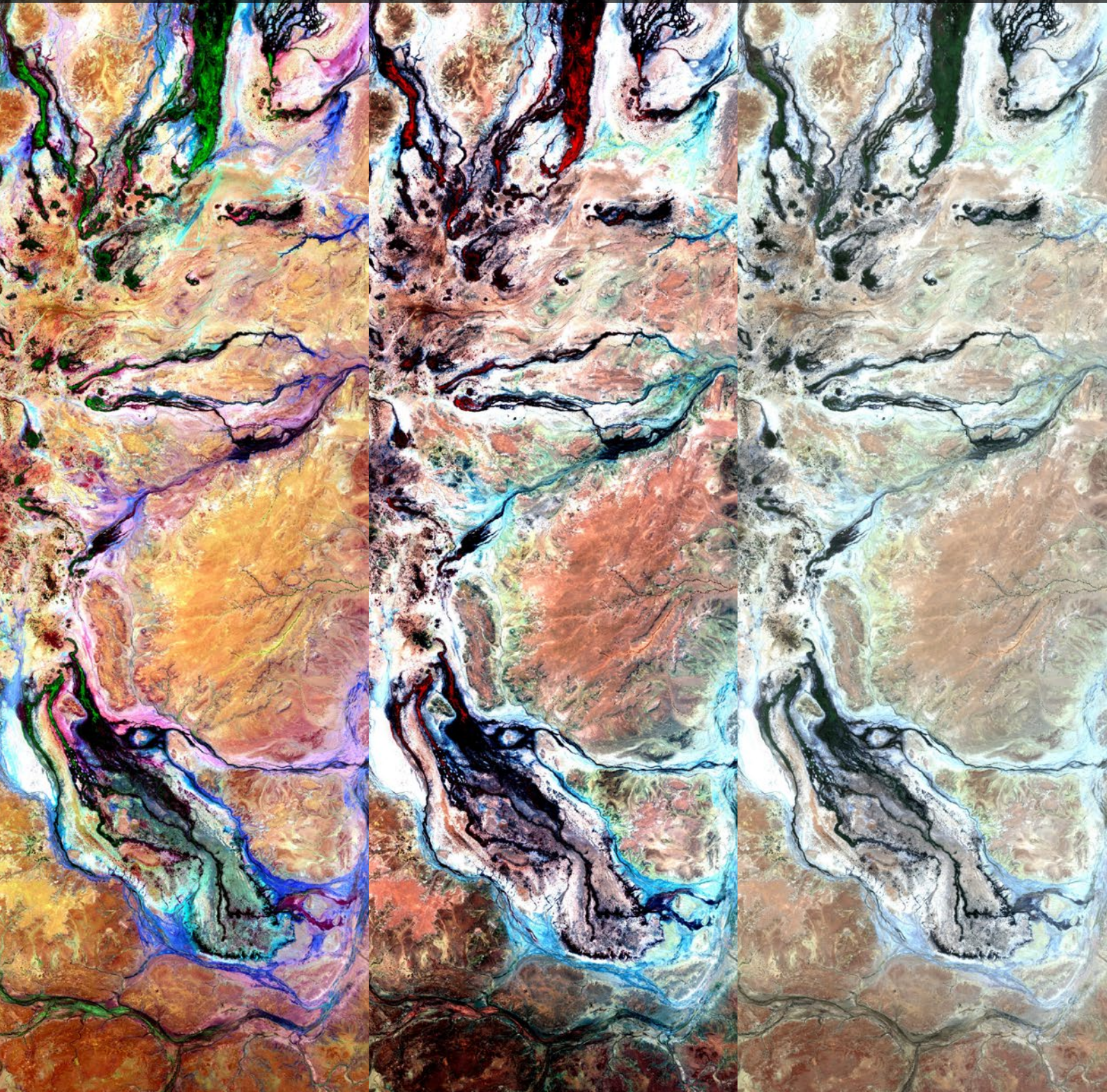


# Earth Observation: Data, Processing and Applications

Volume 1: Data



The report is available in PDF format at <http://www.crcsi.com.au/earth-observation-series>  
We welcome your comments regarding the readability and usefulness of this report. To provide feedback, please contact us at [info@crcsi.com.au](mailto:info@crcsi.com.au).

