Spatial distribution of retrieved water ice cloud properties at Mars using OMEGA

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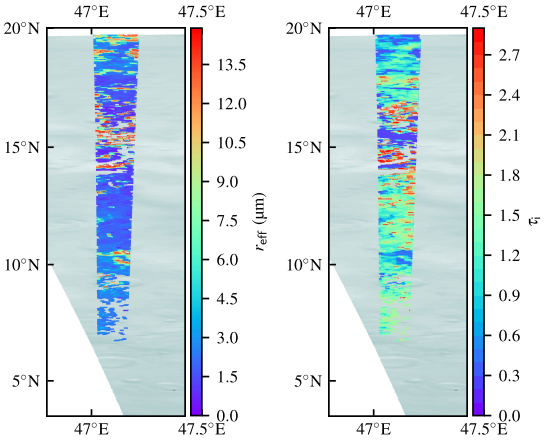
Cloud properties retrievals from MEx OMEGA

We have used the Mars Express OMEGA imaging spectrometer to retrieve the mean effective radius, r_{eff}, and optical depth, τ_{i}, of water ice cloud aerosols.

We can examine the distribution and variability of $r_{\text{eff}}$and τ_{i}in cloud formations and statistically evaluate our results.

OMEGA is the Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité, an imaging spectrometer with three channels:

visible (0.35–1.05 µm),
C (1–2.77 µm),
and L (2.65–5.1 µm).

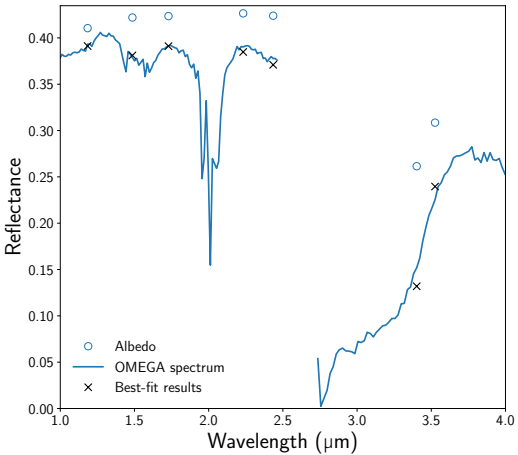


OMEGA data and our retrieval

The inversion method used here fits a computed spectrum at seven wavelengths which cover the 1.5 µm, 2 µm, and 3.1 µm water absorption bands.

Reflectances are computed using the DISORT radiative transfer code (Stamnes *et al. Appl. Opt.* 27 (1988)) and minimization is done using a Levendberg-Marqhardt least squares routine.

To identify clouds, we use the Ice Cloud Index (ICI), the ratio of the reflectance at 3.4 µm to that at 3.52 µm, which reflects the slope of the 3.1 µm water absorption band (Langevin *et al. JGR* 112 (2007)).
Typical values range from 0.7 for very thin clouds, to 0.35 for opaque clouds.

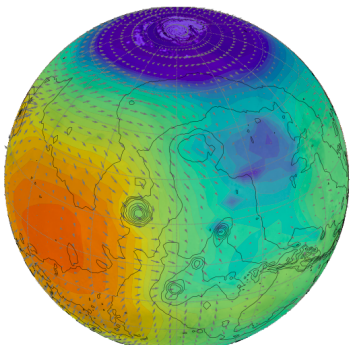


New prior data sets

We are now using:

