Advanced Training Workshop: Capacity Building for Peatland Restoration Monitoring

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Food and Agriculture Organization of the United Nations

SEPAL

Purpose of the working session for peatland restoration monitoring using earth observation data

- Enable the automous creation of soil moisture maps and time series analyses of vegetation indeces
- Introduce new SEPAL features and links to peatland monitoring
- Explore the relationship between ground water levels, soil moisture and vegetation moisture.

Agenda

- Presentation
- Housekeeping
- Install and run soil moisture modules
- Discuss working session priorities
- Intro to the new SEPAL
- Time series analysis of vegetation indices
- Verfication of restoration activities

Assumptions for peatland monitoring with remote sensing

Peatland conditions can be estimated through biophysical parameters detectable from remotely-sensed data.

Vegetation changes can be indicative of some kinds of condition improvements / degradation.

Soil moisture is an important indicator of peatland condition.

Physical location of canals and management activities are important indicators of peatland condition.

Data as a ‘weight of evidence’ approach:

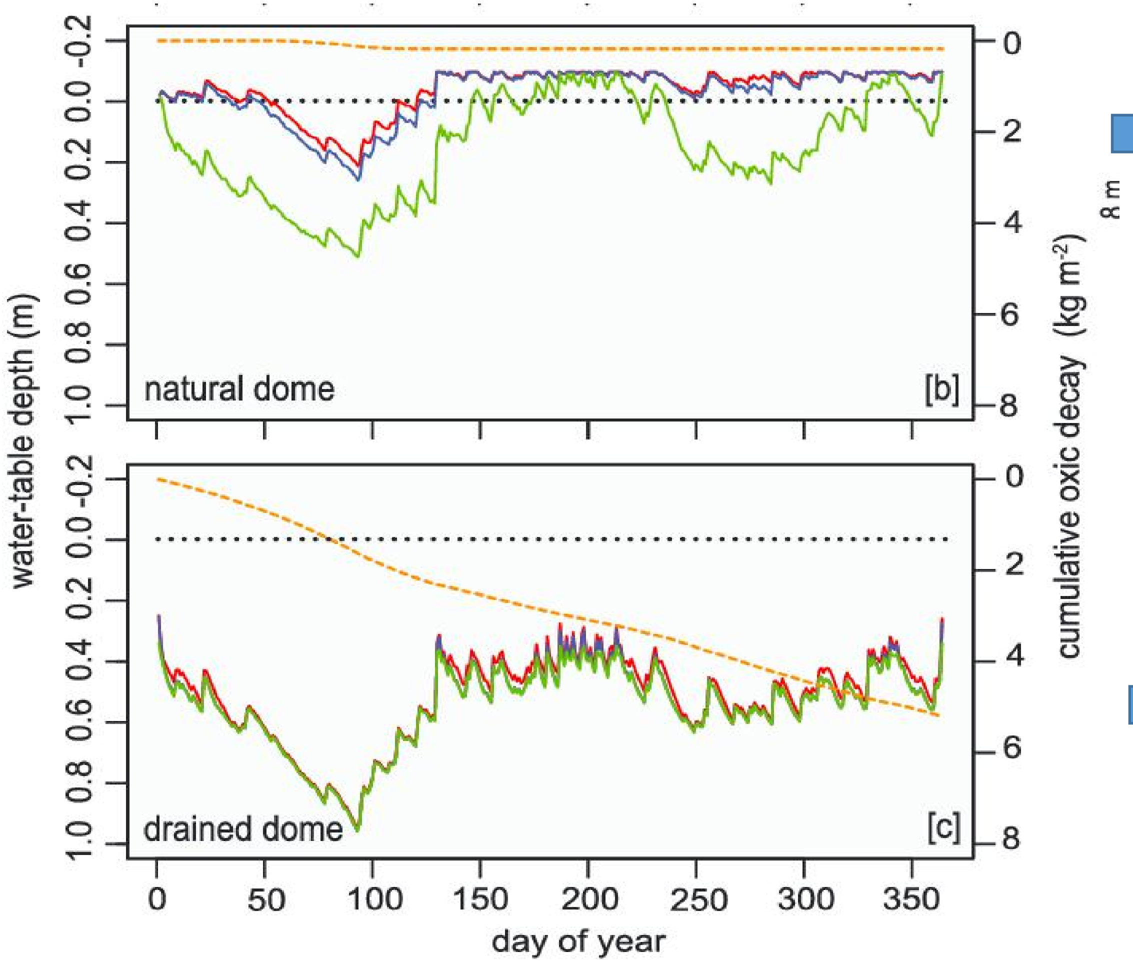
1. Dam detection with high-spatial resolution optical imagery

2. Time-series analysis of field-based observations

3. Time-series analysis of optical spectral indices

4. Radar-based surface soil moisture estimates and trends over time

Impact of peatland drainage on ground water level



In a natural peatlands rain, refills the peatland water balance – in average water table is at surface

In a drained (and/or deforested) peatland rain cannot bring water table back to surface

