Google Earth Engine
Introduction and hands-on

Matthias Demuzere

matthias.demuzere@rub.de
mdemuzere

Remote Sensing of Environment 202 (2017) 18–27

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Google Earth Engine: Planetary-scale geospatial analysis for everyone

Noel Gorelick [a,*], Matt Hancher [b], Mike Dixon [b], Simon Ilyushchenko [b], David Thau [b], Rebecca Moore [b]

[a] Google Switzerland, Brandschenkestrasse 110, Zurich 8002, Switzerland
[b] Google Inc., 1600 Amphitheater Parkway, Mountain View, CA, 94043, USA

ARTICLE INFO

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Keywords:
Cloud computing
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Platform
Data democratization

ABSTRACT

Google Earth Engine is a cloud-based platform for planetary-scale geospatial analysis that brings Google's massive computational capabilities to bear on a variety of high-impact societal issues including deforestation, drought, disaster, disease, food security, water management, climate monitoring and environmental protection. It is unique in the field as an integrated platform designed to empower not only traditional remote sensing scientists, but also a much wider audience that lacks the technical capacity needed to utilize traditional supercomputers or large-scale commodity cloud computing resources.

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satellite imagery and other Earth Observation data

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High-Resolution Global Maps of 21st-Century Forest Cover Change

M. C. Hansen,[1]* P. V. Potapov,[1] R. Moore,[2] M. Hancher,[2] S. A. Turubanova,[1] A. Tyukavina,[1] D. Thau,[2] S. V. Stehman,[3] S. J. Goetz,[4] T. R. Loveland,[5] A. Kommareddy,[6] A. Egorov,[6] L. Chini,[1] C. O. Justice,[1] J. R. G. Townshend[1]

Based on global 30 meter Landsat imagery from 2000 to 2012.

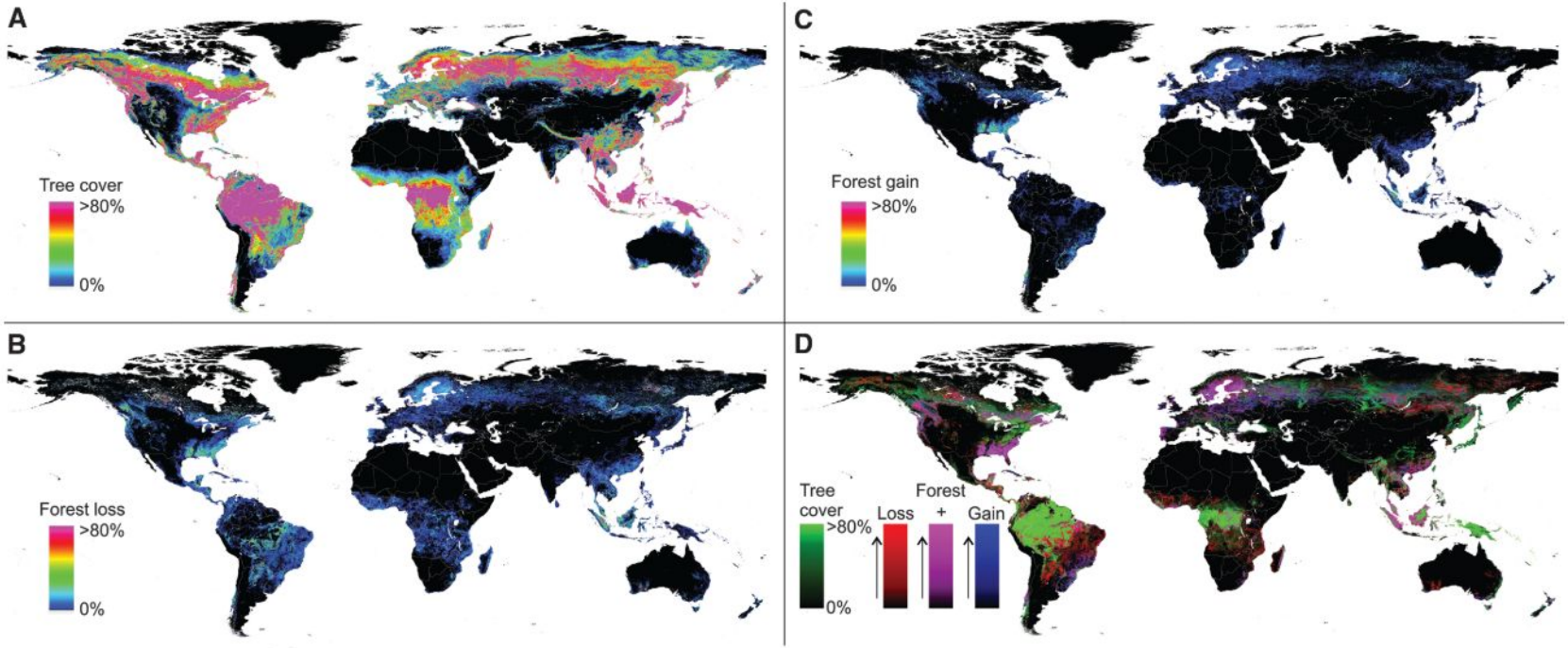

Fig. 1. (A) Tree cover, (B) forest loss, and (C) forest gain. A color composite of tree cover in green, forest loss in red, forest gain in blue, and forest loss and gain in magenta is shown in (**D**), with loss and gain enhanced for improved visualization. All map layers have been resampled for display purposes from the 30-m observation scale to a 0.05° geographic grid.

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ISPRS Journal of Photogrammetry and Remote Sensing

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Google Earth Engine for geo-big data applications: A meta-analysis and systematic review

Haifa Tamiminia[a], Bahram Salehi[a], Masoud Mahdianpari[b,*], Lindi Quackenbush[a], Sarina Adeli[a], Brian Brisco[c]

ARTICLE INFO

Keywords:
Google Earth Engine
Geo-big data
Cloud-based platform
Remote sensing
Planetary-scale
Geospatial
Machine learning
Environmental monitoring

ABSTRACT

Google Earth Engine (GEE) is a cloud-based geospatial processing platform for large-scale environmental monitoring and analysis. The free-to-use GEE platform provides access to (1) petabytes of publicly available remote sensing imagery and other ready-to-use products with an explorer web app; (2) high-speed parallel processing and machine learning algorithms using Google's computational infrastructure; and (3) a library of Application Programming Interfaces (APIs) with development environments that support popular coding languages, such as JavaScript and Python. Together these core features enable users to discover, analyze and visualize geospatial big data in powerful ways without needing access to supercomputers or specialized coding expertise. The development of GEE has created much enthusiasm and engagement in the remote sensing and geospatial data science fields. Yet after a decade since GEE was launched, its impact on remote sensing and geospatial science has not been carefully explored. Thus, a systematic review of GEE that can provide readers with the "big picture" of the current status and general trends in GEE is needed. To this end, the decision was taken to perform a meta-analysis investigation of recent peer-reviewed GEE articles focusing on several features, including data, sensor type, study area, spatial resolution, application, strategy, and analytical methods. A total of 349 peer-reviewed articles published in 146 different journals between 2010 and October 2019 were reviewed. Publications and geographical distribution trends showed a broad spectrum of applications in environmental analyses at both regional and global scales. Remote sensing datasets were used in 90% of studies while 10% of the articles utilized ready-to-use products for analyses. Optical satellite imagery with medium spatial resolution, particularly Landsat data with an archive exceeding 40 years, has been used extensively. Linear regression and random forest were the most frequently used algorithms for satellite imagery processing. Among ready-to-use products, the normalized difference vegetation index (NDVI) was used in 27% of studies for vegetation, crop, land cover mapping and drought monitoring. The results of this study confirm that GEE has and continues to make substantive progress on global challenges involving process of geo-big data.

