13th Webinar on Data Science & Analytics

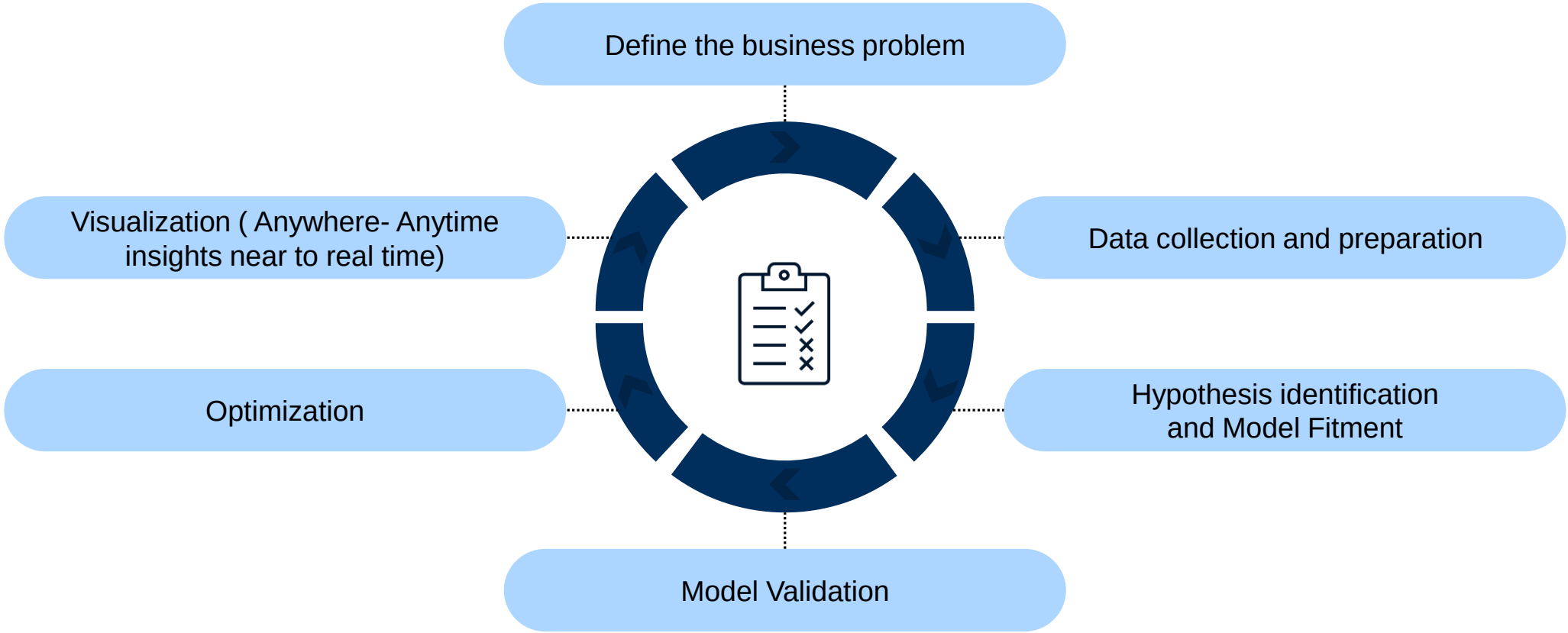
Venue: Zoom
Date: 13th May 2023

Data Analytics
Data Insights Derived from Satellite Imagery Using Machine Learning Techniques
Data Insights Derived from Satellite Imagery Using Machine Learning Techniques - ESG and Climate Risk

Institute of Actuaries of India

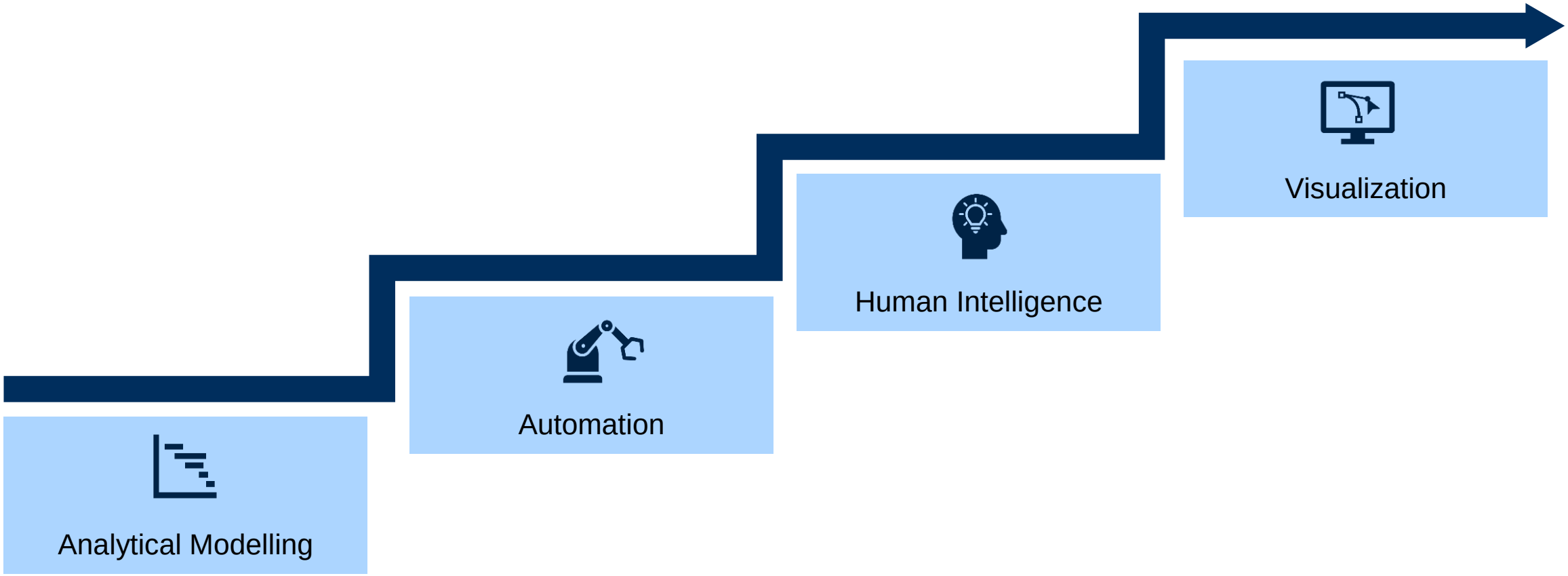
Data Science

How to Solve a Problem



Holistic Approach to a Solution

Re-engineering with Analytics and Digital Levers



Remote Sensing Group | May 2023

Data Insights Derived from Satellite Imagery Using Machine Learning Techniques

Remote Sensing & “GIS is the nervous system for the planet.”

Jack Dangermond

Jack Dangermond is an American businessman and environmental scientist, who in 1969 co-founded, with Laura Dangermond, the Environmental Systems Research Institute (ESRI) , a privately held geographic information systems software company.

Agenda

- Introduction
- Remote Sensing and Machine Learning Overview
- Applications of Remote Sensing with Machine Learning
- Summary

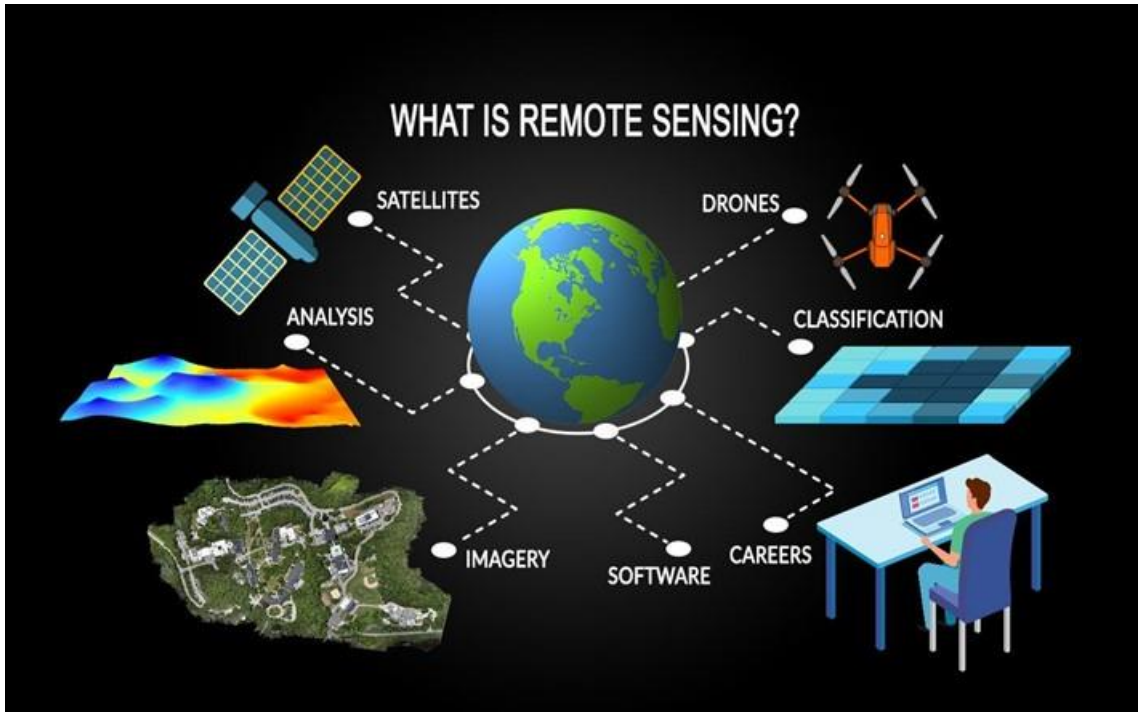
What is Remote Sensing?

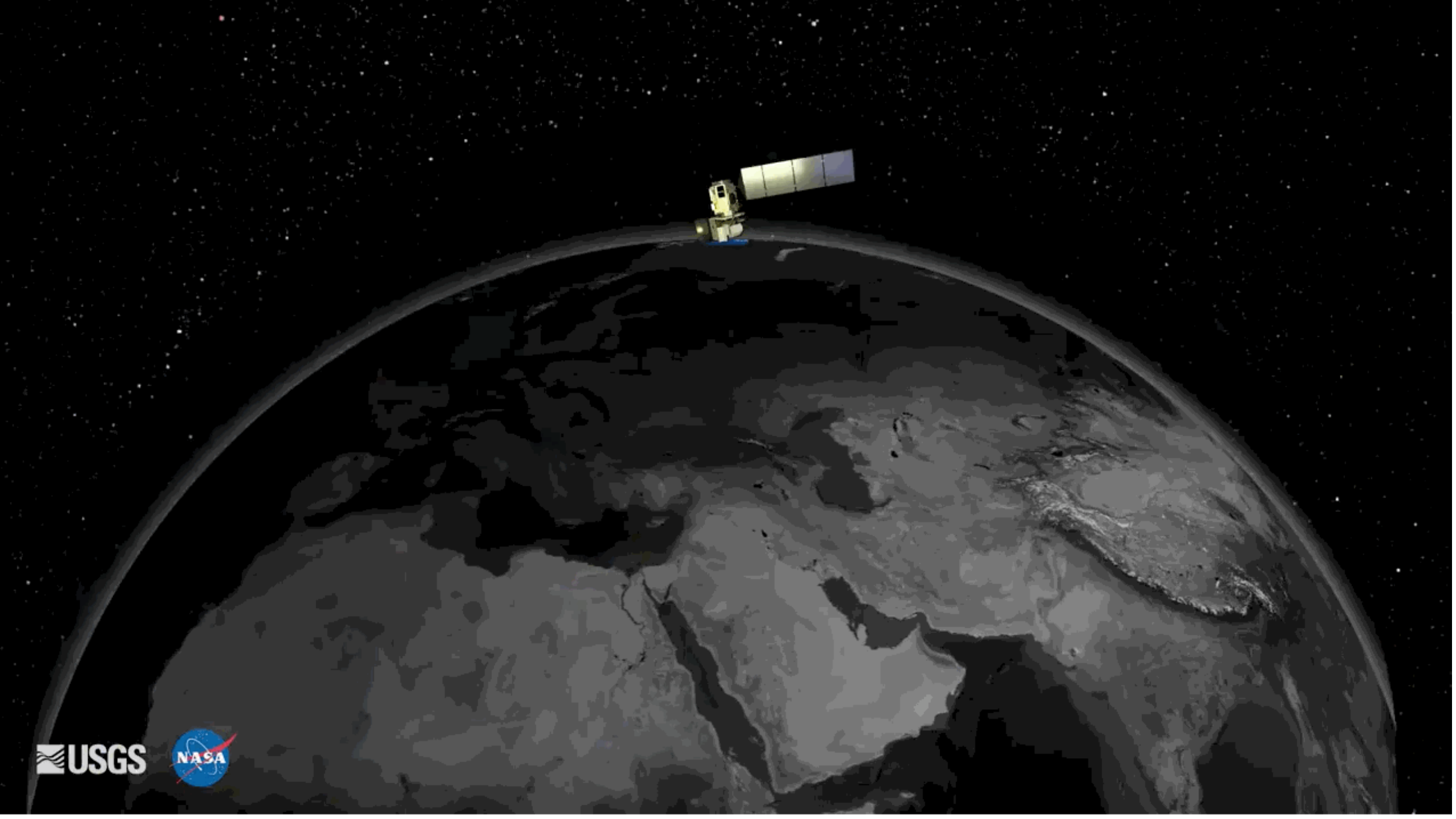
“Remote Sensing is defined as the acquisition of information about an object without being in physical contact with it.”

