Proposal ID: **17-1-05-1**

Title: Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment

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Project Status: **Final Draft**

Start Date: 08/01/2017

End Date: 07/31/2019

Category: Fire Behavior

Project Website:

Project Abstract:

The proposed work will evaluate the ability of operational and experimental versions of the High Resolution Rapid Refresh (HRRR) modeling system for the continental United State and Alaska to forecast the characteristics of mesoscale atmospheric boundaries arising from thunderstorm outflows, gust fronts, and downburst winds (referred collectively as convective outflows). The objective is to lead to enhanced situational awareness within the operational fire weather community of the ability of the HRRR model and predictive tools that rely on its output to nowcast and forecast convective outflows.

Expected benefits from this project include:
1) improved understanding of the ability of HRRR data assimilation/forecast systems to forecast convectively-driven changes in wind, temperature, and moisture that influence fire behavior, which will assist fire weather forecasters in their ability to incorporate high-resolution model output in probabilistic convective outflow forecasts on time scales < 24 h.
2) improved understanding of the impacts of operational model uncertainties in convective outflow characteristics on fire spread scenarios. This will be conducted using: (1) a fire behavior tool that will rely on HRRR output combined with landscape characteristics and fuelbed flammability and (2) simulations of selected case studies using a coupled fire-atmosphere model, WRF-SFIRE.
3) improved communication methodologies for fire weather forecasters, incident meteorologists, and fire behavior analysts to inform alerts and warnings of potential and imminent risks to fire managers and fireline personnel who will be most affected by abrupt changes in weather conditions near wildfires.

The research team led by the University of Utah and University of Alaska-Fairbanks has extensive experience assessing the benefits and limitations of weather forecasts for fire management applications. We will classify and examine many cases in which convective outflow boundaries were identified by on-site fire personnel to have affected fire behavior in complex terrain. We will also objectively identify convective-outflow signatures in the vicinity of wildfires using a wide-array of meteorological resources to identify their critical characteristics, e.g., duration, intensity, speed, and seasonal and time-of-day dependencies.

Using an archive at the University of Utah of HRRR forecasts in the continental United States and Alaska from 2017-2018, we will then assess the ability of HRRR forecasts to detect the presence of outflow boundaries and the fidelity of the forecast guidance available from that model system to

forecast them on a range of temporal and spatial scales. We hypothesize that model guidance will be most useful for: (1) nowcasts of longer-lived (< ~6 h) outflows that develop typically within preferred synoptic-mesoscale situations and (2) forecasts that provide improved situational awareness for the potential for outflows at lead times from 6-24 h rather than accurate depiction of each outflow. Validation of the numerical analyses and forecasts will be completed using a mix of spatial statistical techniques and subjective evaluation emphasizing the overall situation from the perspective of what a forecaster or fire behavior analyst would be able to establish from ~24 hours prior to until immediately before any major changes in the atmospheric state that would affect fire behavior.

The proposed study will equip incident meteorologists and fire behavior analysts assigned to major fires and NWS WFO forecasters and predictive service personnel in the continental United States and Alaska with improved situational awareness of the potential for outflows and their impacts on fire behavior when they examine HRRR output operationally. In order to do so, operational personnel will help evaluate how to interpret the results of the validation studies and design procedures and best practices to inform the wider community.

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Total Funding Requested	Total Inkind Contributions
$277,068.00	$86,646.00

Created on:	Sep 19, 2016 at 08:44:06 AM	By:	jdhorel
Last update on:	Nov 16, 2016 at 08:53:07 AM	By:	jdhorel
Last Submitted on:	(not submitted)		

I. Overview

1. Problem Statement

Our proposed research focuses on improving the information available to firefighting personnel regarding the impacts of mesoscale atmospheric boundaries arising from thunderstorm outflows, gust fronts, and downburst winds (referred hereafter collectively as 'convective outflows') on fire behavior and the ability of current weather prediction models to forecast them. Wildland Fire Associates (2013) concluded regarding the entrapment and burnover on June 30, 2013 of the crew members on the Arizona Yarnell Hill fire: "Fire behavior was extreme and exacerbated by the outflow boundary associated with the thunderstorm. The Yarnell Hill fire continually exceeded the expectations of fire and incident managers, as well as the firefighters". We will examine comprehensively the ability to detect and forecast convective outflows by the operational High Resolution Rapid Refresh (HRRR) modeling system for the continental United States (CONUS) as well as its developmental versions for the CONUS and Alaska (Benjamin et al. 2016). The HRRR modeling system is the most relevant operational forecast system for detecting and forecasting convective outflows and providing that information with sufficient lead time for operational fire decision making.

2. Objectives

The fundamental hypothesis for our research is that the HRRR and fire behavior tools that rely upon it are not able at the present time to provide accurate, highly specific forecast guidance on convective outflows in complex terrain. Rather, **we hypothesize that the HRRR can facilitate nowcasting at lead teams less than 6 h and improve situational awareness for the potential for convective outflows at lead times less than 24 h**, particularly in certain synoptic-mesoscale situations**.** To address those hypotheses, we will focus on potential fire weather situations when operational models are more (or less) likely to provide useful forecast skill. While it may not be possible to expect high forecast accuracy for the timing, speed, and intensity of individual convective outflows in complex terrain, there is considerable potential to improve the operational use of high-resolution model output for convective outflow forecasting at lead times of less than 24 h, as well as how the risks associated with such events can be communicated operationally to the fire weather community based on a careful evaluation of current operational model skill. The specific project objectives for this study are: (1) utilize an extensive array of observational resources to identify and evaluate the characteristics of convective outflow events that had substantive impacts on wildfires in the CONUS and Alaska; (2) use those observational resources to evaluate the ability of the HRRR model to analyze and forecast those events; and (3) assess the sensitivity on fire behavior and spread rate resulting from forecast uncertainty of convectively-driven outflows using a physically-based tool, Rate of Spread Ratio (**ΔROS** , Bishop 2009) and a coupled fire-atmosphere model, WRF-SFIRE (Mandel et al. 2011).

3. Task Statement Relevancy

We will address all four of the research needs identified for this task, as restated here in the context of our proposed research: *(1) evaluate the ability of the HRRR modeling system to characterize the development, movement, and magnitude of mesoscale atmospheric boundaries; (2) assess the HRRR forecast skill in the context of landscape variability, current flammability, and basic fire behavior assessment; (3) demonstrate that model and tool validation is possible in complex terrain using information provided by incident meteorologists on site combined with an extensive array of surface observations, radar and satellite imagery, upper air soundings, and model analyses; (4) illustrate how the potential risks associated with convective outflows can be communicated effectively to the fire weather and fire management community.*

4. Benefits

The research team has a demonstrated record of evaluating model skill relevant to fire weather applications and providing results as publications and web services to the research and operational communities. Our research will be of greatest benefit for the interpretation of model guidance by incident meteorologists and fire behavior analysts assigned to major fires as well as the fire-weather focal points at NWS WFOs and the fire managers they support. Deliverables will include peer-reviewed research articles and webinars and presentations in national and regional venues oriented to fire professionals. In addition, we will develop recommendations for enhanced use of operational tools and communication methods to inform fire managers and fireline personnel on anticipated and imminent threats.

II. Technical Background

Convective outflows influencing fire behavior leading to loss of life and extensive damage have been examined in several instances (e.g., Yarnell Hill, Wildland Fire Associates 2013; and Waldo Canyon, Johnson et al. 2014). Such outflow events are common on many fires. For example, the Incident Meteorologist (IMET) assigned to the 2016 Idaho Pioneer Fire (Fig. 1) noted: "On August 5, a weak disturbance moved into SW ID where afternoon showers and thunderstorms developed. A band of showers east of the fire had an outflow that brought gusts as strong as 40 mph at Jackson Ridge IRAWS 36 (HFNC1) at 3:18 PM. Shortly around this time, a huge pyro-cumulus developed in Division EE. The fire jumped the containment line and over the Payette River about 2.5 miles west of Lowman near the Deadwood Campground."

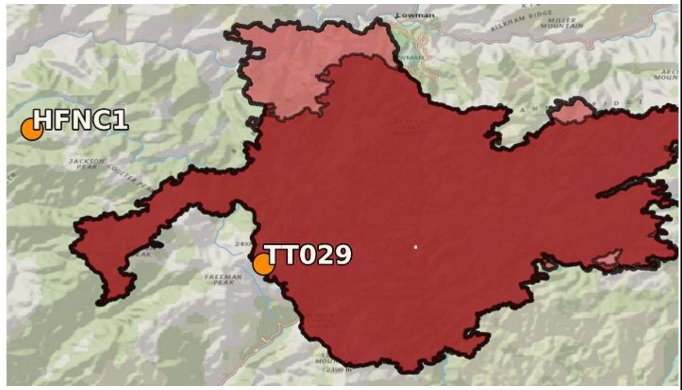

Figure 1. Expansion of the Pioneer fire across the Payette River on 5 Aug 2016 due to thunderstorm outflows. Dark (light) red shading denotes the fire extent on 4 (6) Aug 2016. Locations of the Jackson Ridge IRAWS 36 (HFNC1) and Pilot Peak IRAWS 26 (TT029) deployed to support fire operations indicated.

The potential impacts of such convective outflows on fire behavior are well known and the ability of NWS forecasters to provide general guidance in advance on their likelihood as well as nowcasts of their behavior are greatly appreciated within the fire community. For example, the Fire Weather Forecast issued at 2000 LST 4 August by the IMET on duty recognized the general situation and stated: "An upper level low will be in the region… This will result in cooler temperatures, higher relative humidity and gusty shifting winds. But more importantly there will be a chance for thunderstorms... These storms will likely have brief heavy rain, small hail and gusty outflow winds to 40 mph." Figure 2 summarizes the types of forecasts required to be issued by IMETs and WFO forecasters as a function of lead time. Diverse resources from many sources are available for lead times > ~24 h. *Our proposed work focuses on the needs of forecasters to have resources to improve forecasts and situational awareness of thunderstorm outflow probabilities at lead times of 12-24 h, short-term forecasts at lead times of 6-12 h, and nowcasts at lead times <~6 h.*

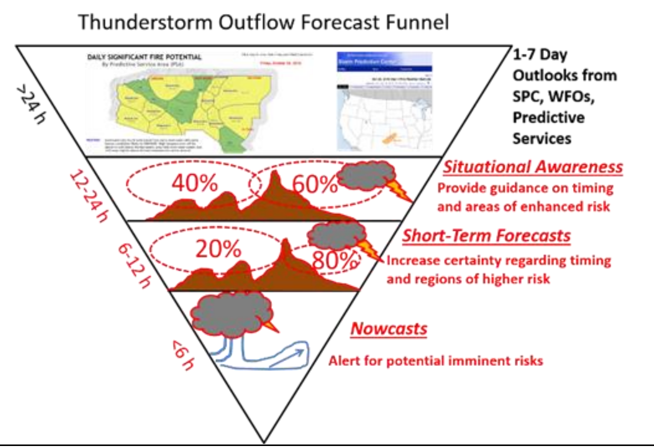

Figure 2. Guidance on the threat posed by convectively-driven outflows is required over a wide range of spatial scales and forecast lead times. This proposal focuses on improving the information available to forecasters for the components of the forecast funnel in red.

