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Land Remote Sensing Program

Development of Climate Data Records (CDRs) and Essential Climate Variables (ECVs) from Landsat Data Project Overview

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Outline

- Project Overview
- Technical Approach
- Collaboration and Partnerships
- Project Timeline

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Global Climate Observing System

Domain	Subdomain	Essential Climate Variable
Atmospheric (over land, sea and ice)	Surface	Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed/direction, Water vapour
	Upper Air	Earth radiation budget, Upper-air temperature, Wind speed and direction, Water vapour, Cloud properties.
	Composition	Carbon dioxide, Methane, Ozone, Other long-lived long lived greenhouse gases, Aerosol properties
Oceanic	Surface	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean color, Carbon dioxide partial pressure.
	Subsurface	Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial	River discharge, Water use, Ground water, **Lakes**, **Snow cover**, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, **Land cover (including vegetation type)**, Fraction of absorbed photosynthetically active radiation (fAPAR), **Leaf area index (LAI)**, **Above ground biomass**, **Fire disturbance**, Soil moisture, Soil carbon, Ice sheets.	

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Overview

- The USGS is the steward of the Landsat archive, which is the longest satellite remotely sensed data record of the Earth's land masses.
- The spatial resolution of Landsat data enables discrimination between natural and human-induced changes to the landscape
- By the time Landsat 8 is operational, the TM and ETM+ data archive will be of sufficient length to qualify as a climate record (30 years)
- The opening of the Landsat archive provides the opportunity to innovate and exploit these data for modeling, scientific assessments, and decision-making
- The retrieval of geophysical and biophysical parameters from remotely sensed data has been demonstrated and proven to be achievable on an operational basis (Terra & Aqua MODIS, Envisat MERIS)

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Goals

- Develop science-quality, applications-ready, time-series of key terrestrial variables produced from historical and current global coverage of Landsat data on an operational basis.
- Develop climate data records for which the uncertainties are well-characterized.
- Develop terrestrial essential climate variables in accordance with the guidelines established through the Global Climate Observing System (GCOS).
- *"Strategic Plan for Developing Landsat-scale Climate Data Records and Essential Climate Variables"* was drafted, distributed for peer review, and submitted for publication as a USGS Circular.

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Objectives

- Construct long term data records to establish historical trends and enable future projections
- Remove the burden of processing from the end user – readily usable information
- Enable quantitative assessments of land surface change – terrestrial monitoring
- *"Implementation Plan for Developing Landsat-scale Climate Data Records and Essential Climate Variables"* has been drafted, distributed for review and comment, and will be revised as necessary after this review prior to execution.
- Requirements analysis being conducted in parallel – leveraging National Earth Observation (NEO) activities

