Recent developments in ASTER Geoscience products for Australia

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Identifying and mapping regolith materials at the regional and continental-scale can be facilitated via a new generation of remote sensing methods and standardised geoscience products. The multispectral Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER) is the first Earth observation (EO) system to acquire complete coverage of the Australian continent. The Japanese ASTER instrument is housed onboard the USA's Terra satellite (see Figure 1) and has 14 spectral bands spanning the visible and near-infrared (VNIR - 500-1,000 nm – 3 bands @ 15 m pixel resolution); shortwave-infrared (SWIR – 1,000-2,500 nm range – 6 bands @ 30 m pixel resolution); and thermal infrared (TIR 8,000-12,000 nm - 90 m pixel resolution) with a 60 km swath.

Figure 1: ASTER sensor on TERRA satellite http://c3dmm.csiro.au/WA_ASTER/index.html).

Although ASTER spectral bands do not have sufficient spectral resolution to accurately map the often small diagnostic absorption features of specific mineral species, which can be measured using more expensive "hyperspectral" systems, current coverage of hyperspectral data is very restricted. The extensive coverage and 30m pixel size of ASTER make it well suited to national scale work. The spectral resolution of ASTER make it best suited to mapping broader "mineral groups", such as the di-octahedral "Al-OH" group comprising the mineral sub-groups (and their minerals species) like the kaolin group (e.g. kaolinite, dickite, halloysite), white micas (e.g. illite, muscovite, paragonite) and smectites (e.g. montmorillonite and beidellite). Extracting mineral group information using ASTER using specially targeted band combinations can find previously unmapped outcrop of bedrocks, weathering products, help define soil type and chemistry, and delineate and characterise regolith and landform boundaries over large and remote areas.

A multi-agency collaboration between state and federal government partners has been working towards making an all-of Australia, public, web-accessible, GIS-compatible ASTER geoscience maps, suitable for mapping down to 1:50,000 scale. Geoscience Australia, along with CSIRO and the Centre for 3D Mineral Mapping have developed and tested methodology for regional-to-state ASTER mosaics and products for many years with several state government geoscientific agencies, including GSWA, GSQ, PIRSA and NTGS. An ASTER mosaic and products for the whole state of Western Australia has been completed and released (see Figures 2 and 3), this work represents the largest ASTER mosaic of this type in the world and sets a new benchmark for state-continent scale spectral remote sensing. A goal for this collaborative group is to complete a world-first continental-scale ASTER Geoscience Map planned for public released at the 34th International Geological Convention in Brisbane, in August 2012. This multi-agency cooperative project is supported both nationally, as well as internationally by the ASTER Science Team, ERSDAC, NASA and the USGS.

Additional outcomes of this collaborative effort include the formation of a national platform for establishing national standards, including: (1) geoscience product nomenclature; (2) processing methods; (3) accuracy assessments; and, (4) traceable documentation. Detailed product notes (see Table 1) outline these standards and provide significant knowledge transfer for existing and new users of this type of data. Fundamental to this initiative is the development and publication of processing methods and quality control (QC) measures that are universally applicable and easy to implement. One of the keys to this project's success is access to extensive Hyperion satellite hyperspectral imagery (~2,700 scenes across Australia) which is critical for calibration and validation of the processed ASTER data. Reduction to "surface" reflectance using independent validation data such as Hyperion, and calculating statistics to generate regression coefficients (gains and offsets), reduces errors in the ASTER instrument and increases reliability and corroboration of spectral responses.

Table 1: Example of ASTER VNIR-SWIR Geoscience Products for the ASTER false colour, CSIRO regolith ratios and Green vegetation products (from WA Product notes, Version 1.1).

<table>
<tr><th>Product name
(in red)</th><th>Base algorithm B=band No. = band No.</th><th>Masks</th><th>Stretch (lower limit)</th><th>Stretch (upper limit)</th><th>Stretch type</th></tr>
<tr><td rowspan="3">1. False colour
(red = green vegetation)</td><td>Red: B3
Green: B2
Blue: B1</td><td>none</td><td>R: 361
G: 309
B: 1</td><td>R: 4241
G: 2913
B: 1961</td><td>linear</td></tr>
<tr><td colspan="5">Accuracy: n/a</td></tr>
<tr><td colspan="5">Suggested use: Use this image to help understand non-geological differences within and between ASTER scenes caused by green vegetation (red), fire scars, thin and thick cloud and cloud shadows. Use band 2 only for a gray-scale background to the content, composition and index colour products.</td></tr>
<tr><td rowspan="3">2. CSIRO Landsat TM Regolith Ratios
(white = green vegetation)</td><td>R: B_3/B_2
G: B_3/B_7
B:B_4/B_7</td><td>composite mask*</td><td>R: 1.128
G: 0.697
B: 1.050</td><td>R: 1.853
G:1.530
B: 1.780</td><td>linear</td></tr>
<tr><td colspan="5">Accuracy: n/a</td></tr>
<tr><td colspan="5">Suggested use: Use this image to help interpret (1) the amount of green vegetation cover (appears as white); (2) basic spectral separation (colour) between different regolith and geological units and regions/provinces; and (3) evidence for unmasked cloud (appears as green).</td></tr>
<tr><td rowspan="3">3. Green vegetation Content</td><td>B_3/B_2</td><td>composite mask*</td><td>1.5
Blue is low content</td><td>2.5
Red is high content</td><td>linear</td></tr>
<tr><td colspan="5">Accuracy: Moderate: Complicated by iron oxides, dry vegetation and uncorrected aerosols (including smoke). Iron oxide produces a small decrease in this green vegetation product. Beware of strong seasonal variations in green vegetation content.

