No. 46-22

Testing the Efficacy of Climate Forecast Maps as a Means of Communicating with Policy Makers

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1. Introduction

In earth science education, understanding and use of real data play an important role: students are expected to gain a better understanding of various aspects of earth phenomena by collecting, analyzing, interpreting, and visualizing empirical data, whether in the lab or in the field. Many instructors, however, have experienced that some students have difficulty with it. In this research, we focus on prospective environmental managers and policy makers, and examine (a) how well they understand data shown on climate forecast maps and (b) how they use the data in decision making.
In cartography, there has been interest in how people understand thematic maps, particularly the relationship between the map maker's intention and the map reader's interpretation (Figure 1). This research builds upon that body of literature, and extends it by examining interpretation of rather complex spatial representations (i.e., going beyond individual map symbols) in the context of decision making.

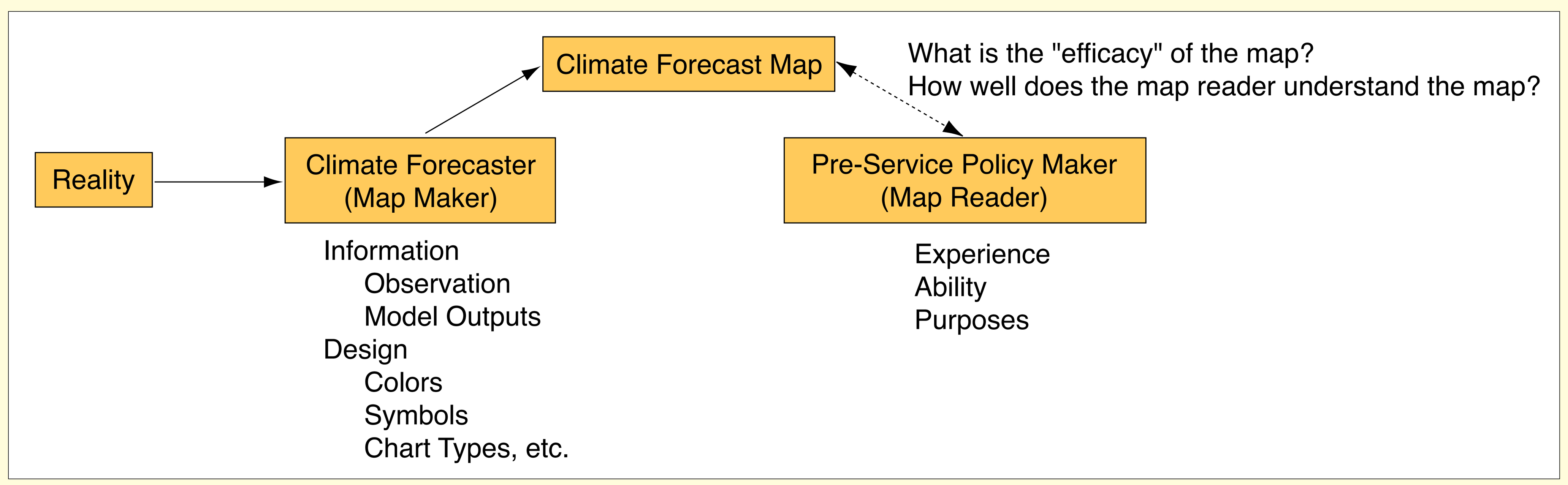


Figure 1. Relationship between the climate forecaster (map maker) and the pre-service policy maker (map reader). The map maker intends to convey specific information with various design tools; the map reader understands the map with varying experience, ability, purposes, and so on. How can the design be improved? How can the map understanding ability be trained? What is a good relationship among these variables?

2. Method

The participants were 47 students (27 male and 20 female) in the MPA (Master in Public Management) program in Environmental Policy Studies at the School of International and Public Affairs, Columbia University.
The materials used were climate forecast maps, constructed and issued by the International Research Institute for Climate Prediction for people in charge of environmental management and decision making (which may be found at http://iri.columbia.edu/climate/forecast/net_asmt).
The participants were shown precipitation forecast maps, and asked questions designed to assess their understanding and interpretation of the data shown on the maps.

3. Major Findings

Major findings from this research can be summarized as follows:

1. Even these qualified and motivated students in the master's program aimed for prospective policy makers failed to interpret some of the forecast maps as the map maker intended: the "efficacy" of the maps as a communication tool was less than one would hope for.

2. They understood observed precipitation maps easily, whereas they had trouble understanding probability forecast maps.

3. It was particularly difficult for them to make a logical inference by referring to and combining two or more maps.

4. Most of the students were not inclined to rely on these types of climate forecast data for agricultural decision making.

