

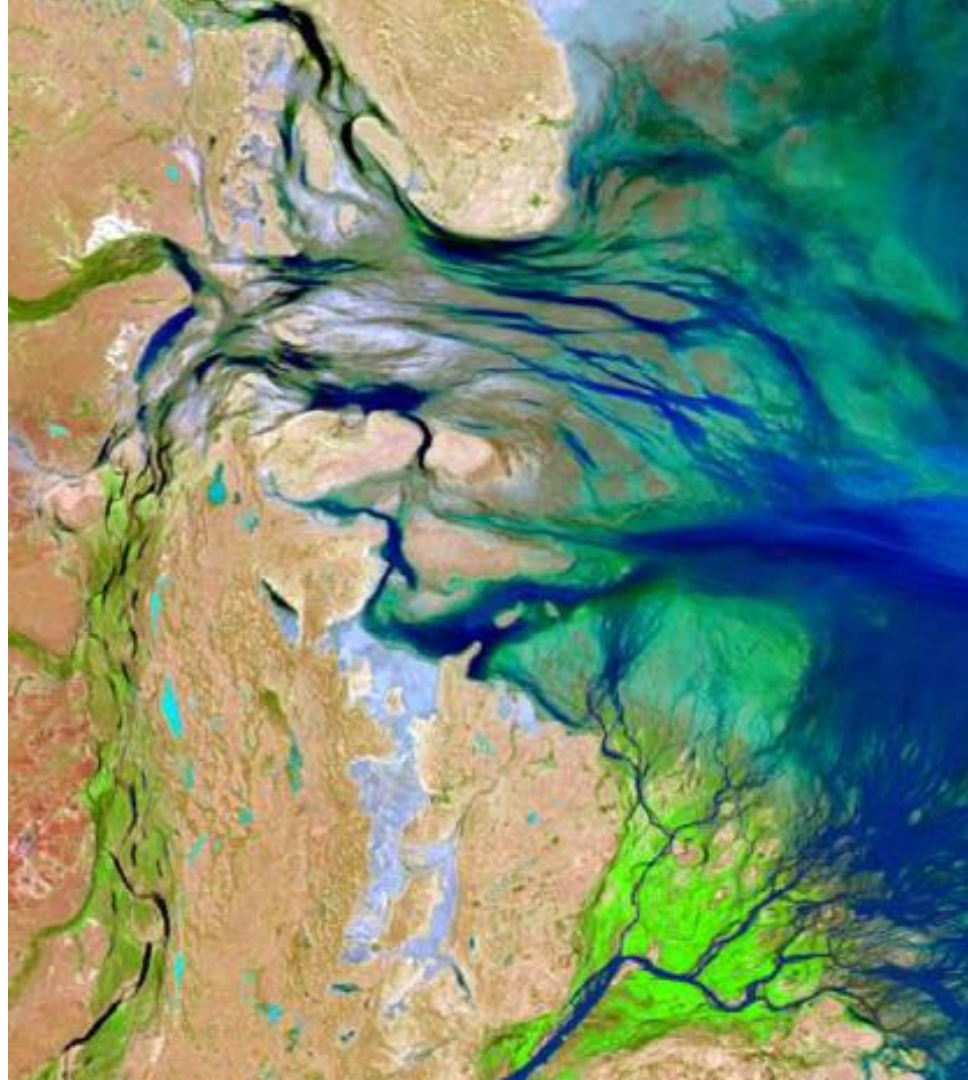


Remote sensing for landscape and water management

Principles for water modellers

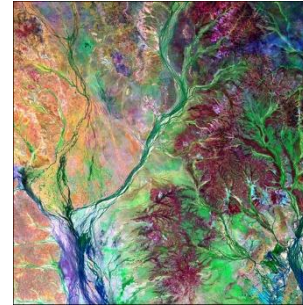
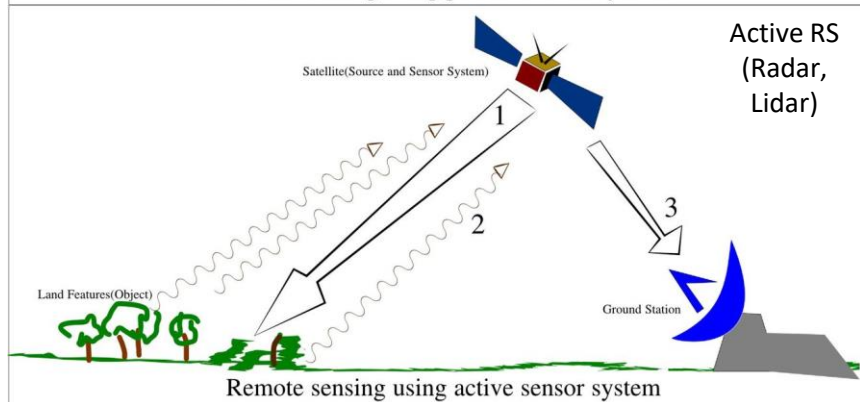
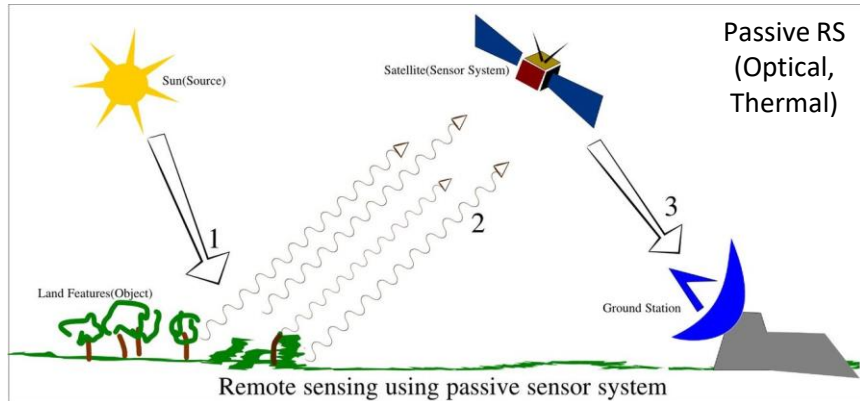
Tim Malthus | CSIRO Oceans and Atmosphere |
2020-06-2