The ability of outflow-resolving numerical models and fire prediction tools that rely on such model output to provide deterministic guidance on their intensity and movement has not been established operationally. As summarized by Hart and Cohen (2016), convective outflows depend on complex interactions involving subgrid-scale processes that operational numerical models do not resolve explicitly (e.g., microphysical processes and turbulence). While research simulations of wildfire behavior are showing great promise (Mandel et al. 2011, 2014a; Coen and Schroeder 2015; Kochanski et al. 2016), such simulation systems are not available nationwide operationally. Software tools such as WindNinja (Wangenbrenner et al. 2016) provide spatially varying wind fields for wildland fire application based on observed or forecast wind inputs. While they have considerable potential to aid fire decision making, their ability to capture the observed wind field in complex terrain depends on the fidelity of the forecast model guidance to capture the correct characteristics of the prevailing conditions and any convective disturbances embedded within those prevailing conditions. Numerical forecast systems that resolve convection increasingly rely on ensemble methods to simulate a range of possible outcomes (Dixon et al. 2016) and small errors on larger scales in the initial state of a forecast model can strongly influence forecast accuracy for thunderstorm outflows (Durran and Weyn 2016). In addition, our understanding of the actual flow characteristics of convective outflows is imperfect, particularly in mountainous areas. For example, Gunter and Schroeder (2014) state: “The limited body of research has illustrated significant differences between the mean characteristics of thunderstorm outflow winds and “standard” boundary layer winds, yet the evolution of the (thunderstorm) wind profiles remains poorly understood.”

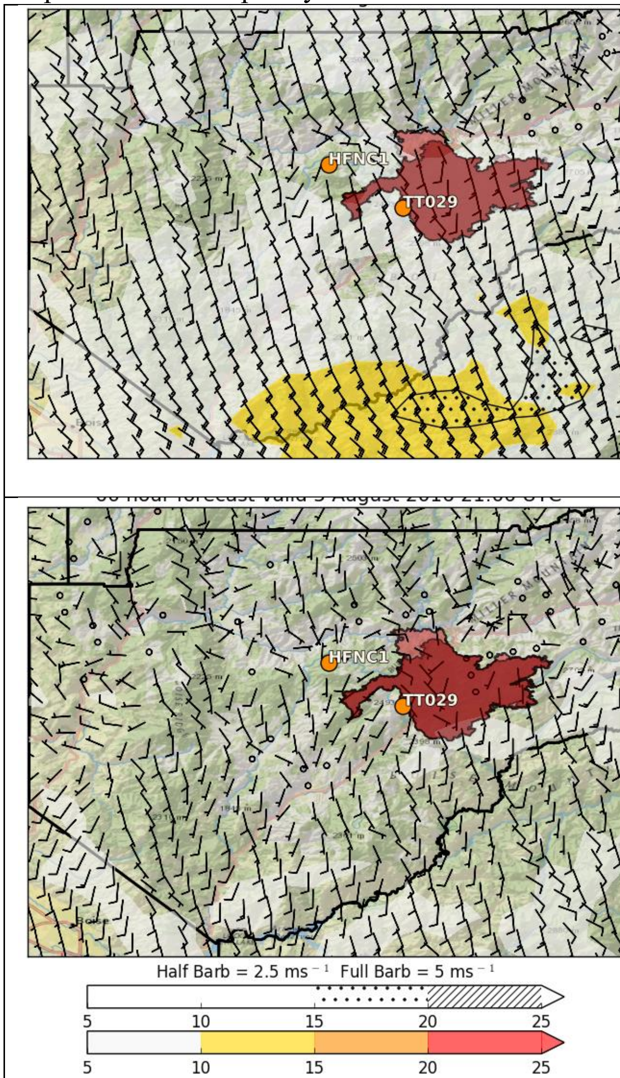

Figure 3. Top panel. 10 m wind vectors from 7 hour HRRR forecast valid at 20 UTC 5 Aug 2016 in the vicinity of the Pioneer fire (red shading). Yellow (hatched) shading denotes winds (gusts) greater than 10 (15) m s^{-1}. Bottom panel. HRRR analyzed wind vectors valid at 20 UTC.

Our core objective is to assess the forecast guidance available for convective outflows in complex terrain, thereby aiding fire weather forecasters in their ability to confidently incorporate the high-resolution model output (such as provided by the HRRR) in probabilistic thunderstorm forecasts on time scales of <~24 h (Fig. 2). We will examine output from the only operational data assimilation/forecast modeling system that is capable to do so. The HRRR modeling system developed at the NOAA Earth System Research Laboratory (ESRL) and implemented operationally at the National Centers for Environmental Prediction (NCEP) for the CONUS provides output at sufficiently fine spatial (3 km) and temporal (15 min to hourly) resolution to be able to diagnose thunderstorm outflows, gust fronts, and downburst winds (Benjamin et al. 2016). While the HRRR relies on the community WRF-ARW model that is commonly run at many NWS WFOs and research universities and usually initialized from other real-time or retrospective model fields (Skamarock et al. 2008), the HRRR’s data assimilation system is designed to incorporate information critical for detecting convective systems including lightning and radar data along with surface and upper-air observations, satellite radiances, and aircraft winds. A separate experimental version of the HRRR assimilation/ forecast system is run for Alaska and additional guidance products are being developed for the CONUS including a Time-Lagged Ensemble.

To demonstrate and validate the HRRR’s ability to forecast thunderstorm outflows and other convectively-driven boundaries in complex terrain, we will build on the extensive experience developed over the past decade directed towards evaluating observational, analysis, and forecast resources relevant to the fire community. These include: evaluation of National Digital Forecast Database forecasts (Myrick and Horel 2006); impacts of RAWS observations (Myrick and Horel 2008, Horel and Dong 2010, Brown et al. 2011); and evaluations supported by the JFSP of NWS Spot forecasts for wildfires and other incidents (Lammers and Horel 2014, Nauslar et al. 2016). In addition, web services and tools have been developed by the MesoWest team (Horel et al. 2002) for the fire weather community including ROMAN (now deprecated to MesoWest http://mesowest.utah.edu), the Great Lakes

Fire and Fuels System (http://glffc.utah.edu; Horel et al. 2014), and the Alaska Fire and Fuels System (http://akff.mesowest.org/). Operational context and additional information required for this study will be provided as well by the web services and tools developed by the Wildland Fire Assessment System (http://www.wfas.net/index.php/support-mainmenu-27) and the national Predictive Service programs (http://www.predictiveservices.nifc.gov/predictive.htm).

For example, Figure 3 illustrates our ability to access, archive, and geolocate HRRR analysis and forecast guidance relative to fire locations and available RAWS and IRAWS observational assets. The 7 h HRRR forecast of 10 m wind valid at the outset of the strong thunderstorm outflows on 5 Aug 2016 is contrasted with the HRRR analysis at that time. The 7 h forecast highlights stronger winds to the south of the fire (shading and stippling) while the analyzed winds are weaker and exhibit more terrain channeling.

III. Methods

1. Study Design

The proposed research will be led by researchers at the University of Utah and the University of Alaska-Fairbanks with collaboration from participants from the NWS, ESRL, and GACC Predictive Services. The proposed project timeline is two years and will have immediate applications during the project as well as upon completion. We will rely on the extensive data archives at the University of Utah. For example, HRRR analyses and forecasts have been archived for the CONUS and Alaska since summer 2016 and will continue to be downloaded during the duration of the project. Data archives at the University of Utah include surface and upper air observations and radar and satellite imagery.

The following sections will expand on our study design. Convective outflow events affecting fire behavior will be identified on the basis of information provided by on-site fire meteorologists and fire behavior analysts. From this large sample of events, representative cases reflecting a wide diversity of regional, terrain, and weather situations will be intensively examined during the 2017 and 2018 fire seasons. The characteristics of the HRRR model analyses and forecasts for those events will be documented as a function of forecast lead time. Where possible, readily available spatial depictions of landscape/land cover and current flammability factors will be included to demonstrate efficacy using generalized depictions of significant changes in potential fire behavior over appropriate temporal and spatial scales, comparing them to events as they actually unfolded. For selected case studies of highest interest, coupled fire-atmosphere WRF-SFIRE model simulations will help validate the HRRR model.

All of this research will be grounded within a framework of risk assessment relevant to the fire community. Werth et al. (2011, 2016) synthesize present scientific understanding of the complex interrelationships between weather, fuel, and terrain affecting fire behavior. We will assess the extent to which it is possible to define higher confidence in model guidance in the context of the information available to a forecaster or fire behavior analyst as a function of forecast lead time or synoptic situation. Objective skill metrics often used for model assessment and development (e.g., Lammers and Horel 2014; Nauslar et al. 2016) are of lesser interest.

2. Identify convective outflow events and assemble data sets

Our primary source for identifying convective outflow events will be information provided by on-site fire professionals, e.g., meteorologists and fire behavior analysts. For example, we have received permission from the NWS National Fire Weather Program Office to examine the IMET Incident Forecast Logs. As illustrated in the first paragraph of Section II, the Narratives, Weather Updates, and Weather and Fire Behavior Forecasts in those Logs provide critical information on weather events that affected fire behavior on major fires. Similar information will be sought from the fire behavior analysts. A secondary source for identifying convective outflow events will rely on our ongoing fire-related web applications. For example, we download metadata (e.g., initial fire location, fire perimeter) on all major fires from the Geospatial Multi-Agency Coordination (GEOMAC) web server and other information can be collected for the case studies (e.g., NDVI, infrared mapping and MODIS/ VIIRS active fire mapping products). It will be possible to identify cases where there are large increases in area burned for selected major fires from one day to the next relative to potential signatures of atmospheric boundary events, e.g., increases in wind speed or changes in wind direction from nearby surface observing sites, lightning, or obvious cloud features in radar and satellite imagery. The August 5 2016 outflow on the Pioneer Fire used to illustrate our capabilities in this proposal is an example of an event that would have been identified using either source approach. We will initially test our analysis methodology on a small representative sample of cases during the 2017 fire season followed by more extensive examination of events during 2018.

Our MesoWest research team maintains an archive of environmental observations obtained from over 30,000 surface platforms in the United States (Horel et al. 2002). These include observations from over 2300 RAWS and IRAWS platforms. Available metadata and data are accessible for all of these observations via an api (synopticlabs.org/api). We also archive the operational NCEP Real-Time Mesoscale (RTMA) analyses of surface fields (e.g., wind, temperature, moisture) available hourly at 2.5 (3) km resolution in the CONUS (Alaska) regions. We also develop similar hourly analyses, University of Utah Two-Dimensional Analyses (UU2DVAR), for quality control of wind, temperature, and moisture observations (Horel and Dong 2010). These analysis products will help to identify the spatial extent of convectively-forced boundaries.

