Introducing a new tile-based irrigation scheme for JULES

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JULES Annual Science Meeting

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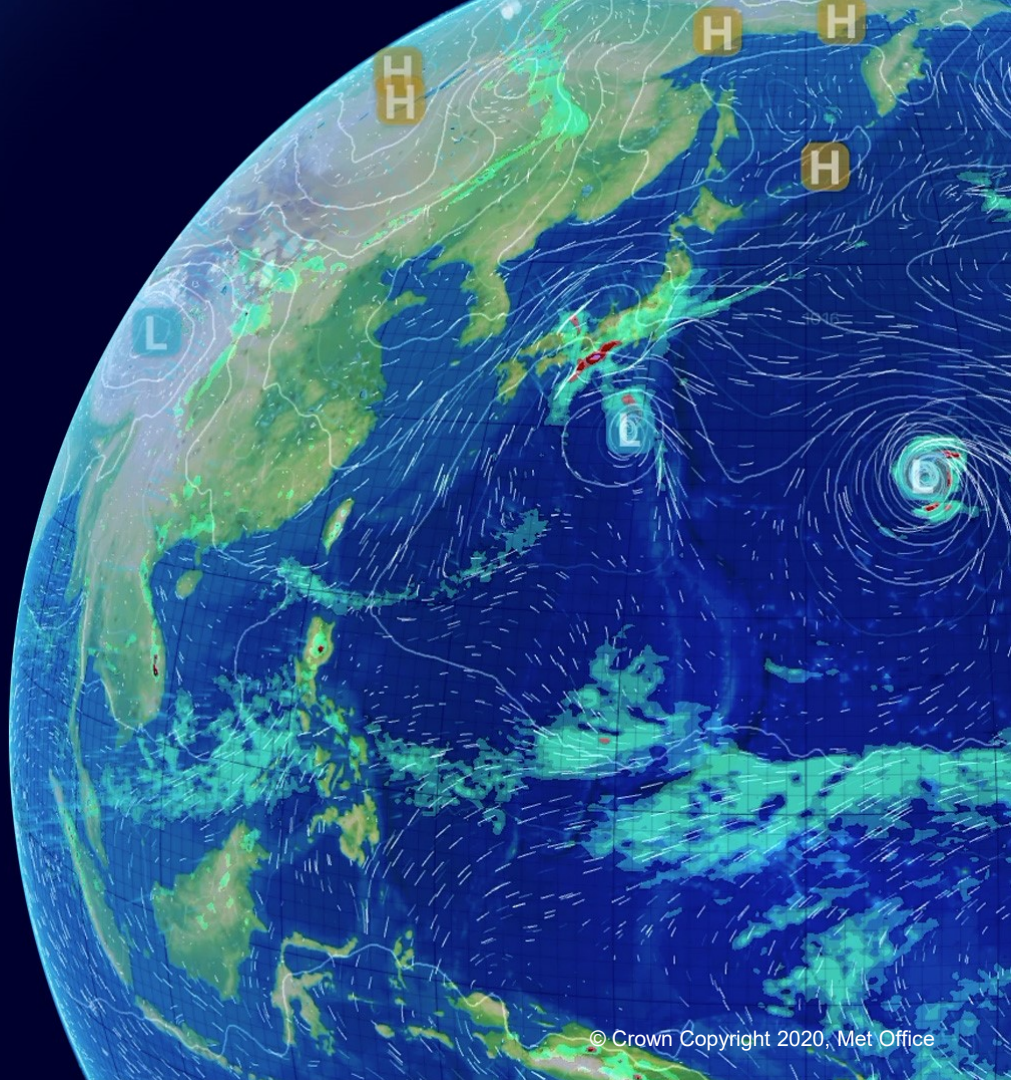
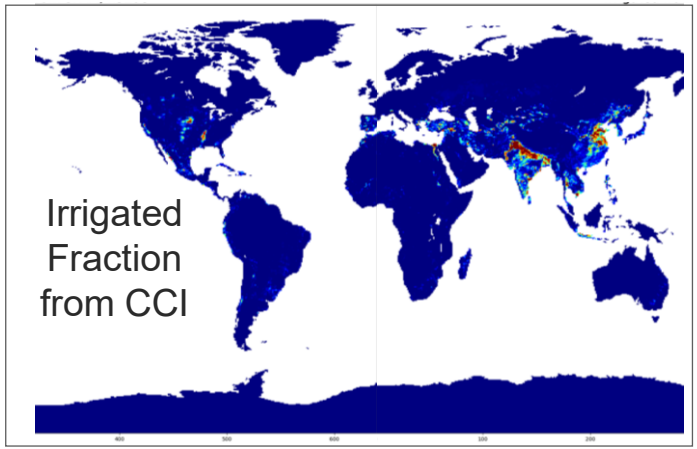
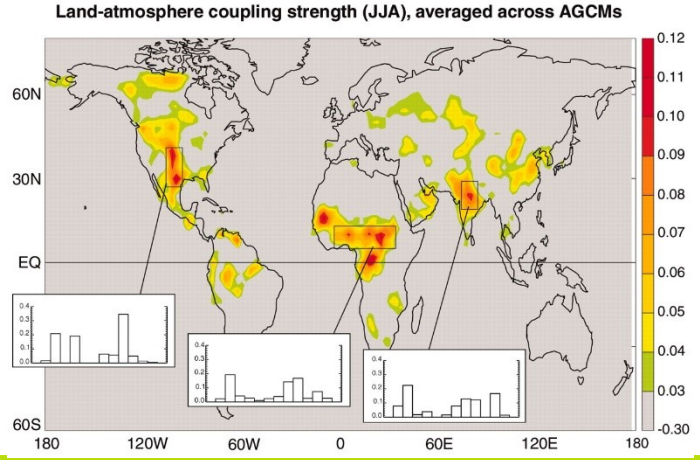


