# *Using Science to Improve Winter Logistics*

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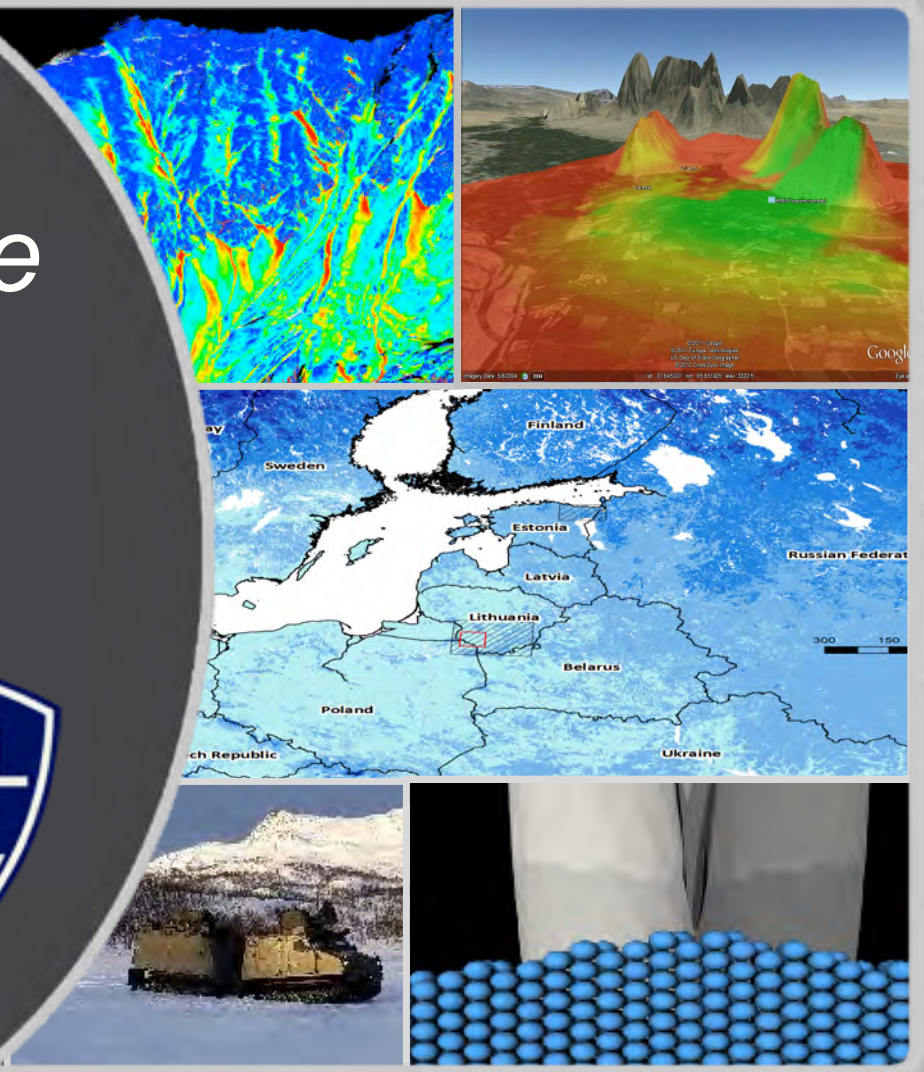
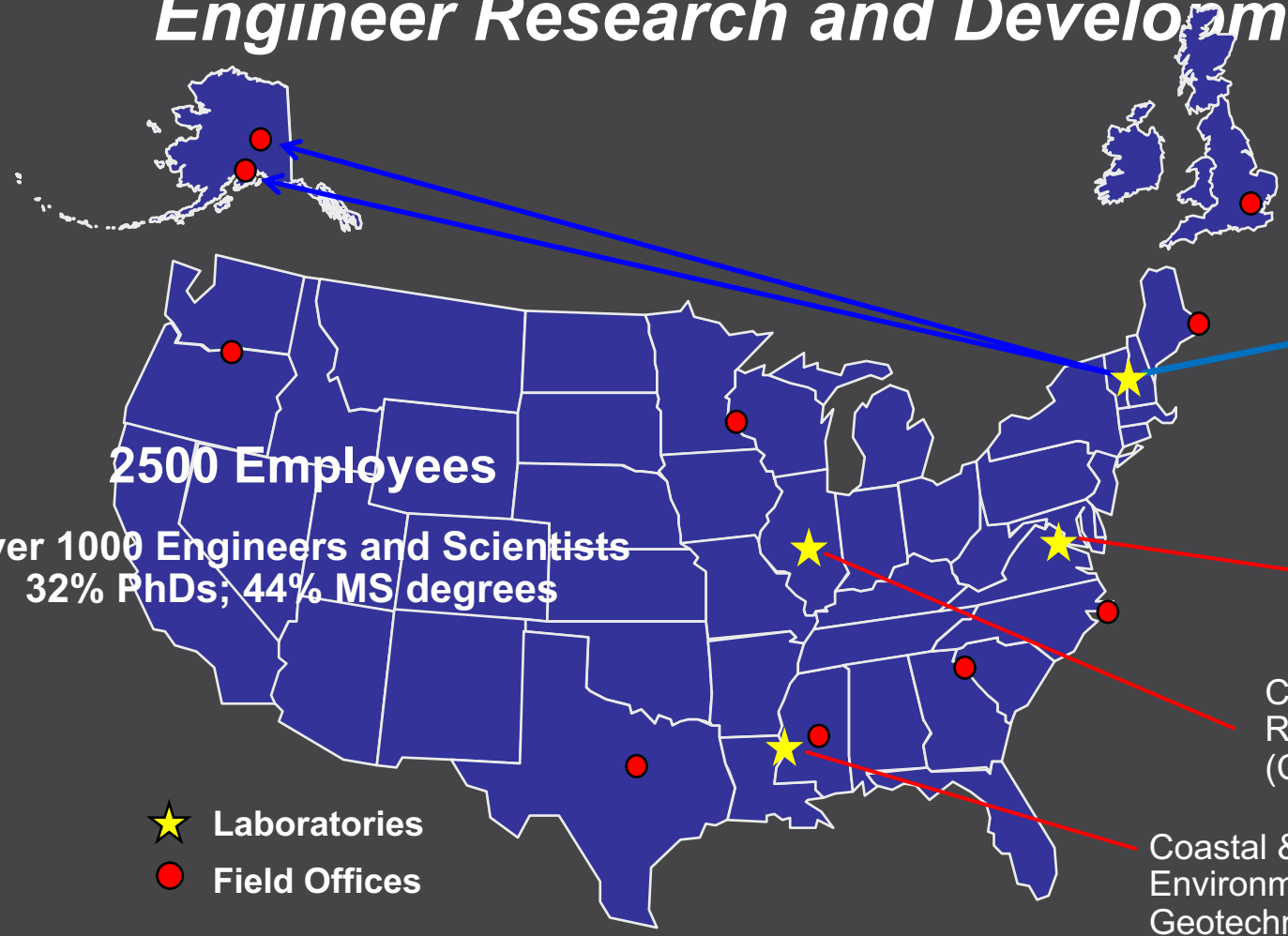



