Photometry In Staring Imaging

Taking full advantage of sampling the Illumination and viewing geometry dependence of the radiance inherent in staring imaging

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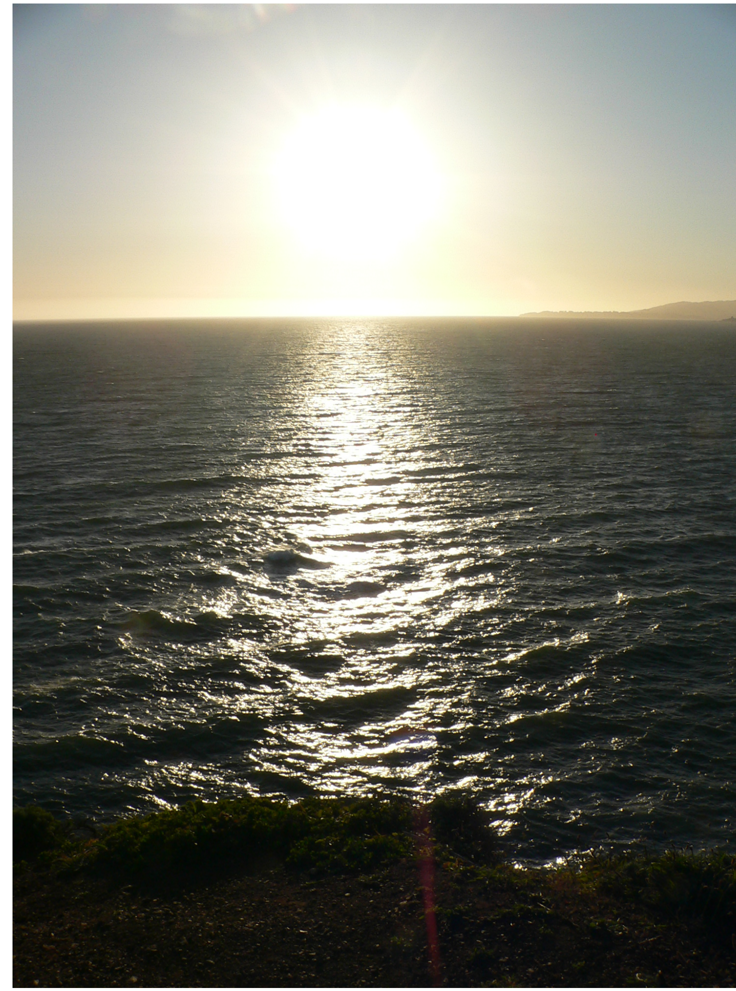
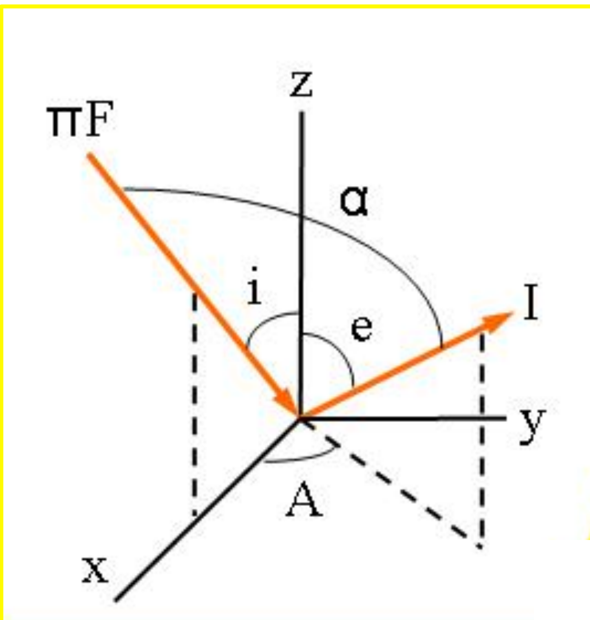


DEMs from Images Provide Knowledge of ***Local Slopes*** of 'Facets'

- **Reconstructing topography (DEMs) from multiple images of a target from different viewpoints uses shifts in the *positions* of features between images to determine their elevations.**

- **Once the DEM is determined, the signal (DN) in each pixel of the same images is a measurement of the radiance I for the *local* illumination i, emission e, and azimuth A angles for each resolved facet of the DEM in each image.**