Australia's National Science Agency

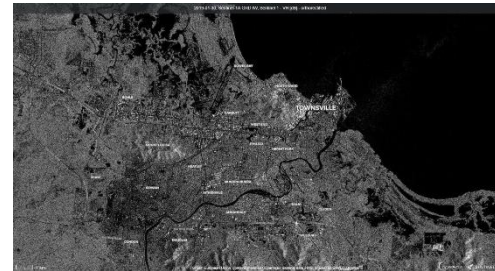
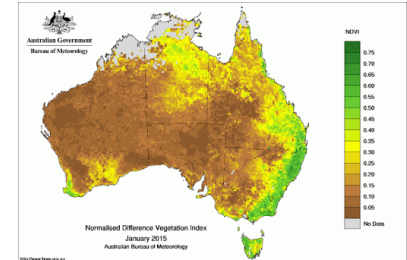




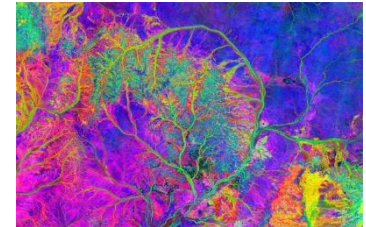
Introduction to remote sensing (in 1 slide...)



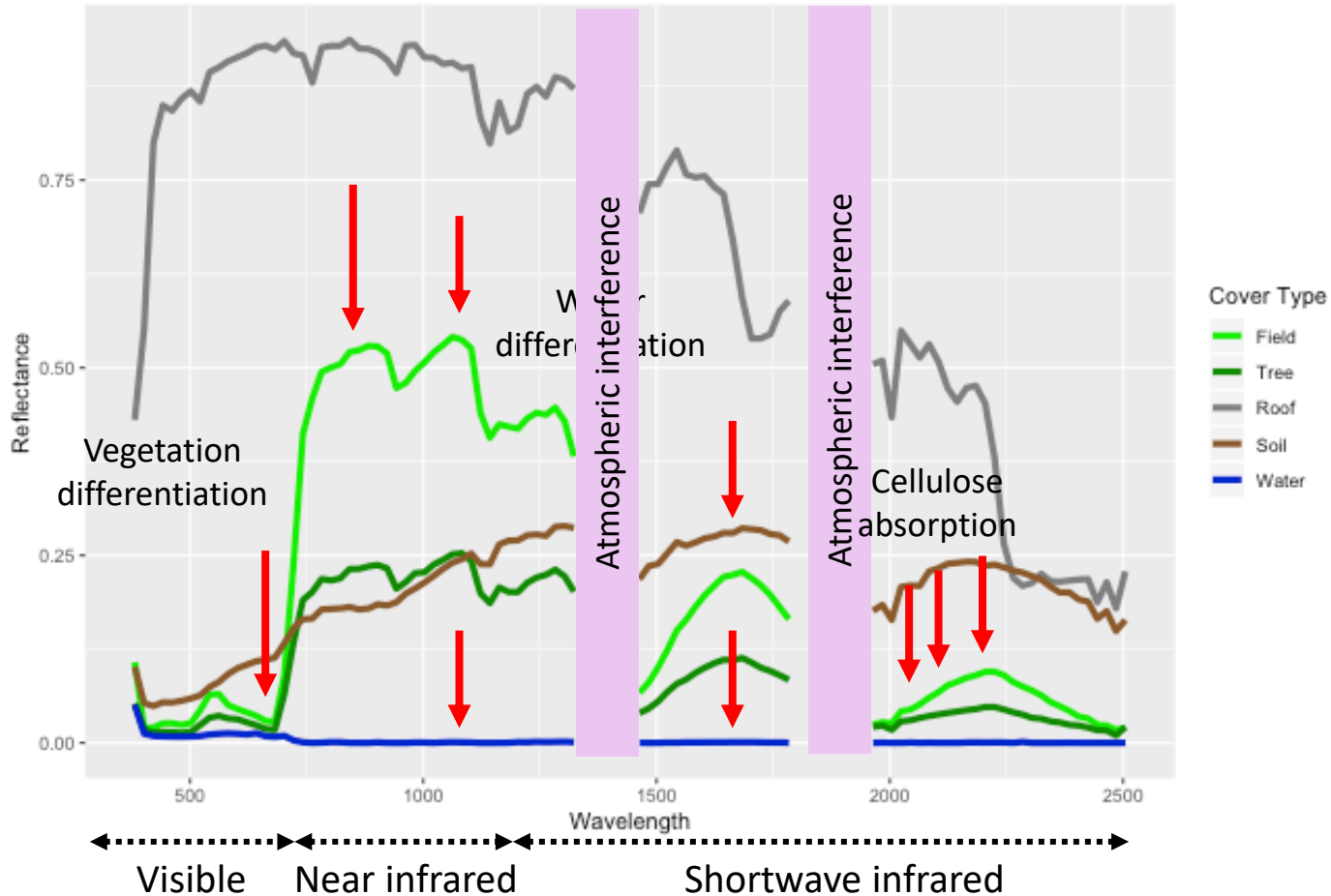
Exploits spectral signature



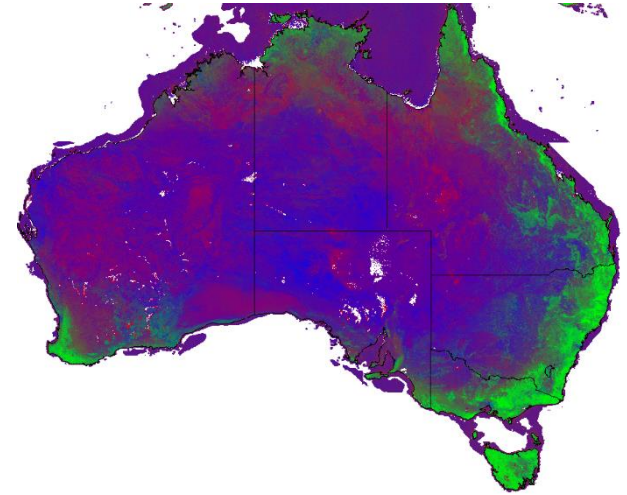
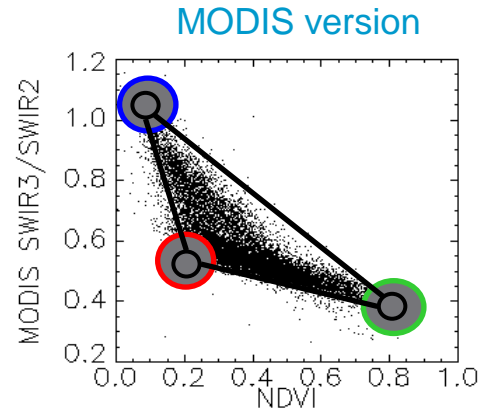
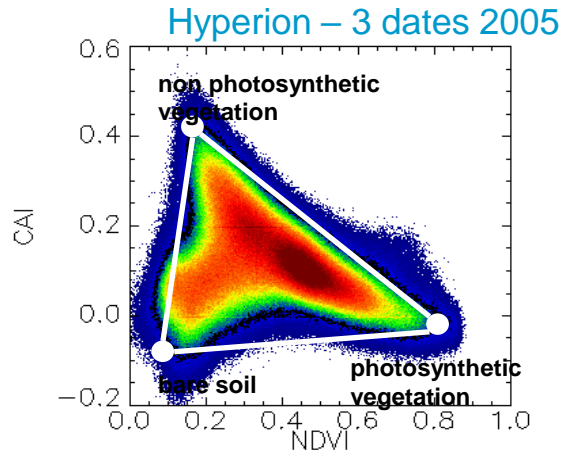
Exploits structural or moisture properties



The spectral signature



Fractional cover



Guerschman et al. (2009). Estimating fractional cover of photosynthetic vegetation, non-photosynthetic vegetation and bare soil in the Australian tropical savanna region upscaling the EO-1 Hyperion and MODIS sensors. *Remote Sensing of Environment*, 113:928-945