Global irrigation context

- Application of water to the land with the aim to maintain plant productivity
- Over 324 million hectares of land are equipped for irrigation worldwide. 42% of this is in only two countries: India and China[1].
- These areas of high irrigation also coincide with hotspots in land atmosphere coupling strength[2], which highlights the importance of irrigation for land atmosphere coupling through the sensitivity of the atmosphere to soil moisture.





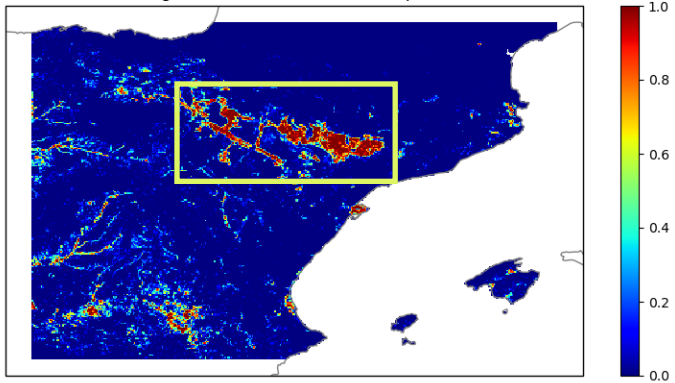
[1] FAO 2014, http://www.fao.org/nr/water/aquastat/infographics/Irrigation_eng.pdf
[2] Koster et al 2004, https://doi.org/10.1126/science.1100217

Impacts of irrigation in Coupled JULES-UM Simulations

Aim: Improve our ability to model a heterogenous irrigated land surface and understand the impact of irrigation on the terrestrial water fluxes, surface fluxes and the atmospheric evolution in UM simulations.

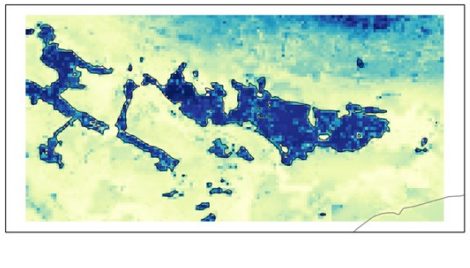
- Tested **existing fraction-based irrigation** code using the UM Regional Nesting Suite over a 2.2km domain centred around the LIAISE field campaign area of north-eastern Spain

