NATIONAL WEATHER SERVICE
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Hand Analysis in a Digital Era

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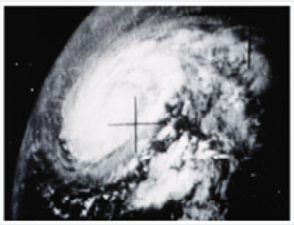
JANUARY 15, 2020

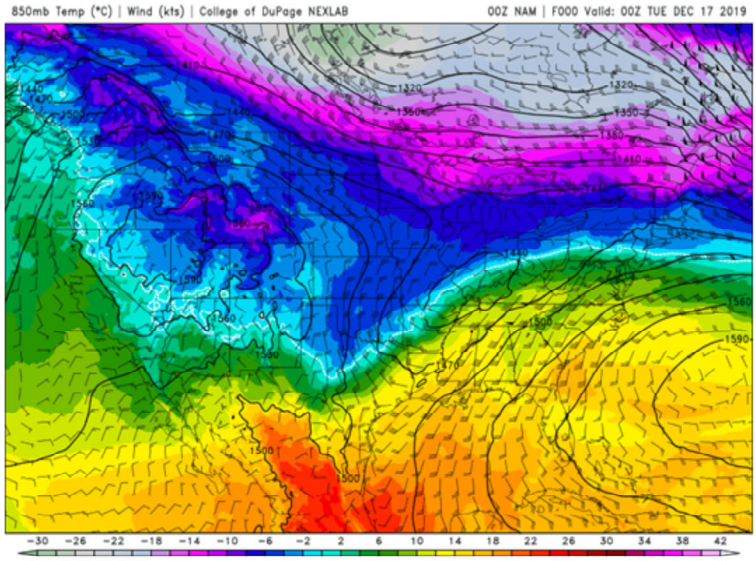


How many in audience are operational mets of some form? Instructors (teachers, faculty)? Perform any kind of hand analysis at least periodically?

Probably 2 groups in here – those who already do hand analysis and those whose arms are crossed and believe it's a waste of time. Opinions on the subject can be passionate. Presenting here what is informed by research, particularly cognitive research.

