DETERMINING THE PUBLIC'S UNDERSTANDING OF PRECIPITATION FORECASTS: RESULTS OF A SURVEY

Shelley A. Sink

North Carolina State University
Department of Marine, Earth and Atmospheric Sciences
Raleigh, North Carolina

Abstract

The uncertainty associated with precipitation forecasts is magnified when people have misconceptions about the meaning of the numbers and words used in the forecast. A questionnaire was distributed to 475 members of the general public to test their understanding of various aspects of precipitation in order to determine the knowledge gaps and ascertain the preferred forecast format. Results showed that the precipitation event was misinterpreted when presented in both verbal and numerical formats and verbal/numerical pairs were incorrectly correlated. Respondents favored a numerical probability of precipitation forecast format but tended to rate verbal ones as better forecasts. There was a good understanding of qualifying and general precipitation terms among those who were sampled. Consistent and proper use of probability of precipitation language by meteorologists and measures to educate the public should be instigated to correct these ambiguities.

1. Introduction

Meteorology, in general, is an inexact science, so uncertainty is inherent in weather forecasts, especially probability of precipitation (PoP) forecasts. Varying regional, cultural, and educational understandings of weather events and terms by the public results in further ambiguity of a forecast's meaning. Thus, one of the primary goals of the meteorology community should be to raise the public's level of understanding of weather, to eliminate misinterpretations of forecasts and to increase the usefulness of the weather services provided.

An insufficient number of public surveys have been conducted in the past few decades to study public understanding of weather terminology, events, probabilities, etc. However, these surveys tend to have major shortcomings which minimize and prevent solid conclusions from being made. Such flaws, as admitted by researchers, included small and/or biased and/or non-random populations (Sherrod and Neuberger 1958; Murphy and Brown 1983b; Murphy et al. 1980; Namm 1979) and lack of detailed, specific questions (Murphy and Brown 1983b).

Meteorologists and broadcasters often question whether probabilities should be worded verbally or numerically. Verbal weather phrases make different impressions on different people, especially in PoP forecasts. Precipitation is personal and circumstantial, whereas numbers are universal and not open to such a wide scope of interpretation. One may argue however, that people are not comfortable with numbers and do not understand probability. Previous surveys have attempted to study a few of these aspects of PoP forecasts but only Murphy et al. (1980) concentrated specifically on PoP forecasts (Namm 1979; Sherrod and Beuberger 1958; Rogell 1972; Murphy and Brown 1983b).

In light of the suggestions of previous researchers, the goal of this survey was to broaden the sample population, to narrow the scope of prior surveys, to include only PoP/precipitation questions arranged in a logical manner so as to achieve a well-defined purpose, and to compare the public's answers to those of a sample of meteorologists.

2. Methods and Materials

Results and conclusions in this study are based on responses to a questionnaire administered in the Raleigh-Durham, North Carolina, area during June and July 1993. A total of 475 subjects completed the survey on a volunteer basis, were provided with (graciously donated) writing utensils, and were confronted individually or in small groups as to the purpose and source of the questionnaire. The following are places in which subjects were interviewed: a local elementary school staff meeting, an oil change waiting room, a local aquatic center, a university summer school biochemistry class, a local ski and outing club monthly meeting, storefront of a recreational gear retailer, the audience of an amateur statewide swim meet, various local businesses, and personal acquaintances. Fifteen professional meteorologists were surveyed at the National Weather Service (NWS) office at the Raleigh-Durham Airport, a local power company, and a local television weather center. Of those indicating their gender, 42% were males and 58% were females. A total of 425 subjects stated their ages which were distributed as follows:

19 & under	16	(4%)
20–29	119	(28%)
30–39	137	(32%)
40–49	124	(29%)
50–59	24	(6%)
60–69	5	(1%)

Subjects had no external time constraints placed on them and the approximate time necessary to complete the survey was 3–7 minutes. Variations in sample number by question are a result of omitted or invalid answers by respondents. Multiple answers for opinion questions were recorded using the highest value or best rating provided by the subject. Smaller random samples taken from the entire population for the purpose of comparing a subject's answers to two different questions were chosen using a random number generator on a scientific calculator and the respective survey numbers. Structure, wording, and order of questions were a combination of original ideas and adaptations of certain items used by previous researchers (Namm 1979; Murphy and Brown 1983b; Murphy et al. 1980; Rogell 1972).