We have extensive experience evaluating forecast guidance using surface observations from diverse sources focusing for fire weather applications on RAWS/IRAWS and NWS/FAA assets. We access and archive for our validation studies upper air soundings and radar and satellite imagery. We will also examine all relevant IMET-initiated sonde launches in the vicinity of major fires, as well as any soundings of other relevant observations collected during the NOAA FIREX study in summer 2018. Lightning data will also be collected and examined particularly for the Alaskan cases where other data assets provide less complete coverage.

HRRR forecast grids will be retrieved and archived at the University of Utah continuously during the project period. The HRRR modeling system is implemented operationally at NCEP with active development of new capabilities by researchers at ESRL. The HRRR is a real-time 3-km resolution, hourly updated, cloud-resolving, convection-allowing atmospheric model, initialized by 3km grids with 3km radar assimilation. As summarized in Table 1, this study will evaluate output from both operational and experimental versions of the HRRR during 2017 and 2018 in order to take full advantage of the capabilities of the current and future versions of the analysis/modeling system. Table 2 highlights some of the wind fields available from HRRR analyses and forecasts. Many additional diagnostic fields for temperature, moisture, and stability are available as well. Project contributor T. Alcott, NOAA/ESRL, will keep us informed on new HRRR capabilities as they become available and improved ways that the modeling systems might be used to diagnose convective outflow events.

Table 1. Currently Available Versions of the HRRR Modeling System to be Evaluated

Version	Domain	Forecast Length (h)	Output Frequency (h)
NCEP	CONUS	18	0.25 & 1
ESRL	CONUS	18; 36 every 3 h	0.25 &1
ESRL Time-Lagged Ensemble	CONUS	24	1
ESRL Alaska	Alaska	36 every 3 h	1

Table 2. Currently Available HRRR wind forecast fields

Version	Variable	Time interval
All	3-D fields	Instantaneous at top of hour
All	10 m & 80 m wind speed, gust, & direction	Instantaneous at valid time
All	10 m and 80 m maximum wind speed	Within time window
NCEP, ESRL	1 h change in 80 m wind speed	Instantaneous at valid time
ESRL TLE	Probability of wind > threshold	Within 4 hours

3. Analysis Plan

a. Observational characteristics of convective outflow events

We will examine initially representative major fires in the CONUS and Alaska where fire behavior was affected by convective outflows. Where in the United States large fires are likely to occur during the 2017 or 2018 fire seasons is of course unknown. Alaska presents unique challenges because of its data sparse environment combined with a high incidence of convective storms over flammable landscapes. Detecting outflows is difficult in most situations due to their shallow nature and the wide separation between NWS radars (and the even more limited radar coverage in Alaska). Hence, tracking outflows is dependent on the temporal and spatial resolution of available surface observing networks.

We will examine a mix of events that will be representative of the variations across the country, time of year and day, fuel types and state, and local topography. We will emphasize cases where diagnostic resources are readily available, e.g., IMET and fire behavior analyst on site, IRAWS stations deployed, and rawinsonde launches occasionally available. We also will begin with events where radar coverage is less affected by terrain beam blockage and the many locations around the western United States where local mesonets provide enhanced coverage of conditions near the fire.

The intent will be to evaluate each event holistically, considering the conditions on that day relative to those on previous as well as subsequent days in terms of the synoptic situation and state of the boundary layer (stability, wind shear, etc.). We will pay particular attention to the temporal evolution of the conditions affecting the fire's behavior, including when initial detection of a convective outflow might have been possible from the available observations. We will assess for each event the information that would be available to a forecaster to brief the on-site team as a function of forecast lead time. Of greatest interest is to assess what are the observed features that are most relevant to the initiation, evolution, and decay of the event and how recognizing those features could be used by a forecaster when examining model output.

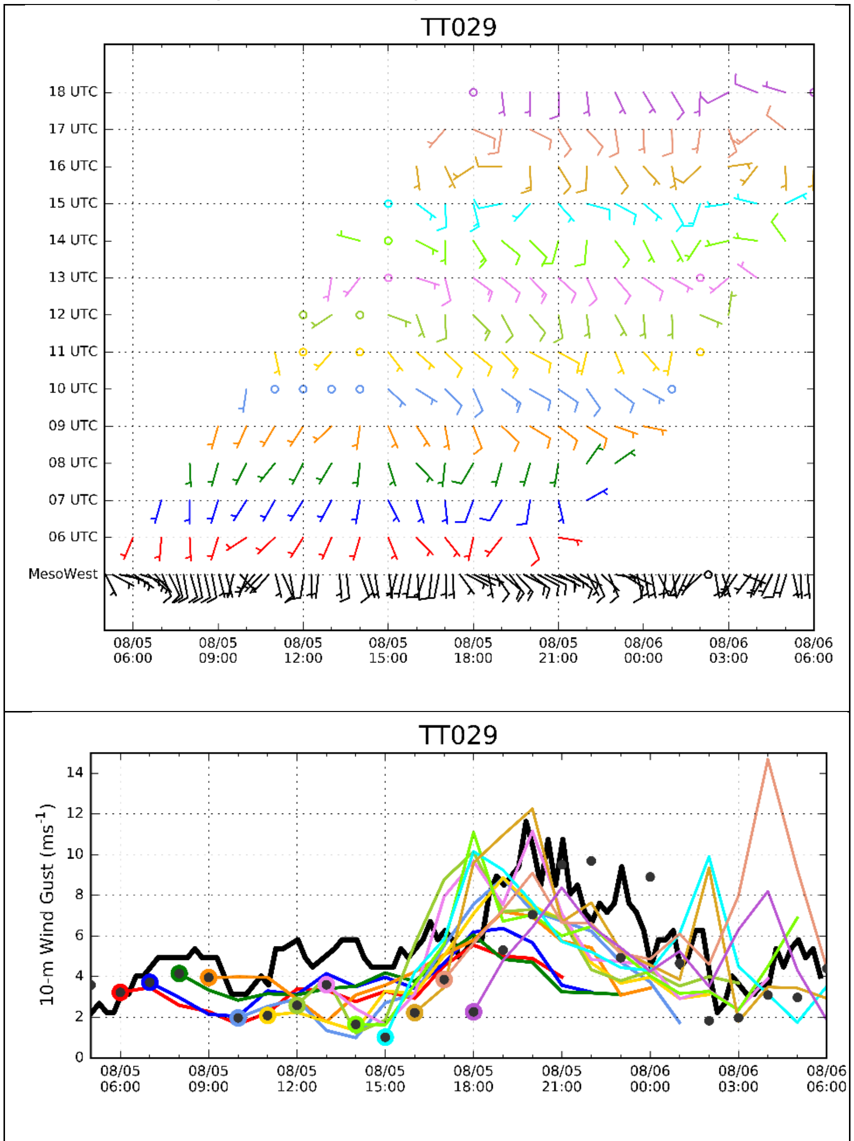

Figure 4. Top panel. Observed vector wind (black) at Pilot Peak IRAWS (TT029) on 5 Aug 2016 and HRRR vector wind forecasts issued from 6-18 UTC on that day (full barb 5 m s^{-1}). Bottom panel. Observed wind gusts (black line), HRRR analyzed gusts (black dots), and HRRR forecasted gusts beginning from hours 6-18 UTC (colored lines).

b. Evaluation of HRRR analyses and forecasts of convective outflow events

After we establish the overall context for why a convective outflow event transpired, we will examine the extent to which the HRRR modeling systems analyzed and forecasted that event. Model output from several days prior to several days after will be reviewed for each case in order to rule out false positives or overwarning. For example, since fire behavior on the Pioneer fire was noted to be affected most strongly by winds on 5 and 7 August, did the model avoid forecasting winds strong enough to affect fire behavior on other days? We expect it is most important to evaluate the ability of the HRRR model to isolate the types of outflows that lead to major impacts on fire behavior rather than its overall ability to forecast convective cells and subsequent outflows.

As a further illustration of our capabilities to compare HRRR model output to observations, Fig. 4

contrasts the winds on 5 August at the TT029 IRAWS site to those forecasted from hourly HRRR runs initialized from 06-18 UTC. Several of the HRRR model runs appear to capture signatures of stronger winds at the time (20-21 UTC) when the fire jumped the containment line. However, we want to make it very clear that simple comparisons of wind fields (Fig. 2), time series (Fig. 3), or aggregate statistics computed objectively from such fields are not expected to adequately characterize model performance. We are less interested in comparing values of specific variables at specific times or places. Those types of comparisons can be of great utility for developers to assess changes made to their models. However**, end users of the model output require information that makes it possible to judge the cumulative impacts of errors in timing, location, and intensity of features that may affect fire behavior.**

Our goal is to characterize the extent to which a forecaster would find the HRRR forecast guidance useful. We expect that the modeling system will be able to provide accurate specificity on convective outflows in only certain situations and forecast lead times. The goal will be to help forecasters gain confidence in probabilistic convective outflow forecasts in these various situations. We hypothesize that the model can highlight in most situations the types of synoptic, mesoscale, and boundary layer environments that lead to outflows and downdrafts that substantively affect fire behavior. For example, Contributor Wachter notes that the HRRR has shown some promise to predict larger scale gust fronts and outflows from several major storm complexes that affected fire behavior.

An extensive volume of data will be available from the multiple HRRR forecast runs (e.g., 3-D fields of temperature, moisture, and wind and diagnostic fields of lightning/convective initiation, convective activity, CAPE, DCAPE, composite reflectivity, probability of winds exceeding a threshold). Because the HRRR model is under constant development, impacts of model changes as new versions are released will be accounted for as part of our analysis. We want to assess the extent to which observed critical features are being forecasted in the context of the 3 distinct forecast lead time scales shown in Fig. 2. We differentiate what is expected for nowcasts/alerts at short lead times (< 6 h) distinct from how those provided at, for example, morning briefings for afternoon conditions (6-12 h lead times) or evening briefings for the next day (12-24 h lead times). Limited attention will be placed on forecasts at lead times greater than ~24 h for which a broader array of modeling systems are available to provide guidance.

We will focus on techniques to identify and track 2-dimensional and 3-dimensional features within multiple model analysis and forecast fields (Bullock 2011; Jacques et al. 2016). We will identify the timing, areal extent, and intensity of the outflow features in the HRRR fields. Initial case studies will focus on situations where observational data resources will be sufficient to verify when they occurred, e.g., where areas of convection can be identified in radar and satellite imagery or sudden changes in wind speed and direction, temperature and moisture are evident at surface stations or in gridded analyses. Particularly for lead times beyond a few hours, we will address these issues in a probabilistic sense. How useful is the combined information over spatial distances in the vicinity of the fires from multiple deterministic runs (i.e., the existing HRRR Time-Lagged Ensemble) or from ongoing development of HRRR ensemble modeling systems to assess the likelihood of the conditions associated with outflows?

