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Remote Sensing of **Coastal Environments**

DIGITAL EARTH AUSTRALIA COASTLINES: THREE DECADES OF COASTAL CHANGE MAPPED USING SATELLITE IMAGERY

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DEDICATED EXPERIMENTS FOR THE DETECTION OF FLOATING MARINE PLASTIC LITTER

IFOV:
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Dr. Elisa Casella
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Photo: Northern coast of the Persian Gulf, pictured from the International Space Station by NASA

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Dear ISPRS SC Newsletter readers,

It is my honour and pleasure to introduce you to the 2nd issue of SpeCtrum (Volume 15), the official ISPRS Student Consortium Newsletter.

This issue's theme is "remote sensing of coastal environments". Coastal science is a bit different from marine science, as it focuses more on that (often) heavily human-modified strip of Earth's surface at the interface between the land and the sea which we call the coast. The coast hosts a plethora of human and natural processes that relentlessly interact with each other at a variety of spatial and temporal scales, resulting in an extremely dynamic ecosystem. Monitoring coastal environments is therefore challenging. However, recent advances in remote sensing techniques, sensors, and processing platforms are enabling scientists to explore new frontiers in this space that were previously unachievable. Scientists are not only capable of upscaling coastal monitoring both in the time and spatial dimensions, but they are also enabled to innovate and quantify previously unquantifiable human impacts on the coast.

To provide a snapshot of what remote sensing of coastal environments has recently achieved, in this issue we have the honour to feature (1) the Allen Coral Atlas, the first globally-consistent coral reef habitat map and dynamic monitoring system in the world, (2) DEA Coastlines, a continental-scale multi-decadal erosion monitoring system, and (3) the Plastic Litter Project 2021, a groundbreaking initiative that builds floating plastic targets to calibrate Sentinel-2 marine plastic detection algorithms.

Moreover, we had the luck to interview some of the personalities that are at the forefront of the coastal remote sensing scene, such as Dr. Daniel Buscombe, oceanographer and open source developer at the United States Geological Survey (USGS), Dr. Elisa Casella, senior scientist at the Leibniz Centre for Tropical Marine Research, and Els Knaeps, senior project manager at the biodiversity, water and coastal applications department in VITO Remote Sensing research institute.

Additionally, the special feature section named "__init__: Pythonic magic for coastal analysis" will present some of the Python code that is currently enabling scientists to perform coastal analysis at scale.

On behalf of the ISPRS SC Board of Directors and the Newsletter Team, I really want to thank all of the amazing contributors that allowed this issue to shine by providing their articles, experiences, and time. These people are those who make the world a better place. Sharing is caring, and there is no better way to protect our planet than by disseminating knowledge and sparking the imagination of readers. We really hope that this issue will be inspirational for you, the Reader.

I am sure you will enjoy this reading!
Nick

NICOLAS PUCINO
Mentee/Volunteer, ISPRS SC
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ABOUT EARTH ENGINE @ SG

The Google Earth Engine (GEE) workshop took place (online) Monday the 13th September 2021, during the Singapore Geospatial Festival 2021. The ISPRS SC and its mentees helped with the organization and execution of this event.

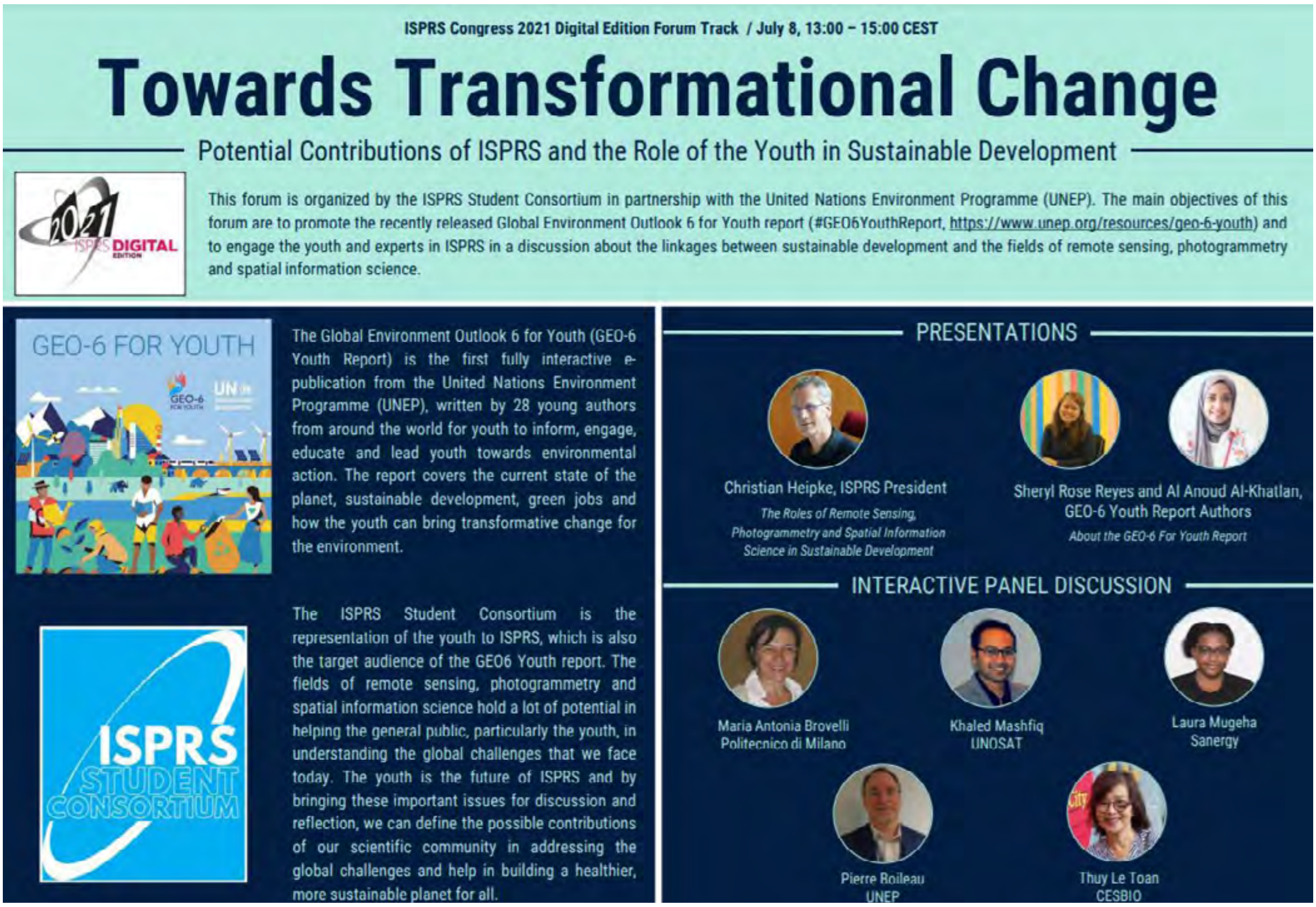
GEE is a powerful cloud-based platform used to process remotely sensed satellite imagery and conduct large-scale land cover mapping on-the-fly. The applications of GEE are numerous and cover a range of topics such as urban expansion, deforestation, and mapping of hazards, just to name a few. This workshop allowed GEE users from academia, industry, as well as the public sector and non-government organisations to connect by engaging them with a keynote talk, several parallel talks on different topics, a networking breakout session, and hands-on GEE workshops.

The keynote talk was given by Nicholas Clinton, developer advocate at Google, who gave an overview of the current and future capabilities of the GEE platform.
After a short break, parallel talks allowed the audience to choose their favourite theme and follow the associated lecture.

Keiko Nomura, director of product development at Climate Engine, delivered a lecture titled "Fate of forests at your fingertips". Nicholas Murray, senior research fellow at James Cook University talked about "Losses and gains of Earth's intertidal ecosystems". Jakrapong Tawala, satellite analyst at the United Nations Satellite Centre, talked about "GEE for the United Nations humanitarian assistance missions", while Mong Suan Yee, director of engineering at Kumi Analytics, provided a lecture on "Machine Learning with Google Earth Engine".
After these parallel talks, a Zoom breakout session was organised to provide the audience with an opportunity to connect and share thoughts and ideas on how GEE can or could help to solve their specific needs. Interestingly, the breakout rooms were themed and moderators gathered information about the type of GEE users, how they use GEE, where in their opinion GEE struggles, and which tools they would love to see added to it in the future.