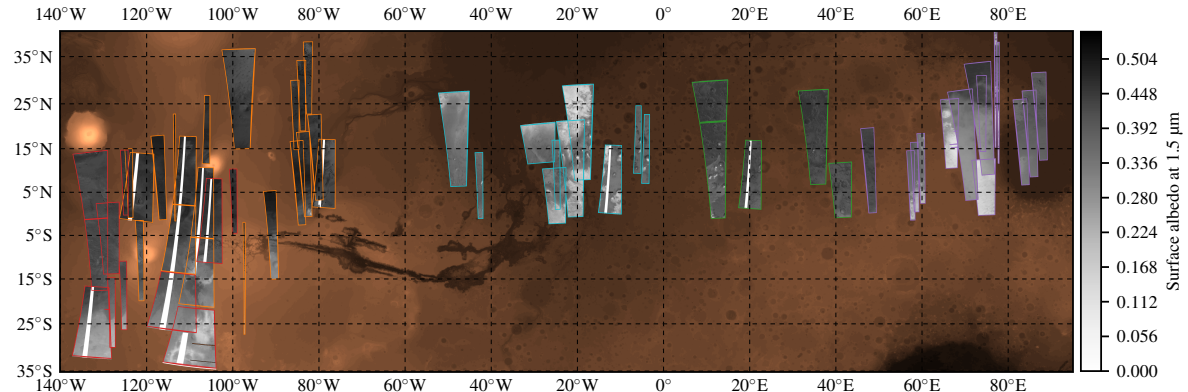
- OMEGA pixels are selected using pre-computed ICI maps,
- vertical profiles of temperature and surface temperature come from V5.2 of the LMD Mars general circulation model (LMDGCM) (Forget *et al. J. Geophys. Res.* 104 (1999); Millour *et al. EPSC* (2015)),
- dust opacity is taken from a climatological database of dust optical depths (Montabone *et al. Icarus* 251 (2015)),
- surface albedo for each analyzed pixel at each wavelength is provided by a new analysis of OMEGA data using principal component analysis (Geminale *et al. Icarus* 253 (2015)).

The retrieval is most sensitive to the surface albedo.