Peat is exposed to oxygen

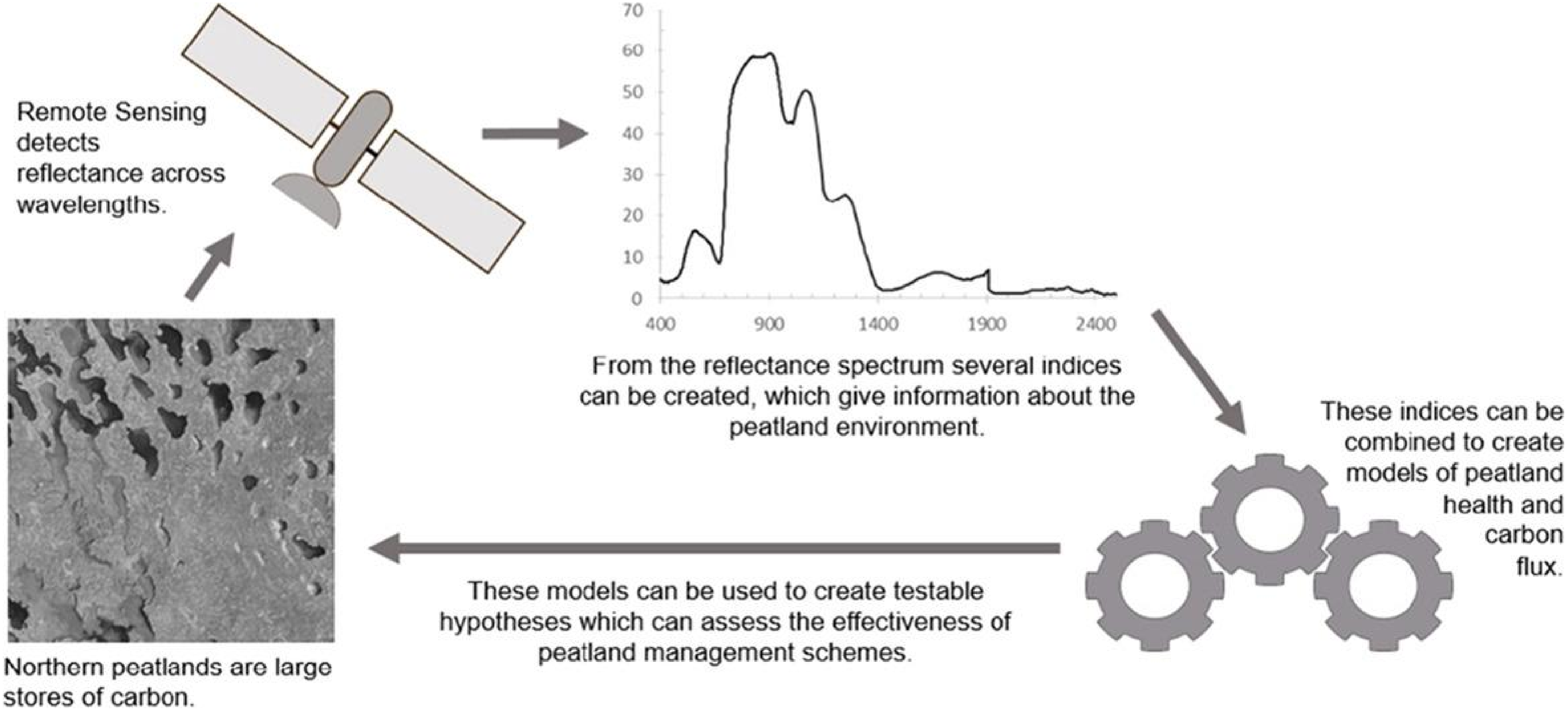
Source and further information: Baird et al. 2017, link: https://www.semanticscholar.org/paper/High-permeability-explains-the-vulnerability-of-the-Baird-Low/462c4bb86a3a8819b98212cb85adece86170f325

Ground water level determines GHG emissions

- Greenhouse gas emissions depend on
  1. **ground water level**
  2. land-use type (e.g. plantation, abandoned)
  3. Climate zone
- Rule of thumb: The lower the water table, the higher the emissions
- Only a mean annual water level **close to surface** can, in the long run, reduce emissions from peatland completely

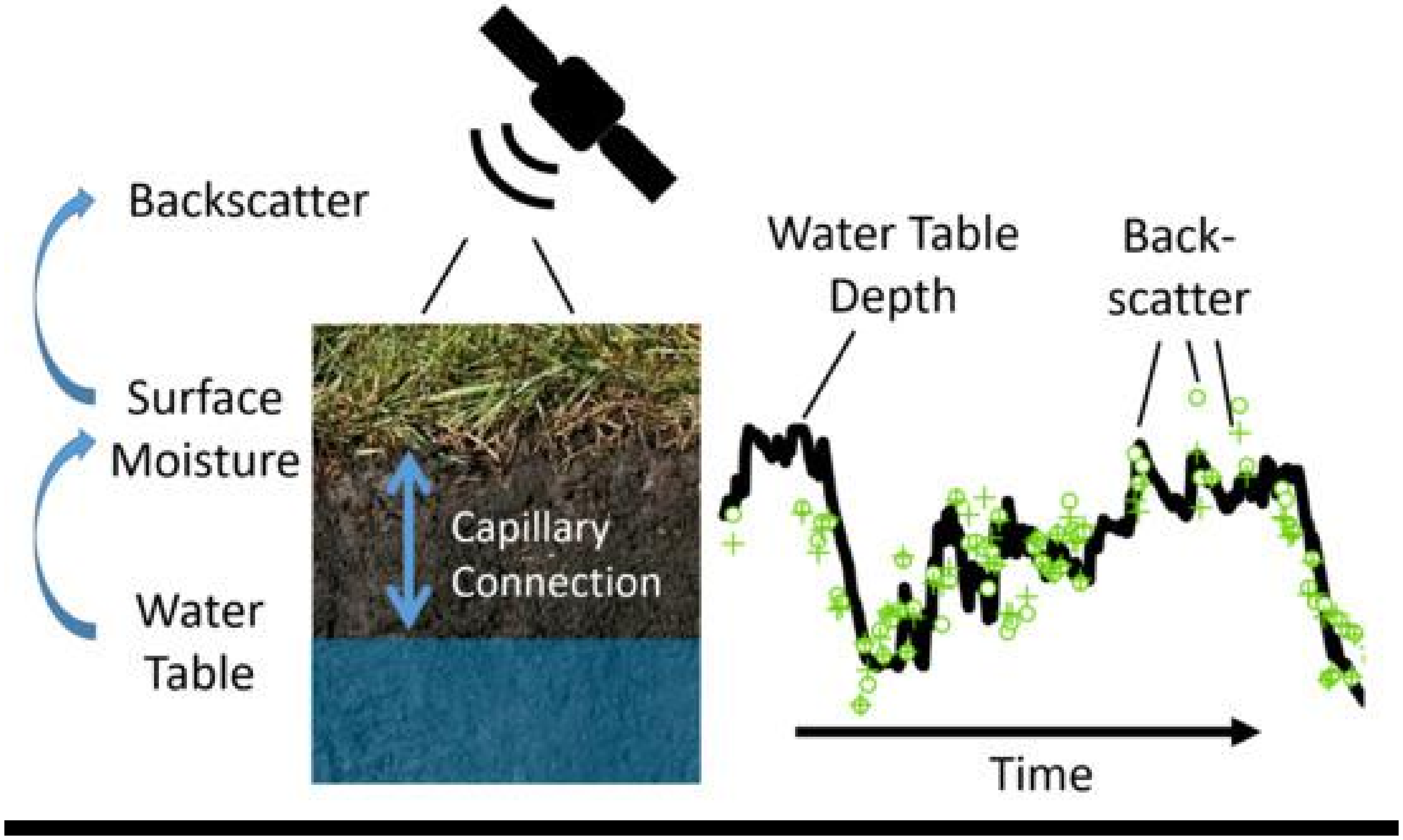
How can optical satellite imagery be used for peatland monitoring?

