Australian Government
Bureau of Meteorology

Environmental intelligence needs for tomorrow

Dr Rob Vertessy
Director, Bureau of Meteorology

Australian Government
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?

Australian Government
Bureau of Meteorology

1. Judgments of adequacy are context sensitive

Australian Government
Bureau of Meteorology

Safety

Sustainability

Well-being

Prosperity

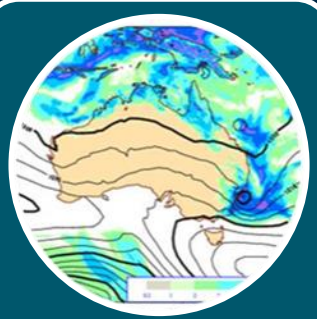
ENVIRONMENTAL INTELLIGENCE

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

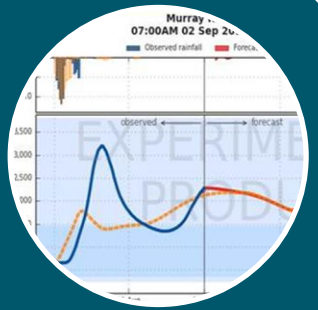
Australian Government
Bureau of Meteorology

Dimensions of Environmental Intelligence

Observe



Model



Forecast

Inform

Warn

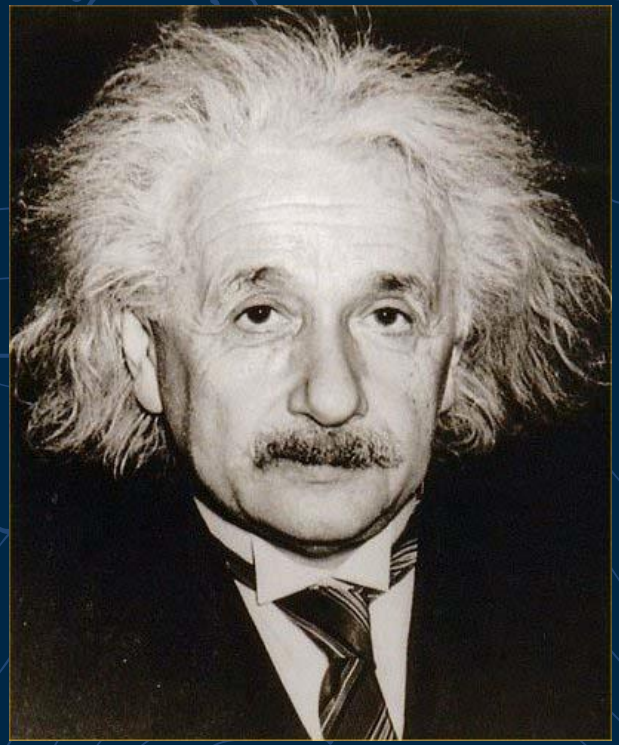
Information from environmental data and models to inform decisions

Australian Government
Bureau of Meteorology

2. History proves we have poor foresight

Australian Government
Bureau of Meteorology

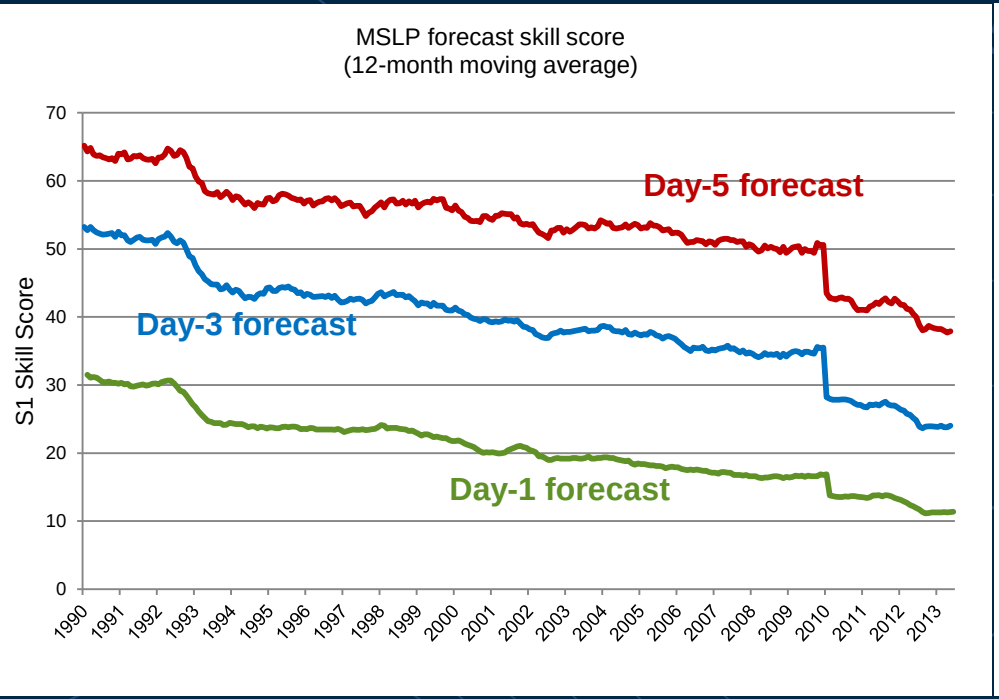
"To be sure, when the number of factors coming into play in a phenomenological complex is too large, scientific method in most cases fails us. One need only think of the weather, in which case the prediction even for a few days ahead is impossible."

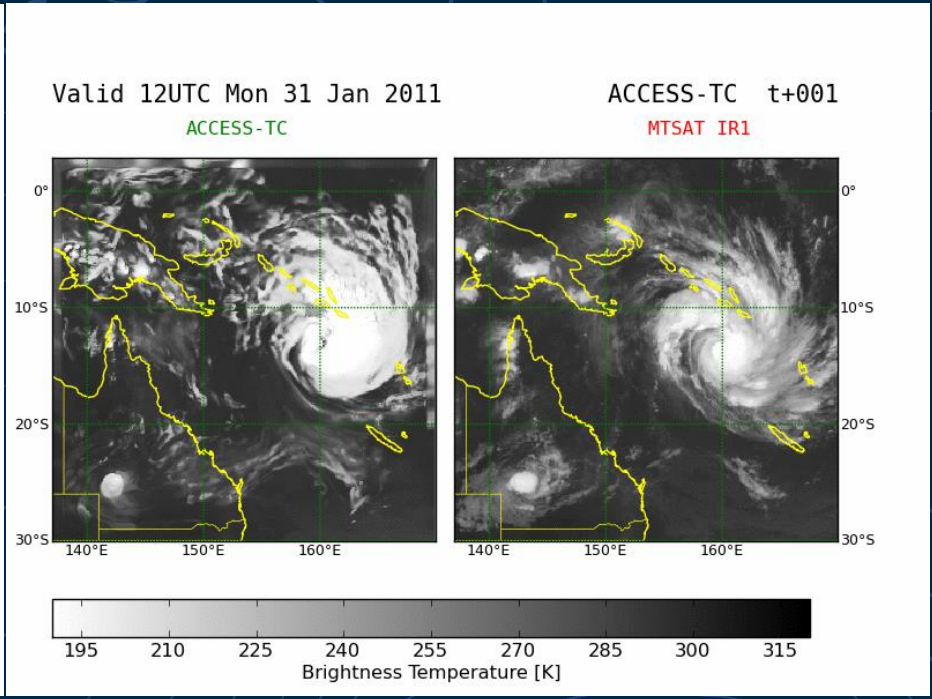


Albert Einstein
Science and Religion (1941).

Australian Government
Bureau of Meteorology

Progress in numerical weather prediction





Australian Government
Bureau of Meteorology

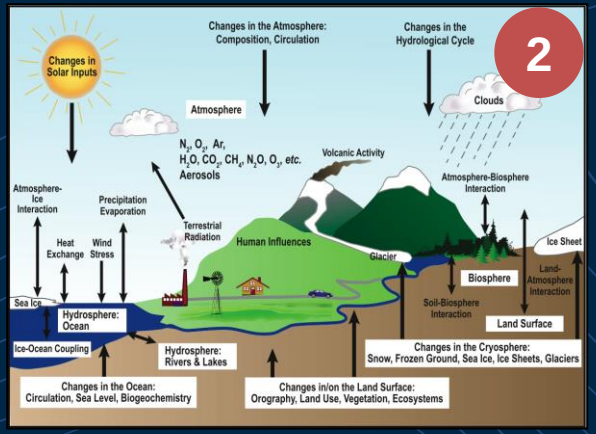
How progress is forged

1

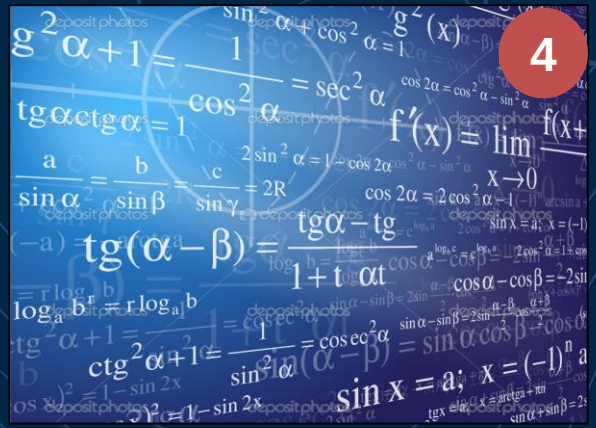
3

5

2



4



6

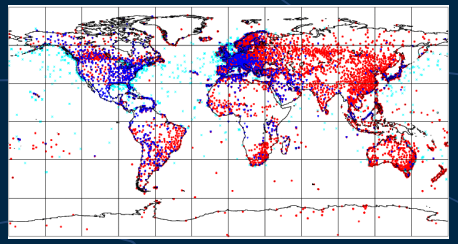
Australian Government
Bureau of Meteorology

3. Observations are key

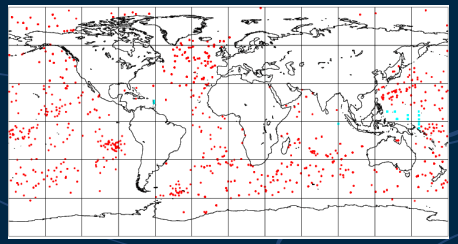

Polar-orbiting meteorological satellite
Polar-orbiting earth resources satellite
Geostationary meteorological satellite
High-altitude aircraft
International aircraft
Meteorological research aircraft
Radiosonde
Baseline air pollution station
Meteorological satellite ground station
Automatic weather station
Automated river-height and rain gauges
Pilotless aircraft
Wind profiler
Voluntary observing ship
Domestic aircraft
Meteorological observing station
Over-the-horizon radar
Drifting buoy

