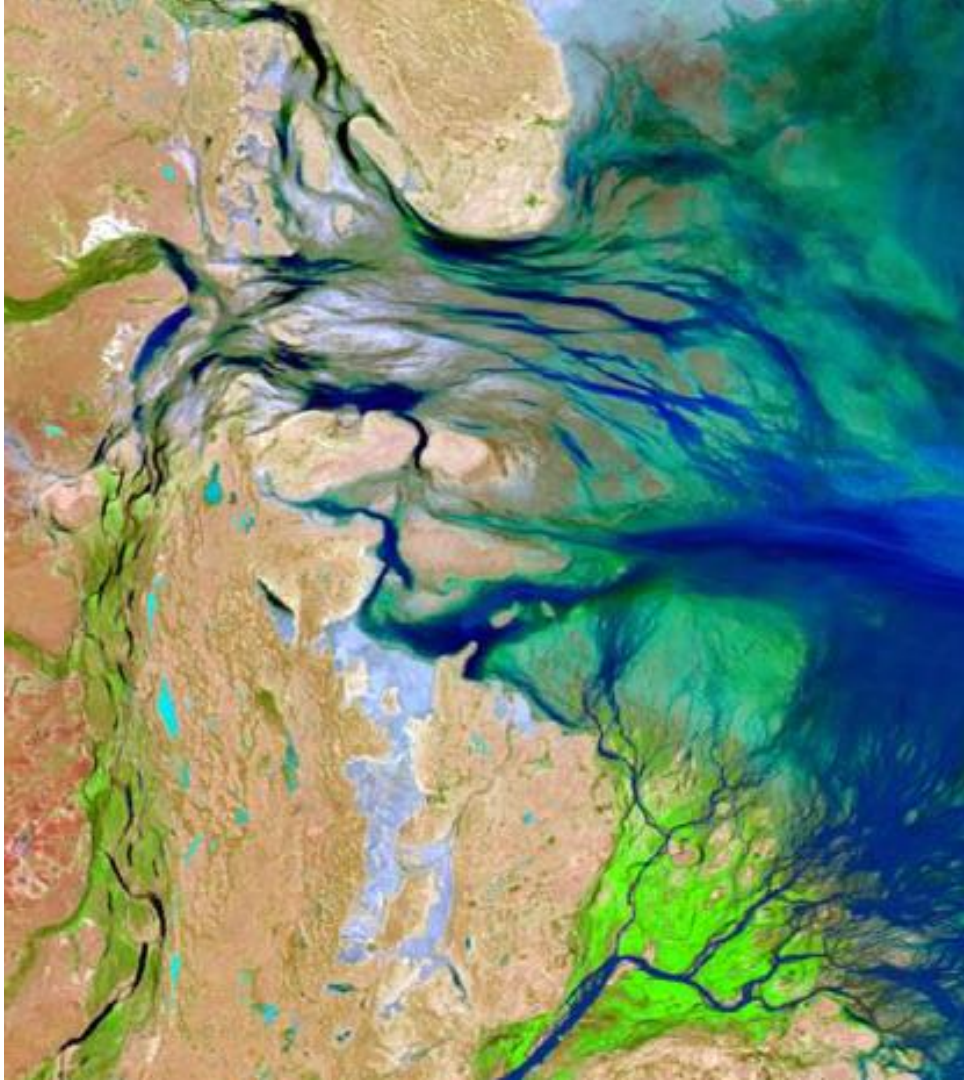
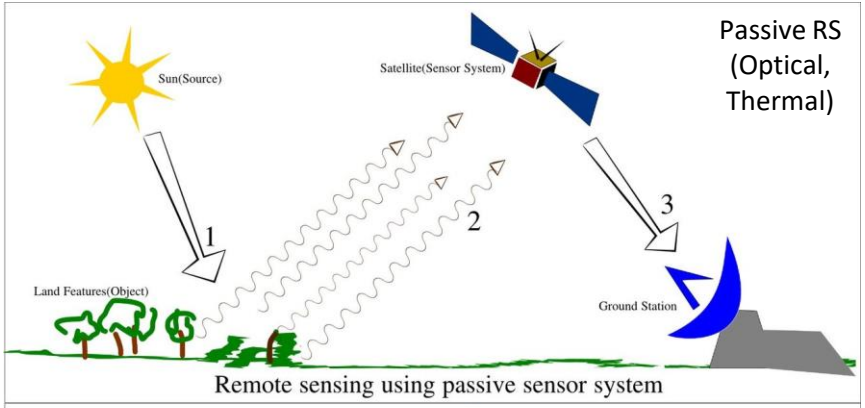
Remote sensing for landscape and water management

