PLANET SCIENCE APPLICATIONS 2019

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Nukuni, Fiji, captured by a Planet Dove satellite
Source: Planet Labs, Inc.

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INTRODUCTION: ABOUT PLANET

Planet is a geospatial enterprise that designs, builds, and operates the world's most capable constellation of Earth-imaging satellites in history.

Founded in 2010 by three NASA scientists, Planet operates more than 150 satellites (Dove/PlanetScope, RapidEye and SkySat), and develops the online software and tools that serves data to users. Planet's constellation of satellites orbit the poles every 90 minutes, capturing imagery over the whole earth landmass, coral atolls and nearshore coastal environment every day.

Decision makers in business, government and academia use Planet's data and machine learning-powered analytics to develop new technologies, power research, and solve our world's toughest challenges. Planet's capabilities are uniquely proven by our space-based constellation and automated image processing pipeline that includes both remote-sensing and machine-learning analytics.

> "Planet's current constellation collects the entire landmass of the earth and its coastal environments every day."

PLANET'S SATELLITES

Doves

SATELLITES	GSD	CAPACITY
120+	3.7 m	200 M km²/day 4 band

RapidEye

SATELLITES	GSD	CAPACITY
5	6.5 m	6 M km²/day 5 band

SkySat

SATELLITES	GSD	CAPACITY
15	0.72 m	400 K km²/day 4 band

SCIENCE AND EDUCATION AT PLANET

Planet has invested in a rigorous, science-first platform, producing an unprecedented volume of absolutely calibrated remote sensing data—approximately 6 Tb per day.

Through our Education and Research Program, we sponsor freemium university access to Dove and RapidEye imagery (up to 10,000 square kilometers per month) for non-commercial research applications. To access this data source, users can apply at go.planet.com/research. As of April, 2019, the Education and Research Program hosts more than 4,000 users across 70 countries and more than 1,000 universities. Since the program launched, on Earth Day, 2017, undergraduates, graduates, faculty and technical staff have used Planet data to publish more than 70 peer-reviewed articles, and have presented scores of talks and research seminars at academic conferences.

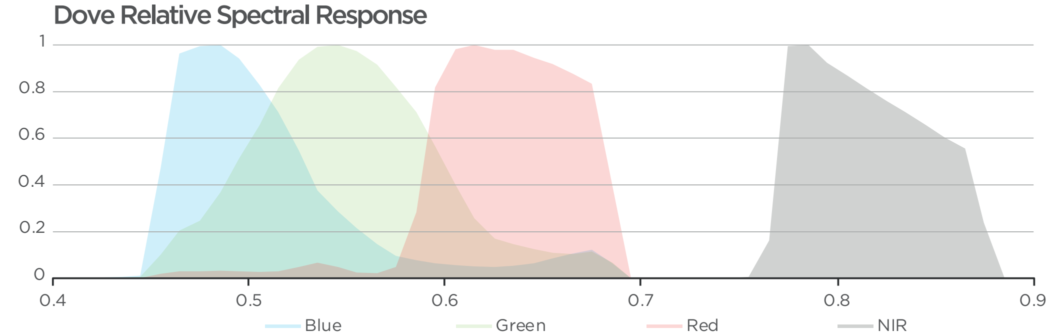
Planet has also partnered with large scientific organizations to engage in world-changing research activities, including NASA, the Paul G. Allen Foundation, Carnegie Institution for Science, The Nature Conservancy, and more.

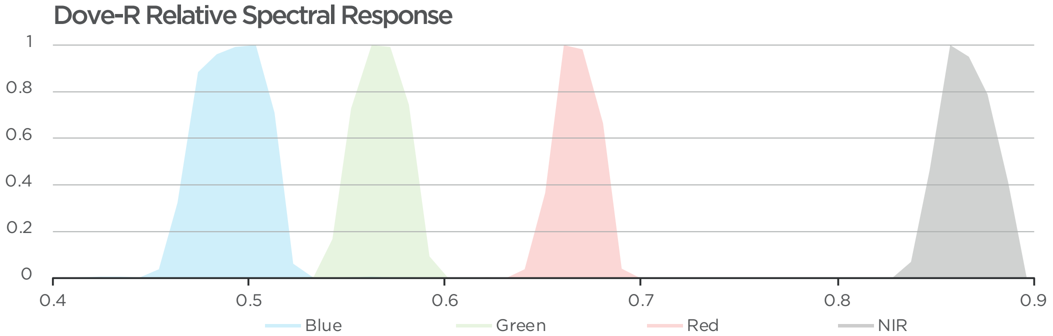
The breadth of research applications of the Planet dataset spans the whole Earth System, from the snow and ice covered regions of the high Arctic and Antarctic, to the jungles of Southeast Asia, to smallholder maize fields in Ethiopia. With each project, researchers are tapping into new methods and analytic tools to better understand natural ecosystems, and the human-used lands that replace them. Many of the projects featured here utilize machine learning, deep learning, and other AI tools to achieve results. Perhaps most critically, Planet research activities have been infused into the classroom by a smaller set of savvy professors and educators who have identified the learning potential of this new approach to remote sensing.

Through our customer and philanthropic network, Planet is committed to scaling applications that provide the greatest benefit to the largest amount of people. We are confident the methods described herein will be used commensurate with Planet's founding intent: to use space to help life on Earth.

Members of Planet's Education and Research Community gather at the American Geophysical Union meeting in December, 2017

EVOLUTION OF THE DOVE RADIOMETRY





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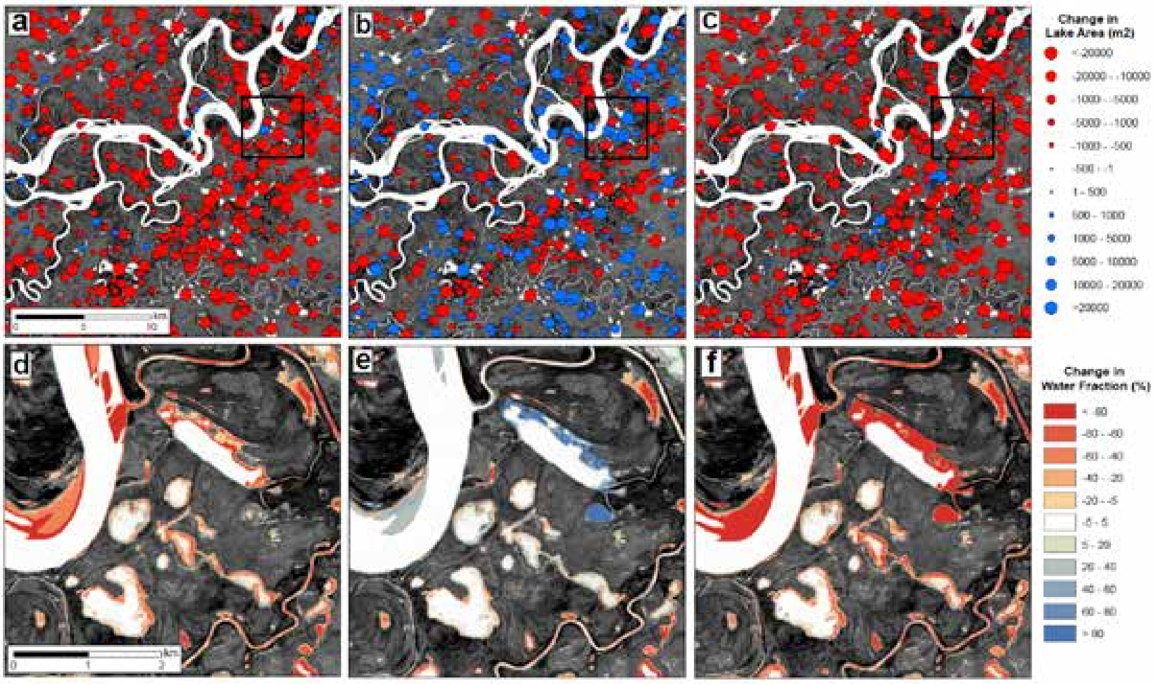
CRYOSPHERE AND HYDROLOGY

The snow and ice covered parts of the Earth house the overwhelming majority of our Planet's freshwater, and they are among those ecosystems that are under the greatest threat from climate change. Because they are so dynamic, cryosphere and hydrological systems stand to benefit the most from high-temporal monitoring provided by the Planet constellation.

DOVE-R IMAGE, ANTARCTICA, FEBRUARY 20, 2019

HIGH-LATITUDE HYDROLOGY

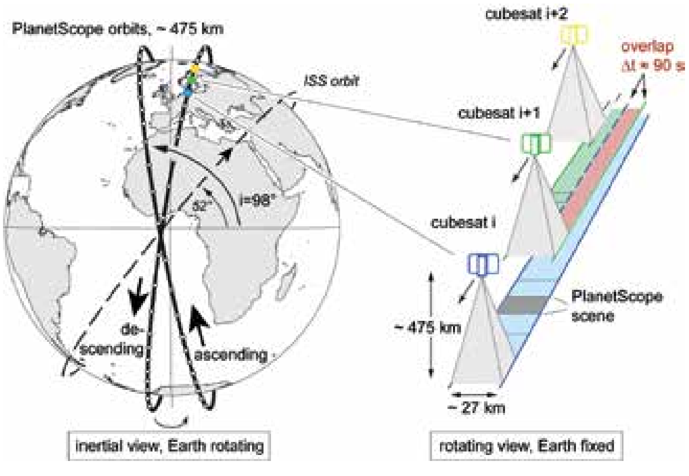


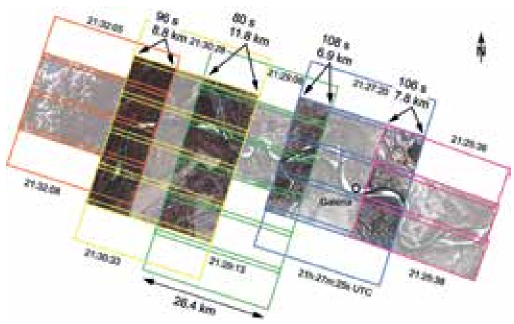
Cooley et al. examined changes in hundreds of small water bodies in Northern Alaska, and found that Planet's dense time series data allowed a unique understanding of the changes in these lakes over time.

