CALIBRATION AND VALIDATION FOR INTERNATIONAL SATELLITE IMAGING SPECTROSCOPY MISSIONS: AUSTRALIA'S CONTRIBUTION

Cindy Ong, Tim Malthus, Ian Lau, Nandika Thapar, Mike Caccetta, Guy Byrne





2014

Standing Committee on Economics

Lost in Space? Setting a new direction for Australia's space science and industry sector

The Senate

2020

A National Space Policy: Views from the Earth Observation Co ANALYSIS OF AUSTRALIAN GOVERNMENT SPACE ACTIVITIES The economic value of earth observation from space Au has been receiving Australian govt spends \uparrow \$100M p.a. A review of the value to Austral EOS for > 50 yrs, of Earth observation from space on EOS and associated data developed world-class processing scientific, environmental > 100 active Federal and State govt and emergency programs with direct dependencies management EOS M SPACE applications on EO data ATSE EOS contribute > \$3B p.a. to GDP National Earth Observation Group ACIL Tasman



Continuity of Earth Observation Data for Australia: Research and Development Dependencies to 2020



Australia's Satellite **Utilisation** Policy ational Remote Sensing Tech

R8: That national EOS calibration and validation infrastructure be established.



National Earth Observations from Space Infrastructure Plan

Prepared by Geoscience Australia and the Bureau of Meteorology



UPTEAL WS FUTURE: THE FOS IMPERATIVE

Survey of national Cal-Val capabilities

Funded by Space Coordination Office and the TCP

Supports NEOS-IP recommendation 'That national EOS calibration and validation infrastructure be established'

- Audited existing Australian cal-val facilities and activities (survey and SWOT analysis)
- Provided recommendations on the path forward for the future of cal-val activities in Australia
- Report soon to be released



Survey findings

Significant infrastructure and activities exist upon which future activities can be developed. 11 calibration (8 optical, 6 in CSIRO), 12 validation (all for value added products). Some long-term.

Recent NCRIS funding (TERN, IMOS and AusScope) has been a significant stimulant (infrastructure and diversity) (\$59.6M, maintenance \$6M)

Good examples of best practice cal-val (e.g. ocean altimetry, ABARES Groundcover validation)

Duplication of effort low

Many strong international connections



SWOT - Geography

Threats

* Initiatives in other Southern hemisphere countries compromise our locational advantage

Strengths

- * Location x 3
- * Austral summer is northern winter
- * Unique environments with low aerosols

Opportunity

- * Diversity of locations (tropics - Antarctic)
- *'Supersites' for international EO calval across continent and oceans
- *Southern hemisphere collaboration

Weakness

- * Environments "too" unique
- * Smoke, dust and haze
- * Remoteness of remote areas



SWOT – Capability

Threats

Insufficient awareness leading to lack of funding Fragmented engagement with CEOS and GEO

Strengths

Small capable teams used to remote area science

Some excellent national and international collaborations

Weakness

Small expert base No coordinated expert community and infrastructure

Opportunity

Expand expert and infrastructure base through international collaboration

Establish Australian CoE for EO calibration/validation

(Tim.Malthus@csiro.au)



Search for vicarious calibration sites •Landsat TM 5 from Geoscience Australia archive

- period 2003-2010;
- total of 824 1 x 1 degree spatial tiles;
- 40-60 images per tile;

•Data processing delivered by GA

 physics-based surface reflectance correction (Nadir BRDF Adjusted Reflectance -NBAR);

Additional data processing

- "bare areas" retrieved by masking out green veg using NDVI >0.3
- masked for standing water (B4/B1)
- Masked out cloud (from GA PQA layer)
- only summer months of no to low rainfall were used; processing partitioned to approximate two climatic zones – sub tropical and temperate separated by the Tropic of Capricorn (-23.5S). Temperate dry season: November to March, Sub tropical zone dry season: May to October
- Calculated temporal mean, standard deviation and coefficient of variation for average albedo across VNIR-SWIR, VNIR and SWIR separately



VNIR-SWIR temporal means



Simpson Desert

Green vectors
show high rainfall
zone >600 mm pa
Red circles show
radius of 400 km
(half day's drive)
from major airport
Image is VNIRSWIR temporal
means

Strzelecki Desert



Lake Lefroy temporal means



Lake Lefroy temporal variations (coefficient of variation)



Desert temporal means and coefficient of variations (VNIR-SWIR)

Birdsville , S 25°53′56", E 139°20′45", Alt 46 m, PI : Ross_Mitchell, Ross.Mitchell@csiro.au Level 2.0 AOT; Data from 2011



Jan Feb har Apr hay Jun Jul aug sep loct nov dec Jan Feb Versizen22 DS 2011

95-



Desert temporal means and coefficient of variations (VNIR) Mitchell, R.M., O'Brien, D.M., Edwards, M., Elsum, C.C., & Graetz, R.D. (1997). Selection and initial characterisation of a bright calibration site in the Strzelecki Desert, South Australia. *Canadian*

CIMEL at Birdsville



51-54 48-51 45-48 42-45 39-42 36-39 33-36

Coefficient of variation

Journal of Remote Sensing, 23, 342-353

Coastal sand









Pure Quartz Sand?

