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FOREST SERVICE RAWS REVIEW AND UPGRADE STUDY

Karl F. Zeller*
USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado

John Zachariassen
USDA Forest Service, Rocky Mountain Research Station, Fort Collins, Colorado

Thomas McClelland
USDA Forest Service, Washington DC

1.INTRODUCTION

The US Department of Agriculture (USDA) Forest Service (FS), the US Department of Interior (USDI) Bureau of Land Management (BLM), the USDI National Park Service (NPS), the USDI Fish and Wildlife Service (FWS) and the USDI Bureau of Indian Affairs (BIA) in addition state forest agencies share a common need for accurate and timely remote weather data for vital operational and program decisions (Finklin and Fischer, 1990). The Remote Automated Weather Stations (RAWS) network evolved over the past 30 years from this multi-agency common need primarily to provide weather data in support of the National Fire Danger Rating System (NFDRS) (NWCG, 2000). The RAWS network has always existed in a state of change, the most recent being a program upgrade requiring RAWS operational and maintenance standards for any individual site to be included in the NFDRS (NWCG, 2000). The current condition of FS owned RAWS varies from NFDRS qualified to both aging and not adequately maintained and so not NFDRS qualified. Beyond NFDRS requirements, in response to other resource and program managers, FS weather data needs are expanding: air resource Clean Air Act issues like EPA prevention of significant deterioration (PSD) assessments (FLAG Phase I Report, December 2000), air pollution deposition impacts (Zeller et al.2000a), ecosystem modeling (Zeller and Nikolov, 2000b), engineering meteorology and environmental engineering, data support for mesoscale meteorological modeling efforts, air quality monitoring, and basic weather forecasting including model output statistics forecasts (Gerber et al. 1998; Gibson et al, 1998), This list is but a small subset of the uses for RAWS data that go beyond fire support that is the primary 'mission' of the RAWS network.

The current study will inventory, assess and evaluate the FS's participation in the RAWS network, to provide recommendations for station and network upgrades to meet future anticipated needs and uses of RAWS data sets.

2. PROCEDURE

2.1 RAWS Review Approach:

Existing Forest Service RAWS sites will be inventoried with respect to location, sensor suite, data transmission, adjacent RAWS, ownership (USFS, BLM, NPS, FWS, BIA), and nearest FS facility. Protocols for data collection, retrieval, and archiving will be evaluated. The site location criteria and station redundancy within an operational area will be assessed to address the question: are additional stations required to optimize fire and non-fire weather data needs; and are any stations no longer needed. Note that based on experience, no stations will be recommended for discontinuation as long as there is an active site 'owner' who wants the station.

*Corresponding author address: Karl F. Zeller, USFS/RMRS, 240 West Prospect Rd. Ft. Collins CO 80526; e-mail: kzeller@fs.fed.us

3. INITIAL RESULTS AND DISCUSION

3.1 The RAWS network

The RAWS network provides fire weather data to federal agencies involved in forest and range fire management. Each day during the fire season (April – October), early-afternoon (13:00 LDT) weather observations are collected from each RAWS site in the US for NFDRS products. The number of RAWS stations has increased significantly over the years. Table 1. is an approximate account showing an increase from about 430 RAWS in 1988 to over 1300 today (Shelley, personal communication, 2001):

Table 1: Approximate number RAWS in 1988 and 2001

Agency and Type	1988	2001
FS – Manual	~ 1000	~ 300
FS – RAWS	265	680
BLM – Manual	?	?
BLM – RAWS	165	381
NPS – RAWS	?	130
BIA – RAWS	?	48
FWL – RAWS	?	71

Most of the RAWS are concentrated in the western US (see: National Weather Service, Boise Fire Weather, http://www.boi.noaa.gov/firewx.htm, and http://raws.boi.noaa.gov/rawsidx.html for exact location information) (K. Shelley, personal communication 2001). There are also numerous portable RAWS that are generally deployed for wild fires and during prescribed burns.

