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Garada

SAR Formation Flying

Annex 14. Interviews with Potential Soil Moisture Data Users

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2. Preface

The following interviews were conducted by Dr. Gordon Roesler of ACSER during the systems engineering requirements definition process. They serve to identify a wide variety of uses to which Garada data could potentially be put. They also validate certain top-level user requirements, such as data timeliness and resolution.

3. Data system manager, Bureau of Meteorology

Go to the MDBA website and look up "Environmental Assets." This is where wetlands and other areas are listed.

It sounds like Garada could help us to determine where the water is, and how it gets there, on some time basis.

We mainly rely now on stream gages.

Idea: might be useful to combine your data with a digital elevation model. These have been obtained via LIDAR with great accuracy (~1 cm) in some areas.

The Environmental Water Holder is in SEWPaC. Recovered water is spent in accordance with recommendations. MDBA recommends environmental assets for application of the water. [Environmental assets are explained in Appendix A of the Proposed Basin Plan.][Hydrological modeling issues are described in Section 10.3 of the document Environmentally Sustainable Levels of Take, http://www.mdba.gov.au/draft-basin-plan/supporting-documents/mdba-eslt/ch10]

BOM's responsibilities under the Water Act 2007 are to provide up-to-date streamflow data to state databases.

[From the BOM weibsite:

"Under Part 7 of the *Water Act 2007*, the Bureau of Meteorology is required to collect, hold, manage, interpret and disseminate Australia's water information. Section 126 of the Act places an obligation on persons specified in the Regulations to give certain water information to the Bureau.

"The Bureau's responsibilities under the *Water Act 2007* include:

- issuing national water information standards
- collecting and publishing water information
- conducting regular national water resources assessments
- publishing an annual National Water Account
- providing regular water availability forecasts
- giving advice on matters relating to water information
- enhancing understanding of Australia's water resources."]

He suggests going to the BOM website, looking at rainfall maps in the Basin for Jan-Feb 2012, when there was significant rainfall and flooding. Where did the water go? Which floodplains were wetted? What was the extent of inundation?

The water holder can direct water to environmental uses by means of channels, gates, weirs, etc.

Certain 'overbank flows' are required in certain areas. Why every year? Why 4,000 GL/year?

An example of how planning and modeling can assist in efficient use of environmental flows: the Perricoota-Kondrook(?) area. Providing water via a circuitous route required 60 GL. Creating a small channel with a regulating gate reduced/would reduce the required flow to 2 GL.

Parliamentary inquiries.

Lower Murrumbidgee floodplain has been denied water since the 1950's. That water used to grow ibis rookeries, etc.

Mimmie-Caira floodplain.

Extensive plains: where does the water go? How does it get there?

Water for Rivers program. Yanco Creek. 1000 ML/day wasn't reflected in water balance. Losses. They built an extensive, computationally intensive hydrologic model. Takes many expensive computers to run. This kind of model could be validated, or an empirical model created.

There are also conventions on wetland preservations such as JAMBA, CAMBA and ROKAMBA. These are bilateral agreements for the protection of migratory birds. Garada data could be helpful in understanding the state of wetlands for compliance. He recommends contacting Richard Kingsford Smith of UNSW, an authority on wetland birds.

Garada data could also be used to improve water models. When there are flooding events, no one knows where the water goes.

There are groundwater-dependent ecosystems.

Garada could help with outcomes aligned with threatened species, particularly birds.

Combining Garada data with a digital elevation model and streamflow data, a hydraulic (as opposed to hydrologic) model could be generated. Either the Garada data could be used to validate the model, or an empirical model could be prepared on the basis of the data.

Water quality is another area that might benefit from the data.

Yet another application: groundwater. Ground water recharge/ water accession to groundwater not understood. Models not very sophisticated. BOM is currently working this problem—National Groundwater Information System, Groundwater Dependent Ecosystems Atlas. These projects are just getting underway. Some groundwater is exceptionally deep [300-400m].

4. Principal Irrigation Designer, Adelaide, SA

Interviewee's customers fall into two categories:

- Government, which is modernizing some irrigation delivery systems; the goal is to improve water efficiency. Company's work is delivery network modernization and efficiency improvement.
- Large agribusinesses, particularly in the design of microirrigation systems. [Note pertaining to resolution: A typical "valve area," that is, the area whose irrigation is controlled by a single valve, is 2-10 hectares.]

