

Public Understanding and Protective Action Thresholds on the Atmospheric River Scale

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Background (Ralph et al., 2019)

- Atmospheric River Scale developed to communicate risk, hazards, and benefits to the public and is now used globally

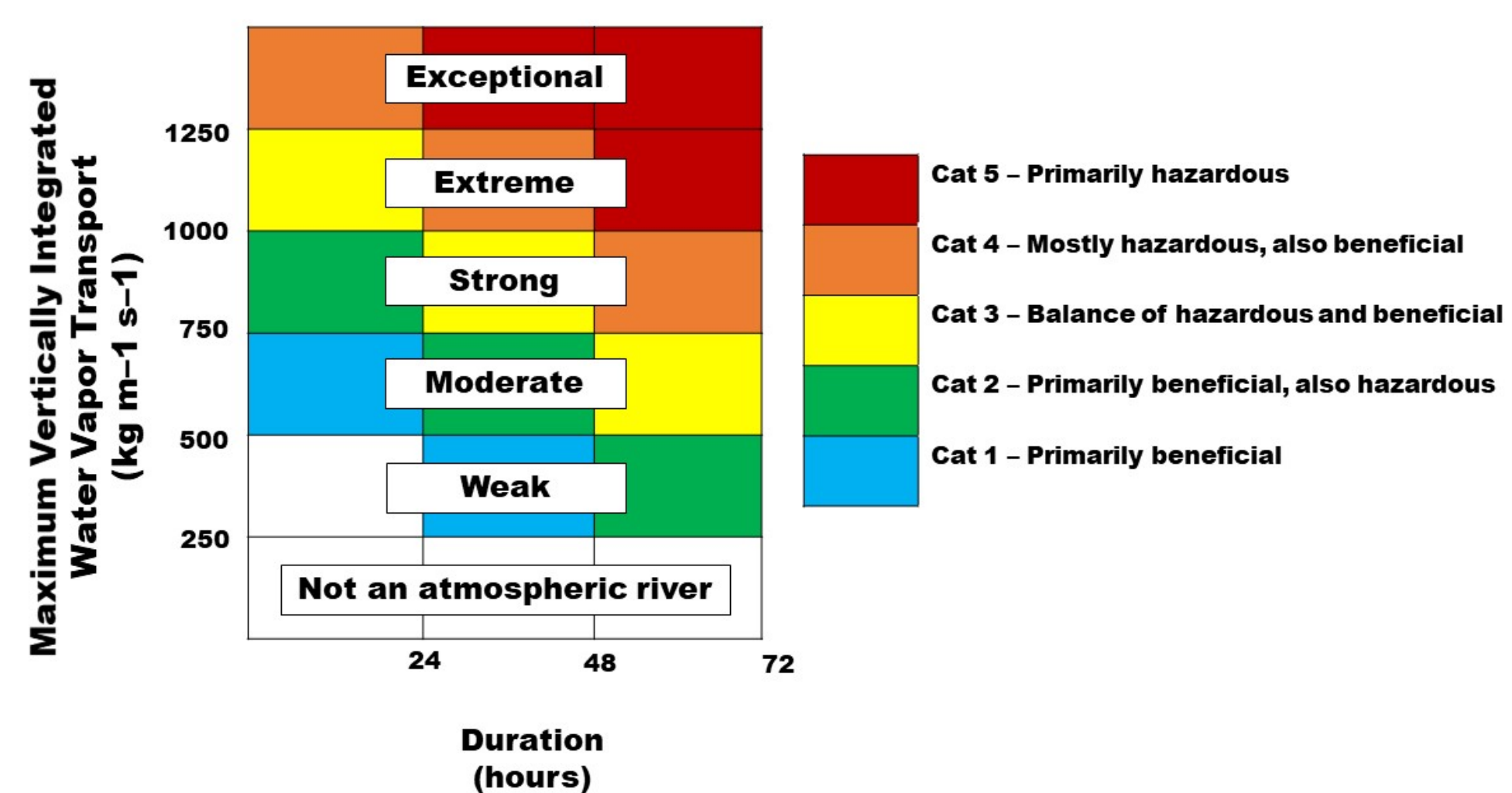


Fig. 1. The Atmospheric River Scale as presented in USGS (2021)