Forecasters are Flooded with Images

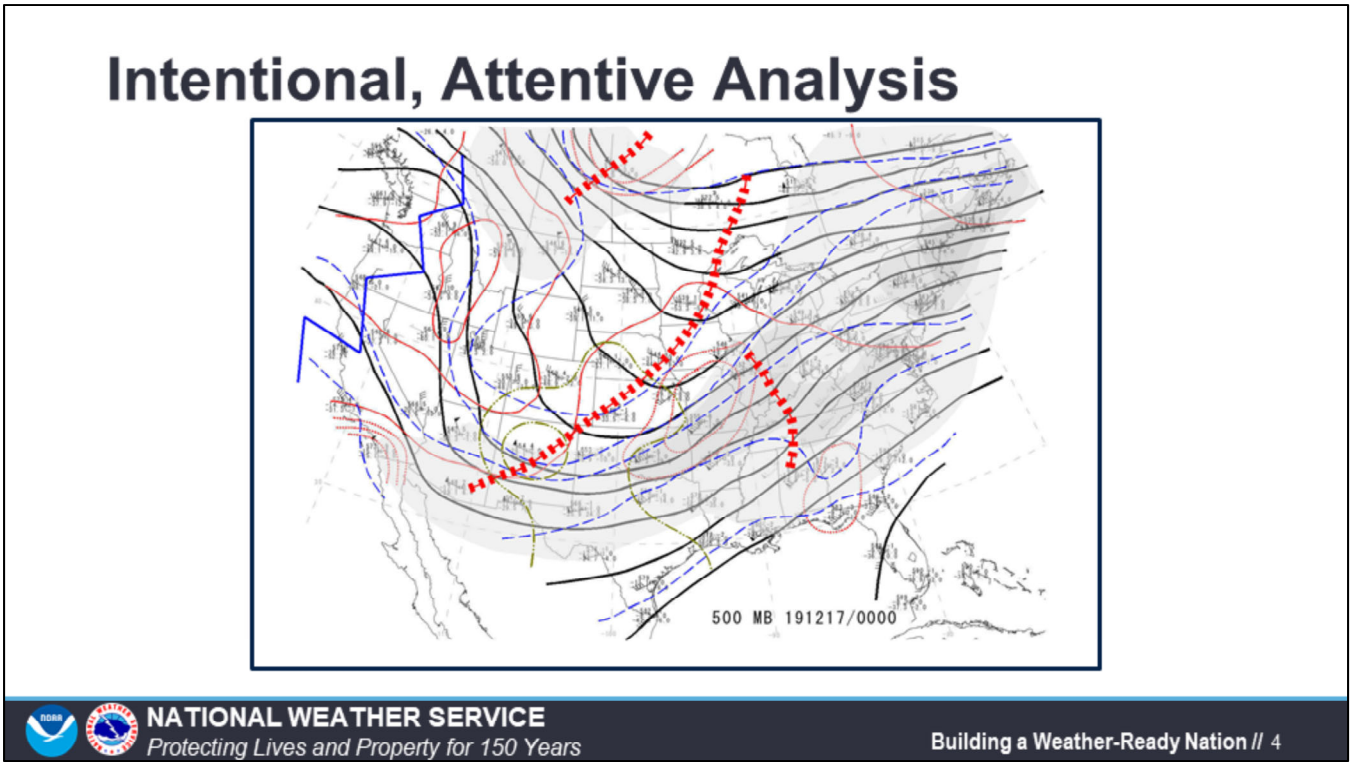


I don't know of any research on the topic, but from experience and observations, I can tell you that we look through hundreds of model timestep images when making any given forecast – <click> several models, from initialization to end (or to period of interest), at multiple analysis levels, from at least the most recent run and possibly either previous runs or new runs coming in. <click> By mathematics alone, any given image is only on our screen for a very short time, measured in seconds, not minutes. <click> We look at these under varying levels of distraction as we also answer phones, talk to colleagues, check email, and so on. How much of an image are we really seeing, let alone encoding into memory?

What Do You Recall?

Where was the 500mb trough axis? (Go ahead, call it out.)
Where were the height falls, and how deep?
At 850mb, where had the 8C+ dewpoints reached? Where is the 0C line?

(Yeah, you didn't know you were going to be quizzed… but after all, it's a presentation and you probably were paying attention!)

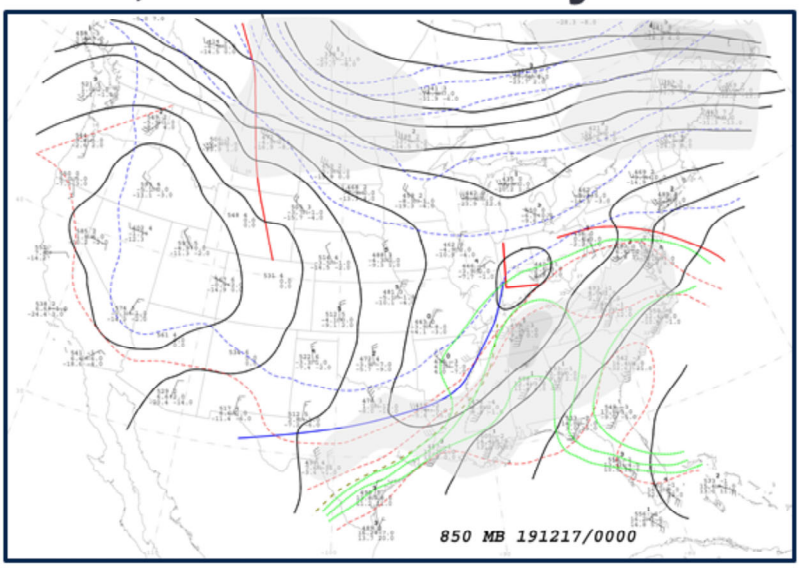


Let's build an analysis, then, one that we can follow more intentionally. In an ideal world, I would draw this for you here, in real time, but technology and time limit it. For demonstration purposes, I'll be layering on digital images of analysis fields. The process of creating these, though, is the cornerstone of the hand-to-brain pathway and not one to neglect. For the sake of time, we will step through two levels: 500mb and 850mb. (I recognize that 850mb is not relevant in some parts of the country/world, but in the central and eastern US, it is vital for near-term weather diagnosis and makes a good example.) These are hand-drawn in digital software by Josh Boustead, and as a reminder, subjective analysis is just that – subjective. Other views could vary, though hopefully the major features will still stand out.

You are not in your synoptic class anymore. You will not be graded down because you used a non-standard color, a solid instead of a dashed line, or the wrong style, color, or letter for a low. *That* you do it matters more than how, as long as you can distinguish your features when you're done. Some people may draw in pencil first and then go over in pen or marker. That's also a personal comfort choice.

