Australian Government
Geoscience Australia

Using a calibrated archive of satellite imagery to map continental surface water dynamics at 25 metre resolution

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Steps required to shift from instrument level data to information about surface water dynamics

- Convert from satellite data to surface reflectance
- Flag non-surface artifacts
- Apply consistent classification algorithm to every observation
- Summarise results

Satellite measurements and the models we apply to them

Satellites measure the amount of photons radiating from the top of the atmosphere

To convert this into comparable measurements of the Earth's surface (specifically surface reflectance) we apply physics based models of:

- Sensor characteristics
- Radiative transfer through the atmosphere
- Sun-sensor geometry

From 'top of atmosphere' to surface reflectance

Satellites measure the radiation from the top of the atmosphere

This needs conversion to surface reflectance

- Removes the effect of the atmosphere
  - Dust, haze, water vapour
- Removes the effect of sun-sensor-target geometry
  - Time-of-year (solar angle)
  - Satellite location (relative to target and sun

NBAR correction

N = Nadir view (viewed from above)

B = Bidirectional Reflectance Distribution Function (sun sensor geometry)

A = Atmospheric Correction (smoke, haze, water vapour)

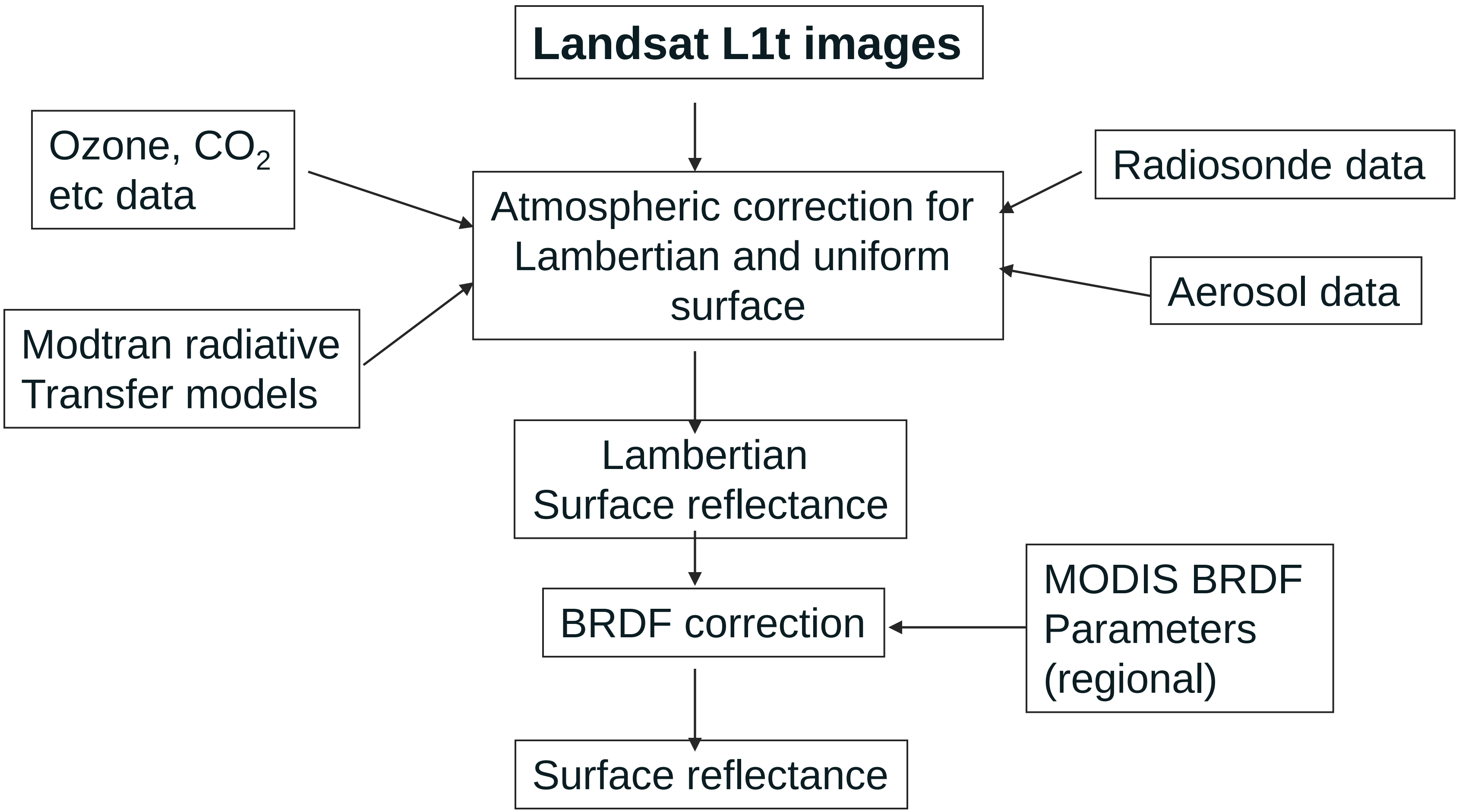
R = Reflectance (what you get once you've corrected the other influences)

NBAR corrected archives

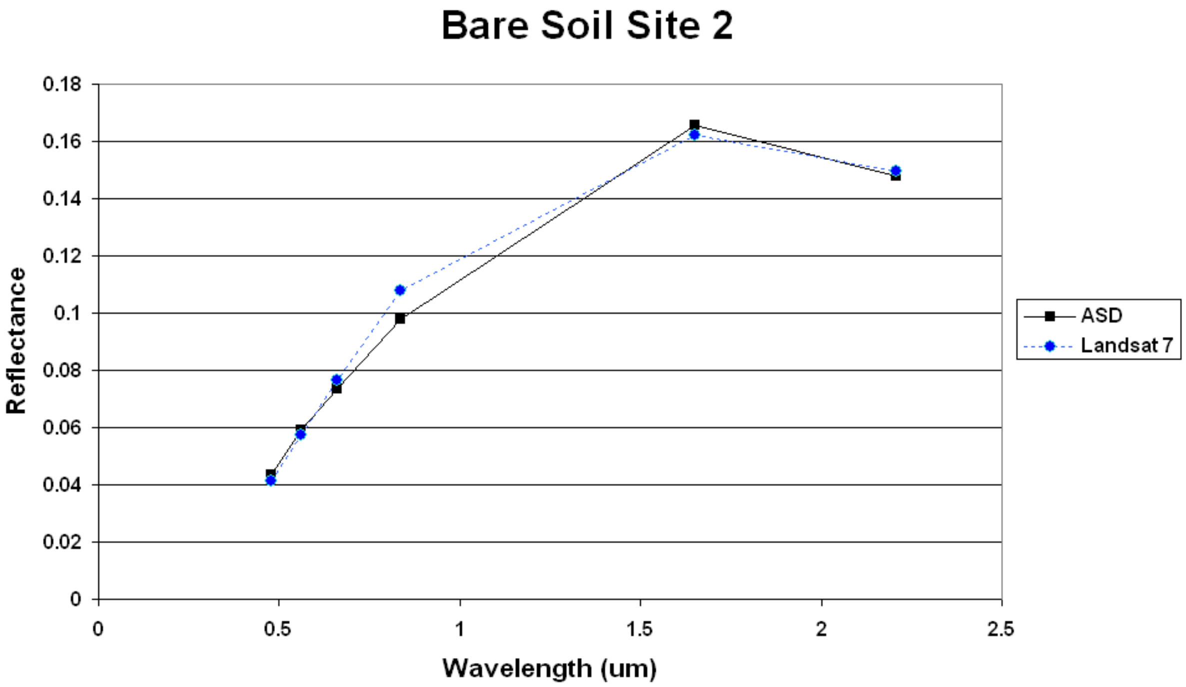
Need to ensure that data from sensors have been converted into comparable units