Atmospheric River (AR): long, narrow bands of concentrated moisture in the atmosphere that transport large amounts of water vapor, producing hazards such as flooding and high winds when interacting with terrain

Broadcast and Previous Scales (Ernst et al., 2026; Trujillo-Falcón et al., 2021)

- The AR Scale is increasingly being used by broadcast meteorologists in both English and Spanish to communicate event intensity and impacts, yet its effectiveness for public understanding has never been empirically tested
- Weather risk communication has a long history of using categorical scales that rely on numerical levels and impact-based wording, like the AR Scale
- Bilingual research on existing scales show that direct translations may not convey equivalent risk, highlighting the need for culturally and linguistically adapted communication

Methods

- Participants:** 2025 IPPRA Flooding and Society Survey
 - Recruited 1223 English and 375 Spanish participants, collected through Verasight, a surveying company
- Weighting:** Benchmarks compared to the U.S. population derived from the 2024 American Community Survey 1-year data through IPUMS USA (Ruggles et al., 2025)
- Analysis:** R version 2026.01.2+418 using the srvyr package (Freedman et al., 2026)

	FL25 (English, n = 1223)		FL525 (Spanish, n = 375)	
	U.S. Adult Population (%)	Participants (%)	Spanish-Speaking U.S. Adult Population (%)	Participants (%)
Gender				
Female	51.0	55.8	50.0	74.4
Male	49.0	44.2	50.0	25.6
Age				
18-29	20.1	16.1	24.2	14.7
30-49	33.8	34.7	40.0	56.3
50-64	23.2	25.3	22.3	26.1
65 and up	22.9	23.9	13.5	2.9
Race				
White	59.2	60.7	N/A	N/A
Black or African American	11.6	11.9	N/A	N/A
Other race	11.0	9.7	N/A	N/A
Hispanic Heritage				
Not Hispanic	N/A	N/A	5.4	2.9
Mexican	N/A	N/A	52.6	17.9
Other Hispanic	N/A	N/A	42.0	79.2
English Language Proficiency				
Does not speak English	N/A	N/A	10.3	12.3
Yes, but not well	N/A	N/A	16.4	44.3
Yes, speaks well	N/A	N/A	18.2	26.1
Yes, speaks very well	N/A	N/A	55.2	17.3

