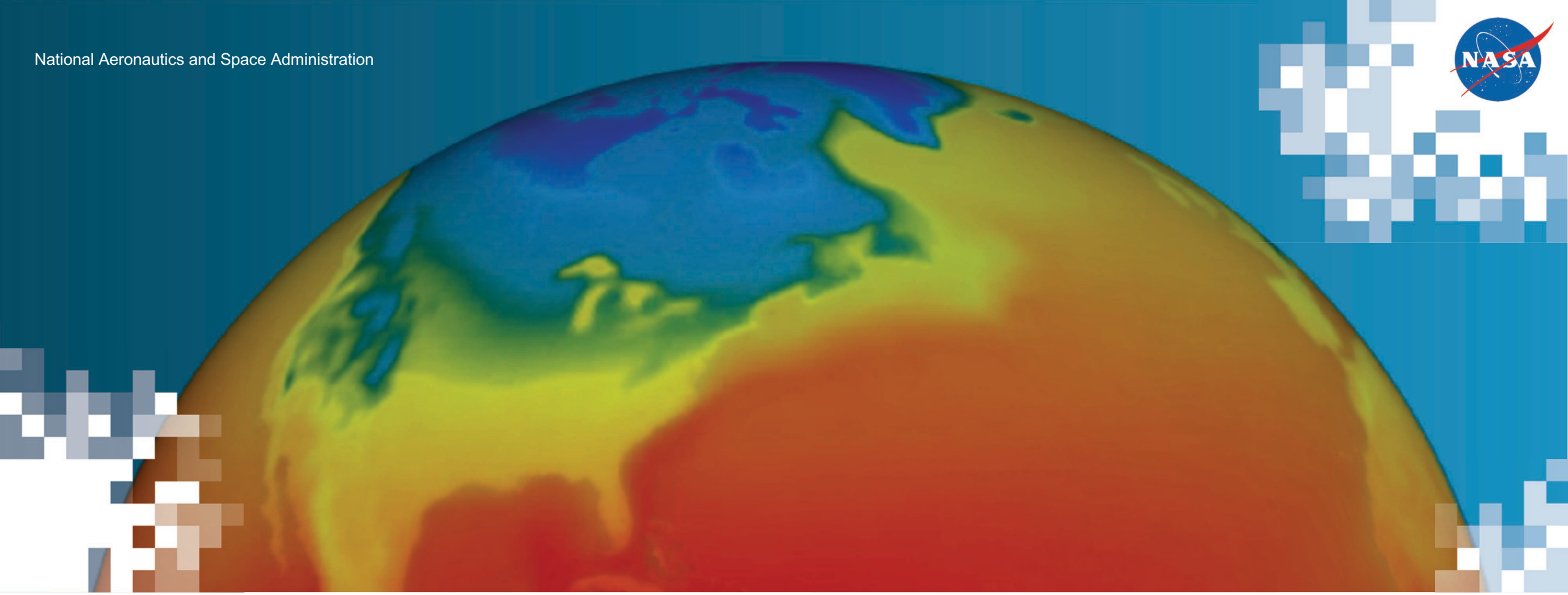
National Aeronautics and Space Administration



Part 1: Introduction to Earth Observations for Energy Management

June 1, 2021

BATTELLE

Training Outline

- Part 1: Introduction to Earth Observations (EOs) for Energy Management
  - June 1
- Part 2: Using NASA Products for a More Climate Resilient Energy Sector
  - June 8
- Part 3: NASA Resources for Renewable Energy and Building Energy Efficiency Applications
  - June 15
- Part 4: Data Access: the NASA Prediction of Worldwide Energy Resources (POWER) Project
  - June 22

Course Logistics

- Four 1-hour presentations with Q&A
  - Course recordings will be available on the training webpage
- **Homework:**
  - One homework assignment given after Part 4
  - Answers must be submitted via Google Forms
  - **HW Deadline: Tuesday, July 6**
- **Certificate of Completion:**
  - Attend all four live parts
  - Complete the homework assignment by the deadline (access from ARSET website)
  - You will receive certificates approximately three months after the completion of the course from: marines.martins@ssaihq.com
- **Prerequisites:**
  - Fundamentals of Remote Sensing

Course Learning Objectives

- Summarize priorities and challenges in the energy management sector and how various Earth observations can support decision-making

- Learn about online tools for acquiring data from satellite missions and visualizing data or conducting analyses

- Gain familiarity with how to use NASA data for various example case studies in renewable energy, energy efficiency, and climate resilience

Speakers

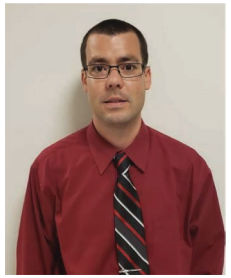
Natasha Sadoff is a Senior Research Scientist at Battelle Memorial Institute who specializes in capacity development, science translation, and stakeholder/end user engagement in environmental management, including energy, air quality, and other areas.

Amy Leibrand is a Lead Social Scientist at Battelle Memorial Institute who has a decade of experience matching Earth observation data with end users' needs to enhance decision making in areas such as climate vulnerability, vector-borne disease outbreaks, and energy management.

Meredith Fritz is a Social Scientist at Battelle Memorial Institute with expertise in information dissemination and outreach in environmental and health topics. She has expertise in global health, human dimensions of environmental change, and how to engage stakeholders and end users in research.

Speakers (Continued)

Paul Stackhouse is a Senior Scientist at the NASA Langley Research Center who leads teams estimating and understanding the Earth's radiative budget at the top of atmosphere and the surface from satellite observations and radiative transfer. He also specializes in preparing those and additional data products for use in renewable energy, sustainable building and agroclimatological applications.