3. Results and Discussion

a. Questions 1 and 7—background information

Determining a subject's source of weather information and how often he/she actually pays attention to the daily weather forecast is important in analyzing his/her understanding of weather forecasts, but the inclusion of these questions had another purpose. They were personal and simple multiple choice questions, thus building the confidence and interest of the respondent. Results (Table 1) were as expected on question 1 showing 59% getting their information from television sources. Only 4% of those surveyed used the NOAA Weather Radio (162.55 MHZ), the only source giving unmodified data directly from the National Weather Service. Perhaps most people are unaware of its existence, and it may be a good idea to promote this valuable service to the public. On question 7, 69% indicated that they paid attention to the weather forecast four or more days a week, suggesting that the respondents were generally interested in weather and therefore made an effort to answer survey questions to the best of their ability.

Table 1. Responses to Questions 1 and 7

Question 1:	Please place a check beside your primary source of weather information. (n = 506)	
	143 (28%)	Radio
	231 (46%)	Local/National TV
	65 (13%)	The Weather Channel
	19 (4%)	NOAA Weather Radio (162.55 MHz)
	20 (4%)	Newspaper
	3 (1%)	Phone Recording
	25 (5%)	Looking out the Window
Question 7:	How often during the week do you pay attention to the weather forecast? (n = 475)	
	17 (4%)	Never
	126 (27%)	1–3 Days a Week
	149 (31%)	4–6 Days a Week
	183 (39%)	Every Day

For each question, number of responses (and percent of total sample) for each possible answer.

b. Question 2—rain vs. showers

Answers to question 2 ("What is the difference, if any, between "rain" and "showers"?") provided some of the most interesting, enlightening, and useful information in this project. Being the first "weather knowledge" question on the survey and one of free response, question 2 produced answers that were purely from the mind of the respondent, were objective and not influenced by information mentioned in later questions (assuming questions were completed in order). Replies were fascinating and not short of amazing. Length and depth of answers and very few fallacies revealed a thoughtful, careful, and serious sample. An encouraging 248 (52%) people included the correct temporal difference (i.e., rain is continuous, showers are intermittent), with answers such as "rain is a set-in, showers are here and gone" or "rain would constitute a steady delivery of precipitation, showers would be intermittent precipitation in discreet breaks without any precipitation." Seventy-one of those 248 also included other incorrect information. For example, "showers are off and on but produce a larger volume of water than rain, rain is constant, general and with a cold front". Answers like "showers means short spells of rain at scattered sites, rain means more likely to be throughout area and longer" demonstrate a common misconception that showers are local and rain is widespread. Standing alone, the term "rain" and "showers" do not imply these meanings. However, with proper areal coverage adjectives, such a meaning would be possible.

Another common misconception was that the terms implied an intensity difference. Twenty-eight percent of the respondents had some kind of intensity difference in their response. There was no agreement as to whether rain or showers was more intense. Answers such as "rain is light, showers are heavy rain", "showers are really hard, rain is very light", "rain is heavy more like a thunderstorm, showers are lighter and in spurts", and "rain is harder, more dense and more water than showers" were very common in this group of respondents. Again, appropriate intensity adjectives are needed along with the terms "rain" and "showers."

Several subjects also defined showers as "a description of rain," or "showers are a type of rain, rain is liquid moisture from the sky." Only 43 people chose to answer that there was no difference in rain and showers which was reassuring both of their knowledge and that people were sincere by not opting for the "easy answer." All meteorologists answered correctly, but one meteorologist did add areal descriptions and another added intensity differences to their responses.

