Modeling County-Specific Chill Hours Based on Daily Maximum and Minimum Air Temperatures

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KEYWORDS: Chill hours, chill units, chill portions, temperature, software, decision support system

INTRODUCTION: Many woody perennial plants require cool winter temperatures to overcome winter dormancy. Unusual changes in the temperature patterns during plant dormancy may lead to significant changes in the accumulation of chilling units during winter and early spring, leading to erratic reproductive behavior, such as advanced or delayed spring blooming (Fadón and Rodrigo, 2018). Knowing the chill unit accumulation at a particular location is essential for making decisions such as the proper selection of plant species or plant cultivars to grow (Alburquerque et al., 2008) and predicting the timing of spring phenological events (i.e., bloom and leaf-out) (Pope et al., 2014). Monitoring winter chill accumulation is also desirable for growers to take timely mitigating actions in years or areas of low chill (Zhang and Taylor, 2011). Some mitigating measures for chill compensation could include planting low-chill cultivars (Rouse and Sherman, 2003), using dormancy-breaking chemicals, forced defoliation, pruning, and other techniques (Melke, 2015). Also, accurate estimates of chill requirements and chill unit accumulation are essential for assessing the suitability of cultivars and potential climate change impacts on fruit production (Delgado et al., 2021). Considerable research has focused on understanding the effect of winter temperature on plant physiological processes, which has resulted in the development of many models to predict the break of tree dormancy using the accumulation of chilling temperatures during the winter. Although many of these predictive models could be very useful for farmers, their practical implementation usually requires collecting or accessing local hourly temperature data and analyzing them using processes beyond most farmers' capabilities. There is a severe lack of easy-to-use tools to obtain and analyze local data and provide relevant and timely information, such as the local accumulation of chill units, to help farmers make better farming decisions. Therefore, this study aimed to develop an online chill calculator for South Carolina utilizing the available temperature data from each county in the state.

METHODS: In this study, a website was developed (https://etcman.shinyapps.io/SC_Chill_App_2022) using *Shiny R* that (1) automatically downloads the daily maximum (T_{max}) and minimum (T_{min}) temperature data from the selected county and date range, and (2) calculates and plots the daily and cumulative chill hours, chill units, and chill portions using four different chill models. The inputs for the app (T_{max}, T_{min}, and latitude) are obtained from the Web Service API made available by the Applied Climate Information System (ACIS) (http://data.rcc-acis.org/). The app uses a procedure (Linvill, 1990) to reconstruct hourly temperatures (T(t)) from the daily T_{max} and T_{min} temperatures. The hourly temperatures are used to calculate the daily chill hours using the T(t)<7.2°C model (Linvill, 1990; Miranda et al., 2013) and the 0°C<T(t)<7.2°C model (Zang and Taylor, 2011). The daily chill units are calculated

using the Utah model (Richardson et al., 1974; Alburquerque et al., 2008) and the chill portions using the Dynamic model (Fishman et al., 1987).

RESULTS: The app results for three years (2019-2022) were illustrated for Spartanburg, Barnwell, and Beaufort counties in South Carolina, which had distinct temperature patterns. The results indicated considerable differences in chill accumulation among chill models and locations. Except for the Utah model, the other three models followed the same trend at all three sites, although the chill accumulation was quite different since the units are different among models. The $T(t)<7.2°C$ model and the $0°C<T(t)<7.2^{o}C$ model tended to be very close to each other since they both resulted in chill hours. However, the $T(t)<7.2°C$ model always accumulated slightly higher chill hours.

CONCLUSIONS: It is expected that the new website will help local farmers easily visualize local chill data and use this information for planning the selection of crops and cultivars and improving crop management practices according to the prevailing local temperature conditions. There is a severe lack of easy-to-use tools to obtain and analyze local data and provide relevant and timely information, such as the local accumulation of chill hours, chill units, and chill portions, to help farmers make better farming decisions. Therefore, it is also expected that this study will serve as an example and template to develop this type of tools for other areas with similar needs.