US Army Corps of Engineers

ERDC
ENGINEER RESEARCH & DEVELOPMENT CENTER

# US Army Corps of Engineers
# Engineer Research and Development Center




**Cold Regions Research & Engineering Laboratory (Hanover, NH)**

CRREL

Geospatial Research Laboratory (Alexandria, VA)

Construction Engineering Research Laboratory (Champaign, IL)

Coastal & Hydraulics Laboratory
Environmental Laboratory
Geotechnical & Structures Laboratory
Information Technology Laboratory

# *CRREL Areas of Research R&D; Unique Capabilities*

**Research & Engineering Division**

- **Terrestrial science and engineering**
- **Biogeochemical sciences**
- **Polar science and engineering**
- **Snow and ice in temperate and mountain regions**

**Remote Sensing and Geographic Information Center**

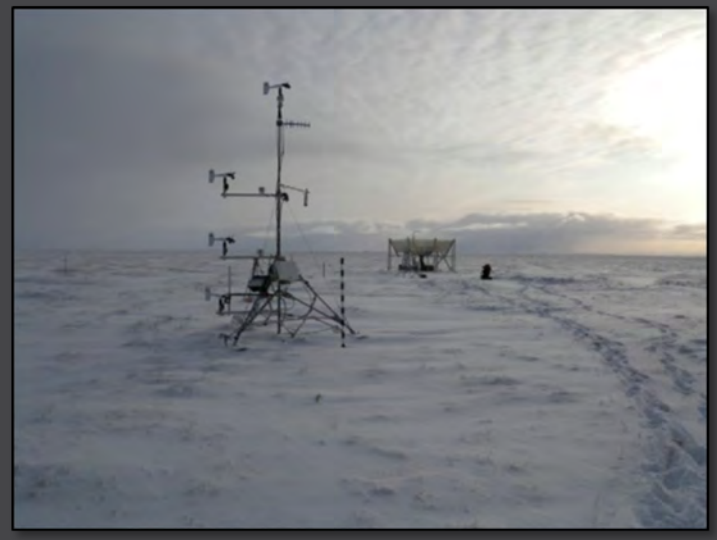
# *Cold Regions Research and Engineering Laboratory*

## *Hanover , NH*

**ERDC-CRREL has been advancing applied science and engineering for complex and strategically-important problems in the Arctic region for more than 50 years.**

## Arctic Vision

*Be an essential federal partner to the Department of Defense and the Nation in meeting the challenges of an evolving Arctic domain.*



## Arctic Strategic Goals

*Enable effective decisions that mitigate risks to national security, operations, and the environment:*

- Enhance Arctic Domain Awareness
- Evolve Infrastructure
- Protect the Arctic Environment

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1. Enhance Arctic Domain Awareness
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# *Enhance Domain Awareness*

**Predictive Capabilities**

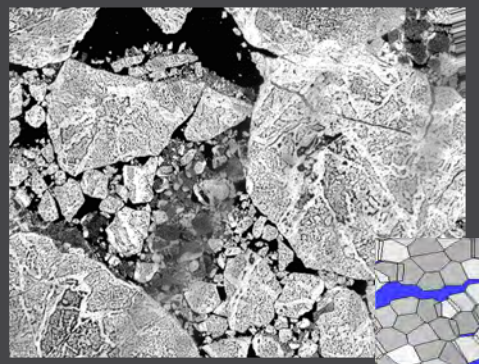
Changing **sea ice dynamics**

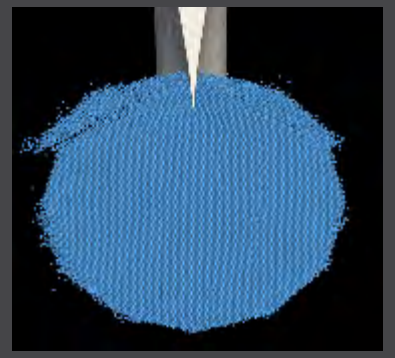
- Ice floe behavior, mechanics and forces

Changing **terrestrial mobility**

- Permafrost thaw effects on transportation networks
- Increased seasonal variability in freeze-thaw cycle