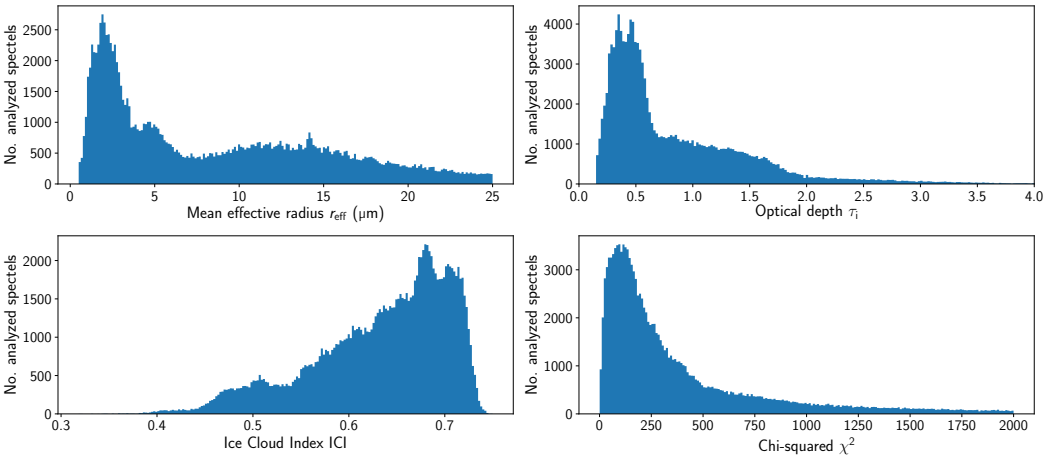


www-mars.lmd.jussieu.fr

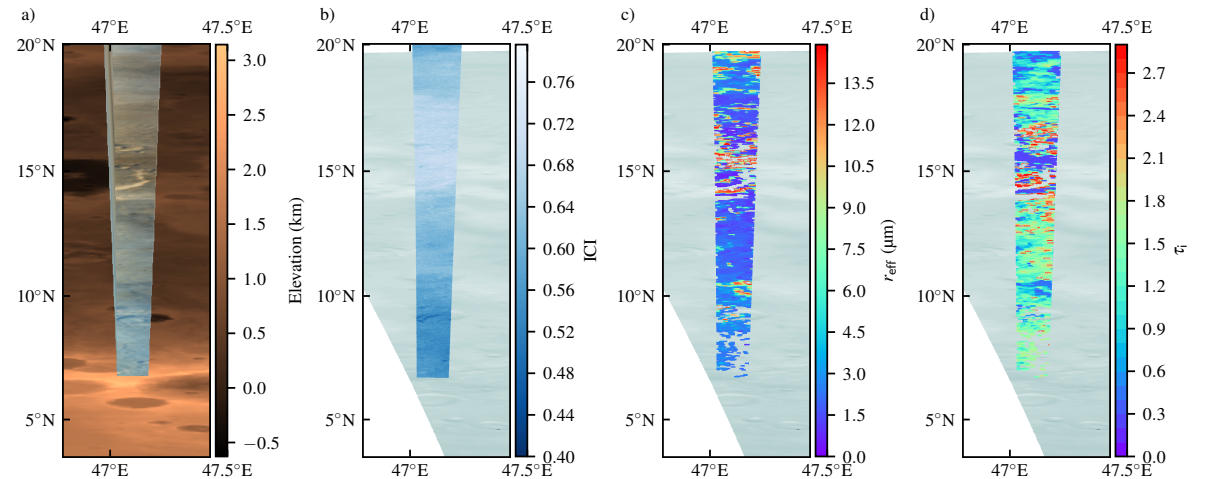
Multi-spectral surface albedo data set



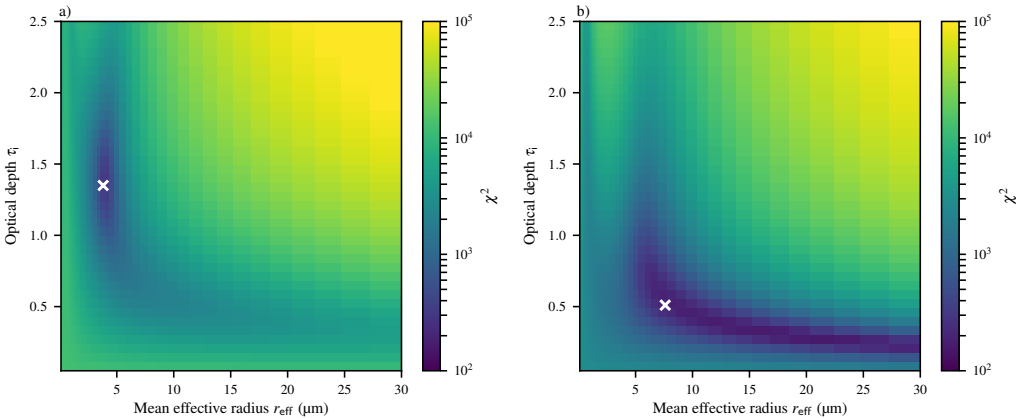
Distribution of retrievals for 209,936 'spectels' from 102 OMEGA observations