Fire weather observations are sent from each RAWS via satellite transmitter to GOES → Wallops Island → DOMSAT → BLM: ASCADS → [WIMS, NIFC, WRCC, BLM, NWS-Boise]. Some RAWS data is transmitted directly to WIMS (Weather Information Management System) via phone line. The data are combined with site fuel type and topographic parameters (i.e. the station catalog aka metadata) then processed through NFDRS algorithms to generate fire danger index product maps to forecast fire potential. Forecasts are also made for next day weather, dead fuel moisture, greenness, drought, atmospheric stability (Haines index), and lightning ignition efficiency (see Wildland Fire Assessment System, http://www.fs.fed.us/land/wfas/).

The RAWS sensor suite and data collection approach are the following:

- Rain gauge/precipitation – tipping bucket, continuous cumulative 0.01 inch; some may be heated
- Wind speed – mph, 10 min mean just prior to data transmission
- Peak wind speed (gust) – max mph from previous hour prior to data transmission
- Wind direction – degrees, 10 min mean prior to data transmission
  - Direction of peak gust – degrees
- Air temperature – °F, instantaneous at time of data transmission
- Fuel temp. (optional) - °F, instantaneous
- Relative humidity – percent, 10 min mean prior to data transmission
- Battery voltage – volts, instantaneous
- Barometric pressure (optional) – inches of Hg, instantaneous
- Fuel moisture (optional) – grams H_2O in a 100 g pine dowel, instantaneous
- Solar radiation – watts/m^2, instantaneous
- Coordinated universal time – WWV clocks required
- Data collection Platform (DCP) (Vaisala/Handar, FTS, or Campbell Sc.)

The network stations are now classified according to the following criteria (NFDRS, 2000).

- NFDRS – Year Round Stations:
  - Operates 12 months to support wildland fire season
  - Equipped with minimum NFDRS sensor suite (see below)
  - Meets min QA requirements
  - Hourly readings are delivered to WIMS via GOES (24/7)
  - NFDRS calculations are processed regularly in WIMS
  - Heated or weighing rain gauge if necessary
- NFDRS – Seasonal Stations:
  - Operates to support fire season (but can operate 12 months)
  - Equipped with minimum NFDRS sensor suite (see above)
  - Meets min QA requirements
  - Hourly readings are delivered to WIMS via GOES (24/7)
  - NFDRS calculations are processed regularly in WIMS (during operational period)
- Other:
  - Includes all other stations that provide accurate weather data but do not meet NFDRS standards
- Manual Stations:

Stations (telephone telemetry (phone in or queried)) providing basic NFDRS inputs to WIMS during operational period – one observation/24 hr. Many of these are in the process of being upgraded.

RAWS upgrades are currently ongoing and should be completed by 2005. Upgrades include replacing sensors (regular yearly maintenance), adding new sensors to the standard suite – solar radiation, combined fuel temperature/moisture, and new DCPs with expanded capability (see RAWS and NWCG internet sites, http://www.fs.fed.us/raws/ and www.nwcg.gov). The upgrade program is designed to improve data collection, to raise non-NFDRS stations to the NFDRS standard and to provide an expanded data set for WIMS and NFDRS for improved fire danger indexes.

3.2 Previous RAWS Studies/Reviews

Two recent studies (Brown et al. 2001a; Marsha, 2001) and a third (Brown et al., 2001b) have explored statistical approaches for analyzing RAWS data to develop a methodology for optimizing inter-regional RAWS deployments. Brown et. al 2001b performed a quality control on historical data improving metadata files for almost 250 RAWS sites in California. Such improved data will be used in support of fire danger rating analyses and RAWS climatological characteristics across the state.

