Comparing Wildfire LEO-GEO and GEO-GEO Stereo Winds and Aerosols to WRF-CMAQ simulations

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NASA POSTDOCTORAL PROGRAM

MOTIVATION

- Impact of plume injection height on air quality and risk assessment prediction of wildfires
- Facilitate furthering our understanding of complex and highly localized wildfires
- Increase spatiotemporal observations of wildfire convective plume dynamics
  - Plume top height, wind velocity, wind direction, and aerosol composition
- Support improvements to regional and local dynamic meteorological models of intense wildfires
  - Pyrocumulonimbus (pyroCb) clouds

BACKGROUND

New satellite observations provide mesoscale details of fire dynamics details, thanks to the latest breakthroughs in satellite stereo-imaging for tracking from the 3D-Winds algorithm [1] and the Multi-Angle Geostationary Aerosol Retrieval Algorithm (MAGARA) for aerosol properties [2]. Enabling this new the state-of-the-art algorithm is the accurate image navigation and registration (INR) from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Geostationary Operational Environmental Satellite (GOES-R) suite Advanced Baseline Imager (ABI) imager. The INRs facilitate the conversion of stereo information into plume height and winds with a high vertical resolution in the planetary boundary layer (PBL) where most wildfire plumes reside [1].

DATA AND METHODS

- Stereo Winds from 3D-Wind [1]
- Stereo Aerosols from MAGARA [2]
- WRF-CMAQ simulations [3]

RESULTS

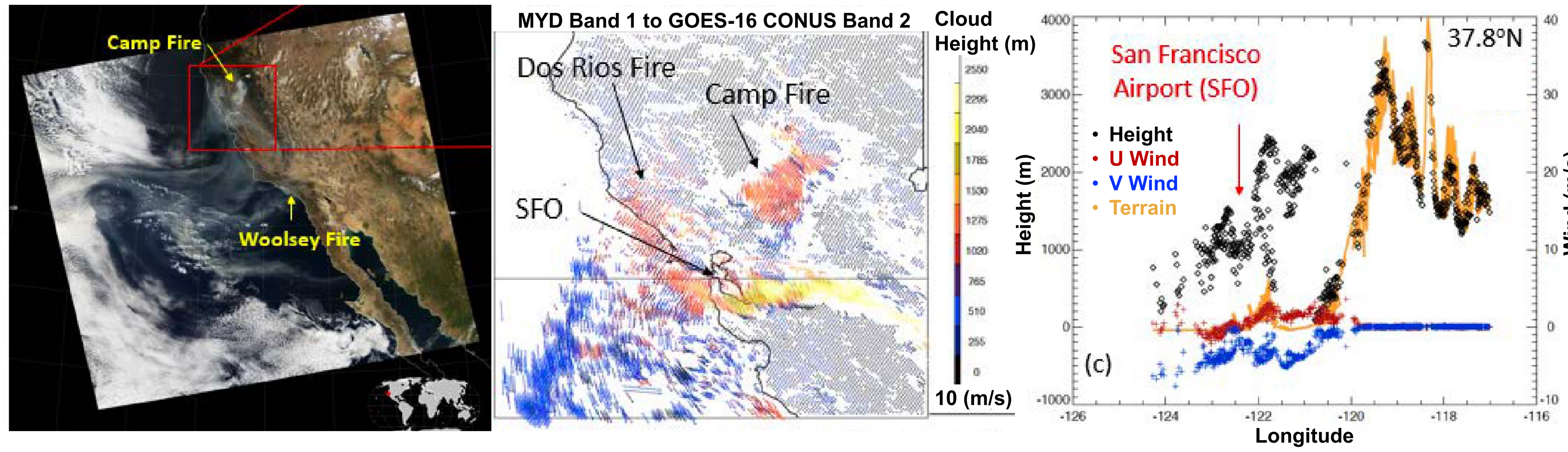

Figure 1. MODIS-GOES 3D-Wind retrieved wind velocity and direction and plume top height during the 2018 Camp Fire on Nov 10th. Left image shows the RGB image of the Camp and Woolsey fires. The top right image shows plume height is higher near the fire source. The bottom right image shows the shows cross-section at 37.8 deg N and the dense fire plume with a top of ~1.2 km above the surface covering the San Francisco Airport and Bay Area [1].