-
- ```

graph TD
 Root["18374 Samples:
NW 71.2%
W 28.8%"]

 Root -- "NDVI S2 <= -0.01" --> L1["63145 Samples:
NW 23.5%
W 76.5%"]
 Root -- "NDVI S2 > -0.01" --> R1["120729 Samples:
NW 96.1%
W 3.9%"]

 L1 -- "TMI <= 298.5" --> L2["56462 Samples:
NW 14.5%
W 85.5%"]
 L1 -- "TMI > 298.5" --> L3["6683 Samples:
NW 99.9%"]

 L2 -- "TMI <= 323.5" --> L4["44788 Samples:
NW 3.2%
W 96.8%"]
 L2 -- "TMI > 323.5" --> L5["11674 Samples:
NW 57.7%
W 42.3%"]

 L4 -- "NDVI 43 <= 0.01" --> L6["44615 Samples:
W 97.2%"]
 L4 -- "NDVI 43 > 0.01" --> L7["173 Samples:
NW 100%"]

 L7 -- "TMI <= 1400.5" --> L8["8607 Samples:
NW 45.7%
W 54.3%"]
 L7 -- "TMI > 1400.5" --> L9["6493 Samples:
NW 30.4%
W 69.6%"]

 L8 -- "NDVI 72 <= -0.23" --> L10["5264 Samples:
W 78.6%"]
 L8 -- "NDVI 72 > -0.23" --> L11["1129 Samples:
NW 69.0%
W 31.0%"]

 L11 -- "NDVI 43 <= 0.27" --> L12["360 Samples:
W 97.6%"]
 L11 -- "NDVI 43 > 0.27" --> L13["160 Samples:
W 83.1%"]

 L13 -- "TMI <= 473.0" --> L14["869 Samples:
NW 96.7%"]
 L13 -- "TMI > 473.0" --> L15["6683 Samples:
NW 99.9%"]

 L15 -- "TMI <= 378.0" --> L16["257 Samples:
W 97.7%"]
 L15 -- "TMI > 378.0" --> L17["3067 Samples:
NW 91.6%
W 8.4%"]

 L17 -- "NDVI 43 <= 0.01" --> L18["257 Samples:
W 97.7%"]
 L17 -- "NDVI 43 > 0.01" --> L19["2810 Samples:
NW 99.7%"]

 R1 -- "NDVI S2 <= 0.23" --> R2["22869 Samples:
NW 84.6%
W 15.4%"]
 R1 -- "NDVI S2 > 0.23" --> R3["97860 Samples:
NW 98.8%
W 1.2%"]

 R2 -- "TMI <= 334.5" --> R4["10428 Samples:
NW 68.5%
W 31.5%"]
 R2 -- "TMI > 334.5" --> R5["12441 Samples:
NW 98.1%"]

 R4 -- "NDVI 43 <= 0.54" --> R6["5925 Samples:
NW 46.6%
W 53.4%"]
 R4 -- "NDVI 43 > 0.54" --> R7["4503 Samples:
NW 97.4%"]

 R7 -- "NDVI S2 <= 0.17" --> R8["2211 Samples:
NW 78.5%
W 21.5%"]
 R7 -- "NDVI S2 > 0.17" --> R9["3458 Samples:
NW 65.6%
W 34.4%"]

 R8 -- "TMI <= 129.5" --> R10["484 Samples:
W 63.2%"]
 R8 -- "TMI > 129.5" --> R11["1727 Samples:
NW 90.2%"]

 R11 -- "TMI <= 300.5" --> R12["889 Samples:
W 75.7%"]
 R11 -- "TMI > 300.5" --> R13["358 Samples:
NW 88.5%"]

 R9 -- "NDVI 43 <= 0.45" --> R14["1877 Samples:
NW 91.3%
W 4.6%"]
 R9 -- "NDVI 43 > 0.45" --> R15["10034 Samples:
NW 98.4%"]

 R14 -- "TMI <= 249.5" --> R16["7580 Samples:
NW 91.3%
W 4.6%"]
 R14 -- "TMI > 249.5" --> R17["17614 Samples:
NW 95.4%
W 4.6%"]

 R17 -- "TMI <= 249.5" --> R18["80248 Samples:
NW 99.6%"]
 R17 -- "TMI > 249.5" --> R19["5703 Samples:
NW 97.9%"]

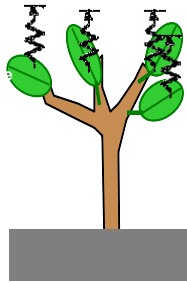
 R19 -- "TMI <= 384.5" --> R20["1877 Samples:
NW 71.2%
W 28.8%"]
 R19 -- "TMI > 384.5" --> R21["620 Samples:
W 58.4%"]

 R20 -- "TMI <= 129.5" --> R22["185 Samples:
W 61.8%"]
 R20 -- "TMI > 129.5" --> R23["1072 Samples:
NW 94.0%"]

```



# Evapotranspiration (ET)

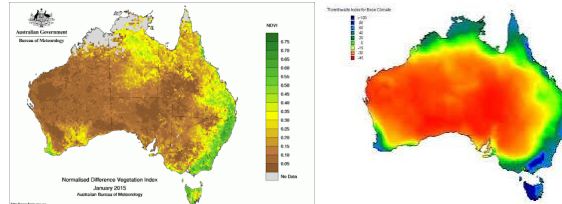


Stomatal conductance  
– vegetation indices

Ground surface  
evaporation

Fluxes

From remote sensing (VI and moisture index):



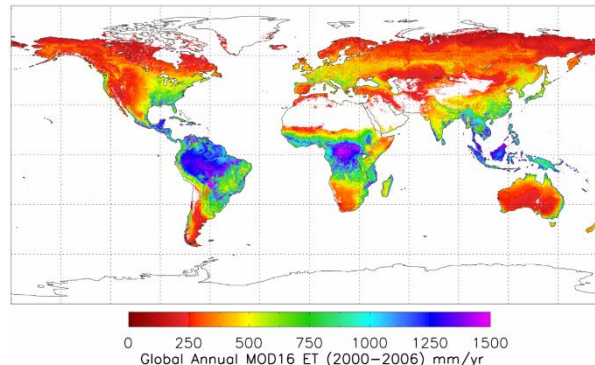
Plus albedo and biome type



Priestley-Taylor Potential Evap  
Penman-Monteith equation:

$$LE = \frac{\Delta Rn + \rho c_p (e_s - e_a) / r_a}{\Delta + \gamma \left( 1 + \frac{r_s}{r_a} \right)}$$

- Net radiation
- Soil heat flux
- Air temperature
- Wind speed
- Vapour pressure deficit
- ...