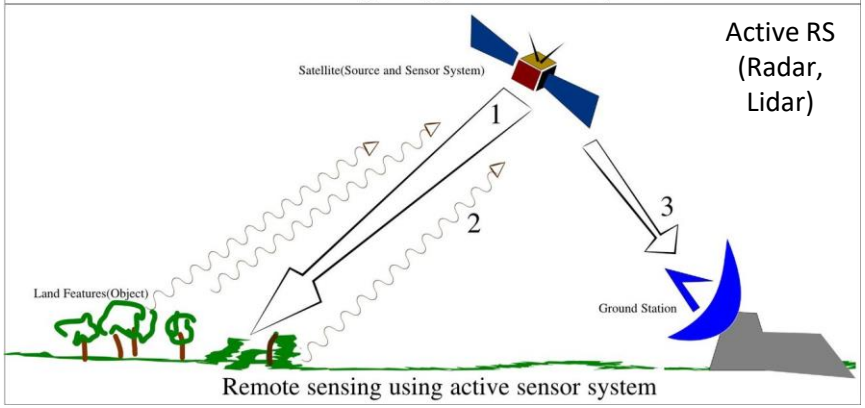
Principles for water modellers

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



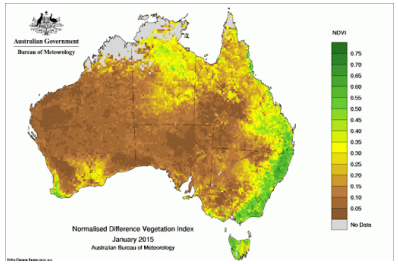
Introduction to remote sensing (in 1 slide…)



