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2025 DRAGON 6 SYMPOSIUM

14-18 JULY 2025

[PROJECT ID. 95452]

FUCEO: EXPLORING SYNERGIES BETWEEN CHINESE AND EUROPEAN EO MISSION
USING DATA FUSION





Project ID: 95452

Project Title: FUCEO: Exploring synergies between Chinese and European EO mission using data fusion

Principal Investigators:

Sun Bin: Institute of Forest Resource Information Techniques, Chinese Academy of Forestry (China)

Rui Song: Sub-department of Atmospheric, Oceanic and Planetary Physics, University of Oxford (UK)

Co-authors:

Zhihai Gao, Hanwen Cui

Jan-Peter Muller, Roy G. Grainger, Xumeng Deng

presented By: Rui Song & Sun Bin

Dragon 6 EO Data Delivery



Data access (list all missions and issues if any). NB. in the tables please insert cumulative figures (since June 2024) for no. of scenes of high bit rate data (e.g. S1 100 scenes). If data delivery is low bit rate by ftp, insert “ftp”

ESA /Copernicus Missions	No. Scenes	ESA Third Party Missions	No. Scenes	Chinese EO data	No. Scenes
1. Sentinel-2		1. Landsat		1.GF-6 WFV	
2. MSG/MTG		2. MODIS		2. SDGSat-1	
3.		3. VIIRS		3.	
4.		4.		4.	
5.		5.		5.	
6.		6.		6.	
Total:		Total:		Total:	
Issues:		Issues: All the data from NASA/USGS		Issues:	



COMPASS INFORMATICS
Information and Location Insights



EO for the Green Transition, the ESA-GTIF (Green Transition Information Factory) showcase for UK, Ireland, & France

Jan-Peter Muller¹, Rui Song^{1,2} & Gill Watson¹

(1. UCL Mullard Space Science Laboratory; 2. NCEO, University of Oxford)

Rob O'Loughlin, Phil Baldacchino-Steward, Adriaan Keurhorst & Marcus Parsley (Compass Informatics, Dublin, Eire)

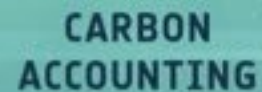
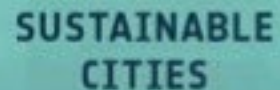
Chrisopher Rampersad, Lynette Olifert, Elaine Ting, John Vu (EarthDaily Analytics, Vancouver, Canada)

Yu Tao (SAIIL)

Patrick Griffiths (ESA-ESRIN TO, Frascati, Italy)

ACTIONABLE INFORMATION: Empower various users (e.g., citizens, policy makers, industry professionals) to better understand Green Transition challenges and opportunities & engage in the public discourse.

Initial focus on 5 Green Transition PRIORITY DOMAINS:





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- in order to move the Green Deal agenda forward across ESA nation states, EO data are understood to play a central role in the Green Transition Information Factory
- The ESA UK-Ireland-France (UKIF) Kickstarter project is assisting in the exploitation of EO data to monitor the environment, with 5 capabilities developed building on the open source Sentinel-2 Global Mosaicing Copernicus Land Monitoring Services (S2GM), public domain ESA, NASA and NOAA data sources, national geospatial data sources and commercial data sources for specific services
- Stakeholders are engaged at government (national & local) along with NGO and private sector enterprises to help shape the requirements



The UKIF multi-national project is demonstrating the use of Earth Observation and geospatial data for five kick-starter applications each of which address challenges in each of five different domains:

- Solar power generation using bifacial PV's and best installation locations - **energy**
- Urban air quality at a street level, to encourage active travel - **mobility**
- Drought and its impact on food systems – **food systems**
- Urban heat islands to enable focused insulation and energy reduction programmes – **sustainable cities**
- Fugitive methane emissions for carbon accounting – **carbon accounting**

Rural Solar Power : The opportunity

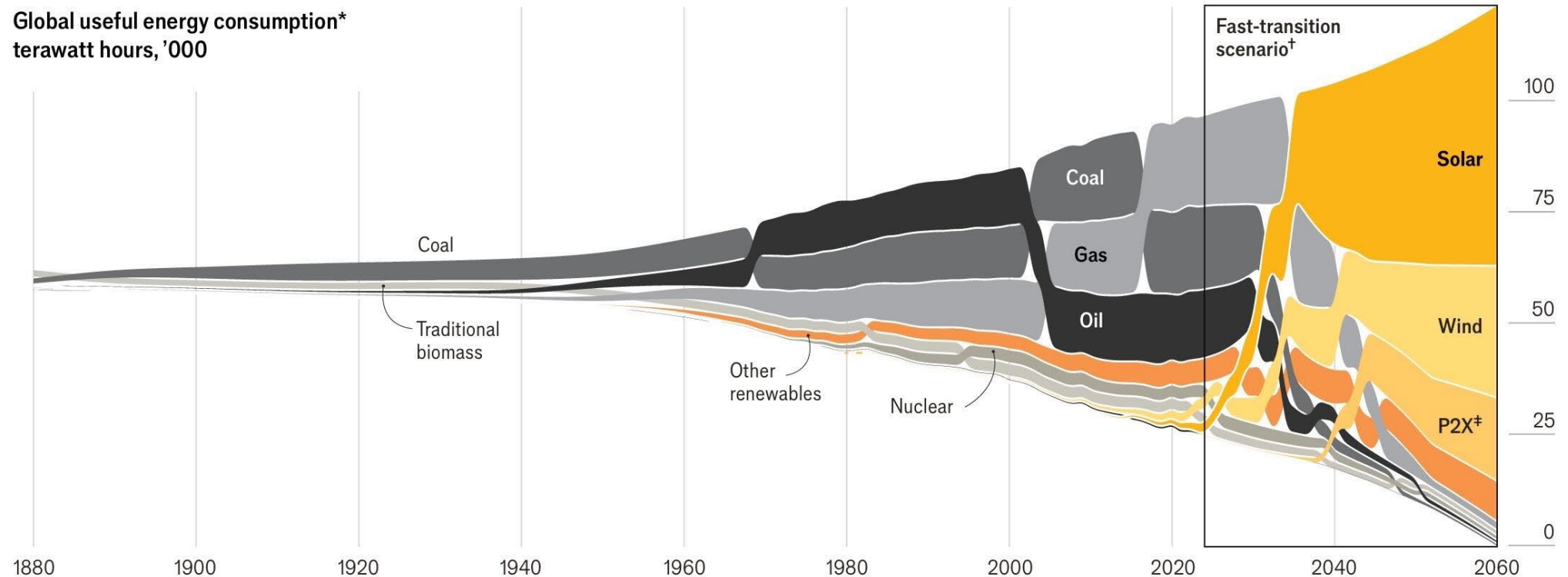


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According to the International Solar Energy Society, solar power is on track to generate more electricity than all the world's **nuclear** power plants in **2026**, than its **wind** turbines in **2027**, than its **dams** in 2028, its **gas**-fired power plants in 2030 and its **coal**-fired ones in 2032. (The Economist, 20.6.24)



Sources: Rupert Way; Our World in Data

*Primary energy adjusted for waste-heat losses [†]From Way et al. (2022) [‡]Electricity-conversion technologies (eg green hydrogen)

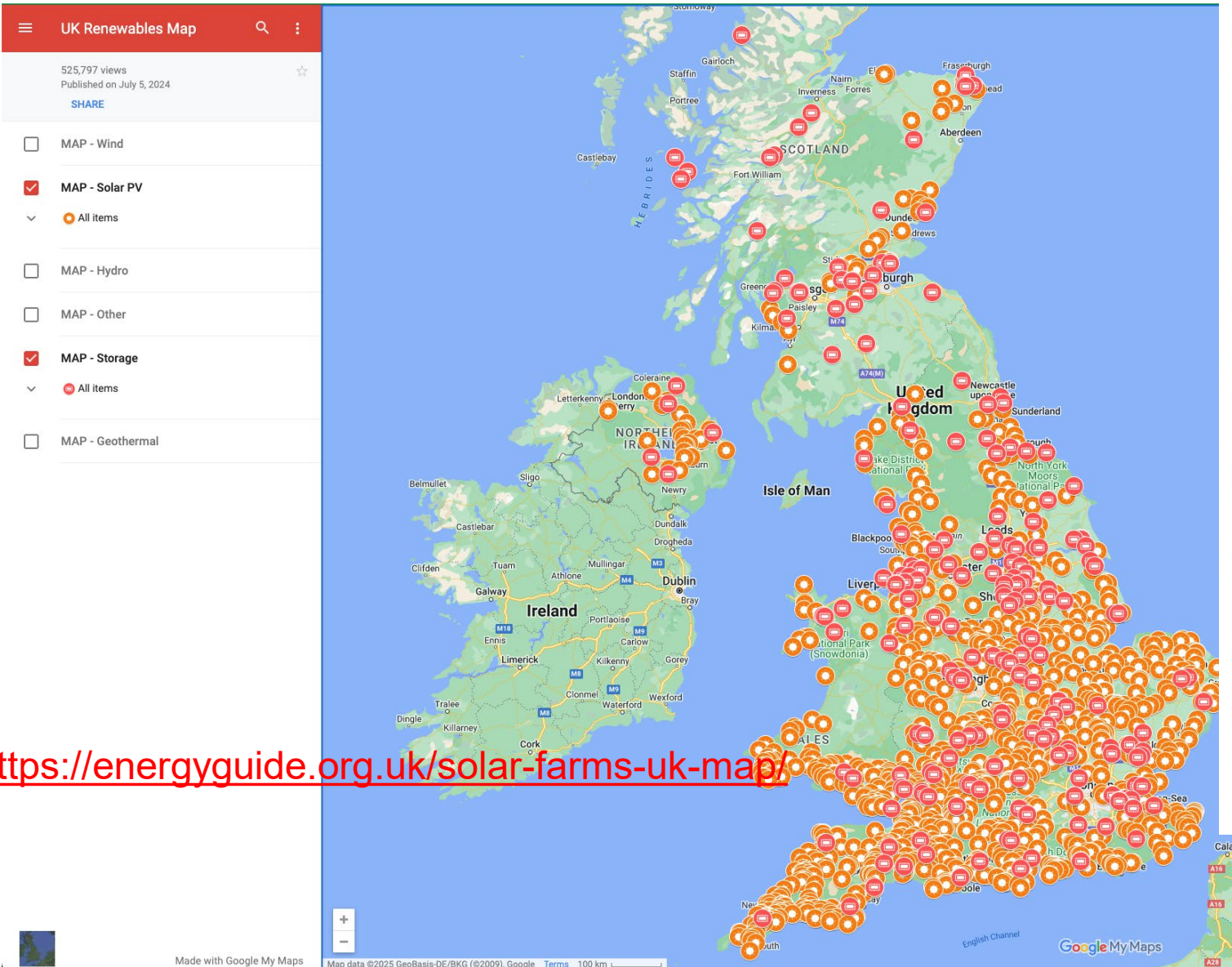
ESA-GTIF Solar rural power generation - context



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Auto AI detection of solar PV (Song, et al.,)
from 10m Sentinel-2 global images

How EO technology can support the renewable transition (PV)



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Framework of developing global facility-level PV energy database



PV output energy estimation

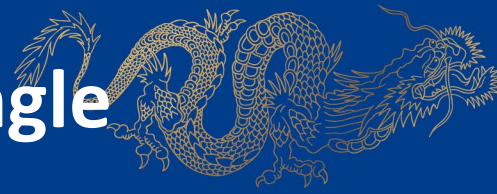


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Solar irradiance at optimal tilting angle



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PV output energy estimation



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PV output energy estimation



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Comparison with other database



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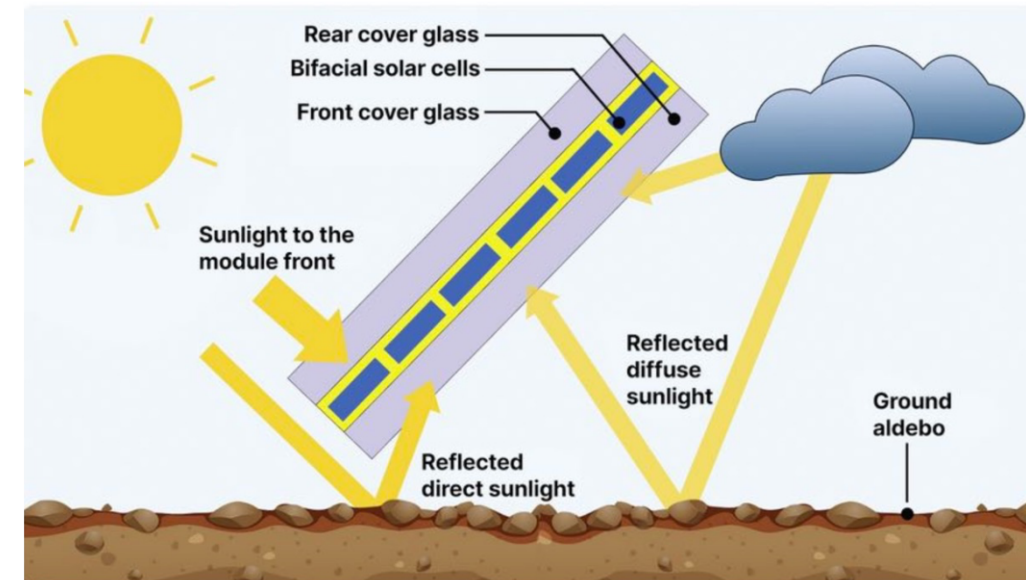
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Metric	Our database	Transition Zero	Microsoft
Number of facilities evaluated	3000	3000	3000
Total PV panel area (km ²)	2100	3038.7	2950.5
Average overestimation relative to our database	-	44.7%	40.5%