Marsha (2001) designed a statistic (correlation coefficient) for parameters such as temperature, humidity, NFDRS indices for the future, and dispersion based on wind speed. The goal for their work was to reduce station redundancy without sacrificing quality. The correlative approach they used involved a correlation matrix of simple linear correlations of temperature and humidity data between stations. Stations with correlated were removed from the matrix until all correlations fell below a pre-set threshold. Results indicated that some stations could be removed from the network. As an example the dispersion statistic for wind speed (WS) took the form:

[(90th percentile peak WS) - (median peak WS)] / (median peak WS)

A wind sensitivity rating (0,1, or 2) was then calculated using both the 90th percentile peak WS and the dispersion statistic. Zero was considered “inadequate”, 1 “adequate”, and 2 “good”. This procedure was followed before running correlations for temperature and humidity so that only those stations with an adequate or good wind sensitivity rating were included in the correlation matrices.

Brown et. al. (2001a) used a formal geo-statistical approach (used for the analysis of meteorological networks) in an analysis of the Great Basin RAWS network. They calculated spatial correlations (r(h)) analyzed over different climate time (days, weeks, months, seasonal, years etc.) and spatial (varying distances and altitude ranges) scales. Highest correlations for temperature were reported for those stations closest to one another in straight distance and within given elevation ranges. Optimal correlations were found for stations within a distance of 27 miles and within 2000 feet (elevation) of one another. The authors suggested that local terrain effects on WS that are less influential on temperature and relative humidity. One of the final recommendations was that no station within the study area should be discontinued.

3.3 Retrieval of RAWS weather data

Users can retrieve RAWS weather data a number of ways: two avenues of retrieval are through the WRCC (Western Regional Climate Center) and through KCFast (Kansas City Fire Access Software). A third is through a new, map intensive website called GEOMAC, the Geospatial Multi-Agency Coordination Group.

WRCC:

1. via internet: http://www.wrcc.sage.dri.edu/cgi-bin/raws1_pl is a page for RAWS station search
2. search criteria are: station name, Ness ID, state, and latitude/longitude pair
3. click on the desired parameter and follow the instructions
4. the html page(s) can be saved as a text file and then opened from within a spreadsheet application

Note: data access via the WRCC allows the user to retrieve ONLY a single month of data at a time. Other arrangements with WRCC are necessary for retrieving/obtaining loner data periods.

Accessing KCFast allows member users to retrieve weather, fire occurrence and station catalog data but does not allow changes to be made to these data and meta data sets. (Note an excellent ‘How to…’ is found in Appendix A of the Fire Family Plus Users Guide V2.0 (RMRS Fire Sciences Lab, Systems for Environmental Management, July 2000)).

1. via internet: http://famweb.nwcg.gov/
2. logon as usual (requires user ID and password) to retrieve data; KCFast will send data file to the usual FTP site
3. go to the FTP site by typing in the address box: ftp://ftp.fs.fed.us/incoming/wo_fam/
4. press ENTER
5. find and select the file that was requested
6. next go up to the FILE menu, scroll down to ‘Copy to folder’, click on browse and select a destination folder and click on OK – the raw data file will be copied into the selected folder

Geomac is a map intensive website and allows member users to access the last 24 hours of transmitted RAWS weather data, if that particular station transmits once per hour, if not then the 13:00 (LDT) observations are given. Various map (information) layers are available such as thermal images (of active fires), sit report fires, available perimeters, RAWS weather, major cities, major roads, lakes, streams etc. Multiple layers can be called up at any one time but only one layer at time is 'active', that is, the top layer.

1. go to the Wildland fire access page: http://geomac.usgs.gov/
2. click on the wildland fire maps button, Note: a password is required but easy to obtain
3. this takes the user to the GeoMAC overview map
4. on the right hand side the user can choose map layers to show, each time different layers are chosen the map needs to be 'refreshed'
5. in the lower left hand corner are application buttons: locator, zoom, pan, hyperlink, etc.
6. if RAWS weather is the active layer then sites will be indicated on the map
7. click on the hyperlink button, then click on any given RAWS site
8. this takes the user to a table of RAWS data provided by the NWS in Boise, ID