Data sources for weather prediction

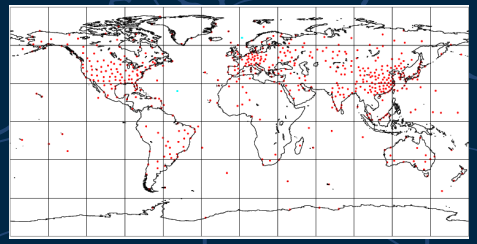
SYNOPS AND SHIPS



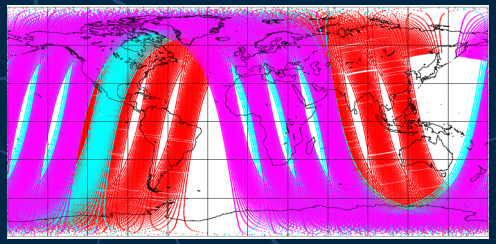
BUOYS



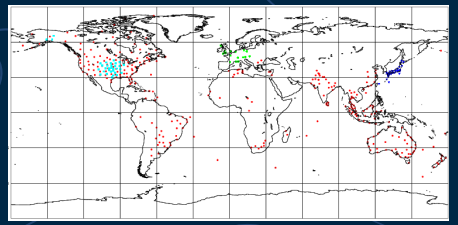
RADIOSONDES



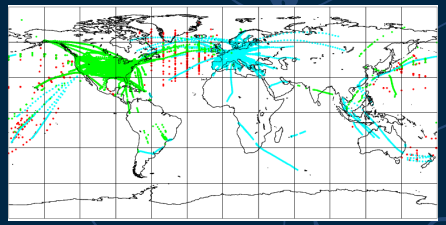
IR AND MW SOUNDERS



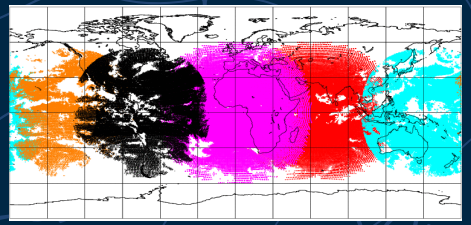
PILOTS AND PROFILERS



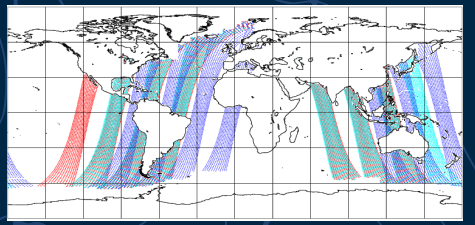
AIRCRAFT



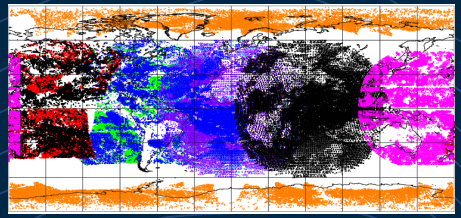
WATER-VAPOUR RADIANCES



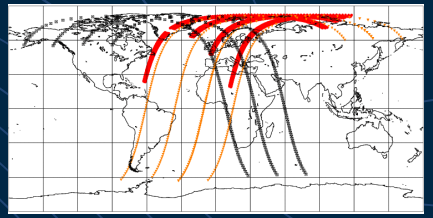
SSM/I



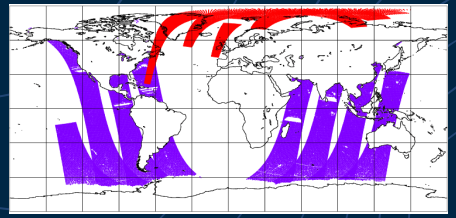
SATELLITE WINDS



OZONE



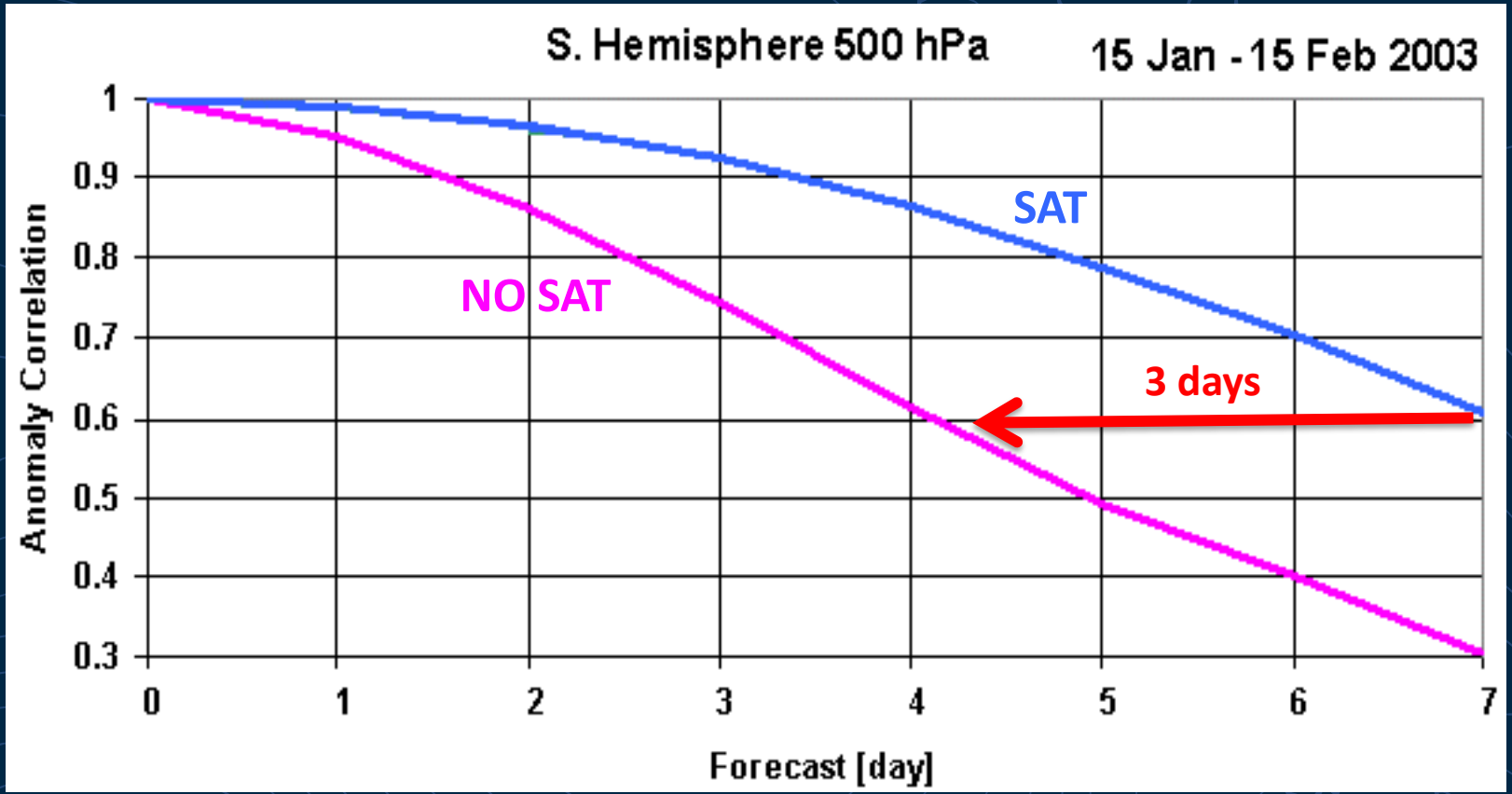
SCATTEROMETER



Australian Government
Bureau of Meteorology

Australian Government
Bureau of Meteorology

Impact of satellite observations on NWP skill

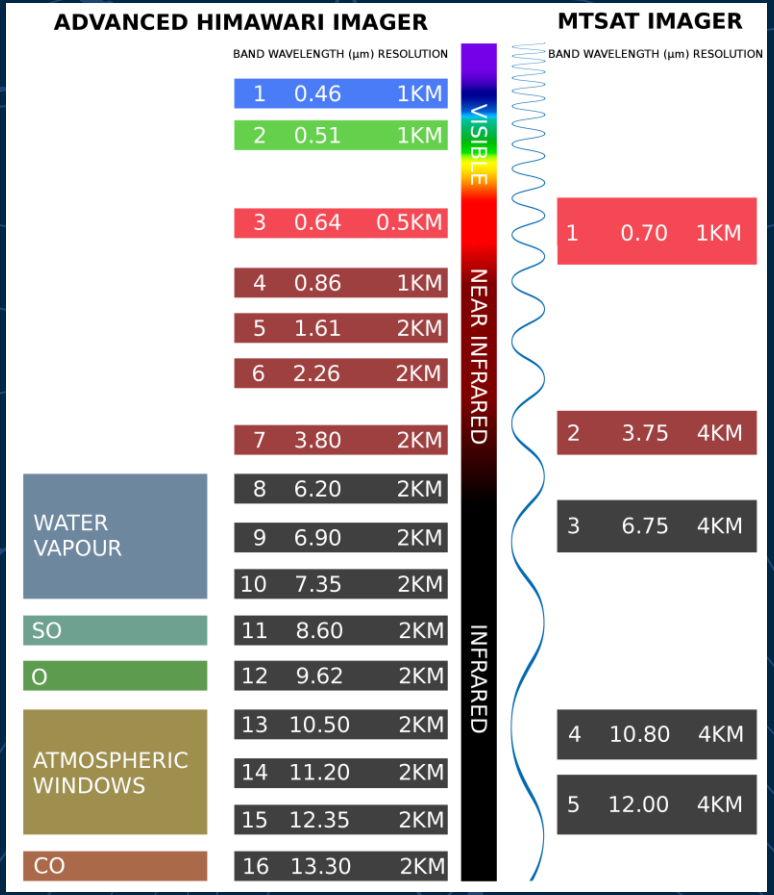


Australian Government
Bureau of Meteorology

Himawari-8

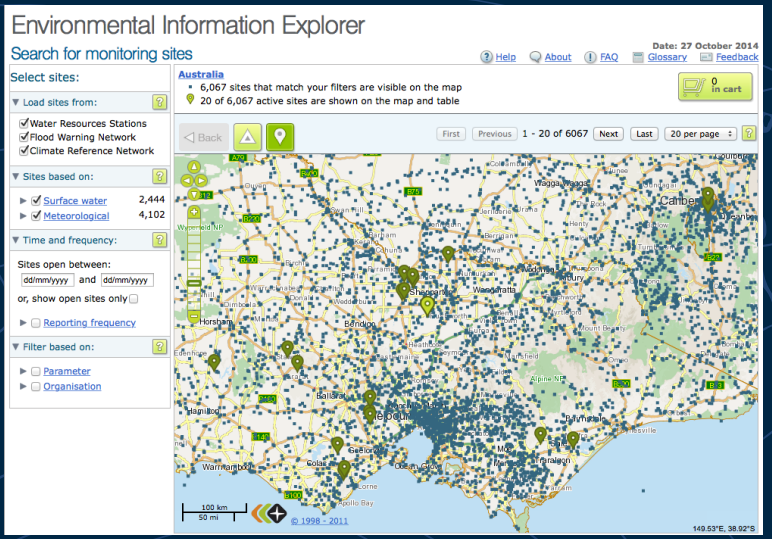
- 3x spectral channels
- 4x spatial resolution
- 6x temporal frequency

… compared to the current generation satellite MTSAT

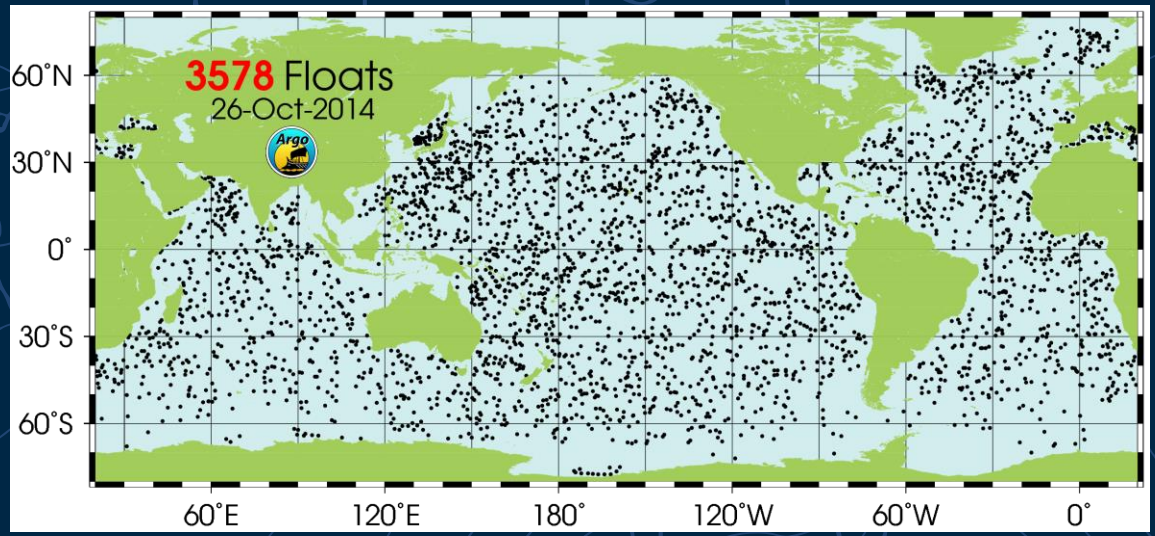


Australian Government
Bureau of Meteorology

Ground ‘truth’



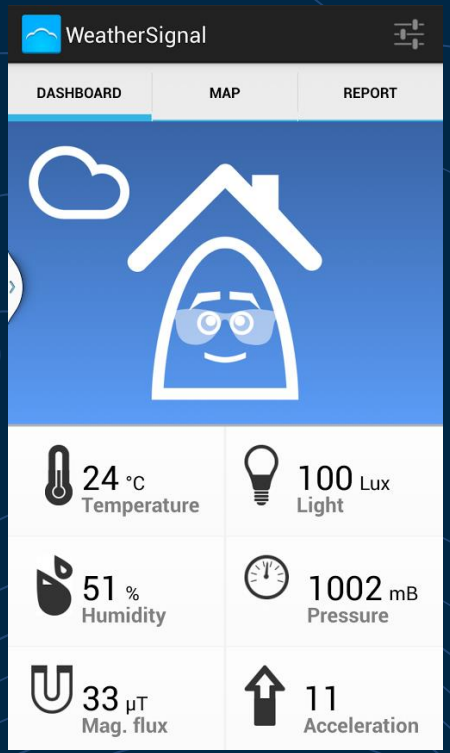
Hydrometric and climate monitoring

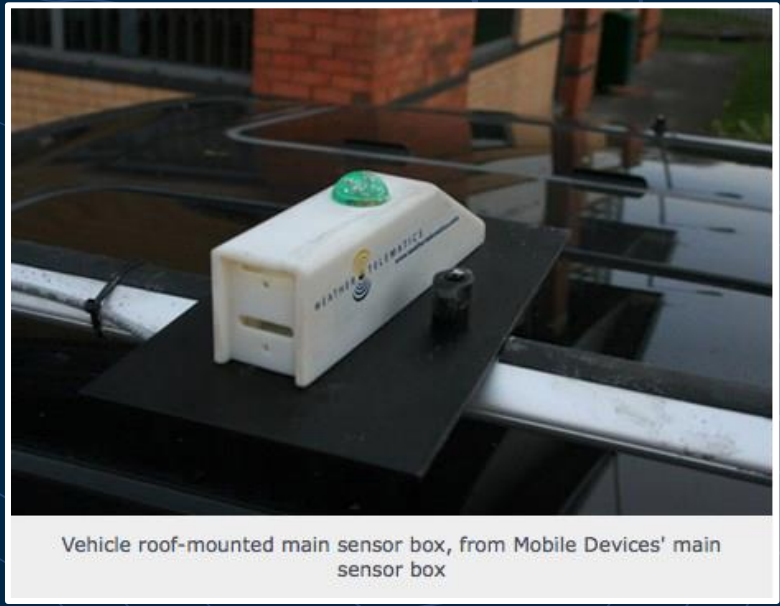


Argo floats

Australian Government
Bureau of Meteorology

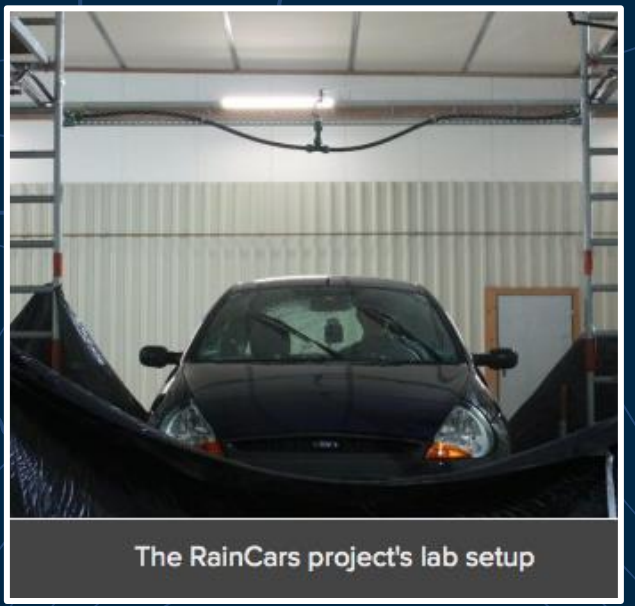
Novel observations: Future shock?





