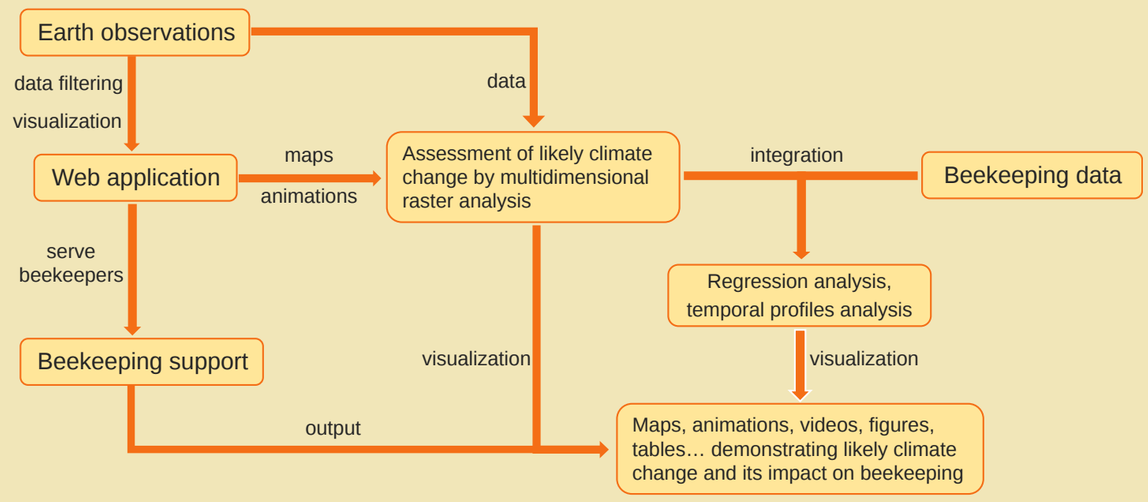
PORTRAYAL OF LIKELY CLIMATE CHANGE IMPACTS ON BEEKEEPING BASED ON EARTH OBSERVATION DATA

Diploma Thesis

OBJECTIVES

1. Develop a web application powered by earth observation data that is relevant to the survival of bees;
2. Analyzing the patterns of climate change in Europe using multidimensional raster data obtained from earth observations;
3. Explore the possibility of integrating data sources from earth observation with crowdsourced information from beekeepers based on the citizen science approach in the Czech Republic;
4. Evaluate the benefits and limitations of available datasets for beekeeping support.

WORKFLOW



DATA & SOFTWARE

DATA SOURCE FOR THE WEB APP

Temeprature	MOD11A1.006 Terra Land Surface Temperature and Emissivity Daily Global 1km
Precipitation	TerraClimate: Monthly Climate and Climatic Water Balance for Global Terrestrial Surfaces
NDVI	Landsat 7 Collection 1 Tier 1 8-Day NDVI Composite
Land cover	Copernicus CORINE Land Cover
Soil moisture	FLDAS: Famine Early Warning Systems Network (FEWS NET) Land Data Assimilation System
Sulphur Dioxide	Sentinel-5P NRTI SO2: Near Real-Time Sulphur Dioxide
PM 2.5	Copernicus Atmosphere Monitoring Service (CAMS) Global Near-Real-Time

MULTIDIMENSIONAL DATA FOR THE ANALYSIS

Copernicus Climate Change Services ERA5-Land monthly averaged data from 1950 to present

MOD11 Land Surface Temperature/Emissivity Daily L3 Global 1km

TerraClimate Global, high-resolution gridded temperature, precipitation, and other water balance variables

BEEKEEPING DATA

Bee colony winter loss Crowdsourced data from beekeepers in the Czech Republic (from the COLOSS survey)

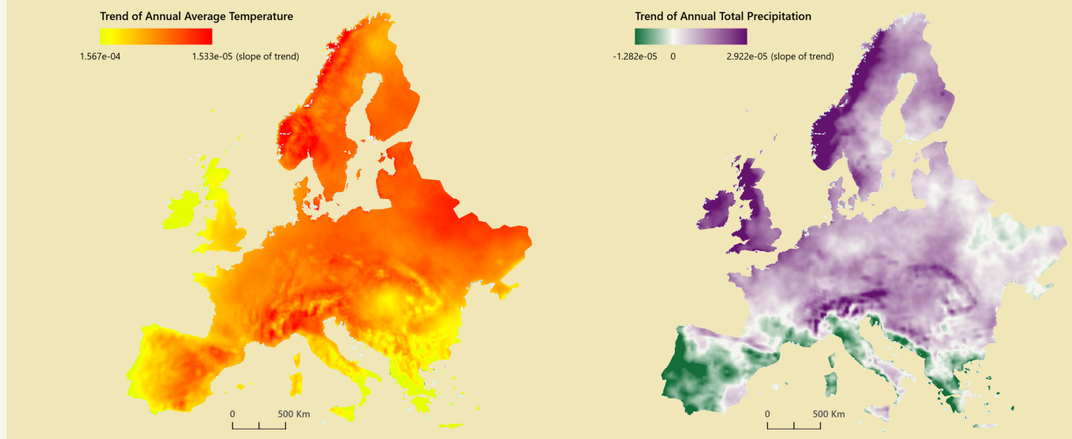
Google Earth Engine — Provide multi-sourced earth observation data service; Support back-end computing of the web app

