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and Space Administration

NASA EARTH SCIENCE

APPLIED SCIENCES PROGRAM

WILDLAND FIRES

2017

Wildland Fire: 2017 Annual Summary

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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.[11] 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 crosscutting 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 wildland fire, addressing issues from pre-fire through active-fire to post-fire stages. The Wildland Fires program issued a dedicated solicitation in 2011 and selected 17 feasibility studies (Phase I). In 2014, the program selected nine of these studies to continue as full-scale applications projects (Phase II).

II. Overview of 2017

The past year was a very productive one for the Wildland Fire program, and the projects made significant advancements. Portfolio projects reached major milestones and advanced and operationalized the use of Earth observations and models to support wildland fire management community in 2017. Projects and their partners were the subject of press releases and videos and received media attention for their achievements. Wildland fire project-related workshops and training were extremely successful, drawing on expertise from across the program portfolio and the NASA ARSET program. These materials can be accessed at the NASA Applied Science Wildland Fire website (https://appliedsciences.nasa.gov/programs/wildfires-program) in the "Videos", "Program Library", and "Program News" sections.

In addition to all of the project-focused activities, there were numerous events, conferences, and committees in which the Wildland Fire program management team

[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.

and project team members contributed. In late February/early March, the program held its third Wildland Fire team meeting. This meeting helped further interactions across projects and inform partners of the applications and their progress. The attendees explored key issues and challenges faced by wildland fire management practitioners and scientists identifying research and applications advances that would improve the understanding and management of wildland fires. Held at the University of Colorado in Boulder, Colorado, the meetings included a site visit to the National Oceanic and Atmospheric Administration (NOAA) and discussions with personnel from the various program offices of NOAA such as the Earth System Research Lab, the National Centers for Environmental Information, the Space Weather Prediction Center, and other facilities.

Throughout the year, the Wildland Fire Program management team and project teams actively participated in symposia, conferences and workshops. Examples of major events included the Global Observation of Forest Cover (GOFC) Fire Implementation Team Meeting, in conjunction with the ForestSAT2016 meeting (Santiago, Chile), the Alaska Fire Science Consortium Meeting/Workshop on "Opportunities to Apply Remote Sensing in Boreal/Arctic Wildfire Management and Science (Fairbanks, Alaska), the 37th International Symposium on Remote Sensing of Environment (ISRSE) (Tshwane, South Africa), the Earth Observing Summit "Wildfire Remote Sensing Workshop" (Montreal, Canada), the 11th European Assoc. of Remote Sensing Labs (EARSeL) Forest Fire Special Interest Group Workshop (Crete, Greece), the Group on Earth Observations (GEO) GEO-XIV Plenary, Global Wildfire Information (GWIS) Side Event, Fire Vision 20/20—7th Association of Fire Ecology and Management Conference (Orlando, Fla.), and the Fall American Geophysical Union (AGU) Meeting in New Orleans, La.

The U.S. endured a significant fire season in 2017.[2] The acreage consumed and the numbers of fires nationwide were above the 10-year averages (71,499 fires vs. 10-year running average of 70,440 fires; 10,026,086 acres consumed vs. 10-year running average of 6,560,000 acres). The year 2017 saw the second ranked fire-consumed acreage amounts (2015 was largest at 10,125,149) in over 60 years, yet the number of fires in 2017 was ranked 43rd out of the past 60 years, indicating a trend towards lower fire counts, but greater acreage consumption by wildfires! There were many large or significant fires, some which set records for size and fire suppression costs values of loss.

In the United States a few significant fire events were noted: There were twelve (12) fires of greater than 100,000 acres in 2017, by far the largest amount of fires of that minimum size in the last 20-years of records (1997-2017).[3] The largest fire in 2017 was the NW Oklahoma Complex, at 779,292 acres; that fire was the third largest fire on record for the U.S. since 1997. I2017 ranked highest in U.S. fire history for suppression

[2] https://www.predictiveservices.nifc.gov/intelligence/2017_Statssumm/intro_summary17.pdf
[3] https://www.predictiveservices.nifc.gov/intelligence/2017_Statssumm/2017Stats&Summ.html

costs ($2,918,165,000). In Montana, 2,422 fires consumed 1,366,498 acres; Nevada had 768 fires consume 1,329,289 acres; California had 9,560 fires consume 1,266,244 acres; Texas had 9,827 fires consume 734,682 acres; Oregon had 2,049 fires consume 714,520 acres; Idaho had 1,598 fires consume 686,262 acres; and Washington had 1,346 fires consume 404,223 acres. Obviously, the Northern Rockies, experiencing below normal precipitation in 2017 accounted for large fire occurrences throughout the region, along with the west coastal states, and the Texas/Oklahoma area.[4]

In late 2017, deadly and destructive fires swept into Northern California (Sonoma, Napa and Lake Counties), as well Southern California, where Santa Ana-driven wildfires, then mudslides in the burn areas, devastated homes and infrastructure. The Tubbs Fire, in the Northern California Wine Country Fire Complex, spread through Sonoma, Napa, and Lake counties in October 2017, and was the most destructive fire in California history. Burning 36,807 acres, the fire killed 22 people (44 were killed in the other fires that composed the Northern California Wine Country Firestorm Complex). The Tubbs Fire incinerated more than 5,643 structures in the city of Santa Rosa. The fire damage was estimated at more than $1.2 Billion, making it the costliest disaster in California history, and causing the loss of over 5 percent of Santa Rosa's housing stock.

Outside of the U.S., major, unique, or significant fires were observed in Greenland, Russia, Portugal, South Africa, Chile, Argentina, and Greece.

In 2017, some of the project teams assisted in fire suppression and post-fire recovery activities on these fires. For example, the RECOVER (Rehabilitation Capability Convergence for Ecosystem Recovery) project team (led by PI Keith Weber, Idaho State University), and the NASA BAER project team (led by PI Mary Ellen Miller (MTRI) supported the Southern California wildfire management teams and post-fire recovery teams, particularly on the Thomas Fire, the largest single-fire burned area in California history (281,893 acres). Their combined efforts provided short-turn-around data on the burn severity and potential soil erosion/landslide potential in sensitive watersheds and environments in that fire. Both teams' investigators supported other fires throughout the United States, and other investigators supported fire management activities with Earth Observation data and access, and provided expert knowledge on the events.

In 2017, the ASP-Program issued a supplemental solicitation and funded four projects that would develop a socioeconomic assessment of their applications efforts, to coincide with the final year of their project. Those efforts are highlighted in this annual report in Section V (Project Portfolio, *Socioeconomic Impact Assessments).*

At the end of the year, the program management team was actively planning the fourth, and final Wildland Fire Project Review team meeting for 21-24 May 2018. The meeting is

[4] https://www.nifc.gov/nicc/sitreprt.pdf

planned to coincide with the International Association of Wildland Fire (IAWF)/ Association of Fire Ecology (AFE) co-organized "*Fire Continuum Conference*" to be held in Missoula, Mont. A pre-conference NASA Wildland Fire Program Workshop and a Special Session have been organized at the meeting.

In 2017, the NASA Wildland Fire Program continued support to the Group on Earth Observations (GEO) Global Wildfire Information System (GWIS) initiative. Associate PM V. Ambrosia represents NASA on the GWIS element. GWIS is developing a global database and web map service to provide EO-acquired active fire, burned area, and other fire-related information. The international GWIS team matured the wildfire web service and web map capabilities to beta-test status in 2016.