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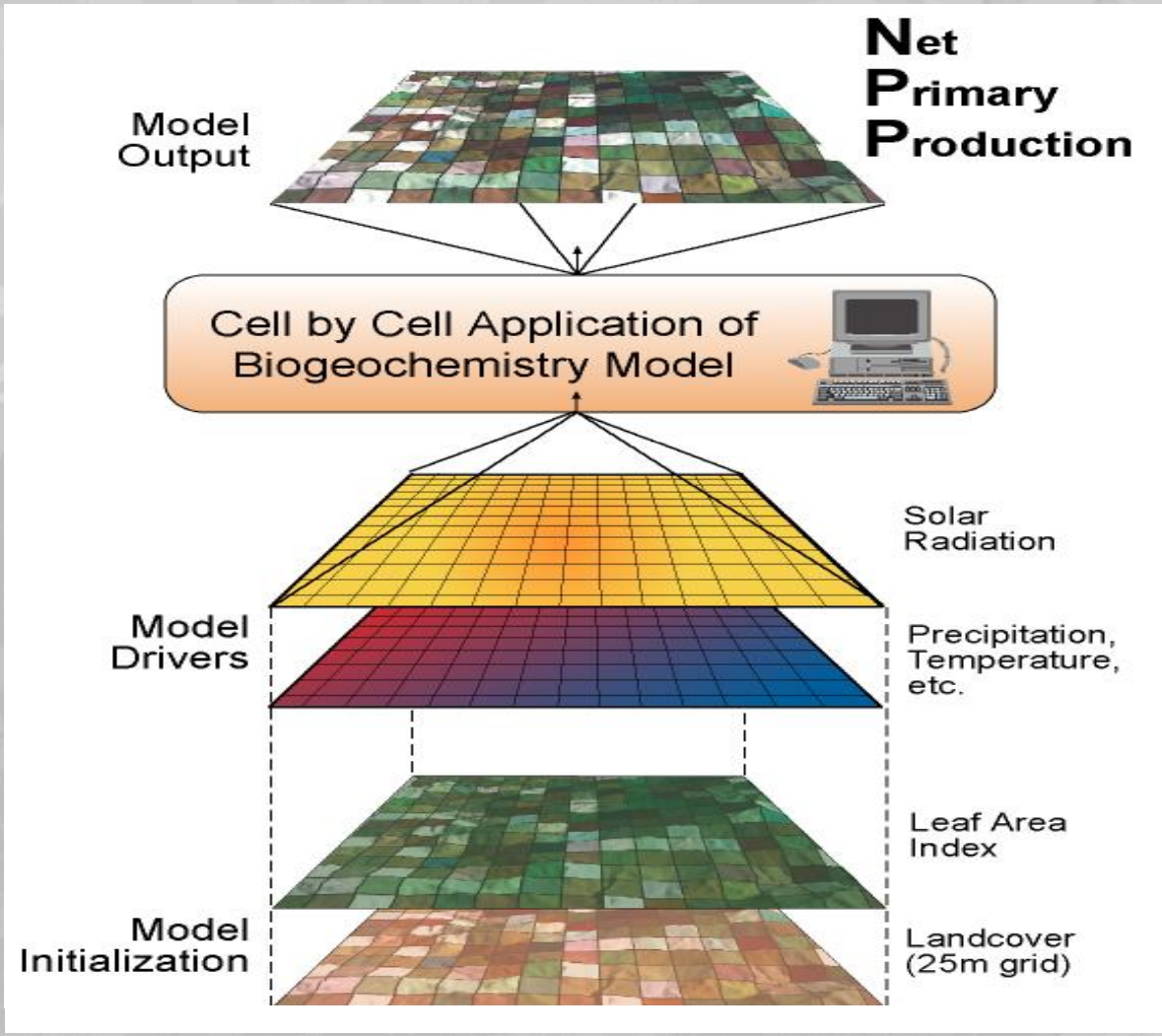
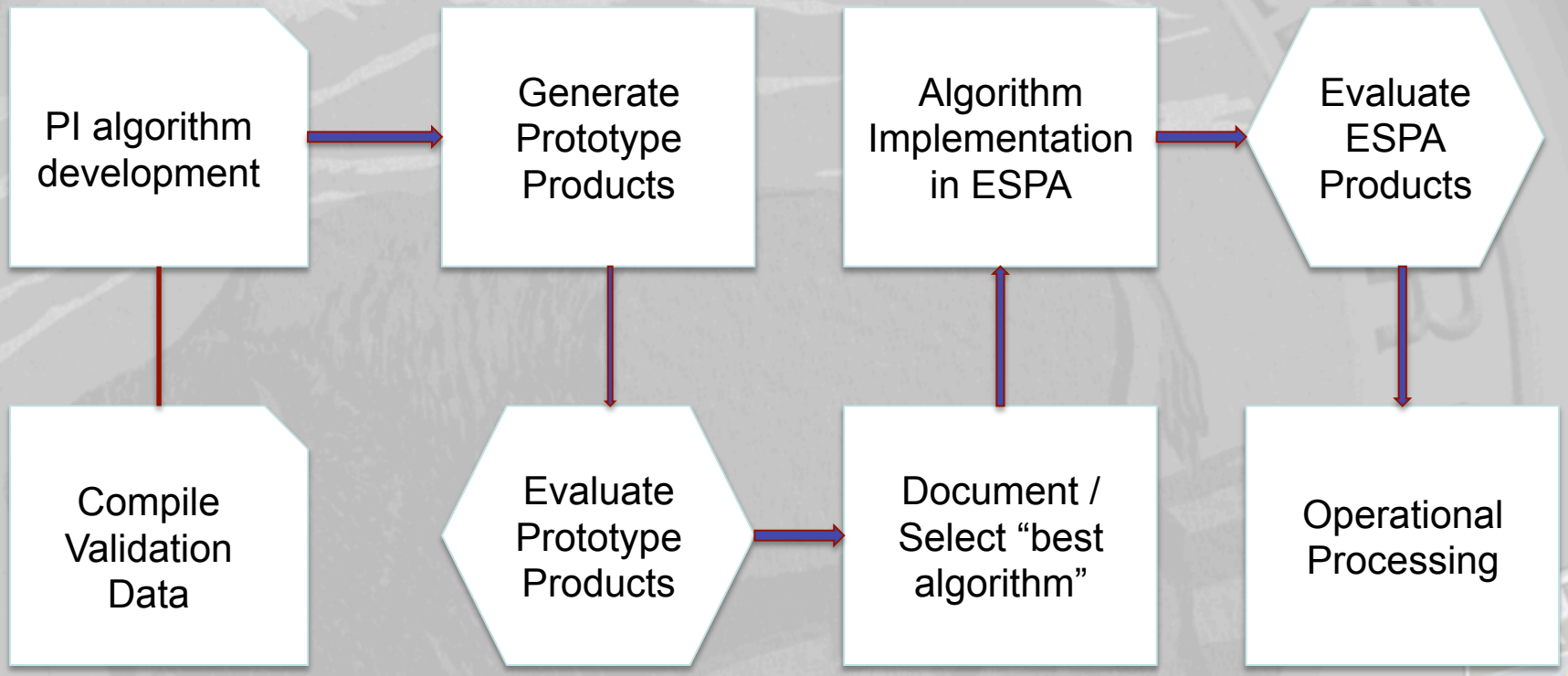
Value of ECVs as Inputs to Models



