NeRF with Optical Satellite Images

(NeRF: Neural Radiance Fields)

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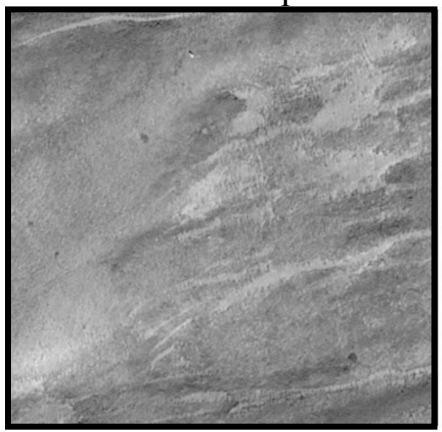
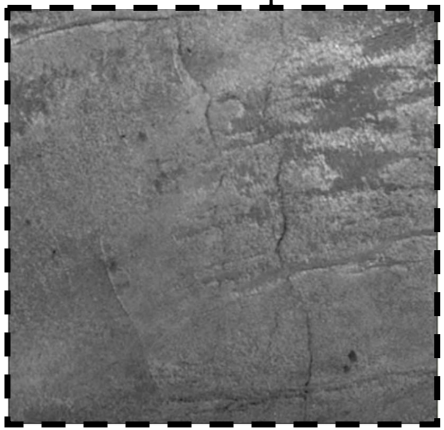
In collaboration with: Stéphane Jacquemoud (IPGP)

