Recent Precipitation, Precipitation Measurements, and more false claims of Global Warming

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18 November 2017

Cruces Atmospheric Sciences Forum

Houston: America First Energy Conference 9 November 2017

One-Day event Topics: Climate, Energy, Law, Policy, EPA

All sessions are now broken out at this site: http://americafirstenergy.org/

Among new friends: Dr Hal Dorian of The Right Climate Stuff

http://www.therightclimatestuff.com/

Hal will accept if we invite him to speak here! He wants to come

Recommend to read book: The Prize by Daniel Yergin “best history of oil ever written.”

Some might want to visit the Cooler Heads Coalition web site, part of Competitive Enterprise Institute http://www.globalwarming.org/category/blog/

The entire legal basis for the EPA taking action and the resultant CO2 Endangerment Finding is based on fraud or at least a fraudulent claim in the case Massachusetts vs. EPA. Massachusetts sued EPA over the notion that human use of fossil fuels has increased the rate of sea level rise. It hasn’t.

But, the science of this was never studied or presented in arguments before the courts.

This graphic came from David Stephenson, Cesar Rodney Institute, his presentation is on line at http://americafirstenergy.org/cr3ativconference/panel-6b-reforming-epa/

Improvements Stalled

- On average, air quality improved 2% a year from 1980 to 2009, but only 1% a year during President Obama's term
- Ozone improved 1% a year from 1980 to 2009, but only ½% total during President Obama's term
- Superfund site construction completion rate under President Bush was 35 a year, under President Obama 16 a year
- Chesapeake Bay water quality improved 49% under state compact from 1985 to 2010, no improvement since EPA took over in 2010
- Diminishing Returns!

This graphic came from Myron Ebell, Competitive Enterprize Institute, his presentation is on line at http://americafirstenergy.org/cr3ativconference/panel-6b-reforming-epa/

What is the goal of all the Obama climate regulations and policies?

- Organize the entire U. S. and global economies around programs to reduce carbon dioxide emissions; that is, around reducing use of coal, oil, and natural gas.
- Turn robust economies based on producing and using abundant, affordable energy (for example, Texas) into economies based on using much less, much more expensive energy (for example, California).

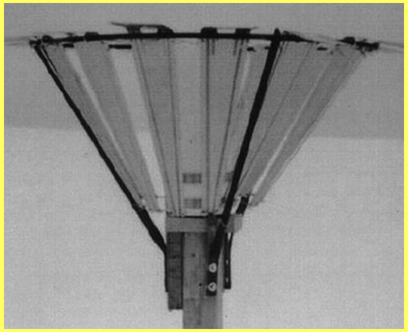
New words for our dictionaries

Alter:

DFIR Dual Fence Intercomparison Reference:

Nipher:

Tretyakov:



Outline

Alarmist claims of increasing heavy rains tied to “global warming”

Background on precipitation types

Background on precipitation measurements

Precipitation Measurement Deficiencies

David Legates’ Analysis

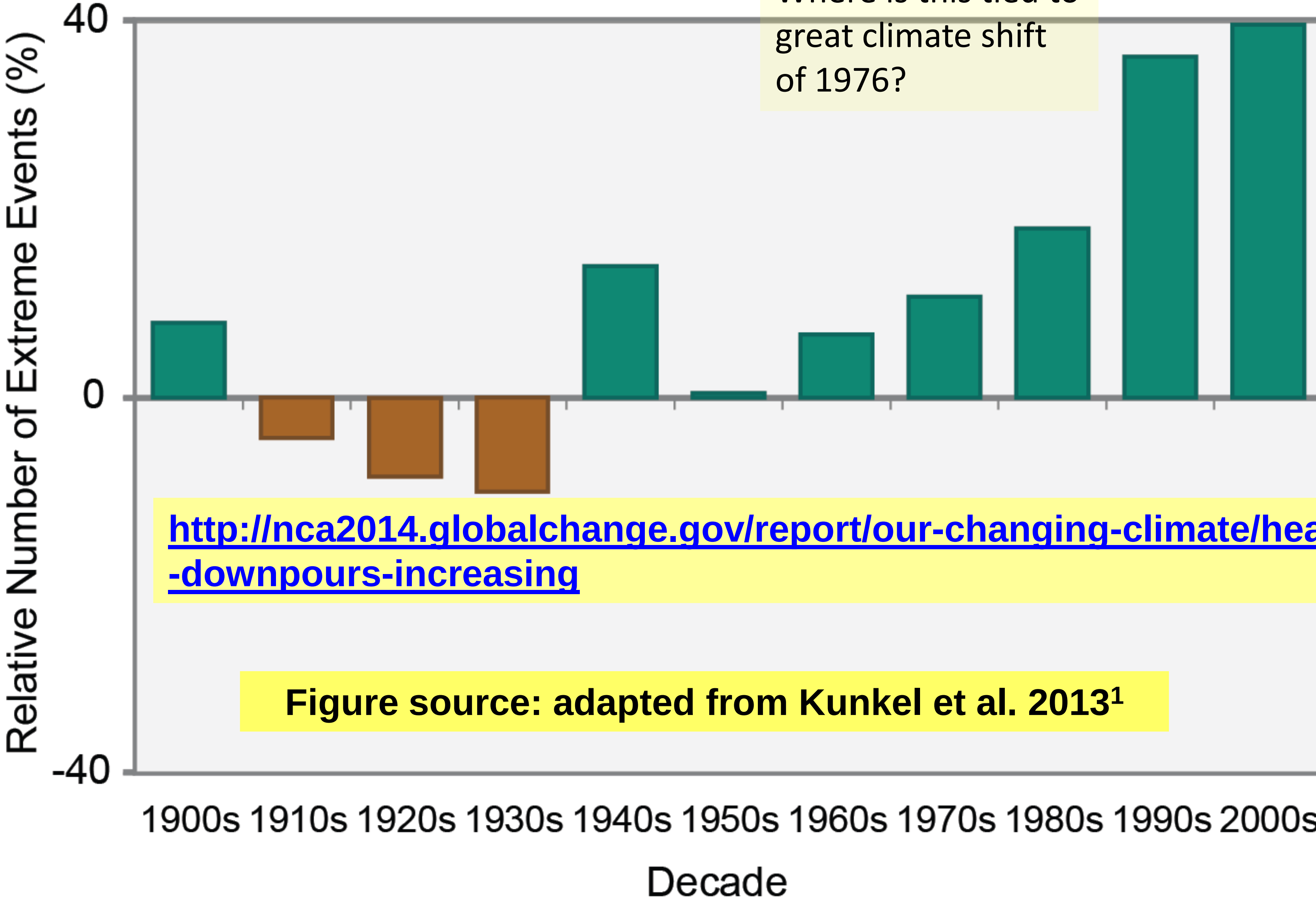
ASOS Precipitation Measurements

ASOS Improvement Program and newer changes to precipitation instrumentation

Proof, the “heavy rains increasing” argument is specious.

Alarmist claims of increasing heavy rain tied to “global warming”

Observed U.S. Trend in Heavy Precipitation



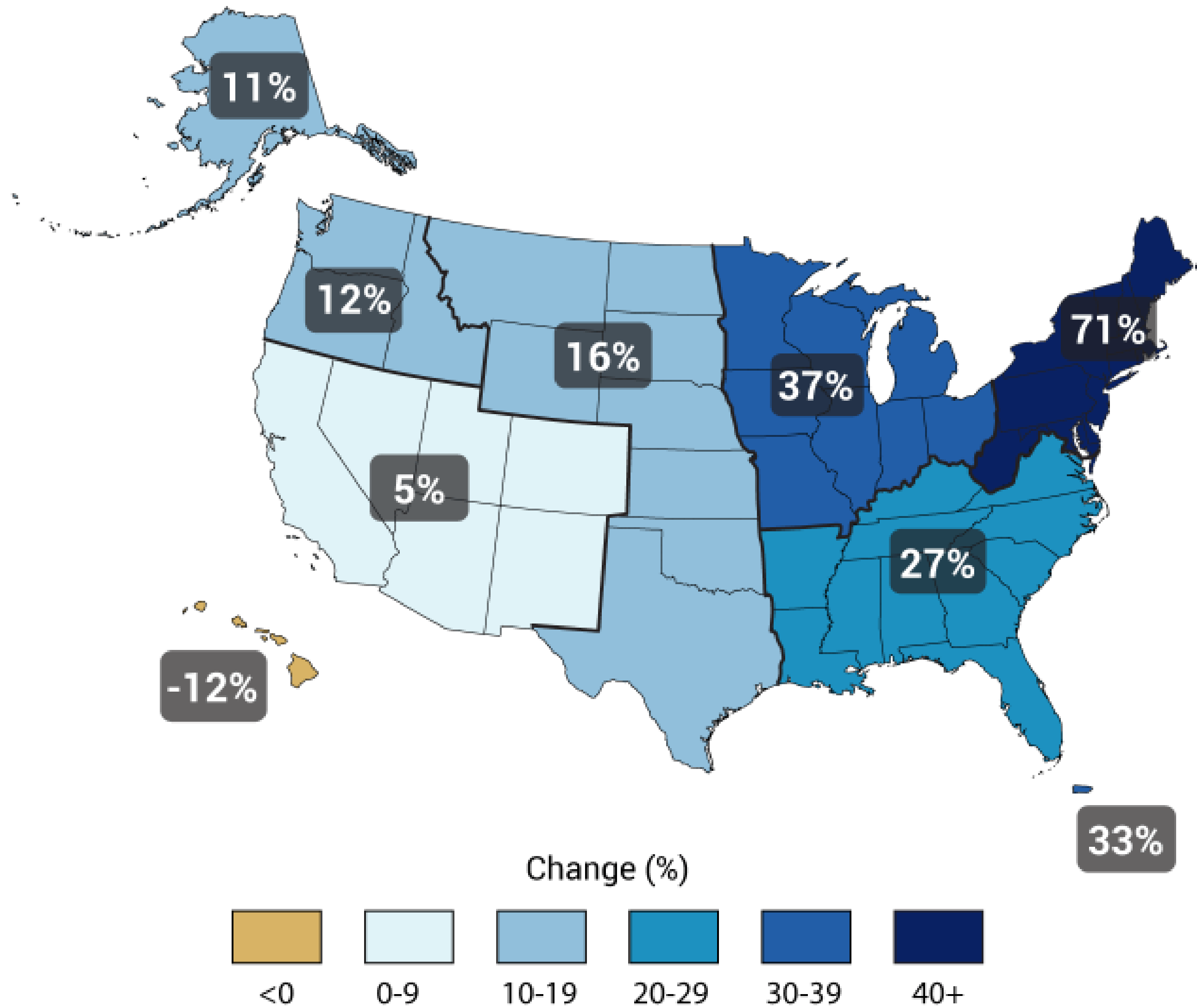
Spoiler Alert!
Where is this tied to great climate shift of 1976?

http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing

Figure source: adapted from Kunkel et al. 2013[1]

http://nca2014.globalchange.gov/report/our-changing-climate/heavy-downpours-increasing

Figure 2.18: Observed Change in Very Heavy Precipitation



http://www.ucsusa.org/global_warming/science_and_impacts/impacts/heavy-flooding-and-global-warming.html#.Wg0K7GCWz1I

Union of concerned Scientists Web Site

Recent heavy rains and flooding in the Northeast, Midwest, and Great Plains are consistent with a warming planet, and such events are expected to become more common over time.

As average temperatures in regions across the country have gone up, more rain has fallen during the heaviest downpours.

Very heavy precipitation events, defined as the heaviest one percent, now drop 67 percent more precipitation in the Northeast, 31 percent more in the Midwest and 15 percent more in the Great Plains, including the Dakotas, than they did 50 years ago.

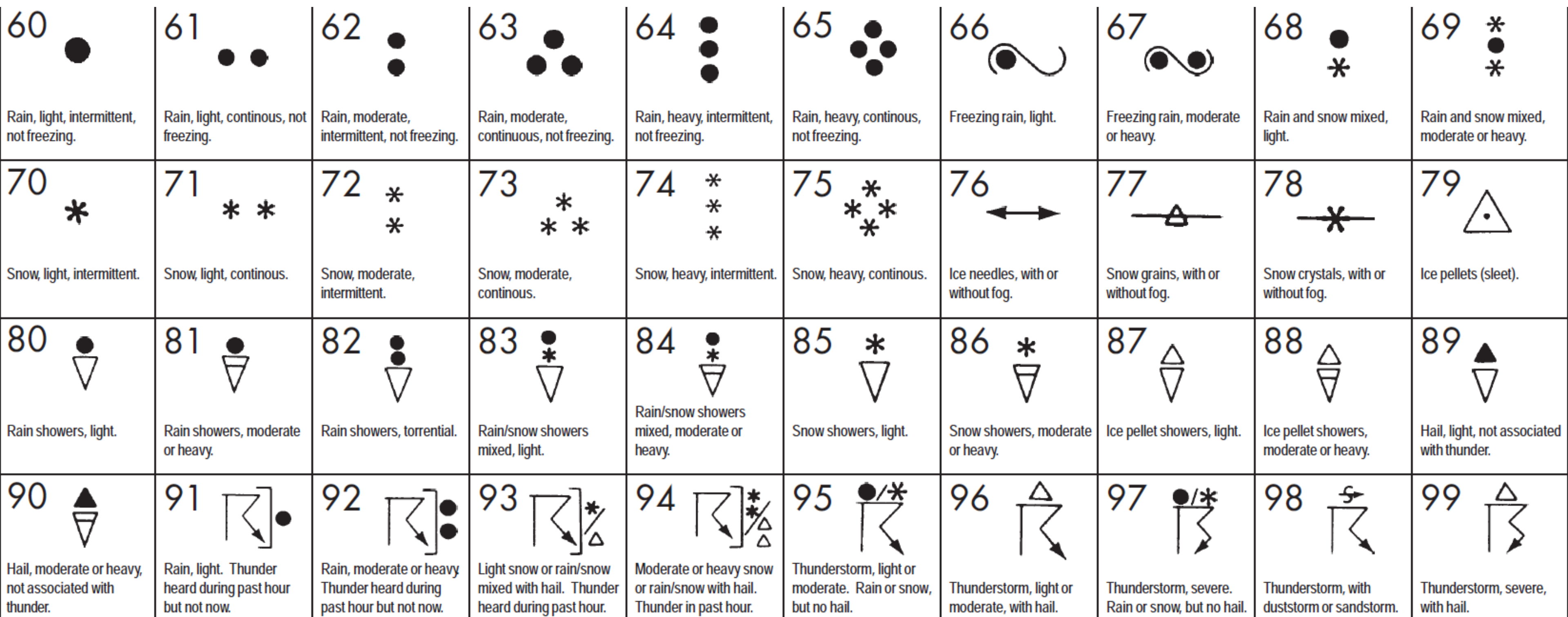
This happens because warmer air holds more moisture.

Northern Plains brace for flooding; power still out in Northeast

March 17, 2010 7:29 a.m. EDT

CNN iReporters Tomas Rozar and Clem Carfaro provided this aerial image of flooding in Bound Brook, New Jersey.

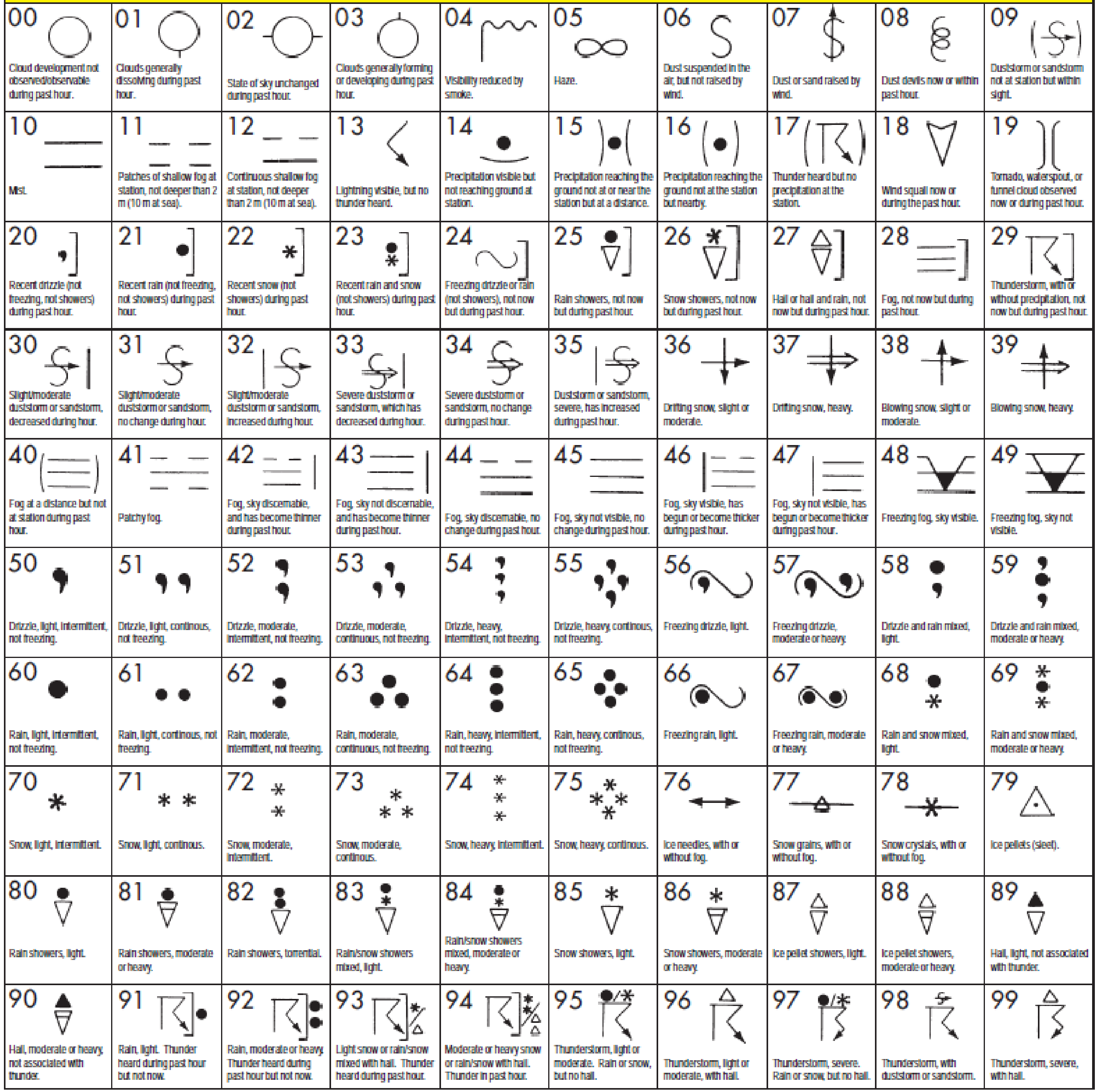
Precipitation Types



ies, we grant

The 99 Synoptic Weather types used in World Meteorological Organization Codes

http://www.weathergraphics.com/dl/wxchart.pdf



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ved.


