6A.6 NUCAPS IN AWIPS – RETHINKING INFORMATION COMPRESSION AND VISUALIZATION FOR FAST DECISION MAKING

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1. INTRODUCTION

The NOAA Unique Combined Atmospheric Processing System (NUCAPS) operationally generates satellite sounding observations from measurements made by instruments on polar-orbiting platforms in mid-morning (MetOp A/B with ~10:00 am/pm local overpass times) as well as early afternoon orbits (Suomi-NPP and NOAA-20 with ~01:30 am/pm local overpass times). With consistent quality across 2,200 km wide swaths and multiple observation times throughout a 24-hour cycle, NUCAPS enables mesoscale situational awareness of the 3-dimensional atmospheric state.

In 2014 NUCAPS became available within the National Weather Service (NWS) Advanced Weather Interactive Processing System (AWIPS-II). Since then, NUCAPS soundings have been assessed in a range of different forecasting scenarios; (i) Wheeler et al. (2018) highlighted four cases of NUCAPS in the pre-convective environment and, (ii) Weaver et al. (2018) discussed how NUCAPS products improve aviation forecasts of cold air temperature (below -65˚C) at flight levels. While some forecasters compare NUCAPS to being like *hundreds of low-cost 1800 UTC radiosondes*, the true value does not necessarily lie in its similarity to radiosondes, but rather in how its strengths can be maximized to fill observational gaps and supplement existing forecast capability. This paper gives an overview of current satellite sounding capability within AWIPS II and explains the type of decisions that typically benefit from having ready access to NUCAPS observations. We argue here that while substantial progress has been made in improving NUCAPS accessibility within the operational forecasting community, much remains to be done to maximally exploit the information content in NUCAPS observations to derive high quality, actionable information that can save forecasters time and improve their decision making.

2. DISCUSSION

NWS Weather Forecast Offices (WFO) are tasked with the difficult challenge of providing quality forecasts and issuing watches/warnings during high-impact weather events. Timeliness is a critical component that often determines whether lives and property can be saved. The three questions forecasters typically wrestle with,

What happened?

What is happening?

What will happen?

can be successfully addressed if the right type of information is available at the right time. In addressing each of these questions, satellite observations play an essential role (Goldberg et al. 2018). For example, to address the questions about **what happened**, whether that be a few hours or days ago, forecasters can turn to archives of high quality satellite data products for in-depth analysis. To answer the question about **what is happening**, forecasters can turn to instruments on

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geostationary platforms such as the Advanced Baseline Imager (ABI) launched on GOES-16 in November 2016, for high-frequency, high-definition images of evolving weather systems and real-time updates on the atmospheric state. The question about **what will happen** is addressed by forecast models that assimilate measurements made by instruments on polar-orbiting platforms. This is especially true for the hyperspectral infrared measurements from the Cross-track Infrared Sounder (CrIS) that are assimilated into global forecast models to reduce bias in thermodynamic parameters. CrIS measurements have proven to be so successful that a second CrIS instrument was launched on the polar-orbiting NOAA-20 platform in November 2017 to continue supporting high quality modeling capability (Goldberg et al. 2018).

This paper argues that NUCAPS soundings have value in addressing a fourth question – **what is about to happen**? – which is answered on a relatively shorter timescale. While monitoring the unfolding weather, forecasters incrementally ask themselves this question to continue to develop, assess, and update their overall prediction of what will happen. This question is most relevant during rapidly evolving weather systems, that occur in temporal or spatial observation gaps (e.g., between two radiosonde launches) or where forecast models are known to have strong biases. Having access to wide swaths of sounding observations tens of minutes before the atmosphere becomes unstable enough to develop into a severe storm can make all the difference to forecasters.

Information on atmospheric instability is derived from soundings, which are vertical profiles of temperature and moisture. Traditionally, soundings are generated by weather balloons carrying radiosonde instruments that make point-source in situ measurements along the ascending balloon path. While radiosondes (RAOB) capture detailed vertical thermodynamic structure, they only measure localized changes and do not measure mesoscale processes. Moreover, RAOBs are routinely valid only around 1200 UTC (with a launch close to 1100 UTC) which is several hours ahead of the peak-heating time when convection typically initiates in the USA. In rare cases a WFO can commission a RAOB launch at 1800 UTC, but resources do not allow many such special launches. It is here where NUCAPS observations address the need for timely soundings to effectively characterize mesoscale thermodynamic processes in the pre-convective atmosphere. As such, NUCAPS soundings help forecasters distinguish *what is actually about to happen from what was predicted to happen a few hours ago.* By being model-independent and thus not affected by known model biases, NUCAPS observes localized extremes and subtle shifts in thermodynamic gradients, which enhances forecaster ability to determine *if* and *how* a storm will evolve.

