Land Science Data Analysis and Multi-Disciplinary Research

Chair: Chris Justice

PIs: Luigi Boschetti (U.Idaho), Mark Friedl (BU), Huilin Gao (TAMU), Eleanor Stokes (USRA/EfSI), and Dorothy Hall (UMD/ESSIC).

Land Science Data Analysis and Multi-Disciplinary Research

- **Is the world burning less?** Luigi Boschetti (UI)
- **Long-Term Changes and Variability in Global Ecosystem Phenology From MODIS** Mark Friedl (BU)
- **Understanding the Long-term Dynamics of Global Lake/Reservoir Storage and Evaporation using T/A/SNPP/JPSS Satellite Observations** Huilin Gao (Texas A&M University)
- **Nightlights-Based Assessment of Global Electricity Infrastructure and Future Emissions to Meet Growing Demand: Motivation and Questions** Eleanor Stokes, (USRA)
- **Status and Fate of Great Basin Terminal Lakes:** Dorothy Hall (UMD)

Is the world burning less?

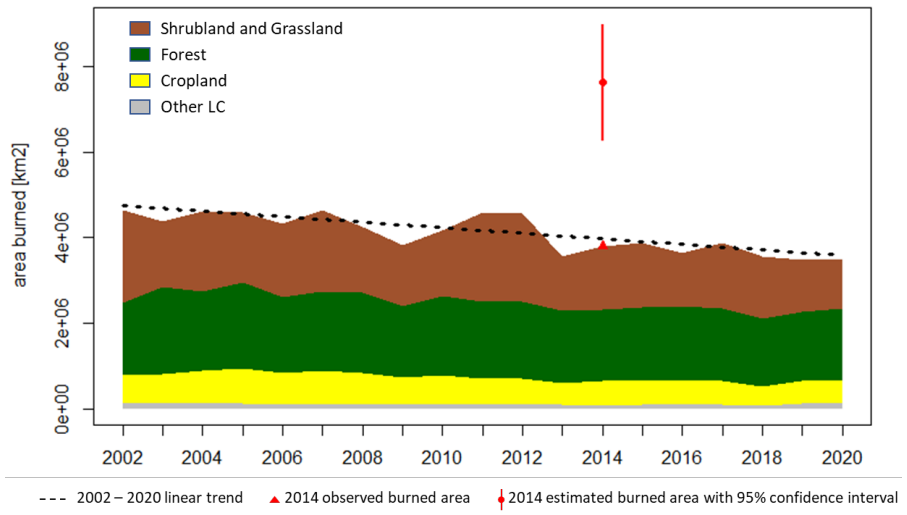
Disentangling decadal trends, inter-annual fire variability and product uncertainties, through harmonization of the NASA MODIS and VIIRS fire product record

Luigi Boschetti (UI), David Roy (MSU) and Louis Giglio (UMD)

Rationale

The combined MODIS / VIIRS burned area time series will provide the first ever global fire record covering the 30 years conventionally required for climate analysis.

Validation with Landsat shows a large bias due to missing small burns. The bias can affect the usefulness of the time series.



Project Objectives and Tasks

- Quantify the discrepancy between active fire counts and burned area detections in the MODIS and VIIRS product record.
- Generate reference L8 / S2 burned area time series at representative locations.
- Derive an unbiased 25-year 0.25° harmonized MODIS/VIIRS time series, with uncertainties, calibrated using the L8/ S2 reference burned area
- Detect burned area trends and interannual variability, identify if observed trends are significant relative to inter-annual fire variability and to the uncertainties.

Is the world burning less?

Disentangling decadal trends, inter-annual fire variability and product uncertainties, through harmonization of the NASA MODIS and VIIRS fire product record

Proposed milestones (deliverables)

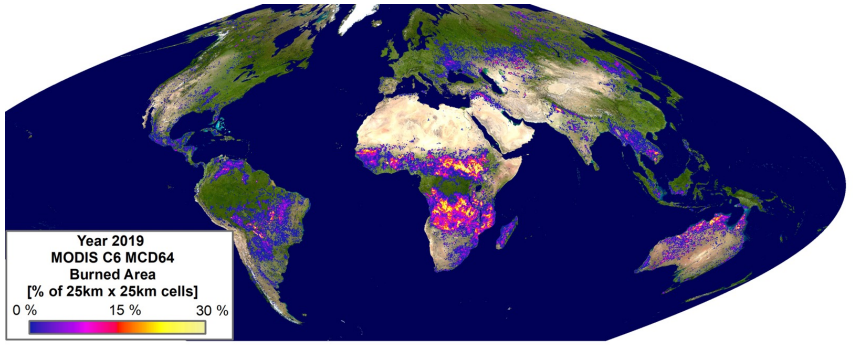
Year 1: Intercomparison of MODIS/VIIRS burned area and active fire products. Selection of locations for L8/S2 reference data.

