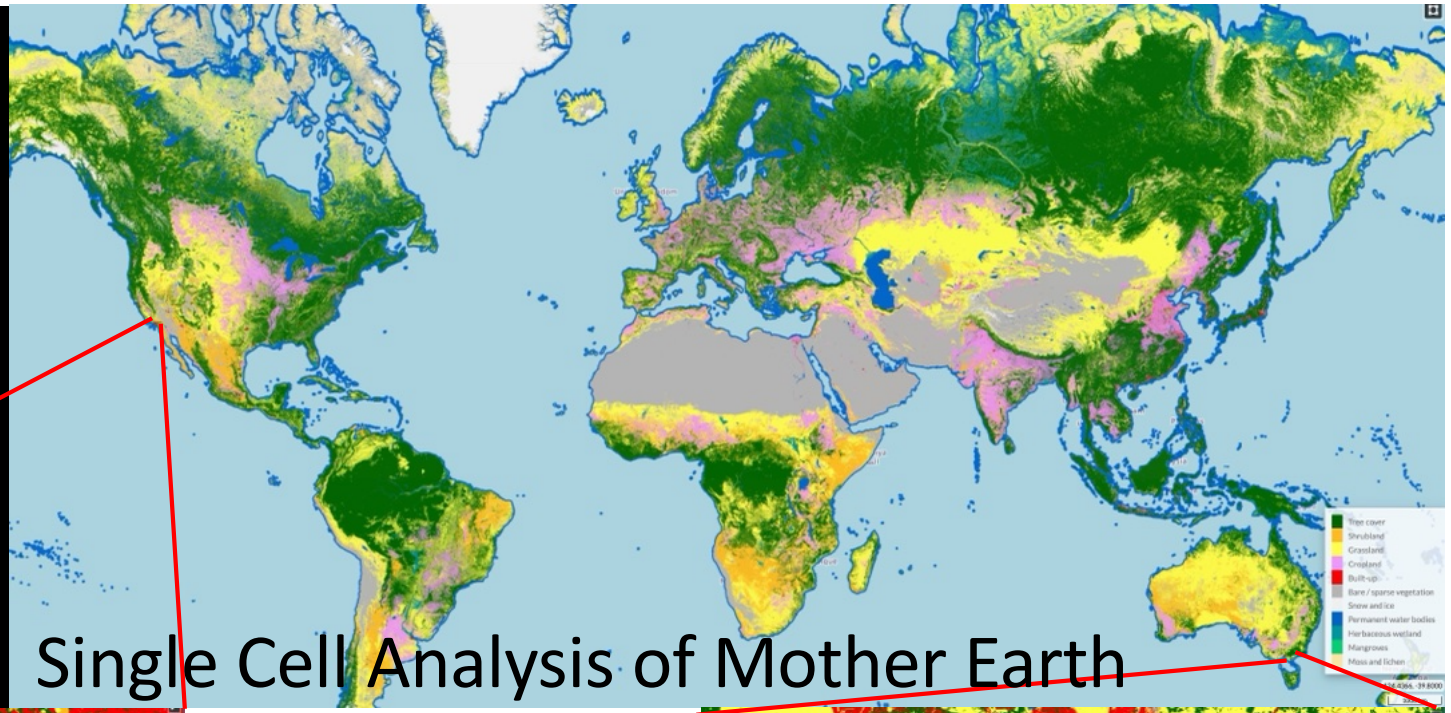
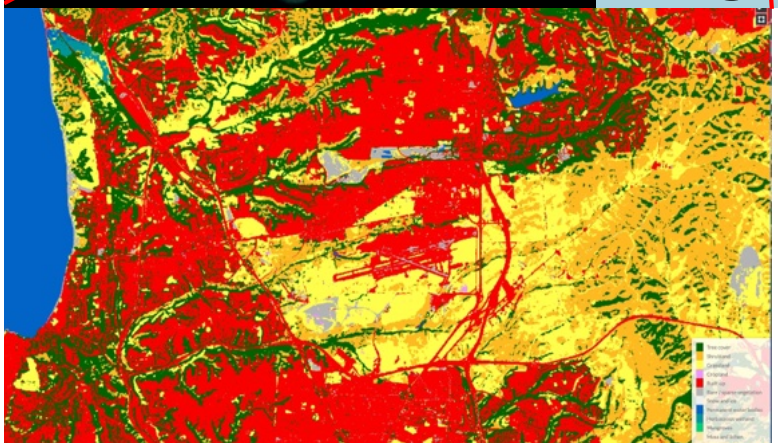
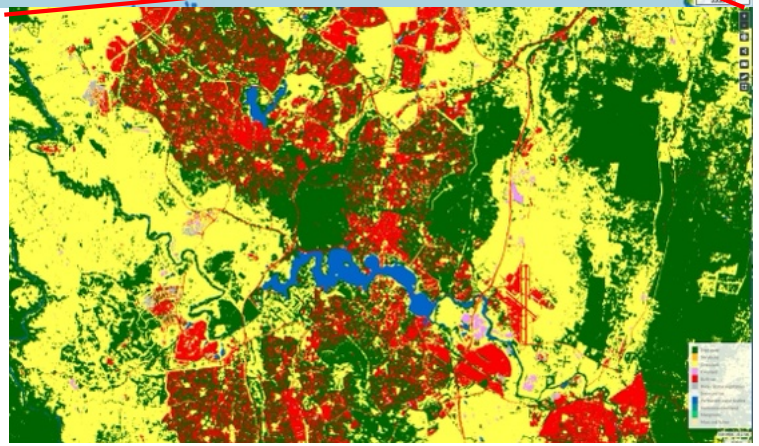


