C21C-0373. Why were buoyant plumes suppressed at a west Greenland tidewater glacier during the record 2012 melt season?

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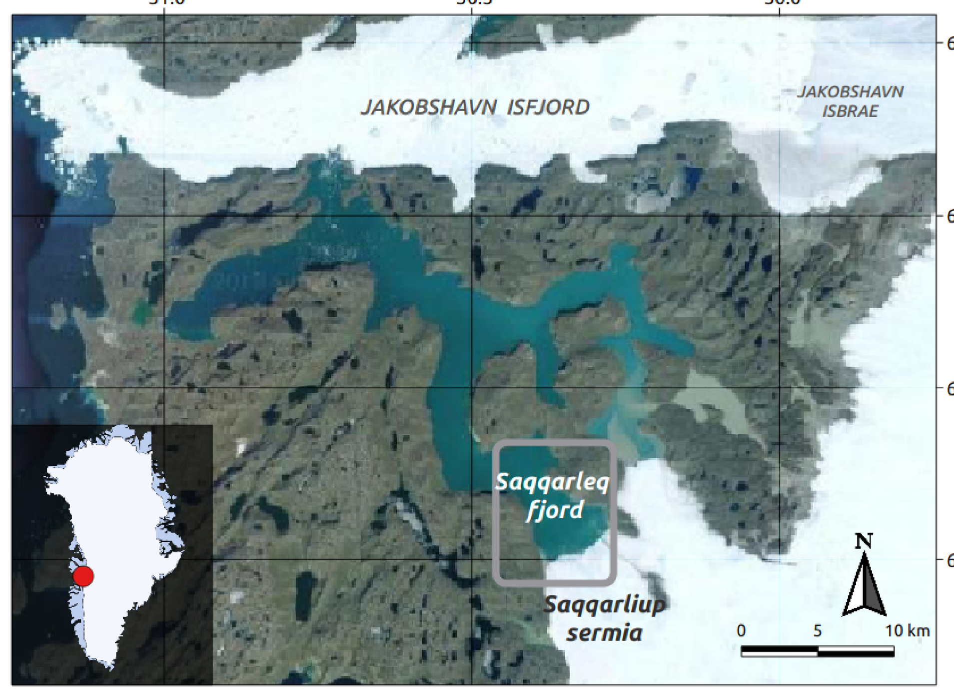
1. Background & Aims

Tidewater outlet glaciers play a major role in Greenland Ice Sheet contribution to sea level rise. A likely trigger is the submarine melting of their calving fronts, which is strongly influenced by rising, buoyant plumes, initiated by subglacial drainage of surface meltwater.

Saqqarliup Sermia is a mid-sized tidewater glacier in west Greenland. One major subglacial discharge plume was mapped on its proglacial fjord during two summer field campaigns in 2012 and 2013. During these campaigns, the plume was observed to surface in 2013 but not in 2012 (even though this was a record melt year).

Our aims:

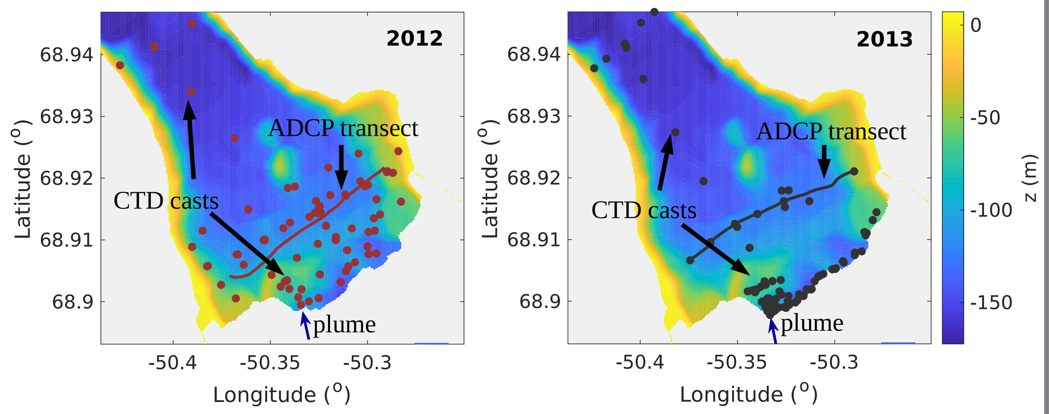
1. **To combine detailed oceanographic observations with plume theory to investigate why the plume surfaced in 2013, but not in 2012**
2. **To assess the freshwater sources that contributed to a more stratified fjord in 2012 than 2013**