Changing **littoral processes**



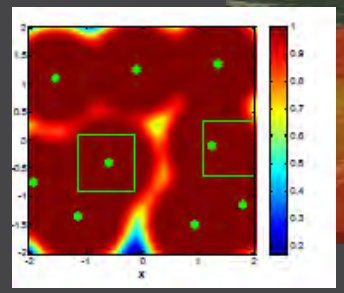


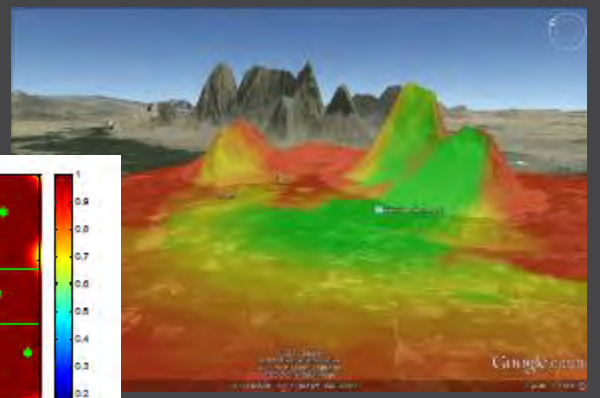

**Sensor Improvement**

Extreme cold effects on sensor technologies

Optimal sensor placement

Signal propagation



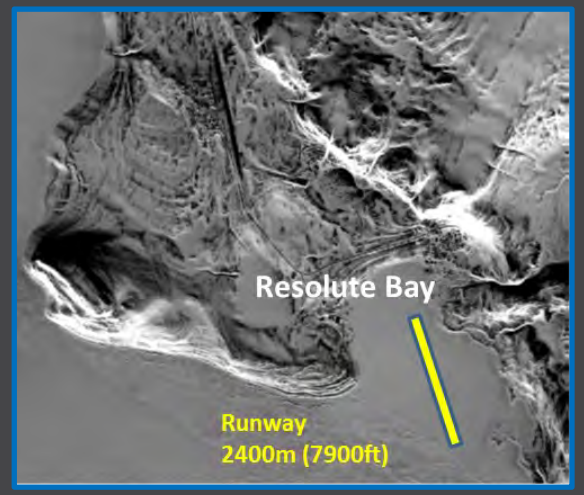


# *Evolve Arctic Infrastructure & Strategic Capabilities*

## Prepare to respond to a wide range of challenges and contingencies

## Engineering for Polar Operations, Logistics and Research (EPOLAR)





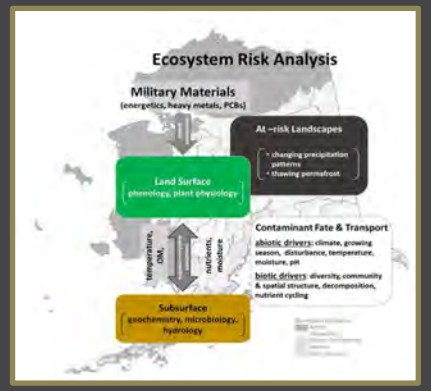



# *Protect the Arctic Environment*

**Provide science and engineering for sustainable solutions**

**Novel approaches to mitigating/managing environmental contaminants**





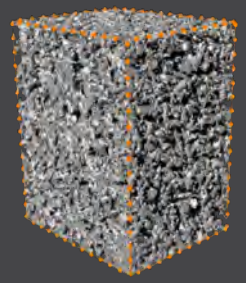



# *Remote Assessment of Snow for Physical Properties and Vehicle Mobility Predictions*

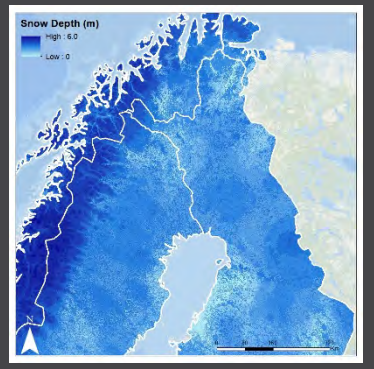
*Approach:*

- Evaluate snow mechanical measurement methods for mobility prediction
- Develop remote assessment methods for of snow mechanical properties
- Enhance SnowModel for snow cover estimation/prediction for mobility
- Mobility model enhancements and validation

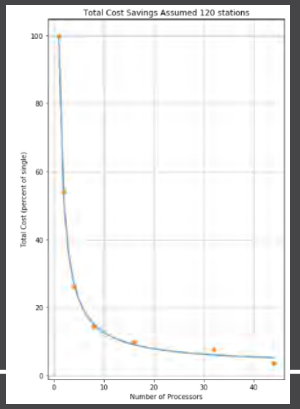
Field Experiments



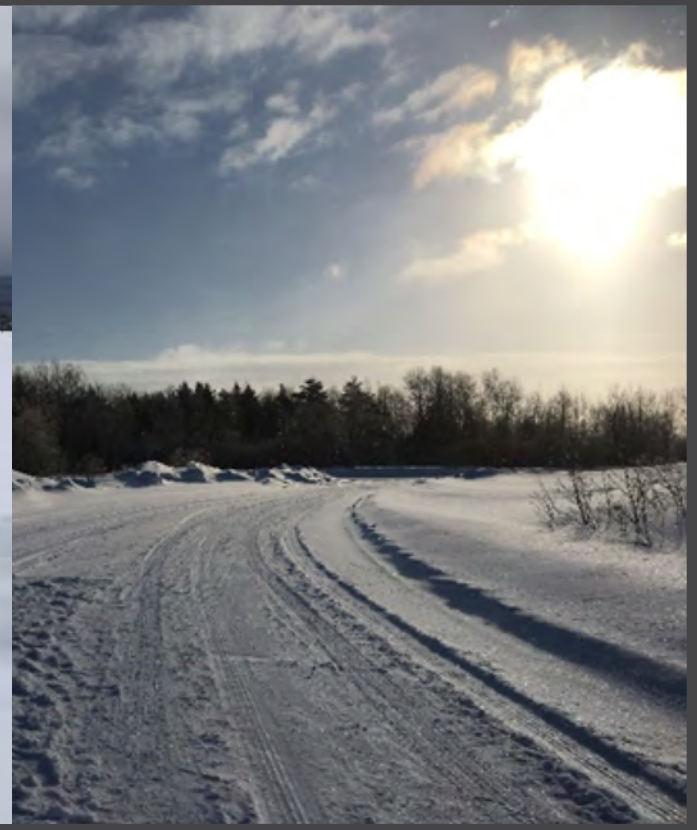
Laboratory




Modeling



# *An Evaluation of Field Mechanical Measurement Techniques on Various of Snow Surfaces*



# *Bearing Capacity and Stiffness*

**Field California Bearing Ratio (CBR)**
Road and airfield design standard

**Lightweight Deflectometer (LWD)**
Stiffness Modulus

**Clegg Impact Hammers**
Converted to CBR

# Controlled Laboratory Testing in Cold Rooms


LWD - Dynatest 3031 Light Weight Deflectometer

Friction Testers (3 types)
- Dynamic Friction Tester (DFT) from Nippo Sangyo
- Micro GripTester (mGT) from Findlay Irvine
- T2Go Portable Continuous Friction Measuring Equipment from SARSYS-ASFT



