UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL ENVIRONMENTAL SATELLITE DATA
AND INFORMATION SERVICE
NATIONAL CENTERS FOR ENVIRONMENTAL INFORMATION
151 PATTON AVE ROOM 120
ASHEVILLE NC 28801-5001

December 7, 2017

MEMORANDUM FOR: Derek S. Arndt
Chief, Climate Monitoring Section, Center for Weather and Climate
National Centers for Environmental Information

FROM: Karin Gleason
Meteorologist, Monitoring Section, Center for Weather and Climate

SUBJECT: SCEC Report for California Maximum Wind Gust on
20 February, 2017

Summary:

On 16 November 2017, a State Climate Extremes Committee (SCEC) convened to verify / validate a report of an observed 199 mph wind gust which occurred on Ward Mountain the evening of 20 February 2017. If verified, this would become the SCEC's inaugural state maximum record wind gust for California, as no previous wind gust was vetted for such purposes.

The committee considered the following factors in their decision: the genuine nature of the reported wind gust, meteorological plausibility and a review of the equipment which measured the observation in question. After reviewing the observational evidence, the SCEC unanimously agreed that the wind gust would establish a new record for the State of California. In particular, the committee found that the following were true and valid:

- LOCATION: Ward Mountain (aka Ward Peak), elevation 8643 ft in the Alpine Meadows Ski Resort
- TIME: Approx. 11 pm PST on 20 February 2017
- WIND GUST: 199 mph

No prior official record was compared. In a search for prior and comparable events, only one event was reported to be as strong as the wind gust in question, but had no verifiable evidence. This and other known strong events are noted in a subsequent section of this report.

Sequence of Events, Examination & Decision

Background

On February 20, 2017 at around 11 pm PST, a gust of 199 mph was recorded in the northern Sierra Nevada of California at a mountain called Ward Mountain (also known as Ward Peak), elevation 8643 ft, in the Alpine Meadows Ski Resort. At the same time, a gust of 193 mph was recorded nearby at Squaw

Peak, elevation 8700 ft, at Squaw Valley Ski Resort (Figure 1). These locations are about 2.5 miles apart, on the Sierra Crest, just west of Lake Tahoe (Figure 2). Investigation suggests that the gust of 199 mph at Ward Mountain is likely the strongest measured surface wind on record in California.

Storm Environment & Meteorological Plausibility

A powerful atmospheric river storm system with an upper level trough off the West Coast was impacting the region at the time of the peak gust, with strong lower and upper level jets flowing perpendicular to the Sierra Crest (Figures 3 & 4). A Winter Storm Warning was in effect for the west slope of the Sierra, with a High Wind Warning for lower elevations into the Central Valley. Strong winds did not mix down into the Valley as projected, as these winds appear to have focused into the Sierra Crest. A stable layer was evident on model soundings at the time of this event, just above the ridge line level (see Figure 5). This produced a favorable setup for constricting the flow, with the well-known Venturi Effect producing rapid acceleration over the ridges around the 8000-9000 foot level. With winds aloft already exceeding 100 mph, extreme sustained winds and gusts, such as those observed, are quite plausible at the Ward Mountain site.

Reports from the ski resort (personal communication) indicate there was wind damage in the area, including 10 to 12 3-foot wide trees blown down, as well as several windows broken at a nearby ski lift building (see Figure 6).

Review of Wind Measuring Equipment

Graphs of wind direction, speed, and gusts can be seen in Figure 1 for the period of strongest winds. Links to the data displayed on the time series can be found at Summit (Ward Mt.)-Alpine (SUMAM) and Siberia (Sierra Crest)-Squaw (SIBSV).

Quality control checks were marked as valid during the period of strongest winds, and the data appears to be consistent between the sustained winds and the gusts for both stations. Sustained winds were 148 mph at the time of strongest gust at Ward Mountain. The SCEC Committee discussed that the Ward Mountain wind equipment were in proper working order both before and after this wind event. On-site quality control personnel inspected the equipment after the event and noted everything appeared to be operating as expected.

Both the Ward Mountain and Squaw Peak anemometers are Campbell Scientific Model CS215, with model WS-3 Heated Rotor Anemometers, produced by Taylor Scientific Engineering (Figure 7). The anemometers are designed for high mountain environments and are rated to a maximum of 200 mph. This information was determined from Mesowest metadata and from personal communication with Philip L. Taylor, who designed and produced the anemometers. The observations were one-second gusts, similar to RAWS stations, but different from 5-second gusts on ASOS stations. Technical documentation for these anemometers, provided by Mr. Taylor, can be found in Appendix A.

Prior Observations

There is not currently a record maximum wind gust for California recognized by the SCEC. Searching on the Internet, there was a news story mention of a record 176 mph from Ward Mountain, date of the gust unknown. On 8 January 2017, Mesowest recorded Ward Mountain had a gust of 174 mph. In a search of Storm Data dating back to 1950, 'Ward Peak' was reported to have a gust of 172 mph on 14 February 2000. Mammoth Mountain had a reported sustained winds of 150 mph on 1 December 2011, with gusts estimated to near 200 mph, but the max range of the anemometer was 150 mph. Mt. Warren also had a gust to 145 mph reported on 28 January 2008.

