Ice Prediction Workshop Proposal for a V&V Technical Focus Group

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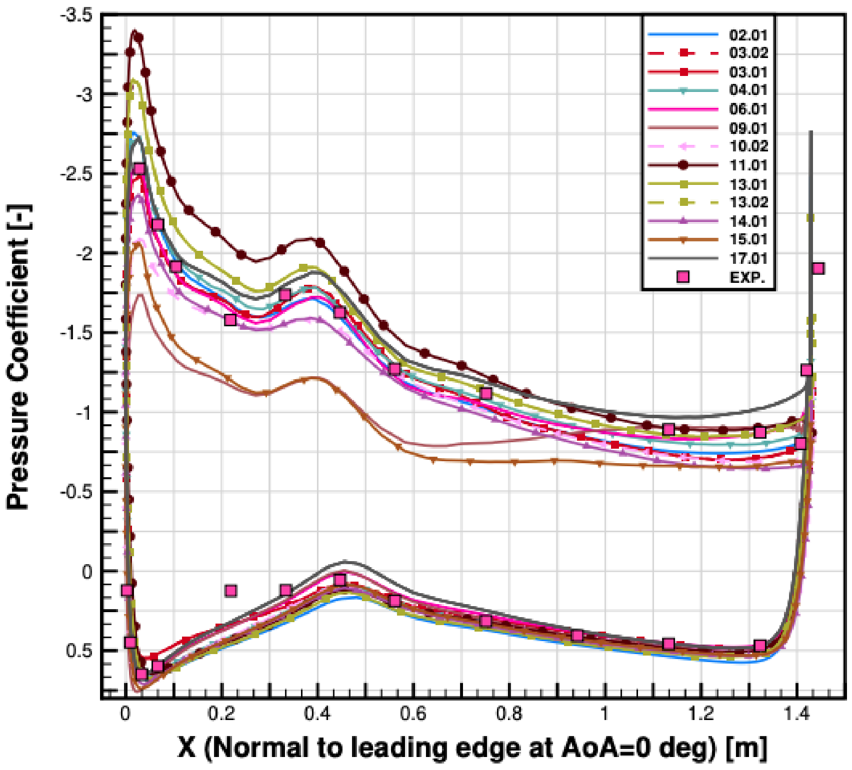
12/10/2024

Motivation

- IPW2 incurred drastic differences in the C_p profiles and attachment line location
- The reason for these discrepancies are multifaceted
- Grid and solution convergence is influenced by the CFD solver, turbulence model, and flux schemes
- Lack of agreement in computational solutions leads to
  – Icing tools being applied to completely different solutions
  – Increased spread of icing results
- These issues impede conclusions and do not convey sound numerical practices being utilized to outside parties
- Improved consistency leads to improved conclusions

