Leaf Area Index in Australian Savannas: Comparison of MODIS and Ground-based Observations

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Outline for talk

- Background
- Field campaign snapshots
- Results
- Summary

Background

•**Leaf Area Index** is the one-sided green leaf area per unit ground surface area in broadleaf canopies

- High quality LAI products are needed for water and carbon balance modeling at the regional to continental to global scales
- Validation of moderate scale remote sensing LAI products are seldom done using ground-based LAI measurements
- Assessment of MODIS Collection 5 LAI/fPAR products needed for savannas regions of Australia
- Such validation work presented us with numerous logistical obstacles but also opportunities for initial observations of the vegetation structure and composition

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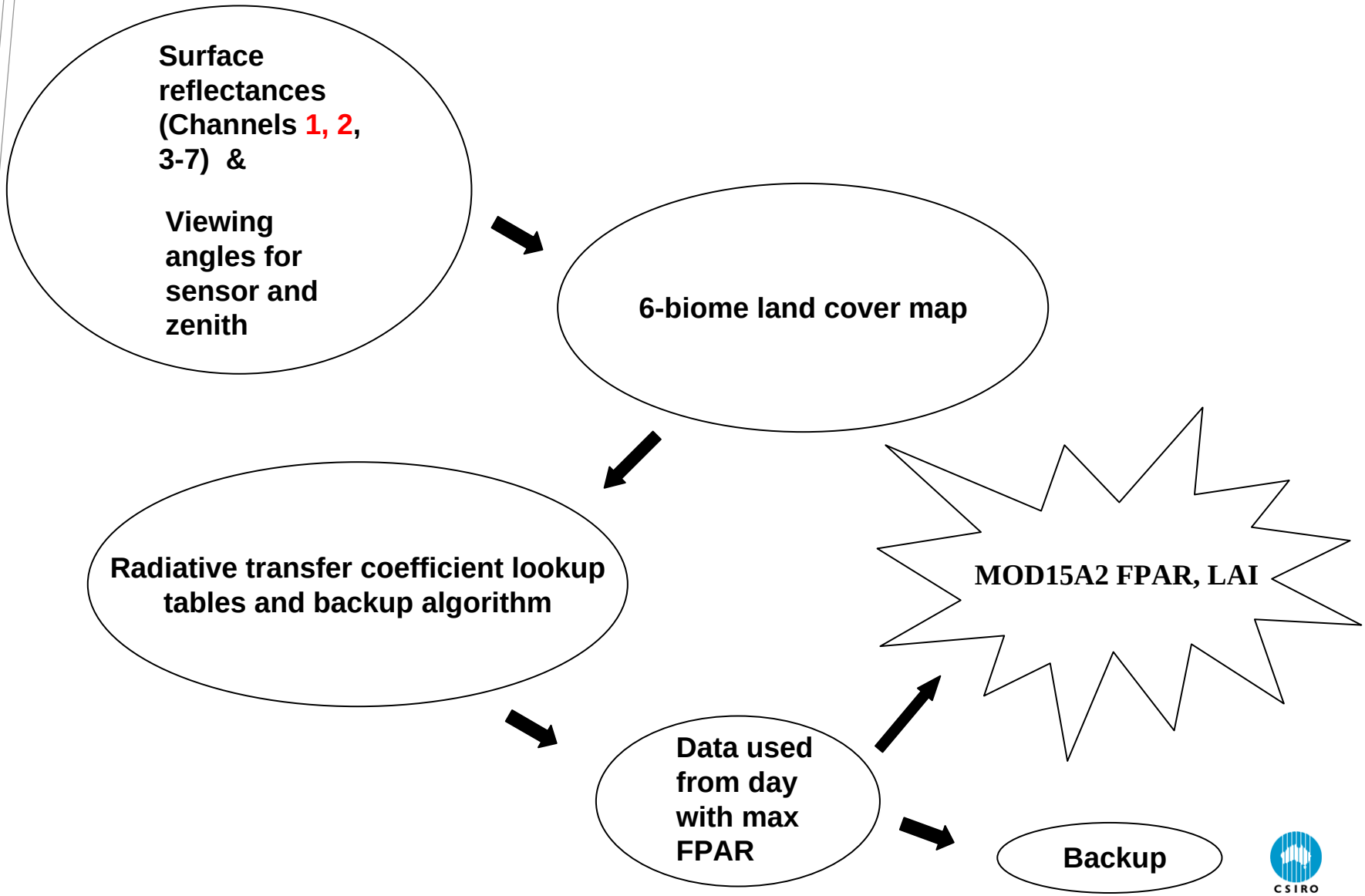
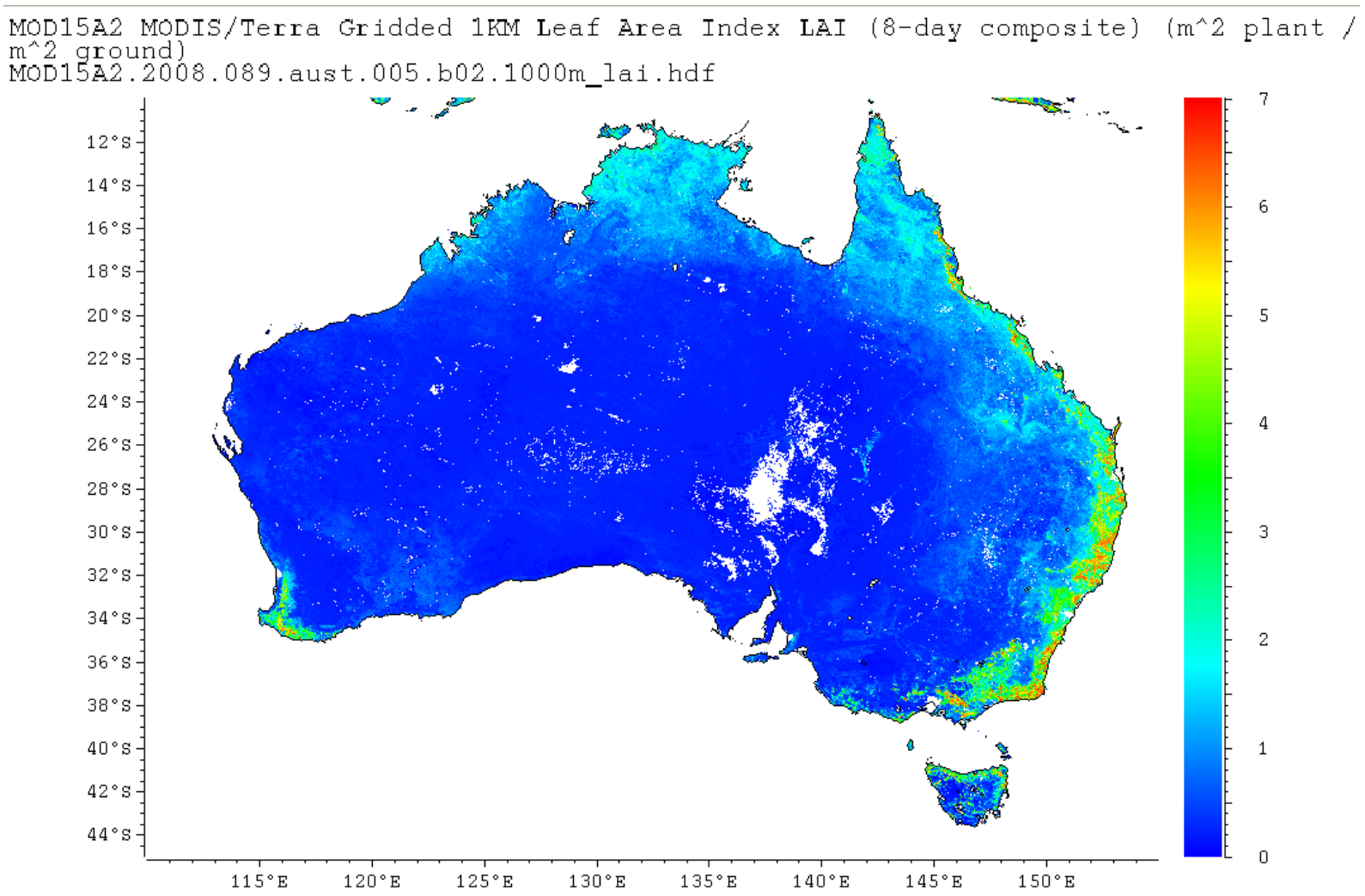
From daily surface reflectances to 8-day LAI