Additional large wind gust reports from 20 December 1977, included a strong gust at Arvin, CA, estimated by the USGS to be 192 mph, presumably from observed damage, and in Lee Vining Hill in 2006, with a gust of 183 mph.

Another comparable, but unofficial, wind gust report occurred on Warren Bench at Lee Vining Hill (Mount Warren) on 26 December 2006. An unofficial gust of 208 mph was reported by a Caltrans weather station, which had been at that location for about a year and regularly reported winds over 100 mph during winter storms. Looking deeper into the data for this storm, it became evident that it was a windy day, but the magnitude of this unofficial gust appears to be unlikely as maximum verifiable gusts on Mount Warren never exceeded 130mph.

Finding of Committee

All of the above evidence was shared with the SCEC by electronic mail leading to a 45-minute teleconference call on 16 November 2017.

The meteorological setup during the 20 February 2017 event was extraordinary, allowing for extremely powerful winds over the Sierra Crest. Two rugged anemometers designed for high elevation winds measured very similar readings for the most powerful gusts, almost simultaneously. These instruments were well maintained and quality controlled. In addition to the automated measurements, there was physical damage observed from this event. The combination of factors make this rare event credible and the creation of a wind speed record for California desirable and appropriate.

Based upon the thoroughly-documented evidence, the SCEC agreed unanimously (by a vote of 5-0) that all measurements associated with the wind gust were valid and **recommends the NCEI Climate Monitoring Chief approve the SCEC action to acknowledge the 199 mph wind gust at Ward Mountain on 20 February 2017 as the inaugural state record maximum wind gust for California**.

Issues Raised:

The lack of a prior record for California made the vetting process more challenging than that for an existing record. Maximum wind gust was not one of the five original state record types established by the SCEC, due largely to the general lack of documentation for wind gust measurements over time. It is generally recognized larger wind gusts have surely occurred across state borders since statehood. Thorough investigation of past events as well as future events will help solidify the record.

NCEI Climate Monitoring Chief Decision

Approved (as recommended in boldface above):

ARNDT.DEREK.SHANE.1384496519

Digitally signed by ARNDT.DEREK.SHANE.1384496519
DN: c=US, o=U.S. Government, ou=DoD, ou=PKI, ou=OTHER, cn=ARNDT.DEREK.SHANE.1384496519
Date: 2017.12.07 09:50:03 -05'00'

Signed ____ Date: __________

Not approved (will be returned to SCEC with no action taken):

Signed ____ Date: __________

Voting Members of the State Climate Extremes Committee:

Craig Shoemaker, Senior Forecaster, National Weather Service (NWS) - Sacramento, CA

Dr. Michael Anderson, California State Climatologist

Dan McEvoy, Regional Climatologist, Western Regional Climate Center (WRCC), Desert Research Institute (DRI)

Andrea Bair, Climate Service Program Manager, Climate Services Division, NWS Western Region

Karin Gleason, Meteorologist, National Centers for Environmental Information (NCEI)

Also participating in the verification:

Eric Kurth, Meteorologist, NWS - Sacramento, CA

See attachments below

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Gusts of 199 mph at Ward Mt., 193 mph at Squaw Peak (Sierra Crest) February 20, 2017 at 11:00 pm PST

