

# PML

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## Building The Welsh Data Cube

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# Cymru Fyw

“ Sicrhau bod  
lloerennau'n gweithio  
dros ein hamgylchedd ”

# Living Wales

“ Making satellites work  
for our environment ”



# Why build a data cube for Wales?

- Framework for products being generated as part of Living Wales
- Support use of Earth Observation data in government
- Link with other international projects (e.g., Australia, Switzerland)

*Promoting and building national capability in earth observation and economic success whilst ensuring long-term care and maintenance of the environment and resources*

## Prosperity for Wales

Providing new opportunities for economic development in all sectors by providing open access and usable earth observation and derived products to the population.



## Sustainability for Wales

Providing a long-term system for understanding, monitoring and planning landscape change that is applicable at a national level and based on historical and near real time earth observations.

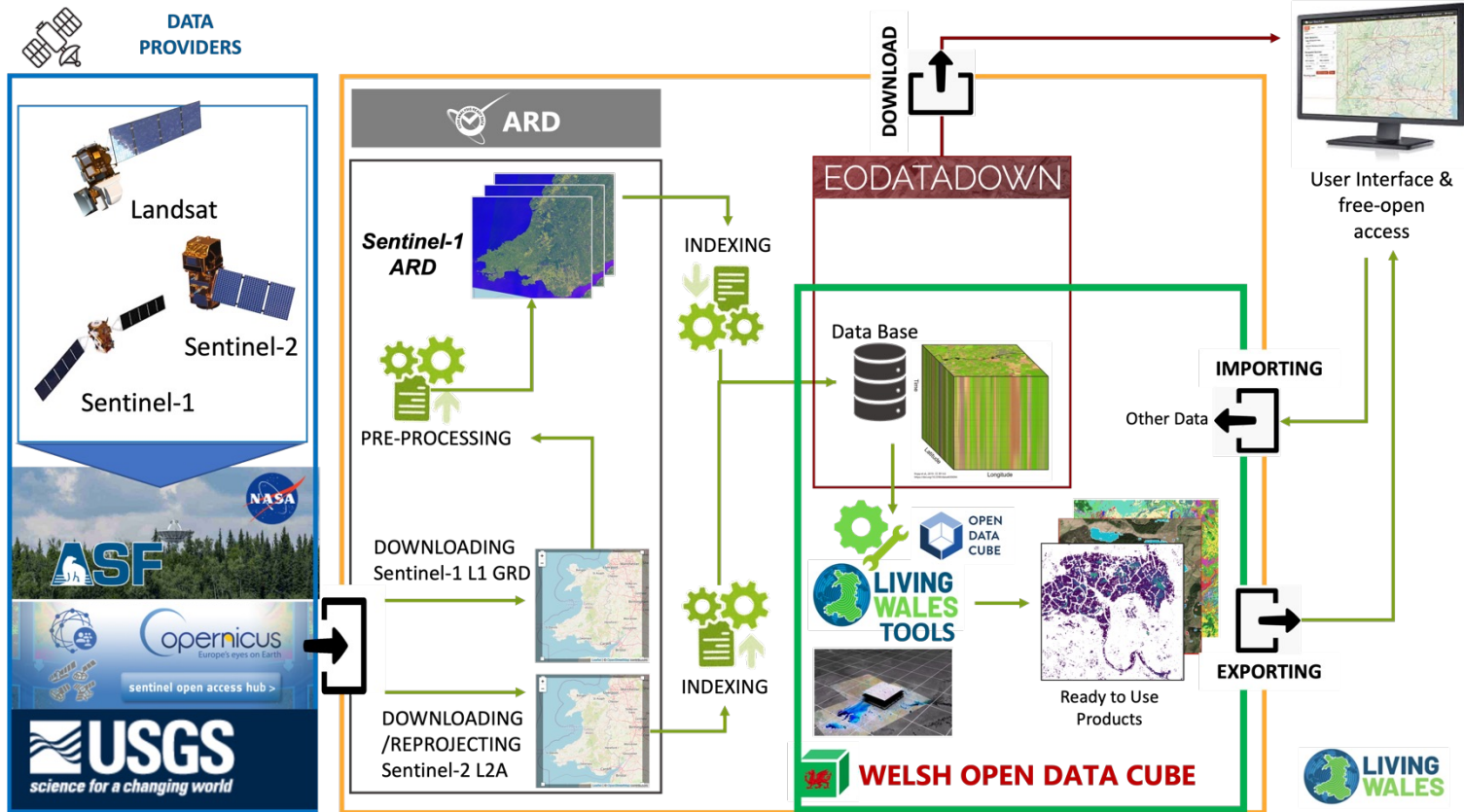


