EARTH OBSERVATION BIG DATA AND ITS APPLICATION IN THE CLASSROOM

Kevin Davies & Christopher Jenkins

Source: NASA image sourced from Observer Research Foundation – https://www.orfonline.org/expert-speak/the-growing-need-for-earth-observation-satellites-to-deal-with-climate-change/

FROM THE FIELD – Kevin Davies

The observation of Earth by satellites plays a critical role in helping us to understand how climate change has impacted our natural and built environments, and for providing crucial information for modelling the severity of potential future climate change related impacts. Satellites can provide consistent and routine coverage over large spatial regions reducing the need for extensive field measurements which can be time consuming and expensive, or just not feasible over large and potentially inaccessible areas. The specific applications for satellite images in the context of climate change are numerous in both the terrestrial and marine domains. Examples include mapping land cover transformation, monitoring deforestation and forest degradation, assessing the impacts of climate shocks and stressors on agricultural productivity, and assessing the impact of sea level rise on the carbon storage potential of coastal ecosystems.

Images from space

One of the most important sources of earth observation data is the Landsat satellite program jointly run by NASA and the US Geological Survey. The first images captured by Landsat 1 in 1972 started a program that is now in its 50th year. The most recent satellite in the series, Landsat 9 was launched in September 2021, and in tandem with Landsat 8 (launched in February 2013), provides a complete set of images of Earth every 8 days. Over ten million images have now been added to the freely available archive. The medium spatial resolution of the Landsat satellite (each pixel represents 30 square metres on the ground) combined with the near-weekly capture provides a platform that is suitable for local to global scale studies of land surface transformations in the context of climate change.

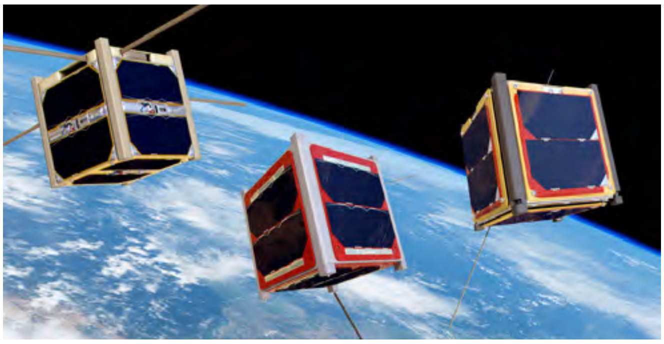
Landsat is not alone in imaging Earth from space. The European Space Agency (ESA) launched the first Earth observation satellite in its Copernicus programme in 2014, while other nations such as Japan, India and China also have well established programmes. These national Earth observation programmes are generally reliable and of high quality (Landsat is regarded as the gold standard) but they are expensive with long development times (Landsat 9 cost almost $200 million AUD and took 5 years to complete). A relatively new paradigm in Earth observation known as CubeSats is challenging these traditional satellite platforms by providing a relatively accessible and low-cost alternative.

CubeSats

CubeSats are miniature satellites with a standard 10 cm cube shape (called a unit). Multiple cubes can be stacked together to make larger CubeSats as required (e.g., 3-unit or 6-unit CubeSats). The original concept of the CubeSat was to enable relatively easy access to space for researchers and educators by providing a standardised form factor, and the use of relatively inexpensive commercial off-the-shelf components with low energy requirements. CubeSat developers can share the launch costs by combining CubeSats into a single rocket payload to reach orbit. CubeSats have opened space to researchers, educators and students. The University of Sydney's Centre for CubeSats, UAVs and their Applications (CUAVA) launched its first CubeSat satellite CUAVA-1 in 2021 which was designed and built by students and researchers in the centre. The launch of CUAVA-2 is planned for 2023. Commercial operators are also using CubeSats for Earth observation with the Planet company operating the largest CubeSat constellation. Planet has over 200 CubeSats in orbit and can provide a high-resolution image of the Earth's terrestrial surface every day.

Figure 1: CubeSats.

