# Deep Learning Based Prediction of Sun-Induced Fluorescence from HyPlant Imagery

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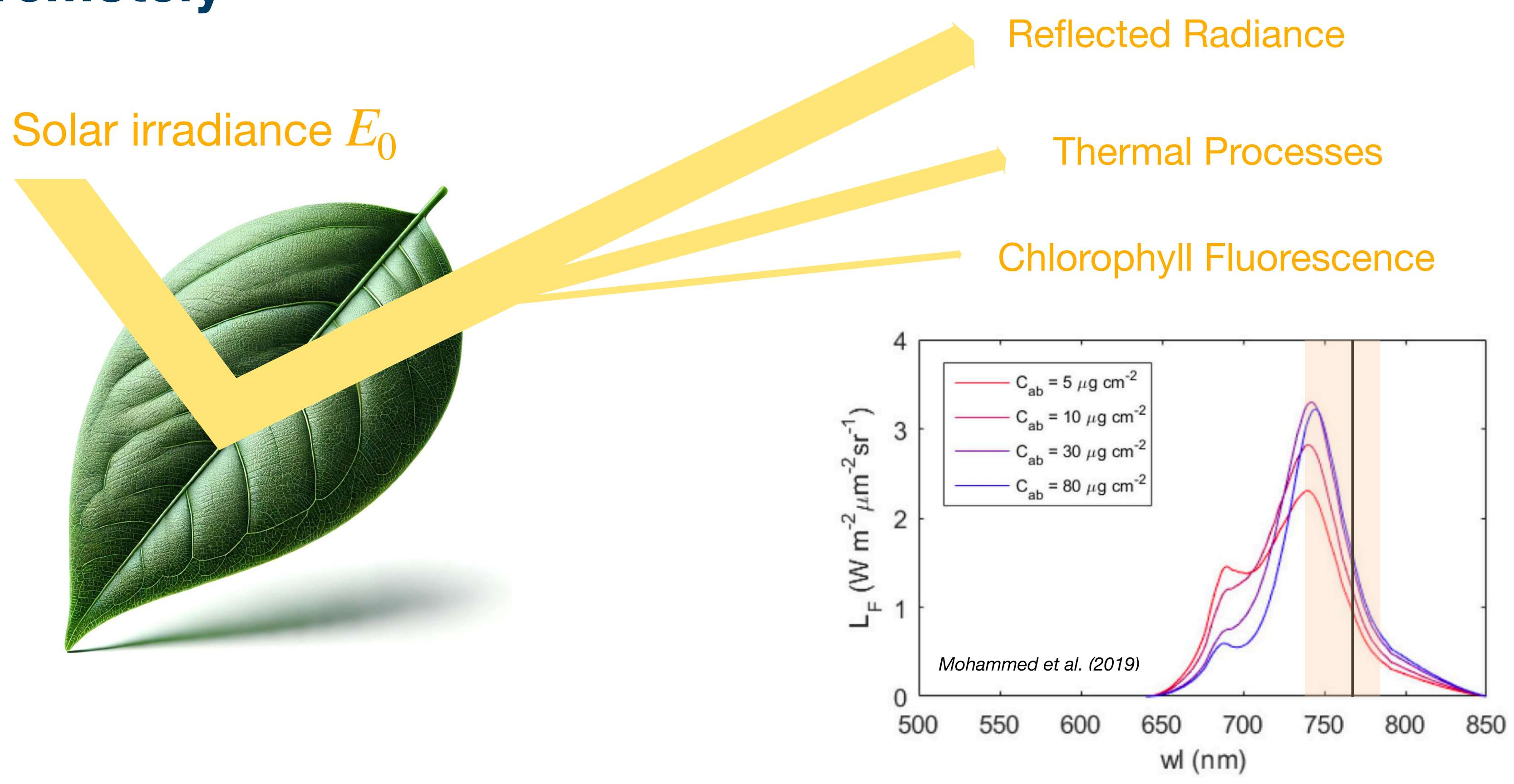
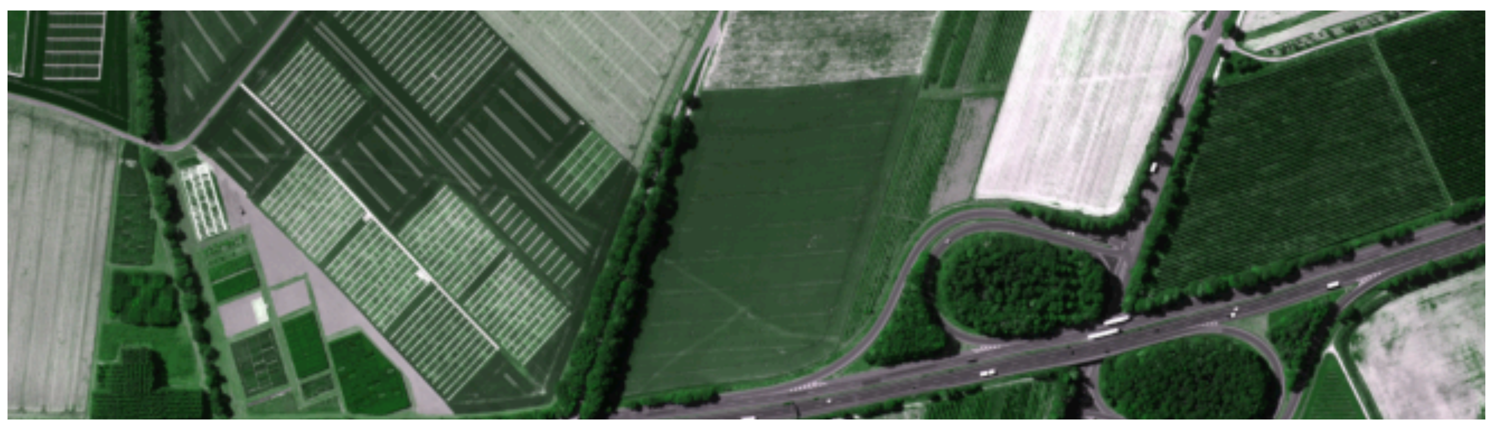
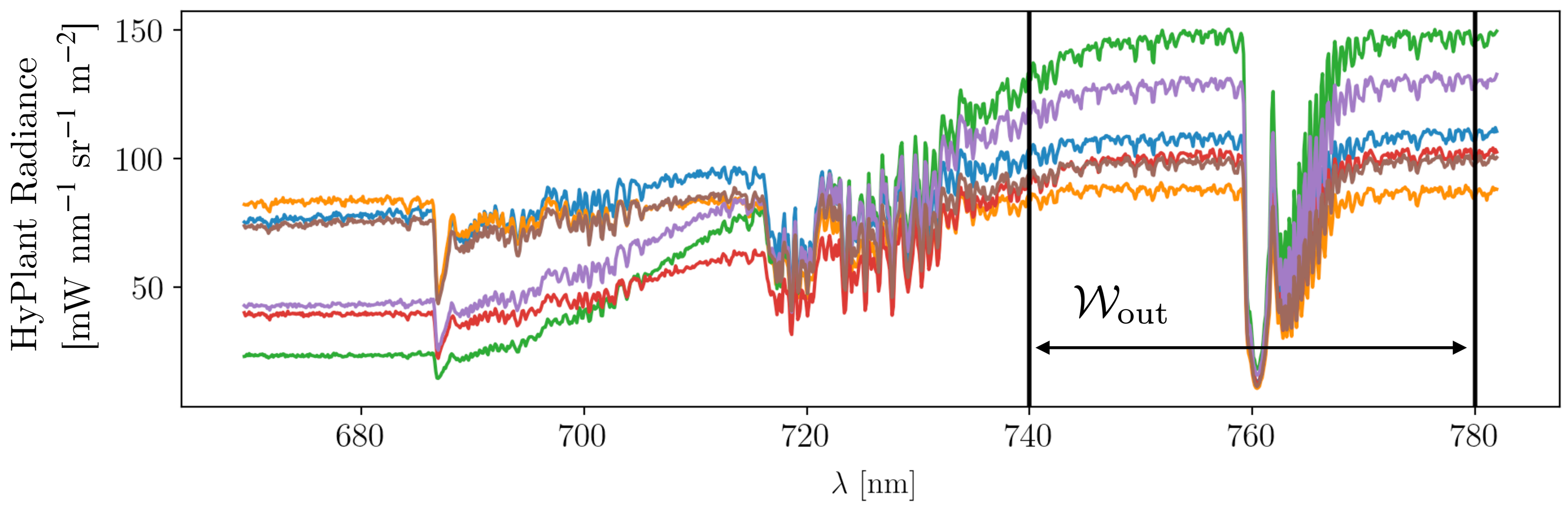
