WELCOME TO
NASA APPLIED REMOTE SENSING TRAINING (ARSET)
WEBINAR SERIES

INTRODUCTION TO REMOTE SENSING FOR WILDFIRE APPLICATIONS

COURSE DATES: EVERY TUESDAY, MARCH 31- APRIL 28
TIME: 11:30 AM-12:30 PM EDT

Important Information

- One lecture per week – every Tuesday from March 31 to April 28 (11:30 AM – 12:30 PM EDT)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: http://arset.gsfc.nasa.gov/disasters/webinars/introduction-remote-sensing-wildfire-applications

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET wildfire webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

ARSET Wildfire Management

http://arset.gsfc.nasa.gov/eco/webinars/land-management

Registration: https://arset.adobeconnect.com/wildfire/event/registration.html
Agenda: NASA_ARSET_Wildfire_Webinar_Agenda.pdf
Keywords: Ecosystems, Fires and Smoke, Satellite Imagery, Vegetation Indices
Instruments/Missions: Landsat, MODIS, NPP, SMAP, VIIRS

Presentations and Recordings

Week	Date	Title	Presentation	Recording	Assignment
1	March 31, 2015	Overview of remote sensing	Week 1 Presentation Week 1 Presentation (Spanish)	View Week 1 Recording	N/A
2	April 7, 2015	Satellite sensors and data products for wildfire applications	Week 2 Presentation Week 2 Presentation (Spanish)	View Week 2 Recording	Assignment 1
3	April 14, 2015	Remote sensing products for pre- and post-fire wildfire planning and assessment	Week 3 Presentation Week 3 Presentation (Spanish)	View Week 3 Recording	N/A

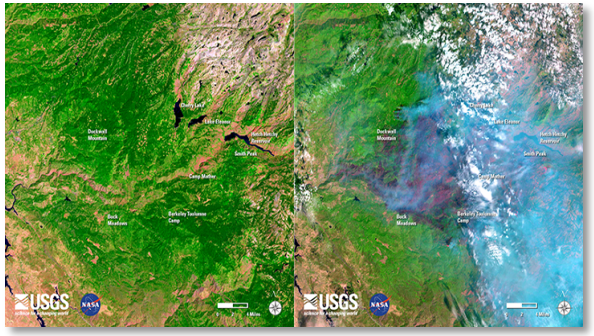
Your Course Instructors

- Cindy Schmidt (ARSET): cynthia.l.schmidt@nasa.gov
- Amber Kuss (ARSET): amberjean.m.kuss@nasa.gov
- Guest Speakers:
  - Tony Guay – USDA Forest Service Remote Sensing Applications Center (week 3)
  - Keith Weber – Idaho State University (week 3)
  - Dale Hamilton – Northwest Nazarene University (week 4)
  - Amita Mehta– NASA Goddard (week 4)
  - Lindsey Harriman – LP DAAC (week 5) lharriman@usgs.gov

General inquiries about ARSET: Ana Prados (ARSET) aprados@umbc.edu

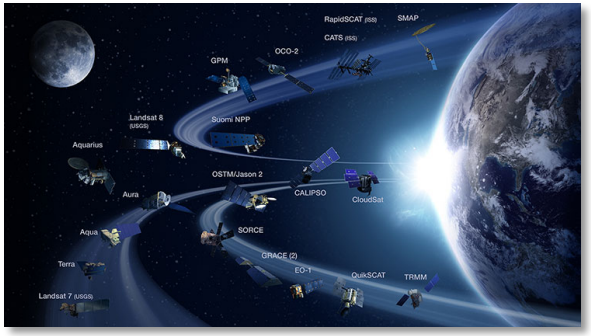
Course Outline

Week 1



Overview of satellite remote sensing

Week 2



Platforms and sensors for wildfire applications

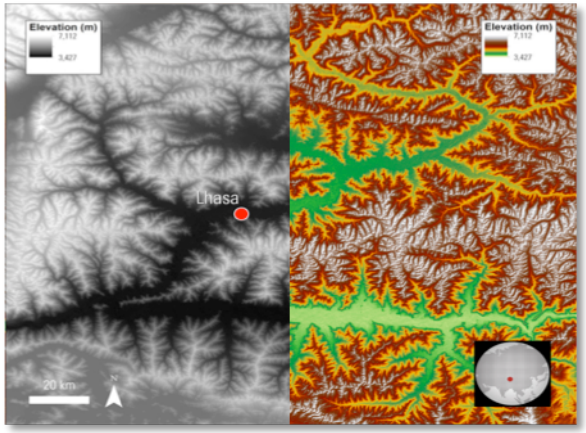
Week 3

Products and tools for pre and post-wildfire

Week 4

New techniques and technologies

Week 5



Terrain data applications

Week 4 Agenda

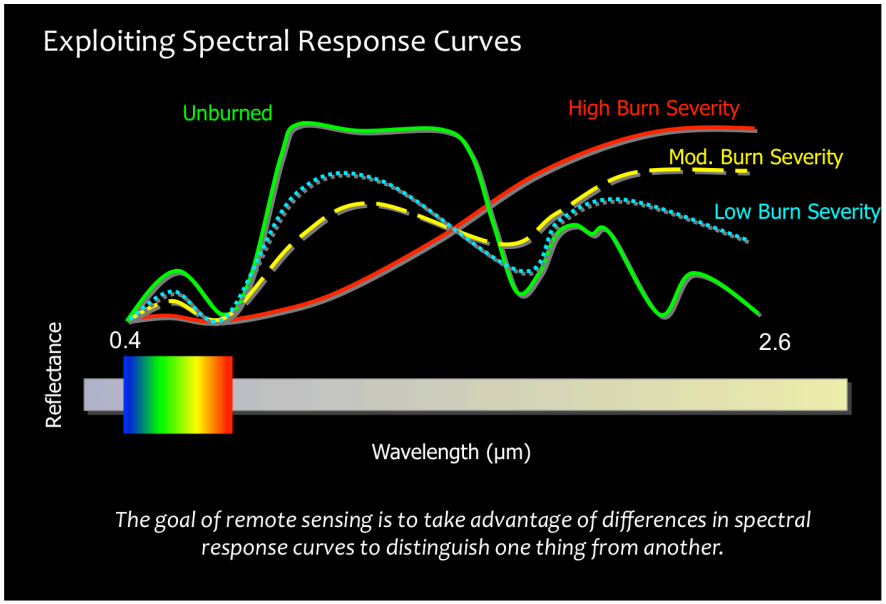
- Brief review of last week
- Guest Speaker: *Dale Hamilton*, Assistant Professor of Computer Science from Northwest Nazarene University
  - What is an Unmanned Aircraft System (UAS)
  - UAS benefits and concerns
  - UAS imagery for wildfire applications
- Guest Speaker: *Amita Mehta*, Research Scientist and ARSET team member at NASA's Goddard Space Flight Center
  - *Soil Moisture Active Passive (SMAP) sensor overview*
  - *SMAP uses for wildfire applications*
  - *SMAP data products*