CubeSats tend to hitch a ride into space using extra space available on rockets, meaning lots of launch opportunities and low launch costs. They are packed in a container which, at the push of a button, ejects them into space via a spring system. A similar technique is used to deploy CubeSats from the International Space Station (ISS)



Source: European Space Agency https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Discovery_and_Preparation/CubeSats

Data deluge

All these Earth observation programmes are contributing huge amounts of data to an already large archive of available images (the Planet CubeSat constellation alone produces over 15 terabytes of data per day). This vast number of images of our planet is an extremely valuable resource; however, this 'data deluge' can represent a significant obstacle to non-technical researchers and educators. Accessing, processing and interpreting these large collections are usually the domain of technical remote sensing and 'big data' specialists with access to significant computational resources.

In the last decade or so there has been a significant paradigm-shift in the way researchers and educators can access and work with large collections of satellite images. The move to shared cloud-based satellite image repositories, and distributed computing platforms has significantly reduced or removed some of the obstacles and barriers and widened the access to satellite image archives to non-specialist users. The most significant development in this new paradigm is by search engine behemoth Google who have created a platform called Earth Engine, a tool which has revolutionised Earth observation science research and education.

Google Earth Engine

Earth Engine is an online platform that provides users free and easy access to large collections of continuously updating satellite images from a web-browser. The platform includes the complete Landsat archive from 1972 as well as other significant Earth observation collections such as from the European Copernicus programme. The platform provides a simple web-based interface where a user can extract information from vast collections of satellite data held and processed by Google. The images are provided in an analysis-ready format, so the user only needs to concentrate on the mechanism used to extract the information they require for their application. The platform is provided free of charge to researchers, educators and government agencies and has already resulted in significant research outcomes such as global forest change and hydrological mapping. Although Earth Engine is the most significant and widely used platform for Earth observation analysis across the globe, other similar cloud-based platforms exist such as Geoscience Australia's Digital Earth Australia which focuses on serving the Australian Earth observation community.

A major goal of Google in developing and providing Earth Engine is education and outreach to school and university students. However, approaching Earth Engine for the first time still presents a significant learning curve in terms of Earth observation science, and potential users may not be comfortable with coding in JavaScript. The 'More Than Maps' initiative was sponsored by the British Council COP26 programme in 2021 with the aim of engaging high school geography students in policy discussions related to climate impacts on coastal ecosystems during the United Nations Climate Change Conference. The University of Sydney along with the University of Western Australia collaborated on developing three workshops as part of the programme, two of which focussed on using Earth Engine to map and analyse climate related impacts to coastal regions and ecosystems in Australia. The workshops are run in a 'follow me' style class where participants learn fundamental concepts in Earth observation science, and learn how to code in JavaScript in small incremental steps. The participants work towards a fully working mapping and analysis project that can form the basis for more complex exploration of Earth Engine's powerful toolset, and potentially adapted for other locations or applications. The workshops have been made freely available online for educators to use as is, or to adapt to their own application interests or better alignment with a teaching curriculum.

FROM THE CLASSROOM – Chris Jenkins

The integration of spatial technologies and Earth Observation Big Data into the classroom is both exciting and daunting. Common questions and constraints in my own planning and with my colleagues include; *what programs/tools should we use? How can we manage this in a classroom setting? How do I differentiate for my students? How do I shift it from basic spatial observations to real world analysis?* I have frequently engaged with and integrated the likes of Google Maps, Google Earth, Google MyMaps, AURIN Maps and SIX Maps into my lessons and programming to engage students in safe, but meaningful, spatial thinking. However, the data collection, collation and analysis behind that drives these spatial technologies was the missing link for myself and students and was needed to help develop a deeper understanding of how the data being presented is gathered, and how it can be manipulated in a geographic context to identify issues and support a solutions based framework to these findings.