Results in this survey were more encouraging than those of Murphy and Brown (1983b) who used multiple choice questions in which only 35% of respondents interpreted rain and showers correctly. It seems that the gap in the public's knowledge of this aspect of weather perhaps results from a lack of being informed of such differences. Misuse and carelessness in the wording of descriptive terms probably contributes to any misunderstandings as well. The following are additional responses to question 2 that were especially interesting:

—with showers you use soap—rain, no soap
—all showers are rain, but all rain is not showers
—showers are brief and often heavy rain, but there are also light showers—rain: stronger precipitation, clouds-dark, showers-"sunshowers, not as dark and fierce"
—I use an umbrella in rain, run through showers
—rain is persistent with the humidity while showers although based on humidity are less likely to occur
—rain: droplets falling, doesn't matter how much, size, etc. showers: describes rain as a steady and intense falling of droplets

c. Questions 3 and 16—verbal/numerical thresholds for altering plans

Questions 3 and 16 (Table 2) were used to try to obtain the "threshold" or "boundary" at which the public actually begins to expect precipitation to occur. A verbal and numerical question was included to compare percentage/term association and to check consistency in responses. Results for question 3 showed that no single percentage dominated but the majority of responses were concentrated between 50% and 80% with a mean of 65.8%. In its verbal partner, question 16, most people (78%) chose either "good chance" or "very likely." Questions 3 and 16 were more general and circumstantial than other items. The questions themselves were open to a variety of interpretations because "plans" could mean something different to every person.

d. Questions 4 and 10—event interpretation

Table 2. Responses to Questions 3 and 16

Question 3: At what percent chance of precipitation would you consider altering plans or adjusting to accommodate precipitation? (n = 464)

1 . . . 0%	41 . . . 40%	95 . . . 80%
3 . . . 10%	76 . . . 50%	28 . . . 90%
3 . . . 20%	76 . . . 50%	36 . . . 100%
16 . . . 30%	89 . . . 70%	

Number of Responses for each Numerical PoP Category

Question 16: Which phrase describing the chance of precipitation would first cause you to consider altering plans or preparing for precipitation? (n = 437)

176 (40%) . . . Good Chance	
14 (3%) . . . Chance	Order of verbal
71 (16%) . . . Likely	descriptors is the
167 (38%) . . . Very Likely	order listed on
4 (1%) . . . Unlikely	the questionnaire.
5 (1%) . . . Slight Chance	

Number of Responses (and percent of total sample) for each verbal PoP Category.

According to Murphy et al. (1980), misunderstanding of PoP forecast could involve misinterpretation of the probability associated with the event, misinterpretation of the event itself (i.e., point versus area probability), or both. Questions 4 and 10 asked respondents to interpret the event in a PoP forecast. The only difference between the two was the way in which the uncertainty of precipitation was expressed in the forecast and the answers. Both questions are adaptations of previously used items in studies by Murphy et al. (1980) and Rogell (1972). Question 4 used a numerical probability of "60%." Question 10 used an equivalent verbal probability "likely" (WSOM 1984). Items were spaced several questions apart to try to eliminate subjects easily correlating the two items. Since the official definition of PoP is "the probability that measurable precipitation (more than 0.005″) will occur at a specific point (i.e., a rain gauge) in a specific period of time" (Rogell 1972; Murphy et al. 1980; WSOM 1984), the correct answer to both questions 4 and 10 is "B." However, as explained by Schaefer and Livingston (1989), PoP can be defined in several different ways. Though a point probability defines PoP in its truest sense, this WSOM (1984) definition also represents the expected areal coverage of the precipitation (Schaefer and Livingston 1989). Thus, answer "D" could also be correct. Since the PoP, as defined and used by the NWS, is an average point probability in which the same PoP value is assigned to each location in the forecast area, the discussion of the results of this survey will accept "B" as the correct answer to questions 4 and 10.

