MEETING MINUTES OF THE

INTERAGENCY COUNCIL FOR ADVANCING METEOROLOGICAL SERVICES (ICAMS)

COMMITTEE ON RESEARCH AND INNOVATION (CoRI)

SECOND WILDLAND FIRE WORKSHOP

2 June 2022 11AM-3PM ET

The second Wildland Fire Workshop focused on Fire/Weather research gaps and opportunities - improving coupled fire behavior models.

Workshop Organizers: Workshop Organizers: David Turner (NOAA), Lesley Ott (NASA), Olga Tweedy (DoE), Paul Steblein (USGS), Marc Stieglitz (NSF), Toral Patel-Weynand (USFS), Gary Geernaert (DOE), Stan Benjamin (NOAA), Kurt Preston (DoD), James Furman (USFS).

Attendees:

ICAMS CoRI: Dr. Stan Benjamin (NOAA), Dr. Gary Geernaert (DOE), Co-Chairs

IMCO Executive Director: Dr. Scott Weaver

Presenters: Invited Talks: Rod Linn (LANL), Jason Knievel (NCAR). Adam Kochanski (SJSU), Kevin Hiers (USGS); Lightning Talks: Greg Snyder (USGS), Lesley Ott (NASA), Yulia Gel (NSF), Heath Hockenberry (NOAA), Paul Steblein (USGS).

216 registered for participation and ~170 attending the workshop. **Introductory Remarks:** Sim James (IMCO) opened the workshop and Lesley Ott (NASA) reminded participants about the code of conduct required during this event. Dr. Stan Benjamin (NOAA), Co-Chair, ICAMS Committee on Research and Innovation, welcomed participants and reiterated that the purpose of this workshop is to learn from each other, identify gaps and opportunities in wildland fire research, and to find new ways to work together not just in meteorological services but across agencies in earth system prediction activities.

Remarks from Scott Weaver (OSTP), Director, Interagency Meteorological Coordination Office (IMCO): Dr. Weaver described the background and need for ICAMS to help address the societal impact of meteorological disasters that have increased from about $50 billion in 1980 to $450 billion in recent years. Of these, the number of wildfires causing $billion disasters has increased from four in the 1980 - 2000-time span, to fifteen in the time span from 2001 – 2021. The variability and impact of these disasters were part of motivation for one of ICAMS high priorities being the need for research to advance meteorological services to better support wildland fire preparedness and response.

ICAMS fulfills the mandate of the 2017 Weather Research and Forecasting Innovation Act to improve coordination of relevant weather research and forecast innovation activities. ICAMS does so by fostering collaboration to advance meteorological services via an Earth system approach, providing societal benefits with information spanning local weather to global climate. A 10-year charter was put in place on July 31st, 2020, after a year of planning and robust engagement with 50+ leaders across ICAMS Federal departments and agencies. The charter spells out the workflow and structure of ICAMS.

The new ICAMS coordination structure aims to simplify and improve coordination. There is a Council of Principals, who are senior executives from ICAMS departments and agencies. The four committees under the Council (x,y,z, w) coordinate across critical topical areas – and with each other. Each committee has a subordinate structure that is flexible and adaptable. Committees are empowered to develop their subordinate structure. The entire ICAMS structure is to coordinate closely with relevant National Science and Technology Council (NSTC) bodies – to fill gaps in the coordination to advance meteorological services, while avoiding unnecessary duplication.

Invited Talks:

Rod Linn (LANL) set the context for wildland fire modeling by describing how wildland fires are not all the same. Variations in wind, fuel, time, and space scales provide the basic differences in the spectrum of fires which can range from low-intensity to intense fires. Many different interactions between many multi-scale processes result in what is called wildland fire behavior.

Intense fires often have strong drivers (winds, dry fuels, and topography factors) while low-intensity fires (e.g., backing, flanking, and prescribed burns) are more influenced by small-scale gaps in fuels, or momentary wind fluctuations. Rod emphasized that low-intensity fires can turn into high-intensity due to changes in meteorological and environmental conditions; therefore, the importance and impacts of low-intensity fires shouldn't be overlooked.

Rod described a spectrum of models and adjustments that can be made to provide a range of applications for decision-makers facing wildland fire contingencies and a range of community risks. Examples were shown of applications for low frequency but high consequent events.

