Generating Daily Gap-filled BRDF Adjusted Surface Reflectance Products with 10 m Resolution Using Geostationary Satellite

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Abstract

Continuous observations from geostationary satellites have been utilized to understand land surface seasonal dynamics and fill data gaps caused by clouds. However, the limited spatial resolution of geostationary satellite products constrained the processes of detecting the terrestrial changes in landscape scale, particularly over heterogeneous areas. Moreover, the variation of sun-target-sensor geometry in geostationary satellites results in diurnal changes in surface reflectance products. To overcome the limitations of geostationary satellite products over heterogeneous areas, we conducted the series of processes: 1) characterizing the effect of the solar and viewing geometry in surface reflectance using the bidirectional reflectance distribution function (BRDF), 2) harmonizing the satellite products from different platforms into a seamless product, and 3) fusing the different satellite products to enhance the spatial resolution of geostationary satellite products. Finally, we adopted spatial and temporal gap-filling methods to achieve daily gap-filled surface reflectance products. For robust application, the results from the integrated process were evaluated in both space and time using hyperspectral maps derived from unmanned aerial vehicle (UAV) and in situ tower-based continuous spectral measurements. We expect the geostationary satellite products with high spatial resolution to uncover the cloud-bound areas towards sensing the changes of the Earth in space and time.

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Q. Can we use geostationary satellite products for generating daily surface reflectance products with 10m spatial resolution?

Challenges and Solutions

1) Spatial resolution → **Spatiotemporal image fusion**
2) Angular effect → **BRDF Correction**
Example of usage → **NIRv = NDVI x NIR** (Badgley et al, 2017)

- Normalized Difference Vegetation Index (NDVI) (Tucker 1979)
- Near-infrared reflectance of vegetation (NIRv) (Badgley et al, 2017)
- For GPP estimation, we recommend 'NIRvP' (Dechant et al., 2020,2022; Baldocchi et al., 2019)

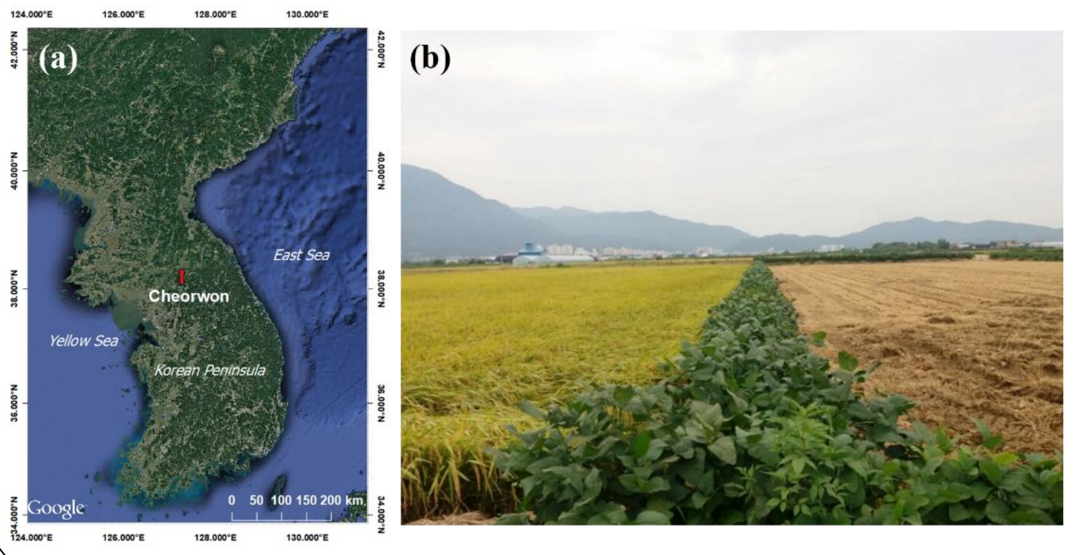
Methods

* All the results derived from 2020 datasets.

Image fusion → **SFSDAF v1.0** (Li et al, 2020)
BRDF Correction → **RossThick-LiSparse model**
Satellite products → **Sentinel 2, Landsat 8, MODIS, GK2A**

- Eddy covariance system includes a three-dimensional sonic anemometer (Model CSAT3; Campbell Scientific Inc. Logan, UT, USA) and an enclosed-path infrared gas analyzer (Model LI-7200; LI-COR Inc., Lincoln, NE, USA)
- The flux data were processed by the KoFlux data protocol including quality control, gap-filling and CO2 flux partitioning (Hong et al. 2009; Kang et al. 2018a; Kang et al. 2018b)
- Hyperspectral system includes hyperspectral sensor (full width at half maximum of 4 nm, Jaz; Ocean Optics, Dunedin, FL, USA) with two optics fibers that equipped with cosine correctors (CC-3; Ocean Optics, Dunedin, FL, USA)

