

# Soil Modelling & Decision-Making

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# Context

- The Moorepark St. Giles (MoSt GG) model is the primary grass growth model used in Ireland.
- Developed by Teagasc.
- Model predicts daily grass – measured in kg of dry matter per hectare, per day.
- Factors in local farm data, paddock management (fertilizer/grazing), and real-time weather data from Met Éireann.

# Model details

- MoSt can be highly localized (county level down to paddock scale).
- Uses three main components for 10 day forecast
  - ▶ **Weather Inputs:** Local rainfall, temperature, and solar radiation.
  - ▶ **Soil Data:** Adjusts for the specific Irish Soil Information System classification (e.g., soil moisture surplus/deficits and drought/flooding risks).
  - ▶ **Management Data:** Accounts for grazing dates, animal stocking rates, and nitrogen/fertilizer application.



# Water sub-model

- MoSt contains a water sub-model which predicts the amount of water in the first 1 m of the soil column.
- Secondary calculation gives the amount of water in the first 10 cm of the soil column – used to restart the model after dry periods.
- A water balance model:

water in = water out.

- Feeds into a model variable called the **water stress**, which directly influences the grass growth.

# The task

The UCD Soil Modelling Group has been tasked by **VistaMilk** to improve the prediction of the soil moisture in the first 10 cm of the soil column, with a view to improving the performance of MoSt model in dry periods.

## Soil Modelling Group:

- Me (Lennon Ó Náraigh) with support from Graham Benham and Saoirse Tracy (School of Agriculture and Food Science)
- 1 PhD student (Charlotte Stammers)
- 1 Postdoctoral Researcher (Saurabh Kumar)

# Context

- VistaMilk: Ireland's national centre for science and digital innovation in pasture-based dairy.
  - ▶ Research centre funded by Research Ireland
- Aim is to deliver breakthrough science and digital solutions that enhance sustainability, productivity, economic viability and animal welfare across the dairy system.
- Centre uses data, sensors, AI and advanced analytics to develop practical tools and technologies.

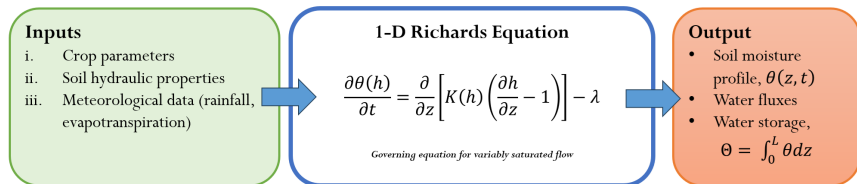


# Plan of Talk

- Overview of Richards-Equation Modelling
- Results
- Work plan
- Implications for local authorities

# Richards Equation

- MoSt uses a simple water-balance model for the 1 m soil column and similarly, for the top 10 cm.
- We propose to use the Richards Equation, which effectively describes the soil moisture at all depths, down to the water table.

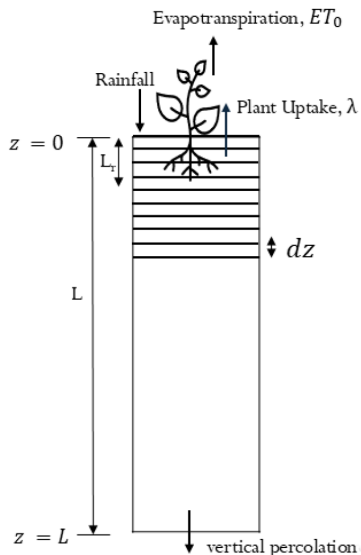


*Credit: Saurabh Kumar*

# Richards Equation – Concept

Describes the flow of water in the unsaturated zone. It combines five key components:

- 1 Moisture content ( $\theta$ ) - how much water is stored in the pores.
- 2 Hydraulic conductivity ( $K$ ) – how easily water flows through the soil.
- 3 Pressure head ( $h$ ) - the pressure or suction that drives water movement.
- 4 Evapo-transpiration (ET), governing the transfer of moisture between roots, leaves, and the soil.
- 5 Rainfall enters as a **boundary condition**.

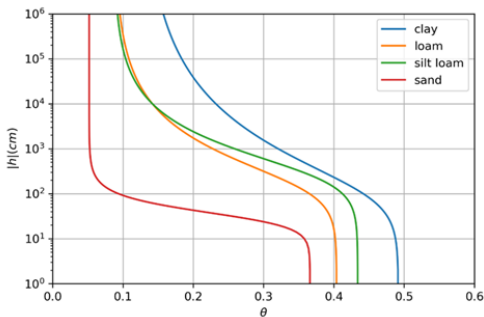


Credit: Saurabh Kumar

# Soil Hydraulic Properties

Soil hydraulic properties determine how water is stored and moves through the soil profile (e.g. infiltration, drainage).