Rain
© Stuart Heath


Snow


Rain and Snow Mixed


Snow and Drifting Snow

Blowing Snow

Drifting Snow

Weather is a “National Responsibility.”

Nations’ response to this doctrine are as varied as the nations themselves

Instruments have been developed and fielded worldwide…but…in ways determined by the nations themselves

The World Meteorological Organization, a technical arm of the UN…

<also, World Health Organization…International Civil Aviation Organization>

WMO has acted to enhance interoperability and has sponsored numerous intercomparisons between the different types of instruments:

Surface and Upper Air

. Some <WMO-sponsored> results of intercomparisons among the different types of instruments…later….

Limitations on precipitation measurements

Wind, wind turbulence adversely affect instruments' ability to measure precipitation

…been known for a long time.

…higher the wind, the worse the problem.

Problem…worse with Snow, worse yet, Snow & Blowing Snow, or just Blowing Snow

Wind increases with height… instruments nearer ground might be good…heavy snow
. can bury the instrument…accuracy…lost.

Winds near trees and buildings can prevent a good capture by the instruments (wind shadow effect)

Ideal location might be a clearing in a wooded area or a park in urban or suburban environment

Wind "shields" have been devised and tested.

Some instruments are shielded..some unshielded…

Problem of maintenance…worse with automated and on-line processed data?

https://www.fs.fed.us/rm/pubs_exp_for/priest_river/exp_for_priest_river_1953_warnick.pdf

This old Forest Service report shows the problem of undercatchment of precipitation during the snow season at the Priest River Experimental Forest, Idaho, 1951, 1952.

Lower Curve A shows unshielded snow accumulation

Curve B Idaho Type II wind shield

Curve C Modified "Alter Type I" shield

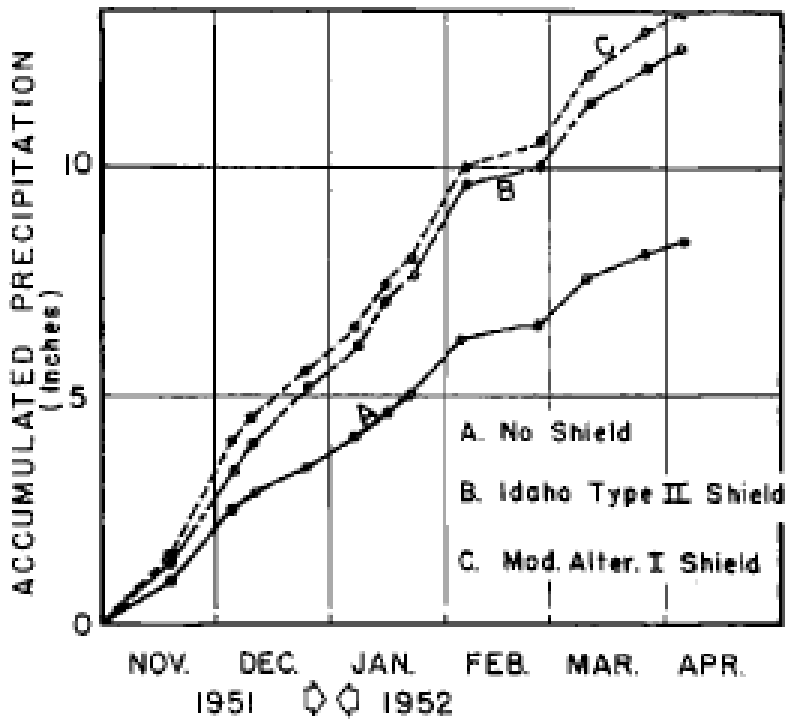


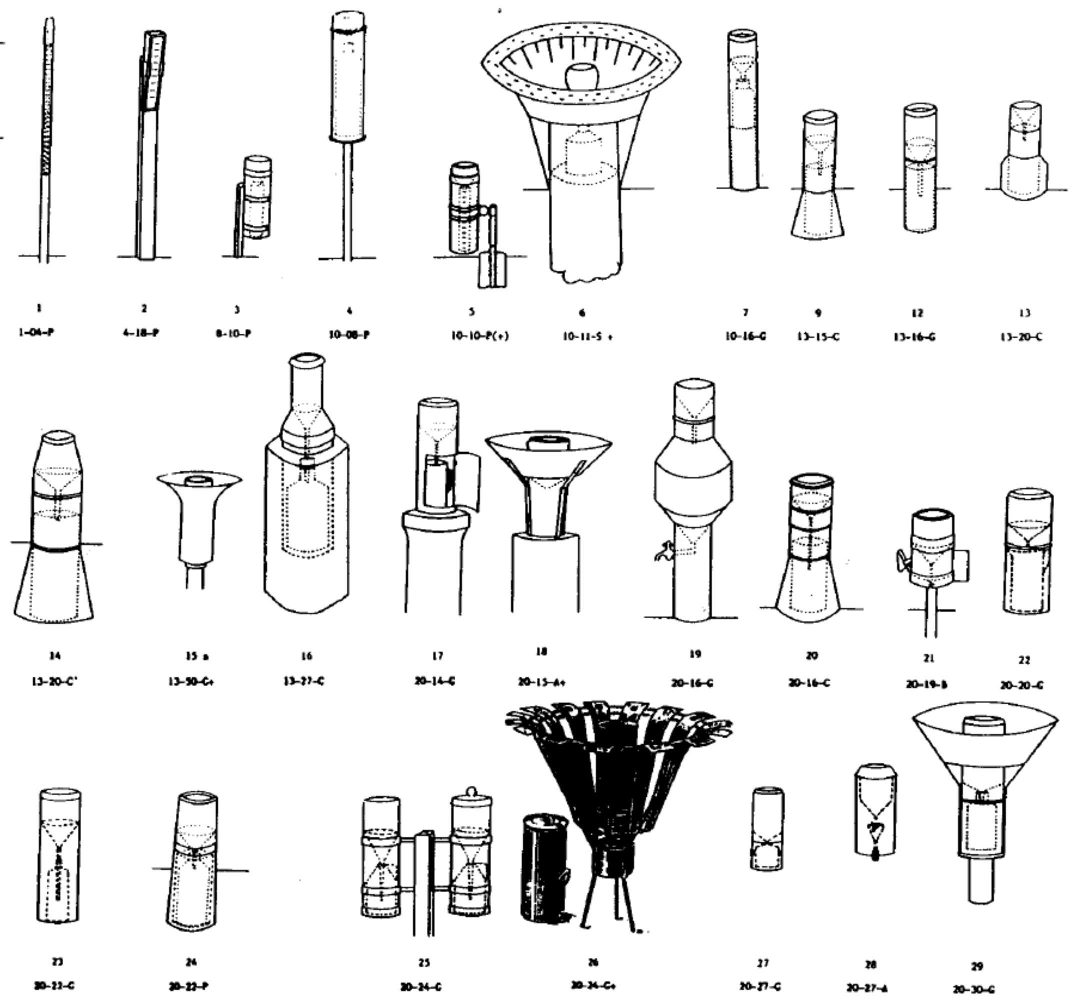
Fig. 12--Comparative winter precipitation catch in experimental U. S. Weather Bureau standard gages at Priest River Experimental Forest, Idaho

Figure 12 gives the comparative performance of three U. S. Weather Bureau standard rain gages located on Gisborne Mountain in the Priest River Experimental Forest. Here is shown the definite value of the windshield. Data on the gage with the modified Alter-I shield indicates the same positive results observed in the wind tunnel. Observations indicate that the Idaho Type II shield becomes frozen up much more quickly than the new shield and probably would cap over on occasions at Gisborne Mountain. Additional field testing is necessary to indicate whether the new shield design will prevent capping over due to formation of rime between the gage and shield.

Precipitation Measuring Instruments

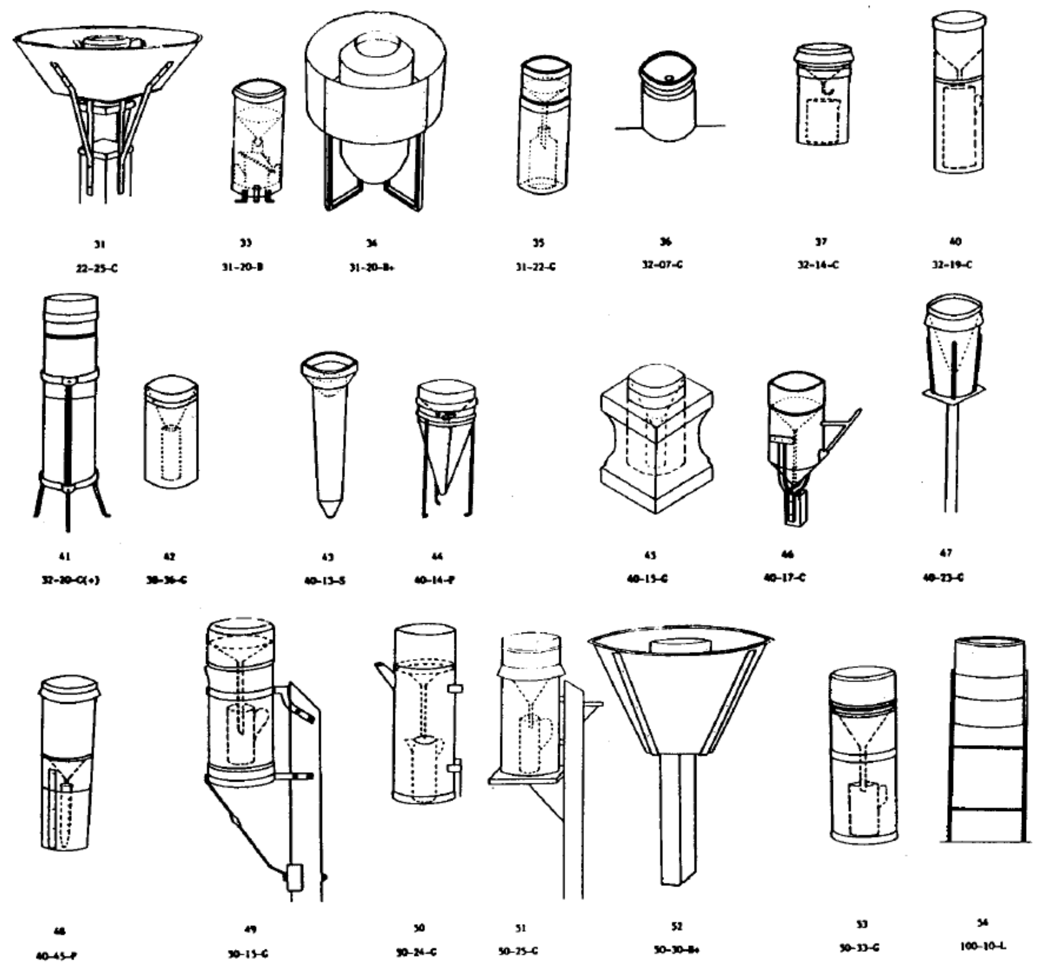
https://www.colorado.edu/geography/class_homepages/geog_4331_s07/slides/week10a.pdf

No		Code	Area of orifice A_o [cm²]	Name	Country of origin	Material	Depth of collector [cm]	Height of gauge [cm]	A_w / A_o
1		1-04-P	7	Small	Israel	hardened P.V.C	4.5	12	5.0
2		4-18-P	36	Tru-chek	Oman	plastic	18	18	9.0
3		8-10-P	81	Nylex 1000	New Zealand	plastic	10	35	3.1
4		10-08-P	100	Amir	Israel	hardened P.V.C	8	50	2.1
5		10-10-P(+)	100	AES Type B	Canada	plastic	10	38	2.7
6		10-11-S +	100	IRM P50	Belgium	stainless steel	11	35	2.9
7		10-16-G	100	MP 100	Mauritius	galv. iron	16	66	5.0
8	*	10- -G	100	Indonesian	Indonesia	galv. iron	--	--	--
9		13-15-C	127	Mk 2	U.K.	copper	15	46	4.2
10	*	13-15-S	127	Mk 2	New Zealand	steel	15	46	4.2
11	*	13-15-P	127	Mk 3	U.K.	fibreglass	15	46	4.2
12		13-16-G	127	Burma	Burma	galv. iron	16	36	1.4
13		13-20-C	127	Snowdon	U.K.	copper	20	46	5.8
14		13-20-C`	127	Octapent	U.K.	copper	20	69	5.7
15	s	13-50-C+	127	Nipher	Canada	copper	50	52	s
16		13-27-C	127	5"		copper	27	76	8.0
17		20-14-G	200	Portuguese	Portugal	galv. iron	14	43	4.0
18		20-15-A+	200	SMHI	Sweden	aluminium	15	35	3.9
19		20-16-G	200	Indonesian	Indonesia	galv. iron	16	90	2.8
20		20-16-C	200	Cyprus	Cyprus	copper	16	49	3.4
21		20-19-B	200	SPGN	Netherlands	brass	19	29	4.3
22		20-20-G	200	Typo B	Paraguay	galv. iron	20	46	4.6
23		20-22-G	200	Standard	Israel	galv. iron	22	50	4.6
24		20-22-P	200	Indian	India	fibre glass	22	50	4.9
25		20-24-G	200	IMC	Romanie	galv. iron	24	45	6.0
26		20-24-G+	200	Tretjakov	U.S.S.R.	galv. iron	24	40	6.0



https://www.colorado.edu/geography/class_homepages/geog_4331_s07/slides/week10a.pdf

27	20-27-G	200	Hellmann	FRG and GDR	galv. iron	27	43	7.1
28	20-27-A	200	Tognini	Switzerland	aluminium	27	50	6.0
29	20-30-G	200	Icelandic	Iceland	galv. iron	30	56	7.7
30 *	20- -A	200	200-100	Colombia	aluminium	--	--	--
31	22-25-C +	225	Norwegian	Norway	copper	25	25	3.1
32 *	31- -G	314	Anagnostou	Greece	galv. iron	--	--	--
33	31-20-B	314	RT-1	Japan	brass	20	40	3.6
34	31-20-B+	314	RT-4	Japan	brass	20	45	3.7
35	31-22-G	314	China	China	galv. iron	22	59	3.5
36	32-07-G	324	Manual 1508	Australia	galv. iron	7	30	1.2
37	32-14-C	324	S 203 DRG	Malaysia	brass	14	38	2.4
38 *	32-16-C	324	ML 17	Iran	copper	16	36	2.9
39 *	32-19-S	324	Nepal 203	Nepal	steel	19	59	3.5
40	32-19-C	324	Casella	U. K.	copper	19	56	3.5
41	32-20-C(+)	324	USWB 8"	U.S.A	copper/steel	20	68	3.2
42	38-36-G	380	Typo A	Bolivia	galv. iron	36	88	3.4
43	40-13-S	400	Ville Paris	Brasil	stainless steel	13	63	2.5
44	40-14-P	400	SPIEA MN	France	fibre-glass	14	44	2.0
45	40-15-G	401	Mexican	Mexico	galv. iron	15	36	1.7
46	40-17-C	400	Van Dorn	Netherlands	copper	17	40	3.0
47	40-23-G	400	Association	France	galv. iron	23	30/38	2.3
48	40-45-P	400	C Type NM	France	fibre-glass	45	80	6.8
49	50-15-G	500	Mountain	Austria	galv. iron	15	56	2.4
50	50-24-G	500	Kostlivi	Austria	galv. iron	24	77	3.4
51	50-25-G	500	Wild	Bulgaria	galv. iron	25	44	3.3
52	50-30-B+	500	Wild	Finland	bronze	30	36	2.6
53	50-33-G	500	Metra 886	CSSR	galv. iron	33	66	3.9
54	100-10-L	1000	SIAP UM8300	Italy	lacquered iron	10	44	2.3