* Corresponding author.
E-mail address: m.mahdianpari@mun.ca (M. Mahdianpari).

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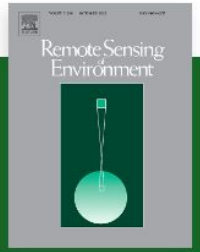


Remote Sensing of Environment

Supports *open access*

20.7
CiteScore

13.85
Impact Factor

REMOTE SENSING OF LAND CHANGE SCIENCE WITH GOOGLE EARTH ENGINE

Edited by Le Wang, George Xian, Chunyuan Diao, David Thau

Last update 29 July 2020

A plethora of multi-temporal remote sensing data ranging from local, regional to global coverage have been acquired and made available to scientific community via many public-domain platforms including Google Earth Engine (GEE). It presents us an unprecedented opportunity to advance our scientific understanding of various dynamic processes associated with earth system, particularly Land Change Science. The use of data sets and development of innovative data processing algorithms provided by GEE also helps to improve our capabilities to process large size of Earth observation data and implement these data to support a variety of management decisions. For example, Hansen et al. (2013) leveraged GEE to analyze global-scale Landsat data and to quantify global forest cover changes from 2000 to 2012. Pekel et al. (2016) analyzed three million Landsat images on the GEE platform to map long-term changes of global surface water at 30 m resolution.

Read more

Review

Google Earth Engine and Artificial Intelligence (AI): A Comprehensive Review

Liping Yang [1,2,3,*], Joshua Driscol [1,2], Sarigai Sarigai [1,2], Qiusheng Wu [4], Haifei Chen [5] and Christopher D. Lippitt [1,2]

[1] Department of Geography and Environmental Studies, University of New Mexico, Albuquerque, NM 87131, USA; joshuadr@unm.edu (J.D.); rsa@unm.edu (S.S.); clippitt@unm.edu (C.D.L.)
[2] Center for the Advancement of Spatial Informatics Research and Education (ASPIRE), University of New Mexico, Albuquerque, NM 87131, USA
[3] Department of Computer Science, University of New Mexico, Albuquerque, NM 87106, USA
[4] Department of Geography, University of Tennessee, Knoxville, TN 37996, USA; qwu18@utk.edu
[5] Interdisciplinary Science Co-Operative, University of New Mexico, Albuquerque, NM 87131, USA; hfchen@unm.edu
* Correspondence: lipingyang@unm.edu

Abstract: Remote sensing (RS) plays an important role gathering data in many critical domains (e.g., global climate change, risk assessment and vulnerability reduction of natural hazards, resilience of ecosystems, and urban planning). Retrieving, managing, and analyzing large amounts of RS imagery poses substantial challenges. Google Earth Engine (GEE) provides a scalable, cloud-based, geospatial retrieval and processing platform. GEE also provides access to the vast majority of freely available, public, multi-temporal RS data and offers free cloud-based computational power for geospatial data analysis. Artificial intelligence (AI) methods are a critical enabling technology to automating the interpretation of RS imagery, particularly on object-based domains, so the integration of AI methods into GEE represents a promising path towards operationalizing automated RS-based monitoring programs. In this article, we provide a systematic review of relevant literature to identify recent research that incorporates AI methods in GEE. We then discuss some of the major challenges of integrating GEE and AI and identify several priorities for future research. We developed an interactive web application designed to allow readers to intuitively and dynamically review the publications included in this literature review.

Keywords: Google Earth Engine (GEE); artificial intelligence (AI); machine learning; deep learning;

Citation: Yang, L.; Driscol, J.; Sarigai, S.; Wu, Q.; Chen, H.; Lippitt, C.D. Google Earth Engine and Artificial Intelligence (AI): A Comprehensive Review. *Remote Sens.* **2022**, *14*, 3253. https://doi.org/10.3390/rs14143253

A review of Google Earth Engine application in mapping aquaculture ponds

Arvinth Rajandran[1], Mou Leong Tan[1], Narimah Samat[1] and Ngai Weng Chan[1]

[1]GeoInformatic Unit, Geography Section, School of Humanities, Universiti Sains Malaysia, 11800 USM, Penang, Malaysia

E-mail: narimah@usm.my

Abstract. Google Earth Engine (GEE) can effectively monitor aquaculture ponds, but it is underutilized. This paper aims to review the application of GEE in mapping aquaculture ponds around the world using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. A total of 16 journal articles have been identified since 2019 from the Scopus and Science Direct databases. Most of the studies were conducted in China and United States using the Sentinel-2, Sentinel-1 and Landsat 8 images. Random Forest and Decision Tree are commonly used machine learning classifiers in GEE-based aquaculture ponds mapping studies. In general, some studies reported that GEE can extract the spatial distribution of aquaculture ponds with great overall accuracies, which are more than 90%. Difficult to detect small ponds and misclassification due to similar spectral reflectance are among the limitations reported in previous studies. Future research directions include incorporation of more aquaculture pond extraction techniques and different types of satellite images in GEE.

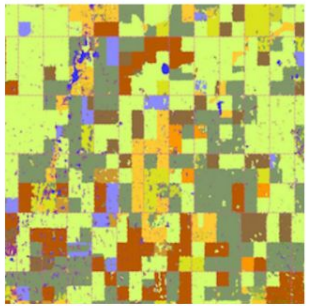
Earth Engine Data Catalog

Earth Engine's public data catalog includes a variety of standard Earth science raster datasets. You can import these datasets into your script environment with a single click. You can also upload your own raster data or vector data for private use or sharing in your scripts.

Looking for another dataset not in Earth Engine yet? Let us know by suggesting a dataset.

Filter list of datasets

Canada AAFC Annual Crop Inventory

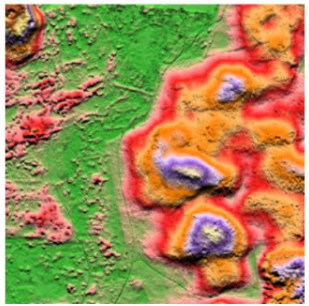


Starting in 2009, the Earth Observation Team of the Science and Technology Branch (STB) at Agriculture and Agri-Food Canada (AAFC) began the process of generating annual crop type digital maps. Focusing on the Prairie Provinces in 2009 and 2010, a Decision Tree (DT) based

Allen Coral Atlas (ACA) - Geomorphic Zonation and Benthic Habitat - v1.0

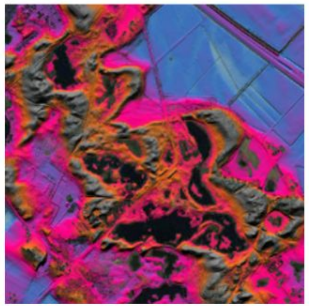
The Allen Coral Atlas dataset maps the geomorphic zonation and benthic habitat for the world's shallow coral reefs at 5m pixel resolution. The underlying satellite image data are temporal composites of PlanetScope satellite imagery spanning 2018-2020. The habitat maps are created

AHN Netherlands 0.5m DEM, Interpolated



The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

AHN Netherlands 0.5m DEM, Non-Interpolated



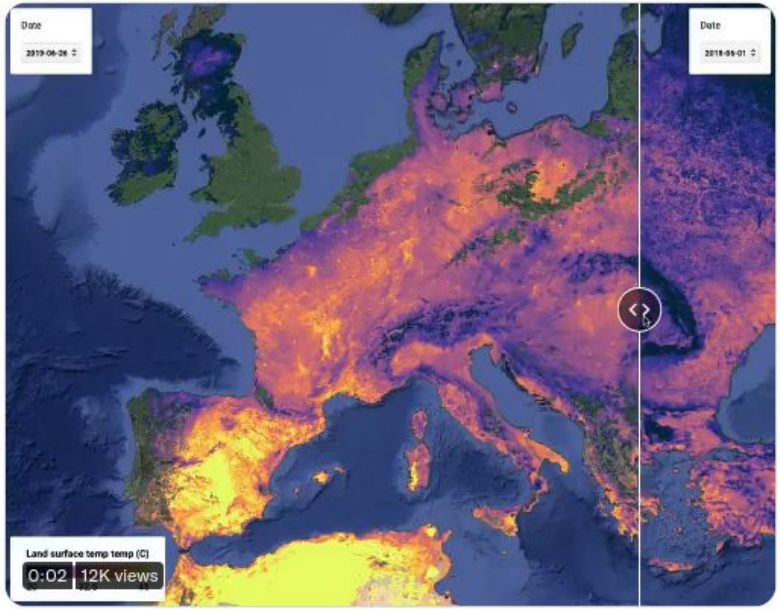
The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. It contains ground level samples with all other items above ground (such as buildings, bridges, trees etc.) removed. This version is ...

