Inferring higher frequency water observations from WOFS & MODIS

OZEWex Summer Institute

14 Feb 2020

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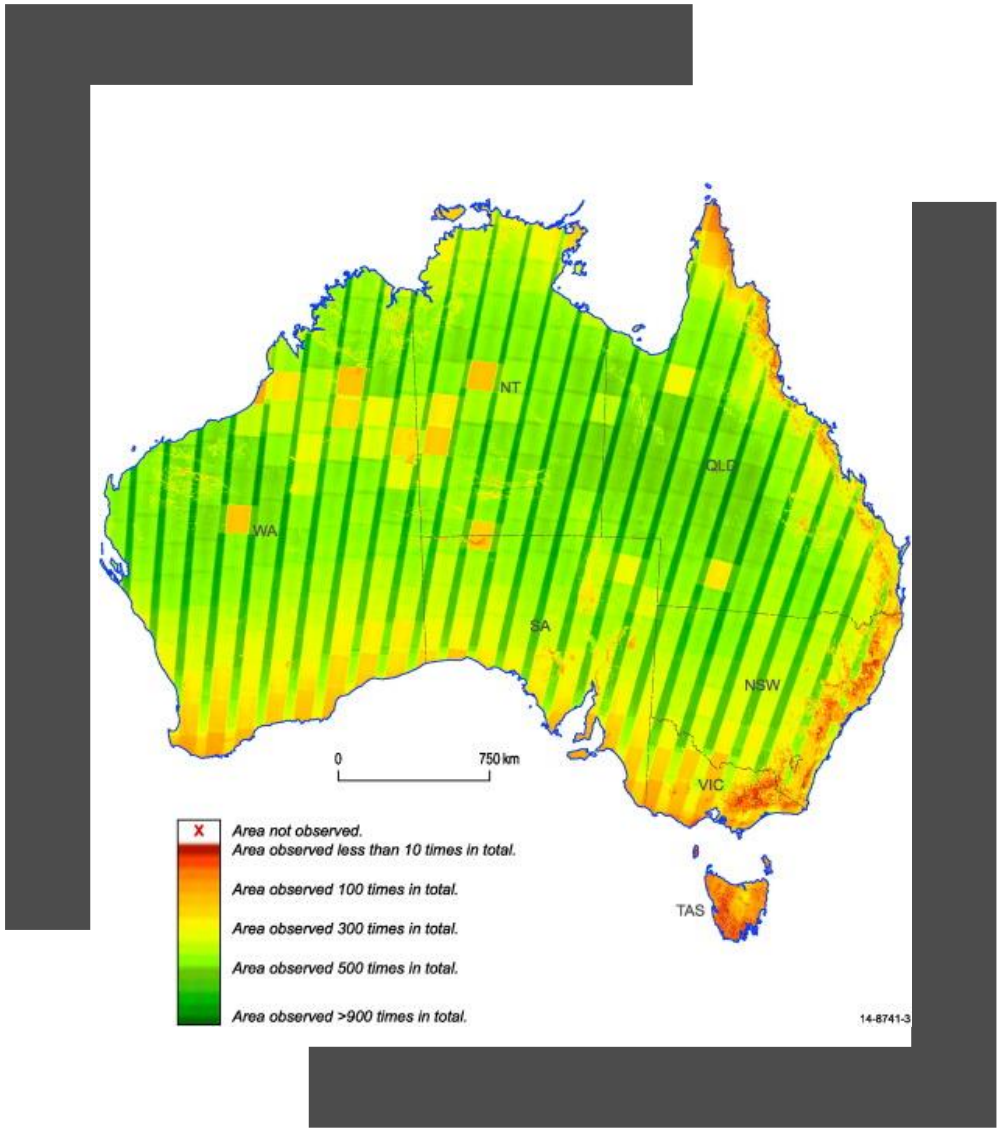


Motivation

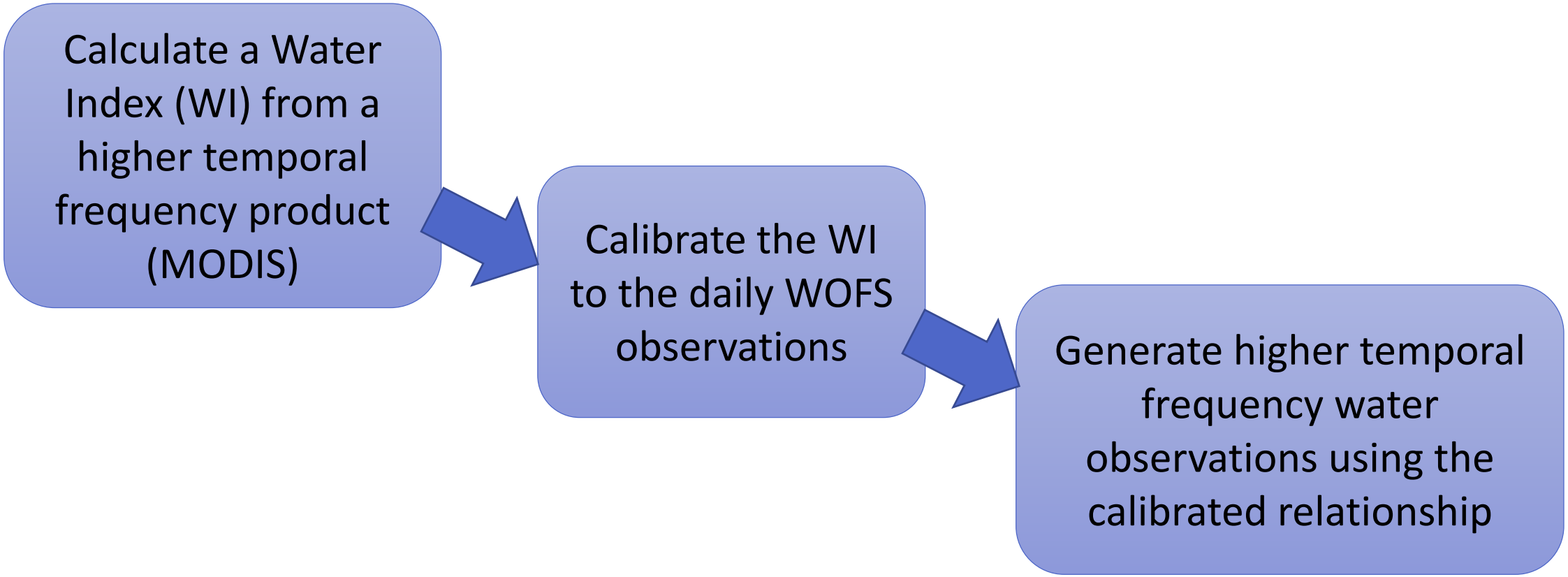
- WOFS (Water Observation from Space)
  - It is the world's first continent-scale map of surface water[1] and provides images and data showing where water has been seen in Australia from 1987 to the present.
  - It is a Landsat derived product
- Daily WOFS observations
  - 25 m grid
  - Infrequent observations (~16 days)

N. Mueller, A. Lewis, D. Roberts, S. Ring, R. Melrose, J. Sixsmith, L. Lymburner, A. McIntyre, P. Tan, S. Curnow, A. Ip, 2016. Water observations from space: Mapping surface water from 25 years of Landsat imagery across Australia. Remote Sensing of Environment 174, 341-352, ISSN 0034-4257.

