# Towards the Development of Real-time Normalized Burn Ratio (NBR) and delta NBR Imagery from GOES-16/17 and S-NPP

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## Introduction

- Burned landscapes present difficult hydrologic forecasting challenges for National Weather Service Offices
- Burned soils and landscapes can be conducive to the development of flash flooding and landslides from heavy precipitation events (Rammsey and Arrowsmith 2001)
- The severity of the burn scar can be directly related to the risk for debris flows (Cannon and DeGraff 2009) and flash flooding (Lewis et. al. 2006)
- Burned Area Reflectance Classification (BARC) map is generated to indicate the degree of burn severity, which is generated initially by high-resolution satellite imagery from sources such as Landsat, and later by labor-intensive efforts conducted at the burn scar by Burned Area Emergency Response (BAER) teams
- The challenge for operational meteorologists is that these sources of information are not readily available in near real-time
  - Landsat imagery, for example, may only be available about once every eight days, and cloudy conditions can obstruct the observation of the burn scar during a single pass.
  - BAER teams cannot conduct assessments until the wildfire has been at least 40 percent contained (up to 80 percent in some regions), and the process itself can take further days to weeks to complete depending on a number of factors
- To help remedy this lapse in knowledge, NASA SPoRT has developed the generation of NBR imagery in the Advanced Weather Interactive Processing System (AWIPS) using data from the operational GOES 16 and 17 satellites and S-NPP
- This presentation will discuss the development of the GOES- and SNPP-derived NBR and dNBR imagery and their initial evaluation by real-time decision makers

## Background/Methodology

- NBR imagery takes advantage of the fact that spectral responses of near-infrared and shortwave-infrared are opposite for burned areas vs healthy vegetation.
- For near-infrared (~0.86 μm): Burned areas have low reflectance, while healthy vegetation has high reflectance.
- For shortwave-infrared (~2.2 μm): Burned areas have high reflectance, while healthy vegetation has low reflectance.

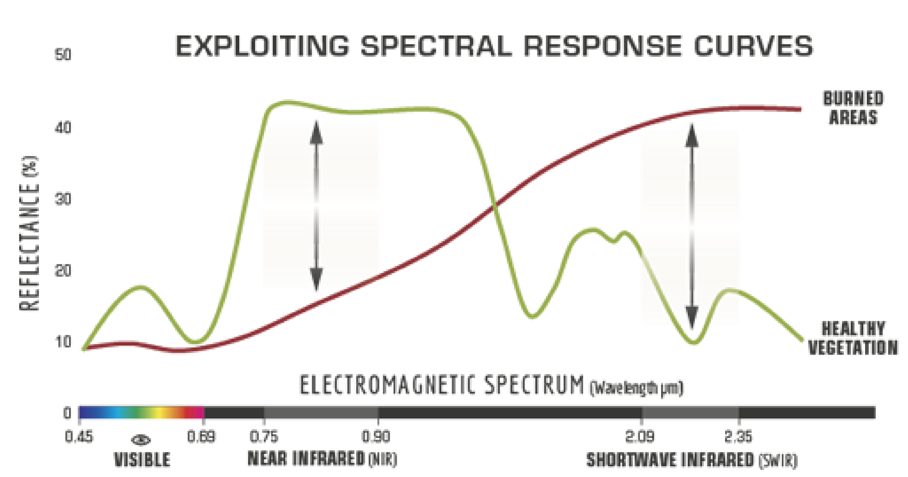
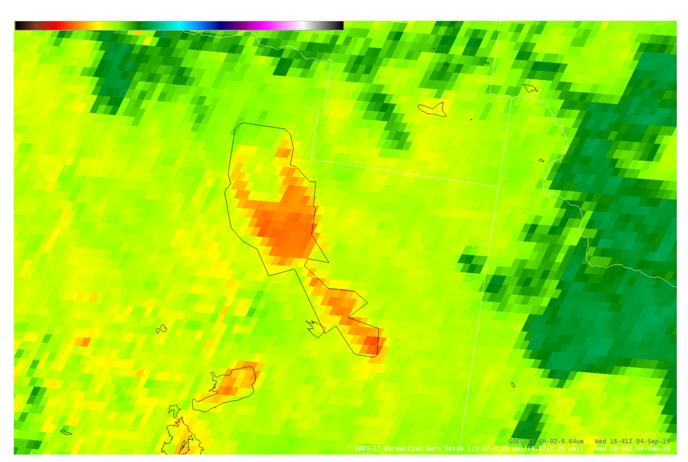



