Università Ca'Foscari Venezia

ISP Istituto di Scienze Polari
Consiglio Nazionale delle Ricerche

# Bromate ($BrO_3^-$) production in the Arctic snowpack

**Stefano Frassati**

Stefano.frassati@unive.it

# Bromine role

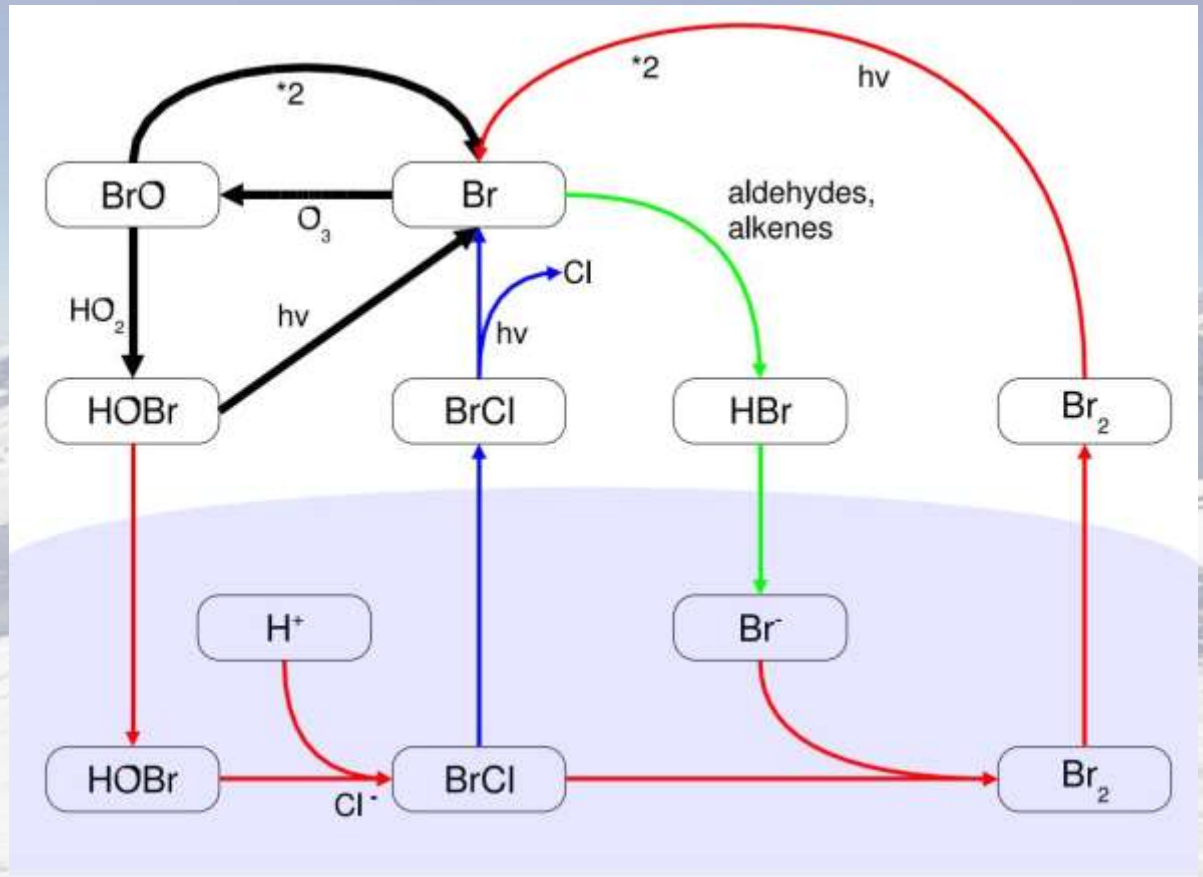
- Halogens affect the oxidative capacity of Earth’s atmosphere
- Oceanic origin, strong dependence with sea ice extent
- Strong correlation between $O_3$ and Hg depletion and atmospheric Br chemistry

Jeong, Daun, et al. "Multiphase Reactive Bromine Chemistry during Late Spring in the Arctic: Measurements of Gases, Particles, and Snow." *ACS Earth and Space Chemistry* 6.12 (2022): 2877-2887.
Pratt, Kerri A., et al. "Photochemical production of molecular bromine in Arctic surface snowpacks." *Nature Geoscience* 6.5 (2013): 351-356..

