Le Plexiglas® comme analogue des glaces planétaires

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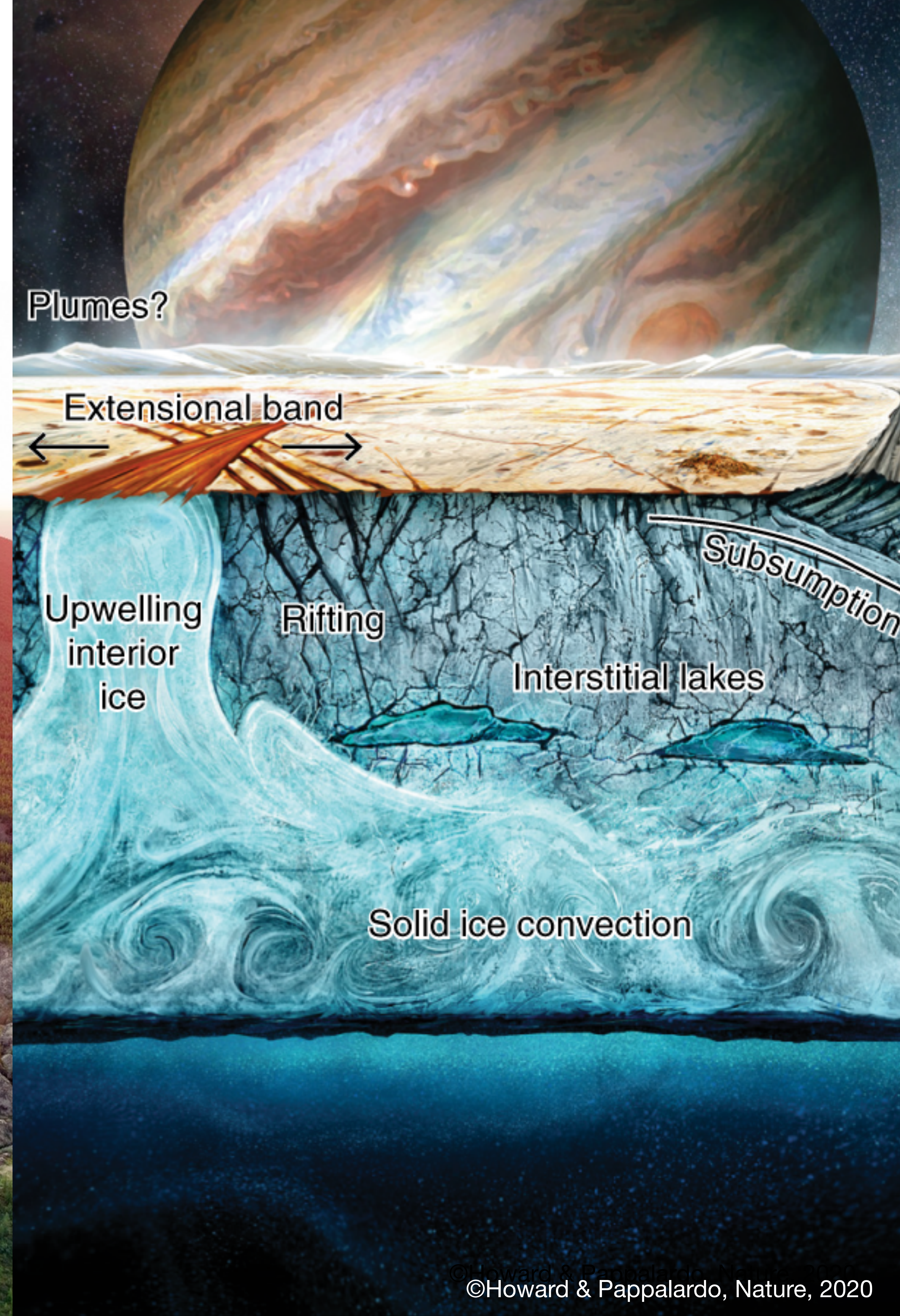
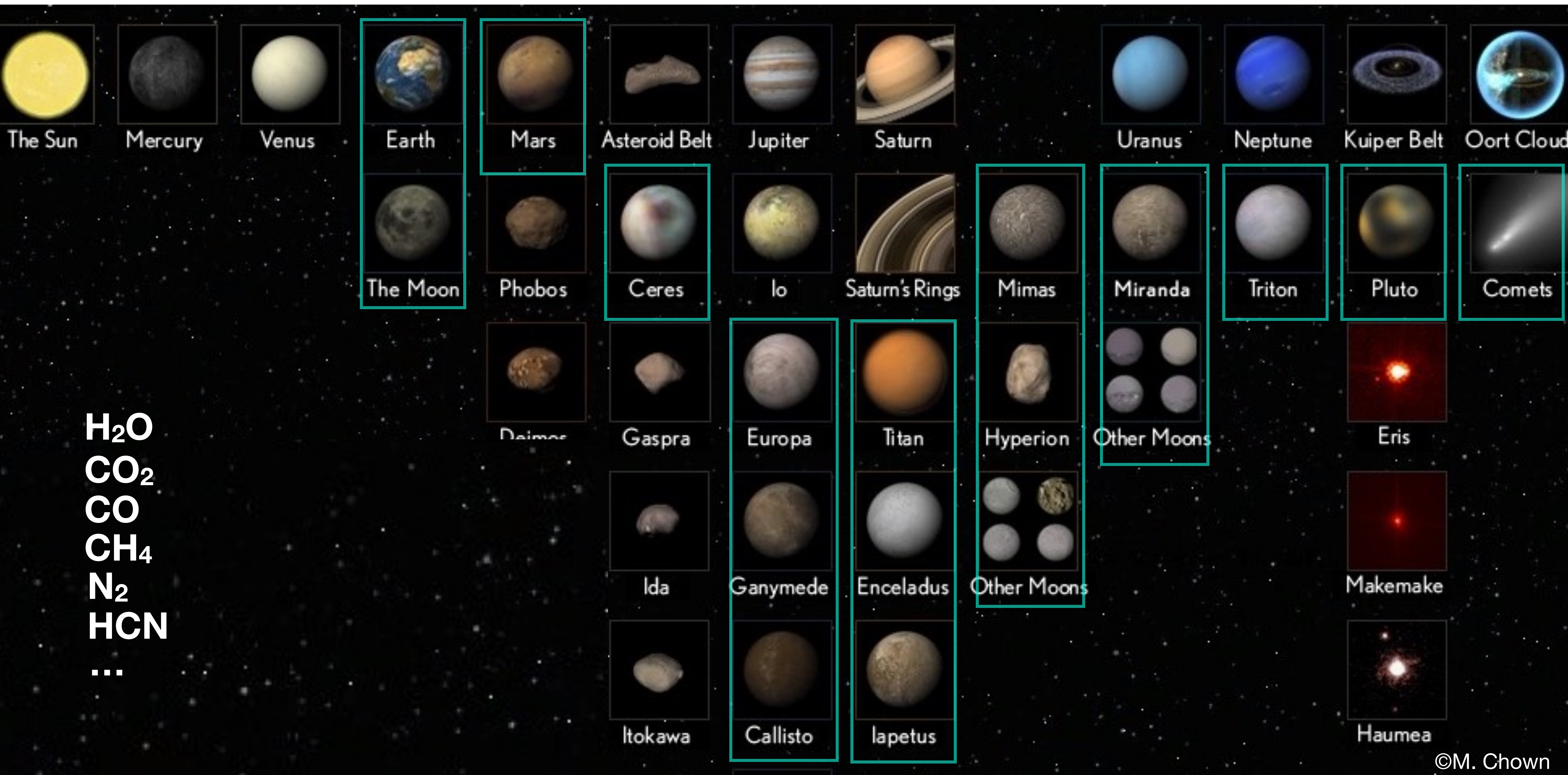
Introduction: planetary ices

- Planetary climates
- Active processes
- Subsurface/surface/ atmosphere exchanges



Introduction: planetary ices

- Present in numerous places in the Solar System
- In various species



Introduction: planetary ices

- Present in numerous places in the Solar System
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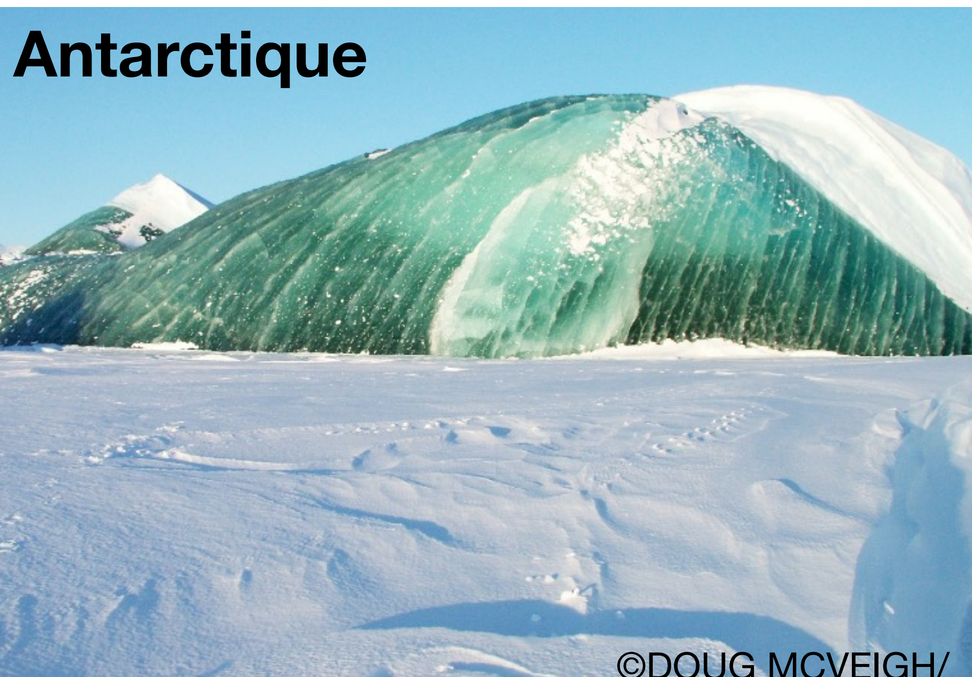
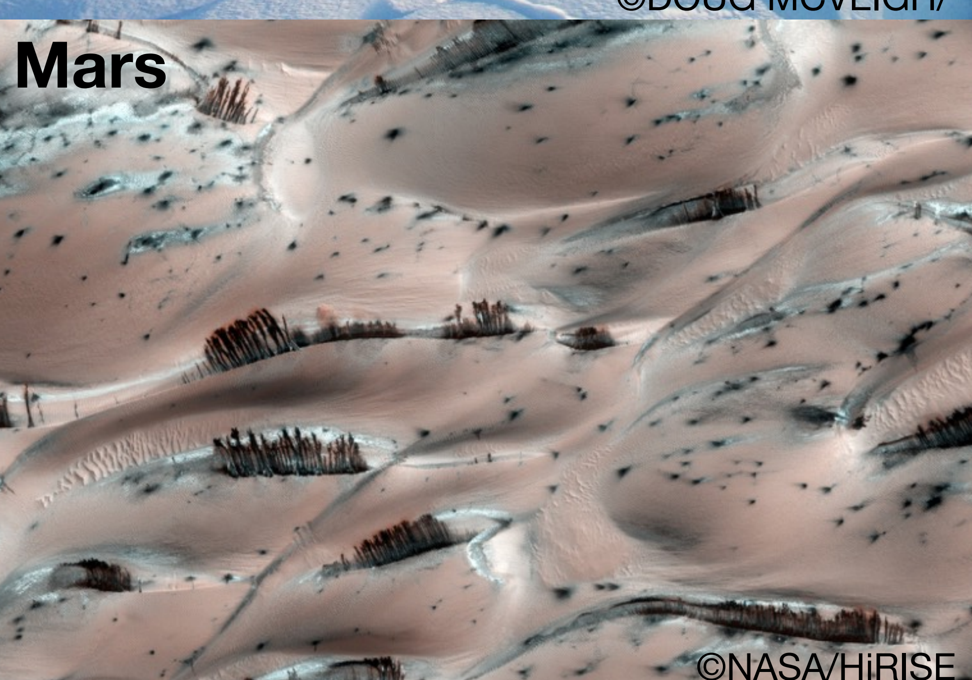
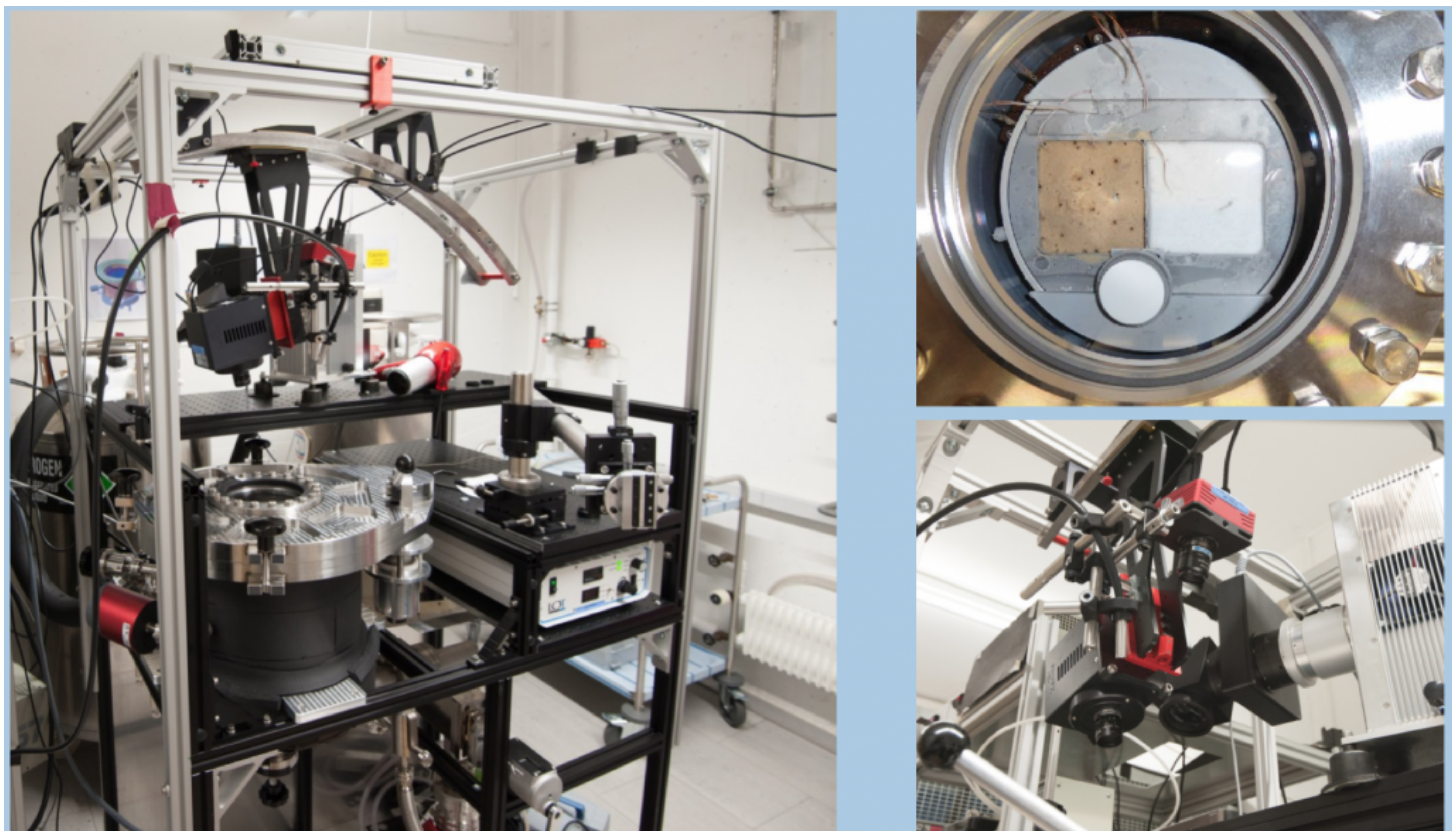
- In various physical forms