In late 2017, NASA selected three projects from the ROSES-16; A.50 solicitation to enhance and develop the GEO-GWIS web service, increase the inclusion of EO data into GEO-GWIS, and develop training and workshops on using GWIS. The selection announcement occurred at the GEO Plenary in Washington D.C. in October 2017. The GEO-GWIS international team organized a GWIS Workshop Side Event at the Plenary, to share the latest developments of the GWIS and detail the new NASA-supported GWIS projects and their expected enhancements over the next three years.

On November 19, 2016, NASA launched the first of the NOAA Geostationary Operational Environmental Satellite-R Series (GOES-R) geostationary weather satellites (now named GOES-16).[5] The NOAA GOES-16, now stationed over the eastern U.S., has increased spatial (0.5 to 2km) and temporal resolution (5-minute refresh), and will improve the early detection and observation of wildfires in the U.S. The wildland fire community is currently assessing wildfire products from GOES-16. With the planned launch of GOES-17 in early March 2018, the two systems will provide complete lower-48 coverage of wildfire events at those improved temporal and spatial scales.

III. Major Accomplishments

The Wildland Fires program's nine projects completed their third and final year as full-scale applications development projects (Phase II) in 2017. 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 2017—the advancements represent emergency support to wildland fire management; maturation of a new EO wildland fire observation capability; a new "catalog request system" for automated access to pre- and post-fire EO data for a specified fire region; simplifying access and modeling with LiDAR data to improve vegetation structure information for

[5] https://www.nesdis.noaa.gov/goes-r-series-satellites.html

fire-modeling efforts; and development and hosting of workshops with national and international agencies to enable increased use of EO data in wildland fire management scenarios. The following subsections detail those accomplishments:

- This year, Keith Weber's team increased the data layers in RECOVER to support 26 distinct data layers and features to expand capabilities for modeling for fire management teams. RECOVER was employed on 21 fires in 2017, bringing the total to 59 wildfires across the western U.S. during the last three years. Also in 2017, the BLM began routinely using the RECOVER tool without any assistance from the RECOVER team.

- Both Keith Weber (RECOVER) and Mary Ellen Miller (NASA BAER project) supported the Incident teams and BAER teams on the Thomas Fire in Southern California in late 2017. RECOVER produced a fire-affected vegetation layer, while Mary Ellen Miller and her USFS Co-investigators used those RECOVER data layers to produce a post-fire erosion/storm runoff potential model data set to develop strategies for mitigating soil erosion in variously burned watersheds on the fire. Their support helped to effect post-fire rehabilitation strategies on the fire, particularly during mop-up operations and in post-fire precipitation events, which caused severe mud slides in regions burned by the fire (and affected infrastructure and homes in their path.

- Mary Ellen Miller's model results were used by the BAER team as one tool that led to the evacuation notice before the debris flows following the Thomas fire (California). Mary Ellen's Water Erosion Prediction Project (WEPP) model was integrated into the BAER system, and was therefore being operationally used to support modeling efforts in California during some of the major fire events in the state.

- Janice Coen (modeling lead on Wilfrid Schroeder's team) identified new uses for her model to locate rapid growth in complex terrain to support pre-fire mitigation strategies. She implemented new approaches make use of NASA LiDAR-derived fuels and the Coupled Atmosphere Wildland Fire Environment model (CAWFE) to provide better information on fuel type and structure to simulate real and potential complex fire events in our national forests. The USDA Forest Service is using this approach to test the impact of its planned fuel mitigation strategies on wildfires within its Tahoe National Forest and evaluate the most effective strategy for shaping fire behavior in an effort to avoid the next big conflagration.

- Joshua Picotte and his team completed the development of an open-source-software tool (QGIS Fire Mapping Tool) that will enable the mapping of all fires nation-wide, regardless of their size, in the USGS and USFS Monitoring Trends in

Burn Severity (MTBS) program. This tool identifies fire occurrences using satellite-based active-fire detections and delineates the spatial extent of burn scars in Landsat data. Ultimately, MTBS mapping and assessment is improved by accounting for fires that would not otherwise be documented and by automating perimeter generation. This tool provides local fire managers and research scientist a "public" tool to map and assess fires that MTBS may not evaluate. With this tool, the MTBS could potentially map twice the fire acreage, if all fires were mapped regardless of size and on non-federal lands.

- Karyn Tabor and the FIRECAST team expanded FIRECAST to support Suriname in September 2017, due to interest expressed by the Government of Suriname. Additionally, one of the FIRECAST's four blogs (FIRECAST Onsight Android) was retweeted by Leonardo DiCaprio to his 17 million followers.

- Four of the Wildland Fire Program Phase II projects were selected in 2017 for supplemental support to develop a socioeconomic impact study of their respective project advancements. The projects were required to collaborate with a social- or economic scientist to evaluate the potential benefits their projects make to the wildfire management communities. The one-year project assessments ran concurrent to their Phase II, final year efforts. The socioeconomic projects are further highlighted in Section V.

IV. Program Assessment

Overall, the Wildland Fire management team was very pleased with the program and the performance of the project portfolio. The program's advancements were significant and noteworthy.

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 partner entities as well as efforts to leverage new resources to support adaptation of the QGIS Fire Mapping Tool in the USGS/USFS MTBS program (J. Picotte, PI) and the Water Erosion Prediction Project (WEPP) model (ME Miller, PI) in the BAER teams toolbox.

The year proved to be a very active and productive one in terms of the Wildland Fire program's participation in domestic and international activities. Associate PM A. Soja served on Strengthening Disaster Risk Reduction across the Americas Workshop/ Conference Planning Committee and was instrumental in the development of the meeting and served numerous roles as session organizer, session chair, and as a Disasters Simulation Exercise coordinator. Also at this event, she led the organization of a training opportunity for the underserved communities in South America "Wildland

Fire: Developing Satellite Information for Managing Fires", taught in Spanish. Soja was invited to teach-the-teachers at Metropolitan State University of Denver, speaking on "NASA Remote Sensing Fire Science and Applications". Both Soja and Associate PM V. Ambrosia were invited to speak at the Association of Fire Ecology Fire Vision 20/20: A 20 Year Reflection and Look into the Future Congress held in Orlando, Fla.[6] Additionally, Soja organized and developed materials for, and staffed the NASA exhibit booth with V. Ambrosia at the meeting. Soja chaired a session the ISRSE Symposium in South Africa, regularly reviews peer-reviewed articles and served as a guest editor on an Environmental Research Letters special issue.