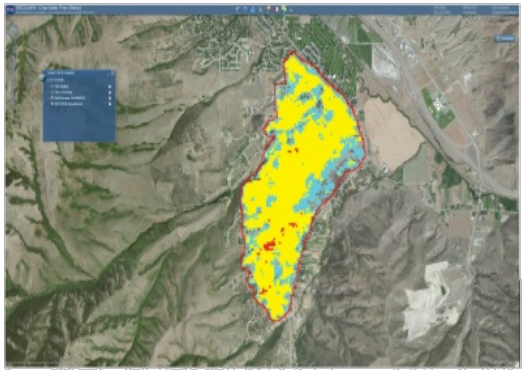
Review of Week 3

Week 3

- Post-fire Mapping Support from the USDA Forest Service
  - Fire intensity vs. burn severity
  - Spectral response curves
    - Health vegetation vs. burned areas
  - Burned Area Emergency Response (BAER)
  - Creating a Burned Area Reflectance Classification (BARC)

- RECOVER DSS
  - Rehabilitation Capability Convergence for Ecosystem Recovery
  - How data are rapidly assembled in a GIS for use by the USDI BLM, Idaho Dept. of Lands, and other wildfire management agencies
  - RECOVER live demo





RECOVER Client Web Map

Guest Speaker: Dale Hamilton

THE USE OF UNMANNED AIRCRAFT SYSTEMS (UAS) WITH WILDLAND FIRE

Dale Hamilton
Assistant Professor of Computer Science
Northwest Nazarene University

NORTHWEST NAZARENE UNIVERSITY

UAS Session Objective

- Unmanned Aircraft Systems (UAS) represent a new technology that presents the possibility of making remotely sensed wildland fire data more:

  Safe

  Responsive

  Affordable

Overview

- What is a UAS?
- UAS Benefits
  - Responsiveness
  - Safety
  - Affordability
- UAS Concerns & Constraints
  - Regulatory Constraints
  - Privacy Concerns
  - Data

What is a UAS?

An unmanned aircraft and all of the associated support equipment, control station, data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft. (www.faa.gov)

Small UAS (sUAS) Benefits

- UAS Improve Safety
  - Safety is top priority – Wildland Fire Leadership Council
  - Unmanned = no one onboard
  - Not restricted by conditions imposed on manned aircraft.
    - Night operations
    - Limited visibility
  - Perform observations unsafe for ground based personnel

UAS Benefits

- UAS Are Responsive
  - Timeliness/Availability
  - Hyperspatial imagery
  - Supplement Helicopter acquired imagery
  - Initial Attack

UAS Benefits

- UAS Are Responsive
  - Mop-up operations
  - Post fire assessments
    - Post-fire recovery plans (BAER teams)
    - Update fire history atlases
    - Update vegetation (fuels) geospatial data to reflect fire disturbance
    - Management of future fires
  - Enhance communications

UAS Benefits

- UAS Are Affordable
  - Consumer grade UAS can be purchased for as little as $1000
    - Very easy to fly
    - Technology improving to automate flight management
  - Contracting cost for a UAS is close to half of the cost of a manned helicopter.
    - Advanced Aviation Solutions / Empire Unmanned
      - www.adavso.com

UAS Concerns & Constraints

- Regulatory Constraints
  - FAA Authorization
    - Certificate of Authorization (COA)
    - Section 333 Exemption
  - Federal Agency Guidelines
    - USDA Forest Service
      - Agency guidelines under development
    - DOI Bureau of Land Management
      - Aviation Services has a nationwide COA
      - Offer training for BLM personnel

UAS Concerns & Constraints

- UAS Privacy Concerns
  - Public Perception
  - Presidential Memo on Federal Use of UAS

UAS Concerns & Constraints

- UAS Generated Data
  - Management of Large Amounts of Hyperspatial Data
    - 1000 acre fire ~= 30 Gigabytes of Data
    - Pixel Count Comparison by Resolution
      - 1 acre at 1inch = 1.4 million acres at 30m
    - Process individual images into georeferenced orthomosaic
  - Extraction of Knowledge
    - Geoanalytics to look at Imagery and extract Actionable Knowledge

UAS Image Capture Capabilities

Image taken with a DJI Phantom 2 Vision Plus at 200 ft.

Agency Points of Contact for UAS

- USDA Forest Service
  - Bob Roth

    Aviation Management Specialist

    Fire and Aviation Management – Washington Office

    rroth@fs.fed.us
- US Department of Interior
  - Brad Koeckeritz

    National Unmanned Aircraft Specialist

    DOI – Office of Aviation Services

    Bradley_koeckeritz@ios.doi.gov

Thank You

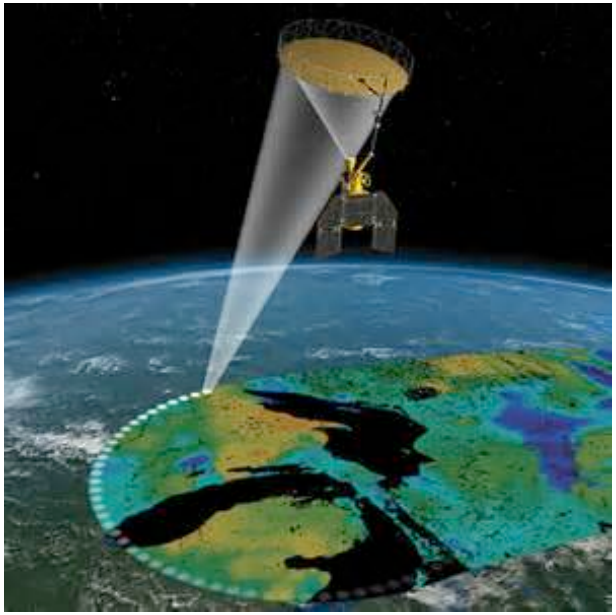
Dale Hamilton
dhamilton@nnu.edu

NORTHWEST NAZARENE UNIVERSITY

Guest Speaker: Amita Mehta

Outline

- Soil Moisture and Wildfires
- Overview of NASA Soil Moisture Data
- Overview of Soil Moisture Active Passive (SMAP) Mission
- SMAP Data Products
- SMAP Applications



