The Photochemical Reflectance Index (PRI) – a measure of photosynthetic *light-use efficiency*

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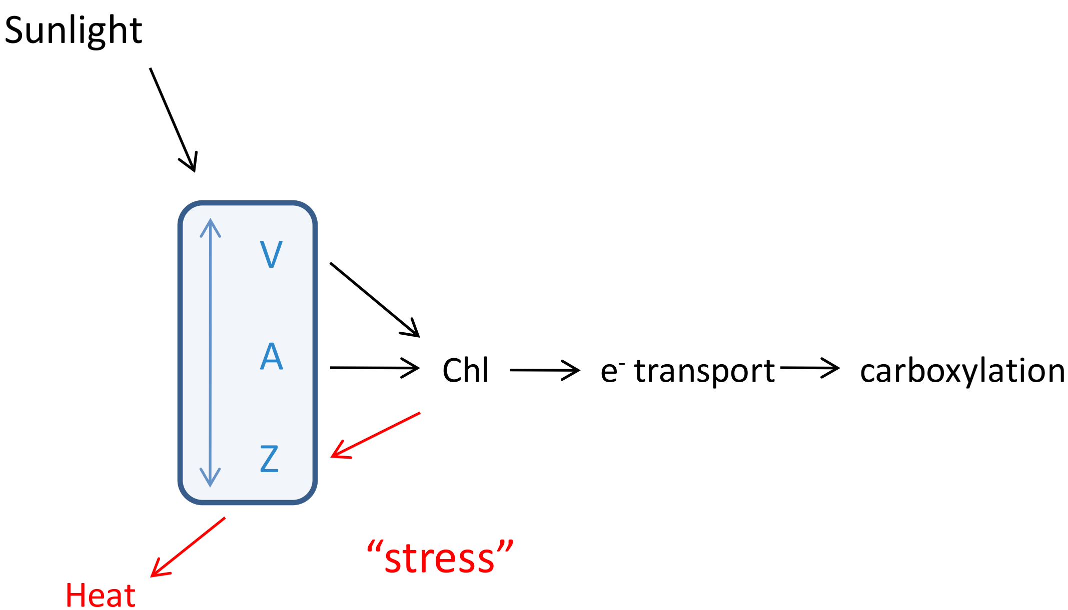
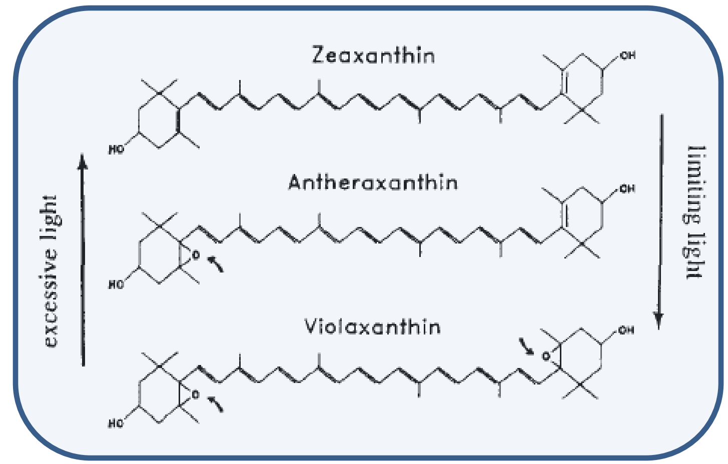
(HyspIRI meeting, May 4, 2010)

PRI Defined

PRI was originally defined as an index of the *xanthophyll cycle activity* on a diurnal time scale.



