Efficient dehazing method for large scale remote sensing images

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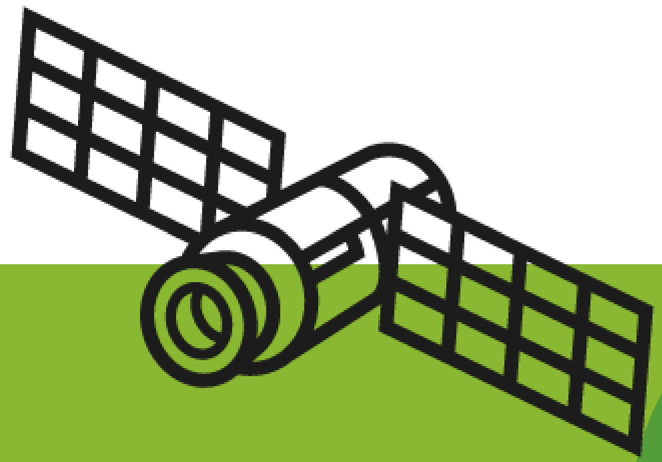
“The dehazers”



Agenda

Introduction and motivation

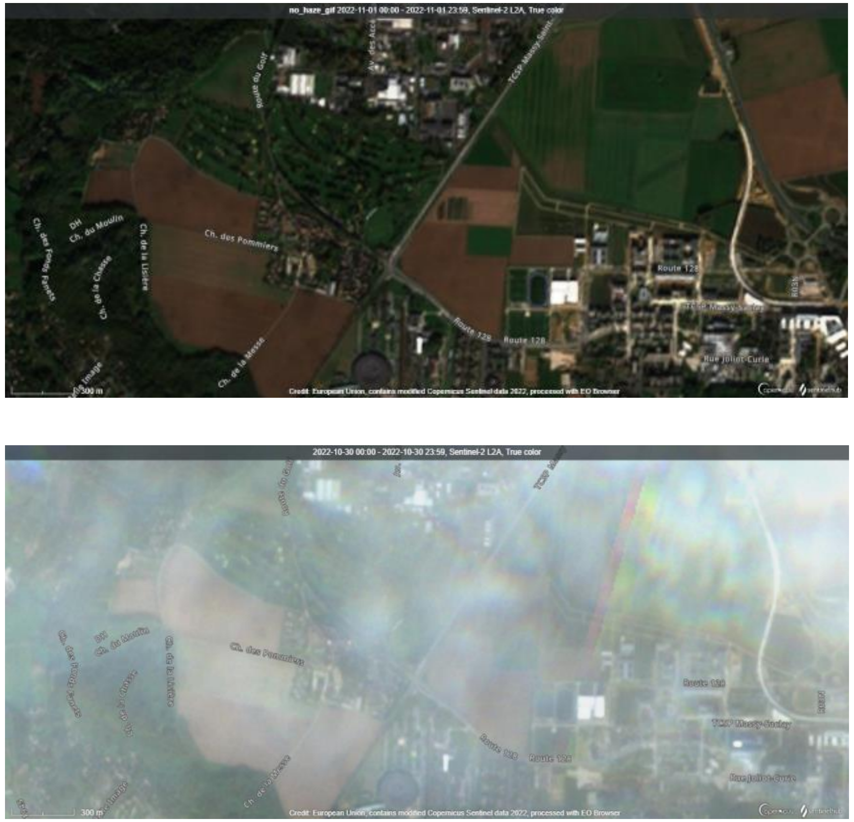
Methodology

Experiments and results

Conclusion

Introduction and motivation

- Nowadays, satellite images are publically available (Copernicus, Sentinel..)
- Applications: Real time monitoring of crops
- Problem:
  - Haze can make images difficult to interpret



Clean (upper) vs hazy (lower) Sentinel-2 images of agricultural fields close to Paris Saclay

Methodology: Model

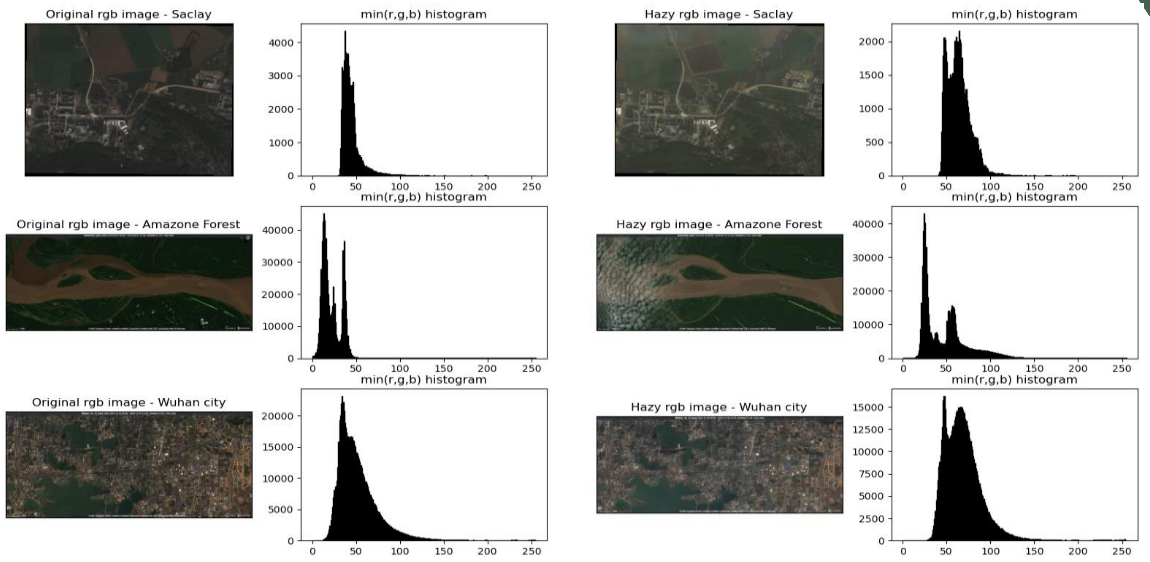
$$\boldsymbol{I}(x) = \boldsymbol{J}(x)t(x) + \boldsymbol{A}(1 - t(x))$$ *

where

- I :the observed intensity,
- J : the scene radiance,
- A : the atmospheric light of the whole image,
- t : the medium transmission coefficient

*S.G. Narasimhan and S.K. Nayar. Vision and the atmosphere. Int'l J.Computer Vision, 48:233–254, 2002.

Methodology: Dark channel prior



RGB image and histograms of the per-pixel minimum channel value for similar haze-free and hazy scenes. Top: Saclay plateau; middle: the Amazone; bottom: Wuhan, China

- Dark Channel prior:
  - pixels in at least one color channel (r, g or b) have a low intensity value and close to zero

$$J(x) = A * \frac{\left(I(x)/A - k * V(x)\right)}{\max(t(x), t_0)} \quad *$$

where

- V (x) is the atmospheric veil
- I stands for the observed intensity,
- J is the scene radiance,
- A stands for the atmospheric light of the whole image

