Through-Ice-Shelf Drainage of Surface Meltwater Lakes and its Implications for Antarctic Ice Shelf Stability

PRESENTER:
Philipp S. Arndt
parndt@ucsd.edu

UC San Diego | Scripps Institution of Oceanography
Philipp S. Arndt and Helen A. Fricker

BACKGROUND: **Meltwater on ice shelves** can lead to their **collapse by hydrofracture.** When ice shelves collapse, more grounded ice flows into the ocean, leading to **sea-level rise.** When a melt **lake drains** through an ice shelf, the **floating ice shelf flexes upward** in response to the removal of the load. This process alters the ice shelf's surface topography and **hydrology.** Observational data of such lake drainage ("ice doline" formation) events across Antarctica's ice shelves **have not been systematically studied** before.

METHODS: We complied an **inventory of through-ice-shelf drainage events** around Antarctica by looking at changes in satellite imagery. We used high resolution **satellite data** of **surface elevation change** (ICESat-2 repeat-track laser altimetry and lagrangian differencing of Worldview3 stereophotogrammetric digital elevation models) to generate **observational data of ice shelf flexure** in response to lake drainage. We tracked resulting **changes in ice shelf surface hydrology** to find out whether this process is more likely to stabilize or de-stabilize ice shelves.

RESULTS:

- Through-ice shelf drainage of lakes is **more widespread than previously thought.**
- **High-resolution satellite data** of surface elevation change can **improve** our **understanding of ice shelf mechanics.**
- Doline formation can significantly **change ice shelf surface hydrology** nearly instantaneously, thus affecting **ice shelf stability.**
  - **Meltwater capture stabilizes:** it removes water from the surface and **prevents future hydrofracture.**
  - **Meltwater diversion de-stabilizes**: it can **re-route water** to downstream areas that are more **vulnerable to collapse by hydrofracture.**

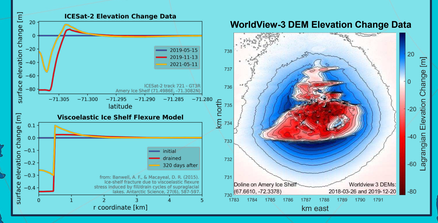
TAKEHOME MESSAGE: Through-ice-shelf lake drainage is an ice shelf process that is more widespread across Antarctica than we thought. It can have large impacts, so **we should care about it.**

We found many examples of melt **lakes draining through ice shelves** around Antarctica.

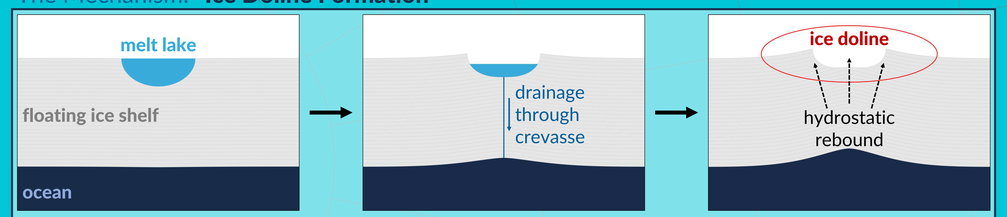
Satellite data of lake drainages can help us **better understand** ice shelf **flexure,** and how meltwater impacts **ice shelf stability**.

Observational Data of Ice Shelf Flexure

High-resolution satellite data of surface **elevation change** provide **observational data** of ice shelf **flexure** in response to lake drainage. This can help us better understand the **mechanical properties** of ice shelves, to validate or **improve models.**



The Mechanism: **"Ice Doline Formation"**



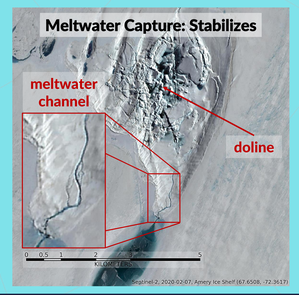
When a melt lake drains through an ice shelf, a large load is removed from the floating ice. The ice shelf compensates by flexing upwards.

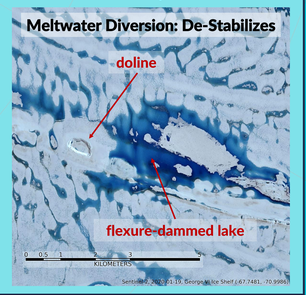
Implications for **Ice Shelf Stability**

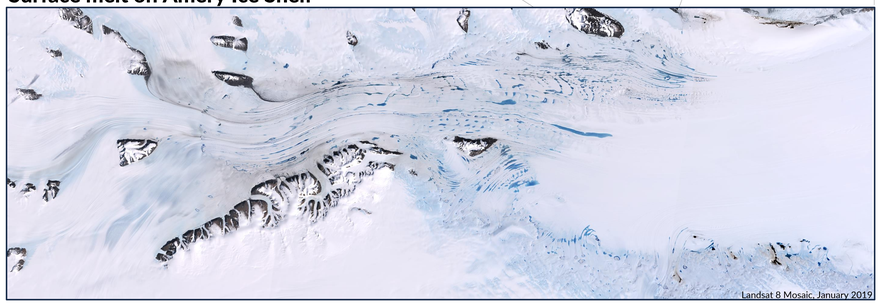
Doline Formation has **two** possible, **opposing mechanisms** on stability:

1) Meltwater **capture stabilizes** the ice shelf: the **drainage crevasse** provides a **pathway to remove water** from the surface, **preventing** future **hydrofracture**.

2) Meltwater **diversion de-stabilizes** the ice shelf: the **flexural uplift** can prevent future meltwater from entering the collapse basin and instead **re-route** it to regions **further downstream** that are more **vulnerable to hydrofracture**.





Take a picture to download data, code, papers and presentations.

Surface melt on Amery Ice Shelf