- • Optical data can be used to drive modelsof peatland carbon flux.
- • Water, temperature and vegetation indices are important model factors.
- • Challenges from peatland heterogeneity and vegetation composition
- • Remote sensing driven models have the potential to fill gaps in current research



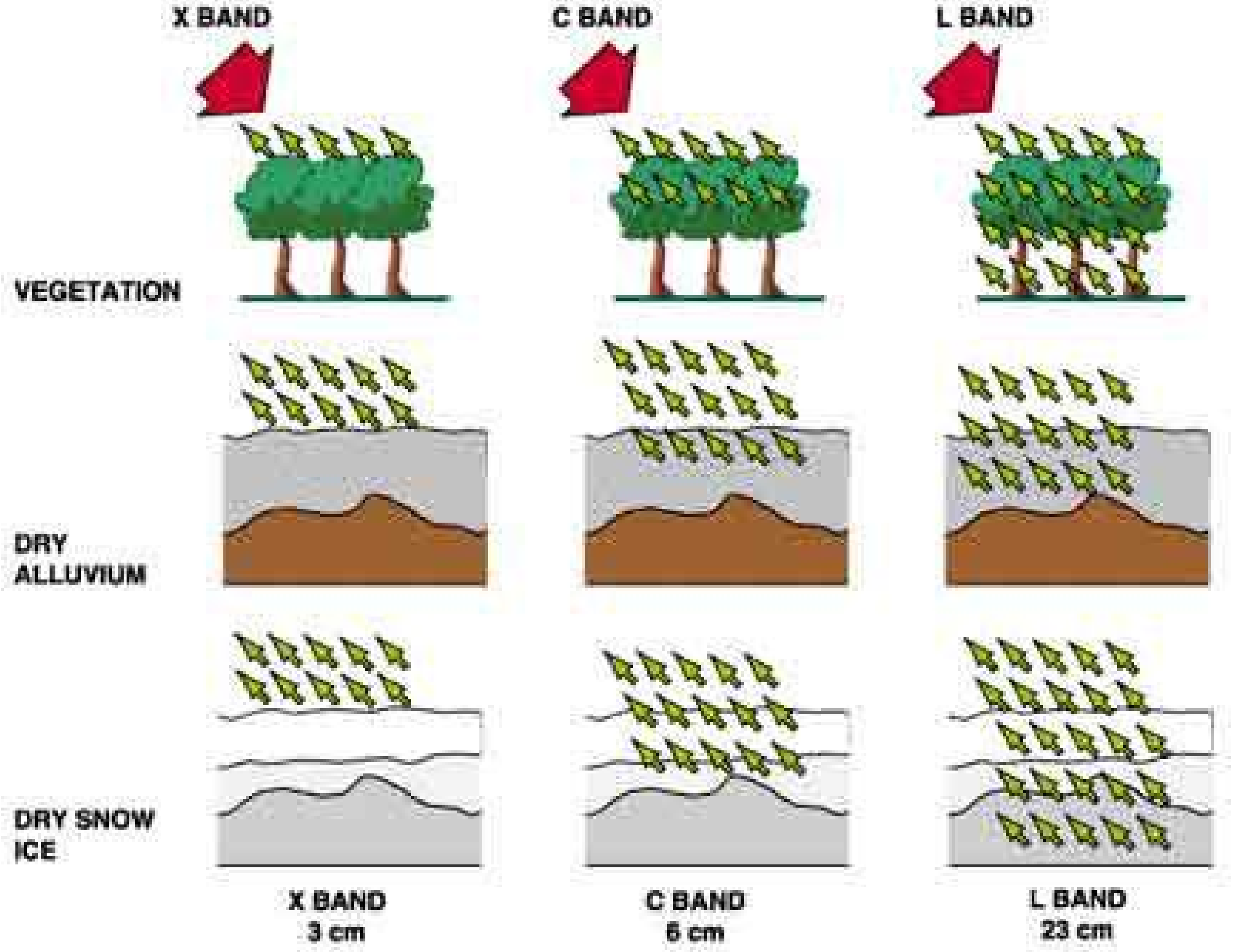
Lee et al. 2018 Potential for using remote sensing to estimate carbon fluxes across northern peatlands – A review

How can SAR satellite imagery be used for peatland monitoring?



Bechtold et al. 2018. Inferring Water Table Depth Dynamics fromENVISAT-ASAR C-Band Backscatter over a Rangeof Peatlands from Deeply-Drained toNatural Conditions

How can SAR satellite imagery be used for peatland monitoring?



- Parameters affecting radar backscatter
- Very sensitive to moisture and changes in moisture content
- In the specific case of vegetation, penetration depth depends on moisture, density and geometric structure of the plants (leaves, branches).

ESA https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/ers/instruments/sar/applications/radar-courses/content-2/-/asset_publisher/qIBc6NYRXfnG/content/radar-course-2-parameters-affecting-radar-backscatter

Latest science on peatland mapping

- Highlights the use of open source optical and radar imagery for peatland mapping.
- Availability of machine learning algorithms in an open-source computing environment, and high-performance computing facilities could enhance the way peatlands are mapped.

Earth-Science Reviews 196 (2019) 102870

Contents lists available at ScienceDirect

Earth-Science Reviews

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Digital mapping of peatlands – A critical review