3.4 Applications/Uses of RAWS data

Brown et al. (2001a) identified four primary categories for RAWS data: NFDRS, fire behavior, fire use, and other. NFDRS use is for daily fire danger indexes and operations (section 3.1). Fire behavior means either the behavior during a fire event or the modeled behavior for planning purposes. Fire use refers to management practices such as prescribed burning. These three categories/applications are the force behind the RAWS network, it's establishment, and it's operation and maintenance and the need to upgrade. The last category (other) refers to all applications that do not fit into the first three groupings; it is rapidly growing. Agencies, businesses, universities and divisions within each request RAWS data in increasing numbers for purposes other than wildland fire danger assessment. Historical and climatological RAWS data has been used in court, for monitoring of soil erosion, for environmental restoration and risk assessment, for budget analysis, for forest health, ground water, watershed, and hydrologic assessments, for impacts upon wild life, soils studies, and for ecosystem model parameterization.

Decision making (short and long term) for fire management is an additional fire related use supported by RAWS data. For short term planning RAWS data supports: tactical planning during a fire, prescribed burning go/no go, staffing levels and duty hours, fire behavior modeling, pre-positioning of resources, and providing weather information to incident commanders and fire crews. For long term RAWS supports: budget planning, resource needs, planning for fire prevention and pre-suppression, restoration of forest and range, seasonal droughts, modeling, seasonal fire danger analysis, and long term climate analysis.

3.5 Other Resource RAWS Applications

Four additional uses of RAWS data are: air quality and pollutant monitoring in the atmospheric boundary layer, aerosol and trace gas flux measurements, environmental aerodynamics, and ecosystem (process) modeling.

Air quality monitoring and flux measurements (of greenhouse gases, H_2O, O_3, CO, and energy) would require additional instrumentation and sensors. Passive devices such as filter packs would be sufficient for collecting dry deposition samples, although pumps would also need to be added to the equipment suite. Flux measurements require near instantaneous sampling (following the eddy covariance method) – the cost of these instruments and power requirements are two factors one would need to consider in configuring such a station. Fluxes could also be calculated using passive devices if a deposition velocity is known (Zeller et al., 2000b).

Wind engineering or environmental aerodynamics – weather data is being used to help in the assessment of future development. Specifically for housing siting and orientation, mitigation of existing problems, locating industrial emission stacks, assessment of biohazards and radioactive exhausts, and determining wind loads on structures (high and low rise buildings and bridges).

Modeling of ecosystem processes (nutrient cycling – of N, C, P, and S, and carbon sequestration) requires 'drivers'; in the case of the Century model two of the most important drivers are soil temperature and moisture. These are parameters that can be collected by adding additional sensors to RAWS DCPs (see super RAWS below). Forest stand (and individual trees) growth models also require weather data input.

3.6 Super RAWS

Funding was approved to evaluate a prototype 'super' RAWS within the Superior National Forest at the Fernberg site near ELY, MN. This site should operational by early autumn 2001. The rationale for a RAWS with extra sensors was based upon an assessment of future needs of: the USFS, other federal land management agencies, and the expanding list of uses and applications of RAWS weather data. Super RAWS will include the standard required suite of sensors, collect, and transmit data as per NFDRS standards. In addition to direct fire danger applications, super RAWS will include sensors to support and provide data for non-fire applications and uses. These include: snow depth (possible snow water equivalent), leaf wetness, soil temperature and moisture, barometric pressure, duff moisture (e.g. from recently dead and decaying surface litter), site plant species list, and leaf area index (LAI – area of leaf surface above a square meter of ground surface). Leaf area index is directly related to net primary production (NPP), CO_2 uptake and plant respiration.

