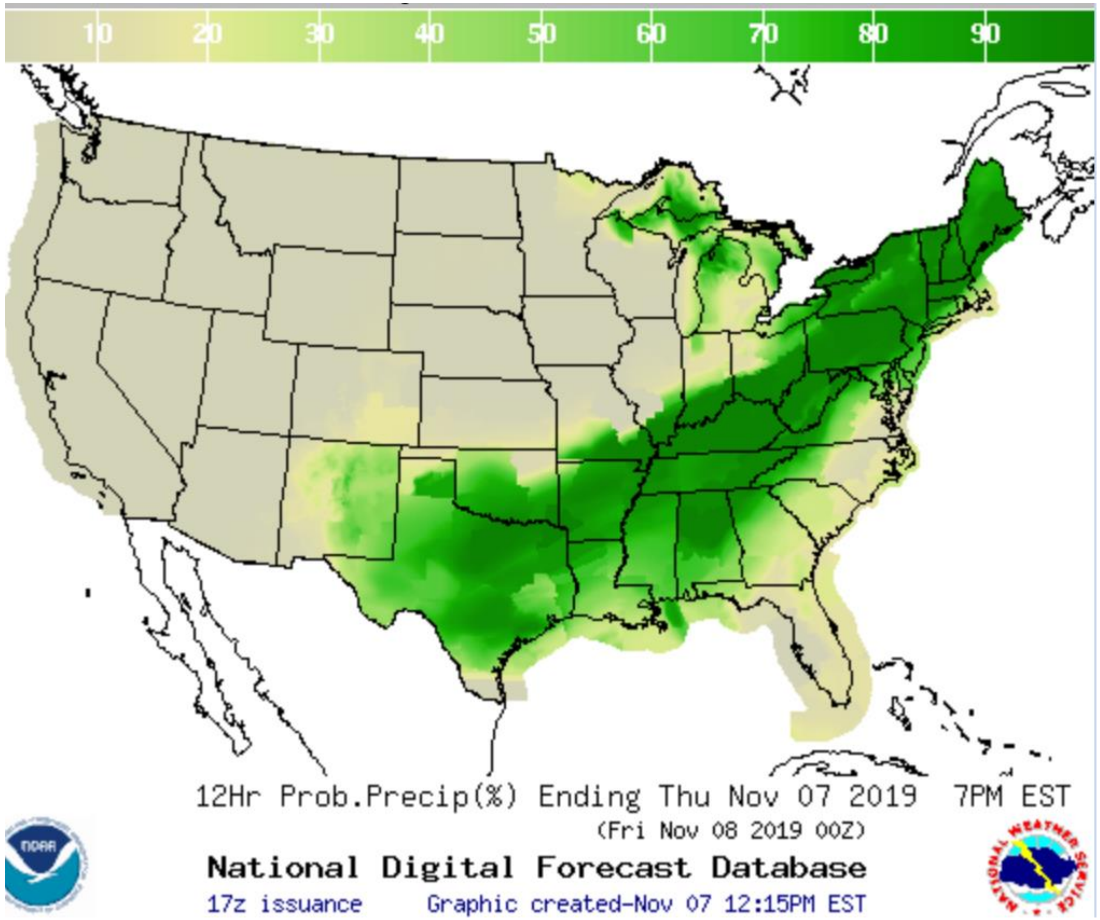
What does it mean when the chance of rain is 60% in the next 12 hours?

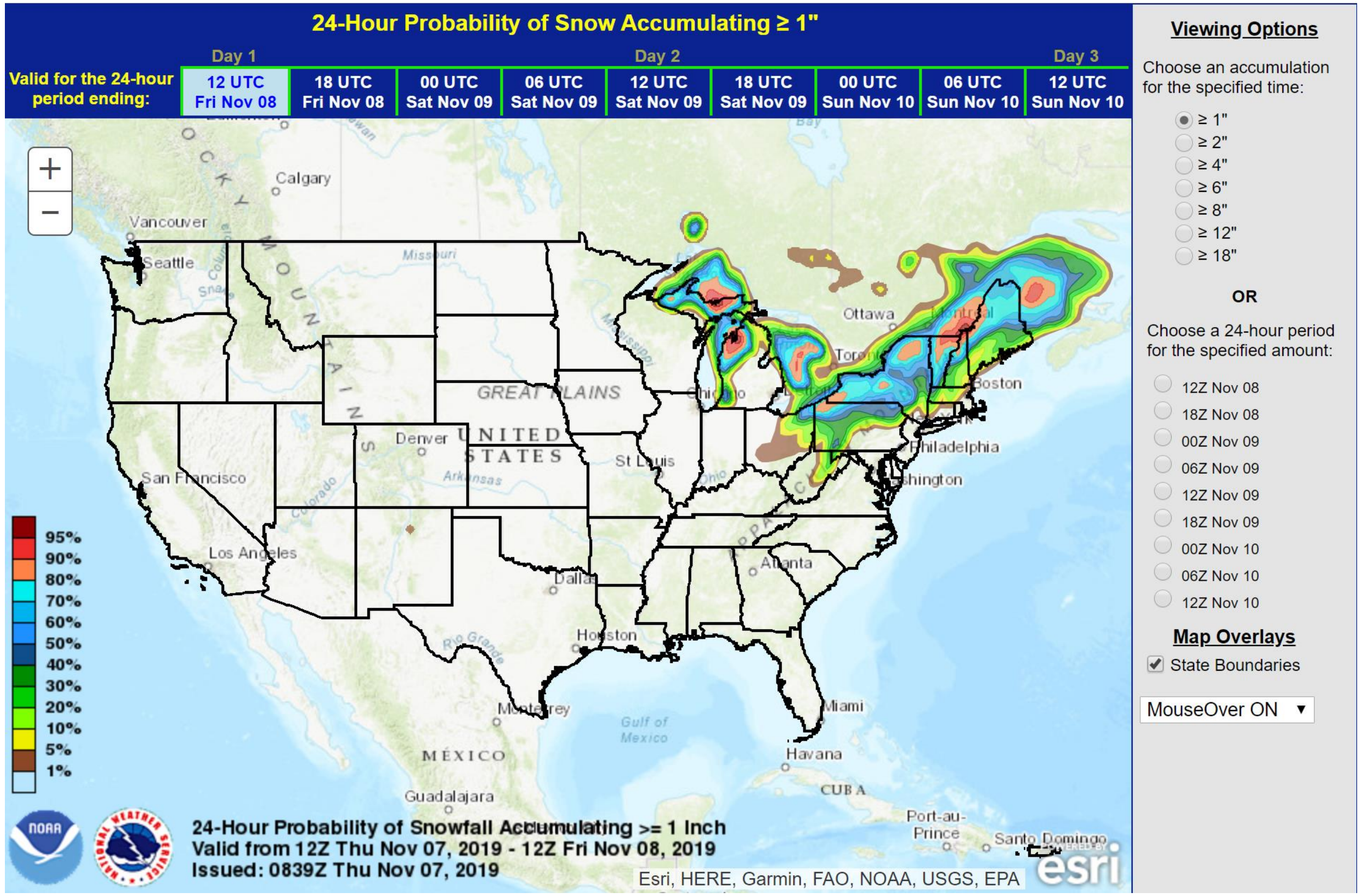
https://graphical.weather.gov/sectors/conus.php?element=PoP12



What does it mean when the chance of rain is 60% in the next 12 hours?