- Rural site suitability maps produced for mono & bi-focal PV placement
- Built GIS exclusion zones for areas with unacceptable costs for solar farm placement (e.g. Areas of outstanding natural beauty)
- Emphasis on croplands & grasslands to **allow mixed use of crops and/or livestock**. New area of agrivoltaics growing worldwide.
- EU-JRC Copernicus Land Monitoring system S2GM to be used to produce land surface spectral albedo of UK + Ireland
- Will use topography from lidar & InSAR, identified sites will be investigated and strategy developed for site selection
- Solar power output will be assessed based on astronomical calculations, PV_{out} and spectral-to-PV solar power O/P



Solar farm location capability 1

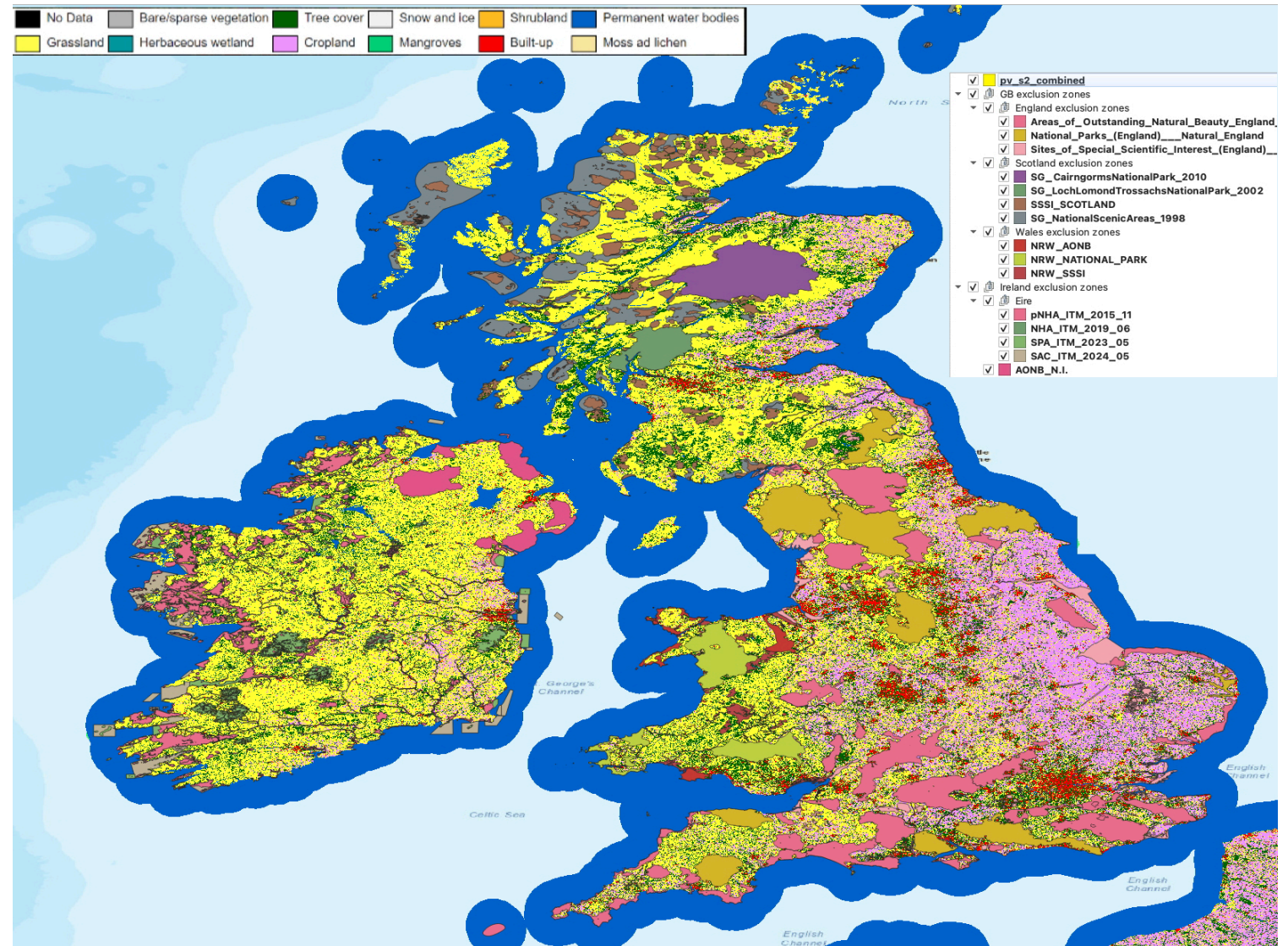


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- To minimise environmental impact through agrivoltaics and maximise income sharing between solar power and the farming community
- Select cropland (pink) and grassland (yellow) areas from 10m ESA WorldCover2021 LULC map
- Exclude environmental sensitive areas from agrivoltaic areas using vector datasets of National Parks, Areas of Outstanding Natural Beauty and Sites of Special Scientific Interest in UK and equivalents in Republic of Ireland
- Compare against CDDA equivalent areas from EU for upscaling to France
- Assess ESA-WC21 LULC maps using national LULC maps, and map annual changes in grassland and croplands



Solar farm location capability 2

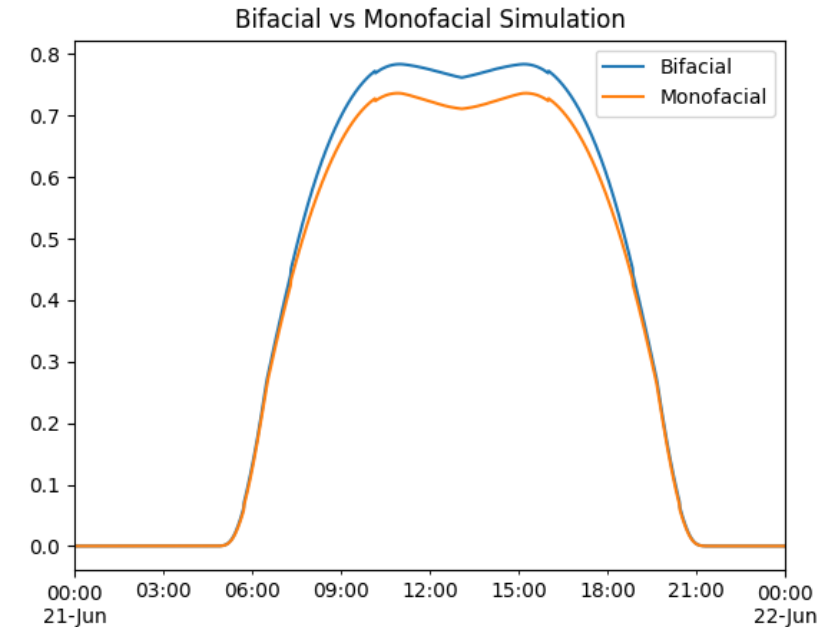
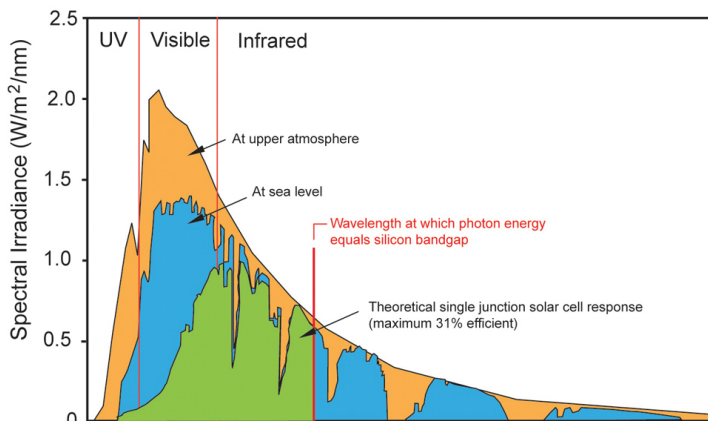


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- Mapped global solar PV locations from 2018-25
- Employ PVout from UN Solar Atlas (250m) for 2009-2023
- Methods developed for calculating bi-facial PV enhancements (6-30%) for agrivoltaics and estimates for average shortwave albedo
- Calculate weighted albedo over suitable spectral area from 4 Sentinel-2 spectral bands (2,3,4,8A) or shortwave albedo using S2GM albedo mosaics



6-10% enhancement from
assumed albedo=0.2

10m S2GM spectral albedo
calculated for 6 spectral bands for
August 2022. Shown here RGB

Solar farm location capability 3

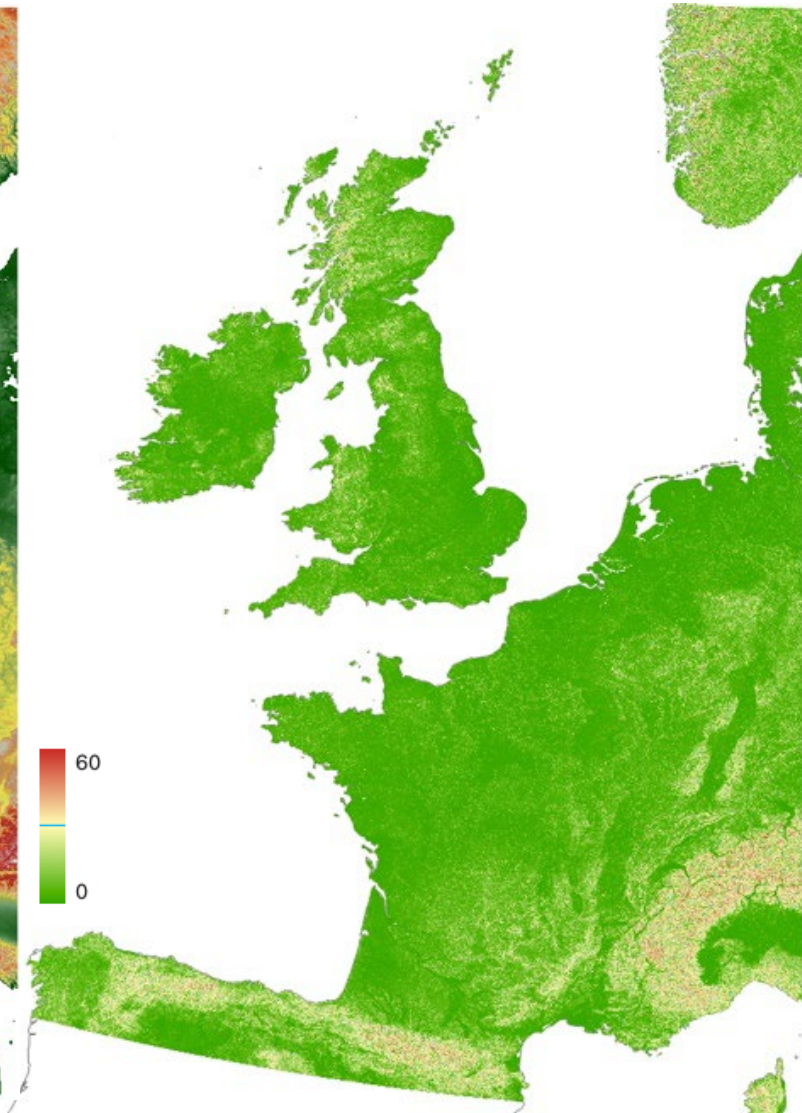
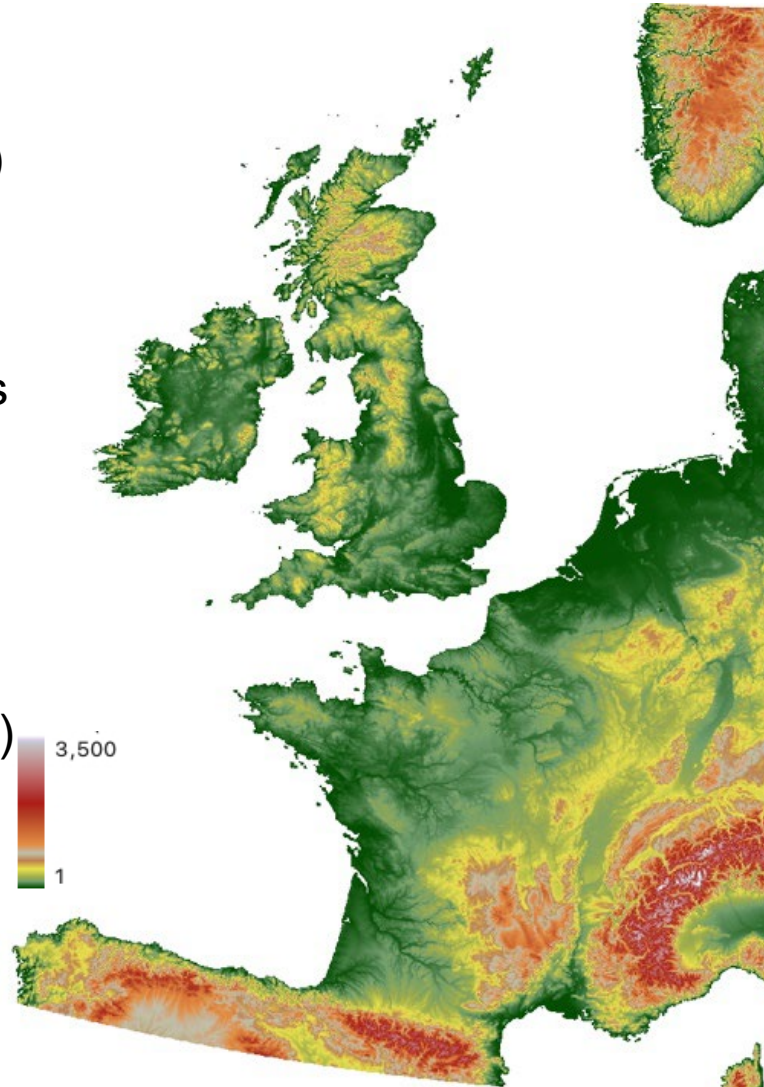