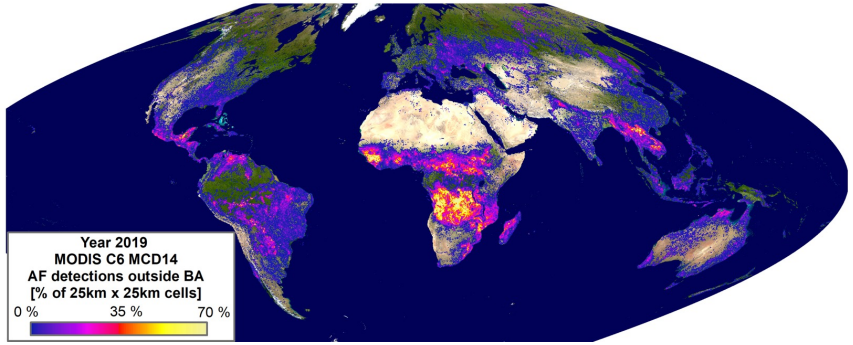
Year 2: Generation of the L8/S2 reference dataset

Define the approach for the AF/BA fusion

Define the approach for the calibration of the 0.25° harmonized product

Year 3: Generation of the calibrated 0.25° MODIS/VIIRS burned area product (2012-2024) and contingency VIIRS only product (2002-





Critical concern: delay in the release of the VIIRS burned area product (L8/S2 reference dataset ideally informed by MODIS and VIIRS)

Long-Term Changes and Variability in Global Ecosystem Phenology From MODIS

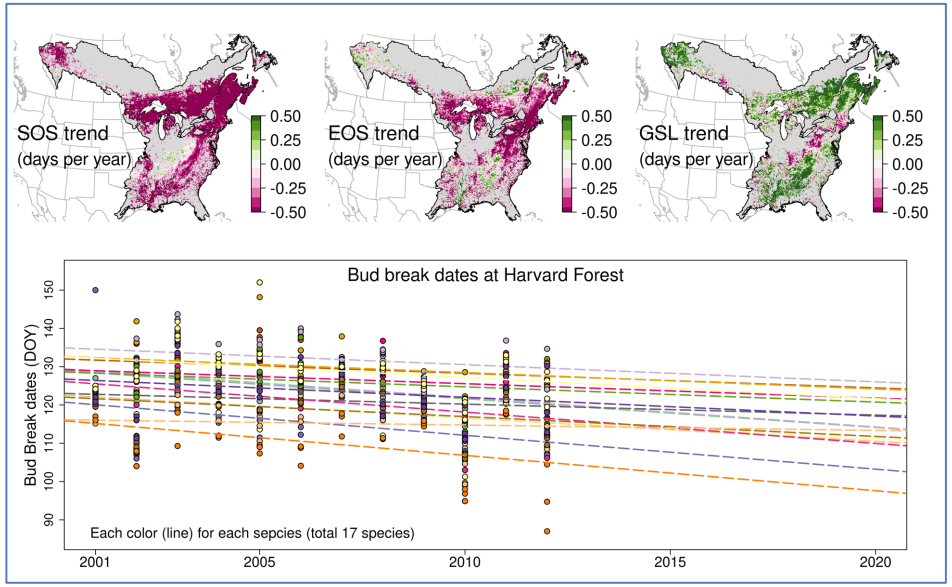
Mark Friedl (BU) , Joshua Gray (NCSU) Andrew Richardson (NAU), Minkyu Moon (BU), Tristan Green (BU)

Project Description

- *How has the timing and length of growing seasons changed over the MODIS era?*
- *How do LSP anomalies and trends impact sub-seasonal and seasonal scale carbon fluxes?*
- *How can joint information from MODIS land surface temperature and land surface phenology be used to characterize the impact of droughts on ecosystems?*