1: https://www.ga.gov.au/dea/products/wofs#_edn1

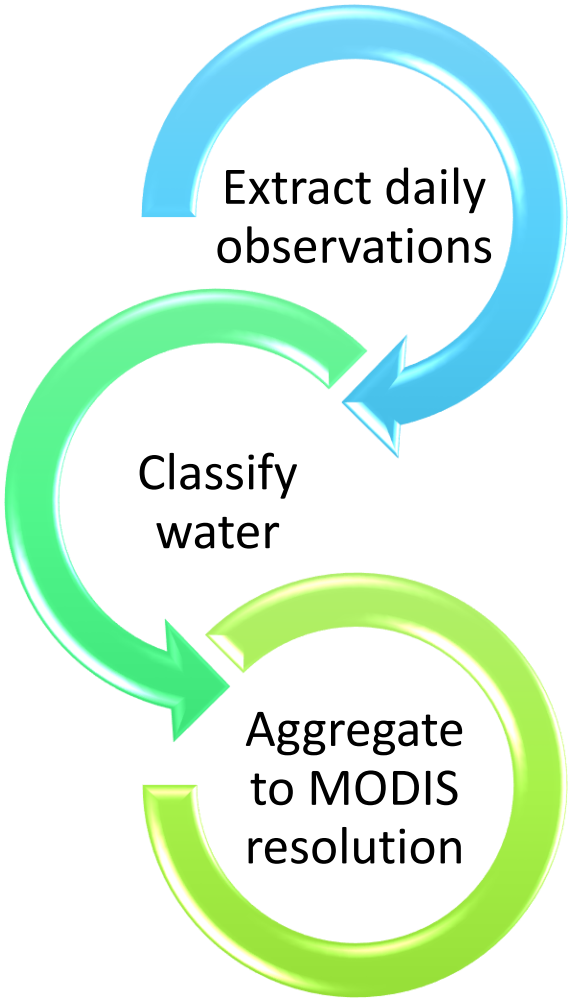
Objective and proposal

- Generate higher temporal frequency water observations from the Water Observation from Space (WOFS) images




Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Image Landsat / Copernicus
Image IBCAO
Google Earth

Methods: Processing Daily WOFS Data



Steps

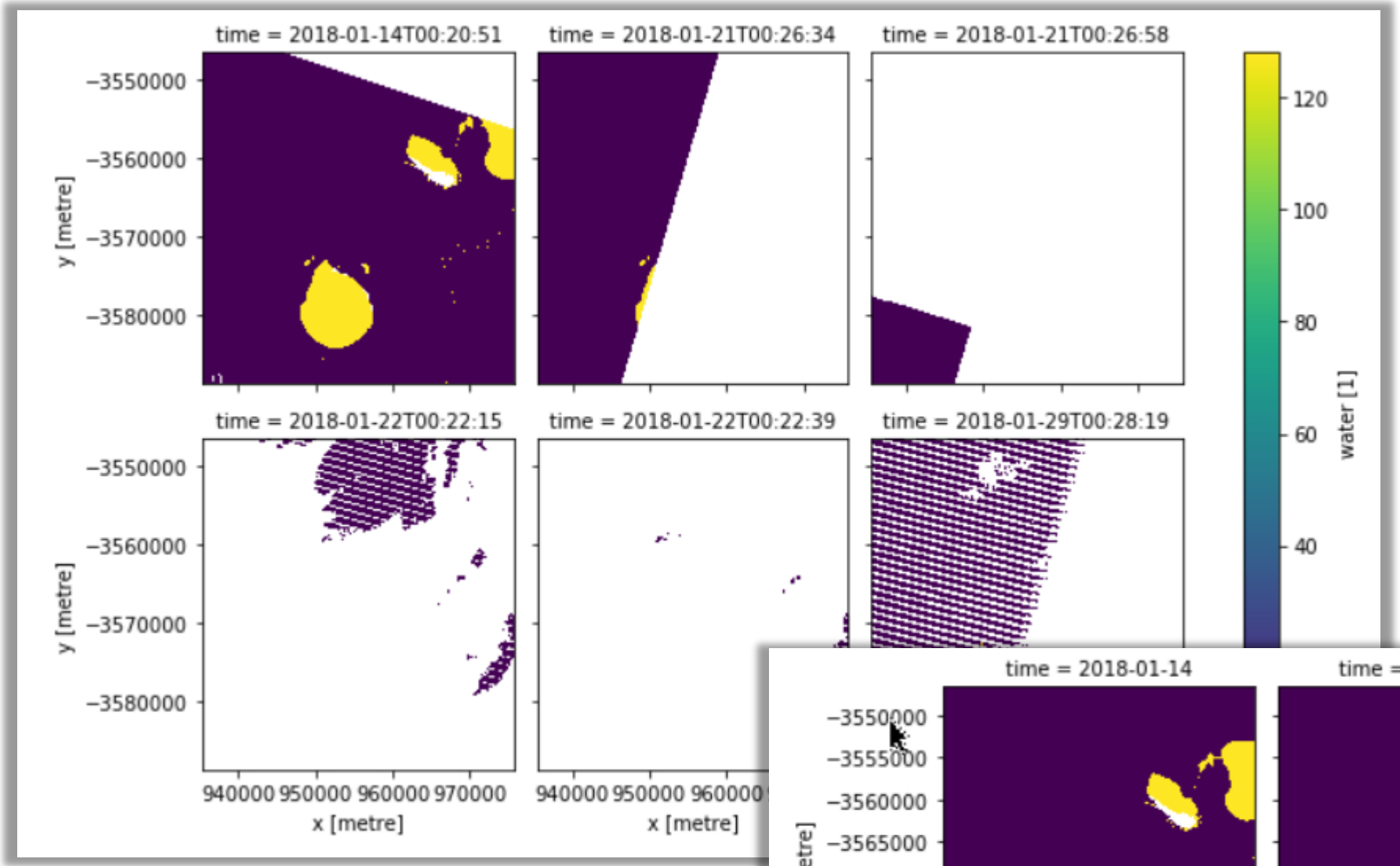
1. Extract daily images (25 m)
2. Convert bitcode flags to dry (0) or water (1)
3. Calculate % water coverage per MODIS cell (500 m)

Challenges

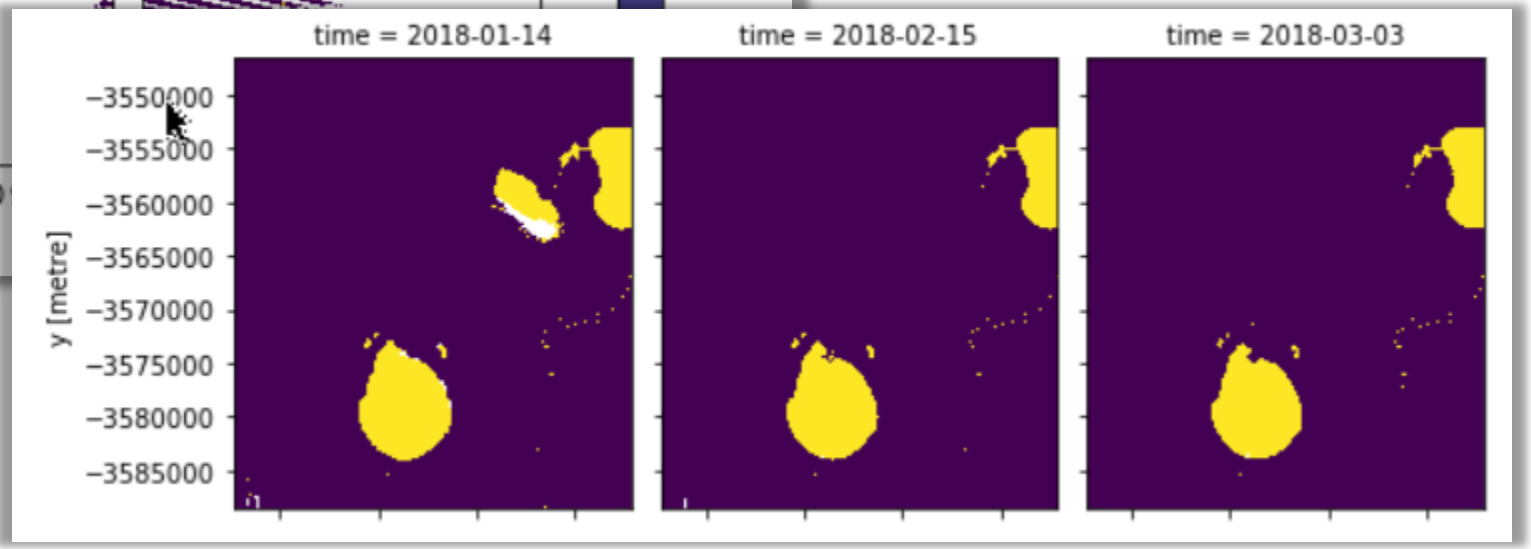
- Many missing days
- Lots of “no data” values
- Multiple scenes per day
- Working with bit codes
- Spatial aggregation to match the MODIS resolution