USE OF GARADA INFORMATION IN AGRICULTURE ("TACTICAL")

Irrigators require soil moisture information at depths of 10-30 cm (up to 60 cm in the case of tree crops). The use of large numbers of soil moisture sensors to help with irrigation decisions has increased across many crops (vegetables, tree crops). Various websites have information to help farmers make irrigation decisions. Various organizations contribute to irrigation decision-making, including:

- Local weather stations
- Agronomic consulting companies
- Inputs from BOM

He does not believe that these services make use of the local soil moisture probes, but isn't sure.

Each state has a Department of Prime Industries, which might be interested in the soil moisture maps for long-term prognoses.

BOM is currently mapping all of the rivers of the MDB, including installing real-time flowmeters. This is primarily for flood prevention. Interviewee would expect that there was a correlation between the measured flows and soil moisture.

All water users including urban are required to make inputs to BOM for the National Water Account. BOM is developing a very large water model intended to include all sources and uses.

Some uses that interviewee thought of for the very shallow soil moisture measurements that Garada could conceivably provide include:

- Leak detection
- Moisture from irrigation in progress or very recent irrigation
- Identifying infiltration problems (rapid decrease in surface moisture)

USE OF GARADA INFORMATION FOR MDB MANAGEMENT (“STRATEGIC”)

Interviewee’s view of the irrigators’ view of the MDB Plan:

1. Irrigation has seen significant reform in the past 10-15 years, meaning significant improvement in water use efficiency. 10-15 years ago, an example usage rate might have been 15 ML/hectare/year would be required for citrus crops; today such figures are frequently halved.
2. It is not the amount of water used, it is how the water is used that is important. Fixating on a certain percentage as a blanket reduction is inappropriate.
3. Irrigators do not believe that the environmental community has the same level of sophisticated control and efficiency of water use. If they were granted 3.5 thousand ML of water to improve the environment, how would it be used? Could the same improvement be achieved with a smaller amount of water? How is the improvement measured?
4. Some of the events decried by the environmental community, such as blackwater events, have been caused by them. Example: Wakool River kills of Murray cod.
5. Therefore, from the irrigators’ point of view, the environmental side should be required to demonstrate reliable and measurable improvement with a given amount of water returned, and then the amounts could be increased.

Possibly the environmental side is the MORE NEEDY customer for Garada-derived soil moisture data:

- Don’t have a network of sensors comparable to the irrigators’ moisture probes
- Have a wider variety of territory to cover and less opportunity to access it

Example of data use for environmental assessment: measure moisture levels in wetlands over time, measure apparent change of wetlands boundaries.

Could Garada also be used to determine river height accurately? The gaging stations being emplaced by BOM provide height data as well as flows, but they are very sparse. If the river heights as well as soil moisture could be measured, a better model of water availability might be developed.

In some ways the environmental and irrigation activities are interrelated. Garada data might reveal inefficiencies in delivery networks, e.g. the creation of “miniature wetlands” where there are leaks. When such areas have occurred in the past, environmentalists have NOT wanted the leaks mitigated, but rather requested that the wet areas be maintained.

Surface water and groundwater are related by infiltration. The MDB plan treats surface water and groundwater as separable, but this is an approximation.

5. Senior environmental scientist, state government

His group consists of 77 staff working on soil, vegetation, testing, modeling, etc. They provide decision support.

In the past they typically used point data and extrapolated. The world is moving toward remote sensing, continuous data. They need better spatial coverage in general.

They are now getting traction on what are the key datasets that are showstoppers. They have a very big push going on in vegetation mapping—pattern recognition, etc.

Tension between people working on production and people working on conservation.

Their biggest tools are for land management. In [state] they have management issues. The maps are static and old. Land management usually is intimately related to land cover; they need to be more dynamic.

Land cover is not necessarily green. Fractional cover can prevent erosion.

All their work now is reactive. They want to move to the responsive (predictive?) side.

They want to be able to send messages like, "Move your animals…"

They see soil moisture as a tool that would allow them to be more responsive. The #1 application is for land management.

Example: 2 paddocks, 2 different land holders, same conditions: why fluctuating, one overworked…

Responsive products are their direction for future research, with universities, etc.

People looking at conservation want to know that their interventions are having a payoff.

