Wildfire monitoring and prediction

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THE BURNING ISSUE

The National Centers for Environmental Information sets its sights on improving wildfire forecasts for Alaska and Hawaii

Clay Trauernicht

The USA had an extraordinarily damaging 2017 wildfire season, burning more than 9.8 million acres, with cumulative wildfire damage costs of approximately US$18bn, US$16bn of which occurred in California alone. These destructive fires damaged or destroyed more than 15,000 homes, businesses and other structures across central California and caused 44 deaths. The US$18bn total triples the previous wildfire record of US$6bn (CPI adjusted) that occurred in 1991.[1]

The USA's need for trusted and authoritative environmental information has never been greater and sectors across the nation are looking for information to improve their resilience in the face of environmental changes.

The National Centers for Environmental Information (NCEI) is the data center for the National Oceanic and Atmospheric Administration (NOAA). NCEI hosts and provides access to one of the most important archives on Earth, with comprehensive oceanic, atmospheric and geophysical data. The organization's goal is to share information and provide robust climate science information to assess vulnerabilities, and enable improved forecasts.

CURRENT WILDFIRE MONITORING – CONUS VERSUS OCONUS

Wildfire is an important part of the environmental system monitored by NCEI and while it includes wildfires in its environmental reports, much of the data comes from the National Interagency Fire Center (NIFC), an interagency collaboration of numerous federal agencies and non-profit organizations started in 1965. NIFC provides access to up-to-date fire statistics as well as to the National Significant Wildfire Potential Outlook, an outlook for fire potential based on predicted environmental conditions that is available months in advance.

While NIFC and the National Wildland Significant Fire Potential Outlook cover the contiguous USA (CONUS), fewer resources are available for regions outside continental United States such as Alaska and Hawaii (OCONUS). OCONUS regions largely rely on

Fire and emergency services tackle a blaze in Hawaii

A section of scrubland is deliberately burned to act as a barrier to prevent the wildfire spreading

unique factors and local indices and data sets for wildfire management.[2] Forecasters, emergency managers and decision makers in Alaska, Hawaii and the US-affiliated Pacific Islands are challenged by several factors each wildfire season.

OCONUS – ALASKA AND HAWAII

Alaska and Hawaii have experienced extreme weather events in the past few years that have caused both the government and the community to look at the resilience of assets and operations for worst-case scenarios. The 2015 Alaska fire season burned 5.1 million acres, the second-largest area burned since 1940. This occurred during a period of vigorous thunderstorm activity resulting in more than 65,000 lightning strikes that gave rise to nearly 270 ignitions of preconditioned fuels. Lightning ignitions alone caused 99.5% of the acreage burned in Alaska in 2015.[3]

The chief factors influencing Alaska's wildfires include lightning strike intensity and location, dryness of fuels, variable amounts of moisture associated with storm cells, snowpack and spring melt-off rates, wetting rains and wind events. Climate impacts are ever increasingly affecting those drivers to produce longer warm seasons, and earlier and often faster snowmelt. Premature snowmelt leads to earlier and more intense seasons, more burnable area due to natural barrier loss of lakes and ponds, and more ignition potential over a wider area due to increased lightning activity. The increasing intensity of fire seasons in Alaska stems from more common high-strike lightning events, increased drying of fuels during late spring and early summer, later end-of-season rains, and a greater potential for human-sourced ignitions as population spreads into the wildlands.[4]

From 2002-2012, Hawaii observed 10,479 wildfires, for an average of over 950 each year. Hawaii sets itself apart from CONUS wildfires when comparing burn acreage. In 2003, 2005 and 2007, the percentage of total land area burned far exceeded that of the US mainland. It is important to note that 2005 and 2007 were the worst wildfire years for CONUS in terms of total area burned during the period 2005-2011.[5] The average annual land acreage burned in Hawaii was 16,275 acres from 2002-2012; of that 7% was state agricultural land and 13% dry/mesic native

Chief Eric Moller, Fire and Emergency Services, US Army Garrison Hawaii

habitat cover. Non-native, invasive grasses are a predominant fuel source, and hence problematic as Hawaii's land cover is 18% non-native grassland and 7% non-native shrubland.[6]