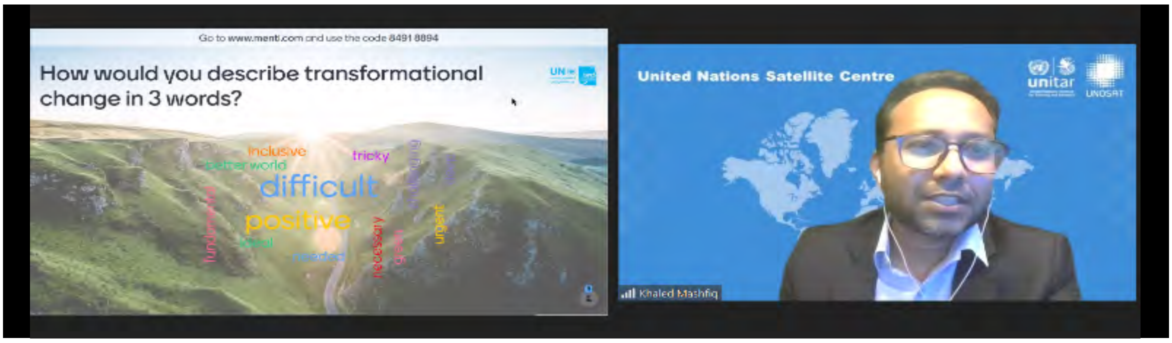
Following the breakout sessions and a short break, the afternoon was reserved for three different workshops where the audience was guided by the demonstrators in practical sessions differentiated according to the expected audience experience level. Minerva Singh, research fellow at Imperial College London, provided an introduction to GEE for beginners, Keiko Nomura presented tips and tricks for the intermediate audience, while Yvonne Fong, data scientist at EO Data Science, provided an intermediate to advanced level overview of the Google Earth Engine Apps.

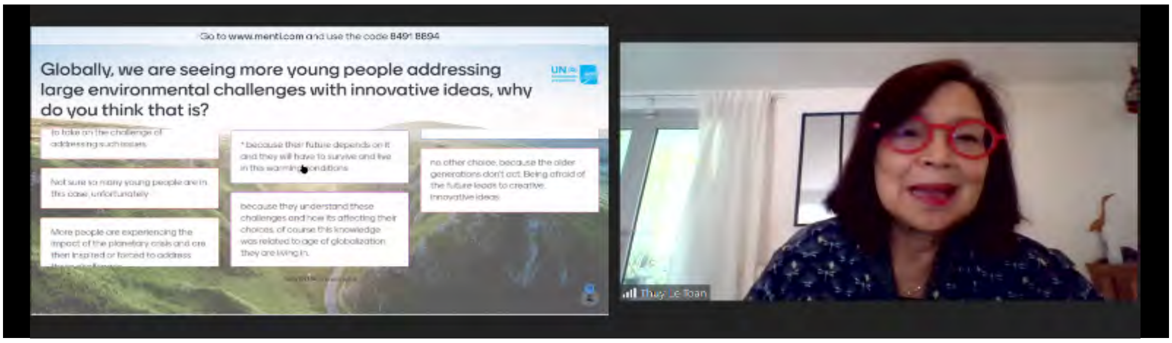
Overall, it all went very well! The audience was engaged and responsive and the organisation was smooth and successful. The success of this event is due to the productive collaboration of all parties involved in its conception and execution, composed of A/Prof Lee Ser Huay Janice Teresa (Nanyang Technological University), Jose Don Tungol De Alban (National University of Singapore), Sabrina Szeto (Sabrina Szeto Consulting), ISPRS SC president Sheryl Rose Reyes, board members Charmaine Cruz and Sona Guliyeva and ISPRS SC mentees Nicolas Pucino, Laxmi Thapa, Saicharan Vasala and Sunni Kanta Prasad Kushwaha.

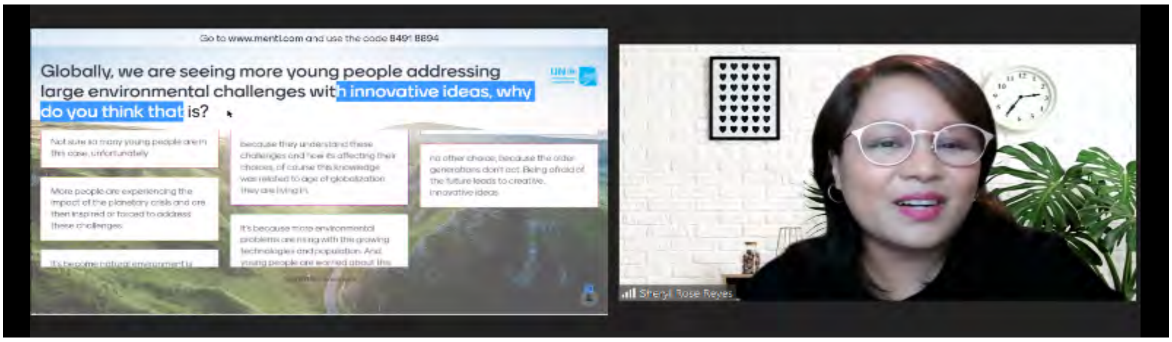


The ISPRS Student Consortium, in partnership with the United Nations Environment Programme (UNEP), organized a Digital Forum titled "Towards Transformational Change: Potential Contributions of ISPRS and the Role of the Youth in Sustainable Development" as part of the ISPRS Congress 2021 Digital Edition on July 8, 2021. The primary objective of the forum was to promote the Global Environment Outlook 6 for Youth report (GEO6 Youth Report) and to engage the youth and experts in a discussion about the links between sustainable development and the fields of remote sensing, photogrammetry, and spatial information science. The event was jointly moderated by Sheryl Rose Reyes, President of ISPRS SC and Adele Roccato, Assessment Specialist at the United Nations Environment Programme (UNEP).

The forum was mainly divided into two parts: presentations and an interactive panel discussion. An informative presentation about the UNEP GEO-6 for Youth Report was delivered by Sheryl and Al Anoud Al-Khatlan, both of whom are the authors of the Report. Likewise, another presentation about the roles of remote sensing, photogrammetry and spatial information science in sustainable development was given by Christian Heipke, President of ISPRS and professor of photogrammetry and remote sensing at Leibniz Universitat, Hannover. After these warmup presentations about the application of GI technologies/Science for sustainable development and briefs on the major contents of the Geo-6 for Youth Report, there was an interesting panel discussion session where five of the diverse and issue-oriented experts and scientists were invited to interact with the participants of the Forum. The panel discussion team consisted of Pierre Boileau, the head of the Global Environment Outlook programme at the UNEP, Khaled Mashfiq, the Liaison Officer for the UNITAR-UNOSAT ASIA Pacific in Bangkok, Maria Antonia Brovelli, Professor of GIS and Copernicus Uptake at the Politecnico di Milano and the Chair of the UN-CGIM (Global Geospatial Information Management) Academic Network, Thuy Le Toan, the P.I. of the ESA Biomass Mission and Co-Chair of the Biomass Mission Advisory Group, Laura Mugheha, the Geospatial engineer at Sanergy and the YouthMappers regional ambassador of East and Central Africa, and our President Christian Heipke.







This multidisciplinary panelist team from different age groups, expertise, and genders had an interesting panel discussion for about 45 minutes with engaging questions on the topics like innovative ideas to address the environment challenges for sustainable development, opportunities for the youth in this challenging time, climate anxiety, and the use of science-based assessments for sustainability. During the discussion and Q&A session, we used an online tool-mentimeter to interact with panelists with the participants' questions and conduct live polls. Nicolas Pucino and Laxmi Thapa, the mentees of the ISPRS SC Leadership and Service Mentorship Programme assisted in the organization of the forum.

We thank all the presenters, panelists and participants for their active participation and contributions to the event. We hope to see you again in future events :)

This summary has been prepared from the originally written content by Sheryl Reyes, President, ISPRS SC. ISPRS SC mentee Laxmi Thapa

Digital Earth Australia Coastlines: three decades of coastal change mapped using satellite imagery