Courtesy Rama Nemani, NASA Ames Research Center

Technical Approach



Algorithm delivery follows LDCM protocols and algorithm description documents

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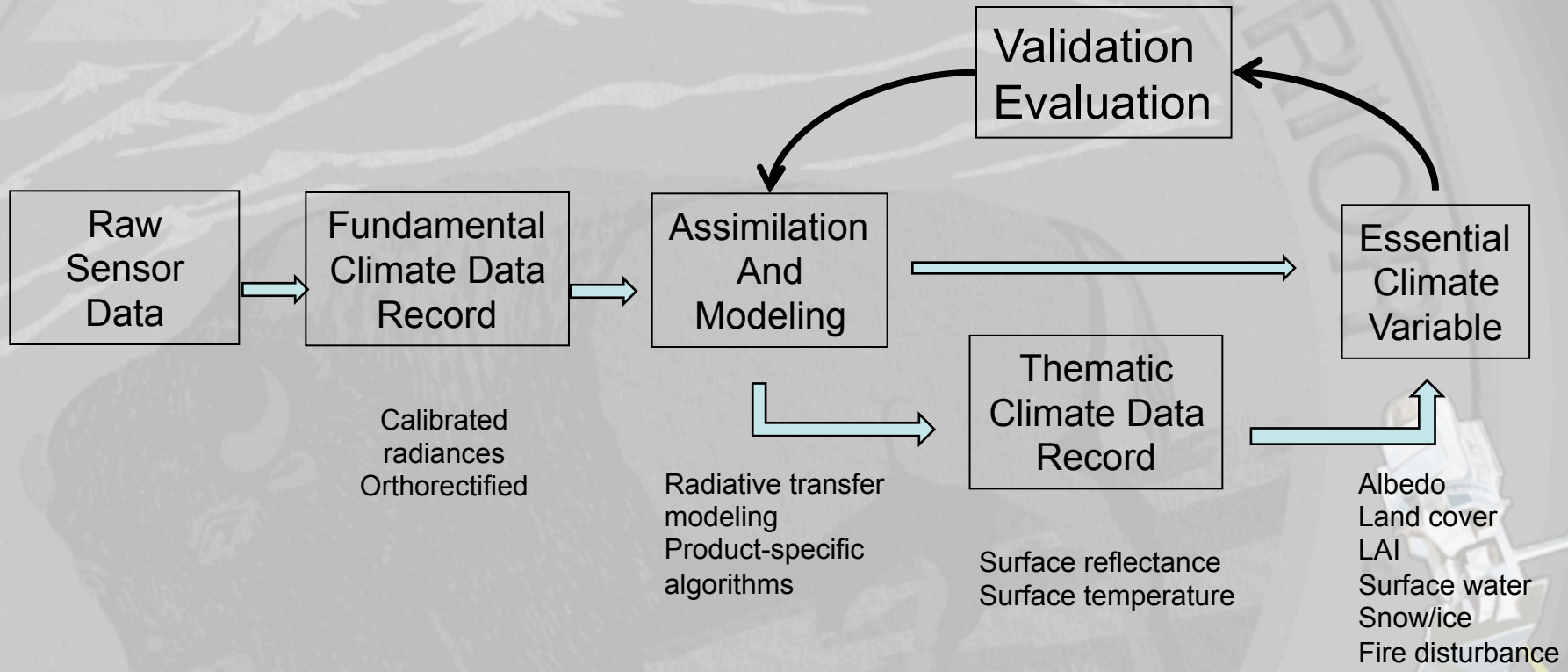
Notional Processing Flow



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CDR and ECV Product Phasing

- Products will be made accessible for distribution in a phased approach as the algorithms mature and product uncertainties have been characterized
- Initial phase of “provisional” CDR and ECV products will be provided through ESPA via “hidden” web pages off the Landsat web site
  - We do this today for surface relfectance and California LAI products from the GLS 2005
  - Review by ECV Project Team, EROS Scientists, Landsat Science Team, LP DAAC User Working Group, and DOI Remote Sensing Working Group
- The second phase is to make “Beta” products available through Earth Explorer, either “on-demand” (surface reflectance) or as standing collections (LAI)
  - Product uncertainties have been characterized for a limited number of sites and time steps
- The final phase would be release through Earth Explorer and GloVis following reprocessing as algorithms become more stable and product uncertainties are well-characterized

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EROS Science Processing Architecture (ESPA)

- Standard service oriented architecture (SOA) interface for software services that can be utilized for science processing
- Open source software – VMware for parallel processing
- Service Framework provides a standard integration infrastructure that optimizes software re-use.
- Capability to use existing distribution interfaces for generated products/data
- Capability to use custom services (e.g., OGC) for distributing data
- Standard storage architecture (HADOOP distributed file system) for data storage