Table 1. Demographic Data of English and Spanish Speakers

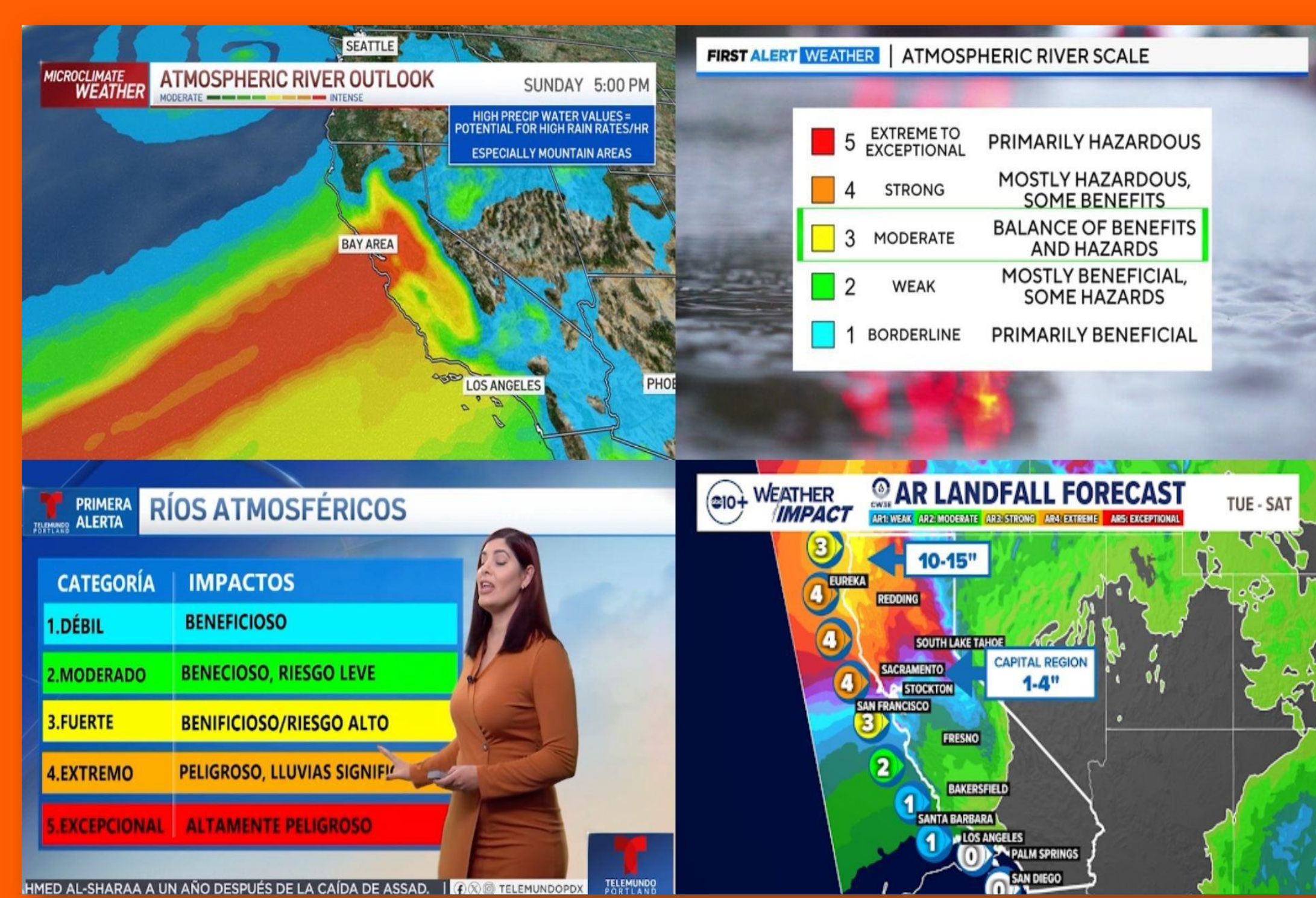


Fig. 3. News Station Atmospheric River Classifications

Based on a nationwide survey, members of the U.S. public interpret Atmospheric River (AR) Scale risk categories in varied ways, and these categories do not consistently translate into specific stated protective actions.

