The Joint Remote Sensing Research Program
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MODIS Monthly Fractional Cover

Product creation and distribution

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Abstract: Consideration of ground cover is an important aspect of land management, particularly in agricultural environments. Land management decisions can be better informed by timely information on ground cover levels. The aim of this work was to establish a process for creating and distributing, to the public, monthly ground cover products within a short period following the end of the month. This paper describes the existing data, algorithms, compute servers, data distribution infrastructure, and goodwill that were leveraged to achieve this goal. The data are currently used by the DustWatch project for monitoring land susceptibility to wind erosion and we expect there will be other beneficiaries.

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Introduction

Consideration of ground cover is an important aspect of land management, particularly in agricultural environments. For example, the DustWatch program monitors and reports on ground-cover levels as an indicator of the land's susceptibility to wind erosion[1]. These reports are produced monthly, and within a short period following each month. The reports depend on timely ground cover information for each month for southern Australia. The aim of this work was to establish a process for creating monthly vegetation cover products from satellite imagery within two weeks of the end of a month, which can be used to assess ground cover. This document describes the method used to create these monthly cover products.

Product creation

The Moderate Resolution Imaging Spectroradiometer (MODIS) sensors, on board the Terra and Aqua satellites, collect up to two observations of each location on Earth every day. Each observation covers a nominal area of 500 m. The spatial coverage, frequent revisit period, and ease of availability make the data an ideal source for producing the monthly cover information.

Figure 1 is an overview of the flow of data in the production of the Monthly Cover products. There are three key products:

- The MODIS Nadir BRDF-Adjusted Reflectance (NBAR) product, MCD43A4, produced by the MODIS team;
- the Fractional Cover product, produced by the Commonwealth Scientific and Industrial Research Organisation (CSIRO); and
- the MODIS Monthly Fractional Cover product, produced by the Joint Remote Sensing Research Program (JRSRP).

Overviews of the MODIS NBAR and the Fractional Cover products, and a detailed description of the MODIS Monthly Fractional Cover, which we refer to as the Monthly Cover product herein, are given below.

[1] www.dustwatch.edu.au; http://www.environment.nsw.gov.au/dustwatch/dwreports.htm