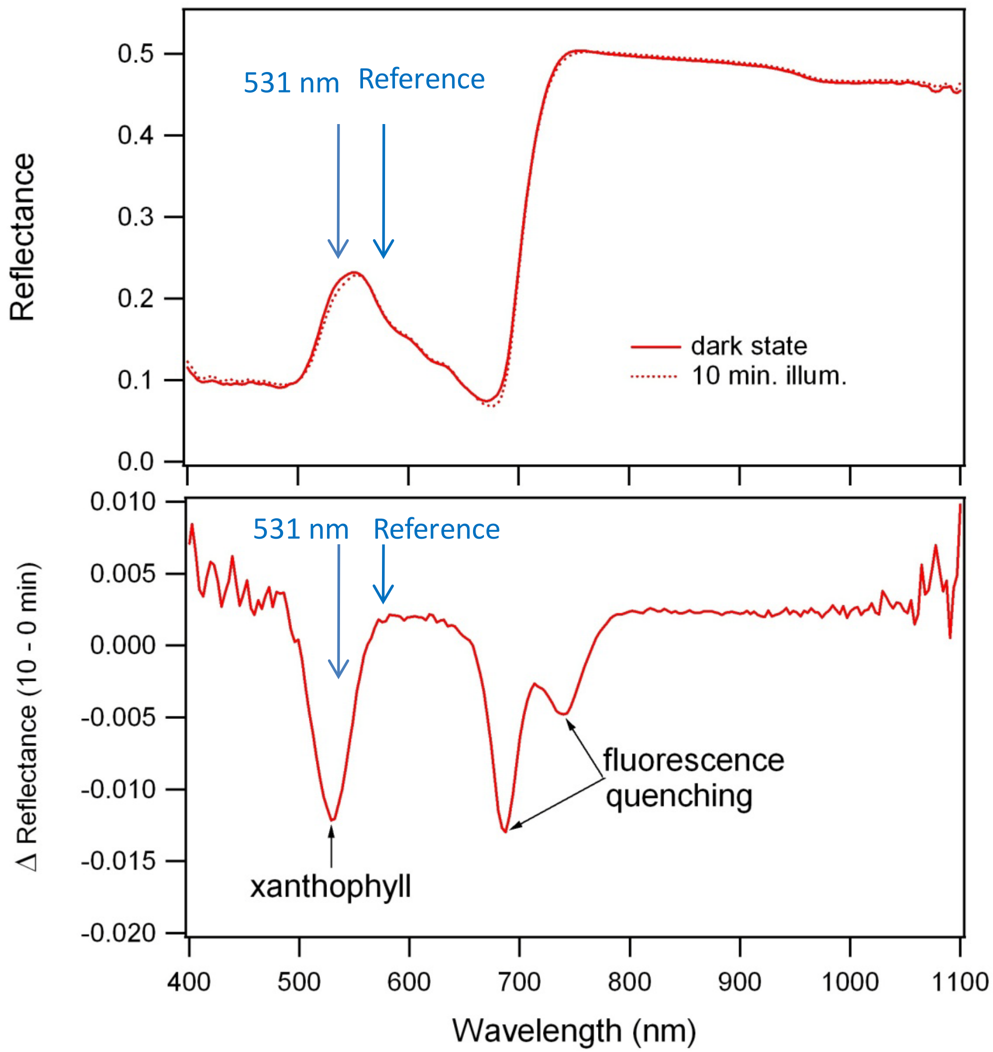


Gamon et al. 1992

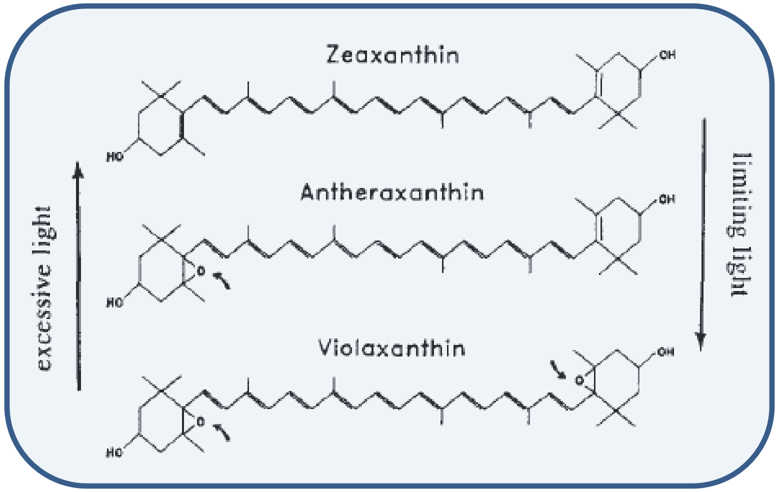
Because xanthophyll cycle pigments adjust the energy distribution at the photosynthetic reaction center, they provide a measure of photosynthetic light-use efficiency (LUE) and indicator of stress.

