Surface effects

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COSMIC 2015, Jodrell Bank, UK

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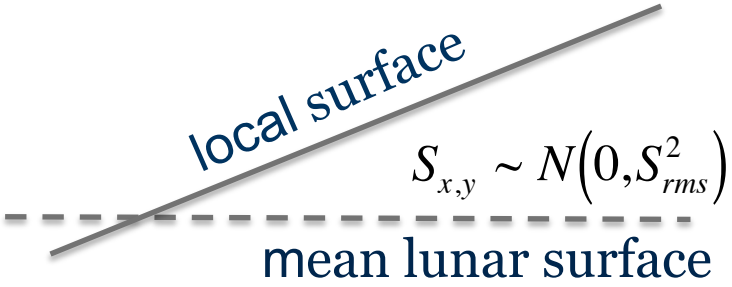
Current treatment

- Step 1: deviate local surface normal $\tan S_{rms} = 0.29\lambda^{-0.22}$

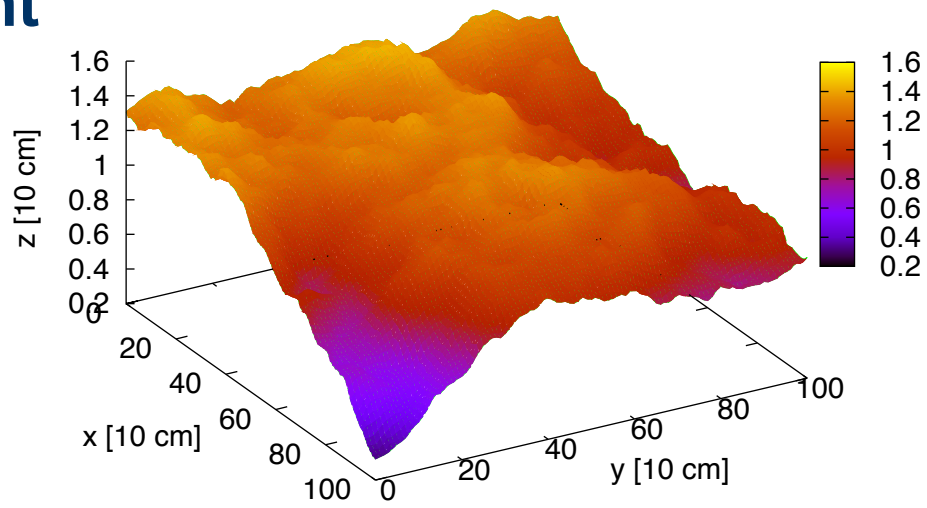


- Treat as simple transmission problem through an infinite plane $t = t_f \frac{n_t \cos\theta_t}{n_i \cos\theta_i}$ $\frac{d\Omega_t}{d\Omega_i} = \frac{\cos\theta_i}{\cos\theta_t}\left(\frac{n_i}{n_t}\right)^2$
  - Use Fresnel transmission coefficients
  - Modify due to ‘solid-angle stretching”
- Problem #1: Retains full coherence – ignores small-scale roughness!
- Problem #2: Roughness at small scales modelled at large scale – this is optimistic (also ignores diffraction)

