**NASA DEVELOP National Program**

****Langley Research Center

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**Northwest US Agriculture II**

*Evaluating Suitability for Apple Cultivation Based on Accumulated Chill Hours*

*in Washington State from 2003 – 2065*

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**Applied Sciences National Applications Addressed:**

Agriculture, Climate

**Study Area:** Washington, USA

**Study Period:** 2003-2065

**Earth Observations & Parameters**

Aqua and Terra, MODIS – Land Surface Temperature

Suomi NPP, VIIRS – Land Surface Temperature

**80-100 Word Objectives Overview**

This project’s purpose was to use current temperature data and temperature forecasts to assess possible shifts in ideal apple growing locations in Washington State. Accumulated chill hours are a climatically controlled factor of a location’s suitability for apple cultivation, which may be influenced as climate changes. Thus, calculating current totals, as well as forecasting chill hours into the future, will give growers a sense of how their lands’ suitability may alter with coming climate change. Due to chill hour requirements, rising temperatures may shift the location of ideal apple growing conditions northward.

**Abstract**

Washington is the top apple producing state in the United States, contributing over half of the nation’s apples. Washington’s climate is ideal for apple growth, but as climate alters, concerns are rising over the continued suitability of the region for apple cultivation. Apple trees require 400 – 1000 hours between 1.4 – 12.5° C, known as chill hours, to break dormancy and homogenously bloom in the spring. Connections to the apple growers in Washington were provided through partnership with the United States Department of Agriculture - Agriculture Research Service (USDA-ARS). Accumulated chill hours was identified as a key factor contributing to the prosperity of apples, which may change due to climate fluctuations. Thus, understanding how climate change may affect chill hours will provide growers with insight as to how their orchards may eventually be affected. NASA Earth observations from Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS) and Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) were used. Accumulated chill hours were calculated for 2003 – 2013 using the Land Surface Temperature products from each sensor. Future climate model outputs were used to project accumulated chill hours to 2065. Resultant maps of current and forecasted accumulated chill hours benefit orchard managers by detailing regions that are currently optimal for apple production and how those regions will shift with forecasted changes in climate.

**Community Concerns**

* With impending climate fluctuations, temperature trends will change in Washington, resulting in possible negative impacts on apple harvests.
* If winter temperatures rise there could be a reduction in accumulated chill hours for locations where apples are currently grown, which could negatively affect the apple trees’ dormancy and spring bloom.
* If summer temperatures increase, the demand for irrigation resources may expand, which could raise the cost of apple production.

**Current Management Practices & Policies**

Apple growers currently use models provided by the National Oceanic and Atmospheric Administration’s (NOAA) climate prediction center, including those for the effects of El Niño Southern Oscillation, to determine future conditions for their fields. Potential evapotranspiration calculations are used to determine how much water will be required by the apple trees to keep them healthy and prevent sunburn. Water rights allocations may be restricted from junior water rights holders if there is not enough water in the reservoir system, which may affect irrigation capabilities of apple growers.

**Decision Support Tools**

* Methodology of calculating accumulated chill hours for the current climate conditions and forecasted into the future
* Current Accumulated Chill Hours Map and Forecasted Accumulated Chill Hours Maps

**Benefit to End-User:**

* Calculations of accumulated chill hours, for the current climate conditions and forecasted into the future, will give growers a better understanding of how apple production will be impacted by climate change.
* Forecasted trends in accumulated chill hours can help apple growers prepare for impending climate change by informing the growers of what to expect.

**Models Utilized**

* Utah Chill Hour Model – Bennett (1949) and Weinberger (1950)

**Ancillary Datasets Utilized**

* NOAA Weather Station Data – Hourly temperature data
* Coupled Model Intercomparison Project phase 5 (CMIP5) Air temperature (RCPs) – moderate and unconstrained
* Climate Models – CCCma-CanESM2 (Canadian model) and Irish Centre for High-End Computing- (ICHEC-EC-EARTH)

**Software Utilized**

Python – data acquisition and processing, used for calculation of accumulated chill hours

R Scripting – statistical analysis of MODIS, VIIRS, and weather station data as well as comparison of fit for MODIS and Climate model data

ArcGIS – Raster Manipulation/Analysis, Image Enhancement and Map Creation of Landsat ETM+, NPP VIIRS, Aqua/Terra MODIS