LCLUC AND USGS: PAST AND CURRENT ACTIVITIES
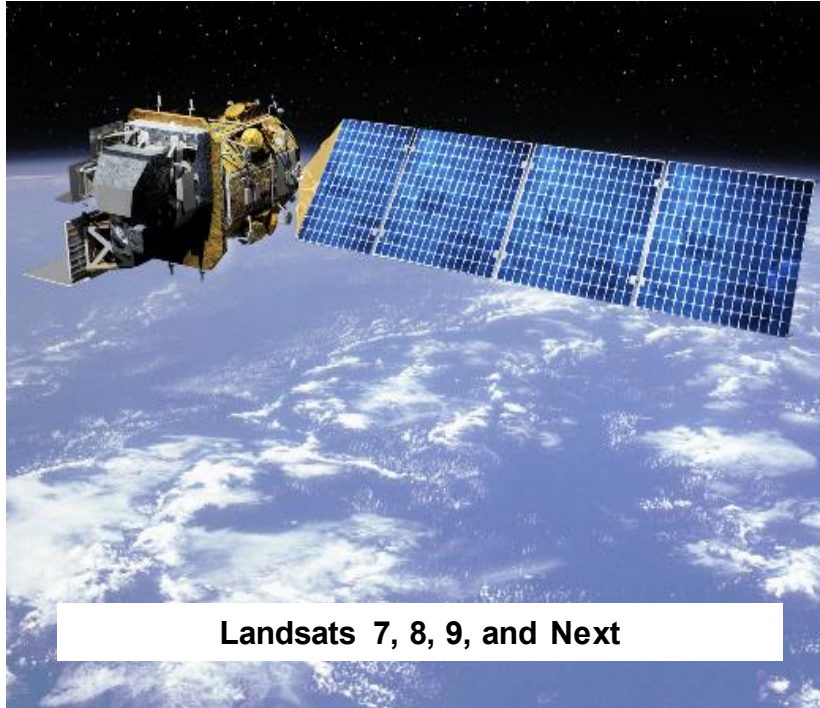
Tim Newman

USGS National Land Imaging Program

October 18th, 2022

USGS National Land Imaging Program

NLI delivers a national and global capability to ensure broad public and scientific availability of observations of the Earth's land surface

Landsats 7, 8, 9, and Next

Earth Resources Observation and Science Center

The National Land Imaging Program funds:
- Landsat Development & Operations
- Applied science and applications
- Remote sensing R&D
- National Civil Applications activities
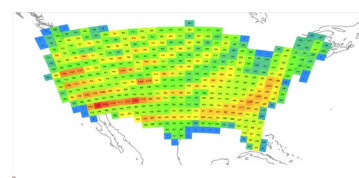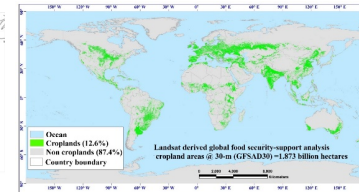- National Land Remote Sensing Education & Outreach Grant

Uncrewed Aircraft Systems (UAS)

National Civil Applications Center

Essential Climate Variables

Global Products

Earth Explorer – https://earthexplorer.usgs.gov/
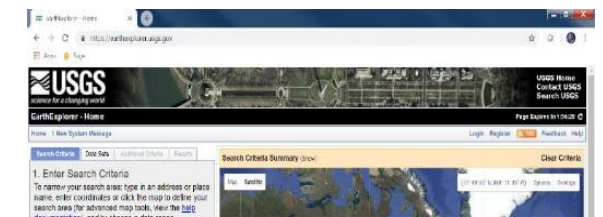
Hazards Data Distribution System - https://hddsexplorer.usgs.gov/

NATIONAL LAND IMAGING PROGRAM SCIENCE PORTFOLIO

NLI funded science projects

- Land cover and change, fire science, cropland, permafrost, surface water, drought, vegetation dynamics, water use/ET, ecosystem services, economic analysis. Global/National Scale

National Civil Applications Center

- Commercial imagery, disaster response
- Remote sensing interdisciplinary research (fire science, water quality/quantity)

External

- Global Ecosystems and Earth Surface Features: Global scale, supporting GEO and working with Gov't, Industry, NGO and Academia.
- SilvaCarbon: Research and tools for global forest monitoring, working with Gov't, Industry and Academia.

USGS
science for a changing world

RESEARCH TO OPERATIONS

- Provide input to other models from local to global scale

- Local land management stakeholders
- Federal agency partners
- Local to global scale mapping

- National-Global scale
- Routine production
- Wide user base
- Research component for product improvement
- *Partner with Federal, commercial and international*