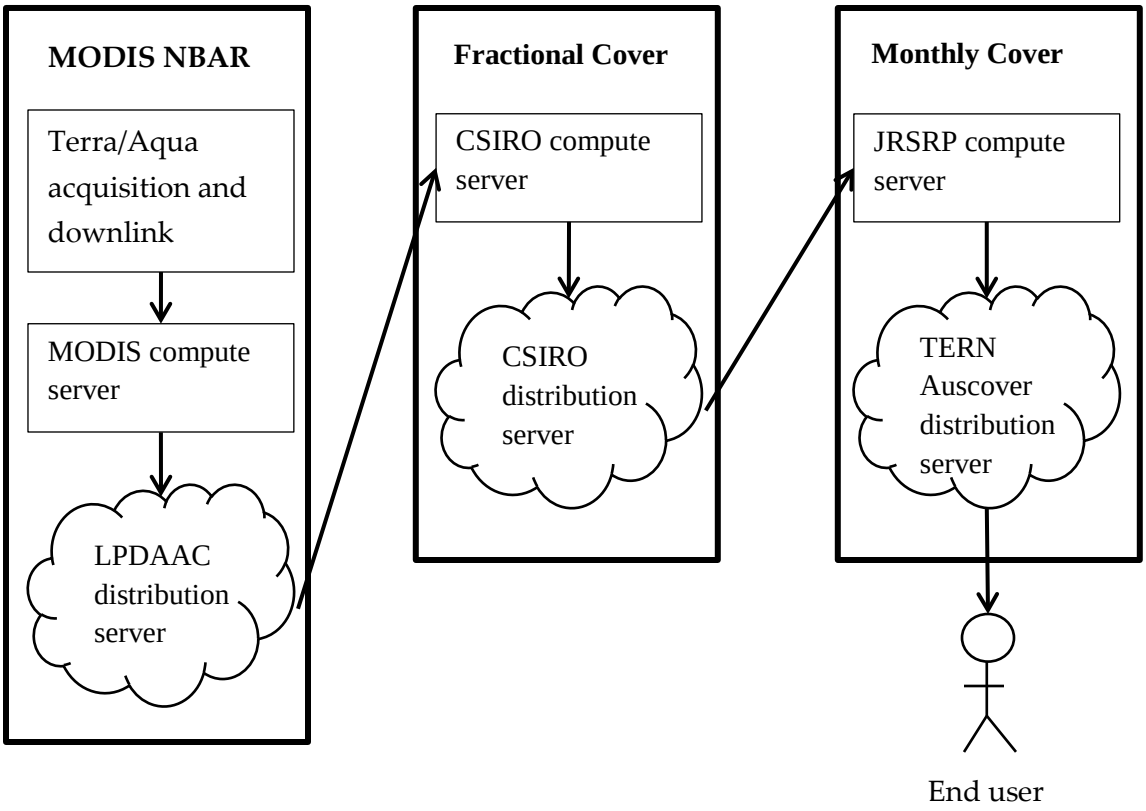

Figure 1: The notional flow of data in the production and distribution of the monthly cover product. The MODIS NBAR product is produced by the MODIS processing system every 8 days using data from the MODIS sensors on the Terra and Aqua satellites. Each pixel represents the surface reflectance as viewed from nadir with a solar zenith angle at local solar noon. CSIRO download the MODIS NBAR products to create the fractional cover products, which the JRSRP use to create the MODIS Monthly Cover products.

MODIS NBAR

Each pixel in the MODIS NBAR product represents surface reflectance as viewed from nadir with a solar-zenith angle at local solar noon (Schaaf *et. al.*, 2002). To generate this product, cloud-free, daily observations from the MODIS sensors on the Terra and Aqua satellites are collected over a 16-day period. Bi-directional surface reflectance is computed for each observation by correcting for atmospheric scattering and attenuation (Vermote and Kotchenova, 2008). These observations are used to parameterise a model of the bi-directional reflectance properties of the surface. The model is used to calculate the surface reflectance at nadir and the solar-zenith angle being the mean angle at local solar noon for the compositing period. The product is produced every 8 days, with 46 images created each calendar year.

Fractional Cover

Each pixel in the Fractional Cover product has three values representing the fraction of bare ground, green vegetation, and non-green vegetation (Figure 2). The vegetation fraction components represent the vertically-projected fraction of vegetation per unit area. The fractions are computed using a linear spectral unmixing model, which was trained on 1171 field observations (Guerschman *et.al.*, 2014; Muir *et.al.*, 2011). The fractional cover values range from 0 to 1, and notionally the sum of the three fractions is 1, although it may not be. An image is produced every 8 days – one for each of the MODIS NBAR images.

At this point it is important to make a distinction between fractional cover and ground cover. Ground cover pertains to the non-woody, understorey vegetation – primarily grasses and forbs. The non-green and green vegetation cover components of the fractional cover product are an estimate of the amount of woody and non-woody cover in the overstorey, mid-storey, and understory stratums combined. The fractional cover product provides estimates of the ground cover where there is little or no woody vegetation.

Monthly Cover

Each pixel in the Monthly Cover product has three values representing the fraction of bare ground, green vegetation, and non-green vegetation, just as the Fractional Cover product does (Figure 2). The product is produced on a monthly basis, as its name suggests, giving 12 images per year. Each Monthly Cover image is a composite of 3 or 4 of the Fractional Cover images produced in the month (Table 1). The main advantage of the monthly cover product is that it is tied to a calendar month, which makes it easier to communicate changes over time to non-technical users. The longer composite period also increases the number of cloud-free pixels, compared to the 16-day product, which can be seen in Figure 2.

Strictly speaking, a monthly image will contain information from one or both of the previous or following months. This is due to the process used to create the MODIS NBAR images from 16 days of observations. Therefore careful consideration was given to the Fractional Cover images to include in the production of the Monthly Cover images. One of the main advantages of MODIS data is its relatively rapid production. We wanted to maintain that advantage and our goal was to make a Monthly Cover image available on the download server within two weeks of the end of the month of interest, but with the constraint that it contained minimal data from adjacent months. Therefore any overlap with adjacent months is biased towards the previous month, allowing us to meet our desired delivery schedule. Table 1 shows the Fractional Cover images used in the production of each Monthly Cover image.

