

Summary of the Polar Clouds Working Group

Hugh Morrison and James Pinto
Co-chairs

June 6, 2008, 4th Pan-GCSS meeting

Overview of the Breakout Sessions

- Review of current research related to polar clouds (13 talks)
- ~ 40 attendees
 - 4 talks on cloud observations, recent field campaigns
 - 2 talks on Arctic cloud-climate feedbacks
 - 2 talks on ice formation processes in mixed-phase clouds
 - 1 talk on parameterization development
 - 4 talks on modeling results from Mixed-Phase Arctic Cloud Experiment (MPACE)

- Description of 2 new case studies for model intercomparison
 - Kinematic 1-D microphysics tests (Ben Shipway)
 - Weakly-forced mixed-phase stratus from Surface Heat Budget of the Arctic Ocean (SHEBA) field experiment
- Discussion of the recently completed ARM/GCSS Mixed-Phase Arctic Cloud Experiment (MPACE) model intercomparison and other modeling studies

Mixed-Phase Arctic Cloud Experiment

- M-PACE took place at ARM's Barrow site in October 2004 (*Verlinde et al. 2007*)
- M-PACE featured numerous aircraft flights that measured clouds and aerosols among other increased observations
- A variety of cloud types were observed

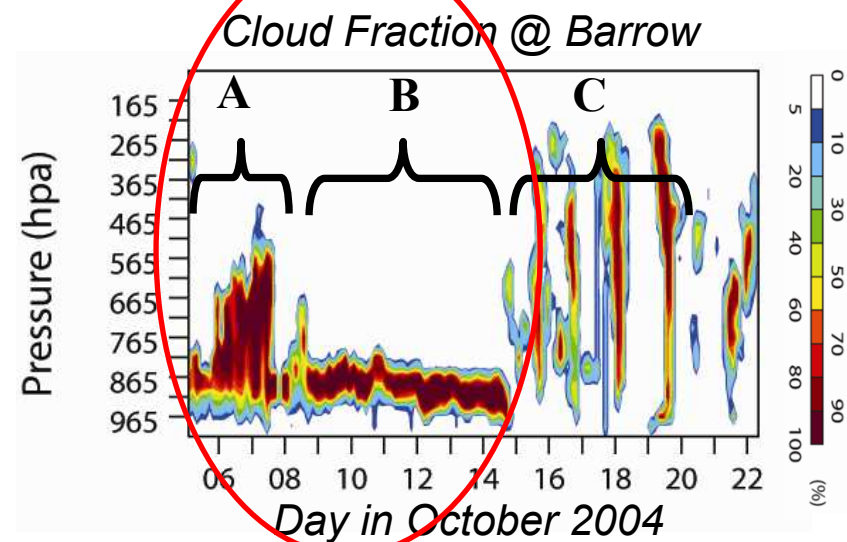
A – multi-layer stratus

B – boundary layer stratocumulus

C – frontal clouds

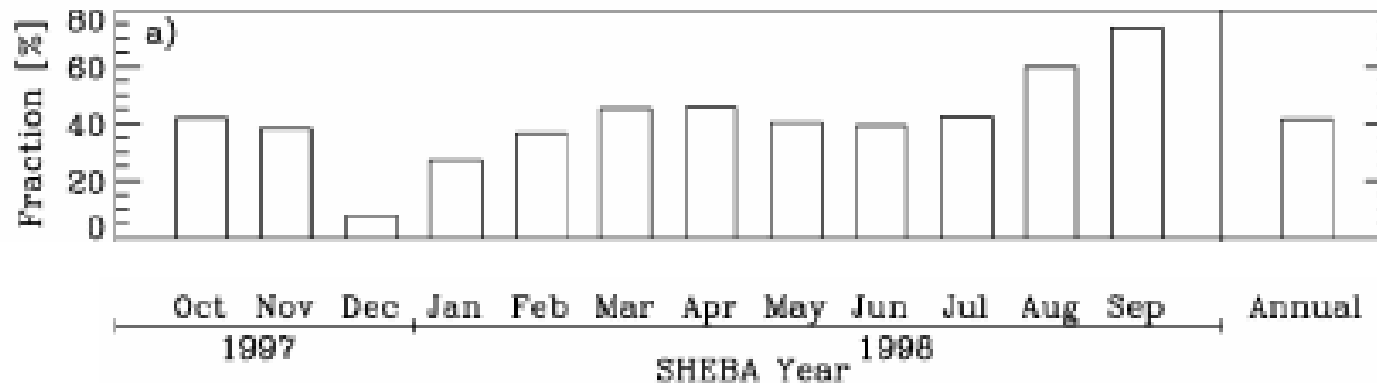


ARM's Barrow site



- Focus on weakly-forced mixed-phase clouds
 - Prevalence in Arctic
 - Large impact on radiative forcing and surface energy budget
 - Climate and weather models have had difficulty correctly simulating them