Social value of ecosystem services

Land cover change impacts on migratory species

AK boreal forest change due to disturbance

Inundation and land cover disturbance

AK permafrost mapping

Forecasting wetland and watershed ecosystem services

Surface water and inundation dynamics

Arid Land Water Harvest

Tribal land vegetation and watershed modeling

Buffelgrass mapping and prediction

Wildland-urban interface mapping

Agriculture conservation practices

Global irrigated cropland

ET and water balance

LCMAP

NLCD

Landsat Science Products
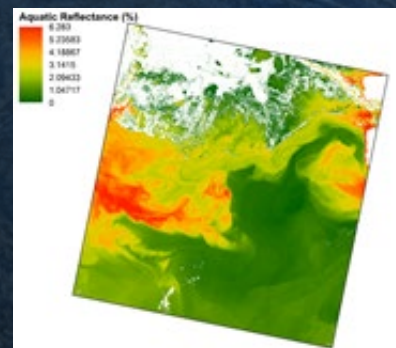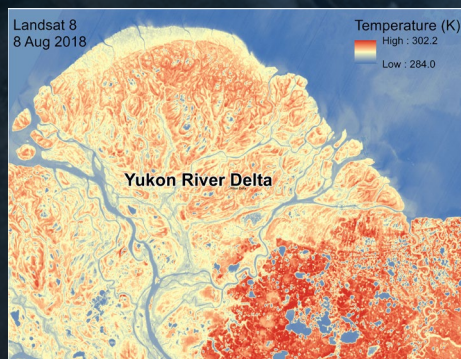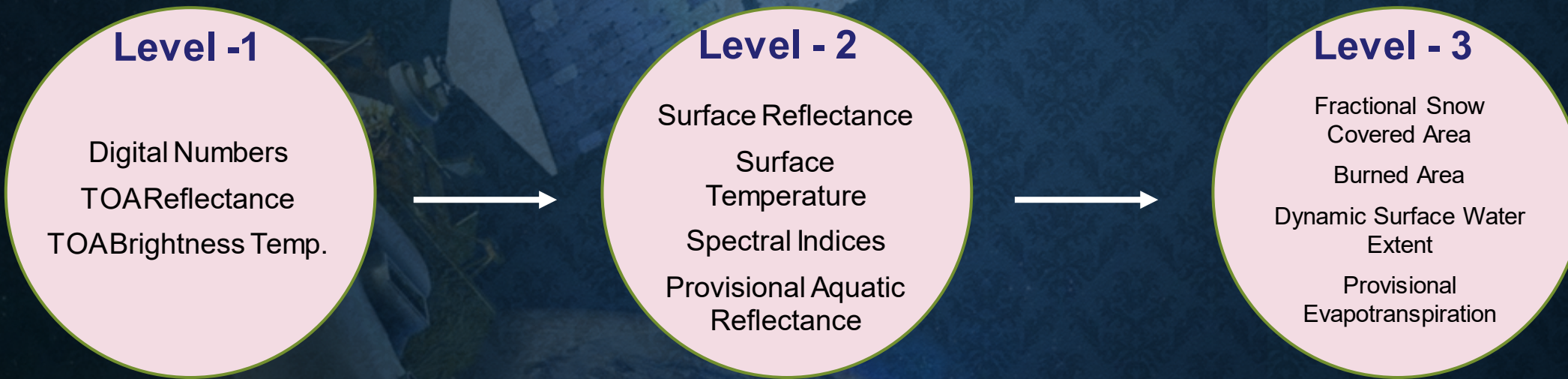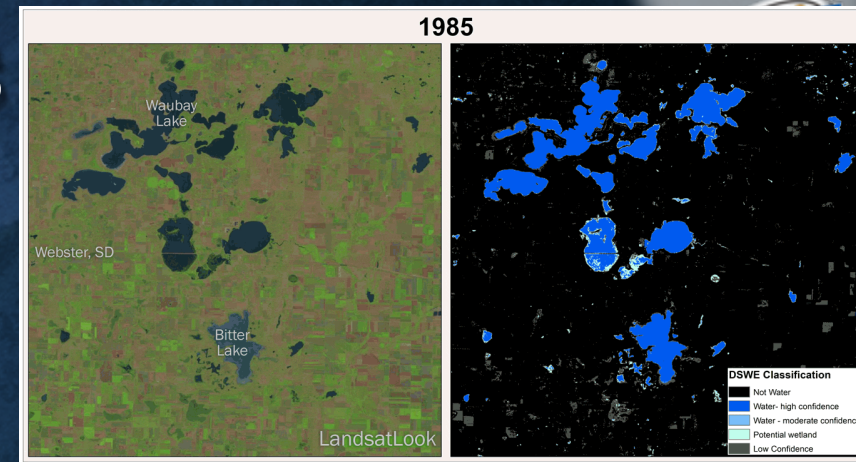
FEWSNET

OpenET

ESRI Global Ecosystems

SilvaCarbon

Research

**Operations**

LANDSAT SCIENCE PRODUCTS

- Relieve the burden of post-processing from the data users
- Help facilitate time-series analysis and land change studies
- Each level of products is tracked to the original data

Level -1

Digital Numbers

TOAReflectance

TOABrightness Temp.

Level - 2

Surface Reflectance

Surface Temperature

Spectral Indices

Provisional Aquatic Reflectance

Level - 3

Fractional Snow Covered Area

Burned Area

Dynamic Surface Water Extent

Provisional Evapotranspiration
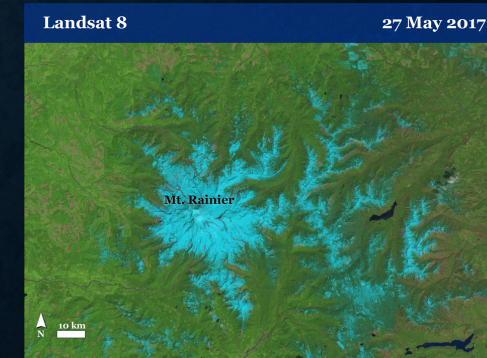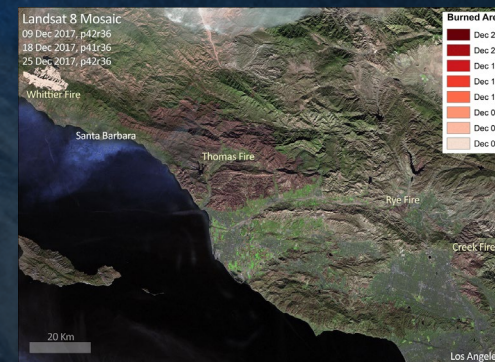
Translating Satellite Data into Information

- Satellites like Landsat record information in multiple spectral bands over decades, with different Earth surfaces responding differently

- A primary USGS activity – Mapping "land cover" from satellite imagery

- USGS provides foundational products on US landscape change

  - Long history, rigorous validation
  - Serve as the "gold-standard" for land cover
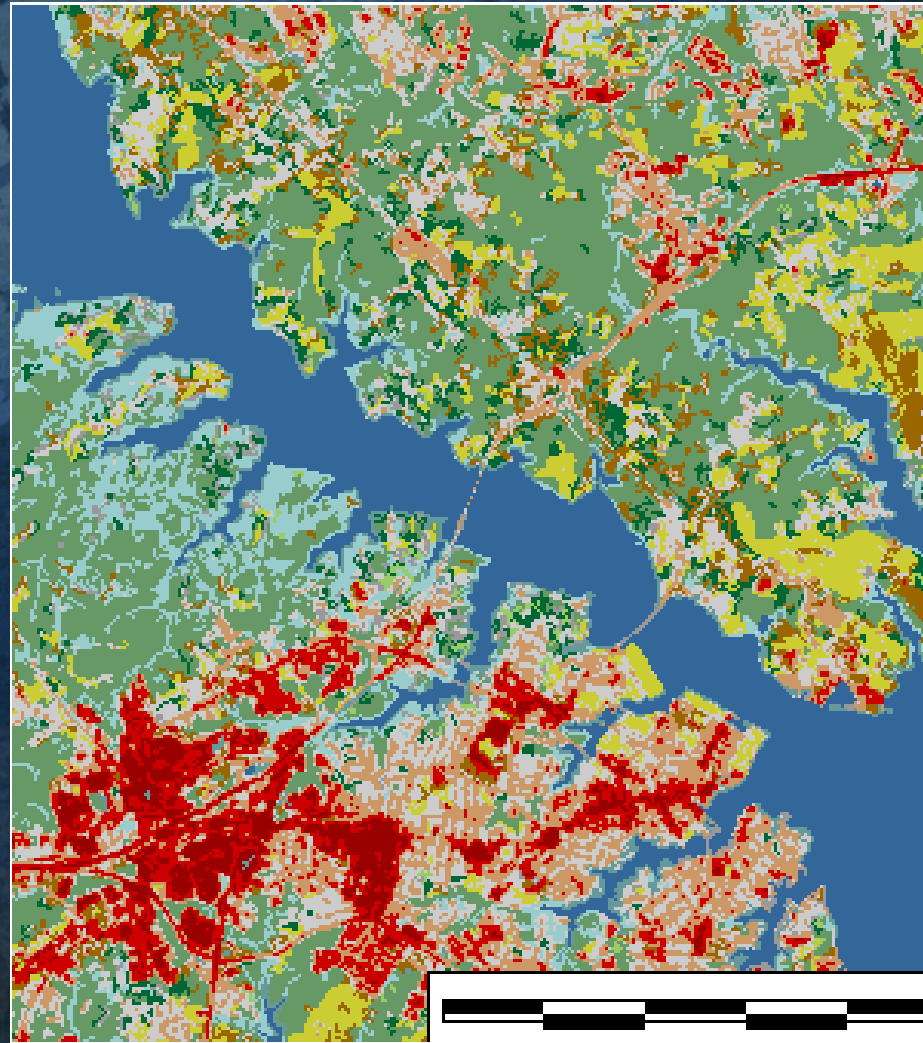
NLCD Land Cover Classification Legend

- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
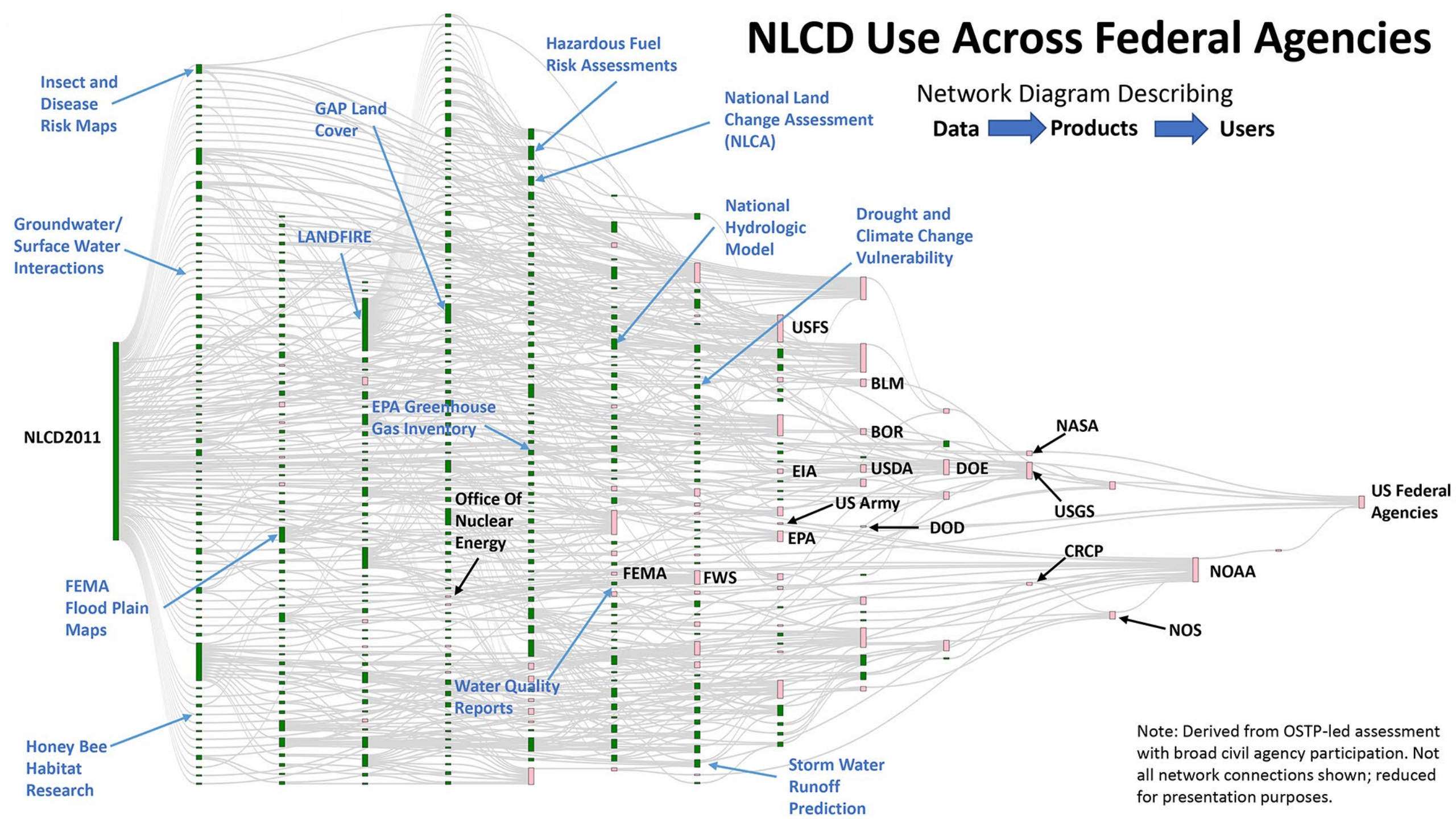- 95 Emergent Herbaceous Wetlands

* Alaska only

5 km

NATIONAL LAND COVER DATABASE (NLCD)

- NLCD is part of the Multi-Resolution Land Characteristics (MRLC) consortium of federal agencies to provide consistent land cover information at the national scale for science, modeling and land management applications.

- Widely cited and used for U.S. and World policy in Greenhouse gas, climate assessment, weather prediction, Environmental impact statements, disease vectors, water impact analysis, ecological restoration, habitat modeling, etc.

- Wide user community of Federal, state, local and private industry; >1 Million downloads and 12,000+ citations

Celebrating

https://www.mrlc.gov/

NLCD Use Across Federal Agencies

Network Diagram Describing

Data → Products → Users

Insect and Disease Risk Maps

Hazardous Fuel Risk Assessments

National Land Change Assessment (NLCA)

GAP Land Cover

Groundwater/ Surface Water Interactions

LANDFIRE

National Hydrologic Model

Drought and Climate Change Vulnerability

USFS

BLM

EPA Greenhouse Gas Inventory

BOR

NASA

NLCD2011

Office Of Nuclear Energy

EIA USDA DOE

US Army

DOD

USGS

US Federal Agencies

EPA

FEMA Flood Plain Maps

CRCP

FEMA FWS

NOAA

Water Quality Reports

NOS

Honey Bee Habitat Research

Storm Water Runoff Prediction

Note: Derived from OSTP-led assessment with broad civil agency participation. Not all network connections shown; reduced for presentation purposes.