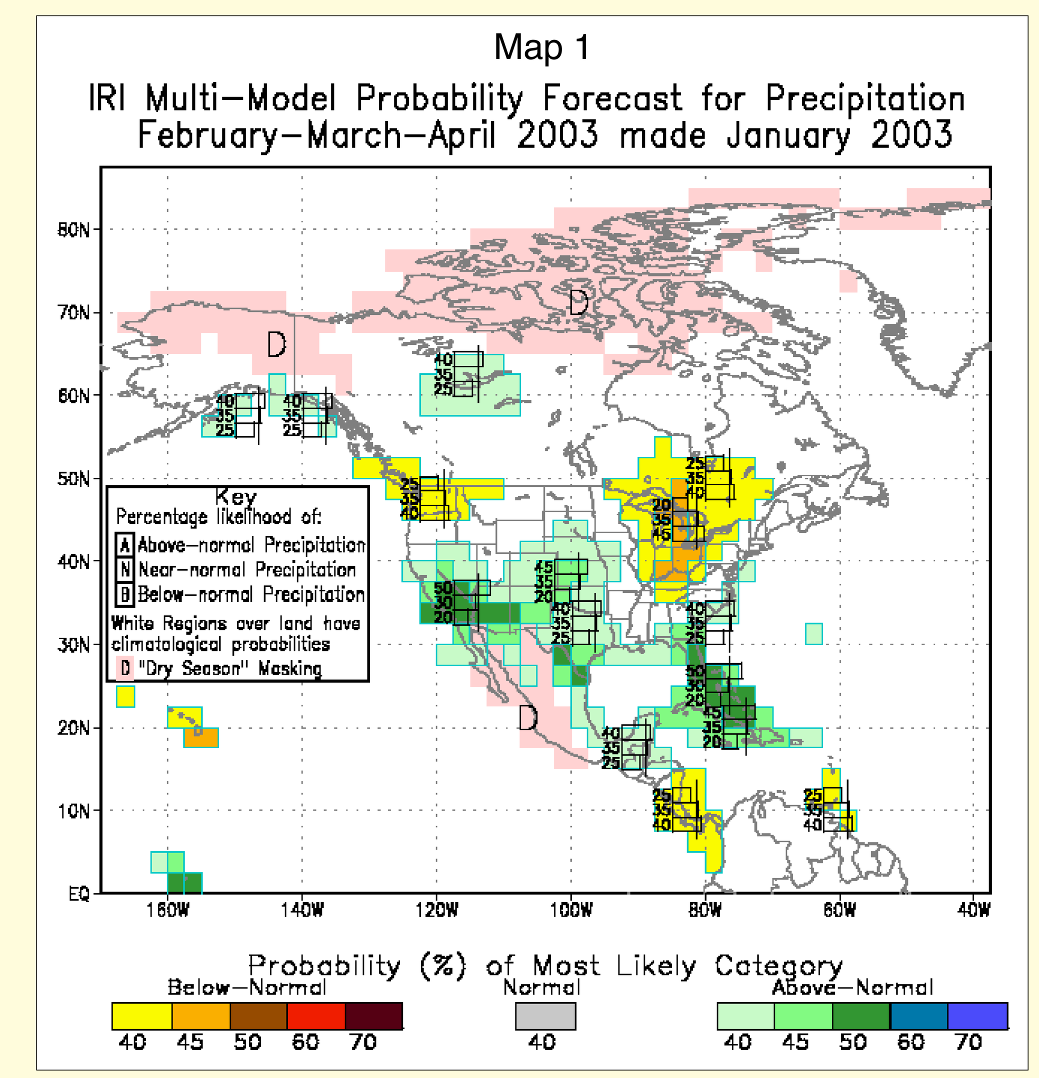
Individual results will be discussed below, along with the questions and maps given to the participants.

4. Results and Discussion

Question 1

The first map (Map 1) is a probability forecast map of precipitation for February-March-April 2003. The map was made in January 2003. It shows in color the probability that individual locations would have more or less precipitation than normal. *Normal* is defined as being in the center one-third of the years in a 30-year database. *Above normal* is defined as being in the wettest one-third of the years, and *below normal* is defined as being in the driest one-third of the years, in the 30-year database. The horizontal bar graphs shown on the colored areas indicate the probability of forecasts falling into, from top to bottom, the *above normal*, the *normal*, and the *below normal* categories.

