National Aeronautics
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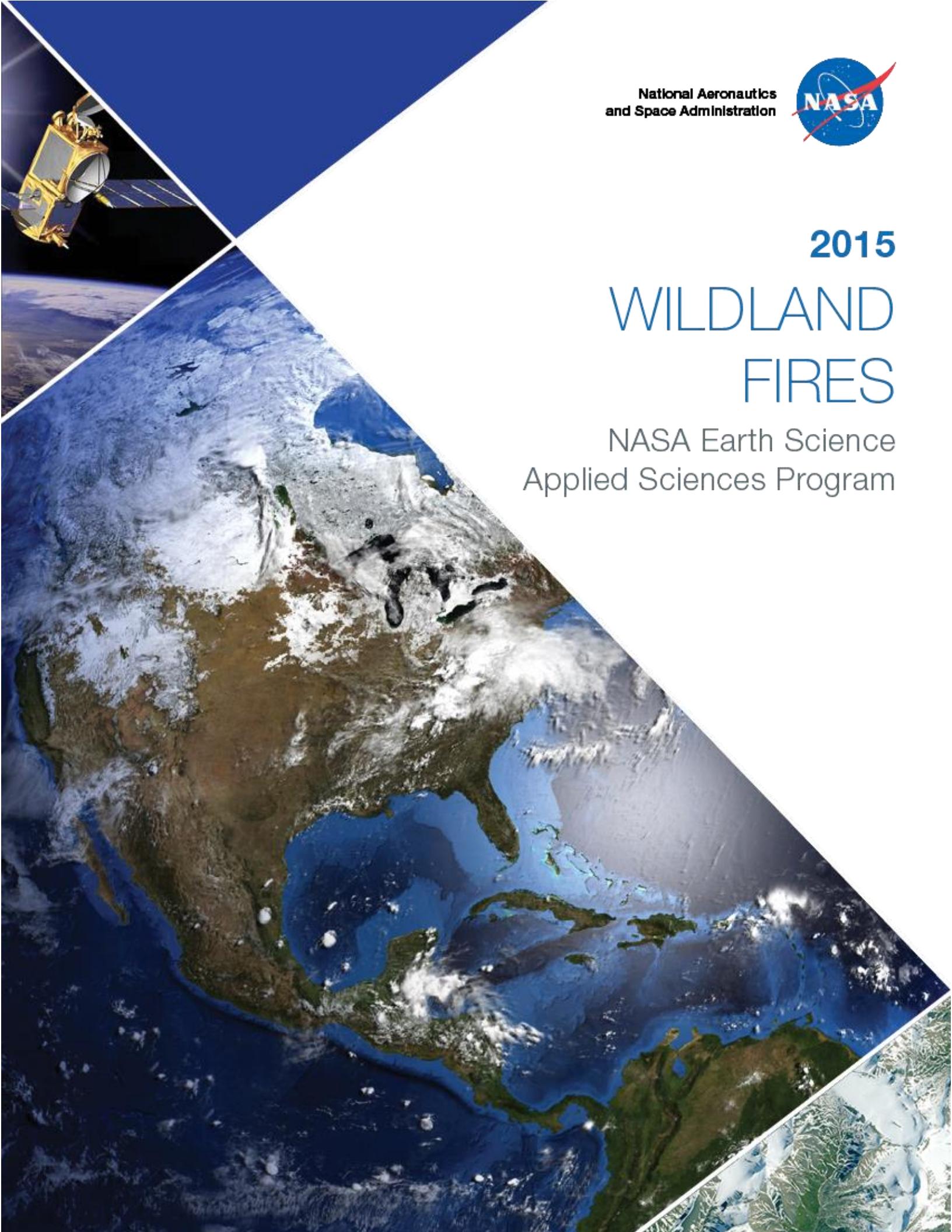
2015
WILDLAND FIRES

NASA Earth Science
Applied Sciences Program



NASA Earth Science Division
Applied Sciences Program

Wildland Fires: 2015 Annual Summary

Table of Contents

I.	Introduction	1
II.	Overview of 2015	1
III.	Major Accomplishments	3
IV.	Program Assessment	5
V.	Project Portfolio	7
VI.	Program Management	11
VII.	Community Leadership	13
VIII.	International Activities	15
IX.	Looking Ahead	17
X.	Appendix	19
	A. Publications, Presentations, Related Items	19
	B. Abbreviations and Acronyms	25

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I. Introduction

The NASA Earth Science Division's (ESD) Applied Sciences Program promotes efforts to discover and demonstrate innovative, practical, and beneficial uses of Earth-observing environmental satellite data, models, and scientific knowledge. All Program activities support goals to deliver near-term applications of Earth observations, build capabilities to apply Earth science data, and contribute to satellite mission planning. The Program conducts projects in partnership with private and public-sector organizations to inform their decisions and actions, transitioning successful, mature applications to sustain the benefits of Earth science to society.

The Applied Sciences Program's applications themes are currently focused on four of the eight societal benefit areas of the international Group on Earth Observations (GEO): Health (including Air Quality), Disasters, Ecological Forecasting, and Water Resources.[1] In addition, there is a Wildland Fires theme and an initiative on Food Security. The Program includes the impacts from a changing climate within each of these topics.

Fire, especially wildland fire (aka, wildfires), constitutes a cross-cutting issue in Earth system science and touches on aspects of many applications areas. From 2002 to 2011, the Applied Sciences Program supported numerous projects and activities related to wildland fire in several applications areas. In 2011, the Program created an element focused specifically on wildfires, addressing issues from pre-fire through active-fire to post-fire stages. The Wildland Fires program issued a dedicated solicitation (ROSES-2011 A.35 Wildland Fires) and selected 17 feasibility studies. In 2014, the program selected nine of these studies to continue as full-scale applications projects.

II. Overview of 2015

The past year was a very productive one for the Wildland Fires program. A majority of the projects advanced one or more Applications Readiness Levels (ARL) in their push towards establishing applications that will be fully adopted by their partner organizations and others. Numerous projects reached major milestones and advanced the use of Earth observations and models to support wildfire management. Projects and their partners were the subject of press releases and videos, and received media attention for their achievements. Two wildfire-related trainings by the Applied Sciences Program were extremely successful, drawing on expertise from across the Wildland Fires project portfolio.

The year was also a very busy one. In addition to all of the project-focused activities, there were numerous events, conferences, and committees to which the Wildland Fires program management team and projects contributed. Early in 2015, the program held its first Wildland Fires team meeting, which helped further interactions across projects and inform partners of the applications and progress. The attendees explored key issues and challenges faced by

[1] The eight GEO SBAs are: Disaster Resilience; Food Security and Sustainable Agriculture; Biodiversity and Ecosystem Sustainability; Energy and Mineral Resources Management; Public Health Surveillance; Infrastructure and Transportation Management; Urban Development; and, Water Resources Management.

wildfire management practitioners and wildfire scientists, identifying research and applications advances that would improve the understanding and management of wildland fires. Throughout the year, the Wildland Fires program team and project representatives actively participated in 12 conferences and workshops, such as the International Symposium on Remote Sensing of Environment, and the International Wildland Fire Conference.

NASA launched the SMAP (Soil Moisture Active Passive) satellite in January 2015. Through two primary instruments (a radar and a radiometer), the SMAP mission measures and maps global soil moisture and its freeze/thaw state from space. For the wildfires community, such information could support regional assessments of soil and fuel moisture anomalies, where moisture deficits can lead to increasing wildland fire potential. Unfortunately, in July 2015, the radar instrument failed. The radiometer instrument continued to perform well, providing coarse-scale information. With the public release of data in 2016, the Wildland Fires program and projects will assess the utility of the radiometer data for wildfires applications and explore combinations with radar data from other satellites.

