Short Comment on "Antarctic Peninsula ice shelf collapse triggered by föhn wind-induced melt" by M. K. Laffin et al., submitted to *The Cryosphere Discussions*, 25 Oct. 2021.

Commenter: Helmut Rott

The authors explored mechanisms triggering the rapid collapse events of the Larsen A and B ice shelves, using a regional climate model and Machine Learning analysis in order to investigate the influence of föhn winds and associated melt on the surface liquid water budget. They conclude that increased surface melt due to föhn supplied water to melt lakes, inducing the crossing of a critical stability of water depth that triggered the rapid Larsen A collapse. The authors claim a lack of high resolution satellite imagery during the collapse and deduce estimates on melt lake surface area from an AVHRR image (1 km spatial resolution) of 8 December 1992. In fact, high resolution synthetic aperture radar (SAR) images (ca. 25 m resolution) of the ESA ERS-1 satellite were acquired during the disintegration event, on 25, 28 and 30 January and 2. February 1995. Some of the ERS-1 SAR images acquired over Larsen Ice shelf are shown in Rott et al., 1998 (paper cited by Laffin et al.). Furthermore, Rott et al., 1996 (not cited), show ERS SAR images acquired during the event and present a report on the state of Larsen A Ice Shelf two months before the collapse, built on field observations.

The ERS SAR images, as well as the report on the field observations in October and November 1994 disprove the hypothesis of Laffin et al. that the Larsen A collapse in January 1995 was triggered in the short-term by hydrofracture processes. According to the ERS image of 25 Jan. 1995, close to the start of the main disintegration event, the extent of surface lakes on Larsen A Ice Shelf amounted to about 1% of the total area (Fig. C1 below). In Oct./Nov. 1994 the ice shelf was already heavily fractured. Cold temperatures and an extended pre-frontal cover of fast ice kept the ice shelf from breaking apart. Details are reported in Rott et al., 1996, e.g. referring to an ice wedge protruding from the level ice shelf several km inland of the front (Fig. C2), on cracks along the border between the Larsen A and Seal Nunataks ice shelves, and rifts along the coastline line to the peninsula.

Regarding the temporal sequence of the collapse event, the ice shelf section downstream of Dinsmoor-Bombardier-Edgeworth (DBE) glaciers retreated to the grounding line faster than downstream of Drygalski Glacier along which Laffin et al. show the location of the LA föhn jet. The pre-collapse crack density was highest on the DBE ice shelf section. Another striking incident was the rapid off-coast drift of detached icebergs and growlers, gaining 40 km in distance between 28 and 30 January 1995, an indication for oceanic mechanic forcing as main factor for the rapidity of disintegration.

This comment is not a review of the paper. Nevertheless I want to address some further issues:

Melt pattern on Larsen A Ice Shelf: The model simulations (Figs. 3 and 6) indicate reduced melt in the northern section of the ice shelf (downstream of DBE glaciers). ERS SAR images, acquired in years preceding the collapse, as well as the 25 Jan. 1994 image (Fig. C1), do not show any significant difference in melt intensity between different ice shelf sections.

Position of föhn jets: The uniqueness of the föhn jets on Larsen A (Drygalski Glacier) and on Larsen B (Hektoria – Green glaciers) needs to be reconsidered. ERS SAR images during the Larsen A event show high reflectivity of the ocean surface and rapid of-coast displacement of ice downstream of DBE glaciers, indications for strong off-shore winds. During the Larsen B disintegration event rapid off-coast drift of icebergs was observed also downstream of Crane and Jorum glaciers (Rack et al., 2004).

Line 289: "... the LAIS and LBIS collapsed catastrophically within weeks and not through long-term thinning and retreat like other ice shelves..." The gradual retreat of the Larsen A front between Seal

Nunataks over 20 years up to the collapse is documented by means of satellite images starting in 1975 (Skvarca, 1993; Rott et al., 1996).

References:

Rack, W. and H. Rott, H.: Pattern of retreat and disintegration of the Larsen B ice shelf, Antarctic Peninsula, Ann. Glaciol., 39, 505 – 510, 2004.

Rott H., Skvarca, P., and Nagler, T.: Rapid collapse of northern Larsen Ice Shelf, Antarctica, Science, Vol. 271, Issue 5250, 788-792, 1996.

Skvarca, P.: Fast recession of the northern Larsen Ice Shelf monitored by space images, Ann. Glaciol., 17, 317-321, 1993.

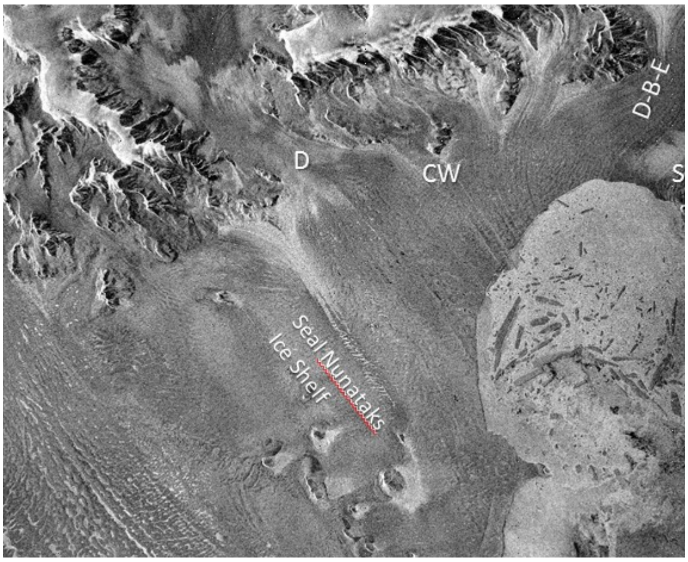

Fig. C1. Section of ERS-1 SAR image, covering Larsen A Ice Shelf, 25 January 1995. CW – Cape Worsley, D – Drygalski Glacier, DBE – Dinsmoor-Bombardier-Edgeworth glaciers, S - Sobral Peninsula.

Fig. C2. Ice wedge on Larsen A Ice Shelf, located several km inland of the front (left). Cracks near the ice front (right). Photos H. Rott, 24 Oct. 1994.