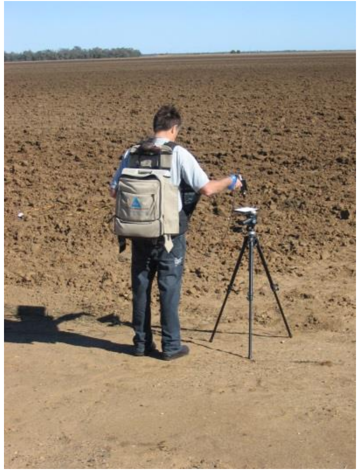
- MODIS
- Landsat TM, ETM+, OLI
- ASTER
- Future sensors such as Sentinel II and III

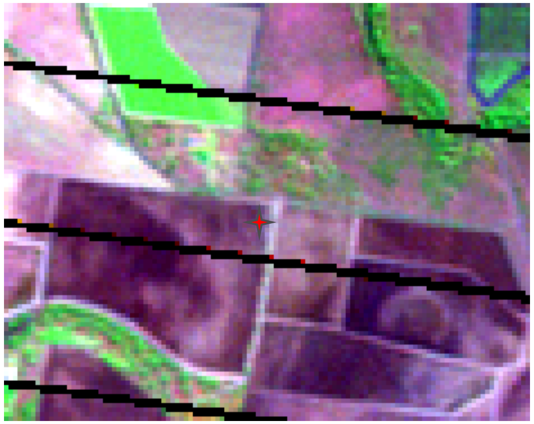
NBAR Correction Algorithm

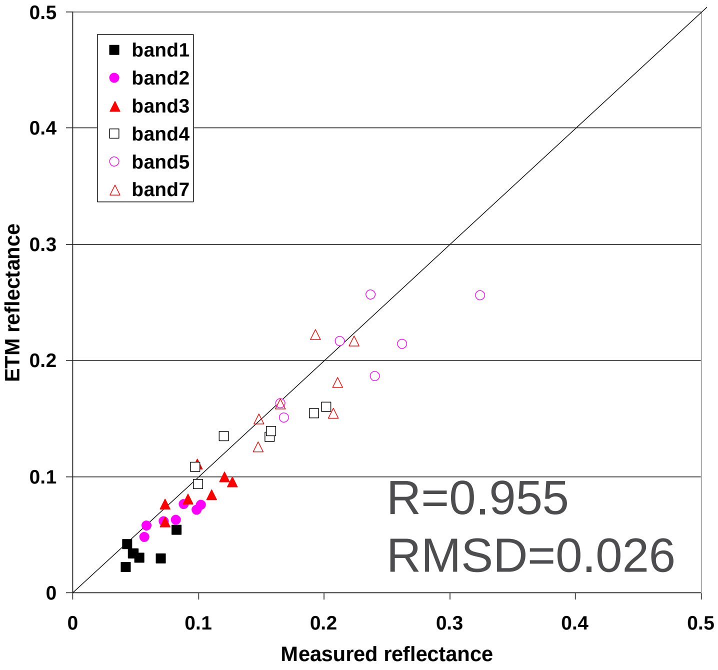


Validating the NBAR Correction Algorithm

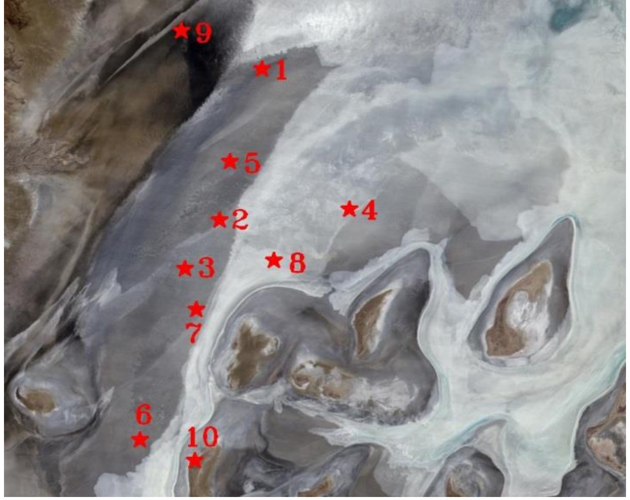




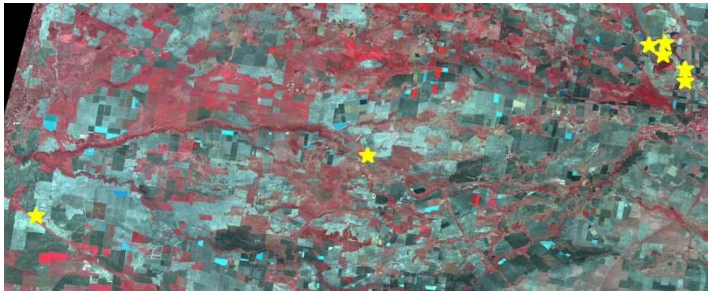


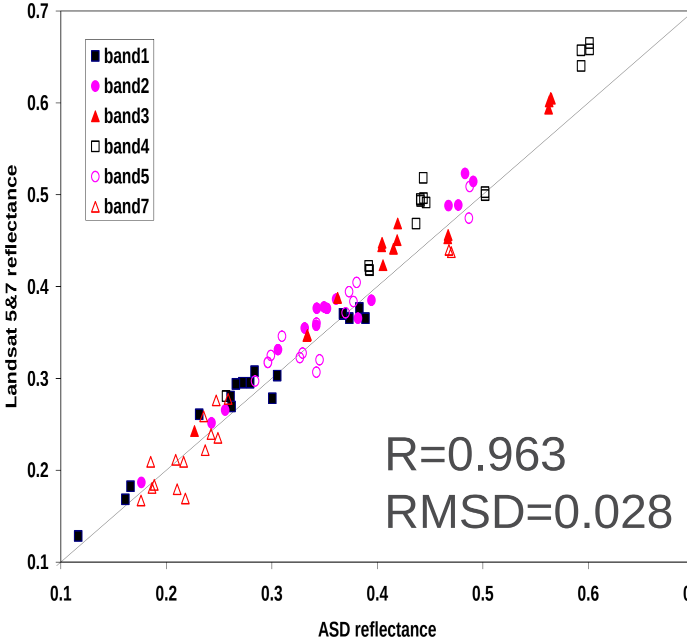


ETM reflectance
Measured reflectance
band1
band2
band3
band4
band5
band7
R=0.955
RMSD=0.026
0
0.1
0.2
0.3
0.4
0.5