Introduction: planetary ices

- Present in numerous places in the Solar System
- In various species
- In various physical forms
- Hard and expensive to study in lab

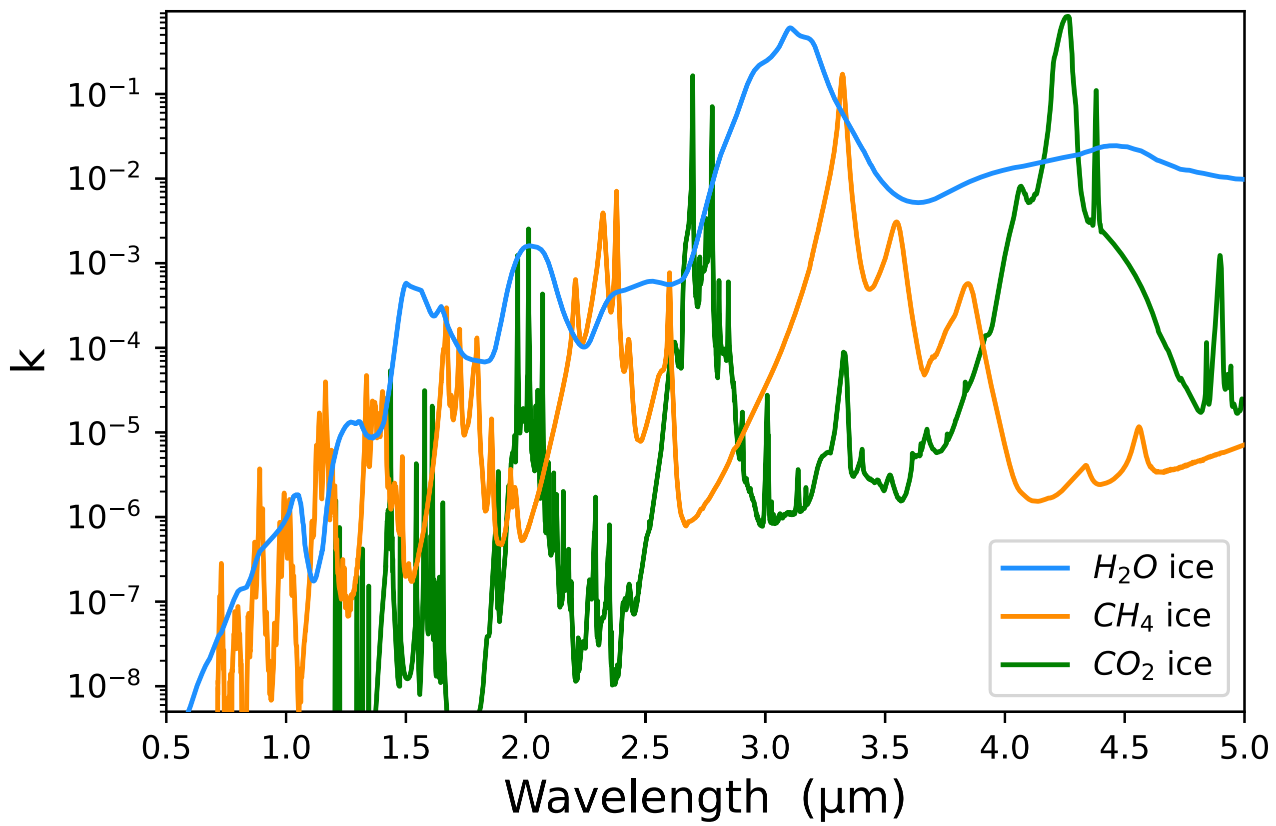


The SCITEAS (Simulation Chamber for Imaging the Temporal Evolution of Analogue Samples) facility.

Introduction: planetary ices

Vis-NIR optical properties:

- Translucent in VIS
- More opaque in NIR
- Characteristic spectral features



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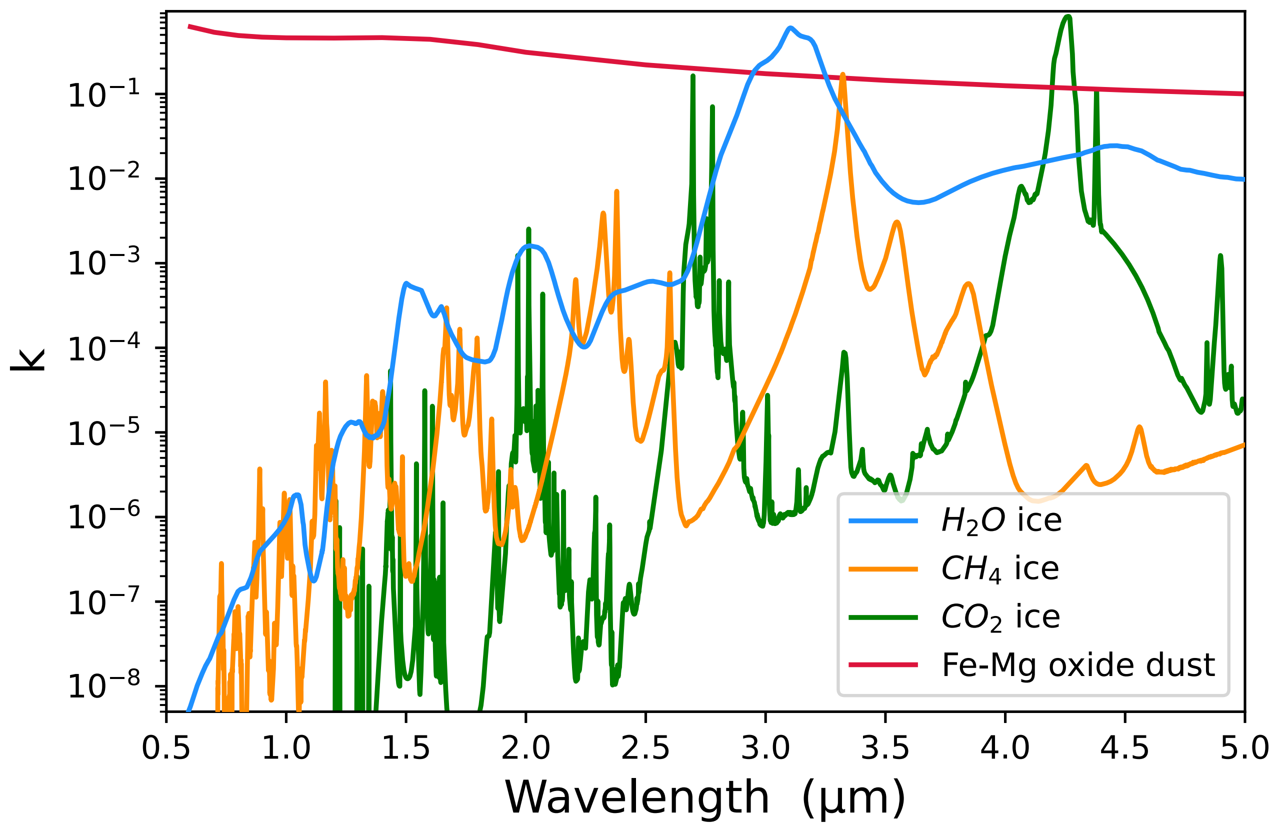


Optical properties radically different from minerals

Are the widely used for mineral radiative transfer models still valid for ices ?

Introduction: planetary ices

Challenges in planetary icy surface studies:

- Ices are in intimate mixture with other components
- The compositions and physical arrangements change over time

Goals:

- Detect all the species present at the surface
- Quantify their proportions and microphysical properties
- Monitor their evolution

Method:

Radiative transfer modeling and inversion

Introduction: planetary ices

Planetary icy surfaces quantitative characterization

Hapke model[1]:

- semi empirical
- Spectro-photometric (BRDF)
- intimate mix
- widely used
- Experimentally validated for photometry

Inversion method:

- gradient descent
- Bayesian inversion

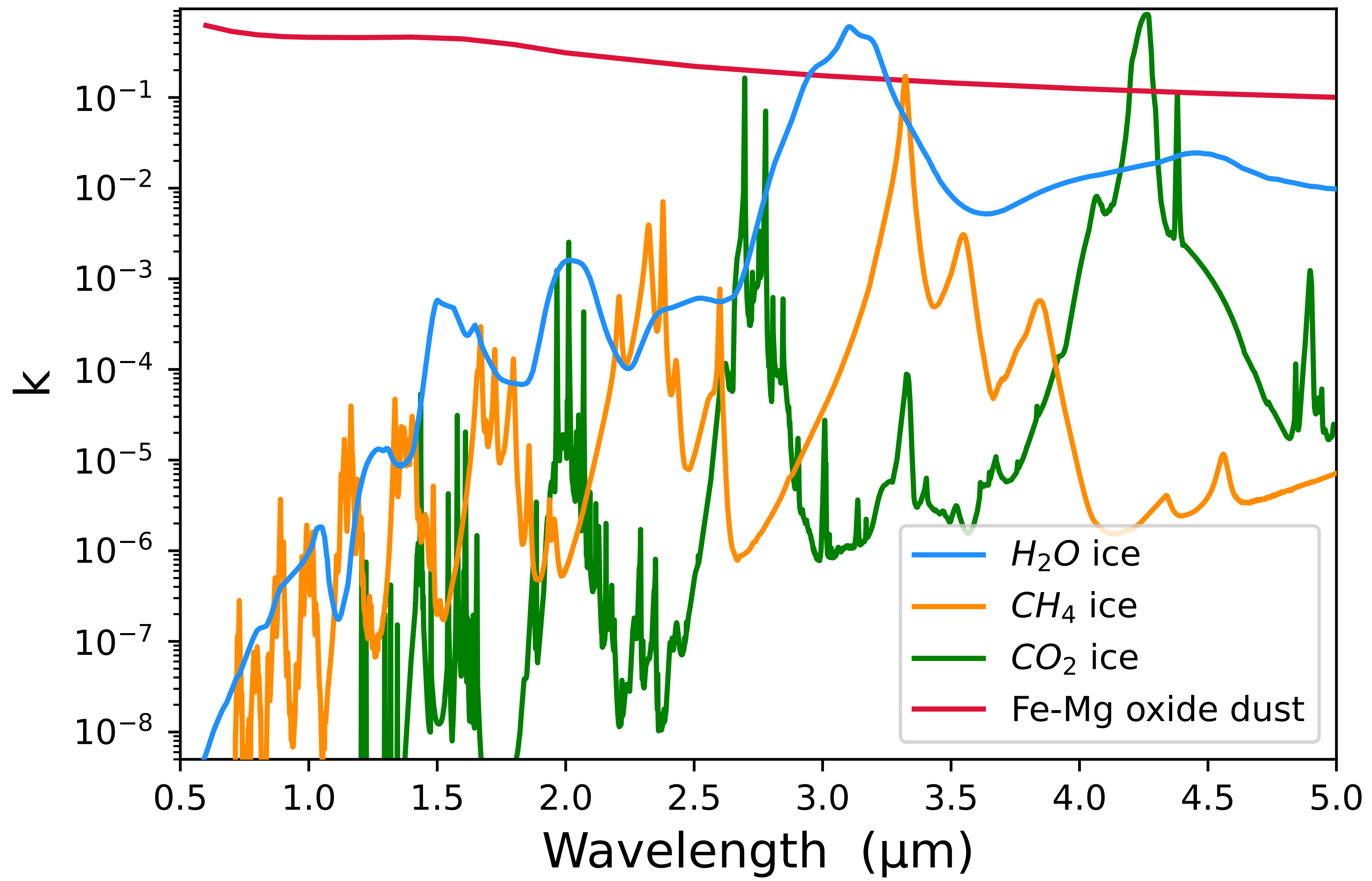
Problem: lack of laboratory or field measurement on controlled materials for characterization of precise composition

Need: Reference dataset of controlled intimately mixed icy surfaces

[1] B.Hapke, Theory of Reflectance and Emittance Spectroscopy, 2012, Cambridge University Press

Introduction: planetary ices

Vis-NIR optical properties of ices:



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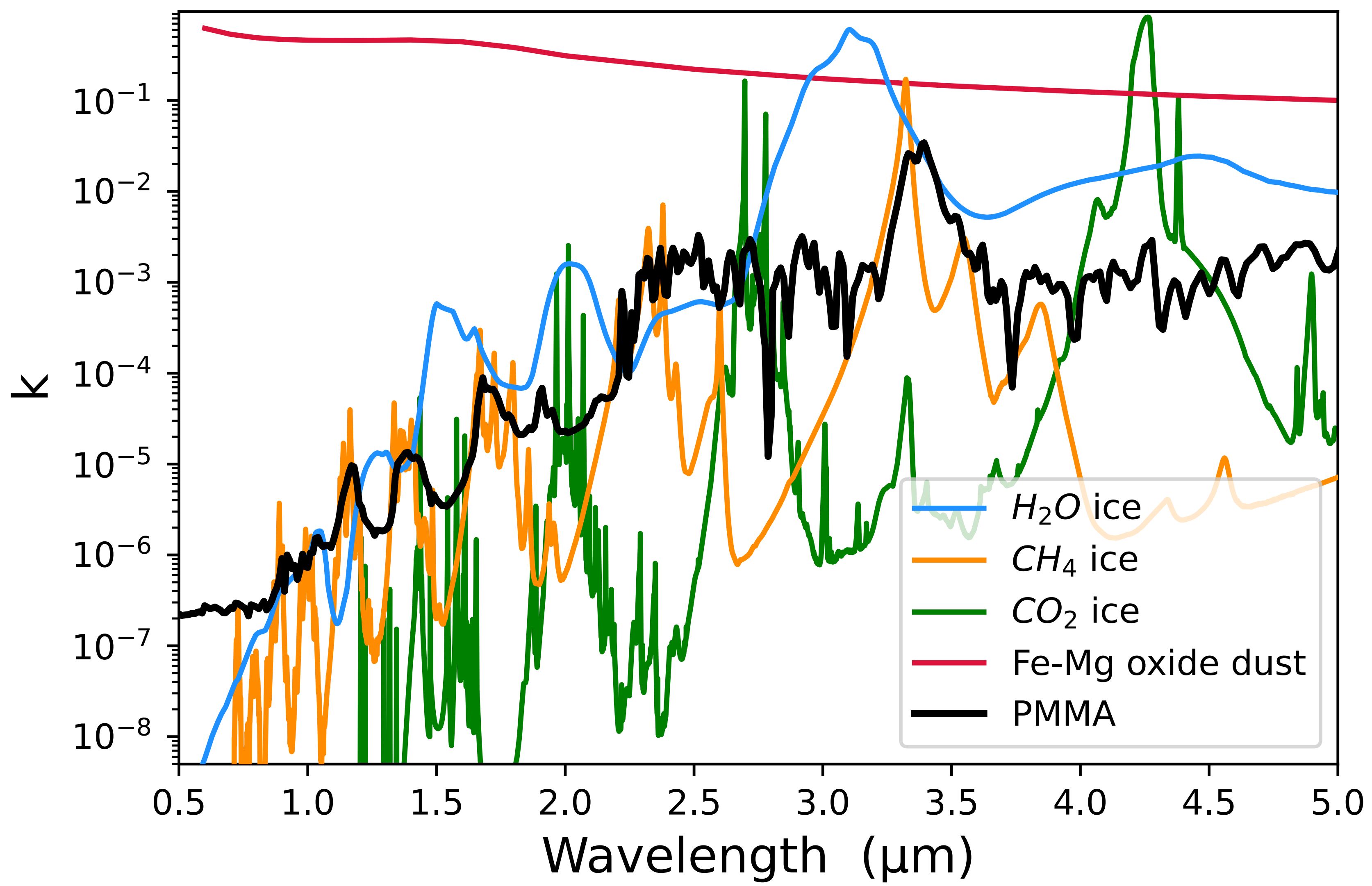
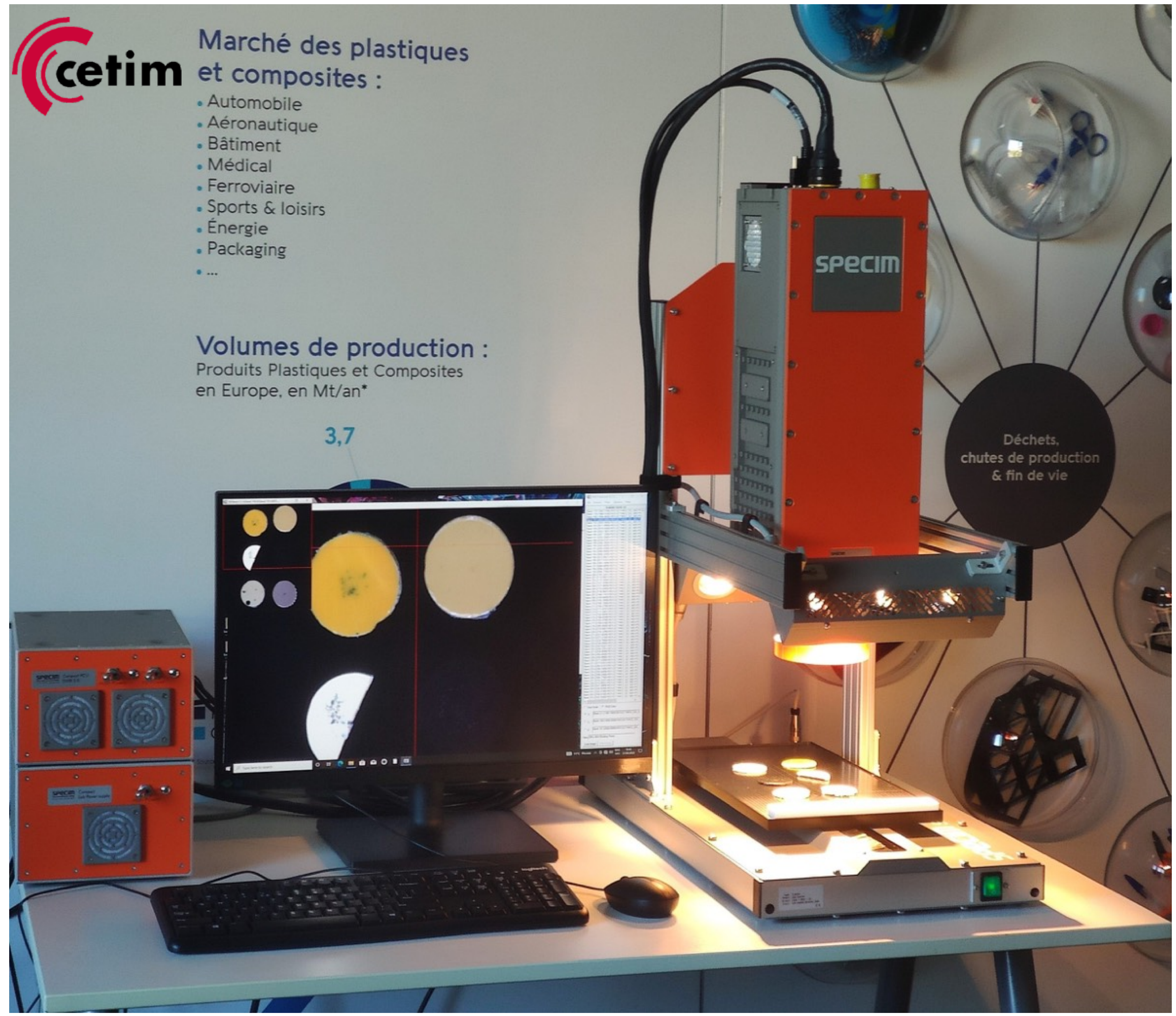


PMMA optically behaves as most planetary ices

Experimental project

Camera hyperspectrale SWIR SPECIM

Range	1-2.5 µm
Resolution	12 nm
Sampling	5 nm
Spatial bands (pushbroom)	384
Spectral bands	288
SNR	Up to 1000



6 halogen lamps at 45°, nadir observation

Experimental project

Plexiglas (and other materials) setup:

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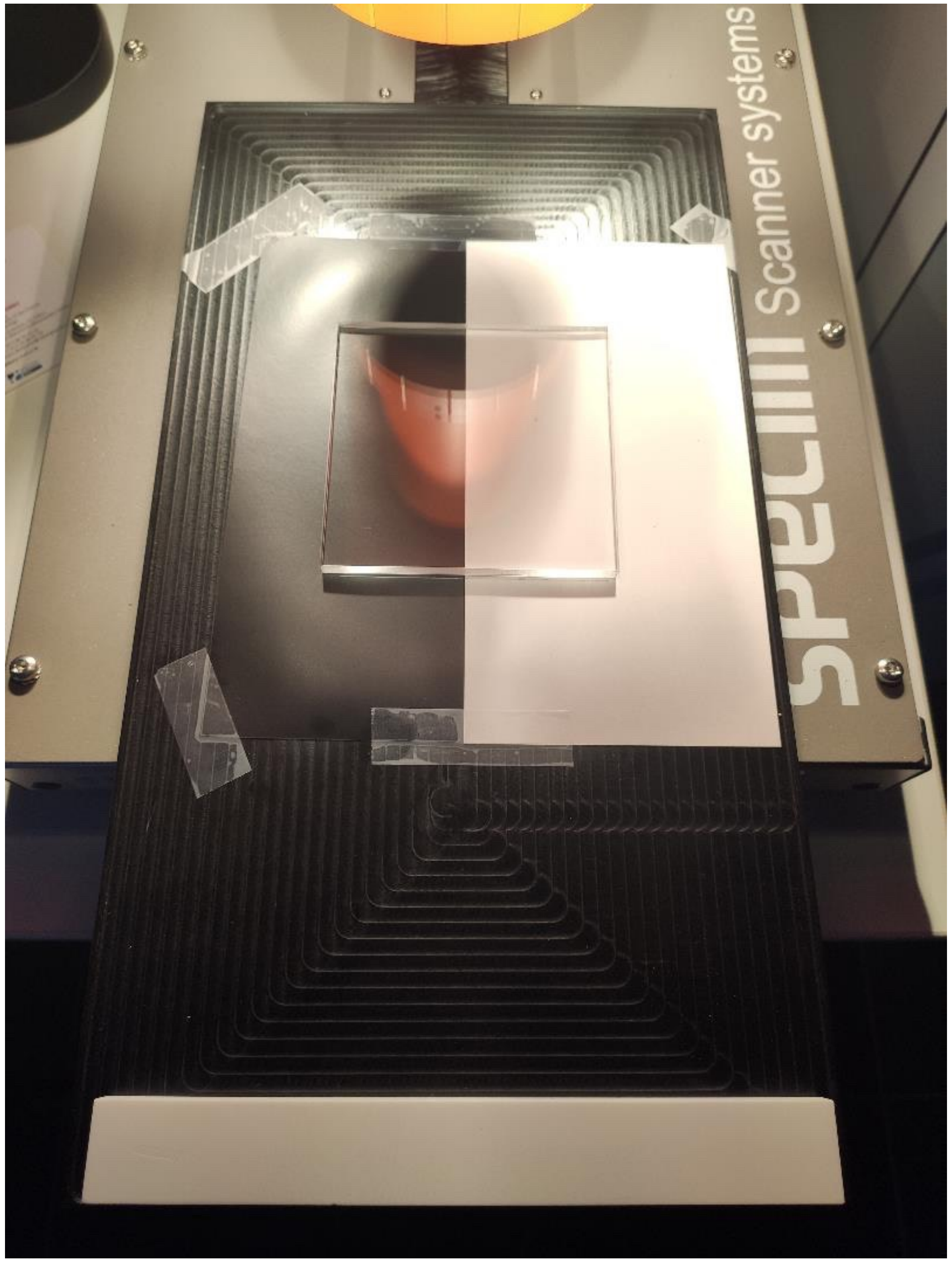

Experimental project

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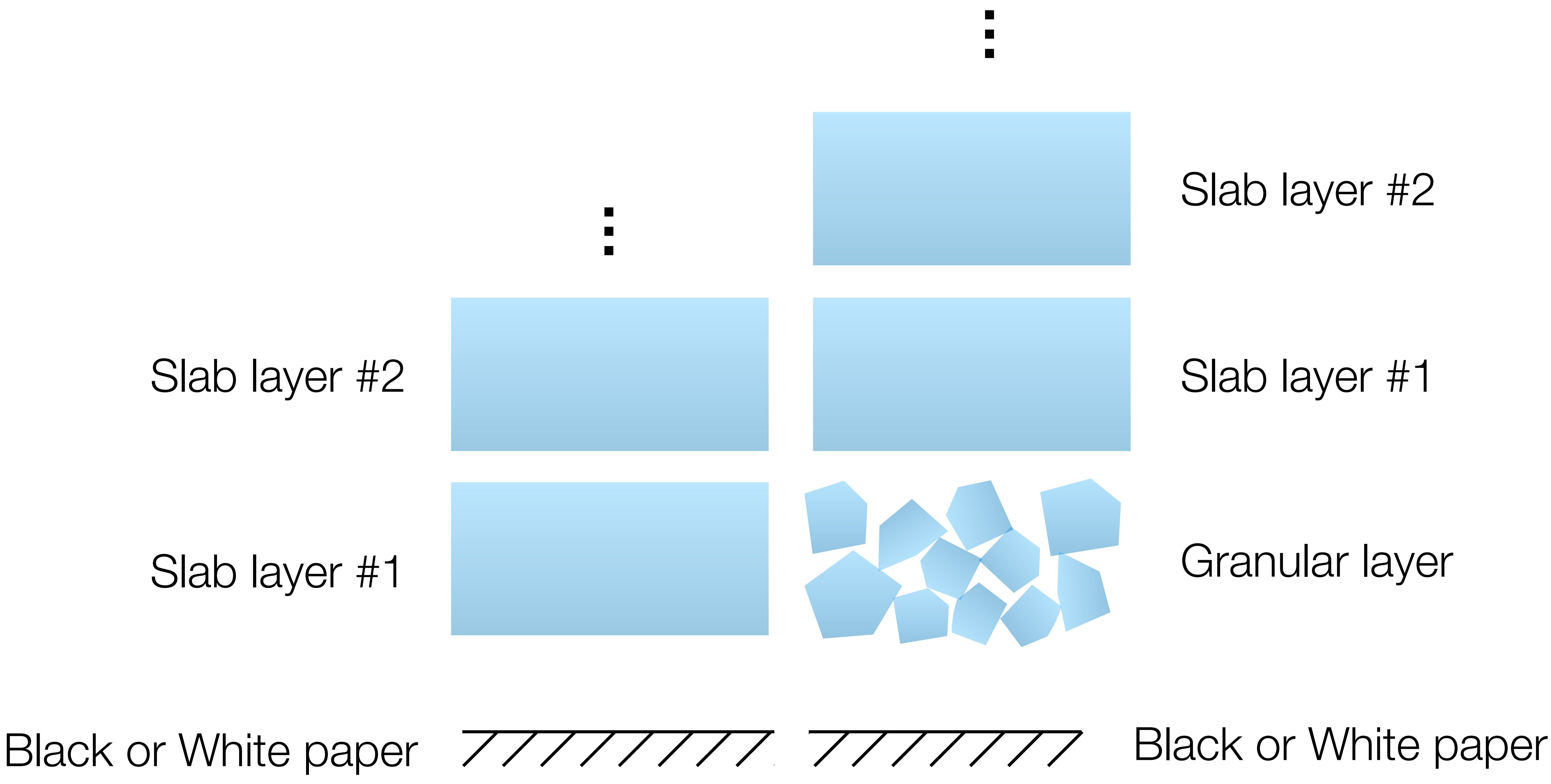
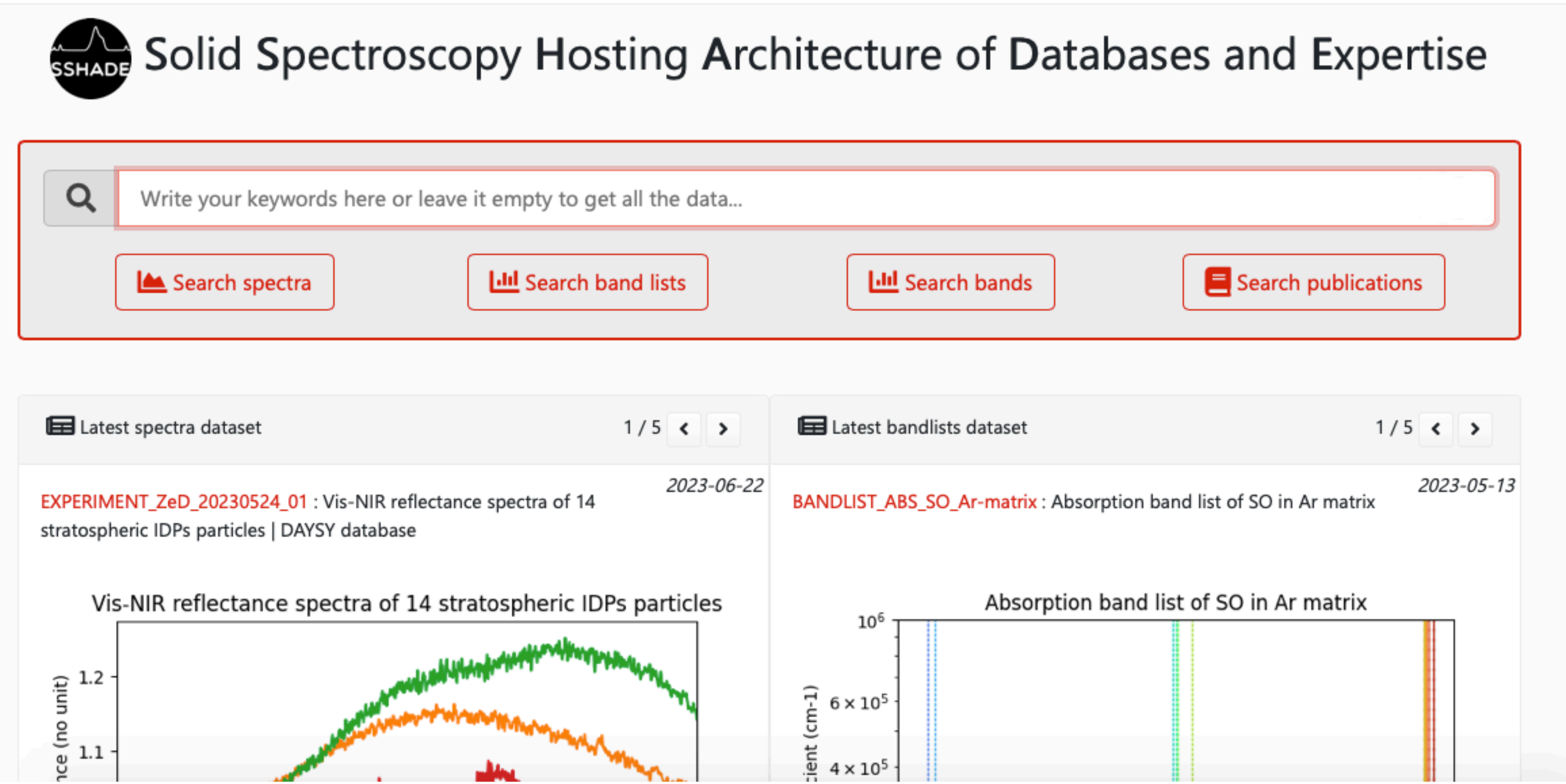