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

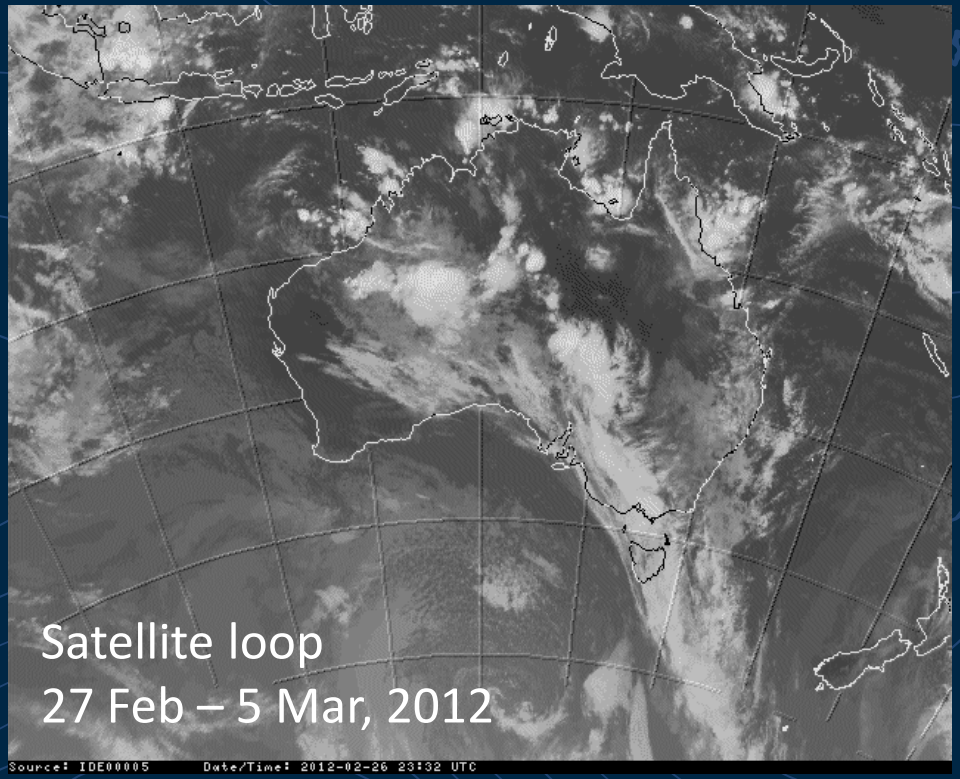
RainCars

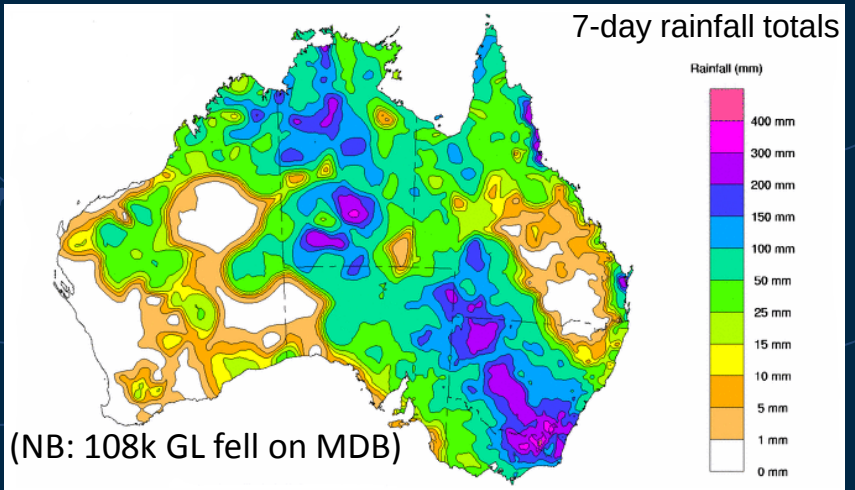
Australian Government
Bureau of Meteorology

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

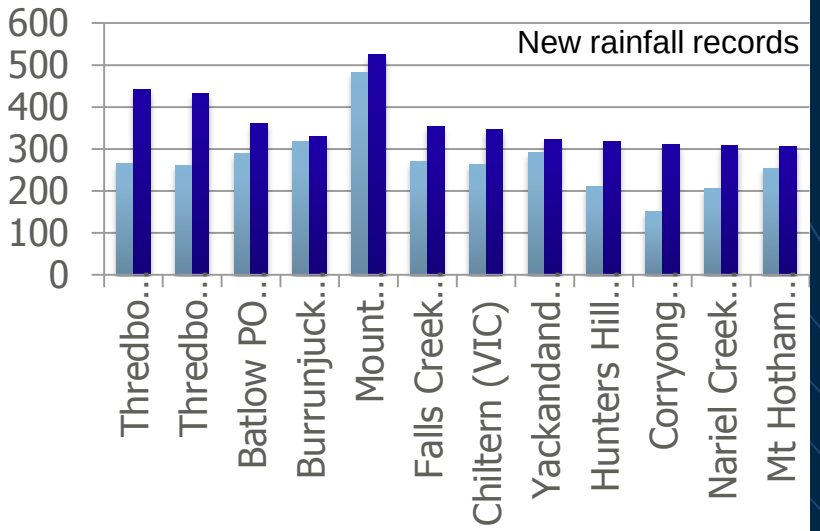
Australian Government
Bureau of Meteorology

Episodic events



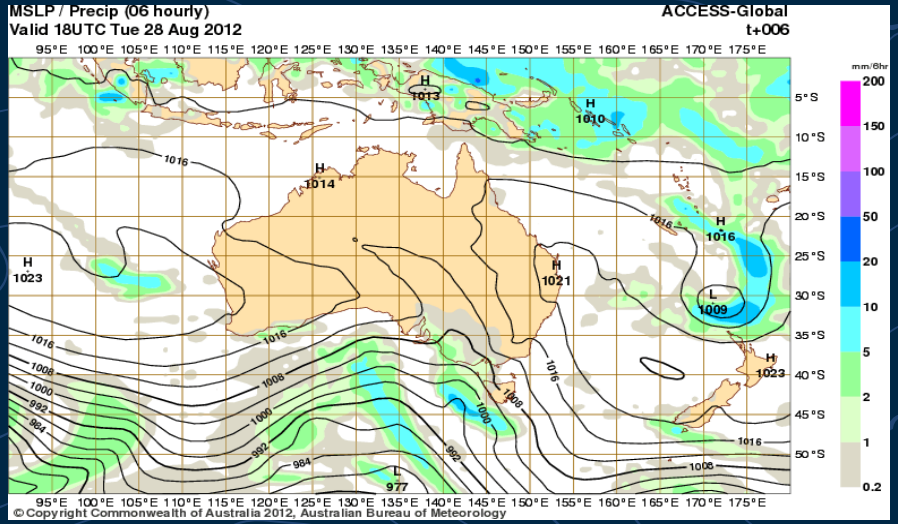


(NB: 108k GL fell on MDB)