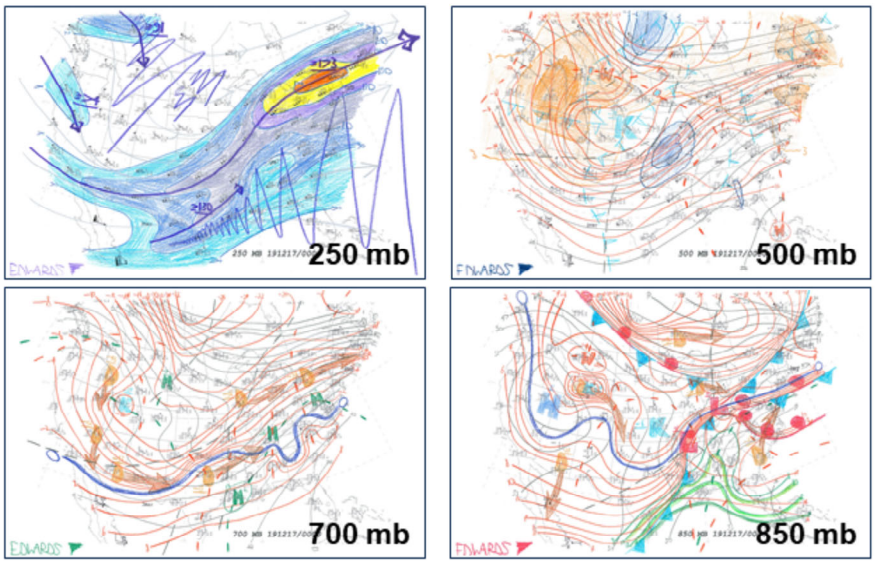
At 500mb, I would analyze the heights first, drawing the isohypses, followed by analyzing height changes, or isallohypses. Then I would add the positions of highs, lows, troughs, or ridges. Subtle shortwave troughs and ridges can make or break daily weather, especially in convective and summer seasons, so I would be very diligent to try to pick these out, matching them to water vapor imagery for confirmation. Next, I would draw in some kind of highlight for stronger winds, above 50kt and especially higher, such as 75 and 100 kt. Finally, I would consider temperatures. For me, at this level, the important feature really is the difference between 700mb and 500mb temperatures, to get after the lapse rates.