Methods: Daily Aggregation & Filtering

~29 useful days per year



Original Scenes



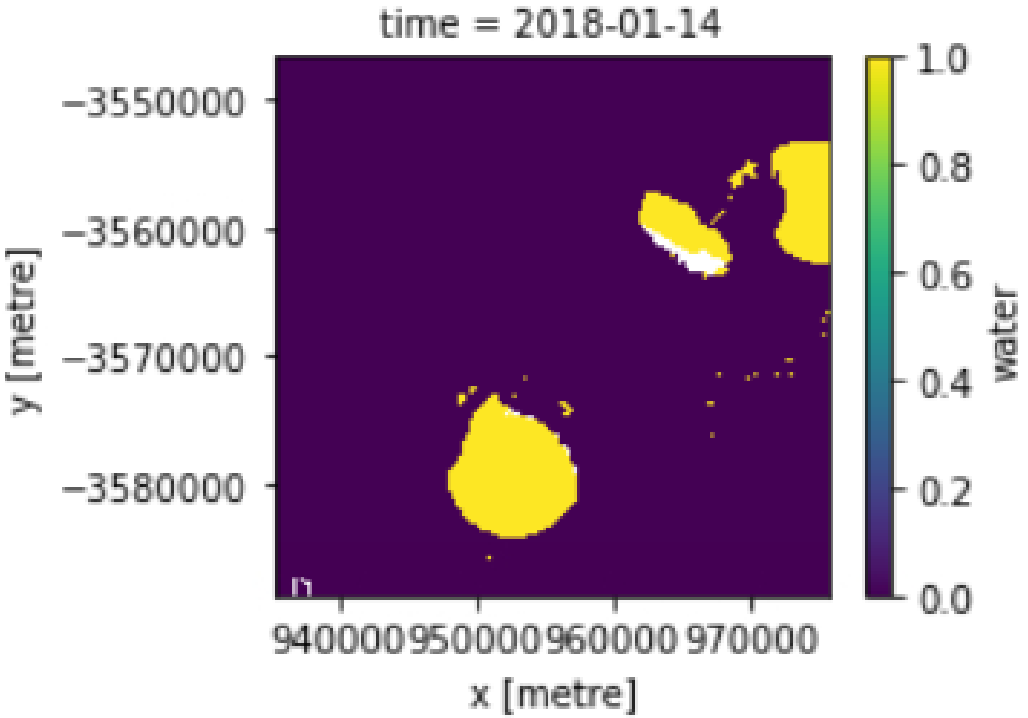
Methods: Spatial Aggregation

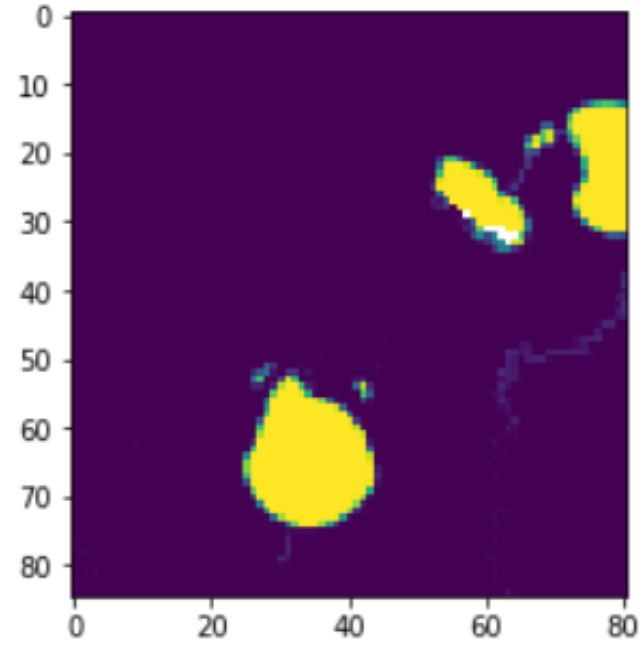
WOFS 25 m data

- 0 = dry
- 1 = wet

Aggregated 500 m data (matching MODIS)

