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2nd AIAA Ice Prediction Workshop

Results post-processing for code-to-code comparison
Final Condensed Version

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June 22, 2023

Participant Identification

Participant	ID
Politecnico Di Milano	02
Seoul National University	03
JAXA	04
Gulfstream	05
ANSYS Canada	06
NTNU	08
Kingston University London	09
Polytechnique Montréal	10

Participant (cont'd)	ID
CIRA	11
Universität Braunschweig	12
ONERA	13
Bombardier	14
Boeing	15
NRC	16
NASA	17

Participant Information Summary

ID	Participant	Code	Data Info (Case 3)	Data Info (Case 1-2)
02.01	Politecnico Di Milano	PoliMIce		
03.01	Seoul National University	ICEPAC, 2023	$LWC = 0.44g/m^3$	Single MVD
03.02	Seoul National University	ICEPAC, 2023	$LWC = 0.76g/m^3$	Multi MVD
04.01	JAXA	FaSTAR/In-house code		
05.01	Gulfstream	NASA USM3D/LEWICE3D		Sweep based density (SB)
05.02	Gulfstream	NASA USM3D/LEWICE3D		Constant density (CD)
05.03	Gulfstream	NASA USM3D/LEWICE3D		SBD Mod. AoA/Flap an
05.04	Gulfstream	NASA USM3D/LEWICE3D		CD Mod. AoA/Flap angl
06.01	Ansys Canada	FENSAP-ICE v23R2		
08.01	NTNU	FENSAP-ICE v22R2		
09.01	Kingston University London	FENSAP-ICE v22R1		
10.01	Polytechnique Montreal	CHAMPS-ICE		2.5D
10.02	Polytechnique Montreal	CHAMPS-ICE	Non-deterministic	3D
11.01	CIRA	SIMBA	Single-Layer	Single-Layer
11.02	CIRA	SIMBA	Multi-Layer	-
12.01	Universität Braunschweig	DICEPS 2D V3/FLUENT		
13.01	ONERA	IGLOO3D v1.3.0.0		Var. Density
13.02	ONERA	IGLOO3D v1.3.0.0	-	Const. Density
14.01	Bombardier	Dragon Ice Suite Version 1.2		
15.01	Boeing	CFD++ Version 17.1/LEWICE3D	Endplates	AoA ↑ 1-2 deg
16.01	NRC	Fluent 2021R2 w/ NRC morphogenetic model		
17.01	NASA	GlennICE v3.1.0		

Participant Codes Information (*Lag=Lagrangian, Eul=Eulerian)

ID	Flow model	Turbulence	Droplet*	Thermodynamic	Surface Deformation*
02.01	RANS	SA	Lag.	Modified Myers?	Level-Set
03.01	RANS	SA, $\gamma-Re_{\theta t}$	Eul.	SWIM	La
03.02	RANS	SA, $\gamma-Re_{\theta t}$	Eul.	SWIM	Lag.
04.01	RANS	SA	Eul.	SWIM	Lag.
05.01	RANS	?	?	?	?
05.02	RANS	?	?	?	?
05.03	RANS	?	?	?	?
05.04	RANS	?	?	?	?
06.01	RANS	SA	Eul.	Messenger	Lag. (+wrapping)
08.01	RANS	SST	Eul.	Modified Messenger	Lag.
09.01	RANS	SA	Eul.	Messenger	Lag.
10.XX	RANS	SA	Eul.	Iterative Messenger	Lag./RBF
11.01	IB	k- ω TNT, LES	Eul.	Iterative Messenger	Lag.
11.02	IB	k- ω TNT, LES	Eul.	Iterative Messenger	Lag.
12.01	RANS	SST- γ	Eul.	?	Lag.
13.01	RANS	SST	Eul.	Extended Messenger	Lag.
13.02	RANS	SST	Eul.	Extended Messenger	Lag.
14.01	RANS	k- ω (1998)	Eul.	Iterative Messenger	Lag./Hyperbolic
15.01	RANS	SARC	Lag.	Modified Messenger	Lag.?
16.01	RANS	SST, SA	Lag.	Messenger	?
17.01	RANS	SA-neg	Lag.	Messenger	Face Offset Method

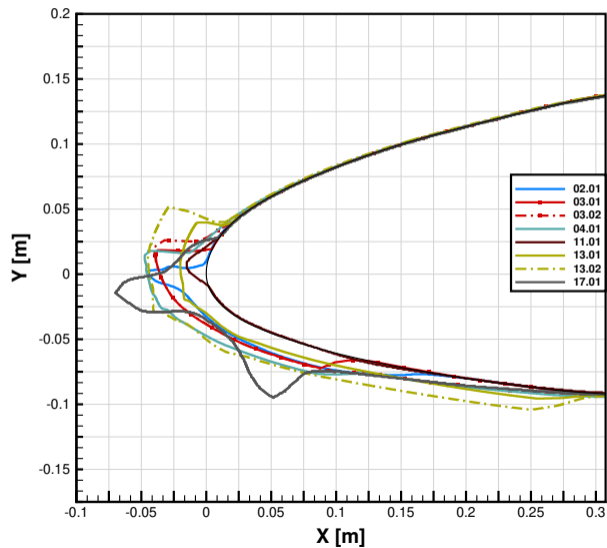
Multi-Step Information

ID	Mid-span			Cases Inboard			RG-15		
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
02.01	5	10	5	1	1	1	60	60	60
03.01	1	1	1	1	1	1	ms	ms	ms
03.02	1	1	1	1	1	1	ms	ms	ms
04.01	1	1	1	1	1	1	1	1	1
05.01	?	?	?	?	?	?	—	—	—
05.02	?	?	?	?	?	?	—	—	—
05.03	?	?	?	?	?	?	—	—	—
05.04	?	?	?	?	?	?	—	—	—
06.01	15	15	15	15	15	15	—	—	—
08.01	—	—	—	—	—	—	7	7	7
09.01	?	?	?	?	?	?	?	?	?
10.01	5	5	5	5	5	5	10	10	10
10.02	—	1	—	1	1	1	s	s	s
11.01	1	—	1	1	—	1	1	1	1
11.02	ms	—	ms	ms	—	ms	ms	ms	ms
12.01	—	—	—	—	—	—	ms	ms	ms
13.01	1?	1?	1?	1?	1?	1?	1?	1?	1?
13.02	1?	1?	1?	1?	1?	1?	1?	1?	1?
14.01	1	1	1	1	1	1	?	?	?
15.01	1	1	1	1	1	1	1	1	1
16.01	s	s	s	s	s	s	s	s	s
17.01	1	1	1	—	—	—	—	—	—

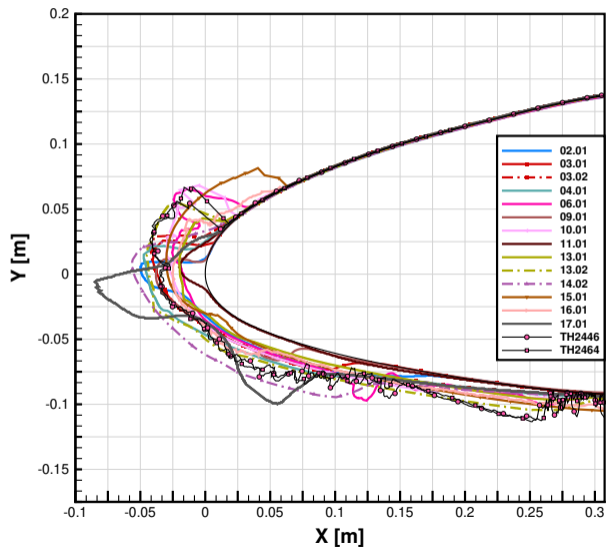
Submitted Data Summary

ID	Mid-span			Cases Inboard			RG-15		
	1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3
01									
02	1	1	1	1	1	1	1	1	1
03	2	2	2	2	2	2	2	2	2
04	1	1	1	1	1	1	1	1	1
05	4	4	4	4	4	4			
06	1	1	1	1	1	1			
07									
08							1	1	1
09	1	1	1	1	1	1	1	1	1
10	1	2	1	2	2	2	2	2	2
11	1		1	1		1	2	1	2
12							1	1	1
13	2	2	2	2	2	2	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	1	1	1						
Total	18	18	18	18	17	18	15	14	15

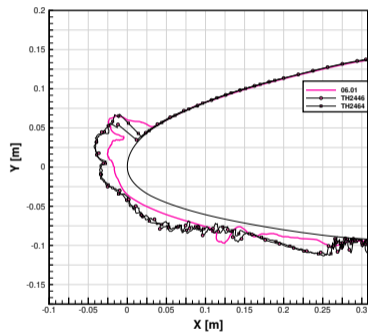
Case 1.1 – Ice Shape – Minimum CCS



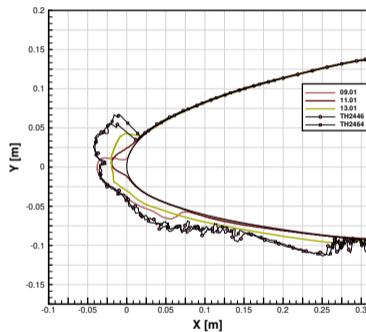
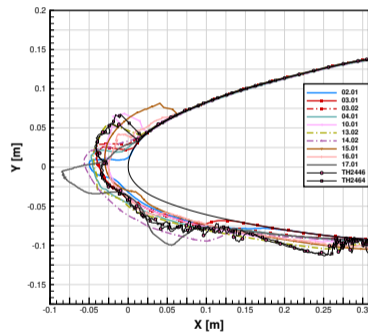
Case 1.1 – Ice Shape vs Experiment – Maximum CCS

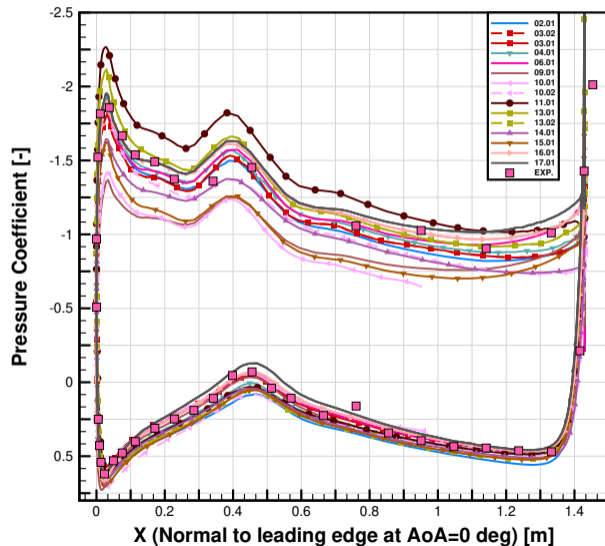


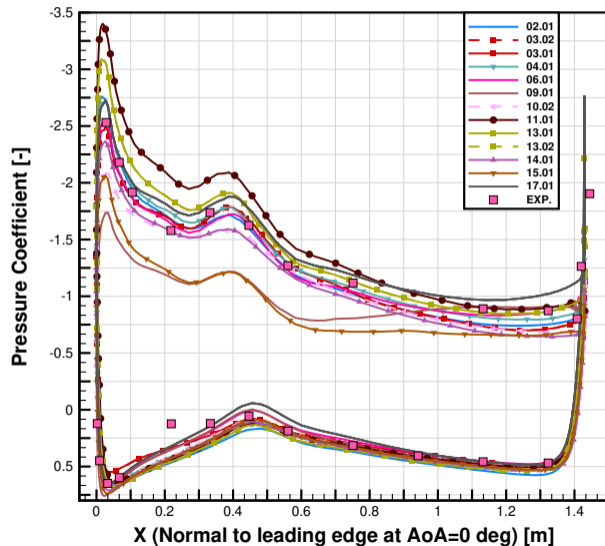
Case 1.1 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison

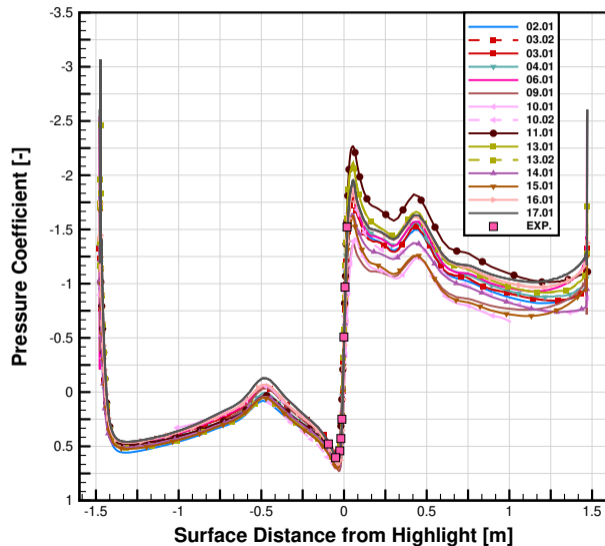


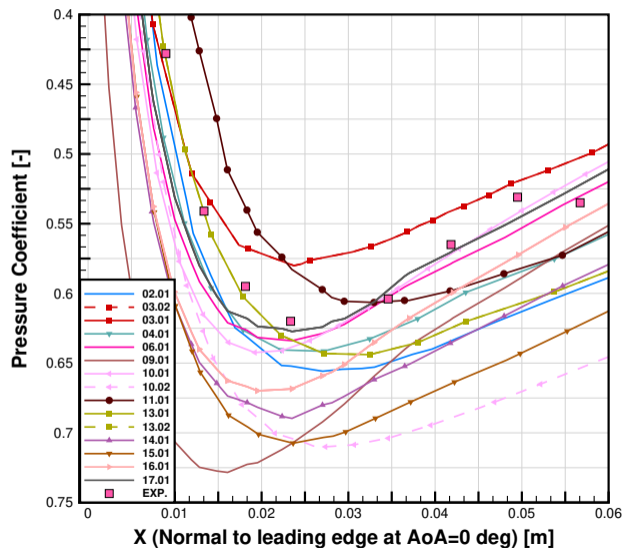
Variable Density

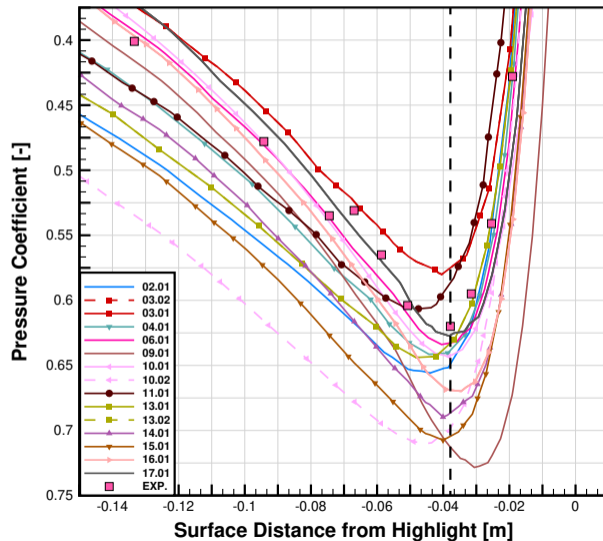
Ice Density = $917 \text{ kg} \cdot \text{m}^{-3}$ Ice Density Range $[300,600] \text{ kg} \cdot \text{m}^{-3}$
(and unknown)