Results

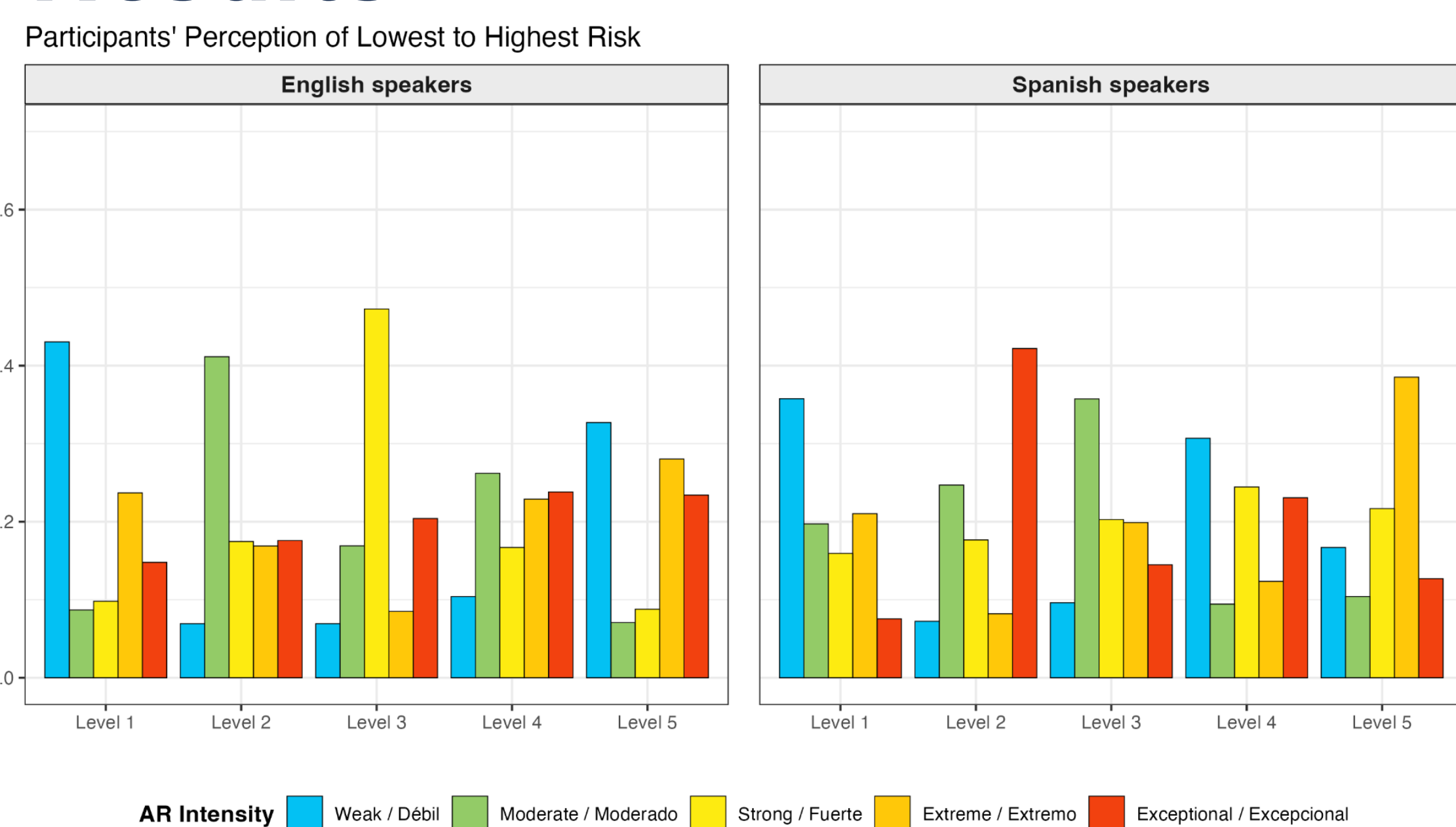


Fig. 4. English and Spanish survey participants' rankings of the AR Scale categorical words