- By Charles Elachi, Former Director Jet Propulsion Laboratory (JPL).

Remote sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite or aircraft). Special cameras collect remotely sensed images, which help researchers "sense" things about the Earth.

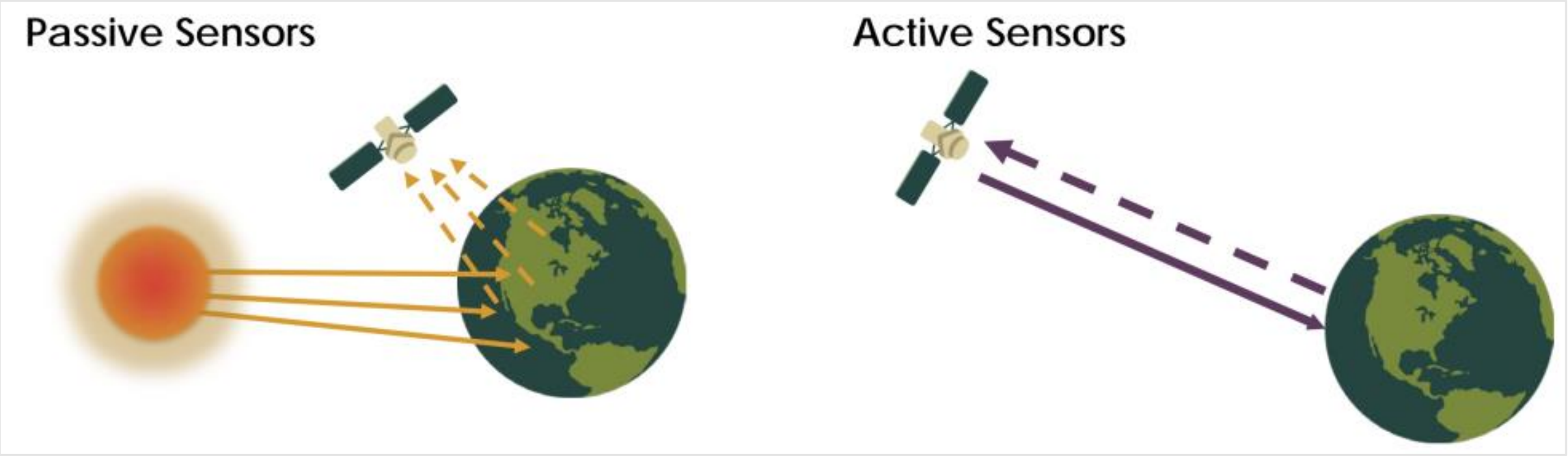
- By USGS




USGS
NASA

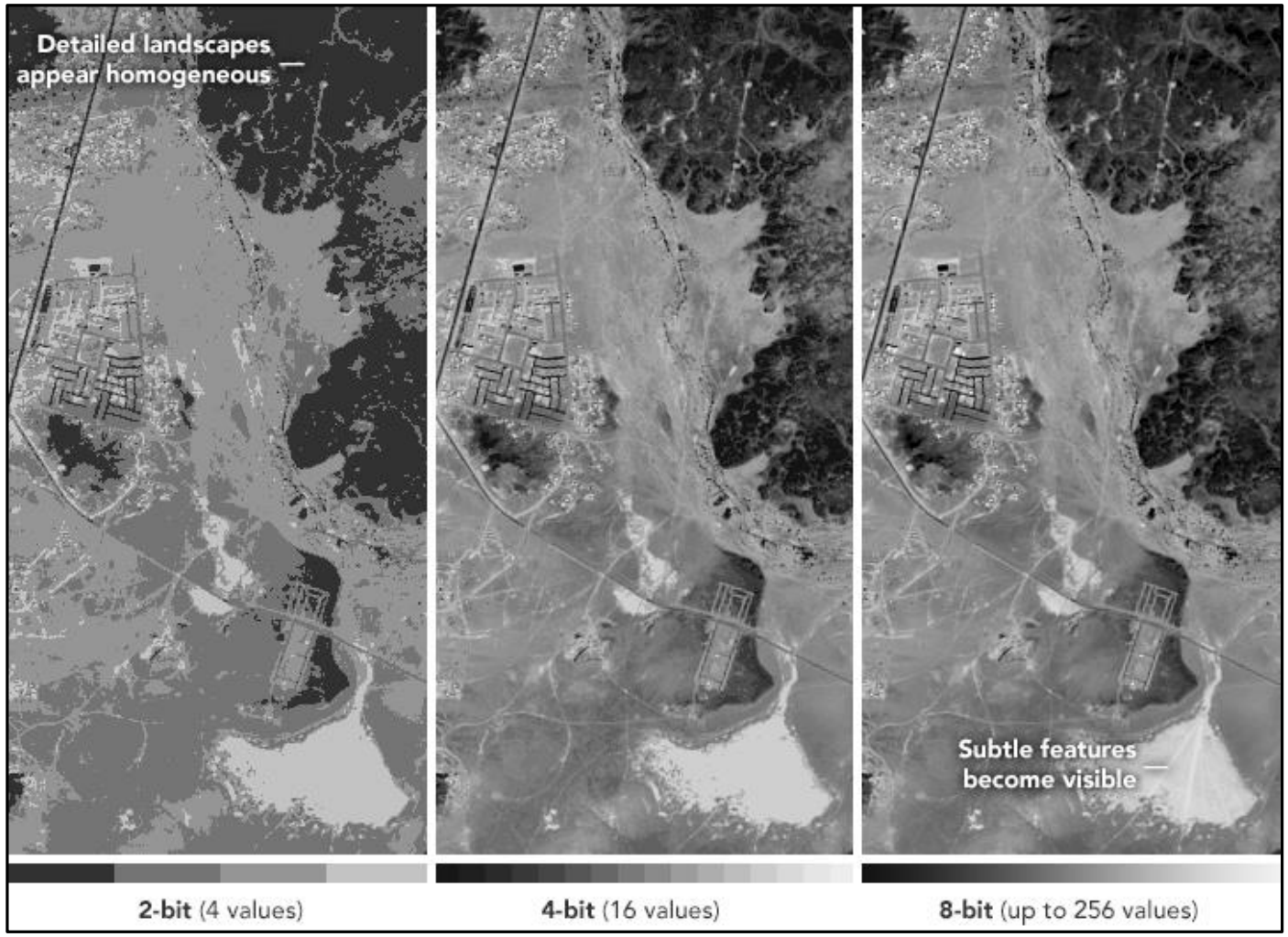
Satellite Sensors

Sensors, or instruments, aboard satellites and aircraft use the Sun as a source of illumination or provide their own source of illumination, measuring energy that is reflected back. Sensors that use natural energy from the Sun are called passive sensors; those that provide their own source of energy are called active sensors.



Resolution

Radiometric resolution is the amount of information in each pixel, that is, the number of bits representing the energy recorded. Each bit records an exponent of power 2. For example, an 8-bit resolution is 28, which indicates that the sensor has 256 potential digital values (0-255) to store information.



Resolution

Spatial resolution is defined by the size of each pixel within a digital image and the area on Earth’s surface represented by that pixel.

High Spatial Resolution

Medium Spatial Resolution

Low Spatial Resolution

What Spatial Resolution Do I Need?

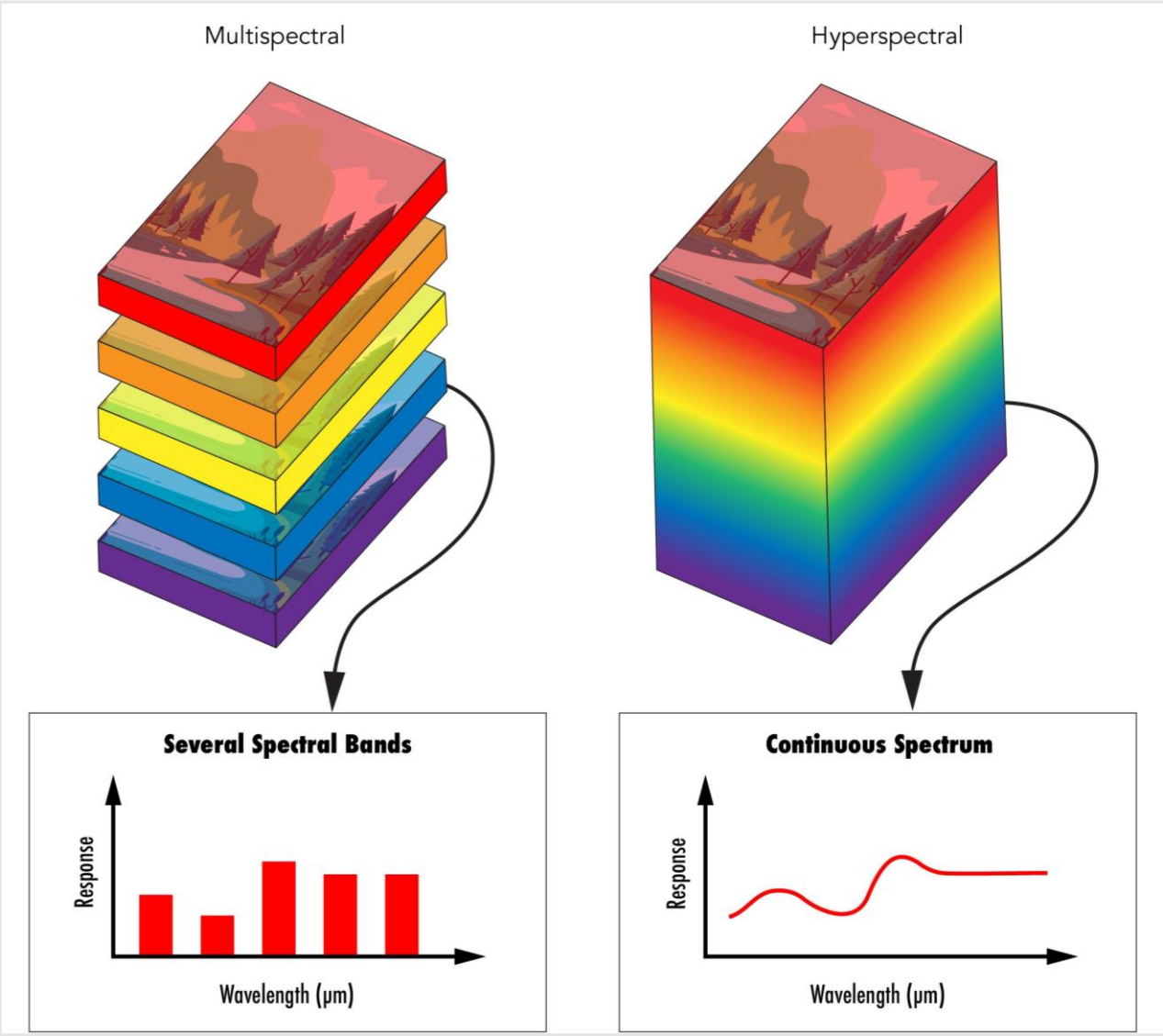
National Aeronautics and Space Administration

NASA

Spatial resolution is the area represented by a pixel. For example, in a 10-meter resolution dataset each pixel represents a 10 m by 10 m square on the ground.

Resolution

Spectral resolution describes the amount of spectral detail in a band. High spectral resolution means its bands are narrower. Whereas low spectral resolution has broader bands covering more of the spectrum. Many sensors are **multispectral**, meaning they have 3-10 bands. Some sensors have hundreds to even thousands of bands and are considered to be **hyperspectral.**



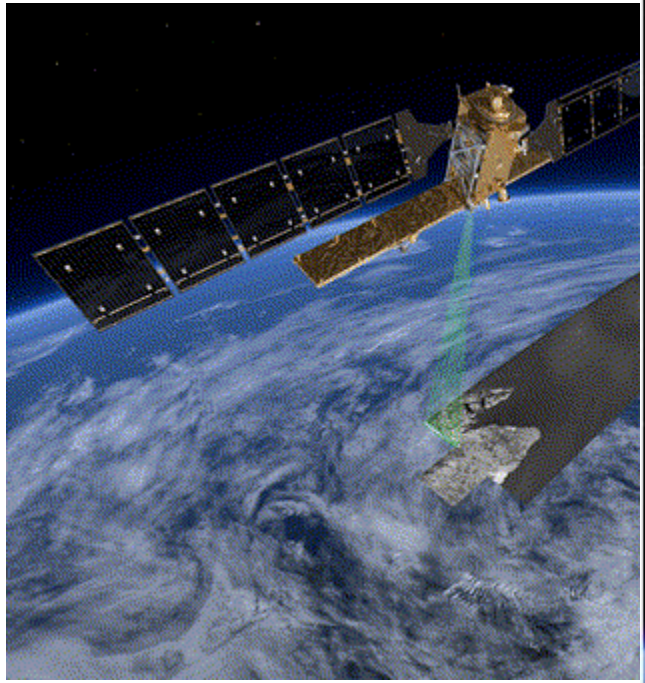
Resolution

Temporal resolution is the time it takes for a satellite to complete an orbit and revisit the same observation area. This resolution depends on the orbit, the sensor's characteristics, and the swath width.