Planet's RapidEye and Dove satellites are ideally suited for monitoring of lake extent over dense time series and large spatial scales (e.g., Cooley et al. 2017), and under the right conditions may be used to determine water depth, giving lake water level (e.g., Giardino et al. 2014).

Cooley et al. (2017) found "that Planet imagery is suitable for mapping and tracking changing inundation extent of hundreds of small, heterogeneous water bodies in a complex, dynamic wetland region." Several areas for improvement were noted, including geolocation error (in arctic regions, this is higher than Planet's global average), as well as the need for atmospheric correction. Planet has since deployed a surface reflectance product, which is now in Beta (Collison and Wilson, 2017). Cooley et al. also note that: "With daily or near-daily acquisitions, Planet CubeSat images therefore hold potential to substantially impact hydrologic research, for example in data assimilation, flood monitoring and prediction, and floodplain connectivity.... Another clear application for Planet CubeSat imagery is remote estimation of river discharge from space.... Planet CubeSat imagery is particularly valuable at high latitudes where orbits converge, surface water is both dynamic and abundant, and in situ observations are sparse."

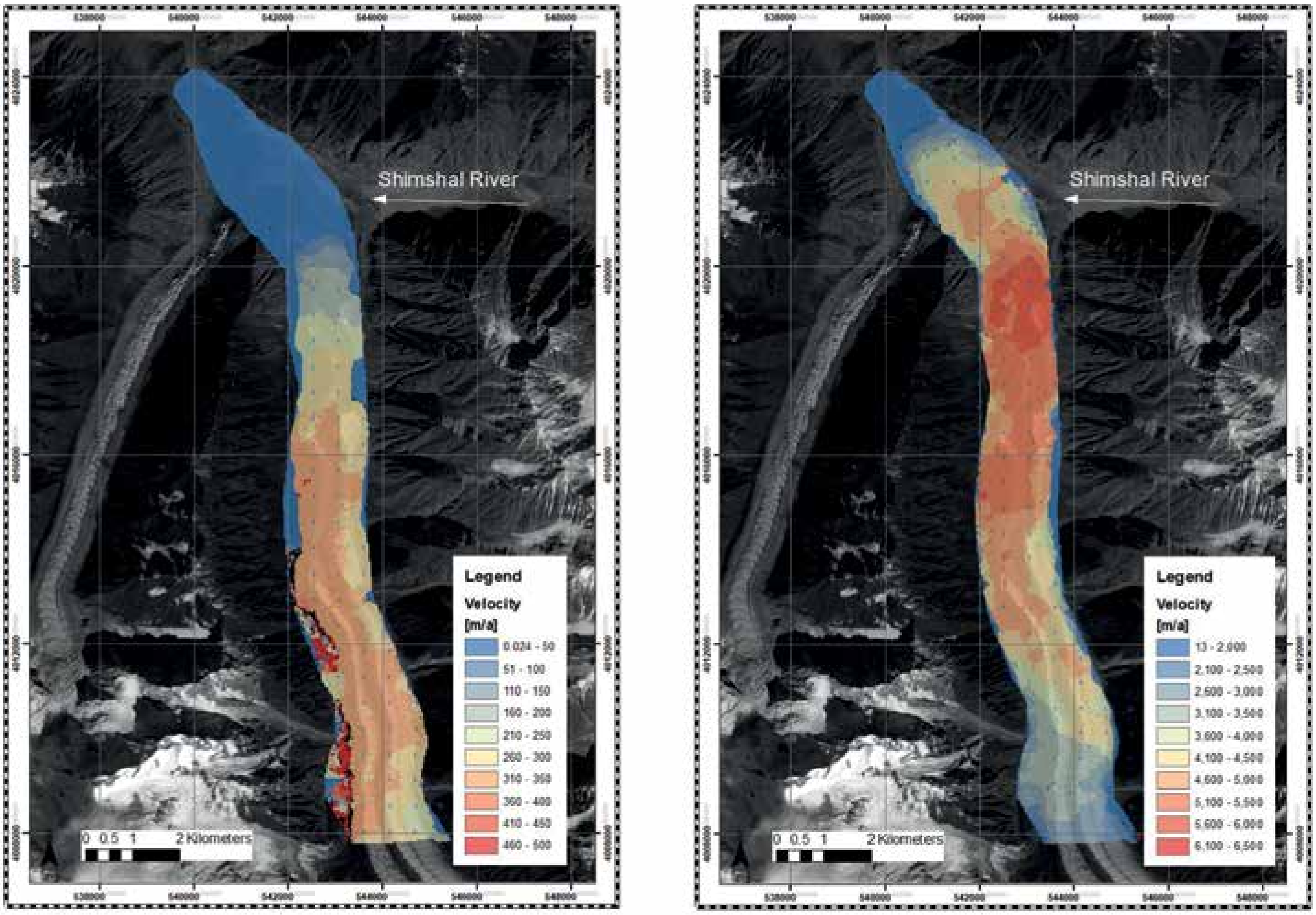
Given Planet's use of sun synchronous orbits, the Dove imagery dataset becomes denser and denser with increasing latitude, meaning that images in the high latitudes are often collected only seconds apart. Kääb et al. (in review) used Dove imagery to characterize river flow rates, utilizing these intraday images. "The approach enables direct remote sensing of river surface velocities over many cold-region rivers and several times per year—much more frequent and over much larger areas than feasible so far, if at all."





Planet's high-density constellations, in which Dove satellites orbit like a strand of pearls, result in overpasses separated by only ~ 90 seconds. At the high-latitudes, these successive passes allow near instantaneous tracking of objects in motion throughout the hydrosphere, such as ice debris in rivers. From Kääb et al., in review.

GLACIERS



Steiner et al. (2017) used a combination of Landsat and Planet imagery to track the surge of the Khurdopin glacier.

The Dove constellation presents an unprecedented opportunity to track the world's glaciers. Steiner et al. (2017) used dense time series to track a surging glacier in Pakistan: "Using high--resolution imagery from the Planet satellites with sub-weekly overpasses (Planet Team, 2017), we are able to characterize the surge event and the surface dynamics on the lower tongue and near the glacier terminus."

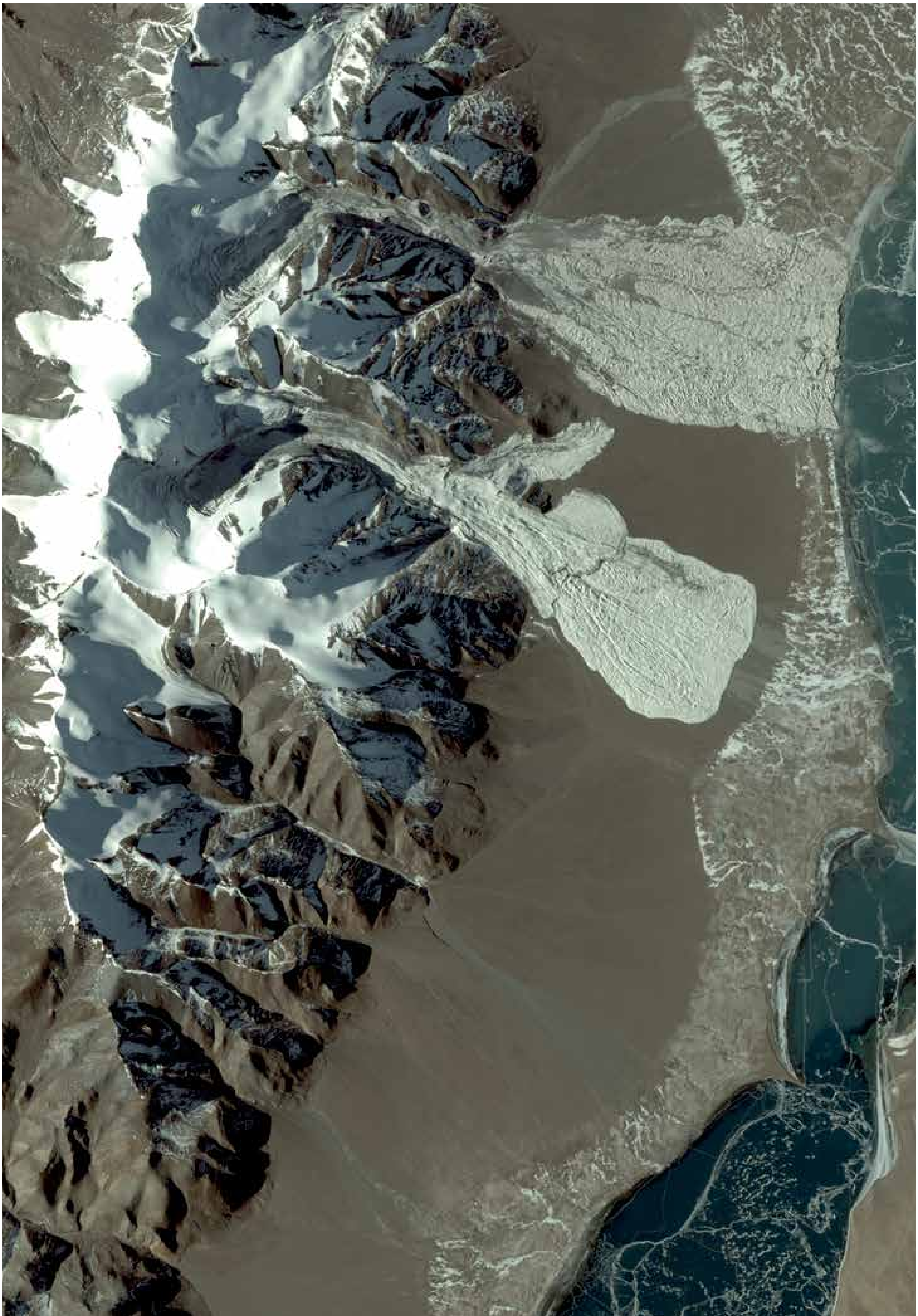
In combination with more efficient algorithms, tracking the flow of all the world's glaciers may become possible (see, e.g. Altena and Kääb, 2017).