Image courtesy: https://www.fs.fed.us/eng/rsac/baer/barc.html

$$NBR = (0.86\ \mu m - 2.2\ \mu m)/(0.86\ um + 2.2\ um)$$

**A couple of examples:**

| *Healthy Vegetation…* | Burned Vegetation… |
|---|---|
| 0.86 = 38% | 0.86 = 18% |
| 2.25 = 15% | 2.25 = 32% |
| NBR = (38-15)/(38+15) = 0.43 | NBR = (18-32)/(18+32) = -0.28 |



Positive values = healthy vegetation
Lower values (negative) = burned areas
NBR Image above indicates burned areas in bright yellows-reds

- The change in pre-fire and post fire NBR is known as dNBR.

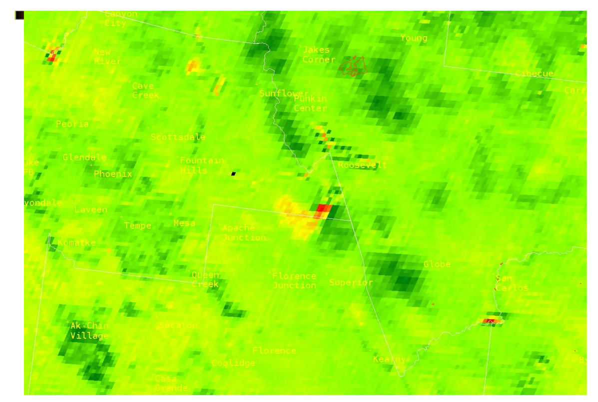
$$dNBR = Prefire\ NBR - Postfire\ NBR$$

- dNBR is used to assess burn severity and vegetation regrowth compared to pre-fire conditions.
- Prefire imagery will have very high near infrared band values and very low mid infrared band values.
- Postfire imagery will have very low near infrared band values and very high mid infrared band values.
- It can be difficult to distinguish between burned and non-vegetated areas in dNBR imagery

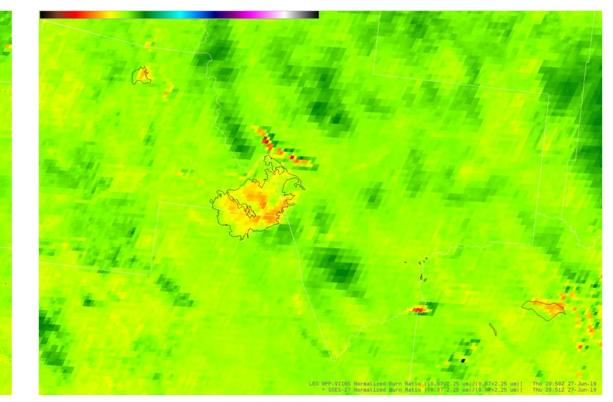
| DNBR | Burn Severity |
|---|---|
| < -0.25 | High post-fire regrowth |
| -0.25 to -0.1 | Low post-fire regrowth |
| -0.1 to 0.1 | Unburned |
| 0.1 to 0.27 | Low-severity burn |
| 0.27 to 0.44 | Moderate-low severity burn |
| 0.44 to 0.66 | Moderate-high severity burn |
| > 0.66 | High-severity burn |