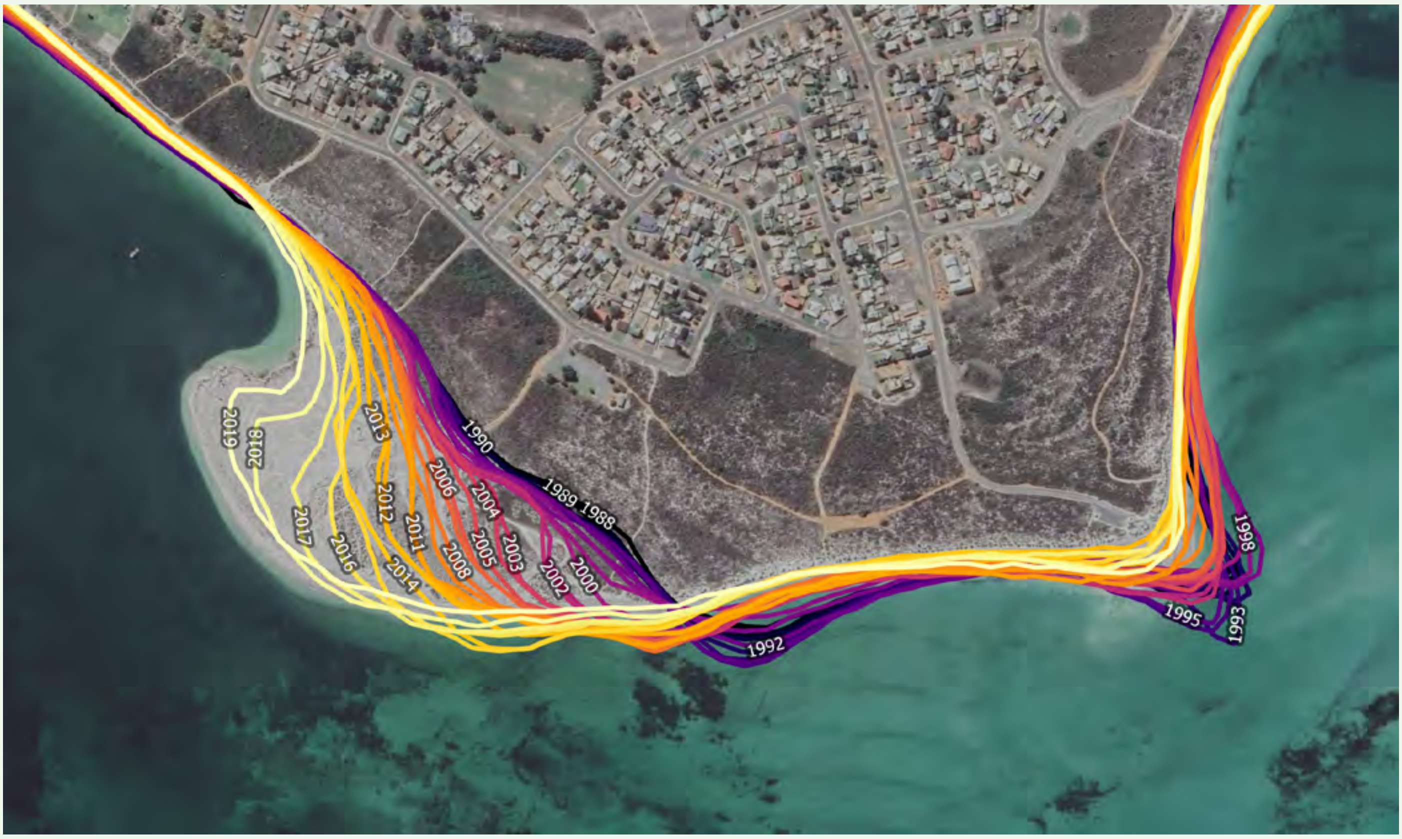


Figure 1. *DEA Coastlines annual coastline vectors from 1988 to 2019 represent the median or 'dominant' position of the coastline at approximately mean sea level tide (0 m Above Mean Sea Level) for each year.*

Australia has a highly dynamic coastline of over 30,000 km, with over 85% of its population living within 50 km of the coast. This coastline is subject to a wide range of pressures, including extreme weather and climate, sea level rise, and human development. Understanding how our coastal environments have responded to these pressures in the past is vital to managing our coastlines now and into the future.

Freely available earth observation data from NASA-USGS's Landsat and the EU's Copernicus Sentinel-2 satellites represent a powerful resource for studying coastal change through time and across large spatial extents. However, previous global-scale satellite-derived coastline datasets have been limited by both the relatively coarse resolution of this satellite data (e.g. 30 m pixels for Landsat), and the confounding influence of tides. The rise and fall of the tides along Australia's coast can dramatically affect the position of the shoreline, making it difficult to separate long-term coastal change from the short-term effect of the tides. This is particularly the case in locations like north-west Australia's Kimberley region, where tides can rise by up to 11 metres, potentially shifting the position of the shoreline by tens or hundreds of metres.

To address these challenges, Geoscience Australia has developed Digital Earth Australia Coastlines: a new continental dataset of annual shorelines (Figure 1) and rates of coastal change (Figure 2) along the entire Australian coastline from 1988 to the present. The product combines analysis-ready satellite data from the Digital Earth Australia (DEA) program with tidal modelling to map the dominant position of the shoreline at the mean sea level tide datum for each year. This enables trends of coastal erosion and growth to be examined annually at both a local and continental scale, and for patterns of coastal change to be mapped historically and updated regularly as data continues to be acquired.

By specifically accounting for tide, DEA Coastlines produces shorelines and rates of coastal change that can be compared consistently across time and between different locations and environments along Australia's coastline. DEA Coastlines also uses an advanced subpixel mapping method that compares subtle differences in the "wetness" of each satellite pixel to draw out high resolution coastlines from lower resolution satellite imagery. Those coastlines have been extensively validated by comparing them to

Figure 2. *DEA Coastlines rates of change points provide robust rates of coastal change for every 30 m along Australia's non-rocky coastlines. Red points represent retreating or eroding shorelines, while blue indicates coastal growth or progradation.*

Figure 3. *DEA Coastlines continental-scale hotspots of coastal change shown on the interactive DEA Maps platform.*

nearly 58,000 independent coastline measurements across Australia, revealing an ability to map the dominant annual position of the coastline with an accuracy of between 10-15 metres.

Data from DEA Coastlines provides valuable new insights into whether changes to our coastline are the result of particular events or actions, or a process of more gradual change over time. This information can enable scientists, managers, and policy makers to assess impacts from the range of drivers impacting our coastlines and potentially assist planning and forecasting for future scenarios. DEA Coastlines is based on freely available data and code, making the approach applicable to monitoring coastal change across any coastal region globally.

To explore DEA Coastlines data for your favourite Australian beach, visit the **interactive DEA Maps platform** (Figure 3). For more detailed metadata and data access (including zipped shapefiles covering the entire Australian continent), visit the official Geoscience Australia product description page.

If you have any ideas for how this data could be used in your own work or research, please get in touch!

About the Authors

Robbi is a Coastal Earth Observation Scientist from the Digital Earth Australia Program at Geoscience Australia. At Geoscience Australia, Robbi works as part of an interdisciplinary team responsible for developing the first continent-wide maps of Australia's vast intertidal zone, and the recently released Digital Earth Australia Coastlines dataset that maps Australia's dynamic coastline using three decades of satellite imagery.

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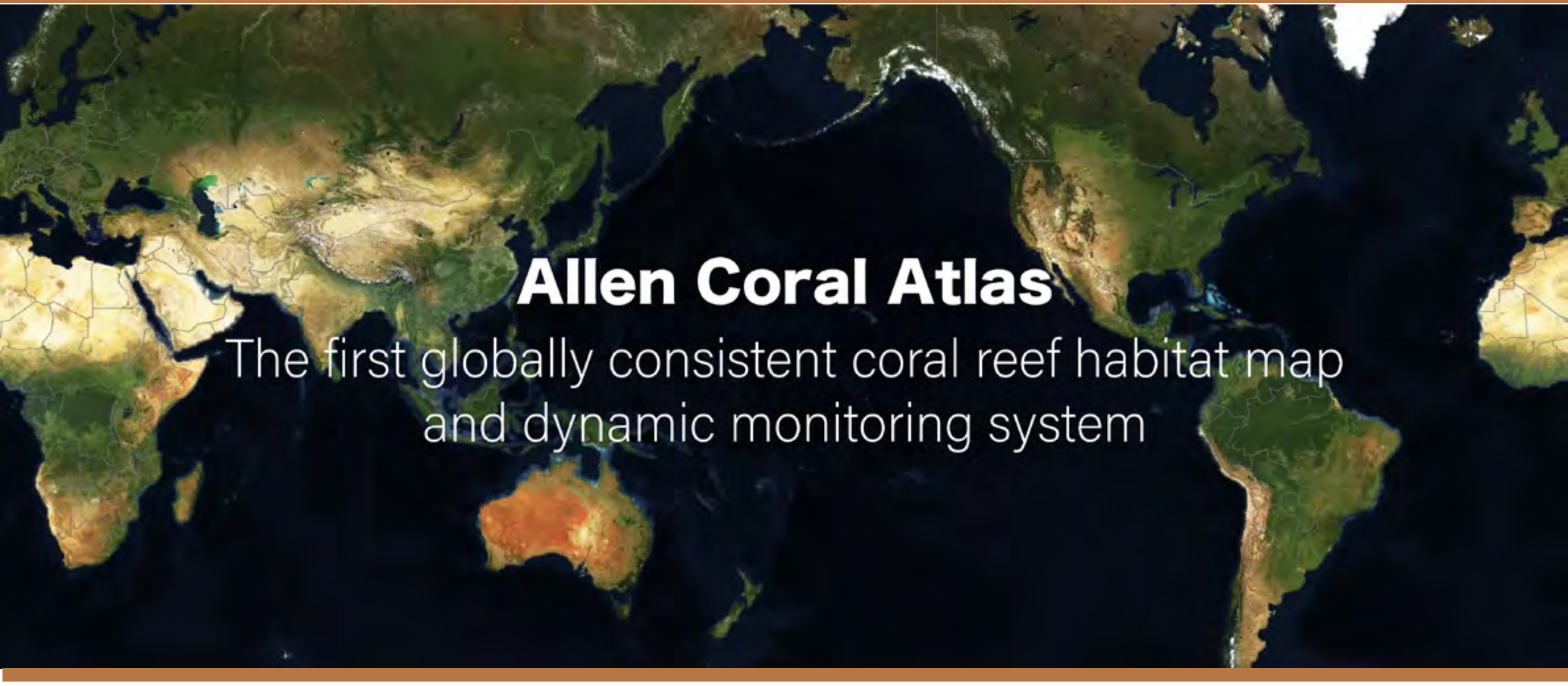
ALLEN CORAL ATLAS:

The first globally consistent coral reef habitat map and dynamic monitoring system



In 2017, the Allen Coral Atlas team set out to build a freely available tool to enhance and support reef science, conservation, management, and policy making. This initiative has involved international collaboration between experts in the fields of reef science, remote sensing and satellite imagery to create a global habitat map and monitoring system for coral reefs. The Allen Coral Atlas was conceived and funded by the late Paul Allen's Vulcan Inc. and is managed by the Arizona State University Center for Global Discovery and Conservation Science. Along with partners from Planet, the University of Queensland Remote Sensing Research Centre, and the National Geographic Society, the Atlas has created the world's first globally-consistent geomorphic and benthic habitat map, and bleaching monitoring system for coral reefs (see https://allencoralatlas.org/).