Single Cell Analysis of Mother Earth



Justin Borevitz (ANU)
For Joanne Chory (Salk)

1M climate tissues
10M land cells
10T planet cells
Worldcover.org



21st Century Plant Science for Climate Adaptation

Justin Borevitz (ANU)

For Joanne Chory

Single Cell Analysis of Mother Earth

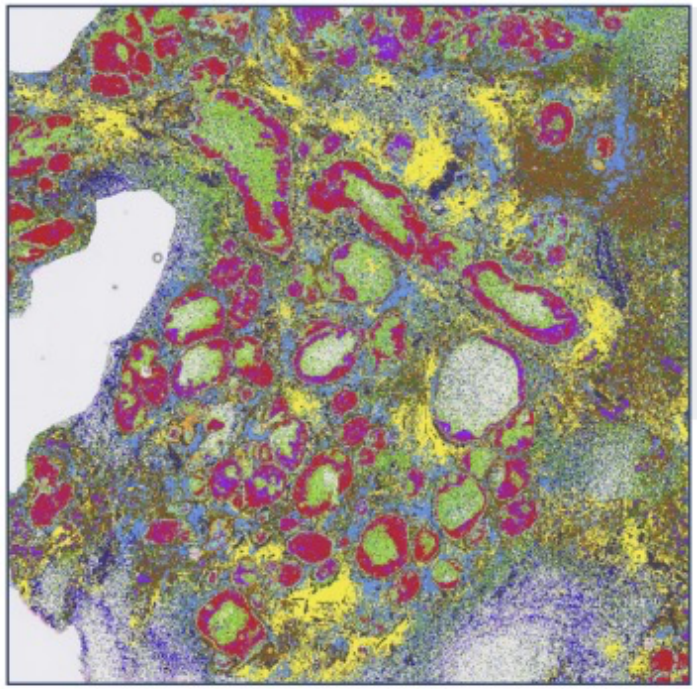
What is a cell? An earth cell?

