WAMSI KMRP
PROJECT 1.4
REMOTE SENSING

Peter Fearns & Jim Greenwood

I would like to acknowledge the Wadjuk Noongar people who are the traditional custodians of this land.

Curtin University

CSIRO

Department of Parks and Wildlife

Acknowledgments

- The State Government of Western Australia and WAMSI partners for funding this research.
- Professor David Antoine, Nick Hardman-Mountford, Jim Greenwood, Nagur Cherukuru, Helen Chedzey, Mark Broomhall, Passang Dorji, Edward King
- WAMSI Dredge Node, Themes 2/3 Predicting and measuring the characteristics of sediment plumes due to dredging operations

Overview

- Phase 1: Where did we start?
- Phase 2:
  - Remote Sensing
  - Development of TSS algorithm
  - Comparison of TSS algorithms
  - Spatial and temporal analysis (Jim)
  - Light at Depth

Review Process

DPaW-defined assets

Define condition/pressure metrics

Consider applicability of remote sensing. Data sources, spatial and temporal resolution, accuracy, confidence etc.

Assets

Finfish

Coral

Seagrass

Invertebrates

Intertidal

Mangroves

Turtles

Cetaceans

Water Quality

Coastal Biological

Wilderness

Example of feedback for coral asset

Condition Metrics (followed through time)	RS possibility Y/N
C: Benthic cover	Y
C: Spp. Composition	N (general classification possible)
C: Diversity	N (depends on number of classes)
C: Size Frequency	N (depends on size)
C: Recruitment	N
Pressure Metrics (followed through time)	**RS possibility Y/N**
P: Temp (air and water)	Y
P: Cyclones	Y
P: Sedimentation	Y (estimates, surrogates possible)
Light Availability (Turbidity)	Y (via surrogates)
P: Predation	Broad scale impacts – Y
P: Vessel activity	Y (depends on spatial/temporal scale)
P: Acidification (long term need)	

After analysis and review…

After analysis and review…

Turbidity (light)

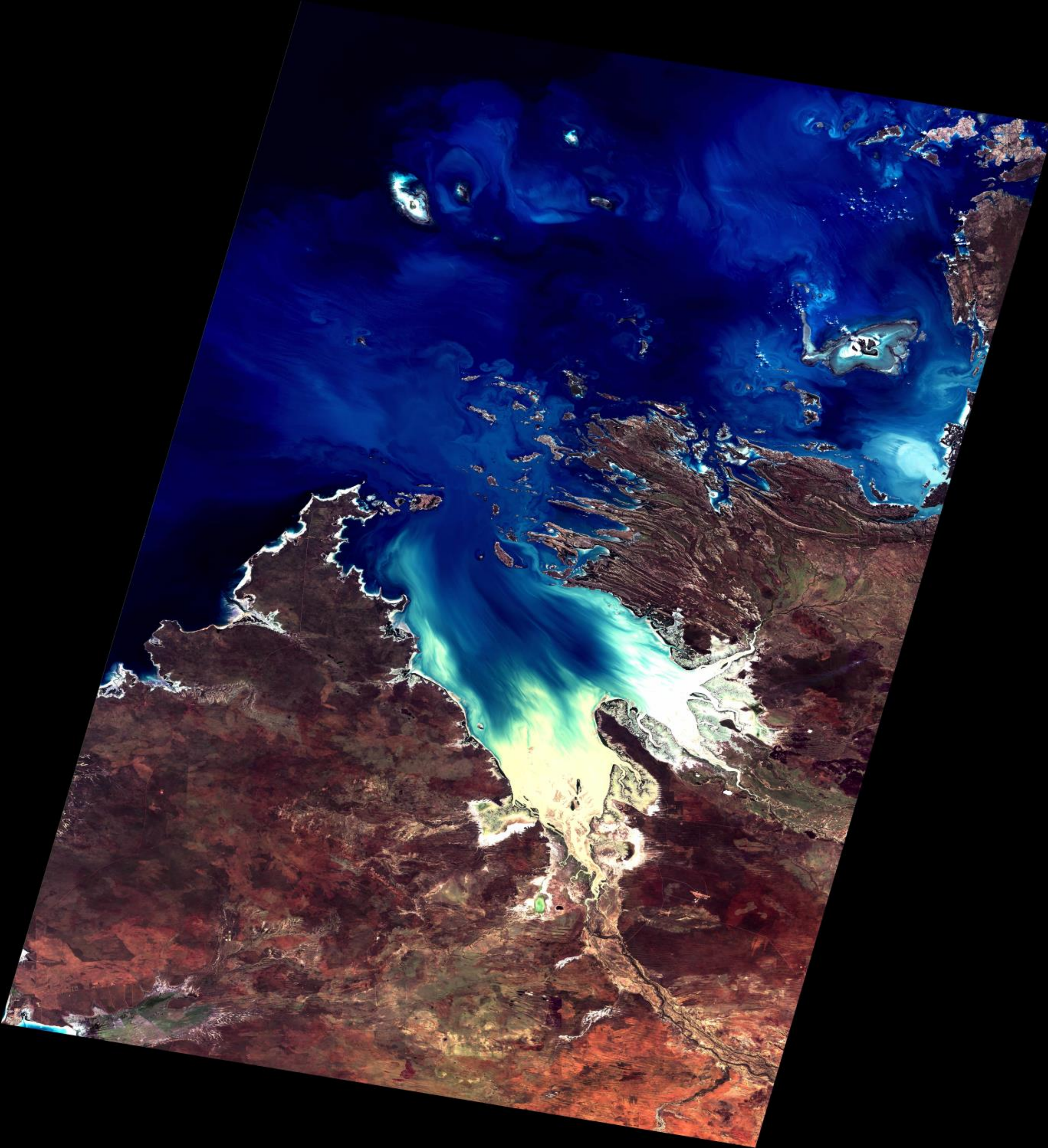
Goal: Quantify the reliability of remotely sensed turbidity products for use in the Kimberley region

Objective 1: Analyse uncertainties of remotely sensed turbidity products by comparison of different algorithms and different resolution products with each other and with archived *in situ* data

Objective 2: Analyse time series of remotely sensed turbidity data to provide first-stage pilot products that may be applicable for future use as marine management tools.

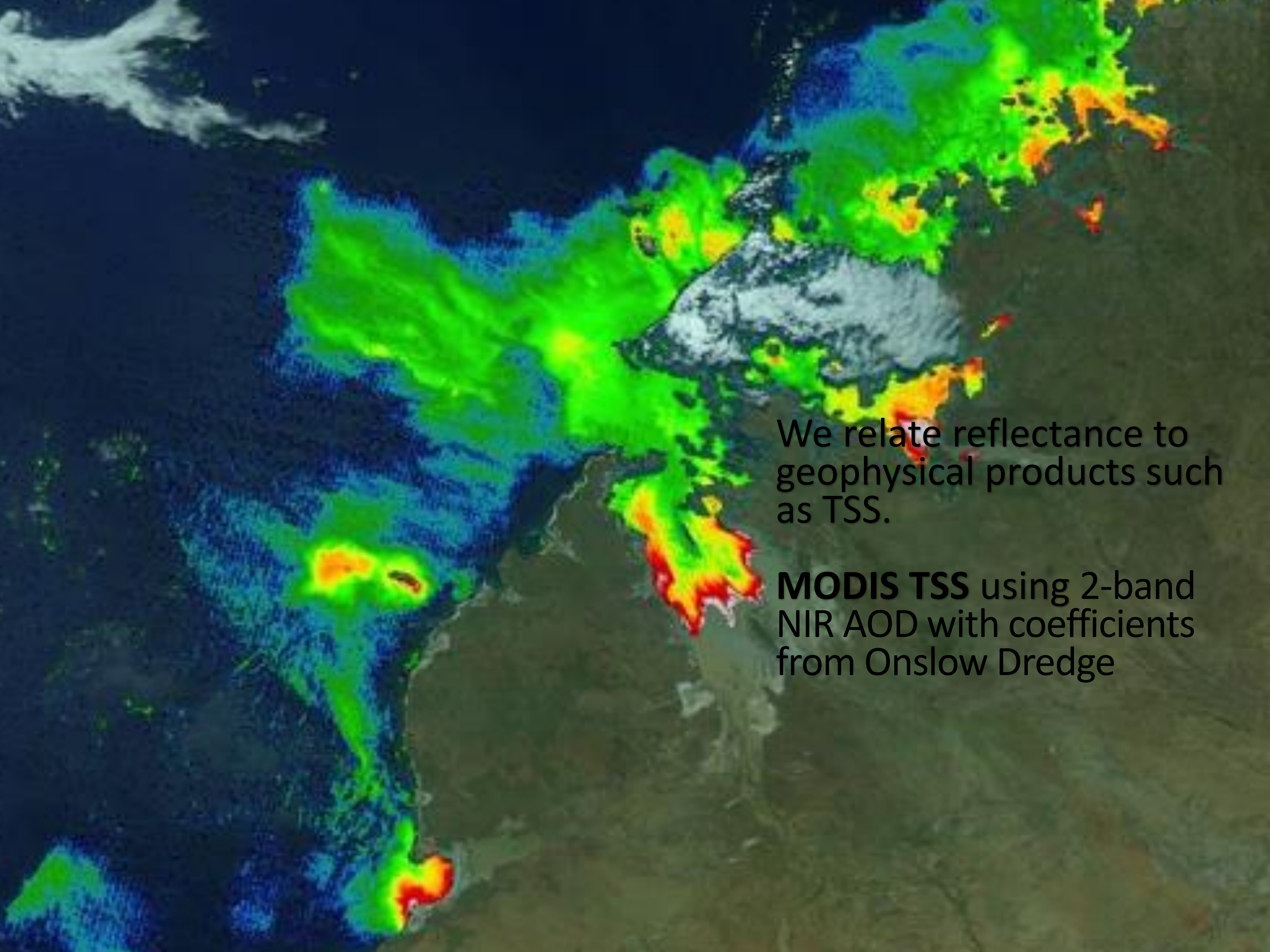
Deliverables

- Analysis of ensemble variability between different algorithms
- Assessment of sub-km scale variability from comparison with high-resolution products
- Quantification of uncertainty from comparison with archived *in situ* data
- Maps of turbidity "hotspot" regions (i.e. regions of frequently occurring high turbidity events and regions of extreme variability).
- Alternative: Maps of different turbidity regimes (e.g. permanently high turbidity, frequent turbid events, infrequent turbid events, persistently clear water).
- Turbidity indicator products (e.g. days above a set turbidity threshold)



Remote Sensing:
A satellite-borne sensor measures radiance.
We convert radiance to surface reflectance.

