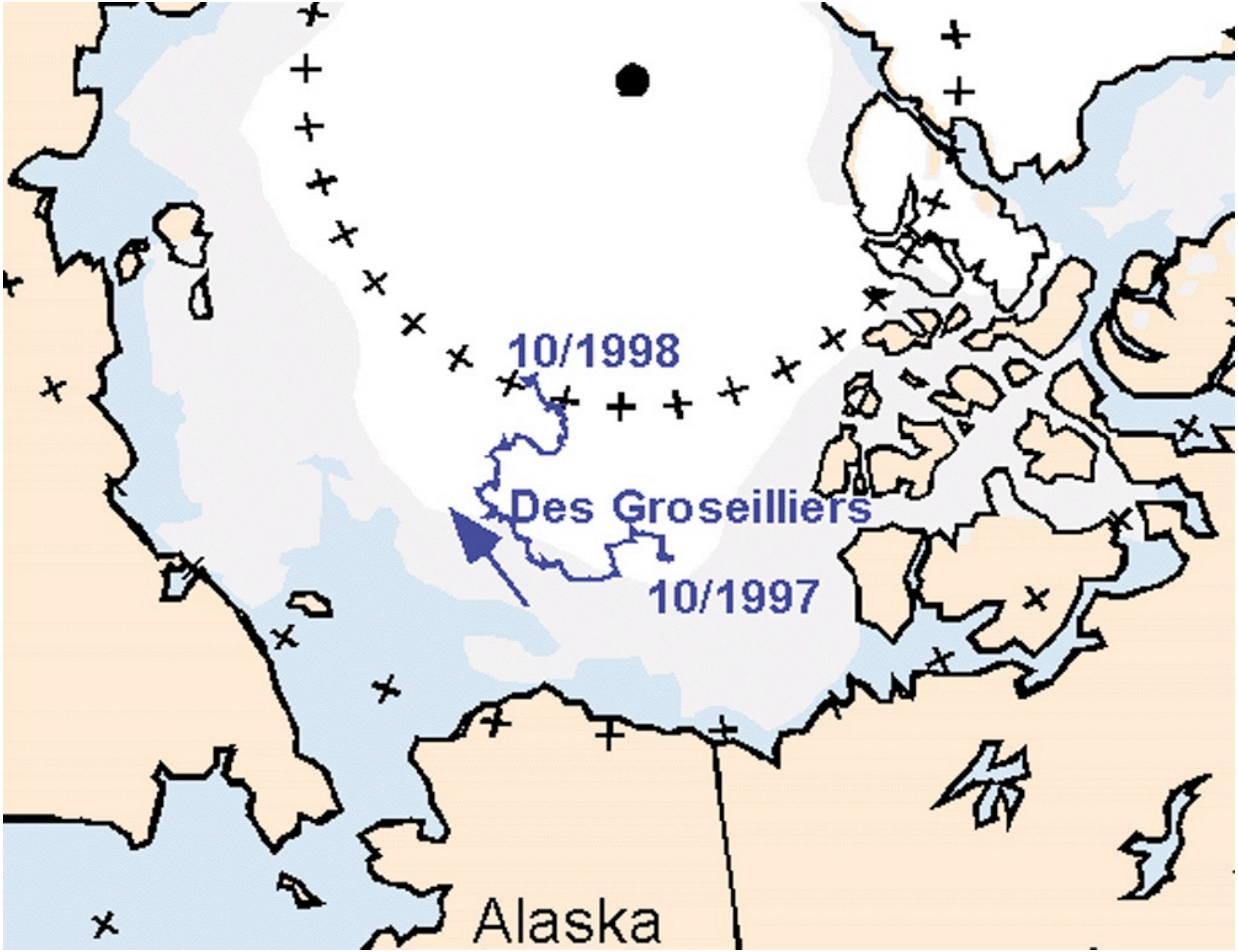
# A SHEBA Testbed for Evaluating the Simulation of High-Latitude Atmospheric and Cryospheric Processes

**Gijs de Boer**

# Introduction to SHEBA



# Introduction to SHEBA

## SHEBA Objectives:

- Support the analysis and interpretation of physical processes that control the surface heat and mass balance and contribute to ice-albedo and cloud-radiation feedback mechanisms,
- Construct and test realistic models and parameterizations of these physical processes on the local and aggregate scales, and
- Provide initial condition, boundary conditions, forcing functions, and test data to support SHEBA modeling efforts.

(Uttal et al., 2002 [BAMS])

# Introduction to SHEBA

## SHEBA Measurements:

(Uttal et al., 2002 [BAMS])

**Atmosphere:** Surface meteorology (T, RH, wind, cloud fraction, pressure, precipitation), 10m and 20m tower meteorology, surface fluxes (radiative, heat), cloud properties (height, thickness, phase, water path), radiosondes for upper air soundings, tethered balloon soundings*

**Ice:** Ice thickness, snow depth, ice stress, thickness distribution*, soot content*, spatial snow cover*, albedo*, ice motion*, melt pond fraction

**Ocean:** Temperature, salinity, conductivity, density, current, salinity flux, turbulent heat flux, lead temperature*, lead salinity*, optical properties*

*Seasonal only

## Additional Datasets:

**Reanalysis products:** ERA-40, ERA-Interim, JRA, NCEP1, NCEP2 -- interpolated to the SHEBA ship location for the entire year.

