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Modernizing Environmental Signature Physics for Target Detection

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Modernizing Environmental Signature Physics for Target Detection

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Final report

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Fort Belvoir, VA 22060

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Preface

This study was conducted for the U.S. Army Combat Capabilities Development Command under Army Direct funds, Program Element Number 0602712A, Project Number 468349, and Task Number A1010. The technical monitor was Dr. Jay Clausen.

The work was performed by the Force Projection and Sustainment Branch of the Research and Engineering Division, U.S. Army Engineer Research and Development Center (ERDC), Cold Regions Research and Engineering Laboratory (CRREL). At the time of the presentation, Mr. Justin B. Putnam was Acting Branch Chief; and Mr. J. D. Horne was Division Chief. The Deputy Director of ERDC-CRREL was Mr. David B. Ringelberg, and the Director was Dr. Joseph L. Corriveau.

This material was originally presented at the ERDC RD20 Conference on 29 October 2020 as part of the Battlespace Terrain Mapping Session.

The Commander of ERDC was COL Teresa A. Schlosser and the Director was Dr. David W. Pittman.

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Modernizing Environmental Signature Physics for Target Detection

ERDC-CRREL Test Bed

Partners
GSL, CCDC-C5ISR,
Desert Research Institute

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OBJECTIVE AND METHODS

OBJECTIVE: DETERMINE EFFECT OF ENVIRONMENTAL PHENOMONOLOGY ON ABILITY TO DETECT BURIED OBJECTS AND PROVIDE A PREDICTIVE CAPABILITY OF WHEN TARGETS ARE BEST DETECTABLE WITH IR SENSORS

SW & LW

Reflectance

Thermal Flux

Meteorology

Wind Speed

Thermal-Spatial Variability

Thermal Discrimination of Materials

Modeling Simulations

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Issue

25 Sep

Pre-Object Emplacement
26 Sep

27 Sep °C

Pre-Object Emplacement

Post-Object Emplacement °C

Test Plot Construction

Environmental Measurements

- Soil Chemistry – ICP-MS, LIBS, XRF, XRD
- Soil reflectance - Field spectrometry
- Surface Topography (roughness) – high resolution LiDAR
- Density – Nuclear Density Gauge
- Temperature (surface and at depth) – Thermocouples, FLIR, PIR
- Heat Flux – Radiometer
- Soil Temperature/Moisture/Conductivity – Field probes
- Grain Size (ASTM)
- Metrological - Air Temperature, Relative Humidity, Precipitation
Barometric Pressure, Wind Speed & Direction
- Solar Radiation (incoming SW & LW, albedo) - Radiometers

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CRREL Test Plot Features

- Bare earth with homogenized (disturbed) test bed at CRREL
- Bare earth and vegetated (undisturbed) control areas
- Four buried object locations + surface objects
- FLIR & EO camera image acquisition
 - 15 minute interval over 1 ½ years
- Surface air temperature measurements at 4 locations
- Soil parameter measurements
 - Thermocouples (150+) at 5 locations at 8 depth intervals
 - 26 moisture probes
 - 2 buried heat plates
 - 15 minute interval over 1 ½ years
- Meteorological parameter measurements
 - 5 minute interval over 1 ½ years

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Data Sets Available

- Phase 1 vegetated on non-vegetated test plots June to November 2016
- Continuous Measurements July to Dec 2018
- Continuous Measurements March to August 2020
- One week study with measurements every 15 seconds
- One week studies each assessing variables: wind speed, solar input, surface topology, soil moisture

Supporting Tools

- Soil thermal heat flow model
- VESPA numerical model test bed

- 3-d animated model simulation (3-months)
 - FLIR surface temperatures
 - Thermocouple subsurface temperatures
 - Soil moisture
 - Corresponding incoming short-wave radiation

Technology Transfer

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FY21 Tasks

- Task 1 - **ML/AI Image Analysis** - Develop statistical learning algorithms to comprehensively analyze and identify important environmental phenomology
- Task 2 - **CRREL Test Plot Manipulations** - Conduct week long controlled tests forcing single variable (wind, solar radiation, soil moisture, camera angle, surface topology soil density)
- Task 3 – **Thermal Modeling** – Develop a high-fidelity model of the CRREL Test Bed incorporating soil, vegetation, weather, atmosphere and sensor blur/noise inputs to produce realistic synthetic sensor imagery for training object recognition algorithms to improve sensor performance
- Task 4 - **Thermal Analysis** - Develop a heat flow (horizontal and vertical) model to assess buried objects under differing environmental conditions
- Task 5 – **Multilevel Modeling** - Determine quantifiable relational properties between surface radiation and surface soil temperature with and without buried objects
- Task 6 – **Seasonal Analysis** – Assess the seasonal impacts (freeze-thaw, frozen soil, snow) on surface soil temperatures as it relates to thermal IR observations
- Task 7 - **Application Development** - Explore methods to identify and develop means to geospatially display guidance/recommendations regarding terrain impacts

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