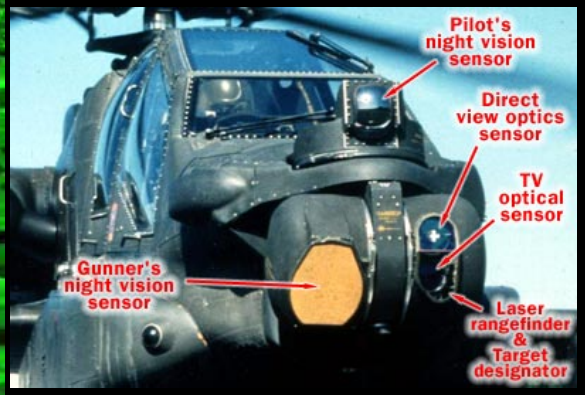
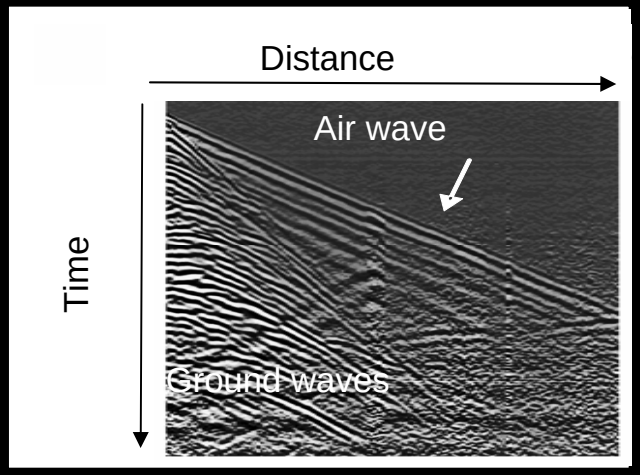
Technical Business Areas

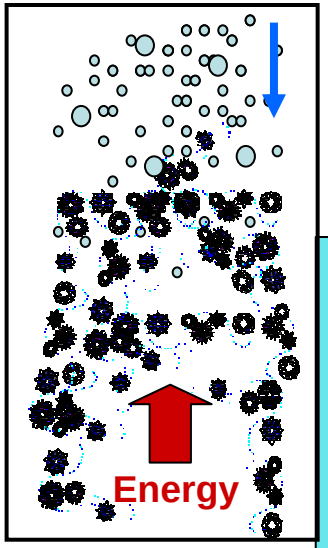
Terrain—Properties and Processes

Summarizes research investigating fundamental processes and properties of terrain as affected by the atmosphere and applying knowledge of the interaction to support a broad rage of problems. Examples include assessing geo-environmental effects on sensing, communications and infrastructure.



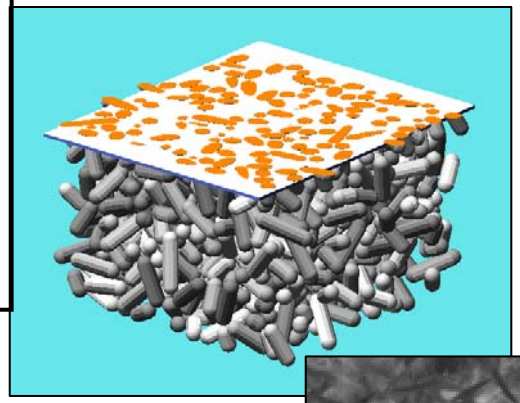


Understanding the Microscale Processes

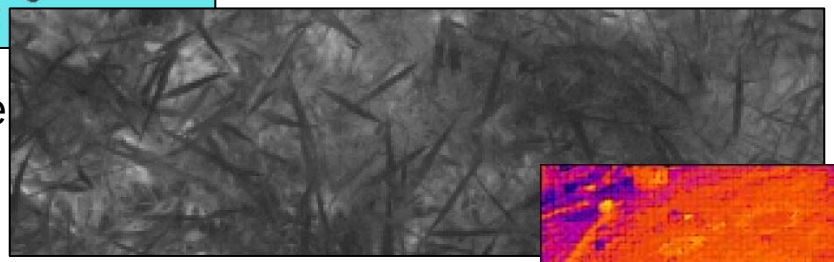


Nucleation of supercooled droplets.