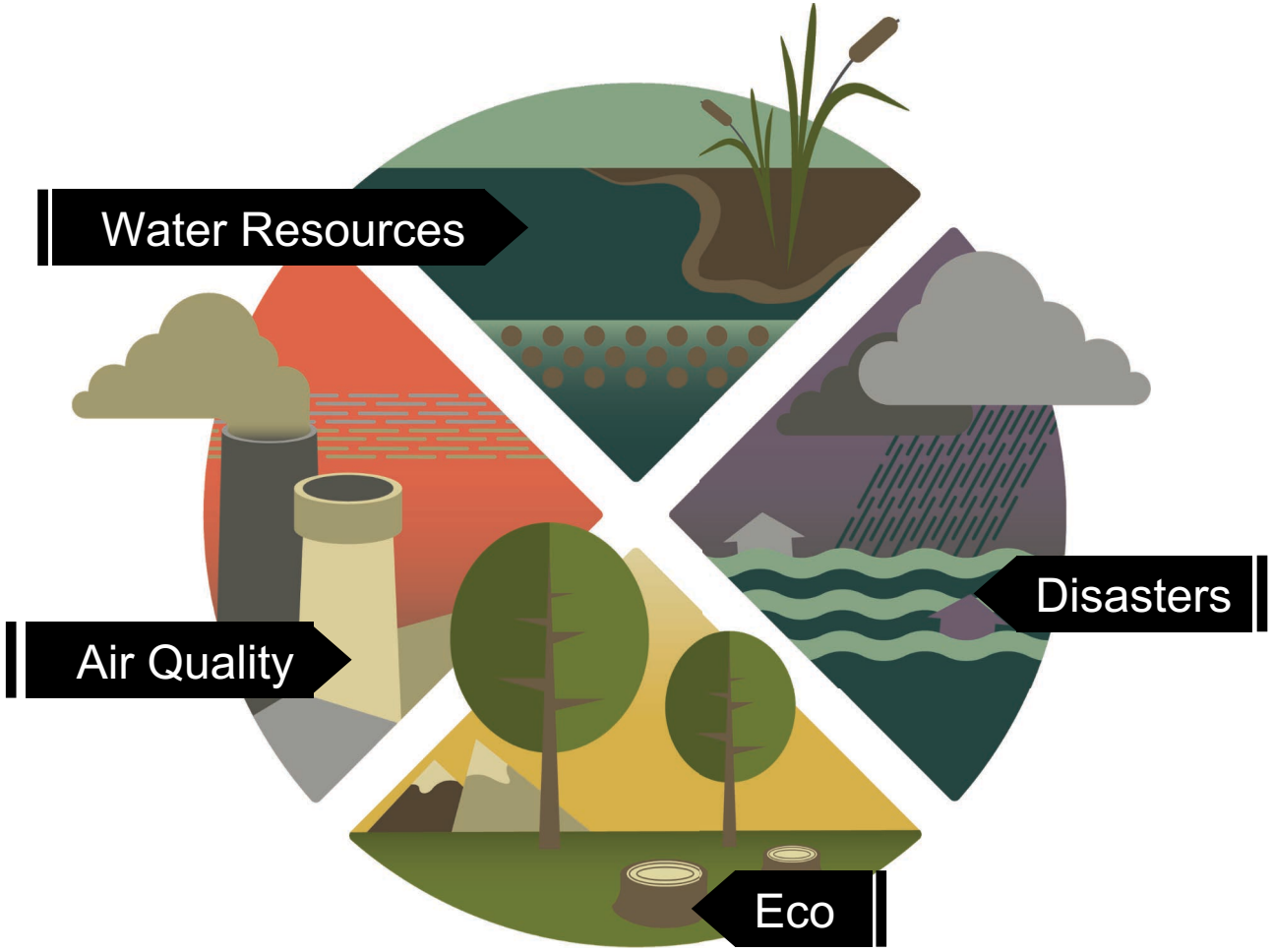


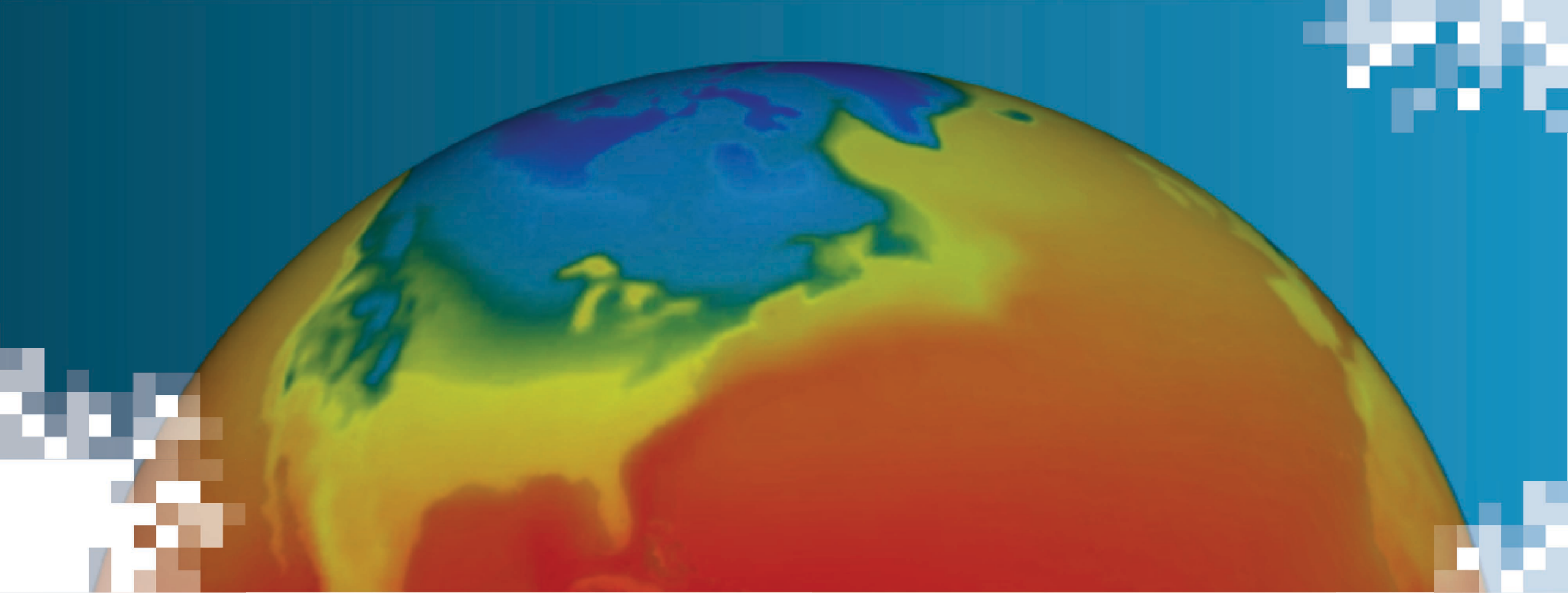
Bradley Macpherson is a Geospatial Developer supporting the NASA Prediction of Worldwide Energy Resources (POWER) project. He leads the development and sustainment of data distribution services and the data processing pipeline to support near-real-time data distribution to the public to enable open science. Additionally, Bradley specializes in data science, spatial analysis, and geospatial policy to support public accessibility and usability of earth observation data.

NASA's Applied Remote Sensing Training Program (ARSET)

https://appliedsciences.nasa.gov/what-we-do/capacity-building/arset/about-arset

- Part of NASA's Applied Sciences Program
- Empowering the global community through remote sensing training
- Seeks to increase the use of Earth science in decision-making through training for:
  - Policy makers
  - Environmental managers
  - Other professionals in the public and private sector