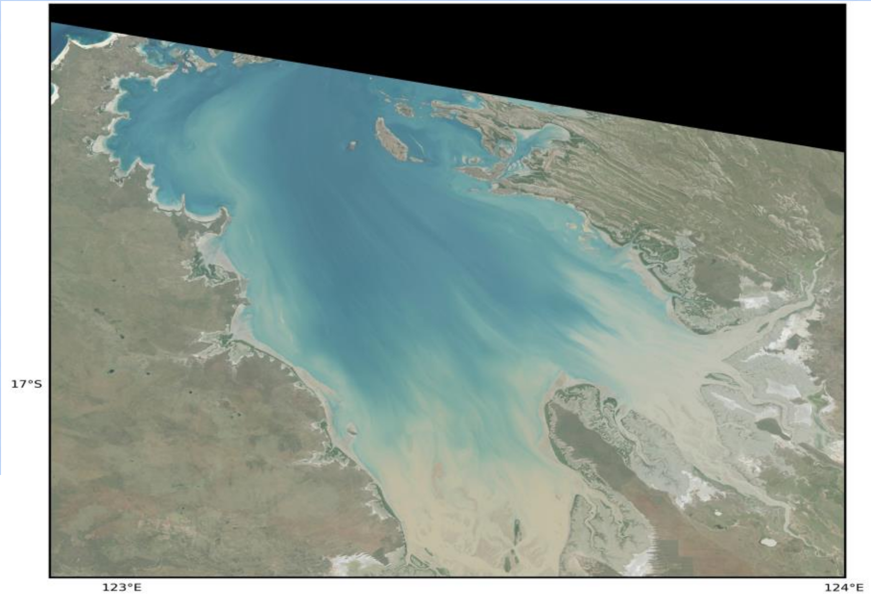
A true colour Landsat image is shown at left.



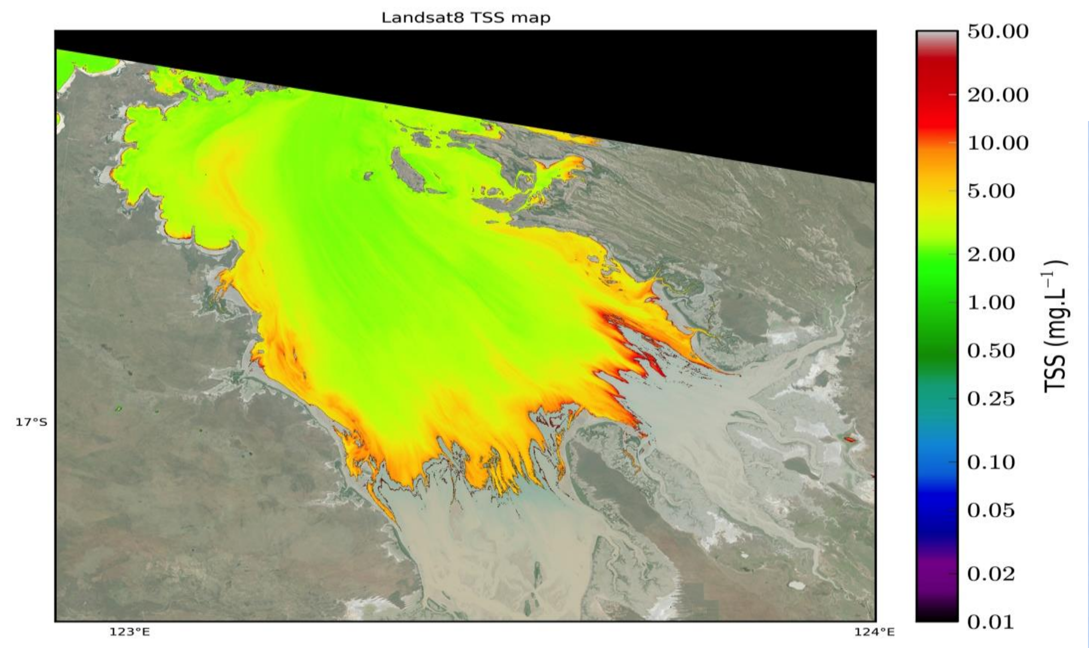
We relate reflectance to geophysical products such as TSS.

MODIS TSS using 2-band NIR AOD with coefficients from Onslow Dredge

Landsat 8 TSS



30 m True colour image



TSS using the 2-band SWIR AOD with coefficients from Onslow Dredge

Develop an algorithm…

remote sensing

MDPI

Article

A Semi-Analytic Model for Estimating Total Suspended Sediment Concentration in Turbid Coastal Waters of Northern Western Australia Using MODIS-Aqua 250 m Data

Passang Dorji *, Peter Fearns and Mark Broomhall

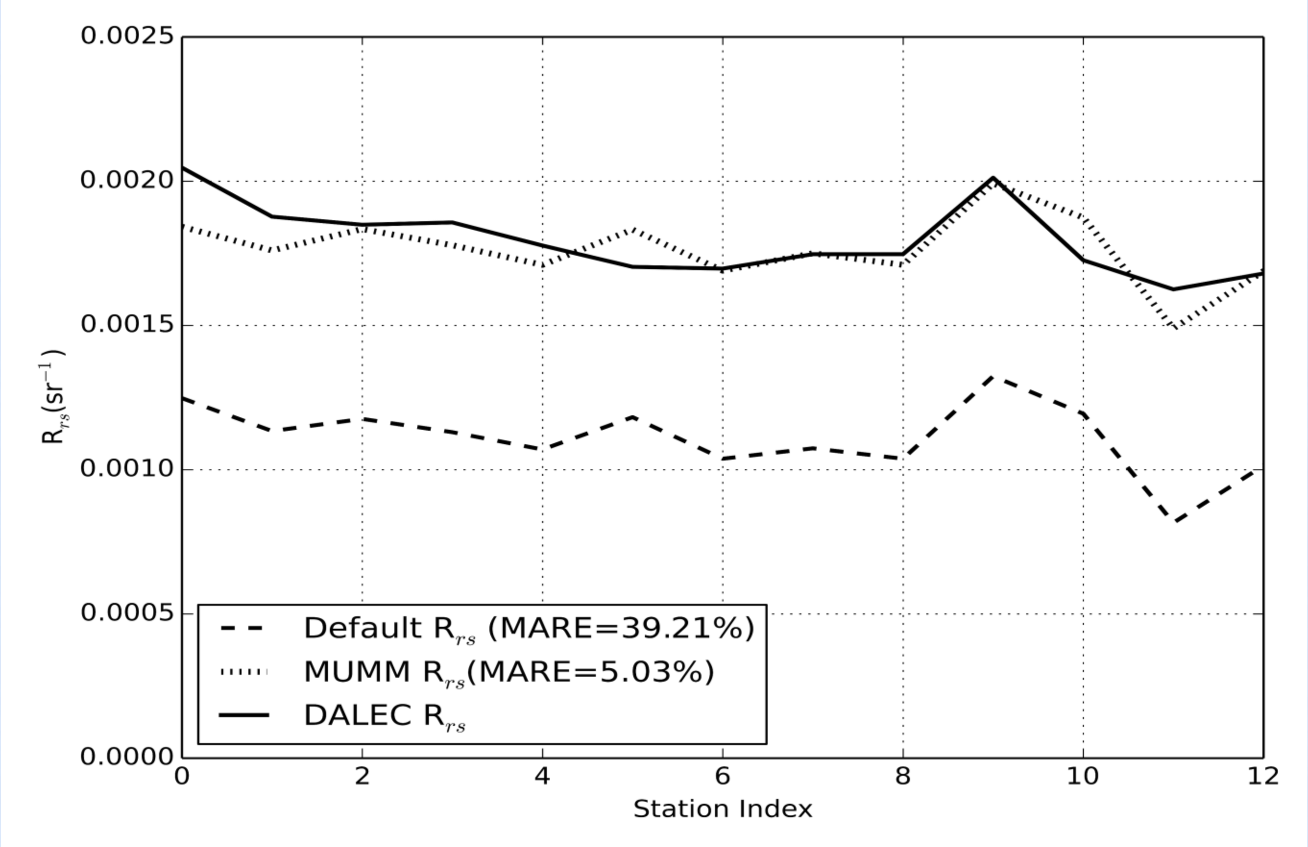
Remote Sensing and Satellite Research Group, Curtin University, GPO Box U1987, Perth, WA 6845, Australia; P.Fearns@curtin.edu.au (P.F.); m.broomhall@bom.gov.au (M.B.)

* Correspondence: dorji.passang@postgrad.curtin.edu.au; Tel.: +61-8-9266-5267

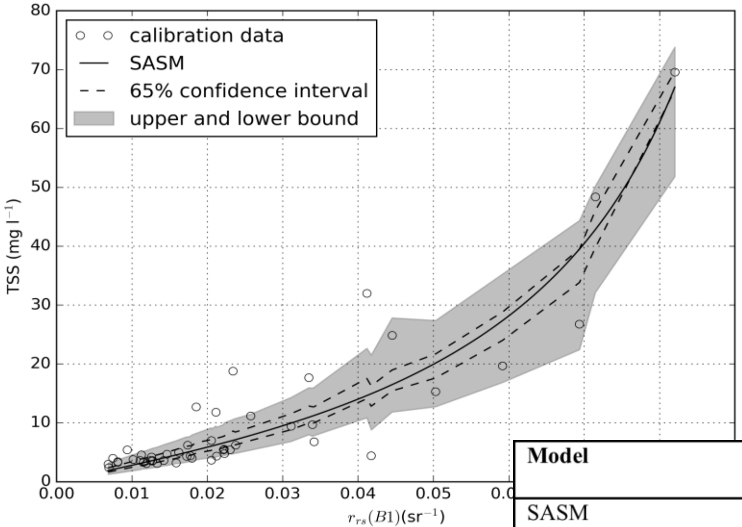
Academic Editors: Xiaofeng Li and Prasad S. Thenkabail

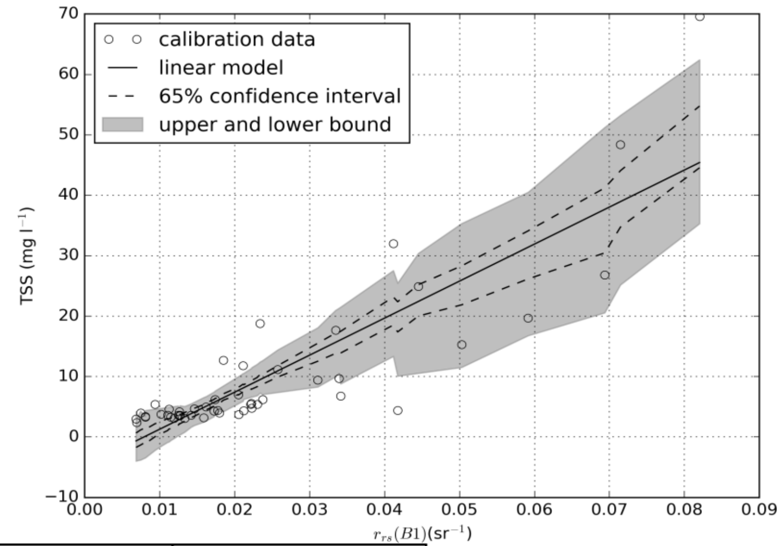
Received: 6 April 2016; Accepted: 24 June 2016; Published: 30 June 2016

- Compared atmospheric correction using the DALEC. Default versus MUMM algorithms. MUMM is best. DALEC is very useful for algorithm development and R validation.