As part of the partnership, the University of Queensland Remote Sensing Research Centre (UQ RSRC) developed and implemented the habitat mapping process used to define the geomorphic zonation and benthic cover for all shallow-water tropical coral reefs, not affected by depth and turbidity. This global mapping effort uses low-tide Planet Lab satellite image mosaics, Sentinel-2 derived water depth data (Li et al 2021), and reference data (Roelfsema et al 2021a), to train and validate the semi-automated machine learning and object-based clean-up process (Lyons et al 2020). Notably, the mapping process follows a globally applied classification scheme to map all reefs in a consistent manner (Kennedy et al 2021). Through this process, the Atlas has mapped twelve geomorphic habitat classes to a depth of 15m, and six benthic habitat classes to a depth of 10m (with a map accuracy level between 61-90% and 65-91%, respectively).

In order to create the reference data to train the machine learning and object-based analysis, the mapping team at UQ RSRC reached out to over 900 scientists and organisations from around the world, with over 400 teams generously sharing almost 500 of their own datasets to support our mapping efforts. These data were vital in helping the Atlas mapping team independently create over 416,000 reference data segments, where ~1 million geomorphic and ~600,000 benthic reference data points were derived for calibration and validation (Roelfsema et al 2021b). As a result of advanced analytics and the contributing teams' support, the Atlas has consistently mapped more than 253,000 km2 of shallow coral reefs. A full list of teams who have contributed data is available on the Allen Coral Atlas website (see https://allencoralatlas.org/attribution/).

As of this September, the first iteration of the global geomorphic and benthic habitat maps are freely available to explore and download from the Allen Coral Atlas. This innovative platform provides the unique opportunity for anyone, anywhere, to make global comparisons between reefs, whilst also having access to habitat maps for reef features that have never before been mapped. The Allen Coral Atlas also houses the world's first satellite-based global

coral reef monitoring system. Launched in May, the system includes bleaching and turbidity components which both analyse time series archives of Sentinel-2 imagery. The bleaching detection system identifies the brightening of corals by analysing the spectral reflectance of satellite imagery for our 'coral/algae' defined areas, which coincide with a "Bleaching Warning" from the National Oceanic and Atmospheric Administration Coral Reef Watch. With the global reef habitat maps and monitoring system, the Atlas provides a full suite of invaluable tools for reef management and conservation.

The Allen Coral Atlas has already had an enormous positive impact on reef conservation around the world, helping researchers, conservationists, and decision-makers achieve their goals, including the proposal of new marine protected areas, informing disaster risk assessments, and reef restoration prioritisation.

Through global collaboration and cutting-edge innovation, the Allen Coral Atlas has become a shared resource with the coral reef community, as we all work towards a common goal - to save the reefs.

Instagram: **@AllenCoralAtlas**
Twitter: **@AllenCoralAtlas**
LinkedIn: **Allen Coral Atlas**
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Figure 1. *SEQ Figure * ARABIC 1. Satellite image of the French Polynesia islands Taha'a and Raiatea, overlaid with the Allen Coral Atlas' geomorphic (left side) and benthic habitat (right side) maps. Colours represent different classifications. You can explore these two islands and the maps in more detail via this Atlas URL: https://allencoralatlas.org/atlas/#9.71/-16.7490/-151.4395*

PROJECT LEADERS:

Greg Asner leads the team at the Arizona State University's Center for Global Discovery and Conservation Science, which is developing the dynamic reef monitoring system along with implementing strategy, innovation, and website engineering for the Allen Coral Atlas.

Chris Roelfsema leads the University of Queensland's Remote Sensing Researching Centre mapping team, creating the benthic and geomorphic habitat maps, and leading field verification.

Brianna Bambic leads the National Geographic Society team, who heads the field engagement and outreach for the Allen Coral Atlas.

Andrew Zolli oversees the Sustainability and Global Impact initiatives at Planet, who provide the pre-processed high-resolution global satellite imagery.

About the Author

I have always been fascinated by the world's unique fauna and flora. My curiosity for nature led me to complete a Bachelor of Science majoring in zoology and marine science (with Honours in geographical science), at the University of Queensland, Australia. My Honours research looked at the effects of oceanographic parameters on the benthic habitat of coral reefs in the Great Barrier Reef and I was also awarded a scholarship to conduct research at Heron Island reef. Upon completing my Honours research, I joined the Allen Coral Atlas team and I feel incredibly privileged to work on this international project, developing this powerful new tool to help protect and preserve the world's coral reefs.

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Additional information for your reference

Vulcan Inc.: https://vulcan.com/
ASU Centre for Global Discovery and Conservation Science: https://gdcs.asu.edu/
UQ Remote Sensing Research Centre: https://www.rsrc.org.au/
Planet Labs: https://www.planet.com/
The National Geographical Society: https://www.nationalgeographic.org/
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PLASTIC LITTER PROJECTS:

Dedicated experiments for the detection of floating marine plastic litter

Figure 1. *HDPE 28 m diameter target during construction showing the white HDPE mesh sheets.*

Marine Litter, and plastic litter in particular, is a global problem affecting the world's oceans. In order to tackle this pressing environmental issue, an in depth understanding of the sources, pathways, drift and circulation, accumulation zones, and general fate of marine litter is necessary. The closing of the knowledge gap that exists between the estimated amounts of plastic that reach the ocean annually and the quantities that we find in the environment, either floating on the sea surface, sunk on the ocean floor, or beached on coasts, is also of significant importance. To achieve these objectives, state of the art techniques are needed for the detection and quantification of floating marine plastics, with remote sensing being a particularly useful tool for the continuous monitoring of large areas. As the scientific community works towards the specification of purpose-built sensors for the monitoring of marine litter, there is a direct need for marine debris indicators for the detection, classification, quantification, and tracking of marine litter.

Towards these goals, the Marine Remote Sensing Group (MRSG) in the University of the Aegean (UoA) in Lesvos, Greece, initiated the Plastic Litter Projects (PLP) http://plp.aegean.gr/, with the objective to design, develop, construct and deploy at sea artificial targets that effectively simulate floating marine plastic litter. The PLP's scope is:

- to explore the feasibility of detecting floating marine plastic litter in the aquatic environment using the open access Sentinel-2 mission (along with other satellite platforms) and Unoccupied Aerial Systems (UAS),
- to extract meaningful spectral measurements in near-real scenarios, creating an online open-access floating marine litter spectral repository and
- to simulate the coarse satellite pixel using the fine UAS resolution.

The first PLP was conducted in 2018 (PLP2018) as an innovative exploratory application of open-access satellite imagery and UAS data for the remote detection of floating marine plastics in coastal waters. Three large artificial 10×10 m plastic targets were designed and constructed, matching the Sentinel-2 RGB and NIR bands spatial resolution. We effectively produced 12 Sentinel-2 10x10 m pixels, extracting floating marine litter spectral information. During

Figure 2. *UAS image of deployment area showing HDPE mesh and wooden targets, dated: 21/06/2021.*

the second PLP (PLP2019), which was part of the European Space Agency (ESA) funded project “EO tracking of marine debris in the Mediterranean Sea from public satellites”, 10 smaller area targets were constructed in order to examine the limitations of detection using Sentinel-2 multispectral data. Since 2020, the University of the Aegean through the MRSG is leading the consortium of the “Plastic Litter Project - Detection and monitoring of artificial plastic targets with satellite imagery and UAV”, under the Discovery Element of the ESA’s Basic Activities. In PLP2020, we worked towards the creation of a reference target for the scientific community while extending the deployment duration in real conditions with the construction of semi-permanent targets. We developed several prototype targets using marine litter collected during beach cleanings and reference materials acting as effective floating marine plastic litter proxies.

In PLP2021 we constructed a large, circular, 28 m diameter, long-term deployment, reference material target. The reference material of choice was a white, high-density polyethylene (HDPE) mesh. The material was chosen by the project consortium from among several candidates through investigation of their properties in order to meet a set of specifications and requirements for it to be considered a representative reference material (primarily: type of material, colour, coverage, robustness, ease of use, environmental safety). The target consisted of a 28 m diameter HDPE pipe ring (made up of 4, 22 m long HDPE pipes connected together using pressure fittings), with sheets of the white HDPE mesh attached to the ring using 5 mm diameter white nylon rope. In addition to the reference target, we constructed a large-area wooden target made up of 350, 4 m long wooden planks, simulating natural floating debris. Both targets covered up an area of more than 600 m^2. We chose to construct such large-area targets so that we could acquire a full 10x10 m Sentinel-2 pixel, containing only the target materials regardless of target orientation in the satellite image pixel grid, essentially ensuring that we extract a pure signature from both target materials. Currently, we have combined the two target materials into a single target, in order to acquire spectral measurements of a mixed material target, simulating near-real conditions.