Courtesy of the Water Resource Observation Network

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Savanna Field Campaign

- 1 September-18 September, 2008
- Darwin-Tennant Creek, NT (~900 km) along the Northern Tropical Terrestrial Transect
- Participants from CSIRO, Monash University, Charles Darwin University, Flinders University, RMIT, and various Europeans
- Field measurements coordinated with low level aircraft flights measuring CO_2 and H_20 fluxes, LIDAR and hyperspectral sensors for vegetation structure, and PLMR for soil moisture (coordination meeting 15-16 April in Melbourne).
- We focused our efforts on comparing ground-based measurement of leaf area index with values derived from MODIS Collection 5 LAI/fPAR.
- This allowed us to actually visit the maximum number of landscapes in the Northern Territory during the campaign.

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Principal Research Questions

- How much improved (if any) are LAI estimates using MODIS Collection 5 (MC5) compared with Collection 4 (MC4) in savanna regions of Australia?
- Is there an LAI offset different from zero at low LAI values?
- How well does MC5 LAI compare with ground-based estimates derived from hemispheric photos?
- What is the pattern of LAI along the NATT?

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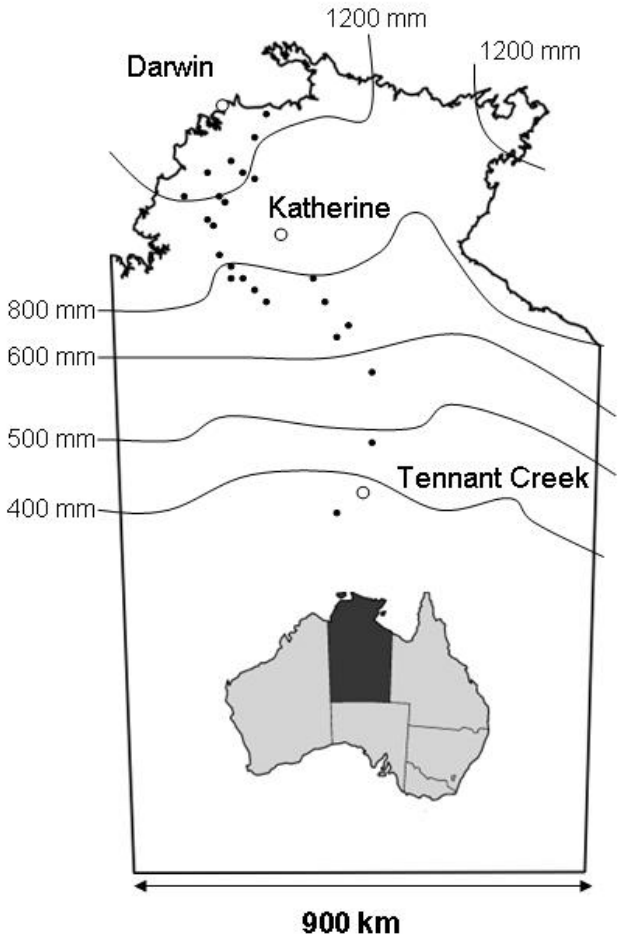
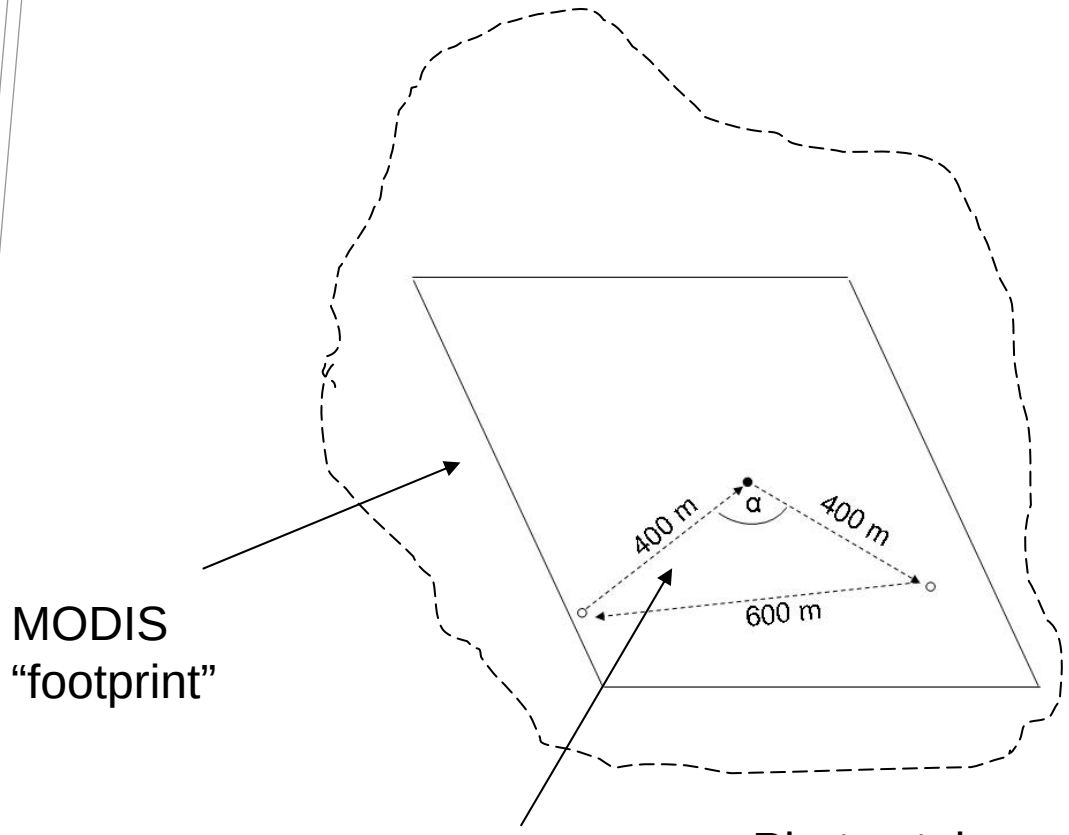
Field sites and rainfall gradient



MODIS pixels & sampling



MODIS
“footprint”

Field
sampling

Photographer: Steve Zegelin

Photos taken ~ every 20 meters
along transects

Advantages of digitial hemispheric photos

Comparison between instruments allowing indirect LAI measurements

System	Illumination conditions	Spectral domain	No. of zenith angles	Azimuthal coverage	Gap size distribution	Reference readings	Post-processing	Computer resources
DEMON	Direct	430 nm	–	–	No	Yes	No	Low
Sunfleck ceptometer	Diffuse, direct	PAR	–	–	Yes	Yes	Yes	Low
AccuPAR	Diffuse, direct	PAR	–	–	Yes	Yes	No	Low
LAI-2000	Diffuse	<490 nm	5	Full range selectable by hardware	No	Yes	No	Low
Tracing Radiation and Architecture of Canopies (TRAC)	Direct	PAR	–	–	Yes	Yes	No	Low
Hemispherical Cameras	Diffuse, direct	Selectable	Full range	Full range selectable by software	Yes	No	Yes	High
Multiband Vegetation Imager (MVI)	Diffuse	VIS and NIR	Full range	Full range	Yes	No	Yes	High
Ideal device	Diffuse and direct	VIS and NIR	Full range	Full range selectable by software	Yes	No	–	–

Interest of digital hemispherical photography (DHP)

- cheap
- Easy to use (illumination conditions)
- No reference measurements
- Possible use over low vegetation canopies
- Directly evaluation of the quality of the measurements (images)
- Possible distinction between green and non green elements
- Possible to derive clumping information