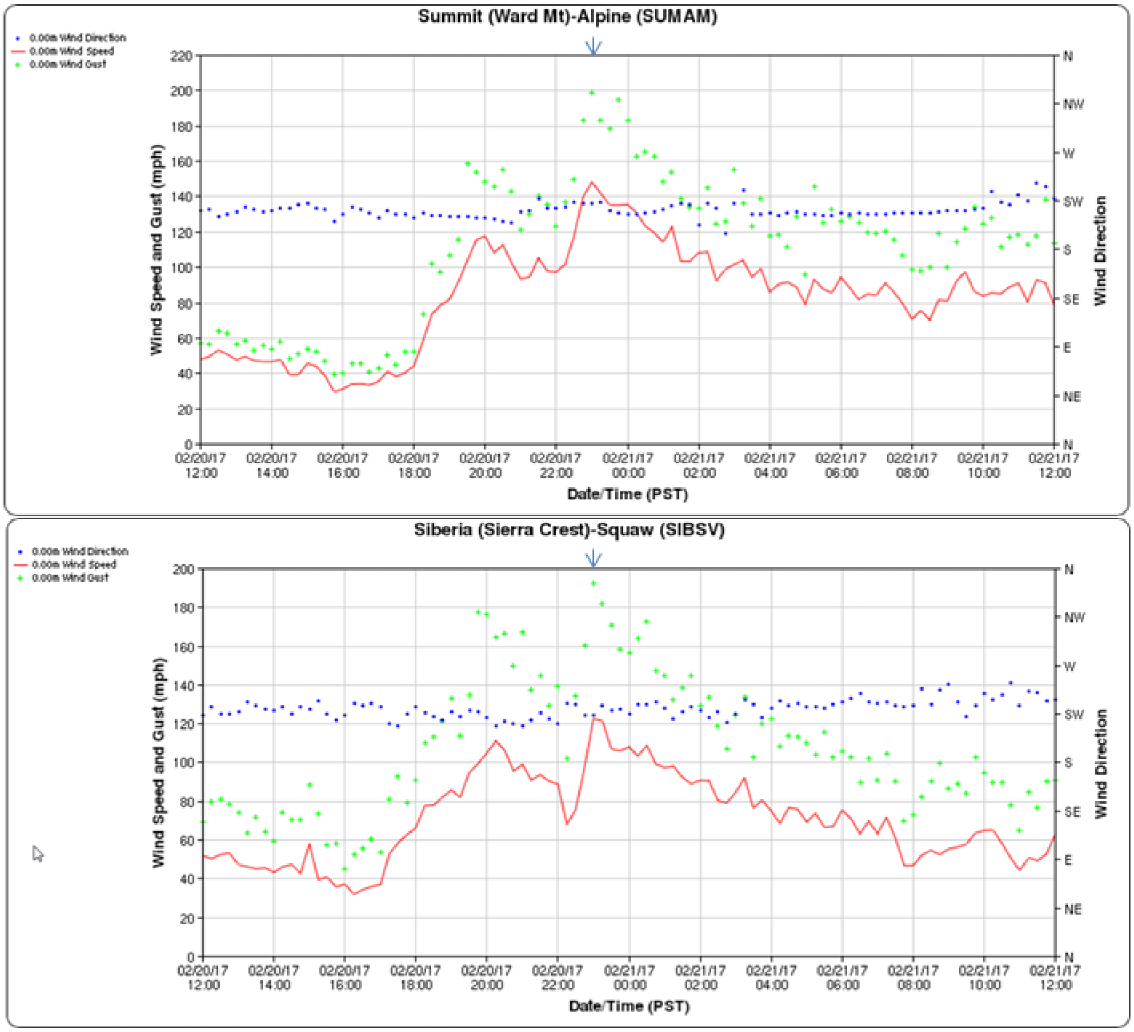

Figure 1. Time series graphs of wind direction, speed and gusts from Mesowest for Ward Mountain and Sierra Crest on 20 February 2017.

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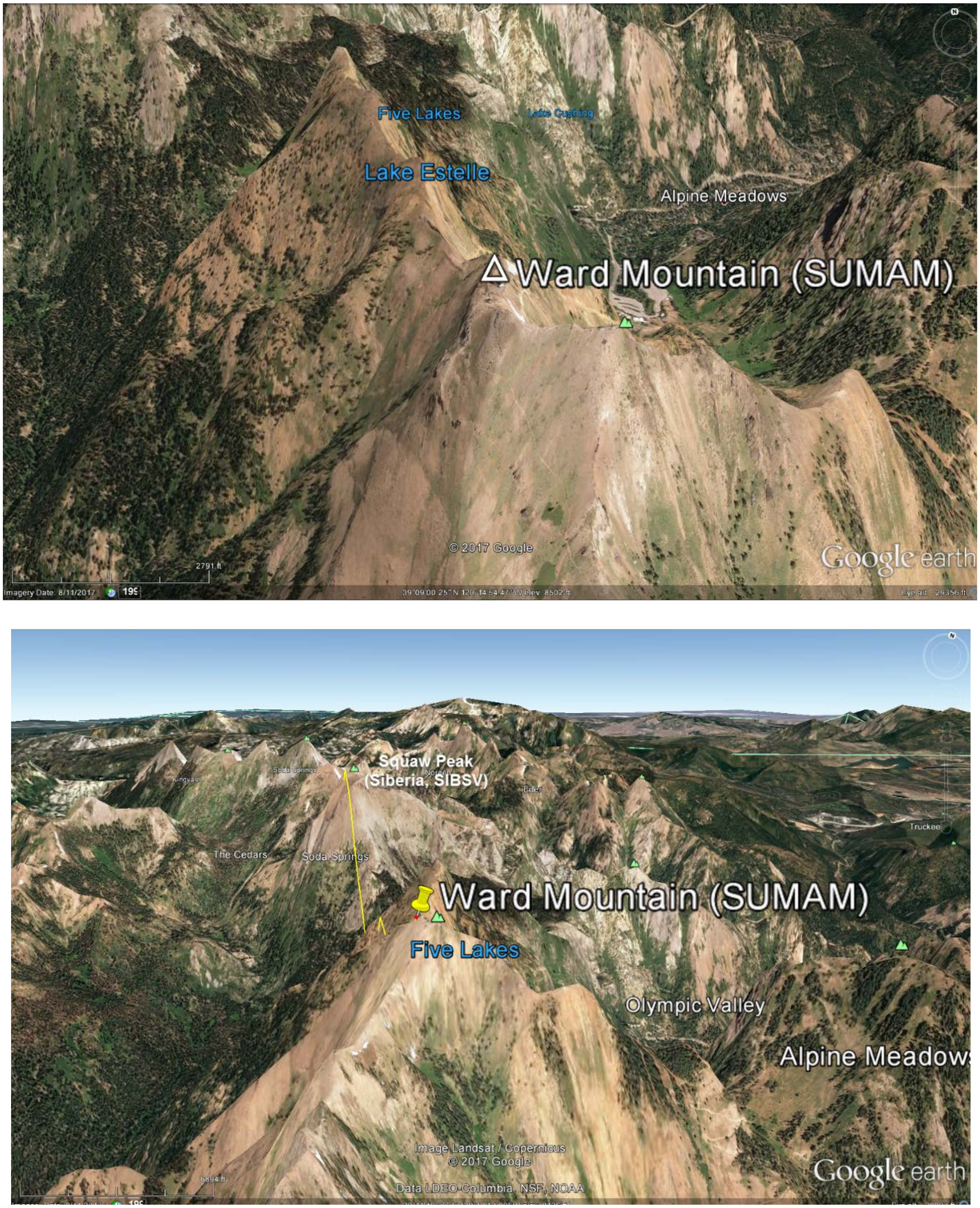

Figure 2. Google Earth views of Ward Mountain and Squaw Peak in the Sierra Nevada Mountain Range.