To date, we have performed 19 data acquisitions of the targets, including 19 Sentinel-2 images, very high resolution UAS images with accompanying RTK GPS measurements, *in situ* spectrometer measurements in the range of 400 to 1000 nm, 3 UAS hyperspectral data acquisitions in the same spectral range, and ancillary metadata including wind speed and direction, light intensity, and empirical measurement of water turbidity using a Secchi disk. The spectral signatures of the targets and their confidence level are under investigation, with initial analysis of the spectral measurements and data processing showing very promising results. More on http://plp.aegean.gr/

Figure 3. *Sentinel-2 true colour RGB of the deployment area showing HDPE mesh and wooden targets, date:21/06/2021.*

About the Authors

Dr. Konstantinos Topouzelis is an Assistant Professor in the Department of Marine Sciences, University of the Aegean and he leads the Marine Remote Sensing Group. His main research interest is the analysis of remote sensing datasets, including satellite and aerial images, for marine and coastal applications. His expertise includes the automatic detection of oceanographic phenomena, Object-Based Image Analysis, image processing algorithms, and coastal mapping. He is an author of more than 50 refereed papers in international scientific journals and books, an editorial board member of several scientific journals, and a principal investigator in international research projects.

Dimitris Papageorgiou is an engineer and environmental scientist specializing in remote sensing and marine plastic pollution. His main research interests include the remote detection of floating marine litter using a variety of remote sensing platforms. He is currently working as a research associate in the Marine Remote Sensing Group in the University of the Aegean, where he is responsible for the design, development, realization and data processing of the Plastic Litter Projects. He holds an MSc in Structural Engineering from the University of Newcastle upon Tyne, an MSc in Environment and Sustainable development studies from the National Technical University of Athens, and an MSc in Integrated Coastal Zone Management from the University of the Aegean.

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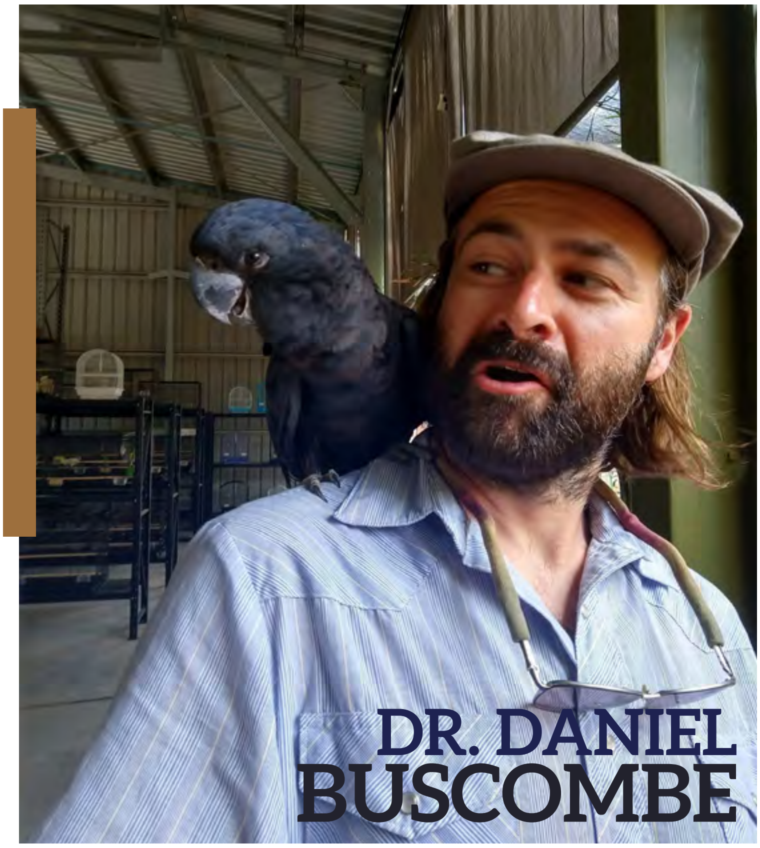
Research Interests and Expertise:
coastal and fluvial geomorphology, sedimentology, sediment transport; coastal data science; machine learning; data assimilation; remote sensing computational modeling



I am a geoscientist with a specialism in coastal geomorphology, and some expertise in researching and implementing methods to extract useful information from geoscientific imagery. I carry out this work in support of research into coastal and fluvial processes, hazards, and ecosystems. Currently I am a coastal data scientist for the U.S. Geological Survey in Santa Cruz, California.

I have a PhD (2008) in coastal geomorphology from Plymouth University, UK. I completed two postdocs at the University of California Santa Cruz, and Plymouth University, from 2008 to 2012. I worked as a Research Geologist for the US Geological Survey Grand Canyon Monitoring and Research Center in Flagstaff, Arizona (2012-16), and have been on many scientific river trips. Later, I was a Research Professor at Northern Arizona University (2016-20). Outside of work I love wild swimming, and hiking in mountains and canyons, which is why I moved to the American West from my native UK. I also play guitar and bass, and working from home during the pandemic, I have started to attempt to compose and record songs.I live with my wife and dog among the redwoods of coastal California.

Can you tell us how you started using remote sensing to study coastal environments? Who or what inspired you to become a scientist in this field?

It depends on what counts as remote sensing. If defined as 'measurement without touching', I think most of my work would count, even though I'm only just starting to work with imagery acquired from satellites. Most of my remote sensing experience has, in fact, been below water. I did my PhD on the dynamics of gravel beaches, and I wanted to understand how gravel moved under near-breaking and breaking waves, so I cobbled together (forgive the pun) an underwater video camera system and after my first foray into statistical image analysis, and ended up publishing the work. Nowadays, I work mostly with aerial and satellite imagery at the intersection of machine learning and photogrammetry, but for many years I used acoustic remote sensing using sonar in rivers to map sediments, which was at the intersection of machine learning and hydrography.

As to how I got into remote sensing of coastal environments, I've always loved natural – especially coastal - environments and especially natural patterns. I have a strong creative side, enjoying music and art as much as science, and I'm particularly drawn to understanding how natural patterns arise. In particular, sedimentary patterns, which are most fascinating and most complex at the shoreline! These days, I'm also strongly motivated to work at the coast owing to the particular vulnerability of coastal dwelling people to the effects of the climate crisis.

I consider myself very lucky – I knew early in my undergraduate at Lancaster University that I wanted to be a coastal scientist, and had a series of great mentors who helped me realize that ambition - thanks Dr Suzana Ilic (my undergraduate advisor), Prof. Gerd Masselink (my PhD advisor), and later Dr Dave Rubin and Dr Jessie Lacy at the USGS who guided me through my first postdoc, and Prof. Dan Conley and Dr Alex Nimmo-Smith who guided me through my second.

Can you tell us about your current research? In your own opinion, why is your research important?

Recently I have been building research infrastructure to help us apply ML tools to study coastal change at regional and continental scales. Historically, we're much better at understanding and forecasting processes at small scale and short time periods. We're also much better at measuring elevation changes, but not as good as detecting other forms of important change that don't necessarily have a large elevation component, like in salt marshes and other sensitive ecosystems. We know relatively little about how antecedent processes affect changes driven by storms and hurricanes, and how coastal environments recover in-between major events. We know relatively little about geological and ecological controls on contemporary physical processes, and vice-versa.

Data-driven methods with remotely sensed data are absolutely what we need to understand linkages across scales, by combining small-scale and large-scale observations, observations of topographic and non-topographic change, and combining quantitative with qualitative information that provides important context.

To that end, for the past 16 months, I've been building and testing end-to-end systems for image labeling, and ML model building and application to photographic imagery of coasts. Myself and my colleagues are building and adapting software for generic image segmentation, classification, object detection, etc, mostly from Deep Learning, and applying them to numerous targets in aerial, close-range, and satellite imagery.

Examples include masking water in imagery, detecting sand and buildings, identifying the shoreline, vegetation and habitat mapping, to name a few. We have a lot to learn from systematic, automated identification and quantification of coastal objects, landcovers, landforms, habitats, settlements and infrastructure at higher-and-higher resolution and coverage. Then carrying out automated change detection to help facilitate the process of scientific discovery.

I currently split my time between:

a) coastal data science projects designed to create and evaluate data labeling tools, generate large labeled datasets using collaborative labeling and community science, and develop operational models for classification and segmentation of SfM-derived data products (DEMs, orthomosaics, and point clouds). This work is supported by the USGS Hurricane Florence Supplemental or FloSup Project, and the USGS Remote Sensing Coastal Change Project.

b) research into mapping coastal sediments for all US gulf and east coast environments from a variety of platforms from cell phones to satellites, including a collaborative project funded by the Office of Naval Research National Oceanography Partnership Program, and collaboration with my partners in the SandSnap beach grain size citizen science project (a collaboration with the US Army Corps of Engineers and others - officially launched soon – watch this space!)

c) research into estimating and forecasting shoreline changes using satellite imagery

d) exploring around with new codes and techniques from the fascinating world of machine vision, machine learning, and other computer science subdisciplines. I never underestimate the skills you obtain in just playing with other people's code constantly trying to understand it and make it work. It's also a good way to stay ahead of the curve (in theory, anyway!)