Questions 4 and 10 (Table 3) were included in this survey in the hope that results would improve since previous surveys yielded disheartening results on similar items (Rogell 1972; Murphy et al. 1980). Unfortunately, the outcome was worse. Eighty-five percent got question 4 wrong and 89% got question 10 wrong. Thus, most interpreted PoP as an area probability and not a point probability. It is interesting and noteworthy that in question 4, 96% of the incorrect responses were "C" (area probability). On the contrary, in question 10, 61% of incorrect responses were "C" (area probability) and 35% were "D" (area coverage). Only 15% selected the correct answer "B" on question 4 and even fewer, 11%, selected the correct answer on question 10. Perhaps the small number of "D" answers in question 4 was because it is rare to hear weather talked about in such a manner whereas "D" in question 10 is more understandable in layman's "weather language." Subjects in the Murphy et al. (1980) study displayed consistency between the numerical and verbal questions. Likewise, 59% of those who supplied answers to both question 4 and question 10 (n = 471) were consistent, but only 7% were correctly consistent (i.e., chose "B" both times). So, obviously those individuals who misinterpret numerical PoP forecasts also tend to misinterpret verbal PoP forecasts. Therefore, the problem in understanding is not how PoP is expressed, but the event behind it. Murphy et al. (1980) suggests that either people do not know what kind of probability PoP forecasts relate to (i.e., point or area) or they do not understand the difference between various kinds of probability. Murphy also stated that the NWS and other weather sources seldom indicate the proper definition and suggested they begin such a practice. This is a good idea and would increase awareness of correct information. First, all forecasters should review the proper definition since 33% of meteorologists surveyed missed question 4 and 40% missed question 10.

e. Questions 5 and 9—precipitation qualifying terms

Question 5 was a true/false statement aimed at testing whether the sample could distinguish the difference between a temporal and spatial modifier of the term "showers." In a survey by Murphy and Brown (1983b), 60% of a sample of students interpreted spatial and temporal variability terms correctly. Likewise, but more impressive, 75% of those answering question 5 (Table 4) chose the correct response of "false." In

Table 3. Responses to Questions 4 and 10

Question 4: On the hourly weather update, the meteorologist says there is "a 60% chance of rain today." You understand this to mean: (n = 473)

1 (<1%) . . .	A. Precipitation will occur 60% of the day.
69 (15%) . . .	B. At a specific point in the forecast area (for example, your house) there is a 60% chance of precipitation occurring.
390 (82%) . . .	C. There is a 60% chance that precipitation will occur somewhere in the forecast area during the day.
13 (3%) . . .	D. 60% of the forecast area will receive precipitation and 40% will not.

Question 10: On the morning weather forecast, the meteorologist says "rain is likely today." You understand this to mean: (n = 474)

17 (5%) . . .	A. Precipitation is likely to occur most of the day.
51 (11%) . . .	B. At a specific point in the forecast area (for example, your house), precipitation is likely.
258 (54%) . . .	C. Precipitation is likely somewhere in the forecast area during the day.
148 (31%) . . .	D. Precipitation is likely to occur over most of the forecast area during the day.

For each question, number of responses (and percent of total sample) for each possible answer.

addition, 75% of those responding to question 9 replied correctly with "true," thus suggesting that the respondents properly characterized "scattered" as indicating a greater likelihood of precipitation at a particular point than "isolated" (WSOM 1984). In a random sample of 50 respondents, a comparison of answers to questions 5 and 9 showed that 50% answered both questions correctly, and 90% got at least one of the two questions correct. Thus, it seems that adjectives describing precipitation terms are better differentiated by the public than the basic precipitation terms (i.e., rain and showers). Somewhat startling is the fact that 13% of meteorologists surveyed missed at least one of the two questions.

f. Questions 6, 8, 11, & 17—forecast rating

Fair or not, the public's judgment of a meteorologist's competence is generally based on the accuracy of the issued 24-hour forecast. Thus, those in the field of weather communication continuously strive for methods to improve 24-hour forecast accuracy. However, the way in which a forecast is worded could influence the public's opinion of the outcome of the prediction. The aim of questions 6, 8, 11, and 17 was to investigate this concern by having the subjects grade a forecast (according to the outcome) worded verbally and numerically. Questions 6 and 11, and questions 8 and 17, respectively, are verbal/numerical pairs according to the WSOM (1984) scale of comparable terms (Chart 1). Probabilities of 30% and 70% were chosen because of their numerical symmetry. The precipitation verification in all cases was that it did not rain. The four questions were strategically spread out and mixed to draw impulse ratings and to reduce successive question association by respondents.