North America endured an extreme fire year in 2015. Canada suffered one of its largest fire seasons on record with more than 10 million acres consumed by wildland fires. It was the worst fire year on record in the United States, in terms of cost and burned area.[2] The U.S. experienced a large number of fires and an above-average amount of fire acreage consumed, in comparison to the 10-year running average. There were a total of 68,151 fires burned nationwide compared to the 10-year running average (66,786 fires). The total burned area was 10,125,149 acres, which is the largest in the last decade and ~35 percent higher than the 10-year average (6,464,947 ac.).[3] It was one of only four fire years since 1960 that burned more than 9 million acres in the U.S.[4]

Northwestern states and provinces bore the brunt of the 2015 fire season. Alaska suffered one of its worst burning seasons on record with 5,110,942 acres consumed from 760 wildland fires; these Alaskan fires accounted for more than 50 percent of the nation's acreage consumed in 2015. Most of the Alaskan burning in 2015 was in the early season, which was unusual since Alaska typically experiences severe burning late in the fire season.

In the Continental U.S., Washington State had two major fires: The North Star Fire (205,605 ac.) and the Okanogan Complex (302,224 ac.). The Bear Creek Fire in Montana (70,906 ac.) was the largest fire in the Bob Marshal Wilderness history. In Idaho, the Soda Fire grew to 218,000 ac. in

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[2] There were numerous stories in the popular press about the 2015 fire year, such as:
http://www.theatlantic.com/national/archive/2015/09/just-how-bad-is-the-2015-fire-season/405439/
http://www.usatoday.com/story/news/nation/2015/12/16/costliest-wildfire-season-record/77417982/
http://www.usatoday.com/story/news/2015/12/26/wildfire-shuts-down-scenic-calif-coastal-highways/77916142/
http://www.usatoday.com/story/weather/2016/01/06/wildfires-burned-record-10-million-acres/78362786/

[3] From 1960 to 2000, the U.S. surpassed 7 million acres burned in only one year (1963).

[4] All four occurred between 2006-2015.

the course of three days. In California, three major fires raged simultaneously: Valley Fire (73,000 ac.), Butte Fire (70,000 ac.), and Rough Fire (140,000 ac.).

Three of the Wildland Fires program's projects were directly involved with the 2015 fire suppression and post-fire recovery activities, including a major effort by the Rehabilitation Capability Convergence for Ecosystem Recovery (RECOVER) project team (led by PI Keith Weber, Idaho State University), which generated near-real-time decision-support tools and products for the Idaho Soda Fire. In addition, the Autonomous Modular Sensor instrument, which NASA transferred to the United States Forest Service (USFS) in 2013, worked early-season spring fires and supported burning operations on prescription fires.

At the end of the year, the program management team was actively planning the second Wildland Fires team meeting for March 2016. The meeting will include end users, such as wildland fire management personnel, task leaders, and incident commanders. The US Forest Service's Remote Sensing Applications Center (RSAC) will co-host the meeting, which will occur near the National Interagency Fire Center (NIFC) in Boise, Idaho.

III. Major Accomplishments

The Wildland Fires program's nine projects completed their first year as full-scale applications development projects. They made substantial increases in their ARL levels (see sections below). The project teams were prolific with publications and presentations, and they received coverage of their results in news media coverage, videos, and press releases.

A few projects deserve special recognition for their progress in 2015 – some for their early beta capability, one for policy impacts, and one for adoption by partners and operational entities:

- The enhanced active-fire detection component of a project led by Wilfrid Schroeder (Univ. of Maryland-College Park) completed beta testing in 2015 and is publically and operationally available through its USFS partner (http://activefiremaps.fs.fed.us/). A new algorithm developed by the project takes advantage of the Suomi NPP's VIIRS 375m I-Band, which enables the detection of smaller fires in comparison to previous space-based products (increases resolution by about three times). NASA, USFS, and NOAA jointly developed press releases on the work, bringing attention to the maturation of the VIIRS I-band fire product as an improved, verifiable monitoring tool for fire. NASA produced a *Taking the Wild out of Wildfires* video based on this project for its ScienceCast series.[5]

- Project efforts led by Mary Ellen Miller (Michigan Tech Research Institute) provided modeling support to Burned Area Emergency Response (BAER) teams on multiple fires

[5] https://www.youtube.com/user/ScienceAtNASA
http://science.nasa.gov/science-news/science-at-nasa/2015/01dec_wildfire/

in 2015.[6] This team tackled numerous emergency fire disaster calls in response to partners' and others' requests. BAER teams on the Valley (76,000 ac.) and Butte (71,000 ac.) fires were concerned that El Niño conditions in winter 2015-16 could result in above-average precipitation for the burned area; therefore, her team developed wetter model runs to showcase possible problematic areas in those post-fire regimes. The USFS BAER team on the Canyon Creek fire (110,000 ac.) wanted to simulate the potential detrimental effects of a 5-year storm event[7] on the burned area. Miller's team provided multiple simulations that were dependent on ground cover type by burn severity, which provided estimates of the potential for debris flows, runoff, slope instability, and erosion.

The project's database expanded to cover 17 Western states.[8] It proved to be indispensable when modeling multiple small fires that burned in national forests in Idaho. The rapid delivery of model inputs provides more time for BAER teams to model different scenarios and propose remediation treatments.

In addition, Miller received the Best Oral Presentation award at the 36th International Symposium on Remote Sensing of Environment in May in Berlin, Germany.

- Colorado Governor John Hickenlooper signed a bill on May 22, 2015, authorizing "the state to spend $1.2 million over the next two years on a 'revolutionary' wildfire prediction system that uses weather data, groundbreaking computer modeling, and high resolution satellite imagery to predict the spread of fires up to 18 hours in advance."[9] This move stemmed from work by Janice Coen (NCAR), a co-investigator on the Schroeder-led project, to implement her coupled weather-wildland fire behavior model that helps forecast fire spread. This model uses the enhanced VIIRS fire-detection data described above to initialize the model. (In this picture from the ceremony, Coen is second from left.)

- The RECOVER project team led by Keith Weber (Idaho State University) was highlighted by the press and the wildfire management community for supporting the massive Soda Fire in southwestern Idaho during the late summer. The RECOVER team provided near-real-time updates of the fire burn area to the Incident Management team on the fire. These updates allowed them to make improved assessments of remediation activities based on burning conditions on varying vegetation and terrain interfaces, and their products aided the planning of logistical support to battle and manage the Soda Fire.

[6] Butte and Valley fires in California, Canyon Creek in Oregon, and 13 fires in the Nez Perce-Clearwater National Forest in Idaho.
[7] A rain event that would statistically occur once every five years.
[8] http://geodjango.mtri.org/geowepp/
[9] http://gazette.com/colorado-to-spend-1.2-million-to-for-wildfire-prediction-system/article/1552242

Weber also helped organize and host a highly-successful Wildland Fires Remote Sensing Applications training workshop at ISU in October. Fifty participants attended from universities, BAER assessment teams, and wildland fire incident management teams from state and national agencies.

- The Firecast project led by Karyn Tabor (Conservation International) expanded significantly in 2015.[10] The Firecast team leveraged contributions from the U.S. Agency for International Development (USAID), World Resource Institute (WRI), and Hewlett Packard (HP) to build capacity in remote regions. In Colombia, Firecast alerts expanded in coordination with the USAID-funded Forest Carbon, Markets, and Communities project and the Institute of Hydrology, Meteorology and Environmental Studies. Through WRI funding, the active fire alert system expanded in Indonesia to include Fire Flammability Risk assessments. With Bolivia's National Forest Department, the team partnered with HP and Logi Analytics to automate processes, so reports are quickly distributed and governments and communities can take immediate actions. A "dashboard" they developed allows end users to drill down into the data to quickly analyze and understand their own local monitoring system data. This allows users to visualize data to gain deeper insights of fire incidences and make quicker decisions to reallocate resources to address fires or fine land owners for violating policies. In addition, Tabor's team worked with Schroeder's team to ensure the new VIIRS fire data being served at South Africa's Advanced Fire Information System (AFIS) would also be available to her local partners.

IV. Program Management Assessment

Overall, the NASA Wildland Fires program management team was extremely pleased with the performance of the project portfolio and program activities in 2015. While the ARL metric is primarily a communications tool for the management team and projects to discuss progress and issues, the team was very pleased with the portfolio's advancement. Through the press coverage, videos, policy impacts, and awards, it was rewarding to see the project teams, partners, and wildfires community recognized for their innovations and achievements. The management team was also pleased by the commitments and contributions of the partners as well as efforts to leverage new resources, such as what the Firecast project leveraged.