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ESPA Provides

- Basic functions, procedures, interfaces, and software services that support generation of higher-level products.
  - Data access
  - Querying and storing metadata
  - Science computing
  - Product distribution
- Algorithm implementation standards and policies for integrating algorithms into the architecture (CM)
- Algorithms can be chained together to build processing workflows
  - Stable and consistent products over time
- On-demand processing and development of standing product collections

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Collaboration and Partnerships

- Build upon existing bodies of knowledge
- Leverage expertise within the research community
- Transition demonstrated successes from research & development into operations
- Characterize product uncertainties
- Understand and satisfy information requirements
- Improve information delivery services
- Enable scientific assessments

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Partnerships

- Landsat Ecosystem Disturbance Adaptive Processing System (LEDAPS) – Jeff Masek, NASA GSFC – surface reflectance
- Surface Temperature – John Schott (RIT) and Simon Hook (NASA JPL) – atmospheric characterization and emissivity grids
- Deriving Biophysical Products from Landsat Data – Rama Nemani, NASA Ames Research Center – Leaf Area Index (LAI)
- Web Enabling of Landsat Data (WELD) – David Roy, South Dakota State University – consistent gridding and tiling
- Landsat Science Team – sensor characterization, algorithm development, product evaluation
- CEOS Working Group on Climate
  - WMO Space-based Architecture for Climate Monitoring
  - Product Maturity Matrix
- CEOS Working Group on Calibration/Validation – Land Product Validation Subgroup

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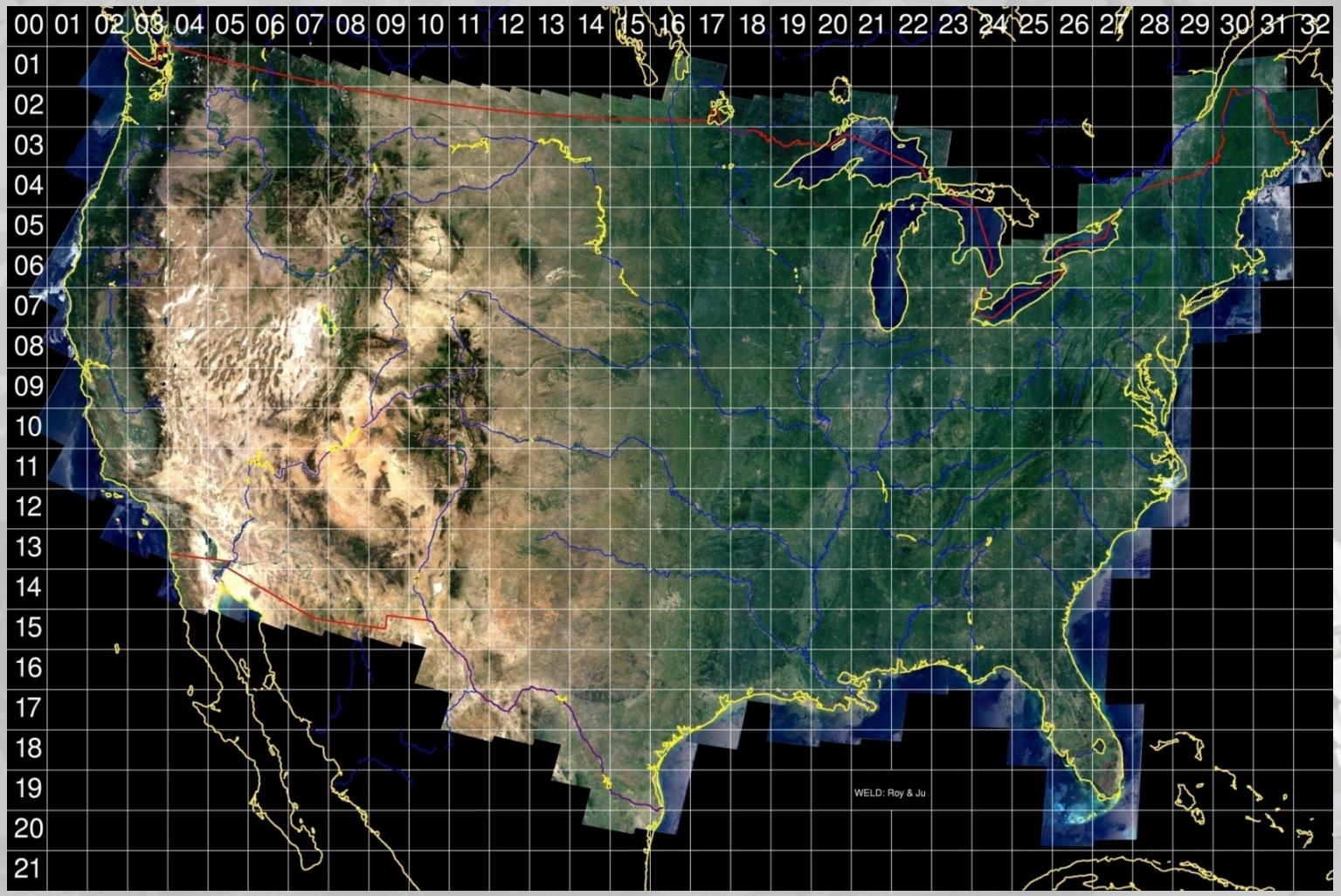
Gridding and Cloud-reduced Composites



