

# Preliminary Investigations into the Effects of Flight Path Variability in Icing

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# Synopsis

Assessment of whether the variability of icing conditions should be accounted for by engineers within aircraft icing

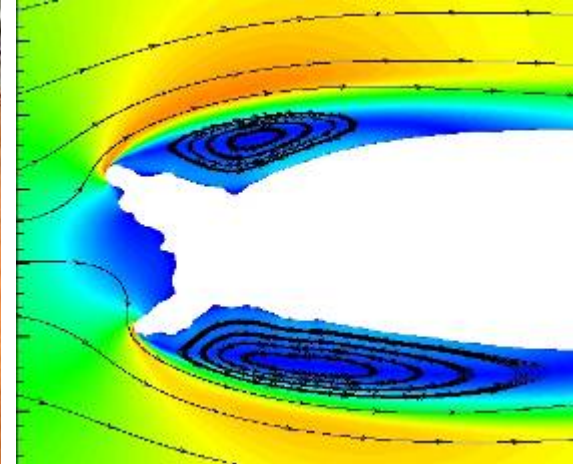
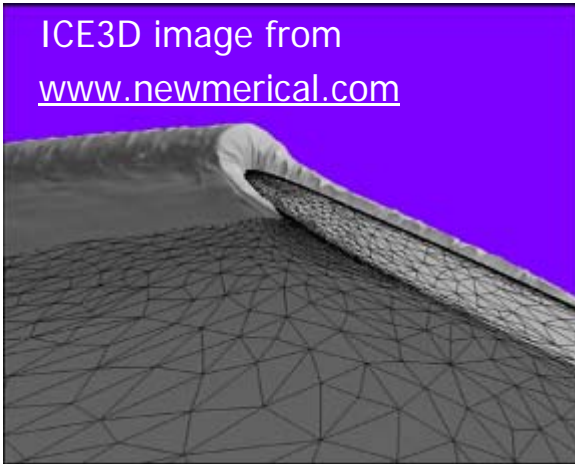


# Presentation contents

1. Rationale for the research work
2. Variability – a basic grasp
3. Design of variability in LWC and temperature
4. Implementation of variability in the CIRT
5. Presentation of selected results

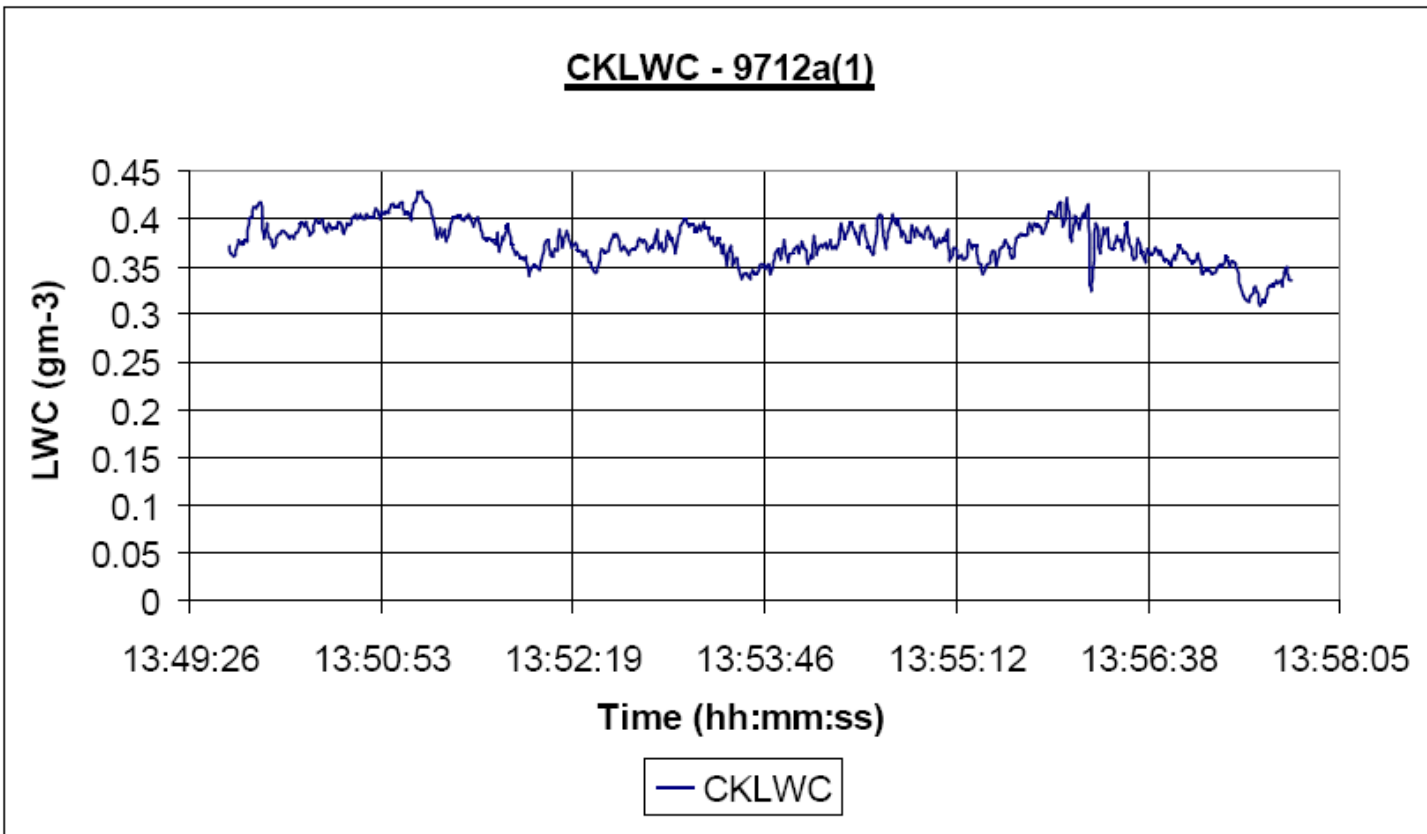
# Rationale for research

ICE3D image from  
[www.newmerical.com](http://www.newmerical.com)



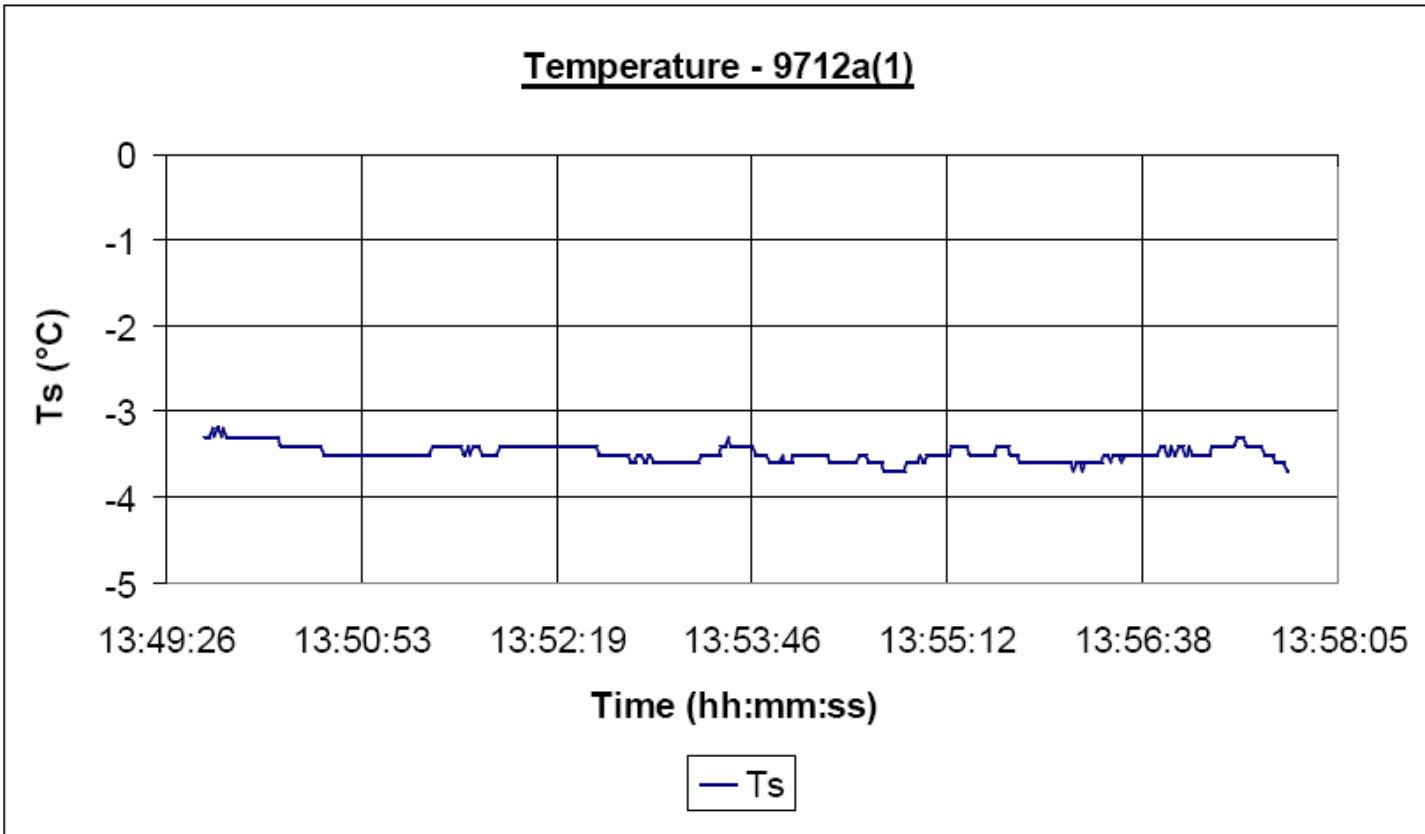
How good does  
it have to be?