Soil Moisture and Wildfire

Impacts of soil moisture conditions on regional fire activities are well documented, for example:

- Satellite observations of terrestrial water provide early warning of drought and fire season severity over Amazon (Chen et al., 2013)
- Soil moisture impacts fire severity and extent of burned area in the Siberian Forest (Bartsch et al., 2009)
- Past season's soil moisture condition provide a good prediction of fire indices (Forkel et al., 2012)
- Satellite-based vegetation and soil moisture help monitor fire risk (Dashupta and Qu, 2006)

Fire also has significant influence on soil moisture conditions through loss of vegetation and is an important factor to consider for post-fire management activities (http://www.fs.fed.us/rm/pubs/rmrs_gtr042_4.pdf)

References provided in the Appendix

NASA's Satellites for Soil Moisture

Satellite	Sensors	Quantities
Aqua	Advanced Microwave Scanning Radiometer for EOS (AMSR-E) (May 2002 to October 2011) (Level-3 data at 25 km Equal area grids)	Snow Water Equivalent, Sea Ice, Soil Moisture, Rain Rate
TRMM (Tropical Rainfall Measuring Mission)	TRMM microwave Imager (TMI) (November 1997 to present – but will end soon) (Level-3 gridded data available at 1/8th degree)	Rainfall, Vertical Rain Profile, Soil Moisture

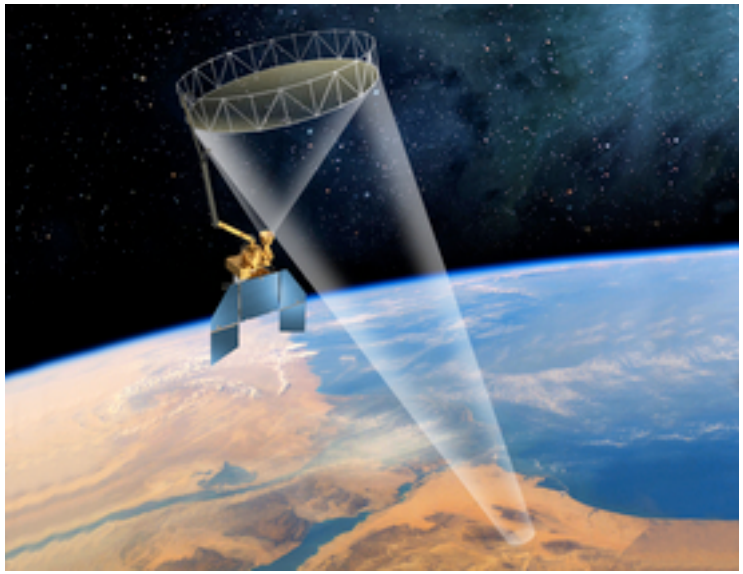
Soil Moisture Active Passive (SMAP) was launched in January 2015, dedicated for high-resolution, high-quality soil moisture measurements

Overview of NASA's Soil Moisture Active Passive (SMAP) Mission

SMAP Mission

http://smap.jpl.nasa.gov/mission

- SMAP is designed to measure the amount of water in **the top 5 cm (2 inches)** of soil everywhere on Earth's surface
- SMAP will also determine if the ground is frozen or thawed in colder areas of the world
- SMAP will produce global maps of soil moisture



SMAP was launched on 31 January 2015

SMAP Mission

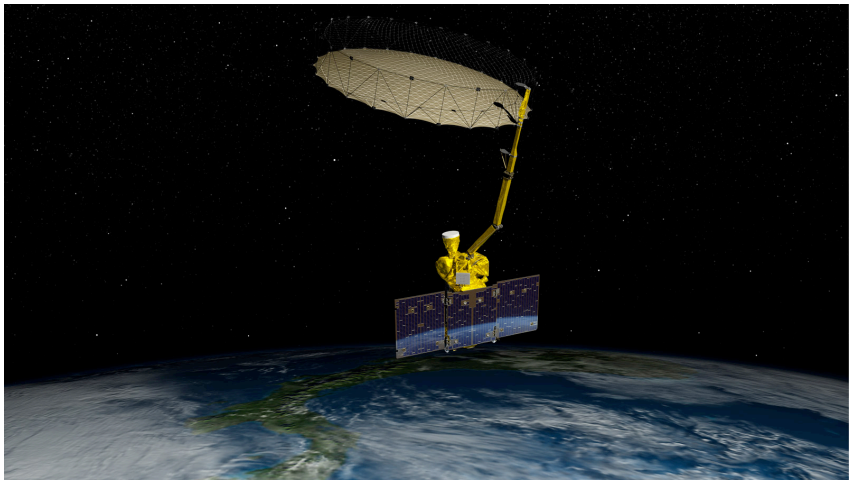
http://smap.jpl.nasa.gov/observatory/specifications/

- SMAP is in a near-polar orbit:

  Altitude *685 km*
  Repeat Ground Track *8 Days*
  Measurements: *6 am/pm*

- SMAP mission life is expected to be ~3 years

- SMAP coverage:
  Global land area at **three-day average intervals**,
  Land region above **45N at two-day average intervals**



20-foot (6-meter) reflector antenna on NASA's new Soil Moisture Active Passive (SMAP) observatory to begin spinning for the first time.

