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Establishing a validation protocol for open air surface BRF data

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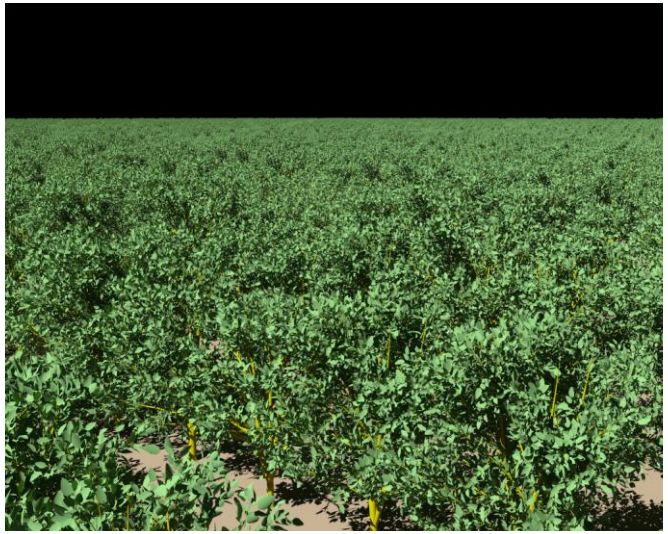
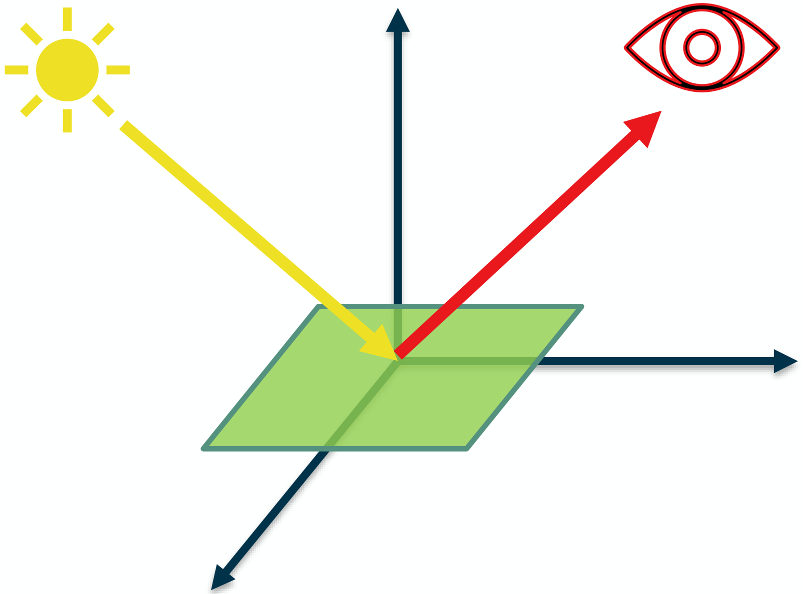
Rayference
6th Sentinel-2 Validation Team Meeting, 12 – 14 September 2023, ESRIN, Frascati.

Background

A bit of theory



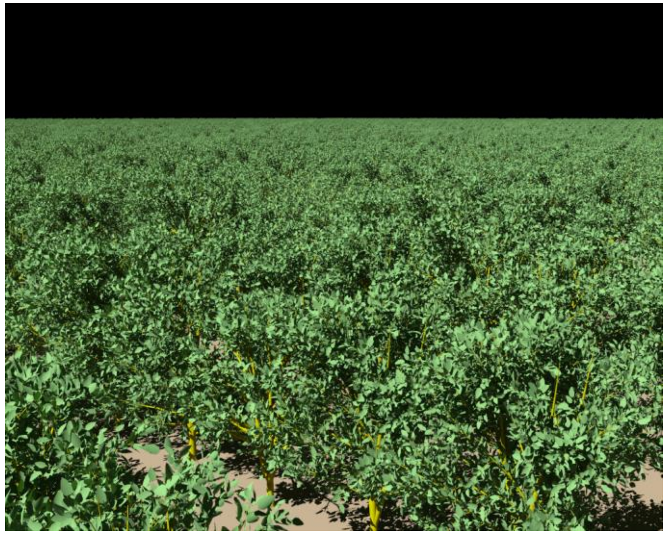


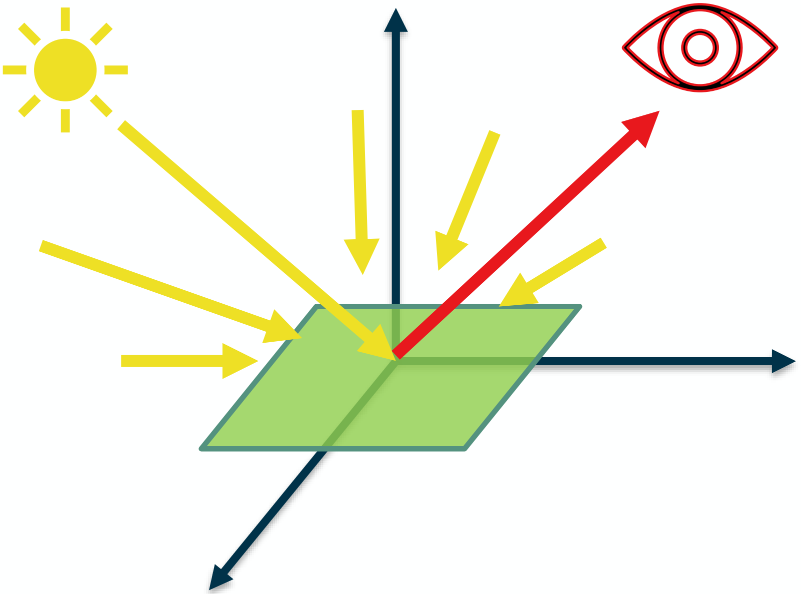
Surface reflectance depends only on the illumination Ω_s and viewing Ω_v directions

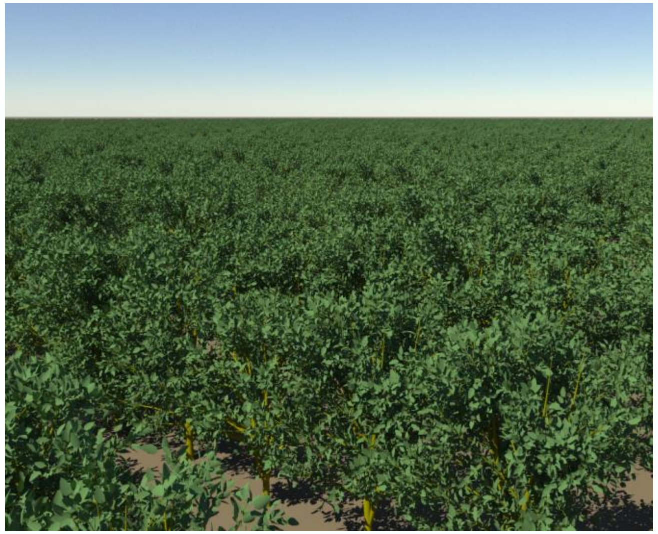
It is referred to as the **B**idirectional **R**eflectance **F**actor (Nicodemus, 1977) or the **black sky surface reflectance**

Does not depend on the illumination (sky radiation) conditions

A bit of theory

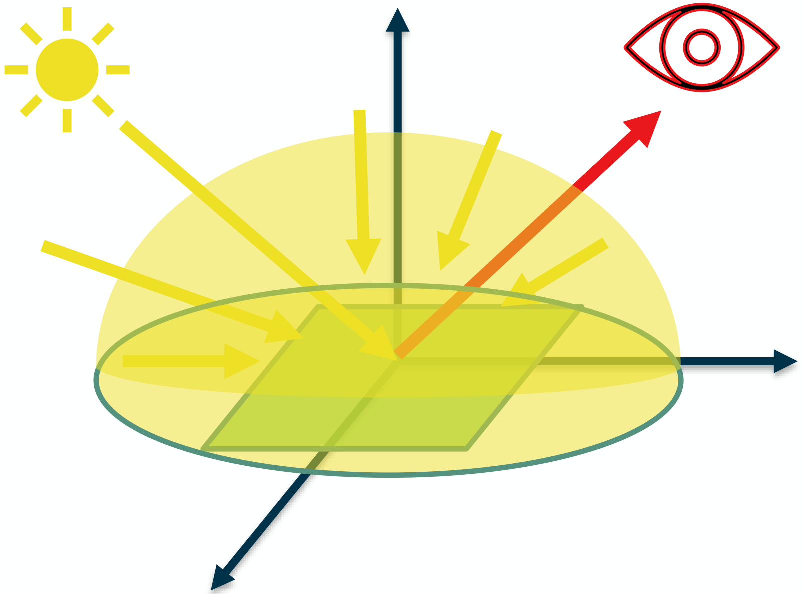


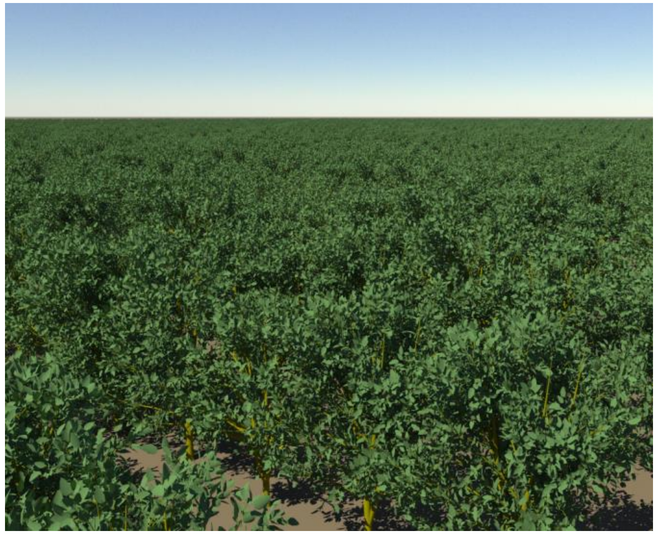




The Bidirectional Reflectance Factor **black sky surface reflectance** cannot be directly observed in the field because of the unavoidable contribution of sky radiation