# Variability – a basic grasp

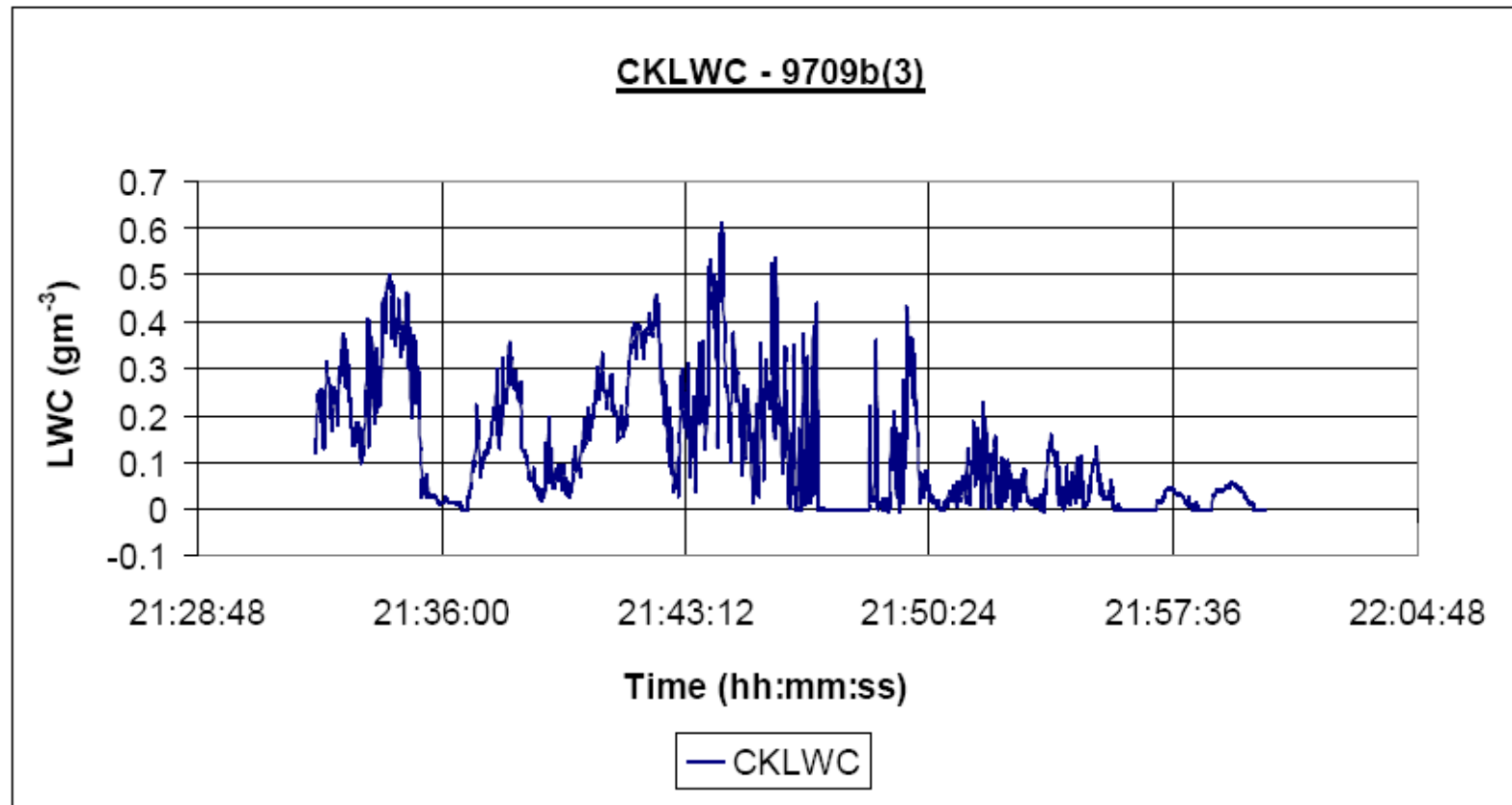


Figures produced using data provided by Dean Miller, from the project previously documented in Miller, D., Ratvasky, T., Bernstein, B., McDonough, F. and Strapp, W. (1998). NASA/FAA/NCAR. Supercooled Large Droplet Icing Flight Research: Summary of Winter 96-97 Flight Operations.