# *Drop Cone Penetrometers*

**CTI Drop Penetrometer**

ASTM Standard

Penetration converted to hard, medium and soft-pack snow


**Yamaha Drop Cone**

Aluminum cone dropped from a specific height

Intended for virgin snow

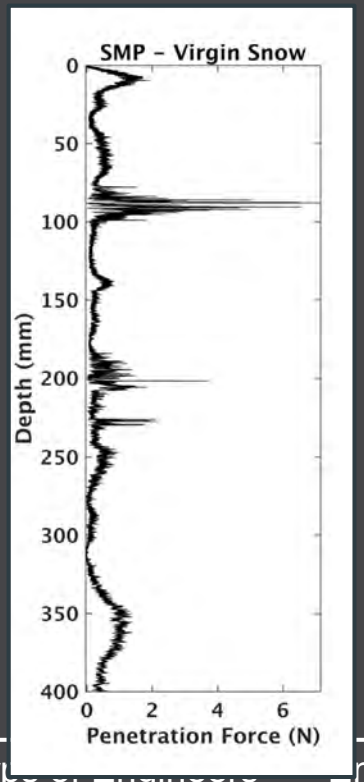
# *Snow Strength Profiles*

**Snow MicroPenetrometer (SMP)**

Mechanically driven

Theoretical basis

Designed for alpine snowpacks. Modified for trafficked and packed snow




**Rammsonde**

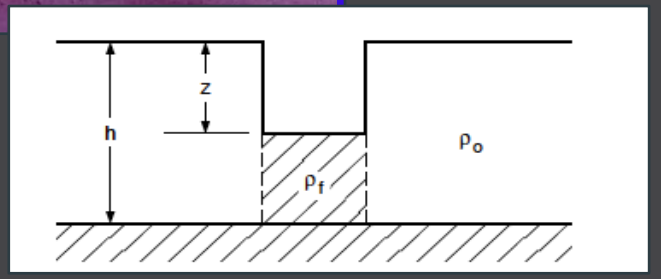
Common avalanche assessment

Modified tip and weights for snow roads and light snow

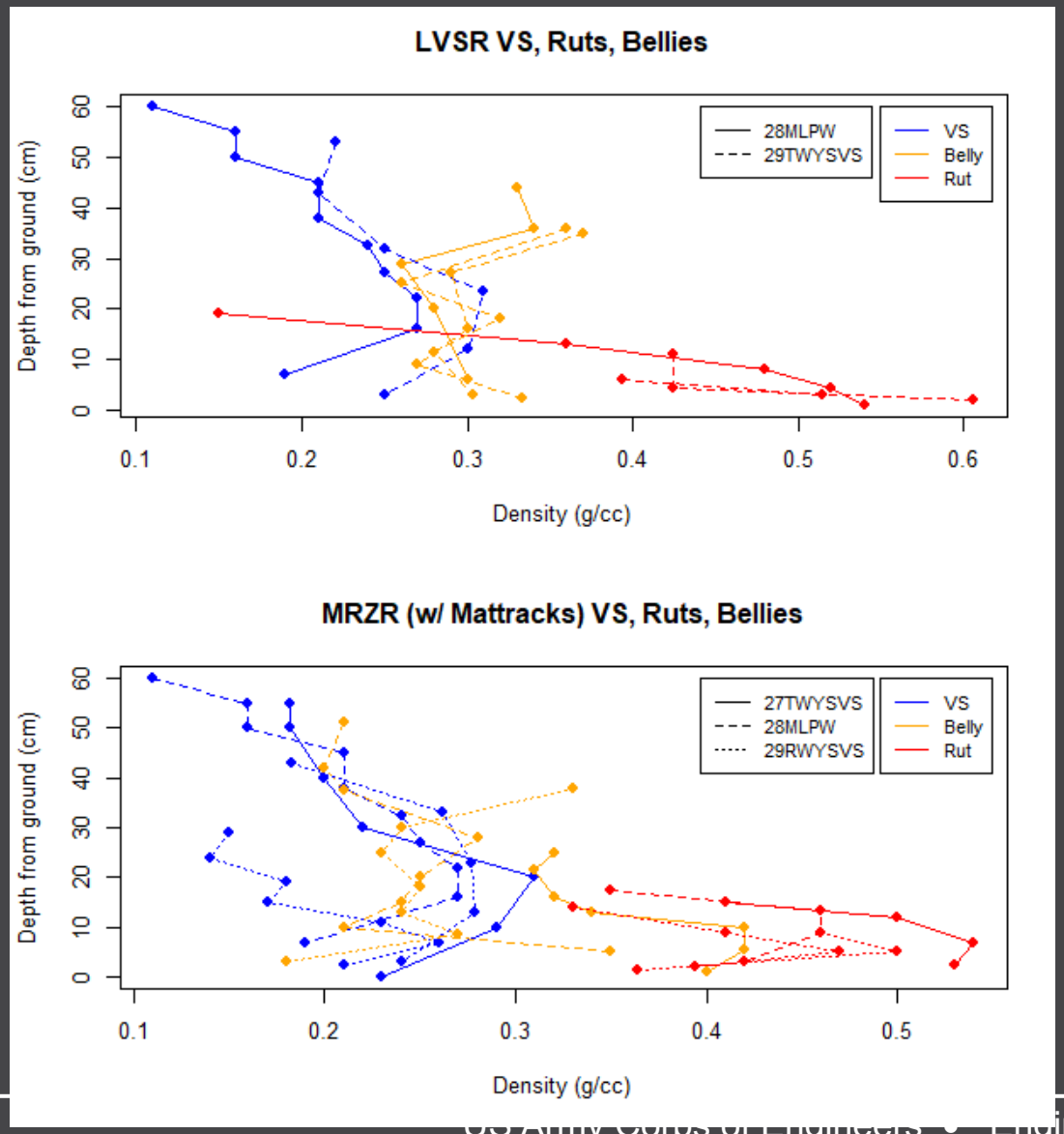
**Russian Snow Penetrometer**

Designed for snow roads and airfields

