The Coleambally Agricultural Component of Hyperion Instrument Validation

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Abstract-The Coleambally Irrigation Area (CIA) in southern New South Wales, Australia, is an agricultural site used in support of validation of the hyperion imaging spectrometer onboard the earth observing-1 (EO-1) satellite. A time series of hyperion imagery has been acquired over the CIA during the 2000/2001 southern hemisphere summer growing season. Within the CIA, there are five different varieties of rice and several row crops grown, specifically corn, soy beans, and sorghum. Imagery has been acquired prior to rice canopy closure, pre panicle initiation, at panicle initiation, during grain filling and after senescence. Extensive in situ ground sampling was also performed several times during the growing season to validate the spectral signatures received from hyperion. In this paper, we describe the databases developed that will be used in future instrument validation efforts. This project also demonstrates successful integration of a time series of hyperspectral imagery to relevant land use and other spatial data.

I. Introduction

Increasing on-farm efficiencies through technology is a common goal in agricultural management [1]. This can be achieved, for example, by altering management actions as situations change on the ground. This, in turn, requires temporally frequent and spatially variable information; potentially acquired from remote sensing. Remote sensing, however, has been limited in its capacity to provide this information to agriculturalists at large. These limitations of remote sensing, among other things, have been related to fixed spectral bands, too coarse spatial resolutions, inadequate repeat cycles, and long delivery times [2]. Hyperspectral sensors eliminate some of the spectral limitations because they provide, in a sense, continuos spectral coverage. Until now, these sensors have been limited to airborne systems, which generate additional problems with increased data processing, making it hard to monitor large areas [2], as well as problems with repeatability, making it difficult or costly to acquire time series imagery. With the recent launch of the earth observing-1 (EO-1) satellite with the hyperion imaging spectrometer (see [3], this session), hyperspectral remotely sensed data is now available from space.

This paper describes the structure of the hyperion validation database developed for the Coleambally Irrigation Area (CIA) in southern New South Wales (NSW), Australia. Specifically, the field data, Geographic Information System (GIS) database, and the land use database developed for crop identification and sensor validation are described.

II. Study Site

The CIA is approximately 95,000 hectares in size, comprising over 500 farms surrounding the township of Coleambally, NSW. The CIA falls completely within two Landsat scenes (Path 92 Row 84, and Path 93 Row 84) allowing for an 8 day repeat cycle for the acquisition of both Landsat and EO-1 imagery (Fig. 1). Water usage and area of crops are well managed at the CIA. Fields are large (up to 70 hectares) and well maintained, making them ideal for instrument validation. The principal summer crops grown at the CIA are rice, corn, and soybeans, while winter crops include wheat, barely, oats, and canola. Pasture is grown in both seasons. The timing of the growing season for the primary crop at the CIA, rice, is: 1) placed under permanent flood and aerially sown in late September / early November; 2) canopies emerging during late October / late November; 3) flowering by late January / early February; 4). de-watered in late February / March; and 5) harvested in March / May.

III. Datasets

A. *Remote Sensing Time Series*

Thirteen hyperion images have been acquired during the 2000/2001 growing season over the CIA (Table 1), while three more are currently planned (at the time of writing). A Hymap airborne hyperspectral site characterisation was also conducted on 08 December 2000, providing crop emergence information. Six of the hyperion acquisitions so far have been severely affected by cloud, leaving at least seven clear or only slightly cloud affected. Associated Enhanced Thmatic Mapper (ETM) images were purchased matching all of the clear hyperion images. A high resolution (2m pixel) digital aerial photograph mosaic was also acquired over the CIA in January 2001.