## Resilience for Wales

Ensuring maintenance and promoting enhancement of the state and function of Welsh landscapes and their ability to respond to adverse environmental change through integration of earth observation data.

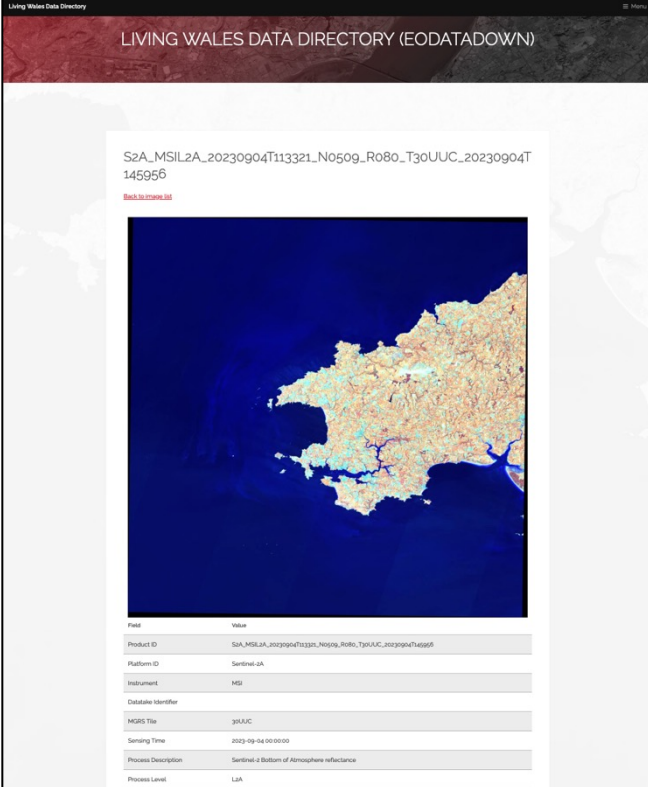


# System overview



# Core technologies: EODataDown

- Python library with postgres database
  - Classes for different providers / sensors
  - <https://github.com/remotesensinginfo/eodatadown>
- Performs the following
  1. Data search
  2. Data download
  3. Conversion to ARD
  4. Quicklook generation
  5. Map tile generation
- Flask web app for data search and download



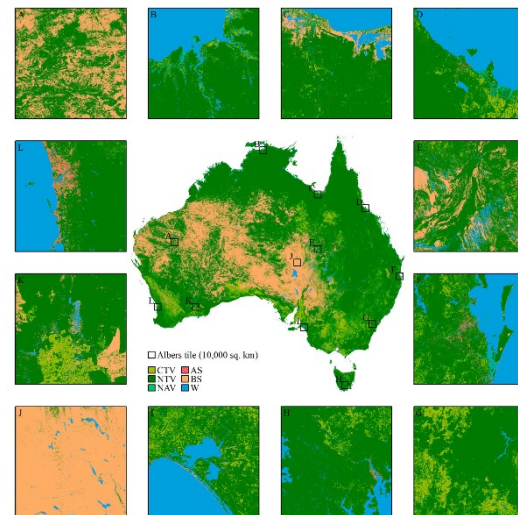
The screenshot displays the 'Living Wales Data Directory (EODataDown)' web interface. At the top, the title 'LIVING WALES DATA DIRECTORY (EODATADOWN)' is visible. Below the title, a specific data entry is shown with the ID 'S2A\_MSIL2A\_20230904T113321\_N0509\_R080\_T30UUC\_20230904T145956'. A red link labeled 'Back to home list' is positioned above a satellite image of Wales. The image shows the coastline and inland features in a false-color composite. Below the image is a metadata table with the following details:

Field	Value
Product ID	S2A_MSIL2A_20230904T113321_N0509_R080_T30UUC_20230904T145956
Platform ID	Satellite 2A
Instrument	MSI
Database Identifier	
MGIS Tile	314.1.1
Sensing Time	2023-09-04 00:00:00
Process Description	Satellite 2 Bottom of Atmosphere reflectance
Process Level	L1A

# Core technologies: OpenDataCube

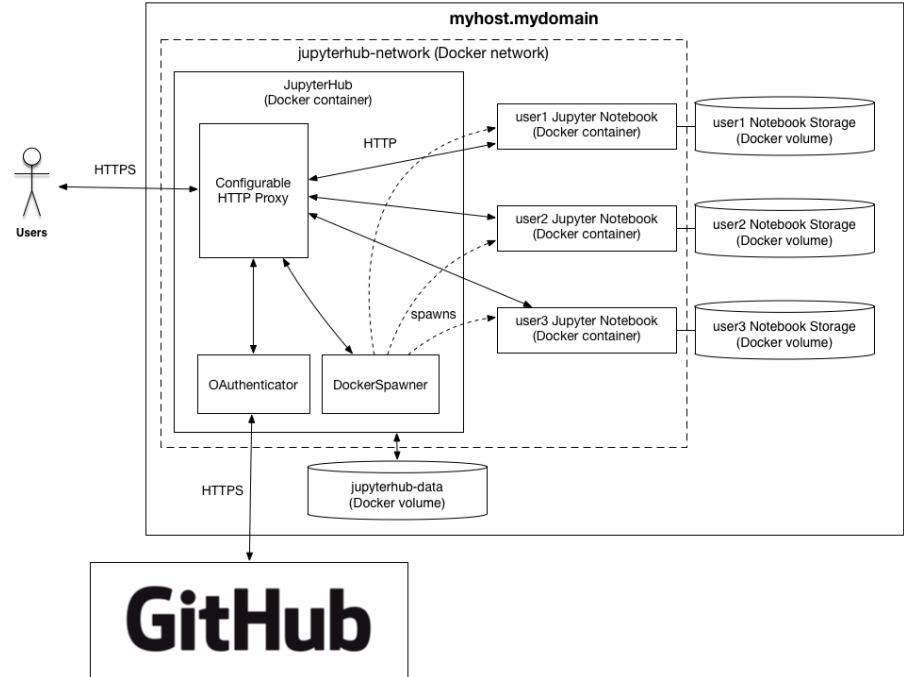
- Python library(s) with postgres database
  - <https://github.com/opendatacube>
- Index data in database, query with Python library
  - Returns as xarray dataset
  - Can use dask
- Can use 'virtual products' to apply algorithms on the fly

```
import datacube
dc = datacube.Datacube()
dataset = dc.load(product="sen2_l2a_gcp",
                  x=(-4.095, -4.076),
                  y=(52.407, 52.422),
                  time=("2018-01-01", "2018-12-31"),
                  output_crs= "epsg:27700",
                  resolution= (-10,10))
```



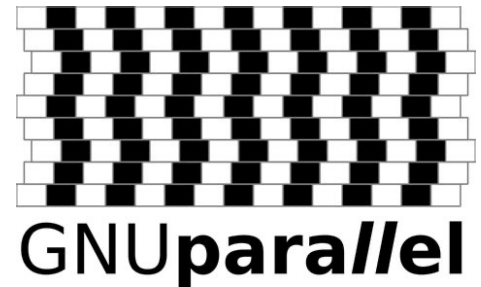
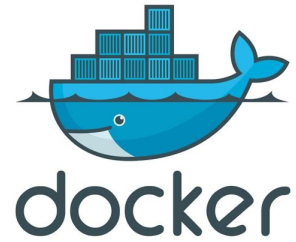
# Core technologies: JupyterHub

- Provides flexible toolkit for analysis
- Using Zero to JupyterHub with Kubernetes
  - <https://z2jh.jupyter.org/en/stable/>
- Investigated other technologies (e.g., the littlest jupyterhub) z2jh determined to be most futureproof



