

Update from the 3rd Workshop on Air Ice Chemical Interactions (AICI 2011)

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(with thanks to Paul Shepson, Markus Ammann,
Florent Domine, Kenjiro Toyota, and Jennie Thomas)

OASIS Meeting – Telluride, CO

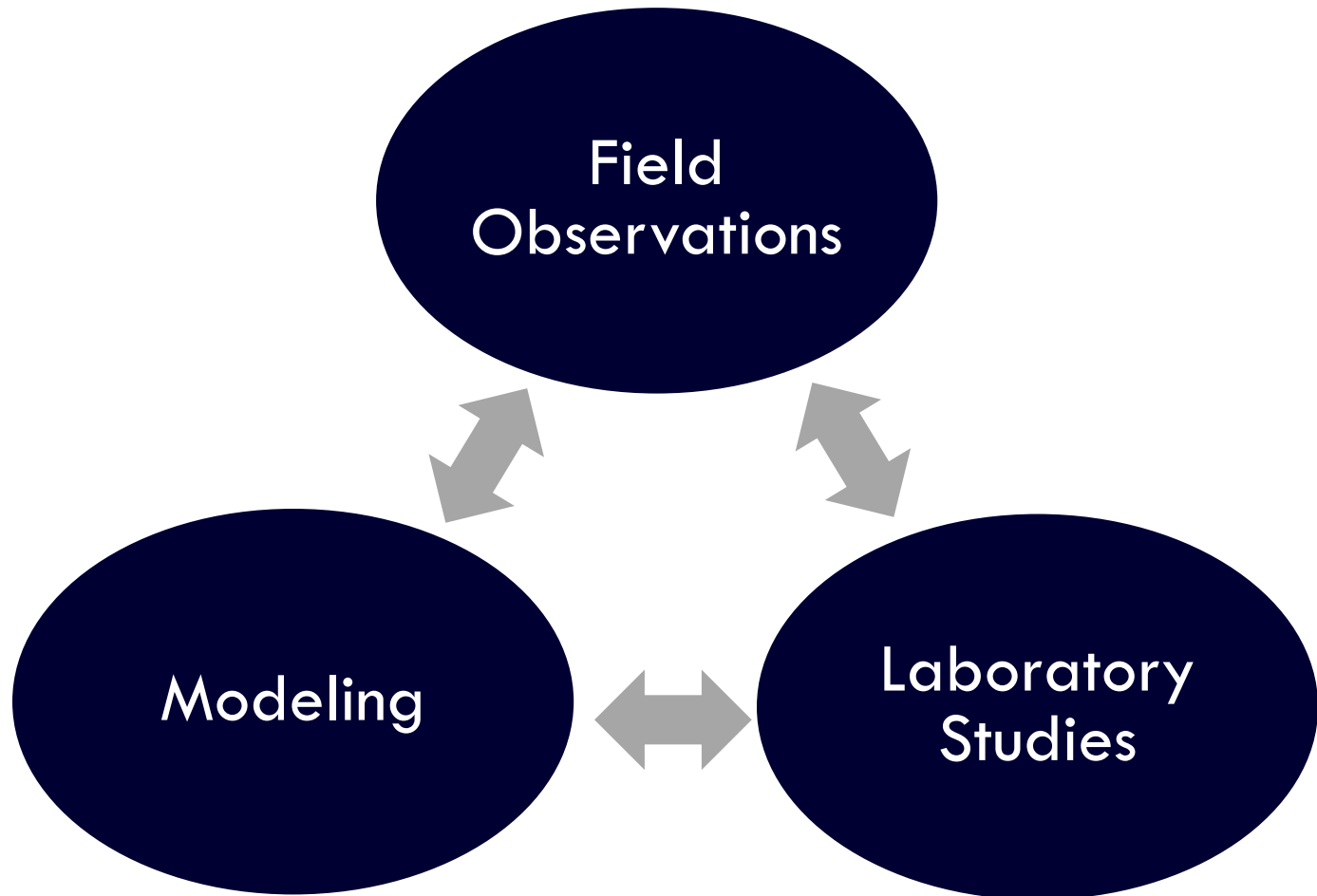
June 21, 2011

AICI: Air-ice chemical interactions

Motivated by atmospheric chemistry.

- Polar Stratospheric Cloud particles and Stratospheric Ozone Depletion *Solomon et al (1986), Molina et al (1987)*
- Cirrus ice and NO_y chemistry of upper troposphere
Gamblin et al. (2006), (2007), von Kuhlmann and Lawrence (2006)
- Air-snowpack exchange
Domine and Shepson (2002), Grannas et al. (2007)
- Role in halogen activation in polar BL *Simpson et al. (2007)*

AICI Motivation



AICI History

- 2005: Grenoble, France (LGGE)
 - Special issue in *Atmos. Chem. Phys.*
- 2008: Cambridge, UK (British Antarctic Survey)
- 2011: New York, NY (Columbia University)