## Woodbury Fire in Arizona June-July 2019

- Since NBR imagery are generated from GOES-16/17 and S-NPP bands in AWIPS, information about the burned vegetation can be observed in real-time
- Low values (bright yellow-orange-red) indicate burned vegetation severity, colors shifted to red with increased negative difference in NIR and SWIR
- High values (light green-dark green) indicate healthy vegetation, colors shifted to darker green with increased positive difference in NIR and SWIR
- Ongoing fires will generally show up as red to dark brown colors due to higher emissions in the 2.2 um band
- False returns at edges of water bodies occur in GOES-16/17 imagery due to differences in spatial resolution of 0.86 μm band (1 km) and 2.2 μm band (2 km)

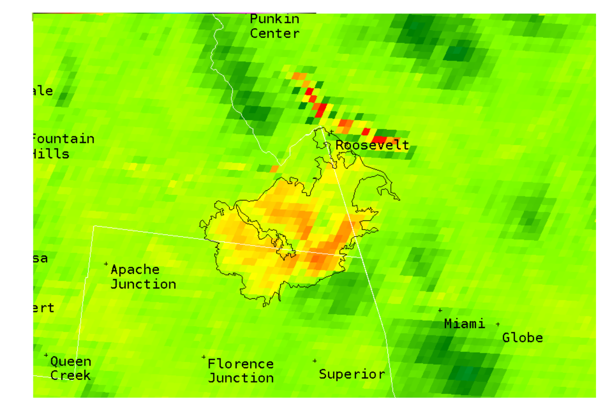


Woodbury Fire, GOES-17 NBR Image
2101 UTC 17 June 2019

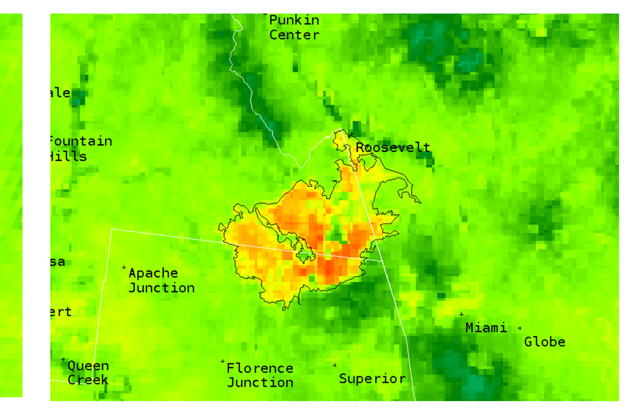


Woodbury Fire, GOES-17 NBR Image
2051 UTC 27 June 2019, with 2019 Fire Perimeters

In the GOES-17 NBR images above, notice the spread of the burn scar from 17 June to 27 June. Burn scar severity in SW portion of the Woodbury Fire remains fairly stable through the period, but the scar has spread due to the ongoing fire and the worst burn severity developed after 17 June. The fire perimeter is also shown for this fire (right) as of 27 June 2019. False NBR returns can be seen along Theodore Roosevelt Lake to the north of the Woodbury Fire. However, other burn scars can be seen in the imagery on the 27 June image (right).

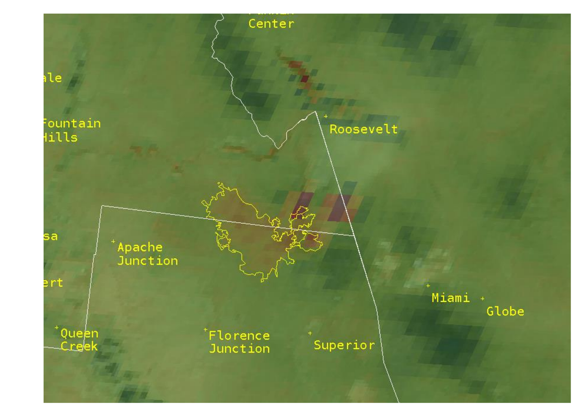



Woodbury Fire, GOES-17 NBR Image
2051 UTC 27 June 2019, with 2019 Fire Perimeters




Woodbury Fire, Suomi-NPP NBR Image
2050 UTC 27 June 2019, with 2019 Fire Perimeters

In this comparison between GOES-17 NBR imagery (left) and S-NPP NBR imagery (right), notice the higher spatial resolution of the S-NPP imagery. Also, issues with false returns, such as those along Theodore Roosevelt Lake to the north of the Woodbury Fire do not occur in the S-NPP imagery as is the case with GOES imagery. However, GOES imagery has the advantage of higher temporal resolution (every 5 min), vs the S-NPP imagery, which will only generally be available once per day at any given location (clouds permitting).