Because it's "always on", the Planet constellation allows characterization of rare events. In 2016, two glaciers in Tibet sheared down to their bed, erupting into avalanches. The first disaster killed nine people. A major study, published in Nature Geosciences, examined Planet imagery in the months leading up to the avalanches, and their aftermath. The work was subsequently featured in the The New York Times: "'...it produced speeds of up to 300 kilometers per hour,' or 186 m.p.h., said Andreas Kääb, a professor of geosciences at the University of Oslo in Norway and lead author of the study."

"On top of the speed, each of the collapses moved enough snow and ice to fill one million freight train cars stretching 7,500 miles, Dr. Kääb said. That's roughly the distance between New York City and Shanghai."

In 2016 alone, Planet captured ~180 images of the region. One of the images was captured just two days before the first glacier's collapse, and contained evidence of hydrodynamic instability in the glacier.

(Image, page 9)
Two Tibet glaciers collapsed into avalanches, first in July and then in September of 2016. A Dove satellite captured this image - one of ~180 in 2016 - on the 8th of December.



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VEGETATION & LAND USE

LAND COVER CHANGE

In the 1970s, Landsat revealed a patchwork of agricultural systems around the world, flickering and changing with each 16-day pass of the first public, dedicated Earth imaging satellite. Today, Planet has launched the first remote sensing constellation capable of keeping up with the true pace of field planting, growth and harvest. Diseases, hail damage, and intrafield detail is exposed with Planet's unprecedented spatiotemporal detail.

Deforestation alerts and land use monitoring have historically been limited by the spatial and temporal resolutions of satellite imagery available (left: Landsat-powered deforestation detections). The spatial and temporal resolution of Dove imagery enables more accurate deforestation detections (right: Dove deforestation detection, overlaid with property data.

NEAR REAL-TIME FOREST COVER MONITORING

Historically, monitoring of forests and land use change through remote sensing has involved a compromise between resolution and frequency of satellite imagery, as well as limited computing capacity for analysis. Recent developments in the spatial and temporal resolution of satellite imagery at global scales by Planet, and in machine learning and cloud computing by Google, offer new opportunities to disrupt these historical limitations.

NexGenMap is an R&D collaboration across Planet, Google, Mapbiomas, and The Gordon and Betty Moore Foundation focused on establishing the next generation of land use and land cover mapping tools by leveraging Planet's satellite imagery and Google Earth Engine's computing platforms. The project is developing object detection based land use classification models throughout Brazil — pioneering new practical and cost-effective tools to track forest loss, classify change, and ultimately help steward more effective decisions about land use.

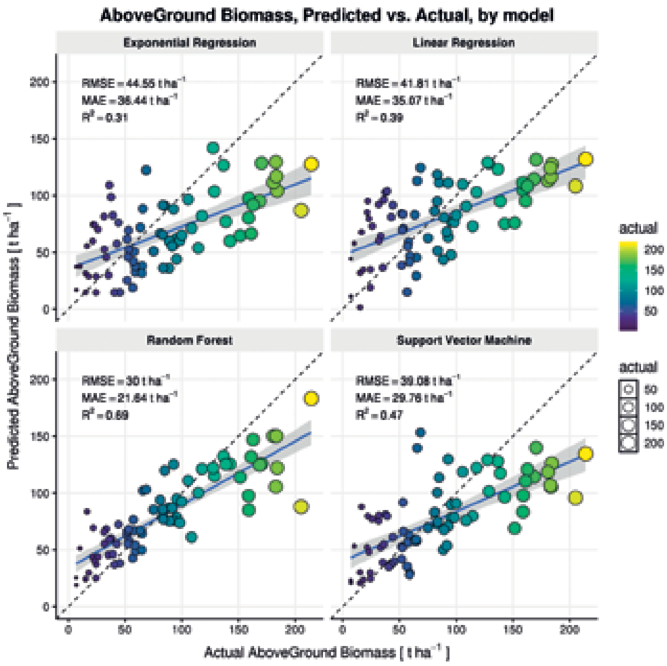
FOREST BIOMASS MONITORING

When working with forest carbon stocks and emissions, it is notable that there is no strictly "true" data. In order to directly measure carbon in forests, one would need to cut the vegetation, dry it, weigh it, chip it up, and push it through a mass spectrometer.

This being a self-defeating enterprise, scientists have for decades estimated carbon content of forests in the field using a mix of volumetric measurements (e.g. tree diameters and height), as well as allometric equations: mathematical relationships between tree volume parameters and carbon measurements collected from harvesting and weighing individual trees. With such equations, one can produce field estimated carbon stocks .

However, the limits of measuring trees in the field are astronomical. In recent years, airborne LiDAR (light detection and ranging) has allowed scientists to produce similar (but not identical) volumetric measurements of forests from the air. But, LiDAR remains expensive to deploy. If high-resolution satellite imagery, such as Planet's RapidEye or Dove data, could be used to sense the volumetric structure of forests, dramatic improvements in carbon mapping would be possible.

Lorena Hojas Gascón, from Universitat de València, and her team used RapidEye data to support a country wide biomass inventory in Tanzania. Using a Random Forest algorithm, the authors were able to explain 69% of variation in forest biomass throughout the country. The authors conclude that "optical data of finer spatial resolution, in this case 5 m resolution, can be used to obtain biomass estimates at a national level."



Lorena Hojas Gascón and her team used regression and machine learning approaches to link RapidEye-based estimates of forest biomass in Tanzania with field estimates. The Random Forest model performed the best, explaining 69% of variation in field estimated forest biomass.

DAILY RETRIEVALS OF LEAF AREA INDEX

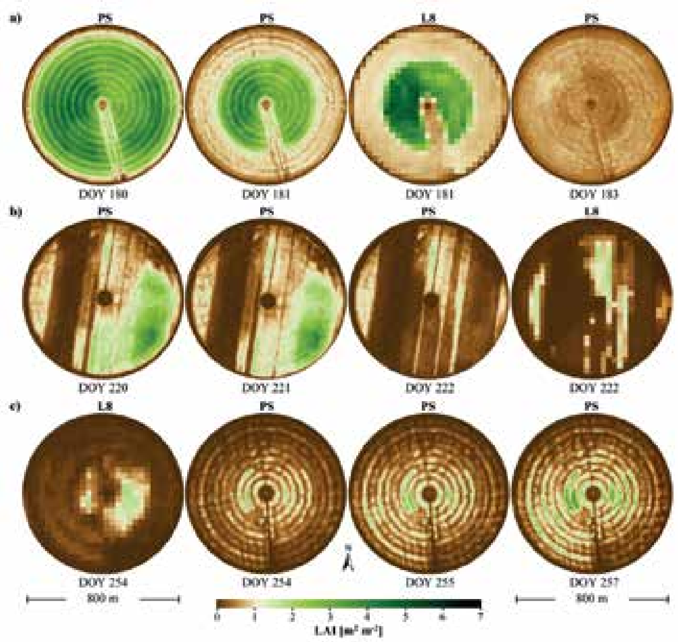
Classic remote sensing for agricultural relies heavily on indices like NDVI (Normalized Differential Vegetation Index), which uses information from the red and near-infrared portions of the spectrum to provide an indicator of vegetation greenness and vitality.

However, other indices, often implicating other parts of the spectrum, may provided added and actionable information for agricultural management. One of these is Leaf Area Index (LAI), a measure of the surface area of vegetation divided by the surface area of the ground. For production alfalfa in the region of Saudi Arabia considered here, LAI can reach 5 to 6 square meters of vegetation per square meter of ground.

LAI has previously been shown to be related to remote sensing observations from Landsat 8, including through the short-wave infrared (SWIR) portion of the spectrum (see, e.g. Houborg and McCabe 2018a). While Planet's Dove satellites do not image in the SWIR, the method employed here by Rasmus Houborg and Matt McCabe still reproduces LAI from L8 with high accuracy:

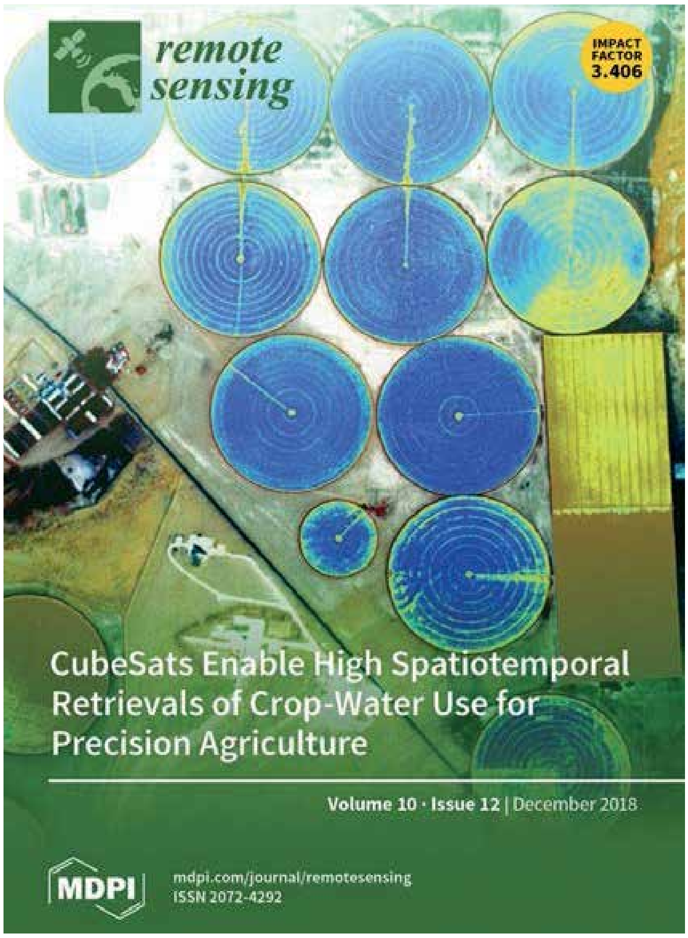
"The adopted RF [RandomForest] machine-learning approach was shown to reproduce the Landsat 8 reference LAI with high accuracy... based on a relatively limited suite of spectral variables.... This was despite the fact that a more spectrally enhanced dataset, including critical bands in the shortwave infrared domain, was needed for the Landsat-based LAI retrieval in order to reproduce observed multiday features with sufficient accuracy."