Rod noted the needs and opportunities to

- explore strategies and tradeoffs for productive fire management (including fuel treatment, smoke tradeoff, landscape level planning, etc)
- accelerate training and supporting communication
- examine fire changes in response to changes in conditions
- identify potentially dangerous scenarios.
- optimize condition-specific prescribed burn strategy to meet safely, smoke, and ecological goals

He emphasized the importance of arming decision makers with information on how prescribed fires would react as fuel and wind conditions change and suggested the use of ensembles to provide this information over a range of changing conditions. Some of the requirements for developing actionable tools include proving 1) the meteorological context for time scales from hours to decades (multi-timescale forecasting and meteorological history projections), 2) fuels context at relevant scales (e.g, 3D fuel heterogeneity, fuel conditions, and influence of fuels management and climate/meteorological history), and 3) coupled fire-atmosphere models.

Rod closed with these conclusions:

- Wildland fire behavior is multi-scale.
- Coupling between fire and atmosphere is essential at a variety of scales.

- Wildland fire feedback is critical for understanding future fire activity and ecosystem sustainability.
- Science is becoming increasingly important as we think about proactive treatment of wildland fire.

Jason Knievel (NCAR) described current and future coupled fire-atmosphere modeling at NCAR's Research Applications Laboratory. He noted that much of their approach is motivated by the fact that interactions between fires and weather are complex and two-way. Accounting for these interactions is a foundation of realistic modeling on scales useful for forecasting wildfires in the way that weather is forecast.

Jason showed an example of a WRF-Fire simulation of one of the many local fires in Colorado in recent years. Changes in wind drive the fire and smoke in different directions throughout the 18-hour simulation.

The CO-FPS framework uses WRF-Fire as its predictive core. Initial and boundary conditions for the weather modeling are drawn from NOAA's High Resolution Rapid Refresh (HRRR). The WRF Model is executed on nested computational domains with the finest having a grid interval of 111 meters. Multiple simulations can be run simultaneously. The rate of spread of the flaming front is computed as a function of fire-affected fuel and wind, and terrain slope using a semi-empirical method. Representative examples of good and poor simulations from the system were shown. In some cases, overprediction is partly because the system does not simulate fire suppression.

Jason described selected sources of uncertainty in simulating fires and smoke. The bottom line is that the atmosphere and wildfires are chaotic, the observations used to characterize them are discontinuous and include errors, and the models used to simulate them are imperfect, so uncertainty is an inevitable part of wildfire prediction. He also noted that a complete treatment of fire ignitions should consider spot fires ignited by embers carried downwind from the main blaze, sometimes over tens of kilometers in extreme cases.

Jason closed with a list of challenges and directions in which NCAR would like to take their lab's research in the coming years and also listed ideas for potential inter-agency collaboration.

Challenges and goals:

- Reliable, well distributed observations of local weather and fire in real time.
- Fast, skillful forecasts with assimilation of relevant data at appropriate scales.
- Accurate, frequently updated databases of fuel and fuel moisture content.
- Understanding urban fuels and other influences of the built environment.
- Ensembles (dynamical, statistical, AI) with probabilistic output (and training).
- Accounting for fire suppression (challenges include getting good reports.)
- Smoke and plume height predictions (smoke affects far more people than fires).
- Simulating pyrocumuli (connecting biomass smoke to microphysics).
- Predicting longer-term effects (e.g., flooding, poor water quality, new land cover).
- Integration into stakeholder workflows (cannot be overemphasized).

Potential focus areas of inter-agency collaboration:

- Sustained funding at meaningful levels for interdisciplinary research and development involving lasting, two-way strategic partnerships with stakeholders.
- Realistic allocations of staff time and resources to work on interdisciplinary teams, such as a rapid-response unit with deployable sensors.
- Testbeds, workshops, multi-agency working groups, and demonstration exercises (NOAA is building a fire weather testbed).
- Collaboratively developed products, workflows, and methods of validation that include decisions and outcomes — more than just model validation.
- Comprehensive, vetted, curated database of selected fires (pre-fire conditions, fire behavior, air quality, emergency response, impact on people and infrastructure, recovery of the ecosystem, etc.)
- More coordinated research on connections among scales (climate to turbulence).

