Application of NUCAPS for Thermodynamic Fire Weather Analysis

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Introduction

- NUCAPS is the NOAA Operational Retrieval algorithm for SNPP and NOAA-20 CrIS/ATMS temperature, moisture, and trace gas retrievals
- The JPSS Sounding Initiative developed an experimental capability for plan-view and cross section displays of NUCAPS Soundings in AWIPS (i.e., Gridded NUCAPS)
- As a result of successful assessment with the NWS Anchorage CWSU and the Hazardous Weather Testbed, Gridded NUCAPS will be baselined in AWIPS 19.2.1
- This offers a new opportunity to explore use of Gridded NUCAPS for various forecasting topics, especially in data sparse, remote areas
- Case studies were examined to assess the utility of NUCAPS Soundings and the NUCAPS Soundings and Gridded product for fire weather potential

Background

- Analyzing thermodynamic conditions are important for assessing the pre-fire environment and fire potential
- Low-level thermal ridges (LLTR's) have been documented as an important influence on wildfire development in the southern Great Plains (Lindley et al. 2017)
- Lindley et al. 2017 studied 11 Great Plains fire events from 2006 – 2014, resulting in representative soundings / thermodynamic fields (Fig. 1a,b) indicating fire potential

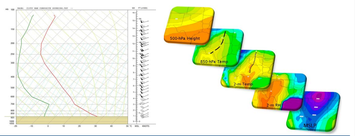

Fig. 1 a. Composite NAM BUFR sounding for 11 LLTR cases and b. composite location of the 2-m and 850-hPa thermal ridge axes from Lindley at al. 2017

- In contrast, Alaska Region forecasters assess fire potential by analyzing thermodynamic fields for warm, dry conditions and descending motion
- The Haines Index is frequently used to determine the potential for large fire growth (Werth and Ochoa 1993)

Haines Index = Stability + Moisture

Stability Term : Lapse Rate			
Low (950-850 mb)	**Middle (850-700 mb)**	**High (700-500 mb)**	**Value**
<= 3	<= 5	<= 17	**1**
4-7	6-10	18-21	**2**
>= 8	>= 11	>= 22	**3**

Moisture Term : Dew Point Depression			
Low (850 mb)	**Middle (850 mb)**	**High (700 mb)**	**Value**
<= 5	<= 5	<= 14	**1**
6-9	6-12	15-20	**2**
>= 10	>= 13	>= 21	**3**

Pressure levels for calculation are adjusted based on elevation and chosen to negate the impact of diurnal surface temperature changes and surface inversions

Haines Index	Potential for large fire growth
2 or 3	Very Low
4	Low
5	Moderate
6	High

Methodology

- NUCAPS data were obtained from NOAA CLASS and reformatted for AWIPS display
- Two southern Great Plains cases and two Alaska cases were chosen for analysis
- AWIPS-II imagery was used to determined of the existence of a low-level thermal trough (Lindley et al. 2017) in the Great Plains or presence of warm, dry conditions in Alaska
- **Southern Great Plains Cases**
  - Low relative humidities from 750 mb to the surface
  - Warm temperatures at 750 mb
  - Strong, westerly to southerly 500 mb winds
  - Soundings were generated to show the vertical temperature and dew point profiles
  - Compared to 13 km Rapid Refresh (RAP) model
  - Assessed Haines Index which was modified to use levels based on Werth and Ochoa 1993
- **Alaska Cases**
  - Analyzed 850 mb and other static levels for warm, dry conditions
  - NUCAPS soundings are used to identify the vertical location of dry layers
  - Assessed Haines Index which was modified to use levels above the Alaska topography
  - Focus on 700 – 500 mb layer above the topography
  - 0.5 degree Global Forecast System (GFS) model analysis was used to help fill in data gaps

Rhea, OK - April 12, 2018

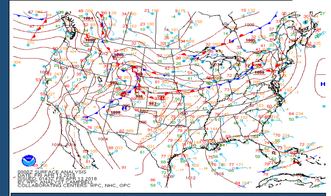

Fig. 2 Surface Analysis of Pressure, Temperature, Dewpoint, and Frontal Boundaries valid 0000 UTC 13 April 2018

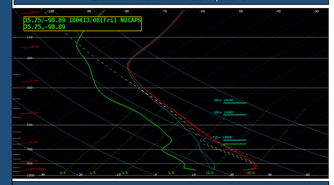

Fig. 3 S-NPP NUCAPS Sounding valid 0800 UTC 13 April 2018

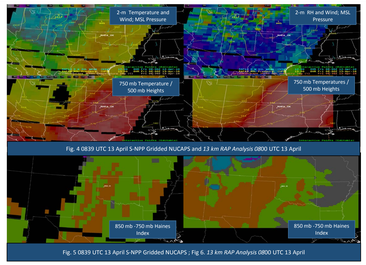

Fig. 4 0839 UTC 13 April S-NPP Gridded NUCAPS and *13 km RAP Analysis* 0800 UTC 13 April