Suppose that you are given this forecast map (Map 1) in January 2003. Based on this map, how would you answer the following question: "Which area will receive a greater amount of total precipitation for this forecast period, Southern California or Washington State?"



To answer this question correctly, students need to understand that the map only shows whether a specific region is likely to receive more or less precipitation than normal for that region, in terms of probability. Because no information is given about the amount of precipitation in the normal years, the correct answer is "cannot tell." If they simply note that Southern California is classified as *above normal*, and Washington State as *below normal*, they are erroneously led to choose Southern California as having a greater amount of precipitation.
Of the 47 participants, 24 students (51%) correctly answered "cannot tell," but 23 students (49%) wrongly answered "Southern California" (Figure 2).

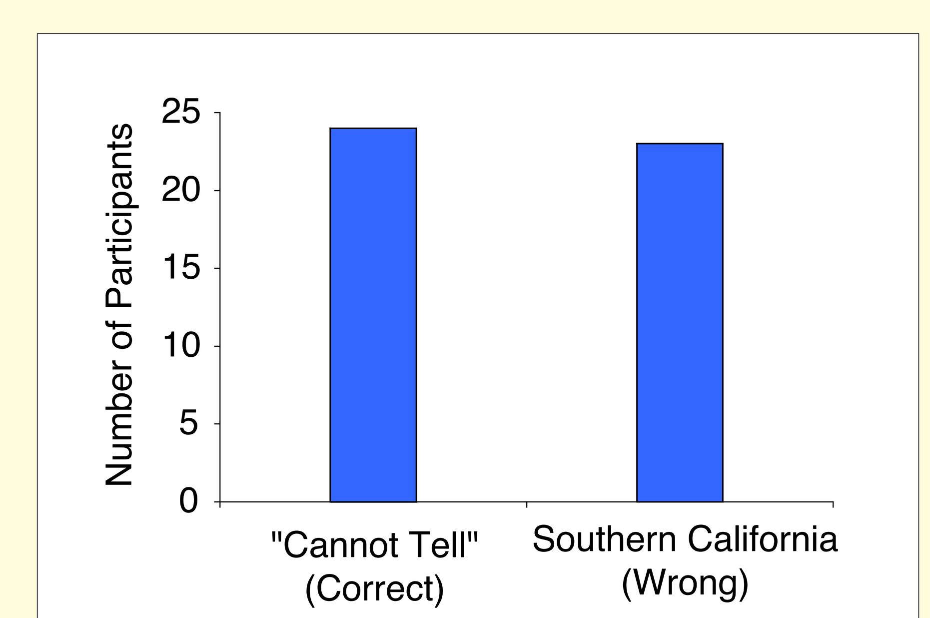


Figure 2. Distribution of responses to Question 1. About half the students came to a wrong conclusion.

Question 2

The second pair of maps compares a forecast of precipitation for October-November-December 2002 (Map 2A), and the observed precipitation during the same time period (Map 2B). The forecast map (Map 2A) was made in September 2002 and shows probability in the same way as in Map 1. The observed precipitation map (Map 2B) shows *precipitation anomaly*, which is defined as the percentage of the long-term median precipitation at that place for those 3 months. In other words, *100%* means that observed rainfall was the same as the median rainfall at that place for those 3 months. On Map 2B, the colors and contours both show precipitation anomaly.

Based on Maps 2A and 2B, please answer the following questions:

(a) Identify a region that may have suffered drought conditions during October-November-December 2002.

(b) Identify a region that may have suffered flood damage during October-November-December 2002.