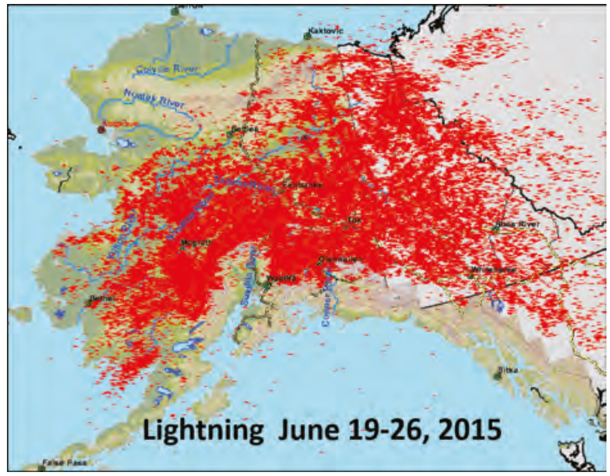
Unlike Alaska, Hawaii's wildfire ignitions from natural sources are rare and lightning accounts for less than 0.2% of ignition sources. Instead there is direct and strong correlation between population density and location of wildfire breakouts.[5]

AMS WILDFIRE PANEL

In an effort to explore the role of environmental information in OCONUS wildfire management, NCEI hosted a side panel event at the American Meteorological Society (AMS) Annual Meeting in Seattle, Washington, on January 24, 2017, titled 'Wildfires in Alaska and Hawaii – A dialog on building disaster resilience'. The panel provided an opportunity to discuss current techniques, data sets and challenges, and identify requirements to enhance OCONUS wildfire disaster resilience and response.

The goal was not only to share the challenges of wildfire management, but to listen carefully to how users applied NCEI data and information products, and how the organization can evolve to further benefit wildfire disaster resilience and response in OCONUS regions.

Panelists and participants included: NOAA's regional climate services director – Alaska Region; Alaska Interagency Coordination Center; USDA Forest Service; University of Guam; NOAA Resources Lab Pacific Marine Environmental Laboratory; NOAA's Western Regional Climate Center; and National Weather Services' (NWS) Environmental and Scientific Services Division – Alaska Region.



Alaska lightning data provided by Alaska Fire Service

In January 2015, a wildfire destroyed more than 430 acres of forest in the Oahu Forest National Wildlife Refuge on the Hawaiian island of Oahu

A wildfire in the Waianae Mountains above Makakilo, Oahu, burned 600 acres of forest

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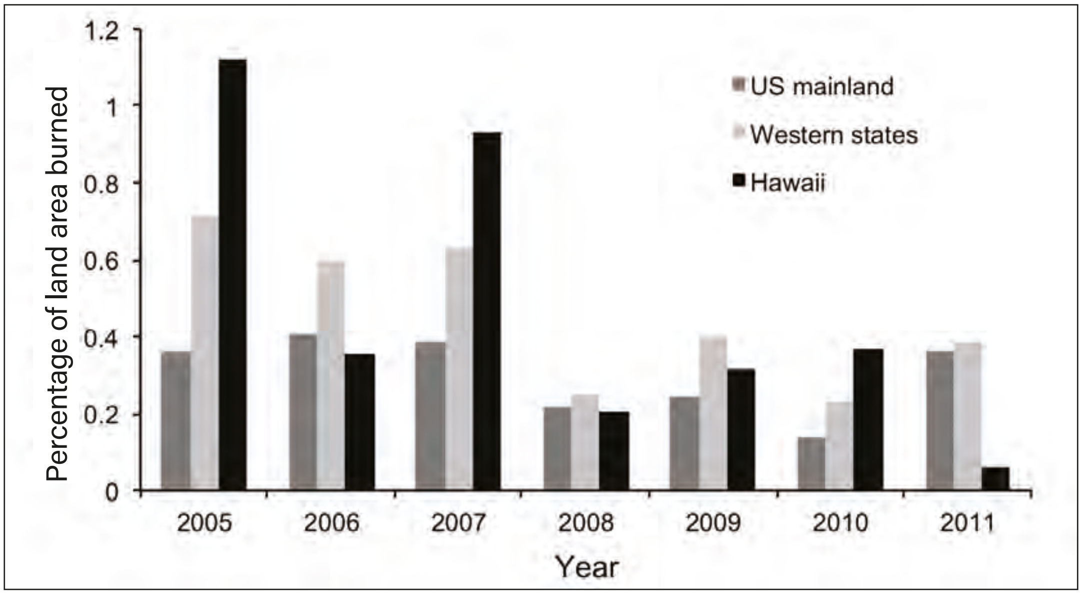
OCONUS CHALLENGES

The AMS panel discussion highlighted several challenges in current operations in Alaska. For example, emergency managers have to coordinate efforts using many data sources and tools from multiple locations and agencies. The different map projections available among the disparate sources is, in itself, a challenge to interpolate data to subregions and may not maintain true shape and size. *In situ* observations are a critical component of day-to-day operations and yet are highly data-sparse within the region.

