Anticipating Winter Weather with Next-Generation Satellite Sensors

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Introduction

- Satellite imagery is not traditionally used to anticipate and forecast winter weather, rather reliance on model data and radar imagery is more common
- Next-generation provide the opportunity to explore the utility of new sensors and bands for diagnosing the environment before and during complex winter weather

Products/Sensors

- **NESDIS Snowfall Rate:**
  - Developed with AMSU, MHS, ATMS, and SSMIS, GMI microwave measurements
  - Detect snowfall rates up to 2 in/hr
  - Useful in locations with radar gaps and beam blockage issues
  - Can be used to track snowfall rate maxima
  - Can be used to anticipate rain to snow transitions or detect cloud seeding before snow reaches the surface
  - Option to view as a product merged with MRMS to increase confidence in the product

- **NUCAPS Soundings:**
  - Hyperspectral infrared soundings from CrIS/ATMS and IASI/AMSU are processed through the NOAA Unique Combined Atmospheric Processing System (NUCAPS) algorithm and available in AWIPS
  - A gridded plan-view display is available in AWIPS from SPoRT
  - Can be used to diagnose the thermodynamic environment leading up to an event
  - Product is best quality in clear to partly cloudy regions

- **Lightning:**
  - Geostationary Lightning Mapper (GLM)
  - Event data at 1-minute increments
    - Individual “pieces” of a flash
    - Typically used for severe weather to identify strong storm core, developing, convection, and spatial extent
  - Can GLM Events be used to anticipate increased snowfall rates?

13-15 March 2017 Northeast Mixed Precipitation Event

- Banded snowfall visible on radar (Fig. 1) near the peak of the event
- Day prior to peak, surface temperatures along coastline were below freezing (Fig. 2)
- Sparse data in region of precipitation and advection of moist air from the south (Fig. 3) is visible during peak of the event

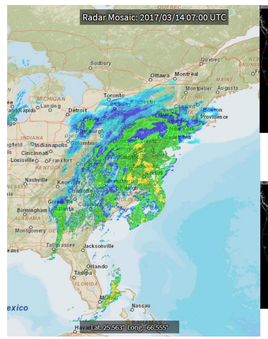

Fig. 1 Radar Reflectivity 0700 UTC 14 March 2017

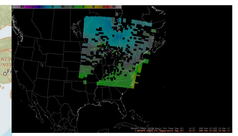

Fig. 2 Gridded NUCAPS – Surface Temp 0700 UTC 13 March 2017

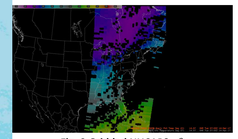

Fig. 3 Gridded NUCAPS - θ_e 0700 UTC 14 March 2017

- 0700 UTC 14 March 2017 surface observations near Sterling, VA
  - T ≈ -2°C, T_d ≈ -4°C
  - Heavy Ice pellets/snow and Mist
- Fig. 4 & 5 depict NUCAPS soundings using ATMS and CrIS/ATMS respectively
  - Vastly different results
- Forecasters currently have access to soundings using both sensors

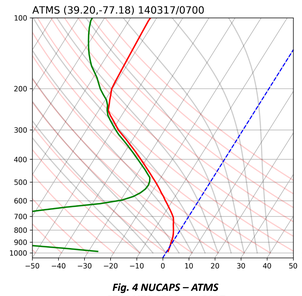

Fig. 4 NUCAPS – ATMS 0700 UTC 14 March 2017

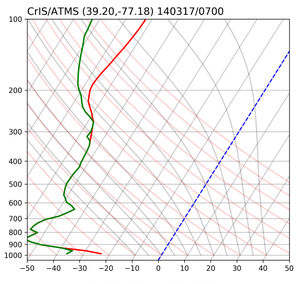

Fig. 5 NUCAPS – CrIS/ATMS 0700 UTC 14 March 2017

- Using only ATMS, vertical sounding depicts extremely dry air in the lower atmosphere but surface temperature closer to that of observations
- CrIS/ATMS vertical sounding shape much more realistic; however, depiction of surface conditions are colder than observations

13 November 2017 Western US data-void Snow Event

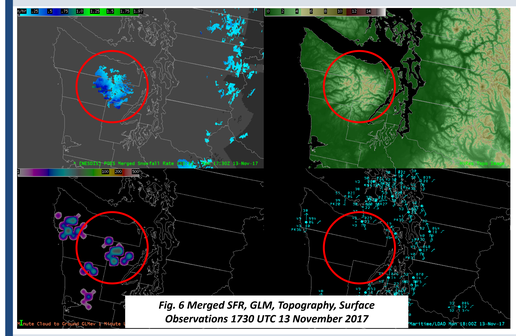

Fig. 6 Merged SFR, GLM, Topography, Surface Observations 1730 UTC 13 November 2017