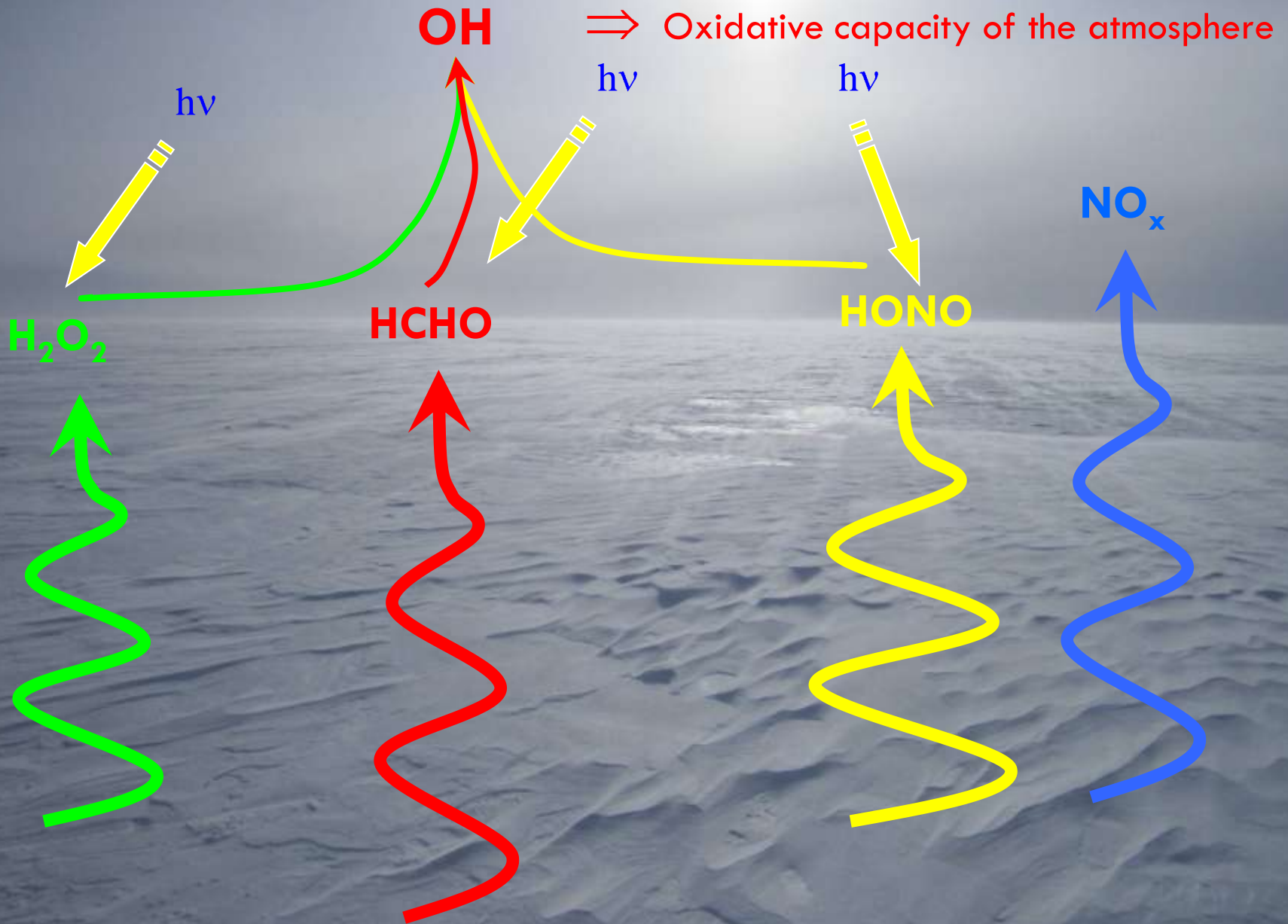


AICI 2011

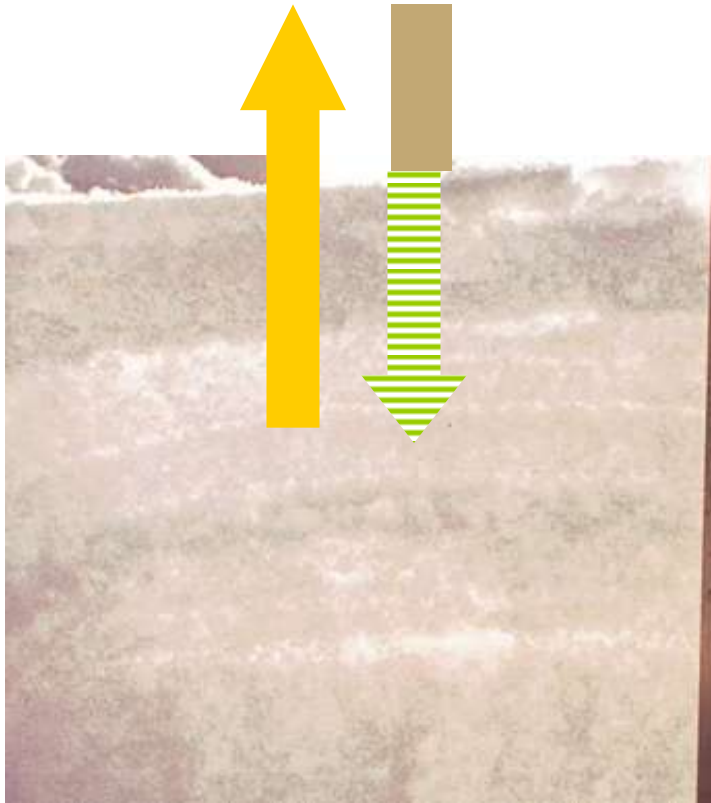
Meeting Objectives and Scope

- Forum to bring together new insights from AICI studies over the last 8 years, including work carried out as part of OASIS, HitT and IPY.
- 1-day workshop on Snow Chemistry Modeling
- Review Articles
- Future of AICI