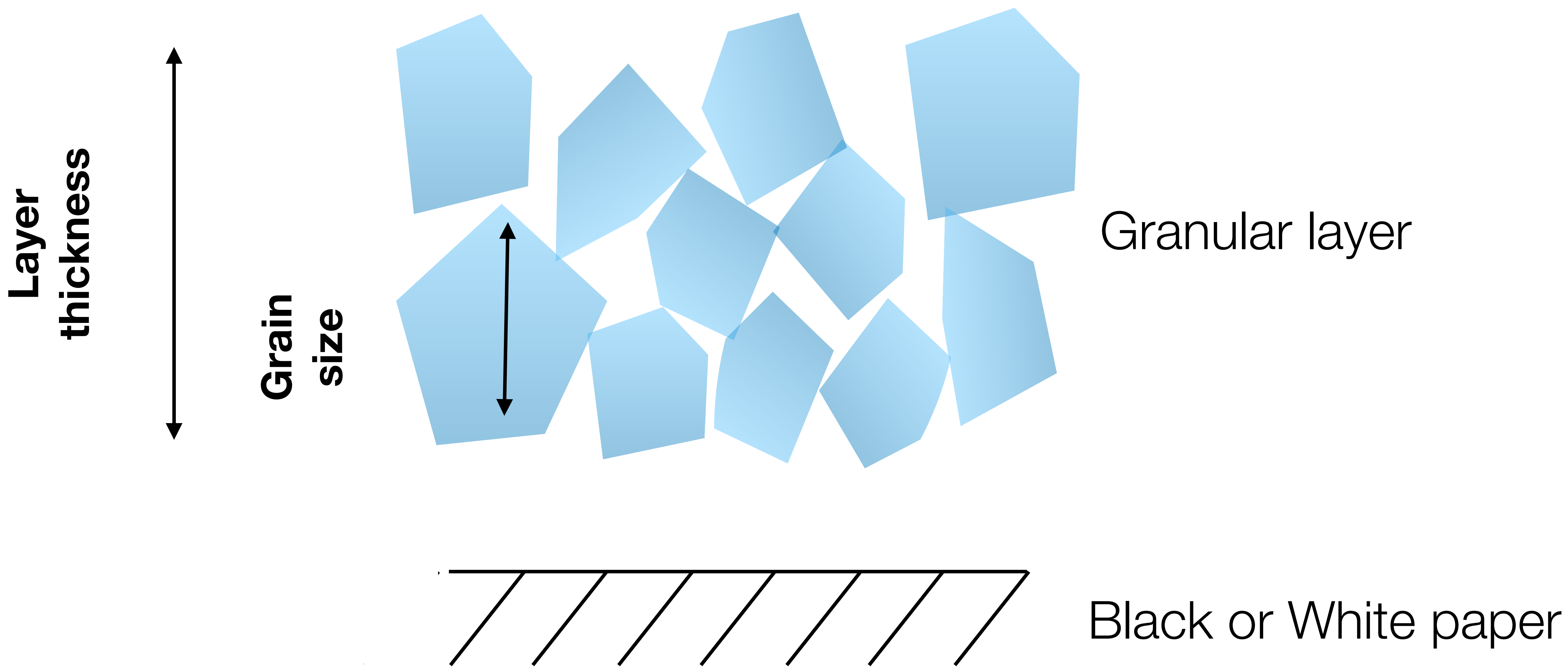
Experimental project

Data management: ll experiments will be publicly available through the SSHADE architecture



Results:

Granular: optically thick layer



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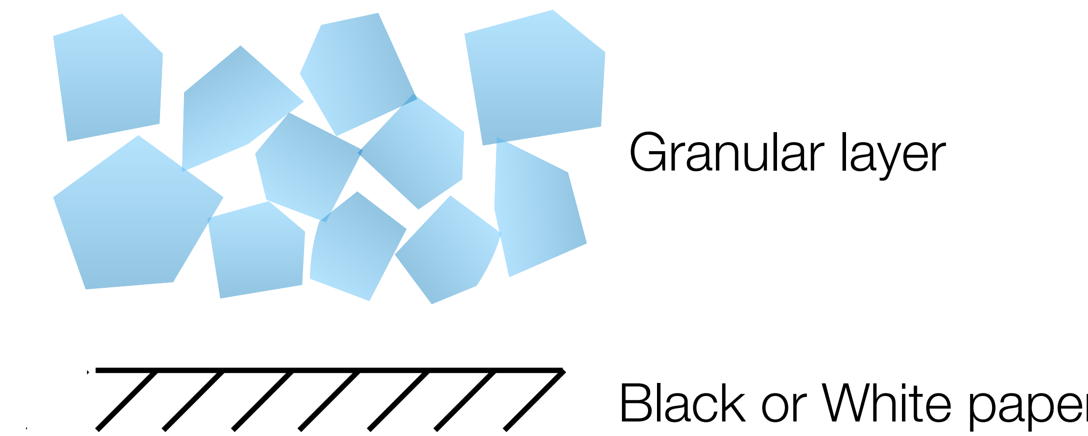
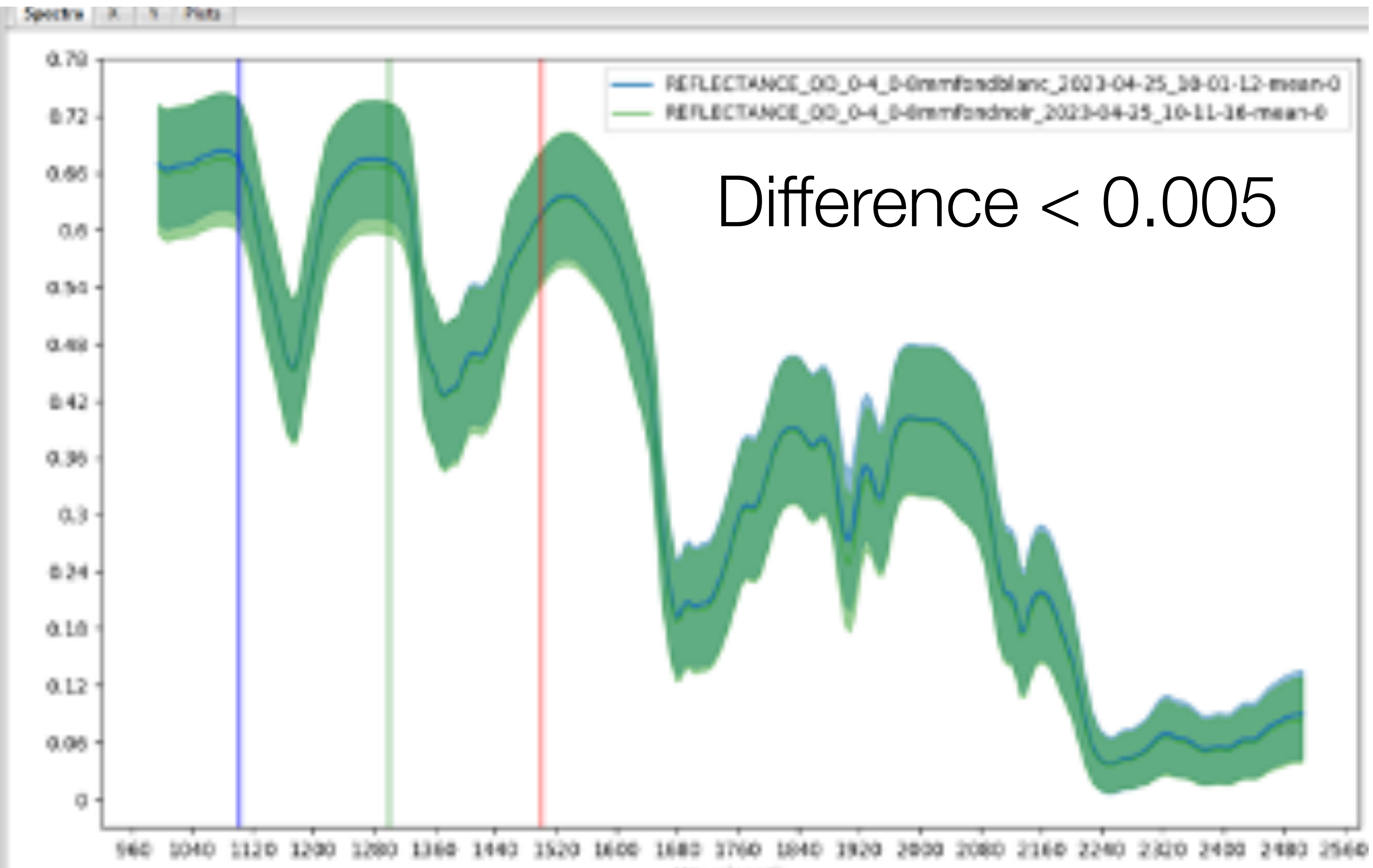


0.4-0.8mm, 9mm -> optically thick

11 to 22 grains thick



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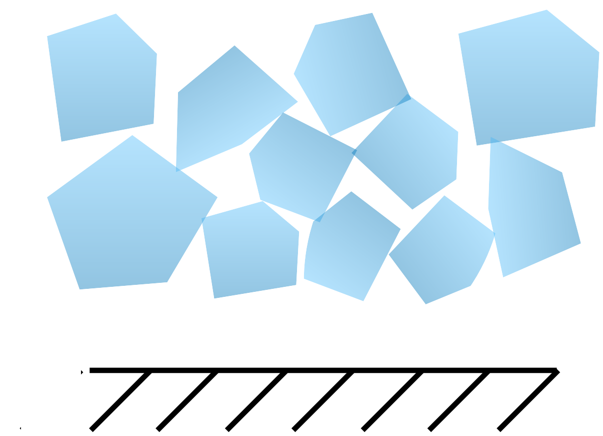
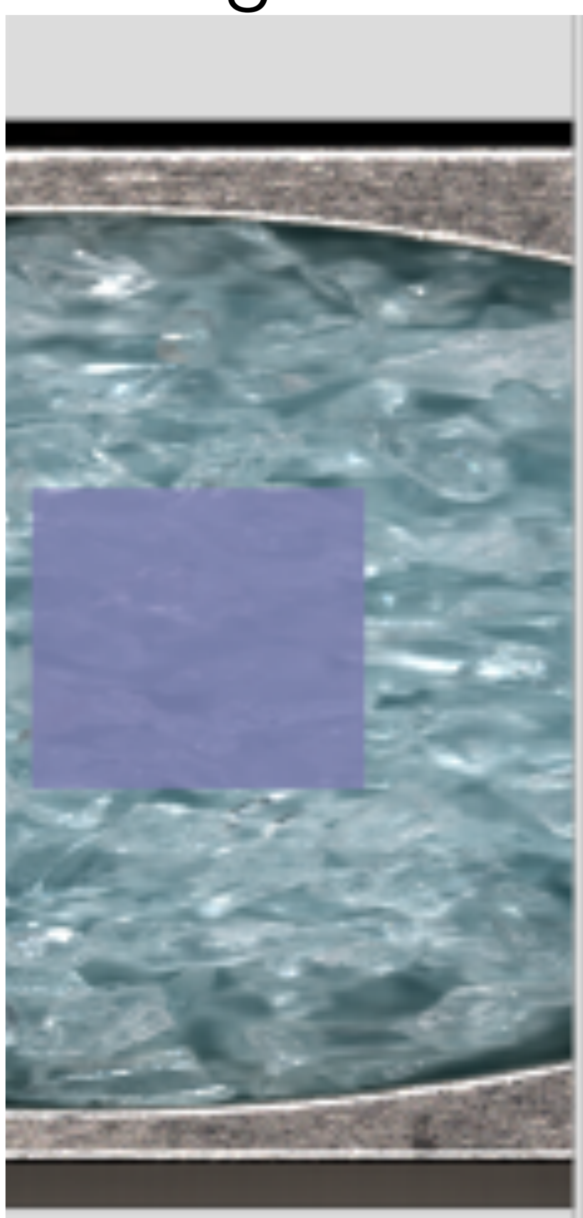
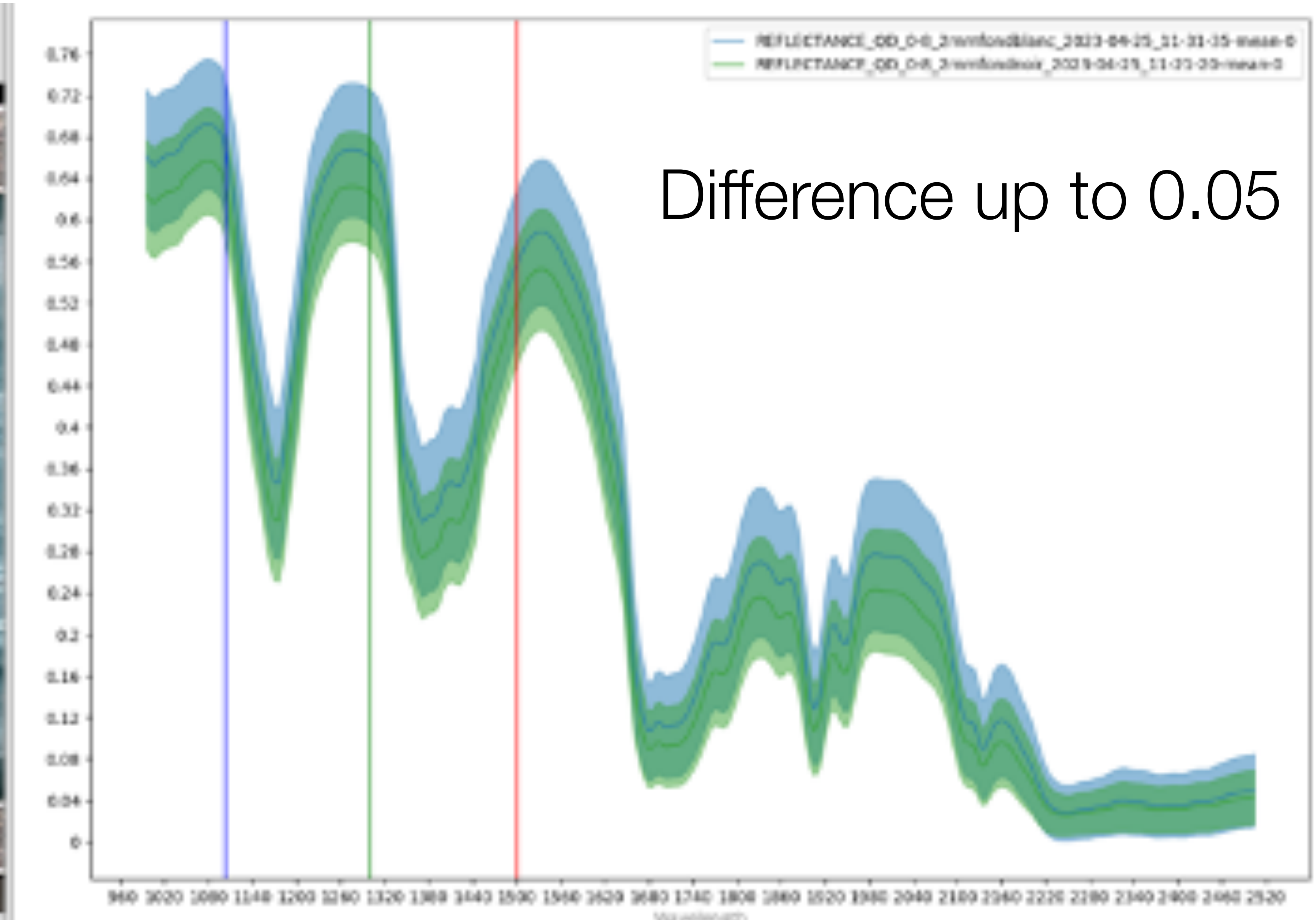