The region also lacks adequate smoke and air quality information and forecasts that impact logistics for firefighters. Snowpack data, another critical factor in determining fire potential, is limited and estimated over large areas. Drought is an emerging issue and yet there is no reliable baseline for an Arctic definition of drought. Adequate convection modeling for lightning and timing for lightning is not yet available. Climate change impact on wildfires in Alaska is not clearly understood, especially as it applies to sea ice and glaciers, earlier spring snowmelt, longer fire seasons and fuel loads.[4]

In Hawaii, emergency managers struggle with different fuel load models, ecosystems and ecosystem shifts due to invasive species. They also lack decision-support tools for the user community, and stress the need for community outreach and education.[6]

Both regions lack adequate fire forecasting tools, operational satellite resources, ample *in*



The annual area burned as a percentage of total land area in Hawaii (black) compared to US mainland (dark gray) and Western states (light gray) for the years 2005– 2011 (Trauernicht, 2015)

situ data, and tools to integrate data needed to communicate to the various communities. Panel discussions also centered on bringing OCONUS services up to the CONUS level, as well as advancing the state of research into OCONUS wildfire-specific issues.

FUTURE SOLUTIONS

In spite of the many challenges, promising opportunities are on the horizon with the launch of the latest GOES series satellites. GOES-16 products deliver increased temporal and spatial resolution and have helped improve early fire detection. The Cooperative Institute for Meteorological Satellite Studies (CIMSS) at the University of Wisconsin-Madison has demonstrated success incorporating the 0.64μ, 3.9μ and 10.3μ GOES-16 channels to provide detailed smoke plumes and 'hot spots' or thermal anomalies in addition to several other tools to support monitoring.

LIGHTNING IGNITIONS CAUSED 99.5% OF ALASKA'S BURNT ACREAGE IN 2015

Unfortunately Alaska and Hawaii are just outside GOES-16's field-of-view. However, GOES-S (the future GOES-17), launched in March 2018, will provide superior coverage over a broad area in the eastern Pacific. Like its sister satellite, GOES-16, its Advanced Baseline Imager (ABI) is capable of observing the full disk Earth as frequently as every five minutes. In its normal mode of operation it will observe Earth at least every 15 minutes, supplying 12 times more coverage than its predecessor. Also the ABI is equipped with 16 spectral bands at higher resolution, which will offer greater opportunity to closely monitor potential fire hazards, aerosols and snowpack. Applications such as CIMSS's can be leveraged and further developed over these regions and forecasters may reap the benefits as soon as late 2018.

Although much lower in temporal resolution, the next generation of polar orbiting satellites offer improvements as well, with NOAA and NASA's new Joint Polar Satellite System (JPSS) satellites. Kicking off the series was the Suomi National Polar-orbiting Partnership (SNPP) satellite, which was launched in October 2011 and became operational in May 2014. Next came JPSS-1, which was launched in November 2017 and is referred to as NOAA-20 to maintain the naming convention of the previous generations of NOAA's polar orbiting environmental satellites.

Both SNPP and NOAA-20 are equipped with the Visible Infrared Imaging Radiometer Suites (VIIRS), which, combined with the proven capability of the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor on board NASA's EOS Terra and Aqua satellites, provide an essential suite of data for fire weather detection applications. Although temporal coverage frequency is far less than for its geostationary satellite counterparts, the increased number of spectral bands and higher spatial resolutions – between 250m (820ft) and 1km (0.6 miles) – will provide key information for specific wildfire outbreaks.

UNIVERSAL DATA SOURCE

For the improvement of OCONUS services, the primary requirement was the provision of a one-stop source for wildfire and environmental conditions that determine wildfire potential. The idea of a web-based clearing house for information is not new and has been successfully implemented for numerous environmental conditions. One such example is the US Drought Portal, the public face of the National Integrated Drought Information System (drought.gov). Although not related to wildfires per se, the Drought Portal contains interagency and partner information from numerous sources to provide decision makers with necessary drought information to mitigate the negative impacts of drought and to take advantage of the positive effects. NCEI could leverage and apply this standards-based technology paradigm to a web-based dashboard for OCONUS wildfire to include key data and information useful primarily to emergency managers. This data would be beneficial in the areas of management, identification of vulnerability in advance of fire potential, predictions of future fire threat, and impacts of fire.