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- Copernicus 30m DEM employed after projection to equal area ITRF (EPSG:3035)
- Slope and aspect derived using open source terrain analysis toolkit
- Almost all croplands have slopes $<8^\circ$ though grasslands can have steeper slopes
- Solar PV deployment auto-detected so far $<0.01\%$ of total GB+IE land area
- Huge potential for future upscaling to cover much larger areas in the UK with bi-facial
- 2 hectares of monofacial generates 1 MW
- Less area for bi-facial (reduction up to 30%)
- Current **0.36 (IE), UK (7.34), FR (6.5) GW**
- Potential **1.06 (IE), UK (3.1), FR (5.7) TW**
- Interactive webGIS developed to explore potential of different areas for solar farm placement



ESA-GTIF webGIS demonstrator for UK-Ireland-France



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GTIF | Green Transition Information Factory

DOMAINS & TOOLS

Energy Transition

Mobility Transition

Food Security

Sustainable Cities

Carbon Accounting

Tools

Air Quality 3

Drought Analysis/Forecast 5

Heat Island 4

Methane Emissions Analysis 3

Solar Rural Power 2

Photovoltaic Output

Photovoltaic Output - Monthly

LAYERS

Overlay Layers

Analysis Layers

Solar Panels

Area of Outstanding Natural Beauty (AONB)

National Parks

SSSI

+

-

Q

Solar Power output at 250m derived from data for several decades up to 2019. These datasets show the predicted solar power output from single-side PV panels across the UK and Ireland. Source of PVout from Global Solar Atlas. These datasets indicate those areas which will be excluded in any search for locating future solar bi-facial farms in rural areas. These exclusion zones include Areas of Outstanding Natural Beauty (AONB), Sites of Special Scientific Interest (SSSI) and National Parks for the UK nations(England, Scotland, Wales and Northern Ireland) and the equivalents for the Republic of Ireland*. The areas left which may be suitable are primarily grassland and arable crops and the land cover is shown here for these areas indicating that there are around 50% of the land area which may be suitable for bi-facial solar farms to allow agriculture to continue and improve the local micro-climate from the Agrivoltaic environment. A colourised by height with hill-shaded Digital Elevation Model (DEM) at 30m grid-spacing mosaic of the whole UKIF area of many tiles (size 26.5Gb), produced by the EU Copernicus program, in WGS84. COP30 DEM is derived from TerraSar-X+TanDEM-X and spans several years of inSAR retrievals. The 10m ESA WorldCover 2021 map for the whole UKIF area. It uses all available Sentinel-2 images for the whole of 2021.

ANALYSIS

EDC service for ESA | Legal | Privacy

edash v4.0 by EOX

FEEDBACK

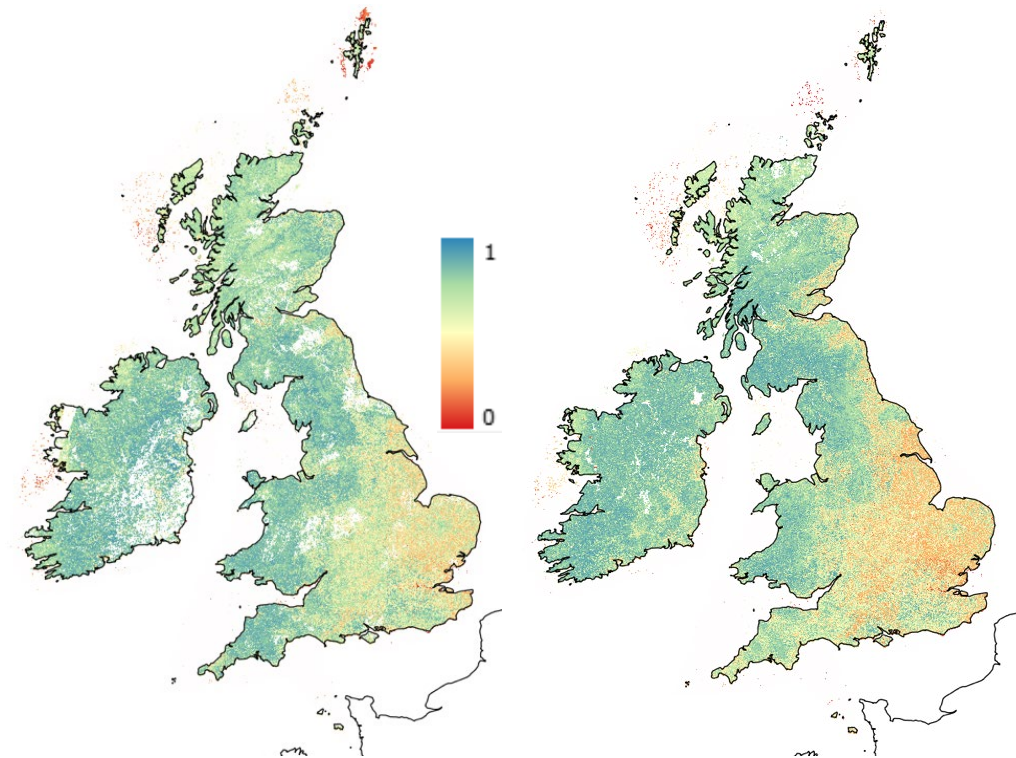


Progress to date:

- S2GM upgraded processing system for complete countries being processed given shapefiles now includes spectral albedo, derived NDVI and fAPAR + LAI.
- Three methods are employed:
 - VCI based on NDVI
 - TCI based on LST
 - fAPAR based on albedo
- Six months of albedo and derived NDVI have recently been processed for Ireland and VCI derived using Vegetation Condition Index (VCI)
 - $VCI_i = 100 * \{(NDVI_i - NDVI_{min}) / (NDVI_{max} - NDVI_{min})\}$
- Difficulty in finding sufficient cloud-free Landsat LST datasets so investigating downscaling VIIRS 375m LST to Landsat

Planned:

- Working on validation sources with UK CEH & Eire DECC
- Searching for crop_type_by_month maps for GB & Ireland



August 2020-NDVI

August 2022-NDVI

ESA-GTIF: Drought Monitoring



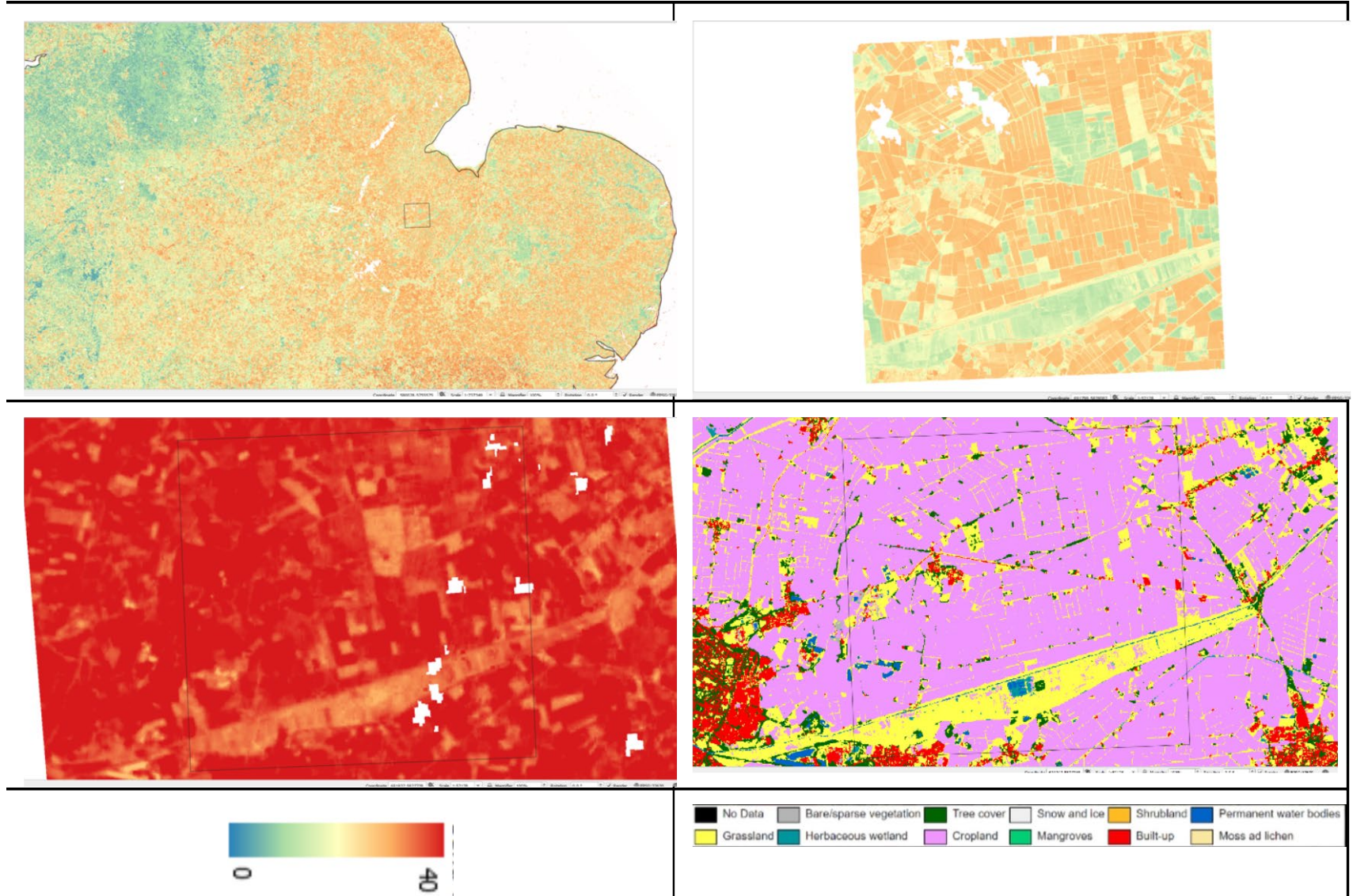
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TEST SITE:

- A small area (11 X 10km) was chosen in a rural location near Peterborough (Lincolnshire)
- Monthly S2GM 10m spectral & broadband albedo & fapar processed for 10 years (2016-2024)
- Landsat LST at 100 m processed for the same time period but only available for limited dates when cloud cover is lowest (e.g. 2021 contains almost no single LST)
- Plan to use VIIRS (375m LST) to provide continuity and downscaling to Landsat resolution