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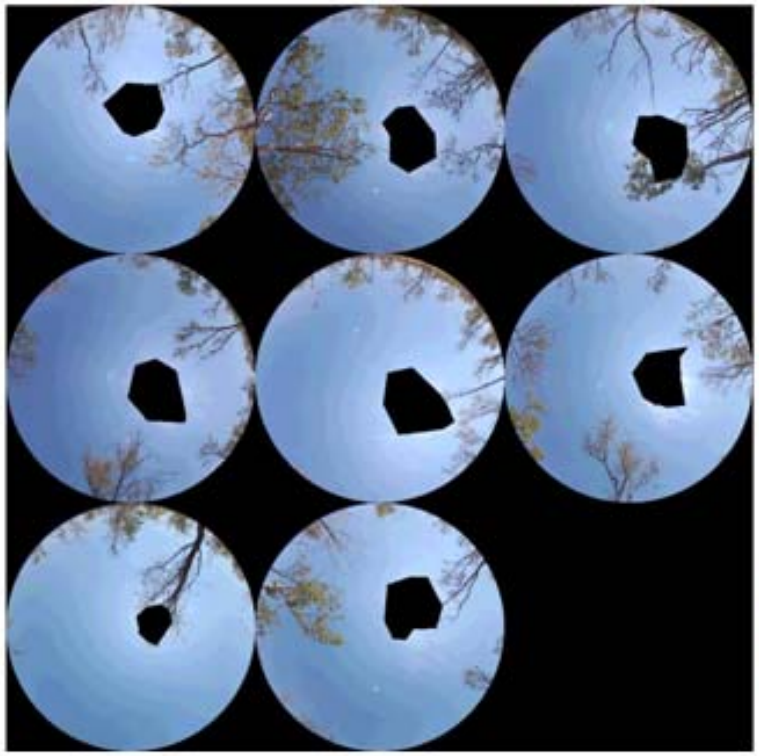
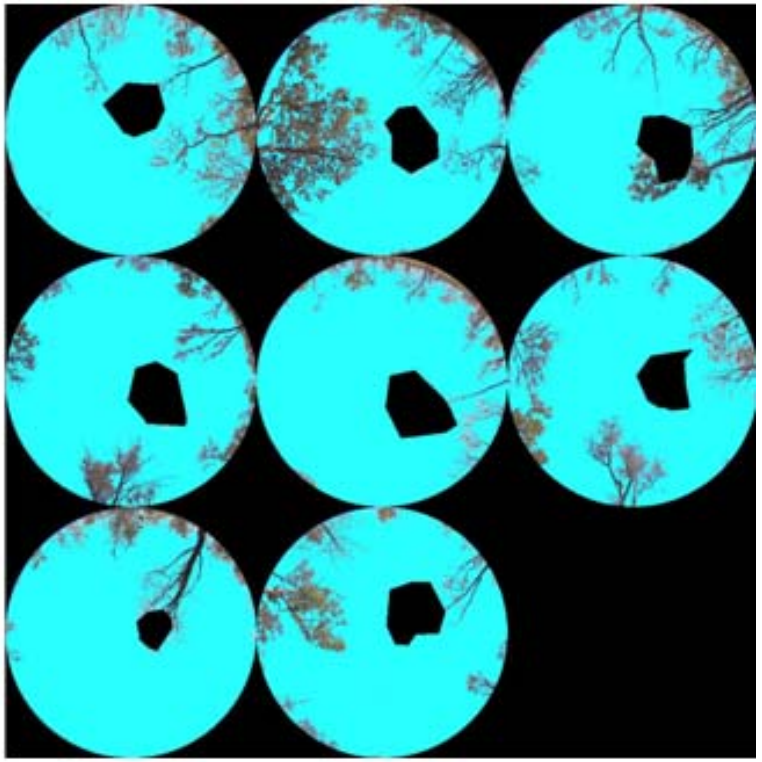
Perfect to not-so-perfect hemispheric photos

Typical Classification using CAN_EYE 5.0 software

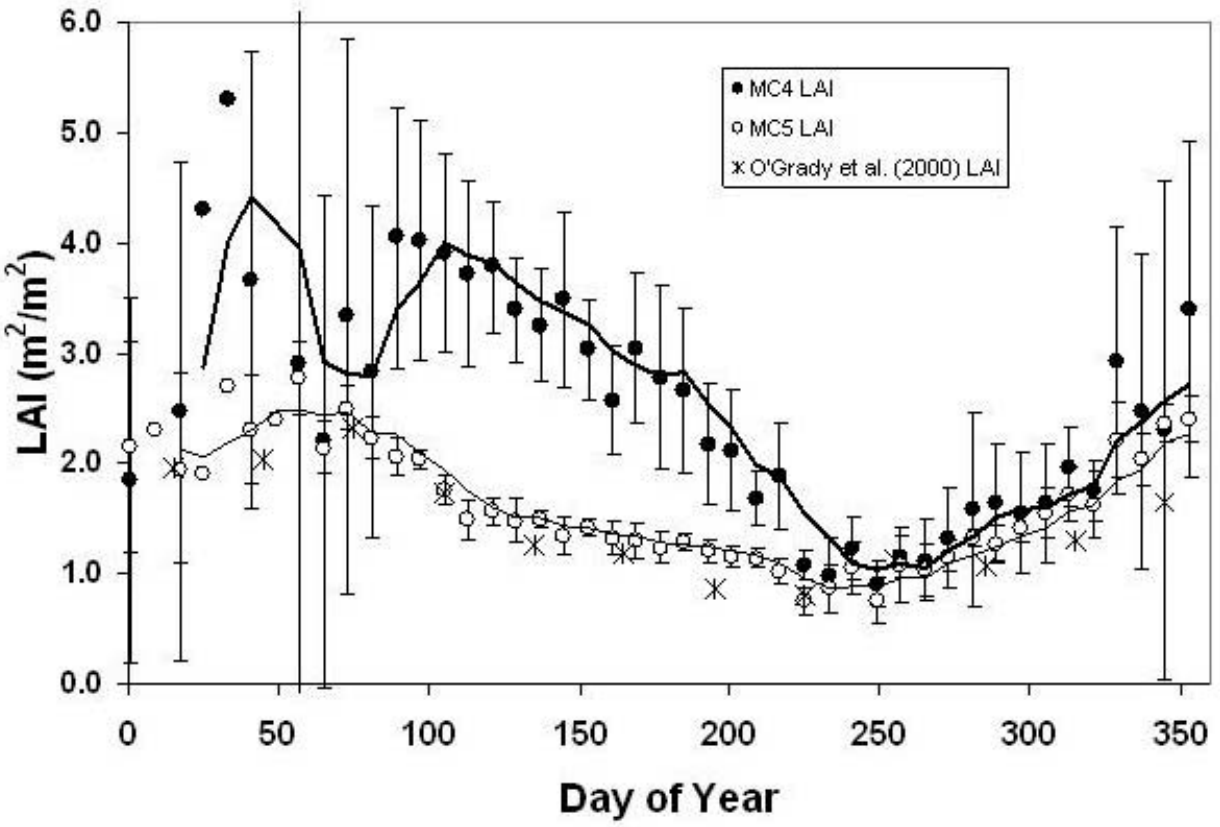




Unclassified hemispheric photos → Two state classification by "filling in the sky"