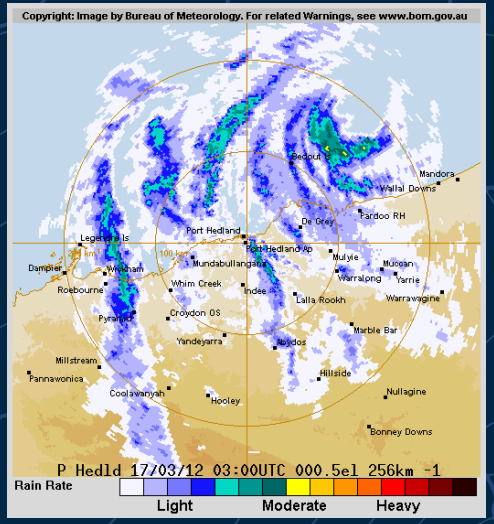


Australian Government
Bureau of Meteorology

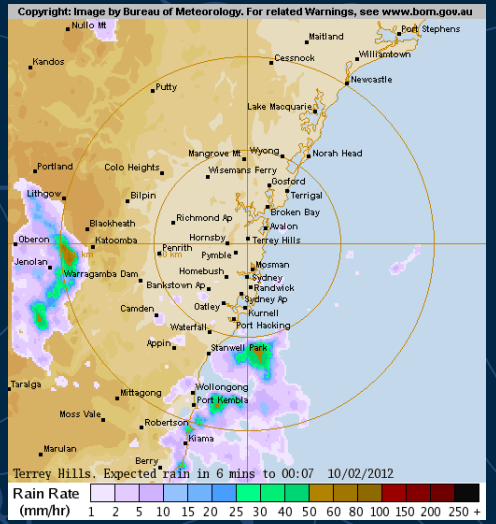
Quantitative Precipitation Forecasting



NWP



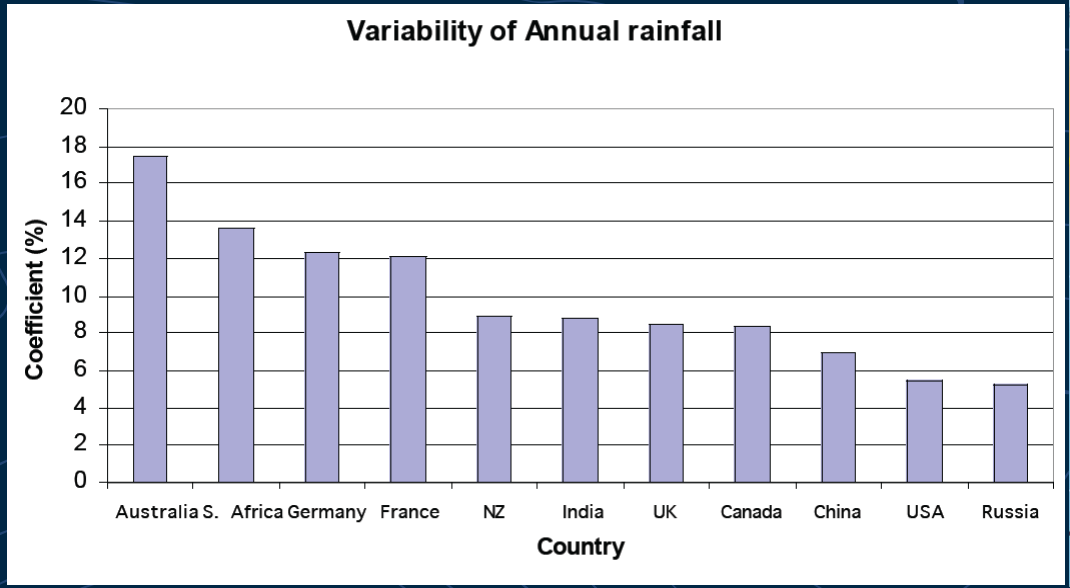
Radar

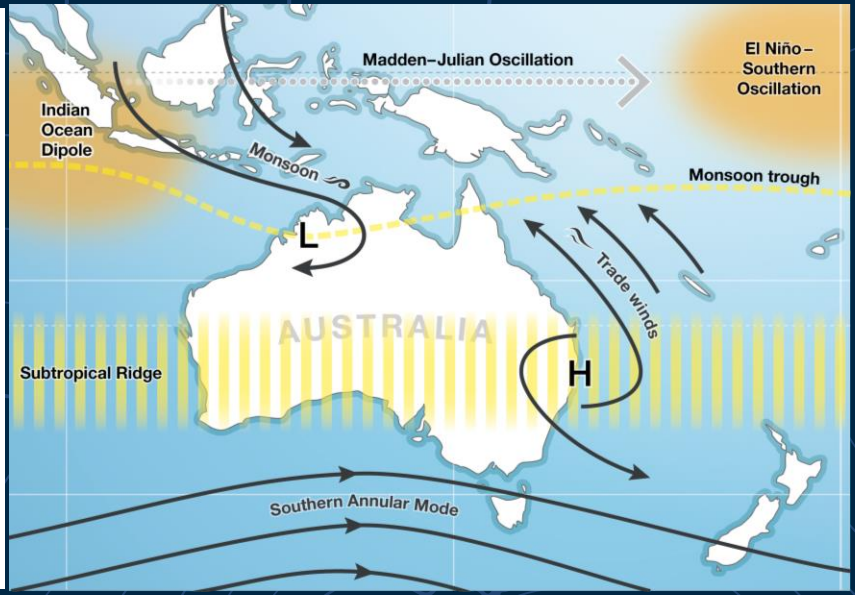


Nowcast

Australian Government
Bureau of Meteorology

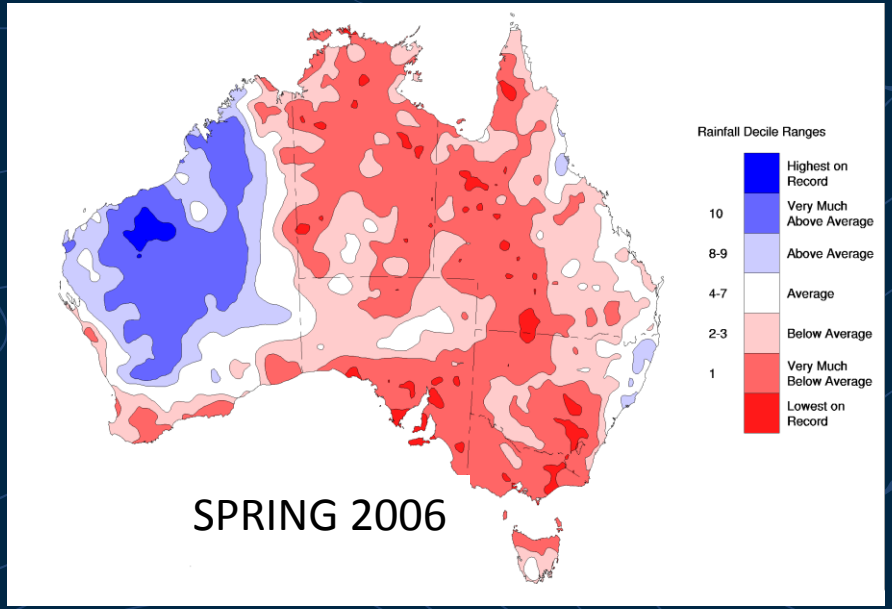
Climate variability

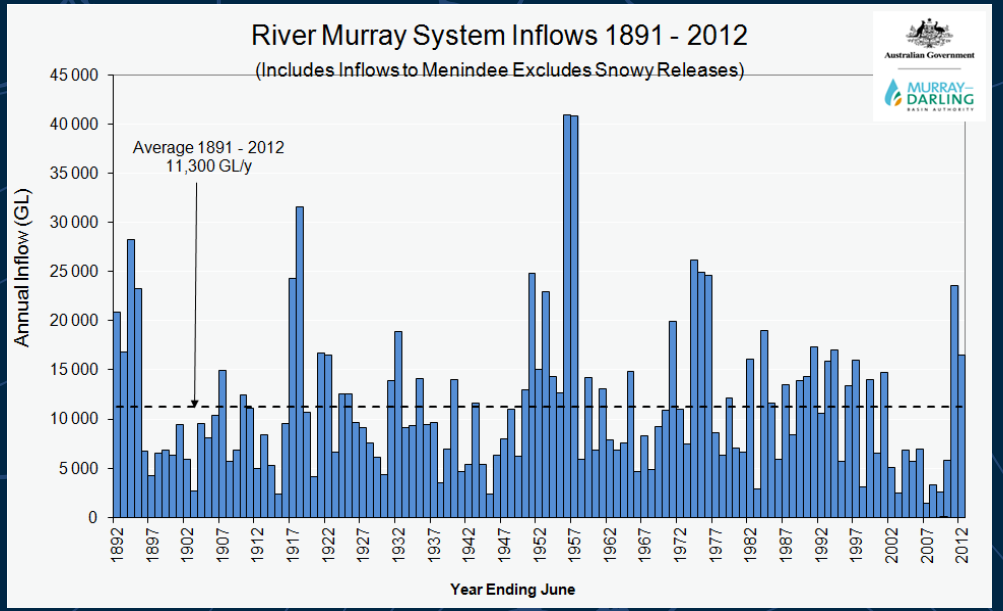




Australian Government
Bureau of Meteorology

The millennium drought

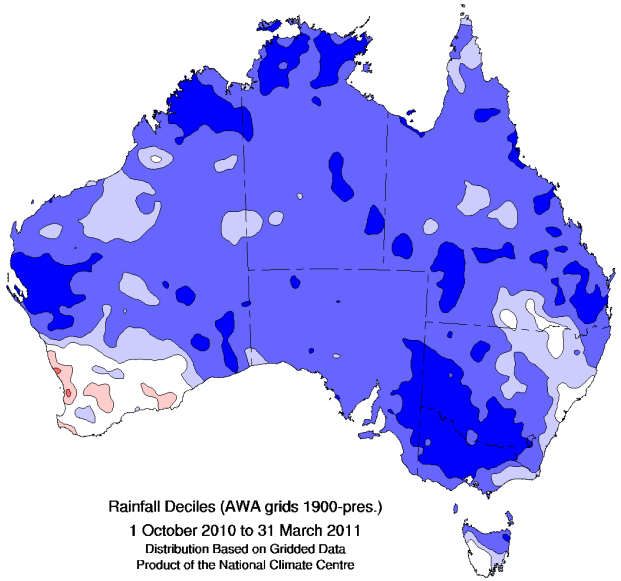




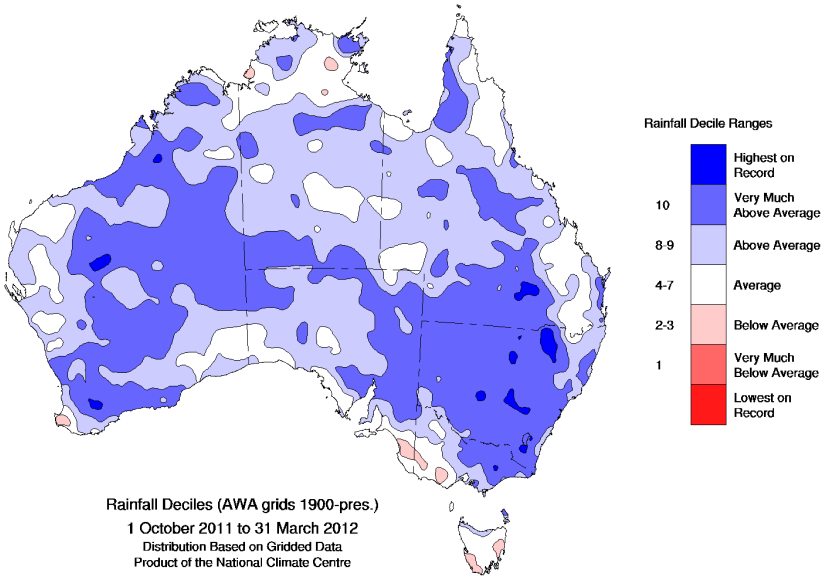
Australian Government
Bureau of Meteorology

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

Rainfall deciles: 2010-11



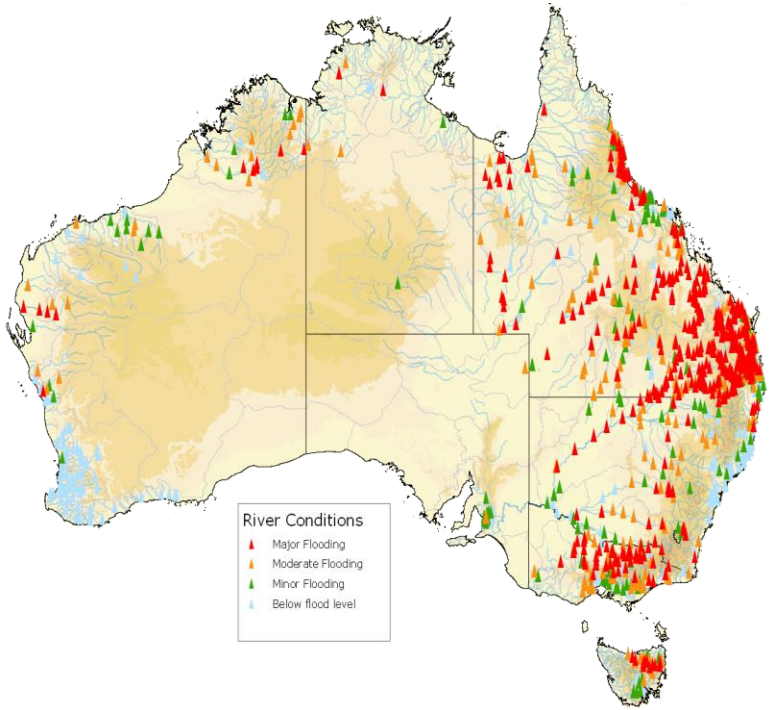
Rainfall deciles: 2011-12



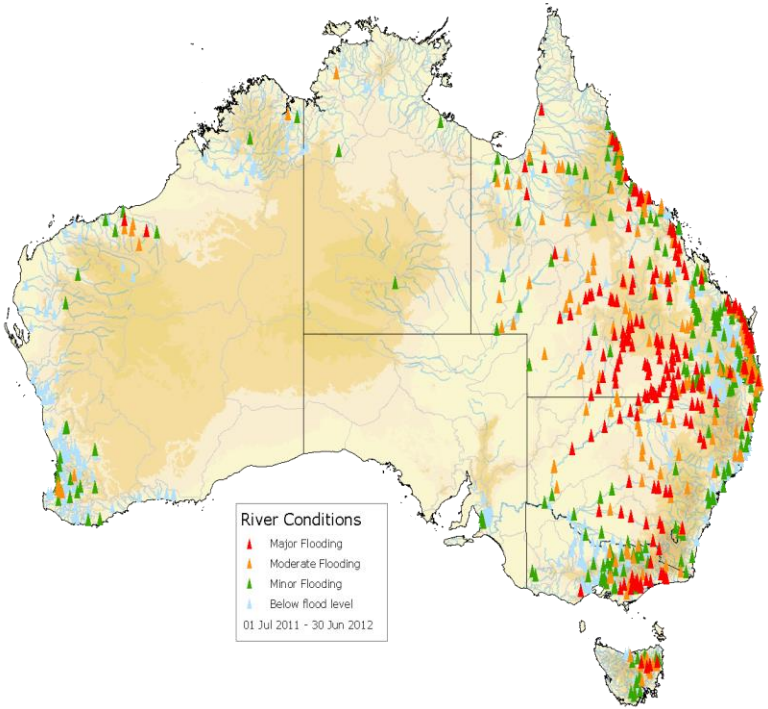
Australian Government
Bureau of Meteorology

