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Perception and confidence on weather forecasts among Spanish undergraduate students enrolled in different subjects related to physics

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Abstract

The current study focuses on Spanish undergraduate students enrolled in Meteorology-related subjects that would make use of weather forecasts in their future professional careers. The main aim of this study is twofold. Firstly, to evaluate the students' confidence in the current weather forecasts. Secondly, to analyze the students' perception and understanding of uncertainty associated with weather-related forecasts. To address these issues, a Google Form questionnaire was developed. A total of 101 students participated in the corresponding survey during the academic year 2018-2019. Results show that students have a well-founded opinion and a fairly solid knowledge of weather forecasts, both regarding confidence and in relation to the trend found in the current weather forecasts towards less accurate predictions for larger lead times. The results found in the current study are in line with previous research conducted in different specific contexts and should be taken into account to implement different learning strategies in the classroom.

Keywords: *weather forecasts; uncertainty; perception; confidence; physics students.*

1. Introduction

Weather predictions have been used in the classroom as part of the learning process in order to facilitate students to better understand complex theoretical concepts as well as different atmospheric processes addressed in the corresponding lectures (Morss and Zhang, 2008; Bond and Mass, 2009; Schultz et al., 2015; Suess et al., 2013; Gómez Doménech et al., 2016). In addition, the usage of weather forecasts in an educational environment provides students with first-hand experiences to visualize and contextualize different theoretical concepts and handle available information. In this regard, Schultz et al. (2015) pointed out that weather forecasts used in the classroom stimulate different levels of Bloom's taxonomy (Bloom, 1956), such as application, analysis, synthesis and evaluation, as well as critical thinking. However, Gómez Doménech and Molina Palacios (2018) found that the use of these models still shows some difficulties regarding how students interpret the uncertainties associated to the weather-related forecasts. This can be a serious limitation for their use if students' expectations on the forecasts skill are far from the current forecasting capabilities.

The aim of this paper is to perform an exploratory analysis to assess to what extent Spanish students enrolled in subjects related to physics interpret correctly the uncertainty of weather predictions as well as determine how they perceive the forecast of the different weather elements. Specific objectives have been defined in this sense: to evaluate students' perception on the weather forecasts and their trust on the accuracy of predictions; to analyze the degree of knowledge of students on the uncertainties of the predictions; to find out how students value forecasts of different weather elements. A survey has been used for these purposes including questions developed in previous studies focused on analyzing these same issues on member of the general public (Morss et al., 2008; O'Hanrahan and Sweeney, 2013; Zabini et al., 2015; Kox et al., 2015). These previous studies have highlighted the need to further testing their results in other contexts. The current work spreads previous research topics, but now focused on Spanish undergraduate students. It is intended to yield valuable information regarding different questions related to their perception and confidence on weather forecasts as well as how these predictions may be effectively used and introduced in the classroom.

2. Methodology

101 individuals enrolled in the Degree in Marine Sciences (University of Alicante, UA), the Degree in Environmental Sciences and the Degree in Physics (University of Valencia, UV) have participated in the current work. The study design was based on the application of a non-experimental quantitative method, and a cross-sectional exploratory and descriptive design, through a survey. There are, thus, three different groups. The first group corresponds to the optional subject "Introduction to Meteorology", taught in the 4th year of the Degree in Marine Sciences at the UA; the second group corresponds to the compulsory subject

"Meteorology and Climatology", taken in the 2nd year of the Degree in Environmental Sciences at the UV; while the third group corresponds to the subject "Atmospheric Physics", taught in the 2nd year of the Degree in Physics at the UV.

A questionnaire directly focused on the research goals of the current study was used to gather student's information. The questions used in this questionnaire were drawn from previously published studies (Morss et al., 2008; O'Hanrahan and Sweeney, 2013; Kox et al., 2015; Zabini et al., 2015). The first question of the survey (Q1) is related to the frequency with which students perceive they receive an inaccurate weather forecast. The degrees of perception in this case are the following: "Very often", "Often", "Sometimes", "Rarely", "I don't know", and an additional point called "Other" (six-point Likert scale). The second question (Q2) refers to the confidence that students have in weather forecasts for different lead times: "Less than a day", "1 day", "2 days", "3 days", "5 days" and "7 to 15 days", from the publication of the corresponding forecast. The degrees of confidence in the corresponding prediction for each of these periods are: "Very low", "Low", "Medium", "High", "Very high" (five-point Likert scale). Finally, students' confidence in the accuracy of the prediction of different weather elements: temperature, wind speed, probability of precipitation and amount of precipitation (Q3).