Mission	Number of Satellites	Temporal Resolution
Sentinel-1	2	6 days
Sentinel-2	2	5 days
Landsat 8	1	16 days
MODIS	2	2 days

Present Satellite Missions

Sentinel-1



Agency	ESA, COM
Mission status	Operational
Launch date	03 Apr 2014
	2038
	Land, Ocean, Snow & Ice
	Landscape topography, Multi-purpose imagery (land), Multi-purpose imagery (ocean), Ocean surface winds, Ocean topography/currents, Ocean wave height and spectrum, Sea ice cover, edge and thickness, Snow cover, edge and depth, Soil moisture, Vegetation
Instruments	C-SAR
Instrument type	Imaging microwave radars

Present Satellite Missions

Sentinel-2

Agency	ESA, COM
Mission status	Operational (nominal)
Launch date	23 June 2015
End of life date	2038
Measurement domain	Atmosphere, Land
Measurement category	Albedo and reflectance, Multi-purpose imagery (land), Radiation budget, Vegetation
Instruments	MSI
Instrument type	High resolution optical imagers

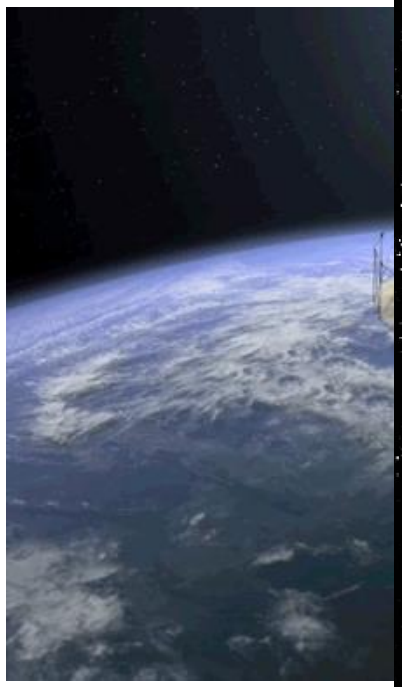
Present Satellite Missions

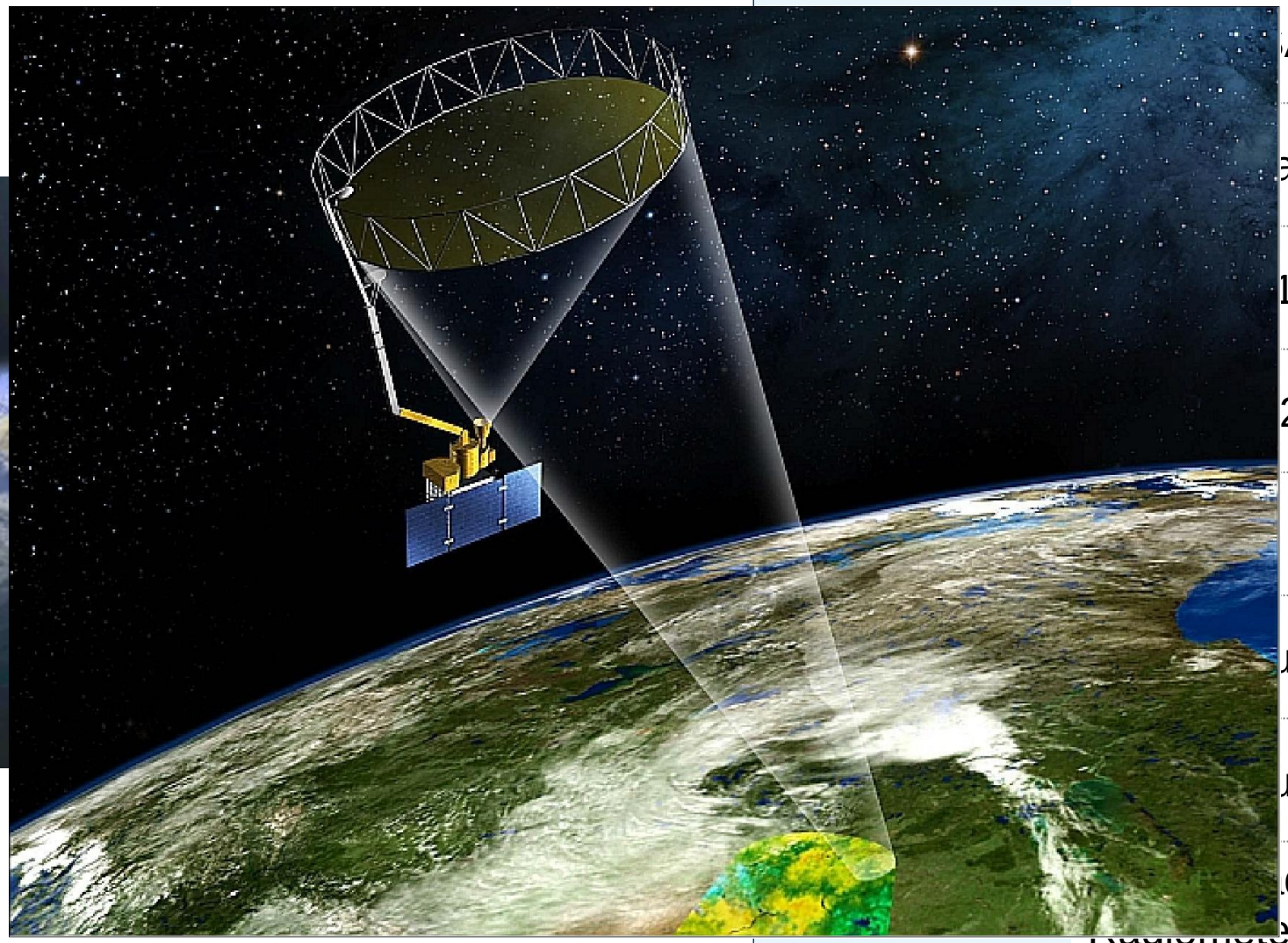
LANDSAT

Agency	USGS, NASA
Mission status	Operational (nominal)
Launch date	27 Sep 2021
End of life date	30 Sep 2026 (Expected)
	cean, Land, Snow & Ice
	Multi-purpose imagery (ocean), Snow cover, , Vegetation, Radiation budget, Ocean rents, Albedo and reflectance, Cloud type, ud top temperature, Surface temperature rpose imagery (land), Sea ice cover, edge and an colour/biology
	Normalized Differential Vegetation Index ave Earth surface emissivity, Cloud Fire Detection, Above Ground Biomass Water Extent, Fire temperature, Mineral of Absorbed PAR (FAPAR), Cloud mask, Leaf), Fire fractional cover, Land surface arth surface albedo, Short-wave Earth surface flectance, Vegetation type, Ocean imagery and water leaving spectral radiance, Land cover, Ocean chlorophyll concentration, Sea-ice cover, Glacier motion, Cloud cover, Snow cover, Sea-ice surface temperature, Iceberg fractional cover, Bathymetry, Land surface imagery, Evapotranspiration, Permafrost
Instrument type	TIRS-2, OLI-2
Instrument	Imaging multi-spectral radiometers (vis/IR)

Present Satellite Missions

SMAP



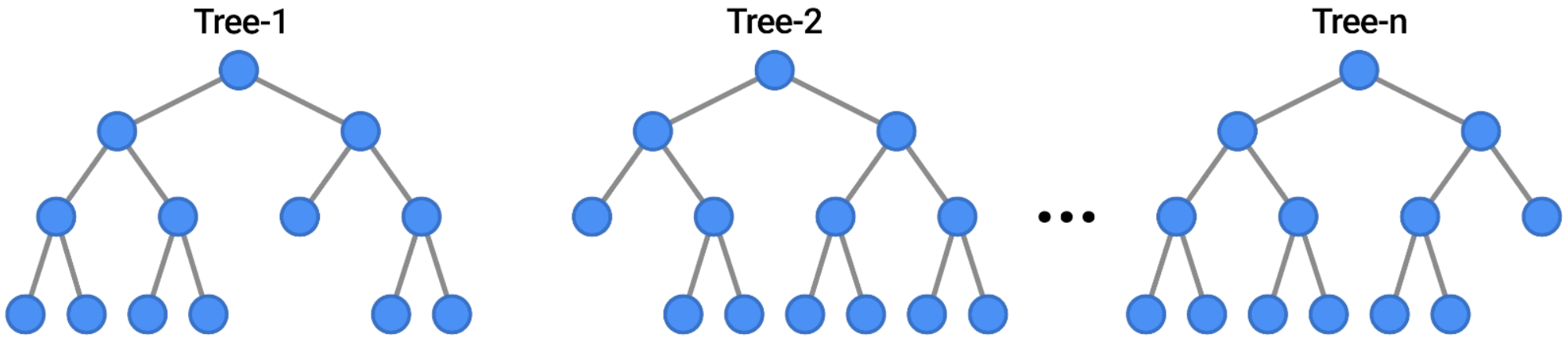


	A
	al (nominal)
	15
	23
	ure
	ure at the surface
	dar (SMAP), L-band er (SMAP)

What is Machine Learning?

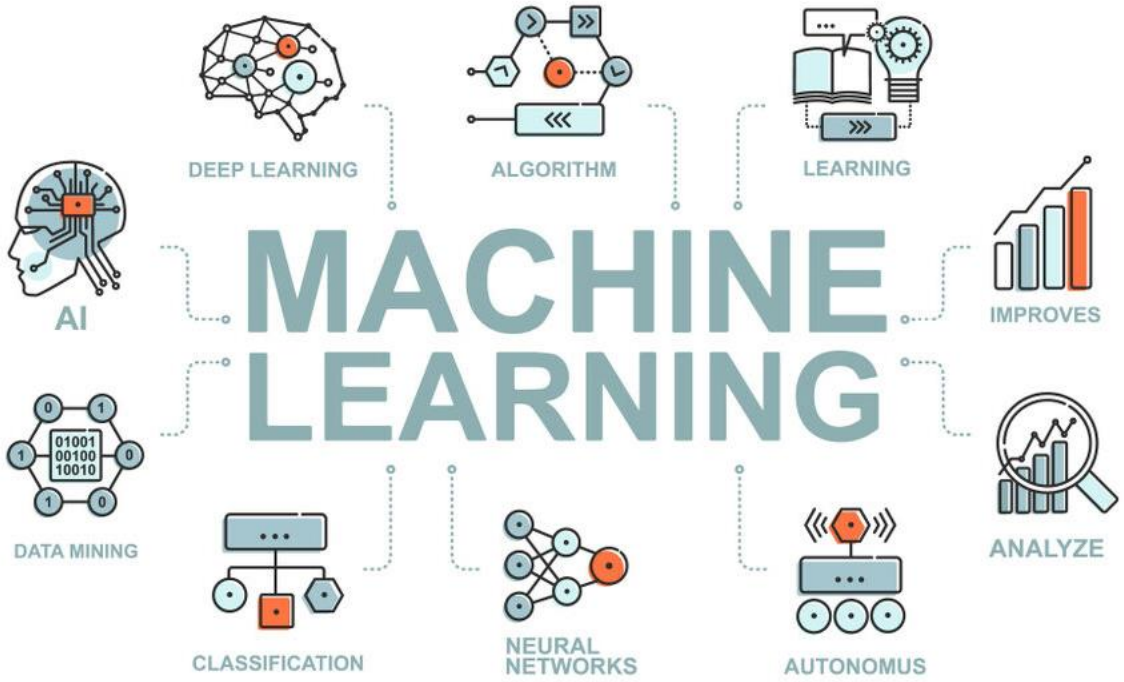
Machine learning is a branch of artificial intelligence (AI) and component of the data science field.

Through the use of statistical methods, algorithms are trained to make classifications, object identification or predictions, in uncovering key insights from the data.