4. Conclusion

Based on initial studies, observations to date, literature review, and personal communication(s) with RAWS personnel, the RAWS network is a national asset and functioning fairly well given that it is a multi-agency network with many user/owner choices as to how to operated individual stations. At the regional level station and data quality varies as the management of the network within each region varies. BLM funds and operates their RAWS stations from the national level under a single QA authority. The FS allows each Region to determine their own approach to management and maintenance. For example: in FS Region 2 (Rocky Mountain) the network is owned and maintained primarily from the region headquarter level whereas in R3 (Southwest) ownership, management and, maintenance is split between individual forests and the region (D. Clement (Region 1) and R. Shindelar (Region 3), 2001, personal communication).

Individual stations meeting NFDRS standards are providing data in support of fire weather forecasting and calculating fire danger rating indexes – the primary mission of the network. The entire network is in perpetual transition – undergoing hardware and software upgrades as well as streamlining data transmission. Apart from the standard maintenance and upgrade schedule for RAWS stations there are other factors 'driving' this process. An increasing number of institutions other than those directly involved with fire weather (both public and private) are requesting and using RAWS data for fire and non-fire uses and applications.

Streamlining and upgrading the network is a priority for those directly involved in RAWS management (K. Shelley and P. Sielaff, 2001, personal communication; NWCG, 2000). Also, suggestions/recommendations have been discussed and are being designed to improve quality control and quality assurance (QA/QC) of data and meta-data for NFDRS calculations. The new NFDRS RAWS protocol will ensure that each NFDRS station and sensors receive regular scheduled maintenance and calibration. The NWCG PMS 426-3 (NWCG, 2000) establishes rigid standards and procedures for NFDRS stations necessary maintain a high level of QA/QC. Changes in the RAWS data transmission pathway are also under consideration: a more efficient path might be for GOES to transmit directly to Boise/ASCADS. RAWS administration, maintenance, and first response personnel (in a given FS Region) provide critically important support as well as being directly involved in data QA/QC. The subject study will add to the current knowledge base of RAWS information and improving it's efficiency and performance.

5. References

Brown, T.J., B.L. Hall, K.T. Redmond, and G.D. McCurdy. 2001a. Great Basin RAWS Network Analysis. Program for Climate, Ecosystem and Fire Applications, CEFA Report 01-01.

Brown, T.J., B.L. Hall, K.T. Redmond, and G.D. McCurdy. 2001b. Quality Control of California Historical RAWS Data. In preparation.

Federal Land Managers' Air Quality Related Values Workgroup (FLAG), Phase I Report, December 2000. http://www2.nature.nps.gov/ard/flagfree/index.htm

Finklin and Fischer, 1990. Weather Station Handbook – An Interagency Guide for Wildland Managers. NWCG

PMS 426-1; NFES 2140. National Interagency Fire Center, Boise, ID. March 1990, 238p.

Gerber, M.E., C.V. Gibson, and S. Ruiyu. 1998. Verification of model output statistical forecasts for remote automatic weather stations. Preprints 2nd Conference on Fire and Forest Meteorology. Phoenix, AZ, Amer. Meteor. Soc., 116-119.

Gibson, C.V., M.E. Gerber, and S. Ruiyu. 1998. Development of MOS equations for remote automatic weather stations. . Preprints 2nd Conference on Fire and Forest Meteorology. Phoenix, AZ, Amer. Meteor. Soc., 111-115.

Marsha, T, Final Draft Spring 2001. Optimization of PacNW RAWS Network. Unpublished USDA/FS report T. Marsha 503-808-2756.

NWCG – National Fire Danger Rating System, Weather Station Standards. 2000. Various authors. Publication of the NWCG PMS 426-3, May 2000.

Zeller, K.F., D. Youngblood-Harrington, R. Fisher, and E. Donev. 2000a. Determining Atmospheric Deposition in Wyoming with IMPROVE and Other National Programs. USDAFS/RMRS General Technical Report RMRS-GTR-52.

Zeller, K.F. and N.T. Nikolov. 2000b. Quantifying simultaneous fluxes of ozone, carbon dioxide and water vapor above a subalpine forest ecosystem. Environmental Pollution 107: 1-20.