Associate PM V. Ambrosia was a co-organizer and chair of the 11th European Association of Remote Sensing Laboratories (EARSeL) Forest Fire Special Interest Group (FF-SIG) Workshop (Crete, Greece), organized Special Sessions and workshops at various symposia and meetings, including the ISRSE Symposium in South Africa, and served on a number of Scientific or Technical Planning Committees for International Conferences including the AFSC Workshop: Opportunities to Apply Remote Sensing in Boreal / Arctic Wildfire Management and Science (Fairbanks, AK), the 37th ISRSE (Tshwane, South Africa), the 5th Conference on Remote Sensing and Geoinformation on Environment (Cyprus), and continued his roles and participation in various fire committees in the U.S. and internationally, including GEO-GWIS, GOFC-GOLD, and the Thermal Working Group. He also continued to serve as a Guest Editor on various peer-reviewed journal Special Issues that focused on wildfire analysis and sensor systems, and as a reviewer various peer-review journals with fire science / applications submissions, including Remote Sensing, Remote Sensing of Environment, PE&RS, Fire Ecology, IEEE TGARSS and others. He also reviews for both NASA SBIR and USDA-Forest Service SBIR programs that involve fire-sensing technologies.

In late 2017, the National Academy of Sciences published the second Earth Science Decadal Survey (2017-2027) [7], which provided recommendations from the Earth science community about research and applications priorities. Several Wildland Fires team members contributed comments and materials for the five (5) white papers that were submitted to the ESDS for consideration. The five white papers from the science and applications community highlighted the importance of EO fire science /applications.

On the program's financial front, the commitment of funding for the final year (FY17) went very smoothly. The majority of projects received their final year (2017) funding in mid-2016 and one project received funding, as planned, in the new fiscal year (FY2017). Beyond when the funds are *sent* to grantees, NASA Headquarters has been paying ever closer attention to when the funds are spent (a term NASA calls "costed"). Thus, the program management team will track this more closely in 2018, to ensure funds get

[6] http://afefirecongress.org/
[7] http://sites.nationalacademies.org/DEPS/esas2017/index.htm

fully costed in this final program year. The program management team will work closely with the nine PIs, and their institutions to ensure that their costing is on pace in FY18.

At the 2017 Wildland Fires team meeting, in Boulder, Colo., we included a session on socioeconomic impacts, including methods to calculate and quantify the benefits of Earth observations, models, and project activities to improve decisions. There was a positive response to this topic from the team. We were pleased that four projects expressed interest in an impacts study for their project, and we were very pleased with the quality of the brief proposals they submitted for supplemental funding. More information on this is found in Section V.

During 2017, we noted an issue with some of our project's adoption of their application by the partners. Despite strong intentions and commitments by the partner organizations at the transition from Phase I to Phase II, there has been indications on the loss or re-prioritization of funding by the partners, which affects their adoption efforts. For instance, the US Forest Service has indicated that the increased costs for active fire suppression has impacted their commitments to, and investments in research, research communication, and pre-fire management.

As we enter the final year of the projects, we plan to put significant attention on the transition to and adoption by the partner organizations of the applications or information products. We're pleased that about half of the projects have demonstrated successful operations of their models or capabilities and have actively participated in "live" demonstrations and support of wildland fire management on various fire incidents.

We will also focus greater attention on lessons learned from the project teams and partners. The lessons will likely cover a range of topics, such as data products and formats, organizational relationships, engagement efforts, methods to achieve applications, training needs and approaches, and unforeseen risks, among others.

V. Project Portfolio

In 2017, the portfolio contained nine projects, and the projects' foci were evenly split between pre-fire, active-fire, and post-fire applications activities. The projects' institutional leads were from universities (3), federal government (5), and one non-governmental organization. All the projects had partner organizations as co-investigators and collaborators, which included federal and state agencies, interagency work groups and international collaborations.

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 Fire section of the Applied Sciences Program website.

The majority of projects focused on the use of 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 including GOES, 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.[8]

Project Summaries

The following section describes the nine active Wildland Fire projects and some related activities from 2017. Further information on these projects can be accessed at the NASA Applied Science Wildland Fire Program web page.

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: Josh Picotte and Stephen Howard (retired), 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 public and two major entities that provide the MTBS products for the fire community: USFS Geospatial Technology Applications Center (GTAC, formerly Remote Sensing Applications Center (RSAC)) and USGS-EROS.

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

[8] See Abbreviations and Acronyms in Appendix B.

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 have led to better assessment tools and post-fire remediation support through erosion modeling. The project focused on supporting end users and partners from the Burned Area Emergency Response (BAER) teams, land managers, and researchers.

In August 2017, Mary Ellen Miller testified before the U.S. Senate Committee on Energy and Natural Resources on her development of the Rapid Response Erosion Database (RRED) to support post-fire remediation using NASA EO data and process-based hydrological models. Mary Ellen and team also supported post-fire debris flow modeling for fires in 2017, and for the devastating Thomas Fire in Southern California in late fall. She also led workshops that trained various burn assessment teams in the use Water Erosion Prediction Project (WEPP) model.

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, and an interactive website, email alerts and mobile systems that are explicitly designed based on management request. The partners in this effort have traditionally included Servicio Nacional de Áreas Naturales Protegidas por el Estado in Peru, the Ministry of Environment and Forests in Madagascar, the Department of Conservation Areas Wildlife Reserves in Indonesia, and Flora and Fauna International based in the U.K. Due to interest expressed by the government of Suriname, FIRECAST was expanded to that country in September 2017.

Outreach and engagement are keys to FIRECAST success. The Indonesian Ministry of Forestry endorsed a workshop focused on addressing multiple challenges in local and global systems in Jakarta in May 2017 in an effort to identify the advances required to achieve sustainable land management. Also, during a workshop in Riau, Indonesia, FIRECAST was introduced, with the inclusion of training on novel techniques for burn-scar mapping with both optical and Synthetic Aperture Radar using open-source software. Additionally, a workshop in Madagascar in June 2017 focused on a knowledge exchange between conservation practitioners on forest monitoring tools using Earth observation data to improve conservation decision-making. One of FIRECAST's four blogs, FIRECAST Onsight Android, was retweeted by Leonardo DiCaprio to his 17 million followers.

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.

In 2017, the Vogelmann project team completed their effort and demonstrated that: 1) Intra- and inter-annual spectral variability in shrublands / grassland ecosystems is high; 2) Spectral variability is highly correlated with climate variables, especially precipitation; 3) Fire activity is more likely in areas where the spring Normalized Difference Vegetation Index (NDVI) values are high and late-summer NDVI values are low; and, 4) Programs such as STARFM and their derivatives can be effectively used to combine the temporally rich attributes of MODIS data (which has relatively low spatial resolution for LANDFIRE applications) with spatially detailed Landsat data (which has relatively low temporal resolution for intra-annual fire applications). During the project they matured the STARFM modeling efforts to operational use in LANDFIRE, by developing a "user manual" and improved algorithms. Although their grant work is completed, the project team is continuing to assist the LANDFIRE team with further refinements of the algorithm development and integration into expand use.

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 wildland fire-related data from days to a matter of minutes. The partners include the BLM, Idaho Department of Lands, and BAER teams.

In 2017, Keith Weber and partners continued support with RECOVER-developed modeling data on numerous fires including the 2017 Napa Valley, Calif. (Atlas Peak) Fire, as well as the So. Calif. Thomas Fire. These proved valuable to the post-fire assessment teams, particularly those working on debris flow issues.

RECOVER also assisted FEMA with supporting recovery operations on Hurricane Maria.

In 2018, the RECOVER team is completing agreements with USGS to include the USGS Debris Flow Models into RECOVER, which should boost its use by the post-fire community.