Another idea discussed by the panel revolved around improved and increased surface observations. Over the past decade, in an effort to improve and sustain high-quality surface observations, NCEI began deployment of US Climate Reference Network (USCRN) stations. Installation of 114 USCRN sites across CONUS were completed in 2008 and included two stations in Hawaii. USCRN stations provide temperature, precipitation, solar radiation, surface skin temperature, surface winds, soil moisture and temperature at five depths, and relative humidity measurements for most platforms. Deployments in Alaska began in 2009. To date, the Alaska network is nearly halfway

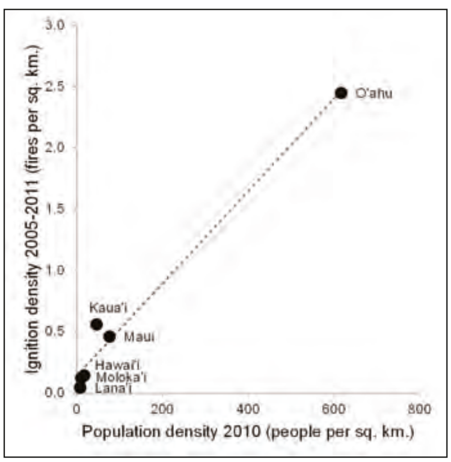
Unmanned microsensors

During the 2017-18 California wildfire season, the local firefighting community deployed several Micro Weather Sensors (MWS) from electronics developer IntelliSense Systems (ISI).

MWS is a lightweight and highly integrated ground sensor capable of being deployed in remote or inaccessible locations. The sensor has the ability to measure temperature, cloud ceiling, wind speed, wind direction and visibility, among other parameters. A built-in iridium satcom transmitter provides real-time weather data to command and control elements via satellite. This was especially important during the wildfires as it provided the leadership of the California Department of Forestry and Fire Protection (Cal Fire) with critical information to help make time-sensitive decisions on how to deploy their firefighters and mitigate further destruction.

The intent for future operations is to have these remote sensors permanently available for rapid deployment throughout Southern Californian counties. The sensors facilitate an increased level of prediction and monitoring in areas most susceptible to wildfires, providing the firefighting teams with improved lead times to help prevent future disasters.

Population density correlated with wildfire ignition density for Hawaii in 2010 (Trauernicht, 2015)



to the 29 stations targeted for the region – a major step to increased station density.

FURTHER COLLABORATION

Shortly after the AMS side panel event in Seattle, a meeting between NCEI scientists, the NWS, organizers of the NOAA NASA DEVELOP program, and Alaskan regional fire meteorologists, helped identify data gaps and potential improvements to Alaska's current wildland fire risk assessments to improve current monitoring efforts.

NCEI leveraged its NOAA NASA DEVELOP node resource as a first step to continue the conversation in Seattle and begin to address some of the gaps identified. The NOAA NASA DEVELOP program at NCEI is a 10-week capacity-building effort to engage young professionals by using NOAA and NASA satellite products and environmental data in applied rapid feasibility Earth science projects that address real-world issues facing a variety of organizations.

During the 2018 spring term, the DEVELOP participants, along with the NOAA Regional Climate Services Alaska Region, plan to work with the Alaska Interagency Coordination Center to guide the current fire risk and monitoring efforts to create a snow cover melt tool that will calculate changes in the near-real time Normalized Difference Snow Index from NASA's Terra and Aqua MODIS data. The team will also study climatological trends in seasonal snow cover melt using NOAA's Snow Cover Extent – Climate Data Record (SCE-CDR) to provide end users with a better idea of historic and expected changes in snowmelt.

To summarize, environmental data and information underpins causes and consequences of wildfires, both nationally and as shared above, particularly in the OCONUS region. Changes in the weather and climatic systems are affecting the wildfire season length, duration and magnitude. Conditions in the OCONUS regions have further exacerbated vulnerabilities to wildfires, and have caused serious damage to life and property. Feedback and discussion from impacted stakeholders resulting from the NOAA NCEI-led discussion in 2017 highlighted needs for environmental information to help inform planning and coordinate information and data across a common dashboard.

NCEI strives to improve engagement with data users, not only to better understand the applications, but also to garner feedback on needs and requirements. As more wildfire observation networks and data become available, whether through the public or the private sectors, wildfire predictions will be key in planning, and in the assessment of the role of climate change in the devastating 2017 wildfire season. ∎

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