AHN Netherlands 0.5m DEM, Raw Samples

The AHN DEM is a 0.5m DEM covering the Netherlands. It was generated from LIDAR data taken in the spring between 2007 and 2012. This version contains both ground level samples and items above ground level (such as buildings, bridges, trees etc). The point cloud ...

Stef Lhermitte
@StefLhermitte

Yesterday's (26 Jun 10h30) land surface temperatures 🌡️ from @NASAEarth's #MODIS 🛰️ clearly show the footprint of the #heatwave 🌞 over Europe when compared to mean June 2018 LST's.

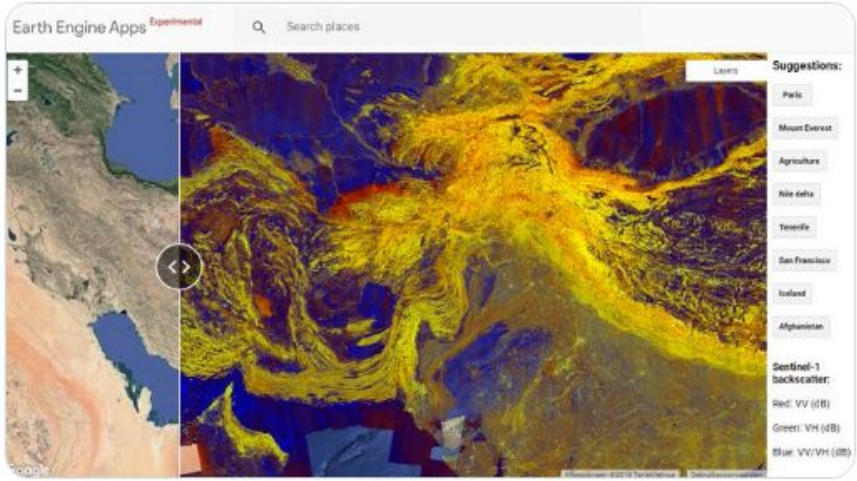


11:56 PM · Jun 27, 2019 · Twitter Web Client

137 Retweets **9** Quote Tweets **272** Likes

Kristof Van Tricht
@K_VanTricht

Did you know how beautiful the Earth is through the eyes of a #radar? Check out my #GoogleEarthEngine app and explore global #Sentinel1 #SAR imagery: bit.ly/2K6ZW0n
#SARworld #eeus18 @googleearth @CopernicusEU @ESA_EO @VITO_RS_



6:40 PM · Jun 20, 2018 · Twitter Web Client

38 Retweets **4** Quote Tweets **106** Likes

Google Earth Timelapse

About the project →

Earth Timelapse is a global, zoomable video that lets you see how the Earth has changed over the past 37 years.

Explore Timelapse in 3D using Google Earth.

Timelapses around the world

Columbia Glacier Ret...
Alaska, USA

Mining
Alberta, Canada

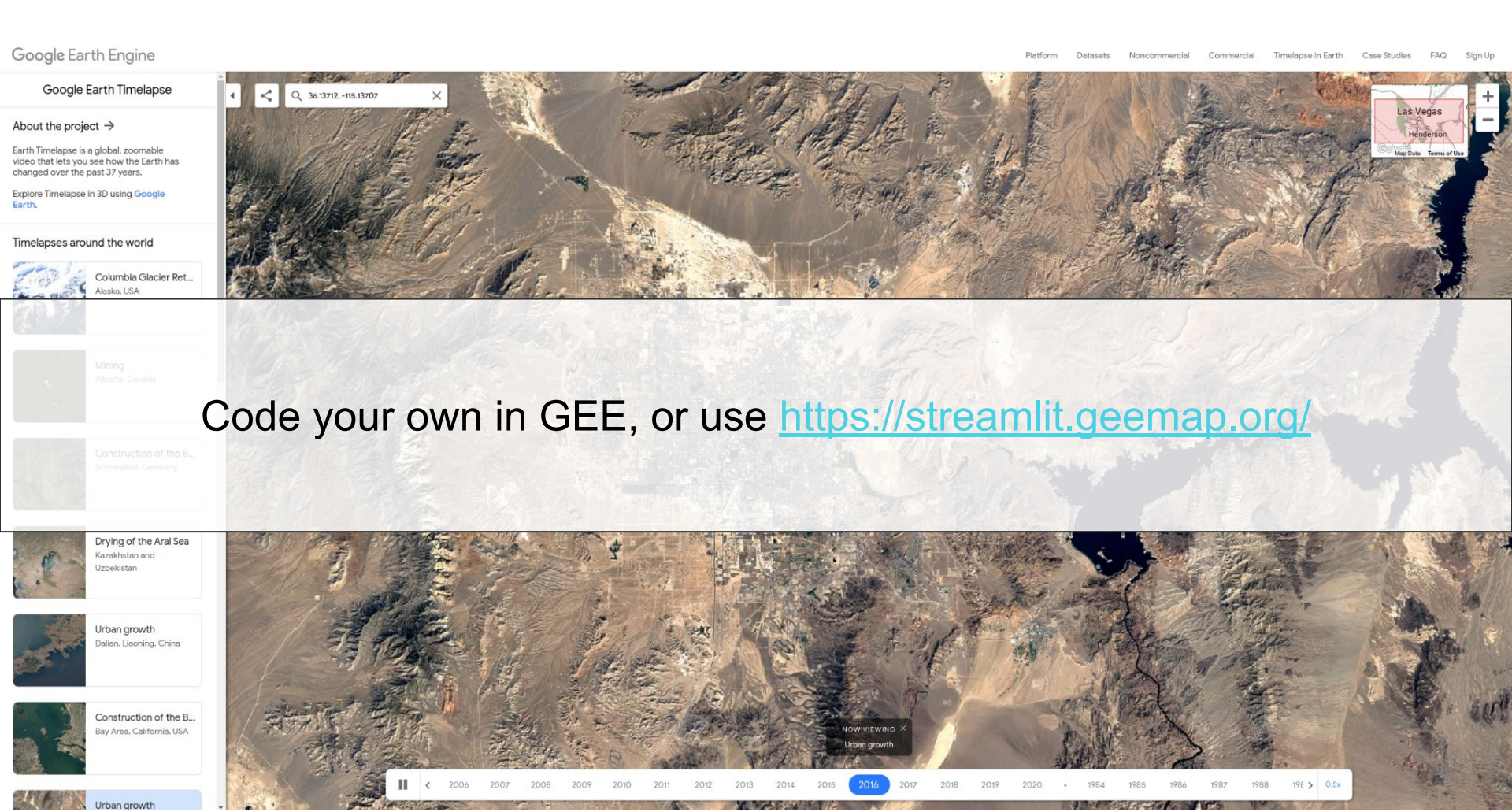
Construction of the B...
Schonefeld, Germany

Drying of the Aral Sea
Kazakhstan and Uzbekistan

Urban growth
Dalian, Liaoning, China

Construction of the B...
Bay Area, California, USA

Urban growth



Code your own in GEE, or use https://streamlit.geemap.org/

Das sind Deutschlands grünste Großstädte

Viele Städte behaupten von sich, besonders viele Grünflächen zu bieten. Die Berliner Morgenpost hat Satellitenbilder ausgewertet und zeigt erstmals, wie grün Deutschland wirklich ist.