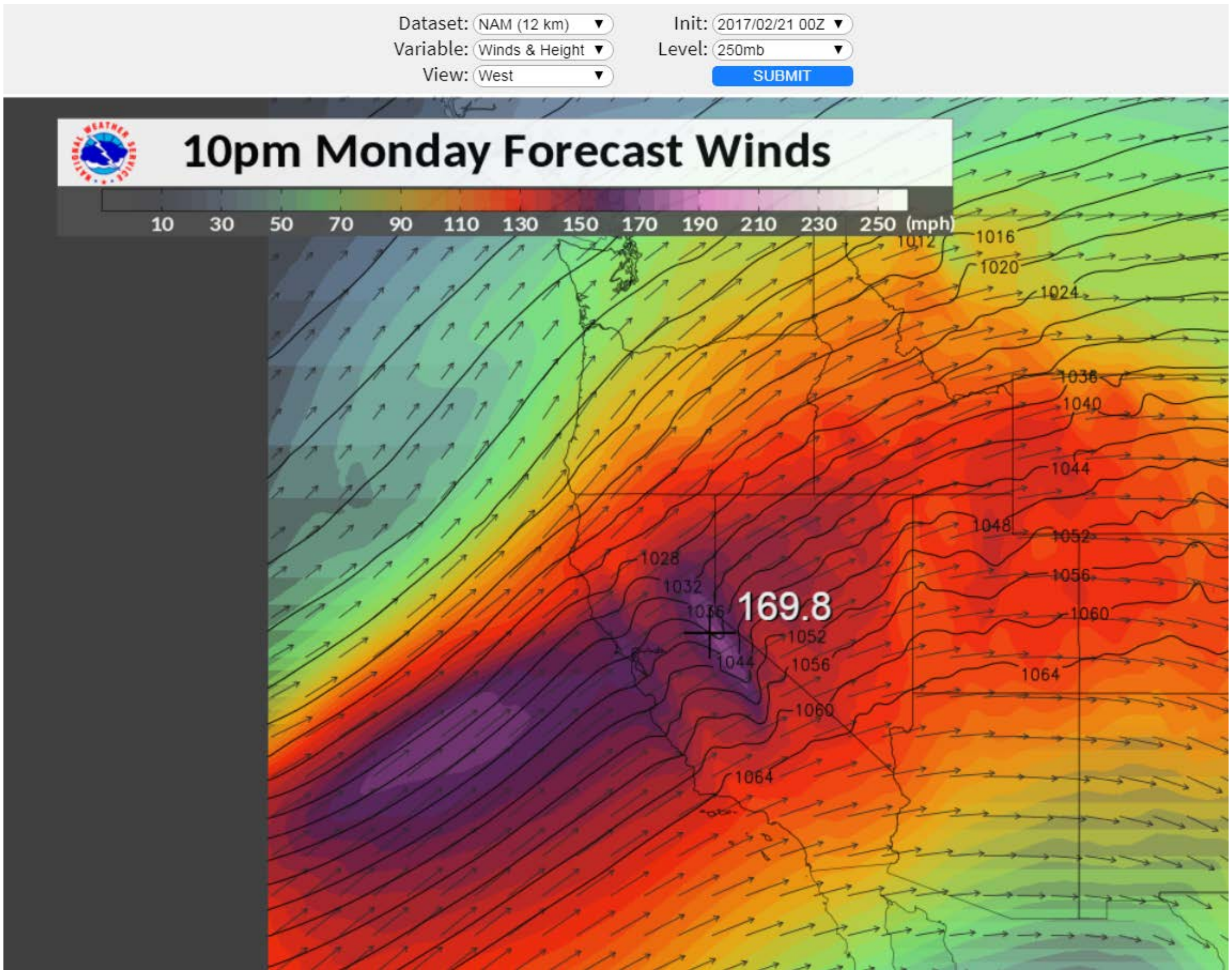

Figure 3. WAVE Graphic, NAM12 2/21/17 00z, 250mb forecast winds

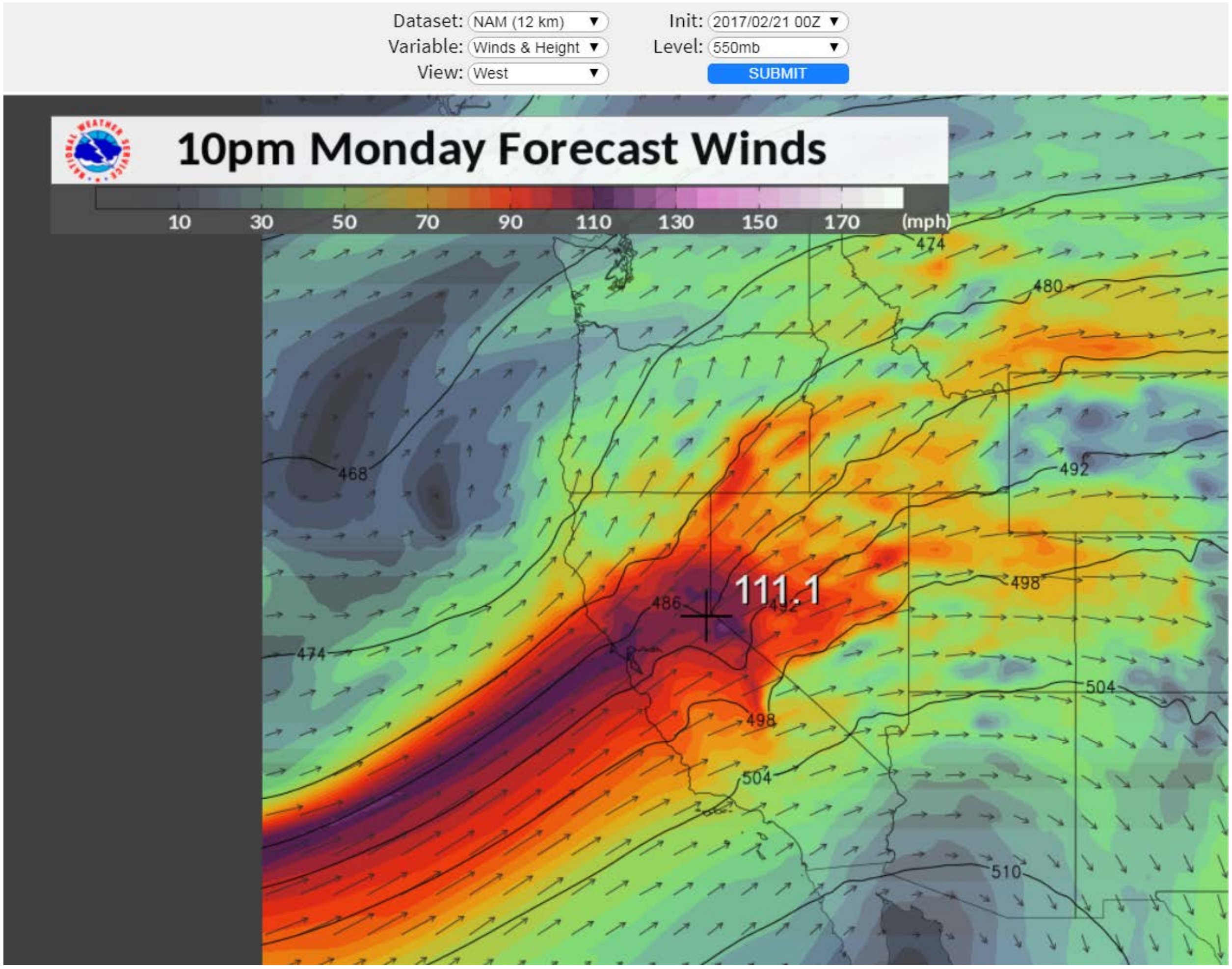

Figure 4. WAVE Graphic, NAM12 2/21/17 00z, 500 mb forecast winds