Intentional, Attentive Analysis

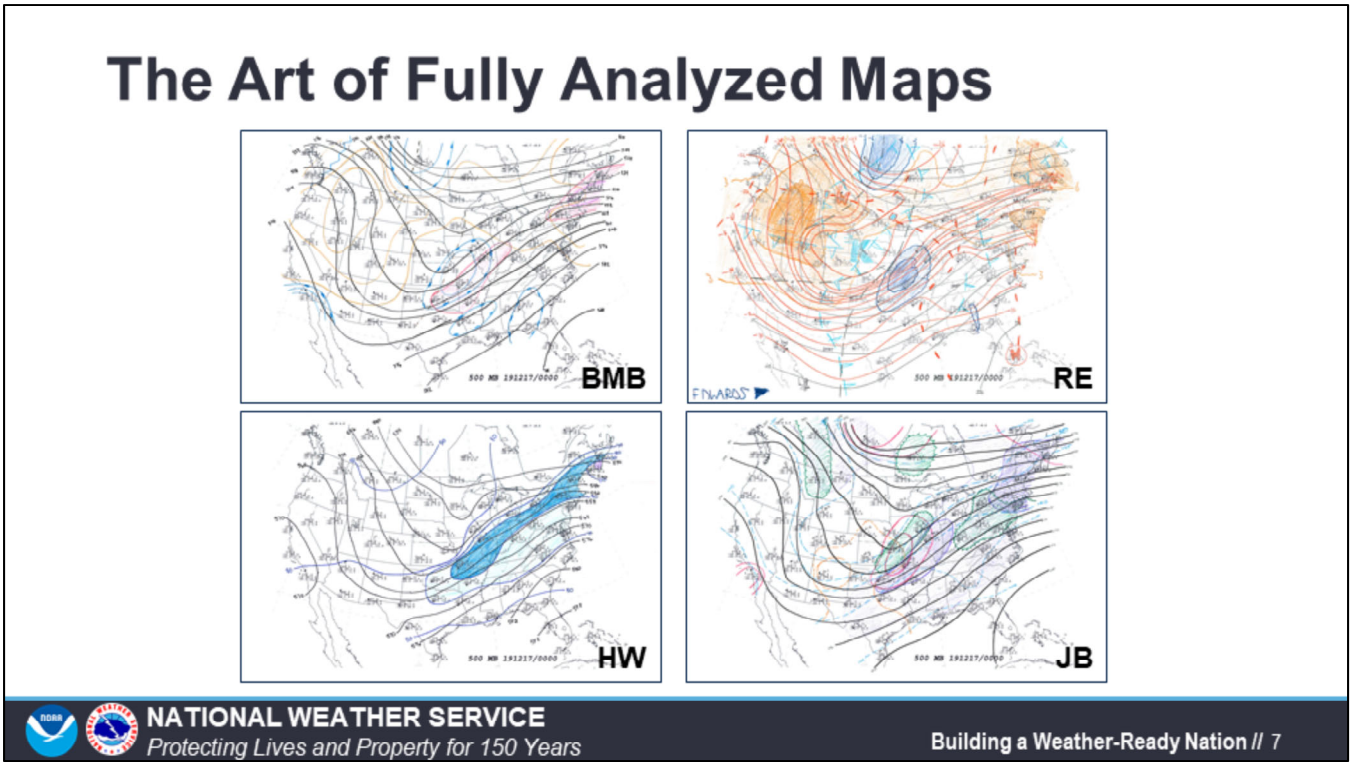


At 850mb, Josh starts with the front and low/high features. YMMV. I would start with isohypses to get the baseline of contours. At that level, temperature and moisture become very important. I contour temperatures next at 5 degree intervals, or more if I'm really looking for temperature-sensitive features like freezing lines. Dewpoint temperatures are next, to show where moisture is pooling. In winter, RH may be more telling. In convective season/summer or during flood threats, the dewpoint itself is of higher value. For me, only after I have drawn all of these features do I attempt to locate and draw in fronts. Again, the boundaries are often subtle. They can be messy, too, with terrain, bodies of water, convective outflow, drylines, pre-frontal troughs, and other features that don't match a perfect Norwegian model.

The Art of Fully Analyzed Maps

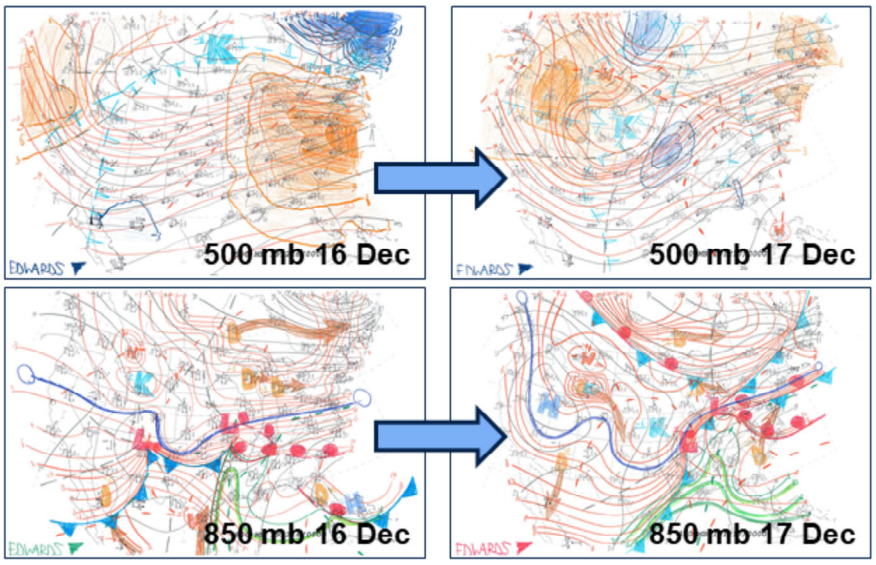


In the end, fully analyzed hand-drawn maps can look something like these works of art from Roger Edwards. Maps are almost a perfect merger of art and science. Just about every forecaster has a different style, a different set of preferences, a different combination of perfect replicas of synoptic class requirements and personal style.



