An Earth Observing System for the Australian Continent

1. Rationale and Objective

The need for comprehensive, coordinated, sustained and high quality observations of the Earth system to monitor its state, improve process understanding, and enhance predictions of Earth system behaviour including natural disasters has been recognized[1]. Current global Earth observations are falling short of this goal for a variety of reasons, including: poor data sharing and communication, inadequate archiving systems, data gaps, the erosion of observational infrastructure, and a lack of certainty in long-term funding for observing systems.

Similar Earth observing networks will be needed in Australia to address the national research priority of an "Environmentally Sustainable Australia" - especially the goals of sustainable water use and land management; reducing and capturing greenhouse (GHG) emissions; and responding to climate change and variability. Currently, Australia lacks the infrastructure and resources to develop and sustain the observation networks (satellite and *in-situ*) in our marine and terrestrial environments needed to deliver sustained, quality-controlled, near real time and continuous data to the relevant research, government and operational agencies.

Our vision is for an Earth observing system for the Australian continent – a truly national research facility providing the data, process understanding, and models to assess the current state, monitor trends and improve predictions of Australia's terrestrial biosphere and climate. The core objective is to deliver reliable retrospective analyses, near real time monitoring and prospective forecasts of land surface condition, climate properties, atmospheric GHG concentrations, and fluxes and stores of water, carbon and nutrients. It will do this by investing in new measurement and data management systems, and smart integration of remote and *in-situ* observing systems. Our long-term goal is to operationalize the observing system to support numerical weather prediction (NWP); environmental monitoring and hydrological forecasting (e.g. air quality, wind & energy resources, bushfires, etc).

Key benefits to Australia include the data and process understanding needed to: i) underpin sound management of natural resources including water, carbon and nutrient resources for environmental and production benefits; ii) monitor, assess, predict and respond to climate change and variability; iii) improve weather and environmental information and forecasting; (iv) support disaster management and early warning systems needed to meet Australia's research priorities in national security; and v) ensure that Earth system models used to underpin Australia's policies and commitments to international treaties adequately represent Australian terrestrial ecosystem processes.

Achieving this vision will require a coordinated partnership between CSIRO, the Bureau of Meteorology (BoM), ACRES (GA) and the Universities who provide Australia's research and operational observational capacity. Federal agencies, such as DEH, BRS, AGO and ANSTO, and State Depts., are important stakeholders – both as data providers and users of such an integrated system. Preliminary discussions with key partners and stakeholders have been positively received. Formal networks and collaborative arrangements already exist to facilitate the development of the proposal and partnership: e.g. the BoM Satellite Group & BMRC, and the ARC Earth Systems Network[2] strongly support the proposal, while the convenor of the terrestrial node of the Earth Systems network (Dr Jason Beringer) will be a co-PI on the proposal. The AGO also support the initiative – they, along with CSIRO and BoM, co-fund

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[1] The defined purpose of CEOS, GMES, US-IGEO and GEOSS (Global Earth Observation System of Systems): http://earthobservations.org/

[2] http://www.es.mq.edu.au/physgeog/staff/ap/ACSN/

the Australian Climate Change Research Program that delivers much of Australia's climate change and carbon cycle science.

2. An Earth Observing System for the Australian Continent (AEOS)

The AEOS builds upon proposals for a "Biosphere Observing Facility for Carbon & Water Resources" (upgraded Ozflux[3]), the recognised need for improved infrastructure to retrieve, archive and share remotely-sensed data, and the commitment to international Earth observing programs such as IGOS, GCOS, GTOS and GEOSS.

The AEOS will comprise 3 core elements, with funding (capital and operating) from NCRIS to support the observing and data management systems needed to achieve the goal of a comprehensive, coordinated and sustained Earth observing system that is Australian owned and operated:

1. **A national observing system**: a hierarchy of measurement networks combining *in situ* and satellite observations (example below) that create new capacity and substantially enhances existing networks and activities in Australia.
2. **A distributed data management system**: a) the infrastructure and tools needed for data acquisition, quality control and gap-filling; and archiving, viewing and analysing data; b) the equivalent for acquiring and archiving retrospective and model-generated datasets.
3. **A system of models**: for gap-filling; data assimilation and predictive modelling. These would range from empirical models (e.g. using neural networks for interpolating in space, time) through to fully coupled, predictive biosphere-climate models needed for assimilating observed data and model simulations predictions.

Proposed *in-situ* & remote sensing observing systems for Australian continent

1. Hierarchy of *in-situ* measurement networks

a. *Comprehensive*: based around the extant AWS network (BoM); baseline monitoring at Cape Grim (BoM, CSIRO) and the global flask sampling network.

b. *Baseline*: sparse, but with sufficient spatial and temporal coverage to capture variability and elicit a clear regional or continental signal. Where possible, supplement existing network infrastructure, e.g. current radiation, aerosol (BoM) and wind (CSIRO) monitoring networks, with a) meteorological, radiation and atmospheric concentration measurements; b) simple measures of surface cover & temperature; soil water & biomass; and c) roving mobile flux (water and CO_2) and tall (CO_2 concentrations) towers.

c. *Research*: a subset of "process laboratories" and an expansion of the current Ozflux[3] network that measures carbon, water and energy fluxes; terrestrial carbon pools and fluxes; soil water balance; CO_2; downwelling and emitted radiances (broadband long- and short-wave; hyperspectral). The extant Ozflux network would be increased to include urban and agricultural land-use; and select sites equipped to measure non-CO_2 GHG fluxes and stable isotopes (^{18}O & ^{2}H). The network would be a member of Fluxnet – a global network of > 200 flux towers.

2. Remote Sensing Infrastructure

Of strategic importance to Australia is assured, continuous and timely access to current satellite systems such as the NASA MODIS sensor and the AATSR (Advanced Along-Track Scanning Radiometer) on ESA's ENVISAT satellite, and access to planned systems such as the Orbiting Carbon Observatory and passive microwave sensors. On-line products (e.g. vegetation indices, albedo, land/ocean surface temperature, soil moisture, column CO_2) from these systems are critical to NWP, climate modelling, and regional resource assessment programs. The following are needed to build the necessary Australia owned and operated Earth observing infrastructure:

a. *New sensors*: aboard internationally-funded satellites – e.g. ESA's 'Sentinel-suite' of satellites.

b. *Dedicated, ground-based receiving facility*: dedicated, ground-based receiving facilities including multiple (~6) X-band receiving stations to ensure real-time access to latest-generation earth observing satellites, and upgrade existing partly obsolescent infrastructure.

c. *Calibration-validation*: facilitate targeted activities using *in-situ* measurement networks.