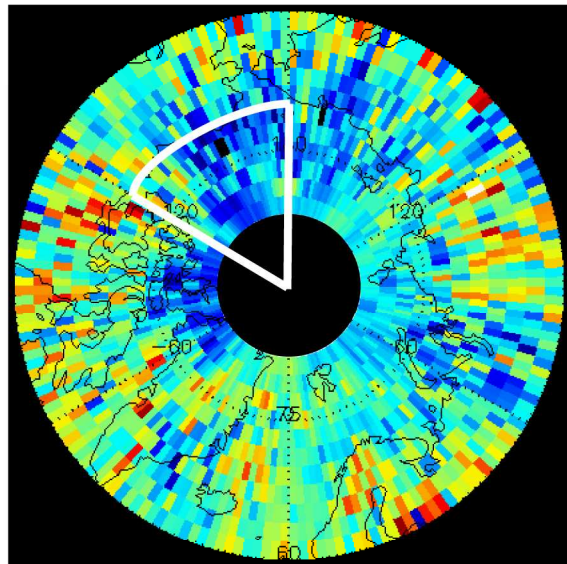
% of clouds retrieved as mixed-phase during SHEBA



Shupe et al. 2006

Cloud and radiative flux differences (2007-2006)

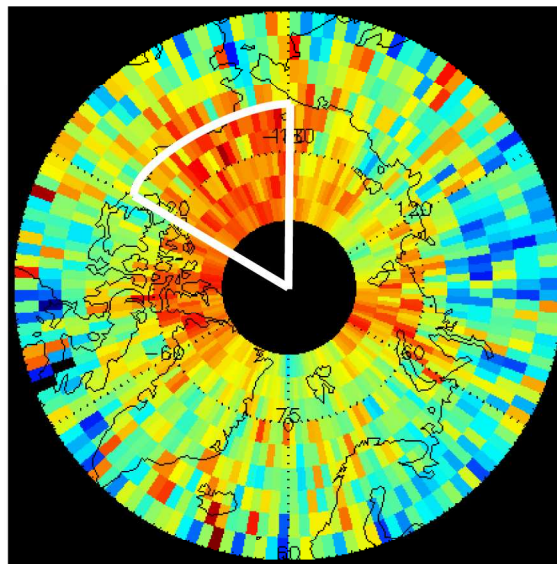
CloudSat/CALIOP
Cloud Fraction



-0.4 0 0.4

Western Arctic:
-16%

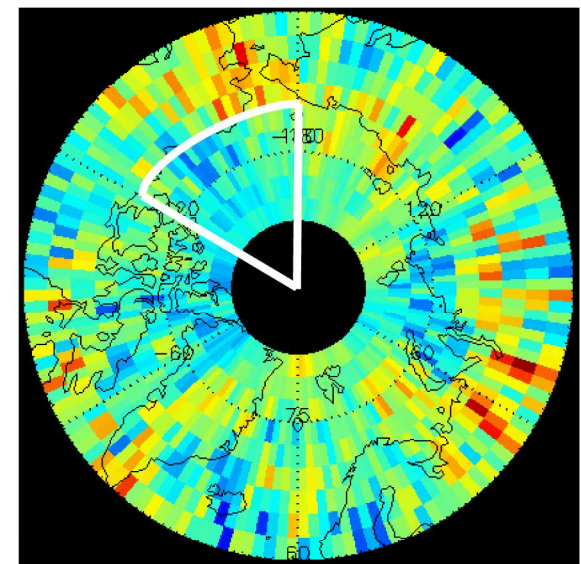
Downwelling SW
Radiation (W m^{-2})



-120 0 120

Western Arctic:
 $+ 32 \text{ W m}^{-2}$

Downwelling LW
Radiation (W m^{-2})



-40 0 40

Western Arctic:
 $- 4 \text{ W m}^{-2}$

From J. Kay

Results from the ARM/GCSS MPACE model intercomparison

- First such model intercomparison undertaken by Polar Cloud Working Group
- Results for Period B and A (Klein et al. 2008, Morrison et al. 2008, QJRMS, submitted)
- Model participation:
 - Period B - 17 SCMs and 9 CRMs
 - Period A – 14 SCMs and 4 CRMs

Period B (single-layer cloud)

- Models tend to underestimate liquid water path, overestimate ice water path, but there is a lot of scatter (no consistent diff. between LES/CRM and SCMs).