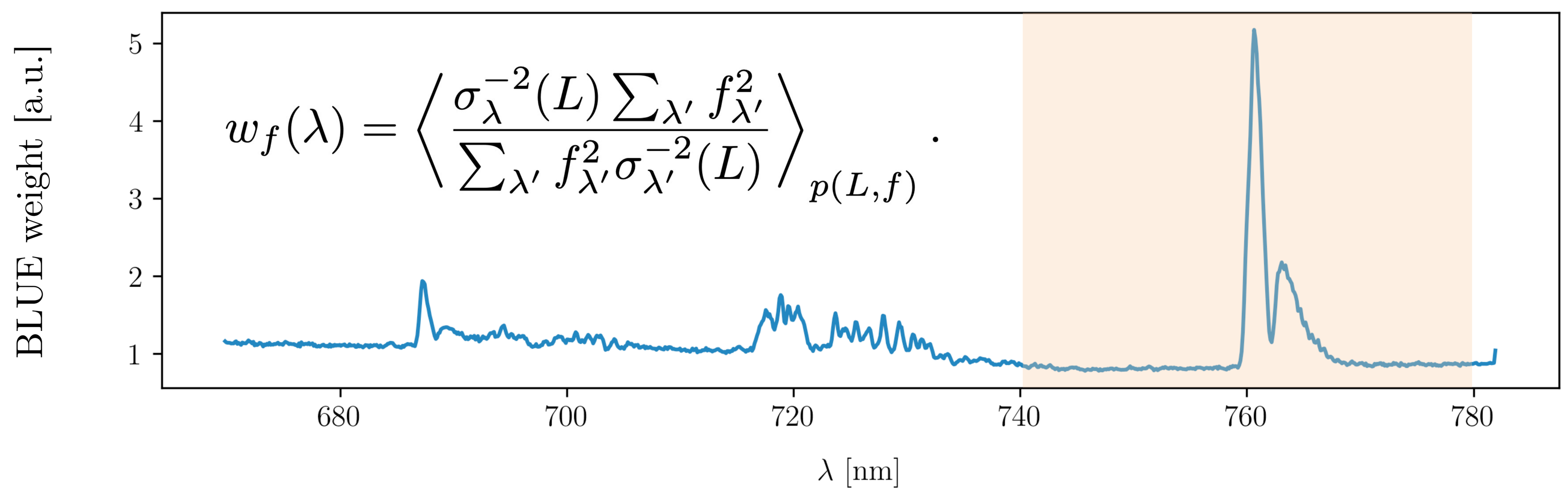
## Sun-induced fluorescence: assessing photosynthesis remotely



