Reactive halogen chemistry in the Arctic boundary layer over snow during spring

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Images by Didier Voisin

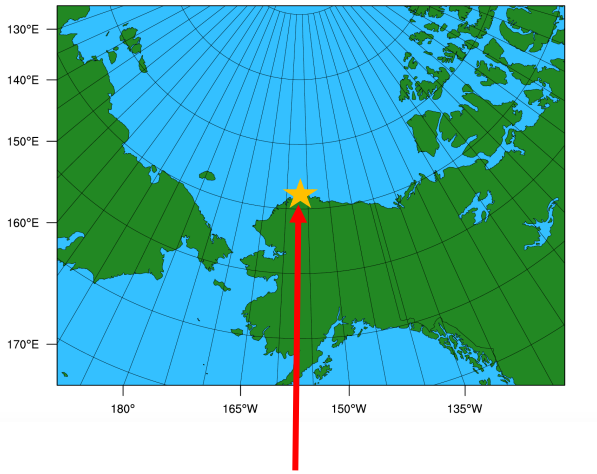
Key highlights

- Halogen emissions from snow & boundary layer dynamics are both important in explaining surface observations and polar boundary layer oxidation chemistry.

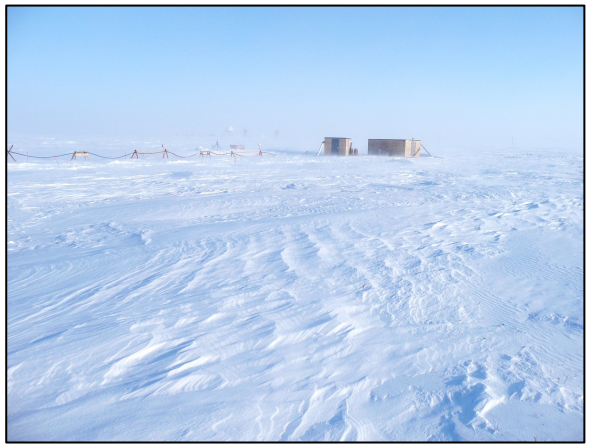
- The lowest portion of the polar atmosphere (~15 m) can experience highly oxidizing chemistry compared to the air above resulting in strong vertical gradients in chemistry and lifetimes.

- Surface HO_x concentrations are increased due to the presence of halogens.