The results (Table 5) were intriguing and should be earnestly considered by anyone issuing weather forecasts. As expected, ratings were better on questions 6 and 11 where the PoP forecast was only "30%"/"chance" respectively, and it did not rain. However, the fascinating aspect comes when the response to verbal items are compared with the numerical responses within verbal/numerical pairs. For both questions 6 and 11, the most common response was "fair", but remaining answers were skewed in opposite directions. In question 6 (verbal), 31% gave the forecast a better than fair rating, whereas, in question 11 (numerical), 37% rated the forecast worse than fair. A similar pattern, though not as pronounced, can be observed on questions 8 and 17. This trend tends to suggest that members of the public are harsher judges and stricter graders of PoP forecasts when they are worded numerically rather than verbally. One explanation could be that numbers have a more standard, universal meaning and lend themselves to intuitive rankings whereas words are open to more subjective interpretations. This will be further validated in question 18. Consistency between numerical/verbal pairs was tested with a random sample of 50 subjects for questions 6 and 11 and a different random sample of subjects for questions 8 and 17. For questions 6 and 11, 58% equally rated "likely" and "70%" equally. Twenty-six percent rated question 6 ("likely") as fair and question 11 ("70%") as poor, which was consistent with the trend of the total population. For questions 8 and 17, 64% evaluated "chance" and "30%" equally. As for the meteorologists, their ratings were comparable to the public's but showed higher consistency within verbal/numerical pairs.

g. Questions 12, 14, and 19—preference of weather

Table 4. Responses to Questions 5 and 9

Question 5:	"Occasional showers" are the same as "scattered showers." (n = 469)
	119 (25%) . . . TRUE 350 (75%) . . . FALSE
Question 9:	When the term "isolated showers" is used, the probability of precipitation is smaller than when the term "scattered showers" is used in a forecast. (n = 468)
	353 (75%) . . . TRUE 115 (25%) . . . FALSE

For each question, number of responses (and percent of total sample) for each possible answer.

Chart 1. Official correlations of PoP percentages and expressions of uncertainty as defined by the Weather Service Operational Manual (1984).

PoP Percent	Expressions of Uncertainty
0	(none used)
10, 20	Slight chance
30, 40, 50	Chance
60, 70	Likely
80, 90, 100	(Categorical—none used)

Table 5. Responses to Questions 6, 8, 11 and 17

Question 6:	What would be your opinion of a forecast that stated "rain is likely" and it *did not* rain at your house? (n = 465)
	10 (2%) . . . EXCELLENT 134 (29%) . . . GOOD 268 (58%) . . . FAIR 53 (11%) . . . POOR
Question 8:	The forecaster said "30% chance of rain today" but it *did not* rain at your house. What is your opinion of the forecast? (n = 467)
	47 (10%) . . . EXCELLENT 330 (71%) . . . GOOD 82 (18%) . . . FAIR 8 (2%) . . . POOR
Question 11:	What would be your opinion of a forecast that predicted a "70% chance of rain" and it *did not* rain at your house? (n = 464)
	10 (2%) . . . EXCELLENT 70 (15%) . . . GOOD 211 (45%) . . . FAIR 173 (37%) . . . POOR
Question 17:	The forecaster said there was "a chance of rain" but it *did not* rain at your house. What is your opinion of the forecast? (n = 440)
	24 (5%) . . . EXCELLENT 241 (55%) . . . GOOD 163 (37%) . . . FAIR 12 (3%) . . . POOR

For each question, number of responses (and percent of total sample) for each possible answer.

forecast content and style

Public information sources vary not only in which elements of weather information they provide, but also in the style of presentation. Some approaches are very technical, official, and require some basic meteorological knowledge, while others are light and entertaining. A previous survey included several questions inquiring the public's preference of forecast format (Namm 1979). Such was the goal of questions 12, 14, and 19. In the comparison that was made between each individual's responses to both parts of question 12 (Table 6), 44% disagreed with both statements, and 31% answered "agree/disagree" respectively. Meteorologists tended to disagree with both statements. These results may suggest that people want to be informed and educated about the weather, but do not want their intelligence insulted with overly juvenile formats.

