Contract Number: OASRTRS-14-H-UARK
Quarterly Report Progress Report Number: 4
Quarter Start and End Date: July 1, 2015 – September 30, 2015
PI Name: Richard A. Coffman
Program Manager Name: Caesar Singh

2. Table of Contents

3. Glossary of Terms

AASHTO	American Association of State Highway Transportation Officials
AEEG	Association of Environmental & Engineering Geologists
ARSET	Applied Remote Sensing Training
BLM	Bureau of Land Management
Co-PI	Co-Principal Investigator
GPRI-II	Gamma Portable Radar Interferometer Version II
GRA	Graduate Research Assistant
ISU	Idaho State University
NASA	National Aeronautics and Space Administration
NI	National Instruments
NSF	National Science Foundation
NRCS	Natural Resource Conservation Service
PI	Principal Investigator
RECOVER	Rehabilitation Capability Convergence for Ecosystem Recovery
TAC	Technical Advisory Committee
TATS	Turrell Arkansas Testing Site
TDiAL	Topographic Differential Absorption Light Detection and Ranging
TRB	Transportation Research Board
TRR	Transportation Research Record
UGRA	Under Graduate Research Assistant
USDA	United States Department of Agriculture
USDOT	United States Department of Transportation
USGS	United States Geological Survey
UofA	University of Arkansas

4. Executive Summary

The Technical Status and Business Status of the OASRTRS-14-H-UARK Contract are presented herein. Specifically, the work completed during the fourth quarter of the federal fiscal year (July 1, 2015 through September 30, 2015) are presented and discussed. Three deliverables were scheduled for completion during this quarter. These deliverables included: 1) a report on the implementation plan, fee structure, and utilization rate of the equipment, 2) a report that included the users manual for the ground-based remote sensing device and 3) a report on the development of a ground-based remote sensing system for collecting data to determine the amount of risk to transportation infrastructure following wildfires. As discussed during the Year 1 meeting with Caesar Singh, none of these deliverables were completed on schedule due to delays in fabrication of the TDiAL device. Although the deliverables were not completed, progress was made on each deliverable. Other completed activities included: 1) a demonstration of the "ground based remote sensing device", 2) preparation of the "users manual for the ground-based remote sensing device".

A total of $53,690.64 of USDOT funds were expended during the quarter. A total of $124,859.59 dollars of cost-share (UofA) were expended during this quarter.

5. SECTION I — TECHNICAL STATUS

Accomplishments by Milestones

Activity 1: Formation of TAC

In addition to the TAC being developed (as reported to Caesar Singh and Vasanth Ganesan on November 24, 2014) and having an in person TAC meeting (December 12, 2014 in Denver, CO), a virtual meeting of the TAC committee was held on August 3, 2015 (minutes of meeting enclosed in Section 7 of this report). The next in-person meeting of the TAC is scheduled for late September or early October 2015. The September/October meeting will coincide with a trip of UofA personnel to Boise, ID, to attend the ARSET workshop.

Activity 2: Development of Website, Implementation Plan, and Service Provider

A website was developed for the project (https://wildfire-landslide-risk-dss.uark.edu). In accordance with Deliverable 2 (and as reported to Caesar Singh and Vasanth Ganesan on November 24, 2014), the website was posted online within the first three months of the project. The official launch of the website was at the TAC Meeting on December 12, 2014. Additional content, including a video of the GPRI-II, and any updates/data from the project have been added as the content became available. The development of the implementation plan and service provider are underway. Although the "Implementation Plan, Fee Structure, and Utilization Rate" report was due within the first 12 months of the project start date, the delay in obtaining the equipment has prevented the completion of this report. All of the required equipment must be obtained prior to the "Implementation Plan, Fee Structure, and Utilization Rate" report because the depreciation schedule and utilization rate will be based on the actual cost of the equipment.

Activity 3: Development of a Ground-based Remote Sensing Device

The optical-mechanical design for the TDiAL device was finalized and the data acquisition system for the active TDiAL portion of the ground-based remote sensing was finalized with National-Instruments (NI). When the data acquisition arrives, all of the pieces of the TDiAL device will be assembled in the weatherproof case and the device will be deployed to the field for verification. This is the final step in the completion of the ground-based device.

Activity 4: Collection of Data/Creation of Databases

As mentioned in the last quarterly report (Quarterly Report 3), data (collected using the GPRI-II device) were collected at the TATS site. Also, laboratory data were collected using the prototype TDiAL device. Full-scale data will be collected during the October 2015 trip to Idaho.

As mentioned in the last quarterly report (Quarterly Report 3), all of the papers containing data that have been used to develop the USGS probabilistic model have been acquired and placed into a spreadsheet. These data will serve as the preliminary data for the database of remotely sensed properties. Moreover, the statistics of the USGS data (for the intermountain region) have also been recalculated using newer statistical techniques than were available to the USGS at the time of publishing of the database. A better statistical technique has been established and will be implemented into the decision support system that is associated with this project, based on the results from the new statistical techniques. Moreover, based on these findings, a journal article has been prepared and submitted.

Activity 5: Development of a Probabilistic Model Decision Support System

As demonstrated during the Year 1 meeting with Caesar Singh (on September 23, 2015), the probabilistic model decision support system has been developed. Specifically, this debris flow decision support system was developed and integrated within the RECOVER decision support system. The RECOVER system (with the new debris flow decision support system module) will be demonstrated at the ARSET workshop that will be held in Pocatello, Idaho from October 6-8, 2015. The URL for this debris flow models for the Charlotte and State Line Fires can be found at: http://recover.giscenter.isu.edu/recover2/charlottefire/ and http://recover.giscenter.isu.edu/recover2/statelinefire/, respectively. Screen shots of these debris flow models are included within the appendix. Moreover, the RECOVER system (with the new debris flow decision support system module) will be used to analyze several previous fires within the state of California to determine the susceptibility of the interstate system to the probability of debris flow. These debris flow models are being developed due to ongoing communication with Herby Lissade, Chief of the Office of Emergency Management for CalTRANS.

Activity 6: Reporting and Publication

This quarterly report is the fourth in a series of quarterly reports. A synopsis of the results from the obtained data is reported herein. Based on the obtained data, several presentations were presented at the 2015 meeting of the AEEG that was held in Pittsburg, PA, on September 24. Specifically, the authors and titles of the abstracts that were presented are included below.

Kern, A., Coffman, R., Oommen, T., Addison, P. (2015) “Predictive Modeling of Debris Flows Probability Following Wild Fire in the Intermountain Western United States.” Association of Environmental & Engineering Geologists Annual Meeting.

Salazar, S.*, Garner, C., Coffman, R., Oommen, T. (2015) “Ultra-violet Near-infrared Reflectance Spectroscopy for Remote Measurement of Soil Potential.” Association of Environmental & Engineering Geologists Annual Meeting.

*For this abstract and presentation, Sean Salazar was selected as the Lemke Scholar by the Association of Environmental and Engineering Geologists at the 2015 Annual Meeting.

A paper is currently being prepared for the Mathematical Geosciences Journal. Also, a paper has been prepared and submitted to the 95th Annual Meeting of the Transportation Research Board. The authors and title of the papers are included below.

Kern, A.N., Addison, P., Oommen, T., Salazar, S.E., Coffman, R.A., (2015). "Machine Learning Based Predictive Modeling of Debris Flow Probability Following Wildfire in the Intermountain Western United States." Mathematical Geosciences. In Preparation.

Garner, C., Coffman, R., (2015). "Evaluation of a field and laboratory remote sensing method for determining soil Atterberg limits and clay content." Transportation Research Record. Submitted for Review. Manuscript Number: 16-6814.

Problems Encountered

The Soda Fire started on August 10, 2015, and was contained on September 10, 2015 (http://inciweb.nwcg.gov/incident/4475/). The Soda fire encompassed the location of the prescribed burn that was scheduled for September 2015. Therefore, collection of pre- and post-fire data of an active prescribed fire, within the Reynolds Creek Watershed, utilizing the ground-based device, will not be able to be performed; the NRCS utilized the funds for the prescribed fire on firefighting efforts associated with the Soda Fire.

Future Plans

Several milestones are required to be accomplished during the next quarter. These milestones include milestones that were not completed during the quarter that is being reported in this quarterly report (Quarter 4) and previously planned Quarter 5 milestones that will be completed, on schedule, during the next quarter. The specific milestones that will be completed are listed below; interesting findings associated with these milestones will also be reported.

"Implementation Plan, Fee Structure, and Utilization Rate" report.

"Users Manual for Ground-based Remote Sensing Device" report.

"The Development of a Ground-based Remote Sensing System for Collecting Data to Determine the Amount of Risk to Transportation Infrastructure Following Wildfires."

Several demonstrations of the device will take place during the upcoming quarters (Quarters 5). These demonstrations include: 1) a post-fire demonstration to potential stakeholders (IDT, USGS, USDA, BLM, NASA) at the location of the Charlotte Fire, East of Pocatello, Idaho, in conjunction with the NASA ARSET workshop from October 6-8, 2015, 2) a post-fire demonstration to potential stakeholders (NRCS, NSF) at the location of the Soda Fire, South of Boise, Idaho, following the NASA ARSET workshop, and 3) a demonstration to the Commercial Remote Sensing Workshop 2 in Oklahoma City, Oklahoma, on December 2-3, 2015.

6. SECTION II — BUSINESS STATUS

As shown in Table 1, the amount of time that was allocated for the project and the amount of time that was expended on the project are documented. Time has been expended and charged for the academic year and summer costs associated with the PI and Co-PI. The number of expended hours that are reported in Table 1 were associated with time spent in: weekly meetings (PI, GRA, UGRA); in bi-weekly meetings (PI, the GRA, the Co-PI, Co-PI's GRA, Co-PI's UGRA); developing and maintaining the website; ordering equipment; preparing assembly of the various pieces of equipment; collecting data with the new equipment; collecting data related to the probabilistic model; developing the probabilistic model; and preparing the quarterly report.

The GRA expended the allocated amount of hours on the project. Cyrus Garner has replaced Sean Salazar on the USDOT project, effective June 1, 2015. Three UGRAs (Johnathan Blanchard, Leah Miramontes, and Brendan Yarborough) spent time working on the project during the fourth quarter. The number of hours (135.75) exceeded the allocated number of hours (40), 1) to make up for the hours that were not worked during the month of June, and 2) hours expended by the students during the May 1 through May 15 pay cycle were not approved until after the reporting of the previous quarter and are therefore reported in this report.

Table 1. Hours allocated and expended.

Quarter 3, Year 1	USDOT Allocated (Hours)	UofA Allocated (Hours)	USDOT Expended (Hours)	UofA Expended (Hours)
PI – Quarterly Report, Meetings	9	10	9	10
PI -Website		10		10
PI – Data Collection	10	30	10	30
GRA – Quarterly Report, Meetings	20		20	
GRA - Website	10		10	
GRA – Data Collection	40		40	
GRA - Publications	40		40	
UGRA - Website	20		20	
UGRA – Data Collection and Processing	20		115.75	
Admin - Website	21.7		21.7	

Based on the number of hours expended, the level of effort that was expended by personnel from the UofA was 100.0 percent for the PI, 100.0 percent for the GRA, 339 percent for the UGRA, and 100 percent for the Admin.

As shown in Table 2, the amount of total funds that were allocated for the project and the amount of funds that were expended on the project are documented. All of the receipts associated with the funds that were expended for equipment during

Quarter 4 are enclosed within this quarterly report. The tuition for the Fall 2015 semester was misappropriated to the sponsor side of the project instead of the cost-share side of the project. These funds will be appropriated to the proper categories during the next quarter.

Table 2. Funds allocated and expended for the project.

Total	USDOT Allocated ($)	UofA Allocated ($)	USDOT Expended ($)	UofA Expended ($)
Salaries	67,410.00	30,706.00	42,527.92	16,439.29
Fringes	5,014.00	7,861.00	4,201.40	4,210.92
Supplies	13,500.00	3,825.00	8,134.72	0.00
Travel	6,500.00	15,000.00	187.63	3,794.84
Other	0.00	150,000.00	0.00	75,493.20
Indirect	42,977.00	96,437.00	11,462.18	0.00
Tuition	0.00	17,111.00	2,399.64	5,284.70
Subcontract	116,864.00	116,864.00	2,561.76	30,002.58
Subcontract Indirect	20,949.00	0.00	0.00	0.00
Equipment	278,635.00	114,051.00	240,709.04	97,189.33

7. ADVISORY/STEERING COMMITTEE MEETING

A virtual TAC meeting was held on August 3, 2015. The minutes for the meeting are included below.

Attendees:
Rick Coffman – University of Arkansas
Sean Salazar – University of Arkansas
Cyrus Garner – University of Arkansas
Thomas Oommen – Michigan Technological University
Priscilla Addison – Michigan Technological University
Ashley Kern – Michigan Technological University
Bill Shaw – Idaho Transportation Department
Jason Kean – United States Geological Society
Keith Weber – Idaho State University
Herby Lissade – California Department of Transportation
Renee Garcia - California Department of Transportation
Ty Ortiz – Colorado Department of Transportation
Scott Anderson – Federal Highway Administration

Items of Discussion:

Rick:

The progress on the ground-based device was discussed. The ground-based device will be demonstrated during the in-person meeting that will be held in late September or Early October. The proposed prescribed burn was also discussed and the opportunity for personnel from the University of Arkansas and the Michigan Technological University to obtain pre- and post-fire measurements was discussed.

Priscilla:

The debris flow decision support system was introduced and discussed. The parameters that were utilized within the model were presented. Moreover, the way in which the parameters were obtained was also presented.
Recent “Soil K Factor” data that were published on July 31, 2015 contained errors. NRCS was made aware of the erroneous data and are making modifications. The data provided by NRCS are raster data with a spatial resolution of 1km.

Jason:

Is there a problem bringing in higher resolution data into a lower resolution dataset? For example, considering topography, would the higher resolution digital elevation model result in higher slope values that would lead to higher risk for the basin even though the basis is the same in both instances. Is there a “scale issue”?

Thomas:

The burn severity or percent of basin burned parameters were discussed. A negative correlation or a positive coefficient was utilized to determine to see how a particular component was contributing to the probability of debris flow.

Keith:

A URL (http://naip.giscenter.isu.edu/recover2/JohnstonPrescribedFire/) has been established for the Johnson Creek area in anticipation of the proposed prescribed burn. Kathleen Lohse at the University of Idaho is very interested in the burn severity models as she thinks that satellite-based remote sensing does not do a good job of determining high-resolution dNBR values. She would like to supplement the satellite-based dNBR values with field obtained (ground-based) values.

Ty Ortiz:

CDOT is interested in the technology for geohazards. Ty assists many CDOT engineers with geohazard risk assessment. More tools are needed to accurately characterize the geohazard risk.

Herby:

CalTRANS FireCAST was discussed. The FireCAST is utilized by 3000-4000 field employees to determine the potential for fires in certain area. This tool was associated with CalFIRE but has since been discontinued and now the employees (every day at 6am) have to print out pages of the fire prediction ratings instead of using an application.

In California, after the fire, the sites of previous fires are document and monitored for two years. A predictive debris flow preliminary investigation is needed to forecast the locations of debris flows. This forecasting will lead to a proactive approach instead of a reactive approach. It would be great if this forecasted debris flow probability could be conveyed to the traveling public via a roadway information system.

8. CONFERENCE PRESENTATIONS/PUBLICATIONS DETAILS BY PROJECT TEAM MEMBER IN UPCOMING QUARTER

As previously mentioned, the personnel associated with this project will prepare abstracts/papers/presentations for several conferences. Specifically, papers and presentations were prepared for the annual meetings of the AEEG and the TRB.

For the paper that has been prepared for the 95th Annual Meeting of the TRB, if the paper is selected to be published in the Transportation Research Record then the paper will be published in this journal. However, if the paper is not selected to be published in the TRR then the paper will be pulled from consideration and submitted to another journal. In either case, a presentation on the research will be presented at the 95th Annual Meeting of the TRB.

Rick Coffman was requested to speak at the AASHTO Subcommittee on Construction meeting that was held in Little Rock, AR, on August 10, 2015. The title of the presentation is included below.

Coffman, Richard A. (2015) "Water: The Enemy of Construction," AASHTO Subcommittee on Construction. Little Rock, AR, August 10, 2015

The personnel associated with this project have also been asked to participate in a NASA ARSET "Remote Sensing for Wildfire Applications" workshop that will be held at ISU in Pocatello, ID, from October 6 through 8, 2015. This participation includes attending the workshop, presenting a poster, and also providing support about the post-wildfire landslide module that is being developed as a part of this USDOT funded project for the RECOVER system. A scaled version of the poster that will be presented at the ASET workshop is included in the appendix.

9. APPENDIX FOR QUARTER

A copy of the receipts for equipment that was ordered/purchased during the quarter are also included herein. These receipts are included for equipment from the following manufacturers: Arroyo, Digikey, Newport, and Thor Labs.

- The Arroyo butterfly laser mount and cabling were delivered on August 20, 2015.
- The Digikey gender changer Dsub 44 position and Dsub 9 position couplers were delivered on July 31, 2015.
- The Newport TLB06700 6-foot long, cable for laser output was received on July 30, 2015.
- The two Newport 1647 avalanche photo detectors were received on July 30, 2015.
- The Newport TLB-6800 laser was received on June 22, 2015 but the charges were not posted to the project until this quarter so this receipt is included in this quarterly report
- All of the pieces of equipment that were ordered from ThorLabs were delivered on or before August 10, 2015.

The agenda for the ARSET Workshop to be held from October 6-8 in Pocatello, Idaho, is enclosed. Screenshots of the debris flow model for several of the fires that will be discussed during the ARSET workshop are enclosed. The poster that Priscilla Addison will present at the ARSET workshop is enclosed. The presentation slides from the Year 1 meeting with Caesar Singh on September 23, 2015 are included. The notes from the commercialization meeting that was held with Dr. Carol Reeves are also included.

D891578

Digi-Key Electronics

www.digikey.com
Orders 1-800-344-4539
Fax 218-681-3380

Invoice # 50340314
U.S. $

701 Brooks Ave. South, Thief River Falls, MN 56701-0677 USA

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UNIVERSITY OF ARKANSAS
OFF OF BUS AFFAIRS
321 ADMIN, UNIV. OF ARKANSAS
FAYETTEVILLE AR 72701-0000

Terms	Invoice Date	Page
Visa	30-JUL-2015	1

Customer Purchase Order	Sales Order
	43740415

Back Orders	Account
Accepts to 29-AUG-2015	739315

Entered By / Date	Shipped Via	Ship Date
A0FX/30-JUL-2015	XGT	30-JUL-2015

Easy to Remember: 1-800-DIGI-KEY

For Office Use Only	Received	VAT/Tax ID	Billing	Pack List No.	Printing Date	Currency Type:	MSC #
	INTERNET		BILL SHIP	1	30-JUL-2015	U.S. $	0

Idx	Box	Ordered	Cancelled	Shipped	Item Number/Description	Back Order	Unit Price US $	Amount US $
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2	1	2	0	2	GCLP09F09F-ND GENDER CHANGER DSUB 09POS F-F HTSUS: 8536.69.8000 ECCN: EAR99 LEAD: LEAD FREE ROHS: ROHS COMP REACH: REACH UNAFFECTED JUN-2014 COUNTRY/ORIGIN: TAIWAN CAGE: 1L3S8		3.88000	7.76
					BOX 1 SHIPPED XGT WEIGHT 0 LBS 7 OZS (0.20 KG) BOX ID 012606079863413			
					TOTAL INVOICED			40.24
					SHIPPING CHARGES APPLIED			8.02
					** CHARGES SUBTOTAL **			48.26
					TOTAL CHARGED TO CREDIT CARD			48.26 U.S. $$
					YOUR CREDIT CARD HAS BEEN CHARGED THE ABOVE INDICATED AMOUNT TAX EXEMPT THE ORDER IS COMPLETE			
					REF #: SA # 43740415			
				Ship To:	UNIVERSITY OF AR/CIVIL ENGINEERING BELL ENGINEERING CENTER 800 W DICKSON ST FAYETTEVILLE AR 72701-0000			
				Ship From:	DIGI-KEY 701 BROOKS AVE. SOUTH P.O. BOX 677 THIEF RIVER FALLS MN 56701-0677			
				General -	WEB ORDER ID: 148889155 30-JUL-2015 12:50:42.37 - A5TR - CUSTOMER'S TAX EXEMPT CERTIFICATE STATES			

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Visa	30-JUL-2015	2

Customer Purchase Order	Shipped Via
	XGT

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Idx	Box	Ordered	Cancelled	Shipped	Item Number/Description	Back Order	Unit Price US $	Amount US $
					VARIABLE TAXATION - USER HAS DETERMINED ORDER WILL NOT BE TAXED DUE TO RESALE.			