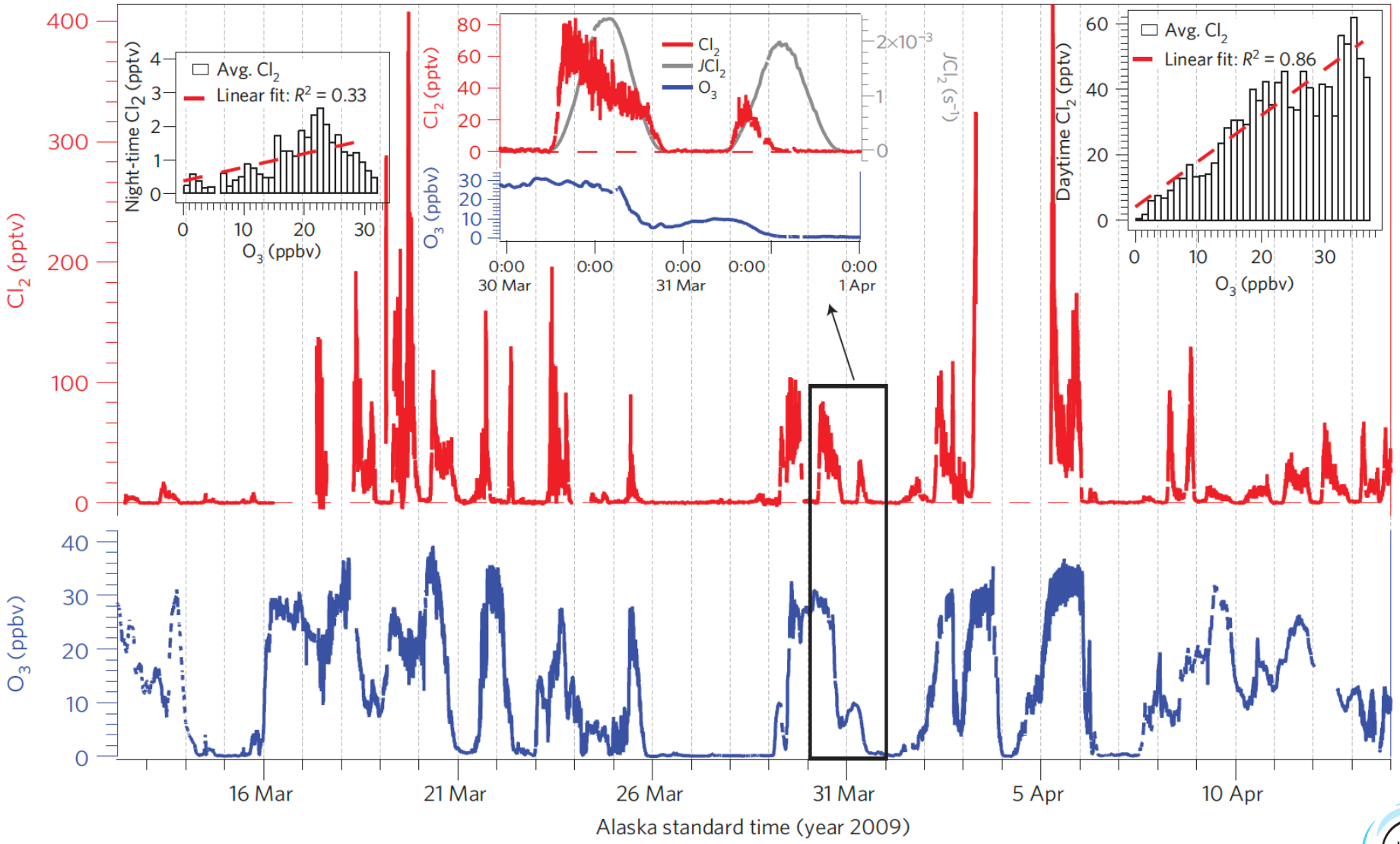
High chlorine concentrations near surface snow