Project Application Readiness Level Metrics

At the end of 2017, the portfolio had three projects at ARL 8, two projects at ARL 7, three projects at ARL 6, and one project at ARL 5. The mean ARL was 6.8 (compared to 5.9 in 2016) and the mode was ARL 8 compared to an ARL mode of 7 in 2016). Overall, 100 percent of our projects advanced one or more ARL levels, and we contributed to the Applied Sciences Program meeting its annual performance goal for 2017.

Wildfire Projects	
End of 2017	
ARL	**Projects**
ARL 9	0
ARL 8	3
ARL 7	2
ARL 6	3
ARL 5	1
ARL 4	0
ARL 3	0
ARL 2	0
ARL 1	0

Socioeconomic Impact Assessments

The Wildland Fires Program selected four projects for a quantitative analysis and valuation (in social and economic terms) of the benefits from the project and the use of Earth observations applications. We provided supplemental funding to these four projects, and the analyses ran concurrently with the final year of the project. The following list the four projects selected and the title of the associated impact study.

- RECOVER, An Automated Burned Area Emergency Response Decision Support System for Post-fire Rehabilitation Management of Savanna Ecosystems
    - *Evaluating the Socioeconomic Impacts of Rapid Assembly and Deployment of Geospatial Data in Wildfire Emergency Response Planning*

- Wildland Fire Behavior and Risk Forecasting; Principal Investigator:

- *Using Earth Observations to Assess the Socioeconomic Impact of Human Decision Making During the Suppression of a Wildland Fire*

- TOPOFIRE: A System for Monitoring Insect and Climate Induced Impacts on Fire Danger in Complex Terrain
  - *Quantifying Potential Economic Benefits of Incorporating Gridded Fuel Moisture and Weather Data into Wildland Fire Decision Support in the Northern Rocky Mountains*

- Linking Remote Sensing and Process-based Hydrological Models to Increase Understanding of Wildfire Effects on Watersheds and Improve Post-fire Remediation Efforts:
  - *Socioeconomic Impact Analysis of Linking Remote Sensing and Process-Based Hydrological Models to Improve Post-Fire Remediation Efforts*

The four projects will be finalizing and presenting their results in 2018.

VI. Program Management

In 2017, Associate PMs Vince Ambrosia and Amber Soja continued to support NASA Earth Science as Associate Program Managers for the Wildland Fire program element. 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. They also represented NASA and the Wildland Fire Program by serving on various national and international committees, and at various conferences, symposia, workshops and exhibitions, communicating the program capabilities and accomplishments.

2017 Team Meeting

The NASA Wildland Fire Program held its third annual project team meeting Feb 28 to March 2, 2017, at the University of Colorado-Boulder, in collaboration with the NOAA-Boulder Labs and Sher Schranz. The meeting focused on reviewing projects status, informing the partner entities of project advancements and readiness for integration, and enabled cross-project interaction. The event explored key science and applications issues and challenges faced by wildland fire management practitioners and scientists.

The meeting included briefings on the PI-led project status, the socio-economic study results to date, and the collaborative fire research efforts of from fire science colleagues Natasha Stavros (JPL) provided training on "*SAR/NISAR for Fire Observations*". Further briefs included those on the USFS Remote Sensing Program Overview, the Wildland Fire Assessment System, NIMO Perspectives, the JFSP activities (including the JFSP Fire

Science Exchange Network), the FASMEE Campaign status, NASA FIREChem, the NASA DEVELOP Program, the LP-DAAC, NASA ARSET, and the X-Prize for Wildfire Suppression, We also had invited speakers, including Dr. Kimberley Rollins, who spoke on Socioeconomic Measurements for Wildfire. A half-day site visit to NOAA-Boulder Labs was also organized, where tours and discussions with personnel from the Earth System Research Lab, the National Centers for Environmental Information, the Space Weather Prediction Center occurred. The NOAA tour was organized and led by Dr. Sher Schranz.

The 2017 meeting agenda and all presentation materials can be accessed at the NASA Applied Science Wildland Fire Program web page within "Past Events" and also in the "Program Library".[9]

Communications

In 2017, the Applied Science Program website was continually updated with new materials and content from wildland fire-related meetings, conferences and symposia.[10] We continued to produce video blogs to convey information about the program to the wildland fires community, NASA News Releases, other articles in the press, and NASA web features related to Wildland Fire projects.

In 2017, the NASA program management team continued to highlight the Wildland Fire program and projects through presentations and briefings to the community. We continued to distribute two-page glossy project highlights at numerous conferences and events (see sections VII and VIII). The Wildland Fires program was displayed in exhibit booths at the FireVision 20/20—7th AFE International Fire Ecology and Management Congress in Orlando, FL in late Nov 2017, at the 37th International Symposium on Remote Sensing of Environment (ISRSE) in Tshwane, South Africa in May, 2017, the 5th International Conference on Remote Sensing and Geoinformation of Environment in Paphos, Cyprus, in March 2017, as well as at the 2017 American Geophysical Union's Fall Meeting in New Orleans, La., in December

The project summaries, press releases, video blogs, reports, outreach and programmatic materials are available via the Wildland Fire page on the Applied Sciences Program website.

VII. Community Leadership

The Wildland Fire program sponsored and supported numerous community activities in 2017 as part of overall efforts to enhance the use of Earth observations and wildland fire science in fire-related management decisions and actions. The following items

[9] https://appliedsciences.nasa.gov/programs/wildfires-program
[10] http://appliedsciences.nasa.gov/programs/wildfires-program

summarize leadership of and participation in key interagency committees as well as conferences and symposia.

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

Associate PM Vince Ambrosia continued to serve as a co-chair of the NASA/USFS TFRSAC. The TFRSAC addresses efforts to share information on wildland fire imaging capabilities, technologies and projects that employ space-borne, airborne, and in situ assets to improve wildland fire characterization capabilities, including pre-fire assessment, active-fire observations, and post-fire recovery and rehabilitation. The community is composed of various federal, and International fire management organizations including: CAL FIRE, USFS, BLM, DOI, Canada Forestry Service, etc. Individuals represent Incident managers, Situation Unit Leaders, wildland fire scientists, geospatial specialists, private industry representatives, Defense Department Personnel, University partner, and engineers. The TFRSAC provides an applications forum for wildland fire management practitioners to interface with technologists and scientists to forge developmental directions for new and evolving technologies and capabilities in wildland fire airborne and satellite observations.

The TFRSAC held its Spring 2017 meeting at NASA Ames Research Center, California, on 24-25 May, with thirty-four attendees and ~25 virtual attendees. The Fall TRFRSAC meeting was held in Boise, Idaho, on 14 December 2017, with 40 attendees and 23 virtual attendees. All TFRSAC meeting presentation materials are available through the NASA Applied Science Wildfire Program website by linking to the meeting agendas in the "Library" section or the "Past Events" section.

NASA NOAA FIREX-AQ

The NASA-led FIREChem airborne campaign[11] and the NOAA-led *Fire Influence on Regional and Global Environments Experiment* (FIREX) [12] campaign announced a joint campaign, (FIREX-AQ), which will occur in 2019. The combined campaigns will leverage interagency efforts to understand the atmospheric impacts of biomass burning on the atmosphere and air quality.

Associate PM Amber Soja continued to serve on the inter-agency planning committee. Soja is a Principle Investigator on one of the FIREX-AQ projects, and both Soja and Ambrosia interact with the community as necessary to support these campaigns.