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624 Clarion Court
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Date: 08/20/2015
Page: 1
Order No.: VERBAL/Sean

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321 Admin
Fayetteville, AR 72701
USA

SHIP TO:

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Attn: Sean Salazar
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Part Number	Qty	Unit	Description	Tax	Unit Price	Amount
205	1	Each	TEC Butterfly LaserMount s/n: 150707000		495.00	495.00
1220B-0.5	1	Each	LaserSource Cable, 4A, 0.5m		70.00	70.00
1260B-0.5	2	Each	TECSource Cable, 5A, 0.5m		70.00	140.00
			Country of Origin: USA FOB: San Luis Obispo, CA Shipping: UPS GND Freight: Prepay and Add Payment: Credit Card			
			Freight			13.81

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$718.89

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ATTN: Sean Salazar
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Information

Invoice Number:	4686842
Date:	07/30/2015
Delivery Note No./Date:	30222919/ 07/30/2015
Reference Order no./Date:	2579226/ 07/30/2015
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PO Date:	07/30/2015
Customer No:	3000419 UNIVERSITY OF ARKANSAS
Currency:	USD
Terms of Payment:	CREDIT CARD PAYMENT
Terms of Delivery:	Prepaid and Add -Domestic Only FOB ORIGIN

Notes

Line	Item/Description	Unit Base Price	Unit Net Price	Quantity	Total Amount
100	TLB-6700-01 CABLE,LASER OUTPUT,6FT,TLB-6700	150.00	150.00	2	300.00

Item Total	USD	**300.00**
Gross Value		300.00
Net Value		300.00
Shipping Fees		10.53
Amount Paid	USD	**310.53**

D892128
- $0.24

Credit Card Charge Details:

VISA ****9322	USD	0.22
VISA ****9322	USD	310.31

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Room 4190
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Invoice Number:	4686843
Date:	07/30/2015
Delivery Note No./Date:	30223102/ 07/30/2015
Reference Order no./Date:	2560334/ 05/07/2015
PO No:	831364
PO Date:	05/07/2015
Customer No:	3000419 UNIV OF ARKANSAS FAYETTEVILE
Currency:	USD
Terms of Payment:	NET 30 DAYS
Terms of Delivery:	Prepaid and Add -Domestic Only FOB ORIGIN

Notes

Line	Item/Description	Unit Base Price	Unit Net Price	Quantity	Total Amount
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Item Total	**USD**	**4,920.00**
Gross Value		4,920.00
Net Value		4,920.00
Shipping Fees		5.05
Total Amount Due	**USD**	**4,925.05**

RUCD AUG 13 11:25

BUSINESS AFFAIRS

3

Newport Corporation
Corporate Headquarters
1791 Deere Avenue, Irvine,
CA,92606
USA
Tel (800) 222-6440 Fax (949) 253-1680
Federal I.D. 94-0849175
Duns No. 00-914-5814
www.newport.com

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Newport Corporation
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Chicago, IL 60673-1276

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JPMorgan Chase Bank N.A.
New York, NY
ABA# 021000021
SWIFTCODE# CHASUS33
For Account: 589267363
Beneficiary: Newport Corporation

06/23/2015

2466046

Invoice

Bill-To
UNIV OF ARKANSAS FAYETTEVILE
321 ADMINISTRATION BLDG.
FAYETTEVILLE AR 72701

Ship-To
UNIV OF ARKANSAS
Attn: Richard Coffman
Bell Engineering Center
800 W Dickson Street
Room 4190
FAYETTEVILLE AR 72701

Information

Invoice Number:	4677456
Date:	06/22/2015
Delivery Note No./Date:	30201265/ 06/22/2015
Reference Order no./Date:	2560334/ 05/07/2015
PO No:	831364
PO Date:	05/07/2015
Customer No:	3000419 UNIV OF ARKANSAS FAYETTEVILE
Currency:	USD
Terms of Payment:	NET 30 DAYS
Terms of Delivery:	Prepaid and Add -Domestic Only FOB ORIGIN

Notes

Line	Item/Description	Unit Base Price	Unit Net Price	Quantity	Total Amount
100	113SI07024 TLB-6800, 823 nm TLB-6800 Center wavelength: 823 nm Free space output power: 10mW best effort Serial numbers: (VP0071-10192)	17,000.00	17,000.00	1	17,000.00

Item Total	**USD**	**17,000.00**
Gross Value		17,000.00
Net Value		17,000.00
Shipping Fees		62.25
Total Amount Due	**USD**	**17,062.25**

D 895087

Thorlabs, Inc.

56 Sparta Avenue
Newton, NJ 07860-2402
Phone ..: 973-300-3000
Fax ......: 973-300-3600
E-mail ..: sales@thorlabs.com

THORLABS

Invoice 2131310

Inv Date ....: 08/11/2015
Due ....: 08/11/2015
Purchase Order ....: WEBTS1416782
Terms of Payment .....: Credit Card
Sales Order ....: TS1416782
Sales Contact ....: Melissa Gupton
Delivery Method ....: FedEx Ground
Terms of Delivery .....: Ex Works Newton
Delivery Date ....: 08/10/2015
Page ....:1 of 3

Bill to

University of Arkansas
Off of Bus Affairs
321 Administration Building
Fayetteville, AR 72701

Attention: Richard Coffman

Ship to

University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701

Attention: Richard Coffman
Telephone: 479 575-8767
Fax: 479 575-7168

Contact ....: Richard Coffman
Customer Account ...: 219328
Invoice Account ....: 219328
Your Tax Exempt No.:
Fax ....: 14795754158
E-mail ....: ssalazar@uark.edu

$2236.84

FOR ADVICE ONLY - PLEASE DO NOT PAY

Item Number	Description	Qty Sold	Std Price	Disc. %	Disc Price	Ext Price
AD1109F	SM05-Threaded Adapter for M11 x 0.5 or M9 x 0.5 Threaded Components Commodity code: 9013900000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	29.58	0	29.580	29.58USD
LMR05	Imperial Lens Mount for Ø1/2" Optics, 8-32 Tap Commodity code: 9002900000 Country/region of origin US Quantity : 2.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	2	15.02	0	15.020	30.04USD
BSF05-B	Ø1/2" UVFS Beam Sampler for Beam Pick-Off, ARC: 650-1050 nm, 3 mm Thick Commodity code: 9001901000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	36.30	0	36.300	36.30USD
H45	45° Mirror Mount for Ø1" Optics Commodity code: 9031900000 Country/region of origin US Quantity : 4.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	4	33.00	0	33.000	132.00USD
CP12	30 mm Cage Plate, Ø1.2" Double Bore for SM1 Lens Tube Mounting Commodity code: 9033000000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	20.00	0	20.000	20.00USD
MRAK25-E03	Knife-Edge Right-Angle Prism Dielectric Mirror, 750-1100 nm Commodity code: 9001901000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	200.00	0	200.000	200.00USD
CM1-4ER	Compact Clamping 4-Port Prism/Mirror 30 mm Cage Cube, 8-32 Tap Commodity code: 9002900000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	131.00	0	131.000	131.00USD
PH1	Ø1/2" Post Holder, Spring-Loaded Hex-Locking Thumbscrew, L = 1" Commodity code: 9031900000 Country/region of origin US Quantity : 4.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	4	7.03	0	7.030	28.12USD

USDOT
Ef.

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THORLABS

Bill to

University of Arkansas
Off of Bus Affairs
321 Administration Building
Fayetteville, AR 72701

Attention: Richard Coffman

Invoice 2131310

Inv Date ....: 08/11/2015
Due ....: 08/11/2015
Purchase Order ....: WEBTS1416782
Terms of Payment ....: Credit Card
Sales Order ....: TS1416782

FOR ADVICE ONLY - PLEASE DO NOT PAY

Item Number	Description	Qty Sold	Std Price	Disc. %	Disc Price	Ext Price
TRA075	Ø1/2" Aluminum Post, 8-32 Setscrew, 1/4"-20 Tap, L = 0.75" Commodity code: 7308901000 Country/region of origin US Quantity : 4.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	4	5.21	0	5.210	20.84USD
ER8-P4	Cage Assembly Rod, 8" (203.2 mm) Long, Ø6 mm, 4 Pack Commodity code: 7308901000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	43.47	0	43.470	43.47USD
KCB1E	Right-Angle Kinematic Elliptical Mirror Mount, 30 mm Cage System and SM1 Compatible, 8-32 and 1/4"-20 Mounting Holes Commodity code: 9002900000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	198.00	0	198.000	198.00USD
BBE1-E03	1" Broadband Dielectric Elliptical Mirror, 750 - 1100 nm Commodity code: 9001901000 Country/region of origin US Quantity : 2.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	2	91.90	0	91.900	183.80USD
H45E1	45° Mount for 1" Elliptical Optics Commodity code: 9013800000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	113.00	0	113.000	113.00USD
RS05P	Ø1" Pedestal Pillar Post, 1/4"-20 Taps, L = 0.5" Commodity code: 7308901000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	19.15	0	19.150	19.15USD
CM1-4ER	Compact Clamping 4-Port Prism/Mirror 30 mm Cage Cube, 8-32 Tap Commodity code: 9002900000 Country/region of origin US Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	131.00	0	131.000	131.00USD
BS029	90:10 (R:T) Non-Polarizing Beamsplitter Cube, 700-1100 nm, 1" Commodity code: 9001901000 Country/region of origin CN Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	1	206.00	0	206.000	206.00USD
CP08FP	FiberPort and LaserPort Adapter for 30 mm Cage System, Enhanced Clamping Commodity code: 9033000000 Country/region of origin US Quantity : 2.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	2	28.00	0	28.000	56.00USD
ER05-P4	Cage Assembly Rod, 1/2" (12.7 mm) Long, Ø6 mm, 4 Pack Commodity code: 7308901000 Country/region of origin US Quantity : 2.00 Packing slip No.: PS02066103 Ship date: 8/10/2015	2	18.77	0	18.770	37.54USD
PM100USB	USB Power and Energy Meter Interface for C-Type Sensors Commodity code: 9031498000 Country/region of origin DE Quantity : 1.00 Packing slip No.: PS02066103 Ship date: 8/10/2015 S/N: P2004927 Qty : -1.00	1	410.00	0	410.000	410.00USD

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Newton, NJ 07860-2402
Phone ..: 973-300-3000
Fax ......: 973-300-3600
E-mail ..: sales@thorlabs.com

Bill to

University of Arkansas
Off of Bus Affairs
321 Administration Building
Fayetteville, AR 72701

Attention: Richard Coffman

Invoice 2131310

Inv Date ....: 08/11/2015
Due ....: 08/11/2015
Purchase Order ....: WEBTS1416782
Terms of Payment ....: Credit Card
Sales Order ....: TS1416782

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Item Number	Description	Qty Sold	Std Price	Disc. %	Disc Price	Ext Price

Please pay in US funds by check to the above address, credit card, or wire to Thorlabs, Inc Acct#205000754, bank routing # 021205376 C/O Lakeland Bank, 615 Rt.206N.,Newton, NJ, 07860 EIN: 22-2873153. DUNS 19-395-3726. For international wires only use Wells Fargo Bank, 190 River Road, Summit, NJ 07901, Account#2000039124913, SWIFT code WFBIUS6S, ABA#121000248. Thorlabs' Terms and Conditions (www.thorlabs.com) control and supersede any other terms and conditions. Export Administration Regulations and European Export Laws may apply to the sale, destination and end use of these items and any related technical data. Any diversion contrary to US and European export control regulations is strictly prohibited: www.bis.doc.gov
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Subtotal:	2,025.84	
Total Discount:	0.00	
Shipping & Handling:	12.28	
Sales Tax:	0.00	
Invoice Total:	2,038.12	USD

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Newton, NJ 07860-2402

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E-mail : sales@thorlabs.com

THORLABS

Invoice 2064859 - A

2481075

Inv. Date	4/24/2015
Due	**5/24/2015**
Purchase Order	829540
Terms of payment	Net 30
Sales Order	TS1354612
Sales Contact	Jennifer Geerhart
Delivery Method	UPS Ground
Terms of Delivery	Ex Works Newton
Delivery Date	4/23/2015
Page	1 of 1

Bill to

University of Arkansas
Accounts Payable
321 Administration Building
Fayetteville, AR 72701

Ship to

University of Arkansas
Bell Engineering Center Rm 4190
800 W Dickson Street

Fayetteville, AR 72701

Attention: Richard Coffman
Telephone: 479 575-8767
Fax: 479 575-7168

Contact	Richard Coffman
Customer Account	219328
Invoice Account	219328
Your Tax Exempt No.	
E-mail	
Fax	14795754158

Item Number	Description	Qty Sold	Std Price	Disc. %	Disc. Price	Ext Price
BE052-B	Variable Beam Expander 0,5-2X	1	814.00		814.000	814.00 USD

Commodity code: 9013800000 Country/region of origin SE
Quantity : 1.00 Packing slip No.: PS01995646 Ship date: 4/23/2015

Please pay in US funds by check to the above address, credit card, or wire to Thorlabs, Inc Acct#205000754, bank routing # 021205376 C/O Lakeland Bank, 615 Rt.206N.,Newton, NJ, 07860 EIN: 22-2873153. DUNS 19-395-3726. For international wires only use Wells Fargo Bank, 190 River Road, Summit, NJ 07901, Account#2000039124913, SWIFT code WFBIUS6S, ABA#121000248. Thorlabs' Terms and Conditions (www.thorlabs.com) control and supersede any other terms and conditions. Export Administration Regulations and European Export Laws may apply to the sale, destination and end use of these items and any related technical data. Any diversion contrary to US and European export control regulations is strictly prohibited: www.bis.doc.gov
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Subtotal:	814.00
Total Discount:	0.00
Shipping and Handling:	0.00
Sales Tax:	0.00
Invoice Total:	814.00 USD

USDOT EQUIPMENT

D900648

Thorlabs, Inc.

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Phone ..: 973-300-3000
Fax ......: 973-300-3600
E-mail ..: sales@thorlabs.com

THORLABS

Invoice 2141907

Inv Date ....: 08/27/2015
Due ....: 08/27/2015
Purchase Order ....: WEBTS1416782
Terms of Payment ....: Credit Card
Sales Order ....: TS1416782
Sales Contact ....: Melissa Gupton
Delivery Method ....: FedEx Ground
Terms of Delivery .....: Ex Works Newton
Delivery Date ....: 08/27/2015
Page ....:1 of 1

Bill to

University of Arkansas
Off of Bus Affairs
321 Administration Building
Fayetteville, AR 72701

Attention: Richard Coffman

Ship to

University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701

Attention: Richard Coffman
Telephone: 479 575-8767
Fax: 479 575-7168

Contact ....: Richard Coffman
Customer Account ...: 219328
Invoice Account ....: 219328
Your Tax Exempt No.:
Fax ....: 14795754158
E-mail ....: ssalazar@uark.edu

FOR ADVICE ONLY - PLEASE DO NOT PAY

Item Number	Description	Qty Sold	Std Price	Disc. %	Disc Price	Ext Price
KM100-E03	Kinematic Mount for Ø1" Optics with Near IR Laser Quality Mirror Commodity code: 9002900000 Country/region of origin US Quantity : 4.00 Packing slip No.: PS02077567 Ship date: 8/27/2015	4	103.50	0	103.500	414.00USD

$454.37

Please pay in US funds by check to the above address, credit card, or wire to Thorlabs, Inc Acct#205000754, bank routing # 021205376 C/O Lakeland Bank, 615 Rt.206N.,Newton, NJ, 07860 EIN: 22-2873153. DUNS 19-395-3726. For international wires only use Wells Fargo Bank, 190 River Road, Summit, NJ 07901, Account#2000039124913, SWIFT code WFBIUS6S, ABA#121000248. Thorlabs' Terms and Conditions (www.thorlabs.com) control and supersede any other terms and conditions. Export Administration Regulations and European Export Laws may apply to the sale, destination and end use of these items and any related technical data. Any diversion contrary to US and European export control regulations is strictly prohibited: www.bis.doc.gov
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Subtotal:	414.00
Total Discount:	0.00
Shipping & Handling:	0.00
Sales Tax:	0.00
Invoice Total:	414.00 USD

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56 Sparta Avenue
Newton, NJ 07860-2402

Phone: 973-300-3000
Fax : 973-300-3600
Email: sales@thorlabs.com

THORLABS D903665

USDOT EQUIP.

Order confirmation

Sales Order ....: TS1431653-1
Created date ....: 9/8/2015
Date ....: 9/8/2015
Purchase order ....: WEBTS1431653
Terms of payment ....: Credit Card
Sales order ....: TS1431653
Sales Contact ....: Laura Justin
Mode of Delivery ....: FedEx Ground
Terms of Delivery ....: Ex Works Newton
Invoice Account ....: 219328
Your Tax Exempt No. ...:
Page ....: 1 of 2

Bill to

University of Arkansas
OFF OF BUS AFFAIRS
321 ADMIN, UNIV. OF ARKANSAS
Fayetteville, AR 72701

Attention: Richard Coffman

Ship to

University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701

Attention: Richard Coffman
Telephone: 479 575-8767
Fax: 479 575-7168

Line	Item Number	Description	Quantity	Price Each	Disc. %	Disc. Price	Amount	Ship date
1.0	TR075-P5	Ø1/2" Optical Post, SS, 8-32 Setscrew, 1/4"-20 Tap, L = 0.75", 5 Pack	2.00	21.33		21.330	42.66 USD	9/8/2015
2.0	TH060	Ø1/2" Optical Post with Hex Top, SS, L = 0.60"	2.00	5.05		5.050	10.10 USD	9/8/2015
3.0	MC-5	Lens Tissues, 25 Sheets per Booklet, 5 Booklets	1.00	9.80		9.800	9.80 USD	9/8/2015
4.0	MRAK25-E03	Knife-Edge Right-Angle Prism Dielectric Mirror, 750-1100 nm	1.00	200.00		200.000	200.00 USD	9/8/2015
5.0	PH1-P5	Ø1/2" Post Holders, Spring-Loaded Hex-Locking Thumbscrew, L = 1", 5 Pack	2.00	35.15		35.150	70.30 USD	9/8/2015
6.0	TR1	Ø1/2" Optical Post, SS, 8-32 Setscrew, 1/4"-20 Tap, L = 1"	1.00	4.74		4.740	4.74 USD	9/8/2015
7.0	SS25S050	1/4"-20 Stainless Steel Setscrew, 1/2" Long, Pack of 25	1.00	5.50		5.500	5.50 USD	9/8/2015

$386.23

Thorlabs, Inc.
56 Sparta Avenue
Newton, NJ 07860-2402

Phone: 973-300-3000
Fax : 973-300-3600
Email: sales@thorlabs.com

THORLABS

Order confirmation

Bill to

University of Arkansas
OFF OF BUS AFFAIRS
321 ADMIN, UNIV. OF ARKANSAS
Fayetteville, AR 72701

Attention: Richard Coffman

Ship to

University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701

Attention: Richard Coffman
Telephone: 479 575-8767
Fax: 479 575-7168

Sales Order ....: TS1431653-1
Created date ....: 9/8/2015
Date ....: 9/8/2015
Purchase order ....: WEBTS1431653
Terms of payment ....: Credit Card
Sales order ....: TS1431653
Sales Contact ....: Laura Justin
Mode of Delivery ....: FedEx Ground
Terms of Delivery ....: Ex Works Newton
Invoice Account ....: 219328
Your Tax Exempt No. ...:

Subtotal:	343.10	USD
Total Discount:	0.00	USD
Shipping and Handling:	8.82	USD
Sales Tax:	0.00	USD
Grand Total:	351.92	USD