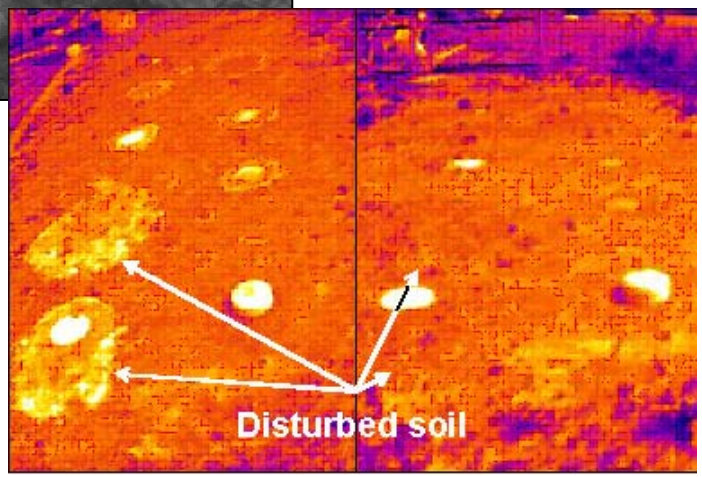
Discrete element simulation of thermal conduction.



Radiant temperature variations in grass.



Thermal effects of disturbed soil.



Products:

- Icing: data sets of microphysics clustering
- DEM for virtual 3-D snow and soil
- Description of factors affecting IR response from grass
- Measurements and modeling of moisture distribution around buried objects

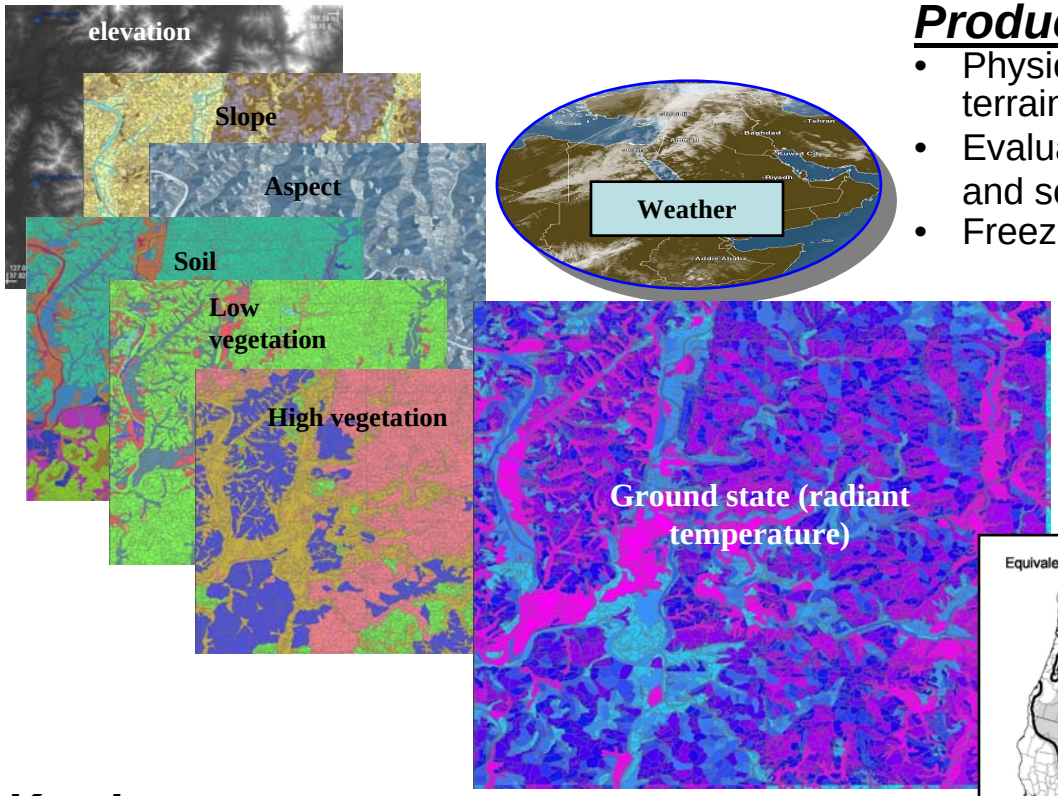
Advances:

- Discovery of importance of cloud droplet clustering on icing
- Microscale simulation of thermal conduction in snow
- Improved understanding on contributing processes to infrared observations

Key Issues:

- Improving understanding of the physical processes associated with mass, momentum and thermal transport in atmosphere and at terrain surface.
  - o measurements and theoretical development to improve prediction
  - o integration of understanding into larger-scale models

