F3 Innovate Frost Risk Forecasting Challenge Brief

Version 1.2

1. Context

Frost remains one of the most damaging weather risks to California's crops, especially during bloom. Accurate local frost prediction requires models that can understand both microclimate behavior and large-scale weather dynamics.

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2. Challenge Overview

In this sprint, participants will build short-term frost risk forecasting models using 15 years of hourly weather data from 18 CIMIS stations across California.

The goal is to explore whether machine learning models can generalize frost prediction across diverse topographies and climates, and to benchmark how data-driven approaches compare to traditional heuristics.

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3. Data Provided

All challenge datasets are cataloged, documented, and accessible through the National Data Platform (NDP) (see Section 9). Participants are encouraged to use the NDP environment for data access and model development; however, direct download options are also provided for teams working locally.

Dataset	Description	Period	Direct Download Link
CIMIS Weather Data - Multiple Stations	Combined hourly meteorological observations from 18 stations statewide over a period of 15 years	2010–2025	See Section 10 - Additional Resources

Individual Station Data	Individual hourly meteorological observations from a single station	2010-2015	See Section 10 - Additional Resources

Participants may also integrate external open datasets to enhance model performance - for example, reanalysis or forecast products (e.g., ERA5, HRRR), satellite-based radiation data, or topographic features.

All supplementary datasets must be:
- Publicly accessible or shareable
- Documented and reproducible in the team's submission notebook
- Used in compliance with their respective data licenses

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4. Tasks

All tasks must be completed and reproducible in the final submission unless explicitly labeled as optional.

1. **Probabilistic Frost Forecasting**
   Train models to predict the **probability that a frost event (**$T < 0$°C**)** occurs as well as the expected temperature within the next 3, 6, 12, and 24 hours, using only information available up to the forecast time.

   Your model should output calibrated probabilities equivalent to: *"There is a 30% chance of frost in the next 3 hours, predicted temperature: 4.50 °C"*

2. **Calibration & Reliability:**
   Evaluate the quality of your probabilistic forecasts using:
   - **Brier Score** – mean squared error between forecast probability and observed event.
   - **Reliability Diagram** – visual diagnostic of calibration.
     Expected Calibration Error (ECE) – summary statistic of probability calibration.
   - **PR–AUC and ROC–AUC** – discrimination skill (identifying frost vs. non-frost hours).

   You may include additional metrics if motivated.

3. **Spatial Generalization:**
   Test how well your model transfers to unseen sites using Leave-One-Station-Out

(LOSO) or Group K-Fold by station.
Report per-station metrics (e.g., Brier, ECE) and the mean ± SD across stations.
Ensure no data leakage, preprocessing and feature scaling must be fit on training stations only.

4. **Synoptic Integration (OPTIONAL):**
Incorporate ERA5 or HRRR data to represent cold-air advection, cloud cover, and radiative cooling patterns that drive frost formation. Compare models trained with and without these features to quantify their added value.

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5. Evaluation Criteria

Criterion	Weight	Description
Forecast Accuracy	35%	Brier Score, ECE, reliability, PR-AUC, ROC-AUC
Methodology & Reproducibility	30%	Clear documentation of data sources, preprocessing, validation splits, and code. Reproducible workflow. Proper baselines and uncertainty treatment.
Innovation	20%	Novel use of features, domain knowledge, or cross-scale integration. How well the method contributes to understanding frost dynamics, not just prediction.
Communication	15%	Clarity of write-up and presentation

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7. Questions

All questions must be addressed in the PDF report unless explicitly labeled as optional.

1. Describe your full modeling pipeline, including which datasets you used, how you preprocessed them, and how your model was trained and evaluated. Include a flowchart or diagram to visualize your workflow.
2. How does model performance degrade when applied to unseen stations?
3. Which combinations of near-surface variables maximize early frost detection skill?