Irrigated Fraction Ancillary

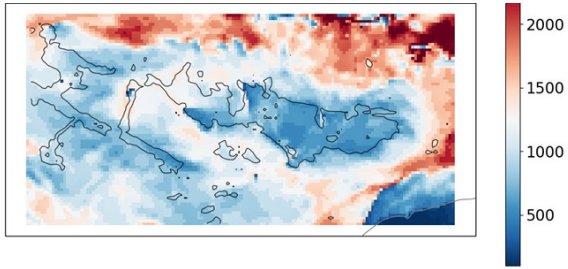


Ancillary derived from ESA Climate Change Initiative (CCI) land cover dataset

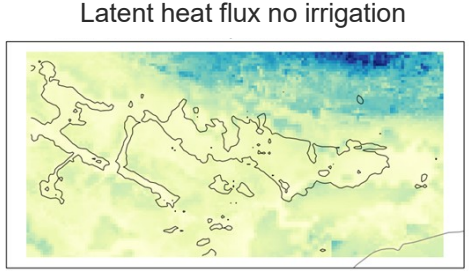
Latent heat flux with irrigation



Boundary layer height (m) with irrigation



Latent heat flux no irrigation



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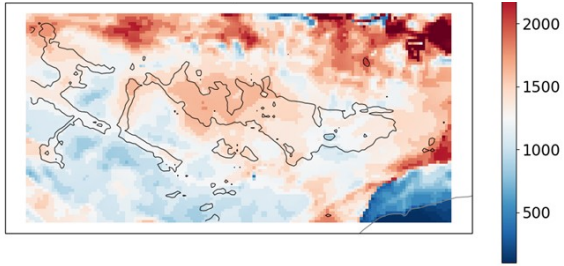

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Future Requirements for irrigation modelling

- Capability for partial irrigation of grid boxes which could include an irrigated and non-irrigated soil moisture column for each surface type.
- Irrigate surface tiles rather than fractions of grid boxes.
- Different types of irrigation and different crop based PFT's
- Irrigation seasonality
- Irrigation limitation and water conservation
- Adequate data sources for ancillary information (irrigated types, seasonality etc.)
- Need flexibility to run with/without soil tiling

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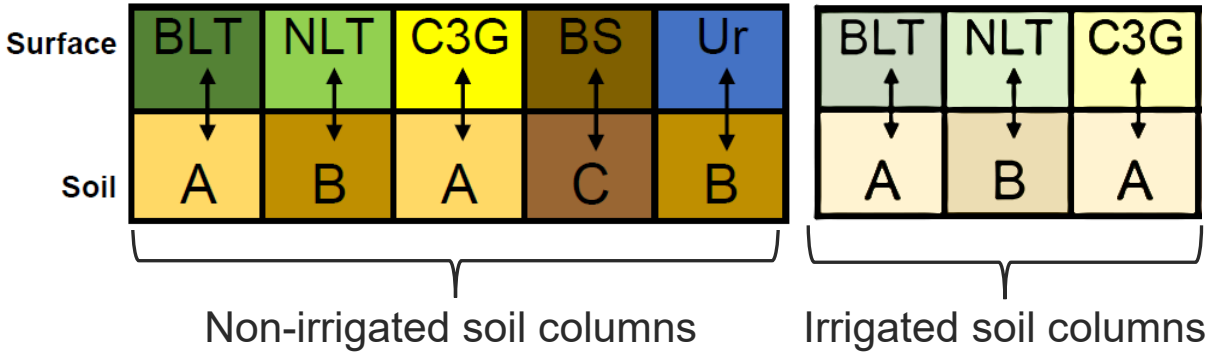
Does the current scheme fulfil future requirements?