Woodbury Fire, GOES-17 NBR/Vis Image
1911 UTC 20 June 2019, with 2019 Fire Perimeter

GOES-17 NBR image with visible (0.64 μm) imagery overlays provides context for clouds and smoke, and makes the imagery appear more intuitive. Notice that smoke can be observed from the ongoing fire. The visible imagery is set to partial transparency (75%).

## Timeline of Analysis for Burn Scar Severity

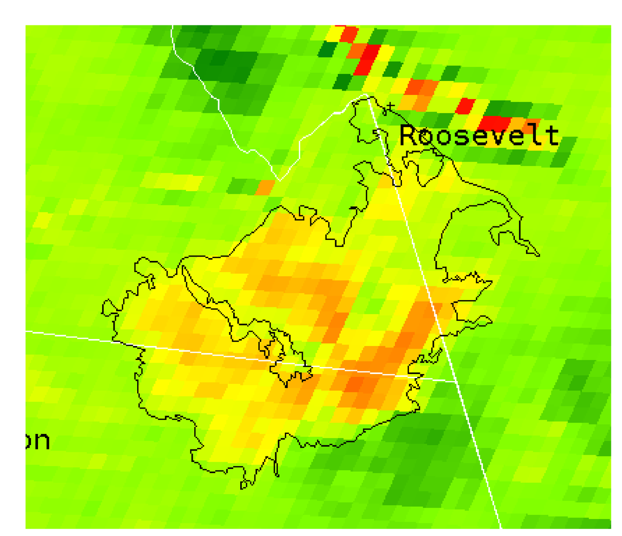
GOES-16/17 NBR imagery available first, minutes to hours (clouds permitting)

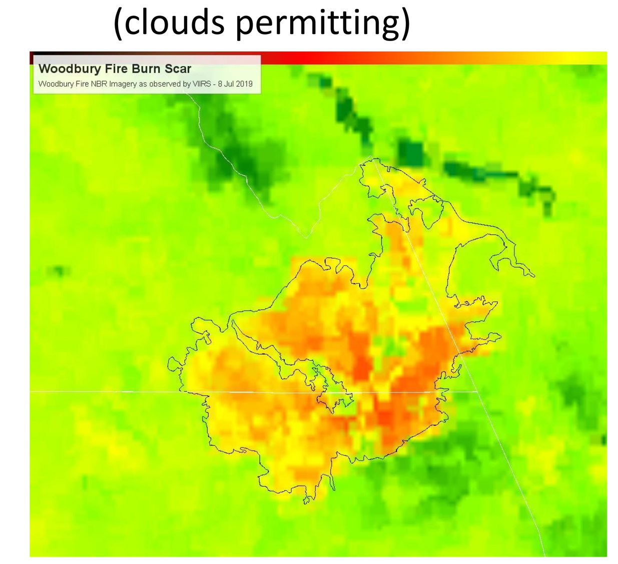
S-NPP NBR and/or dNBR imagery, once per day (clouds permitting)