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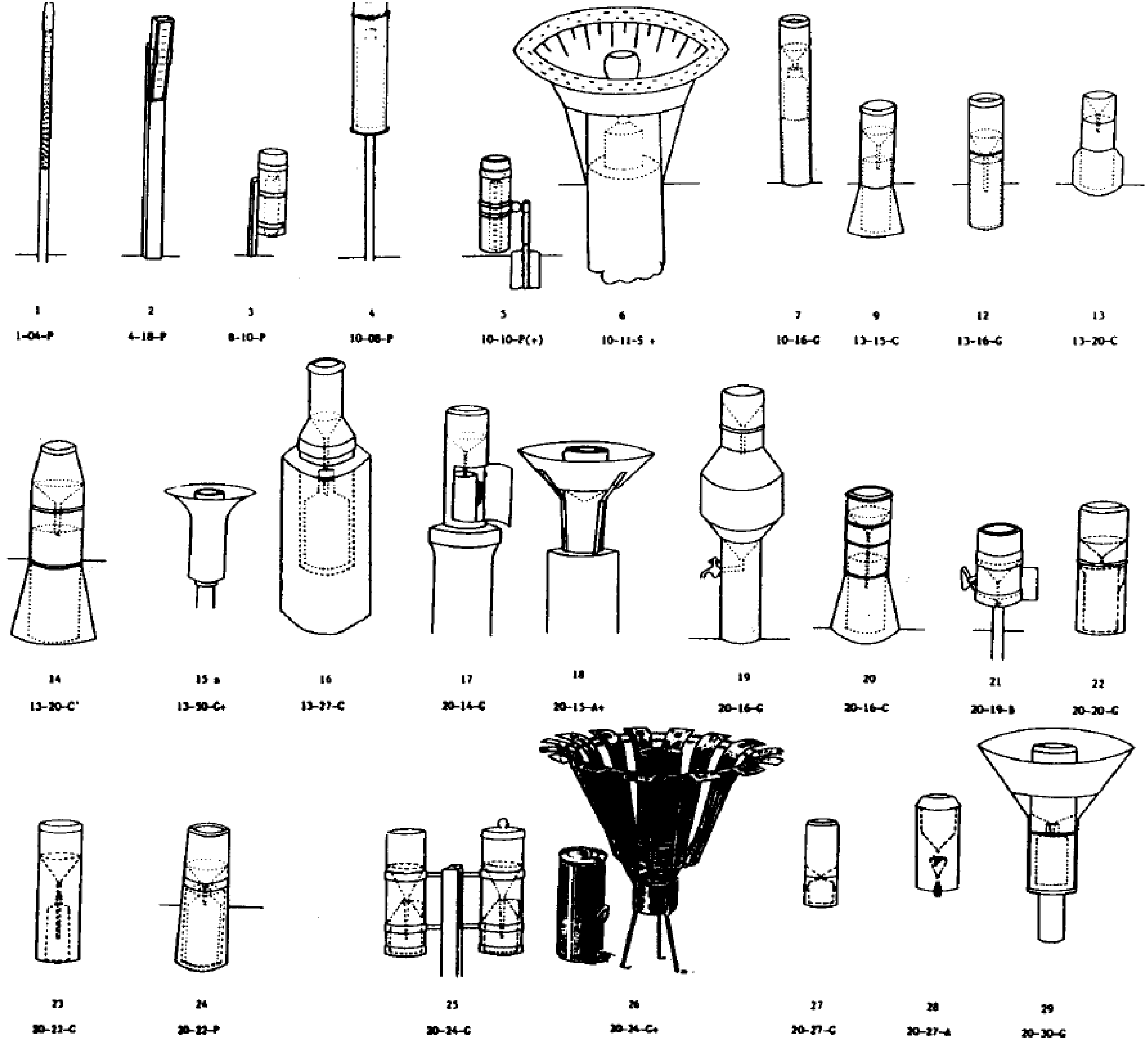

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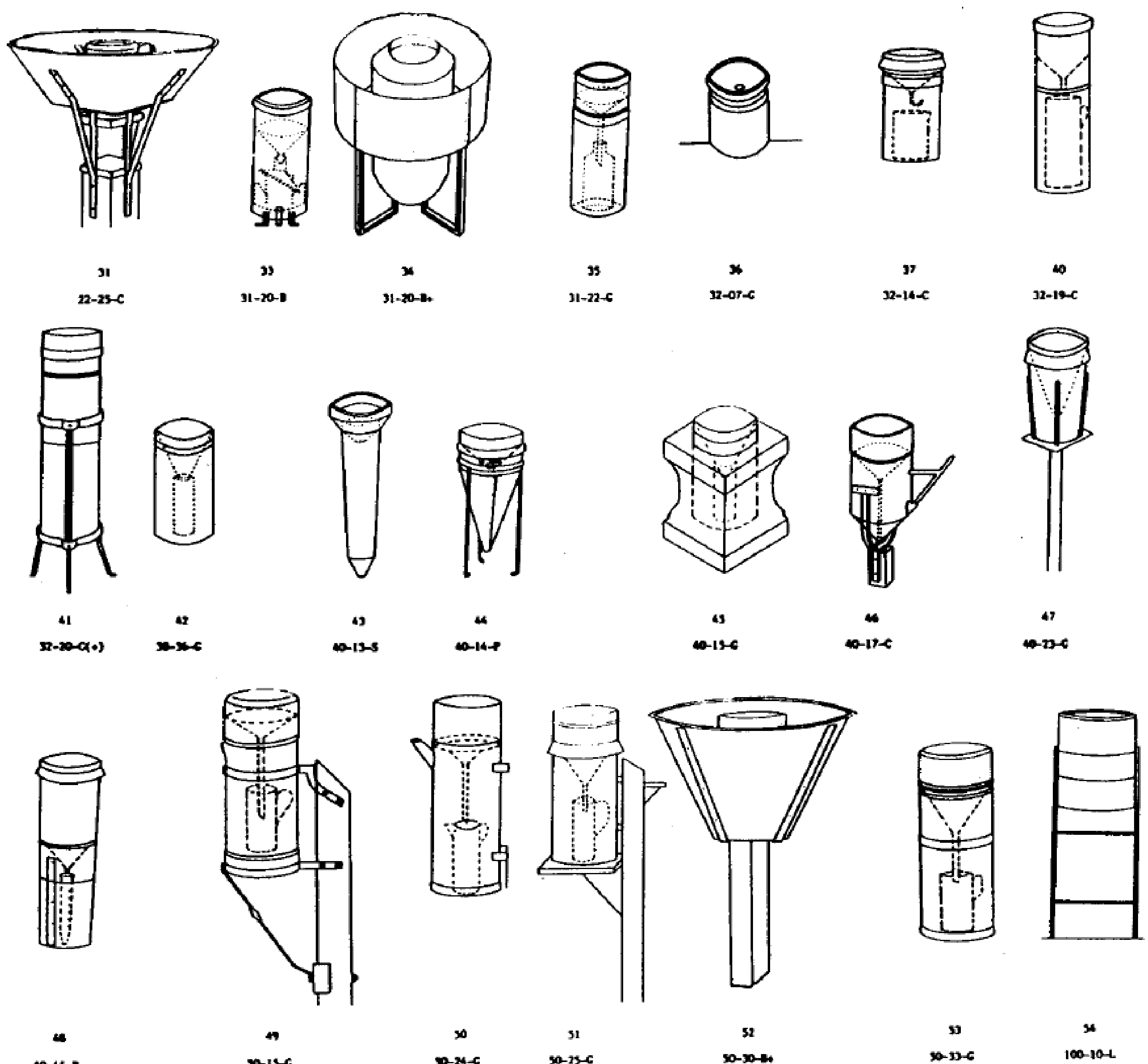


US standard 8-inch rain gage.

Site looks ideal today. What happens in 30 years when that nice blue spruce matures?

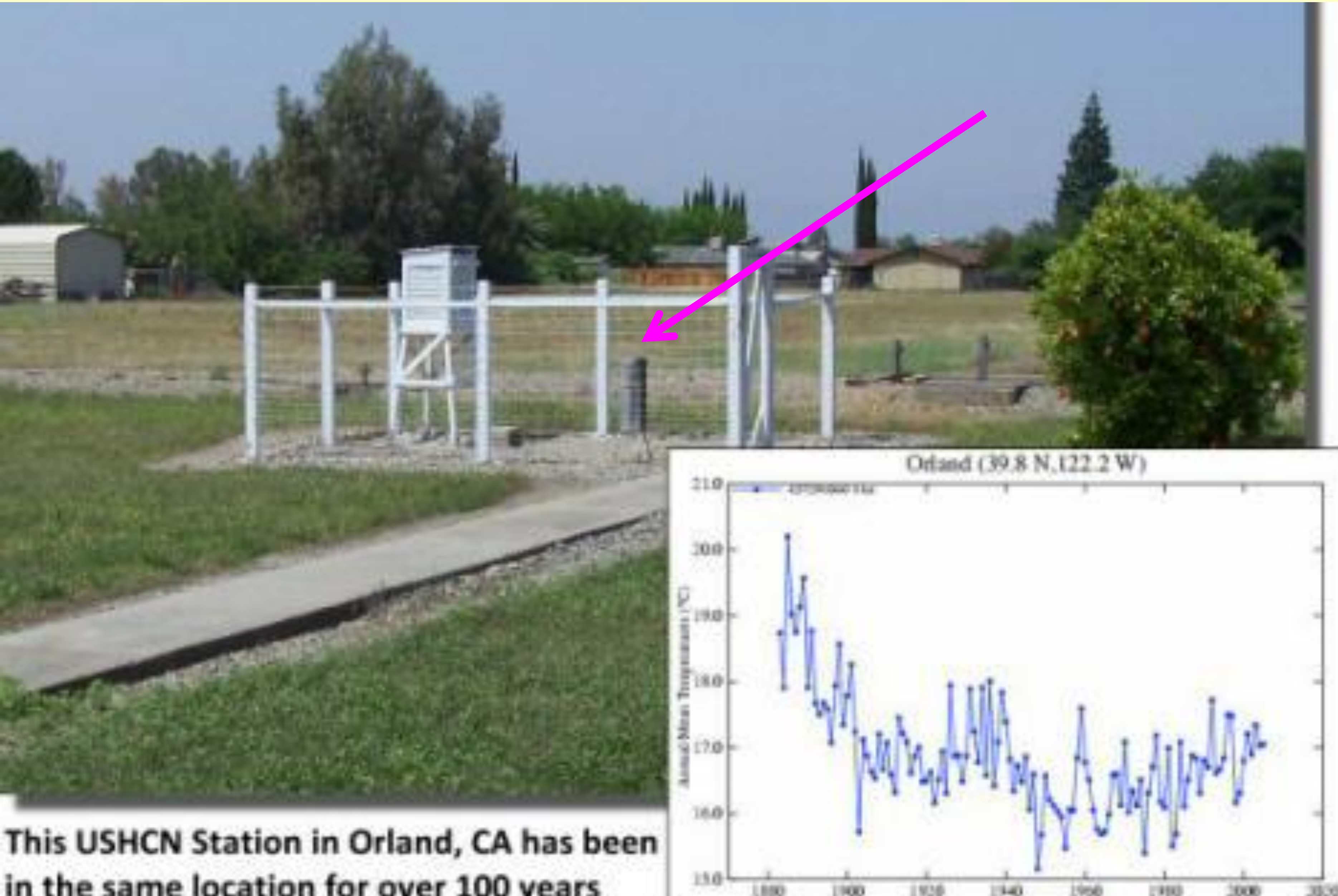
Reading a standard 8-inch rain gage.

This one appears to have been in this site for some time.

This site may be in Pennsylvania.

Is that corrosion or dirt on the surface of the funnel affecting the quality of the measurement?

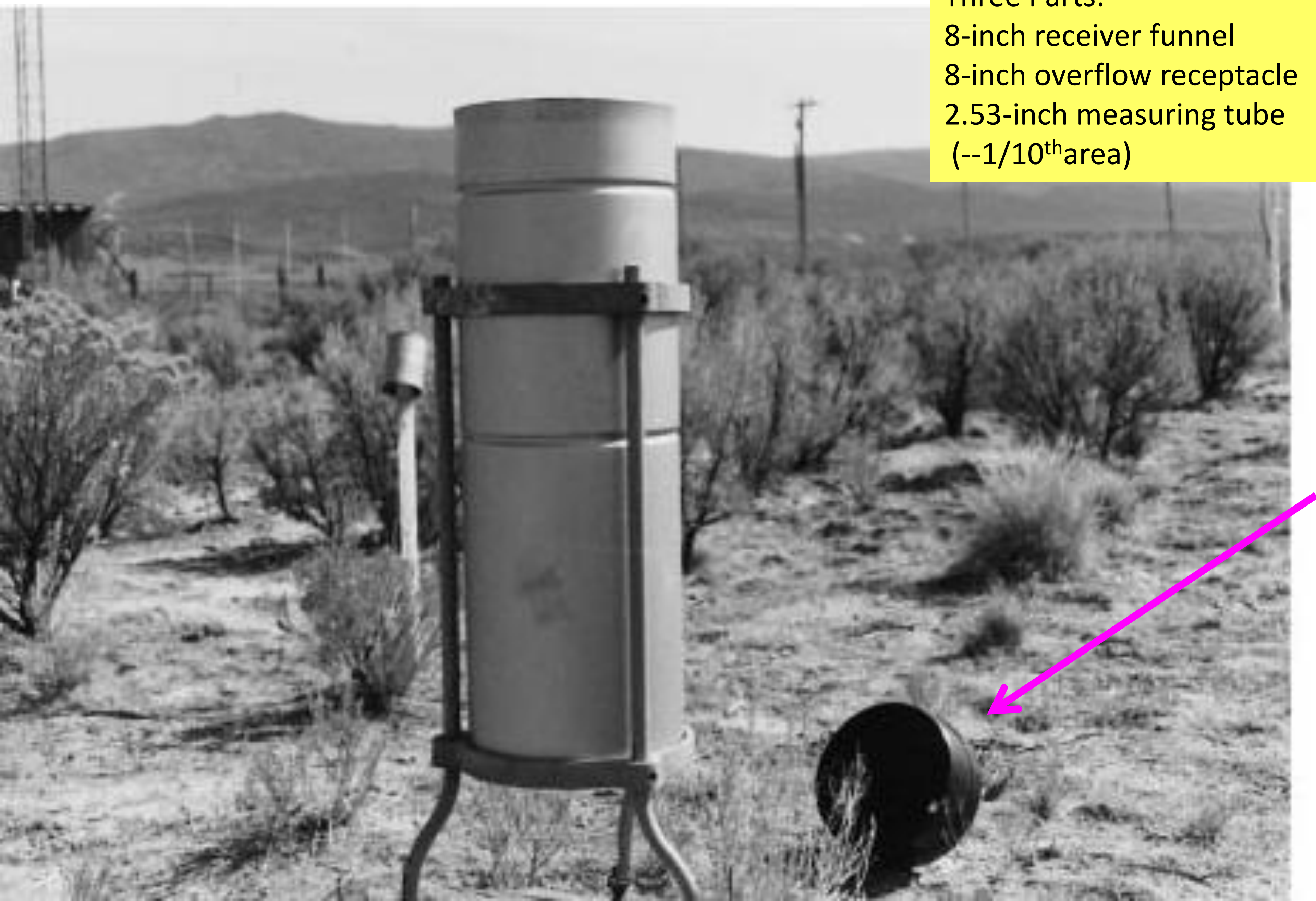
Orland, California, Poster Child for a well-exposed station, data set posted June, 2007



This USHCN Station in Orland, CA has been in the same location for over 100 years

NWS 80 nonrecording gauge, rainfall collector off, as used for snowfall measurement

Three Parts:
8-inch receiver funnel
8-inch overflow receptacle
2.53-inch measuring tube
(--1/10th area)



Fayetteville, NC, Fischer-Porter recording rain gage, weighs the sample
Rain gage appears to have been tilting over the years, introducing systematic errors.

From Steven Burt, Weather Observer's Handbook.

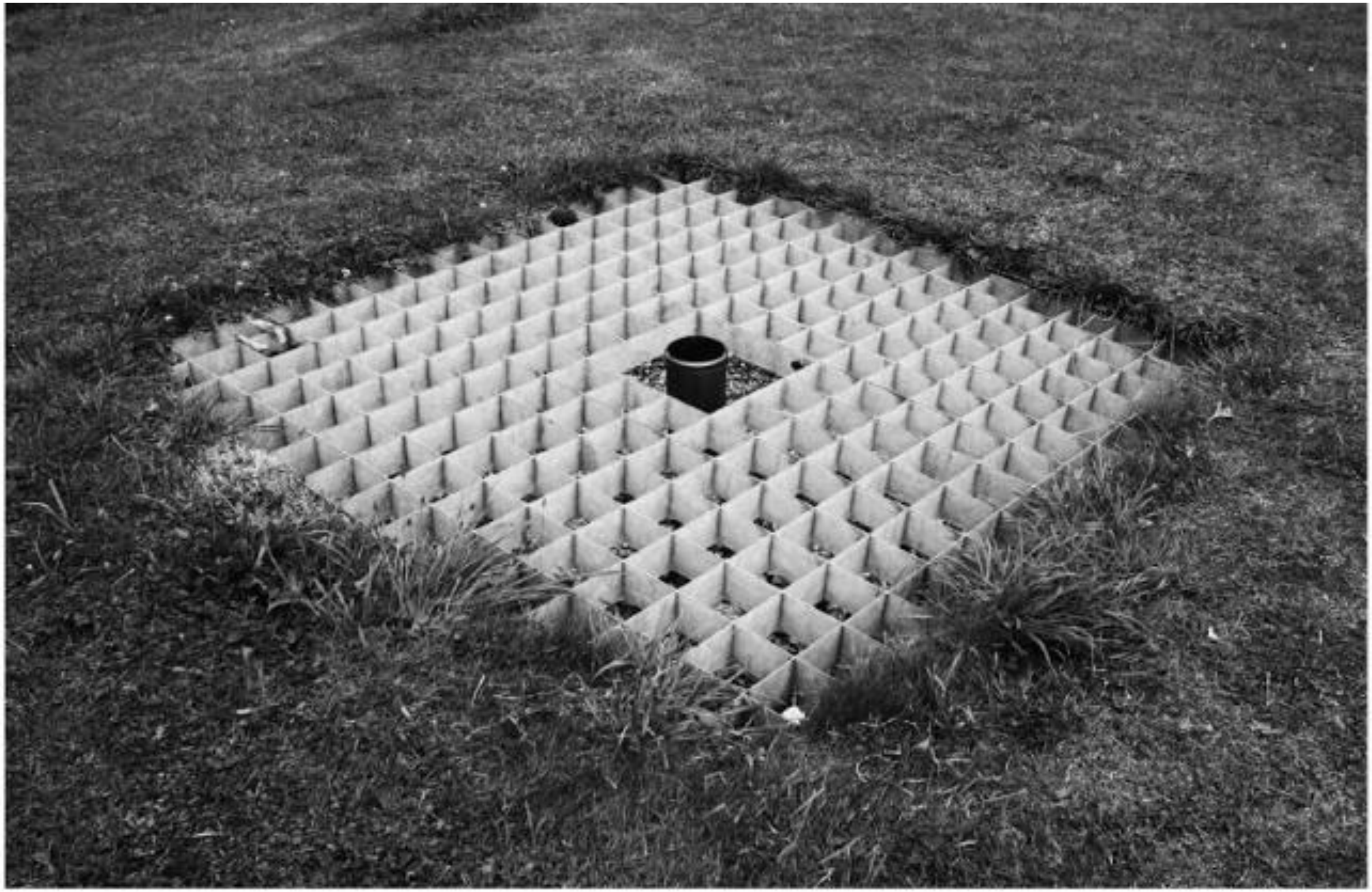
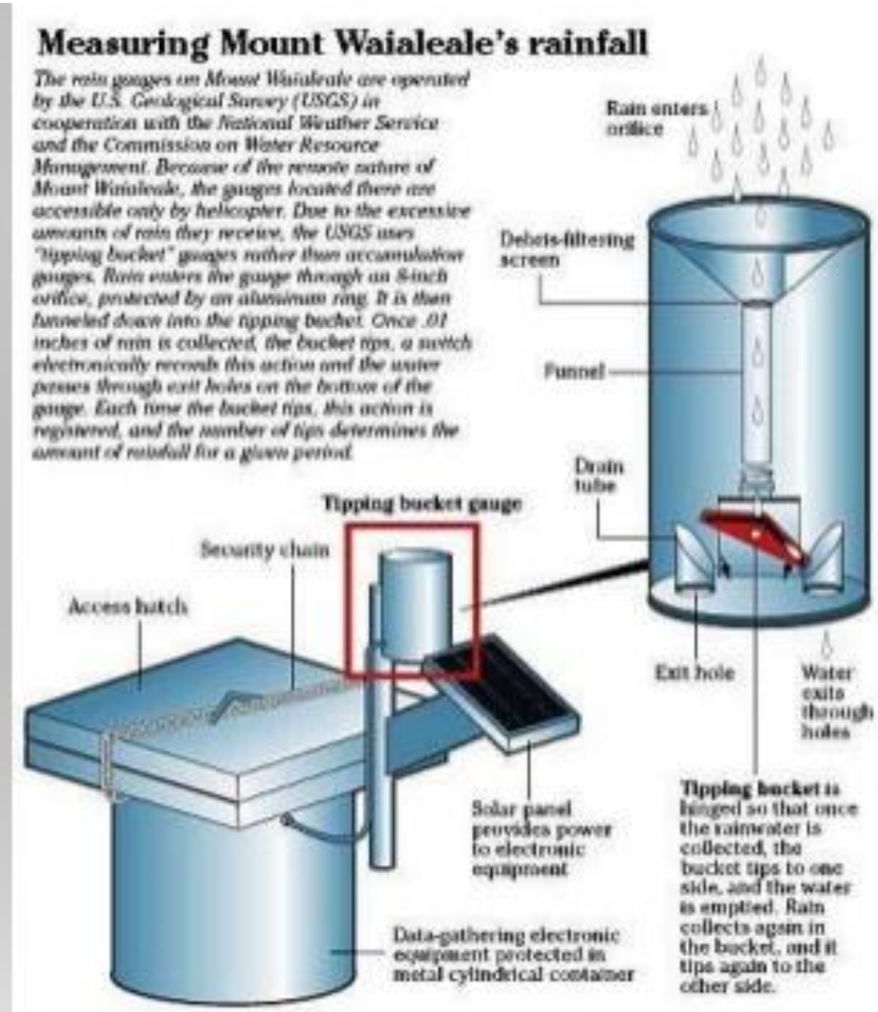