Technical Challenges

- Establishing uncertainty of MCD12Q2 metrics & trends (Moon et al, in review, Scientific Data)
- Estimating models linking dynamics in terrestrial carbon & water to variation & trends in LSP (Gao et al, in review, GCB)



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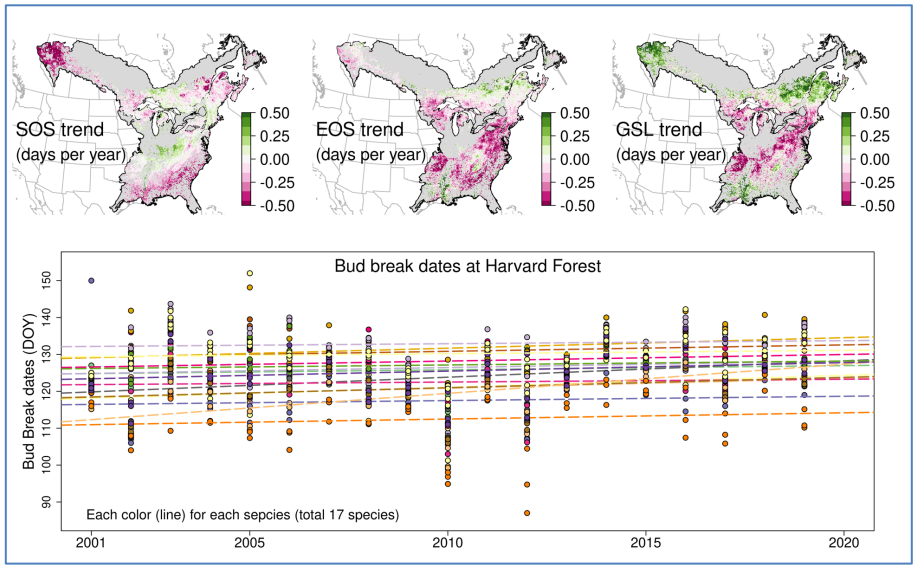
Long-Term Changes and Variability in Global Ecosystem Phenology From MODIS



Proposed Milestones

- *Year 1: Characterization of Variability and Trends in Global LSP*
- *Year 2: Develop Model of Joint Variability in LSP & Carbon Fluxes*
- *Year 3: Mapping Ecological Impacts of Droughts*

Deliverables

1. A detailed characterization of global-scale trends and changes in phenology with much higher spatial resolution and ecological interpretability than is currently available.
2. Improved understanding of seasonal-to-decadal scale joint variability in land surface phenology and ecosystem-scale carbon fluxes arising from climate variation and change.
3. Improved ability to map the extent, duration, and ecological impact of drought events.

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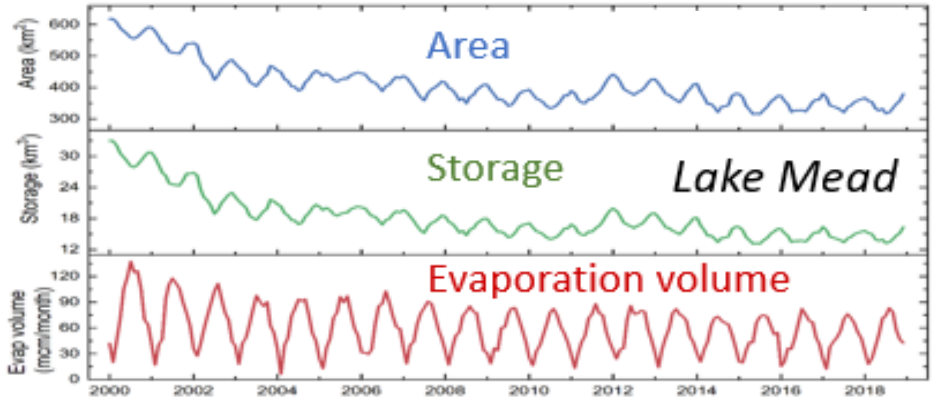
Understanding the Long-term Dynamics of Global Lake/Reservoir Storage and Evaporation using T/A/SNPP/JPSS Satellite Observations

PI: Huilin Gao (Texas A&M University)