Note 1. The standard NDVI $[(B_3-B_2)/(B_2+B_3)]$ and the B_3/B_2 combination used are highly correlated.

Note 2. The spectral band-passes of ASTER do not cover diagnostic dry vegetation features (e.g. cellulose at 2080 nm) such that measuring, mapping and removing the effects of dry vegetation is difficult with these data.</td></tr>
<tr><td colspan="5">Geoscience Applications#: Use this image to help interpret the amount of "obscuring/complicating" green vegetation cover.</td></tr>
</table>

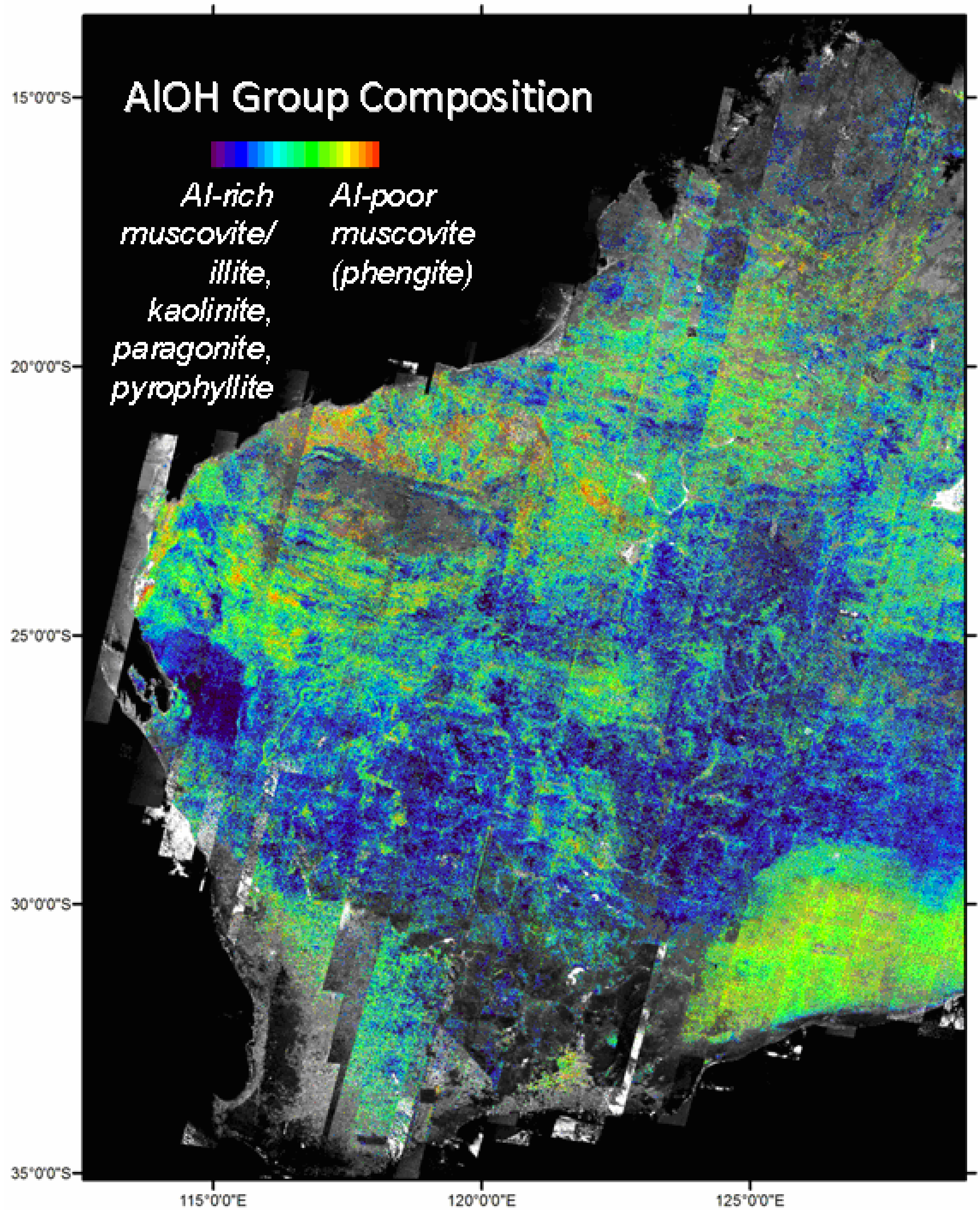

Figure 2: Example geoscience products: AlOH group composition ASTER map coverage for Western Australia (band 2 used as reference background image) available from http://c3dmm.csiro.au/WA_ASTER/index.html