Forecast features deemed most important to members of the general public should be the ones most emphasized and explained by meteorologists, and should thus be the ones best understood by the public. Probability of precipitation forecasts are the most desired (Namm 1979), yet least understood aspect (Rogell 1972) of a weather forecast. Results of question 14 (Table 6) showed that the five most crucial parts of the forecast to respondents of this survey were (in descending order) PoP, high and low temperatures, 5-day forecast, relative humidity, and travel/radar (tie). As in previous studies, PoP towered above the rest, yet so much confusion surrounds its meaning.

In question 19 (Table 6), 76% of respondents preferred numerical PoP forecasts making results of this survey question consistent with two similar items on earlier questionnaires (M.S.I. 1981; Murphy and Brown 1983b). Perhaps, however, the 2% who wrote in the answer of "both" have suggested the best idea. Presenting proper verbal/numerical pairings would begin to instill correct correlations in the public's mind as well as catering to everyone's preference and level of understanding.

h. Question 13—qualifying precipitation terms

The Weather Service Operational Manual (1984) contains very specific yet simple guidelines for PoP forecasts. These rules for using proper terminology, wording, and phrasing, are violated regularly, especially by non-meteorologists who give weather information and by other weather forecasters outside the NWS offices. Some of the PoP regulations most often disobeyed are the ones for combining qualifying terms. Uncertainty, areal, and duration qualifying terms must stand alone and should not be combined with each other (WSOM 1984). However, they can be combined with intensity terms. A phrase such as "chance of scattered showers" may be technically correct but confusion may arise because it is unclear whether the uncertainty applies to the precipitation event (as it should), or the term "scattered" (WSOM 1984). Question 13 (Table 7) of the survey was intended to analyze the people's understanding of an acceptable phrase which combines an uncertainty qualifying term with an intensity qualifying term (e.g., "chance of heavy rain"). The correct interpretation, "D" was selected by an overwhelming 73% of respondents (n=458). These results were redeeming and encouraging in light of results of some of the questions, especially since answers A and C sounded reasonable in layman's weather language. Answer "B" was intended as a comical choice, but was the second most common answer. Meteorologists faired well on this question with 85% answering correctly. The others were perhaps unfamiliar with the rules for combining qualifying terms.

i. Question 15—probability understanding in

Table 6. Responses to Questions 12, 14 and 19

Question 12: Weather forecasts should be more technical (i.e., more numbers, probabilities, scientific reasons and explanations for weather events, weather history & climate data, etc.) (n = 469)

195 (42%) . . . AGREE
274 (58%) . . . DISAGREE

Weather forecast should be more casual and entertaining (i.e., weather trivia, animated graphics, no "why" explanations of events just "whats" and "whens", puns, etc.) (n = 462)

111 (24%) . . . AGREE
351 (76%) . . . DISAGREE

For each question, number of responses (and percent of total sample) for each possible answer.

Question 14: How important to you are the following parts of a weather forecast?

	Critical	Very Important	Somewhat Important	Needless	n
Travel Forecast	40	124	229	44	437
5-Day Forecast	47	229	161	14	451
Cloud Cover	10	58	259	114	441
Likelihood of Precipitation	113	246	90	6	455
Relative Humidity	42	147	214	42	445
High & Low Temperatures	93	231	114	14	452
Radar	51	126	176	85	438
Lake Levels	6	26	147	265	444
Wind Speed & Direction	20	91	237	99	447
Sunrise/Sunset	11	57	228	149	445

For each question, number of responses for each possible answer.

Question 19: I would prefer probability of precipitation forecasts to be expressed: (n = 435)

99 (23%) . . . A. Verbally (ex. "rain is very likely")
336 (77%) . . . B. Numerically (ex. "50% chance of rain")

For each question, number of responses (and percent of total sample) for each possible answer.