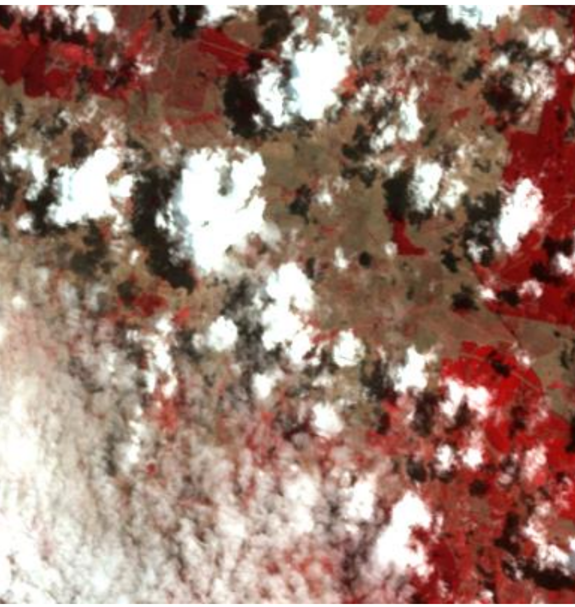
9
1
5
2
4
3
8
7
6
10

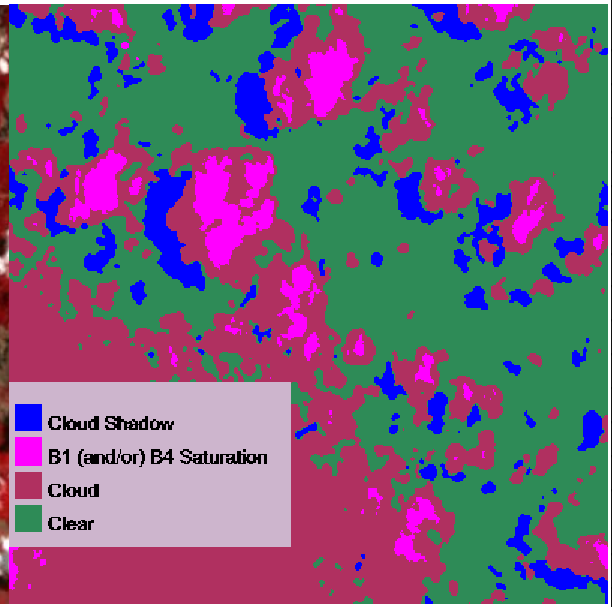




Landsat 5&7 reflectance
ASD reflectance
band1
band2
band3
band4
band5
band7
R=0.963
RMSD=0.028
0.1
0.2
0.3
0.4
0.5
0.6
0.7

Pixel Quality Layer





Test	Bit	Value	Cumulative Sum
Saturation band 1	0	1	1
Saturation band 2	1	2	3
Saturation band 3	2	4	7
Saturation band 4	3	8	15
Saturation band 5	4	16	31
Saturation band 61*	5	32	63
Saturation band 62*	6	64	127
Saturation band 7	7	128	255
Contiguity	8	256	511
Land/Sea	9	512	1023
ACCA	10	1024	2047
Fmask	11	2048	4095
Cloud Shadow (ACCA)	12	4096	8191
Cloud Shadow (Fmask)	13	8192	16383
Topographic Shadow **	14	16384	32767
To be determined **	15	32786	65535

Fmask – Zhu and Woodcock, 2012
ACCA – Irish et al, 2006

Australian Government
Geoscience Australia

Australian Geoscience Data Cube

A Collaboration between

Geoscience Australia, CSIRO and NCI

Current Tile Contents (for Landsat 5 &7)

Level 1 Topographic (ORTHO)

1. LS5-B60 – Thermal Infrared

or

1. LS7-B61 – Thermal Infrared Low Gain
2. LS7-B62 – Thermal Infrared High Gain

(Byte datatype)

ARG-25 (NBAR)

1. LS5/7-B10 – Visible Blue
2. LS5/7-B20 – Visible Green
3. LS5/7-B30 – Visible Red
4. LS5/7-B40 – Near Infrared
5. LS5/7-B50 – Middle Infrared 1
6. LS5/7-B70 – Middle Infrared 2

(Int16 Datatype)

Pixel Quality (PQA)*

1. PQ – Bit-array of PQ tests

(UInt16 Datatype)

Fractional Cover (FC)**

1. Photosynthetic Veg. (PV)
2. Non-Photosynthetic Veg. (NPV)
3. Bare Soil (BS)
4. Un-mixing Error (UE)

(Int16 Datatype)

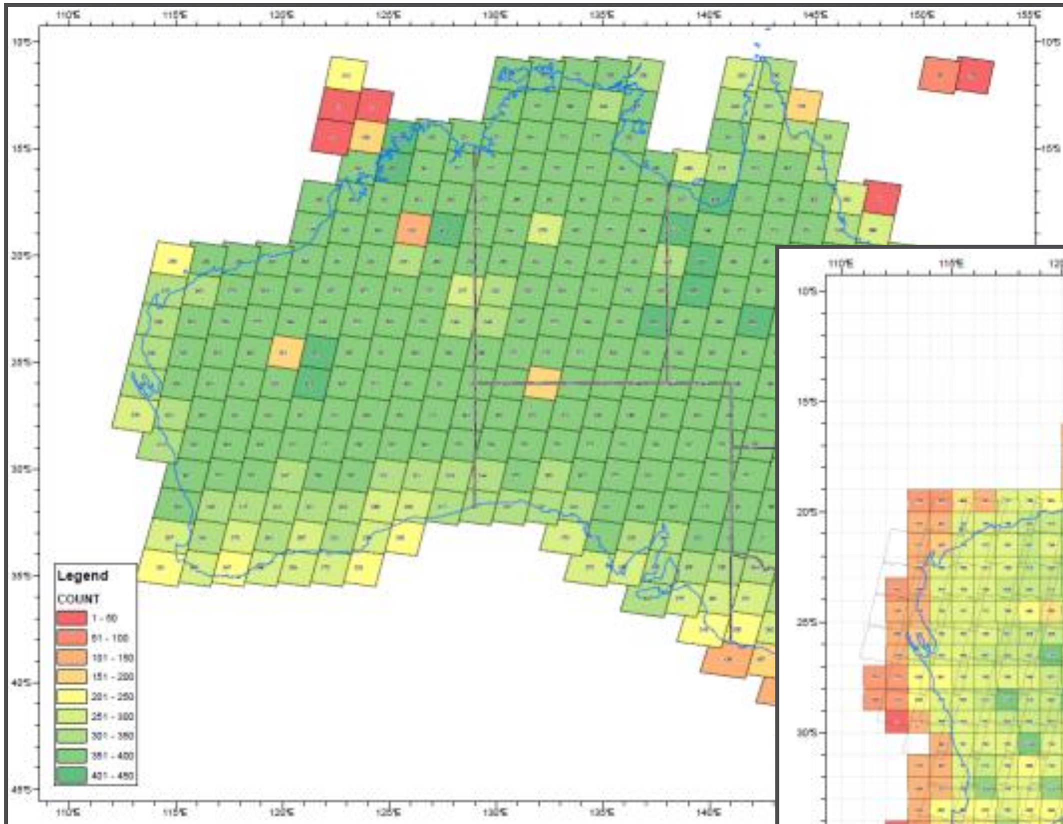
Digital Surface Model (DSM)***

1. Elevation
2. Slope
3. Aspect

(Float32 Datatype)