A bit of theory

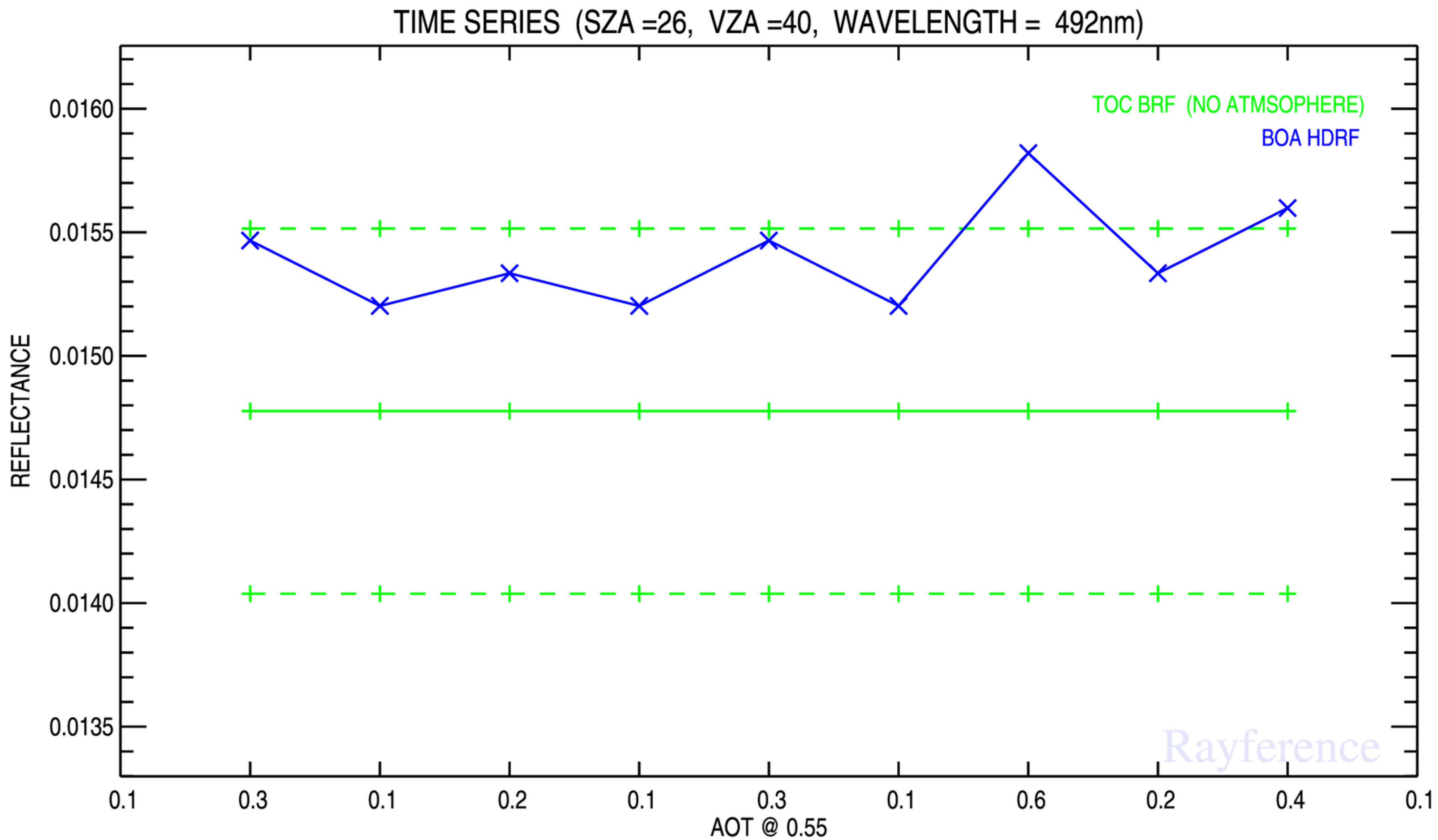




Only the so-called **H**emispherical **D**irectional **R**eflectance **F**actor at the Bottom-of-Atmosphere (**BOA HDRF**) can be observed directly in the field;

HDRF depends on the state of the atmosphere (illumination conditions). It is referred to as the **blue sky surface reflectance**.

HDRF time series



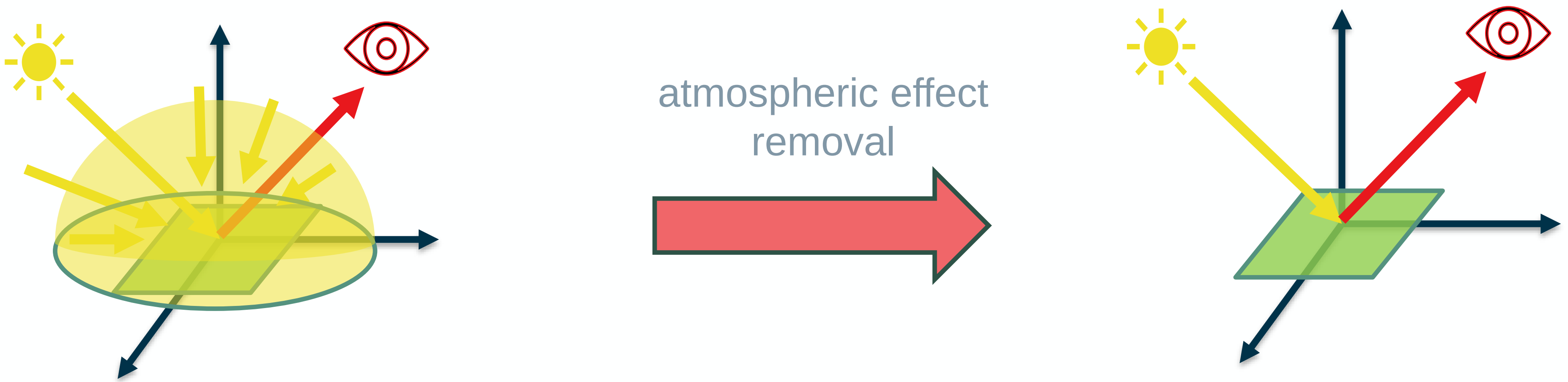
Blue sky reflectance

Black sky reflectance

All parameters are invariant except the AOT

Objective

Elaborate a protocol to validate the retrieval of **black sky surface reflectance** from **blue sky surface reflectance**



Based on:

1. The use of an artificial target of ***known BRF value***
2. The acquisition of HCRF (blue sky reflectance) over that target
3. The use of a rigorous method to remove atmospheric effects

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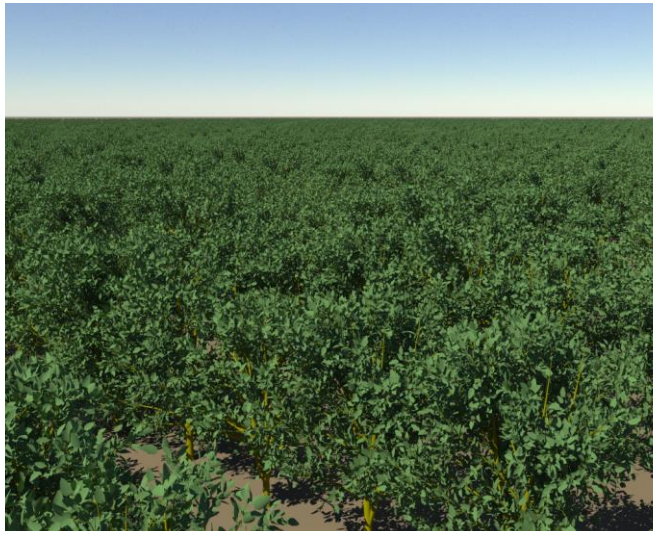
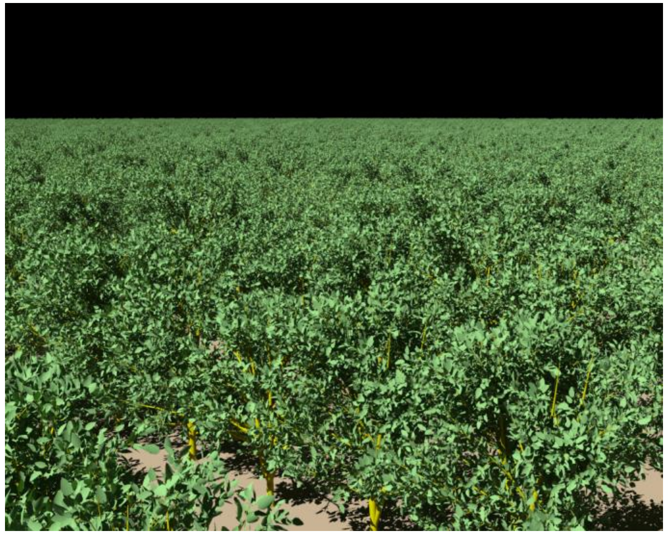


atmospheric effect removal



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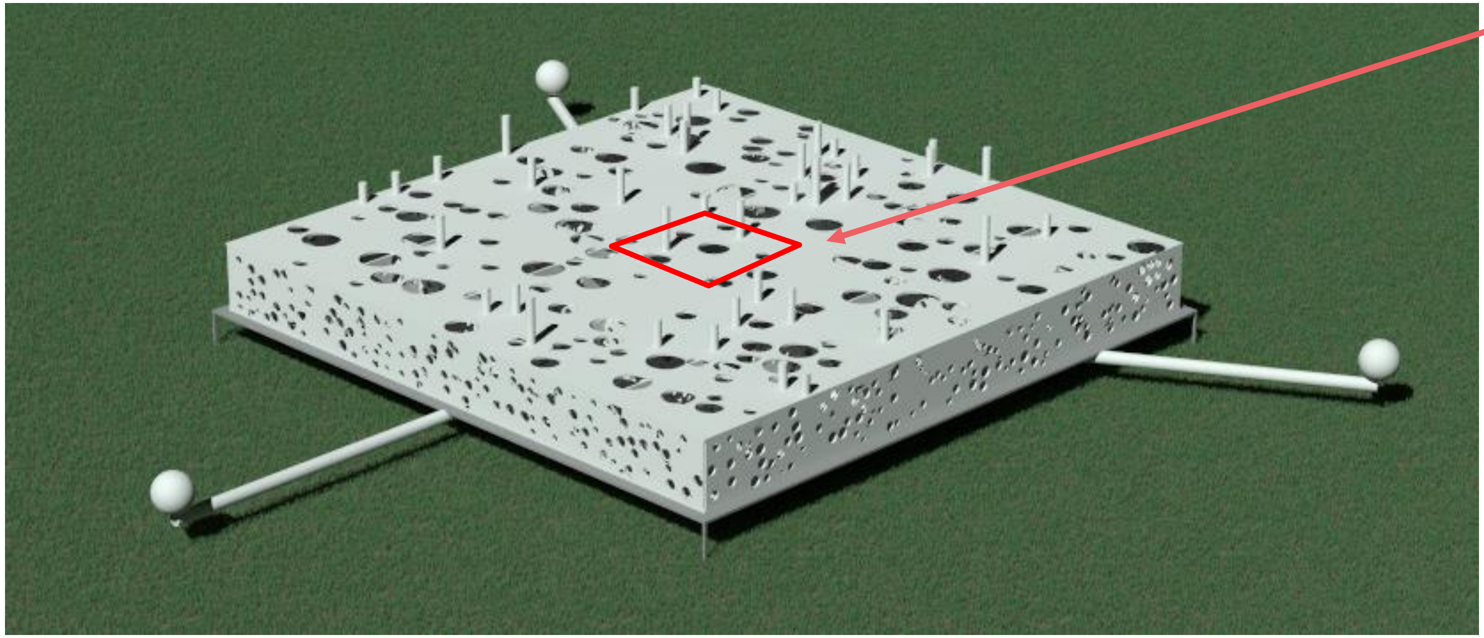
Artificial target design to validate open-air BRF retrieval