Although many indices for thunderstorm potential and extreme fire behavior (e.g., fire danger rating, Haines, dry lightning, potential lightning ignition) are available from many sources (e.g., WFAS, SPC), most are available at coarse spatial (> 10 km) and temporal (once per day) scales and generally intended for 12-72 h forecast lead times. We will test whether a "convective outflow index" at short lead times (6-24 h) can be developed that incorporates key factors in the weather environment that can be used to communicate outflow potential to end users in an effective manner. Field experience by Contributor Wachter, NWS WFO Albuquerque, suggests that such an index might involve weighting stability (DCAPE), low level moisture (surface relative humidity), temperature anomaly, and boundary layer wind (transport wind). The research by Carlaw et al. (2016) supports an approach of that type where DCAPE and low-level lapse rates offered the best guidance regarding the propensity for Arizona monsoonal thunderstorms to produce severe wind gusts, with larger values suggesting deeper vertical mixing and a pre-conditioned boundary layer for enhancing evaporation in downdrafts and severe wind gusts.

c. Evaluate and communicate indicators of potential fire behavior based on HRRR Forecasts

Since we will rely on a large volume of data that will be available from the multiple HRRR forecast runs available for each outflow event, evaluating the role and impact of these forecasts on potential fire behavior will require an understanding of their temporal and spatial accuracy in a fashion relevant to operational personnel. Is there a tendency to under- or over-warn for convective events in the vicinity of major fires? Will terrain and fuel flammability factors exacerbate the impacts of a possible outflow event? How long should fireline personnel "hunker down" once the imminent threat of a convective outflow is communicated to them?

Our objective is to estimate how outflow forecasts made from the HRRR modeling systems may enhance firefighter safety. The accuracy and uncertainties of HRRR forecasts are expected to depend greatly on forecast lead time, geographic location, time of day and season, synoptic/mesoscale situation, and the data available to be assimilated in that locale. Subsequent estimates of fire behavior that rely on those forecasts require incorporating the impacts of the underlying terrain and fuel types. Fire meteorologists and behavior analysts need model guidance and tools based on that guidance with sufficient lead time to allow them to express the potential uncertainties in fire behavior arising from convective events.

We propose to investigate the impact of the forecast guidance on potential fire behavior in two ways using: (1) the Rate of Spread Ratio (Bishop 2009) that will rely on HRRR meteorological output combined with landscape characteristics and fuelbed flammability and (2) simulations of selected case studies using a coupled fire-atmosphere model, WRF-SFIRE.

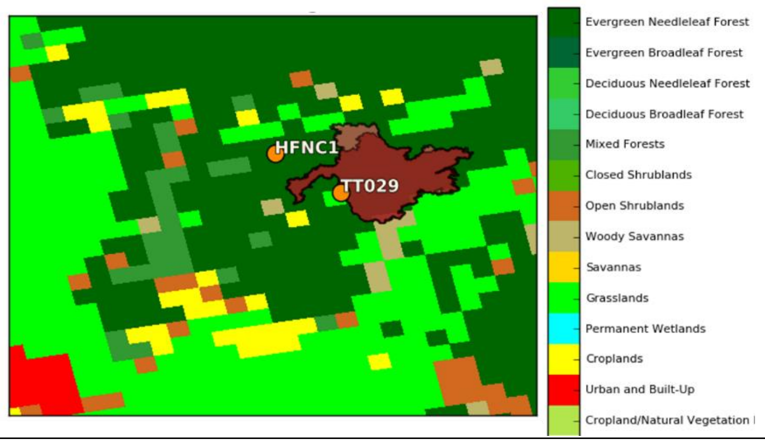

Figure 5. NCEP HRRR land use in the vicinity of the Pioneer Fire derived from 2001 MODIS imagery.

1. Rate of Spread Ratio

The Fireline Assessment Method, or FLAME (Bishop 2009), was developed as a firefighter tool, simplifying the Rothermel (1972) fire spread model with only 3 fuel types (grass, litter, and shrub/crown) and emphasizing wind, fuel, and terrain as the most important factors in assessing short term changes in fire behavior. Its primary tool, the **Rate of Spread Ratio (ΔROS)**, is designed to characterize the scale of the resulting change in fire spread. Bishop defined thresholds in **ΔROS** that are useful in identifying critical changes to the fire environment and to expected fire behavior. Although FLAME is not widely used in the field and may be removed from planned revisions of firefighter training, it provides a useful framework for examining the dominant drivers of large, short-term changes in the fire environment.

We will be able to calculate **ΔROS** using only inputs found within the HRRR computing environment for each fire event studied. We will examine for each fire location the characteristics of the HRRR's terrain and land use relative to that available from other sources. For example, Figure 5 illustrates that the HRRR land use at 3 km resolution in the vicinity of the Pioneer fire adequately captures the basic vegetation types for the application of the FLAME methods in that area. The resulting gridded **ΔROS** forecast values as a function of forecast lead time can then be compared to that observed to estimate temporal and spatial uncertainties that operational personnel might consider. We wish to assess whether **ΔROS** might be a useful means to help highlight fire behavior concerns in parallel with predicted weather concerns seamlessly within the same modeling framework.

A critical aspect of this study is to assess the extent to which false alarms/overwarning may be reduced by recognizing those situations when the fuels are not sufficiently flammable to support significant increases in fire behavior or the forecasted changes in wind arising from outflows are not substantive enough to trigger extensive fire spread. We will consider both short-term and cumulative fuel flammability factors to further refine assessments of critical areas and events. Both the Energy Release Component (ERC) from the National Fire Danger Rating System throughout CONUS and the Buildup Index (BUI) from the Canadian Forest Fire Danger Rating System in Alaska are produced on a gridded basis using gridded weather elements spatially compatible with HRRR outputs.

2. WRF-SFIRE

As a means to test results obtained from **ΔROS** as well as estimate independently fire behavior in several outflow cases of highest interest, co-PI Kochanski will lead research to simulate fire behavior using WRF-SFIRE (Mandel et al. 2011, 2014a,b) that relies on the WRF model framework coupled with the Rothermel (1972) fire-spread model. The fuel and topographical data are defined on a high-resolution surface fire mesh (typically ~30m) used for fire spread computations. Fire-emitted heat and moisture fluxes computed at the fire mesh are integrated into WRF's coarser mesh. The fluxes affect the atmospheric state, changing local winds that drive fire propagation (Mandel et al. 2011). WRF-SFIRE is also coupled with a prognostic fuel moisture model and assimilates fuel moisture observations from RAWS (Vejmelka et al. 2016). WRF-SFIRE is designed to simulate the landscape-scale physics of the coupled fire-atmosphere phenomenon and focuses on the importance of rapidly changing meteorological conditions at the fire line, taking into account local feedbacks between the fire, fuel, terrain and the evolving atmospheric boundary.

We will drive WRF-SFIRE with HRRR model output for the selected cases and generate downscaled weather simulation at a resolution at 333 m, resolving small-scale interactions between the convective outflow, terrain and fire. Its performance has been evaluated at ~30-m resolution using FireFlux data (Kochanski et al. 2013a) and at sub-kilometer horizontal grid resolutions (Kochanski et al. 2013b, Kochanski et al. 2016). The purpose of our simulations using WRF-SFIRE will be to evaluate more carefully flow-fire interactions and the degree to which using operational HRRR forecasts combined with the simpler **ΔROS** tool are able to estimate their potential.

IV. Project Duration and Timeline

Project Milestone	Description	Delivery Dates
Collect data and begin analyses of 2017 cases	Assemble validating and HRRR data sets. Select and begin analyses of southwestern US and Alaska cases	January 2018
Assess uncertainty of HRRR outflow forecasts	Examine the accuracy and variability of HRRR nowcasts (<~6h) and forecasts (6-24 h) for the cases	July 2018
Test outflow and spread indices	Formulate and test convective outflow indices. Assess whether **ΔROS** is suitable to evaluate sensitivity of fire behavior to HRRR forecast uncertainty	July 2018
WRF-SFIRE simulations	Perform simulations on 1-2 high-interest 2017 cases	July 2018
Collect data and begin analyses of 2018 cases	Assemble validating and forecast data sets for a wider set of cases throughout the CONUS and Alaska	January 2019
Quantify impacts of HRRR forecast uncertainty	Document the ability of the HRRR modeling systems to provide effective guidance for nowcasts (<~6 h) and forecasts (<~24 h)	July 2019
WRF-SFIRE simulations	Perform simulations on 1-2 additional high-interest cases	July 2019
Recommendations for effective communication	Provide guidance on how to improve managing risks in the fire environment associated with outflows for fire managers and fireline personnel	July 2019

V. Project Compliance - NEPA and Other Clearances

No NEPA or other clearances are required for this project.

VI. Research Linkage

Participation of the MesoWest team in the National Mesonet Program supports the acquisition, archival, and dissemination of observations from over 30,000 locations in the CONUS and Alaska. The Alaska and Great Lakes Fire and Fuel Systems are undergoing technical refreshes in 2017 followed by ongoing maintenance and support. Co-PI Kochanski has two JFSP WRF-SFIRE modeling studies underway.

Grant Program	Project or Proposal Description/Identification	Funding Amount	PI	Completion Date
NOAA/NWS	National Mesonet Project	750,000	Horel	Sept. 2017
Alaska BLM	Alaska Fire and Fuels System	78,476	Horel	June 2019

Great Lakes Fire Compact	Great Lakes Fire and Fuels System	85,000	Horel	Oct. 2019
JFSP	Modeling support for FASMEE experimental design using WRF-SFIRE-CHEM	139,471	Kochanski	July 2017
JFSP	AIRPACT-Fire for enhanced communication of human health risk	376,113	Kochanski (Co-PI)	June 2018

VII. Deliverables

Project deliverables are described further in the Science Delivery section and include: (1) results from all phases of the analysis of outflow cases and (2) delivery of improved communication protocols to express the potential uncertainty associated with forecasts of them. NOAA, NWS, and Predictive Service contributors will advise the research and receive updates on project progress from the research team. Project results will be described and summarized in both the JFSP report and submitted journal publications. Components of a Ph.D. will result from the project. Conference presentations will be given at the 2019 AMS Fire and Forest Meteorology Symposium or other suitable venue. Webinars will be provided annually as well.

Deliverable Type	Description	Delivery Dates
Archive of convectively-driven outflow cases	Develop repository of all information required to analyze the observed conditions and the forecasts of outflow events	January 2018 and 2019
Conference presentation	Present research results at national weather or fire conference	Fall 2018-Spring 2019
Journal articles	Submit findings on assessing forecast uncertainty, impacts on potential fire behavior, and WRF-SFIRE simulations of fire behavior	May 2019
Doctoral thesis	Evaluation of high impact case studies of outflow events	May 2019
Final report	Submission of final report including recommendations to improve communication of outflow forecasts to fire personnel	July 2019

VIII. Roles of Investigators and Associated Personnel

Our team will collaborate effectively through frequent interactions that will help blend the evaluation of convective-outflow modeling with impacts of those outflows on fire behavior.