Spectral Model Quality | Time Since Last Change | Spectral Stability Period | Change Magnitude | Time of Spectral Change

Primary Land Cover | Primary Land Cover Confidence | Secondary Land Cover | Secondary Land Cover Confidence | Annual Land Cover Change

LAND CHANGE MONITORING, ASSESSMENT AND PROJECTION (LCMAP)

- LCMAP
  - Monitoring: Continuous tracking of land surface change using ARD
  - Assessment: Summarizing landscape change, its causes, and consequences
  - Projection: Backcasting past and Forecasting future landscapes

- Based on a time series approach to track pixel behavior, detect land surface change, and classify land cover

- Suite of 10 land cover and land surface change products are provided for each year from 1985-2020 at 30m spatial resolution for the conterminous United States
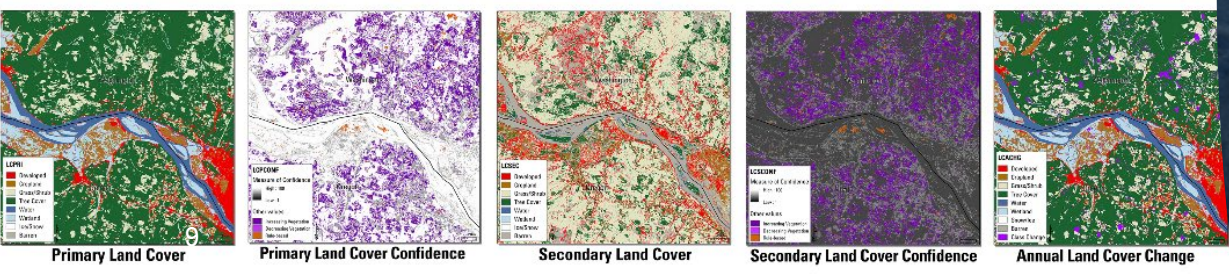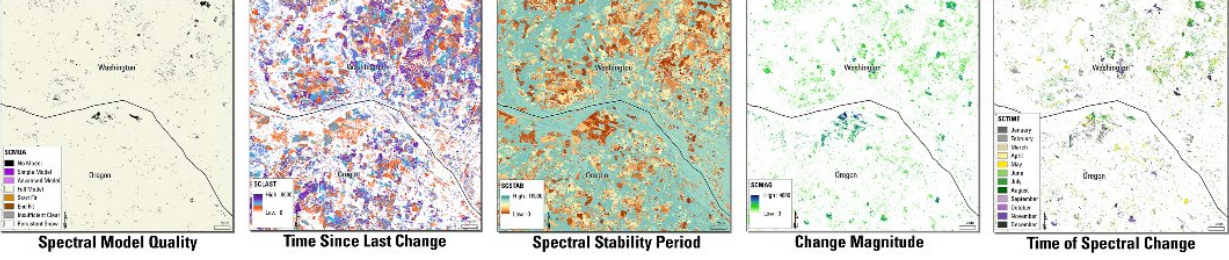
Landsat and Climate Analyses: Monitoring Landscape Condition

Projection of future rangeland vegetation
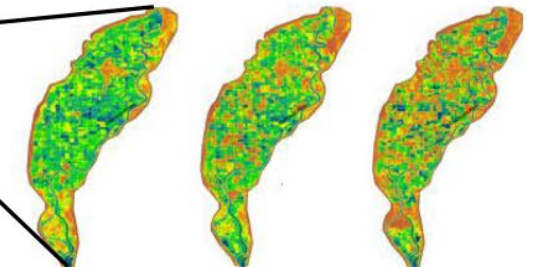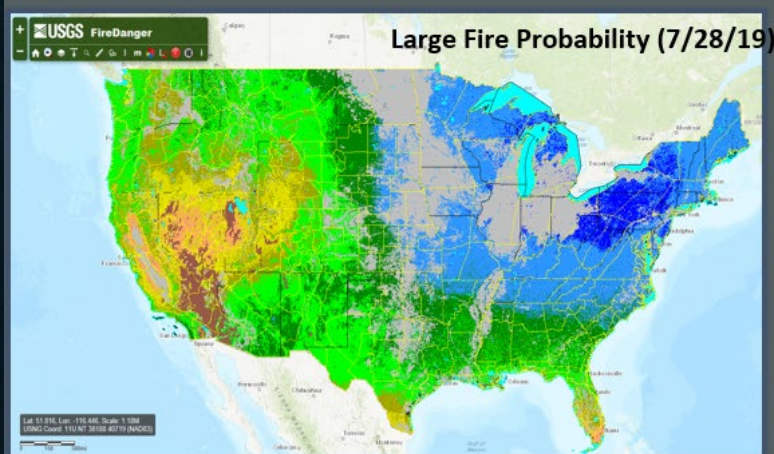
Fractional snow cover data, critical to climate and water science
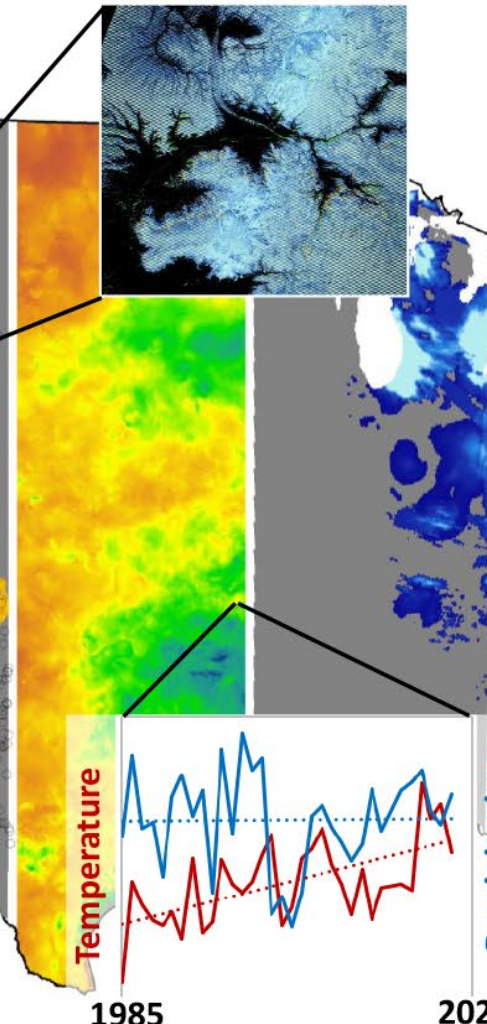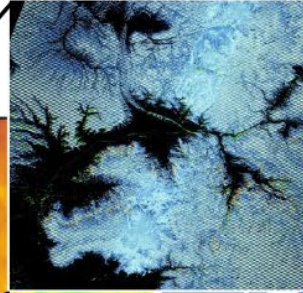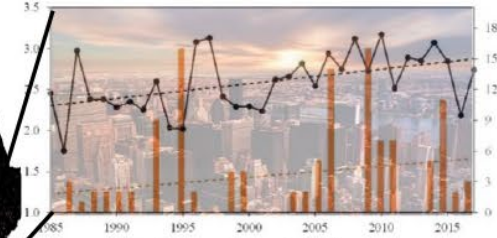
Urban heat island monitoring, critical to human health under a changing climate