Target design requirements

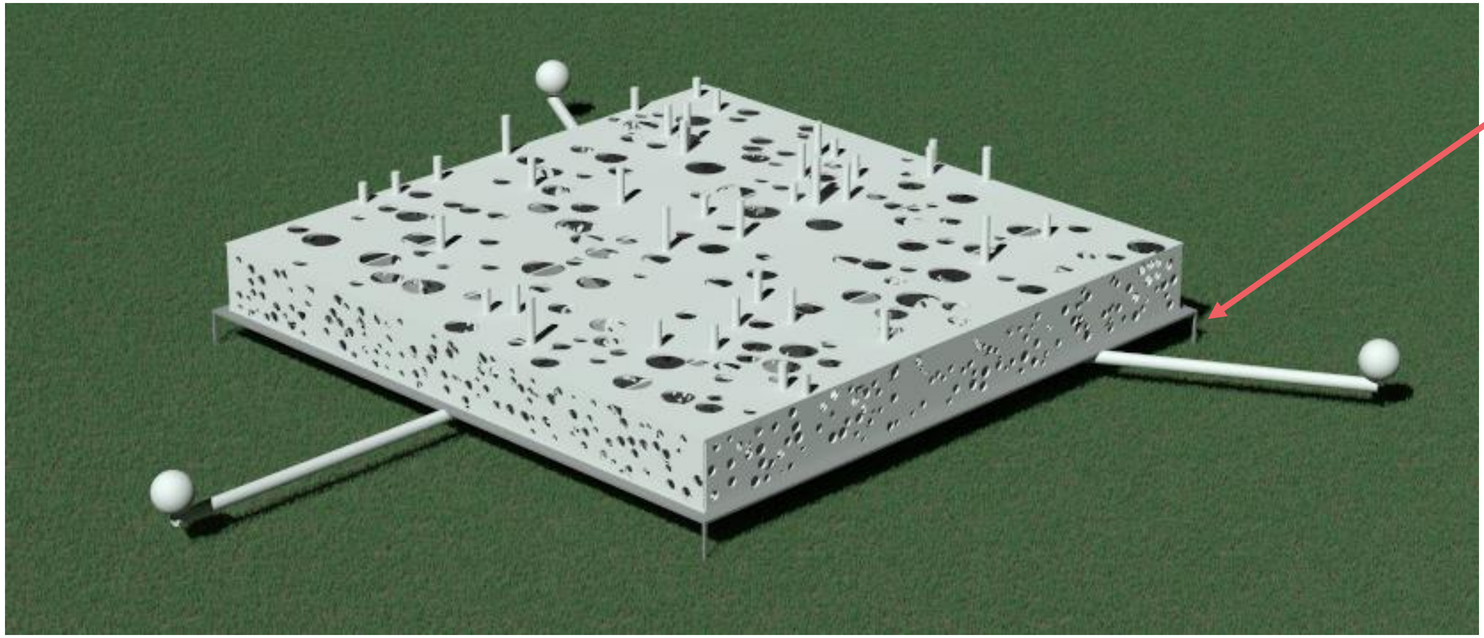
- Design of an artificial target with a controlled BRF shape mimicking the one of homogeneous vegetated surface;
- Simple design to ease its 3D simulation and manufacturing process;
- Use of material with a reflectance close to Lambertian surface;
- Transportable in the field.

Target design

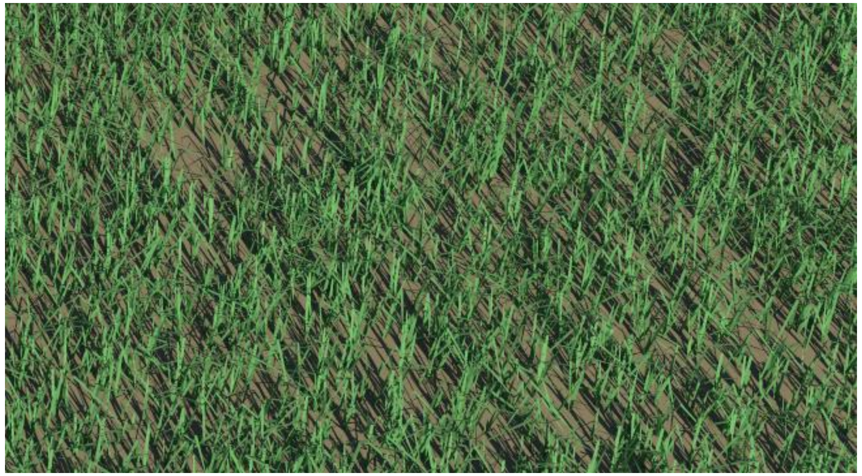


5 x 5 m target with an effective area of 1 x 1 m to minimise the effects due to its finite size.

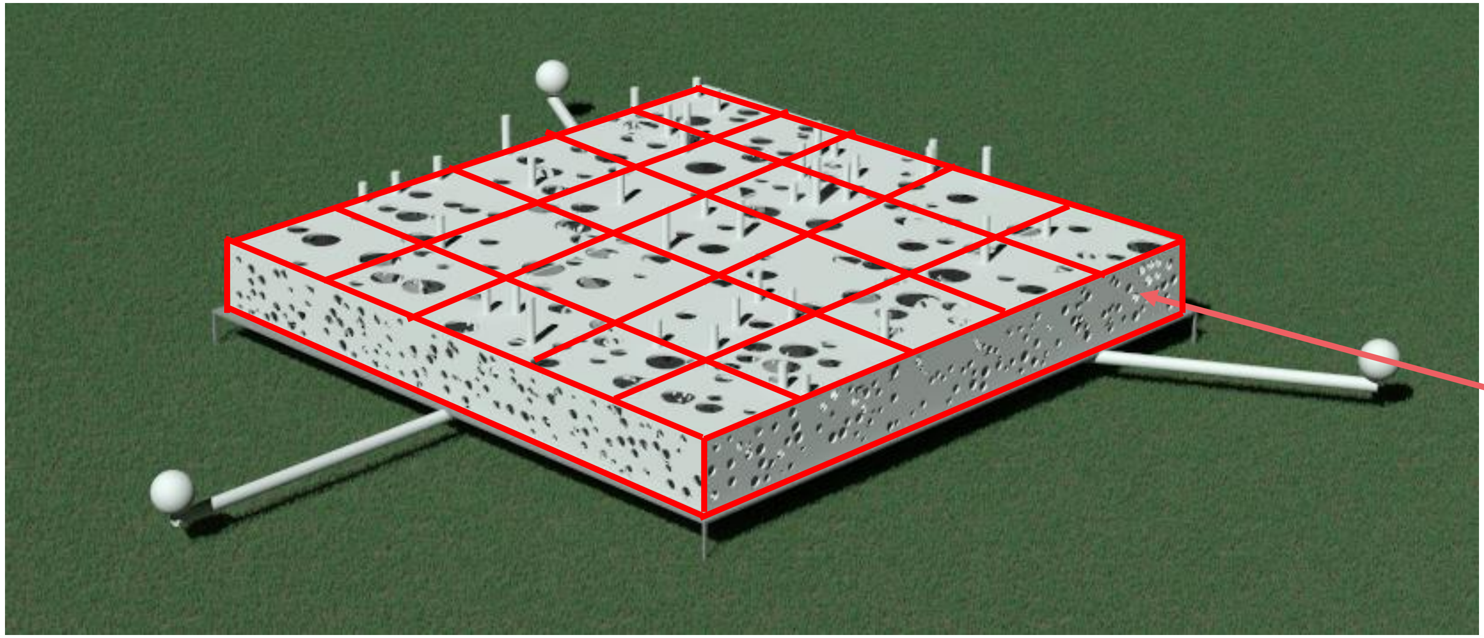
Target design



It includes a **mounting table** that allows to deploy the target in the field with controlled levelness.



