InterACTWEL Cyberinfrastructure
Enabling Long-term AI-driven Decision Support for Adaptive Management of Water, Energy, and Land Resources in Watershed Communities

Oregon State University (OSU): Dr. Meghna Babbar-Sebens, Dr. Samuel J. Rivera
Cyberinfrastructure Integration Research Center (CIRC): Suresh Marru, Eroma Abeysinghe
Outline

1. Overview of InterACTWEL
2. Description of Data, Data Parsers and Computations Involved
3. UX Approach
4. Gateway Development and Integration Plan
5. Future Work
Overview of InterACTWEL
(Interactive Adaptation and Collaboration Tool for managing Water, Energy and Land)

Dr. Meghna Babbar-Sebens
InterACTWEL: Web-based Decision Support for Adaptation Scenario Planning in Local Communities

Who?
• InterACTWEL aims to empower communities in watersheds

Do What?
• To coordinate and plan adaptation strategies for responding to stresses and changes to water, energy, and land resources.

How?
• By providing data-driven services for planners and managers to simulate, visualize, evaluate, and share scenarios of multi-sectoral adaptation actions that reduce their community’s vulnerability to stresses
InterACTWEL: Overall Vision

In-person Stakeholder Facilitation & Engagement

Legend for Conceptual Model

Development of Scenarios of Adaptation Pathways for Community-generated Model of System-of-systems

Multi-sectoral Data

Integrated Assessment Models

Visualization of Scenarios of Adaptation Pathways for Seeking Community Feedback and Evaluation

Socio-economic Systems in agriculture community

Conceptual System-of-systems Model of Perturbations, Ripple Effects, Actions, Impacts, and Constraints

Integrated Assessment Models for Adaptation Planning in Agriculture Communities

Socio-economic Systems in agriculture community
InterACTWEL: Workflow Stages for Stakeholder-Driven Adaptation Planning

Stage 1
- Co-production of knowledge

Stage 2
- Setup of community projects

Stage 3
- Simulation and distributed optimization of adaptation plans

Stage 4
- Visualization of Adaptation Plans

Stage 5
- Feedback and Evaluation of Adaptation Plans by Community

Conceptual Systems Diagram
Science Gateway
Website: http://interactwel.org
Description of the data, data parsers and computations involved
&
UX approach

Dr. Samuel J. Rivera
End users of InterACTWEL and their Roles

- **Global Administrator (GA)**
  - Set up InterACTWEL Project
  - Identify and invite Local Administrators (described below)
  - Complete control of the project, the data and models, and the members of the project

- **Local Administrators (LA)**
  - Sector technical leads or managers in one or more individual FEW sectors of a local community
  - Provide relevant data, models, decision strategies, and cost-benefit goals and constraints that represent their FEW sector
  - Have complete control over their data (e.g., sharing privileges, visibility and use restrictions, etc.)
  - Can run “pre-setup” simulations/experiments using a different parameters
End users of InterACTWEL and their Roles

- **Global Administrator (GA)**
- **Local Administrators (LA)**
- **Actor Users (AU)**

- End users are most closely related to the impacted community members (e.g., residents of the watershed, tribal communities), actors in each of the FEW sectors (i.e., farmers, water utilities) and other interested actors from the public (e.g., researchers, students).

- Interaction with the ScG is limited to the visualization and evaluation of the model results from the experiments through a visualization GUI.
Overview of technology components and computational resources
Simulation and Optimization of Adaptation Plans

- Plug-n-play modeling platform to simulate Impacts of actors, decision and perturbations in systems diagram
  - Land and water management model: Soil and Water Assessment Tool (i.e., SWAT; Neitsch et al. (2011))
  - Energy model: Energy portfolio planning model (Northwest Power & Conservation Council)
  - Economic model: Input / Output Economic Model (OSU)

- An open-source and decentralized multi-disciplinary design optimization (MDO) framework was used to develop a multi-objective optimization formulation of the conceptual model
  - Models of different spatial and temporal resolutions are coupled by using a dynamic planning approach
  - A top-bottom approach is used to combine different optimization approaches (i.e., NLP, Evolutionary algorithms) are used to find near-optimal solutions
Conceptual Socio-economic system’s Actions/Decisions

Modeling of decisions and impacts (i.e., Model Inputs/Outputs)

How much? When? What type?

Quantification of an Actor’s Impacts

Fertilizer amount (lbs)

1.64 - 2.25
2.35 - 3.48
3.48 - 8.74
8.74 - 551.59
551.59 - 1746.82

Potential actions for an individual/group
InterACTWEL: SWAT Model

- **Model boundary**
  - Watershed Boundary Dataset (WBD) – USGS

- **Elevation**
  - Digital Elevation Model (DEM) – USGS

- **Streams**
  - National Hydrography Data (NDH) – USGS

- **Land use**
  - Cropland Data Layer (CDL) – USGS (NASS)
  - National Land Cover Dataset (NLCD) – USGS

- **Soil**
  - Soil Survey Geographic Database (SSURGO) – USGS (NRCS)

- **Many more types of data**
  - Water rights, crop yields, field management data, water quality/quantity, dam operations, etc.
Hydrologic Response Units (HRUs)
- Unique combination of soil, slope, and land use (i.e. crop)

Field level HRUs
- Each field may be independently managed
  - Crop choice
  - Irrigation source/application technology
  - Fertilizer type/amount
  - Tilling practices

InterACTWEL: SWAT Model
InterACTWEL: SWAT Model

- Three watershed with significant economic and environmental impacts to the region
  - Willow
  - Walla Walla
  - Umatilla

- Three separate SWAT models
Frameworks & Models are packaged as “Applications” in the ScG.

