

## **Southern Africa Validation of EOS (SAVE) Status Report**

**Period of Report: 6 June 2000 -- 28 Sept. 2001**

J. L. Privette, R.J. Swap, A. Thompson and the SAVE Team

### **a) Project Objectives**

In the period since the last Status Report (6 June 2000), SAVE was primarily occupied with the SAFARI Dry Season Aircraft Campaign, analysis of field data, and publication of validation results.

### **b) Major Tasks Accomplished**

- **3<sup>rd</sup> SAVE/SAFARI Field Campaign (August/September, 2000)** SAVE conducted its third significant field effort in Africa as part the third SAFARI 2000 campaign. As the primary emphasis during IFC3 was on fires, smoke and aerosols, SAVE's atmospheric scientists (R.J. Swap and A. Thompson) led critical parts of the campaign. Specifically, in addition to helping organize the entire campaign, Swap led IFC3 flight planning (ER-2, CV580, and two smaller planes) and actively participated in in situ aerosol monitoring by small aircraft. Thompson conducted ozonesonde sampling in Lusaka, Zambia during a period of particularly elevated burning. SAVE land scientists collected validation-relevant data in part to support use of MODIS products (e.g., % cover, LAI) for fire fuel load estimation. Further, SAVE conducted normal maintenance and recalibration of sensors and helped lead a SAFARI data workshop at the aircraft flight center (Pietersburg, S. Africa) midway through the campaign.

Details of the measurements and sites are in the Appendix. Participating SAVE personnel included Privette (GSFC), Thompson (GSFC), Swap (UVA), and Pinheiro (GSFC). Swap is leading an overview article on the dry season campaign for S. African J. of Science (Privette is a coauthor).

- **Ozonesonde releases (Collaboration with SHADOZ/SAFARI)** Thompson released ~20 ozonesondes from Lusaka during a 1-week period of IFC3 (the aircraft campaign). The data are currently under analysis, however initial results suggest extremely high levels of tropospheric ozone. As these data were collected in the midst of the extensive aerosol and fire experiments in Zambia, further analysis may better link the role of fire in ozone production.

- **Other SAVE/SAFARI Field Campaigns (August 1999, March 2000, September 2001)** SAVE continues to reduce and analyze data collected during previous SAFARI campaigns. A complete list of parameters collected is in the Appendix. Multiple external scientists have asked for and received SAVE data. In addition to its many MODIS collaborations, SAVE is actively collaborating with MISR validation scientists (Jim Conel and Mark Helmlinger) on BRDF and albedo validation. Privette has led two publications on MODIS product validation (submitted in 2001). Privette conducted a joint measurement campaign in Mongu in September 2001 with fire scientists from Univ. of Virginia (Hely, Alleaume). Privette collected TRAC data while the UVA team collected fire fuel data. Three plots with vegetation dissimilar to the SAVE tower measurement area were targeted. These will be remeasured with TRAC during the wet season.

In sum, SAVE has participated in three of the four major SAFARI campaigns, and conducted additional dry season mini-campaigns in 1998 and 2001.

- **Year-round measurements** Besides field campaigns, SAVE is collecting year-round measurements at the two core sites (Skukuza and Mongu). Since 8/99, SAVE has collected LAI, albedo, aerosol, and soil temperature and moisture data at Skukuza, and aerosol, LAI, thermal IR, irradiance and albedo data at Mongu. A nearly one-year record of soil temperature and moisture was also collected at Mongu. A full list is provided in the Appendix.

- **Satellite data procurement** We continue to receive excellent support from various "tasked" satellite systems (e.g., Landsat 7, ASTER, IKONOS and MISR) for regular collection of scenes over SAFARI 2000 Core Sites. Data from each of these systems were collected during each 2000 campaign. Our GSFC-based data group has also requested and distributed more than 100 Landsat 7 ETM+ scenes over Africa to support SAFARI-based validation of EOS by outside investigators. These are staged at the TRFIC ESIP II site at Mich. State Univ. (PI: Skole) through a negotiated arrangement. Jim Tucker's GSFC/GIMMS group delivered 1 km AVHRR data products and a "quick-look" aircraft planning product over the region. The former product was a critical part of Volume I of the SAFARI CD-ROM Series.