Target design

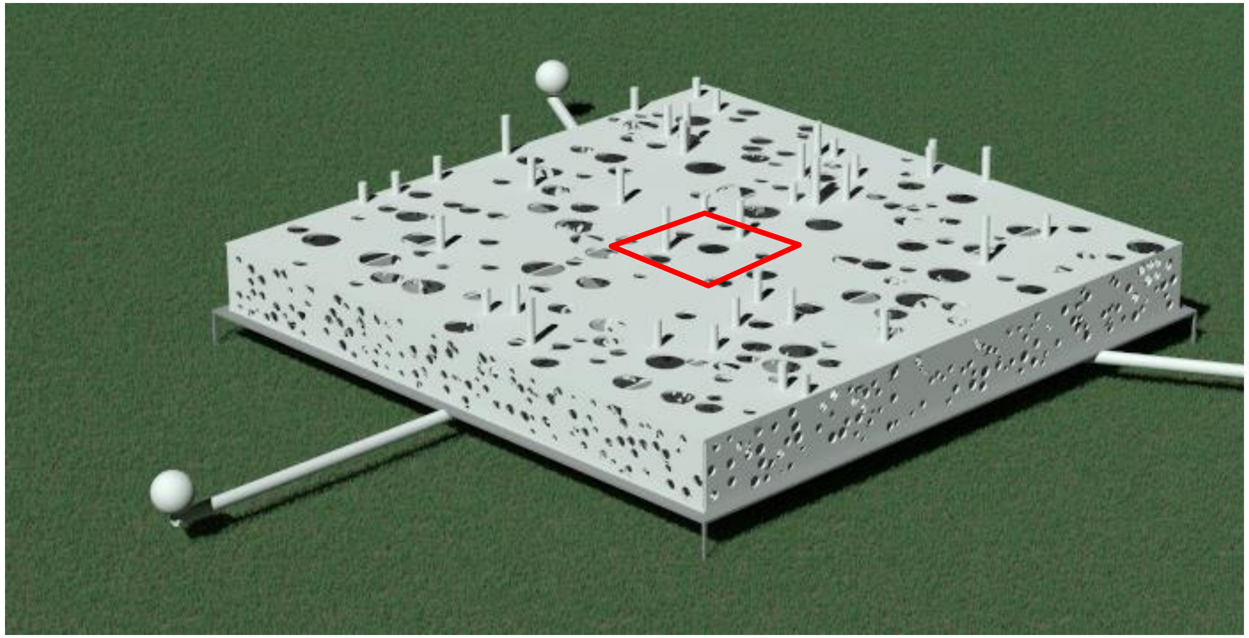


It is composed of

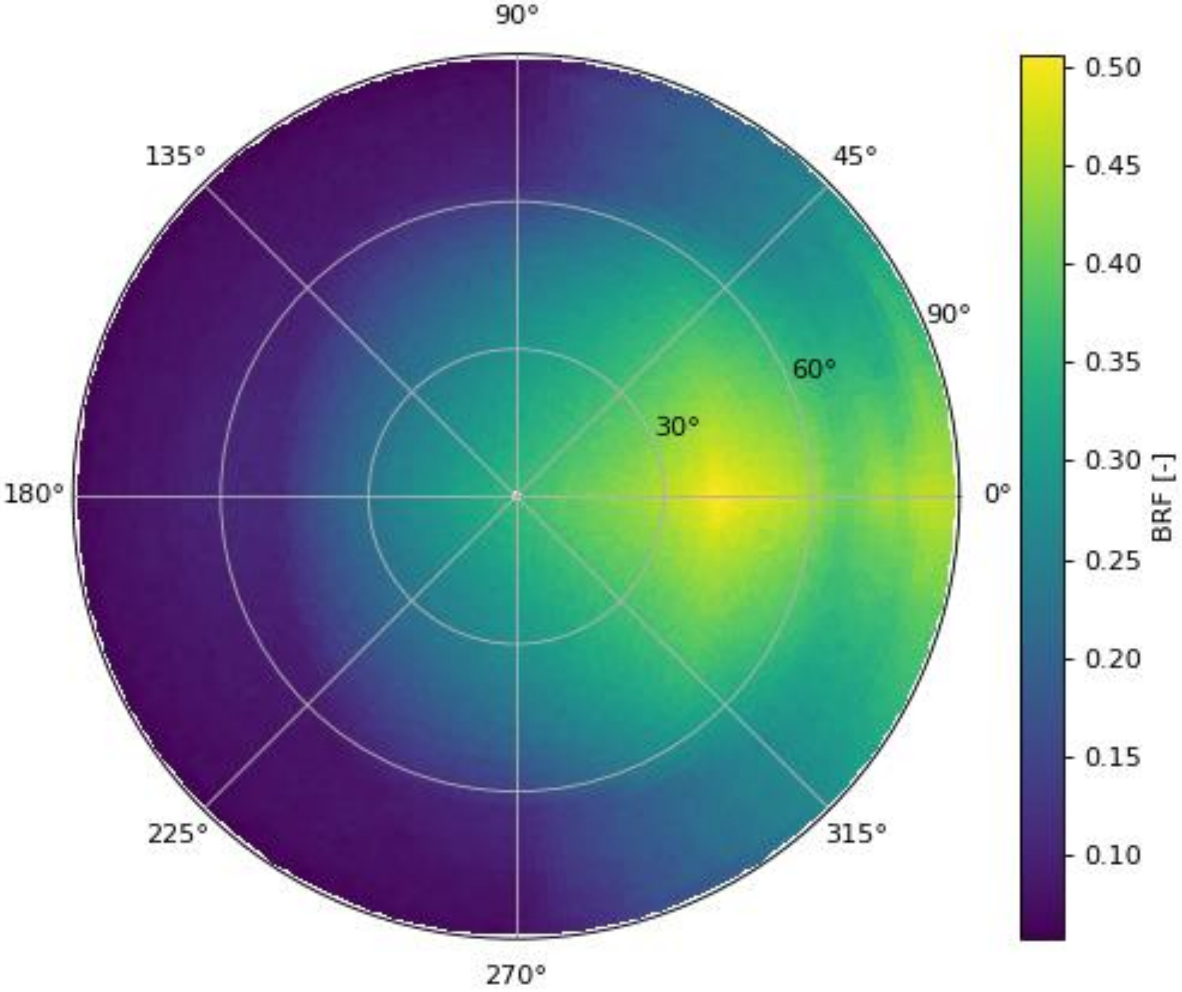
- perforated vertical panels distant of 1m responsible for multiple scattering within the target.
- Vertical poles that cast shadow.

These two elements allow to control the shape of the target BRF.

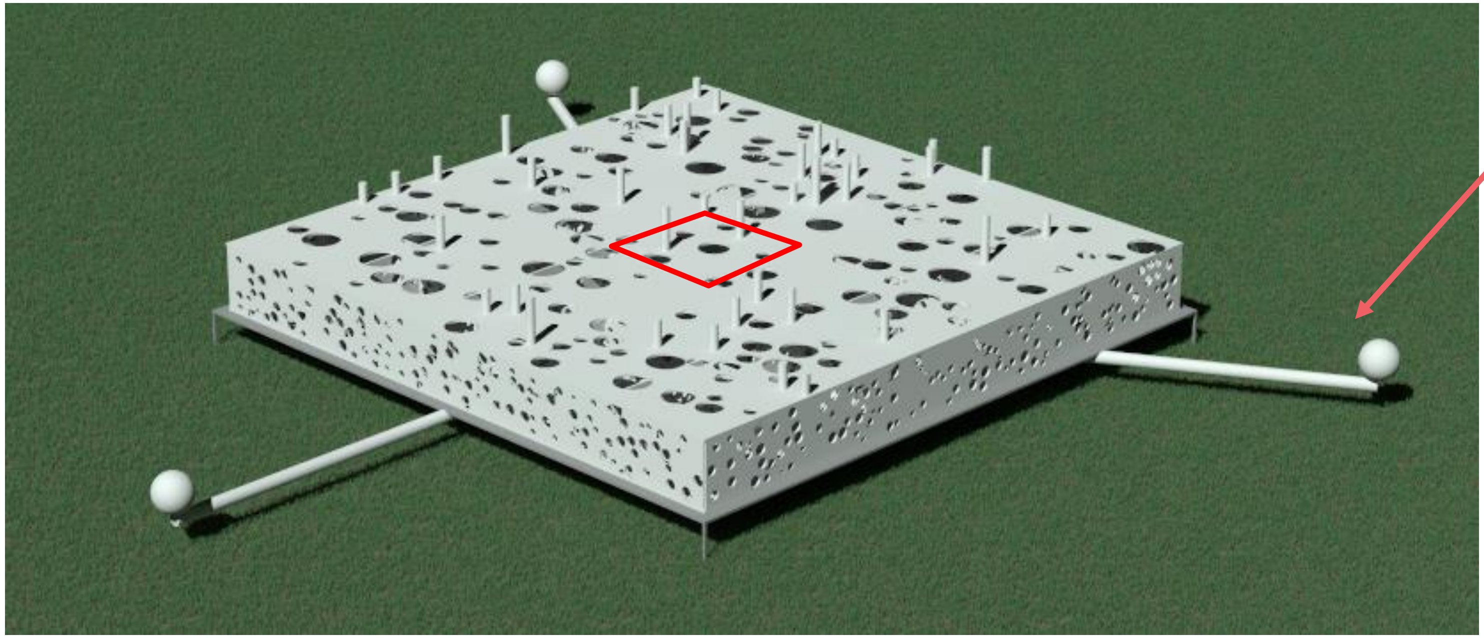
Target design



Black sky surface reflectance



UAV HDRF acquisition



It includes three harms supporting spheres to ease the UAV image navigation for the FOV cropping.

How accurately can the artificial target BRF be simulated?

Verification with a target in a SI-traceable goniometer

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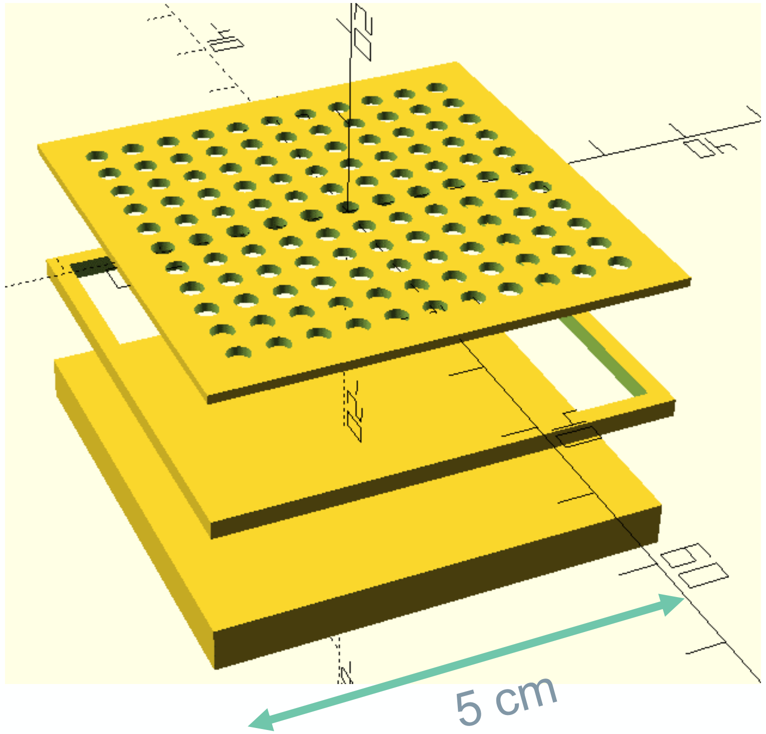
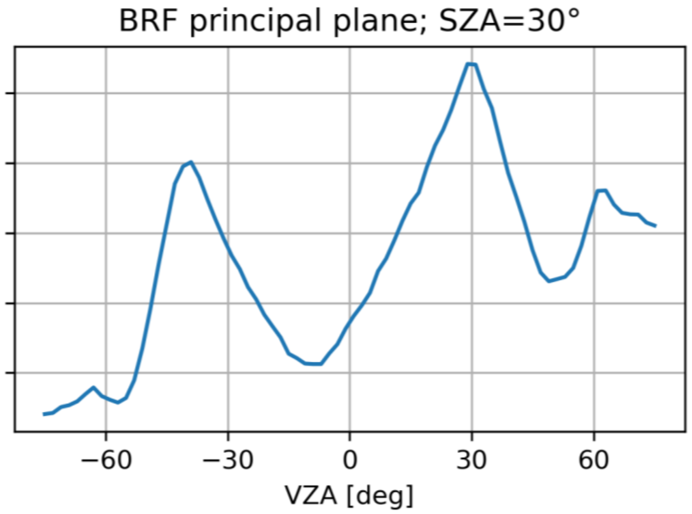
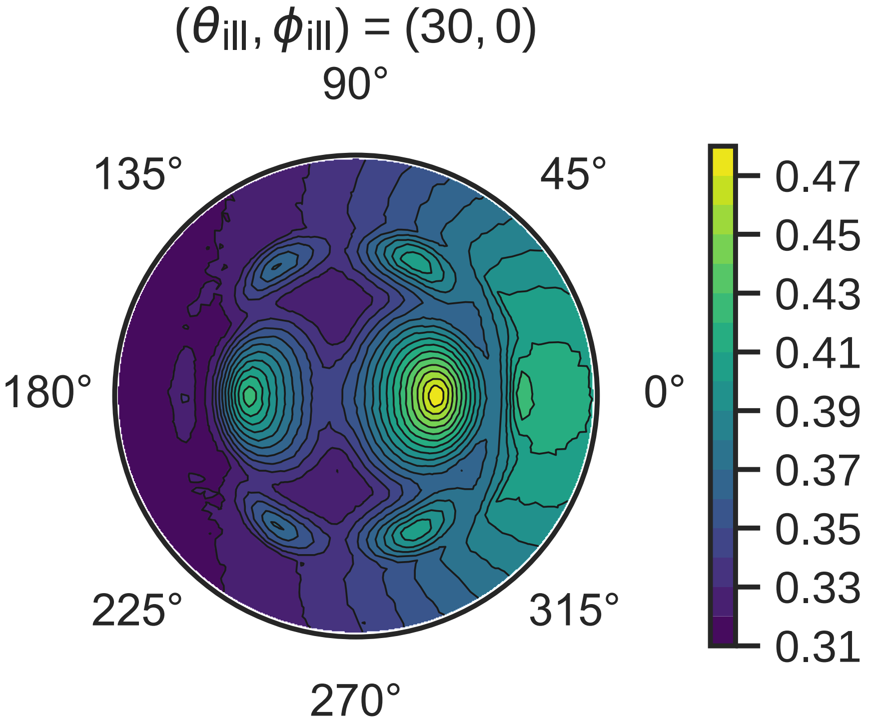
Simulated reflectance







