Using High-Speed Infrared Cameras to study Fire Spread

Introduction

Scientists have developed several theoretical models to better understand and predict various aspects of wildfire behaviour. However, the lack of experimental data from real wildfire renders the validation of the models difficult and thus limits their applicability. More validation data would enable a better characterization of the valid boundaries within which the models can be applied. The Fire and Smoke Model Evaluation Experiment (FASMEE) aims at resolving this issue. “The Fire and Smoke Model Evaluation Experiment (FASMEE) is a large-scale interagency effort to identify how fuels, fire behavior, fire energy and meteorology interact to determine the dynamics of smoke plumes, the long-range transport of smoke and local fire effects such as soil heating and vegetative response.” FASMEE collects a wide of range of data from large prescribed fires by bringing together different instruments such as Light Detection and Ranging (LiDAR), radar, ground monitoring, aircraft and satellite imagery, and weather and atmospheric measurements. More recently, a fast infrared camera was added to the list of instruments ready to deployed. This technology intends to cover four main study areas: fuels and consumption, fire behavior and energy, plume dynamics and meteorology, and smoke and emissions.

Controlled burn in Utah

The camera was used to collect infrared data from a large controlled burn in Utah. The burn was part of a large restoration project launched by the Forest Service in 2015 to revive the area’s ailing aspens. The goal was to collect data on every aspect of the fire at once, in order to improve the models scientists and land managers use to predict the impacts of fires. Figure 1 shows the camera capturing images 3.5km away from the raging fire. The camera is responsive from 3 to 5 µm and is equipped with a 4-position filter wheel containing neutral density filters to handle high intensity scenes and a through-flame filter to look at objects located behind the hot gases generated by the combustion.

Figure 1 Telops Fast M150 infrared camera used to image a controlled burn in Utah.

First Light!

Figure 2 presents a few images from the initial data collection. Even from 3.5 km away, the camera reveals the tremendous heat generated as well as the dynamics of the fire.

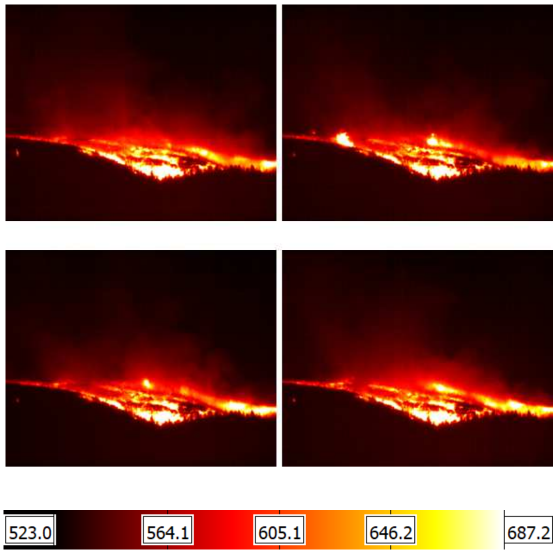

Figure 2 Four Extracted Infrared images of the burn.

Benefits of using Telops Fast IR Cameras to study Fire Spread

All Telops broadband infrared cameras feature a **unique, exposure time-independent radiometric calibration**[2,3] to accurately convert the observed detector signal into physical units of radiance or temperature. Telops calibration method utilizes detected photon flux (detector counts divided by exposure time) rather than detector counts directly to produce absolutely calibrated images. This calibration method enables the user to adjust exposure time on the fly without having to perform the additional blackbody calibration acquisitions required for infrared cameras using traditional multipoint calibrations. The exposure time flexibility inherent in the Telops calibration not only allows for significant ease of use, it also enables several unique features that enhance the operational capabilities of the system. **Automatic Exposure Control (AEC)**[4] is one such advanced feature where the camera is allowed to autonomously adjust the exposure time parameter in order to prevent saturation or maximize signal-to-noise ratio in response to changing scene radiance conditions.

Moreover, Reveal IR software accompanying the camera offers an **emissivity / atmospheric compensation tool**. This enables the user to quickly enter atmospheric parameters and target's emissivity value and effortlessly perform appropriate corrections and thus obtain a temperature value much closer to the thermodynamic temperature of the target.

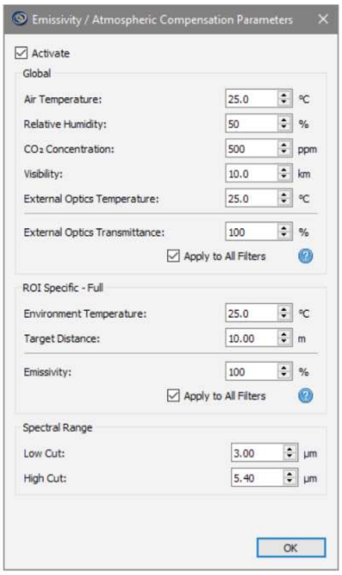

Figure 3 Reveal IR Emissivity / Atmospheric Compensation Parameters window.

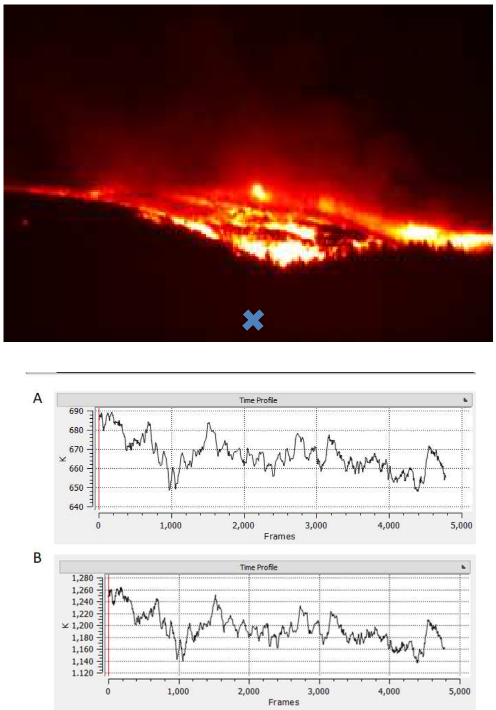

Figure 4 Temperature time profiles from a single pixel indicated by the blue cross in the image; A) raw temperature measured by the camera; B) atmospheric and emissivity compensated temperature.

Conclusion

Infrared data from a high-speed IR camera brings new information to the Fire and Smoke Model Evaluation Experiment (FASMEE). Initial infrared measurements are encouraging and will likely offer new insights into various research areas such as fuels and consumption, fire behavior and energy, plume dynamics and meteorology, and smoke and emissions.

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References

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[2] Tremblay, P. & al. Pixel-wise real-time advanced calibration method for thermal infrared cameras. Proc. SPIE 7662. (2010).

[3] Exposure Time-Independent Permanent Calibration. Telops Product Features Note. (2020).

[4] Automatic Exposure Control. Telops Product Features Note. (2020).

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