Towards an assessment of photosynthesis from space: Upscaling of PRI reflectance

Thomas Hilker*, Nicholas C. Coops*, Forrest G. Hall†, Alexei Lyapustin†, T. Andrew Black*

*University of British Columbia, Vancouver BC, Canada  
†NASA Goddard Space Flight Center, Greenbelt, MD
Overview

- Remote Sensing of Gross Primary Production (GPP)
- Upscaling to stand-level measurements
- Spaceborne assessment of GPP
- Relevance to HyspIRI mission: Assessment of Biogeochemical cycles (VQ3)
Remote Sensing of GPP

Monteith (1972, 1977):

\[
GPP = \varepsilon \times f_{\text{PAR}} \times PAR
\]

energy input available to system

efficiency, with which absorbed radiation energy gets used (light-use efficiency)
Leaf-level remote sensing of $\varepsilon$

$$PRI = \frac{\rho_{531} - \rho_{570}}{\rho_{531} + \rho_{570}}$$

Leaf Pigments

Gamon et al., 1992, 1993 ...
Upscaling $\varepsilon$ beyond leaf level

$\rho_{PRI} \propto (\varepsilon, Q, \text{BRDF}, \text{AOT}, \zeta)$

$\varepsilon = \text{Physiological status of the canopy}$

$Q = \varepsilon$

$\text{BRDF}$

$\zeta = \text{Footprint of satellite pixel}$

$\rho_{PRI} \propto (\varepsilon, Q, \text{BRDF}, \text{AOT}, \zeta)$
I. Stand level remote sensing of $\varepsilon$

Automated Multi-Angular Spectro-radiometer
AMSPEC system

@ sunrise to sunset
Establishing BRDF surfaces for strata

BRDF models developed for observations made under different $Q$ and $\varepsilon$ conditions (strata)

Hilker et al., 2008 Remote Sens. Environ., 112
Modeling stand level \( \varepsilon \) (2006)

Accounting for stand level effects

Hilker et al., 2008 Remote Sens. Environ., 112
II. Landscape level:
Comparing Amspec /MODIS footprint

Legend
- view area radiometer
- location DF-49 tower
MODIS footprint

Forward and inverse mapping of up to multiple MODIS pixels

Ungridded (swath)
Determining MODIS footprint

\[ \alpha = \lambda_1 + \frac{1}{2} (\lambda_2 - \lambda_1) \]
\[ \beta = 180 - (\lambda_2 + 90) \]
\[ \gamma = 180 - (\alpha + \beta) \]
Adjusting viewing geometries

Adjusting geometry of AMSPEC to that of each satellite overpass
Multi-angular implementation of atmospheric correction (MAIAC)
Landscape level $\varepsilon$ (2006)

Hilker et al., 2009 Remote Sens. Environ., in press

Gridded, AC using single orbit algorithm (MAIAC)
Using HyspIRI for sensing PRI

- VISWIR provides hyperspectral wavebands at 531 and 570 nm.
- Spatial resolution of 90 m is a great improvement over MODIS (≥ 1000 m).
- HyspIRI allows parameterization of PRI models by vegetation type.
- Pointing ability facilitates multi-angular observations and atmospheric correction.

Spatial and spectral specifications are highly suitable to sense $\varepsilon$ from space.

- Pointing ability facilitates multi-angular observations and atmospheric correction.
Temporal resolution: 24 days

Combining high spatial and temporal resolution satellites
Global Assessment of GPP

Current Amspec sites

Network of ground stations: Verify and upscale PRI-measurements to space

> 400 flux tower sites, spatially discrete observations (image credit NASA)
Conclusions

• Remote sensing of stand level ϵ is possible when carefully considering BRDF
• Spaceborne observations require multi-angle atmospheric correction
• Suggested network of ground based stations can help verifying PRI
• HyspIRI mission will be highly useful to observe fine scale changes in PRI
• Temporal resolution of HyspIRI very useful for seasonal trends, can be complemented
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