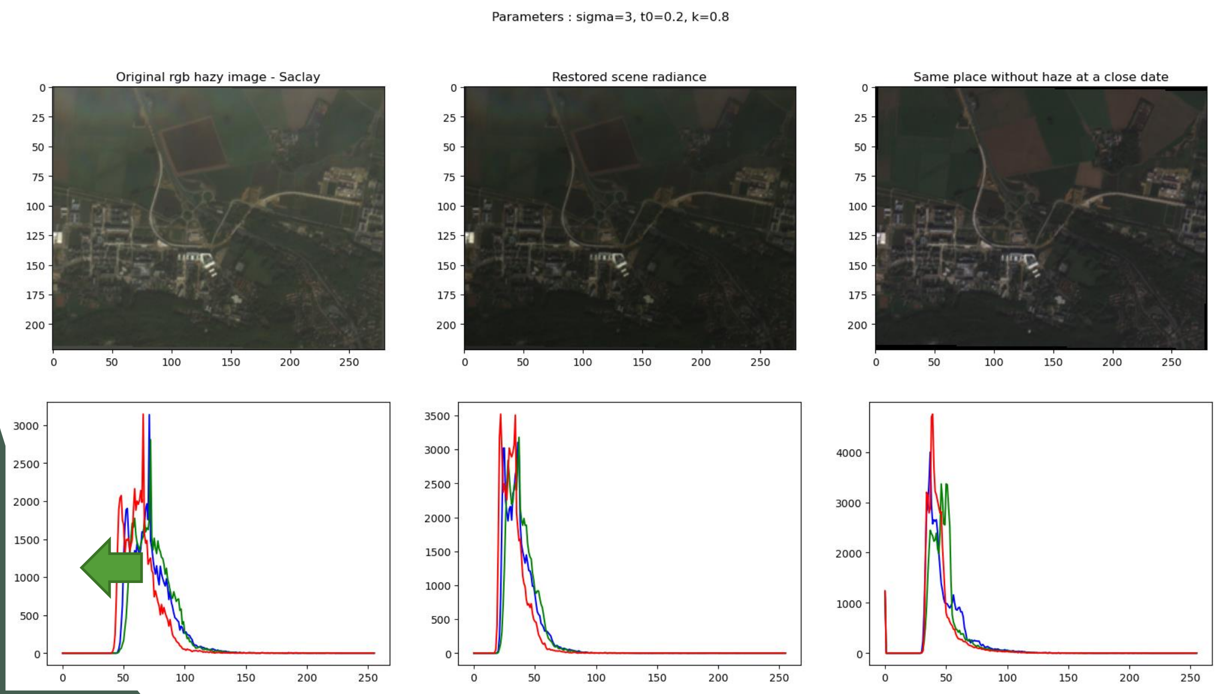
*Jiao Long, Zhenwei Shi, and Wei Tang. Fast haze removal for a single remote sensing image using dark channel prior. pages 132–135, 2012