What inspired you to work in this field? What do you consider your greatest achievement? Can you tell us a challenge that you faced in your career and what did you learn?

I'm only 40 now so I hoping for many more in the future, but I consider my career highlight to date is the role I played in supporting the Grand Canyon Adaptive Management Program, during my years as a research scientist at Grand Canyon Monitoring and Research Center (2012 - 2016) and later as a NAU professor (2016 - 2020). During that time, I worked in a team that helped solve two important applied science questions: 1) how much sand is there on the bed of the Colorado River in the Grand Canyon?, and 2) how much sand moves as bedload in Colorado River in Grand Canyon, as opposed to suspended in the flow?

Both of these questions are fundamental to the management of the river, and directly contribute to the adaptive management of Glen Canyon Dam that controls river flow. Making annual estimates of the sediment makeup of the riverbed, and quantifying the relative importance of bedload and suspended load, have now become an established practice and are part of the ongoing management of the river, for multi stakeholder use.

Coming from a coastal background, I quickly had to teach myself ML and swath acoustics to make progress with these topics! Working on an applied river science question while responding to the constant feedback from policymakers was definitely a rewarding experience, and seeing policy decisions made partly on insight you've obtained is satisfying. Fieldwork at the bottom of the Grand Canyon was also a life-changing experience!

I'm also proud of having mapped the sediments at the bottom of the Grand Canyon in Arizona, and also the sediments at the bottom of the Delgada Canyon, offshore of the King Range in California, both times using sound waves from a moving vessel, using an algorithm I invented. If you had told me 10 years ago I was going to do that, I would not have believed you!

> **"I have a strong creative side, enjoying music and art as much as science, and I'm particularly drawn to understanding how natural patterns arise."**

What are the most important areas of research you'd like to see tackled over the next ten years?

We're only just beginning to grapple with the decades of satellite data we now have for coastal environments, which are thin and complex with strong gradients in every conceivable environmental variable, and historically hard to quantify change with relatively coarse resolution imagery from satellites. With the advent of smallsats, we are only now beginning to be able to image everywhere from space at a requisite scale for capturing the more subtle and important changes to coastal environments. So the next 10 years will continue to be about integrating spatially rich and temporally rich data to understand processes at larger and larger scales. Yes, SAR and other new imaging technology enables us to image at night and in bad weather, and yes, there will be better and better ML model architectures that will enable us to estimate more quantities more reliably from imagery and data of every type.

However, measurement technological advances will only get us so far. That just gets us lots of data, but we don't yet have good ways to distill information from Big Data, to help us as scientists interpret efficiently and finally obtain new knowledge. We need to develop automated or semi-automated frameworks that properly distill and visualize all available heterogeneous information about a location, process, event, phenomenon of interest. So scientists can make better interpretations of data to draw conclusions from. Such an 'Oracle' could conceivably do a number of things; for example, distill the knowledge from literature in a particular domain, helping researchers identify problems with data through consistency checks (checking against established theory and other datasets in the domain); rank data by relevance, quality, and other attributes that could be defined in bespoke ways; recommend additional data sources that a researcher may not know; identify important context to change from qualitative and other sources; search relevant literature; and generally act as a 'research buddy' for complex problems with unmanageably large or complicated datasets.

Such a tool would ideally incorporate both 'hard data' from instrumental records, and 'soft data' from qualitative sources, and from ML models that only weakly predict phenomena. Transitioning from a 'hard-evidence-only' to a 'lines of evidence' approach that may assimilate qualitative and quantitative information over a range of scales, and it may require developing ML and data assimilation models frameworks that help researchers grapple with disparate lines of evidential data. If today's revolution is Big Data, then tomorrow's is Knowledge Distillation. Otherwise, in the background of exponential growth in published scholarly works, we will never see the wood for the proverbial trees.

What are some of the biggest challenges you face as a scientist in your field? Are there any common misconceptions about this area of research?

There is a widespread misconception that data science is mostly about developing or selecting the right model. But in most applied cases, my colleagues and I have found that it's more about the data than the model. A lot of applied scientists engaged with ML appear to want to do the 'model work' more than the 'data work'. However, as a data scientist, I am actually a 'data modeler', and I am concerned primarily with the end-to-end or 'cradle-to-grave' systems that facilitate acquiring the data, cleaning, labeling and wrangling the data into ML-ready formats, building and evaluating models, then iterating on this process with more and more data. After doing this now for a few years on larger and larger datasets, I'm slowly discovering that data science is mostly data labeling, data wrangling, and creative ways to transform data to be amenable to specific ML architectures. Good ML models are never finished; instead, they continue to improve with more data. That data is often qualitative, or a mixture of quantitative and qualitative, and we're just beginning to develop strategies to deal with it. Many of my short-term ambitions involve developing quicker and more efficient ways to label data and train and evaluate 'boilerplate', 'vanilla', or 'generic' models to provide more and more useful and sophisticated information with faster and faster turnaround.

However,"Garbage in, garbage out" is real; data creation, curation, cleaning, labeling, and evaluating are the aspects of the job that should take the most amount of time and effort. Many ML models that classify and segment and find objects in Earth science data essentially do the same things for similar reasons on good quality data. The focus should be on creating large and good quality datasets that we can teach machines to find, categorize and quantify everything of conceivable interest. A criticism that could be levied at that standpoint is that supervised ML will one day be superseded by unsupervised ML. While that may be true, we don't need to wait, and we'll still need labeled data to know how good our unsupervised models will be.

> **I'm also proud of having mapped the sediments at the bottom of the Grand Canyon in Arizona, and also the sediments at the bottom of the Delgada Canyon, offshore of theKing Range in California, both times using sound waves from a moving vessel, using an algorithm I invented.**

What lessons or tips would you like to share with students and young researchers who are just starting their careers in your field?

It's ok to change, to evolve, and to have false-starts. I have already had many different jobs, in different countries, in a varied career, and mentored a few students, and I am only 40. I was never very interested in computers until I realized I really needed to master them to do the research of interest to me. And I was never exposed to much mathematics and statistics at university, so I had to acquire those skills myself. I've spent my career teaching myself, and have had the privilege to do so, and to influence many others, directly and indirectly. I got into data science long before I knew what that even was. In 2007 I published my first paper describing how to turn one form of data (images of sediment) into useful information (grain size), and I've never looked back! But I never really intended any of it, and I love that.

Don't be typecast; change, do interesting stuff with nice people. And if that changes over time; great! Change is good; be agile, and open to different ideas.

Define yourself by both what you study, as well as how you study. Ethics are important. Embrace open-source, openness, reproducibility, and transparency. Challenge norms, and get involved in reform of scientific publishing; peer-review only works if we all take an interest.

Don't compare yourself to others. Nobody has everything figured out. Trust individual thought, but not herd mentality, and be protective of your time – you're a scientist, know your value. Lastly, find a good mentor. Someone who you can talk to formally and informally; they can change your life. And, in turn, become a mentor to someone else.

“Don't be typecast; change, do interesting stuff with nice people. And if that changes over time; great! Change is good; be agile, and open to different ideas.”

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Current Position - Affiliation:
Senior Scientist - Leibniz Centre for Tropical Marine Research, Bremen, Germany

Research Interests and Expertise:
UAS platforms and SfM-MVS methods to study coastal environment and coastal changes

Elisa Casella is a Senior Scientist at the Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany. She is an environmental engineer with a dual Italian-French PhD in Methods for Environmental Monitoring and Sciences de l'Univers. After her PhD, she did a postdoc at the University of Genoa and CIMA Research Foundation (Italy) focusing on the study of the regional physical oceanography in the North-West Mediterranean using numerical models. In 2013, she co-founded an Academic SpinOff company and she took part in a project aiming at developing innovative methods to survey and monitor coastal environments using Unoccupied Aircraft Systems (UAS) and coastal numerical models. Her current studies focus on environmental changes in coastal environments using UAS and Structure from Motion - Multi-View Stereo reconstruction method to gather high-resolution information on coastal processes. She is the author of 20 scientific papers and several conference communications. Her work has been featured on media outlets, including newspapers, radio, and TV shows. She took part in 7 research campaigns in different countries (e.g. Ghana, Cape Verde, Bahamas, Curacao, French Polynesia, Fiji) which allowed her to gather also experience in planning and performing efficient and law-compliant field activity where UAS is involved.

Can you tell us how you started using remote sensing to study coastal environments? Who or what inspired you to become a scientist in this field?

In 2013 I was granted a research fellowship within the "MIRAMar" (Innovative Methodologies for Coastal Environmental Monitoring and Analysis) project funded by the European Social Fund and it is within that project that I started to use UASs. That was before DJI conquered the drone market, therefore the choice between UAS types was rather limited. With the Academic SpinOff company I co-founded, we bought a professional Mikrokopter Okto XL. Operating it was not as easy as it is for many consumer-grade drones on the market today. Together with the project partners, we managed to perform several UAS surveys. First, we tested the performance of UAS and Structure from Motion - Multi-View Stereo reconstruction method (SfM-MVS) on sandy beach environments, then we started to monitor short-term beach changes. The work not only led to several scientific publications but we also gathered many contacts with other scientists working on other coastal environments. From that moment, I never left this exciting field that brought me to work in many different coastal environments (e.g. beaches, coral reefs, mangroves) in many interesting countries and with many enthusiastic scientists!