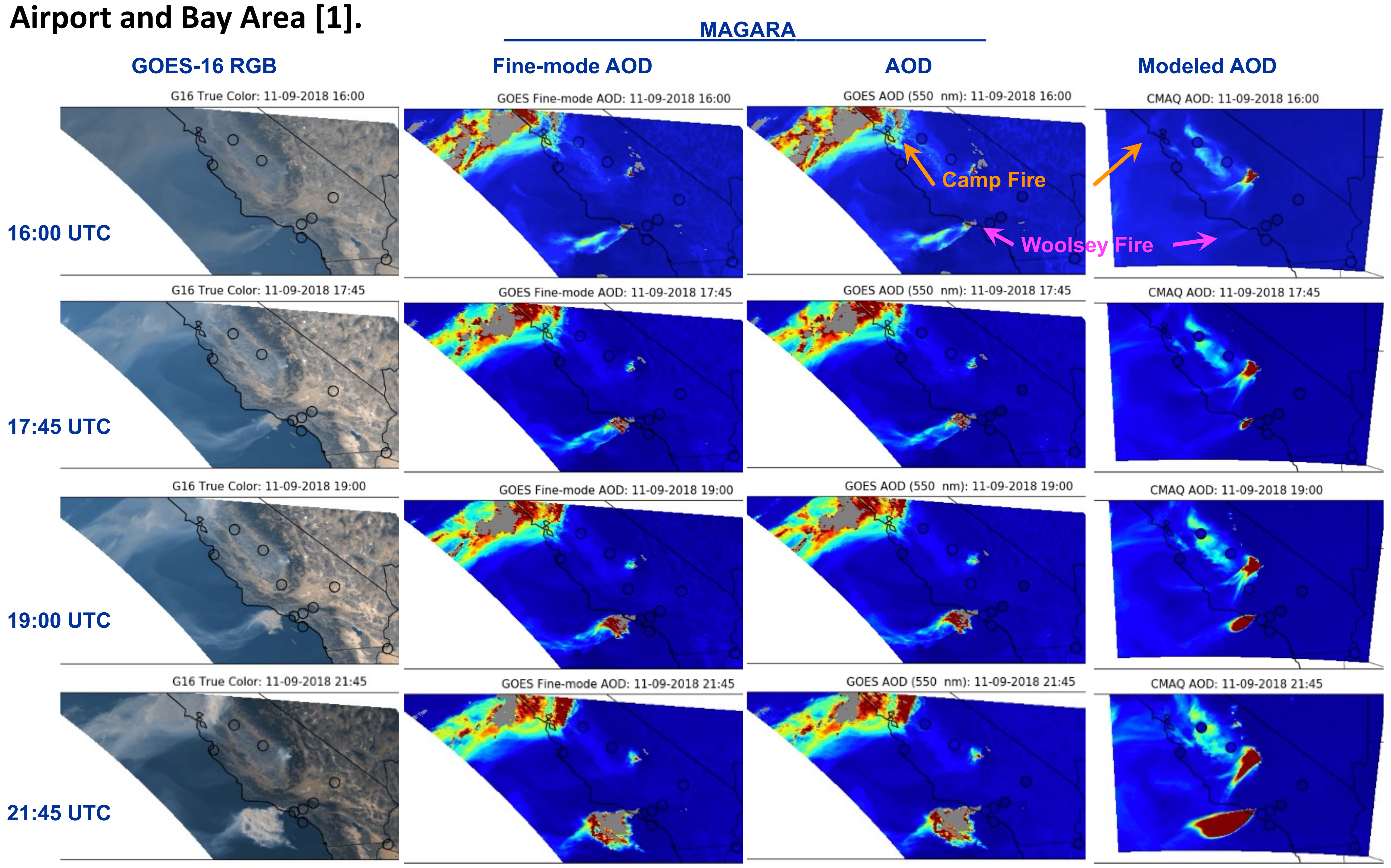

Figure 2. The images show the (a) GOES-17 RGB, (b) Fine-mode AOD and (c) AOD from MAGARA retrievals, and (d) modeled AOD (CMAQ) for the Camp and Woolsey fires. Injection time for the Camp Fire is a significant contributor to the difference between observed and modeled AOD plumes. While the Woolsey Fire observed and modeled injection time were similar, the AOD injection height and emission loadings most likely contributed to transport differences.