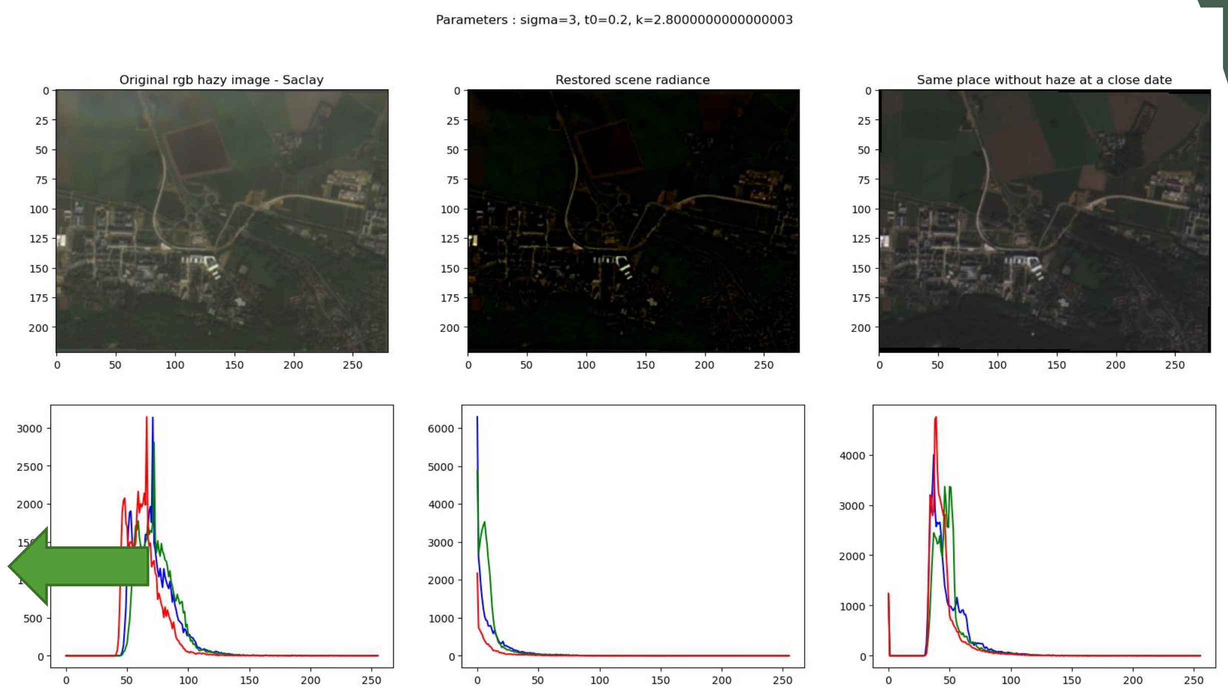
Experiments and results

Tuning the parameters

Tuning k

$$J(x) = A * \frac{\left(I(x)/A - k * V(x)\right)}{\max(t(x), t_0)}$$





Correct value for k

Too high value for k

Manual tuning required

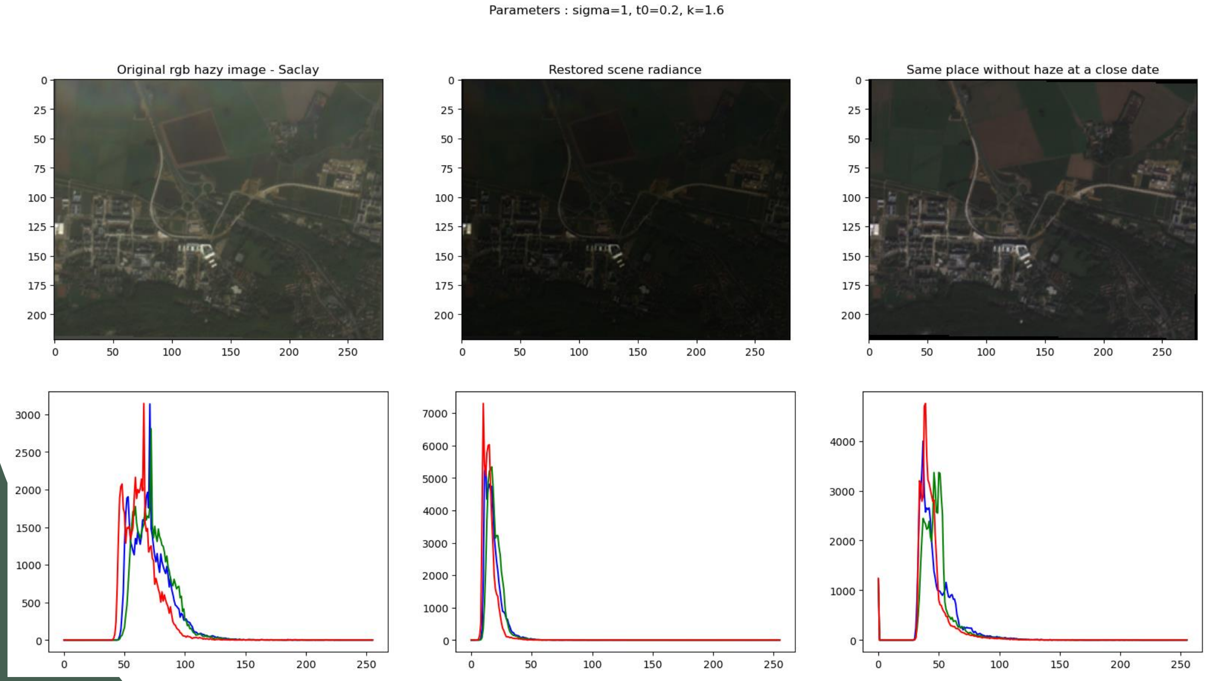
Experiments and results

Tuning the parameters

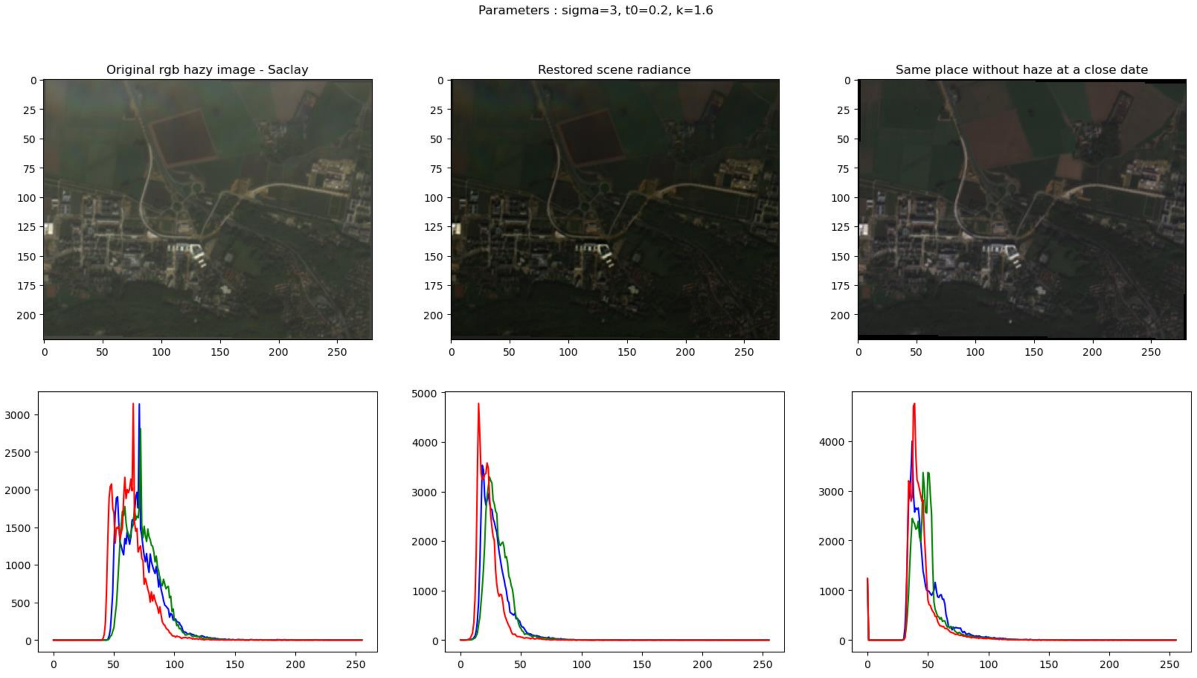
Tuning σ

$$J(x) = A * \frac{\left(I(x)/A - k * V(x)\right)}{\max(t(x), t_0)}$$

$$V(\mathbf{x}) = \frac{1}{W^g} \sum_{\mathbf{y} \in S} G_\sigma(|\mathbf{x} - \mathbf{y}|)\tilde{V}(\mathbf{y})$$



Too low value for sigma



Correct value for sigma

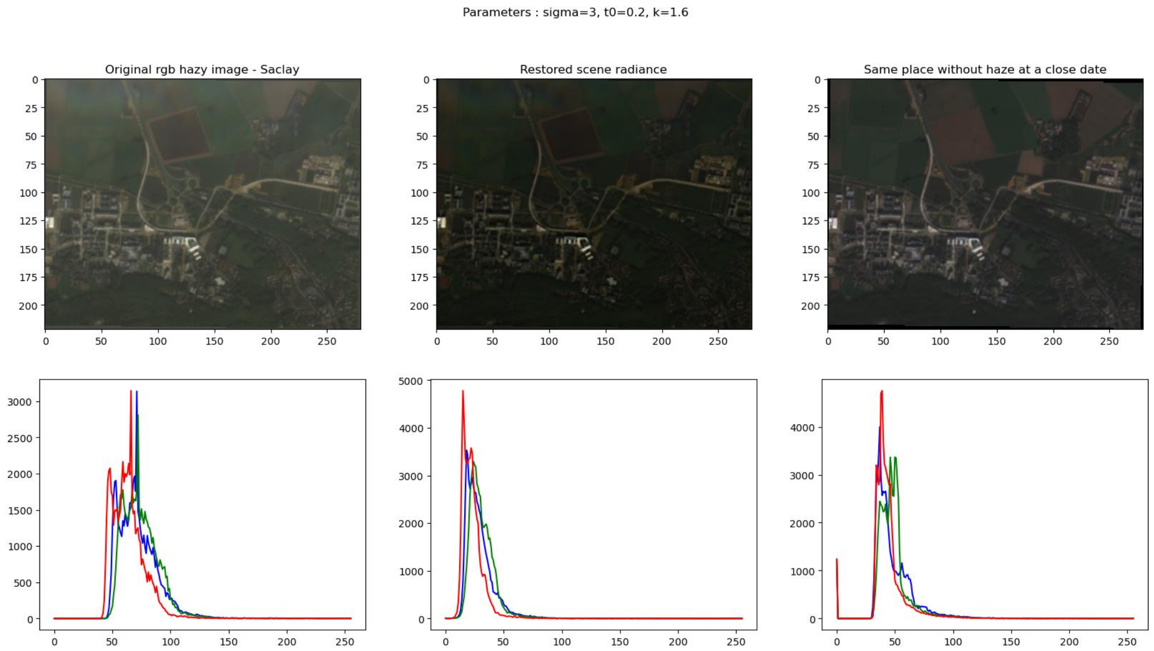
Choose a value >=2 (3 in practice) to avoid dark images

