



Australian Government
Bureau of Meteorology

Environmental intelligence needs for tomorrow

Dr Rob Vertessy
Director, Bureau of Meteorology





Workshop questions

- Are we getting close to integrating water and climate prediction?
- With ground networks in decline, can satellites meet our needs?
- How well can we trust our models, and how can we be sure?
- What new water and climate information should we be developing?
- Is Australia's data and model infrastructure ready for the future?
- Have we reached the limits of what can be forecast?



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1. Judgments of adequacy are context sensitive





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Safety



Sustainability



Well-being



Prosperity



ENVIRONMENTAL INTELLIGENCE

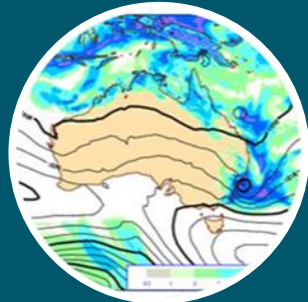
Conclusions drawn from environmental observations and models to guide decisions and actions by governments, businesses and individuals.



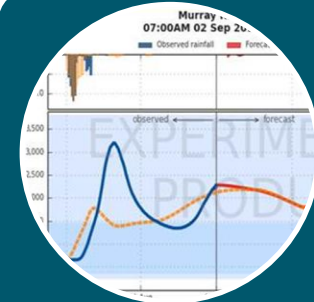
Dimensions of Environmental Intelligence



Observe



Model



Forecast



Inform



Warn

Information from environmental data and models to inform decisions



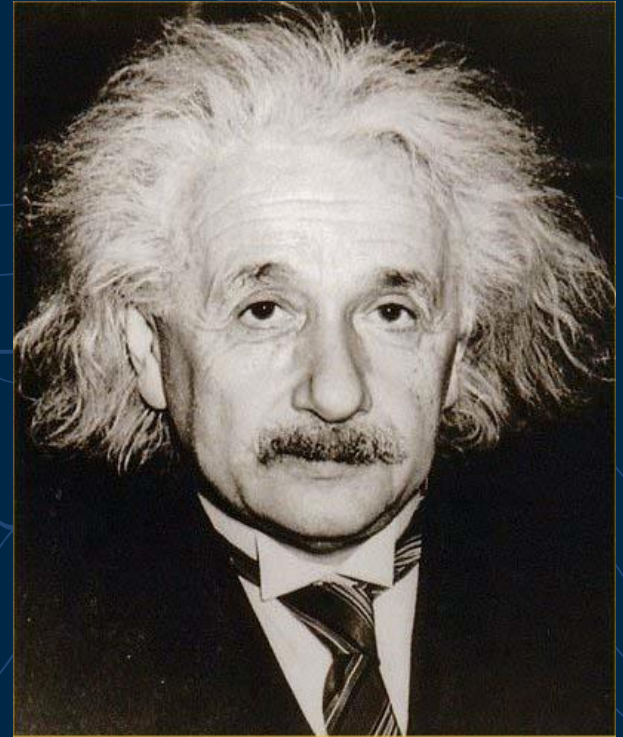
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2. History proves we have poor foresight





“To be sure, when the number of factors coming into play in a phenomenological complex is too large, scientific method in most cases fails us. One need only think of the weather, in which case the prediction even for a few days ahead is impossible.”

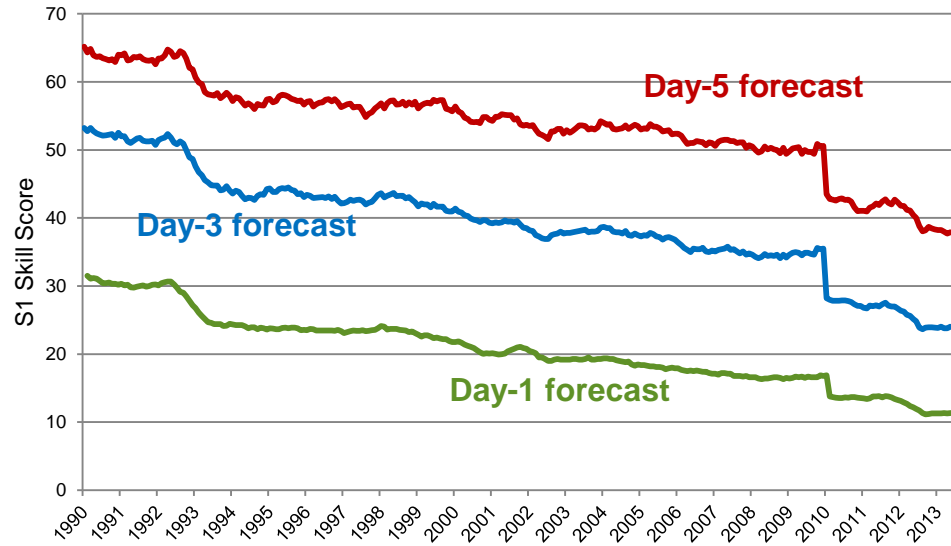


Albert Einstein
Science and Religion (1941).



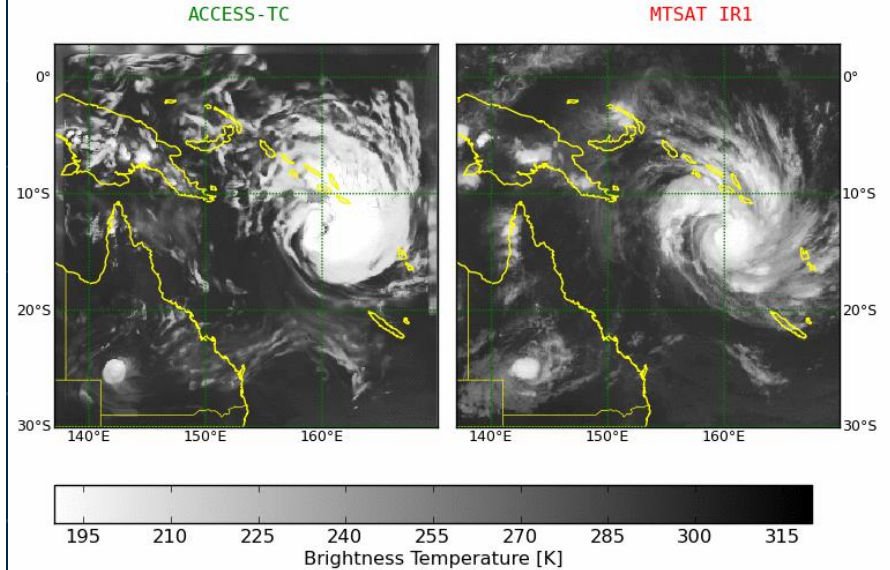
Progress in numerical weather prediction

MSLP forecast skill score
(12-month moving average)



Valid 12UTC Mon 31 Jan 2011

ACCESS-TC t+001





How progress is forged

1



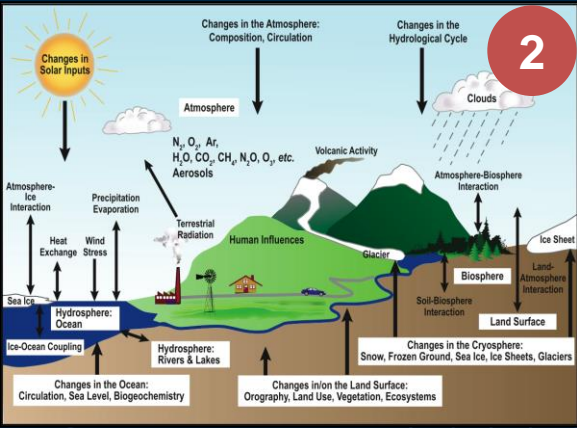
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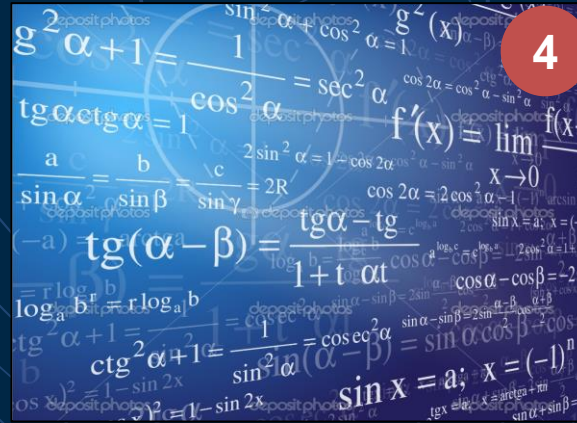
5