Fast jeder dritte der 82 Millionen Einwohner Deutschlands lebt in einer Großstadt, immer mehr Menschen zieht es dahin. Es gibt mittlerweile 79 Städte

Berliner Morgenpost, 10.05.2016

Personal use?

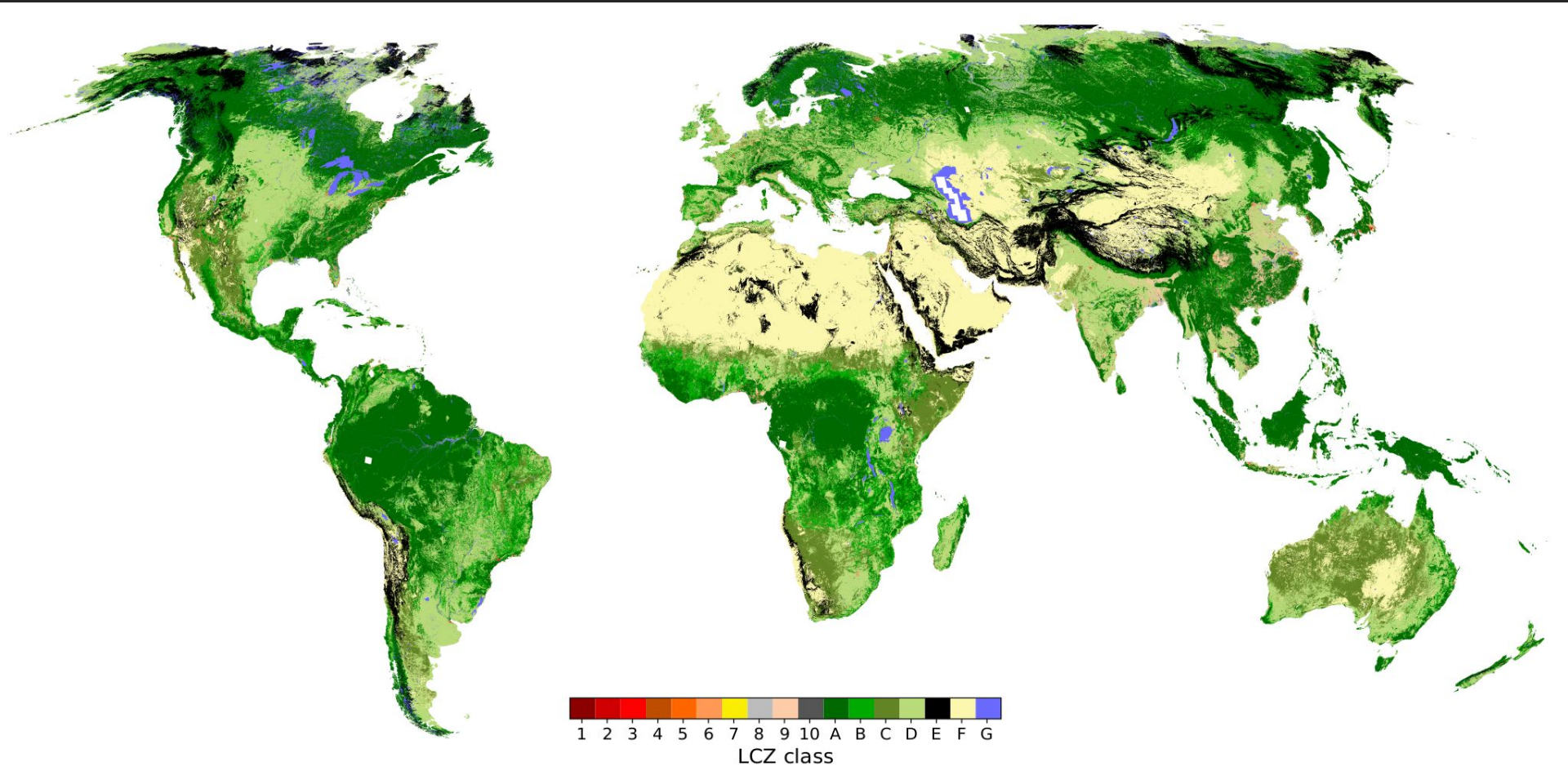
Earth Syst. Sci. Data, 14, 3835–3873, 2022
https://doi.org/10.5194/essd-14-3835-2022

Open Access Earth System Science Data

A global map of local climate zones to support earth system modelling and urban-scale environmental science

Matthias Demuzere[1], Jonas Kittner[1], Alberto Martilli[2], Gerald Mills[3], Christian Moede[1], Iain D. Stewart[4], Jasper van Vliet[5], and Benjamin Bechtel[1]

Personal use?



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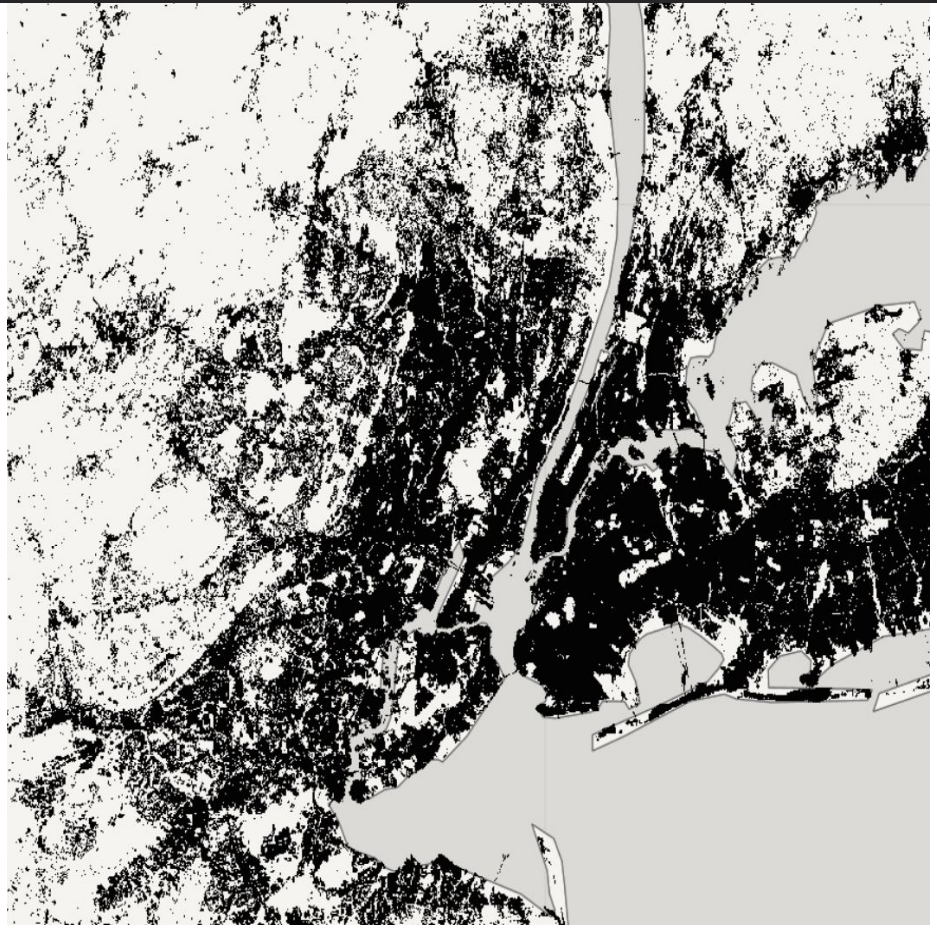