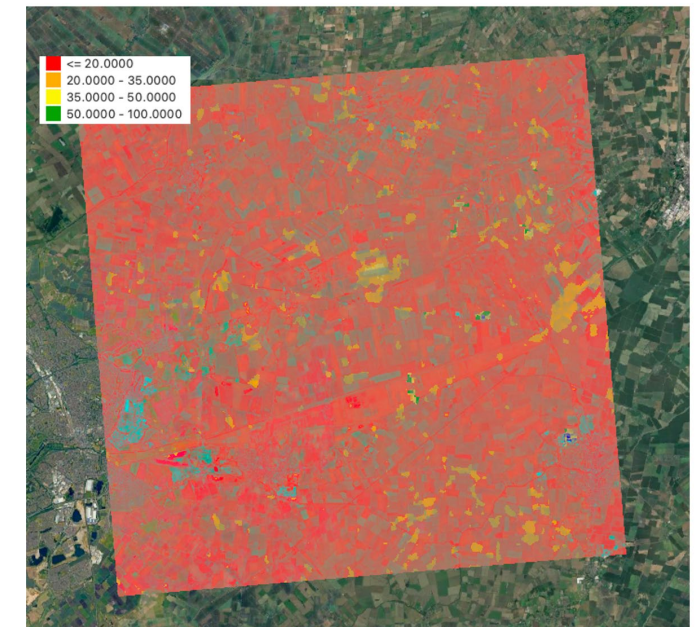
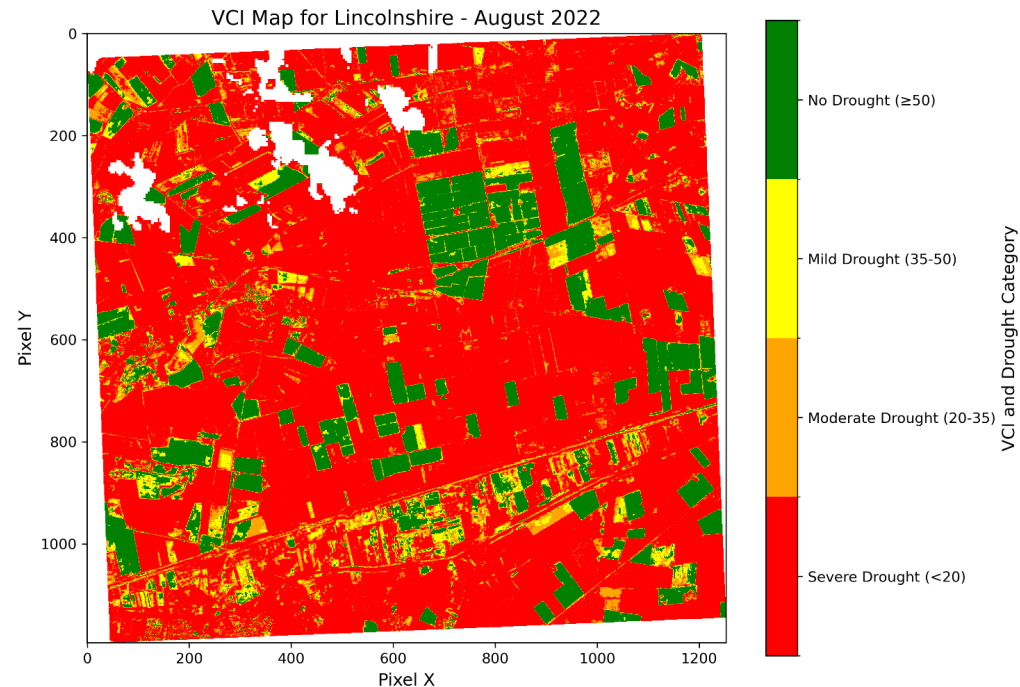
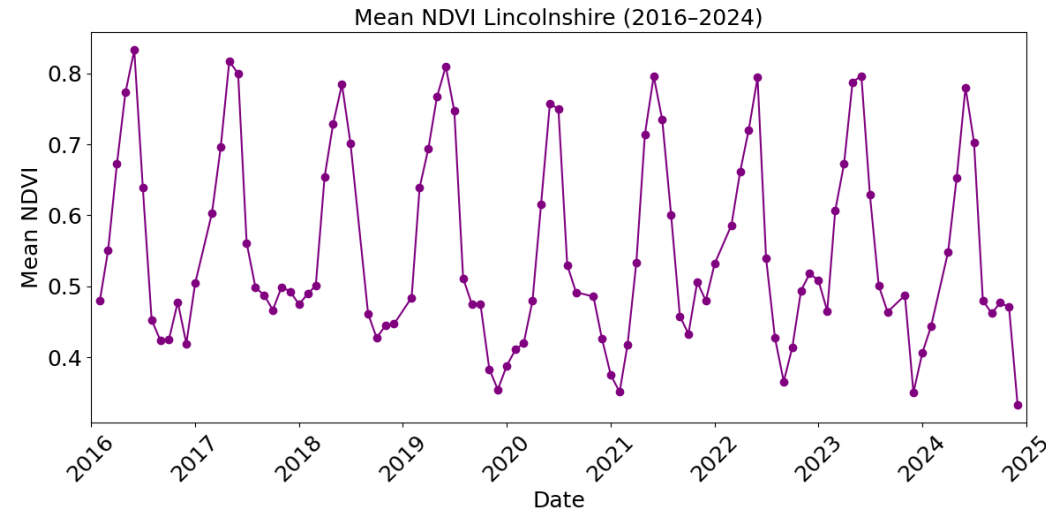


Drought impact mapping:

- NDVI was calculated for this small area for 10 years
- VCI was calculated based on this 10 year time series
- A VCI threshold was used to define drought
- TCI calculated from Landsat LST each month from all available (1 or 2 maximum pcm)
- Plan to employ validation dataset (CEH-UKWRP) SPI & SPEI for drought assessment.

Drought forecast

- Deep learning based short-term forecasting focus at 10m



ESA-GTIF: Drought Monitoring



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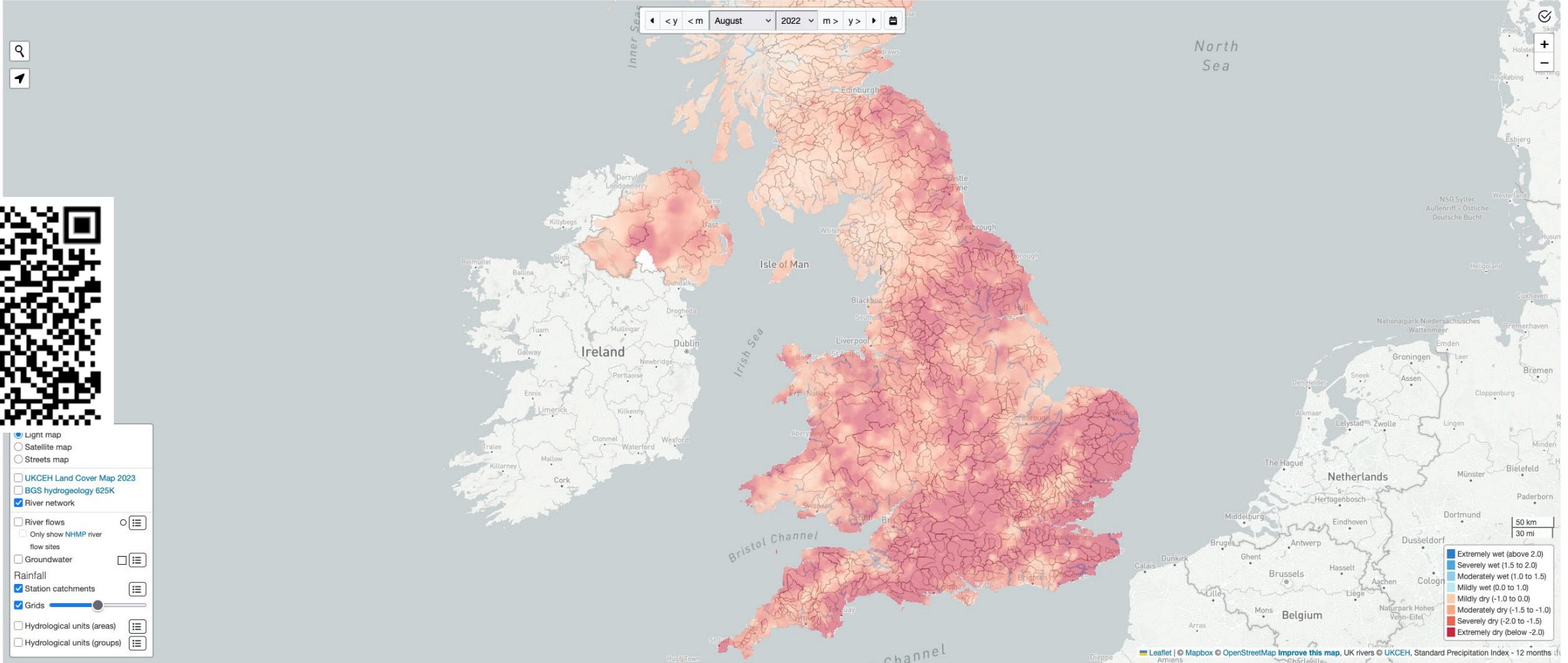
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UK Water Resources Portal

Home About Toggle introduction

Data type: **Raw data** **Drought Indices** Accumulation period: 1 3 6 12 18 24

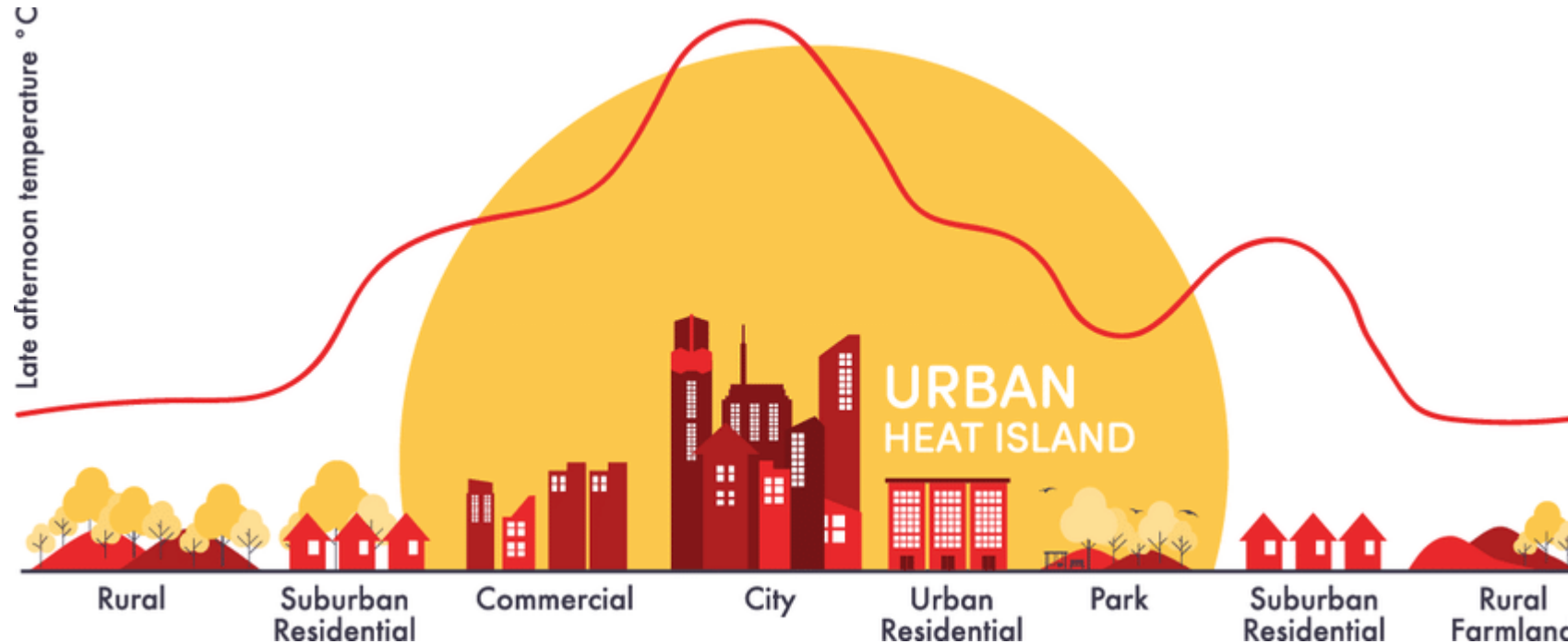


UK drought indices:

- Validation dataset (CEH-UKWRP) 1km SPI & SPEI for drought measures about to be released.



Urban Heat Island – Area within a city that is significantly warmer than its surrounding rural areas



(World Meteorological Organization)

- Lack of green spaces, building materials, sky-view factor, dark surfaces, air pollution, lack of water bodies