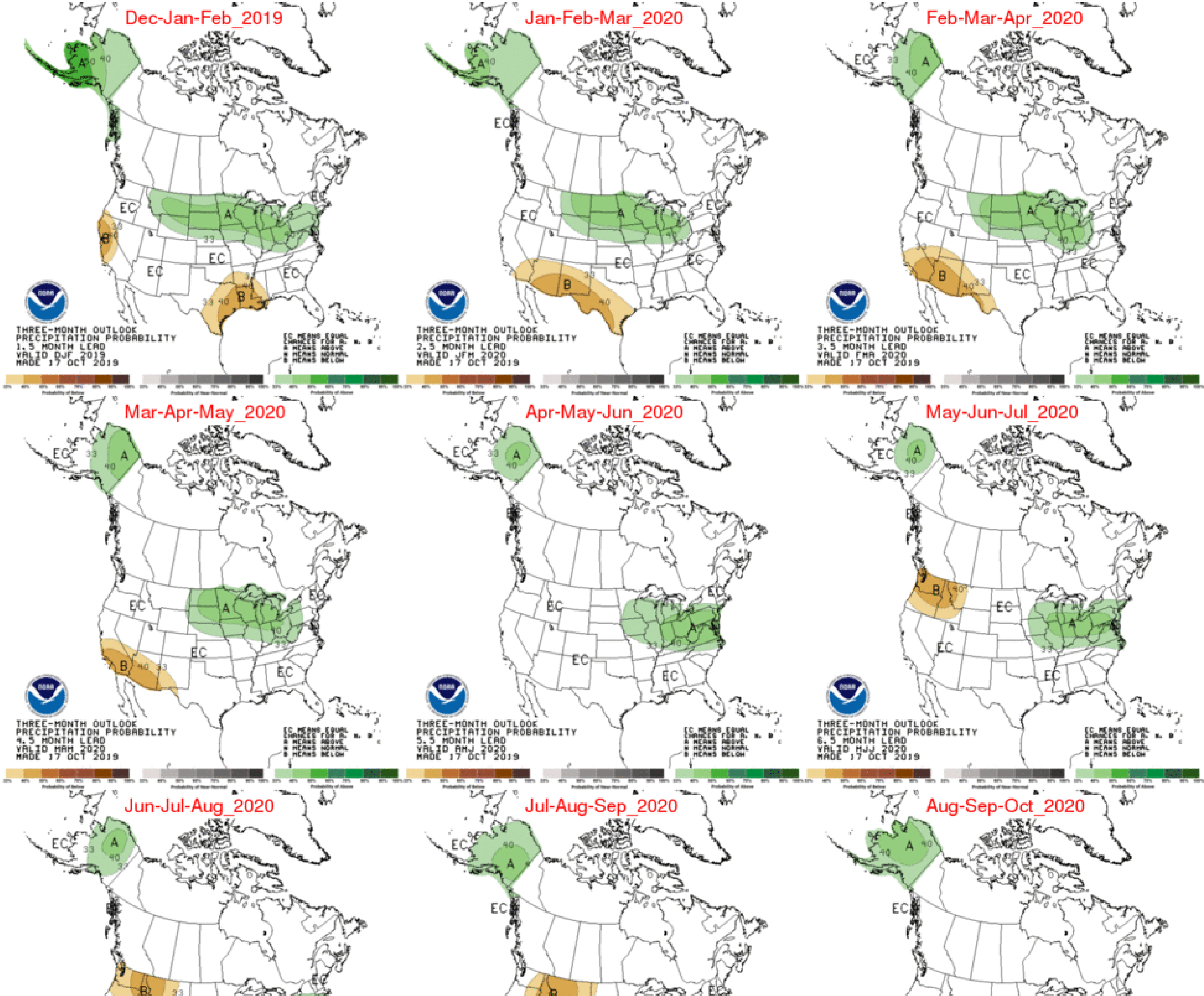
- There is a 60 percent chance that measurable precipitation (0.01 inch) will occur at any given point (grid box) in the area for which the forecast is made in the next 12 hours
- The complicated version that is not really that relevant:
- "Probability of Precipitation" (PoP) describes the chance of precipitation occurring at ***any*** point within an area.
- PoP = C x A
  - "C" = the confidence that precipitation will occur ***somewhere*** in the forecast area,
  - "A" = the percent of the area that will receive measureable precipitation, ***if it occurs at all.***
- If the forecaster knows precipitation is sure to occur (confidence is 100%), then indicating that only 60% of the area will receive measurable (>0.01 inch) precipitation
- Or, if expecting precipitation everywhere (A=1), then confidence is only 60% that rain will fall
- *But*, usually the PoP is a combination of confidence and areal coverage: most of the time, the forecaster is expressing a combination of degree of confidence (say 75%) *and* areal coverage (80%)