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**Cover Image:** This HyMap airborne hyperspectral image mosaic was acquired in 2009 over the Dalhousie Springs Complex, in far-northern South Australia. Three colour composite strips are juxtaposed using bands 2.22  $\mu\text{m}$ , 0.833  $\mu\text{m}$ , 0.444  $\mu\text{m}$  as RGB on the left, bands 0.833  $\mu\text{m}$ , 0.666  $\mu\text{m}$ , 0.559  $\mu\text{m}$  as RGB in the centre and bands 0.636  $\mu\text{m}$ , 0.544  $\mu\text{m}$ , 0.467  $\mu\text{m}$  as RGB on the right. This region features extensive wetlands in an arid environment, fed by Great Artesian Basin spring flows.

This imagery was acquired by HyVista Corporation for *Allocating Water and Maintaining Springs of the Western Great Artesian Basin* project, 2009.

**Source:** Megan Lewis, University of Adelaide

# About this Series

This text, *Earth Observation: Data, Processing and Applications*, is an Australian Earth Observation (EO) community undertaking, which has been jointly sponsored by the Cooperative Research Centre for Spatial Information (CRCSI), the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Geoscience Australia (GA) and the Bushfire and Natural Hazards Cooperative Research Centre (BNHCRC). This publication describes EO data, processing and applications in an Australian context, and includes a wide range of local case studies. It aims to:

- Consolidate EO teaching resources in Australia;
- Encourage a greater number of tertiary courses involving EO in Australia; and
- Promulgate Australia's growing dependence on EO data.

This new text substantially revises and updates two previous books published by CSIRO, namely *Introduction to Remotely Sensed Data* and *Introduction to Image Processing*<sup>1</sup>, which were written to support users of the microBRIAN Image Processing system and used as tertiary texts throughout Australasia for over a decade. The new series comprises multiple volumes, with the option to expand into the future. Unlike the previous publications, the new text is envisaged as an ongoing, community resource, involving a broader range of professionals from academia, government and industry, with relevance to a wider audience. Each volume has been prepared by an editorial panel of local experts, supported by contributing authors who have written and/or reviewed application chapters and case studies. Planning and production of the series has been overseen by advisors from the sponsor organisations.

This series currently comprises three volumes:

## Volume 1: Data

This volume outlines the basics of EO in terms of energy sources, data acquisition, sampling characteristics, and image availability. Discussion focuses on the scientific foundations of EO. This volume also considers the interactions of electromagnetic radiation with various targets and media, as relevant to understanding optical, thermal, passive microwave and radar imagery. Volume 1 comprises three sub-volumes:

- 1A—Basics and Acquisition
- 1B—Image Interpretation
- 1X—Appendices

## Volume 2: Processing

Volume 2 describes the various options involved with image representation, analysis, transformation, integration and modelling, including details of relevant algorithms, with emphasis on their underlying mathematical and statistical principles. It comprises six sub-volumes:

- 2A—Basic Image Operations
- 2B—Image Rectification
- 2C—Image Transformations
- 2D—Image Integration
- 2E—Image Classification
- 2X—Appendices

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1. Harrison, B.A., and Jupp, D.L.B. (1989) *Introduction to Remotely Sensed Data: Part ONE of the microBRIAN Resource Manual*. CSIRO, Melbourne. 156pp.  
Harrison, B.A., and Jupp, D.L.B. (1990) *Introduction to Image Processing: Part TWO of the microBRIAN Resource Manual* CSIRO, Melbourne. 256pp

## **Volume 3: Applications**

This final volume introduces the Australian environment in terms of topography, climate, ecoregions, land use and vegetation dynamics, then covers a broad range of application areas reliant on EO data. Specific case studies are included to demonstrate individual applications as appropriate. Volume 3 currently comprises two sub-volumes:

- 3A—Terrestrial Vegetation
- 3B—Surface Waters

This structure has been designed to easily enable expansion of volumes in the future.