# *Quantifying how the snow deforms under the vehicle*



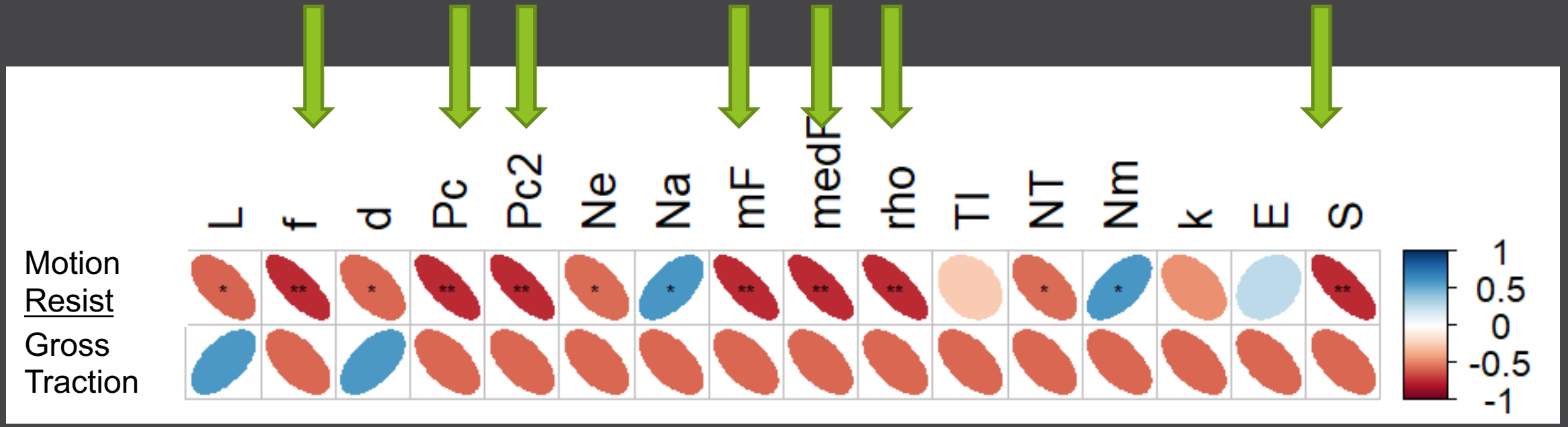
# Density Profiles




**LVSR – MKR18 41900 kg (92,400 lbs)**

**MRZR w/ Mattracks 860 kg (1900 lbs)**

# *Correlating snow strength variables to vehicle performance*

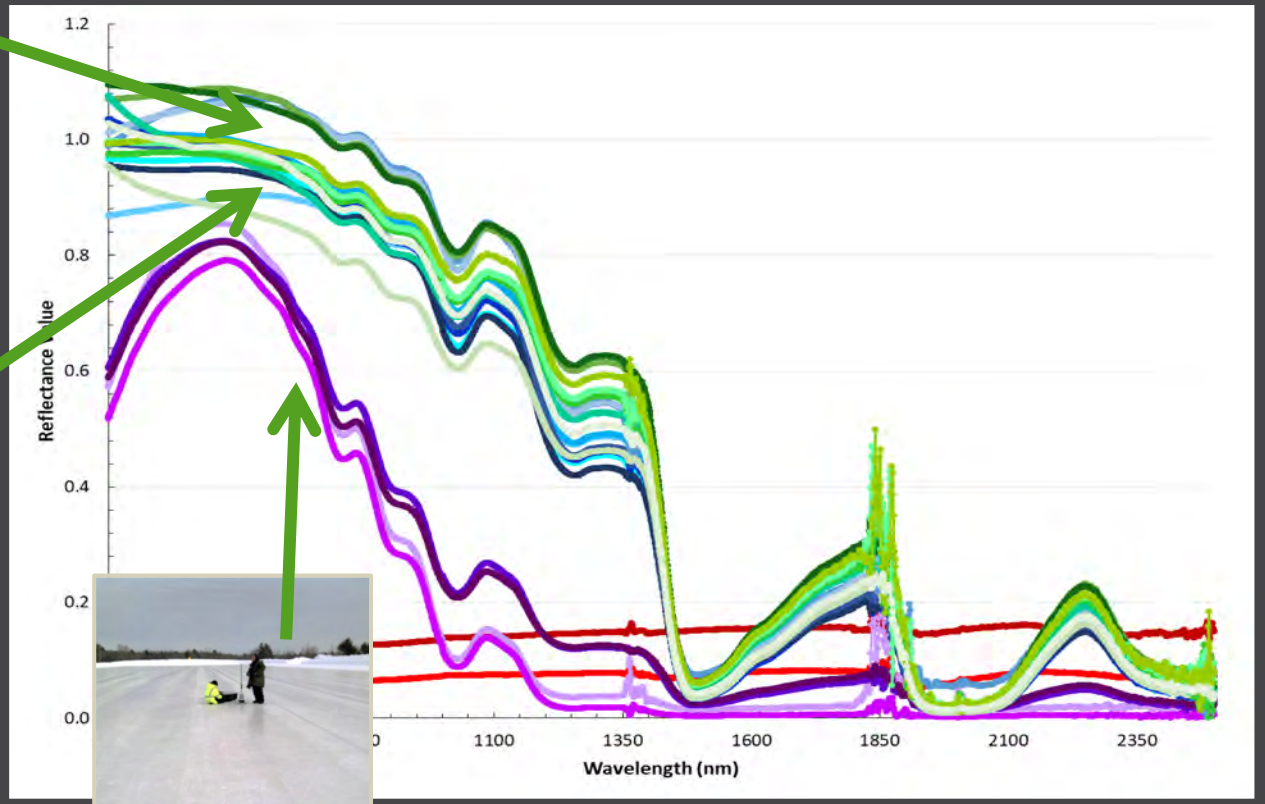



**Spearman Correlation matrix for vehicle and snow data with n > 1 comparative observations.**
**The p values are indicated as * < 0.1, ** < 0.05, and ***<0.01**

# Standoff Assessment: Winter Surface Spectral Content

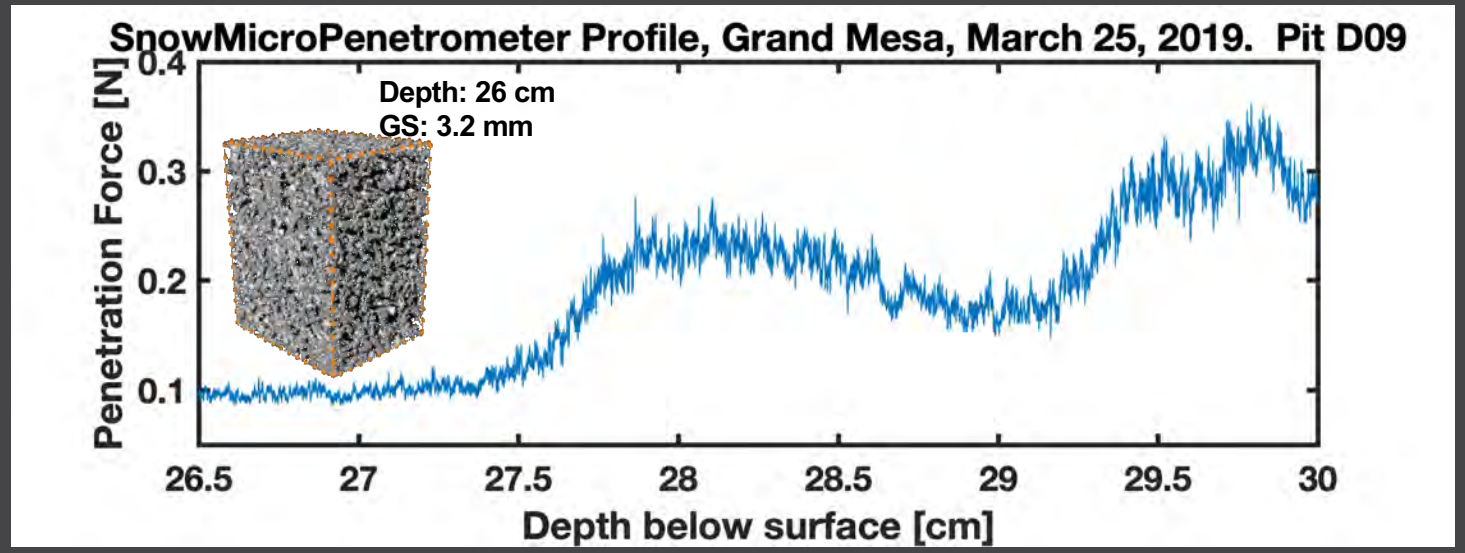



Reflectance of surfaces with Surface ASD Spectrometer
Asphalt (*red*), ice (*purple*), groomed snow (*blue*), and virgin snow (*green*)