**Satellite products**

# Previous SHEBA Model Studies

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 106, NO. D14, PAGES 15,345–15,355, JULY 27, 2001

## Applications of SHEBA/FIRE data to evaluation of snow/ice albedo parameterizations

J. A. Curry and J. L. Schramm
Program in Atmospheric and Oceanic Sciences, Department of Aerospace Engineering Sciences, University of Colorado, Boulder

D. K. Perovich
U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire

J. O. Pinto
Program in Atmospheric and Oceanic Sciences, Department of Aerospace Engineering Sciences, University of Colorado, Boulder

J. Adv. Model. Earth Syst., Vol. 3, Art. M06003, 23 pp.

## Intercomparison of cloud model simulations of Arctic mixed-phase boundary layer clouds observed during SHEBA/FIRE-ACE

Hugh Morrison[1]*, Paquita Zuidema[2], Andrew S. Ackerman[3], Alexander Avramov[3,4], Gijs de Boer[5], Jiwen Fan[6], Ann M. Fridlind[3], Tempei Hashino[7], Jerry Y. Harrington[8], Yali Luo[9], Mikhail Ovchinnikov[6] and Ben Shipway[10]

Michael Tjernstrom, Mark Žagar and Gunilla Svensson

## Model Simulations of the Arctic Atmospheric Boundary Layer from the SHEBA Year

JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 108, NO. C4, 3107, doi:10.1029/2002JC001557, 2003

## An improved single-column model representation of ocean mixing associated with summertime leads: Results from a SHEBA case study

Marika M. Holland
National Center for Atmospheric Research, Boulder, Colorado, USA

Terr. Atmos. Ocean. Sci., Vol. 21, No. 1, 1-15, February 2010 doi: 10.3319/TAO.2009.03.20.01(IWNOP)

## One-Dimensional Sea Ice-Ocean Model Applied to SHEBA Experiment in 1997 - 1998 Winter

Wen-Yih Sun[1,2,3,*] and Jiun-Dar Chern[4,5]

JANUARY 2012 FRIDLIND ET AL. 365

## A FIRE-ACE/SHEBA Case Study of Mixed-Phase Arctic Boundary Layer Clouds: Entrainment Rate Limitations on Rapid Primary Ice Nucleation Processes

ANN M. FRIDLIND,* BASTIAAN VAN DIEDENHOVEN,+ ANDREW S. ACKERMAN,* ALEXANDER AVRAMOV,+ AGNIESZKA MROWIEC,+ HUGH MORRISON,# PAQUITA ZUIDEMA,@ AND MATTHEW D. SHUPE&

# Planned Simulations

**As part of the PCWG CSL Proposal:**

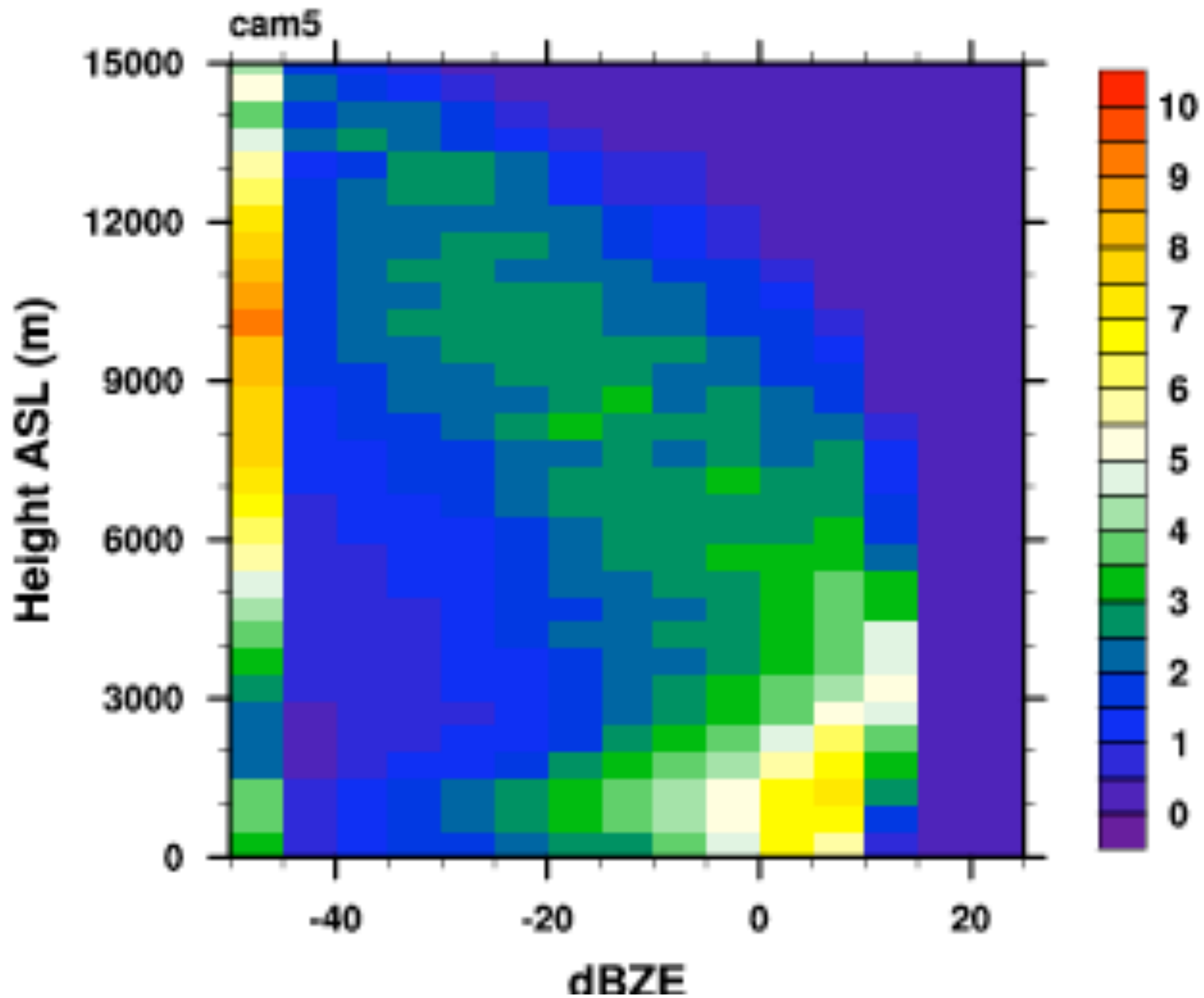
- 2 degree FV CESM CAM5 DART for entire SHEBA year
- 1 degree FV CESM CAM4 DART for entire SHEBA year

