Earth observations for Water-Related Applications, 28-29 March 2018, ANU Canberra

Workshop Summary and Recommendations

Background

The recent establishment of the Earth Observation for Government Network to coordinate Earth Observation (EO) activities across government entities, the expected establishment of an Australian Space Agency, and preparations for an International Committee on Earth Observation Systems (CEOS) "Freshwater from Space" workshop in May 2018 to be held in The Netherlands and co-chaired by Australia, have together prompted an expert workshop on the use of EO for Water-Related Applications in Australia.

The workshop was organised jointly by the CSIRO, Geoscience Australia, the Bureau of Meteorology, the Terrestrial Ecosystem Research Network (TERN), the Australian National University, Earth Observation Australia, and the Australian Energy and Water Exchanges Initiative (OzEWEX), and involved 22 experts from across research, government and private industry (Appendix A).

The range of EO for water applications is broad. Australia has unique capabilities in this area, across the continuum from sensor development, data analytics to practical applications. Applications include measurement of water in different stores, water flows, water extent and flooding, and water quality. EO techniques that have been applied include optical imagers, as well as radar, passive microwave, GRACE gravimetry, and altimetry sensors.

The workshop objectives were to:

1. assess the current state of the art in Australia regarding the use of EO for water-related applications, including water management, economic production, natural hazards and scientific research;
2. identify EO investment priorities to meet future data requirements; and
3. determine where among these priorities Australia appears to have a competitive R&D advantage.

Thematically, the workshop addressed the following areas: EO strategy, EO infrastructure, wetlands and Groundwater-Dependent Ecosystems (GDEs), environmental flows, water quality, rainfall and flooding, soil moisture and water use, and the water budget.

Below follows a summary of the workshop conclusions and makes seven recommendations, drafted during the workshop and further refined by circulation of a consultation draft to a broader range of experts afterwards. They cover the topics (i) Current EO data infrastructure, (ii) Calibration and validation; (iii) Product development; (iv) Skills and Capacity; and (v) Future missions.

Summary and Recommendations

(i) Current EO data infrastructure

The unprecedented volume, diversity and quality of EO data currently available creates much scope for continued and deepened application of EO data for water-related applications. Many water-related EO applications require a substantially long and consistent time series of satellite derived products (e.g., of inundation, greenness, soil moisture or precipitation). The need for continuity in current missions and product services was emphasized, rather than a requirement for new missions (with the exception of a hyperspectral water quality mission, see below). Examples include consistency between AVHRR missions, between Landsat and Landsat-like missions, and continuity of some key MODIS products. Australia should at least meet its own requirements in this area but should also have the capacity to contribute to international efforts.

> ***Recommendation 1:*** *That relevant Australian organisations and a future Australian space agency emphasise maintenance of long-term data time series, providing continuity in satellite data archives and derived products, and promoting gapless and seamless consistency between different missions for key hydrological and environmental variables.*

The systematic processing, storage and indexing of satellite data through initiatives such as Digital Earth Australia and TERN is welcomed by the expert group. However, access to these data archives and the ability to process the archives using high performance computing is currently limited and creates inequality in opportunities, as well as the duplication of data archives (e.g., Landsat, MODIS) within several Australian organisations. The expert group suggests that an infrastructure solution be found that maximizes broad access to satellite data archives and standardised derived products whilst leveraging the capacity of existing infrastructure and product development.

The timeliness of satellite data availability is seen as a constraint on applications such as natural hazard warning and compliance monitoring. Timeliness here primarily refers to the time that passes between data acquisition and availability of Analysis Ready Data (ARD) products. This time needs to be particularly short for natural hazard warning applications.

> ***Recommendation 2:*** *That Australia's data custodians undertake steps to optimize the timeliness of data provision, either through reviewing their own processes or through advocacy at international fora.*

(ii) Calibration and Validation (cal/val)

Australia has historically contributed to the calibration of space-borne instruments and the validation of derived products. Australia's landscapes have features that make them ideally suited for cal/val activities. Examples include CSIRO's contributions to sensor calibration over salt lakes, and measurement networks such as the OzNet soil moisture network, the Lucinda Jetty water quality station, and others. Although informal, these contributions have been and are highly valued by overseas investigators, as is evident from the frequent use of these data in technical documents and peer-reviewed scientific studies. Unfortunately, the capacity to continue, let alone expand, these cal/val activities is under continued threat from ad hoc and short-term funding arrangements.

> ***Recommendation 3****: that the Australian space agency formalize Australia's contribution through cal/val activities, and actively support the maintenance and expansion of this capacity to support continuous satellite data benchmarking.*

In many (but not all) cases, the development and provision of EO products has been partially supported by Australia's National Collaborative Research Infrastructure Strategy (NCRIS) facilities such as TERN and the Integrated Marine Observing System (IMOS). However, these facilities have limited scope to invest in data collection for the purpose of product development and validation. Moreover, currently there is insufficient attention for a range of environments that are critical for water-related applications. These include estuaries, mangroves, inland wetlands and water bodies, urban environments and managed landscapes such as irrigated crops and pastures.