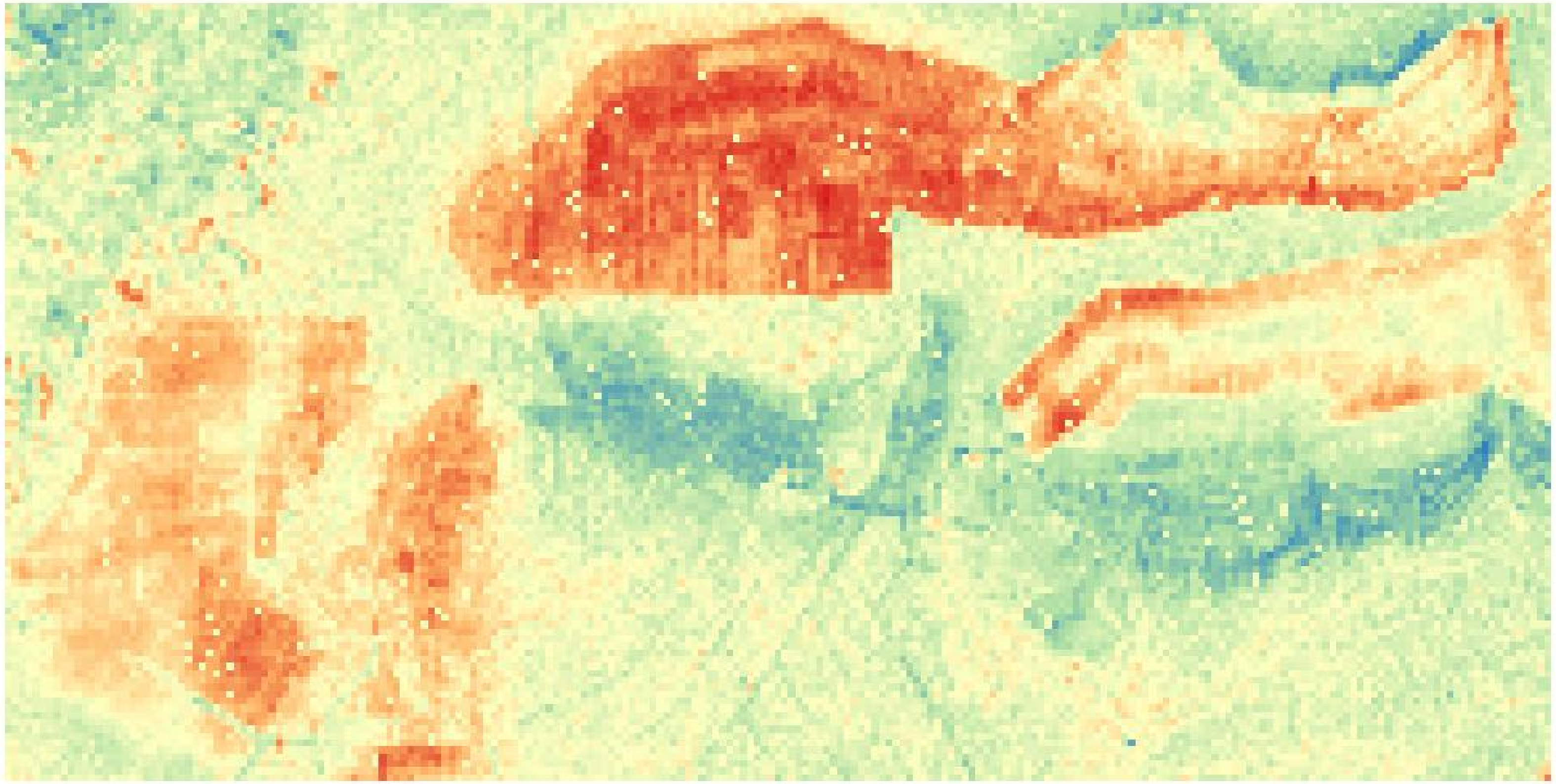
Budiman Minasny[a,*], Örjan Berglund[b], John Connolly[c], Carolyn Hedley[d], Folkert de Vries[e], Alessandro Gimona[f], Bas Kempen[g], Darren Kidd[h], Harry Lilja[i], Brendan Malone[a,p], Alex McBratney[a], Pierre Roudier[d,q], Sharon O'Rourke[j], Rudiyanto[k], José Padarian[a], Laura Poggio[f,g], Alexandre ten Caten[l], Daniel Thompson[m], Clint Tuve[n], Wirastuti Widyatmanti[o]

https://doi.org/10.1016/j.earscirev.2019.05.014

Soil moisture maps at 100m resolution

Down-scaling GLDAS soil moisture using Sentinel-1

GLDAS info here: https://ldas.gsfc.nasa.gov/index.php



Soil moisture content from Sentinel-1

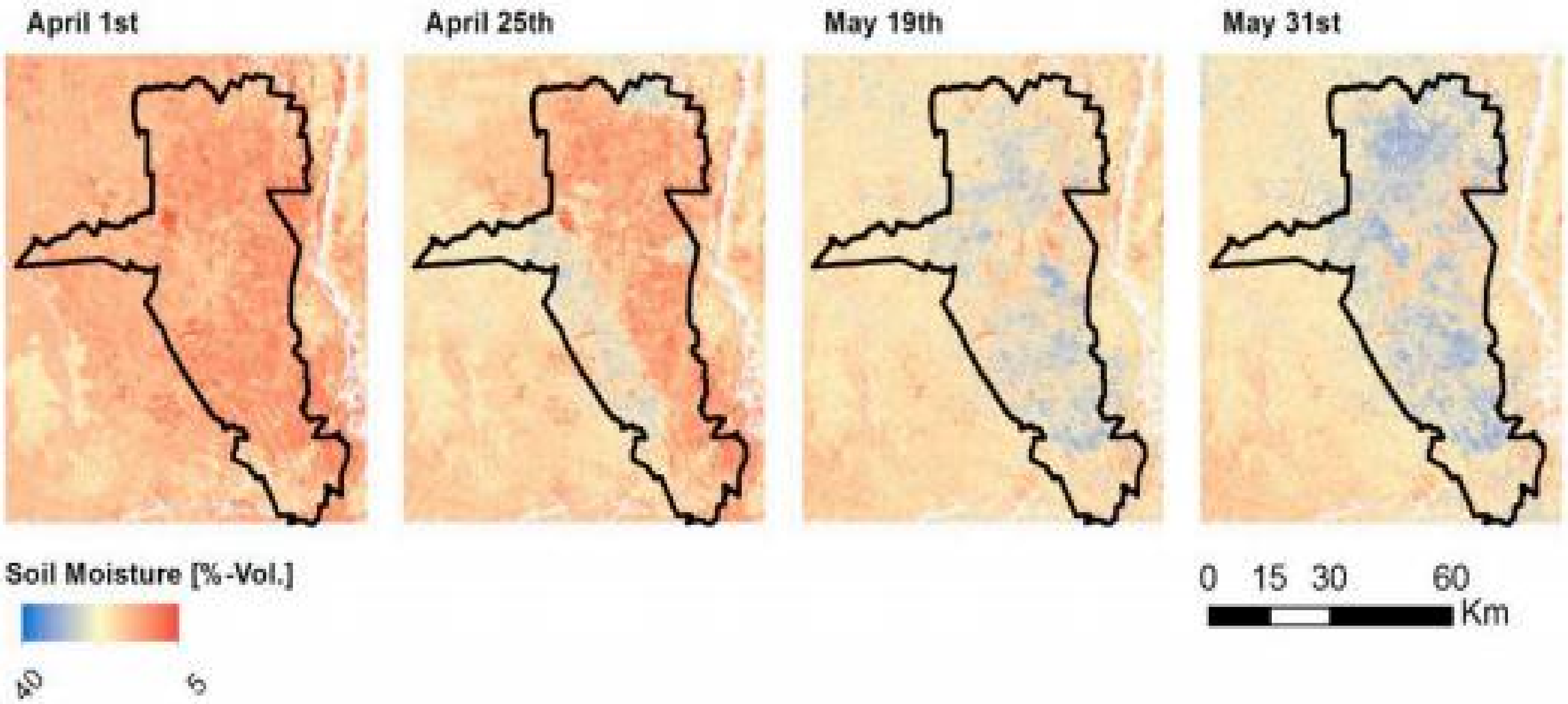


Fig. 5. A time-series of SMC maps showing covering the time-span between April 1st, 2017, and May 31st, 2017, which shows of that year's rainy season. The black line represents the boundary of Uasin-Gishu county.