**Outside of the PCWG CSL Proposal:**

- Single column CICE simulations driven by atmospheres from CAM4/5, reanalyses and observations
- WRF LES simulations of limited cases to evaluate transitions between cloudy and clear states

# Processes Of Interest

## Ice Cloud Macrophysics:




(Figure courtesy of J. Kay)

# Processes Of Interest

## Ice Cloud Macrophysics:

(Park et al., 2010 [J. Clim.])

In CAM5, macroscale ice cloud fraction diagnosed separately from liquid cloud fraction. For initially clear sky, ice cloud fraction within the grid box:

$$CF_i = min(1, RH_d^2)$$

Where:

$$RH_d = max\left(0, \frac{RH_{ice} - 0.8}{0.3}\right)$$

For Liquid:

$$CF_{liq,st} = \begin{cases} 1 & \text{if } RH_{liq} \geq 1 \\ 1 - \left[\frac{3}{\sqrt{2}}\left(\frac{RH_{liq} - RH_{cl}}{1 - RH_{cl}}\right)\right]^{2/3} & \frac{1}{6}(5 + RH_{cl}) \leq RH_{liq} \leq 1 \\ 4cos\left[\frac{1}{3}\left(acos\left(\frac{3}{2\sqrt{2}}\left(\frac{RH_{liq} - RH_{cl}}{1 - RH_{cl}}\right)\right) - 2\pi\right)\right] & RH_{cl} \leq RH_{liq} \leq \frac{1}{6}(5 + RH_{cl}) \\ 0 & RH_{liq} \leq RH_{cl} \end{cases}$$

# Processes Of Interest

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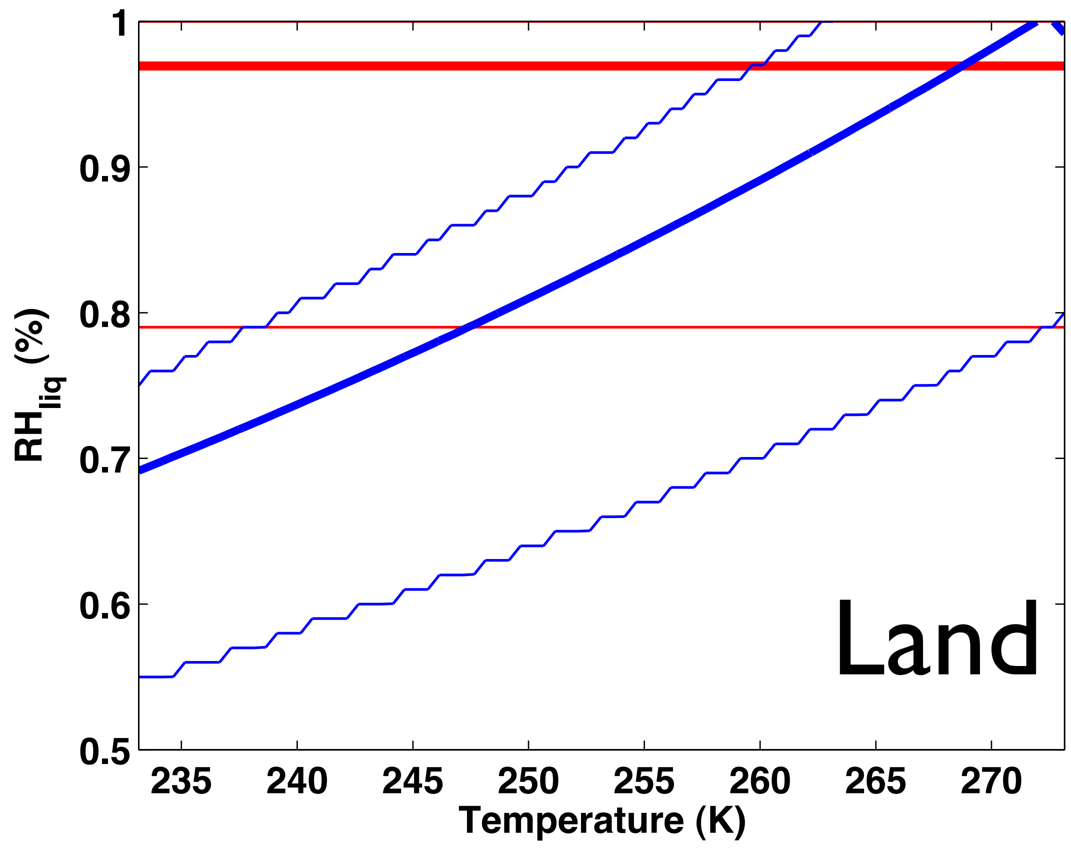