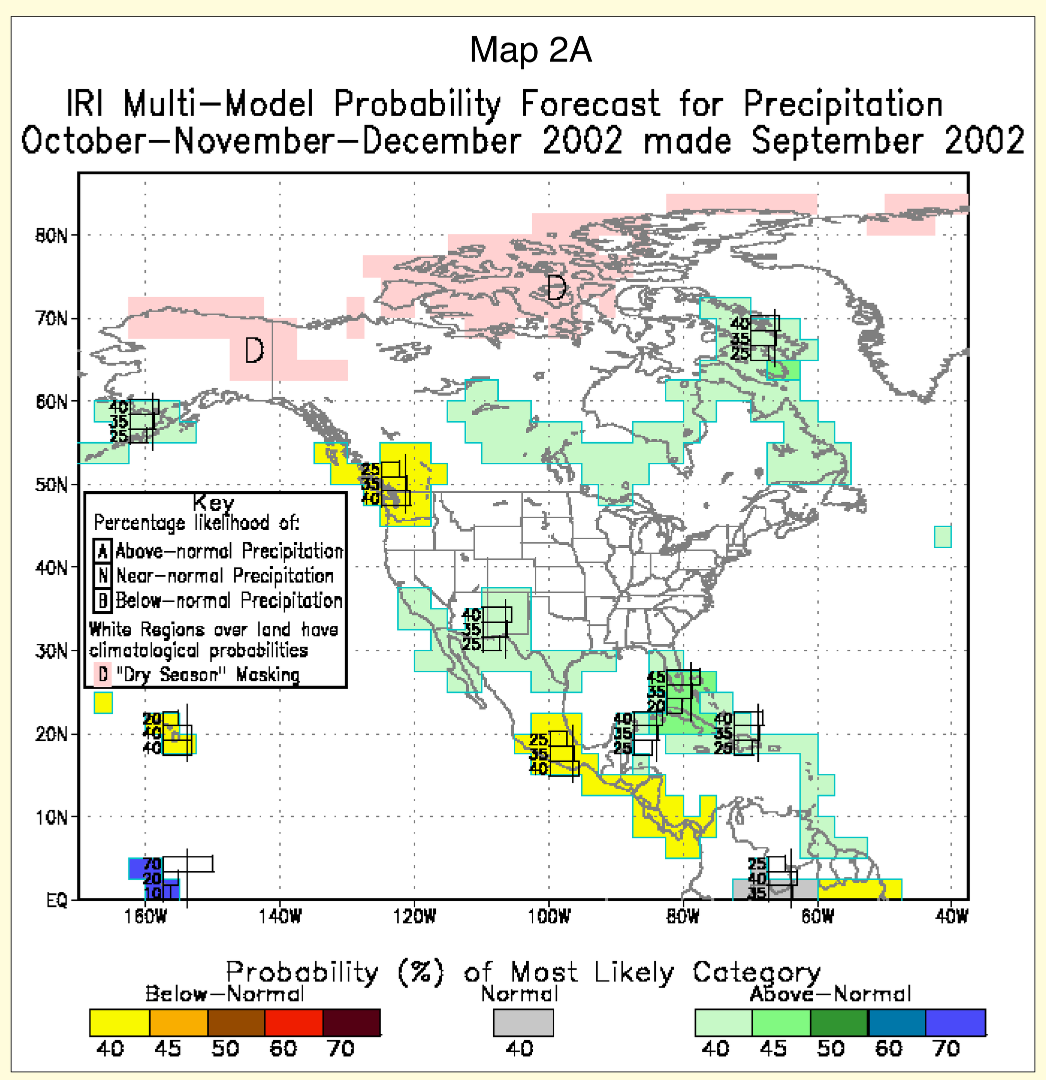
(c) Suppose that past data show that Nevada normally receives 10 inches of precipitation. Then, how would you answer the following question:
"Was it wetter or drier in Nevada for this period, compared to the normal year?"