PRI Defined

The Photochemical Reflectance Index (PRI) measures xanthophyll cycle activity



Gamon & Qiu 1999



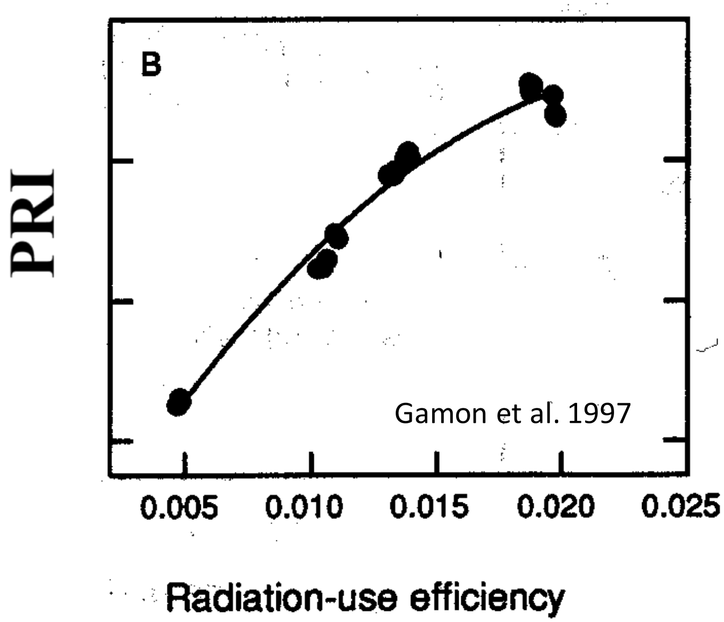
PRI = $(R_{531}-R_{ref})/(R_{531}+R_{ref})$

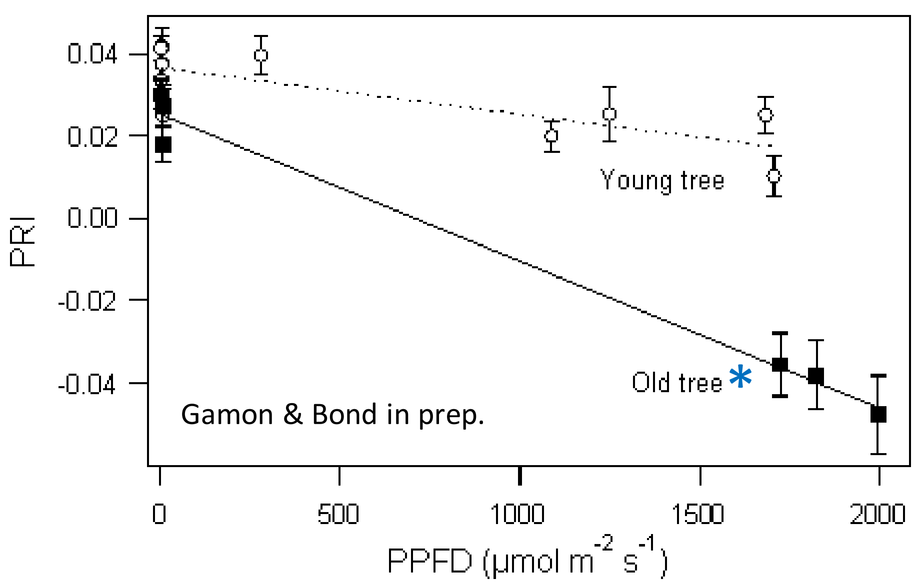
Where reference =
550 nm
570 nm
etc.

Gamon et al. 1992

PRI as a measure of LUE

Because xanthophyll cycle pigments adjust the energy distribution at the photosynthetic reaction center, they provide a measure of photosynthetic light-use efficiency (LUE) .

