

## Response to the review of David Hammond.

On behalf of my coauthors, I am very thankful for your review on the paper "Design, Construction and Commissioning of the Braunschweig Icing Wind Tunnel". Please find our comments below, which will be implemented in our paper accordingly.

The paper is of very great interest to the users and makers of icing test facilities and a good many others. The paper includes fresh information which is specifically about the exciting new facility but also contains much text about the generalities of icing. It is my firm opinion that this general material is dealt with much better elsewhere and should be edited out of the paper.

Writing that introduction & manuscript was a balancing act between two perspectives. On the one hand, we wanted to present some new ideas to experienced icing researchers. On the other hand, we wanted to explain our experiences to a general audience, to someone who is new in the topic, and who does not know all the specific vocabulary. It is therefore our feeling, that some of the general material provided shall not simply be omitted. Nevertheless, we agree with you, that this manuscript shall not become a textbook, likewise. In consequence, we will modify the introduction, see also our later comments.

Abstract, slightly wordy. The main message is relegated to lines 8 & 9 and dealt with almost in passing. I suggest something along the lines of "The unique aspect of this facility is ...(the combination of an icing tunnel with a cloud chamber system for making ice particles which are more realistic than those usually used for mixed phase and ice crystal icing experiments).

We will point out the unique aspect of our tunnel more specifically in the abstract. Your suggested sentence is appreciated.

Introduction. Paragraph 1 & 2 OK. Paragraph 3 might be stronger if the influence of temperature & heat capacity (water & ice) are mentioned alongside latent heat.

We are not sure on how to answer that question. The nucleation process itself is not primarily influenced by the heat capacity. Is it the reviewer's intention to point out the anomalies of water? We kindly ask the reviewer to clarify on that point. Of course we will implement his suggestions afterwards.

Page 2, line 13 to page 4, line 31 needs a good shake up to omit the generalities and concentrate on the aspects of direct significant to the development of an icing tunnel, this particular one.

Starting at line 13, the first paragraph summarizes the important boundary conditions of an icing wind tunnel experiment. It is our intention to address a broad readership with this article. Not every reader is familiar with either the aerodynamic parameters or the icing parameters. An explanation of these parameters seems only logical.

The next paragraph was further elucidating on the MVD. We have combined this paragraph with the enumeration of boundary conditions.

We will further omit the paragraph, which explains how the MVD is determined with a given droplet size spectrum.

Page 3 Line 30 then elucidates on quantitative values for boundary conditions. The second reviewer even suggested adding some quantitative information on ice crystals at that

occasion. From our point of view, it is very important to provide that kind of quantitative information for a general audience.

We will then reduce the paragraph on scaling laws significantly, but we will mention a reference to them.

The last two paragraphs explain are the outline for the following sections, and summarize the introduction. We suggest to keep them.

Design & Construction....(starts Page 5) Lines 6-10. The rationale is incompletely described. No mention of air speed of opportunities taken or lost by opting for a smaller or larger section.

Based on the Reynolds number ( $\sim V \cdot l$ ) criterion, it is indeed a compromise between velocity ( $V$ ) and test section dimension ( $l$ ) that has to be made. The consideration of wind tunnel and chilling power is even more significant, which we have explained in the subsequent paragraph, because it directly relates to your investment costs. From a pure mathematical point, the two parameters of drive Power ( $\sim V^3 \cdot l^2$ ) and Reynolds number will uniquely determine the velocity  $V$  and the size  $l$ .

From an engineering perspective, there is of course some choice between test section size and velocity. From our point of view, the test section size of 0.5 m x 0.5 m was quite important. Below that size, it would not have been possible to install the canister probes (shown in Figure 34) or any other significant aircraft subsystem. A test section, which is even larger would have reduced the maximum speed in the test section at a given fan power. We did not want to go below 40 m/s because our major customers indicated a desire for even higher speeds. Finally, the tunnel dimensions are also a constraint of available space.