Personnel	Role	Agency	Responsibility
John Horel	PI	University of Utah	Overall project responsibility
Robert Ziel	Co-PI	University of Alaska-Fairbanks	Lead evaluation of managing risks in the fire environment associated with outflows
Erik Crosman	Co-PI	University of Utah	Lead validation of the HRRR model forecasts
Adam Kochanski	Co-PI	University of Utah	Comparisons to WRF coupled fire modeling
John B. Wachter	NWS Collaborator	Albuquerque WFO	Guidance from NWS fire weather forecaster perspective
Trevor Alcott	NOAA Collaborator	NOAA/ESRL	Guidance on HRRR modeling systems
Heidi Strader	Predictive Services Collaborator	Alaska Interagency Coordination Center	Guidance from Alaska fire behavior analyst perspective
Charles Maxwell	Predictive Services Collaborator	Southwest Coordination Center	Guidance from a fire environments decision support perspective
Brian Blaylock	Ph.D. Student	University of Utah	Analysis of convective outflows

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Proposal ID: 17-1-05-1
Proposal Title: Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment
Principal Investigator: John D. Horel

Acronyms

- CHPC- University of Utah Center for High Performance Computing
- CONUS- continental United States
- CAPE- convective available potential energy
- CFFDRS - Canadian Forest Fire Danger Rating System
- DCAPE- downward CAPE
- ESRL- Earth Systems Research Laboratory
- FAA-Federal Aviation Administration
- FBAN- fire behavior analyst
- FIREX-Fire Influence on Regional and Global Environments Experiment
- FLAME- FireLine Assessment MEthod
- GACC- Geographic Area Coordination Center
- GEOMAC-Geospatial Multi-Agency Coordination
- HRRR- High Resolution Rapid Refresh
- IMET- Incident meteorologist
- IRAWS- Incident RAWS
- MODIS- Moderate Resolution Imaging Spectroradiometer
- MySQL- an open-source relational database management system (RDBMS)
- NCEP- National Centers for Environmental Prediction
- NDVI- Normalized Difference Vegetation Index
- NFDRS - National Fire Danger Rating System
- NOAA- National Oceanographic and Atmospheric Administration
- NWS- National Weather Service
- RAWS- Remote Automated Weather Station
- ROS-Rate of spread
- RTMA- Real Time Mesoscale Analysis
- SPC-Storm Prediction Center
- TLE- Time-Lagged Ensemble
- UTC- Universal Time Coordinated
- URMA- Unrestricted Mesoscale Analysis
- UU2DVAR- University of Utah 2-dimensional VariationalAanalysis
- VIIRS- Visible Infrared Imaging Radiometer Suite
- WFAS-Wildland Fire Assessment System
- WFO- Weather Forecast Office
- WRF- Weather Research Forecasting model
- WRF-ARW- WRF- Advanced Research WRF
- WRF-SFIRE- WRF-Spread FIRE model

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EDUCATION

* Ph.D. 1982, Atmospheric Sciences, University of Washington
* B.S. 1977, Meteorology, San Jose State University

PROFESSIONAL EXPERIENCE

* 1986-present, Assistant, Associate and Full Professor, University of Utah
* 2002-2006, Director, NOAA Cooperative Institute for Regional Prediction, University of Utah
* 1982-1986, Assistant Research Professor, Scripps Institution of Oceanography

RELATED RESEARCH ACTIVITIES

My research is centered on the observation and analysis of weather processes. My current research activities include further development of MesoWest/SynopticLabs (see http://synopticlabs.org), which provide access to surface weather observations for operational, research, and educational applications. MesoWest has provided a foundation from which to meet operational needs within the fire weather community and conduct research on topics highly relevant to fire weather applications, including: forecast verification, data assimilation and objective analysis techniques, and cost effectiveness of surface observing networks.

AWARDS

* American Meteorology Society Francis W. Reichelderfer Award "For development and leadership of the MesoWest observational network in support of operations, research, and education to improve understanding and forecasting of mountain meteorology." 2016
* Fellow of the American Meteorological Society 2002
* Outstanding Service Award, National Weather Service Western Region, "For outstanding service to the weather support group for the 2002 Olympic Winter Games" 2002

SELECTED REFEREED PUBLICATIONS MOST RELATED TO THE PROPOSED ACTIVITIES

Nauslar, N. J., T. J. Brown, and J. D. Horel, 2016: Verification of National Weather Service spot forecasts using atmospheric sounding observations. *J. Operational Meteor*., 4 (4), 46-57, doi: http://dx.doi.org/10.15191/nwajom.2016.0404.
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OTHER REFEREED PUBLICATIONS IN THE PAST TWO YEARS

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Jacques, A., J. Horel, E. Crosman, F. Vernon, J. Tytell, 2016: The Earthscope US Transportable Array 1 Hz Surface Pressure Dataset. *Geoscience Data Journal*, 3: 29–36.

Crosman, E., and J. Horel 2016: Winter lake breezes near the Great Salt Lake. *Boundary Layer Meteorology.* 1-26. doi:10.1007/s10546-015-0117-6

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SELECTED EDUCATIONAL AND PROFESSIONAL ACTIVITIES IN PAST THREE YEARS

* Supervising 1 Ph.D. and 3 M.S. students presently
* Supervisor of graduate students leading to completion of 2 Ph.D. and 6 M.S. theses
* Chair, AMS Nationwide Network of Networks Committee. 2016-2018
* Program Co-Chair, Forum on Observing the Environment from the Ground Up. 2016
* NSF Advisory Committee for Workshop on Intelligent Systems for Geosciences. 2015
* External Reviewer, Oklahoma Mesonet. 2014
* National Weather Association 2014 Annual Meeting Local Committee. 2014
* Co-Chair, 2014 AMS/AGU Heads and Chair Meeting, 2014
* Steering Committee, Program for Air Quality, Health, and Society, University of Utah. 2013-
* AMS Committee on Open Environmental Information Services. 2013-
* Chair, AMS Board of Higher Education. 2013-2015

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EDUCATION

- B.S.F. 1975, Forestry, University of Michigan

PROFESSIONAL EXPERIENCE

- 2016-present, Fire Analyst, Alaska Fire Science Consortium, University of Alaska-Fairbanks
- 2013-2016, Fire Analyst, Alaska Interagency Coordination Center, Alaska Division of Forestry
- 2010-2013, Program Manager, Lake States Fire Science Consortium, Ohio State University
- 1984-2010, Forester-Fire Manager, Michigan Department of Natural Resources
- 1981-1984, Registered Forester, Chenoquet Consulting
- 1976-1981, Forest Technican and Forester, Michigan Department of Natural Resources

RELATED SKILLS

- 2002-Present, Long Term Fire Analyst (LTAN), National Wildfire Coordinating Group
- 1991-Present, Fire Behavior Analyst (FBAN), National Wildfire Coordinating Group
- 1981-Present, Registered Forester, State of Michigan.

SELECTED PUBLICATIONS AND TECHNICAL GUIDES

Ziel, R., J. Wolken, T. St. Clair, M. Henderson, 2015: Modeling Fire Growth Potential by Emphasizing Significant Growth Events-Characterizing a Climatology of Fire Growth Days in Alaska's Boreal Forest. 11th Symposium on Fire and Forest Meteorology, Minneapolis MN.

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EDUCATION

* Ph.D. 2011, Atmospheric Sciences, University of Utah
* M.S. 2005, Atmospheric Sciences, University of Utah
* B.S. 2003, Earth Science in Meteorology, University of Northern Colorado

PROFESSIONAL EXPERIENCE

*2015-present, Assistant Research Professor, University of Utah *2011-2015, Postdoctoral Research Assistant, University of Utah *2003-2011, Research Assistant, University of Utah

RELATED RESEARCH ACTIVITIES

My research interests fall broadly is in four key areas: 1) Numerical weather prediction, 2) meteorological and air quality observations in complex mountainous terrain, 3) thermally-driven flows with an emphasis on lake and sea breezes, and 4) remote sensing of lakes. I am currently working with the Utah Division of Air Quality to improve the meteorological simulations of winter stable layers for input into air quality models. Other active projects include understanding the impact of thermally-driven flows in the Salt Lake Valley on ozone and $PM_{2.5}$ concentrations and transport, developing an observational platform to measure ozone and particulate sensors on light rail trains in an urban environment, and improving retrievals of lake surface temperature from polar orbiting satellites for input into regional and climate models.

AWARDS

* Edward Zipser Outstanding Graduate Student Award, University of Utah. 2011
* Outstanding Service and Leadership Award for the Persistent Cold Air Pool Study (PCAPS). 2011
* Best Student Oral Presentation award at the 14th Conference on Mountain Meteorology. 2010
*NASA Earth Systems Science Fellowship Recipient. 2006-2009
*2006-2009 College of Mines Outstanding Teaching Assistant Award, 2006

SELECTED PUBLICATIONS

Crosman, E., J. Horel, 2016: Large-eddy simulations of a Salt Lake Valley Cold-air Pool. *Atmospheric Research*. Submitted.
Foster, C., E. Crosman, J. Horel, 2016: Simulations of a Cold-Air Pool in Utah's Salt Lake Valley: Sensitivity to Land Use and Snow Cover. *Boundary Layer Meteorology*. Accepted.
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Jacques, A., J. Horel, E. Crosman, F. Vernon, J. Tytell, 2016: The Earthscope US Transportable Array 1 Hz Surface Pressure Dataset. *Geoscience Data Journal*, 3: 29–36.

Crosman, E., and J. Horel 2016: Winter lake breezes near the Great Salt Lake. *Boundary Layer Meteorology.* 1-26. doi:10.1007/s10546-015-0117-6

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Lehner, M., C. David Whiteman, S.W. Hoch, E.T. Crosman, M.E. Jeglum, N.W. Cherukuru, R. Calhoun, B. Adler, N. Kalthoff, R. Rotunno, 2015: The METCRAX II field experiment—A study of downslope windstorm-type flows in Arizona's Meteor Crater. *Bull. Amer. Meteor. Soc*., 97, 217-235.

Neemann, E., E. Crosman, J. Horel, L. Avey, 2015: Simulations of a cold-air pool associated with elevated wintertime ozone in the Uintah Basin, Utah. *Atmos. Chem. Phys*., 15, 135-151.

Strong, C., A.K. Kochanski, E. Crosman, 2014: A Slab Model of the Great Salt Lake for Regional Climate Simulations. *J.* Adv. Model Earth Systems, 6, 602-615.

Grim, J.A., J.C. Knievel, E. Crosman, 2013: Techniques for Using MODIS Data to Remotely Sense Water Surface Temperatures. *Journal of Atmospheric and Oceanic Technology*, 30, 2434-2451.

Silcox, G. D., K. E. Kelly, E. T. Crosman, C. D. Whiteman, B. L. Allen, 2012:Wintertime PM2.5 Concentrations in Utah's Salt Lake Valley during Persistent, Multi-day Cold-air Pools. *Atmos. Environment*, 46, 17-24.