Figure 6.1. Ground-level or 'pit' raingauge; the gauge is exposed at ground level within a strong metal mesh which reduces turbulence and prevents insplash. Wallingford, Oxfordshire, England. (Photograph by the author)

TIPPING BUCKET RAIN GAUGE



https://wattsupwiththat.com/2011/05/13/measuring-rain-the-easy-way-using-an-automatic-logging-rain-gauge/

NWS Employee:

“Part of my job is to QC over a thousand tipping bucket gages hourly for input into radar precipitation estimation corrections….

… clogs and partial clogs are a constant problem.

Dew forms on the funnels first, and, if next to a dusty environment such as a gravel road or a farm field, the dust interacts with the dew and slides down to the funnel neck, creating a very effective adobe plug.

Spiders build nests inside, which interfere with the tipper movement.

Blowing leaves collect to create partial plugs, so, as mentioned above, a one-hour rain storm may dribble out for hours or days after the event.

Dirt collecting in the buckets can cause over-estimation…

During high rain rates, water is lost during the transition from the full tipper to the empty tipper.

Long term climatologies show tipping buckets collect about 70% of what a co-located 8″ standard rain gage collects.”

https://www.meted.ucar.edu/hydro/precip_est/part1_measurement/print.php#page_3-4-0

NCAR Video of Tipping Bucket Rain Gage; Requires login to COMET

DFIR Double Fence Intercomparison Reference

The Double Fence Intercomparison Reference gauge (DFIR, figure 1) was used as a standard for all other windshields in the WMO's intercomparison study and at the Marshall Field site study. The DFIR consists of two fences, one 4 meters in diameter and the other 12 meters in diameter, circling a Tretyakov or Geonor gauge. For the Marshall Field site study, the Geonor gauge was used almost exclusively. This system's catch as a function of windspeed has consistently proven to be 92 to 96 percent of the actual snowfall in most wind events. Unfortunately, the sheer size of the system limits its placement.

Figure 1—The double fence intercomparison reference gauge catches 92 to 96 percent of the precipitation that falls.

The full-sized DFIR is massive: 12 meters or 39 feet in diameter for the outer fence
the DFIR was developed as the “Gold Standard” after numerous WM0 intercomparisons

http://journals.ametsoc.org/doi/full/10.1175/1520-0426(1998)015%3C0054%3AAONSNP%3E2.0.CO%3B2 Tretyakov Rain Gage -- Idaho

This, other B&W “Idaho” photos, from above report, Journal of Atmospheric Technology.

Alter shield with Universal Recording Gage - Idaho

Wyoming Shield with Universal recording gage - Idaho

…Wyoming windshields were also tested at the Marshall Field site <part of NCAR, Boulder, CO>.

A Wyoming shield consists of two mesh fences slanting outward at the top.

The outer fence is 20 feet in diameter. <compared with 39-ft for DFIR>

The catch efficiency for a Geonor gauge in the Wyoming shield decreased rapidly at windspeeds higher than 4 meters per second.

A catch of about 50 percent of the DFIR was recorded at wind speeds of about 8 meters per second.

A half-scale Wyoming shield was developed by Roy Rasmussen and others for the Marshall Field site study.

Catch efficiency for a Geonor gauge in a Small Wyoming shield is less than 50 percent of the DFIR in winds higher than 5 meters per second.

Catch efficiency continues to drop to around 10 percent of the DFIR at windspeeds of 8 meters per second

<u>This says that in snow, when winds exceed 8 m/s a Small Wyoming-shielded gage captures only 10 % of the snow that felt, for instance, in **"snow, when winds are 15-gusting 25 knots,"**</u>

Canadian Nipher snow gauge in Idaho

https://www.fs.fed.us/t-d/pubs/htmlpubs/htm02252325/

Watershed, Soil, and Air Tech Tips

United States Department of Agriculture
Forest Service
Technology & Development Program

MTDC
Technology & Development Center

October 2002 | 2500 | 0225-2325-MTDC

Windshields for Precipitation Gauges and Improved Measurement Techniques for Snowfall

Seth Hansen, Project Assistant
Mary Ann Davies, Project Leader

The chemistry of snow water is measured by accurately collecting snowfall amounts and analyzing the snow that has been melted—usually in a glycol mixture. The problem with current snow measurement techniques is that with almost any wind, collection efficiency is questionable, leading to large uncertainties in estimates of pollutant concentration. Most current combinations of windshields and gauges are ineffective, requiring the gauges to be maintained and monitored frequently.

The issue of measuring snow and frozen precipitation in windy situations has been heavily researched. While many gauges and windshields have been developed and tested during the last 150 years, no combination of windshield and gauge has 100-percent catch efficiency in all wind events. The World Meteorological Organization (WMO) has organized three international intercomparisons of gauges and windshields since 1959, the most recent including data collected from 1985 to 1998. The National Center for Atmospheric Research (NCAR) recently completed a study at the Marshall Field site (Rasmussen and others. 2001. Bulletin of the American Meteorological Society. 82: 4. p. 579–595).

Figure 4—The catch efficiency for the half-scale Wyoming windshield drops rapidly as wind increases.

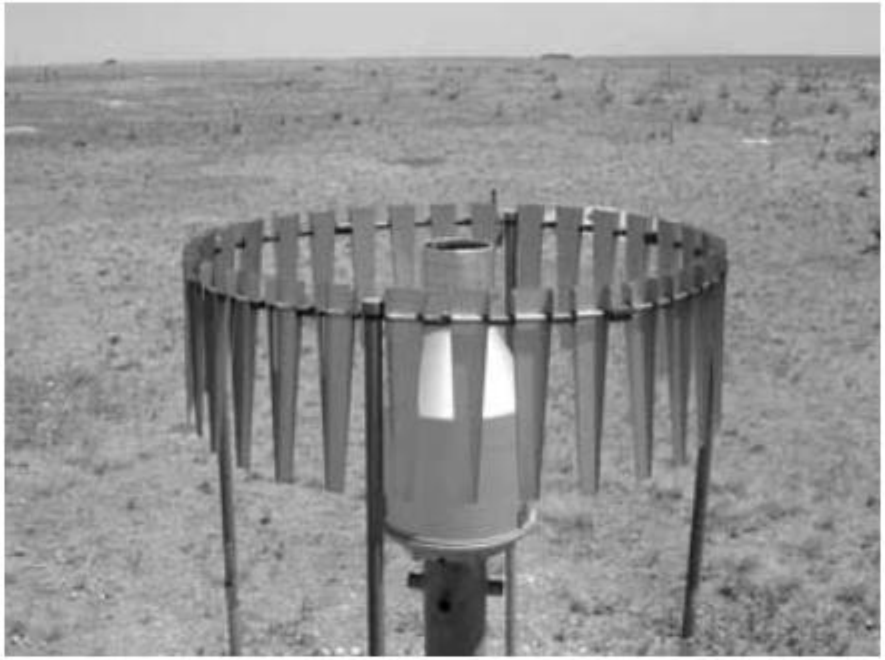


Figure 2—The Alter windshield catches little of the precipitation that falls during high winds.

Figure 3—The double Alter windshield performs well in high winds.

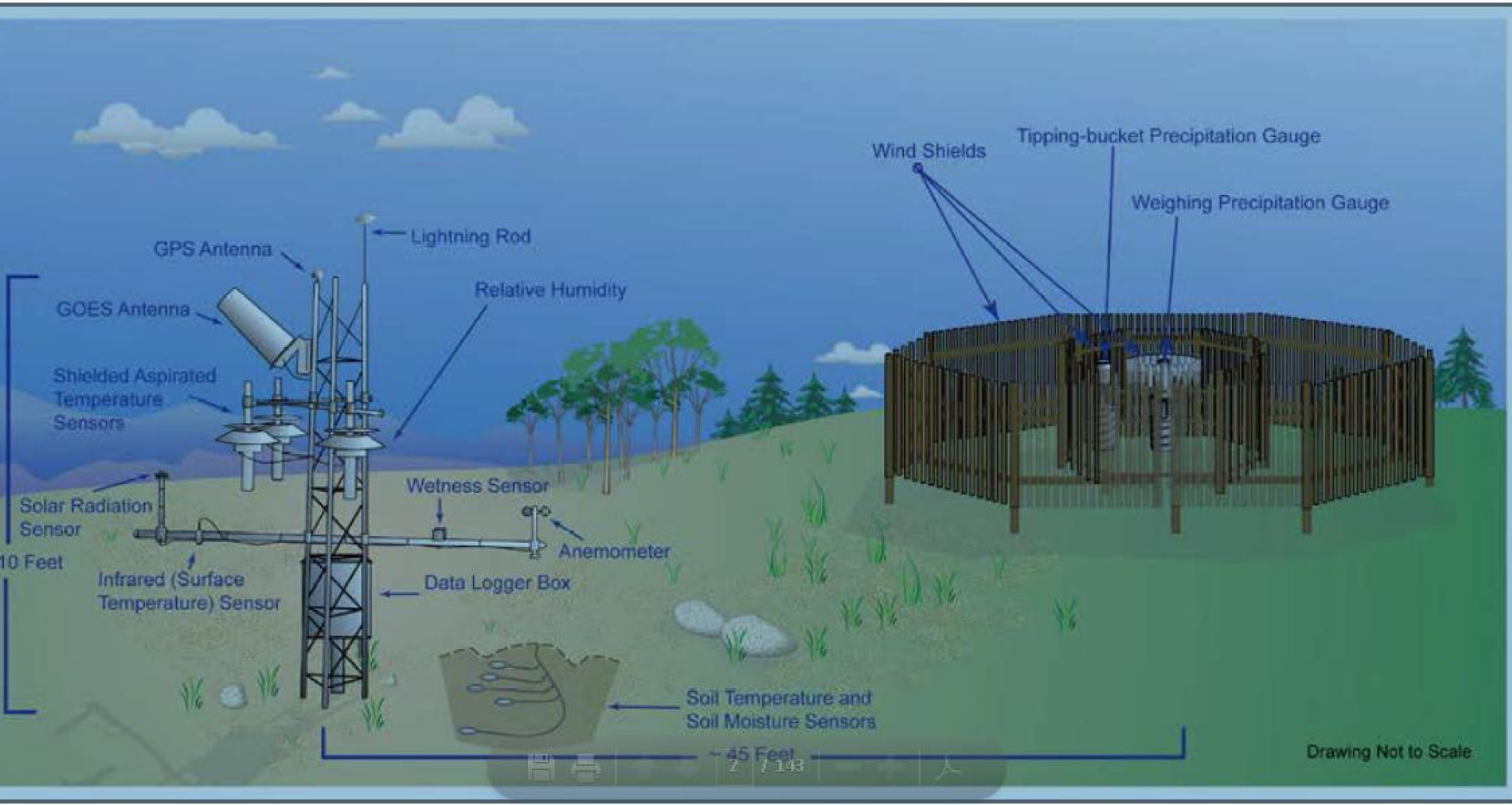
Next several slides delve into the USCRN, US Climate Reference Network

USCRN is the “unimpeachable” climate reference network…

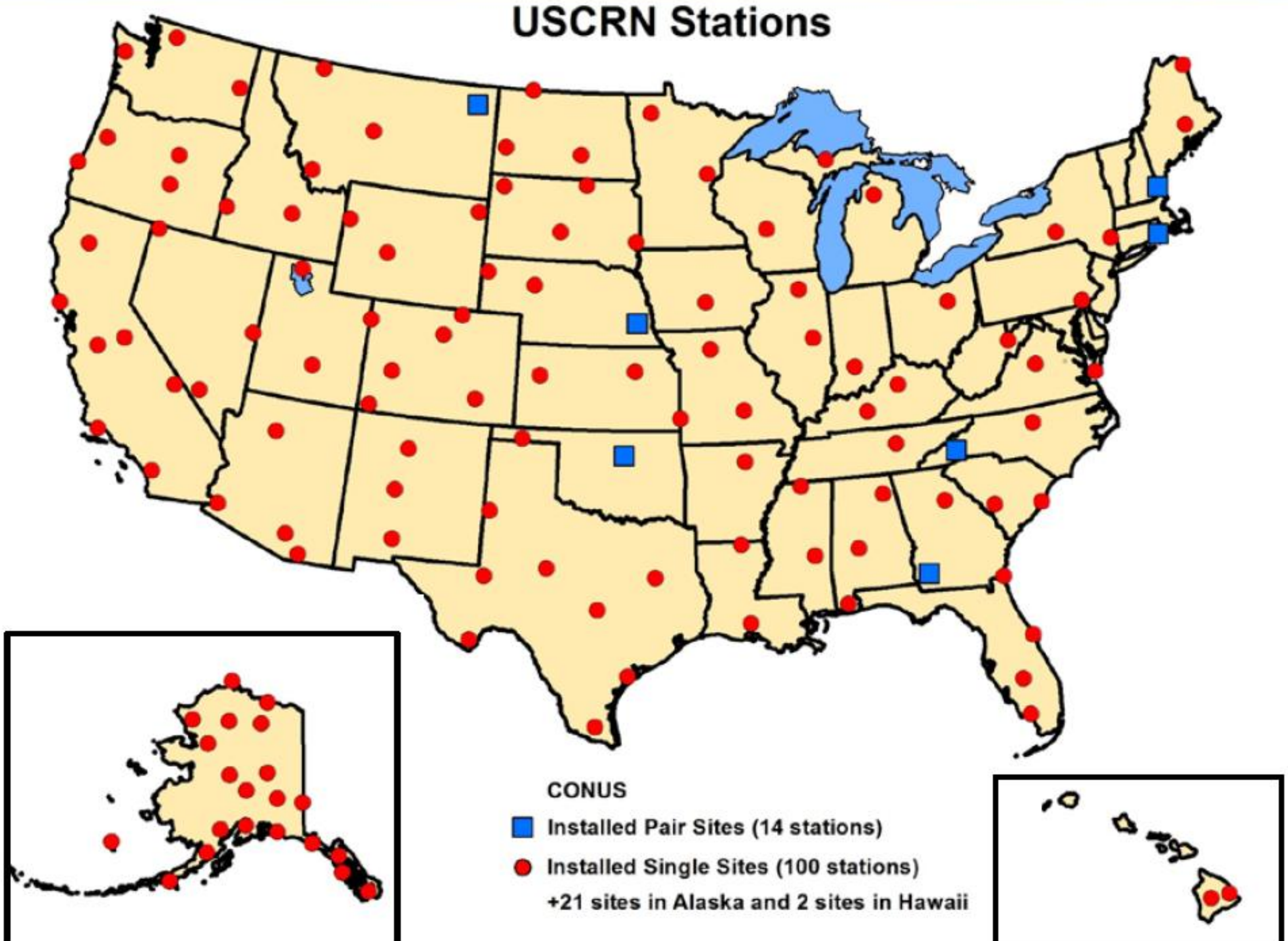
but…what about the operational world…airports?