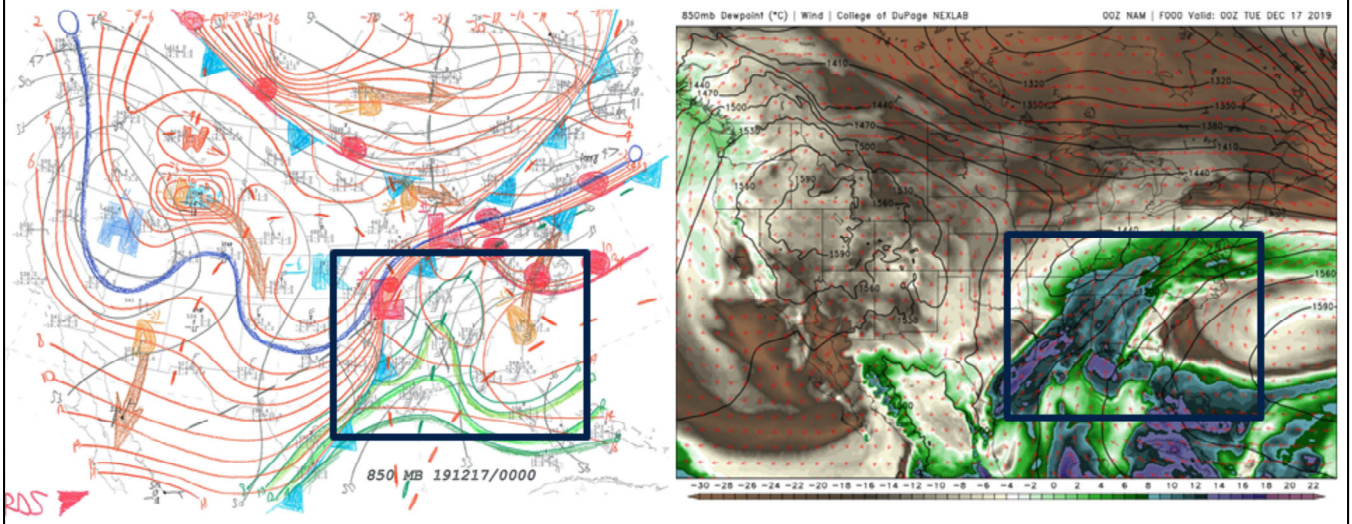
In fact, there is variability even among the four co-authors of this study. And yet, even so, the major features emerge – the trough in the central US with several pockets of falling heights, and the jet axis across the eastern US, for example.

Map Analysis Aids Event Continuity



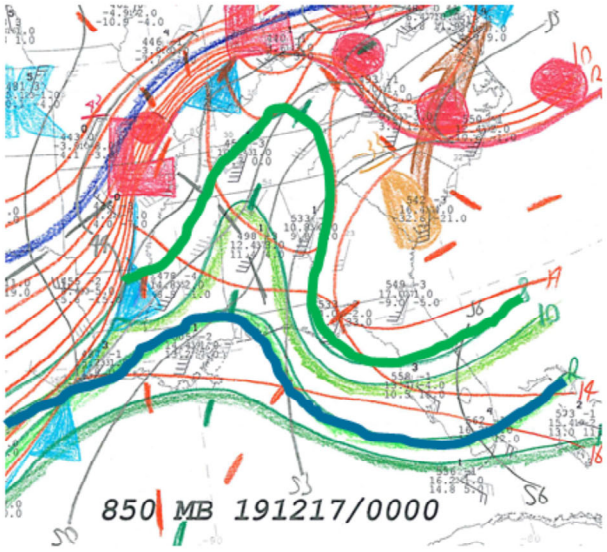
Roger worked this event and also had done an analysis of 00Z on the day prior to our 00Z example. By analyzing a series of maps as an event approaches, a forecaster gains an even greater sense of the continuity of the event – how the features are evolving and changing.

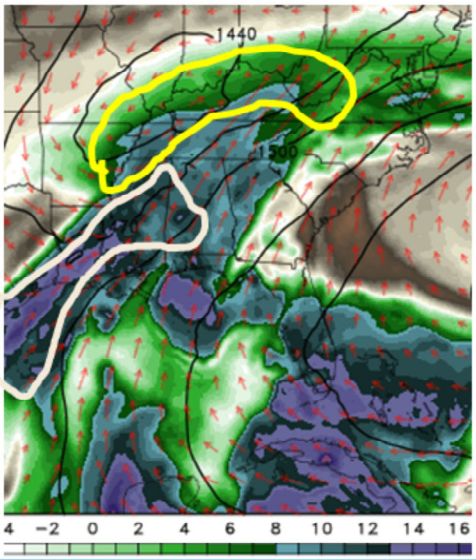
Map Analysis Aids Model Diagnosis



The analysis also helps identify more readily where models are getting it wrong in the initial conditions. Now, if your weather event of interest is on day 7, I might actually agree with you that map analysis probably isn't going to be super helpful unless you're doing it globally. But if your weather event is in the next, say, 24 to 48 hours, those initial conditions become far more important to sort out. Where is the model biased too warm or cold, too dry or wet? Did it pick up on subtle shortwaves, or subtle height falls like those in the southeastern US? Is the position of, for example, a shortwave ridge in wake of overnight convection accurate?