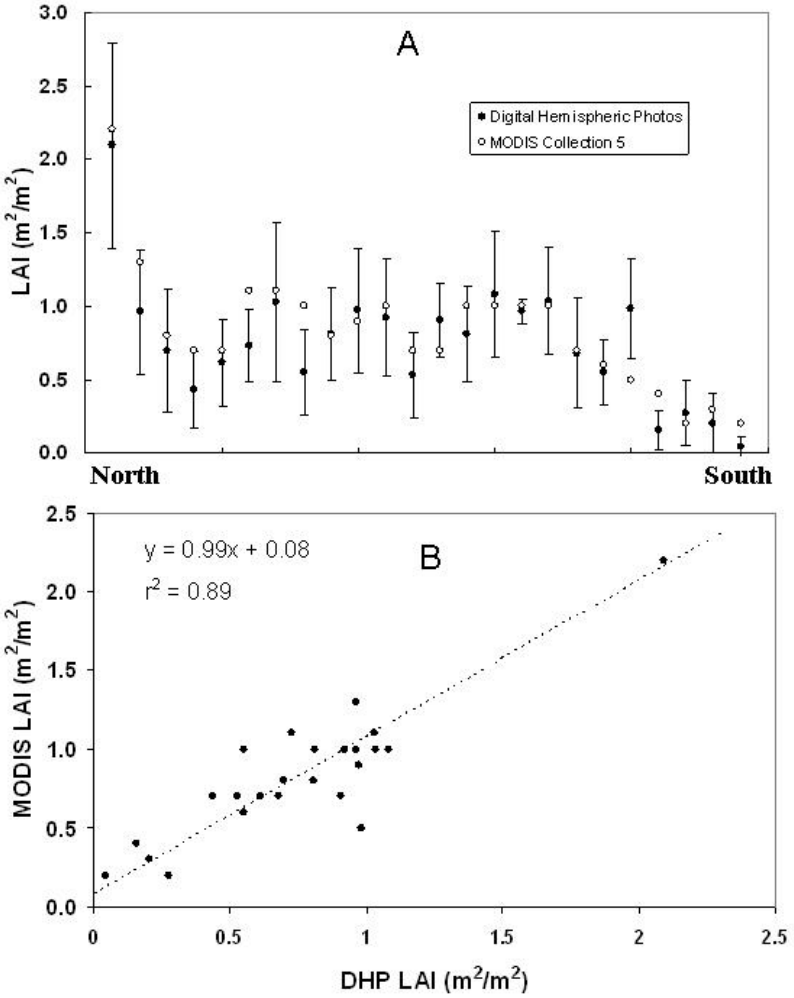
Result 1: Comparison of MODIS Collection 4 and 5

LAI Mean +/- 1 SE



Sea et al. (2009) submitted to Remote Sensing of Environment

Result 2: Comparison of MODIS to hemispheric photos



Sea et al. (2009) submitted to Remote Sensing of Environment

Result 3: Leaf area index where there should be none!

Table 1. LAI offset sampling sites in the Northern Territory.

Site	Latitude	Longitude	Description	Ground LAI	MODIS LAI
1	-14.0103	131.3646	Bare	0.0	0.3
2	-14.0631	131.3167	Senescent	0.0	0.5
3	-17.1517	133.3485	Senescent	0.0	0.2
4	-17.8974	133.9301	Bare	0.0	0.2
5	-17.9918	134.0157	Senescent	0.0	0.2
				0.0	Mean = 0.28 Std = 0.13