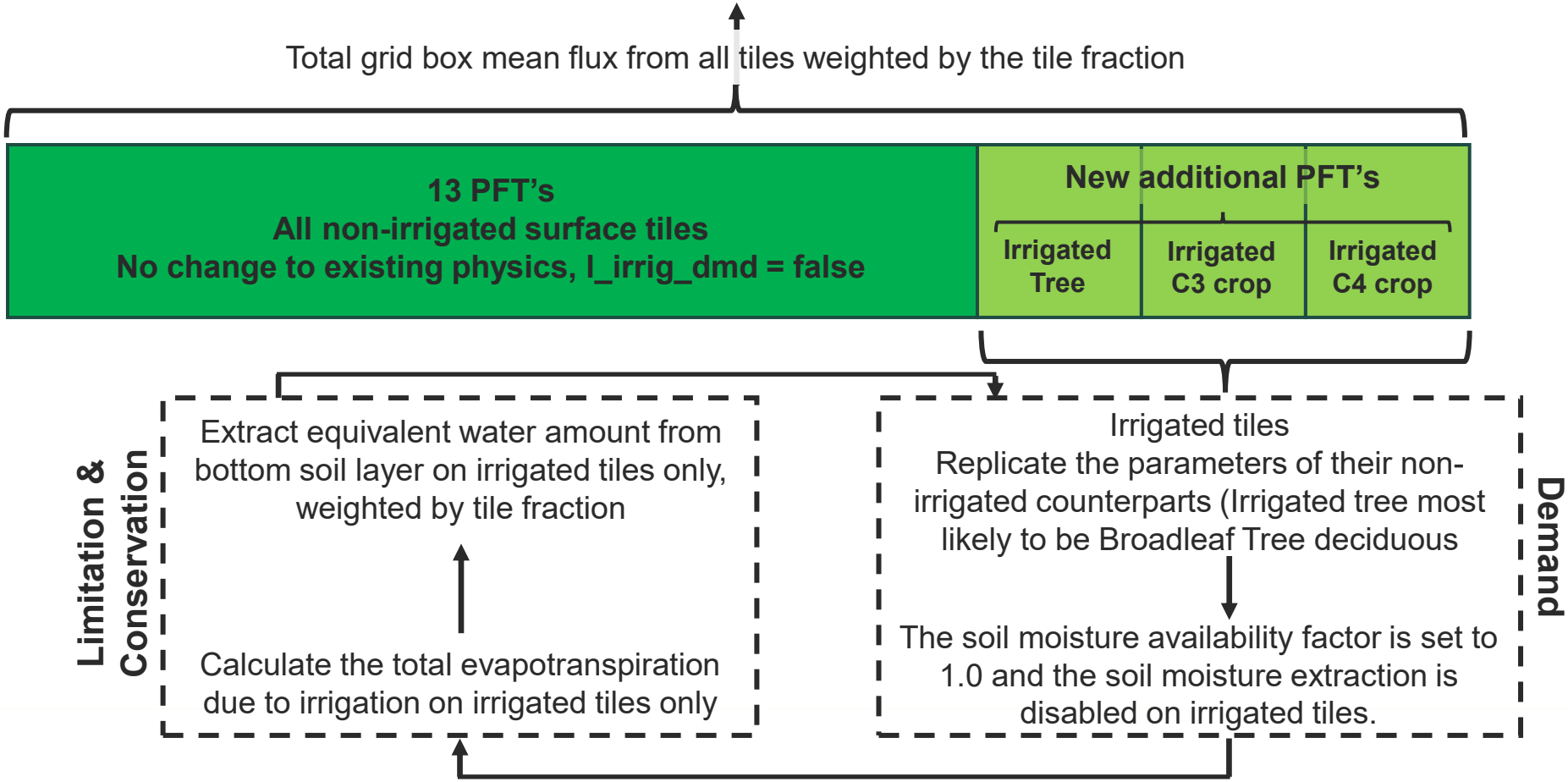
- **Current fraction-based** scheme is not flexible enough
- Can not easily model irrigated and non-irrigated soil moisture for each surface type separately
- Assumptions made about the distribution of irrigated tiles within a grid box (e.g. preferentially irrigates C3 grass first).
- No distinct irrigation types, uses irrigated grid box fraction
- No irrigation limitation or water conservation for the coupled implementation
- No interfaces with existing water resources code or human influences (e.g. licensing of water, extraction, abstraction and dam controls)

Long term solution: Soil Tiling



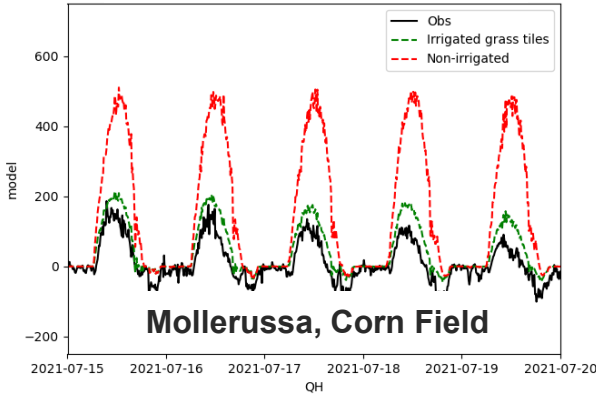
- Irrigated and non-irrigated surface tiles run with own soil tiles, separate non interacting soil water profiles, all within a single grid box.
- Irrigated soil moisture profiles to evolve independently, different rates of evapotranspiration.
- Flexibility to have different irrigation methods, flooded or ponded water.
- Good option for simulating irrigation in the longer term.
- However, due to technical complications, the soil tiling functionality won't be available until after LFRic is implemented.