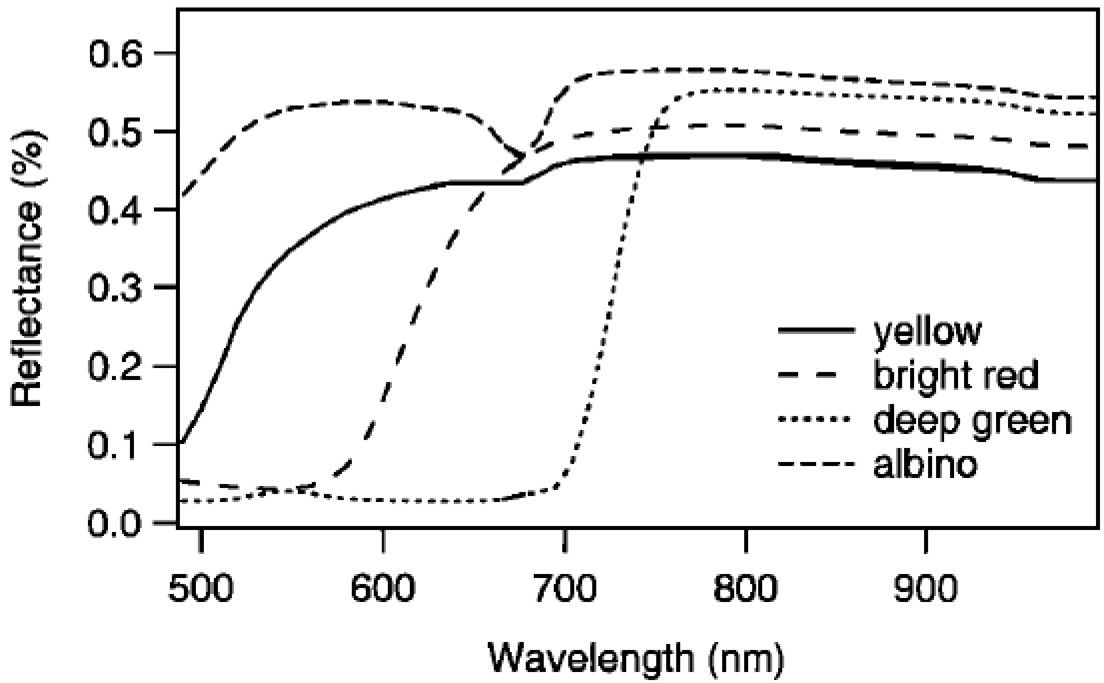




***Midday LUE is reduced for stressed vegetation (downregulation & reduced evapotranspiration)**

PRI Defined

At larger time spans and at progressively larger spatial scales PRI is strongly influenced by other factors (e.g. leaf color, determined by bulk pigment pools, stand structure)



These effects can either confound or amplify the xanthophyll signal

Fuentes et al. 2001

Justification for PRI-type product

Amount of "Green stuff"

Physiological state (stress)

Photosynthetic rate = f(*APAR*) x ε

PRI – carotenoids
Canopy water
Temperature

NDVI

Note synergy

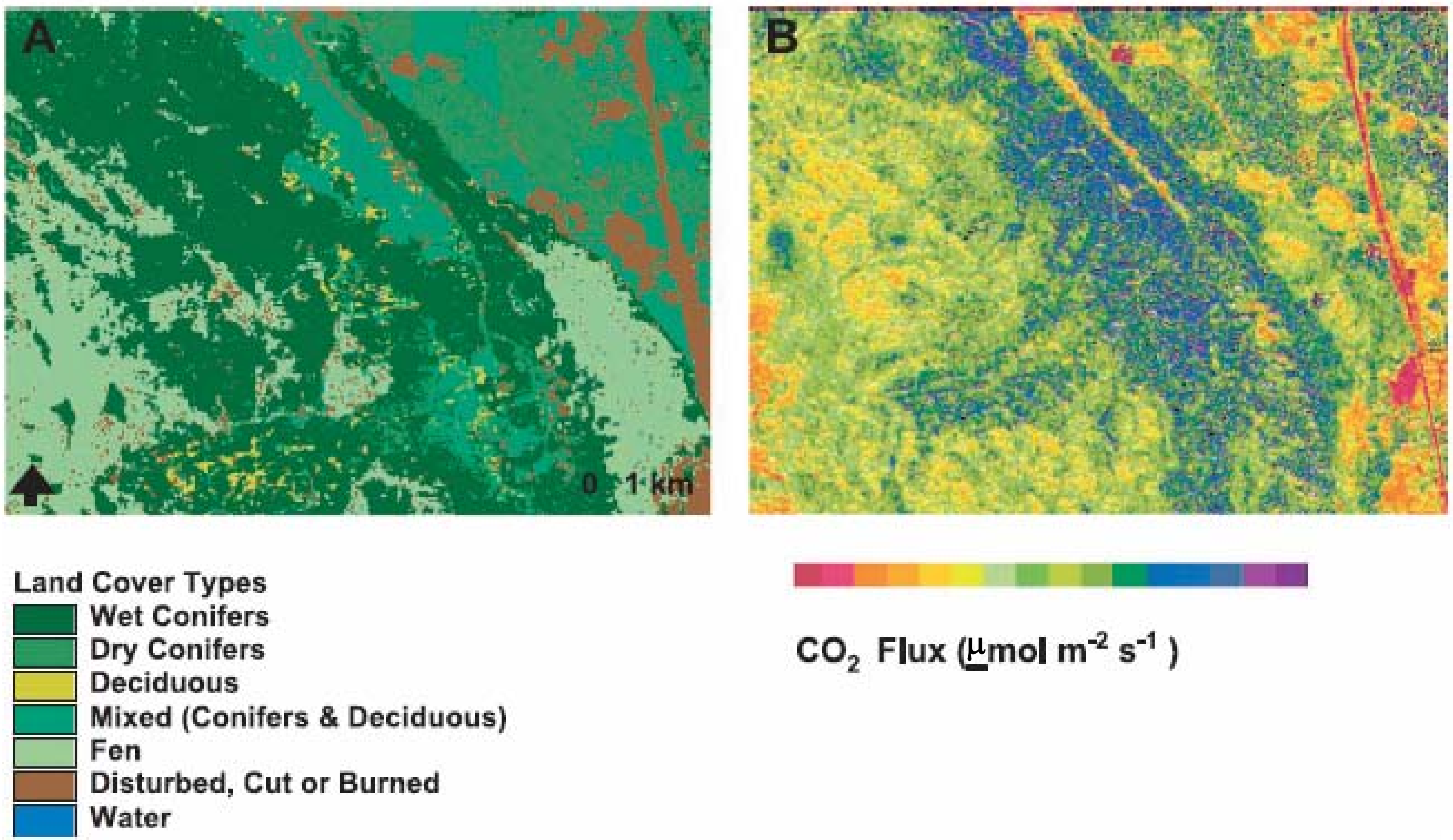
Where:

APAR = Absorbed photosynthetically active radiation

ε = *Efficiency* with which absorbed radiation is converted to fixed carbon

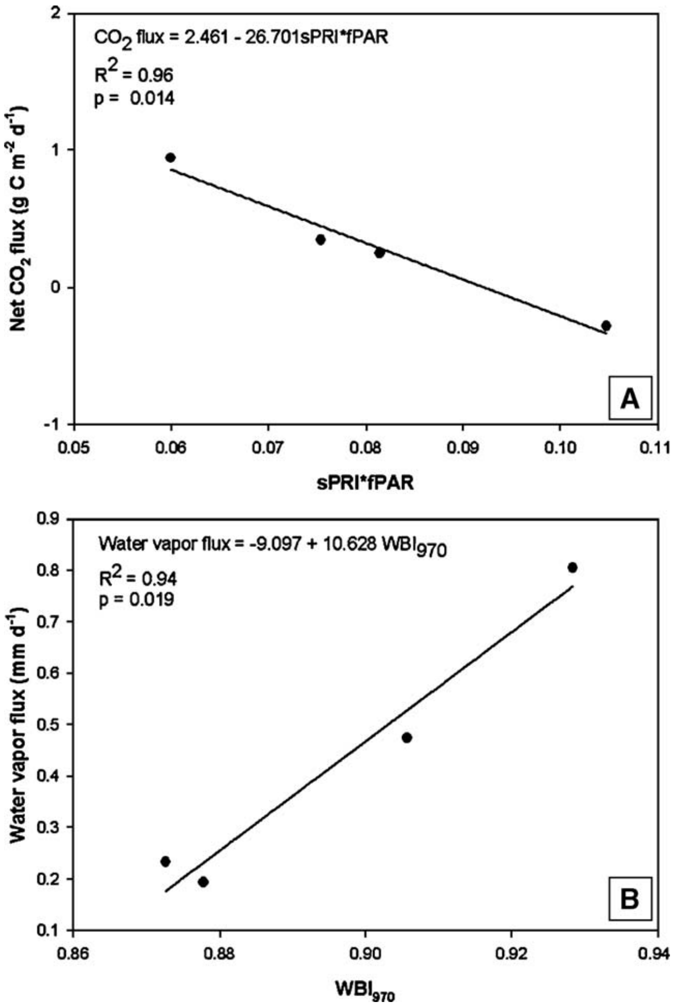
Determination of ε remains a primary challenge
(Field et al. 1998, Running et al. 2009)

An operational PRI product could improve ecosystem carbon flux estimates, capturing physiological change under disturbance, stress, and changing vegetation composition



