The ICNet REU Freeze-Thaw Research Project:
Project Scope of Work

Summer 2015

Highlighting Convention: Green = Completed, Yellow = Not Completed

1. Baseline (Comparison)
    1. Research
        i. Review historical approaches to collecting climate data – Ashley and Tova
        ii. Consult climate change experts– Ashley and Tova
            1. Which other sources besides the Federal Highway Admin. can provide viable climate data?
            2. Are current proposed methods sound?
    2. Gather data from RCP 4.5 and RCP 8.5 (low and high emissions scenarios) & Measured data sets – Not RCP 2.6
        i. Federal Highway Data - Jill
        ii. RCP 4.5 and RCP 8.5: identical overall baseline climate for each available model across both scenarios (i.e. model 1 in RCP 4.5 will be the same as model 1 in RCP 8.5) - Jill
        iii. How many reliable models (according to fact sheet) in each scenario- Jill
        iv. If desired, select data from outside sources (not Federal Highway) to check for differences between sources – Team decided not to get data from outside sources after consulting climate scientists
    3. Assess data collection process
        i. Document steps so this can be repeated in the future- Ashley F.
            1. What was successful?
            2. What was unsuccessful or inaccurate?
    4. Plots (Excel Graphs for Each Year)
        i. Frost-Thaw - Ashley T. & Brazilian Interns
            1. Max frost depth and end of thaw dates are going to be taken from these graphs for the time being but the plots are still going to be prepared to better understand other results
        ii. Cumulative Freezing Index (CFI) - Ashley T. & Brazilian Interns
            1. Dates corresponding to when CFI >280^{0}F - Days and then when CFI <280^{0}F – Days (during thawing season) will be pulled off of this graph and compiled in a summary table
        iii. Cumulative Thawing Index (CTI) - Ashley T. & Brazilian Interns
            1. Dates corresponding to when CTI >25^{0}F - Days will be pulled off of this graph and compiled a summary table
    5. Summary Tables & Important Results - Observed Data & Models
        i. Information pulled from data table- Ashley T. & Brazilian Interns
            1. Maximum frost depth
                a. Calculated automatically for each year using the excel template and is reported at the top of the page
        ii. Winter Weight Premium (WWP) - Ashley T. & Brazilian Interns
            1. Date to apply
                a. Start of Freezing (CFI Threshold Exceeds = CFI >280^{0}F - Days)

(actual date and Julian days)

2. Date to end
    a. Varies by state; some states using beginning of SLR period (see below) to end WWP

iii. Spring Load Restriction (SLR) - Ashley T. & Brazilian Interns
1. Date to apply
    a. CTI Final > 25^0F - Days
2. Date to lift restriction: this is very important, but we do not currently have an accepted protocol based upon air temperature indices

iv. Length of Subsurface Freezing Season (days) - Ashley T. & Brazilian Interns
1. Method 1
    a. Difference between the CTI Final and the CFI Exceeding the Threshold in Julian days[(CTI Final > 25^0F - Days) - (CFI >280^0F - Days)]
2. Method 2
    a. Difference between the CFI Thresholds in Julian days [(CFI <280^0F - Days) - (CFI >280^0F - Days)]

6. Credibility of each of the reliable models
    i. Visualization- Masoumeh
    1. *Graph box plots, PDFs and histograms* for the data
        a. Fifty years of data overlap for the observed data and models
            i. Mean shift or complete data shifts will show if a model is credible when compared with the actual values
    ii. Rework list of models being used if needed – Based on input from climate scientists, the team decided not to reject any models
7. Comparison of models – The team skipped over the comparisons based on average daily temperature data
    i. Graph showing the days on the x-axis (October 1st to May 2nd) and the average temperature on the y-axis (must have same axis scale for all graphs)
        1. Each year is graphed on a separate line
        2. Median temperature for a particular model represented as a bold line through the other lines
    ii. Graph showing the median temperatures for each model
        1. Able to see how each of them compare to each other on one graph instead of on many different graphs
8. Automate engineering process w/ baseline data
    i. Use R scripts with functions applicable to climate datasets being used- Jill and Masoumeh
    ii. Determine which parts of steps d-g require human or situational judgement and which calls R can make- Jill and Masoumeh
9. Assess effectiveness of engineering process w/ baseline data
    i. Document steps d-h so they can be replicated by others- Ashley F.
        1. What worked?
        2. What did not?
        3. What has been refined to work better now?