SMAP Sensors

http://smap.jpl.nasa.gov/observatory/specifications/

SMAP carries two sensors

Sensor	Frequency (L-Band)	Spatial Resolution
Radar (Synthetic Aperture)	1.26 Ghz	10 km Soil Moisture 1-3 km Freeze-Thaw
Radiometer	1.41 Ghz	40 km (IFOV 38 km x 49 km)

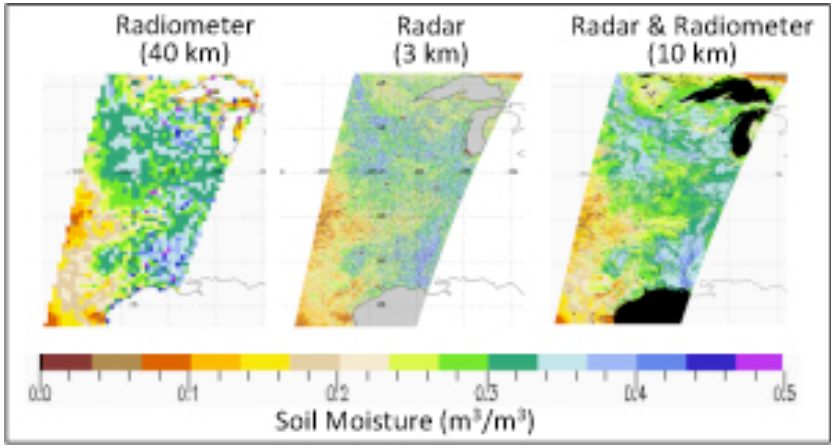
SMAP Data Products

SMAP Data Products

http://smap.jpl.nasa.gov/data/

SMAP Data Products Include Soil Moisture Content and Freeze-Thaw Sate

- More accurate soil moisture data from the radiometer with lower resolution (36 km) are combined with higher resolution (3 km) but less accurate moisture data from the radar
- The combined data provide accurate soil moisture (units m^3/m^3) maps with resolution of 9 km



SMAP algorithm details can be found at http://smap-archive.jpl.nasa.gov/science/dataproducts/ATBD/

SMAP Data Products

http://smap.jpl.nasa.gov/data/

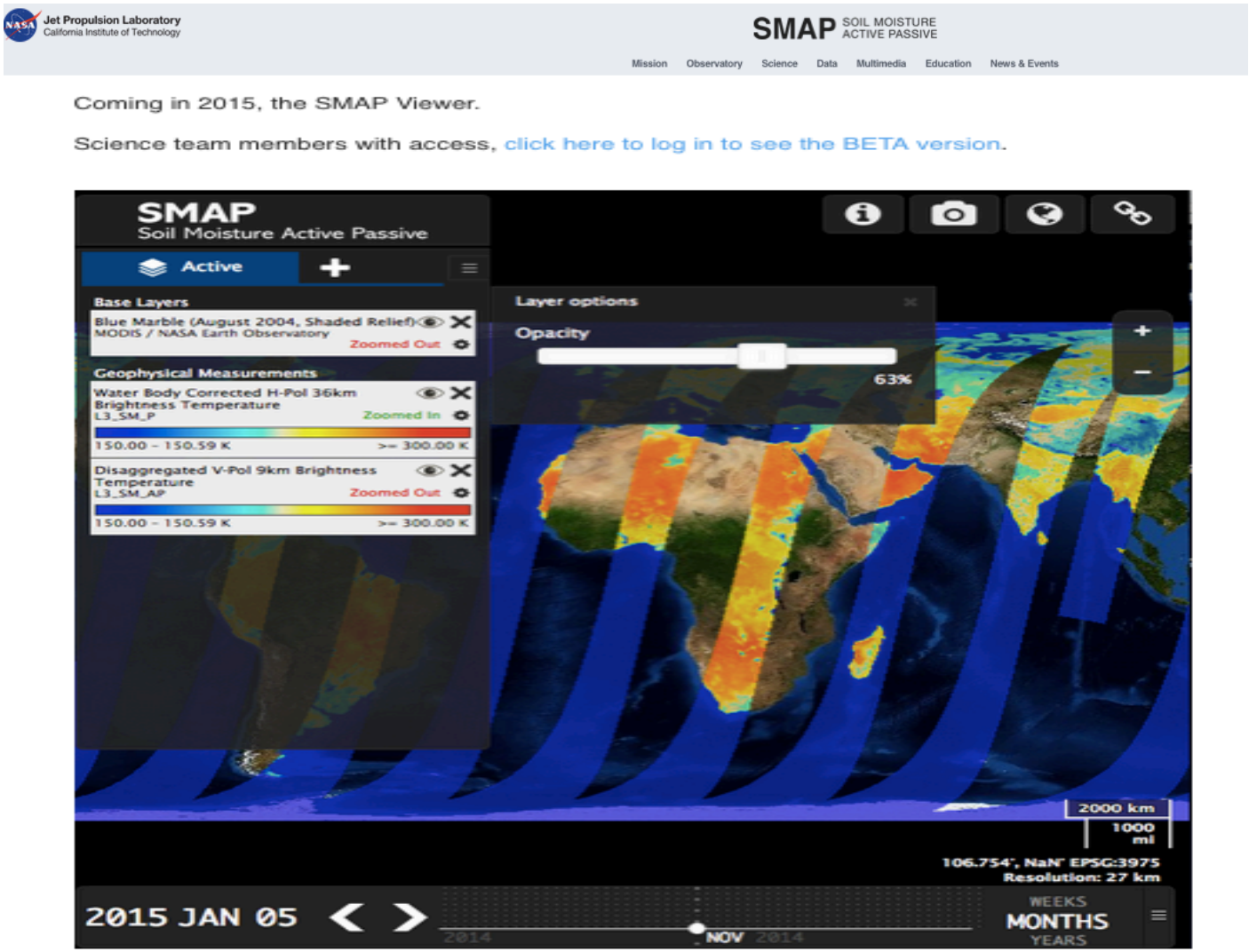
Product	Description	Gridding (Resolution)	Latency**	
L1A_Radiometer	Radiometer Data in Time-Order	-	12 hrs	Instrument Data
L1A_Radar	Radar Data in Time-Order	-	12 hrs	
L1B_TB	Radiometer T_B in Time-Order	(36×47 km)	12 hrs	
L1B_S0_LoRes	Low-Resolution Radar σ_o in Time-Order	(5×30 km)	12 hrs	
L1C_S0_HiRes	High-Resolution Radar σ_o in Half-Orbits	1 km (1−3 km)#	12 hrs	
L1C_TB	Radiometer T_B in Half-Orbits	36 km	12 hrs	
L2_SM_A	Soil Moisture (Radar)	3 km	24 hrs	Science Data (Half-Orbit)
L2_SM_P*	Soil Moisture (Radiometer)	36 km	24 hrs	
L2_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	24 hrs	
L3_FT_A*	Freeze/Thaw State (Radar)	3 km	50 hrs	Science Data (Daily Composite)
L3_SM_A	Soil Moisture (Radar)	3 km	50 hrs	
L3_SM_P*	Soil Moisture (Radiometer)	36 km	50 hrs	
L3_SM_AP*	Soil Moisture (Radar + Radiometer)	9 km	50 hrs	
L4_SM	Soil Moisture (Surface and Root Zone)	9 km	7 days	Science Value-Added
L4_C	Carbon Net Ecosystem Exchange (NEE)	9 km	14 days	