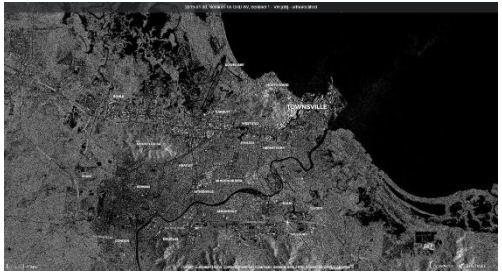


Landsat scene

Exploits spectral signature

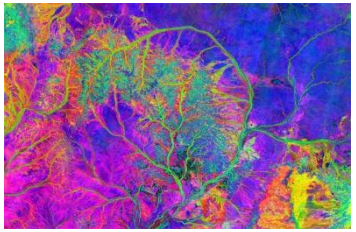


NDVI composite



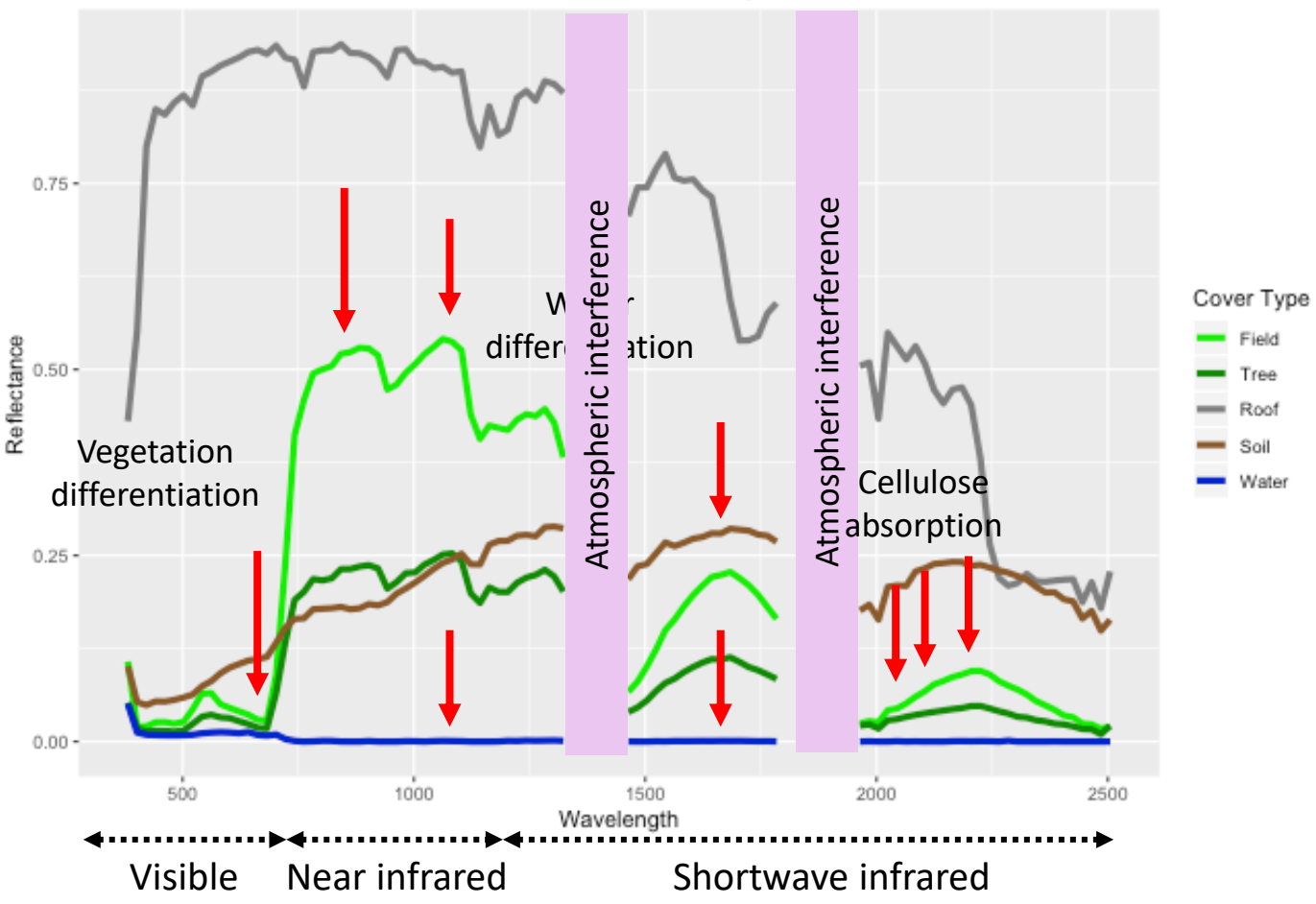
Sentinel-1 scene

Exploits structural or moisture properties



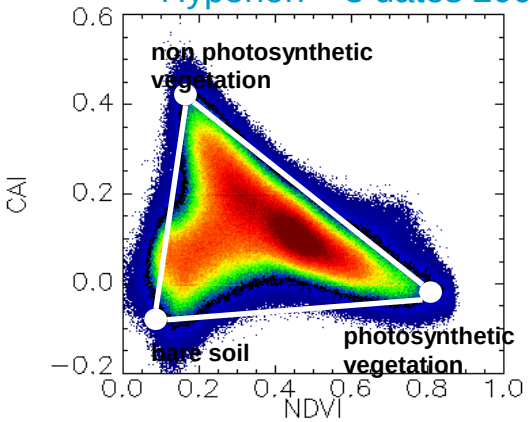
Sentinel-1/2 composite

The spectral signature

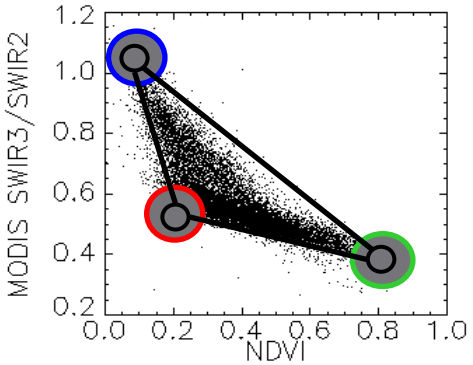


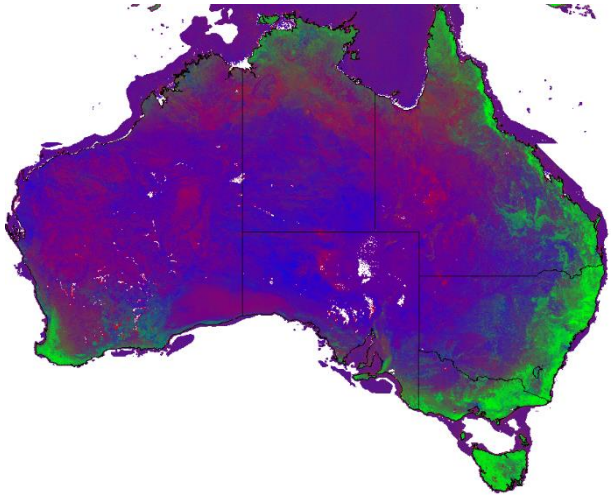
Fractional cover

Hyperion – 3 dates 2005



MODIS version

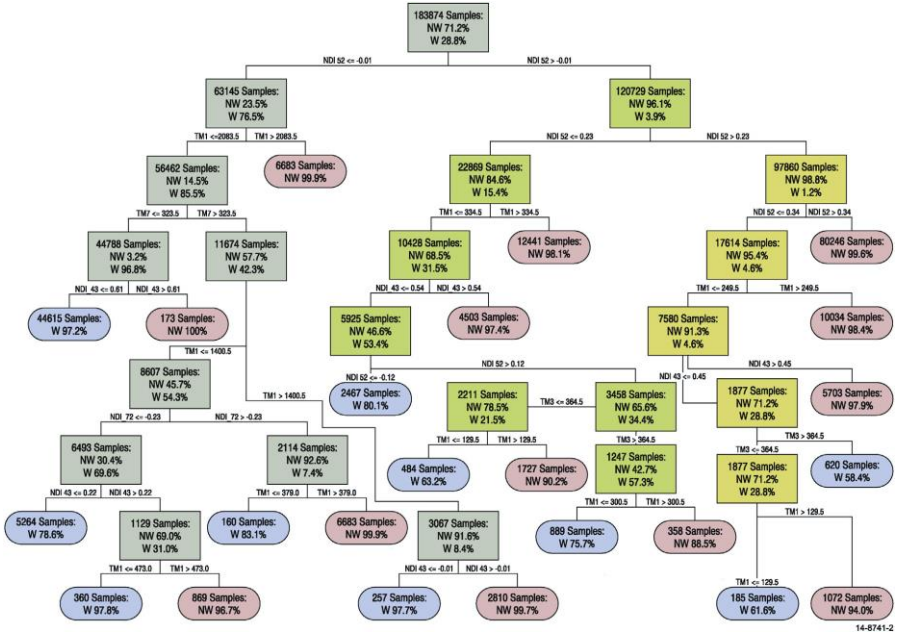




Guerschman et al. (2009). Estimating fractional cover of photosynthetic vegetation, photosynthetic vegetation and bare soil in the Australian tropical savanna region upscaling the EO-1 Hyperion and MODIS sensors. *Remote Sensing of Environment*, 113:928-945

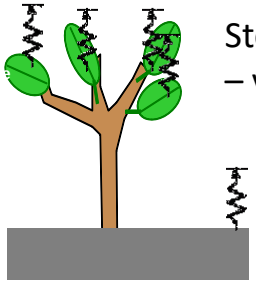