2



4



6





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3. Observations are key



**Polar-orbiting
meteorological
satellite**



**Polar-orbiting
earth resources
satellite**



**Geostationary
meteorological
satellite**



**High-altitude
aircraft**



**International
aircraft**



**Meteorological
research aircraft**



**Baseline
air pollution
station**



**Meteorological
satellite
ground station**



**Automatic
weather
station**



**Automated
river-height
and
rain gauges**



Radiosonde



**Pilotless
aircraft**



**Voluntary
observing ship**



**Wind
profiler**



**Drifting
buoy**



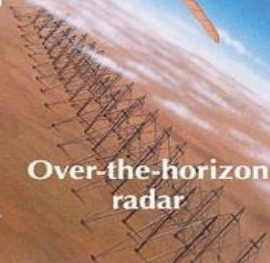
**Domestic
aircraft**



**Meteorological
observing
station**

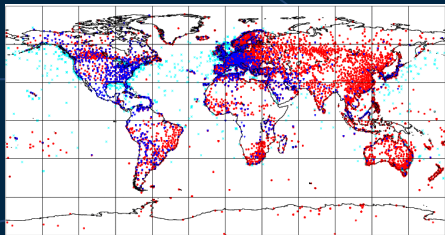


**Over-the-horizon
radar**

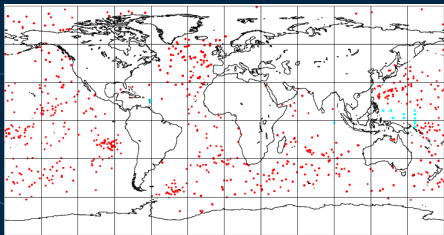


Data sources for weather prediction

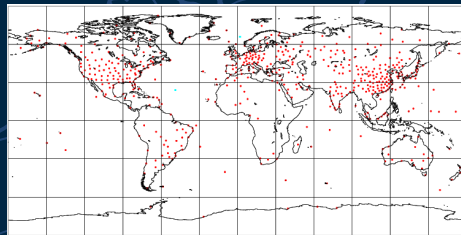
SYNOPS AND SHIPS



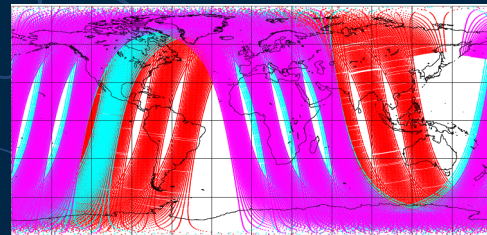
BUOYS



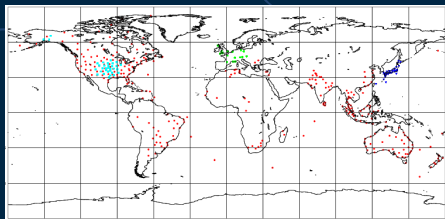
RADIOSONDES



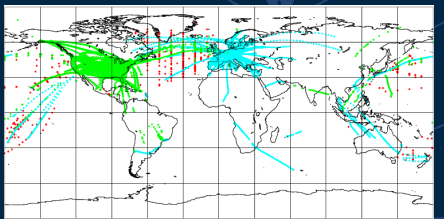
IR AND MW SOUNDERS



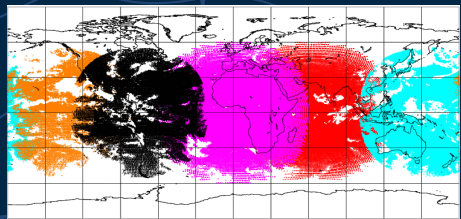
PILOTS AND PROFILERS



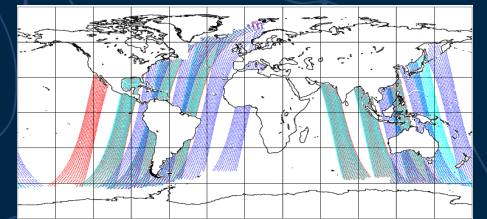
AIRCRAFT



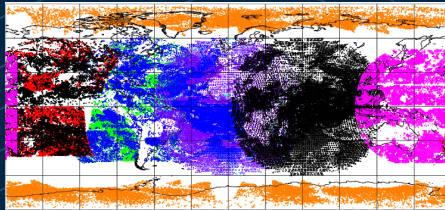
WATER-VAPOUR RADIANCES



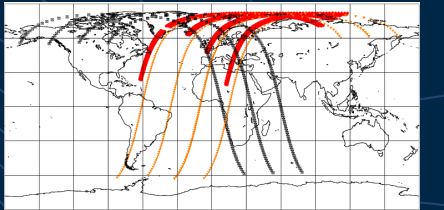
SSM/I



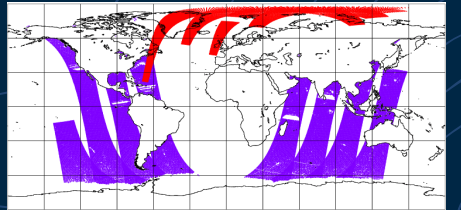
SATELLITE WINDS



OZONE

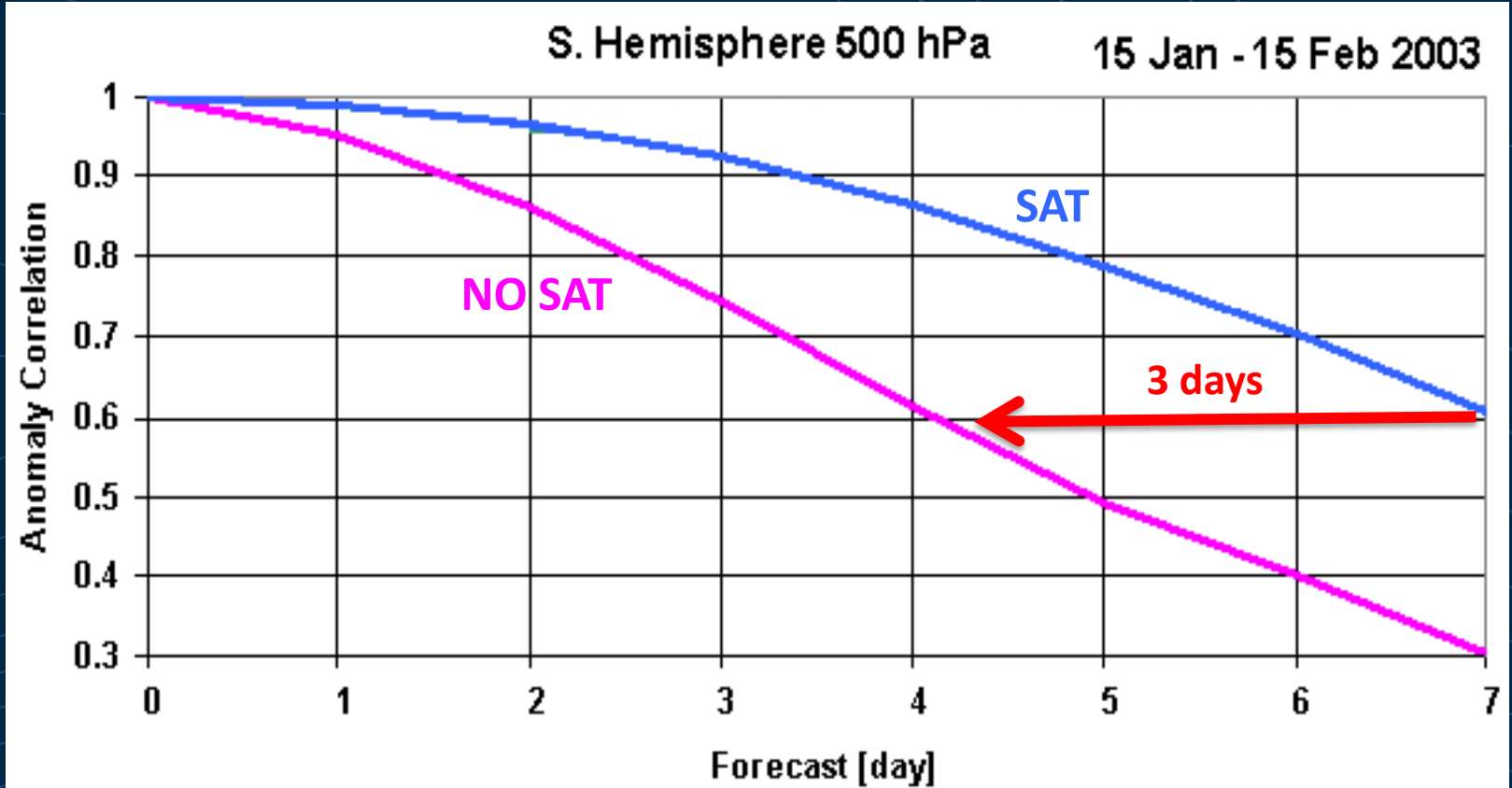


SCATTEROMETER





Impact of satellite observations on NWP skill

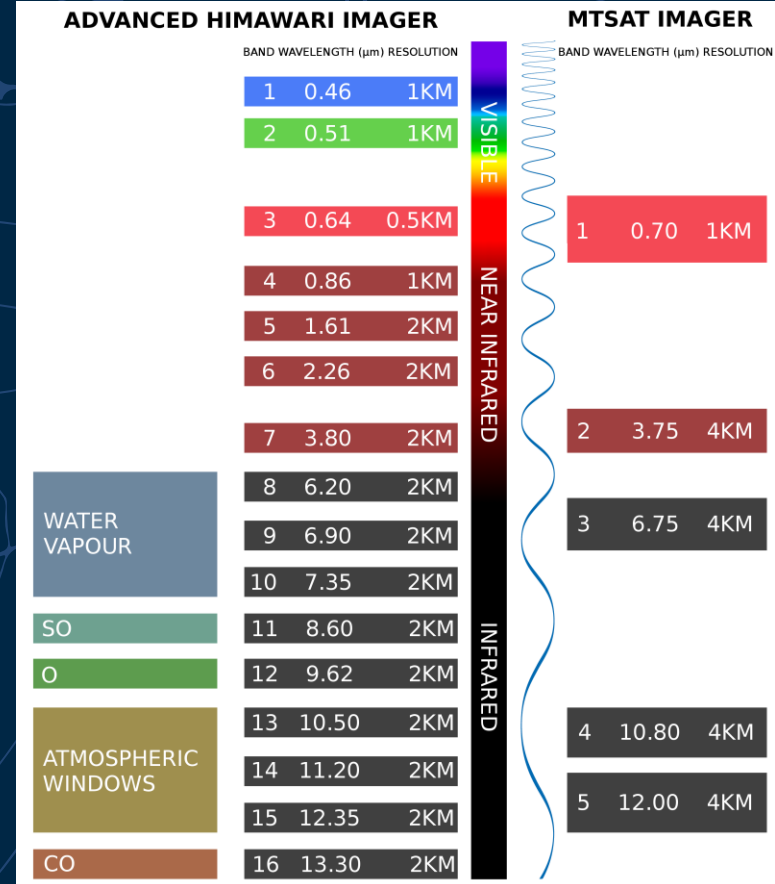




Himawari-8

- 3x spectral channels
- 4x spatial resolution
- 6x temporal frequency

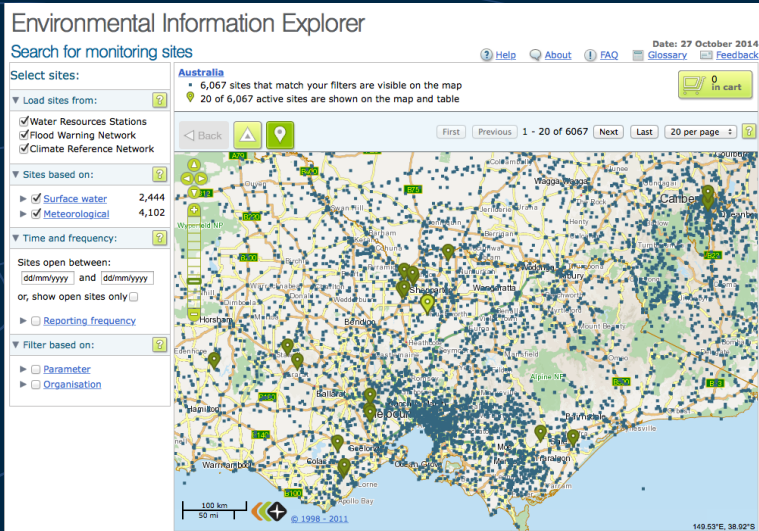
... compared to the current generation satellite MTSAT



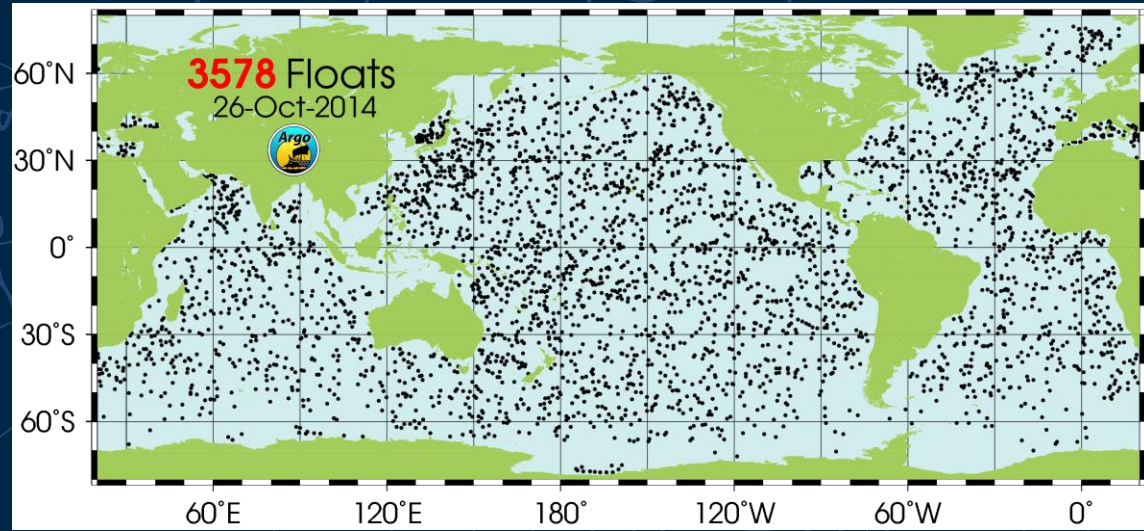


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Ground 'truth'



Hydrometric and climate monitoring



Argo floats



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Bureau of Meteorology

Novel observations: Future shock?

WeatherSignal

DASHBOARD | MAP | REPORT

24 °C
Temperature

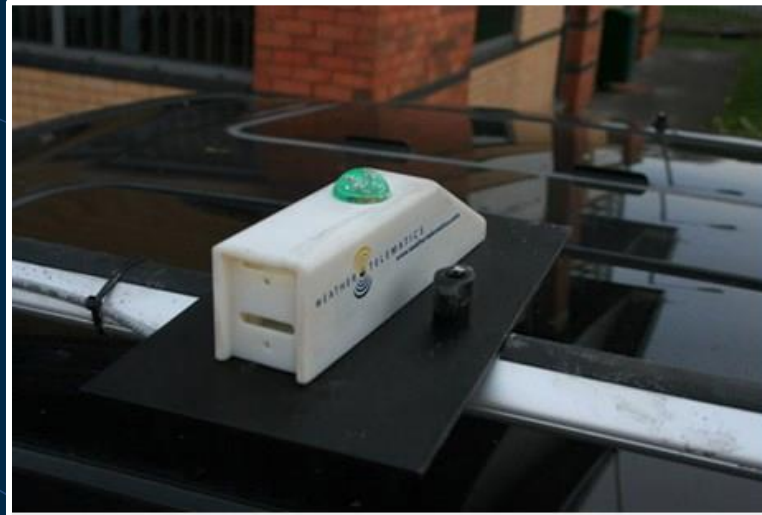
100 Lux
Light

51 %
Humidity

1002 mB
Pressure

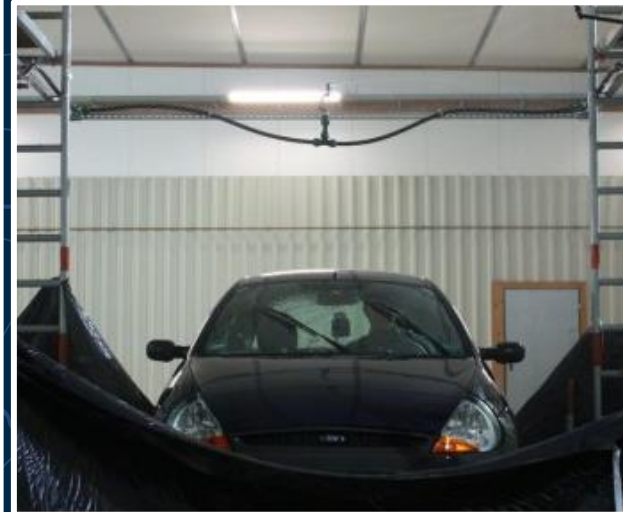
33 μ T
Mag. flux

11
Acceleration



Vehicle roof-mounted main sensor box, from Mobile Devices' main sensor box

Weather telematics
(1500 vehicles > 27Bn points per year)