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.

[11] https://espo.nasa.gov/firechem/

[12] https://www.esrl.noaa.gov/csd/projects/firex/

Associate PM Vince Ambrosia represents NASA on the IARPC's Wildfire Collaboration Team (WCT). In 2017, the WCT helped organize a workshop focused on the use of Earth observations for wildfire analysis in boreal and Arctic systems. 2017 also marked the transition of the WCT into the IARPC Terrestrial Ecosystem Collaboration Team, upon completion of the WCT charter efforts and program schedule of tasks. One of the main contributions of NASA to the WCT was the development of a white paper report, "*Satellite and Airborne Fire Sensor Systems for Arctic Wildfire Observations",* which cataloged and highlighted the orbital and airborne sensor assets that are available for observations of wildland fire events or for post-fire assessment in the Arctic (and applicable throughout the globe).[13]

AFSC Workshop: Opportunities to Apply Remote Sensing in Boreal / Arctic Wildfire Management and Science

In early 2017, NASA Applied Sciences funded a workshop proposal submitted by the Alaska Fire Science Consortium to inform the boreal and Arctic science community on the importance and uses of EO in the study and analysis of wildfires in the boreal and Arctic systems. The workshop was held April 3-6, 2017 at the University of Alaska Fairbanks, and was attended by scientists and fire management personnel from throughout the world. Both Amber Soja and Vince Ambrosia helped organize and MC the event and presented at the workshop. NASA ARSET also held a one-day training event, led by C. Schmidt and A. McCullum focused on access and utilization of EO data supporting wildfire management decision-making. The workshop presentations can be accessed at the website.[14]

American Geophysical Union Fall Meeting

The AGU Fall Meeting in December 2017, in New Orleans, La., included sessions with wildland fire-related topics. Amber Soja presented a NASA Hyperwall talk in the Exhibit Hall entitled: "*NASA is Hot on Wildland Fire"*. The NASA booth included literature on the Wildland Fire program, especially the one-page project summaries as part of the materials available to the +20,000 delegates

VIII. International Activities

The Wildland Fire program included a larger number of internationally focused activities in 2017 and increased its activities in a wildland fire task of the intergovernmental Group on Earth Observations (GEO). The following summarize participation in key international committees, conferences, workshops, and the GEO task.

5th International Conference on Remote Sensing and Geoinformation of Environment

The Fifth International Conference on Remote Sensing and Geoinformation of Environment meeting was held March 20-23, 2017 in Paphos, Cyprus.[15] Associate PM

[13] http://www.iarpccollaborations.org/uploads/cms/documents/wildfire-sensor-systems_v5.pdf
[14] https://www.frames.gov/partner-sites/afsc/events/previous-events/workshops/2017-rs-workshop/
[15] http://www.cyprusremotesensing.com/rscy2017/

Ambrosia served on the conference Technical Planning Committee, presented a Keynote Address entitled: "*NASA Earth Science and Applications: New Perspective and Opportunities in a Changing World*", and chaired two sessions titled "Natural Hazards" and "Forests and Forest Fires".

37th International Symposium on Remote Sensing of Environment (ISRSE)
The ISRSE Symposium was held May 8-12, 2017 in Tshwane, South Africa.[16] Associate PM V. Ambrosia served on the symposium Technical Planning Committee and also organized two Special Paper Sessions were organized at the symposium, entitled "*Improving Wildfire Knowledge Through Earth Observations: From Local to Global Perspectives*", where 12 presenters provided insights into their nation's fire monitoring capabilities. Associate PM Amber Soja presented a paper in the special session entitled "*NASA Fire Science and Applications: Technology, Satellites, Airborne Data, and Models*".

Earth Observation Summit 2017—Wildfire Remote Sensing Workshop
The Earth Observation Summit, organized collaboratively with the 38th Canadian Symposium on Remote Sensing was held June 20-22, 2017 in Montreal, Canada.[17] A workshop entitled: The Role of Remote Sensing in Wildfire Management and Research" was held all three days of the meetings. Associate PM V. Ambrosia was a panel member of a session on "*Ground, Air and Space Helping Each Other Out*". A workshop results document will be available at the NASA Applied Science Wildfire Program website in the "Library" section, in early 2018.

11th EARSeL Forest Fire Special Interest Group Workshop: New Trends in Forest Fire Research Incorporating Big Data and Climate Change Modeling
Associate PM Ambrosia, was a co-organizer and co-chair of the 11th EARSeL FF-SIG Workshop held September 25-27 in Chania, Crete, Greece.[18] A few NASA Wildfire Program Principal Investigators also participated in the Workshop, presenting their applications efforts focused on improving EO for wildfire information enhancement. The EARSeL FF-SIG has held workshops every two years since 1995, and has built a strong international community of fire scientists and remote sensing and geospatial scientists to share emerging trends in EO/fire science and applications. NASA scientists have been involved in these meetings since the first, held in Spain in 1995. The Workshop is also producing a Special Issue of the peer-reviewed e-journal Remote Sensing, focused on global systems for monitoring wildfires, missions providing data for this purpose, and wildfire modeling endeavors with regards to climate change.

FireVision 20/20—7th AFE International Fire Ecology and Management Congress
Associate PMs Amber Soja and Vince Ambrosia, along with a few of the NASA Wildfire PIs participated in the FireVision 20/20 Conference in late November/early December

[16] http://isrse37.org/
[17] https://crss-sct.ca/earth-observations-eo-summit-2017/
[18] http://ffsig2017.maich.gr/

2017 in Orlando, Fla. [19] NASA was a major sponsor of the conference and both Amber and Vince supported a NASA exhibit at the conference. Additionally, Amber Soja presented two papers entitled "*Biomass burning smoke plume injection height: CALIOP-based estimates and comparisons to CMAQ*" and "*NASA Fire Science and Applications: Technology, Satellites, Airborne Data and Models*". Vince Ambrosia represented the NASA Applied Science Wildfire Program on a panel session entitled "*The Fire Science Sandbox: Who Provides What Science Support on Wildland Fire*. NASA Wildfire PIs / Co-PIs: B. Peterson, J. Picotte, Z. Holden (3 papers), V. Miller, P. Robichaud (3 papers) all represented the Wildfire program with papers presented at the conference as well.

Group on Earth Observations - Global Wildfire Information System

The Group on Earth Observations (GEO) Work Program included a task entitled the *Global Wildfire Information System (GWIS),* and GEO included GWIS in the 2017-2019 Work Programme. [20] The GWIS initiative provides a platform for harmonized information and enables the coordination of information among major national and regional fire information providers. GWIS relies on collaborative sharing of international EO data systems, as well as national and regional information sources (fire records, etc.). It provides a web-based, gap-filler system for countries and regions that do not maintain a comprehensive wildfire database. For countries and regions where wildland fire information systems exist, GWIS provides a complementary and independent source of harmonized information adding to national and regional information sources. There are four main GWIS elements: Harmonized Fire Information Data Sets; International Networking; Workshop Training; and Cross-Platform Info Sharing at Common Scales.[21] The GWIS seeks to link various national, global and regional systems to make complementary Earth observations data more readily available on wildland fires.