Engineered porosity bone scaffolds bioceramics via directional freeze casting

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Keywords: Hydroxyapatite, porosity, sintering, freeze-casting, lamellar structure

ABSTRACT

Hydroxyapatite (HA, $Ca_{10}(PO4)_6(OH)_2$) based porous scaffolds have been widely investigated in the last three decades. HA's excellent biocompatibility and osteoconductivity have made this material widely used in bone and tissue engineering. In this study, we have investigated engineered porosity bone scaffold bioceramics via freeze cast with tunable porosity and pore architecture. This simple process, where a material suspension is simply directionally frozen and then sublimated, provides materials with unique porous architectures, where the porosity is almost a direct replica of the frozen solvent crystals. It leads to hierarchical porosity with interconnected micro- and aligned macro-pores. The porous scaffolds were sintered at 1250, 1350 and 1450 °C, for 2 h to control the micro and macro porosity. The microstructure of interconnected lamellar pore channels examined by SEM and phase purity by XRD. As the HA content was increased from 10 to 30 vol.%, the porosity decreased from 80 to 49%. The scaffolds with 30 vol% of HA (1450°C) content possessed unidirectional pore channels with a porosity of around 49 % and showed compressive strength of up to 16.3 MPa and compressive modulus of 1.2 GPa. *In vitro* and *in vivo* investigations are underway to determine the potential of these engineered porosity scaffolds.

Multiphysics Simulation of Thermoelectric Material (Fe0.2V0.8W0.2Al)

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Presentation Keywords: Multi Comsol Physics, Thermal, Seebeck Coefficient, Resistivity, Power Factor, Temperature Distribution, Electroconductivity

Abstract: Thermoelectric materials hold immense promise for sustainable energy generation by directly converting heat directly into electricity. Among these materials, the Heusler alloy Fe2V0.8W0.2Al stands out due to its exceptional thermoelectric properties. In this study, we employ Multiphysics simulations to delve into the intricate behavior of Fe2V0.8W0.2Al as a thermoelectric material.

COMSOL Multiphysics is comprehensive simulation software. It allows calculations of electrical and thermal profiles in different geometries with temperature dependent material properties. Our Multiphysics approach encompasses electrical, and thermal, accounting for the alloy's complex crystal structure. We use COMSOL to find out the temperature distribution in Fe2V0.8W0.2Al sample. The Simulation results of other properties of Fe2V0.8W0.2Al will be presented.

Conclusion: COMSOL Multiphysics is a powerful and versatile tool for conducting research in the fields of physics, engineering, and other related disciplines. Additionally, the software is constantly updated with new features and capabilities, making it a valuable investment for any research institution. Overall, the use of COMSOL Multiphysics can greatly enhance the research capabilities of scientists and engineers, leading to more innovative and impactful discoveries.

El Niño Southern Oscillation (ENSO) Variability Changes 4,000 Years Ago

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Keywords: ENSO, Climate

Abstract: El Niño-Southern Oscillation (ENSO) events are year-to-year changes in sea surface temperatures and air pressure of the atmosphere across the equatorial Pacific Ocean that have a broad impact on global climate, which in turn have global socioeconomic impacts. The current generation of climate models disagree as to how ENSO will respond to global warming in the future. To address this uncertainty, we seek to reconstruct past ENSO variability using coral skeleton geochemistry and compare the records to climate models run under past boundary climate conditions. Modern coral geochemical records agree with instrumental ocean data, thus demonstrating that they are applicable for researching ENSO variability. Past paleoclimate conditions are generated using corals from Espiritu Santo, an island in the nation of Vanuatu, by analyzing the ratio of elements such as strontium to calcium (Sr/Ca) and the stable oxygen isotopic composition ($\delta^{18}O$). The Sr/Ca in coral changes in response to variability in sea surface temperatures, while $\delta^{18}O$ shows changes in temperature and salinity. An individual coral can provide hundreds of years of climate data about past tropical ocean conditions. Using a range of laboratory techniques, we produced a record of paleoclimate conditions over several decades dating back approximately 4,000 years ago, or around 2,000 BC/BCE. We will use this data to address uncertainty in climate models that are used to project future climate patterns, including changes in ENSO events.