US Climate Reference Network

Instruments at a Typical USCRN Station



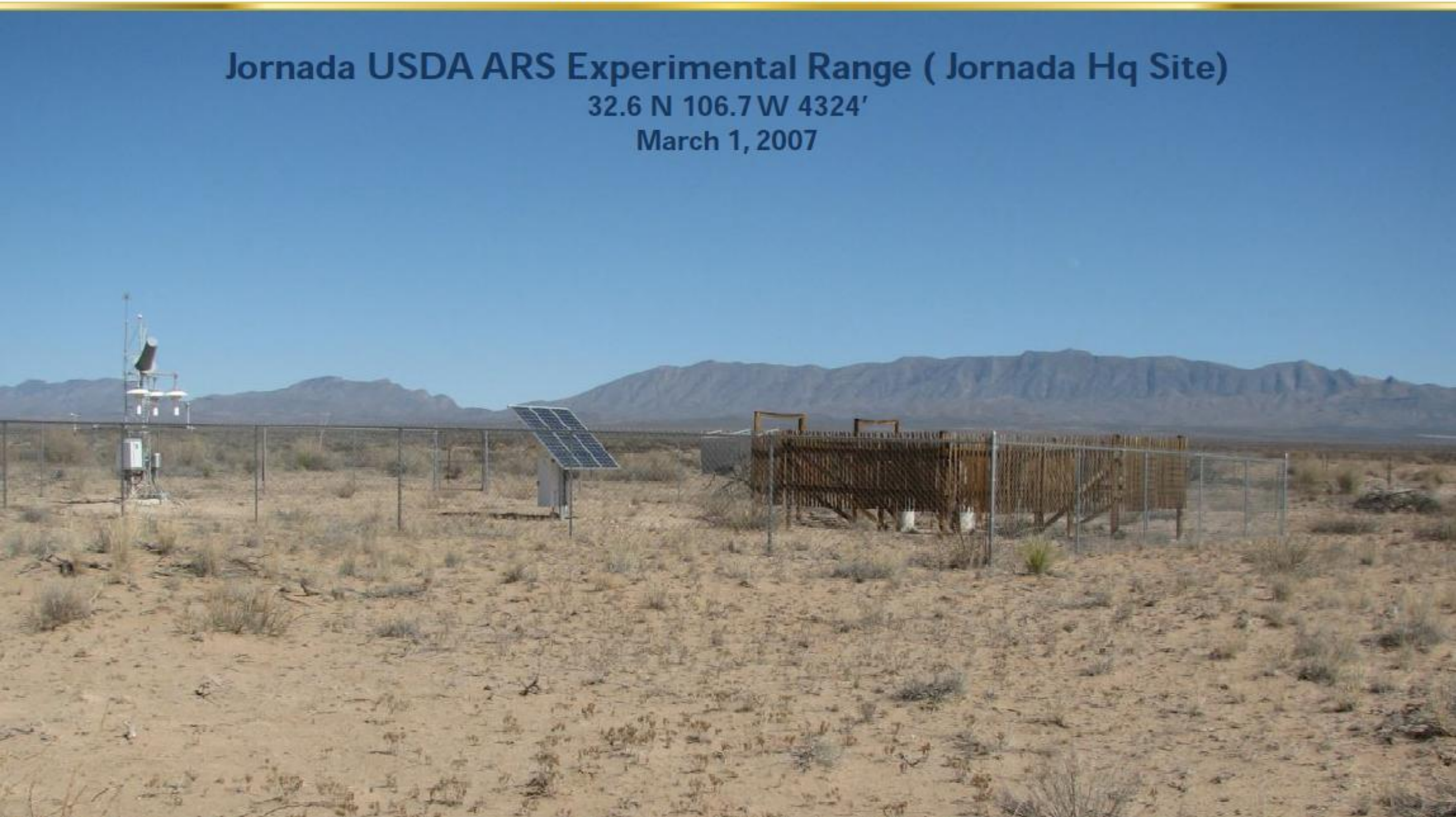
US Climate Reference Network



https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/site/photos/stationsbystate_lores.pdf

US Climate Reference Network

NM Las Cruces 20 N



https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/site/photos/stationsbystate_lores.pdf

US Climate Reference Network

NM Socorro 20 N

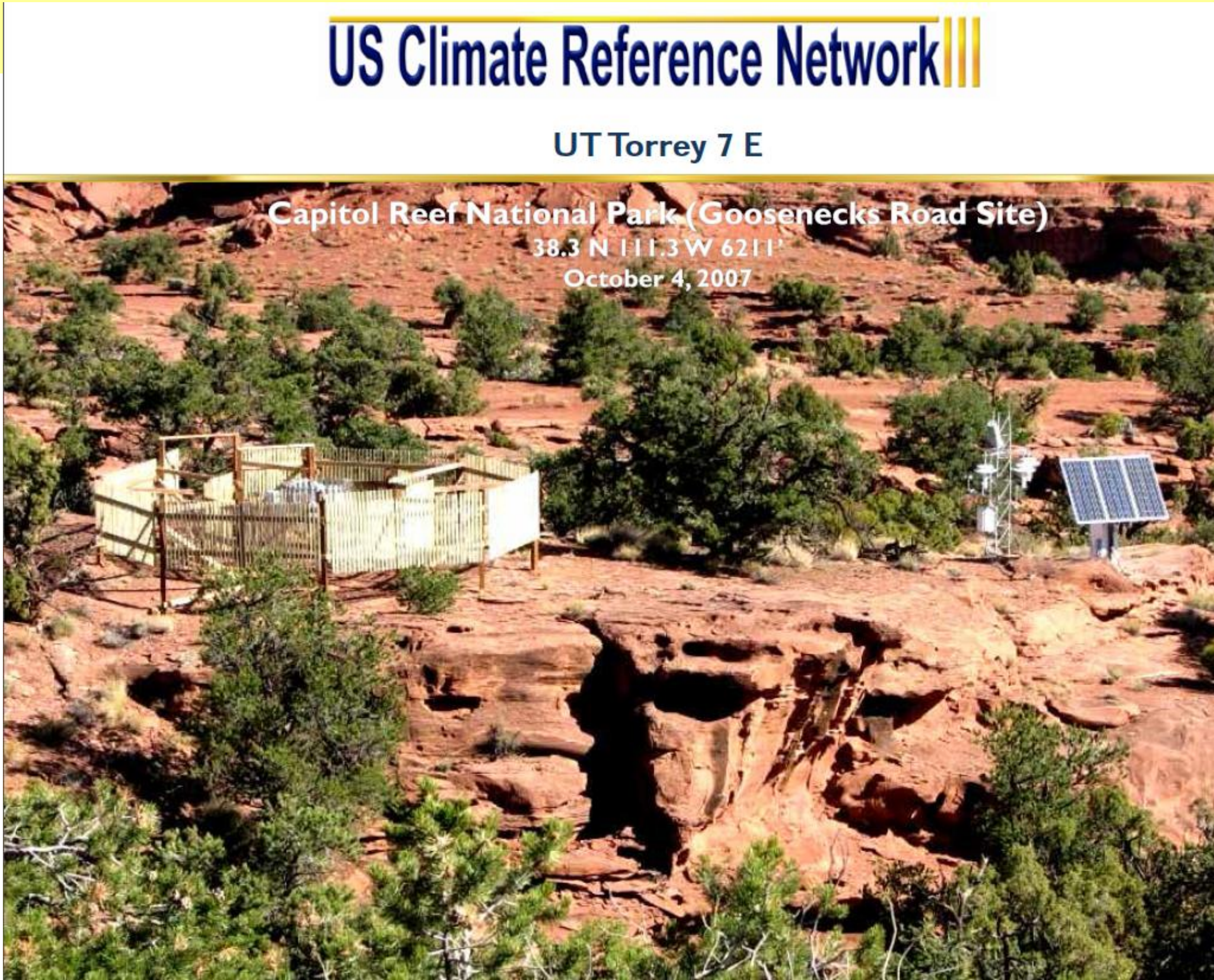
https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/site/photos/stationsbystate_lores.pdf

US Climate Reference Network

NM Los Alamos 13 W

NPS, Valles Caldera National Preserve
35.9 N 106.5 W 8705′
July 31, 2004

https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/site/photos/stationsbystate_lores.pdf



https://www.ncdc.noaa.gov/crn/measurements.html

Air Temperature

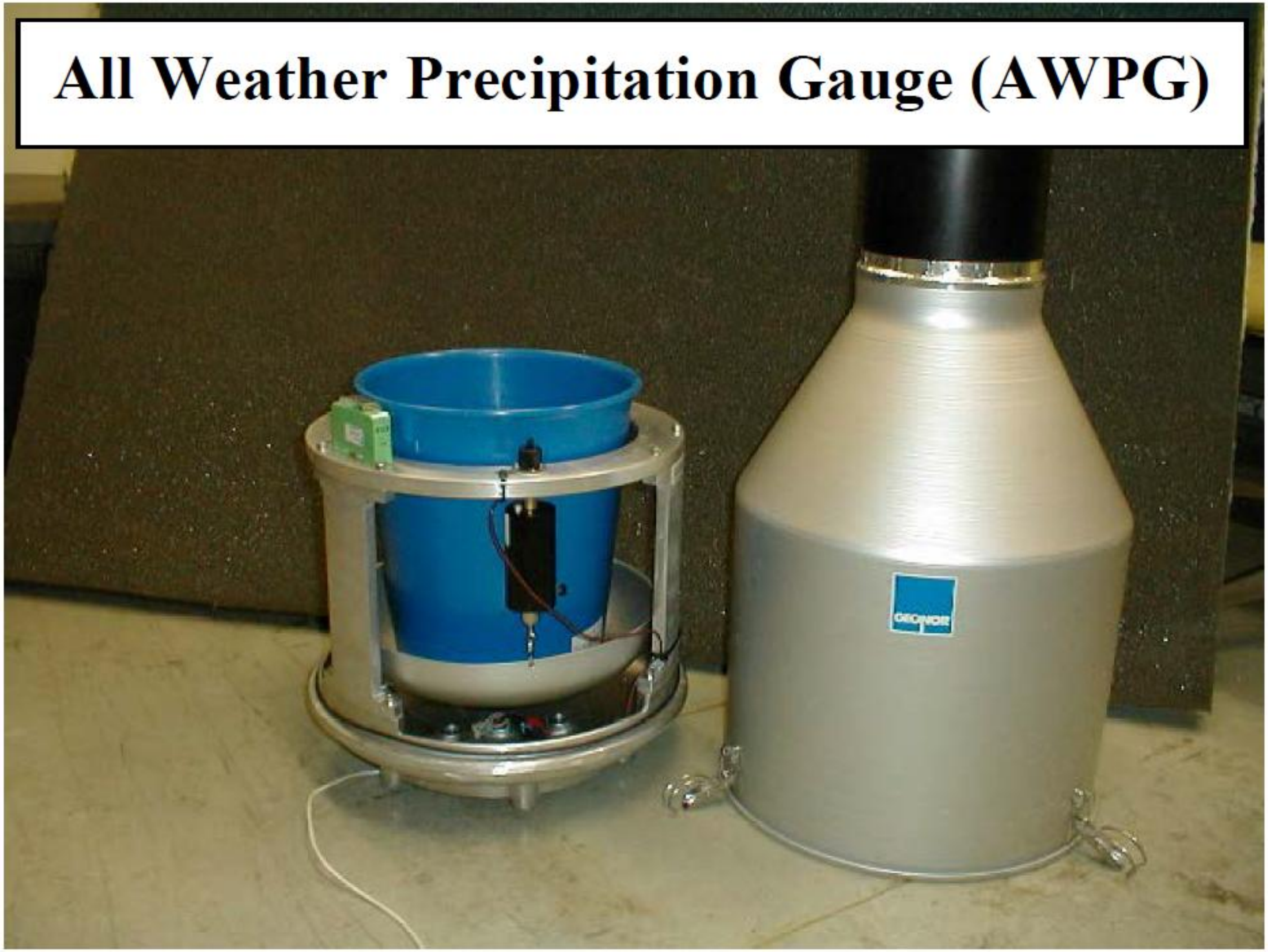
USCRN stations are equipped with three independent thermometers which measure air temperature in degrees Celsius.

The station's datalogger computes independent 5-minute averages using two-second readings from each thermometer. These multiple measurements are then used to derive the station's official hourly temperature value.

Precipitation

Each station has a weighing precipitation gauge which is equipped with three load cell sensors to provide three independent measurements of depth change (in millimeters) at 5-minute intervals.
The three series of 5-minute values are then used in an algorithm to derive the station's official 5-minute and hourly precipitation value.

https://www1.ncdc.noaa.gov/pub/data/uscrn/documentation/site/sensors/precipitation/Descriptions/Precip_GeonorT-200B.pdf



Description:

The Geonor precipitation gauge is a weighing type gauge.
The T-200B uses vibrating wire strain gauge load cells to continuously weigh the collection bucket.
The collection bucket is suspended by three vibrating wire sensors.
Most gauges in the USCRN have a capacity of 600 mm precipitation, but in some remote or very wet locations, a 1000 mm capacity gauge is used to extend the time before the gauge reaches capacity and needs to be drained.

How is it installed?

The gauge is mounted to a poured concrete pedestal such that the gauge opening is about 1.5 m above the ground.
A controlled heater is attached to the outer surface of the inlet throat of the gauge so that wet snow between -10°C and +5°C doesn’t clog the opening, but slides in instead.
The gauge is surrounded by a
Small Double Fence Intercomparison Reference (SDFIR)
Shield and a Single Alter wind/snow shield.

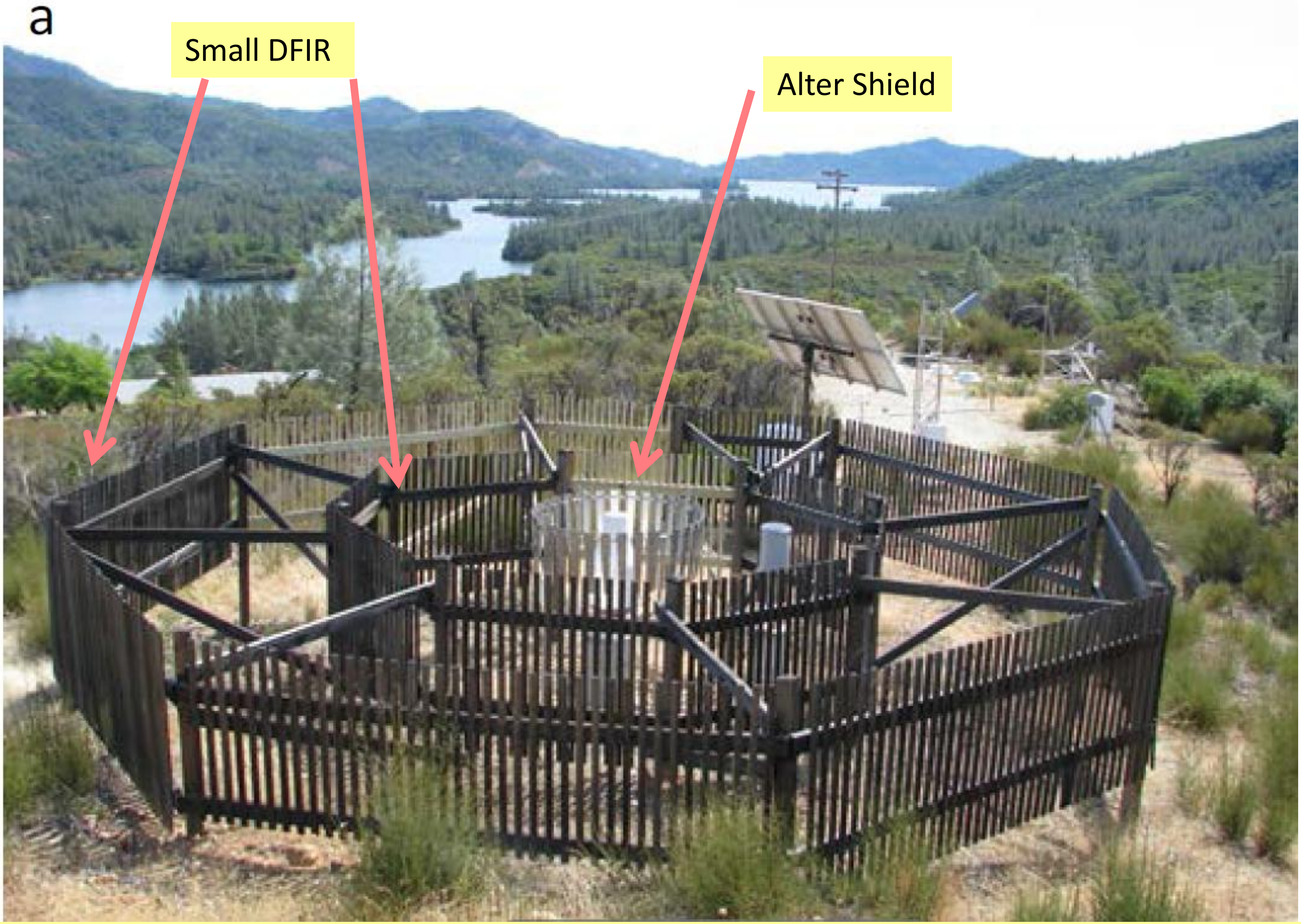
In cold weather, an antifreeze mix is added.

http://geonor.com/live/products/precipitation-and-snow-depth/t-200b-weather-precipitation-rain-gauge/

Geonor T-200B series
All-weather precipitation gauges
600 mm • 1000 mm • 1500 mm

- More than 25 years of field use
- Easy installation and maintenance
- Precipitation intensity can be calculated
- Proven long term reliability
- No internal heating required
- No moving parts
- Interfaces to most data acquisition systems
- Vibrating wire weighing sensors

http://geonor.com/live/products/precipitation-and-snow-depth/t-200b-weather-precipitation-rain-gauge/



USCRN Geonor-T200B gauge within both a Small double fence Intercomparison Reference <Small DFIR> shield and Alter shield, near Merced, CA…

https://www.ncdc.noaa.gov/news/uscrn-implements-new-approach-precipitation
Redding, CA.