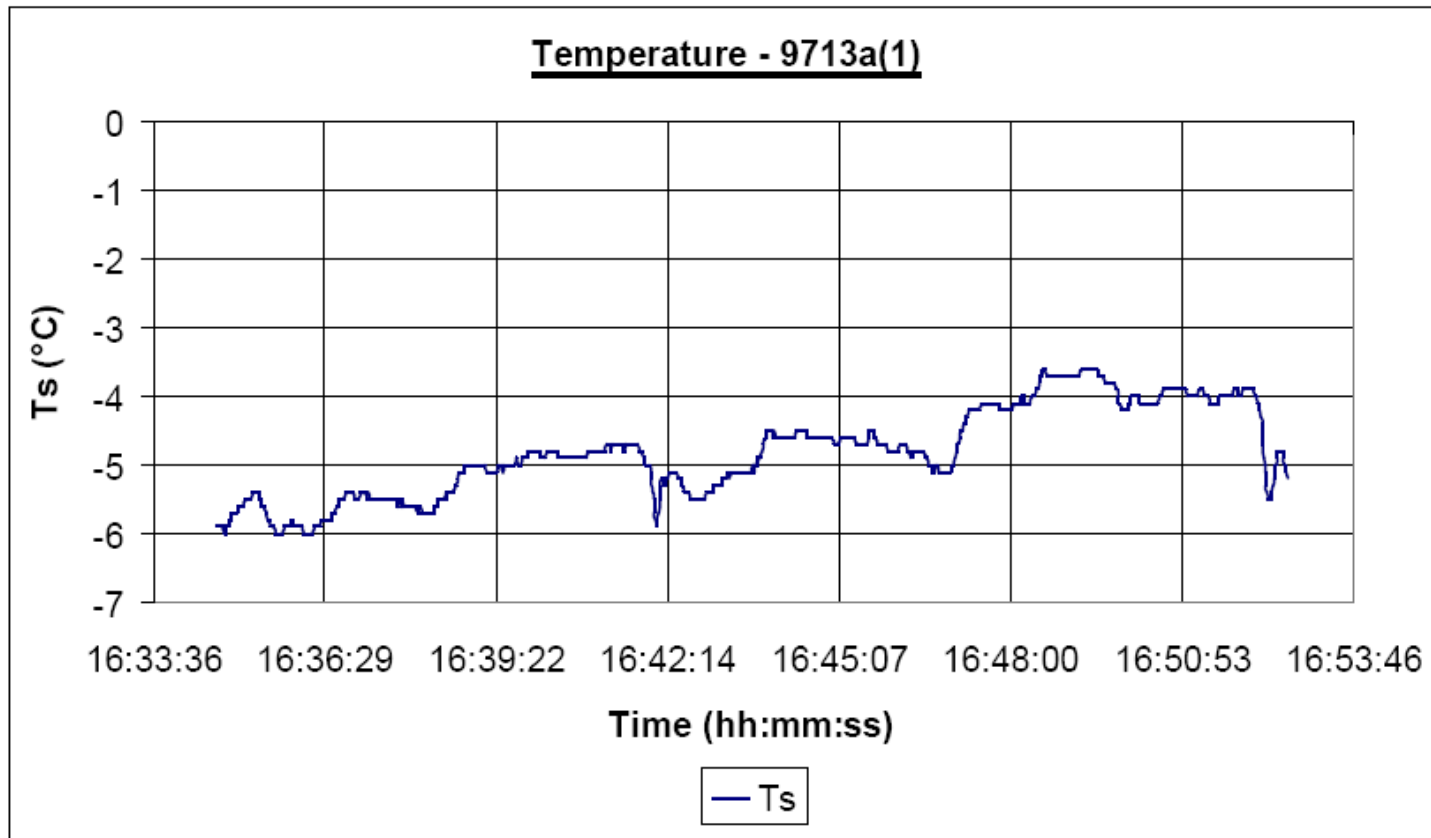
# Variability – a basic grasp



# Variability – a basic grasp

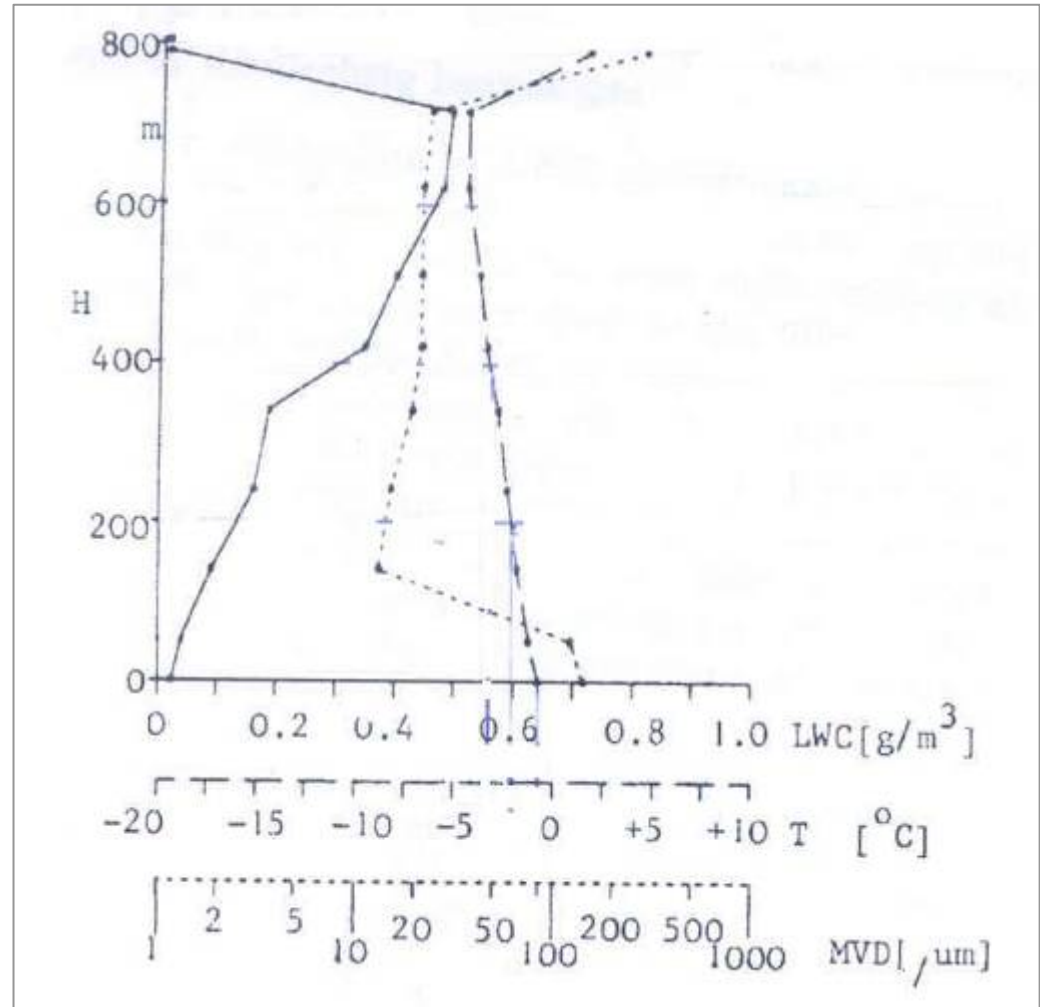


# Variability – a basic grasp



# Variability – a basic grasp

Figure from: Hoffmann, H-E. and Roth, R. (1989) Cloudphysical parameters in dependence on height above cloud base in different clouds.



# Design/implementation of variability

Design of reference case

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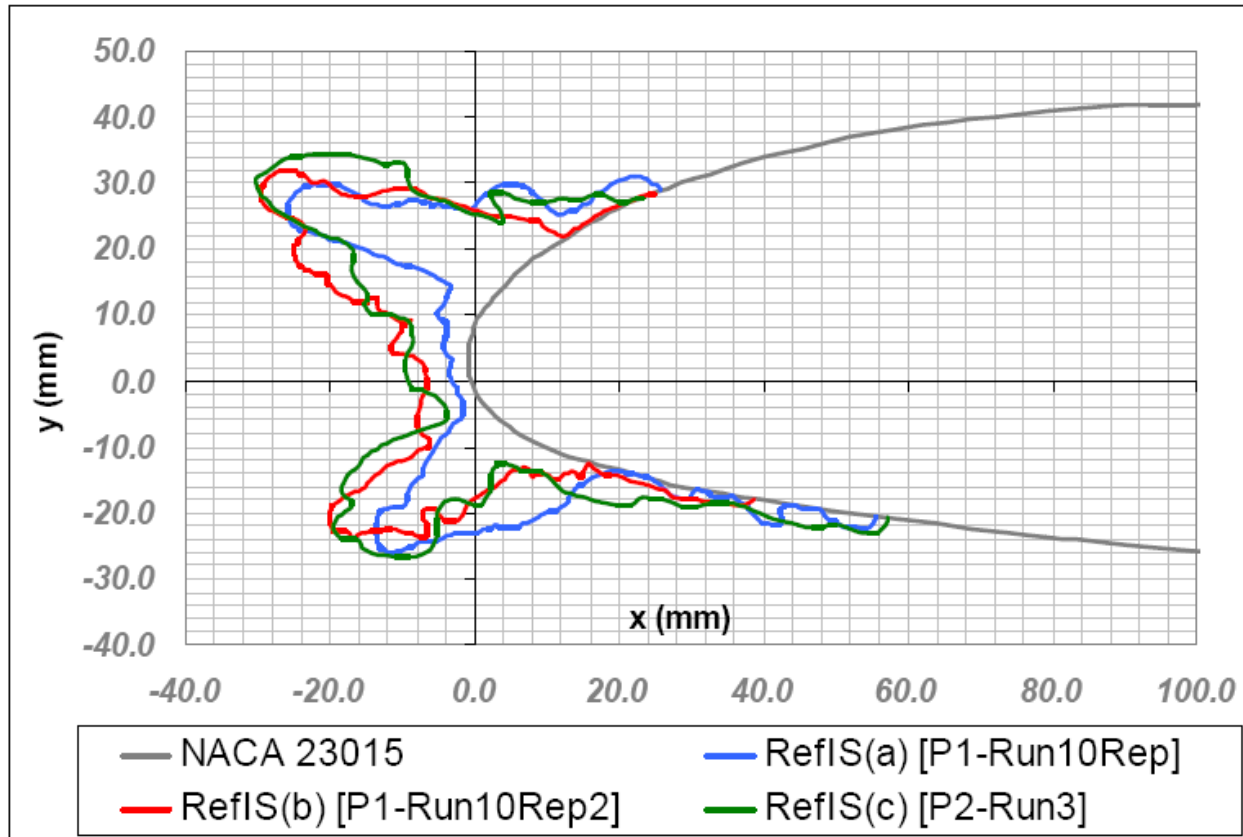
Aspiration to undertake several types of variation within LWC and temperature

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Nominal variable cases and modifications

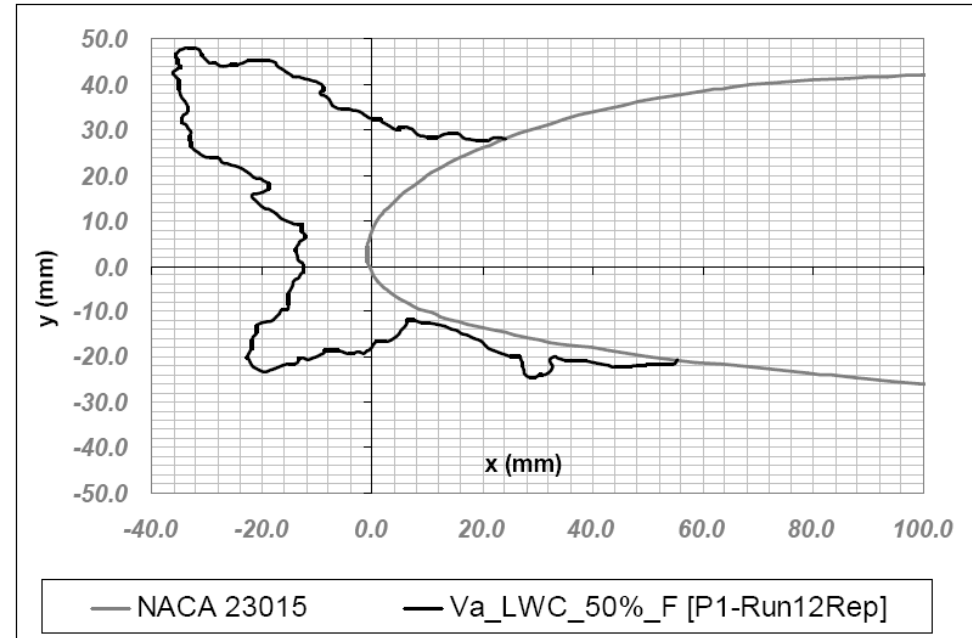
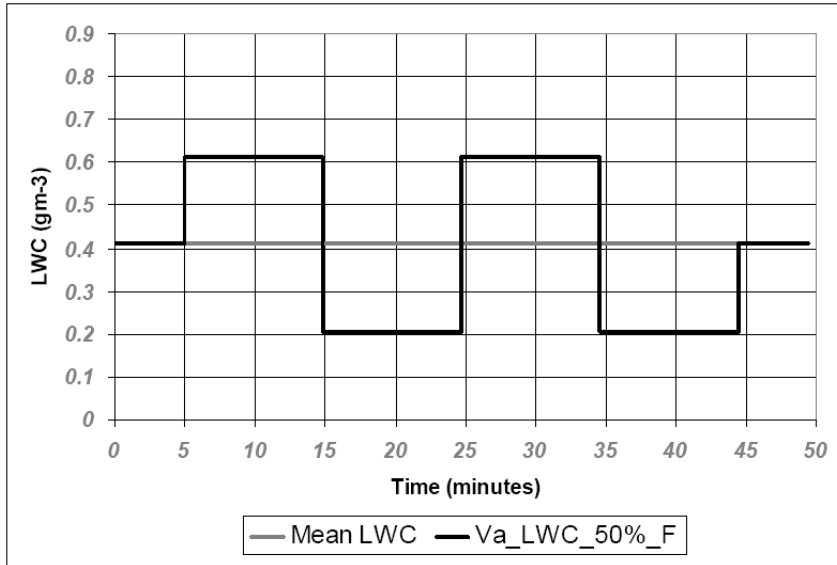