The RainCars project's lab setup

RainCars



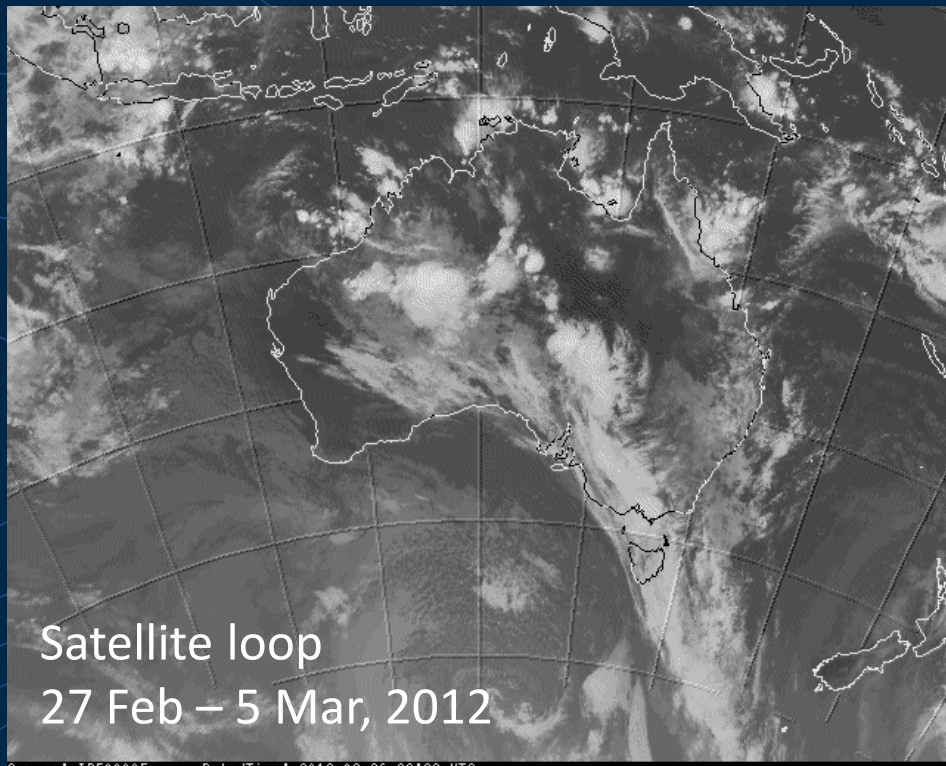
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4. Advances in hydrology will continue to be dependent on improvements in meteorology

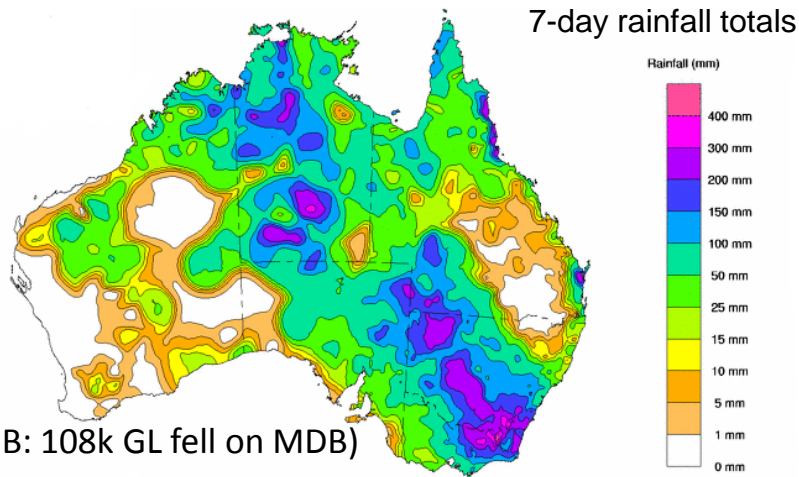




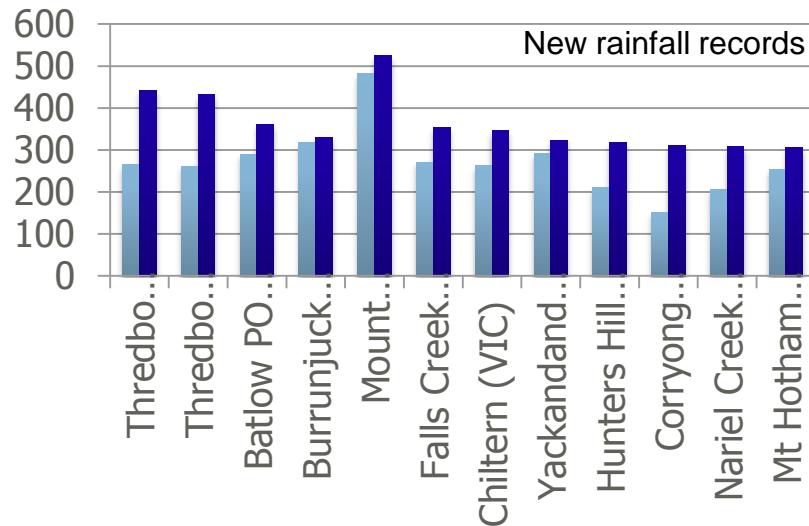
Episodic events



Satellite loop
27 Feb – 5 Mar, 2012

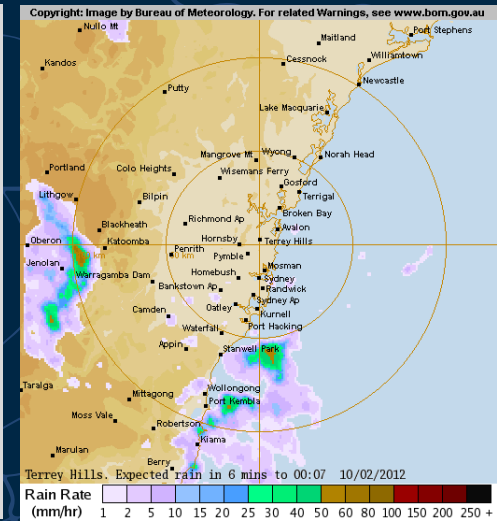
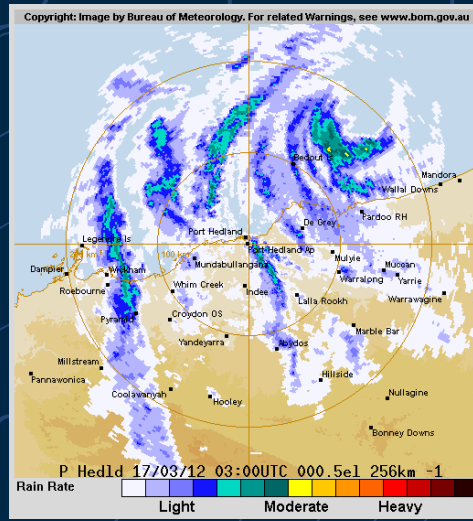
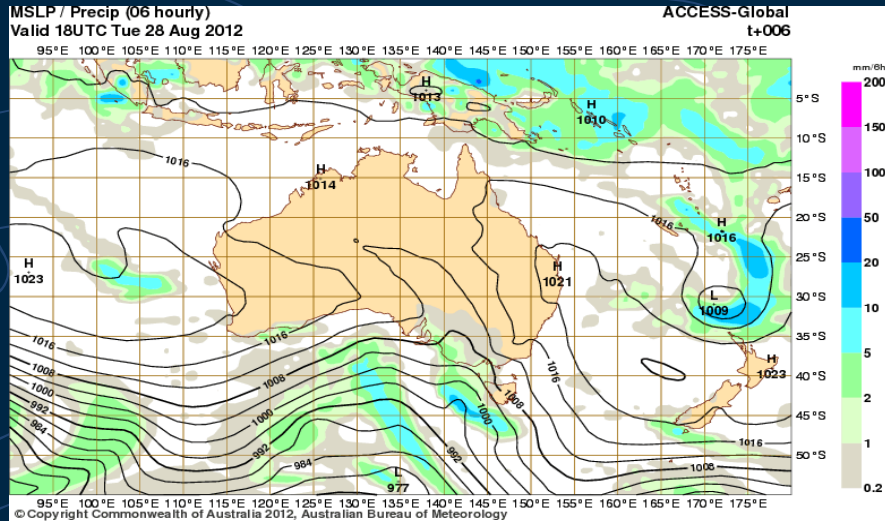


(NB: 108k GL fell on MDB)





Quantitative Precipitation Forecasting



NWP

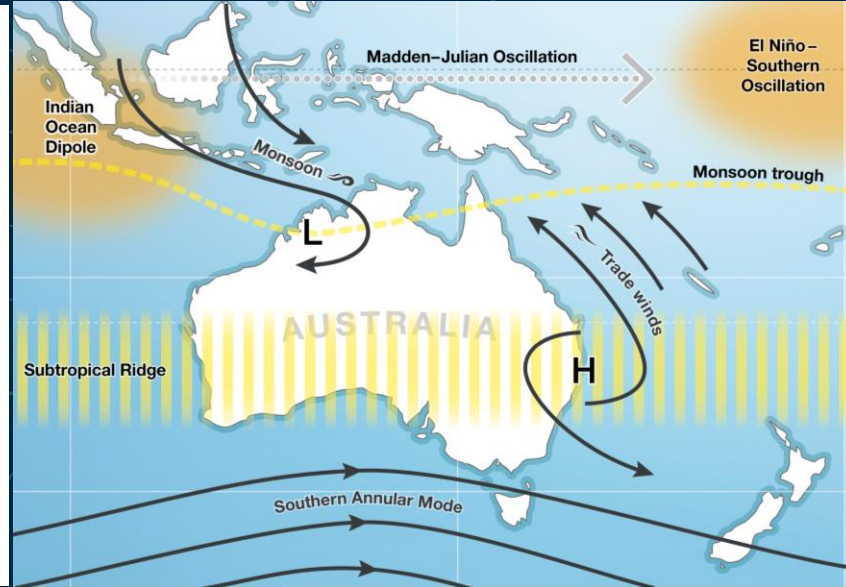
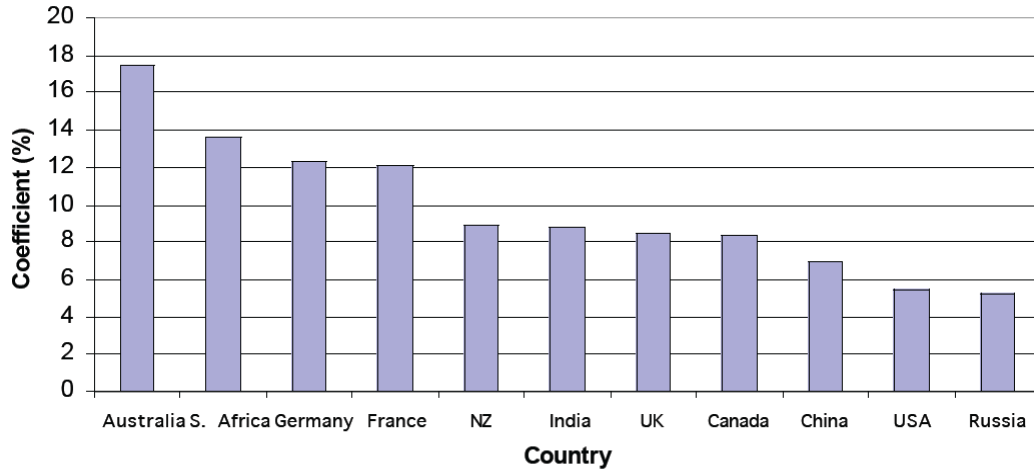
Radar

Nowcast



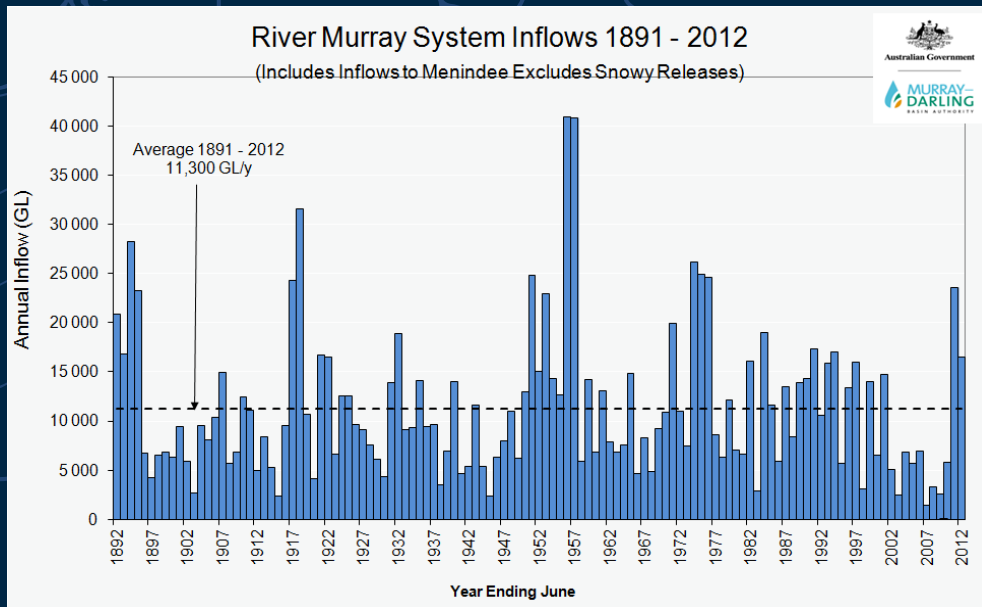
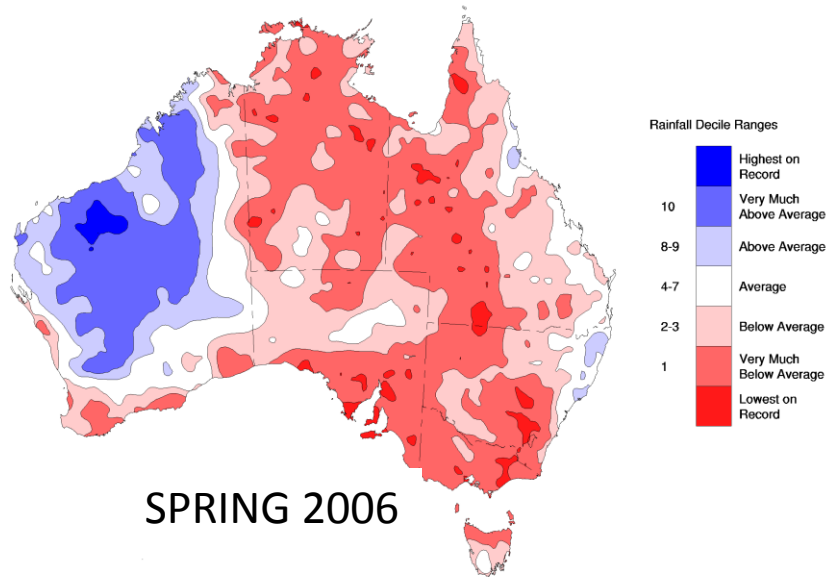
Climate variability