Sea et al. (2009) submitted to Remote Sensing of Environment

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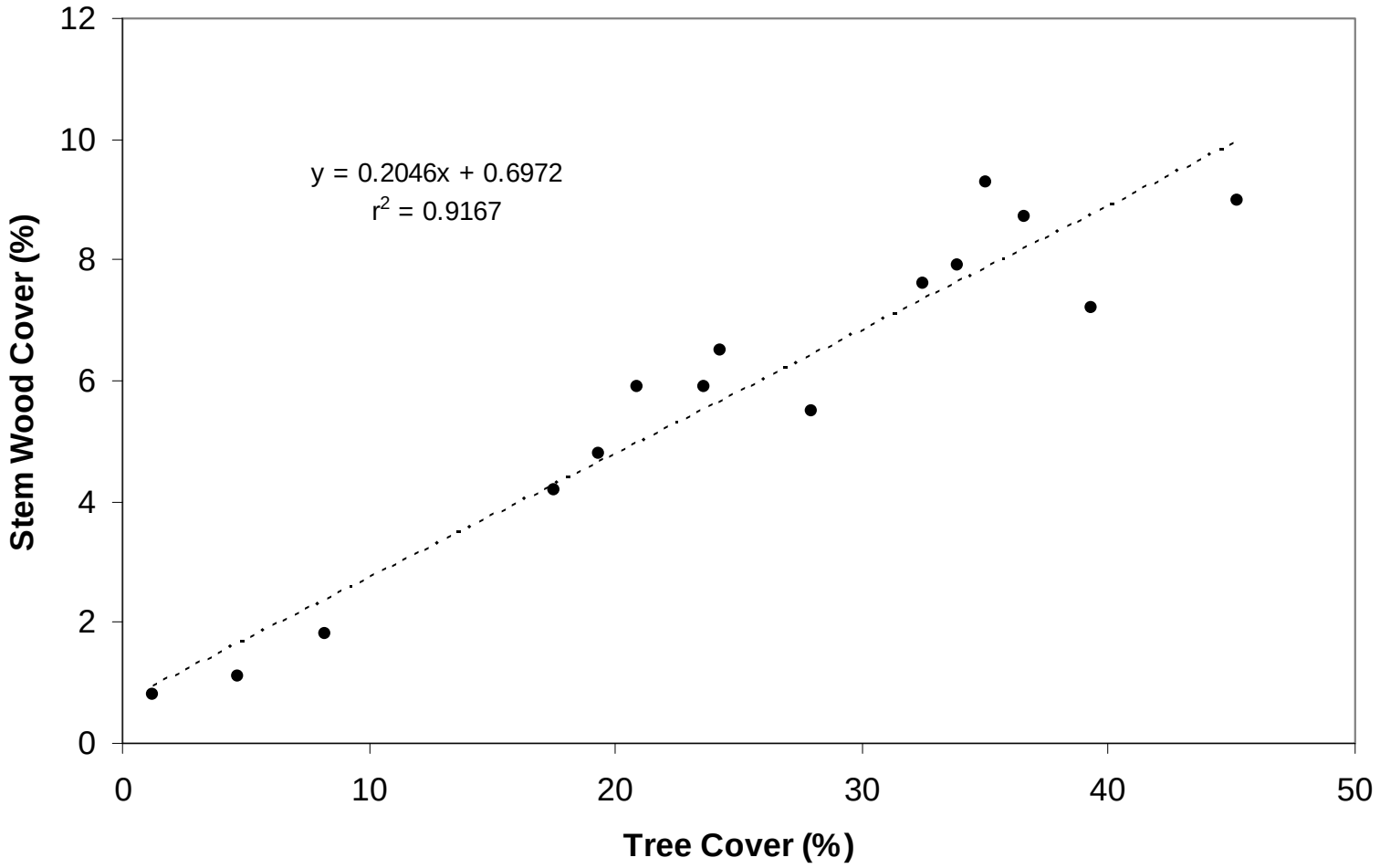
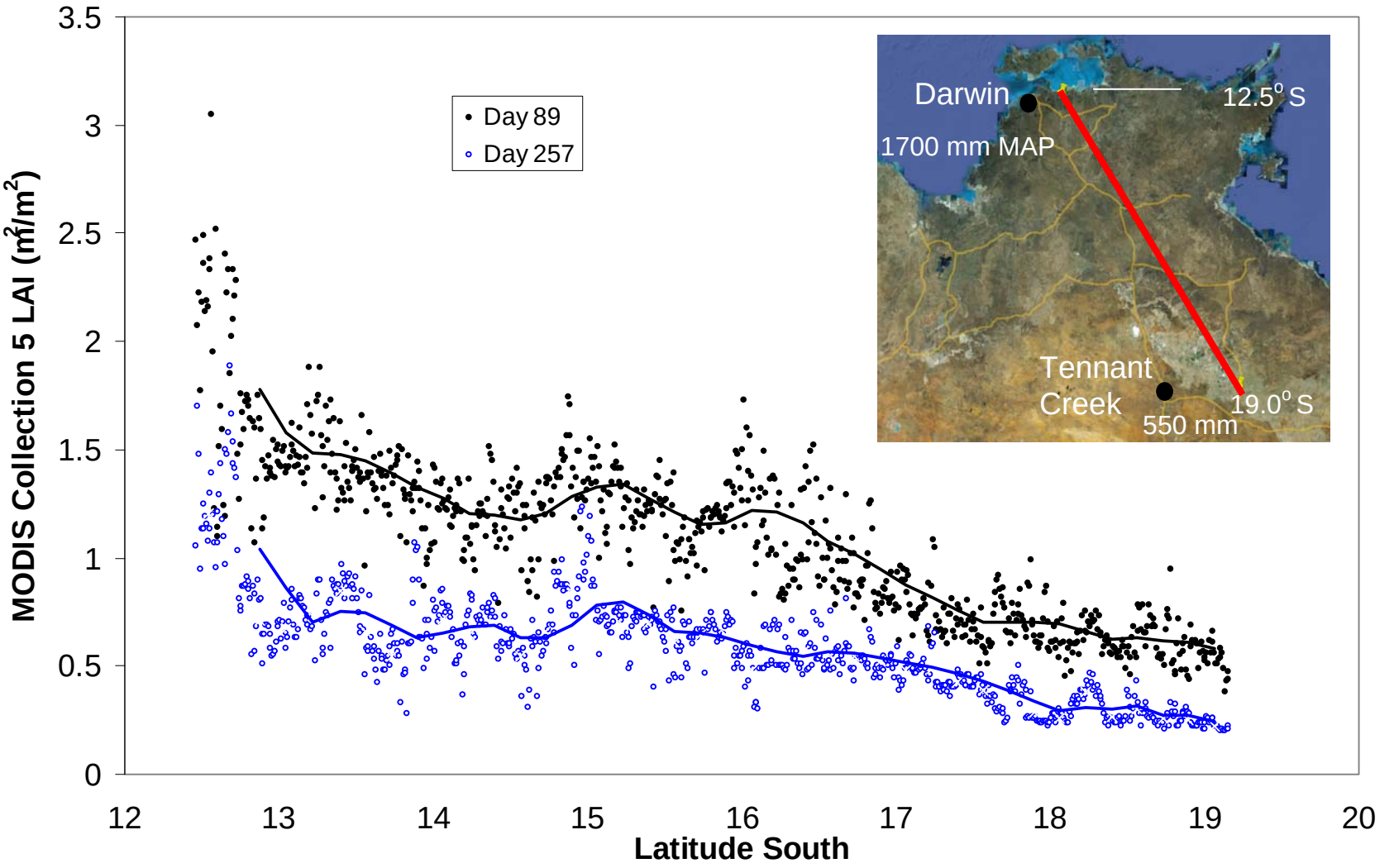
Result 4: Stem LAI ~ 20% of total LAI