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Manufactured samples

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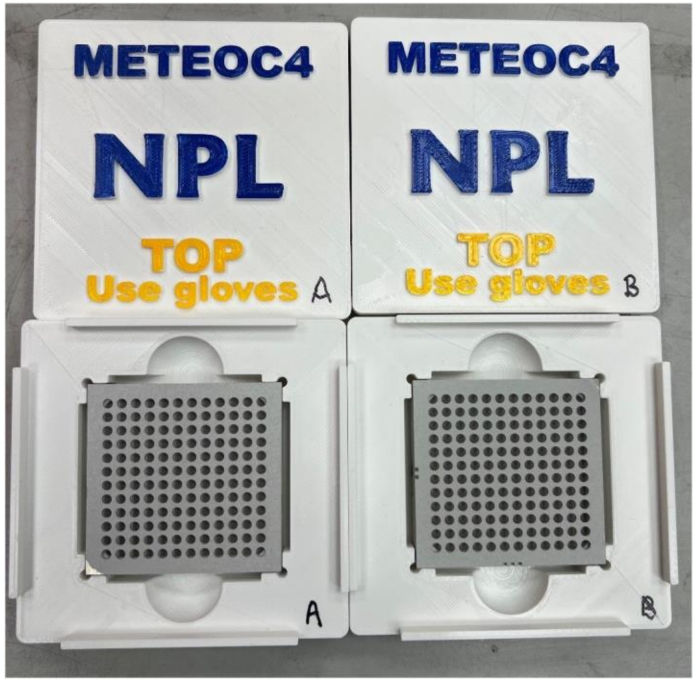

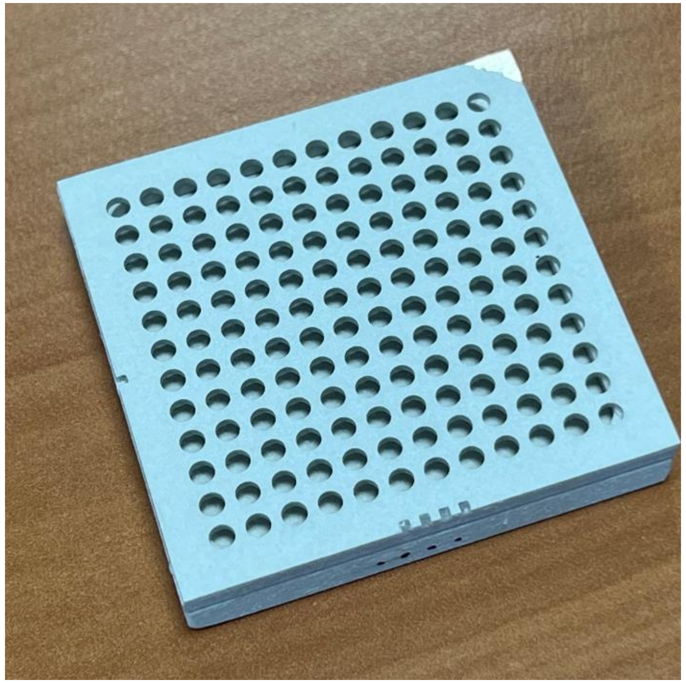

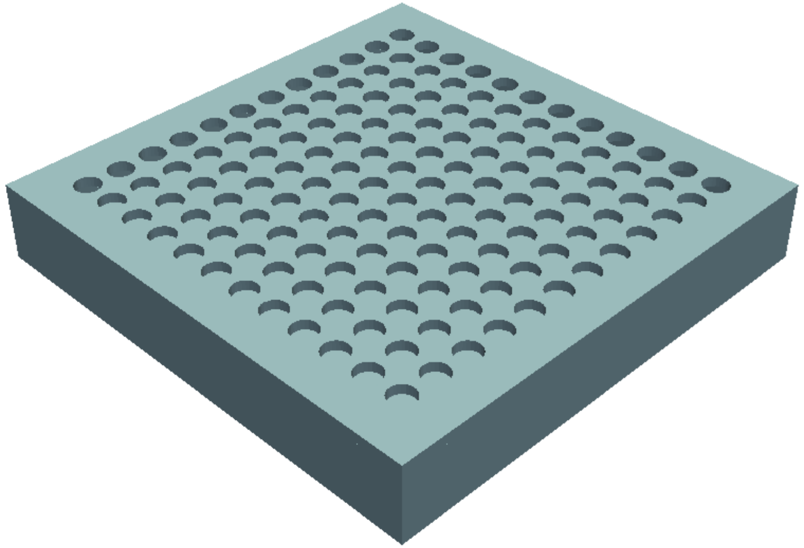

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Si traceable goniometer measurement

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Simulated components

Light source (collimated beam)

Sensor (single-pixel radiometer)

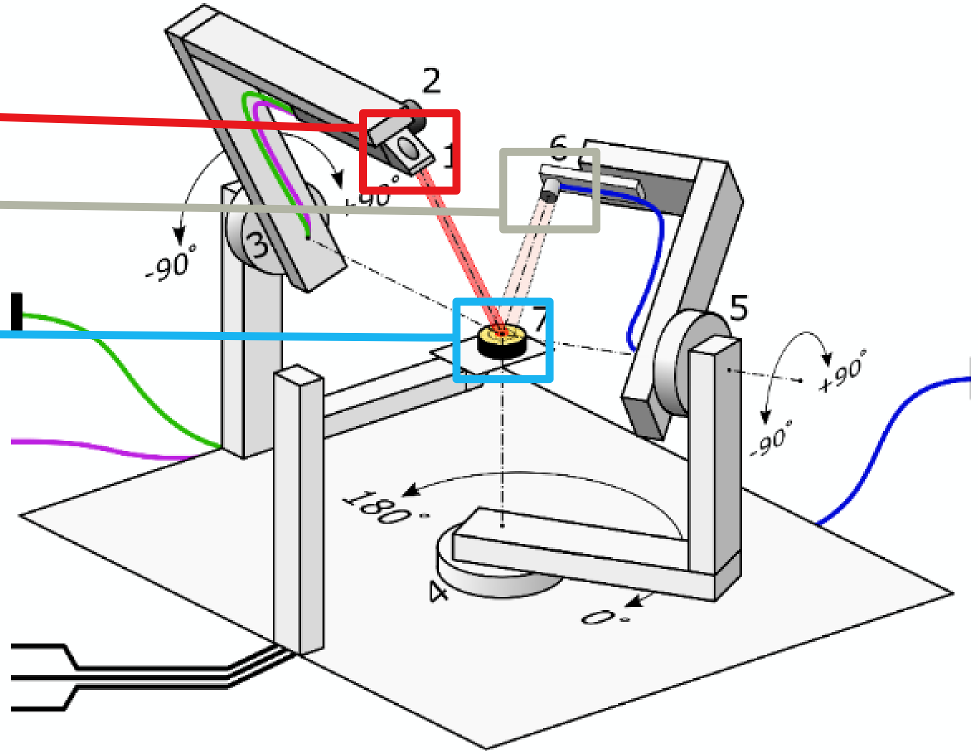
Artefact model (triangulated mesh) and BRDF (measured data table)