# Selected results – Reference Case



$LWC = 0.41\text{gm}^{-1}$ ,  $T = -2.0^{\circ}\text{C}$ ,  $MVD = 17\text{mm}$ ,  $t = 50\text{mins}$

# Selected results – LWC Variation

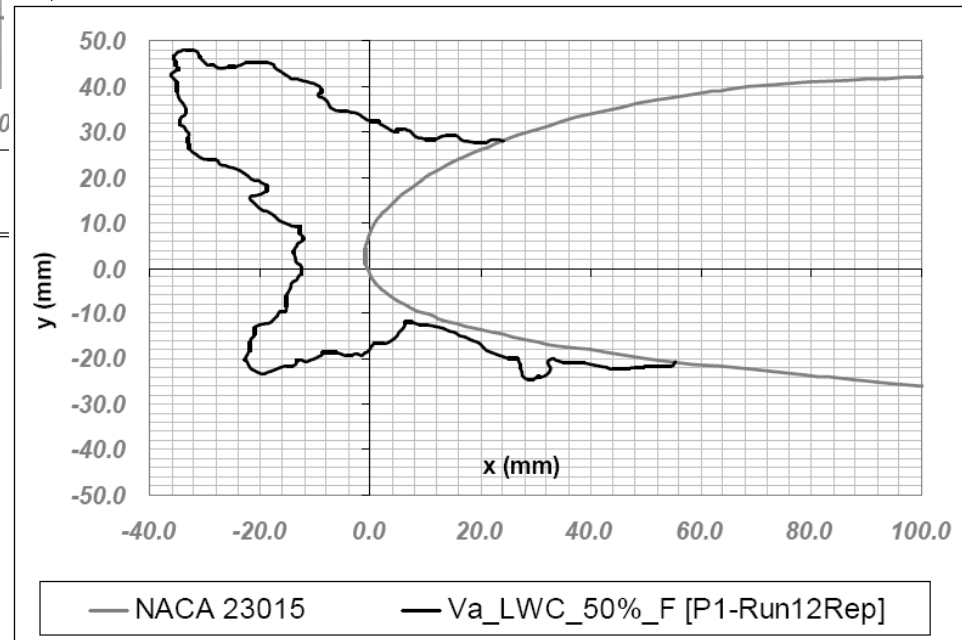
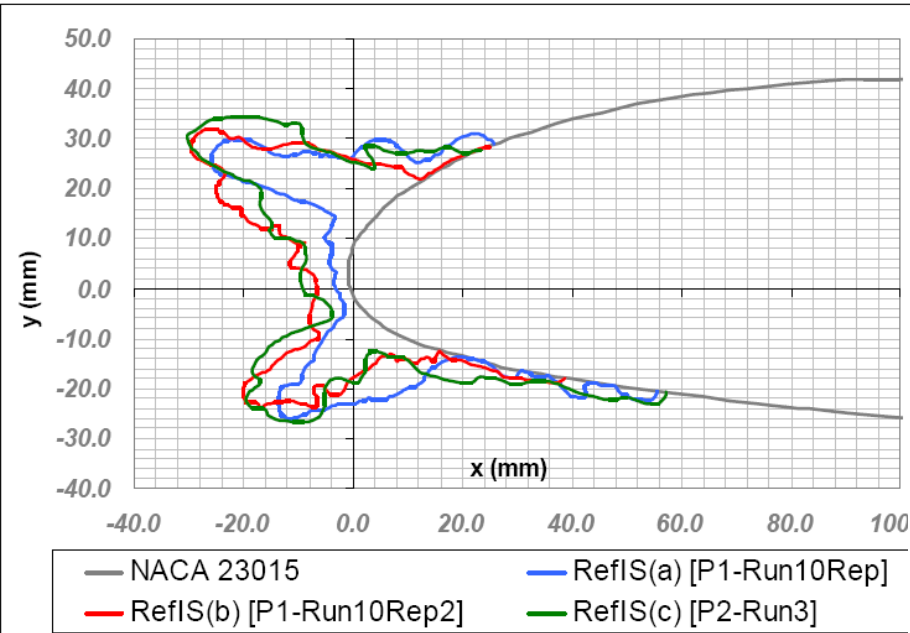


LWC Variation About Mean Value [Equivalent Average LWC]

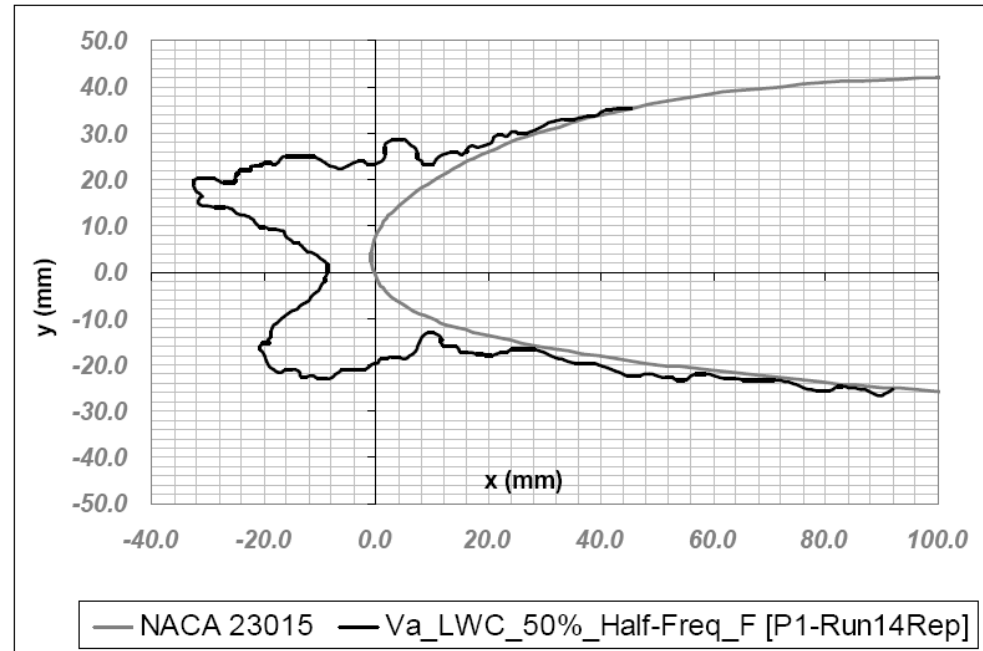
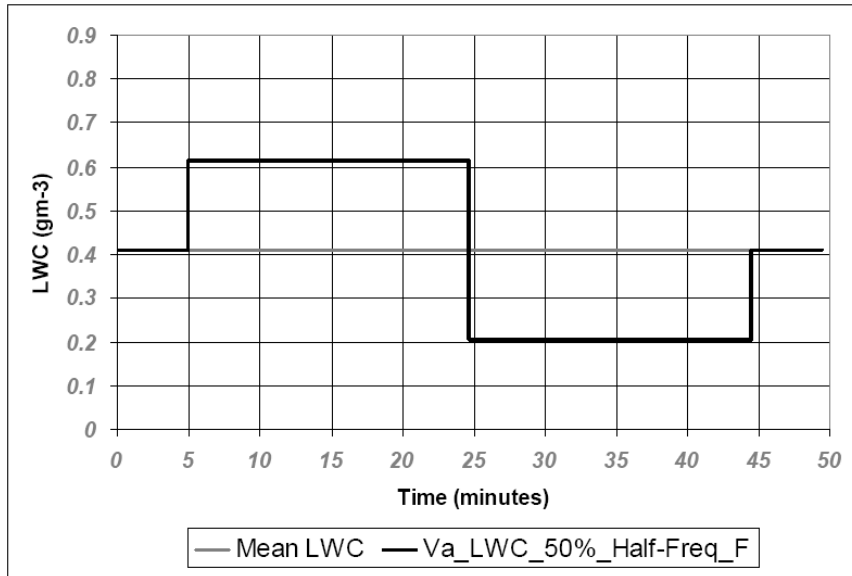
Reference Case:  $LWC = 0.41 \text{ gm}^{-1}$ ,

