Geophysical Research Abstracts
Vol. 20, EGU2018-11378, 2018
EGU General Assembly 2018

Microclimatological feedbacks at a migrating abrupt alpine treeline.

Miroslav Kummel
Colorado College, Environmental Science, United States (mkummel@coloradocollege.edu)

Broadly speaking, an alpine treeline is constrained by the regional climate (and it's changes). However the treeline also creates it's own microclimate to which it responds. Treelines respond differently to climate change depending on the spatial structure of the moving edge. Abrupt treelines are least responsive, and may be governed by strong internal climate modifications by the trees
Here I present a detailed study of the microclimate at an abrupt treeline (3,600m asl) on Pikes Peak in Central Rocky Mountains, Colorado. Immediately above the treeline, there is a clear sheltered zone, above which all saplings are wind-damaged. Ongoing tree recruitment into the sheltered zone began in 1990's in response to abrupt spring warming.
To understand the sheltering, an 8m meteorological tower instrumented (T/RH/WS) at 0.5, 1, 2, 4, 6, 8m was moved along a transect from the abrupt treeline to open tundra. Measurements were normalized to a stationary 2m tower in the open tundra, to create wind speed and temperature profiles across the ecotone. The wind speed profiles differed based on wind direction and time of day. The environmental wind during the day had typically (93%of time) a significant uphill component and created a sheltered zone that (at 50% ambient speed) extended 4-6m into the air column and stretched well into the tundra. The air within the sheltered zone was significantly warmer than the air in the open tundra. At night the wind usually had a downhill component (87% of the time), likely due to gravity-driven drainage. The treeline, acting like a dam, appeared to make a still pool of air (at 50% ambient wind speed) approximately 1-2m deep extending from the treeline into the tundra. The air within this pool was significantly cooler than air in the open tundra.
To understand the spatial structure of the microclimate at a finer resolution, and to examine it's impacts on seedlings, we used an UAV (drone) with a thermal and a multi-spectral camera along a 190m span of a treeline and mapped daytime and nighttime temperatures, and positions of pre-marked seedlings (n=2,253). The thermal photographs of surface "skin" temperatures corroborated with the air temperature profiles: Highest daytime temperatures were within the sheltered zone just upslope of the treeline. However, this zone also contained the lowest daytime temperatures in the shadows of the scattered saplings. Seedlings preferentially recruited into the sheltered zone, but away from the shadows. At night the area immediately above the treeline was cold and temperatures increased with increasing distance up into the tundra. Individual trees and saplings modified the microclimate further: they were the warmest objects with their crowns being significantly warmer on the upwind side. IR radiation from the trees created small "heat islands" under their canopies. However, the trees in the tundra also created large cold spots on the ground on their down-wind side. Seedlings significantly avoided these cold areas. Overall seedlings preferentially recruited close to existing trees in the tundra, but avoided proximity of existing trees in the zone immediately above the existing treeline.