Greifeneder, F., Physics and Chemistry of the Earth, https://doi.org/10.1016/j.pce.2018.11.009

Soil moisture content from Sentinel-1

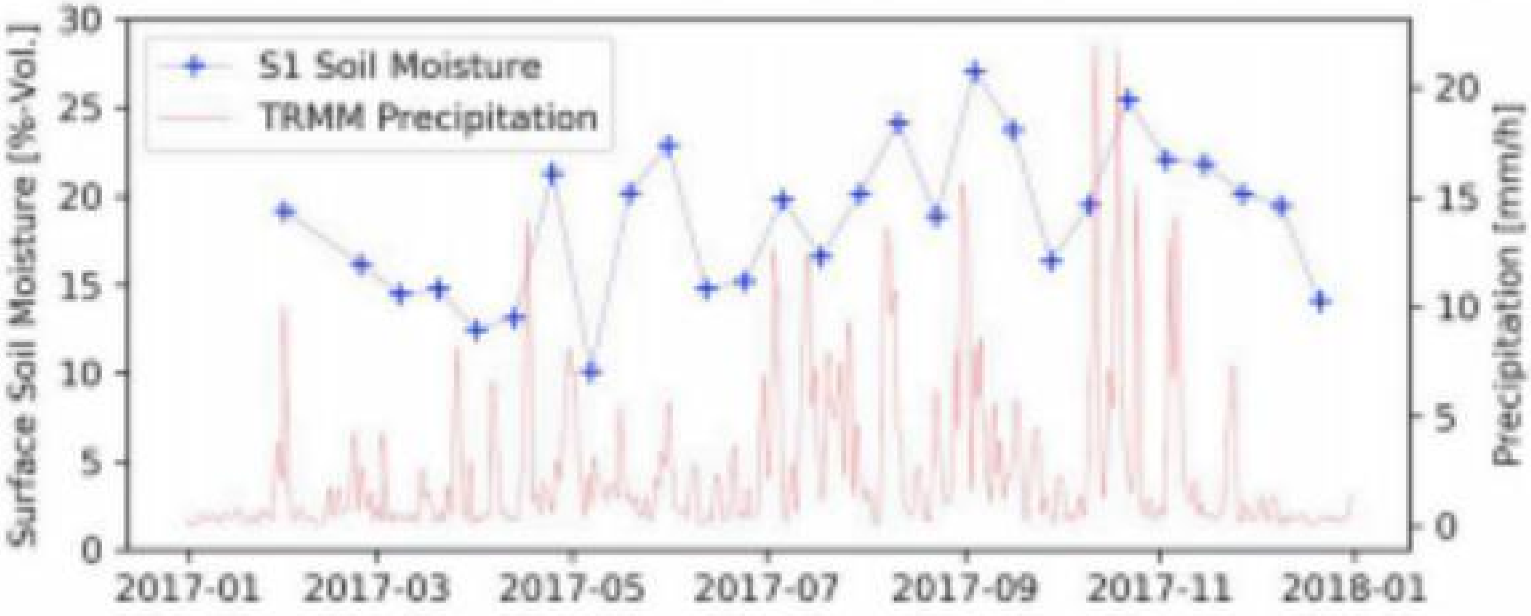
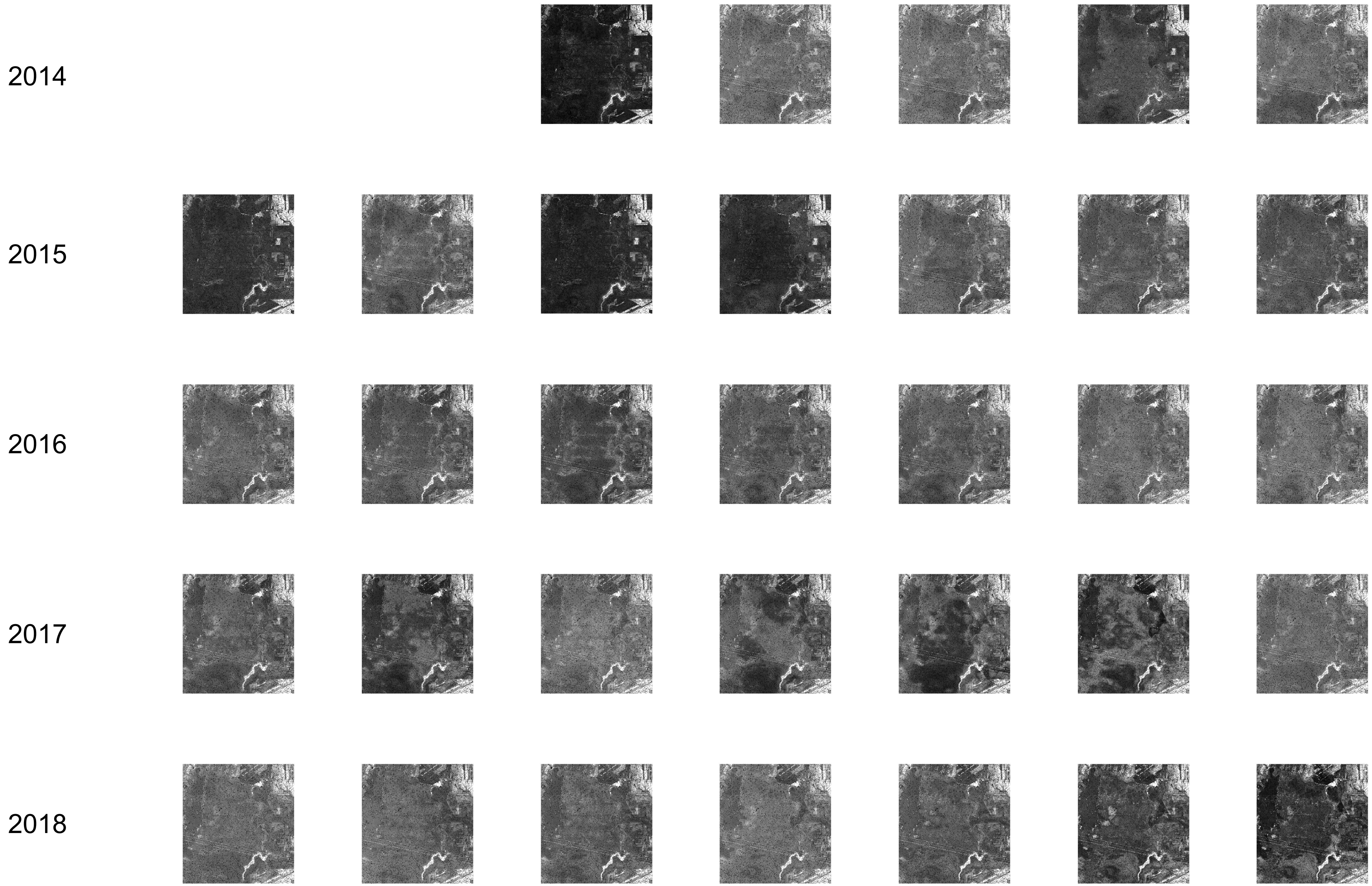