$T = -2.0^\circ\text{C}$ ,  $MVD = 17 \text{ mm}$

# Selected results – LWC Variation



# Selected results – LWC Variation

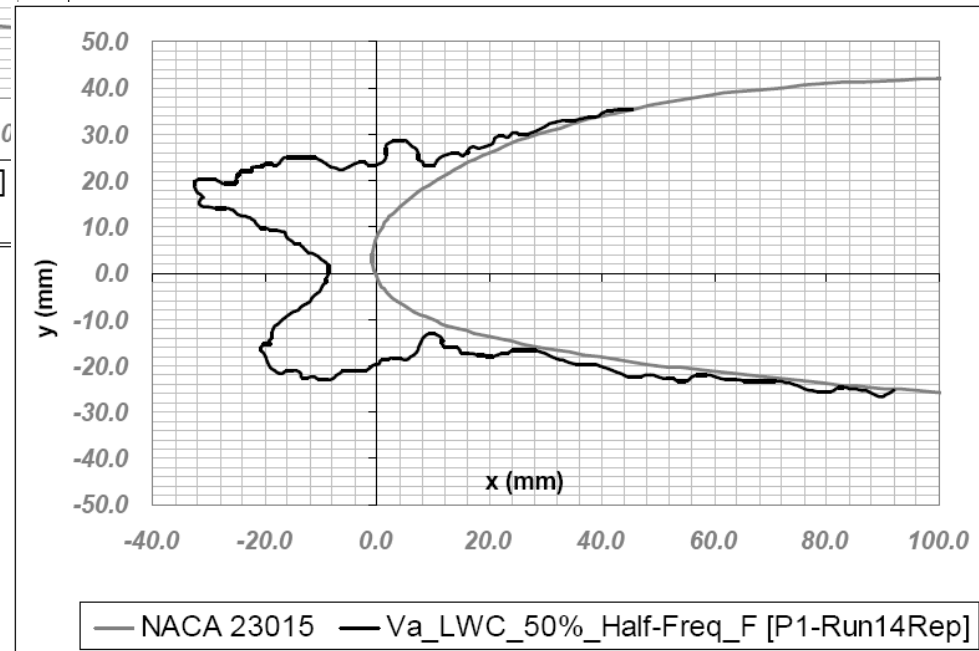
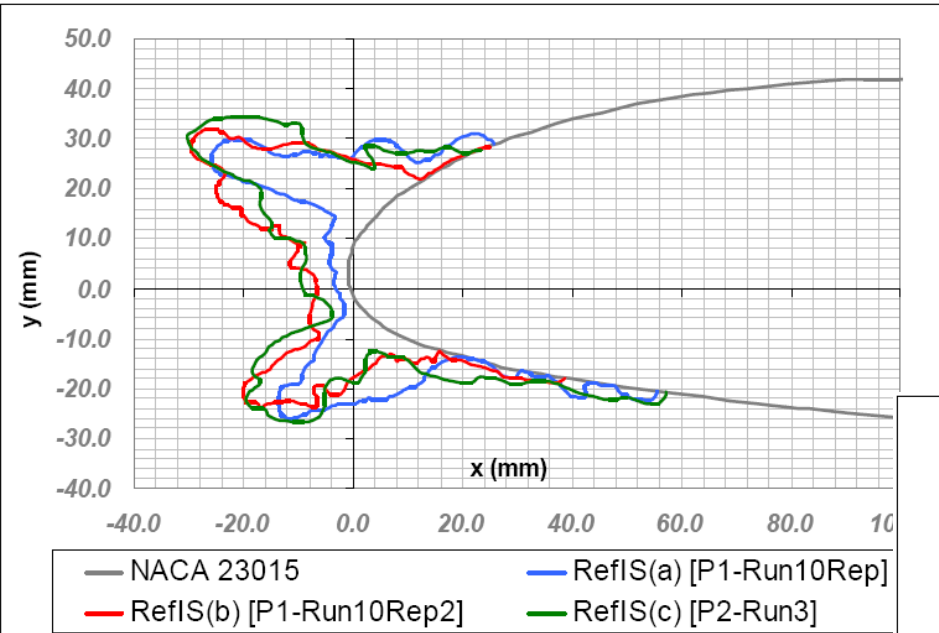


LWC Variation About Mean Value [Equivalent Average LWC]

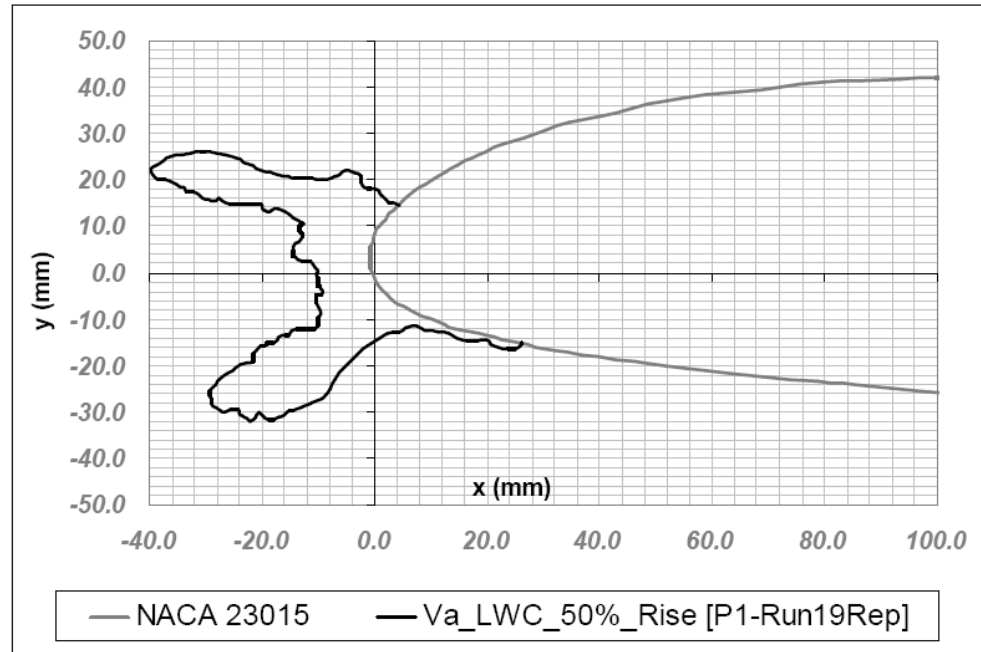
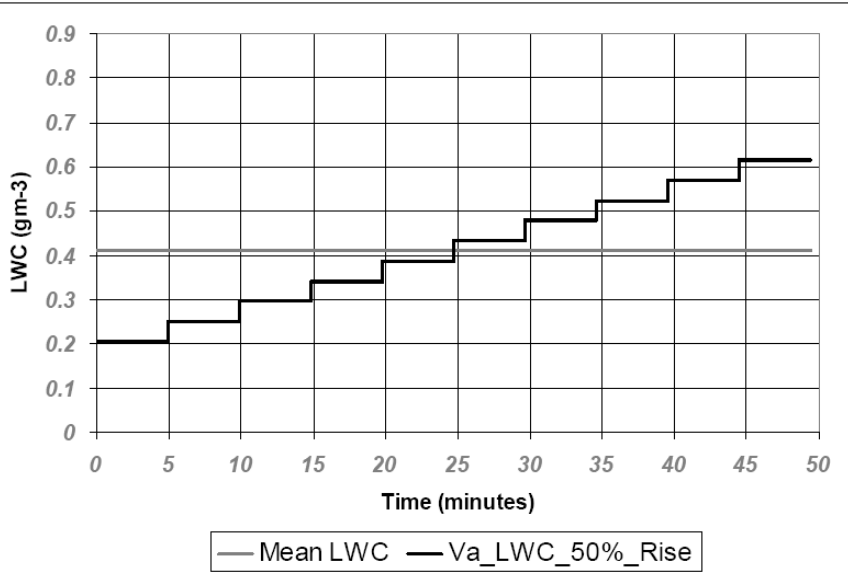
Reference Case:  $LWC = 0.41 \text{ gm}^{-1}$ ,

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# Selected results – LWC Variation



# Selected results – LWC Variation

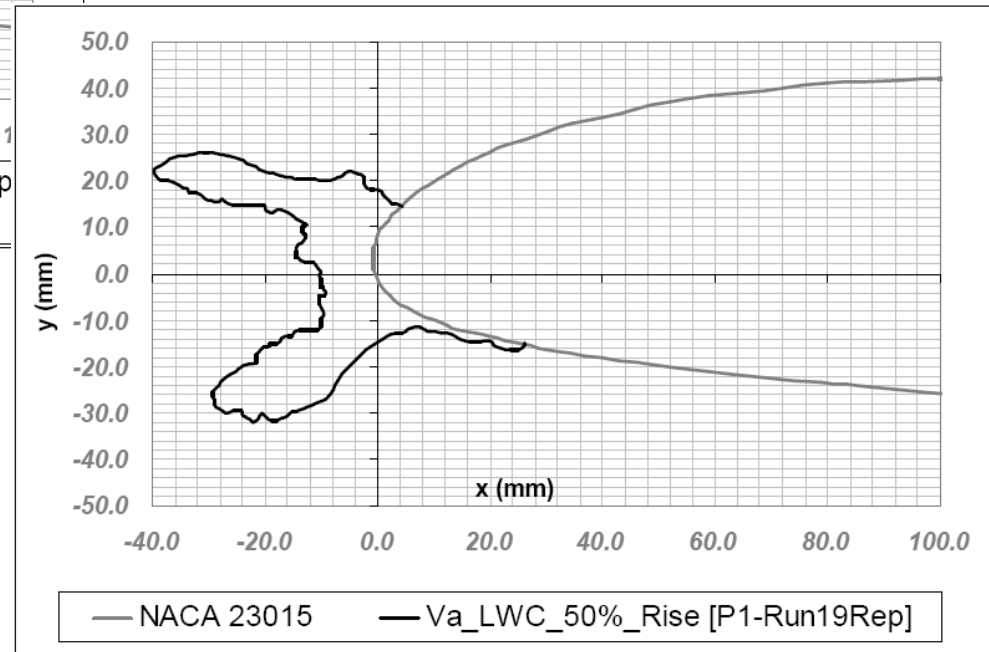
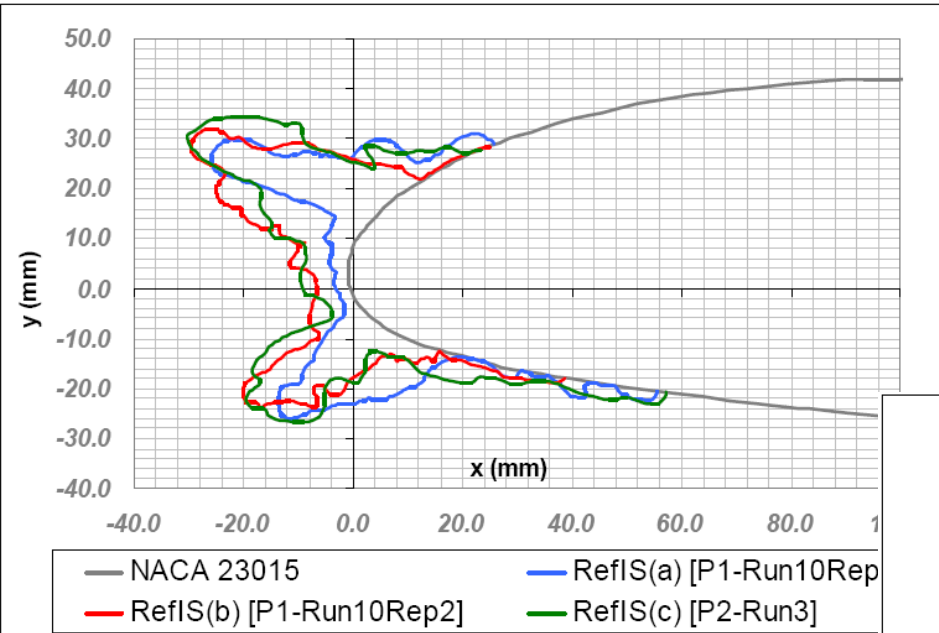