Adam Kochanski (SJSU) presented "Coupled fire-atmosphere forecasting with WRF-SFIRE; a look beyond the model itself."

He cited examples of Wildland Fire Weather Needs (FCM-R33-2007) as motivation for research and improved support for fire weather users and the meteorological community. These needs include:

- The rapid transfer of fine-scale modeling, coupled fire-atmosphere modeling, and climate modeling advances into operations.
- Higher resolution meteorological model fields in complex terrain and the tools and input data to understand fire behavior and smoke dispersion.
- Improved fuel moisture data and forecasts that provide more timely, reliable, and spatially resolved information.
- Model output information available in easy-to-use graphics and in high-bandwidth and low-bandwidth formats for use with workstations, PDAs, and text messaging. Products also need to be available in GIS format.
- A coordinated, "one-stop" fire weather Internet presence facilitates fire weather user access to pertinent weather data and products for their region of interest.

Adam described the integrated approach to wildfire and forecasting using WRFx (integrated framework for on-demand weather, fire, fuel moisture and smoke forecasting), assimilation of fire observations, and provided examples of forecasts initialized using satellite data and IR perimeters.

The operational forecast cycle provides 48-hour forecasts twice a day. The fire initialization method has a significant impact on the accuracy of the forecast. Satellite or IR data are used to initialize the fire at the start of the forecast, identify active fire regions and provide fire history for the initial model spin-up. Each forecast starts with a 2hr spin-up, during which recent fire history is replayed, after 2hr once the fire model is in sync with the atmospheric model the coupled model takes over and continues simulating fire progression. Each forecast is ready in 3-5hr depending on the domain size.

Future and ongoing work includes an updated hybrid method integrating low-latency satellite detections, satellite-driven life fuel moisture, new sub-grid scale wind model, and integration with HRRR-smoke.

Challenges include:

- Interdisciplinary nature – fire, weather and AQ that does not fit within the mandate of any single agency.
- Availability of comprehensive datasets for model initialization and evaluation.
- Observational data availability and latency.
- Accessibility of high-resolution forecasting products.
- Targeting users' needs and integration with their platforms.
- Computational and data storage requirements.

Opportunities include the growing interest in the wildfires and wildfire modeling; research projects targeted at collecting new fire, weather and AQ information; new satellite products; coordination across agencies; collaboration with industry partners and industry-driven research; increasing computational capacity and cloud computing, and machine learning.

Kevin Hiers (USGS) presented "Coupled Fire-Atmospheric Modeling Applications."
Computational Fluid Dynamics (CFD) modeling can be a useful tool in smoke control for fire protection applications. CFD is also used to determine the speed and intensity of a fire, depending on the fuel, configuration, and other factors.

Applications for coupled fire atmospheric models include prescribed fire planning, fuel treatment effectiveness evaluations, advanced training, ember transport, and ecological fire effects. Increased prescribed fire treatments are needed but prescribed burning is increasingly complex.

CFA tools allow exploration of ignition patterns and outcomes for burn objectives. To understand ember transport and spot fire potential it is critical to account for coupled fire/atmosphere interaction.

Other topics covered included:

- Variation in vegetative properties governed by ecosystem processes can be linked to fire behavior.
- High resolution winds are needed for ensembles.
- Barriers to applying advanced modeling CFA models provide a chance to learn with the modeling community.
- Managers overwhelmingly agreed that CFD solutions were appropriate and met prescribed fire expectations.

Kevin closed by describing an Interagency Advanced Fire and Ecosystem Modeling Collaborative. He explained that it would be a community of willing experts – modeling, analytics, data; the need to join efforts to solve science and management problems; an organized partnership with some core funding, home, and operational principles. Next steps would be to assemble leads from core groups, identify principles and near-term operational aspects, and establish a Fire Science Enterprise Architecture.

Lightning Talks:

NLI Rapid Fire Needs assessment. Greg Snyder (USGS) reported on a rapid assessment of fire weather observations and information shortfalls and needs. He described the methodology used by the study group (which included USGEO members) to categorize and format the information collected from ninety-nine subject matter experts (from an array of agencies) on pre, active, and post fire activities.

Three summary tables of recommendations were shown. Next step is for ICAMS and USGEO to monitor progress on the recommendations by the agencies involved.

