Stability of Atmospheric Flow and Low-Level Jets Influencing Forest Fire Behaviour - An EFFIS Report
Abstract:
During the past years, there have been a considerable number of occasions that a forest fire burns with such strong intensity that seems far out of proportion to apparent burning conditions. This proved to be the case for the Sweden fire “blow-up” that took place during 4 August 2014 between Sala and Surahammar municipalities. The fire broke out after an unusual spell of hot, dry summer weather in northern Europe and proved to be the Sweden’s largest wildfire in 40 years encompassing...
an area of ~15,000 hectares. The fire was declared a national emergency. Close investigation of fire weather parameters revealed the existence of an upper-air trough linked to a dissolving warm front on the previous day (3 August) providing low stability values over the fire centroid and the approach of a cold front from southwest further lowering the stability of the atmosphere. But above all, the air dryness and the prevailing of strong surface wind gusts due to a Secondary Low-Level Jet (SLLJ) at 950 hPa accompanied by a short-wave trough most pronounced at 700 hPa (the level of the main LLJ’s kernel of max winds) made ideal conditions for such an extreme event. In such a case, the left entrance area of SLLJ would have allowed an ageostrophic circulation to feed dry air the fire by a direct downward current during the critical hours of 4 August. The time that the SLLJ was crossing and intensifying over and to the east of fire centroid found to be in agreement with the position and movement of the area of maximum instability as defined by the very high (and at times “saturated”) values of Haines Index (HI) being combined with almost “saturated” Fire Weather Index (FWI) values. The HI gives an indication about the potential for a fire “blow-up” due to low stability values of the atmosphere whereas FWI provides a description of the fire suppression difficulty. It should be noted that a fire blow-up would lead to erratic/extreme fire behavior. Most of the initial simulations utilising ECMWF instantaneous wind speed values, as driving terms for EFFIS (European Forest Fires Information System) fire evolution models, namely FireSim and FARSITE, were inaccurate due to errors in the intensity and gustiness of true prevailing winds. By introducing model gust factor values (GFs) instead of instantaneous wind speeds (WSs) significant improvement in accuracy was accomplished in all fire evolution simulations. In such distinct unstable environment and under the presence and influence of both LLJ and SLLJ the utilization of model gust factors instead of instantaneous winds found to be more appropriate for simulating fire evolution behavior. Overall, it seems quite important to consider the concept of atmospheric stability, dryness and the presence of LLJs/SLLJs as key elements in the forest fire management system particularly in circumstances conducive to interactions within the PBL (Planetary Boundary Layer).

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