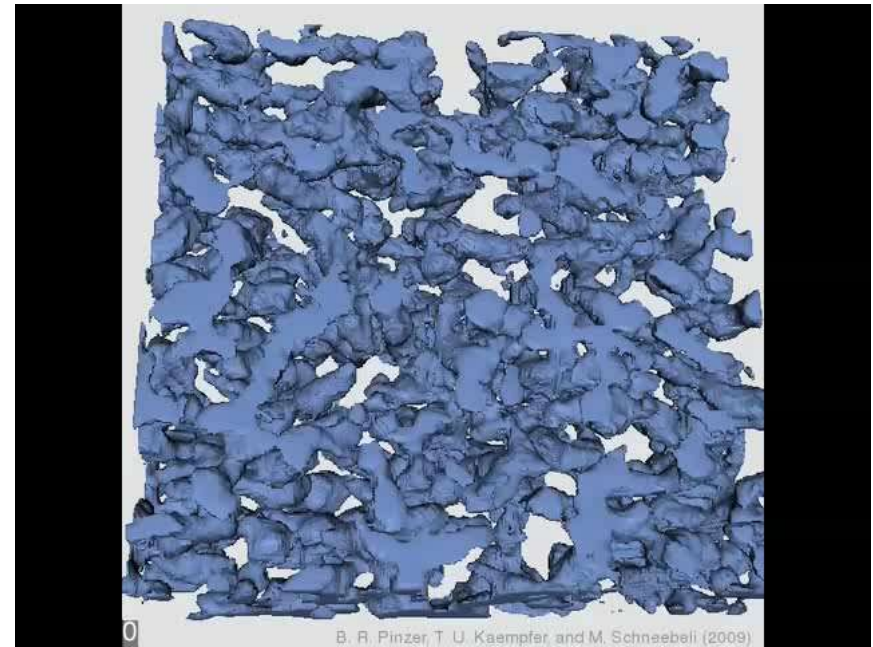




AICI: Physical (“macro”) processes

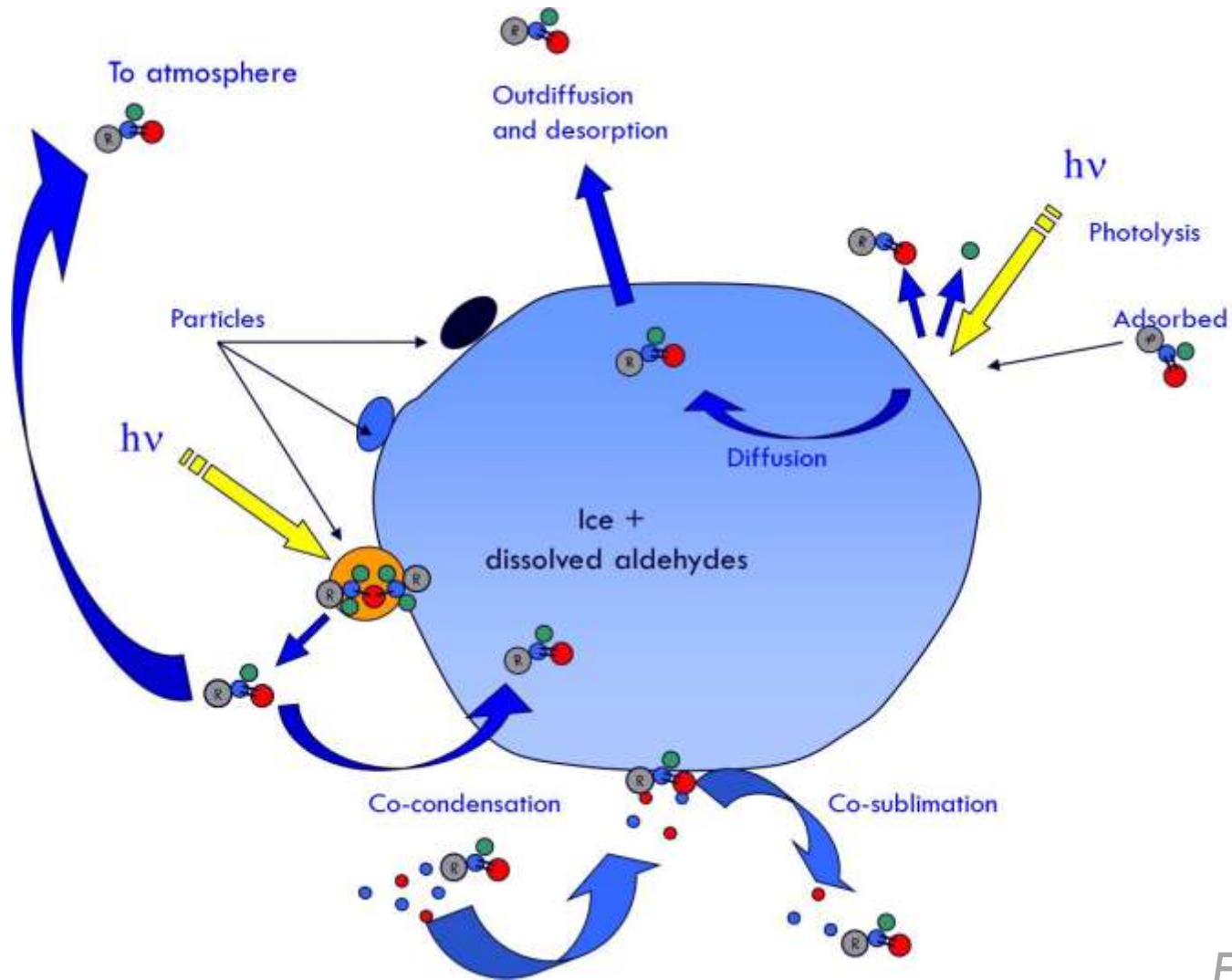


Transport processes in and out of snow



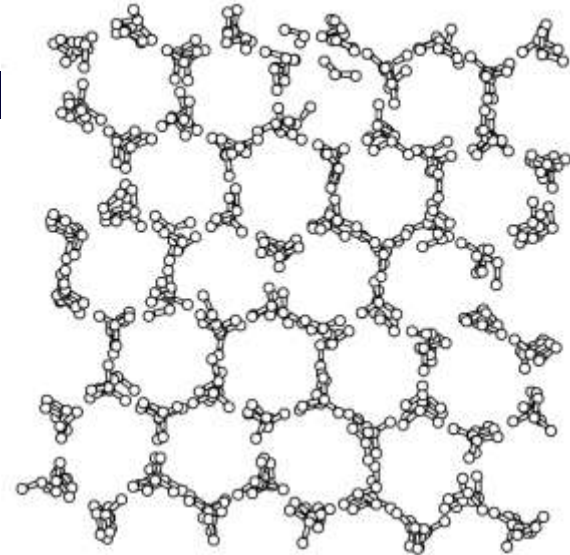
Snow metamorphism

AICI: Microscale

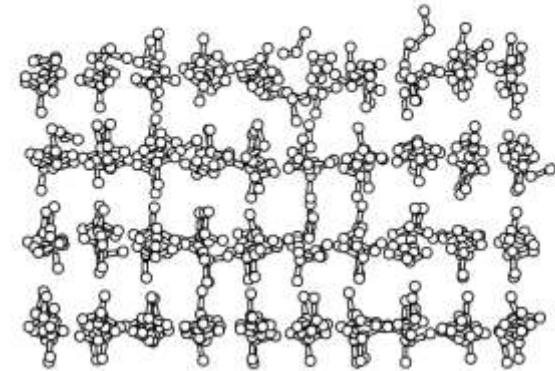


Quasi-liquid layer on ice

- Nanoscale region of disorder at surface
- Not true liquid! Distinct from brine.
- Thickness increases with increasing temperature



