J7.4 WHAT IS A SATELLITE MEASUREMENT? COMMUNICATING ABSTRACT SATELLITE CONCEPTS TO THE WORLD

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1. INTRODUCTION

Communication is a fundamental aspect of scientific inquiry. We continually communicate new ideas, research goals, methods and significant results, whether that be to our scientific peers, stakeholders, decision makers, students, congressional staffers or society in general. Effective pathways of communication enable full and unbiased knowledge transfer. It is our duty to find, create and maintain such pathways. But this is easier said than done. Too often our communication falls short of delivering a clear message and we fail to inspire scientific understanding or trust in the message. This paper analyses some of our recent efforts in scientific communication with a closer look at challenging cases to try understand the root causes and identify room for improvement. Far from being specialists in communication theory we turn, instead, to Claude Shannon's ground-breaking paper in 1948, entitled "*A Mathematical Theory of Communication*", to provide the necessary structure to our thoughts and enable specific questions: Was our message distorted? What are the sources of noise in our communication pathway? How can the signal-to-noise ratio of our communication system be improved?

2. DISCUSSION

This discussion is centered on our challenges in communicating abstract concepts about the NOAA Unique Combined Atmospheric Processing System (NUCAPS) to stakeholders. NUCAPS retrieves satellite soundings from top-of-atmosphere infrared and microwave radiance measurements. A retrieved satellite sounding is a set of vertical profiles of temperature, moisture and trace gases that characterizes thermodynamic structure and chemical composition of the atmosphere. NUCAPS soundings have been operationally available to forecasters since 2014 but these soundings were initially not readily adopted into operations because forecasters did not know what they were and how to use them. It took effective communication to overcome their initial resistance. Now that forecasters have better knowledge of satellite soundings and how they complement radiosondes (in situ soundings), we see NUCAPS products routinely used in operational forecasting. Five years ago this felt like an impossible feat.

Shannon (1948) described a general system of communication as consisting of five parts. There is (i) the **Information source** that produces the message, (ii) the **Transmitter** that operates on the message to produce a signal, (iii) the **Channel** or medium that transmits the signal, (iv) the **Receiver** which inverts the signal back into a message, and lastly (v) the **Destination** for which the message is intended. The flow of information in this schematic system (Fig. 1) is strictly one-way; from Source to Destination. We make the case here to adopt an iterative cycle between Transmitter and Receiver to improve Transmitter quality, reduce Receiver bias and minimize Noise.

Following the pathway depicted in Figure 1, communication starts off with an Information Source, which in the present context is NUCAPS. The message about a NUCAPS sounding typically has to do with communicating its quality and value in analyzing specific weather systems, in providing mesoscale situational awareness or in adding value to air quality monitoring applications. Communication can be technical, conceptual or scientific at times. As NUCAPS developers we know we have a strong message that is worth transmitting. Our challenge, thus, does not lie in having a weak start to our communication pathway but instead in transmitting our message through the

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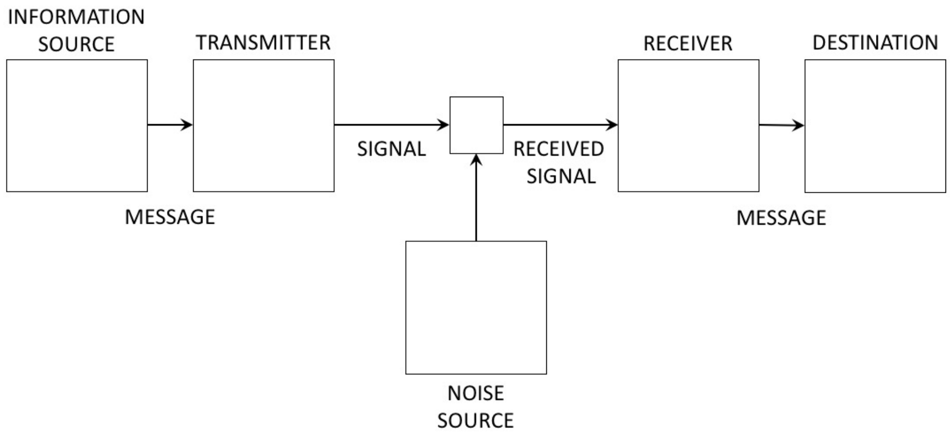

Fig. 1: Schematic diagram of a general communication system. Source: Shannon (1948)

next three steps, namely the Transmitter, the Channel and the Receiver.

The Transmitter Challenge is an example where a Transmitter can turn a strong message into a weak signal and thus fail to maintain an effective communication pathway. For a while satellite scientists communicated as Salesmen trying to sell their products to forecasters and environmental decision makers. Each scientist would proclaim that their product is better than all the rest and the only product of value in decision making. Even though scientists had a strong message to communicate, their approach as Salesmen hindered effective communication by weakening the signal transmitted to the Receiver. A Salesman approach to communicating satellite concepts tends to oversimplify product capability, operational context as well as user requirements. In their operational capacity, forecasters need to understand complex atmospheric processes and have access to all relevant data products that complement each other with their individual strengths and weaknesses. As NUCAPS developers we have had the opportunity to evaluate our communication pathways in the Joint Polar Satellite System (JPSS) Proving Ground and Risk Reduction (PGRR) Sounding Initiative that has been funded by NOAA since 2014. Working in multi-disciplinary teams alongside forecasters, we are learning to be more effective communicators by ceasing to be Salesmen. We now adopt an approach that encourages honest questions about product quality and value. By listening actively forecaster their response and follow-on questions, we can be more effective Transmitters of messages about our product.

The Channel Challenge is an example where a strong message passes through a strong Transmitter but due to various sources of noise reaches the Receiver as a weak signal. Vocabulary is often a source of noise that distorts a message into a weak signal. The words we use to describe NUCAPS characteristics and quality can promote or hinder understanding. On one occasion, a NUCAPS sounding was described as a *volume measurement* to distinguish it from radiosondes, which are in situ soundings. A NUCAPS sounding of temperature and moisture depict the entire column of atmosphere from surface to top with a diameter determined by the satellite footprint, which is ~50 km at nadir for NUCAPS. This is unlike a radiosonde that measures the vertical atmosphere as a series of point-source measurements along the ascending balloon pathway. Describing a NUCAPS sounding as a *volume measurement* made sense at the time but we later learned that the use of the word *volume* was confusing to atmospheric chemists because NUCAPS soundings are measured in [K] and [g/kg] and are, therefore, not *volume* measurements in the strictest sense. To improve our communication, we have since adopted the term *column measurement* to describe NUCAPS soundings.

The Receiver Challenge is an example where a strong message passes through a strong Transmitter with minimal noise interference, but a Receiver hinders the transformation of a message into understanding. This challenge can be addressed if we as a scientific community create and nurture more opportunities for active dialog and debate. Enabling a two-way communication stream between Transmitter and Receiver can allow iterative signal flow (back-and-forth) to ensure that a clear message is delivered clearly or that an Information Source is transferred into Knowledge and Understanding.

3. CONCLUSION

A radical change in communication can lead to a paradigm shift in the quality and value of our scientific work. As a satellite sounding community we now find ourselves working through decades of miscommunication in an attempt to create new and more effective communication pathways. The goal is to improve understanding and knowledge about weather systems and their effects on society.

4. REFERENCES

Shannon, C.E. 1948: A mathematical theory of communication. *The Bell System Technical Journal*, 27, 379–423.