0.8mm-2mm, 9mm -> optically thin

4 to 11 grains thick



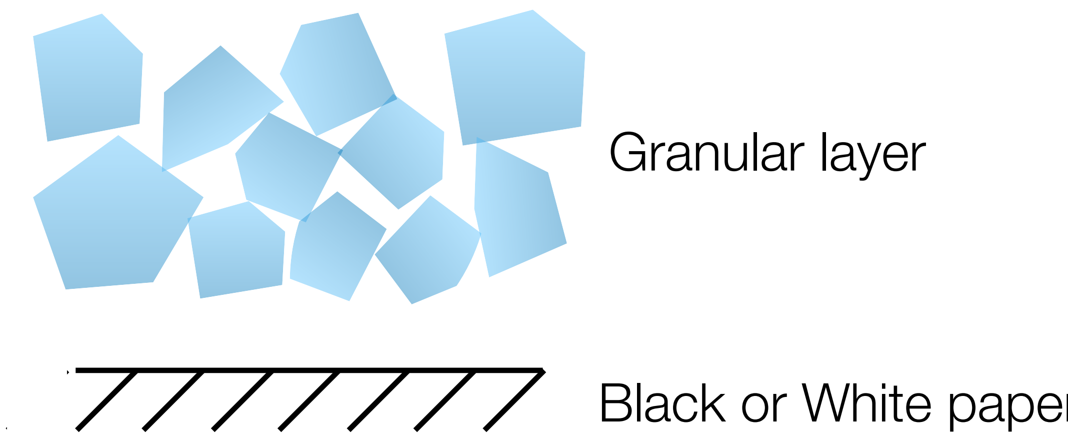


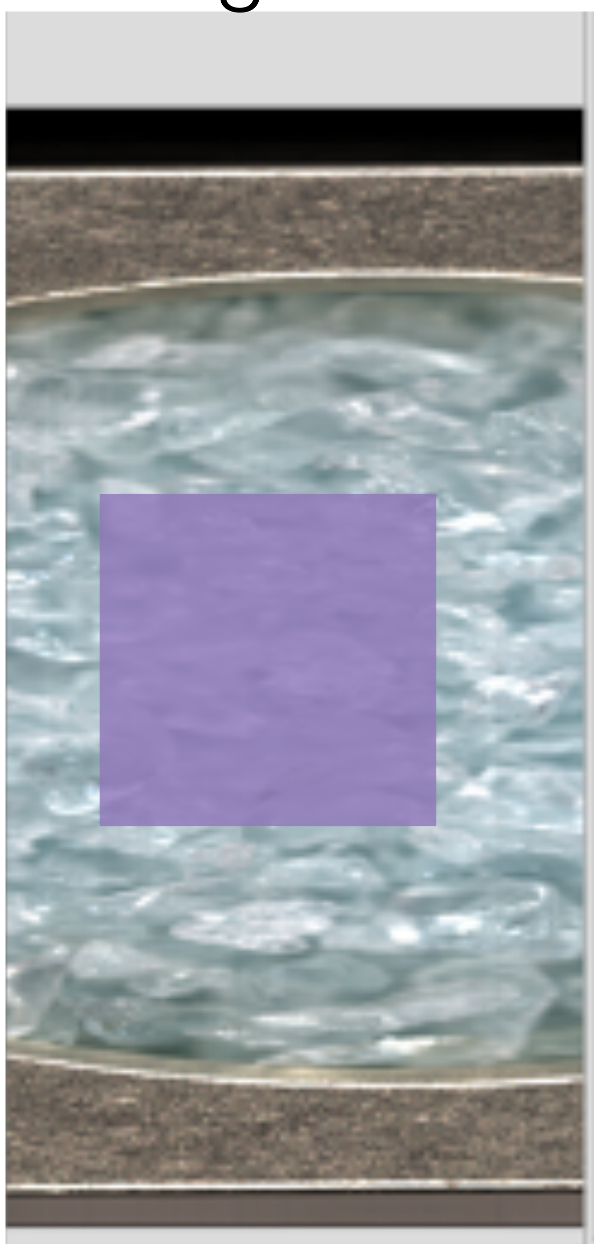
Results:

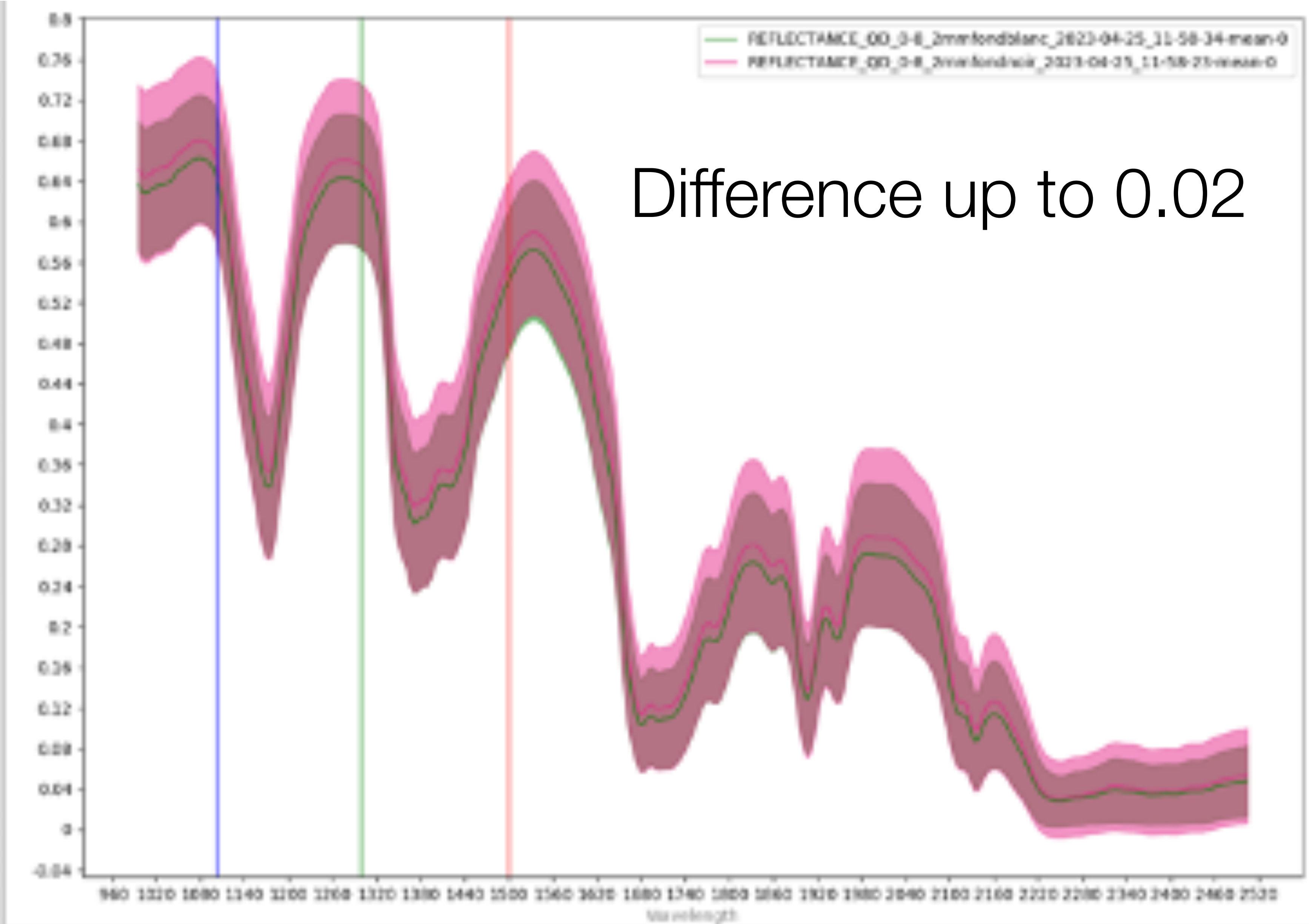
Granular: optically thick layer

0.8mm-2mm, 18mm -> optically thin

9 to 22 grains thick



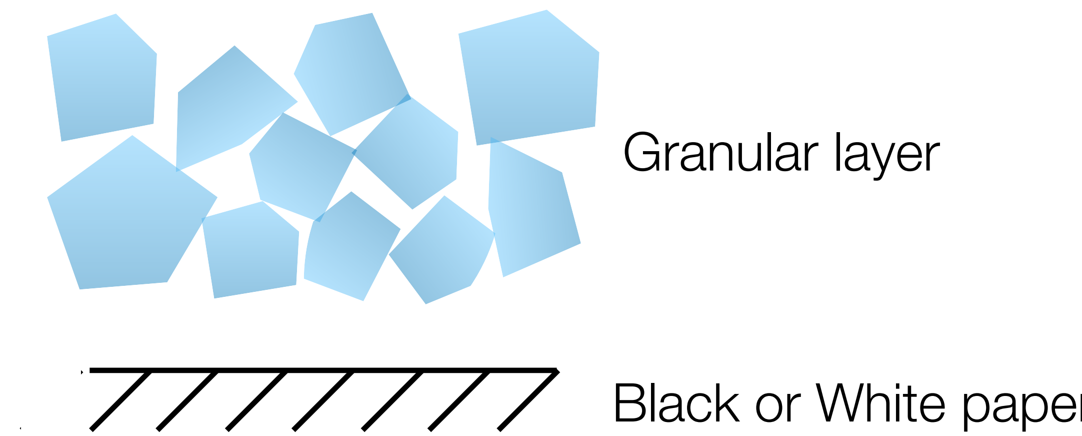


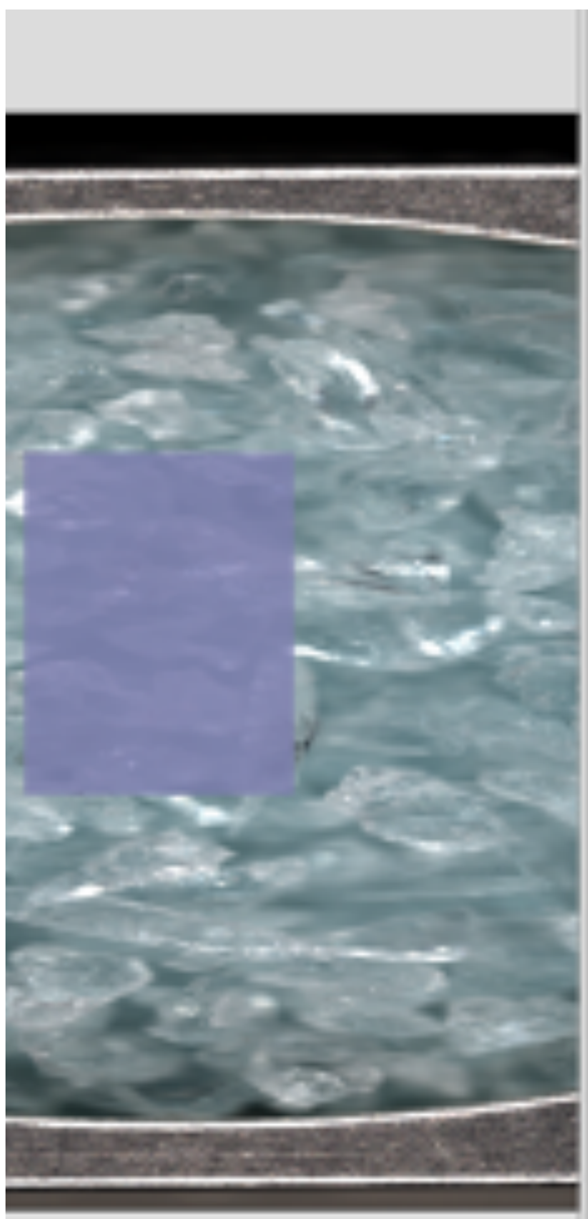


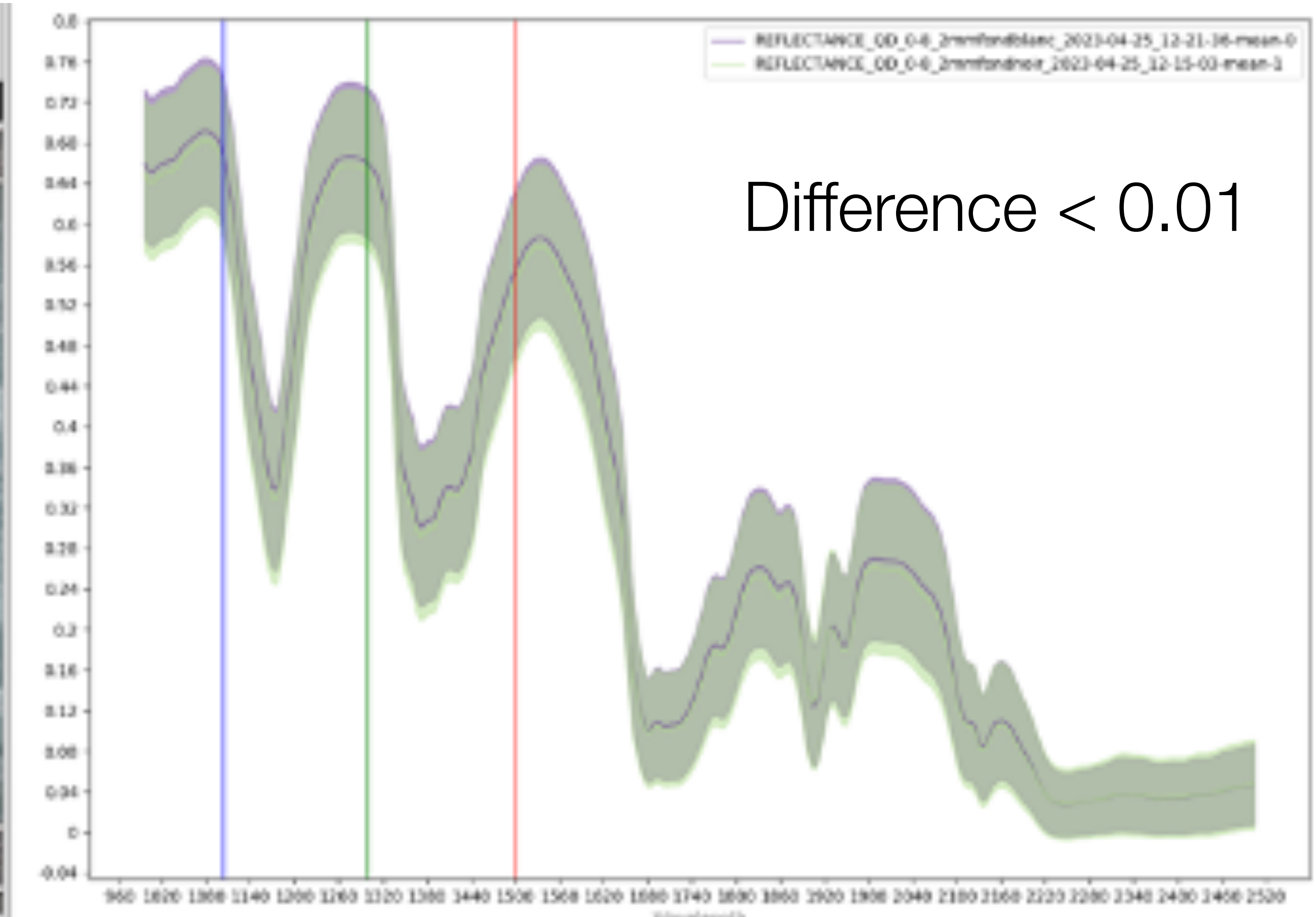
Results:

Granular: optically thick layer

0.8mm-2mm, 9mm -> optically thin
18 to 45 grains thick



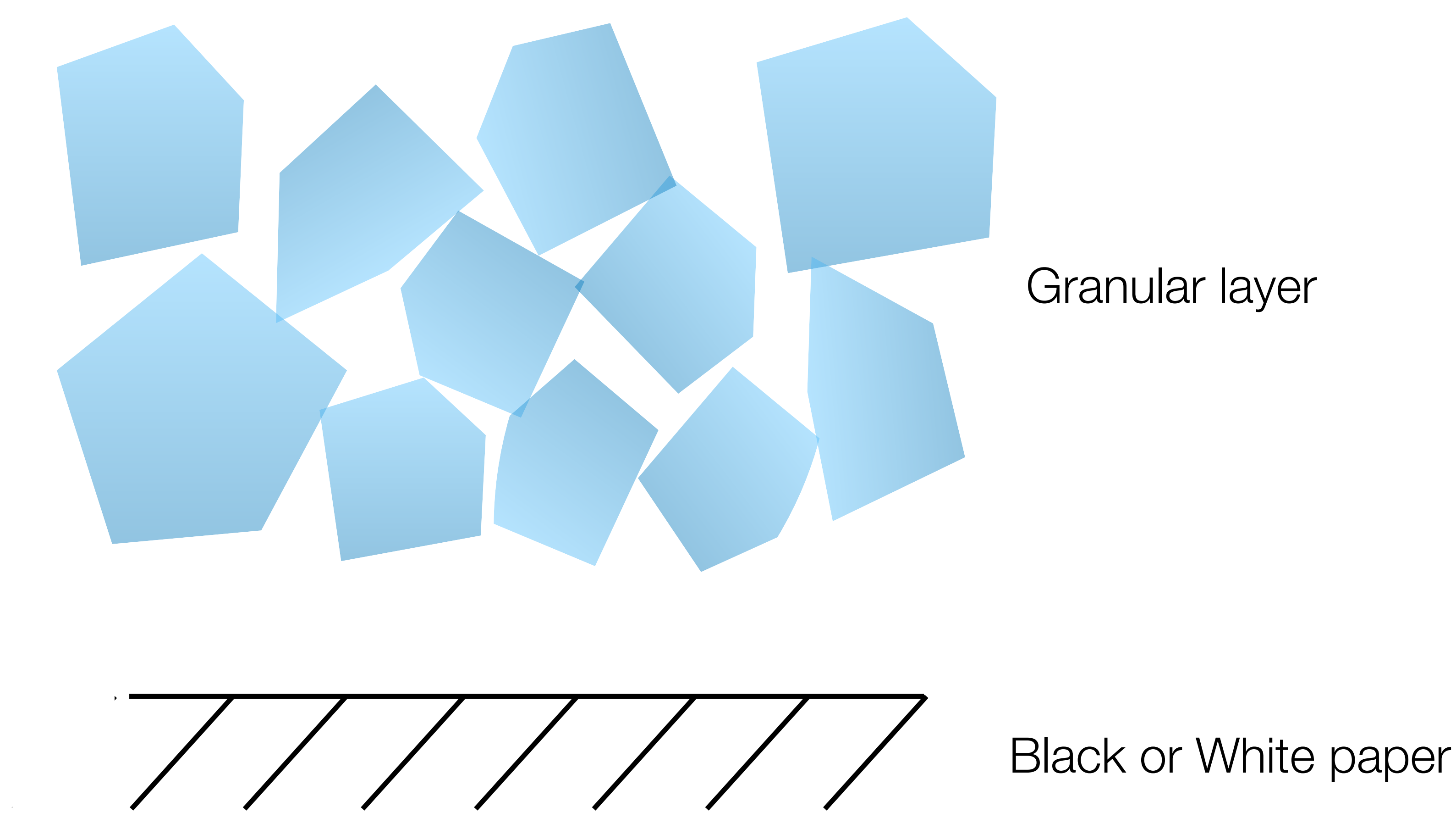




Results:

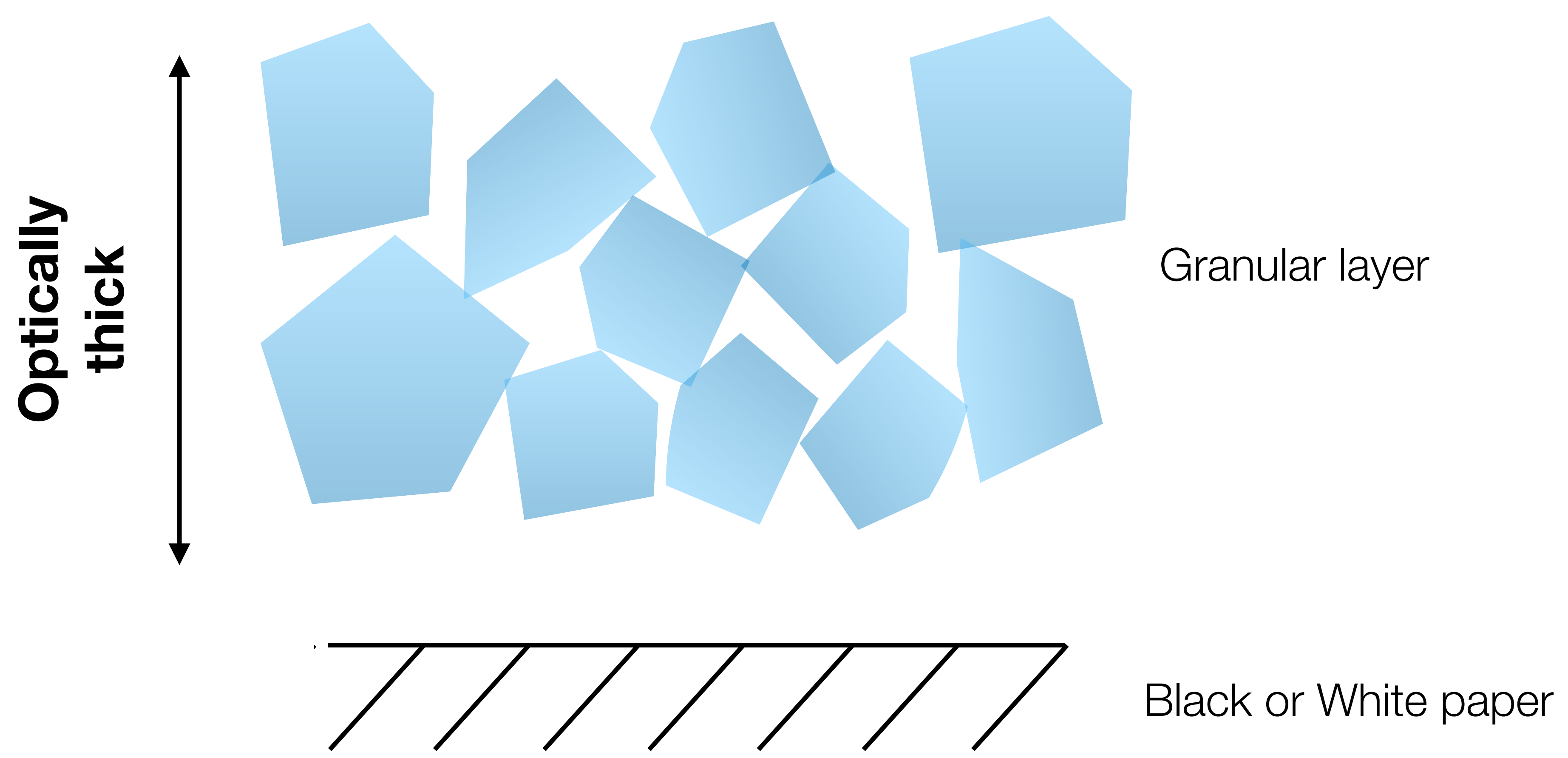
Granular: optically thick layer

The number of grains needed to be optically thick depend on the grain size



Results:

Granular: grain size and roughness with Hapke[1] model and Monte Carlo inversion



[1] B.Hapke, Theory of Reflectance and Emittance Spectroscopy, 2012, Cambridge University Press

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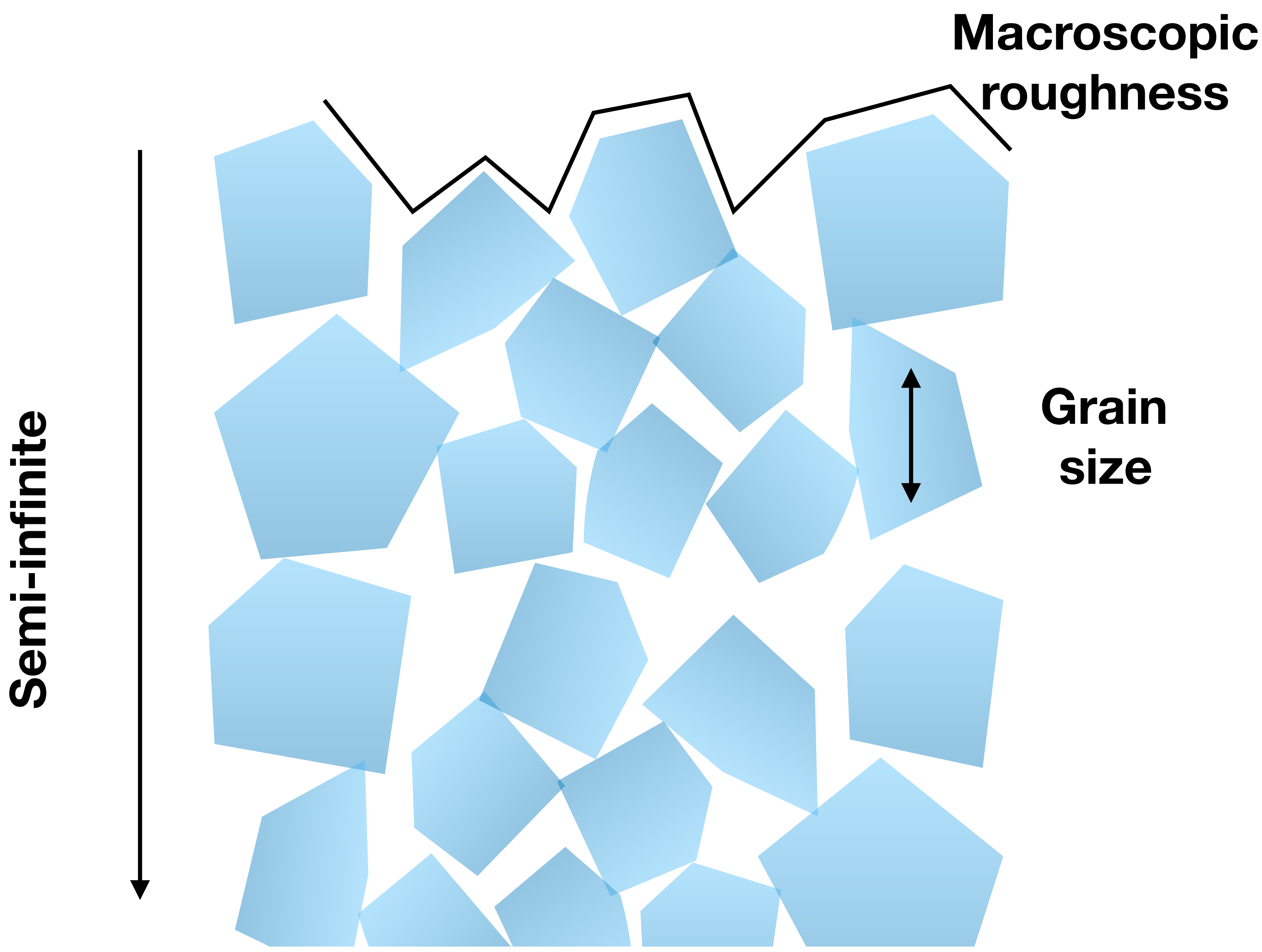