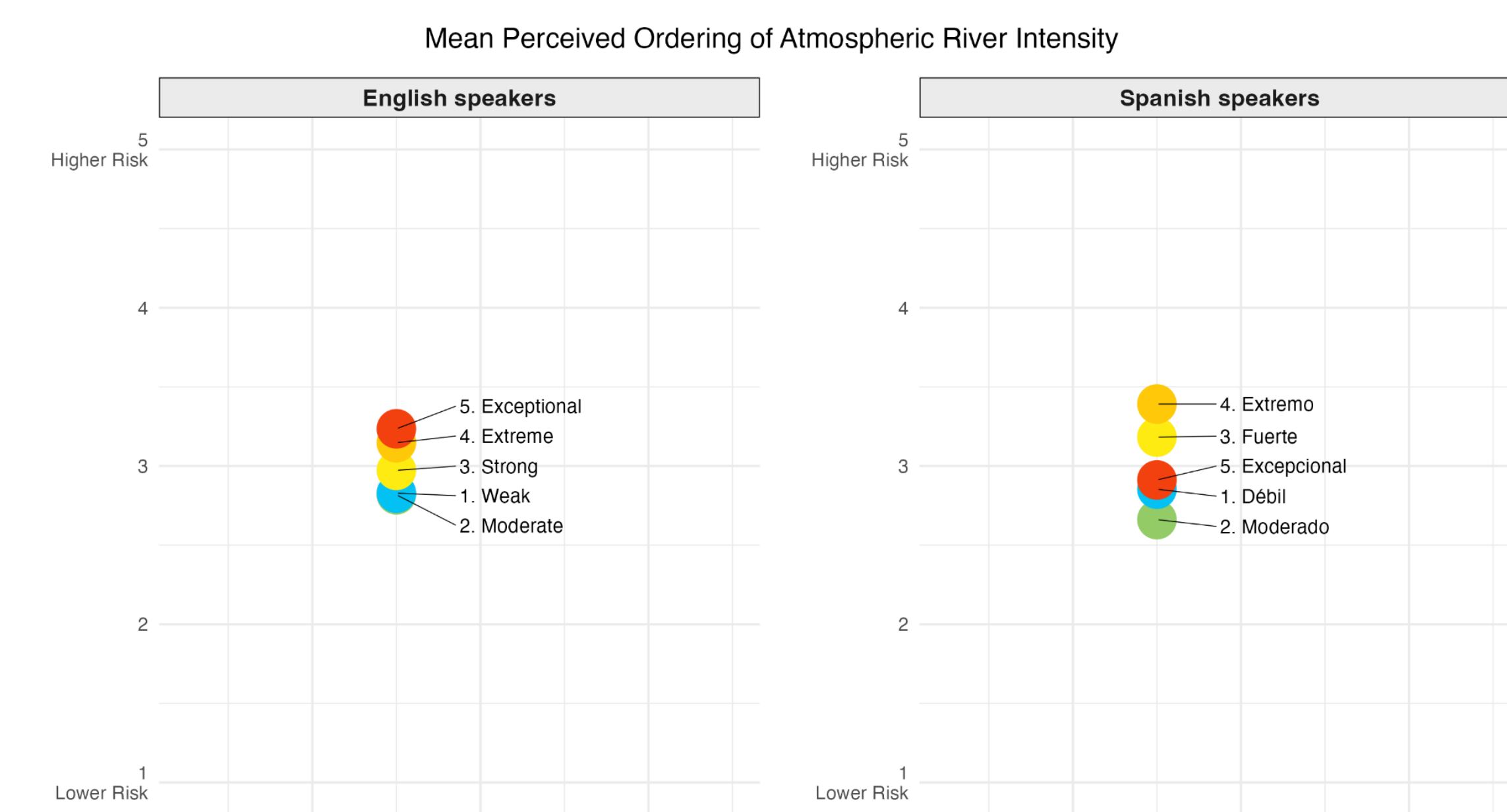


Fig. 5. Mean placement of each AR Scale term among English and Spanish participants

Top Five Order of Common Responses (English)	n	%
Weak → Moderate → Strong → Exceptional → Extreme	175	27.78
Weak → Moderate → Strong → Extreme → Exceptional	167	26.51
Extreme → Exceptional → Strong → Moderate → Weak	80	12.70
Exceptional → Extreme → Strong → Moderate → Weak	70	11.11
Extreme → Strong → Exceptional → Moderate → Weak	69	10.95

Top Five Order of Common Responses (Spanish)	n	%
Débil → Moderado → Fuerte → Extremo → Excepcional	30	27.27
Débil → Moderado → Excepcional → Fuerte → Extremo	29	26.36
Débil → Moderado → Fuerte → Excepcional → Extremo	13	11.82
Débil → Excepcional → Moderado → Fuerte → Extremo	10	9.09
Débil → Extremo → Moderado → Fuerte → Excepcional	7	6.36

Fig. 6. Top five most common ordering patterns of AR Scale intensity terms among English and Spanish-speaking participants