Fuentes et al. 2001 Rahman et al. 2001

Mapping disturbance impacts on carbon and water vapor fluxes



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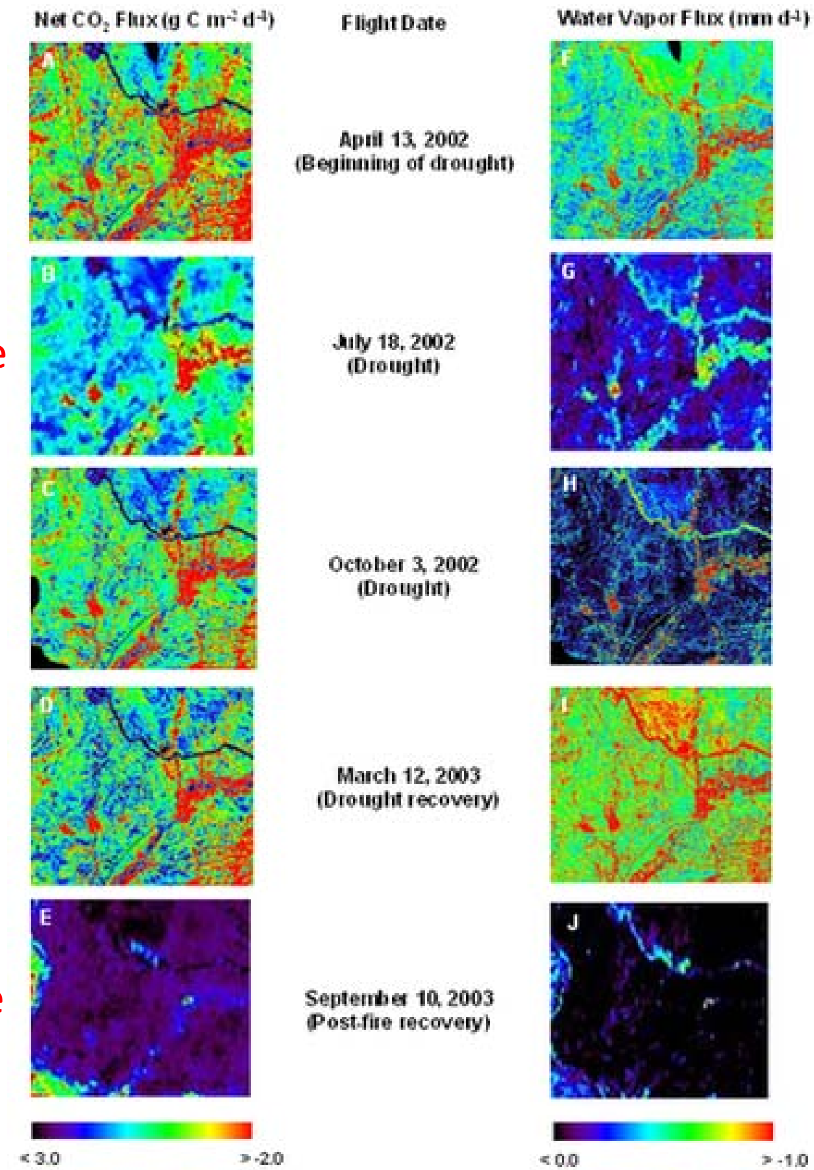


Fuentes et al. 2006

PRI-LUE relationships strongest in backscatter direction (hot spot)

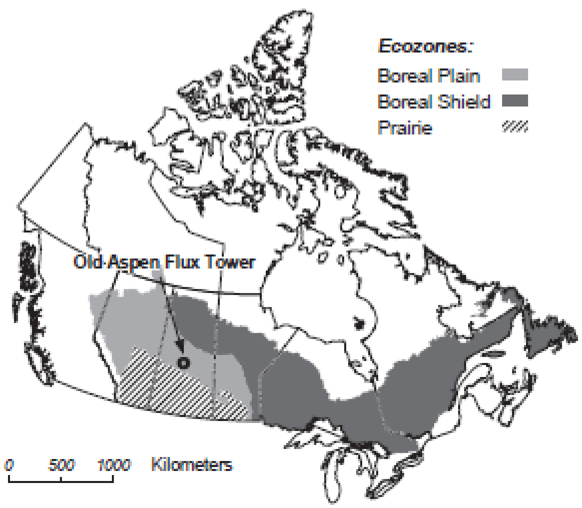
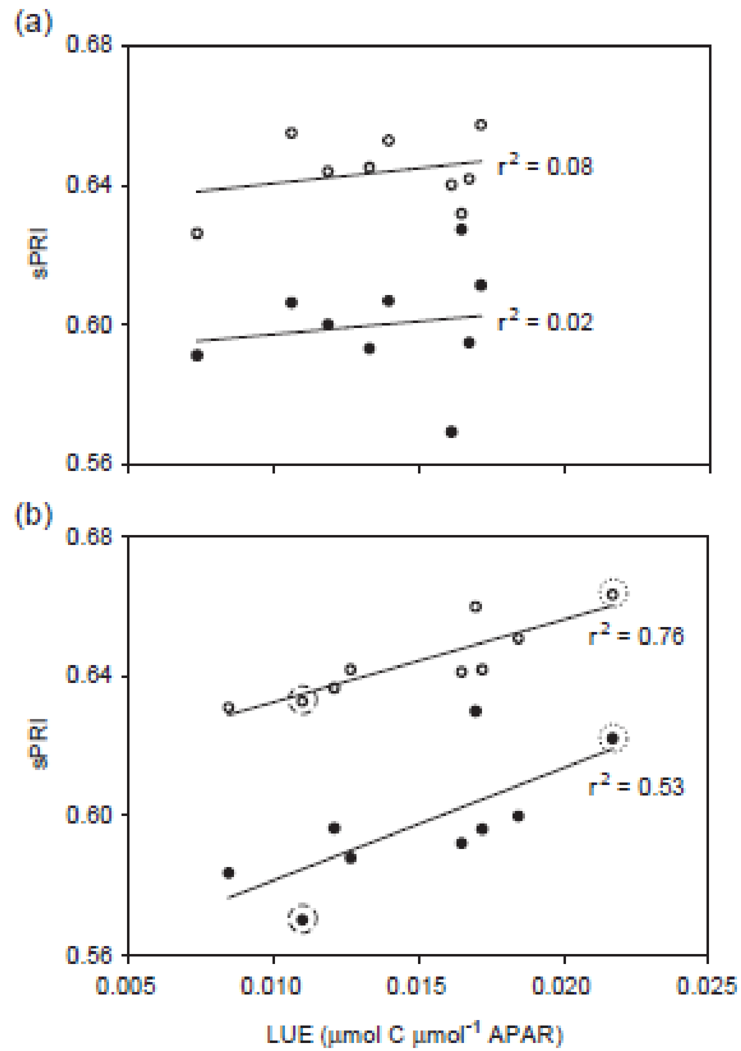