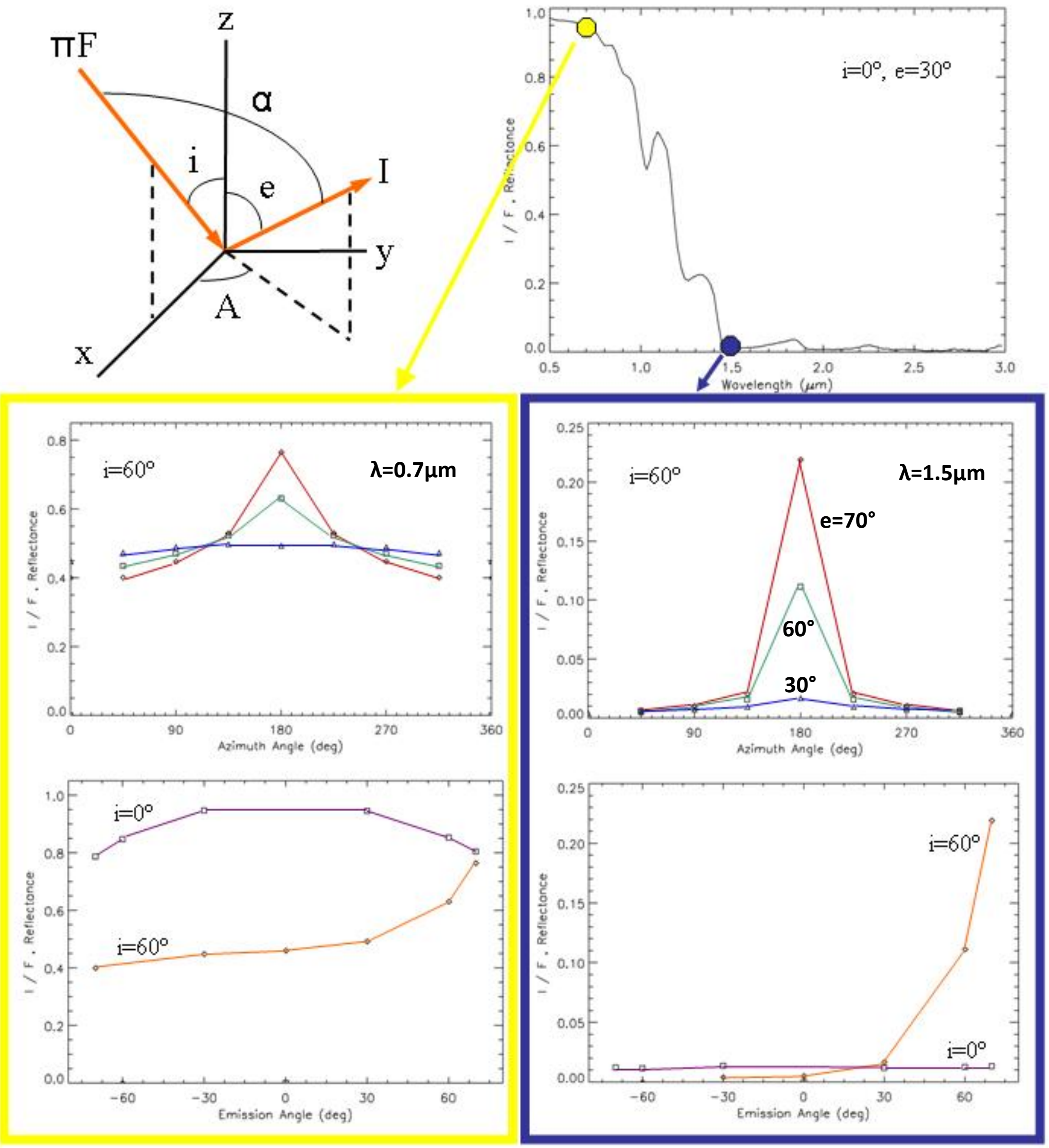


I / F (i, e, A; λ) depends on the composition and physical structure of the facet.