Small DFIR, Alter shield, Geonor T-200B weighing gage and tipping bucket gage (gray)

This photo’s exposure / composition shows the shields better than other photos.

Accuracy of NWS 8″ Standard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison

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VALENTIN S. GOLUBEV

State Hydrological Institute, St. Petersburg, Russia

ROY BATES AND TIMOTHY PANGBURN

U.S. Army CRREL, Hanover, New Hampshire

CLAYTON L. HANSON

U.S. Department of Agriculture, Agricultural Research Service, Northwest Watershed Research Center, Boise, Idaho

(Manuscript received 21 December 1995, in final form 1 August 1996)

Dual-gauge measuring system (bridled shield and unshielded universal recording gauges) Idaho.

The title of this report is, Accuracy of NWS 8" Standard Nonrecording Precipitation Gauge: Results and Application of WMO Intercomparison.

Data is displayed in tables showing measurements from shielded and unshielded standard 8-inch rain gages,
but the report does not show photos of them side by side.

Here is the 8-inch gage in Idaho where some of the intercomparisons were done.

Figure 5 NWS 8-inch Manual Gauge

Figure from SAIC report, “Interim Report For The Winter Test of Production All-Weather Precipitation Accumulation Gauge (AWPAG) Winter 2008-2009”

Results

“Ground Truth” was established using collection inside a DFIR

Wind speed -- most important in reducing efficiency of catch

Correction equations were derived to improve the unshielded 8-inch gage <manual collection>

<The correction equation used on-line with ASOS is called a “Transfer Function”>

Depending on the winds, they had to add 20% for rain, and 90% for snow.

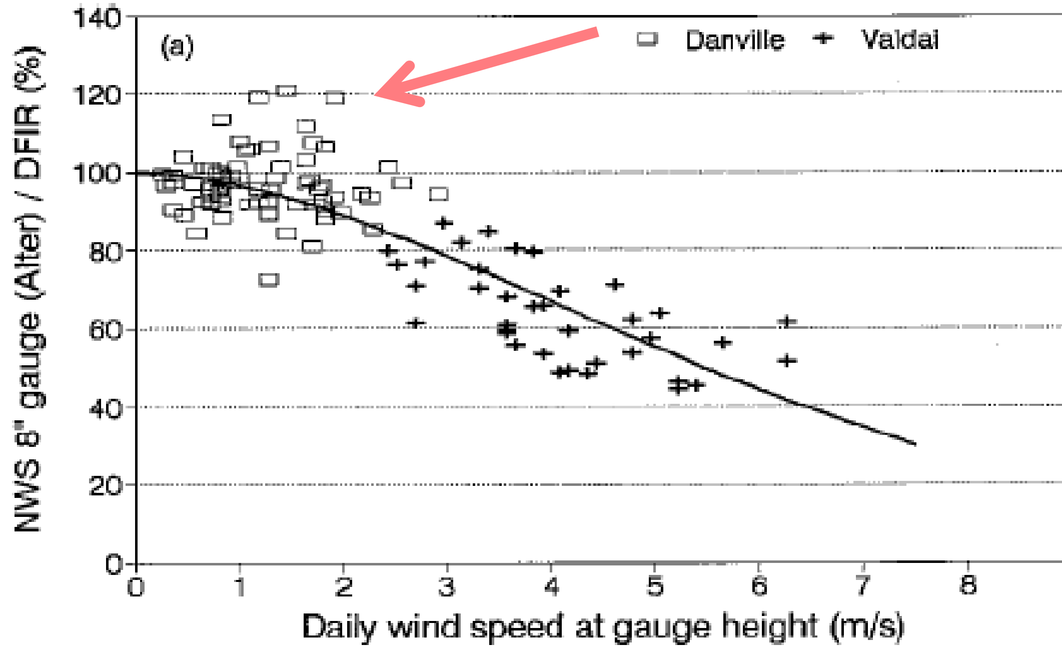
TABLE 1. Summary (total and percentage of the DFIR) of daily observed precipitation for the NWS 8″ standard gauge (with an Alter shield or unshielded) at Valdai, Reynolds Creek, and Danville WMO Intercomparison stations.

Type of precipitation	Number of events (Day)	T_{max} (°C)	T_{min} (°C)	Ws(@ 3 m) m s^{-1}	DFIR	NWS 8″ measured	
						Alter	Unshielded
(a) Valdai WMO site, October 1991 to March 1993							
Snow	154	−4.1	—	3.8	357.4 mm 100.0%	248.8 mm 69.6%	156.5 mm 43.8%
Mixed	73	0.7	—	4.5	463.9 mm 100.0%	361.4 mm 77.9%	303.4 mm 65.4%
Rain	108	10.0	—	3.6	434.5 mm 100.0%	400.8 mm 92.2%	386.0 mm 88.8%
All	335	2.2	—	4.0	1255.8 mm 100.0%	1011.0 mm 80.5%	845.9 mm 67.4%

At the Valdai site in Russia, not far from Finland, the unshielded 8-inch gage had about 11% undercatch for rain, but ~57% of the snow was not caught.

Nowhere in the text does it explain how the 8-inch gage records 20% HIGHER than the DFIR…At Low Wind Speeds!

As wind speed increases, >2m/sec, precipitation falls off significantly.



All data below this line show the 8-inch rain gage captures less than half that captured by the DFIR!

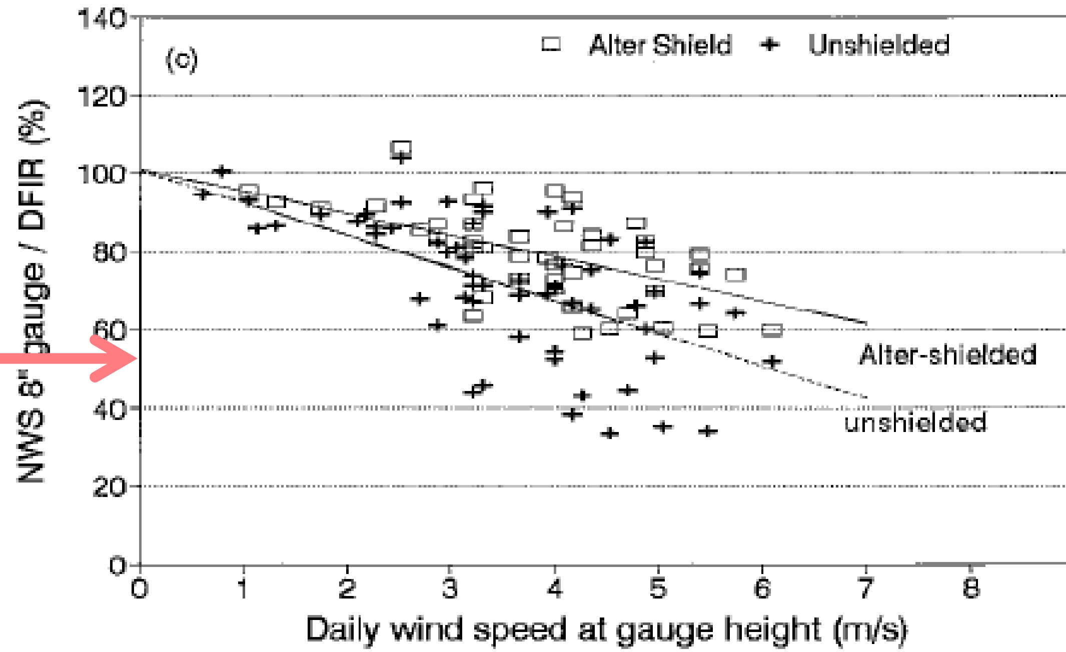


TABLE 2. Summary (total and percentage of the DFIR) of daily corrected precipitation for the NWS 8″ standard gauge (with an Alter shield or unshielded) at Valdai, Reynolds Creek, and Danville WMO Intercomparison project stations.

Type of precipitation	Events (Days) All	Events (Days) DFIR > 3.0 mm	DFIR	NWS 8″ measured Alter	NWS 8″ measured Unshielded	NWS 8″ corrected Alter	NWS 8″ corrected Unshielded
(a) Valdai WMO site, October 1991 to March 1993							
Snow	154	37	357.4 mm 100.0%	248.8 mm 69.6%	156.5 mm 43.8%	334.7 mm 93.6%	374.0 mm 104.6%
Mixed	73	45	463.9 mm 100.0%	361.4 mm 77.9%	303.4 mm 65.4%	457.8 mm 98.7%	448.5 mm 96.7%
Rain	108	47	434.5 mm 100.0%	400.8 mm 92.2%	386.0 mm 88.8%	435.1 mm 100.1%	431.6 mm 99.3%
All	335	129	1255.8 mm 100.0%	1011.0 mm 80.5%	845.9 mm 67.4%	1227.6 mm 97.8%	1254.1 mm 99.9%

This shows the data after it has been corrected by the equations derived during the experiments at Valdai, Russia, Reynolds Creek, Idaho, and Danville, Vermont.

Precipitation Measuring Instruments

Wind shields

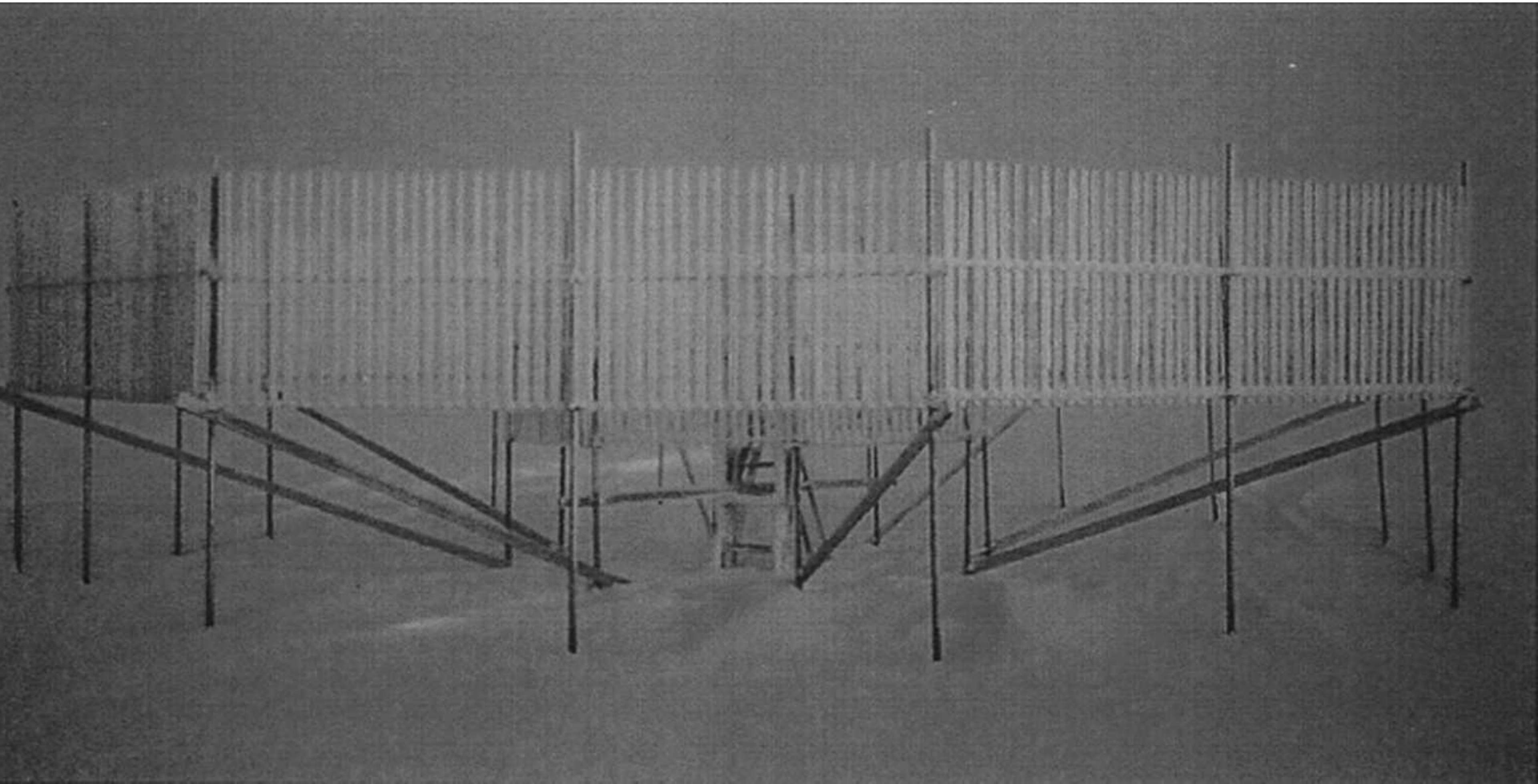
Combinations

DFIR, Dual Fence Intercomparison Reference wind shield equipped with Tetryakov precip gage
Outer: 12m Diameter, top 3.5m AGL, lath 1.5m long, 50% coverage
Inner: 4m Diameter, top 3.0m AGL, lath 1.5 m long, 50% coverage
Shown with Tretyakov precipitation gage among items for sale Almaty, Kazakhstan

DFIR, Dual Fence Intercomparison Reference wind shield, equipped with Tretyakov precip gage

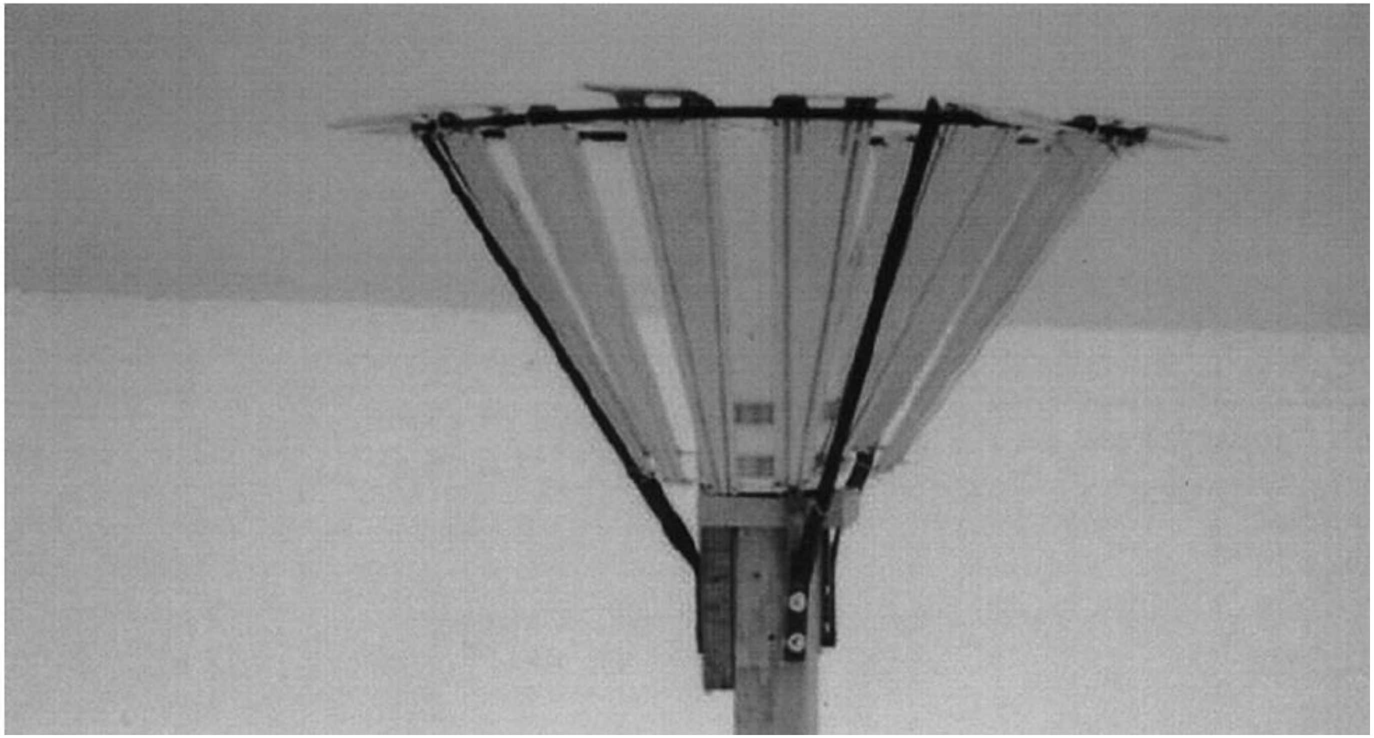
Outer: 12m Diameter, top 3.5m AGL, lath 1.5m long, 50% coverage
Inner: 4m Diameter, top 3.0m AGL, lath 1.5 m long, 50% coverage

On site at NOAA Climate Modeling and Diagnostics Laboratory Point Barrow, Alaska, 550 km north of Arctic Circe (71 Deg 19 min North, 156 Deg 36 min West.)



Tretyakov precipitation gage.