Over outer 70% of swath.
** The SMAP Project will make a best effort to reduce the data latencies beyond those shown in this table.
* Product directly addresses the mission L1 science requirements.

SMAP Data Merged with Land Surface Model

SMAP Data Viewer Coming Soon

http://smap.jpl.nasa.gov/map/



View SMAP satellite data in a visual format

SMAP Data Products Portals

http://smap.jpl.nasa.gov/data/

- The SMAP science data products will be available to the public through two NASA-designated Earth science data centers

  - The Alaska Satellite Facility (Level 1 radar products) https://www.asf.alaska.edu/

  - The National Snow and Ice Data Center (all other products) http://nsidc.org/

- The SMAP data products will be in Hierarchical Data Format version 5 (HDF-5) format

SMAP Data Products Availability

http://smap.jpl.nasa.gov/data/

- The SMAP mission is currently conducting a post-launch calibration and validation (Cal/Val)

- The duration of the Cal/Val phase:

  6 months for Level 1 products
  12 months for Level 2, Level 3, and Level 4 products

SMAP Data Products Strengths

- High-resolution and high-accuracy than earlier soil moisture data from AMSR-E/ TMI
- Better sensing over vegetated surface
- Deeper soil moisture (1-5 cm) available
- Freeze-Thaw state available


(NASA Goddard, 2014)


(NASA JPL, 2014)

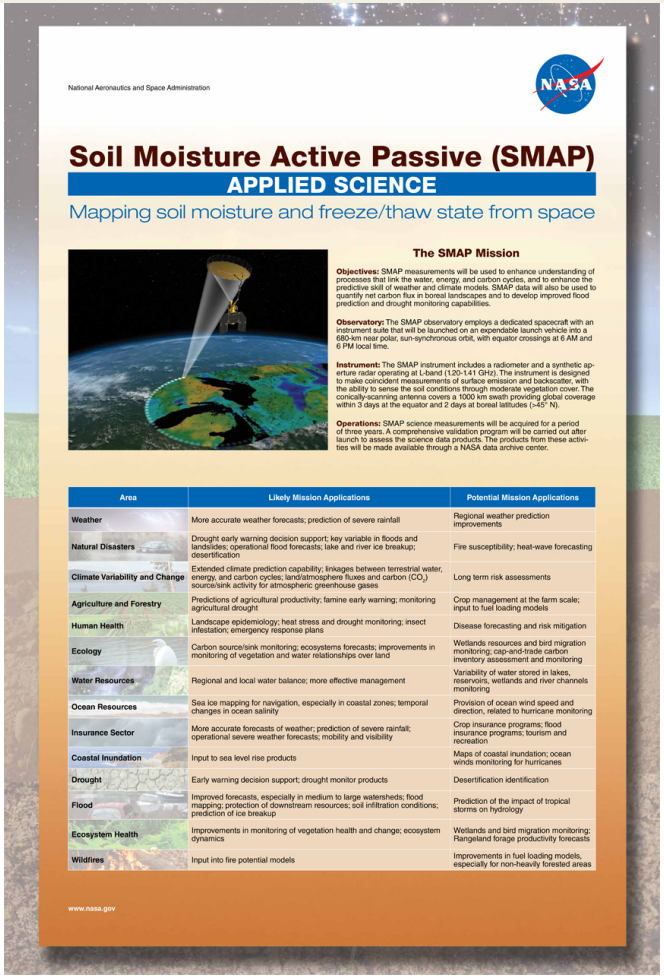
SMAP Applications

SMAP Application Areas

http://smap.jpl.nasa.gov/science/applications/

- Weather and Climate Forecasting
- Droughts and **Wildfires**
- Floods and Landslides
- Agricultural Productivity
- Human Health
- National Security

Applied Science Poster available from the SMAP Applications Web-site



National Aeronautics and Space Administration

Soil Moisture Active Passive (SMAP)

APPLIED SCIENCE

Mapping soil moisture and freeze/thaw state from space

The SMAP Mission

Objectives: SMAP measurements will be used to enhance understanding of processes that link the water, energy, and carbon cycles, and to enhance the predictive skill of weather and climate models. SMAP data will also be used to quantify net carbon flux in boreal landscapes and to develop improved flood prediction and drought monitoring capabilities.

Observatory: The SMAP observatory employs a dedicated spacecraft with an instrument suite that will be launched on an expendable launch vehicle into a 680-km near polar, sun-synchronous orbit, with equator crossings at 6 AM and 6 PM local time.