LWC Variation About Mean Value [Equivalent Average LWC]

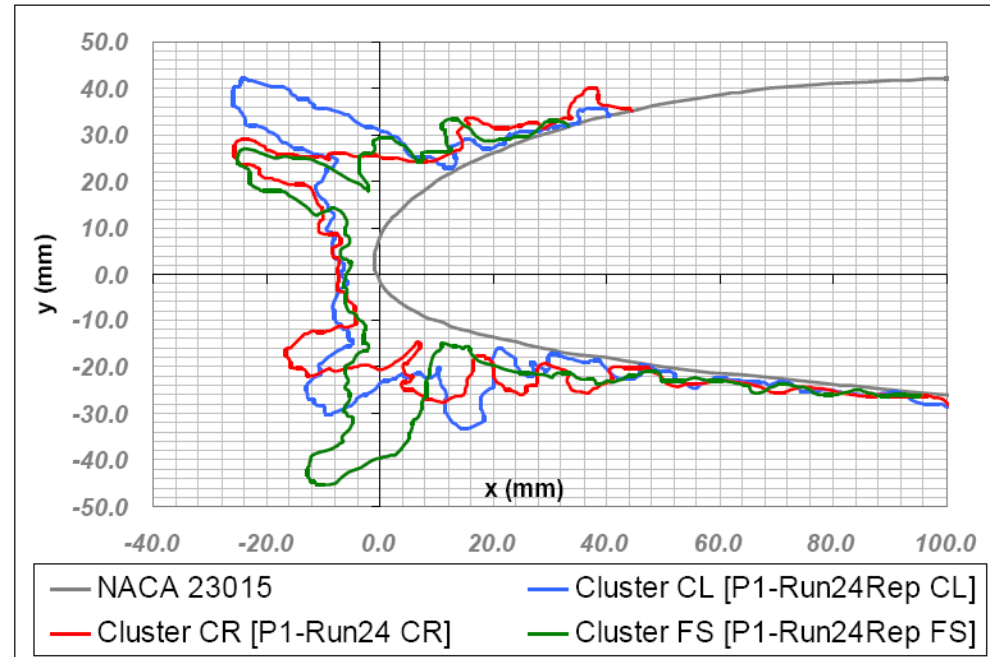
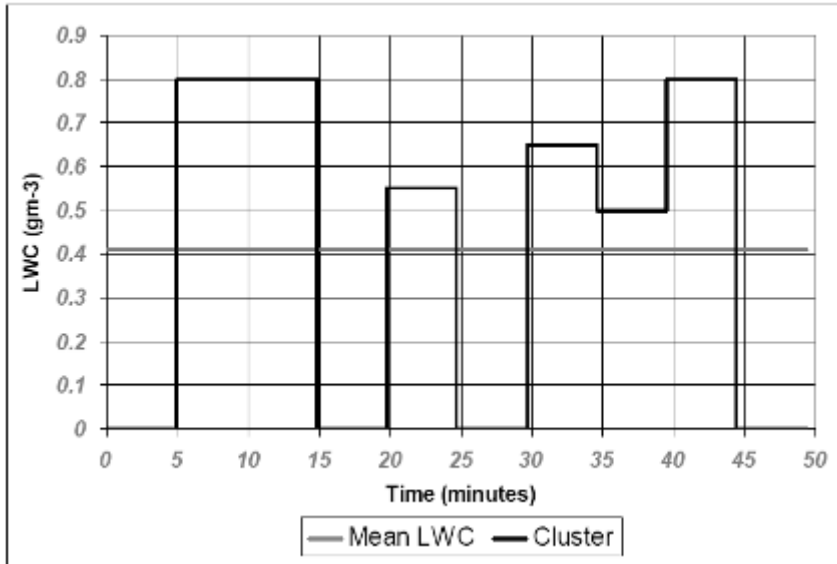
Reference Case:  $LWC = 0.41 \text{ gm}^{-1}$ ,

$T = -2.0^\circ\text{C}$ ,  $MVD = 17 \text{ mm}$

# Selected results – LWC Variation



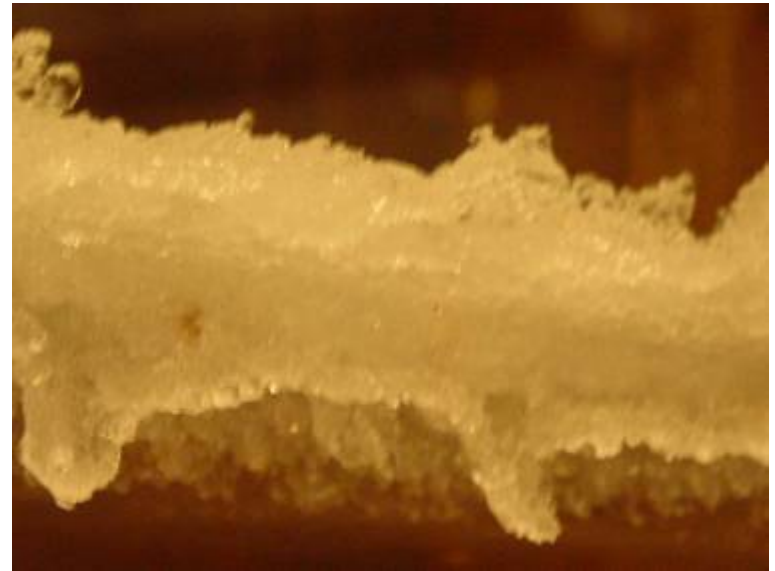
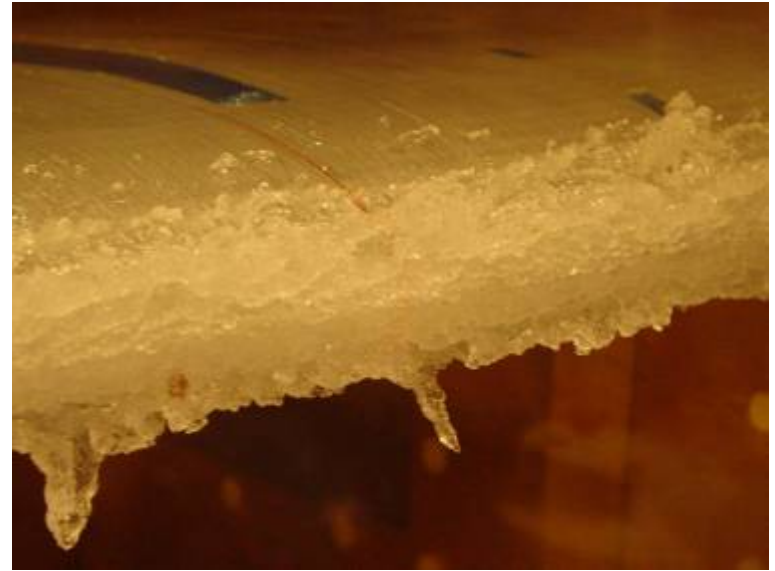
# Selected results – LWC Variation