Variability of Annual rainfall





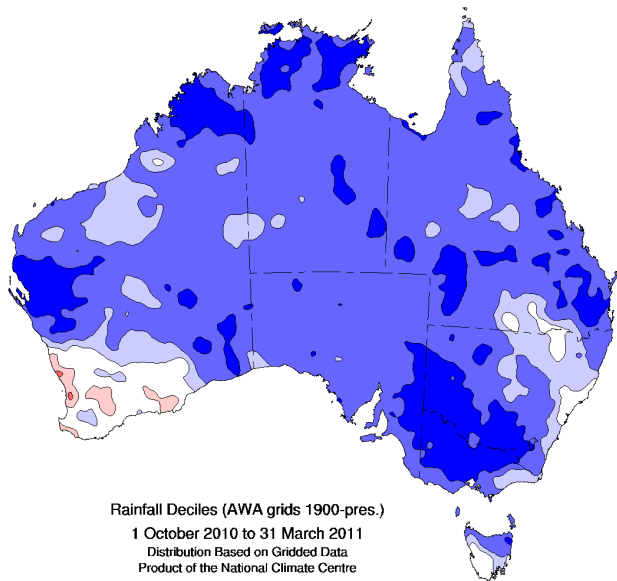
The millennium drought



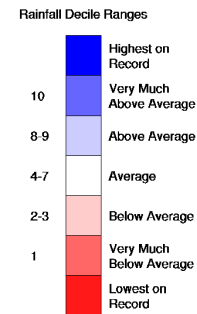
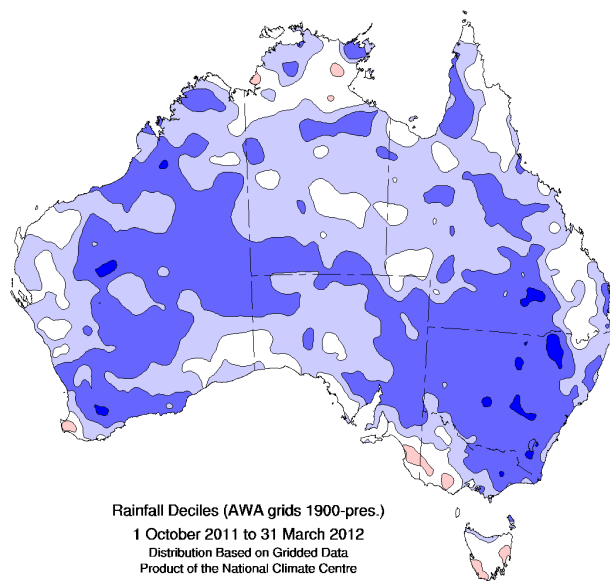