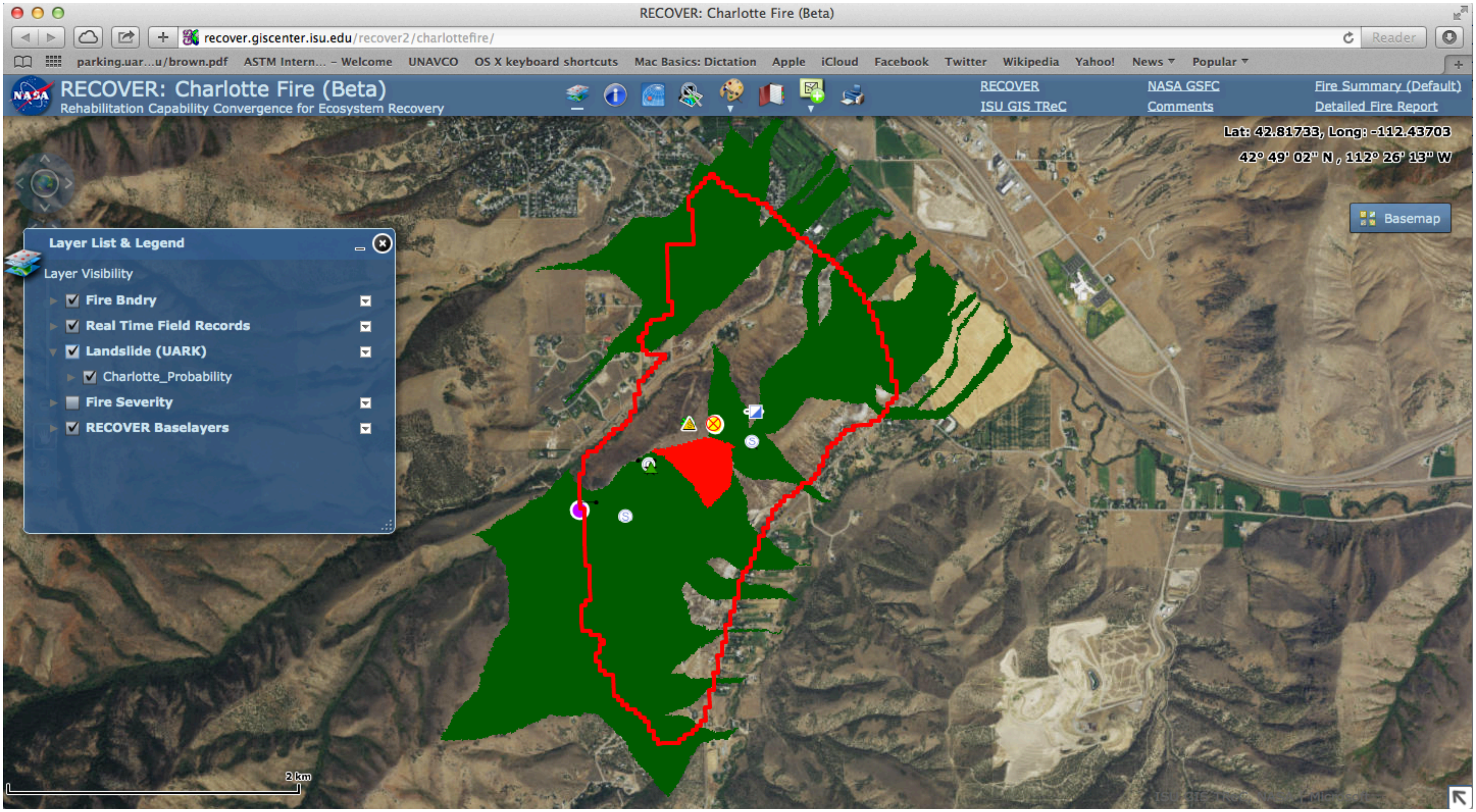
NASA Applied Remote Sensing Training
Wildfire
October 6-8, 2015

	Day 1	
8:00am	Introductions	
8:30am	GIS and geospatial data review	
9:15am	Satellite remote sensing review	
9:45am	BREAK	
10:00am	Overview of fire related remote sensing platforms and products	
	Landsat	
	MODIS	
	MERRA	
	SMAP	
	NDVI	
	fPAR	
	NBR	
10:30am	Hands-on exploration exercise (team A)	(team B in breakout)
11:15am	Breakout session 1: A season of fire (team A)	(team B in exercise)
NOON	LUNCH	
1:00pm	What to expect from Geospatial data and technologies	
	Spatial resolution	
	Temporal resolution	
	Understanding error	
1:30pm	Hands-on exploration exercise (team A)	(team B on BREAK)
2:00pm	BREAK	(team B in exercise)
2:30pm	Pre-fire assessment with satellite remote sensing imagery	
3:00pm	Hands-on exploration exercise (team A)	(team B in breakout)
3:45pm	Breakout session 2: satellite imagery in your workflow (team A)	(team B in exercise)
4:30pm	END	
6:00pm	Evening social and student poster session	

	Day 2	
8:00am	Review of day 1 materials and exercises	
8:15am	Integrating other geospatial data	
	Elevation	
	Slope	
	Aspect	
8:45am	Hands-on exploration exercise (team A)	(team B in breakout)
9:15am	Breakout session 3: Current bottlenecks (team A)	(team B in exercise)
10:30am	BREAK	
10:45am	Fire management and planning with geospatial technologies	
	MODIS active fires	
	VIIRS	
	Early detection systems	

	Fire behavior in response to landscape elements	
11:15am	Hands-on exploration exercise (team A)	(team B in breakout)
11:45am	Breakout session 4: Future missions wishlist (team A)	(team B in exercise)
12:15pm	LUNCH	
1:15pm	Field trip/Technical tour of a regional fire site	
4:30pm	END	

	Day 3	
8:00am	Review of day 1 and 2 materials and exercises	
8:15am	Post fire planning from an end-user perspective	
	BAER	
	ES&R	
9:00am	Hands-on exploration exercise (team A)	(team B in breakout)
9:45am	Breakout session 5: DEVELOP (team A)	(team B in exercise)
10:30am	BREAK	
10:45am	RECOVER Decision support system	
11:15am	Hands-on exploration exercise (team A)	(team B free)
11:45am	Hands-on exploration exercise (team B)	(team A free)
12:15pm	LUNCH	
1:15pm	Long-term monitoring with satellite remote sensing	
	Past research	
	Understanding NPP	
2:00pm	Hands-on exploration exercise (team A)	(team B in breakout)
2:45pm	Breakout session 6: Future research needs (team A)	(team B in exercise)
3:15pm	BREAK	
3:30pm	New techniques and technologies	
	UAS and aircraft systems	
	SMAP	
4:15pm	Wrap up Q&A	
5:00pm	END	


RECOVER: Charlotte Fire (Beta)
recover.giscenter.isu.edu/recover2/charlottefire/
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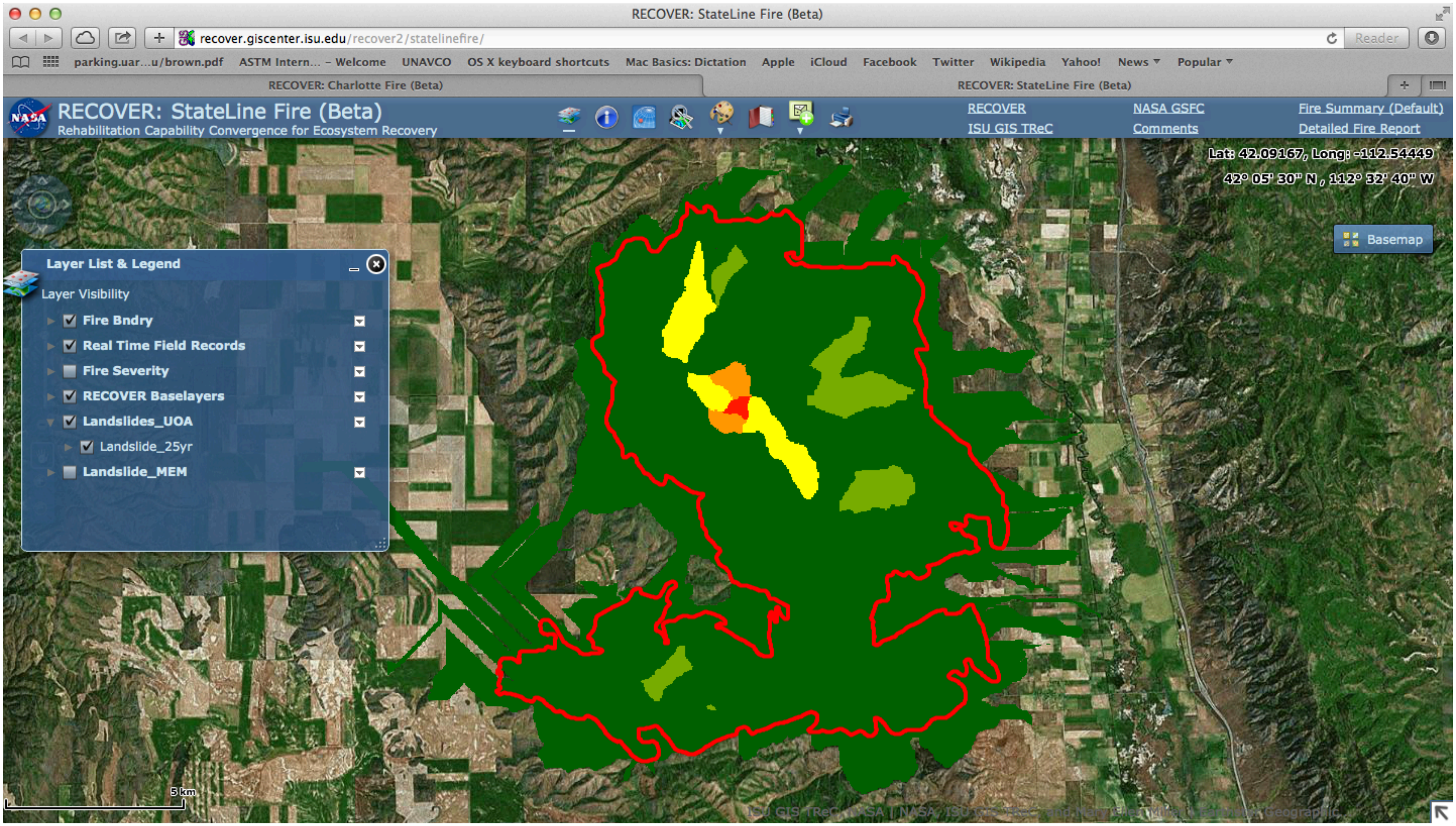
ASTM Intern... – Welcome
UNAVCO
OS X keyboard shortcuts
Mac Basics: Dictation
Apple
iCloud
Facebook
Twitter
Wikipedia
Yahoo!
News
Popular
RECOVER: Charlotte Fire (Beta)
Rehabilitation Capability Convergence for Ecosystem Recovery
RECOVER
ISU GIS TReC
NASA GSFC
Comments
Fire Summary (Default)
Detailed Fire Report
Lat: 42.81733, Long: -112.43703
42° 49' 02" N , 112° 26' 13" W
Basemap
Layer List & Legend
Layer Visibility
Fire Bndry
Real Time Field Records
Landslide (UARK)
Charlotte_Probability
Fire Severity
RECOVER Baselayers
2 km



RECOVER: StateLine Fire (Beta)
recover.giscenter.isu.edu/recover2/statelinefire/
RECOVER: Charlotte Fire (Beta)
RECOVER: StateLine Fire (Beta)
RECOVER: StateLine Fire (Beta)
Rehabilitation Capability Convergence for Ecosystem Recovery
RECOVER
ISU GIS TReC
NASA GSFC
Comments
Fire Summary (Default)
Detailed Fire Report
Lat: 42.09167, Long: -112.54449
42° 05' 30" N , 112° 32' 40" W
Basemap
Layer List & Legend
Layer Visibility
Fire Bndry
Real Time Field Records
Fire Severity
RECOVER Baselayers
Landslides_UOA
Landslide_25yr
Landslide_MEM
5 km

Machine Learning Based Predictive Modeling of Post Wildfire Debris Flow Probability in the Intermountain Western United States

Michigan Tech — Create the Future

Priscilla Addison[1], Ashley Kern[1], Thomas Oommen[1], Sean Salazar[2], and Richard Coffman[2]

1. Department of Geological and Mining Engineering and Sciences, Michigan Technological University, Houghton, MI-49931.

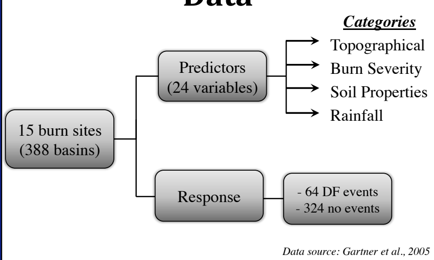
2. Department of Civil Engineering, University of Arkansas, Fayetteville, AR-72701

University of Arkansas

Introduction

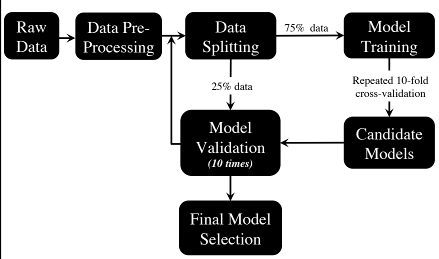
- Mountainous regions have been recognized for producing post wildfire debris flows (DF).
- Ability to predict DF events accurately will protect public safety and infrastructure.
- Advancements in remote sensing allows for generation of large scale and timely information than previous field assessments.
- Goal 1: Explore machine learning models to possibly capture nonlinear relationships between predictor variables and DF events using data from USGS.
- Goal 2: Explore the susceptibility of recently burned basins to DF events with focus on their impact on surrounding transportation infrastructure.

Data

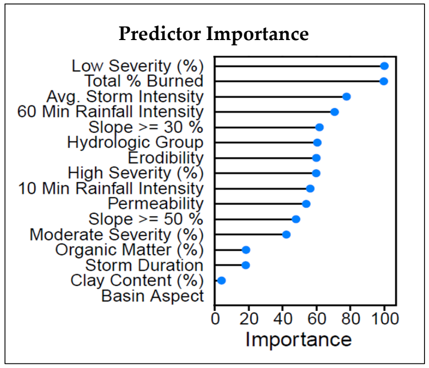


Data source: Gartner et al., 2005

Methodology



Results and Discussion

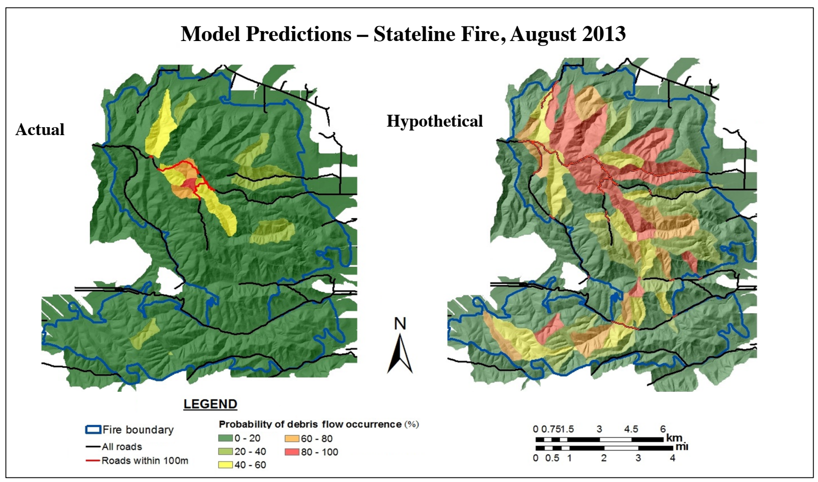


Variable importance plot determined by considering the relative influence of each predictor when added to the model (naïve Bayes). Predictor size was reduced from 24 to 16.

Top Four Models

Model	Sensitivity (std. dev.)	ROC
Naïve Bayes	0.72 (0.08)	0.94
Mixture Discriminant Analysis (MDA)	0.71 (0.10)	0.98
Classification Tree	0.46 (0.15)	0.90
Logistic Regression	0.42 (0.12)	0.90

Naïve Bayes, which is a nonlinear model, was selected after rigorous testing as the overall best model. This was because it recorded the highest averaged sensitivity with a corresponding small standard deviation.



The maps above display debris flow probability estimates (%) made by the Naïve Bayes model after a recently burned site encompassing the Idaho/Utah state border in August 2013- *Stateline Fire*. These were generated for a 25-year storm event. Since fire severity was founded to be a very important influence on the model, the maps were generated first for actual severities of the fire that occurred (left), then for a hypothetical case of if all affected basins burned at a high severity (right). The predictions for “actual” indicated 5 out of 185 basins have probabilities above 50% and the “hypothetical” had 37 out of 185 basins with probabilities above 50%. Roads within 100m buffer of ‘unstable’ basins have been delineated with red lines.

Conclusions

- The Naïve Bayes model outperformed the logistic regression model with an average sensitivity of 72% versus 42% respectively.
- Better performance of machine learning models likely due to:
  - Non-linear relationships within the data
  - Advanced variable selection methods
- Rigorous machine learning model development techniques promote confidence during out of sample predictions.
- Model predictions made for the Stateline fire identified 5 out of 185 basins as likely unstable.

Future Work

- Validate model through prescribed burns and model application.
- Develop a similar predictive model for Southern California with data collected for the region by USGS.
- Develop models that estimate associated debris volumes to be generated from candidate ‘unstable’ basins.
- Incorporate hazard map generation in the NASA RECOVER platform.

Acknowledgement

This project was made possible by the US Department of Transportation (USDOT) through the Office of the Assistant Secretary for Research and Technology.

USDOT
FY 2015 Yearly Report
OASRTRS-14-H-UARK

Principal Investigator: *Richard Coffman*

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Undergraduate Researcher: *Leah Miramontes, Brendan Yarborough, Johnathan Blanchard*

Wesite Manager: *Travis Hefley*

Co-Principal Investigator: *Thomas Oommen*

Graduate Researcher: Priscilla Addison

Undergraduate Researcher: Ashley Kern

Team Member: Keith Weber

Programmer: Bryan Nicholson

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Overview

Task 1 : TAC Development ✔

Task 2 : Website, ✔ Implementation Plan, ✔ Service Providers ✔

Task 3 : Development of Ground-based Remote Sensing Device ✔

Task 4 : Collection of Field Data, ✔ Collection of Lab Data ✔

Task 5 : Development of Probabilistic Model Decision Support System ✔

Task 6 : Reporting and Publication ✔

Expenditures

Background

Soil water potential $\Psi_T = \Psi_p + \Psi_z + \Psi_o + \Psi_m$ $\quad \Psi_T = \frac{RT}{V_w} \ln\left(\frac{\rho_{H_2O}}{\rho_{sat}}\right)$

Soil water potential provides more complete understanding of soil hydraulic and mechanical behavior

Unsaturated soil conditions affect:

- Shear strength of soil
- Hydraulic conductivity of soil

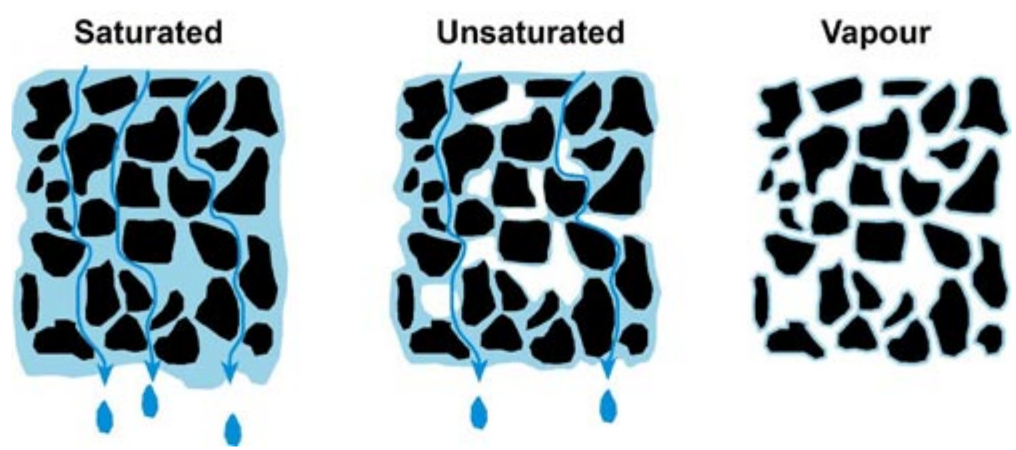

Image from the University of New South Wales

Motivation

Hazards related to unsaturated soil conditions:

- *Post-Wildfire Debris Flow* (Landslides)

  Erosion

  Slope stability

  In-situ hydric capacity
- *Expansive Soils*

Images from the Coalition for the Upper South Platte and The Denver Post

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Measurement Techniques

Traditional

- Tempe cell
- Pressure plate extractor
- Tensiometer
- Electrical resistance sensor
- Heat dissipation sensor