Crosman, E.T., J.D. Horel, 2012: Idealized Large-Eddy Simulations of Sea and Lake Breeze: Sensitivity to Lake Diameter, Heat Flux, and Stability. *Boundary Layer Meteorology. 144, 309-328*.

Crosman, E.T., J.D. Horel, 2012: Sea and lake breezes: A review of numerical studies. *Boundary Layer Meteorology. 137, 1-29*.

Crosman, E.T., J.D. Horel, 2009. MODIS-derived Surface Temperature of the Great Salt Lake. *Remote Sensing of Environment. 113, 73-81*.

SELECTED EDUCATIONAL AND PROFESSIONAL ACTIVITIES IN PAST THREE YEARS

* Supervising 1 Ph.D. student presently
* On Supervisory committees of 1 student M.S. thesis and 1 student Ph.D. thesis
* Co-Chair, 17th AMS Mountain Meteorology Conference, Burlington VT. 2016.
*Faculty advisor, U. of Utah Student Chapter of the American Meteorological Society. 2016-
*Instructor, ATMOS 5050/6050: Atmospheric Instrumentation. 2014, 2016.
*Team Member, Cold Pool Modeling Working Group, Environmental Protection Agency (EPA). 2015-
*Team member, NASA Multi-sensor Improved Sea Surface Temperatures (MISST). 2011-

Adam Kochanski
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A. PROFESSIONAL PREPARATION:

Technical University of Lodz (Poland) Chemical and Process Engineering, B.Eng	1997
Technical University of Lodz (Poland) Chemical and Process Engineering, M.Eng	1998
Technical University of Lodz (Poland) Marketing and Management, MBA equivalent	2002
University of Nevada-Reno, Atmospheric Sciences, M.S.	2004
University of Nevada-Reno, Atmospheric Sciences, Ph.D.	2008

B. APPOINTMENTS:

2013-present	Research Assistant Professor, University of Utah, Department of Atmospheric Sciences, Salt Lake City, Utah.
2008-2013	Research Associate, University of Utah, Department of Atmospheric Sciences, Salt Lake City, Utah.
2005-2008	Doctoral Graduate Research Assistant, Desert Research Institute, Department of Atmospheric Sciences, Reno, Nevada
2003-2004	Graduate Research Assistant, Doctoral Graduate Research Assistant, Desert Research Institute, Department of Atmospheric Sciences, Reno, Nevada
1999-2002	Development and Strategy Director, Optimus Lodz (subsidiary of the biggest Polish IT Company and Internet Services Provider), Lodz, Poland
1998-1999	Manager of Internet Services Department, Optimus Lodz (subsidiary of the biggest Polish IT Company and Internet Services Provider), Lodz, Poland
1997-1998	Technician, Department of Chemical and Process Engineering, technical University of Lodz, (Poland)

C. PRODUCTS – most related to the project

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

Mandel, J., Amram, S., Beezley, J. D., Kelman, G., Kochanski, A. K., Kondratenko, V. Y., Lynn, B. H., Regev, B., and Vejmelka, M (2015).: *Recent advances and applications of WRF–SFIRE*, Nat. Hazards Earth Syst. Sci., 14, 2829-2845, doi:10.5194/nhess-14-2829-2014, 2014.

Kochanski A. K., Jenkins M.A., Krueger S. K., Mandel J., and Beezley J. D., (2012): *Real time simulation of 2007 Santa Ana fires*, Forest Ecology and Management 15, 136-149, 2013 doi:10.1016/j.foreco.2012.12.014

Kochanski, A. K., Jenkins M. A., Mandel J, Beezley J. D. and Krueger S. K., (2013): *Evaluation of WRF-Sfire Performance with Field Observations from the FireFlux experiment*. Geoscientific Model Development 6, 1109-1126, 2013 doi:10.5194/gmd-6-1109-2013

Vejmelka M, Kochanski A, Mandel J, (2015) *Data assimilation of dead fuel moisture observations from remote automated weather stations,* International Journal of Wildland Fire **25**, 558–568. http://dx.doi.org/10.1071/WF14085

C. PRODUCTS – other significant:

Kochanski, A. K., Jenkins M. A., Sun R., Krueger S. K., and Charney J. J., (2013): *The importance of low-level environmental vertical wind shear to wildfire propagation: Proof of concept*, Journal of Geophysical Research 118(15) 8238-8252 DOI: 10.1002/jgrd.50436.

Kochanski A. K., E. R. Pardyjak, R. Stoll, A. Gowardhan, M.J Brown, W.J. Steenburgh (2015) *One-Way Coupling of the WRF–QUIC Urban Dispersion Modeling System* Journal of Applied Meteorology And Climatology (in press) DOI: 10.1175/JAMC-D-15-0020.1

Strong, C., A. K. Kochanski, and E. T. Crosman (2014), *A slab model of the Great Salt Lake for regional climate simulation*, J. Adv. Model. Earth Syst., 06, doi:10.1002/2014MS000305.

Mandel J., Beezley J. D., Kochanski A. K. (2011), *Coupled atmosphere-wild land fire modeling with WRF 3.3 and SFIRE 2011*, Geoscientific Model Development, 4, 591–610

Jordanov, G., J. D. Beezley, N. Dobrinkova, A. K. Kochanski, J. Mandel, and B. Sousedik, 2012: *Simulation of the 2009 Harmanli fire (Bulgaria)*. 8th International Conference on Large-Scale Scientific Computations, Sozopol, Bulgaria, June 6-10, 2011, I. Lirkov, S. Margenov, and J. Wansiewski, eds., Springer, volume 7116 of Lecture Notes in Computer Science, 291–298, 2012

D. SYNERGISTIC ACTIVITIES:

Co-developer of WRF-SFIRE

Co-developer of the coupled Wildland-Fire forecasting system in Israel implemented by Weatheritis Inc.

Leader of the WRF-Sfire practical workshop organized by the International Center for during the Workshop on Modeling Wildfires and their Environmental Impacts, Theoretical Physics (ICTP) in Trieste, Italy, 23-25 June 2015

Proposal ID: 17-1-05-1
Proposal Title: Assessment of HRRR Model Forecasts of Thunderstorm Outflows in the Fire Environment
Principal Investigator: John D. Horel

I. Data Management Plan Justification

The proposed project will result in the acquisition and temporary storage of tbytes of information collected routinely in real time from diverse observational resources and the NCEP and NOAA/ESRL servers that host output from the operational and experimental HRRR data assimilation and modeling systems, respectively. A subset of the model output and validating observational data sets will be permanently archived, primarily in the vicinity of those wildfire cases that will be investigated in detail during the 2017 and 2018 fire seasons.

II. Project Data Management

1. Data types

HRRR Forecasts: Roughly 6-10 wildfire cases in the southwestern United States and Alaska will be investigated during the 2017 fire season with 15-25 cases examined throughout the CONUS and Alaska during the 2018 season. Since the selection of these cases will depend on many factors (e.g., type of outflow event, region, availability of validating data), we will temporarily archive output from versions of the HRRR operational and experimental modeling systems (Table 1 in the proposal body) continuously during the project period. Typical data volumes are 3 gbytes per day for Alaska and 100 gbytes per day for one version of the HRRR for the CONUS. We already have procedures in place to access the data available from NCEP and NOAA/ESRL. As part of data processing, we will subset the data and archive relevant fields for selected time periods and regions in the vicinity of the wildfire events receiving extensive evaluation.

Verification Data Sets: NWS and RAWS station observations at over 6000 locations around the United States are archived as part of the MesoWest MySQL database at the University of Utah with observations from an additional 20,000 locations available from other networks. RTMA grids in grib2 format at 2.5 km for CONUS and 3 km for Alaska will be archived at the University of Utah (400 mbytes per day). Many additional data streams are available from archives (e.g., Amazon Web Service archive of Level-II radar, numerous satellite image repositories, lightning data bases) from which we can access the requisite information. Imagery and data post-processed for the validation of specific cases will be permanently archived. Textual information that helps identify case studies of interest, place the events in context, and describe the alerts provided (e.g., from IMET and FBAN Narratives) will be archived as well for those case studies selected. Fuel flammability assessments will also be obtained from RAWS stations, WFAS and Alaska Fire and Fuels grids.

WRF-SFIRE Simulations: Coupled fire-atmospheric simulations of selected case studies using WRF-SFIRE will be completed on compute clusters available from the University of Utah Center for High Performance Computing (CHPC) . Output from each run exceeding usually a ~tbyte will be archived on existing CHPC resources available to the research team.

2. Quality Assurance

HRRR Forecasts: Output from the operational and experimental versions of the HRRR model run at NCEP and NOAA/ESRL are provided in a widely-used data format (grib2) that insures consistency in the fields.
Verification Data Sets: All observations in the MesoWest archive are processed and subjected to quality control procedures upon receipt. Procedures that will be established to select case studies will include vetting verification data subjectively to insure that sufficient high-quality information is available to document the timing, areal coverage, and intensity of the convectively-driven events.

3. Data Access

Nearly all of the information we will use in our analysis is in the public domain. Only information in original format obtained from fire personnel (IMETs, FBANs, etc.) that helps us select specific case studies and evaluate the outflow events would require permission of the agencies who supplied that information. All of the research to be completed will be undertaken within the secure computing environments of the research teams at the University of Utah and University of Alaska that have appropriate security measures in place to limit direct access to the project team. As the project progresses, processed information will be accessible via a web server at the University of Utah for other members of the research team and anyone interested in the research to help in the evaluation of the project results.

4. Storage and Backup

Procedures are already in place to manage the large data sets received and archived at the University of Utah. The PIs have over 100 tbytes of disk storage available in the CHPC computing system. CHPC provides a robotic tape system that is capable of hosting critical data required for our study and the Principal Investigator has sufficient numbers of tapes to store data resources during the project

III. Long-Term Data Management

1. Metadata

Our metadata documents will be deposited with the Forest Service Research Data Archive (http://www.fs.usda.gov/rds/archive) prior to completion of the project conforming to appropriate standards specified by the Forest Service Research Data Archive. The Principal Investigator participated in the August 2016 webinar on the JFSP Data Availability Requirement to insure that our plans will conform to what is expected. Some of the underlying data, particularly the HRRR output fields, will be archived in real-time in the context of Thematic Realtime Environmental Distributed Data Services (THREDDS; http://www.unidata.ucar.edu/ projects/THREDDS/), which is an approach in the geosciences community to bridge the gap between data providers and data users. Catalogs of metadata are the heart of the THREDDS concept to describe on-line datasets and our team has extensive experience managing metadata. We will adapt the THREDDS xml schema (http://www.unidata.ucar.edu/projects /THREDDS/tech/catalog/v1.0.2/InvCatalogSpec.html) to bridge and conform to the standards appropriate for the Forest Service Research Data Archive. We will update earlier metadata provided to JFSP as needed: repository name, URL, and repository-assigned identifier.