The big wet: back-to-back La Niña events

Rainfall deciles: 2010-11



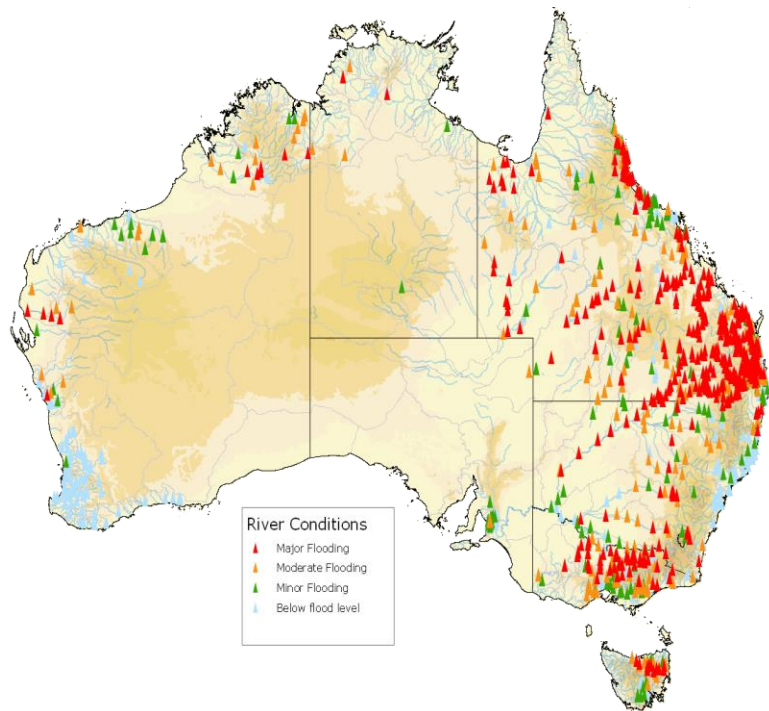
Rainfall deciles: 2011-12



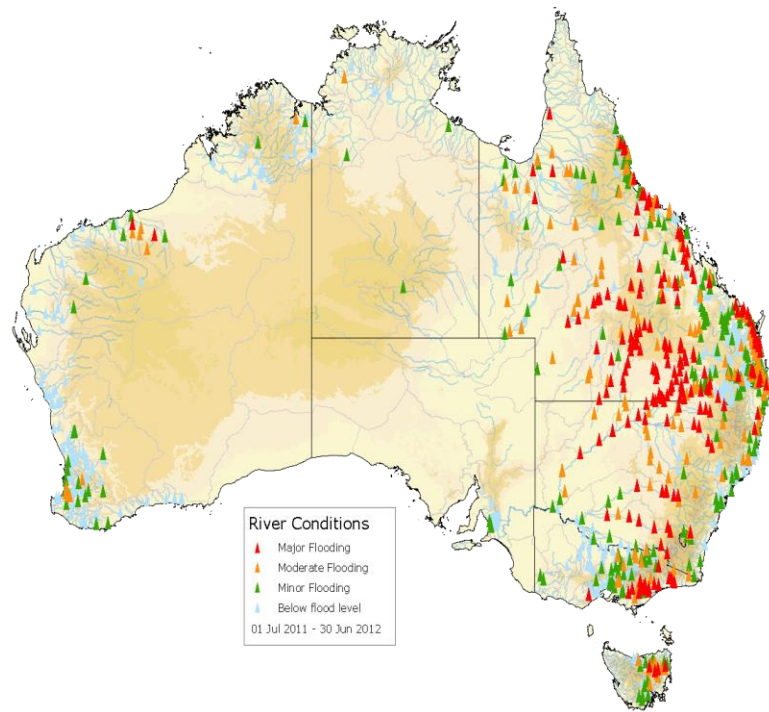


Record flooding ensues

River Conditions: 2010-11

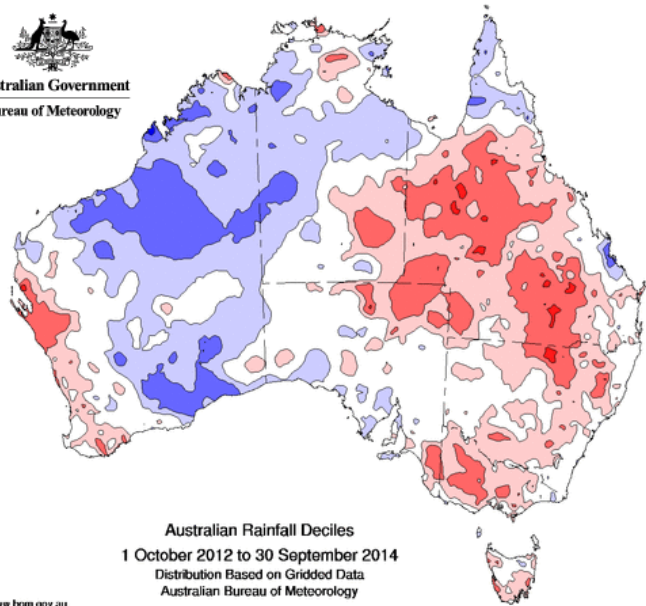


River Conditions: 2011-12

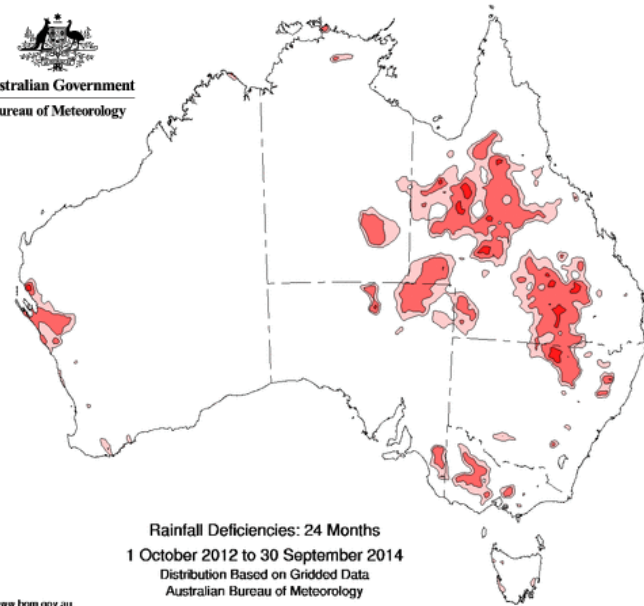




Drought conditions return



<http://www.bom.gov.au>

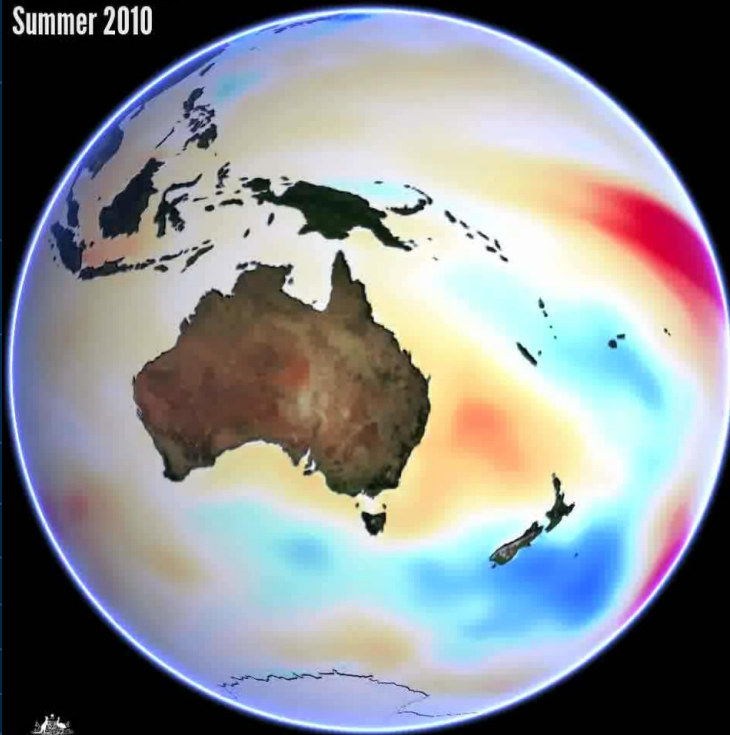


<http://www.bom.gov.au>

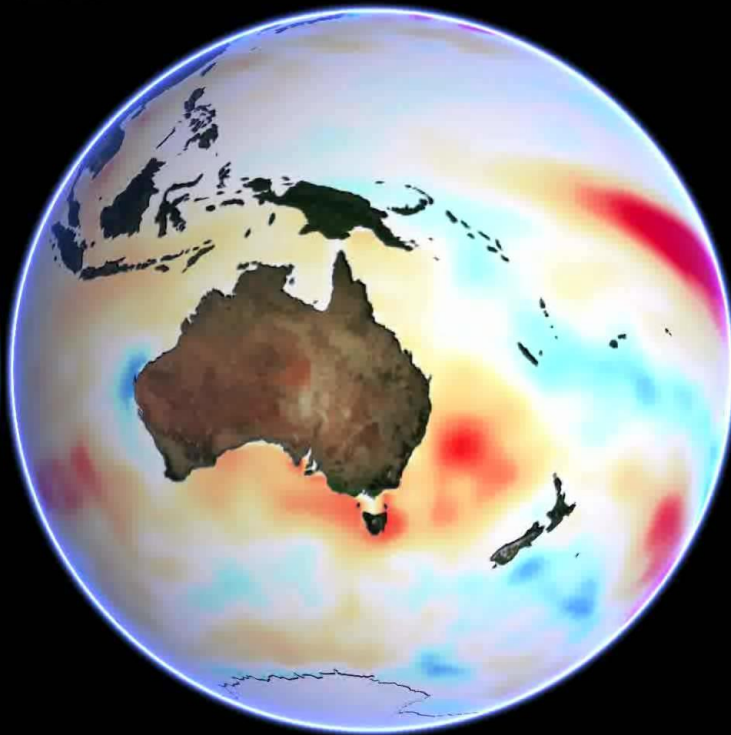


Seasonal Forecasting: Much room for improvement

POAMA Forecast
Summer 2010



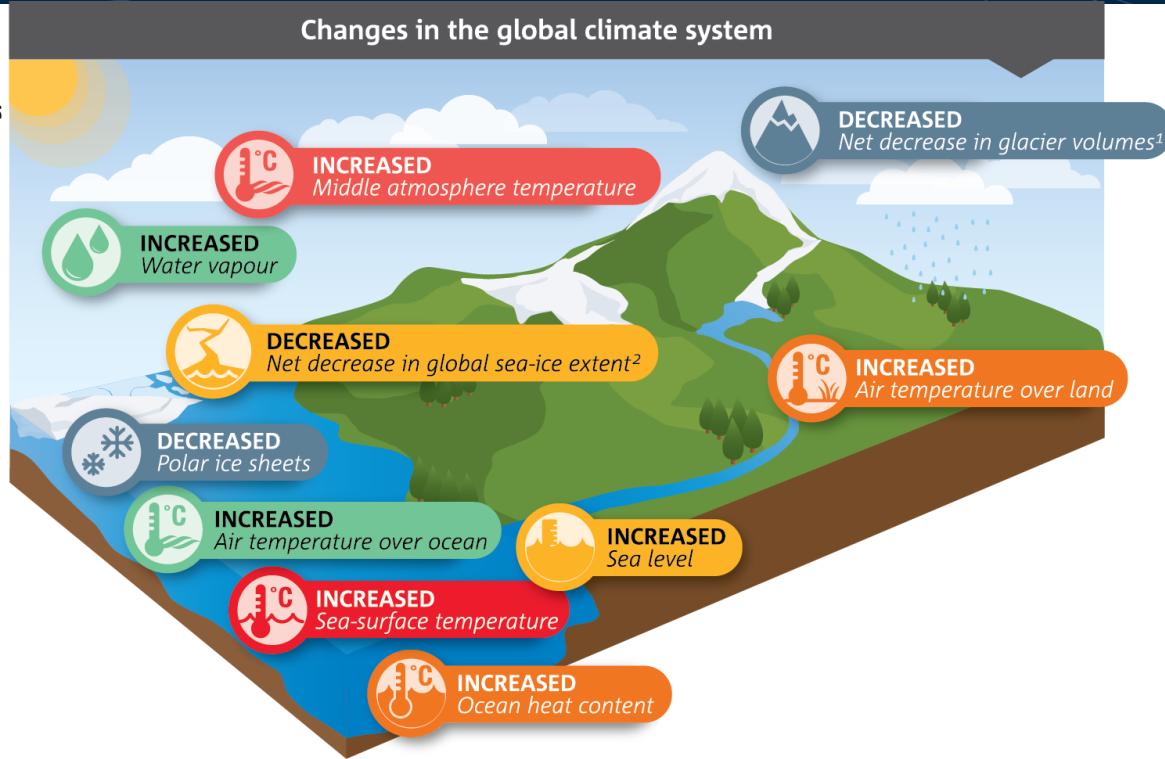
Observed





Changes in the global climate system

Source: Bureau of Meteorology and CSIRO



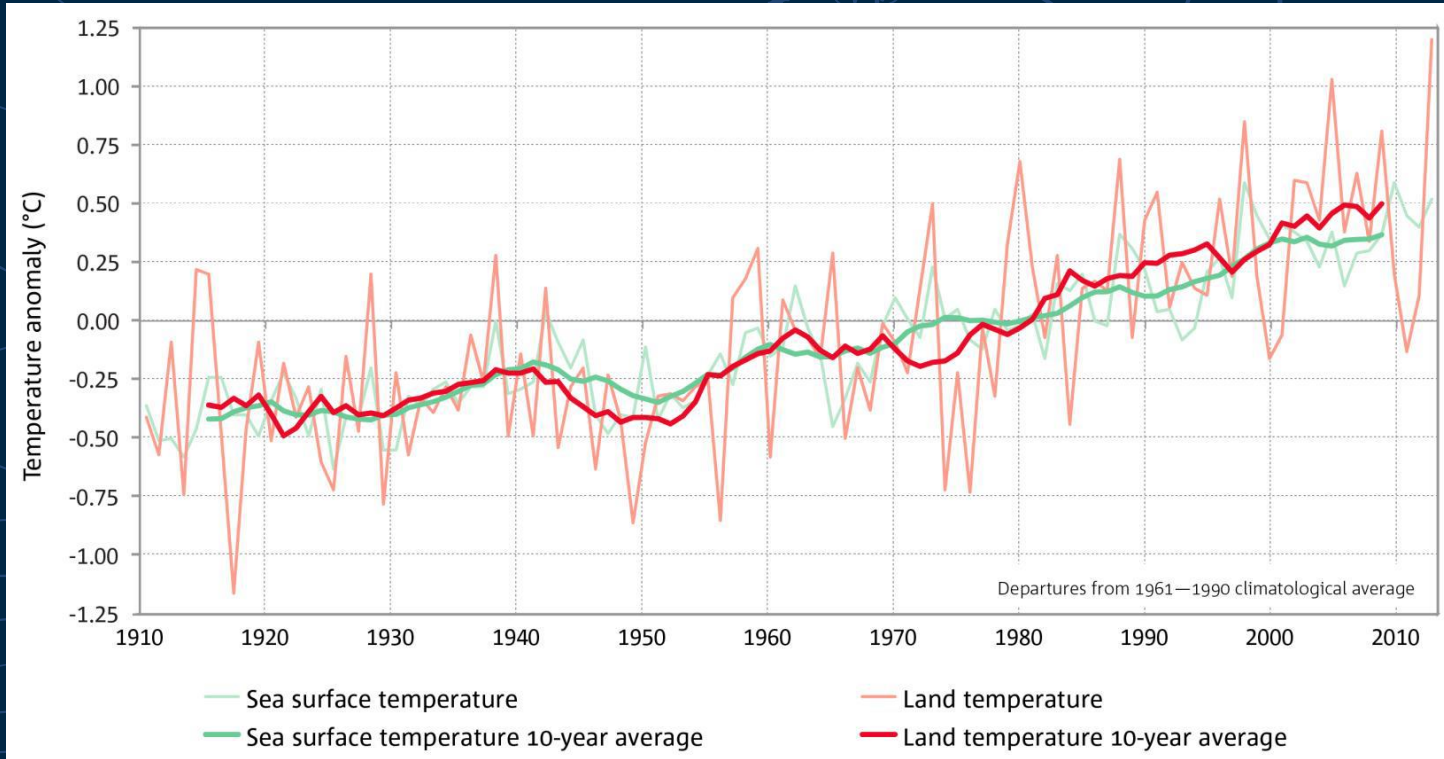
Global mean temperature has risen by 0.85°C from 1880 to 2012.

The amount of heat stored in the global oceans has risen, and global mean sea level has increased 225 mm from 1880 to 2012.

1. With regional variation (almost all glaciers worldwide losing mass but some gaining) but overall net loss.
2. With regional variation (large loss in the Arctic, small net gain in the Antarctic) but overall net loss.

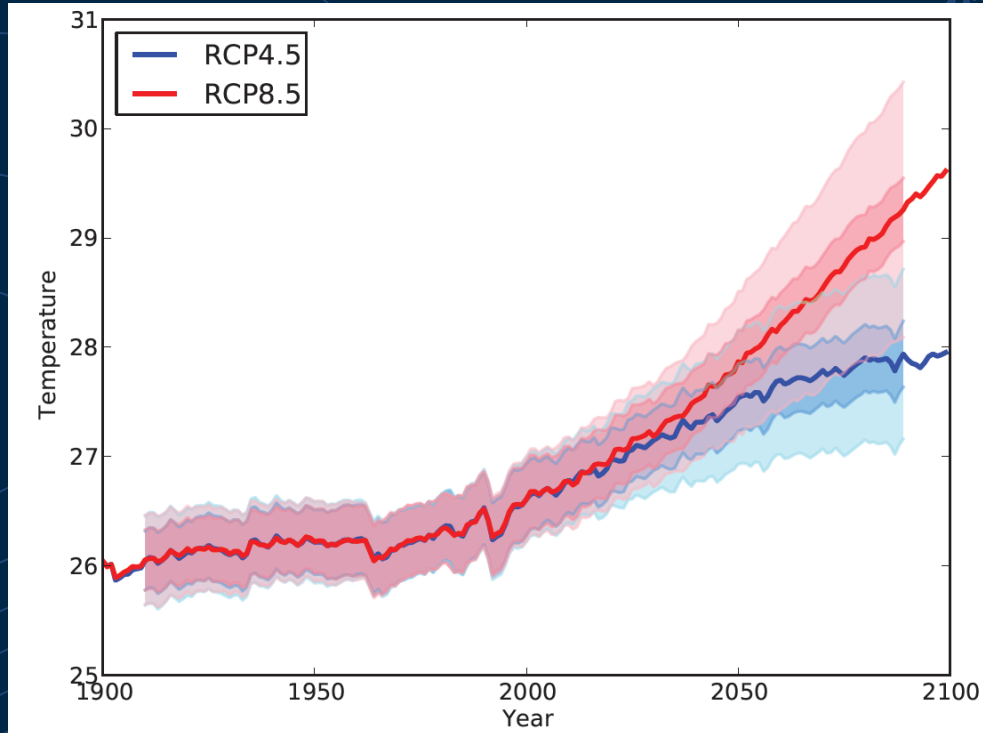


Land and sea surface temperatures anomalies





Assessing water security under climate change

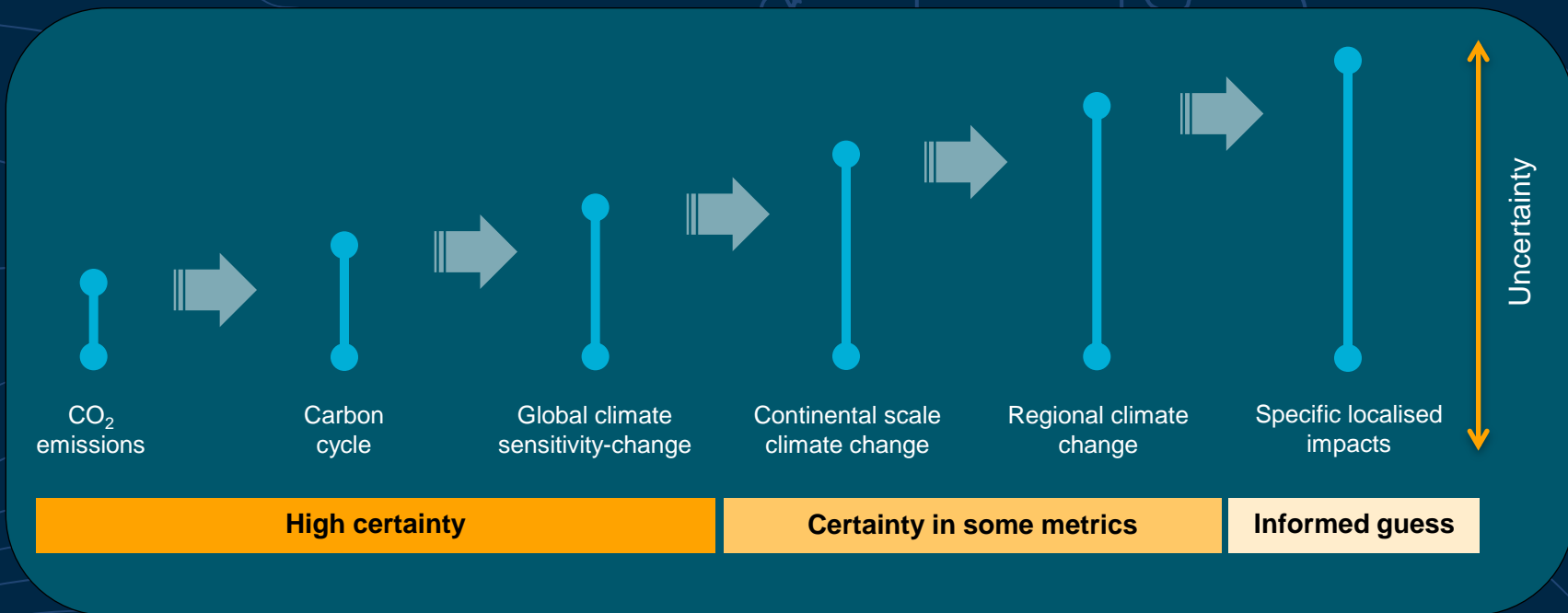


- Future climate change scenarios span quite a range
- GCMs skillful at simulating temperature, but less good at rainfall
- Can plan for the worst case, but expensive
- Water planners need to adopt a risk based approach



The uncertainty cascade

The more localised and specific impacts are the least certain ones ...