Most MODIS data collected during the campaigns is undergoing reprocessing, however we have analyzed products from early algorithm versions and found they compare very well (LAI) with SAVE field data. We are in frequent communication with the MODLAND team and are primarily collaborating with Boston Univ. investigators thus far (Myneni, LAI/FPAR; Strahler, BRDF/albedo). SeaWiFS data were collected and archived online and on the CDROM for SAFARI 2000 active test sites.

- **SAFARI data system** The current distributed system for SAFARI registration, data submission (via ORNL's Mercury) and data distribution through individual WWW sites, a regional data center, ORNL and CD-ROMs, has stabilized significantly over the past year and seems to be meeting the investigators' needs. SAVE scientists helped in several phases of the GSFC effort to gather, document, disseminate and archive SAVE/SAFARI data via CDROMs (J. Nickeson, D. Landis, and J. Morisette, POCs). This activity formally began in May, 2000, and forced many decisions concerning SAFARI data priorities and formats, including a revision of the Data Policy and the SAFARI registration system to allow open data access at multiple WWW sites for official participants. We've also developed at SAFARI 2000 Data Newsletter which provides information and instructions for access SAFARI data sets.

CD-ROM Volume I (500 copies) was released in August 2001 and distributed to participants at the First SAFARI 2000 Data Workshop in Siavonga. The CD is online at the ORNL DAAC and at:

[http://ds20.gsfc.nasa.gov/data/SAFARI\\_1/html\\_pages/s2k\\_home.html](http://ds20.gsfc.nasa.gov/data/SAFARI_1/html_pages/s2k_home.html)

### c) Infrastructure/Facilities/Instrumentation

- **Towers** SAVE's 33 m Mongu, Zambia tower is currently being used for ongoing albedo (NIR and shortwave), irradiance and thermal infrared measurements. The 22 m tower in Skukuza, South Africa is currently outfitted with an eddy covariance system as well as albedometers. The eddy covariance system was installed by Hanan (SAVE Co-I) and Scholes (SAVE Co-PI) and was funded by the NASA TEP. After some processing, the albedometer data will be used to validate the MODIS and MISR albedo products, while the eddy covariance data will be used to validate the MODIS NPP product.

- **Instrument procurement** Twenty balloons and ozonesondes and their associated helium supplies were purchased for use in IFC3/Zambia (Thompson). No other significant instrument procurement occurred in the past year.

- **Instrument development** The simple up and downlooking red/NIR high-speed sensors are still under development. This will allow estimation of grass NDVI/LAI, and measurement of overstory fractional cover.

The SAVE version of the MQUALS package (MODIS Quick Airborne Looks) has flown several times at Kruger National Park under the guidance of B. Scholes. The instrument appears to have an reversed bit-plane readout but works acceptably otherwise.

Privette, together with Code 553 and AERONET personnel, were funded by GSFC DDF to develop an advanced sunphotometer to eventually replace the current CIMEL design. We have developed a 14-band sensor and have fit it to a CIMEL robot. A laptop computer is currently used for both operating the instrument and storing the data. AERONET personnel deployed and analyzed data collected with this instrument during IFC3 at Mongu.

#### **d) Personnel**

- **Collaborating and Support Personnel in Past Year** SAVE collaborated extensively with various researchers and projects during the August 2000 field campaign, including work with scientists from Univ. of Virginia, Zambian Meteorological Services, Kruger National Park, Univ. of London, GSFC, CSIR/LEAD, and Univ. of the Witwatersrand. SAVE hosted collaborators H. Eckhardt & D. Woods of Kruger Nat'l Park, S. Africa in July '01 at GSFC. Eckhardt gave a Code 923 Seminar.