In 2014, NUCAPS became available in the NWS Advanced Weather Interactive Processing System (AWIPS-II) (Fig. 1) and has since been heralded as a key dataset in promoting situational awareness of important atmospheric variables related to temperature and moisture. NUCAPS in AWIPS-II enables on-the-fly visualization and inter-comparison with any number of data sources, be that from geostationary platforms, in situ observational networks or forecast models. The power of this capability is self-evident as forecasters are now putting NUCAPS soundings up with radiosondes to analyze the pre-convective environment. Being able to visualize individual soundings across large regions is only one aspect of its success in AWIPS-II. NUCAPS also has value in capturing spatial gradients of physical quantities such as lapse rate or convective available potential energy (CAPE).

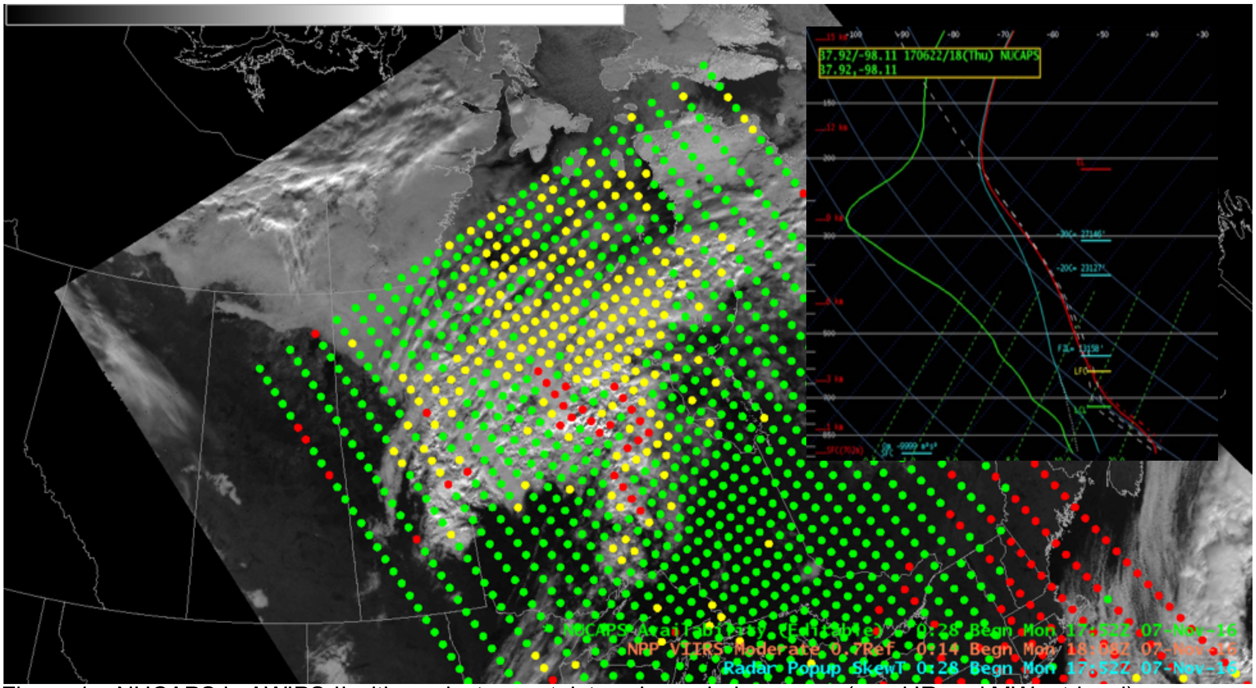

Figure 1: NUCAPS in AWIPS-II with product uncertainty color-coded as green (good IR and MW retrieval), yellow (IR retrieval failed but MW retrieval succeeded) and red (both IR and MW failed). NUCAPS soundings overlay visible imagery (0.7 µm) provided by the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument. The insert is a skew-T plot that is created when a forecaster clicks on one of the dots. The dots represent the NUCAPS footprint center and not the NUCAPS footprint extent which ranges ~50 km diameter at nadir and ~140 km diameter at edge-of-scan.