Courtesy of David Roy, SDSU

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Project Timeframe

- FY10 - Initial definition and feasibility study
- FY11 - Research and development effort exploring existing and/or creating new algorithms suitable for ECV generation and eventual upscaling
- FY12 - Employing rapid prototyping techniques to demonstrate capabilities and validating results
- FY13 - Define Initial Operating Capability and deployment
- FY14- Scale up to Operating Capability and Capacity

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Questions?

Backup Slides

The Family of 'Data Records' 1/2

- Climate data record (CDR) – A time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change. Consistency in processing and reprocessing over years and decades is an essential requirement.

- Fundamental climate data record (FCDR) – Long term satellite data record, involving a series of instruments, with potentially changing approaches, but with overlap and calibrations sufficient to allow the generation of homogeneous products providing a measure of the independent variable that is accurate and stable enough for climate monitoring.

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The Family of 'Data Records' 2/2

- Thematic climate data record (TCDR) – Geophysical variables derived from the FCDRs, with well-defined levels of uncertainty. An ongoing program of correlative in situ measurements is required for validation.

- Essential climate variable (ECV) – Measurements that are technically and economically feasible for systematic observation. Variables that are currently feasible for global implementation for the Global Climate Observing System (GCOS), and have high impact on the UNFCCC and IPCC requirements.

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Science Heritage of Climate Data Records

- Climate Data Record (CDR)
- Fundamental Climate Data Record (FCDR)
- Thematic Climate Data Record (TCDR)
- Environmental Data Record (EDR)
- Earth Science Data Record (ESDR)
- Essential Climate Variable (ECV)

- U.S. National Research Council defined CDR, FCDR, and TCDR
- EDR terms used by NOAA for the Visible Infrared Radiometer Suite (VIIRS) land products
- ESDR terminology developed by NASA because of perceived deficiencies in EDRs
- ECVs defined by GCOS, FCDRs are required inputs

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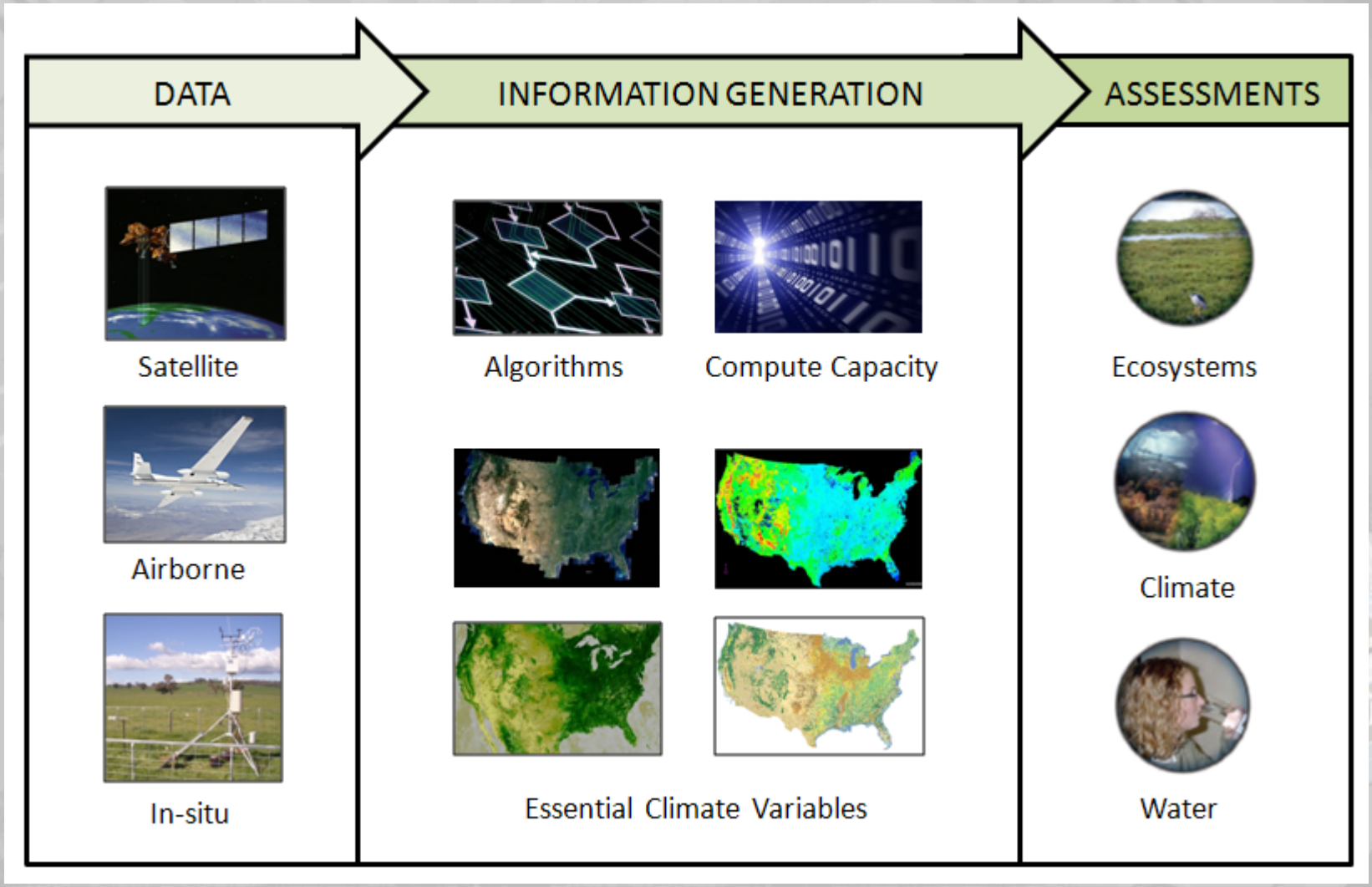
Conceptual Framework