Partial funding was provided by SAVE to:  
K. Caylor, UVA  
A. Pinheiro, New Univ. of Lisbon/GSFC  
K. F. Huemmrich, UMBC/JCET

Dr. K. Fred Huemmrich began working part-time on SAVE data analysis. Fred is developing a method to estimate FPAR from TRAC data at Skukuza and Mongu. Caylor is a PhD student in the Dept. of Environmental Sciences at UVA. His research concerns the measurement, characterization and modeling of canopy structure.

A. Pinheiro ( New Univ. of Lisbon, NASA GSFC) is continuing to lead SAVE surface temperature and hydrology validation activities in Southern Africa. She currently collects soil temperature and moisture profiles year-round in Skukuza; operations in Mongu have been curtailed indefinitely. The soil profile data collected have been supporting other investigators' activities (e.g. NO emission modeling studies). Additionally, she collects continuously (30 minute interval) surface radiometric temperature at both validation sites. Thermal infrared radiometers were deployed at the main validation tower, in Mongu, and at the Acacia and Combretum ancillary towers, in Skukuza. The data collected is being used, in conjunction with modeling activities, to evaluate angular effects on thermal observations.

- **Issues**

None. Essentially all field work is complete; emphasis is on analysis and publication.

**e) Production (Outreach, Publications, Presentations)**

• **Jornada/PROVE Special Issue of Remote Sens. Environ.** Twelve articles from the Prototype Validation Exercise (PROVE) were published in the October 2000 special issue of RSE (Ed. Privette and Huemmrich).

• **Implementation Plan and WWW Site.** The SAVE Implementation Plan (V 2.0) is available on the WWW site. This WWW site is currently being revamped. See: <http://modarch.gsfc.nasa.gov/MODIS/LAND/VAL/terra/privette>

• **CEOS WGCV Land Product Validation Subgroup** The Land Product Validation subgroup of the CEOS Working Group for Calibration and Validation (WGCV) was formally ratified in October 2000 and held its first topical workshop in June 2001. The workshop brought together ~25 international scientists interested in validation of satellite LAI products. Privette chaired the workshop, and plans a systematic validation of the 'reprocessed' MODIS LAI product by the workshop participants were developed. Further, the workshop summary and recommendations on field practices will be documented online and in a peer-reviewed article. SAVE is one of several key projects addressing LAI at present.

• **Validation-related Meetings, Chronological (Privette, Pinheiro only)**

- MODIS Science Team Meeting, GSFC, 6/6-9/00 (P)
- Validation of Moderate Resolution Satellite Land Products, first meeting of the Land Product Validation Subgroup of CEOS WGCV, Ispra, Italy (P)
- SAFARI 2000 Data System Coordination Mtgs, UVA/GSFC, 6/13-15/00 (P)
- SAFARI 2000 Data Meeting, Pietersburg, S. Africa, 9/7/00 (P)
- ISPRS Phys. Meas. & Signatures in Remote Sens, France (P) 1/8-12/01
- UVA EOS IDS meeting, Charlottesville (P), 1/18-19/01
- MODLAND Validation and Science Team Meetings, Columbia (P), 1/22-26/01
- Kalahari Transect vegetation structure meeting at UVA (4/11/01)
- IKONOS Workshop in College Park (3/19-21/01)
- SAFARI 2000 Integration Planning Workshop, GSFC (30-31 May /01)
- CEOS Work. Group on Cal/Val, Italy (4-6 June/01)
- International Workshop on LAI Product Validation (LPV Subgroup), Italy, 6-7 June
- Global Obs. Of Forest Cover (GOFC) Sci. Technical Board Meeting, Italy, 8-11 June
- SAFARI 2000 PreConference Planning Mtg, UVA (8 August 01)
- SAFARI 2000 First Data Workshop, Siavonga, Zambia (28-31 August 01). P
- Toured/reviewed the Regional Data Center in Pretoria, a joint center of SAFARI 2000 and the S. African National Disaster Management Centre. (6 Sept/00)

• **Validation-related Publications/Presentations/Posters (SAVE team; submitted or published since 6/6/00 – representative sample of posters and presentations)**

Asner, G.P., C.A. Wessman, C.A. Bateson and J.L. Privette (2000), Impact of tissue, canopy and landscape factors on reflectance variability of arid ecosystems, *Remote Sens. Environ.*, 74(1):69-84.