2. Future Data - Ashley T. & Brazilian Interns
    1. Plots (Excel Graphs for Each Year)
        i. Frost-Thaw - Jill and Masoumeh
        ii. Cumulative Freezing Index (CFI) - Jill and Masoumeh
        iii. Cumulative Thawing Index (CTI) - Jill and Masoumeh

2. Information pulled from data table and frost-thaw plot
    i. Maximum frost depth and end thaw dates- Jill and Masoumeh
3. Winter Weight Premium (WWP)
    i. Date to apply - Jill and Masoumeh
        1. Start of Freezing (CFI Threshold Exceeds = CFI >280^{0}F - Days) (actual date and Julian days)
    ii. Date to end- Jill and Masoumeh
        1. Varies by state; some states using beginning of SLR period (see below) to end WWP
4. Spring Load Restriction (SLR)
    i. Date to apply- Jill and Masoumeh
        1. CTI Final > 25^{0}F - Days
    ii. Date to lift restriction: this is very important, but we do not currently have an accepted protocol based upon air temperature indices
5. Length of Subsurface Freezing Season (days)
    i. Method 1- Jill and Masoumeh
        1. Difference between the CTI Final and the CFI Exceeding the Threshold in Julian days[(CTI Final > 25^{0}F - Days) - (CFI >280^{0}F - Days)]
    ii. Method 2
        1. Difference between the CFI Thresholds in Julian days [(CFI <280^{0}F - Days) - (CFI >280^{0}F - Days)] - This method was calculated but not used further
2. Automate engineering process w/ future data
    i. Use R scripts with functions applicable to climate datasets being used- Jill and Masoumeh
    ii. Determine which parts of steps a-e require human or situational judgement and which calls R can make- Jill and Masoumeh
3. Assess effectiveness of engineering process w/ future data
    i. Document steps a-f so they can be replicated in the future- Ashley F.
        1. What worked?
        2. What did not?
        3. What has been refined to work better now?

2. Analyzing Changes Between Models
    1. Excel Graphs in Summary Table –Used Plot.ly and R to create visuals
        i. Lump the data for each of the models together (model ensemble) - Ashley F. and Masoumeh
        ii. Compare using maximum frost depth, length of freezing season, dates for WWP & SLR - Ashley F. and Masoumeh – Also looked at the number of years the CFI threshold is not exceeded, the end of thaw date, length of thawing season, the date the CFI drops back below the threshold, and the number of times the CTI threshold is exceeded before the final date
            1. Presented in either a measurement of inches or length of time measured in Julian days
            2. Consider impact of forest and vegetated systems in the area (Note: considered in future research, not in current scope) – This component of the analysis is not possible with the Army Corps Model 158
            3. Analyze potential impact of results (How would this affect an industry? Ex. three month time period for work reduced to one month) – Visualized via the length of the freezing and thawing seasons
    2. Automate engineering process w/ model comparisons
        i. Use R scripts with functions applicable to climate datasets being used- Jill and Masoumeh
        ii. Determine which parts of step a require human or situational judgement and which calls R can make- Jill and Masoumeh

3. Assess Effectiveness of engineering process w/ Model Comparisons
    i. Document step a and b so they can later be repeated- Ashley F.
        1. What worked?
        2. What did not?
        3. What has been refined to work better now?

3. Document, Archive, and Communicate
    1. Examining effectiveness of the entire engineering process
        i. Compile work from all separate tasks- Ashley F.
    2. Archive condensed notes on entire process- Tova and Ashley F.
    3. Organize automated R scripts for executing tasks
        i. Determine criteria for possible climate datasets to be used with the code (file type, headings, length, etc.) - Jill
        ii. Ensure the automation is practical and easy to replicate for other engineering projects- Jill
    4. Communicating results to other scientists and engineers
        i. Explain relevance of climate change knowledge in engineering industries- Tova
        ii. Illustrate the accuracy of using credible climate projections to predict changes in engineering equations and ultimately construction and industries themselves – Team does not have the expertise to assess the accuracy of climate projections
            1. Describe the Freeze-Thaw Project and how this idea was proven to be a valid approach to addressing the issue around WWP and SLR
        iii. Detail how, using R scripts, this integration of emerging climate science and engineering is readily accessible and useful- Tova