* PQA Geoscience Australia
** QDERM, Currently only a 3x2 path/row test area of FC data held in AG-DC. Planned to complete load by end June 2014
*** Single, static source dataset, i.e. not time varying. Resampled from 1” DSM. Licensed for Government Use Only

Current AG-DC Holdings

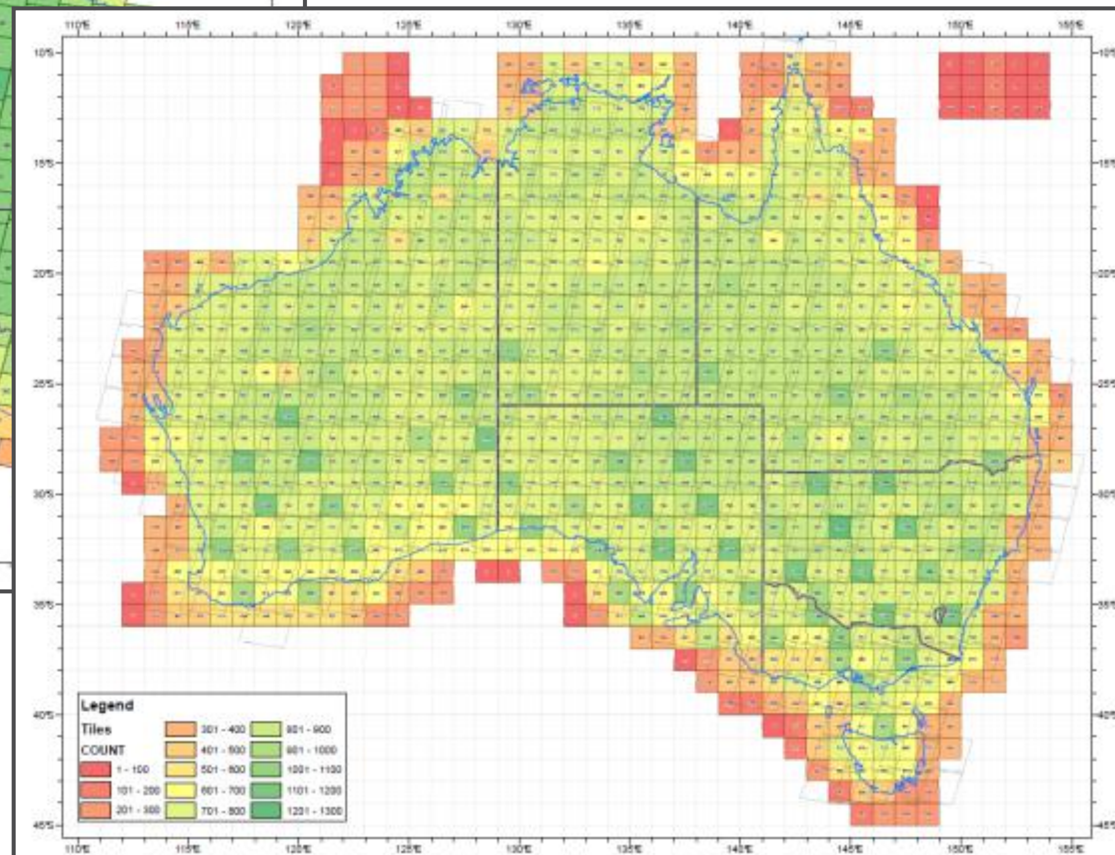


Landsat Source Scenes

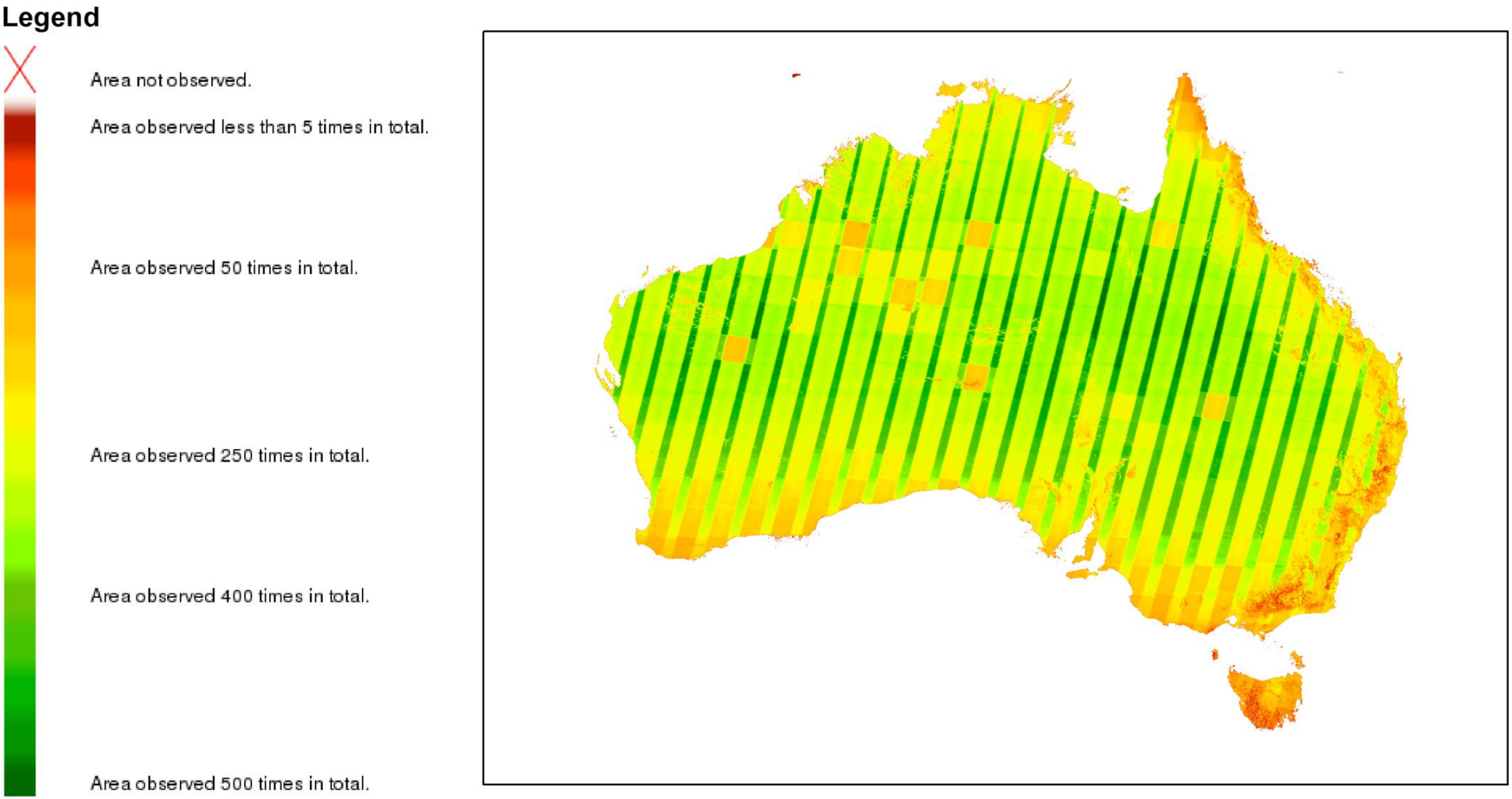
(Currently approx. 636,000 scene datasets)

