If the RSL water were sourced from a subsurface reservoir too small to be seen in MONS data then we may expect that improving the resolution would go some way towards alleviating this discrepancy. Fig. 2 show the MONS data around Valles Marineris before and after reconstruction and we find no evidence of a systematic increase in water abundance at the RSL with reconstruction. It is interesting to note that so far all of the confirmed RSL lie in the drier half of Valles Marineris east of Ius Chasma. Also, fluctuations apparent only in the reconstructed count rate maps match well with topographic features, e.g. eastern Valles Marineris and Eos Chasma appear dry compared to their surroundings. If the water source for the RSL is not subsurface then it must be atmospheric, that is the deliquescence of chlorate and perchlorate salts (the presence of which has been confirmed by CRISM and in-situ measurements) produces sufficient quantities of liquid brines to darken the soil and produce the RSL.

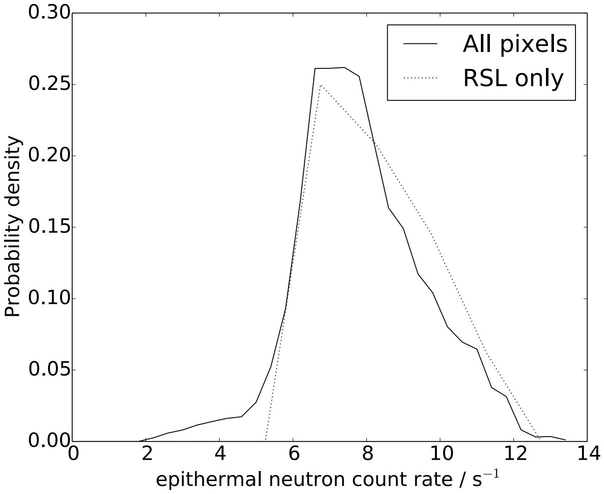

Fig. 3: The probability density function of the count rate between 53°S and 30°S (solid line) and just those pixels containing RSL (dotted line).

These results support the hypothesis that the RSL are replenished not by subsurface water stores but by water vapour in the atmosphere causing deliquescence of near-surface hygroscopic salts. Whether the water produced by this process forms a small local reservoir or is responsible directly for the renewal of RSL remains to be determined. The results of the reconstruction are available publicly and will provide a useful resource for those interested in processes involving water on the surface of Mars.

References: [1] McEwen A. S. et al. (2011) *Science, 333*, 740–. [2] Ojha L. et al. (2015), *Nature Geosci, 8(11)*, 829–832. [3] Feldman W. C. et al. (2004), *JGR (Planets), 109*, E09006. [4] Eke V. R. et al. (2009), *Icarus, 200*, 12–18. [5] Wilson J. T. et al. (2015), *JGR (Planets), 120*, 92–108. [6] Stillman D. E. et al. (2014), *Icarus, 233*, 328–341. [7] Stillman D. E. et al. (2016), *Icarus, 265*, 125–138. [8] C. M. Dundas and A. S. McEwen (2015). *Icarus, 254*, 213–218.