> ***Recommendation 4****: that NCRIS invest in the development of a suite of satellite products in a manner that substantially supports cal/val activities for continuous benchmarking, and that investment occur to address mismatches between information requirements and current NCRIS foci.*

(iii) Product development

Australia can boast a proud history in the pragmatic development of fit-for-purpose and validated water-related remote sensing products and applications. Examples include the GA Water Observations from Space product, as well as national scale soil protection, evapotranspiration and water quality products derived from AVHRR and MODIS. Similar contributions have been made in precipitation, soil moisture, ecosystem, and fire applications.

There has been a proliferation in EO missions, observation types and observed quantities in recent years. This, along with greater computational capacity, has changed the emphasis from single-sensor, short-term products to the development of temporal merging for longer-term multi-sensor products, and water quantity and water quality model-data assimilation approaches. Australia has considerable capacity in this area, and arguably the general lack of agency- or mission-specific funding has encouraged Australian researchers to use multi-sensor data and products based on merit rather than origin. In some cases this has resulted in a strengthened 'community-of-practice' approach with robust protocols and standards. On the downside, Australian funding arrangements mean that there has been little incentive or support to develop such approaches globally (e.g. as a contribution to bi- or multilateral initiatives or missions) rather than national scale.

> ***Recommendation 5****: that Australia's strengths in developing pragmatic EO applications and multi-sensor and model-data blending approaches is formally recognized and strengthened and contributes to international efforts where appropriate. Furthermore, that this capacity by supported and contributed at global scale in the context of international efforts.*

(iv) Skills and Capacity

While Australia's capacity in the use of optical remote sensing is considerable, the same cannot be said for the use of radar for water-related applications. Nonetheless, several experts recognized the contribution that radar should be able to make. The acquisition of time series radar at moderate resolution by Sentinel 1 is having a major impact on the consideration of radar for use in all-weather inundation mapping. The application of radar for this purpose has been lagging in Australia, but could develop rapidly once Analysis Ready Data (ARD) are made available. Similarly, the availability of tasked radar is increasing and the cost is falling, including through CSIRO's participation in the future NovaSAR mission.

> ***Recommendation 6****: that Geoscience Australia develop ARD radar products from Sentinel 1 that can be used to infer inundation dynamics. That universities develop training programs for the use of radar observations in water-related applications.*

(v) Future missions

The greatest future benefits in hydrological applications were expected from the ongoing increase in resolution from geostationary instruments. The Himawari 8 instrument is revolutionizing Australia’s capacity for monitoring natural hazards, and further applications are likely to be developed over the coming years. Moreover, NASA’s planned Global Ecosystem Dynamics Investigation (GEDI) LiDAR mission will provide high-resolution observations of forest vertical structure and bare earth topographic elevations. These data should prove pivotal for environmental and water flow applications. At present, it appears that Australia can offer limited help to speed up of such developments.

One area where a new missions should be considered is for the acquisition of hyperspectral imagery that has characteristics suited to aquatic water quality remote sensing in near-coastal waters, estuaries and inland waters, including for the monitoring of harmful algal blooms. Such hyperspectral imagery would likely also support other relevant application areas, such as vegetation classification, pest detection and biophysical parameter estimation. The tradeoff between spatial and temporal requirements needs to be considered carefully, although with the blending of hyperspectral with multi-spectral sensors (such as Landsat or Sentinel), the potential application areas could broaden, taking advantage of their respective spectral, spatial and temporal resolutions.

> ***Recommendation 7:*** *That Australia advocate for a hyperspectral mission suited to water quality monitoring where opportunities arise.*

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For further enquiries:

Professor Albert Van Dijk, workshop chair and rapporteur
Centre for Water and Landscape Dynamics
Fenner School of Environment & Society
The Australian National University
E: albert.vandijk@anu.edu.au
T: (02) 612 52197

Appendix A. List of workshop participants

Name	***Organisation***
Albert van Dijk	Australian National University
Alex Held	CSIRO
Arnold Dekker	SatDek Pty Ltd
Ben Starkey	Ozius Pty Ltd
Chantal Donnelly	Bureau of Meteorology
Chris Rudiger	Monash University
David Antoine	Curtin University
David Weldrake	Murray-Darling Basin Authority
Dongryeol Ryu	University of Melbourne
Enzo Guarino	Commonwealth Environment Water Office
Janet Anstee	CSIRO
Juan Pablo Guerschman	CSIRO
Leon Majewski	Bureau of Meteorology
Luigi Renzullo	Australian National University
Matt White	Department of Environment, Land, Water and Planning, Victoria
Mirela Tulbure	University of New South Wales
Norman Mueller	Geoscience Australia
Paul Tregoning	Australian National University
Rachael Thomas	Office of Environment & Heritage, New South Wales
Stefania Grimaldi	Monash University
Tanya Doody	CSIRO
Tim McVicar	CSIRO