Near real time invasive grass map indicates high fire risk

National monitoring of evapotranspiration is invaluable to agricultural and water resources

Fire Monitoring, Risk, and Mitigation
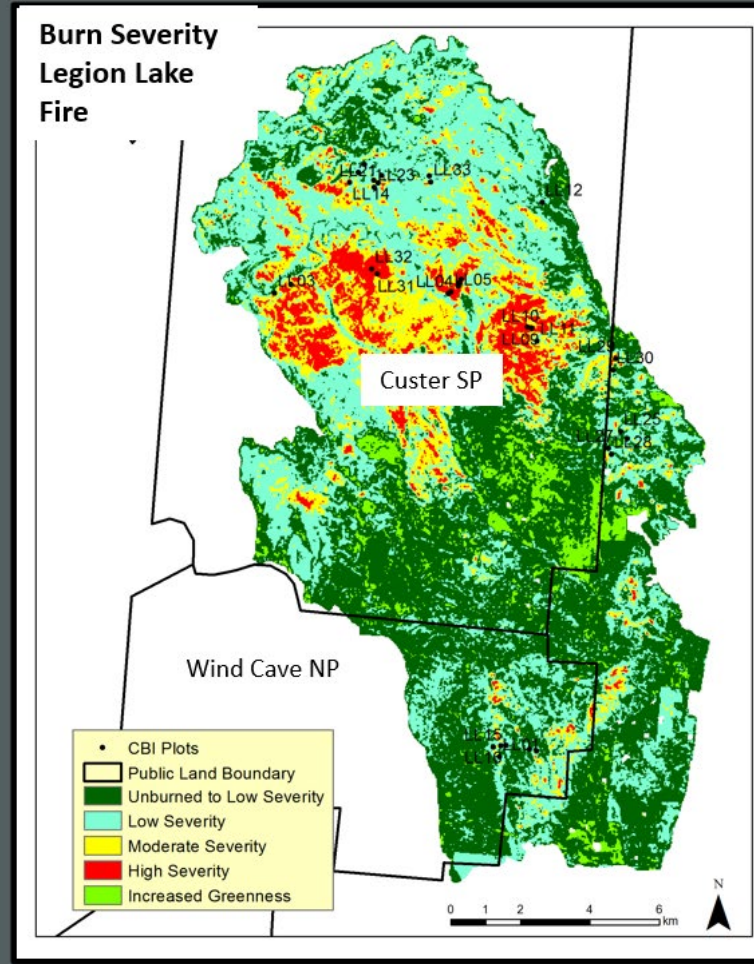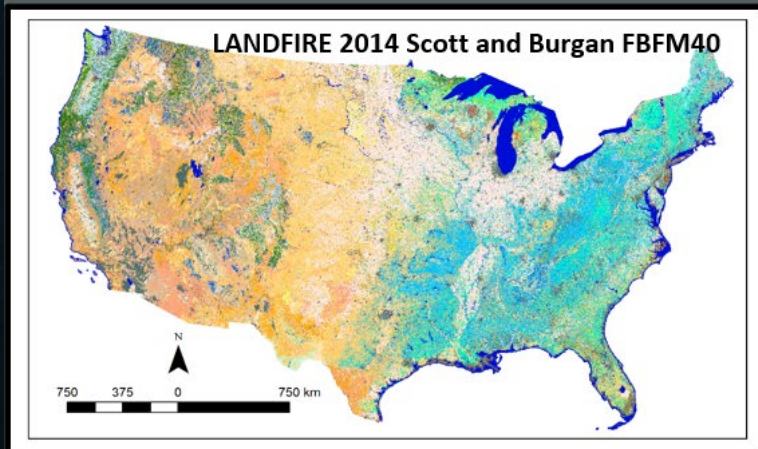
LANDFIRE Program and Fire Science