The year proved to be a very active and productive one in terms of the Wildland Fires program's participation in domestic and international activities. The program participated actively in three interagency committees, five domestic conferences, four international

[10] As a fire alert system, Firecast puts data into a useable context so local governments can better track ecosystem disturbances such as fires, fire risk conditions, deforestation, and protected area encroachment. By using these data products, communities can improve critical decision-making, allowing them to quickly recognize and respond to fire threats that can directly threaten human life, biodiversity, and forest health, as well as provide critical ecosystem services like water availability, water quality, and forest pollination.

conferences, four workshops, two trainings, and one international work project. Beyond reflecting the commitment and capabilities in the wildfires community to connect research and management, these activities reflect the growing interest in the use of Earth observations for all aspects of fire science and the application of these data. In addition, as reports suggest that USFS has been forced to tap funds for wildfire suppression that typically would go to prevention and research, we're pleased that the projects' efforts help make the Earth observations, models, and tools more timely, valuable, and effective.

In 2015, the program put special emphasis on the upcoming Earth Science "Decadal Survey" conducted by the National Academy of Sciences. Since this Decadal Survey generates consensus recommendations from the Earth science community about research and applications priorities, the program team encouraged the wildfires projects and community to engage and contribute. And they did. There were multiple activities during the year: There were wildfire-centric Decadal Survey sessions at the Wildfires team meeting in February, and the Wildfires training workshop in October; people nominated community representatives to serve on the Decadal Survey committee panels; and, people submitted a community white paper in November 2015 to convey key fire science and applications tractable challenges. In addition, Sonoma Technology Inc., led an effort to compile the results of interviews and questionnaires with the wildland fire community on the scientific and applications priorities for the next 10-15 years for publication (in 2016) for the Decadal Survey committee and panels to reference.

The wildfires project teams were extremely flexible with regards to funding of their projects. Due to a financial need elsewhere in the Applied Sciences Program, the Wildfires program management team needed to split the "year two" funding between FY2015 and FY2106. The project teams were very accommodating, and this funding split seemed to go very smoothly (again, in large part due to the project teams' support).

Beyond wildfires applications, the program management team observed that the integral nature of fire science to terrestrial, atmospheric, and climate processes is becoming increasing recognized and demanded beyond the fire community. For example, there appears to be a growing appreciation of fire as a consequential feedback with weather and climate systems. Fire is recognized as a catalyst for land-cover change, one that initiates the beginning and end of succession or promotes ecosystem transition more quickly towards unique ecosystems, in sync with the changing climate. The program team noted that fire scientist involvement and participation is requested more frequently on cross-disciplinary project efforts and topics. This recognition bodes well for opportunities for fire science to inform policy and management decisions across disciplines, as well as for the identification and development of rich research and applied science questions.

While there have been tremendous advances, the program management team still sees issues to address to further advance applications of Earth observations by the wildfires community. One area to address is the information NASA puts out about its data products. The informational handouts seem geared for audiences with significant Earth science experience. In

2016, the program management team plans to pursue efforts to produce wildfires-specific handouts aimed at and designed for broader audiences with varying experience.

In addition, while projects are continuing to actively progress forward, the management team has noted a hesitancy in some partner organizations to evaluate and review new products or models, despite strong commitments in letters-of-support in the proposals. In some cases, there may be clear reasons for a delay or hesitancy. For example, if wildfire management agency budgets for research, development, and applications are redirected to support fire suppression activities, there can be shortfalls in funds available for testing and evaluation of new models. Additionally, because Incident Meteorologists are responding to emergencies and are temporarily assigned to fire events, integration of new models into operations are hindered; the potential users do not have the long-term exposure to new capabilities to effectively evaluate and propose operationalization of the models and information developed to support those transitory events. In 2016, the program management team will examine the situations in-depth, especially as the projects enter the final year of the applications development stage, as well as the expectation for transition to and adoption by the partner agencies and user community.

The program management team was a bit delayed in responding to a STI proposal for support on the Decadal Survey wildfires community input. There were numerous iterations in the negotiation with STI; however, the program management team regrets that it wasn't more expedient in pursuing and completing its work so the activity could have commenced sooner.

An unexpected highlight for the year was the wildfires training workshop in October (see Sections III and VI). This event was organized with the Applied Sciences' Applied Remote Sensing Training (ARSET) program, and the wildfires program management team received numerous, independent accounts praising it as a positive event. The Applied Sciences Program was very appreciative that several project team PIs and members contributed to making it successful.

V. Project Portfolio

In 2015, the project portfolio contained nine projects that were in year two of the full-scale applications development phase. The projects' foci were evenly split between pre-fire, active-fire, and post-fire applications activities. The organizations for the principal investigators of the nine projects include universities (3), federal government (5), and one non-governmental organization. All the projects had partner organizations as co-investigators or collaborators.

Of the nine projects, three have a particular focus on fuels; four address aspects of fire detection, behavior, and forecasting; and two focus on post-fire remediation. A brief description of each project is below; more information is in the Wildland Fires section of the Applied Sciences Program website.

The majority of projects focused on the use of the Moderate Resolution Imaging Spectroradiometer (MODIS), S-NPP VIIRS, and Landsat data and products (and combinations of them). Collectively, projects also used data products from other space-based sensors and satellites:[11] ASTER, AMSR-E, AVHRR, ESA ATSR, MOPITT, CALIPSO, DLR FireBird, OMI, GLAS, and SMOS; data from aerial imagery, airborne LiDAR scanning (ALS), AVIRIS, and UAVSAR; data from community databases, such as MTBS, DEMs and LANDFIRE; and numerous models and model outputs.

Wildfire Projects	
End of 2015	
ARL	*Projects*
ARL 9	0
ARL 8	0
ARL 7	1
ARL 6	3
ARL 5	2
ARL 4	2
ARL 3	1
ARL 2	0
ARL 1	0

Each project tracked and recorded their ARLs during the year. At the end of 2015, the portfolio had one project at ARL 3, two projects at ARL 4, two projects at ARL 5, three projects at ARL 6 and 1 project at ARL 7. The mean ARL was 5.1 (compared to 4.3 in 2014) and the mode was ARL 6 (compared to ARL 4 in 2014). For the Applied Sciences Program's performance year (ending September 2015), 56 percent of the portfolio advanced one or more ARL levels.

The following are summaries of the nine projects.

TOPOFIRE: A System for Monitoring Insect and Climate Induced Impacts on Fire Danger in Complex Terrain; Principal Investigator: Zachary A. Holden, USFS
This project integrates NASA remote sensing and climate products into a decision support tool, TOPOFIRE, which delivers a suite of high spatial resolution real-time information sets essential to wildland fire management. The end user/partners community includes the modeling community employing the Wildland Fire Assessment System (WFAS) and the Wildland Fire Decision Support System (WFDSS).

Utilization of Multi-Sensor Active Fire Detections to Map Fires in the United States: The Future of Monitoring Trends in Burn Severity; Principal Investigator: Stephen Howard, U.S. Geological Survey (USGS)*:* This project applies fire detection data from MODIS, AVHRR, *GOES* (fire and smoke sensing), federal fire occurrence data, and NOAA Hazard Mapping System information to identify undocumented fires, improving the Monitoring Trends in Burn Severity (MTBS) mapping process, and developing user-friendly tools and applications that can be installed locally to support local fire assessments. The end users/partners include the two major entities that provide the MTBS products for the fire community: USFS RSAC, and USGS-EROS.

[11] See Abbreviations and Acronyms in Appendix B.

Linking Remote Sensing and Process-based Hydrological Models to Increase Understanding of Wildfire Effects on Watersheds and Improve Post-fire Remediation Efforts; Principal Investigator: Mary Ellen Miller, Michigan Tech Research Institute: This project creates an online spatial database to instantaneously provide end users with the basic tools and data needed to incorporate Earth observations (Landsat *8*, ASTER, MODIS, VIIRS, process-based hydrological models, spatial dry ravel model) into process-based erosion models. Improving accessibility of both modeling capabilities and the required data sets will lead to better assessment tools and support post-fire remediation through erosion modeling. The project focused on supporting end users and partners from the BAER teams, land managers, and researchers.