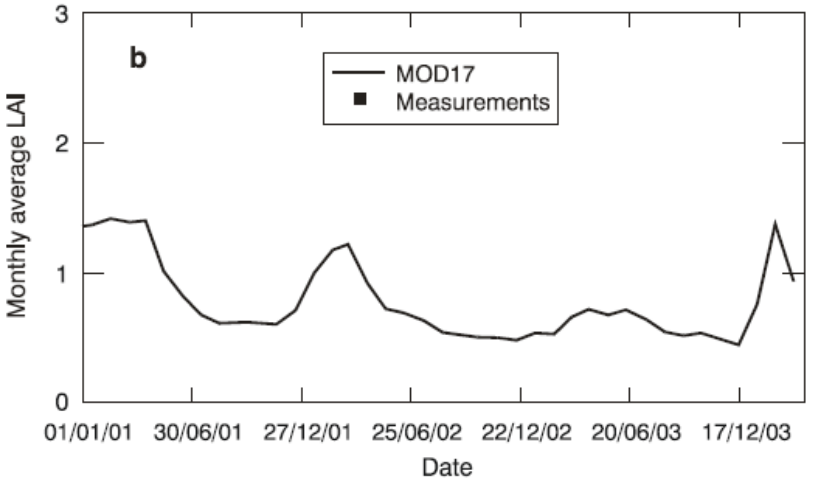
Sea et al. (2009) submitted to Remote Sensing of Environment

Result 5: LAI along the rainfall gradient

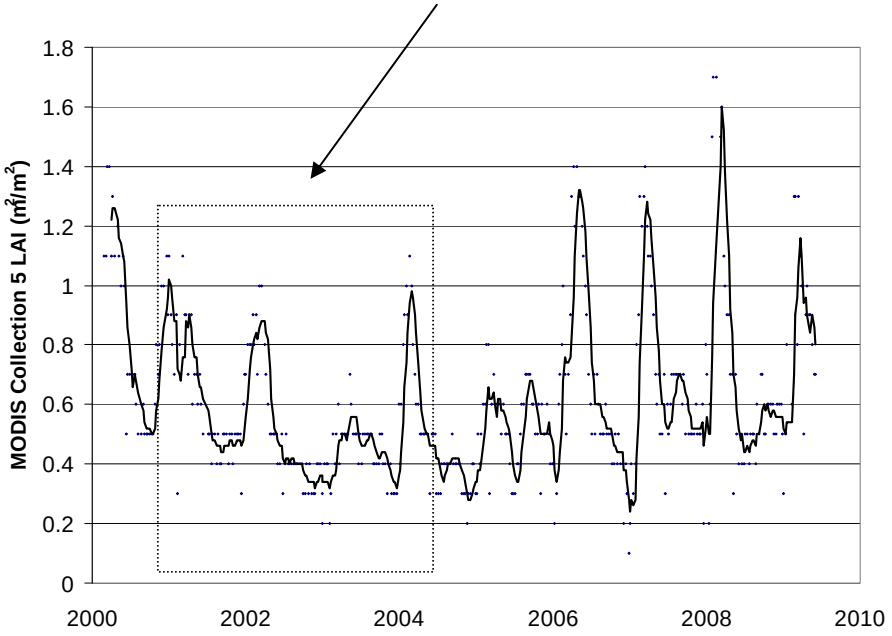


Data via DAAC ONRL MODIS website

LAI at other Ozflux sites: Virginia Park



Leuning et al. (2005)



Data courtesy of DAAC ONRL website

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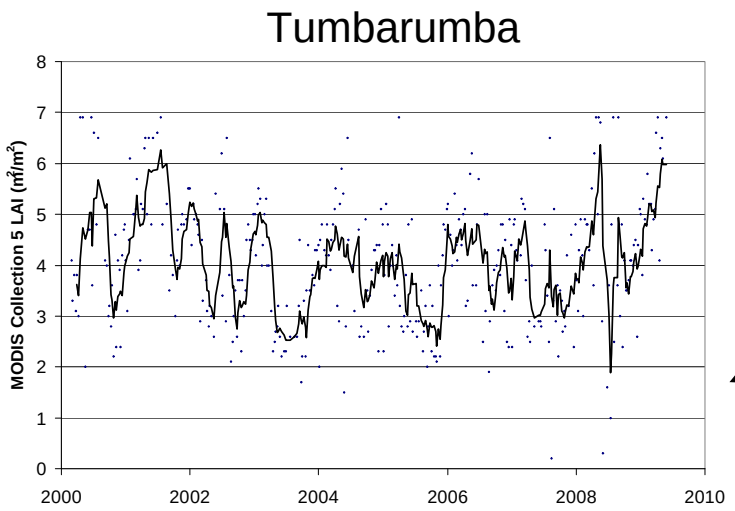
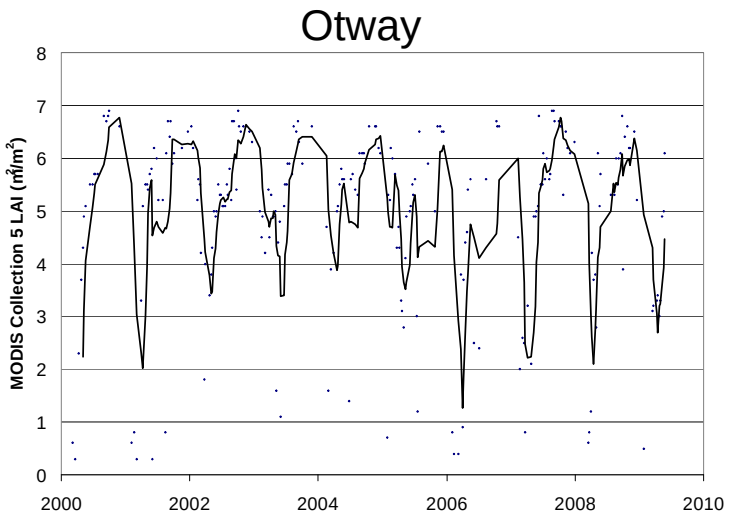
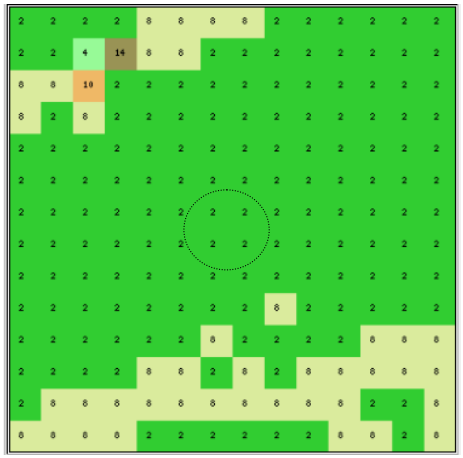
Tumbarumba & Otway