- 0 = 0% water coverage
- 1 = 100% water coverage

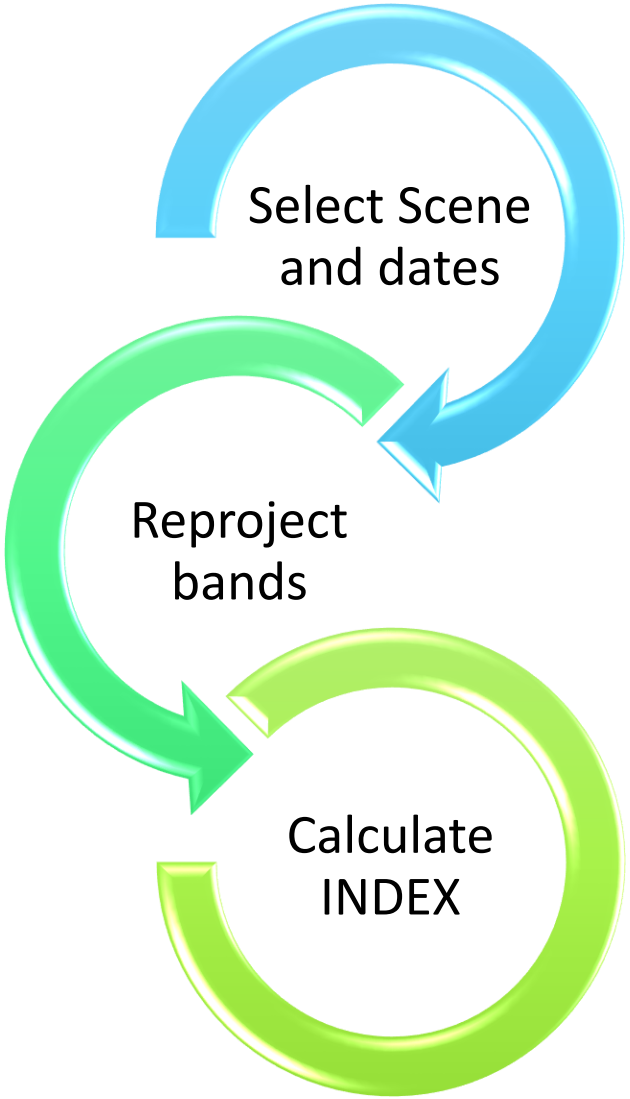




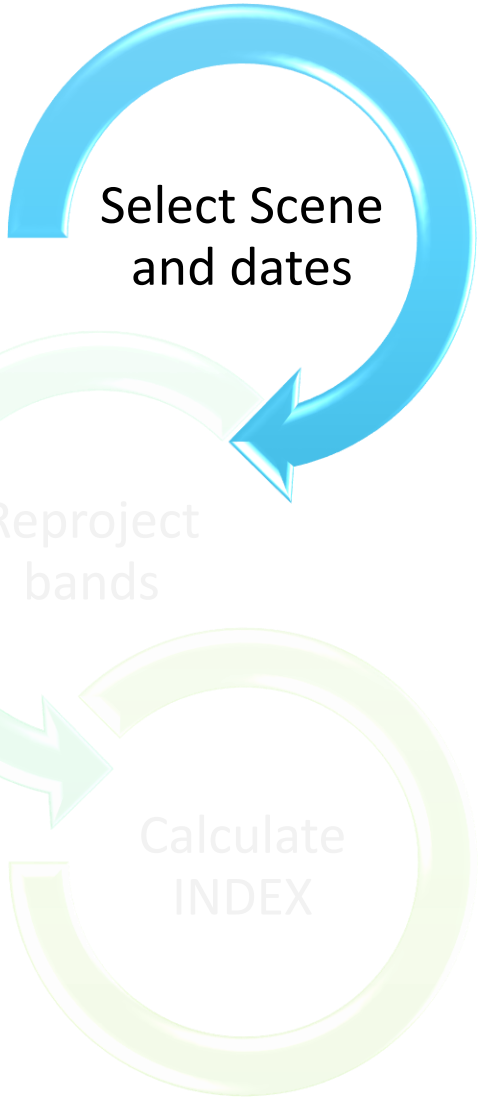
Methods: Processing MODIS

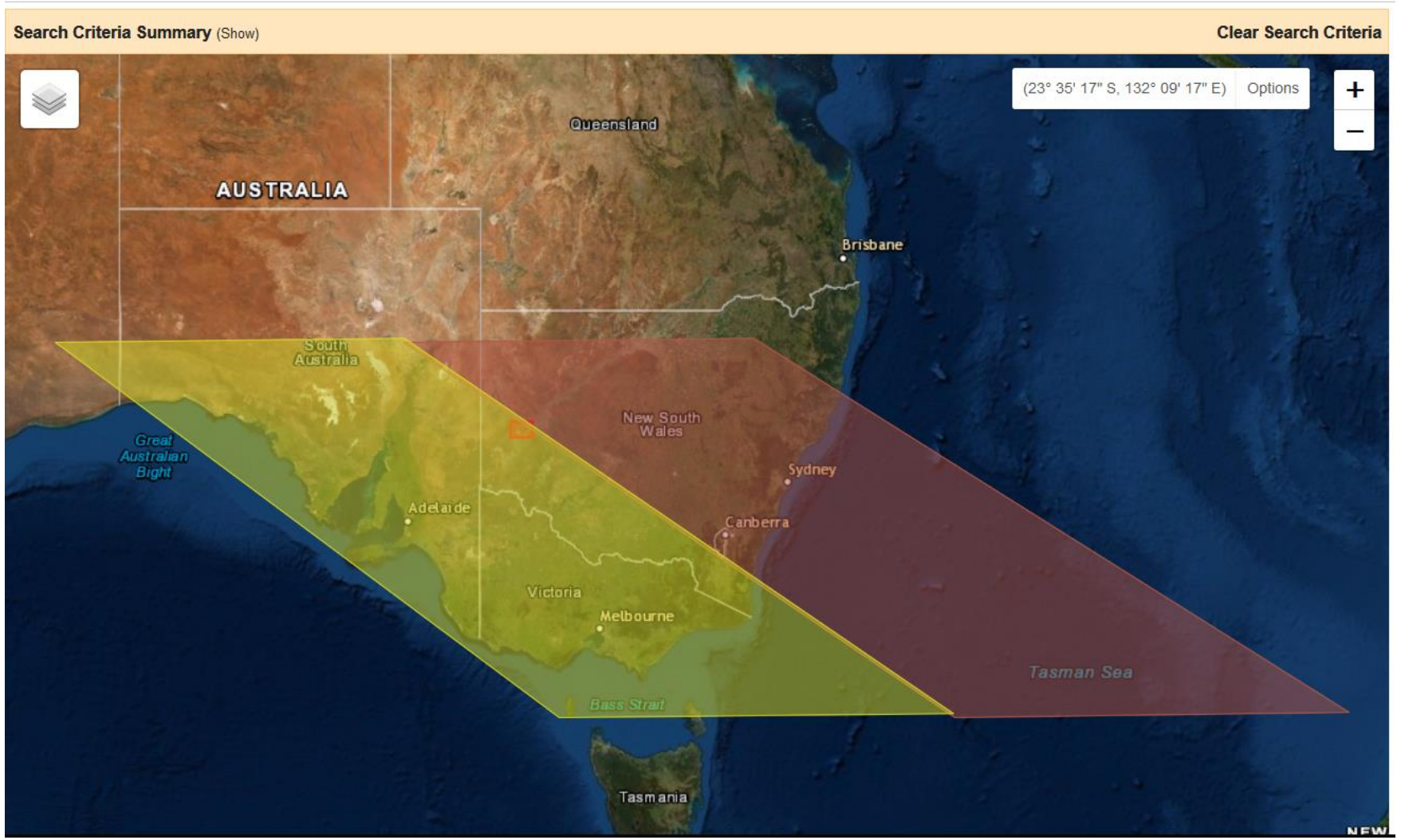
- MODIS (Moderate Resolution Imaging Spectroradiometer)
  - 705 km, TERRA: descending node, AQUA: ascending node.
  - Sun-synchronous, near-polar, circular.