- **Facet dimension is determined by the number of DEM points needed to define the facet normal with sufficient accuracy (*gradient* of DEM).**

- **Effects of roughness on scales smaller than the facet contribute to I / F of the facet. (Amit Mushkin's talk)**

Example: I / F of a Snow Facet



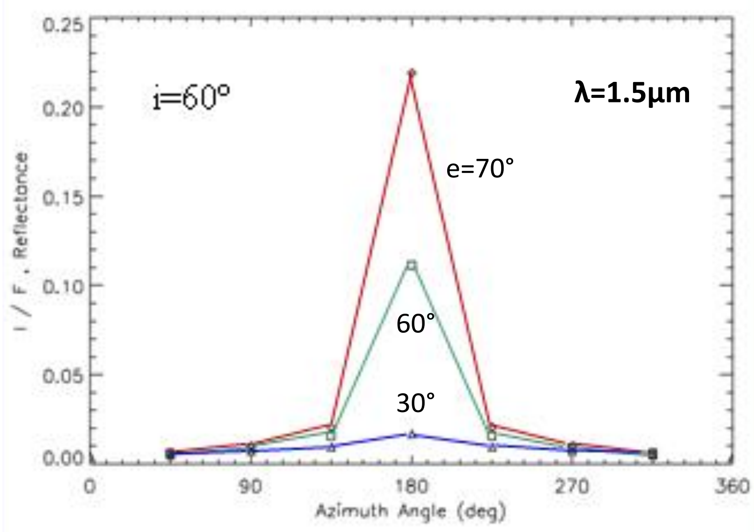
Data from Dumont *et al* (2010) *Atmos Chem Phys* 10, 2507-20. (Best I/F lab measurements)

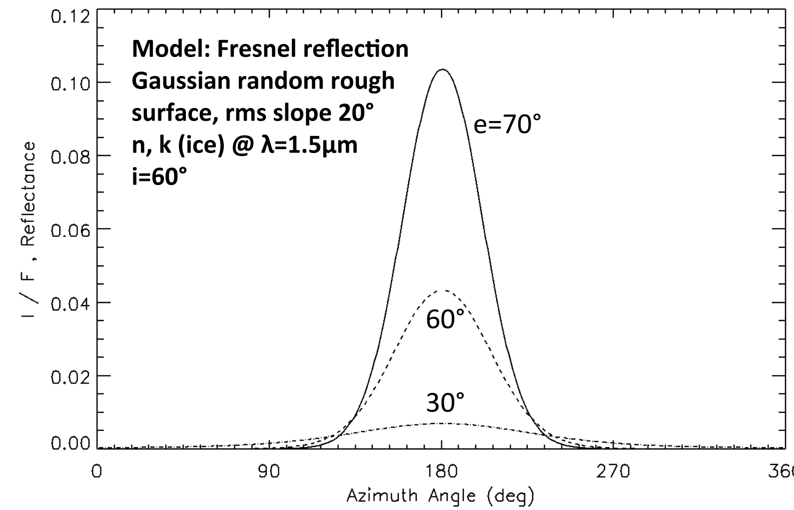
Nearly new snow - Weak cohesion
***Surface:* dendritic fragments**
***Depth:* Stellar crystals and frag -mented particles , ρ=0.19 g cm^{-3}**

Snow is *black* at λ=1.5μm, except for large i and e for A~180° where there is a strong forward scattering enhancement.

This enhancement is also seen at λ=0.7μm where snow is white, but it contributes only a portion of I/F.

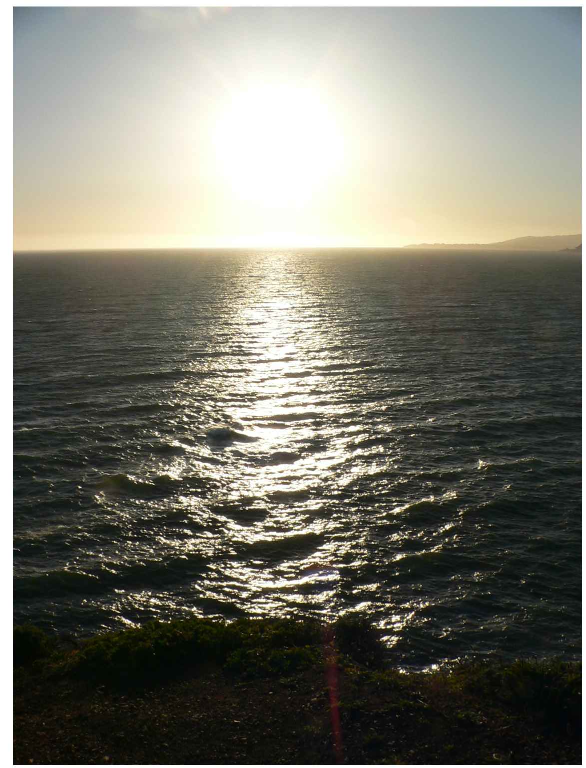
What could cause this forward scattering enhancement in I/F ?