Experiments and results

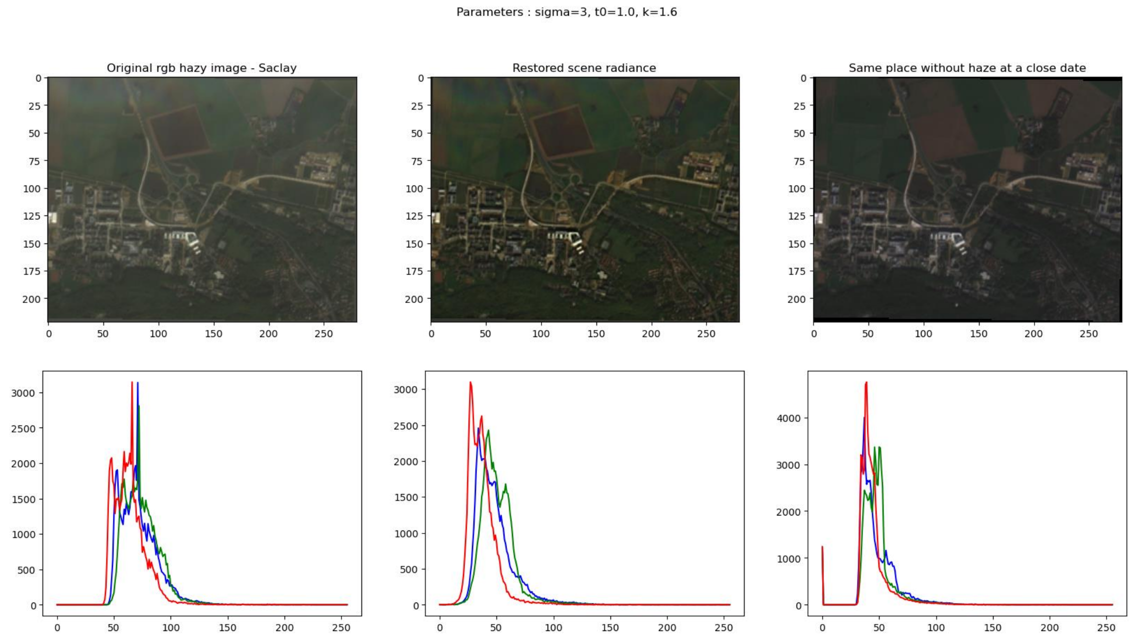
Tuning the parameters

Tuning t0

$$J(x) = A * \frac{\left(I(x)/A - k * V(x)\right)}{\max(t(x), t_0)}$$



Too low value for t0



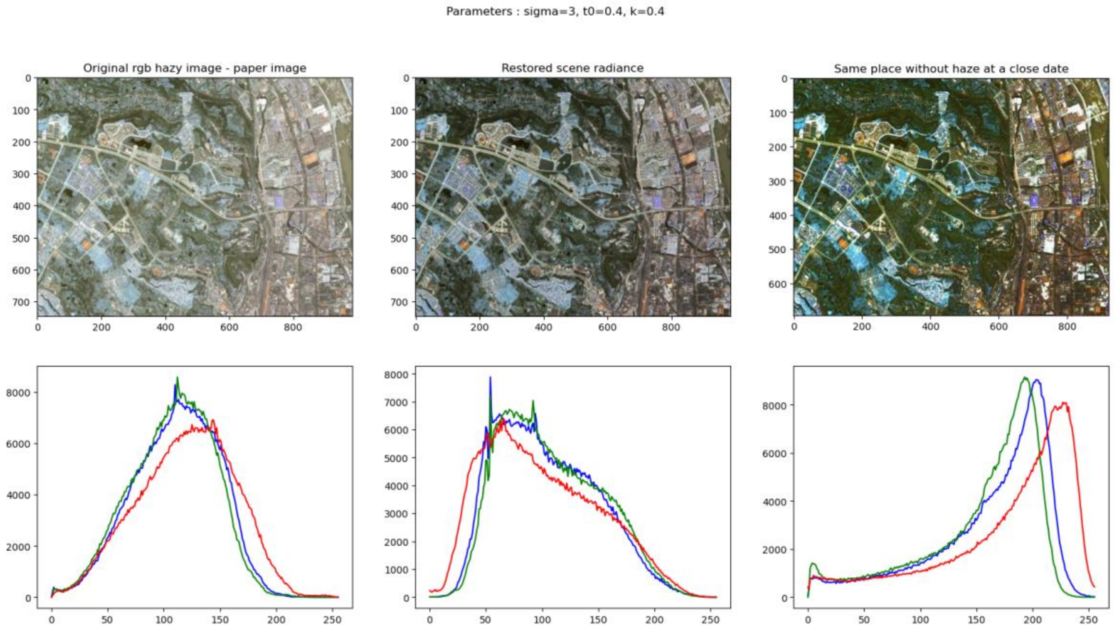
Too high value for t0

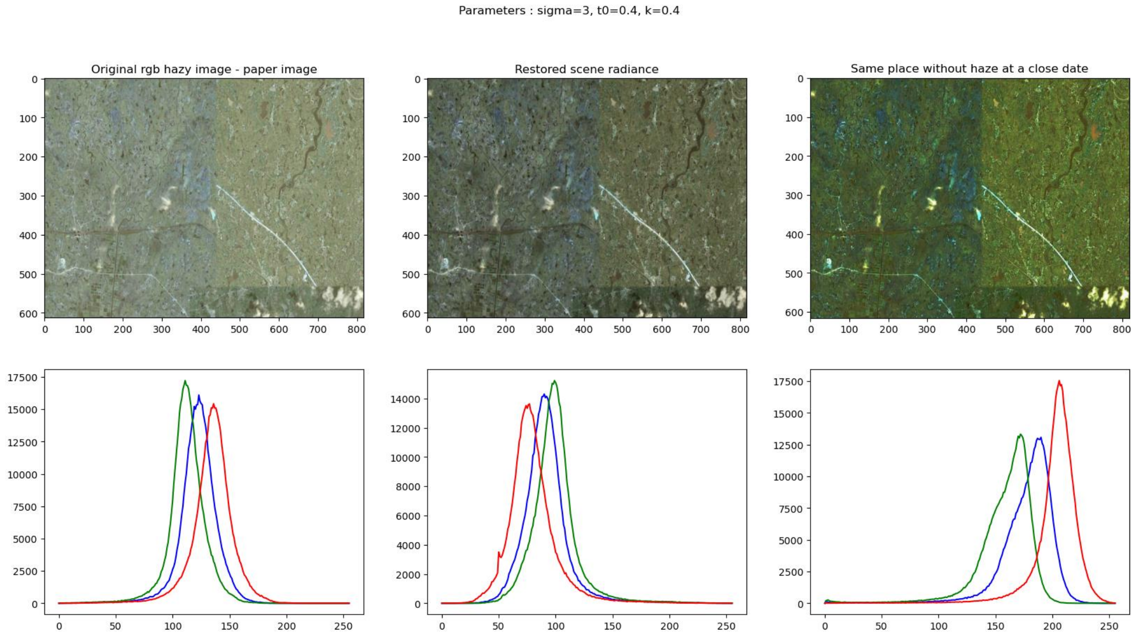
Brightening effect : choose intermediary value of 0.6