# Bromine role

Bromine takes part in numerous reactions that can be:

- biologically induced
- induced or not by sunlight
- affected by pH
- (Photo)catalytic reactions (e.g. by $Fe_2O_3$)

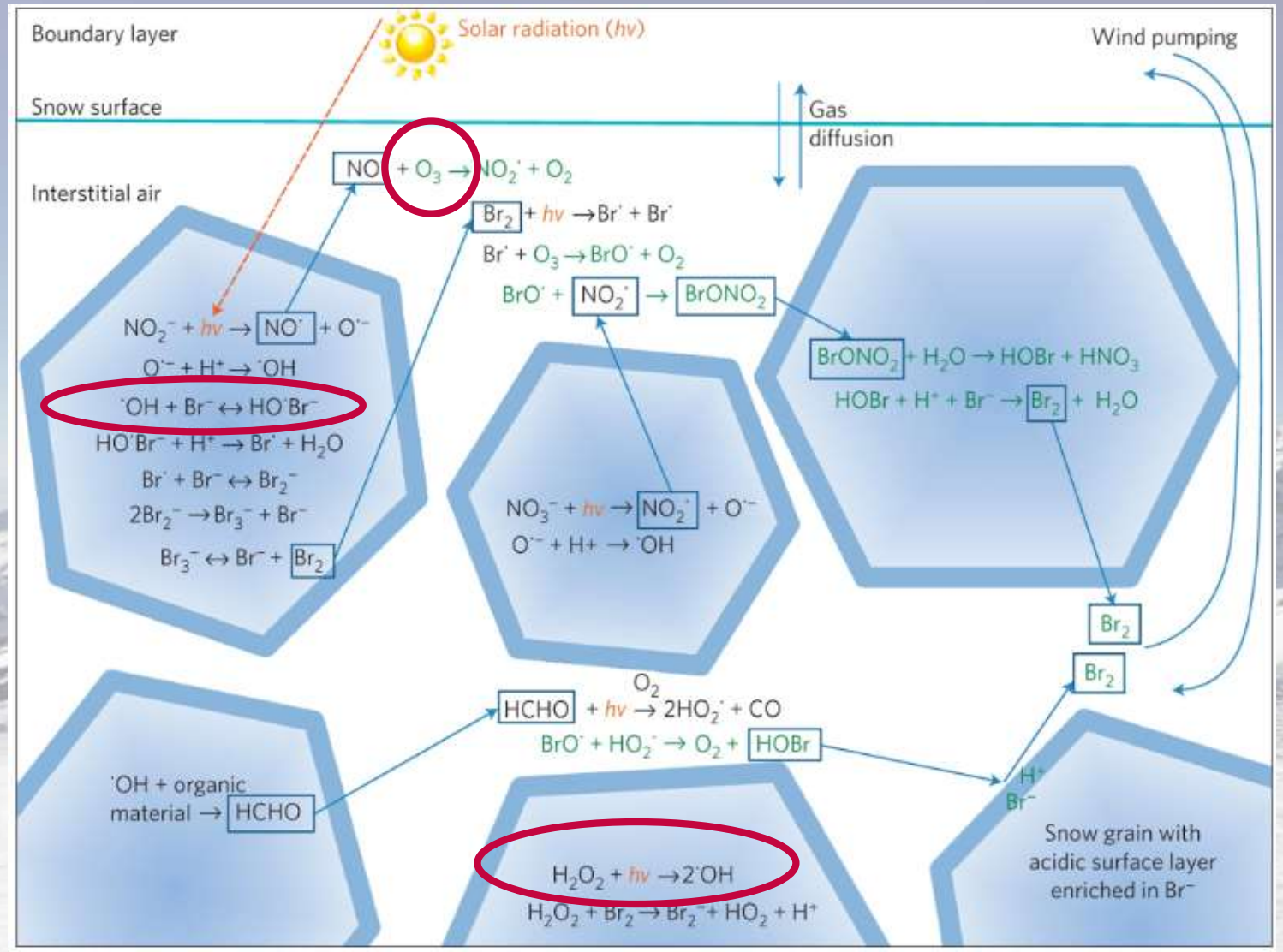



Pratt, Kerri A., et al. "Photochemical production of molecular bromine in Arctic surface snowpacks." *Nature Geoscience* 6.5 (2013): 351-356..
Simpson, W. R., et al. “Halogens and their role in polar boundary-layer ozone depletion” Atmos. Chem. Phys., 7, 4375–4418.