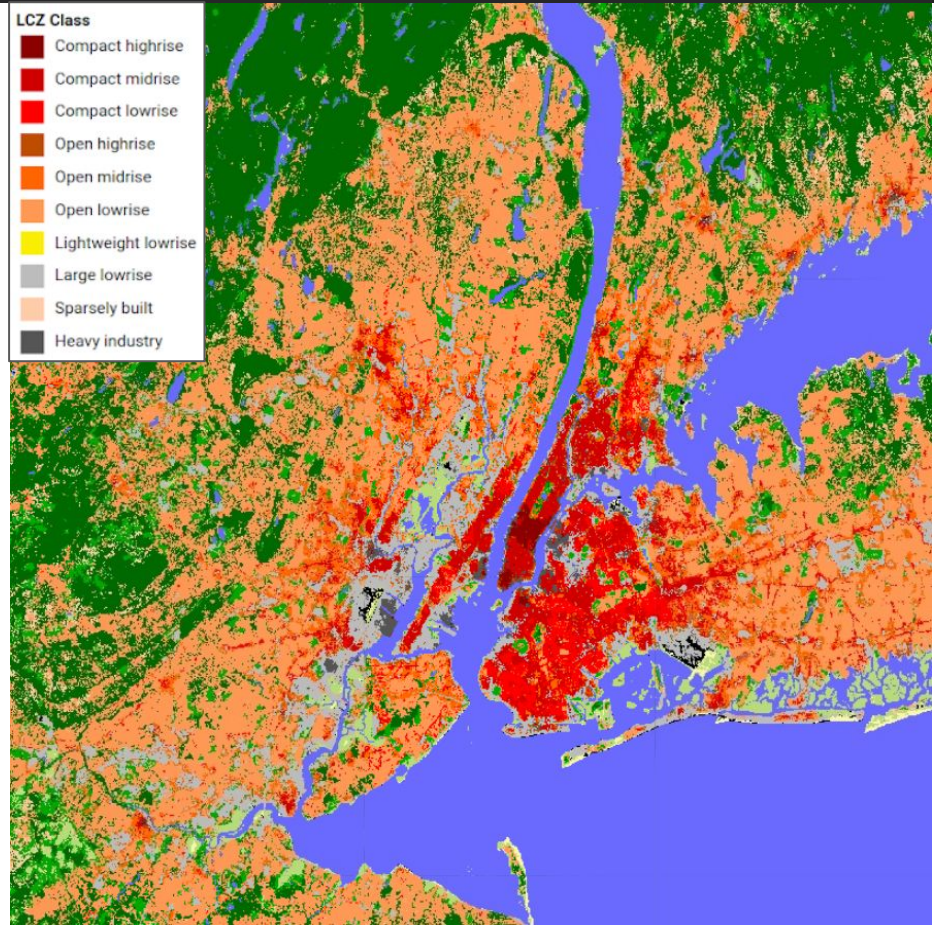

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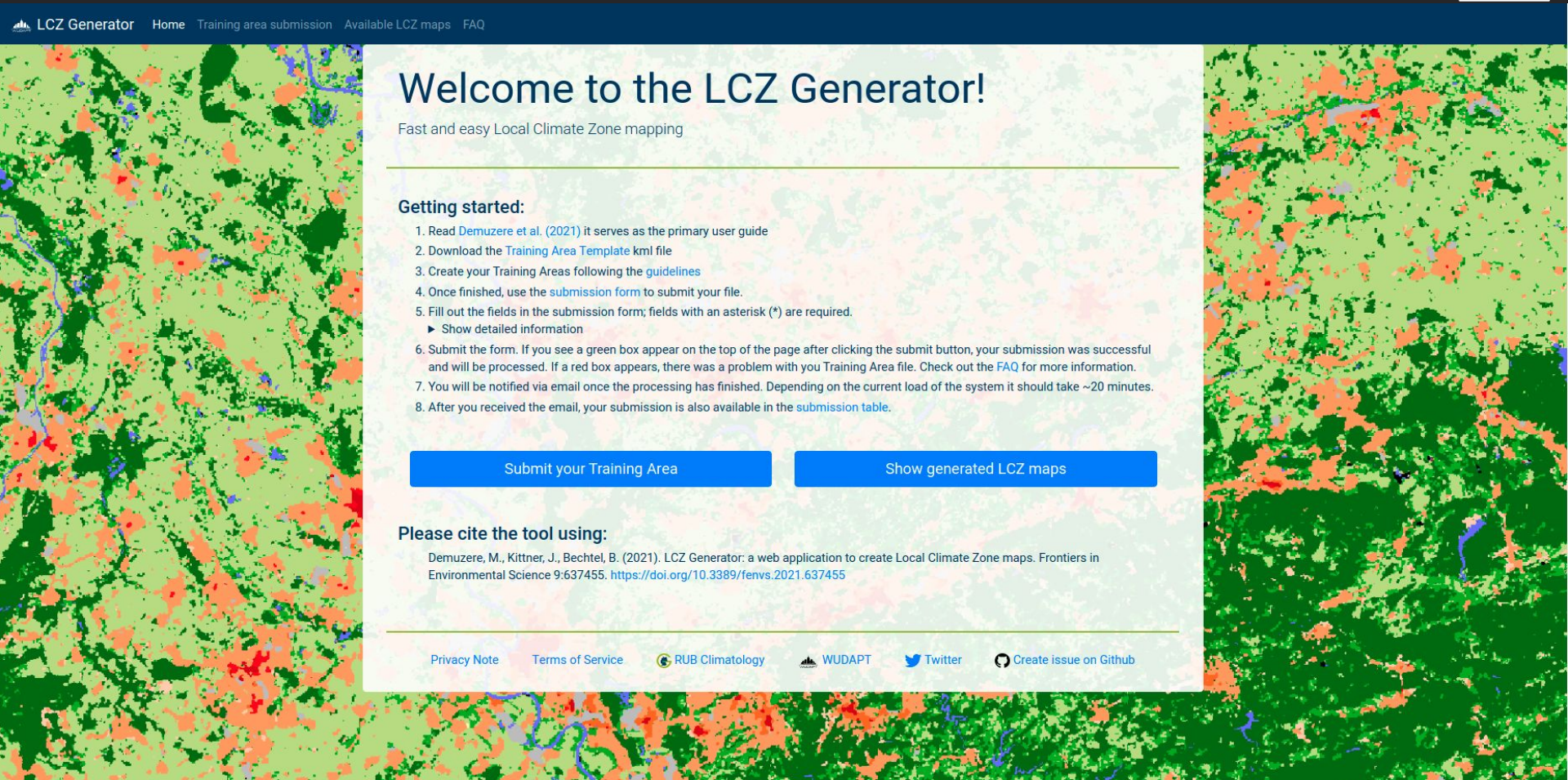
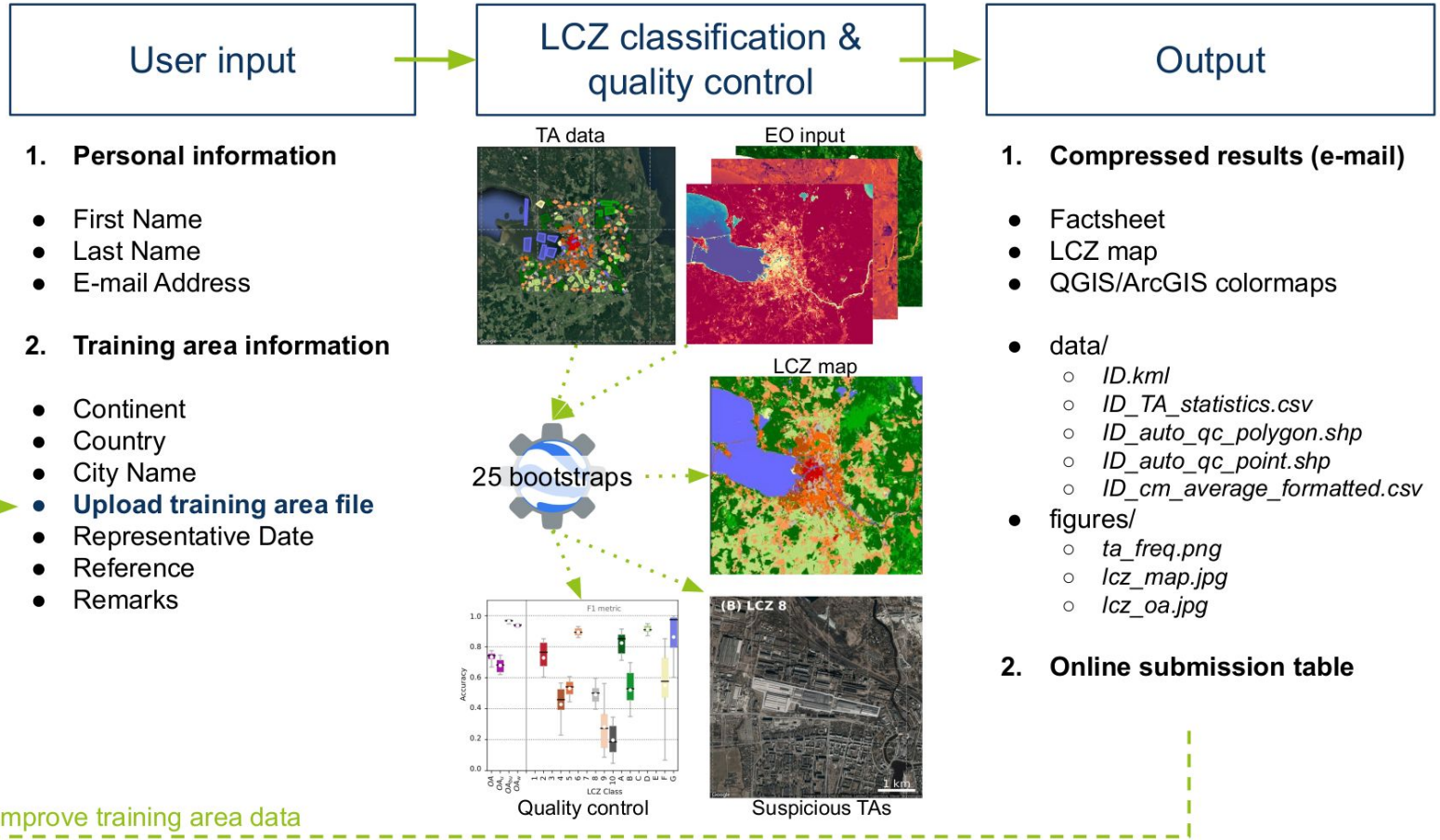