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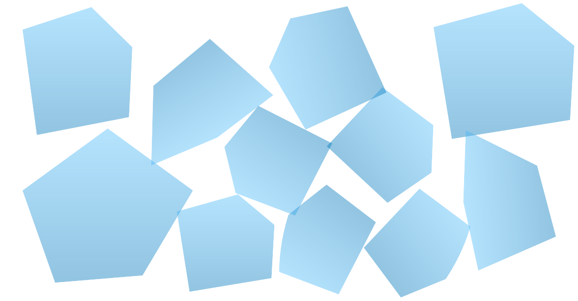
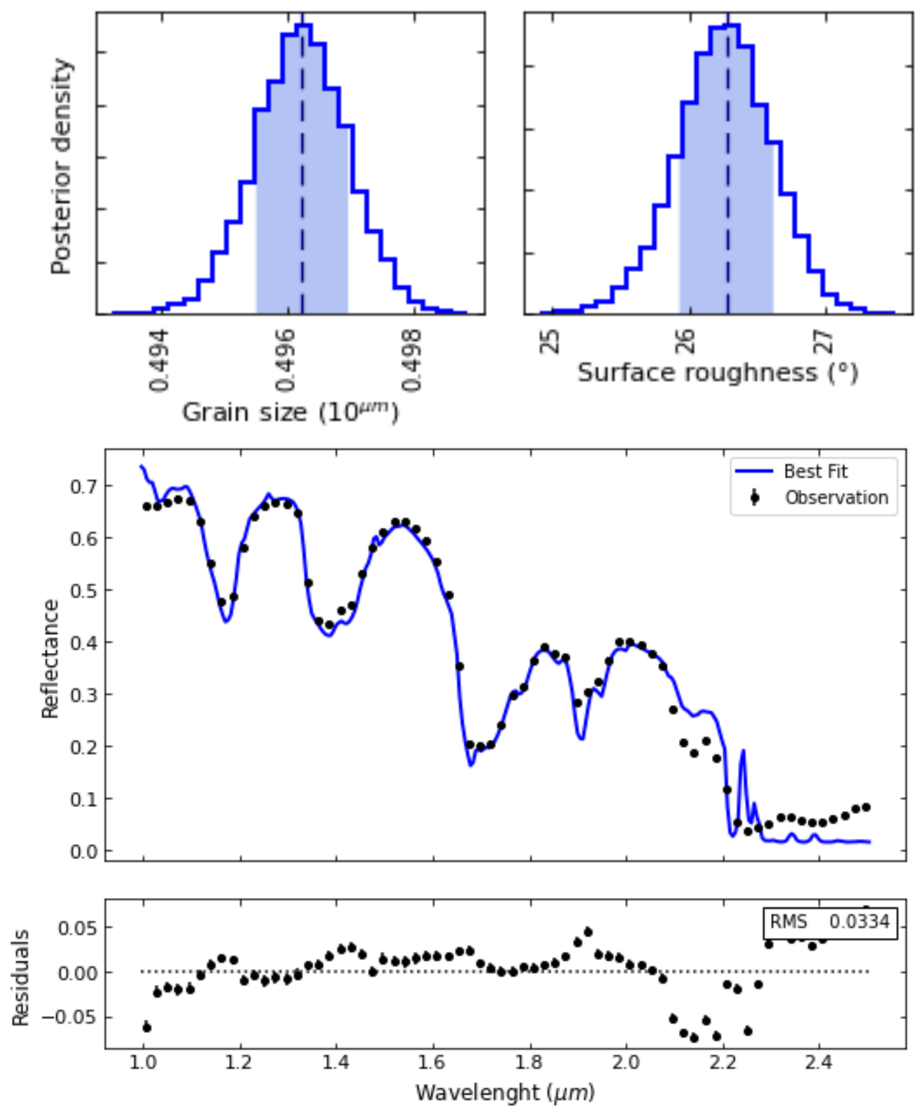
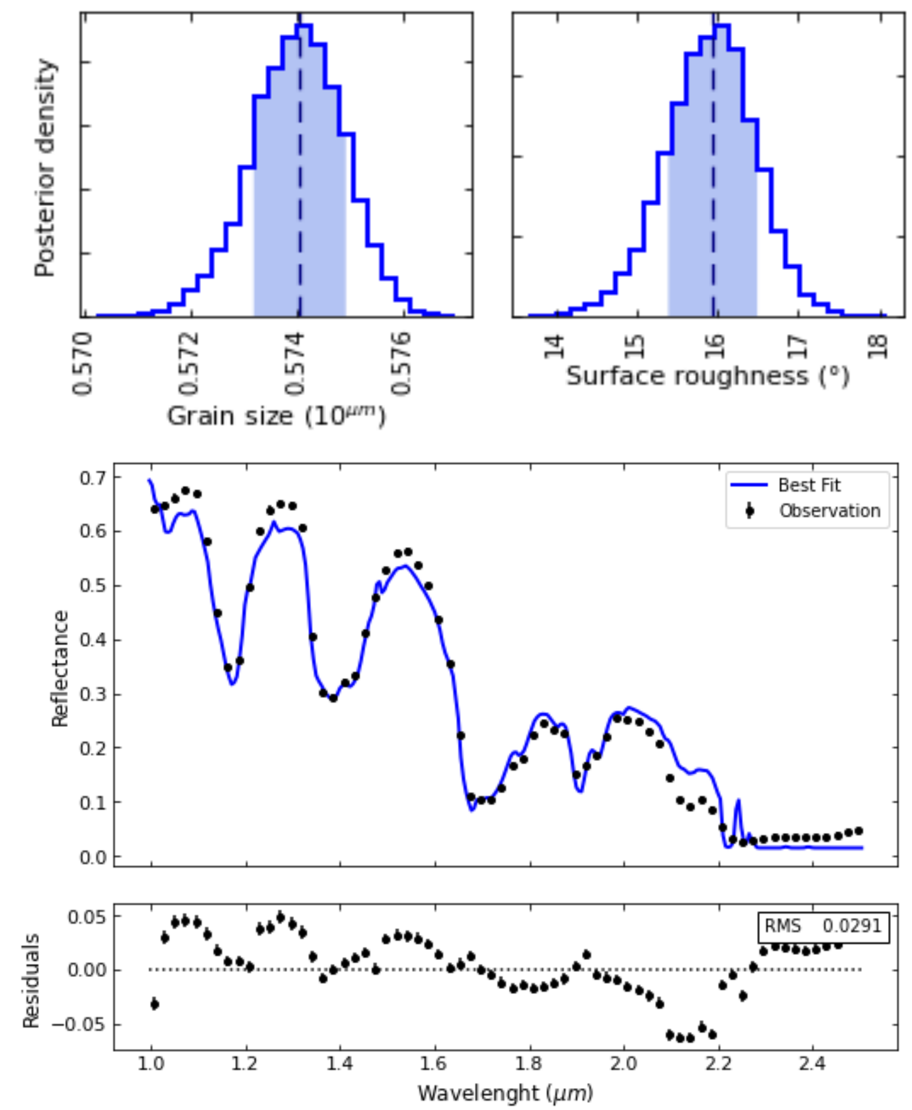
Results:

Grain size and roughness inversion: multi chain Markov chain Monte-Carlo[1]



Granular layer





Real grain size : 0.4mm - 0.8mm | 0.8mm-2mm

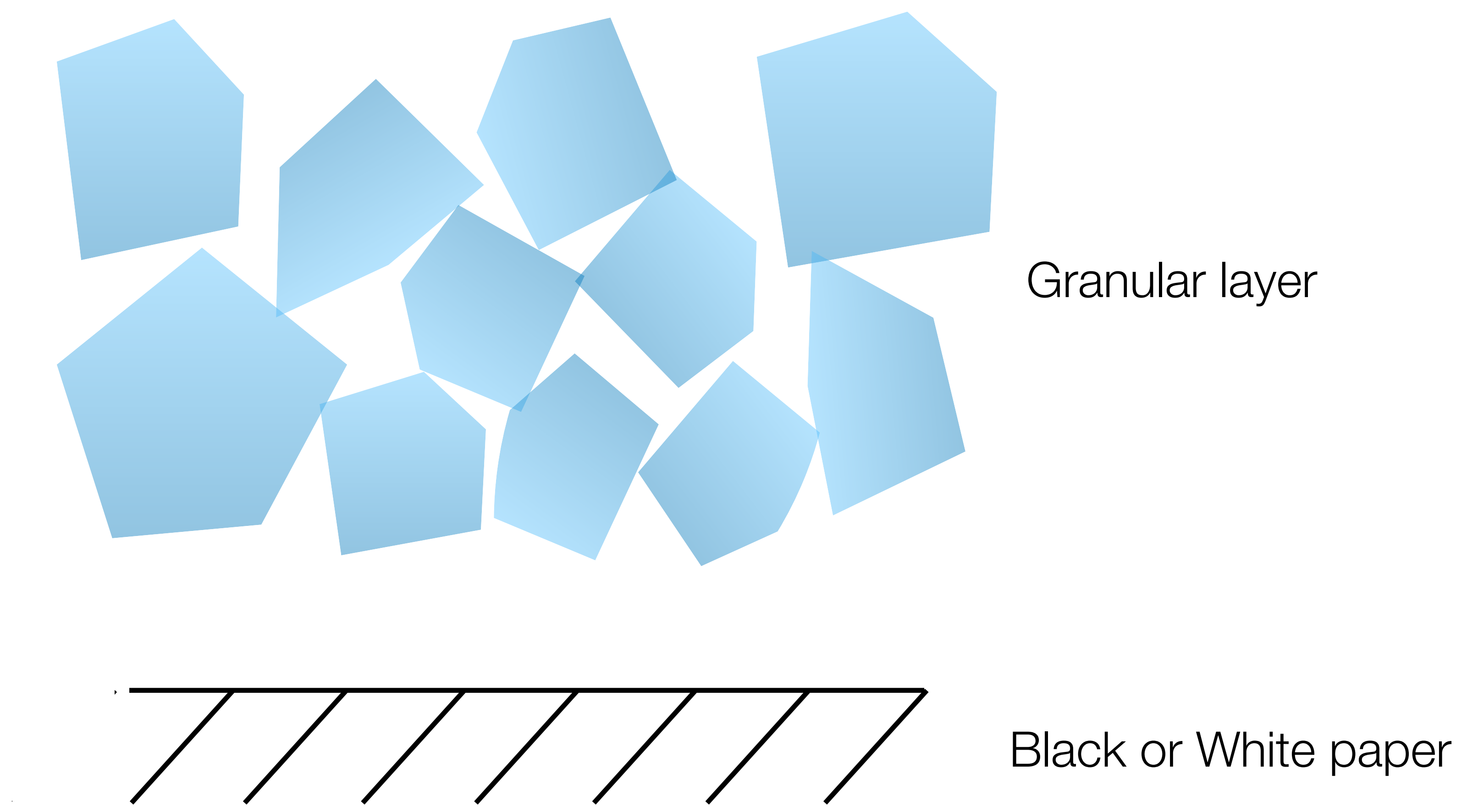
Retrieved grain size : 0.758mm ± 0.03mm | 1.98 + 0.05 -0.04 mm

[1] Cubillos et al, The Astrophysical Journal, 2017

Results:

Granular: optically thick layer

- Roughness decrease with grain size
- We are sensitive only to the biggest grains with the model

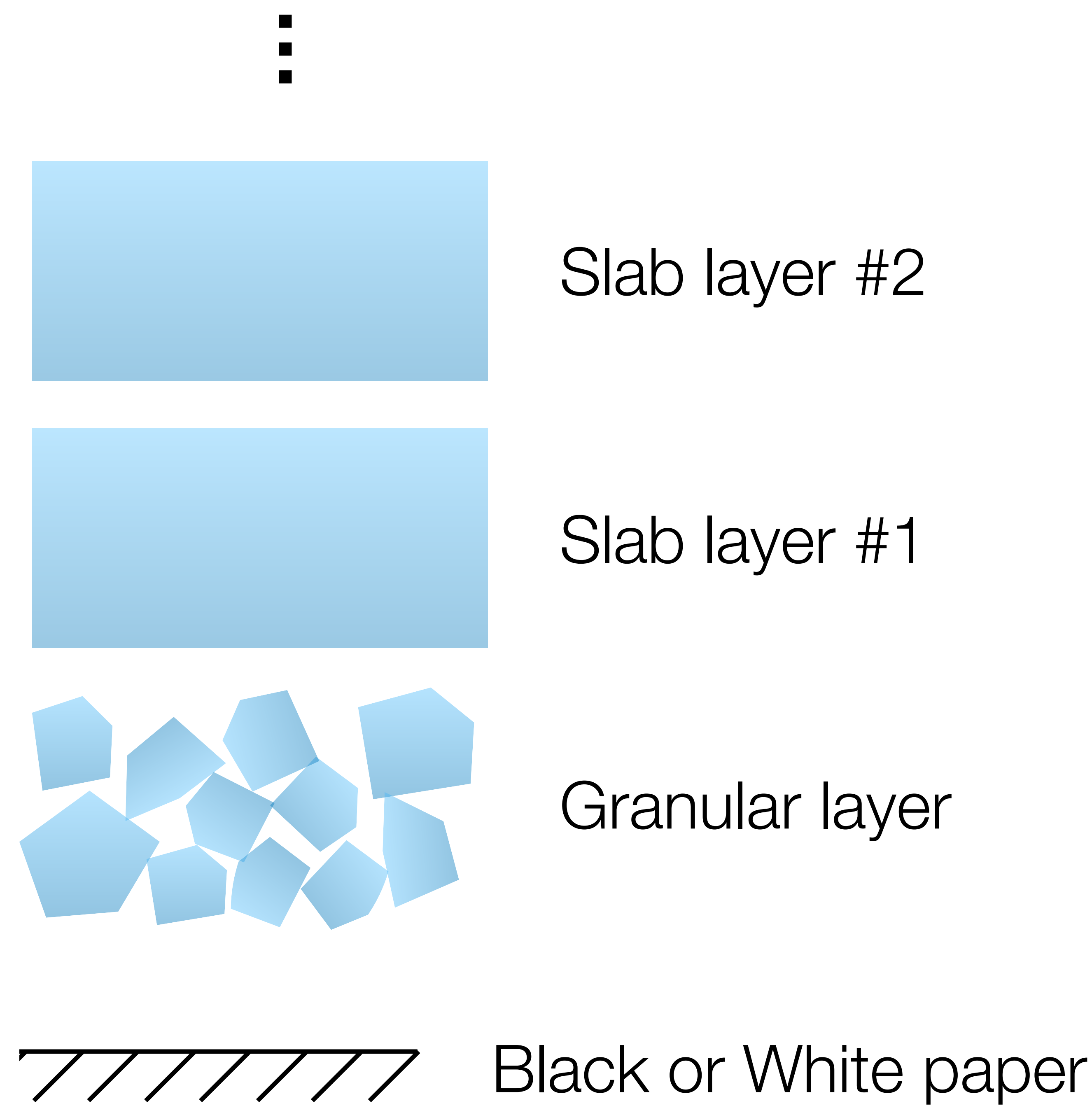


Results:

Thin slab overs granular optically thick layer using RT model and Monte Carlo inversion

RT model : Hapke + geometrical optics, coupled[1]

Inversion: multi chain Markov chain Monte-Carlo[2]