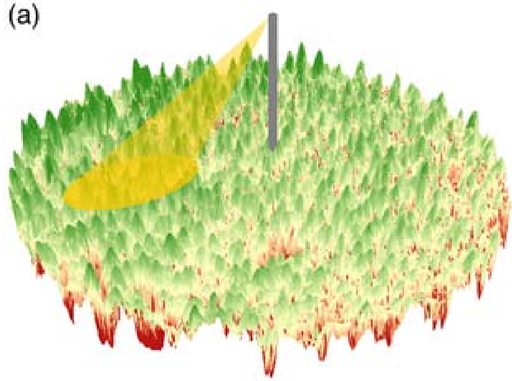
Fig. 1. Location of the study site in Canada.



Drolet et al. 2005

PRI-LUE relationship strongest in backcatter direction (hotspot) where sun exposure is highest

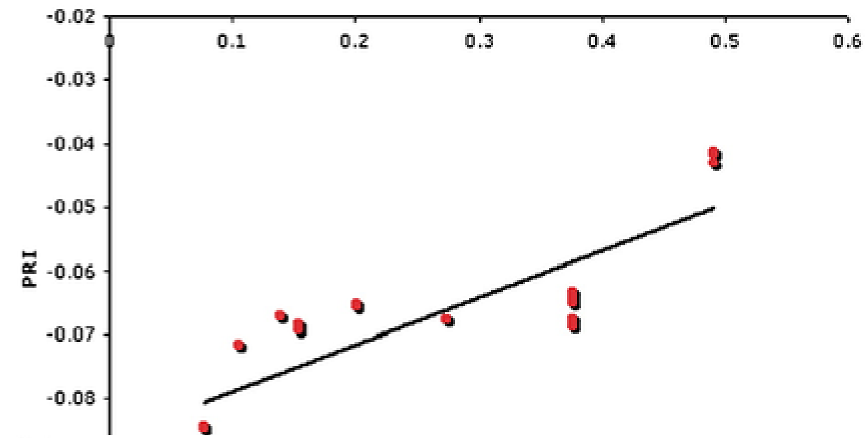
(a)