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*5. The last few years have
been very productive*





WaterML2

A Global Standard for Hydrological Time Series



WaterML2 is a new data exchange standard in Hydrology which can basically be used to exchange many kinds of hydro-meteorological observations and measurements. WaterML2 has been initiated and designed over a period of several years by a group of major national and international organizations from public and private sector, such as [CSIRO](#), [CIAHS](#), [USGS](#), [ECM](#), [NOAA](#), [KISTERS](#) and others. WaterML2 has been developed within the OGC Hydrology Domain Working group which has a mandate by the WMO, too.

[Download PDF](#)

Examples:
[example.wml](#)
[example.wmz](#)

Related links:
[WaterML2 @ OGC](#)
[HydroDWG](#)
[SWG](#)
[GML](#)
[O&M](#)

Objectives of WaterML2:

- provide a common exchange format for hydrological time-series
- build on existing standards like GML and Observations & Measurements
- provide the option to fully store information including information regarding quality, validity/interpolation, and remarks
- currently it is NOT an objective to provide a comprehensive format with a minimum of characters

Small code example with explanations:

```

1. <wml2:Collection xsi:schemaLocation="http://www.opengis.net/waterml/2.0
2. http://www.opengis.net/waterml/2.0/waterml2.xsd" gml:id="Ki.Col.1">
3.   <gml:description>KISTERS KIXIS WaterML2.0</gml:description>
4.   <wml2:metadata>
5.     <wml2:DocumentMetadata gml:id="Ki.DocMD.1">
6.       <wml2:generationInfo>2012-06-12T12:18:12.670+08:00</wml2:generationInfo>
7.       <wml2:generationSystem>KISTERS</wml2:generationSystem>
8.     </wml2:DocumentMetadata>
9.   </wml2:metadata>
10.  <wml2:temporalExtent>
11.    <gml:timePeriod gml:id="Ki.TempExt.1">
12.      <gml:beginPosition>1998-09-02T00:00:00.000+01:00</gml:beginPosition>
13.      <gml:endPosition>1998-09-30T00:00:00.000+01:00</gml:endPosition>
14.    </gml:timePeriod>
15.  </wml2:temporalExtent>
16.  <wml2:observationMember>
17.    <om:OM_Observation gml:id="Ki_OM_Obs.1">
18.      <om:phenomenonTime>
19.        <gml:timePeriod gml:id="Ki.ObsTime.1">
20.          <gml:beginPosition>1998-09-02T00:00:00.000+01:00</gml:beginPosition>
21.          <gml:endPosition>1998-09-30T00:00:00.000+01:00</gml:endPosition>
22.        </gml:timePeriod>
23.      </om:phenomenonTime>
24.      <om:resultTime>
25.        <gml:timeInstant gml:id="Ki.ResultTime.1">
26.          <gml:timePosition>1998-09-30T00:00:00.000+01:00</gml:timePosition>
27.        </gml:timeInstant>
28.      </om:resultTime>
29.      <om:procedure xlink:href="http://kixis.kisters.de/ts/Day_Cnd" xlink:title="10 - DailyMean"/>
30.      <om:observedProperty xlink:href="http://kixis.kisters.de/parameters/557" xlink:title="Q"/>
31.      <om:featureOfInterest xlink:href="http://kixis.kisters.de/stations/1732100"

```

File extensions

- XML: the typical file extension of an XML file
- WML: the wml extension is a typical abbreviation of WaterML2 and can be used as a file-extension as well
- WMZ: similar to KM/LKMZ we suggest to use the file extension "WMZ" to indicate that the file has been zipped

How to transport WaterML2

- email, ftp, file-copy
- any arbitrary http-transfer, or via standardized http transfer mechanism (e.g. OGC, SOS)
- any other transfer option (the above just focus to internet use-cases)

This site is owned and operated by [KISTERS](#), Hydrological Time-Series Management Software, to support and promote open standards



National Environmental Information Infrastructure: Reference Architecture



Contributing to the Australian Government National Plan for Environmental Information initiative



Climate data on tap

Climate and oceans data and analysis

Access past weather and climate information from the Bureau's vast data archives. Much of this information is freely available for immediate download. Also explore our range of specialised climate services such as certified extracts (legal), storm confirmations, data subscriptions and custom analyses (charges may apply).

Latest news

[Changes to solar data](#)



Storm confirmer
Check for recent storm activity at Australian locations

Help us design a new service

How can we make our new event planner more useful for you?



Event planner
See what the weather is typically like on any day



Find data

Data charges

About data and observations

FAQs and help

Service feedback

Daily weather

Daily rainfall

Climate averages

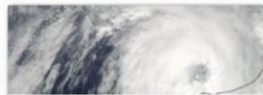
Climate maps



Past observations and statistics



Radar, satellite and MSLP maps



Past forecasts and warnings

Select using Text
Select using Map

Home
Go to
Bookmark
[Print](#) | [Help](#)

Data | Map layers

I would like

Climate statistics

Stations Open Closed

Zoom to

Enter location

0 400 800 km

152.65°E, 40.36°S

[Disclaimer](#)

Click on a weather station for information.

Tip: Hold down the Shift key and drag your mouse to zoom in to an area or use the 'Zoom to' search tool.



Hydrometric and hydrogeologic data on tap

Australian Groundwater Explorer

Quick Search

Layers

- General
 - All Bores
 - By Purpose
 - By Status
 - Availability of bore data
 - Construction log
 - Hydrostratigraphy log
 - Lithology log
 - Screened hydrogeologic unit
 - Water level (pilot sites)
 - 3D hydrogeology models
 - Landscape characteristics
 - River region
 - Groundwater management areas
 - Sedimentary basins
 - Surface geology
 - Elevation

Legend

Search

Search Results (0)

Explorer Site Id State/Territory Bore Depth (m) Status Drilled Date Aggregated Bore Purpose Aggregated Bore Status HGU Name

Page 1 of 1 | 20 items per page

Australian Groundwater Explorer

Water data online

Search
Darling

Filter

Parameter
All parameters

Station name
All stations

Station number
All stations

Show advanced search options

Clear filters

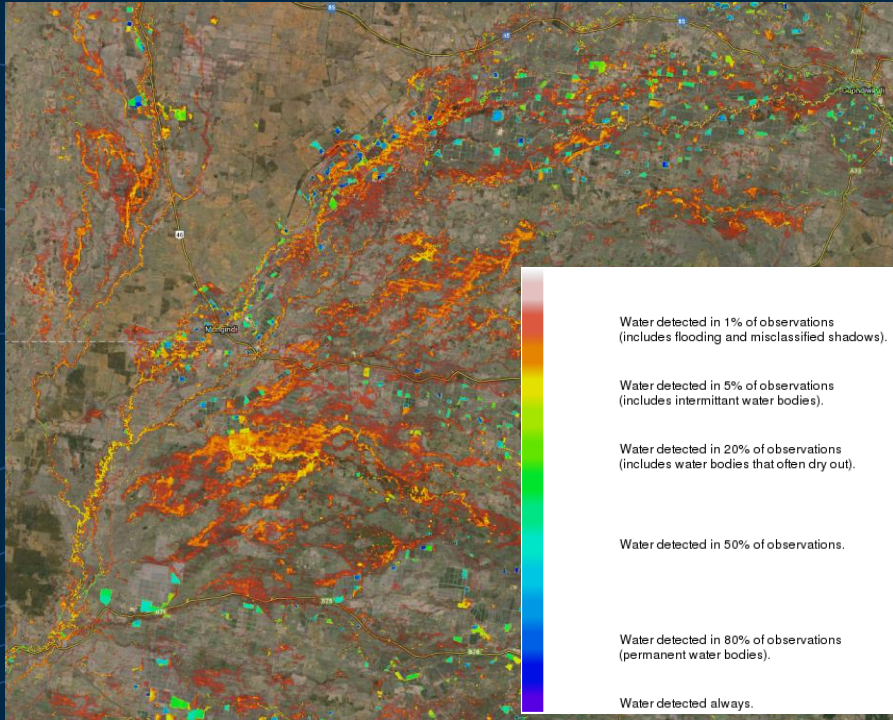
DARLING RIVER AT BURTUNDY
Station number: 425007
Parameter: Water Course Discharge
Water Course Level

2014 MapInfo Services Pty Ltd (RUS), PSMA

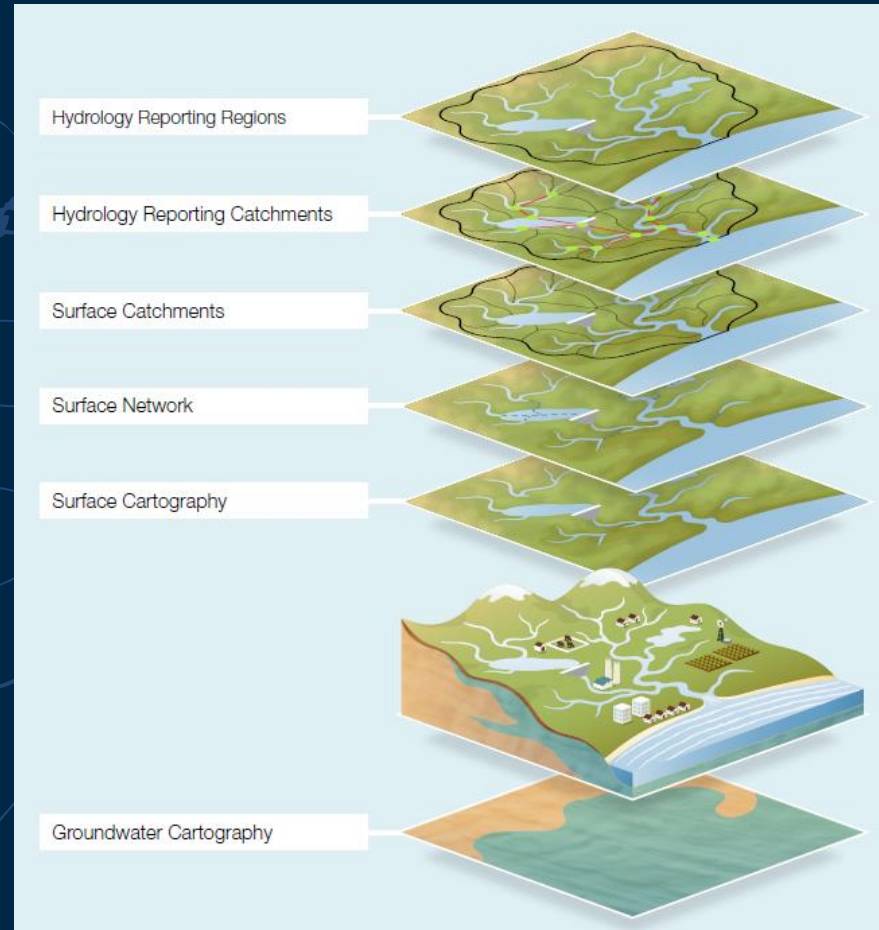
Water Data Online



Spatial data on tap



Water Observations from Space (GA)



Geofabric



National reporting on water


Big ideas start here

CSIRO

Explore CSIRO Partner Media Events Education Publications Careers Contact

Sustainable Yields Projects

CSIRO is undertaking a comprehensive scientific assessment of current and future water availability in major water systems across Australia to provide a consistent framework for future water policy decisions.



Flinders and Gilbert Agricultural Resource Assessment »
CSIRO has completed, for the Australian Government, an investigation of opportunities for water and agricultural developments in the Flinders and Gilbert catchments of north Queensland.

The Murray-Darling Basin Sustainable Yields Project »
This project provided a comprehensive assessment of current and future water availability in the Murray-Darling Basin.

The Northern Australia Sustainable Yields Project »
This project reported on current and future water availability for the catchments of Northern Australia.

The Tasmania Sustainable Yields Project »
This project provided the most comprehensive assessment of water yield undertaken to date in Tasmania.

The south-west Western Australia Sustainable Yields Project »
This project provided information on current and future water yields from both surface water catchments and aquifers in south-west Western Australia.

Great Artesian Basin Water Resource Assessment »
CSIRO is reappraising the water resources of the Great Artesian Basin, which underlies about one-fifth of the Australian continent.