Halogen Bonding in Cocrystals of Organoiodines with Diphenyliodonium Chloride/Iodide Salts

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Keywords: Halogen bonds, cocrystals, solid state X-ray, Diphenyliodonium Iodide/Chloride Salts

A noncovalent interaction known as halogen bonding occurs when a nucleophilic region of one molecule interacts with an electrophilic region (sigma hole) of a halogen in another molecule. A series of novel halogen bonded cocrystals of diphenyliodonium iodide (DPhII) and diphenyliodonium chloride (DPhICl) with the organoiodines: 1,2-diiodotetrafluorobenzene (1,2-F4DIB), 1,3-diiodotetrafluorobenzene (1,3-F4DIB) and 1,4-diiodotetrafluorobenzene (1,4-F4DIB) are reported. Cocrystals obtained by solution synthesis and mechanochemical synthesis are compared. The assembled cocrystals were studied by X-ray diffraction and powder X-ray Diffraction (PXRD) to evaluate the structures. Interestingly, the chloride and iodide systems often demonstrate differing behavior, either through the formation of different cocrystalline ratios, or through the formation of non-isostructural assemblies. A key feature of the structures is the formation of a rhombus-like halogen bonding core between the cations and anions in the cocrystal structures. The organoiodines are appended to this core in various ways, depending on the organoiodine isomer involved, and the cocrystal ratio. This study compares structural features such as the halogen bonding strength (distance) and long-range halogen bonding patterns involving the iodide and chloride anions. More broadly, the study develops the rhombic halogen bonding motif to develop reliable crystal engineering principles.

From Curvature to Stability: Unraveling the Physics of Blue Phase Soft Crystals

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Presentation Keywords –Blue Phase Liquid Crystals, Curvature, Polyme-stabilized, Photonic

Introduction: Liquid crystals (LCs) with both liquid and solid characteristics, present distinctive properties such as birefringence, and exceptional dielectric capabilities, positioning them as ideal candidates for advanced photonic applications. LCs can be found in several phases, among which chiral LCs are distinguished by their pitch length, p—the distance over which the director, **n**, completes a full 2π rotation [1]. Before transitioning to an isotropic phase, chiral molecules with compact pitch lengths ($p < 500$ nm) organize themselves into double-twisted cylinders (DTCs) to lower the system's free energy. These DTCs then organize into thermodynamically favored 3D structures with cubic patterns, known as Blue Phases (BP). This self-organizing process can lead to the creation of BPI, with a body-centered-cubic structure and BPII with a simple-cubic structure. The cubic lattice of BPs, maintained by a network of defect lines with minimal molecular order, can reflect visible light due to their lattice size being in the order of a few hundred nanometers [2]. Their fluidic crystalline nature also makes them sensitive to external stimuli, making them suitable for diverse photonic and electro-optic devices. However, their application is restricted by their limited thermal stability and polycrystalline formation. In this study, we delve into the thermal stabilization of BPs within microdroplets, examining the effects of curvature, confinement, and photopolymerization of defects on the nucleation, growth, and thermal stability of BP soft crystals in microdroplets [3]. We have developed microfluidic systems to produce BP droplets and explored the influence of varying confinement and curvature degrees on the structural stability and optical behavior of the thermally stabilized BP droplets. Varying the degree of confinement and curvature, we investigated the structural stability and corresponding optical responses of the stabilized BP droplets.

Methods: BP liquid crystals (high chirality liquid crystal) were prepared by mixing the chiral dopant (S-811) with a nematic liquid crystal (MLC 2142) in a 63:37 %wt ratio. The transition temperature of the mixture was measured to be 40.2 °C and 41.2 °C for BPI and BPII, respectively. The phase transition was detected by a sharp transition in the reflection peak of [110] and [200] lattice planes of BPI to the [100] plane of BPII.