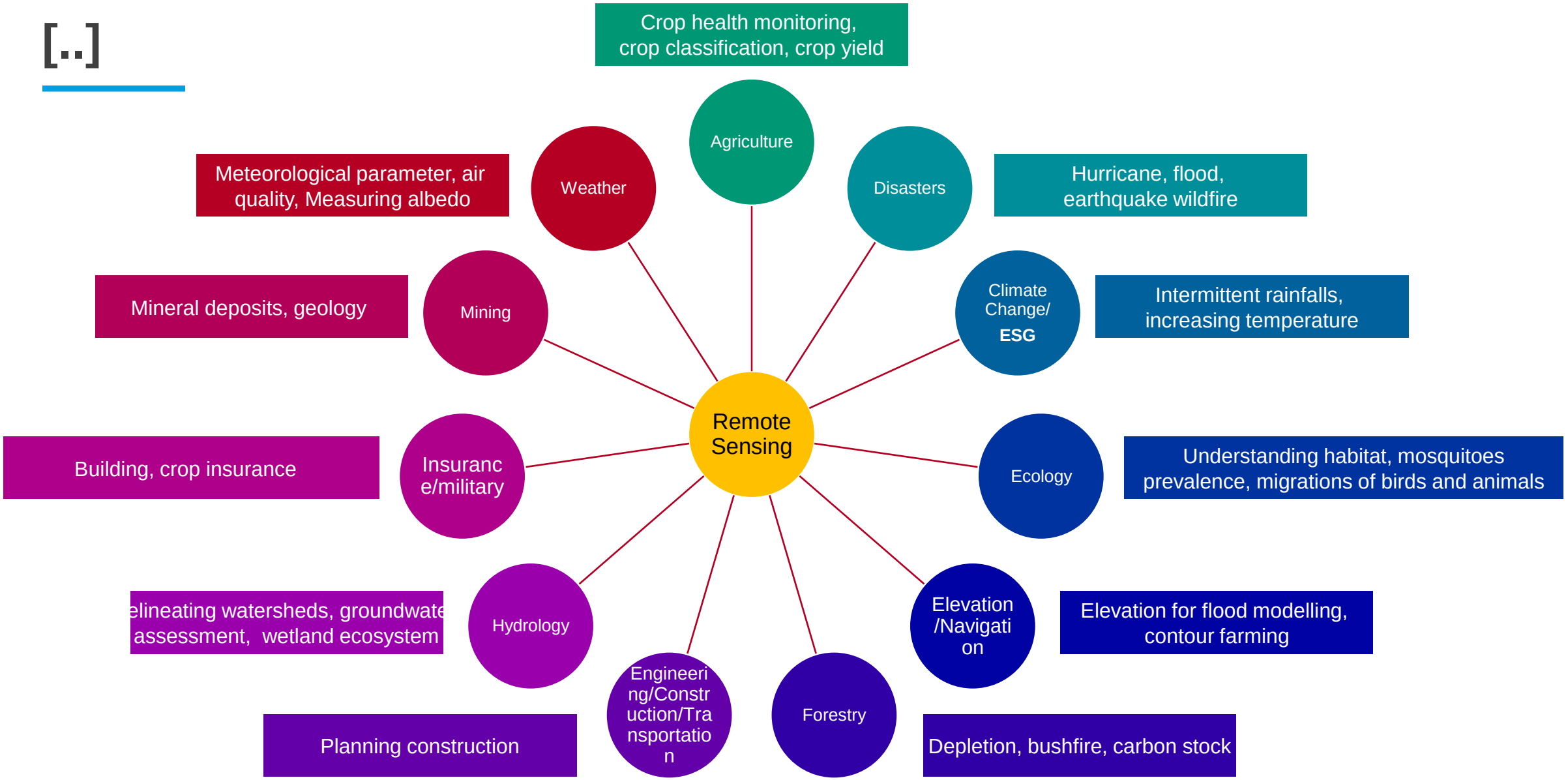
Machine Learning vs Traditional Methods

- Machine learning allows working with big data with multiple factors in deriving relationships between the data to get valuable accurate information. It can be used to model complex and non-linear relationships, and can automatically adapt to new data.
- Machine learning models are designed to make the most accurate predictions possible whereas statistical models or regression models are designed for inference about the relationships between variables into the strength and direction of relationships between variables, and don't consider every scenario and situation.
- While working at a large spatial level, machine learning algorithms provide valuable insights with limited training data.



Applications of Remote Sensing

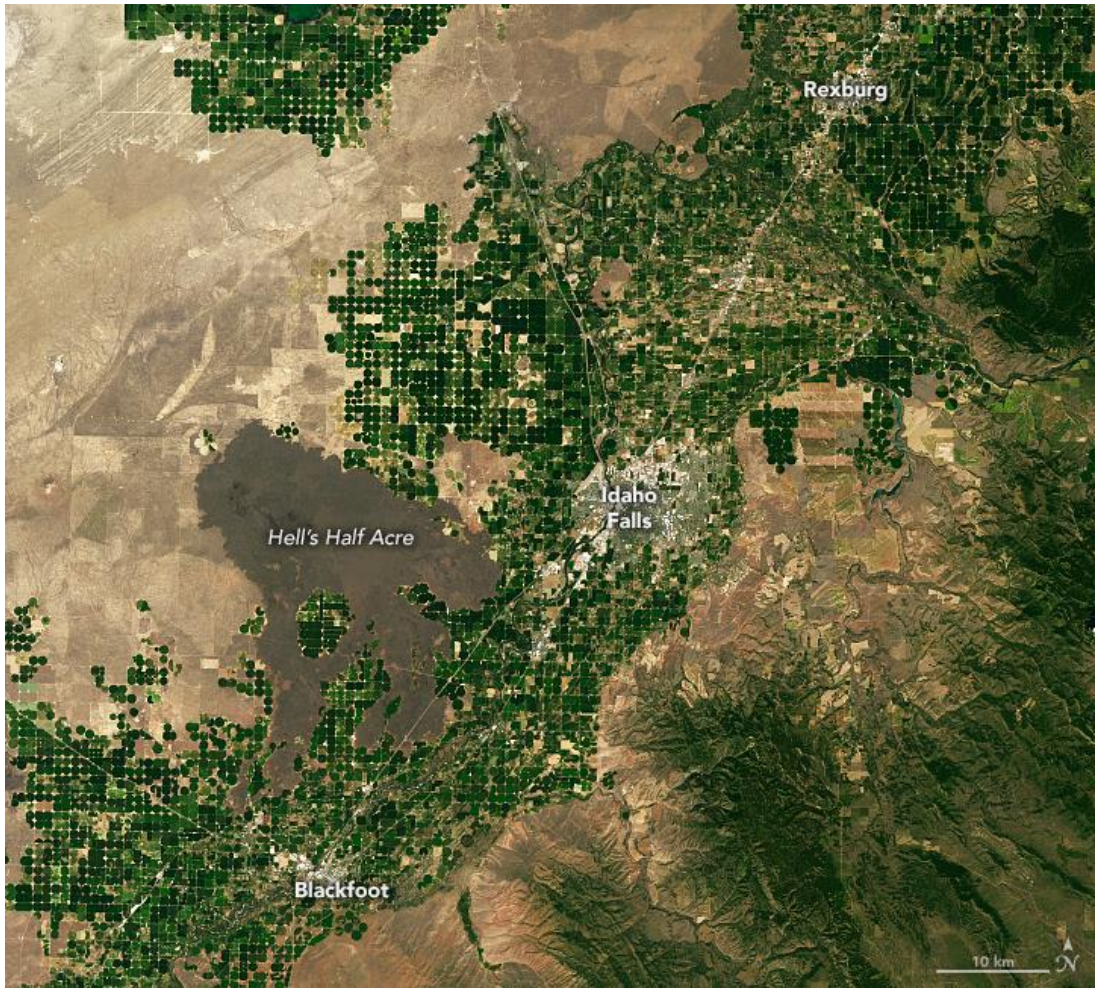
[..]



Flooded Rice Fields in Louisiana

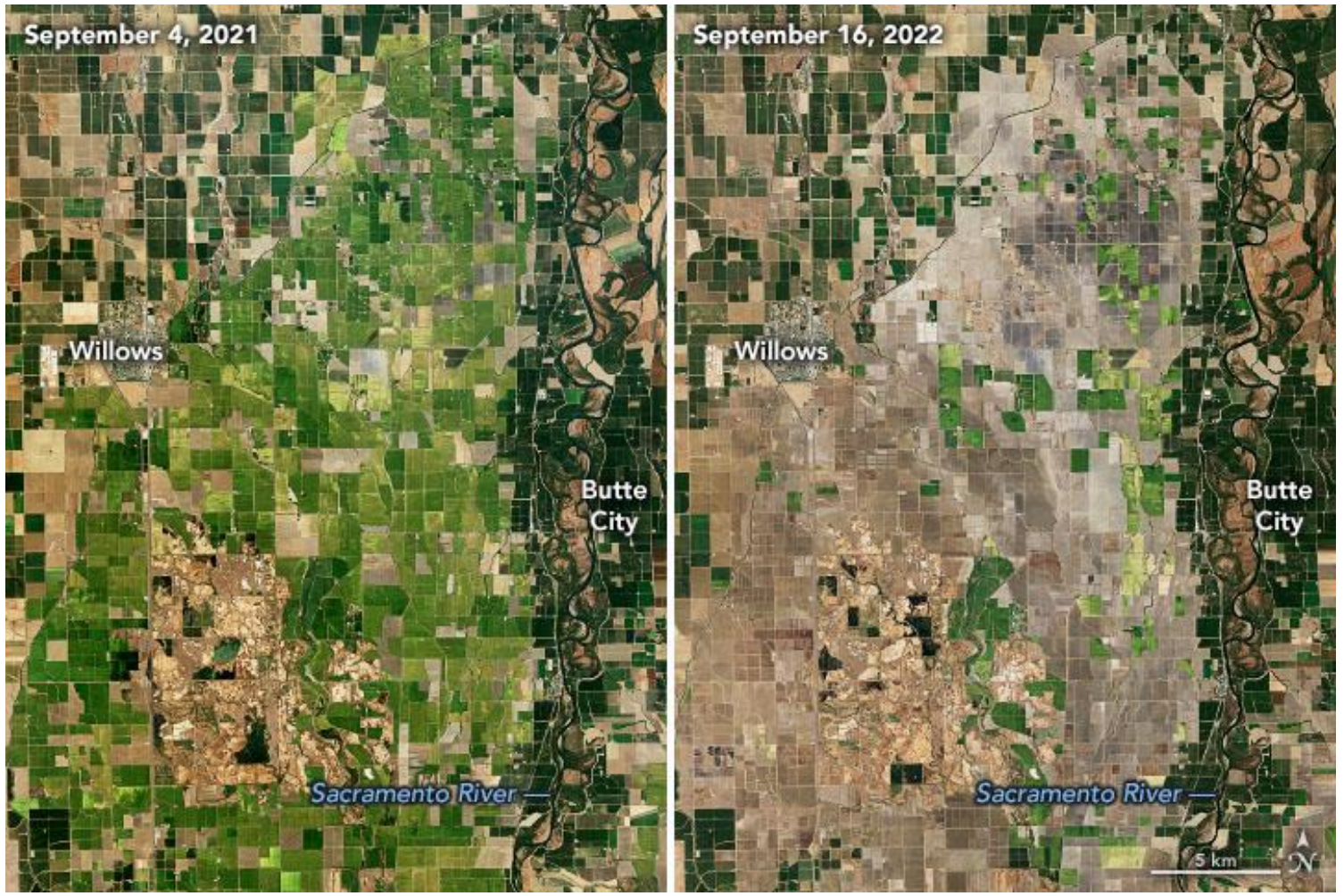
These images highlight the patchwork of flooded rice fields in Jefferson Davis Parish in southwestern Louisiana on February 3, 2023.

Idaho’s Potato Belt



Idaho is the top potato producing state in the United States. Almost one-third of the nation’s potatoes are grown in the Snake River Plain, a belt of low-lying land that extends across southern Idaho.

Crop Fields Status in Willows, California

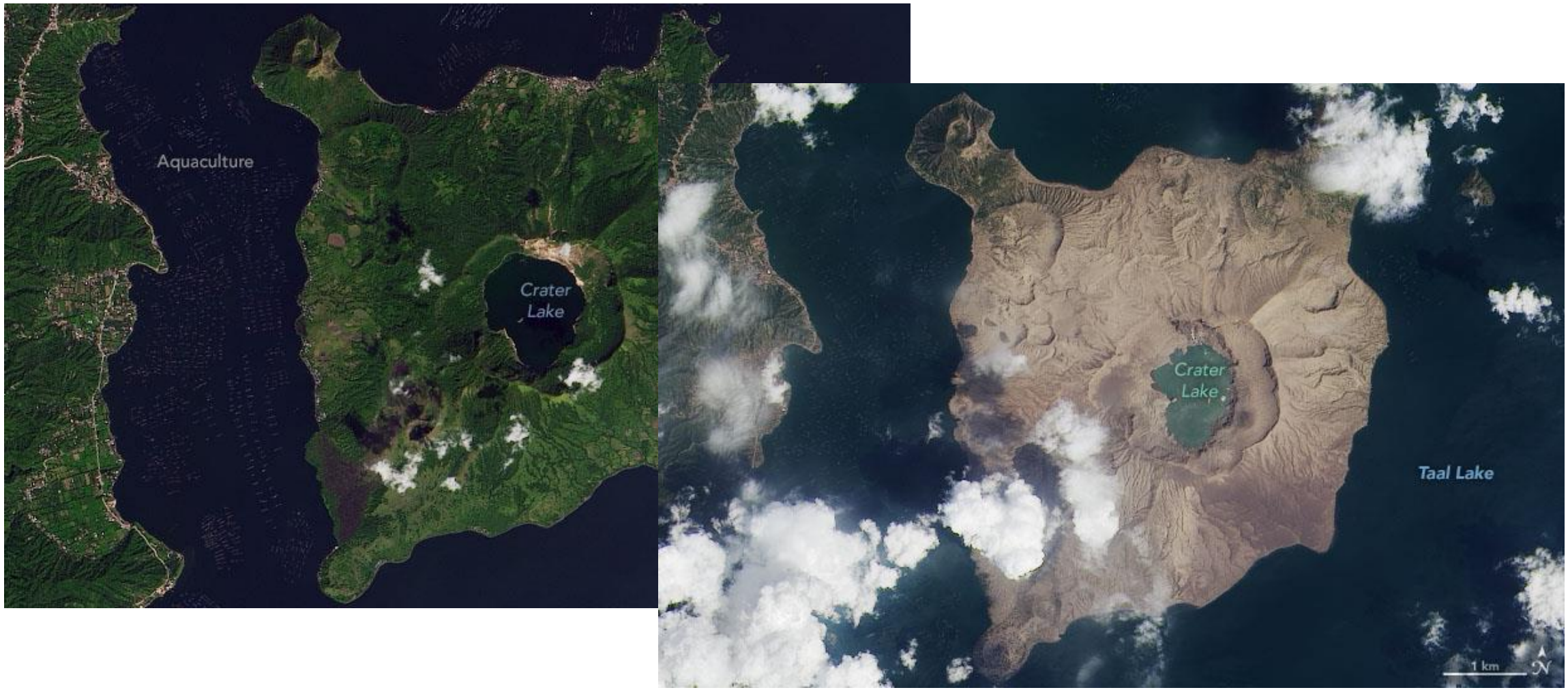


The Sacramento Valley is normally the largest rice-growing region in California, producing hundreds of millions of dollars worth of rice each year. However, 2022 has been anything but normal. Drought and water shortages have meant rice growers have only planted half as much of the grain as usual.