Table 7. Responses to Question 13

Question 13: A forecast that reads "chance of heavy rain" means: (n = 458)

16 (3%) . . . A. Rain may occur during the forecast period.
69 (15%) . . . B. If rain occurs, the rain drops will be heavier than normal rain drops.
38 (8%) . . . C. There will either be heavy rain or no rain at all.
335 (73%) . . . D. Rain will most likely occur and there is a chance that it will be heavy.

precipitation context

Question 15 (Table 8) was designed to test the public's general understanding of probability. Answer ideas were derived from an item used in a survey conducted several years ago (Murphy et al. 1980). The response intended to be correct was "B", but in order to be totally correct the word "approximately" should have been inserted before "25" since it is only in the limit that the probability and relative frequency must be equal (Murphy et al. 1980). Though this detail was probably not detected by respondents, the wording/concept was awkward to many people. Numerous subjects corrected answer "C" to read "1:4" and commented that it was a typographical error. Such responses were in some ways more encouraging than those choosing "B" because they had actually shown an accurate understanding of the phrase and a careful reading of the question. It is hard to determine whether the 28% who selected "C" did not understand odds notation, or whether they also thought that there was a typographical error and were not satisfied with any of the remaining choices. The 17% choosing "E" and the 63 people who did not answer might have done so out of frustration for a better answer and not because they were disinterested. Most meteorologists correctly chose "B", probably because they were more familiar with such phrasing.

j. Question 18—verbal/numerical probability correlation

The primary issue, with respect to the usefulness of numerical and verbal expressions of a PoP forecast, is the ability of members of the public to correctly interpret and make use of the information contained is such phrases (Murphy and Brown 1983a). Numerical probabilities express the uncertainty in PoP forecasts in an explicit, precise manner whereas verbal expressions of PoP impose a double uncertainty because words themselves invite many interpretations. This broad range of understanding is most evident in this survey in question 18 (Table 9). Subjects were asked to circle the percent probability they correlated with ten verbal phrases commonly used to describe the likelihood of an event. "No chance" was included as a "reliability check" of sorts, and the results were very satisfactory with 94% choosing "0." The range of answers was expected but astonishing nevertheless. Further support of the supposition that diversity in numerical verbal pairings exists is that results differed significantly from two earlier studies by Lichenstein and Newman (1967) and Rogell (1972). Likewise, symmetrical sets of phrases (e.g., "likely": mean = 56.1% and "unlikely": mean = 10.7%) showed an asymmetry of response similar to the results in Lichenstein and Newman's (1967) study. The phrases "slight chance", "chance", "good chance" and "likely" have defined ranges for use in official NWS forecasts (WSOM 1984). Numerical means corresponding to these four phrases were compared to those ranges. Only "slight chance" and "chance" correctly matched up with the official definitions. The order of rank, according to the calculated means, from both the public's and meteorologist's responses turned out as follows:

PUBLIC	METEOROLOGISTS
No chance	No chance
Unlikely	Very unlikely
Very unlikely	Unlikely
Slight chance	Slight chance
Chance	Possible
Possible	Chance
Likely	Probable
Probable	Good chance
Good chance	Likely
Very likely	Very likely

Meteorologists' scores were excellent and all fell within correct ranges suggesting that more education of the public as to the meaning of the verbal terms is needed. "Unlikely" and "Very unlikely", though reversed are not a major concern. The positions of "Good chance" and "Likely", however, are the most surprising and noteworthy. Results were consistent with those in the random sample comparison of questions 3 and 16 ("good chance": mean = 77.6%; "likely": mean = 57.1%). Such a distinct misinterpretation cannot be ignored and educational efforts should be made to correct it so that PoP forecasts will be correctly interpreted by, and thus useful to the public.