ArcGIS Pro — Multidimensional raster analysis; Visualization of the final result

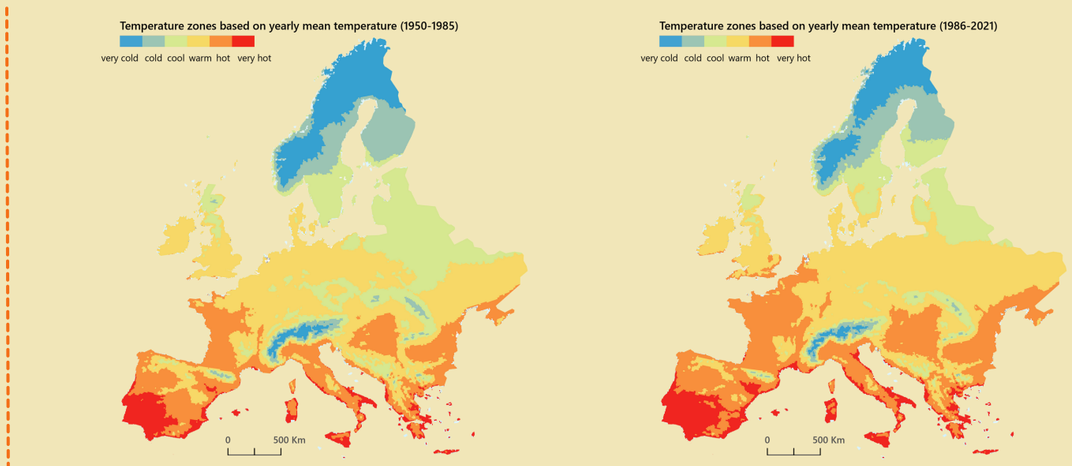
Jupyter Notebook — Integrated Development Environment (IDE) for the development of the EO4BEE web app