Personal use?

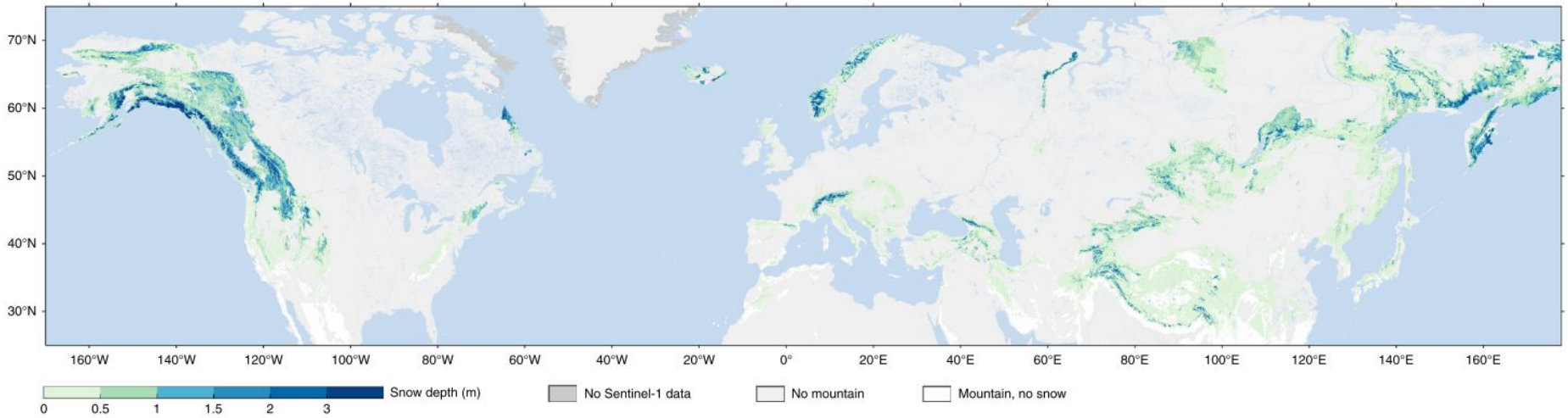
https://lcz-generator.rub.de/



nature COMMUNICATIONS

Snow depth variability in the Northern Hemisphere mountains observed from space

Hans Lievens[1,2*], Matthias Demuzere[2,3], Hans-Peter Marshall[4,5], Rolf H. Reichle[6], Ludovic Brucker[6,7], Isis Brangers[1], Patricia de Rosnay[8], Marie Dumont[9], Manuela Girotto[6,7,10], Walter W. Immerzeel[11], Tobias Jonas[12], Edward J. Kim[6], Inka Koch[13], Christoph Marty[12], Tuomo Saloranta[14], Johannes Schöber[15] & Gabrielle J.M. De Lannoy[1]



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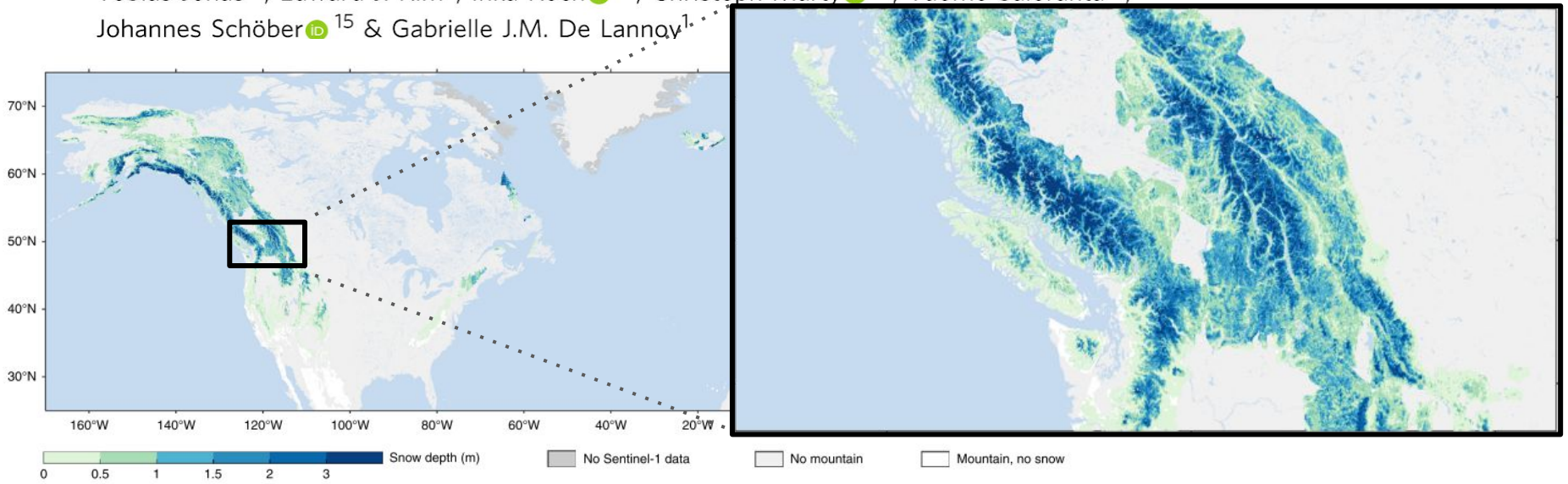