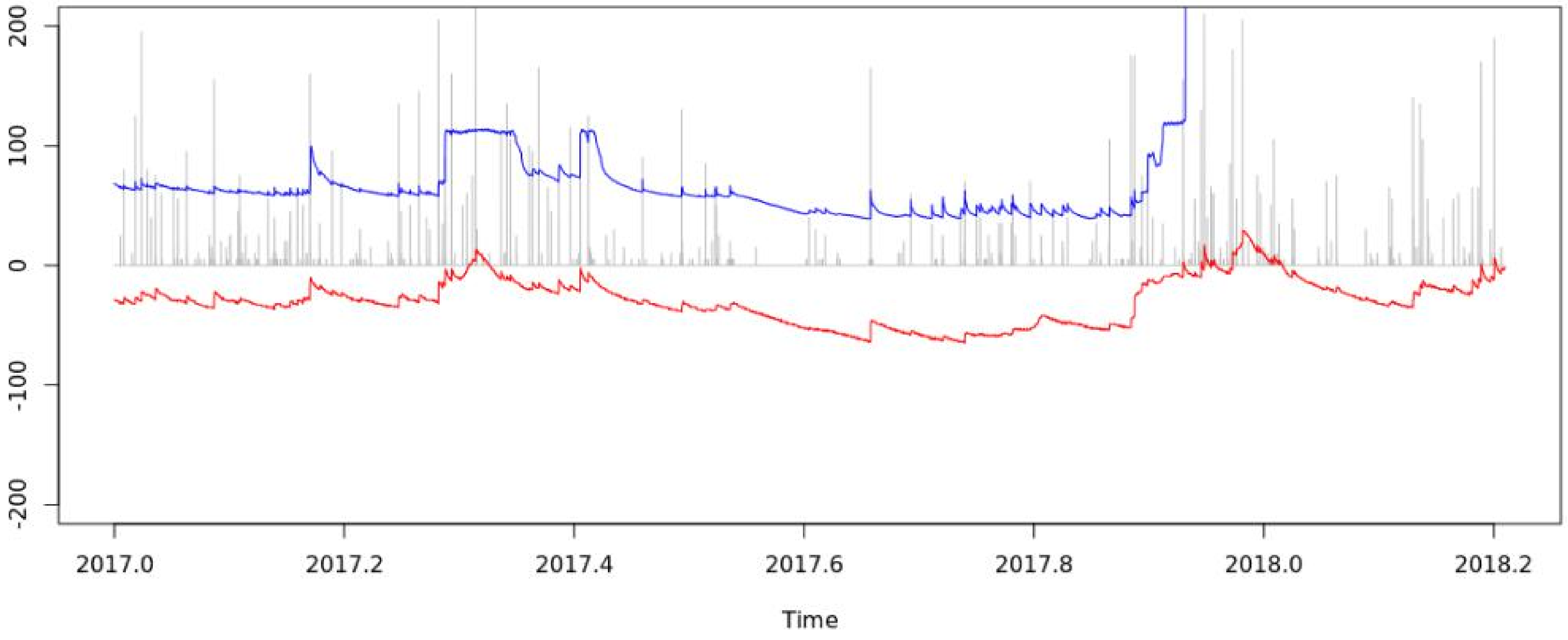
Fig. 6. Comparison between spatially averaged Sentinel-1 SMC (based on the boundaries of Uasin-Gishu county) and daily precipitation, derived from the global precipitation dataset TRMM.

Greifeneder, F., Physics and Chemistry of the Earth, https://doi.org/10.1016/j.pce.2018.11.009

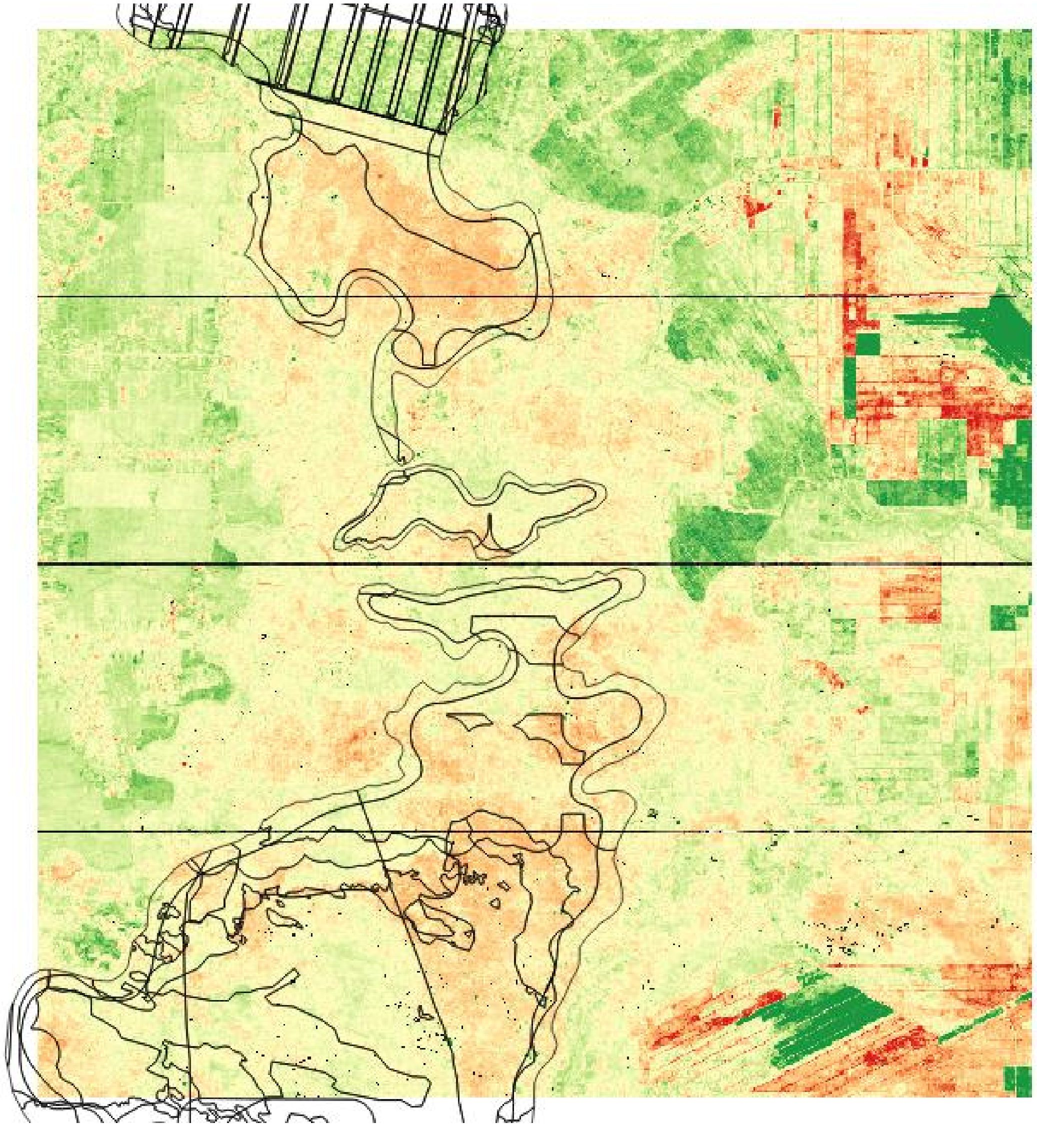
Surface Soil Moisture Maps - 2014 to 2018



