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Hyperspectral remote sensing of fire: state-of-the-art and future perspectives

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Fire is a widespread Earth system process with important carbon and climate feedbacks. Multispectral remote sensing has enabled mapping of global spatiotemporal patterns of fire and fire effects, which has significantly improved our understanding of interactions between ecosystems, climate, humans and fire. With several upcoming spaceborne hyperspectral missions like the Environmental Mapping And Analysis Program (EnMAP), the Hyperspectral Infrared Imager (HyspIRI) and the Precursore Iperspettrale Della Missione Applicativa (PRISMA), we provide a review of the state-of-the-art and perspectives of hyperspectral remote sensing of fire. Hyperspectral remote sensing leverages information in many (often more than 100) narrow (smaller than 20 nm) spectrally contiguous bands, in contrast to multispectral remote sensing of few (up to 15) non-contiguous wider (greater than 20 nm) bands.

To date, hyperspectral fire applications have primarily used airborne data in the visible to short-wave infrared region (VSWIR, 0.4 to 2.5 μm). This has resulted in detailed and accurate discrimination and quantification of fuels, fire temperatures and emissions, fire severity and vegetation recovery. Many of these applications use processing techniques that take advantage of the high spectral dimensionality such as advanced spectral mixture analysis. So far, hyperspectral VSWIR fire applications are based on a limited number of airborne acquisitions, yet techniques will approach maturity for larger scale application when spaceborne imagery becomes available. Recent innovations in airborne hyperspectral thermal (8 to 12 μm) remote sensing show potential to improve retrievals of temperature and emissions from active fires, yet these applications need more investigation over more fires to verify consistency over space and time, and overcome sensor saturation issues. Furthermore, hyperspectral information and structural data from for example light detection and ranging sensors are highly complementary. Their combined use has demonstrated advantages for fuel mapping, yet its potential for post-fire severity and combustion retrievals remains largely unexplored.