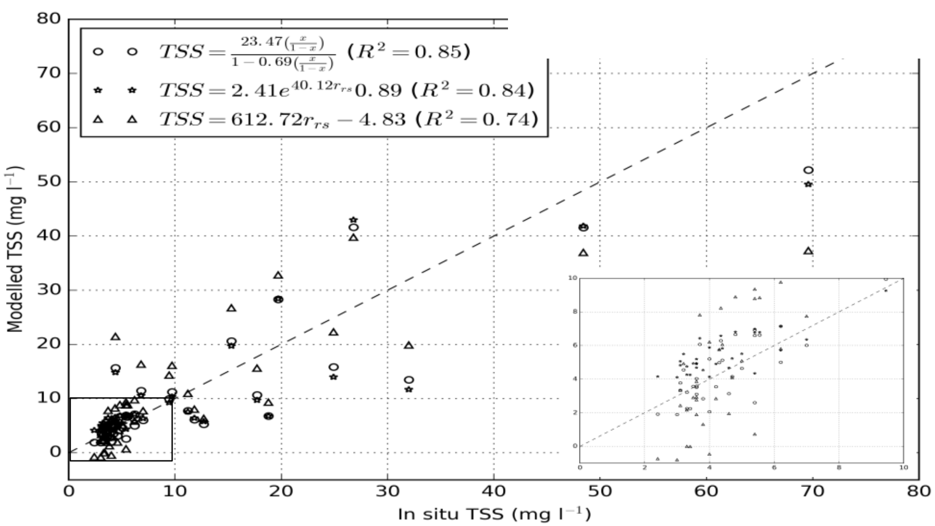


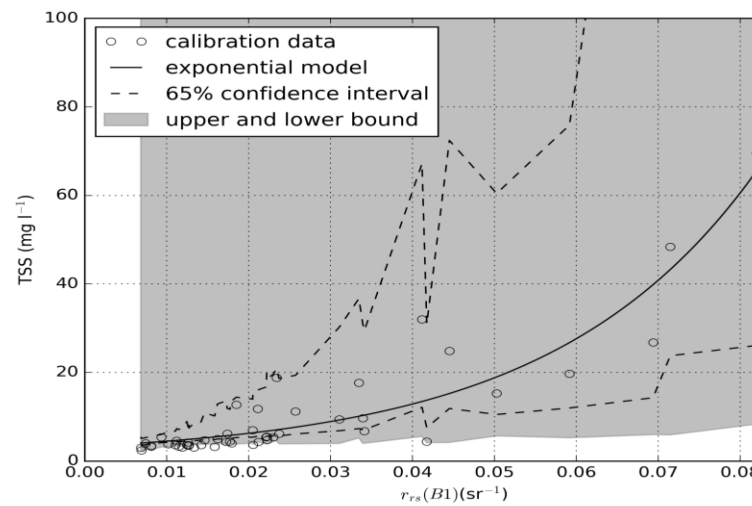
- Compared exponential, linear and semi-analytical models





Model	*Lowest ARE (%)*	*Mean ARE (%)*	*Largest ARE (%)*
SASM	1.20	30.93	228.15
linear	2.20	53.64	349.90
exponential	1.03	38.39	195.55





Compare all algorithms…

remote sensing

MDPI

Article

A Quantitative Comparison of Total Suspended Sediment Algorithms: A Case Study of the Last Decade for MODIS and Landsat-Based Sensors

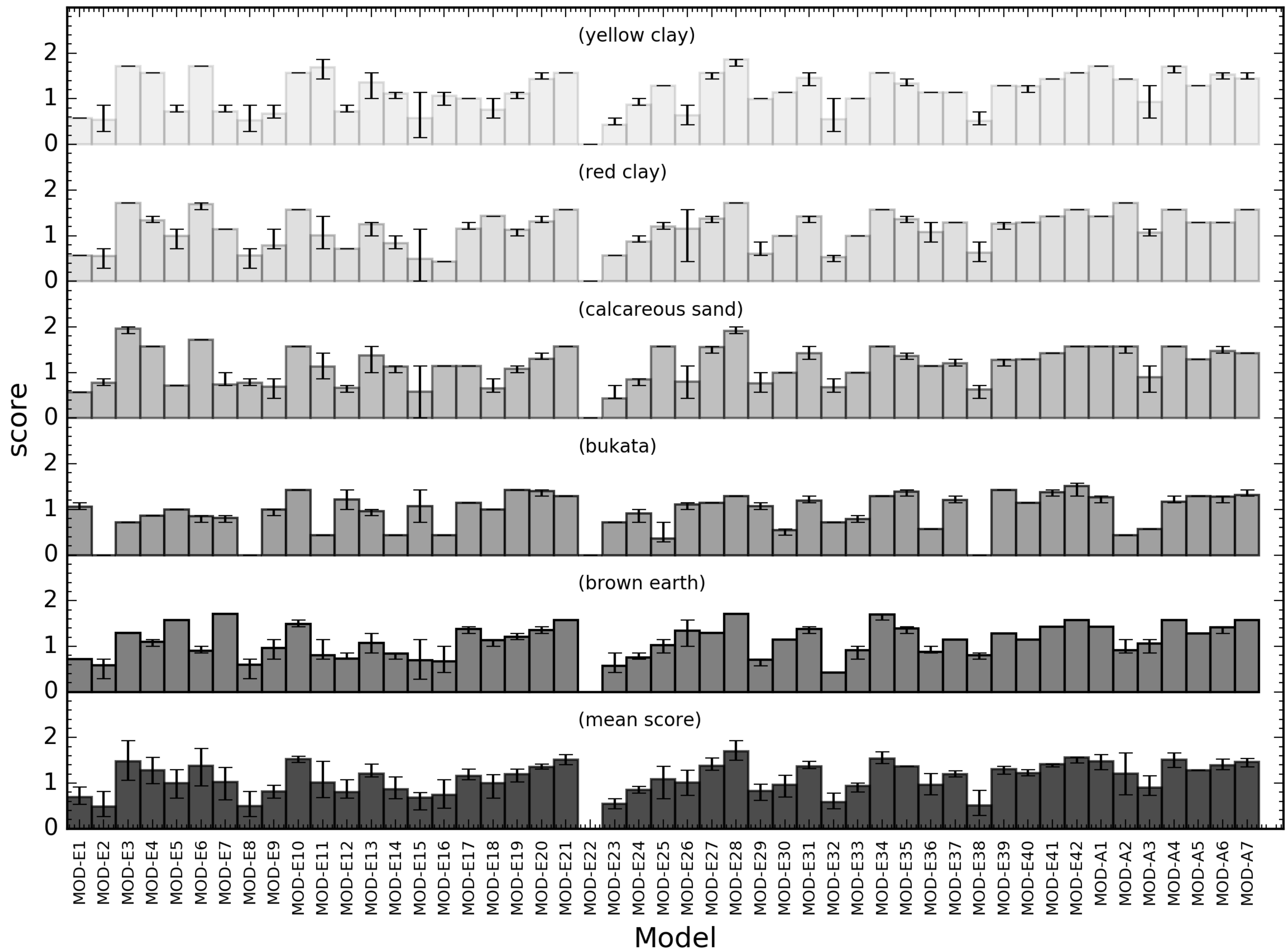
Passang Dorji * and Peter Fearns

Remote Sensing and Satellite Research Group, Curtin University,
GPO Box U1987, Perth 6845, Australia; P.Fearns@curtin.edu.au
* Correspondence: dorji.passang@postgrad.curtin.edu.au; Tel.: +61-8-9266-5267

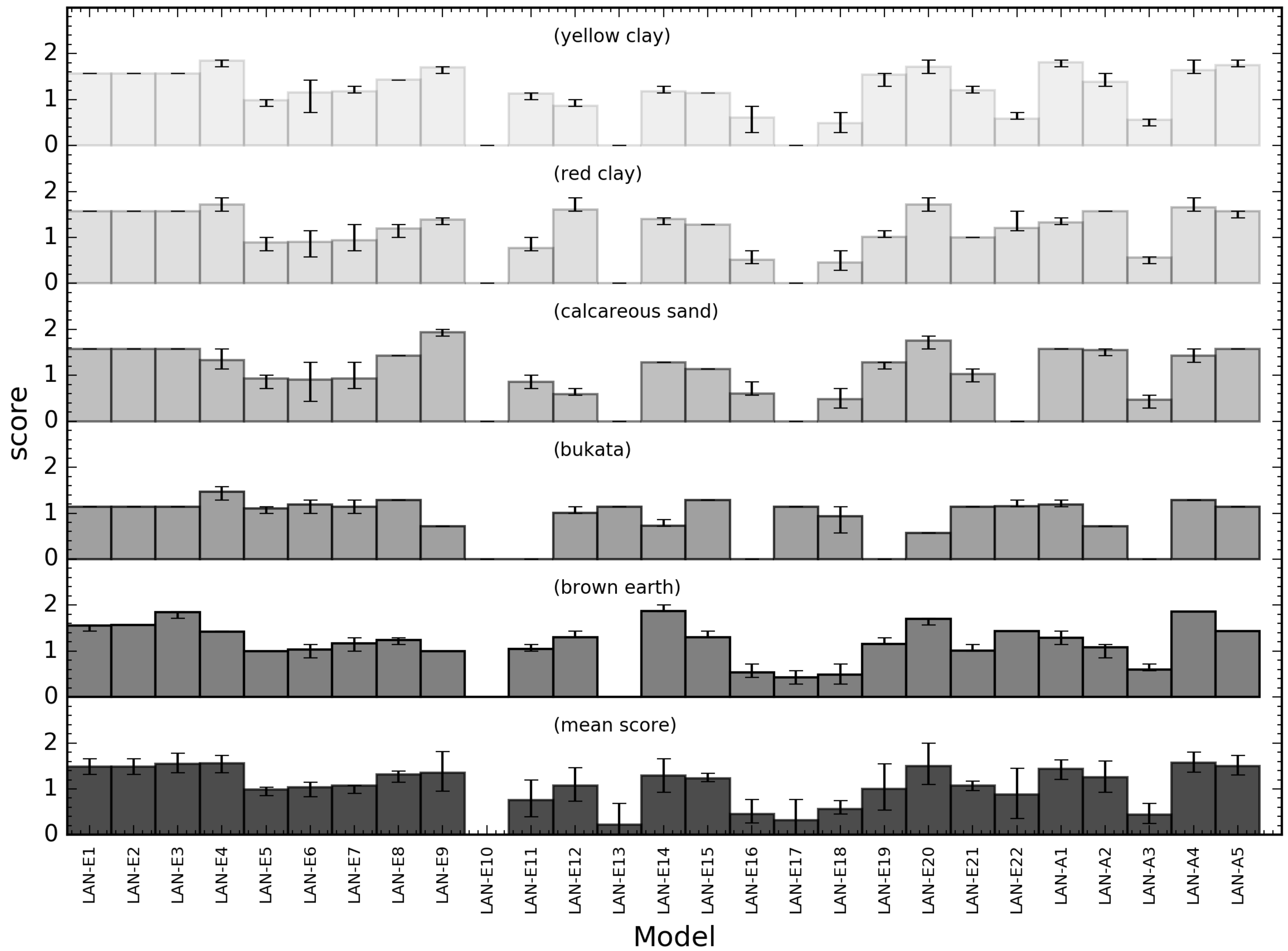
Academic Editors: Richard Gloaguen and Prasad S. Thenkabail
Received: 2 June 2016; Accepted: 24 September 2016; Published: 30 September 2016