# Bromine and snow photochemistry

- Marine sources
- [Br-] ~ 100 nM
- High photoreactivity in snow

**Is it possible produce $BrO_3^-$?**

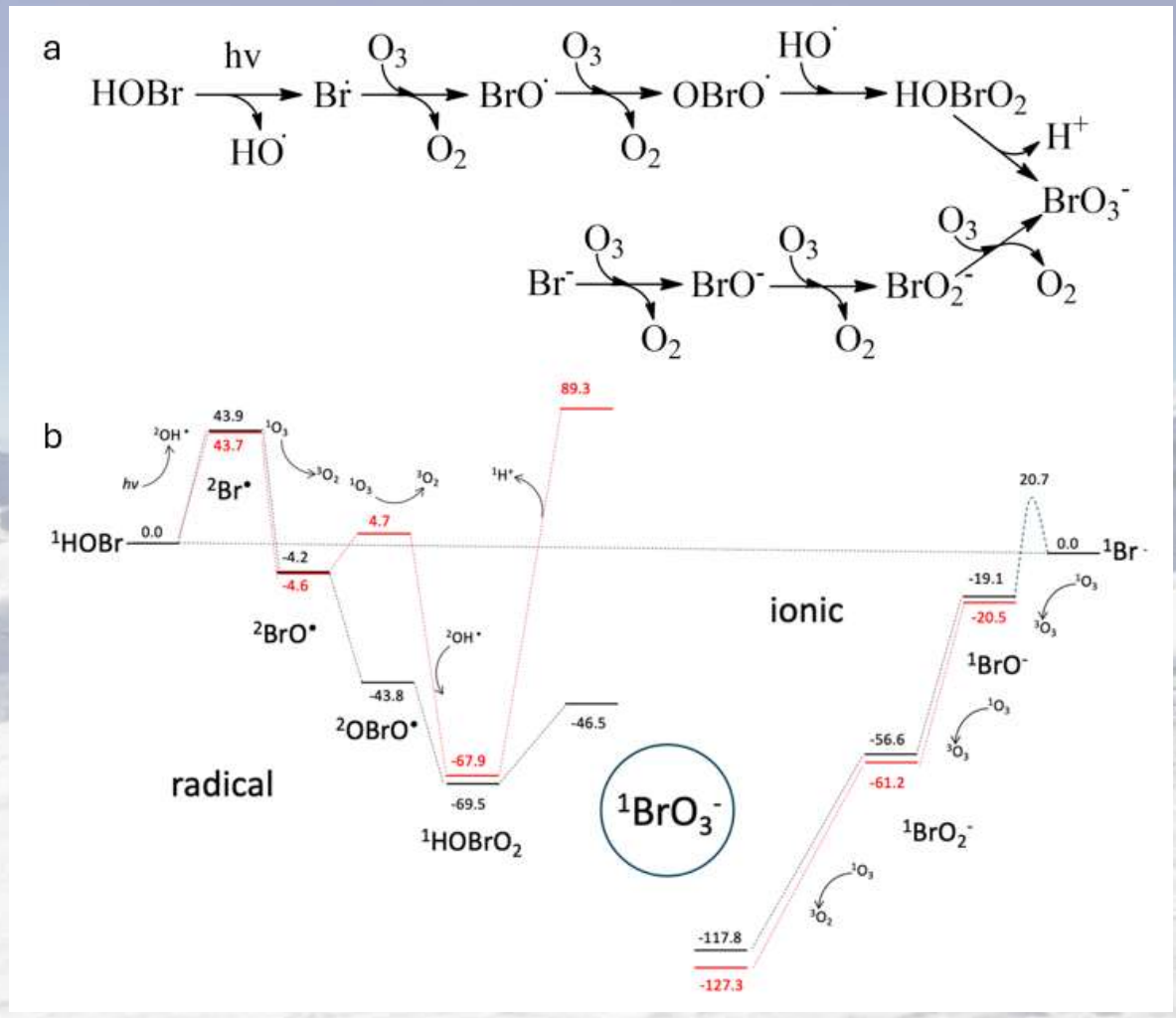



Pratt, Kerri A., et al. "Photochemical production of molecular bromine in Arctic surface snowpacks." Nature Geoscience 6.5 (2013): 351-356.