https://www.wpc.ncep.noaa.gov/pwpf/wwd_accum_probs.php

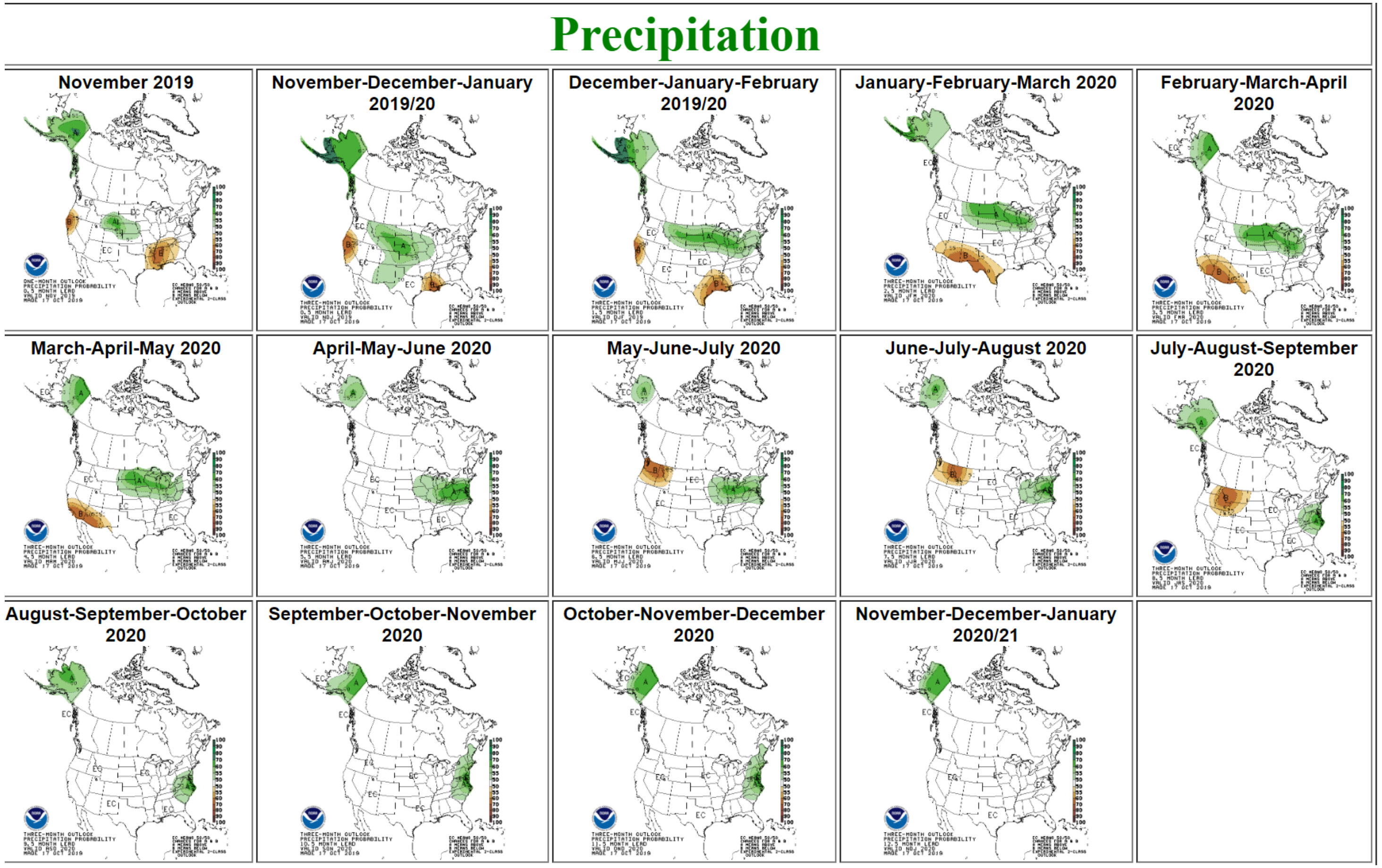


3 month outlooks
3 categories:
above
equal chance
below

https://www.cpc.ncep.noaa.gov/products/predictions/multi_season/13_seasonal_outlooks/color/p.gif



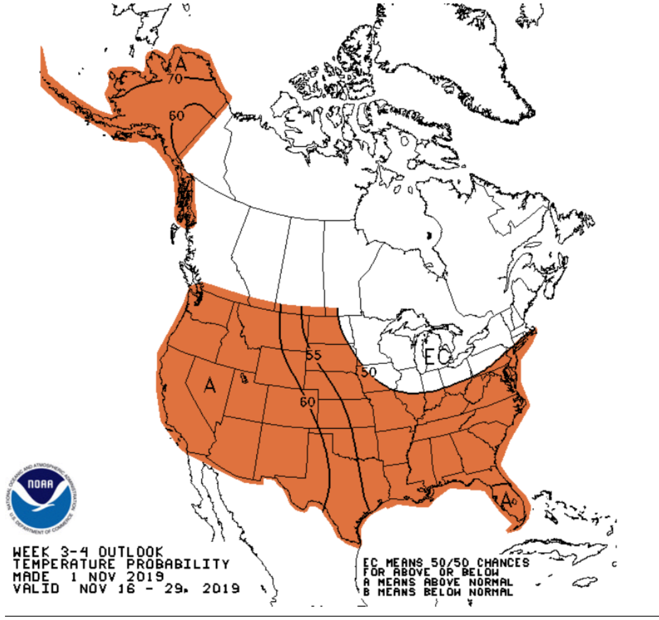
https://www.cpc.ncep.noaa.gov/products/predictions/long_range/two_class.php

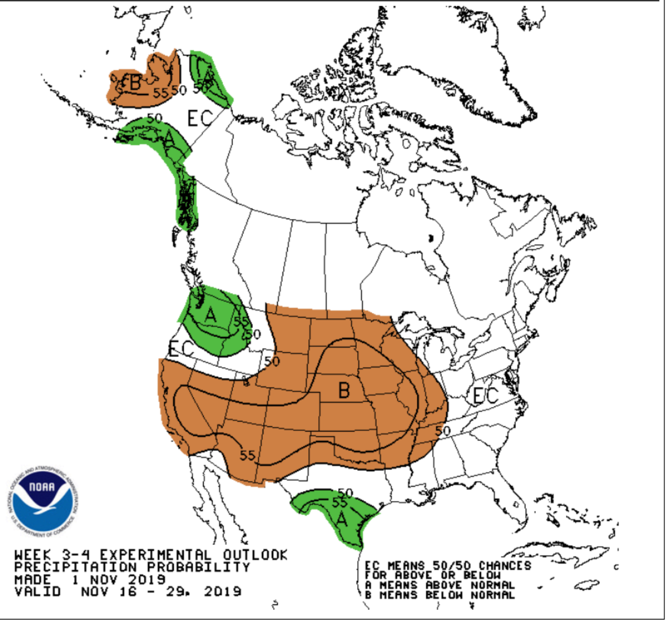


https://www.cpc.ncep.noaa.gov/

Click on product title to go to product page. Move cursor over product parameter name to display the graphic -- click to enlarge. Links to these same products are also available below.

6-10 Day Outlook (Interactive) Temperature Precipitation	**One Month Outlook (Interactive)** Temperature Precipitation
8-14 Day Outlook (Interactive) Temperature Precipitation	**Three Month Outlook (Interactive)** Temperature Precipitation
Week 3-4 Outlooks Temperature Exp. Precipitation	**U.S. Hazards Outlook** Composite 8-14 Day Probabilistic 8-14 Day: Temp Precip Wind
U.S. Drought Information Monitor Monthly Outlook Seasonal Outlook	**Global Tropics Hazards Outlook** Weeks 1 and 2





Probability Definitions

- Event- possible uncertain outcomes
- Null event- can’t happen
- Elementary event- can’t be decomposed into other events
- Compound event- decomposable into 2 or more elementary events
- S- sample or event space- all possible elementary events
- Mutually exclusive- two events that can’t occur at same time
- MECE- Mutually exclusive and collectively exhaustive- no more than 1 event can occur and at least one event will occur

More Definitions

- E- Event
- Pr{E}- probability of Event E; $0 \leq Pr\{E\} \leq 1$
- Pr{E} = 0, event does not occur
- Pr{E} = 1 event occurs