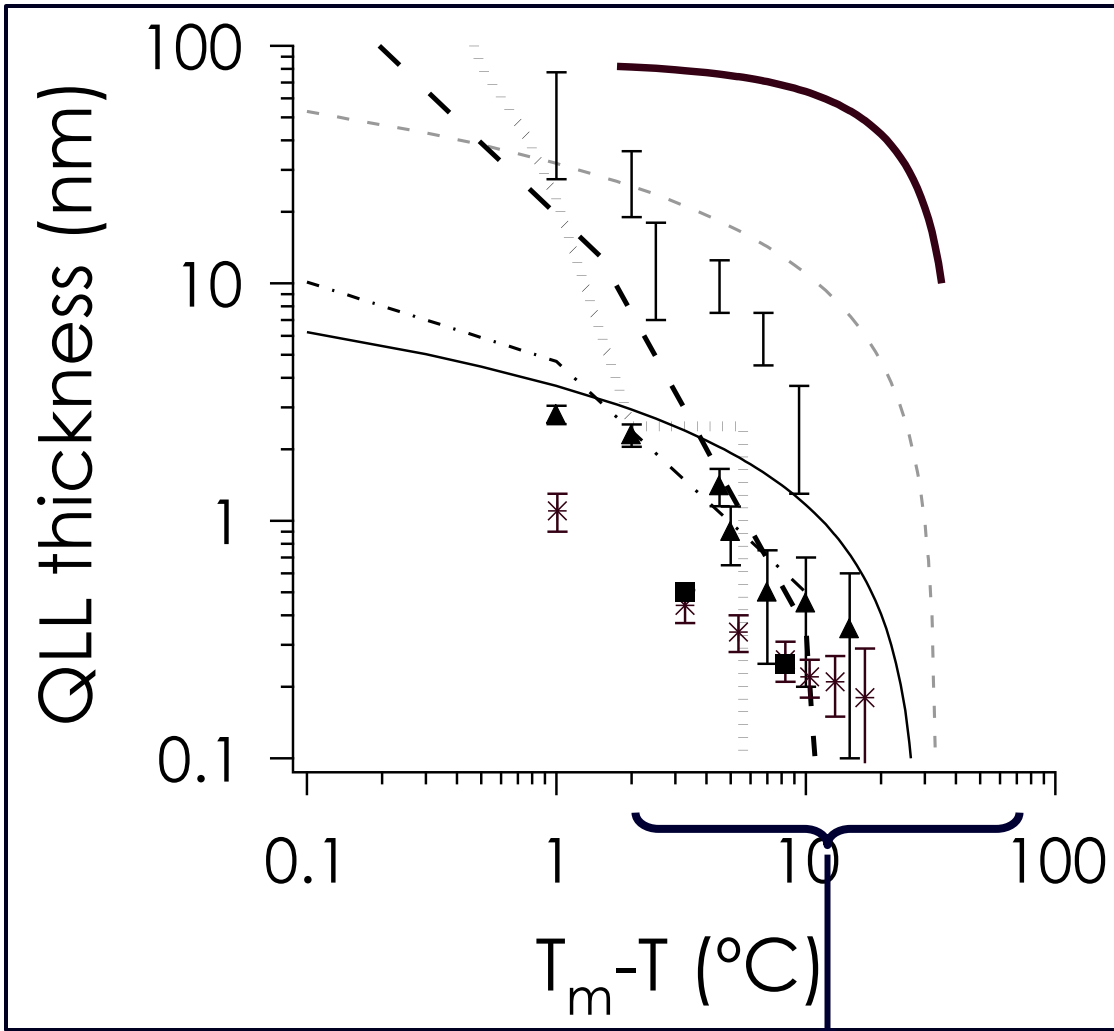
(a)



(b)

Disordered ice surface, 190 K

QLL on pure ice

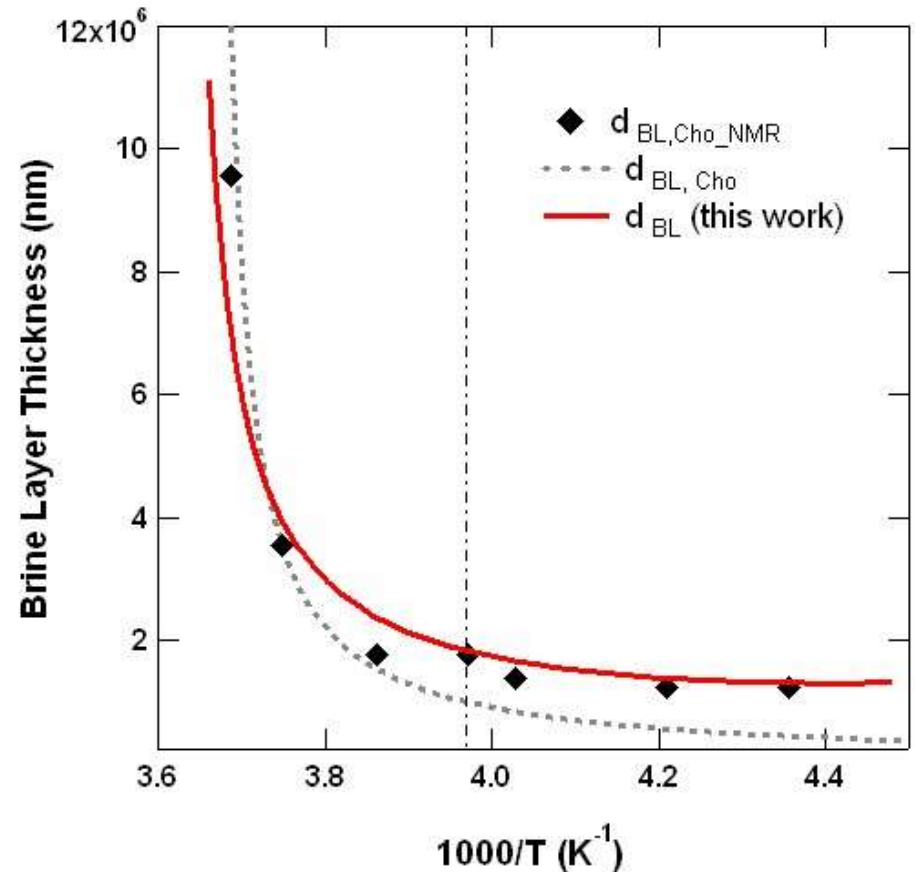


- Onset temperature, thickness measured dependent on technique
- Which technique most relevant for chemistry?
- Better just to measure chemistry as $f(T, x, \text{QLL})$?