Field observation data to build a Soil Moisture / Ground Water Level model



Vegetation moisture index as a proxy for soil moisture

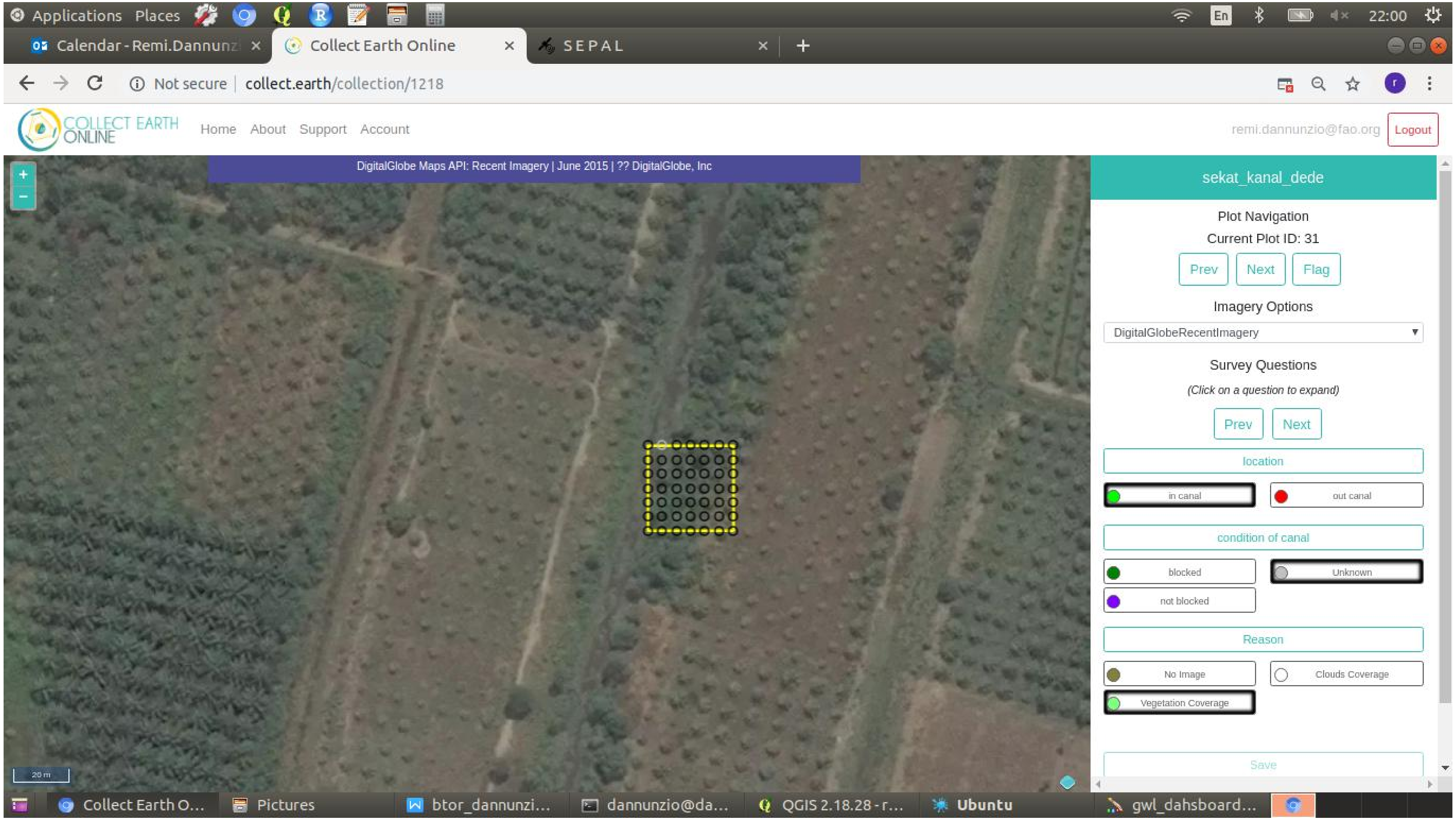


Can we observe the effects of canal blocking from satellite imagery?

© Walhi Kalteng

Image: https://en.pantaugambut.id/peatland-101/restoration-of-peatlands/what-is-a-canal-blocking

Canal blocking validation in CEO



Data needs

- locations of restoration measures
- date of establishment of restoration measures
- consistent time series of ground water levels
- vegetation cover information
- time series of satellite imagery - optical or radar depending on vegetation cover

Time series of freely available satellite imagery

- Earth observation imagery- Landsat, Sentinel-1 and -2
- Sentinel-1 SAR
  - C-band Synthetic Aperture Radar (SAR)
  - main operational mode over land
  - provides the data foundation for high resolution mapping of SMC
  - short time series (about 1 acquistion per month) since 2014
  - limited penetration of vegetation

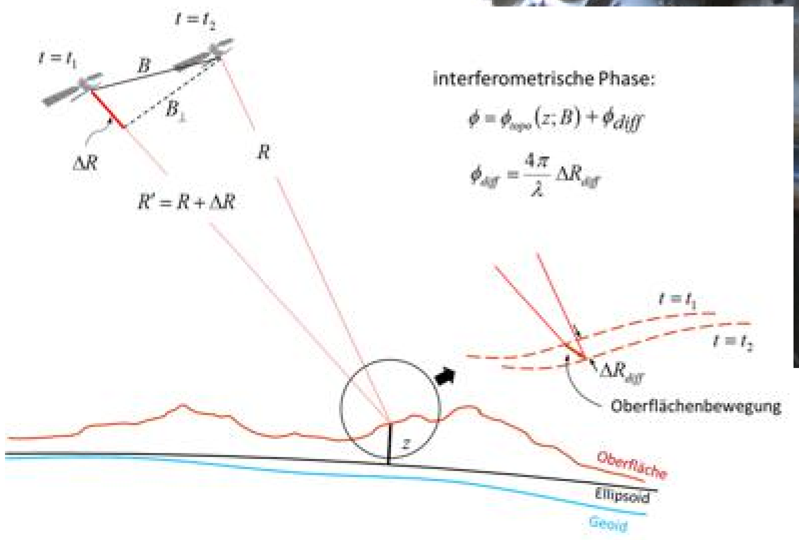
Time series of freely available satellite imagery