Can you tell us about your current research? In your own opinion, why is your research important?

My current research deals with the study of tropical coastal environments (e.g. coral reefs, mangroves, paleo landscapes) using UASs and SfM-MVS to unravel information that was not easily accessible before with traditional survey methods. I believe that UAS and SfM-MVS democratised aerial data collection and fostered the development of high-resolution 3D models of coastal environments. This can help, in turn, the observation and understanding of coastal processes and changes. This third-generation source of remote sensing data is revolutionizing many fields where a high-resolution aerial view can provide important information in the study of ecosystems. This point is very important. We just started to discover the power of this new source of data and if we manage it in a FAIR way (e.g. geonadir.com portal), who knows what scientific boundaries we will be able to push forward...

> **"From that moment, I never left this exciting field that brought me to work in many different coastal environments (e.g. beaches, coral reefs, mangroves) in many interesting countries and with many enthusiastic scientists!"**

What is the most interesting project (or research) that you've undertaken so far? Can you share with us some of your most memorable experiences or some of what you consider as the highlights of your career?

I consider myself very fortunate since I had the opportunity of working on many interesting projects in different countries. Together with my colleagues from the University of Ghana and the University of Bremen (Germany), I performed a survey in a region of Ghana which is subject to dramatic coastal erosion. The high-resolution data collected by a consumer-grade drone allowed a detailed definition of the coastal retreat that is now monitored by my colleagues at the University of Ghana. In French Polynesia, I had the opportunity of working with experts on coral reef ecology from the CRIOBE research station. Using aerial photos, we managed to reconstruct one of the first centimetre-resolution 3D models (using this method) of a portion of the inner lagoon in Moorea. This in turn was used by the École des Hautes Études in France to expand the high-resolution information that we

collected on a limited area to the whole coral reef of the island of Moorea using an artificial neural network. In Fiji, with the University of the South Pacific and the Mangrove Ecology working group (ZMT), I surveyed a portion of a mangrove forest to assess its status combining high-resolution satellite imagery, drone-based imagery and field-based measurements. In the Bahamas I was part of a team of scientists from the University of Bremen and Columbia University that investigated the impact and the power of storms that happened 125.000 years ago (a past period called the Last Interglacial) when the sea level was 5-10 meters higher than today. Here drones and SfM-MVS were used to reconstruct the 3D model of large boulders and calculate their volume which was then used in numerical models to study the energy necessary to move the giant boulders.

Now, I am looking forward to the next project with the Reef Systems working group (ZMT) which integrates knowledge on coral reef ecology, geosciences, and environmental economics to investigate if backreefs' geomorphology is a proxy for their capacity to provide food fishes, and the capacity of adjacent barrier reefs to protect shorelines. This will bring me together with the project partners in the Maldives and I am looking forward to it!

What are the most important areas of research you'd like to see tackled over the next ten years?

I believe that the information we are using today from drone-derived data is very minimal therefore I would like to see more investigation into the potential use of this information in all fields. It is important to draw the attention of ecologists, biologists, geologists and data scientists to the dataset we can collect with drones and the peculiarities of these datasets. New methods to observe the environment can bring new knowledge on natural systems which in turn can help to define better management plans to protect our planet.

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In the Bahamas I was part of a team of scientists from the University of Bremen and Columbia University that investigated the impact and the power of storms that happened 125.000 years ago (a past period called the Last Interglacial) when the sea level was 5-10 meters higher than today.

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What are some of the biggest challenges you face as a scientist in your field? Are there any common misconceptions about this area of research?

I saw many times a misconception about the use of drones: it is seen as something that does not need to be taken into account during the project planning. Also, some scientists/managers abandon the idea of using drones once they are aware of the existence of drone regulations. Drone regulations have hindered some scientific uses of drones in the recent past, but I can see that things are changing. As an example, we now have in the European Union a unified regulation that clarified many aspects and unified the rules among all EU countries. Based on the type of UAS and the category of the UAS operations, risks are now better defined and less work is asked of UAS operators to ensure compliance with the regulation. As with any new technology, we are facing initial challenges, but the potential of the information that we can unravel using drones is worth the effort.

What lessons or tips would you like to share with students and young researchers who are just starting their careers in your field?

Remote Sensing and Geomatics are fields that open many doors and not only in academia: the industry, commercial, and public sectors are very interested in hiring people with skills in these fields. Many different works and studies are conducted under these disciplines, therefore you will not get bored! Within remote digital surveying, the SfM-MVS method is a very significant advance that simplifies data collection and the development of high-resolution 3D models. Given the simplicity of using SfM-MVS software, my advice is to be a more critical user of the method, to validate with independent measurement the dataset that you collect/produce and to analyse processes at a scale consistent with the accuracy of your dataset regardless of the resolution of your data. Finally, a tip to drone beginners, develop your piloting skills and try not to rely completely on automated flight aids. This can avoid unpleasant moments and allows you to enjoy your fieldwork!

“Remote Sensing and Geomatics are fields that open many doors and not only in academia: the industry, commercial, and public sectors are very interested in hiring people with skills in these fields.”

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Current Position - Affiliation:
Project Manager at VITO

Research Interests and Expertise:
Remote sensing, water quality, marine plastics

ELS KNAEPS

I graduated from the University of Leuven (BE) and Purdue (US) in 2005. I have a masters degree in geography and a second masters degree in GIS and remote sensing. I have 15 years of experience in remote sensing image processing for water quality, biodiversity and coastal management. Today, I coordinate several research and commercial projects and lead a team of researchers focusing on water and coastal applications.

Can you tell us how you started using remote sensing to study coastal environments? Who or what inspired you to become a scientist in this field?

From a very young age, I was fascinated by space technology and genuinely loved being outside enjoying nature. During my masters in Physical Geography, I loved learning about the origin and evolution of landforms and landscapes. Afterwards I got the opportunity to join the advanced masters program in Earth Observation where I could combine my interests in space technology and geomorphology/geography.

Can you tell us about your current research? In your own opinion, why is your research important?

My research mainly focuses on the monitoring of water quality with drones and satellites. Drones and satellites allow us to look into various aspects of water quality including the monitoring of suspended sediments and algae blooms as well as the detection of marine plastic litter and oil. We are continuously looking into the latest technologies to tackle water quality problems. These can be new sensors or new ways of processing the data. I believe remote sensing can play an important role in the digitalisation of this domain and allow us to make better informed decisions in the end.

> **“Although most of my work is desktop work and I am spending many hours behind my desk, I do love going back in the field from time to time.”**

What is the most interesting project (or research) that you've undertaken so far? Can you share with us some of your most memorable experiences or some of what you consider as the highlights of your career?

Although most of my work is desktop work and I am spending many hours behind my desk, I do love going back in the field from time to time. Most of my memorable experiences are linked to the field and flight campaigns we organized at VITO. A combined flight and field campaign on water takes many hours of preparation and flexibility from the people involved. Hence, it is very satisfying when the campaigns are successful and everything goes as planned. It is also a great way to get to know your colleagues!

What are the most important areas of research you'd like to see tackled over the next ten years?

One of the research areas I focus on is marine plastic litter. Research on remote sensing of marine litter is in its early stages. It is very exciting to be part of this and try to contribute to a better understanding of the marine litter problem. Although in its early stages, you see the technologies and research in this area progressing fast.

> “I guess it is good to have some perseverance and not to panic when something goes wrong.”

What are some of the biggest challenges you face as a scientist in your field? Are there any common misconceptions about this area of research?

The biggest challenge for me is probably convincing new stakeholders to use the new technologies. Most of our stakeholders are used to deriving water quality information from field observations. Remote sensing is a completely new technology for most of them and is very complementary to the field observation being done. However, it takes some perseverance to convince them of the benefits.

What lessons or tips would you like to share with students and young researchers who are just starting their careers in your field?

I guess it is good to have some perseverance and not to panic when something goes wrong. This is true for the science, the field campaigns, and the time when you are convincing your stakeholders. I believe those are the moments you learn the most.

____init____:
PYTHONIC MAGIC FOR COASTAL SCIENCE

Python is the fastest growing programming language out there. Far from being the best or the only one heping coastal scientists with their analysis, it nevertheless hosts some of the most useful and free resources coastal peeps can be looking for, especially when these are Open Source and community-grown.

In this Special Feature are some of the most useful Open Source Python code to help solve coastal remote sensing issues that came up during a recent Twitter thread amongst coastal scientists around the globe. These are obviously only some of the many resources that exist in the coastal Python universe. Still, this list highlights how much effort the coastal science community has put into creating Open Source software that benefits everyone who wants to use it, for free. This is love!

These resources are freely hosted in GitHub at ***www.github.com***. Head to GitHub and search for their names. Remember, if you use these resources, you should always give credit to the authors by citing their work using the (usually) supplied accompanying scientific publication or suggested citation. The descriptions reported here are adapted from the README files provided in their GitHub repo or associated websites.

Enjoy!