- Fundamental biological unit of organization
- It can divide, differentiate, die and be replaced.
- Performs physiology and biochemistry
  - Cycles water, carbon and nutrients
- Grows in size (height-depth, area index, mass partition)
  - According to environmental inputs and genetic program
- Changes into different types (annual, perennial, woody)
- Develops states - new organ(ell)s and allocations
  - According to environmental inputs and genetic program

1M tissues * 10M cells = 10T cells in the body

Boundless discovery potential in every micron

Spatially mapped GEX clustering



10X Genomics Visium HD
2um pixel (3000x4000=12M)
Up to 20k genes, clustered into
7+ cell types
1 time point

10T Cells in Gaia - Mother Earth

10M Tissues (Agro-Ecosystems) 10km^2 – 1M cells

Single cell - 10m square pixel - ~30cm-1m deep - ~30cm-10m /tall

Gaia Cell types

- Annual Crop – Canola/Arabidopsis | legume | cereal
- Perennial pasture/grassland
- Woody tree

Gaia Cell States

- Environmental input in daily time steps
  - Model water and carbon flows and stocks
  - through plant organs and soil
- Weekly observations from 2017
  - Developmental stages –germ, veg, flowering
  - harvest, stubble/litter, bare

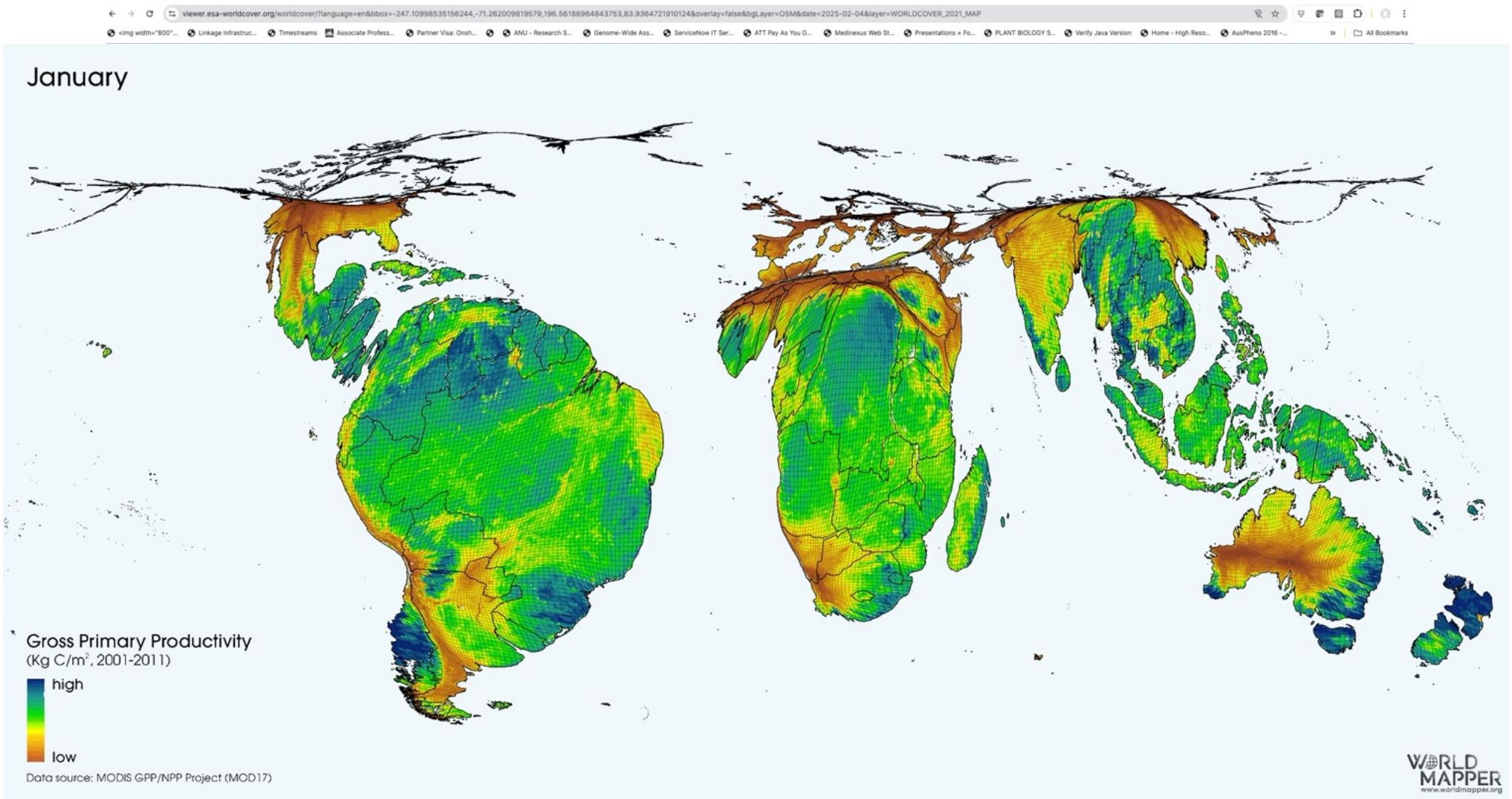
Healthy Natural and Farm Systems

- Natural Ecosystems are a mix of cell types
  - Need to account for dynamic changes - drought, fire and flood
  - on ecosystem growth and development as a measure of health

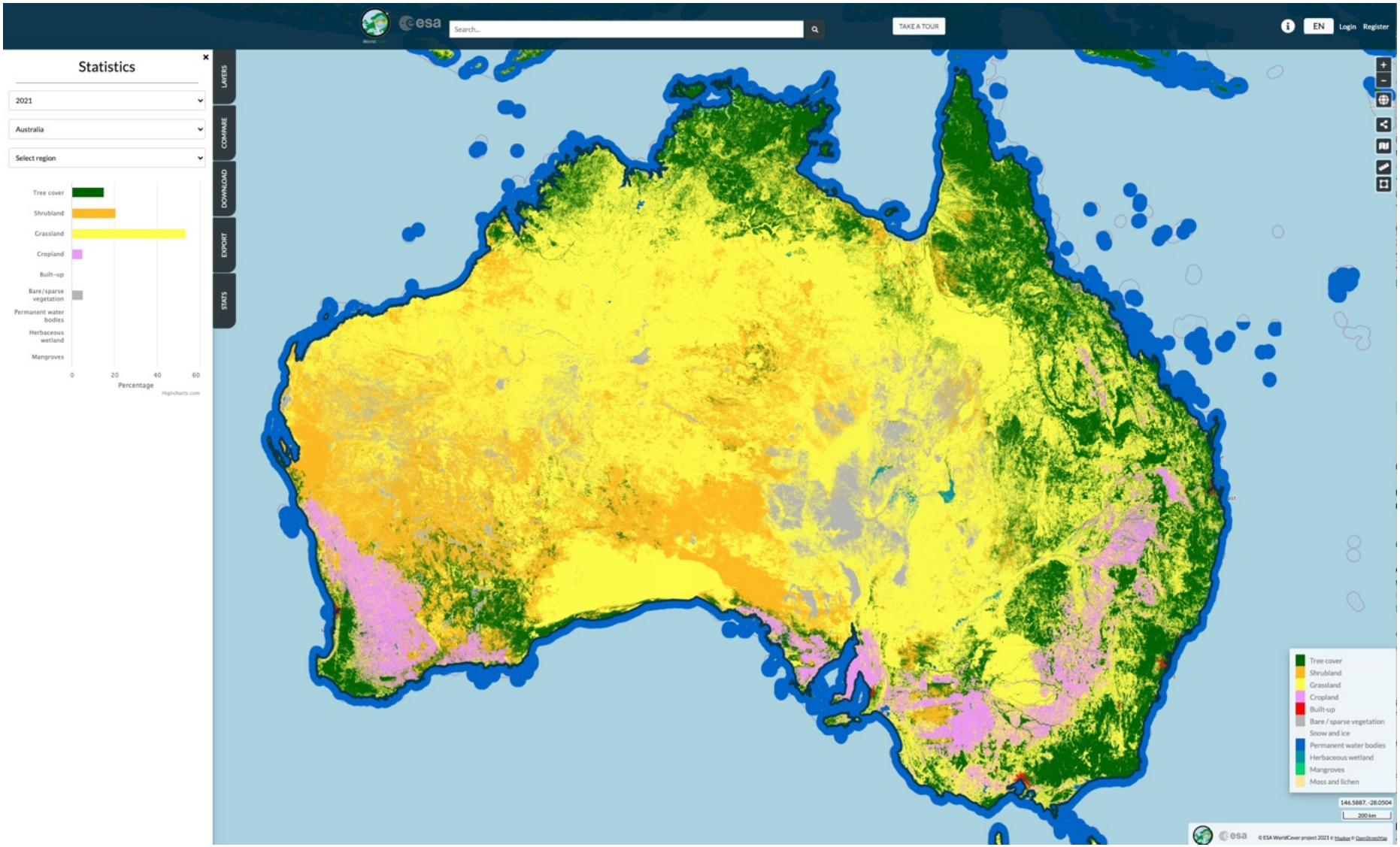
- Humans are altering cell types in Agriculture and Forestry
  - Need to account for **natural and managed** dynamic changes
  - on seasonal biomass and yield – health and productivity