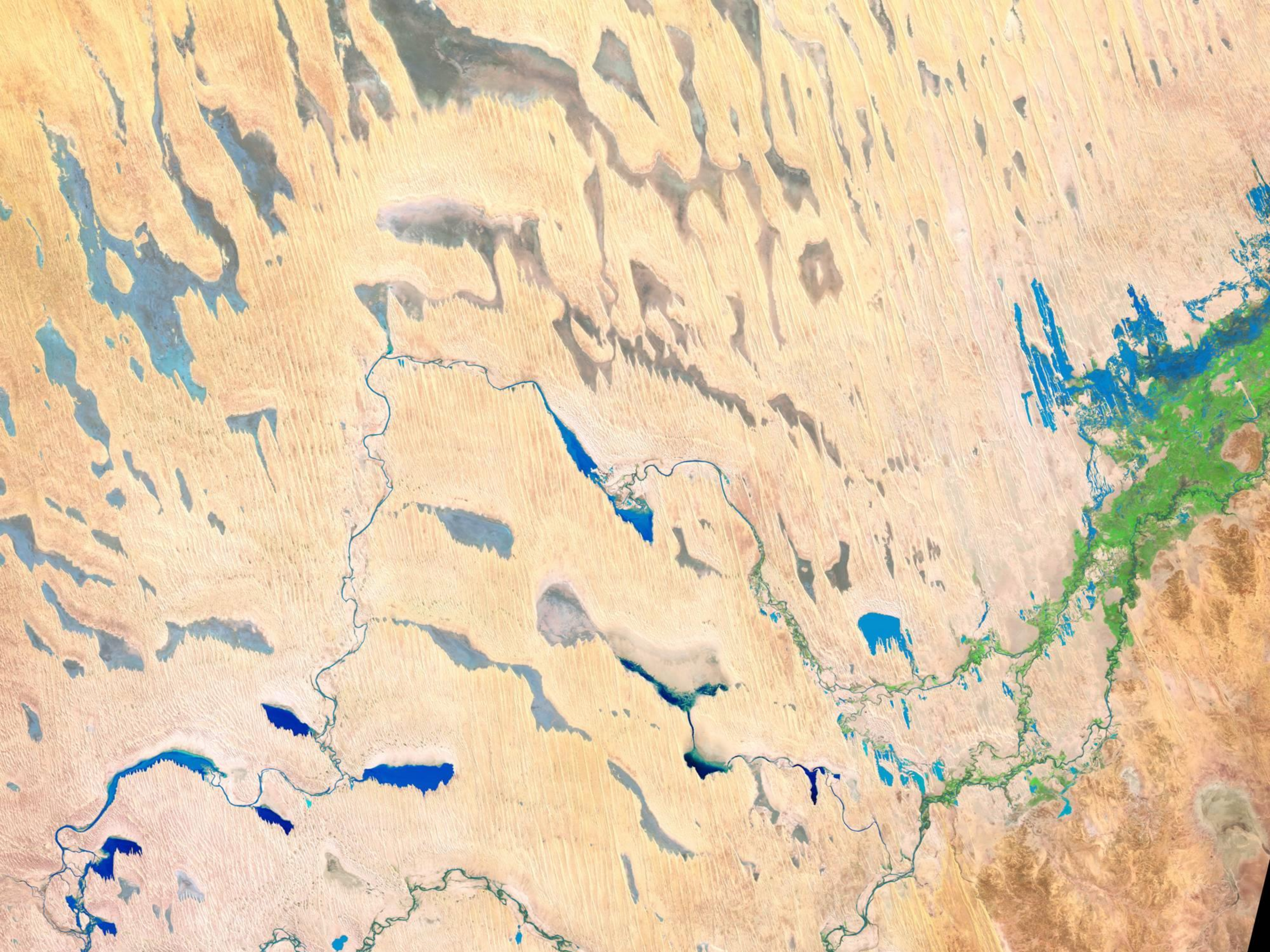
AG-DC Tiles

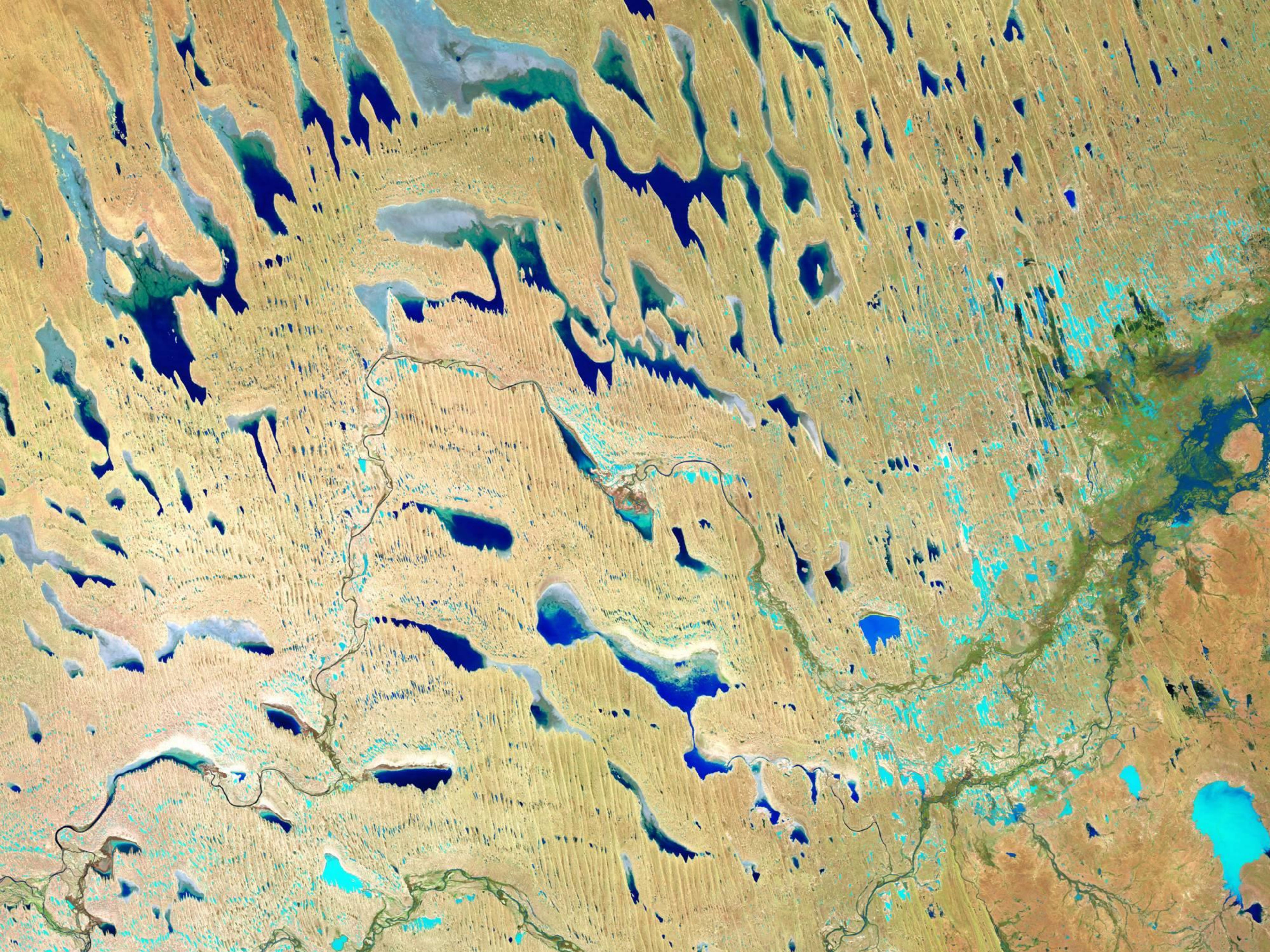
(Currently approx. 4M tiles)