- If we take an algorithm from the literature, how well can we expect it to perform?
- 5 different TSS types and a range of different Chl and CDOM conditions, how do the various TSS algorithms compare.
- Hydrolight modelling
- MODIS and Landsat
- 49/27 different algorithms
- Empirical and (semi)analytical

MODIS TSS algorithm comparisons



Landsat TSS algorithm comparisons



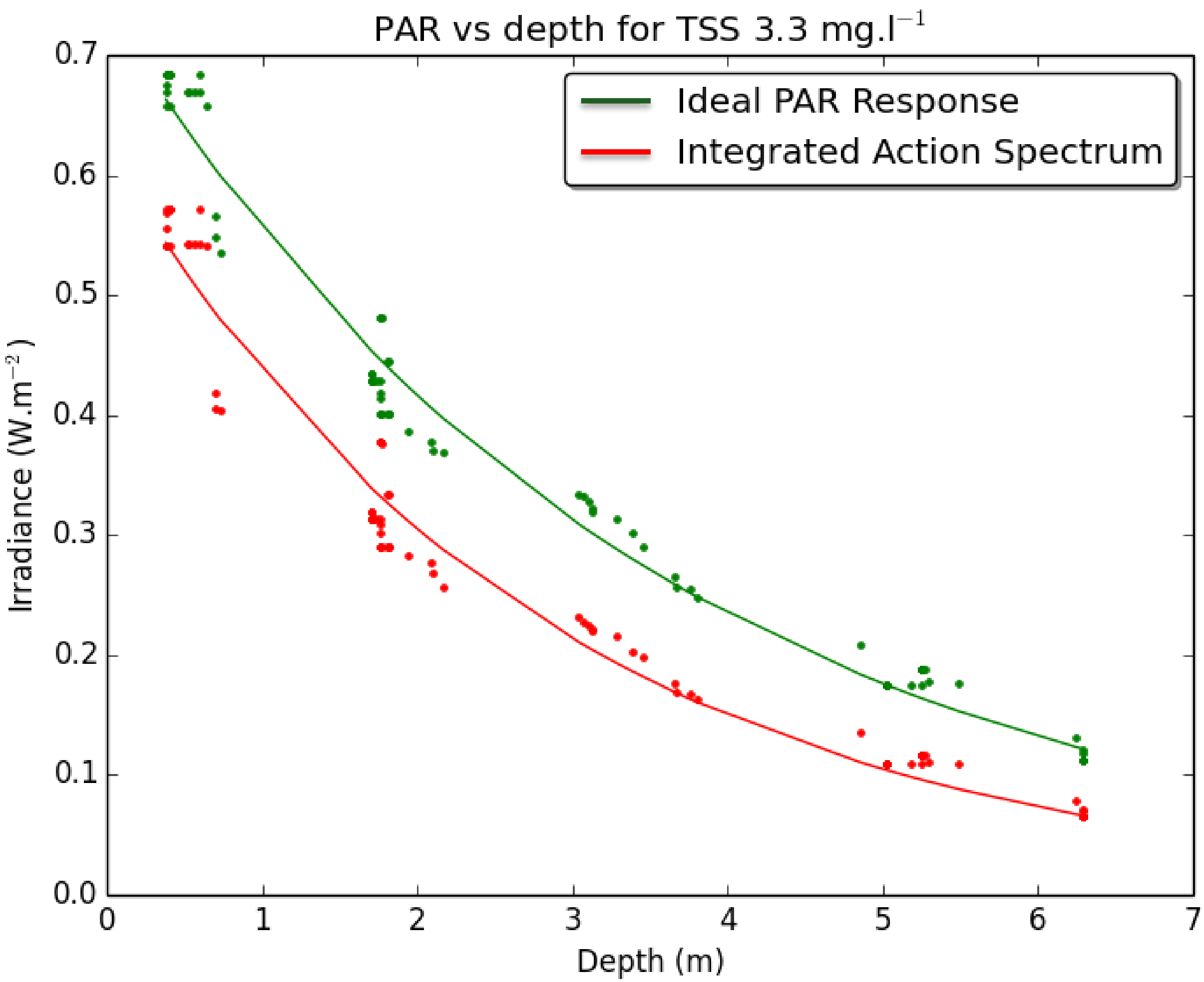
Impact of the Spatial Resolution of Satellite Remote Sensing Sensors in the Quantification of Total Suspended Sediment Concentration: A Case Study in Turbid Waters of Northern Western Australia.

Passang Dorji and Peter Fearns

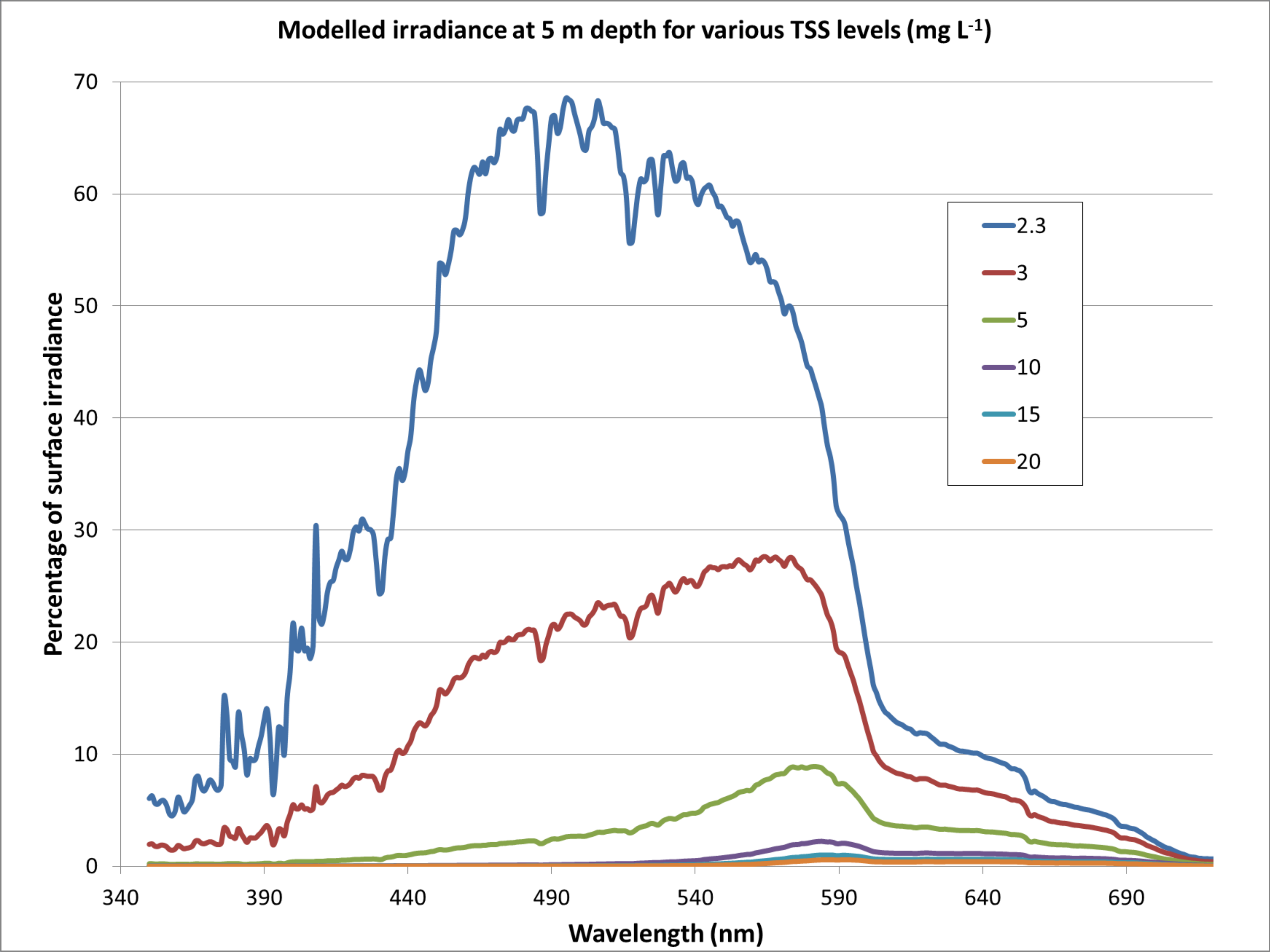
(submitted)