Experiments and results

Verifying the implementation

On a source article images

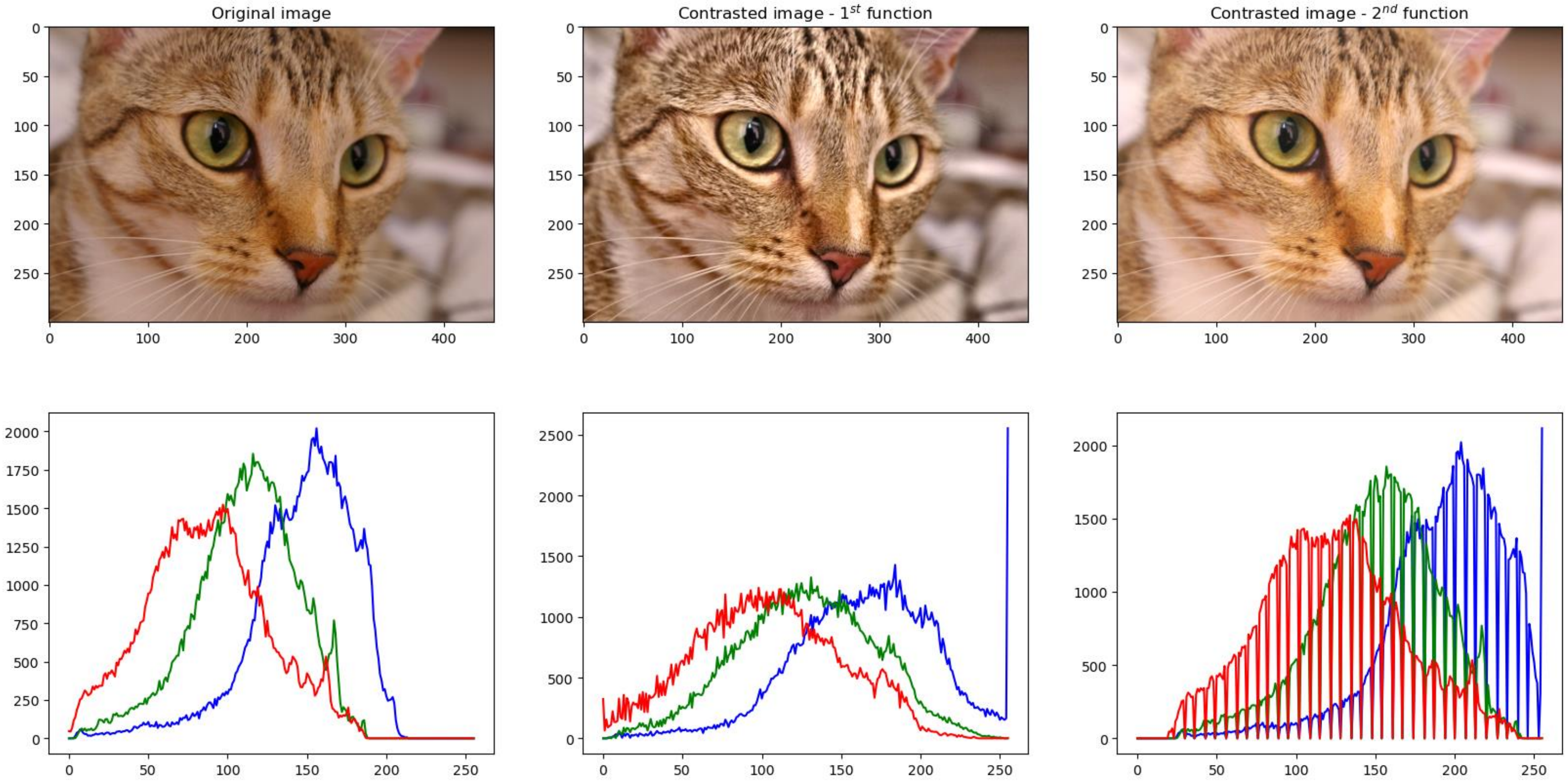




Our histograms are less distorted than the output of the paper : our implementation is more physically conservative and visually appealing