Enhanced Wildland Fire Management Decision Support Using Lidar-infused LANDFIRE Data; Principal Investigator: Birgit Peterson, USGS: This project is developing a tool to incorporate Lidar data (ALS and GLAS) and data from the LANDFIRE program. The Creating Hybrid Structure from LANDFIRE/Lidar Combinations (CHISLIC) tool allows users to automatically generate a suite of improved vegetation structure and wildland fuel parameters from Lidar data and infuse these into existing LANDFIRE data sets, ensuring the best data are available to support tactical and strategic wildland fire management decisions. The partner/end-user community involves those that utilize both the Wildland Fire Assessment System (WFAS) and the Wildland Fire Decision Support System (WFDSS) in their assessment tools for wildfire management and reporting.

Wildland Fire Behavior and Risk Forecasting; Principal Investigator: Sher Schranz, Colorado State University: This project applies data from MODIS and VIIRS to derive Normalized Difference Vegetation Index (NDVI) and Normalized Difference Water Index (NDWI) maps, and government databases (LANDFIRE and fuel moisture from the network of Remote Automated Weather Stations (RAWS)) to test the probability of providing forecasting of wildland fire behavior and risk, integrated within the NOAA fire weather forecasting systems. This effort supports decision making by providing integrated local numerical prediction of weather, fuel properties, fire risk, and fire behavior.

Development and Application of Spatially Refined Remote Sensing Active Fire Data Sets in Support of Fire Monitoring, Management and Planning; Principal Investigator: Wilfrid Schroeder, University of Maryland: This project builds on proven science algorithms (fire detection from MODIS) to apply new spatially-refined satellite active-fire detection products from the VIIRS and Landsat 8 sensors that yield significantly improved active fire information. The project team uses these products to initialize and validate fire growth predictions in a coupled weather-fire model - an approach that can be applied to monitor and predict the growth of a fire or a group of simultaneous wildfires in a management unit from first detection until containment. The partners involved include USFS, NWS, and WFDSS.

An Integrated Forest and Fire Monitoring & Forecasting System for Improved Forest Management in the Tropics; Principal Investigator: Karyn Tabor, Conservation International: This project is enhancing a near-real-time alert system (FIRECAST) that incorporates active-fire identification from VIIRS and MODIS to improve decision making related to forest and fire management in "under-served" communities and better addresses the challenges decision makers face in making timely decisions related to wildland fire management and prevention that have immediate conservation impacts. Specific improvements to FIRECAST are the inclusion of fire risk warnings, seasonal severity forecasting, as well as an interactive website, email alerts, and mobile systems that are explicitly designed based on management request. The partners in this effort include Servicio Nacional de Áreas Naturales Protegidas por el Estado in Peru, Ministry of Environment and Forests in Madagascar, Department of Conservation Areas Wildlife Reserves in Indonesia, and Flora and Fauna International based in the U.K.

Improving National Shrub and Grass Fuel Maps Using Remotely Sensed Data and Biogeochemical Modeling to Support Fire Risk Assessments; Principal Investigator: James Vogelmann, USGS: This project is applying Landsat and MODIS data to improve shrub and grassland mapping for fire applications, develop temporally-frequent data sets, and therefore determine if improvements in shrub and grassland data layers will alter and improve fire behavior model results. The end user partners include the USFS, Bureau of Land Management (BLM), and Multi-Resolution Land Characteristics Consortium.

An Automated Burned Area Emergency Response Decision Support System for Post-fire Rehabilitation Management of Savanna Ecosystems in the Western United States; Principal Investigator: Keith T. Weber, Idaho State University: This project integrates the rapid resource allocation capabilities of cloud computing to automatically collect Earth observations data (Landsat 8, MODIS, AMSR-E (historical, non-operational since Oct 2011), Modern Era Retrospective Analysis for Research and Applications (MERRA)), derived decision products, and historic biophysical data for BAER teams to have a comprehensive RECOVER (Rehabilitation Capability Convergence for Ecosystem Recovery) data set in a GIS analysis environment that is customized for the target wildfire, thus reducing the time required to assemble and deliver crucial wildfire-related data from days to a matter of minutes. The partners include the BLM, Idaho Department of Lands, and BAER teams.

In the portfolio is a "Phase I" project that the Wildfires program supported for a one-year effort to demonstrate the use of remote-sensing data and effective fuels management strategies.

Automated Fuels Treatment Effectiveness Evaluation Using Remote Sensing Information (AFTEERS); Principal Investigator: Stacy A. Drury, Sonoma Technology, Inc.: This project demonstrated that it is feasible to use Earth observations products such as MODIS and MTBS to evaluate fuels treatments as a tool to mitigate wildfire

hazard. The project team created a set of methods that provide land manager partners (USFS, National Park Service, and Bureau of Indian Affairs) with easy-to-use, cost-effective data products that utilize satellite observations to evaluate fuels treatment options. The team is sharing the analysis, modeling framework, and environment to partner entities to continue the AFTEERS development outside of NASA Phase II levels of support.

In the portfolio is a project the program supported in response to the 2014 King Fire.[12]

Rapid Response to the 2014 King Fire; Principal Investigator: D. Schimel (NASA-JPL) and C. Ramirez (USFS-R5)*:* This project collects observations, builds an applications data base, and shares the data with post-fire study teams on the King Fire. The project provides data for pre-burn forest condition class, fuel moisture, fire behavior, post-fire burned area and severity, post-fire forest structure, erosion, re-vegetation, and targeted mitigation for fire science and management. The King Fire started September 13, 2014, in an area north of Pollock Pines, California. Overall, the fire burned more than 97 thousand acres, destroying 12 single residences and 68 other minor structures.

The 18-month project (extending into late 2015), successfully integrated pre-HyspIRI imaging spectroscopy data during active- and post-fire along with post-fire observations of forest structure change (LiDAR), topography, and burn severity (imaging spectroscopy) to obtain baseline science data and to use in immediate post-fire mitigation activities with USFS partners (USFS Region 5). This project provides data critical to understanding the behavior and post-fire ecological recovery for extreme mega-fires, and informing post-fire and long-term management responses. The airborne and field campaigns started in November 2014 and continued into 2015. The USFS Region 5 is a partner in the project, contributing 50 percent of the financial resources to the effort.

VI. Program Management

In 2015, Vince Ambrosia and Amber Soja continued to serve as Associate Program Managers for the Wildland Fires program. They each managed a portfolio of projects, tracking progress, budgets, spending plans, and applications performance. They also further enhanced routine communications with the PIs, project teams, and their partner organizations. Among their activities, the associates discussed projects and program objectives with the project teams, evaluated project progress, assessed ARLs, described expectations, and addressed PI questions and concerns.

2015 Team Meeting

The NASA Wildland Fires program held its first team meeting 10-12 February 2015 in Salt Lake City, Utah. The focus of the team meeting was to review the projects and inform the partner

[12] Proposal received through NASA ROSES-2014, A.27 Rapid Response and Novel Research in Earth Science.

entities of project advancement for eventual integration into operational utility within the fire management community; the event also encouraged cross-project interaction. Attendees participated in site visits to the USFS-RSAC, the USDA Aerial Photography Field Office, and the Great Basin Wildfire Geographic Area Coordination Center. The workshop explored key science and applications issues and challenges faced by wildfire management practitioners and wildfire scientists. The participants developed prioritized science and applications needs that would facilitate improved understanding of wildfire impacts in the future. The key aspirational fire science questions and applied tools identified were collected and used to support a Wildland Fire Community White Paper submitted to the National Academy of Sciences as input to the Earth Science Decadal Survey.

Wildfire Trainings

The Applied Sciences' ARSET training program element held two wildfires-related trainings in 2015. In April, ARSET conducted a webinar series entitled "Introduction to Remote Sensing for Wildfire Applications." The webinars occurred over a five-week period, with a one-hour session each week. The series provided an overview of remote sensing, details on how to access and visualize relevant NASA Earth science data, and how to use these data for wildland fire applications. Additionally, the course assisted wildland fire management professionals in decision-making through the use of NASA data, relevant tools and assessment methods.[13]

In October 2015, ARSET conducted a three-day Wildland Fires Remote Sensing training at the Idaho State University in Pocatello, Idaho. ARSET conducted this in conjunction with Keith Weber (RECOVER project lead), who applied for and received a grant from the Wildland Fires program to support this training. For the ~50 attendees, the workshop provided an opportunity for course lectures and hands-on experiences for handling remote sensing data by state and national wildfire incident management teams, university personnel, and restoration and rehabilitation personnel. The training featured dynamic speakers and an interactive class structure, including a mixture of lectures, hands-on exercises with GIS and remote sensing data, and a field trip to the Charlotte fire, which validated the value of remote-sensing data.