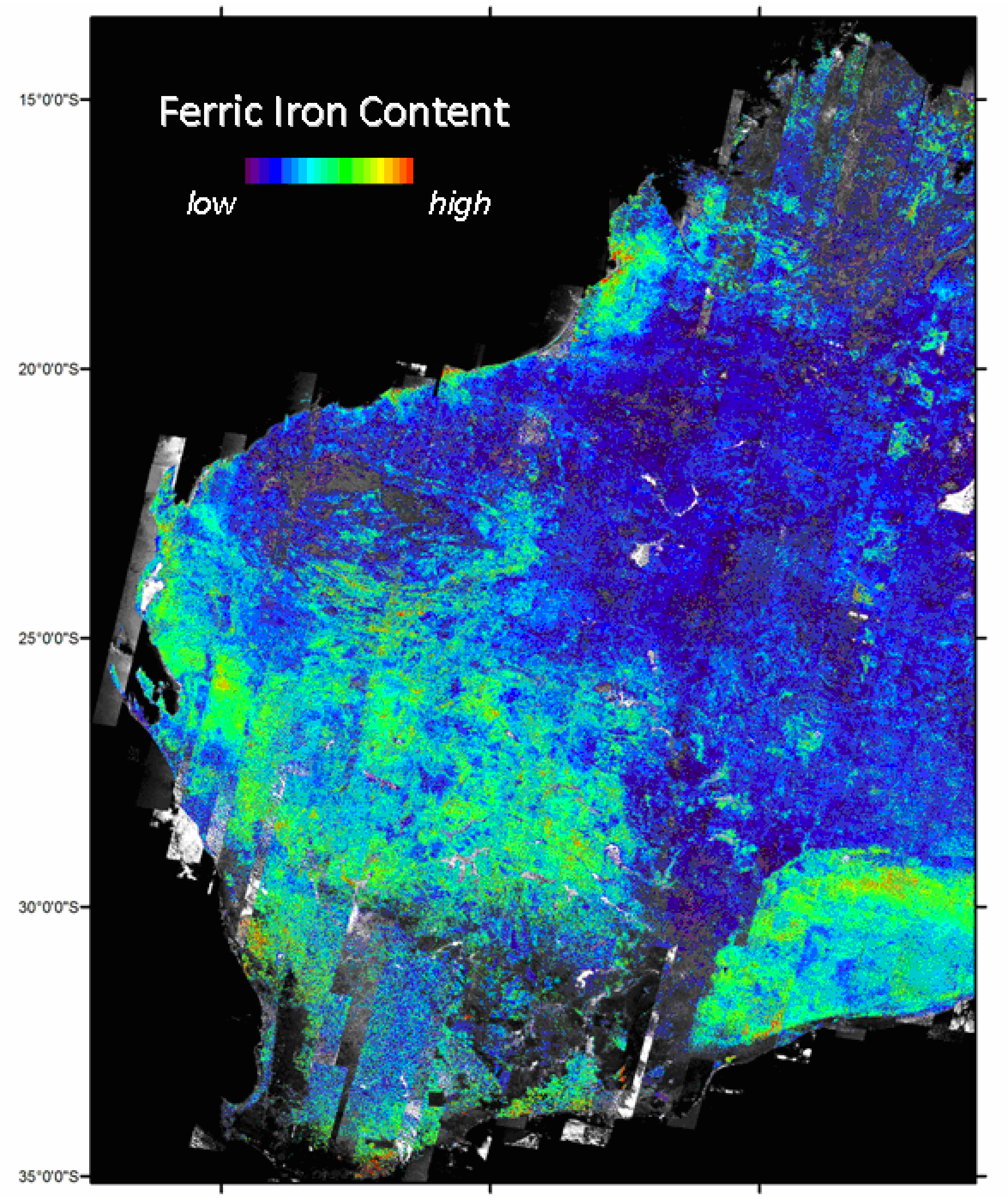

Figure 3: Example geoscience products: iron oxide content from ASTER map coverage for Western Australia (band 2 used as reference background image) available from http://c3dmm.csiro.au/WA_ASTER/index.html