Record flooding ensues

River Conditions: 2010-11

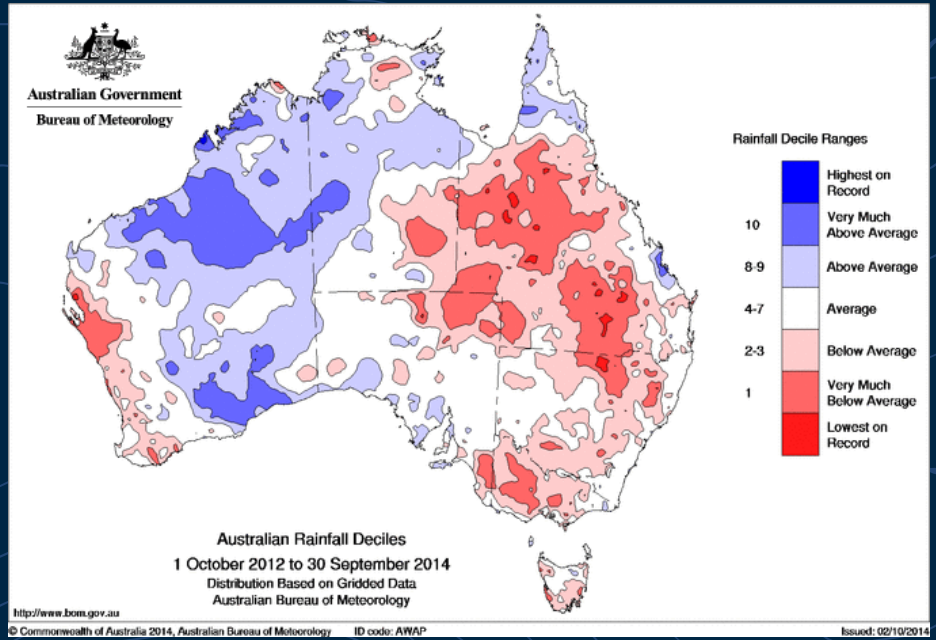


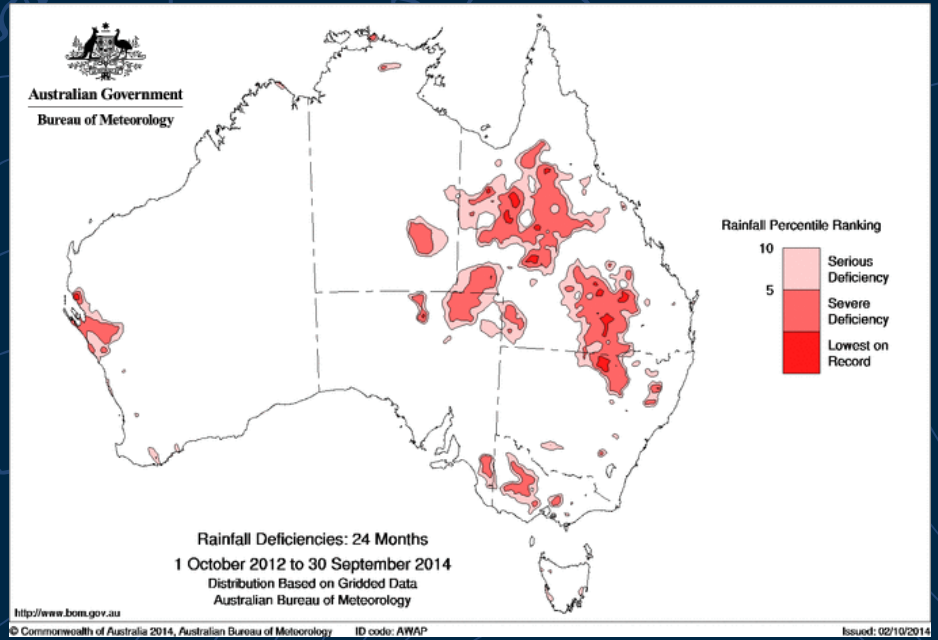
River Conditions: 2011-12



Australian Government
Bureau of Meteorology

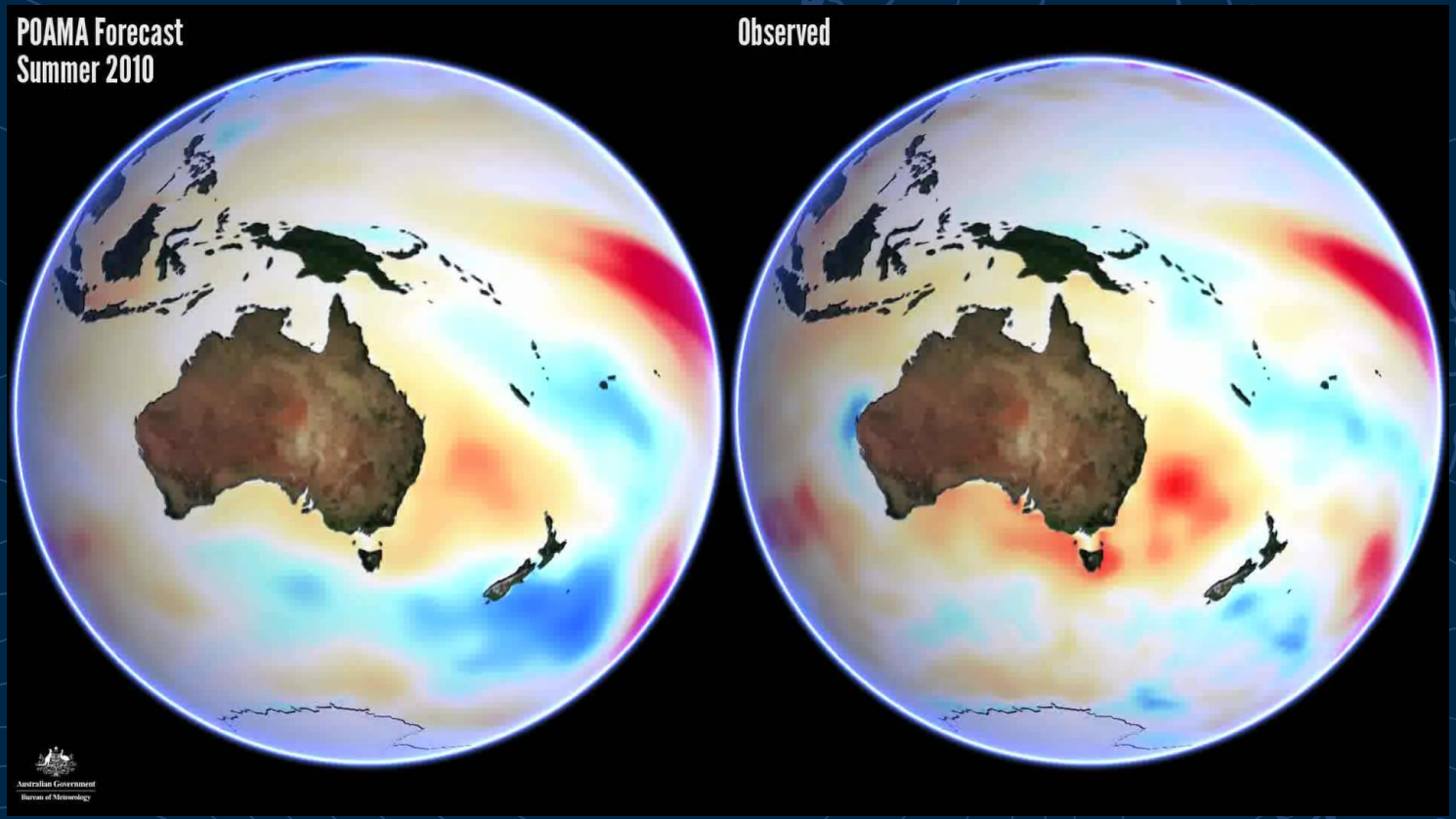
Drought conditions return



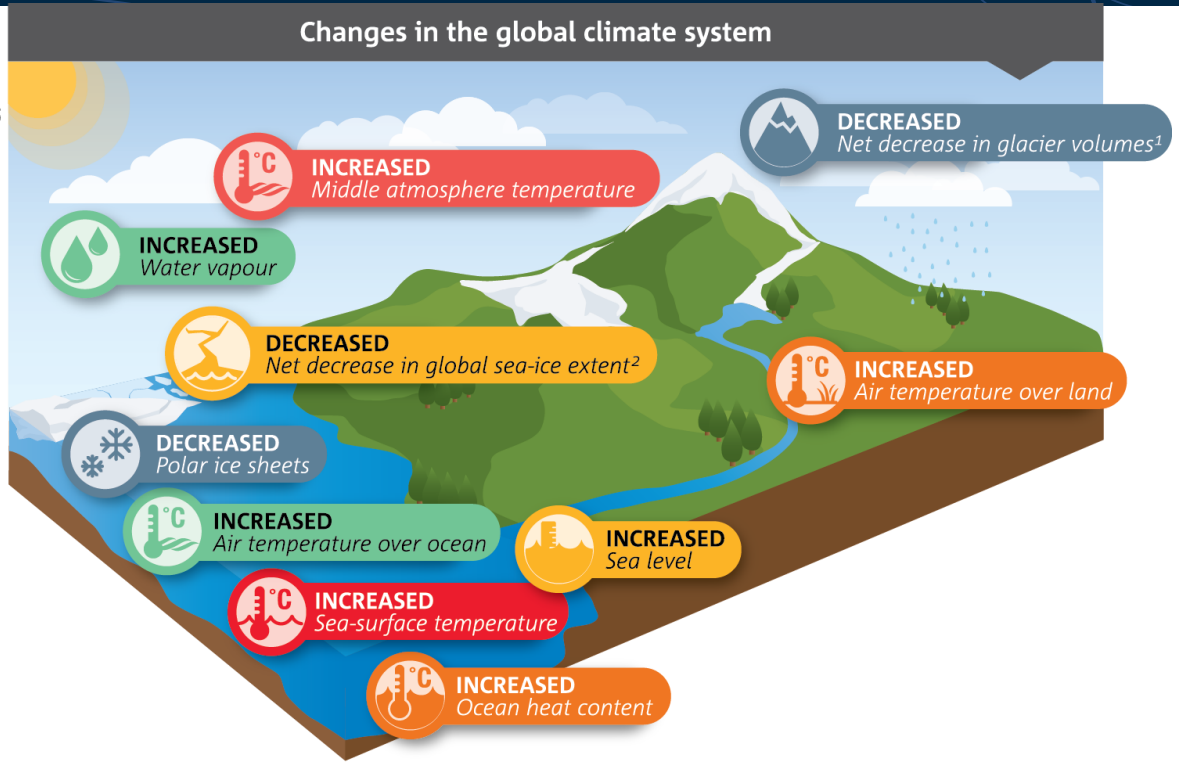


Australian Government
Bureau of Meteorology

Seasonal Forecasting: Much room for improvement



Changes in the global climate system



Source: Bureau of Meteorology and CSIRO

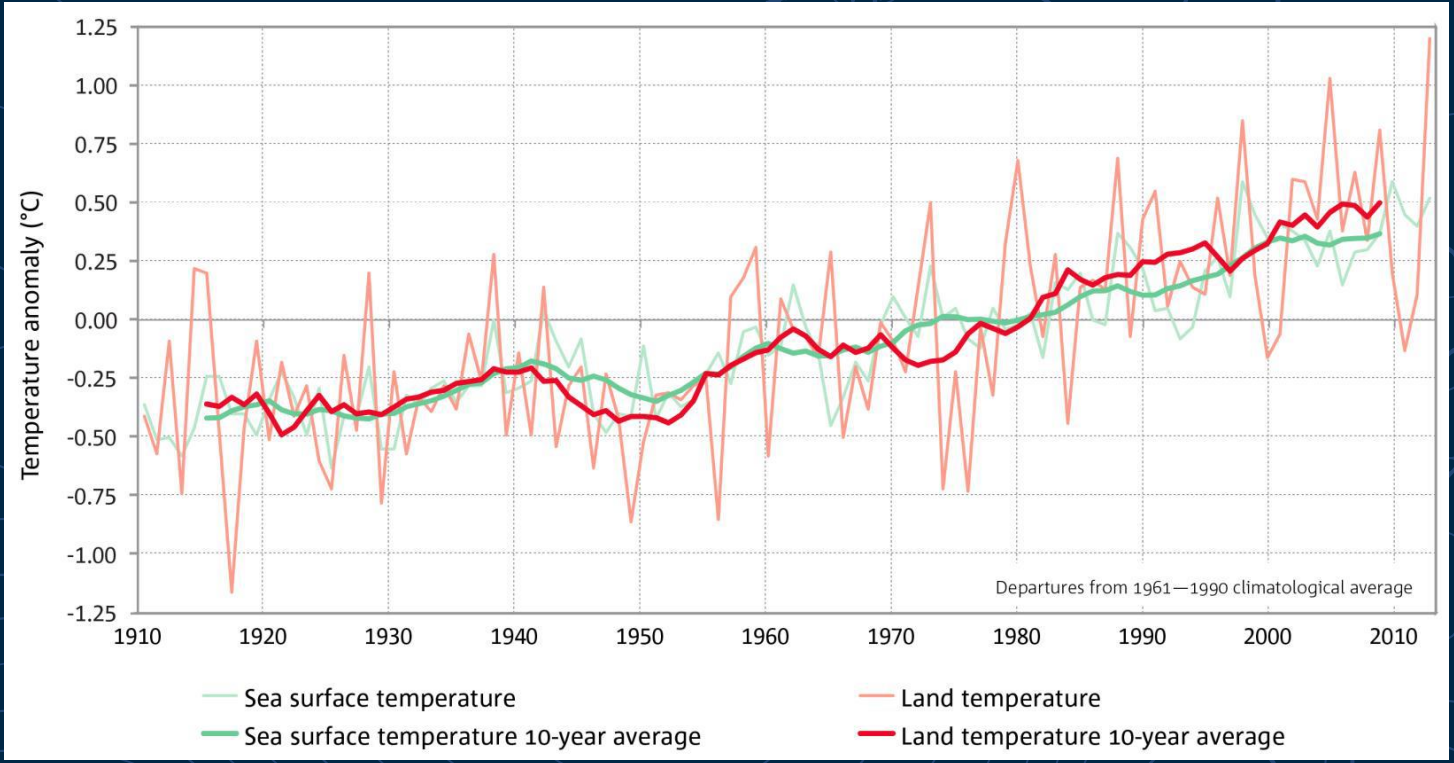
Global mean temperature has risen by 0.85˚C from 1880 to 2012.

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.

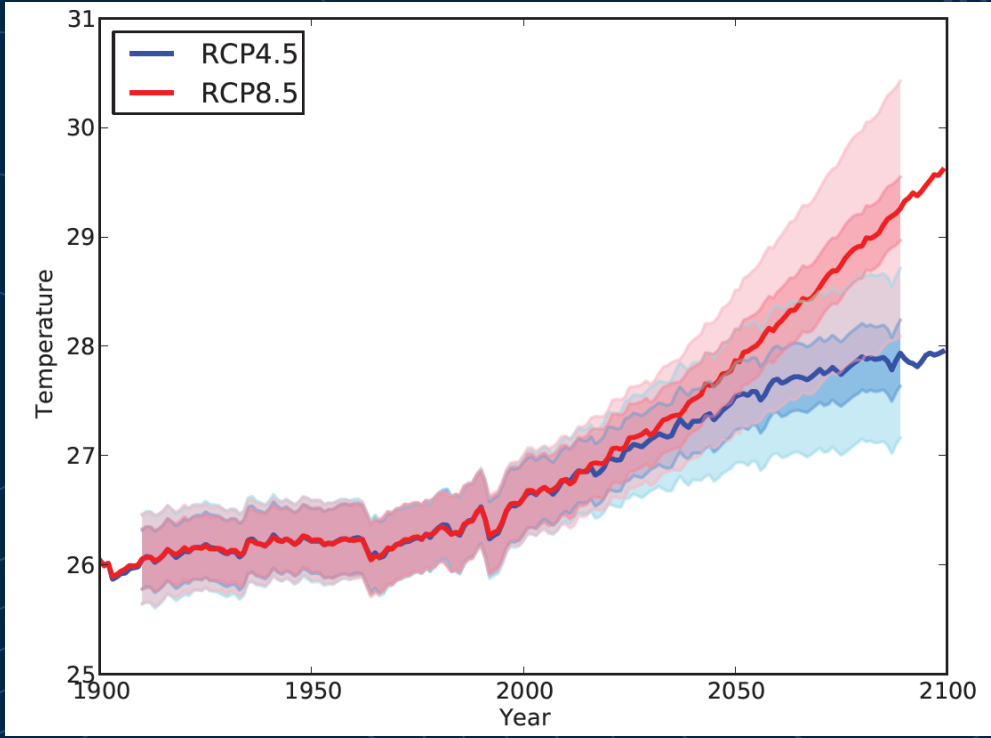
Australian Government
Bureau of Meteorology