2. Data Repository

We have experience undertaking research that culminates in the underlying data being archived in a data repository (doi:http://dx.doi.org/10.5065/D6028PRS) and having that data described in a peer-reviewed data journal (Jacques et al. 2016). The Marriott Library at the University of Utah is in the process of developing a data repository designed to meet the needs of researchers who intend to archive data relied upon to complete sponsored research. We have been in contact with the Library's data repository team to assess whether the resources will be available at the completion of our project to archive the critical data for the cases evaluated in this study that are not being archived elsewhere. Because of the potential high interest in the data for further research, we will pursue describing a sample of the case studies in a publication in a data science journal, such as that by Jacques et al. (2016).

3. Data Access

All of the data permanently archived in the Marriott Library or other data repository will be classified as "open access".

Reference

Jacques, A., J. Horel, E. Crosman, F. Vernon, J. Tytell, 2016: The Earthscope US Transportable Array 1 Hz Surface Pressure Dataset. *Geoscience Data Journal*, 3: 29–36. doi: 10.1002/gdj3.37

Proposal ID: 17-1-05-1
Proposal Title: Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment
Principal Investigator: John D. Horel

I. Science Interpretation and Delivery

Our research team has extensive experience conducting research and development that has been transitioned to operations. Web services such as MesoWest, ROMAN, Great Lakes Fire and Fuels, and Alaska Fire and Fuels and JFSP-sponsored research such as the incident Spot forecast verification project involved close attention to the requirements and feedback provided by subject matter experts who helped direct those projects.

We are confident in our ability to meet the science needs expressed in the RFP: characterize atmospheric boundaries using existing models and tools and validate their forecast accuracy for outflow situations that affect fire behavior in complex terrain. We are also very confident in our ability to recommend improved approaches to communicate model and tool forecasts within a risk management context that is meaningful to the operational fire weather community and firefighters. In order to do so, we recognized at the outset the need to foster leadership, advice, and coordination from a diverse team familiar with: observational assets relevant to fire studies (PI Horel); numerical modeling (Co-PIs Crosman and Kochanski and Contributor Alcott); operational fire weather forecasting (Contributor Wachter), Interagency Predictive Services decision support (Contributors Maxwell and Strader) and fire behavior analysis (Co-PI Ziel). Our operationally-focused participants will be involved in evaluating how to interpret the results of the validation studies and help design procedures and best practices to inform the wider community.

II. Description of Results and Products

Clear linkages exist between our proposed work and the needs of end users. Our project is intended to provide fire weather meteorologists, fire behavior analysts, and predictive service personnel in the continental United States and Alaska with improved situational awareness of the potential for thunderstorm outflows. At the outset of the project, we will discuss among the team whether we need to expand to involve other researchers and operational personnel who may be interested in participating and help provide additional perspectives on the research.

The core results of this project will include: identify atmospheric boundary events that had substantive impacts on wildfires in the southwestern United States and Alaska in 2017 and nationwide in 2018; evaluate the ability of operational and experimental versions of the HRRR data assimilation and modeling system to forecast convectively-driven changes in wind, temperature and moisture that affect fire behavior; improve understanding of the ability of operational and experimental data assimilation/forecast model systems to forecast convectively-driven changes in wind, temperature, and moisture that influence fire behavior; use the meteorological output from these HRRR modeling systems combined with information on landscape characteristics and fuelbed flammability to examine the impacts of temporal and spatial uncertainties in the meteorological state on fire spread relative to that observed during major fire events; utilize WRF-SFIRE fire-atmosphere model simulations of selected case studies; and identify improved methods for fire weather forecasters, incident meteorologists, fire managers and fire behavior analysts to communicate alerts and warnings of potential and imminent risks to fire managers and fireline personnel who will be most affected by abrupt changes in weather conditions in the vicinity of wildfires.

As summarized briefly in Section VII of the main proposal and described in more detail below, products to be provided beyond the Final Report include: web-accessible archive of the outflow cases; conference presentations; journal articles; and a doctoral thesis. We are appreciative of the support letters highlighting the relevance of our proposed research from representatives of two Regional Consortia, the Alaska Wildland Fire Coordinating Group, and National Predictive Services.

III. Delivery Methods and Tools

We have extensive experience managing on-line archives of observational and modeling data. As mentioned in the proposal and data management plan, much of the HRRR model output and verification data sets will be hosted at the University of Utah and accessible to the project team and others interested in the information.

We also have extensive experience processing the model and verification data and summarizing that data on web pages in order for the project team to evaluate the research as it proceeds (e.g., the JFSP-sponsored spot forecast verification remains available at http://meso1.chpc.utah.edu/jfsp/). That type of platform will help us organize and post information that helps the project team and interested end users contribute to the assessment of the sensitivity to HRRR forecast uncertainty of outflow characteristics upon fire behavior and spread rate initially from the 2017 fire season in the southwestern United States and Alaska. Then, a more diverse set of major fire events will be examined throughout the CONUS and Alaska during the 2018 season. As the cases are identified, we will develop and maintain web pages for each one that include much of the graphical output from the HRRR model runs and verification data sets. As the analysis proceeds, the case study web pages will fill in. Summary assessments and recommendation of what is learned overall from the cases will then be developed and made available to the team and end users on the top level web page.

During Fall 2017 and 2018, we will provide webinars via the Southwest and Alaska Fire Science Consortia tailored to the southwestern United States and Alaska fire science communities to provide status updates on the project. During Spring 2019, we propose to provide a webinar of interest to the entire fire community advertised through JFSP and the Fire Research and Management Exchange System (FRAMES). If invited to do so, we would present results at 2019 IMET and Predictive Service annual meetings.

We expect that the research will have progressed by Fall 2018 to present results at regional and national weather or fire conferences. We will assess as the project proceeds which venues are most appropriate. We also expect to submit three journal articles by early 2019 to: (1) *Weather Analysis and Forecasting* evaluating HRRR model accuracy for thunderstorm outflows and (2) *International Journal of Wildland Fire* focusing on the impacts of the outflow forecast uncertainty on fire behavior and case study simulations of WRF-SFIRE.

IV. List of Additional Planned Publications

Graduate student Brian Blaylock will be extensively involved in the analysis of the HRRR modeling systems' ability to forecast thunderstorm outflows. He has already developed considerable experience using the WRF model and evaluating output from the HRRR modeling system (Blaylock et al. 2016). He is expected to complete the requirements for the Ph.D. in early 2019 in part based on his evaluation of outflows in the HRRR modeling systems.

V. Coordination with JFSP Fire Exchange Network

As evident from the support letters from the Alaska and Southwest Fire Science Consortia, we are committed to extensive interactions with those organizations and expect as well to keep other regional Consortia aware of our research. Through research team conference calls, webinars and other interactions between the project team and Consortia participants in person, we expect to have frequent interactions with the broader fire science community.

Literature Cited

Blaylock, B., J. Horel, E. Crosman, 2016: Impact of Lake Breezes on Summer Ozone Concentrations in the Salt Lake Valley. *J. Appl. Meteor. Clim.* In press.

Budget Narrative

Proposal Title: Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment
Project #: 17-1-05-1
Principal Investigator: John Horel

Budget information is provided in three parts: PI Institution (University of Utah), subcontractor Institution (University of Alaska- Fairbanks) and a summary of in-kind contributions from project collaborators employed by federal agencies.

Budget Costs for PI Institution: University of Utah

Labor:

All personnel are budgeted at the percentage of time spent directly on proposal activities and uses their actual labor in the calculation.

PI Horel's time includes overall project management, supervision of graduate student Brian Blaylock, and participation in the design of the model evaluation. Co-PI Crosman will lead the validation of the HRRR model forecasts. Co-PI Kochanski will conduct research to compare WRF-SFIRE model simulations to output from the HRRR model forecasts and the ΔROS tool.

PI John Horel Labor: $4,823/wk (including 37% benefits)	
4 weeks (2 weeks/year)	Yr 1: $9,645
	Yr 2: $10,031
Co-PI (Erik Crosman) Labor: $1,912/wk (including 37% benefits	
24 weeks (12 weeks/year)	Yr 1: $22,950
	Yr 2: $23,868
Co-PI (Adam Kochanski) Labor: $1,997/wk (including 49% benefits)	
16 weeks (8 weeks/year)	Yr 1: $15,975
	Yr 2: $16,614
Graduate Assistant: Brian Blaylock ($1,180/wk labor (including 8% benefits)	
52 weeks (26 weeks/year)	Yr 1: $30,675
	Yr 2: $31,902

* Labor costs assume a 4% annual increase

Travel:

Co-PI Crosman and graduate student Brian Blaylock will travel to Boulder, CO for a week-long training on the HRRR model at the outset of the project. PI Horel will participate in the first 2 days of that training.

Training (Year 1)
Crosman and Blaylock
Airfare - $375 estimated flight costs x 2 persons = $750
Lodging - $160/night x 5 nights x 2 persons = $1,600
Meals (per diem) - $59/day x 5.5 days x 2 persons = $649
Car Rental - 45/day x 5 days = $270
Total Costs = $4,000

Horel
Training (Year 1)
Airfare - $393 estimated flight cost = $393
Lodging - $160/night x 1 nights = $160
Meals (per diem) - $59/day x 1.5 days = $88
Car Rental - 45/day x 2 days = $90

Total Costs = $4,000

Costs are estimates based on prior conference attended in 2015 in Boulder, CO.

As the project evolves and opportunities arise, decisions will be made regarding how to cost effectively present research results at national fire weather and fire behavior workshops and conferences. We estimate here that two members of the research team will attend two such conferences or workshops in each of the two years. Which individuals attend will depend on the conference or workshop themes.

Conferences (Year 1)
Conference Costs - $510 estimated conference registration x 2 persons x 2 conferences = $2,040
Airfare - $500 estimated flight costs x 3 persons x2 year = $2,000
Lodging - 180/night x 4 nights x 3 persons x2 year = $2,880
Meals (per diem) - $60/day x 4.5 days x 2 persons x 2 year = $1,080
Car Rental - 0/day x 5 days = 0
Total Costs = $8,000

Costs are estimates based on prior conference attended in 2016 in New Orleans, LA.

Conferences (Year 2)
Conference Cost - $510 estimated conference registration x 2 persons x 2 conferences = $2,040
Airfare - $600 estimated flight costs x 2 persons x2 year = $2,400
Lodging - 190/night x 4 nights x 2 persons x2 year = $3,040
Meals (per diem) - $60/day x 4.5 days x 2 persons x 2 year = $1,080
Car Rental - 44/day x 5 days = 220
Total Costs = $9,000

Costs are estimates based on prior conference attended in 2016 in New Orleans, LA.

Workshop costs:
No Workshop costs being requested.

Field Site Travel Costs:
No Field Site Travel costs being requested.

Equipment:
The University of Utah is contributing all of the computer resources required for this project.

Materials and Supplies:
No Material and Supplies costs being requested.

Contracts (University of Alaska- Fairbanks):

Work to be provided by the University of Alaska Fairbanks is explained in the body of the proposal and briefly below. Costs for this work are described below as well and provided in the budget spreadsheets.