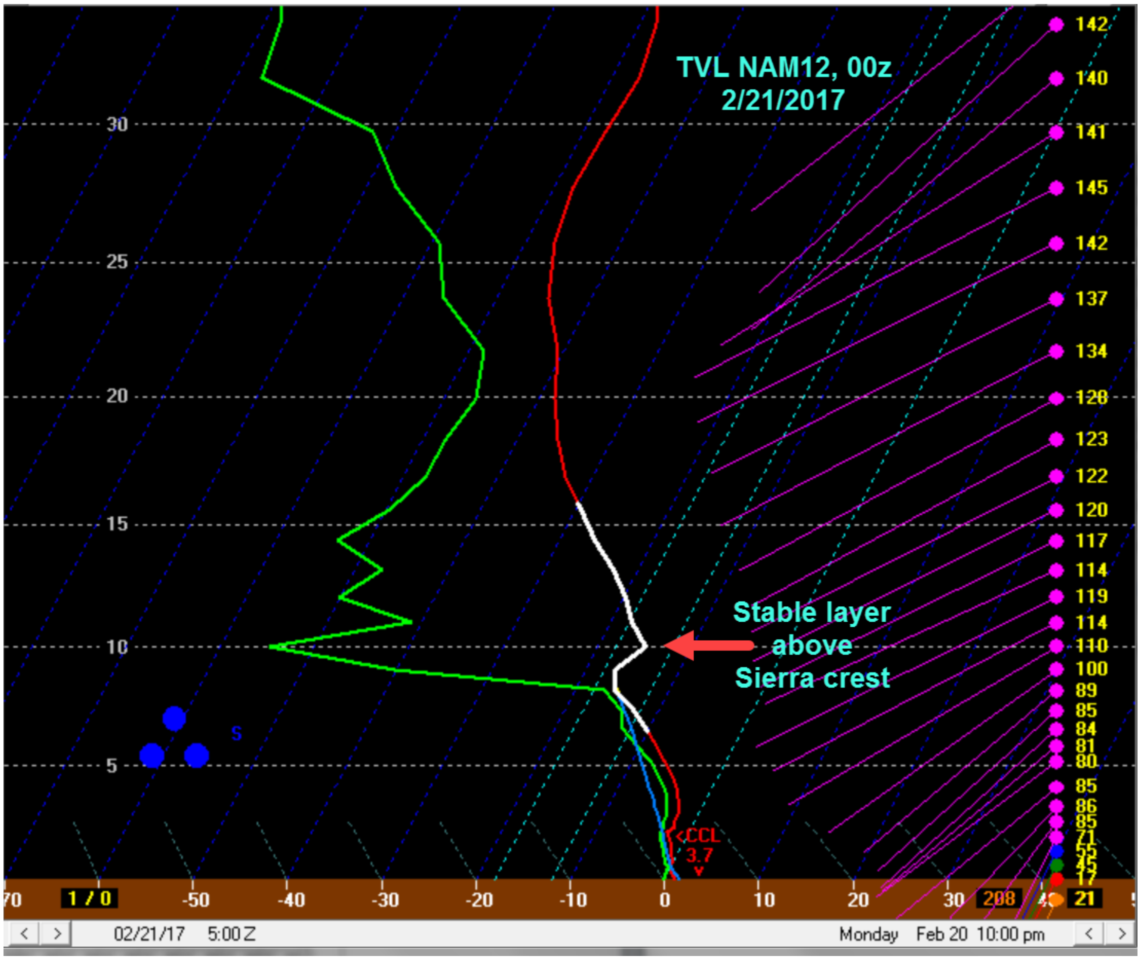

Figure 5. BUFKIT NAM12 00z 2/21/2017 sounding at South Lake Tahoe (TVL)

Figure 6. Wind damage to large tree near Ward Mountain, CA.