Methods: Processing MODIS



Methods: Processing MODIS





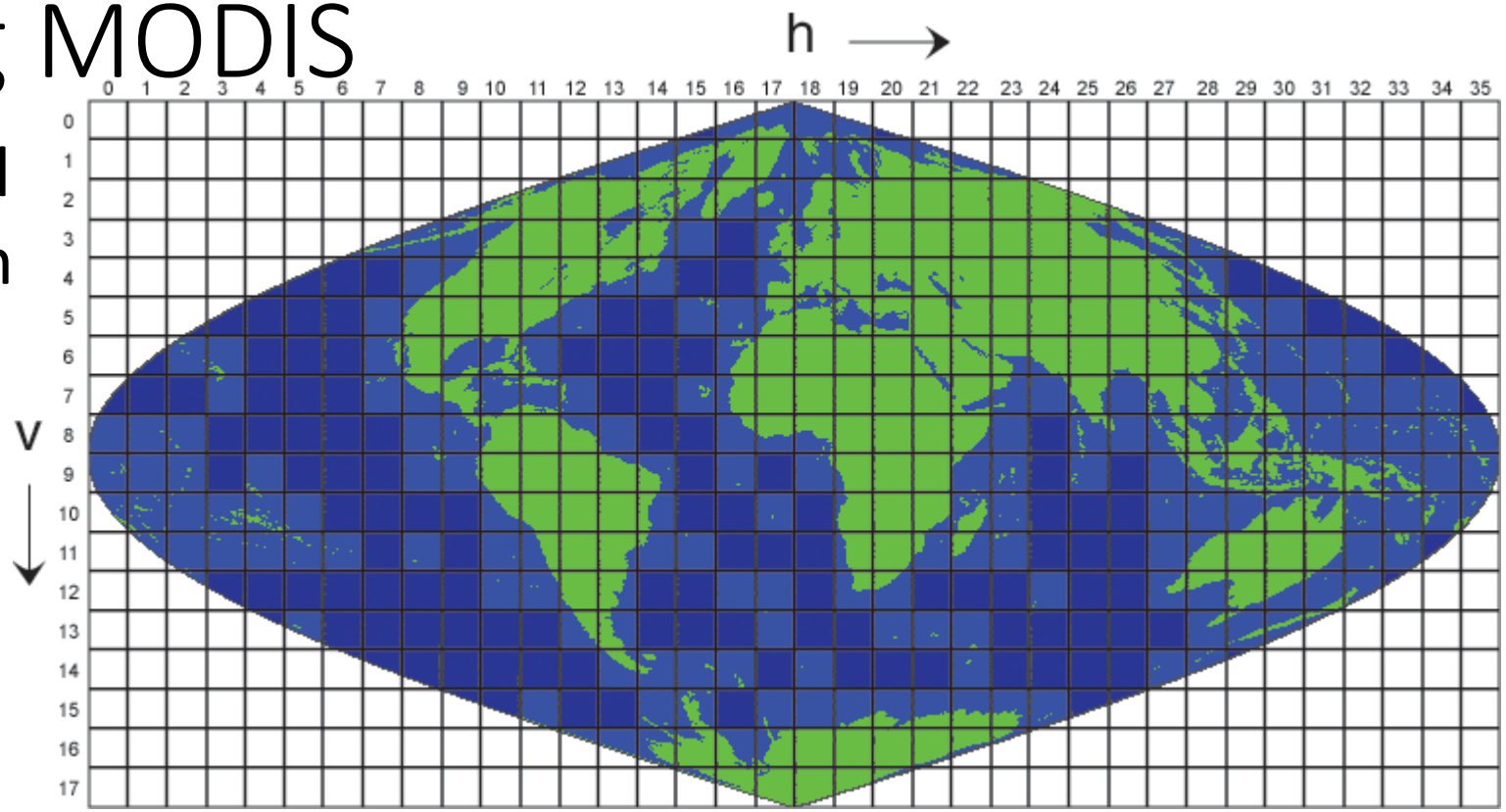
Methods: Processing MODIS

Select Scene and dates

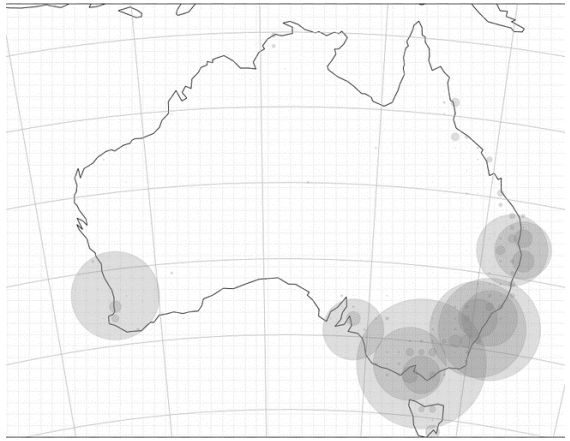
Reproject bands

Calculate INDEX

Sinusoidal Projection



Australia Albers Equal Area



Methods: Processing MODIS

Select Scene and dates

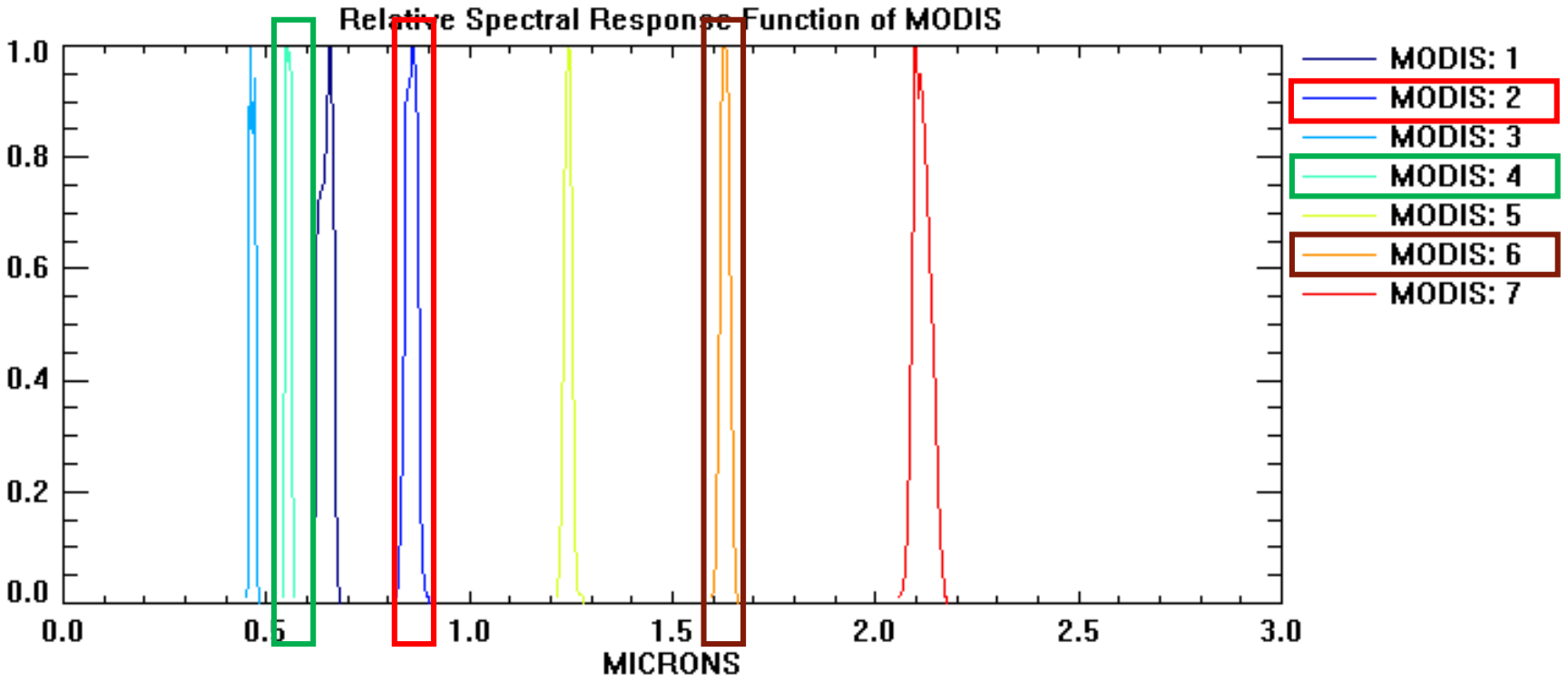
Reproject bands

Calculate INDEX

- Water Index Calculation from MODIS[1]

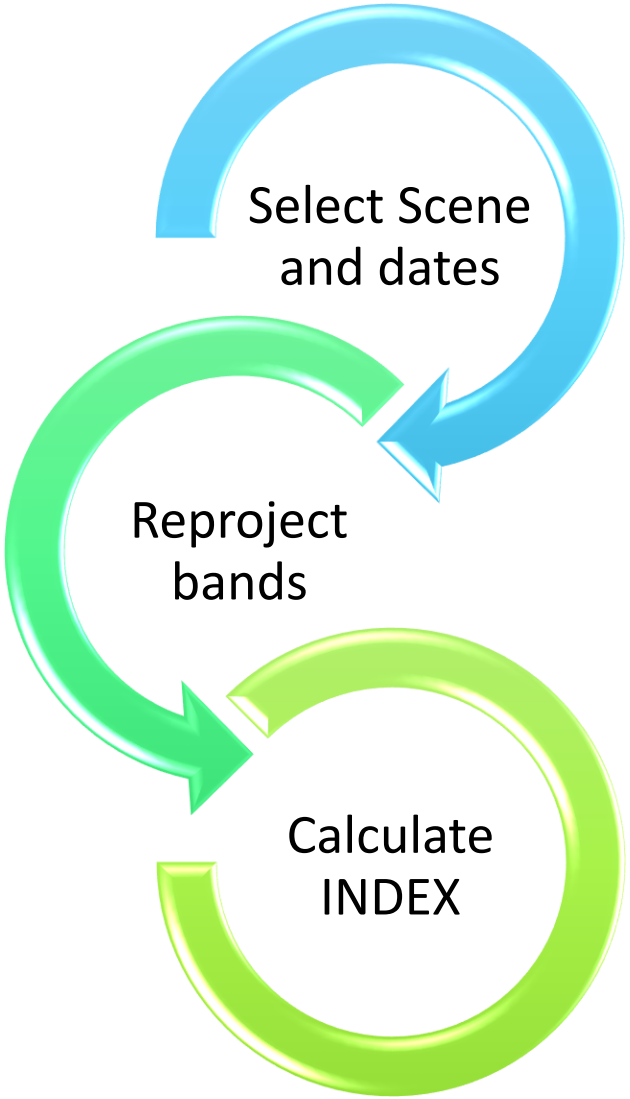
$$NDWI = \frac{B4_{Green} - B2_{NIR}}{B4_{Green} + B2_{NIR}}$$