Associate PM V. Ambrosia continued to serve as the U.S. lead on the GWIS task, helping to identify U.S. interests and priority contributions in the task and GWIS system. The Applied Sciences Program included GWIS in the ROSES-16 A.50 solicitation in early 2017, for proposals to support the GEO Work Programme. In 2017, a selection of three PI-led projects are in their first year of development to mature the GEO-GWIS services with the community.

The GEO-GWIS team organized a workshop Side Event at the GEO Plenary in Washington DC in late October 2017, where GEO participants could learn more about the web map services and the next NASA-supported contributions to the operationalization of the system.

[19] http://afefirecongress.org/
[20] https://www.earthobservations.org/activity.php?id=126
[21] http://gwis.jrc.ec.europa/eu/

IX. Looking Ahead

AFE / IAWF Fire Continuum Conference (and Wildland Fire Program Team Meeting)

The Fire Continuum Conference, organized by the International Association of Wildland Fire and the Association of Fire Ecology will be held May 21-24, 2018 in Missoula, Mont.[22] NASA will be a major sponsor of the Conference and the Wildfire Program has organized a Workshop and a Special Session to highlight the developments of the Applied Sciences Wildfire Program endeavors. The conference will also serve as an opportunity for our final annual team meeting of the PIs, their project partners and the fire community to share in their findings and collaborative efforts.

Sonoma County Fires Rapid Response Project

In late 2017, NASA selected a proposal submitted to the ROSES-17, A.19 Rapid Response and Novel Research in Earth Science (RRNRES) solicitation, entitled "*Post-Fire Assessment, Mapping and Monitoring in Sonoma County in Response to the Pocket, Tubbs, and Nuns Fires*". The project, led by K. Gaffney of the Sonoma County Agricultural Preservation and Open Space District, is a one-year effort focusing on analysis of EO data for assessment of burn variables in the region of the No. California Fires to better assess the damage and recovery of the vegetation communities during the next year. The project will also highlight, share and train the use of EO data to other county management entities to expand the use and knowledge of EO uses. The effort is supported and managed by the NASA Applied Science Disaster and Ecological Forecasting Programs.

GEO GWIS

The GEO GWIS activities will continue with NASA involvement in the GEO Work Programme 2017-2019. The major focus will be on building capacity in under-served regions for utilizing and feeding information into GWIS, and training uses of the system through regionally oriented workshops and webinars. The program will support the management of the three GWIS-related projects that were selected from the ROSES-16 A.50 solicitation. The three projects and their Principal Investigators are:

- *"Using the NASA Polar Orbiting Fire Product Record to Enhance and Expand the Global Wildfire Information System (GWIS)",* (PI: L. Boschetti, University of Idaho);
- *"Enhancement to the Global Wildfire Fire Information System: Fire Danger Rating and Applications in Indonesia", (PI: Robert Field, Columbia University);*
- *"Development of a Harmonized Multi-Sensor Global Active Fire Data Set*", (PI: Wilfrid Schroeder (NOAA) & Louis Giglio (UMd)).

[22] http://firecontinuumconference.org/

The projects are three-year efforts and will be managed by Associate PM Ambrosia, who will also continue in his role as NASA representative on the GEO-GWIS element within the GEO Work Programme 2017-2019.

Partnership Efforts

The Wildland Fire program team expects to continue its discussions with USFS GTAC, JFSP, NIFC, and others concerning collaborations and communications on wildland fire science and applications. Program Manager Lawrence Friedl will continue to 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 wildland fire-related goals. Associate PM Soja will serve on the newly established Federal Fire Science Coordination Council, and Associate PM V. Ambrosia will continue activities with GWIS, TFRSAC, and others.

NASA Disaster Program Support

In 2018, the Applied Sciences Disaster Program[23] and the Ecological Forecasting Program[24] will subsume the Wildland Fire Program. Future program solicitations with a wildfire theme will be released as components of one of these two program elements. Wildfire-related proposals submitted in response to the Rapid Response and Novel Research in Earth Science solicitation (RRNRES), will necessary be reviewed and managed by the NASA Earth Science Research and Analysis or Applied Science Program management team members were the proposals are most closely affiliated. Future Wildland Fire Applications solicitations are currently undetermined, but will remain a component of the overall Applied Science Program areas of interest and efforts.

[23] https://appliedsciences.nasa.gov/programs/disasters-program
[24] https://appliedsciences.nasa.gov/programs/ecological-forecasting-program

X. Appendix

A. Publications/Presentations/Related Items

This appendix highlights 2017 peer-reviewed publications, white papers, reports, conference proceedings, presentations, abstracts, 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 Fire program element.

Armenteras, D., J. S, Barreto, **K. Tabor**, R. Molowny, and J. Retana (2017), Changing Patterns of Fire Occurrence in Proximity to Forest Edges, Roads and Rivers Between NW Amazonian Countries. *Biogeosciences*. No. 14, 2755-2765. https://doi.org/10.5194/bg-14-2755-2017.

Coen, J. L. 2018: Some Requirements for Simulating Wildland Fire Behavior Using Insight From Coupled Weather-Wildland Fire Models. *Fire*. 1, 6.

Coen, J. L. and W. Schroeder, 2017: Coupled Weather-Fire Modeling: from Research to Operational Forecasting. *Fire Management Today*. 75:39-45.

Coen, J. L., E. N. Stavros, and J. A. Fites-Kaufman 2017: Deconstructing the King Megafire. *Ecological Applications*. Submitted.

Coen, J. L., W. Schroeder, S. Rudlosky, 2016: Transforming Wildfire Detection and Prediction Using New and Underused Sensor and Data Sources Integrated with Modeling. *Proceedings Infobiotics/DDDAS Conference*, Hartford, CT, Aug 9-12. 16 pp. Ch. 11, E. Blasch, ed. Springer. Accepted.

Cohen, W.B., S. P. Healey, Z. Yang, S. V. Stehman, C.K. Brewer, E.B. Brooks, N, Gorelick, C. Huang, M. J. Hughes, R. E. Kennedy, T.R. Loveland, G.G. Moisen, T.A. Schroeder, **J. E. Vogelmann**, C.E. Woodcock, L. Yang, and Z. Zhu (2017), How Similar Are Forest Disturbance Maps Derived From Different Landsat Time-Series Algorithms? *Forests.* 8: 98, http://doi:10.3390/f8040098.

Hawbaker, T.J., Vanderhoof, M.K., Beal, Y. J., Takacs, J.D., Schmidt, G.L., Falgout, J.T., Williams, B., Fairaux, N.M., Caldwell, M.K., & **Picotte, J.J.** (2017), Mapping Burned Areas Using Dense Time-Series of Landsat Data. *Remote Sensing of Environment*, 198, 504-522.

Healey, S.P., W.B. Cohen, Z. Yang, C.K. Brewer, E.B. Brooks, N. Gorelick, A.J. Hernandez, C. Huang, M.J. Hughes, R.E. Kennedy, T.R. Loveland, G. G. Moisen, T.A. Schroeder, S.V. Stehman, **J. E. Vogelmann**, C.E. Woodcock, L. Yang, and Z. Zhu (2018), Mapping

Forest Change Using Stacked Generalization: An Ensemble Approach, *Remote Sensing of Environment* 204: 717-728.