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Sandpyper (Nicolas Pucino)
This package helps with profile-based volumetric and behavioural analysis of large numbers of sandy beach digital surface models and orthophotos, normally acquired during monitoring programs using Unoccupied Aerial Vehicles and Structure from Motion algorithm.

CoastSat (Kilian Vos)
CoastSat is an open-source software toolkit written in Python that enables users to obtain a time series of shoreline positions at any coastline worldwide from 30+ years (and growing) of publicly available satellite imagery.

InletTracker (Valentin Heimhuber)
InletTracker is a Google Earth Engine enabled open source Python software package that first uses a novel least cost path finding approach to trace inlet channels along and across the berm (i.e., barrier, bar), and then analyses the resulting spectral transects to infer whether an inlet is open or closed. InletTracker is built on top of the imagery download and pre-processing functionality of the CoastSat toolbox.

dea-tools (Robbi Bishop-Taylor, Claire Krause, Bex Dunn and many others from Geoscience Australia)
This is a repo holding Python functions and algorithms developed to assist in analysing the open data cube Digital Earth Australia (DEA) (e.g. loading data, plotting, spatial analysis, machine learning). Included in this toolset are some python functions for conducting coastal analyses on DEA Coastlines data (see spotlight article in this Newsletter).

dash-doodler (Daniel Buscombe)
dash-doodler is a "human in the loop" web application for image segmentation (designed to work with natural environments) which basically allows the user to interactively sparsely annotate images by literally doodling over classes of interest (water, sand, vegetation, etc…) with a mouse/stylus. Then, the application does the rest, using a model to 'auto-complete' all the pixels the user didn't label, creating precise pixel-level labelled images useful as training dataset for further deep learning model development.

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Coastal-Image-Labeler (UNCG-DAISY, Evan B. Goldstein and others)
The Coastal Image Labeler is focused on easily accommodating multiple users labeling the same images to ensure consensus for (potential ambiguous) discipline-specific labels. This tool allows us to crowdsource the development of a labeled image dataset that is relevant for coastal scientists. In this case, labels are applied at the image level (image classification) and not at the pixel level (semantic segmentation), there is dash-doodler for pixel-level fun!

SediNet (Daniel Buscombe)
SediNet is a configurable machine-learning framework for estimating either (or both) continuous and categorical variables from a photographic image of clastic sediment.

segmentation_zoo (Daniel Buscombe & Evan Goldstein)
Segmentation Zoo is a toolbox to segment imagery with a variety of supervised deep-learning models for image segmentation. Current work is focused on building a family of UNet models. Zoo is designed to be a "one stop shop" for image segmentation on N-D imagery (i.e. any number of coincident bands). It is tailored to Earth Observation and aerial remote sensing imagery.

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py-wave-runup (Chris Leaman)
This is a Python module which makes it easy for coastal engineers and scientists to test and use various empirical wave runup models which have been published in literature.is a list of function to compute empirical wave runup models implemented in Python for coastal engineers and scientists.

awesome-coastal (Chris Leaman)
This is a list of resources which coastal engineers and scientists might find useful. This list brings together useful datasets, tools and scripts that people might not have been aware of.

oyster_net (Patrick Gray)
This repository has the code needed to go along with the Remote Sensing in Ecology and Conservation paper "Deep learning for coastal resource conservation: automating detection of shellfish reefs." . This work uses Mask R-CNN for detecting oyster reefs in aerial drone imagery and in this repo you will find all the steps involved in building and training a successful Mask R-CNN semantic segmentation model.

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py_sfm_depth (James Dietrich)
This Python script is designed to perform an iterative, multi-camera refraction correction on Structure from Motion point clouds. This is used to produce bathymetric datasets with accuracies of ~0.02% of the flying height and precisions of ~0.1% of the flying height under ideal conditions (e.g. clear water) and provides an additional tool for collecting high-resolution bathymetric datasets for a variety of river, coastal, and estuary systems.

CoastalImageLib (Maile McCann)
CoastalImageLib is a Python library that produces georectified images as well as common coastal image products intended for quantitative analysis of coastal environments. This library contains functions to georectify and merge multiple oblique camera views, produce statistical image products for a given set of images, as well create subsampled pixel instruments for use in bathymetric inversion, surface current, run-up calculations, and other quantitative analyses. Additionally, this library contains support functions to format camera intrinsic values from various input file formats, convert extrinsic values from geographical to user defined local coordinates, and functions to interface with Argus software such as the Argus tower in Duck, NC and mini- Argus stations throughout the U.S.

KEY DATES

10 JANUARY 2022	Deadline fpr Abstracts & Full paper
2 FEBRUARY 2022	Abstract Notification to authors
23 FEBRUARY 2022	Full paper notification to authors
23 MARCH 2022	Deadline for camera ready papers

MS&PHD Scholarships & Fellowships

- **MS or PhD Assistantship in Urban Ecohydrology and Land-Atmosphere Interaction**
  Washington State University Vancouver
  United States
  Deadline: 10 January 2022
  Link

- **PhD position - Impacts of climate and land use change on the hydrological cycle of the Karnali basin in the Himalaya (1.0 FTE)**
  Utrecht University
  Netherlands
  Deadline: 05 January 2022
  Link

- **PhD Position in crop science with focus on forage crops**
  Swedish University of Agricultural Sciences
  Sweden
  Deadline: 31 December 2021
  Link

- **Artificial intelligence approaches to reconstruct changing landscapes with remote sensing**
  Application of Artificial Intelligence to the study of Environmental Risks (AI4ER) Centre for Doctoral Training (CDT)
  University of Cambridge
  Link

- **Ph.D. in Geoinformatics and Remote Sensing**
  Institute of Geography, Faculty of Science Pavol Jozef Šafárik University in Košice
  Slovakia
  Link

- **Ph.D. Fellowship on Deep Learning in Remote Sensing**
  State University of New York College of Environmental Science and Forestry
  New York, United States
  Link

- **6 PhD/PostDoc positions in new center for Machine Learning in Earth Observation (ML4Earth)**
  Technical University of Munich
  Germany
  Star date: 2022
  Link

PostDoc Positions & Job Opportunities

Post-Doctoral Position in LiDAR remote sensing 2021
King Abdullah University of Science and Technology
Saudi Arabia
Deadline: 1 January 2020
Link

Postdoctoral Fellowship and support program at KIT: Young Investigator Group Preparation Program (YIG Prep Pro)
Karlsruhe, Germany
Deadline: 113 February 2020
Link

Post Doctoral Research Assistant (PDRA) - Research Associate
Manchester Metropolitan University
United Kingdom
Deadline: 16 December 2021
Link

Post doctoral researcher in Fluvial Research
School of Engineering, Department of Built Environment, Aalto University
Aalto, Finland
Link

Postdoc in Ocean state imaging
Swiss Federal Institute of Technology & EPFL
Lausanne, Switzerland
Link

Research Associate
Michigan State University
United States
Deadline: 21 December 2021
Link

Tenure Track Assistant Professor in Remote Sensing Applications
Technical University of Munich
Germany
Deadline: 31 January 2022
Link

Research Associate (Department of Architecture)_Geospatial Developer
National University of Singapore
Kent Ridge, Singapore
Link

Research Associate - Marine Ecosystems Remote Sensing
University of Tasmania
Hobart, Australia
Link

Senior Scientific Officer - in-situ observations for the Copernicus Climate Change Service (C3S)
European Centre for Medium-Range Weather Forecasts
Bonn, Germany
Link

Postdoc position in polar climate modelling and remote sensing (0.8 - 1.0 FTE)
Physics, Institute for Marine and Atmospheric research Utrecht (IMAU), Utrech University
Netherlands
Link

upcoming events 2022

15-16 Aug
CLIMATE CHANGE AI SUMMER SCHOOL 2022
Virtual Mode
Deadline: 17 Dec 2021 | Website

summerschools

18-24 Sep
INNSBRUCK SUMMER SCHOOL OF ALPINE RESEARCH 2022
Obergurgl University Center, Obergurgl, Austria
Deadline: 15 Jan 2021 | Website

01-04 Feb
GEO WEEK 2022
Denver, USA
Website

03-04 Feb
JOINT URBAN REMOTE SENSING EVENT - JURSE 2022
Virtual Mode
Website

23-24 May
ICMMT 2022: 16. INTERNATIONAL CONFERENCE ON MOBILE MAPPING TECHNOLOGY
Montreal, Canada
Website

20-25 Jun
8TH INTERNATIONAL CONFERENCE ON CARTOGRAPHY AND GIS
Nessebar, Bulgaria
Website

13-16 Sep
58TH PHOTOGRAMMETRIC WEEK
Stuttgart, Germany
Website

19-22 Sep
EUROCARTO 2022
Vienna, Austria
Website

May the **warmth**, **peace**, & **sincerity**
of this holiday season
fill your **hearts**
as we all look forward
to **better days**.

Please visit our ISPRS SC web page

sc.isprs.org

where you will find more information about Student Consortium, our previous Newsletter issues, SC activities, photo galleries from previous Summer Schools, interesting links etc.

ACKNOWLEDGEMENT

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Let us continue to support and care for each other during this pandemic!

Stay safe, everyone!

Photo: The shallow, clear blue waters off the coast of the Bahamas pictured from the International Space Station by NASA

SPECTRUM