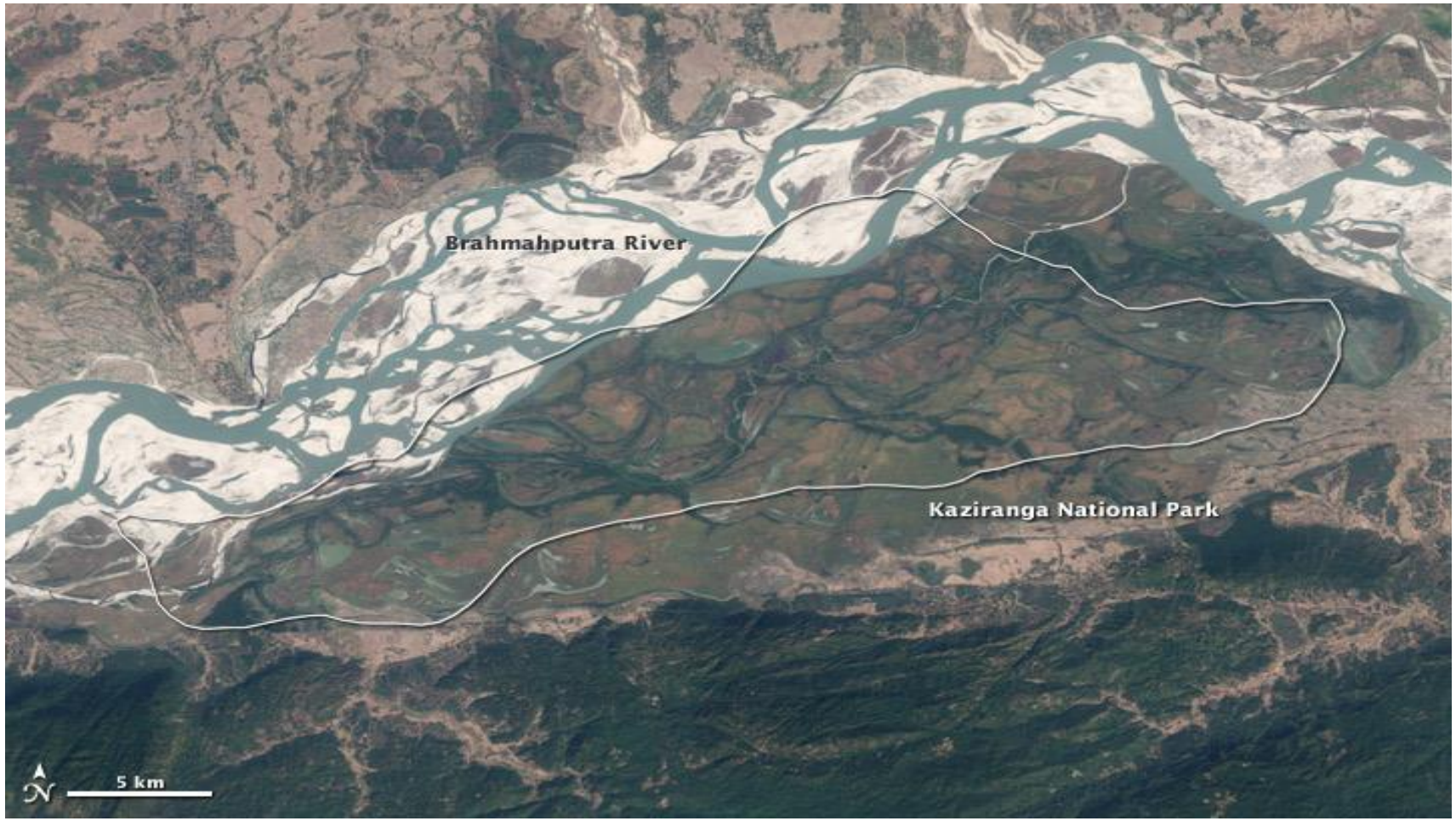
Tracking Amazon Deforestation

Since 2008, new forest-clearing hotspots have emerged in Peru and Colombia. While the spread of small-scale cattle ranching played a key role, other activities have also contributed. In Peru, gold mining, road building, and the establishment of oil palm plantations have all helped push annual clearing rates to some of the highest levels in that country since the early 2000s.

An Ash-Damaged Island in the Philippines



Kaziranga National Park, India

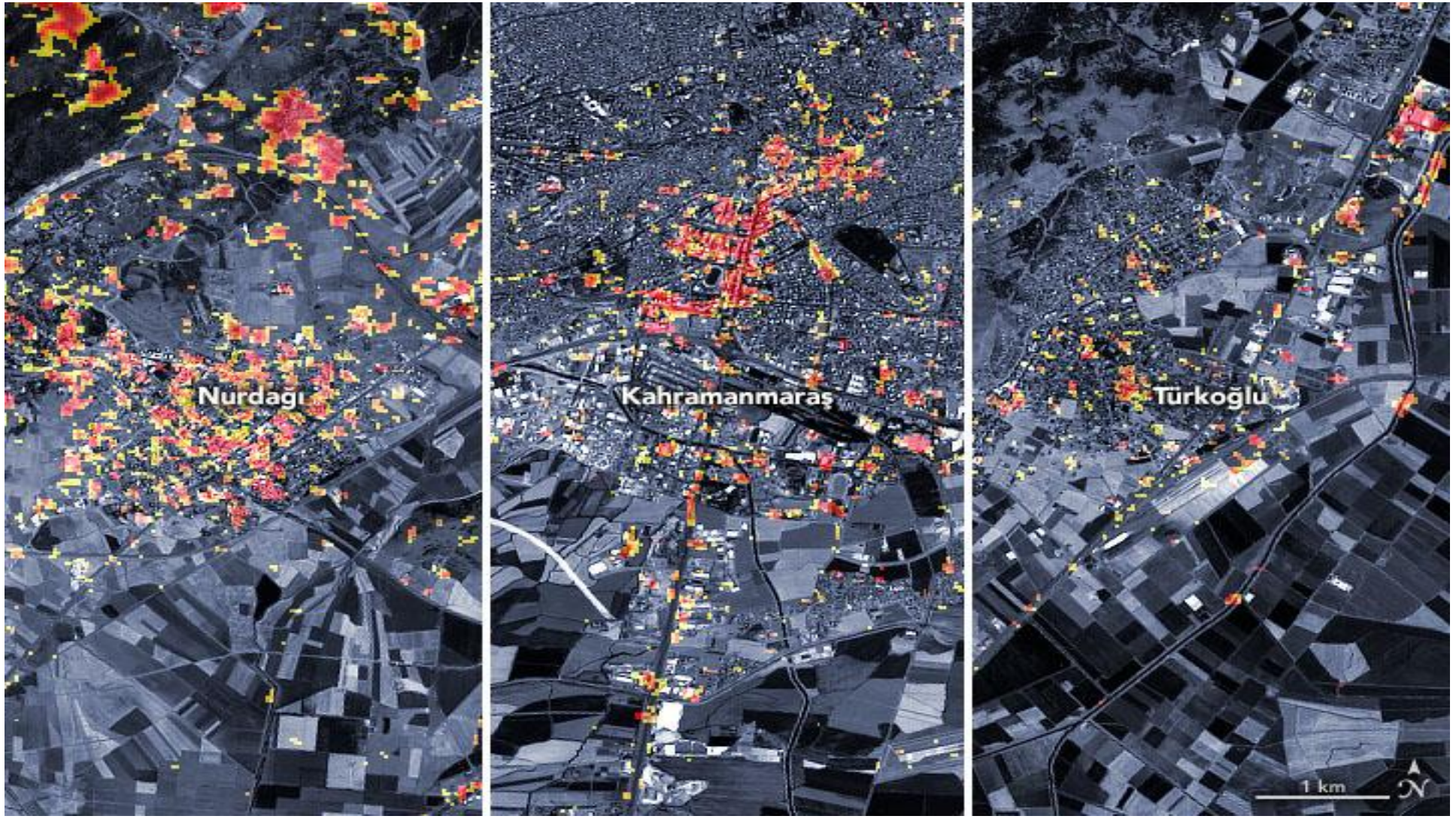


Kaziranga National Park protects a few hundred square miles of the Brahmaputra River's natural floodplain.

Landslide in Northern India

December 31, 2014, landslide blocking the Tsarap River may lead to a damaging flood downstream.

Earthquake Damage in Türkiye

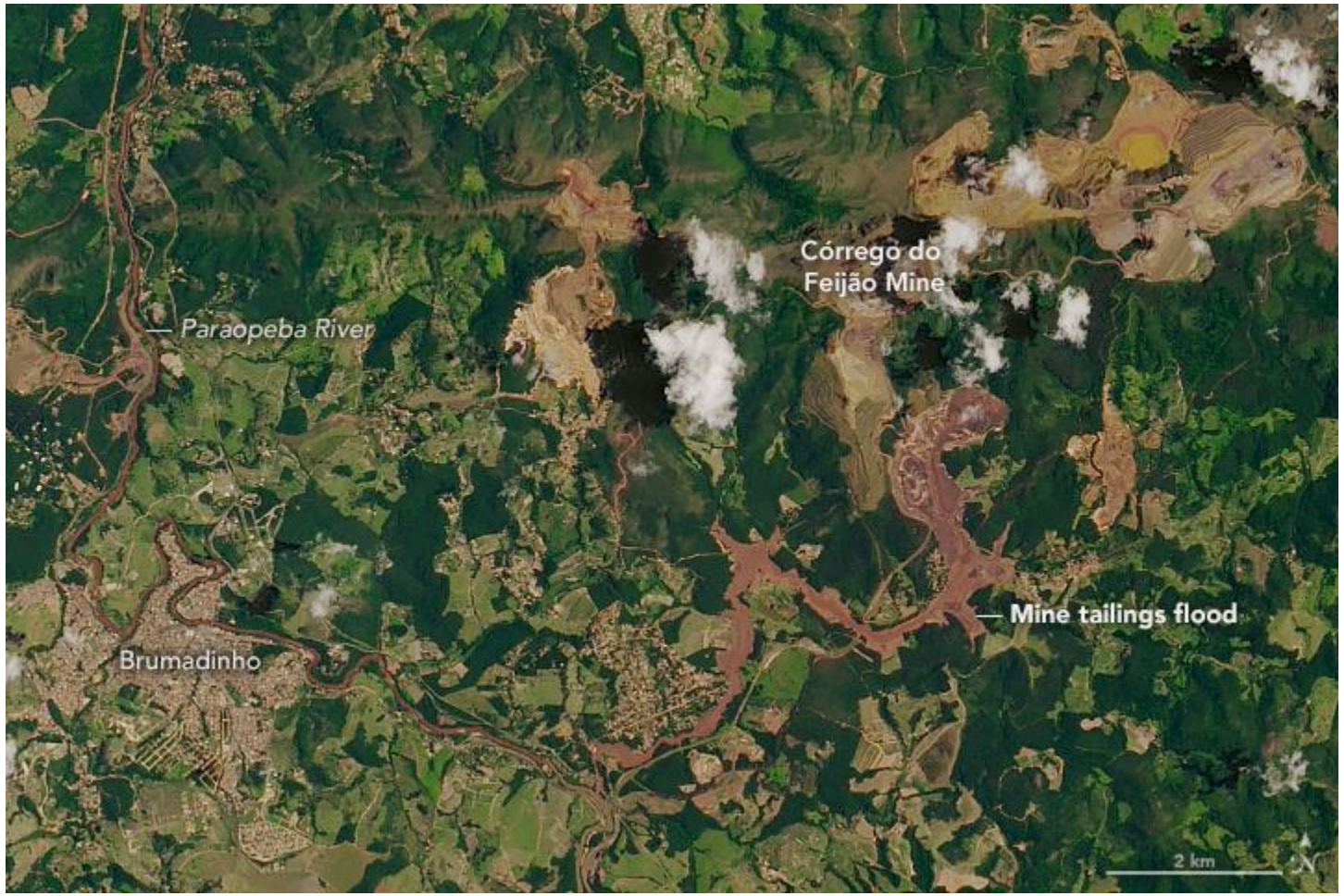


The magnitude 7.8 and 7.5 earthquakes that struck southern Türkiye and western Syria on February 6, 2023, caused widespread destruction in both countries.

Hurricane Ida Leaves a Trail of Oil

Hurricane Ida left an extensive trail of damaged homes, infrastructure, and lives from Louisiana to New England. It also has left a stain on the sea. Two weeks after the storm, several federal and state agencies and some private companies are working to find and contain oil leaks in the Gulf of Mexico.