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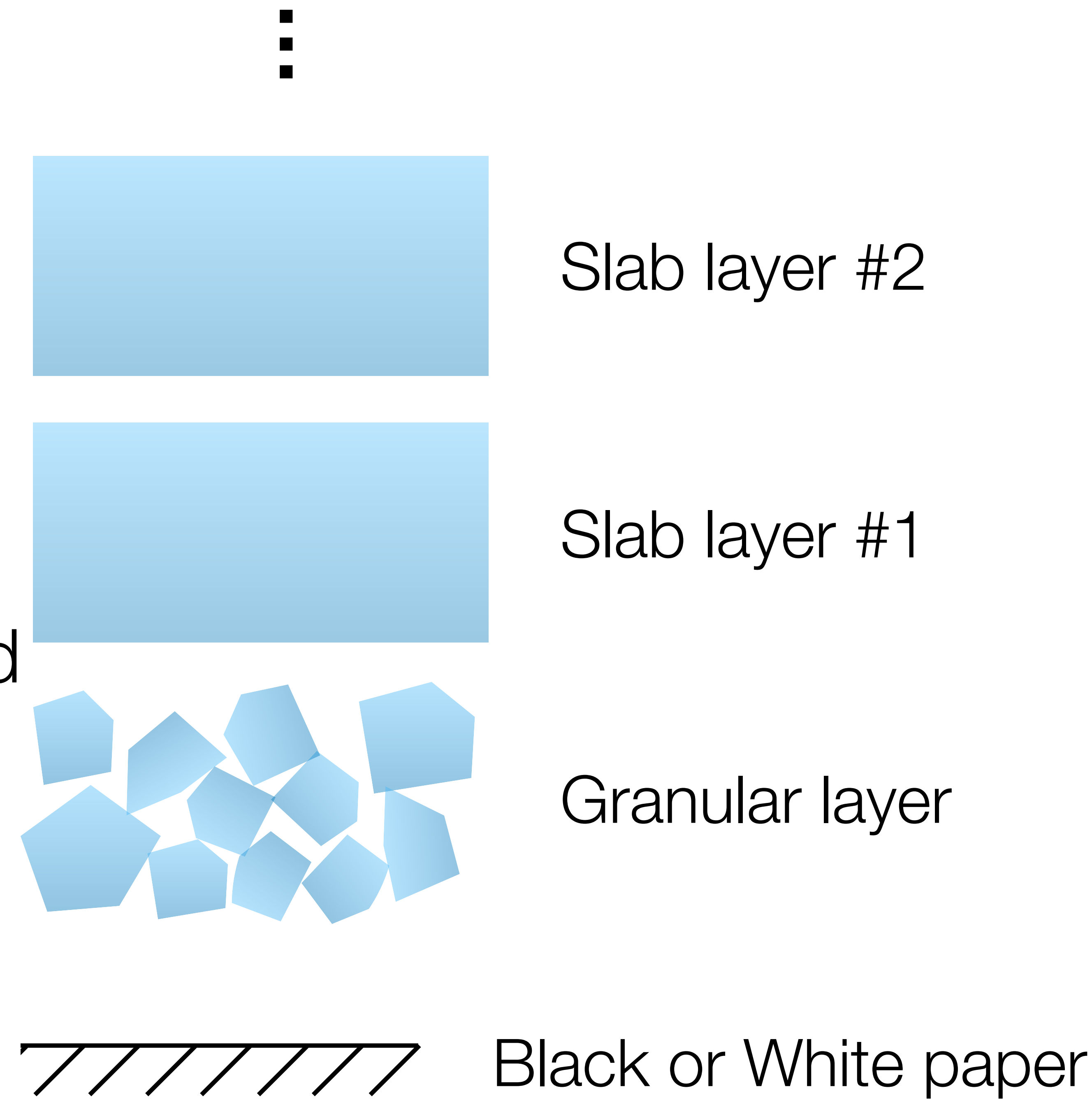
Goals:

- Quantify the impacts of layering
- Quantify surface contact between granular layer and slab
- Validate RT models and inversion methods



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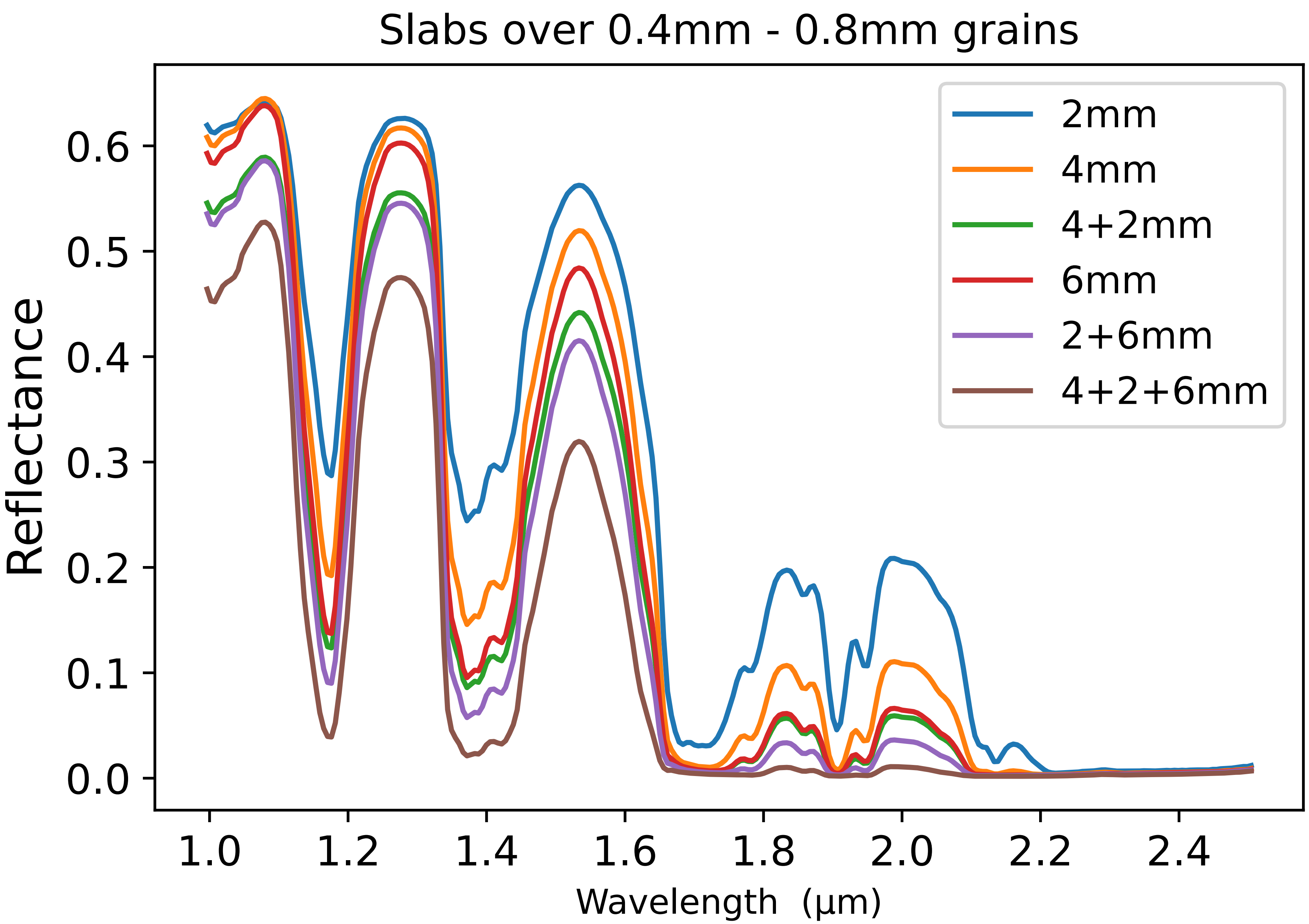
data:



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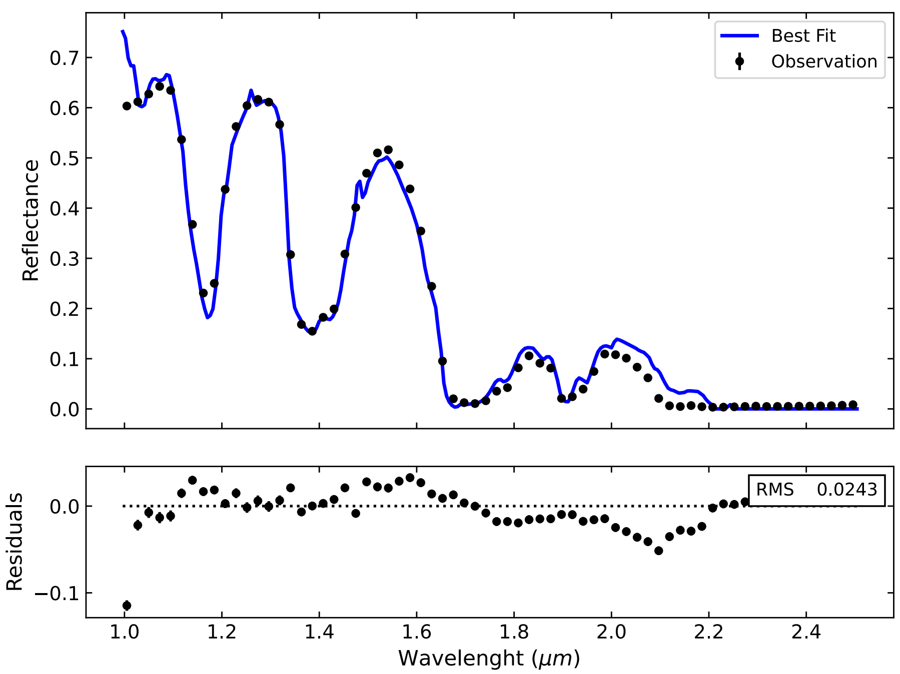
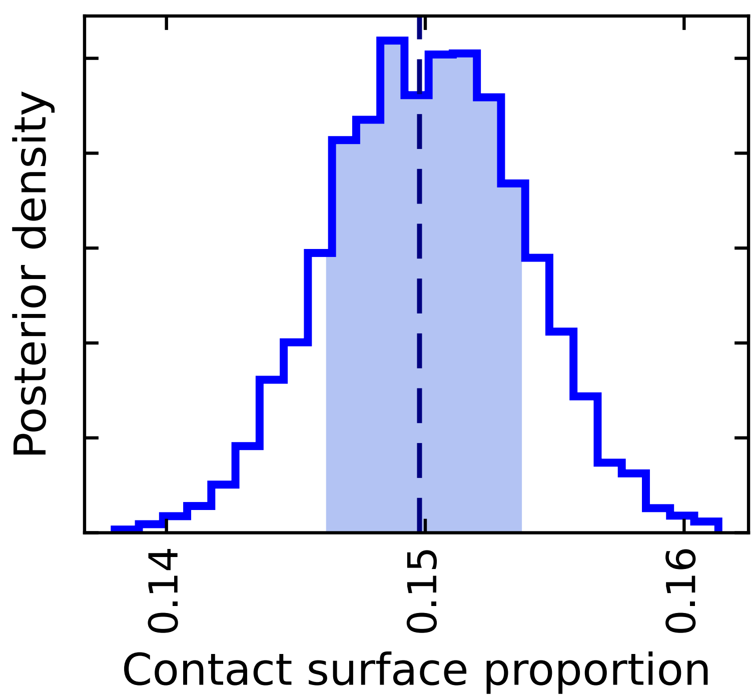
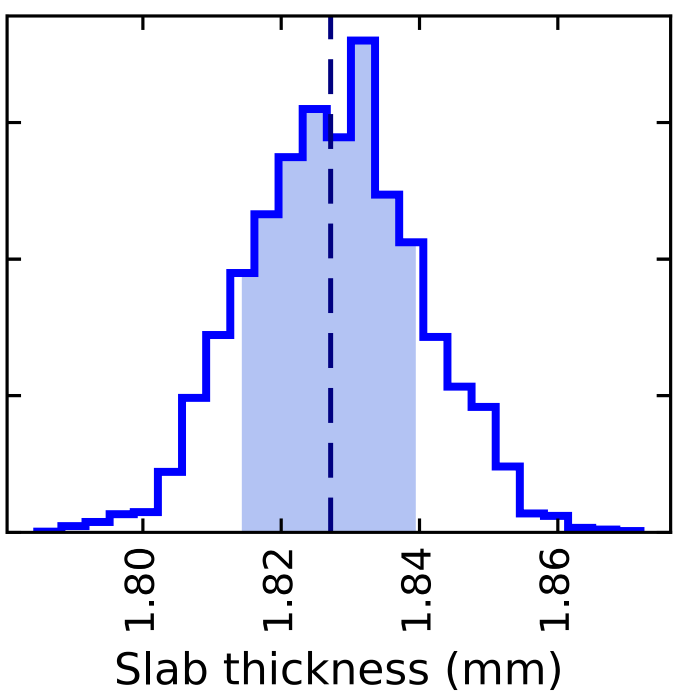
Inversions (very preliminary):



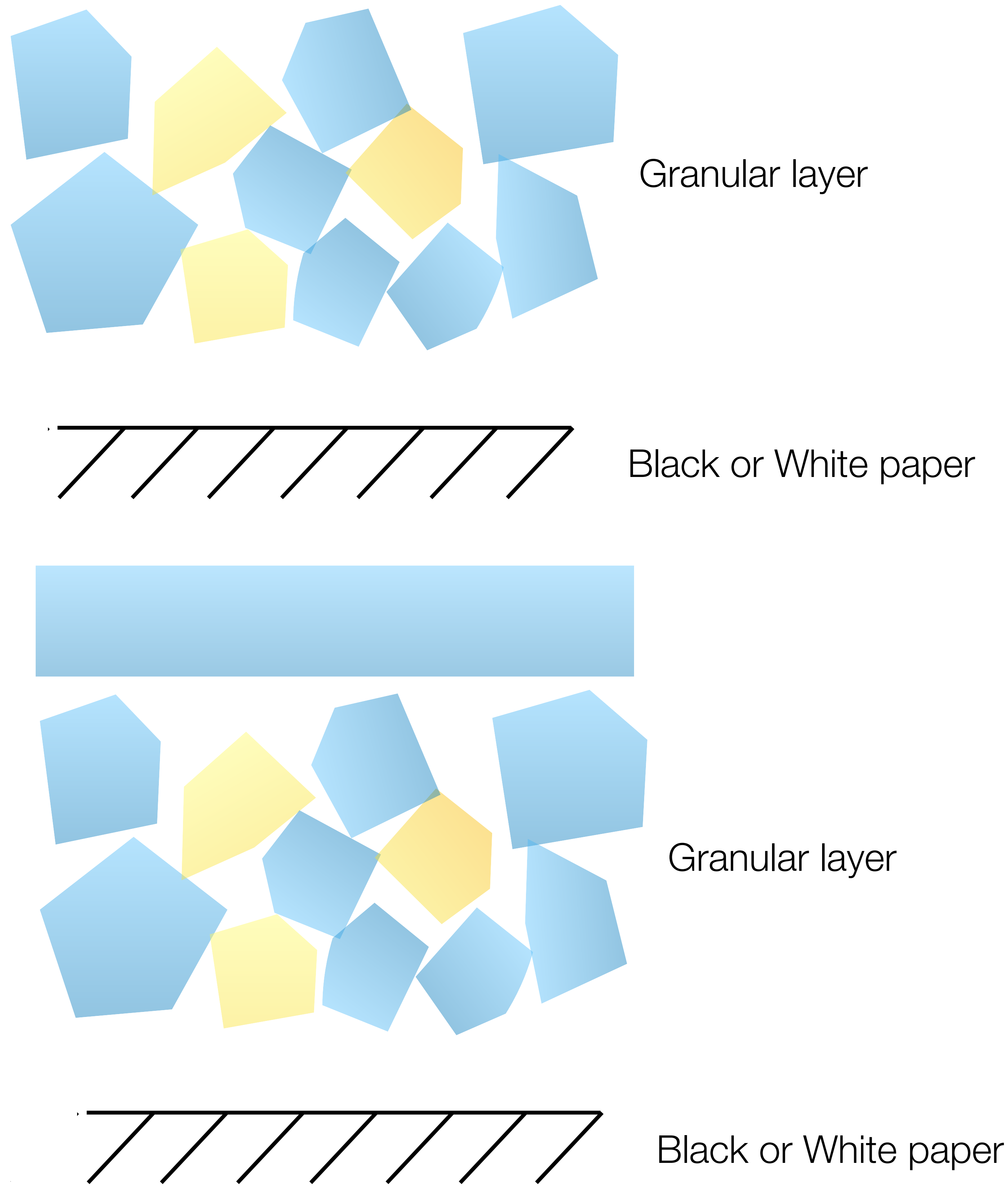




- Good fit
- Low surface contact
- Bad estimation of thickness

In the future:

- Controlled granular mixture including PMMA
- Improving slab over granular results
- Controlled slab over granular mixture including PMMA
- Contaminated slabs?



Conclusion

- Need of a reference database for granular and slab intimate mixtures: we are making an effort in this direction

- PMMA optically behaves as ice (in VNIR)

- The data we create will be available publicly through the SSHADe infrastructure

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