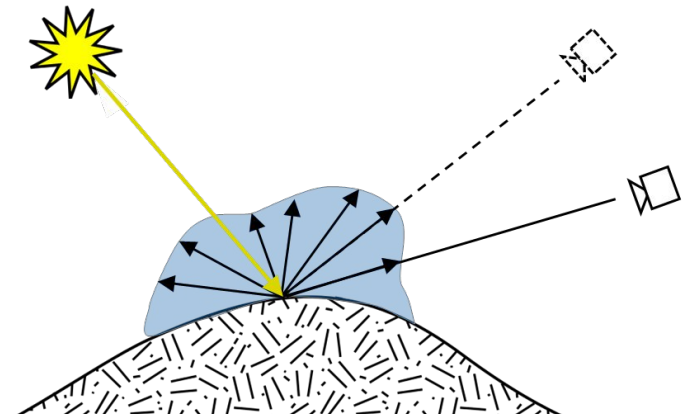
Context

before earthquake



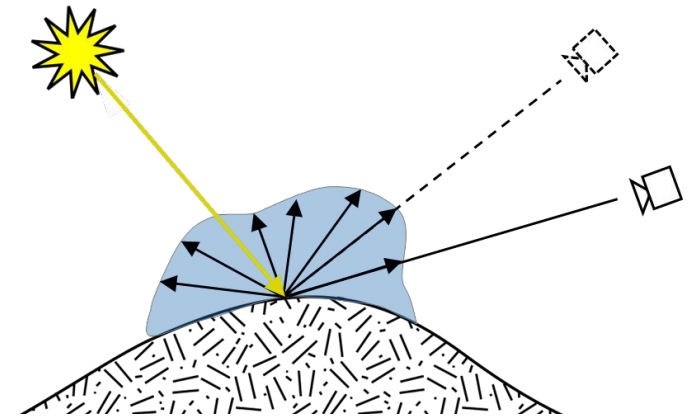
after earthquake



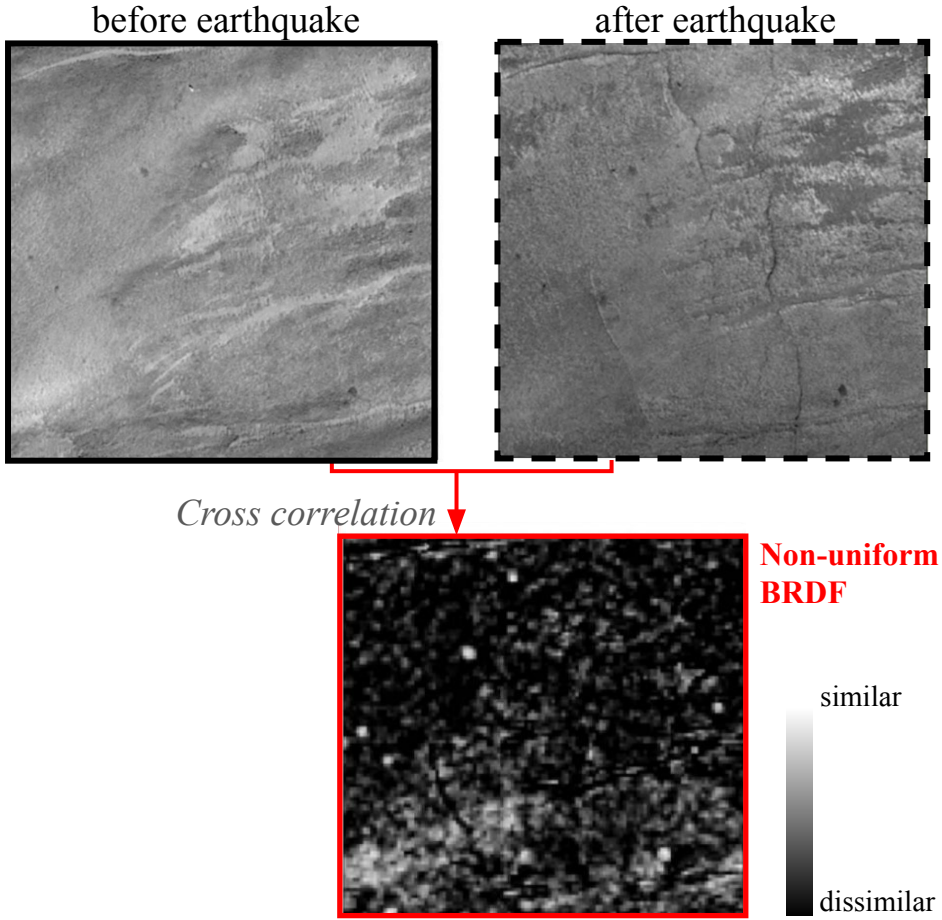


BRDF: Bi-directional Reflectance Distribution Function

Context

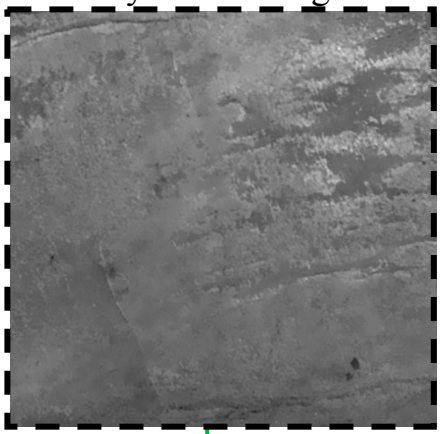


BRDF: Bi-directional Reflectance Distribution Function

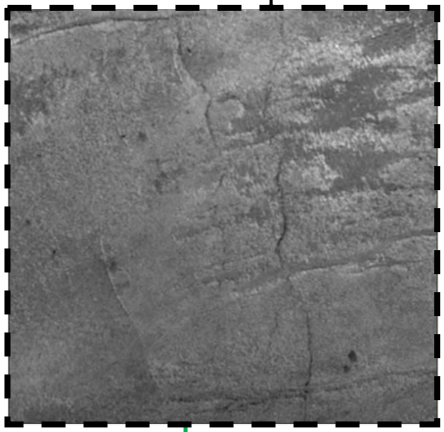


Context

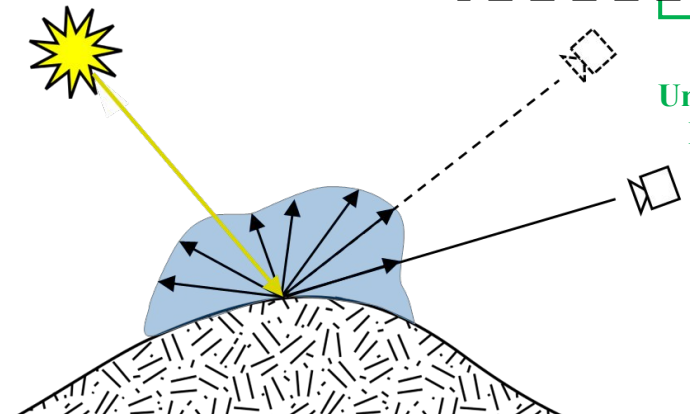
Synthetic image



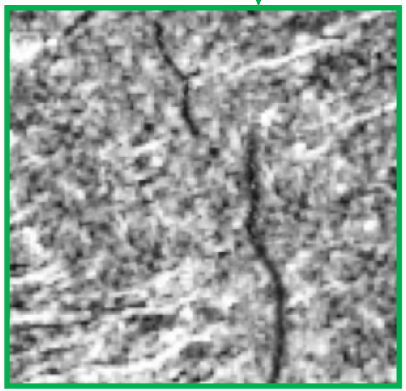
after earthquake



Cross correlation



Uniform BRDF



similar

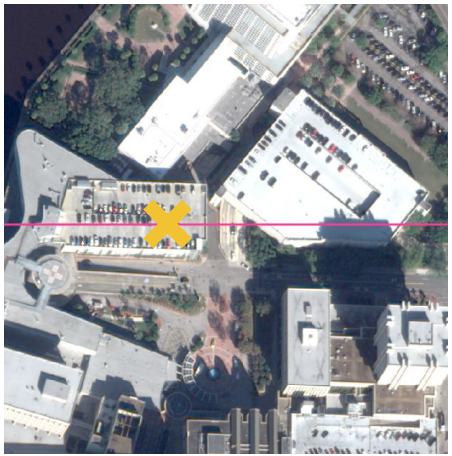
dissimilar

BRDF: Bi-directional Reflectance Distribution Function

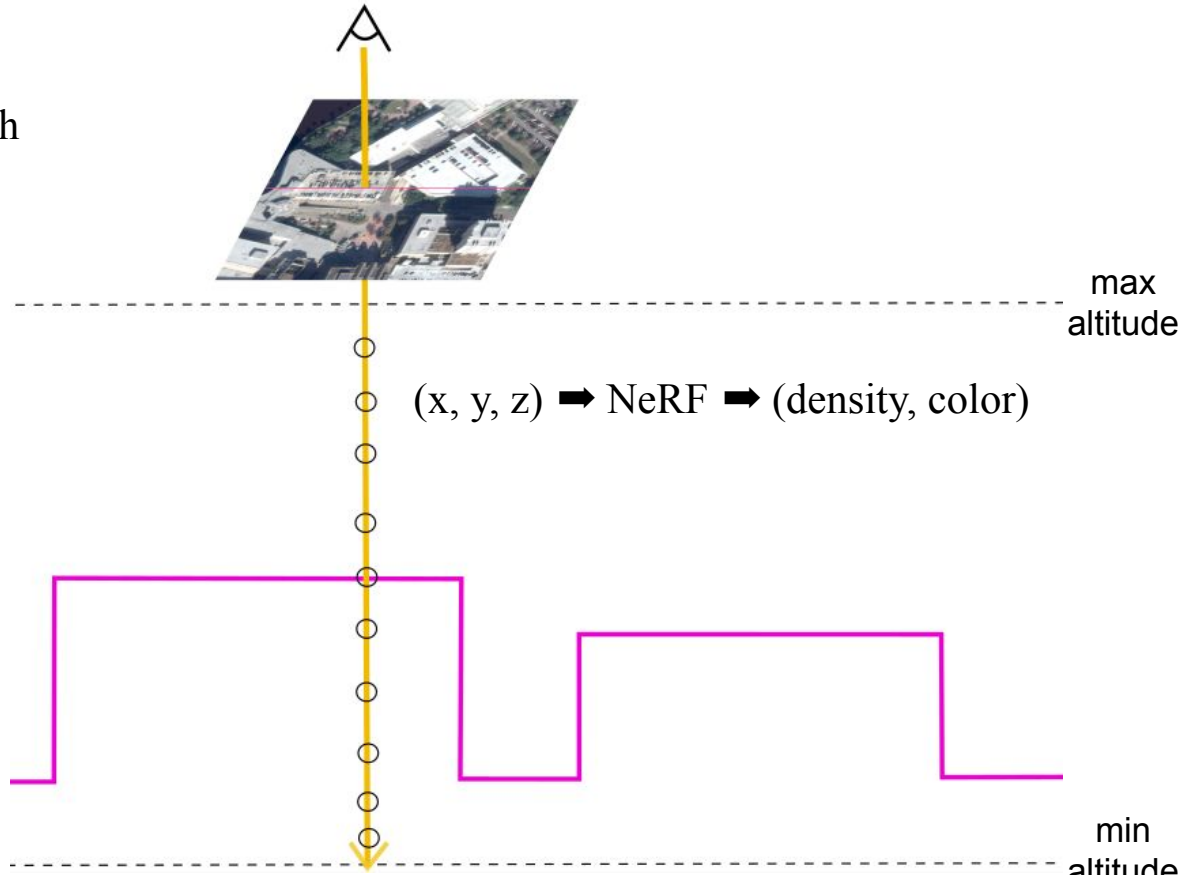
NeRF (Neural Radiance Fields)

NeRF:

- Deep learning.
- Treat the scene as a volume with density and color.
- Lots of variants.