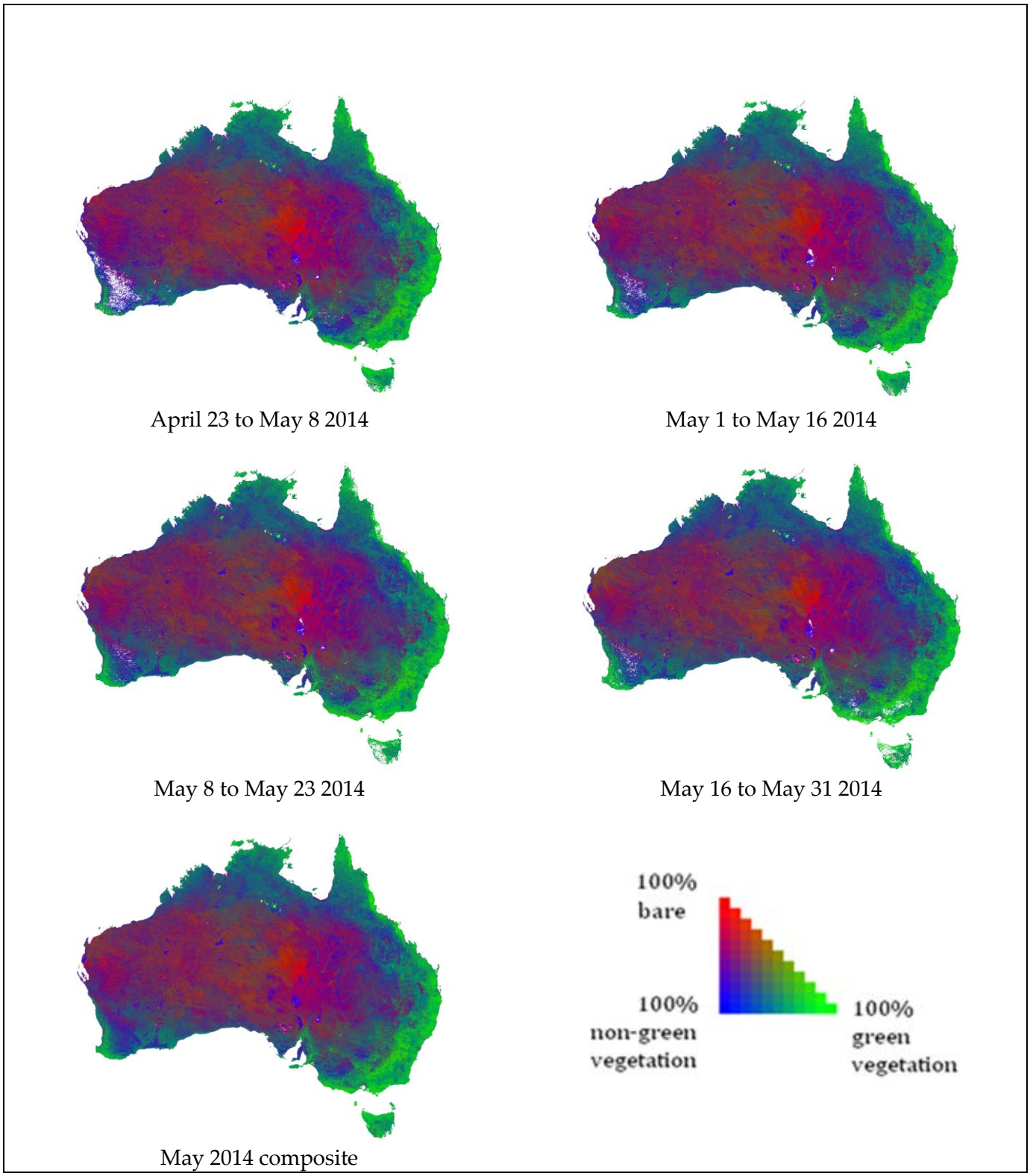

Figure 2: A compositing example. The cover image for May 2014 has been created from four fractional cover images. There may be overlap with previous and following months in the monthly composite. The choice of input images is biased so that the monthly image is available soon after the end of the month.

Table 1: The Fractional cover images used in the creation of the monthly images. The day of year refers to the date of the first observation used in the production of the MODIS NBAR images. Therefore a monthly image will contain information from one or both of the previous or following months. *Day 361 refers to the image with a start date in December of the previous year.

Month	MODIS 'day of year' images	Dates of satellite observations
Jan	361*, 1, 9, 17	Dec 27 – Feb 2
Feb	25, 33, 41, 49	Jan 25 – Mar 6
Mar	57, 65, 73	Feb 26 – Mar 30
Apr	81, 89, 97, 105	Mar 22 – May 1
May	113, 121, 129, 137	Apr 23 – Jun 2
Jun	145, 153, 161, 169	May 25 – Jul 4
Jul	177, 185, 193, 201	Jun 26 – Aug 5
Aug	209, 217, 225, 233	Jul 28 – Sep 6
Sep	241, 249, 257	Aug 29 – Sep 30
Oct	265, 273, 281, 289	Sep 22 – Nov 1
Nov	297, 305, 313, 321	Oct 24 – Dec 3
Dec	329, 337, 345, 353	Nov 25 – Jan 4

Each pixel in the Monthly Cover image is chosen from one of the pixels, at the corresponding location on the pixel grid, from the input Fractional Cover images (Figure 3). For each of the input pixels the distance to all other input pixels is calculated in feature space, using the sum of squared differences – in this case the feature space is the bare, green, and non-green fractions. The pixel to be included in the Monthly Cover image is that with the smallest distance, and it is known as the medoid value. The medoid represents a statistically-robust estimate of the central value of multi-dimensional data and has been shown to produce composite images that are representative of a period of interest (Flood, 2013; Struyf, *et.al.*, 1997).