More than Maps workshops

One of the main ways I began overcoming these constraints was to upskill myself and this is where my connection with Kevin started. I was fortunate enough to be connected with him through a mutual colleague and my journey with Google Earth Engine started. I had looked and dabbled with this before, however, my use had barely moved beyond creating an account and learning some basic functions. I was fortunate enough to participate in a ***More Than Maps*** workshops where I was able to create a fully functioning Earth Engine map that using basic programming techniques to process and analyse remote sensing images (Google Earth Engine JavaScript API) and further develop my understanding of how satellite images and vegetation indices can be used to monitor mangroves. The ***More Than Maps*** workshop was the beacon of hope that I needed, and the inspiration to take on the challenge in a structured, supported and student friendly environment. In 2021 I had a highly engaged and capable mixed-ability Year 10 Elective Geography class with 22 students. In this setting, I was able to prioritise time to have students engage with the 'safe' spatial technologies commonly integrated into my practice to build curiosity and develop their spatial thinking and reasoning. From this foundation, we pivoted into the ***More Than Maps*** program with Kevin to complete the two hour Google Earth Engine workshop to develop the technical skills to understand the process for how these maps are created, and how the data is presented. Within a 2 hour window, double session after lunch, all students moved from complete beginners, to capable novices with basic programming within the program. They understood where the data was coming from, how it was being applied within the specific context, and how to manipulate it to highlight a geographic issue and construct a narrative or story that was worth telling. Students were supported through the differentiated instructions, written, visual, and modelled on the big screen, and were able to troubleshoot on their own or with peers when the coding or data represented wasn't joining the party.

Figure 2: More than Maps workshops

For more information and to access the workshops visit the More than Maps website http://morethanmaps.earth.

Skill development and transfer

The flow on from this one isolated experience was not only the buzz myself and the students had for what we had created and now understood about spatial technologies, but the ongoing discussion about what data could be gathered and how it could be used. In the preceding weeks, students were using allocated and spare time at school and at home to work through the other workshops and some even began exploring other locations and transferred the skills they had learnt. It extended to the student-led use of spatial technologies for all school-based fieldwork and discussion on how it could be used more effectively next time. I was also fortunate to track the progression of some of these geographers into the Senior course, where the increased confidence with spatial technologies led to a more involved, insightful and meaningful integration of spatial technologies into the Senior Geography Projects.

Conclusion

So what have I learnt from this experience and what am I thinking now?

The main lesson for me, which deep down I think I had always known, is that if I want to use it I have to prioritise it. For my own practice I have consciously made the step to prioritise my own and my students' time to engage with and upskill themselves with what is available, and to then apply it to their learning once the skill has been mastered (or at least become familiar!).

Starting in one classroom, for one activity, was the safety net I needed. My Elective Geography class was the perfect environment for this and since then the expansion to a smaller capable Senior Geography group. From here, it will be the intentional, relevant and meaningful integration to build my own confidence, capability and processes to then integrate into wider programming from my colleagues. Small steps, isolated activities and a risk free setting for students is what lays before me in 2023.

I have also learnt that the support is out there and that connecting to academic and professional geographers in a range of settings begins with an email, a phone call or an introduction from a colleague or friend. When we believe in what we teach, the relevance of this for students, and the future pathways that our students can explore, we owe it to them to show and engage with those out there living and breathing what we teach in their work. Kevin is just one of these people, however, we all have that one friend or acquaintance that's out there researching an obscure frog species and mapping the habitat data, the one person we knew at university that's investigating the structure and flow of ancient riverbeds to track our changing climate.

Make 2023 your year for prioritising the integration of spatial technology, you won't regret it.

About the authors

Kevin Davies is a lecturer in the School of Geosciences at the University of Sydney. His research focuses on the use of Earth observation by satellite, geospatial analysis, and geographical information systems (GIS) to address local scale geographical issues in the context of a changing climate. Kevin's current research includes satellite-based land use mapping for improving livelihoods and natural resource management in Pacific Island Countries and developing satellite-based methods for more accurate mapping and monitoring of carbon sequestration by coastal ecosystems. Kevin also investigates the use of miniaturised satellites (CubeSats) for fine-scale environmental monitoring as part of the University's Centre for CubeSats, UAV's and their Applications (CUAVA).

Chris Jenkins is an experienced Junior and Senior Geography teacher and current Head Teacher Teaching & Learning–Stage 5, at Castle Hill High School. As a Geography Educator, Chris privileges geographical thinking in the classroom to support students to develop a deep understanding of geographical processes and content to create transferable knowledge. He prioritises showing and engaging young geographers in vocations and the application of Geography in a range of settings to create future pathways for their learning and careers. My Geography is promoting a functional understanding integrating the latest data and spatial technologies available in the field to develop deeper knowledge and understanding within our discipline, and to make clear connections between geographic thinking, concepts and its application in the real world.