Sustainable Yields Assessments

2012 Assessment: Analysis by region

Analysis is presented for thirteen regions across Australia.



- 2012 Assessment**
- Introduction
 - National overview
 - Analysis by region
 - Technical Supplement
 - References (794Kb)
 - Glossary
 - Data and metadata
 - Feedback
 - Copyright
- Regions**
- North East Coast
 - South East Coast (NSW)
 - South East Coast (VIC)
 - Tasmania
 - Murray-Darling Basin
 - South Australian Gulf
 - South Western Plateau
 - South West Coast
 - Pilbara-Gascoyne
 - North Western Plateau
 - Tanami - Timor Sea Coast
 - Lake Eyre Basin
 - Carpentaria Coast
- 2010 Assessment**

Australian Water Resource Assessments

National Water Account 2013

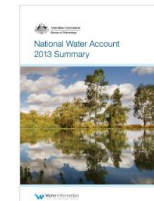
The 2013 Account contains a set of water accounting reports for nine nationally significant water management regions.

It covers a one year period, from 1 July 2012 to 30 June 2013.



2013 Account regions

- Adelaide
- Canberra
- Daly
- Melbourne
- Murray-Darling Basin
- Perth
- South East Queensland
- Sydney



National Water Account



Catchment and river modelling with Source



New release of a **free** public version of Source,
Australia's national hydrological modelling platform

eWater Source combines a leading integrated water resource management modelling system with the sophisticated water governance arrangements that reflect the Australian management approach towards sustainable water policy development and operation. Source allows water managers and planners to design and implement defensible policy to support ecologically and economically sustainable use of water and river systems in transboundary and cross-jurisdictional rivers and catchments.

Source is a nationwide collaborative effort backed by the Australian government, with over 20 years of scientific research, development and applications.

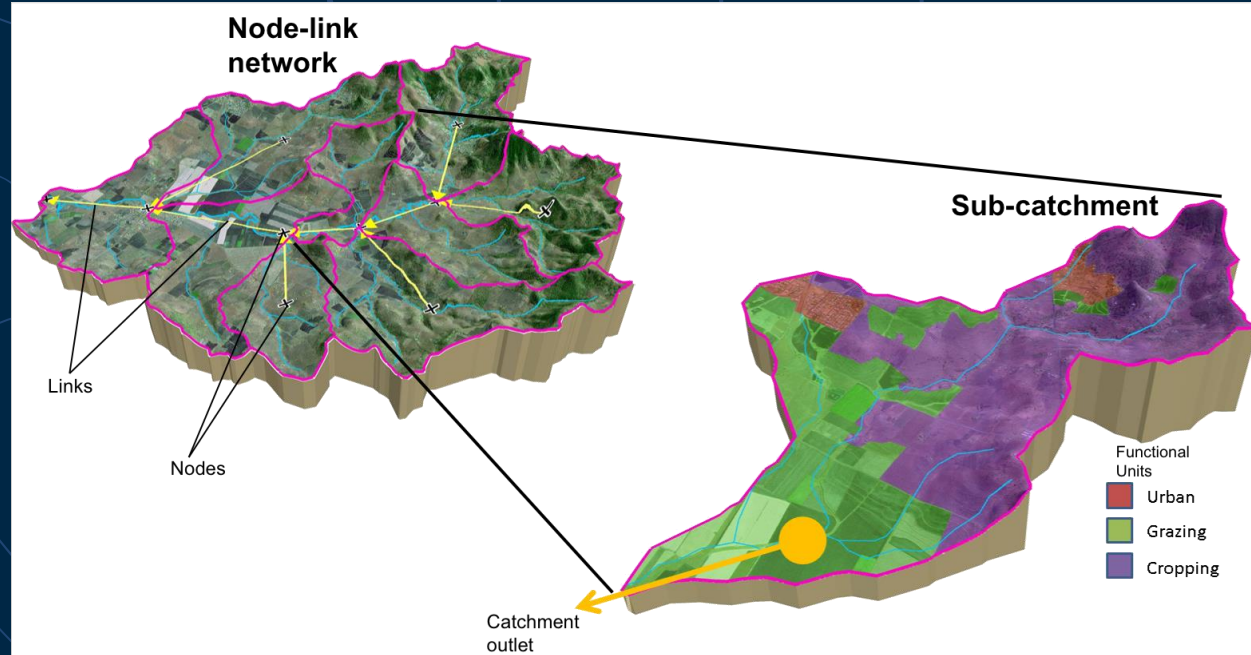
Consistent with our not-for-profit mission of supporting better water management through a community of practice, eWater has released a free version of Source as a public offer.

Managers, modellers, researchers, students and consultants can now readily access the benefits of Australia's leading hydrological approaches as a foundation towards the full version of Source, Australia's national hydrological modelling platform.

To find out more visit www.ewater.com.au/source

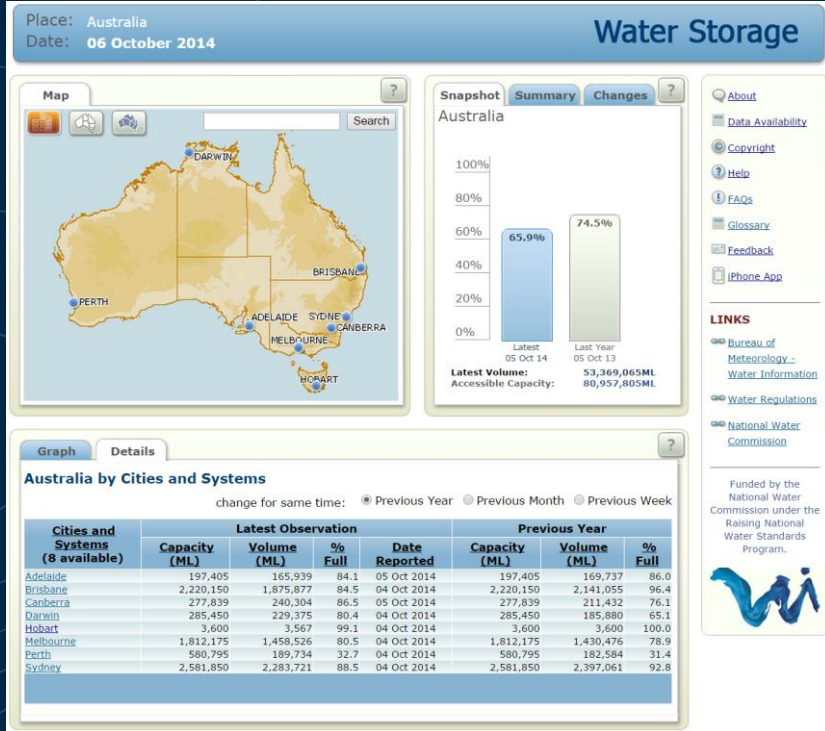


eWater and its Australian government and industry partners have completed more than 100 Source applications, and plans on water policy, water sharing plans and catchment management. Visit www.ewater.com.au

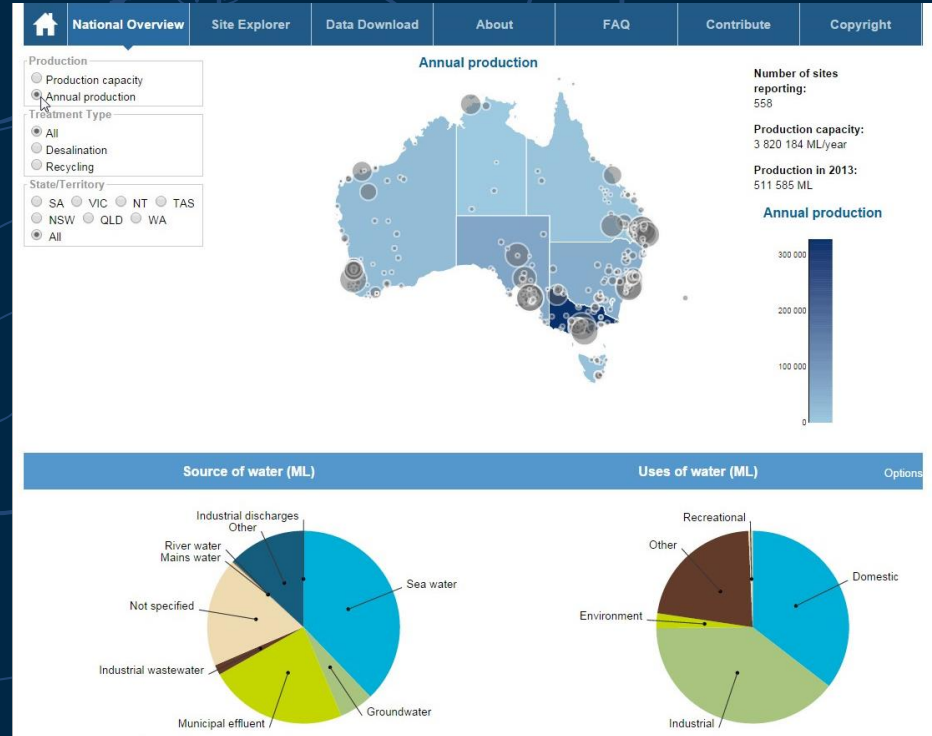




Dashboards



Water Storage



Climate Resilient Water Sources




Reference climate and streamflow series

ACORN-SAT
Data and network
Antarctic and island data
Methods
Expert review
Adjustments
Early data

ACORN-SAT station data and network

The ACORN-SAT dataset includes data from 112 locations across Australia which provide homogenised, ground-based temperature records. The locations are chosen to maximise the length of record and network coverage across the country. Combined, these stations hold over 100 years of records.



Station details are available from the [ACORN-SAT station catalogue](#). The catalogue includes current details of each weather station and a history of observations at the location, including record length and relevant metadata.

Number	Station name	Latitude °S	Longitude °E	Elevation m	Start year	Minimum °C	Maximum °C
023090	Adelaide	34.92	138.62	48	1910	Min data	Max data
009741	Albany	34.94	117.8	68	1910	Min data	Max data
015590	Alice Springs	23.8	133.89	546	1910	Min data	Max data
040004	Amberley	27.63	152.71	24	1941	Min data	Max data
036007	Barcaldine	23.55	145.29	267	1962	Min data	Max data
063005	Bathurst	33.43	149.56	713	1910	Min data	Max data
038026	Birdsville	25.9	139.35	47	1954	Min data	Max data
038003	Bouliá	22.91	139.9	162	1910	Min data	Max data
048245	Bourke	30.04	145.95	107	1910	Min data	Max data
009510	Bridgetown	33.96	116.14	150	1910	Min data	Max data
040842	Brisbane Airport	27.39	153.13	5	1949	Min data	Max data
003003	Broome Airport	17.95	122.24	7	1910	Min data	Max data

ACORN-SAT (112)

Hydrologic Reference Stations

Introduction
Feature Stations
Selection Guidelines
FAQs
Glossary
Methods
Stakeholder
References and Papers
Feedback
Copyright

Station Selector

Region
Australian Capital Territory

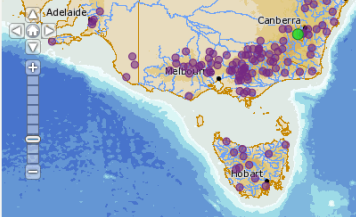
Basin
Murrumbidgee River

Station
Cotter River at Gingera (410730)

Neary stations

- 📍 Gudgenby River at Tennent (410731)
- 📍 Murrumbidgee River at Lobb Holes (410761)
- 📍 Queanbeyan River at Tindery (410734)

Cotter River at Gingera (410730)



Quick Facts

Catchment

Area 130 km²

Stream Length 98 km

Time series

Start Date 05-07-1963

End Date 04-10-2012

Gap-filled 0.36 %

Daily Max 4507 ML

Daily Min 1 ML

Daily Average 119 ML

Annual Average 43 GL

Water Year Mar to Feb

Snapshot
Data Explorer
Trend Explorer
Station Facts
Data Download

Display

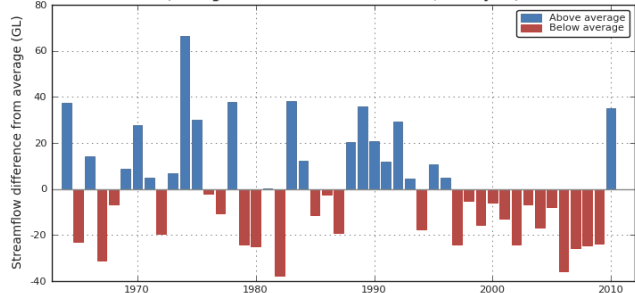
- Graphic
- Data
- Description

Download ⬇

- [Graph data](#)
- [Gap filled daily data](#)

Cotter River at Gingera (410730)

(Average annual streamflow: 42.89 GL/water year)



Water Year (March to February)

Generated: 12:58 17/06/2013 © Commonwealth of Australia 2013, Australian Bureau of Meteorology

Hydrologic Reference Stations (221)