Case 1 – C_p vs X – 50 percent span

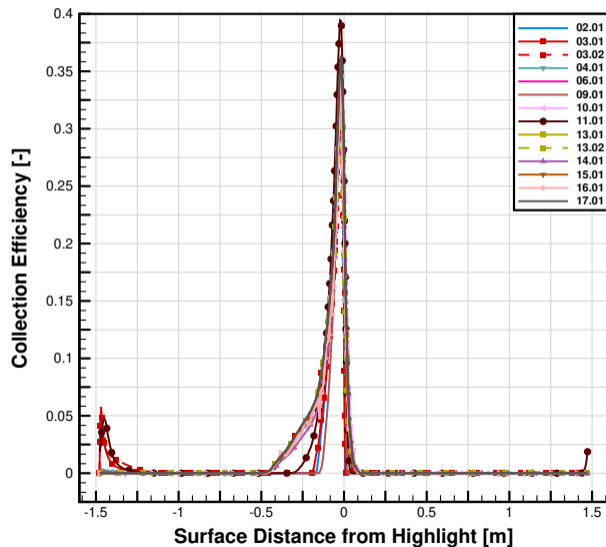
Case 1 – C_p vs X – 75 percent span

Case 1 – C_p vs S – 50 percent span

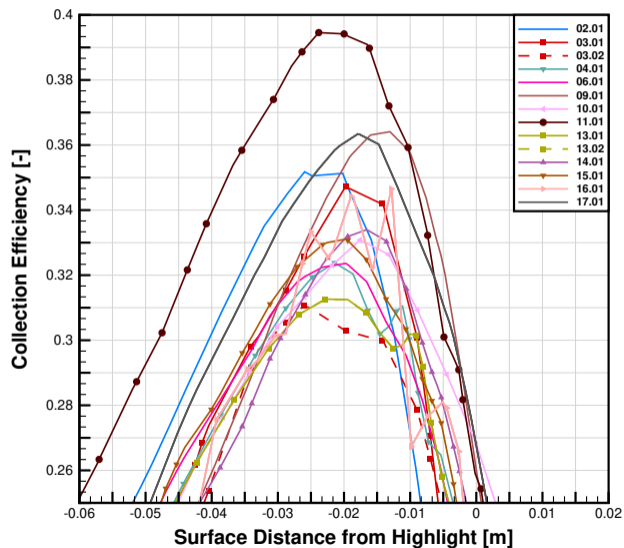
Case 1 – C_p vs X – Close to SP – 50 percent span

Case 1.3 – C_p vs S – Close to SP – 50 percent span

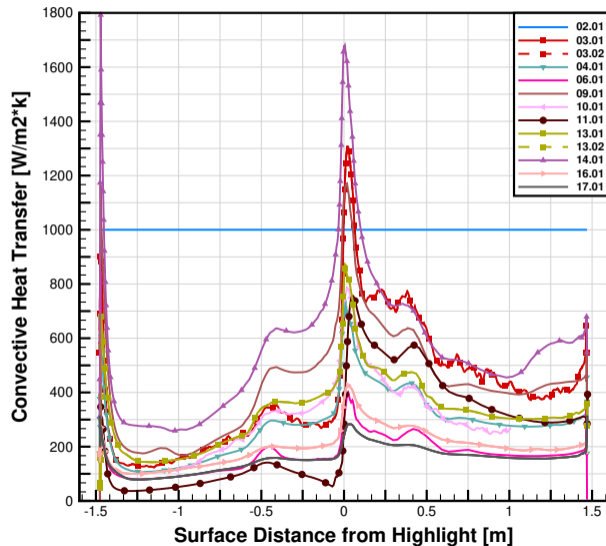
Case 1.1 – Collection Efficiency vs S – 50 percent span



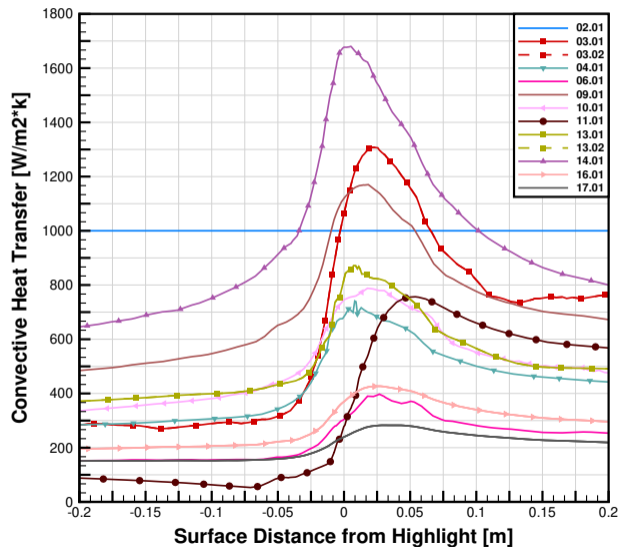
Case 1.1 – Collection Efficiency vs S – Close to SP – 50 percent span



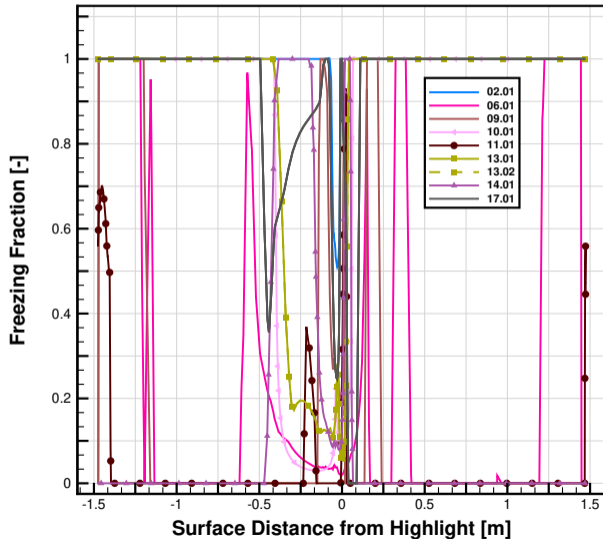
Case 1.1 – HTC vs S – 50 percent span

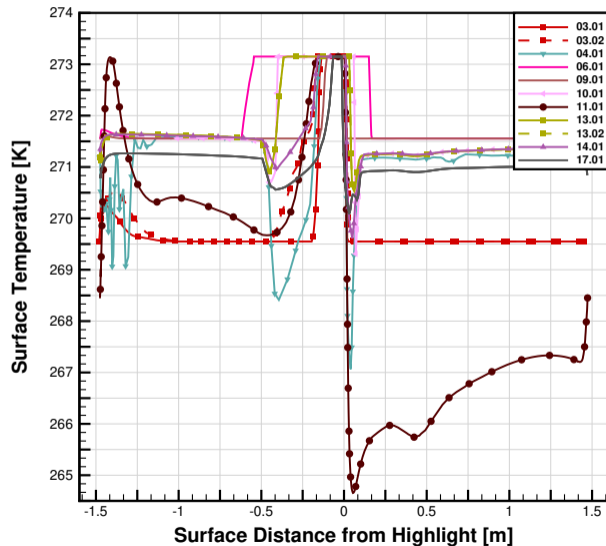


Case 1.1 – HTC vs S – Close to SP – 50 percent span

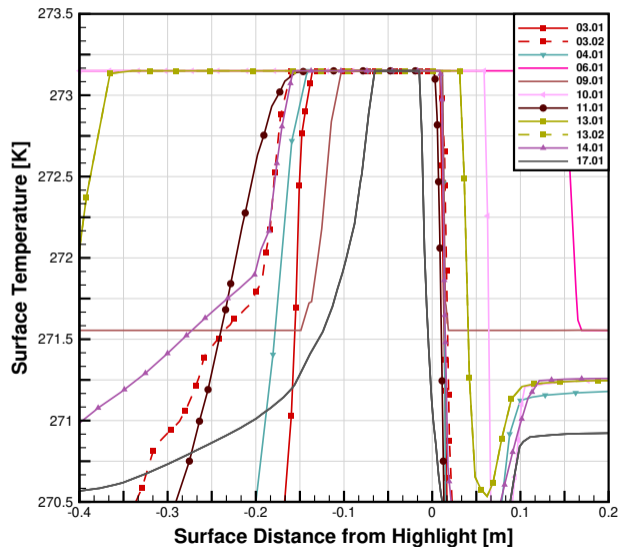


Case 1.1 – Freezing Fraction vs S – 50 percent span

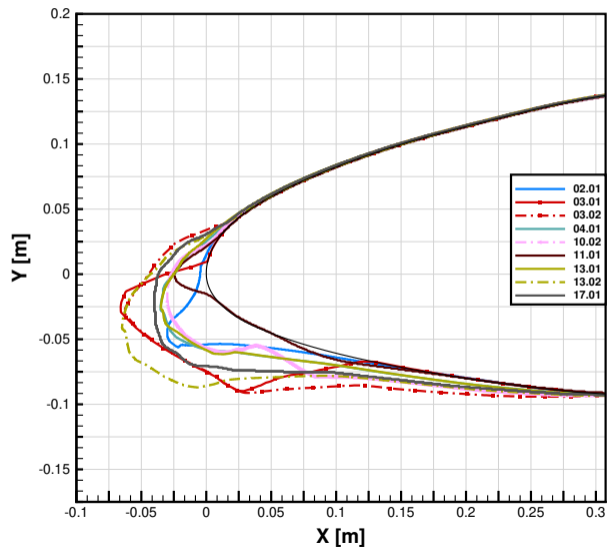


Case 1.1 – T_s vs S – 50 percent span

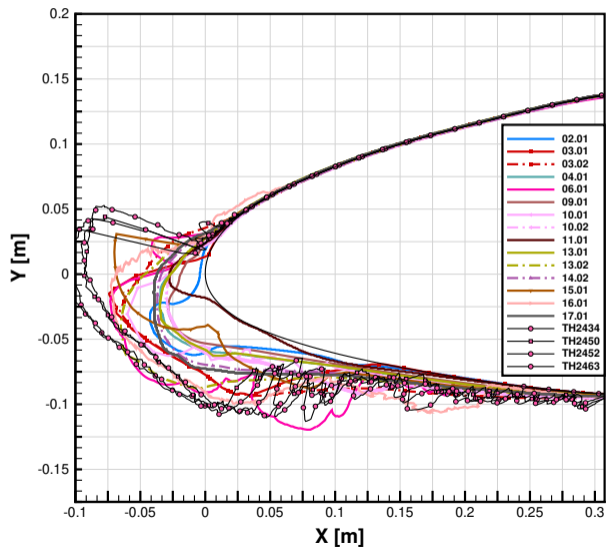
Case 1.1 – Ts vs S – Close to SP – 50 percent span



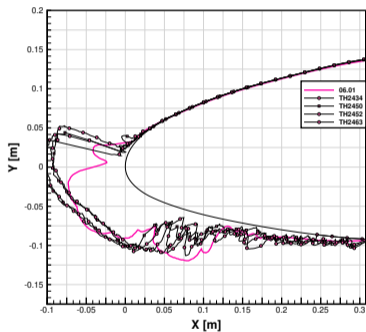
Case 1.2 – Ice Shape – Minimum CCS



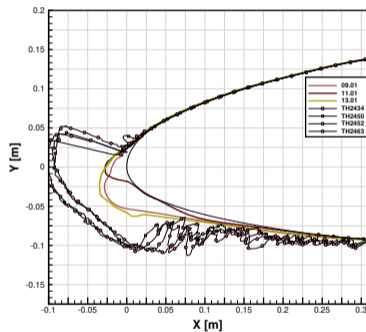
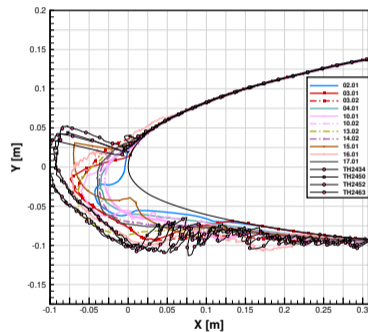
Case 1.2 – Ice Shape vs Experiment – Maximum CCS



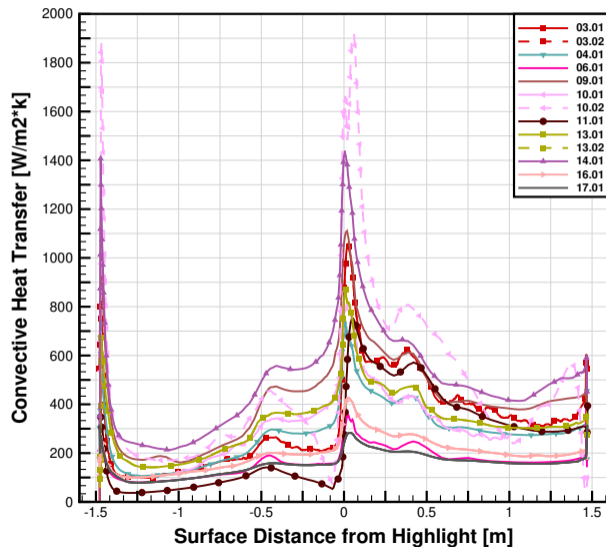
Case 1.2 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison



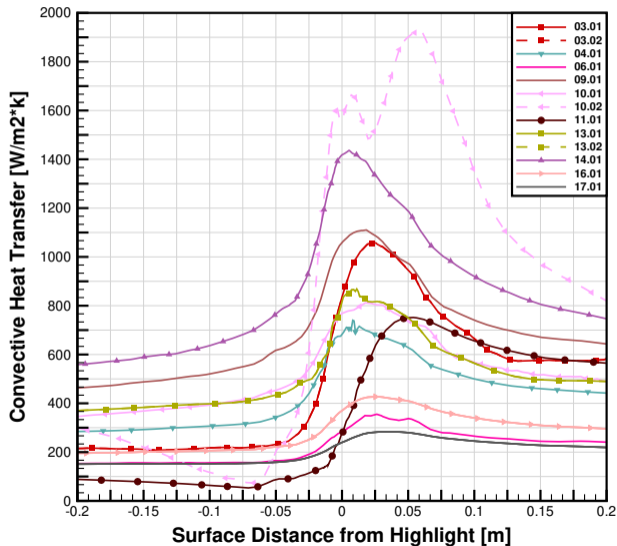
Variable Density

Ice Density = $917 \text{ kg} \cdot \text{m}^{-3}$ Ice Density Range $[300,600] \text{ kg} \cdot \text{m}^{-3}$
(and unknown)

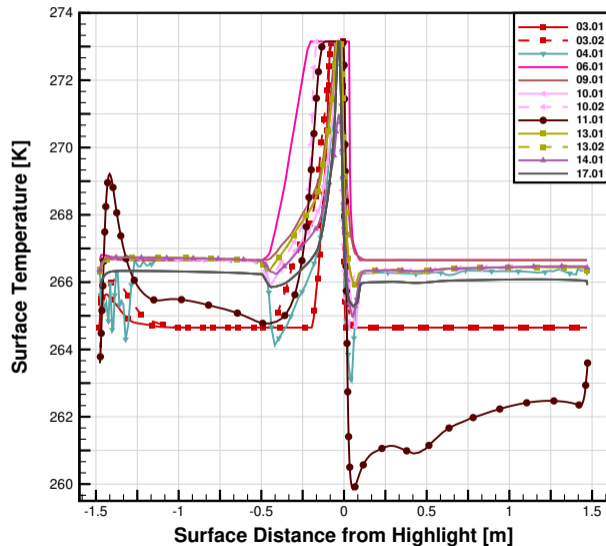
Case 1.2 – HTC vs S – 50 percent span

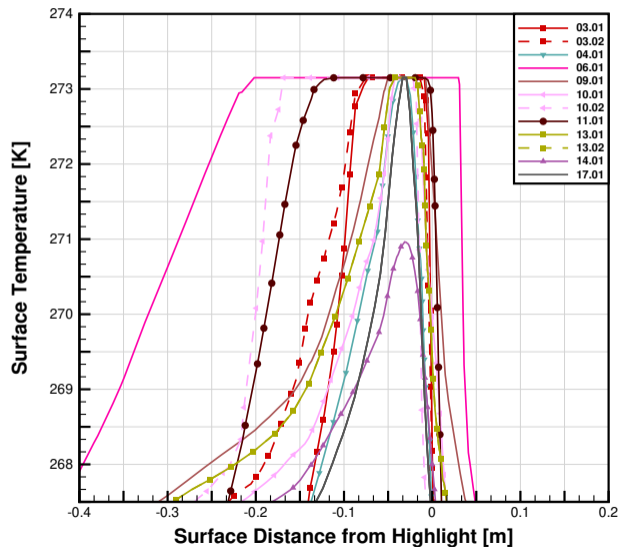


Case 1.2 – HTC vs S – Close to SP – 50 percent span

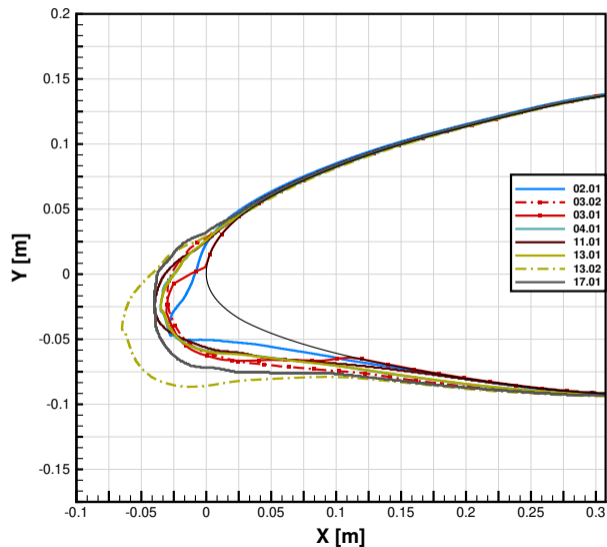


Case 1.2 – Ts vs S – 50 percent span

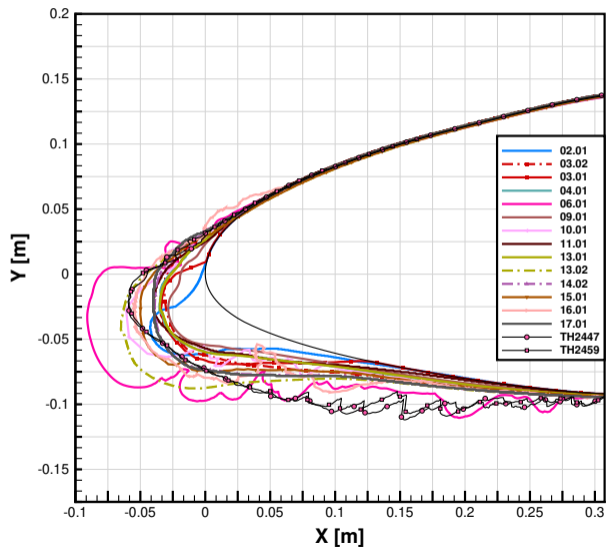


Case 1.2 – T_s vs S – Close to SP – 50 percent span

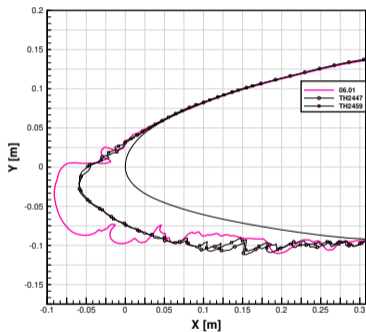
Case 1.3 – Ice Shape – Minimum CCS



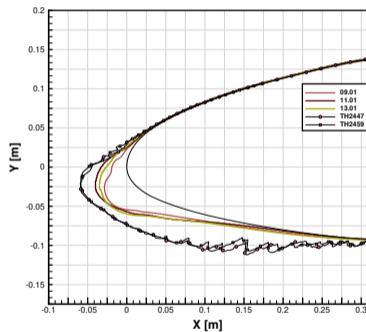
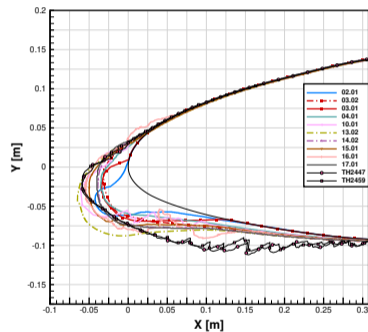
Case 1.3 – Ice Shape vs Experiment – Maximum CCS



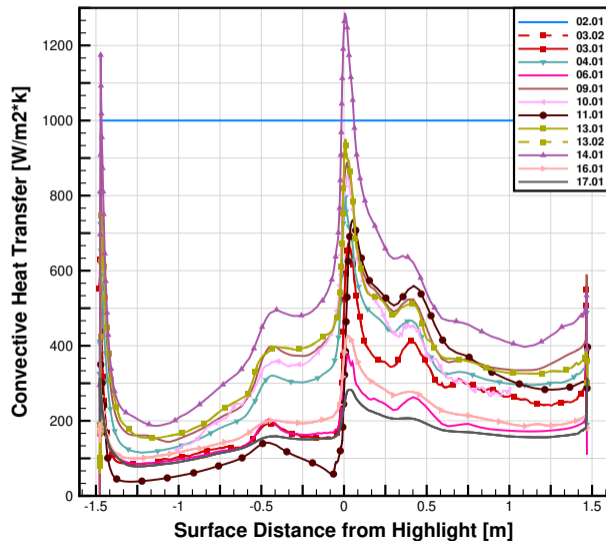
Case 1.3 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison



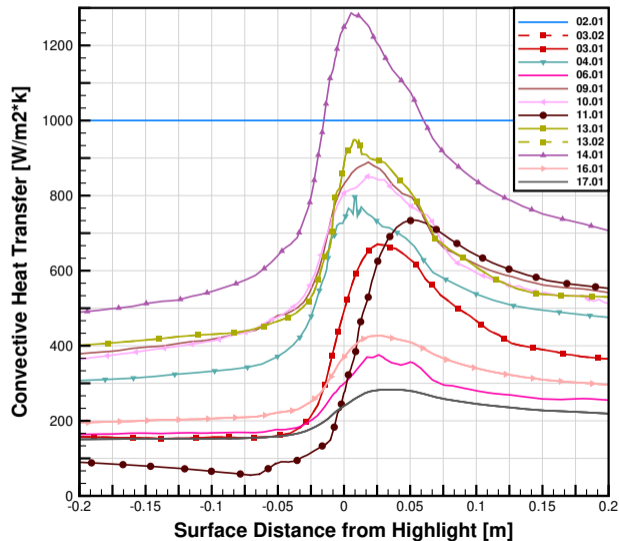
Variable Density

Ice Density = 917 kg.m^{-3} Ice Density Range $[300,600] \text{ kg.m}^{-3}$
(and unknown)

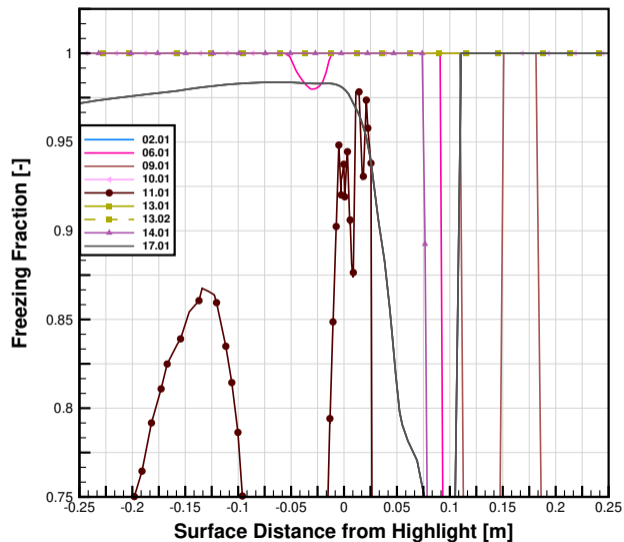
Case 1.3 – HTC vs S – 50 percent span



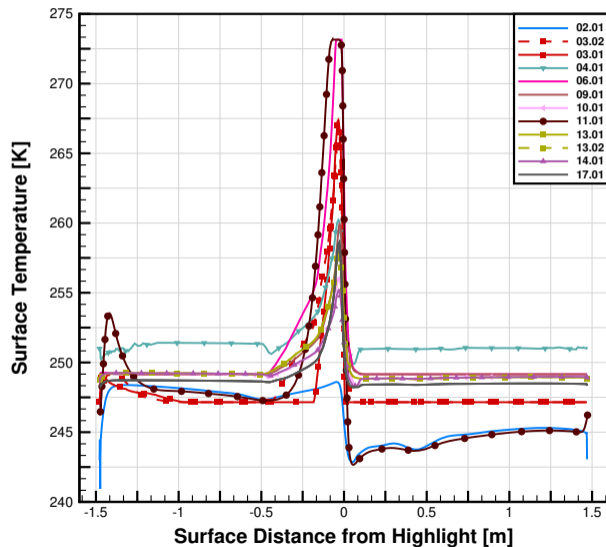
Case 1.3 – HTC vs S – Close to SP – 50 percent span



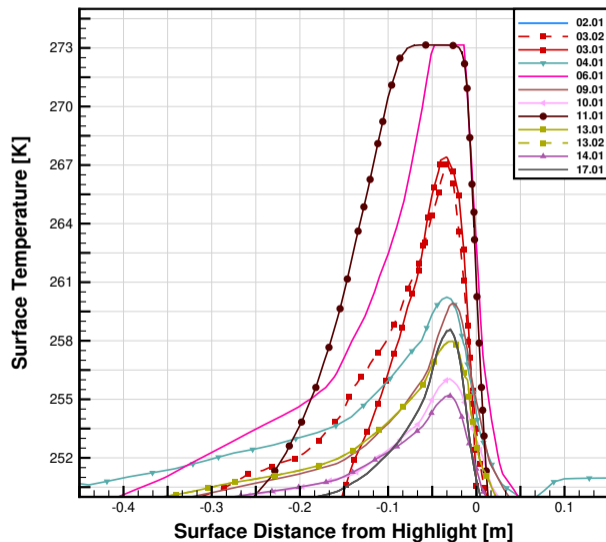
Case 1.3 – Freezing Fraction vs S – Close to SP – 50 percent span