Heroku — Platform as a service (PaaS) for hosting the web app in the cloud

RESULT - MULTIDIMENSIONAL RASTER ANALYSIS



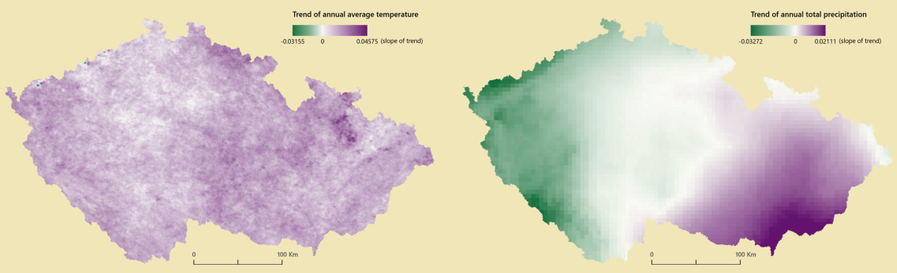
TREND ANALYSIS



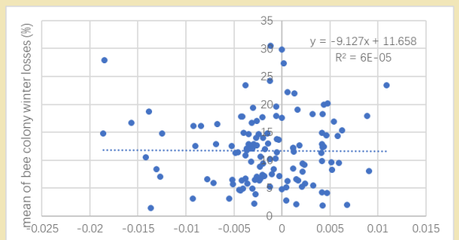
MULTIDIMENSIONAL PCA ANALYSIS

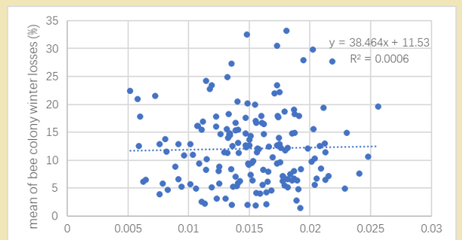
RESULT - INTEGRATION WITH BEE DATA

TREND ANALYSIS

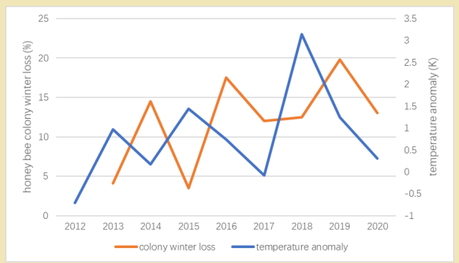


REGRESSION ANALYSIS





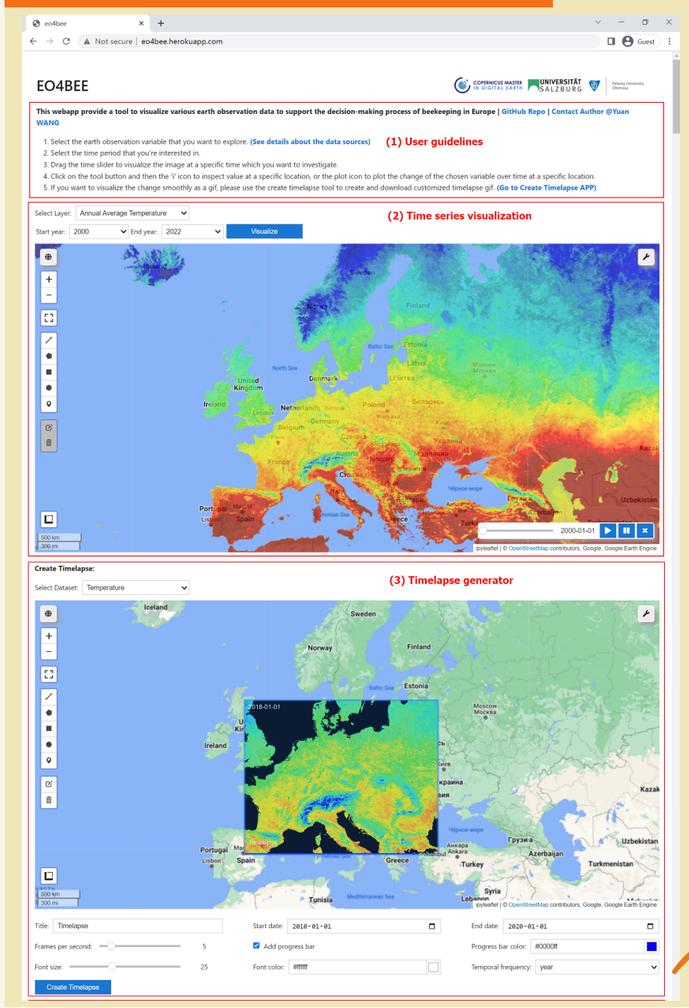
TEMPERATURE ANAMALY & BEE COLONY LOSS



Regression analysis was conducted for 162 districts with valid bee colony data to explore how bee colony winter losses are related to the temperature trend or the precipitation trend. The results for both regression analyses didn't show statistically significant correlations.

The fluctuations in bee colony winter losses have a similar pattern to the variation in temperature anomalies with one year delay. The temperature anomalies had three peaks in 2013, 2015, and 2018, while the peaks of honey bee colony winter losses can be observed in 2014, 2016, and 2019, and for both temperature anomaly and honey bee colony winter loss, each of the three peaks are higher than the previous one.

RESULT - EO4BEE WEB APP



CONCLUSION

To achieve the practical goal of this study, a web application named "EO4BEE" has been developed using the geemap Python package and the Google Earth Engine Python API in Jupyter Notebook. It managed to enable the time-series visualization of earth observation variables that might have an impact on bee health based on the implementation of a time slider, and allow users to generate timelapse to have an overview of the changing pattern of the selected variable.

In terms of theoretical objectives, several multidimensional raster analyses have been applied to the time series raster datasets of temperature and precipitation in ArcGIS Pro to investigate the patterns of likely climate change, the results of which were further integrated with bee colony winter loss data to assess the possible impacts climate change has on beekeeping. The study area is Europe, where the trend raster was calculated and visualized for both annual average temperature and annual total precipitation from 1950 to 2021. The results indicated that the whole study area demonstrated a rising trend of temperature, which provides strong evidence for the warming of the climate, whereas the annual total precipitation didn't show a consistent direction of change in Europe. The statistics for temperature trend and precipitation trend have also been calculated and summarized for 44 countries covered by the study area as a result table. Due to the limited availability of bee colony data, the area was limited to the Czech Republic when analyzing the integration of climate data and bee colony winter losses. Regression analyses were performed to study the relationship between bee colony winter loss and temperature trend, and between bee colony winter loss and precipitation trend. Although no statistically significant correlations were found for both of them, the methodologies applied in the analysis can still produce new inspiration from earth observation in the research on beekeeping with concerns of climate change. Furthermore, the time profiles were plotted for bee colony winter losses and temperature anomalies calculated for every year from 2012 to 2020, and similar patterns of fluctuation were discovered from the comparison: the changing pattern of bee colony winter losses basically followed the evolution of temperature anomalies but with exactly one year delay, which indicates that high bee colony winter loss can be associated with high temperature anomalies.

In conclusion, this study provided a new perspective for beekeeping support research in the context of likely climate change, namely the application of earth observation data. The methodologies applied in this thesis can be easily transplanted to any region of interest, any other observation variables such as NDVI, or even any specific bee species, to study the influence of the changing earth's surface on bee survival.

VISIT EO4BEE WEB APPLICATION AT:
http://eo4bee.herokuapp.com

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Univerzita Palackého v Olomouci

COPERNICUS MASTER IN DIGITAL EARTH

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