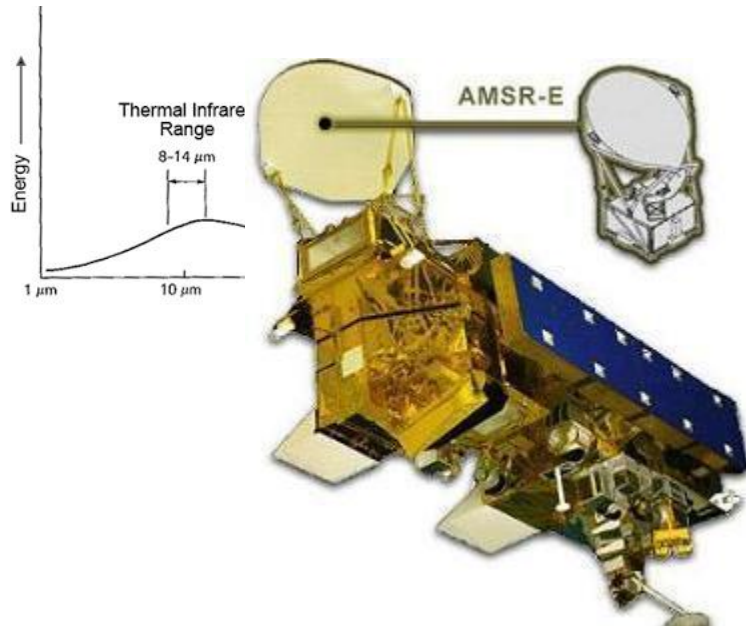


- Guerschman et al (2009). Scaling of potential evapotranspiration with MODIS data reproduces flux observations and catchment water balance observations across Australia. *J Hydrol*, 369:107-119
- Glenn et al. (2011). Actual evapotranspiration estimation by ground and remote sensing methods: the Australian experience. *Hydrological Processes*. doi.org/10.1002/hyp.8391
- Yebra et al. (2012). Evaluation of optical remote sensing to estimate actual evapotranspiration and canopy conductance. *Remote Sensing of Environment*, doi.org/10.1016/j.rse.2012.11.004

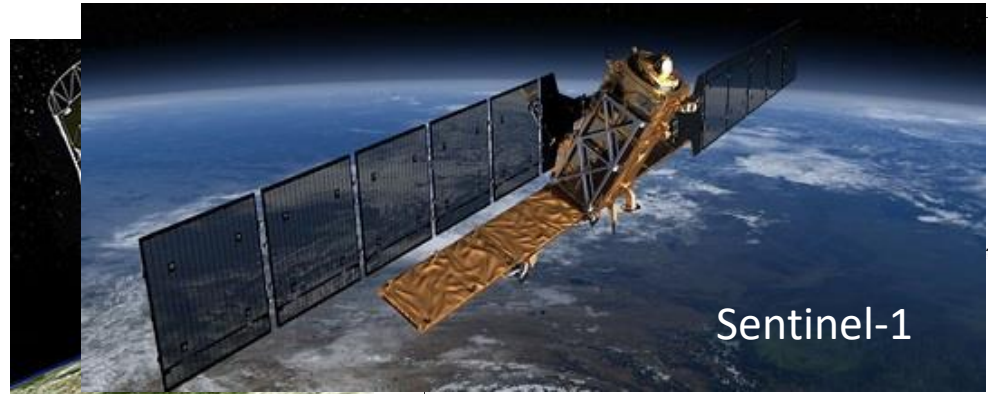


# Soil moisture detection

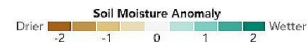
- Exploits active and passive microwave measurements
- Large differences in the **dielectric constant** between dry and wet soils