The UV reactive precursor was composed of 5.17 wt %trimethylol propane triacrylate (TMPTA, Aldrich), 7.49 wt.% 4-(3-Acryloyloxypropyloxy)benzoesure 2-methyl-1,4-phenylester(RM257), 0.75 wt % DMPA (IRG65, Aldrich) as a photoinitiator,and 86.59 wt % of the high chirality liquid crystal. In the absence of UV light irradiation, the mixture was heated beyond isotropic temperature for 1h and stored overnight at room temperature to ensure complete dissolution and homogeneity of the components.

To create uniform microdroplets, we engineered a microfluidic device featuring a capillary with a flow-focusing design [4]. This setup includes a finely tapered cylindrical capillary, meticulously

positioned inside a square capillary. By fine-tuning the orifice sizes and the flow rates of the liquid crystal and water-based phases, we achieved precise control over the droplet dimensions. Poly(vinyl alcohol) (PVA) was utilized to promote planar alignment of the molecules within the droplets.

For the photopolymerization process, we exposed the reactive emulsion to ultraviolet light (365 nm) at a temperature 0.5°C higher than the temperature at which the high-chirality liquid crystal within the droplets transitions to exhibit the BPI optical state (39°C).

Results and Discussions: In this study, we used lab-designed microfluidic devices to produce microdroplets of reactive BPs with controlled size to systematically, aiming to methodically explore how geometrical confinement, curvature, and photopolymerization of reactive mesogens influence the crystallization behaviors and thermal stability of BPs. Our findings indicate that while photopolymerization within microdroplets leads to stabilized BPs, the stability of these structures is significantly influenced by their size and the degree of curvature. We delved into the underlying mechanisms of these molecular arrangements through a combination of experimental and theoretical simulation approaches [3, 5]. Our study offers novel insights into the design of optically active microstructures, addressing the inherent challenges of BPs and unlocking new possibilities for advanced photonic and sensing technologies, particularly in the realm of flexible and wearable devices.

Conclusions: In summary, we studied the molecular ordering of stabilized BPs within spherical microdroplets. We have found that the photopolymerization of defect within curved geometries significantly impacts BP molecular structures and their thermal stability. Moreover, curvature promotes the formation of stabilized and monodomain crystal strctures.

Scenario-Based Learning: Pedagogy for Teaching Undergraduate Statistics

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Presentation Keywords: statistics, social determinants, community, pedagogy, scenario

Diverse pedagogical approaches invite active learning and boost student engagement in the undergraduate classroom. Incorporating scenario-based pedagogy encourages students to consider and grapple with course content in a non-traditional way. According to Weston (2018), "the basic goal is to put students into a self-unfolding and urgently engaging setting, scenario, or simulation, and then trust it, and them, to carry it forward, helping or even spark-plugging or provoking at times if needed" (p. 3). The author used scenario-based learning to create an active and collaborative learning space for students in an undergraduate-level statistics course during the spring 2023 semester. Students were introduced to foundational concepts in statistics and social determinants of health (SDOH) simultaneously. Students exercised their role as community members and engaged the statistical research process, focusing on ways these nonmedical factors affect people's health in the Lowcountry community. Majority of students were interested in one major SDOH – health care access and quality. These students visited a free health clinic to better understand how the organization meets the needs of community residents and the challenges they continue to face. A smaller group of students focused on another SDOH - social and community context. These students visited an organization that provides varied services to the community. After their visits, students developed creative approaches for solving community issues using quantitative data and statistical analysis. This type of engagement affords students an opportunity to become active members and influence positive change in their community. Student learners presented their research in their role as community members at a 'town council meeting' at the end of the semester.

STAR Teachers of South Carolina: Early Observations and Lessons Learned from the Research Experience for Teachers in Biological Sciences (BIORETS) Program at Converse University

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Presentation Keywords: BIORETS, Research Experience for Teachers, STEM outreach, Lesson plans, Teacher professional development.