Water Observations from Space algorithm

- Individual spectral bands and normalised difference indices (NDI)
- Basis to detect water from non-water
- Regression tree used to handle potential interferences
  - Shadow
  - Other dark features
  - Size of the features –small water bodies
- Overall classification accuracy of 97%



Mueller et al (2016). Water observations from space: Mapping surface water from 25 years of Landsat imagery across Australia. *Remote Sensing of Environment*, 174, 341–352

Evapotranspiration (ET)

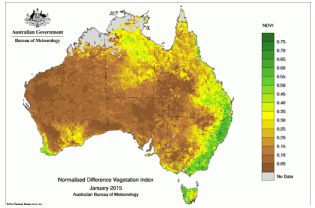


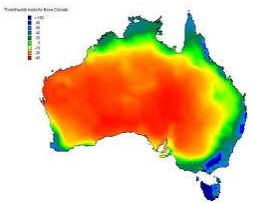
Stomatal conductance – vegetation indices

Ground surface evaporation

Fluxes

From remote sensing (VI and moisture index):



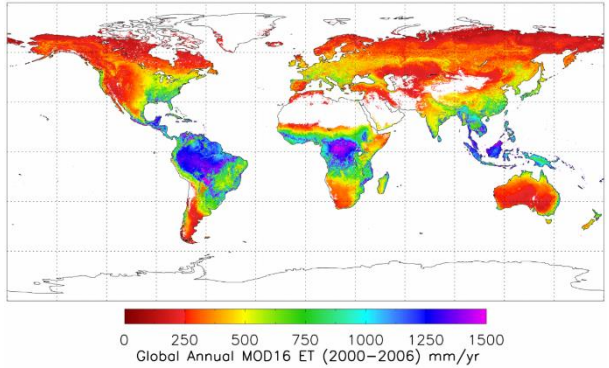


Plus albedo and biome type

Priestley-Taylor Potential Evap
Penman-Monteith equation:

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

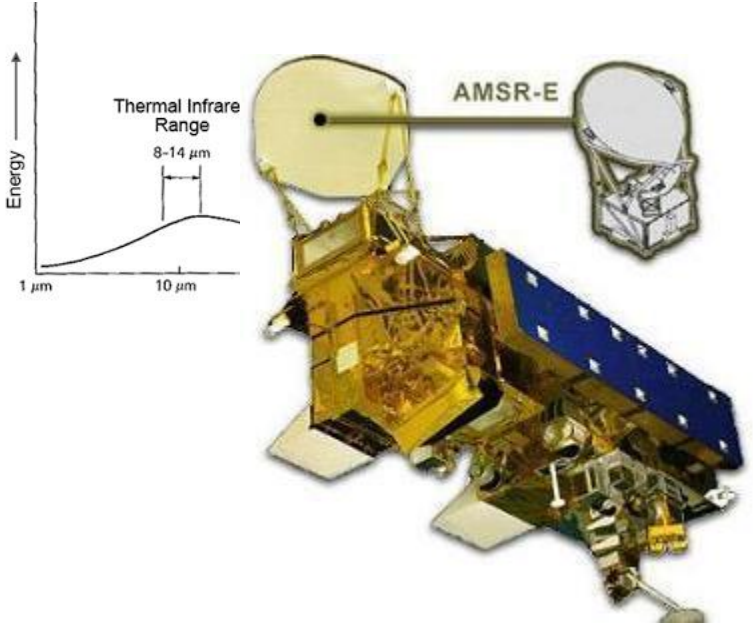
- Net radiation
- Soil heat flux
- Air temperature
- Wind speed
- Vapour pressure deficit
- …