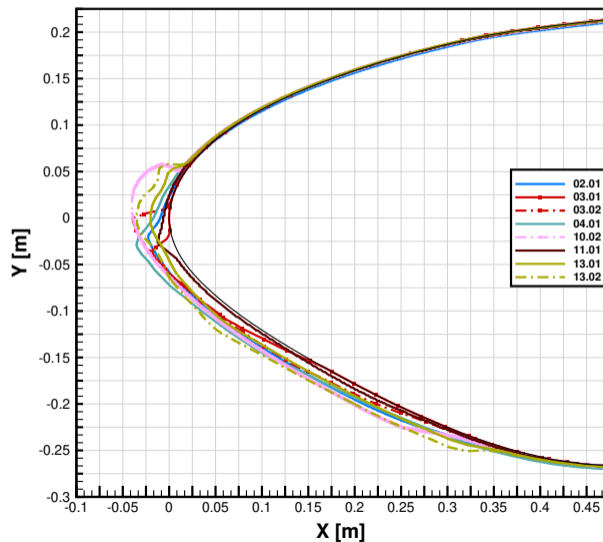
Case 1.3 – Ts vs S – 50 percent span



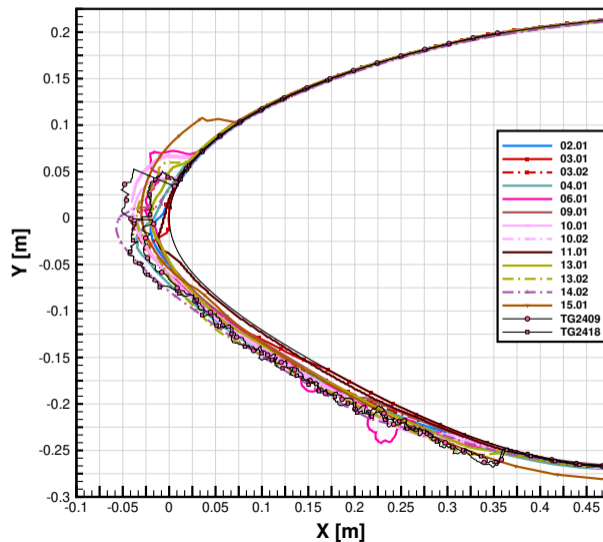
Case 1.3 – Ts vs S – Close to SP – 50 percent span



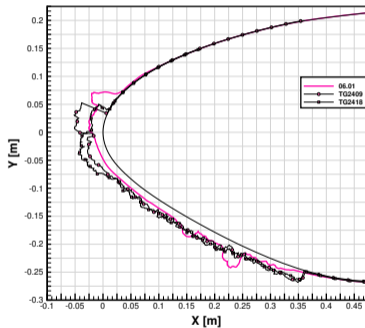
Case 2.1 – Ice Shape – Minimum CCS



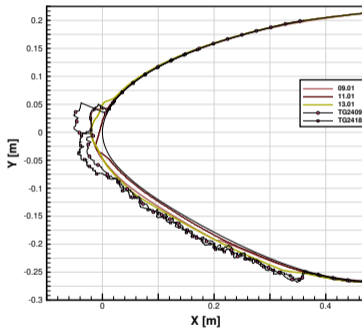
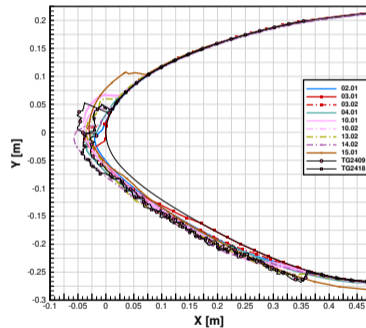
Case 2.1 – Ice Shape vs Experiment – Maximum CCS

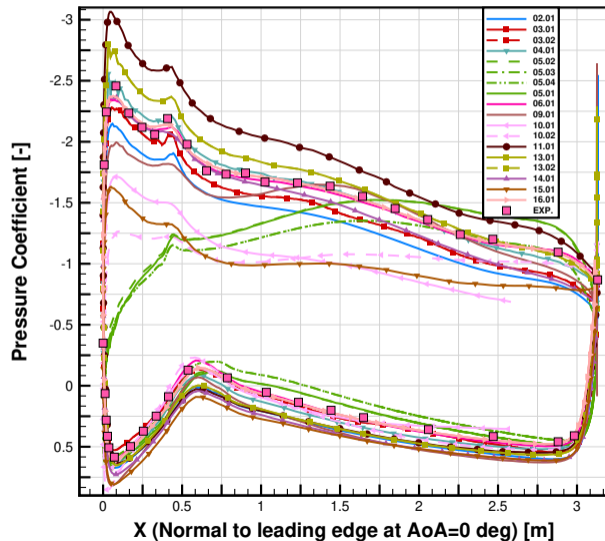


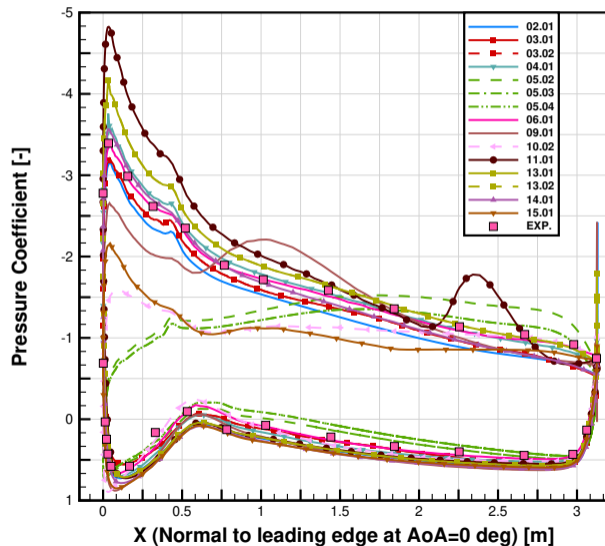
Case 2.1 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison

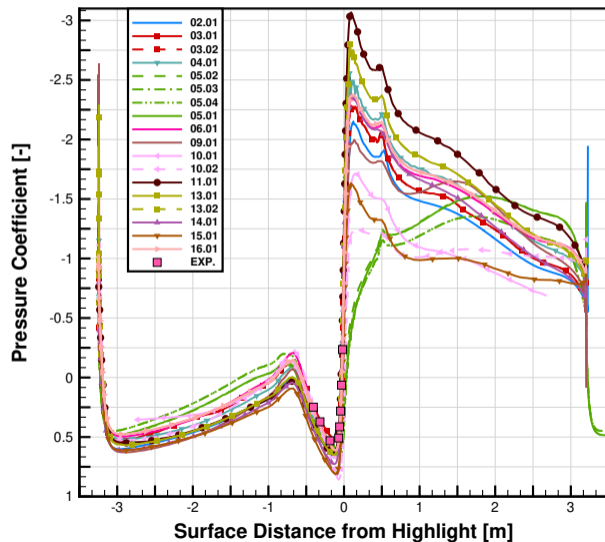


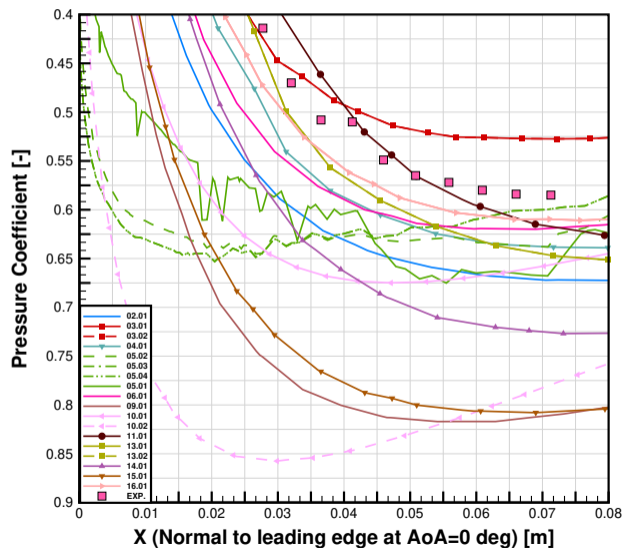
Variable Density

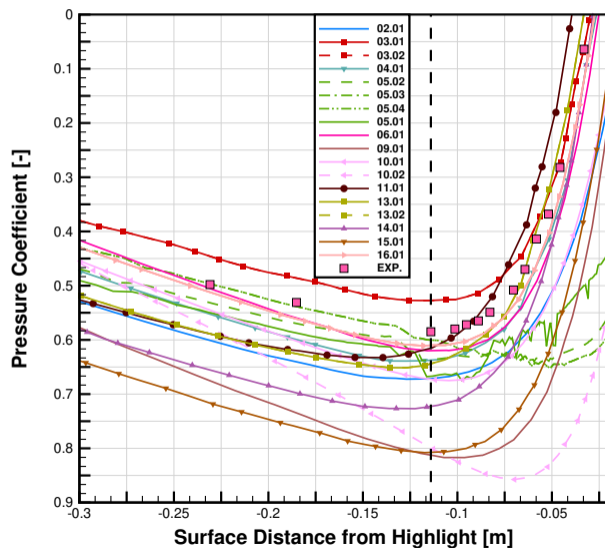
Ice Density = $917 \text{ kg} \cdot \text{m}^{-3}$ Ice Density Range $[300,600] \text{ kg} \cdot \text{m}^{-3}$
(and unknown)

Case 2 – C_p vs X – 50 percent span

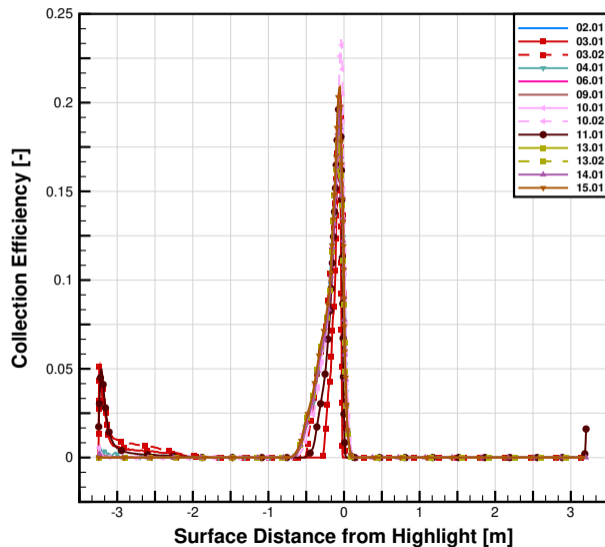
Case 2 – C_p vs X – 75 percent span

Case 2 – C_p vs S – 50 percent span

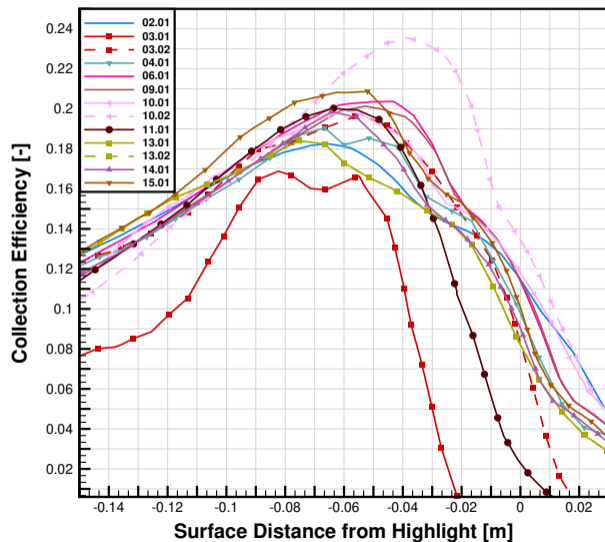
Case 2 – C_p vs X – Close to SP – 50 percent span

Case 2 – C_p vs S – Close to SP – 50 percent span

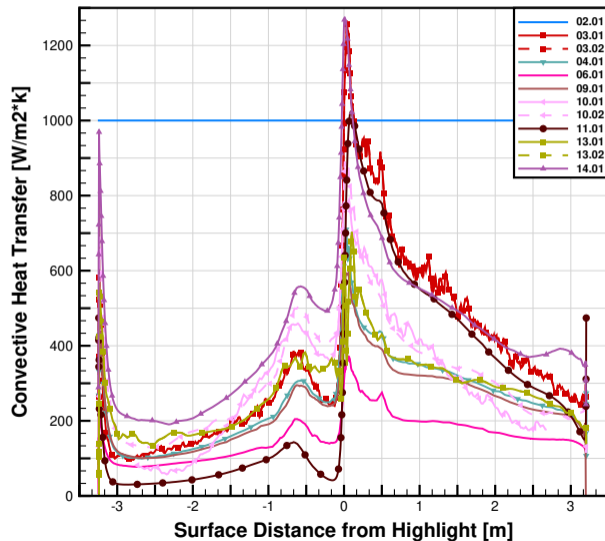
Case 2.1 – Collection Efficiency vs S – 50 percent span



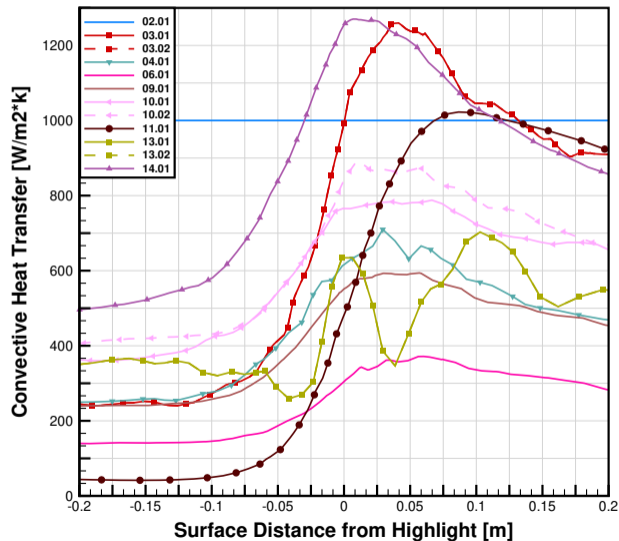
Case 2.1 – Collection Efficiency vs S – Close to SP – 50 percent span