- Characterizes landscape and fuel conditions
- Maps all US fires and characterizes severity
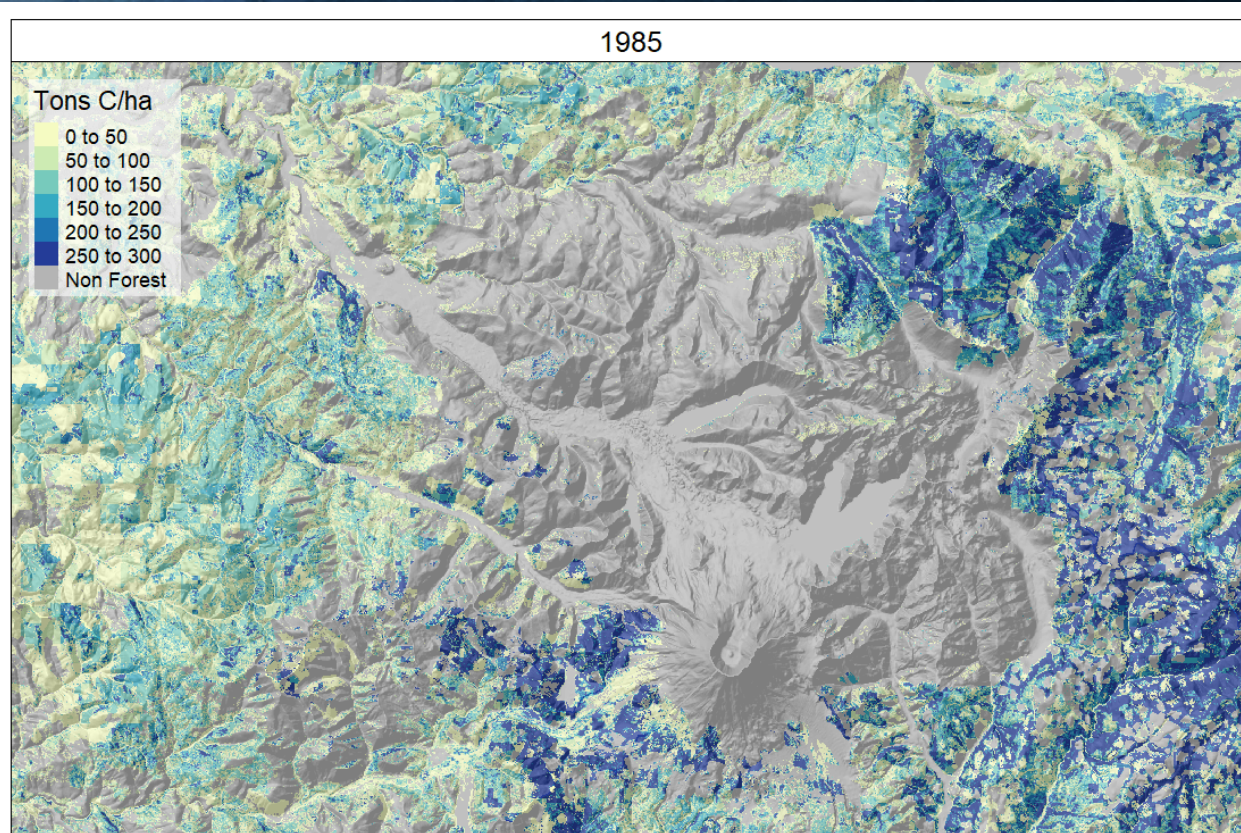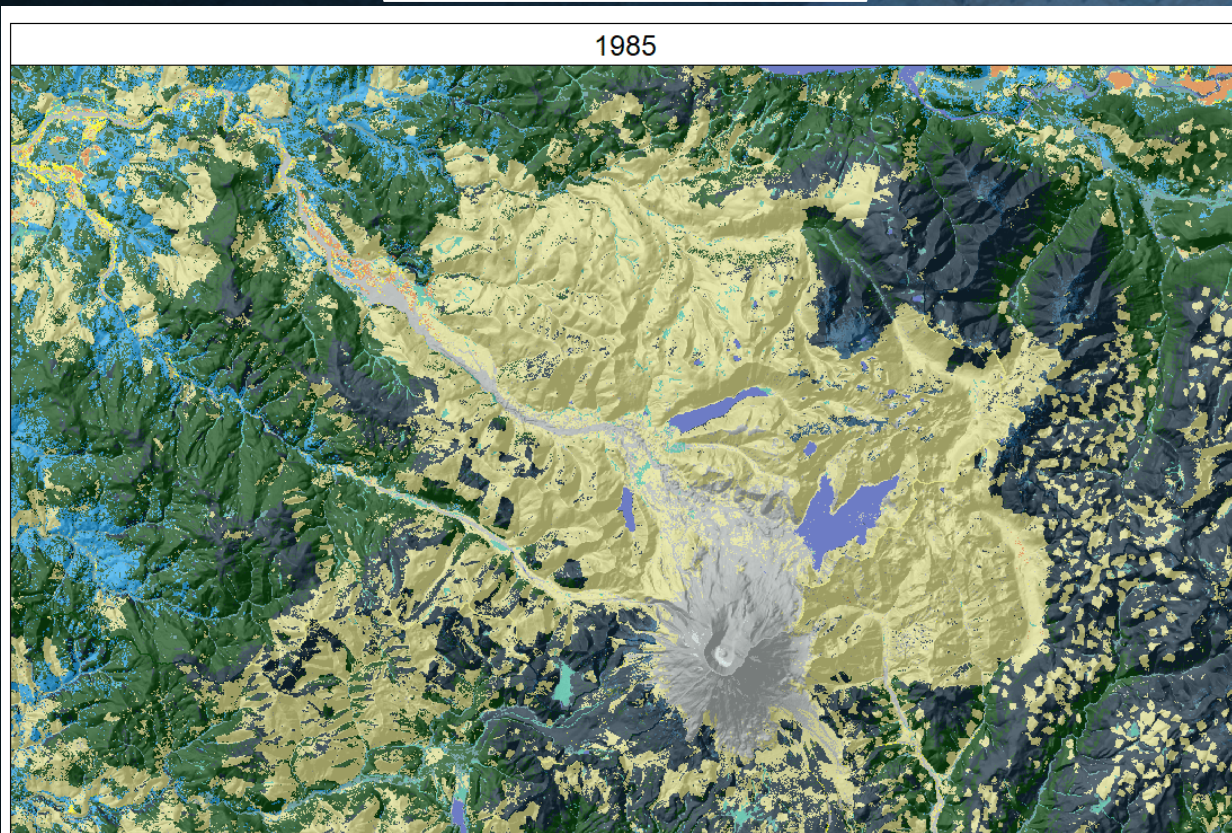- Post-fire regeneration
- Supports fire modeling and management