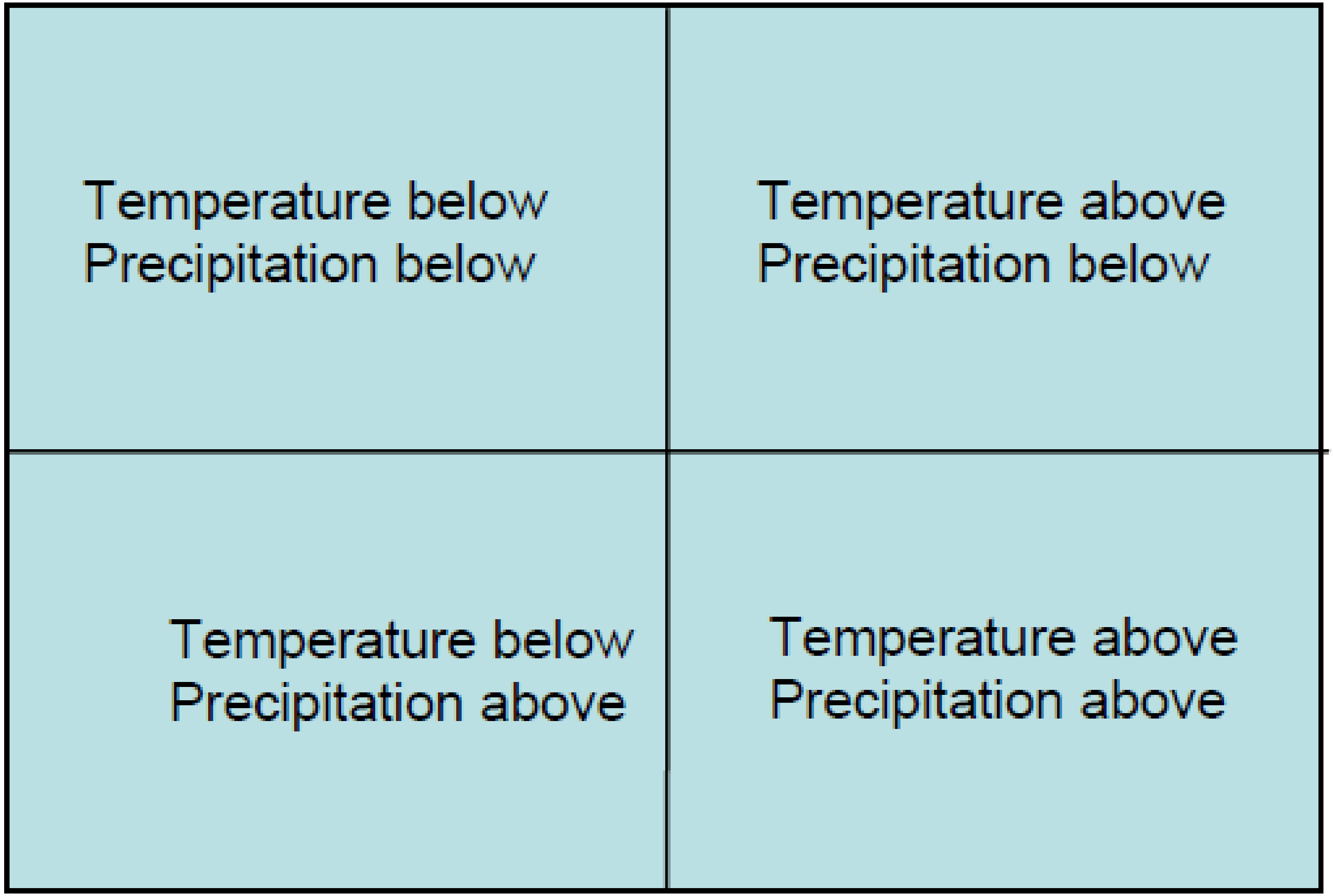


Figure 4.2. MECE possibilities for seasonal forecasts temperature and precpitation anomalies for a specifi location.

Two Statistical Frameworks: Frequency vs. Bayesian

- Frequency- probability of an event is its relative frequency after many trials
- a- number of occurrences of E
- n- number of opportunities for E to take place
- a/n- relative frequency of E occurring
- $Pr\{E\} \rightarrow a/n$ as $n \rightarrow \infty$

Two Statistical Frameworks: Frequency vs. Bayesian

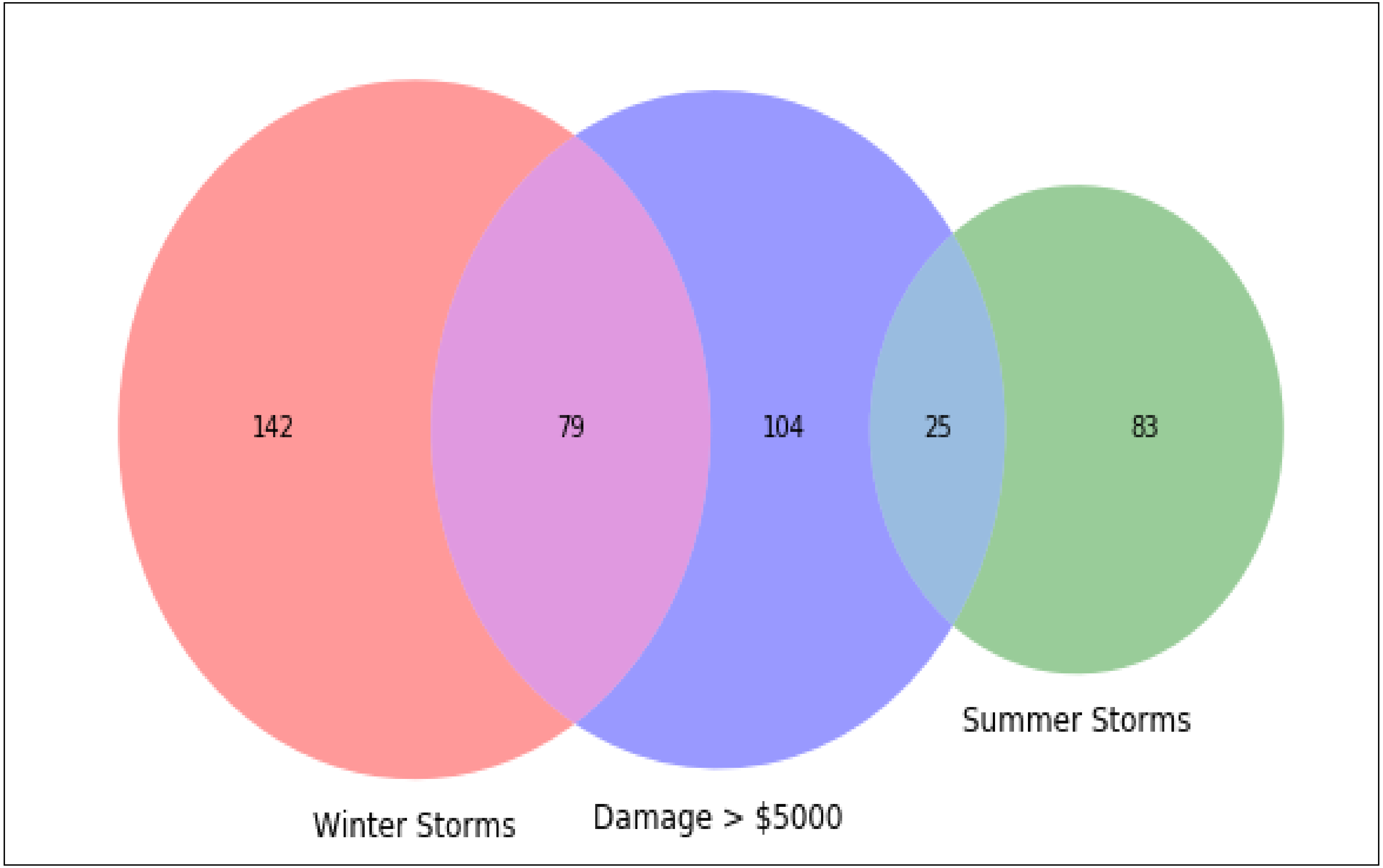
- Bayesian- probability represents the degree of belief of an individual about an outcome of an uncertain event
- Some events occur so rarely that there is no long-term relevant probability
- Two individuals can have different probabilities for same outcome
- Bookies are Bayesian
    - **Super Bowl odds 2019: Heavy Patriots money had sportsbooks rooting for Rams**