Dam Collapse in Brazil Leading to Floods



On January 25, 2019, a retaining wall abruptly failed along the edge of a pond of mud-like waste material from a Brazilian mine.

The Landsat 8 acquired an image of the tailings dam flood on January 30, 2019. The mine wastewater appears brown. The second image shows the same area on January 14, 2019.

Wildfire in Corrientes, Argentina

Amidst a record-setting heatwave and ongoing drought, northeastern Argentina has been experiencing widespread wildfires. In late January 2022, more than a thousand fires were burning around Corrientes province, a predominantly rural and agricultural region that has seen little to no rain in two months.

Hurricane Matthew's Aftermath in Haiti

The greener image shows the area on September 26, 2016, a week before the storm.

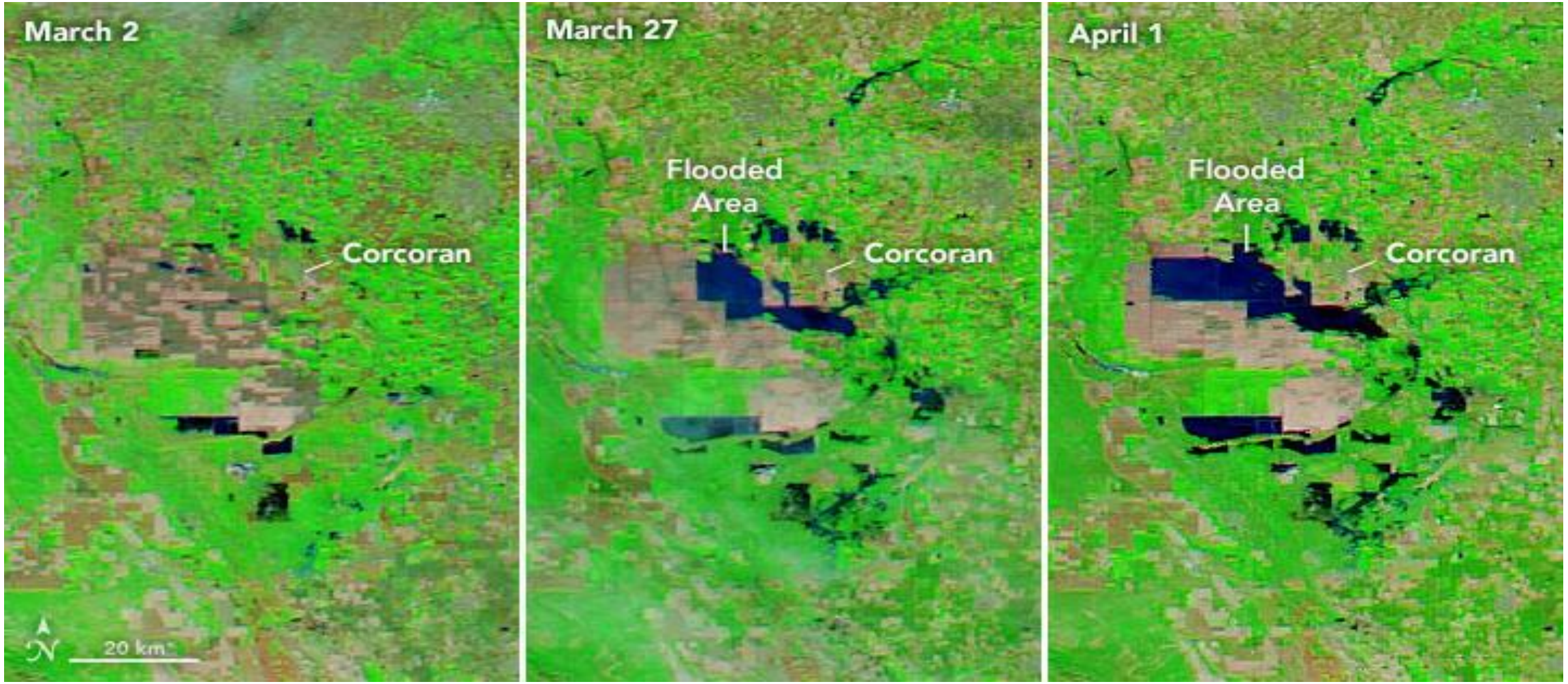
The second, browner image shows the same area on October 12, 2016, eight days after Matthew made landfass as a category-4 storm.

There is a definitive vegetation loss.

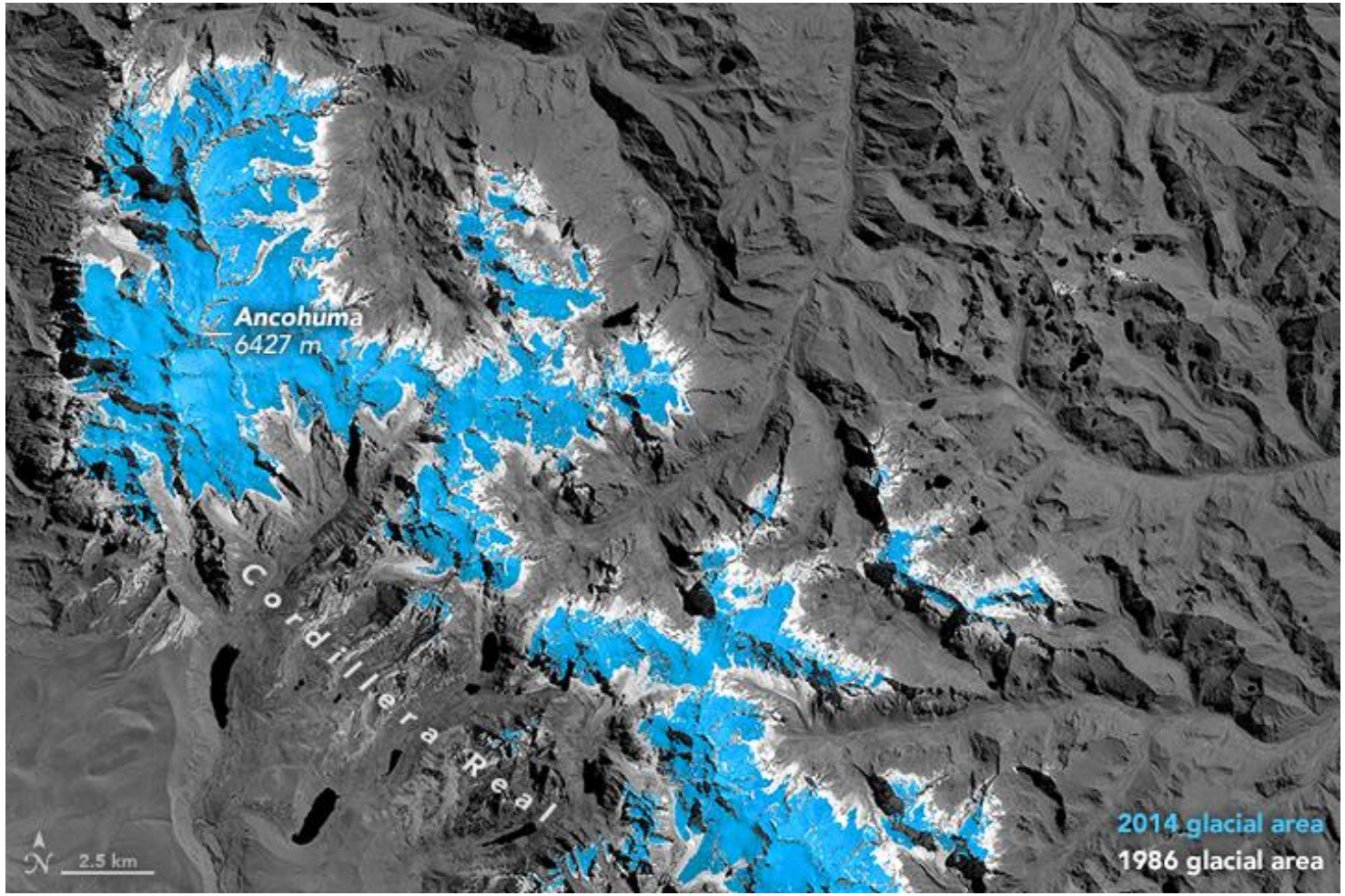
European Floods 2021

On July 18, 2021, flooding is captured along the Meuse and Roer rivers.

Return of Tulare Lake

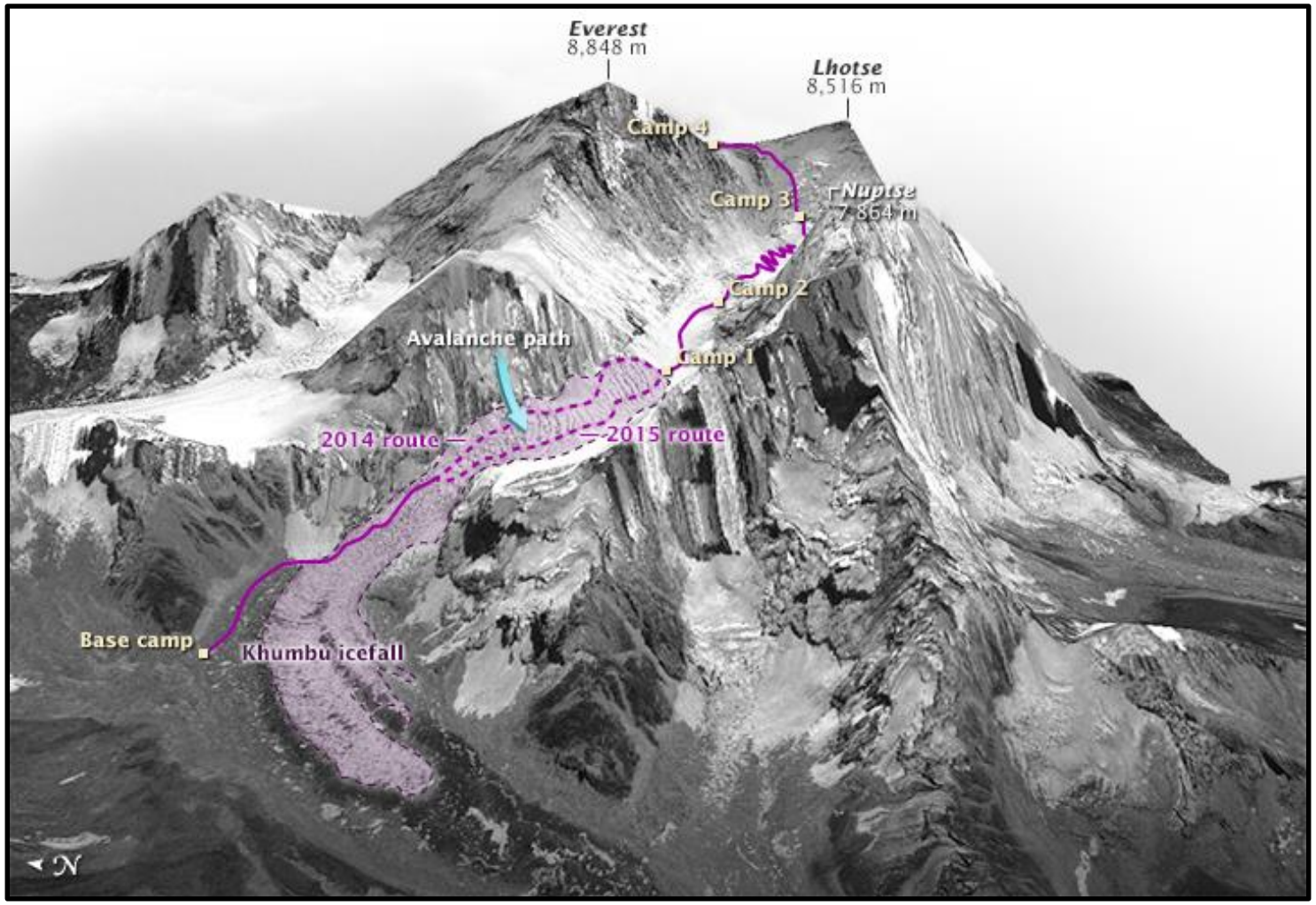


Glacier Change



The study found that glaciers in the Cordillera Real mountain range shrank in area by at least 43 percent between 1963 and 2006. The false-color image above, which uses satellite data, to observe the ice retreat along this section of the Andes.