Advantage: Mature, documented and well-understood

Disadvantage: Time-consuming, point-wise, limited spatial coverage

Remotely-sensed

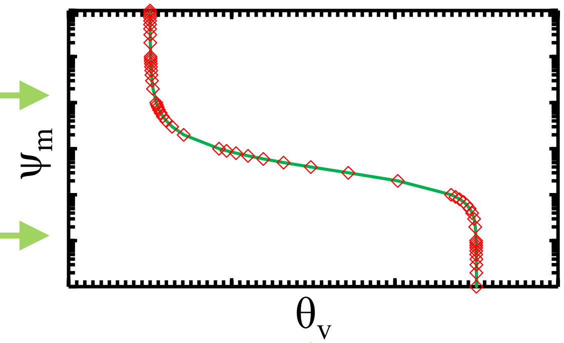
- Laser Analysis of Soil Tension (LAST)

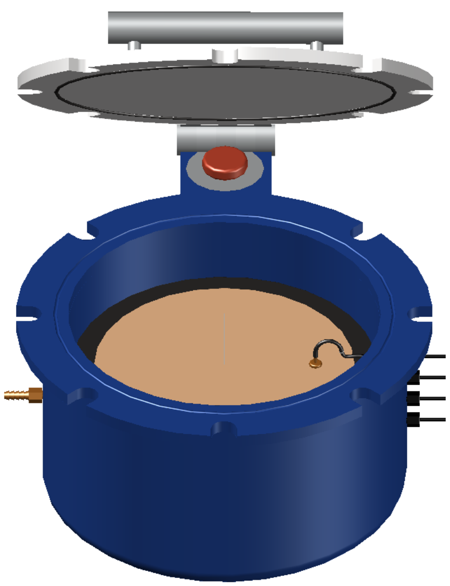
Advantage: Rapid, high spatial and temporal resolution

Disadvantage: Not validated, indirect measurement, computationally intensive

Traditional Laboratory Techniques for Unsaturated Soils

Soil Water Characteristic Curve (SWCC)





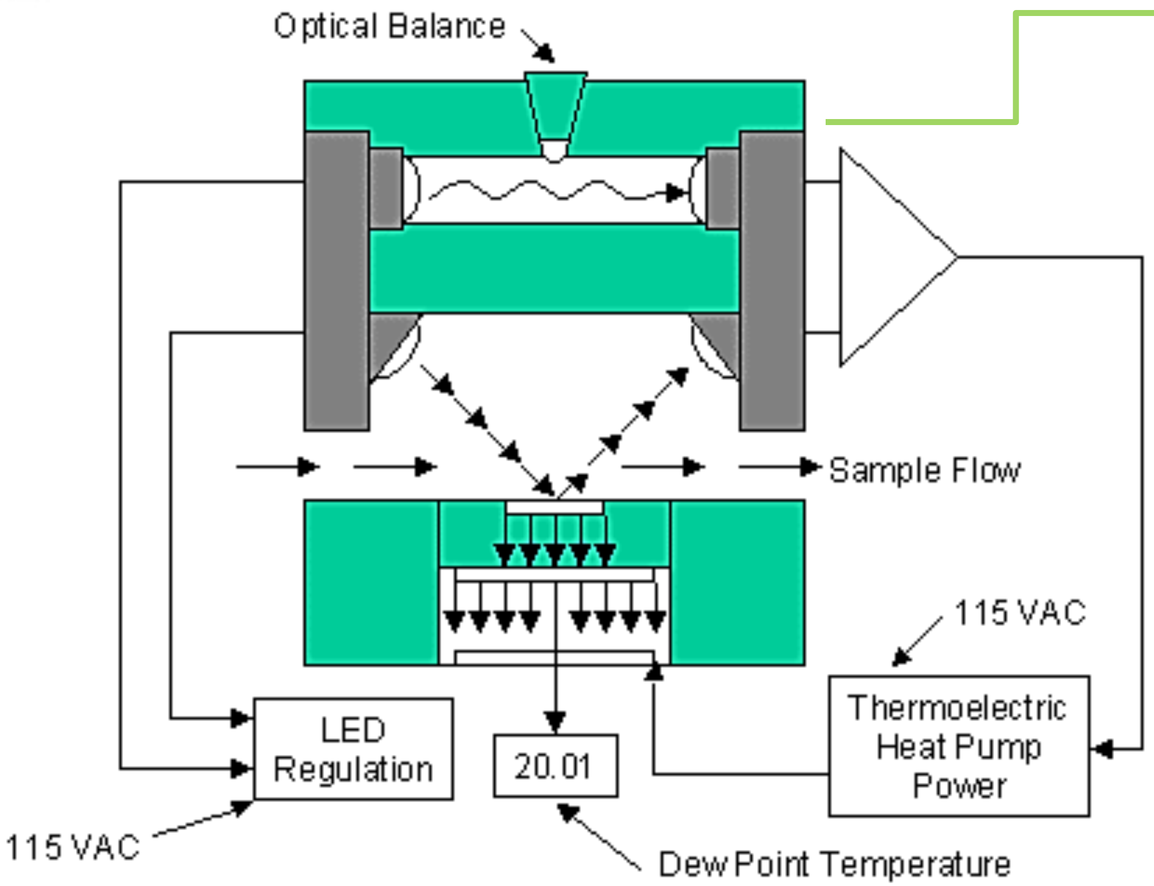
Pressure Plate Extractor

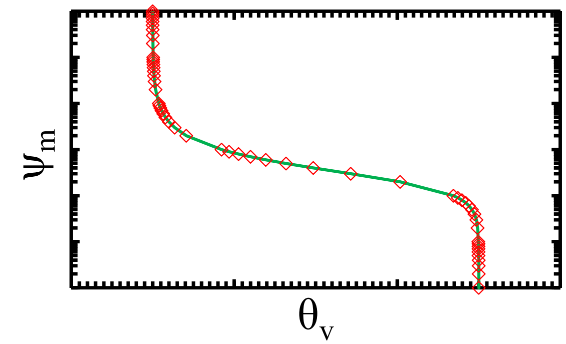
Tempe Cell

ASTM D2216
Water Content
&
Phase Relationships

Images from APSWT and San Diego Zoo

Traditional Laboratory Techniques for Unsaturated Soils





Chilled Mirror Hygrometer

Image from Thunder Scientific

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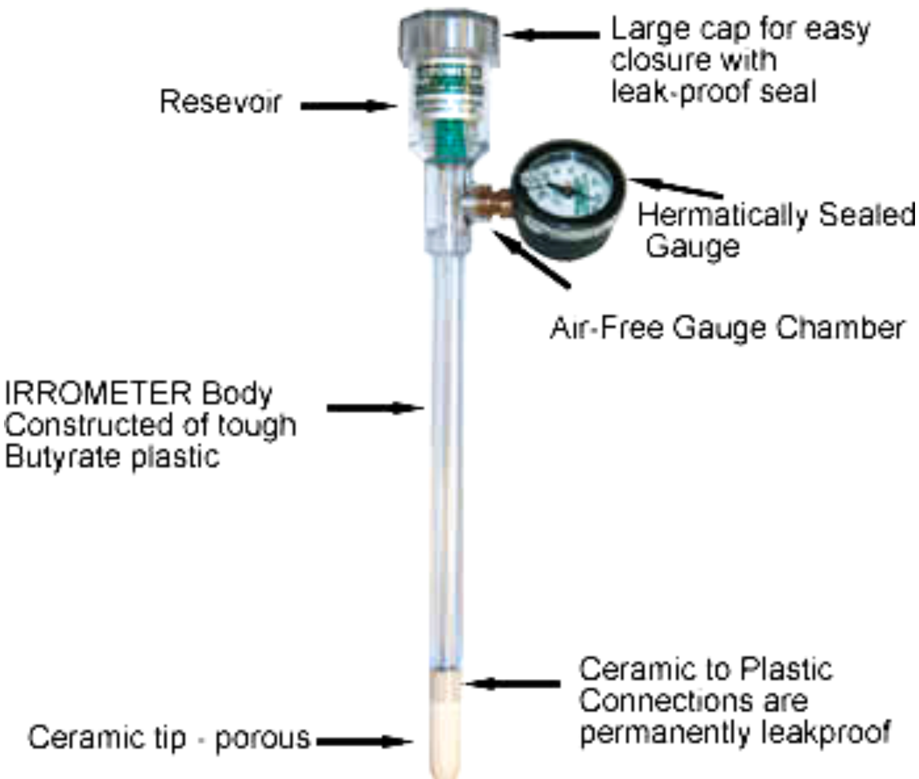
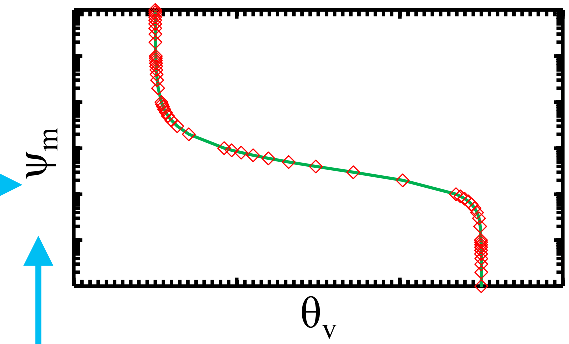
In-Situ Measurement Techniques for Unsaturated Soils

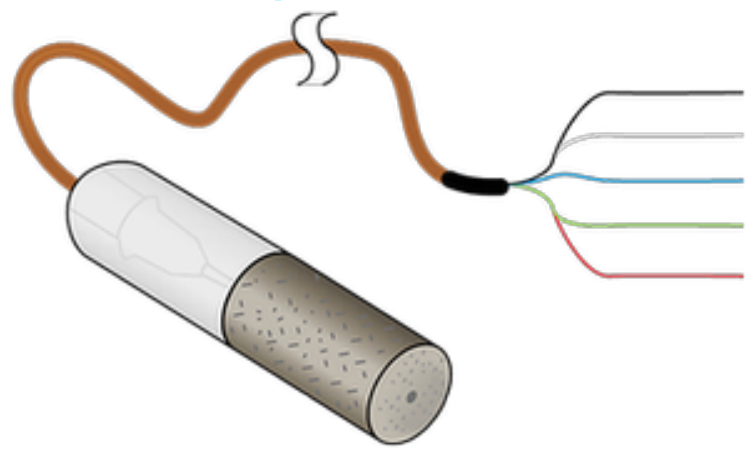


Tensiometer

0-100 kPa
+/- 1 kPa



10-2500 kPa
+/- 1 kPa

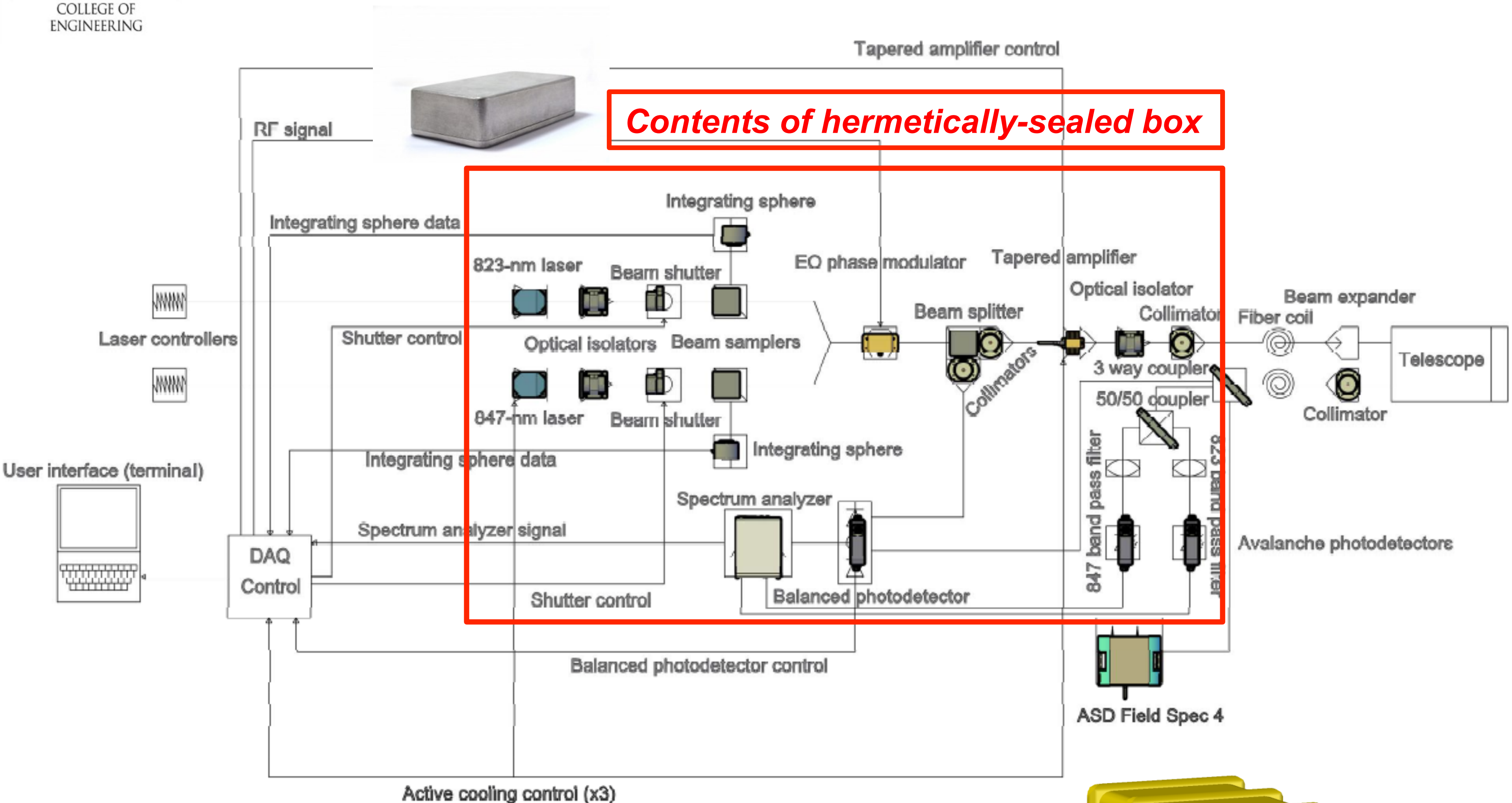


Heat dissipation sensor

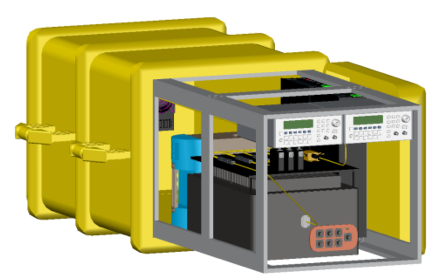
Images from Calafrica SA and Campbell Scientific

TASK 3

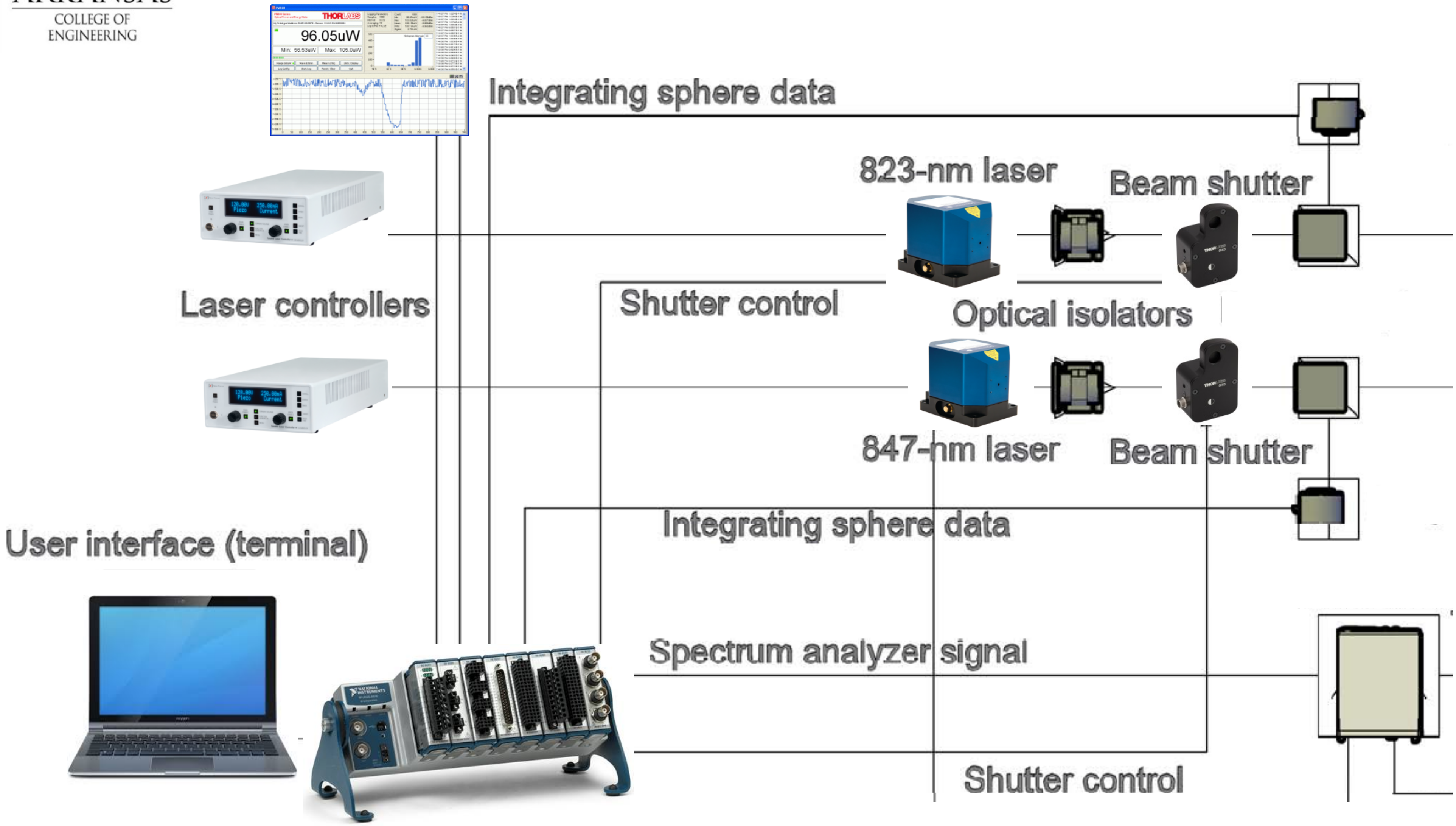
Development of Topographic Differential Absorption LiDAR (TDiAL)



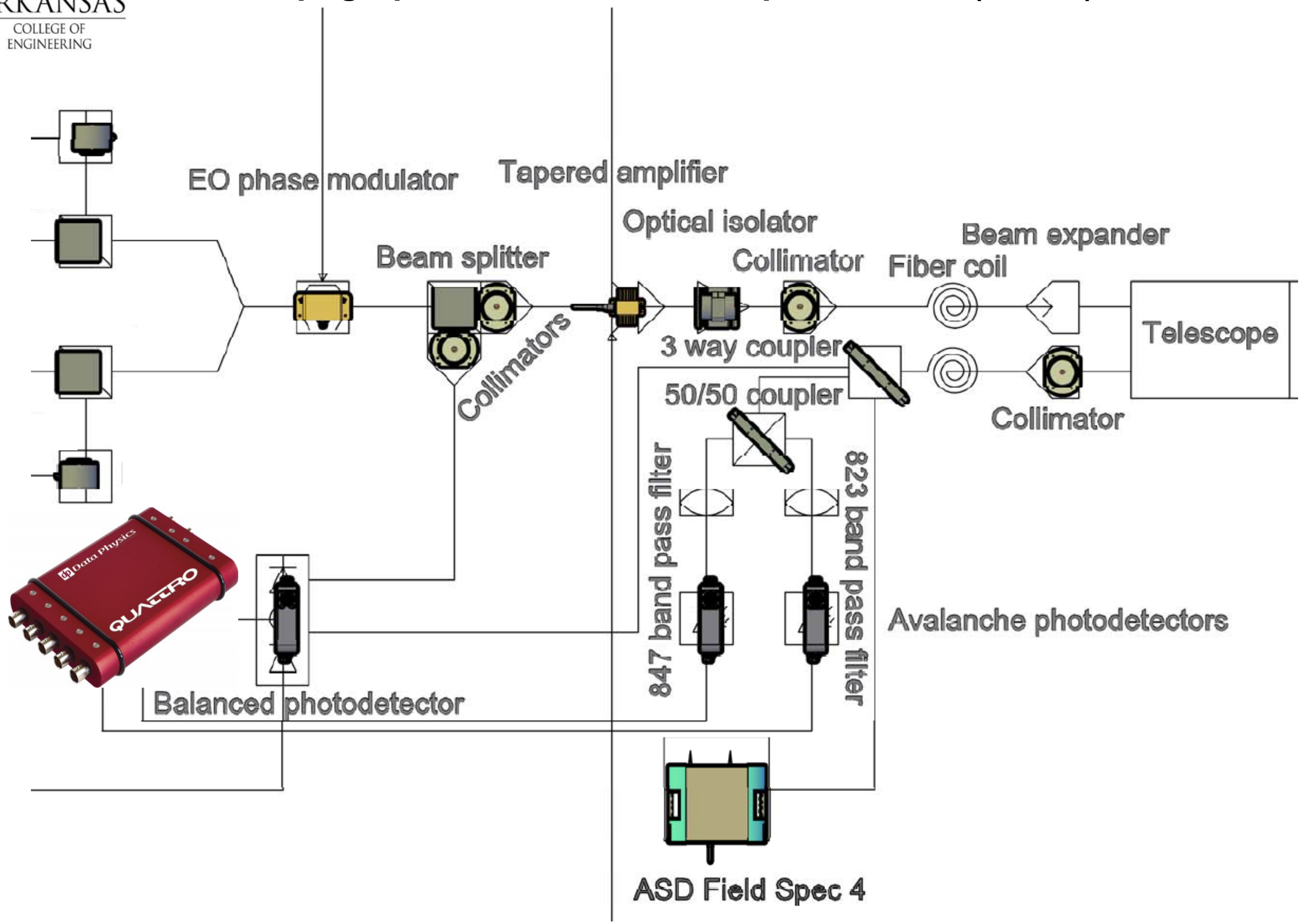
1-line diagram of TDiAL device



Development of
Topographic Differential Absorption LiDAR (TDiAL)