LANDSCAPE CHANGE AND CARBON

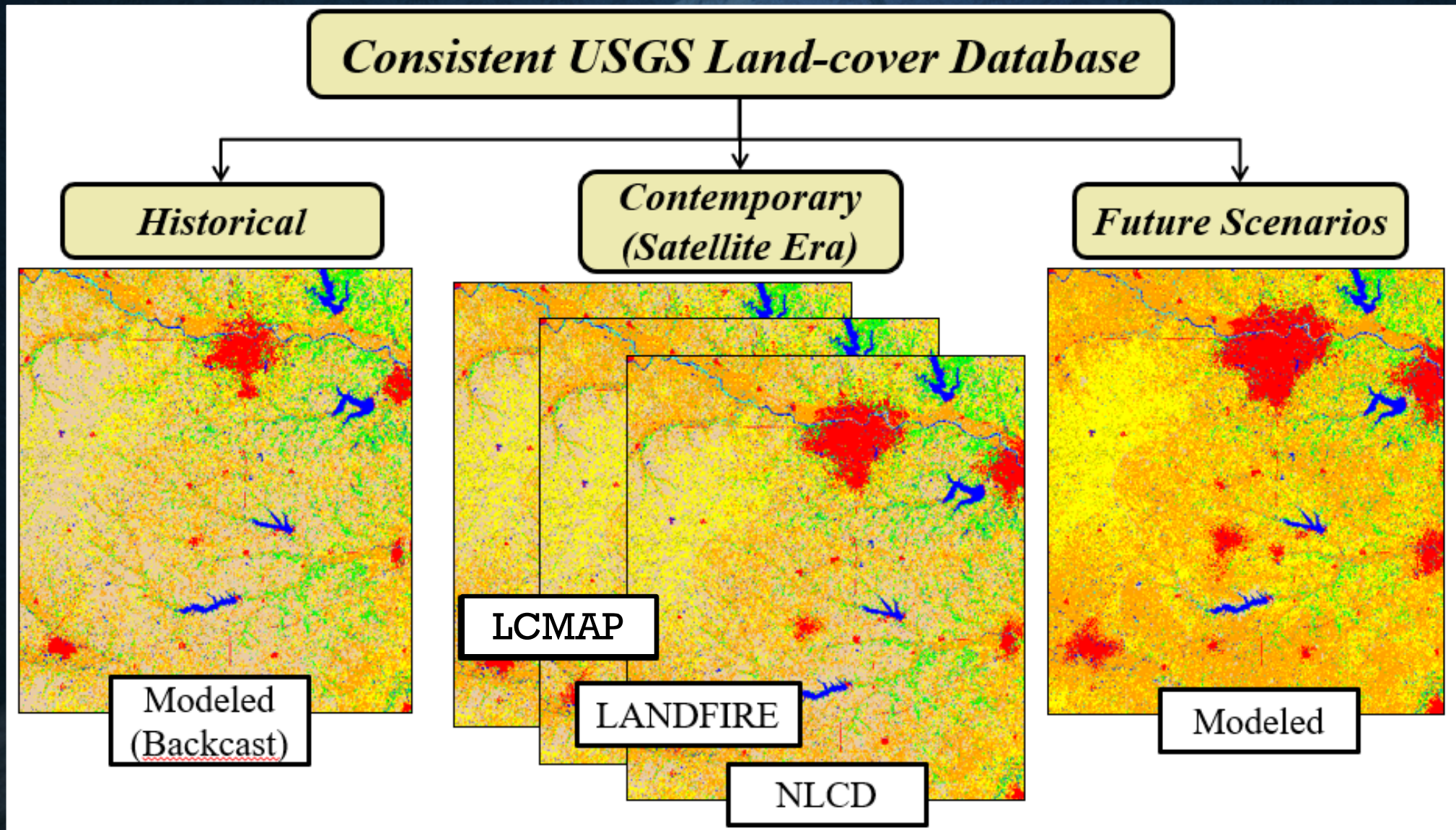Mount St. Helens – Forest cutting and regeneration, post eruption regeneration

LUCAS Credit: USGS – Ben Sleeter – Land Use and Carbon Scenario Simulator (LUCAS)
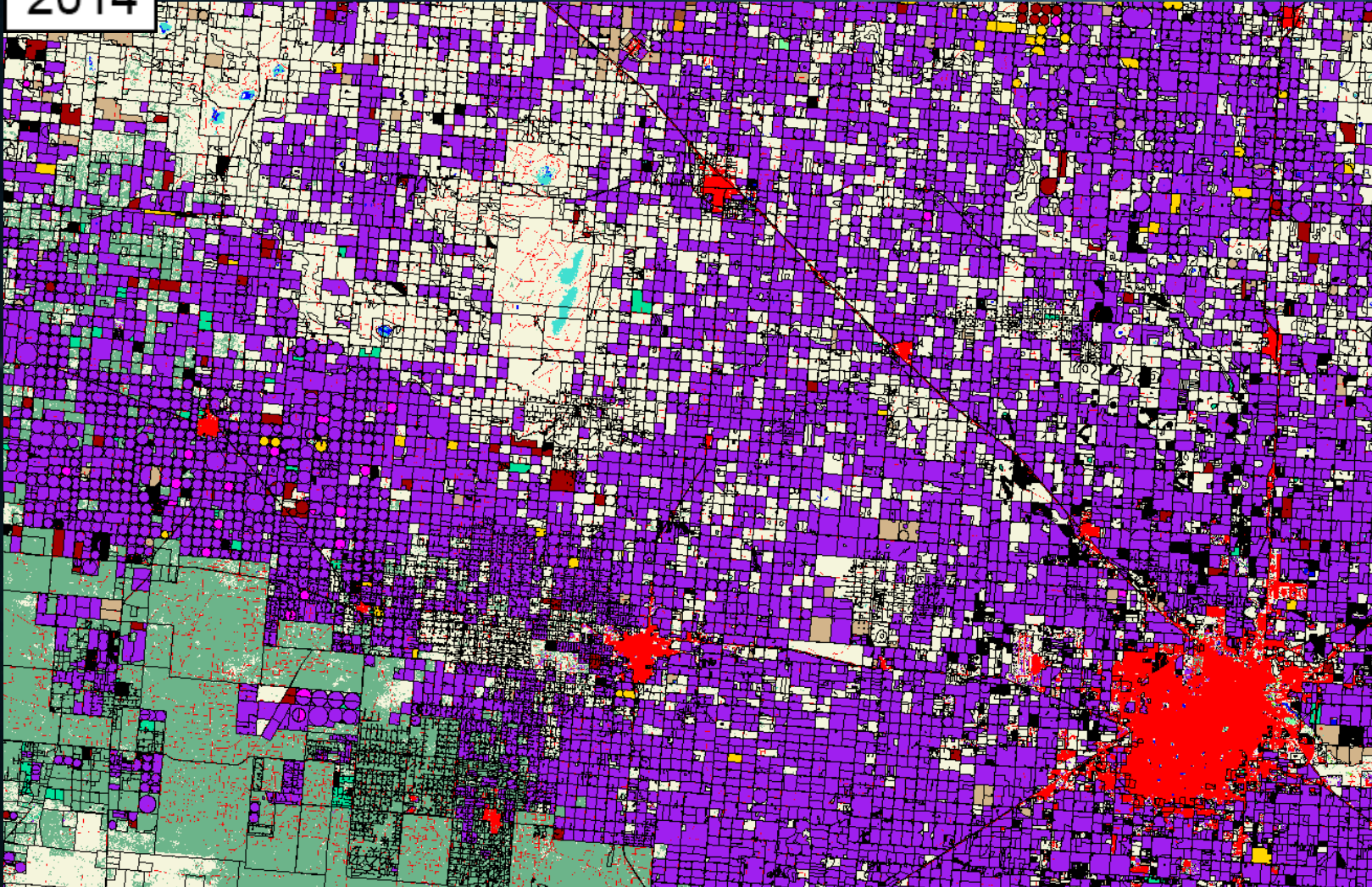
Modeling Past, Present, and Future Landscapes

Long-term Landscape Modeling – Climate and Land Use

2014

Lubbock, Texas area

As the aquifer becomes depleted and the climate changes, irrigated cotton (purple) can no longer be supported, and ag fields shift either to dryland wheat, or revert to grass or shrub states.