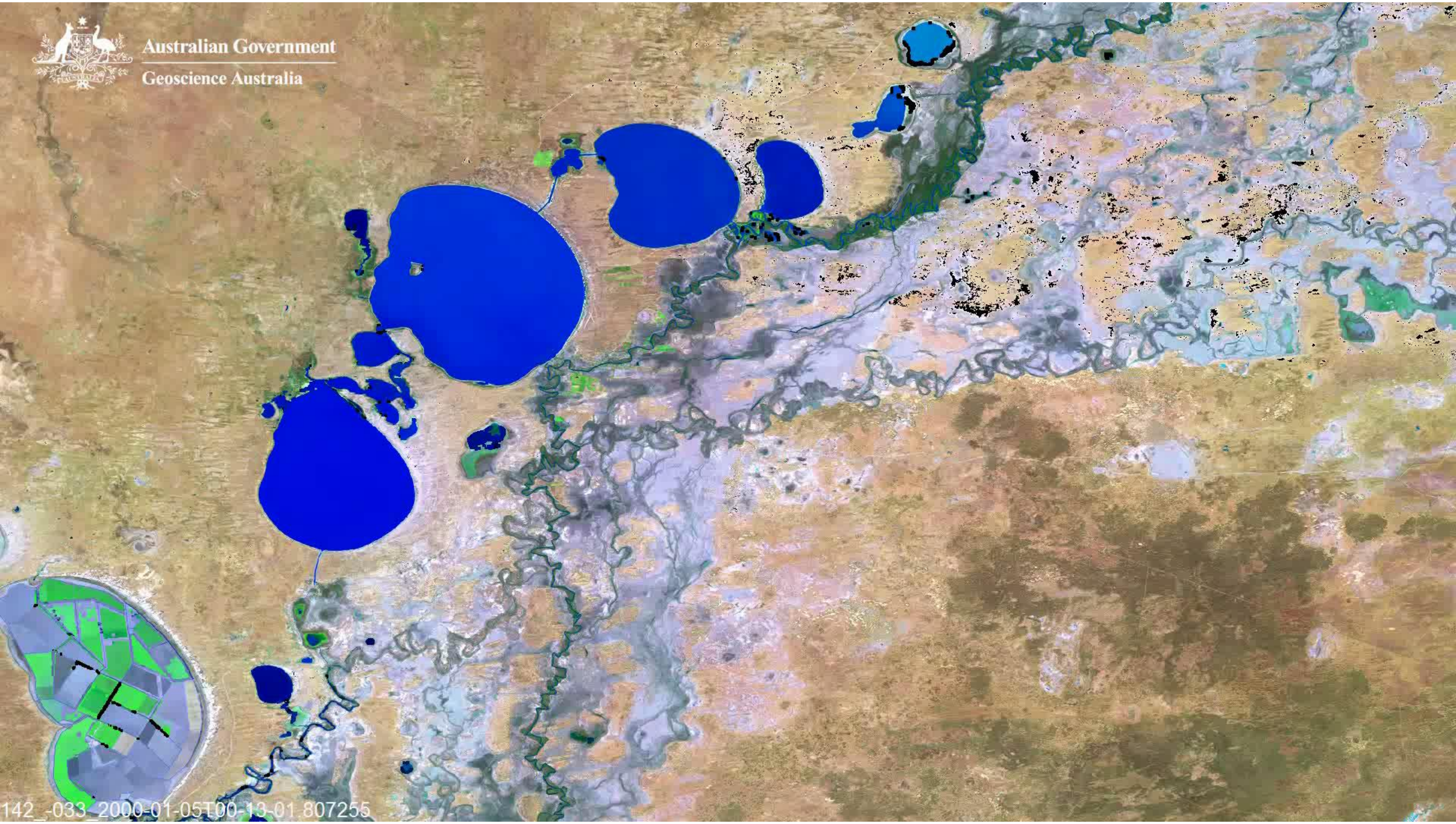


Quality Assured Observations





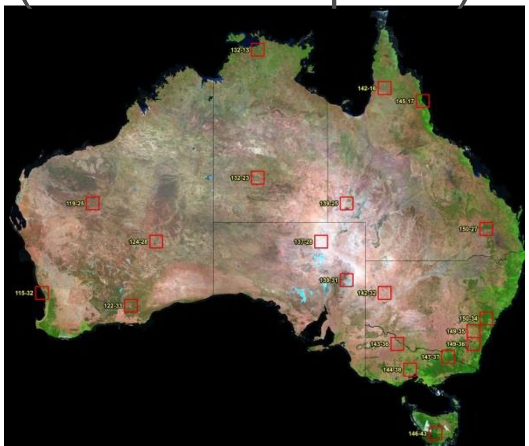




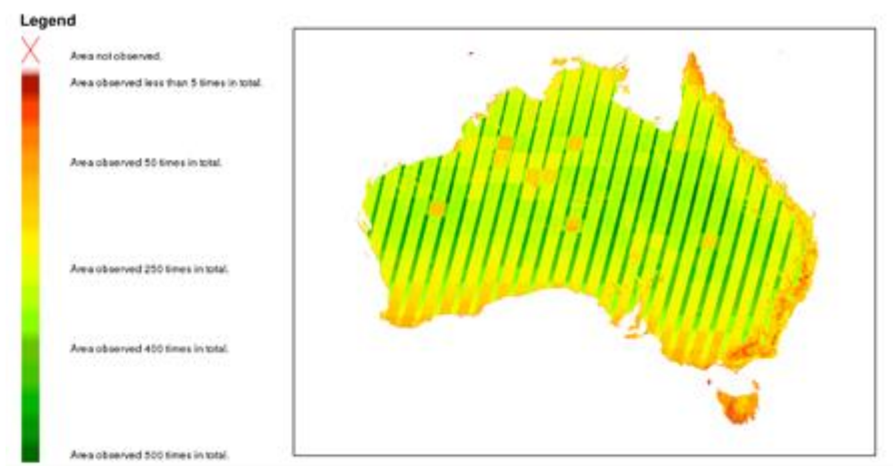
Menindee Lakes 1998-2012 (Water Management)