The work builds upon a series of efforts undertaken by Houborg and McCabe. They conclude: "Daily sequences of CubeSat-based LAI highlighted the spatial resolution advantage and provided critical temporal insights into within-field variations in vegetation health and condition, the rate of vegetation green-up, and the timing and progress of harvesting events, features that were largely uncaptured by the 8–16-day Landsat imagery."



(Image on the left)
Subfield dynamics in Leaf Area Index (LAI) are shown for alfalfa fields investigated by Rasmus Houborg and Matt McCabe in Saudi Arabia. Harvesting and intrafield transitions are captured on a daily basis by Planet imagery (PS), while more limited and coarser information can be derived from Landsat 8 (L8). From Houborg and McCabe 2018b.

(Image on the right)
Bruno Aragon, from King Abdullah University of Science and Technology, and his team used Dove imagery to produce the highest spatial resolution temporal sequence of crop water use ever retrieved from space.



CROP WATER USE

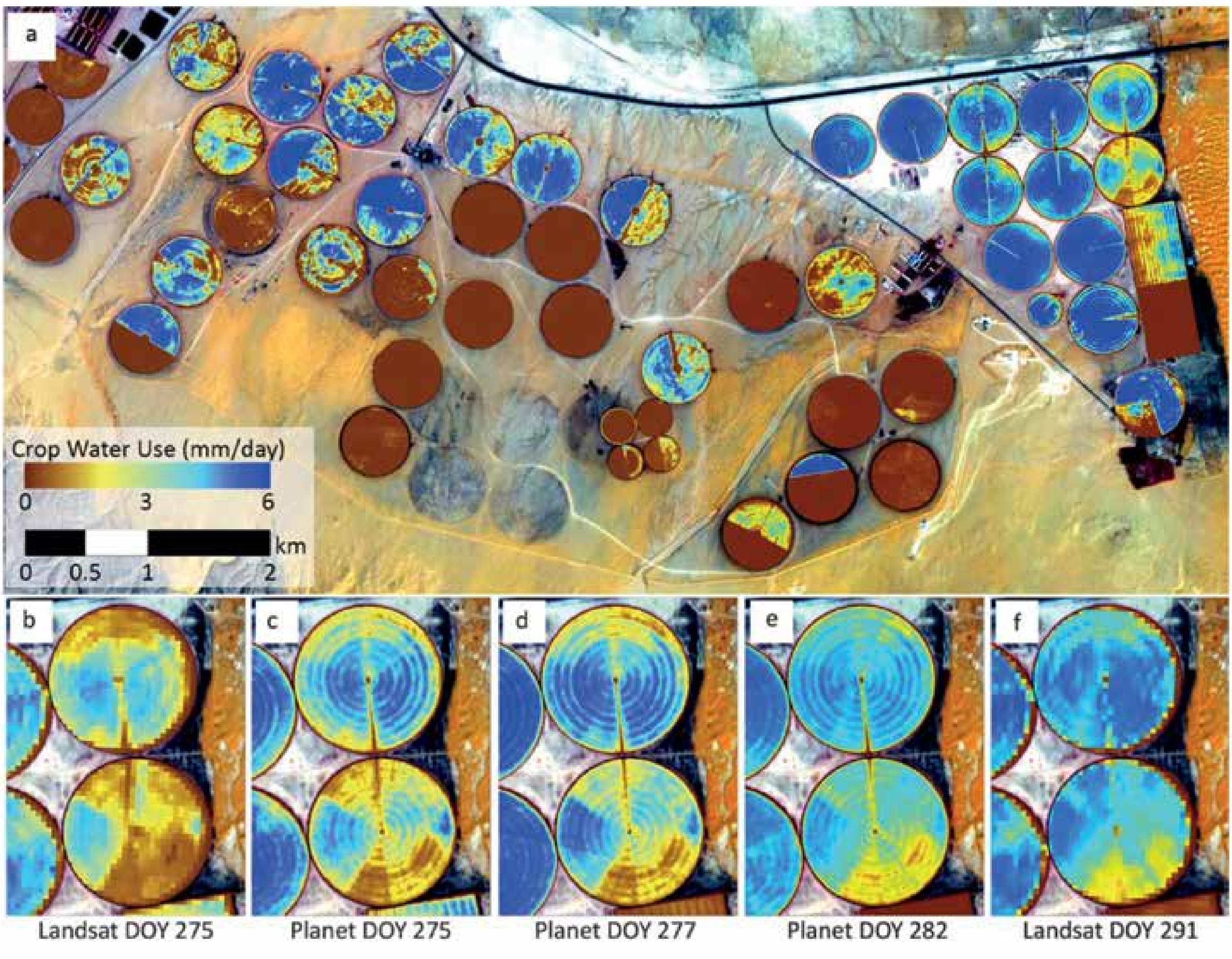
Global agriculture implicates roughly ¾ of all freshwater use on Earth. With demand on the global food supply increasing with population growth, and agricultural systems falling under greater stress due to climate change, water security is under increased risk. Remote sensing of evapotranspiration—the amount of water evaporated off, or transpired by vegetation—offers the possibility to more accurately monitor water loss due to agricultural practices. And with more accurate monitoring, more efficient water use methods can be deployed.

Bruno Aragon, from King Abdullah University of Science and Technology, and his team used Dove imagery to produce the highest spatial resolution temporal sequence of crop water use ever retrieved from space.

Remote sensing of evapotranspiration implicates the flux of water, making it exceedingly difficult to accomplish compared to direct assessment of a spectral property of the vegetation such as NDVI. In order to estimate evapotranspiration, vegetation spectral reflectances are ingested into biophysical models that have been parameterized based on ground data. Then, remote sensing estimates are evaluated against measurement of evapotranspiration on the ground using eddy covariance observations—direct measurements of the flux of water out of the vegetation layer.

Using this methodology, Aragon and team were able to explain 86% of evapotranspiration for maize fields in Saudi Arabia using Dove imagery. This unprecedented result opens the potential for greatly improved monitoring of global agricultural water use. Although the research represents early work, it highlights perhaps the most important value of dense time series multispectral data from the Planet constellation: the ability to leverage sparser (either in space or time) observations from other sensors.

PT-JPL-based crop water use (mm/d) derived from ultrahigh-resolution Planet-LAI and ground-based meteorological data for DOY 275 (1 October 2016). (b, f) Two separate Landsat images on DOY 275 and 291 bound a temporal sequence of Planet imagery for DOY (c) 275, (d) 277, and (e) 282. Brown areas within the center-pivots denote no to low vegetation cover, while the desert background is depicted as a false color composite. From McCabe et al. (2017).



MEASURING WATER POTENTIAL IN COMMERCIAL VINEYARDS

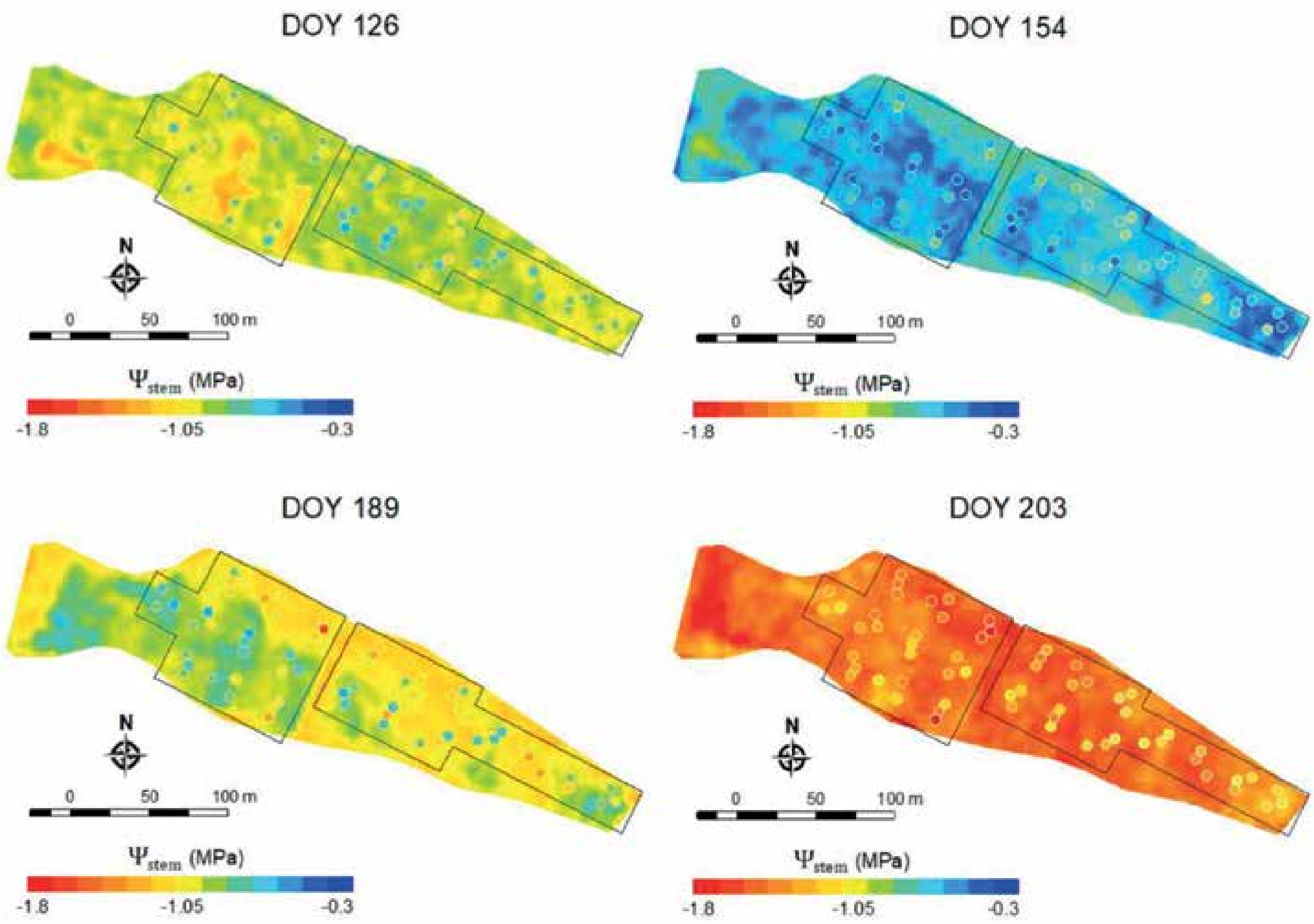
Lianas—woody vines, including grapes—are structural parasites. Climbing on their hosts to get to the sunlight means lianas can spend less energy supporting themselves, devoting more to producing leaves and fruit.