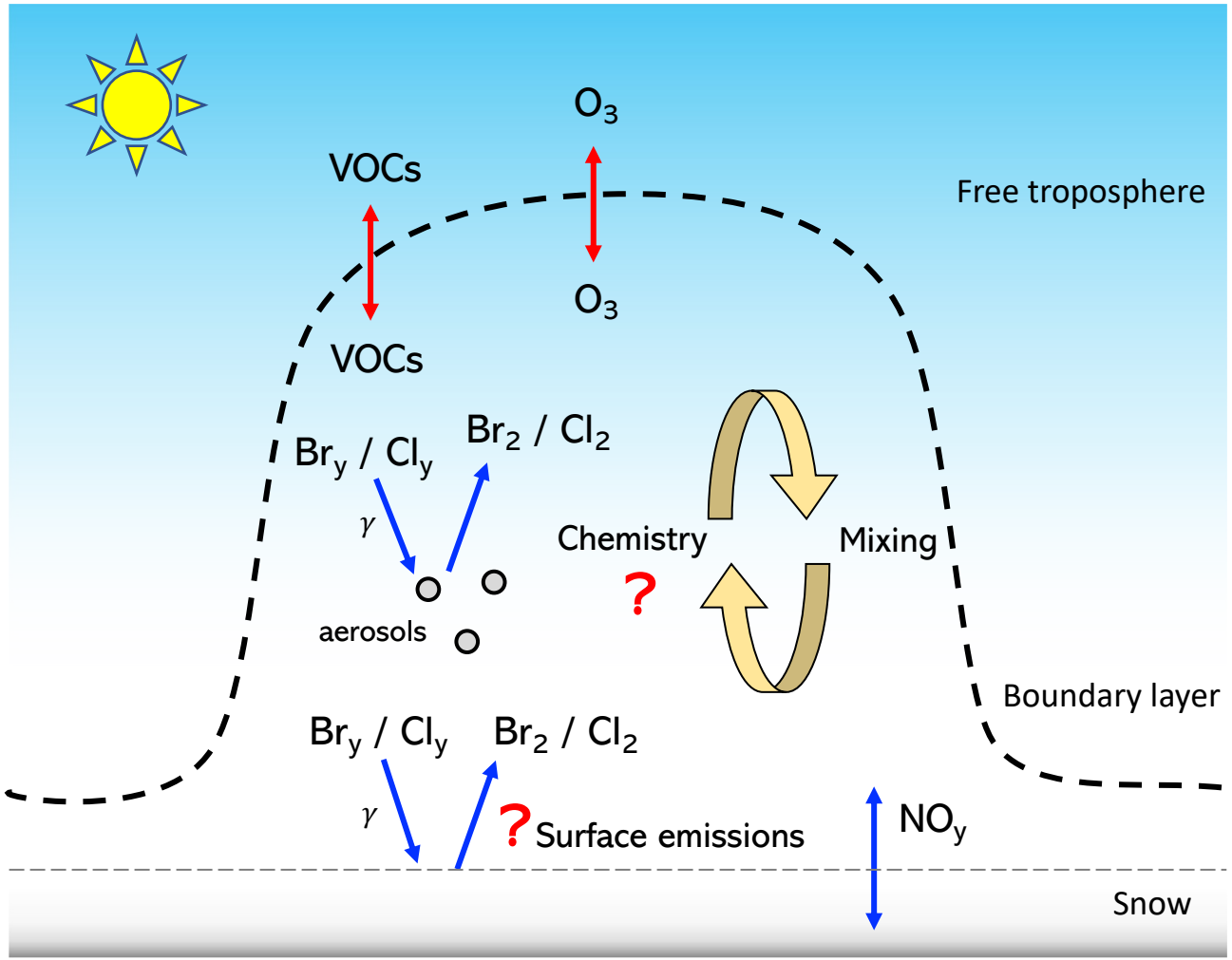
Utqiaġvik, Alaska



Liao et al., Nature Geosci., 2014

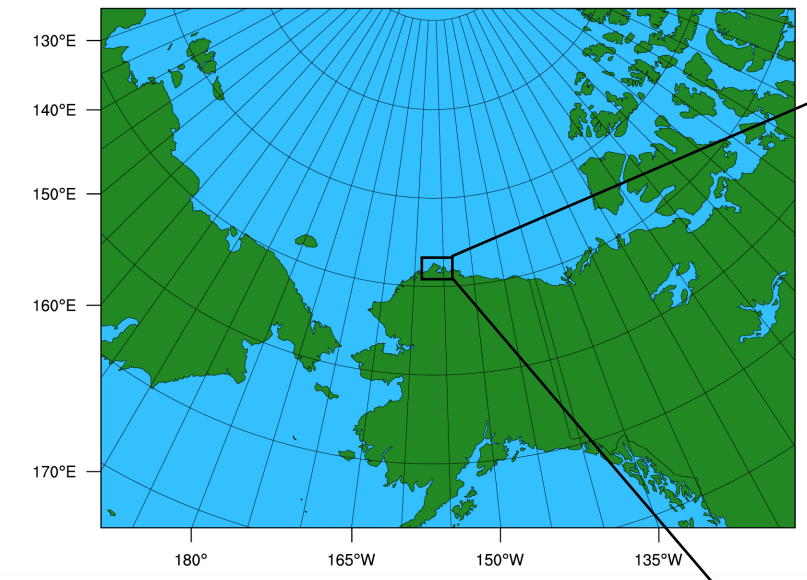


How do halogen emissions from snow impact BL chemistry?



