Fixed and Mobile Fire Weather Observatories in the U.S. Intermountain West

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Wildfire photo by Robert Hyatt, NOAA National Weather Service

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Motivation

- 10 M+ acres burned in 2020, the most on record (NCEI)
- $4.4 B: amount spent on fighting wildfires in the U.S. in 2021 (NIFC)
- $10 B+: amount of damages in 2021 incurred from wildfires in the Western U.S. alone, including the unexpected late December Marshall fire in CO that destroyed more than 1000 structures in Boulder County and surrounding unincorporated areas (NOAA)

- The Bipartisan Infrastructure Law (BIL) Provision 15 awarded NOAA $50 M in FY2022 "*for observation and dissemination of infrastructure used for wildfire prediction, detection, and forecasting*"

- BIL-Provision 15 includes funding to build four fixed and two mobile ground-based fire weather observatories

Science questions

- What role does soil moisture play in the seasonal development of the boundary layer?
- What is the seasonal cycle of the Bowen ratio and how is it affected by location, precipitation, and soil moisture?
- What are the structure and turbulent characteristics of the boundary layer and how are these impacted by complex terrain?
- What is the annual cycle of leaf area, NDVI, and canopy conductance and does it vary seasonally? How much does it vary on a year to year basis?
- How coupled are boundary layer heights to surface fluxes? Does this vary seasonally, annually?
- How much does land surface heterogeneity play a role in boundary layer development and variability of boundary layer turbulence statistics?
- How does boundary layer evolution and stability impact the possibility and timing of mixing down higher wind speeds from aloft
- What are the diurnal wind patterns (surface and aloft) and as a function of season?

Considerations for fixed, ground-based fire-weather sites

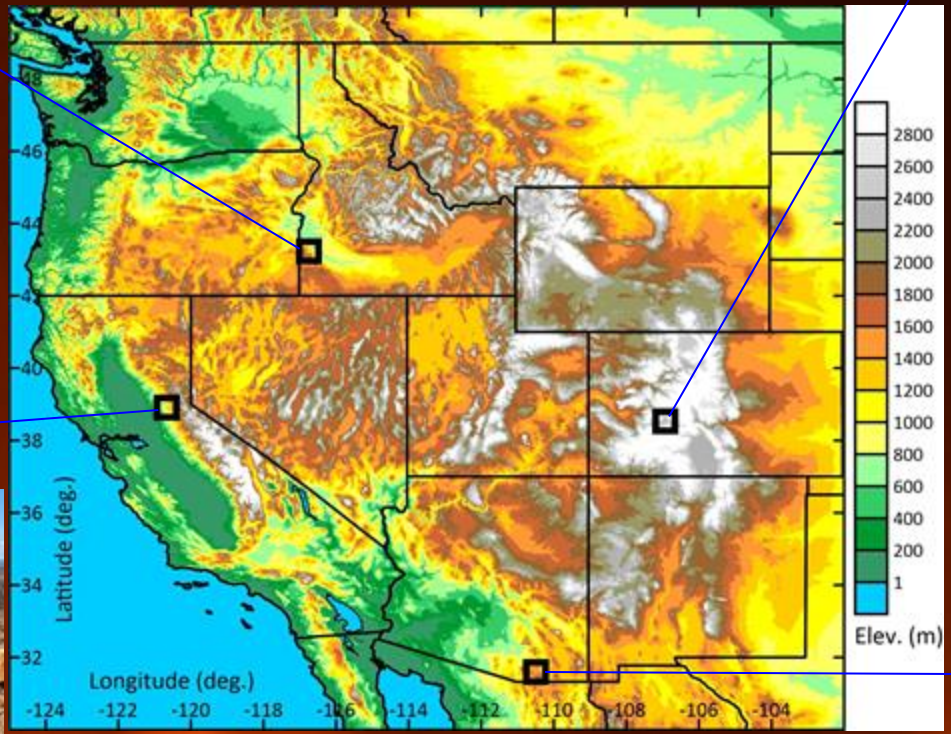
- Climate regime - sites should be susceptible to wildfires
- Varying surface land cover characteristics
- Varying levels of topography
- Varying climatological conditions that pose model challenges
- Varying atmospheric/topographic forcing such as thermally induced flows
- At least one tall-forested site
- Avoid narrow valleys that cannot be adequately represented in current NWP