Experiments and results

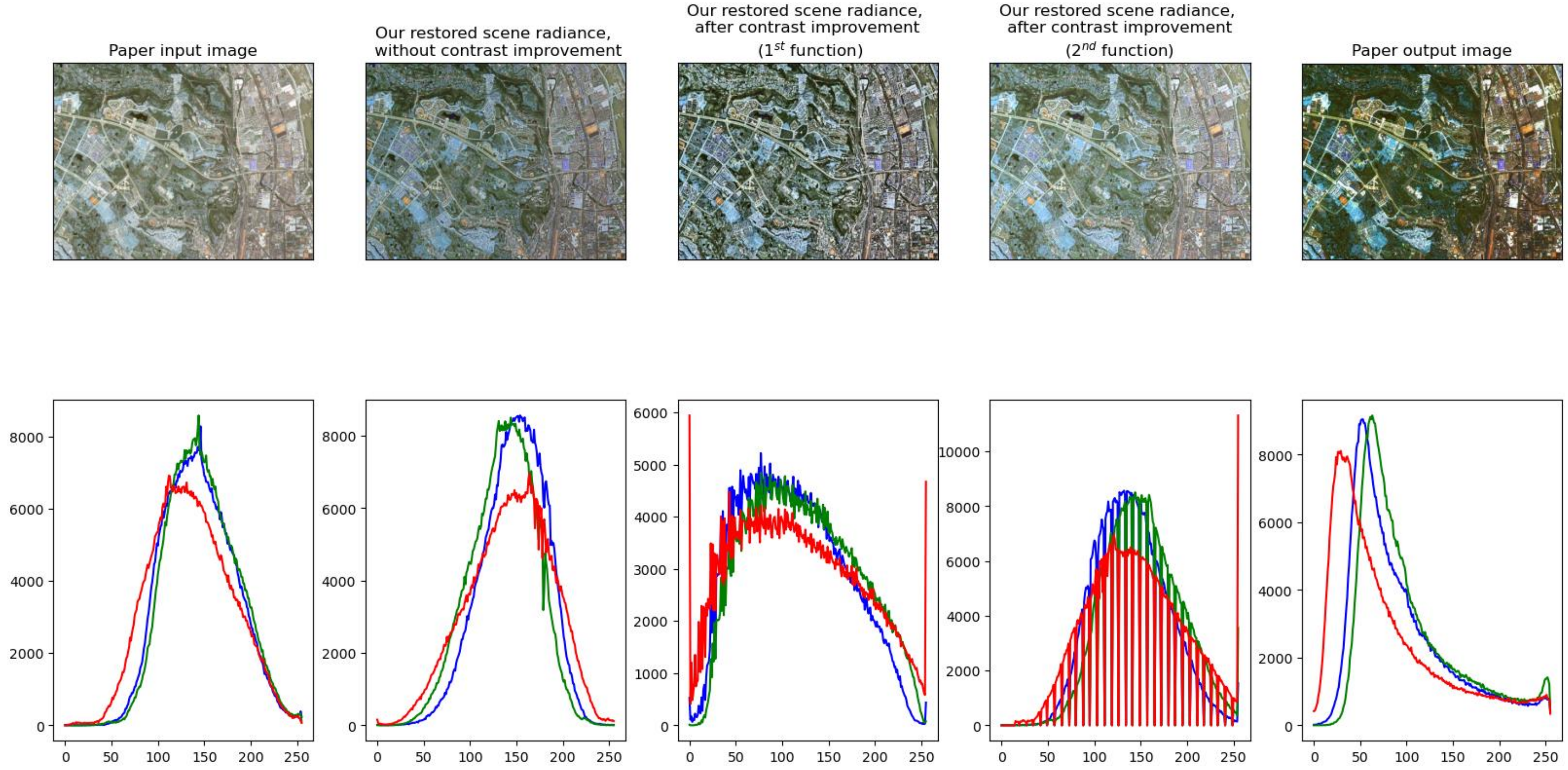
Contrast enhancement



Application of two contrast improvement functions to our restored scenes

Experiments and results

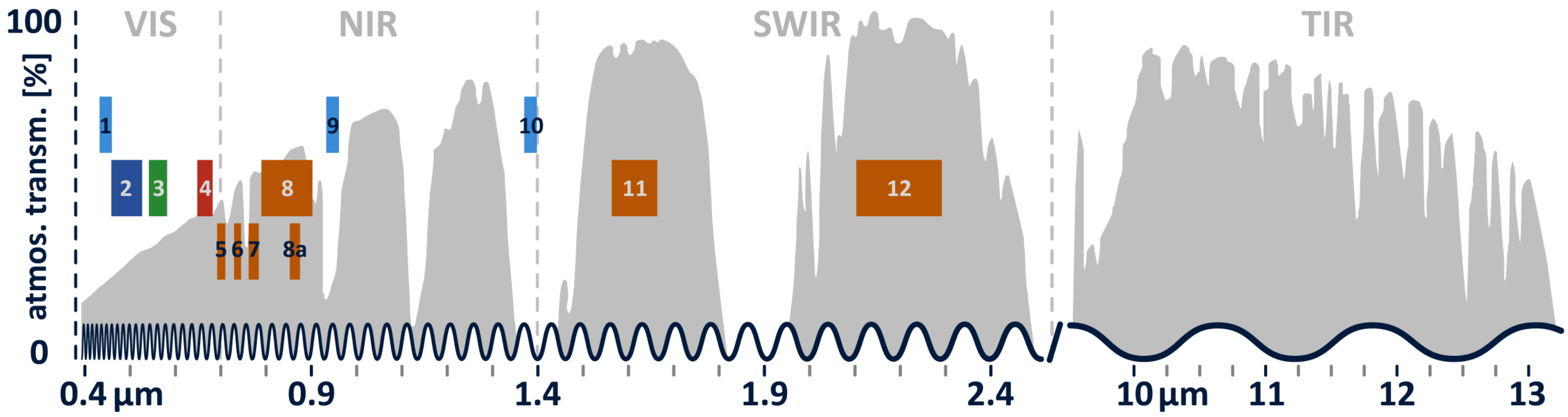
Contrast enhancement



The histograms are distorted too much : we gave up the contrast enhancement

Experiments and results

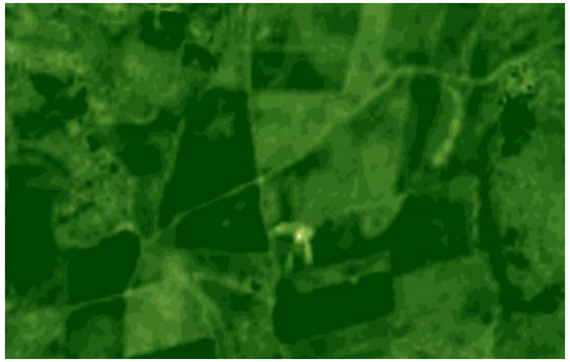
Application to other spectral bands



The Sentinel-2 spectral bands

NDVI definition and an example of plot from EO Browser:

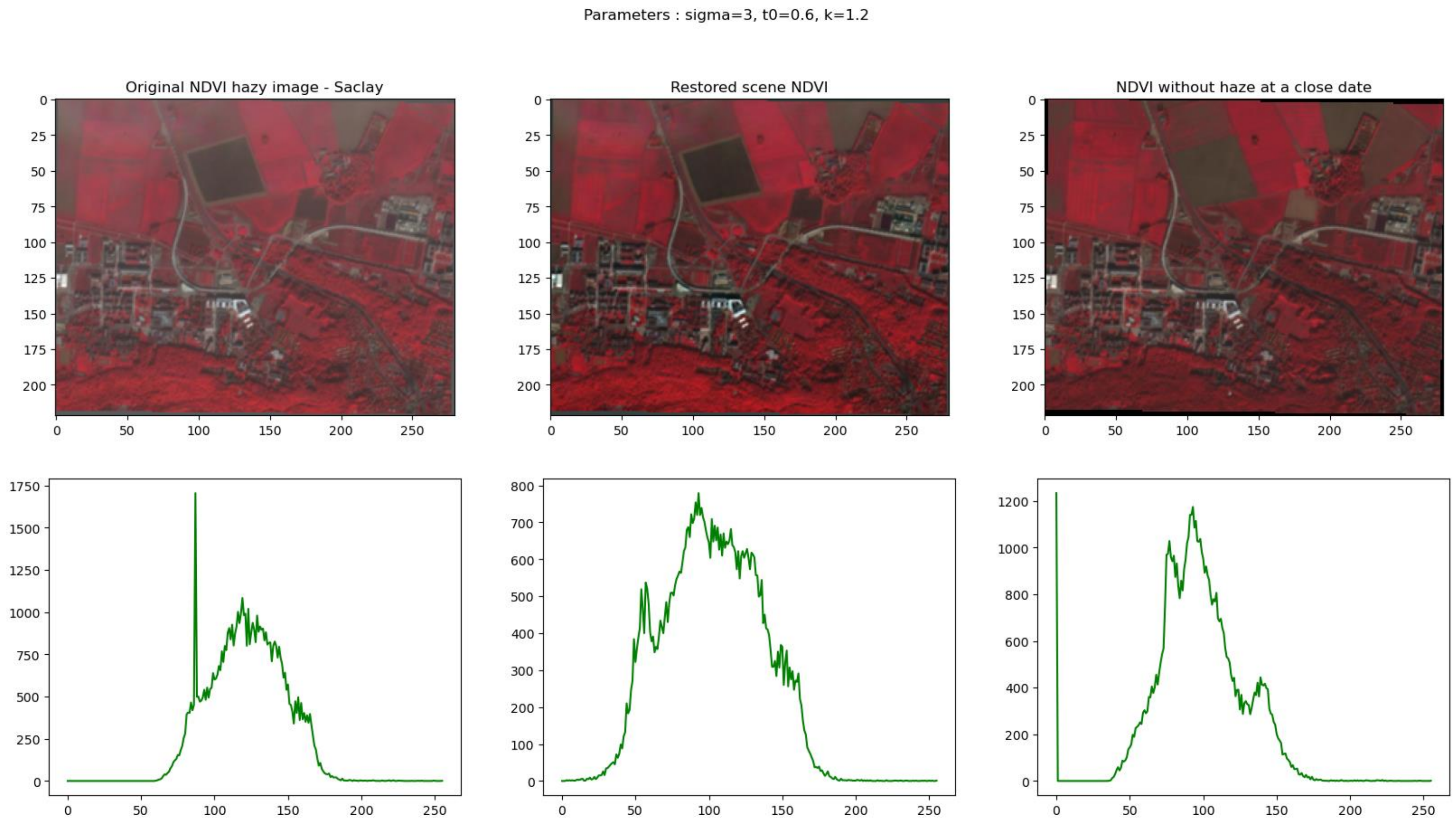
$$NDVI = \frac{NIR - Red}{NIR + Red}$$



Experiments and results

Dehazing NIR and deriving NDVI

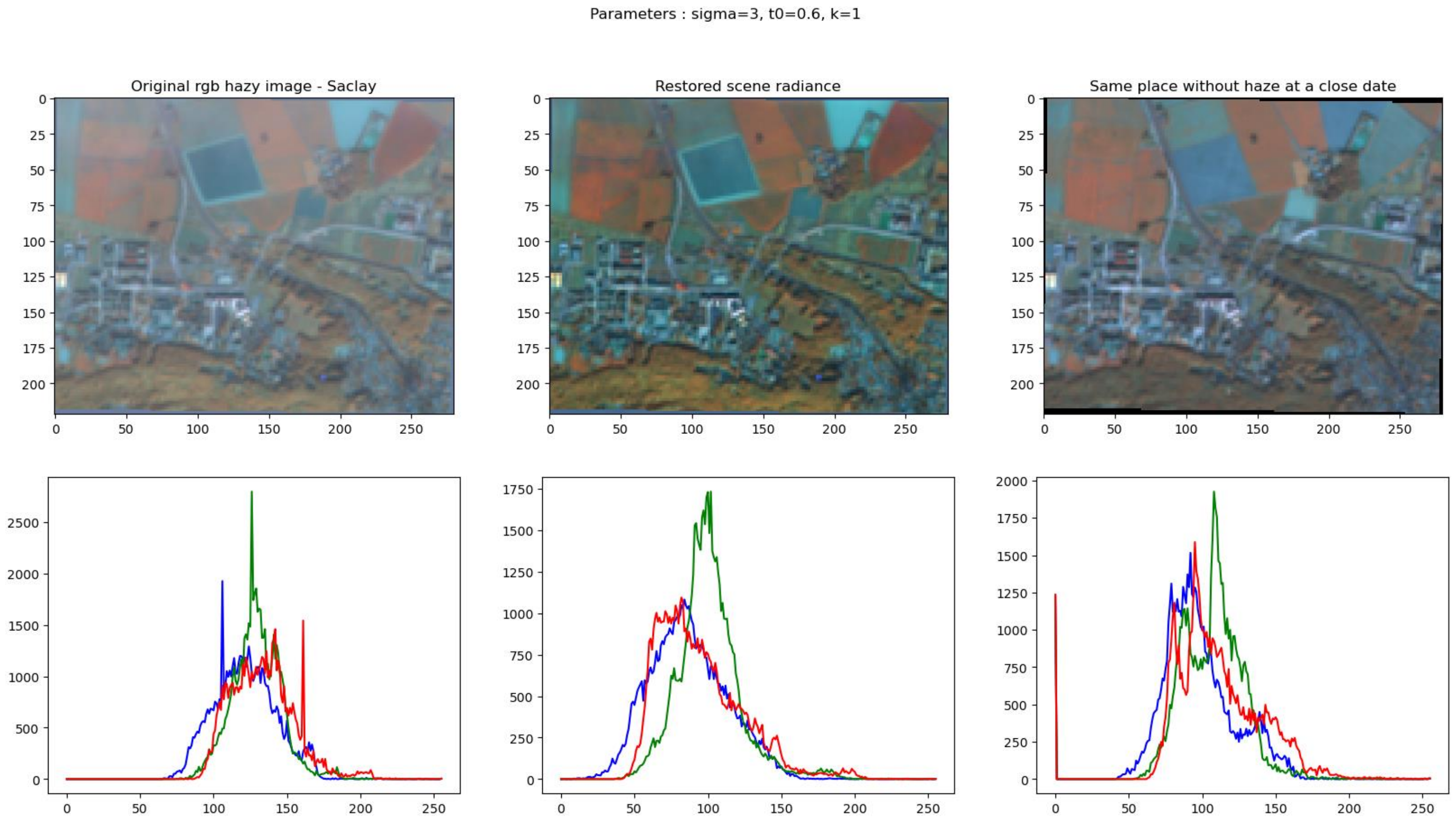
$$NDVI = \frac{NIR - Red}{NIR + Red}$$



(NIR, Red, Green) dehazing and NDVI histograms obtained

Experiments and results

Dehazing other IR bands



(Vegetation red edge, SWIR 1, SWIR 2) image dehazing

Experiments and results

Extension of the method to a 10-band multispectral image

$$I^{\text{dark}}(\mathbf{x}) = \min_{\mathbf{y}\in\Omega(\mathbf{x})}\left(\min_{c\in\{r,g,b\}} I^c(\mathbf{y})\right) \qquad \tilde{V}(\mathbf{x}) = \min_{c\in\{r,g,b\}} \frac{I^c(\mathbf{x})}{A^c}$$