Kasanický, I., **J. Mandel** (2017), On Well-Posedness of Bayesian Data Assimilation and Inverse Problems in Hilbert Space, *arXiv:* 1701.08298, *Journal of Inverse and Ill-Posed Problems,* submitted.

Musinsky, J., K. Tabor, C. Cano, J.C. Ledezma, E. Mendoza, A. Rasolohery, E, Sajudin (2018), Conservation Impacts of a Near Real-time Monitoring and Alert System for the Tropics. *Remote Sensing in Ecology and Conservation*, (in press).

Shi, H., M. Rigge, C.G. Homer, G. Xian, D.K. Meyer, and B. Bunde (2017), Historical Cover Trends in a Sagebrush Steppe Ecosystem from 1985-2013: Links with Climate, Disturbance, and Management, *Ecosystems* (online). https://doi.org/10.1007/s10021-017-0191-3.

Souri, A. H., Y. Choi, W. Jeon, A. **K. Kochanski**, L. Diao, **J. Mandel**, P. V. Bhave, S. Pan (2017), Quantifying the Impact of Biomass Burning Emissions on Major Inorganic Aerosols and Their Precursors in the US. *Journal of Geophysical Research: Atmospheres*, 122, 12,020–12,041.

Tabor, K. and J. Hewson (2018), The Evolution of Remote Sensing Applications Vital to Effective Biodiversity Conservation and Sustainable Development. Chapter in *Satellite Remote Sensing for Conservation Action - Case Studies from Aquatic and Terrestrial Ecosystems*. Buchanan and Leidner (eds). Cambridge University Press, (in press).

Turčičová, M**., J. Mandel**, K. Eben (2017), Multilevel Maximum Likelihood Estimation with Application to Covariance Matrices, *arXiv:* 1701.08185, *Communications in Statistics - Theory and Methods*, in print.

Vogelmann, J.E., P.V. Khoa, D.X. Lan, J. Shermeer, H. Shi, and M.C. Wimberly (2017), Assessment of forest degradation in Vietnam Using Landsat Time-Series Data, *Forests,* 8: 238, http://doi:10.3390/f8070238

Conference Proceedings/Presentations:

Ambrosia, V.G., 2017. *Playing in the Fire Science Sandbox: NASA Applied Sciences Wildland Fire Program,* FireVision 20/20—7th AFE International Fire Ecology and Management Congress, Orlando, Fla., 29 Nov 2017.

Ambrosia, V. G., (2017). *Wildfire Applications at NASA and Extension of GEO-GWIS.* Plenary Address at 11th European Remote Sensing Laboratories (EARSeL) Forest Fire Special Interest Group Workshop, Chania, Crete, 26 September 2017.

Ambrosia, V. G., L. Friedl and A. Soja, 2017. *NASA Applied Science Program: Wildland Fire.* Earth Observation Summit, The Role of Remote Sensing in Wildfire Management and Research, Montreal, Quebec, 20-22 June 2017.

Coen, J., W. Schroeder, S. Rudlosky. *Transforming Wildfire Detection and Prediction using New and Underused Sensor and Data Sources Integrated with Modeling*. 2016 InfoSymbiotics/DDDAS Conference, Hartford, Conn., 10 August 2016.

Coen, J., W. Schroeder, P. Oliva, P. Riggan, B. Quayle, E. Hinckley, J. Fites-Kaufman, M. Shapiro, D. Schimel, N. Stavros, B. Eisele, and K. Close. Supercomputing 2016 - Advances and Challenges in Wildland Fire Monitoring and Prediction. (Invited.) 17 November 2016.

Coen, J., W. Schroeder, P. Oliva, P. Riggan, B. Quayle, E. Hinckley, J. Fites-Kaufman, M. Shapiro, D. Schimel, N. Stavros, B. Eisele, and K. Close. *Analysis, Monitoring, and Prediction of Wildland Fires*. Stanford University, (Invited.) 5 April 2017.

Coen, J., W. Schroeder, S. Rudlosky, D. Stow, W. Brewer, L. Coulter, P. Riggan. *Data-driven methods to improve fire detection and prediction*. NCAR Networking & Discovery Day, 28 April 2017.

Coen, J., W. Schroeder, L. Giglio, S. Rudlosky, D. Stow, W. Brewer, P. Riggan, B. Quayle, L. Tarnay, S. Conway, J. Fites-Kaufman, D. Schimel, and N. Stavros. *High Performance and Distributed Computing Using Scientific Computing to Advance Wildland Fire Monitoring and Prediction*. ACM International Symposium on High-Performance Parallel and Distributed Computing. (Keynote) 30 June 2017.

Fournier, A., **J. Mandel, A. Kochanski**, Statistical Analysis of Initial-Condition Constraints and Parametric Sensitivity, The 3rd Annual Meeting of SIAM Central States Section, Colorado State University, Fort Collins, Colo., 29 September — 1 October 2017.

Kochanski, A., J. Mandel, *Data Exchange for Wildland Fire Modeling & How it All Started*, NCAR RAL, Boulder, Colo., 19 July 2017.

Kochanski, A., J. Mandel, S. Schranz, *Fire and Smoke Modeling with WRF-SFIRE*, Fire and Smoke Initiative bimonthly NOAA/JPSS Telecon, 19 April 2017.

Kochanski, A., V. Herr, J. Mandel, V. Miller, R. McCrea, D. O'Brien, *An Analysis of Socio-Economic Impact of Fire Modeling and Fire Detection Data*, Oral presentation, Fire Prediction Across Scales, Columbia University, New York, N.Y., 25 October 2017.

Kochanski, A. K., *Fire and Smoke Modeling – Challenges and Opportunities.* Invited seminar at the Washington State University, Pullman, 17 January 2017.

Kochanski, A. **K., J. Mandel**, F. Banaei-Kashani, C. Pennypacker, V. Ambrosia, *Data Needs for the New Generation of Coupled Fire-Atmosphere Models*, US Forest Service Data Management Meeting, Boise, Idaho, 3 October 2017.

Mandel, J., A. K. Kochanski, S. Schranz, M. Vejmelka, *Coupled Fire--Atmosphere--Fuel Moisture--Smoke Online Modeling With WRF--SFIRE*. The 3rd Annual Meeting of SIAM Central States Section. Colorado State University, Fort Collins, Colo., September 29—1 October 2017.

Mandel, J., A. K. Kochanski, S. Schranz, M. Vejmelka, *Coupled Fire-Atmosphere--Fuel Moisture Online Modeling System WRF--SFIRE*. Poster, Fire Prediction Across Scales, Columbia University, New York, N.Y., 25 October 2017.

Mandel, J., J. Haley, I. Kasanicky**, A. K. Kochanski**, M. Vejmelka, *Functional Data Assimilation with White- Noise Data Error and Applications to Assimilation of Active Fires Satellite Detection Data*. The 3rd Annual Meeting of SIAM Central States Section. Colorado State University, Fort Collins, 29 September— 1 October 2017.

Mandel, J., V. Herr, M. A. Jenkins, **A, Kochanski, S. Schranz**, M. Vejmelka, *Towards Integrated Fire, Atmosphere, and Smoke Modeling with WRF-SFIRE-Chem*, NOAA CSD/GSD joint seminar, Boulder, Colo., 11 January 2017.