We will elaborate more in detail in our manuscript on our design choices.

Page 8 Lines 10 to 13. The LWC range for larger droplet mode is given but it is not given for the smaller droplet mode.

We have added that information in the manuscript.

Page 11 lines 15 to 20. It would be nice to say a bit about how well this construction method worked out in practice. Was it easy to control leaks? How easy was it to avoid steps in the wall?

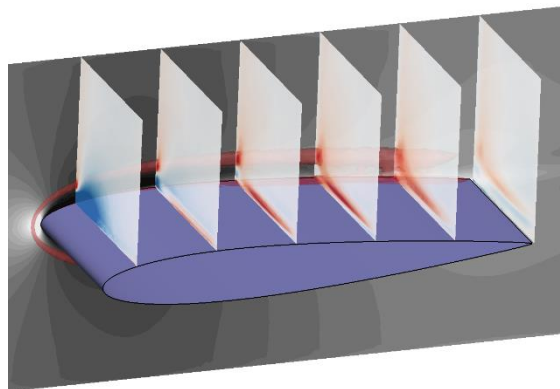
A company that is specialized on sheet metal forming manufactured the parts. Small tolerances of all parts were ascertained. The step size between the segments is negligible. Since the flanges were fastened with many screws, the leakage was minimal. To make the joints fully watertight, we sealed the inner groove with another acrylic compound.

We will add some statements about these practical aspects.

Page 11 lines 21 to Page 12, line 2. I find this rather unclear. Specifically, the figure (12) appears to show ice thickness. It drops off at the ends of the aerofoil but this could be for a number of reasons not discussed in the text. We are left wondering about the conditions modeled and learn nothing of the predicted velocity field which I would surely prove the central point more effectively.

The flow around a NACA0012 airfoil is simulated. It is a 3D RANS computation that predicts the junction flow between airfoil and sidewall. This junction flow creates a horseshoe vortex.

We created an additional picture, see below, to visualize this horseshoe vortex. The velocity in spanwise direction is shown there for different slices. The gray contour represents the shear stress at the sidewall. We simulated LWC  $1\text{g/m}^3$  and MVD  $20\mu\text{m}$  at  $40\text{m/s}$ ,  $T=-10^\circ\text{C}$  and  $Re=2*10^6$ . Note that the boundary conditions are already mentioned in the figure caption. Indeed, the horseshoe vortex alters the velocity distribution at the junction. When velocity is altered, the heat transfer is influenced and so the ice accretion rate (glaze ice). The flow solver is coupled to a trajectory solver and an ice accretion model, see the references already provided. The ice thickness shown in Figure 12 results after an ice accretion time of 120 seconds. We will include this additional information in the manuscript.



Page 12 lines 11. Here the heat exchanger is said to be off galvanised mild steel. On page 7, line 28, we are told that it is of a mix of steels, galvanised together and coated with an epoxy based film. So which is it? There is also a reference to sub sub sub section in some other document which I recon should not be in the text.

Indeed, the statements of page 7 are correct. The intention of page 12 is to elucidate on the corrosion process, if the epoxy coating were not be present / or deteriorated. We will clarify this point and correct the reference.

Ice Crystals & mixed phase... (starts page 13) Page 14, lines 17 to 26. To me this is a bit muddled. For me the problem is exemplified best by the description of the blobs in figures 16 as "crystals" rather than hydrometers or lumps. They are aggregates, possibly of some single crystal particles but also, I would suggest, some degree of rime growth. Other references to "ice crystals" through the rest of the text need to be checked to ensure that the vocabulary does justice to the work.

We agree with the reviewer that the wording ice crystals may be too specific for the various types of ice particles found in convective clouds. The definition of ice crystal is given in the AMS glossary: [http://glossary.ametsoc.org/wiki/Ice\\_crystals](http://glossary.ametsoc.org/wiki/Ice_crystals)  
For simplicity we have chosen to use "ice particles" instead and only "ice crystals" for the column and capped column type ones.