- How do halogen emissions from snow impact oxidative chemistry in the polar boundary layer?
- What is the vertical extent of this impact?
- Can surface observations of halogens and VOCs be explained by considering chemistry, snow emissions, and vertical mixing?

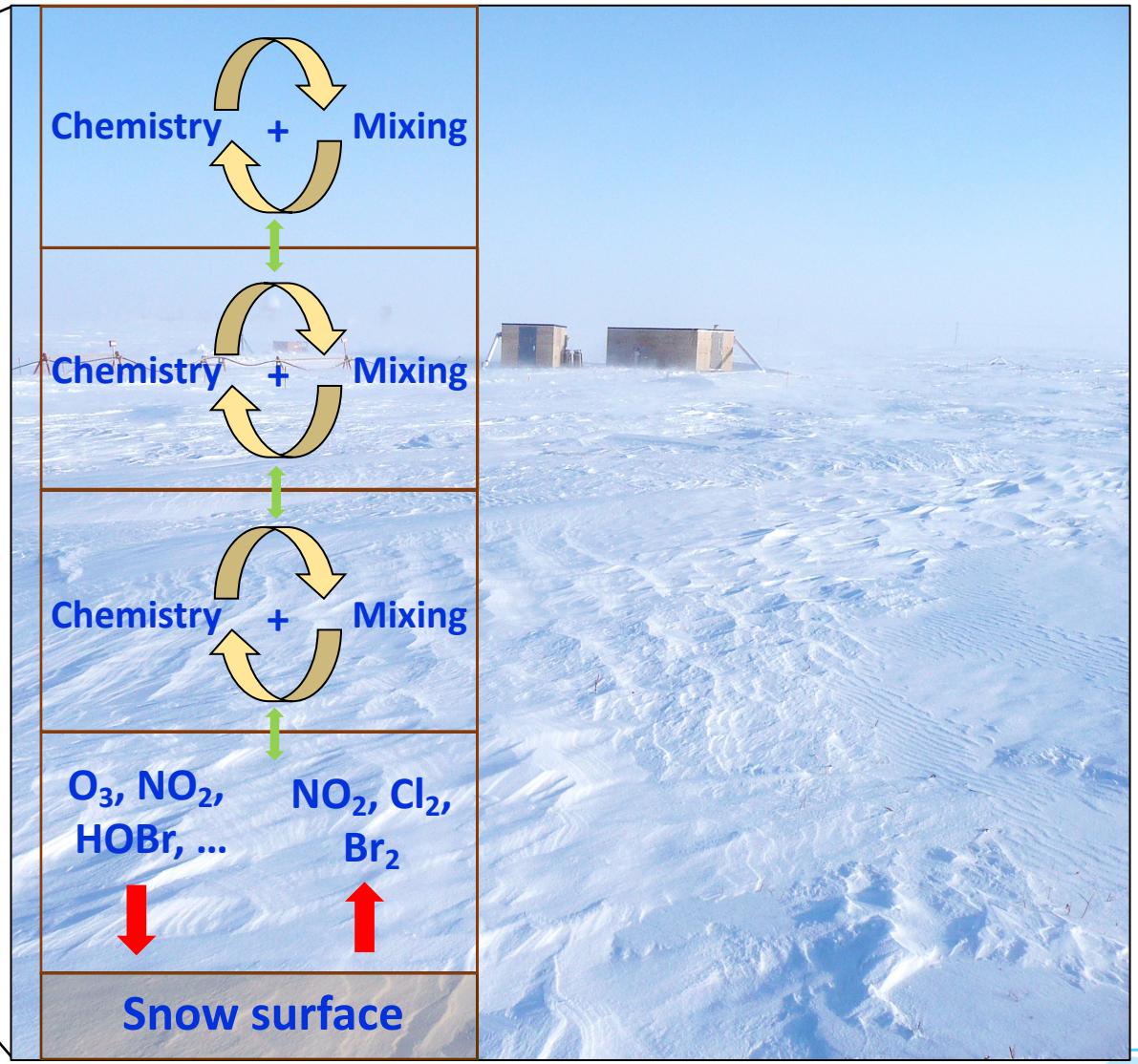
1-Dimensional model (PACT-1D)