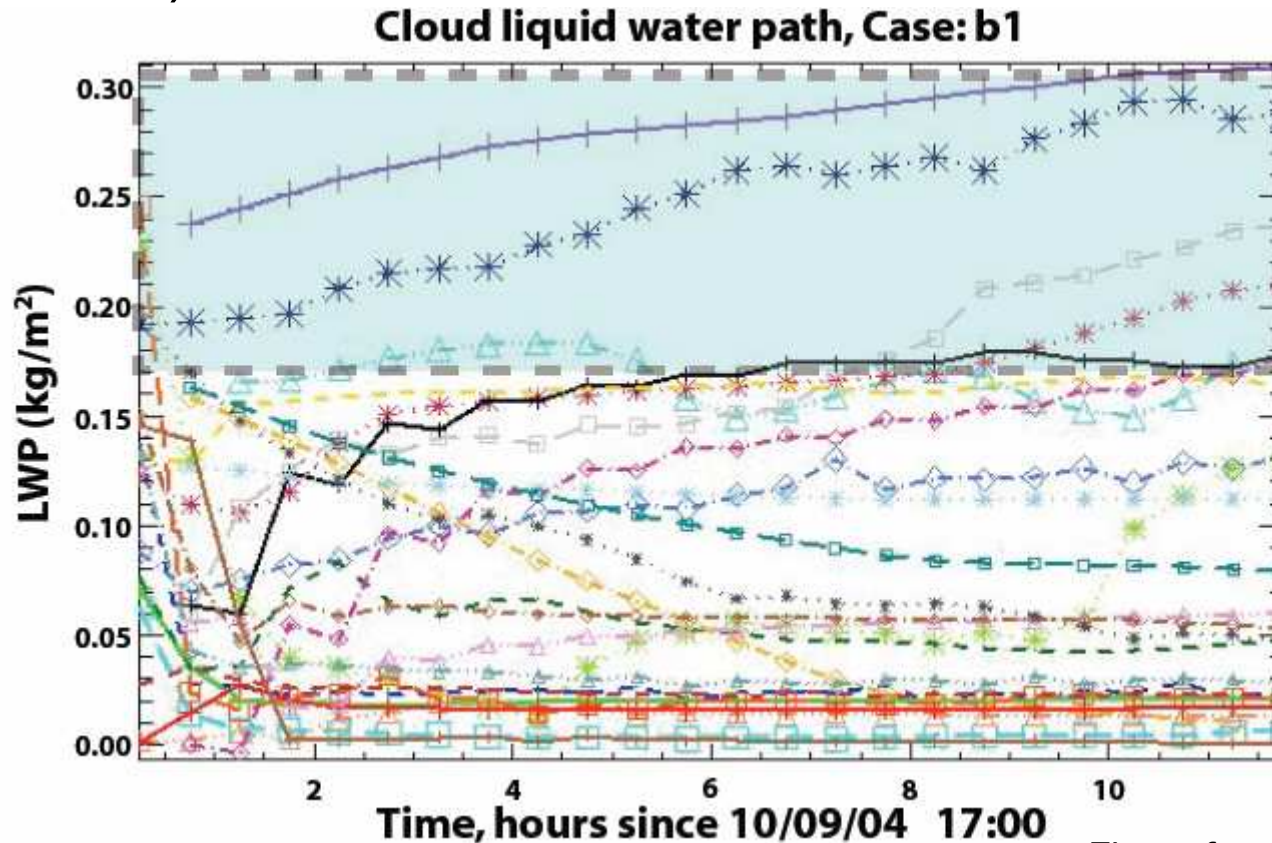


Figure from G. De Boer

**surface
downward
longwave
radiation
($W m^{-2}$)**

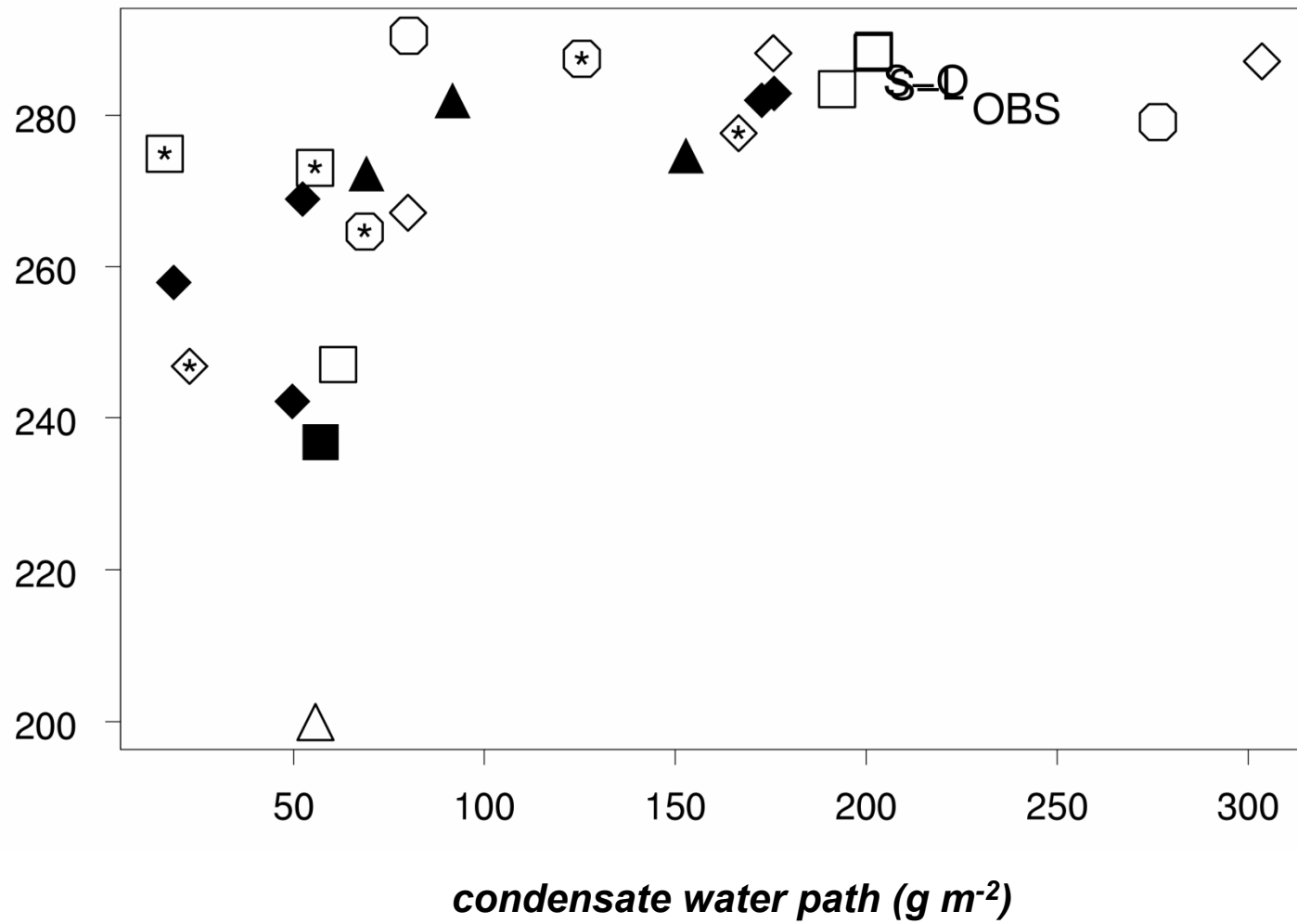


Figure from S. Klein

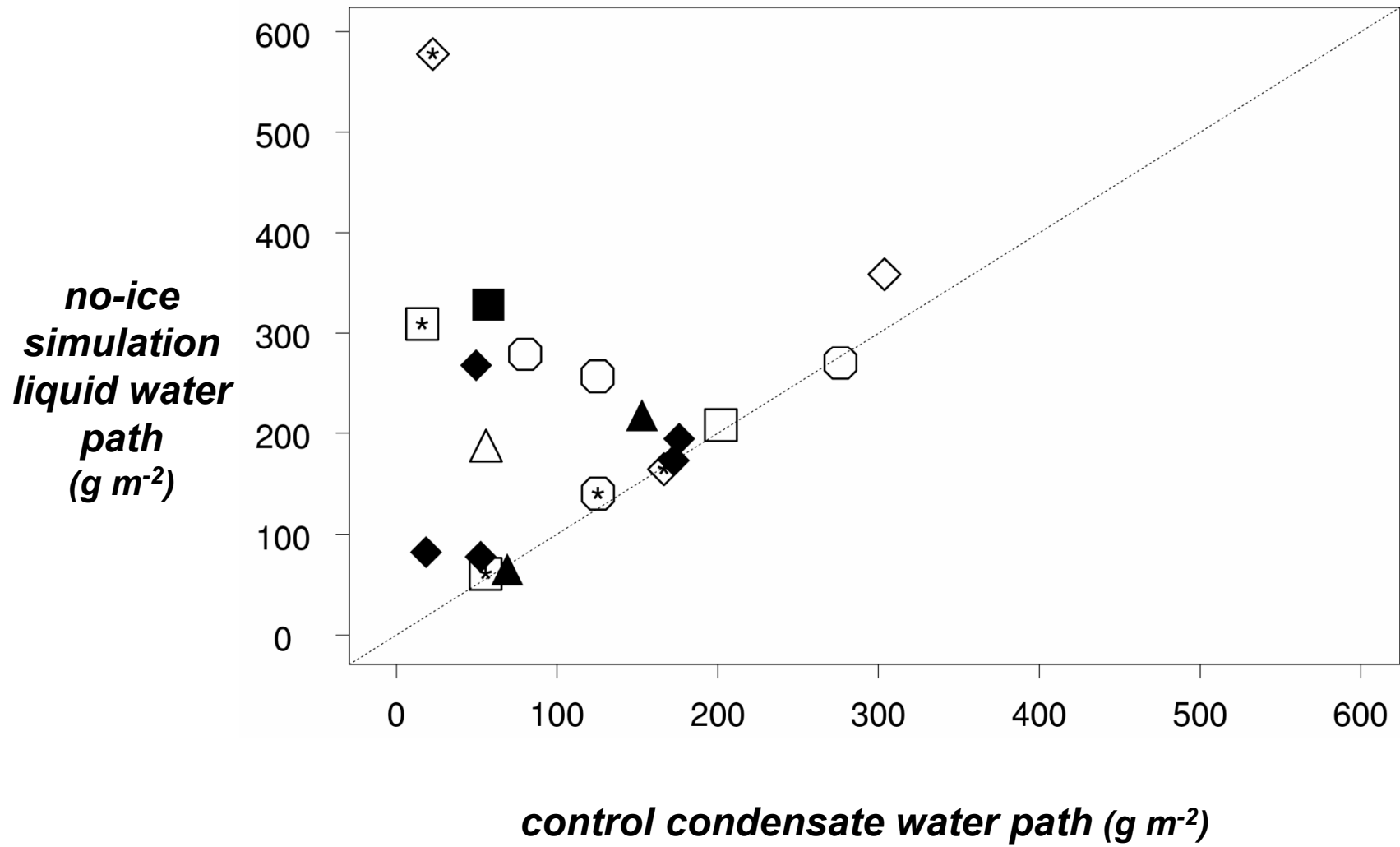


Figure from S. Klein

Period A (multi-layer cloud)

- In contrast to Period B, models tend to overestimate liquid water path, underestimate ice water path, but again there is a lot of scatter.
- Results suggest differences in model's ability to simulate low-level single-layer clouds versus deeper multi-layer clouds.
- Some evidence that increasing complexity of microphysics parameterization improved results in both Periods A and B, but lots of scatter and physical mechanisms for this are

- Importance of ice phase microphysics in weakly-forced mixed-phase clouds, especially ice initiation processes.
- Large discrepancy between observed ice nuclei and crystal concentration – not explained by any quantified ice formation mechanisms.