- Soil water retention curve,  $\theta(h)$
- Hydraulic conductivity curve,  $K(h)$

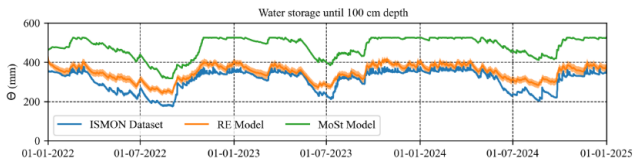


**Van Genuchten Model:** Six model parameters,  $\theta_r$ ,  $\theta_s$ ,  $\alpha$ ,  $n$ ,  $K_{sat}$ ,  $\eta$ .

Different parameter values for different soil types, obtained through laboratory measurements, available through what is effectively a lookup table (ROSETTA-3).

# Key results to date

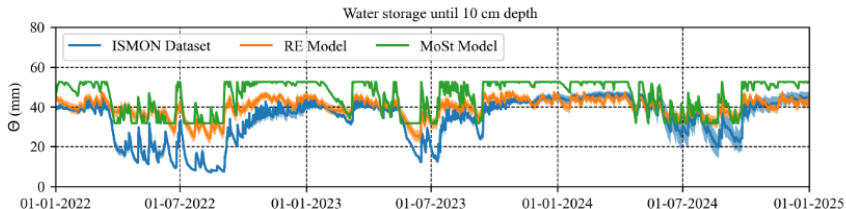
- Developed a code (in Python) to solve the Richards Equation.
- Takes in historical meteorological data as well as soil parameters and models historical time series of soil water content.
- Obtained ISMON data<sup>1</sup> for Johnstown Castle (soil moisture at different depths) and validated our model.



- Results shown for **depth-averaged soil moisture**.
- Comparison between Richards Equation (RE), MoSt, and ISMON data (OBS).

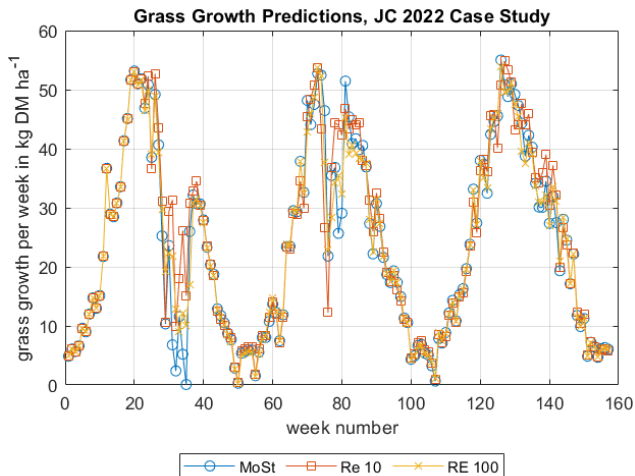
<sup>1</sup>Irish Soil Moisture Monitoring Network: a long-term observation platform covering major soil types, land uses and climatic regimes across Ireland, led by UCD, Teagasc, and Met Éireann.

## Results at 10 cm depth



- Trends the same at 1 m depth.
- Trends differ at 10 cm depth.
- Scope for improving predictions of MoSt model.

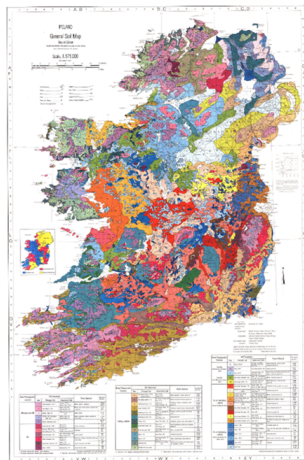
# Grass Growth



- RE model 'less aggressive at killing off grass' in hot summers
- Need to validate if this is the right approach.
- Work in progress.

# Work ahead

- Understand parameter selection better – for Van Genuchten parameters and root water update function.
  - ▶ Current approach uses ROSETTA-3 for VG parameters.
  - ▶ Based on soil type (e.g. Irish soil map)
  - ▶ Need to localize this for different sites.
  - ▶ Also need to better understand parameters in root water uptake function.
- Aim is to implement the RE model into the GG model for **one site** as a use case by September.
- Thereafter, aim is to operationalize the RE equation so that it feeds into the GG model to make **real-time predictions**.



# Implications for Local Authorities (blue skies)

- Water-balance model is a powerful tool for computing soil moisture content.
- Richards Equation is more detailed and can be used as a supplement.
- Possible uses:
  - ▶ Flood modelling – e.g. saturation levels?
  - ▶ Support decision-making in land management and infrastructure planning?
  - ▶ Pitch maintenance – are the playing pitches saturated? Will they be playable on the weekend?
- Important to have a **data-driven approach** – combining sensor data, soil monitoring, and weather station information.

# Acknowledgments

- Soil-Modelling team (faculty): Graham Benham, Saoirse Tracy
- Soil-Modelling team (project): Saurabh Kumar (postdoc), Charlotte Stammers (PhD student).
- VistaMilk: Elodie Ruelle (Teagasc).
- Supporters in ISMON: Tamara Hochstrasser (UCD), Owen Fenton (Teagasc), Konstantin Shishkin (PhD Student, Teagasc)
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