WyCEHG: Water in a Changing West: Wyoming Center for Environmental Hydrology and Geophysics

University of Wyoming
Wyoming EPSCoR RII Track-1 Award

Award of $20M for 5 years, announced July 13, 2012

- Research Infrastructure Improvement
- One WyCEHG with multiple facets
- Integration of research & education
- Infrastructure investments include people
  - Faculty, post-docs, Program in Hydrology
 WyCEHG Overview

The goal of this program is to establish a lasting center of excellence in environmental hydrology and hydrogeophysics that will transform practical approaches to watershed management and runoff prediction across the public and private sectors in the region.

Rationale:

Scientific
Fate and transport of water poorly understood; requires coupled surface/subsurface models

Practical
Water managers need predictive models => Requires up-to-date science, which we will provide
Critical Needs for Wyoming

• Snow is the key driver for water, and its fate is still undetermined
  – Links to managers, recreation, municipalities

• Mountain-front recharge of aquifer systems

• Changing hydrological systems
  – Next few decades will be challenging
Scientific Questions

• How do hydrological systems respond to change?
  - e.g., oil and gas development, bark beetle infestations, fires, floods, climate change

• How do snow processes, particularly moisture content (SWE) and the timing of snowmelt, affect the downstream system?

• What information and approaches are needed to upscale from the point scale to the watershed scale in hydrological modeling?
A Field-Based Framework for HydroGeophysics

Surface Processes and Measurements
A: Snow and Rain
B: Sublimation
C: Evaporation and Transpiration
D: LiDAR and Airborne Geophysics
E: Water Storage in Snow and Snowmelt Runoff
F: Water Storage in Lakes
G: Aquifer Recharge
H: Streamflow
I: Overland Flow
J: River Discharge

Subsurface Processes and Measurements
1: Infiltration
2: Boreholes for Ground Truth
3: Groundwater Discharge
4: Geochemical Interactions
5: Groundwater Recharge
6: River Losses

- Sapflux, Isotopes
- Runoff, Isotopes, Geochemistry
- Climate, Soil Moisture, Snow
- Groundwater Depth, Isotopes, Geochemistry
- Lysimeters, Geochemistry
- Geophysics Arrays
Research Program

We will establish:

1. *The Wyoming Center for Environmental Hydrology and Geophysics (WyCEHG)*
   (co-Directors, Holbrook & Miller)
   - Physical and intellectual infrastructure (“stuff, people, and science”)
   - Multidisciplinary center
   - Links to/strengthen PhD Program in Hydrology

2. *The Facility for Imaging the Near- and Sub-surface Environment (FINSE)*
   - Integral part of WyCEHG
   - Geophysical imaging instrumentation
   - Facility manager to be hired on grant & eventually picked up on state line

3. *The Surface and Subsurface Hydrology Lab (SSHL)*
   - Co-located with FINSE
   - Hydrology, atmospheric instrumentation
   - Facility manager & asst. manager
New Infrastructure: Environmental Hydrology

- **Surface & Subsurface Hydrology:**
  - Flow gages
  - Climate stations
  - Snow water equivalent
  - Groundwater wells / piezometers

- **Tracers:**
  - Stable isotopes
  - Radiogenic isotopes
  - Real-time chemistry
  - Met-flux towers

- **Goal of these measurements**
  - Provide field link to geophysical instrumentation
  - Build new models; support existing systems
  - Rapid response team
Linkage Between Research, Outreach & External Engagement

- Outreach and Diversity
  - Community & Tribal Colleges
  - Industry Internships
  - Water Management
  - JSU Partnership

- Physical Infrastructure
  - Field Work
  - Technical Training
  - Surface Processes
  - Hydrology

- Research
  - Town Meetings
  - Technology Transfer

- Education
  - Ph.D. Program in Hydrology
  - Summer Field Course in Hydrogeophysics
## Workforce Development

**Goal of Workforce Development Plan:** Implement a $2W$ (Science to Work) program that produces an educated workforce in STEM and will contribute to continued economic growth and public/private sector engagement in Wyoming