(a) A selected image row (–)

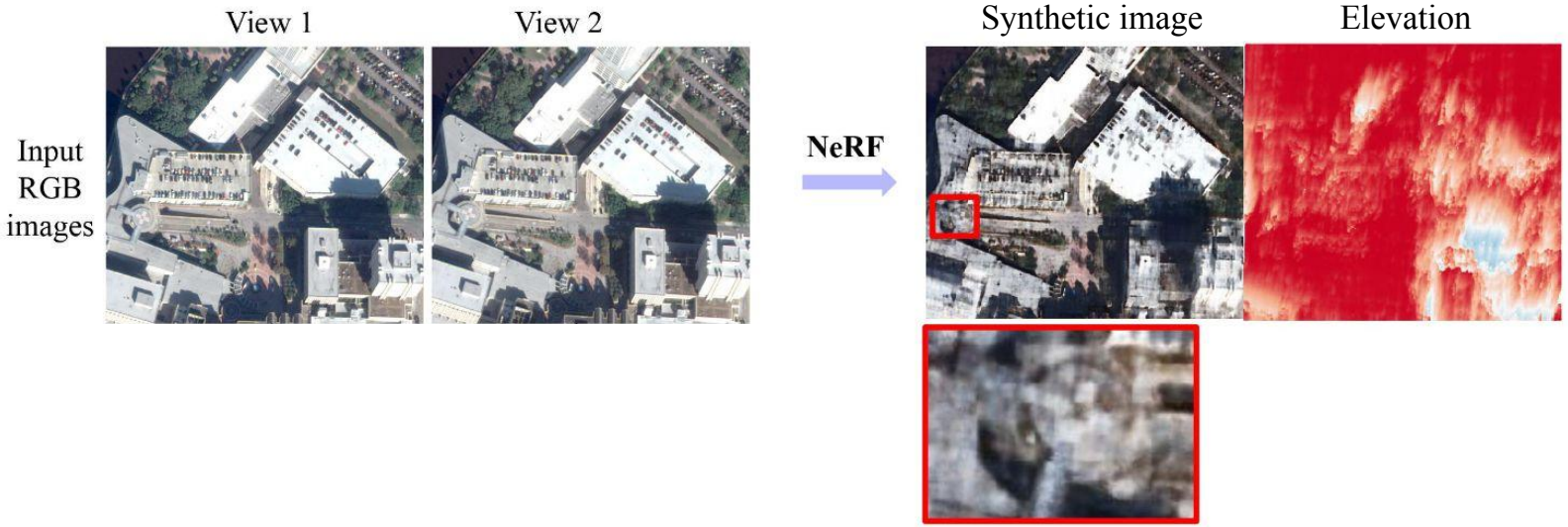


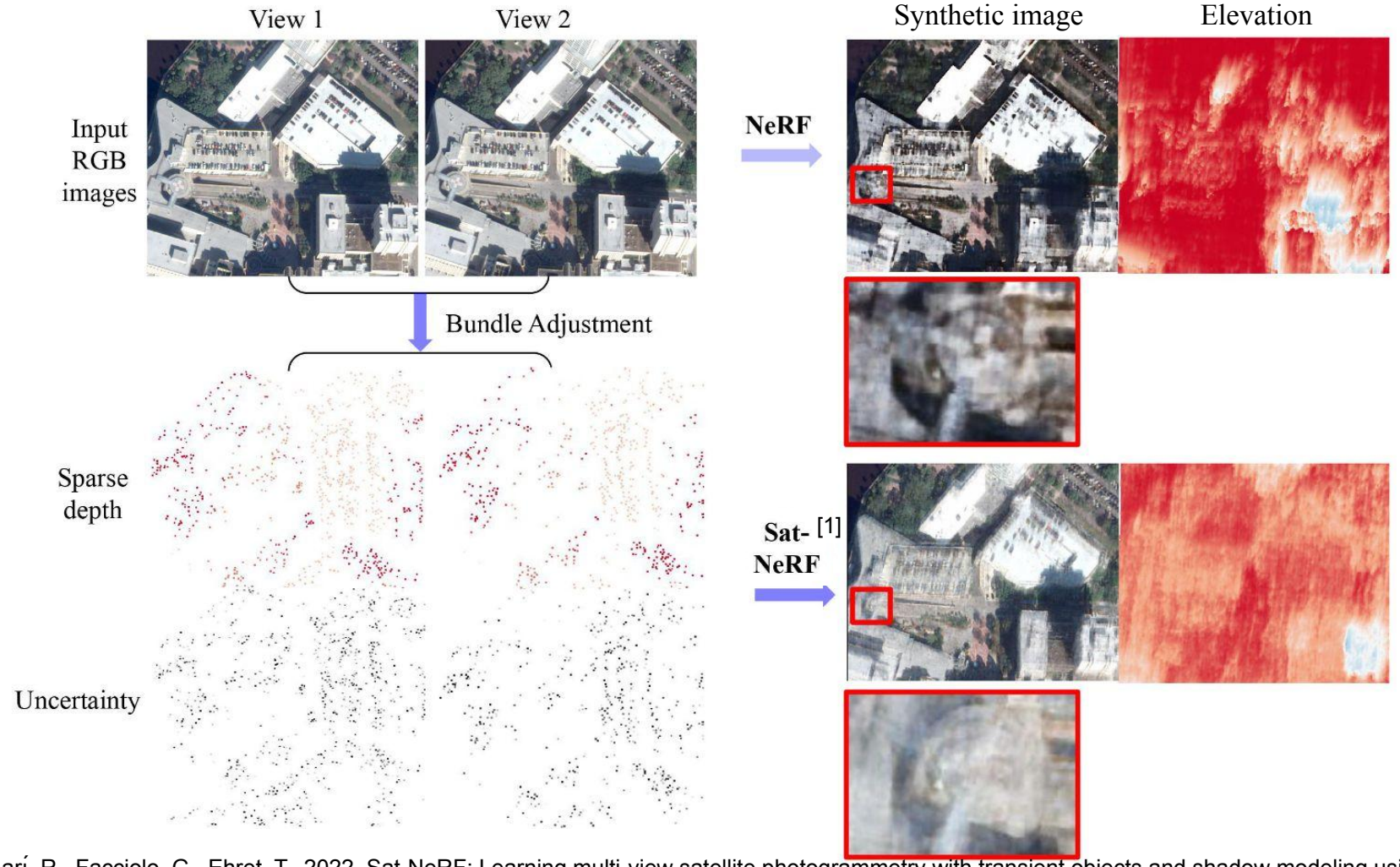
(b) cross section

Challenges

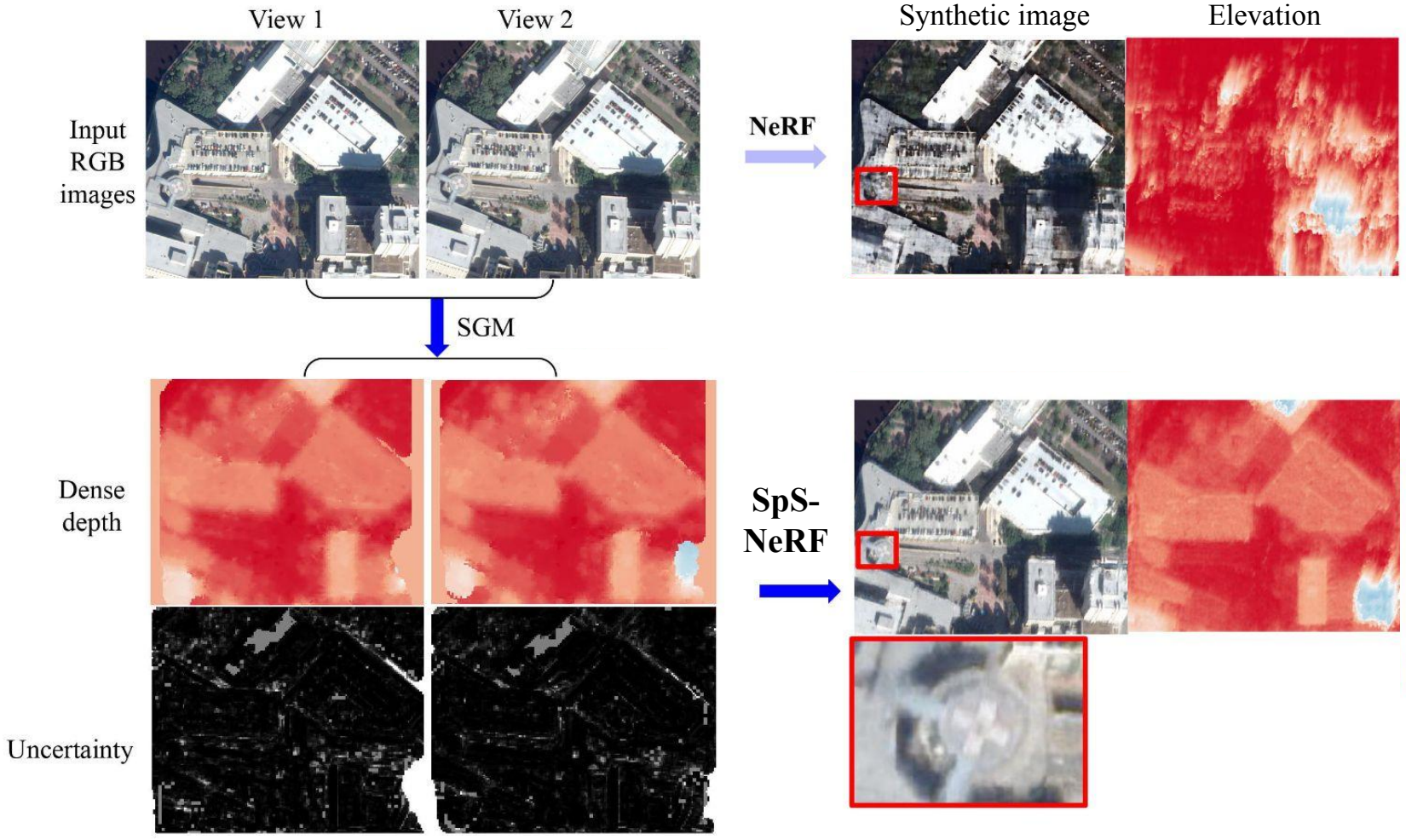
Two big challenges in our work:

1. Sparse input images

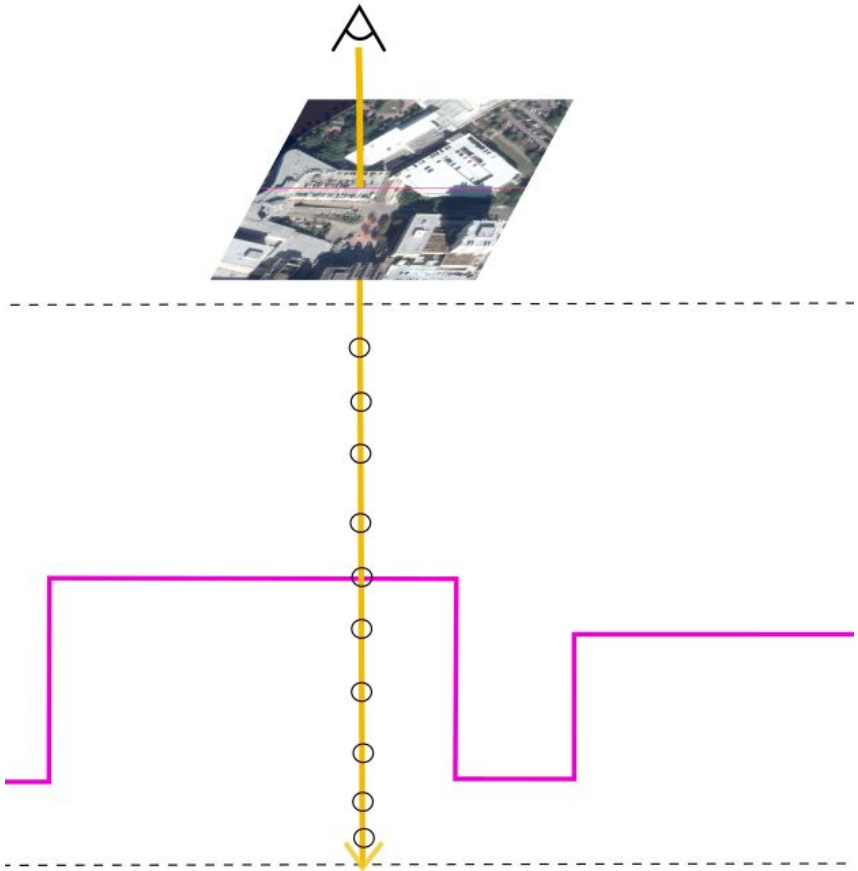