- Site infrastructure (electrical power, data communications, secure location)
- Proximity to fire weather research groups
- Availability of personnel to take care of instrument issues

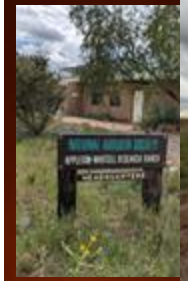
Candidate sites for fixed, ground-based observatories

Reynolds Creek
Watershed, ID
USDA

Blodgett Forest, CA
U. Cal. Berkeley



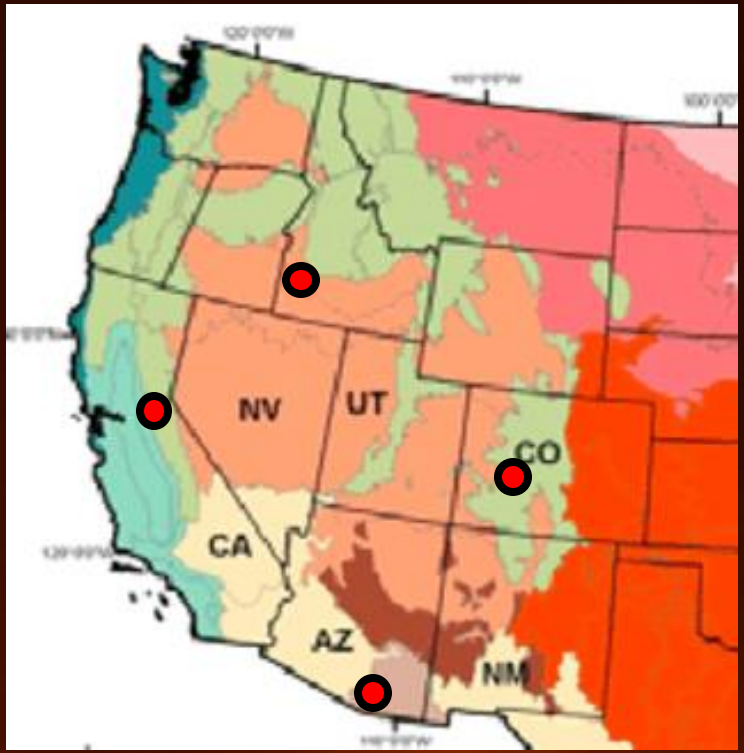
Gunnison, CO
Site TBD



Appleton-Whittell
Research Ranch, AZ
Audubon Society

Motivation behind site selection

- Envision an interactive wildfire-atmosphere model running at ~100m
- Likely similar to the Warn-on-Forecast System (WoFS)
  - Ensemble system driven by the operational 3 km ensemble system (RRFS)
- Observations will be used for
  - Process-level understanding
  - Model verification (esp at 3 km)
- In complex terrain, sampling different ecological regions
- Ability to support additional obs for focused field campaigns
- These obs be used to improve “before fire”, “during fire” and “post fire” predictive models



Fixed, ground-based observatory instrumentation

Instrument	Measurements
449-MHz radar wind profiler	Wind profiles, snow level
Infrared spectrometer	Temperature and water vapor profiles, cloud properties, PBL height
Polarization sensitive ceilometer	Cloud base height, cloud layers, PBL height, discrimination between spherical and non-spherical scatterers
Flux / Met tower	P, T, RH, wind, solar/infrared radiation, precip., turbulent fluxes of sensible and latent heat/momentum
Broadband radiometers (LW & SW)	Downwelling and upwelling LW and SW radiative fluxes, cloud rad forcing
Gas concentration analyzer	CO, CO_2, CH_4, water vapor
Mass monitor	PM1, PM2.5, PM10
Multi-filter shadowband radiometer	Aerosol optical depth at 5 wavelengths
Total sky imager	Sky images to characterize cloud cover, cloud type, and sky conditions

Mobile fire-weather observatories

- Mobile observatories will be deployed near prescribed burns or active wildfires (e.g. upwind and downwind) or be used for other atmospheric research field campaigns
- Based on previous work at NSSL and OU on their Collaborative Lower Atmosphere Profiling System (CLAMPS-I and CLAMPS-II)
- The BIL-supported mobile observatories will use similar instruments and will be named CLAMPS-3 and CLAMPS-4