Annegarn, H., S. Cole, T. Suttles, R. Swap: SAFARI 2000 Dry-Season Airborne Campaign, *Earth Observer*, September/October 2000, Vol. 12 No. 5, pp.18-23

Aplin, Privette, Morisette, Swap, Dawson, Ringrose, Roberts and Francis (2000), The remote sensing component of the southern African regional science initiative (SAFARI 2000), *Proc. Remote Sens. Soc. Ann. Conf. 2000*.

Billmark, K.A., P. J. Yanik, R. J. Swap, and S.A. Macko, Stable isotope geochemical characterization of southern African aerosols, submitted to special issue of the *Journal of Arid Environments*

Caylor, K.K., P.R. Dowty, H.H. Shugart, S. Ringrose (2001), Vertical patterns of vegetation structure along the Kalahari: The importance of spatial heterogeneity in modeling system productivity. *Global Change Biology*, submitted.

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Hély, C., S. Alleaume, R.J. Swap, H.H. Shugart, and C.O. Justice, SAFARI-2000 characterization of fuels, fire behavior, combustion completeness, and emissions from experimental burns in infertile grass savannas in western Zambia, submitted to special issue of *the Journal of Arid Environment*

Justice, Belward, Morisette, Lewis, Privette, Baret (2000), Developments in the validation of satellite sensor products for the study of the land surface, Letter in *Int. J. Rem. Sensing*, 21(17):3383-3390.

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Morisette, J., J. Privette, D. Olson and P. Davis (2000), Spatial statistical analysis of three global land cover maps, Geoscience and Remote Sensing Symposium, IEEE IGARSS'00 Proceedings, Honolulu, 5:1990-1992.

Morisette, J., J.L. Privette, K. Guenther, A. Belward, C.O. Justice (2000), The CEOS Land Product Validation (LPV) Subgroup: Summary of May 23-25 Meeting," *EOS Earth Observer*, 12(4):6-7.

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Morisette, Privette and Justice (2001), Moderate resolution imaging spectroradiometer (MODIS) land product validation, *Remote Sens. Environ.*, submitted.

Myneni, R.B., Y. Knyazikhin, J.L. Privette, et al. (2001), Global products of vegetation leaf area and fraction absorbed PAR from year one of MODIS data, *Remote Sens. Environ.*, submitted.

Otter, L.B., R.J. Scholes, P. Dowty, J.L. Privette, K. Caylor, S. Ringrose, M. Mukelabai, P. Frost, O. Totolo, E.M. Veenendaal (2001), The SAFARI 2000 wet season campaigns, *S. African J. Sci.*, submitted

Pinheiro et al. (2001), Assessing the relationship between surface temperature and soil moisture in southern Africa, *Proc. Remote Sens. Hydrol. 2000*, IAHS Publ. #267, in press.

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Swap, B., T. Suttles, ..., J. Privette et al. (2000), Report on SAFARI 2000 outreach activities, intensive field campaign planning meeting, and data management workshop, *EOS Earth Observer*, 12(3):26-28.

Swap, R.J., H. Annegarn,, J.L. Privette, et al. (2001), The SAFARI 2000 dry season campaigns, *S. African J. Sci.*, submitted.

Swap, RJ, Aranibar, Dowty, Gilhooly and Macho (2001), Natural abundance of <sup>13</sup>C and <sup>15</sup>N in C3 and C4 vegetation of Southern Africa: Patterns and implications, *Global Ch. Biol.*, submitted.

White, M.A., G.P. Asrar, R.R. Nemani, J.L. Privette and S.W. Running (2000), Measuring fractional cover and leaf area index in arid ecosystems: digital camera, radiation transmittance and laser altimetry results, *Remote Sens. Environ.*, 74(1):45-57.