The one in the center of the DFIR field is 3m AGL, making it the same height as the height of the inner lath shields



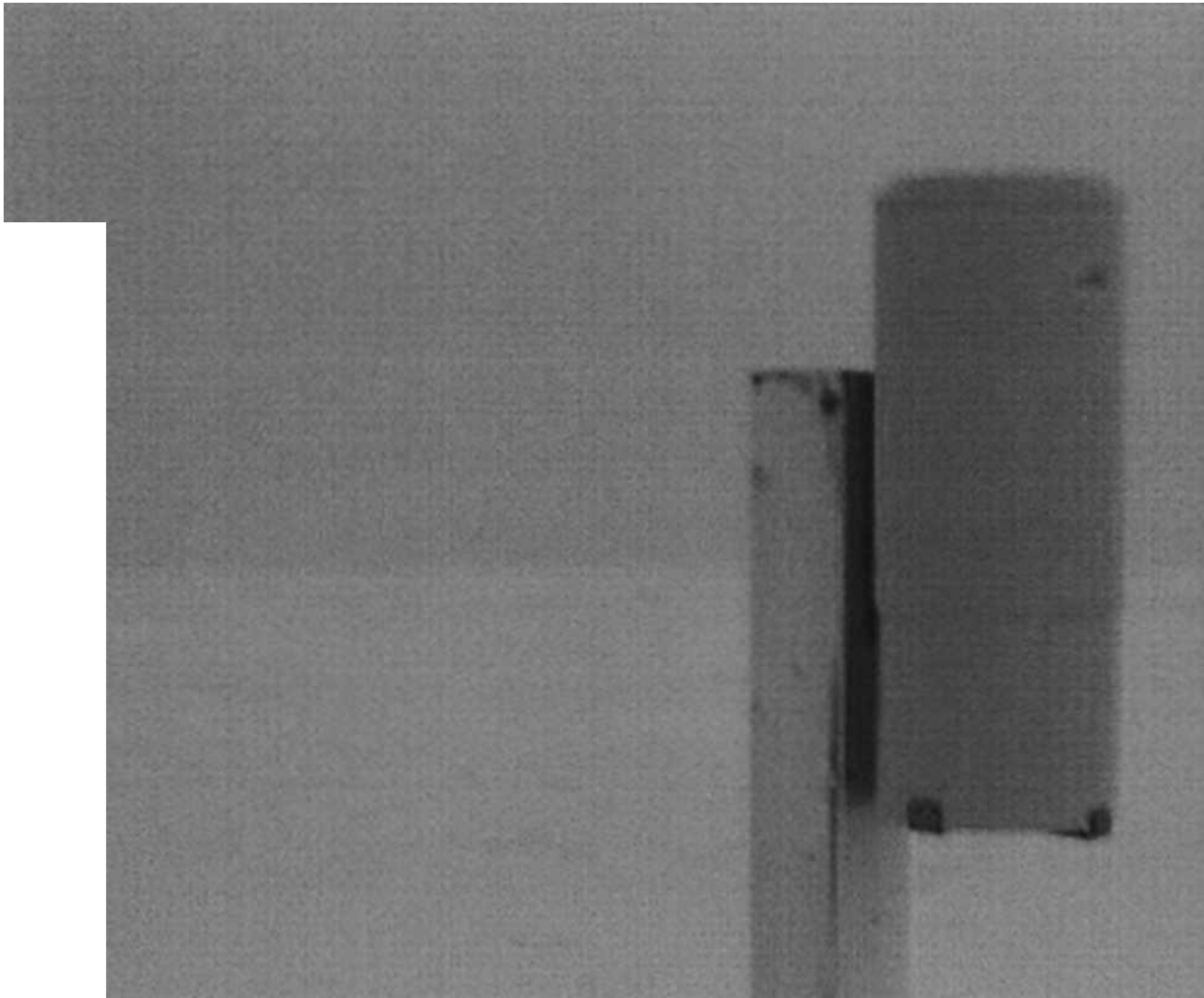
Right: Tretyakov Precipitation Gage at University of Colorado, Boulder

Left: Tretyakov Precipitation Gage for sale Almaty, Kazakhstan

Canadian Nipher Gage.

Top bell is 610 mm wide, bottom is 229 mm diameter, horn is 508 mm long.
Inner diameter of collection cup is 127 mm and the height of the measuring cup is 2 m AGL.

Hellmann Gage, bucket height is 2m AGL.
Hellmann Gages are used… in Argentina, Austria, Chile, Croatia, Denmark, Germany, Greenland, Hungary, Poland, Portugal, Romania, Spain, Switzerland, and Turkey



https://www.ars.usda.gov/research/publications/publication/?seqNo115=96710

QUANTIFICATION OF PRECIPITATION MEASUREMENT DISCONTINUITY INDUCED BY WIND SHIELDS ON NATIONAL GAUGES

Technical Abstract: <extracts>

Various combinations of wind shields and national precipitation gauges commonly used in countries of the Northern Hemisphere have been studied using the combined intercomparison data collected at 14 sites during the WMO Solid Precipitation Measurement Intercomparison Project.

The results show that

wind shields improve gauge catch of precipitation particularly for snow.

Shielded gauges, on average, measure 20-70% more snow than unshielded gauges.

Without a doubt, the use of wind shields on precipitation gauges has introduced a significant discontinuity into precipitation records particularly in cold and windy regions.

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https://www.ars.usda.gov/research/publications/publication/?seqNo115=96710

QUANTIFICATION OF PRECIPITATION MEASUREMENT DISCONTINUITY INDUCED BY WIND SHIELDS ON NATIONAL GAUGES

This discontinuity is not constant and it varies with wind speed, temperature and precipitation type.

Adjustment for this discontinuity is necessary to obtain homogenous precipitation data for climate change and hydrological studies

The relation of the relative catch ratio (RCR, ratio of measurements of shielded gauge to unshielded gauge) versus wind speed and temperature has been developed for Alter and Tretyakov wind shields.

Strong linear relations between measurements of shielded gauge and unshielded gauge have also been found for different precipitation types.

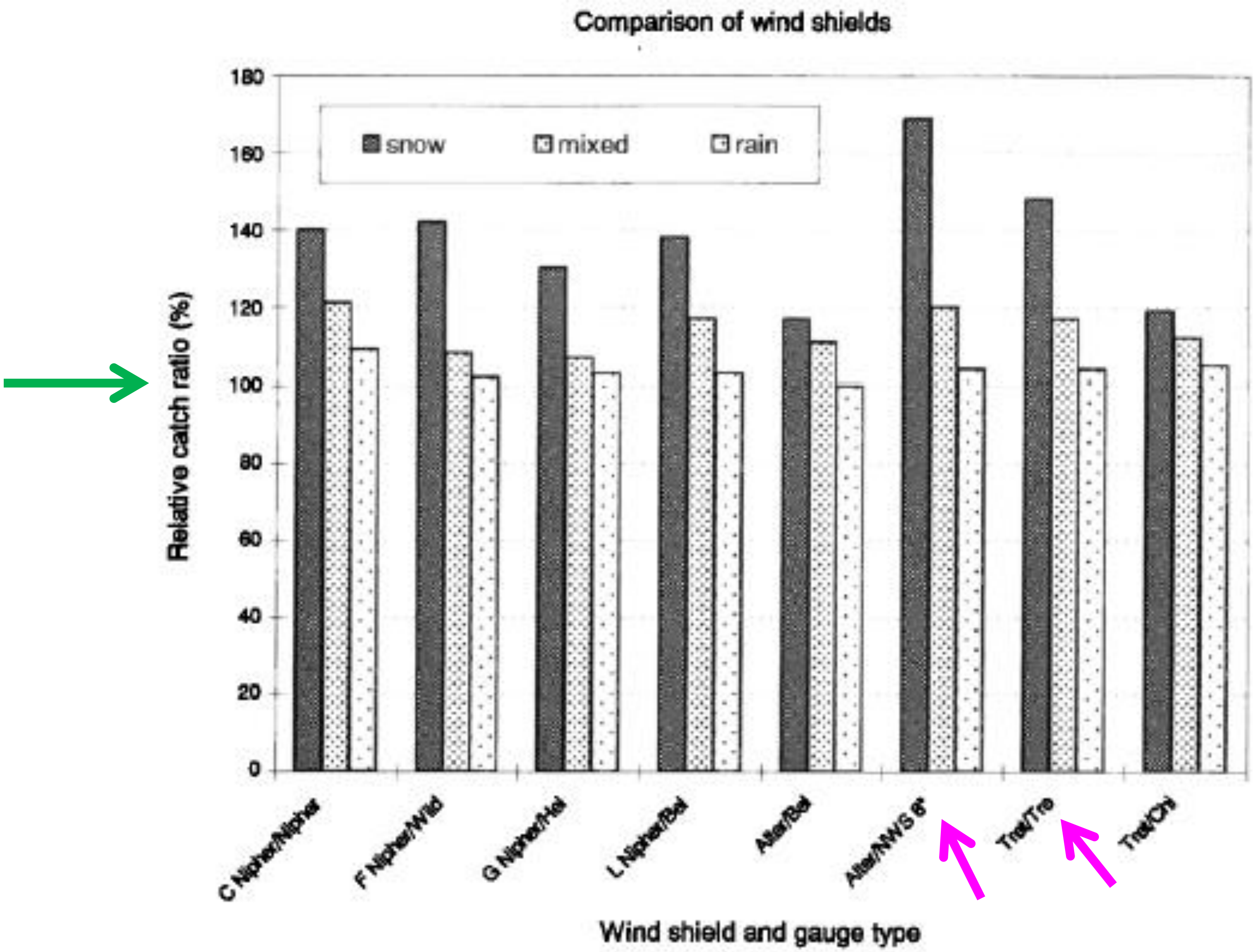


Figure 9. Mean relative catch ratios (RCR) for various shield and gauge combinations. Abbreviations a as follows: C Nipher/Nipher, Canadian Nipher shield with Nipher snow gauge; F Nipher/Wild, Finnish Niph shield with Wild gauge; G Nipher ?Hel, Herman Nipher shield with Hellmann gauge; L Nipher/Bel, lar Nipher shield with Belfort gauge; Tre/Tre, Tretyakov shield with Tretyakov gauge; Alter/NWS 8", Alter shie with NWS 8-inch nonrecording gauge; Tre/Chi, Tretyakov shield with Chinese standard gauge.

http://journals.ametsoc.org/doi/abs/10.1175/15200477%281994%29075%3C0215%3ATAOUSP%3E2.0.CO%3B2

The Accuracy of United States Precipitation Data

Pavel Ya. Groisman*,+
and David R. Legates@

Bulletin of the AMS, Feb, 1994.

Abstract says that errors go from 5% to 40%, worse in winter and in northern states because of strong winter storms (wind and snow effects)

In the West, stations are in the valleys, but much of the terrain is a
lot higher, and much of that is in the mountains, and unsampled.

. . . the HCN and, to a lesser extent, the CDDB are likely the best available sources of historical precipitation data. The question we address here, however, is: Is the absolute accuracy of these data adequate to meet the diverse needs of scientists who use historical precipitation data? We believe that for many applications, the answer is no.

HCN = United States Historical Climatology Network

CDDB = Climate Division Data Base (Part of National Climate Data Center)

Figure 5 NWS 8-inch Manual Gauge

Here is the 8-inch gage in Idaho where some of the intercomparisons were done.

Figure from SAIC report, “Interim Report For The Winter Test of Production All-Weather Precipitation Accumulation Gauge (AWPAG) Winter 2008-2009”

Groisman and Legates find the precipitation records in the US have a discontinuity caused by the 1940s introduction of the Alter shields to some, but not all, of the US standard 8-inch rain gages.

More discussion on the problems with rain gage data by Groisman and Legates, 1994:

Vegetation growth and removal

Construction, removal of fences, buildings

Installation of instruments on building roof

then removing them from the roof…

and moving them to the airport…

A significant improvement to precipitation measurements in the US would be to add precipitation shields to the gages.

Groisman and Legates, Summary and Conclusions (1994)

We are undercounting precipitation especially where it is windy and snowy

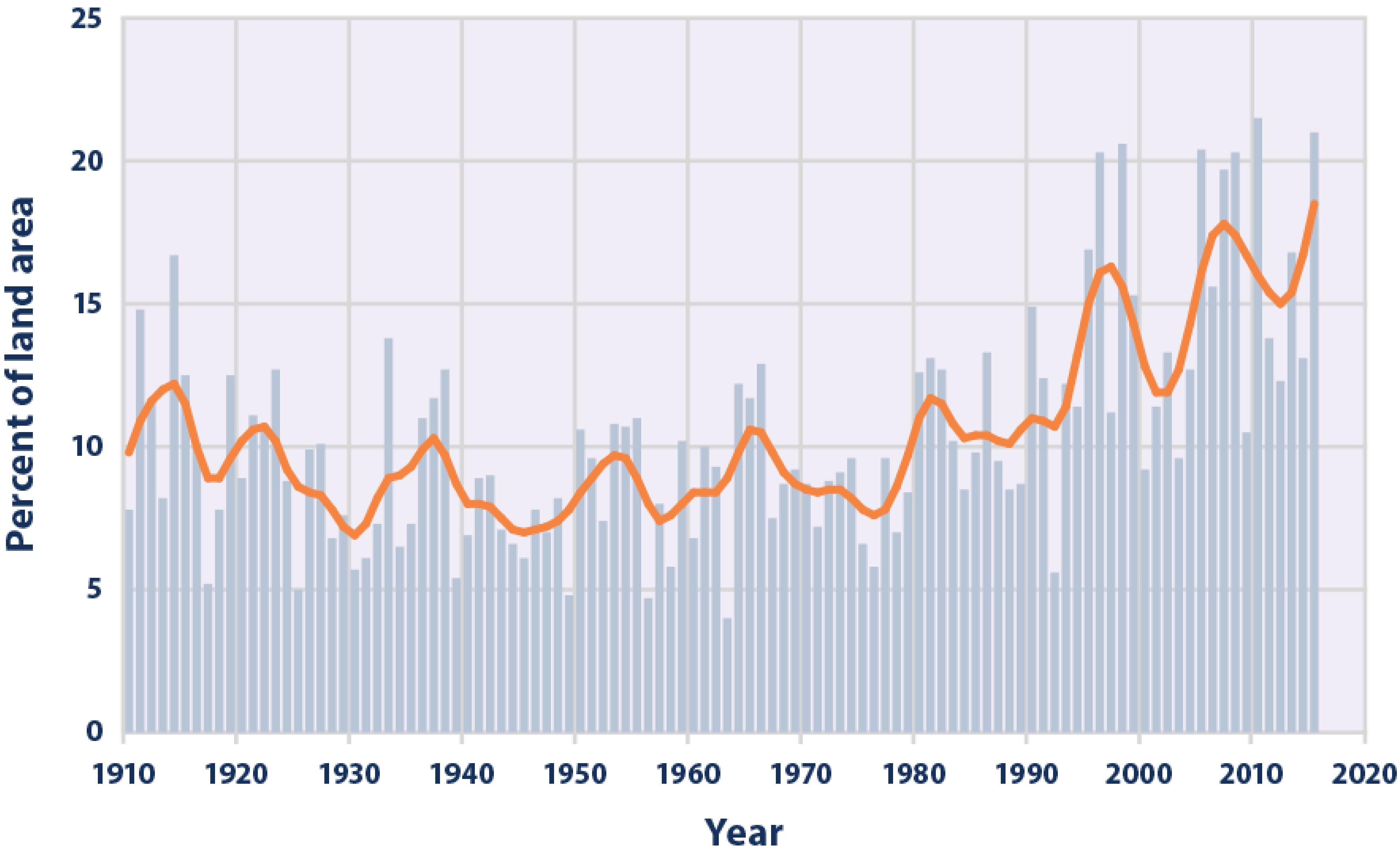
These problems are compounded in the mountain West

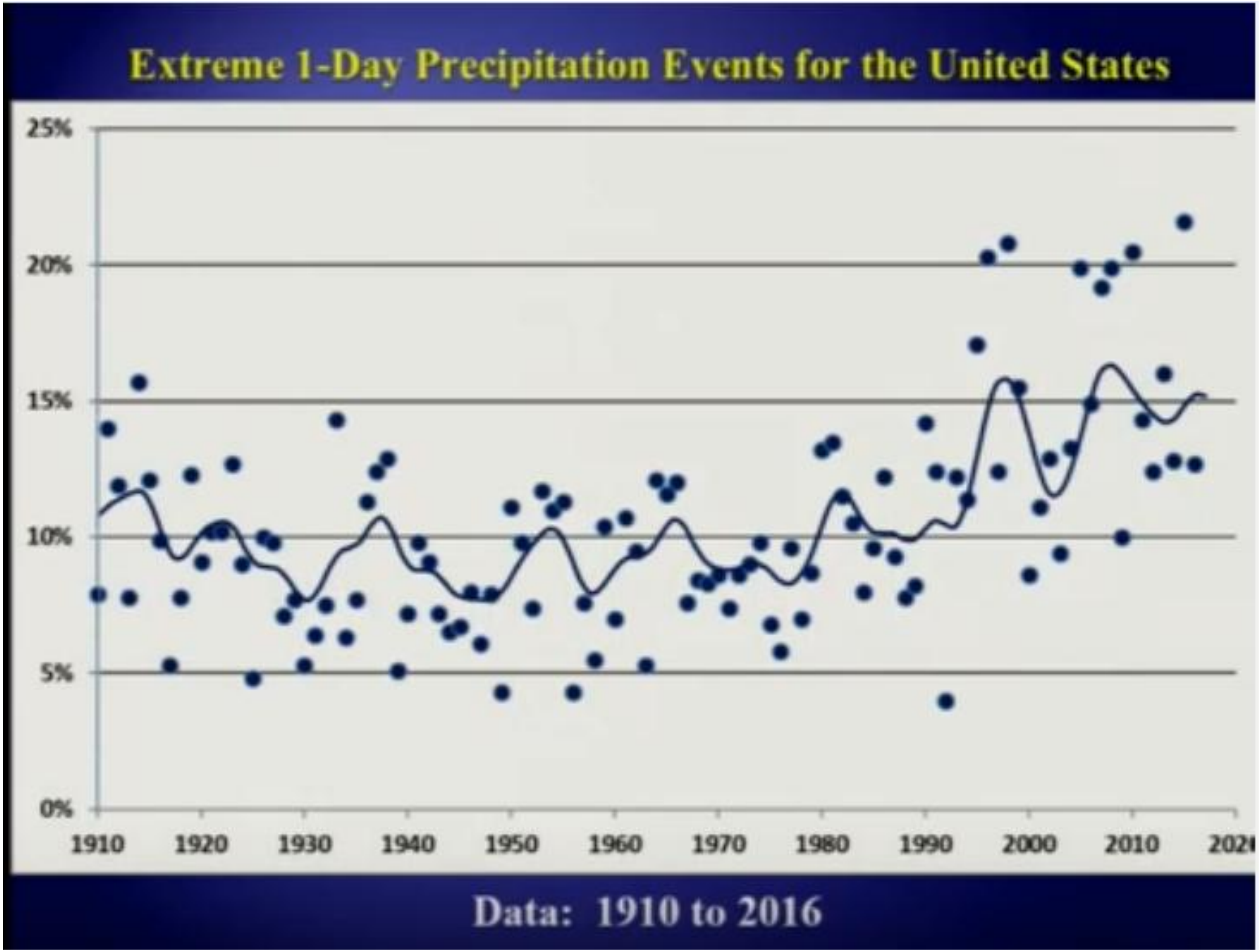
Introduction of shields in the 1940s to some, not all, of the gages presents a discontinuity