Time Series Analysis

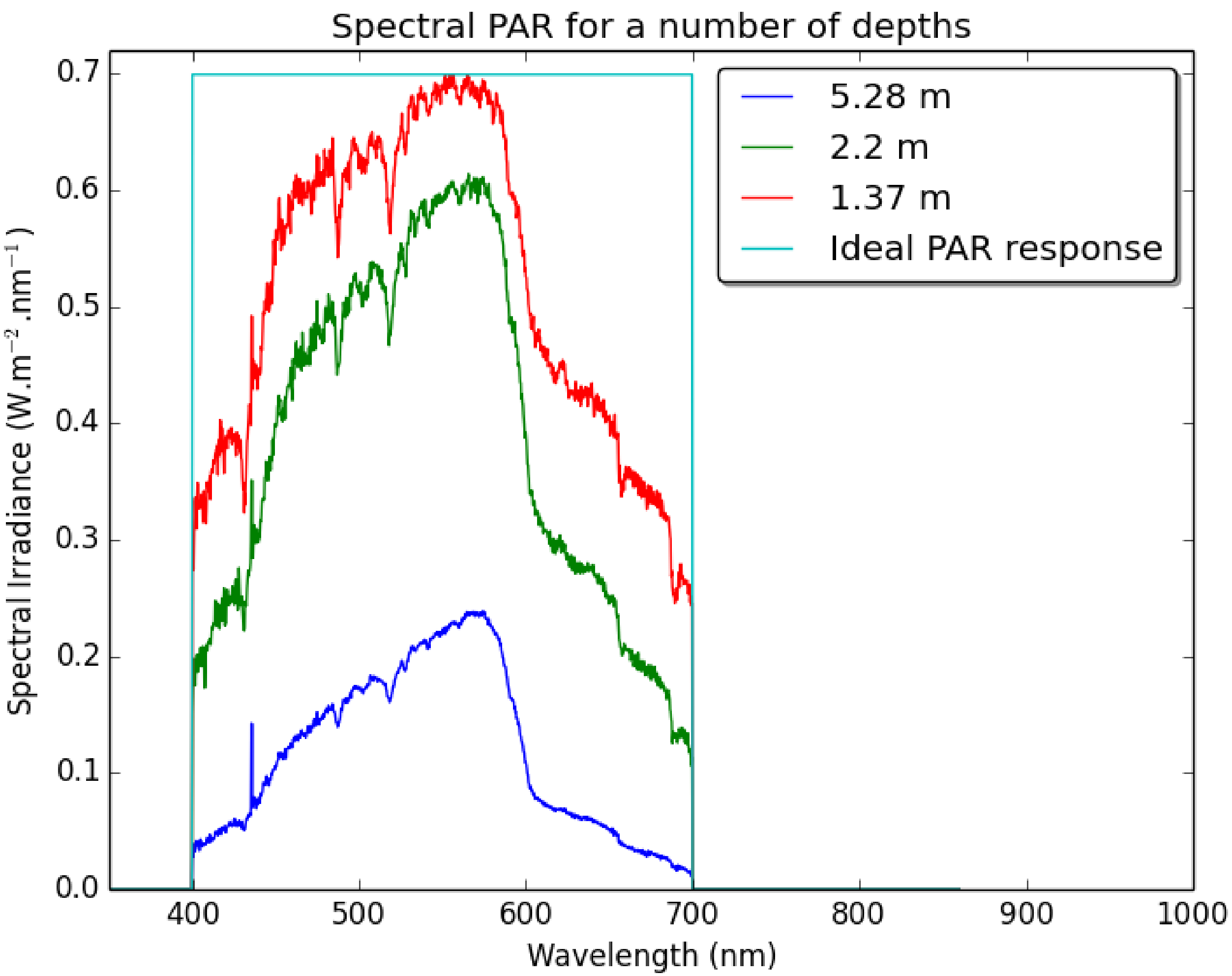
Light At Depth (LAD)



Sub-surface Photosyntetically Active Radiation (PAR) irradiance from the Hydrorad

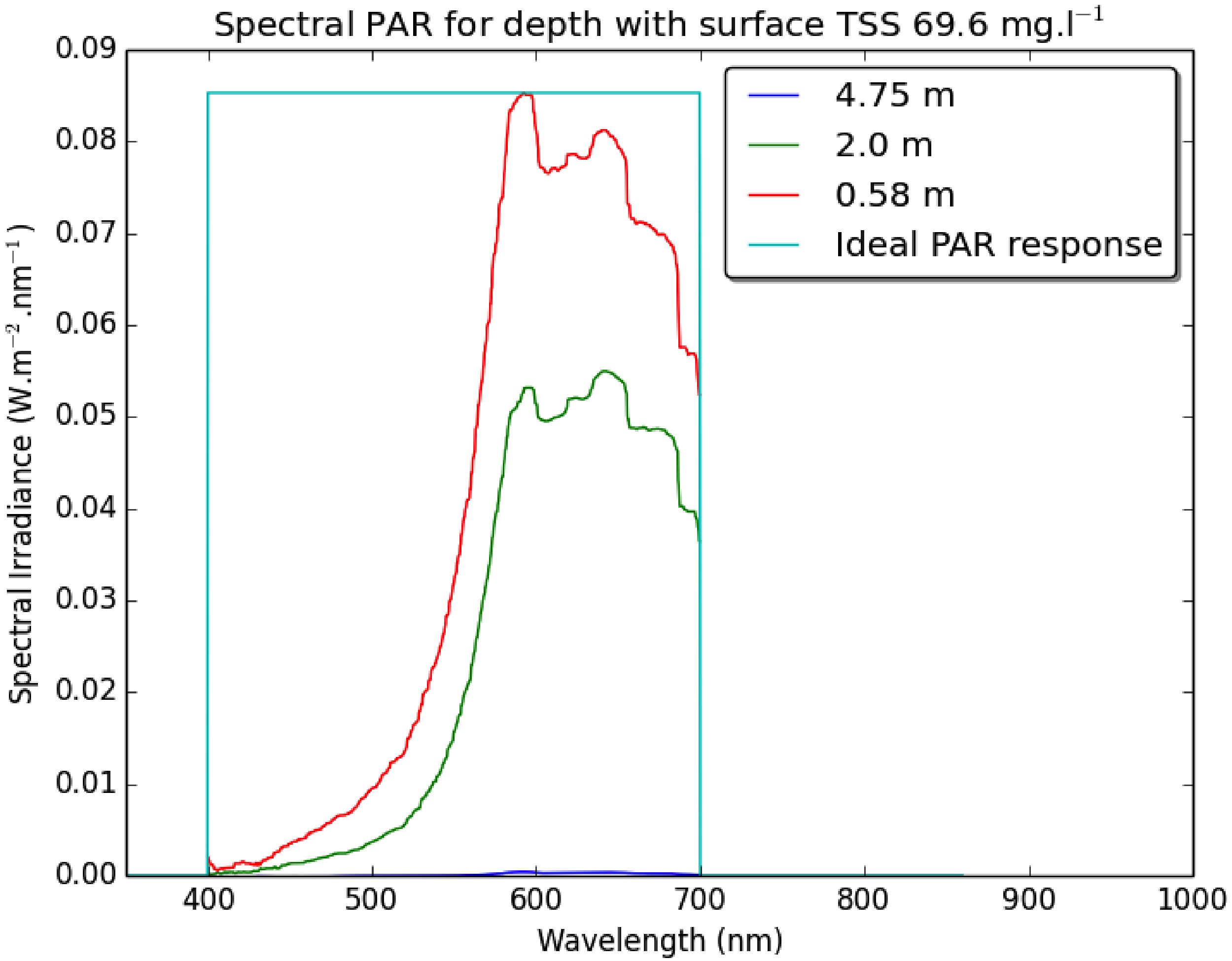

Modelled irradiance at 5 m depth for various TSS levels (mg L-1)
Percentage of surface irradiance
Wavelength (nm)
0
10
20
30
40
50
60
70
340
390
440
490
540
590
640
690
2.3
3
5
10
15
20

Spectral light profiles



Sub-surface hyperspectral irradiance from the Hydrorad for low value of TSS

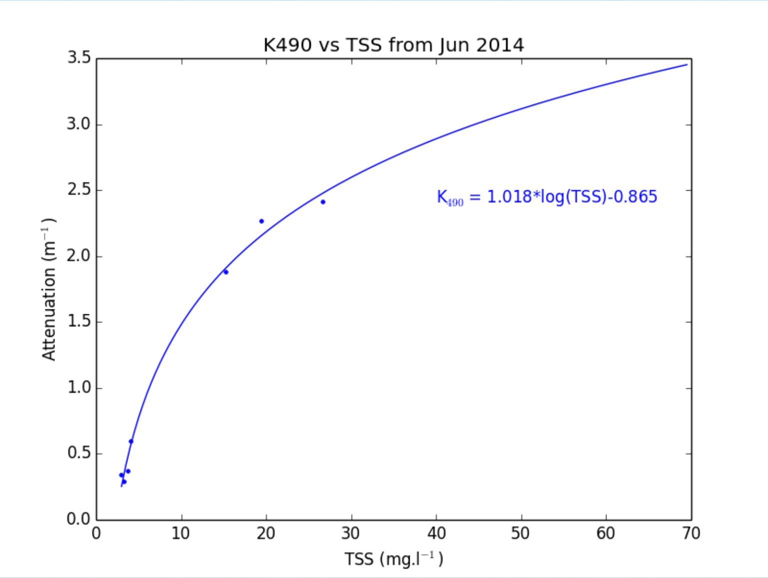
Spectral light profiles



Sub-surface hyperspectral irradiance from the Hydrorad for high value of TSS

TSS to Attenuation (K_{d490})

- TSS and K_d relationships developed from fieldwork measurements taken near Onslow, June 2014
- K_{d490} and K_{dPAR} developed.
- Natural logarithmic relationship strong for “high” TSS concentrations but produces negative K at “low” TSS.
- Smith and Baker (1981), K_{d490} for clear ocean water = 0.0212 m^{-1}.



- Linear relationship used for TSS < 3 mg/L

$K_{d490} = 0.0765(TSS) + 0.0212$

- Natural logarithmic relationship used for TSS > 3 mg/L

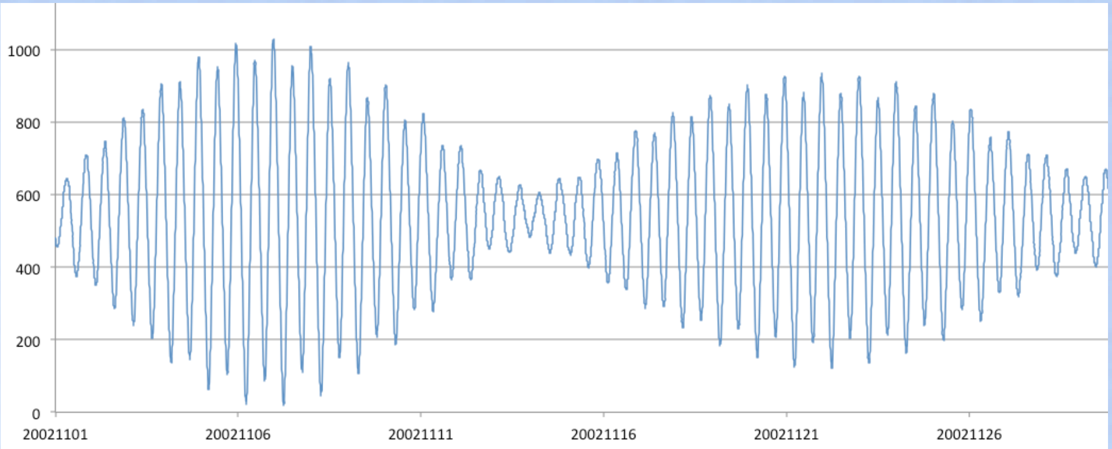
$K_{d490} = 1.018 (\ln(TSS)) - 0.865$

MTLs

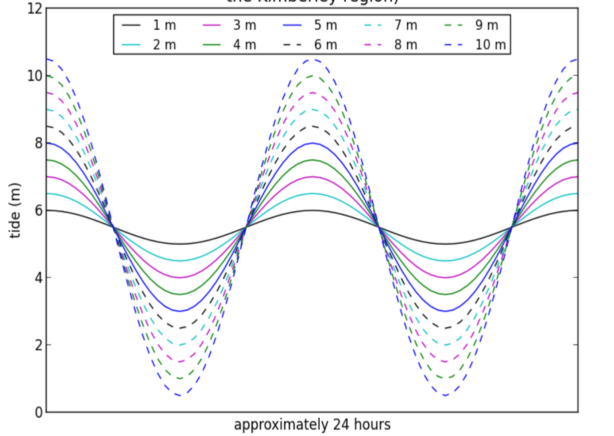
- Broome – 2002, MTL = 5.39 m
- Koolan Island – 1984, MTL = 5.69 m
- Wyndham – 2015, MTL = 4.57 m
- Other reference MTLs
  - Cape Lambert = 3.23 m
  - Onslow = 1.60 m
  - Carnarvon = 1.08 m
  - Jurien Bay = 0.84 m
  - Barrack St, Perth = 0.85 m