# Bromine and snow photochemistry

## Why bromate?

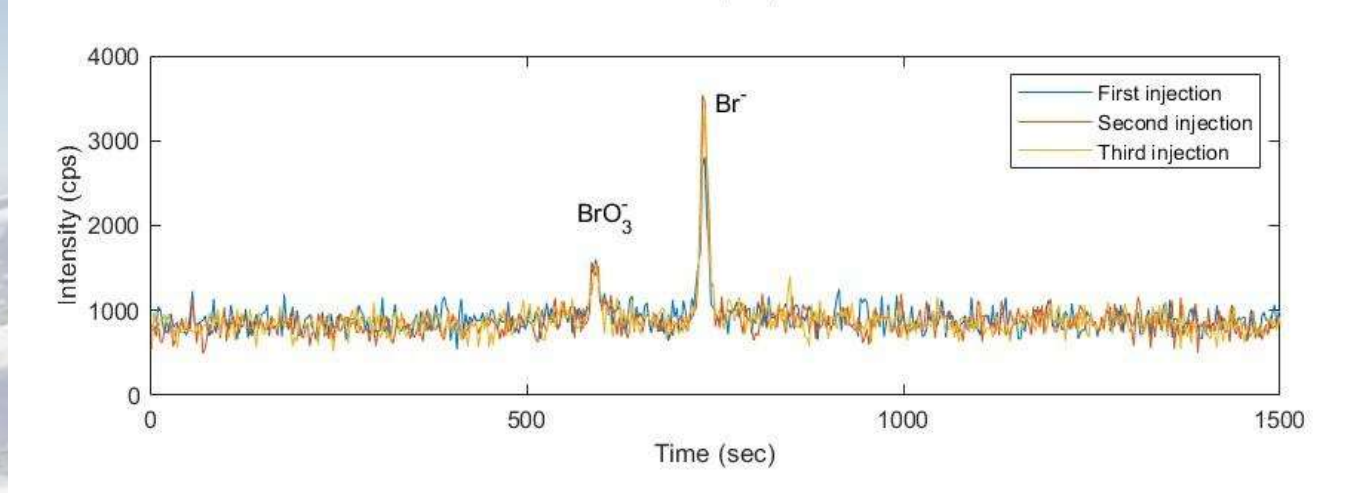
- Well known reactions in water treatment systems
  - More stable than $Br^-$
- Possible stable bromine reserve in snow



# Bromine and snow photochemistry

## Bromate analytical method

- Analysis by IC-ICP-MS
- 1 mL injection volume
- Dionex Ion AS19 2×250 mm + Dionex Ion Pac AG19 guard column




Frassati, Stefano, et al. "Inorganic iodine and bromine speciation in Arctic snow at picogram-per-grams levels by IC-ICP-MS." Journal of Analytical Science and Technology 15.1 (2024): 49.

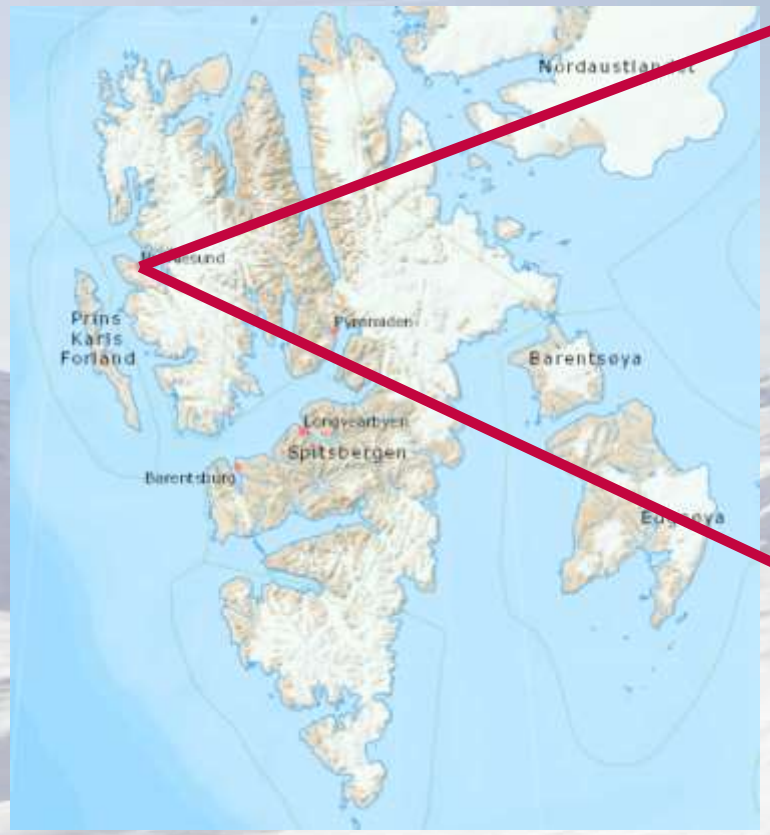
# Linearity, detection limit and reproducibility