• **Abstracts submitted for presentations after 26 Sept. 2001 (SAVE team)**

Annegarn, Swap, Suttles, Privette, et al. (2001), Ground, Airborne and Satellite Observations of the “River of Smoke” Biomass Burning Plume over Southern Africa During SAFARI 2000, Regional Haze and Global Radiation Balance Aerosol Measurements and Models: Closure, Reconciliation and Evaluation, a speciality conference of AGU

Hanan, Scholes and Privette (2001), Carbon, water and energy fluxes in an African savanna ecosystem, abstract submitted to AGU Fall Meeting, San Francisco

Helmlinger, M., Privette, J.L. and Buerman W. (2001), BRFLAI linkages for the Sua Pan and Skukuza tower sites, SAFARI 2000 Dry Season Campaign, abstract submitted to AGU Fall Meeting, San Francisco

Privette, Morisette, Myneni, Tian, Swap and Thompson (2001), Satellite validation in SAFARI 2000: Southern Africa Validation of EOS, abstract of invited talk for AGU Fall Meeting, San Francisco

Schaaf, C.B.,..., Privette and Roy (2001), Annual Cycle of MODIS Albedo, Nadir BRDF-Adjusted Reflectance and BRDF Products, abstract submitted to AGU Fall Meeting, San Francisco

**APPENDIX I.**

**SAVE-sponsored year-round data collection**

<b>Parameter</b>	<b>Location</b>	<b>Start</b>	<b>Frequency</b>	<b>SAVE Lead</b>
Soil moisture	Skukuza	8/99	Continuous	Pinheiro
Soil temperature	Skukuza	8/99	Continuous	Pinheiro
LAI/ %Cover	Skukuza, Mongu	8/99, 3/00	Periodic	Privette
Surface albedo	Skukuza, Mongu	8/99, 3/00	Continuous	Privette
Aerosol AOT	Skukuza, Mongu	7/98	Continuous	Swap
Aerosol source attribution	Skukuza, Mongu	7/99	Continuous	Swap
Surface temperature	Skukuza, Mongu	2/00, 9/00	Continuous	Pinheiro

**Ground-based data collection during Intensive Flying Campaign (August, September 2000) by SAVE researchers\***

<b>Instrument</b>	<b>Measured Parameter</b>
Handheld spectrometer (ASD)	Endmember and landscape spectra
Handheld radiometers (Everest and Teletemp)	Endmember or scene brightness temperature
GPS camera (Konica LandMaster)	Color photographs with imprinted coordinates
Multispectral camera (Dycam Agric. Digital Camera)	Vegetation Index photography
PMS Pressure chamber (PMS)	Leaf water potential
LI-1600 Steady-state porometer (LICOR)	Leaf stomatal conductance
Soil characterization	Soil bulk density, texture, %sand, % silt, %clay
Tracing Radiation and Architecture of Canopy (TRAC; 3 <sup>rd</sup> Wave Engineering)	Leaf area index (LAI), overstory gap fraction, clumping index
Plant Canopy Analyzer (LICOR LAI-2000)	Effective LAI
Albedometers (Kipp and Zonen CM14)	Canopy albedo (shortwave and near-infrared)
Pyranometers (Skye and Eppley)	Shortwave irradiance
Soil temperature thermistors (Campbell Sci. 107L)	Soil temperature at 4-5 depths
Soil water reflectometers (Campbell Sci. CS615)	Volumetric soil moisture at 4-5 depths
Thermal radiometers (Apogee IRTS-P)	Overstory and understory brightness temperature

\*All data were collected in Mongu, Zambia and Skukuza, South Africa. Highlighted parameters are collected year-round.