- 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

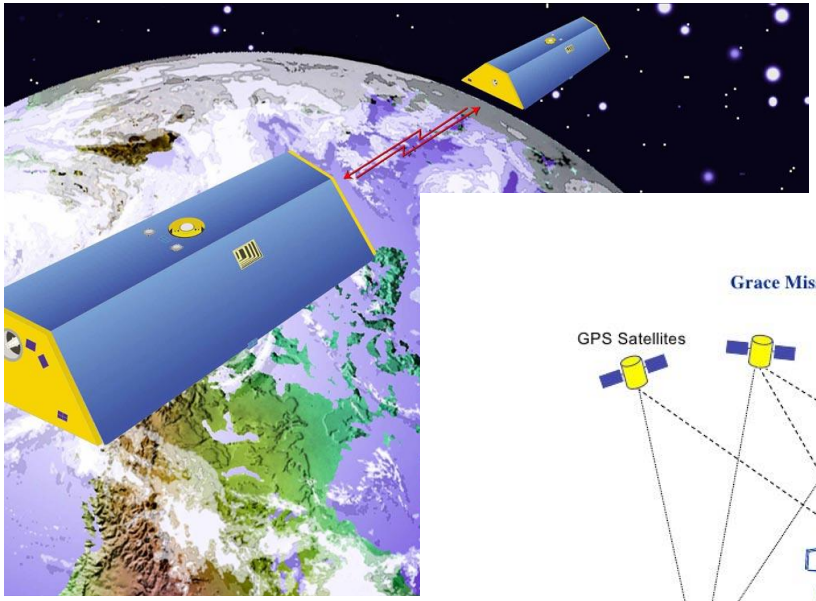
Soil moisture detection

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

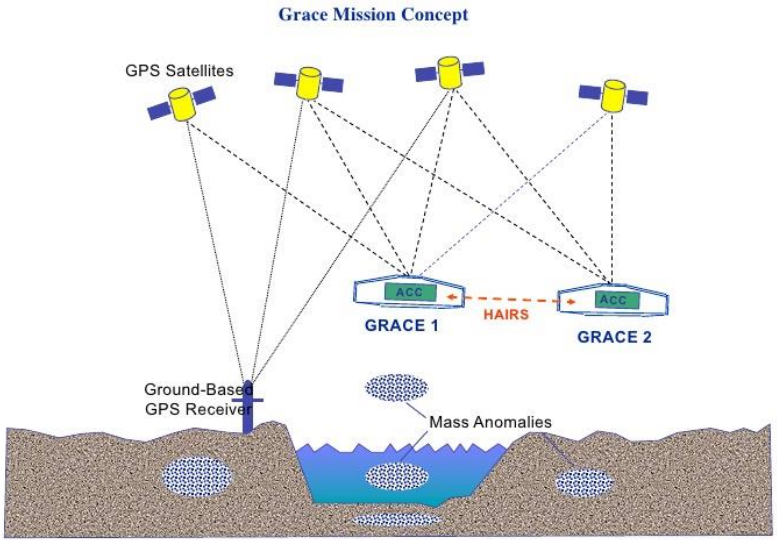


Soil Moisture Active Passive (SMAP) mission

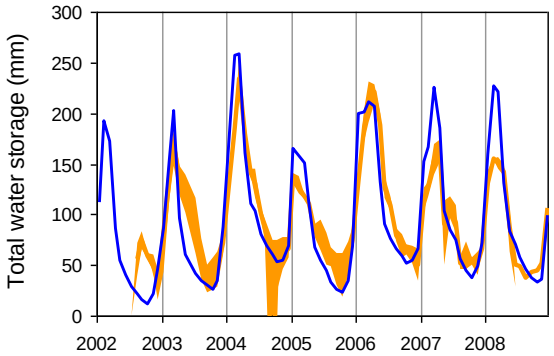
GRACE



Differential effect of gravity on the two satellites



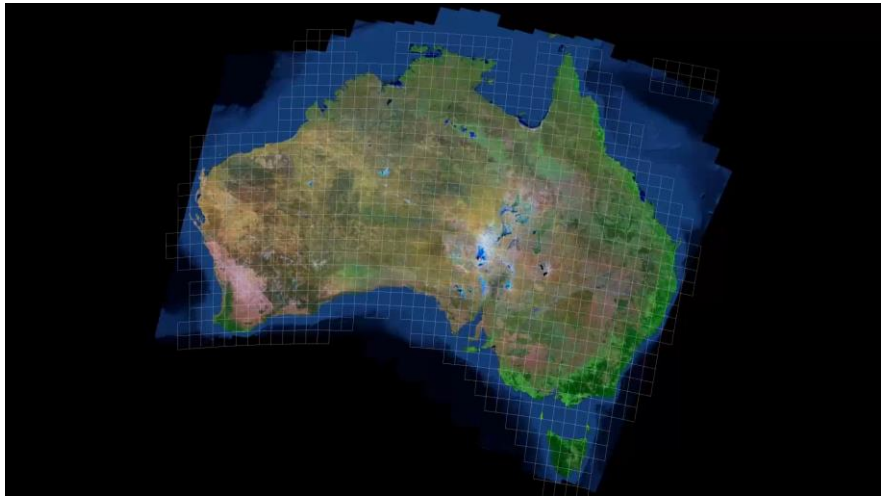
Total water storage

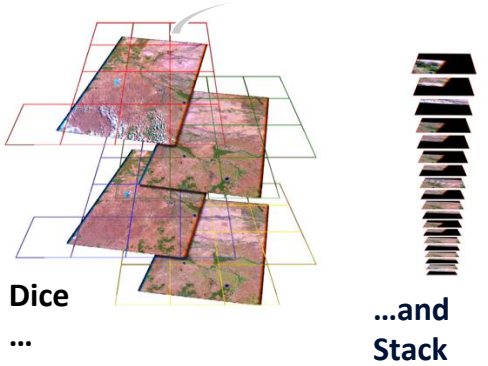


Gravity Recovery and Climate Experiment GRACE (2002-2017); GRACE Follow On (2018-2023)

Analysis Ready Data and Data Cubes

- 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/).

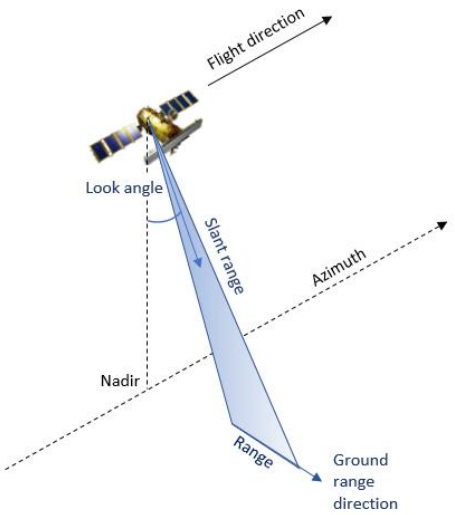
How are ARD produced?