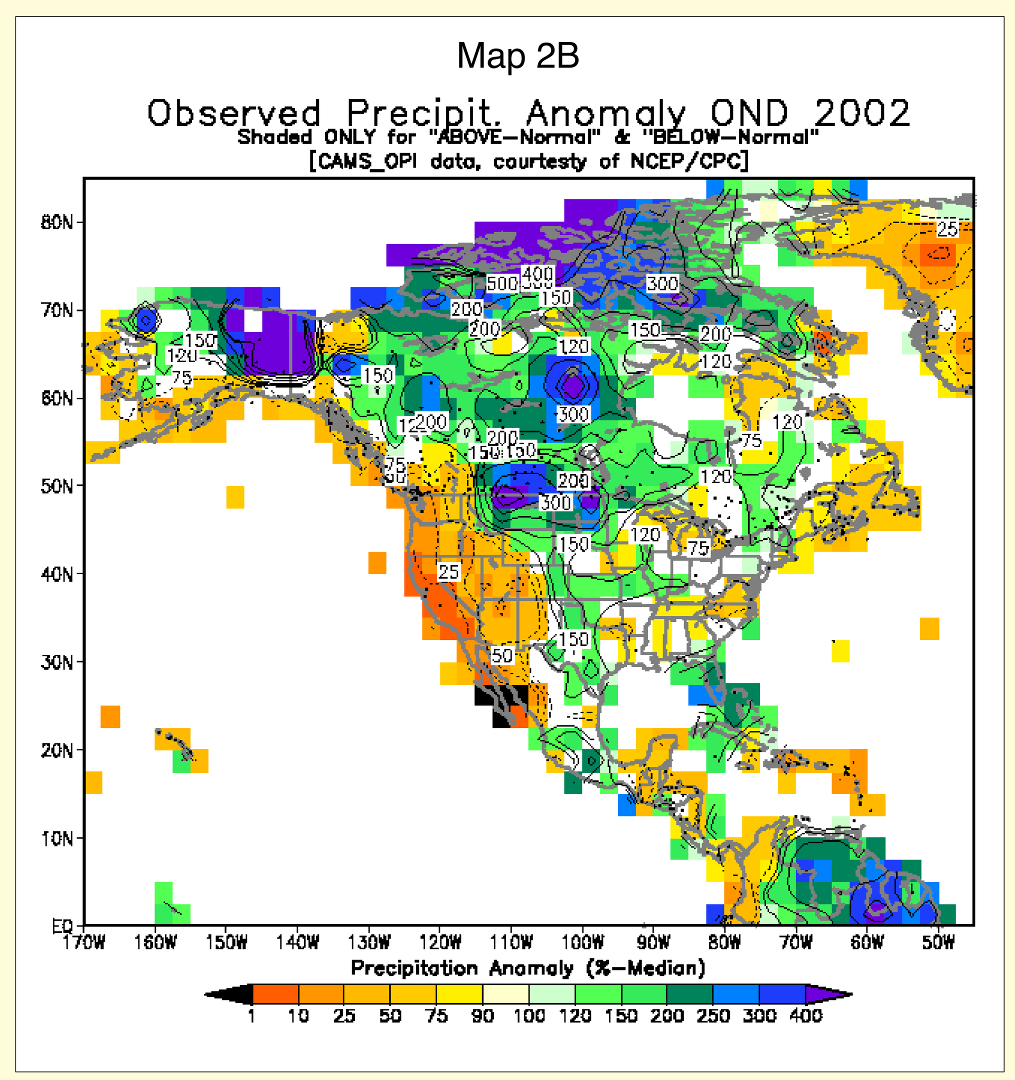
(d) Considering all of North America on Maps 2A and 2B, how would you characterize the correspondence between the forecast and the observation?
Circe one number from 1 to 5 below:

1. They tend to be opposite.
2. They are unrelated to each other.
3. They agree only slightly.
4. They agree somewhat.
5. They agree quite closely.

(e) Imagine that you are the Secretary of Agriculture of the US and that this pair of forecast/observed maps is representative of the last 5 years of forecasts.
Would you recommend that these forecasts be used to make decisions about what crops to plant? Circle one number from 1 to 5 below concerning your action:

1. Strong recommendation for using the forecasts.
2. Weak recommendation for using the forecasts.
3. No recommendation in either way.
4. Weak recommendation for NOT using the forecasts.
5. Strong recommendation for NOT using the forecasts.





Most of the students answered Questions 2(a)-2(c) correctly, indicating that they did not have difficulty reading from Map 2B whether a specific region received more or less precipitation than normal.
Questions 2(d) and 2(e) examined how they evaluate the degree of agreement between the forecast and the subsequent observations (Figure 3), and their willingness to use the forecast as a basis for taking some action about agriculture (Figure 4). Their evaluation and action scales showed a significant correlation ($r = -.42$, $p < .01$), but what is noteworthy is the variability in the course of action that they would take based on the forecast. Although the forecasters consider it to be a fairly successful forecast (Map 2A), only a minority of the policy students would be willing to recommend people to use this forecast in making a decision about what crops to plant.