Development of Topographic Differential Absorption LiDAR (TDiAL)



TASK 4

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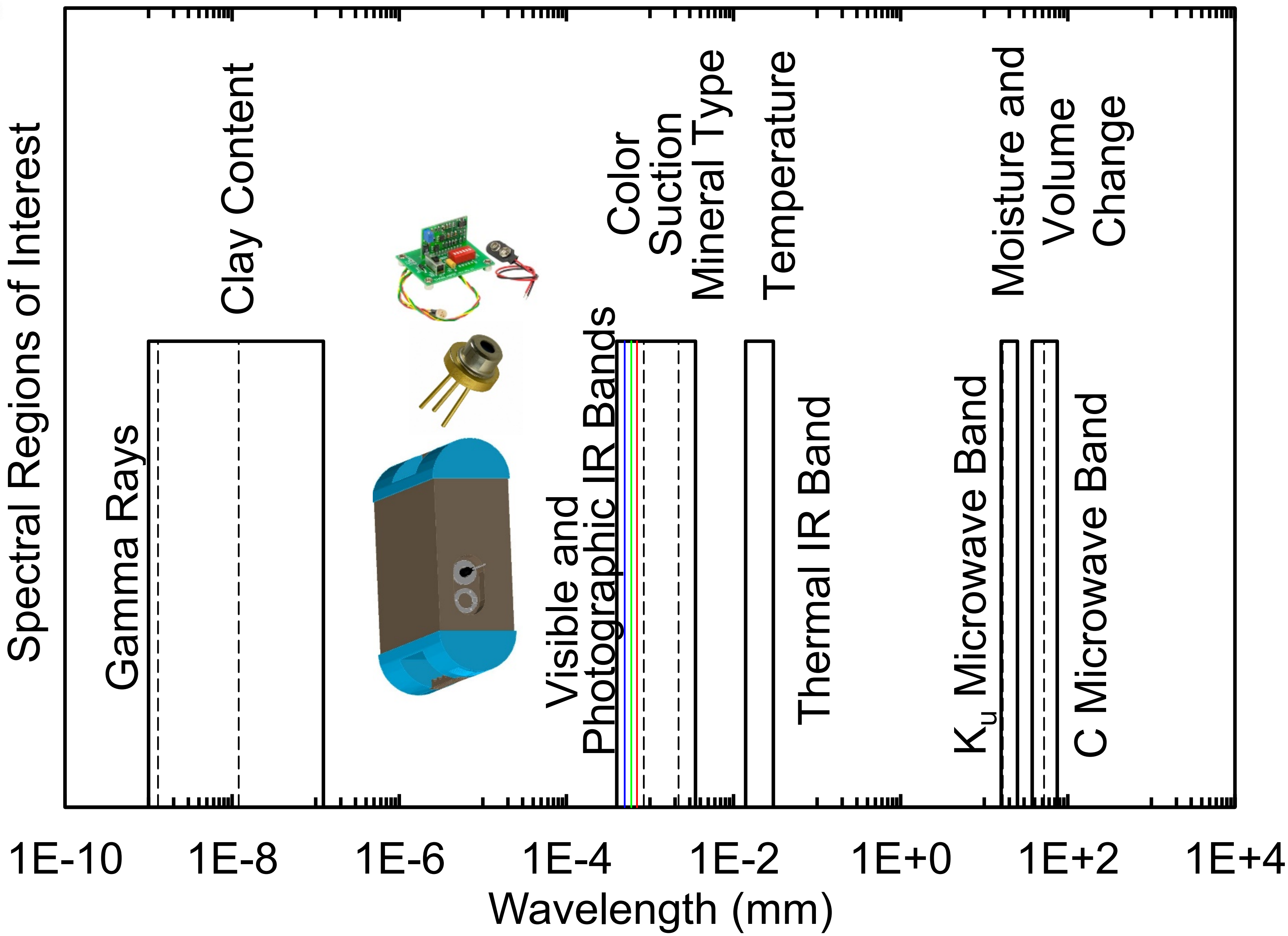
Operating Wavelengths for Remote Sensing of Unsaturated Soils



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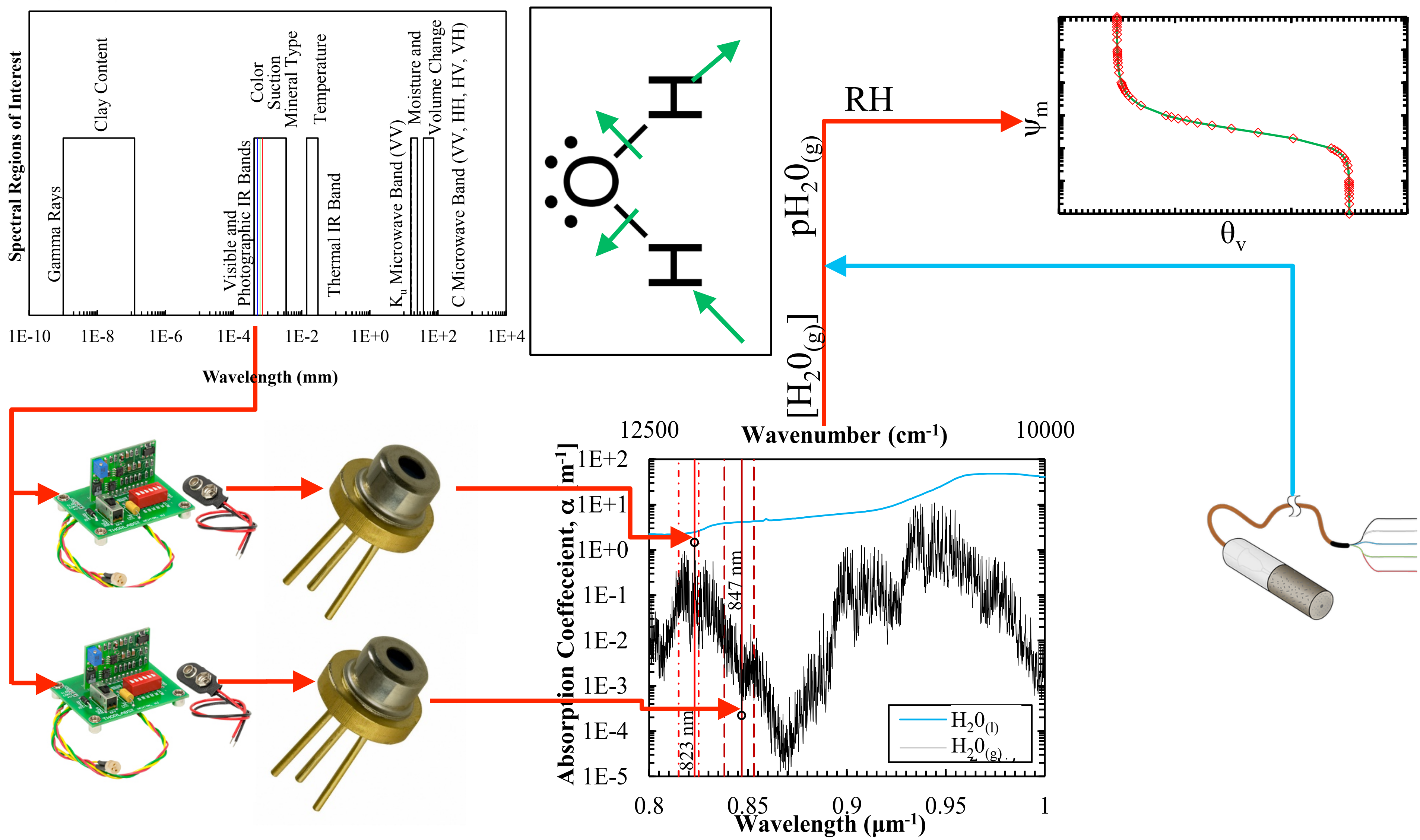
Development of Laser Analysis of Soil Tension (LAST) Device



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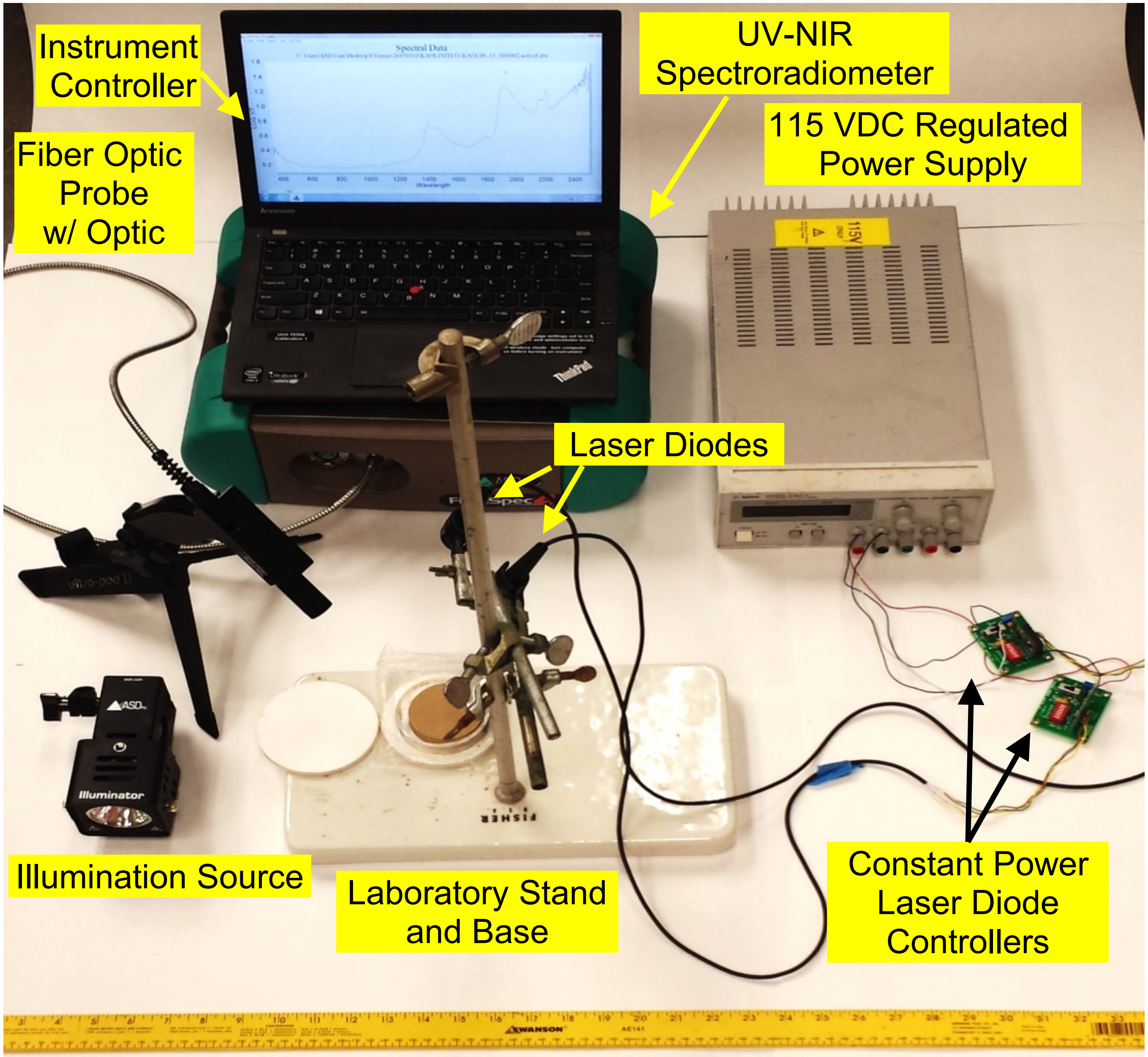
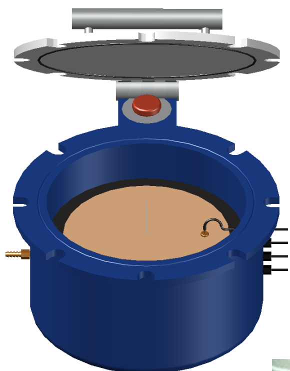
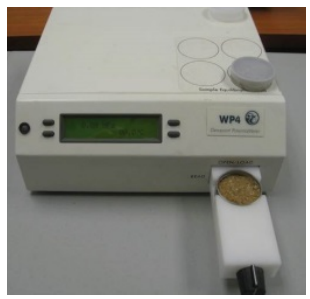
LAST Device



All Techniques Employed

Laboratory Techniques

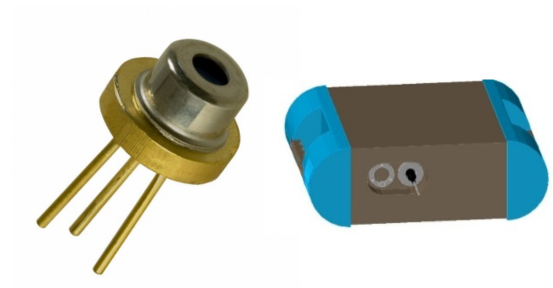




Pressure Plate Extractor

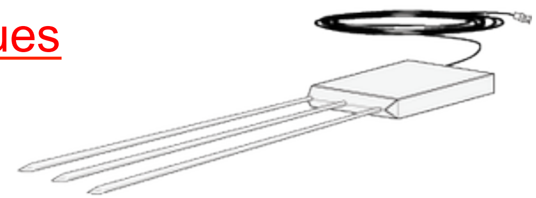
Chilled Mirror Hygrometer

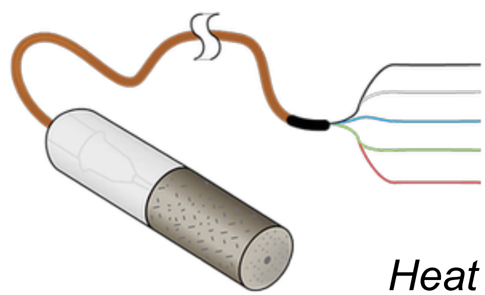
Remote Sensing Technique



Laser Analysis of Soil Tension

In-situ Techniques

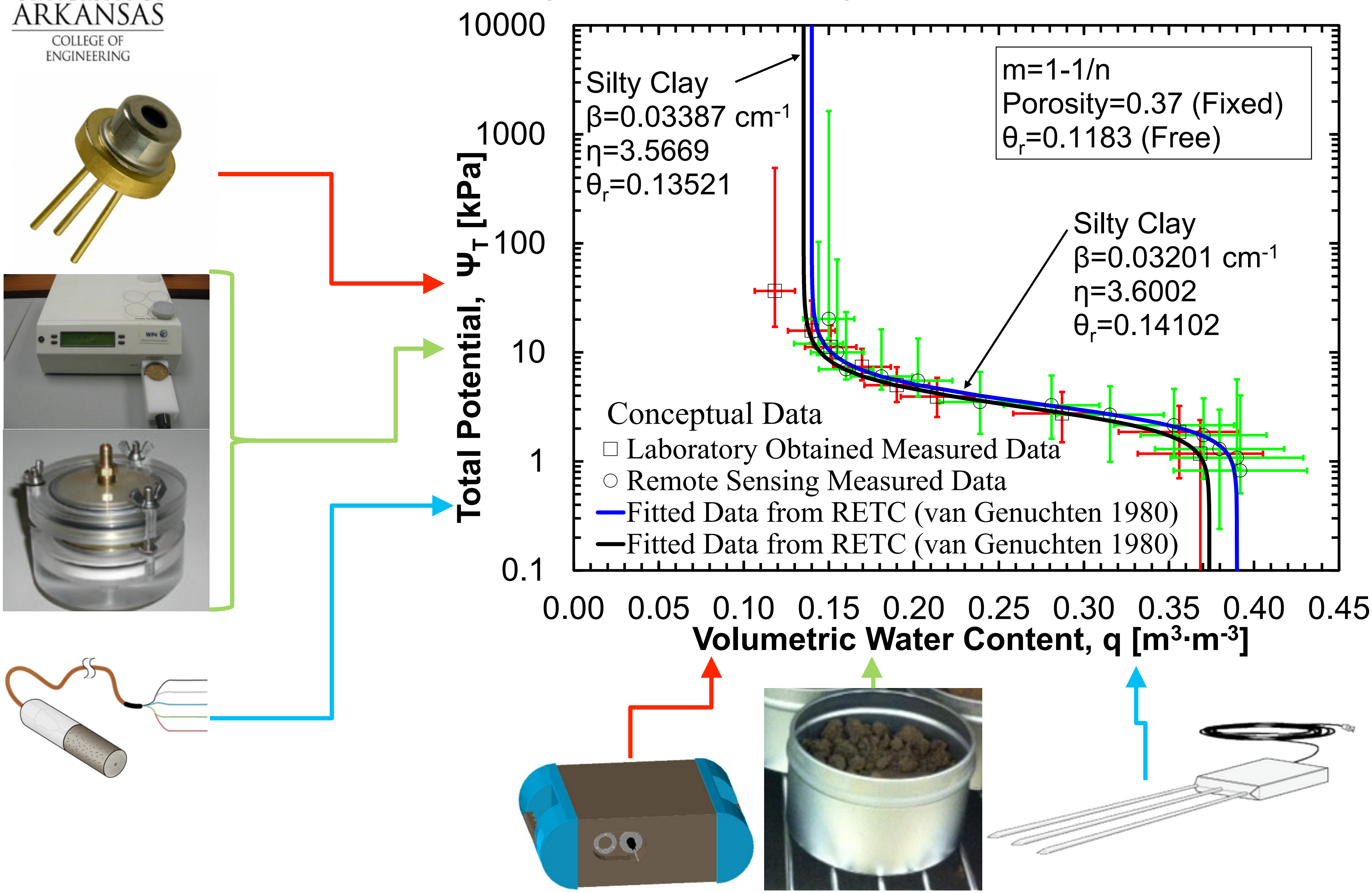




Heat Dissipation Sensor

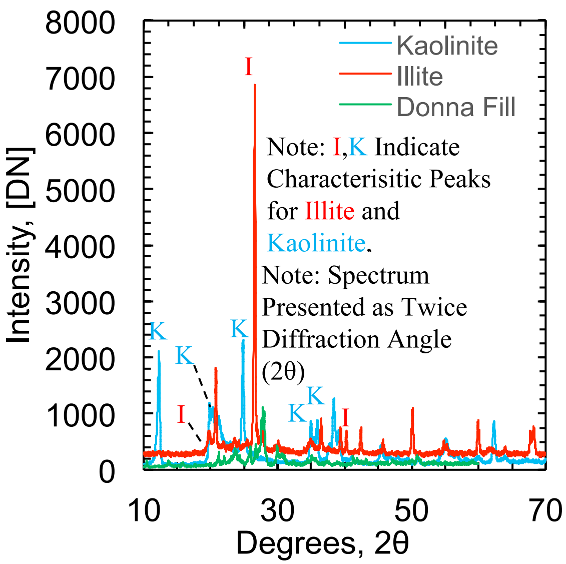
Time-Domain Reflectometer

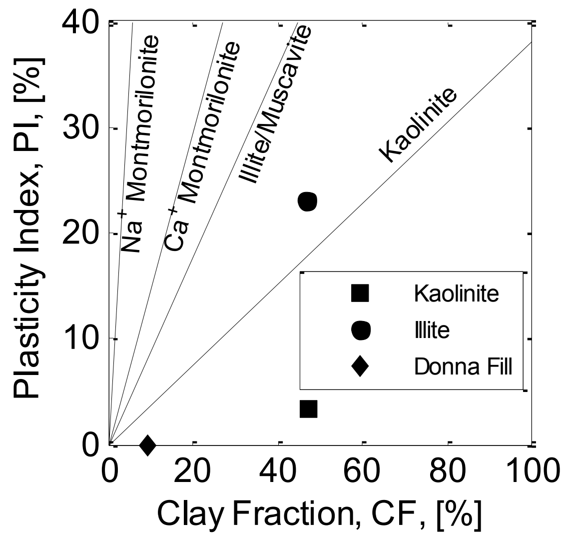
Coupled Soil Water Characteristic Curve
Laboratory, In-Situ, Remotely Sensed

