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MAPPING THE THERMAL CLIMATE OF THE HJ ANDREWS EXPERIMENTAL FOREST, OREGON

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1. INTRODUCTION

The HJ Andrews Experimental Forest is located 80 miles east of Eugene, Oregon in the central Cascades. It is one of 21 Long-term Ecological Research (LTER) sites in the United States and is a major environmental research area in the Pacific Northwest. Covering an entire 64 square-kilometer mountain watershed, the HJA is geographically complex and is blanketed by a highly variable forest cover with dense old growth, open clearings, and emerging clearcuts. Though the climate of the HJ Andrews (HJA) is generally understood, few studies have looked at the myriad of environmental factors affecting its local microclimates and none have quantified these factors to spatially predict its temperature regimes. This study used a 30-year (1971-2000) dataset, computer software to analyze the effects of topography and vegetation on microclimate (specifically radiation effects), and a reliable temperature interpolation model together with GIS capabilities to create the most realistic mean monthly maximum and minimum temperature maps of the HJA to date. Climate stations in the HJA are located in nearly every conceivable type of physical environment (from steep slopes under dense canopies to flat open areas). In order to make the results as widely applicable as possible, temperatures were modeled to simulate the absence of vegetation.

2. METHODS AND DISCUSSION

Climate stations have existed in the HJA for 50 years. but continuous long-term records are uncommon. This is because most stations in the HJA were never intended to be part of a comprehensive network, but rather existed for temporary studies in various locations. The first step in the project was to compile all datasetsknown to have existed for the HJA, quality-check and filter them, and format them into a consistent database.

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The result was a set of 38 stations with periods of record ranging from one to 28 years. Any site with less than three years of data was immediately discarded. In order to eliminate temporal biases in the datasets, remaining short-term datasets (with less than 75%, or 22.5 years, of the 30-year period) were adjusted with their highest-correlated long-term (greater than 75%) datasets. In this way, temperatures at short-term sites were adjusted to what they would be had they operated for the full 30-year period.

To adjust temperature datasets to take into account radiation effects, mean monthly radiation grids were generated using the Image Processing Workbench (IPW), a portable UNIX-based image-processing system with utilities to map solar radiation in mountainous terrain (Frew and Dozier, 1986). IPW takes into account topographic influences such as surface slope, azimuth, elevation, and horizon shading, and is able to separately calculate direct and diffuse components of incoming solar radiation. In order to make the output as realistic as possible, monthly cloudiness was calculated based on observations at the most open site with the most dependable radiation data, and taken to represent the HJA as a whole. Cloudiness for each month was used as input to the Bristow-Campbell equation to determine the ratios of direct and diffuse radiation to total incoming radiation. These monthly ratios were input into IPW to account for cloudiness when estimating daily radiation values for each month in the absence of vegetation. Calculations were performed at 20-minute intervals on the 15th of each month and summed together to get the daily totals.

Total monthly radiation at each climate station was then estimated taking into account forest canopy. Fisheye photographs were taken at every climate station in the HJA and analyzed with the HemiView program to determine proportions of direct and diffuse radiation blocked by vegetation and surrounding topography for each month. From IPW, monthly radiation was calculated at each site both with and without topography taken into account. Together with proportions of radiation blocked by topography and vegetation from HemiView, it was possible to determine the amount of solar radiation blocked by canopy only. This allowed daily radiation to be accurately modeled for each month at every climate station taking into account the major factors of topography and forest canopy.

Regression functions were then calculated to bring maximum and minimum temperatures 'out into the open' by eliminating canopy and topography effects. Only pairs of sites with dependable temperature datasets and reliable fisheye photographs were used. For maximum temperatures, differences in total radiation between the two sites were plotted against differences in temperatures for each month. For minimum temperatures, differences in sky view factors (the amount of sky visible from a location) were plotted against differences in temperatures for each month.

The resulting regression functions were then applied to each climate station record and its temperatures adjusted accordingly. Maximum temperatures were adjusted by adding a factor based on the difference between the site's topographically-adjusted radiation and the radiation the site would have received if it were completely open. Minimum temperatures were adjusted by subtracting a factor based on the difference between the site's sky view factor and 1.0 (completely open site). The final adjusted temperature datasets simulated what the mean monthly temperatures would be if each site were completely free of vegetation.

The Parameter-elevation Regressions on Independent Slopes Model (PRISM) was used to spatially interpolate temperatures over the HJA on a 50-meter grid. PRISM (Daly, et al, 1994, 2002) is a coordinated set of rules, decisions, and calculations designed to mirror the decision-making process a climatologist would use in making a map, and operates under the premise that elevation is the most important determinant of temperature. It interpolates temperature by calculating a climate-elevation regression function over an area using data from surrounding stations in a user-defined radius. It was especially appropriate for this project because it operates a two-layer atmosphere model to account for temperature inversions, known to exist in the HJA. Once mean monthly maximum and minimum temperature grids were generated for the HJA, radiation effects on temperature were calculated by using the regression functions with the IPW radiation grids and PRISM temperature grids.

Besides mean monthly maximum and minimum temperature grids of the HJA, this project had several secondary objectives. Mean monthly radiation grids of the HJA accounting for topography and cloudiness and their effects on direct and diffuse radiation were created. Historical temperature datasets and site specifications were quality-checked and inventoried, and site radiation regimes were summarized with hemispherical fisheye photographs. The regression functions developed here for quantifying the effects of topography and canopy on temperatures may be useful in other climate studies.

3. REFERENCES

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