Photo courtesy of Will Paden

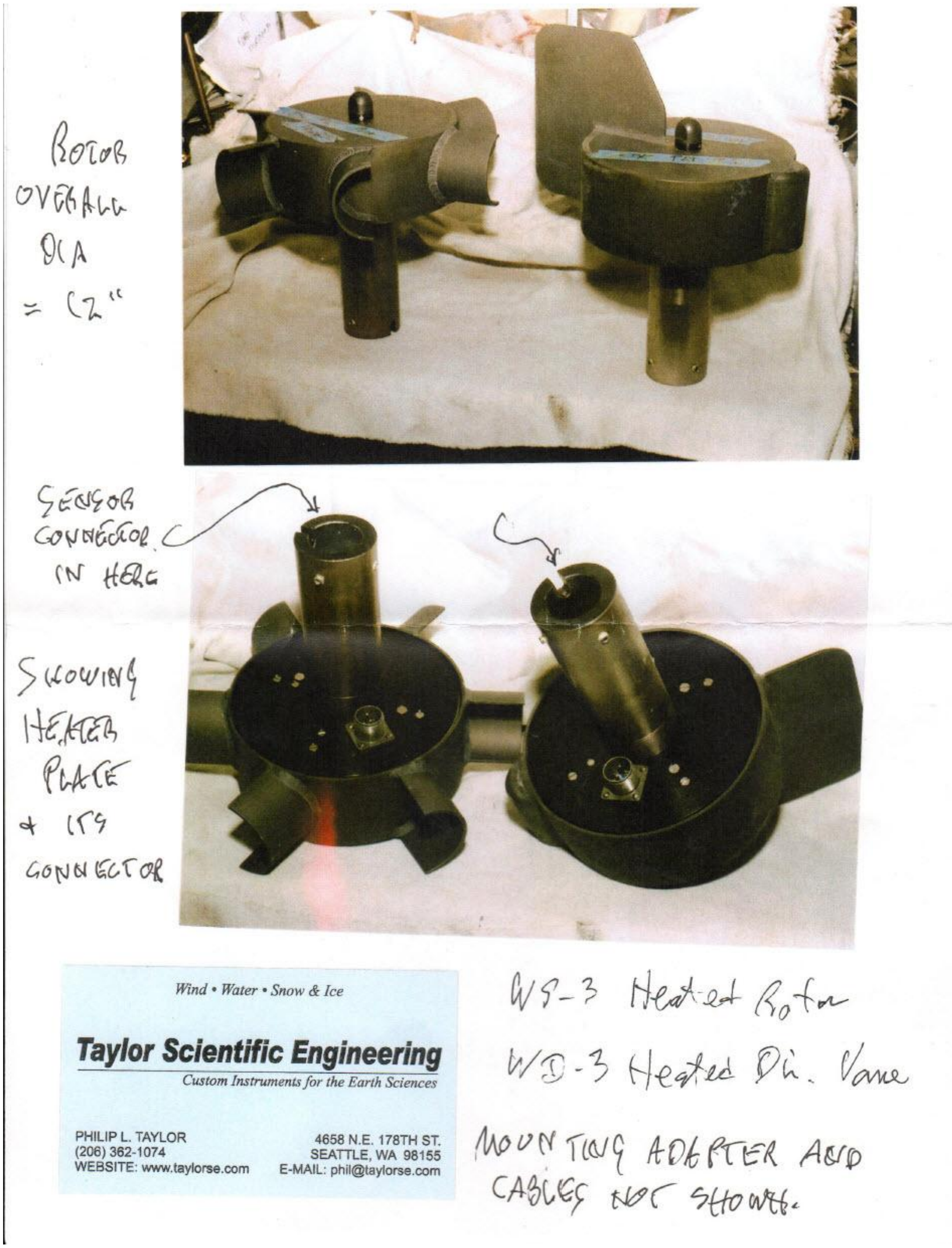

Figure 7. Campbell Scientific anemometer, model CS215 and model WS-3 heated rotor anemometers. Photos courtesy of Phil Taylor.