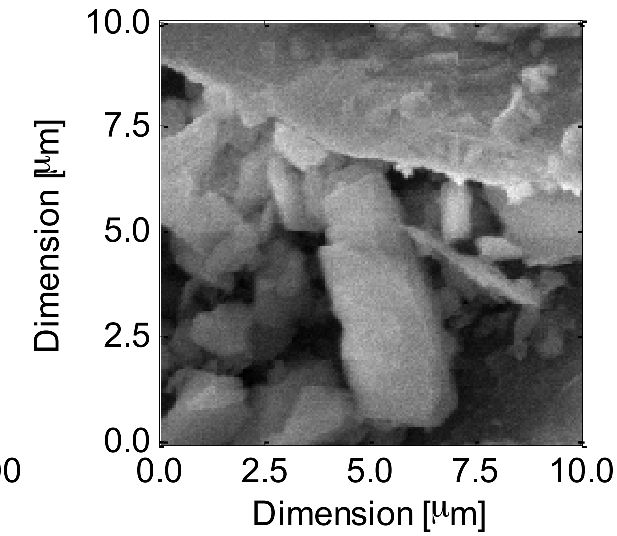


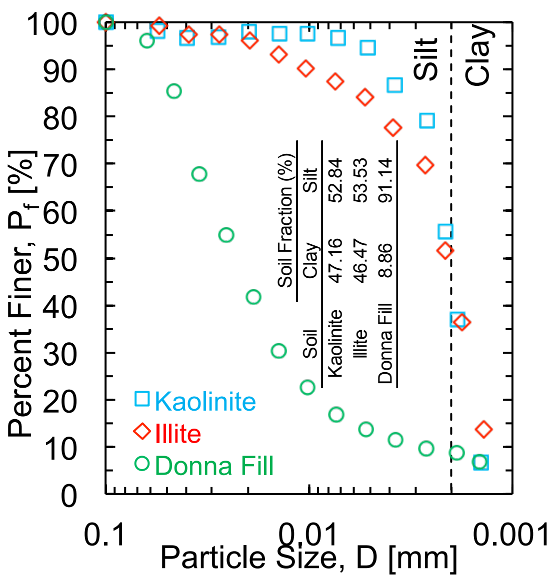
Images from Campbell Scientific, Soil Moisture, APSWT, Thorlabs, AEC, and San Diego Zoo

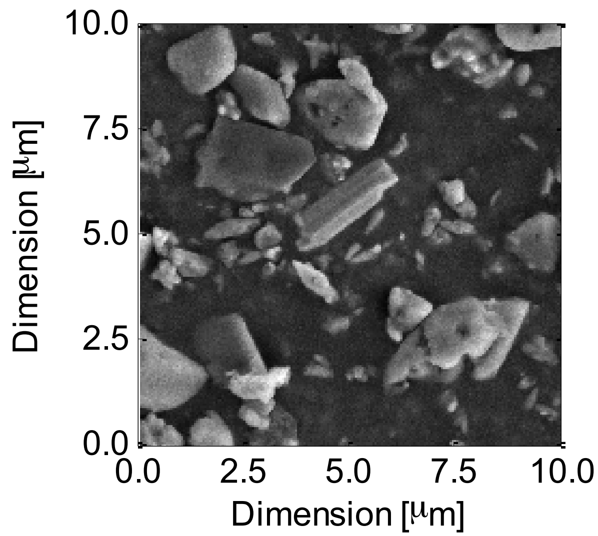
Results of Soil Characterization

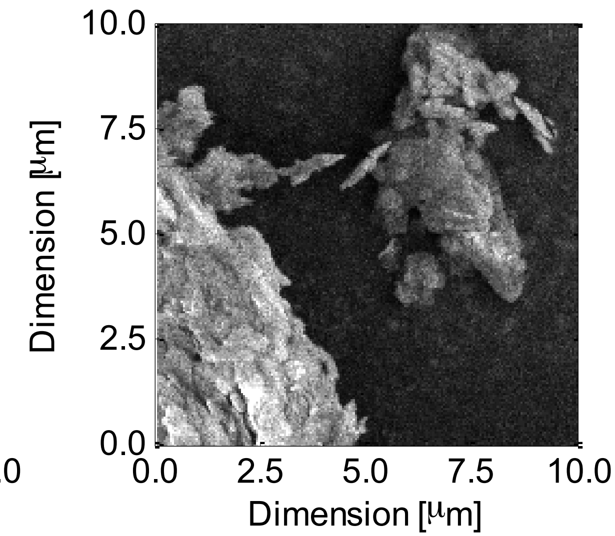




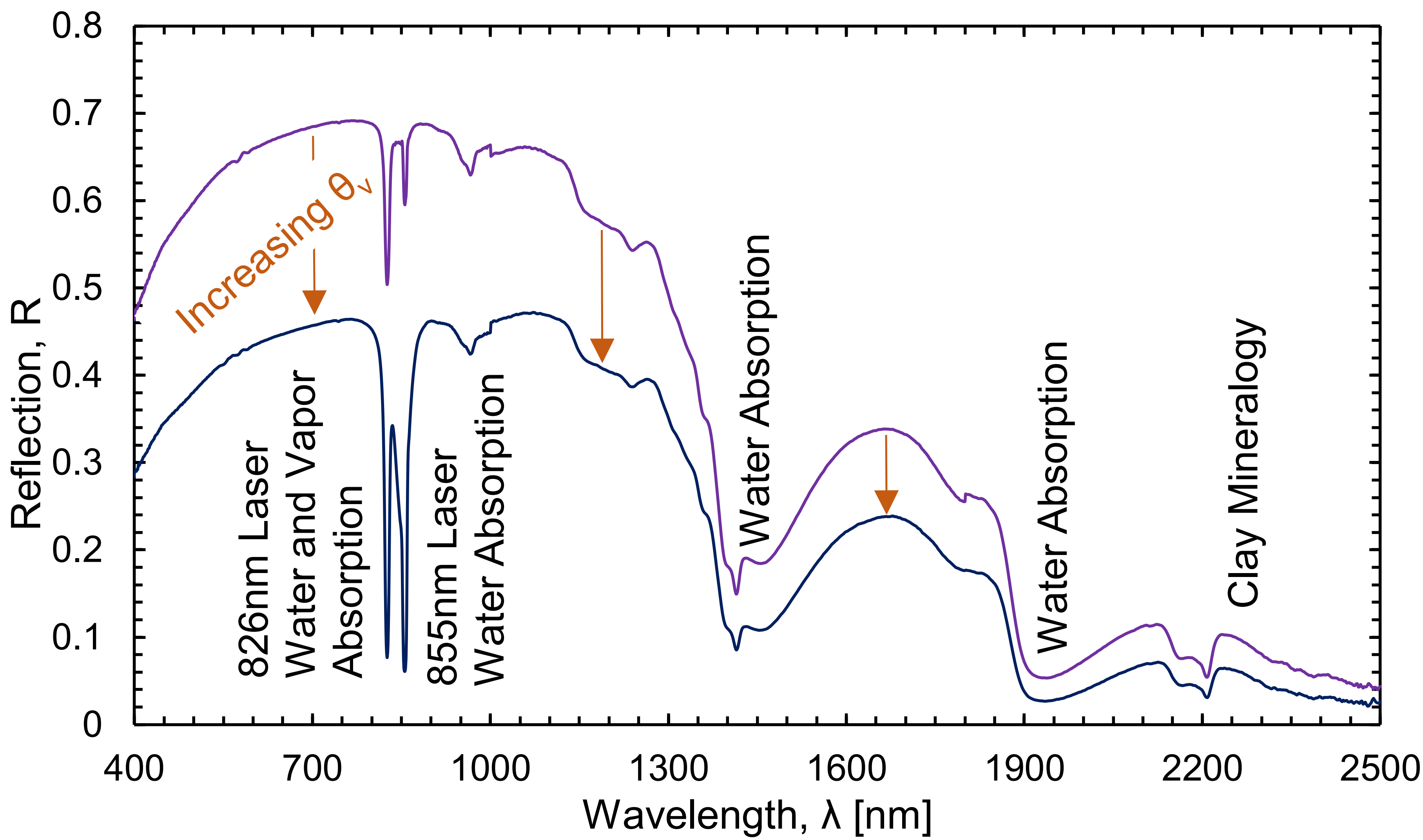








Example UV-NIR Reflectance Spectra



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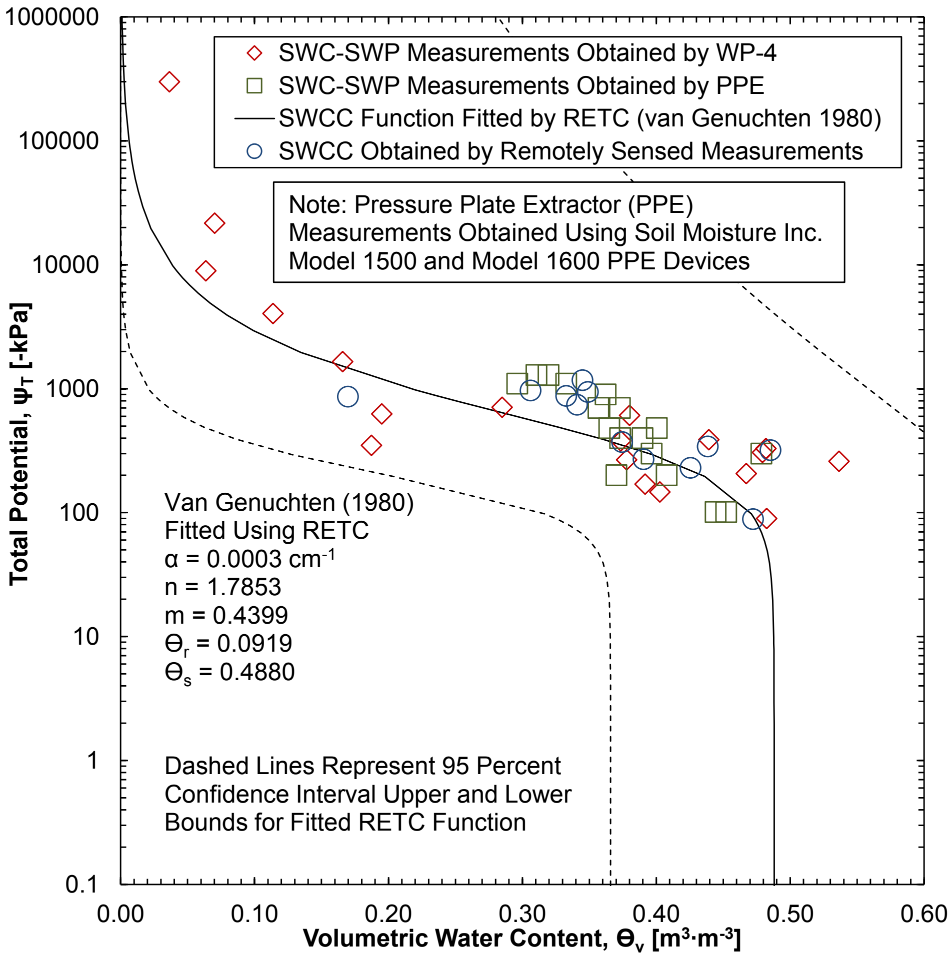
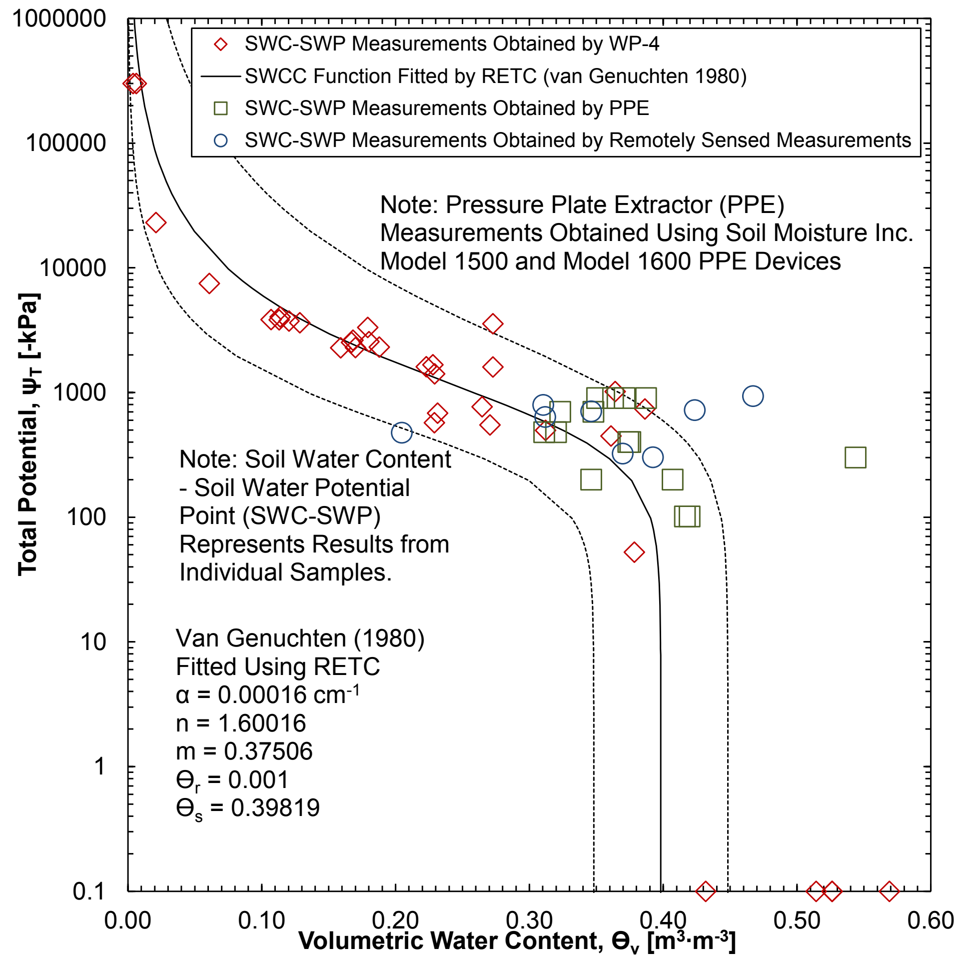
Preliminary Experimental Results



SWCC for Illite soil



SWCC for Kaolinite soil

TASK 5

Remote Sensing Based Assessment System for Evaluating Risk to Transportation Infrastructure Following Wildfires

Co-PI: Thomas Oommen

PI: Richard Coffman

Graduate Students @ Michigan Tech: Ashley Kern, Priscilla Addison

Michigan Tech
Create the Future

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Background

- Debris flows are associated with wildfires in mountainous regions (Eaton, 1935; Bailey et al., 1947; Wells, 1987; Cannon, DeGraff, 2009)
  - Ground cover is burned off, increasing runoff and erosion susceptibility (Kinner and Moody, 2007 Wondzell and King, 2003; Meyer, 2002)
  - Fire generated ash fills pore spaces resulting in water repellent soils (Shakesby and Doerr, 2006; Neary et al., 2005; Martin and Moody, 2001; Doerr et al., 2000)

- Ability to accurately predict debris flow events may protect public safety and infrastructure

- Current probabilistic models for predicting debris flow events use logistic regression (Cannon et al., 2010)
  - Assumes linear relationship between predictors and outcome

- Advancements in remote sensing allows for generation of more precise, consistent and timely information than previous field assessments (NASA 2011; De Graff, 2014;)

Background & Problem Statement

- Current models used in predicting debris flow information post-wildfire for Southern California and Intermountain Western United States separately: *
  - Probability of Debris Flow
    - Logistic Regression
  - Volume of Debris Flow
    - Multivariate Linear Regression
  - Hazard ranks are assigned to basins based on outcome of both models

No work that relates the debris flow hazard to the transportation infrastructure

Activity 5: Decision Support System

- Debris flow model
    - Build on the scientific advancement and develop advanced machine learning based probability models for decision support system
    - Evaluate the applicability of higher resolution remotely sensed products for debris flow hazard
- Integrate with NASA RECOVER decision support system

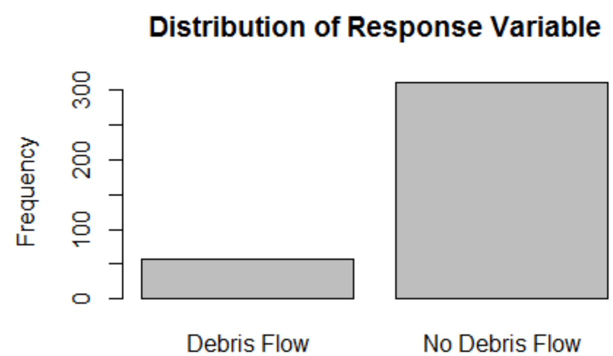
Initial Data

Advanced machine learning techniques were applied to data supplied by USGS** in development of new models for high sensitivity prediction of debris flow events in the Intermountain Western U.S. regions.