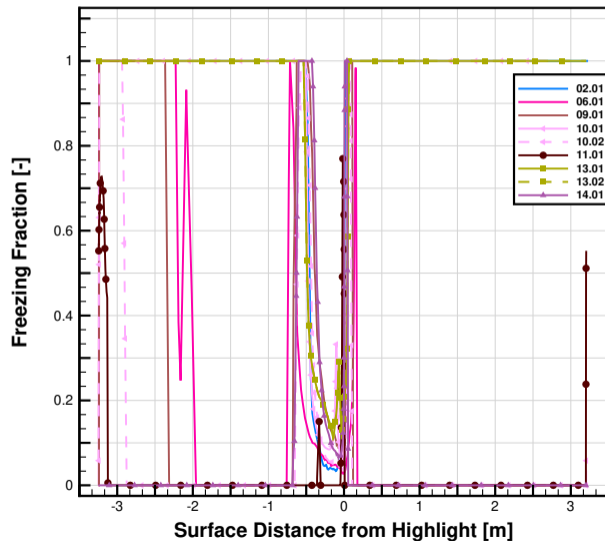
Case 2.1 – HTC vs S – 50 percent span



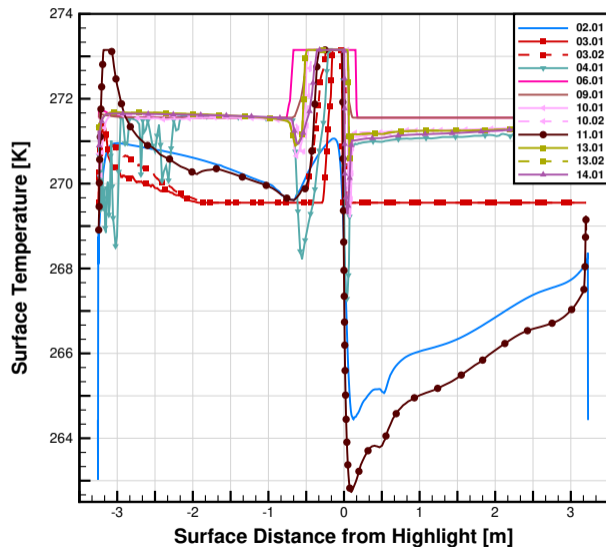
Case 2.1 – HTC vs S – Close to SP – 50 percent span



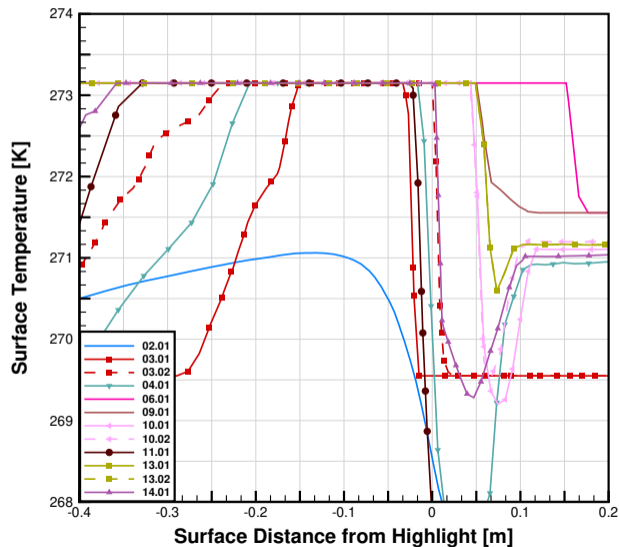
Case 2.1 – Freezing Fraction vs S – 50 percent span



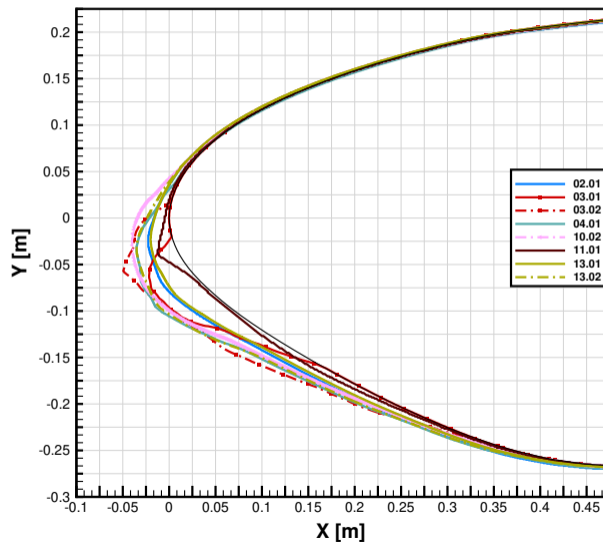
Case 2.1 – Ts vs S – 50 percent span



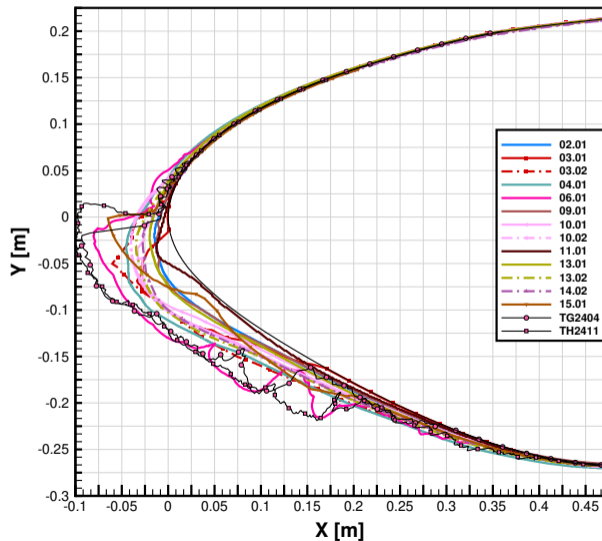
Case 2.1 – Ts vs S – Close to SP – 50 percent span



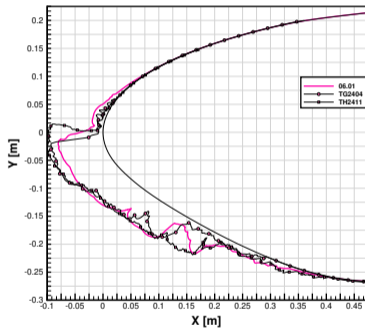
Case 2.2 – Ice Shape – Minimum CCS



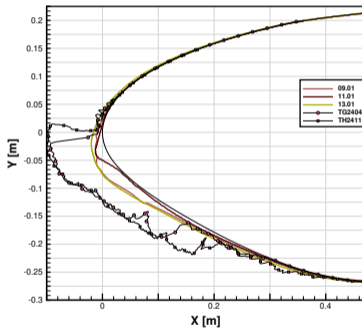
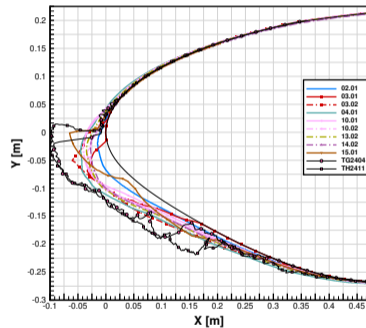
Case 2.2 – Ice Shape vs Experiment – Maximum CCS



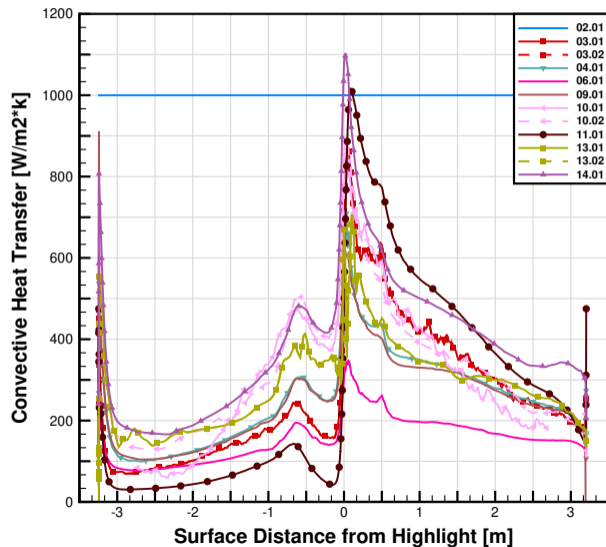
Case 2.2 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison



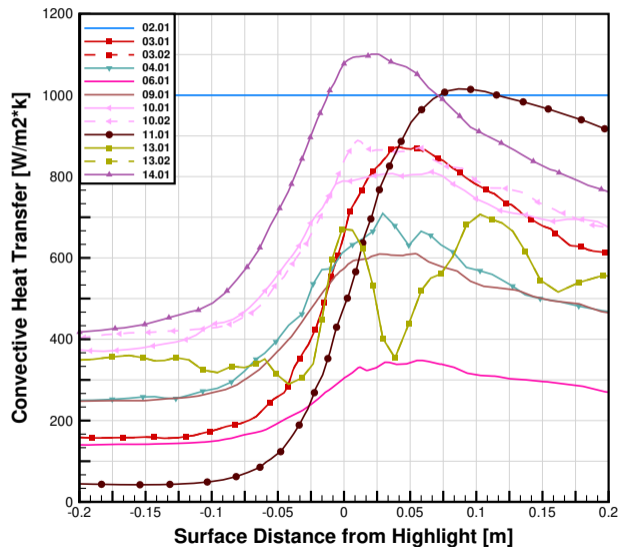
Variable Density

Ice Density = 917 kg.m^{-3} Ice Density Range $[300,600] \text{ kg.m}^{-3}$
(and unknown)

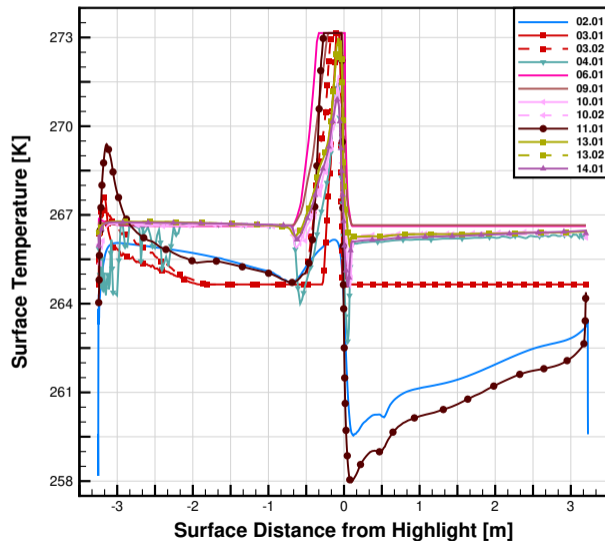
Case 2.2 – HTC vs S – 50 percent span



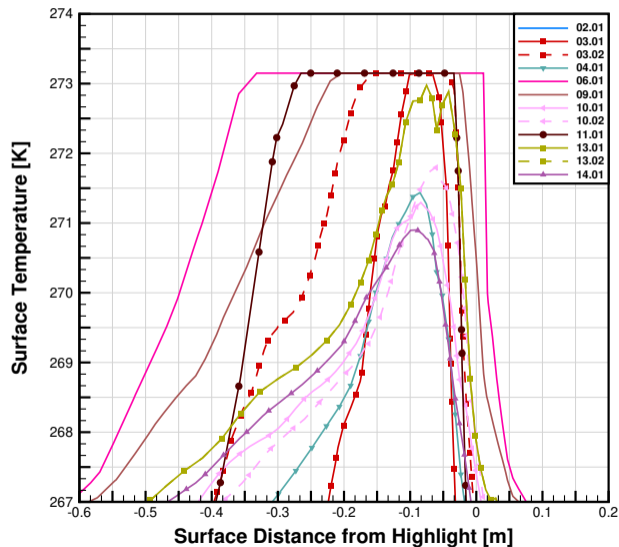
Case 2.2 – HTC vs S – Close to SP – 50 percent span



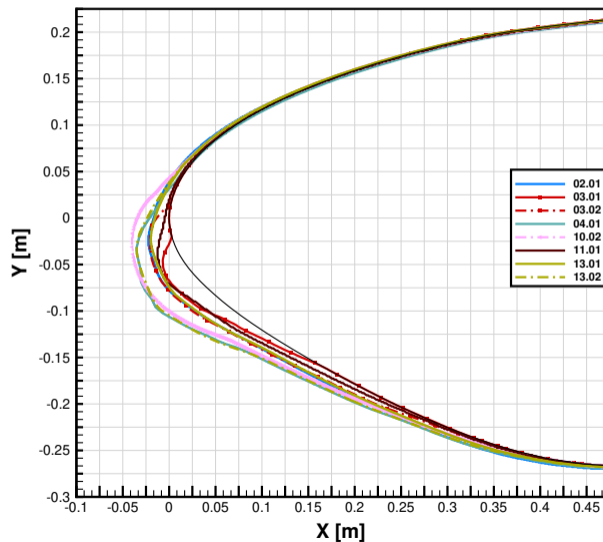
Case 2.2 – Ts vs S – 50 percent span



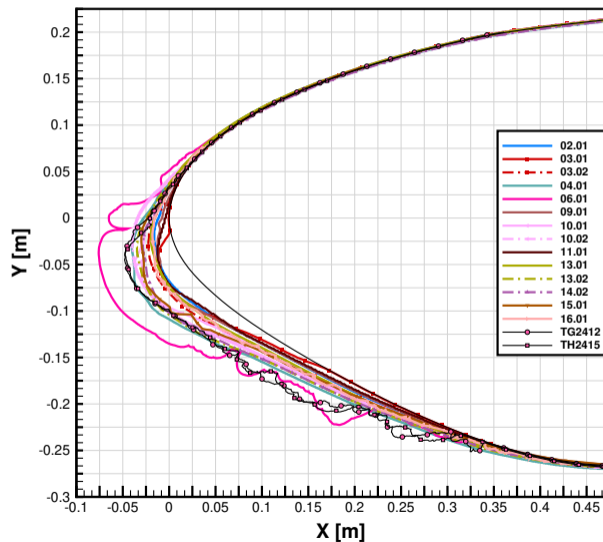
Case 2.2 – Ts vs S – Close to SP – 50 percent span