Fig. 5 0839 UTC 13 April S-NPP Gridded NUCAPS ; Fig 6. *13 km RAP Analysis* 0800 UTC 13 April

- Rhea, OK fire started on April 12, 2018 which burned approximately 400,000 acres
- Location just west of a dry line in an area of extreme drought
- S-NPP NUCAPS Sounding (Fig. 3) shows a deep layer of dry air throughout the atmosphere
- Gridded NUCAPS shows that the surface has warm night time temperatures (approx. 25 °C) with extremely dry air (RH approx. 15%) with a southwesterly wind (Fig. 4 Top-Left and Top Right)
- Gridded NUCAPS and RAP data shows a matching area of 750 mb extremely hot air (approx. 25 °C) at the location with a southwesterly flow at 500 mb (Fig. 4 Bottom-Left and Bottom-Right)
- The AWIPS-derived Haines Index from both Gridded NUCAPS and RAP show the location in an area of moderate potential for fire growth surrounded by areas of high potential of fire growth (*Fig. 5 and 6)*
- Analysis shows that a LLTR present in the area
- Along with the surface observations and Haines Indices, Gridded NUCAPS data is supportive of the potential for large fire development and growth

Ryan, CO – September 15, 2018

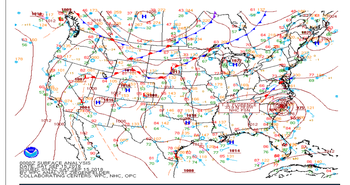

Fig 7 Surface Analysis of Pressure, Temperature, Dewpoint, and Frontal Boundaries valid 0000 UTC 15 September 2018

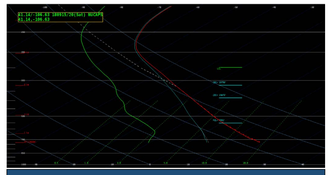

Fig. 8 S-NPP NUCAPS Sounding valid 2000 UTC 15 September 2018

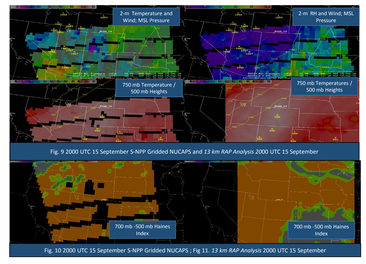

Fig. 9 2000 UTC 15 September S-NPP Gridded NUCAPS and *13 km RAP Analysis* 2000 UTC 15 September

Fig. 10 2000 UTC 15 September S-NPP Gridded NUCAPS ; Fig 11. *13 km RAP Analysis* 2000 UTC 15 September

- Ryan, CO fire started on September 15, 2018 which burned approximately 28,500 acres
- Location inside a surface high pressure system in an area of extreme drought
- S-NPP NUCAPS Sounding (*Fig. 8*) shows a deep layer of dry air throughout the atmosphere
- Gridded NUCAPS shows mild 2-m temperatures (approx. 17 °C) with extremely dry air (RH approx. 10%) with a southwesterly wind (Fig. 9 Top-Left and Top Right)
- 750 mb thermodynamic fields were analyzed to adjust for elevation
- Gridded NUCAPS and RAP data shows a matching area of 750 mb extremely hot air (approx. 25 °C) at the location with a southwesterly flow at 500 mb (Fig. 9 Bottom-Left and Bottom-Right).
- The AWIPS-derived Haines Index from both Gridded NUCAPS and RAP show the location in an area of high potential for fire growth (Fig. 10 and 11)
- Analysis shows that a broad LLTR is present in the area, with a less-defined signal compared to the Rhea, OK case

Taixtsalda Hill, AK - July 23, 2018

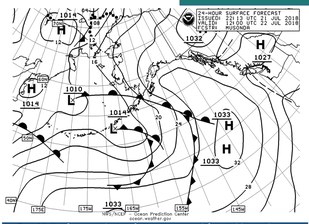

Fig. 12 Surface analysis of pressures and frontal boundaries valid 1200 UTC 22 July 2018

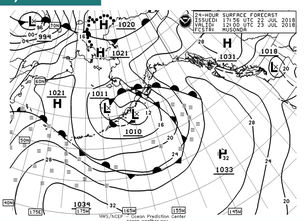

Fig. 13 Surface analysis of pressures and frontal boundaries valid 1200 UTC July 2018