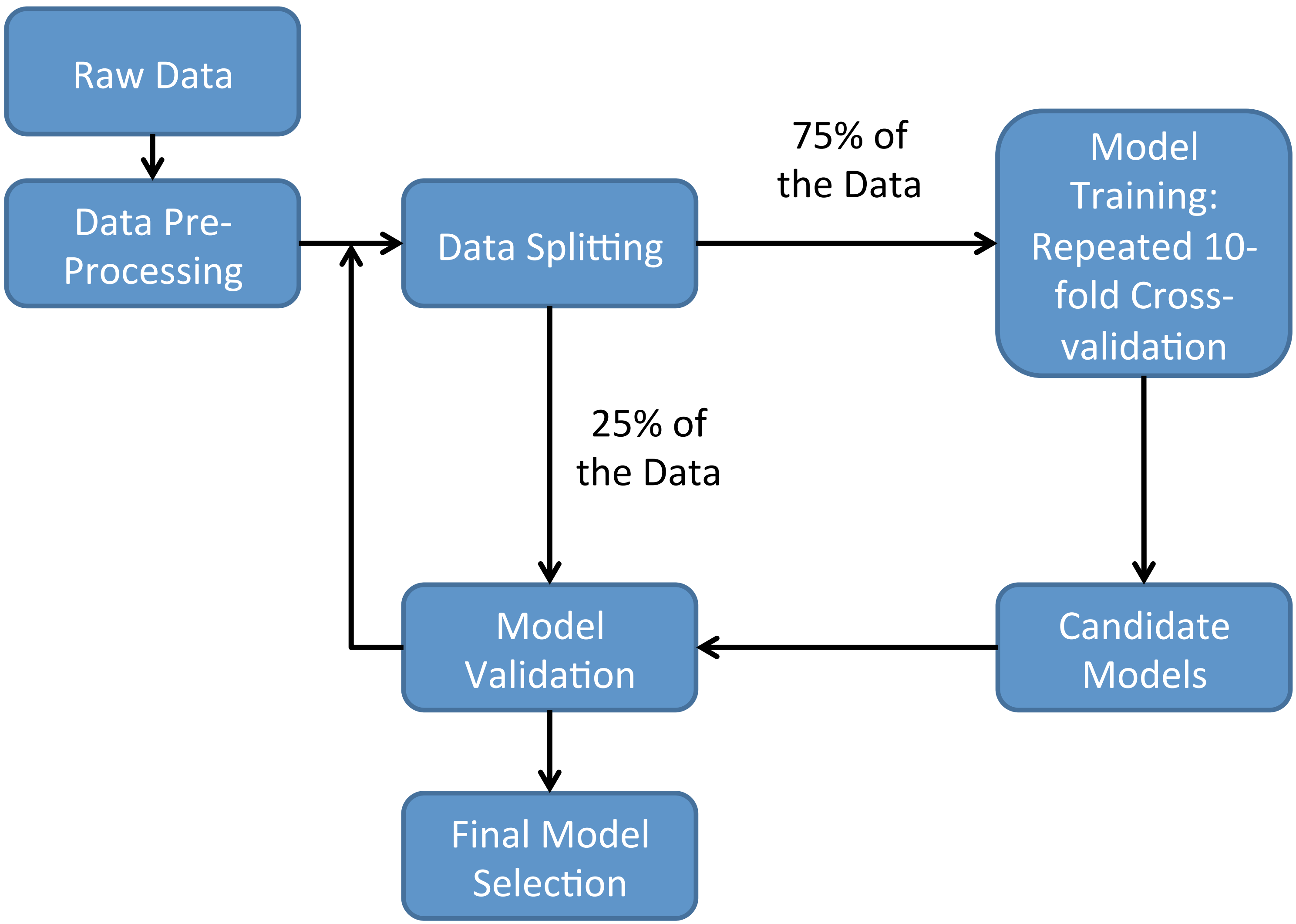
* Cannon, S. H., J. E. Gartner, M. G. Rupert, J. A. Michael, A. H. Rea, and C. Parrett. "Predicting the Probability and Volume of Post-wildfire Debris Flows in the Intermountain Western United States." Geological Society of America Bulletin (2009): 127-44.
** http://pubs.usgs.gov/of/2005/1218/Report.html

Introduction: The Data

- Data provided by the United States Geological Survey
- 388 samples from 15 burn basins in intermountain western U.S.
- 24 Predictor Variables:
  - Topographical
  - Burn Severity
  - Soil Properties
  - Rainfall
- Response Variables: presence of absence of a debris flow following wildfire
  - No debris flow event: 324 samples
  - Debris flow event: 64 samples



Methods


Raw Data
Data Pre-Processing
Data Splitting
75% of the Data
Model Training: Repeated 10-fold Cross-validation
25% of the Data
Model Validation
Candidate Models
Final Model Selection

Data Pre-processing

	Basin Aspect	Slope >= 30 %	Slope >= 50 %	Basin Burned: Low Severity (%)	Basin Burned: Moderate Severity (%)	Basin Burned: High Severity (%)	Total % Burned	Storm Duration	Avg. Storm Intensity	10 Min Rainfall Intensity	60 Min Rainfall Intensity	Clay Content (%)	Erodibility	Organic Matter (%)	Permeability	Hydrologic Group
Basin Aspect	1	0.16	0.2	0.06	0.05	-0.18	-0.1	-0.27	0.04	[illegible]	-0.13	0.17	0.08	0.05	-0.08	-0.08
Slope >= 30 %	0.16	1	0.74	-0.13	0.24	0.06	0.19	-0.41	0.12	0.2	-0.04	0.29	-0.08	0.05	-0.15	-0.1
Slope >= 50 %	0.2	0.74	1	-0.17	0.24	0.03	0.14	-0.29	0.03	0.11	-0.11	0.22	-0.16	-0.02	-0.16	[illegible]
Basin Burned: Low Severity (%)	0.06	-0.13	-0.17	1	-0.25	-0.39	0.09	-0.11	0.23	0.04	0.04	-0.2	-0.04	0.06	0.14	0.07
Basin Burned: Moderate Severity (%)	0.05	0.24	0.24	-0.25	1	-0.28	0.49	-0.04	-0.03	-0.08	[illegible]	-0.07	-0.06	-0.17	-0.13	[illegible]
Basin Burned: High Severity (%)	-0.18	0.06	0.03	-0.39	-0.28	1	0.46	0.25	-0.18	[illegible]	0.06	-0.02	-0.02	0.03	0.11	-0.16
Total % Burned	-0.1	0.19	0.14	0.09	0.49	0.46	1	0.13	-0.04	-0.04	0.09	-0.24	-0.1	-0.09	0.06	-0.1
Storm Duration	-0.27	-0.41	-0.29	-0.11	-0.04	0.25	0.13	1	-0.3	-0.25	0.08	-0.44	0.04	-0.02	0.16	0.27
Avg. Storm Intensity	0.04	0.12	0.03	0.23	-0.03	-0.18	-0.04	-0.3	1	0.68	0.52	-0.02	-0.42	0.37	0.24	0.34
10 Min Rainfall Intensity	[illegible]	0.2	0.11	0.04	-0.08	[illegible]	-0.04	-0.25	0.68	1	0.69	0.11	-0.21	0.33	0.06	0.17
60 Min Rainfall Intensity	-0.13	-0.04	-0.11	0.04	[illegible]	0.06	0.09	0.08	0.52	0.69	1	-0.09	-0.08	0.17	0.07	0.12
Clay Content (%)	0.17	0.29	0.22	-0.2	-0.07	0.02	-0.24	-0.44	0.02	0.11	-0.09	1	0.35	0.3	-0.06	-0.3
Erodibility	0.08	-0.08	-0.16	-0.04	-0.06	0.02	-0.1	0.04	-0.42	-0.21	-0.08	0.35	1	0.3	-0.34	-0.45
Organic Matter (%)	0.05	0.05	-0.02	0.06	-0.17	0.03	-0.09	-0.02	0.37	0.33	0.17	0.3	0.3	1	-0.03	0.02
Permeability	-0.08	-0.15	-0.16	0.14	-0.13	0.11	0.06	0.16	0.24	0.06	0.07	-0.06	-0.34	-0.03	1	[illegible]
Hydrologic Group	-0.08	-0.1	[illegible]	0.07	[illegible]	-0.16	-0.1	0.27	0.34	0.17	0.12	-0.3	-0.45	0.02	[illegible]	1

- Filtering sparse variables and data points with any missing information
- Removing variables with near zero variance
- Systematically removing highly correlated variables ($\rho > 0.75$)

Exploring Candidate Models

- Linear Models
  - Logistic Regression
  - Penalized Regression
  - Linear and PLS Discriminant Analysis
- Nonlinear Models
  - Support Vector Machine
  - K-Nearest Neighbors
  - Mixture Discriminant Analysis
  - Neural Network
  - Naïve Bayes
  - Classification Trees

Quantifying Model Performance

- Accuracy is misleading because it is dominated by non-events which are common
- A model with a high sensitivity rate is preferred
  - When a debris flow occurs, how 'sensitive' is our model in identifying it

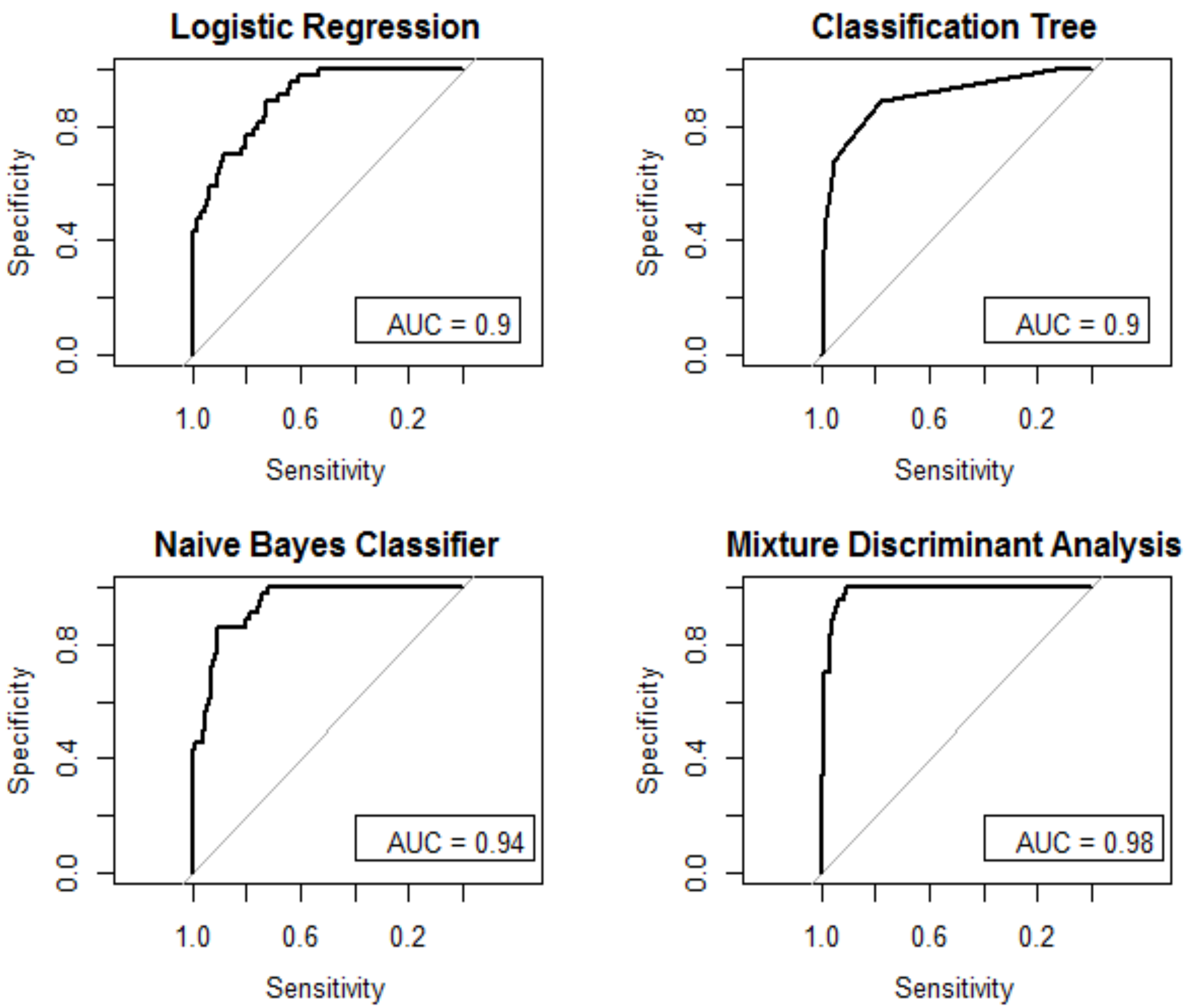
$$\text{Accuracy} = TP+TN/TP+FP+FN+TN$$

$$\text{Sensitivity} = TP/TP+FN$$

$$\text{Specificity} = TN/TN+FP$$

Prediction	Reference	
	No Debris Flow	Debris Flow
No Debris Flow	TN	FN
Debris Flow	FP	TP

Top Candidate Models



Model Training and Validation Metrics

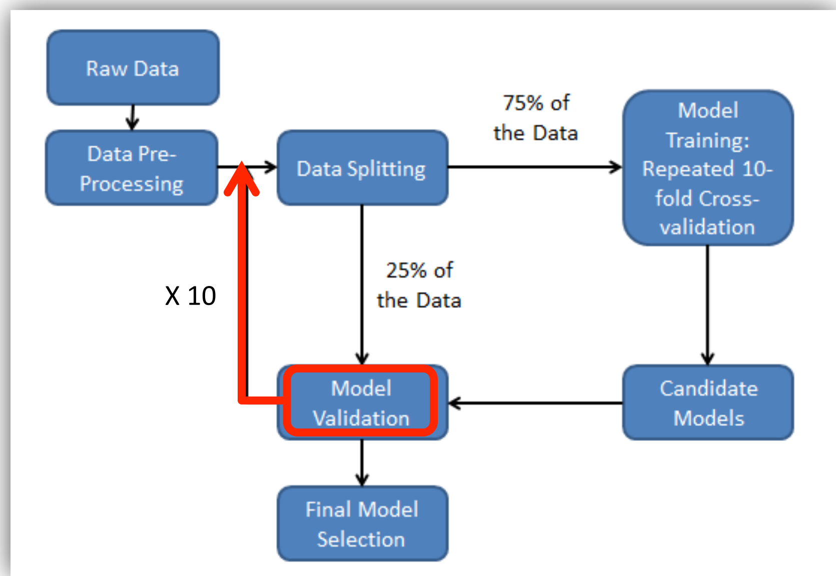
- Performance metrics should represent model performance in future predictions for new burn basins
- Overall decrease in model sensitivities when predicting on validation data
- May indicate over fitting to training data

Training Data Set Performance Metrics for Top Four Models			
Model	Accuracy	Sensitivity	Specificity
Logistic Regression	0.9	0.48	0.98
Classification Tree	0.91	0.95	0.68
Naïve Bayes	0.87	0.86	0.88
Mixture Discriminant Analysis	0.92	1	0.91

Validation Data Set Performance Metrics for Top Four Models			
Model	Accuracy	Sensitivity	Specificity
Logistic Regression	0.84	0.36	0.92
Classification Tree	0.87	0.50	0.94
Naïve Bayes	0.79	0.64	0.82
Mixture Discriminant Analysis	0.88	0.71	0.91

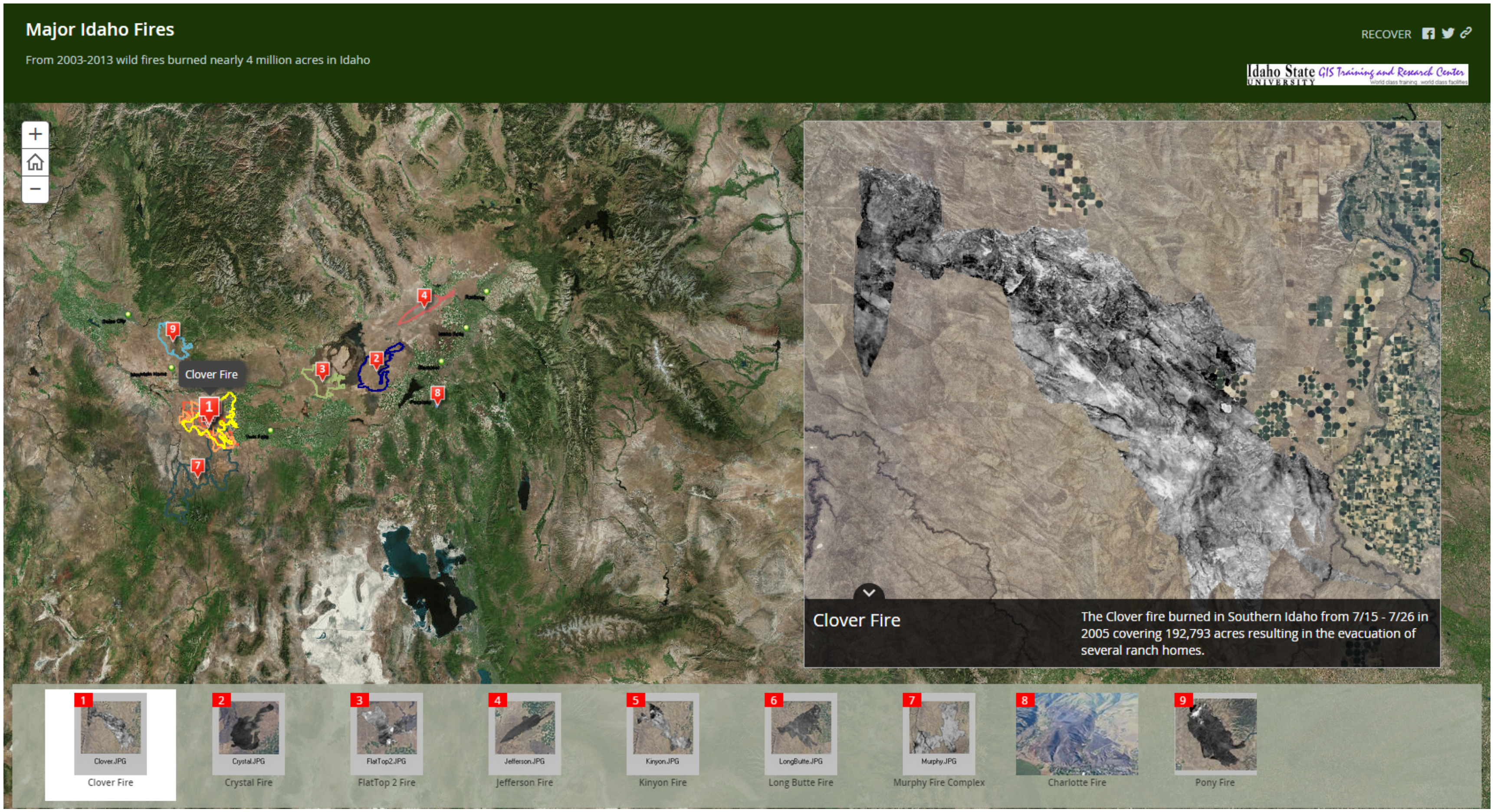
Further Model Validation

- The initial validation data set may have been 'unusual' or 'lucky'
  - A more rigorous model validation scheme is necessary
- Repeat data splitting, training, and validating steps 10 times
- Overall, naïve Bayes is the most sensitive and consistent model



Repeated Validation Metrics		
Model	Mean Sensitivity	Standard Deviation
Logistic Regression	0.42	0.12
Classification Tree	0.46	0.15
Naïve Bayes	0.72	0.08
Mixture Discriminant Analysis	0.71	0.1

DSS: NASA RECOVER



Idaho State University

DSS: Idaho State Line Fire

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Stateline Fire Reaches 3,000 Acres Near Wallula

Posted: Sep 13, 2015 10:35 PM EDT
Updated: Sep 13, 2015 10:47 PM EDT

Posted by Morgan Ashley CONNECT

WALLA WALLA COUNTY, WA- Firefighters are currently battling a 3,000 acre blaze called the Stateline fire in Walla Walla County.

The Walla Walla County Emergency operations center says it activated just before 1 p.m. on Sunday. The fire is burning near Wallula and Port Kelly, where level two evacuation notices have been issued. Those who live in the area are asked to be on standby to evacuate.

Highway 730 is closed from the Wallula Junction to the Oregon state line. An evacuation center is set up at the Columbia Burbank Middle School on Maple Street.

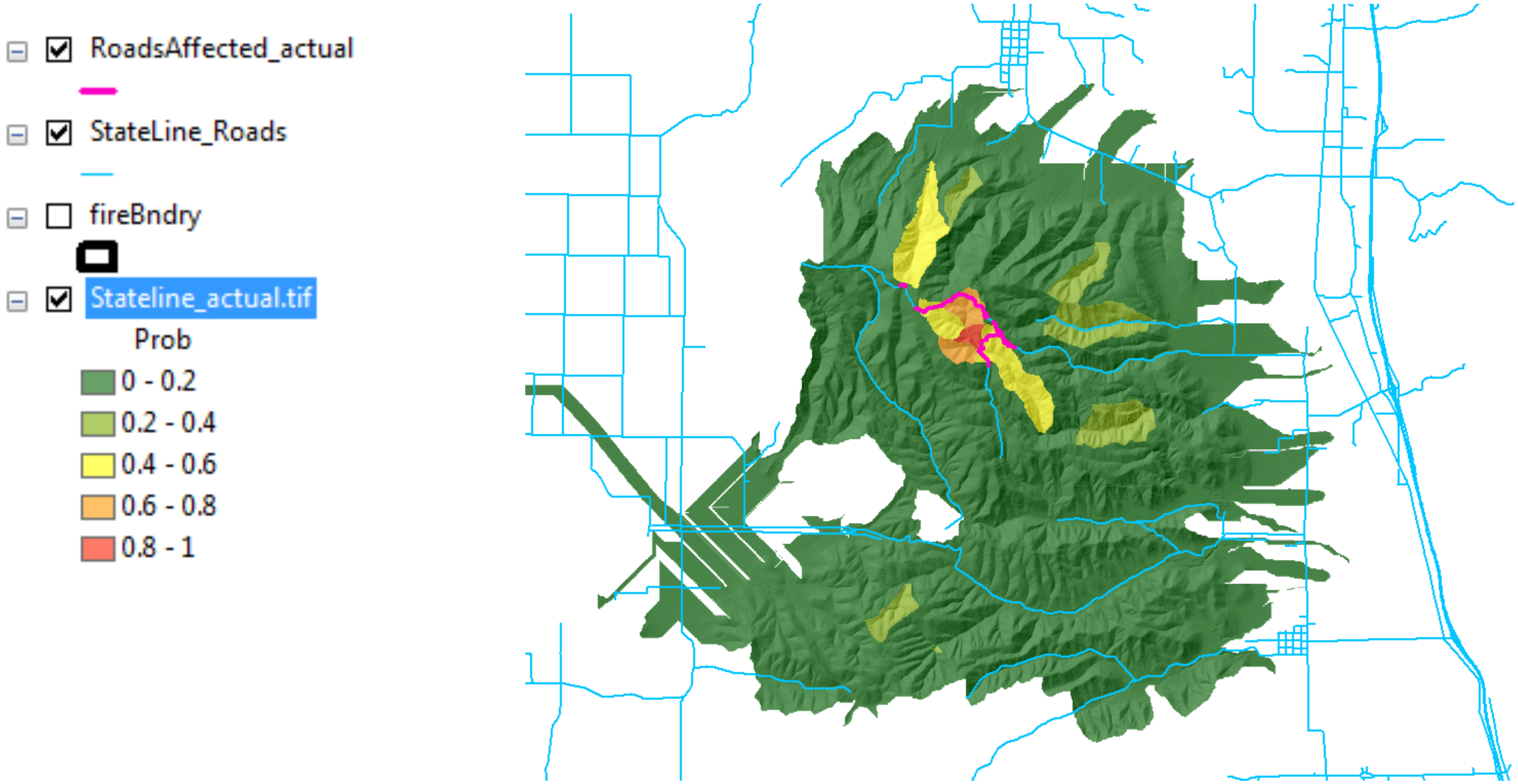
A type 3 incident management team is fighting this fire, and state mobilization has been called in.