- How best to integrate human and natural systems?

  While dealing with extreme climates going forward - not back



Nature’s heartbeat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Bare/sparse vegetation
Permanent water bodies
Herbaceous wetland
Mangroves
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60
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Cropland
Built-up
Bare / sparse vegetation
Snow and ice
Permanent water bodies
Herbaceous wetland
Mangroves
Moss and lichen
146.5887, -28.0504
200 km
esa
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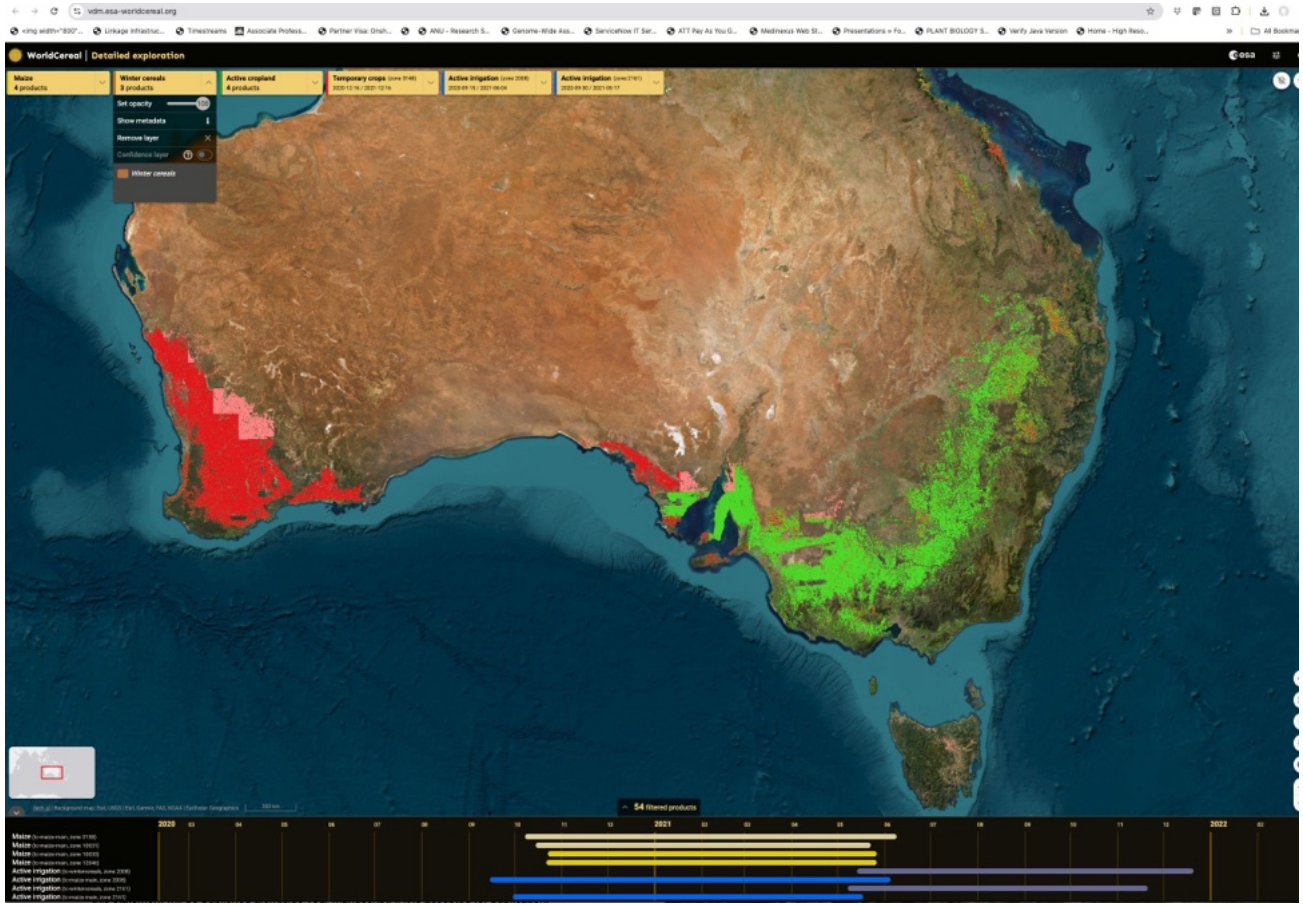
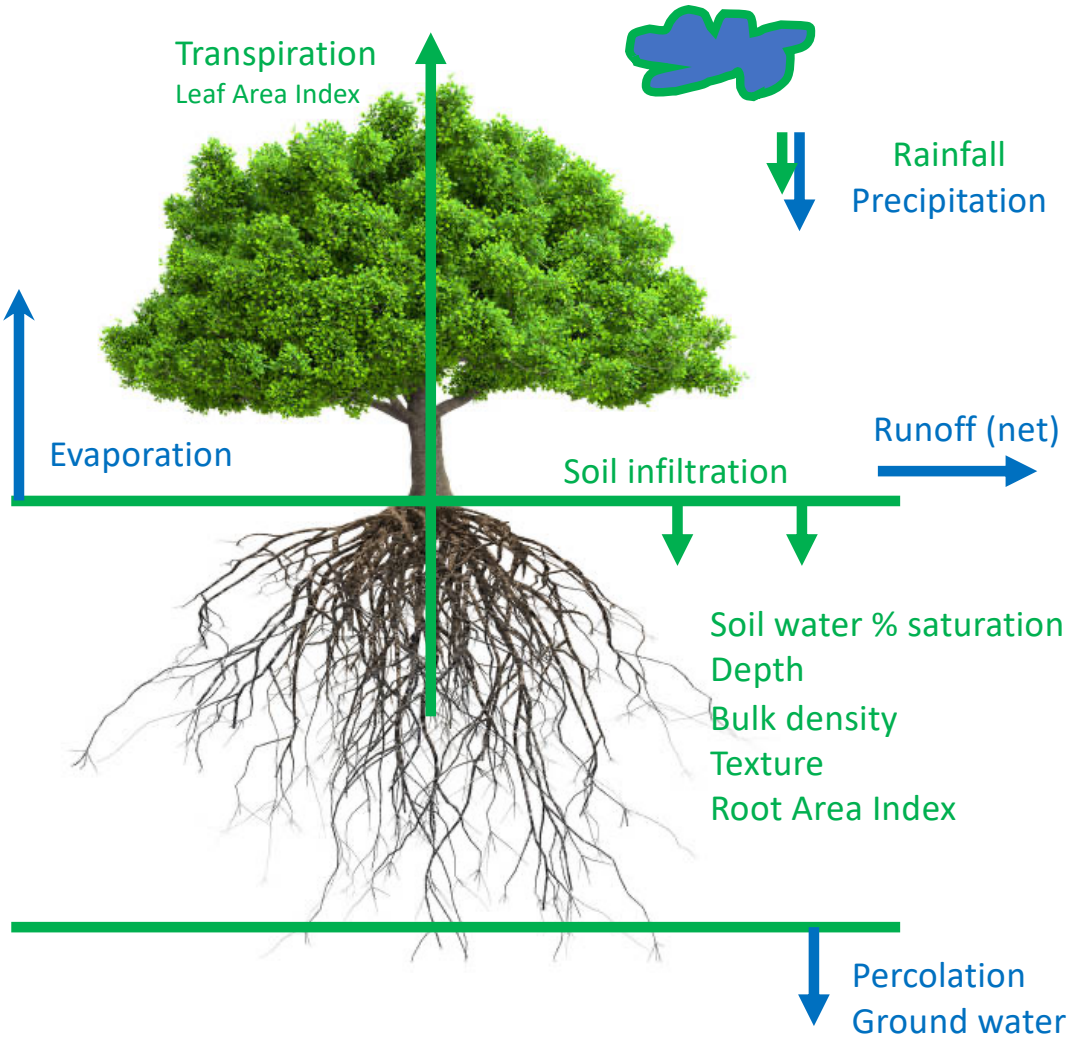
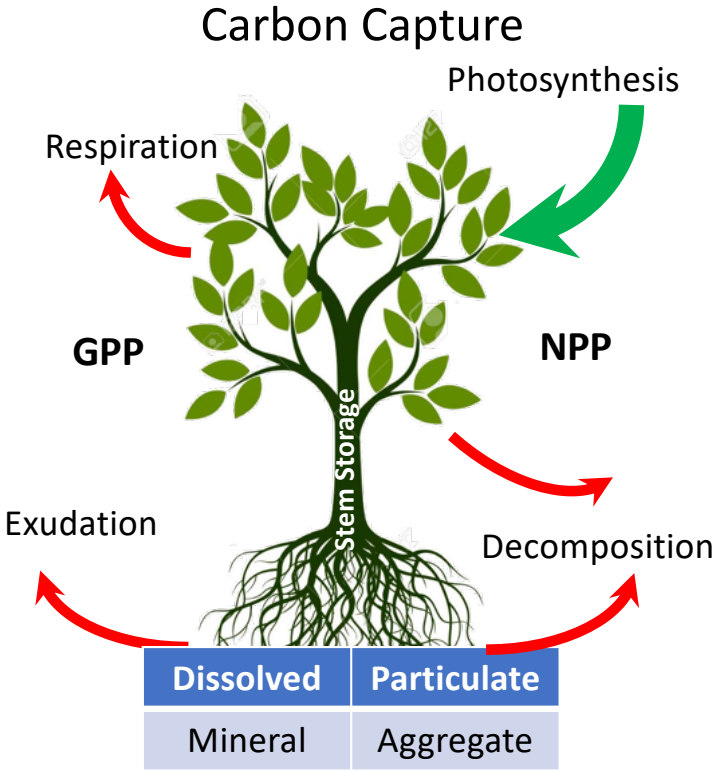
Global crop calendars of maize and wheat in the framework of the WorldCereal project