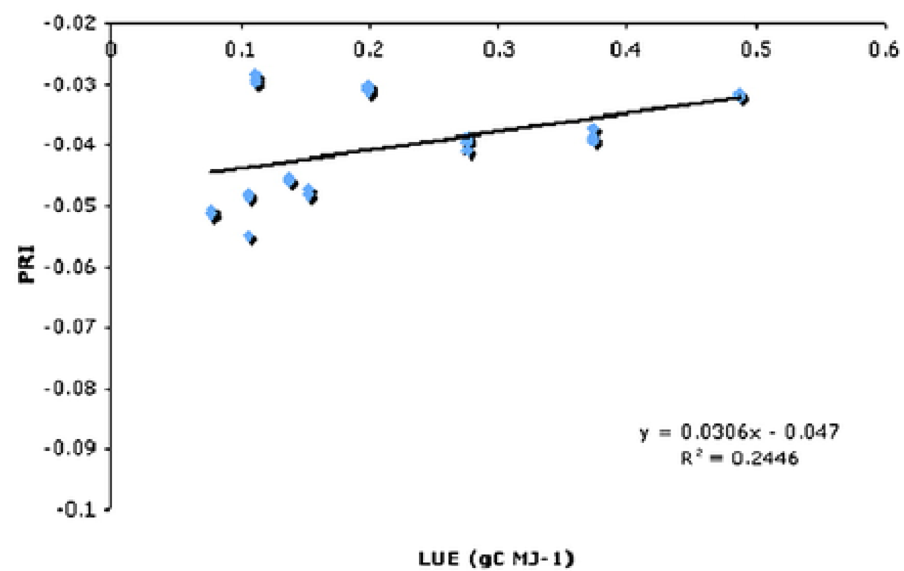
(b)

Hall et al. 2008
Hilker et al. 2008
Middleton et al. 2009

(a)



(b)



Why HyspIRI?

- High Spectral resolution needed*
- Multiple bands provide essential spectral “context”*
  - Choice of reference bands
  - Normalize for green cover
  - Correct for sunlit canopy fraction
  - Synergy with other products
- Spatial resolution needed to resolve uniform vegetation stands
- Temporal coverage can resolve seasonal patterns

**Critical features*

Producing a LUE Product from PRI

$$PRI = (R_{531} - R_{ref})/(R_{531} + R_{ref})$$

$$sPRI = (PRI + 1)/2$$

- Normalize to vegetation “greenness” (pigments, LAI…)

- Correct for sunlit fraction (hotspot effects)

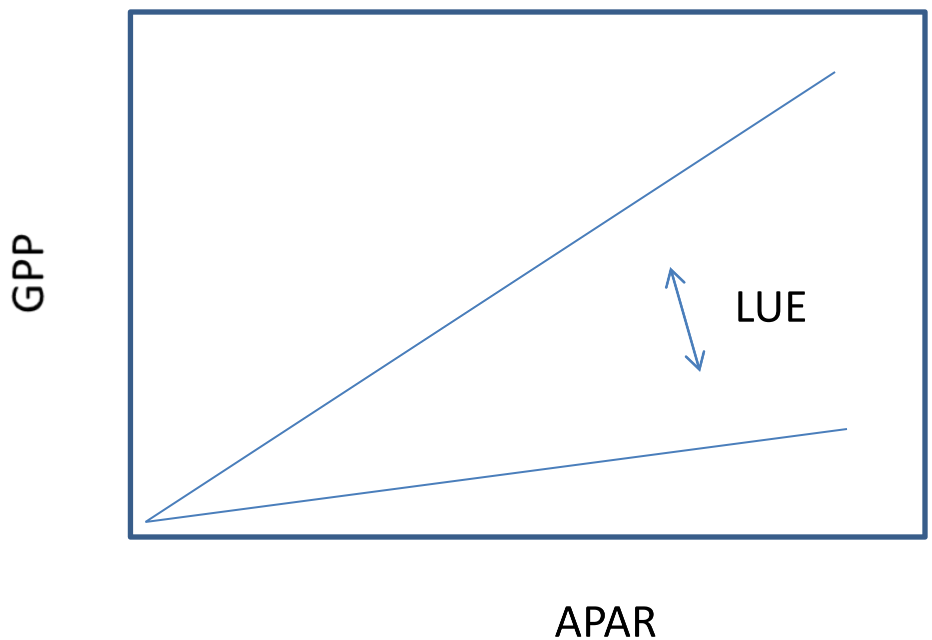
- Stratify for look angle, sun angle (?)

Operational LUE product

?

Canopy temperature & water content

Airborne & field validation still needed
(FLUXNET, SpecNet, BioSpec, COST, SensorVeg)



A "global" LUE metric should be able to account for slope differences between vegetation types or across seasons

Synergy & Links to other products

- Vegetation greenness (e.g. NDVI, EVI, green vegetation fraction…)
- Canopy water content (Water indices, EWT, …)
- Temperature (thermal bands)

Benefits of a HyspIRI LUE product

- Better mapping of *carbon dynamics* (carbon balance) via improved "stress detection" (physiology)
- *Explicit links between carbon, water, and temperature* dynamics (VSWIR-TIR synergy)
- Better characterization of *surface-atmosphere energy feedbacks* (climate modeling)
- Improved *vegetation mapping* (functional diversity)
- Key metric of *"vegetation health"* (economic and human impacts)