There is about 75 firefighters working on the Stateline fire. Crews tell us they ho morning but will stick around overnight to monitor fire activity.

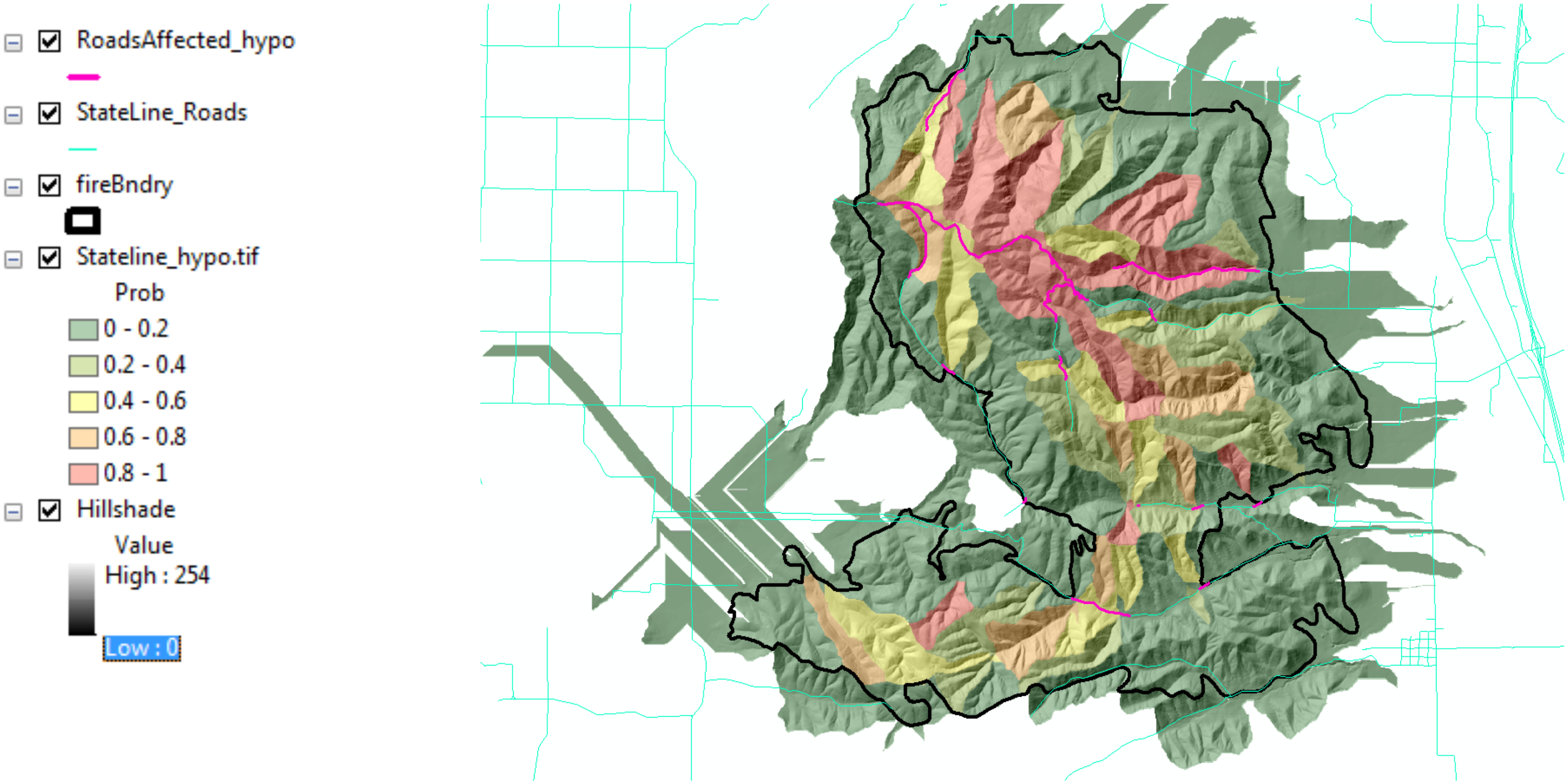
No homes have been lost, and the cause of the wildfire is under investigation.

To sign up for alerts from the Walla Walla County Emergency Managment, click

DSS: Idaho State Line Fire (Actual Scenario)



DSS: Idaho State Line Fire (Hypothetical Scenario)



Future Work

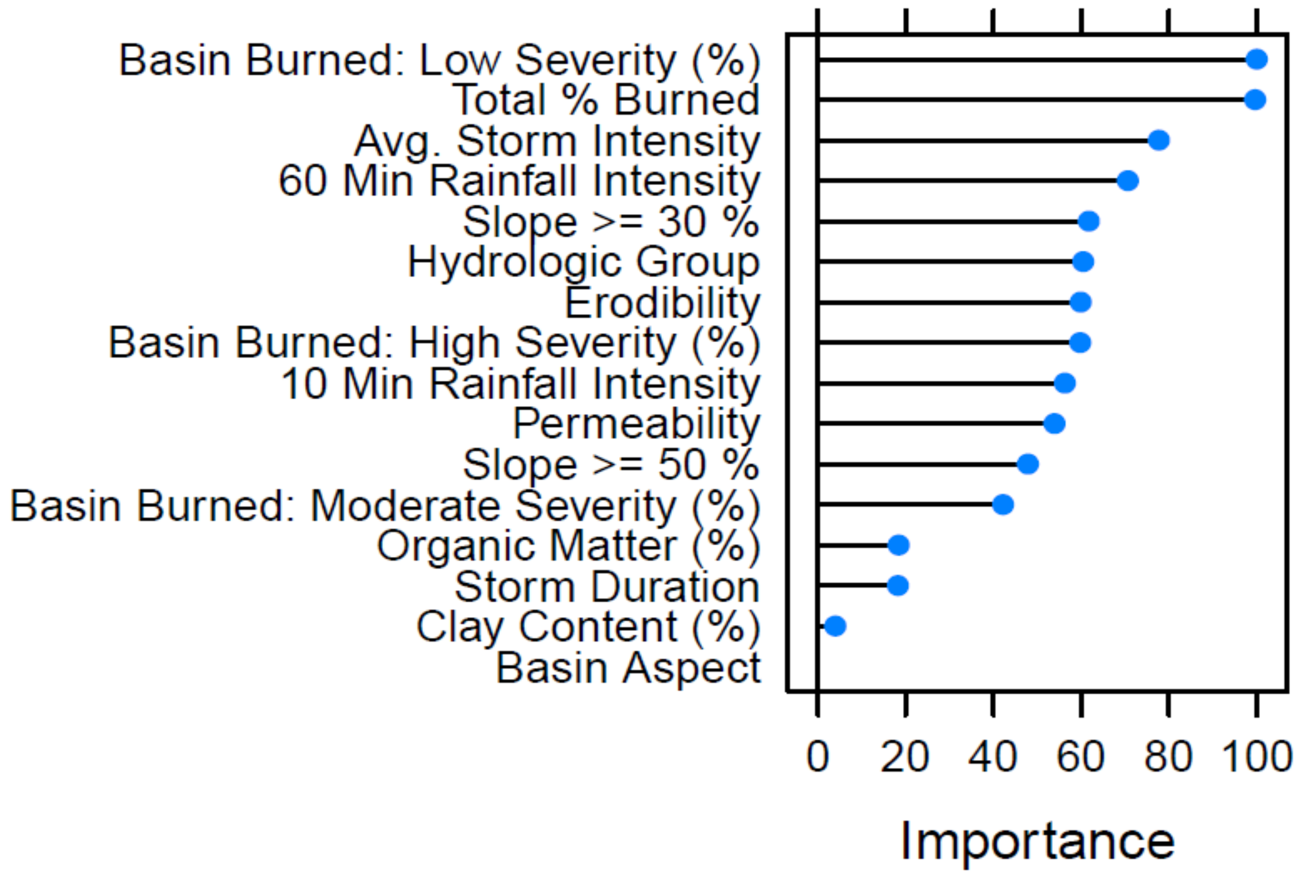
- Improve the model with higher resolution data from Univ. of Arkansas
- Integrate risk with Hazard
- Expand the model for other part of the country
- Develop levels of warning for transportation community

Questions?

Thank you,

This project was made possible by the US Department of Transportation (USDOT) through the Office of the Assistant Secretary for Research and Technology.

Naïve Bayes: Variable Importance



- Variable importance was determined by the relative influence of each variable when added to the model

TASK 6

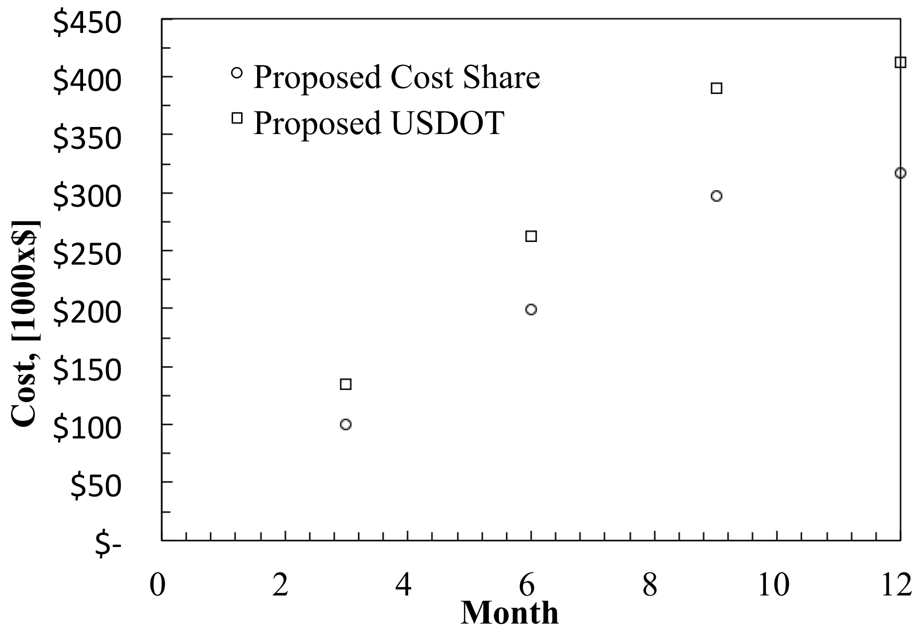
Coffman, Richard A. (2015). "Water: The Enemy of Construction." American Association of State Highway and Transportation Officials. Subcommittee on Construction Meeting. Little Rock, Arkansas, August 10, 2015.

Kern, A., Addison, P., Oommen, T., Salazar, S.E., Coffman, R.A., (2015). "Machine Learning Based Predictive Modeling of Debris Flow Probability Following Wildfire in the Intermountain Western United States." In Preparation.

Garner, C.D., Salazar, S.E., Coffman, R.A., Oommen, T. (2015). "Ultra-violet Near-infrared Reflectance Spectroscopy for Remote Measurement of Soil Water Potential." Presentation given at the 58th Annual Meeting of the Association of Environmental & Engineering Geologists, Pittsburgh, Pennsylvania, September 24, 2015. NOTE: Sean Salazar was awarded the 2015 Lemke Scholar for this paper.

Garner, C.D., Salazar, S.E., Coffman, R.A., (2015). "Evaluation of a Field and Laboratory Remote Sensing Method for Determining Atterberg Limits and Clay Content." 2016 Transportation Research Board Annual Meeting. Submitted for Review. Manuscript Number 16-6814.

Expenditures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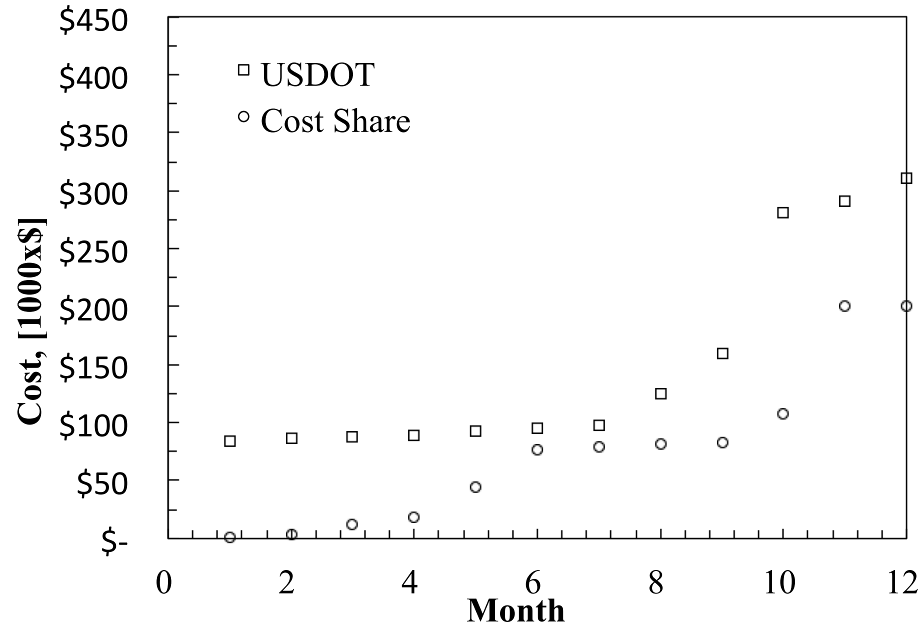
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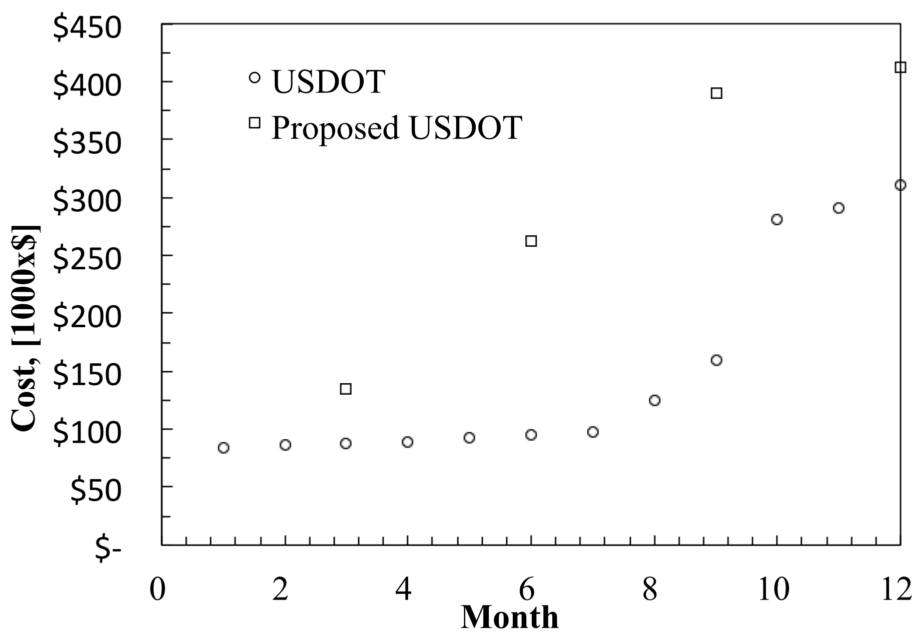
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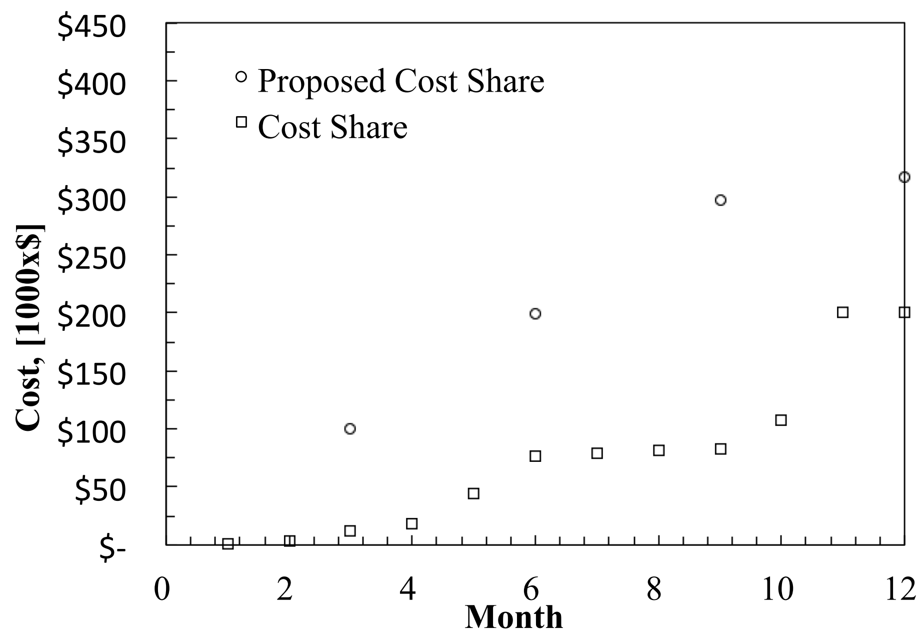
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Commercialization Meeting as Part of Caesar Singh's Yearly Meeting
Willard J. Walker Hall Room 515
September 23, 2015
3:00pm – 3:40pm

Attendees:
Caesar Singh, USDOT
Amy Sterns, USDOT
Dawn Tucker-Thomas, USDOT
Vasanth Ganesan, USDOT (via telephone)
Carol Reeves, University of Arkansas
Rick Coffman, University of Arkansas
Suzie Engle, University of Arkansas

Caesar:

Common method of federally funded, applied/advanced, research at USDOT is the final report model. The findings from these final reports were not being implemented. Historically, the research was technically sound but there was a problem in implementing the research. Therefore, around six or seven years ago there was a push to start developing prototypes of products. Academic institutions were charged with leading the effort.

The principal investigators from ongoing OASRTRS projects will be meeting in December to discuss current status of projects. Part of this meeting will be a workshop with field demonstrations to stakeholders. Instead of developing XYZ product and wanting a given state transportation department to buy and be the custodian of XYZ product, the ownership, operation and maintenance will be supplied by a vendor.

The workshop will include vendors, stakeholders, and researchers. The goal of the workshop is to determine how to roll out the research to the stakeholders. I asked Rick to put together the meeting today to learn about the Arkansas Commercialization Workshop.

Carol:

The Arkansas Commercialization Workshop was held for the 4th time in June. Most of the attendees are from STEM disciplines. Participants attended representing all of the Arkansas schools (University of Arkansas-Fayetteville, University of Arkansas-Little Rock, Arkansas State University, University of Arkansas Medical Science).

The workshop provided a discussion of the I-Crops program to develop a culture of entrepreneurship. Other federal agencies have started implementing the I-Corps model (NIH, NSF, ARL). For the I-Corps, a team including a principal investigator, a graduate student, and a mentor complete a seven-week program. There are different nodes and different sites of the I-Corp program (national and local).

During the seven-week program, the team conducts 100 interviews (100 different customers). The I-Corps program is based on the lean canvas/business model startup approach. If the interviews lead the proposers down a different path the proposers can PIVOT to a different outcome. In the end there is a go/no go decision. The breakdown of go/no go decisions is typically (0.3 to 0.7, respectively).

Since 2009 the entrepreneurship program at the University of Arkansas has developed 18 high growth startups. There have been two exits. Student teams from the University of Arkansas have been awarded with 40 million in winnings from entrepreneurship competitions.