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Landsat Next -- Requirements Meet Emerging Needs

Multi-spectral→ Super-spectral

Celebrating 50 YEARS of Landsat 1972-2022

User need surveys provided a clear set of priorities for Landsat Next requirements to meet emerging needs at breakthrough effectiveness:

Improved Revisit Frequency. Dynamic phenomena (crop health & productivity, water quality, snow/ice state, wildfire) which require ~weekly clear views.

Higher Spatial Resolution. Experience with Sentinel-2 has underscored importance of 10-meter data for monitoring small agricultural fields, forest disturbance, urbanization, and other applications.

Additional spectral bands to support emerging applications in water quality, snow hydrology, soil mapping, and other areas.

Maintaining radiometric quality established by Landsat 8/9

Spectral Comparison: Landsat 8/9, and Landsat Next
Increased spectral coverage with Landsat Next will enable new applications
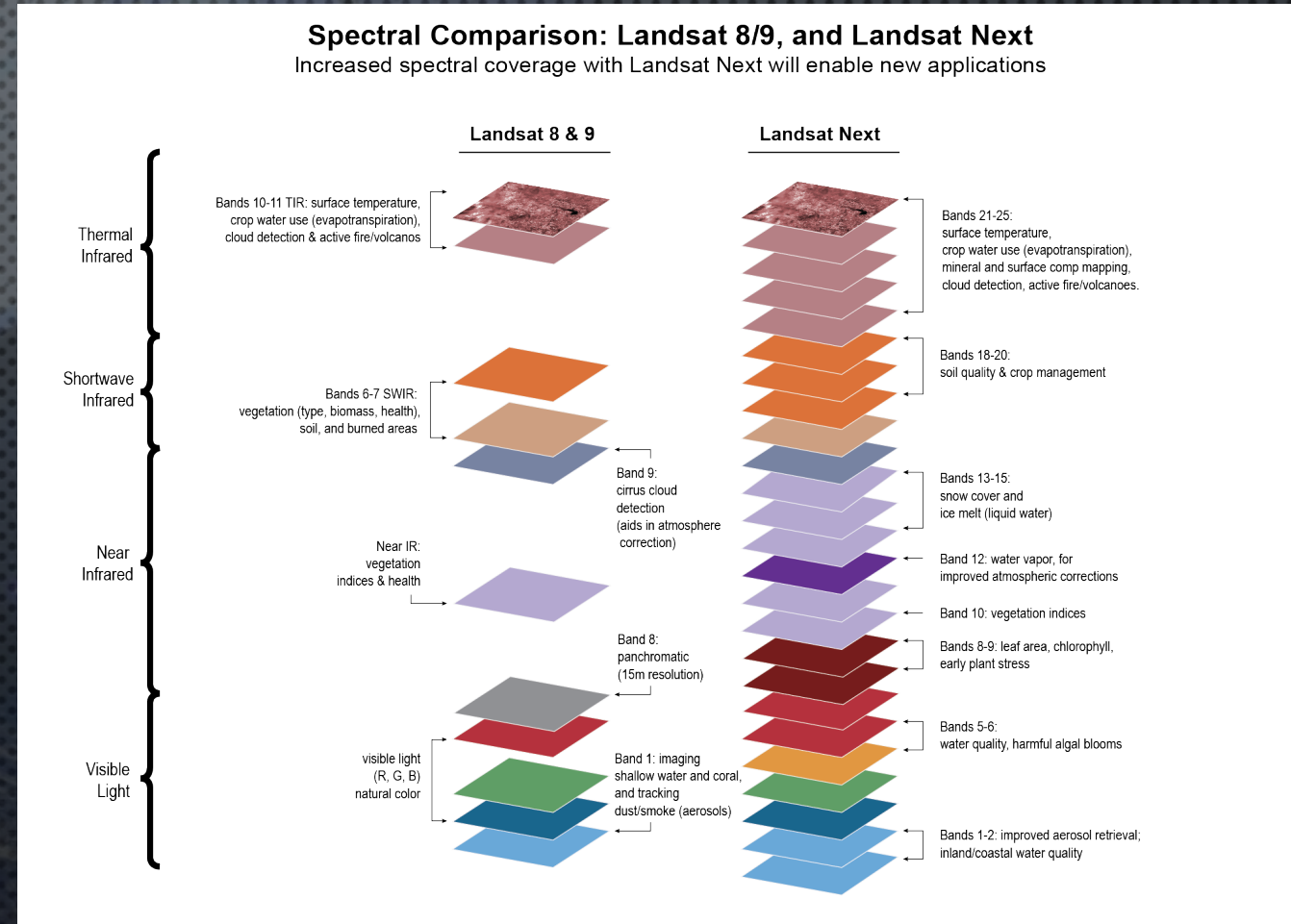
Landsat Next will provide more than twice as many spectral bands, with resolution improved by a factor of 2, and with the repeat coverage of Landsats 8 and 9, *combined*

≋USGS

It's a whole new world...

- Cloud computing and Artificial Intelligence / Machine Learning approaches for mapping make converting data to information easier than ever before
- USGS no longer alone in LCLUC mapping at national or global scales
- Commercial and international entities (Google, ESRI, ESA, IO, etc.) are also creating land cover products at global scale using multiple sensors

USGS Role in LCLUC Monitoring

- Reliable source of ***Gold-Standard***, validated, national-scale land-change data
- Linking LCLUC to climate change and hydroclimate signals using the long, consistent Landsat record
- Longevity/persistence/continuity of our foundational products
- Focus on characterizing change as opposed to one-off LULC mapping
- Comprehensive assessment of landscape change, including changes in land cover, use, condition, and management.
- Syntheses – collaborative, cross project, cross mission, cross agency

Pecora-22: October 23-28, 2022

Denver, Colorado

- Flagship land-imaging satellite applications conference; longstanding USGS-NASA partnership
- Highlights Landsat's 50th anniversary
- Features Landsat 9, Landsat Next and the many innovative developments in government and commercial land-imaging programs
- Inviting Secretary Haaland and NASA Administrator Nelson for Plenary & Evening Celebration on the 26th
- Website: pecora22.org

PECORA 22

Opening the Aperture to Innovation: Expanding Our Collective Understanding of a Changing Earth

Celebrating **50** YEARS of Landsat 1972-2022

October 23-28, 2022
Denver, CO • Hilton City Center

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