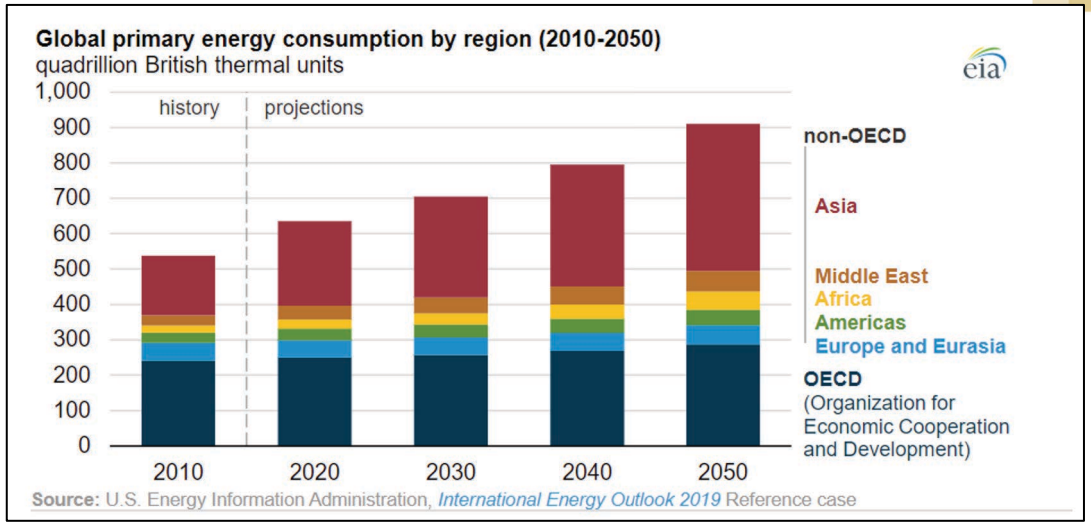


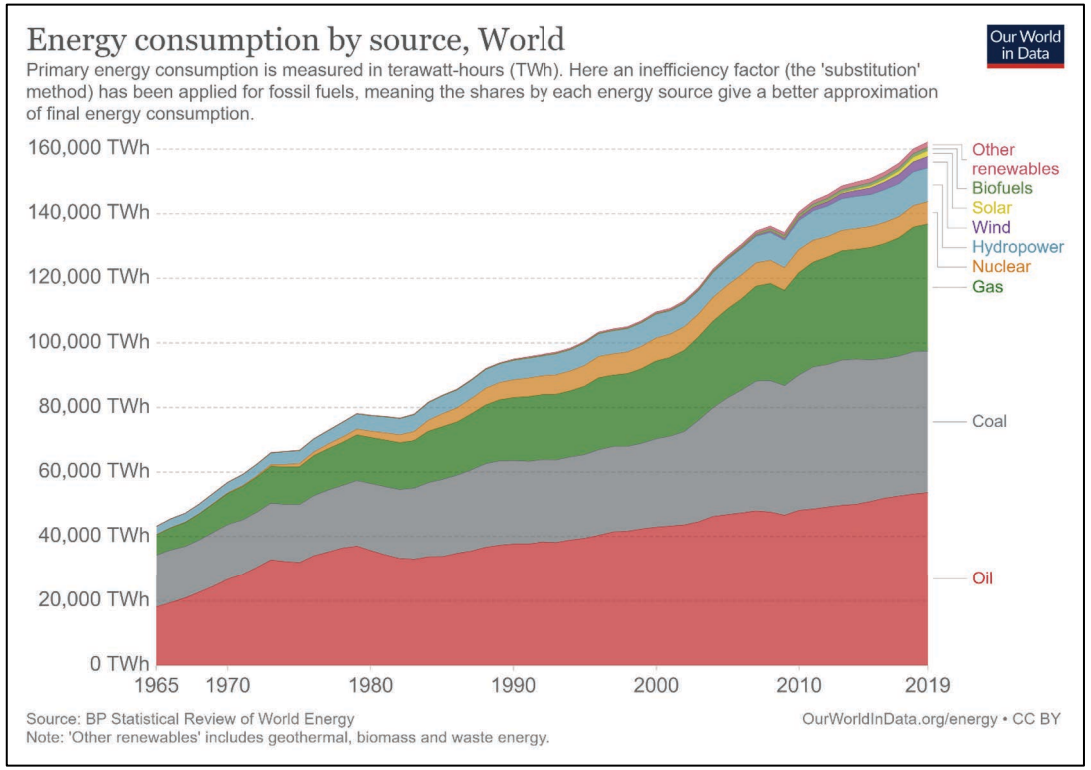
Introduction to Earth Observations (EOs) for Energy Management

Overview of the Energy Sector

Global Energy Sector Snapshot

- Sourcing
  - Until 2019, global energy use consisted primarily of fossil fuels, but renewable energy incentives and falling technology costs support robust competition with natural gas as coal and nuclear power decrease in the electricity mix
  - Solar taking the lead in renewable energy generation
  - Coal demand decreases worldwide
  - Natural gas demand projected to increase in South and East Asia

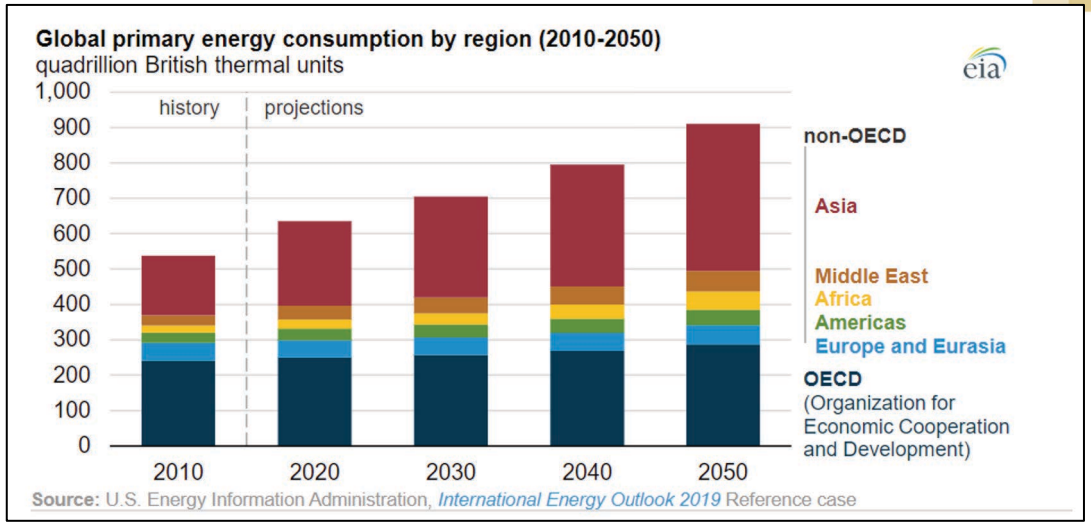


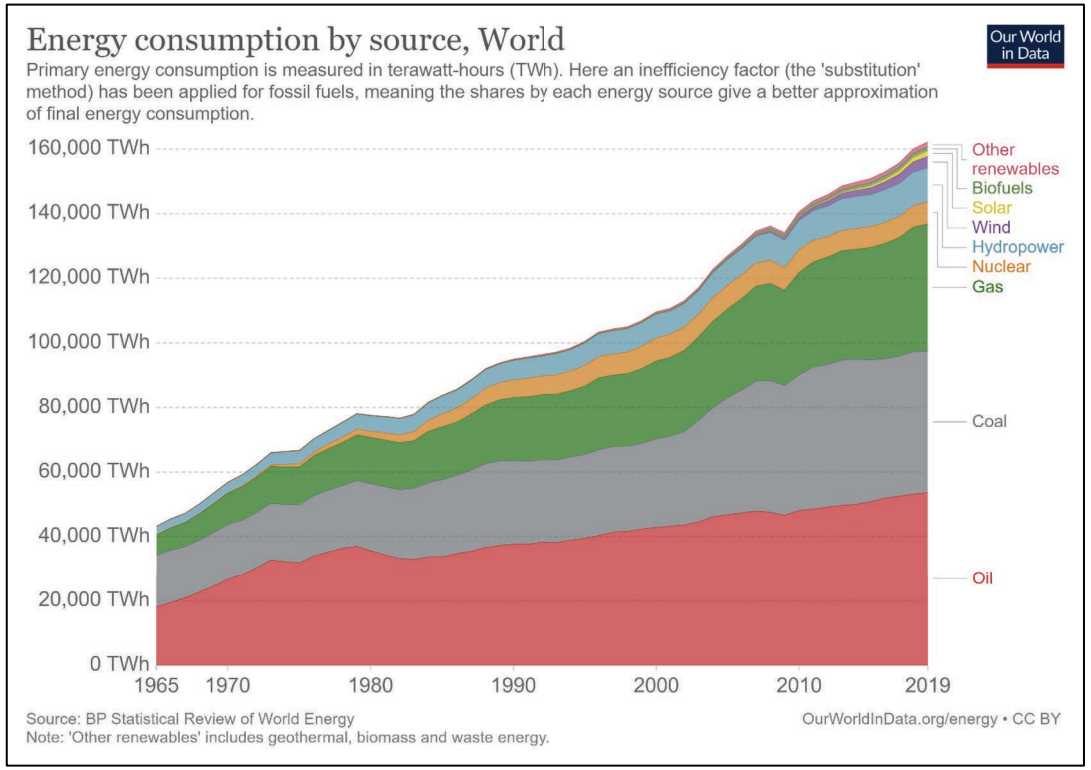


Overview of the Energy Sector

Global Energy Sector Snapshot

- Demand
  - Energy demands across sectors (residential, commercial, transportation, industrial) will increase
  - Change due to population growth, increasingly tech-heavy society, expansion of access to electricity per SDG 7, and increasing demand for green energy