- Taixtsalda Hill near Northway, AK: July 23, 2018 - ~ 27,000 total acres burned
- The fire started on 23 July 2018 near the towns of Northway and Tok Alaska
- The fire continued through 4 August 2018
- Warm, dry conditions persisted as south/southwesterly flow prevailed (Fig. 12 and 13)

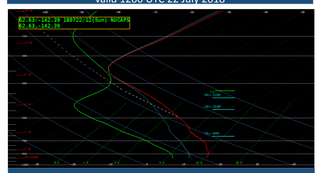

Fig. 14 S-NPP NUCAPS Sounding near Northway, AK 1200 UTC 22 July 2018. Temperature (red) and Dewpoint (green)

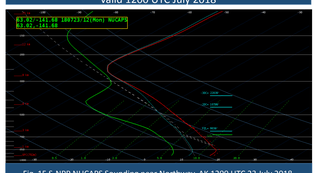

Fig. 15 S-NPP NUCAPS Sounding near Northway, AK 1200 UTC 23 July 2018. Temperature (red) and Dewpoint (green)

- NUCAPS Soundings can be used to assess the vertical temperature/moisture characteristics for fire weather potential
- Soundings near Northway, AK on 22 July (Fig. 14) and 23 July (Fig. 15) indicate a deep layer of dry air present

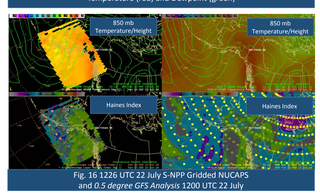

Fig. 16 1226 UTC 22 July S-NPP Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 22 July

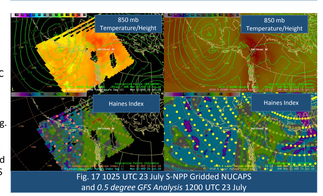

Fig. 17 1025 UTC 23 July S-NPP Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 23 July

- Gridded NUCAPS 850 mb temperatures compared to GFS, indicate a region of higher temperatures in southern AK (Fig. 16) and near Northway by 1025 UTC 23 July (Fig 17)
- The AWIPS-derived Haines Index indicates a moderate potential for fire growth (Fig. 16 and 17)
- The Gridded NUCAP spatial pattern for temperature and Haines Index match the GFS analysis

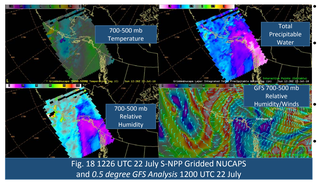

Fig. 18 1226 UTC 22 July S-NPP Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 22 July

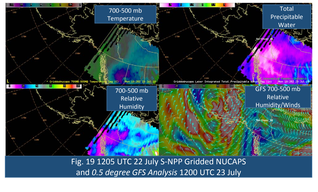

Fig. 19 1205 UTC 22 July S-NPP Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 23 July

- Assessing Gridded NUCAPS fields over a layer can be valuable.
- Warmer 700-500 mb temperatures and lower precipitable water values were present over southern Alaska (Fig. 18)
- The warmer, drier air persisted into 23 July as the fire began (Fig. 19)
- Compared to the GFS analysis, Gridded NUCAPS captured the spatial gradients in relative humidity (Fig 18 and 19).

North River Fire, AK – June 10, 2019

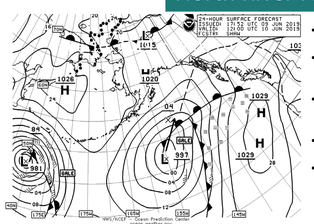

Fig. 20 Surface analysis of pressures and frontal boundaries valid 1200 UTC 10 June 2019

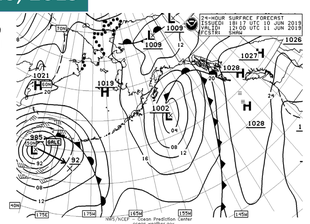

Fig. 21 Surface analysis of pressures and frontal boundaries valid 1200 UTC 11 June 2019

- North River, AK: June 10, 2019 – ~112,000 total acres burned
- The fire started on 10 June 2019 near the towns North River and Galena AK.
- A stationary front was in northern Alaska bringing the potential for thunderstorms
- The fire was a result of a lightning strike
- NUCAPS is used to assess the environment factors after the fire started to determine the potential for fire growth