Spatial distribution of r_{eff} and τ_i: obs. 0937_5



Some retrievals return $r_{eff} > 10$ µm – a look at the χ^2



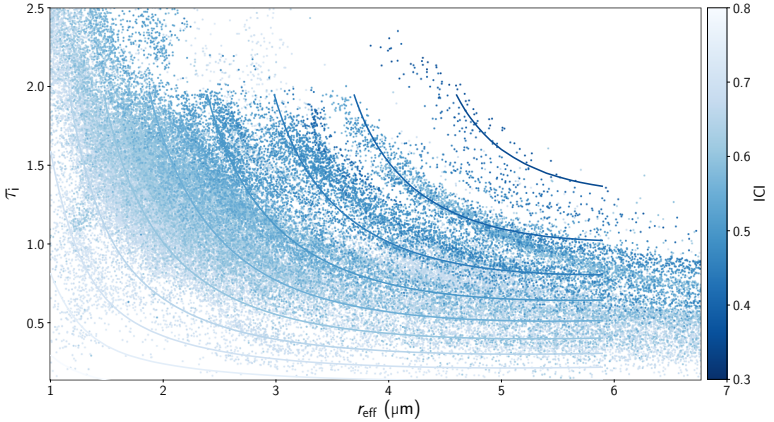
The r_{eff}–τ_i phase space

$$\tau_i = \frac{3MQ_{ext}}{4\rho r_{eff}},$$

M is water ice mass,

Q_{ext} is the extinction efficiency,

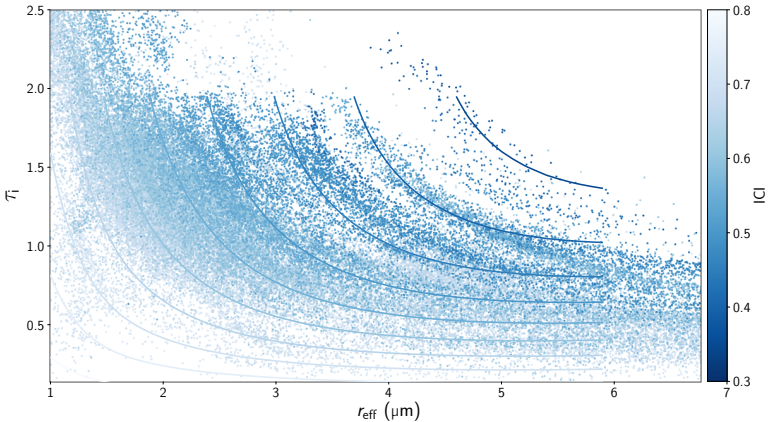
and ρ is the density of water ice.



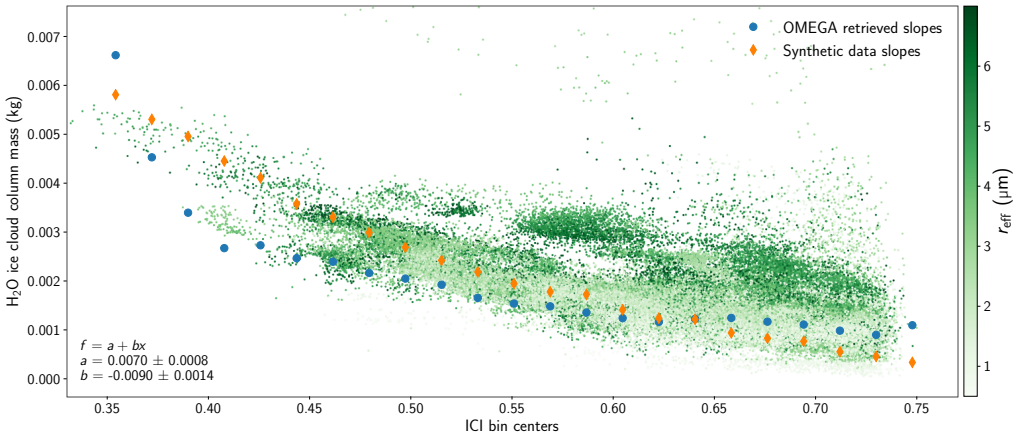
Modelling the results

$$\tau_i = \frac{3MQ_{ext}}{4\rho r_{eff}},$$

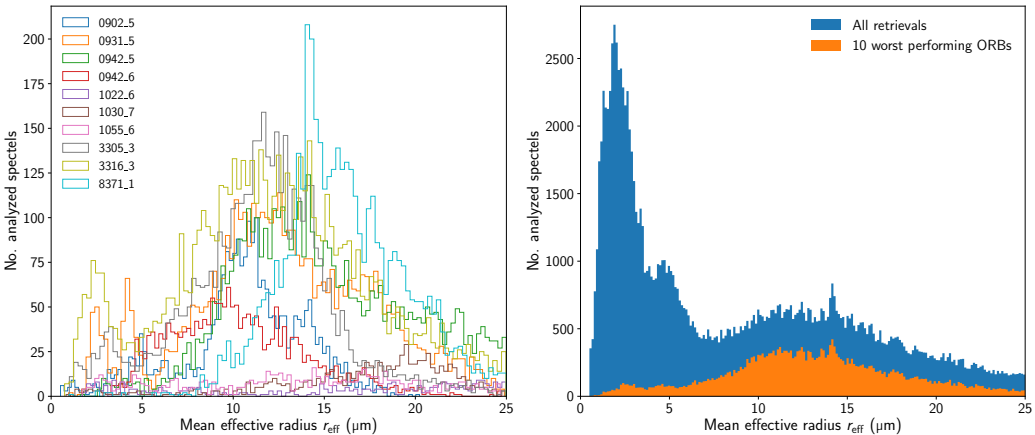
Synthetic spectra were created for the entire r_{eff}–τ_i phase space and ICIs were computed to confirm the observed trend.