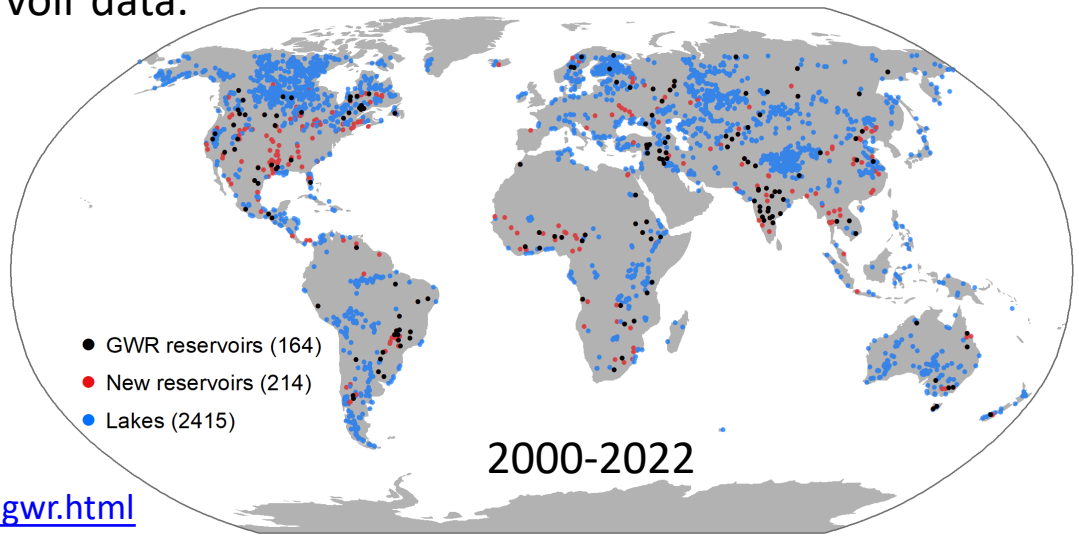
Project Description

Product objective: to generate ***a comprehensive, coherent, and long-term global lake/reservoir dataset*** at improved spatial coverage by combining Terra/Aqua/Suomi NPP/JPSS-1 observations.

Science objective: to address important science questions related to the long-term lake/reservoir storage variations and evaporation trends; and to monitor flood & drought using lake/reservoir data.



References: Global Water Reservoir (GWR) Product https://modis-land.gsfc.nasa.gov/modgwr.html
Algorithm Theoretical Basis Document (ATBD), Zhao et al., 2020, and Li et al., 2021.



The 2793 global lakes and reservoirs identified for this project.

Technical Challenges

- Some locations where the A-E relationships are not sufficiently robust may need to be excluded
- If large inconsistencies are found among the T/A/SNPP/JPSS MODIS/VIIRS based results, a plan for bias correcting the low quality results may be needed

Understanding the Long-term Dynamics of Global Lake/Reservoir Storage and Evaporation using T/A/SNPP/JPSS Satellite Observations

PI: Huilin Gao (Texas A&M University)

Proposed Milestones

- **Establishing the Area-Elevation relationships** (year 1)
- **Developing the lake/reservoir dataset series** (year 1.5)
- **Validating the results & evaluating consistencies** (year 2)
- **Addressing critical science research questions**
  - Analyzing the long-term lake/reservoir storage dataset (year 2.5)
  - Analyzing the long-term lake/reservoir evaporation loss (year 2.5)
  - Assessing the impacts of climate extremes on lakes/reservoirs (year 3)
- **Decimating research results** (throughout the project period)

Deliverables

- **Data Products:**
  - The Area-Elevation relationships at the 2000+ lakes/reservoirs
  - 8-day area/elevation/storage time series at each location based on T/A/SNPP/JPSS MODIS/VIIRS data (2000-2022)
  - monthly area/elevation/storage/evaporation time series at each location based on T/A/SNPP/JPSS MODIS/VIIRS data (2000-2022)
  - Validation of results using in-situ observations and/or cross-validation of results using other satellite products