Hazy image

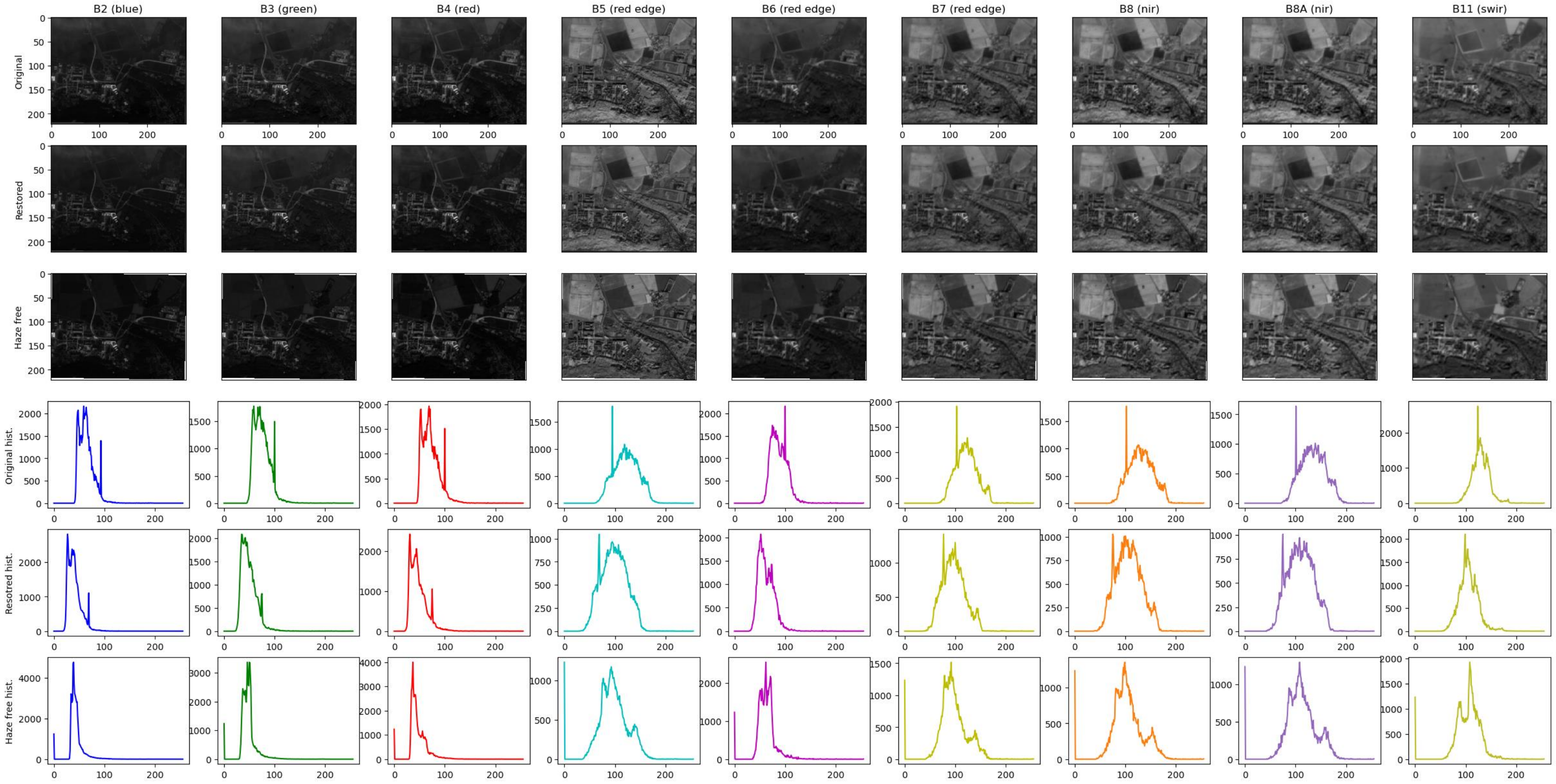
Dehazed image

Haze free image
at a close date

Hazy histograms

Dehazed histograms

Haze free histograms



Dehazing all the raster bands at once

Experiments and results

Extension of the method to a 10-band multispectral image

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Hazy image

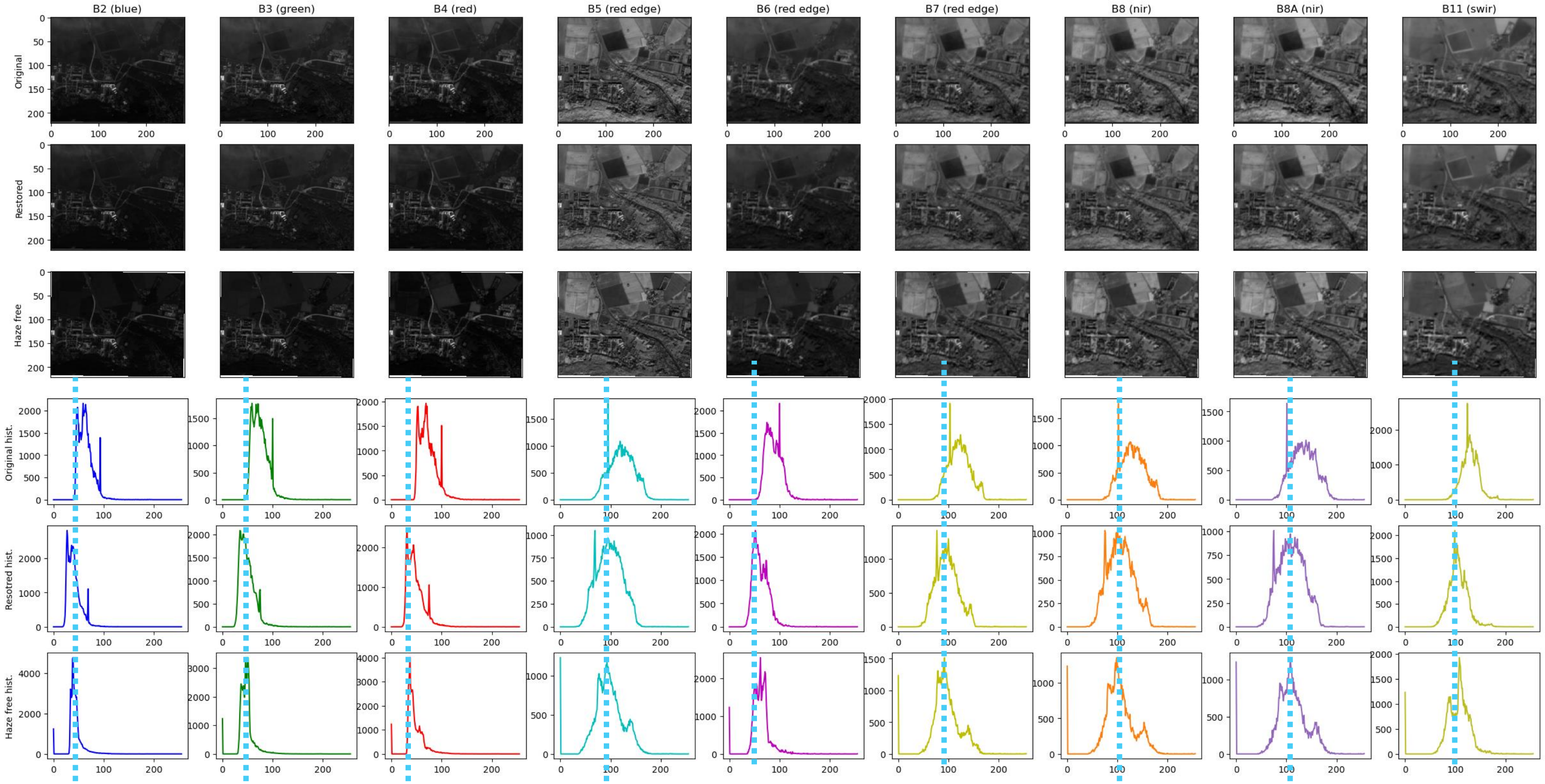
Dehazed image

Haze free image
at a close date

Hazy histograms

Dehazed histograms

Haze free histograms



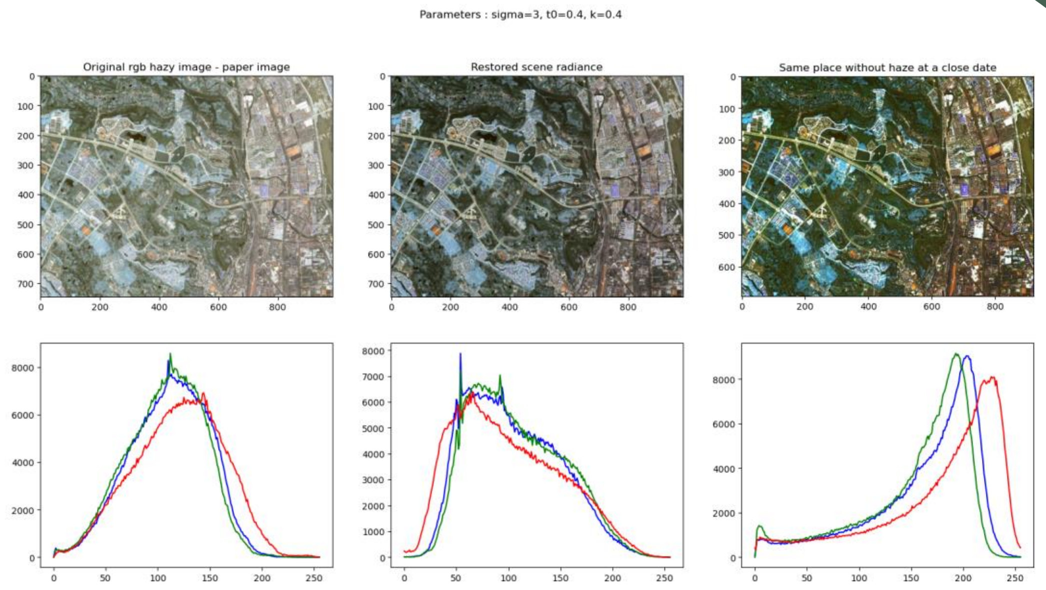
Dehazing all the raster bands at once

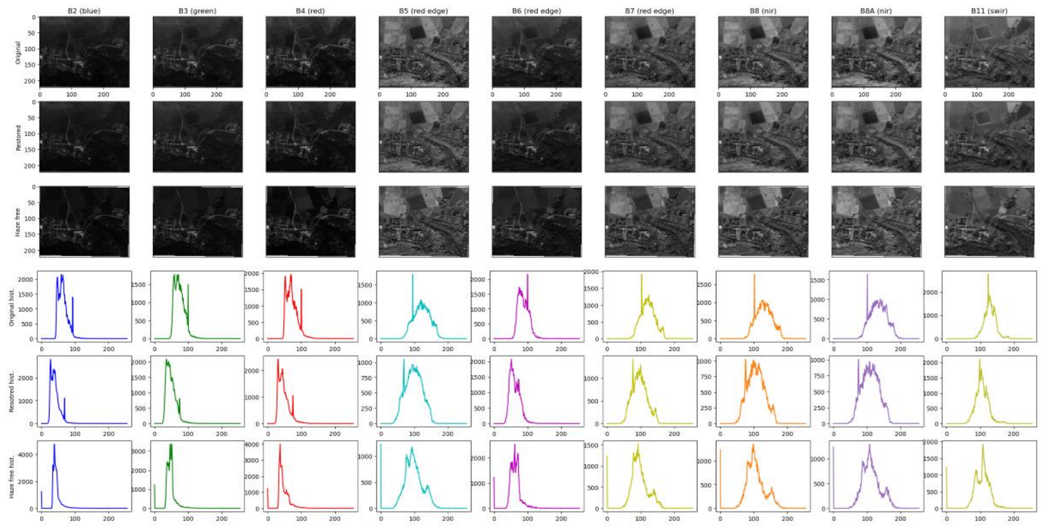
Conclusion

- Fast algorithm for image dehazing
- Good results with various landscapes
- Extend this method to dehaze all the bands of multispectral images

Next steps

- Automatic tuning of hyperparameters
- Application to crop monitoring, using Normalized Difference Vegetation Index (NDVI)





Thank you