Deck of Cards

- If don’t look at cards, then the odds of getting any specific card when dealt cards is the same as if you only were dealt one card: they are independent events

Pr{ace}	Pr{10-K}	Pr{2-9}	Pr{21}
7.7	30.8	61.5	4.8

	Tally of occurrences	Total number of occurrences (a)	Tally of opportunities (2 x number of hands)	Total # of opportunities (n)	Observed probability a/n *100 (%)	Expected Probability from Part 1 (%)	Expected number of outcomes if n opportunities
ace				20		7.7	1.5
10-K				20		30.8	6
2-9				20		61.5	12
21				10		4.8	.5



Number of Opportunities: 2340 (180 days * 13 years)

More concepts

- $\{E\}^c$- complement of $\{E\}$, event does not occur
- $Pr\{E\}^c = 1-\{E\}$
- $Pr\{E_1 \cap E_2\}$- joint probability that E_1 & E_2 occur
- $Pr\{E_1 \cap E_2\} = 0$ if E_1 & E_2 are mutually exclusive
- $Pr\{E_1 \text{ U } E_2\}$- probability that E_1 OR E_2 occur
- $Pr\{E_1 \text{ U } E_2\} = Pr\{E_1\} + Pr\{E_2\} - Pr\{E_1 \cap E_2\}$

Conditional Probability

- Conditional probability: probability of $\{E_2\}$ given that $\{E_1\}$ has occurred
- $Pr\{E_2 \mid E_1\} = Pr\{E_1 \cap E_2\} / Pr\{E_1\}$
- E_1 is the conditioning event
- If E_1 and E_2 are independent of each other, then $Pr\{E_2 \mid E_1\} = Pr\{E_2\}$ and $Pr\{E_1 \mid E_2\} = Pr\{E_1\}$
- Fair coin- Pr{heads} = 0.5
  - chance of getting heads on second toss is independent of the first

    Pr{heads | heads} = 0.5

    Pr{heads} twice = 0.5 * 0.5 = .25

Bayes Theorem

- $Pr\{E_2 \mid E_1\} = Pr\{E_1 \cap E_2\} / Pr\{E_1\}$
- E_1 is the conditioning event
- What is the advantage? Probability of conditioning event E_1 only computed once

- $Pr\{E_1 \mid E_2\} = Pr\{E_2 \mid E_1\} * Pr\{E_1\} / Pr\{E_2\}$

- $Pr\{E_1 \cap E_2\} = Pr\{E_2 \mid E_1\} * Pr\{E_1\}$
- $Pr\{E_1 \cap E_2\} = Pr\{E_1 \mid E_2\} * Pr\{E_2\}$ then

Bayesian Application: how you should respond to "evidence"

	Pos Test	Neg Test	TOTAL
DRUG USER	0.495%	0.005%	0.5%
NOT DRUG USER	.995%	98.505%	99.5%
TOTAL	1.49%	98.51%	1

How many drug users test positive? 99%
*Out of a ten thousand people, how many drug users do they catch? .00495*10000=~50*

What are odds of falsely accusing non drug user?
E_1 – not drug user
E_2 - positive test
$Pr\{E_1\}$ – 99.5%
$Pr\{E_2\}$ – 1.49%
$Pr\{E_2 \mid E_1\}$ – .995%
$Pr\{E_1 \mid E_2\} = Pr\{E_2 \mid E_1\} * Pr\{E_1\} / Pr\{E_2\} = 0.995 * 99.5 / 1.49 = 68\%$

- If you are a non drug user, you have a 68% chance of getting a "false positive"
- *How many non-drug users get falsely accused?.00995*10000=~100*