Mt. Everest New Path



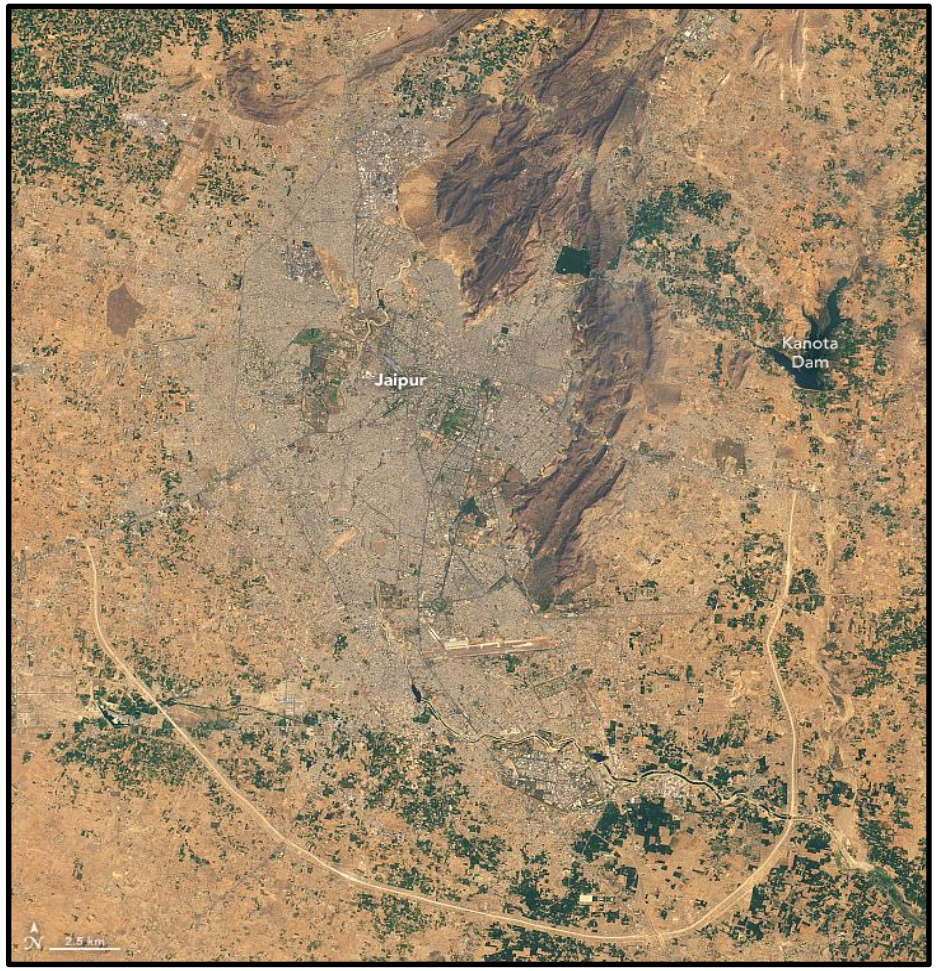
The new route reduce the avalanche risk, it will also expose climbers to more chaotic terrain. The subtle shadows that give the center of the icefall texture may seem innocuous from a satellite perspective, but at ground level these represent gaping crevasses and towering seracs that pose deadly challenges.

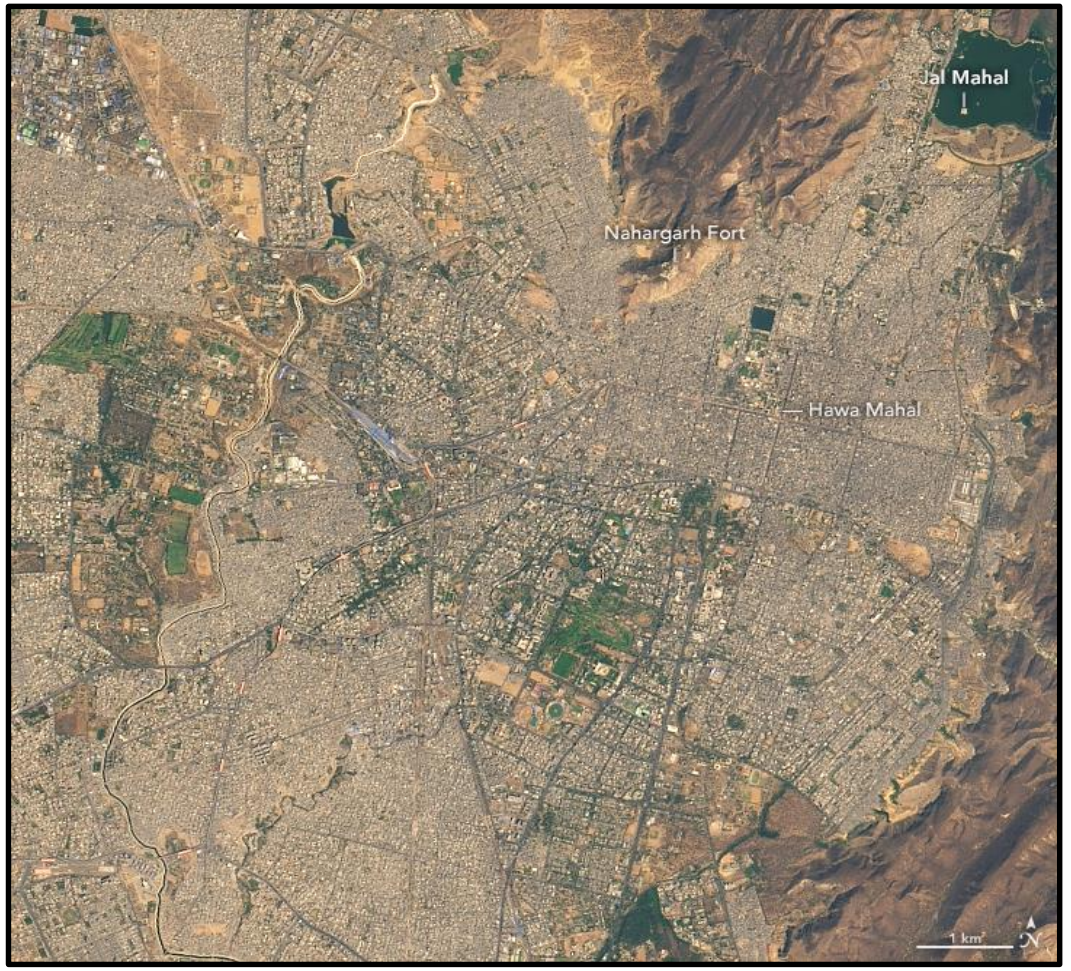
India’s Largest Salt Producer

The majority of India’s salt production: the west central-state of Gujarat accounts for almost three-quarters of the country's annual salt production.

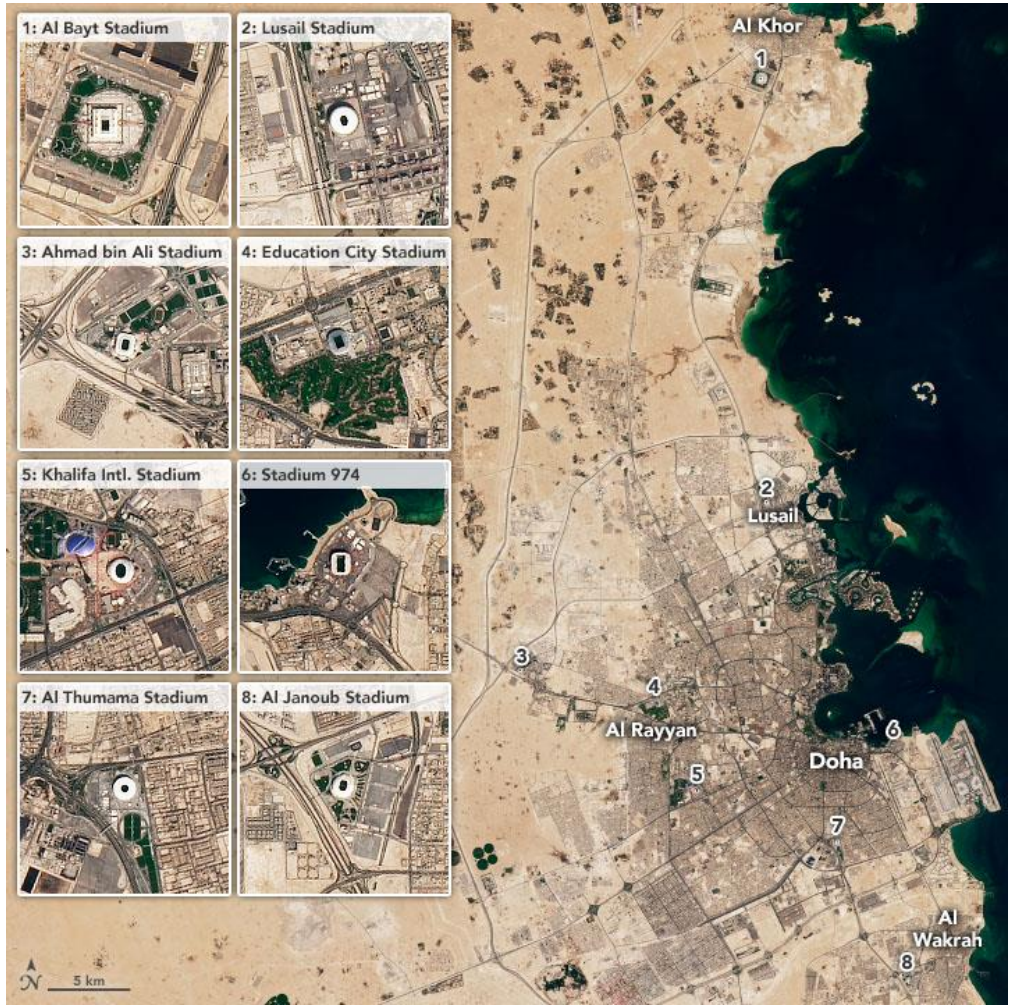
The First “Planned” City in India

The city was listed as a UNESCO World Heritage Site in July 2019.



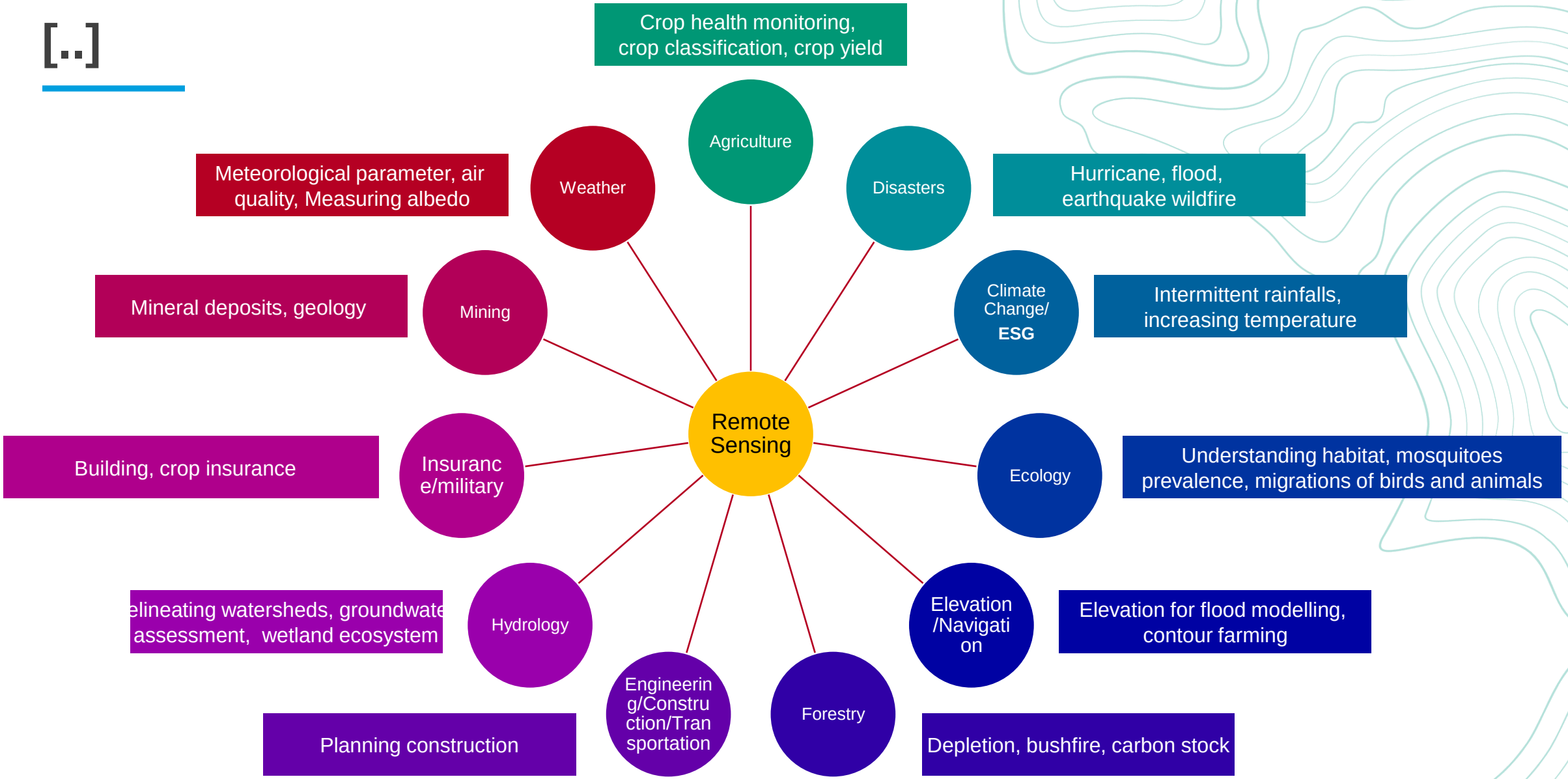


Stadium City Qatar



Thirty-two teams and more than 1 million football (soccer) fans headed to Qatar in November 2022 for the World Cup. The destination is Doha, Qatar's fast-growing capital city.