View 1
View 2
Synthetic image
Elevation
Input
RGB
images
NeRF



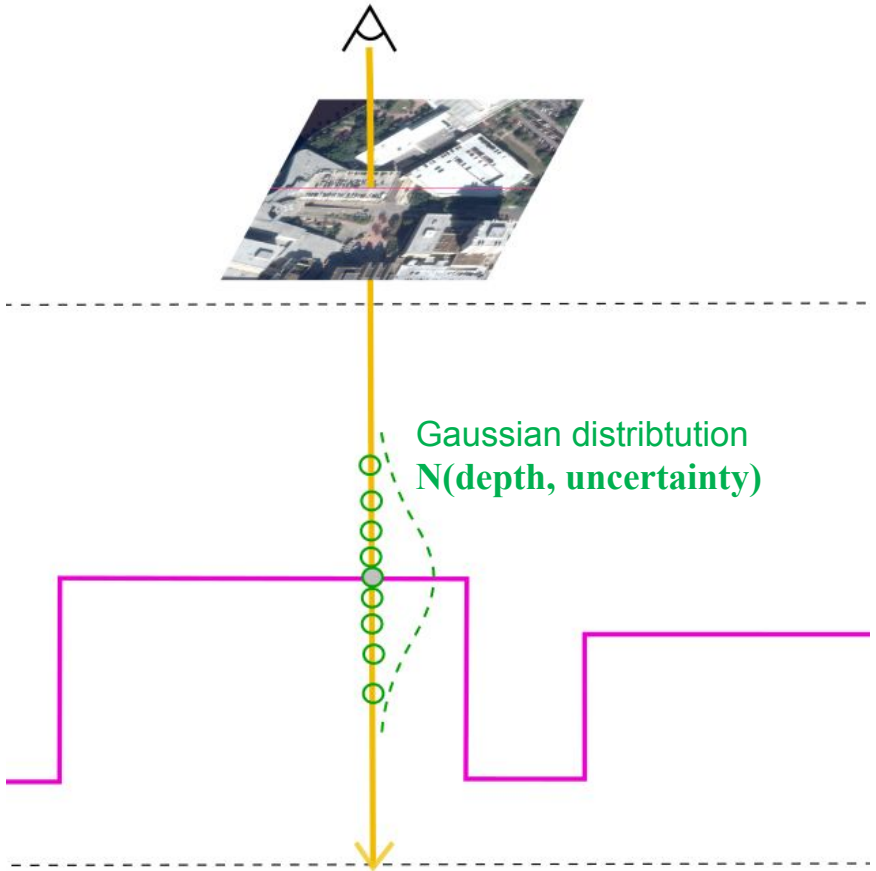
[1] Marí, R., Facciolo, G., Ehret, T., 2022. Sat-NeRF: Learning multi-view satellite photogrammetry with transient objects and shadow modeling using RPC cameras. CVPRW, 1311–1321.