The resulting publication aims to be both comprehensive and current. It will also enable consistent definitions to be established within the Australian EO sector. Ongoing inclusion of methods, applications and case studies, which utilise a wide range of data sources, will enhance its value to our whole community.

# About this Volume

The term ‘Earth Observation’ (EO) embraces a wide range of technologies that derive valuable information about planet Earth by detecting different types of energy. It should be stressed that, while EO is a unique and irreplaceable dataset for our planet, its value can only be realised through informed interpretation and analysis. EO technologies rely on the physical properties of matter, an understanding of which is essential to appropriate use and interpretation of the acquired data. The data itself merely provides an interesting view of Earth; the real benefits of the data are derived by extracting timely, reliable and repeatable measurements about Earth surface features and processes.

The first volume, Data, introduces sources, characteristics, uses and limitations of EO data. Several introductory sections provide an overview of relevant information from physics, geography and ecology.

Volume 1 in this series comprises three sub-volumes:

## Volume 1A — Basics and Acquisition

Volume 1A introduces EO, and is structured into four parts:

- Background—presents relevant foundational concepts that underpin remote sensing:
  - ♦ Scientific Foundations—reviews basic physical principles (see Section 2);
  - ♦ Planet Earth—summarises established facts about our planet and its processes (see Section 3);
  - ♦ Energy pathways—describes thermal, biochemical, photosynthetic and carbon cycles (see Section 4);
- Energy Sources used for EO—includes electromagnetic radiation (EMR; see Section 5); radioactivity (see Section 6), magnetism (see Section 7), gravity (see Section 8), and vibrations (see Section 9);
- Platforms used for EO—describes ground-based (see Section 10), airborne (see Section 11) and spaceborne (see Section 12); and
- Sensors used for EO that detect EMR—covers sensing principles (see Sections 13) plus passive imaging sensors (see Section 14), active imaging sensors (see Section 15) and non-imaging and sounding sensors (Section 16).

## Volume 1B—Image Interpretation

Volume 1B focuses on characteristics and interpretation of EO imagery:

- Image Characteristics—discusses spectral, spatial, radiometric and temporal dimensions of data resolution, density and extent (Section 1) and imaging artefacts (Section 2);
- EMR Interactions—reviews interactions between EMR and the target surface (Section 3) and atmosphere (Section 4), plus radiative transfer modelling (Section 5);
- Interpreting EO imagery—includes interpretation of optical (Section 6), thermal (Section 7), and microwave imagery (Section 8); and
- Using EO imagery—overviews aspects of image availability including communication, processing and legal issues (Section 9), and also looks ahead to future developments in this field (Section 10).

## Volume 1X — Appendices

Volume 1X provides additional information about:

- Recommended Reading (Appendix 1);
- Professional Societies (Appendix 2);
- EO Data and Information Sources (Appendix 3);
- Photographic Products (Appendix 4); and
- Measuring Reflectance (Appendix 5).

# Preface

It has been suggested that business schools do three things for students<sup>2</sup>:

- provide them with a vocabulary that enables them to talk with authority about subjects they do not understand;
- transmit to them a set of principles that have demonstrated an ability to withstand any amount of disconfirming evidence; and
- provide a ticket of admission to a job where they can learn something about these subjects.

Some would say that these characteristics apply to current approaches to education in many other disciplines, including Earth Observation.

It is the aspiration of the authors of this text that students will learn more than the vocabulary of Earth Observation from these pages; hopefully they will acquire the knowledge to develop robust analytical and synthetic skills that will enable this field to advance and expand with insight and integrity.

A range of additional resources to assist readers is compiled in various Appendices. In particular, numerous online tutorials are now available from a range of sources to complement the material presented in this series.

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2. Comments by Russell L. Ackoff in an interview with Robert J. Allio as reported in: Allio, R.J., and Ackoff, R.L. (2003). Iconoclastic management authority, advocates a 'systematic' approach to innovation. *Strategy and Leadership* 31 (3), 19–26.