NASA Fire Needs Scoping Results. Lesley Ott (NASA) summarized information and key findings from the NASA Wildfire Stakeholder Engagement Workshop. Two virtual half-day sessions were held in February and included six panels followed by 2 hours of breakout discussion. There were around eight hundred registered participants, 120 from NASA.

The overarching themes of the key findings were data requirements, data services, communications, research to operations (R2O), and lack of personnel/resources. Key finding for pre-fire were categorized as weather and climate, and fuels and ignition. Key findings for active fire were categorized as fire detection and tracking, and emissions, air quality, and fire weather. Key findings for post-fire were categorized as landslides and water quality, and ecosystems and Infrastructure Impacts.

A summary of the report can be found at: https://nari.arc.nasa.gov/smdwildfire

NSF Needs Assessment Workshop. Yulia Gel (NSF) presented information from the five-day Innovation Lab event held online May 17-19, 21, and 26, 2021. The event brought together diverse research communities to generate creative strategies and new research collaborations aimed at improving understanding and prediction of the causes and consequences of future fires. This lab developed a coordinated roadmap for the direction of this research area.

Collaborations between researchers in diverse biological fields and quantitative scientists (e.g., mathematicians, computer scientists, Earth scientists, and engineers) with relevant expertise could lead to better approaches to interrogate and predict wildfire behavior and ecological consequences using available data, in situ and remote sensing, and new experimental systems.

Yulia identified three NSF fire related research thrusts:

- Data driven forecasting platforms.
- Need for land surface models.
- Need for fire enabled Earth System models.

The Workshop report can be found at: https://wildfire.hub.ki/

Incident Meteorologist. Heath Hockenberry (NOAA) provided a perspective on National Weather Service front-line support for wildfire preparedness and response. NWS needs to continue its capability and resources and training to get Incident Meteorologists to the front line to provide spot forecasts and boundary layer observations.

There is a lot of legislation being considered in Congress now related to fire weather and the fire environment. He hopes that a consolidated approach comes from these efforts.

The idea of an interagency fire center is exciting and could include modeling and messaging to the public.

There is also a need to loop in the emergency management community and get FEMA partners on board to get fire information messages to the public at the community scale. Communication to the public is key.

USGS Needs Assessment. Paul Steblein (USGS) reported on the USGS Stakeholders Needs Assessment that was conducted in support of the USGS Wildland Fire Science Strategic Plan 2021-2026. Stakeholders from various agencies and other government and non-government entities were surveyed.

The participants were asked five questions and the question being reported on today is "Stakeholders' perceptions of the most pressing science needs for fire managers in the near-term (within 10 years) and longer term (10 years and beyond)".

Paul summarized the results of the assessment:

- Priority science needs (63), which included climate, fuels, and fire behavior.
- Planning for uncertainty (40), which included risks, hazards, vulnerability, and planning for change.
- Science practices (36), which included application of science, tools, and fire economics.
- Data needs, tools, products (13), which included specific data products, tools, and data support.

Paul closed by summarizing priority science needs:

- Climate change impacts on fire and management.
- Fuels, fire behavior and fuels management.
- Planning for uncertainty.
- Multiple threats, interactions, and management.
- Uncertain future of fire behavior, vegetation, what to manage for.
- Craft research for applied need.
- Collaboration/coordination across agencies, jurisdictions, geographies.
- Synthesis & translation across topics and sources.
- Improved data and models (like physics-based fire models).

Breakout Room Session: Participants were assigned to one of four virtual breakout session rooms.

Breakout Session Objectives were to:

- Focus on points brought by the invited speakers and discuss possible cross-agency collaborations with an ultimate goal of improving fire behavior modeling and meeting fire management needs.
- Identify opportunities for cross-agency collaboration that would benefit from future investments.
- The overall objective was to advance meteorological services to better support wildland fire preparedness, mitigation, and response.

Each Breakout Group addressed the same three questions::

- What are the three most important applications for fire behavior modeling to better support wildland fire preparedness, mitigation, and response?
- What are the gaps/barriers (observations, physical parametrizations, understanding of physical processes, computing, communications, etc.) in modeling capabilities and suggestions for overcoming them?
- What are possible cross-agency collaborations to overcome these barriers with a goal of improving fire behavior modeling and meeting fire management needs?