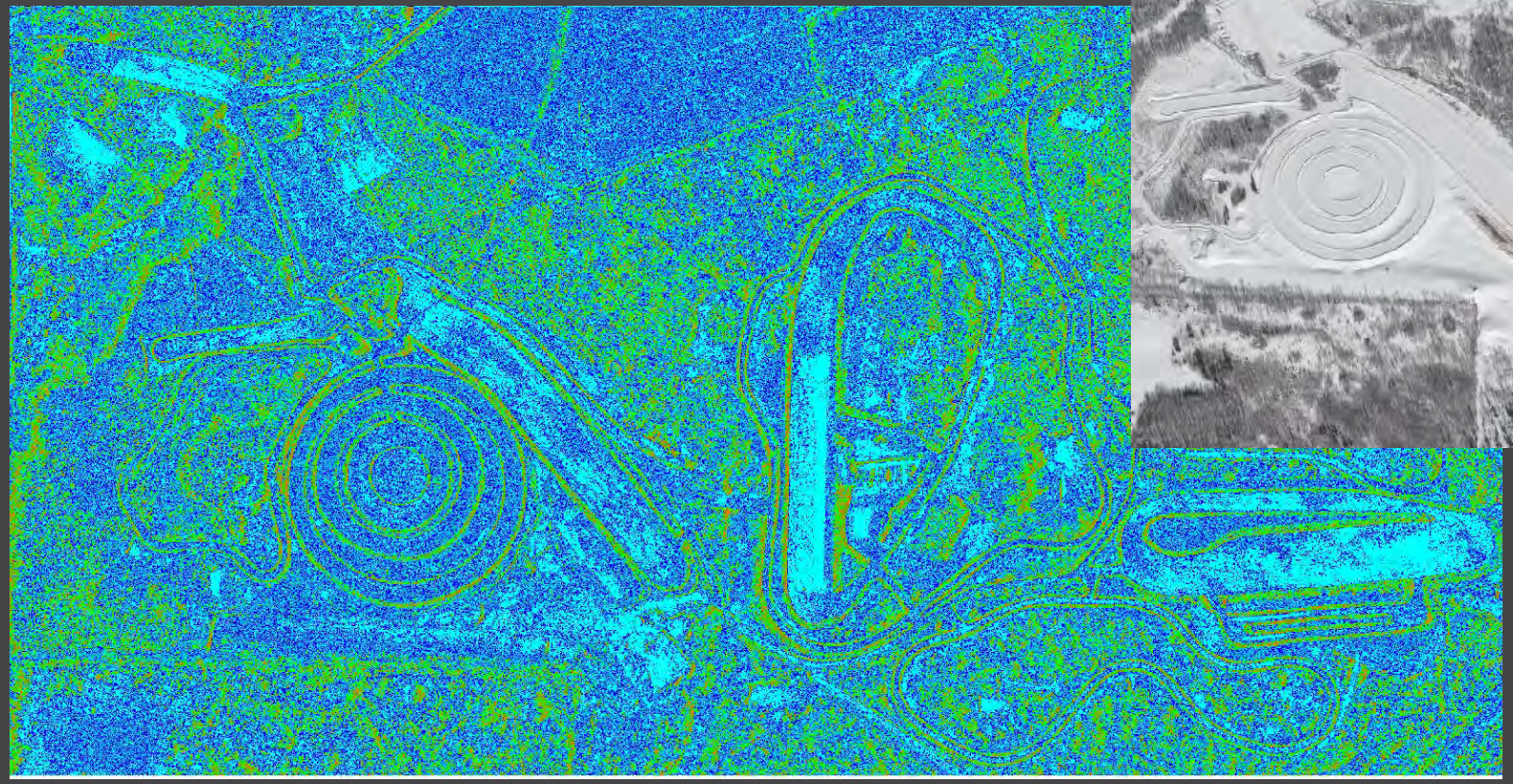
# *Linking microstructure, strength and radar*

- Snow strength controlled by microstructure
- Microstructure characterized using microCT
- SnowMicroPenetrometer (SMP) measures micromechanical and microstructure
- Microwave radar is sensitive to microstructure




# *Image Classification for Snow Types*

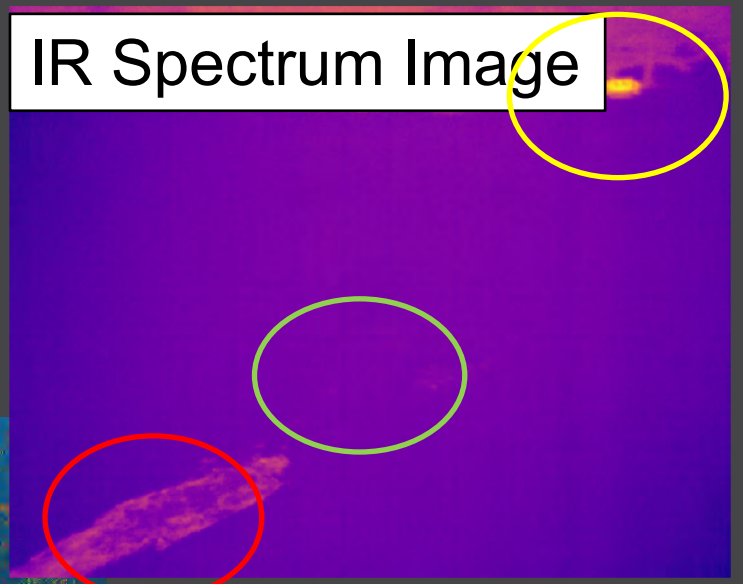
Unsupervised Classification of Imagery – K-Means, 5 classes