The risk is that their wood is less robust to stress, like freezing cold temperatures. As the water in the plant's veins gets cold, air bubbles form, which can mean death. Temperate lianas such as grapes have various adaptations to deal with the cold, including an ability to generate positive root water pressure: in the spring, pruned grapes will drip or even erupt water from their root stock, which helps clear the veins of possible air bubbles.

In the field, stem water potential can be measured using electric probes, but it is difficult and time consuming. Leveraging satellite imagery could make those field measurements more efficient, allowing stem water potential to be estimated over larger areas and over different time periods.

Here, David Helman and his team (2018) utilized Planet's high-revisit Dove imagery to produce weekly estimates of stem water potential over commercial vineyards in Israel: "the approach presented here shows promise in exploiting these technologies, which include resolving the mixed-pixel problem in agriculture as well as in the ecological monitoring of natural vegetation systems from satellites."

Helman and team also used the Google Earth Engine platform to ingest and process Planet data: "The tools developed here, i.e., the combination of Planet images and GEE platform, with the aforementioned mixed-pixel separation approach, may be also used for water status monitoring of agricultural fields other than vineyards."



David Helman and his team of Israeli researchers used a combination of field measurements and Planet Dove images to produce estimates of stem water potential for commercial vineyards. Effective management of water stress is among the greatest challenges in viticulture, and enabling it from space could improve efficiency in irrigation and fertilizer application. From Helman et al. 2018.

DOVE-R IMAGE, GERMANY, FEBRUARY 18, 2019

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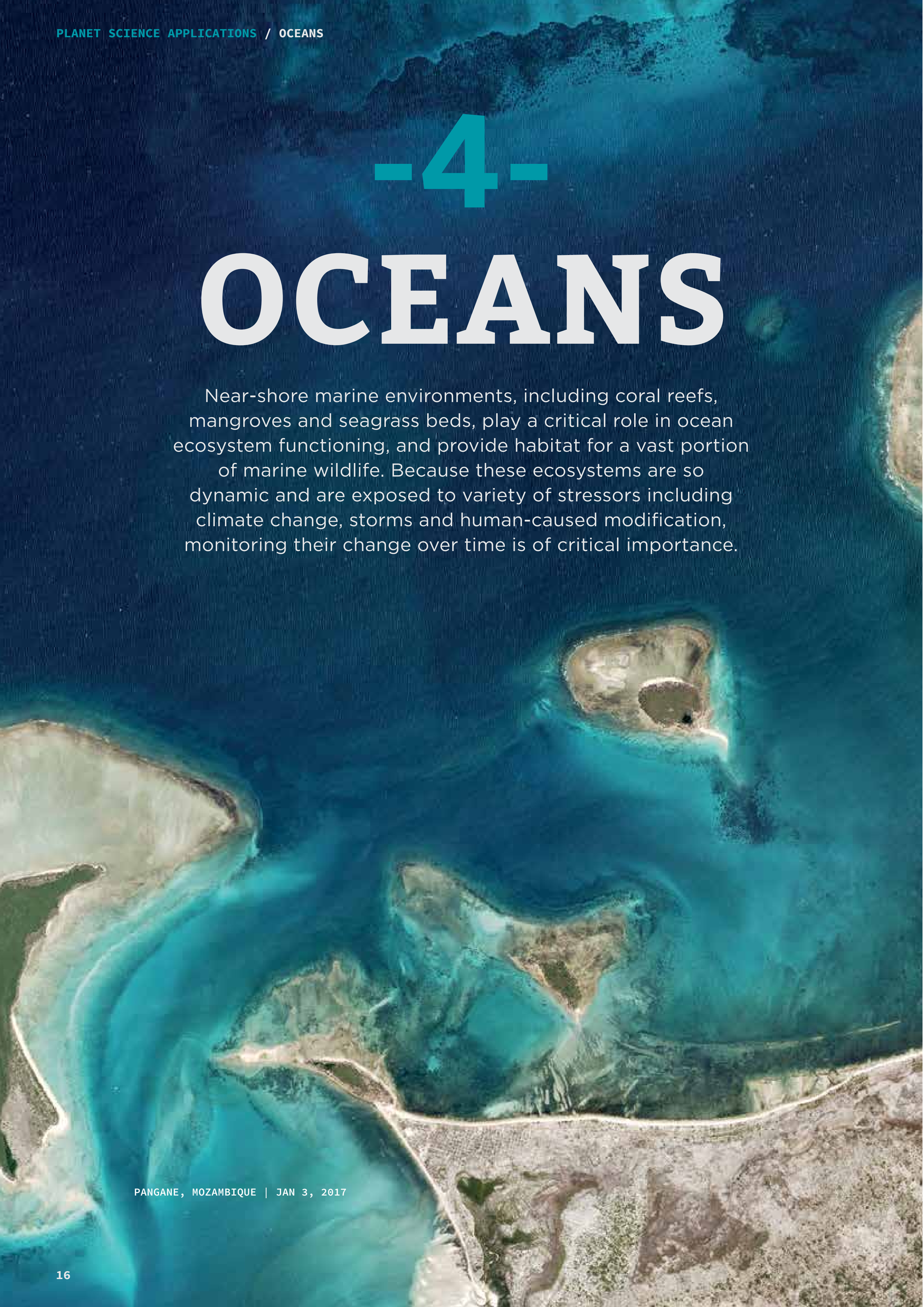
OCEANS

Near-shore marine environments, including coral reefs, mangroves and seagrass beds, play a critical role in ocean ecosystem functioning, and provide habitat for a vast portion of marine wildlife. Because these ecosystems are so dynamic and are exposed to variety of stressors including climate change, storms and human-caused modification, monitoring their change over time is of critical importance.



PANGANE, MOZAMBIQUE | JAN 3, 2017

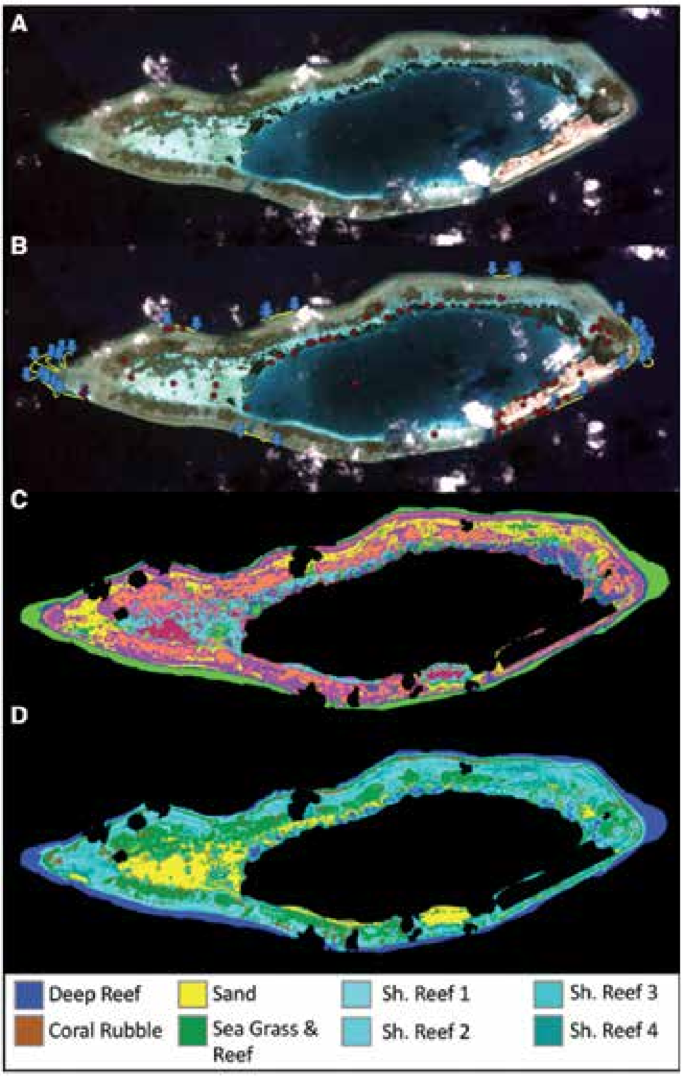
CORAL REEFS

Informed with field and airborne data, Planet's imaging constellations can be calibrated to produce critical ocean surface and bottom products, including water-leaving reflectance, bathymetry and benthic habitat characterization.

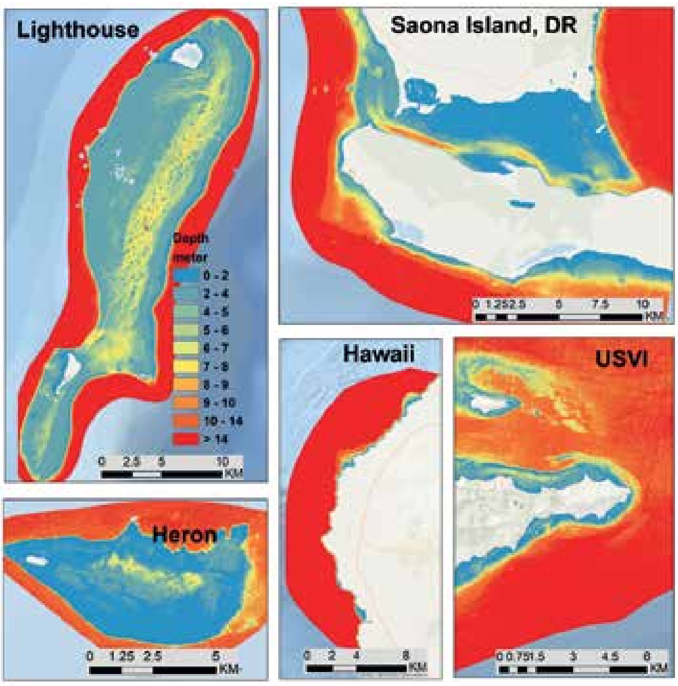
Planet is working with several researchers in this field, and preliminary work indicates that Dove data is excellent in producing high-resolution maps of shallow coral cover, enabling an analysis of human impacts on reefs in the Spratly Islands for example (Asner et al. 2017).