Site



(a) A map of Korean Peninsula (image source: Google Earth) with the study site, which is registered in Korea Flux Network (KoFlux) as well as Asia Flux Network (AsiaFlux), Cheorwon marked in red arrow.
(b) The study site image acquired on 5th September 2017, which shows rice paddy fields with different harvest dates boarded with soybean plants

Overall processes and Results with evaluation

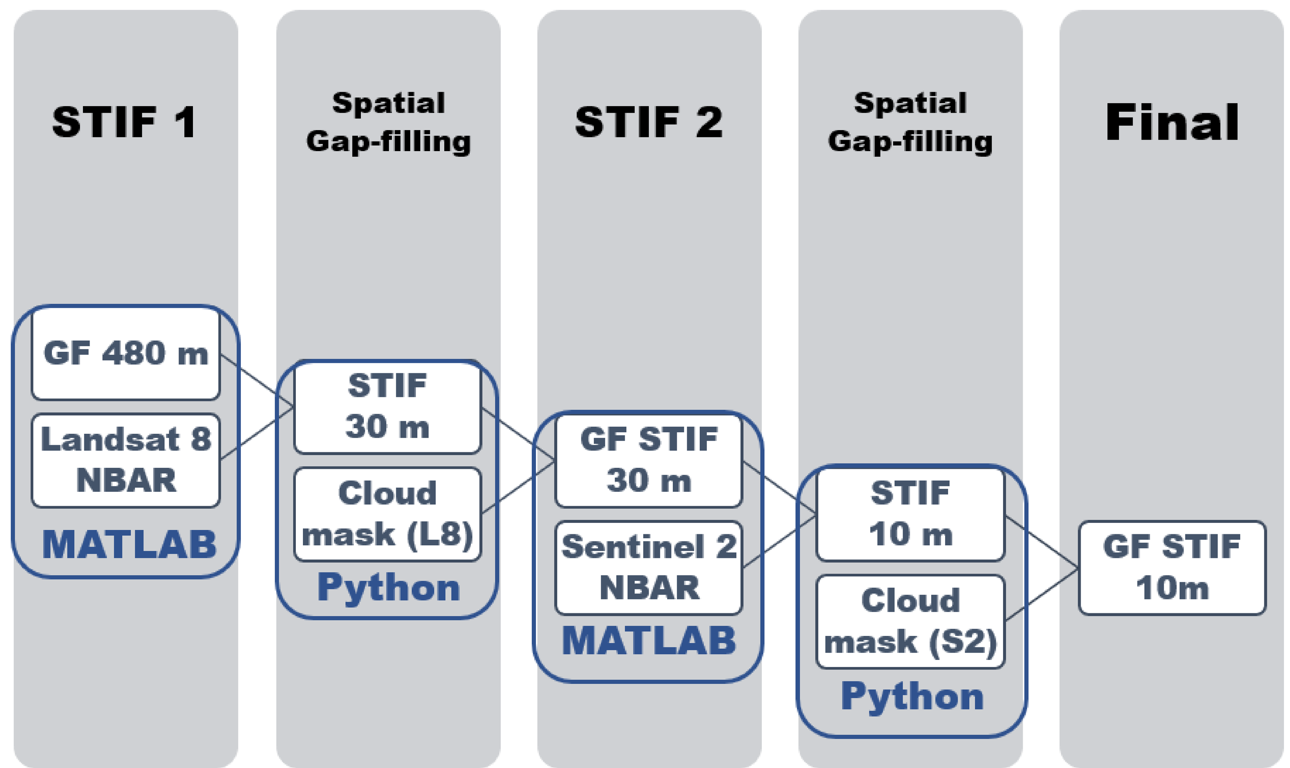


Figure 1 Overall process of spatiotemporal image fusion (STIF) after the preprocessing