Map Analysis Aids Model Diagnosis





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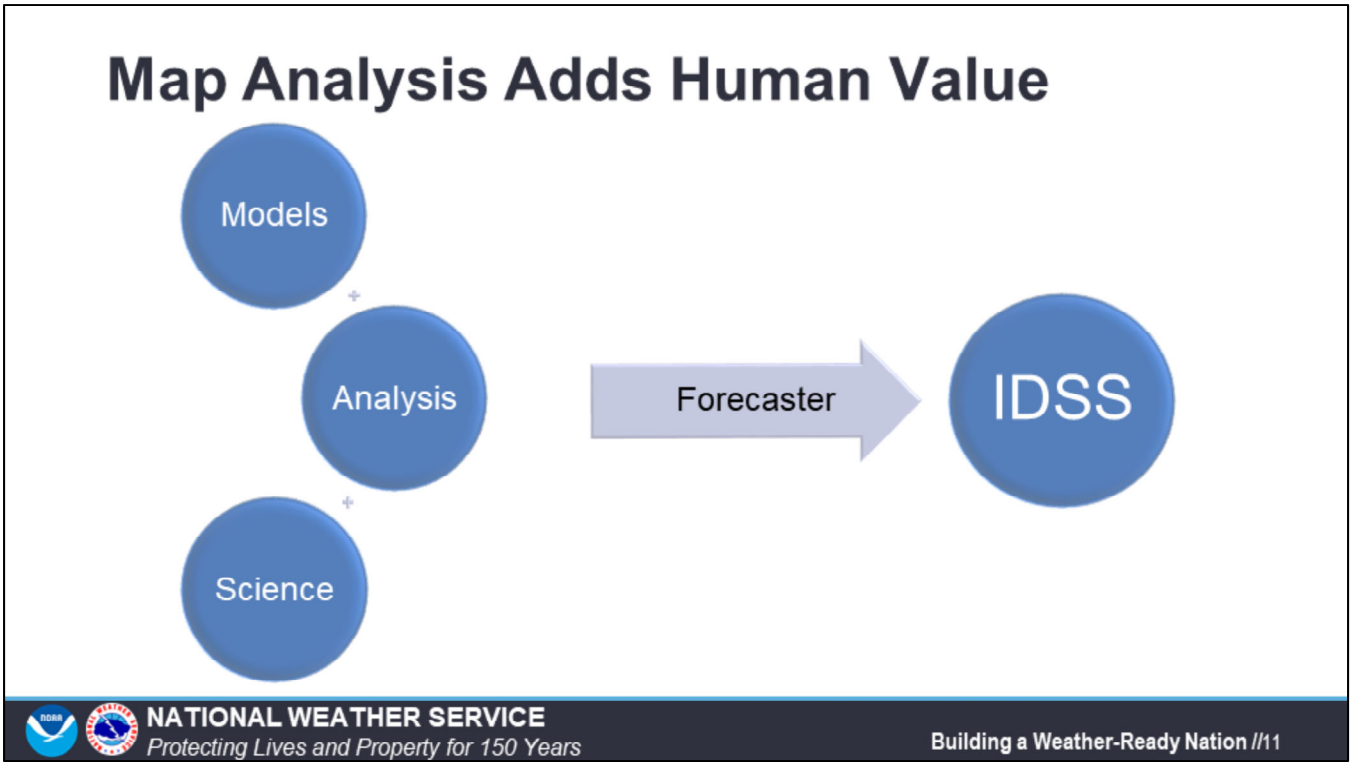
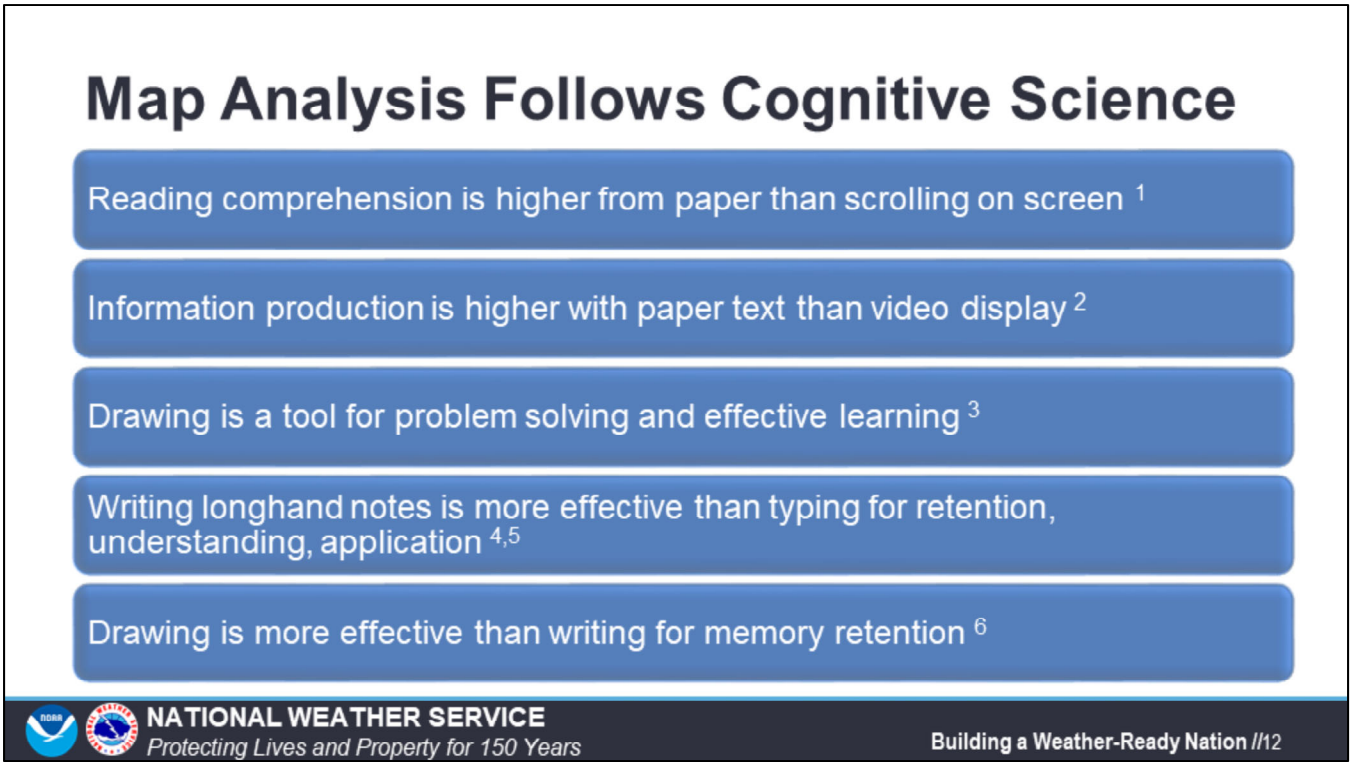