$$MNDWI = \frac{B4_{Green} - B6_{SWIR}}{B4_{Green} + B6_{SWIR}}$$

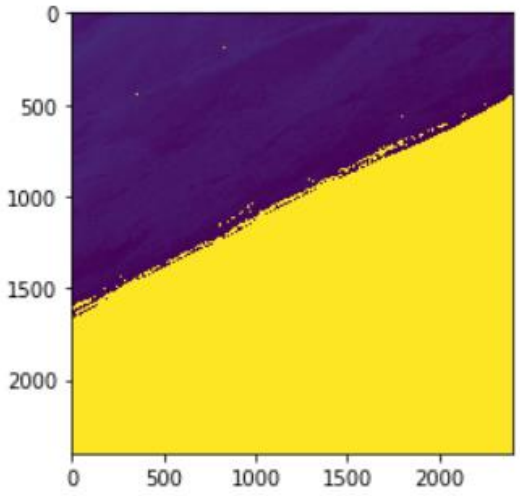


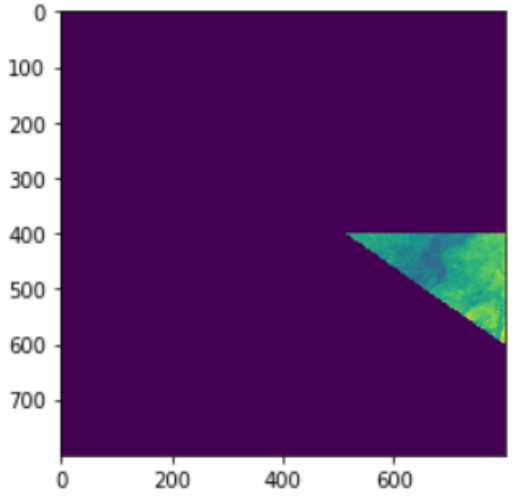
1 Che, X., Feng, M., Jiang, H., Song, J., & Jia, B. (2015). Downscaling MODIS surface reflectance to improve water body extraction. *Advances in Meteorology*, *2015*.

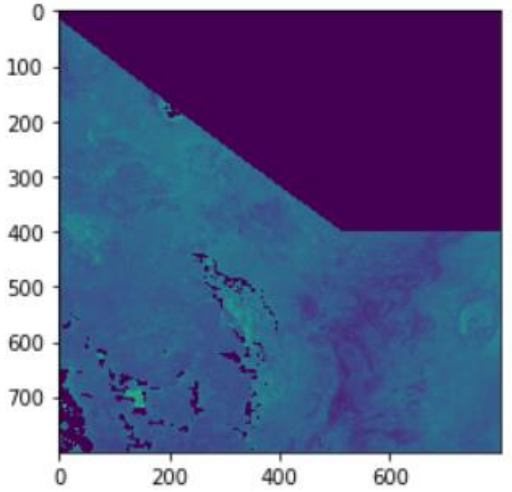
Methods: Processing MODIS



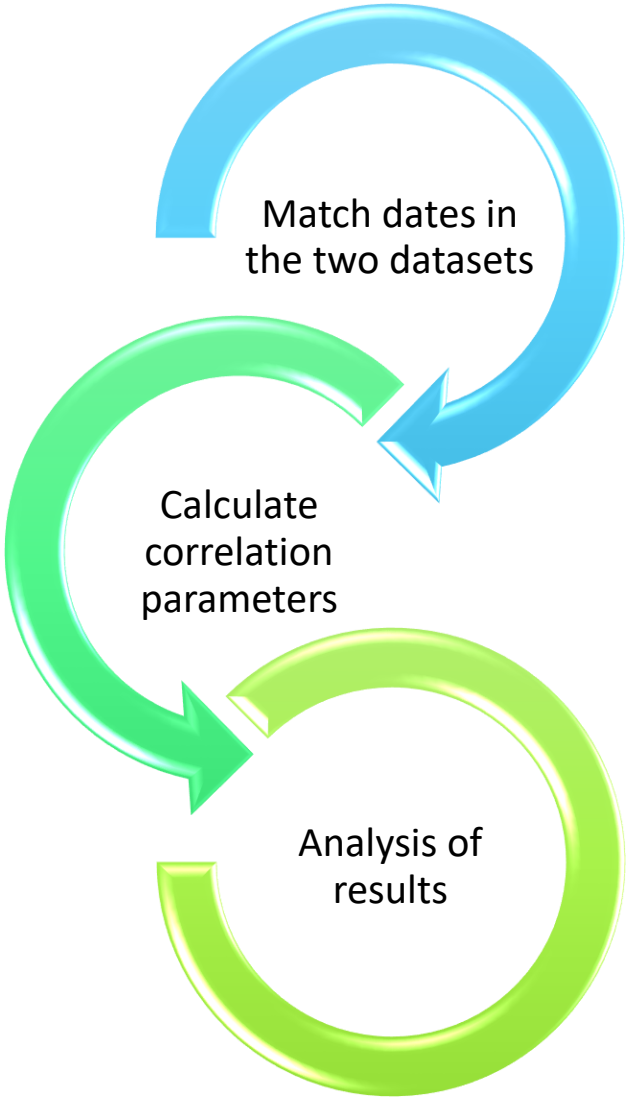
- Challenges
  - Two Scenes for our Study Area: reprojection and join the scenes.
  - It works individually for each single band
  - The images cannot be read as a xarray
  - 8-days composite images → 46 images per year







Correlating MODIS and WOFS



Steps

1. Identify common dates for WOFS and MODIS
2. Correlate:
   - WOFS % water coverage
   - MODIS Water Index (WI)
3. Predict % water coverage for dates where WOFS images are not available

Challenges & limitations

- MODIS 8-days composite images → WOFS images represent a single day
- Unexpected % water vs WI relationships