Figure 2 demonstrates how information from NUCAPS soundings is compressed into derived convective indices and visualized as gridded "plan views" of 2-D isothermal, isobaric surfaces and derived imagery. Being able to observe the spatial distribution of minima and maxima helps direct attention to target regions for in-depth investigation. Time is a limited resource in real-time decision-making environments and if forecasters can have access to clean, simple information that better directs their attention to areas of instability or change then they can be more effective.

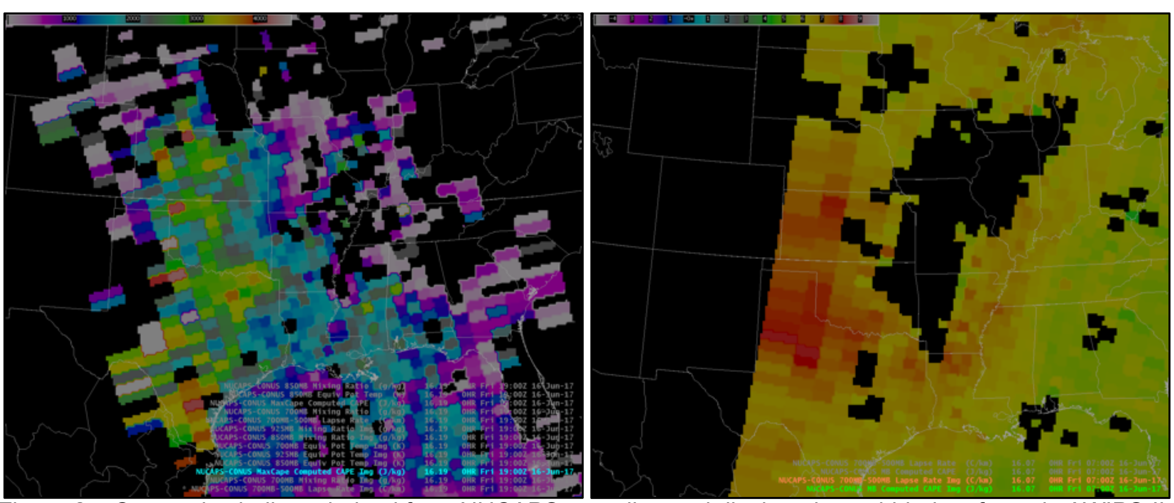

Figure 2: Convective indices derived from NUCAPS sounding and displayed as gridded surfaces in AWIPS-II. (left) Convective available potential energy and (right) 700-500 hPa lapse rate. The data gaps are due to the presence of optically thick clouds.

NUCAPS soundings have higher accuracy than the GOES-16 Legacy Atmospheric Products (LAP) derived from ABI because they have significantly higher vertical resolution both for temperature and moisture. This enables the ability to observe vertical atmospheric structure such as surface inversion and mid-level moisture anomalies routinely missed by other products. When one considers the importance of monitoring changes in the thermodynamic state then it is the high vertical resolution model-independent NUCAPS soundings that help forecasters differentiate *what is actually happening where*.

3. CONCLUSION

Thus far our application of NUCAPS soundings follows traditional pathways; they are treated either as radiosondes or model fields. There remains much to be done to exploit and maximize their value as 3-D mesoscale observations in an operational forecast environment. For example, in 2018 a new data delivery pathway will be tested, which will see the release of NUCAPS soundings in AWIPS-II within 30 min of a satellite overpass. This will be three-fold improvement in latency and address a primary need expressed by forecasters: fast access to accurate and actionable information. We will continue to develop innovative methods that compress and simplify NUCAPS products into readily accessible information that alert forecasters to areas of interest, such as rapid change, steep gradients or disagreement with forecast models. The investment we make now to develop innovate data products is well worth it because the Joint Polar Satellite System (JPSS) has a long-term plan to launch three more identical instrument suites. We can look forward to a consistent record of satellite soundings with the quality and space-time coverage to significantly improve weather forecasting.

4. REFERENCES

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