Specular (Fresnel) reflection on scales λ << d << facet from random rough ice surface has similar variation with scattering geometry. (Alternate possibility: strongly forward scattering particles).

Need to look at large emission angle in the sunward direction (large phase angle) to see this (analogous to this sun on the ocean image) ➔



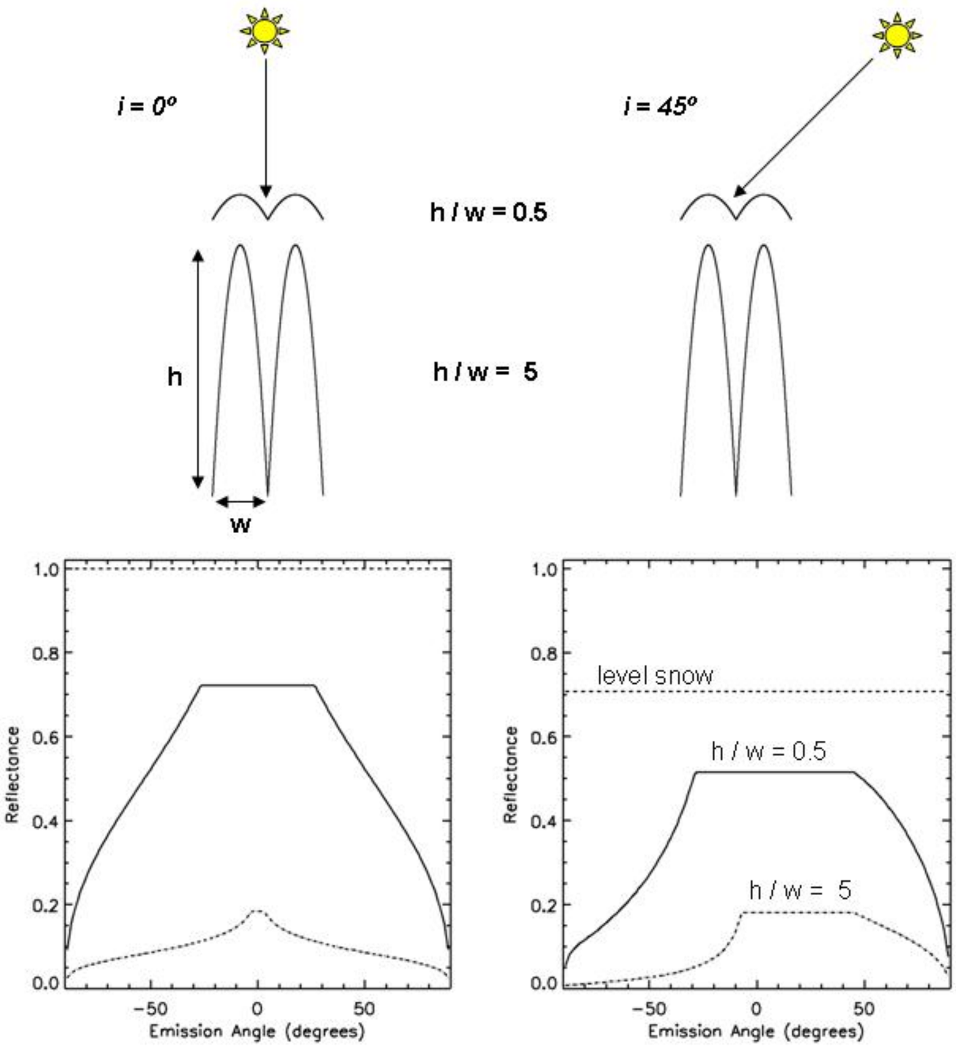
Could potentailly use to determine >> λ roughness of facet which may be applicable across spectrum.

This large phase angle geometry is rarely targeted.