Earth Cell Processes





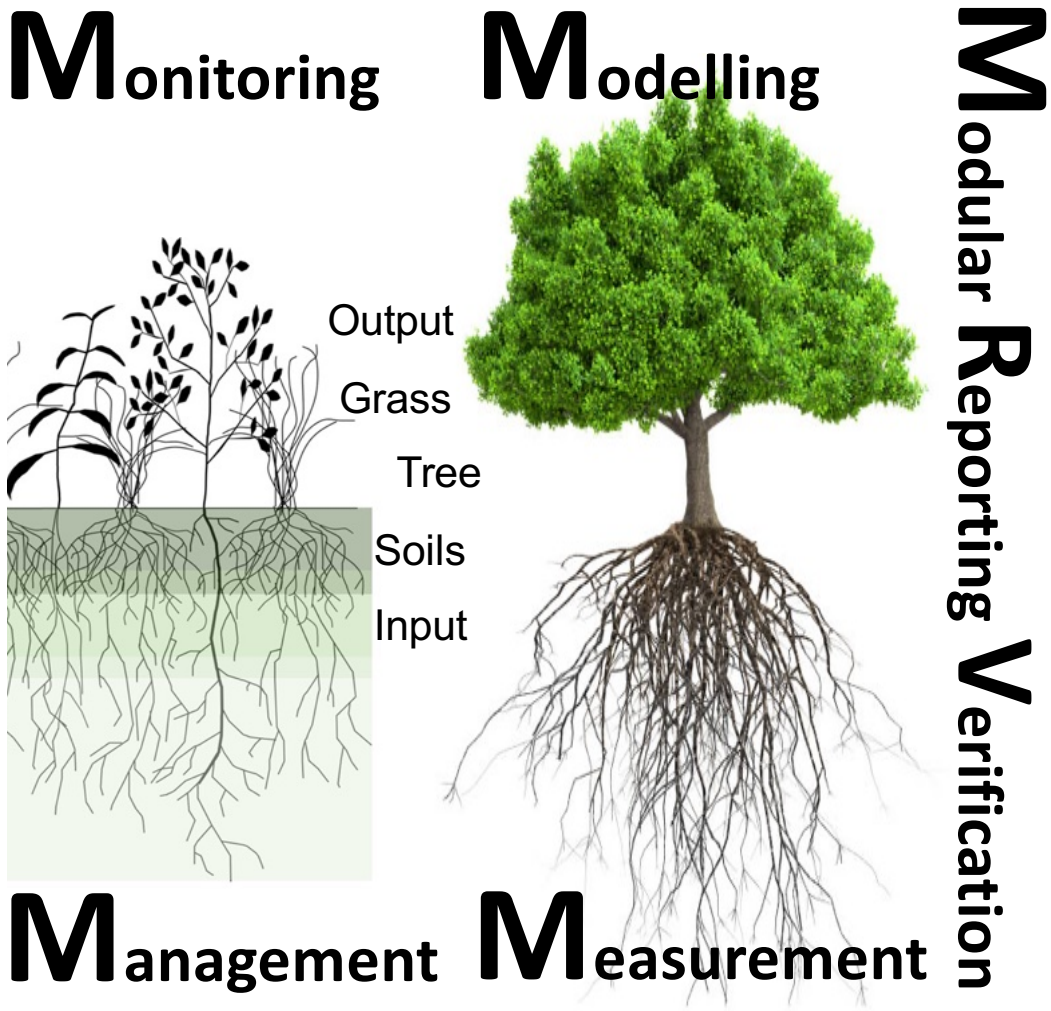
DAESim Dynamic Agro-Ecosystem Simulator
Alexander.Norton@anu.edu.au

Land and Soil uncertainty on Earth

- The land component of the earth system **cycles** 10X more carbon than human's emit in a year.
- When and where is it growing or breaking down?
- Are those natural OR anthropogenic cycles?
  - Are we taking credit for natural processes?
  - How does land management interacts with natural cycles?
  - We need to **restore** and **regenerate** and build **resilience** to extremes.
- Precision accountability
  - To provide carrots and sticks to shift management
  - Informed buyers, producers and regulators (lenders, insurance, traders)

5MRV
Accounting system

observe cell types
simulate processes with
local environment
Add up cells on a farm



Monitor Agro-Ecosystems for Plant Cell –Carbon Capture and Soil Storage

- Intro about Global Carbon Cycle
  - Organic and Inorganic Carbon
  - Land use and change and accounting
- Single Cell in Ago-Ecosystem (multi-spectral, weekly)
  - Single Tree cell
  - Single crop - paddock map
  - Growth and Development Process Model DAESim2-Plant
- Soil (In)organic Carbon
  - Enhanced Rock Weathering, Organic Carbon Fractions
  - Soil microbiome – metagenomics
- Farm Product Accounting