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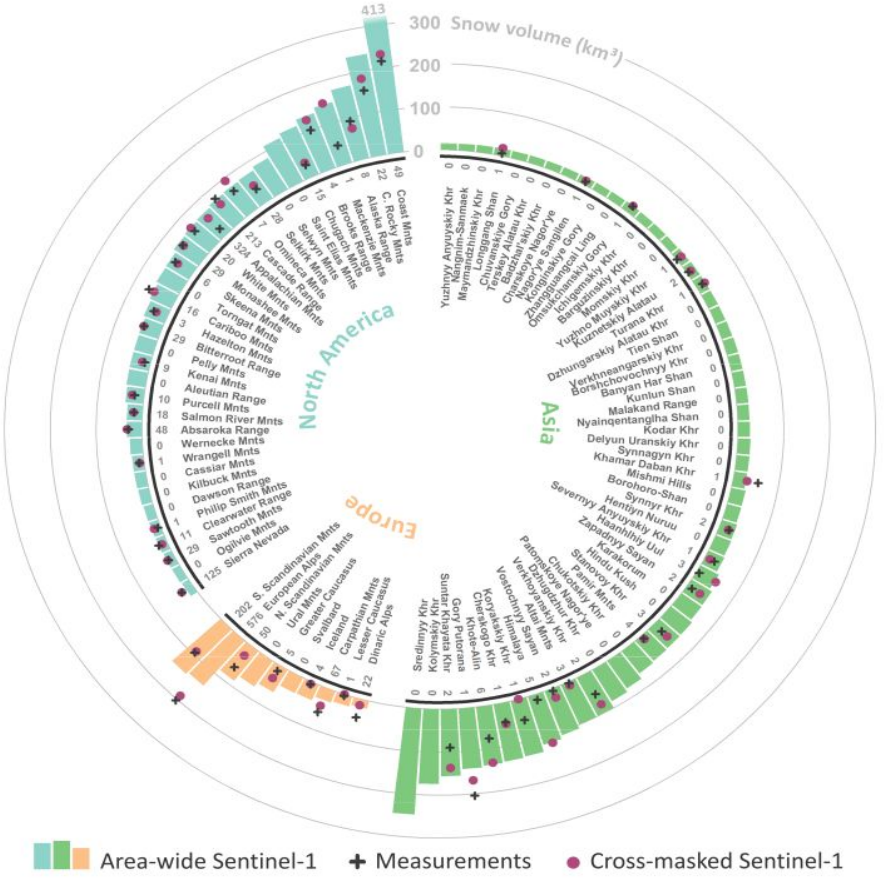
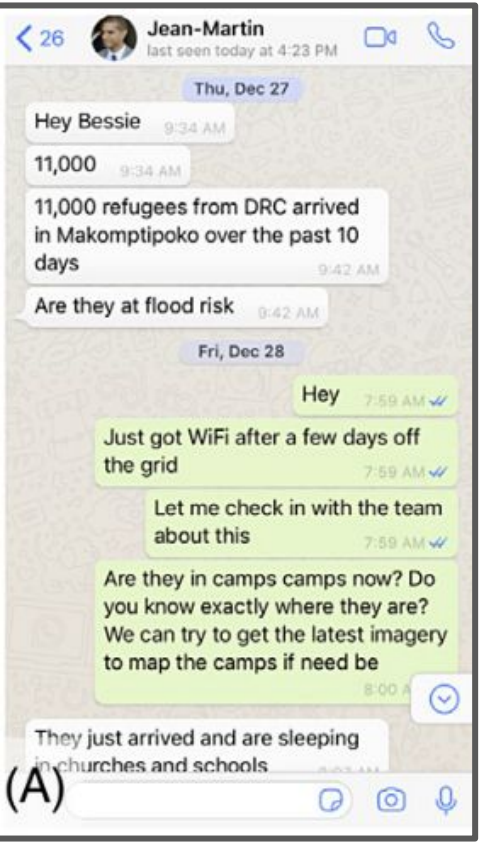


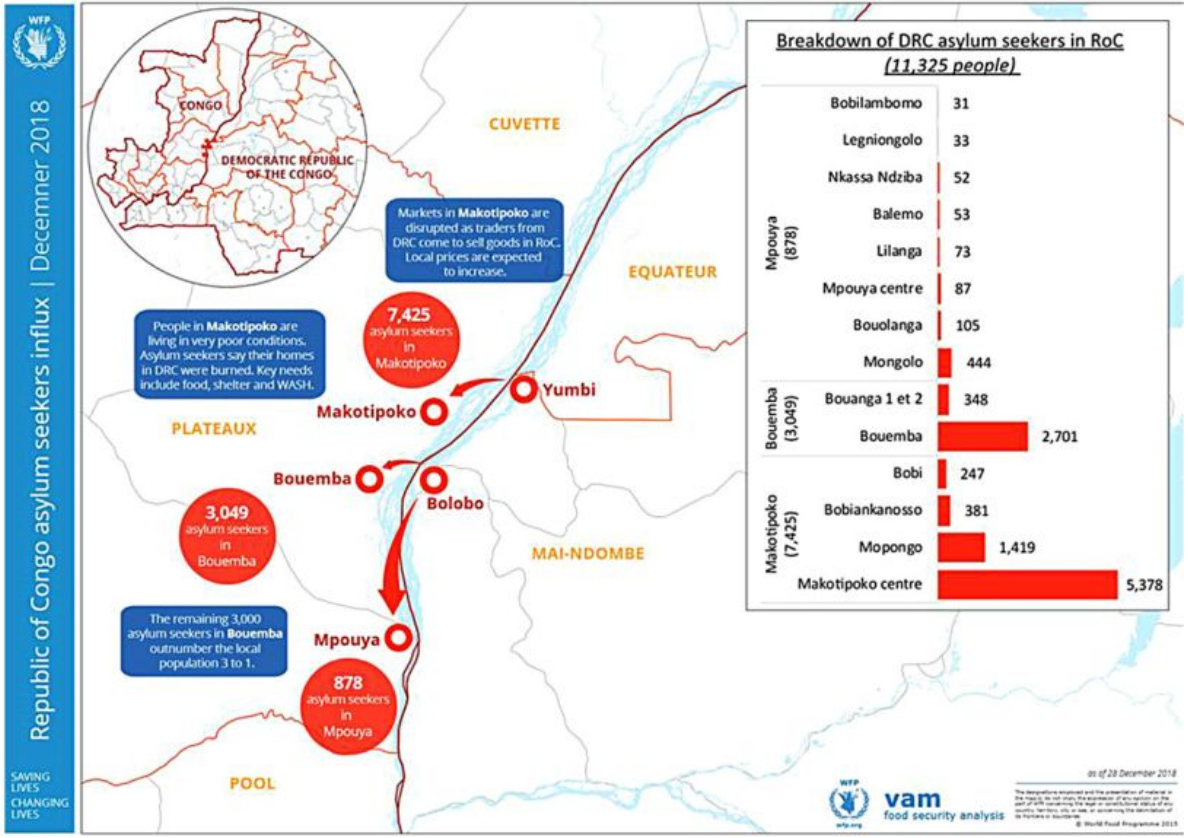
Personal use?