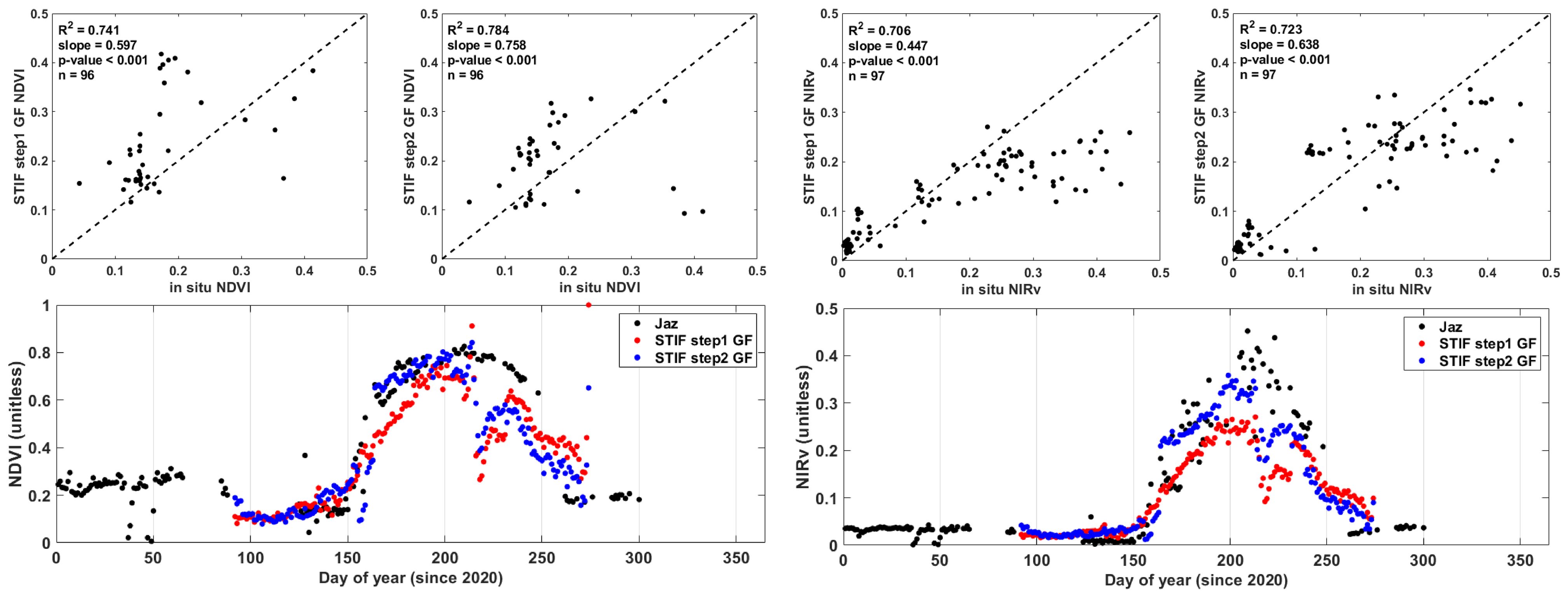


Figure 2 Evaluation of spatiotemporal image fusion products NDVI and NIRv against in-situ NDVI and NIRv

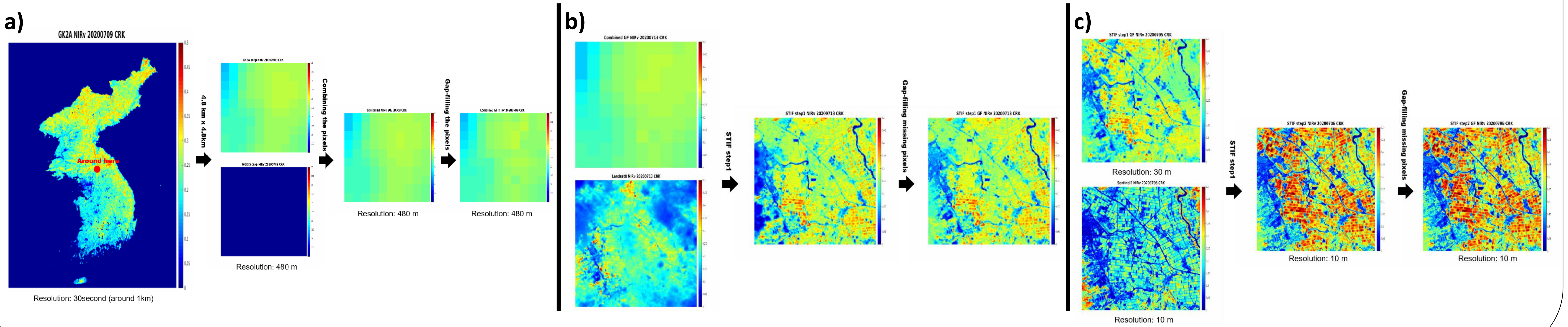


Figure 3 Examples of STIF-based NIRv maps (July 2019). a) Gap-filling the coarse spatial resolution products. b) STIF step1 using 30m resolution SR products c) STIF step2 using 30m resolution SR products

Discussion & Conclusion

1. What causes the uncertainty of STIF based maps?

- For gap-free surface reflectance product, we conducted two gap-filling process, which double the uncertainty.
- Spatial and temporal resolution difference between coarse and fine resolution products were over 10 times.

2. Can STIF based maps detect the spatial heterogeneity over fields?

- STIF based maps can detect the spatial heterogeneity over fields.
- STIF based maps can track the changes of land surface reflectance.

3. The strength of current STIF based map compared to the other STIF

- When using full BRDF inversion produces, MODIS products cannot monitor land surface during the monsoon season. However, Continuous observations from geostationary satellites have been utilized to understand land surface seasonal dynamics and fill data gaps caused by clouds.
- By utilizing continuous observations from geostationary satellites products into STIF, data gaps caused by clouds can be filled and seasonal dynamics can be understood.

Future study

- We expect that further studies evaluate STIF based map over variety of ecosystem

Answer. YES WE CAN.

For precision agriculture and monitoring seasonal variation of GPP over heterogeneous landscape

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