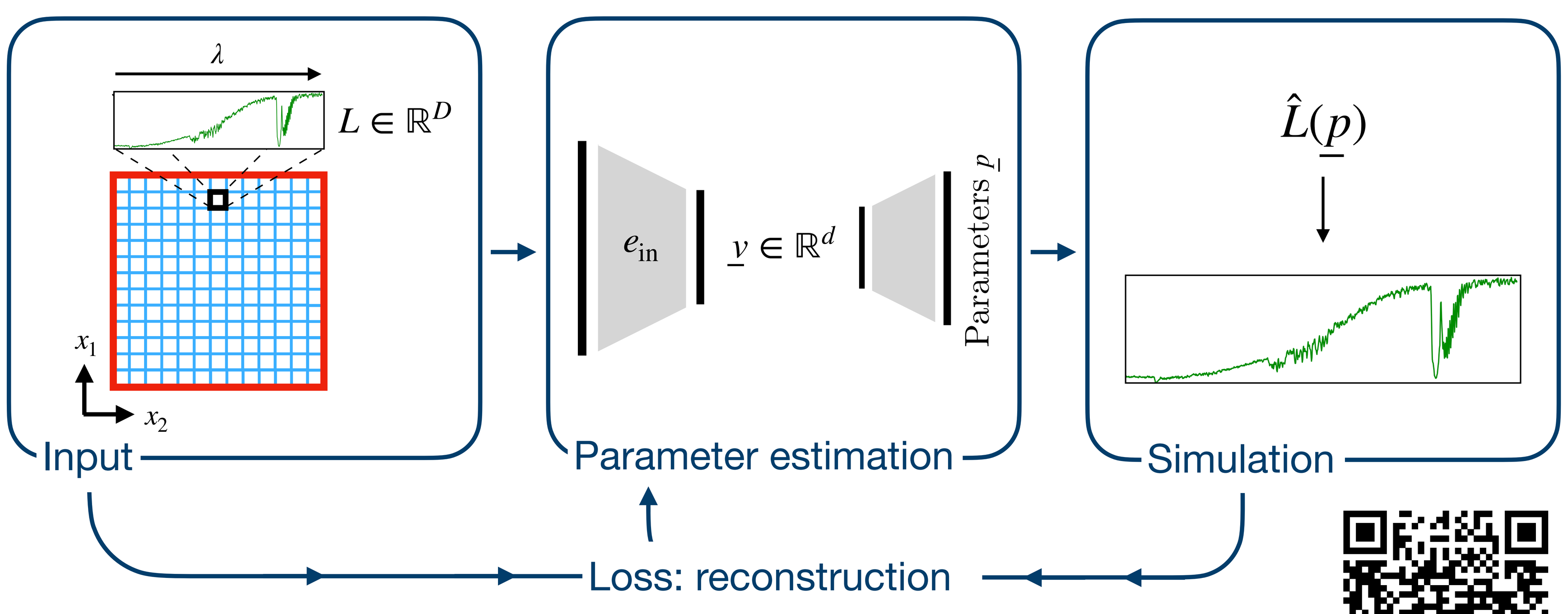

## HyPlant: hyperspectral imagery for SIF retrieval from airborne and spaceborne platforms






## Self-supervised training set-up




Updated preprint

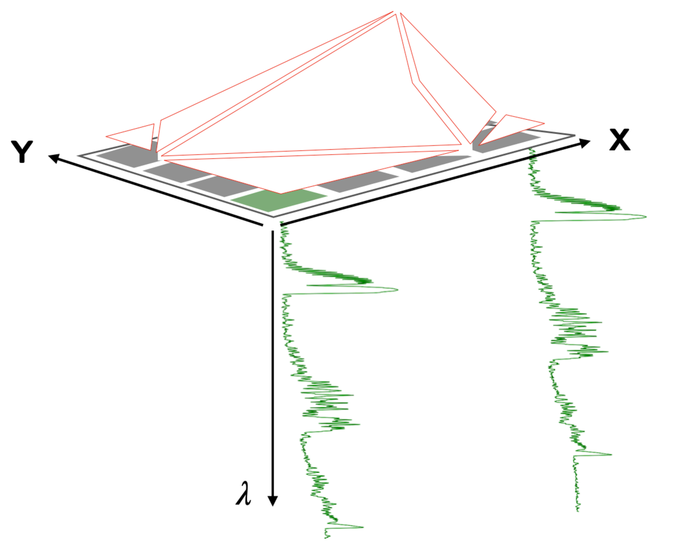
## Loss and constraints for label-free training

$$\ell(L,\hat{L}) = \left\langle \left(L_\lambda - \hat{L}_\lambda\right)^2 + \gamma_f \left(w_f(\lambda)\left(L_\lambda - \hat{L}_\lambda\right)^2\right) \right\rangle_{\delta R=0}$$

$$+ \gamma_N \hat{f}\, \delta\left(\mathrm{NDVI}_L < \tau\right) + \gamma_a \mathrm{ReLU}(\hat{t}_{\mathrm{tot}} - 1)$$