This can be seen from space

UHI – Sample Outputs



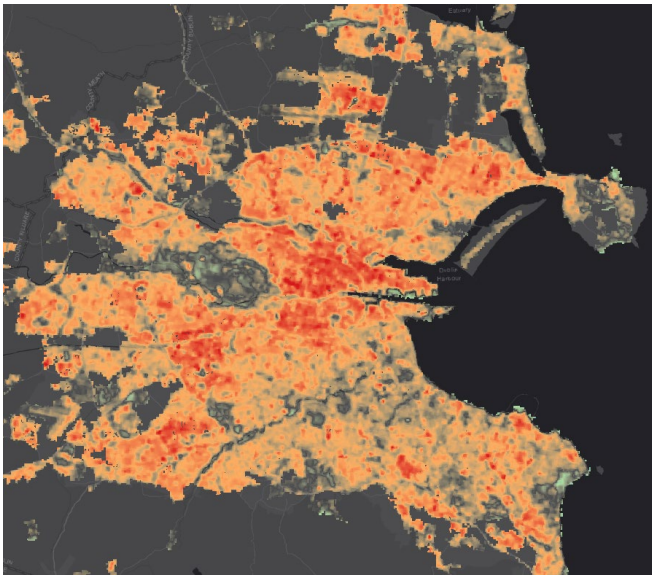
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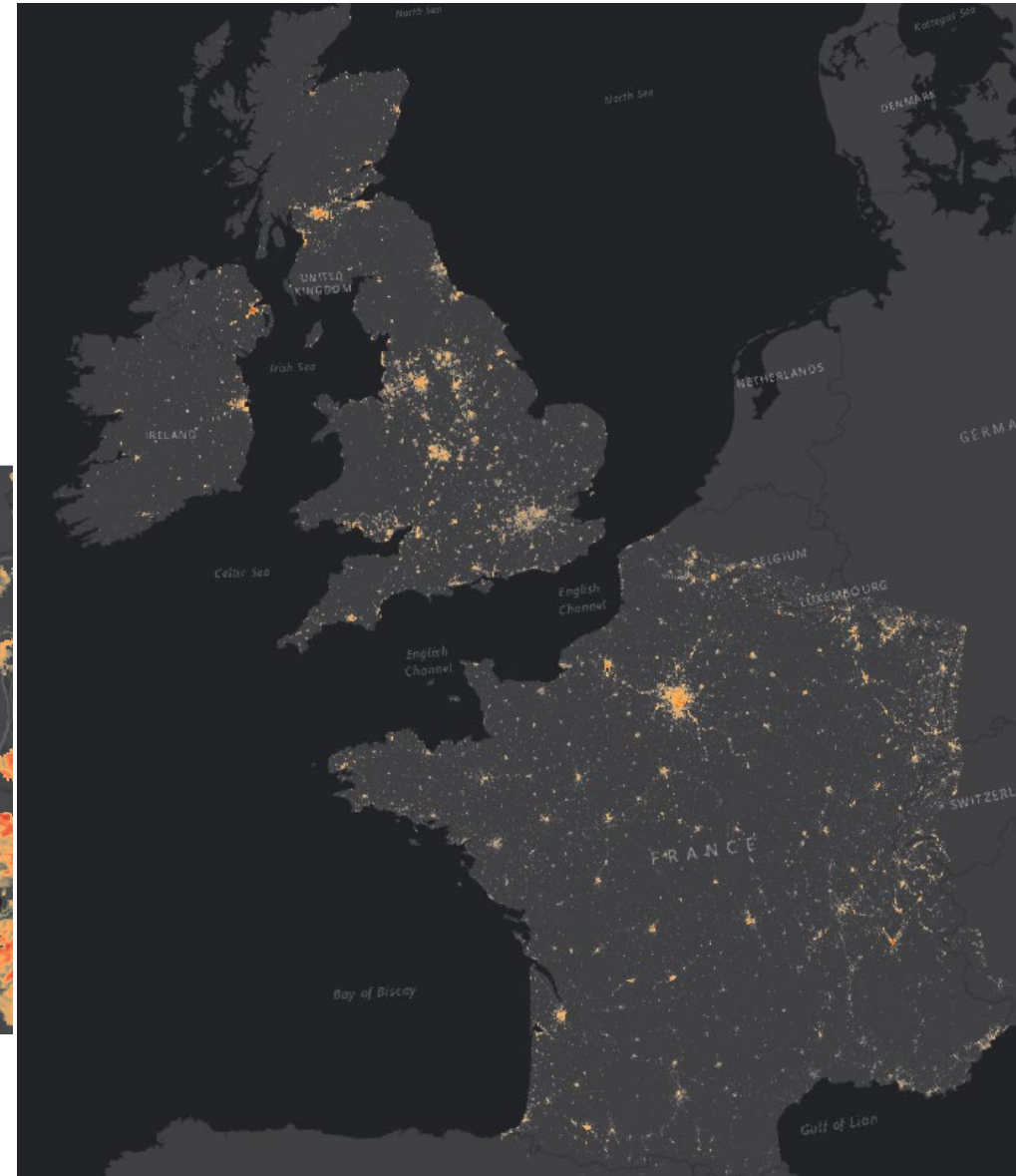
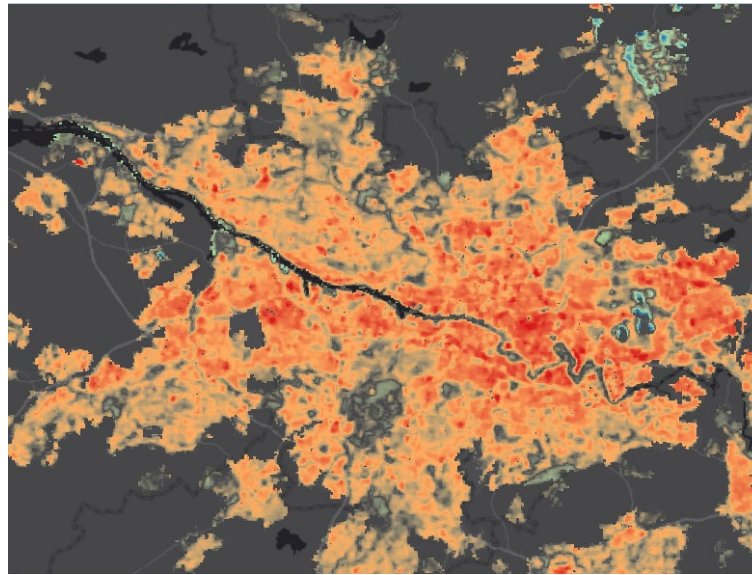
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- Thermal Landsat-8/9 imagery
- UHI maps from aggregated Land Surface Temperature data
- Mean LST data between 2022-2024 in summer months output the following images

Dublin



Glasgow



UHI – Sample Outputs

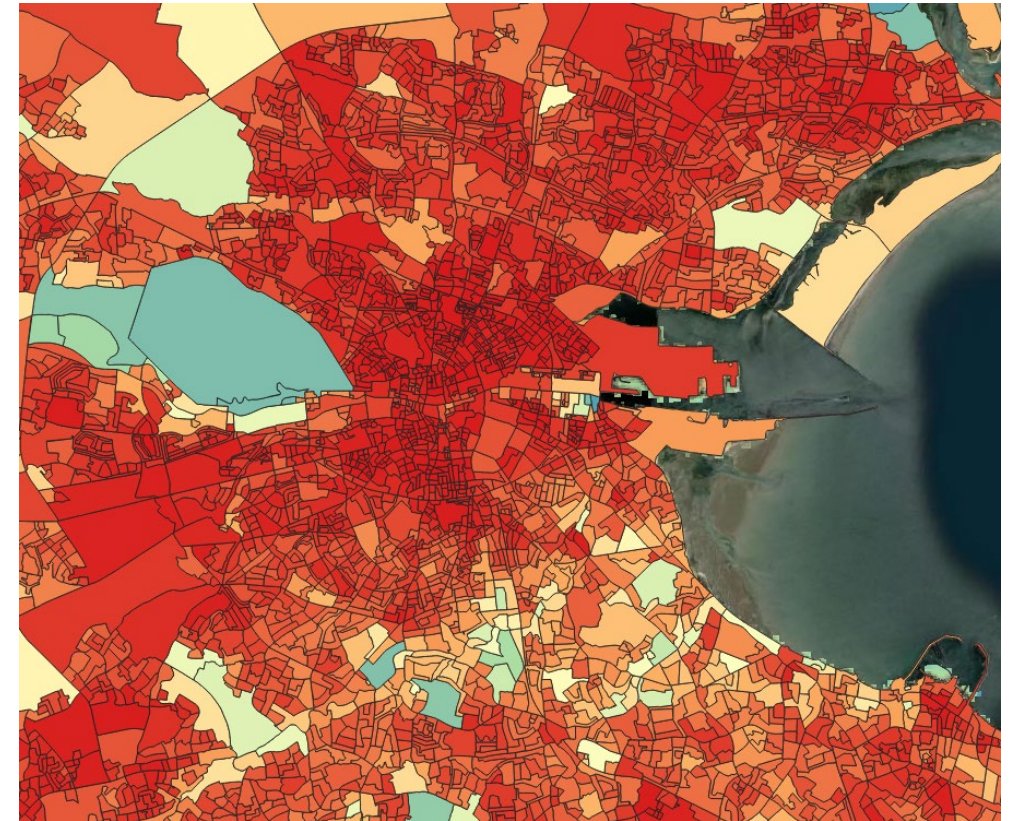
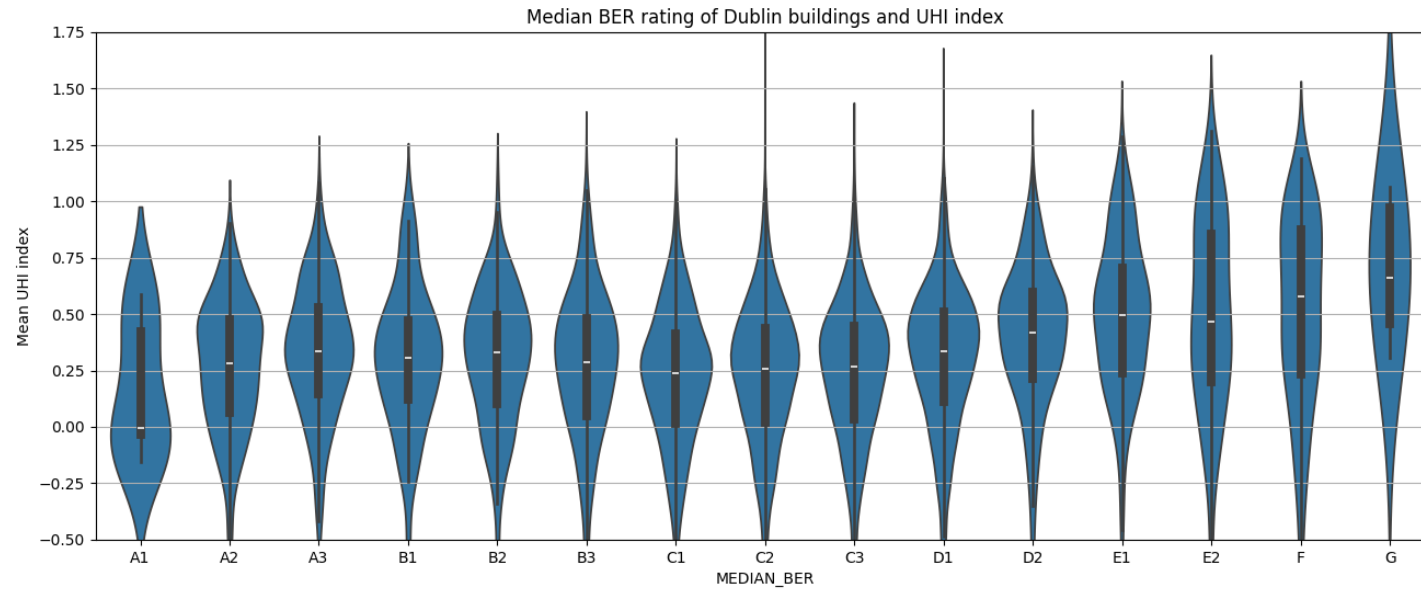


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UHI and Building Efficiency Rating Ireland relationship