Conclusion: always always ask for second opinion if clean and test positive

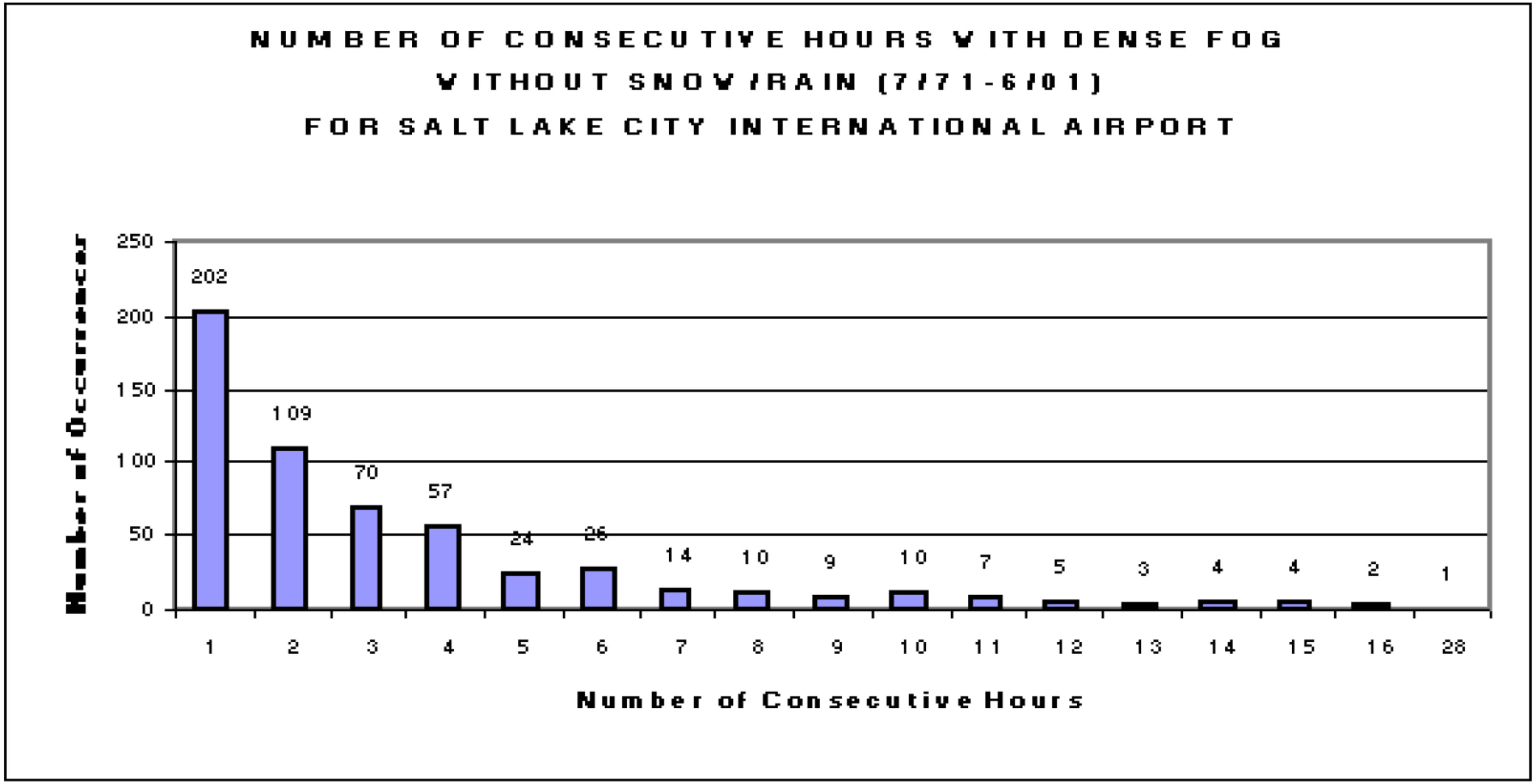
Application of Bayes theorem: how to be rational responding to probabilities

	Pos Test	Neg Test	TOTAL
DRUG USER	0.495%	0.005%	0.5%
NOT DRUG USER	.995%	98.505%	99.5%
TOTAL	1.49%	98.51%	1

What are odds of a drug user skating?
E_4 – drug user
E_3 - negative test
$Pr\{E_3\}$ – 98.51%
$Pr\{E_4\}$ – 0.5%
$Pr\{E_3 \cap E_4\}$ – .005%
$Pr\{E_4 \mid E_3\} = Pr\{E_4 \cap E_3\} / Pr\{E_3\} =$
$= 0.005 / 98.51 = .0051\%$
Out of 10000 people, maybe 1 drug user will test negative
Conclusion: people who give drug tests are more interested in making sure drug users are caught than worrying about innocent people being falsely accussed

Olympic Fog Climatology

When phenomena are persistent, then “odds” are higher once an event is underway



Forecast Verification

- What is your reason for doing it?
- (Brier and Allen 1951; Compendium of Meteorology)
  – Administrative: who's blowing the forecasts?
  – Scientific: why do errors happen?
  – Economic: what's the impact of forecast errors?

What you should be doing

- Read Chapter 2 & 3a Notes
- Assignment 4 due November 8. Finish it today
- Assignment 5 Extra Credit . Due Nov. 15

Measures oriented: "give me a number!"

- Distill set of forecasts and observations into small # of metrics

		Observed	Observed	Forecast marginal totals
		Yes	No	
Forecast	Yes	a	b	a+b
Forecast	No	c	d	c+d
	Observed marginal totals	a+c	b+d	n=a+b+c+d sample size

- PC = percent correct = $\frac{a+d}{n}$
- FAR = false alarm ratio = $\frac{b}{a+b}$
- TS = CSI = $\frac{a}{a+b+c}$
- POD = HR = $\frac{a}{a+c}$

What if it just happened by chance?

		Observed	Observed	Forecast marginal totals
		Yes	No	
Forecast	Yes	a	b	a+b
Forecast	No	c	d	c+d
	Observed marginal totals	a+c	b+d	n=a+b+c+d sample size

- Random correct yes forecast by chance = $\frac{(a+b)}{n}\frac{(a+c)}{n}$
- Random correct no forecast by chance = $\frac{(b+d)}{n}\frac{(c+d)}{n}$
- $SS = \frac{(correct\ forecasts - random\ correct\ forecasts)}{(total\ forecasts - random\ correct\ forecasts)}$
- $HSS = \frac{2(ad-bc)}{(a+c)(b+d)+(a+b)(b+d)}$

Verifying wind forecasts

		Observed	Observed	Forecast Marginal totals
		≥ 5m/s	<5 m/s	
Forecast	≥ 5m/s	11	6	17
Forecast	<5 m/s	16	44	60
	Observed Marginal totals	27	50	77

PC= 71.4%; FAR= 35.3%; TS= 33.3%; and POD = 40.7%
randomly correct yes forecast: 7.7%
randomly correct no forecast: 50.1%
HSS= 31.4%

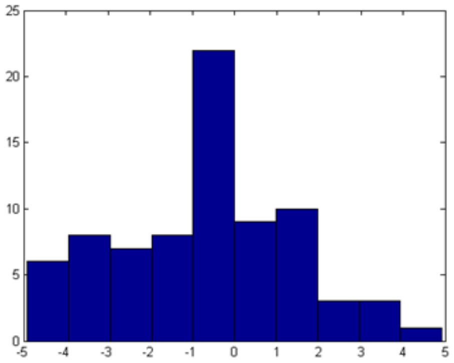
Distributions oriented: “ how close am I?”