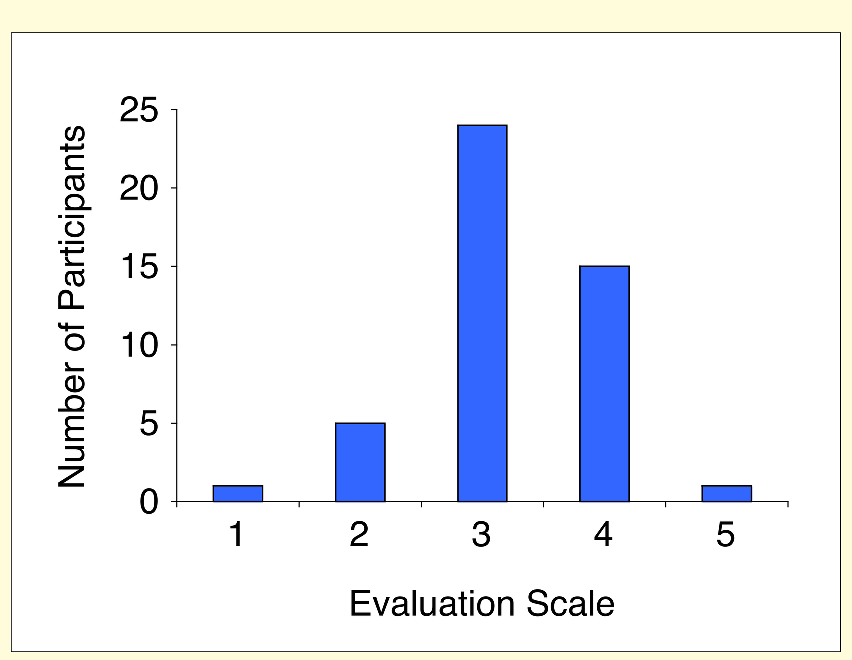


Figure 3. Distribution of the students' evaluation of the degree of agreement between the forecast and the observation, from Question 2(d) (1 = *no agreement*; 5 = *close agreement*).

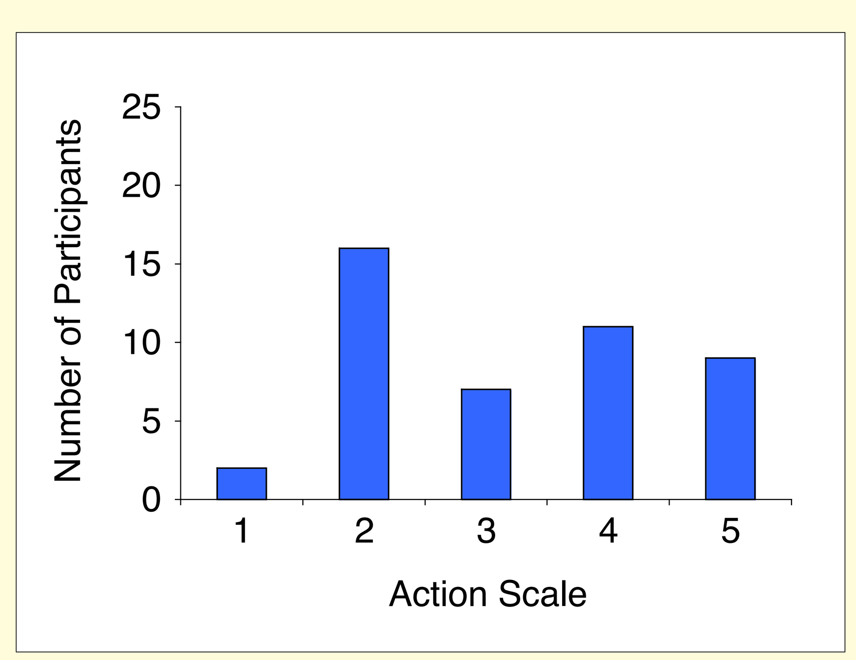


Figure 4. Distribution of the students' willingness to use the forecast in agricultural decision making, from Question 2(e) (1 = *strong recommendation*; 5 = *against recommendation*).