Correlating MODIS and WOFS

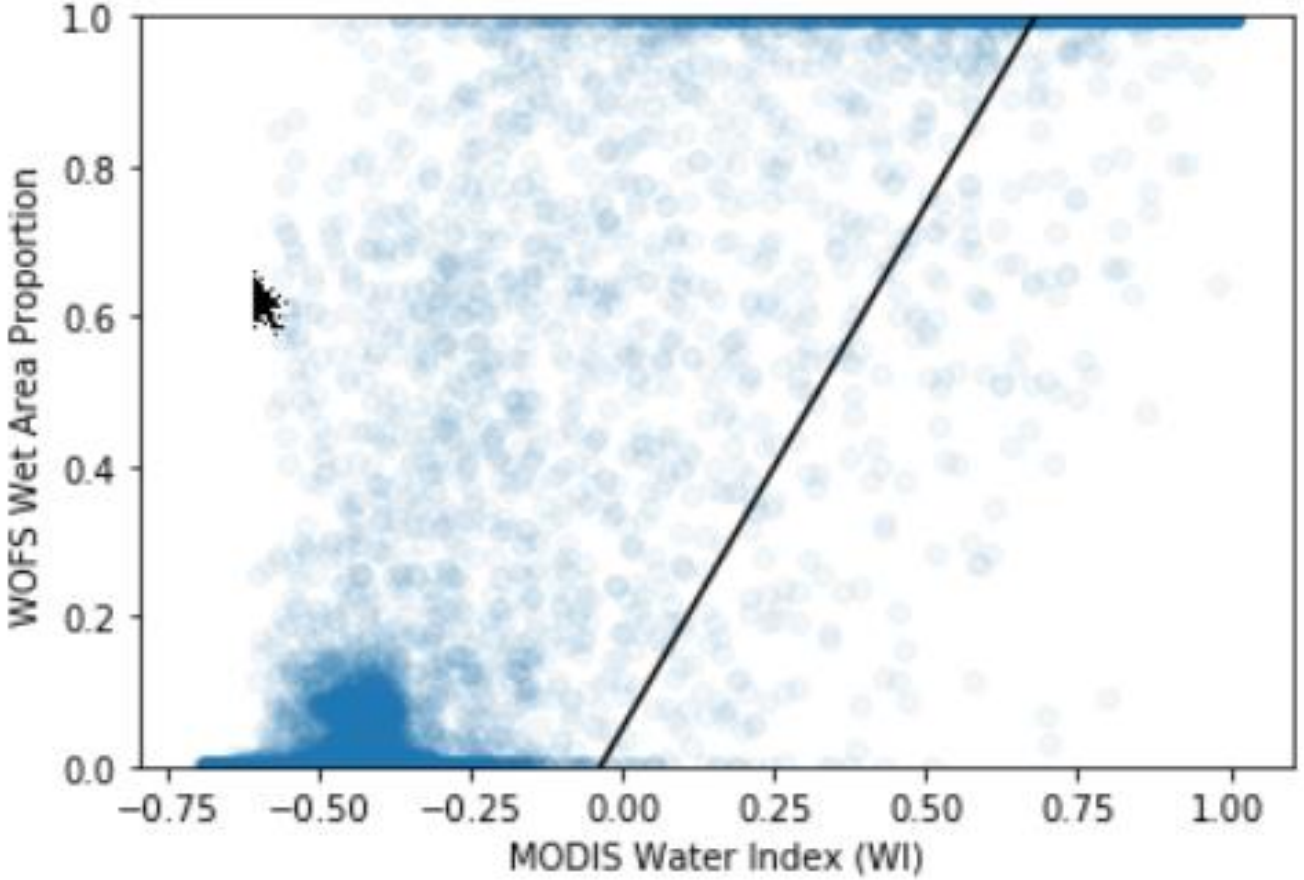
Initial testing indicated a strong correlation: Pearson's r = 0.91

Visualisation shows that the relationship is not linear

Adopted a threshold approach

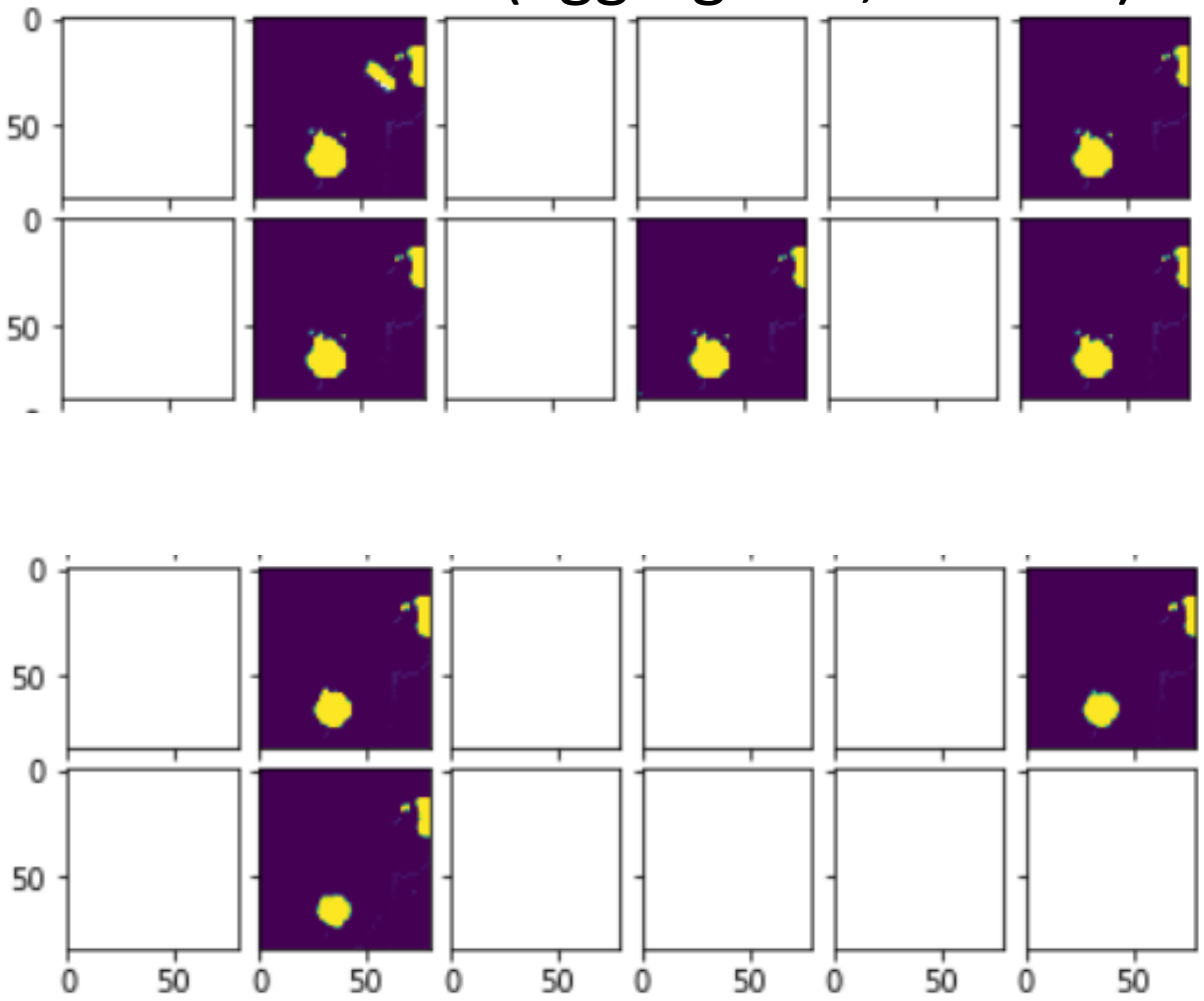
- Dry: WI <-.20
- Wet: WI > -0.19
- Partially inundated:

(-0.19 <= WI <= -0.2)