## Soil Moisture Active Passive (SMAP) mission

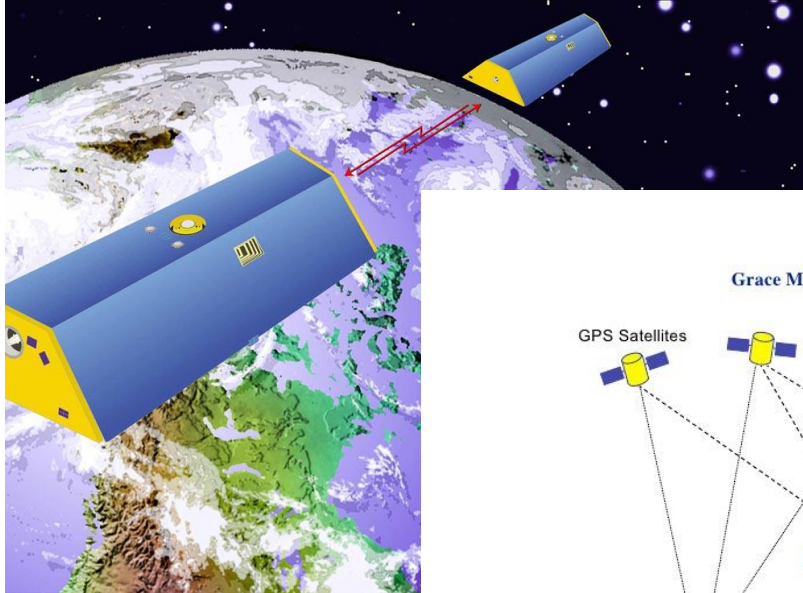


Sentinel-1

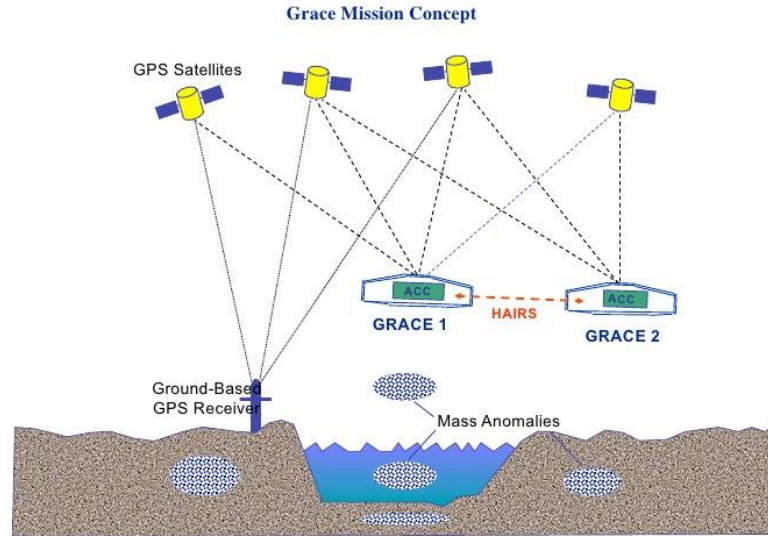




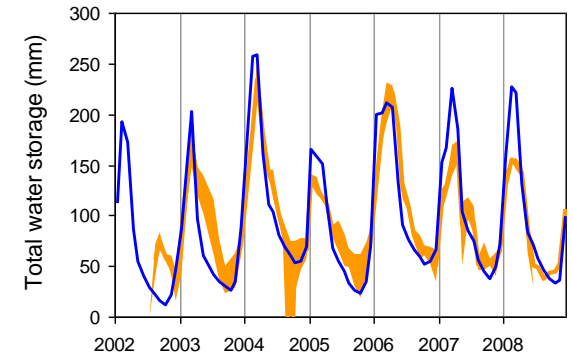
# GRACE



Differential effect  
of gravity on the  
two satellites



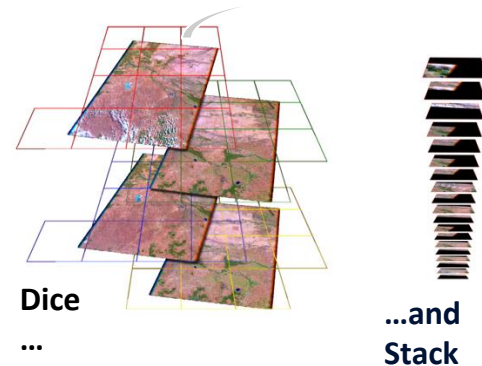
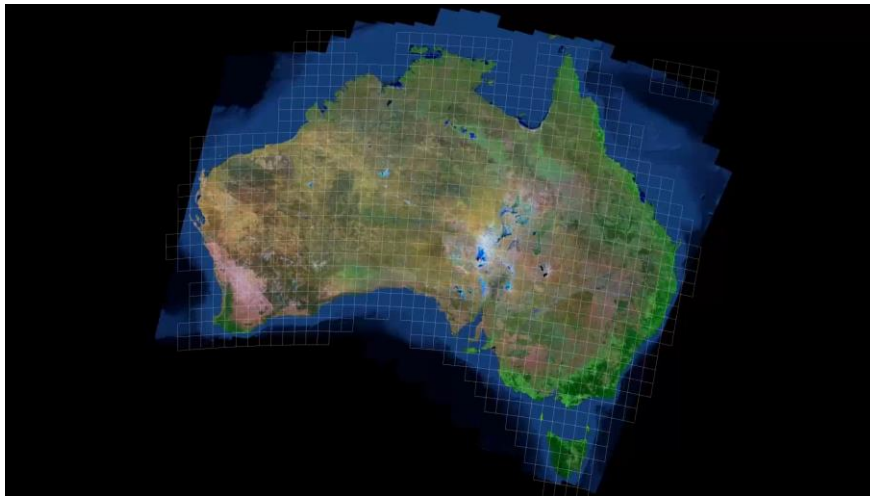
## Total water storage



Gravity Recovery and Climate Experiment GRACE (2002-2017); GRACE Follow On (2018-2023)



- Data cubes are collections of Analysis Ready Data
- Hubs for product generation and analytics



ARD: 'satellite data that have been processed to a minimum set of requirements and organized into a form that allows immediate analysis without additional user effort and interoperability with other datasets both through time and space' (<http://ceos.org/ard/>).



# How are ARD produced?

- Pre-processing
  - Geometric correction / spatial alignment
  - Atmospheric correction } conversion of raw digital numbers
  - Terrain correction } to surface reflectance
  - Quality assurance
  - Spatial partitioning and packaging for delivery
- Additional for aqueous ARD:
  - Land masking
  - Sun-glint removal
  - Water column (depth) correction