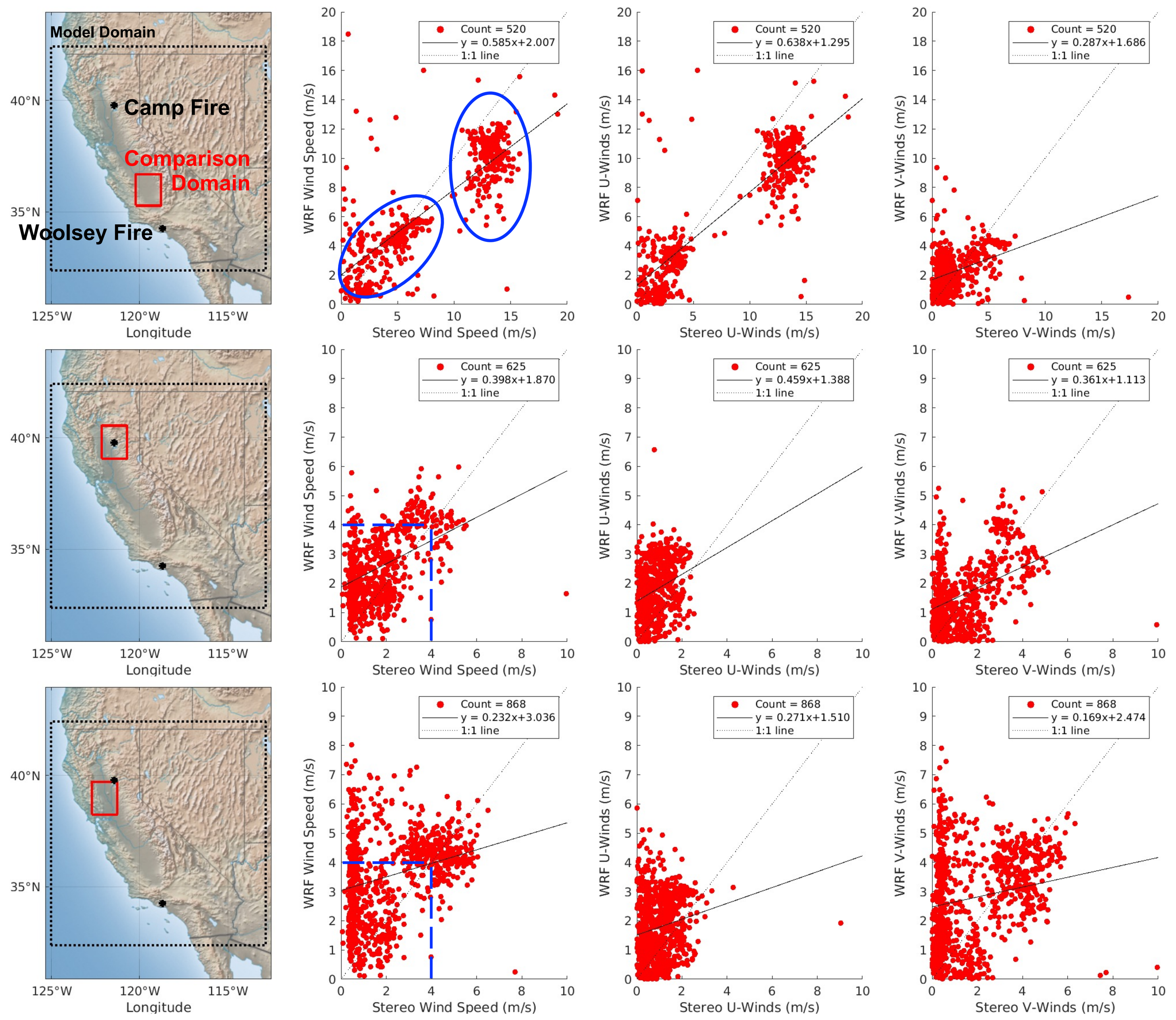

Figure 3. Preliminary scatter plots compare absolute values of MODIS-GOES Stereo and WRF wind speed, u- and v- components (m/s) for the Camp and Woolsey Fires Nov 8-16, 2018. Dashed black line show WRF domain. Red boxes show different comparison domains. Black stars indicate the ignition locations of the Camp and Woolsey Fires. The lower speed cluster appears to follow the 1:1 line, while higher speed cluster indicates WRF winds are slightly lower than those of Stereo.