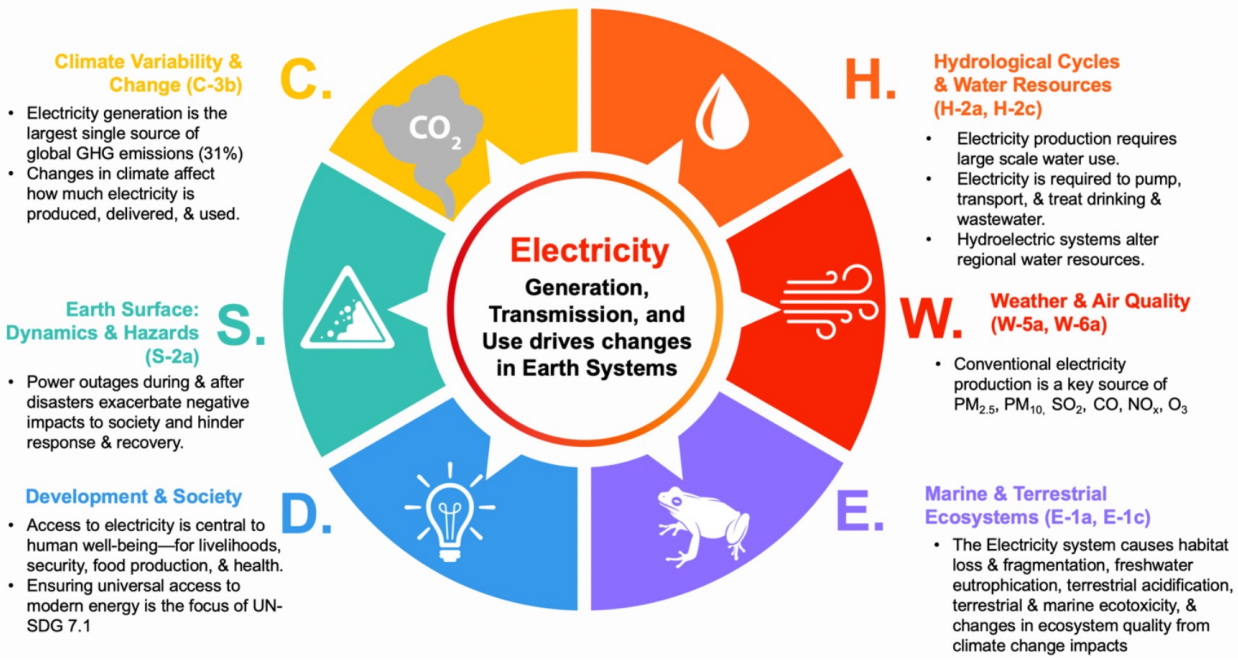
  - Generation and availability of products:
  - To be generated on GEE and PI's cluster; to be made available at TX Data Repository and GEE (interactive data)
- **Conferences presentations and journal papers:**
  - Presentations at AGU, AMS, and science meetings
  - Manuscripts (from data product to analysis and applications) in peer-reviewed high-impact journals.

Nightlights-Based Assessment of Global Electricity Infrastructure and Future Emissions to Meet Growing Demand: Motivation and Questions

PI: Eleanor Stokes, (USRA)

Co-I: Yuyu Zhou (Iowa State), Srija Chakraborty (USRA) ; Collaborators: World Resources Institute, CIESEN

The Electricity system has broad and significant impacts on Earth's natural processes.



- Links between electricity infrastructure development and use and the priorities of the U.S. Decadal Survey for Earth Science and Applications from Space (ESAS). We expect the insights and datasets developed with this work to inform eight of the ESAS Decadal Survey questions (H-2a, H-2c, W-5a, W-6a, E-1a, E-1c, C-3b, S-2a).

Research Questions:

(1) Where and to what degree are there gaps in electricity reliability and electrification, globally, and how have these gaps changed over the past decade? *Task 1: Develop a replicable, satellite-based methodology to quantify and map grid-connections and changes in the intermittency of the electricity grid over time.*