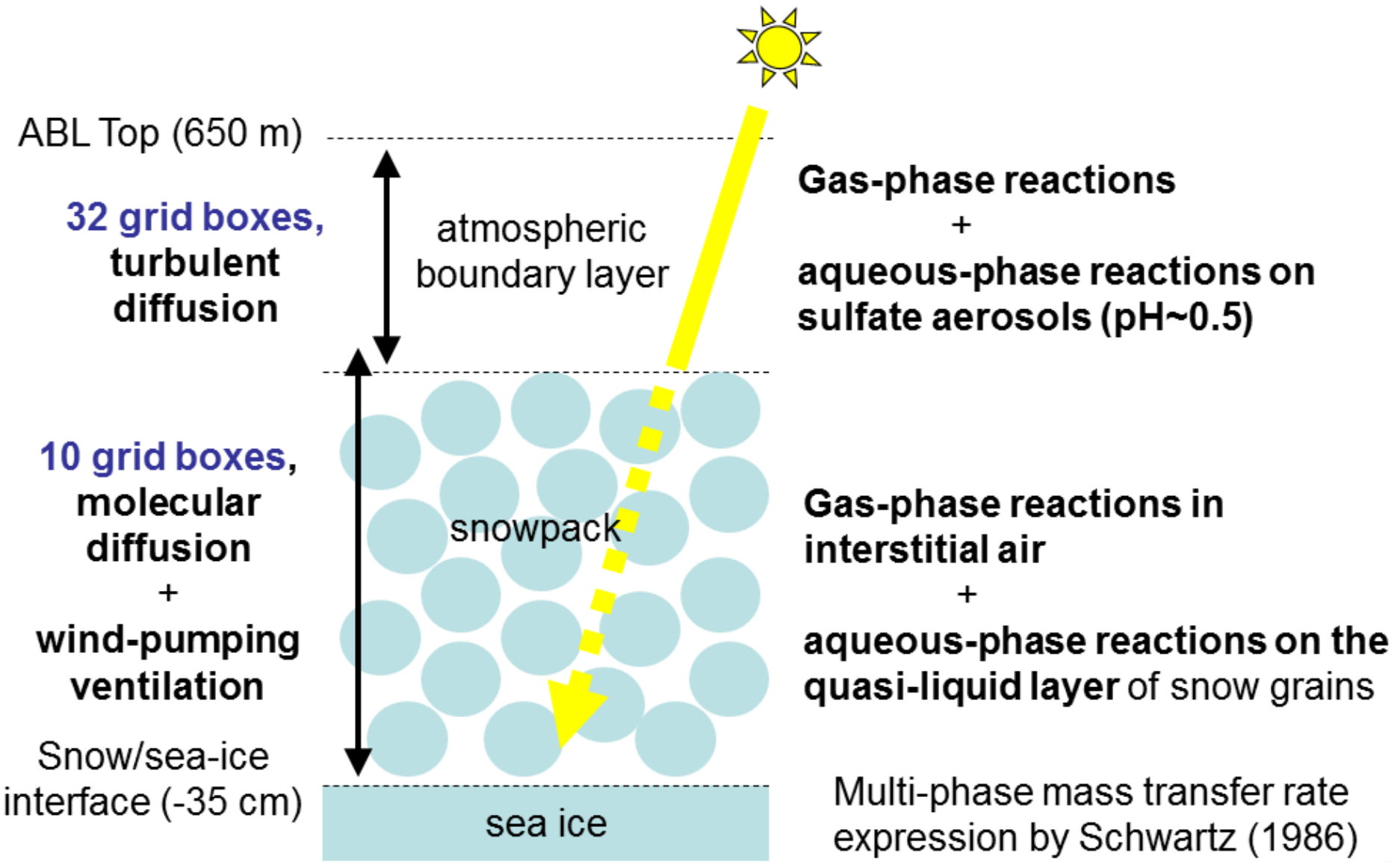
Literature Summary : $-2 \text{ }^\circ\text{C} < T_{\text{QLL}} < -80 \text{ }^\circ\text{C}$