3. Results and discussion

Fig. 1 shows the answers related to the confidence of students in weather forecasts (Q1). 28% of students experienced wrong forecasts "Rarely", whereas 62% experienced wrong weather forecasts "Sometimes".

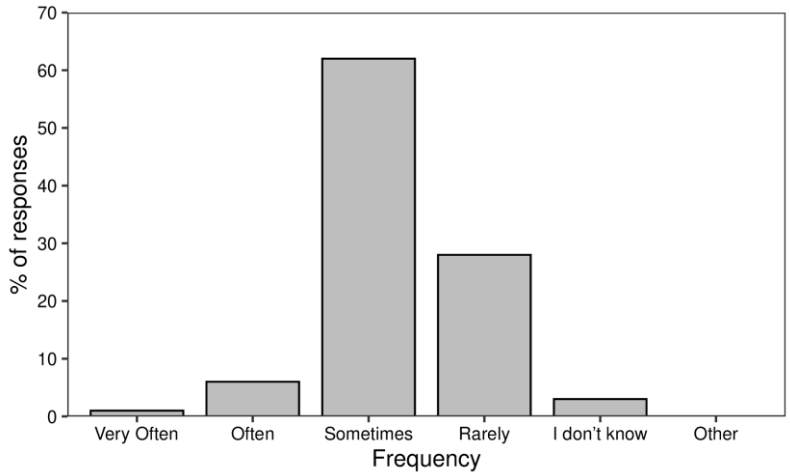

Figure 1. Percentage of responses related to the frequency with which students perceived incorrect weather forecasts.

Comparing the current results shown in Fig. 1 with those previously obtained by O'Hanrahan and Sweeney (2013) among the Irish public, a similar distribution of results is found in both studies. In this regard, O'Hanrahan and Sweeney (2013) concluded that 25% and 46% of their survey participants considered weather forecasts "Rarely" and "Sometimes" inaccurate. At the other end, 25% of the Irish public experienced weather forecasts as inaccurate "Often" or "Very often".

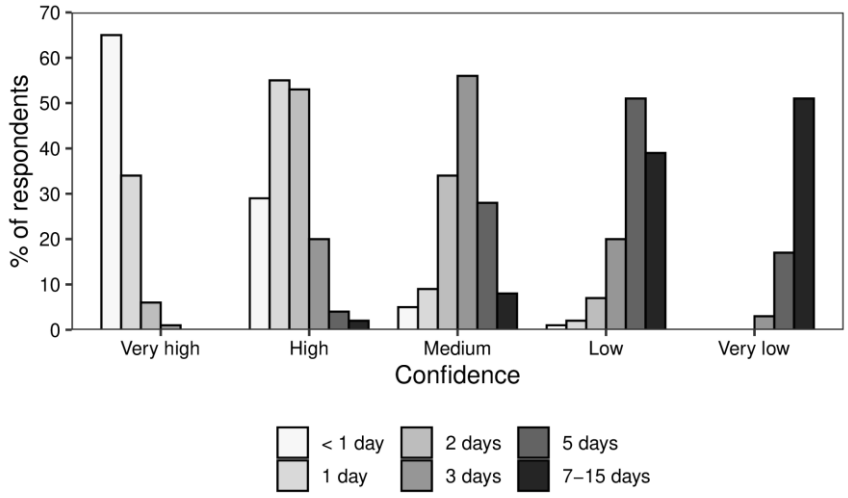

Figure 2. Percentage of responses related to the confidence in weather forecasts for different lead times.

Fig. 2 displays that students' levels of confidence in weather forecasts lead times (question Q2). 65% of the answers showed a very high level of confidence in forecasts for lead times of a few hours. In addition, medium-high confidences were obtained for 2-day forecasts. For 5-day forecasts, 51% of the answers corresponded to "Low" confidence levels, while the confidence was "Very low" for forecasts lead times of 7 days or higher, with 51% of the answers. From Fig. 2, it seems clear that confidence decreases as the forecast lead time increases. The results shown in Fig. 2 are coincident to those found in other previous works (e.g. Morss et al., 2008; Zabini et al., 2015). For instance, O'Hanrahan and Sweeney (2013) showed that, on the one hand, 48% of students experienced very high levels of confidence in the forecast lead times of a few hours, whereas only 2% reported this same confidence in the longest forecast lead times (more than 7 days). On the other hand, no answers were obtained for very low confidence levels for time scale forecasts lower than 24 hours. Morss et al. (2008) obtained that 40% of the answers of their respondents reported a very high confidence in forecast lead times lower than 1 day, while less than 2% showed a very low confidence considering this time interval. Lazo et al. (2009) concluded that nearly half of the answers reported a medium confidence in predictions within the first 3 forecast days and a similar

percentage (47%) reported a very low confidence in forecast lead times of 7 days and beyond. Similar results were reported by Joslyn and Savelli (2010), Zabini et al. (2015) and Kuonen et al. (2019). Likewise, Kox et al. (2015) found that the confidence in 2-day forecasts was higher than the confidence in 7-day forecasts. The results found in the current study, therefore, confirms the correct understanding of students that forecast uncertainty increases for longer lead times (Vitart, 2014).