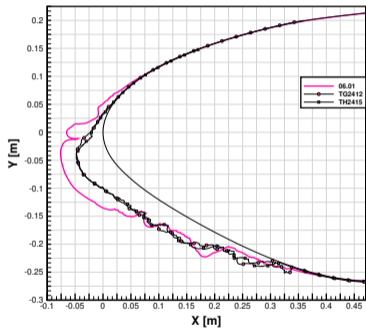
Case 2.3 – Ice Shape – Minimum CCS



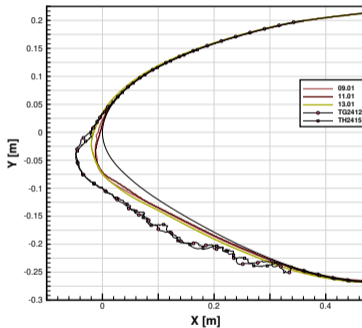
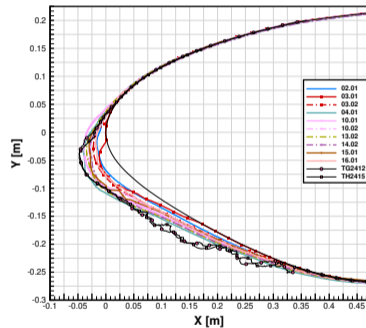
Case 2.3 – Ice Shape vs Experiment – Maximum CCS



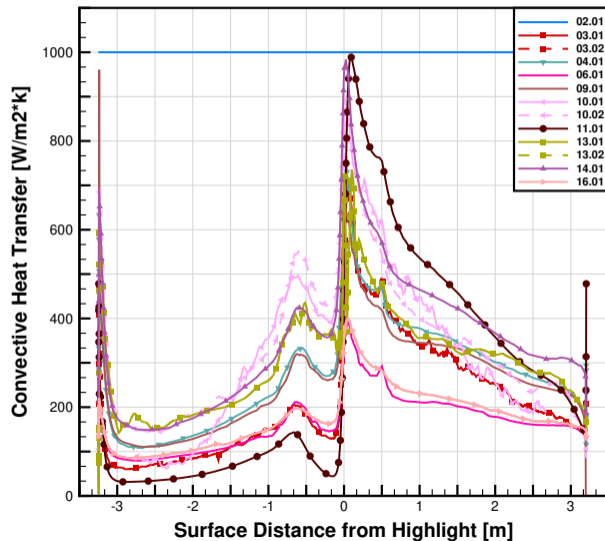
Case 2.3 – Ice Shape vs Experiment – Maximum CCS - Density Based Comparison



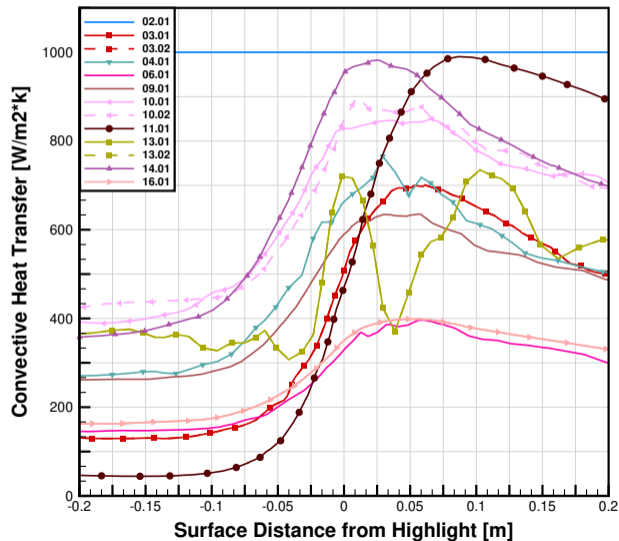
Variable Density

Ice Density = $917 \text{ kg} \cdot \text{m}^{-3}$ Ice Density Range $[300,600] \text{ kg} \cdot \text{m}^{-3}$
(and unknown)

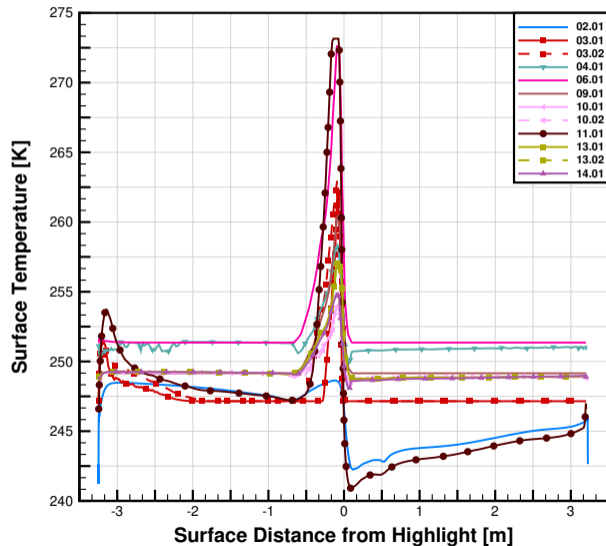
Case 2.3 – HTC vs S – 50 percent span



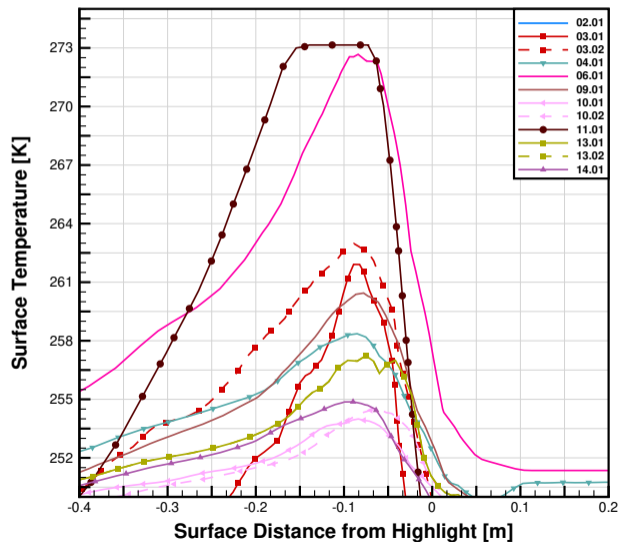
Case 2.3 – HTC vs S – Close to SP – 50 percent span



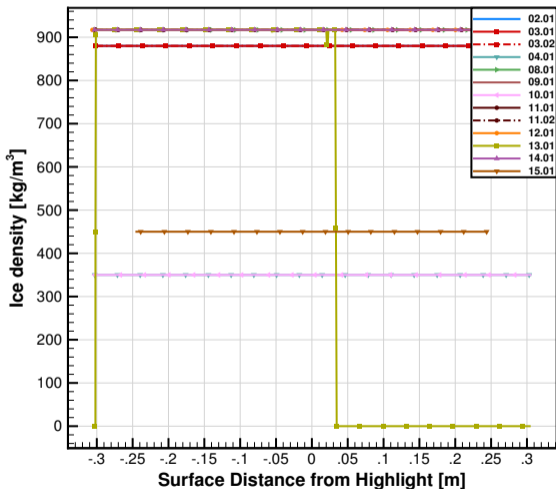
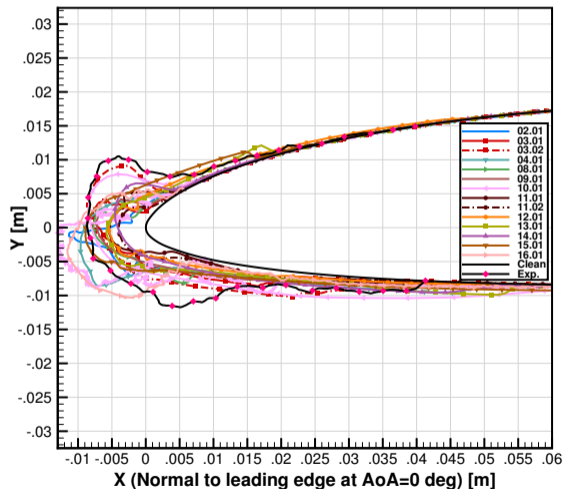
Case 2.3 – Ts vs S – 50 percent span

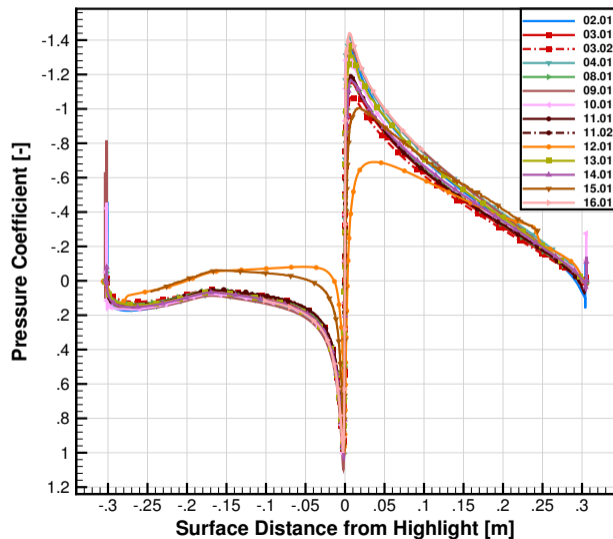


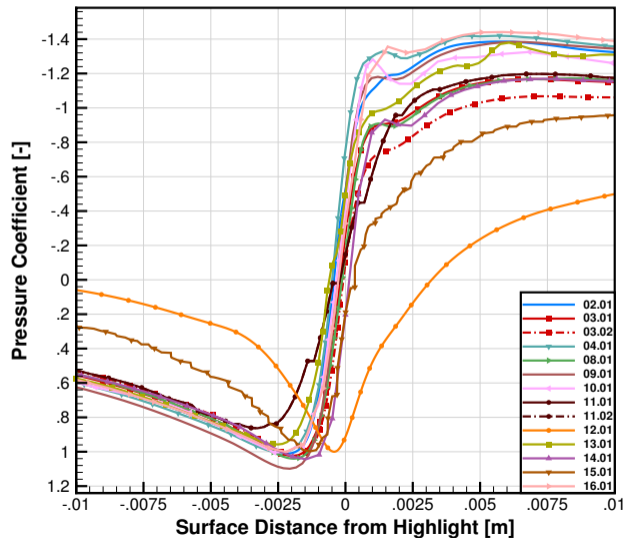
Case 2.3 – Ts vs S – Close to SP – 50 percent span