UHI – Sample Outputs

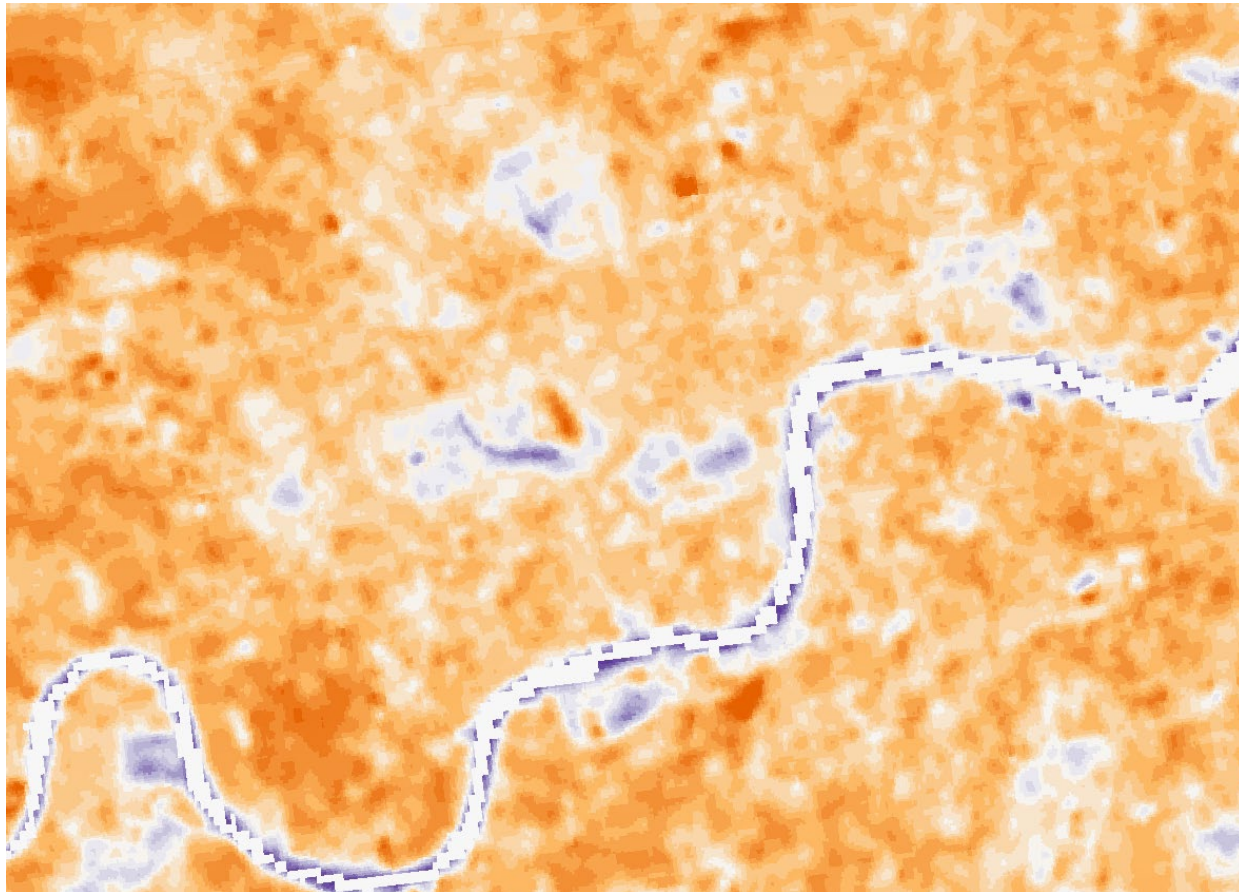


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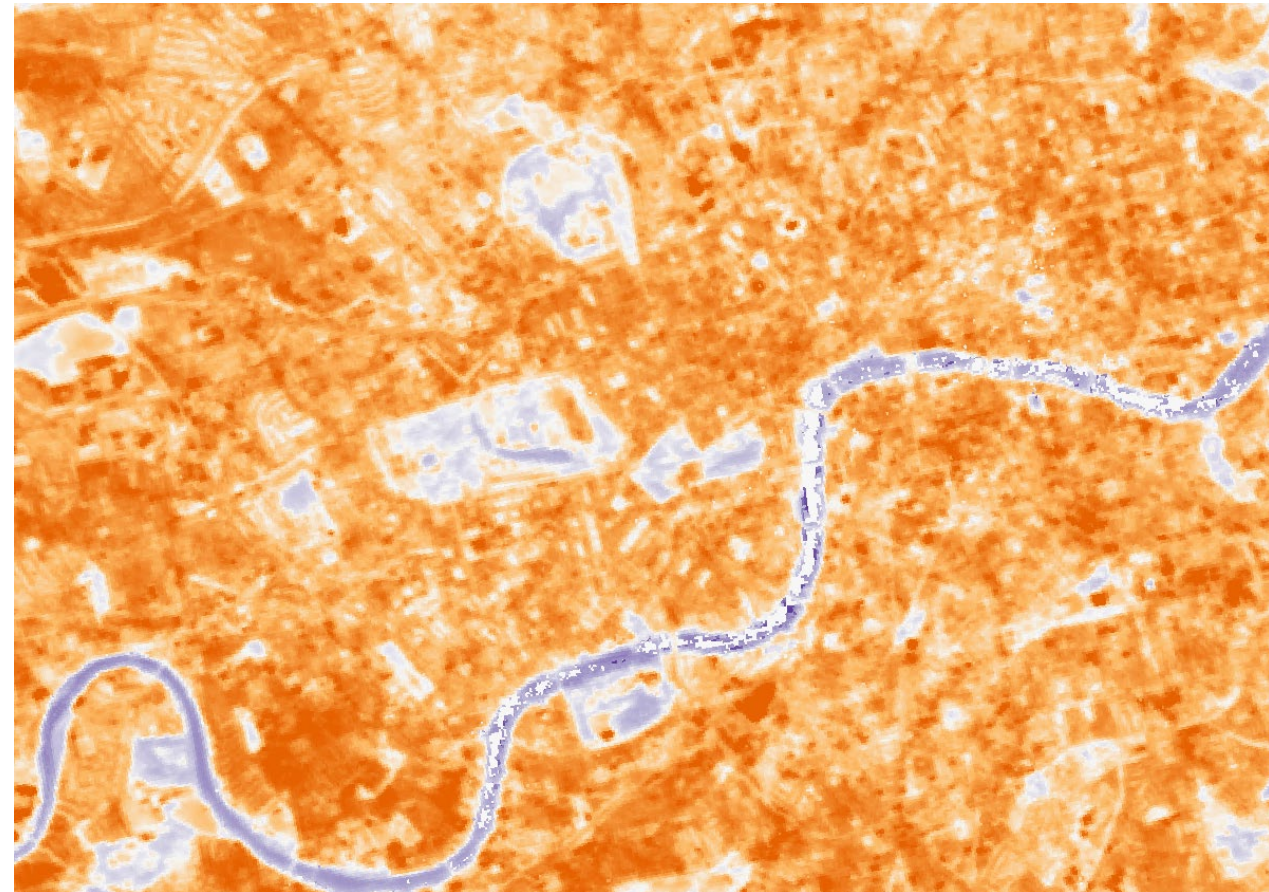


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Landsat-8 (100m resolution)



SDGSat-1 (30m resolution)



European Young Scientists contributions in Dragon 6



Name	Institution	Poster title	Contribution including period of research
Xumeng Deng (Andy)	University of Oxford	Validation of Reference Forward Model Simulation of Atmospheric Radiative Transfer by Comparison with IASI Satellite Observations	Jan – May 2025
	University College London (UCL)	Inclusive Storylines for Sustainable Governance in Urban Adaptation to Uncertainties in Future Heat Extremes	Oct 2025 –

Overview of European YSs research

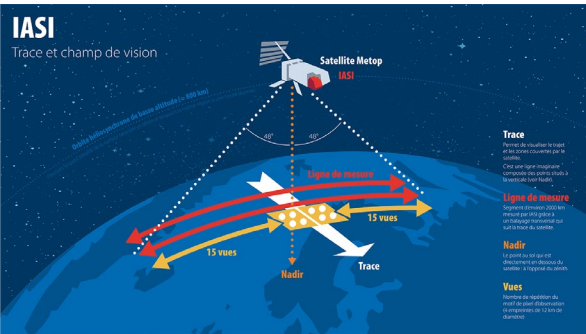


January – May 2025
University of Oxford, Earth Observation Data Group

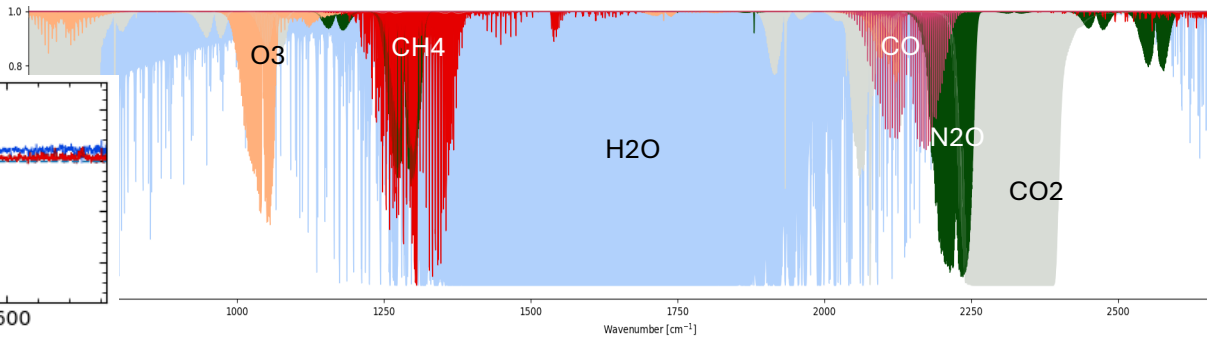
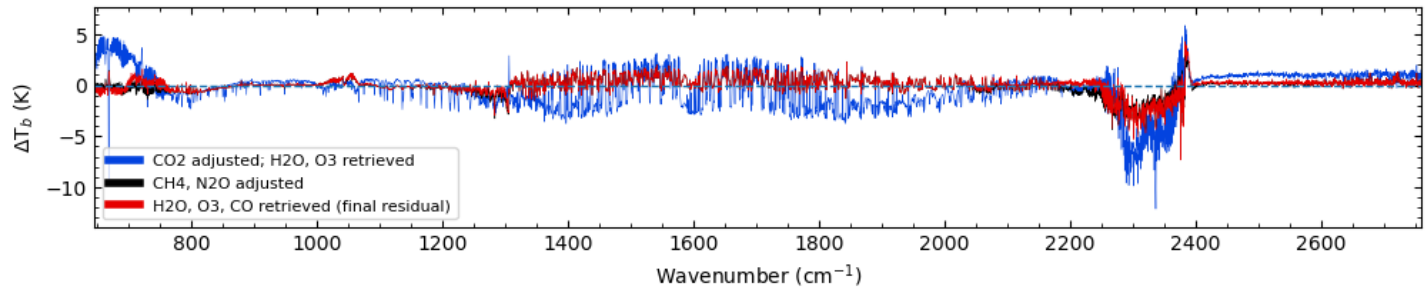
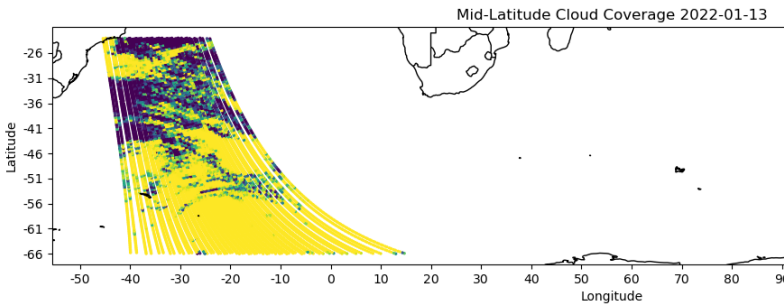
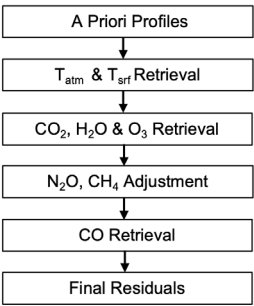
Reference Forward Model (RFM): general-purpose radiative transfer model developed by EODG.

Radiance closure: validating RFM simulation of Infrared Atmospheric Sounding Interferometer (IASI) spectra in mid-infrared

RFM inputs first optimised; averaging cloud-free IASI pixels to reduce noise and comparing RFM output using a priori atmospheric profile which was iteratively improved via retrieval, attempting to minimise residuals - anomalous features identified for future RFM development



```
*HDR      ! text for headers of output spectra
Example of nadir brightness spectrum
*FLG      ! flags defining type of calculation:
NAD       ! nadir-viewing, plane-parallel atmosphere
BBT       ! output Brightness Temperature spectra
SFC       ! default surface temperature, emissivity=1
AVG       ! apply triangular instrument line-shape
*SPC      ! define spectral range/resolution of output
1200 1300 0.25
*GAS      ! list of absorbing molecules to consider
CH4 H2O N2O
*ATM      ! atmospheric profile: T,p,VMRs on height grid
../atm/usa.atm
*SEC      ! Viewing angle, sec(theta)=1 is nadir
1.0
*HIT      ! HITRAN data, in RFM binary format
../hit/hitran_2012.bin
*END
```



Overview of European YSs research



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October 2025 -
UCL STEaPP / UNRISK CDT
PhD Project



Extreme heat events - increasing severity, frequency, and persistence
Significant sustainable governance challenges - urban environments
feature interplay of many systems e.g. public health, energy, transport
→ Interdisciplinary approach to develop inclusive policy solutions

Diverse stakeholder collaboration e.g. governments, academics,
education groups, NGOs in case study cities incl. in China and EU

Key points:

- data collection through engagement with most affected peoples (MAP) by interviews, focus groups, surveys
- evaluating effectiveness of trial solutions (e.g. green infrastructure)
- in situ environmental measurements (WBGT)
- remote sensing: thermal data fusion of SDGSAT, Sentinel-3, Copernicus LSTM datasets support land surface temperature (LST) analysis
Custom interpolation, spatiotemporal modelling used to improve LST continuity → Dragon 6 contribution

Perspective | Published: 11 October 2024

Plural climate storylines to foster just urban futures

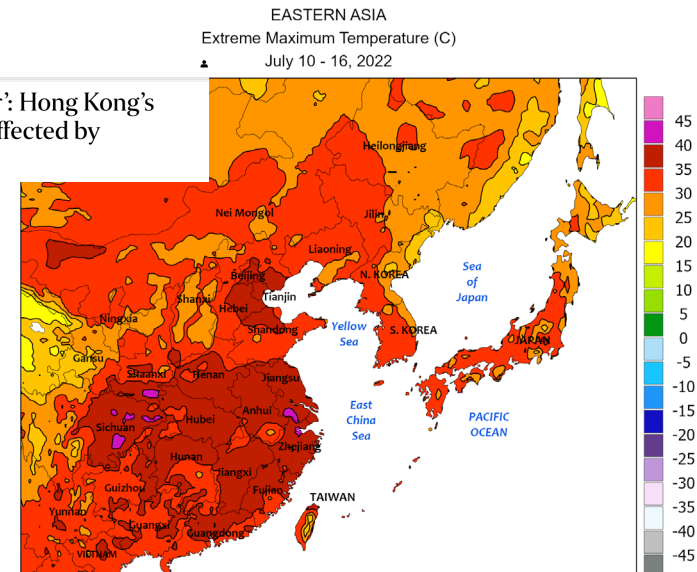
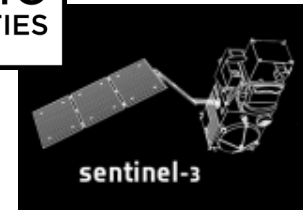
[Maria Rusca](#) ✉, [Alice Sverdlík](#), [Amitangshu Acharya](#), [Britt Basel](#), [Emily Boyd](#), [Thaisa Comelli](#), [David](#)

THE STRAITS TIMES

ASIA

'Feels like a bun steamer': Hong Kong's poorer residents most affected by heatwave

C4O
CITIES





Objectives

- To develop new methodologies for estimating grassland parameters, such as vegetation structure, grassland use intensity etc., based on multi-source ESA and Chinese EO data;
- To establish a method to integrate a daily land surface reflectance dataset based on Harmonized Landsat-Sentinel (HLS) data and GF-6 WFV data, and constructed a grassland use intensity index based on time series data to estimate the use intensity.

