AREN, GLOBE and NASA Resources

http://www.globe.gov/web/aren-project

NASA Science Mission Directorate Science Education Cooperative Agreement Notice (CAN)
Solicitation: NNH15ZDA0044C
Award Number: NNX16AB95A
Principal Investigator: David Bydlowski, Wayne RESA, Wayne, MI
AREN Partners
(Attendees at GLOBE Conference Listed)

• Anasphere, Inc.
• Chesapeake Bay Environmental Center
• Goddard Space Flight Center — Geoff Bland, Brian Campbell and Sallie Smith
• Montana State University — Kelly Boyce
• Public Lab — Jeff Warren
• University of Maryland Eastern Shore — Willie Brown
• University of South Florida
• Washington College
• Wayne RESA — David Bydlowski and Andy Henry
• Evaluation — Anil Aranha
Observing or measuring phenomena without direct physical contact, often from a distance.

Observing or measuring phenomena in place, often with direct physical contact.

In situ (on site) measurements

Remote sensing
LOCAL SCALE REMOTE SENSING:
WHAT CAN WE OBSERVE FROM KITES?
AEROKATS
Advancing Earth Research Observations with Kites and Atmospheric/Terrestrial Sensors

Using NASA’s kite based Aeropod systems to capture remotely sensed imagery and in-situ atmospheric data for use in the classroom
Kite based Aeropods allow students to:
• collect and process real data about their environment,
• learn image processing and data analysis skills,
• validate the remote sensing process.
ALIGNING WITH GLOBE DATA COLLECTION

THE GLOBE PROGRAM
CONNECTING THE NEXT GENERATION OF SCIENTISTS
Global Learning and Observations to Benefit the Environment

Protocols and Learning Activities

Site Definition Sheet
Name, time, location, type
Atmosphere – air temperature, barometric pressure, precipitation, relative humidity, wind
Surface temperature
Soil moisture and temperature
Site photos
Land cover sample site
Biosphere investigation instruments - MUC

Computer-Aided Land Cover Mapping
Discovery Area Post-Protocol
Do You Know Your MUC
Getting to Know Your Satellite Imagery and GLOBE Study Site
Land Cover Change Detection
Manual Land Cover Mapping
Odyssey of the Eyes (Beginning and Intermediate Levels)
Using GLOBE Data to Analyze Land Cover
Aeropods are the result of development efforts at NASA’s Goddard Space Flight Center

- Monopods, aka Monocam: Single, low cost camera used for aerial imaging.
- Procam: High resolution single camera
- Twincam: Multiband/multicamera for image processing
- Thermocam or Thermopod: Thermal imaging system
- Profiler: Atmospheric (air-column) profiling
AERIAL IMAGING
Example using TwinCam visible and near infrared imagery

TwinCam - Visible Light Image

TwinCam - Near-Infrared Image
TwinCam Examples - Knabusch Center for Science and Mathematics
Use MultiSpec to produce classified image and vegetation indices.
The numbers behind the imagery - quantifying the data

### TRAINING CLASS PERFORMANCE

(Re-substitution Method)

OVERALL CLASS PERFORMANCE \( \frac{10940}{16080} = 68.0\% \)

Kappa Statistic \( (X100) = 64.5\% \). Kappa Variance = 0.000016.

+ (100 - percent omission error); also called producer's accuracy.

* (100 - percent commission error); also called user's accuracy.

### CLASS DISTRIBUTION FOR SELECTED AREA

<table>
<thead>
<tr>
<th>Class</th>
<th>Number Samples</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass(Lawn)Green</td>
<td>5,300</td>
<td>1.8</td>
</tr>
<tr>
<td>Roof</td>
<td>3,479</td>
<td>1.2</td>
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<tr>
<td>Grass(Lawn) G Shdw</td>
<td>8,360</td>
<td>2.8</td>
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<tr>
<td>Drain (Water)</td>
<td>6,310</td>
<td>2.1</td>
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<tr>
<td>Green Plot</td>
<td>4,241</td>
<td>1.4</td>
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<tr>
<td>Grass Lawn (Mixed)</td>
<td>36,889</td>
<td>12.4</td>
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<tr>
<td>Tree (bare)</td>
<td>26,951</td>
<td>9.1</td>
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<tr>
<td>Tree Greening</td>
<td>19,617</td>
<td>6.6</td>
</tr>
<tr>
<td>Conifer</td>
<td>21,020</td>
<td>7.1</td>
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<tr>
<td>Mixed Shrubs</td>
<td>29,286</td>
<td>9.8</td>
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<tr>
<td>Bare Soil</td>
<td>14,946</td>
<td>5.0</td>
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<tr>
<td>Soil-veg_rows</td>
<td>16,959</td>
<td>5.7</td>
</tr>
<tr>
<td>ShdSoil and Grasses</td>
<td>23,493</td>
<td>7.9</td>
</tr>
<tr>
<td>Shrubs bare</td>
<td>27,118</td>
<td>9.3</td>
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<tr>
<td>Tall grasses (Mixed)</td>
<td>12,176</td>
<td>4.1</td>
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<tr>
<td>GrassLawn*(Mix)Shd</td>
<td>40,903</td>
<td>13.7</td>
</tr>
</tbody>
</table>