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<tr>
<th>Objectives</th>
<th>Implementation Strategies</th>
<th>Outputs</th>
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<tr>
<td>1. Offer G6-14 teacher training with Teton Science School: = WY Water in the Classroom (WWC)</td>
<td>Train teachers at WyCEHG research sites around Wyoming&lt;br&gt;Engage teachers in research using FINSE equipment&lt;br&gt;Transfer knowledge to the classroom to practice citizen science</td>
<td>Train 50 new teachers, 10% from water districts</td>
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<td>2. Offer research to undergrads and community college (CC) students</td>
<td>Offer undergrad and CC student fellowships&lt;br&gt;Establish CC Transition to UW program&lt;br&gt;Partner with CC faculty to incorporate FINSE instrumentation</td>
<td>Support 75 undergrads /yr; 25% from Geohydro Transition 5 CC/yr</td>
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<td>3. Career path to public/private sector</td>
<td>Support the new Graduate Program in Hydrology&lt;br&gt;Offer $10K student/postdoc entrepreneurial competition&lt;br&gt;Support student internships in the private sector</td>
<td>Support 10 new PiH students /yr</td>
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Teacher training program using FINSE with TSS/SMTC/EPSCoR

Community College partnerships:
- training in FINSE equipment at CC’s; they will use FINSE
- fellowships and transitions to UW

Private Sector partnerships:
- summer internships offered by 3 companies (TriHydro, Lowham-Walsh, Intertech)
New Infrastructure: Geophysics

• Imaging of Surface and Shallow (upper ~200 m) Subsurface:
  • Seismic (Refraction & Reflection)
  • Magnetic (Total Field and Gradiometry)
  • Gravity (Precision microgravity)
  • MRS (Magnetic resonance sounding)
  • Resistivity (DC)
  • Induced Polarization
  • Self Potential
  • Ground-Penetrating Radar
  • CHIRP
  • CSEM (Controlled-source EM)
  • Surface LiDAR
Field Instrumentation
Fate of Water in Changing Systems

- Goal is to monitor and interpret changes in flow and temperature in Wyoming rivers
  - Response to GCC, beetle kill, management
- Look for changes in surface/subsurface flux
  - Stress on hydrology, ecology, fish
- Use runoff gaging, temperature probes, and groundwater samples
- Target critical hydrologic & ecologic locations

- Partner with USFS, share data with FS, WY G&F
- Private landowners as cooperators for site locations
- Outreach to agencies, citizens through hydrologic extension
WyCEHG Summary

With WyCEHG we seek these outcomes:

• Nationally significant facilities in near surface geophysics and hydrology;
• Interdisciplinary, cross-institutional teams focused on transforming water research in Wyoming;
• A comprehensive external engagement program that includes stakeholders and new tools for decision-makers in water management;
• A novel workforce development program that will train students and connect them to industry internships;
• An open-access, national facility for hydrogeophysics that will include state-of-the-art instrumentation and will be sustained by an industry endowment;
• Cutting-edge computational research that makes use of the new NCAR-Wyoming Supercomputing Center.
• Transformative outreach and diversity programs that establish research linkages with underserved populations inside and outside the state; and
• A broad educational program that boosts STEM education in Wyoming’s tribal college and bolsters the recently established Ph.D. Program in Hydrology at UW.
Contact Information

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Water Storage Capacity on a Hillslope
Field Studies
Student Training

- Summer Field Course in hydrogeophysics
- Hydrology, ecology, field observations, geophysical instrumentation
- Training for students
- Opportunity for faculty
- Integrated education & research
Looking Upstream
Snowy Range Field Site

- North Platte Drainage
- Nested sample design
- High mountain to valley
- Snow-driven
- Fracture flows
- Managed water
- Beetle-kill pervasive
- Local field site
- Summer field course
Significant Features

Lakes Region. Steep Quartzite gives way to undulating terrain.
Significant Features

- Fluvial setting.
- Mountainfront stream systems.
- Fracture flow (?)
Significant Features

Outwash Plain. Thick glacial outwash deposits. Abundant divergent flow, cobbly landscape.
Tools to Answer the Questions

• Sap flux and leaf gas exchange quantify plant water loss from different plant types
Tools to Answer the Questions

- Plant hydraulic measurements connect plant evolutionary tradeoffs to watershed hydrology
From green trees...

To red trees... in less than a year
Tools to Answer the Questions

• Eddy covariance flux towers directly measured evapotranspiration from ecosystems