Advancing the Utility of CI in Environmental Science

Craig Tweedie and Vladik Kreinovich in collaboration with Miguel Argaez, Olac Fuentes, Ann Gates, Deana Pennington, Paulo Pinheiro da Silva, Steve Roach
Meeting critical gaps in observations, knowledge, and human capacities.
- What controls land-atmosphere transfer of carbon, water and energy in arctic and Chihuahuan Desert ecosystems over multiple spatial and temporal scales?

Developing, assessing, and applying new prototype CI in environmental science.
- Can new CI improve the acquisition, processing, quality, trust and usefulness of ES data?

Working groups Cyber-ShARE I:
- Static tower systems
- Sensors and sensor networks
- Mobile sensing platforms
- Web mapping applications
- *Middle/software development*
People:
- Involved 8 faculty, 1 postdoc, 2 technicians, 9 PhD, 10 MSc, 3 Ugrad students
- 8 graduates at MSc or PhD

Infrastructure:
- Jornada Experimental Range
- UAV, KAP, Servers, SAN

Educational Framework:
- Classes in ES and CS, internships, travel scholarships, research scholarships

Research Publications and other products:
- 33 Peer review publications, more than 70 presentations

Outreach:
- Museum display, school visits, public talks, demonstrations, field tours

Collaborators:
- USDA-ARS JER, JRN-LTER, NEON, Ameriflux, NPN, SpecNet, UNM, NMSU, ITEX
Environmental Science – e.g. cross correlation of spectral instruments, light use efficiency models of land-atmosphere carbon flux, relationships between phenology, climate, fluxes and optical properties.

Implementation/Engineering – e.g. site choice, eddy covariance tower, robotic tram system, sensors/networks, phenocams, wireless comms, remote power, software, ontologies & SAWs, WebGIS.

CI Research – e.g. processing and optimization, data QAQC specification and flagging, machine learning algorithms, performance testing, web service generator.

e.g. Analysis, data, models

e.g. Hardware, software, best practice, data archives, web GIS

e.g. Algorithms, prototype software, theory, data specifications
New prototype CI for Environmental Science...
Schematic of an end-to-end system

Site Selection → Sensors and data acquisition → Communication → Processing

With support from Cyber-ShARE and our many collaborators…

Christine Laney
Prevailing Wind

Sampling Footprint

Plant Phenology Measurements

• 9 Towers
• > 130 sensors
• > 300 derived variables
• NRT data transfer ~10Hz
• >350 phenology stations

Web mapping and Information System

Eddy Tower

Solar Power and Communication

Phenocams

Robotic Tram

Sensor Network

Site construction, testing and implementation

Solar Power and Communication

Sampling

Footprint

• Prevailing Wind

• Plant Phenology Measurements

• Web mapping and Information System

9 Towers

> 130 sensors

> 300 derived variables

NRT data transfer ~10Hz

>350 phenology stations
New research and education collaboration
Trans-disciplinary communication and activity
Tools (SAWs, software, algorithms)
Infrastructure development
Publication, presentation, graduation, participation
Synergism with other projects
Weaknesses of ES Cyber-ShARE I

- Data documentation
- Targeting bang for buck
- Hardening of software tools
- Diffusion of innovation
- Speed of cycling ES to CS to ES
- Human capacity versus demand
- How can small labs play with larger entities
Budget Items:

- 0.5 months summer salary (Tweedie, Kreinovich)
- 3 yrs junior programmer (workforce development)
- Grad. students (8 total, 2 working group, 2yr cap)
- Grad. student tuition
- Undergraduate hourly salary (recruitment)
- Travel (JRN, conferences, study abroad)
- Materials and supplies (minimal)
- Ca. $900K/5yr
- Links to other grants
Questions – same as Cyber-ShARE I

Working Groups:
1. Sensor technologies
2. Middleware and software development
3. Computational science
4. Web mapping and information systems

Overarching themes:
- Faculty mentorship, peer training
- 2 grads/group plus synergies from other grants
- Undergraduates ~ recruitment
- Programmer ~ prototyping and showcasing
Scaleable and dispersable prototype technologies
Cheaper and effective ~ enhance network science
   - Android applications
   - Arctic coastal monitoring stations
   - 3d mapping technologies
   - Robotic tram automation and enhancement
   - Re-purposing off the shelf technologies

Target improved automation, trust, efficiency
Synergies with NSF BAID, NSF AON, JRN LTER, BOEMRE
- Target bang for buck
- Develop prototypes to showcase
  - Enhanced site choice
  - Web-based phenology analysis
  - Data QAQC
  - Hyperspectral reflectance processing routine
  - Joggler – data handler
  - Analytics for geospatial web services
  - UAV flight optimization

- Link sensors to info systems…
- Synergies with NSF BAID, NSF ARMAP, NSF AON, BOEMRE
WG3: Computational science

- Enhance trust, optimization, reduce uncertainty
  - Anomaly detection
  - Gap filling
  - Spatial and temporal scaling
  - Propagation of error
  - Optimization
  - Visualization

- Functionality embedded in an end-to-end system.
- Synergies with NSF BAID, BOEMRE
Tool and data integration, visualization, analysis
For cellular, mobile, desktop devices
  Interoperability and best practice
  Analytical, decision, and visualization tools
  Data streaming
  Web services
  Provenance, SAWs, ontologies

Products for research, education, showcasing
Synergies with NSF ARMAP, NSF BAID, BOEMRE
Focal ES Activities for Cyber-ShARE II

- **Research, education, training:**
  - Excellence in research and engineering
  - Education, training, workforce development
  - Scientific process, standards
  - Trust, uncertainty, optimization
  - Network and collaboratory science

- **Pipelines for dispersion of innovation**
  - Prototype development and assessment
  - Publication and presentation
  - Catalyzing opportunity, entrepreneurialship

- **Institutional enhancement - recognition**
How ES contributes to Cyber-ShARE

- Disciplinary expertise
- Education and training
- Scientist-centered tools
- Generation of research challenges
- Platforms for case driven development and enquiry
- Local to international exposure
How Cyber-ShARE contributes to ES

- Cross disciplinary expertise
- Synergy and transfer of knowledge
- CI tools, hardware, other infrastructure
- Novel innovation
- Connectivity – institutional, agency, other
- Collaboration
The REAL ES Cyber-ShARE...