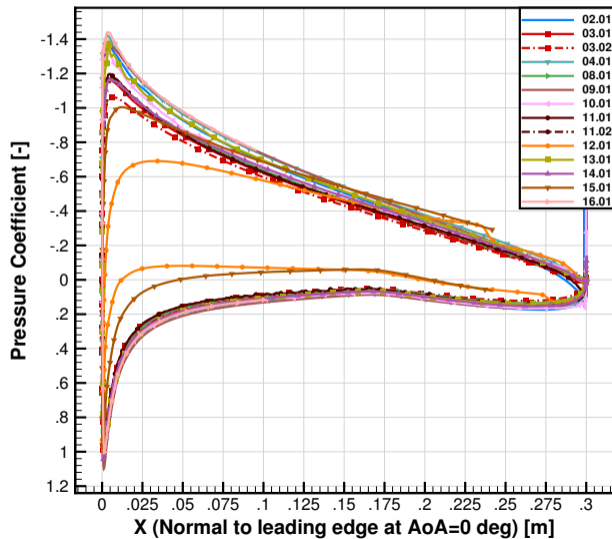


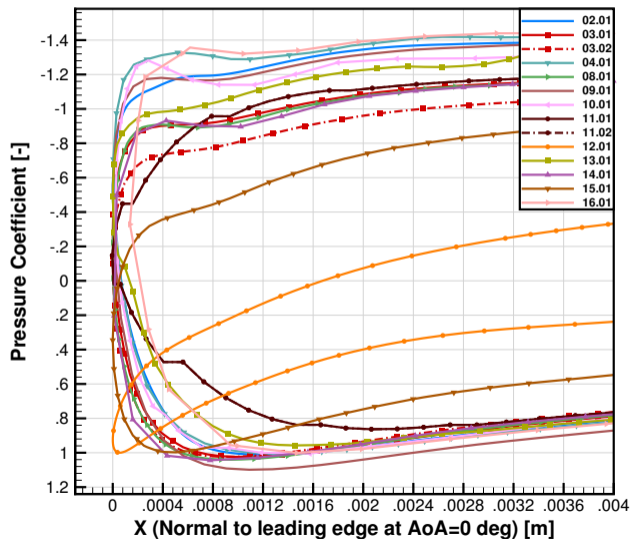
Case 3.1 – Ice Shape vs Experiment



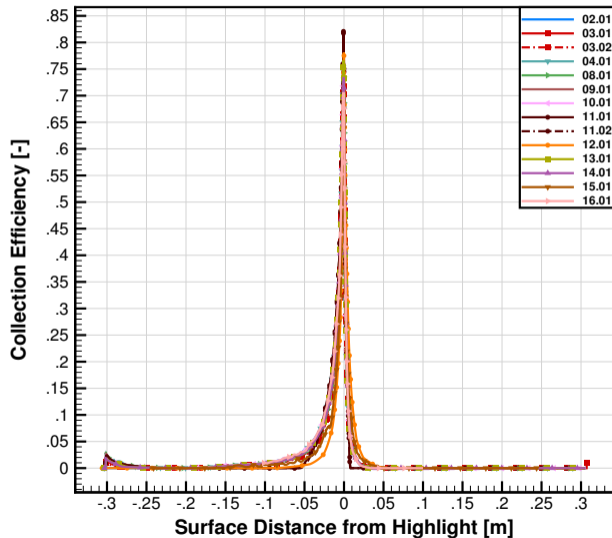
Case 3.1 – C_p vs S 

Case 3.1 – C_p vs S – Close to SP

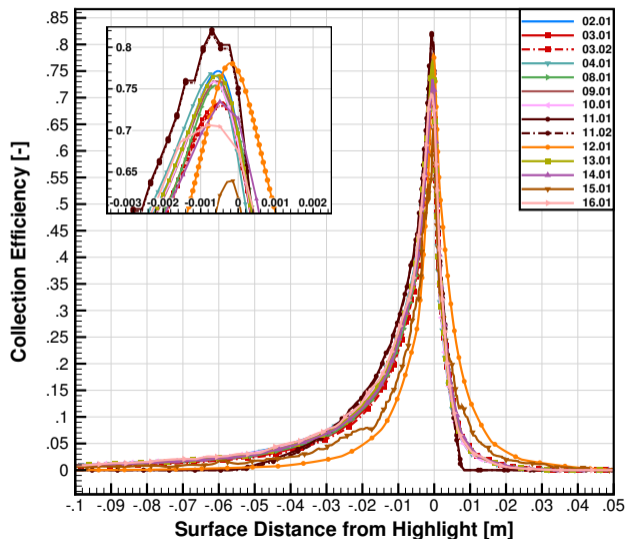
Case 3.1 – C_p vs X

Case 3.1 – C_p vs X – Close to SP

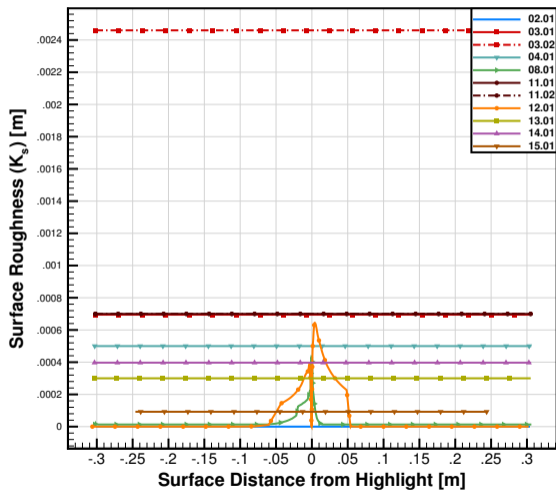
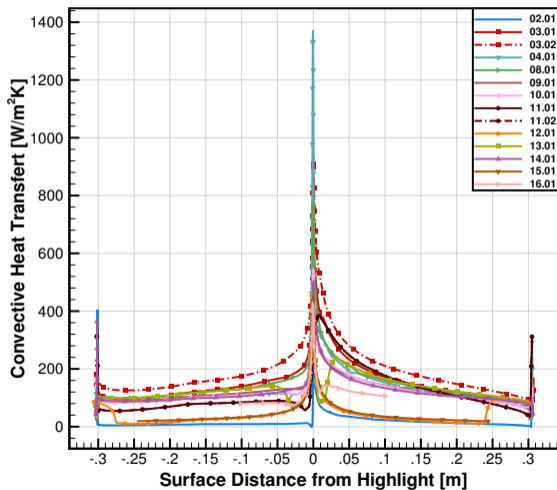
Case 3.1 – Collection Efficiency vs S



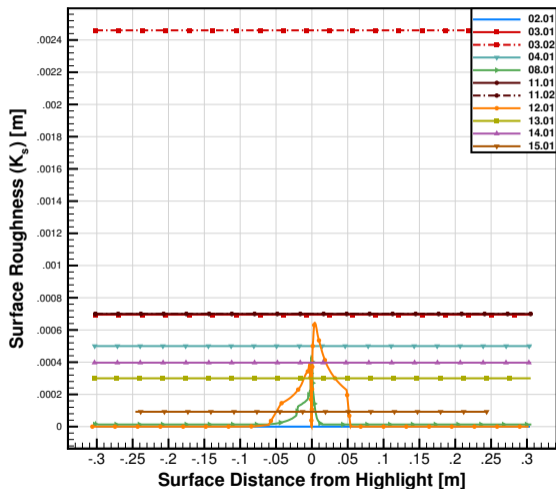
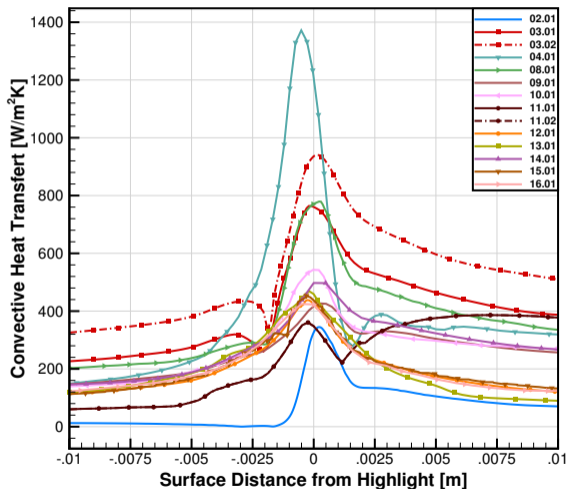
Case 3.1 – Collection Efficiency vs S – Close to SP



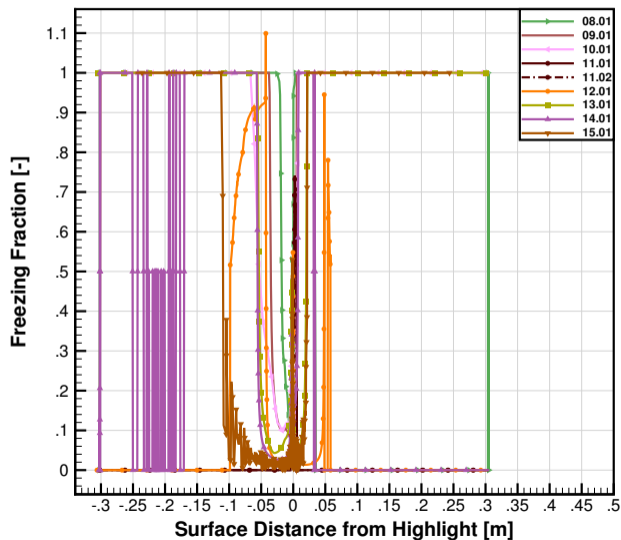
Case 3.1 – HTC vs S



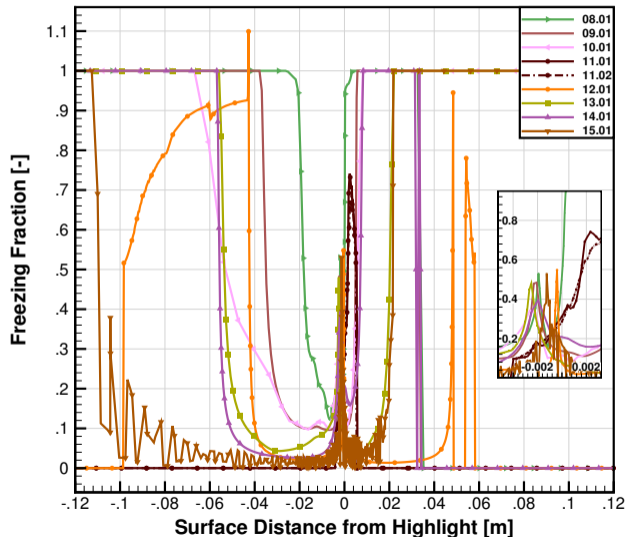
Case 3.1 – HTC vs S – Close to SP

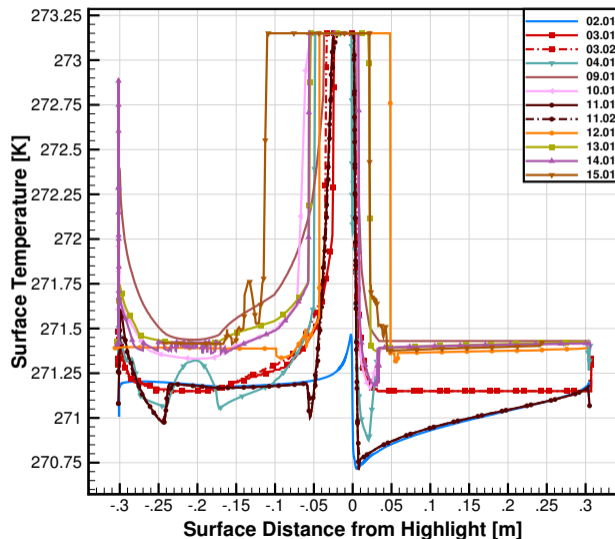


Case 3.1 – Freezing Fraction vs S

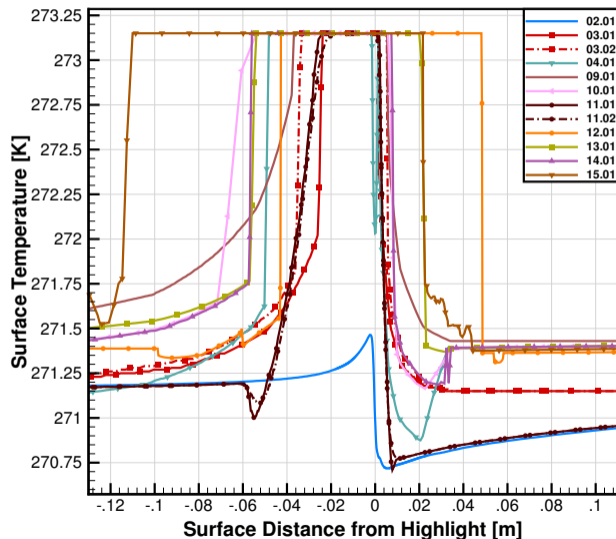


Case 3.1 – Freezing Fraction vs S – Close to SP

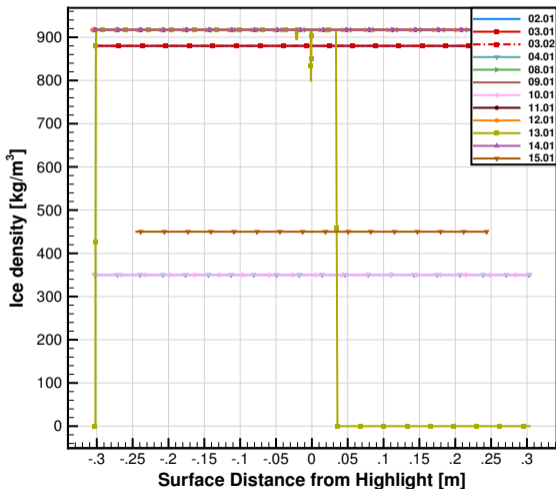
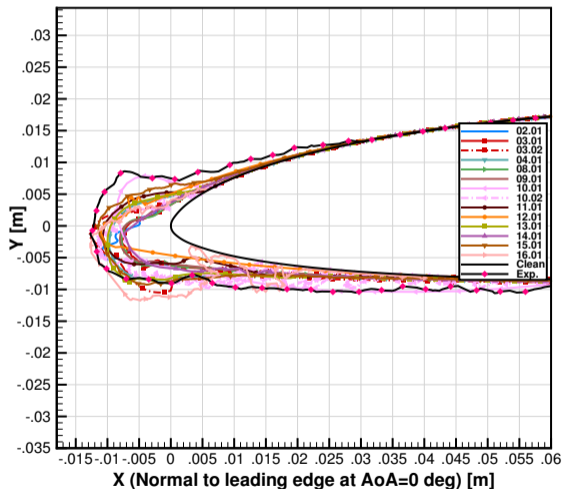


Case 3.1 – T_s vs S 

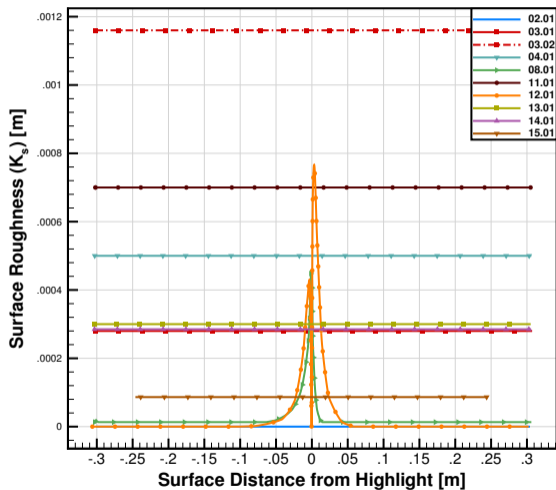
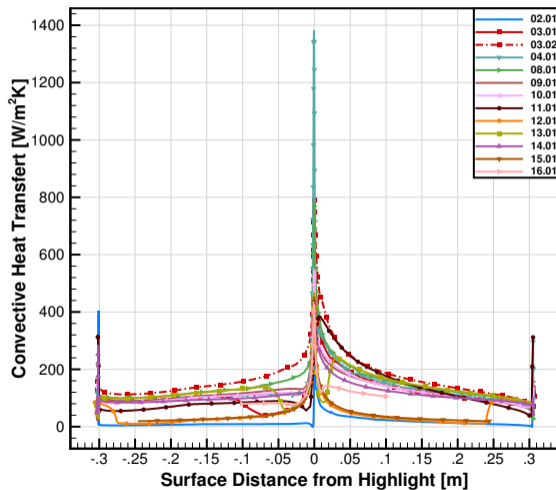
Case 3.1 – Ts vs S – Close to SP



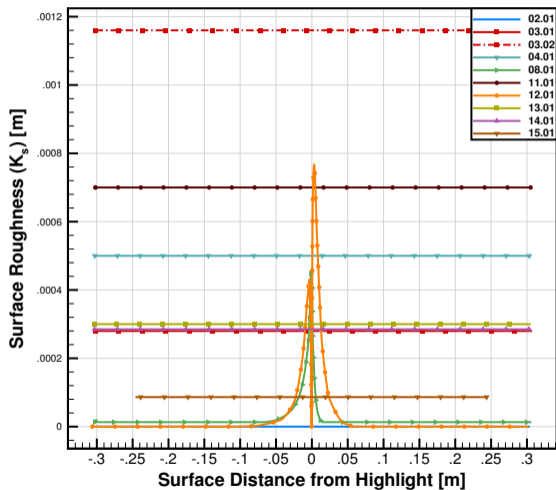
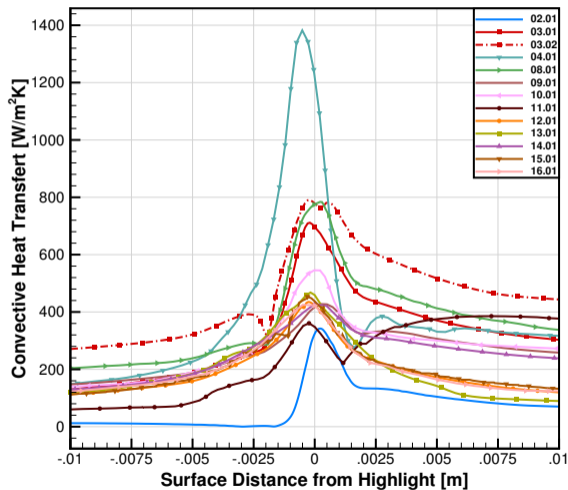
Case 3.2 – Ice Shape vs Experiment