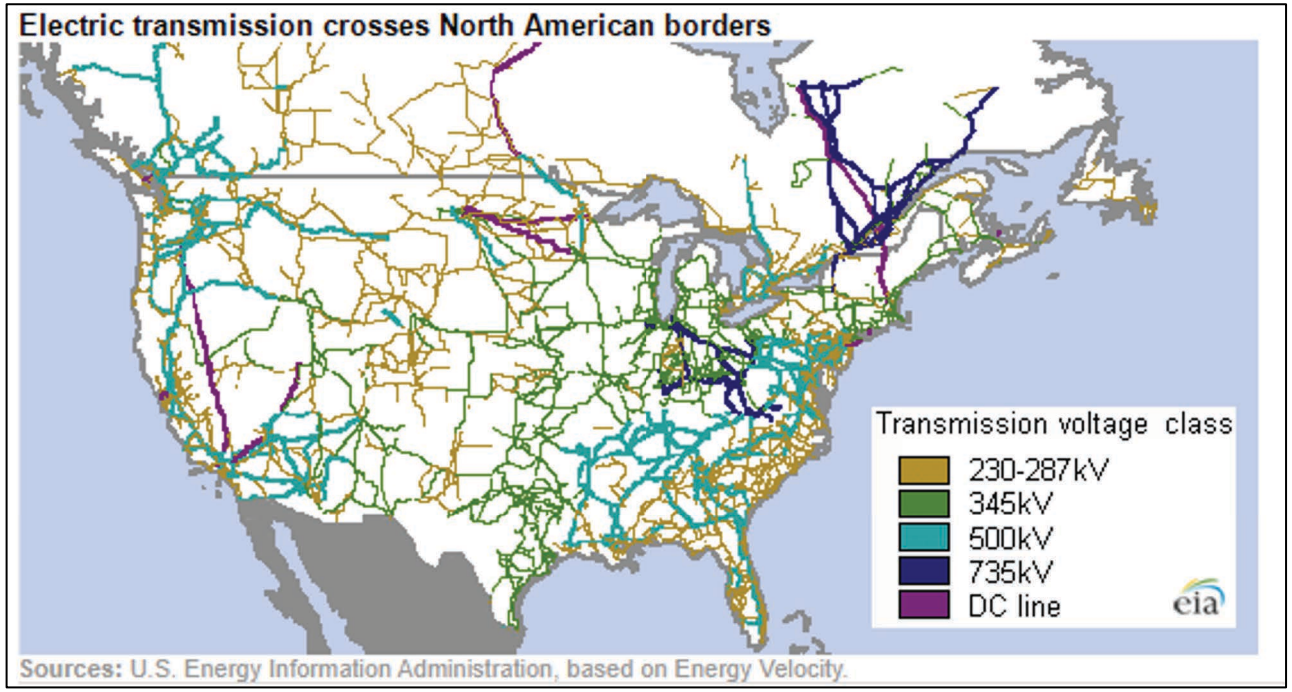




Overview of the Energy Sector

Global Energy Sector Snapshot

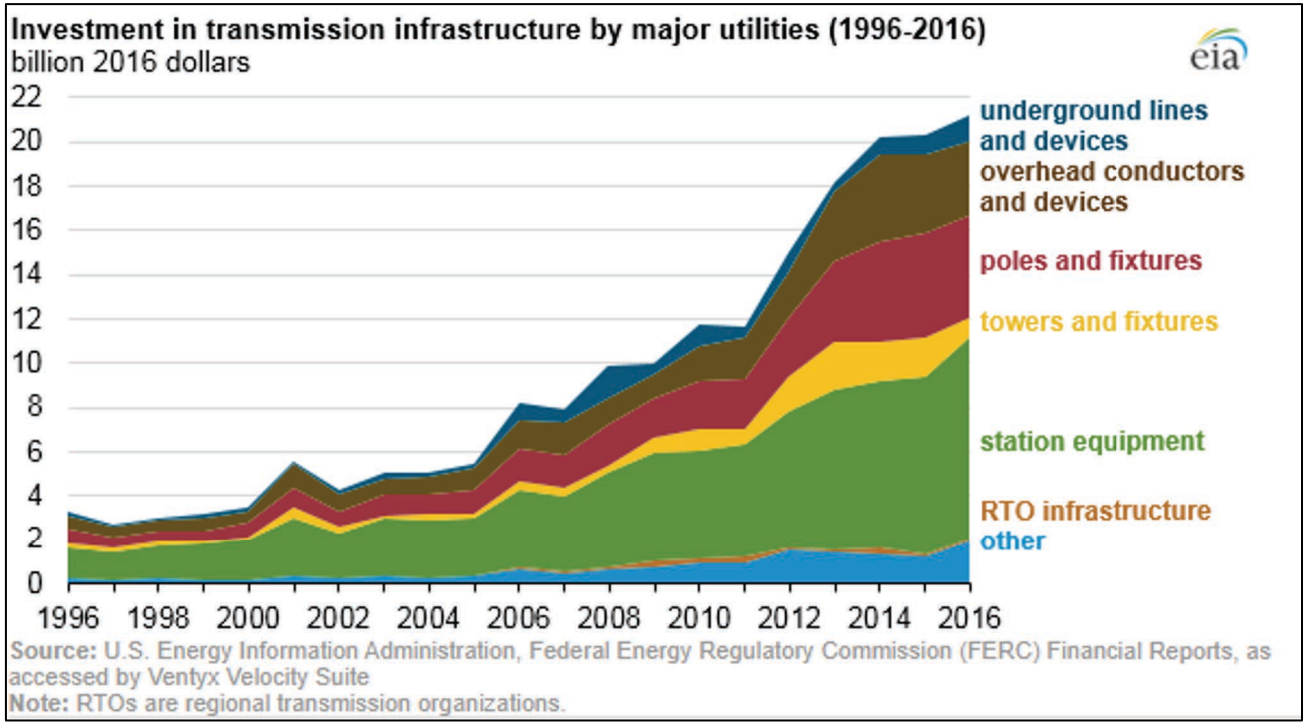
- Energy Transmission and Distribution
  - Infrastructure improvements to maintain and sustain reliable transmission and service
  - Grids may not be adequate for transmission as demand increases and generation shifts to renewables
    - Reliability may be affected by shift to renewables
    - Grid was built with different energy system in mind



Overview of the Energy Sector

Global Energy Sector Snapshot

- Infrastructure
  - Investments in infrastructure improvements (aging infrastructure, deterioration or damage, etc.)



Overview of the Energy Sector

Global Energy Sector Snapshot

- Vulnerabilities
  - Global events and other geopolitical factors worldwide may affect energy production and usage
    - Global financial changes, volatile oil prices, policy changes
    - COVID-19 has resulted in rural electrification projects put on hold and the number of people without electricity in sub-Saharan Africa projected to rise
  - Cybersecurity threats
  - Environmental threats such as extreme weather and climate change

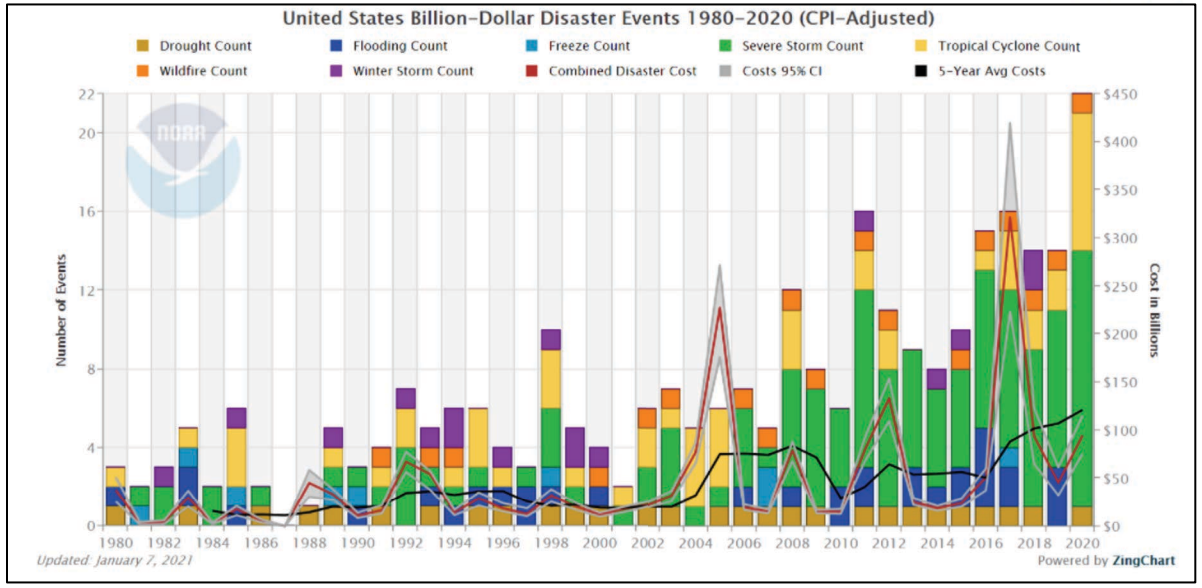
Source: National Grid Partners

Source: The Energy Mix. H. Bieser/Pixabay

Overview of the Energy Sector

The Necessity of Climate Resilience

- Increasing attention to vulnerability and resilience of energy infrastructure to extreme weather, climate change, other environmental changes
- Recognition of energy sector emissions
- Shift to resilient and renewable energy
- Emphasis on building energy efficiency
- Quantification of impact of weather and climate disasters