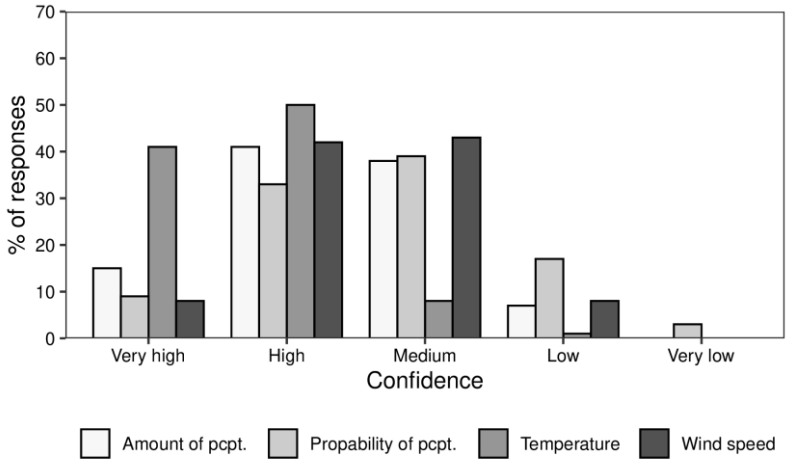

Figure 3. Percentage of responses related to the confidence in weather forecasts for different weather elements.

Fig. 3 shows the confidence in the 24-hour weather forecasts for different weather elements: temperature, amount of precipitation, probability of precipitation and wind speed. Among these weather elements, temperature forecasts are rated as those with the highest confidence and the amount of precipitation is the one with the least confidence levels among students. However, the confidence levels for the probability of precipitation were rated high-medium, similarly to the wind speed. In addition, "Very low" level responses were only obtained in the case of the probability of precipitation. These results agree with those previously found by Morss et al. (2008). In this case, temperature forecasts were as well rated with the highest confidence. In contrast, the lowest confidence was reported for amount of precipitation forecasts, whereas the probability of precipitation presented an in-between confidence. Considering expectation ranges in different weather elements, Joslyn and Savelly (2010) showed wider expectation ranges in the case of wind speed compared to temperature forecasts, thus indicating a lower confidence in these weather forecasts. Regarding wind speed, an intermediate confidence is also found for this magnitude in the present work.

Demuth et al. (2011) evaluated the perceived importance of and confidence in forecast information. They concluded that among the different weather elements, temperature and precipitation were the most relevant ones. Therefore, students in the current study have a clear understanding that the forecast of some weather elements presents a higher uncertainty

than others, in agreement with members of the general public (Morss et al., 2008). These results are in line with those obtained in different studies related to operational Numerical Weather Prediction (NWP) systems (Gómez et a., 2014). Moreover, it appears that confidence in forecasts addressing probabilities, such as precipitation chance, is higher than confidence in forecasts addressing absolute values, such as wind speed or precipitation amount.

4. Conclusions

The results found in the current study show that students appear to accept that forecasts are not perfect as they expect some degree of uncertainty. They reported well-founded intuitions about uncertainty on a practical level and a well-formed opinion on weather forecasts. In this regard, students are aware of the fact that larger errors on longer-term forecasts are expected. The outcomes obtained in the current study have also been compared with to date preexisting literature. This issue has permitted us to answer three different questions. Firstly, whether the same research questions are comparable among different contexts and cohorts. Secondly, whether the responses to the same research questions have evolved and changed over time. And finally, whether responses among undergraduate students are different from those reported by members of the general public and students in different countries and contexts. As a general conclusion, we may say that the outcomes of the current work support and reinforce previous research studies regarding confidence on weather forecasts, but in this case applied to undergraduate students in a pedagogical context. Understanding students' preexisting concepts related to the forecast uncertainty is important for designing and developing teaching and learning strategies directed to establish when and how to provide additional forecast uncertainty information in the classroom. In this regard, considering the usage of open and available models and weather forecasts to introduce complex meteorological concepts in the classroom should first explore the perceptions, expectations and confidence of students in weather forecasts. Previous studies have been focused on the general public, whereas this study focuses on undergraduate students that have a scientific education. Therefore, the comparison conducted in this study may be considered as a limitation. In this sense, extending the study to the general public would be an interesting topic bearing in mind the need of comparing the results among people with different levels of formal education, but sharing the same cultural background. The results of such a study would yield a broaden perspective on the research questions addressed in the current study.

