The 4D Fire Cube: Fires and Fuels at Various Scales – towards a Holistic Approach in Wildland Fire Risk Assessment

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Abstract

Wildland fire can be approached from very different perspectives, from a scientific, an operational, or 'simply' from a land owner perspective. However, it usually proves to be more difficult to integrate these different views than first anticipated. One possible way of approaching fire is to 'reduce' its multifaceted aspects to the following three domains: fire behavior, fire occurrence and fire effects. By adding the time axis a virtual, '4-dimensional fire coordinate system' or '4D fire cube' can be established, that integrates short-term and small scale as well as long-term and large scale processes for all the 'fire axes'. Such an approach appears to help the structuring, production, retrieval, and assessment of knowledge on fire including fuels in all domains and for all perspectives.

Often, (fuel) data use mismatches the acquisition and production of the data. Too often, only the 'best (and available) data there is' gets used and too little thought is given to whether or not these data fit the actual purpose. The same is true for models. Numerous implementations of Rothermel's famous 1972 fire behavior equations are used at a large range of spatial scales and with input data of highly variable resolution. However, this model was originally designed only for low intensity surface fires in homogenous fuel beds up to the (forest) stand level.

With the help of sensitivity analysis we show how data and fire model implementations perform and how they can be positioned and evaluated in the 'fire-cube' and how this may affect (field) data acquisition design and model use. We use e.g. LIDAR and hyperspectral imagery data, 'traditional' fuel type maps and fuel models from our own investigations (in e.g. pine dominated and/or deciduous forest stands), and data from literature to demonstrate, how different fire behavior model implementations and data may lead to conflicting or varying results and how this may affect subsequent wildland fire assessment procedures, namely in wildland fire risk analysis. We also describe which information and associated uncertainty can be expected at what spatial and temporal scales for a range of wildland fire management applications. Finally we demonstrate how our proposed approach

can help to identify constraints to overcome gaps in data retrieval and models in face of fire management needs.