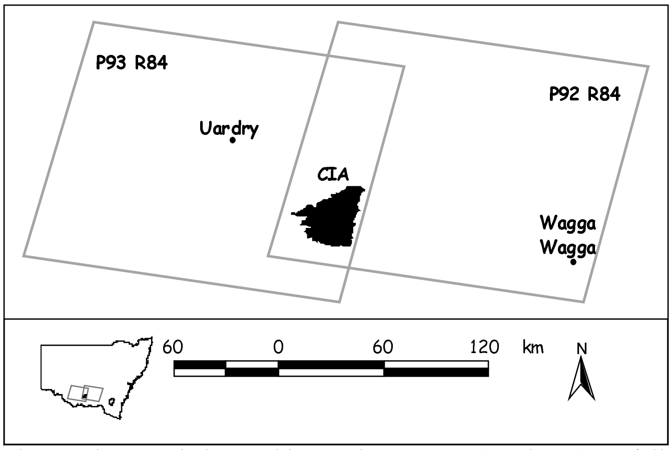

Fig. 1. The CIA is located in southern NSW (see inset). It falls completely within two Landsat ETM scenes, allowing for an 8-day repeat cycle.

TABLE 1
HYPERION ACQUISITIONS AT CIA FOR 2000/2001 SUMMER GROWING SEASON EXPRESSED IN LOCAL DATES (AUSTRALIAN EASTERN TIME). ITALICISED TEXT REPRESENTS PLANNED ACQUISITIONS AT THE TIME OF WRITING.

Acquisition date (local time)	Cloud cover (%)	Field data
24 Dec 2000	10	Rice plant samples
02 Jan 2001	0	Rice plant samples, chlorophyll meter
18 Jan 2001	90	None
25 Jan 2001	40	None
03 Feb 2001	0	ASD spectra, albedo, LAI
10 Feb 2001	100	None
19 Feb 2001	5	Plant samples
26 Feb 2001	100	None
07 Mar 2001	0	ASD spectra, plant samples
14 Mar 2001	0	None
23 Mar 2001	90	None
30 Mar 2001	0	None
08 Apr 2001	100	None
15 Apr 2001	*Unknown*	*None planned*
24 Apr 2001	*Unknown*	*None planned*
01 May 2001	*Unknown*	*None planned*

B. GIS Database

The centreline of over 466 km of road (comprising over 20,000 individual positions) was digitised using a Trimble Pro XRS differential global positioning system (DGPS), including 83 road-road intersections and 46 road-canal intersections. These ground control points are used for image registration of the remotely sensed data and for positional accuracy assessment of critical GIS data [4]. Field and rice bay boundaries were digitised from the 2001 high resolution mosaic image and given unique identifiers so they can be linked to the land use database.

C. Land Use Database

Land use information within the focus hyperion acquisition boundary of the CIA is being collected. Information about crop type, variety, and management practices are linked to individual paddocks within the GIS. Also, Coleambally Irrigation Limited (CIL), have provided water use information by farm. This database provides the validation of remotely sensed site characteristics for this study.

D. Meteorological Data

Air temperature, solar radiation, relative humidity, precipitation, wind speed, and wind direction are all collected on site at the CIA. The nearby Uardry weather station (Fig. 1) may be very important for instrument validation. An Australian Bureau of Meteorology and NASA Earth Observing System (EOS) land validation core site, Uardry has a permanent tower and provides continuous readings of solar radiation, albedo and other meteorological data. Radiosonde data is also provided for EO-1 acquisitions by the World Meteorological Organisation (WMO) weather station (Id: 910) at Wagga Wagga, NSW (Fig. 1). Pressure, humidity, and air temperature are recorded from ground level to 20,000m above the surface from a PTU radar radiosonde close to 10:15am local time (23:15 UTC).

E. Ground Data

Rice samples were collected in association with both the 24 December 2000 and 02 January 2001 E0-1 overpasses (see Fig. 2 for photograph of rice crop). Locations of rice samples were digitised with the DGPS and marked with white poles prior to the December acquisition so they could be easily resampled during the January acquisition. In both cases, 38 1m^2 samples were analysed for nitrogen (N) and biomass. Twenty-three of these same locations were measured with a chlorophyll meter (SPAD-502) in the field on 03 January 2001 (Table 1).

Analytical Spectral Devices (ASD) spectroradiometers (full range 350 – 2500 nm) were used to collect *in situ* surface spectral measurements in association with the 03 February 2001 and 07 March 2001 EO-1 CIA overpasses. Soil, soybean, rice, and bright stubble targets were measured between approximately 10am and 1pm local time on both occasions; EO-1 passes over the CIA close to 11am local time.