Appendix A. Technical description and calibration notes for the Taylor Scientific Heated Rotor Anemometer

Taylor Scientific Engineering
Custom Instruments for the Earth Sciences
Wind, Water, Snow & Ice

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4658 N.E. 178th st.
Seattle, WA 98155

6/84,rewritten 2/98,11/01, update 5/16

TECHNICAL DESCRIPTION

Heated Rotor Anemometer Model WS-3 and **Heated Direction Vane** Model WD-3

These are electrically heated, temperature controlled wind sensors designed for the mountain environment. Winds to 200+ mph have been handled successfully. Users report reliable operation in storms that have regularly incapacitated or destroyed other wind systems. These instruments were introduced in 1982, and over 400 systems are now in use around the world in the worst possible weather.

The anemometer is exceptionally rugged, and has been designed for ease of mounting on the tower, ease of disassembly and maintenance, standardization of parts, and accommodation of options for the heater and the output signal.

The wind sensor is a disk rotor, 3" high and 12" overall diameter, with six radial cups, heliarc-welded 1/8" aluminum construction, carefully balanced, and black anodized. This design gives an even distribution of heat, and is virtually indestructible. Response is linear, and the threshold is 3 mph. (Useable below once started.) The time constant is 7-8 sec for a step increase. (See the Calibration Notes for additional information.) Because of the rugged construction, I feel confident that winds of 250+ mph can be handled.

The deriming heat source is internal, rather than external. The heater is an electrical "Cal-Rod"-type, circular in form, rated at either 120 or 240 VAC, 1500 watts maximum, and is supported on a base plate fastened to the body of the anemometer. A protective overheat thermostat is in series with the heater. A temperature sensor is located in the air space just beneath the spinning rotor, and is wired through the heater cable to an automatic proportional temperature controller mounted in a weather-tight control box (Hoffman NEMA 4, 12" X 12" X 6"), which is hung at a convenient height near the base of the tower. The box also contains a manual temperature adjustment, a load lamp to monitor input and output power, an on/off circuit breaker switch, and a junction terminal strip for the tower sensors. Normal power consumption is about 100 watts, and increases automatically in a storm as the controller responds. Cables are shielded neoprene. A special low temperature (-50C) teflon/polyurethane cable is available.

The speed output can be either an analog dc voltage, or a pulse rate proportional to speed. The analog dc option utilizes a commercial dc tachometer generator, and a simple calibration scheme is used to accommodate long land lines if necessary. Output is 0 to +5 vdc (and 0 to 1 ma) over the desired full scale wind speed; for example, 100 mph, 125 kts, 200 km/hr, 100 m/sec, etc. The pulse output option produces a square wave, one cycle per revolution, of approximately 50% duty cycle, utilizing a hall-effect transistor.

The direction vane uses an identical heater assembly and proportional controller along with many other parts identical to those used in the speed sensor. The direction output is a 0 to 360° potentiometer, 5 K ohms resistance. Other resistances are available.

Adapters are provided for the tower mounting, so the sensors can be easily installed and removed with one hand. The adapters fit on 1-1/4 IPS ss pipe stubs, 6" long, also provided. Cross-arm assemblies for the Rohn 25G and 45G towers, or to special customer specifications, are also available.

The anemometer is also available with no heater installed, in which case a dummy heater plate replaces the original. The operation of the anemometer is not affected. This gives a very rugged unheated wind system that has a much better chance of surviving an icing, or severe storm than would conventional anemometers. The heater–related parts can be easily added later.

See also: Calibration Notes, Typical Installation, notes on components, and notes on customer experiences and applications.

Write or call if you have any questions.

Appendix A – cont'd

Taylor Scientific Engineering
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rewritten 2/98 from
3/90 and later data.
Added to 4/01.

SUMMARY OF SPECIFICATIONS

Model WS-3 Heated Rotor Anemometer & Model WD-3 Heated Direction Vane

See also: Technical Description, Calibration Notes, Typical Installation, ,etc.

These are extremely rugged, internally heated, deriming, temperature-controlled wind sensors designed for severe wind and icing conditions. Except for the icing capability, the heated and unheated versions are identical in specifications. They have been in production since 1982; my former business name was HYDRO-TECH. The instruments are the same.

Wind Speed Range: Threshold to 200+ mph (100+ m/sec). See Note 1 below.

Wind Speed Accuracy: ± 2% and linear. Calibration is 850rpm at 100mph (45m/sec), See Note 2.

Wind Direction Accuracy: ± 1%, linearity ± 0.5%, dead zone at cross-over 2-3°. .

Gust Survival: Unknown. See Note 1.

Starting Threshold: Speed: 3 mph (1.3 m/sec) pulse option, See Note 3.
4-5 mph (1.8-2.2 m/sec) dc tach option.
Direction: 2-3 mph (0.9-1.3 m/sec), See Note 4.