BRDF model

Direct usage of measured data

Linear interpolation in table

⇒ No model fitting, but sparse data



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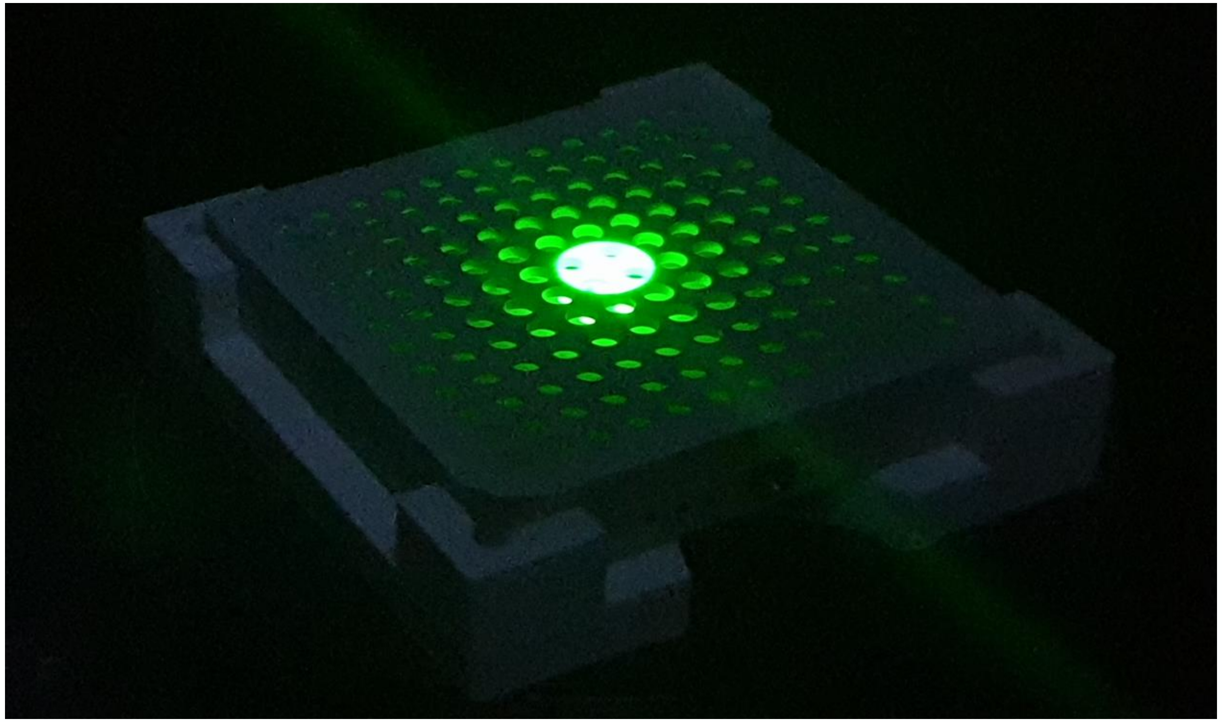
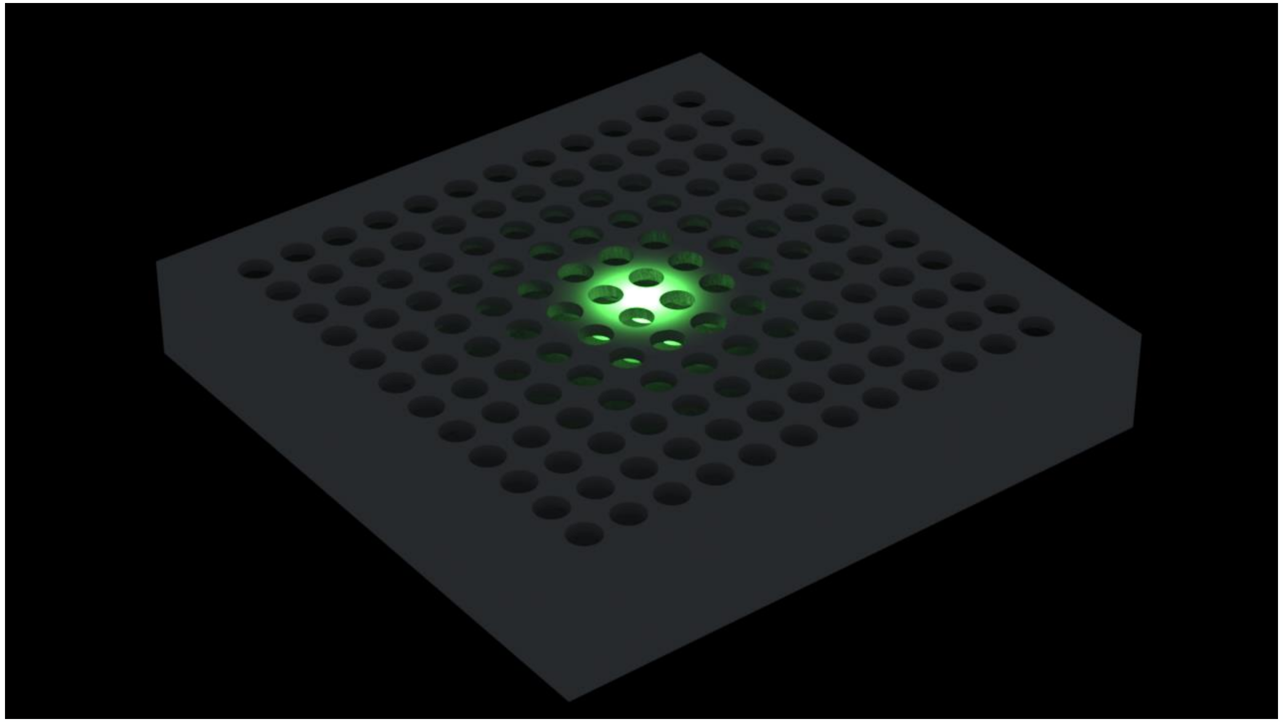
Si traceable goniometer measurement