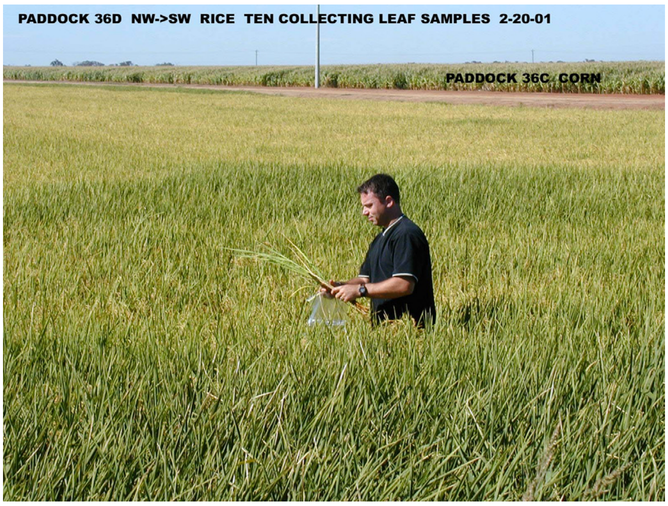

Fig. 2. Rice crop at CIA during grain filling. This photograph was taken 19 February 2001 by Jay Pearlman, TRW.

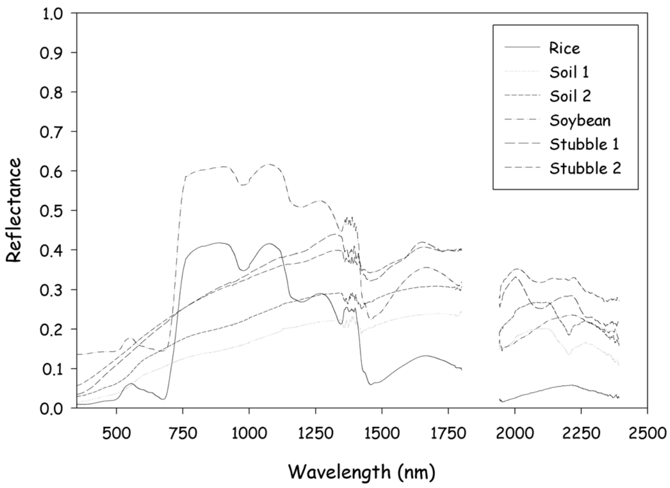

Fig. 3. Mean ASD spectra recorded at CIA during the 03 February 2001 EO-1 overpass for six different surface targets.

Multiple samples were collected systematically for each target. Multiple replicates were automatically collected at each sample by the ASD. Spectral measurements were converted to reflectance values through calibration to associated white panel reference readings taken before and after target measurements (Fig. 3). Associated albedo measurements were taken at matching locations during the 03 February 2001 acquisition. GPS readings were taken at the central location of each target. Positional accuracy of these GPS readings is expected to be within 10 metres of truth. Leaf Area Index (LAI) readings were also taken to characterise crop structure near the time of the February overpass.

A few crop plant samples were collected in association with the 19 February 2001 acquisition, including corn, sorghum, soybeans, and sunflower. Also, plant samples of common rice weeds were collected on 07 March 2001.

III. Disscussion

This project demonstrates successful integration of a time series of hyperspectral imagery to relevant land use and other spatial data. The Coleambally agricultural database will allow for the characterisation of several types of crops through an entire growing season. This analysis will be very important for hyperion instrument validation. The data acquired ancillary to the hyperion images are critical in this process. The GIS database developed at the CIA will enable accurate geo-location of spectra, ground spectral measurements will be crucial in atmospheric testing, plant samples will enable physiological characterisation, and land use information will be important for describing variation within the remote spectra.

Acknowledgment

The Hyperion data were collected by NASA and processed by TRW for the evaluation of the experimental sensors on the New Millennium EO-1 mission. Data were provided to CSIRO through its membership with the EO-1 Science Validation Team (SVT). The special efforts of TRW to facilitate access to the data are gratefully acknowledged. Thanks also to Coleambally Irrigation Limited for their cooperation and support.

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