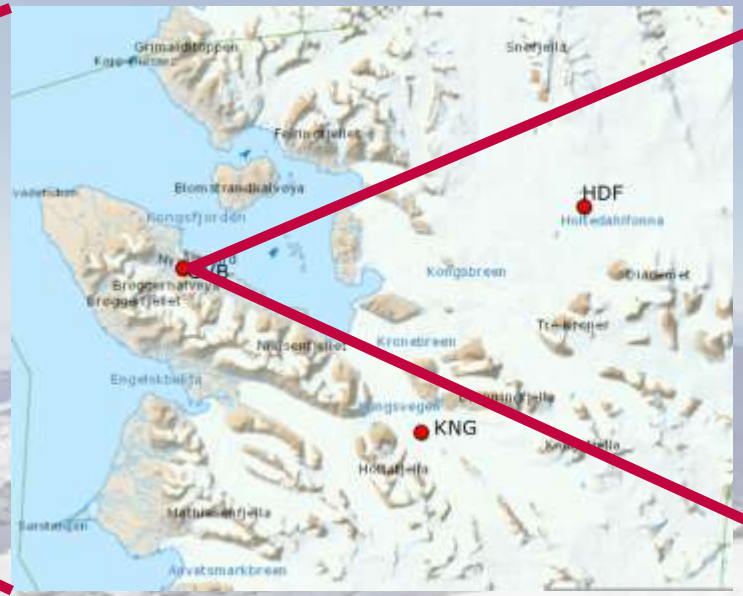
- $R^2 > 0,99$ for all calibration curves
- RSD from 2% $Br^-$ to 8% $BrO_3^-$

| **Species** | LOD (ppt) |
|---|---|
| $I^-$ | 0,4 |
| $IO_3^-$ | 0,8 |
| $Br^-$ | 4 |
| $BrO_3^-$ | 1,2 |

# Bromate production

Experimental design




Daily surface snow

and

Weekly snowpit sampling

GVB

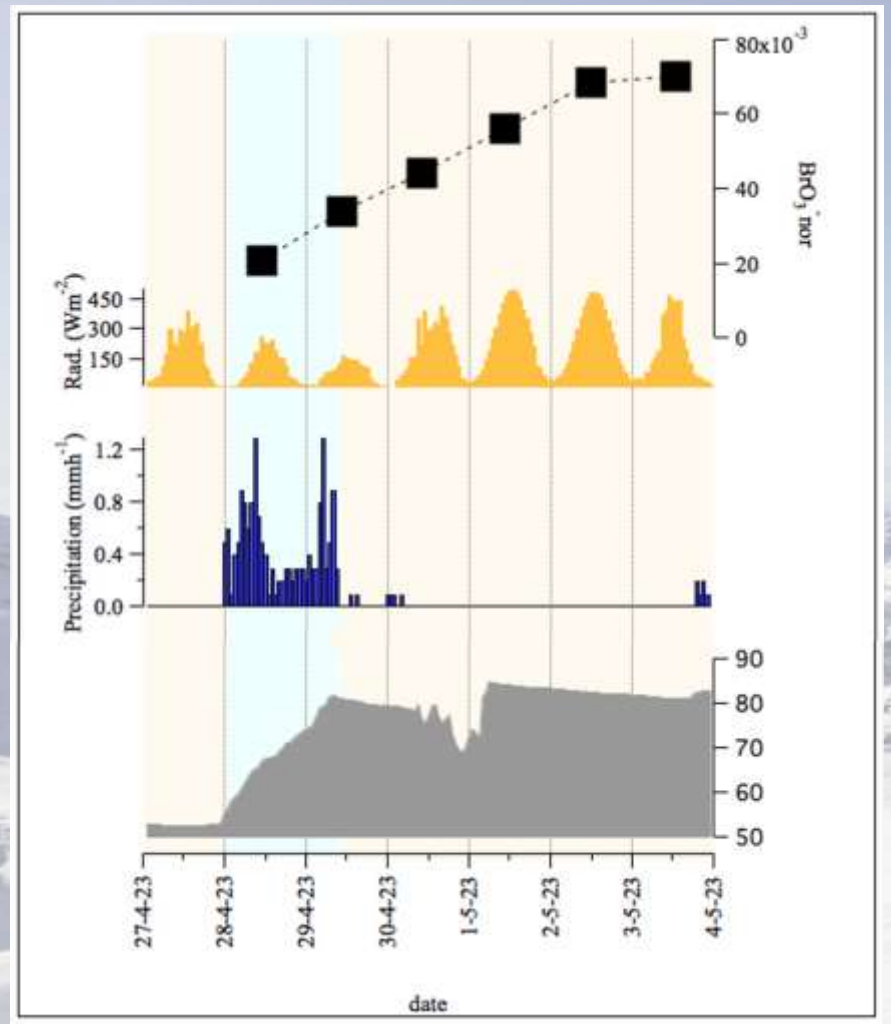
Seasonal snowpit:

HDF 2022

KNG 2015

# Bromate production

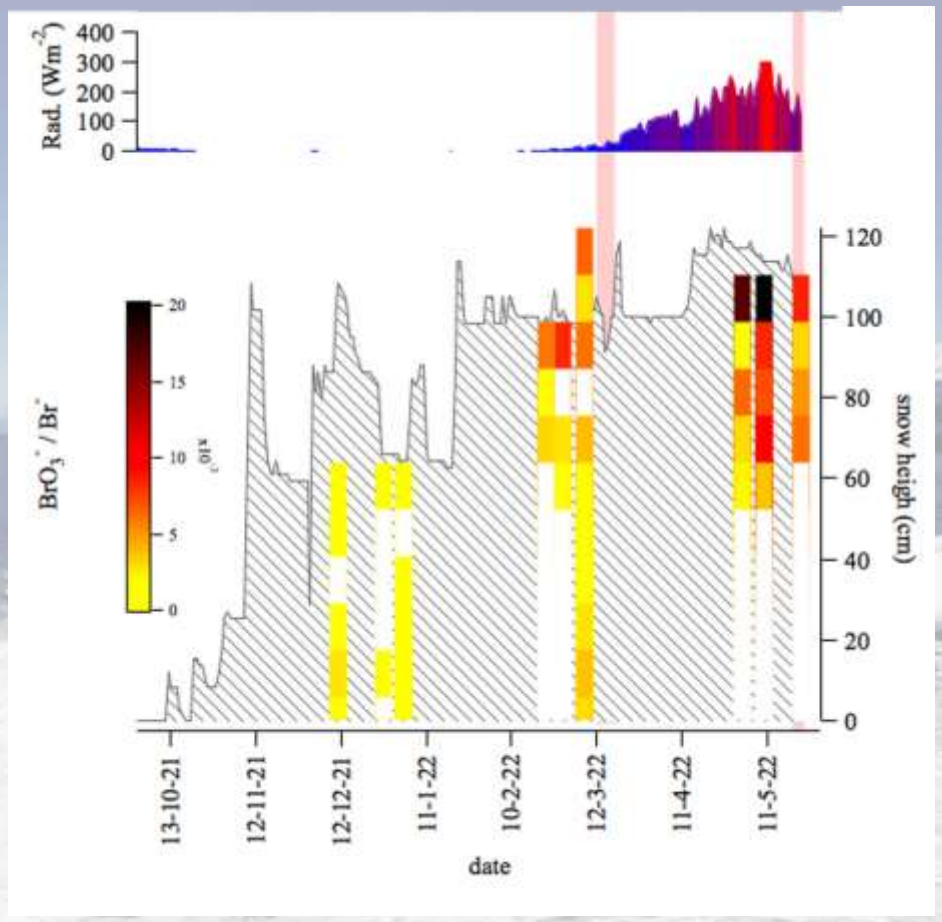
## Daily snow sampling



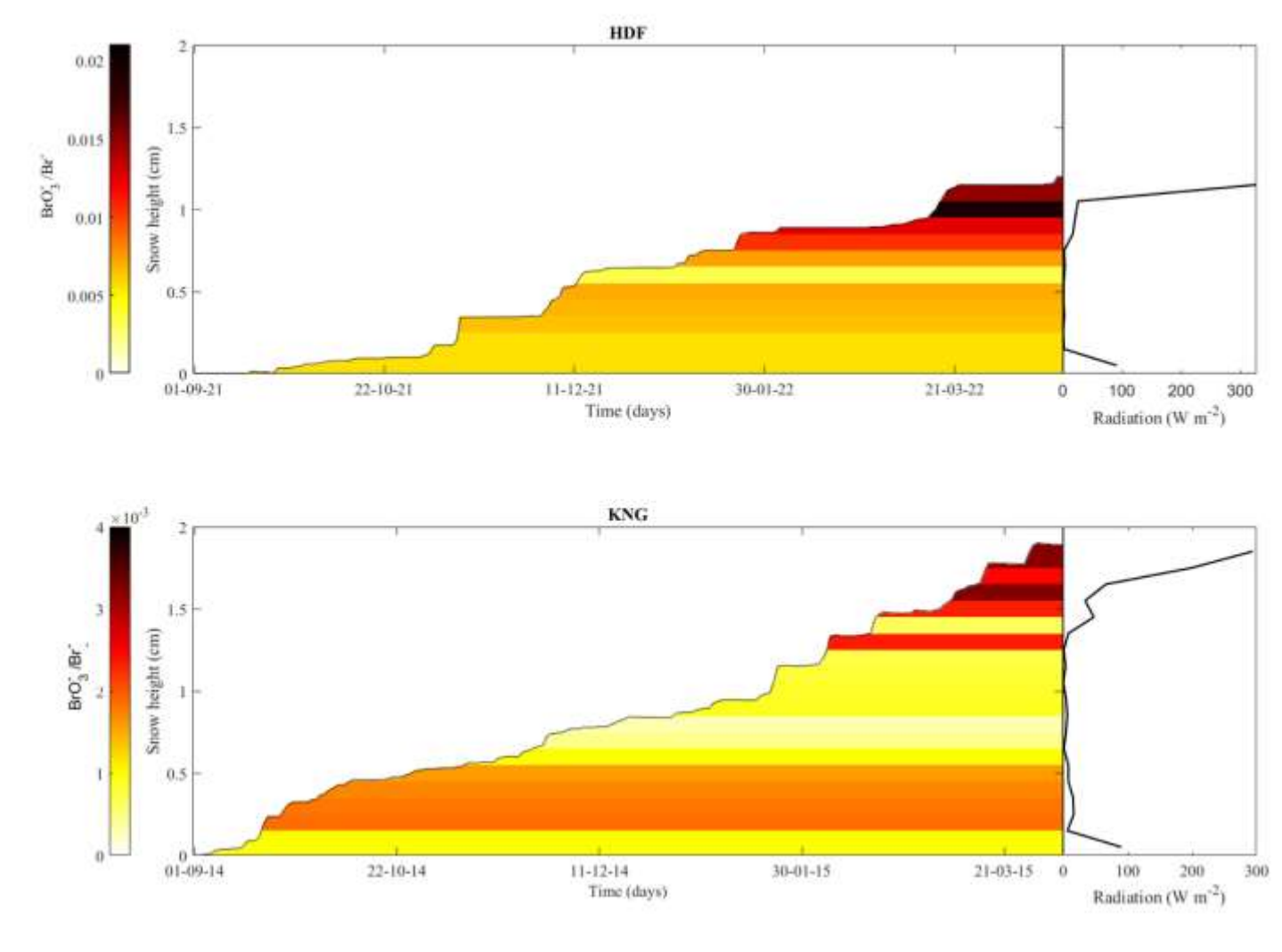

The $BrO_3^-/Br^-$ ratio increases with increasing radiation.

No aerosol contribution

## Weekly snowpit sampling



# Bromate production




Stable reservoire of bromine

up to 5% total bromine

Possible implications of implementing ODE models

# Bromate production

## Sum up

- Development of a method for bromine speciation at the pg $g^{-1}$ level
- Possible complete oxidation of $Br^-$ to $BrO_3^-$
- Formation of a non-reactive bromine reservoir
- Implementation of ozone depletion models considering the role of bromine


Thanks for your attention!

# Bromate concetration