Another important area: climate change adaptation. Modeling skills needed—within our reserves and landscapes, which are the critical areas? "Adaptation work"

Soil moisture is a key driver of "tipping points"—when land becomes unproductive and/or habitat, etc., vanishes.

In remote sensing, there is an argument over which sensors to use. Some applications relatively static, e.g. vegetation mapping, detecting clearing. There resolution of a few meters every 7-14 days is adequate. Whereas looking at dust and ground cover, every 3 days is important; using a different satellite, only get 20 km pixels. Pass times are important.

Dust has public health impacts: respiratory conditions.

The key objective is to empower land management with knowledge—want to make decisions before rather than reacting after.

Ground cover important for retaining moisture.

The agriculture in Australia is changing. They are using European farming practices, farming on top 2cm of topsoil. Australian farmers are the most water-efficient in the world. Everything we do is about soil moisture retention. Farmers use satellite info, they are very advanced.

The Murray-Darling Basin is one of the world's food bowls. Every time we hit a tipping point, the recovery is so long…If you can stop an area from crashing*, it has tremendous value. Australia has the most variable climate; so there is EVEN MORE need to be responsive. Australia hasn't really been around long enough to know what "normal" is.

Average rainfall is 550mm, but it is shifting from winter to summer.

Need to empower farmers with responsive knowledge.

*Crashing: when farmers walk off the farm.

When they do walk off and lock the paddock gate, the land doesn't just revert to a pristine environment. Weeds are the result. The Government is saddled with a weed management issue.

Justifications for Garada/soil moisture measurements:

- Food security
- Responsiveness
- Empowering farmers with information

Australian farmers are efficient because they are adaptive. Garada would allow them to look over the whole catchment, not just their paddocks, for a bigger picture, to see what's going on around them.

Paranoia—farmers think America is watching what they are doing and adjusting the price—probably some of that.

Carbon: in soils = volatile, can only count what's in the root zone = permanent. Soil moisture helps, but above-ground carbon is volatile, only root zone is stable.

There is some study that says if farmers could just increase the amount of carbon in the root zone, perennial plants, fungi develops, biomass is altered, stable carbon is stored. Carbon problem solved.

6. Senior environmental scientist, Australian Government

The MDB has 40% of Australian agricultural production.

There are a number of international icon sites in the MDB. There is an obligation to the United Nations under the Ramsaar convention.

Their uses of remote sensing include:

- Hydrological modeling
- Environmental modeling
- Water accounting
- Information collated by ABS: national accounts in water, land, vegetation, environmental

Draft basin plan is in Parliament

Next year will come the implementation plan. Will employ various remote sensing techniques: vegetation, water, land use change, socioeconomic change.

Also link with compliance—assurance regime

- Condition of vegetation over time
- Patterns and trends of change

Other ways of monitoring soil moisture:

- Other satellites—but they are not the full solution
- Hyperspectral, multispectral, if funding permits—e.g. MODIS for vegetation (greenness)
- Want to find alternative sources

Three levels of requirements:

- Basin-wide
- Catchment level (23 catchments)
- Environmental assets (26,000)
    - Icon sites
    - Vegetation patches (eucalyptus, red gum,…)

Link each site into trends and changes (go upward in the list)

[Agency] wants to be users of remote sensing data, not interested in data management. Will enter into agreements for sharing data.

National Computing Infrastructure in Canberra.

Interested in information and knowledge, not data. Not clear where we will be sitting, requirements not developed yet. They are being developed to look at vegetation accounts.

BOM is doing water accounting and remote sensing.

GA is doing remote sensing, has a groundwater group.

Objective of basin plan is Sustainable Diversion Limits.

There is a group at [agency] whose job is water accounting. Another: regulatory affairs.

[Agency] is working on scoping requirements. Not formal yet.

7. Soil scientist, state government

Within the [state office], responsible for soil erosion assessments and forecasts.

Australia currently uses the Australian Water Availability Product from CSIRO. This is an input to state's models. [State] is also currently working on a wind erosion product, being developed by the University of South Queensland.

A method was developed to calculate soil moisture in the early 2000's, which has never been updated or improved.

The current numerical model uses environmental conditions (soil type and characteristics, rainfall, solar irradiation, etc.) to calculate soil moisture. That is the current input layer. They would like to move to a remote sensing input layer.

AWAP is currently under evaluation. It came out of the former Environmental Mechanics group at CSIRO, who are modelers. It is probably a hybrid model.