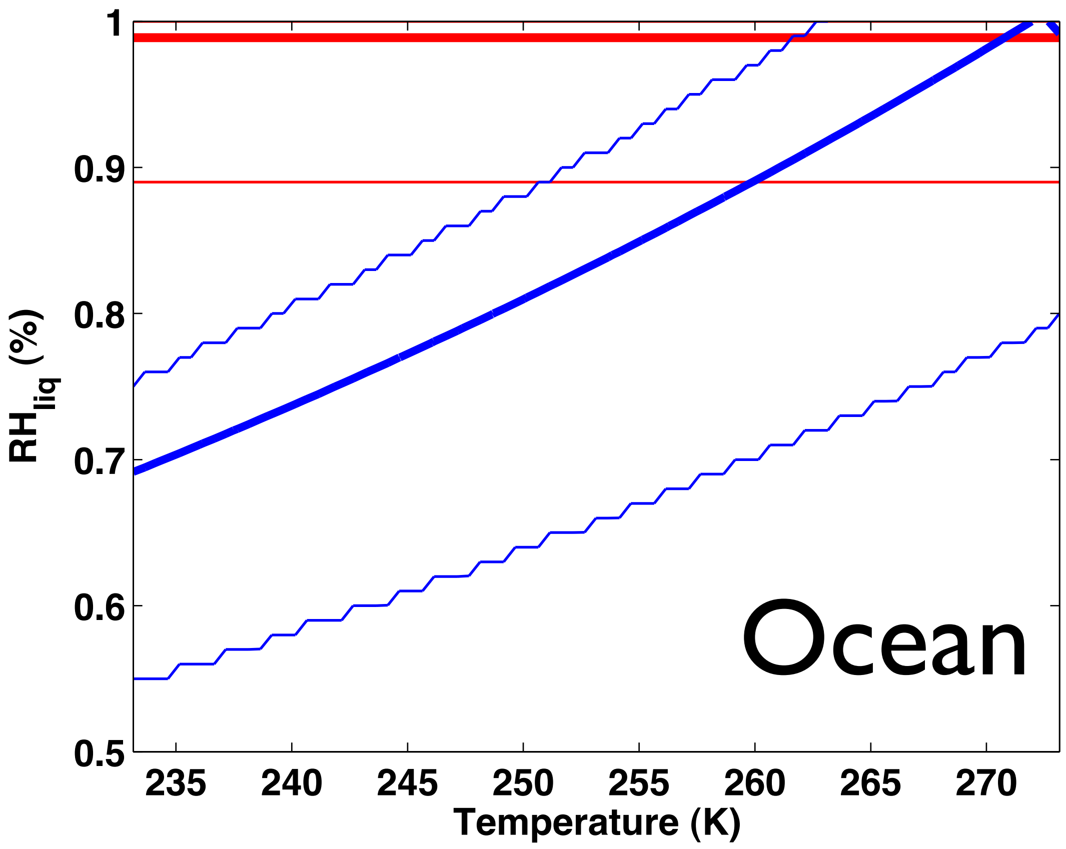

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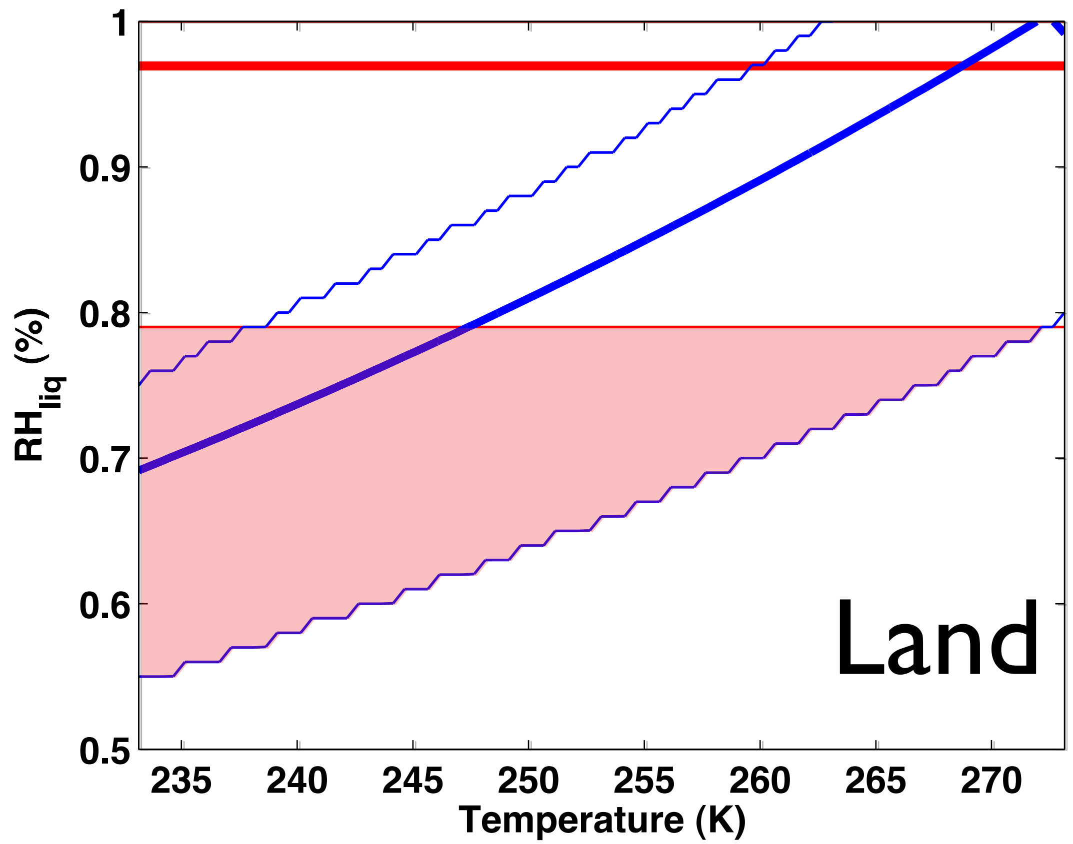