Tides in Kimberley region

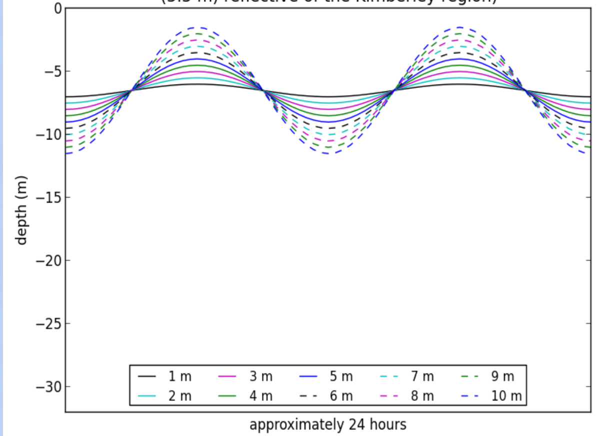
- Use a MTL of 5.5 m
- Tidal ranges: 1 m to 10 m
- Bathymetry levels: 1 m to 20 m
- Attenuation coefficients: low (0.05), medium (0.15), high (0.40)
- Real Broome tide:
  - November 2002



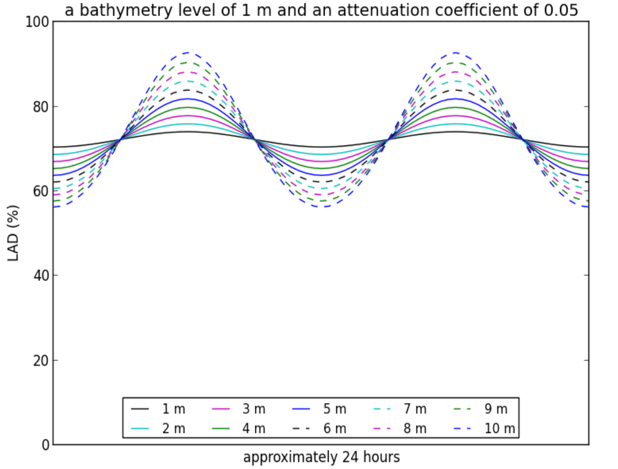
Theoretical tide of varying ranges over a time period of 24 hours (Tides centred around an example mean level tide (5.5 m) reflective of the Kimberley region)



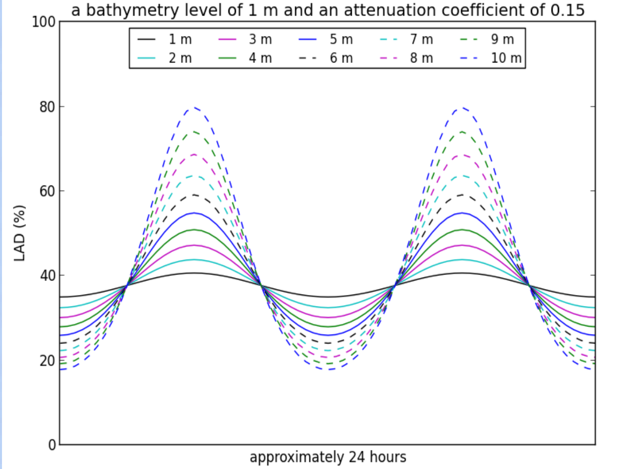
Theoretical tide of varying ranges at a bathymetry of 1 m over a time period of 24 hours. (Tides centred around an example mean level tide (5.5 m) reflective of the Kimberley region)



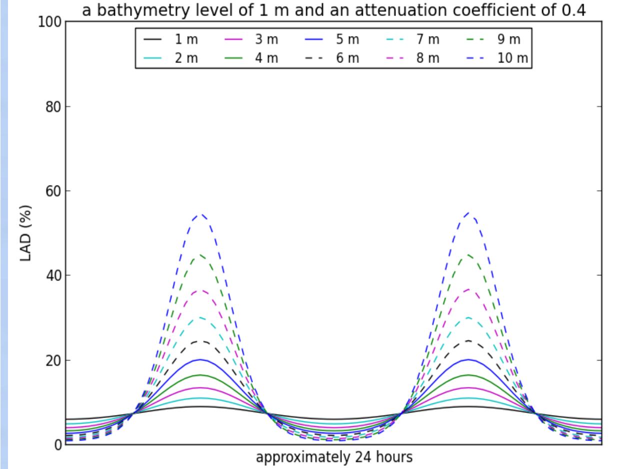
Theoretical percentage of light at depth over varying tidal ranges at a bathymetry level of 1 m and an attenuation coefficient of 0.05

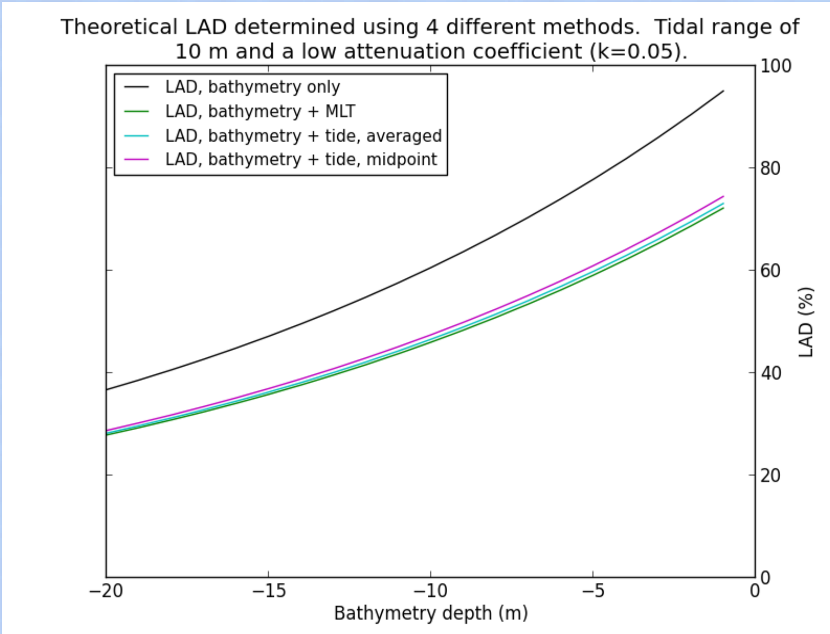


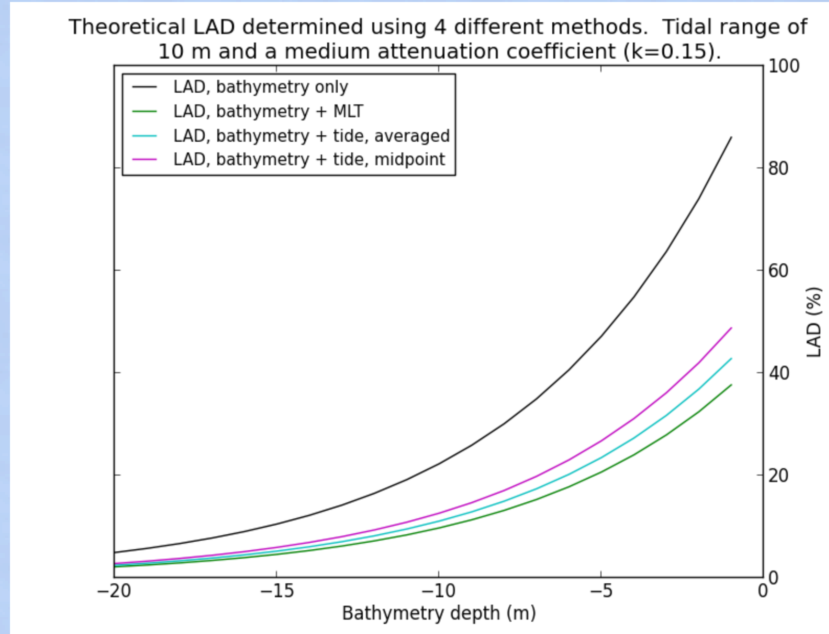
Theoretical percentage of light at depth over varying tidal ranges at a bathymetry level of 1 m and an attenuation coefficient of 0.15



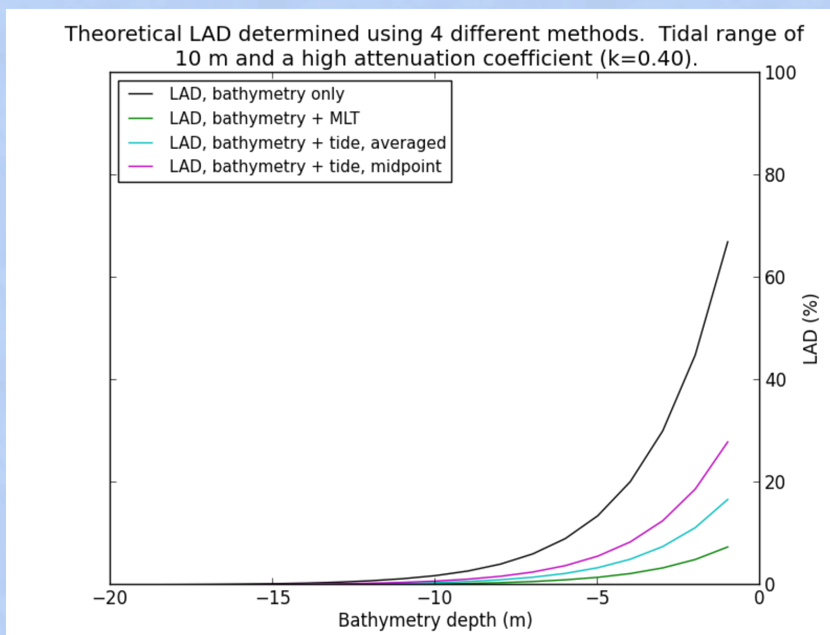
Theoretical percentage of light at depth over varying tidal ranges at a bathymetry level of 1 m and an attenuation coefficient of 0.4