3. Conclusion

The daily weather report is often the principal contact Americans have with the world of meteorology. The information the public obtains from the weather statement may serve as the basis for making important personal decisions. The meteorologist's reputation is also "at stake." Inconsistent or incorrect use of the verbal and numerical components of a forecast by those

Table 8. Responses to Question 15

Question 15: Which of the following is a correct interpretation of a "25% chance of precipitation today"? (n = 413)

55 (13%) . . . A. 1/4 of the area will get rain today.
134 (32%) . . . B. Out of 100 days like today, on 25 of them rain will occur.
117 (28%) . . . C. Odds in favor of rain are 4:1.
5 (1%) . . . D. There's a 75% chance that some form of water will fall from the sky today.
71 (17%) . . . E. The forecaster's predictions of precipitation are correct 1 out of 4 times on days like today.
31 (8%) . . . F. 3/4 of the sky will be sunny today.

For each question, number of responses (and percent of total sample) for each possible answer.

Table 9. Responses to Question 18

Question 18: Circle the percent probability you associate with the following terms:

example:

SLIGHT CHANCE
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Term	Range (%)	Mean (%)	Median (%)	Mode (%)	StnDev (%)	n
Slight Chance	0– 70	17.3	15	10	10.1	433
Likely	10–100	56.1	60	70	20.4	434
Probable	10–100	59.0	60	70	19.8	434
Chance	0–100	36.5	30	30	16.4	433
Very Likely	0–100	75.2	80	90	16.0	434
Good Chance	20–100	67.2	70	80	14.4	433
Unlikely	0–100	10.7	10	10	12.4	432
No Chance	0–100	2.17	0	0	11.6	438
Very Unlikely	0–100	13.6	10	0	24.6	432
Possible	0–100	37.4	40	50	17.4	434

presenting weather along with the public's varying interpretations of the information that is given, results in a general misunderstanding of weather events by the public. The uncertainty intrinsic to weather forecasts creates an enormous challenge for those in the field of weather communication. Gelber (1993), a broadcast meteorologist for WCMH-TV in Columbus, Ohio, says, "The goal is to describe the probable state of the atmosphere hours into the future based on a reasonable knowledge of current conditions. But, at best, the result is uncertain. Although our dynamical earth-atmosphere-ocean system can be well depicted by mathematical equations, correctly timing a line of showers during a big collegiate football rivalry can still prove painfully inadequate. Weather forecasting for the mass media market remains a tenuous proposition, sometimes bordering on an art form."

In light of results in this survey, the major problem seems to be a break-down in the communication line between meteorologists and the public. A review of the fundamental definitions and other guidelines by meteorologists and the consistent application of them on a daily basis over time is definitely necessary to insure effective information relay. Measures to educate the public of such guidelines would also be helpful. These rules should be publicized and printed on reference cards for all weather announcers, meteorologists and non-meteorologists alike. Perhaps public awareness campaigns including weather fairs, creative public education tools (placements with information, milk cartons, contests etc.), special media reports and phone recordings would be helpful. It is the author's hope that this research survey will increase awareness of some of the shortcomings in weather communication, and encourage others to pursue ways to make forecasts more "user friendly." Devotion to this task will repair the communication gap in the bridge connecting meteorologists with the public.

Acknowledgments

The writer would like to thank the following individuals for their various contributions to this project: Jeff Hickman (REI Inc.), Scott Brown (PG Research), Steve Swienckowski (WLFL Fox 22), Joel Hoffman (Raleigh Ski and Outing Club), RDU-NWS forecasters, Jeff Wagstaff (Best Products), Raleigh Golf Association, Dr. Robert Bereman (NCSU), Dr. Al Riordan (NCSU), Dr. Jerry Watson (NCSU), Dr. Steven Koch (NCSU), Steve Harned (NWS), Staley Smith (Smith & Smith Surveyors), Dr. Michael Carter, Randy Sink, Carolyn Sink, and Makesha Sink.

Author

Shelley Sink graduated magna cum laude in meteorology from North Carolina State University on 14 May 1994. She plans to pursue a career in broadcast meteorology. Shelley was a student volunteer at the Raleigh-Durham NWS office during the summer of 1992 and has been a meteorology intern at WLFL-FOX 22 during 1993–1994. She is also a volunteer teacher for the Research Triangle Science and Mathematics Partnership.

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