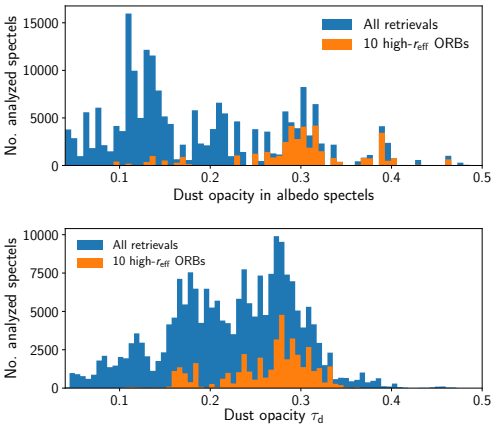
Ice cloud mass (from slopes) *vs*. ICI

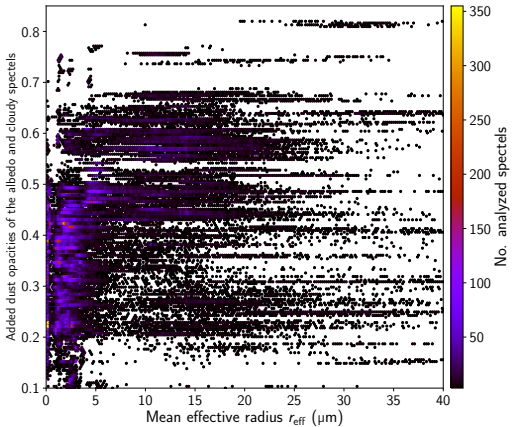


Some retrievals return $r_{\text{eff}} > 10$ µm – are these reliable?

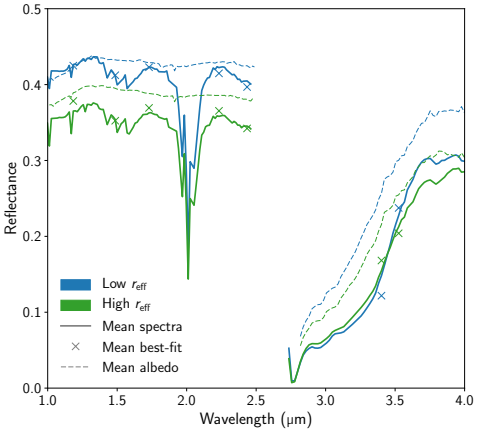


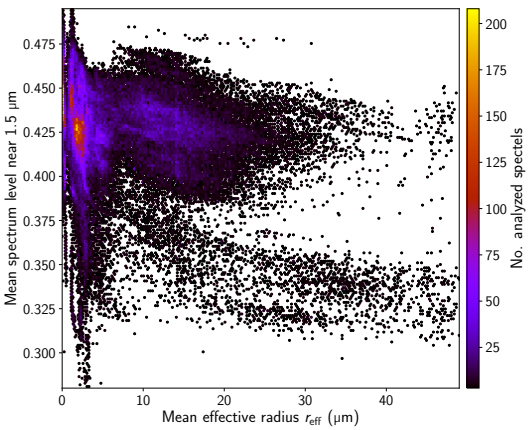
What is it about these observations? It's dust, everywhere.





Spectroscopy at the extremes: some spectra defy our assumptions.





La fin, merci!

Conclusions

r_{eff} and τ_{i} have been retrieved from 209,936 cloudy spectels in 102 OMEGA spectral images.

r_{eff} can vary significantly within a cloud, but has an overall mean of 2.1 µm.

We are confident in our data set and it will be distributed on the ESA Planetary Science Archive as part of the UPWARDS project.

ICI can act as a proxy for column mass for optically thick clouds, allowing the study of the global, 14-year OMEGA data set (*see the presentation here by* Andre Szantai).

Acknowledgements

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Anna Geminale and her team as IAPS/INAF are generating the albedo maps.
Luca Montabone generated the dust climatology.
Joachim Audouard and Andre Szantai provided ICI maps and databases.
Temperature data came from the LMD GCM.
Jean-Baptiste Madeleine developed the retrieval algorithm which uses DISORT.
The OMEGA team provided their data.