Predicting Atmosphere-Terrain Interaction

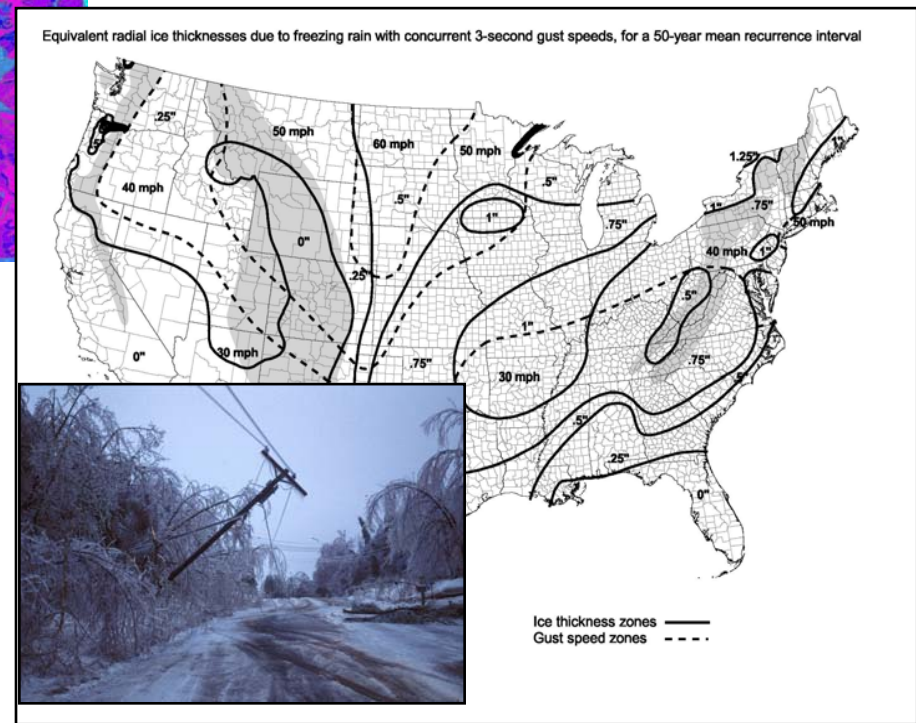


Products:

- Physics-based phenomenology models that predict terrain condition in wide range of environments.
- Evaluation of models for detecting terrain features and soil strength
- Freezing rain return period maps

Advances:

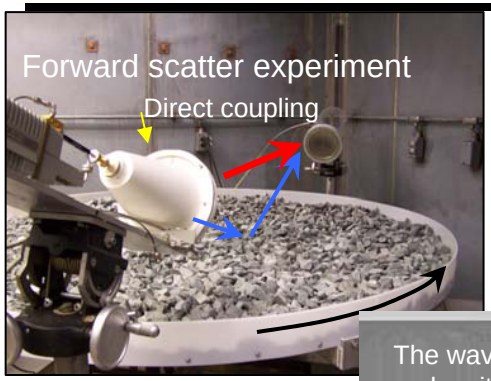
- Methodology for predicting solar flux at the ground-vegetation interface based on viewable gap fraction
- Methodologies for predicting structure ice and wind loads



Key Issues:

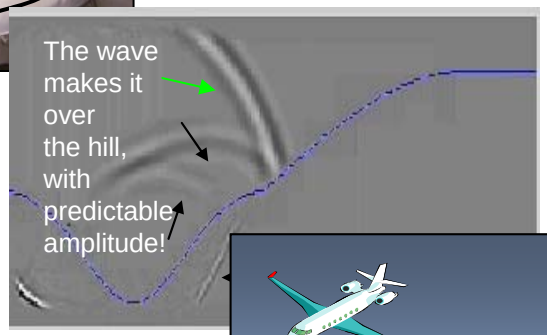
- Integrating the impact of discontinuous short vegetation (grass & Shrubs) on thermal and spectral signatures
- Developing computationally efficient SVAT for very high spatial resolution
- Identification of terrain features and soil strength with spectral imagery
- Modeling freezing rain return periods in complex terrain

Investigating and Modeling EM Propagation



Laboratory experiments of surface scattering.

3-D full-wave EM modeling over complex terrain.

