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The Indispensable Role of People in the Weather and Climate Forecast Value Chain

A Statement of the American Meteorological Society

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Today, more than ever, it is imperative that society invest in human capacity across the weather value chain to optimally benefit and advance weather and climate forecasting.

Over the past decades of investment in atmospheric science, we have observed remarkable improvements in the skill and accuracy of weather forecasts. Yet, too often, those forecasts fall short of their full potential—not because the science is lacking, but because the information is not being communicated in ways that people can easily understand and take action—that last mile in an effective and successful overall warning system. Recent tragedies, like the devastating Texas flash floods, remind us that effective communication is as critical as the forecast itself. The next great leap in atmospheric science will not necessarily come from advancing the relevant physical sciences alone (as it has in the past), but from investing in how humans—forecasters, emergency managers, community leaders—convey this life-saving information. We must act now to strengthen the social and communication sciences that bridge the gap between forecasts and decisions, ensuring not only that every forecast is technically accurate but that it reaches those affected with the proper urgency and is truly actionable.

In an era of data abundance, the bottleneck is not collection but synthesis. The scientific forecast process converts observations and information into knowledge: designing experiments, tuning models, interpreting ensemble spreads, and contextualizing outputs with analog cases and local insights. Even as artificial intelligence (AI) and machine learning (ML) systems excel at pattern detection and automated nowcasting, true value primarily emerges when experts discern which signals matter, recognize artifacts, and integrate socioeconomic considerations.

This requires human capacity. Certified broadcast and digital meteorologists, National Weather Service (NWS) forecasters, and the expanding commercial weather industry all serve as trusted translators of science, bringing forecasts to life for millions of people every day. Through television, radio, social media, and digital platforms, they are the voices and faces that communities rely on when storms threaten. While artificial intelligence will increasingly support forecast delivery in the years ahead, we must not lose sight of the trust and credibility that human forecasters provide. For many stakeholders, it is the local meteorologist—or the NWS forecaster on the other end of a warning—that makes the difference between confusion and

action, between uncertainty and safety. Protecting and amplifying this human connection is essential to ensuring that advanced forecasts reach their full potential in safeguarding lives and property.

Background: A Deeper Dive

The Forecast Value Chain: Weather and climate forecasting is often regarded as a scientific and technological enterprise—from satellites and supercomputers to automated nowcasting tools—but human expertise remains the essential thread weaving together every element of the forecast value chain.[1] From raw observations to risk-based decision-making, people (including researchers, modelers, operational forecasters, broadcast meteorologists, and communicators) shape, interpret, and contextualize data into actionable wisdom. The value chain perspective illuminates the myriad relationships, processes, inputs, contributions, and outcomes that are essential to forecasting and warning services, and it underscores why human judgment is vital for communicating uncertainty and prompting timely protective action, especially when an event is high-impact but low probability.

The value chain approach makes clear how observations feed models, models inform forecasts, forecasts become warnings, and warnings drive decisions. Of the many different forecast scenarios for weather and climate projections, conveying uncertainty—especially when early action is required for a potentially catastrophic, though initially unlikely, event—remains a formidable communication challenge. Human intermediaries excel at framing low-probability, high-impact risks in terms that resonate locally and emotionally, helping audiences weigh precautionary measures against uncertainty in ways that rigid automated bulletins cannot.

Certified Broadcast and Digital Meteorologists: Trusted Communicators and Community Scientists: Local meteorologists embody the human face of forecasting. They live, shop, coach youth sports, and volunteer alongside their audiences, forging personal connections that no synthetic voice or AI avatar can replicate today. Drawing on the Yale Attitude Change Approach[2] (where the communicator's credibility and attractiveness, together with the sincerity of the message, influence persuasive impact) community meteorologists leverage their local visibility and authenticity to build trust. Viewers recognize them not only as science experts but as neighbors who understand regional nuances—from flood-prone streets to urban heat islands—and personal concerns.

Over years of community engagement, broadcast meteorologists become the go-to authorities during extreme events. During hurricanes or tornado outbreaks, audiences tune in to see a familiar, calm presence translate complex watches and warnings into clear guidance. Empirical studies confirm their unique role: viewers consider AMS certified meteorologists as "highly trusted sources of information" on both weather and climate change, and many stations now encourage their on-air scientists to cover broader environmental topics (from water safety to renewable energy) leveraging their station scientist credentials.[3]

Moreover, community-based meteorologists serve as critical liaisons in the warning process. They interpret National Weather Service warnings and advisories, adapt them for local streets

and neighborhoods, and convey protective actions in real time while balancing lead time, geography, and audience risk perception. AI tools can generate routine forecasts, but they lack emotional intelligence and empathy: they can present the situation and its evolution, but only human communicators address the questions "What does this mean to me?" and "What can I do to mitigate the impact?" that are central to the principles of risk communication.