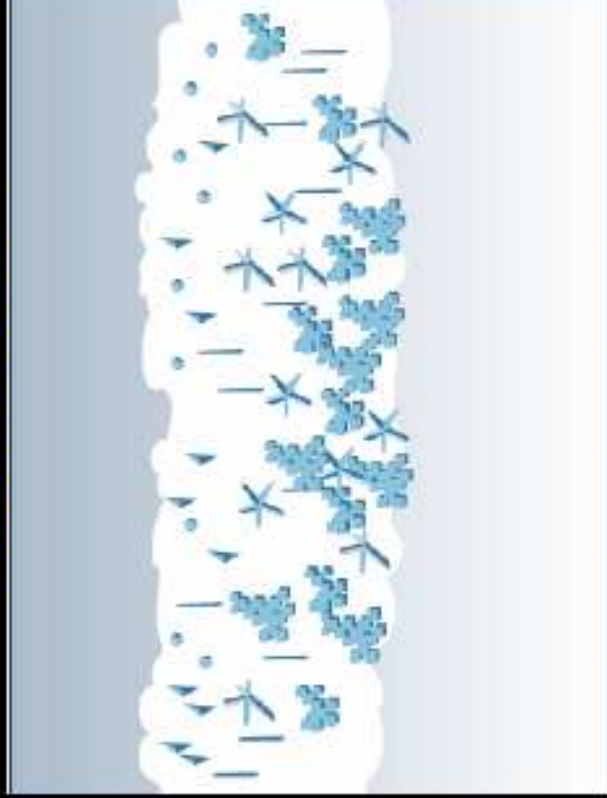
Early results from the April 2008 Indirect and Semi-Direct Aerosol Campaign (ISDAC)

PIs Greg McFarquhar, Steve Ghan, Hans
Verlinde
(presented by M. Dubey)

- Most comprehensive set of in-situ microphysical measurements ever taken in Arctic clouds
- Goals are to provide new insights on ice formation and cloud-aerosol interaction in mixed-phase clouds

M-PACE

October 2004



- **Pristine Conditions**

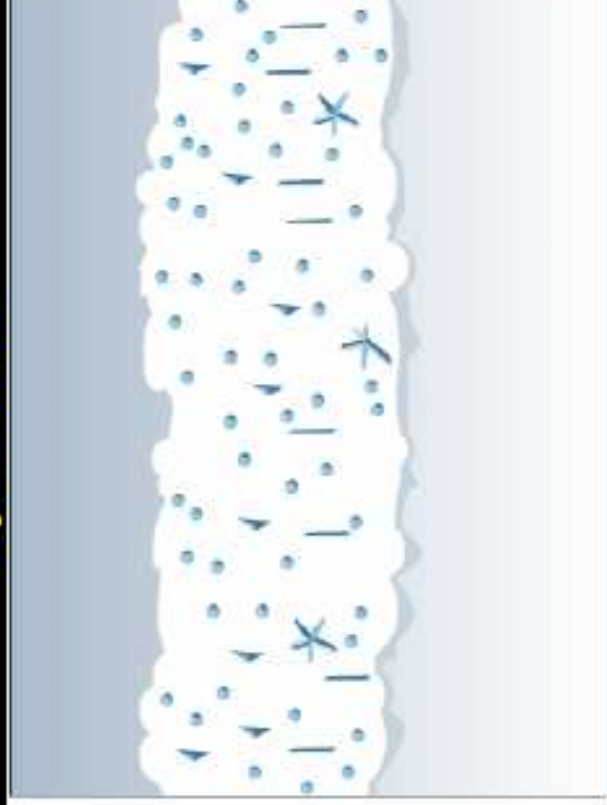
- Open ocean
- Few cloud droplets
- Ice multiplication
- Precipitation

- **Measurements by ~10 instruments**

- aerosol properties
- cloud microphysics
- atmospheric state.

ISDAC

April 2008



- **Polluted Conditions**

- Sea Ice
- Many cloud droplets
- Ice nucleation
- Little precipitation

- **Measurements by ~40 instruments**

- aerosol properties
- cloud microphysics
- radiative energy
- atmospheric state.

1-D kinematic mixed-phase microphysics test (Ben Shipway)

- Basic idea is to test microphysics schemes in a simplified framework with specified dynamics, allows for testing of microphysics in the absence of feedbacks with dynamics
- 1D column with specified vertically- and temporally-varying vertical velocity to mimic updraft/downdraft cycle of large eddy in stratocumulus

SHEBA mixed-phase stratus model intercomparison case

- Long-lived low-level mixed-phase stratus were observed during early May, focus is on May 7, 1998
- Several key differences from MPACE cases:
 - Colder temperatures (~ -22 C vs. -15 C)
 - Much smaller surface turbulent heat fluxes (ice-covered vs. open ocean)
 - More polluted aerosol
 - Much smaller amounts of cloud liquid water
- Intercomparison being conducted jointly with July 2008 WMO Cloud Modeling Workshop in Mexico

Broader outlook/questions

- Focus has been on mixed-phase clouds, future cases on ice-phase (diamond dust)?
- Bias toward evaluation of models based on point measurements in western Arctic - new satellite tools and observation ground sites