Challenges and Opportunities in Remote Sensing of Global Savannas: A Scoping Study for a New TE Field Campaign

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The geographic scope of woody-herbaceous systems

Figure 1. Global distribution of ‘savannas’ (mixed woody-herbaceous systems). For the purposes of this proposal (in which we seek to improve satellite remote sensing capabilities in woody-herbaceous systems) we include shrublands and savannas in both tropical and temperate regions. *Figure after Olson, 1994 and Loveland et al., 1998.*
Savanna Remote Sensing Scoping Study
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Global savannas: Australia:
i) sorghum woodland (Photo: Marks); ii) Aristida spp woodland, Larimah sandy site, NATT; iii) Triodia spp woodland, Larimah loam site, NATT; and iv) Dichanthium woodland, Larimah clay site, NATT (Photos: Hill).
Global savannas: South America:
i) cerrado (Photo: Bustamante); Colombian llanos – gallery forest (photo: Devia); iii) Colombian llanos – rolling savanna (Photo: Etter); and iv) Colombian llanos – grassland with sparse shrubs (Photo: Repizzo).
Savanna Remote Sensing Scoping Study

Santa Rita Experimental Range, Arizona
The geographic scope of woody-herbaceous systems

Figure 1. Global distribution of ‘savannas’ (mixed woody-herbaceous systems). For the purposes of this proposal (in which we seek to improve satellite remote sensing capabilities in woody-herbaceous systems) we include shrublands and savannas in both tropical and temperate regions. *Figure after Olson, 1994 and* Loveland et al., 1998.
**NASA Science Priorities:** relating to rates and causes of change in the Earth system, Earth system responses to climate and land use, and impacts of change on human civilizations.

**Priority Science Themes in the savannas**

<table>
<thead>
<tr>
<th>Climate &amp; climate change</th>
<th>Carbon, H2O, energy cycles</th>
<th>Desertification/degradation</th>
<th>Shrub encroachment</th>
<th>Livelihoods &amp; sustainability</th>
<th>LCLUC</th>
<th>Fires &amp; Atmospheric chemistry</th>
</tr>
</thead>
</table>
Participants by Continent

North America  -  32
Europe          -  7
South America   -  4
Australia       -  4
Africa          -  3
Priority Science Themes in the savannas

Breakouts 1: Science Priorities and RS Opportunities

Science Needs

Remote Sensing

Field Measures

Management & application needs; local-global model needs
Breakouts 2: Geographic Priorities and Opportunities

1. Africa
2. Australia
3. North America
4. South (and Central) America
5. “Distributed”
Savanna Remote Sensing Scoping Study

SRS Workshop Outcomes

New developments and new opportunities since earlier field campaigns!!
New opportunities: RS retrieval of vegetation structure

MODIS VCF WOODY COVER

OPTICAL-RADAR SYNERGY

woody cover %

- 0
- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- NoData

Bucini in prep.
SRS Workshop
Outcomes

New developments and new opportunities since earlier TE field campaigns!!
An example: Model development

Savanna modeling – synthesis, DA, & prognosis

Model structures and processes generally not appropriate

- Heterogeneous woody-herbaceous canopy
- Drought-prone and pulse-driven
- Disturbance-prone (fire and herbivory)

Need to be more fully developed in

- Land Surface Models
- Carbon and nutrient cycle models
- Dynamic vegetation models
An example: Model data assimilation of soil moisture

Forcing: 
- \(T\) 
- \(e_a\) 
- \(R_n\) 
- PPT

Forward model: 
- Water budget
- \(\theta_z\) 
- \(\theta_z^m\) 
- \(\theta_z^a\) 

Analysis: 
- 3D Variational Assimilation
- \(T_s(\theta_z)\)
- \(T_B(\theta_{S1})\)

Measured parameters (observations): 
- \(\rho, \rho_s\)

Forecast: 
- \(\theta_z\) 
- \(\theta_z^m\) 
- \(\theta_z^a\) 

Barrett and Renzullo (2009)
Savanna Remote Sensing Scoping Study

SRS Workshop Outcomes

Recognized need to incorporate ‘applications’ and ‘human dimensions’ in field program design

Management & Applications

Savanna modeling – synthesis, DA, & prognosis

RS Science – vegetation structure, function & change

Savanna communities – land management, LCLUC, & livelihoods

Savanna ecology, function and change
On-line evaluation: key science questions
On-line evaluation: new understanding

Rate the potential of the prototype field programs to deliver new data, understanding and synthesis on savanna function.
On-line evaluation: technical feasibility

Rate the technical feasibility (i.e. measurements, flights, ability to derive relationships, build models, drive models, estimate fluxes or change etc etc) for the prototype field programs.

- Distributed
- USA
- Australia
- South America
- Africa

Legend:
- Highly effective
- Effective
- Partially effective
- Less effective
- Not effective
International Participation

1. Africa
2. Australia
3. Europe
4. South (and Central) America
5. Distributed
Savanna Scoping Study

Developing white paper for NASA TE

Submission due Fall 2010

Participation and inputs very welcome!!

http://www.nrel.colostate.edu/projects/srs/
SRS OBJECTIVES A:
Improve passive and active RS of tree-grass systems

Associated Science Goals

➢ ... carry out a field campaign (in one or several locations) to collect essential data for development, parameterization, and validation of remote sensing algorithms associated with tree-grass mixtures, savanna structure and function

➢ ... use remote sensing for separate quantification of woody and herbaceous vegetation structure, phenology and function in savannas

➢ ... examine synergy among different sensors (radar, lidar, broad-band, thermal and hyperspectral) and different spatial and temporal resolutions for quantification of savanna state, process, and change
SRS OBJECTIVES B: Stimulate “savanna model” development and testing

Associated Science Goals

➢ … stimulate development and testing of RS-driven land surface, biogeochemistry and dynamic vegetation models appropriate for savanna systems
➢ … provide required field data for model development, parameterization and data assimilation
➢ … stimulate exploration of the role of soil moisture in driving ecosystem function (carbon and water cycles, biogeochemistry) in heterogeneous, water-limited savanna ecosystems
➢ … stimulate exploration of the role of fire as a critical factor controlling vegetation structure, carbon storage and release of pyrogenic carbon and reactive gases
SRS OBJECTIVES C: 
Apply new remote sensing and modeling techniques in savannas

Associated Science Goals
➢… have algorithms and data processing systems in place for regular and routine extraction of savanna information (at landscape to global scales) using the suite of space-borne instruments currently operating and planned
➢… stream savanna information to appropriate models (land surface models, biogeochemistry models, DGVM) to simulate and diagnose states and processes relevant to scientists and managers (e.g. vegetation structure, productivity, sustainability, carbon, water and nutrient dynamics)
➢… facilitate long term monitoring (structure, function and response to anthropogenic and natural change) of savannas for improved management
➢… make data and analyses freely and easily available to managers, scientists and the general public to enhance understanding and sustainable development of the savanna biomes
Richard Lucas, March 2010
Ecosystem Function in Savannas: Measurement and Modeling at Landscape to Global Scales

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