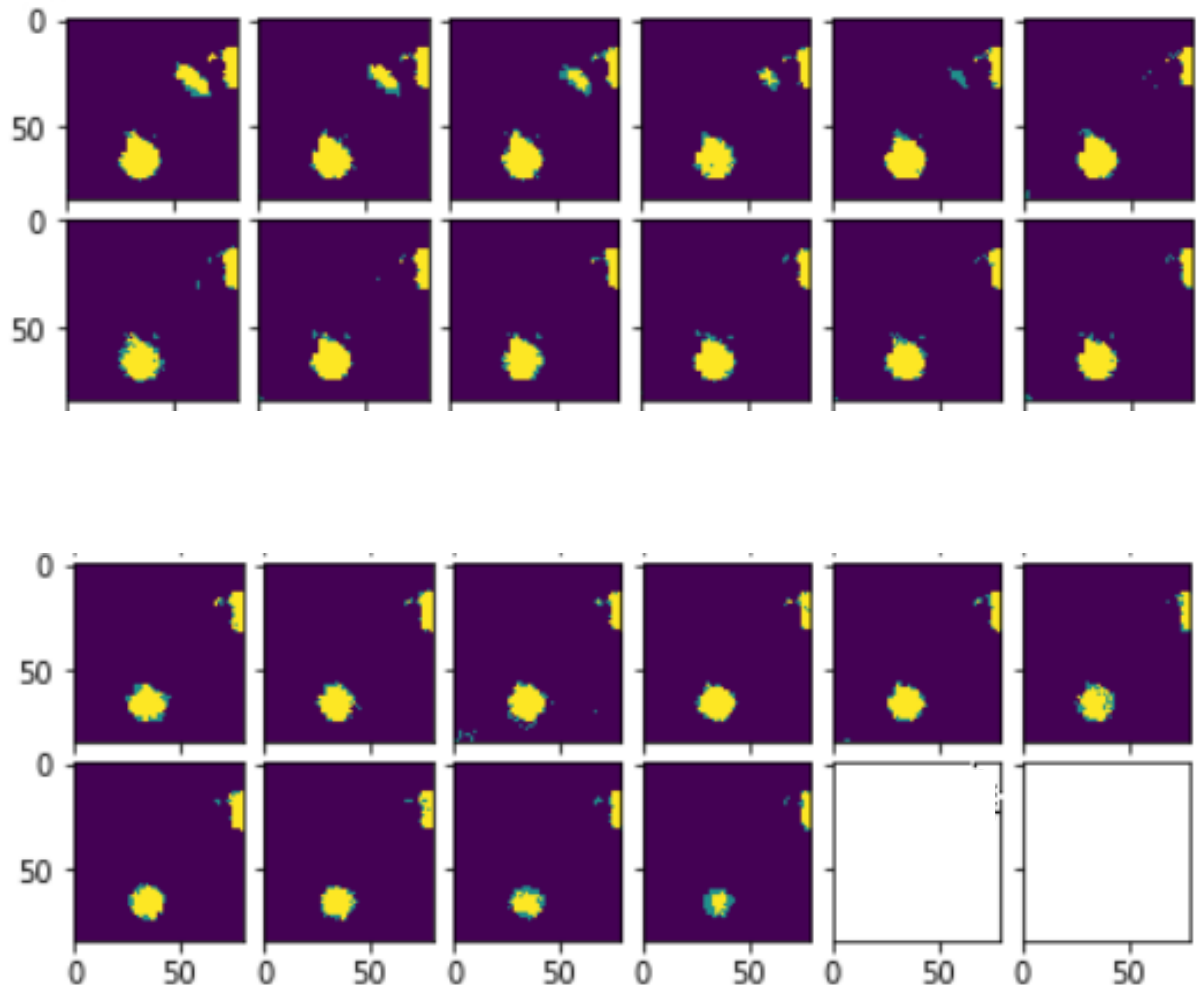


Example Results (Jan-Feb & Nov-Dec 2018)

WOFS Data (aggregated, filtered)



Water classification from MODIS



Performance Metrics

Dry cells

0.8% misclassified

Wet cells:

4.7% misclassified

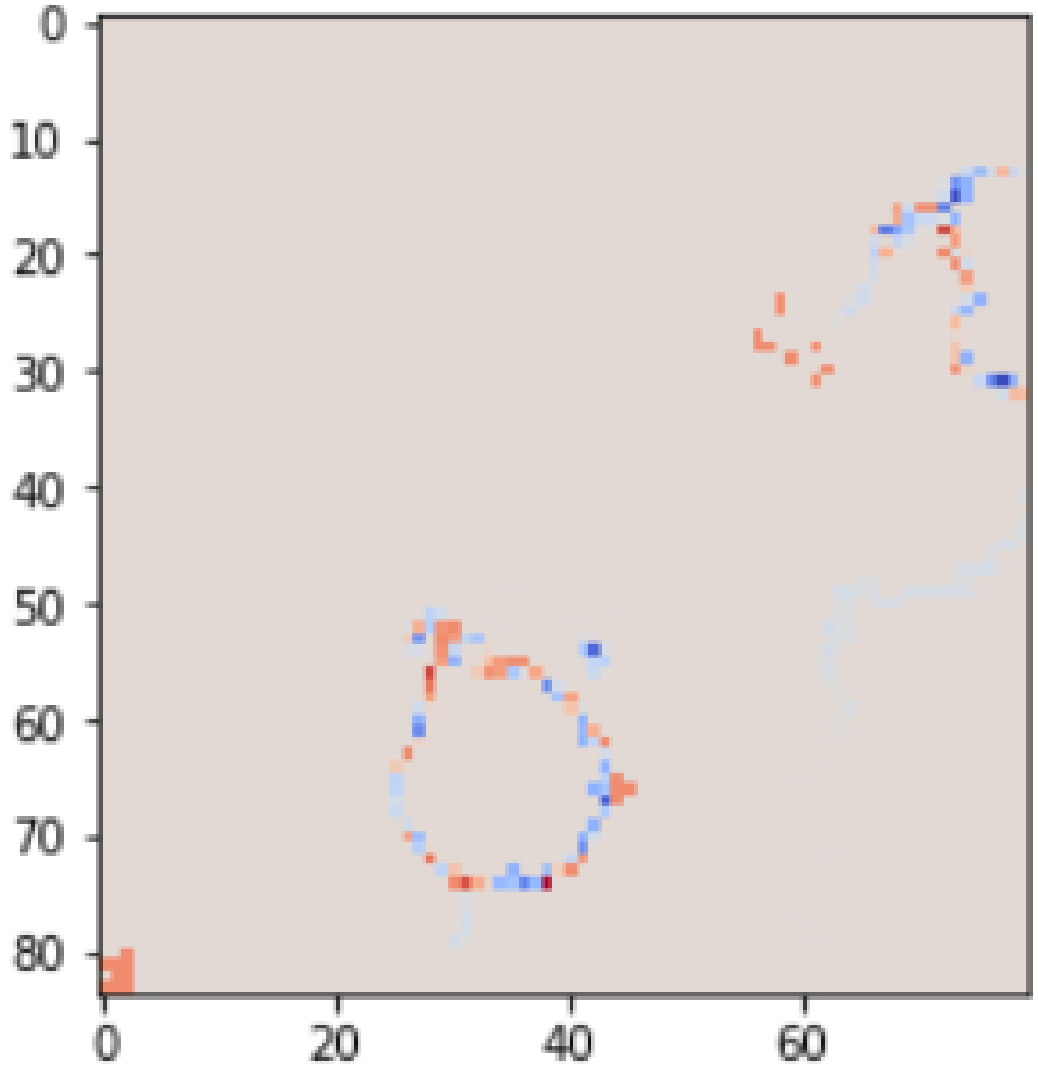
Partially wet cells:

53% misclassified

Misclassified partially wet cells:

43.5% wet

56.5% dry



Conclusions

- Calibrating water indices derived from MODIS to the WOFS water data is fast & effective
- Results useful for large-scale assessments of inundation area at a more frequent temporal resolution than offered by WOFS

Limitations include:

- 8 day time step insufficient to capture transient events
- Unable to identify rivers and streams during within bank flows

Future Work

Improve Water Index (WI)

- Calculate additional indices from MODIS
- Optimise thresholds (rather than manual adjustment)

Downscale 500m cells to WOFS 25m cells

- Establish relationship between inundated cells in WOFS and strength of MODIS WI

Validate on independent data

Thanks to the OZEWex tutors, trainers & staff

Software Environment

Jupyter Notebook

Key packages:

- Xarray
- Digital Earth Australia

Git Hub version control

NCI computing environment