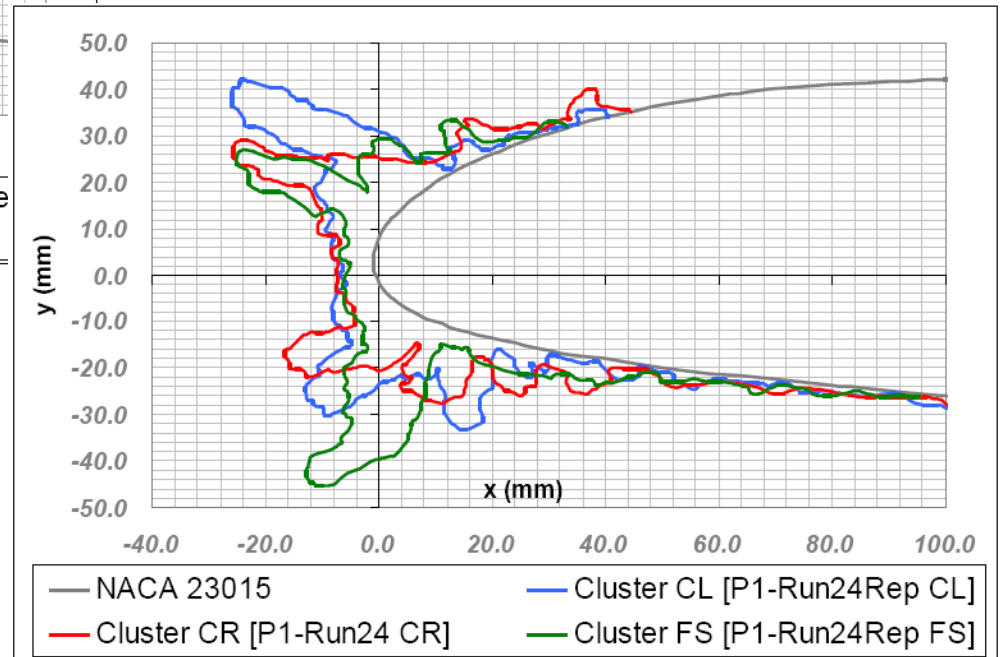
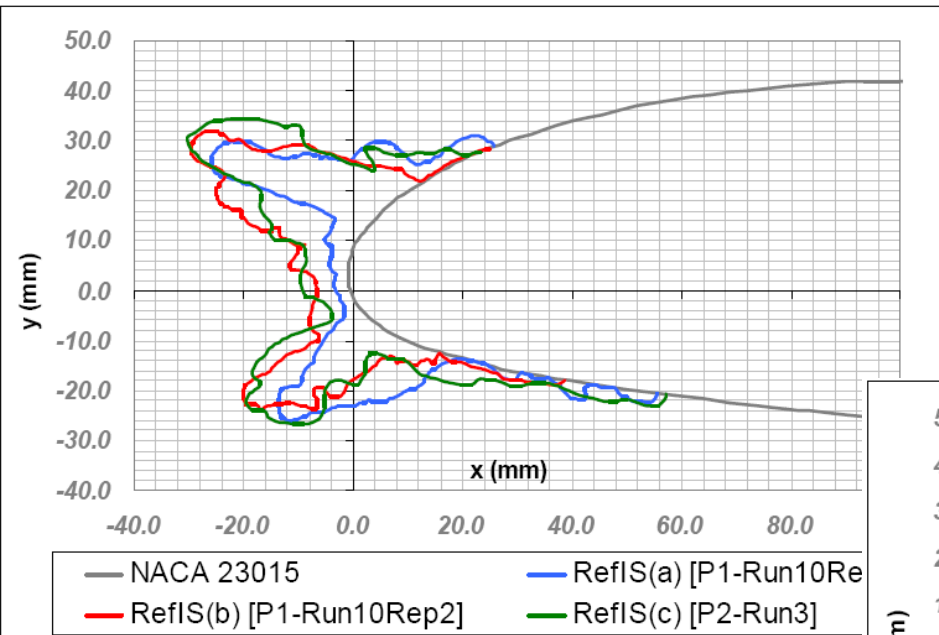
LWC Variation About Mean Value [Equivalent Average LWC]

Reference Case: LWC = 0.41gm<sup>-1</sup>,

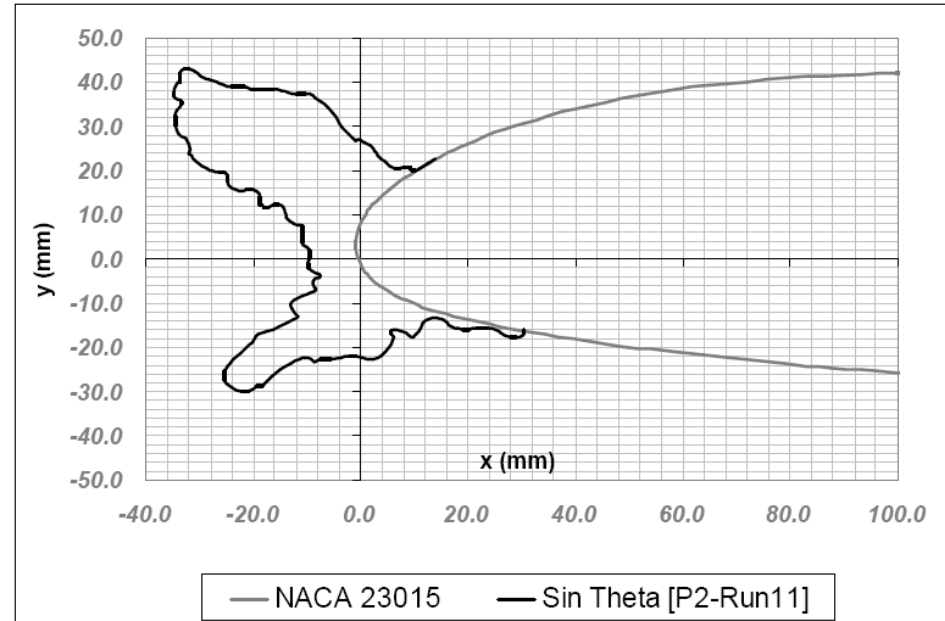
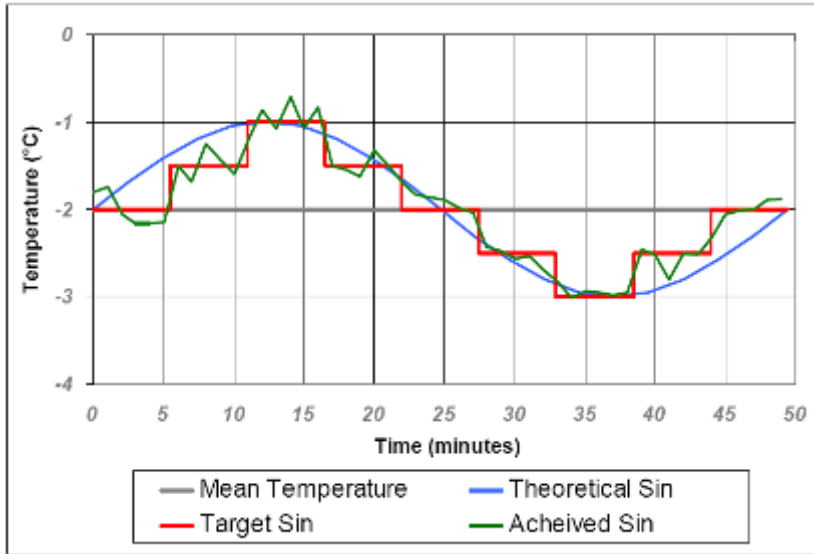
T = -2.0°C, MVD = 17mm



# Selected results – LWC Variation

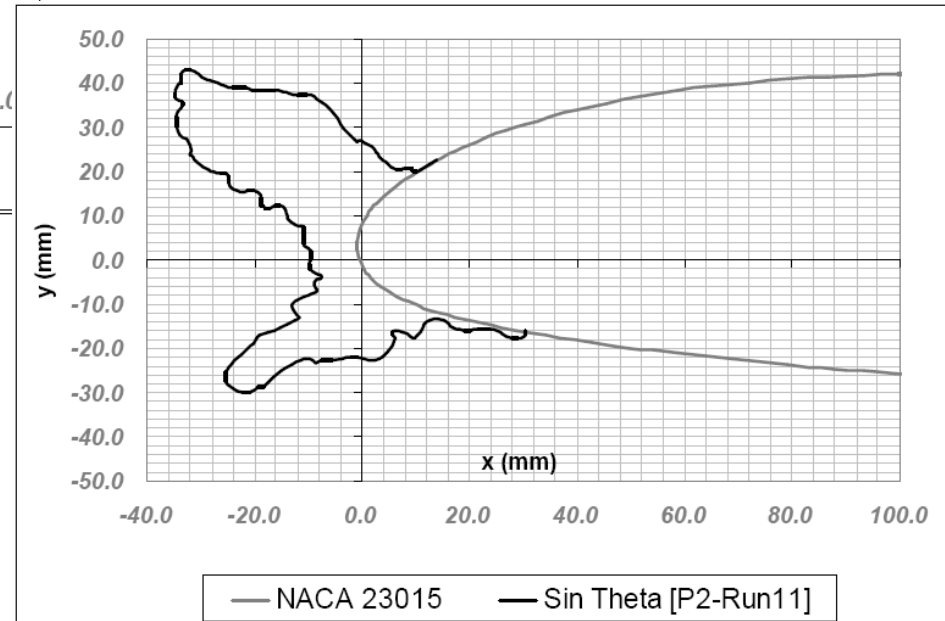
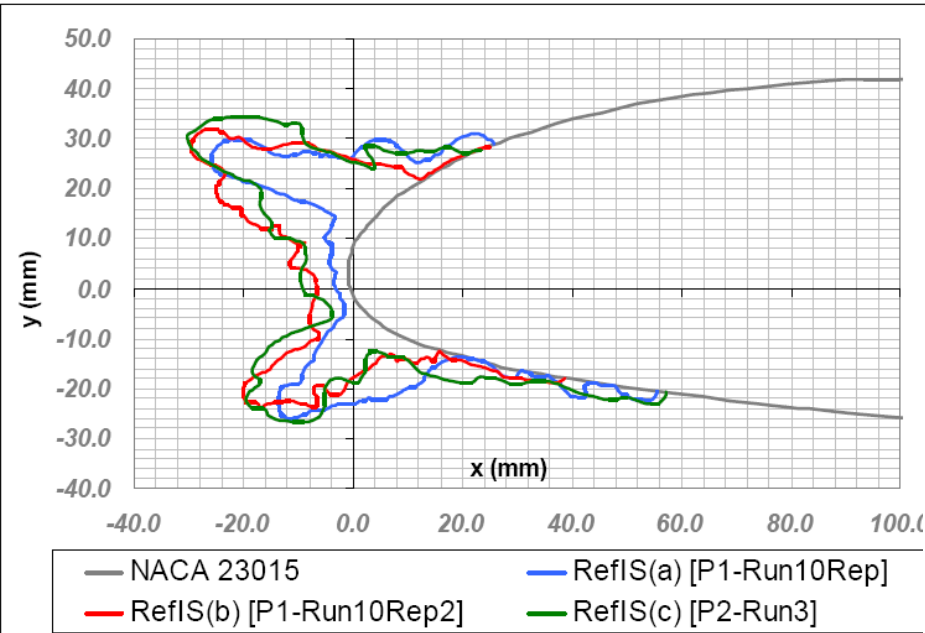