Global administrators can create or choose an existing “Application” that will be used in their community’s project.
Dashboard usability testing and redesign

Heuristic Evaluation
September 2020

Usability Testing
October 2020

New Mockups
November 2020

Plans

What's with all these tabs?

When looking at projects, users get confused about what each category/tab was for. They were confused about the ownership and privacy of the projects.

One user was also confused about the difference between projects and plans.

"I assume these are all my projects and they’re private... I'm not sure about projects though because is it just projects I’ve created?"

[as assigned projects] "I'm not sure how different it is from the other tabs..."

"I don't know what invited projects would be for.

Dashboard usability testing and redesign
Gateway development and integration plan

Eroma Abeysinghe
InterACTWEL Infrastructure

ECSS Symposium
Sept/21/2021
Eroma Abeysinghe and Eric Coulter
Indiana University, CIRC

Supported by OAC 15-48562.
InterACTWEL Gateway

- Gateway is hosted with SciGaP (https://scigap.org/), with Apache Airavata (https://airavata.apache.org/) as the middleware.
- Range of non-traditional users, non traditional gateway.
- Less focus on computations more on visualization and sharing.
Security and Extendability

- Security is a main focus.
- Different levels of users, administrators, policy makers, researchers with multiple levels of access.

- The gateway was developed using Django framework.
- Easier to modify, extend.
- InterACTWEL needed visualizing capability for all its different users.
- PI and the team designs, reviews and develops the user interfaces.
Data Handling & Sustainability

- Computed output to post process for visualization.
- Data framework used for data parsing and depositing to database.
- Parsers are executed in Docker containers.

- Frequent stakeholder feedback sessions.
- Active development and improvements.
- Enables seamless development and integration.
- Continuity beyond ECSS consultation.
HPC infrastructure in the Cloud

- Virtual HPC Infrastructure deployable on Openstack clouds
  - Focussed on a handful of open research clouds
- Deployed ~30 production VCs
  - From Quantum Chemistry to Textual analysis
  - Training and education on all sides of the spectrum (Admin -> Users)
- Combine with containers for portability across the resource spectrum
XSEDE CRI Virtual Cluster

- Container Registries
  - docker
  - <registry>
  - <registry>

- XSEDE-like User Environment
  - Containerized Applications

- Headnode
  - slurmdctl
The building blocks:

- OpenHPC (https://openhpc.community)
  - SLURM (https://slurm.schedmd.org)
    - with scripts for creation and destruction of worker nodes
  - MPI implementations
  - Singularity
- Jetstream - (https://jetstream-cloud.org) and
  - Openstack (https://openstack.org)
## Deployment

- Simple scripts for creation/destruction (~10 minutes to running jobs)
  - Headnode instance and Openstack infra is created
  - SLURM+MPI+Singularity are installed & configured
  - Optional shared storage is created
  - A cluster-specific image is created to base compute nodes on (via Ansible)
  - Ready to roll!
- [https://github.com/XSEDE/CRI_Jetstream_Cluster/](https://github.com/XSEDE/CRI_Jetstream_Cluster/)
Building SWAT on Linux is non-trivial! (in some sense)
- Took a few days, but we were able to get a workflow established
- Passed on to Sammy and Meghna, hands-off since

Next step is to containerize this for greater flexibility
- This will also create a record of the painful steps involved in getting SWAT working on a Linux environment!
Questions?

help@xsede.org with XCRI in the subject for XSEDE Q’s

circ-group@iu.edu for Gateways questions

jecoulte@iu.edu - to talk to me

https://github.com/XSEDE/CRI_Jetstream_Cluster

https://github.com/XSEDE/container-template-lib

This work funded and supported by Extreme Science and Engineering Discovery Environment (XSEDE), under National Science Foundation grant number ACI-1548562
Future Work

Dr. Sammy Rivera
Lessons Learned and Future Directions

• InterACTWEL as a “safe digital space” for coordinating design of scenarios of community adaptation plans
  – Sustaining long-term stakeholder engagement and community interactions.
  – Maintaining privacy and transparency in decision-making
  – Enabling continual discovery of community insights
  – Sustaining improvements in data analyses and underlying models for scenario development

• Future Directions
  – Build community of practice (researchers and community end-users)
  – Advance Artificial Intelligence capabilities to support InterACTWEL workflows
Thank you!

Questions?

Project Website:
http://interactwel.org