Level 0



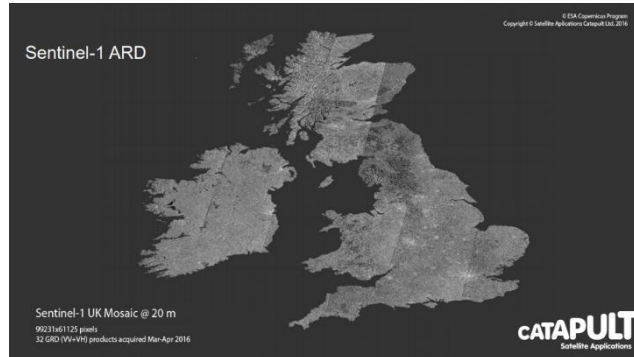
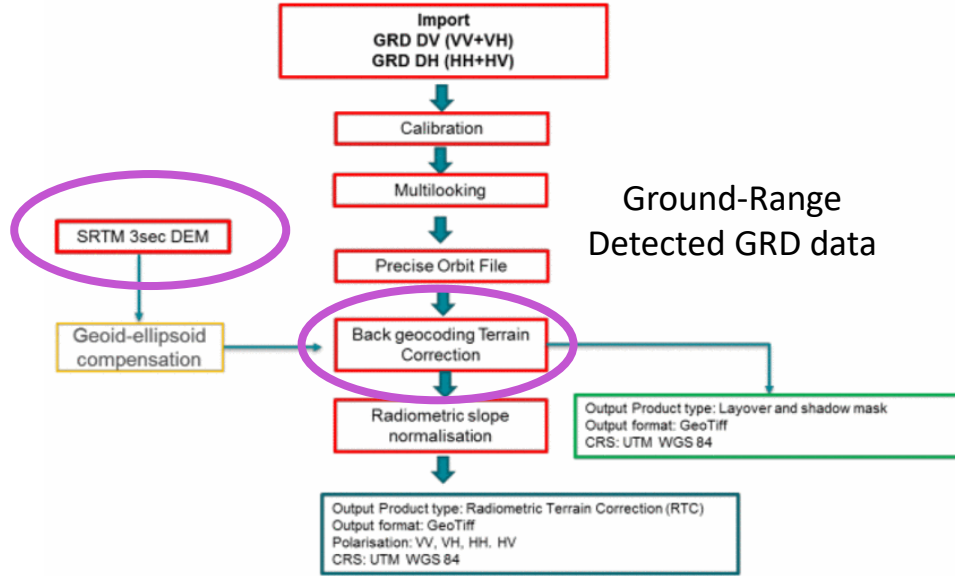
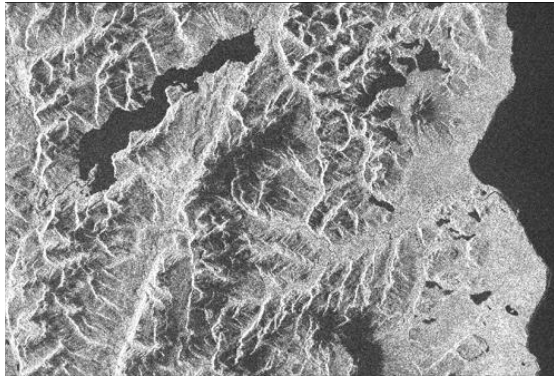
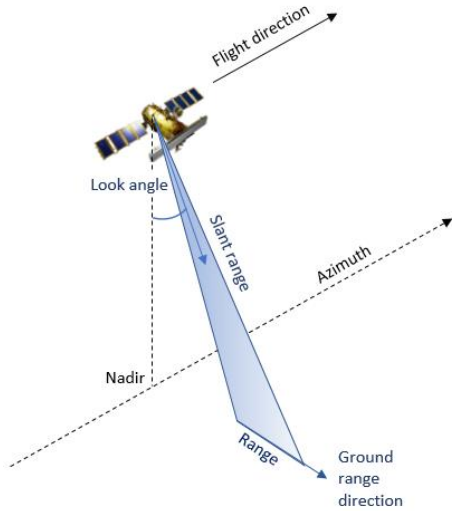
Level 1



Level 2



# Radar ARD





# Copernicus programme / Regional hub



Australian Government | European Union | Copernicus Europe's eyes on Earth | copernicus AUSTRALASIA REGIONAL DATA HUB

[Regional Data Access](#) [User Guide](#) [News & Events](#) [About Us](#) [Links & Resources](#) [Contact Us](#)