Brine

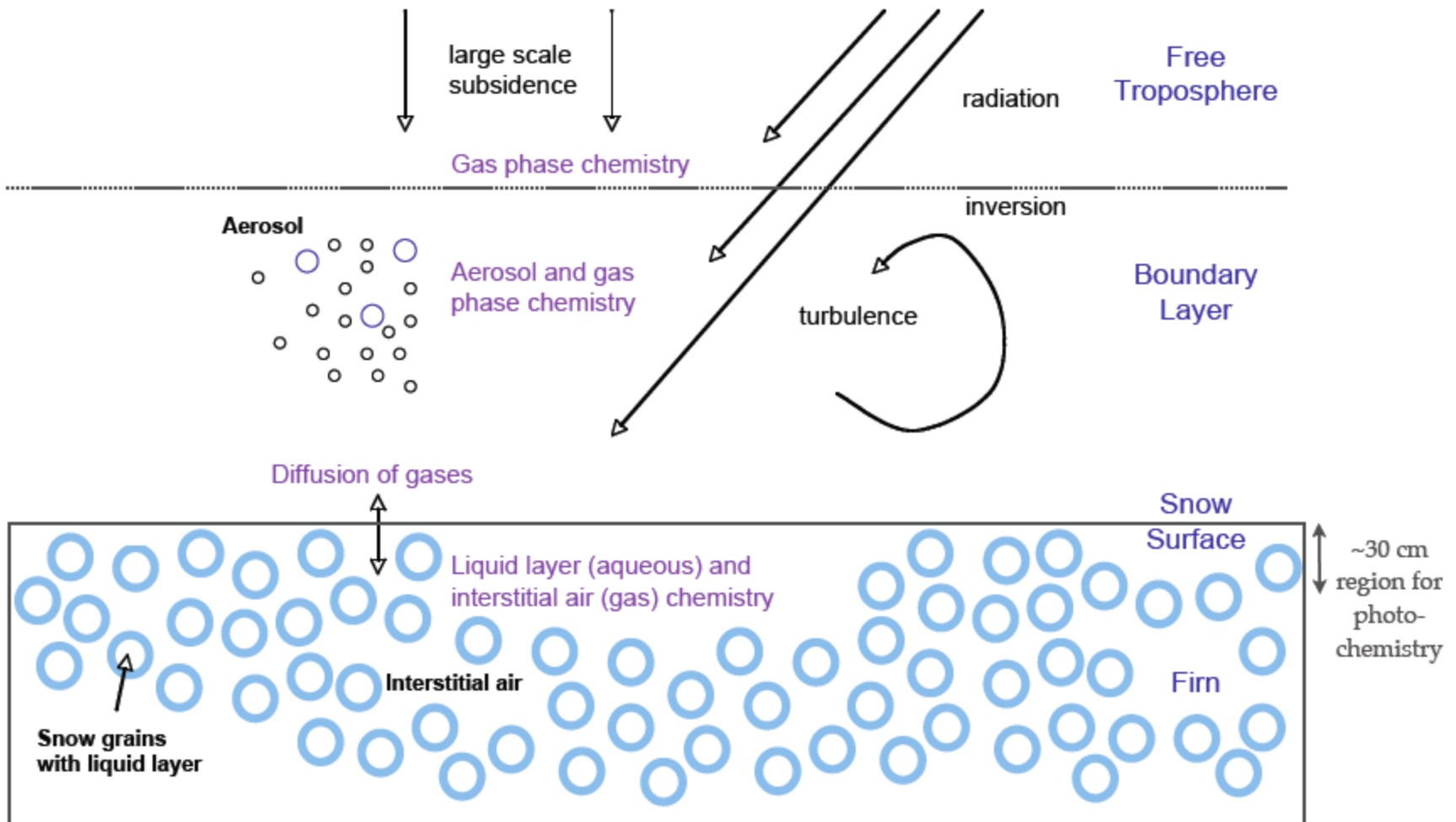
- Formed by solute rejection upon freezing
- Pockets, layers
- True liquid, described well by equilibrium thermodynamics
- How is it different from
 - ▣ Solute-containing QLL (cleanish snow, lab ice)?
 - ▣ Bulk aqueous-phase chemistry (besides freeze concentration effects)?