- Assessing the characteristics of joint distribution of errors
- Categorize errors: which errors are smallest, which are biggest as a function of the range of values?
- Relies heavily on conditional probabilities
- http://meso1.chpc.utah.edu/jfsp/

Forecast Verification

- http://meso1.chpc.utah.edu/jfsp/
- Select Wildfires by WFO
- Select SLC
- Look at over all years, then focus on wildfires in Utah in 2016
- Then follow along in class

Assessing Forecast Accuracy



		Observed	Observed	Observed	Error Marginal totals
		≤3 m/s	3-6 m/s	≥6 m/s	
Error	≤ -2 m/s	0	10	11	21
Error	± 2 m/s	22	20	7	49
Error	> 2 m/s	0	7	0	7
	Observed Marginal totals	22	37	18	77

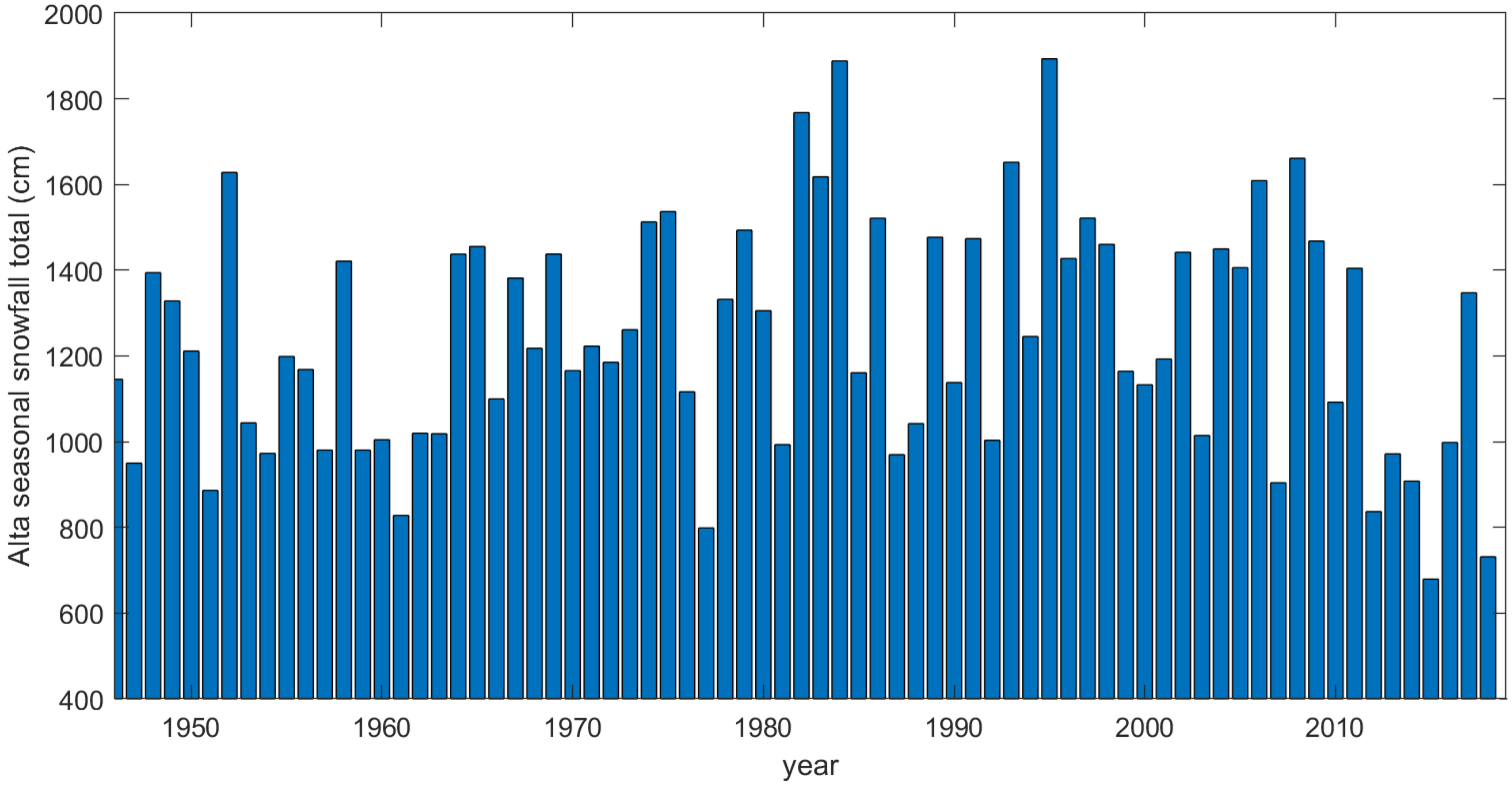
- 26% of the forecasts were within 2 m/s when the wind speeds were between 3 and 6 m/s (20/77)
- Given that the observed wind speed is greater than 6 m/s: ($Pr\{E_1\} = 18/77 = 23.4\%$)
- Probability that the forecasters predict strong winds to be too light $Pr\{E_2 \mid E_1\}$:

$Pr\{E_2 \mid E_1\} = Pr\{E_1 \cap E_2\} / Pr\{E_1\} = ((11/77)/(18/77)) = 64.7\%$

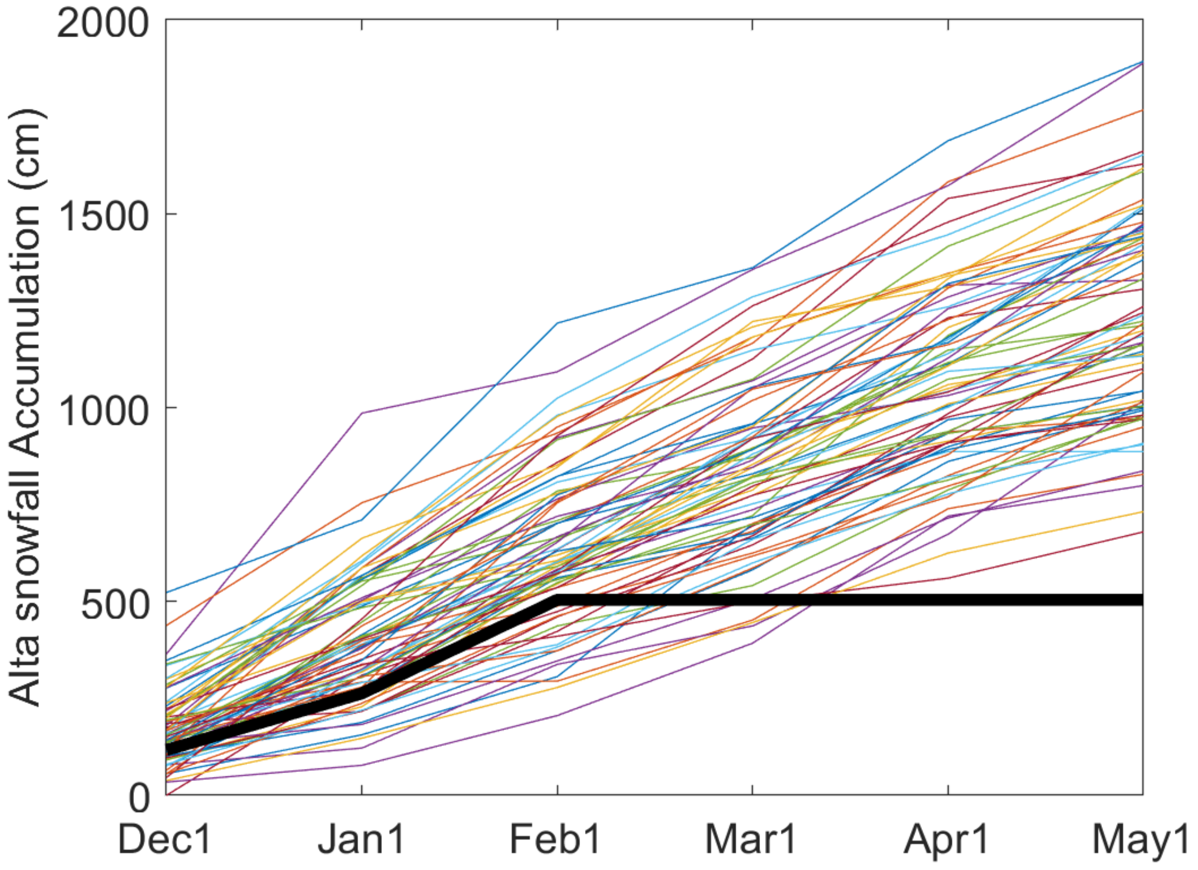
What can we say about estimating this winter's snow total will be?