Abstract

Converse University is a small, primarily undergraduate institution (PUI) in Spartanburg, SC. In 2023, Converse received a National Science Foundation Research Experience for Teachers in Biological Sciences (BIORETS) award that has a focus on neuroscience. The program aims to expand our award- winning K-12 outreach program, the Science, Technology, and Research Scholars (STARS) program, for Spartanburg County high school students. Over the next five years, the Research Experience for Teachers program will train 24 South Carolina middle school and high school STEM teachers in three cohorts of 8 during a 6-week summer research experience and academic year activities during the subsequent Fall and Spring. As a secondary goal, this project aims to provide a best practice model for primarily undergraduate institutions to strengthen teacher training and help STEM teachers become transformative leaders.

STAR Teachers of South Carolina program provides middle and high school STEM teachers with a 6- week authentic summer research experience followed by an academic year follow-up to enhance their scientific disciplinary knowledge and experience. Teachers receive mentoring to develop pedagogical tools to implement their research experience into their classroom activities and curricula. As a follow-up during the academic year, Converse faculty visits the teachers in their classrooms to support the implementation of the curricular materials in classroom activities. Teachers present their authentic research experiences and original lesson plans in a variety of national and regional research and education symposiums. Surveys of the first-year participants in the program show that:

1. Teachers who had another teacher on the research team were more satisfied with the program.
2. Teachers reported that neuroscience did not easily match state standards, especially for middle school teachers. They would prefer a broader research topic for their research experience.
3. Teachers reported that their students enjoyed the hands-on activities and field trips to the university. They asked for more opportunities like this.
4. Teachers reported that they think the university faculty is not aware of the reality of teaching middle and high school students. They recommend that faculty mentors can spend time in the classroom before the summer research experience program.
5. Teachers recommended that the second cohort of teachers interact with the first cohort to enrich their experiences.

We are reviewing and refining the program based on feedback received from teachers in order to improve the experiences of future cohorts.

ADAPT in SC: Investigating Structural Dynamic Identification Using Time Series TopologicalFeatures

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Keywords: Topological data analysis, feature engineering, structural systems, time series, structural health monitoring

This work performs an exploratory investigation into the utilization of Topological Data Analysis (TDA) for assessing the dynamic response of structures subjected to shock and impact events. This approach is grounded in the observation that data generated from a system experiencing continuous vibrations, when disrupted by a shock event, present unique opportunities to study structural dynamics through a topological view. Specifically, the paper focuses on the application of persistence diagrams, a key tool in TDA, to quantify and analyze the structural dynamics and their alterations post-shock events. The study explores a methodology for extracting and analyzing topological features from vibration data, particularly through persistence diagrams, which track the birth and death of topological features within the data as a function of time. By examining these diagrams before, during, and after shock events, the paper proposes a novel framework for identifying and quantifying damage or changes in the structure, emphasizing the exploratory nature of leveraging TDA for structural health monitoring.

Stress and Mental Workload Factors in Human - Robot Collaboration: Investigating Speed, Robot Density, and Robot Orientation Effects

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Keywords: Human - Robot Collaboration, Robotics, Cobots

I. Introduction

With further advancements in robotics and sensor technology, collaborative robot (cobot) technology is experiencing an increase in applications and implementations. One of the most relevant applications of collaborative robots is their implementation in factory settings. Manufacturing Cobots can safely work at a closer distance to factory employees, which revolutionizes the factory management and physical safety attributes. These cobots allow for increased productivity and efficiency as the cobots complete menial tasks and the operators can focus on the tasks with higher complexity and dexterity requirements. While cobots produce a physically safer environment than their traditional counterparts, the consideration for the mental and emotional safety of operators must be expanded upon. As operators are working in these conditions for at least 40 hours a week, mitigating mental and emotional strain is not only highly relevant from an ethical perspective, but additionally could lead to decreased productivity and long-term physical and mental illnesses, negating the entire motivation for their implementation. Previous literature conducted in factory settings has found that higher robot speed, lower movement legibility, and closer proximity of robots to operators results in higher mental workload and stress levels. Our research seeks to expand on these results, studying the effect of variations in robot speed, robot number, and left-right orientation on stress, attention, and mental workload levels.