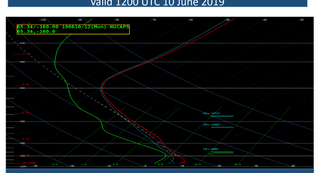

Fig. 22 NOAA-20 NUCAPS Sounding near North River, AK 1200 UTC 10 June 2019. Temperature (red) and Dewpoint (green)

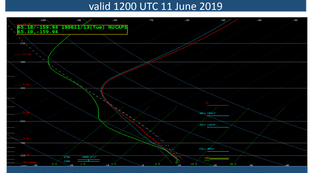

Fig. 23 NOAA-20 NUCAPS Sounding near North River, AK 1300 UTC 11 June 2019. Temperature (red) and Dew point (green)

- NUCAPS Soundings near Koyuk, AK on 10 June (Fig. 22) and 11 June (Fig. 23) indicate a moistening low-levels with time

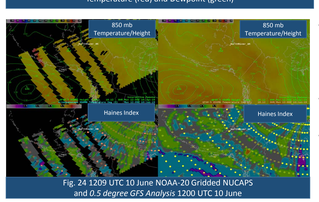

Fig. 24 1209 UTC 10 June NOAA-20 Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 10 June

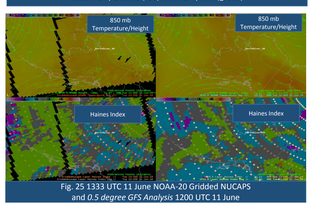

Fig. 25 1333 UTC 11 June NOAA-20 Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 11 June

- Gridded NUCAPS 850 mb temperatures compared to GFS, indicate a broad region of higher temperatures in over AK (Fig. 24) and near North River by 10 June (Fig 25)
- The AWIPS-derived Haines Index indicates a low potential for fire growth (Fig. 24 and 25)
- The Gridded NUCAP spatial pattern for temperature and Haines Index match the GFS analysis

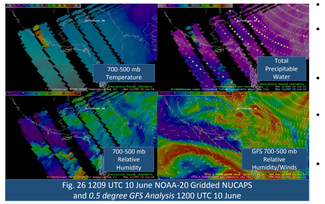

Fig. 26 1209 UTC 10 June NOAA-20 Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 10 June

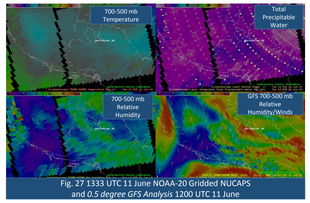

Fig. 27 1333 UTC 11 June NOAA-20 Gridded NUCAPS and *0.5 degree GFS Analysis* 1200 UTC 11 June

- Assessing Gridded NUCAPS fields over a layer can be valuable.
- Some warming of 700-500 mb temperatures takes place from 10 June (Fig. 26) to 11 July (Fig. 27)
- There is not a strong gradient or signal of low precipitable water (Fig. 26 and 27).
- The Gridded NUCAPS 700-500 mb Relative Humidity values are lower in magnitude but capture a similar signal as the GFS analysis
- Analysis indicates there isn't a sufficient warm, dry signal to maintain fire potential/growth

Conclusion

- Atmospheric conditions favorable to fire weather development were observable in three out of four cases, with one demonstrating low fire weather potential
- Spatial gradients in single level, layer, and derived fields were evident in Gridded NUCAPS
- New fields such as Haines Index and Total Precipitable Water were assessed
- Gridded NUCAPS can be used with model data where topography limits coverage
- NUCAPS Soundings and Gridded NUCAPS show potential for assessing the thermodynamic environment related to fire weather potential

More Information on NUCAPS

Advanced Satellite Sounding Foundational Course for JPSS
Gridded NUCAPS VLab page
NUCAPS Soundings Quick Guide
Gridded NUCAPS Quick Guide
OSPO NUCAPS Information
OSPO Skew-T Viewer

References

Lindley, T. T., B. R. Bowers, G. P. Murdoch, B. R. Smith, and C. M. Gitro, 2017: Analyses of Fire-effective Low-level Thermal Ridges on the Southern Great Plains. *J. Operational Meteor.*, 5 (12), 146-160, doi: https://doi.org/10.15191/nwajom.2017.0512

Werth, P. and R. Ochoa, 1993: The Evaluation of Idaho Wildfire Growth Using the Haines Index, *Wea. Forecasting*, **8**, 223–234, https://doi.org/10.1175/1520-0434(1993)008<0223:TEOIWG>2.0.CO;2

Acknowledgements

This work is funded by the JPSS Proving Ground and Risk Reduction Program under the project "Expanded Application and Demonstration of Gridded NUCAPS in AWIPS"