Current solution: New Tile-based Scheme



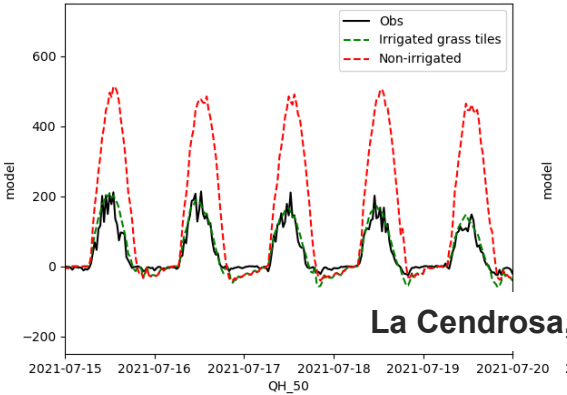
Early results from LIAISE flux tower sites

Sensible Heat Flux @3m

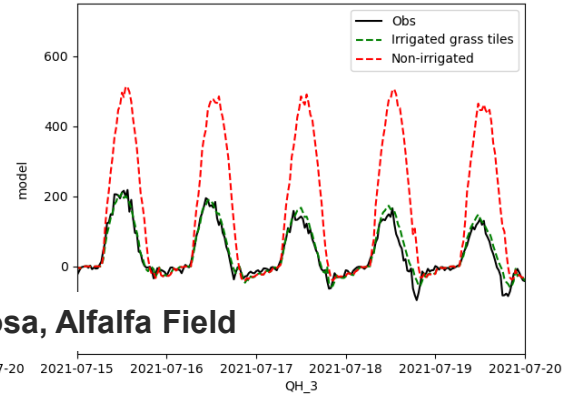


Mollerussa, Corn Field

Sensible Heat Flux @50m

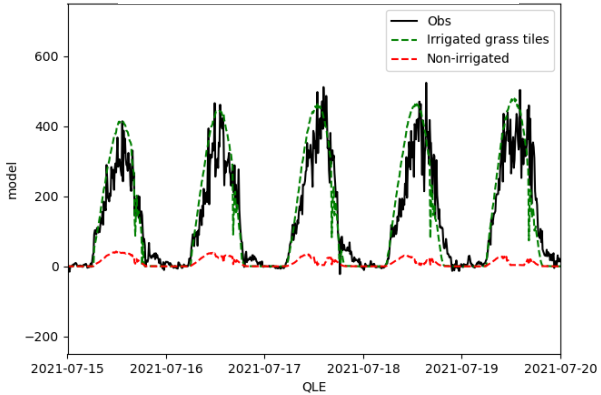


Sensible Heat Flux @3m

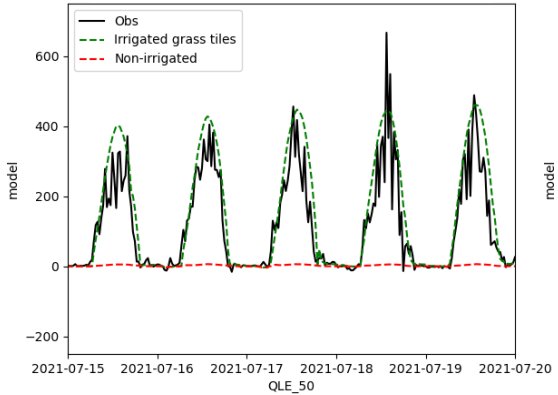


La Cendrosa, Alfalfa Field

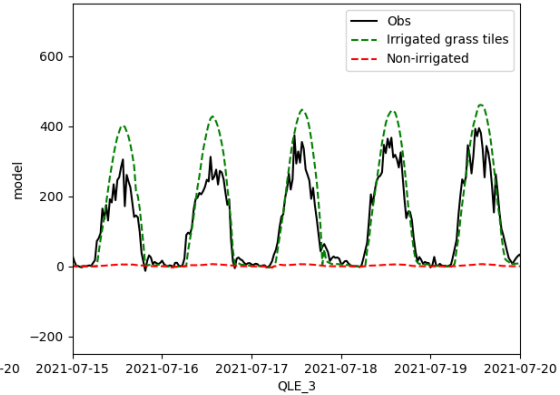
Latent Heat Flux @3m



Latent Heat Flux @50m



Latent Heat Flux @3m



Irrigation tickets

#1529 Implement new irrigation scheme into standalone JULES

- Technical code to add two new surface tiles - C3_irrig and C4_irrig
- The science code required to calculate irrigation on the new surface tiles
- Two new namelist variables added to enable irrigation to be switched on for individual surface tiles. Plus, associated metadata and upgrade macro required for JULES (and UM).
- Standalone Rose-stem test to protect the new science added.
- Technical infrastructure to allow the code to couple to the UM/LFRic in a future ticket.

#1628 Include irrigation correction for bare soil evaporation.