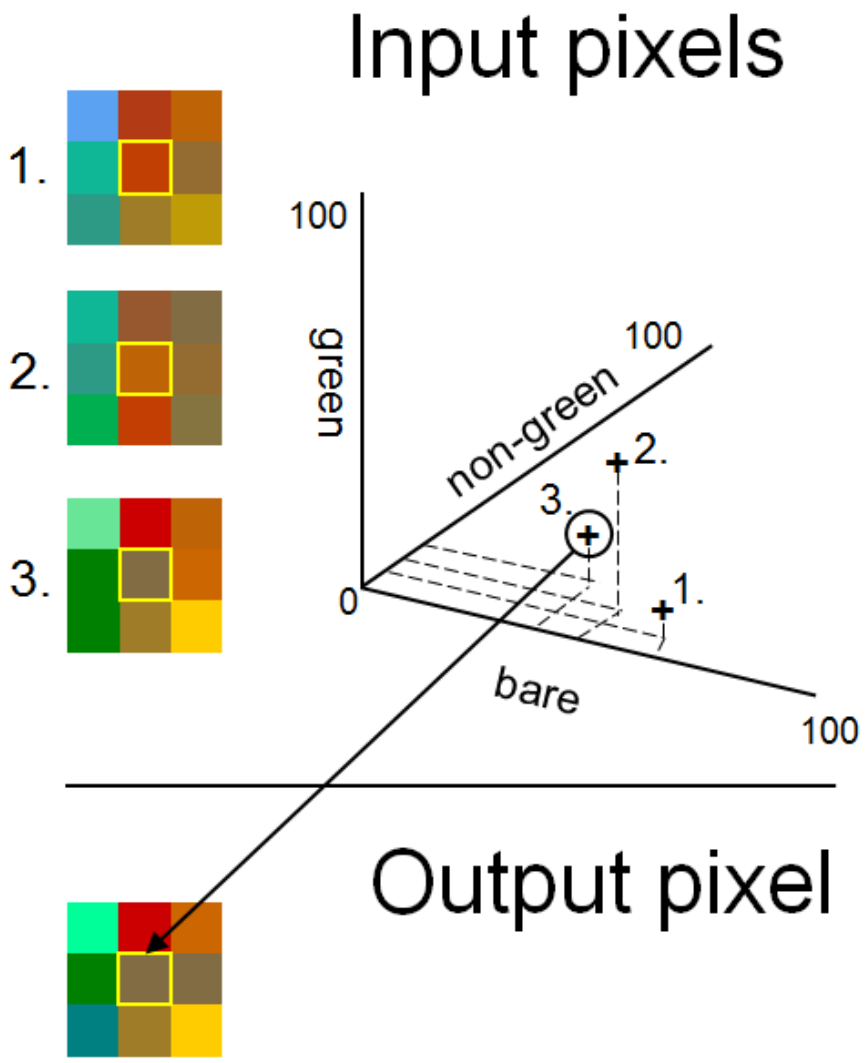

Figure 3: The method used to select the pixel for the output image from the available input pixels. For each pixel the distance to all other pixels is calculated in feature space, using the sum of squared differences. The pixel with the smallest distance is considered to be closest to the centre of the data cloud, and is chosen as the output pixel. The output pixel is the medoid of the input pixels.

Data access and rights

Data is available through the TERN Auscover download portal and is provided free under a Creative Commons by Attribution license. Further information on data access and licensing is available on the product's web page:
http://www.auscover.org.au/xwiki/bin/view/Product+pages/FC+Composites+MODIS+OEH

Conclusions

We started with the goal of producing Monthly Cover images in a timely manner for use in reporting the state and change of vegetation cover for monitoring wind erosion for DustWatch. We were able to achieve this relatively simply using existing data, algorithms, compute servers, data distribution infrastructure, and the goodwill of a number of organisations and individuals. We expect that other projects will benefit from the timely production of the Monthly Cover images as the DustWatch program has.

References

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