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Candidate ECVs for Development

Terrestrial ECV	Technical Consideration			Requirements / Demand		
	Landsat Potential	USGS Readiness	USGS Uniqueness	USGS Relevance	Importance to DOI	Overall Community Demand
*Land Cover	High	High	High	High	High	High
*Leaf Area Index	High	Low	Low	Medium	Medium	Medium
FPAR	High	Low	Low	Medium	Low	Low
Biomass	Low	Low	Low	High	High	High
*Albedo	Medium	Low	Low	Medium	Low	Low
*Fire Disturbance (burned area)	Medium	High	Medium	High	High	High
*Lakes (surface water)	High	High	Medium	High	High	Medium
*Snow cover	Medium	Medium	Low	Medium	Medium	Medium

*ECVs with highest initial potential for development

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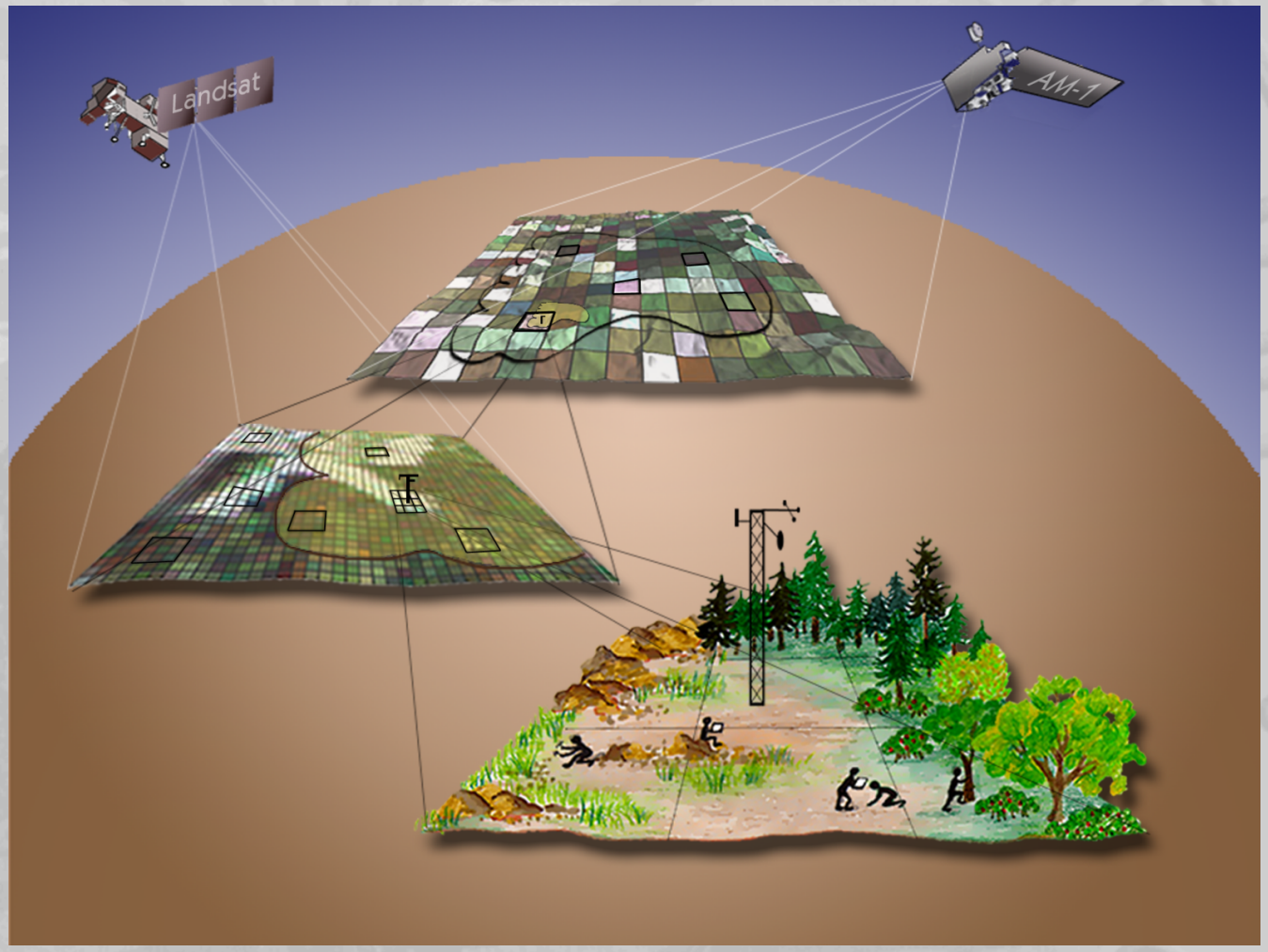
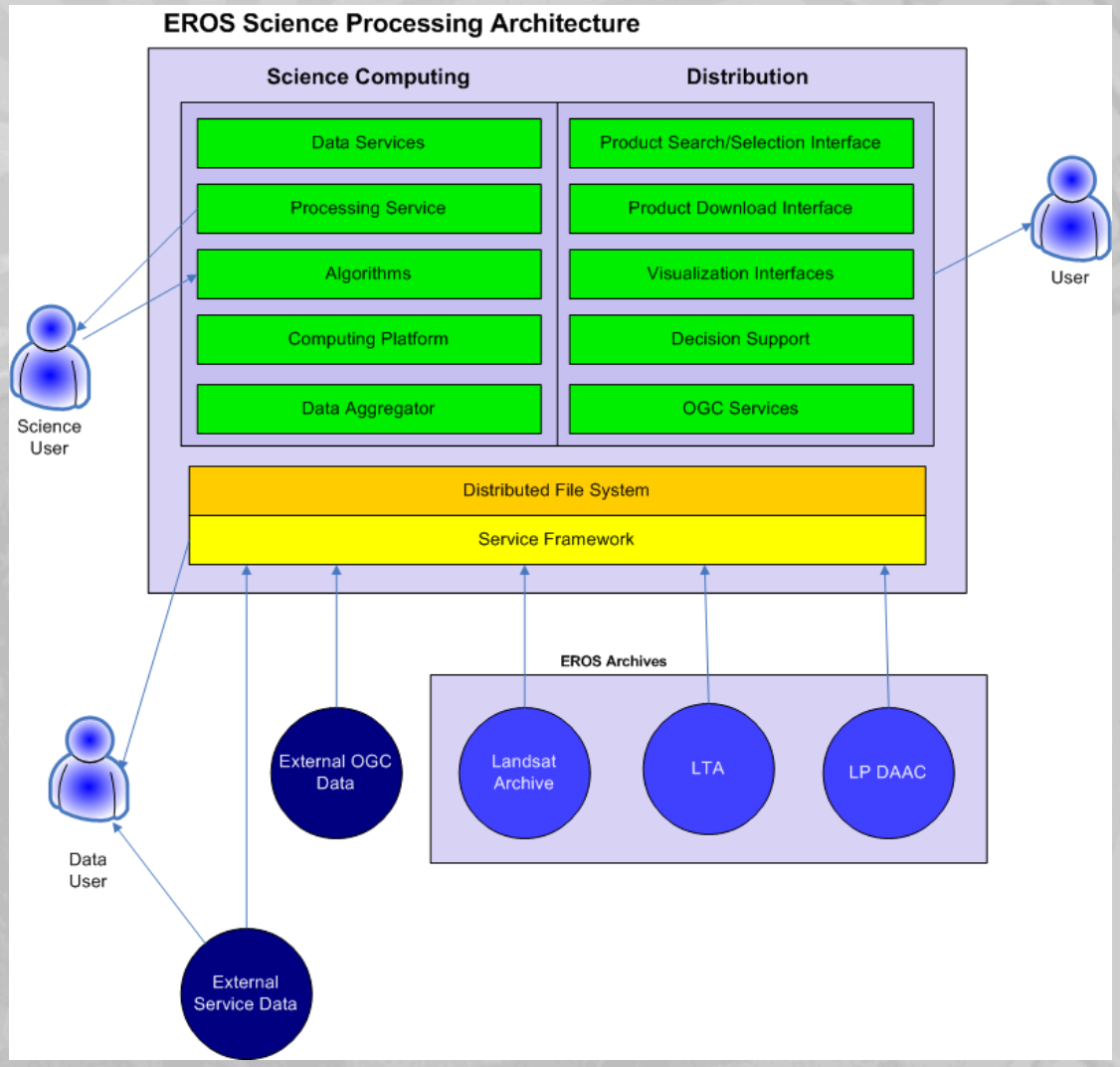
Multi-resolution Data Framework For Calibration and Validation