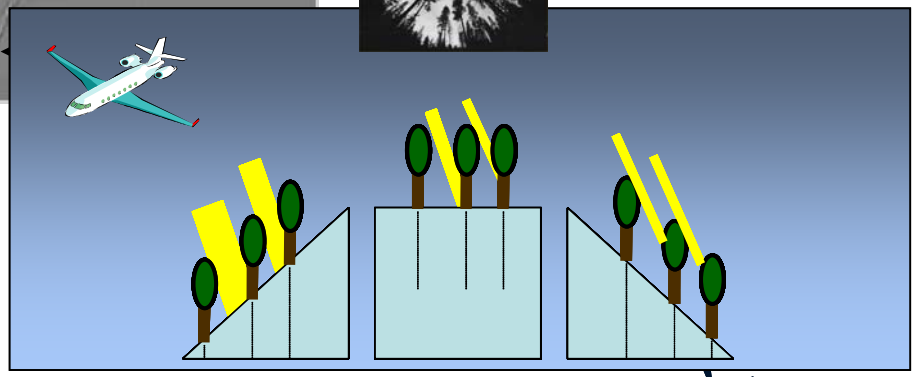


Products:

- Forward scatter data for assessing ground reflectivity
- 3-D topographic EM pulse model
- Sensor performance prediction in variety of terrain

Advances:

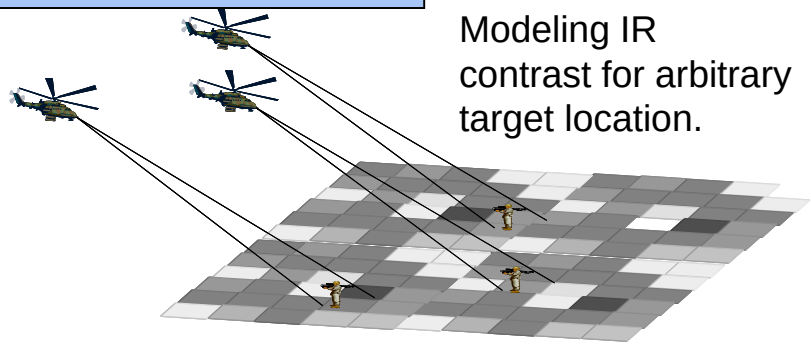
- Predicting viewable gap fraction as a function of vegetation, slope and aspect
- A test of the specular reflection hypothesis for radiation at grazing incidence.



Schematic of viewable gap fraction through forest on complex topography.

Key Issues:

- Radiowave reflectivity of ground surface vs. roughness, dielectric permittivity, polarization, and angle of incidence
- Predicting viewable gap fraction in complex terrain with vegetation, slope, and aspect.
- Area-wide assessments of target IR contrast.



Modeling IR contrast for arbitrary target location.

Terrain - Properties and Processes

1. What is the problem?

- Mircoscale properties and processes: We cannot predict with accuracy the processes controlling properties of interest at the microscale, which in turn affect properties and propagation of EM energy near the terrain surface at scales of 10s and 100s of meters.
- Terrain state prediction: We need to develop the ability to create image/map products that depict the changing terrain material properties that affect EM propagation and effects.
- Sensing: Both as key R&D measurements, and as observations made by users, phenomenology affects what we try to sense. Improved understanding will lead to better R&D and management of sensor assets.

2. What are the barriers to solving this problem?

- Incomplete understanding of EM propagation
- Insufficient definition of energy exchange effects on geophysical processes
- Distributed terrain state modeling requires correct spatial and temporal scaling issues

3. How will you overcome those barriers?

- Laboratory, field and simulation studies and modeling
- Determine scaling relationships between weather and terrain state, tie to sensor performance and soil moisture
- Investigation sensing phenomenology from basic understanding to applications

4. What are the results of this research and what is the value?

- Discovery of key microscale processes that affect larger scales
- New models that predict terrain processes and properties
- User decision aids

5. What is innovative about this work?

- Using short pulses to understand communication modes and ranges
- Observing disturbed soil to find mines; using radiometry to identify aircraft icing conditions
- DEM of particles to determine bulk snow properties

6. What is your technology transfer 2000-2005?

- Models: SNTHERM, FASSTC, WVAT, FPSS, SODTT
- Standards documents: ASCE icing design loads
- Reports: 25; Journal Articles: 60; Conferences: 91

7. Collaboration across ERDC, commercial firms, and/or academia:

NASA, FAA, EPRI, Mt. Washington Observatory, NCAR, AF Weather Agency, Physical Security Center of Expertise Huntsville OLS, NVESD, FHWA, AF, DTRA, FAA, University of Colorado, University of Santa Barbara, Boston University

8. Team

- Dr. George Koenig – terrain state prediction
- Dr. Steve Arcone - energy propagation
- Dr. Susan Frankenstein – terrain state prediction
- Dr. Lindamae Peck – energy exchange
- Dr. Charles Ryerson – energy exchange
- Dr. Bert Yankielun – energy propagation