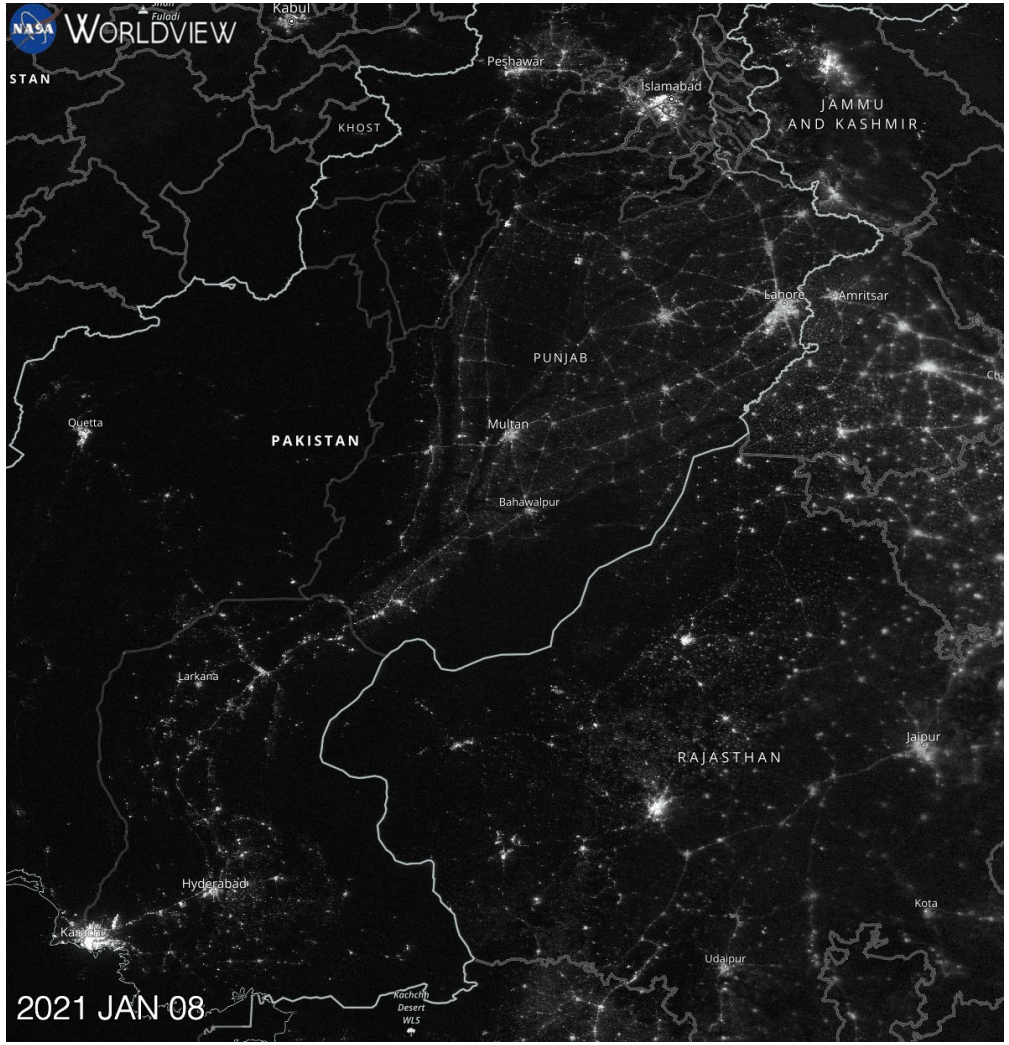
(1) What is the latent unmet electricity demand in areas without electrification or with intermittent electricity access? *Task 2: Construct an energy model to measure building electricity demand at 1 km2 spatial scale. Apply the electricity model to estimate (1) current building electricity consumption and (2) unmet electricity demand from intermittent access.*

(2) How will electricity demand for low and no access areas evolve, given different socioeconomic and climate futures? How will the electricity supply required to meet the growing demand shape emissions and impact climate commitments? *Task 3: Construct future electricity demand scenarios over low-access/intermittent areas and scenarios for how demand will be met. Quantify associated emissions to understand what these scenarios will imply for meeting climate change targets.*

Nightlights-Based Assessment of Global Electricity Infrastructure and Future Emissions to Meet Growing Demand: Deliverables

PI: Eleanor Stokes, (USRA)

Co-I: Yuyu Zhou (Iowa State), Srija Chakraborty (USRA) ; Collaborators: World Resources Institute, CIESEN



Key Deliverables:

(1)Global gridded dataset describing month of electrification; 2012-2022; 1km^2

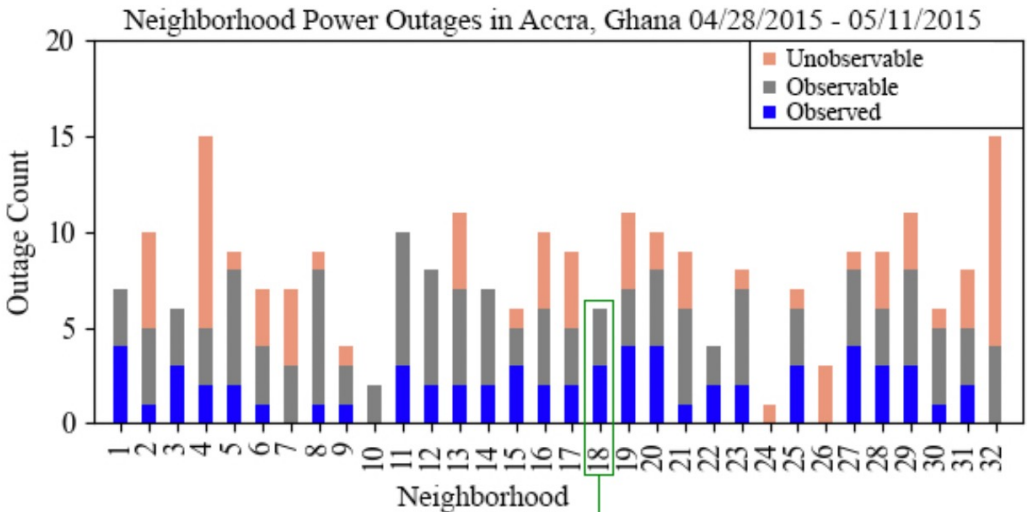
(2)Global gridded dataset of power access frequency and consistency; 2012-2022; 1km^2 grid, reported quarterly

(3)Satellite-derived estimates of annual System Average Interruption Frequency Index (SAIFI); at administrative levels 1, 2, & 3

(4)Gridded estimates of building electricity consumption and unmet demand; 2012-2022; 1km^2 grid, coverage over low-access areas, reported annually

(5)Annual forecasts (2020- 2050) of building electricity demand and emissions for 18 socioeconomic, climate change, and behavior scenarios; 1km2 grid, coverage over low-access areas

(6)Quality control and assessment flags for the previous measures (1-4)



Short Title: Status and Fate of Great Basin Terminal Lakes

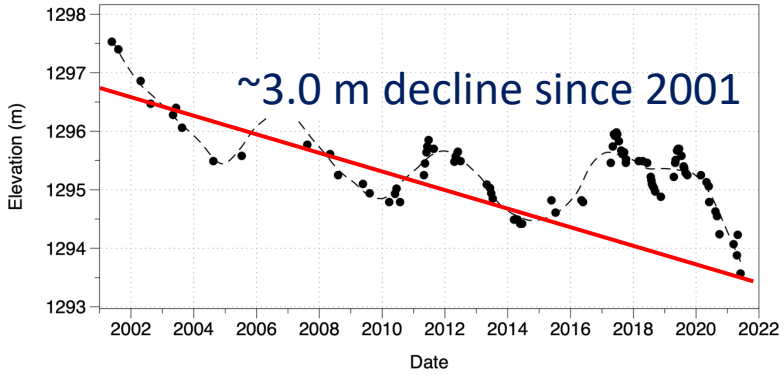
PI: Dorothy Hall/UMD; Co-Is: Kimberly Casey/USGS; Kelly Gleason, PSU; Bryant Loomis/GSFC; Nima Pahlevan/SSAI;
Student: Lara Jansen/PSU; Collaborators: Ron Larson/OLA & Crystal Schaaf/UMB

Project Description/Objective: To assess the hydrological and ecological status and sustainability of terminal lakes in the Great Basin

Terminal lakes are lifesaving stopovers for migratory birds, are of great cultural significance to tribal nations, and lead to hazardous air quality as they recede and desiccate