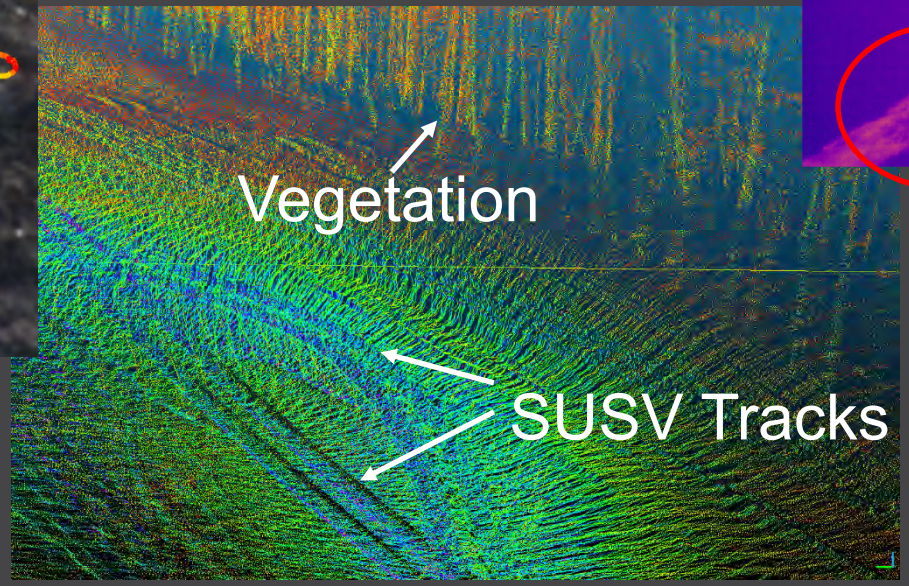


Winter test course at Mich Tech. U., Keweenaw Research Center

# *Vehicle In-board and Out-board Sensors*


1 m/s
2 m/s
3 m/s
4 m/s
5 m/s
6 m/s

# NASA SnowEx 2020

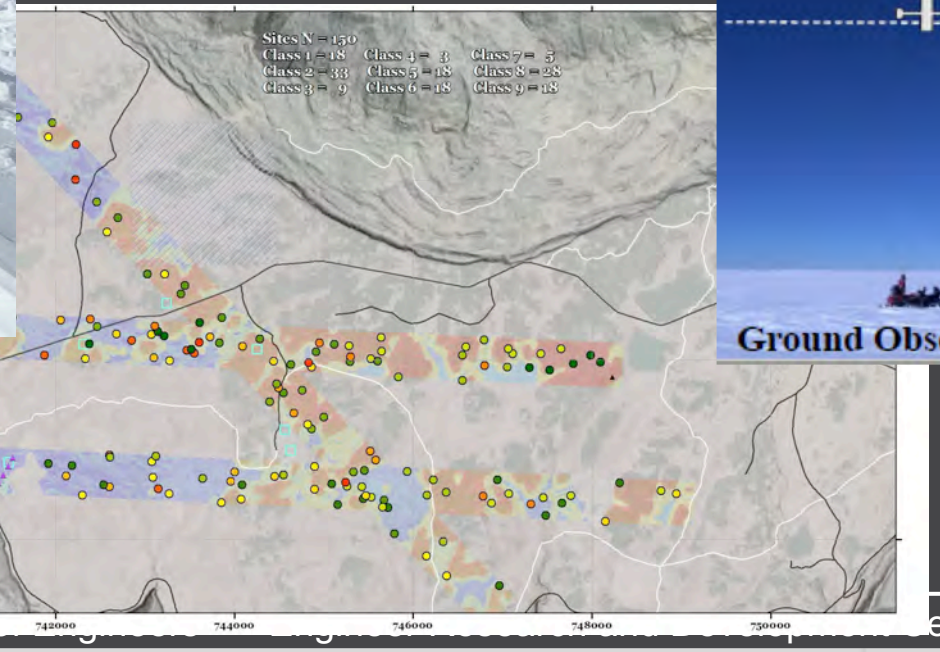
**Organizing Team:** HP Marshall, Carrie Vuyovich, Jerry Newlin, Chris Hiemstra, Ludo Brucker, Kelly Elder

Photo Credit, Andrew Hedrick

## Grand Mesa, Colorado, Jan and Feb 2020

# CO National Guard Partnership for SnowEx 2020

Instrumented COARG SUSV oversnow vehicle for Snow ground and airborne data comparisons

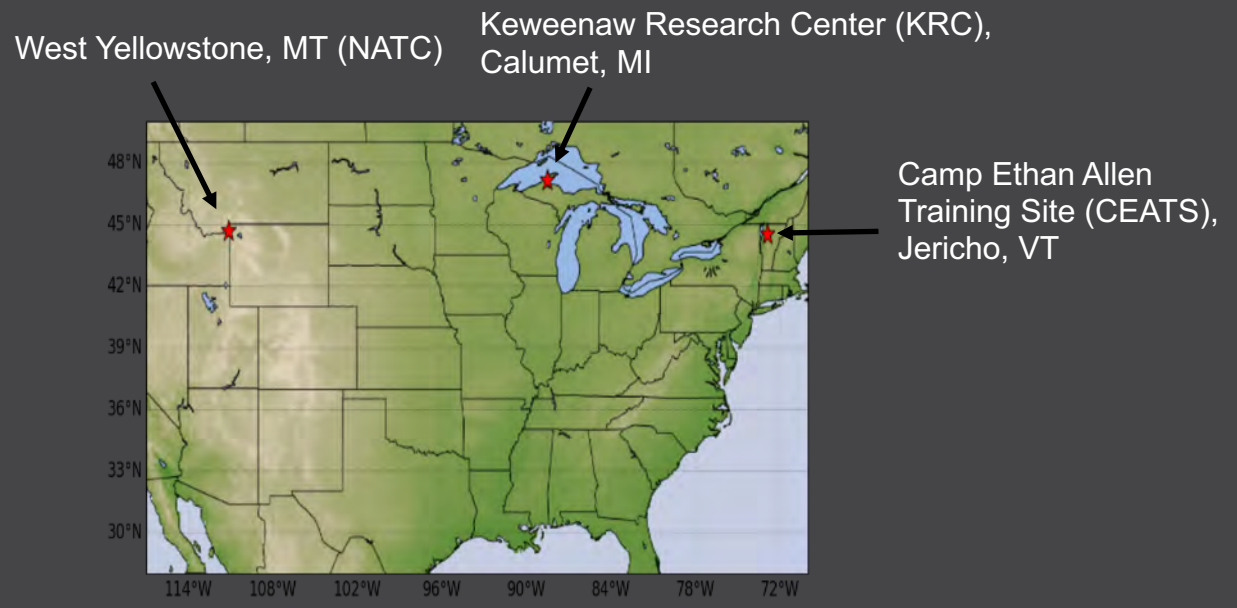




# *Enhancing SnowModel for Vehicle Mobility*

SnowModel energy and mass balance snow evolution model from CO State University

Experimental sites chosen to cover a variety of snow conditions at locations with concurrent vehicle testing

- Parallelization and code enhancements
- Post processing and instruction
- Improve tree canopy interception algorithms
- Quantify & minimize SWE and snow depth data assimilation uncertainties




*HUGH (95%) improvements in run time*

**ERDC-CRREL's mission is to solve scientific and engineering challenges in cold and complex environments through effective, interdisciplinary solutions for our Warfighters and the Nation**

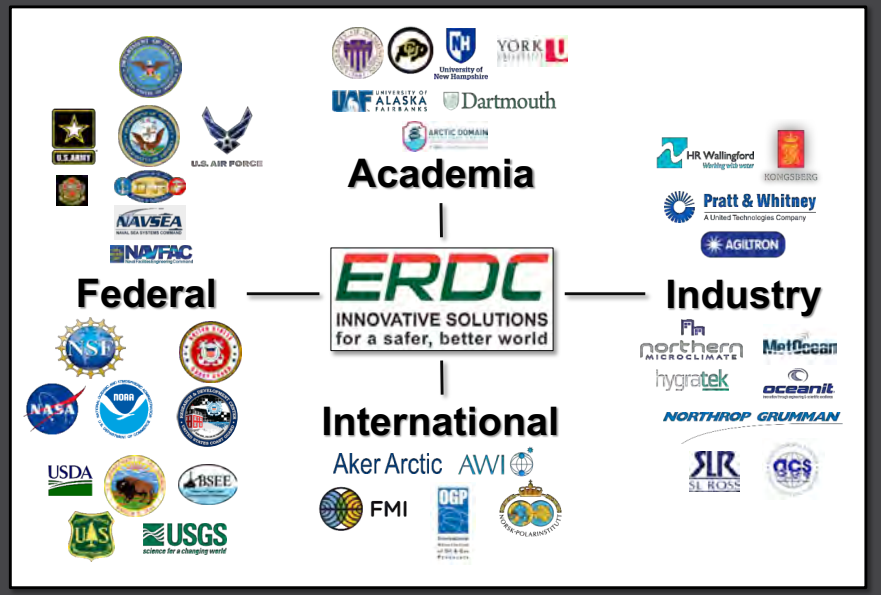
# Coordination of Arctic Interactions

The ERDC works closely with the Department of Defense in implementing the departments strategy for the Arctic region. In addition, towards an enhanced unity of scientific effort in the region, the ERDC coordinates a number of its research efforts through the Interagency Arctic Research Policy Committee.