Wagner et al. 2019, BAMS

Fixed, ground-based observatory instrumentation

Instrument	Measurements
Lidar wind profiler	Wind profiles, turbulence profiles
Infrared spectrometer	Temperature and water vapor profiles, cloud properties, PBL height
Polarization sensitive ceilometer	Cloud base height, cloud layers, PBL height, discrimination between spherical and non-spherical scatterers
Flux / Met tower	P, T, RH, wind, solar/infrared radiation, precip., turbulent fluxes of sensible and latent heat/momentum
Broadband radiometers (LW & SW)	Downwelling and upwelling LW and SW radiative fluxes, cloud rad forcing
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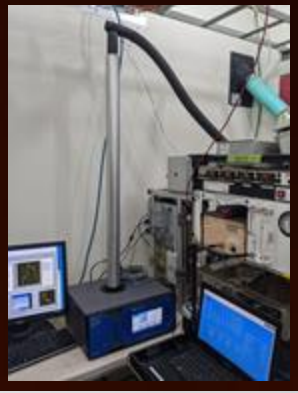
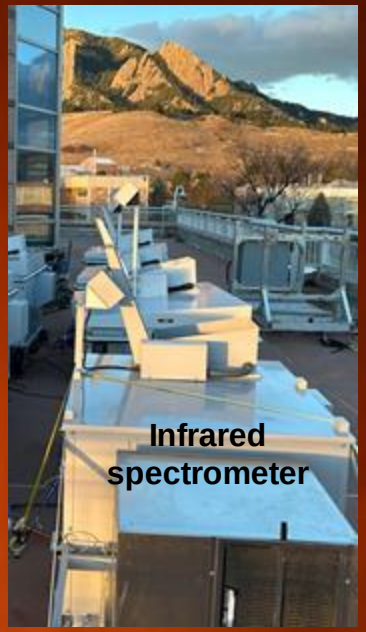
449-MHz radar wind profiler