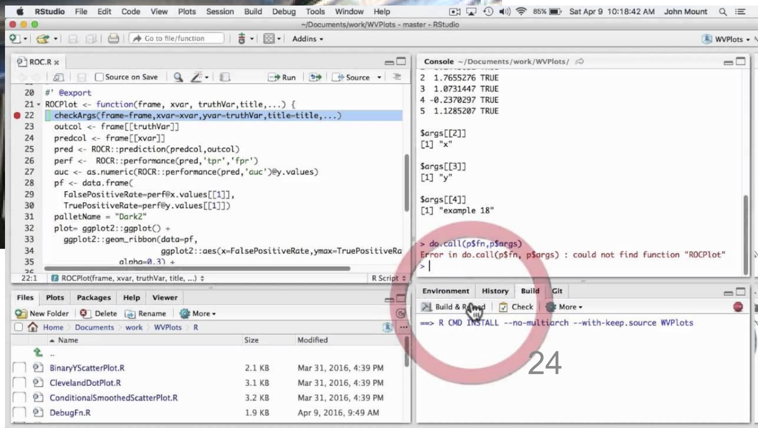
- Earth observation imagery- Landsat, Sentinel-1 and -2
- Landsat and Sentinel-2
  - optical imagery
  - 10 to 60m spatial resolution
  - frequent temporal resolution- revisit ~every 5 days
  - vegetation wetness or moisture time series analysis
  - cannot penetrate clouds or vegetation

Technical objectives

- Create process and analyze soil moisture maps
- Create process and analyze time series of vegetation moisture and water content
- Explore the relationship with ground water level measurements
- Verify the locations of peatland restoration activities
- Introduce new features in SEPAL

under the hood of peatland restoration modules using earth observation data






FM ch1


Using Jupyter Notebooks as an interface for soil moisture mapping

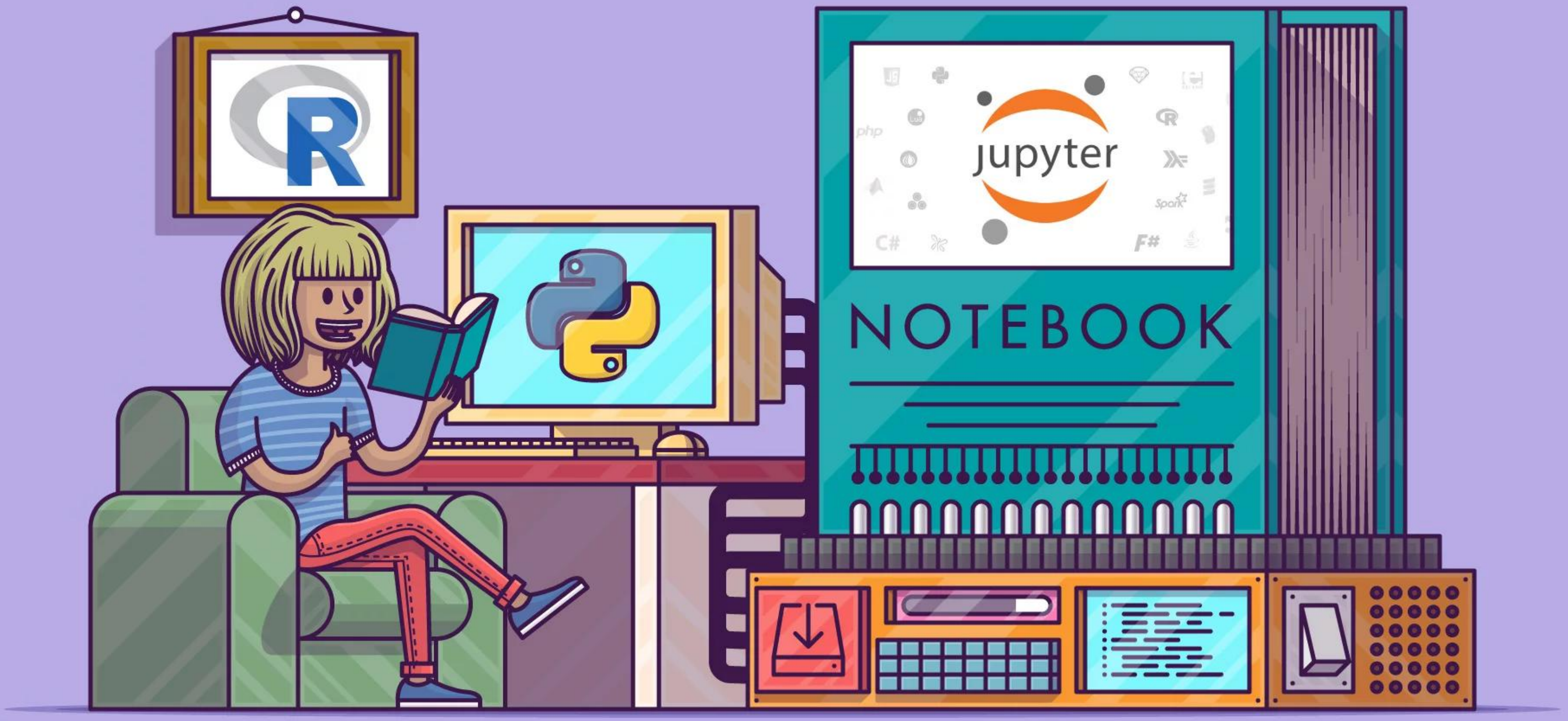


Image credit: https://realpython.com/jupyter-notebook-introduction/

Housekeeping

- Does anyone not have a SEPAL account?
- Does anyone not have a Google account and a Google Earth Engine approved user
- Does anyone have less than $10 USD in their SEPAL instance budget?

Getting started

- sign into SEPAL
- ensure budgets for everyone
- update participants list
- connect Google account to SEPAL
- clone github repository
- review documentation
- start jupyter notebook

Getting started

- new SEPAL 2.1
  - radar and optical mosaics
- uploading a Google Earth Engine asset
- uploading a Google fusion table
- exploring Google Earth Engine
- Climate Engine for assessing precipitation and vegetation index trends

git clone
https://github.com/yfinegold/ws_idn_20190819

Example data set - PHU 778