Geophysical Research Abstracts,
Vol. 11, EGU2009-6445-2, 2009
EGU General Assembly 2009

Spatial modeling and mapping the stable isotopic composition of Alaskan water, grasses and marijuana

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The spatial variation of isotope signatures in organic material is a useful forensic tool, particularly when applied to tracking the production and distribution of plant-derived illicit drugs. In order to identify the likely grow-locations of drugs such as marijuana from unknown locations (i.e. confiscated during trafficking), base isotope maps are required that include measurements of plants and water from known grow-locations. This task is logistically challenging in remote, large regions such as Alaska. Toward this aim, we are generating high-accuracy predictive maps, explicit in space and time, of the stable isotope (oxygen, hydrogen. nitrogen and carbon) composition of environmental components (plants, ground water, precipitation) specifically for the state of Alaska. Our models are using Geographic Information Systems (GIS) and are based on high performance mathematical tree algorithms, TreeNet and RandomForest - referred to as 'boosting and bagging' – that get widely used in industrial data mining due to their ability to model-predict complex data. In creating such predictive maps, we overcome data gaps efficiently and intend to ultimately provide an open-access resource for testing and creating a range of hypotheses in areas concerning, for example, past Beringian environmental change, ecosystem ecology, biogeochemistry, ecohydrology, animal migration, forensics, human ecology, and climate change in the Arctic and sub-Arctic. Here we present results from stable isotope analysis and modeling of a range of environmental variables within the state of Alaska. These currently include >250 geo-referenced ground water samples, >150 samples of modern C3 grasses (Poaceae), as well as marijuana samples (n = 18) from known grow-locations across the state. We conducted oxygen, carbon and nitrogen stable isotope analyses of marijuana and grasses (Poaceae). Water samples were analyzed for δ^{18}O and $\delta\Delta$. Poaceae samples were obtained from the University of Alaska Fairbanks (UAF) Museum of the North herbarium collection, originally collected by field botanists from around Alaska. Results indicate that the oxygen isotopic composition of these grasses range from 10‰ to 30‰, and broadly mirror the spatial pattern of water isotopes in Alaska. Marijuana samples were confiscated around the state of Alaska and supplied to us by the UAF Police Department. The δ^{13}C, δ^{15}N and δ^{18}O values exhibit geographic patterns similar to the modern grasses, but carbon and nitrogen isotopes of some marijuana plants appear to be influenced by additional factors related to indoor growing conditions (supplementary CO_2 sources and the application of organic fertilizer). The predictive models of the isotopic composition of the Alaskan environment will provide a useful resource for a range of land managers, ecologists, environmental scientists and law enforcement agencies across the state.