4. How can your model's probabilistic forecasts be interpreted for real-world decisions? For example, how might a grower use your predicted frost probabilities (e.g., 20%, 50%, 80%) to decide when to activate frost protection or monitor conditions more closely?
5. **OPTIONAL:** To what extent do ERA5 or HRRR reanalysis features improve performance relative to surface-only baselines?

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8. Deliverables

- **Reproducible Pipeline (Code + Documentation)**
  Submit either:
  - A Jupyter Notebook that executes end-to-end
  - A Command-line / Script-based workflow (e.g., Python scripts, Makefile, or shell commands) with clear run instructions in a README.md.
  - Include links to your public GitHub repo.

- **PDF Report:** Submit a report in PDF format, addressing the four (or five) questions. Ensure your responses are clear, concise, and well-supported.

9. Platform

The challenge will take place on the National Data Platform (NDP) -a collaborative research environment that connects datasets, cloud supercomputing, and analysis tools through an integrated online interface.

The NDP allows teams to:
- Access high-value, curated datasets directly through the platform
- Run analyses and model training on cloud or supercomputing resources provided by the **National Research Platform (NRP)**
- Collaborate seamlessly with teammates in shared workspaces
- Publish reproducible workflows and results for open science impact.

While all teams must register and access challenge materials through the NDP, participants may choose to complete their analysis either:
- Within the NDP environment, using its JupyterLab and containerized compute tools, or
- On their own infrastructure, by downloading the data locally.

Office Hours Support

All participants are encouraged to request office hours with NDP representative Pedro Ramonetti for technical assistance or onboarding support throughout the duration of the challenge. When booking, please note in your reservation message that you are participating in the F3i Frost Risk Forecasting Challenge.
Schedule office hours here >

Helpful Links

- National Data Platform Website
- Site Documentation
- Data Challenge Onboarding Guide

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10. Additional Resources

For any questions, comments, or concerns please contact the program director:
Ryan Dinubilo - ryan@f3innovate.org

Link to Challenge Data

All challenge datasets are cataloged, documented, and accessible through the National Data Platform (NDP) (see Section 9). Participants are encouraged to use the NDP environment for data access and model development; however, download options are also provided for teams working locally.

- Github Repo for Challenge Data

To help teams better understand the expected structure, workflow, and deliverables of this challenge, participants are encouraged to review the following reference materials hosted on the National Data Platform (NDP):

Example Data Challenge

Explore the *Fire Ready Forests* example challenge on the NDP to see how data challenges are structured, what materials are provided, and how submissions are evaluated.

- Fire Ready Forests – Example Data Challenge

Winning Solutions (Reference Only)

Review three winning submissions from the Fire Ready Forests Data Challenge to understand the quality of deliverables, including the final PDF report and reproducible GitHub repository.

- Team Agni Astra
- Team SDHCN
- HeatMappers

Rewards Structure

F3i

Data Challenge #1 - Frost Risk Forecasting

Rewards Structure

Top Research Track Awards

First Place - $1500 Award

Second Place - $750 Award

Third Place - $400 Award

Presentation & Recognition

The **Top 3** teams will be invited to present their methods and findings to F3 Innovate's industry and grower partners.

Certificates & Digital Badges

All teams submitting valid, reproducible entries will receive a Certificate of Participation.

The **Top 3** teams will earn an official F3 Innovate Digital Credential, verifiable through our open badging system and suitable for inclusion on professional profiles or academic CVs.

Mentorship & Collaboration Opportunities

Selected participants may be invited to join future sprint design teams and commercialization cohorts supported by F3 Innovate and partner institutions.

Interested? Apply today!

Frost Risk Data Challenge - Key Dates

November 10 - Launch Challenge #1, Kickoff Webinar via Zoom
10am / 3pm PST*

November 17 - Check-in
Schedule per team

November 27 - THANKSGIVING

December 1 - Check-in
Schedule per team

December 5 - Submission Deadline
11:59pm PST

December 12 - Winners Announced, Awards Webinar
10am / 3pm PST*

*Multiple times available to accommodate for student schedules