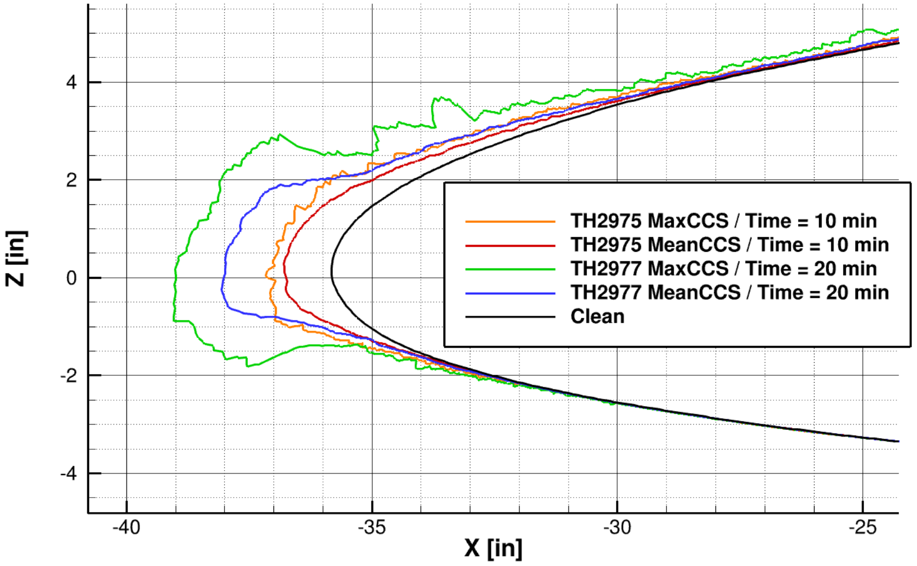


From IPW2 Comparisons by Blanchet Case 1, Slide 10

<u>We don't have one problem to get right, we have two</u>

Proposed Test Case

- CRM65 Midspan Hybrid Model (Similar to Test Case 1 from IPW2) but with the $\alpha = 0^{\circ}$ and $\partial = 0^{\circ}$ configuration (Ozoroski et al.)
- By using the 'nominal' configuration the comparisons become simpler
  - No more complicated rotation schemes for C_p
  - Separation is reduced and ceiling gap influences are decreased
  - Installation discrepancies are reduced
  - Overall, the problem is more well behaved
- The effort can leverage already obtained and usable experimental icing and pressure data for this configuration



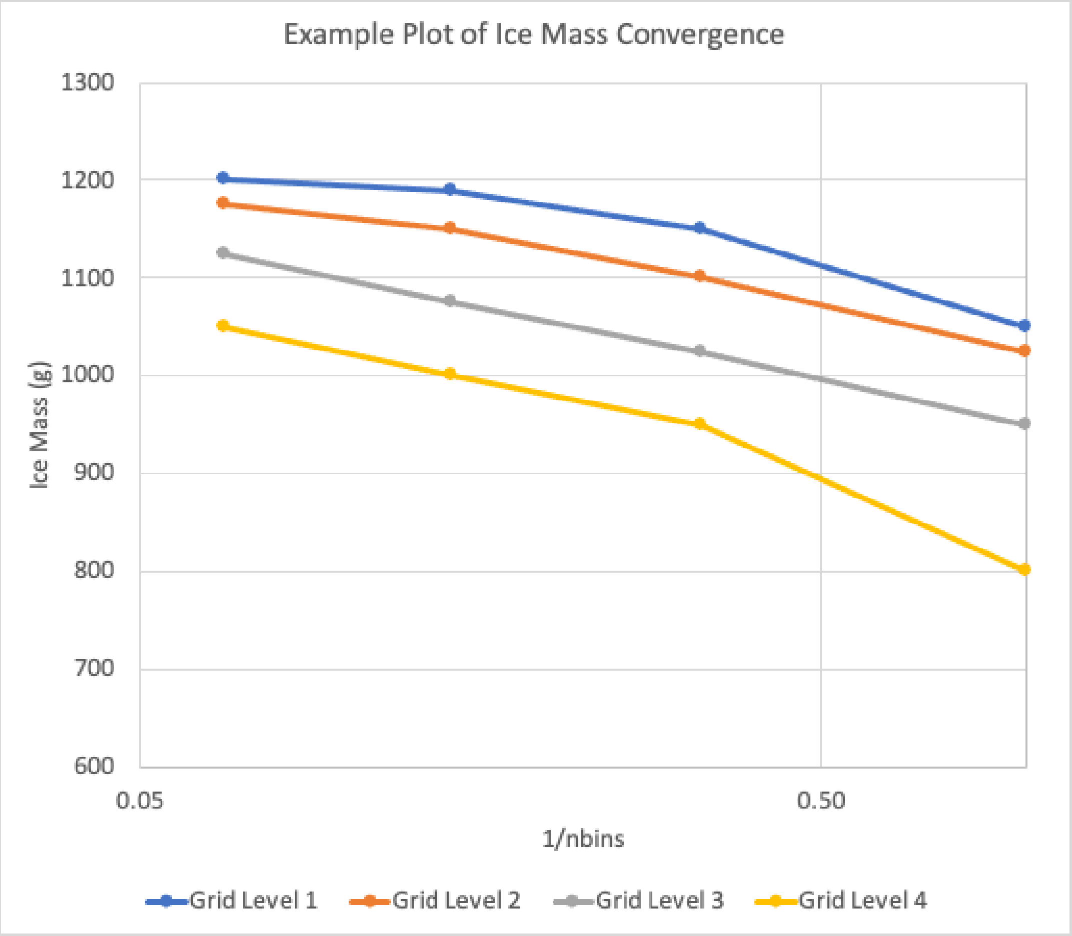
Brief Condition Overview

Icing Time	T_0	Velocity	MVD
10 min	-11.3˚C	130 kts	25.0 µm
20 min	-11.3˚C	130 kts	25.0 µm