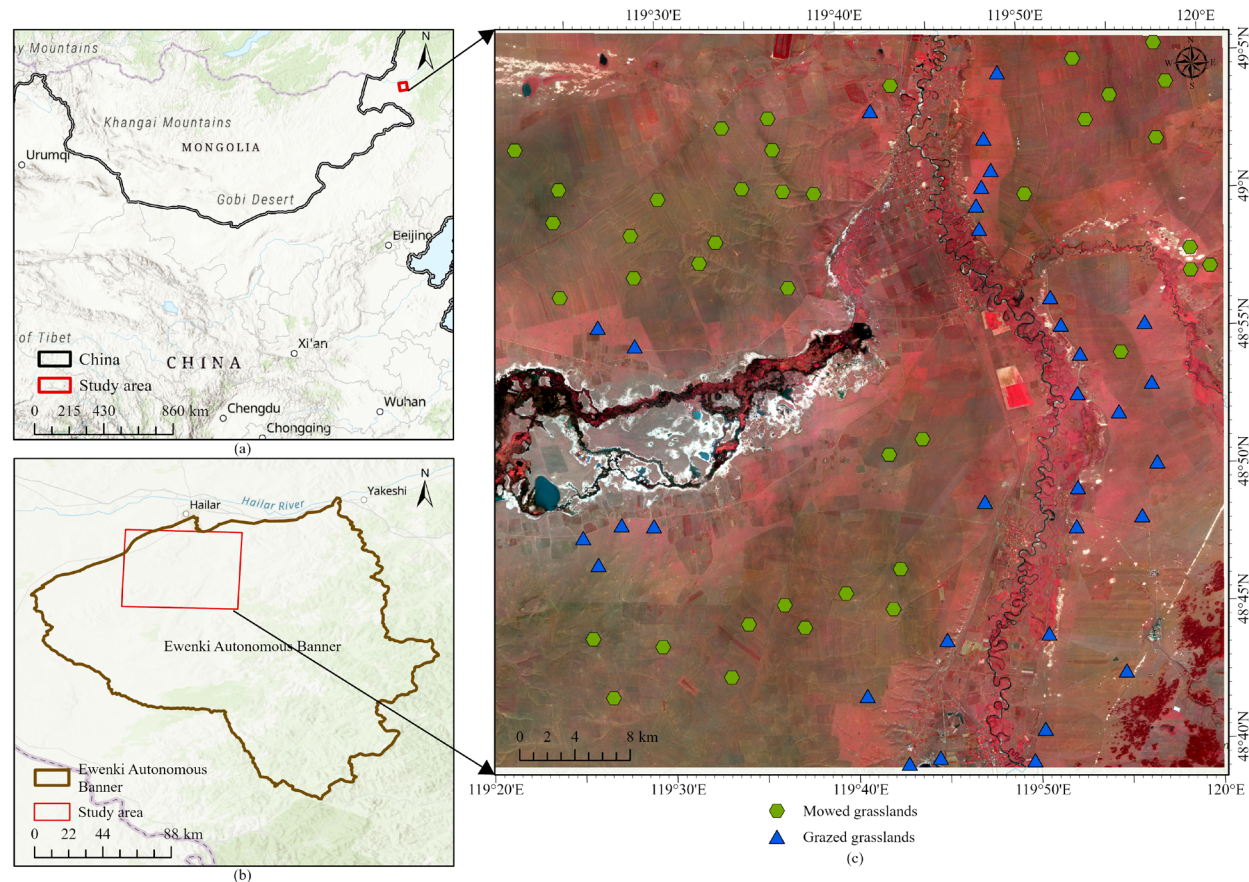


Study area—Ewenki Autonomous Banner of Hulunbuir City

- Within this region, a $50 \text{ km} \times 50 \text{ km}$ plot was selected for the study.
- This area lies in the heartland of the Hulunbuir grassland.
- Grassland use is primarily categorized into **mowed** and **grazed**.

In-situ data measurements

- Collect time: 2022
- Type and quantity: 40 mowed points
33 grazed points



Overview of Chinese YSs research



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Method

Generation of daily land surface reflectance dataset

Integrated GF-6 WFV and HLS data

Least Squares Regression Model

$$\begin{aligned} y_i &= \beta_1 + \beta_2 x_i \\ x_i &= \{x_1, x_2, x_3, \dots\} \\ y_i &= \{y_1, y_2, y_3, \dots\} \\ \beta_1 + \beta_2 x_1 + r_1 &= y_1 \\ \beta_2 + \beta_2 x_2 + r_2 &= y_2 \\ \beta_3 + \beta_2 x_3 + r_3 &= y_3 \end{aligned} \quad \rightarrow \quad \begin{aligned} \frac{\partial S}{\partial \beta_1} &= 0 \\ \frac{\partial S}{\partial \beta_2} &= 0 \end{aligned}$$

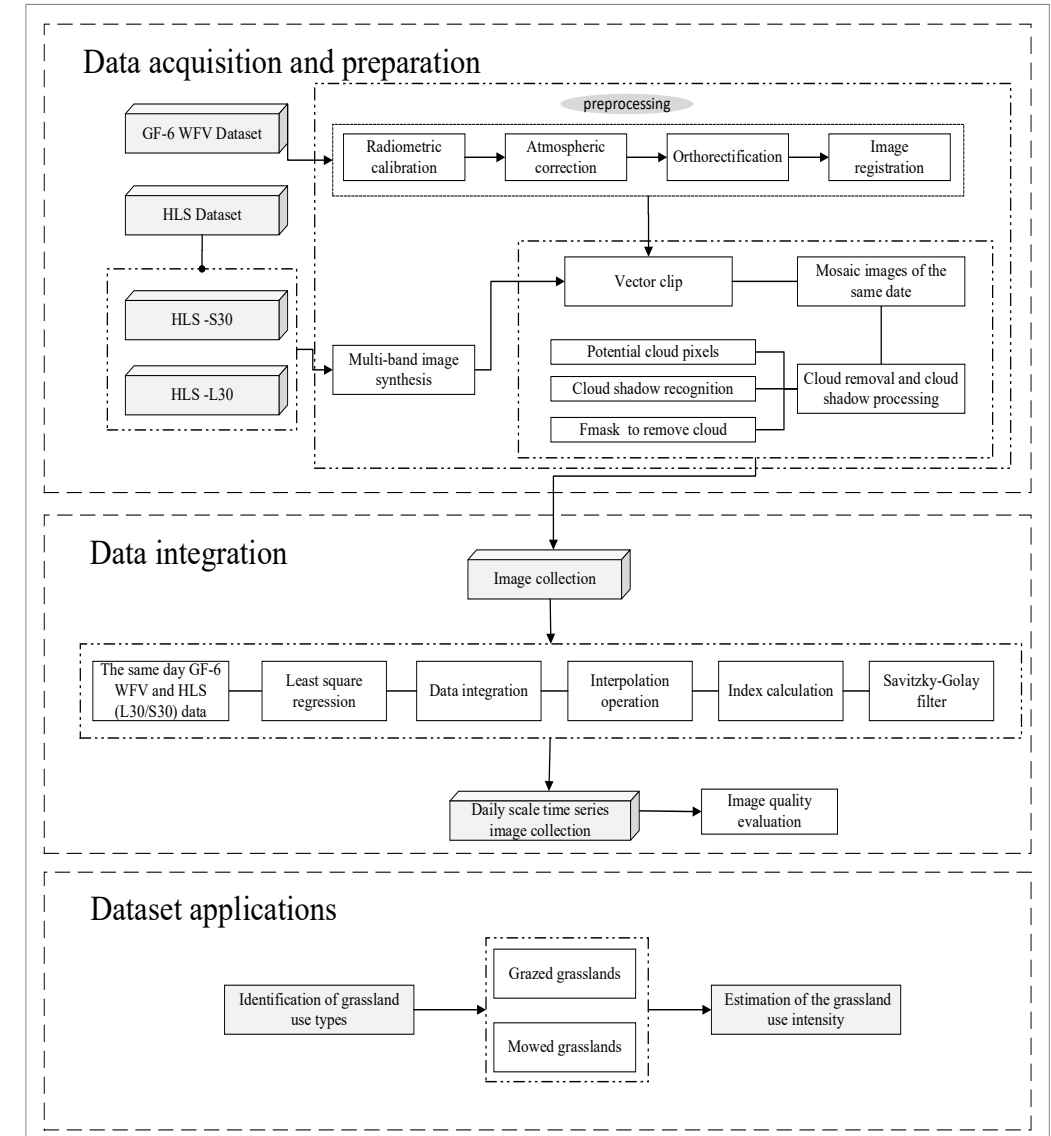
Quantitative evaluation indexes

$$R = \frac{\sum (O_i - \bar{O})(P_i - \bar{P})}{\sqrt{\sum_{i=1}^n (P_i - \bar{P})^2} \sqrt{\sum_{i=1}^n (O_i - \bar{O})^2}}$$
$$RMSE = \sqrt{\frac{\sum_{i=1}^n (y_i - f_i)^2}{n}}$$

Generation of a daily scale time series dataset

Savitzky-Golay

$$Y'_j = \frac{\sum_{i=-n}^n C_i Y_{j+i}}{N}$$





Method

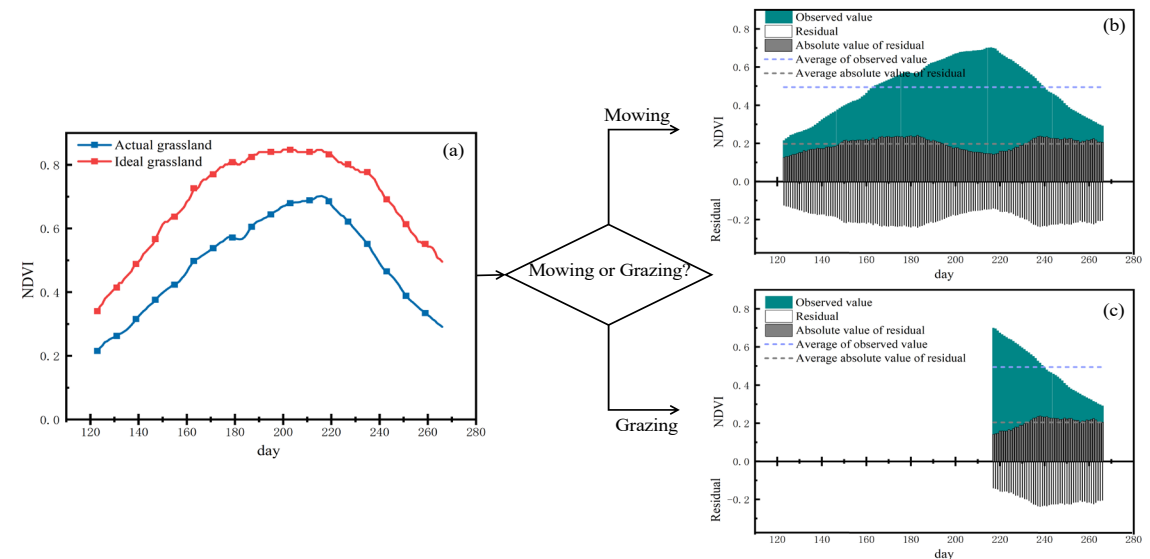
Identification of grassland use types

- Clustering analysis based on threshold methods was applied to the NDVI time series dataset, classifying **CV** values into two distinct groups: high and low.
- To distinguish different types of grassland use, two categories were considered: **mowed** and **grazed**.

$$CV = VI_{std} / VI_{ave}$$

Estimation of the grassland use intensity

Grassland Use Intensity index



$$Mean_{offset} = \frac{\sum_{n=1}^n (O - I) \times (-1)}{n}$$

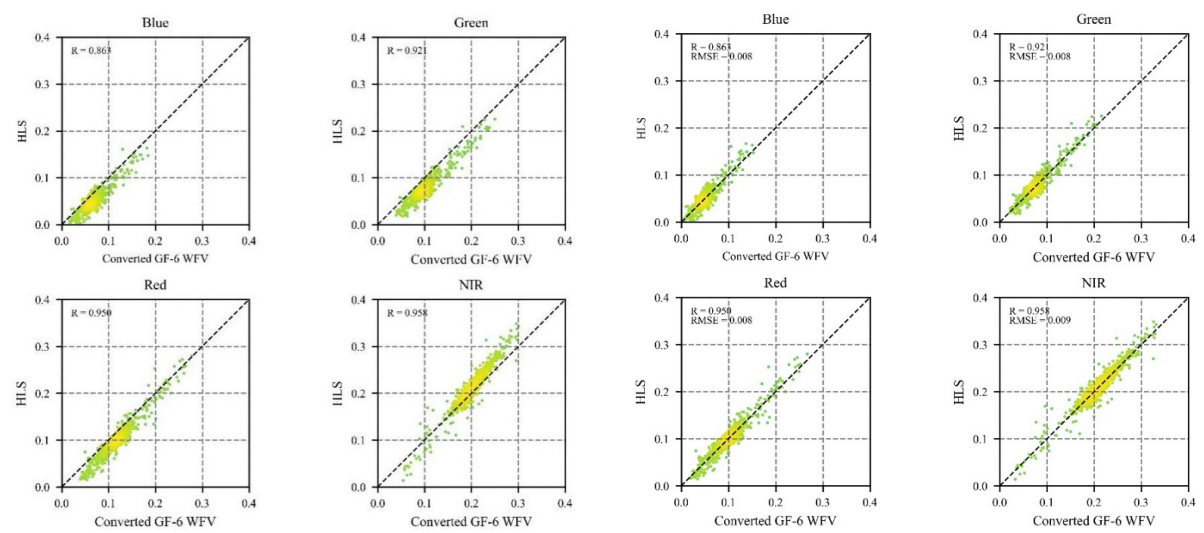
$$GI = (Mean_{offset} / Mean_{true}) \times 100\%$$