King Fire Rapid Response

The program management team continued to work with PI David Schimel (JPL) and his project team to collect and distribute data on the 2014 King Fire. The project successfully compiled and made accessible all the airborne and spaceborne data collected on the King Fire. Data and information are accessible at http://wildfire.jpl.nasa.gov/ .

Autonomous Modular Sensor Instrument

In the spring of 2015, the NASA-developed Autonomous Modular Sensor (AMS) supported USFS airborne fire imaging operations. The USFS/NIFC – National Infrared Operations installed the AMS on the USFS Cessna Citation jet in March 2015 and flew bore-sight and integration, test

[13] ARSET website: http://arset.gsfc.nasa.gov .

and calibration missions, sensor operations training flights, On-Board Processing System test flights, and AMS sensor and AirCell data telemetry system link test-flights. In April and May, USFS used AMS to support prescribed fires, post-fire assessment flights (2012 Trinity Ridge Fire, 2013 Pony-Elk Complex Fire, 2014 Timber Butte and Whiskey Springs Fires), and forest pest damage assessment site flights in Idaho (aerial detection surveys for mountain pine beetle and western spruce beetle). The AMS was not employed on wildfire events in 2015, as the system was undergoing major hardware and software updates as well as upgrades by USFS technicians to improve the sensor for operations in 2016 and beyond. The USFS continued to fund AMS hardware and software engineering capabilities at NASA-Ames, under a NASA Space Act Agreement.[14]

Communications

Applied Sciences released a new website design, and the Wildfires program provided significant content for the wildfires page (http://appliedsciences.nasa.gov/programs/wildfires-program). Applied Sciences also submitted numerous project achievement summaries for the "monthly status reviews" that the NASA Science Mission Directorate (SMD) senior management conducts to review noteworthy advancements. SMD also sponsored the development of a *Taking the Wild out of Wildfires* video (see footnote 5) based on the project led by Wilfrid Schroeder.

The program management team worked with the project teams to update two-page summary documents on each project. These summaries are handouts for distribution at conferences, for partners' use, and for public awareness. The documents highlight the projects' objectives, major milestones, applied Earth observations, and implementation approaches. Collectively, these documents highlight the role of partners and NASA to inform decisions and improve wildfires characterization with Earth observations data. The Wildland Fires program, Applied Sciences, and NASA Earth science distributed these handouts at numerous conferences in 2015, such as the American Geophysical Union and others (see sections VII and VIII). These project summaries are available via the Wildland Fires page on the Applied Sciences website.

VII. Community Leadership

The Wildland Fires program sponsored and supported numerous community activities in 2015 as part of overall efforts to enhance the use of Earth observations and wildfire science in fire-related management decisions and actions. The following summarize participation in key interagency committees as well as conferences and symposia.

NASA/USFS Tactical Fire Remote Sensing Advisory Committee (TFRSAC)

Program Associate Vince Ambrosia continued to serve as a co-chair of the NASA/USFS TFRSAC, which addresses efforts to share information on wildland fire imaging capabilities, technologies, and projects that employ spaceborne, airborne, and in situ assets to improve wildfire characterization capabilities, including pre-fire assessment, active-fire observations, and post-fire recovery and rehabilitation. The community is composed of incident managers, situation

[14] The Space Act Agreement started its second 5-year extension, enabling collaboration through 2020.

unit leaders, wildfire scientists, geospatial specialists, private industry representatives, and sensor engineers. The TFRSAC community has become increasingly focused on the use of small UAS, given the interest in federal and state agencies to near-real-time wildfire information support on events to support the safety of line crew operations, provide tactical-level observations during night operations, and in post-fire hotspot detection. The TFRSAC provides an applications forum for wildfire management practitioners to interface with technologists and scientists to forge developmental directions for new and evolving technologies and capabilities in wildfire airborne and satellite observations.

The TFRSAC committee held its spring meeting at NASA Ames Research Center in California. Thirty-five people participated in person and an additional 25 people joined virtually via web interface; participants represented federal and state agencies, universities, private companies, and international institutions. The meeting included a live flight demonstration of a near-real-time, inexpensive aircraft sensor system and web-map application that provides fire information to Incident Command on wildfire events, which can be transmitted to line crews, retardant-drop aircraft, etc.

NIFC hosted the Fall TFRSAC meeting in Boise, Idaho, in October. More than 30 participants attended in person and another 25 attended virtually. The meeting featured a presentation of the Schroeder-led project involving the integration of VIIRS I-Band data observation capabilities for improved spatial resolution of fire growth through multiple-daily and multi-day observations. In addition, CalFire demonstrated that it is integrating orbital asset information more frequently into large-scale fire operations, as showcased by its use of VIIRS data on California fires in summer 2015. The meeting also included a proposal to develop a fire-focused satellite observation system for quick, global observations of new fire starts.

Wildland Fire Science and Technology Task Force

Program Associate Amber Soja continued to serve as the NASA representative on this interagency task force, which was tasked to analyze missions, portfolios, and existing coordination and application mechanisms employed by the relevant federal agencies with respect to wildland fire science and technology. The task force is part of the Subcommittee on Disaster Reduction within the Committee on Environment, Natural Resources, and Sustainability.

In 2015, the task force produced a report that identified several topics for high-priority attention and action on the part of the Federal fire research community. The group proposed mechanisms to improve coordination between fire science producers and the community of users of fire science. For example, one recommendation in the report is for the establishment of a standing Federal Fire Science Coordination Council. This council would ensure regular exchange among the leaders of the Federal organizations, which either produce or use fire science, to strengthen coordination and collaboration. Specifically, the report defines agency roles and responsibilities, identifies opportunities for increased coordination, and aligns science and technology with a cohesive strategy. The White House released the report in November at

the National Security Council's *Fire Chiefs Roundtable on Climate Change Impacts at the Wildland-Urban Interface* event.[15]

IARPC Wildfire Collaboration Team
The Interagency Arctic Research Policy Committee (IARPC) is charged with enhancing both the scientific monitoring of and research on local, regional, and global environmental issues in the Arctic. IARPC consists of 16 Federal agencies and offices.

Program Associate Vince Ambrosia represents NASA on the IARPC's Wildfire Collaboration Team (WCT). The WCT addresses the frequency, extent, and severity of wildfires in the arctic as a component of understanding high-latitude terrestrial ecosystem process, ecosystem services, and climate feedbacks. Ambrosia was the lead author of a report, *Satellite and Airborne Fire Sensor Systems for Arctic Wildfire Observations,* which cataloged and highlighted the orbital and airborne sensor capabilities that are available for observations of wildfire events or for post-fire assessment in the Arctic (and applicable throughout the globe).[16] In 2015, the authors decided to revise the document as necessary, enabling frequent updates as various sensor systems and platforms are added or removed from operations. The IARPC WCT plans a 2016 workshop focused on the use of remote sensing assets to improve Arctic and boreal-system wildfire observations capabilities and knowledge of available resources.

American Geophysical Union Fall Meeting
At the AGU event in December 2015, scores of sessions included wildfire-related topics, and several Wildland Fires project teams gave oral or poster presentations. On behalf of the wildfires community, Vince Ambrosia and Amber Soja gave talks, entitled *NASA and Wildfires: Science and Technology Supporting the Nation*, at the NASA exhibit booth's hyperwall display. The NASA booth included literature on the Wildland Fires program, especially the project summaries.

VIII. International Activities

The Wildland Fires program included a larger number of internationally-focused activities in 2015 and increased its activities in a wildfires task of the intergovernmental Group on Earth Observations (GEO). The following summarize participation in key international committees, conferences, workshops, and the GEO task.