My attempt at full treatment

- Model full surface: use facets

$$\tan S_{rms} = 0.29\lambda^{-0.22}$$



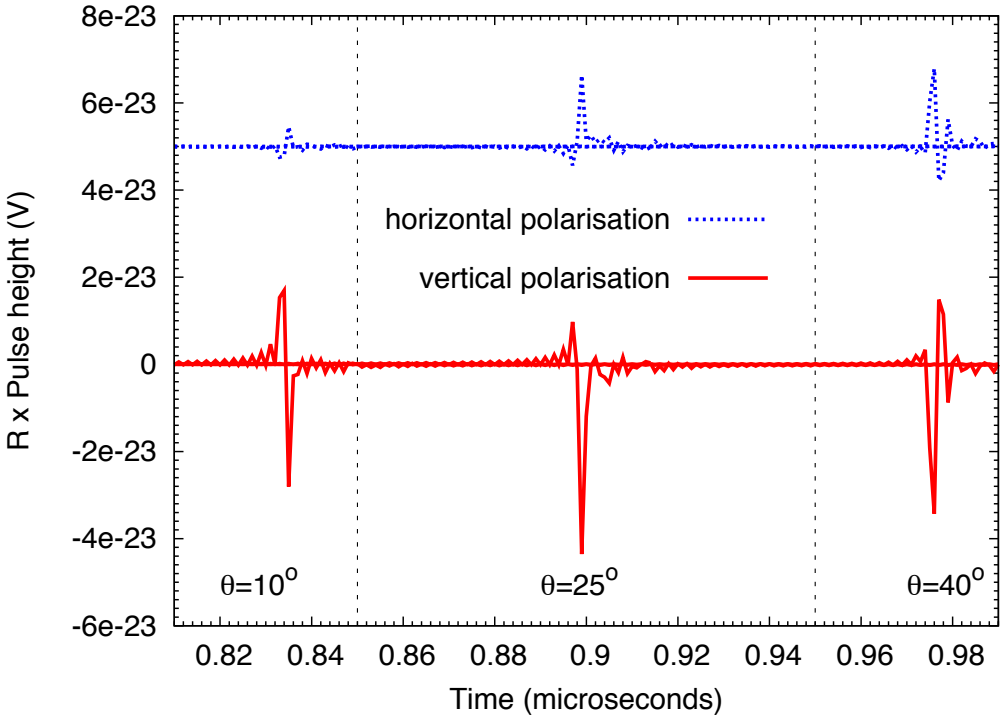
- Calculate nearfield emissions onto surface facets

- Propagate fields through surface facets

Sample results

- Calculations of time-domain pulses (neutrinos)
- Computing time – > 1 event / CPU-day (currently)

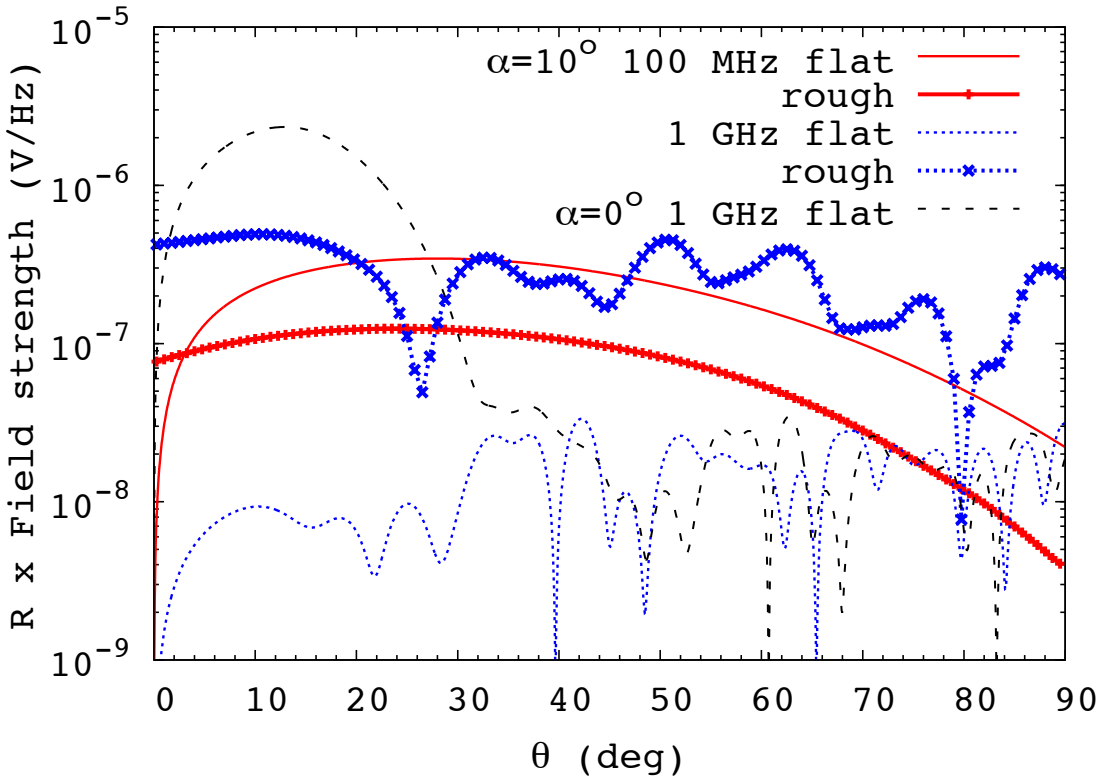
Simulations of pulses over a 1-2 GHz band