PHANTAS model – Kenjiro Toyota

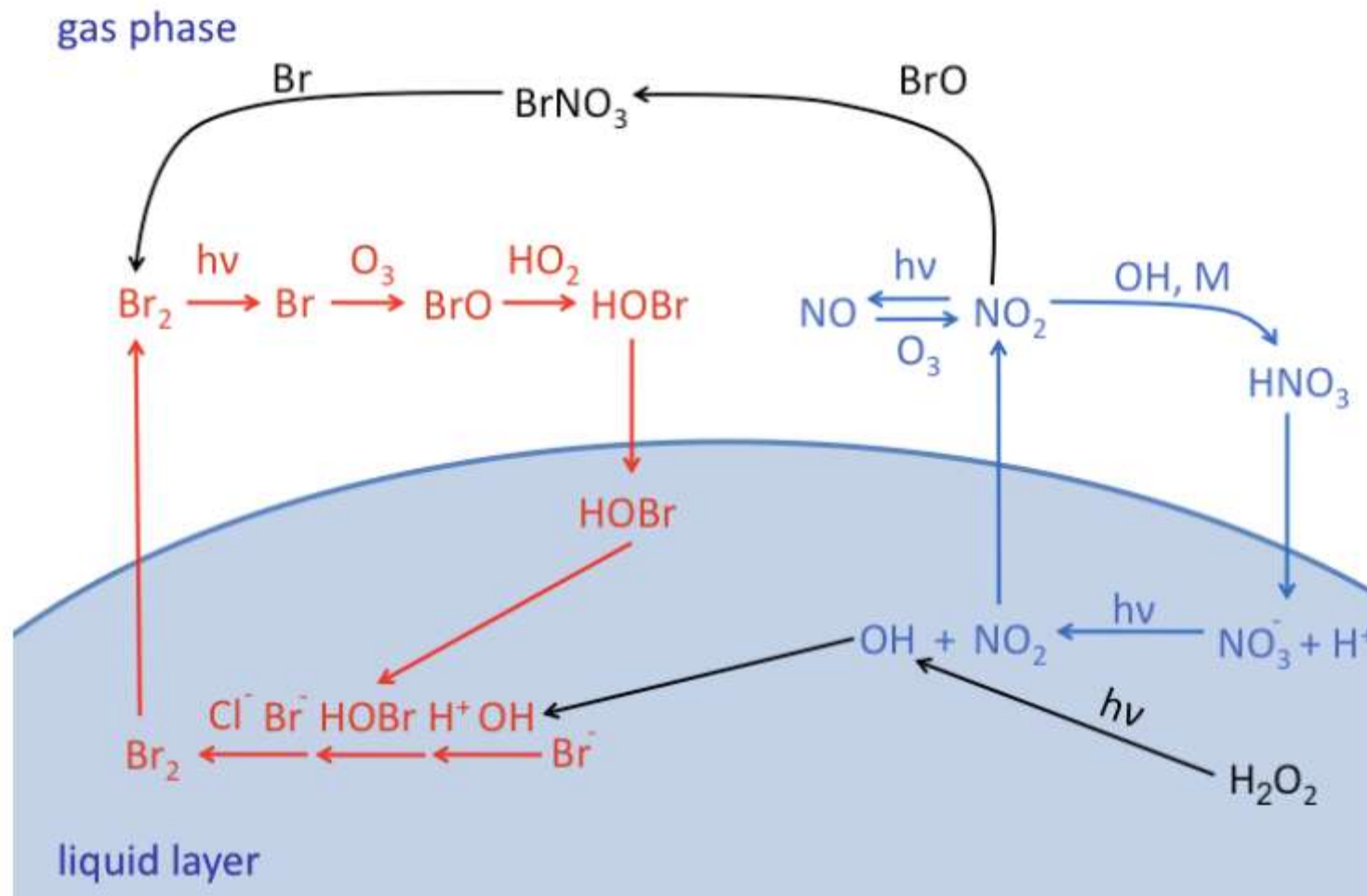


A SIMPLIFIED VIEW OF THE COUPLED SNOW-ATMOSPHERE SYSTEM



SUMMARY OF NO_x AND BROMINE CHEMISTRY OCCURRING AT SUMMIT

Jennie
Thomas



Modeling AICI: Challenges and unknowns

- Many molecular-scale and microscale processes poorly constrained
- Some of the things we don't know (completely):
 - ▣ What kind of surface is presented to the gas phase?
 - ▣ WHERE are the reactions occurring?
 - ▣ Chemical mechanisms & their rates?
 - ▣ Physical models/parameters for uptake
 - ▣ What else besides the ice & gases do we need to consider (Biology)?
- How much detail do we really need to know in order to model the system well? Which processes are important?

“So, in other words:

We don’t understand our container.

We don’t understand the bulk solvent.

We don’t know what our reactants are.

**We don’t know where they are in the container
or what their concentrations are.”**

-Paul Shepson

Future of AICI...

- Continue productive communication among field, lab, and modelers (more workshops!)
- Focus on modeling
- Importance of connecting AICI community to other Earth System areas
 - Biology
 - Hydrology
 - Climate
 - Etc.
- AICI and changing climate

Review Articles

Joint special issue between
Atmospheric Chemistry and Physics and
Earth System Science Data:



New Perspectives on Air-Ice Chemical Interactions (AICI)

Editors: V. Faye McNeill, Thorsten Bartels-Rausch, Eric Wolff

- Organized by science topic, integrating field/lab/modeling.
- Not only update since 2007 special issue. Retrospective, but written from the newly updated perspective of the current state of the science

Review Articles

- ▣ Halogen-Ice Interactions in the Polar Boundary Layer *Jon Abbatt, Lead*
- ▣ Influence of Snow and Ice Microstructure on AICI *Thorsten Bartels-Rausch, Lead*
- ▣ Organic Material in Environmental Ices: Sources, Chemistry, and Impacts *Faye McNeill, Lead*
- ▣ Polar Measurements *Rolf Sander and Paul Shepson, Leads*
- ▣ AICI and climate *Paul Shepson, Lead*
- ▣ AICI and POPs *Amanda Grannas, Lead*

Acknowledgements

- Paul, Paty, Jan
- Paul Shepson & Eric Wolff
- Thorsten Bartels-Rausch
- Hans-Werner Jacobi
- McNeill Group