In this era of national blended models, of ensembles and their ranges and means, many forecasters have asked each other and themselves what their role will be. It is here. It is this. Deep analysis and understanding of the current state of the atmosphere, how it aligns with our conceptual scientific understanding, and how well models are resolving it, all supports our ability to translate the weather and our forecast decisions to our core partners and to our publics.



Hannah Wells has dug into cognitive science publications. Our ability to recall information – and, thus, to use it – depends on how we encode it. That matters because as you go through your forecasting process, you are trying to recall the initial state of the atmosphere as the starting point for a forecast going forward. Your ability to accurately recall what it was increases if you encoded it manually – via drawing. That could save you from flipping back and forth a bunch of times through your shift, increasing your efficiency later in the process.

References:

1 – Mangen, A., Walgermo, B. R., & Brønnick, K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. International journal of educational research, 58, 61-68. https://www.sciencedirect.com/science/article/pii/S0883035512001127

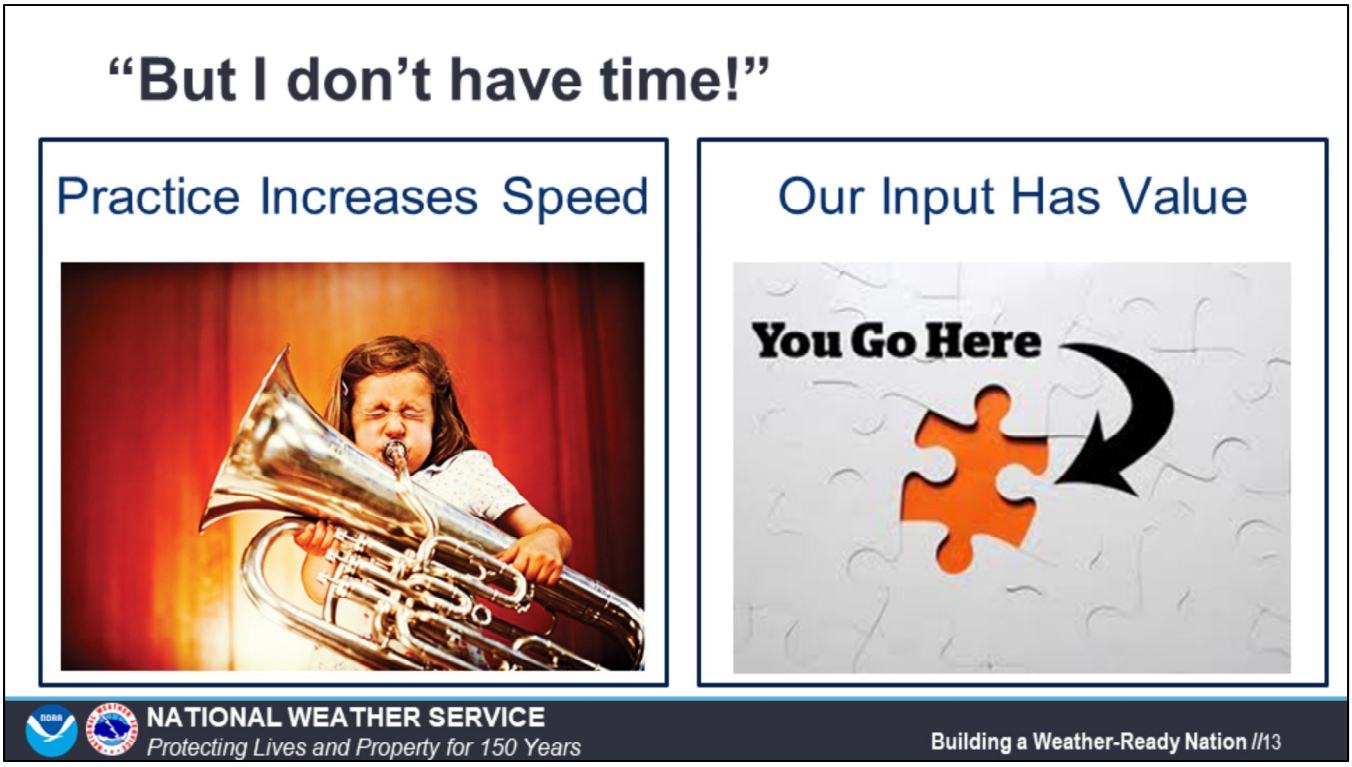
2 – Wästlund, E., Reinikka, H., Norlander, T. and Archer, T., 2005. Effects of VDT and paper presentation on consumption and production of information: Psychological and physiological factors. *Computers in human behavior*, *21*(2), pp.377-394. https://www.sciencedirect.com/science/article/pii/S0747563204000202

3 – Musgrove, L. and Musgrove, M., 2015, Drawing is Learning, Journal of the Assembly for Expanded Perspectives on Learning, Vol. 20, Article 12. 91-102. https://trace.tennessee.edu/cgi/viewcontent.cgi?article=1267&context=jaepl

4 – Stephens, A., 2017: The benefits of hand-written versus digital notetaking in college lecutres. MS Thesis, James Madison University. https://commons.lib.jmu.edu/cgi/viewcontent.cgi?article=1056&context=lexia

5 – Luo, L., K.A. Kiewra, A.E. Flanigan, and M.S. Peteranetz, 2018: Laptop versus longhand note taking: Effects on long-term achievement. Instructional Science, 46(4). https://link.springer.com/article/10.1007/s11251-018-9458-0

6 – Meade, M.E., J.D. Wammes, and M.A. Fernande, 2018: Drawing as an encoding tool: Memorial benefits in younger and older adults. Experimental Aging and Research, 44(5), 369-396. https://www.tandfonline.com/doi/full/10.1080/0361073X.2018.1521432



Practice will make the process flow more naturally. The high-impact weather days are when we need a deep fundamental understanding of the atmosphere the most, and yet is also the kind of day we might be tempted to neglect a thorough analysis. Practicing in big bubble weather will help you do it when it counts.

Also, consider what your role is, as an operational meteorologist, to best serve your partners and publics. We put our time into tasks we prioritize. When we are forecasting, prioritizing a thorough understanding of the atmosphere allows you to provide better service to your partners and do more intentional model browsing – more focused on important features, more ready to neglect models that missed the mark at initialization. At the heart of all of our IDSS activities must be a strong understanding of the meteorology of our forecast, and hand analysis puts a valuable and irreplaceable tool into your toolbox. Anyone can access model output online, but practicing meteorologists are the ones with the skill to create and interpret subjective analyses and apply them to the forecast process, going beyond the model output. This is where we add value.

Go on, Give Hand Analysis a Try!

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