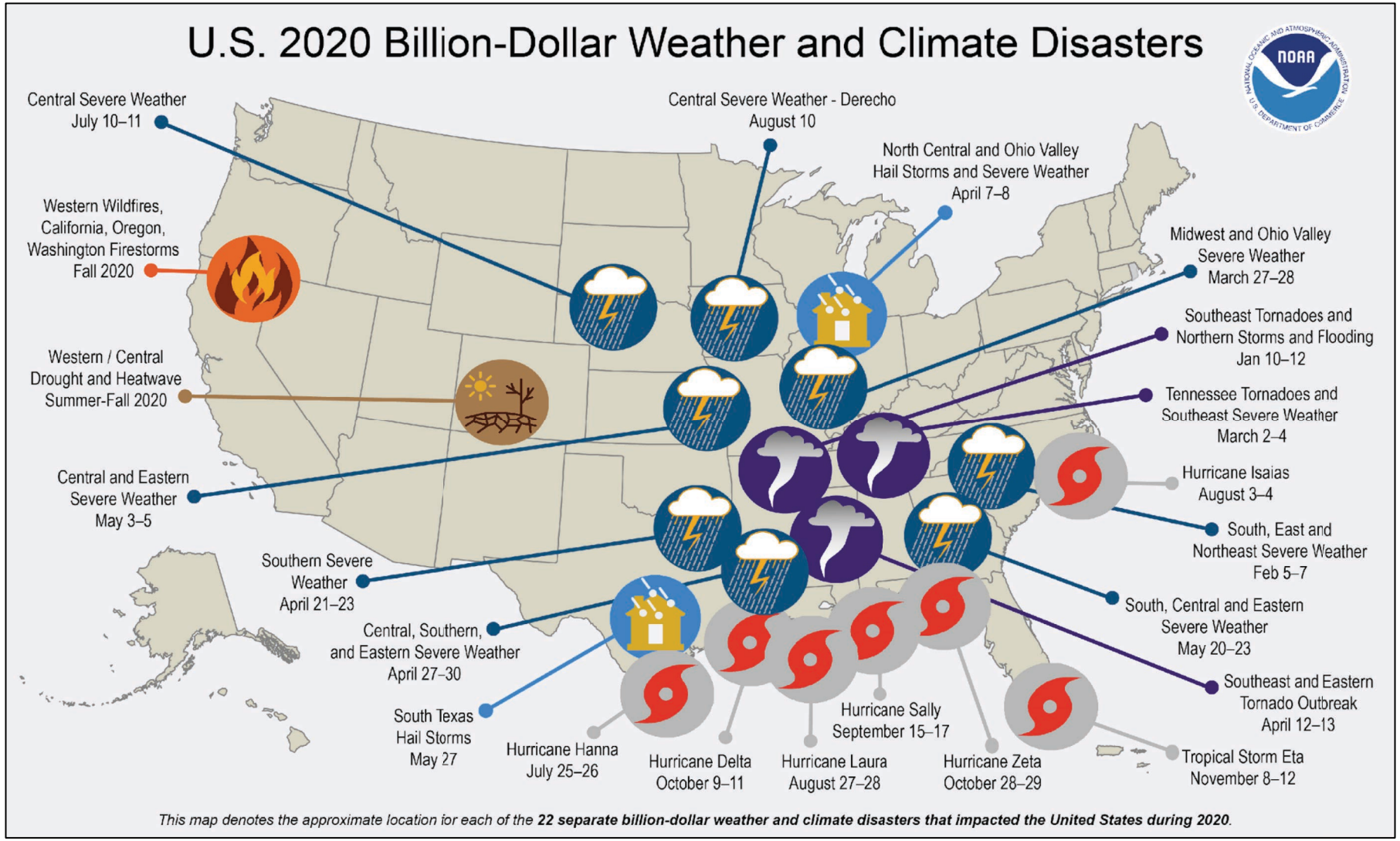


Source: National Oceanic and Atmospheric Administration

Powerline damage during Hurricane Gustav.
Source: Matt Slocum/AP

Texas power systems were unprepared for extreme winter temperatures. Source: Texas Tribune, February 2017

As energy demand increases, the climate changes and extreme events intensify. Utilities will need to invest in resilience activities to maintain reliable energy supply.

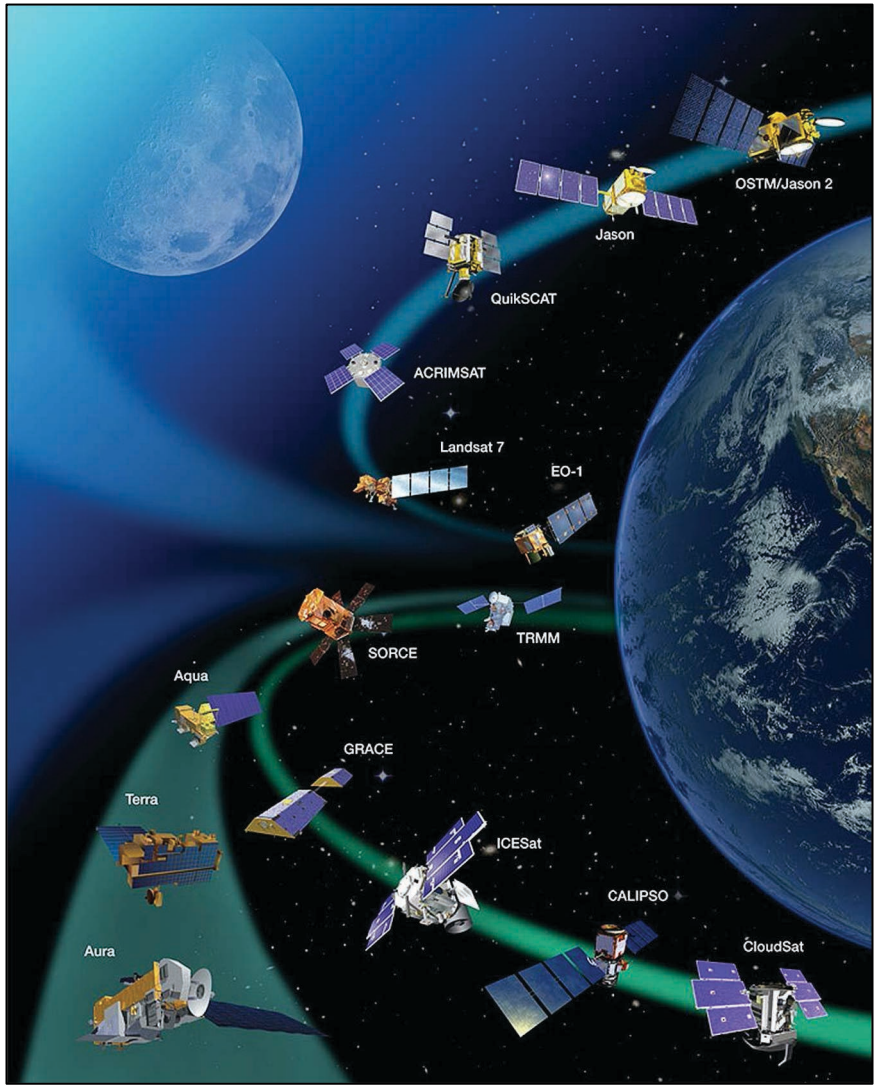


Source: NOAA National Centers for Environmental Information

Earth Observations and Energy Management

NASA EOs are underutilized in energy management.