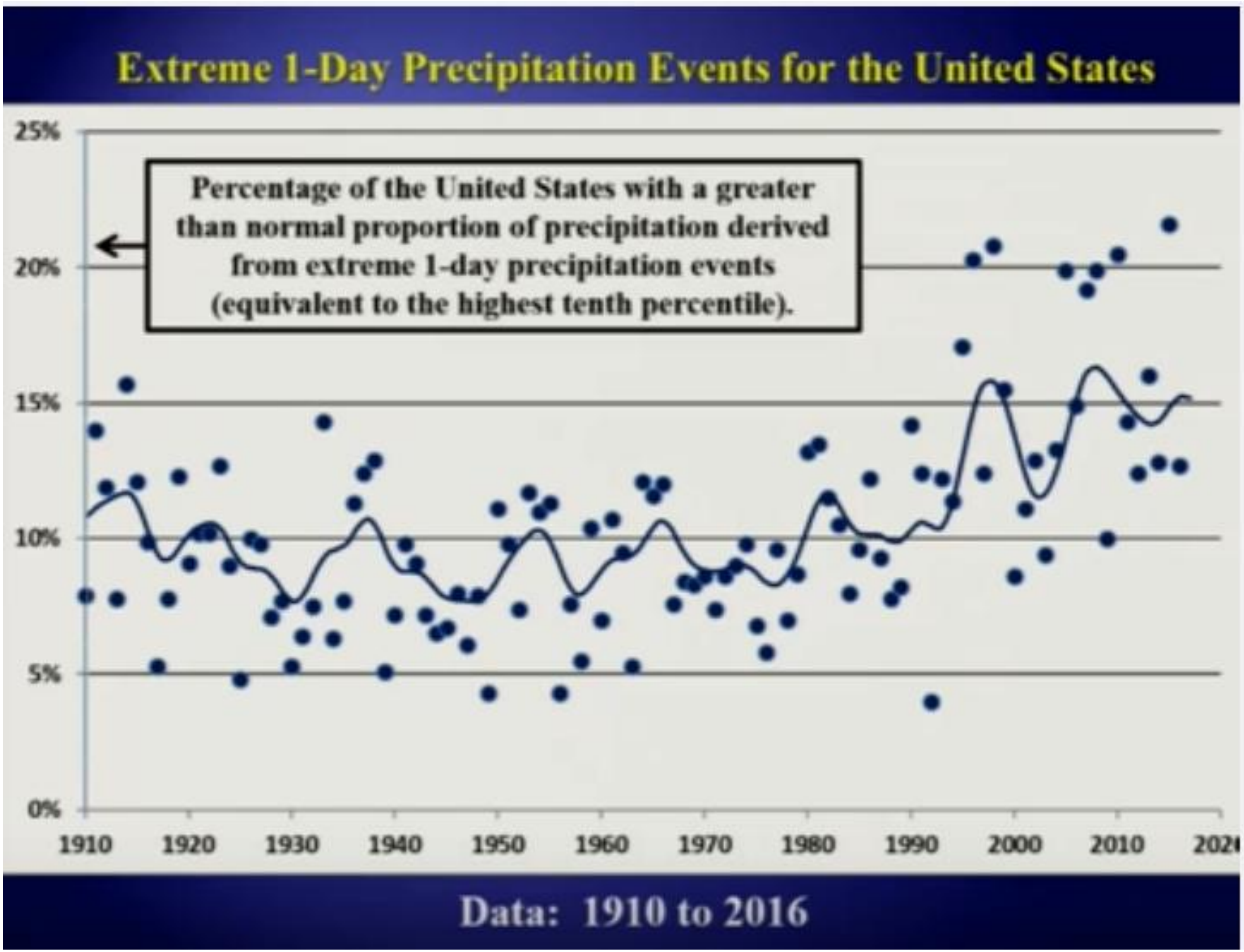
Studies of “climate change” not taking the above are likely to be misleading.

https://www.youtube.com/watch?v=yB6cbwVTWs4
1:42:00 to 1:57:00

https://www.epa.gov/climate-indicators/climate-change-indicators-heavy-precipitation

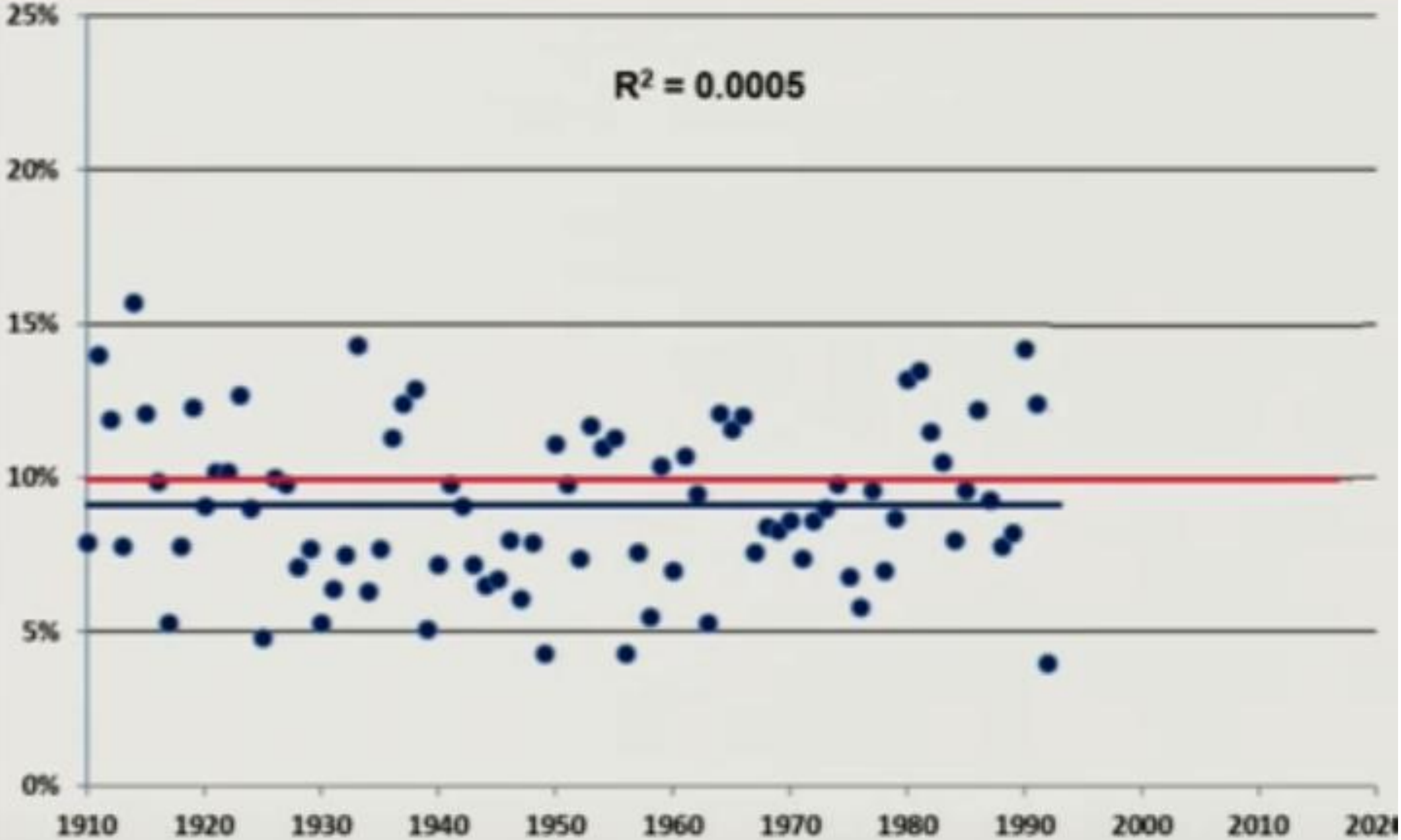



Extreme 1-Day Precipitation Events for the United States
25%
20%
15%
10%
5%
0%
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Data: 1910 to 2016



Extreme 1-Day Precipitation Events for the United States
Percentage of the United States with a greater than normal proportion of precipitation derived from extreme 1-day precipitation events (equivalent to the highest tenth percentile).
25%
20%
15%
10%
5%
0%
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Data: 1910 to 2016

Extreme 1-Day Precipitation Events for the United States

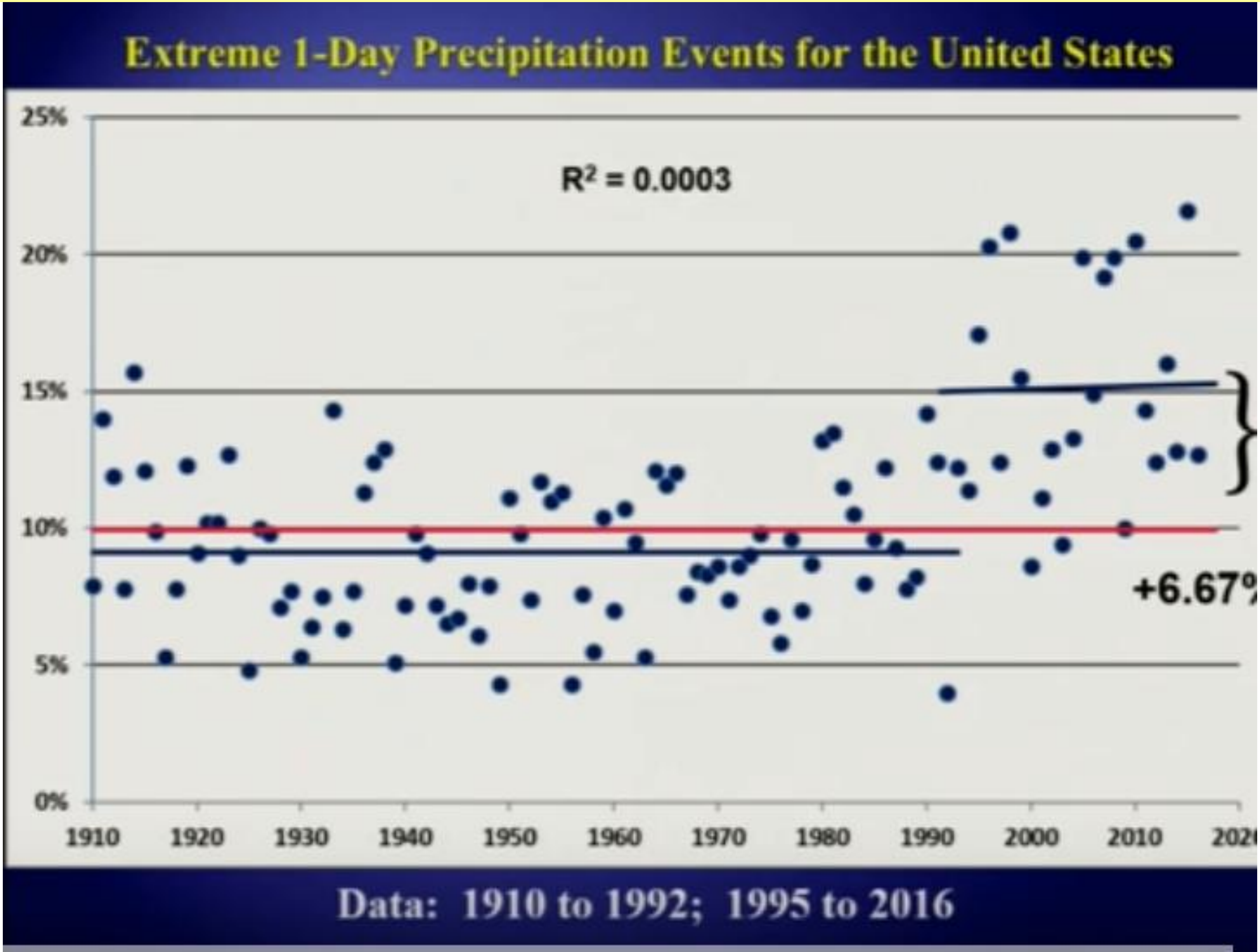


Data: 1910 to 1992

Extreme 1-Day Precipitation Events for the United States

Data: 1995 to 2016

Jump discontinuity, “square wave,” in the record!



Through 1992: Manual NWS 8" Raingage

Through 1992: Manual NWS 8" Raingage

An early Automated Surface Observation System (ASOS) Precipitation Sensor

Heated mouth allows collection of snow melt.

Wind Shield reduces precipitation losses.

Right:
Detail of Tipping Bucket mechanism used

NWS Modernization Program for Surface Weather Observations:

Since 1995 the ASOS Modernization program has replaced most 8-inch rain gages.

Shielded Rain Gages, closer to the ground, using automated, tipping-bucket gages.

Wind increases with height so lower collection mouth is better in principle.

Better Measurement, fewer precipitation wind/turbulence losses at rain gage height.

More information

NWS Surface Modernization Program

ASOS, Automated Surface Observation System

ASOS improvement program

“Final” -- ASOS precipitation measurement configuration

According to NOAA, completed in 2011

https://ams.confex.com/ams/Annual2005/techprogram/paper_82895.htm

Figure 2 **Frise tipping bucket gauge**

Early ASOS having the Frize heated tipping bucket rain gage

Source: Weather in Your Backyard, Ray Martin, Lead Forecaster NWS, powerpoint presentation on NWS Modernization Effort

https://ams.confex.com/ams/Annual2005/techprogram/paper_82895.htm

Ott weighing gage with integral Tretyakov shield

All-Weather Precipitation Accumulation Gauge, AWPAG

Figure 1 **Ott AWPAG**

https://ams.confex.com/ams/Annual2005/techprogram/paper_82895.htm

AWPAG, Integral Tretyakov shield, and 8-foot Alter style shield

ASOS, Automated Surface Observation System. Left, the All Weather Precipitation Accumulation Gage, AWPAG. 10-meter wind mast has the red and white color scheme.

Source: Weather in Your Backyard, Ray Martin, Lead Forecaster NWS, powerpoint presentation on NWS Modernization Effort

ASOS AWPAG in Wikipedia:

All-Weather Precipitation Accumulation Gage inside

8-foot Alter shield

https://www.meted.ucar.edu/hydro/precip_est/part1_measurement/navmenu.php?tab=1&page=3-7-0&type=text

Snow Measurements

NOAA/NWS Current Standard

Observing Practices

ASOS, Snow Paid and Snow Spotters

Thomas Townsend
Regional Observations Program Manager
NWS Central Region

May 25, 2011

ASOS

All LCD ASOS locations

- replaced Heated Tipping Bucket (HTB) with All Weather Precipitation Accumulation Gaug (AWPAG)
- Added a 8 ft double Alter shield during the last year

We now know that these precipitation increases are real, but they are artifacts of improved collection of precipitation with dual-shielded ASOS gages, not changing weather or climate.

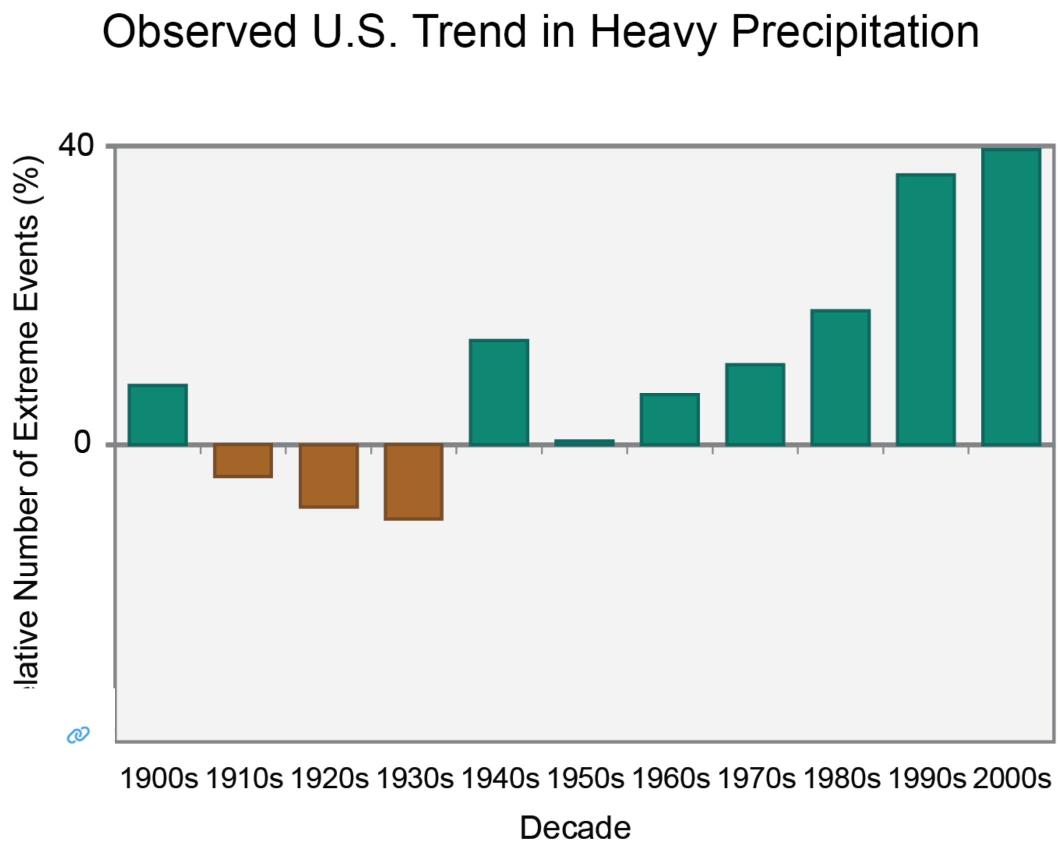


Figure 2.18: Observed Change in Very Heavy Precipitation