Illumination beam at 500nm

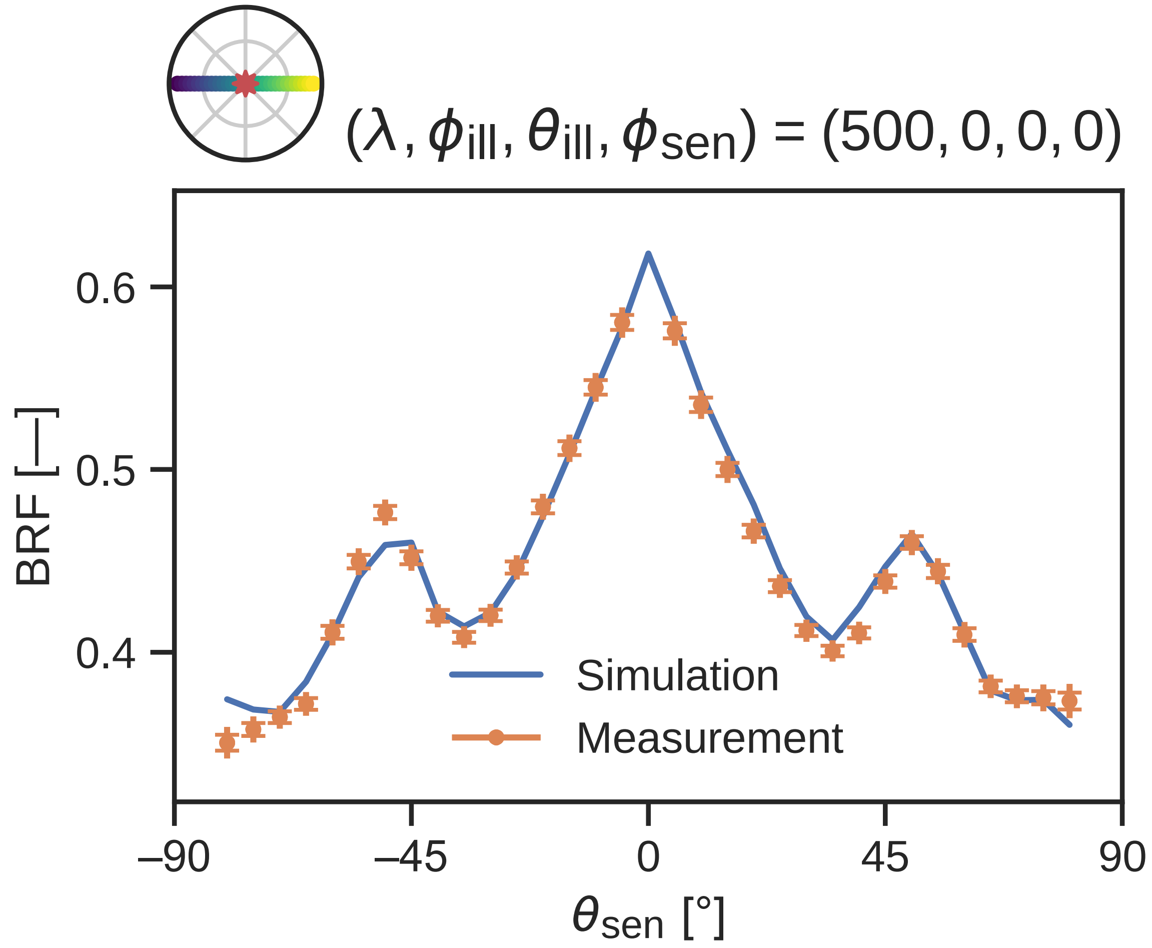
RGB picture

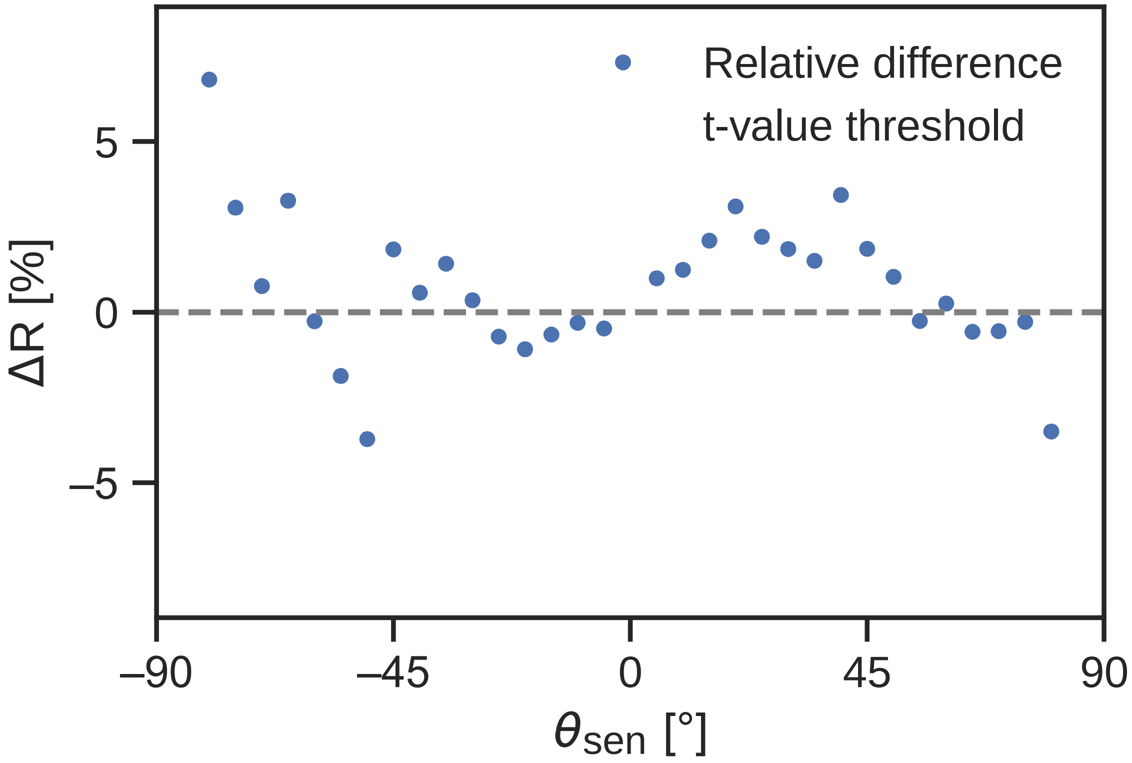
Eradiate





Comparison between simulation and observation





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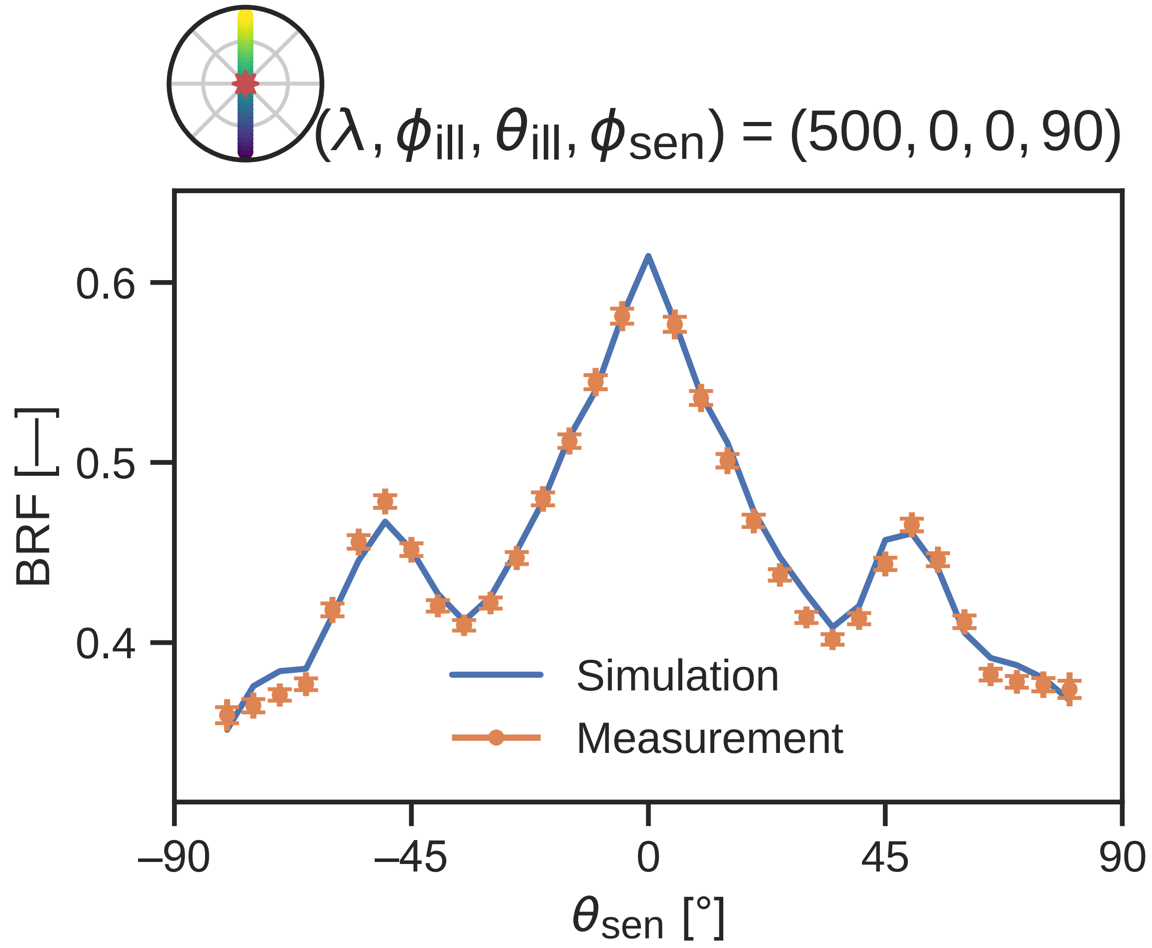