Land and sea surface temperatures anomalies



Australian Government
Bureau of Meteorology

Assessing water security under climate change

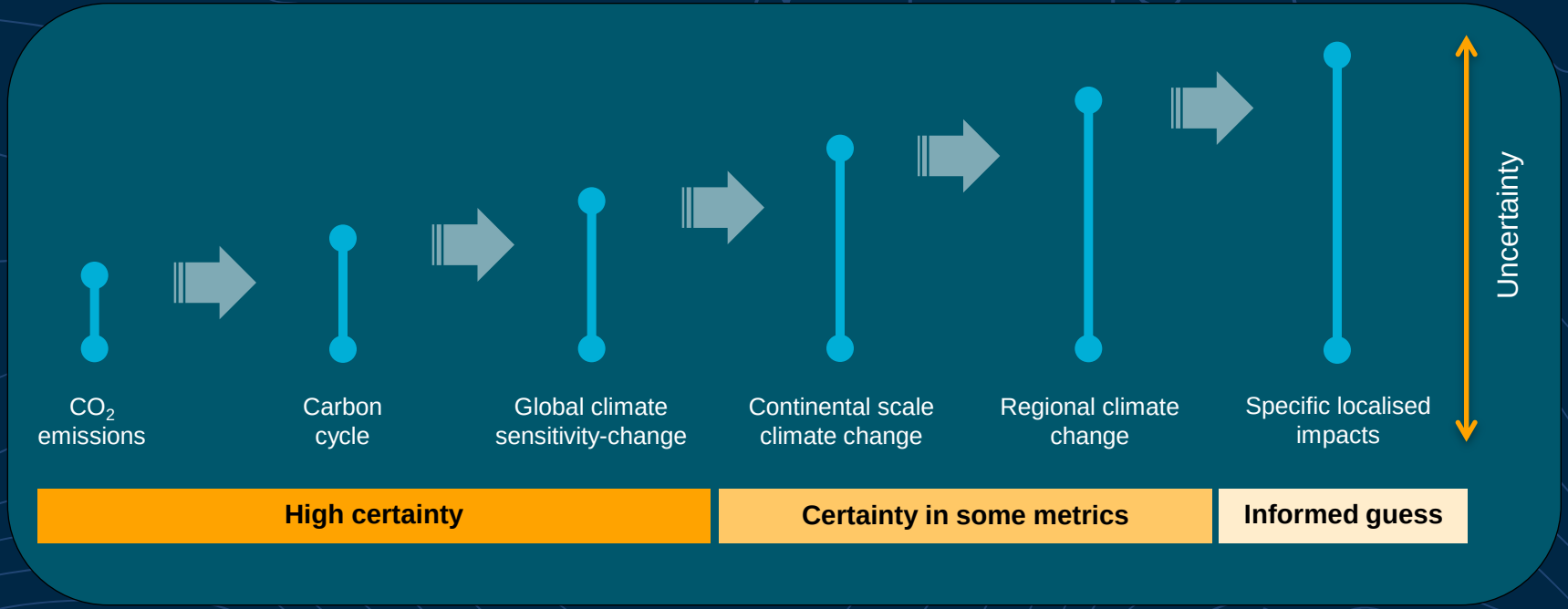


- Future climate change scenarios span quite a range
- GCMs skillful at simulating temperature, but less good at rainfall
- Can plan for the worst case, but expensive
- Water planners need to adopt a risk based approach