Miller, V.V, V. Herr, A. Kochanski, J. Mandel, *Modeling Wildland Fire Suppression Decisions Using GIS and Remote Sensing Data*, 7th International Fire Ecology and Management Congress 2017, Orlando, Fla., 28 November -2 December 2017.

Picotte, J.J. *Mapping Fire Events Using an Open Source Tool*. National Indian Timber Symposium, Yakima, Wash., 26 June 2017.

Picotte, J.J. *Mapping Fire Events Using an Open Source Tool*. South Dakota Statewide Geospatial Conference, Sioux Falls, S.D., 25 July 2017.

Picotte, J.J. *Burn Mapping Processes and Tools Developed at USGS*. Mapping Fires Across Florida, Tall Timbers Research Station, Tallahassee, Fla., 22 September 2017.

Picotte, J.J. *Burn Mapping Processes and Tools Developed at USGS*. Mapping Fires Across Florida, University of Idaho, Moscow, Idaho, 23 October 2017.

Picotte, J.J. *Dickens' Ghosts: The Monitoring Trends in Burn Severity Project's Past, Present, and Future*. Fire Vision 20/20, The 7th AFE International Fire Congress, Orlando, FL., 1 December 2017.

Reeves, M., *Effects of Drought on Rangelands: Modeling and Empirical*. A Webinar for the Office of the Chief Economist (USDA), 6 June 2017. http://www.climatewebinars.net/webinars/drought-rangelands.

Reeves, M., *Quantifying Post-fire Recovery of Rangeland Productivity*. Society for Range Management Annual Meeting, Reno, Nev., 1 Feb 2018.

Reeves, M., *Evaluating Drought Monitors Relations with Rangeland Production*. Society for Range Management Annual Meeting, Reno, Nev., 2 Feb 2018.

Schnase, J., M. Carroll, R. Gill, M. Wooten, K. T. **Weber, K**. Blair, J. May, and W. Toombs, *NASA Wrangler: Automated Cloud-Based Data Assembly In The RECOVER Wildfire Decision Support System*. 2017 IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Paper: FR1.L2.2, Fort Worth, Texas., 28 July 2017.

Shi, H., *Historical Cover Trends in a Sagebrush Steppe Ecosystem from 1985-2013: Links with Climate, Disturbance, and Management*, US-IALE 2017 Annual Meeting, Baltimore, Md., 9-13 April 2017.

Soja, A., 2017. *Biomass Burning Smoke Plume Injection Height: CALIOP-Based Estimates and Comparisons to CMAQ*. FireVision 20/20—7th AFE International Fire Ecology and Management Congress, Orlando, Fla., 28 Nov-Dec 2, 2017.

Soja, A., V.G. Ambrosia, and **L. Friedl**, 2017. *NASA Fire Science and Applications: Technology, Satellites, Airborne Data and Models,* FireVision 20/20—7th AFE International Fire Ecology and Management Congress, Orlando, Fla., 28 Nov-Dec 2, 2017.

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Vogelmann, J.E., C. Barber, D. Selenak, Q. Zhou, and A. Gallant (2017). *A new Generation of U.S. Land Change Products*, Pecora 20 Remote Sensing Symposium, Sioux Falls, S.D., 13-16 November 2017.

Vogelmann, J.E., **H. Shi**, Q. Zhou, A. Gallant and **R. Dittmeier**, *Monitoring Vegetation Change Using Time-Series Data: Challenges and Opportunities*, Landsat Science Team Meeting, Sioux Falls, S.D., 11-13 July 2017.

Weber, K. T., *NASA RECOVER*. Idaho State Office of BLM Meeting, Boise, Idaho, 2017.

Weber, K. T., *NASA RECOVER.* National Interagency Fire Center (NIFC) Meeting, Boise, Idaho, 2017.

Weber, K. T., *Using GIS for Wildfire Decision Support With NASA RECOVER*. Intermountain GIS' Users Conference, West Yellowstone, Mont., 18-21 April 2017.

Weber, K. T., *NASA RECOVER and MERRA-2.* MERRA-2 Applications Workshop, Goddard Space Flight Center, Greenbelt, Md., 2017.

Weber, K. T., *NASA RECOVER.* Southeast Idaho Emergency Planning Committee, Pocatello, Idaho, 2017.

Weber, K. T., *NASA RECOVER.* US Department of Transportation Meeting, Sacramento, Calif., 2017.

Press releases/Press stories:

Video:

Weber, K., Tutorial on using RECOVER (recorded from webinar) posted to the GIS Center's YouTube channel https://www.youtube.com/watch?v=cdglU5UrVSw&feature=youtu.be

Weber, K., Using the NASA RECOVER DSS (part 1), the RECOVER generator https://youtu.be/i_j9wmbTvOs

Weber, K., Using the NASA RECOVER DSS (part 2), RECOVER web maps https://youtu.be/4Lhatls15jY

Workshops:

Tabor, K., FIRECAST Training Workshop. Chiclayo, Peru, March 23rd-24th, 2017.

Tabor, K., Early Warning Systems for Forest Monitoring Workshop. Jakarta Indonesia, May 4th, 2017.

Tabor, K., Early Warning Systems for Forest Monitoring Workshop. Riau, Sumatra, May 9th-10th, 2017.

Tabor, K., Madagascar Outreach and Engagement Workshop, Antananarivo, Madagascar, June 22-23rd, 2017.

Tabor, K., FIRECAST Suriname Workshop. Paramaribo, Suriname, February 20th, 2018.

Webinars:

Weber, K., *Using the RECOVER DSS,* with 56 registered attendees (BLM, USFS, etc.)

Communications:

Retweet of FIRECAST blog by Leonardo DiCaprio to his 17 million followers. May 5th, 2017, (Tabor, CI).

NASA Ames division seminar. " How NASA's NEX Helped Scale-up Fire Weather Modeling to Improve Forest Management in the Tropics", Moffett Field, Calif. August 7th, 2017. (Tabor, CI).

B. Abbreviations/Acronyms

ALS: Airborne LiDAR Scanner
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
CAL FIRE: California Department of Forestry and Fire Protection
CALIPSO: Cloud-Aerosol LiDAR and Infrared Pathfinder Satellite Observations
CHISLIC: Creating Hybrid Structure from LANDFIRE/LiDAR Combinations
CMAQ: Community Multi-scale Air Quality
CY: calendar year
DEM: Digital Elevation Model or 3-D representation of a terrain's surface
DLR: German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt)
DOI: Department of the Interior
EARSeL: European Association of Remote Sensing Laboratories
EPA: United States Environmental Protection Agency
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
GTAC: Geospatial Technology Center
GWIS: Global Wildfire Information System
IAWF: International Association of Wildland Fire
IARPC: Interagency Arctic Research Policy Committee
JFSP: Joint Fire Science Program
JPL: Jet Propulsion Laboratory
JRC: Joint Research Center
LANDFIRE: Landscape Fire and Resource Management Planning Tools
LiDAR: Light Detection and Ranging
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
S-NPP: Suomi National Polar-orbiting Partnership
SBIR: Small Business Innovation Research
SMOS: Soil Moisture Ocean Salinity
TFRSAC: Tactical Fire Remote Sensing Advisory Committee
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
WRF: Weather Research and Forecasting
WRF-SFIRE: WRF-Spread Fire