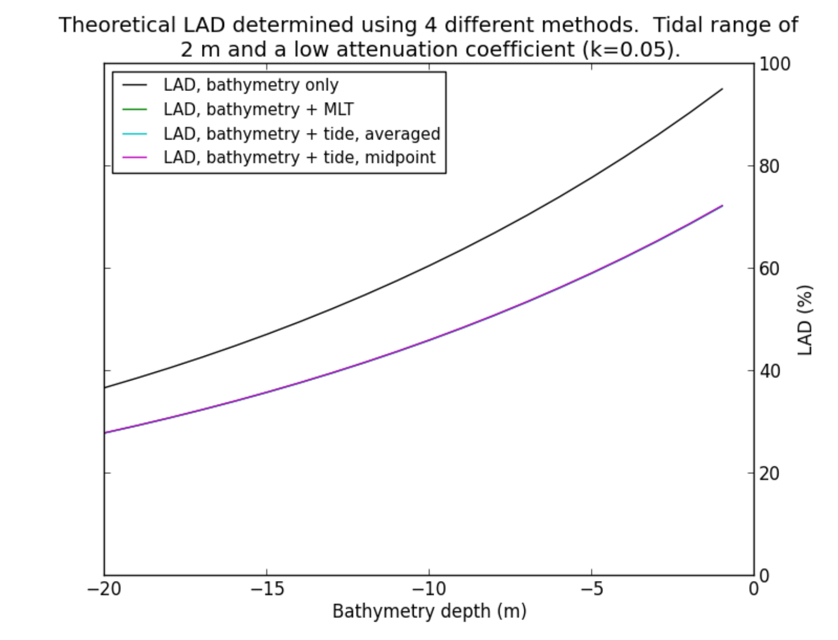


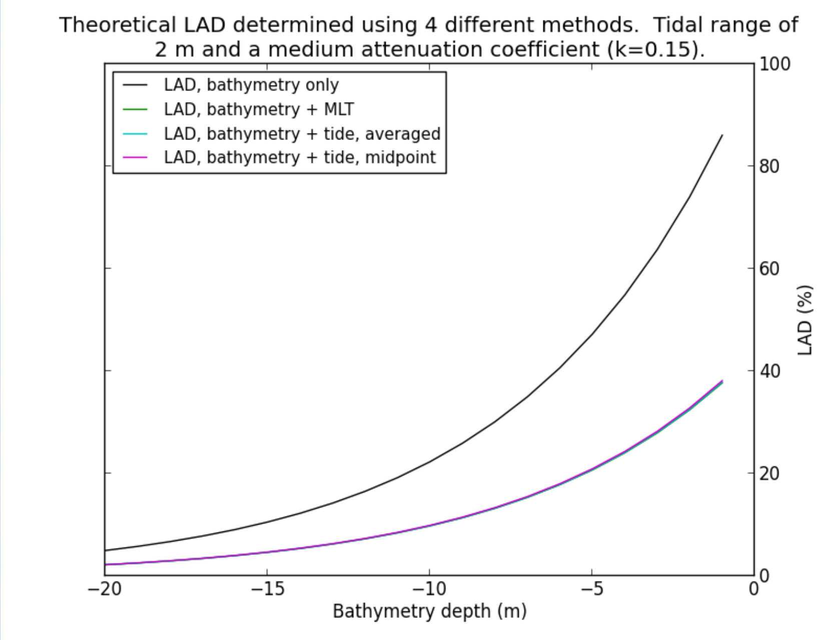




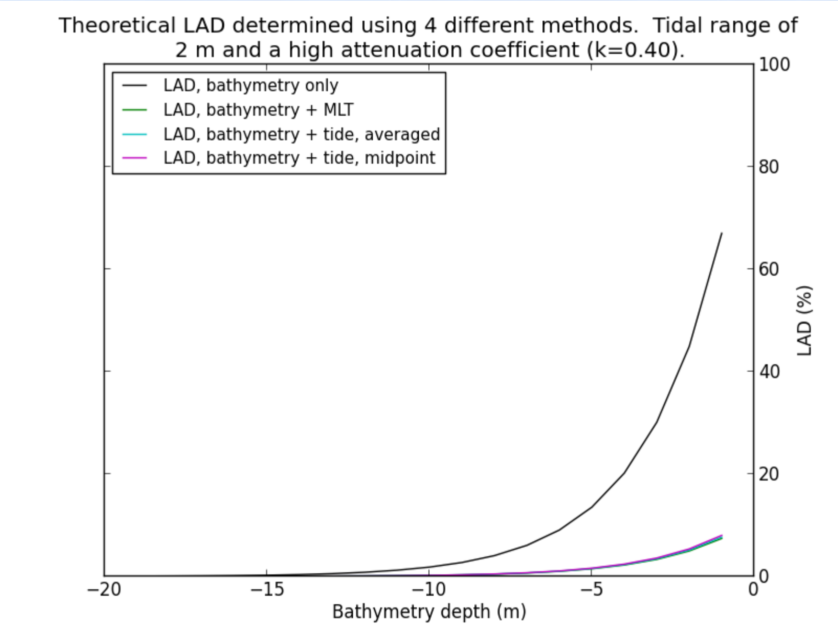
Spring tides




Theoretical LAD determined using 4 different methods. Tidal range of 2 m and a low attenuation coefficient (k=0.05).
LAD, bathymetry only
LAD, bathymetry + MLT
LAD, bathymetry + tide, averaged
LAD, bathymetry + tide, midpoint
LAD (%)
Bathymetry depth (m)
100
80
60
40
20
0
−20
−15
−10
−5
0

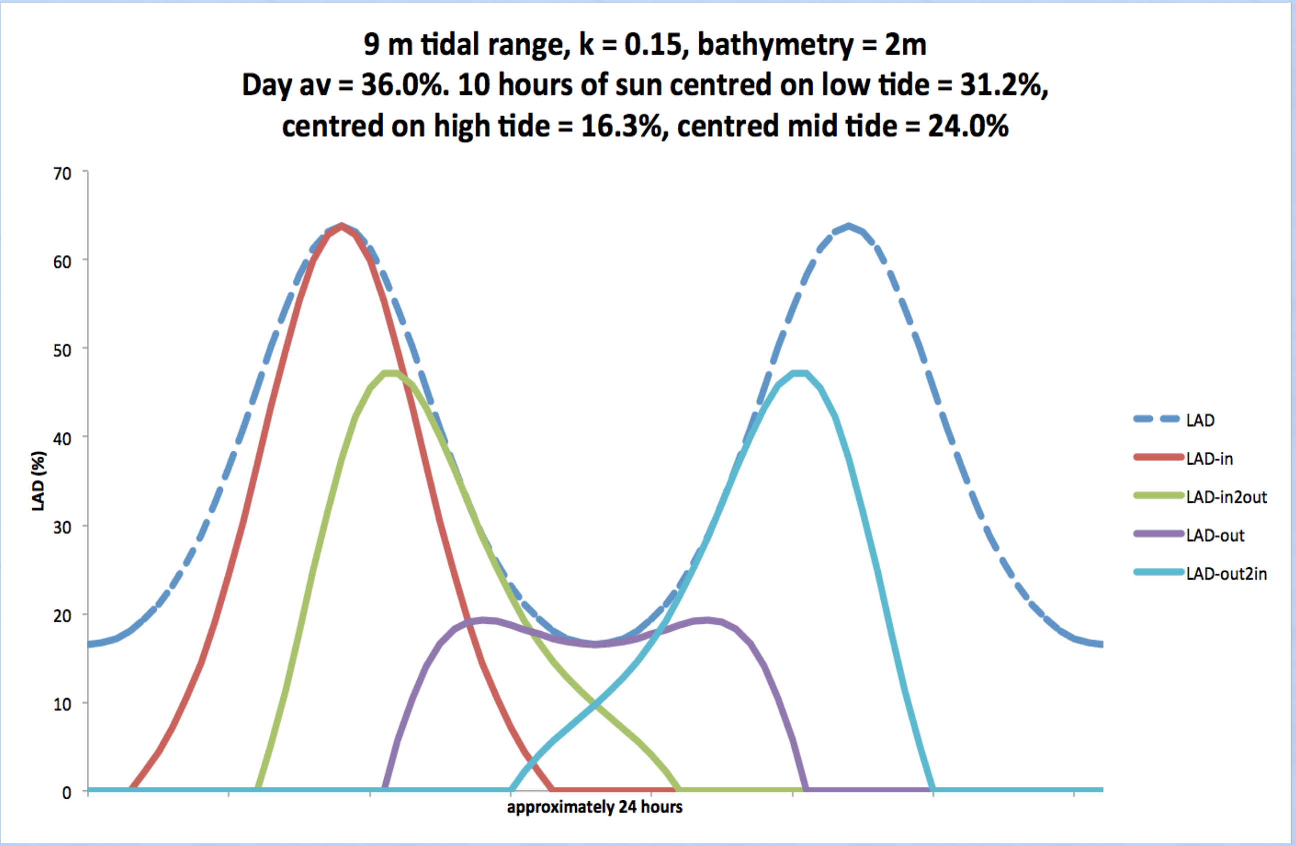

Theoretical LAD determined using 4 different methods. Tidal range of 2 m and a medium attenuation coefficient (k=0.15).
LAD, bathymetry only
LAD, bathymetry + MLT
LAD, bathymetry + tide, averaged
LAD, bathymetry + tide, midpoint
LAD (%)
Bathymetry depth (m)
100
80
60
40
20
0
−20
−15
−10
−5
0

Neap tides


Theoretical LAD determined using 4 different methods. Tidal range of 2 m and a high attenuation coefficient (k=0.40).
LAD, bathymetry only
LAD, bathymetry + MLT
LAD, bathymetry + tide, averaged
LAD, bathymetry + tide, midpoint
LAD (%)
Bathymetry depth (m)
100
80
60
40
20
0
−20
−15
−10
−5
0