- Overlap of NESDIS Merged SFR and GOES-16 GLM (Fig. 6)
  - “Thundersnow” Event
- Event coincides with abrupt elevation change from Olympic Mountains
- Virtually no surface observations in area of interest
  - Area received upwards of 18” of snow in 24 hour period
- Lightning dwindled within the following hours but snowfall continued

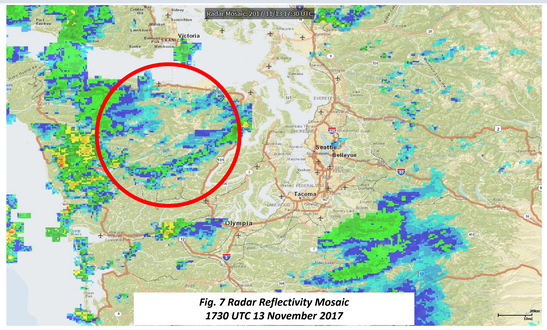

Fig. 7 Radar Reflectivity Mosaic 1730 UTC 13 November 2017

- Large data-void in radar reflectivity where “Thundersnow” event occurred (Fig. 7)
- Showcases that NESDIS Merged SFR can be beneficial to forecasters in data deprived mountainous regions
- First unique look at using GLM and Merged SFR
  - Possible correlation with heavier snowfall rates, lightning, and vertical motion enhancement

27 November 2017 New York Lake Effect Snow (LES) Event

- First “Thundersnow” event that had overlap of merged SFR, GLM, and NUCAPS (IASI/AMSU)
- GLM observed lightning from 0140 – 0200 UTC
- NUCAPS overpass around 0200 UTC
- During this time, LES band orientation transitions from Northeast to East
  - >1 in/hr snowfall rates
- Area received upwards of 4-6” of snow accumulation

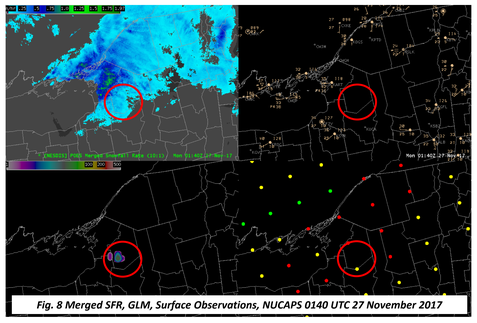

Fig. 8 Merged SFR, GLM, Surface Observations, NUCAPS 0140 UTC 27 November 2017

- Close proximity of lightning to highest snowfall rates (Fig. 8)
- Surface T_d in AMSU sounding (Fig. 9) is closer to observations in the region comparing to that to IASI/AMSU sounding (Fig. 10)
  - Both suggest dry air at the surface
- Majority of IASI/AMSU soundings were “low” quality due to the cloud cover

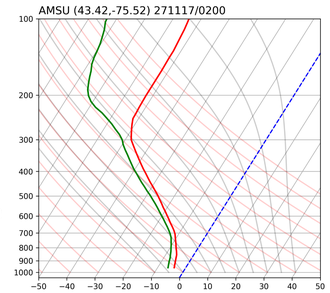

Fig. 9 NUCAPS – AMSU only 0700 UTC 27 November 2017

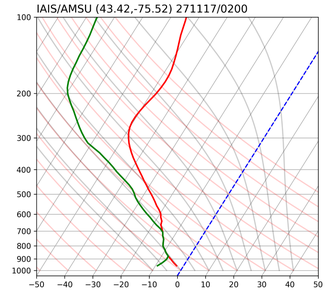

Fig. 10 NUCAPS – IASI/AMSU 0700 UTC 27 November 2017

Summary and Future Work

- CrIS/ATMS and IASI/AMSU (T and T_d) correlate better to surface observations when areas are not receiving precipitation and deal with quality issues when cloud cover is persistent
- Possible correlation of NESDIS merged SFR and GOES-16 GLM to anticipate snowfall rates when areas experience vertical motion enhancement and thus warrants further investigation
- Next-generation satellite sensors have the potential of revolutionizing the understanding and anticipation of winter weather
- Apply the use of these next-generation satellite sensors to heavy-banded snowfall attributed to mid-latitude cyclones
- Incorporate additional sensors/products, GOES-16 ABI/RGB, to develop and implement a product for forecasters to identify heavy-banded snowfall and/or related features (i.e. TROWAL)
- Continue to collect “Thundersnow” events for satellite climatology

Acknowledgements:
- SHARPpy – Python Soundings
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- NOAA CLASS – NUCAPS Data
- NCEI – Radar Mosaic