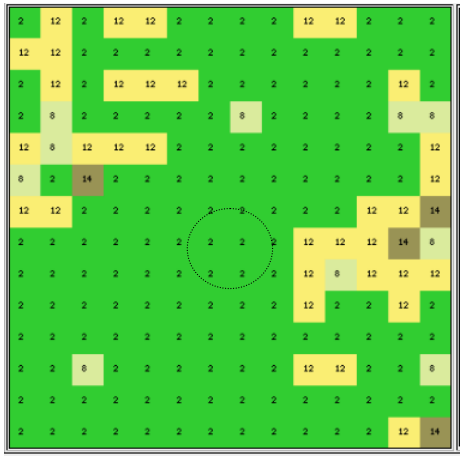




Land Cover

Evergreen Broadleaf Forest (green)





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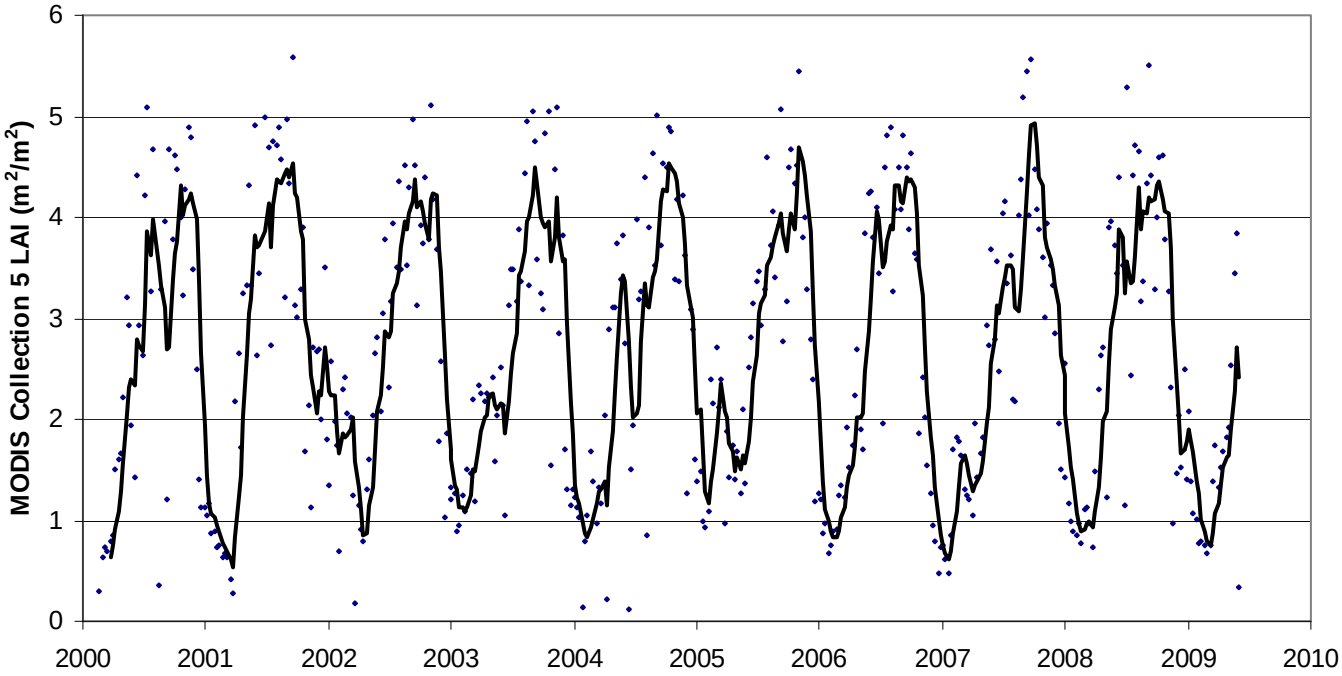
Otway area LAI with correct cropland/grassland land cover



Summary

- MODIS Collection 5 LAI provides superior performance at the Howard Springs flux tower site where comparison can be made against Collection 4 and ground based measurements throughout the year.
- Based on 24 sites throughout the Northern Territory, Collection 5 does a reasonable job compared to LAI estimates from ground-based hemispheric photos.
- There appears to be a positive “offset” with non-zero MODIS LAI value where vegetation is absent.
- The performance of MODIS Collection 5 LAI at other Ozflux sites varies from reasonable at Virginia Park (now defunct) to poor at Otway (likely due to misclassified land cover) to poor at Tumbarumba (unknown reasons).
- More on the ground validation data is needed, as always!

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