Sastrugi and Penitentes

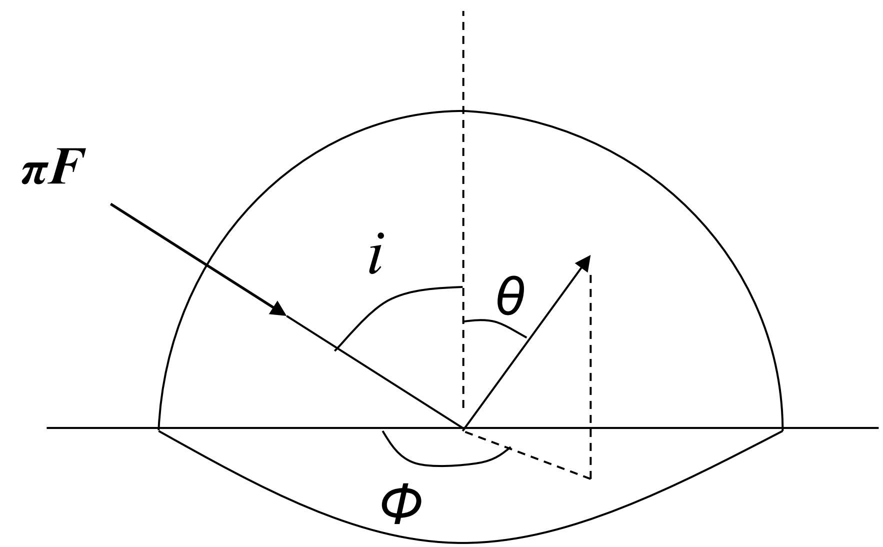
http://www.dreamsofmountains.co.uk/winter2009-10/20100310Sastrugi.jpg

http://www.panoramio.com/photo/49439172



Albedo and Power Input

Albedo is the integral of the scattered radiance over the upper hemisphere and all wavelengths. Power absorbed is proportional to [1 – A(i)]



Albedo = (Power Out) / (Power In)

Both the angle and λ dependence of I/F are essential inputs to accurately determining the albedo.

Conclusions

- **Staring imaging and DEM generation from the images promises to increase our knowledge of I/F by a large factor by removing topographic effects and providing I/F measurements over the range of illumination and viewing geometries in the image set at little to no cost.**

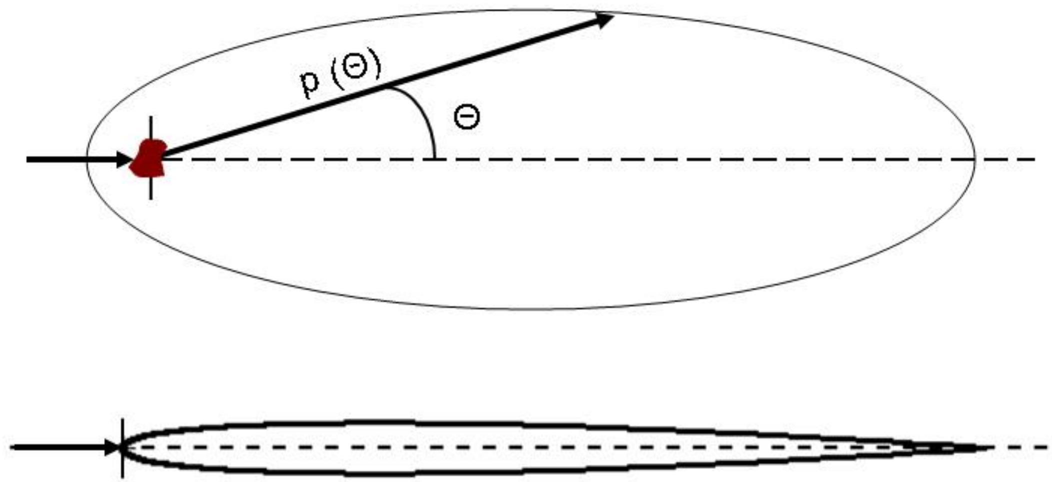
- **A broad a range of scattering geometries, particularly large phase angles, is desirable for determining I/F, albedo and constraining the surface particles/structures/roughness.**

- **Estimates of the total power absorbed will be improved if I/F is measured for the range of wavelengths spanning the solar spectrum.**

- **Combination of I/F and albedo measurements (solar input driver) with self-consistent measurements of volume changes (surface response) from DEMs is a powerful advantage of staring imaging approach.**

Supplementary Slides

Representative single scattering 'phase function' for a particle



Top: Schematic polar plot of scattering by a particle with photons incident from the left. The scattering angle Θ measures the change in direction of propagation of a photon and p(Θ) dΩ the probability of scattering into solid angle dΩ in direction Θ.

Bottom: Polar plot of the measured p(Θ) for irregular olivine M particles (reff = 2.6 μm) from Muñoz *et al* (2000).