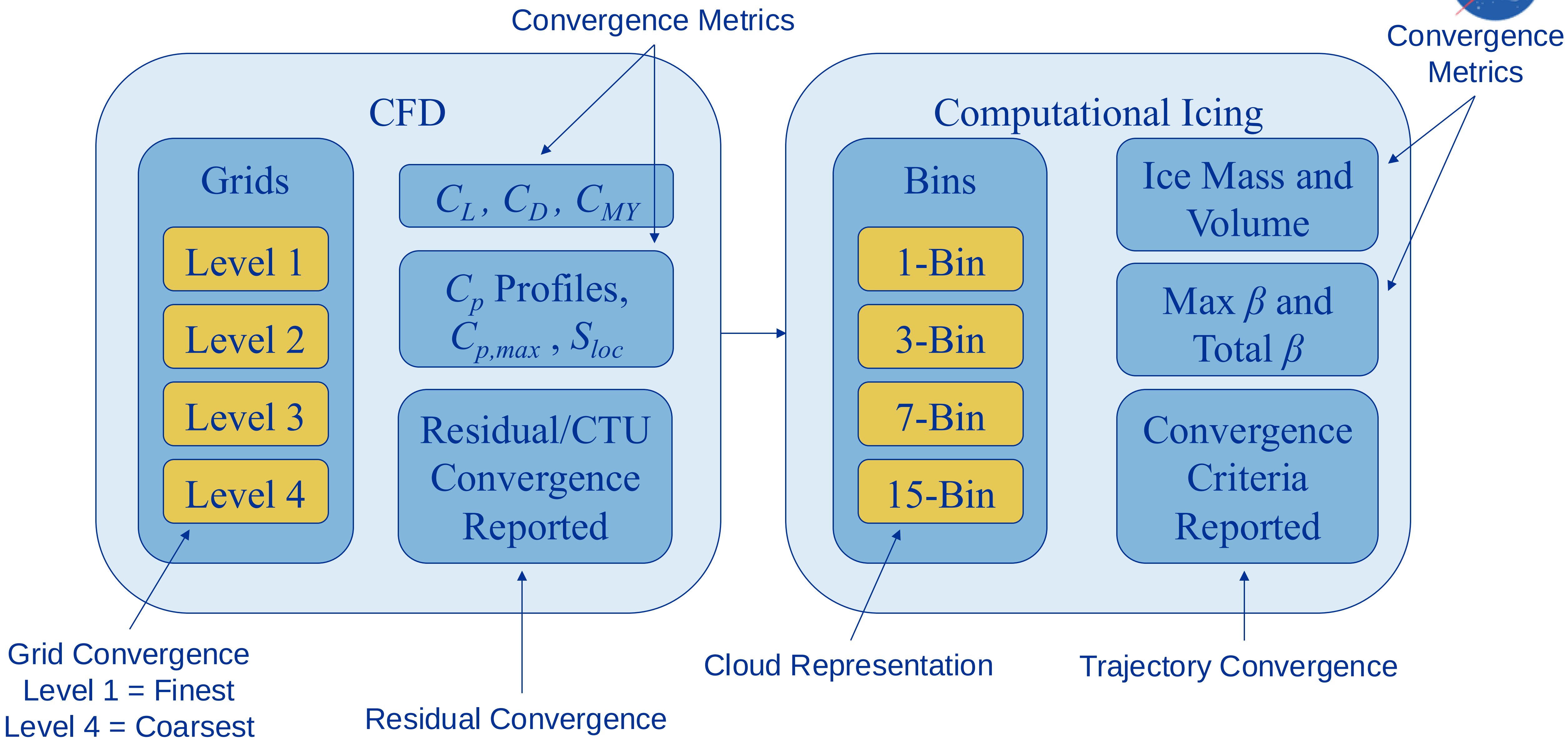
[1] Analysis of Ice Mass Growth Over Time on the CRM65 Midspan Hybrid Model, Ozoroski, Broeren, Lee, and Porter, AIAA 2024