**APPENDIX 2.**

**SAVE Instruments and Data Products (Land and Atmosphere)**

Tracing Radiation and Architecture of Canopy (TRAC)	% cover, clumping index, LAI
LiCor Plant Canopy Analyzer (LAI-2000)	effective LAI
ASD Handheld spectrometer	endmember spectra
Kipp and Zonen NIR and SW albedometers	canopy albedo
Streaker Samplers/PIXE analysis	aerosol source attribution
CIMEL sunphotometers	aerosol opt. Depth, size distribution
Microtops II sunphotometers	aerosol opt. Depth
Campbell Sci. soil temperature thermistors (CS107)	soil temperature at 4-5 depths
Campbell Sci. soil water reflectometers (CS615)	soil moisture at 4-5 depths
Everest and Teletemp handheld radiometers (skin temperature)	endmember or scene brightness temperature
GPS photography (Konica LandMaster)	color pictures
GPS receiver data (Garmin II+)	geographic coordinates
Apogee radiometers (skin temperature)	overstory and understory brightness temps.
PMS pressure chamber (leaf water potential)	leaf water potential
Aircraft-based pyranometer (2)	landscape albedo
Aircraft-based digital camera (3 band CCD)	landscape reflectance
LI-1600 Steady-state porometer (Licor)	Leaf stomatal conductance
Soil characterization	Soil bulk density, texture, %sand, % silt, %clay



### Temporal Data Collection Frequency:

Tracing Radiation and Architecture of Canopy (TRAC)	Mongu/Skukuza: approx. monthly KT and MT campaigns: once/site
LiCor Plant Canopy Analyzer (LAI-2000)	“ “
ASD Handheld spectrometer	each IFC
Kipp and Zonen NIR and SW albedometers	Mongu/Skukuza: 10 min, year-round
Streaker Samplers/PIXE analysis	from Swap
CIMEL sunphotometers	archived at AERONET/GSFC
Microtops II sunphotometers	ea. 30 min during KT and MT site visits
Campbell Sci. soil temperature thermistors (107L)	Mongu/Skukuza: 30 min, year-round
Campbell Sci. soil water reflectometers (CS615)	Mongu/Skukuza: 30 min, year-round
Everest and Teletemp handheld radiometers (skin temperature)	each IFC
GPS photography (Konica LandMaster)	each IFC
GPS receiver data (Garmin II+)	each IFC
Apogee radiometers (skin temperature)	Mongu/Skukuza: 30 min, year-round
PMS pressure chamber (leaf water potential)	Skukuza: approx. monthly
Aircraft-based pyranometer (2)	Skukuza: approx. monthly > 9/00
Aircraft-based digital camera (3 band CCD)	Skukuza: approx. monthly > 9/00
LI-1600 Steady-state porometer (Licor)	Skukuza: each IFC
Pressure Chamber Instrument (PMS Instrument Company)	Skukuza: each IFC
Soil characterization	Mongu/Skukuza: IFC2

### In-situ Data Processing/Reduction Status as of May 2001

#### Measurement/Processing Status:

- \* Canopy Structural Data (TRAC; LAI-2000)
  - \* all Mongu data reduced and processed through Dec. '00
    - seasonal variability profile produced
  - \* Four other Kalahari Sites: data reduced and processed
  - \* Skukuza data unprocessed
  - \* Mongu and Skukuza data collection ongoing
  
- \* Albedo (Landscape scale)
  - \* Separate NIR and Shortwave
  - \* Limited Mongu data reduced and processed
  - \* Skukuza data unprocessed
  - \* Acquired overlapping MODIS albedo product
    - will validate with CAR/AirMISR products
  - \* Data collection ongoing
  
- \* Spectrometry
  - \* Landscape endmember and leaf optics acquired during IFCs
  - \* None processed
  
- \* GPS Photography Archive

- \* 4"x6" hardcopy for all KT sites and Skukuza
- \* Photos at each 50 m along each of three 750 m transects
  
- \* Soil Moisture, Temperature and Heat Flux Profiles
  - \* Heat flux only at Mongu
  - \* Skukuza: processed data from 1999 to present
    - data collection ongoing
  - \* Mongu: processed all data from 2000 (~230 days)
    - data collection stopped
  
- \* Surface Brightness Temperature (TIR)
  - \* Skukuza - Acacia and Combretum (separate stands; separate tree, grass)
    - Acacia: Day 083/2000 to present; unprocessed
    - Combretum: Day 045/2000 to present; unprocessed
    - data collection ongoing
  - \* Mongu (2 sensors on tower: 20 and 57 deg.)
    - Day 246/2000 to present; unprocessed
    - data continue to be collected