# Selected results – Temp Variation

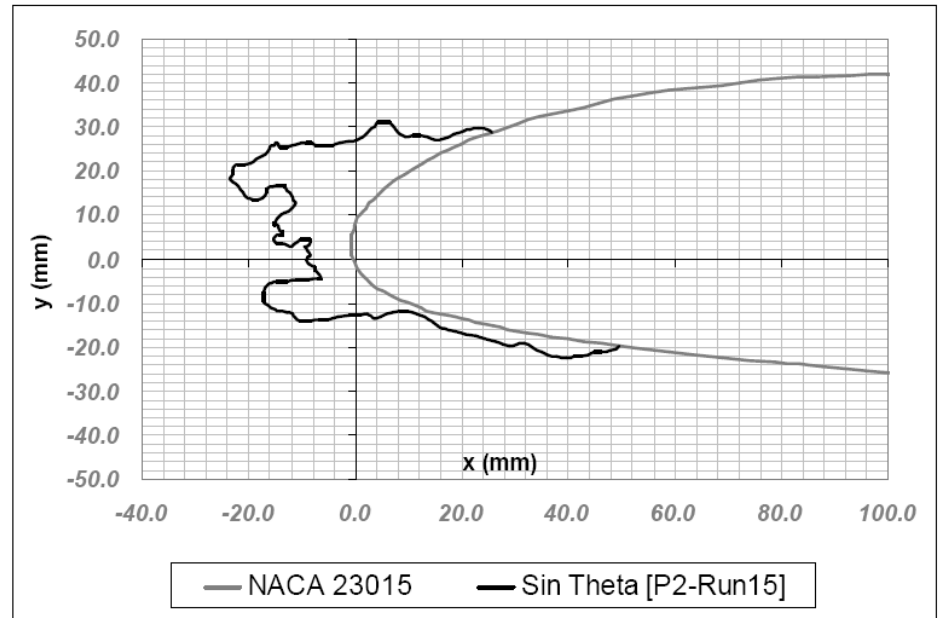
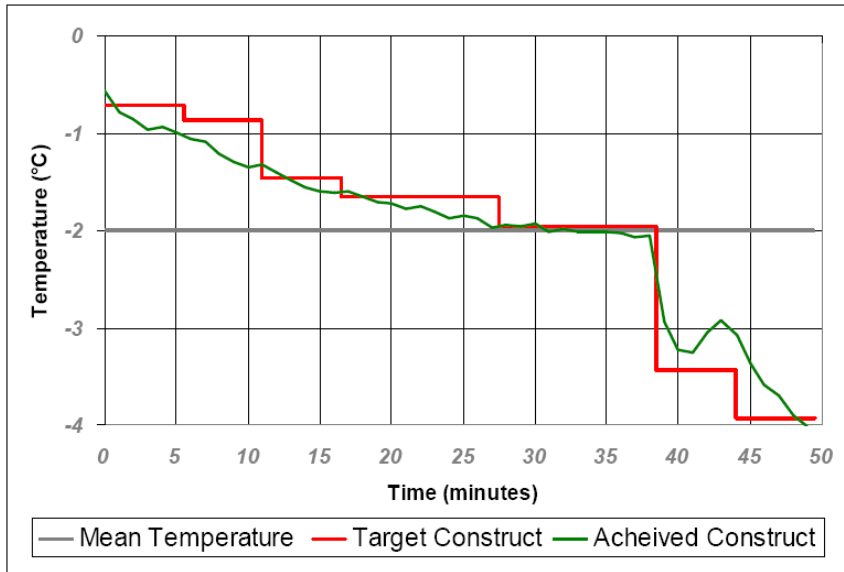


Temp Variation About Mean Value [Equivalent Average T]  
Reference Case:  $LWC = 0.41\text{gm}^{-1}$ ,  
 $T = -2.0^\circ\text{C}$ ,  $MVD = 17\text{mm}$

# Selected results – Temp Variation

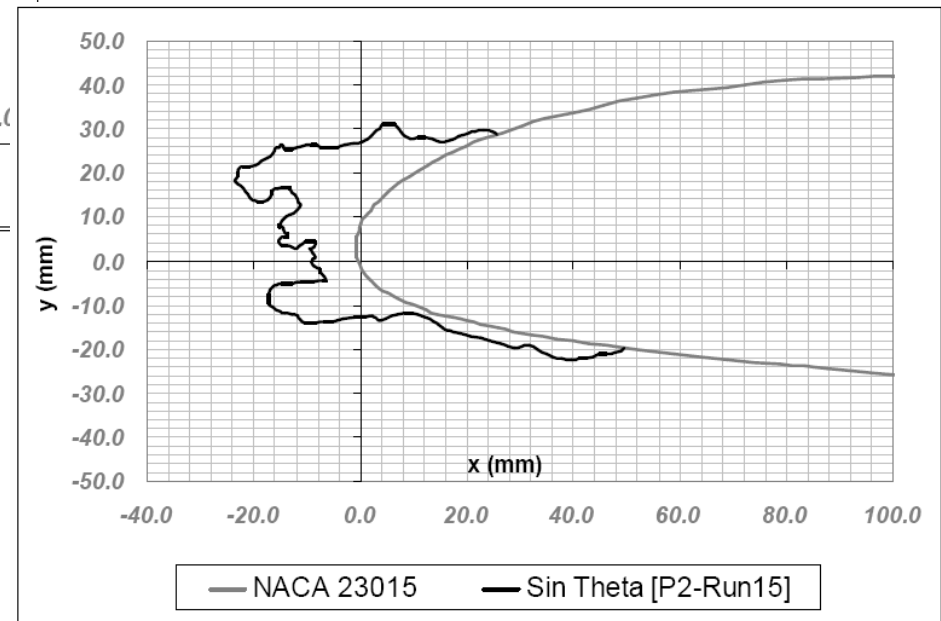
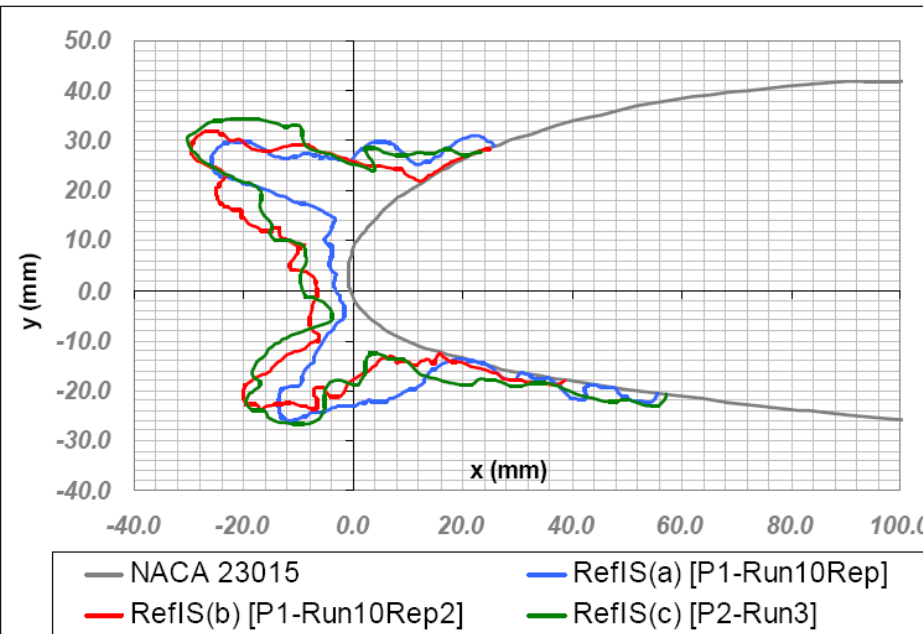


# Selected results – Temp Variation



Temp Variation About Mean Value [Equivalent Average T]  
Reference Case:  $LWC = 0.41\text{gm}^{-1}$ ,  
 $T = -2.0^\circ\text{C}$ ,  $MVD = 17\text{mm}$

# Selected results – Temp Variation



# Summary

- We know that variability exists
- We have modelled variability:
  - (a) with basic resemblance to reality
  - (b) simply so that it can be implemented
  - (c) within certain limitations
- Results indicate variability can make a difference
- Results promote thoughts on runback/runoff, roughness/ridge development, overall thermal environment and collection efficiency development.

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