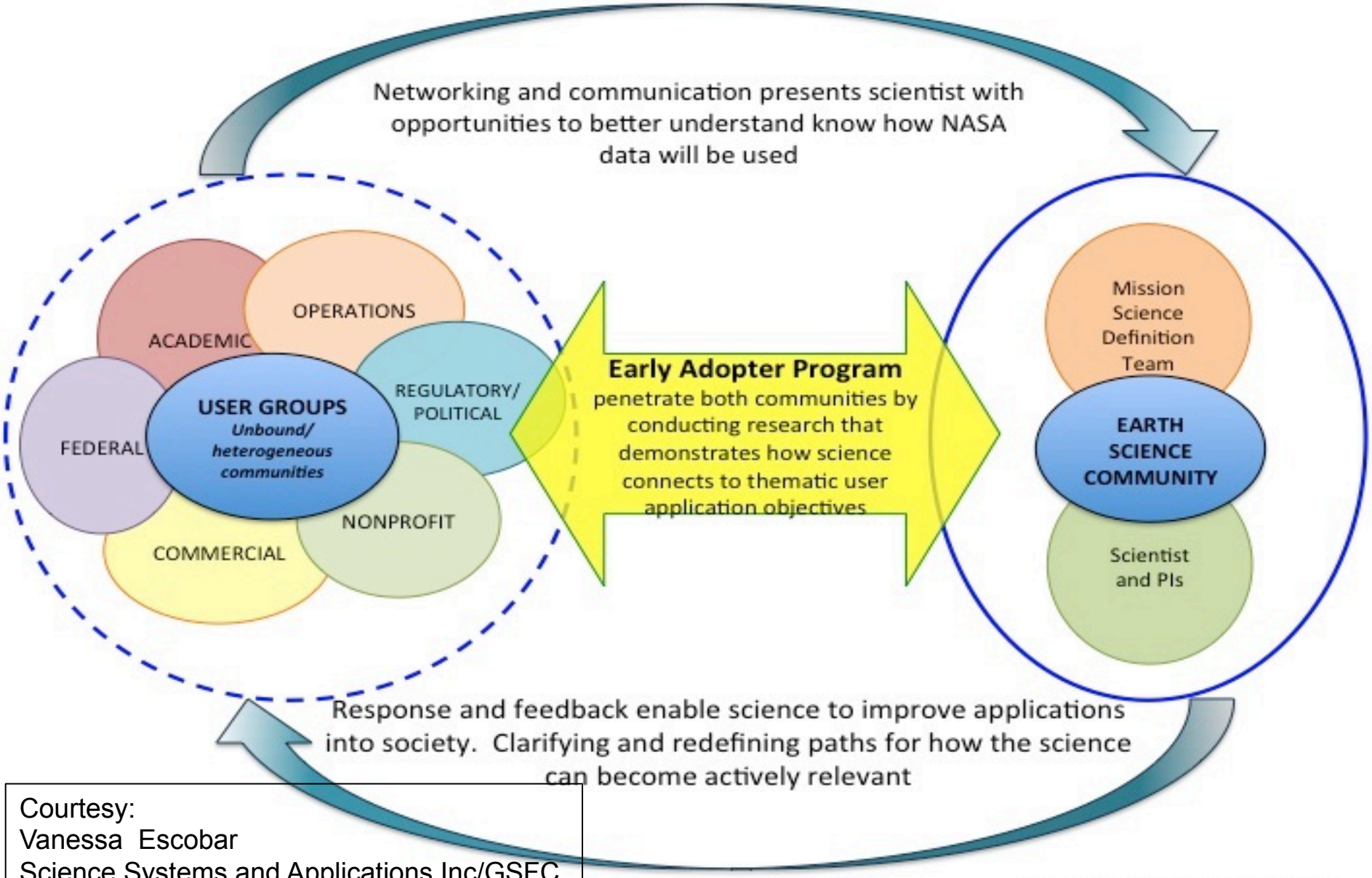
Instrument: The SMAP instrument includes a radiometer and a synthetic aperture radar operating at L-band (1.20-1.41 GHz). The instrument is designed to make coincident measurements of surface emission and backscatter, with the ability to sense the soil conditions through moderate vegetation cover. The conically-scanning antenna covers a 1000 km swath providing global coverage within 3 days at the equator and 2 days at boreal latitudes (>45° N).

Operations: SMAP science measurements will be acquired for a period of three years. A comprehensive validation program will be carried out after launch to assess the science data products. The products from these activities will be made available through a NASA data archive center.

Area	Likely Mission Applications	Potential Mission Applications
Weather	More accurate weather forecasts; prediction of severe rainfall	Regional weather prediction improvements
Natural Disasters	Drought early warning decision support; key variable in floods and landslides; operational flood forecasts; lake and river ice breakup; desertification	Fire susceptibility; heat-wave forecasting
Climate Variability and Change	Extended climate prediction capability; linkages between terrestrial water, energy, and carbon cycles; land/atmosphere fluxes and carbon (CO_2) source/sink activity for atmospheric greenhouse gases	Long term risk assessments
Agriculture and Forestry	Predictions of agricultural productivity; famine early warning; monitoring agricultural drought	Crop management at the farm scale; input to fuel loading models
Human Health	Landscape epidemiology; heat stress and drought monitoring; insect infestation; emergency response plans	Disease forecasting and risk mitigation
Ecology	Carbon source/sink monitoring; ecosystems forecasts; improvements in monitoring of vegetation and water relationships over land	Wetlands resources and bird migration monitoring; cap-and-trade carbon inventory assessment and monitoring
Water Resources	Regional and local water balance; more effective management	Variability of water stored in lakes, reservoirs, wetlands and river channels monitoring
Ocean Resources	Sea ice mapping for navigation, especially in coastal zones; temporal changes in ocean salinity	Provision of ocean wind speed and direction, related to hurricane monitoring
Insurance Sector	More accurate forecasts of weather; prediction of severe rainfall; operational severe weather forecasts; mobility and visibility	Crop insurance programs; flood insurance programs; tourism and recreation
Coastal Inundation	Input to sea level rise products	Maps of coastal inundation; ocean winds monitoring for hurricanes
Drought	Early warning decision support; drought monitor products	Desertification identification
Flood	Improved forecasts, especially in medium to large watersheds; flood mapping; protection of downstream resources; soil infiltration conditions; prediction of ice breakup	Prediction of the impact of tropical storms on hydrology
Ecosystem Health	Improvements in monitoring of vegetation health and change; ecosystem dynamics	Wetlands and bird migration monitoring; Rangeland forage productivity forecasts
Wildfires	Input into fire potential models	Improvements in fuel loading models, especially for non-heavily forested areas