2. Methods

I. Data acquisition

- **Aerial images of plume patch**
- **Hydrographic measurements (CTD)**
- **Velocity data (ADCP)**
- **Runoff estimations (RACMO2.3)**

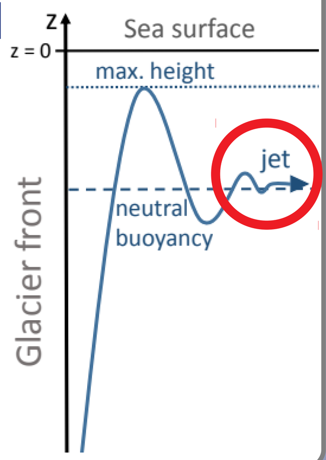


II. Plume Model

Line source (Jenkins, 2011)

1. Inputs:
- T, S obs.
- Runoff estims.

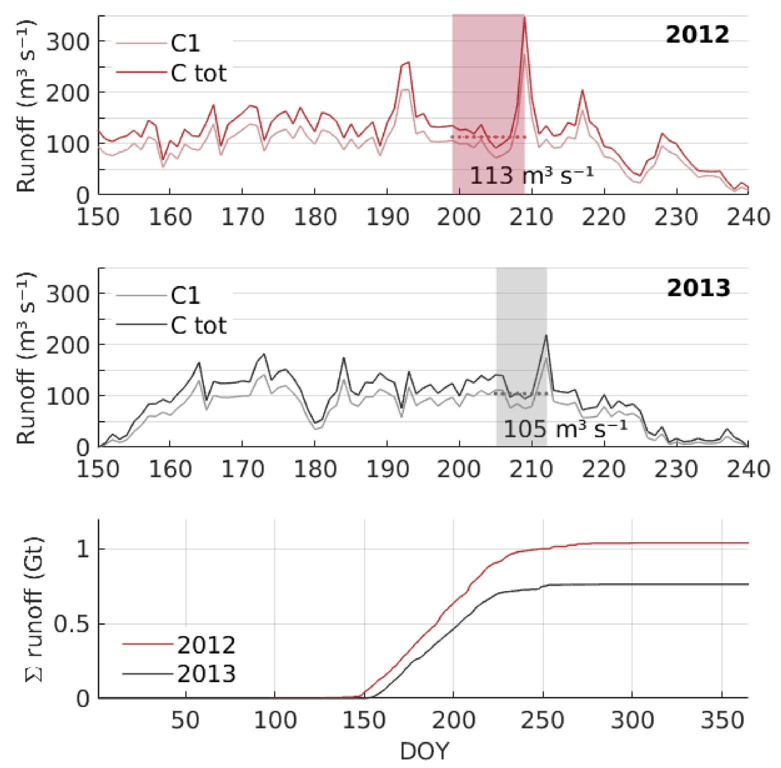
2. Validation:
- Observed jet depth
- T, S from xCTDs