OASIS 2009 at Utqiagvik, Alaska

18 – 19 March 2009

- High Cl_2 observations
- Background ozone concentrations
- Pollution-free conditions

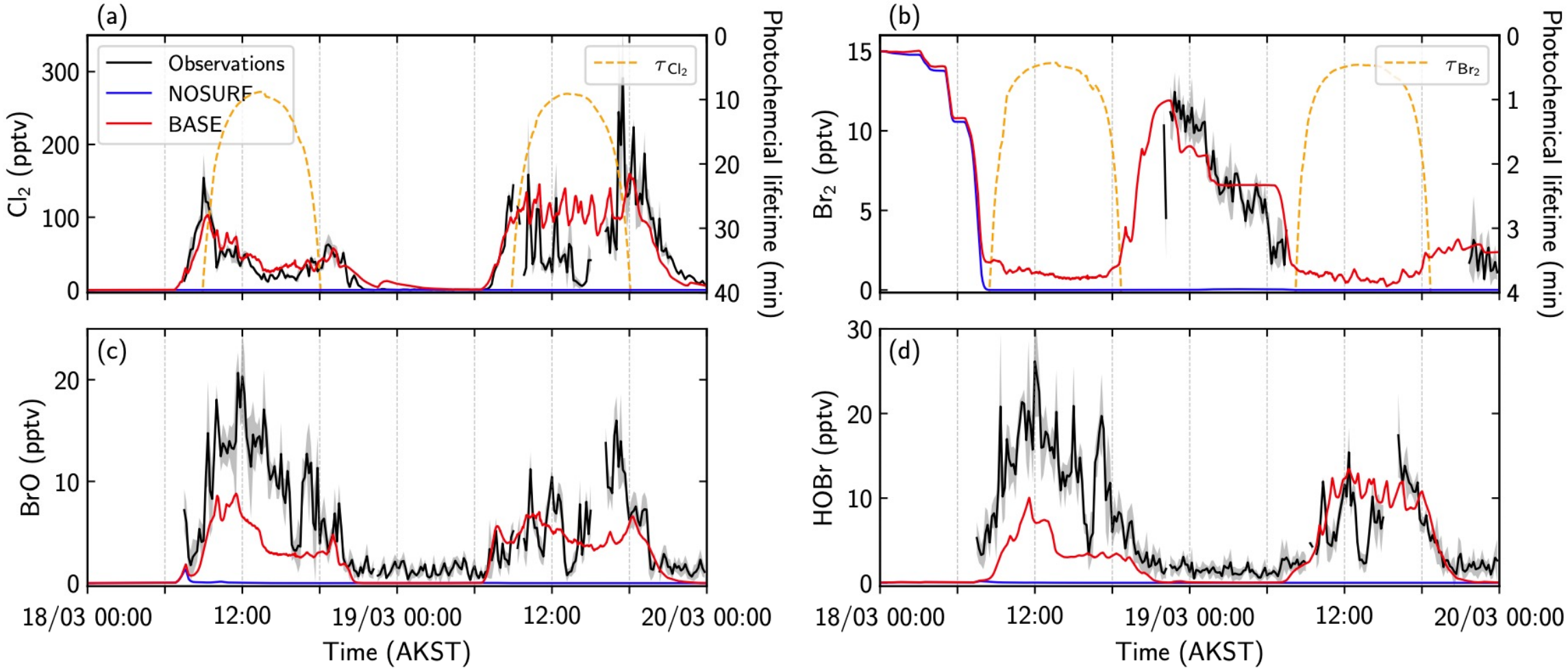


Tuite et al., JGR Atmos., 2021

Ahmed et al., JGR Atmos., 2022

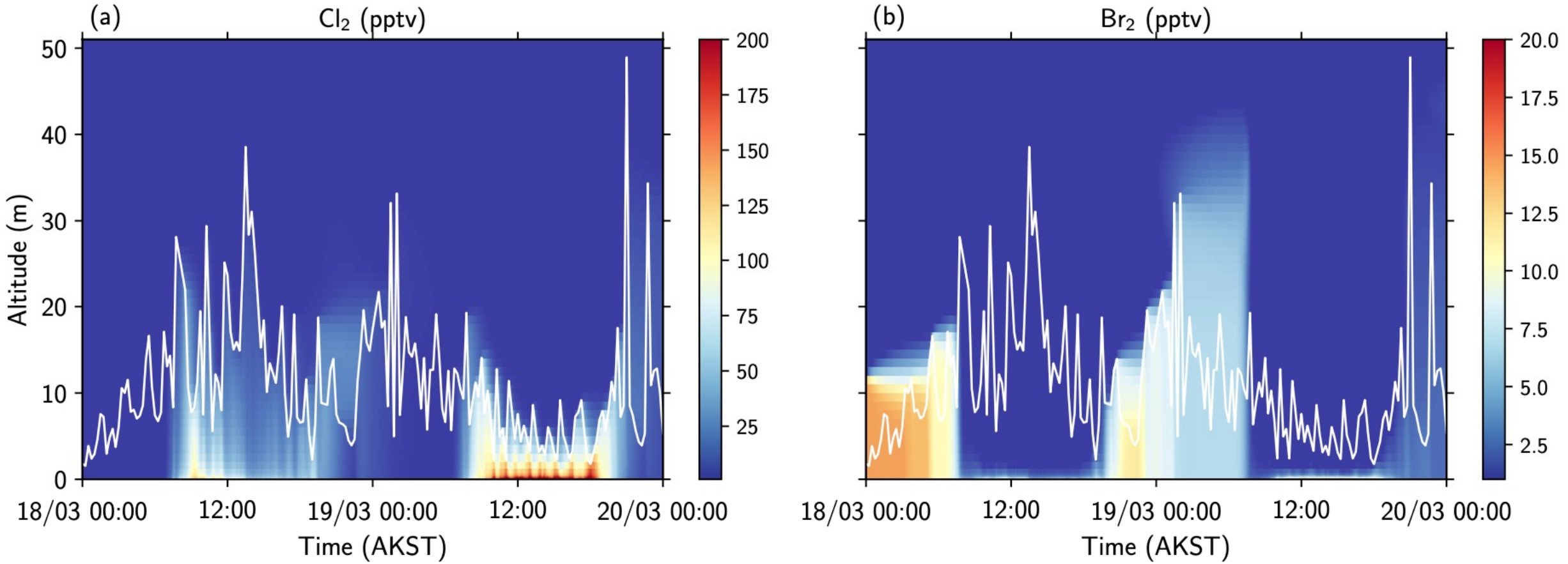
PACT-1D surface halogen prediction vs observations

NOSURF: No snowpack halogen emissions BASE: Halogen surface snow emissions active



Ahmed et al., JGR Atmos., 2022

PACT-1D predicted vertical distribution of Cl_2 and Br_2



Ahmed et al., JGR Atmos., 2022

- Modelled Cl_2 confined to the lowest 15 m of the atmosphere
- Halogen vertical distribution is highly impacted by boundary layer dynamics

Thank you for your attention

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Additional information

Work described in Ahmed et al., JGR Atmos., 2022

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RESEARCH ARTICLE

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Key Points:

- A combination of factors including snow emissions, vertical mixing, and atmospheric chemistry explain surface Arctic halogen observations
- Snow emissions of halogens impact atmospheric chemistry within a shallow layer near the surface

The Role of Snow in Controlling Halogen Chemistry and Boundary Layer Oxidation During Arctic Spring: A 1D Modeling Case Study

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Model code available on GitHub:

https://github.com/PACT1D/PACT-1D-HALOGENS/releases/tag/v1.1

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