Breakout Sessions outcomes:

Important applications for fire weather modeling:

- Understanding risks of prescribed fire and planning for prescribed burns.
- Improved representation of NOAA analog conditions.
- Understanding, quantifying, and communicating fire hazards, risks, and health/air quality impacts (e.g., advanced tools for communicating information to the public; fire modeling tools that provide understanding of the various elements of fire hazards and risks)
- Predicting fire spread and impacts of active fire events.
- Understanding how fire risks are evolving with climate change.
- Formulating tactical perspective for active fire management.
- Educational and training components for prescribed and wildfire managers.

Gaps/Barriers in modeling capabilities:

1. Data and computational challenges:
    - Hosting data to support applications.
    - Integrating data from different sources.
    - High computational costs of data needed for advanced modeling tools.
    - Determining what types of field data would be most useful (e.g characterization of fire perimeter, intensity as they evolve over time, horizontal and vertical winds, plume dynamics, and smoke properties (composition and optical)).
    - Need for improved coordination and integration of data services and better use of GEO data.
    - Need for procedures on data transmission and archiving
    - Assimilating new data that often requires manual intervention and a lot of new effort. Also, data assimilation has issues with data latency and methods to assimilate high resolution observations into high resolution models.
2. Modeling and prediction needs and challenges:
    - Inadequate model certification and evaluation.
    - Uncertainty in key physical processes and science that underpins models.
    - Lack of integrated observations to parameterize processes and validate models.
    - Need for development of AI/ML techniques and their integration with other modeling approaches to deal with lingering knowledge and scale gaps.
    - Need to address 2-way coupling to ensure broader AQ impacts are represented in regional/global models.
    - Need to incorporate human impacts on wildland fire. This is especially important as the fire moves into urban areas.
3. R2O challenges:
    - Strengthening the R2O pipeline.
    - Transferring innovation into operational space.
    - Operational constraints on what can be deployed (e.g., UAS limited by airspace issues, challenges with getting remote sensors close).
4. Institutional challenges:
    - Each agency is trying to solve all the fire weather problems.
    - Lack of clarity on interagency roles/responsibilities.

- Lack of centralization of materials, information, and platforms among agencies.
- Lack of communications among agencies.

5. Research challenges:
    - Better understanding of fuel moisture evolution, especially by fuel type.
    - Boundary layer profiles: wind profiles, then static stability, then moisture. Need the entire depth of PBL ideally (which changes day to night).
    - PyroCbs remain challenging. Need to understand the connection to pyroCb and fire. Requires integration of multiple, complex components and a strategy for how to deploy.

Opportunities for interagency collaboration:

Fire is a multidisciplinary problem and requires multiagency solutions. Below are listed some potential ways for multi agency collaborations:

- Need for interagency fire center and Federal Fire Science Center.
- Need to recognize interagency center activities and support the Joint Service Science program activities.
- Developing interagency vision.
- The Moonshot approach may be the way to bring about significant changes rather than concentrating on low-hanging fruit.
- Creating/supporting cross platform data and tool sharing.
- Coordinate intensive, airborne campaigns to gain holistic understanding of processes, and validation.
- Work to deconflict airspace to maximize ability to leverage advances in UAV technology.
- Opportunities for interagency activities could be:
    - The Fire Weather Testbed.
    - Modeling and data assimilation.
- Need to support ability to share advances in research and technology for rapid progress, including shared technical capabilities (e.g., tools, code repositories).
- Need to find ways to engage with and learn from international efforts.
- Multiagency collaborations and partnerships associated with data services. For example, coordinated services to provide more reliable access to datasets, facilitate integration for model initialization, and data assimilation are needed.
- Create opportunity to engage with the energy sector who need information for planning
- R2O and O2R to get the right products developed that can be used efficiently.
- Updating documentation and creating opportunities to train more people to use fire modeling tools efficiently.

Concluding Remarks and Next Workshop:

(Note that questions and comments by participants during this Workshop were made and primarily addressed in the virtual chat log).

Wrap Up/Final Thoughts: Information about ICAMS/ IMCO and Workshops will be presented at the January 2023 AMS Conference. There may also be a related article in the BAMS.

Next Workshop: Thanks to all who participated in this ICAMS workshop. The next ICAMS Fire-weather/Wildfire Workshop is tentatively planned for this Fall.