## Regional Data Access

Regional data access is currently provided through both NCI's [THREDDS server](#) and the [Sentinel Australasia Regional Access \(SARA\) interface](#). SARA provides

<http://www.copernicus.gov.au/regionaldataaccess>





# Thank you

**Oceans and Atmosphere**

Tim Malthus

Research Group Leader

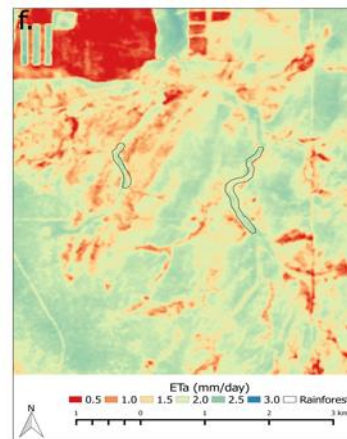
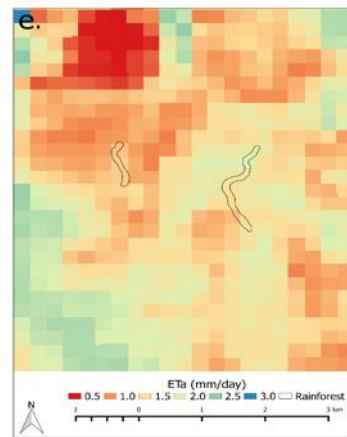
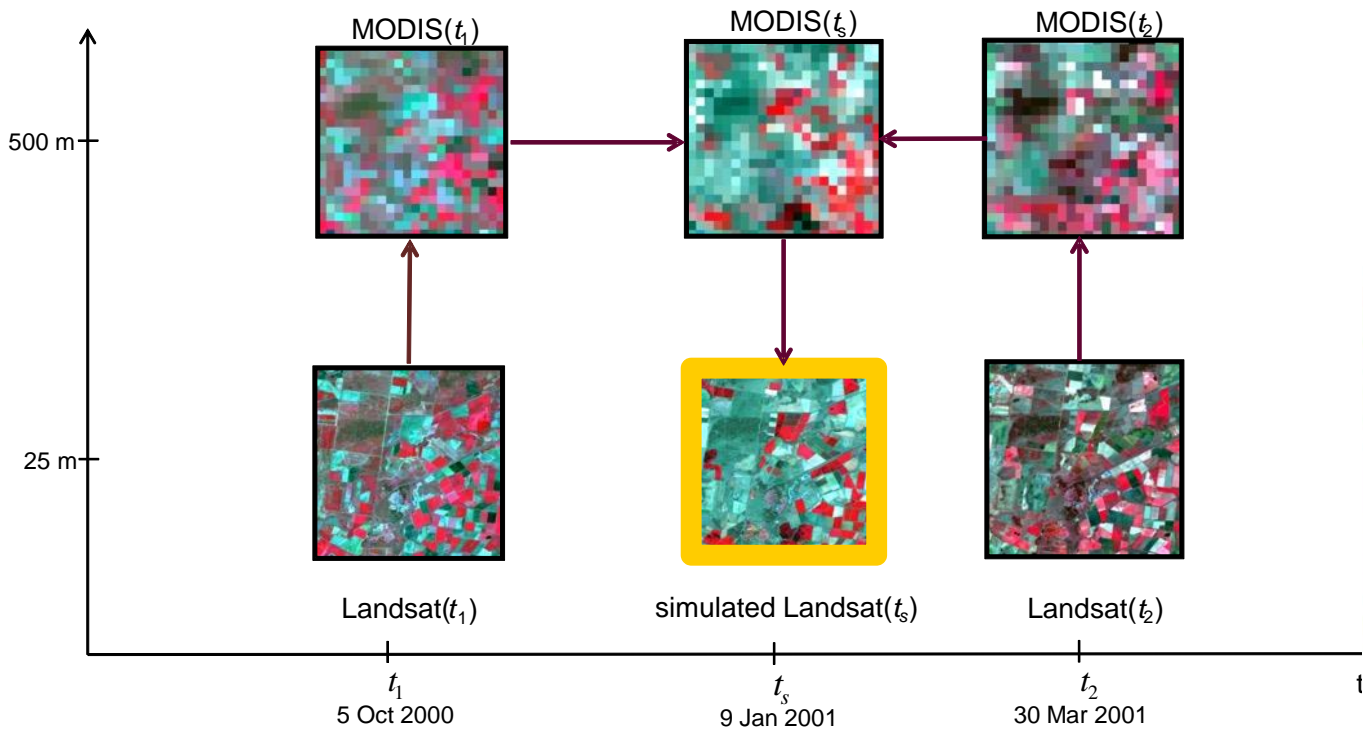
+61 3 3833 5583