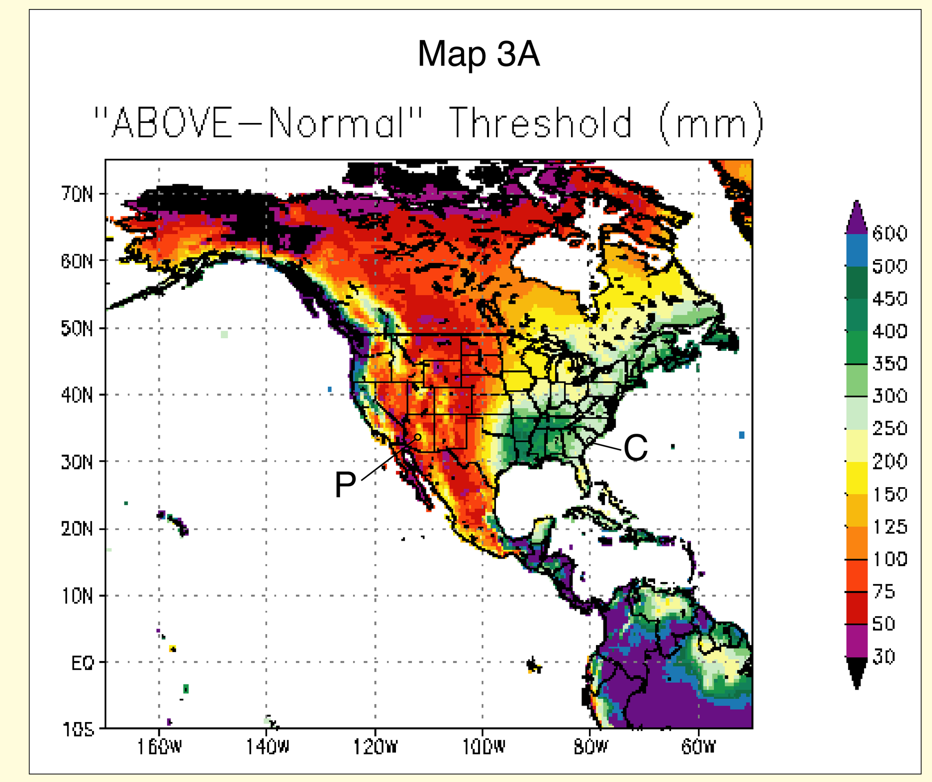
Question 3

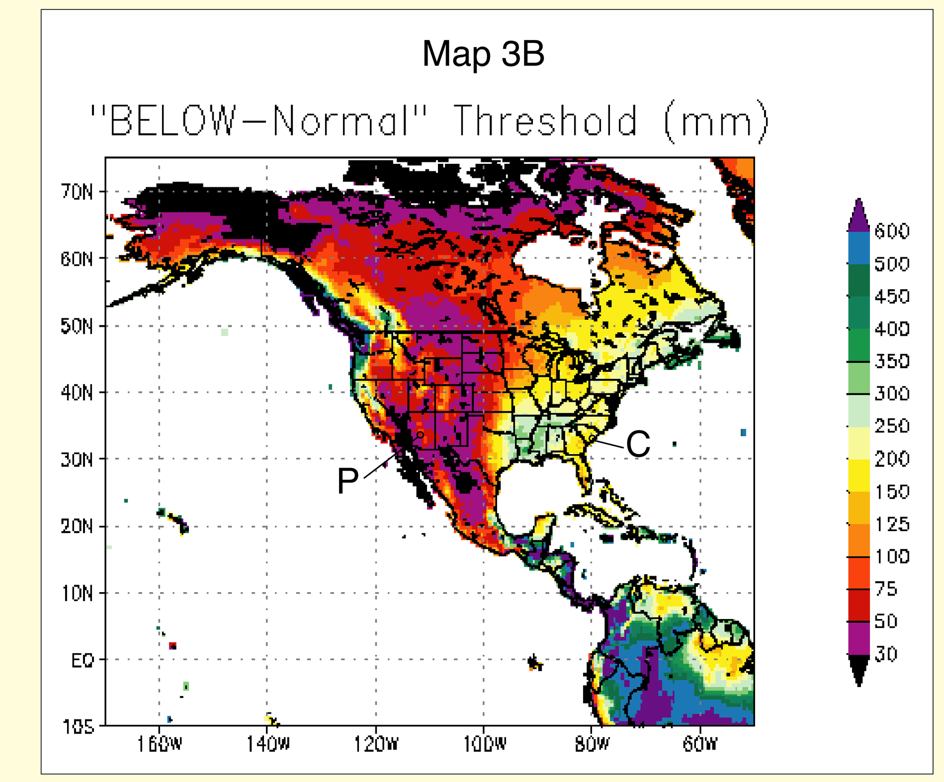
The third pair of maps shows the *above normal* threshold (Map 3A) and the *below normal* threshold (Map 3B). The *above normal* threshold is the border between the *normal* category and the *above normal* category; the *below normal* threshold is the border between the *normal* category and the *below normal* category. These thresholds are used in making the forecast maps such as Map 1. Maps 3A and 3B cover the same 3-month period as for Map 1.

Suppose that you are given Maps 3A and 3B, together with Map 1. Please complete the following statements about the probabilities of *above normal* and *below normal* precipitation at the two locations for this forecast period:

(a) (i) *Above normal:* The probability is _____% that Charleston, South Carolina (denoted by C on Maps 3A and 3B), will receive *more* than _____ mm of precipitation.
(ii) *Below normal:* The probability is _____% that Charleston, South Carolina, will receive *less* than _____ mm of precipitation.

(b) (i) *Above normal:* The probability is _____% that Phoenix, Arizona (denoted by P on Maps 3A and 3B), will receive *more* than _____ mm of precipitation.
(ii) *Below normal:* The probability is _____% that Phoenix, Arizona, will receive *less* than _____ mm of precipitation.