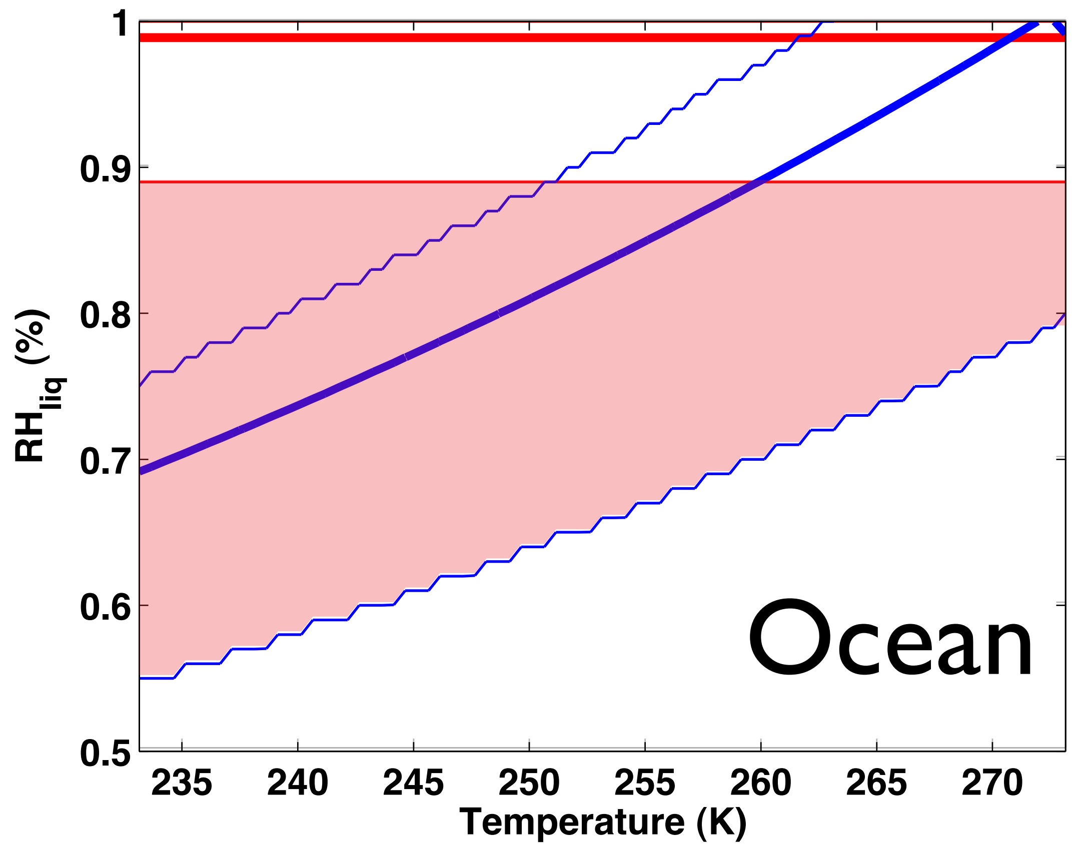

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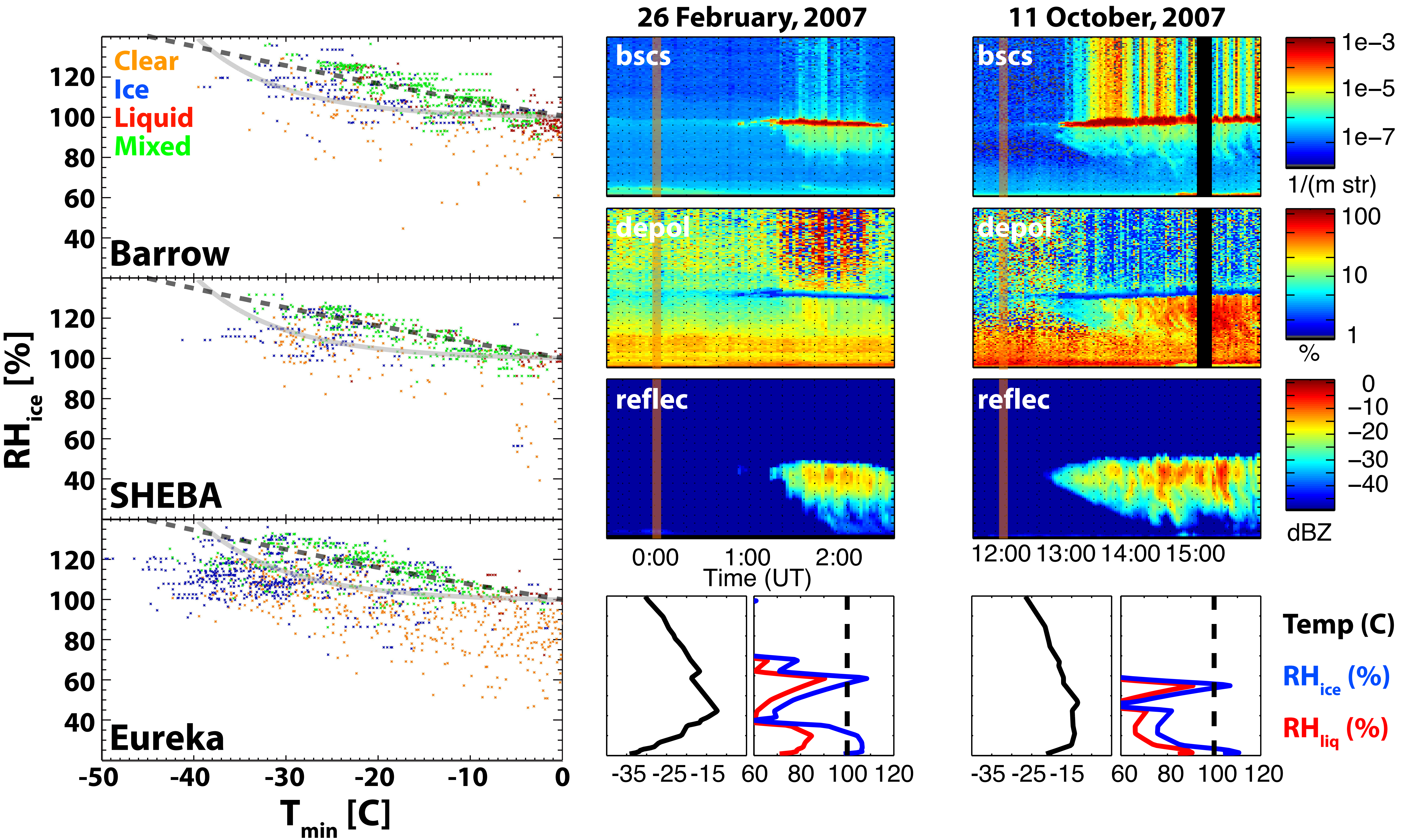
## Ice Macrophysics:

(de Boer et al., 2010b [GRL])



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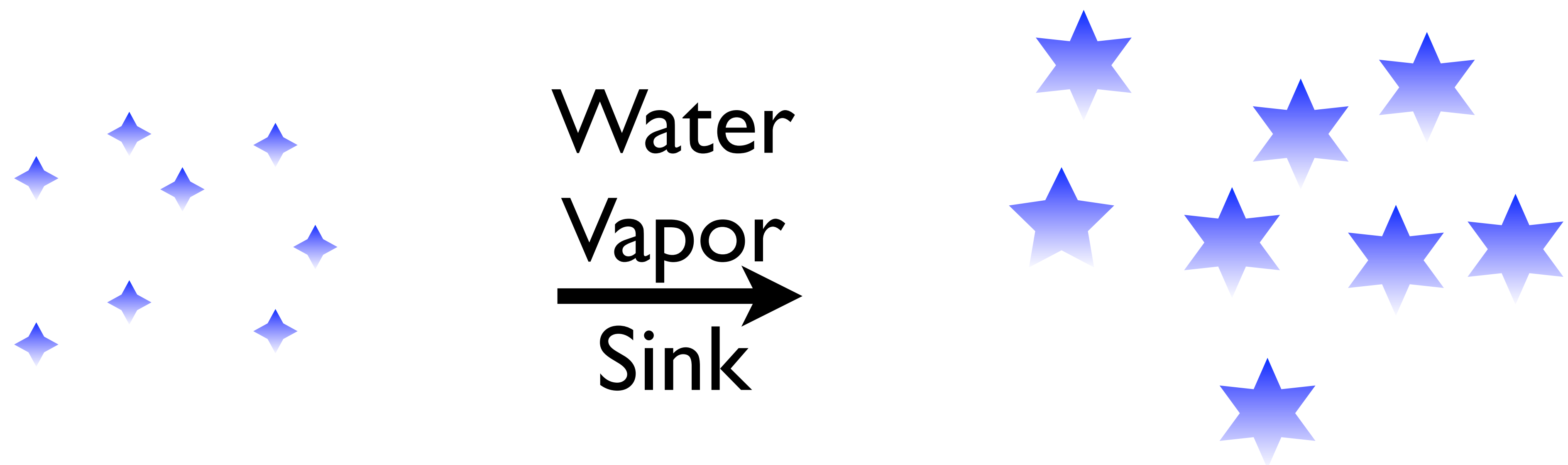
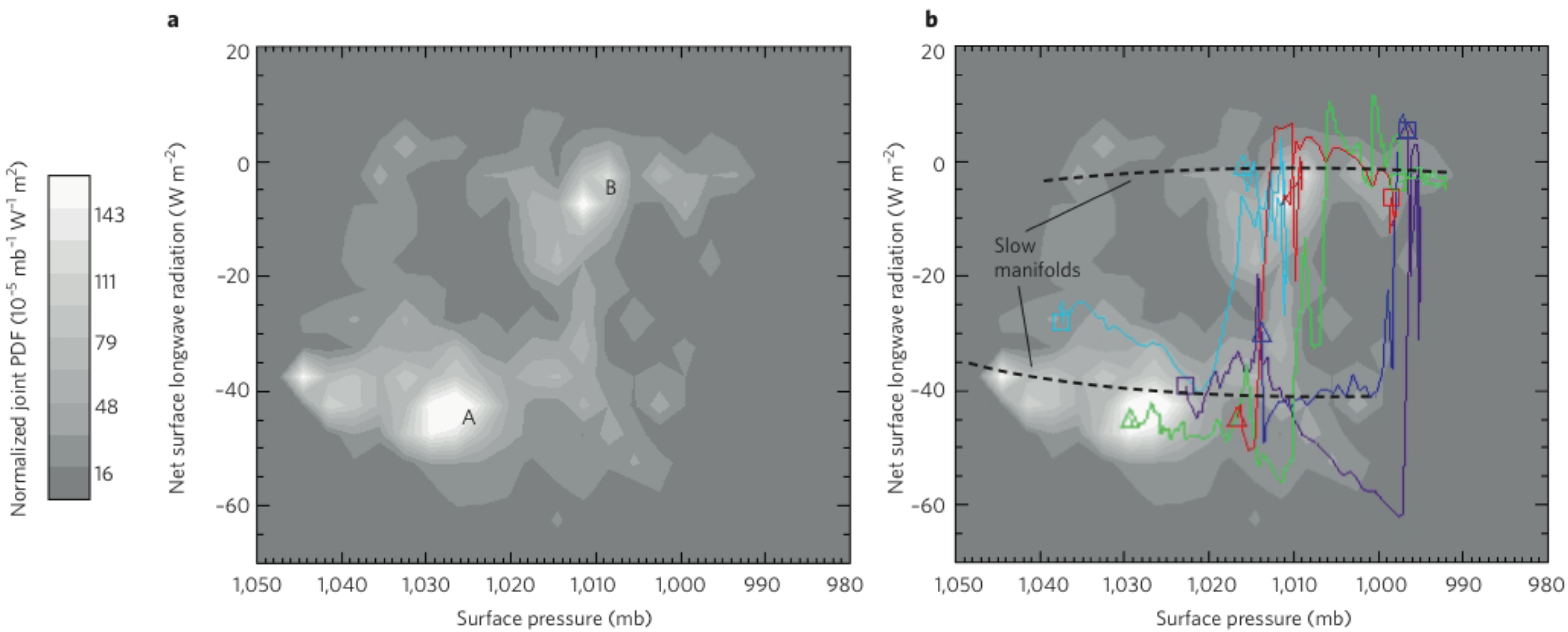