New Intensity-Frequency Duration Design Rainfalls

- Released July 2013
- Based on a more extensive dataset
 - nearly 30 years' additional rainfall data
 - 2300 extra rainfall stations
- Combined contemporary statistical analyses and techniques with an expanded rainfall database
- Provides better estimates

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Bureau Home » Water Information » Rainfall IFD Data System

Rainfall IFD Data System

[Help](#) | [Revised IFD feedback](#)

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Search

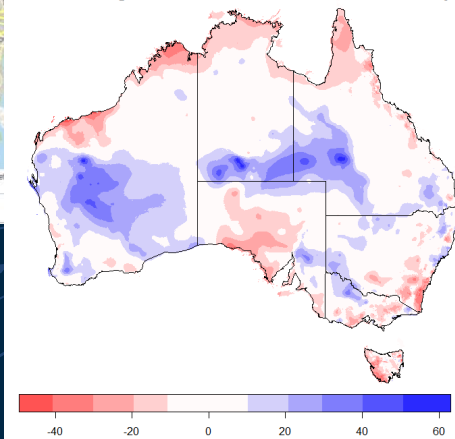
Decimal degrees
Latitude:
Longitude:

Degrees, Minutes, Seconds
 Easting, Northing, Zone

Label:

Powered by Leaflet

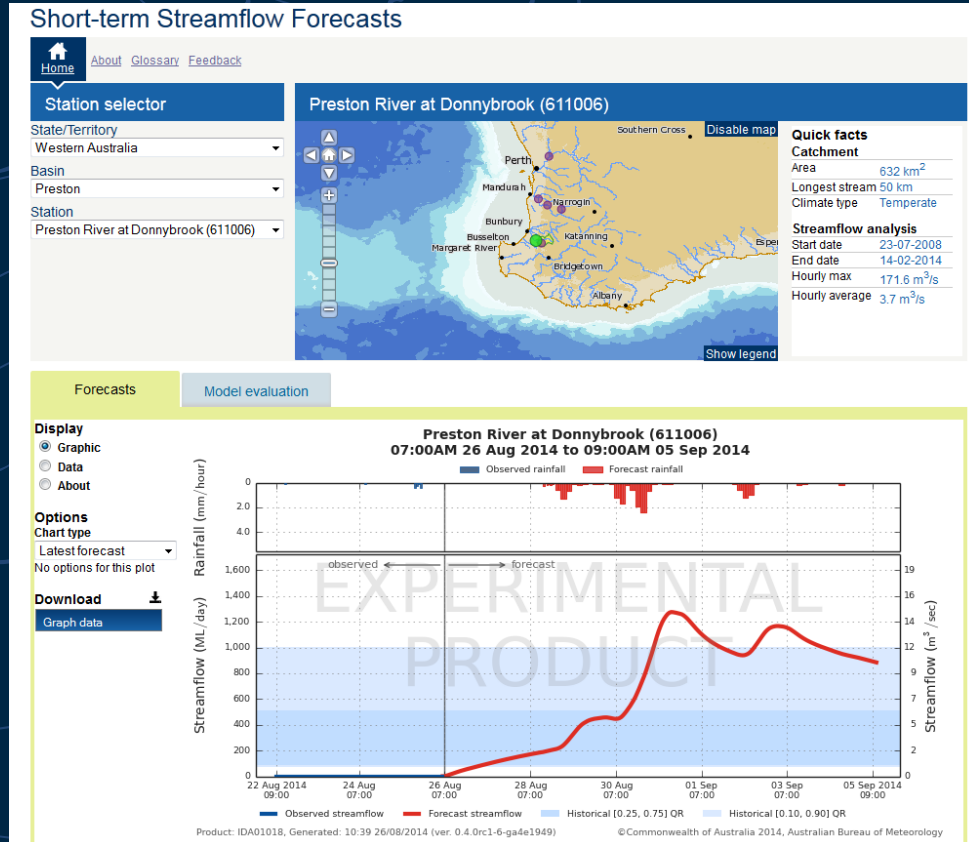
Percent change - 1hr; 1% Annual Exceedance Probability





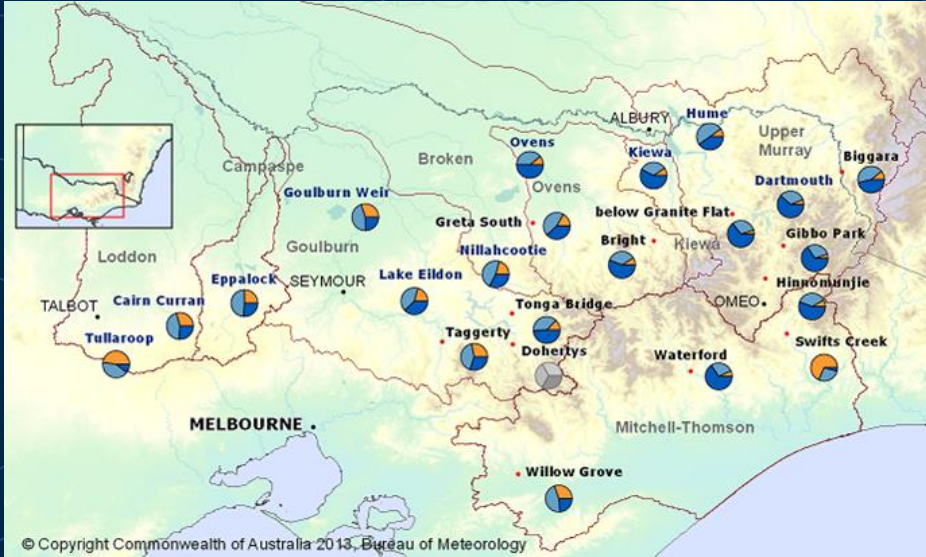
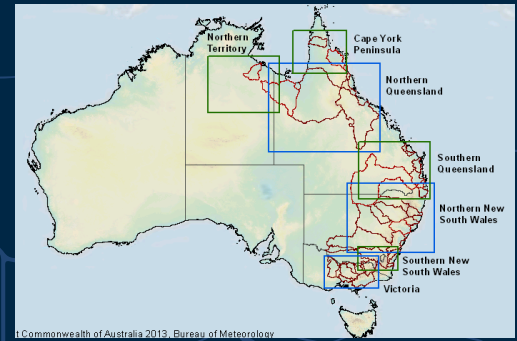
Operational Short-term Streamflow Forecasts

- Short-term streamflow forecasts, to 7 days
- Updated daily
- Targeted at river and storage operations
- Useful for 'heads up' flood guidance
- 20 catchments in system so far
- 60 catchment by end of this year
- Now available to registered users
- Public release in June 2015

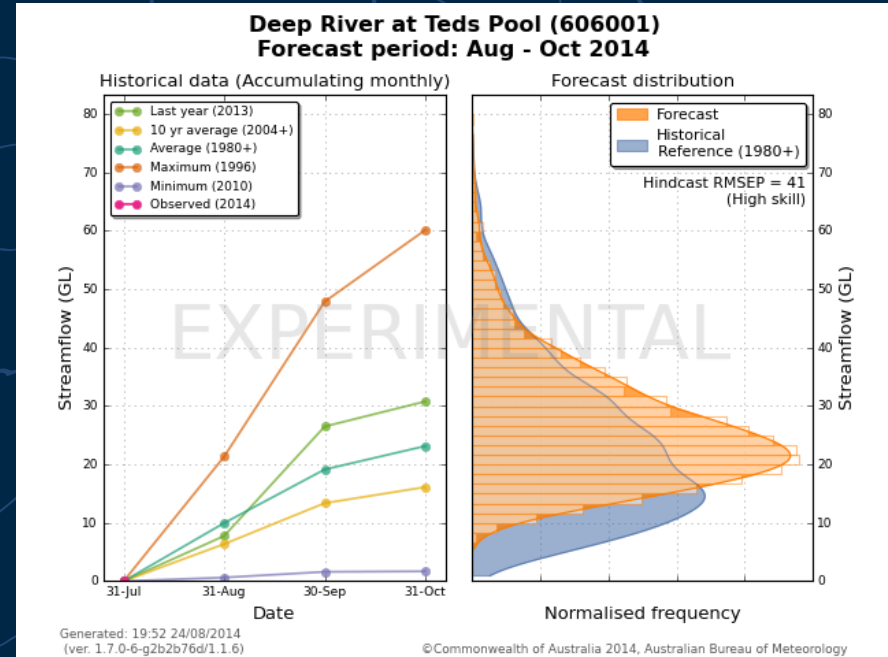




Operational Seasonal Streamflow Forecasts

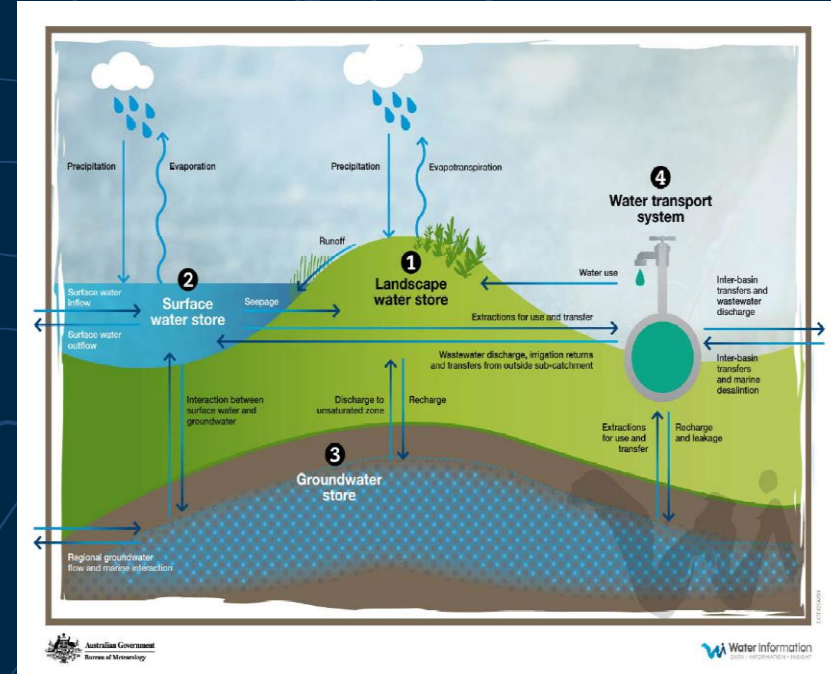
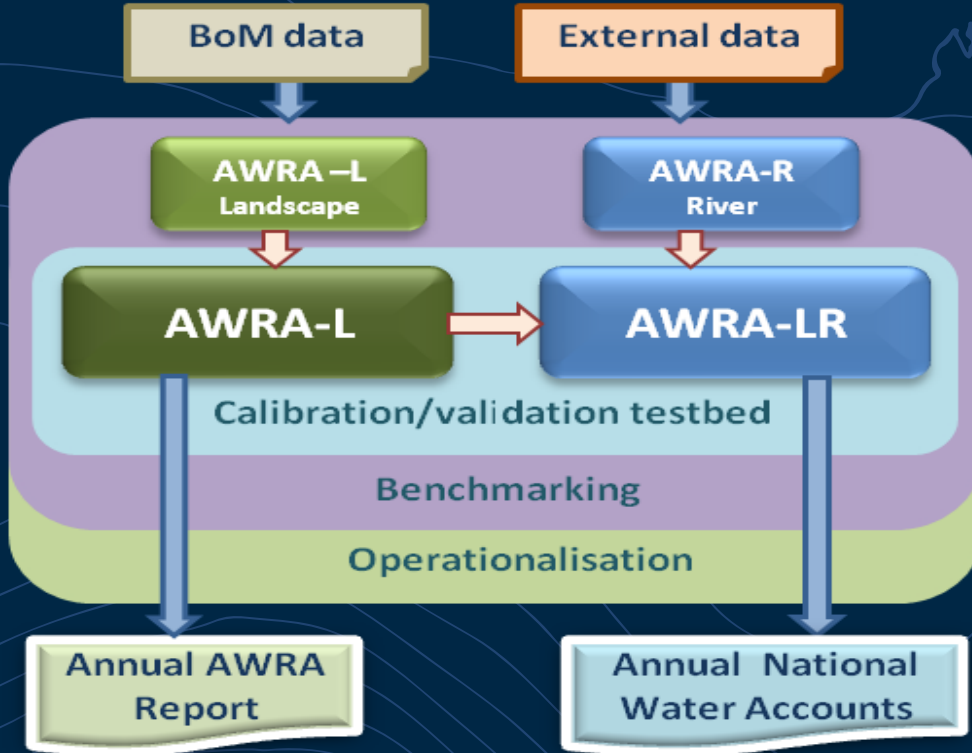


- 3 months ahead, updated every month
- 74 locations in 32 river basins





Operational, daily continental water balance model





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*6. We have great foundations
and thus great opportunities*





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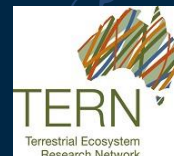
Collaboration: Essential for future success



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Safety



Sustainability



Well-being



Prosperity



ENVIRONMENTAL INTELLIGENCE

Conclusions drawn from environmental observations and models to guide decisions and actions by governments, businesses and individuals.



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Thank you
Any questions?