Australian Government
Bureau of Meteorology

The uncertainty cascade

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



Australian Government
Bureau of Meteorology

5. The last few years have been very productive

Australian Government
Bureau of Meteorology

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, CUAHSI, USGS, BOM, 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:
- WaterML 2 @ 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:

```
<wml2:Collection xsi:schemaLocation="http://www.opengis.net/waterml/2.0
http://www.opengis.net/waterml/2.0/waterml2.xsd" gml:id="Ki.Col.1">
    <gml:description>KISTERS KiWIS WaterML2.0</gml:description>
    <wml2:metadata>
        <wml2:DocumentMetadata gml:id="Ki.DocMD.1">
            <wml2:generationDate>2012-06-12T12:10:12.670+00:00</wml2:generationDate>
            <wml2:generationSystem>KISTERS KiWIS</wml2:generationSystem>
        </wml2:DocumentMetadata>
    </wml2:metadata>
    <wml2:temporalExtent>
        <gml:TimePeriod gml:id="Ki.TempExt.1">
            <gml:beginPosition>1990-09-01T00:00:00.000+01:00</gml:beginPosition>
            <gml:endPosition>1990-09-30T00:00:00.000+01:00</gml:endPosition>
        </gml:TimePeriod>
    </wml2:temporalExtent>
    <wml2:observationMember>
        <om:OM_Observation gml:id="Ki.OM_Obs.1">
            <om:phenomenonTime>
                <gml:TimePeriod gml:id="Ki.ObsTime.1">
                    <gml:beginPosition>1990-09-01T00:00:00.000+01:00</gml:beginPosition>
                    <gml:endPosition>1990-09-30T00:00:00.000+01:00</gml:endPosition>
                </gml:TimePeriod>
            </om:phenomenonTime>
            <om:resultTime>
                <gml:TimeInstant gml:id="Ki.resTime.1">
                    <gml:timePosition>1990-09-30T00:00:00.000+01:00</gml:timePosition>
                </gml:TimeInstant>
            </om:resultTime>
            <om:procedure xlink:href="http://kiwis.kisters.de/ts/Day.Cmd" xlink:title="10 - DailyMean"/>
            <om:observedProperty xlink:href="http://kiwis.kisters.de/parameters/557" xlink:title="Q"/>
            <om:featureOfInterest xlink:href="http://kiwis.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 KML/KMZ 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

WaterML 2.0

Australian Government
Bureau of Meteorology

National Environmental Information Infrastructure:

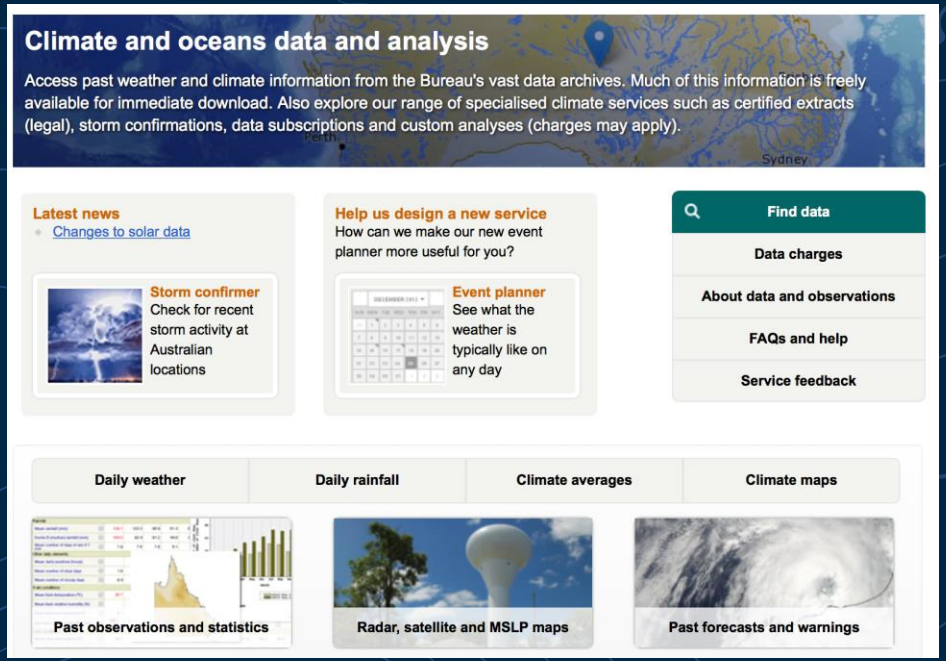
Reference Architecture

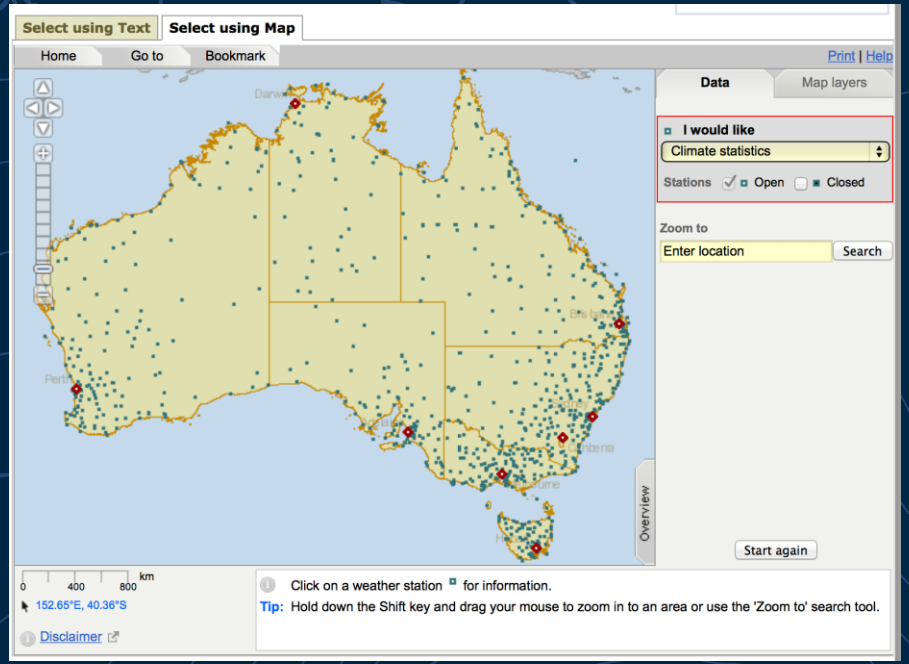
Contributing to the Australian Government National Plan for Environmental Information initiative

NEII

Australian Government
Bureau of Meteorology

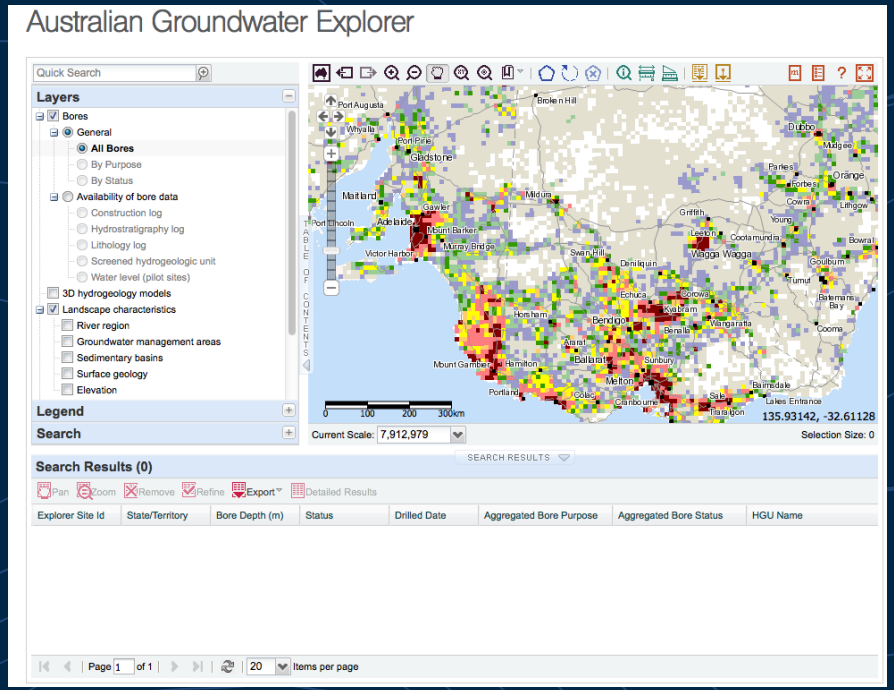
Climate data on tap

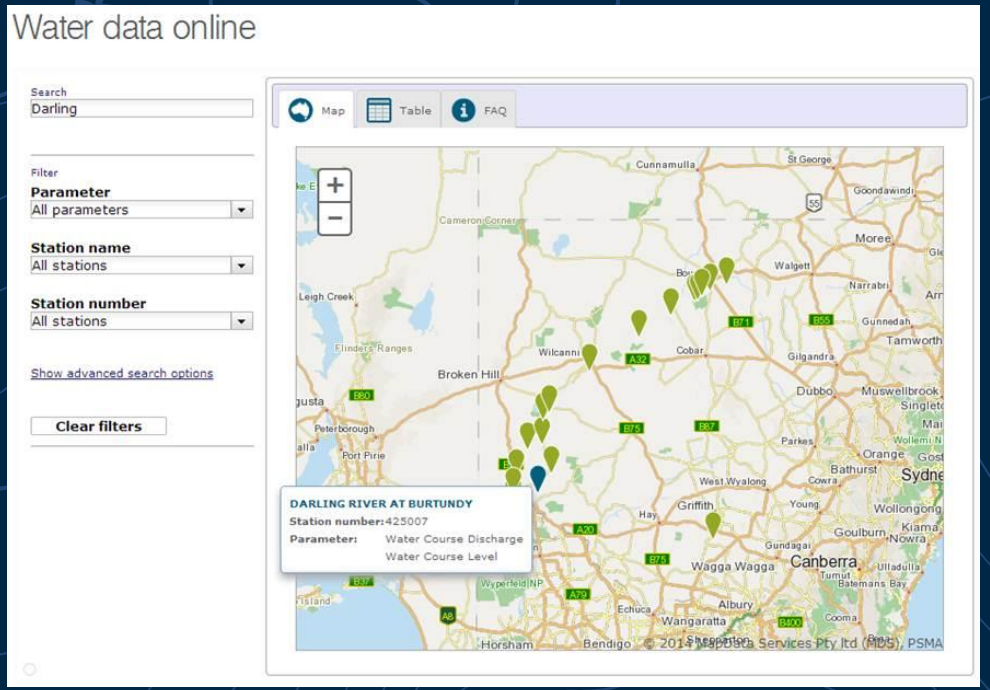




Australian Government
Bureau of Meteorology

Hydrometric and hydrogeologic data on tap



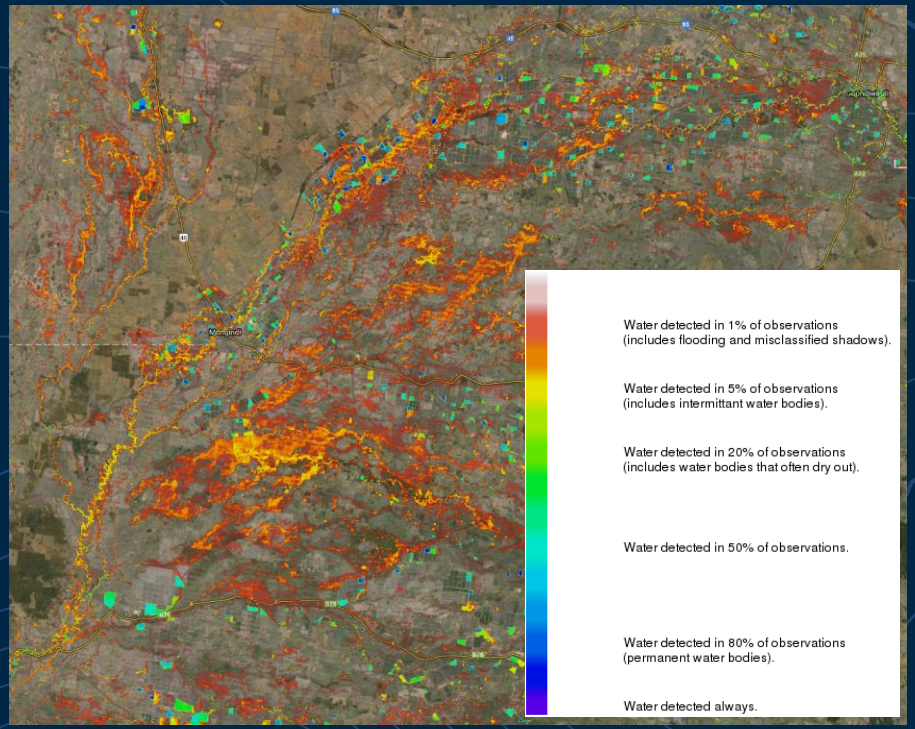


Australian Groundwater Explorer

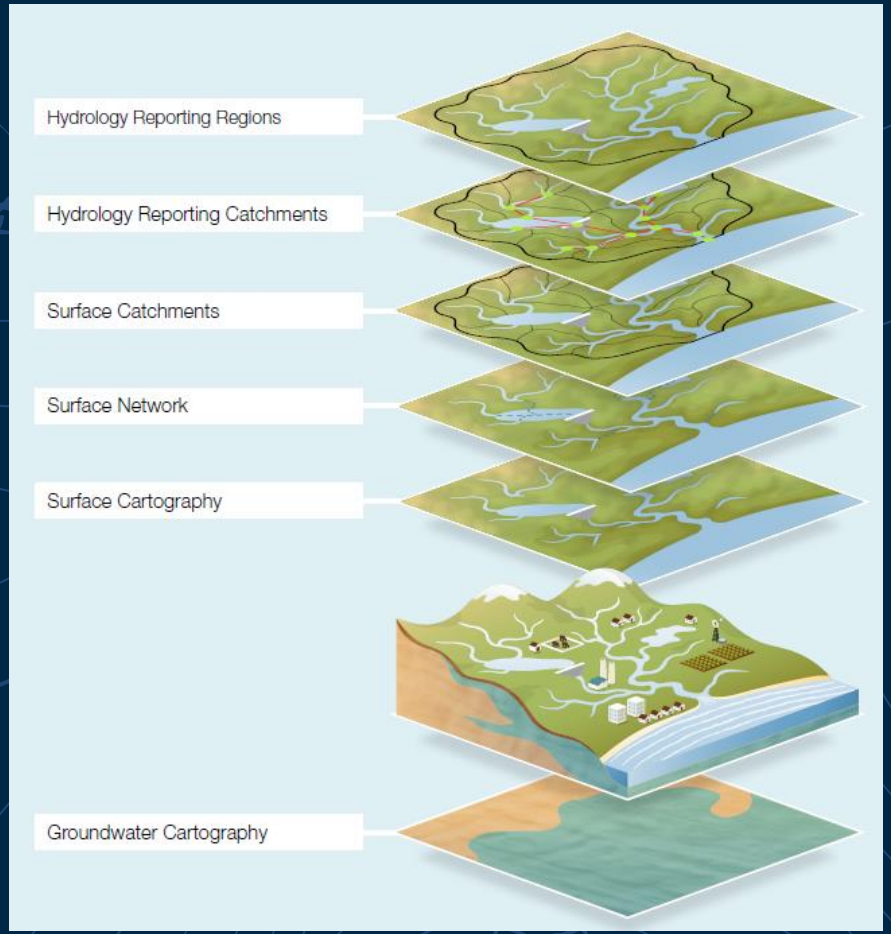
Water Data Online

Australian Government
Bureau of Meteorology