www.nasa.gov

SMAP Early Adopter Concept



Courtesy:
Vanessa Escobar
Science Systems and Applications Inc/GSFC

Diagram by V.M. Escobar, 2012

SMAP Early Adopters through mid 2013

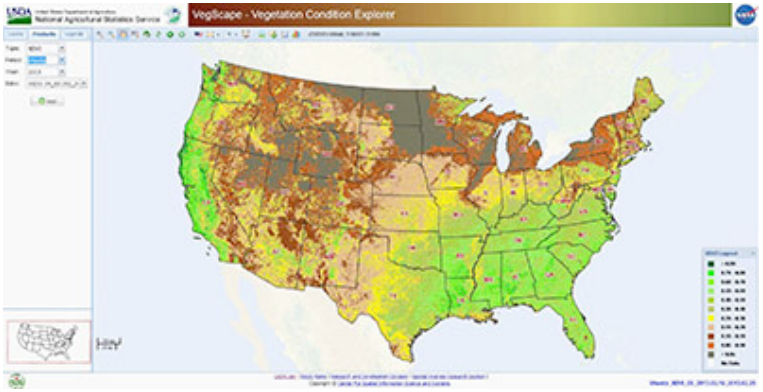
SMAP Early Adopters		
	Investigator and Institution	**Applications Research Topic**
Selected in 2011		
1	**Stephane Belair**, Meteorological Research Division, Environment Canada (EC)	*Assimilation and impact evaluation of observations from the SMAP mission in Environment Canada's Environmental Prediction Systems*
2	**Hosni Ghedira**, Masdar Institute, UAE	*Estimating and mapping the extent of Saharan dust emissions using SMAP-derived soil moisture data*
3	**Zhengwei Yang and Rick Mueller**, USDA National Agricultural Statistical Service (NASS)	*U.S. National cropland soil moisture monitoring using SMAP*
4	**Catherine Champagne**, Agriculture and Agri-Food Canada (AAFC)	*Soil moisture monitoring in Canada*
5	**Amor Ines and Stephen Zebiak,** International Research Institute for Climate and Society (IRI) Columbia University	*Seasonal climate forecasts with dynamic crop simulation models for crop forecasting and food security early warning applications*
6	**Lars Isaksen and Patricia de Rosnay**, European Centre for Medium-Range Weather Forecasts (ECMWF)	*Monitoring SMAP soil moisture and brightness temperature at ECMWF*
7	**Xiwu Zhan, Michael Ek and John Simko**, NOAA National Environmental Satellite Data and Information Service, Center for Satellite Applications and Research (NOAA-NESDIS-STAR)	*Transition of NASA SMAP research products to NOAA operational numerical weather and seasonal climate predictions and research hydrological forecasts*
Selected in 2012		
8	**Curt Reynolds**, USDA Foreign Agricultural Service (FAS)	*Enhancing USDA's global crop production moni SMAP soil moisture products*
9	**John Eylander**, U.S. Army Engineer Research and Development Center (ERDC) Cold Regions Research and Engineering Laboratory (CRREL)	*U.S. Army Engineer Research and Development adoption for USACE civil and military tactical s*
10	**Jim Reardon and Gary Curcio**, US Forest Service (USFS)	*Wildfire danger and estimated smoldering pote soils of the North Carolina coastal plain*
11	**Gary McWilliams, Li Li, Andrew Jones and George Mason**, Dept. of Defense - Soil Moisture Applications Consortium (SMAC)	*Exploitation of SMAP data for Army and Marine assessment*
12	**Michael Ek, Marouane Temimi, Xiwu Zhan**, NOAA National Centers for Environmental Prediction (NCEP)	*Integration of SMAP freeze/thaw product into the NOAA NCEP weather forecast models*
13	**John Galantowicz**, Atmospheric and Environmental Research, Inc. (AER)	*Use of SMAP-derived inundation and soil moisture estimates in the quantification of biogenic greenhouse gas emissions*
14	**Jingfeng Wang, Rafael Bras and Aris Georgakakos**, Georgia Institute of Technology (GIT)	*Application of SMAP observations in modeling energy/water/carbon cycles and its impact on weather and climatic predictions*
15	**Kyle McDonald**, City College of New York (CUNY) and CREST Institute, and **Don Pierson**, New York City Dept. of Environmental Protection	*Application of SMAP freeze/thaw and soil moisture products for supporting management of New York City's potable water supply*
16	**Chris Funk, Amy McNally and James Verdin**, US Geological Survey & UC Santa Barbara	*Incorporating soil moisture retrievals into the Famine Early Warning System (FEWS) Land Data Assimilation System (FLDAS)*
17	**Fiona Shaw**, Willis, Global Analytics	*eNCOMPASS – A risk identification and analysis system for insurance; Multiple catastrophe risk models, risk rating tools and risk indices for insurance and reinsurance purposes including a Global Flood Model*
18	**Rafael Ameller**, StormCenter Communications, Inc.	*SMAP for enhanced decision making (emergency management)*
Selected in 2013		
19	**Jonathan Case and Clay Blankenship,** Marshall Space Flight Center and Universites Space Flight Center	*Application of Next-Generation Satellite Data to a High-Resolution, Real-Time Land Surface Model with SMAP.*
20	**Barbara S. Minske**, University of Illinois and sponsored by John Deere Inc.	*Comprehensive, Large-Scale Agriculture and Hydrologic data Synthesis*
21	**Thomas Harris,** Exelis Visual Information Solutions	*Utilization of SMAP Products in ENVI, IDL and SARscape-Products L1 to L4*

Courtesy:
Vanessa Escobar
Science Systems and Applications Inc/GSFC

SMAP Early Adopters Examples

http://smap.jpl.nasa.gov/science/early-adopters/

USDA has VegScape for accessing, visualizing, assessing and disseminating crop soil moisture condition derivative data products produced using SMAP data



USDA VegScape Application

Global Insurance and Re-Insurance

Willis Global Analytics is merging satellite data from NASA into existing risk identification and analysis systems for insurance and reinsurance, engaging end users to enhance decision making with SMAP products.