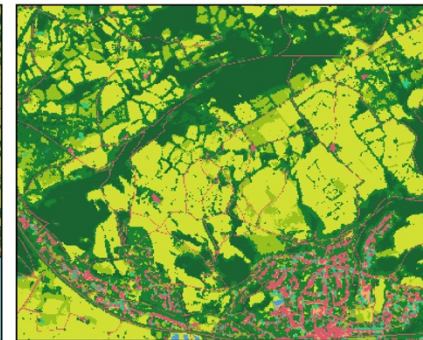
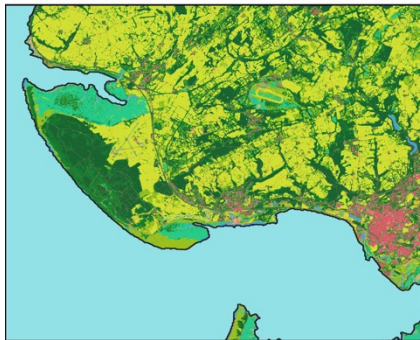
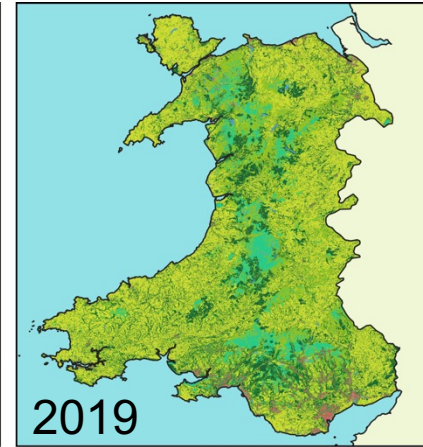
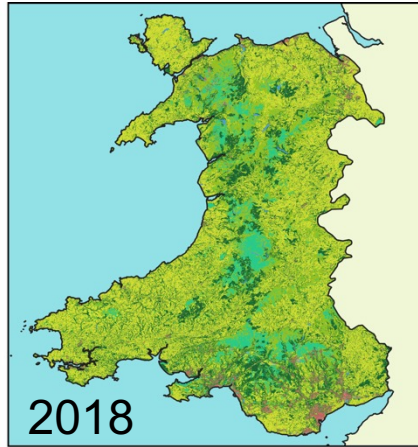
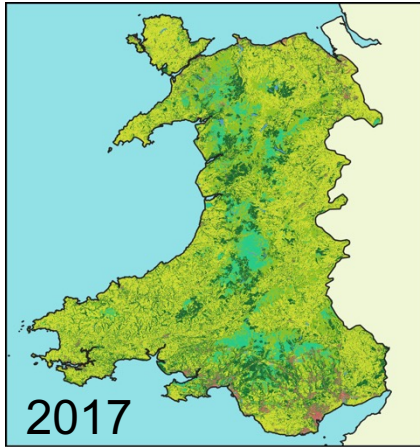
# Current Deployment

- Single server within Supercomputing Wales
- Technologies:
  - Singularity for EODataDown (avoids elevated permissions)
  - Docker for EODataDown front end
  - microk8s for JupyterHub
  - GNU parallel for batch processing as needed