[tim.malthus@csiro.au](mailto:tim.malthus@csiro.au)



# Example - Landsat-MODIS blending

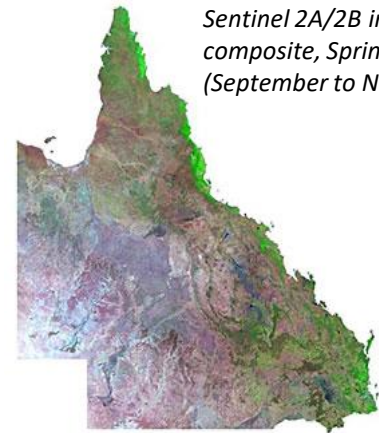
Spatial resolution



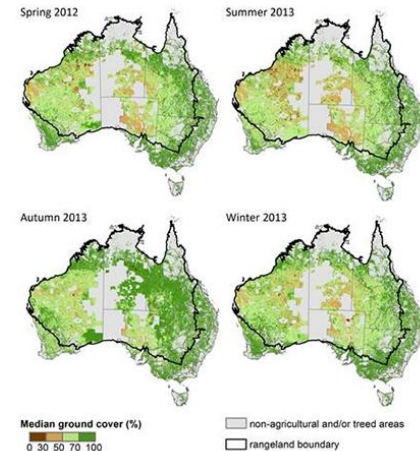


# Sources of data and products

- **Copernicus Regional Hub** – Source of Sentinel ARD data
- **Geoscience Australia** – DEA, WofS, fire/flood related products...
- **DNRME, QLD Govt** – remotely sensed imagery, lidar, photography, floods
- **DES, QLD Govt** – Ground cover, land use, vegetation change, structure
- **The Long Paddock** – Met data and forecasts, fires, SST...
- **BoM** – Reef Temp, eReefs marine water quality dashboard...
- **TERN** – Land cover dynamics, vegetation structure, fire related
- **IMOS** – SST, Ocean colour, altimetry, surface waves...
- **CSIRO** – NovaSAR data



*Sentinel 2A/2B image composite, Spring 2017 (September to November).*



*Fractional cover dynamics, MODIS*



# Remote sensing and modelling

| Remote Sensing                                                 | Models                                    |
|----------------------------------------------------------------|-------------------------------------------|
| Higher spatial and temporal coverage than in situ measurements | High spatial and temporal resolution      |
| 40+ year time series (hindcasting)                             | Tool for forecasting, scenario assessment |
| Surface view only, some structural info                        | 3D structure                              |
| Cloud interference in optical, thermal                         | Cloud free, continuous                    |
| Large uncertainties                                            | Uncertainties?                            |
| Satellite drifts, calibration for time series                  | Process understanding                     |
| Regional and temporal biases                                   |                                           |





# Radar as detector of water

- Dielectric constant...
- Example of flooding / flood detection



# A role for Remote Sensing ?

- Visualisation strengths, contextual information
- Well suited for repeated monitoring of intertidal and subtidal zones
- Provides near-instantaneous synoptic coverage
- Objective, non-invasive
- Digital
- Rapid
- Cost effective
- Is an aid to field survey - can be used to target field survey, reduce costs and labour intensity



# Satellite optical remote sensing - issues

- Limited spectral resolution
- Restricted penetration in water column
- Dependence on cloud free weather
- Acquisition limited by overpass of satellite
- Requires low tide acquisition for intertidal studies
- Needs ground support (field work, calibration)