SMAP Application for Wildfire

http://smap.jpl.nasa.gov/science/applications/

SMAP Data will be useful to:

- Assess conditions conducive to wildfires
  - Surface soil moisture
  - Vegetation water content
- Determine prescribed burning conditions
- Estimate smoldering combustion potential of organic soils
- Provide input for post-fire burn severity assessment
- Improve wildfire information with SMAP soil moisture products to provide more useful and accurate data on toxic air-quality events and smoke white-outs (increasing transportation safety)

Thank You

Amita Mehta email: amita.v.mehta@nasa.gov

Appendix

References:

Bartsch, A., H. Balzter, and C. George, 2009: The influence of regional surface soil moisture anomalies on forest fires in Siberia observed from satellites, *Environ. Res. Lett.* **4** 045021 doi:10.1088/1748-9326/4/4/045021,

Chen, Y., I. Velicongna, J. Faniglietti, J. Renderson, 2013: Satellite observations of terrestrial water storage provide early warning information about drought and fire season severity in the Amazon, JOURNAL OF GEOPHYSICAL RESEARCH-BIOGEOSCIENCES , 118, DOI: 10.1002/jgrg.20046 .

Dasgupta S. and J. Qu, 2006: Combining MODIS and AMSR-E based vegetation moisture retrievals for improved fire risk monitoring, Proceedings of SPIE - The International Society for Optical Engineering 01/2006; 6298. DOI: 10.1117/12.681147

Forkel, M., T. Kirsten, B. Christian, C. Wolfgang, B. Sergey , C. Schmullius, 2012: *ENVIRONMENTAL ENVIRONMENTAL RESEARCH LETTERS*, 7 (4), DOI: 10.1088/1748-9326

Coming up next week!

Week 5: Terrain data applications

Important Information

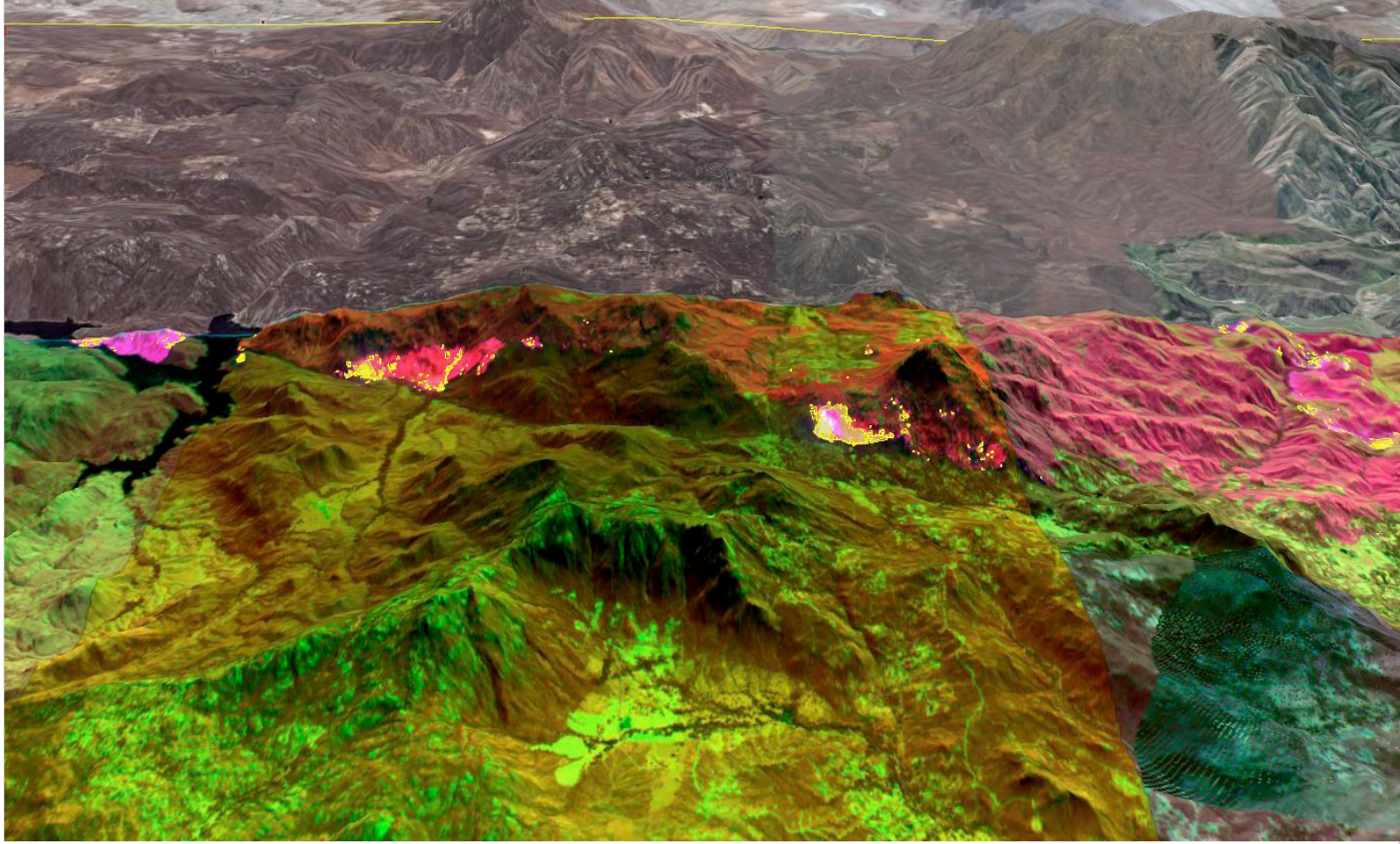
- One lecture per week – every Tuesday from March 31 to April 28 (11:30 AM – 12:30 PM EDT)

- Webinar recordings, PowerPoint presentations, and homework assignments can be found after each session at: https://arset.gsfc.nasa.gov/disasters/webinars/introduction-remote-sensing-wildfire-applications

- Certificate of Completion
  - Attend 4 out of 5 webinars
  - Assignment 1 and 2 – access from the ARSET wildfire webinar website (above)
  - You will receive certificates approximately 1 month after the completion of the course from: marines.martins@ssaihq.com

- Q/A: 15 minutes following each lecture and/or by email (cynthia.l.schmidt@nasa.gov)

Thermal-infrared image from NASA's Ikhana unmanned aircraft of the Harris fire in October 2007. The active wildfire fronts are in yellow and red, while hot, previously burned areas are in shades of dark red and purple. Unburned areas are shown in green hues.



Thank You!!

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