Courtesy of Warren Cohen / Bigfoot Project, Oregon State University

Architecture Overview



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Data Access and Distribution

- Prototype GUI developed for GLS 2005 and 2010 surface reflectance collections
- Products generated on demand through ESPA order interface
  - Currently restricted until product uncertainties are characterized and documented
- Product options will be made available through Earth Explorer or GloVis interfaces
- May adapt WELD gridding and tiling schemes for standing collections

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USGS Principal Investigators

- John Dwyer and Tom Dinardo – Project Management
- John Dwyer – Surface Reflectance CDR, Surface Temperature CDR, Leaf Area Index ECV, Data Processing Framework
- Chandra Giri and Tom Loveland – Land Cover ECV
- John Jones & Mike Starbuck Surface Water Extent ECV
- Susan Stitt – Fire Disturbance Burned Area Extent ECV

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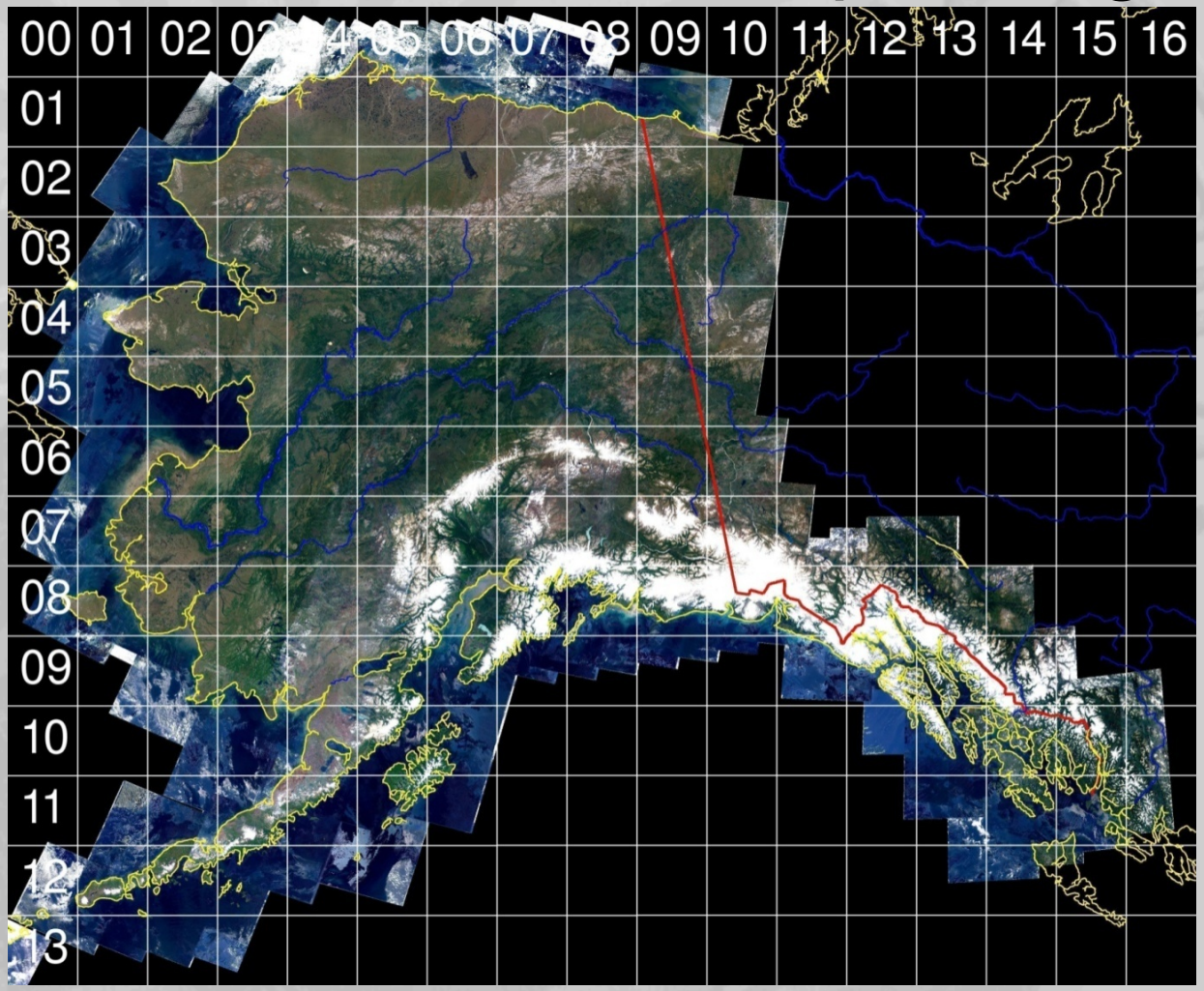
Cloud Reduced Compositing



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