Overview of Chinese YSs research



Results and analysis

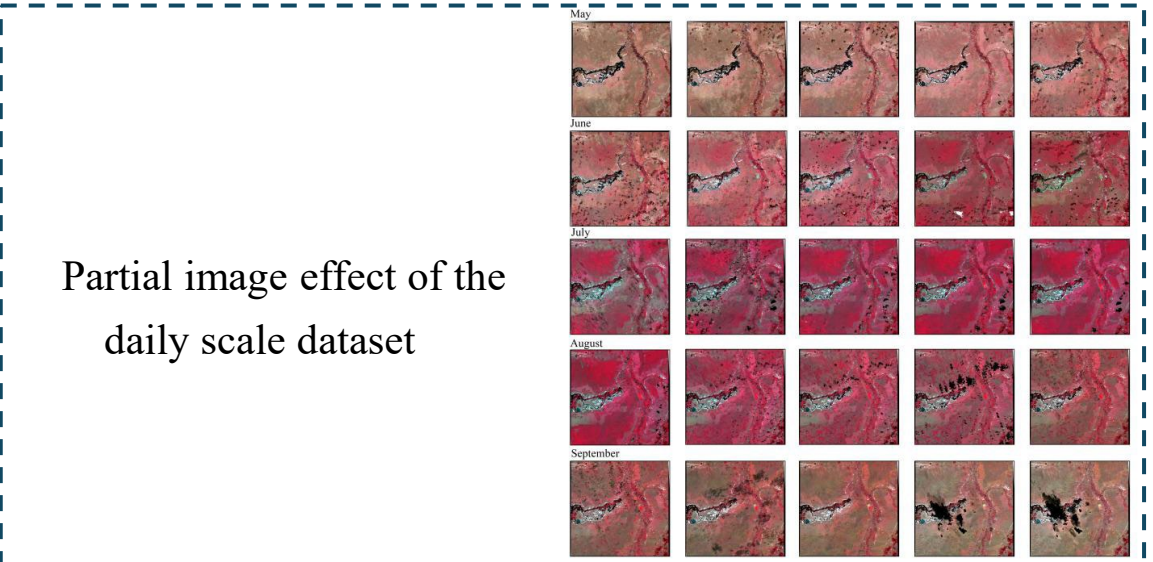
Estimation of the grassland use intensity



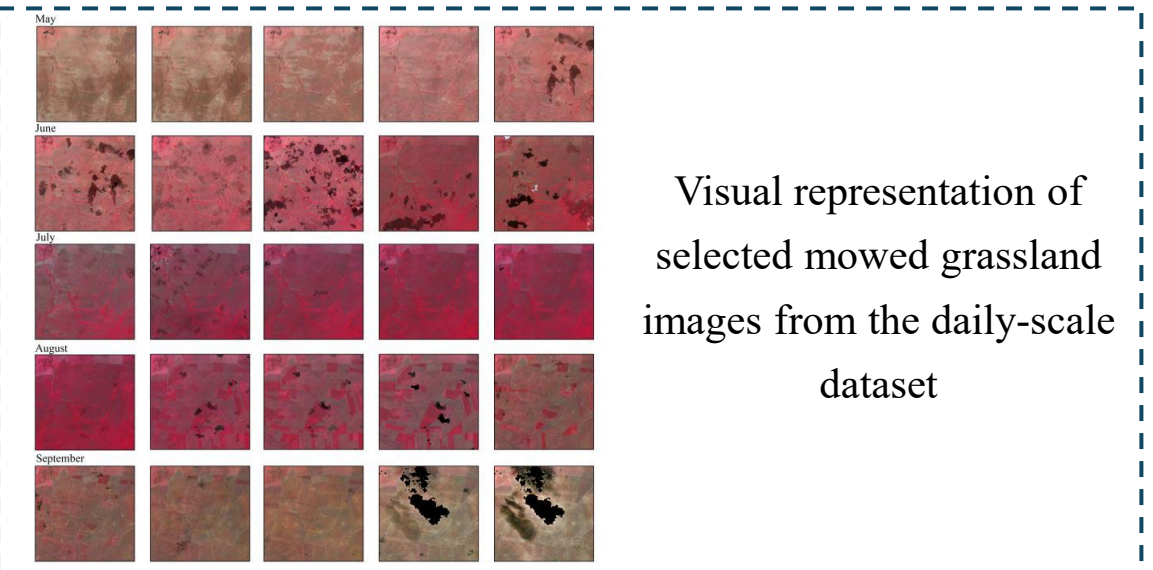
Comparison of the original images Comparison of converted images

Bands before and after integration

Evaluation indicators	Band			
	Blue	Green	Red	NIR
R	0.852	0.914	0.946	0.958
RMSE	0.08	0.07	0.08	0.09



Partial image effect of the daily scale dataset



Visual representation of selected mowed grassland images from the daily-scale dataset



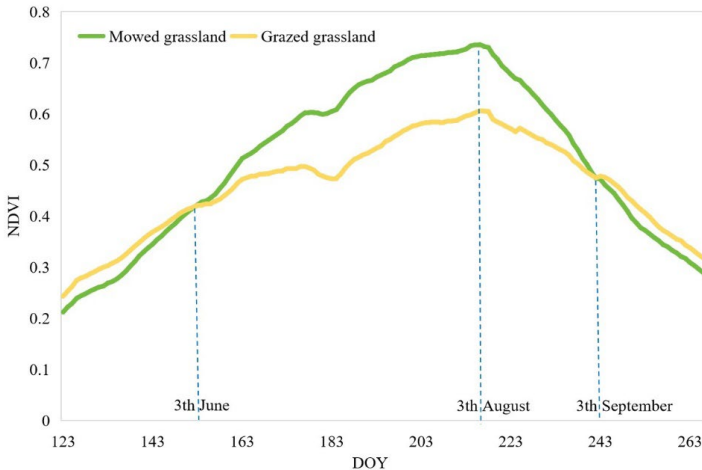
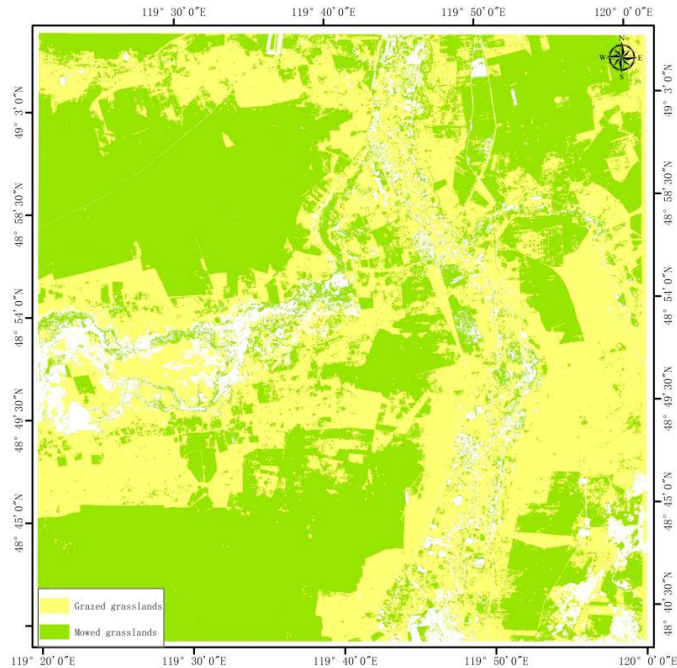
Identification of grassland use types and their growth and change patterns

Accuracy table for extracting use types based on **HLSG**

Class	Producer accuracy	User accuracy	Overall accuracy	Kappa coefficient
Grazed grassland	0.79	1	0.90	0.80
Mowed grassland	1	0.85		

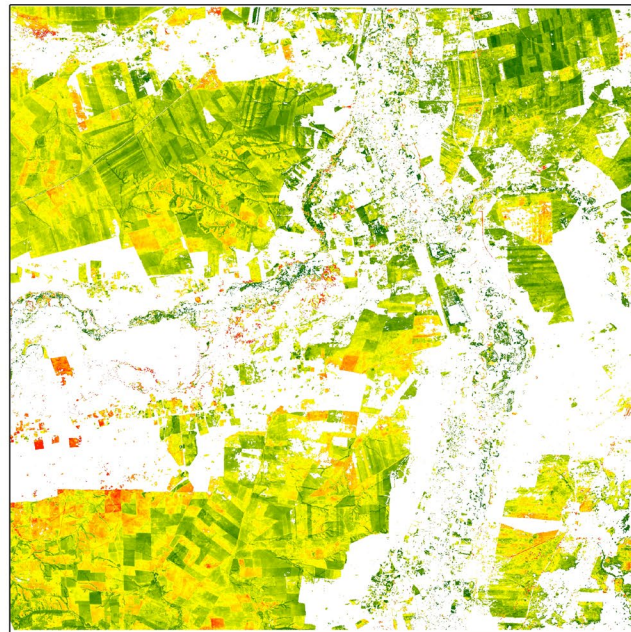
Accuracy table for extracting use types based on **GF-6 WFV**

Class	Producer accuracy	User accuracy	Overall accuracy	Kappa coefficient
Grazed grassland	0.54	0.90	0.64	0.33
Mowed grassland	0.87	0.47		

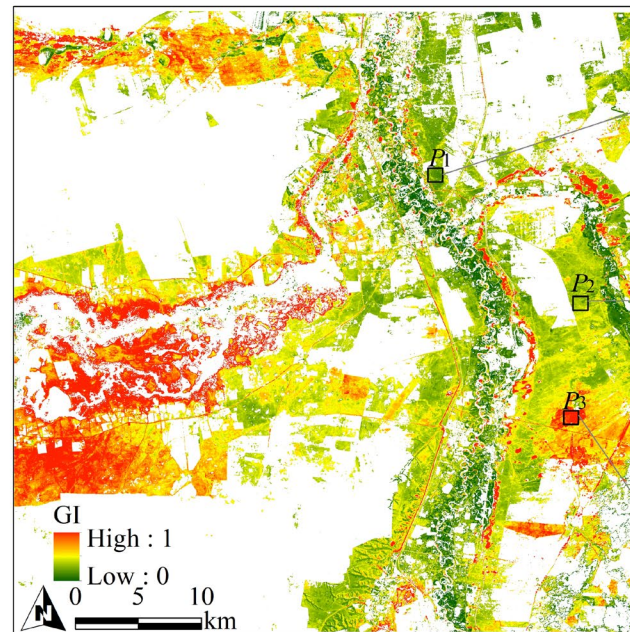




Estimation of the grassland use intensity



mowed grassland



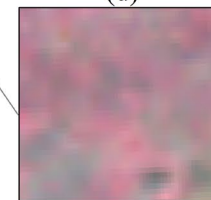
grazed grassland



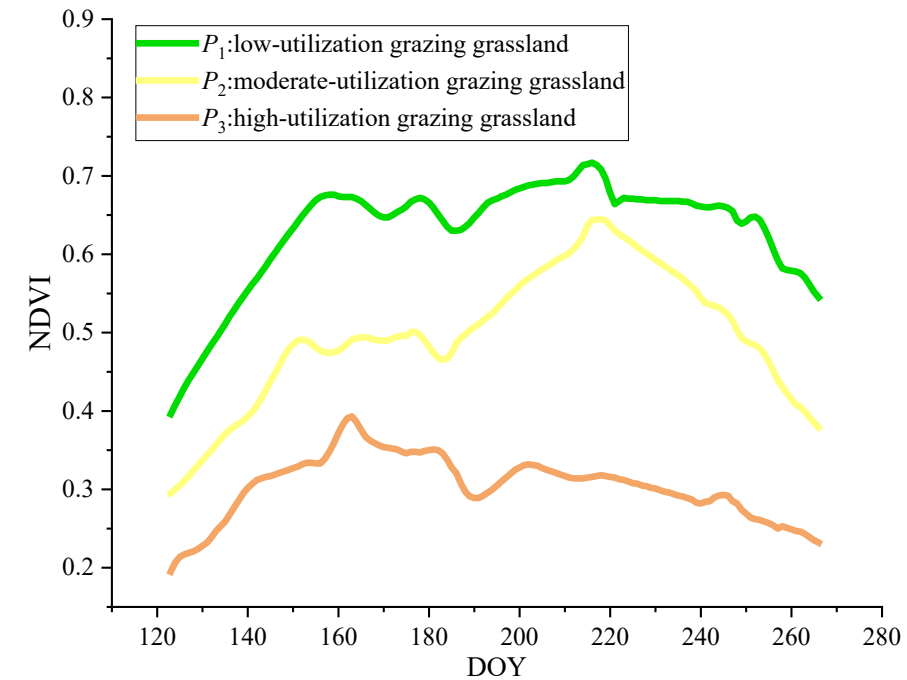
(c)



(d)



(e)



Sampled sites with grazed traces: GI ranked in descending order as $P_1 < P_2 < P_3$