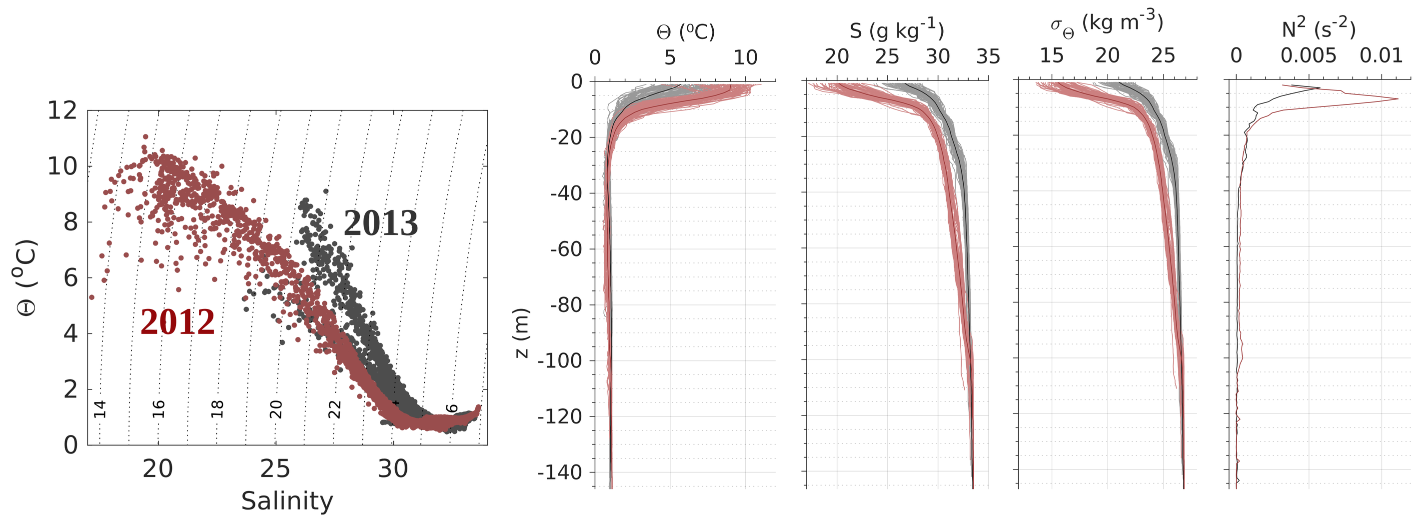
3. Results I: OBSERVATIONS

A. Plume patch observed in 2013 but not in 2012

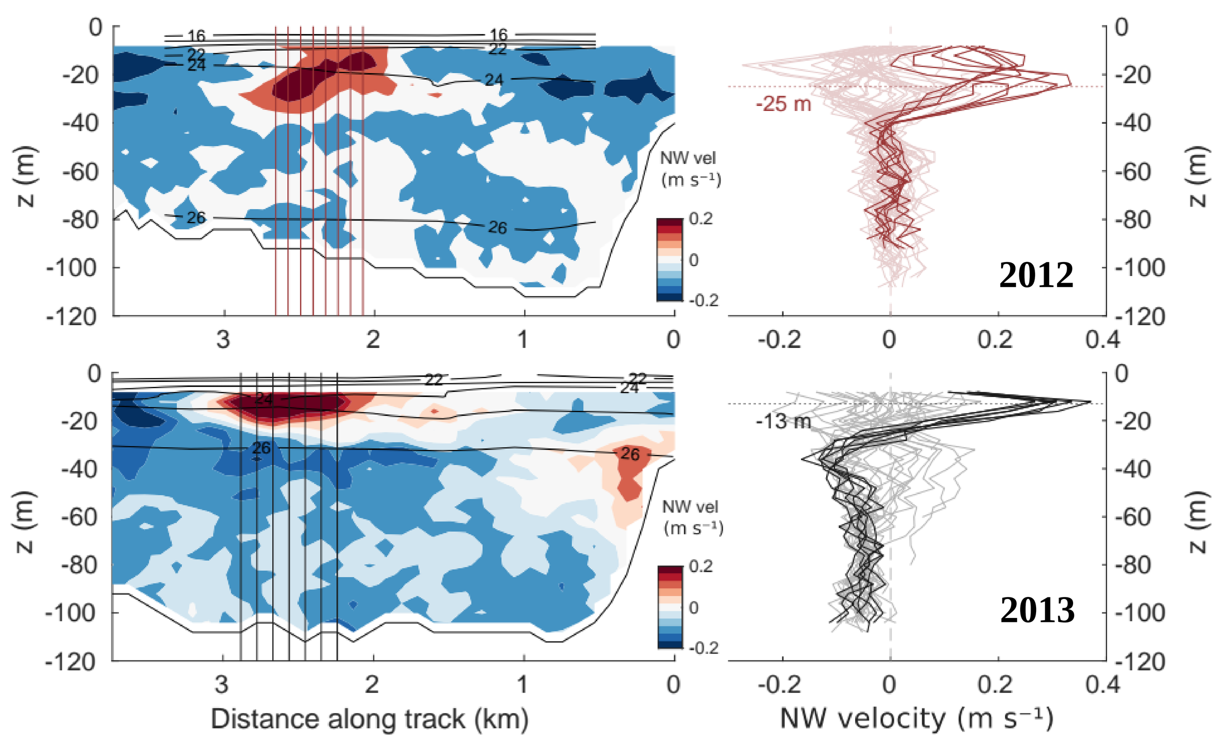
B. Higher (record) runoff in 2012



C. The fjord was fresher and more stratified in 2012



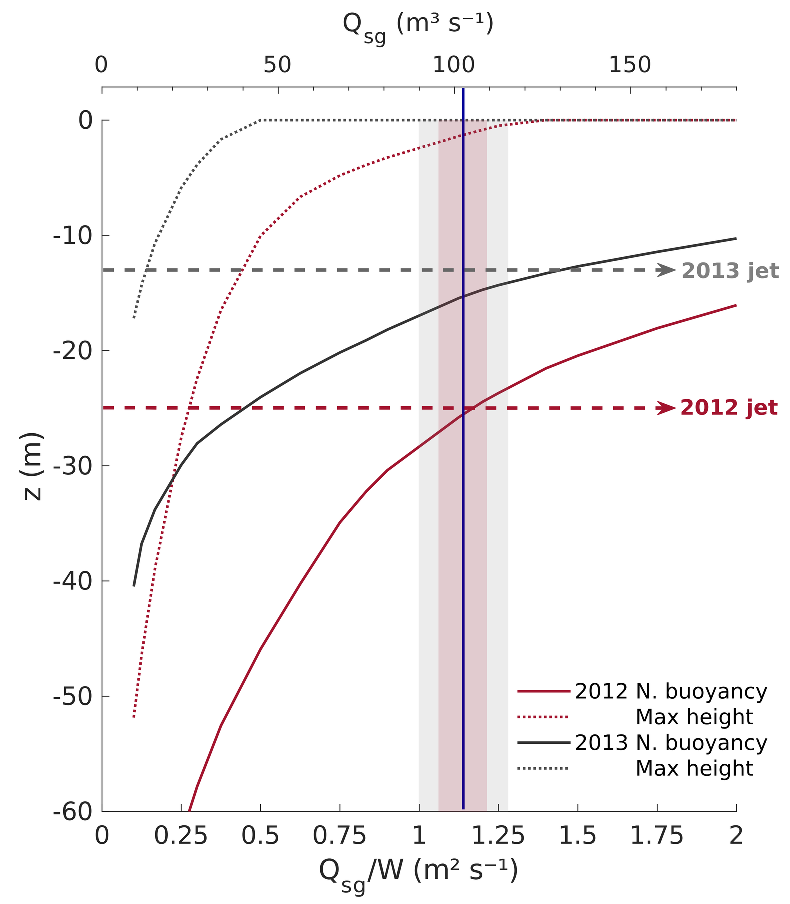
D. Jet driven by plume equilibrates deeper in 2012



4. Results II: PLUME MODEL

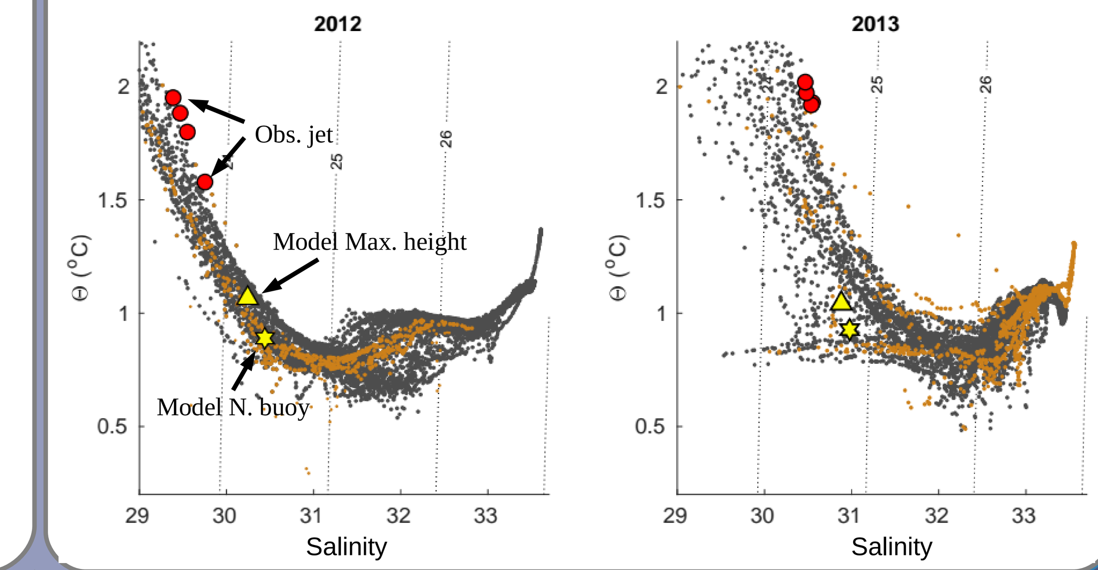
- Vertical extent (max. height) and equilibration depth (neutral buoyancy) of the plume, higher in 2013 than 2012, for any given subglacial discharge (Q_{sg}).
- Channel width (W) of 90 m (Jackson et al., 2017)
- Q_{sg}^{2012} ~3 times Q_{sg}^{2013} to reach similar plume extent/eq. depth.
- Plume model captures plume surfacing in 2013 but not 2012. Also good prediction of observed jet depths (equilibration) depths