Acknowledgments

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References

Bond, N. A., & Mass, C. F. (2009). Development of skill by students enrolled in a weather forecasting laboratory. *Weather and Forecasting*, 24, 1141-1148. doi: 10.1175/2009WAF2222214.1.

Demuth, J. L., Lazo, J. K., & Morss, R. E. (2011). Exploring Variations in People's Sources, Uses, and Perceptions of Weather Forecasts. *Weather, Climate, and Society*, 3(3), 177-192. doi: 10.1175/2011WCAS1061.1.

Gómez, I., Caselles, V., & Estrela, M. J. (2014). Real-time weather forecasting in the Western Mediterranean Basin: An application of the RAMS model. *Atmospheric Research*, 139, 71-89. doi: 10.1016/j.atmosres.2014.01.011.

Gómez Doménech, I., Molina-Palacios, S., & Reyes-Labarta, J. A. (2016). Aplicación de una metodología de enseñanza-aprendizaje en Meteorología a través de herramientas de software libre y datos de modelización numérica. En Roig-Vila, R. (Ed.), *Tecnología, innovación e investigación en los procesos de enseñanza-aprendizaje* (pp. 2078-2087). Barcelona: Octaedro.

Gómez Doménech, I., & Molina-Palacios, S. (2018). Aprendiendo a mirar profesionalmente utilizando episodios meteorológicos reales de interés para el alumnado. En Roig-Vila, Rosabel (Ed.), *El compromiso académico y social a través de la investigación e innovación educativas en la Enseñanza Superior* (pp. 582-591). Barcelona: Octaedro.

Hanrahan, P. O., & Sweeney, C. (2013). Odds on weather: Probabilities and the public. *Weather, 68*, 247-250. doi: 10.1002/wea.2137.

Joslyn, S., & Savelli, S. (2010). Communicating forecast uncertainty: public perception of weather forecast uncertainty. *Meteorological Applications*, 17, 180-195. doi: 10.1002/met.190.

Kox, T., Gerhold, L., & Ulbrich, U. (2015). Perception and use of uncertainty in severe weather warnings by emergency services in Germany. *Atmospheric Research*, 158-159, 292-301. doi: 10.1016/j.atmosres.2014.02.024.

Kuonen, J., Conway, F., & Strub, T. (2019). Navigating Mental Models of Risk and Uncertainty within the Ocean Forecast System: An Oregon Case Study. *Weather Climate and Society*, 11(2), 431-447. doi: 10.1175/WCAS-D-18-0057.1.

Lazo, J. K., Morss, R. E., Demuth, J. L. (2009). 300 billion served. *Bulletin of the American Meteorological Society*, 90, 785-798. doi: 10.1175/2008BAMS2604.1.

Morss, R. E., Demuth, J. L., & Lazo, J. K. (2008). Communicating uncertainty in weather forecasts: a survey of the U.S. public. *Weather and Forecasting*, 23(5), 974-991. doi: 10.1175/2008WAF2007088.1.

Morss, R., & Zhang, F. (2008). LINKING METEOROLOGICAL EDUCATION TO REALITY: A Prototype Undergraduate Research Study of Public Response to Hurricane

Rita Forecasts. *Bulletin of the American Meteorological Society*, 89(4), 497-504. doi: 10.1175/BAMS-89-4-497.

Schultz, D. M., Anderson, S. A., Fairman Jr., J. G., Lowe, D., McFiggans, G., Lee, E., & Seo-Zindy, R. (2015). ManUniCast: a real-time weather and air-quality forecasting portal and app for teaching. *Weather*, 70(6), 180-186. doi: 10.1002/wea.2468.

Suess, E. J., Cervato, C., Gallus, W. A., & Hobbs, J. M. (2013). Weather Forecasting as a Learning Tool in a Large Service Course: Does Practice Make Perfect?. *Weather and Forecasting*, 28(3), 762-771. doi: 10.1175/WAF-D-12-00105.1.

Zabini, F., Grasso, V., Magno, R., Meneguzzo, F., & Gozzini, B. (2015). Communication and interpretation of regional weather forecasts: a survey of the Italian public. *Meteorological Applications*, 22, 495–504. doi: 10.1002/met.1480.

Vitart, F. (2014). Evolution of ECMWF sub-seasonal forecast skill scores. *Quarterly Journal of the Royal Meteorological Society*, *140*, 1889-1999. doi: 10.1002/qj.2256.