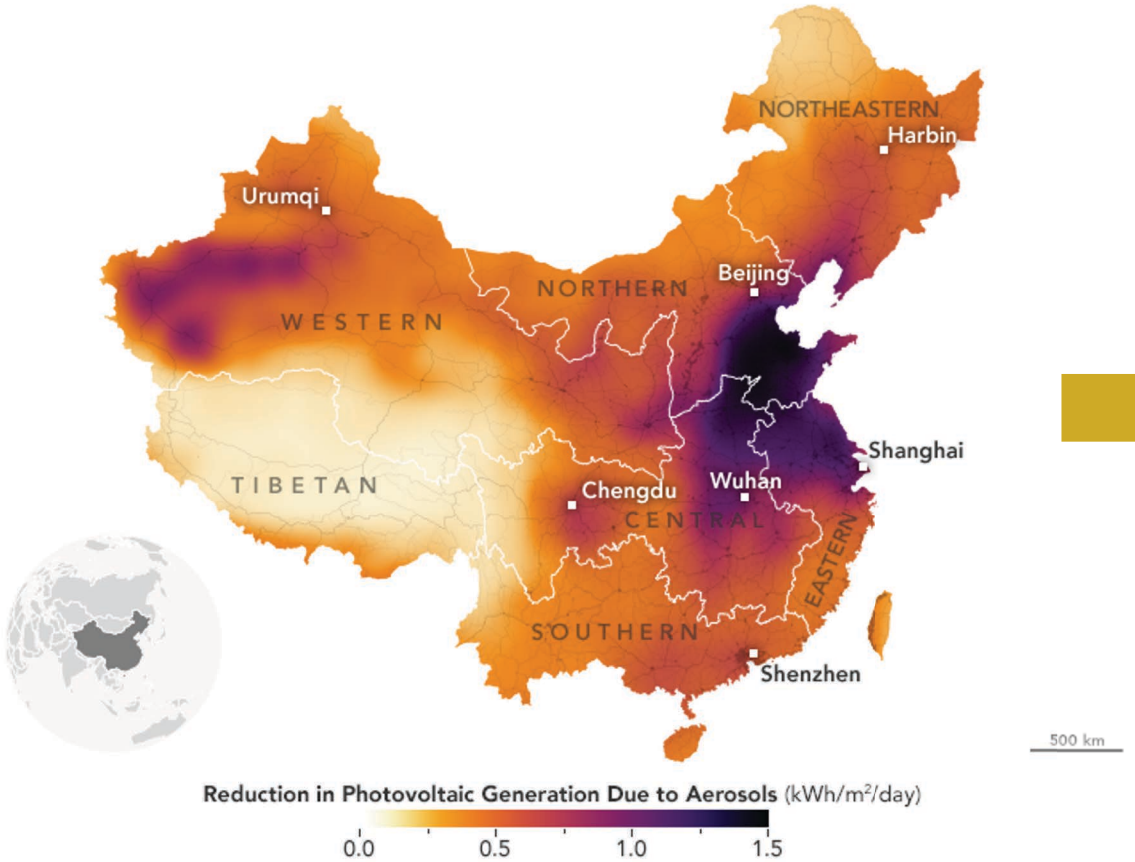
- Challenges in climate resilience, sustainability, and costs can be informed by NASA Earth observations that, taken together, can provide valuable insight into energy infrastructure and energy management systems
  - Renewable resource availability (wind, solar, water)
  - Weather and climate/meteorology (precipitation, humidity, temperature)
  - Water cycle/hydrology
  - Land cover and vegetation