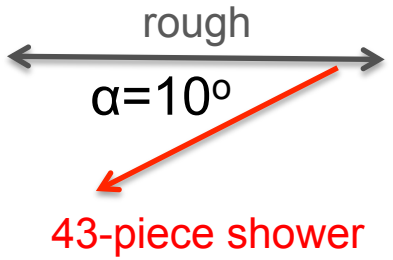


Tentative results: cosmic rays

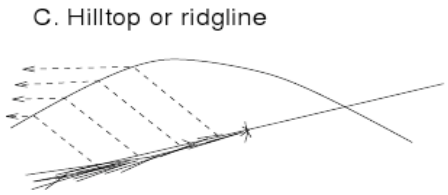
PRELIMINARY
(numerical dials still need turning)

- 10^{20} eV hadronic cascade, 10^{o} angle of incidence, shower max 4.6m after initial point

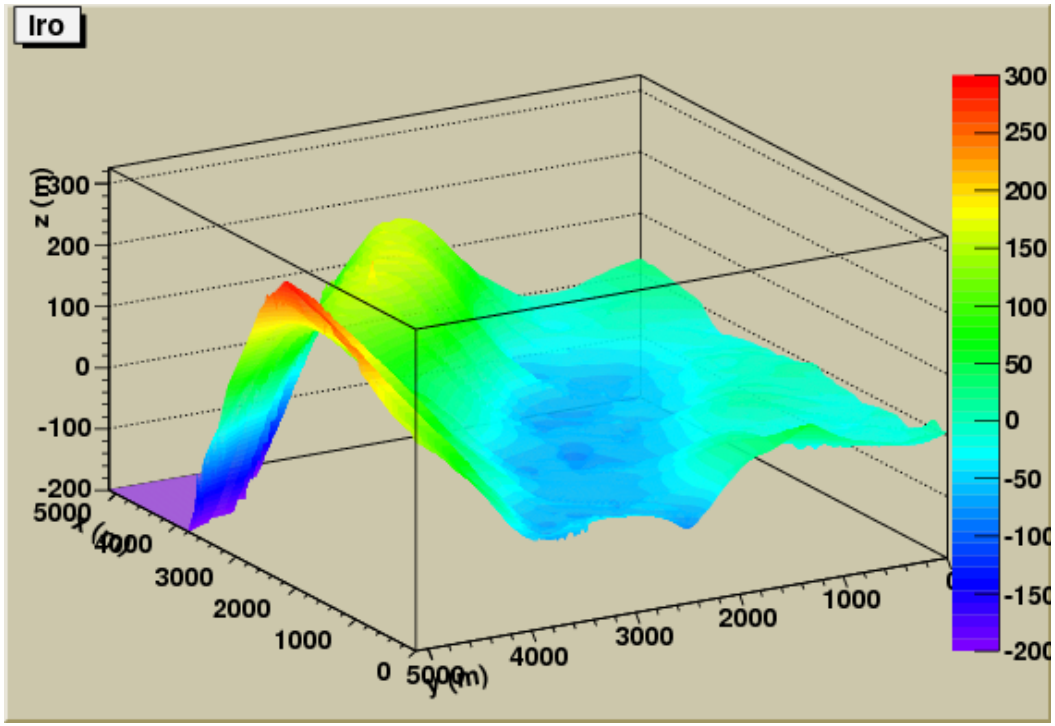




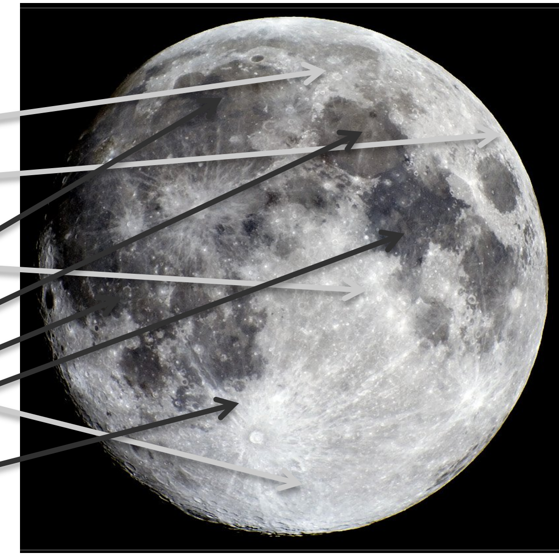
Large scale



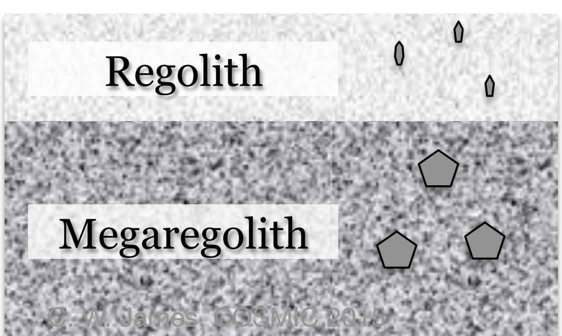
- Affects initial cosmic ray interactions
- Data from lunar reco orbiter (~5m at poles, few hundred m at equator)
- Not included in models



Subsurface issues

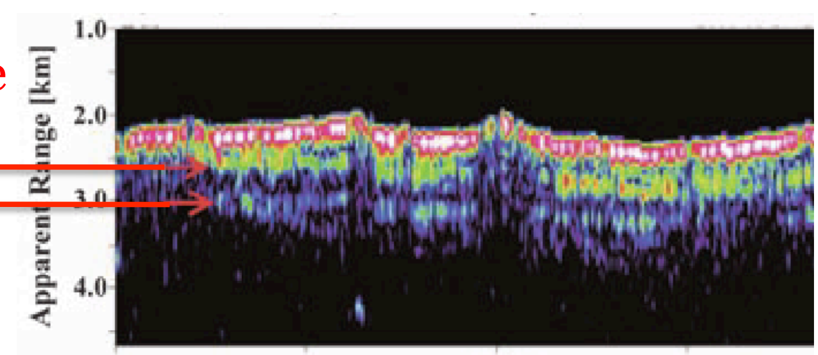


- Highlands (white bits):
  - No strong radio-absorbency
  - No sharp boundaries
  - Increased density w depth?
- Mare (grey bits):
  - Strong(er) radio absorbency