A. Model captures observed jet depths and predicts plume subsurface in 2012



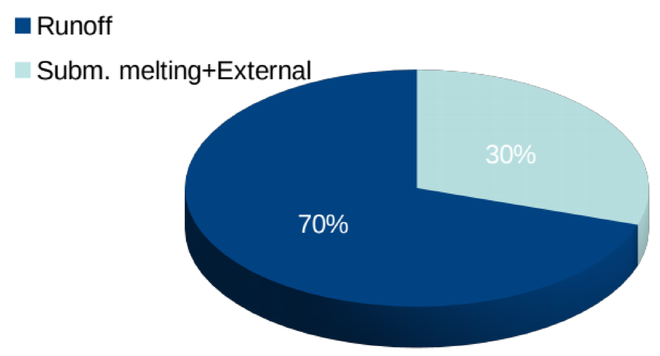
B. Model match T-S properties observed in plume vicinity

- Plume model properties (T and S) fall into the range of observations near the plume (xCTD data)
- Plume properties at max. height warmer and fresher than at neutral buoyancy. Greater difference in 2012 due to the stronger salinity gradient on the top layer.
- Jet properties (1.5 km from glacier front) very close to ambient properties, indicating high dilution with little signature of the subglacial runoff.
- Exported waters much fresher in 2012



5. Fjord stratification sources and implications

- From CTD data and following Camarck et al. (2016) → **freshwater content in the inner part of the fjord was ~0.21 Gt larger in 2012 than in 2013**
- From May to end of July, **runoff accounted for** ~0.15 Gt (0.14 Gt from catchment and 0.1 Gt from land and rainfall), which is **~70% of the observed over freshening**
- Remaining freshwater could come from both submarine melting and external fjord water exchange
- Surface ice melting directly affects fjord stratification. So, as the summer advances, the fjord becomes more stratified. **Fjord stratification is dynamic**



- Stratification affects glacier-fjord systems by modulating plume dynamics, determining the depth reached by the plume, and the depth and properties of exported water. In turn this may impact shelf water properties around Greenland, and biological activity in the fjord, which is known to be highly sensitive to the upwelling of deep nutrient rich waters

6. Conclusions

- Our study demonstrates that **fjord stratification modulates plume dynamics**, determining the properties and depth of the export from the fjord.
- We also show how **in glacier-fjord systems, the glacier itself has a strong impact on the stratification** of the fjord.
- The **main freshwater source of fjord stratification was surface melting runoff**, explaining ~70% of the additional fjord stratification in 2012.
- Beyond...
  With surface melting of the ice sheet projected to increase, the influence of this increased freshwater input on fjord stratification and plume dynamics may be an important feedback in glacier-fjord systems.

References

Slater et al. (2018). *GRL*, 45. DOI: 10.1029/2018GL080763

Wagner et al. (2018). *TC*. DOI: 10.5194/tc-2018-143

Jackson et al. (2017). *GRL*, 44. DOI: 10.1002/2017GL073602

Mankoff et al. (2016). *JGR* Oceans, 121. DOI: 10.1002/2016JC011764

Stevens et al. (2016). *TC*, 10. DOI: 10.5194/tc-10-417-2016

Carmack et al. (2016). *JGR Biogeosci.*, 121. DOI: 10.1002/2015JG003140

Jenkins (2011). *JPO*, 41. DOI: 10.1175/JPO-D-11-03.1

Acknowledgements

This research was funded by the EU's Horizon 2020 RIA programme under GA No 727890 and by grants CTM2014-56473-R and CTM2017-84441-R (MICIU/AEI/FEDER, UE).

Support was also provided by the National Science Foundation (NSF) through PLR-1418256 and PLR-1744835, and through Woods Hole Oceanographic Institution (WHOI) Ocean and Climate Change Institute (OCCI) and the Clark Foundation

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