International Symposium on Remote Sensing of Environment
The 36th International Symposium on Remote Sensing of Environment (ISRSE) occurred in May, 2015, in Berlin, Germany. NASA was a key sponsor of this event, and the Wildfire Program Management team organized sessions focused on forest ecosystem analysis, wildfires, and other topics. Several of the Wildland Fires project team members participated in a series of sessions on Wildland Fire Remote Sensing Observations. Program Associates Soja and Ambrosia

[15] https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/sdr_wildfire_st_task_force_final_report.pdf .
[16] http://www.iarpccollaborations.org/uploads/cms/documents/wildfire-sensor-systems_v5.pdf

presented the Wildland Fires program at the NASA exhibit booth and hyperwall. PI Mary Ellen Miller won the ISRSE Best Oral Presentation award for her wildland fire project.

International Wildland Fire Conference
Program Associate Amber Soja represented the Wildland Fires team at the IWFC *Fire of the Past; Fire in the Future* conference in October in Korea (http://en.wildfire2015.kr/). Soja highlighted the program and the availability of wildland fire data and applications to this international community. The meeting focused on the challenges faced by the global community as the patterns of wildland fire change under the control of weather and climate.

10TH International Workshop of the European Association of Remote Sensing Laboratories (EARSeL) Forest Fire Special Interest Group (FF-SIG) on Forest Fires
Program Associate Ambrosia was the keynote speaker at the EARSeL FF-SIG meeting in November in Cyprus (http://www.ffsig2015.com/). He spoke on the role of applications in wildfire remote sensing, discussed the programmatic directions of the Wildland Fires program, and highlighted the nine projects. He chaired two sessions and co-chaired the workshop wrap-up session. The meeting focused on validation of post-fire burn products to improve estimates of vegetation consumption and recovery as well as supporting inputs to carbon emissions from wildland fire.

GEO Global Wildfire Information System
The GEO Work Plan includes a wildfires task entitled Global Wildfire Information System (GWIS). The task focused on providing a platform for harmonized information and to enable the exchange and coordination of information among major national and regional fire information providers (e.g., existing systems in the United States, Canada, South Africa, Russia, Australia, and China). This GWIS platform provides information to all aspects of fire management - from pre-fire danger forecasts to active-fire monitoring and post-fire assessments - including burned area maps, land-cover alteration, protected-area damage, fire emissions, and potential soil erosion. The GWIS seeks to link various national, global, and regional systems to make complementary Earth observations data more readily available on wildfires. The task builds on the ongoing activities of the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) Fire Implementation Team and its regional networks.

In 2015, Program Associate Ambrosia again served as the U.S. lead on this GWIS task. He coordinated with the other leads to develop plans for GWIS, and he helped to identify US interests and priority contributions in the task and GWIS system. In late 2015, GEO adopted a new 2016-2015 Strategic Plan and Work Programme, and this task continues.[17]

[17] http://earthobservations.org/documents/geo_xii/GEO-XII_15_2016%20Work%20Programme.pdf

IX. Looking Ahead

Wildfire Program Team Meeting

The Wildland Fires program will hold the second team meeting in March 2016. By design, the meeting will occur near NIFC in Boise to enable direct interaction between the project teams and wildland-fire-oriented organizations located there. The meeting supports efforts to expand the application and societal value of Earth observations. The meeting will include end users, such as task leaders and incident commanders, to help build connections and ensure the views of managers and practitioners are well represented. The event includes site visits to NIFC and the National Incident Command Center to help the project teams better understand the operations of the nation's over-arching wildland fire management organization.

Earth Science Decadal Survey

The Wildland Fires program will continue to support opportunities for the wildfires community to contribute to the Earth Science Decadal Survey and express its research and applications interests. In 2016, Sonoma Technology Inc. will finalize its program-sponsored report on the priorities of the wildfire community to improve understanding, use, management, and mitigation of wildfires.

IARPC

Program Associate Ambrosia will continue as the NASA representative on the IARPC WCT. In 2016, the WCT may hold a workshop in coordination with the Alaska Fire Science Consortium and the Geographic Information Network of Alaska. This workshop, *Opportunities to Apply Remote Sensing in Boreal/Arctic Wildfire Management & Science*, will occur in March prior to the 18th Arctic Science Summit and 3rd Biennial Arctic Observing Summit. The primary goal of the workshop is to convene an international, inter-disciplinary workshop of remote-sensing scientists, ecologists, hydrologists, as well as agency fire managers and decision-makers, to develop new opportunities for the use of remotely-sensed data in boreal and Arctic wildfire management and science communities.

Fire and Smoke Modeling Evaluation Experiment (FASMEE)

FASMEE is an experimental fire initiative being developed by multiple fire communities to include the Joint Fire Science Program (JFSP), Army Corps of Engineers, USFS and others to evaluate the observational data necessary to advance fire and smoke modeling and understanding. Program Associates Soja and Ambrosia have been participating in the planning initiative in hopes of linking the detailed data collected during this experiment to NASA satellite and airborne resources. This field campaign is unique in the amount of area and fuel that is being proposed [4 to 8 large (>500 acre) plots in heavy fuels], the realistic burn type (high intensity), and the detailed coincident measurements (e.g., fuel characterization, weather). This type of data collection provides a strategic link to NASA models, aircraft (emissions factors) and satellite data that are not possible to collect during fires of opportunity. The organizers

identified discipline leads in 2015 and will likely select observational teams in 2016; the experimental burns are expected to be conducted in 2018 through 2020.[18]

Partnership Efforts

The Wildland Fires program team expects to continue its discussions with USFS RSAC, JFSP, NIFC, and others concerning collaborations and communications on wildland fire science and applications. Program Manager Lawrence Friedl will serve as a Co-Lead of a GEO task on the Sustainable Development Goals, and he will look for opportunities for the program to contribute to the use of Earth observations on wildfire-related goals. Program Associate Soja will serve on the newly-established Federal Fire Science Coordination Council, and Program Associate Ambrosia will continue to serve as the U.S. lead on the GEO GWIS. In 2016, the GWIS task team plans a workshop of GWIS partners and development of a consolidated prototype of the system by the end of the year.

[18] http://www.fasmee.net/ and http://www.firescience.gov/index.cfm

X. Appendix

A. Publications

This appendix highlights 2015 peer-reviewed publications, white papers, reports, conference proceedings, presentations, workshops, blogs and press releases related to the Applied Sciences Program's Wildland Fires program. Bolded text indicates authors and co-authors that are Principal Investigators, Co-Investigators, and programmatic management staff with the Wildland Fires program.

Coen, J.L. and **W. Schroeder** (2015), High Park Fire: Coupled weather-wildland fire model simulation of a windstorm-driven wildfire in Colorado's Front Range, *Journal of Geophysical Research - Atmospheres*, doi:10.1002/2014JD021993.

Coen, J.L. and **W. Schroeder** (2015), Coupled Weather-Fire Modeling: from Research to Operational Forecasting, *Fire Management Today*.

Holden Z.A., A. Swanson, A. Klene, J.T. Abatzoglou, S.Z. Dobrowski, S.A. Cushman, J. Squires, G.G. Moisen and J.W. Oyler (2015), Development of high resolution (250 m) historical daily gridded air temperature data using reanalysis and distributed sensor networks for the US Northern Rocky Mountains, *Int. J. Climatol.* DOI: 10.1002/joc.4580.

Jolly W.M., M.A. Cochrane, P.H. Freeborn, **Z.A. Holden**, T.J. Brown, G.J. Williamson and D.M.J.S. Bowman (2015), Climate-induced variations in global wildfire danger from 1979-2013, *Nature,* DOI:10.1038/ncomms8537.

Kochanski, A.K., M.A. Jenkins, K. Yedinak, **J. Mandel**, J D Beezley, and B. Lamb, (2015), Toward an integrated system for fire, smoke and air quality simulations, *International Journal of Wildland Fire*, doi:10.1071/WF14074.

Miller, M.E., W.J. Elliot, K.A. Endsley, P.R. Robichaud and M. Billmire (2015), Rapid Response Tools and Datasets for Post-fire Erosion Modeling: Linking Remote Sensing and Process-based Hydrological Models to support Post-fire Remediation, *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci*., XL-1, 257-263, doi:10.5194/isprsarchives-XL-1-257-2014.