View 1
View 2
Synthetic image
Elevation
Input RGB images
NeRF
SGM
Dense depth
SpS-NeRF
Uncertainty

SpS-NeRF: Guided sampling



Stratified sampling



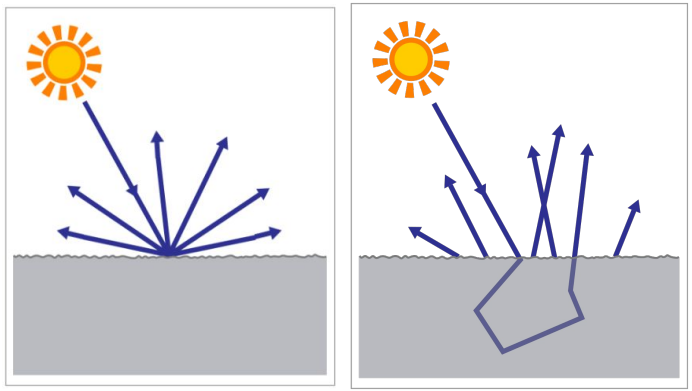
Guided sampling

Challenges

Two big challenges in our work:

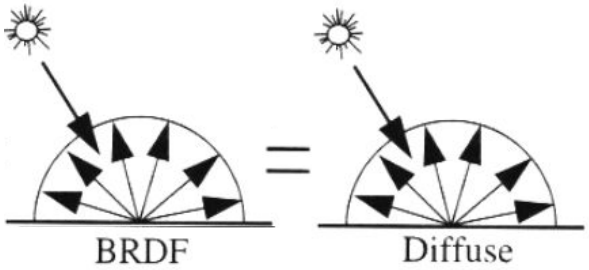
1. Sparse input images

2. Complex BRDF in remote sensing images



BRDF model

Lambertian:



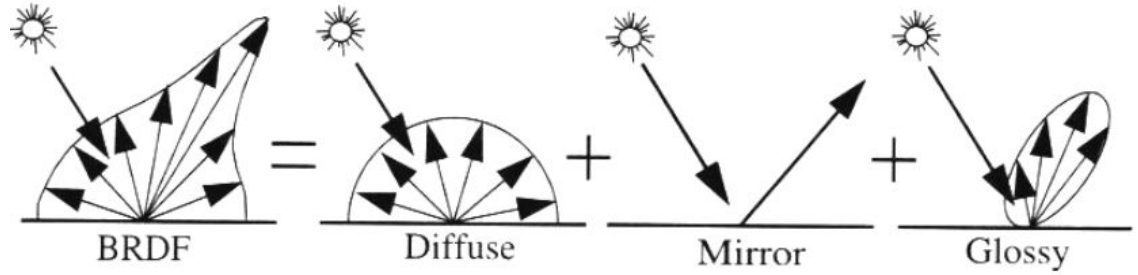
Reflectance:

- All the light is reflected **equally in all direction**.

Example:

BRDF model

Microfacet:



Reflectance:

- Some light is reflected **equally in all direction**.
- The rest is reflected **near the specular direction**.

Example:

BRDF model

RPV: $$BRF(\theta_i,\theta_e,\phi,\lambda)=\rho_0(\lambda)\times M_I(\theta_i,\theta_e,k)\times F_{HG}(g,\Theta)\times H(\rho_c,G)$$

Hapke: $$r(i,e,g)=\frac{w}{4\pi}\frac{\mu_{0e}}{\mu_{0e}+\mu_e}\left\{p(g,b,c)+H(\mu_{0e})H(\mu_e)-1\right\}S(i,e,g,\theta)$$

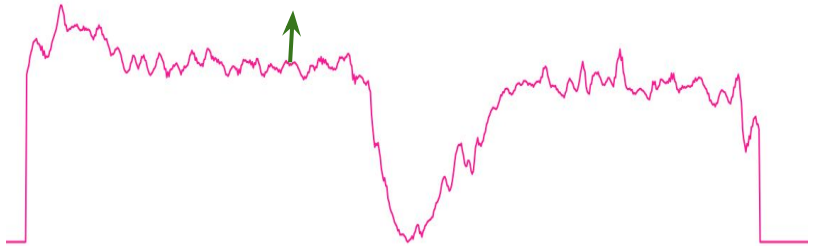
Reflectance:

- Some light is reflected **equally in all direction**.
- The rest energy can be reflected **in arbitrary direction with arbitrary amplitude**, depending on parameters.
- Suitable for arbitrary natural surfaces, including bare soils and vegetation.

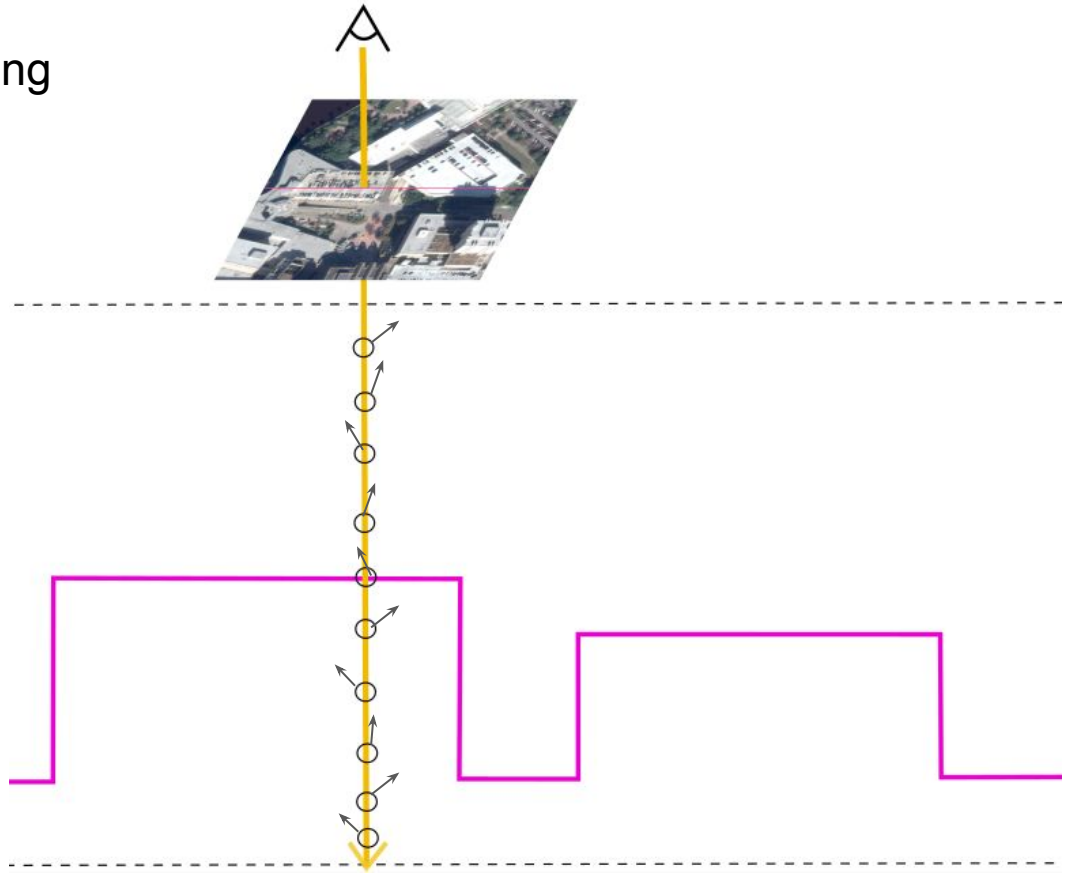
Example:

Normal supervision (nr)

Surface normal is essential in estimating BRDF.