Li et al. (in review) used Dove imagery for bathymetric estimation at five coral reef sites (Lighthouse Reef, Belize; Saona Island, Dominican Republic; St. Croix, U.S. Virgin Islands; Hero Reef, Australia; Hawaii Island, U.S.).

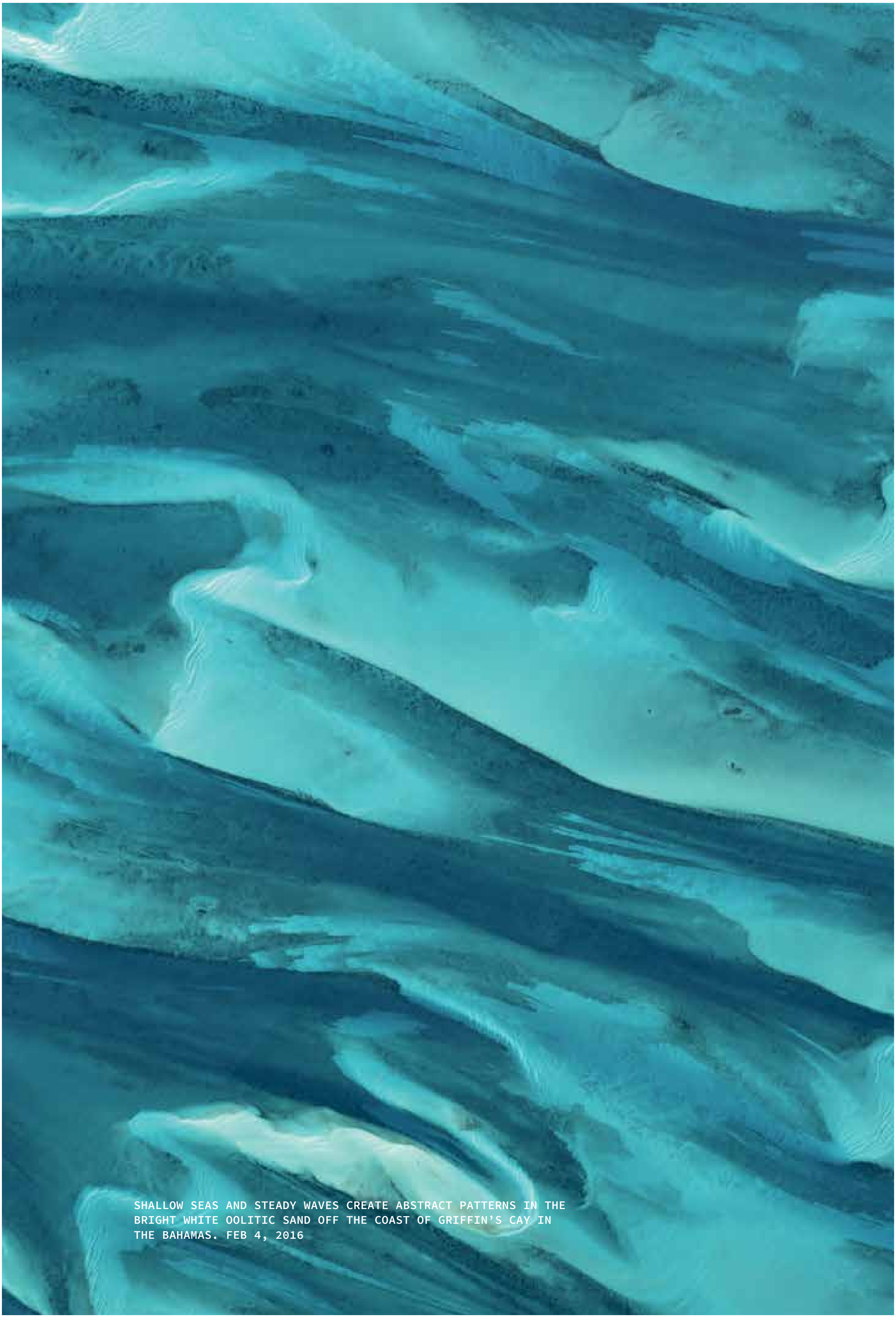
Beginning with Planet's TOAR product, Li et al. applied atmospheric correction, masking of non-water pixels, removal of sun glint and water attenuation to determine bathymetry. Li et al. found that they could estimate depth versus field-measured sampling locations within 1 - 15m of water with an RMSE of -1.22 - 1.86m .



(Image, right)
Asner et al. (2017) used Dove imagery, trained from airborne and field observations, to map coral, sea grass, and other habitats in the Spratly Islands.



(Image, right)
Bathymetric maps of five coral reef sites based on Planet's Dove imagery (Li et al., in review).



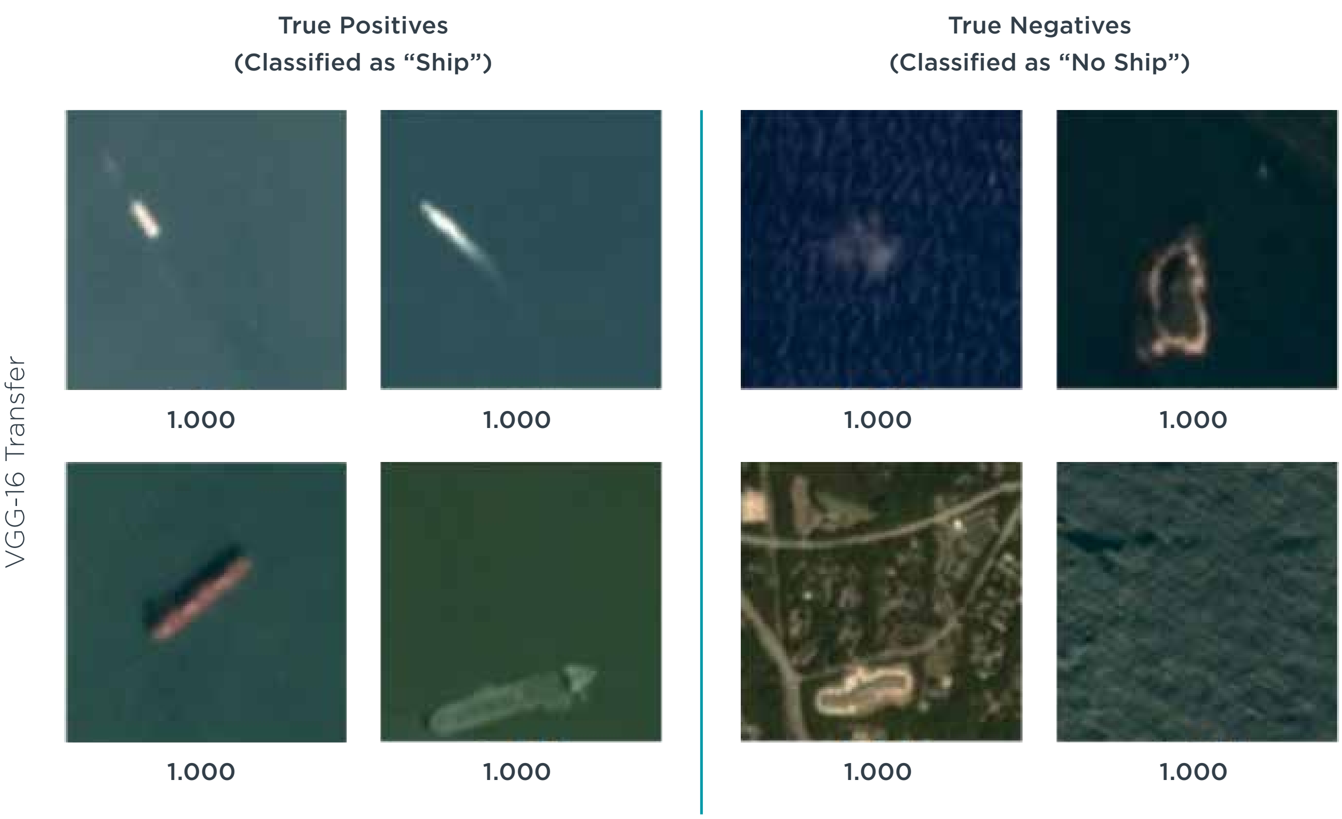
SHALLOW SEAS AND STEADY WAVES CREATE ABSTRACT PATTERNS IN THE BRIGHT WHITE OOLITIC SAND OFF THE COAST OF GRIFFIN'S CAY IN THE BAHAMAS. FEB 4, 2016

SHIP DETECTION

With daily imagery over ports and coastlines, one of the most useful potential applications of Planet's Dove imagery is the detection and classification of maritime vessels. Ship tracking has a vital role in security, but the enormous number of ships at sea at any given time limits the effectiveness of classical, human--powered analyses. Using machine learning, it may ultimately be possible to detect millions of vessels, in near real time.

In her Master's Thesis at the Naval Postgraduate School, Katherine Rice used transfer learning of a previously trained Convolutional Neural Network (CNN) to first detect, and then classify different types of maritime vessels. Trained with 1,800 hand selected chips, Rice demonstrated a recall of 1.00 and precision of 0.98 on sets of 200 validation and test images—a nearly flawless ship classifier. Rice was also able to glean limited information about the type of vessel, classifying barges, fast ships (i.e. with a wake) and merchant vessels with an average recall of 0.83 and precision of 0.85.

The results suggest that detection and classification of ships over large scales and dense time series is within the grasp of open source CNNs provided they are re-trained with an expert human classifier. Limits were observed, consistent with other ship tracking efforts, including white caps, image artifacts and islands being mislabeled as ships in some analyses.