Most of the students (about 90%) correctly answered the *above* and *below normal* thresholds in mm; that is, they did not have difficulty reading the maps which showed the thresholds separating the *above normal*, *normal*, and *below normal* categories (Maps 3A and 3B). On the other hand, they had trouble understanding the probabilities of each city falling into *above* and *below normal* categories, particularly the latter (only about 20% of them answered correctly; see Figure 5). Since both cities are classified as *above normal*, the *above normal* probability can be read off from Map 1, whereas the *below normal* probability needs to be extracted from the horizontal bar graphs. This shows that it was difficult for them to understand what the horizontal bar graphs depicted, and probably the concept of error (or uncertainty) inherent in climate forecast.

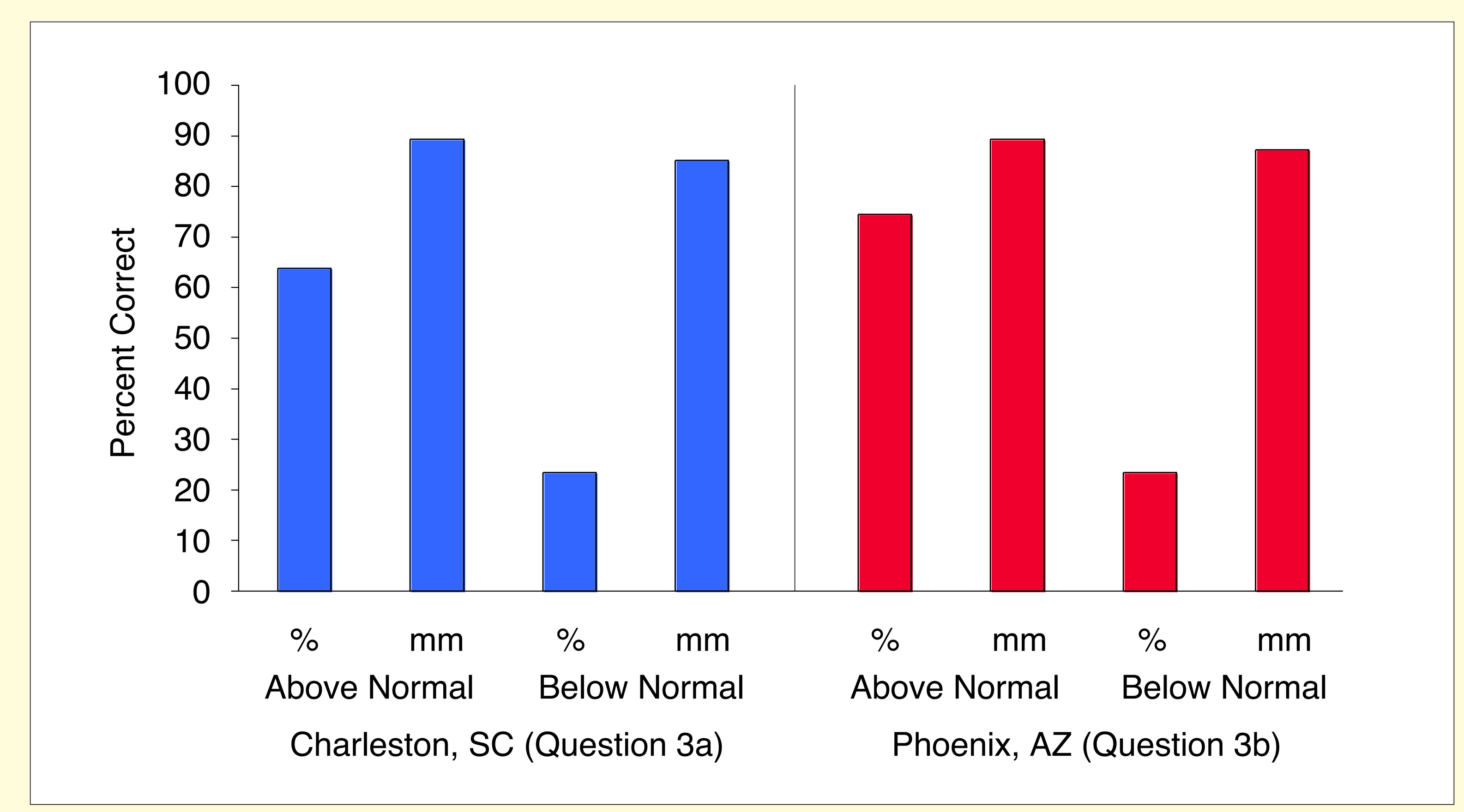


Figure 5. Percent of the correct response to the threshold questions. Note the low accuracy for the questions about the probability (%) of each city falling into the *below normal* category.

Comments and Suggestions Welcomed

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