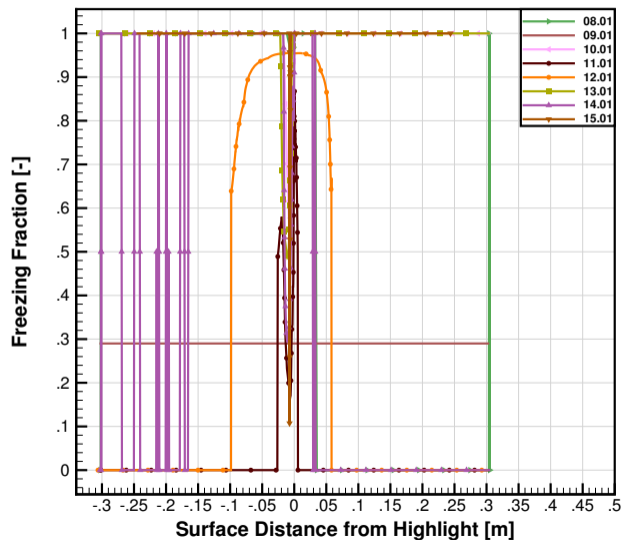
Case 3.2 – HTC vs S



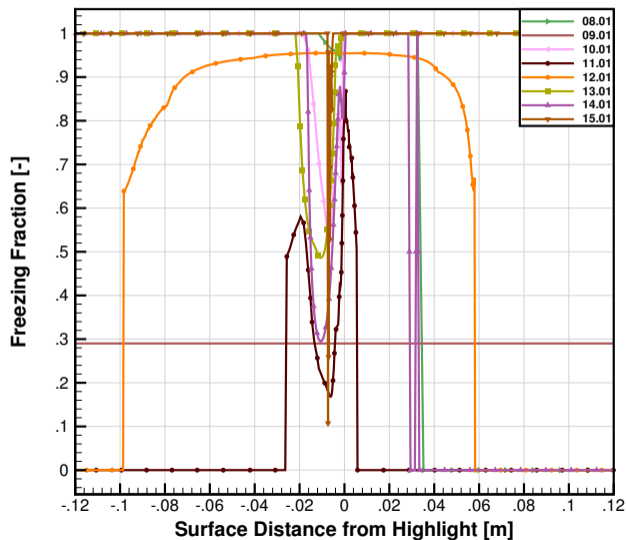
Case 3.2 – HTC vs S – Close to SP

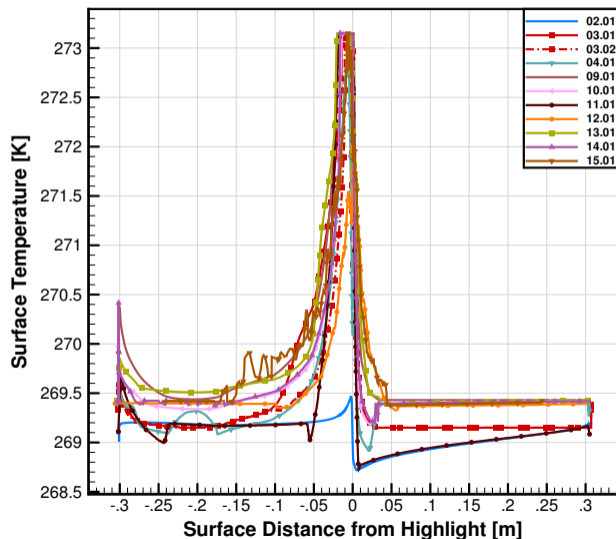


Case 3.2 – Freezing Fraction vs S

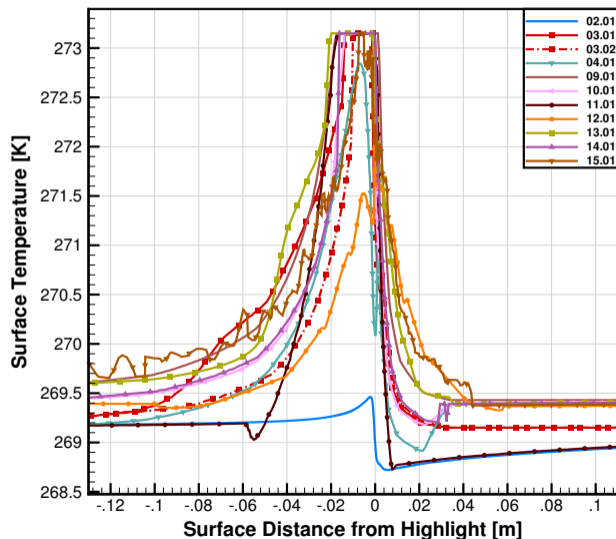


Case 3.2 – Freezing Fraction vs S – Close to SP

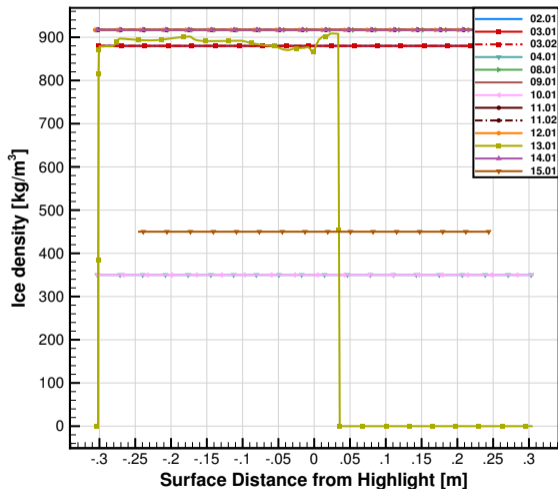
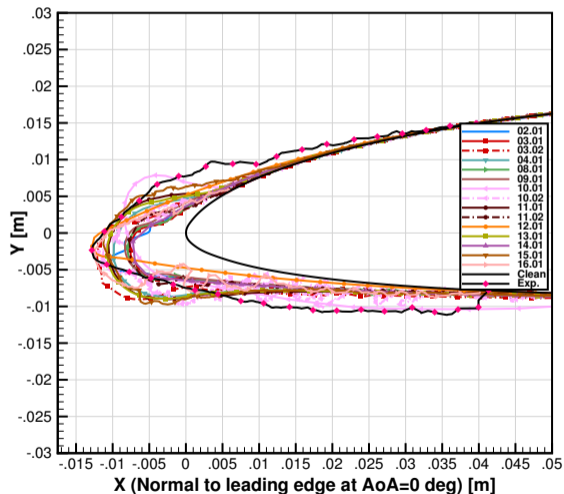


Case 3.2 – T_s vs S 

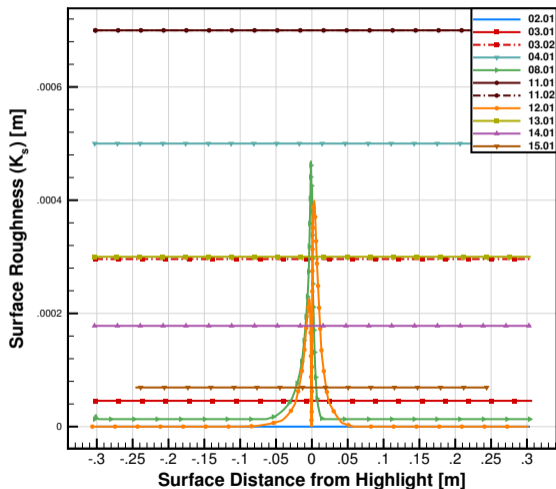
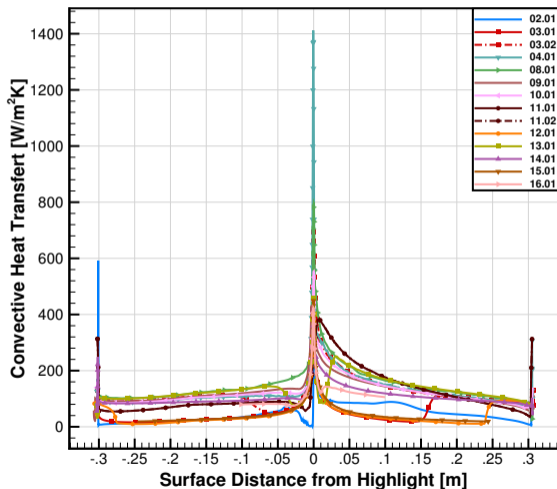
Case 3.2 – Ts vs S – Close to SP



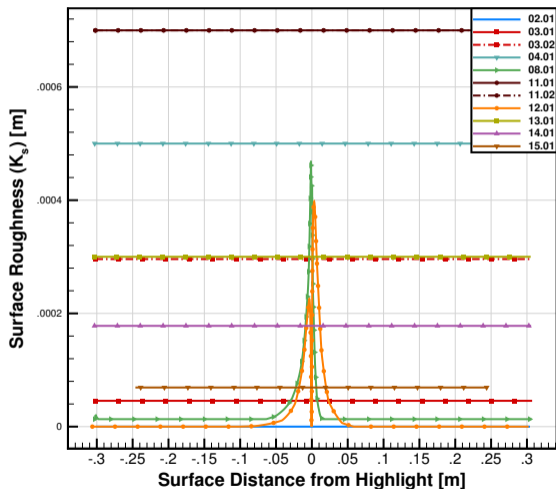
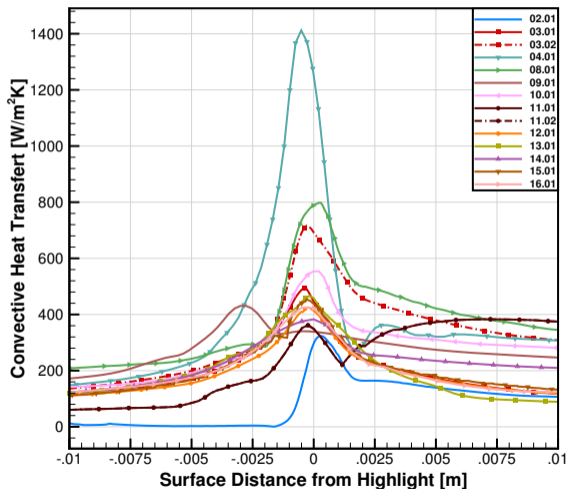
Case 3.3 – Ice Shape vs Experiment



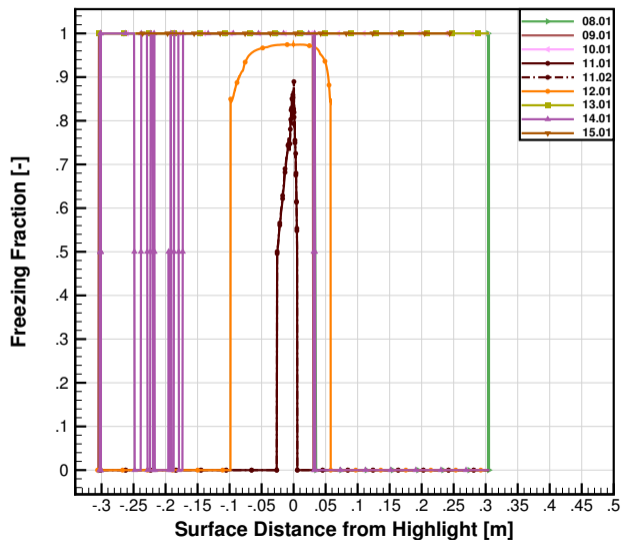
Case 3.3 – HTC vs S



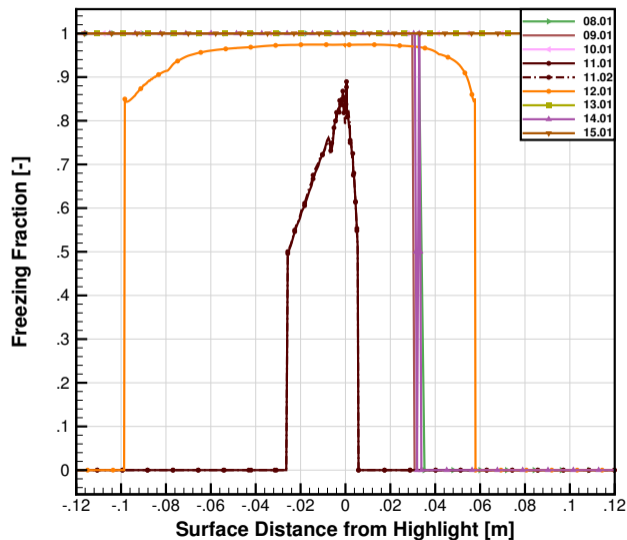
Case 3.3 – HTC vs S – Close to SP

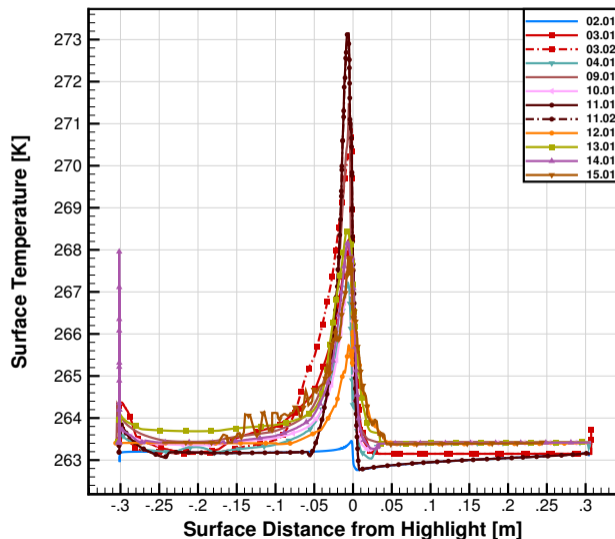


Case 3.3 – Freezing Fraction vs S



Case 3.3 – Freezing Fraction vs S – Close to SP



Case 3.3 – T_s vs S 

Case 3.3 – T_s vs S – Close to SP