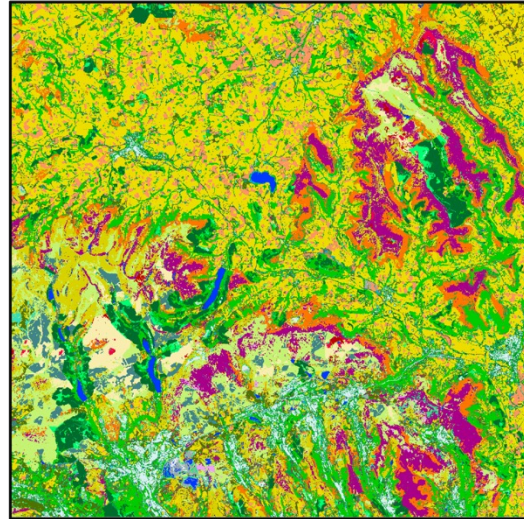
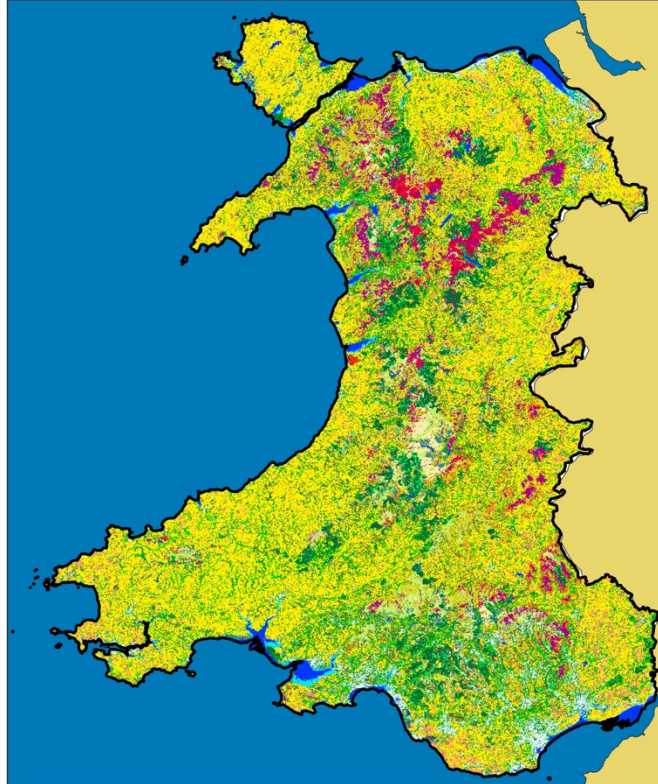




# Outputs: National Land Cover Maps



# Outputs: National Habitat Maps



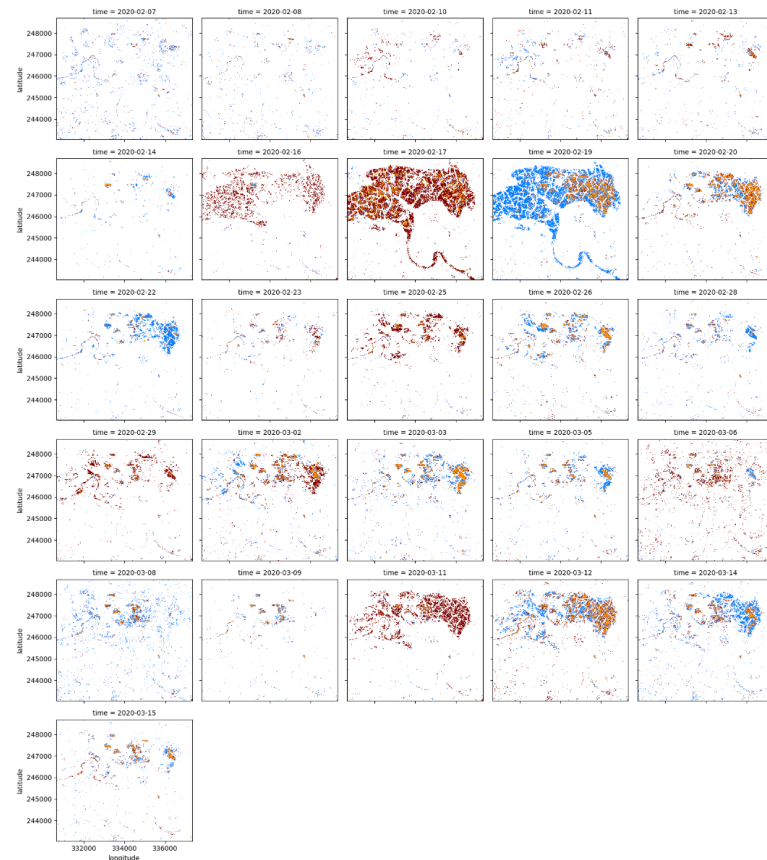
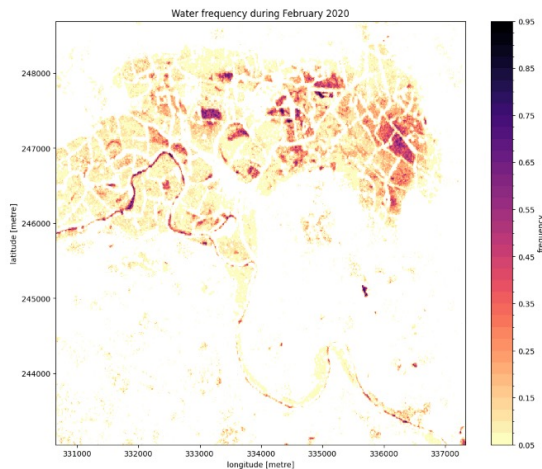
Living Wales habitat map (2020) translated from the FAO LCCS land cover map