#1629 Correction to enable soil moisture extraction from irrigated tiles when $\theta > \theta_{crit}$

#1630 Include irrigation limitation for water conservation

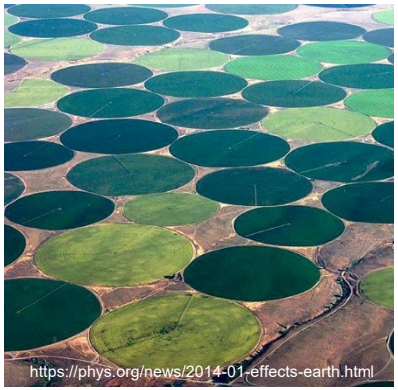
#1631 Fully couple the tile-based irrigation scheme to UM/LFRic.

How can we simulate different types of irrigation?

- Many different methods used in practise
- Bringing in water via pipes from rivers, canals and reservoirs
- Huge spatial and temporal variability in application of irrigation

Flood

Sprinkler



Drip

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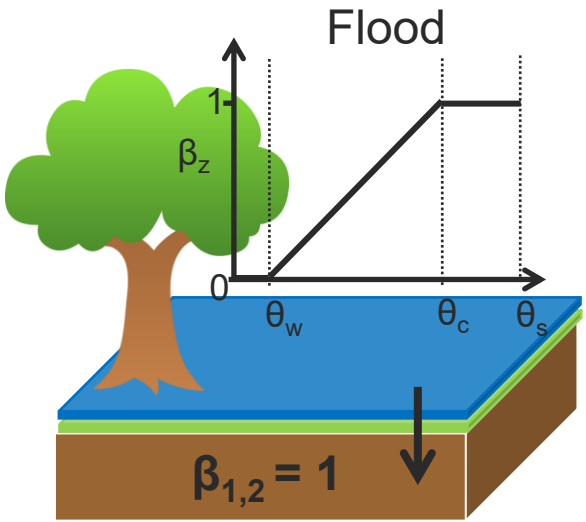
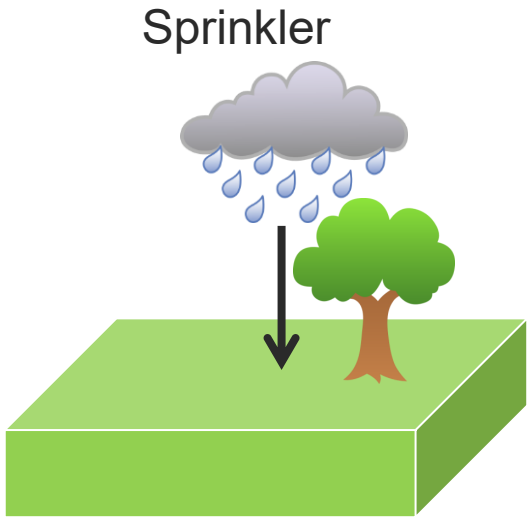
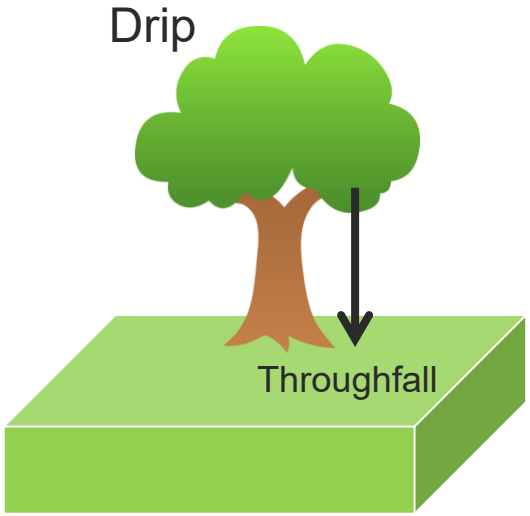


+ review infiltration & add ponding





Future Priorities

- Developing a **new tile-based** irrigation scheme
  - Global/regional testing of the scheme implemented in UM/LFRic
  - Implementation of water conservation and water extraction
  - Integrate with CaMa-Flood through water extraction
  - Irrigation types and ponding
  - Case studies: Spain (LIAISE), India (RAL-City), Australia (Momentum Partnership)

- Developing code for **irrigation ancillaries** within ANTS.
- Scoping the practicalities for integrating with the existing JULES **soil tiling** code post-LFRic (standalone and coupled).
- Moving forward together with the fraction-based scheme

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Thank you for listening

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