Katherine Rice used transfer learning to train a CNN classifier to detect ships in Planet's Dove imagery. The core methodology resulted in a recall of 1.00 and precision of 0.98, a nearly flawless ship classifier.

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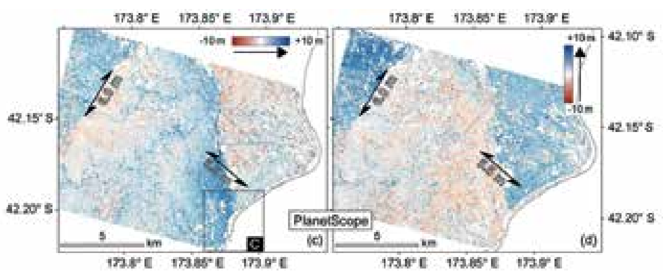
SURFACE DEFORMATION

Many communities live in mountainous or glaciated terrain, with a constant threat of landslides and avalanches. Remote sensing methods, including construction of digital elevation models (DEMs), have the potential to detect deformation of the Earth's surface—not only horizontally, but also vertically.

EARTHQUAKE DISPLACEMENT

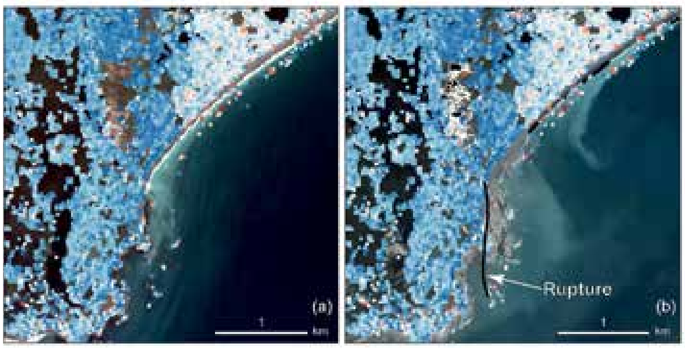
Just after midnight, November 14, 2016, a 7.8 magnitude earthquake struck the town of Kaikoura, New Zealand. Many structures were destroyed, and several landslides triggered, in what was determined to be the second strongest earthquake in New Zealand since European settlement.

Andreas Kääb and his team used Planet's Dove imagery, from before and after the earthquake, to produce displacement maps that were far more detailed than those produced from Landsat or Sentinel data.



(Image, above) Dove imagery highlights E-W (left) and N-S (right) surface displacement caused by the November 2016 earthquake in NZ. The vector fields highlight pixels that shifted either to the east or the north, respectively.

Overall, the Dove imagery produced displacement maps of high quality, which in principle could be generated only hours after an earthquake and used to manage emergency resources. Kääb et al. note "one of the main advantages of using PlanetScope data for coseismic displacements is their anticipated daily repeat. This maximizes the chances of receiving cloud-free images and to cover unexpected events such as earthquakes."



(Image, above) Dove imagery highlights a surface rupture caused by the NZ earthquake in 2016, in which a portion of the ocean floor was exhumed.

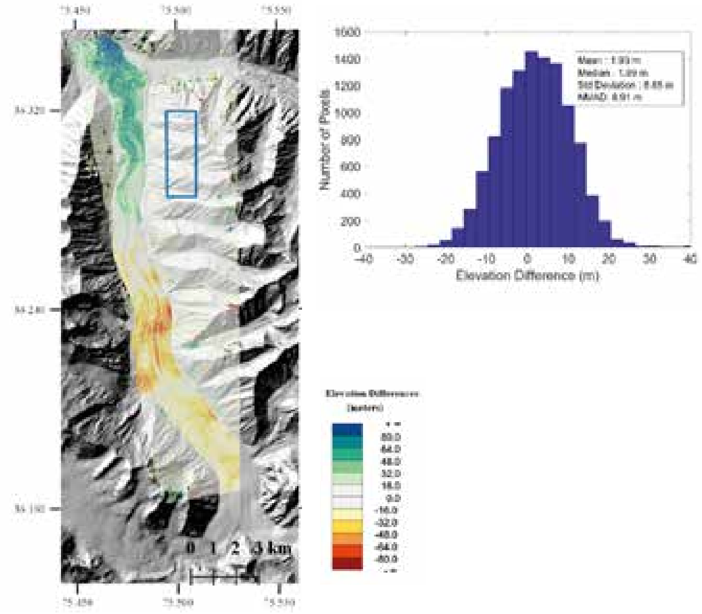
THREE DIMENSIONAL CHANGE DETECTION

While active sensors like radar are excellent for detecting this 3D change, passive optical data can also be used: when several images overlap, but are captured from different camera positions, remote sensing scientists can use the parallax of the various images to reconstruct the 3D picture of a target.

Professor Sajid Ghuffar, in the Department of Space Science at the institute of Space Technology in Pakistan, used Planet's Dove images to build 3D models in the Canary Islands and the Nanga Parbat massif in the western Himalaya.

Most strikingly, he was able to detect vertical changes of ~80m on the Khurdopin glacier in Pakistan, which has been surging recently.

Professor Ghuffar concludes that "the proposed methodology and results are especially significant for studying dynamic phenomenon as well as investigating the disaster related events such as avalanches or landslides because the pre and post event images are acquired daily by PlanetScope satellites."



Professor Sajid Ghuffar used multiple Dove images to build 3D models of the land surface (DEMs), in this case allowing 3D change detection over the Khurdopin glacier in Pakistan.

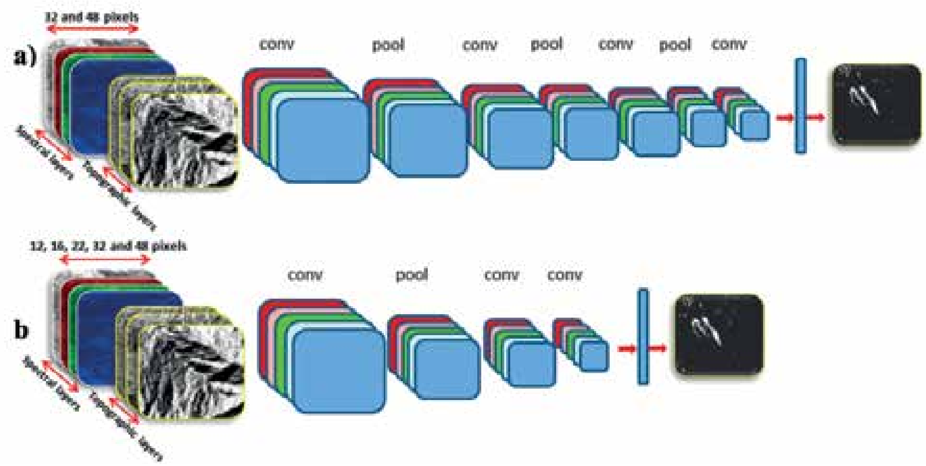
LANDSLIDES

Landslides pose a major threat to people and property throughout the world, and particularly in landslide-prone regions. Improving our ability to monitor those landslides can improve mitigation, and may ultimately reveal approaches that could predict certain types of landslides in the future.

Omid Ghorbanzadeh, from the University of Salzburg, and his team applied convolutional neural networks and other methods to identify landslides in RapidEye data. Working in the Rasuwa district in Nepal, Omid and team tested their ability to detect thousands of landslides based on a variety of image spectral features from RapidEye data, as well as topographic inputs including digital elevation models from ALOS data.

The results were encouraging. Across all methods, their model precision ranged from 50 – 82%, while recall ranged from 60 – 93%. The group found that spectral features from RapidEye data were more important than topography for identifying landslides.

They conclude that: "the increasing availability of [Very High Resolution] remotely sensed imagery opens many options for landslide mapping and for producing and updating landslide inventories." The authors caution, however, that landslide mapping remains challenging due to the wide diversity of forms landslides can take.



Convolution neural network architecture used by Omid Ghorbanzadeh, from the University of Salzburg, and his team to identify landslides in RapidEye data.

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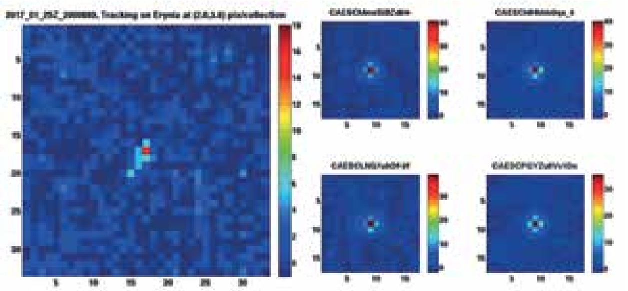
THAT'S RIGHT, ASTEROIDS

The proliferation of small satellites may make it easier to track near-Earth objects—asteroids and other potentially hazardous objects that could impact our Planet. In collaboration with Planet, Chengxing Zhai and team (2018) utilized SkySat-3 to demonstrate imaging of the main belt asteroid, 889 Erynia, and near-Earth object 1998YP11.