Behavioral Nuances and the Limits of Automation: Human salience to weather varies by individual and experience. The Joplin tornado service study by the National Weather Service[4] revealed that, despite timely warnings, many residents in a tornado-prone area delayed their response; instead, milling around, calling neighbors to confirm if the warning was "for them." This underscores that effective messaging must account for personal risk tolerance, social behavior, and the emotional dimension of trust. By weaving scientific guidance with empathetic, urgent appeals—"I'm one of you; we face this storm together"—broadcast meteorologists bridge the gap between technical warnings and immediate protective action.

It is likely that, in the future, synthetic voices will mimic a "steady, calm" on-air personality, yet, today, even the most advanced large language models (LLM) or voice-rendering algorithms are challenged to replicate the empathy, beneficence, authenticity, and local relationships cultivated by a human professional. Training meteorologists in social-science principles (understanding audience biases, heuristics, and decision triggers) remains essential to prompt early action when warnings are issued well before an event.

Human Expertise in Research, Modeling, and Research-to-Operations (R2O) Integration: Behind the scenes, an extensive network of scientists and technicians drive continuous improvements in numerical weather prediction (NWP) and climate modeling. Meteorologists, climatologists, mathematicians, and computer scientists refine dynamic cores, parameterizations, ensemble systems, and data-assimilation algorithms. Although automated data ingestion and algorithmic tuning process enormous data streams, human insight is indispensable for quality control, experimental design, and translating research advances into operational products.

The R20 process exemplifies this human bridge: program offices coordinate collaborations between academic labs and forecast centers. A university team may develop a novel convective-scale model, but it takes operational forecasters and engineers to validate that model against real storms, assess its societal value, and integrate it into live forecasting workflows. Similarly, climate scientists downscale global projections for regional impact assessments, guided by practitioners who understand decision-making contexts.

Decision Support and Impact-Based Forecasting: Operational meteorologists embed with emergency managers, utility operators, and event planners to tailor forecasts into actionable decision support. Incident meteorologists translate standard forecasts into briefings on flood timing for road crews or surf conditions for lifeguards. Decision-support specialists in national services interpret global model fields for military or humanitarian missions. Across these roles, human liaisons adjust messaging in real time, responding to audience cues and feedback with an agility beyond automated dashboards.

Similarly, private-sector meteorologists advise clients on rerouting flights or managing power loads, integrating forecast uncertainty with business risk thresholds. Their counsel is interactive: explaining caveats, answering questions, and co-developing mitigation strategies—a human-centered process that AI cannot fully replicate.

Community Engagement and Citizen Science: Observers including trained field crews, citizen spotters, and community networks supplement official data with ground truth during events. While crowdsourced reports flood systems during crises, experts validate, assimilate, and prioritize this input. Volunteer weather spotters reporting hail sizes or flash flooding enhance situational awareness, but only human scientists and forecasters can adjudicate quality and integrate these observations into operational forecasts.

Communities also provide feedback on forecast usability: surveys, focus groups, and social-media listening inform refinements in messaging. This two-way communication—co-production of forecasts—addresses a critical gap highlighted by WMO's World Weather Research Programme (WWRP) Societal and Economic Research Applications (SERA) conference: inclusive user engagement, integration of social and physical sciences, improved uncertainty communication, and evaluation of forecast value from the user perspective.[5]

Artificial Intelligence, Machine Learning, and Large Language Models: Partners, Not Replacements: AI and ML offer powerful complements: automated pattern recognition in satellite or radar data, rapid ensemble post-processing, draft forecast discussions, real-time translation, and personalized communication. AI can help address bottlenecks and/or alter the strategic allocation of people (a limited resource) in the value chain. Pilot tools like ClimSight illustrate how LLMs can summarize localized climate data for non-experts.[6] Yet these technologies handle "What is happening?" and "How will it evolve?" more readily than "What does it mean to me?" and "What can I do?" Emotional intelligence, empathy, and the capacity to judge audience readiness remain inherently human.

Overreliance on opaque algorithms risks eroding trust and stifling innovation; many AI-generated forecast products lack source attribution. If forecasts are perceived as black-box outputs, public confidence may falter when discrepancies arise. Human validation and explanation sustain credibility, ensuring that technical advances translate into social resilience.

Conclusion and Call to Action: The forecast enterprise is as much a human endeavor as a technological one. Each satellite launch, model upgrade, or AI prototype becomes effective only through people—researchers, engineers, forecasters, communicators, and educators—who apply judgment, context, and emotional intelligence. Broadcast meteorologists, as "station scientists," epitomize this synergy: trusted neighbors who transform data into guidance.

Moving forward, investments must balance hardware and algorithms with human capital: social-science training for communicators, interdisciplinary research hubs, and expanded professional development in data science and risk communication. By valuing expertise in uncertainty framing, emotional engagement, and behaviorally informed messaging, we ensure

that forecasts are not only technically advanced but also trusted, understandable, and action-oriented. In an age of sophisticated automation, preserving the human touch remains our surest path to safeguarding lives and communities.

For additional information on AMS certification programs, please refer to the following links: Certified Broadcast Meteorologists; Certified Digital Meteorologists

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