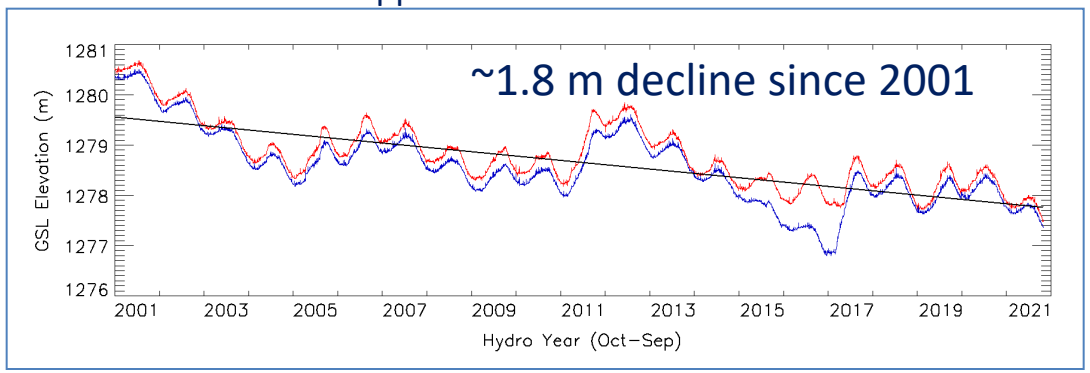
Photos: Ron Larson

Photo: D. Hall



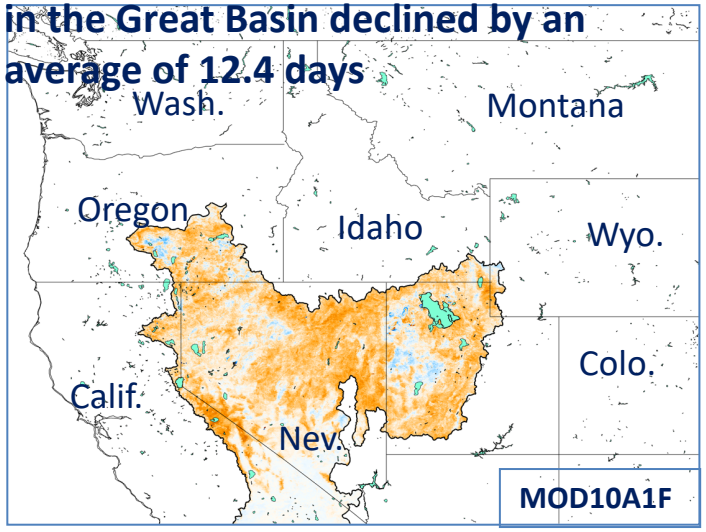
The surface-water elevations of all terminal lakes in the GB have declined during the MODIS era

Great Salt Lake dropped to its lowest recorded level in 2021



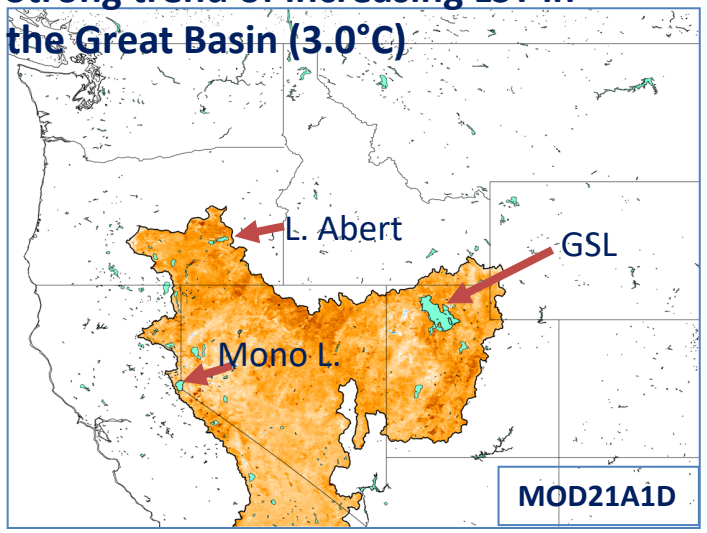
MODIS data products along with ancillary data help us to understand the reasons for the decline in the terminal lakes in the context of the ongoing megadrought

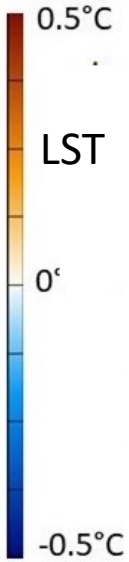
Trend map shows #days of snow cover in the Great Basin declined by an average of 12.4 days



Meltwater from snow in the mountains feeds the terminal lakes

Strong trend of increasing LST in the Great Basin (3.0°C)





Technical challenges/Milestones:

- USGS to collect water-quality samples of key lakes in the GB, spring/summer/fall 2022 – K. Casey
- R. Larson to collect samples from lakes in Oregon if there is sufficient water in the lakes, in 2022

Deliverables:

- Water samples will be sent to L. Jansen for analysis & results used to validate water quality algorithms that are under development (Chla/TSS/a_{cdom}(440)) - N. Pahlevan
- Planned conference presentations: Joint Aquatic Sciences Meeting (JASM), IGS & AGU

Near-term milestones:

- Complete trend analysis for the Great Basin and for individual lake basins (#days of snow, LST & ET)
- Start GRACE/GRACE-FO analysis with B. Loomis to study change in water storage in the GB