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*Publication date:*  
2017

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Wang, S., Bandini, F., Jakobsen, J., Zarco Tejada, P. J., Liu, X., Olesen, D. H., Ibrom, A., Bauer-Gottwein, P., & Garcia, M. (2017). *Continuous estimation of gross primary productivity and evapotranspiration from an Unmanned Aerial System*. Abstract from 2017 AGU Fall Meeting, New Orleans, Louisiana, United States.

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Continuous estimation of gross primary productivity and evapotranspiration from an Unmanned Aerial System

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Model prediction of gross primary productivity (GPP) and evapotranspiration (ET) using optical and thermal satellite imagery is biased towards clear-sky conditions. Unmanned Aerial Systems (UAS) can collect optical and thermal signals at unprecedented very high spatial resolution (< 1 meter) under sunny and cloudy weather conditions. However, methods to obtain model outputs between image acquisitions are still needed. This study uses UAS based optical and thermal observations to continuously estimate daily GPP and ET in a Danish willow forest for an entire growing season of 2016. A hexacopter equipped with multispectral and thermal infrared cameras and a real-time kinematic Global Navigation Satellite System was used. The Normalized Differential Vegetation Index (NDVI) and the Temperature vegetation dryness index (TVDI) were used as proxies for leaf area index and soil moisture conditions, respectively. To obtain continuously daily records between UAS acquisitions, UAS surface temperature was assimilated by the ensemble Kalman filter method into a prognostic land surface model (Noilhan and Planton, 1989), which relies on the force-restore method, to simulate the continuous land surface temperature. NDVI was interpolated into daily time steps by the cubic spline method. Using these continuous datasets, a joint GPP and ET model, which combines the Light Use Efficiency GPP model (Potter et al., 1993) and the Priestley–Taylor Jet Propulsion Laboratory ET model (Fisher et al., 2008; Garcia et al., 2013), was applied. The simulated GPP and ET were compared with the footprint of eddy covariance observations. The simulated daily GPP has a root mean square error (RMSE) of  $1.56 \text{ g}\cdot\text{C}\cdot\text{m}^{-2}\cdot\text{d}^{-1}$  and a correlation coefficient of 0.87. The simulated daily ET has a RMSE of  $14.41 \text{ W}\cdot\text{m}^{-2}$  and a correlation coefficient of 0.83. This study demonstrates the potential of UAS based multispectral and thermal mapping to continuously estimate GPP and ET for both sunny and cloudy weather conditions.

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