Cloud to Street

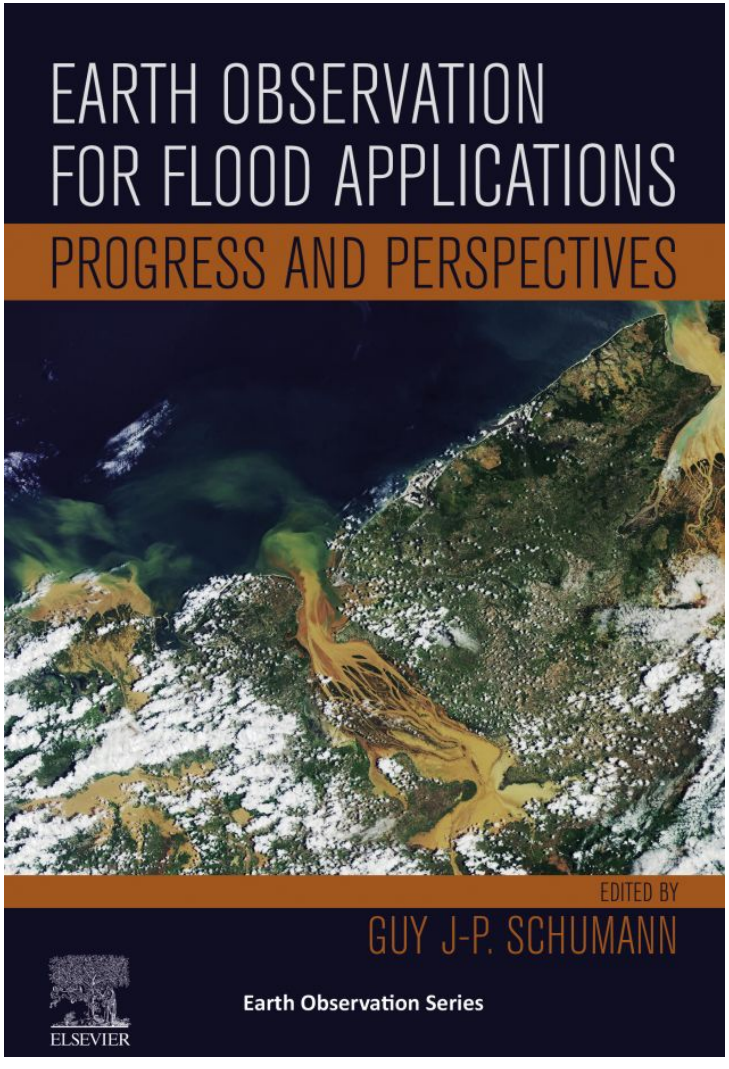
WFP World Food Programme

UNHCR The UN Refugee Agency





Ho et al. (2021)



From Cloud to Refugee Camp: A Satellite-Based Flood Analytics Case-Study in Congo-Brazzaville

Jeff C. Ho[a], William Vu[b], Beth Tellman[a,c], Jean Bienvenu Dinga[d], Patrick Impeti N'diaye[e], Sam Weber[a,f], Jean-Martin Bauer[g], Bessie Schwarz[a], Colin Doyle[a,h], Matthias Demuzere[i,j], Tyler Anderson[a] and Emmalina Glinskis[a]

[a]Cloud to Street, New York, NY, United States; [b]World Food Programme, Johannesburg, South Africa; [c]Columbia University, New York, NY, United States; [d]Ministère de la recherche scientifique et de l'innovation technologique (MRSIT/IRSEN), Brazzaville, Republic of Congo; [e]Agence Nationale de l'Aviation Civile (ANAC), Brazzaville, Republic of Congo; [f]University of California, Irvine, CA, United States; [g]World Food Programme, Congo-Brazzaville, Brazzaville, Republic of Congo; [h]University of Texas, Austin, TX, United States; [i]B-Kode VOF, Ghent, Belgium; [j]Department of Geography, Ruhr-University Bochum, Bochum, Germany

1 Introduction

A community's ability to absorb a shock and prevent a flood from becoming a disaster is a key to its long-term resilience. However, governments, communities, and other government actors can only reliably reduce the number of deaths and protect their economies if they know where vulnerable people and assets are at key moments to make risk mitigation decisions. For flood preparedness, the identification of people and assets most exposed to flooding would enable the government and World Food Program (WFP) to prepare aid and plan response, as well as rezone assets and design protective infrastructure. For emergency response, reliable flood information would enable the government to better locate people for immediate rescue and aid and would enable WFP to provide faster food relief. This would reduce the number of deaths, injuries, illnesses associated with the flood, and more precisely allocate scarce resources. Such a solution would have several co-benefits, which include increased transparency and

Let’s dive in …

RUB

- **Global forest change** (Hansen et al., 2013):
  - *Browser environment / components*
  - *Search bar*
  - *Data catalogue*
  - *Script example*

Let’s dive in …

RUB

- **Global forest change** (Hansen et al., 2013):
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- **The greenest large cities of Germany?** (Berliner Morgenpost, 2016)
  - *ImageCollection: filter by dates, day of your, bounds, metadata, map*
  - *Display on map*
  - *Upload and export data (Image & table to Asset, Drive)*
  - *Reducer functionality*
  - *External libraries*
  - *…*

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Berliner Morgenpost

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Je hellgrüner die Fläche, desto stärker die Vegetation

Wie grün ist es in Ihrer Nähe?

What type of information is required to perform this analysis?

Fast jeder dritte der 82 Millionen Einwohner Deutschlands lebt in einer Großstadt, immer mehr Menschen zieht es dahin. Es gibt mittlerweile 79 Städte

Leaflet | OpenStreetMap-Mitwirkende, Mapbox, Google Earth Engine

Berliner Morgenpost, 10.05.2016

Berliner Morgenpost

Das sind Deutschlands grünste Großstädte

Viele Städte behaupten von sich, besonders viele Grünflächen zu bieten. Die Berliner Morgenpost hat Satellitenbilder ausgewertet und zeigt erstmals, wie grün Deutschland wirklich ist.

Je hellgrüner die Fläche, desto stärker die Vegetation

Wie grün ist es in Ihrer Nähe?

Leaflet | OpenStreetMap-Mitwirkende, Mapbox, Google Earth Engine

What type of information is required to perform this analysis?

- A measure of greenness monitored by satellite(s)
- Assumption about what is green and what not
- City boundaries

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Plan of action?

- Get Sentinel-2 imagery:
  - Over Germany,
  - With a cloud cover of less than five percent,
  - For the months of June and July in the years 2017 to now
  - Calculate NDVI
  - Categorize: NDVI < 0.45 = No Green; NDVI ⩾ 0.45 = Green
- Get city boundaries, including surface area and population?
- Extract green surface area (in %) per city geometry
- Export table to drive

Je hellgrüner die Fläche, desto stärker die Vegetation

Wie grün ist es in Ihrer Nähe?

Beispiele: Siegen, Berlin, Hamburg

Großstadt finden ...

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Other resources ...

RUB

- GEE developers forum
- GEE Javascript and Python guides
- Official self-paced GEE tutorials
- Google (Earth Engine) outreach, Geo for good
- List of official GEE developer resources
- GEE resources for higher education
-
- Swiss Army Knife Package by Gena: see here (presented at EGU19 - Agenda)
- GEEMAP, a Python package for interactive mapping with Google Earth Engine, ipyleaflet, and ipywidgets
- EEMONT, a Python package that extends GEE
- EE tool developments by Samapriya Roy on github

- Follow EarthEngineBot on Twitter
- GEE stories on Medium
- ...