WIRADA: Developing coupled model-data systems to deliver comprehensive water resources information

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A water information R & D alliance between the Bureau of Meteorology and CSIRO’s Water for a Healthy Country Flagship
Water crisis in the Murray-Darling Basin

Did we see it coming?

Whole of Murray-Darling Basin

Total system inflows (10-y average)
Irrigation use
Dam storage capacity

Source: Murray-Darling Basin Sustainable Yields project

Perhaps we could have..
Poor water information systems

There is a need for country-wide, consistent, up to date and accurate water information

• How much water resources have been generated?
• How much has been used, for what purpose?
• How much have we got left?
• How much can we expect to be available in the future?
• How can we improve the benefits of water use?

Currently there is no holistic and accurate information of Australia’s water resources use, availability and prospects

• On-ground data is collected by 100s of organisations, but hardly shared
• Satellite data have revolutionised climate information, but are grossly underutilised for water information
• Assessments occur ad hoc, unstructured and in widely varying ways
Four project areas

1. **Water Informatics**
   - Hydrologist workbench
   - Australian Hydrological Geospatial Fabric Design
   - Water Data Transfer Standards

2. **Foundation data**
   - SRTM Digital Elevation Model
   - Precipitation and Actual Evapotranspiration Products *

3. **Water Resources Assessment and Accounting** *

4. **Water Forecasting**
   - Flood and short-term water forecasting
   - Seasonal and long-term forecasting
Outputs:
• Merged station and satellite precipitation product
• Explore inclusion of rainfall radar and NWP models
• Operational best practice AET product
• Next generation AET estimation methods
Our current rainfall data are not good enough

Linear trend in annual rainfall (percent change per decade, 1980-2008)
Merged station and satellite product

Interpolated station rainfall (SILO)

Satellite rainfall product (TRMM)

Difference (SILO-TRMM)

Output: Algorithms for combining the available precipitation measurements and estimates.

Explore inclusion of rainfall radar and NWP

Renzullo, 2008
First best practice AET product

Intercomparison and evaluation of existing ET algorithms against a variety of relevant data

Output: Recommendations for operational best practice AET product.

Guerschman et al., 2008 (MDBSY report)
Output: next generation model-data fusion techniques for ET estimation

Example: LST can provide a powerful constraint on evapotranspiration (ET) estimation

Renzullo, in prep.
Output:

- An Australian Water Resources Assessment (AWRA) system that couples observations with models.
- Produces comprehensive water balance information to underpin water resources assessments and water use accounts.

Requires:

- National coverage but local detail (planning, management, trading).
- Evidence-based selection of model components.
- Efficient and flexible model-data fusion infrastructure.
- Quantification of uncertainty in estimates.
Model-data fusion – the best of three worlds

On-ground observations
- relatively direct
- sparse and/or infrequent
- not predictive

Satellite observations
- full and frequent coverage
- relatively indirect
- not predictive

Hydrological models
- predictive
- directly interpretable
- full and continuous coverage
- unhindered by reality
Where we want to be in a few years

- evapotranspiration
- vegetation
- soil water
- groundwater
- rivers, water bodies
- runoff
- rainfall
- atmospheric vars
- station rainfall
- satellite rainfall
- station meteo
- station radiation
- cloud cover
- LS temperature
- radiation
- greenness
- roughness
- albedo
- water content
- vegetation
- dry down
- soil water
- soil moisture
- bore data
- groundwater
- flood recharge
- water bodies
- irrigation
- gravity anomaly
- station streamflow
- metering
- land cover
- rainfall radar
- SRTM DEM
- station meteo
- atmospheric RS
- cloud cover
- LS temperature
- atmospheric vars
- station radiation
- rainfall radar
- satellite rainfall
- station meteo
- station radiation
- cloud cover
- LS temperature
- atmospheric vars
Where we are now

We have most of the pieces, and tried some of the puzzle
• A prototype system exists
• Supports variable spatial resolution and component exchange
• Model-data fusion has only been tested on components.
• Several model components are interim solutions while formal intercomparison and targeted developments are underway

Data currently used for forcing, fusion or evaluation
• daily rainfall (SILO, TRMM RS)
• potential ET (contains gauging and RS)
• vegetation greenness (MODIS RS)
• site streamflow (~300 stations)
• site ET (4 flux towers)
• soil surface wetness (multi-sensor RS)
• gravity anomalies (GRACE RS)
Example output: streamflow trends

Variable: Linear trend in streamflow
Period: 1980-2008
Resolution: 0.5°
Variable: Linear trend in combined soil and groundwater storage
Period: 1980-2008
Resolution: 0.5°
Remote sensing of soil surface wetness

Soil surface wetness (<5 cm) can be estimated from passive microwave sensors since 1978.

Primarily related to rainfall occurrence (rather than total rainfall or deeper soil moisture).

**Relative trend in soil surface wetness (1980-2006)**

**Correlation with ocean indices and seasonal average**

<table>
<thead>
<tr>
<th>SILO precip</th>
<th>RS surface wetness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>Autumn</td>
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<tr>
<td>Autumn</td>
<td>Winter</td>
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<td>Winter</td>
<td>Spring</td>
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<td>Spring</td>
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</tr>
</tbody>
</table>

Correlated at p<0.05

- SOI
- SAM
- IOD

*Liu et al., 2008; Liu et al, submitted*
Field observations are crucial for evaluation
Example: soil moisture sensor network

Purchase of a network of 13 cosmic ray soil moisture probes has been approved in principle.

Data will be made public in nrt over the web.
Vegetation reflects soil water status

Satellite observed and model estimated vegetation trends (1980-2006)

AVHRR vegetation fractional cover (FPAR change/year)

Donohue et al., 2008

Passive microwave vegetation water content (change/year)

Liu et al., 2008

Model simulated greenness (AWRA)

Vegetation coupled water-carbon modelling post-doc opportunity to be advertised in May
Linking spatial ET to sector water use (MDBSY)

• Hydrological landscape mapping by combining:
  • remote sensing of inundation
  • remotely sensed ET
  • topographic and land use mapping

• QA/QC with high resolution satellite data
  First consistent, complete, quality-controlled hydrological landscape map for the MDB.

• Documented and freely available..

Kirby et al., 2008 (MDBSY report)
Example: high resolution classification

Dynamic high resolution mapping of water uses

• Q: Landsat TM high resolution (25m), but operationally very laborious to classify continentally

• A: Automatic classification for priority regions

• Example: water features

27 Jan 2004

5 Jul 2004

28 Dec 2004

Byrne and González, in prep
(In collaboration with Geoscience Australia)
Key points

- Through the water information R&D alliance, CSIRO and the Bureau of Meteorology are developing rainfall and actual ET products, and a modelling system that merges them with other observations.

- A prototype Australian Water Resources Assessment (AWRA) system has been built. Satellite remote sensing plays an essential role alongside on-ground data.

- Current R&D priorities include effective and efficient model-data fusion methods, and targeted field verification and test uses.

- We are very keen to collaborate: providing existing published data products or experimental products, or through joint research and field experiments.

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