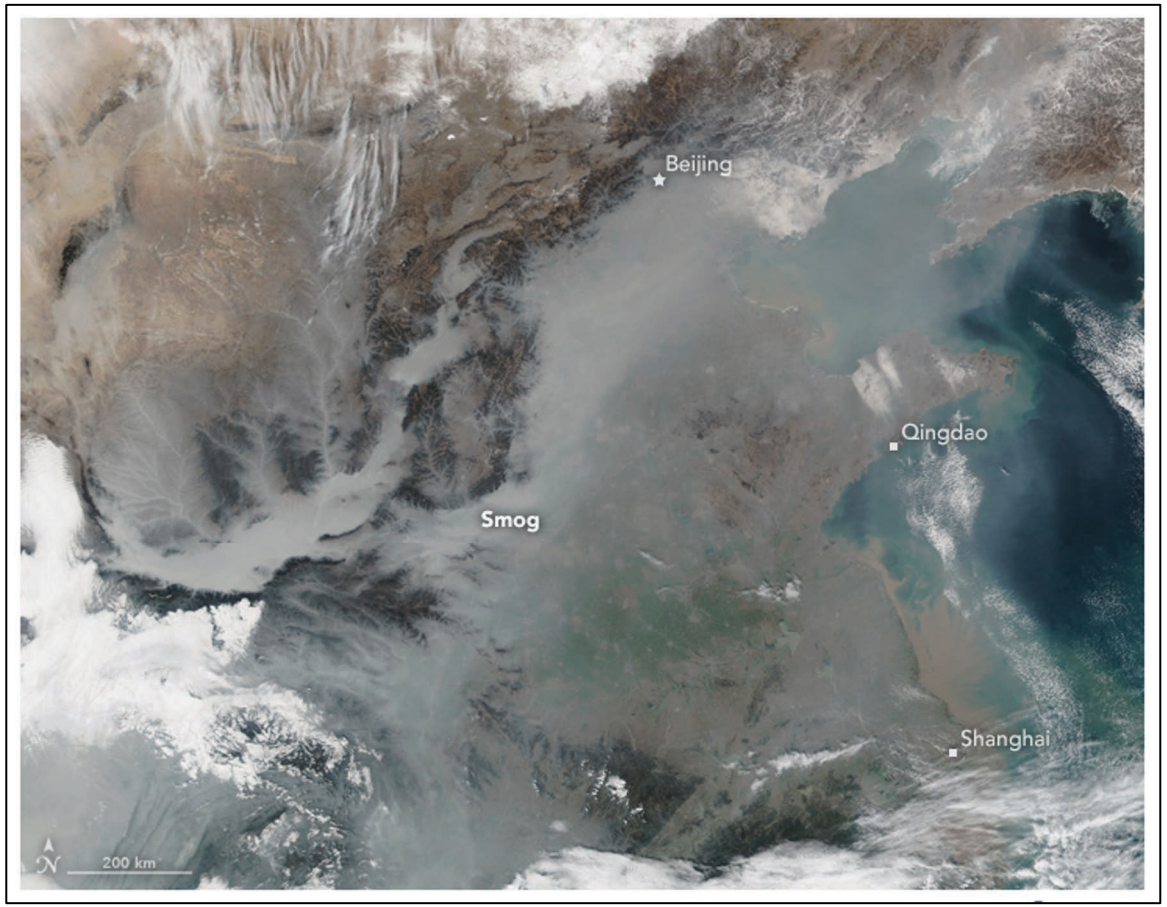


Source: NASA.gov

Earth Observations and the Energy Sector

Using NASA EOs to Visualize Physical, Climate, & Hydro-Meteorological Parameters





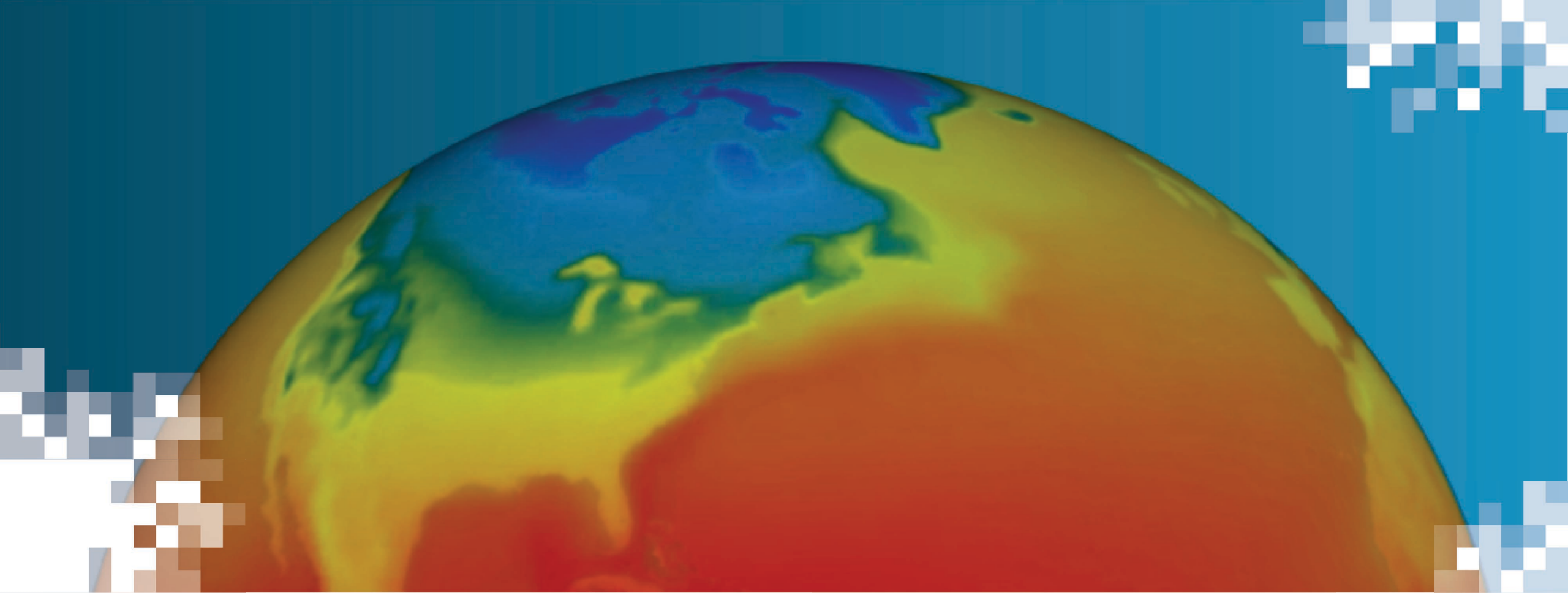
Source: Smog smothers solar energy in China. *NASA Earth Observatory*
https://earthobservatory.nasa.gov/images/92054/smog-smothers-solar-energy-in-china

Benefits of Satellite EOs for Energy Management

- Freely available through NASA data centers, tools, portals, or Google Earth Engine
- EOs can be used to fill gaps when ground-based data are limited
- EOs can be used to enhance, evaluate, or improve (or validate/calibrate) other sources of data or models
- Generally short repeat time (product dependent)
- Broad coverage (product dependent)
- Long historical data record (product dependent)
- Data are available in a variety of formats and can be imported into data analysis, visualization, and statistical tools, such as ArcGIS and Python

Limitations of Satellite EOs for Energy Management

- Course spatial resolution (product dependent)
- Geographic coverage limitations (product dependent)
- Cloud cover, in the case of optical sensors, can obscure surface features and block data, limiting data availability or coverage
- Latency, or the time it takes for data to be retrieved and made available to the user, can range from an hour to several days; therefore, NASA EOs are not always appropriate for real-time needs
- Review of metadata and uncertainty is needed to ensure appropriate interpretation and understanding



Selected NASA Datasets Used in Energy Management Applications

Increasing Awareness and Accessibility of NASA EOs for Energy Management

- Underutilization of NASA EOs in energy management Battelle grant to increase uptake of NASA data among electric utilities
  - Funded by NASA Applied Sciences in support of the Group on Earth Observations (GEO)

Increasing Awareness and Accessibility of NASA EOs for Energy Management

- Underutilization of NASA EOs in energy management Battelle grant to increase uptake of NASA data among electric utilities
  - Funded by NASA Applied Sciences in support of the Group on Earth Observations (GEO)
- Using a capacity building approach to identify means of improving the availability of electric utilities to utilize EOs
  - Secondary and primary information gathering on priorities, needs, and gaps
  - Mapping existing NASA EOs to a decision-making scale
  - Engage end users and an expert Advisory Group to identify and prioritize data needs and topics
  - Improve awareness of existing NASA data, products, and tools

Using the StoryMap: NASA Earth Observations for Electric Utility Applications

- Designed to provide practical, actionable information for utility applications, but relevant for broad energy management and energy sector needs
- Content developed through user engagement and feedback
- Organized by case study and dataset

Click here to go to the StoryMap (https://bit.ly/2Oe7tOI)

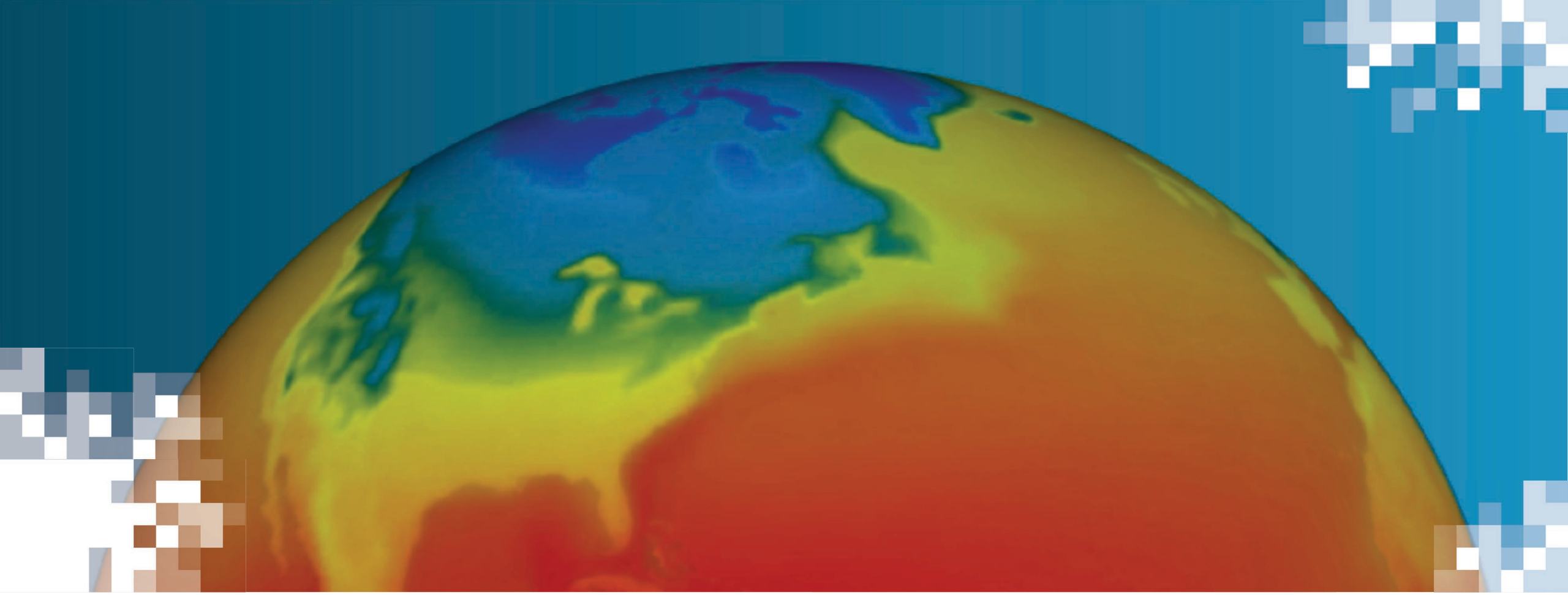
Using the StoryMap: NASA Earth Observations for Electric Utility Applications

- Not meant to be an all-inclusive list of NASA resources, rather focus on those easiest to use and access
  - Generally, at least L3 or variables mapped on uniform space-time grid scales, usually with some completeness and consistency
- Includes the most "accessible" tools for visualizing a broad array of EO data – Worldview and Giovanni visualization tools
  - Accessible in terms of criteria related to temporal and spatial resolution, data output type, ease of use, and applicability or relevance
- Comprehensive perspective on management or resilience application needs considering any combination of NASA EO datasets, infrastructure and asset datasets, and other non-NASA EO datasets

Click here to go to the StoryMap (https://bit.ly/2Oe7tOI)

Parameters Included in the StoryMap

- Base layers (energy infrastructure and assets)
- Elevation
- Evapotranspiration
- Fire and burn products
- Groundwater and soil moisture
- Land cover/land use change
- Land surface assimilation and reanalysis models
- Landslide products
- Nighttime lights
- Precipitation
- Sea level change
- Snow
- Solar radiation
- Surface water and flooding
- Temperature (air and land surface)
- Vegetation indices and height
- Wind



DEMO: Using the StoryMap to Access EO Data

Ancillary Data Products for Energy Management

Data available through various sources, such as:

- Climate Resilience Toolkit (https://toolkit.climate.gov/)
- NOAA/NWS
  - StoryMap of NOAA resources for Electric Utilities (https://bit.ly/38rnZlS)
- Infrastructure/asset location information from other sources (links in StoryMap)
  - US Electric Utility Infrastructure (HIFLD)
  - US Energy Mapping System (EIA)
  - US Wind Turbine Database (USGS)
  - US National Inventory of Dams (USACE)
  - Global Dam and Reservoir Database (NASA SEDAC)
  - HydroSource Program (ORNL)
  - Private sector datasets or data collection for payment
  - ENTSO-E Transmission System Map (for EU and nations bordering the Mediterranean)
  - EnergyData.info (Country-specific data)

Summary

- Overview of the energy sector today:
  - Energy consumption is expected to increase over time.
  - Climate change and outdated infrastructure necessitate a focus on resilience
- EOs can be used by utilities to better understand threats and vulnerabilities to reliable generation.
  - There are benefits and limitation of EOs broadly – each dataset has different capabilities and applications
- With NASA funding, Battelle developed a user-driven StoryMap that organizes NASA EO data into a user-friendly format to improve access barriers (https://bit.ly/2Oe7tOI)
- Others (NOAA, USGS, Copernicus, etc.) have EO data that complements NASA data

References

- Short Term Energy Outlook
  - https://www.eia.gov/outlooks/steo/#:~:text=Coal's%20forecast%20share%20of%20electricity,and%20to%2019%25%20in%202022
- 2021 renewable energy industry outlook
  - https://www2.deloitte.com/us/en/pages/energy-and-resources/articles/renewable-energy-outlook.html
- Canada Week: Integrated electric grid improves reliability for United States, Canada
  - https://www.eia.gov/todayinenergy/detail.php?id=8930
- Rising renewables penetration is a threat to grid reliability in some regions, NERC concludes
  - https://www.utilitydive.com/news/rising-renewables-penetration-is-a-threat-to-grid-reliability-in-some-regio/592356/
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- World Energy Outlook 2020
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- Subsidies would help deliver mini-grids as cheapest rural electrification for sub-Saharan Africa
  - https://theenergymix.com/2019/06/16/subsidies-would-help-deliver-mini-grids-as-cheapest-rural-electrification-for-sub-saharan-africa/
- Seven things to know about NCEI's U.S. billion-dollar disasters data
  - https://www.ncei.noaa.gov/news/calculating-cost-weather-and-climate-disasters
- 2020 U.S. billion-dollar weather and climate disasters in historical context
  - https://www.climate.gov/news-features/blogs/beyond-data/2020-us-billion-dollar-weather-and-climate-disasters-historical?utm_campaign=Latest%2BMississippi%2BRiver%2BDelta%2BNews&utm_medium=web&utm_source=Latest_Mississippi_River_Delta_News_13
- Smog Smothers Solar Energy in China
  - https://earthobservatory.nasa.gov/images/92054/smog-smothers-solar-energy-in-china


APPLIED REMOTE SENSING TRAINING PROGRAM
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Questions?


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Thank You!

Appendix A: Datasets/Products Included in StoryMap

Energy Infrastructure & Assets	Evapotranspiration	Fire & Burn Products	Groundwater & Soil Moisture
U.S. Electric Utility Infrastructure (HIFLD)	ECOSTRESS Evaporative Stress Index	FIRMS: Fire Information for Resource Management System	Groundwater & Soil Moisture Conditions (GRACE and GRACE-FO)
U.S. Energy Mapping System (EIA)	ECOSTRESS Evapotranspiration Product (PT-JPL)	MODIS Burned Area Product (MCD64A1)	Water Storage Anomalies (GRACE and GRACE-FO)
U.S. Wind Turbine Database (USGS)	MODIS MOD16 Net Evapotranspiration Product	VIIRS Burned Area Product	Soil Moisture Conditions (SMAP)
U.S. National Inventory of Dams (USACE)	Evapotranspiration Mapping using Landsat-8 OLI/TIRS Collection 1 Data	Landsat Burned Area Product	Freeze-Thaw Conditions (SMAP)
Global Reservoir and Dam Database (NASA SEDAC)	EEFlux Data Visualization Tool		Surface Soil Moisture (GCOM-W1/AMSR2)
HydroSource Program (ORNL)	Evapotranspiration Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)		Soil Moisture from NASA Disasters Mapping Portal
			U.S. Drought Monitor (NDMC)
			Soil Moisture & Subsurface Runoff Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)

Appendix A: Datasets/Products Included in StoryMap

Land Cover and Land Use Change	Land Surface Models and Reanalysis Models	Landslide Products	Nighttime Lights
Land Cover and Land Use Change (Landsat-7 ETM+, Landsat-8 OLI)	NLDAS-2 Land Surface Model	NASA Landslide Viewer	NASA Black Marble
MODIS Terra+Aqua Combined Land Cover Product (MCD12)	GLDAS-2 Land Surface Model	Global Landslide Nowcast from NASA Disasters Mapping Portal	
VIIRS Global Surface Type Map	MERRA-2 Reanalysis Model	Global Landslide Susceptibility Basemap from NASA Disasters Mapping Portal	
		NASA Global Landslide Catalog	
		LHASA: Landslide Hazard Assessment for Situational Awareness Model	

Appendix A: Datasets/Products Included in StoryMap

Precipitation	Snow	Solar Radiation	Surface Water
National Weather Service (NOAA)	MODIS Snow Cover Products	Solar Radiation Budget & Flux (NASA POWER)	MODIS Surface Reflectance Products (MOD09)
Multi-satellite Precipitation Models (GPM IMERG)	VIIRS Snow Cover Product Suite	National Solar Radiation Database (NREL)	MODIS Corrected Reflectance Bands 7-2-1
AIRS/Aqua Moisture & Precipitation Data	AMSR-E/AMSR2 Snow Water Equivalent (SWE) Data	MODIS Surface Radiation & Photosynthentically Active Radiation (MCD18)	VIIRS Surface Reflectance Product Suite
Precipitation Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)	Snow Mass (SMAP)	SRB Surface Radiation Budget (GEWEX)	Dynamic Surface Water Extent (Landsat-4/5 TM, Landsat-7 ETM+, Landsat-8 OLI)
	Fractional Snow-Covered Area (Landsat-4/5 TM, Landsat-7 ETM+, Landsat-8 OLI)	Top-of-Atmosphere (TOA) & Surface Radiative Flux (CERES)	Inland Water Surface Height (ICESat-2)
	Near Real Time Snow & Ice Extent (NISE, SSM/I-SSMIS)	Top-of-Atmosphere (TOA) Outgoing Longwave Flux (AIRS/Aqua)	GRACE Water Storage Anomalies (NASA JPL)
	Snow Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)	Radiative Flux Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)	Surface Runoff Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)
			Surface Water and Ocean Topography (SWOT) – future mission

Appendix A: Datasets/Products Included in StoryMap

Flooding	Temperature	Terrain	Vegetation
VIIRS-ABI Floodwater Fraction Map Products	MODIS Land Surface Temperature & Emissivity (MXD11, MXD21	Shuttle Radar Topography Mission (SRTM) Digital Elevation Models	MODIS Vegetation Index Products
NASA Disasters Program Flood Dashboard	VIIRS Land Surface Temperature and Emissivity Data Sets	Global Digital Elevation Models (ASTER)	VIIRS Vegetation Index Product Suite
Dartmouth Flood Observatory (DFO)	AIRS Support Product Air/Land Surface Temperature Estimate Data Sets	Land and Vegetation Height (ICESat-2)	Normalized Difference Vegetation Index (Landsat-4/5 TM, Landsat-7 ETM+, Landsat-8 OLI/TIRS)
Flood Detection & Intensity (GFMS)	Land Surface Temperature Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)		GEDI LiDAR Forest Canopy Height & Vertical Structure (GEDI02)
NWS Advanced Hydrologic Prediction Service			Land and Vegetation Height (ICESat-2)
			Vegetation Data from NLDAS-2, GLDAS-2, MERRA-2 (Land Surface Models/ Reanalysis Models)