II. Methodology

15 participants, ages 18 - 48, 7 female, 5 male, were recruited from a college community.

The study was developed as a mixed factor (2 x 2 x 2) within-subject design. The independent variables were robot speed (fast vs. slow), robot number (1 vs. 2) and orientation (left focus vs. right focus). The independent variables were mixed into eight 3-minute sessions completed by the participants in a randomized order. The experiment used HiWonder xArm Robots configured on the participant's left and right side. The robots were each in the center of a semi-circle of Lego blocks, with variations in size (4-prong squares and 8-prong rectangles). In each session, the robot or robots delivered the blocks one at a time to a basket placed next to the participant, at the designated speed for that session, for the three-minute time interval. The participant was tasked with using the blocks to make stacks of 5 on a Lego board centered in front of them.

The data was collected in a short survey asking to rate stress, attention, and robot predictability on a scale from 1-5. Robot predictability was included in order to better analyze the results, based on its relevance previous literature. There were four mental workload questions which were answered on a scale from 1-20, then compiled into a total mental workload factor for the data analysis. Additionally, there was an option to detail the particular cause of stress within the session, if anything. The intervention ran 1.5 hours. The participant began by watching a 5-minute meditation video, then completed a collection of baseline data. The participant then was trained on the task, running through

each experiment type in a pre-determined order for one minute each. They then completed the actual sessions in their individual randomized order. After each session they completed the survey for data collection.

Both a one- and two- factor analysis were conducted on the results. For the one-factor analysis, the conditions of interest were Robot Number (1 vs. 2 robots), Speed (Fast, Slow, or Mixed), and Orientation (Left vs. Right Focus). The two factor analysis evaluated Speed vs. Robot number and Speed vs. Orientation. The significance of data was considered based on a 95% confidence interval, therefore data with a p-value ¡ .05 was deemed significant. The relationships of the significant data types to the dependent variables were interpreted based on their distributions and median values.

III. Results

The results of the data analysis show a strong effect of speed and robot density on the dependent variables. The one-factor analysis considering 1- vs. 2- robot scenarios returned significance for stress and robot predictability, showing higher stress and lower robot predictability in 2-robot scenarios. The one-factor analyses of speed showed significance in two of the comparisons: Fast vs. Slow and Slow vs. Mixed (note that there were no significant relationships found in the Fast vs. Mixed scenarios). The stress levels and attention levels in the fast and mixed speed scenarios were higher than in the slow speed scenarios, and the robot predictability was lower. The Fast vs. Slow analysis also returned a significant mental workload result, showing higher mental workload in the fast scenarios. Additionally, there was a significant relationship found in a two-factor analysis combining Robot Number and Speed, in the 1 Robot Fast vs. 2 Robots Fast comparison. This comparison showed that two robots at a fast speed produced higher attention and mental workload than one robot at a fast speed, and decreased the robot predictability.

IV. Conclusion

This study investigated the effect of variations in robot speed, robot number, and robot orientation on stress, attention, and mental workload in Human-Robot Collaboration. These results show that there is relevance to speed and robot density factors on stress, attention and mental workload during human-robot collaboration, but no significant difference of left/right orientation. Higher speeds cause higher stress, mental workload, and attention levels. While two robots were related to higher stress levels, it is possible that the slow speed of the two - robot scenario had minimal increases in stress levels, and could be a promising implementation into a factory setting for increased predictability. The Slow vs. Mixed speeds analysis did not have a significant result for mental workload, indicating the possibility of a slow robot arm in addition to a fast robot arm providing minimal difference in mental workload. These results will be confirmed and extrapolated on in further research, with the addition of more participants and modes of data collection. These results are not only relevant for increasing health and safety of cobot operators, but provide insight into the effects of robot interaction as technological advances continue to implement robots into our everyday lives.