CSIRO and BOM have a suite of met-type products of which AWAP is one.

One thing being looked at is runoff—what changes to be expected in water available to streams.

There is a large project in Australia called Terrestrial Ecosystem Research Network—it is intended to consolidate all the layers of remote sensing products. It is heavily funded, Australia's largest portal for this kind of data.

There are lots of groups in TERN. Probably the relevant one is AusCover, which is the surface data group. TERN might also have a microclimate/micrometeorology group. TERN grew out of AusFlux, which has some very heavily instrumented sites for calibration.

For soil erosion, they are interested in the moisture of the <u>top millimeter</u> of soil. This is where adhesion from moisture influences wind erosion. Their models are currently highly unresponsive, because they use moisture to 5-10 cm depth, which does not change rapidly with solar irradiance. Whereas it is known that in a few hours the sun can dry the top millimeter and erosion will occur.

Very little calibration data for soil moisture vs. wind erosion. They have been getting some from time domain reflectometry.

Rule of thumb: most erosion after midday. Last Friday there was a major erosion event at 10 AM. The biggest dust storms usually occur at dawn. The emission is usually midday to midnight.

Fractional ground cover is a MODIS data product. They look at photosynthesis bands, non-photosynthesis bands, bare ground.

This is also a horizontal measurement—no structure, don't know how high the vegetation is. High dead grass is very effective at preventing soil wind erosion, 1 cm grass less so. They do not have a good handle on the structure of vegetation in Australia. They need to know the zero displacement : the height above ground where V=0. Forests: ZD is several meters; 50 cm grass, about 2 cm; bare surfaces, small fractions of a millimeter.

Ground cover is a single indicator, the most robust for predicting erosion. Fractional cover is important when evaluating carbon storage. It also affects biodiversity.

As resources (e.g. ground cover) decrease with climate change, they are looking for indicators of how these parameters might change.

They develop soil moisture maps. They have been looking at the last 3-6 months and trying to determine how big a deficit exists in soil water availability. Using historical data, they are assessing how much water is NOT in the system. It appears that there will be a big deficit going into this summer, both of water and biomass (?)

Soil moisture is a critical indicator of what's going on. As antecedent water increases, there is also increased risk of soil erosion from WATER. Soil moisture is also critical for flood prediction.

This is not done much in Australia, hard to calibrate. They typically use 10km data, it is scarce.

A colleague is looking at water movement across the landscape, water balance on the surface. There was also someone in the Department of Primary Industries but he is presently on leave.

Another knowledge gap is to locate where stony surfaces are—covered in either rock or gibber. These are not well mapped in Australia. Can Garada help with this? (I speculated: possibly may be able to tell from quality of echo returns in individual images; also perhaps could make some deductions from speckle.)

Another colleague in their group was previously doing his PhD on trying to map stony surfaces. They are not necessarily bad from a soil erosion point of view—bare rock is a non-eroding surface. This is a data gap at the national level.

Another question: canopy cover. They are looking at it down to 10-20%. (I speculated that biomass measurements would be more accurate at low cover levels than full canopy.)

Does Garada measure woody or total biomass? (Don't know.)

Carbon accounting—need to understand biomass production from each season.

Ground cover is important for agricultural production predictions. Number of tons of grass per hectare determines what the stocking rate is, how long the ground can hold cattle. Non-woody vegetation cover is important here. Currently this is a modeled product. Example:

range lands with 2T grass per hectare—cattle can only reside 3-4 months rather than entire season.

Ground cover is important for protection; biomass for production.

In central NSW, they have used the water spreading methodology. In areas of low rainfall, carefully constructed banks are used to catch water and distribute more evenly. Remote sensing data could help to determine moisture response before and after implementing such earthworks. This method was popular in the ‘80s, and caused more problems than solutions. But at a recent conference, he learned that the methods have improved, and people are more choosy about where to use it. “Irrigating with natural water.” Intercept water before it gets to the lowest point; spill water evenly over the banks. Must grade with great care. In the past, there was human error; now laser levelers allow the needed precision. Look at pre- and post-investment in contour banks.

Water ponding is another approach—an earthen ring on flat ground. It traps water, which then diffuses into the soil. It has been used 30-40 years. It is driven by production; it also has massive carbon storage capacity.

Effect of climate change: if there are more days of dryness and less vegetation, there will be more erosion. There is no clear idea of how ground cover will change with climate.