Evaluation Goals

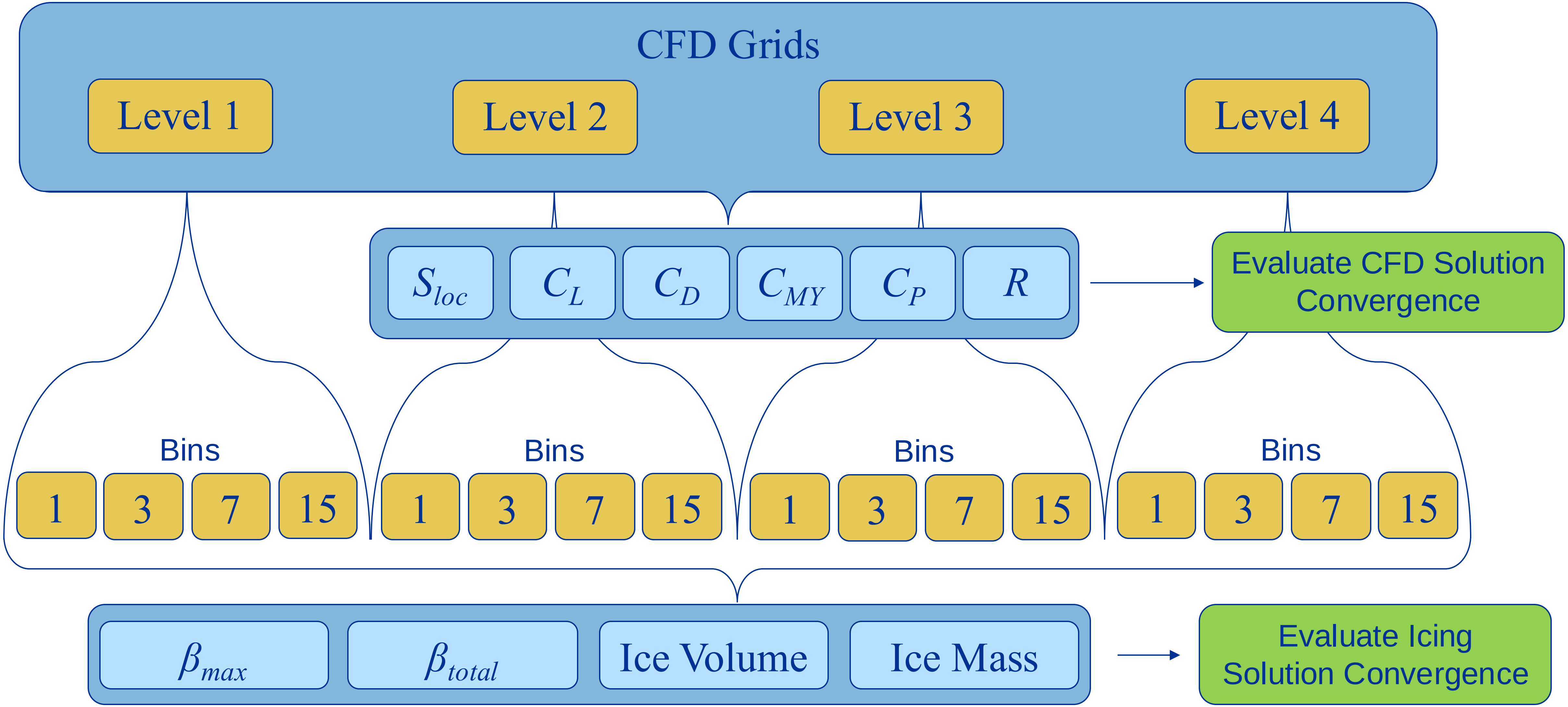
- Evaluate each CFD grid computationally through a grid study and evaluation of attachment line parameters
- Evaluate icing codes based on properties such as
  - Mass
  - Volume
  - Maximum Local Collection Efficiency
  - Total Collection Efficiency
- Demonstrate convergence of both the CFD and Icing solutions
- Once we have a converged solution
  - Compare ice shapes (Participants)
  - Compare properties (Participants)
  - Compare to experimental data (Mass, Volume, Ice Shape)



Assuming Single Shot



Process Workflow



Additional Context

- The goal would be to evaluate icing tools on a consistent problem with consistent error
  - We know that SA, SA-rough, kω, etc. will converge to different flowfields
  - Use constant roughness height for rough-wall turbulence models
  - Solution convergence simply needs to family together
- We only do single-shot accretions to reduce temporal error and subsequent discretization errors
- We know ice density will play a role
  - Use a constant computational ice density value
  - For those unable to do that, show convergence of density
- An ideal situation would be a consistently used CFD solution
  - Problems with grid types, roughness, HTC, and solution compatibility
- Emphasis on converging to a computational solution and evaluate the modeling error as the main source of differences
- Try to pull uncertainty quantification into the results when possible

QUESTIONS AND FEEDBACK