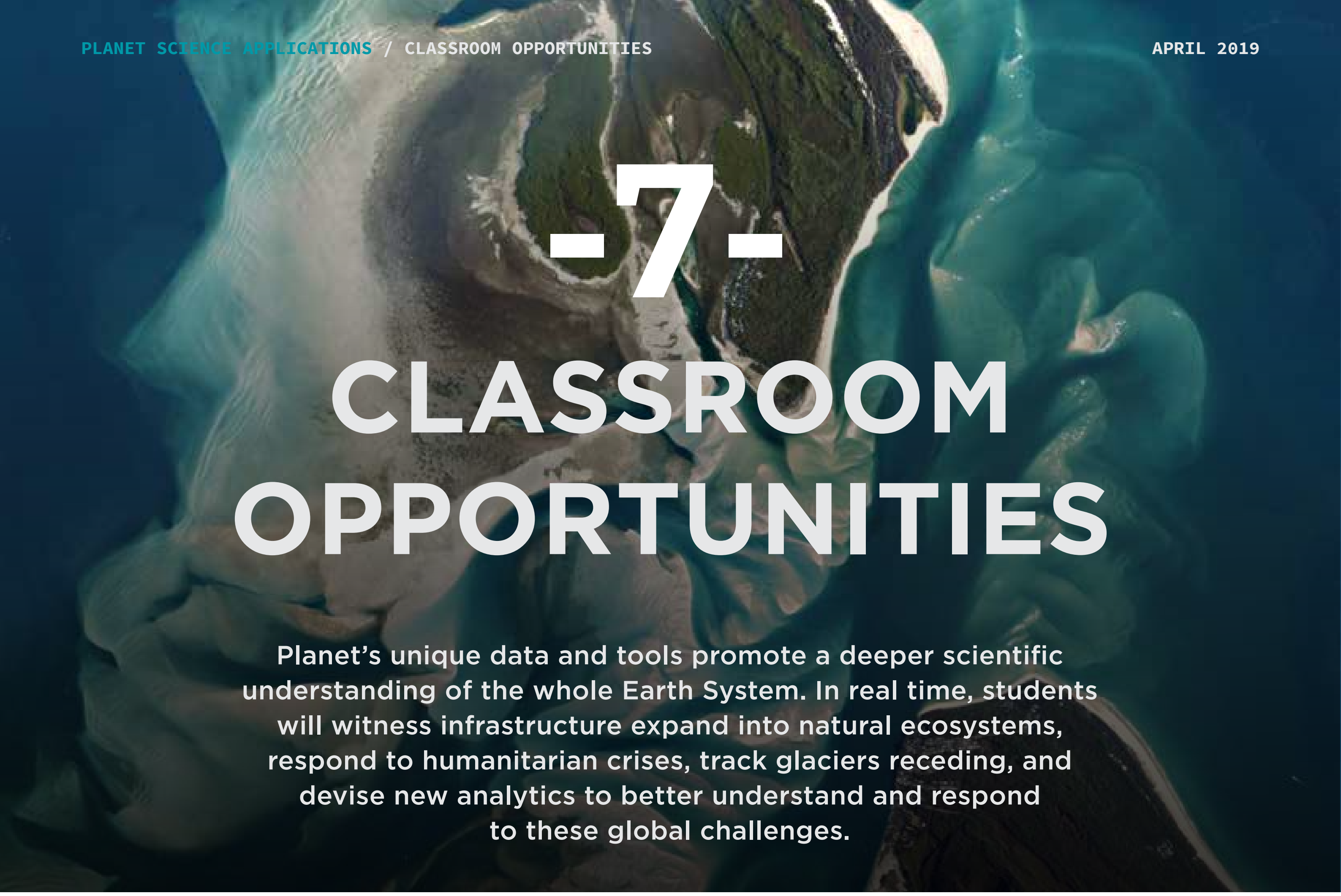
From January through April of 2017, SkySat-3 conducted asteroid observations while the spacecraft was in Earth's shadow. A considerable amount of post-processing was applied to isolate images of the asteroids. Background and incidental signals from cosmic rays were removed, individual observation frames were registered to offset jitter from the spacecraft's attitude determination and control systems, and then the resulting frames were "stacked" to create a single synthetic image.



Chengxing Zhai and team used six passes of SkySat-3 observations to image a main-belt (Erynia) and near-Earth asteroid (1998YP11). Here, observations of Erynia are shown for individual SkySat collections (right), and synthesized into a single image (left).

Erynia, with an apparent magnitude of 14.5, was detectable even in short, 3.3 second video observations. NEO 1998YP11, with a lower apparent magnitude of 16.1, required five orbital passes to complete a single synthetic image.

The authors note that if the SkySat-3 hardware and camera settings were optimized for asteroid detection (rather than Earth imaging), objects with an apparent magnitude of 21.7 would potentially be detectable. Large, small satellite constellations could therefore be used to better characterize the risks posed by near-Earth objects.



-7- CLASSROOM OPPORTUNITIES

Planet's unique data and tools promote a deeper scientific understanding of the whole Earth System. In real time, students will witness infrastructure expand into natural ecosystems, respond to humanitarian crises, track glaciers receding, and devise new analytics to better understand and respond to these global challenges.

Example Course: PYTHON FOR GEOSCIENCE

For students interested in private sector or government careers in geospatial data and tools, such a course provides an opportunity to target their python training. For example, students may co-develop an earthquake monitoring and response tool, which would use the Planet API, combined with image processing and photogrammetry, to automatically analyze crustal deformation caused by an earthquake, generate shakemaps and build alerts.

Example Course: GEOGRAPHIC INFORMATION SYSTEMS

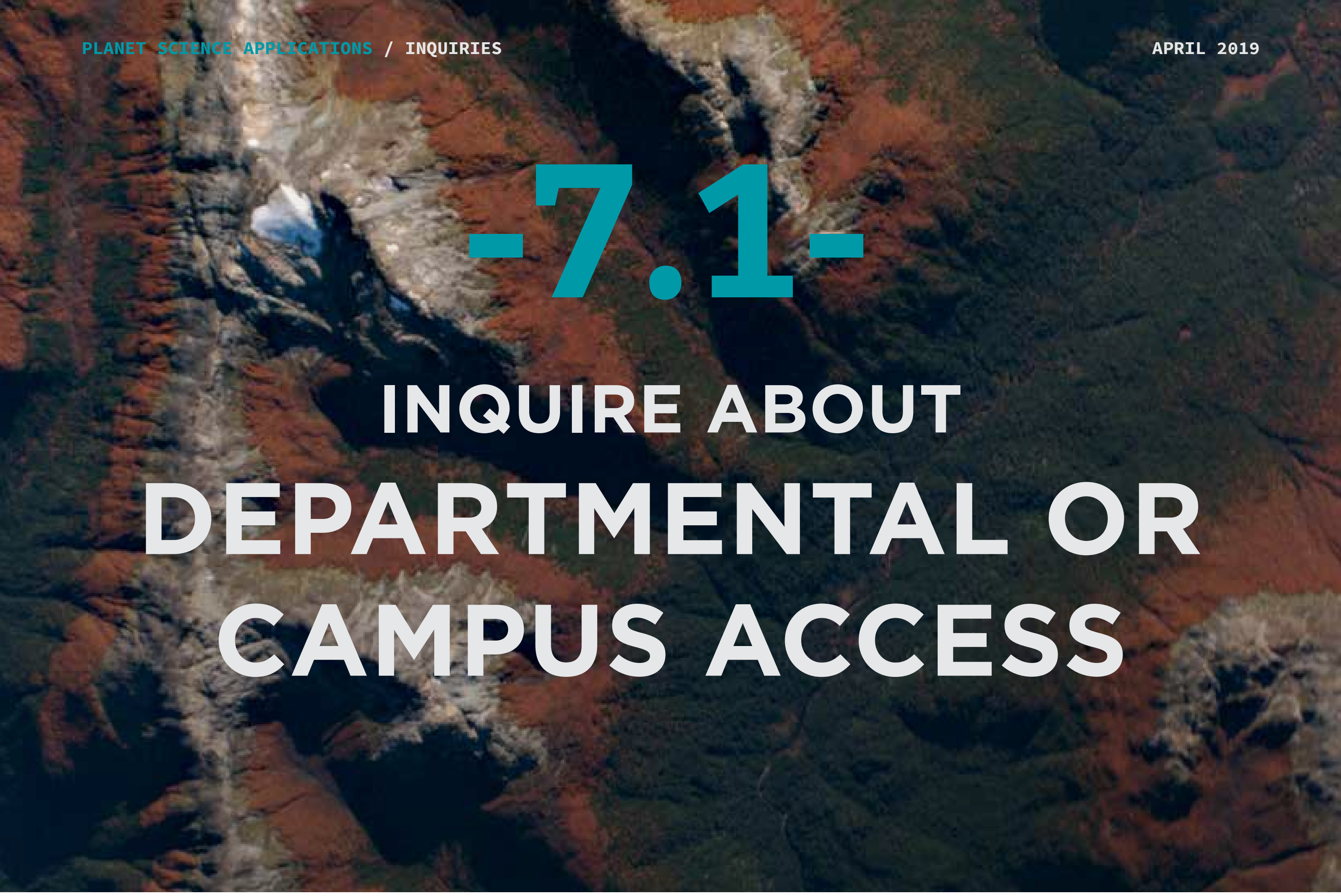
Planet will serve as an exemplar of very high spatial and temporal resolution data for GIS students, and also as a powerful data set for their course projects. We envision sourcing Planet data for lectures about scale, data sources, and the scene model, as well as a tool for Object Oriented Classification. By working with Planet data early in their GIS training, these students gain the advantage of becoming familiar with the future of remote sensing and will be better suited to apply their education in the field.

Example Course: AI FOR EARTH SCIENCE

By applying machine learning techniques to Planet data, students will be on the cutting edge of innovation in remote sensing analytics. At Stanford University, for example, several students recently utilized Planet imagery in Computer Science 230: Deep Learning. Students examined deforestation near Kibale National Park in Southern Uganda, an incredibly diverse tropical forest, and home to a large Chimpanzee population. The team used the "U-Net" algorithm, originally devised for biomedical image segmentation, to separate forest patches from surrounding non-forest habitat, producing a binary classification. They subsequently expanded their effort to parse forest density across multiple classes. Read their final report here.[1]

> "For the first time, scientists will have access to dense image time series from high-spatial-resolution satellite data."
>
> JIM KELLNER, Professor, Brown University

[1] http://cs230.stanford.edu/files_winter_2018/projects/6934326.pdf



-7.1-

INQUIRE ABOUT DEPARTMENTAL OR CAMPUS ACCESS

Planet's Education and Research program promotes a deeper scientific understanding of the whole Earth system. In real time, your students will witness infrastructure expand into natural ecosystems, respond to humanitarian crises, track glaciers receding, and devise new analytics to better understand and respond to these global challenges. Our Campus program is designed to provide access to Planet data across the entire university ecosystem: from undergraduates to postdocs, lecturers to research specialists.

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> "Planet data could be a great tool to introduce Object Oriented Classification, or even a great lecture about scale and data sources. Truly the options are endless!"
> RYAN FRAZIER, Lecturer, Arizona State University

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