Spatial data on tap



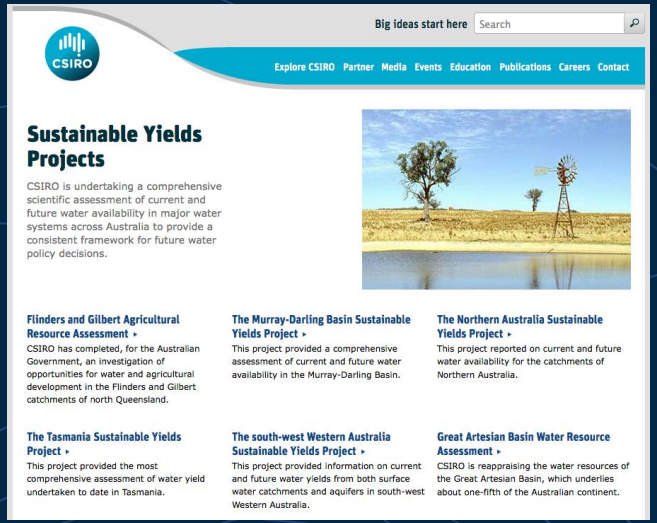
Water Observations from Space (GA)



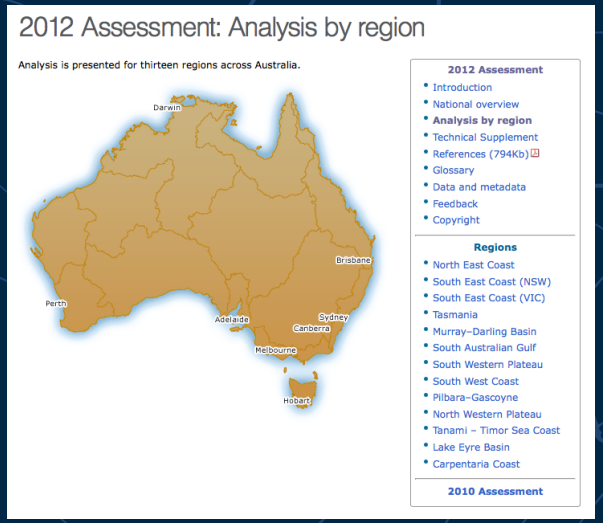
Geofabric

Australian Government
Bureau of Meteorology

National reporting on water



Sustainable Yields Assessments

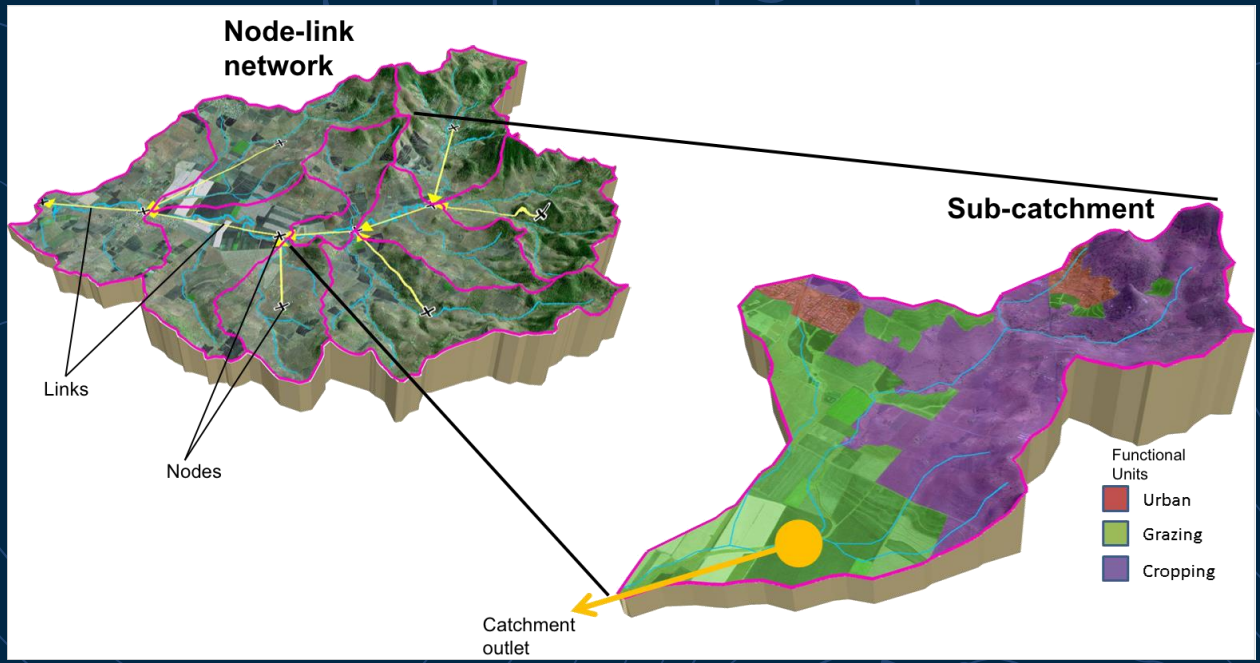


Australian Water Resource Assessments

National Water Account

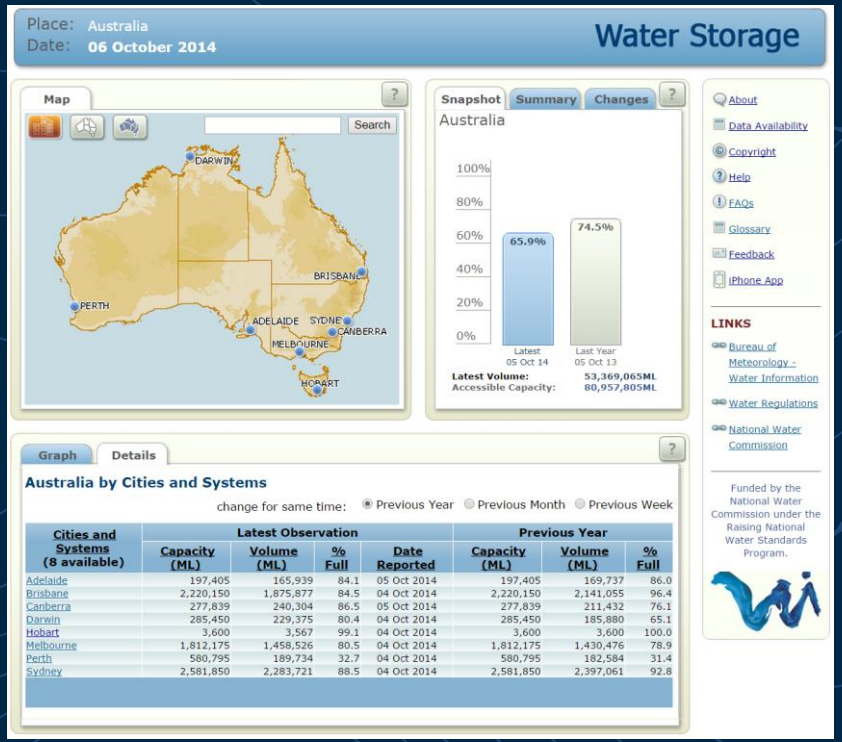
Australian Government
Bureau of Meteorology

Catchment and river modelling with Source

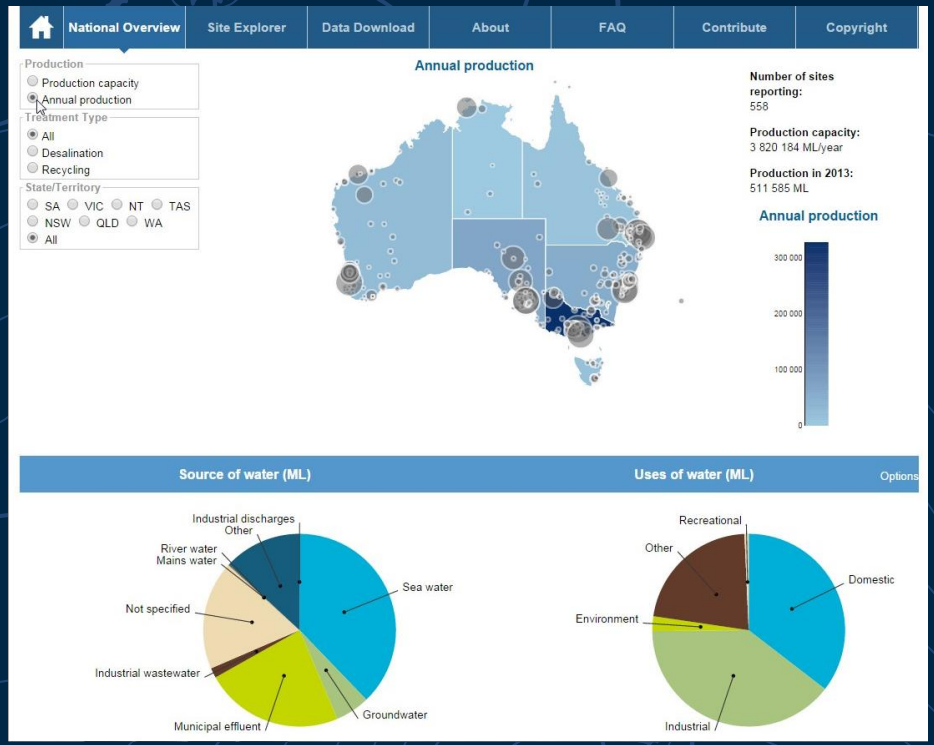


Australian Government
Bureau of Meteorology

Dashboards



Water Storage



Climate Resilient Water Sources

Australian Government
Bureau of Meteorology

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	Boulia	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

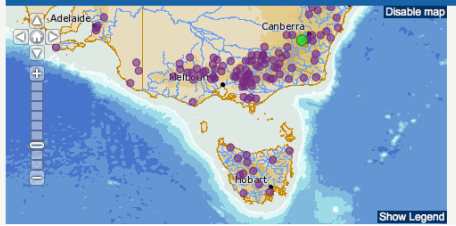
Introduction | Feature Stations | Selection Guidelines | FAQs | Glossary | Methods | Stakeholder | References and Papers | Feedback | Copyright

Station Selector

Region: Australian Capital Territory
Basin: Murrumbidgee River
Station: Cotter River at Gingera (410730)

Nearby stations
- Gudgenby River at Tennent (410731)
- Murrumbidgee River at Lobb Holes (410761)
- Queanbeyan River at Tinderry (410734)

Cotter River at Gingera (410730)



Quick Facts

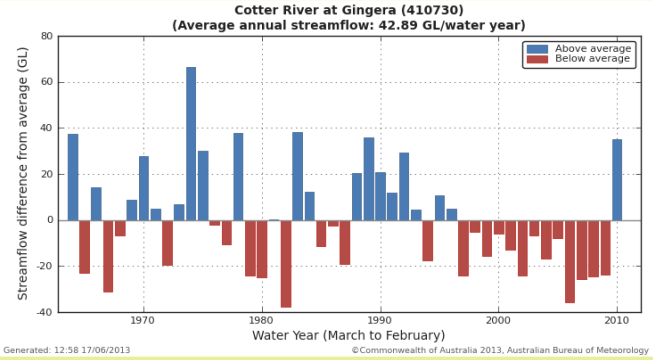
Catchment
- Area: 130 km²
- Stream Length: 98 km

Time series
- Start Date: 05-07-1963
- End Date: 04-10-2012
- Gap-filled: 0.38 %
- 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

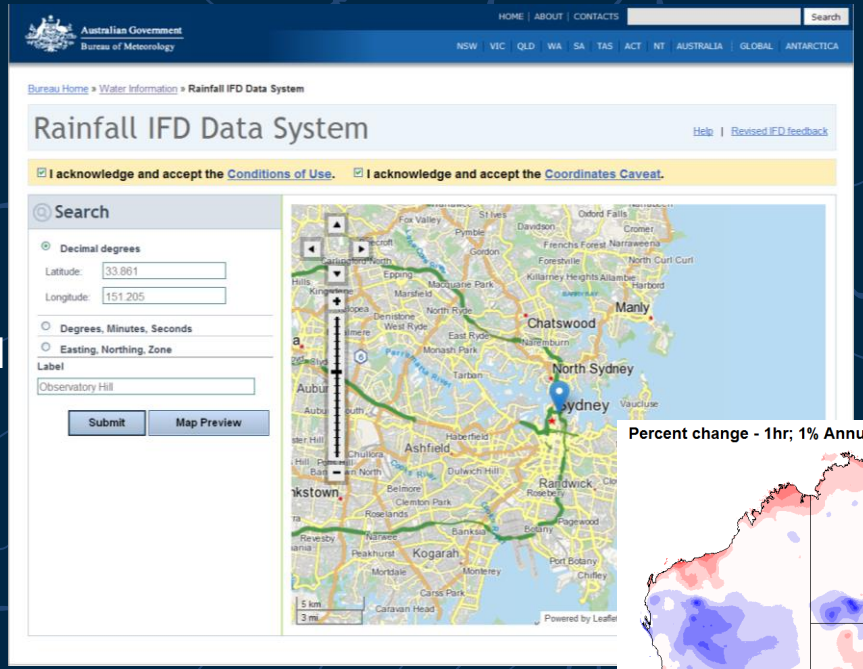


Hydrologic Reference Stations (221)

Australian Government
Bureau of Meteorology

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

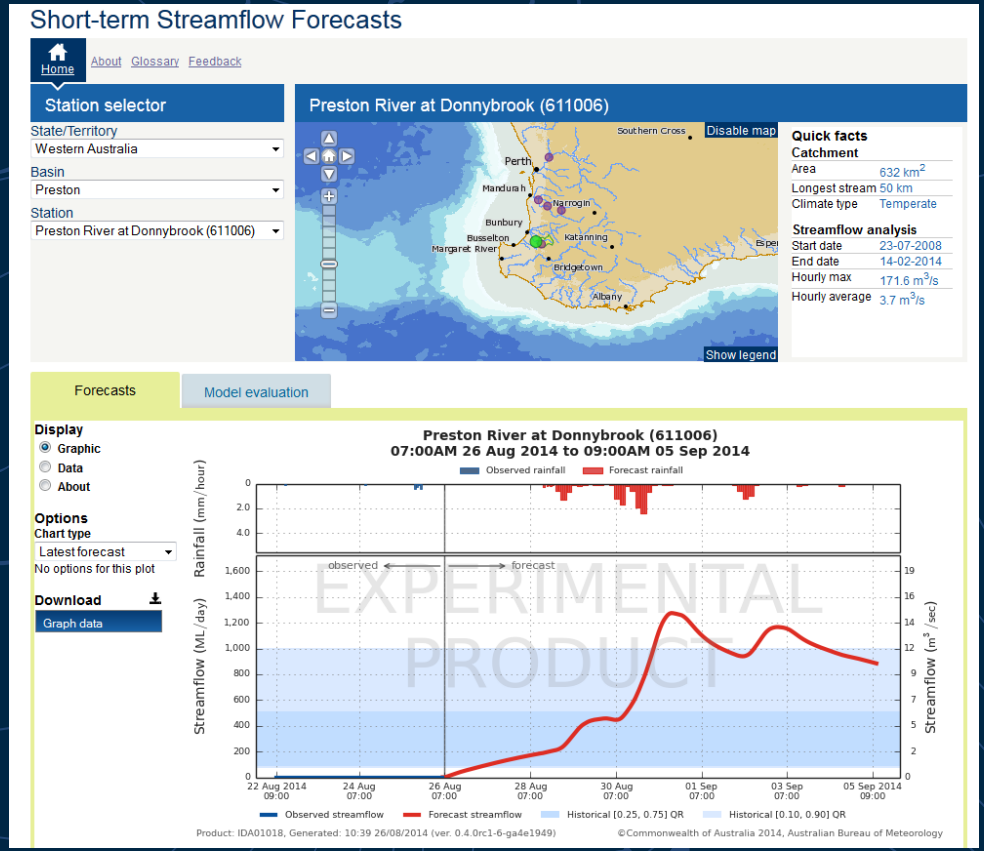


Australian Government
Bureau of Meteorology

Operational Short-term Streamflow Forecasts

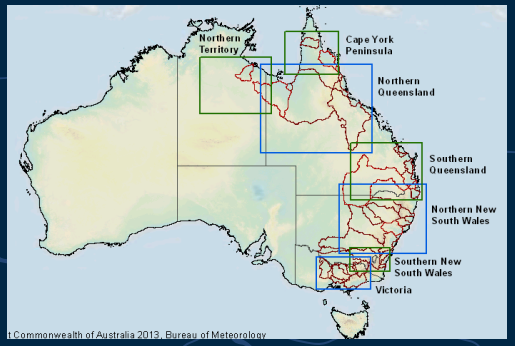
- Short-term streamflow forecasts, to 7 days
- Updated daily
- Targeted at river and storage operations
- Useful for ‘heads up’ flood guidance

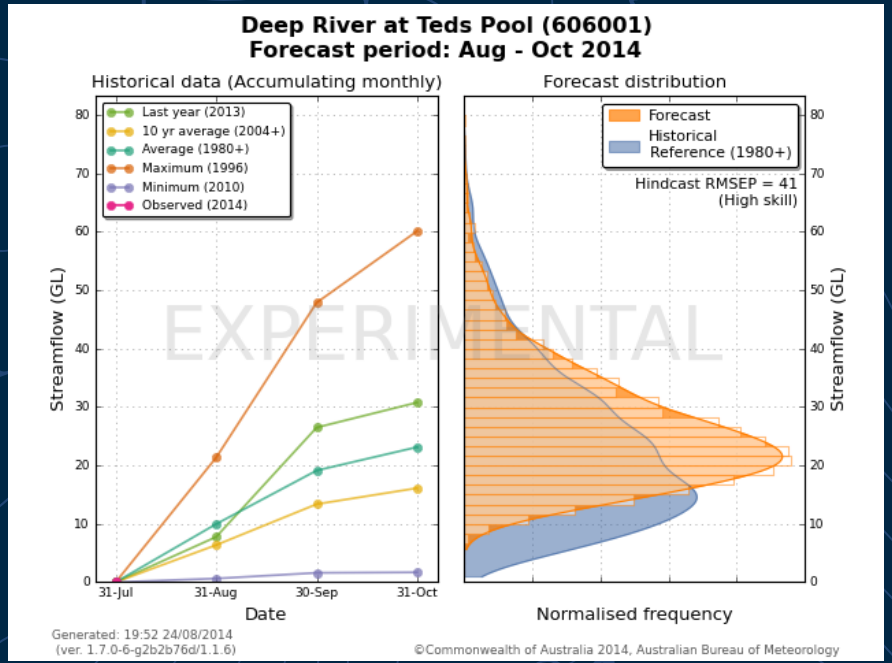
- 20 catchments in system so far
- 60 catchment by end of this year
- Now available to registered users
- Public release in June 2015



Australian Government
Bureau of Meteorology

Operational Seasonal Streamflow Forecasts

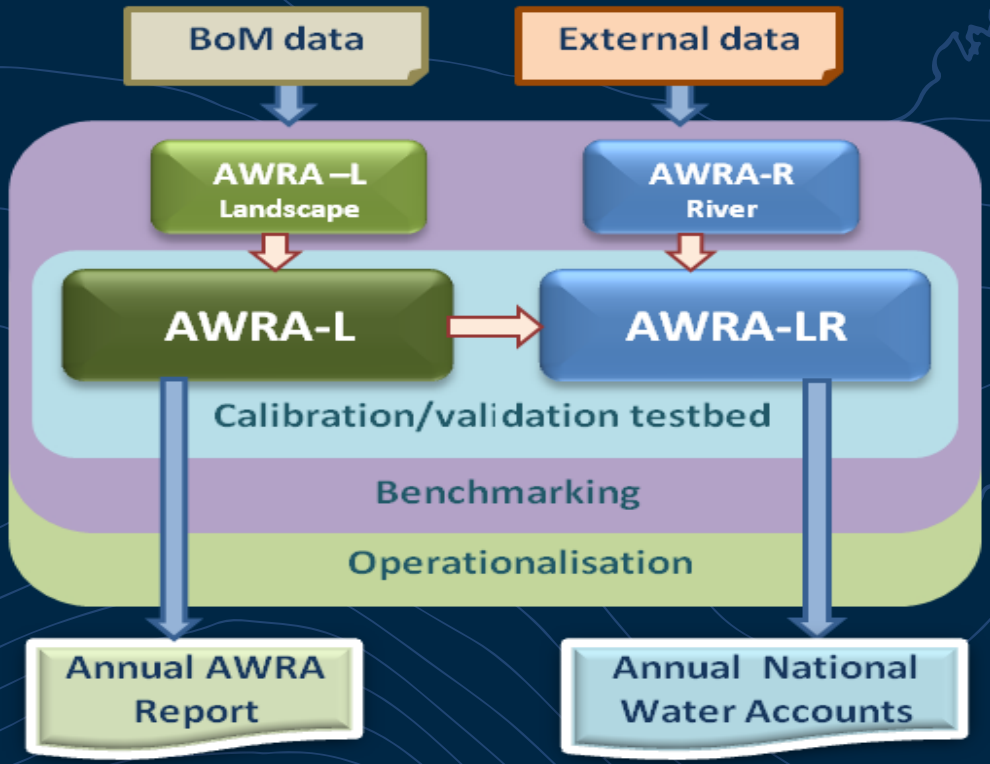


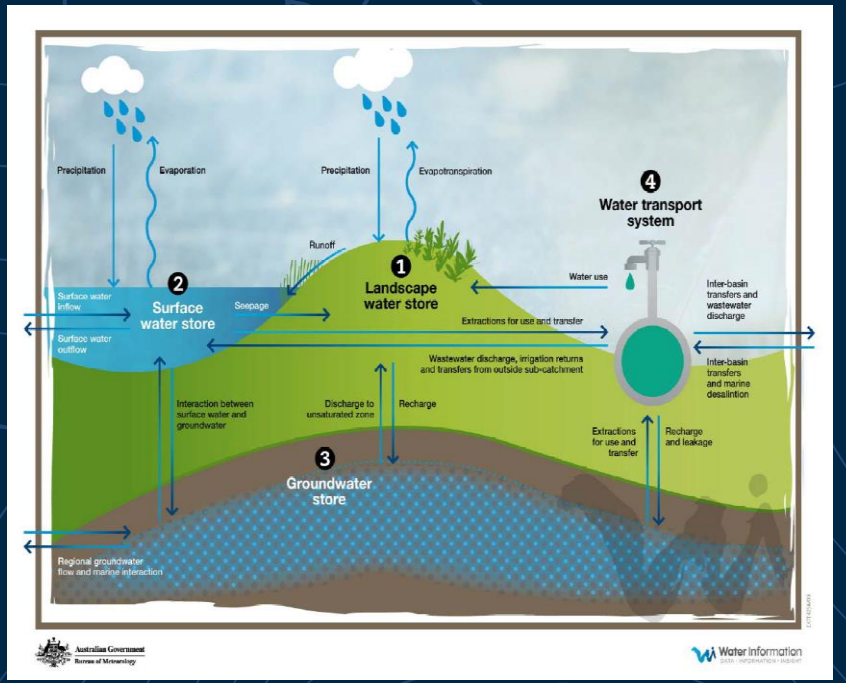


- 3 months ahead, updated every month
- 74 locations in 32 river basins

Australian Government
Bureau of Meteorology

Operational, daily continental water balance model





Australian Government
Bureau of Meteorology

6. We have great foundations and thus great opportunities

Australian Government
Bureau of Meteorology

Collaboration: Essential for future success

Australian Government
Bureau of Meteorology

Safety

Sustainability

Well-being

Prosperity

ENVIRONMENTAL INTELLIGENCE

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

Australian Government
Bureau of Meteorology

Thank you

Any questions?