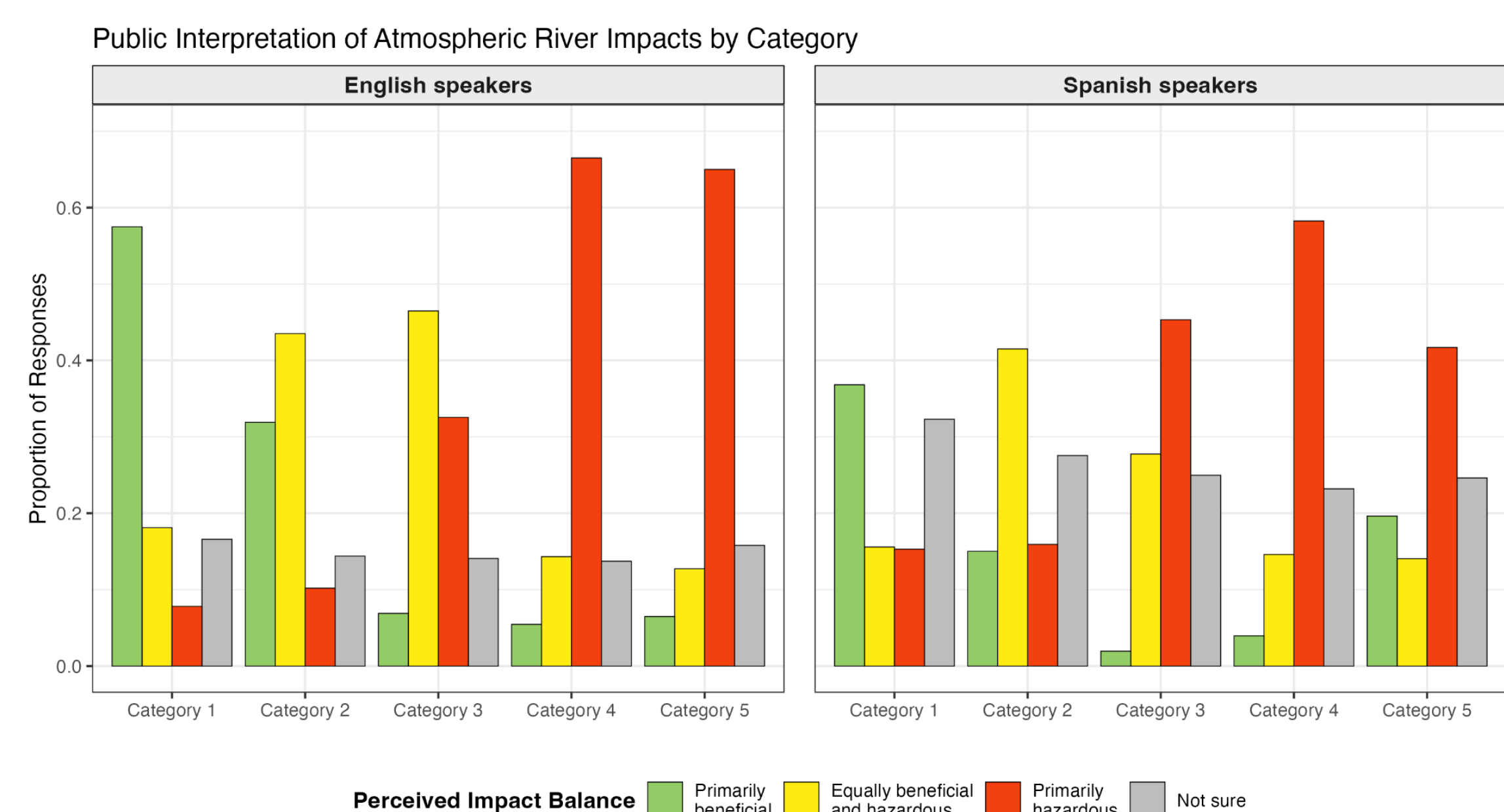


Fig. 7. English and Spanish participants' characterizations of expected impacts by category