For liquid formation, either water vapor supply rate (from surface or large scale advection) or large scale temperature advection must be large enough to overcome sink of water vapor due to depositional growth of ice clouds.

At moderate (-25C < T < -5C) temperatures, this does not appear to happen in observations.

# Processes Of Interest

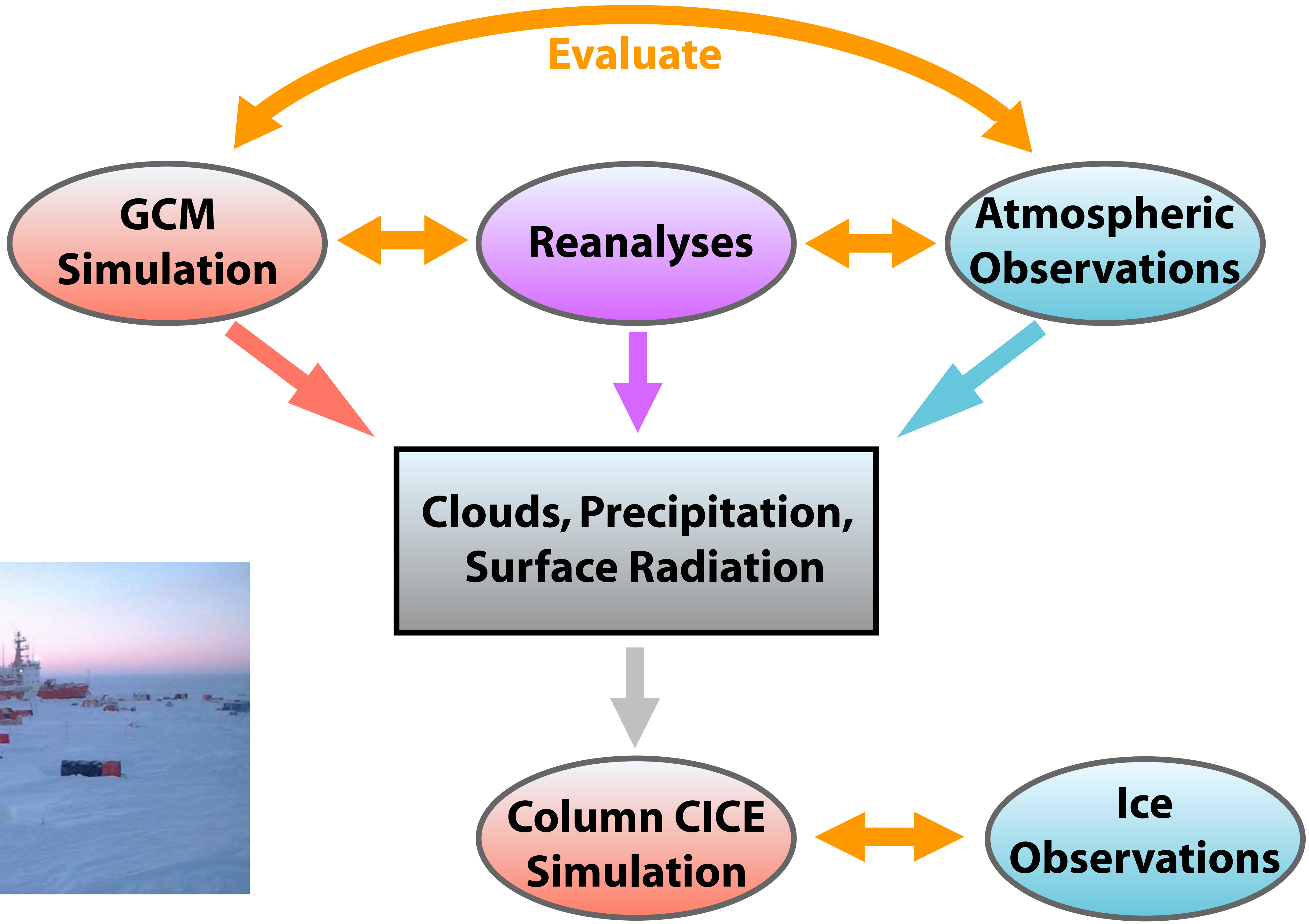
## Atmospheric State Analysis

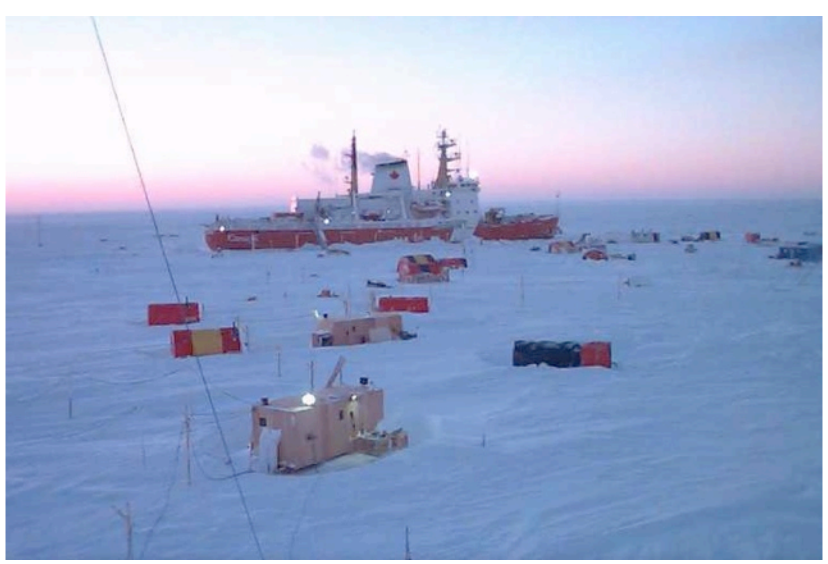



(Morrison et al., 2011 [Nature Geosci.])

# Processes Of Interest

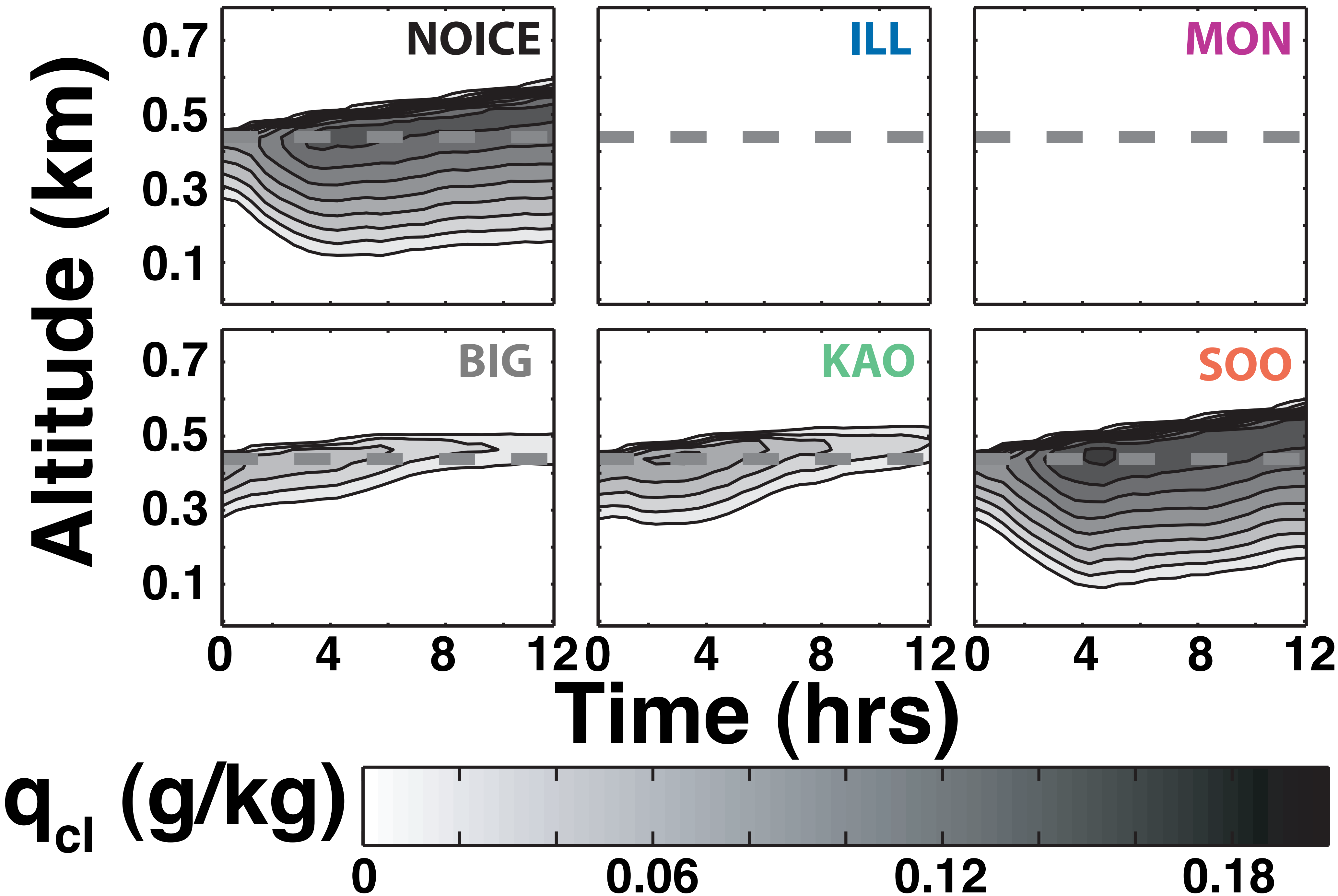
## Atmosphere-Ice Interaction



# Processes Of Interest

## Aerosol Cloud Interactions




(de Boer et al., 2012 [ACP])

# Discussion

## What's the point?

- Integrated effort within the PCWG
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- Process understanding vs. climate understanding
- Representativeness of SHEBA year
- Lack of Aerosol Measurements
- Others?

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## Ideas for other process evaluations?

- Cryosphere?
- Ocean?(?)
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## Ideas for other process evaluations?

- Cryosphere?
- Ocean?(?)
- Atmosphere?

## Integration into funded research projects (current or future)?

- DOE Cryosphere (funded)
- EaSM RFP on Decadal and Regional Climate Prediction using Earth System Models (Deadline 5/11/12)
- Others?

# References


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