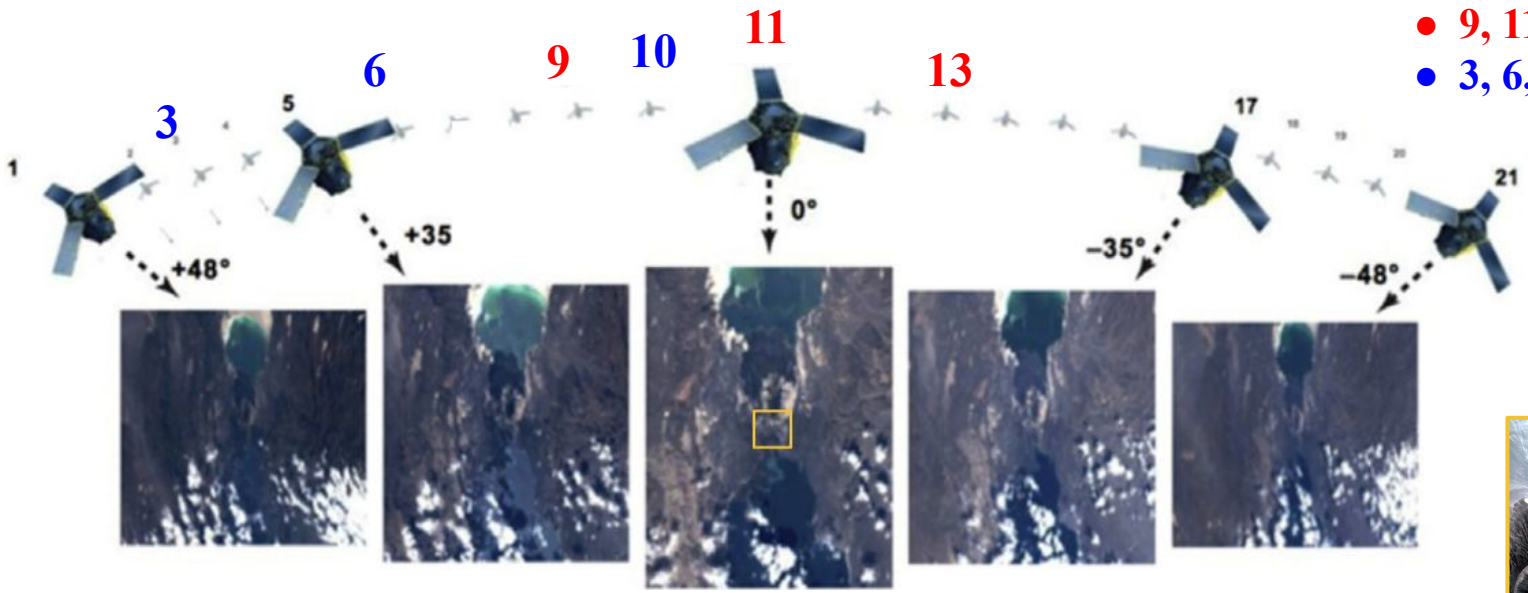
Normal from dense depth



Normal from network

Experiments

Djibouti dataset. It contains 21 multiangular Pléiades images collected in a single flyby.



- 9, 11, 13 for training
- 3, 6, 10 for validation

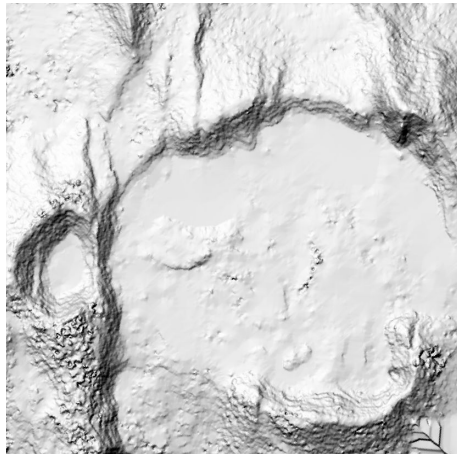
Test site

S. Labarre, S. Jacquemoud, , C. Ferrari, A. Delorme, A. Derrien, R. Grandin, M. Jalludin, F. Lemaître, M. Métois, M. Pierrot-Deseilligny, E. Rupnik, B. Tanguy, 2019. Retrieving soil surface roughness with the Hapke photometric model: Confrontation with the ground truth. Remote Sensing of Environment, 225, 1–15.

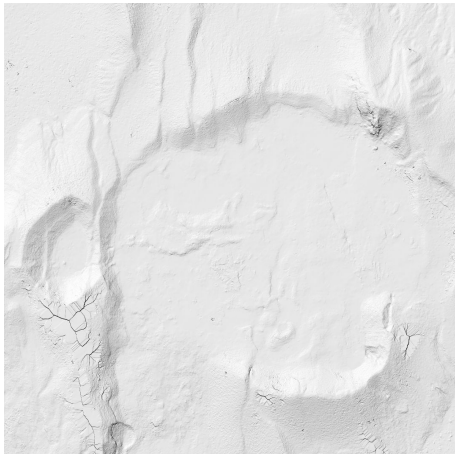
(1) Elevation:

NeRF

Sat-NeRF



SGM

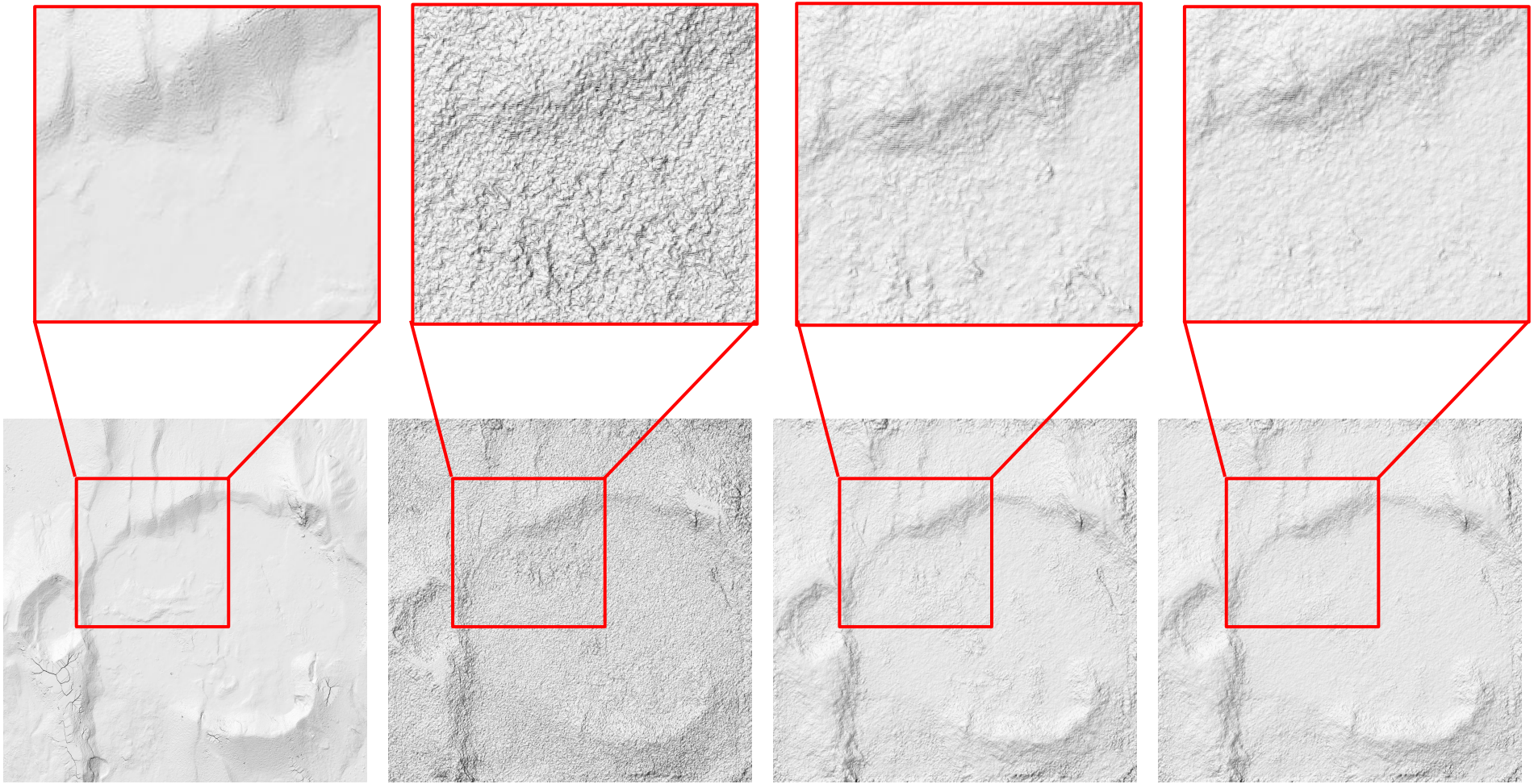


GT

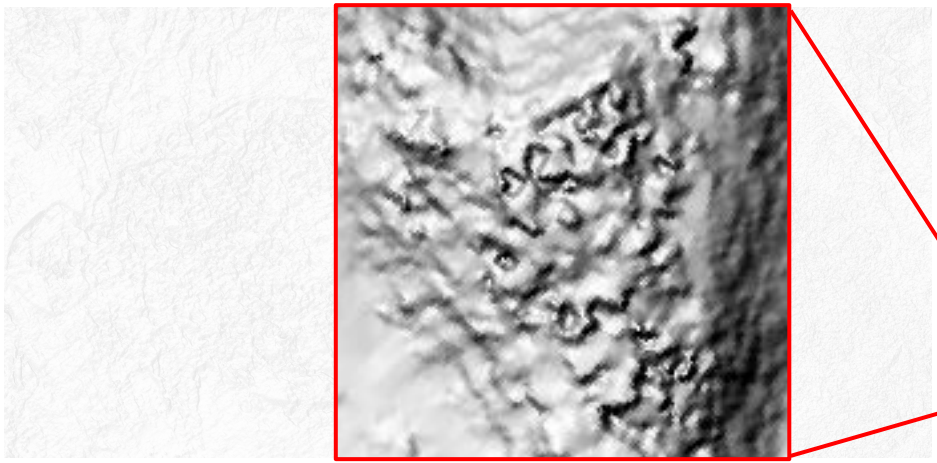
SpS-NeRF

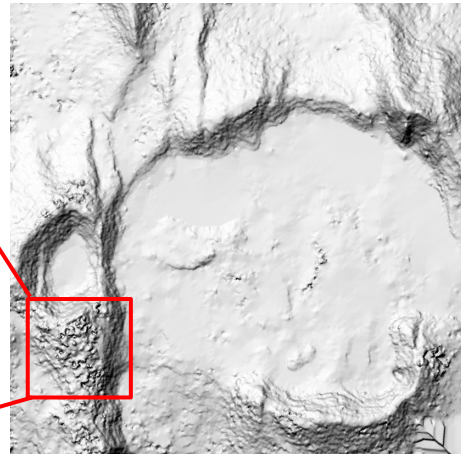
SpS-NeRF + nr

SpS-NeRF + nr + RPV


GT
SpS-NeRF
SpS-NeRF + nr
SpS-NeRF + nr + RPV

(1) Elevation:

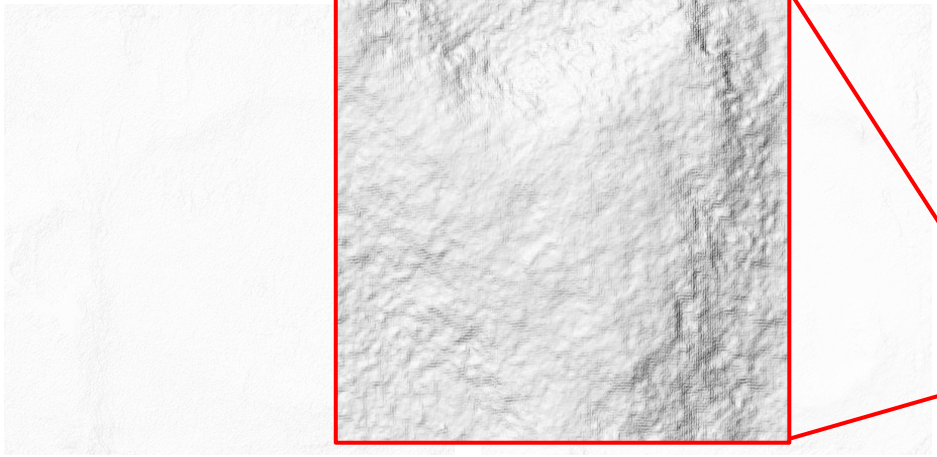


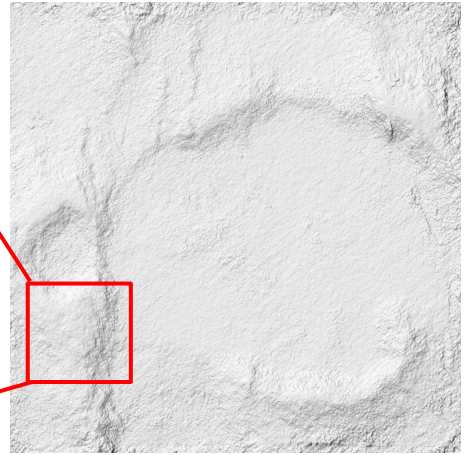


NeRF

Sat-NeRF

SGM





GT

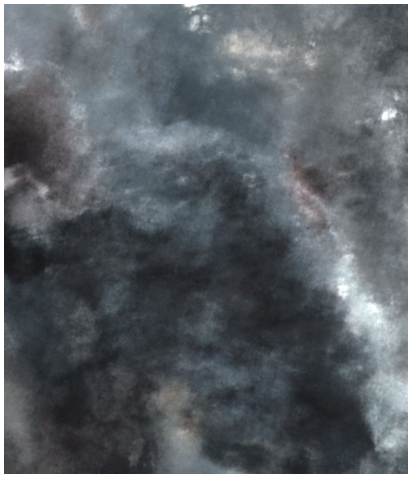
SpS-NeRF

SpS-NeRF + nr

SpS-NeRF + nr + RPV

(2) Synthetic image:

NeRF



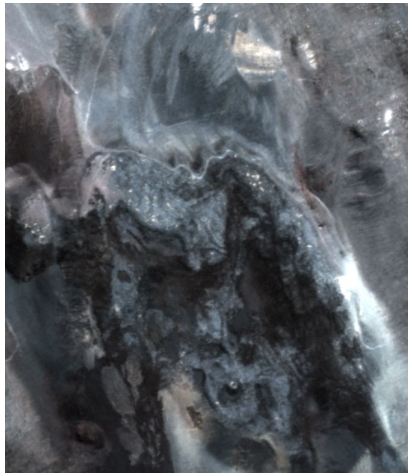
Sat-NeRF

SGM

GT

SpS-NeRF

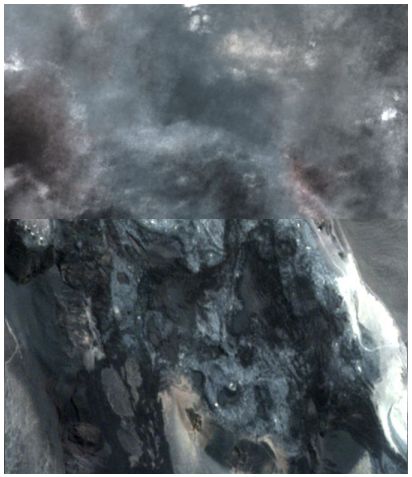
SpS-NeRF + nr



SpS-NeRF + nr + RPV

(2) Synthetic image:

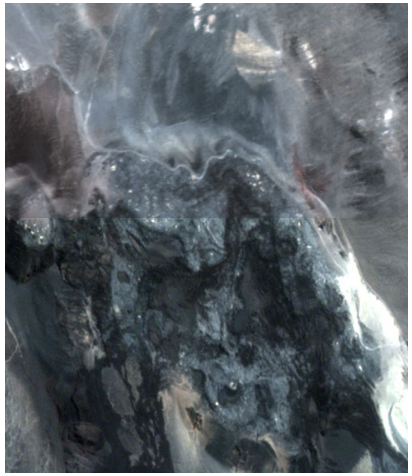
NeRF



Sat-NeRF

SGM

GT

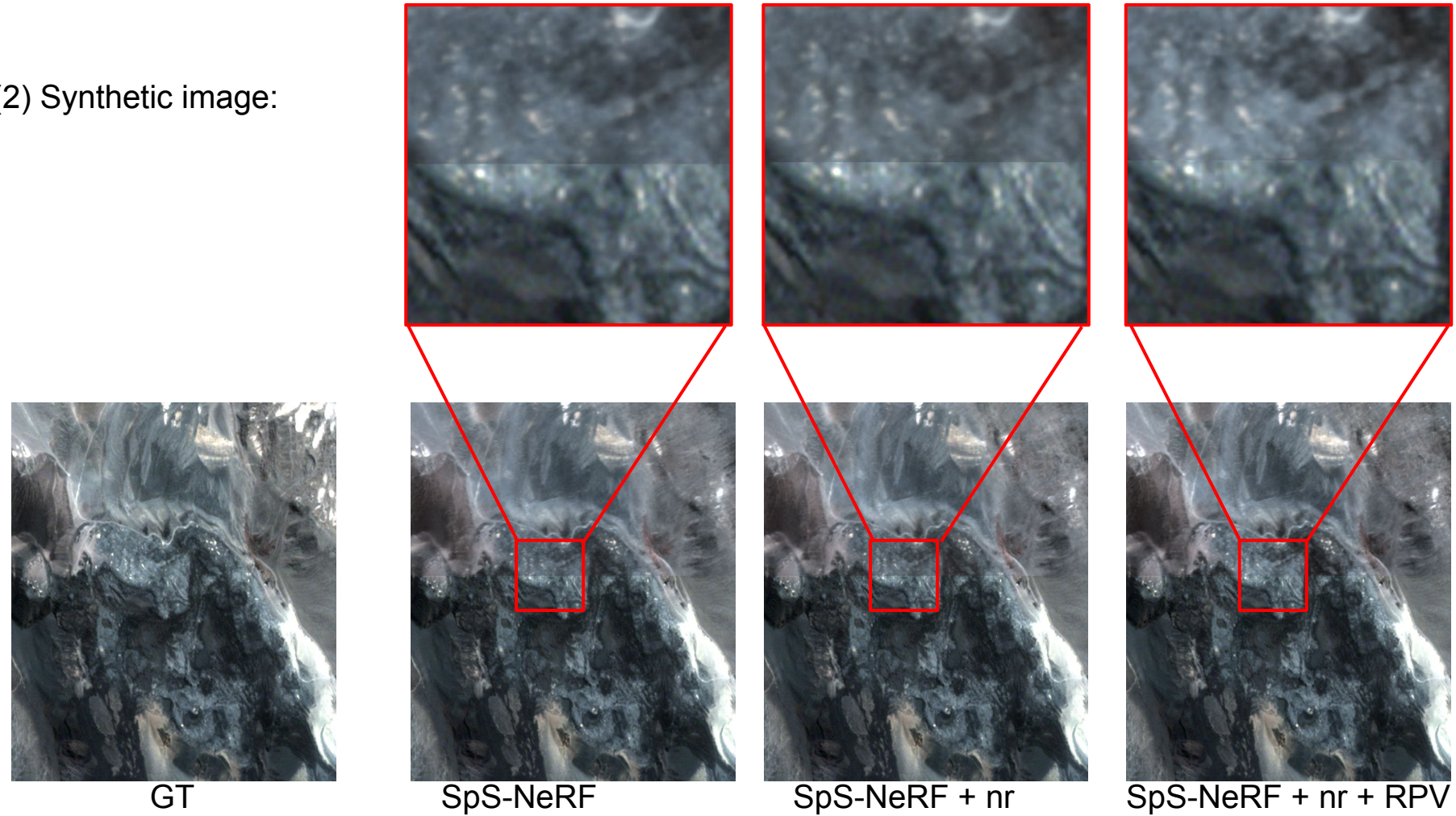


SpS-NeRF

SpS-NeRF + nr

SpS-NeRF + nr + RPV

(2) Synthetic image:



GT

SpS-NeRF

SpS-NeRF + nr

SpS-NeRF + nr + RPV

Quantitative metrics:

	PSNR ⬆️	SSIM ⬆️	MAE ⬇️
NeRF	29.24	0.83	13.38
Sat-NeRF	29.65	0.85	10.11
SpS-NeRF	31.47	0.91	2.09
SpS-NeRF + nr	31.72	0.91	1.52
SpS-NeRF + nr + RPV	**31.81**	**0.93**	1.36
SGM	/	/	**0.81**

*mean value on 3 validation images.

Thank you

for your attention !

Code

Project page

Email me