## Habitat classes

-  Semi-natural grassland
-  Juncus rushes
-  Molinia grassland
-  Broadleaved woodland
-  Coniferous woodland
-  Acid grassland
-  Improved grassland
-  Marshy grassland
-  Bracken
-  Dry dwarf shrub heath
-  Wet dwarf shrub heath
-  Blanket bog
-  Raised bog
-  Modified bog
-  Fen
-  Swamp
-  Open water
-  Saltmarshes
-  Sand dune
-  Dune grassland
-  Cultivated (arable)
-  Natural bare surfaces
-  Artificial bare surfaces

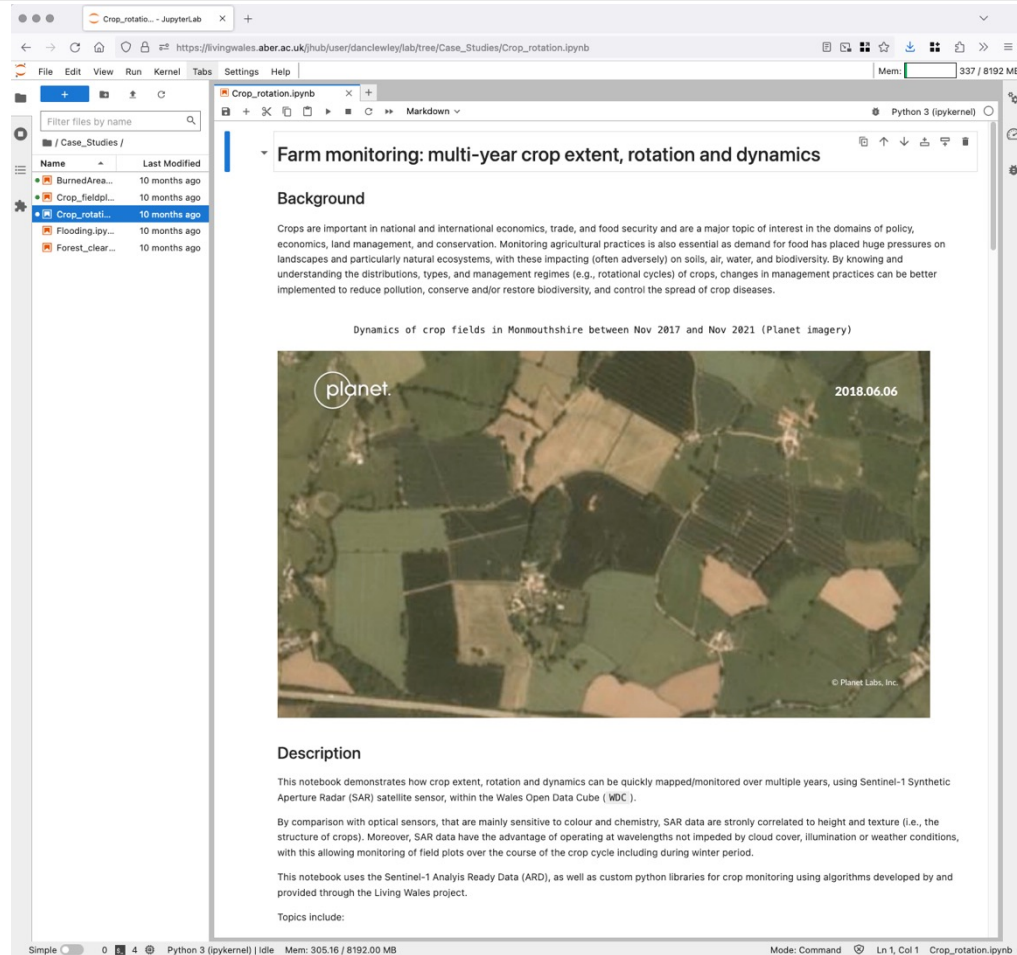
# Outputs: Flood mapping

- Demonstrated can track floods
- Using Sentinel-1 SAR data
- As new data is downloaded, processed and indexed in OpenDataCube can track in real time



# Outputs: Training

- Jupyter Notebooks guiding through common tasks
- Demonstrate going from large dataset to something which can be:
  - Added directly to reports
  - Used in Excel
  - Used in GIS package



The screenshot displays a Jupyter Notebook environment. The left sidebar shows a file explorer with a list of files in the 'Case\_Studies' directory, including 'BurnedArea...', 'Crop\_fieldpl...', 'Crop\_rotati...', 'Flooding.ipy...', and 'Forest\_clear...'. The main notebook area is titled 'Farm monitoring: multi-year crop extent, rotation and dynamics'. It contains a 'Background' section with text about the importance of crop monitoring in national and international economics, trade, and food security. Below the text is a satellite image from Planet Labs, Inc., dated 2018.06.06, showing a patchwork of agricultural fields. The 'Description' section explains that the notebook uses Sentinel-1 Synthetic Aperture Radar (SAR) satellite data to monitor crop extent and dynamics over multiple years, highlighting the advantages of SAR data over optical sensors.

Crop\_rotatio... - JupyterLab

https://livingwales.aber.ac.uk/jhub/user/danclewley/lab/tree/Case\_Studies/Crop\_rotation.ipynb

File Edit View Run Kernel Tabs Settings Help Mem: 337 / 8192 MB

Filter files by name

Name	Last Modified
BurnedArea...	10 months ago
Crop_fieldpl...	10 months ago
Crop_rotati...	10 months ago
Flooding.ipy...	10 months ago
Forest_clear...	10 months ago


Crop\_rotation.ipynb Python 3 (pykernel)