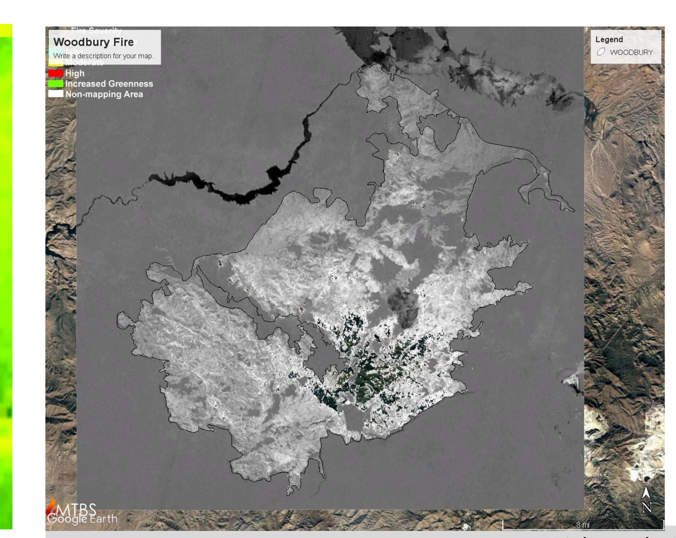
Higher-res dNBR imagery (e.g., Landsat, Sentinel), based on satellite, but typically days to weeks (clouds permitting)

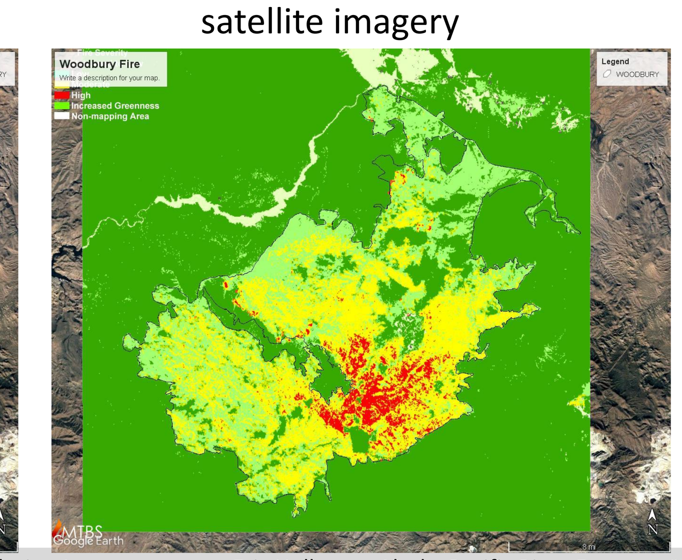
High-res BARC map produced from hi-res satellite imagery

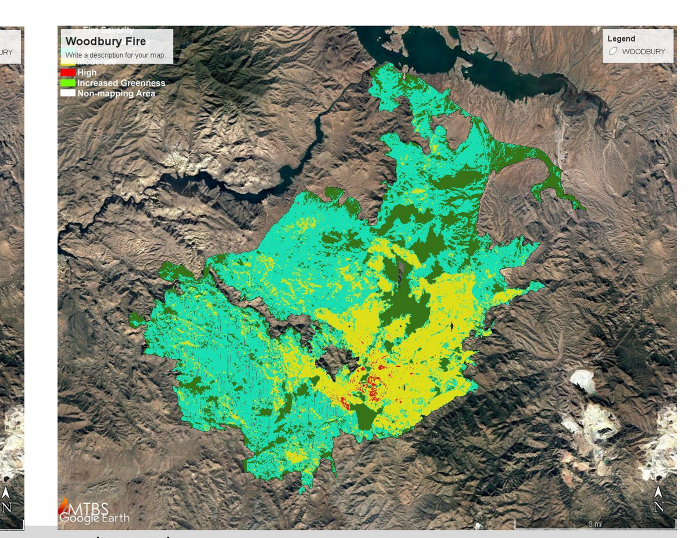
BAER team and soil burn severity map (containment/availability permitting), several weeks plus









High resolution Images courtesy Eric Holloway, Alaska Pacific River Forecast Center (APRFC)

## Conclusions

- Developed a process in collaboration with NWS to assess burn scar severity with new generation satellites in the early stages of fire development and growth
- Limited feedback due to lack of fires in initial test WFO (ABQ), but future users in ABQ and APRFC have provided feedback that data are sufficient to aid in decision-making.

## Next Steps

- Continued testing with and feedback from NWS Western Region HQ and Albuquerque Forecast Office, planned discussions this fall
- Refine a technique for processing and disseminating GOES and S-NPP dNBR imagery in GIS format, minimizing cloud effects

## References

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