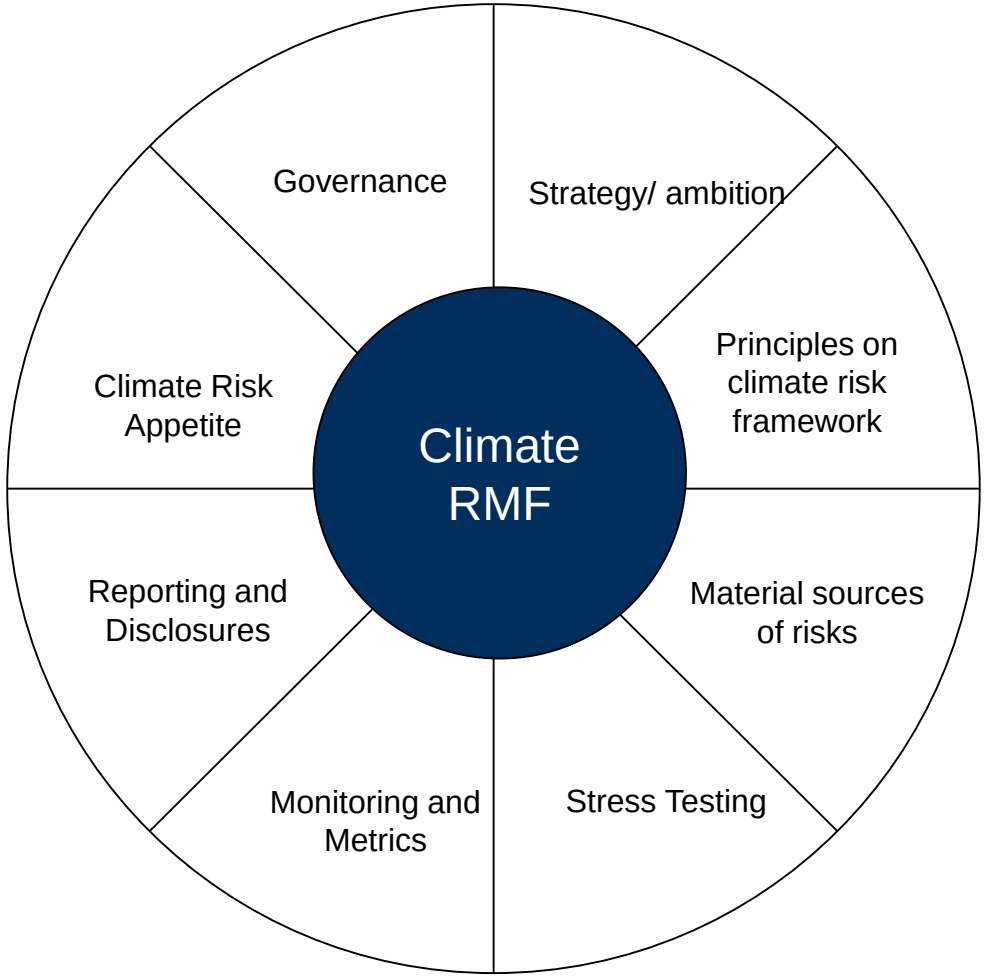
[..]



Key Drivers for ESG and climate risk

Race to Net Zero	$130 trillion AUM of financial institutions have now pledged to align financing with net zero by 2050, as signatories of GFANZ Flows into sustainable investment funds in the U.S. in 2022 reached > $55 billion
Regulatory Drivers	EIOPA, EBA, SEC, APRA , SEBI, RBI released guidance and rule books to assist financial and non - financial institutions for managing climate-related risks and opportunities.
Government Action	Significant increase in public and blended finance commitments, including $180 billion mobilized to finance climate adaptation and resilience in developing countries
Shareholder Pressure	32% CEOs, 28% Boards, 44% Investors see climate as top three challenge to negatively impact business growth
Global pressure	Globally TCFD, SASB, CDP,CSRD, SFDR and similar framework, central banks, and International Sustainability Standard Board (ISSB) are pushing for better practice in sustainable finance

Embedding climate risk into business model



Physical Risk

- Physical risks corresponds to the potential impacts caused by climate-related hazards, which can be acute (i.e., event driven) or chronic (i.e., long-term shifts in climate patterns)

Transition Risk

- Transition Risks corresponds to the potential impacts associated with the process of transitioning to toward a low-carbon economy. Examples include policy, innovation, customer, market, and reputation

Litigation Risk

- Any risk related to litigation pertaining to climate change and breach of the underlying legal frameworks on both the business and corporate levels

ESG Data Fabric - Growth of ESG and climate risk data

ESG Data fabric

Business resilience Data focus

Regulation Harmonization

- Perform assessments on this data to produce economic classifications
- Enabling reporting on regulations such as SFDR, TCFD, EU Taxonomy

Reputation Risks

- Manage reputational risks through stress testing, staying on top of regulations, and being aware of investment and credit risks
- Protect customer data and protect reputation

Strategic and Differentiating Data Focus

Commercial Strategy

- How to align portfolios to ESG targets and engage with customers and investors
- How to construct new products tapping into retail customer demand for Sustainability linked offerings and Corporate clients funding needs for their transition

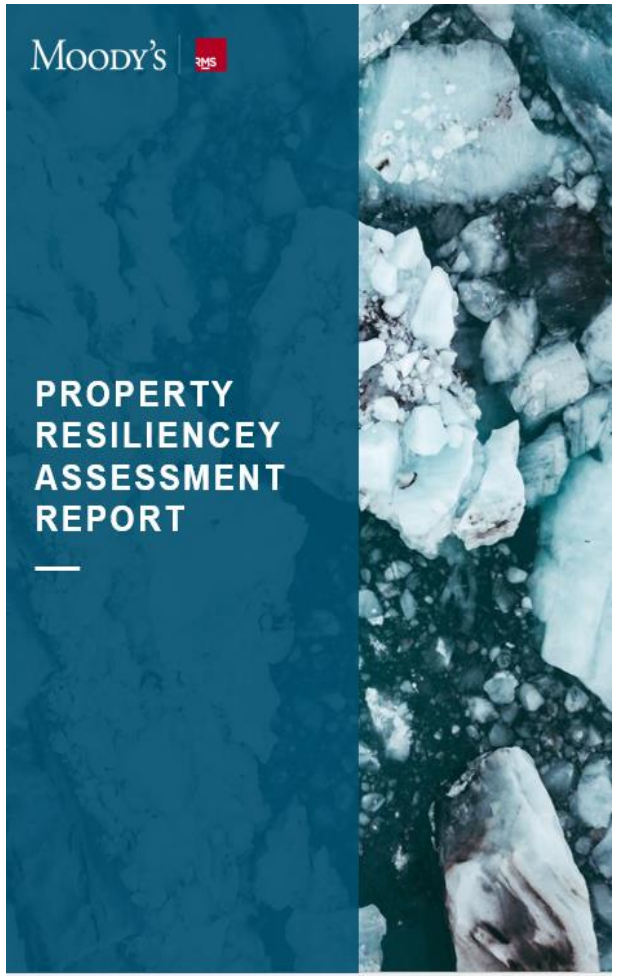
Supply chain management

- Identification of key strategic suppliers and develop a program that increases collaboration, engagement and upskill suppliers
- Maximize use of known and ‘hidden’ supply chain and other data (e.g. Tax)

Data challenges - ESG & Climate risk

	Volume of Data	Data Accuracy	Data processing	Cost of data
Traditional Challenges and Impact	Volume of data needed is growing day by day due to changes in Business environment, regulations, and evolving business landscape	This shortfall in data completeness reduces the accuracy of modeled results and heighted uncertainty of loss estimates, hence impacting financial decisions	Volume and Frequency	• Third-party vendors • Storing, achieving and housekeeping
Additional complexities	• Commitment to incorporating ESG and Climate risk > 3000 Asset managers and US $ 75 + trillion of assets • 85% of S&P index companies publish sustainability and climate risk reports • Standardization- Multiple sources of Data, multiple regulations and frameworks • Different needs for large and SMEs. • Lack of reliable data- Huge financial risk		• Data processing speed • Data Ingestion • Frequency of change • Green-washing	• ESG data is an additional cost to the company • Housekeeping • Compliance • Auditability and traceability
New age Tech enablement	• AI/ML algorithms leveraging learnings from thousands of accounts processed each year to validate data by running over 800 checks for data anomalies. • Automated end-to-end workflows with minimum manual interference to maintain the purity of data • API based tools to reduce processing time • Multi Discipline Workforce of more than 350 analysts at Moody's RMS (Engineering, Economics Mathematics & Statistics, ESG and climate experts) bringing their expertise to the organization • Capabilities beyond models – (best in class database), ESG score predictor)			

Commercial Real Estate – Sample Report



Our Solution for CRE

1. Physical Risk Scoring

PHYSICAL CLIMATE RISK SCORE CARD

RMS has assessed facility's potential exposure to hazards affected by climate change. The assessment includes impact scores, loss cost and standard deviation across all seven risk categories (Tropical Cyclone, Inland Floods, Coastal Floods, Wildfire, Heat Stress, Water Stress, and Earthquake). The tool utilized for this assessment is Moody's *Climate on Demand Pro (CoD Pro)*. The application enables to quantify the relative risk associated with different RCPs at selected eras between 2020 and 2100. As shown in the table below, the *CoD Pro* impact scores indicate that the sample property is at high risk of hurricanes and coastal flooding. Further hazard analysis of the location shows that location is in regular path of cyclones and is close to coastline.

Physical Climate Risk	Climate Impact Score		Loss Cost		Standard Deviation	
	Baseline	RCP 4.5 2030	Baseline	RCP 4.5 2030	Baseline	RCP 4.5 2030
Water Stress	0	0	0	0	0	0
Wildfire	0	0	0	0	0	0
Inland Flood	1	1	0.001	0.001056	0.001545	0.001723
Coastal Flood	59	62	0.683354	0.804474	7.481966	8.341801
Tropical Cyclone	98	99	1.920722	2.141454	30.774356	32.494587
Earthquake	30	30	0.004586	0.004586	1.722743	1.722743
Heat Stress	54	67	0.065902	0.107522	0.091333	0.119878

Low Med High None Red Flag

2. Sensitivity Analysis of Modifiers

DETAILED ANALYSIS OF A SINGLE PROPERTY ATTRIBUTE

Modifier	Ground-Level Equipment
Physical Risk Factor	Surge
Implementation Priority	High
Estimated Implementation Cost	$25,000
Reduction in annual expected damage	$3,108

Existing Condition of the Attribute:

The condensing units present at this property are not fastened to the concrete pads which are at grade level. This may lead the equipment to lift-off or become loose during high wind or flooding events.

Recommendation:

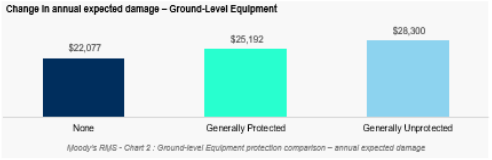
The presence of ground-level equipment increases the vulnerability of the location to surge (sea level rise) damage. It is recommended to structurally fasten the condensing units.

Cost benefit analysis:

By securing the mechanical or electrical systems at the ground level of the building, the average damage from flooding can be reduced to $25,192 from $28,300 i.e., - $3,108

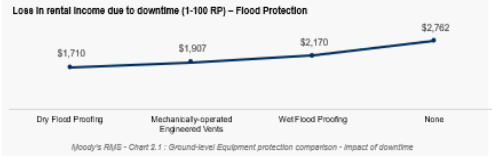
Current state Alternatives Recommended

Change in annual expected damage – Ground-Level Equipment



Moody's RMS - Chart 2 : Ground-level Equipment protection comparison – annual expected damage

Loss in rental income due to downtime (1-100 RP) – Flood Protection



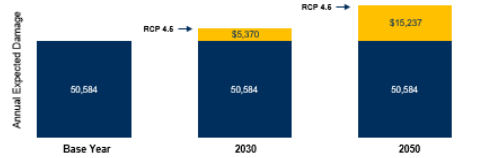
Moody's RMS - Chart 2.1 : Ground-level Equipment protection comparison - impact of downtime

3. Climate Change Scenario Analysis

CLIMATE SCENARIOS ANALYSIS USING PROBABILISTIC MODELLING

The expected damage to the property is $50,584. For RCP 4.5, this damage can increase up to 11% for 2030 and 30% for 2050. The difference in the risk to property between base year damage and RCP 4.5 damage is $5,370 in near term, 2030, and increases to $15,237 for 2050.

Change in Annual Expected Damage under different climate scenarios

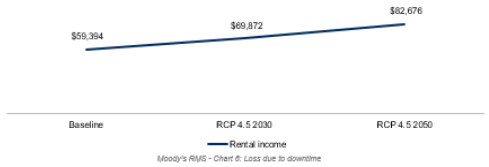


99% VaR (1-100 RP damage)	Baseline	RCP 4.5 2030	RCP 4.5 2050
Windstorm	$95,074	$111,615	$125,286
*Surge	$142,263	$283,566	$652,153

Estimated loss of gross rental income due to downtime (1-100 RP)

Assuming that per annum gross rental income per multi-family unit is $24,000, the property can expect almost 12 days of downtime from a 1-100 year return period event. This translates into a loss of $59,394 in rental income per annum due to wind and surge events under a baseline scenario.

Loss due to downtime (1-100 Year RP)



Moody's RMS - Chart 6: Loss due to downtime

Summary

Summary

- Applications of remote sensing technology
- Machine learning utility with remote sensing to derive numerous products and valuable data towards development at global scale
- The scope is endless and with advancement of technology, data science, cloud platform, expansion and innovation is vast

Thank you.