Total: 297,648 100.0

Average likelihood probability is 46.7%.  
Maximum likelihood classification

### Project

<table>
<thead>
<tr>
<th>Class</th>
<th>Reference Name</th>
<th>Number of Samples in Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass(Lawn)Green</td>
<td>1 98.3</td>
<td>652 628 0 0 0 0 0 23 0 0 0 0 0 0 1 0 0 0 0</td>
</tr>
<tr>
<td>Roof</td>
<td>2 98.7</td>
<td>150 150 0 0 0 0 0 0 1 0 0 0 0 0 0 1 0 0 0 0</td>
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<tr>
<td>Grass(Lawn) Green Shadow</td>
<td>3 100.0</td>
<td>422 422 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Drain (Water)</td>
<td>4 98.6</td>
<td>276 276 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Green Plot</td>
<td>5 98.3</td>
<td>233 233 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Grass Lawn (Mixed)</td>
<td>6 81.9</td>
<td>3348 171 0 0 0 0 0 230 2742 0 127 0 0 0 13 0 0 0 65</td>
</tr>
<tr>
<td>Tree (bare)</td>
<td>7 64.3</td>
<td>1205 0 0 0 0 0 0 0 33 775 38 16 92 16 67 7 18 57 39</td>
</tr>
<tr>
<td>Tree Greening</td>
<td>8 26.8</td>
<td>1799 0 0 0 0 0 0 0 466 218 482 1 32 16 118 0 15 47 402</td>
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<tr>
<td>Conifer</td>
<td>9 93.0</td>
<td>812 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Mixed Shrubs</td>
<td>10 46.3</td>
<td>1887 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Bare Soil</td>
<td>11 81.8</td>
<td>782 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Soil-veg_rows</td>
<td>12 21.4</td>
<td>327 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
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<tr>
<td>Shded Soil and Grasses</td>
<td>13 89.1</td>
<td>976 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Shrubs bare</td>
<td>14 61.3</td>
<td>711 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>Tall grasses (mixed)</td>
<td>15 21.8</td>
<td>596 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>GrassLawn*(Mixed)Shadow</td>
<td>16 76.9</td>
<td>1895 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
</tr>
</tbody>
</table>

**TOTAL** 16080 799 213 422 336 468 3315 1334 940 978 1315 778 388 1032 1015 647 2080

Reliability Accuracy (%)* 72.7 32.3 100.0 91.8 16.9 92.7 57.2 51.3 72.2 64.5 92.3 100.0 84.3 43.6 32.1 70.9
DIRECT (IN-SITU) OBSERVATIONS FROM KITE-BORNE SENSORS

Air Column Profiler (Why is this in-situ?)
Engineering is a **systematic and often iterative** approach to designing objects, processes, and systems to meet human needs and wants.
Engineering focus: New Aeropods

- MonoCam HD and TwinCam HD
- New Air-Column Profiler (w/ Kestrel)
- New Arduino based Air-Column Profiler
- HoboPod - Using Hobo Data Loggers
- ThermoPod-TC
- Aerosol Sampler
Air-Column Profiler Arduino

- Arduino Uno rev3
- Sparkfun weather shield
- GPS chip
- WeatherFlow Anemometer

Records:
- Wind speed
- Temperature
- Humidity
- Barometric Pressure
- Light sensor
- Position (Longitude/Latitude)
Engineering focus: New Aeropods

HoboPod - Using Hobo Data Loggers

Graph showing temperature and light intensity over time.
Engineering focus: New Aeropods

TwinCam ThermalPod

- Raspberry Pi based
- Includes Raspberry Pi Camera (5mp)
- Flir Lepton thermal imager
- and other stuff to make it work…

(Thermal-guy)
Engineering focus: Student Designed Systems
THE AREN PROJECT
AEROKATS AND ROVER EDUCATION NETWORK
GLOBE.GOV/WEB/AREN-PROJECT

We will begin the AEROKATS and ROVER Education Network (AREN) Project in 2016, with a combination of activities that will compliment and augment NASA’s established Global Learning and Observations to Benefit the Environment (GLOBE) program.

**Applicable GLOBE Protocols**

<table>
<thead>
<tr>
<th>AEROKATS</th>
<th>ROVER</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Up - Green Down</td>
<td>Conductivity</td>
</tr>
<tr>
<td>Land Cover Classification</td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>Fire Fuel Classification</td>
<td>Nitrates</td>
</tr>
<tr>
<td>Phenological Gardens</td>
<td>Salinity</td>
</tr>
<tr>
<td>Barometric Pressure</td>
<td>Water Temperature</td>
</tr>
<tr>
<td>Albedo</td>
<td>Water Transparency</td>
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<tr>
<td>Air Temperature</td>
<td>pH</td>
</tr>
<tr>
<td>Surface Temperature</td>
<td>GPS</td>
</tr>
<tr>
<td>Air Temperature</td>
<td></td>
</tr>
</tbody>
</table>
ADDITIONAL RESOURCES:

Please visit:

http://www.globe.gov/web/aren-project

The AEROKATS program was developed by Geoff Bland at the NASA/GSFC Wallops Flight Facility. Aeropods and the Aeropod concept are the Intellectual Property of NASA and are considered competition sensitive. Aeropods or other aerodynamically stabilized tethered remote sensing systems based on the Aeropod concept may not be produced without the express consent of NASA through a formalized Space Act Agreement. Please contact Andy Henry at Wayne RESA henry@resa.net with questions.