- 1. Investigated potential new vicarious calibration site
 - Esperance
 - Wylie Bay Sand Dunes
 - Wharton Bay Beach
 - Lucky Bay Beach (whitest sand



- Collected 4 buckets of samples (1 Wharton, 2 Wylie, 1 Wharton, I Lucky)
- Analysed mineralogy of samples: VIS-SWIR, TIR, XRD, Cathode Luminescence (fluorescence of carbonate minerals (aragonite and calcite)), LOI experiments



Some insights

- Most salt lakes are similar with high spatial homogeneity (overall within 6% for VNIR-SWIR and 9% for VNIR with large patches of within 3% reflectance difference);
- Temporal variations are higher than coastal and inland sand sites (lakes are mostly <25% difference for VNIR. NB. This is between dates not reflectance);
- Meets albedo threshold criteria (>30%) for VNIR but signal low for SWIR (water);

Coastal sands

- Spatial homogeneity not as good as salt lakes (up to 15% reflectance value difference);
- Temporal variations low (<10%);
- Meets albedo threshold criteria for all wavelengths;
- Have to consider issues related to aerosols, spatial extent and topography;

Inland sand dunes/deserts

- Spatial homogeneity similar to coastal sands (up to 12% reflectance value difference);
- Temporal variations low similar to coastal sands;
- Meets albedo threshold criteria for all wavelengths;
- Have to consider issues related to access/remoteness and topography;



CSIRO calibration and validation laboratories in East and West of Australia

Instrumentation, mirrored at each facilities at Canberra and Perth:

- Calibrated, stable current power supply (Precision current source Gooch and Housego)
- Calibrated irradiance source (OL-FEL-C lamp)
- Calibrated radiance source (Custom 20 inch integrating sphere Labsphere)
- Calibrated 99% reflectance targets (Spectralon[™] Labsphere)
- Optical breadboard and mounting accessories
- ASD FieldSpec spectroradiometers (Mk2,3,4)
- ASD Contact probe measurement apparatus
- Calibrated wavelength standards (doped (rare earth and talc) sintered Fluorilon by Avian Tech
- Wavelength calibration lamps (HgAr)





Calibration and validation laboratories – protocols (Ian.Lau@csiro.au;Nandika.Thapar@csiro.au)

Protocols have been written for

- Spectrometer baseline calibration
- Spectrometer performance (SNR, NER, NEdL, wavelength)
- Reflectance target checking and calibration
- Cross calibration of reflectance targets
- Cross calibration of irradiance and radiance sources





Summary

- Significant infrastructure already exist;
- Southern hemisphere advantages;
- Good climatic conditions for a large part of the country;
- Large expanse of land away from "interferences"; temporal analysis shows quite a number of potential sites that will be further investigated;
- Significant capabilities and experience;
- Backed up by NEOS-IP (approved by Australian government).



Vicarious Cal - Lake Lefroy ongoing upgrade

Climate

- rainfall @ Kambalda (on lake shore) mean 266.2 mm, lowest 13.7 mm (June), highest 69.5 mm (January);
- Temperature @ Kalgoorlie (60 km away) mean 25.3°C, highest 33.6°C (January), lowest 16.7°C (July);
- average number clear days is 151.1, annual average cloudy days 89.2.

Landscape/Landform

- medium-sized playa lake within Lefroy Palaeodrainage on Yilgarn Craton of Western Australia;
- bed of Lake Lefroy is extremely flat, mean elevation of the lake bed approximately less than 286 m, crust is halite up to 10 cm thick, but often no more than 1-2 cm in thickness. Halite covers approximately 64% of the lake bed, the crust becomes thinner towards the lake shore and lake islands.

Vegetation

 No vegetation on lake bed but surrounding vegetation consists of 50 vascular plant species with the predominant families of species being Chenopodiaceae, Asteraceae, Aizoaceae, Poaceae, Portulacaceace and Frankeniaceae.

Instrumentation

- CIMEL (on Aeronet);
- Weather station (to be upgraded this year);
- Cosmic Ray probe (moisture);