  - Dense subsurface rock
  - Possible multiple subsurface layers



Subsurface reflective layers

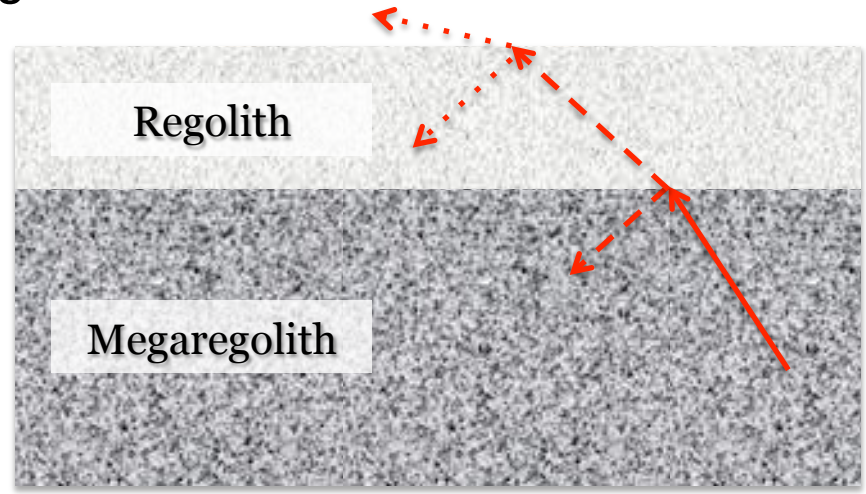
SELENE Radar Sounder: Ono et al (2008)



Current treatment (by me)

- Two-layer model (~to regolith and mare subsurface)

- Less dense top layer (~1.8 g/cm^3)
- Denser lower layer (~3 g/cm^3)
- Allow transmission losses



Summary

- Surface roughness
  - Important at low frequencies too!
  - 100 MHz sees 60% of the roughness of GHz! (10^-0.22)
  - Really need to do this
- Problem: calculations are time-consuming! Limited by submission time on a cluster – and by my contract ;-)
- Cosmic rays: large-scale features important
- Low frequencies – deeper interactions. Inhomogeneities / subsurface layers important?