- What physically is happening?
- Could we use last winter's snow total to predict this winter's?
    - Persistence from one year to next
- What about the amount of snow earlier this winter or right now?
    - Persistence from one month to the next…

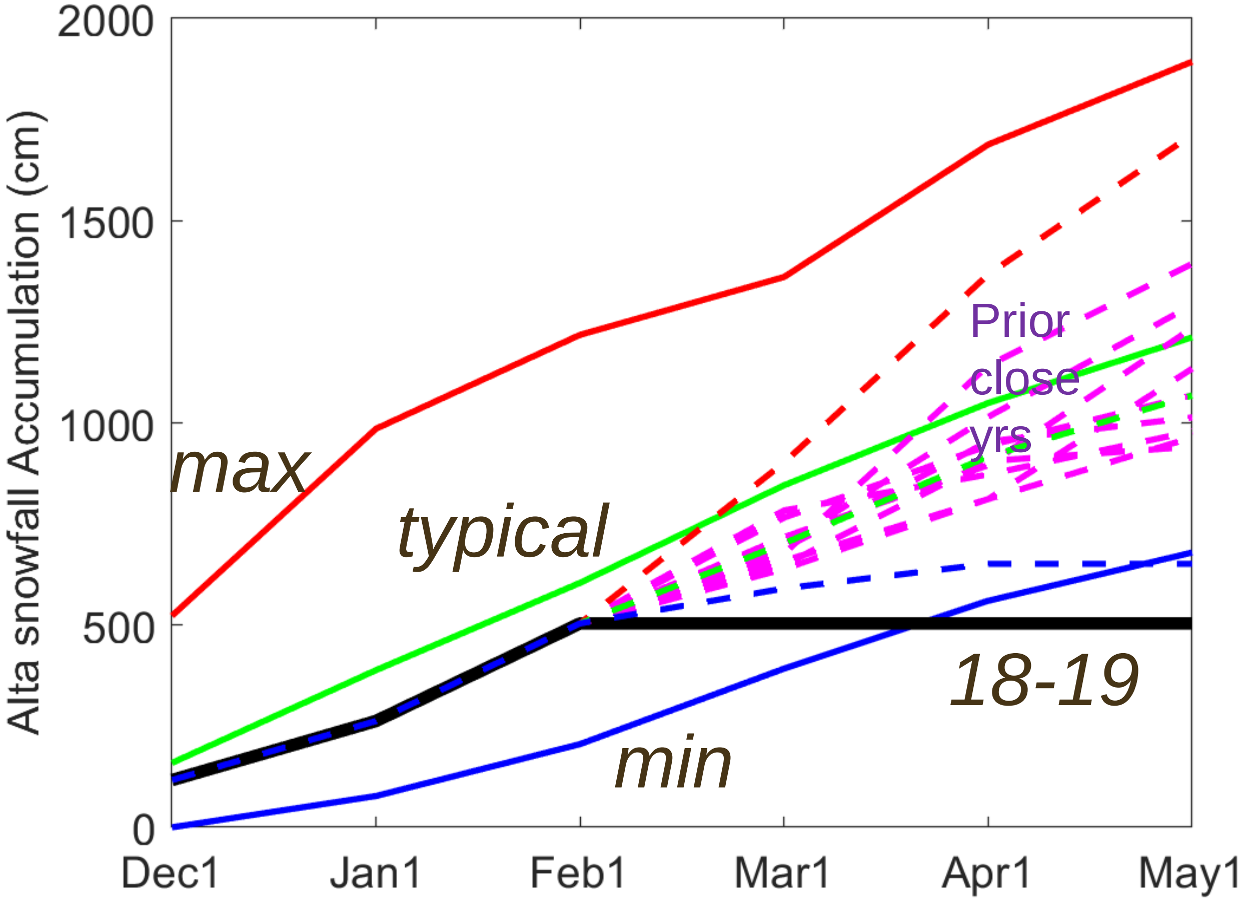
Alta Snowfall Seasonal Totals



Atla Snowfall Accumulation Each Winter



How Much Snow Might Accumulate During the Season at Alta?



Predict May 1 Snowfall from Dec 1 Snowfall

Case 1. Predictor: Dec1 total snowfall (cm)					
Predictand: May 1 Total snowfall at Alta (cm)		Below	Near	Above	Marginal Totals
	Below	14	9	1	24
	Near	6	9	10	25
	Above	4	7	13	24
	Marginal Totals	24	25	24	73

Predict May 1 Snowfall from Dec 1 Snowfall

$Pr\{E_1\}$	24/73=33%	$Pr\{M_3 \mid E_3\}$	13/24=54%
$Pr\{E_1 \cap E_2\}$	0	$Pr\{E_1 \mid M_1\}$	14/24=58%
$Pr\{E_1 \cap M_1\}$	14/73=19%	$Pr\{E_2 \mid M_1\}$	9/24=38%
$Pr\{E_1 \cap M_3\}$	4/73= 5%	$Pr\{E_3 \mid M_1\}$	1/24=4%
$Pr\{M_1 \mid E_1\}$	14/24=58%	$Pr\{E_3 \mid M_3\}$	13/24=54%
$Pr\{M_3 \mid E_1\}$	4/24=17%	$Pr\{E_1 \cap M_1\}$ IF random	9/72=11%
$Pr\{M_3 \mid E_2\}$	7/24=29%	% May 1 total same as Predictor	36/73= 49%

Predict May 1 Snowfall from Last Year's May 1 Snowfall

Case 6. Predictor: May1 Prior Year total snowfall (cm)					
Predictand: May 1 Total snowfall at Alta (cm)		Below	Near	Above	Marginal Totals
	Below	10	7	7	24
	Near	5	12	7	24
	Above	8	6	10	24
	Marginal Totals	23	25	24	72