Distance Constant: 47 m for 63% response to step increase at 10 m/sec (20 mph).

Sensor Power Requirements: dc tachometer and direction pot none.
pulser 12 vdc nom. See Note 5.

Heater Power Requirements: Speed or Direction Heaters: Standard 120VAC, (or 240VAC option), 1200 watts max., (temperature controlled). Optional lower wattage heaters available depending on voltage and power available, and the icing expected.

Environmental: Exposure to rain, snow, ice, dust, 100% humidity, salt spray (maritime climates), to –25C no significant adverse effects. See Note 6.

De-Icing Capability: Direct Observation: 25-30 kts (13-15 m/sec), ice rate of 3-4 g/cm /hr, instrument ice-free, working normally, about 500 watts consumption. (1990, Sierra Nevada Mts., Calif.)
Design Calculation: Original design to handle 6 g/cm ^{2}/hr at 50 m/sec. (See Icing Rate Notes) See Note 7.

Note 1: Upper limit is unknown – no failures. Instruments have worked normally after 180-200+ mph (80-90 m/sec) storms. Instrument probably useful to 250-300 mph (110-140 m/sec).

Note 2: From wind tunnel calibration, accuracy for horizontal wind (perpendicular to axis):
± 1 mph (± 0.45 m/sec) to 55 mph (25 m/sec.).
± 2 mph (± 0.9 m/sec) to 110 mph (50 m/sec) by comparison.
Off-axis response also noted in calibrations. No calibration data over 50 m/sec at this time, assume linear. (Calibrations at 250-300 mph planned for near future.)

Note 3: These values from wind tunnel tests. Numbers very sensitive to orientation, turbulence, and ambient vibration (which reduces it). Once started, unit operates below threshold, typically down to 2.3 mph (1.1 m/sec) for the pulser. (Steady wind below this results in rotor stopping eventually after a minute or so). Response is non-linear below 4 mph (1.8 m/sec). Linear transfer function on complete calibration intercepts speed axis at 1.5 mph (0.67 m/sec). (con't page 2)

Appendix A – cont'd

Note 4: Depends on orientation (of the vane to wind direction).

Note 5: Pulser will operate from 4-24 vdc, (4-8 ma at 12 vdc), is a Hall-effect transistor, open-collector output to 25 ma max. Operating temperature range is –40C to +150C. Square wave output, approx 50% duty cycle, 1 cycle per revolution, rise/fall times typically 0.1 ms. The dc tachometer is self-generating, 7vdc/1000 rpm, operating temperature of –55 to +100C, brush life 100,000 hrs.

Note 6: Black sulphuric anodize is standard. An optional hard coat anodize is available. Standard cables are shielded neoprene. Optional special cables of teflon/polyurethane to –50C are available.
The instruments are constructed of anodized aluminum, stainless steel, and MDS nylon. O-rings are used as shaft and body seals.

Note 7: Assumptions for the icing rate calculation are: wind 50 m/sec, temp –2 to –10C, cloud LWC (liquid water content) 0.2 to 2 g/m^3, droplet radius 5-20µm, collection efficiency 0.2-0.3 (based on cylinder diameter), and assumptions on evaporative loss and wind cooling.
See Icing Rate Notes for more on this and wet snow near the freezing point. (I would like to co-operate on any icing wind tunnel experiments under controlled conditions, with an eye toward some kind of an icing rate certification for wind instruments. This doesn't exist at present.)

Please contact me about any questions, comments, or suggestions you may have.

Philip L. Taylor

Appendix A – cont'd

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Jan 01

WS-3 Rotor Anemometer Calibration Notes

These notes are for the pulse output standard rotor with a one pulse out per revolution of the shaft.

Using the calibrations outlined in the Calibration Notes of Mar 90, the rotor turns at 850 rpm at 100 mph, and the linear calibration line passes through the origin.

From this, the following equivalents can be calculated:

WIND SPEED		PULSES/SEC		PULSES/MIN
@ 1 mph	=	0.142	=	8.50
@ 1 meter/sec	=	0.317	=	19.02
@ 1 knot	=	0.163	=	9.79

and the following conversion factors can be calculated: (Measure pulse rate; calculate speed.)

CONVERSION FACTORS

TO GET:	MULTIPLY PULSES/SEC BY:	MULTIPLY PULSES/MIN BY:
mph	7.06	0.118
meters/sec	3.16	0.0526
knots	6.13	0.102

EXAMPLE:

say you measured 850 pulses/min (= 14.17 pulses/sec)

wind speed = 850 (0.118) = 100.3 mph
= 850 (0.053) = 44.7 meters/sec
= 850 (0.102) = 86.7 knots

or

= 14.17 (7.06) = 100.0 mph
= 14.17 (3.16) = 44.8 meters/sec
= 14.17 (6.13) = 86.9 knots

(1 mph = 0.868 knots = 1.61 km/hr = 0.447 meters/sec)

Note also that the numbers in the Conversion Factors table above also represent the resolution of + or – 1 count over the time indicated. If higher resolution is desired, especially at the lower wind speeds, accumulate counts over a longer time span, or program your data logger to do a period (or multiple period) count. More on this later.

If you have any questions or comments please let me know.