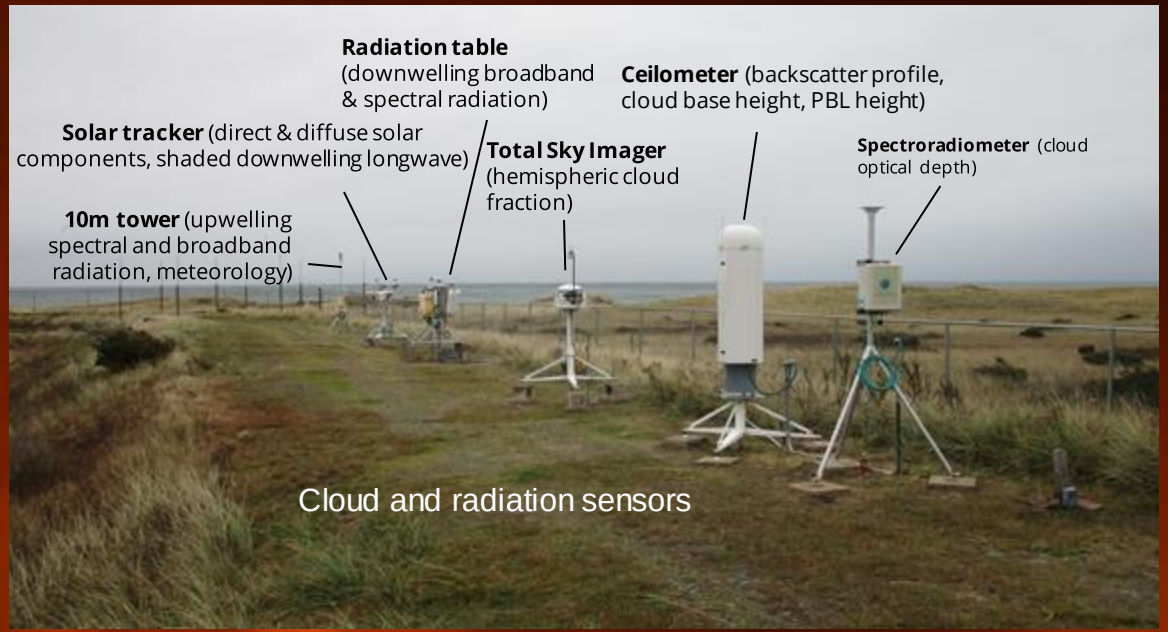

Doppler lidar

Gas concentration analyzer and mass monitor

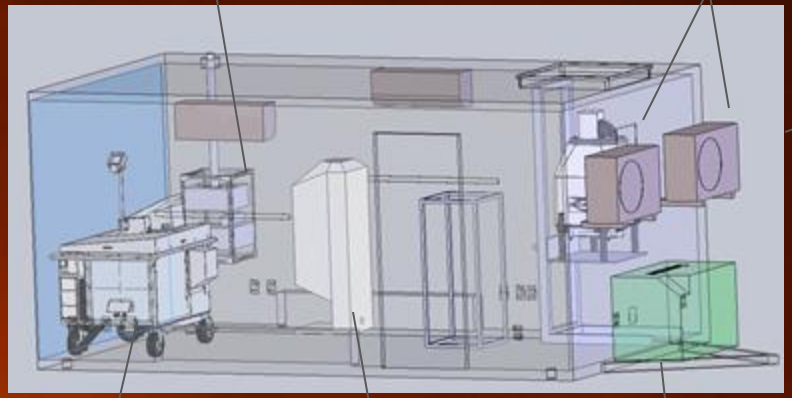


Flux / Met tower

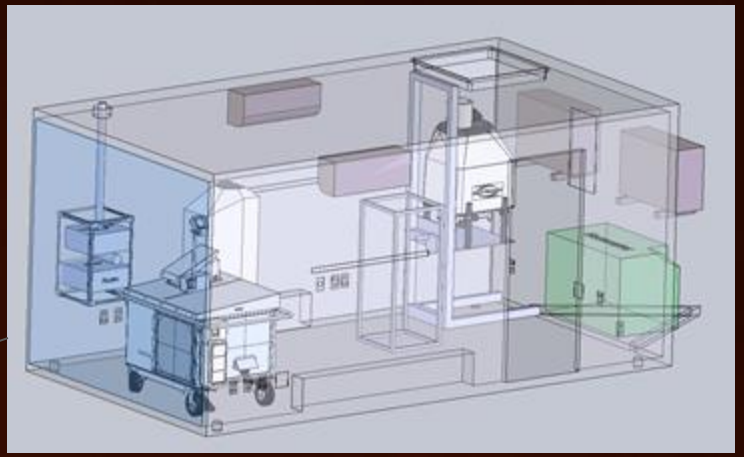

Infrared spectrometer

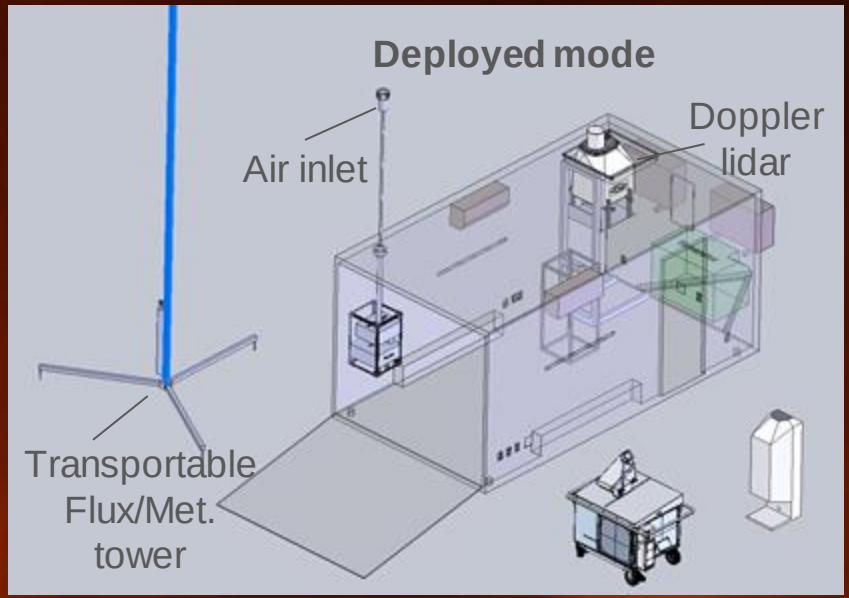


Mobile fire-weather observatory



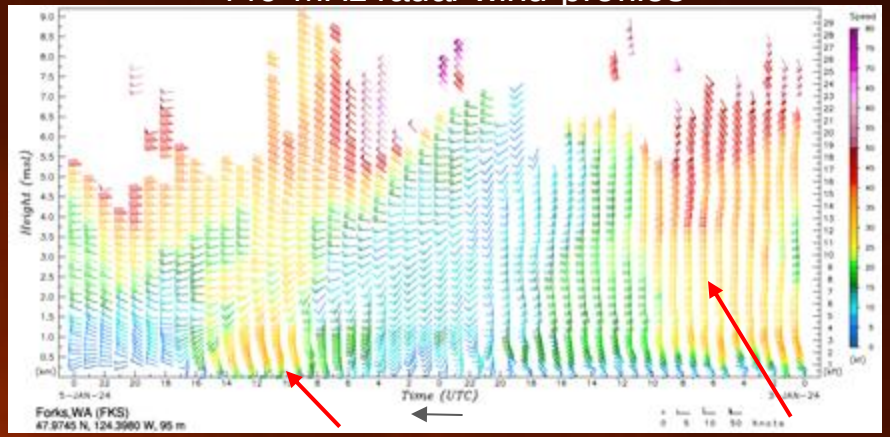
Curb-side view with instruments stowed and secured for transport





Sample Data and Analysis Products

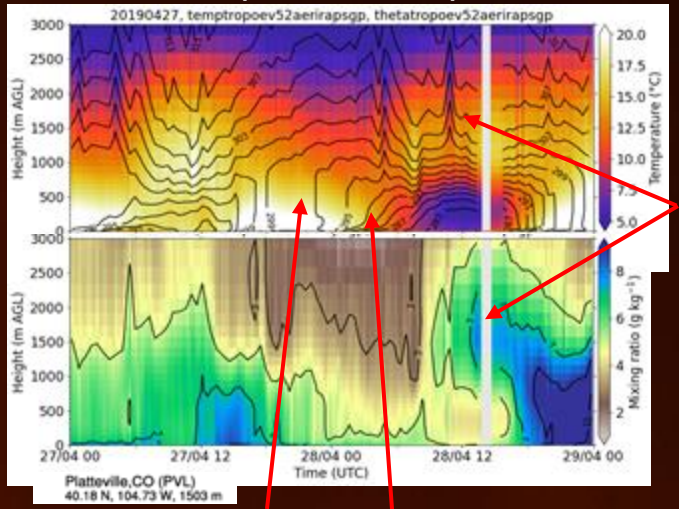
449-MHz radar wind profiles



Low-level jet in advance of Pacific cold front

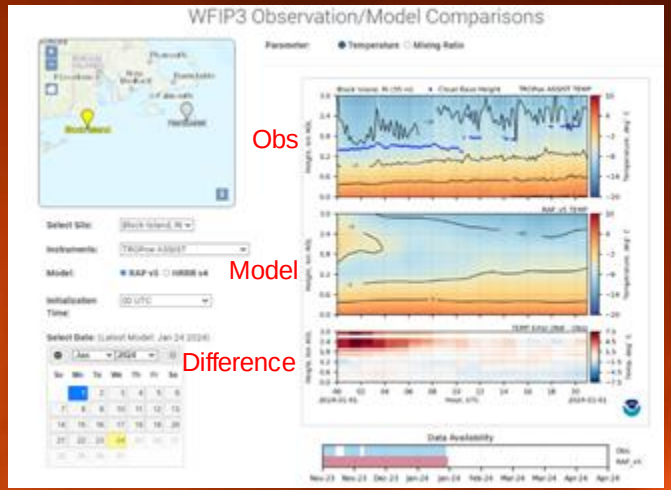
Higher altitude increased wind speeds available for downward mixing

Infrared spectrometer profiles



Advection of warm and moist elevated layer

Convective boundary layer and nocturnal surface inversion



Forecast Evaluation Tool

- Developed for other field campaigns and will be made available for the fire-wx observatories, too.
- Near real-time comparisons with RAP and HRRR (other models being added
- Many different variables from different instruments may be evaluated

Summary

- BIL Provision 15 includes funding to build four fixed and two mobile ground-based fire weather observatories
- Most of the instruments have been acquired
- Candidate sites for the fixed observatories have been identified, and have different climate, topographic, and surface land cover characteristics
  - Real estate permits are in process
  - Hope to be installing 1-2 sites this CY, with remaining sites spring 2025
- Specially designed trailers for the mobile observatories have been ordered
  - Instrumentation and data acquisition systems will be installed this summer/fall
- As much data as possible from the fixed and mobile observatories will be transmitted to a data hub in near real time and will be shared with fire fighters, forecasters, incident meteorologists, researchers, and the general public

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