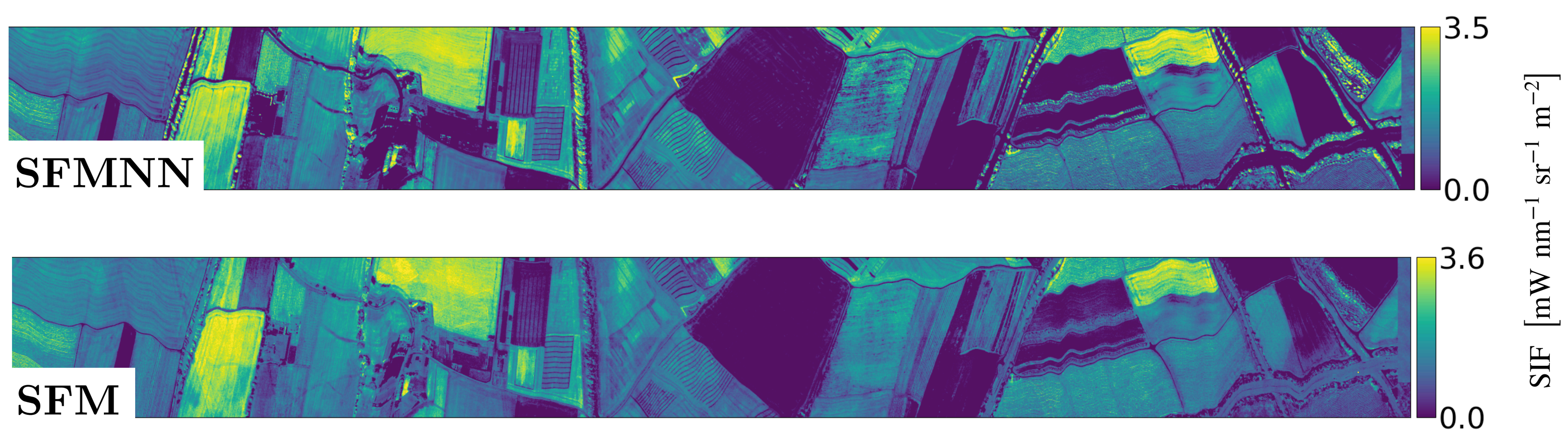
Overall reconstruction MSE — BLUE weighted MSE — Signal constraint — Physical constraint

- **Loss constraints**
  - Sensor: BLUE weighting
  - Signal source: NDVI
  - Physical atmosphere
- **Architectural constraints:**
  - differentiate between patch-wise and pixel-wise prediction




## Comparison with in-situ SIF measurements


| Data Set | | r | MAE | N |
|---|---|---|---|---|
| SEL-2018 (600m) | SFM | 0.89 | 0.80 ± 0.10 | 11 |
| | SFMNN | **0.96** | **0.68 ± 0.08** | 11 |
| | iFLD | 0.80 | **0.67 ± 0.08** | 10 |
| WST-2019 (1500m) | SFM | -0.36* | 0.46 ± 0.05 | 22 |
| | SFMNN | **0.62** | **0.19 ± 0.03** | 22 |
| | iFLD | -0.59 | 4.81 ± 0.09 | 22 |
| CKA-2020 (350m) | SFM | **0.90** | 0.36 ± 0.04 | 37 |
| | SFMNN | 0.87 | **0.31 ± 0.04** | 37 |
| | iFLD | 0.55 | **0.28 ± 0.05** | 36 |
| CKA-2020 (600m) | SFM | **0.83** | 0.42 ± 0.05 | 23 |
| | SFMNN | **0.83** | **0.24 ± 0.05** | 23 |
| | iFLD | 0.52 | **0.39 ± 0.08** | 23 |
| CKA-2021 (350m) | SFM | 0.64* | 0.44 ± 0.07 | 7 |
| | SFMNN | 0.82 | 0.49 ± 0.08 | 7 |
| | iFLD | **0.87** | **0.12 ± 0.15** | 7 |
| CKA-2022 (350m) | SFM | 0.57* | **0.39 ± 0.13** | 6 |
| | SFMNN | **0.69*** | **0.33 ± 0.16** | 6 |
| | iFLD | -0.88* | 1.13 ± 0.21 | 4 |
| GLO-2021 (1150m) | SFM | 0.89 | **0.24 ± 0.09** | 6 |
| | SFMNN | **0.92** | **0.28 ± 0.14** | 6 |
| | iFLD | 0.81* | 0.74 ± 0.16 | 5 |




## Outlook

- Improved simulation $\hat{L}$ with RTM emulation
- Applied approach to spaceborne DESIS
- Adapting for use with ESA's coming FLEX

The authors gratefully acknowledge computing time on the supercomputer JURECA [1] at Forschungszentrum Jülich under grant no. fluomap-ct.

[1] Jülich Supercomputing Centre. (2021). JURECA: Data Centric and Booster Modules implementing the Modular Supercomputing Architecture at Jülich Supercomputing Centre Journal of large-scale research facilities, 7, A182. http://dx.doi.org/10.17815/jlsrf-7-182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