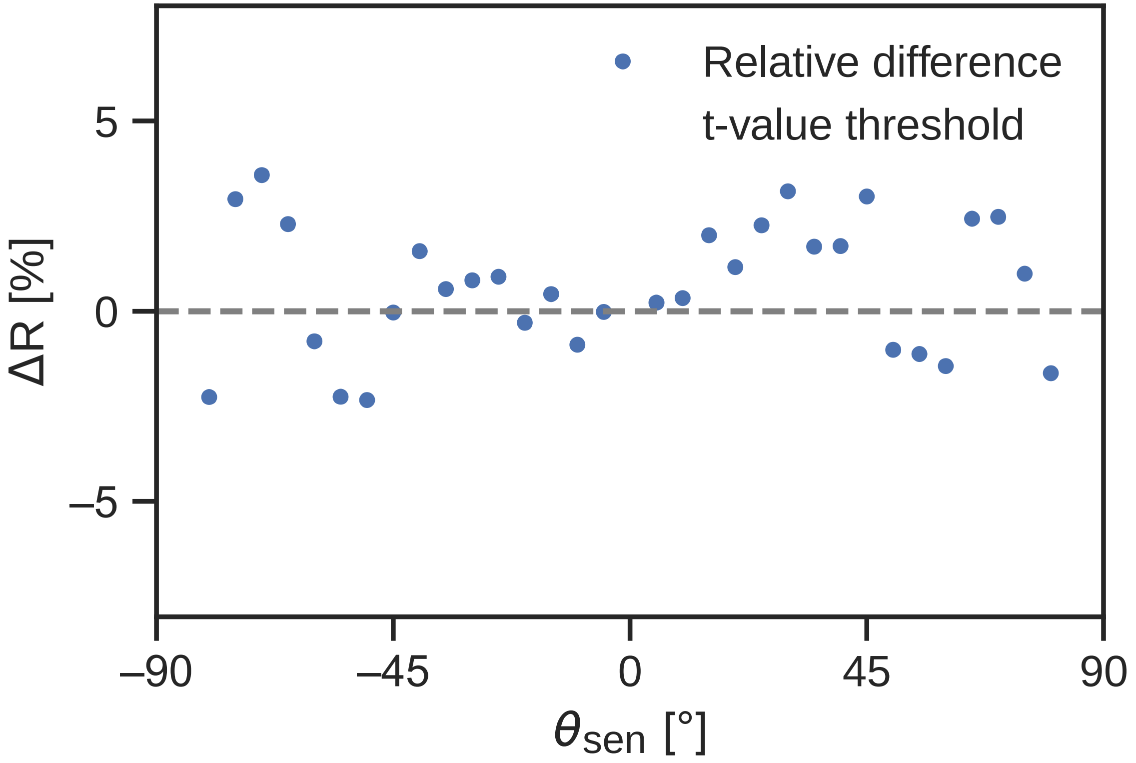

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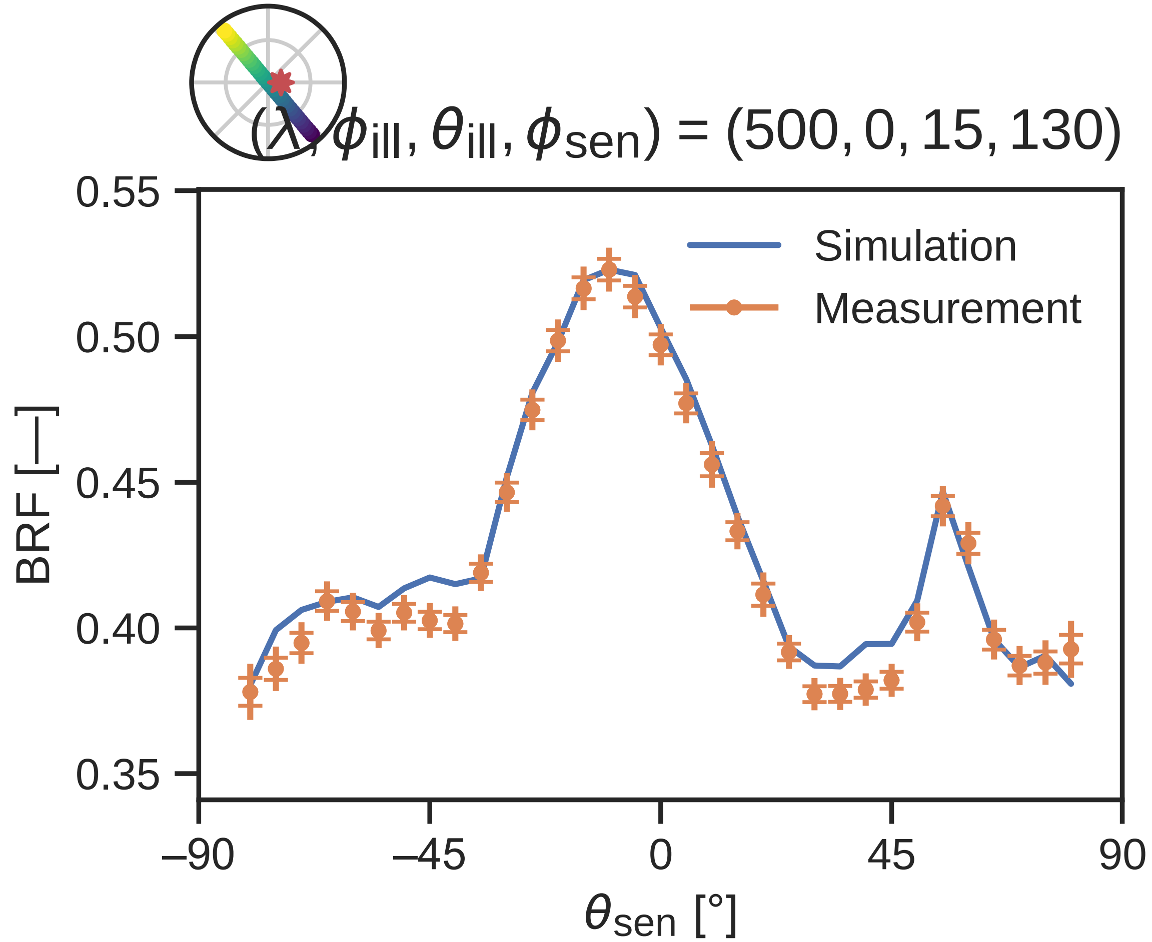
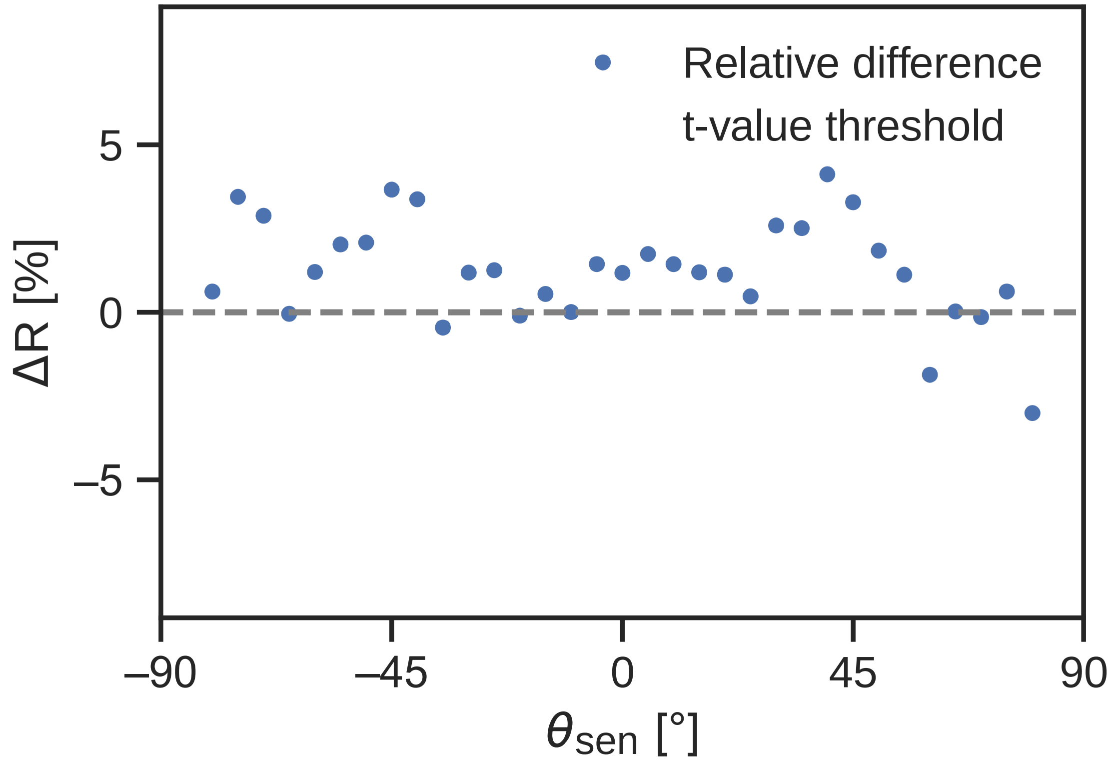
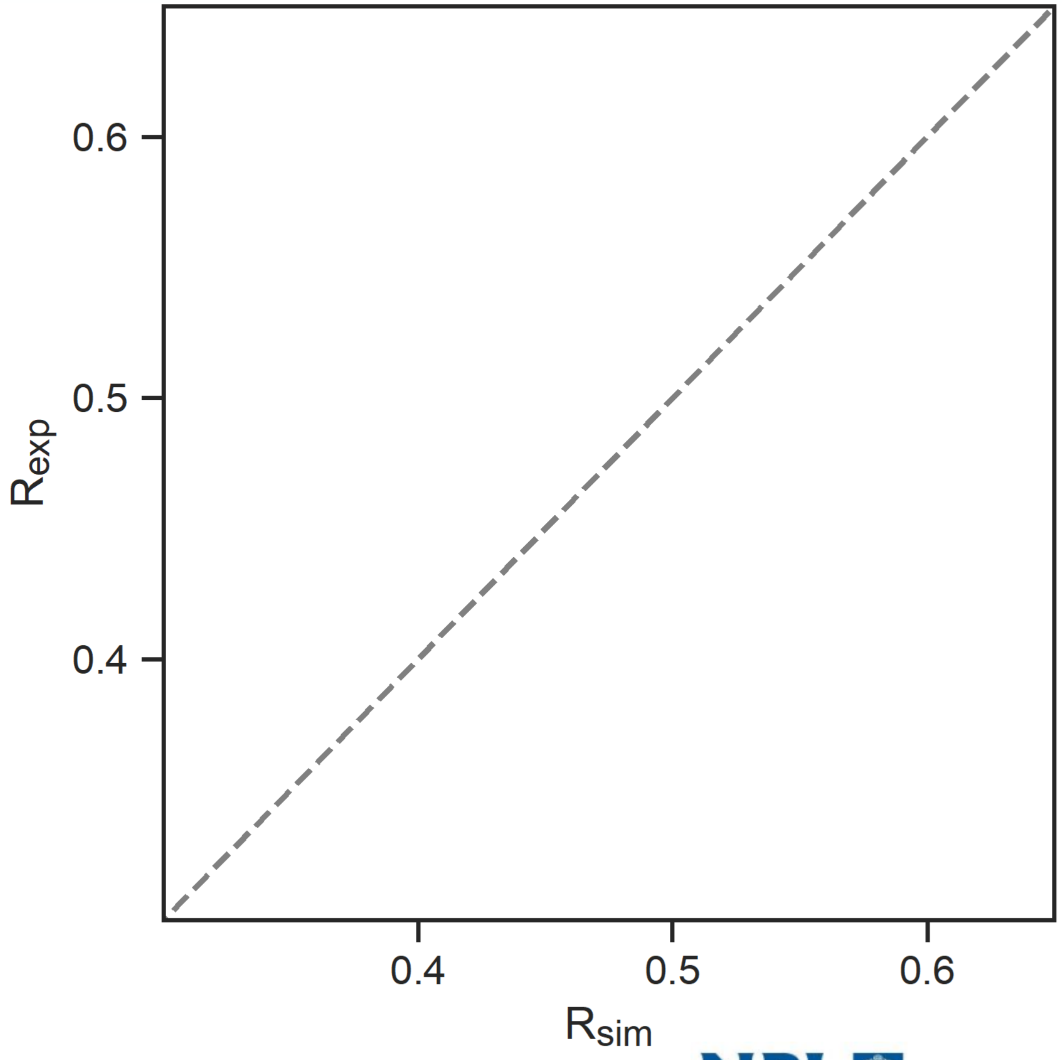
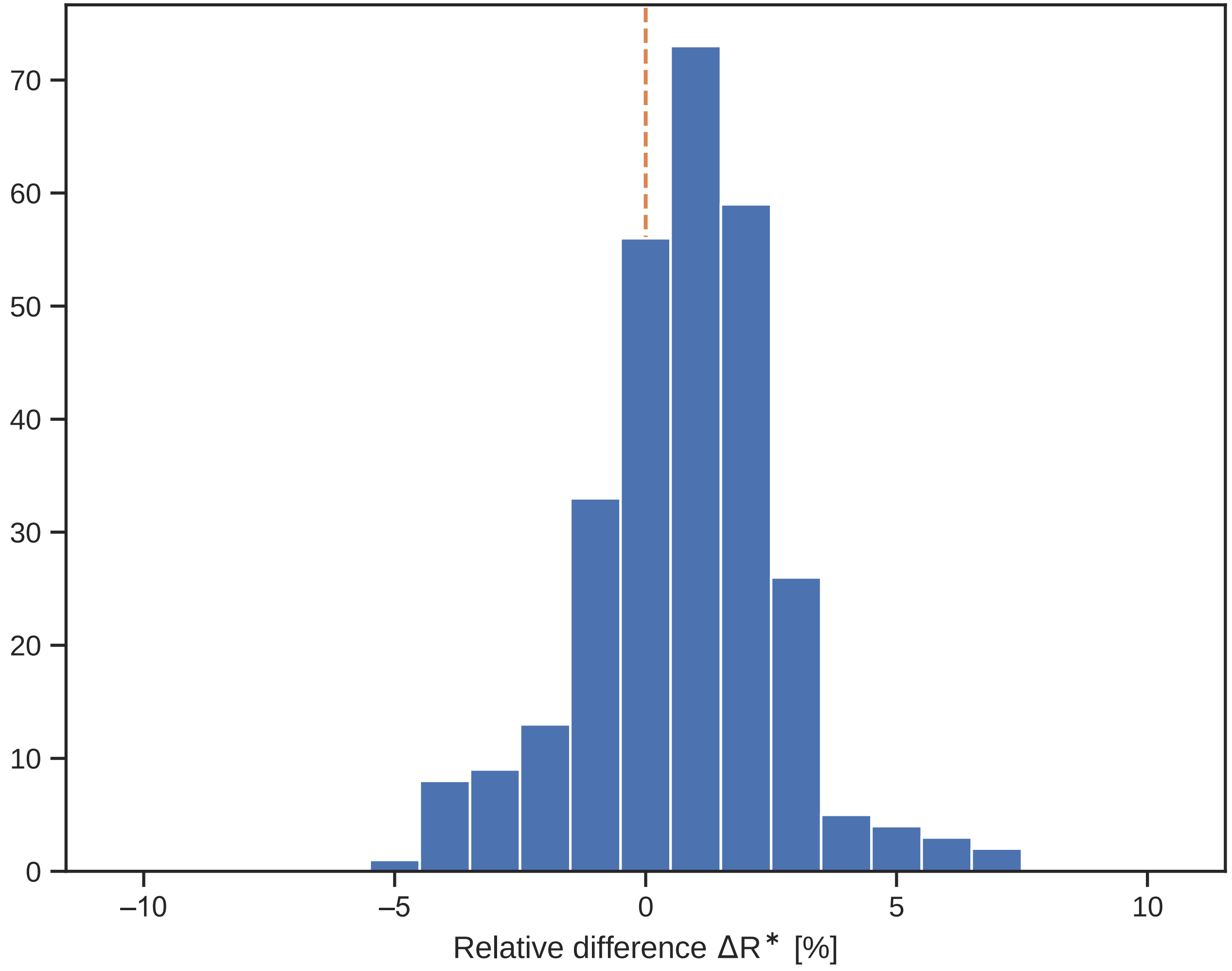




Overall comparison results





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Messages to take home

- A protocol is proposed to validate open-air BRF (**black sky surface reflectance**) retrieval from HCRF (**blue sky surface reflectance**) observations.

- It is based on the use of a 5 x 5 m artificial target with 3D simulated BRF values (Eradiate).

- Goniometer measurements have demonstrated that this approach is accurate within less than 1 % and precise within 2.5%

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All the simulations are performed with the Eradiate 3D RTM freely available at www.eradiate.eu

ERADIATE