From surface reflectance to ‘Water Observations from Space’

Training data
(4 million data points)



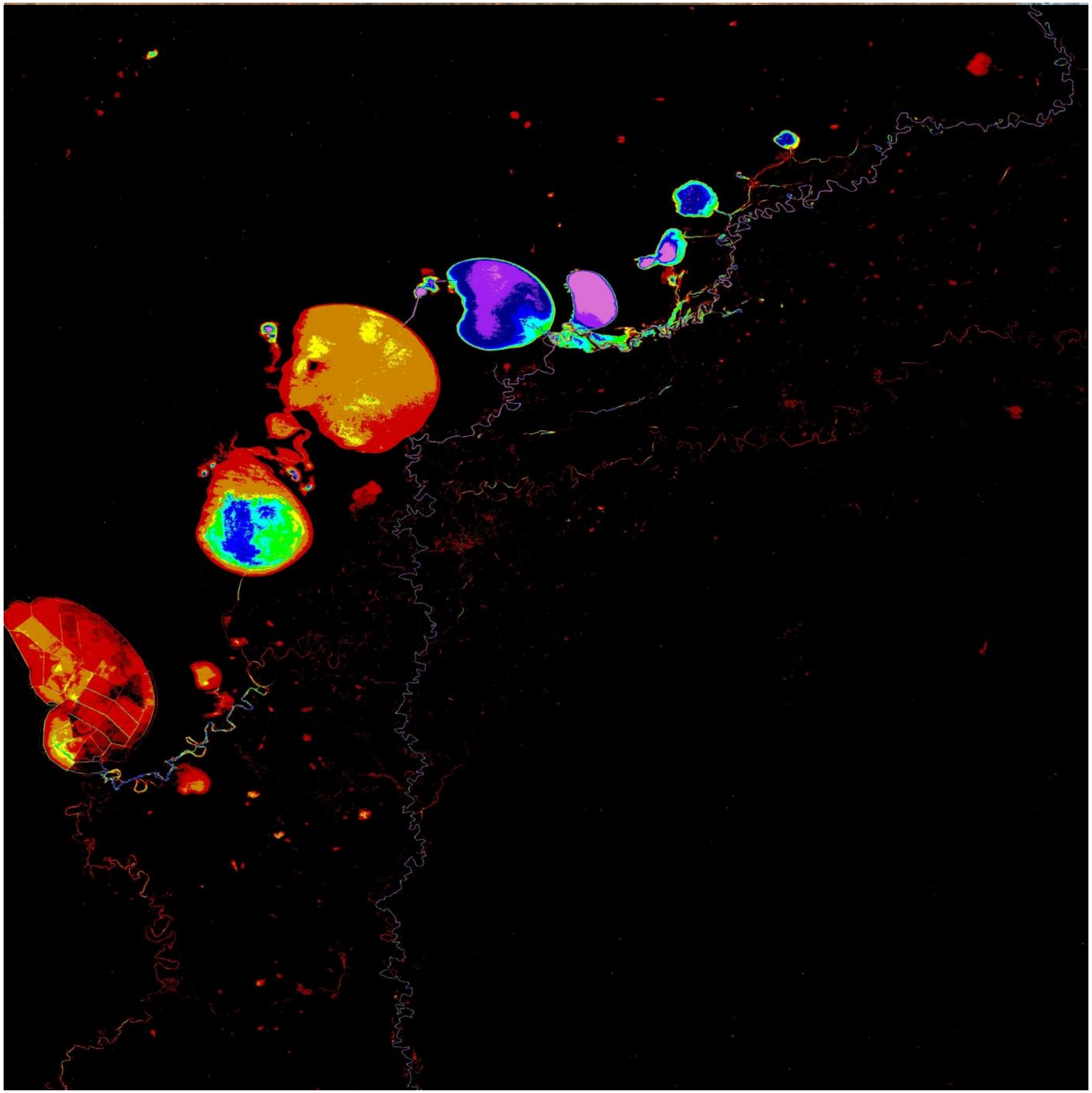
Every surface observations
($21x10^{12}$ pixels)



Random forest classifier

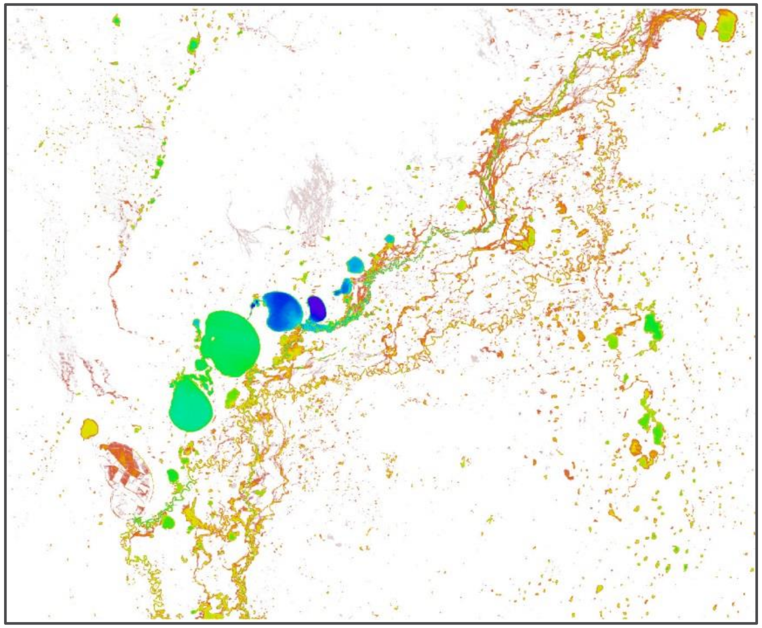
Evaluation data
(different period of time)
(3.4 million data points)

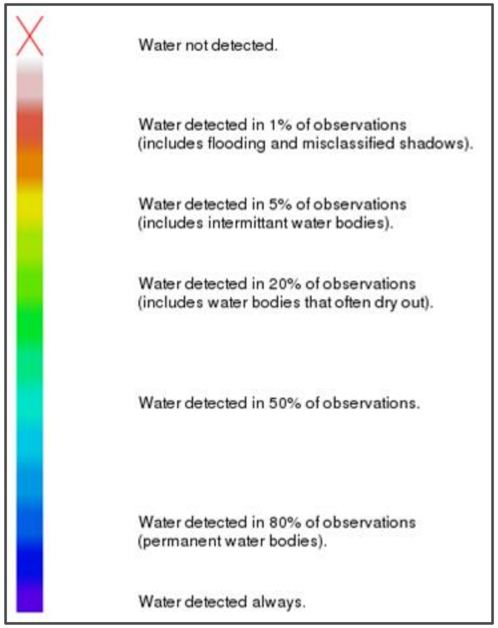
Class		Water	Not Water
Producers accuracy		93%	98%
Users Accuracy		92%	98%
Overall accuracy	97%		