In support of the National strategy for the Arctic region, the ERDC fosters partnerships across many agencies and departments as well as with academia and industry.

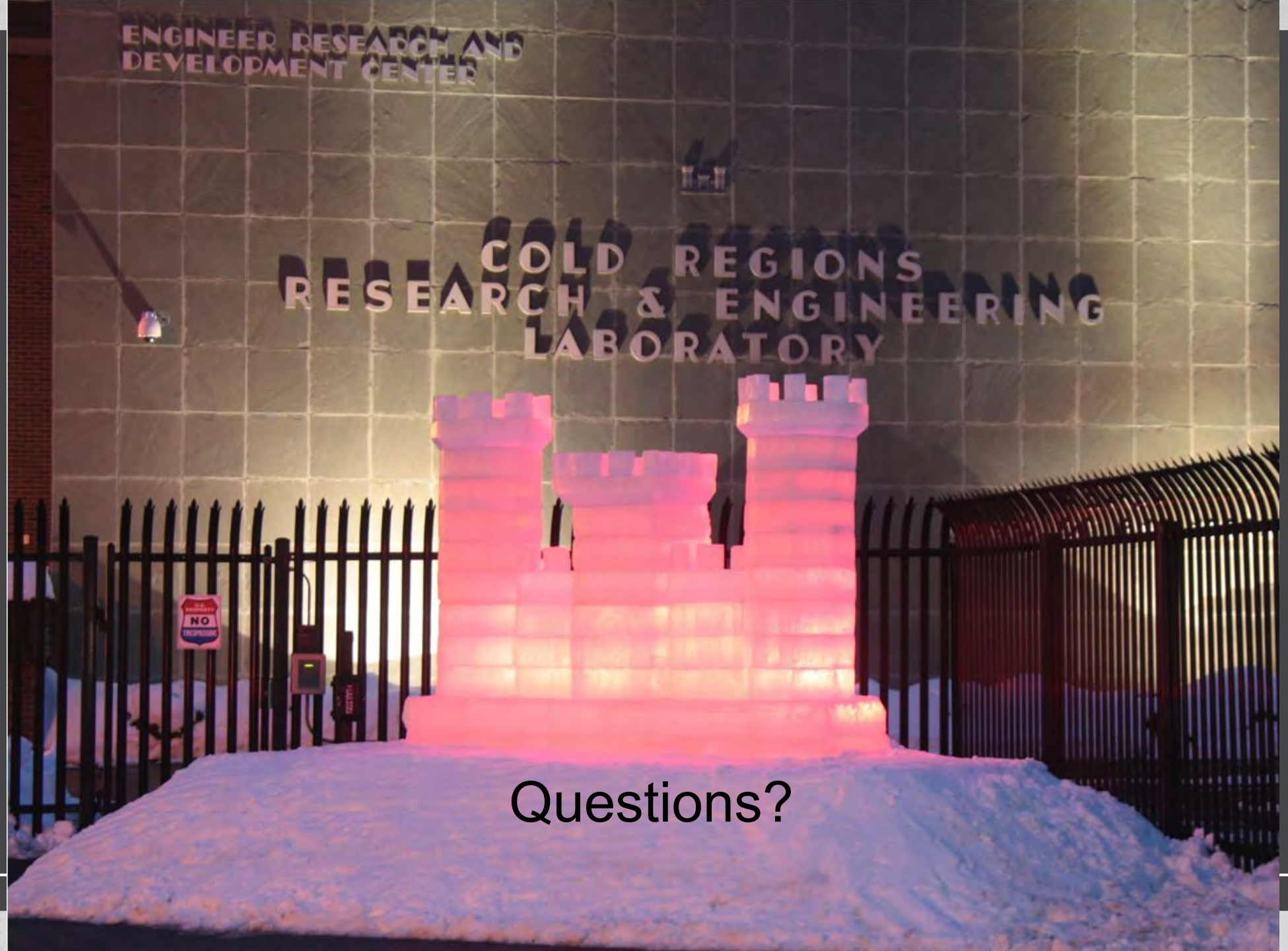
Some of the national and international Arctic region advisory groups that the ERDC actively contributes to include:

- Arctic Report Card
- Interagency Arctic Research Policy Committee (IARPC)
- Interagency Coordinating Committee on Oil Pollution Research (ICCOPR)




**ERDC's research into a changing climate and resulting effects on the Arctic region encompasses dozens of projects, all performed under a unifying approach and theme: the Study of Environmental Arctic Change (SEARCH).**

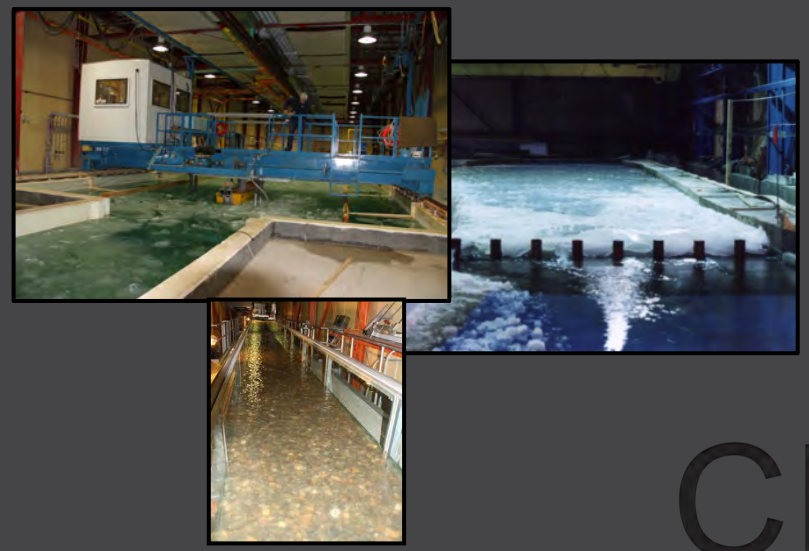
***Partnering to Support Department of Defense and National interests in the Arctic region***


ENGINEER RESEARCH AND
DEVELOPMENT CENTER
COLD REGIONS
RESEARCH & ENGINEERING
LABORATORY
NO

Questions?

# Unique 'Cold' Facilities

## Ice Engineering Facility



## Geophysical Research Facility

CRREL

Cold Regions Research and Engineering Laboratory

## Frost Effects Research Facility

## Materiel Evaluation Facility