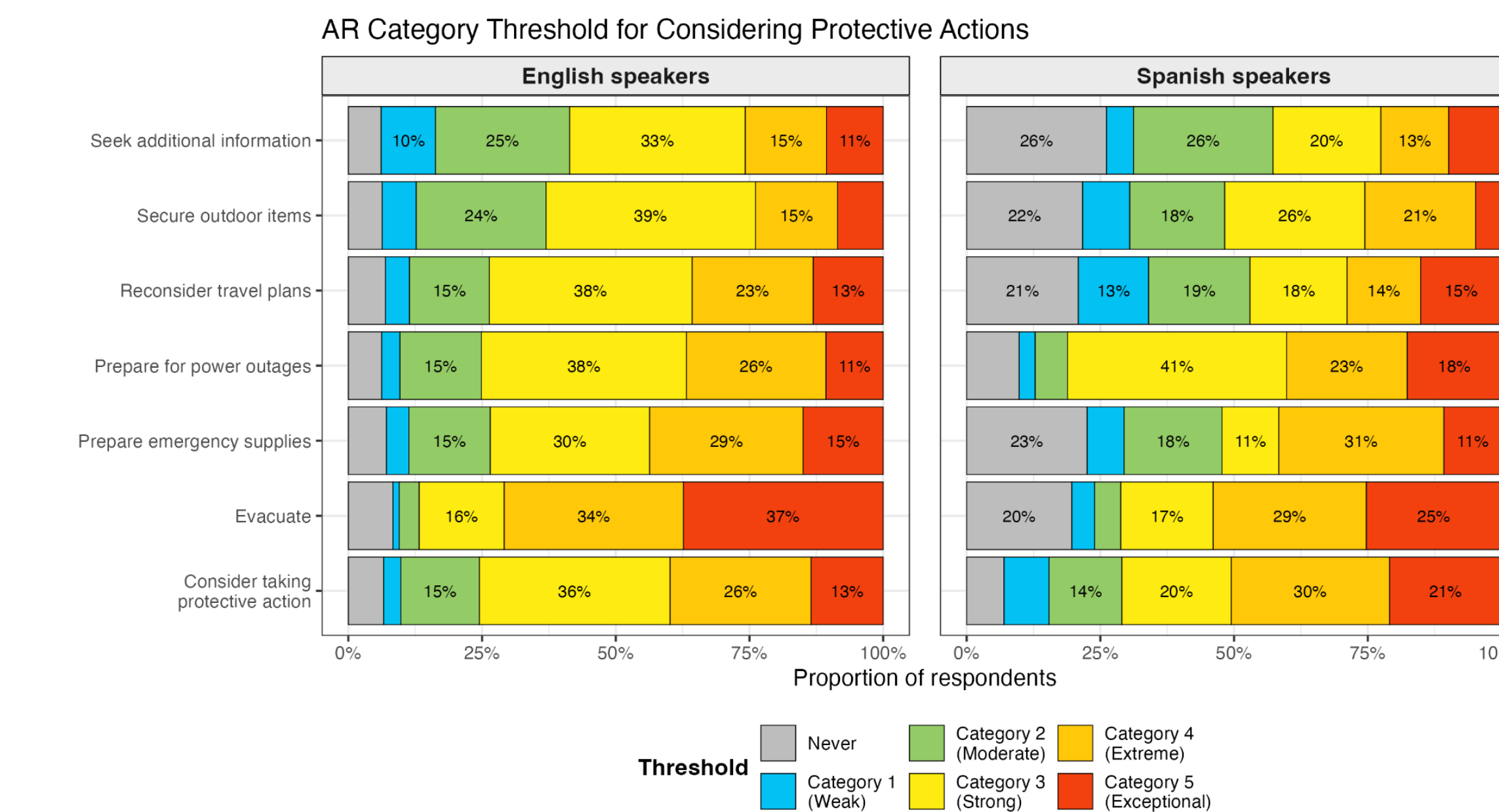


Fig. 8. Stated protective action thresholds by category among participants

Discussion

- Participants struggled to correctly order AR scale categories, with confusion at the highest levels, indicating the scale does not clearly communicate increasing risk
- Perceptions of AR impacts generally followed the intended beneficial to hazardous scale, but lower categories (AR1-AR2) were not clearly distinguished
- Spanish speakers showed higher levels of uncertainty and misclassification
- Intended protective action thresholds differed across language groups, with English speakers beginning to act around AR3-AR4 and Spanish speakers showing more dispersed responses and higher likelihood of reporting no action

Research Implications

- Improve forecast communication tools and products by refining AR Scale terminology to better align with public interpretation
- Expand public education and outreach efforts to build a baseline of AR risks and how to respond
- Support equitable risk communication strategies, particularly for Spanish-speaking and underserved communities with higher uncertainty and lower action rates
- Inform policy and emergency management messaging by identifying when people are likely (or unlikely) to take protective action, enabling more targeted warnings and interventions

Limitations & Future Work

- Study focuses on wording of the AR Scale and does not test other key components such as color or duration
- The use of a nationwide online survey leads to problems with representation, including self-selection bias and a smaller Spanish-language sample, which may affect generalizability
- Future research should evaluate alternative terminology, especially at the upper end of the scale and treat Spanish-language communication as an independent system instead of a translation
- Additional work should incorporate qualitative methods to examine how the AR Scale interacts with other hazard communication products



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