Science Delivery:

Publication costs in the amount of $5,000 are being requested for two journal publications in year 2, in addition to one publication likely to be developed for a no-cost online journal.

Tuition:

Tuition cost is not allowed by JFSP and will be covered by the University.

Indirect and Pass-through Rates:

Indirect costs of $42,248 (20% maximum allowed by JFSP) are requested. Pass-through costs of $4,716 (10%) of direct costs passing through to Institution 2. The difference between the University's federally-negotiated indirect cost rate of 50.5% and the 20% maximum allowed by JFSP results in an in-kind contribution from the University of Utah of $59,113 over the two years of the project.

Budget Costs for Institution 2: University of Alaska Fairbanks

Labor:
Co-PI Ziel is budgeted for 3 months annually. His time includes leading the evaluation of the broader impacts of convective outflows on the fire environment including leading the efforts to improve managing risks in the fire environment arising from outflows. He will also help identify example fires of interest throughout the US during the 2017 and 2018 fire seasons and assist in collection of pertinent anecdotal information from incident management personnel. Further, he will evaluate analyses conducted, forecasts produced, and communications provided in each of those example situations as well as conduct fire behavior analyses utilizing currently available tools along with interpretations of HRRR output.

Co-PI Robert Ziel Labor: $1,250/wk (including 9.5% benefits)	
24 weeks (12 weeks/year)	Yr 1: $15,000
	Yr 2: $15,300

*Labor costs assume a 1% annual increase

Other Travel:
To insure close coordination within the project team, Co-PI Ziel will travel to Salt Lake City twice per year.
Other Travel for 1 person x 2 trips during 2 years = Total 4 Trips
Airfare - $987.50 estimated flight costs x4 trips = $3,950
Lodging - $115/night x18 nights (over 4 trips) = $2,070
Meals (per diem) - $59/day x20 days (over 4 trips) = $1,620
Car Rental - $100/day x18 days (over 4 trips) = $1,800
Total Costs = $9,000
Costs are estimated based on prior travel in 2016 to Salt Lake City, UT.

Field Site Travel Costs:
No Field Site Travel costs being requested.

Supplies:
No Material and Supplies costs being requested.

Equipment costs:
No Equipment costs being requested.

Science Delivery:
No Science Delivery costs being requested.

Tuition:
Tuition cost is not allowed by JFSP and will be covered by the University.

Indirect Rates:
Indirect costs of $7,860 (20% maximum allowed by JFSP) is requested. The difference between the University's federally-negotiated indirect cost rate of 50.5% and the 20% maximum allowed by JFSP results in an in-kind contribution from the University of Alaska-Fairbanks of $11,987 over the two years of the project.

In-kind Contributions from Project Collaborators

NOAA Collaborators

John Wachter from the Albuquerque WFO will provide guidance from the NWS fire weather forecaster perspective, particularly with potential tools such as a model-derived predictive outflow index. Trevor Alcott from NOAA/ESRL will keep us informed about the current status and resources associated with HRRR modeling developments. Mr. Wachter and Dr. Alcott will participate in the project at no cost to the JFSP devoting approximately 6 days (@$336 per day) and 8 days (@$325 per day) per year respectively for a total salary in-kind contribution from NOAA over the two years of $7216.

Predictive Services Collaborators

Heidi Strader from the Alaska Interagency Coordination Center will help provide advice on the utility of the project results obtained in the Alaska region, particularly with respect to methods to assess critical changes in fire behavior arising from convective outflows. Charles Maxwell from the Southwest Coordination Center will evaluate the project results obtained in the southwestern United States in the context of fire environments decision support. Ms. Strader and Mr. Maxwell will participate in the project at no cost to the JFSP devoting approximately 5 days (@$413 per day) and 6 days (@$350 per day) per year respectively for total two-year salary in-kind contributions of $4130 from the Bureau of Land Management and $4200 from the U.S. Fish and Wildlife Service, respectively.

A Member of the Joint Fire Science Program Exchange Network
http://akfireconsortium.uaf.edu
International Arctic Research Center, University of Alaska Fairbanks
PO Box 757340, Fairbanks, AK 99775

November 10, 2016

Dear JFSP Board and Proposal Review Committee,

The Alaska Fire Science Consortium (AFSC) is writing in support of the 17-1-0501 Proposal, " **Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment**", submitted by PI John Horel. AFSC and our agency partners have worked with John and his team previously and found them extremely responsive to agency interests and feedback. On previous collaborations such as the Alaska Fire and Fuels project (http://fire.synopticlabs.org/alaska/), John's team had an outstanding track record of follow through and communication with regional managers, and the resulting product has been a major leap forward in the information resources available to Alaska's managers regarding fire weather and fuel conditions. This proposal's topic is one of the Alaska fire management community's top research priorities (fire weather forecasting, particularly for critical events) as indicated by the Alaska Wildland Fire Coordinating Group's Research Committee (https://www.frames.gov/partner-sites/afsc/partner-groups/frdac/research-needs-list/).

AFSC assisted with the development of the proposed project's science delivery plan. If funded, AFSC is prepared to assist the research team by facilitating discussions with managers at all stages of the project to encourage research products that are useful and relevant, helping with technology transfer and outreach, hosting the webinars identified in the science delivery plan, and ensuring that information about this project and its results are made available to Alaska's managers. As the project progresses, we will work closely with this research group to fine tune and carry out their science delivery plan and develop other appropriate outreach products. Potential avenues of outreach may include but are not limited to workshops, meetings, newsletter updates, web products, our social media outlets, fact sheets and/or project summaries, and other printed and online materials. We anticipate seamless communication between AFSC and the project as AFSC's fire behavior analyst (Robert Ziel) is a member of the project team, and we look forward to working with John and his team in the future.

Sincerely,

Alison York
Coordinator, Alaska Fire Science Consortium

Randi Jandt
AFSC Fire Ecologist

SOUTHWEST FIRE SCIENCE CONSORTIUM

A JFSP KNOWLEDGE EXCHANGE CONSORTIUM

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School of Forestry
PO Box 15018
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928-523-1148
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swfireconsortium.org

Joint Fire Science Program
Attn: John Hall, Program Manager

November 11, 2016

Dear Dr. Hall:

The executive board for the Southwest Fire Science Consortium supports Dr. Horel and colleagues' proposal titled "Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment". If members of the board were involved in a proposal in any way, they abstained from the evaluation of that proposal.

We feel the proposed use of the High Resolution Rapid Refresh (HRRR) modeling system has potential to help improve prediction of thunderstorm outflows, gust fronts, and downdrafts which in turn would improve firefighter safety in the Southwest.

We welcome the opportunity to have the researchers present their research findings and get feedback from the fire community via webinar.

Sincerely,

Alexander Evans, PhD.

Research Director, Forest Stewards Guild,
Member of the Executive Board of the Southwest Fire Science Consortium

Alaska Wildland Fire Coordinating Group

November 10, 2016

U.S. Department of the Interior

Bureau of Indian Affairs

Bureau of Land Management

National Park Service

US Fish and Wildlife Service

State of Alaska

Department of Fish and Game

Department of Natural Resources Division of Forestry

Department of Environmental Conservation

U.S. Department of Agriculture

US Forest Service

Native Organizations

Association of Village Council Presidents

Chugachmiut

Tanana Chiefs Conference

Structural Fire Departments & other Organizations

Anchorage Fire Department

Joint Fire Science Board of Governors
Joint Fire Science Program
National Interagency Fire Center
3833 S. Development Center
Boise, ID 83705

Dear Board of Governors:

The Alaska Wildland Fire Coordinating Group (AWFCG), comprised of federal, state, and Alaska Native corporation land managers, endorses the proposal submitted by Horel (PI), et al. for funding consideration under the Joint Fire Science Program funding opportunity "Validating mesoscale, atmospheric boundary prediction models and tools (FA-FON0017-05).

The AWFCG is a statewide organization that provides guidance and direction on interagency fire management issues and activities, including wildland fire research. The Fire Research subcommittee of AWFCG reviewed and ranked the submitted Alaska wildland fire research proposals based upon the criteria provided AWFCG. The four criteria are: the proposal meets the established AWFCG research needs; it benefits multiple agencies; the proposal has direct management application; and the proposal provides for appropriate technological transfer

The following proposal for the JFSP FA-FON0017-05 titled *Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment* directly addresses several knowledge gaps in Alaska identified on the 2014 AWFCG Research Needs list: Fire Weather Forecasting, Fire Season Weather Forecasting, and Fire Behavior Models: Validation and Applications. With Alaska's land size and burnable acreage, plus the limited weather data, this project will help to improve the short-term forecasting of convectively driven changes that influence fire behavior in the vicinity of thunderstorms. This project will help to improve communication for fire weather forecasters, fire managers and fire behavior analysts to form alerts and warnings of potential and imminent risks. Currently short-term fire management decisions are not possible for the detection and prediction of thunderstorm outflows, gust fronts, and downdraft winds.

The AWFCG believes that this proposal addresses needs identified by land managers concerned with the effects of thunderstorms on wildland fire behavior and the safety of personnel suppressing the fire. The results and deliverables from this project would also assist the National Weather Service forecasters in their daily forecasts. Please consider funding this project that addresses critical research needs for wildland fire and fire weather prediction throughout Alaska.

Sincerely,

Bobette Rowe

Bobette Rowe

Chair, Alaska Wildland Fire Coordinating Group

CC: John D. Horel

NATIONAL INTERAGENCY FIRE CENTER
3833 South Development Avenue
Boise, Idaho 83705-5354
10 November 2016

Memorandum

To: JFSP Board and Proposal Review Committee

From: Edward Delgado
Program Manager
National Predictive Service

Subject: Letter of support for JFSP proposal titled "Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment" from John D. Horel et al

I would like to offer my support for the proposal titled "Assessment of HRRR Model Forecasts of Convective Outflows in the Fire Environment."

The conditions in which wildland fires develop are highly dynamic and very difficult to forecast, creating an extremely variable and dangerous environment with very narrow margins for safety for firefighters. Convective outflows often contribute to the erratic and extreme fire behavior that can quickly overwhelm firefighting resources. High resolution weather prediction models are improving the ability to forecast convective environments but still fall short of forecasting when and where outflows will develop and how they will affect a fire. Nevertheless, understanding model capabilities, skill and limitations at forecasting the conditions that contribute to outflow formation can improve the decision-support capabilities of meteorologists who support wildfire operations. This can lead to better awareness of potential threats to firefighters and improve forecasters' and fire managers' ability to communicate those threats earlier and more accurately to resources on the ground. Predictive Services meteorologists generally look at larger-scale patterns but in periods of high fire activity, their focus can turn to smaller areas where fires have a higher potential for outflow interactions and can inform resource realignment decisions. Incident meteorologists can provide more timely information that can help determine when resources must disengage. The findings of this study can help identify the best method for communicating these risks to resources on the ground.