## Farm monitoring: multi-year crop extent, rotation and dynamics

### Background

Crops are important in national and international economics, trade, and food security and are a major topic of interest in the domains of policy, economics, land management, and conservation. Monitoring agricultural practices is also essential as demand for food has placed huge pressures on landscapes and particularly natural ecosystems, with these impacting (often adversely) on soils, air, water, and biodiversity. By knowing and understanding the distributions, types, and management regimes (e.g., rotational cycles) of crops, changes in management practices can be better implemented to reduce pollution, conserve and/or restore biodiversity, and control the spread of crop diseases.

Dynamics of crop fields in Monmouthshire between Nov 2017 and Nov 2021 (Planet imagery)



planet 2018.06.06

© Planet Labs, Inc.

### Description

This notebook demonstrates how crop extent, rotation and dynamics can be quickly mapped/monitored over multiple years, using Sentinel-1 Synthetic Aperture Radar (SAR) satellite sensor, within the Wales Open Data Cube (WDC).

By comparison with optical sensors, that are mainly sensitive to colour and chemistry, SAR data are strongly correlated to height and texture (i.e., the structure of crops). Moreover, SAR data have the advantage of operating at wavelengths not impeded by cloud cover, illumination or weather conditions, with this allowing monitoring of field plots over the course of the crop cycle including during winter period.

This notebook uses the Sentinel-1 Analysis Ready Data (ARD), as well as custom python libraries for crop monitoring using algorithms developed by and provided through the Living Wales project.

Topics include:

Simple Python 3 (pykernel) | Idle Mem: 305.16 / 8192.00 MB Mode: Command Ln 1, Col 1 Crop\_rotation.ipynb

# Future plans

- Continue to support more users
- Continue developing products
- Continue international links
- Infrastructure moving to Microsoft Azure
  - Allows better separation
  - Can scale better to meet demand (more users, more resources)
- Better integration with DataMapWales



# Thank you