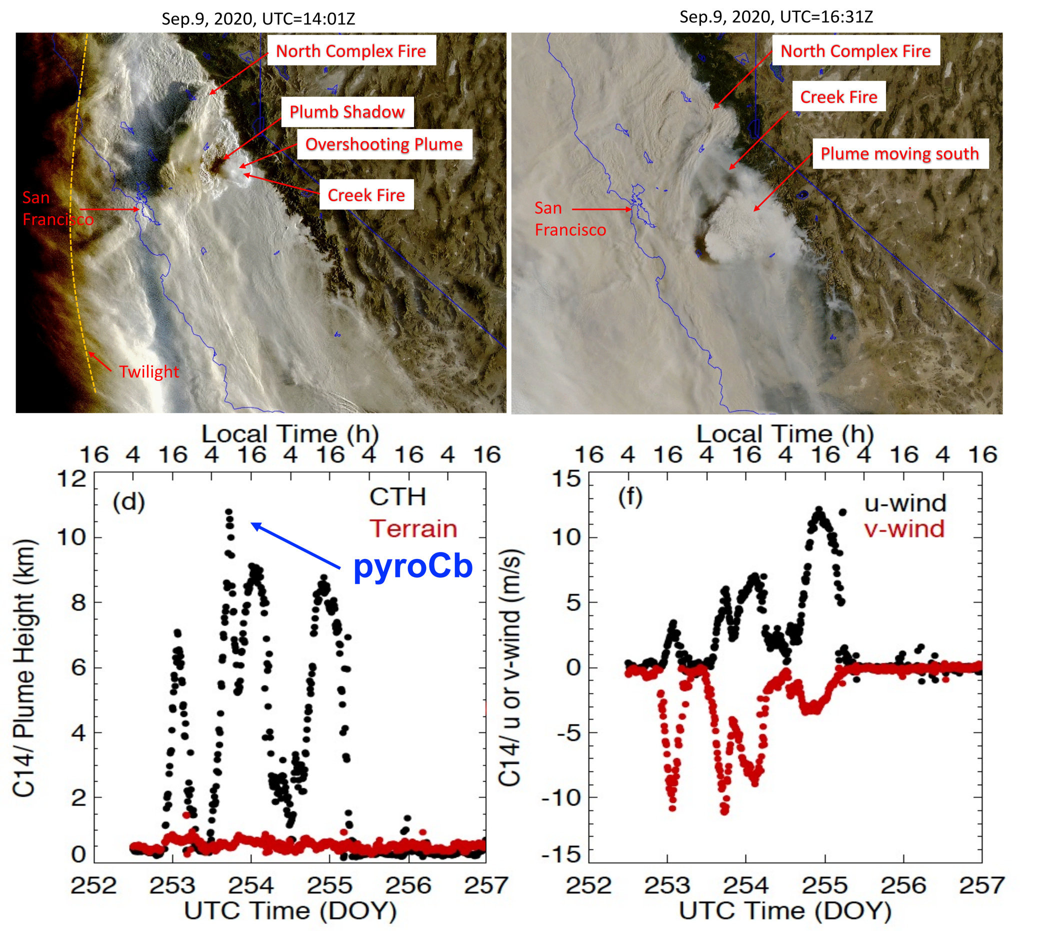

Figure 4. Sep. 9th snapshots of the explosive 2020 California Creek Fire pyroCb at 14 UTC (top left) and 16:31 UTC (top right). The GOES-16 &-17 3D-Wind retrievals show dynamic wildfire PBL variations and capture the pyroCb plume top height reached ~11 km above the terrain (bottom left) with a wind speed of ~15 m/s (bottom right) [1].

CONCLUSIONS

Our preliminary results highlight the importance of our sub-daily (LEO-GEO) and sub-hourly (GEO-GEO) stereo retrieved observations for model simulations. Using stereo retrieved products to constrain model input parameters (data assimilation) such as (1) injection height and time, (2) plume wind speed and direction, and (3) aerosol loading (relating to emissions) and aerosol transport.

References

1. Carr, J.L et al., "GEO-GEO Stereo-Tracking of Atmospheric Motion Vectors (AMVs) from the Geostationary Ring," Remote Sensing, 2020.
2. Limbacher, J.A. et al., "A Multi-Angle Geostationary Aerosol Retrieval Algorithm," AGU, 2019.
3. O'Neill, S. et al. A Multi-Analysis Approach for Estimating Regional Health Impacts from the 2017 Northern California Wildfires. JAWMA, 2021.