WOfS Summary Product

- Sum the derived temporal water stack: number of water observations per pixel
- Sum the derived "real" observations for every pixel from the Pixel Quality
- Produce the ratio as a percentage for display





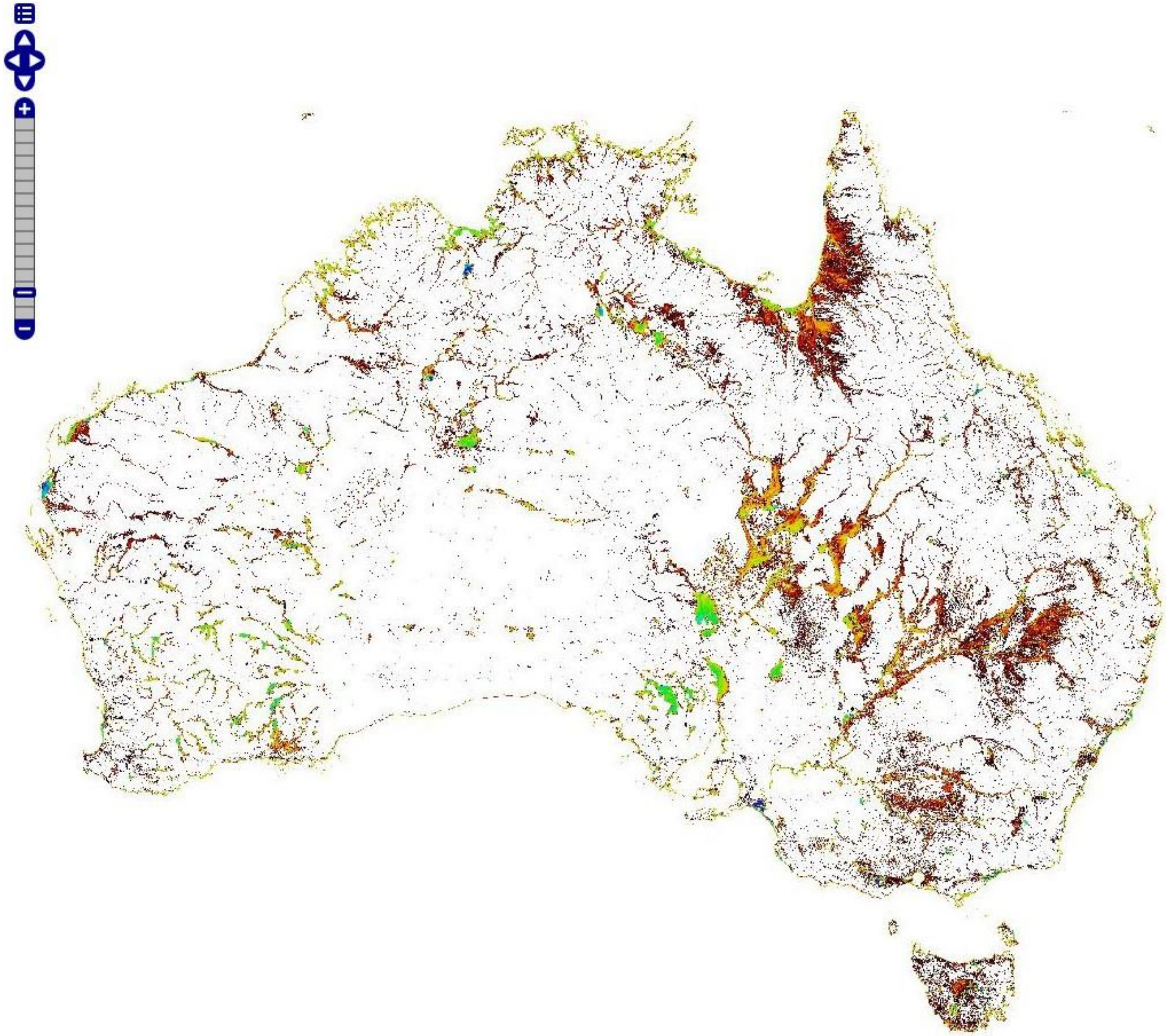
Menindee Lakes as shown in WOfS, with associated legend

Confidence filters

Confidence by comparing classification output with other relevant datasets using logistic regression:

- MODIS Open Water Likelihood
- Multi-resolution Valley-Bottom-Flatness
- Slope of terrain from SRTM
- Built-up areas
- Frequency of water observation from WOfS

National scale Water Observations from Space



NFRIP water detection

- 15 Years of data from LS5 & LS7(1998-2012)
- 25m Nominal Pixel Resolution
- Approx. 133,000 individual source scenes in approx. 12,400 passes
- Entire archive of 1,312,087 NBAR tiles => 21×10^{12} pixels visited
- WOfS WMS

Questions

		WOfS class = water		WOfS class = not water	
WOfS class	Spectral sub-class	Water %	Number of samples	Not Water %	Number of samples
Not water	Bare	0%	2	100%	756,974
Not water	Building Shadow	6%	198	94%	2,903
Not water	CloudShadow_Bare	6%	4,167	94%	67,852
Not water	CloudShadow_Veg	2%	3,033	98%	134,788
Not water	Cropping_Bare	0%	-	100%	60,210
Not water	Cropping_DenseVeg	0%	-	100%	34,762
Not water	Dark_Soil	0%	36	100%	17,450
Not water	Road	1%	60	99%	5,337
Not water	Salt	1%	1,023	99%	93,141
Not water	Snow	0%	113	100%	93,695
Not water	TerrainShadow_Bare	11%	44,492	89%	352,121
Not water	TerrainShadow_Snow	1%	64	99%	7,659
Not water	TerrainShadow_Veg	4%	3,161	96%	74,022
Not water	V_Forest	0%	24	100%	285,875
Not water	V_Grassland	0%	28	100%	594,384
Not water	V_Riparian	0%	184	100%	61,587
Water	CloudShadow_Water	99%	1,676	1%	11
Water	W_Estuary	95%	72,585	5%	3,850
Water	W_LargeBody	98%	124,826	2%	3,057
Water	W_River	80%	46,778	20%	11,651
Water	W_SalineFlats	92%	404	8%	33
Water	W_Salt_Lake	99%	13,982	1%	139
Water	W_Sea	98%	339,876	2%	5,932
Water	W_SmallBody	88%	12,266	12%	1,730
Water	W_Swamp	63%	22,758	37%	13,519
Water	W_VegMix	74%	34,636	26%	12,060
Producers accuracy			93%		98%
Users Accuracy			92%		98%
Overall accuracy		97%			

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