Miller, M.E. and **W.J. Elliot**, Predicting post-fire hillslope erosion for the Butte fire, CA, *Burned Area Emergency Response (BAER) report,* 2015.

Miller, M.E. and **W.J. Elliot**, Predicting post-fire hillslope erosion for the Valley fire, CA, *BAER report, 2015*.

Oliva, P. and **W. Schroeder** (2015), Preliminary assessment of VIIRS 375 m active fire detection product for direct burned area mapping: Limitations and capabilities, *Remote Sensing of Environment,* http://dx.doi.org/10.1016/j.rse.2015.01.010.

Peterson B., K. Nelson, C. Seielstad, J. Stoker, W.M. Jolly and R. Parsons (2015), Automated integration of Lidar into the LANDFIRE product suite, *Remote Sensing Letters*, 6: 247-256.

Soja A, D. Schimel, L. Giglio, T. Loboda, N. French, J. Dibb, T. Moore, J. McCarty, A. da Silva, Jr., S. Conard, J. Douglas, R. Kahn, R. Sohlberg, A. Pankratz, R. Swap, C. Ichoku, D. Hamilton, **V. Ambrosia**, C. Rodriguez-Franco, B. Stocks, **Z. Holden**, **M. Carroll**, **K. Weber**, T. Harbour, **J. Schnase**, **E. Hinkley**, **M. Miller**, M. Rollins, S. Goodrick, A. Watts, S. Goetz, **B. Peterson**, R. Ziebart, B. Barnard, **J. Coen**, **J. Cissel**, **T. Brown**, C. Wiedinmyer, C. Justice, **J. Vogelman**, **J. Brass**, J. Randerson, **B. Quayle**, B. Schichtel S. Hook, S. Phillips and D. Roy (2015). Decadal Survey White Paper. http://surveygizmoresponseuploads.s3.amazonaws.com/fileuploads/15647/2289356/36-d45105ffaca08b3dd397e8c09cec93d0_SojaAmberJ.docx

Wildland Fire Science and Technology Task Force Final Report, 2015. Committee on Environment, Natural Resources, and Sustainability, Subcommittee on Disaster Reduction of the National Science and Technology Council. https://www.whitehouse.gov/sites/default/files/microsites/ostp/NSTC/sdr_wildfire_st_task_force_final_report.pdf

Conference Proceedings / Presentations:

Ambrosia, V.G., A. Soja, L. Friedl, *NASA Fire Science and Applications: Building Capacity and Understanding of Ecosystem Dynamics*. Keynote Address at 10th European Remote Sensing Laboratories (EARSeL) Forest Fire Special Interest Group Workshop, Limassol, Cyprus, 2 November, 2015.

Ambrosia, V.G., A. Soja, L. Friedl, *NASA Applied Science Program - Wildfires: Driving Research to Operations*. 36th International Symposium on Remote Sensing of Environment (ISRSE), Berlin, Germany, 14 May, 2015.

Coen, J.L., *Distilling and disseminating new scientific understanding of wildland fire phenomena and unfolding of large wildfires to prevent wildland firefighter entrapment.* Proc. 13th Intl. Wildland Fire Safety Summit & 4th Human Dimensions of Wildland Fire Conf. 20-24 April, 2015, Boise, Idaho, USA. Published by the International Association of Wildland Fire, Missoula, Montana, USA.

Coen, J.L., W. Schroeder, P. Oliva, *Coupled Weather-Fire Modeling of Landscape-scale Wildland Fires using Spatially Refined Satellite Remote Sensing Fire Detection Data*, Association for

Fire Ecology, 6th International Fire Ecology & Management Congress: Advancing Ecology in Fire Management, 16-20 November, 2015. San Antonio, Texas, USA.

Coen, J.L., E. N. Stavros, J. A. Fites-Kaufman, V. Kane, R. E. McGaughey, P. Oliva, **C. Ramirez, D. Schimel, W. Schroeder**, H. Singh, Z. Tane, *The King Megafire: Coupled weather-fire modeling enhanced by pre-HyspIRI imaging spectrometer and LiDAR fire and fuel products*, Association for Fire Ecology, 6th International Fire Ecology & Management Congress: Advancing Ecology in Fire Management, 16-20 November, 2015. San Antonio, Texas, USA.

Elliot, W.J., M.E. Miller and N. Enstice, *Combining fire and erosion modeling to target forest management activities*. Proceedings of the 10th Federal Interagency Sedimentation Conference, Reno, NV, 19–23 April, 2015.

Hewson, J., K. Tabor, *Fire and forest monitoring and forecasting system*. Presented at the GFOI-SilvaCarbon capacity building NRT monitoring tools for MRV. INPE São José dos Campos, São Paulo, Brazil, 21 January, 2015.

Howard, S., Picotte, J., & Coan, M., *Utilizing Multi-Sensor Fire Detections to Map Fires in the United States*, Wildfires Session at 36th International Symposium on Remote Sensing of Environment in Berlin, Germany, 11-15 May, 2015. http://giscenter.isu.edu/research/Techpg/nasa_RECOVER/pdf/RECOVERFlexApp.pdf

Holden Z., *TOPOFIRE: A system for mapping spatial variability in fire danger in complex terrain*. Presentation to the Wildland Fire Research and Development group, 4 April, 2015.

Holden Z., *Downscaled climate and hydrologic modeling in the US Northern Rockies for fire and vegetation management*. A technology transfers session presentation to the USFS Region 1, Missoula, MT., May 2015.

Holden Z., *Downscaled climate and hydrologic modeling in the US Northern Rockies for fire and vegetation management*. A presentation at the USFS Region 1 soil scientists' annual meeting, Missoula, MT., April 2015.

Kochanski A.K., **M.A. Jenkins, J. Mandel**, J.D. Beezley, K. Yedinak, and B.K. Lamb, *Multiscale fire modeling with WRF-Sfire*, Workshop on Modelling of Wildfires and their Environmental Impact International Center on Theoretical Physics, Trieste, Trieste, Italy, June 22, 2015 – invited talk.

Kochanski A.K., Hands-on WRF-Sfire workshop for 40 participants from developing countries, International Center on Theoretical Physics, Trieste, Italy, June 22-24, 2015.

Kochanski A.K., **M. Vejmelka, J. Mandel, M.A. Jenkins**, and **S. Schranz**, Integrated fire-atmosphere prediction system with data assimilation. 11th Symposium on Fire and Forest Meteorology, 5–7 May, 2015, Minneapolis, MN.

Kochanski A.K., **M.A. Jenkins, J. Mandel**, K. Yedinak, and B.K. Lamb, *Smoke modeling in a coupled fire-atmosphere framework*. 11th Symposium on Fire and Forest Meteorology, 5–7 May, 2015, Minneapolis, MN.

Mandel J., A.K. Kochanski, **M. Vejmelka,** and **S. Schranz**, *Coupled Atmosphere-Fire Modeling with Data Assimilation*. Workshop on Modelling of Wildfires and their Environmental Impact International Center on Theoretical Physics, Trieste, Italy, 22 June, 2015 – invited talk.

Miller, M.E., Billmire, M., Elliot, W. J. and Robichaud, P.R., *Post-fire sedimentation modeling (Rapid response tools and datasets: linking remote sensing and process-based hydrological models to support post-fire remediation)*. Presented at California, Nevada, Hawaii Fire Council Meeting, South Lake Tahoe, California, 21-22 October, 2015.

Miller, M.E., Billmire, M., Elliot, W. J. and Robichaud, P.R., *Rapid Response Tools and Datasets for using Remote Sensing and Hydrological Models to support Post-fire Remediation and fuels planning.* Presented at Sixth International Fire Ecology and Management Congress in San Antonio, Texas, USA, 16-20 November, 2015.

Peterson B., K. Nelson, C. Seielstad, J. Stoker, W.M. Jolly and R. Parsons, *Enhanced wildland fire management decision support using lidar-infused LANDFIRE data*, 36th International Symposium on Remote Sensing of Environment, Berlin, Germany, 11-15 May, 2015.

Soja, A., V. Ambrosia, and **L. Friedl**, *NASA Fire Science and Applications: Technology, Satellites Airborne Data and Models Supporting Earth Science Applications,* Wildland Fire Workshop for Air Quality, Longmont CO, 13-14 August, 2015.