Hours of sun

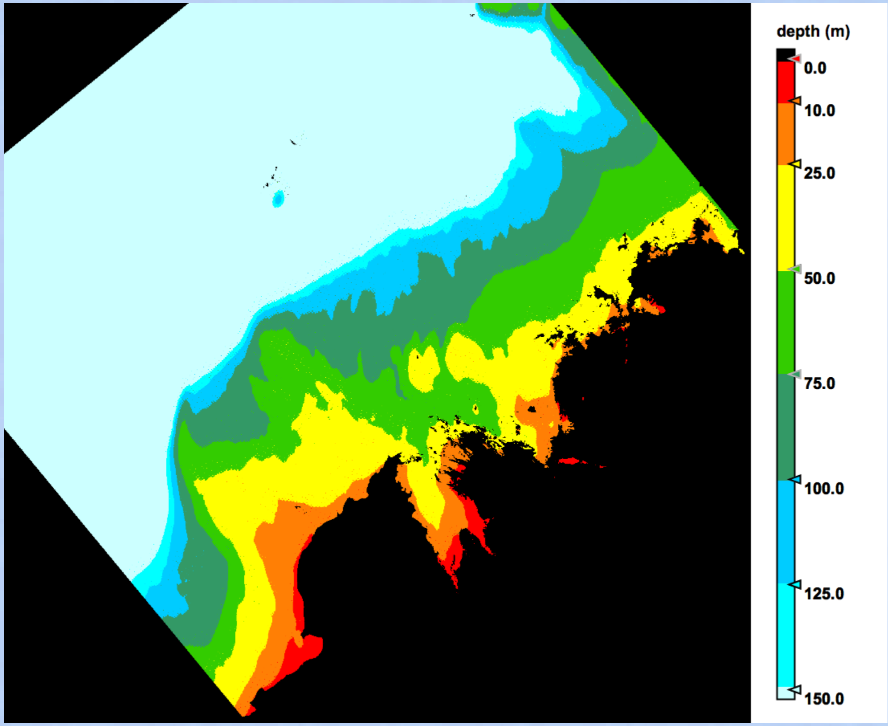
- Broome Airport – approx. 10 hours of direct solar irradiance (not counting diffuse)

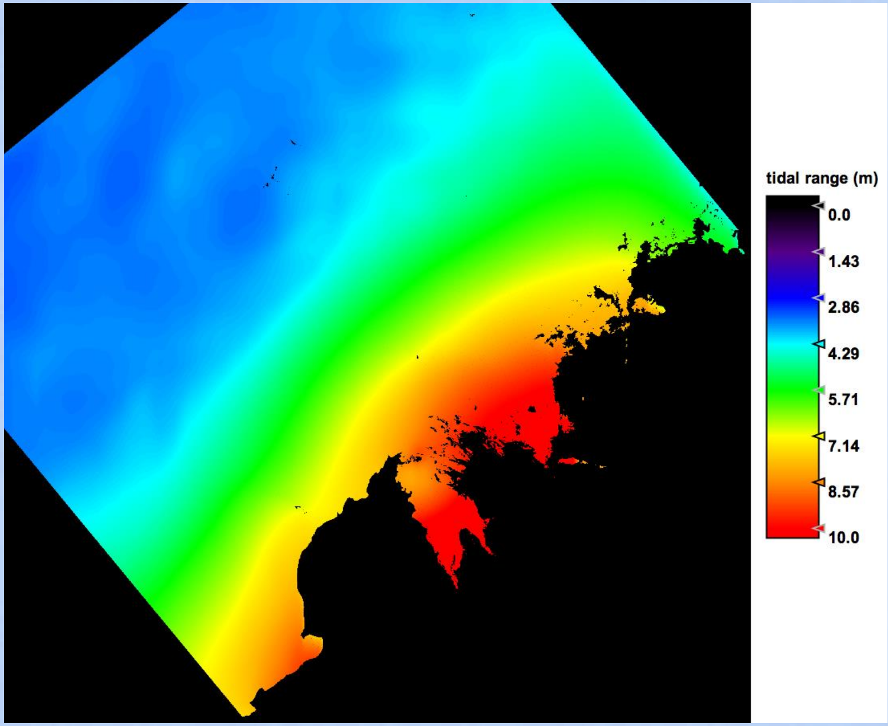


western australian marine science institution

Bathymetry (m)

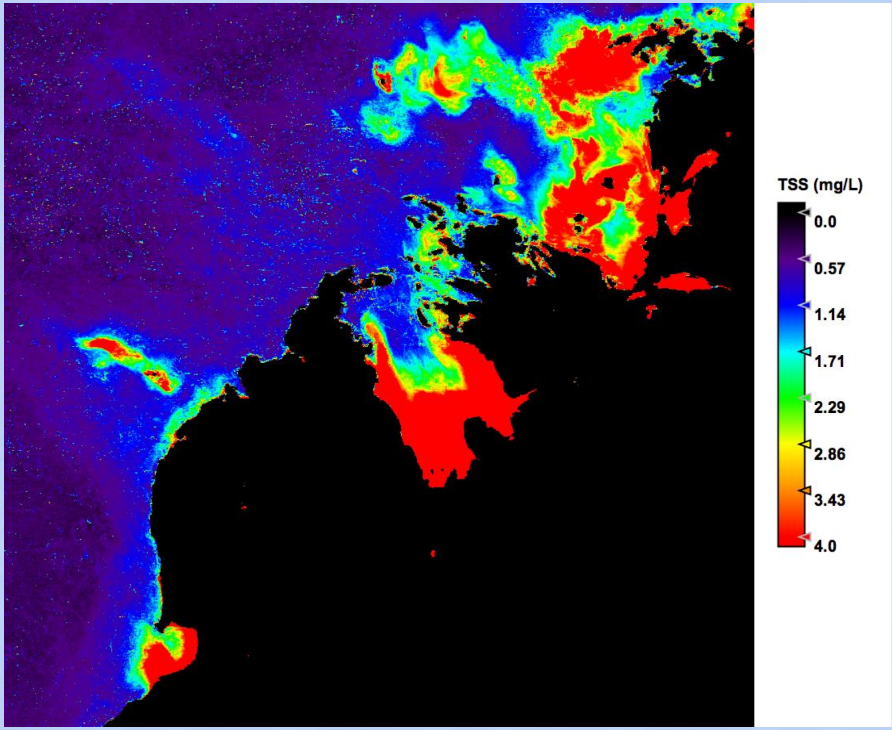
Tidal Range (m)





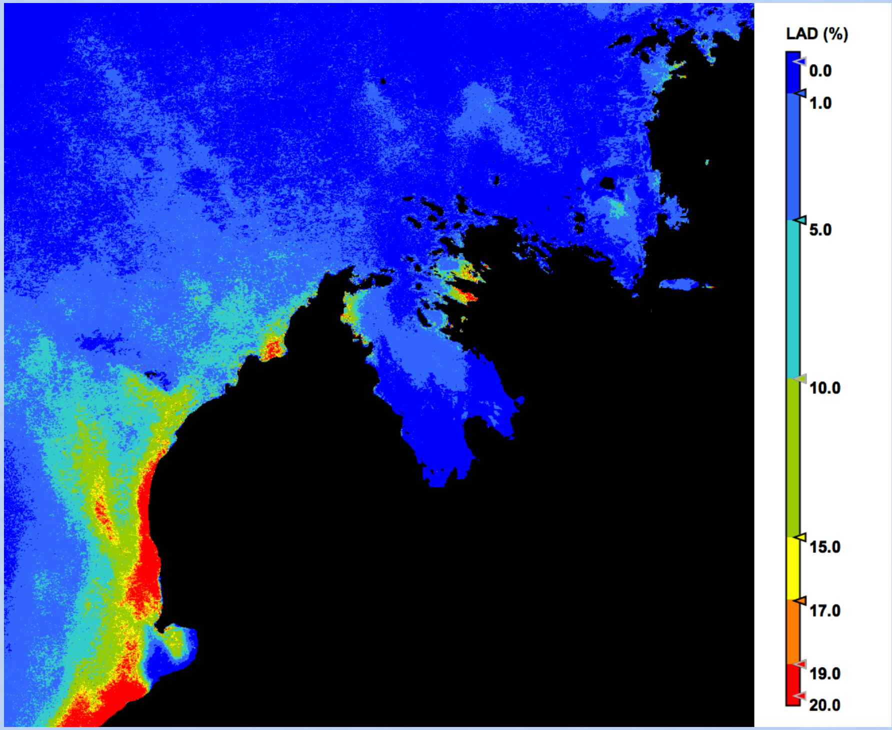
TSS (mg/L)

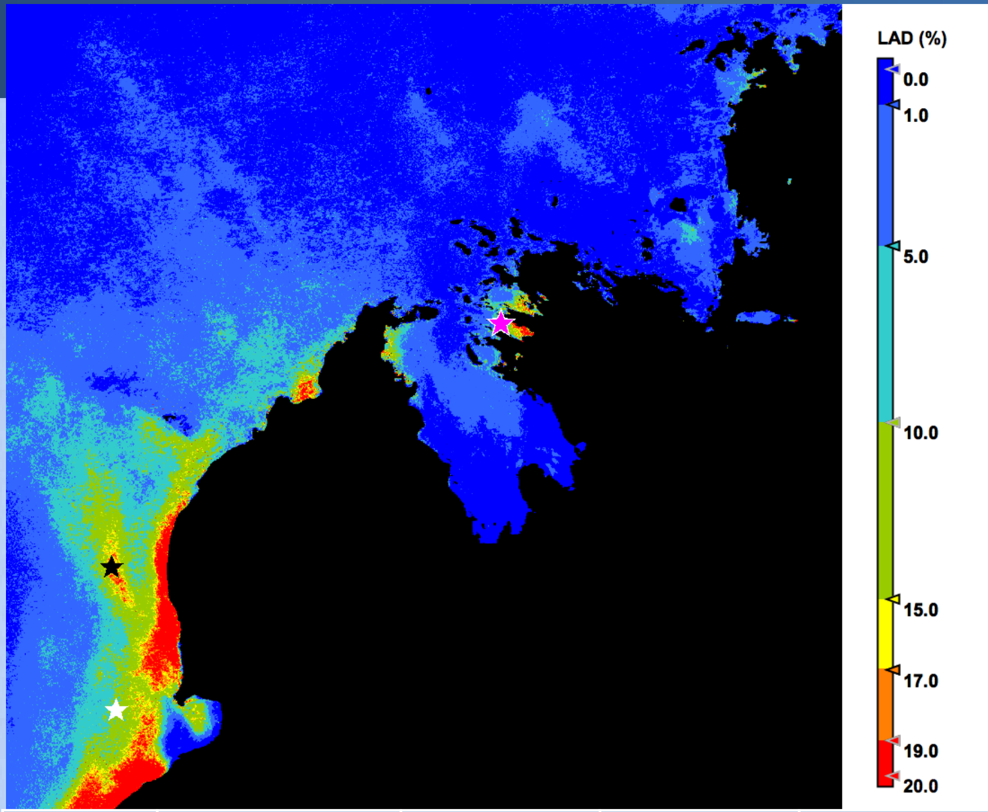
TSS time averaged between 1/2/10 – 28/2/10



LAD_{PAR} (%)

Percentage of light at depth time averaged between 1/2/10 – 28/2/10





LAD_{PAR} (%) @ 3 locations

	Lat/Lon	Bathy. (m)	Tidal Range (m)	TSS (mg/L)	High Tide LAD	Mid Tide LAD	Low Tide LAD
☆ (white)	18.06° S, 121.94° E	18.0	8.4	0.80	8%	12%	17%
★ (black)	17.47° S, 121.89° E	19.5	7.6	0.25	19%	23%	28%
★ (orange)	16.44° S, 123.48° E	16.3	9.3	2.40	2%	4%	7%

Thank You.

Questions?