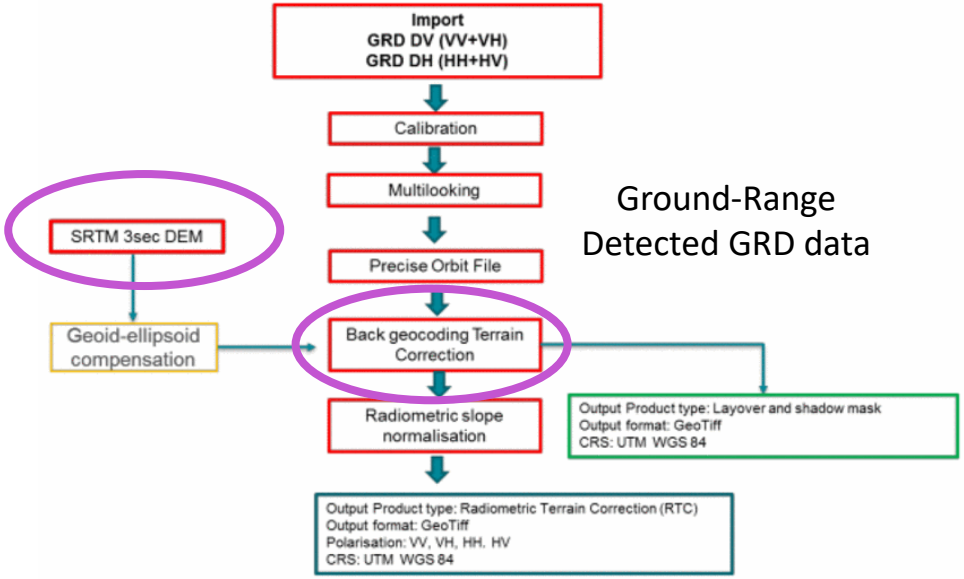
- Pre-processing
  - Geometric correction / spatial alignment
  - Atmospheric correction } conversion of raw digital numbers
  - Terrain correction } to surface reflectance
  - Quality assurance
  - Spatial partitioning and packaging for delivery

  - Additional for aqueous ARD:
    - Land masking
    - Sun-glint removal
    - Water column (depth) correction

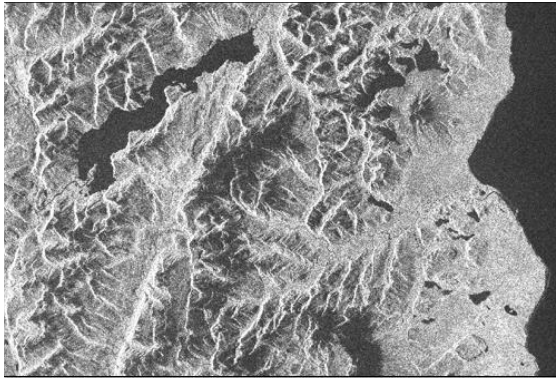
Lewis et al (2017). The Australian Geoscience Data Cube — Foundations and lessons learned. *Remote Sensing of Environment*, 202:276–292