Soja, A., V. Ambrosia, and **L. Friedl**, *NASA Fire Science and Applications: Technology, Satellites Airborne Data and Models,* 6th International Wildland Fire Conference: Fire of the Past; Fire in the Future, Pyeongchang Korea, 12-16 October, 2015.

Troëng, S., **K. Tabor**, *Conservation Impacts of a Near Real-time Monitoring and Alert System in the Tropics*. Presented at Conservation International's Board Meeting. Menlo Park, CA, 6 February, 2015.

Vogelmann, J., T. Hawbaker, H. Shi, Z. Li, and **M. Reeves**, *Improving national shrub and grass fuel maps using remotely sensed data to support fire risk assessments*, 36th International Symposium on Remote Sensing of Environment, Berlin, Germany, 11-15 May, 2015.

Weber, K.T., J.L. Schnase, M. L. Carroll, M. E. Brown, R.L. Gill, *NIFC NBAER meeting*, Boise, ID, 4 February, 2015.

Weber, K.T., J. May, **J.L. Schnase, M.L. Carroll**, *RECOVER: A Geotechnical Approach*. Presentation at the Idaho Geospatial Council Spring Meetings, Boise, ID, 2015.

Watts, A., **V. Ambrosia**, and E. Hinkley, 2015, *Unmanned Aircraft for Wildland Fire Science and Operations: Classification and Considerations for Use*. 36th International Symposium on Remote Sensing of Environment (ISRSE), Berlin, Germany, 15 May 2015.

Press releases:

Coen, J., NCAR UCAR AtmosNews (2015)
http://www2.ucar.edu/atmosnews/news/18317/ncar-develop-wildland-fire-prediction-system-colorado

Coen, J., Colorado State Governor John Hickenlooper signed House Bill 15-1129 on 20 May, 2015, that directs the Colorado Division of Fire Prevention and Control to establish, support and maintain a Colorado wildland fire prediction and decision support system for all Colorado government users, which will be developed by NCAR and the University of Maryland based upon technology developed during this project. This partner support is valued at $3M over 5 years.
http://www.bizjournals.com/denver/news/2015/05/20/hickenlooper-gives-colorado-new-fire-prediction.html
http://www.durangoherald.com/article/20150520/NEWS01/150529982//article/20150520/NEWS01/150529982/Hickenlooper-signs-fire-prediction-bill-
http://gazette.com/colorado-to-spend-1.2-million-to-for-wildfire-prediction-system/article/1552242
http://www.denverpost.com/breakingnews/ci_28155094/colorado-investing-new-wildfire-prediction-system
http://time.com/3992447/technology-wildfire-predictions/
http://www.weather.com//safety/wildfires/news/fire-models-mistakes
http://www.routefifty.com/2015/07/wildfire-science-research-colorado/116911/?oref=rf-home-latest-top

Miller M.E., Modeling Tool Helps Minimize Flood And Landslide Risks After Wildfires, article in *Environmental Monitor: Application and technology news for environmental professionals* by Daniel Kelly on 10 September, 2015. http://www.fondriest.com/news/modeling-tool-helps-minimize-flood-and-landslide-risks-after-wildfires.htm

Miller M.E., Michigan Tech Researcher Works to Make Burned Areas Safer, on *Great Lakes Radio News* 22 August, 2015. http://broadcast-everywhere.net/56373/great-lakes-radio-news/press-releases/michigan-tech-researcher-works-to-make-burned-areas-safer/

Miller M.E., Preventing Floods and Erosion After Fire, article in *Informed Infrastuture: The construction engineer's source for project, products and technology* by Matt Ball, 20 August, 2015. https://informedinfrastructure.com/16616/preventing-floods-and-erosion-after-fire/

Schroeder, W. https://www.nasa.gov/press-release/battling-wildfires-from-space-nasa-adds-to-firefighters-toolkit

Video:

Schroeder, W. http://science.nasa.gov/science-news/science-at-nasa/2015/01dec_wildfire/

Tabor, K. https://www.youtube.com/watch?v=cOpIB_SizaQ&noredirect=1

Training Seminars / Workshops:

Tabor, K., *Near Real-Time Monitoring for Conservation Management*. Presented as part of NASA's ARSET online training seminars. 22 June, 2015. https://arset.gsfc.nasa.gov/ecoforecasting/webinars/introduction-remote-sensing-conservation-management.

Weber, K.T., *Remote Sensing Products for Pre- and Post-Fire Wildfire Planning and Assessment*, Presented as part of NASA's ARSET online training seminars. 14 April, 2015. https://arset.gsfc.nasa.gov/disasters/webinars/intro-wildfire-applications

Weber, K.T., C. Schmidt, A. Soja, M. Carroll, W. Schroeder, B. Quayle, D. Hamilton, *NASA Applied Remote Sensing Training: Wildfire*, Idaho State University, Pocatello Idaho, 6-8 October, 2015.

Blog:

Tabor, K., *Madagascar's sacred forests have a guardian — in space*, by Koenig, K. October 2015.

http://blog.conservation.org/2015/10/madagascars-sacred-forests-have-a-guardian-in-space/

B. Abbreviations and Acronyms

AFIS: Advanced Fire Information System
AFTEERS: Automated Fuels Treatment Effectiveness Evaluation Using Remote Sensing
ALS: Airborne Lidar Scanner
AMS: Autonomous Modular Sensor
AMSR-E: Advanced Microwave Scanning Radiometer-EOS
ARC: Ames Research Center
ARL: Application Readiness Level
ARSET: Applied Remote Sensing Training
ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer
ATSR: Along Track Scanning Radiometer
AVHRR: Advanced Very High Resolution Radiometer
AVIRIS: Airborne Visible/Infrared Imaging Spectrometer
BAER: Burned Area Emergency Response
BLM: Bureau of Land Management
CALIPSO: Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations
CHISLIC: Creating Hybrid Structure from LANDFIRE/lidar Combinations
DEM: Digital Elevation Model
DLR: German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DOI: Department of the Interior
EARSeL: European Association of Remote Sensing Laboratories
ESA: European Space Agency
ESD: Earth Science Division
FF-SIG: Forest Fire Special Interest Group (part of EARSeL)
FY: Fiscal Year
GEO: Group on Earth Observations
GIS: Geographic Information System
GLAS: Geoscience Laser Altimeter System
GOES: Geostationary Operational Environmental Satellite
GOFC-GOLD: Global Observation of Forest and Land Cover Dynamics
GWIS: Global Wildfire Information System
IARPC: Interagency Arctic Research Policy Committee
ISPRS: International Society for Photogrammetry and Remote Sensing
ISU: Idaho State University
JFSP: Joint Fire Science Program
JPL: Jet Propulsion Laboratory
LANDFIRE: Landscape Fire and Resource Management Planning Tools
MERRA: Modern Era Retrospective-Analysis for Research and Applications
MODIS: Moderate Resolution Imaging Spectroradiometer
MOPITT: Measurement of Pollution in the Troposphere
MTBS: Monitoring Trends in Burn Severity
NASA: National Aeronautics and Space Administration

NDVI: Normalized Difference Vegetation Index
NDWI: Normalized Difference Water Index
NIFC: National Interagency Fire Center
NOAA: National Oceanic and Atmospheric Administration
NWS: National Weather Service
OMI: Ozone Monitoring Instrument
PI: Principal investigator
RECOVER: Rehabilitation Capability Convergence for Ecosystem Recovery
ROSES: Research Opportunities in Space and Earth Sciences
RSAC: Remote Sensing Applications Center
SBA: Societal Benefit Area
S-NPP: Suomi National Polar-orbiting Partnership
SMAP: Soil Moisture Active Passive
SMOS: Soil Moisture Ocean Salinity
STI: Scientific and Technical Information
TFRSAC: Tactical Fire Remote Sensing Advisory Committee
TOPOFIRE: (Not an acronym)
UAS: Unmanned Aircraft System
UAVSAR: Uninhabited Aerial Vehicle Synthetic Aperture Radar
USFS: United States Forest Service
USGS: United States Geological Survey
VIIRS: Visible Infrared Imaging Radiometer Suite
WFAS: Wildland Fire Assessment System
WFDSS: Wildland Fire Decision Support System