Radar ARD





Ground-Range Detected GRD data



Copernicus programme / Regional hub

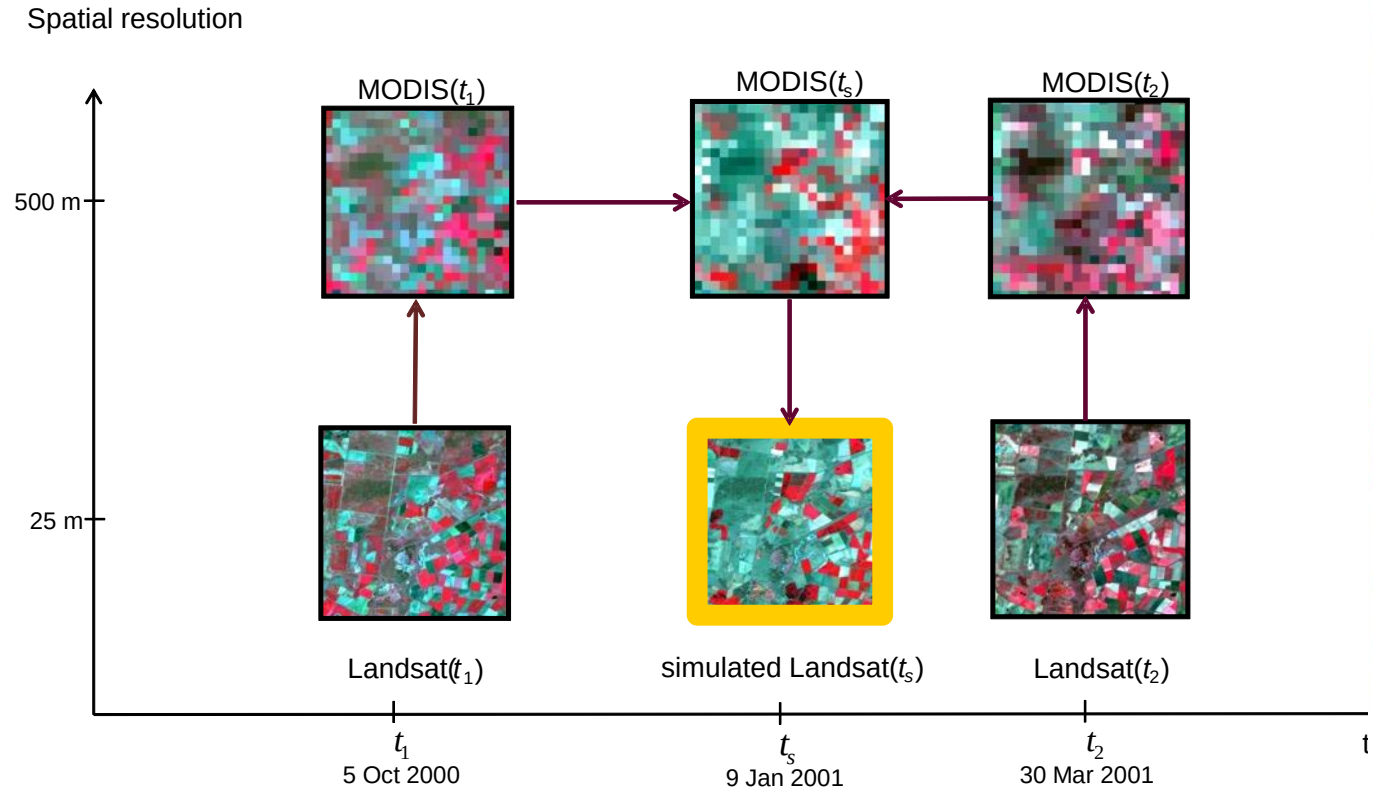
http://www.copernicus.gov.au/regionaldataaccess

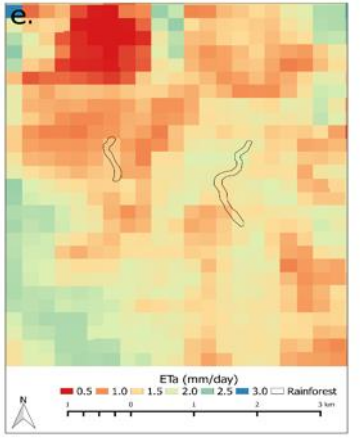
Thank you

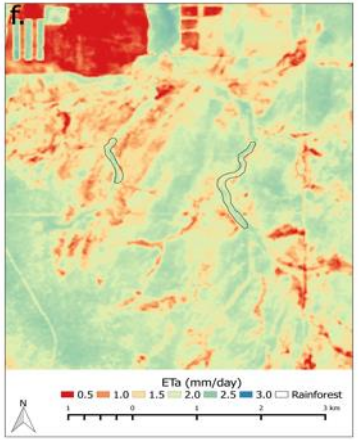
Oceans and Atmosphere
Tim Malthus
Research Group Leader

+61 3 3833 5583
tim.malthus@csiro.au

Example - Landsat-MODIS blending

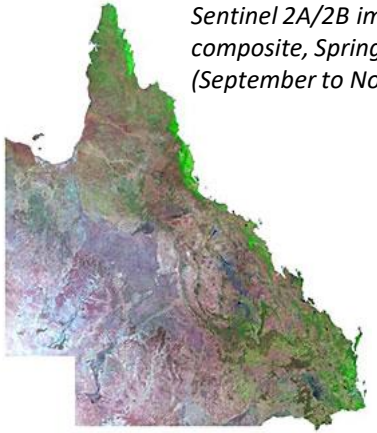




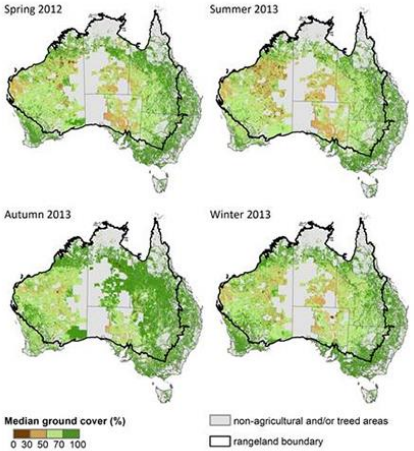


Sources of data and products

- **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)