

Overview of SHEBA & a Focus for ARCSS

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Motivation for SHEBA

- Large Variability of Arctic Ice and Climate
- Feedback Mechanisms: Ice-Albedo & Cloud-Radiation
- Sparse Data on Ocean-Atmos-Ice Coupling Processes
- Wide Range of GCM Results (e.g. Greenhouse Warming)
- Improved Use of Polar Remote Sensing

SHEBA Goals

- To determine the ocean-ice-atmosphere processes that control the surface albedo and cloud-radiation feedback mechanisms over arctic pack ice, and to use this information to demonstrably improve models of arctic ocean-atmosphere-ice interactive processes.
- To develop and implement models that improve the simulation of the present day arctic climate, including its variability, utilizing coupled global climate models.
- To improve the interpretation and application of remote sensing observations of the arctic oceanatmosphere-ice system.

SHEBA Objectives

Establish Data Set

Characterize the OAI State & Structure
Quantify the Heat, Ice, Moisture budgets
Analyze, Interpret, Simulate Key Processes
Evaluate Impact on Feedbacks & GCM's

Experiment Design

- Environment: Multiyear pack ice
- Spatial: The O-A-I Column, Local & Aggregate
- Temporal: Annual Cycle Core Time Series
- Process Studies and Campaigns
- Budgets: Heat, Ice & Snow Mass, Moisture



Models: Process, SCM, Regional, GCM

The Field Experiment

Ice Station Site and Drift

Measurements



Core Time Series at the Station



Area Aggregation and Variability Measurements

Remote Time Series (Buoys, Ice, PAM)

- Aggregate Scale Surveys (SCICEX, Helo, A/C, Snowmobile)
- Satellite Data (RADARSAT/RGPS, AVHRR, SMM/I,TOVS)
- IOP's (Ocean BL, Ice Hydro/Pond, Summer Lead, Cloud)



ARCSS Meeting

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The SHEBA Station Site



Air View of the ice station before melt ponds

Air View of the ice station with melt ponds

The SHEBA Percent Year Flux (Wm²) ĝ Depth (cm)



Upper Ocean Structure (McPhee, et al.) Ocean City at SHEBA Ice Camp CTD Cast 10/12/97 0410Z Approx.Position 75° 23'N 144°W Temperature (°C) Salinity (ppt) -0.5 -1.5 -1 28 29 30 31 32 33 34 35 0 -2 100--100200 -200(dbar) (dbar)

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Ice Mass Balance (Perovich, et al)





Surface Albedo Time Series (Perovich, et al.)



Atmospheric Structure (SPO/ATD)

SHEBA--GPS Soundings in the Arctic Floe Fixed, SHE, 1997,11,17, 23:15:04



Clouds and Precip (Uttal, et al.)

14nov1997.12:00-24:00.98.nc



SHEBA Data Sets

Data Management: SPO, UCAR-JOSS

SHEBA Data Online: www.joss.ucar.edu

* Near Real-Time (Ship, Shore)

- * Research Quality Datasets CODIAC
- * Data Protocol

* PI Questionnaires, Online Submission Form

Integrated Data Sets

* Phase 3 (due Feb-Mar)

Case Studies

SHEBA Data to NSIDC ARCSS Data Center

* Migration underway

* Long term archival

Integrated Data Sets: Elements

- TOA Radiation
- Atmospheric Boundary Layer
- Incoming Surface Radiation
- Atmospheric T, RH, Wind, Pressure
- Atmospheric Advection, Vertical Motion
- Surface Turbulent Fluxes
- Cloud Bulk and Microphysical Properties
- Surface Optical Properties
- State of the Sea Ice and Snow Cover
- Ice Deformation
- Ocean T, S, Current
- Ocean Turbulence and Boundary Layer
- Basic Stuff (Position, Velocity, Log Info)



SHEBA Discovery

- Surface Cloud Radiative Forcing was Positive
- Year-round Signature of Cloud Liquid Water
- 5 Stages of Surface Albedo Development
- Importance of Surface Stratification/Mixing for Fw
- Thin Ice Initially, Net Thinning, But...
- Thin, Multiyear Ice Survived a warm year
- Role of 2D, 3D Ice/Snow Heat Conduction
- Impact on Models: CCSM, ARCMIP, ECMWF * Short Term: albedo, CCN, LW, Fw, Slab Cp

 - * Parameterization development
- **JGR** Special Issue
 - \rightarrow 22 papers accepted, 2002 publication

Single Column Modeling

- Community Climate System Model
- Arctic OAI Column
- Prescribed Forcing (ECMWF, TOA SWD)
- Overall Performance Good
- Focus: Cloud formation, Cloud Microphysics, Onset of Melt
- Sensitivity studies with new parameterizations

SHEBA Contributions

- Summary Articles
 - →EOS 1999
 - → BAMS 2001 (Accepted*)
- Special Session 1999 Fall AGU
- 23 Articles Published/In Press
- 31 + Papers AMS 6th Polar Conf.
- Impact on Models: CCSM, ARCMIP, ECMWF
 - * Short Term: albedo, CCN, LW, Fw, Slab Cp
 - * Parameterization development
- JGR Special Issue
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SHEBA Phase3 Plans and Activities 2001-2003



13 July, 2001

July '01 - March '02

- Prepare Integrated Data Set and Case Study Data Sets
- Provide Access to Data Sets on CODIAC
- Study, Write Up Process Analyses and Case Studies
- Develop plans for Synthesis Workshop



March - December, 2002

- Work with Integrated Data Set
- Preliminary work toward syntheses
- Synthesis Workshop (July 2002)
- Complete work on syntheses
- Present Syntheses (Fall AGU? SHEBA Symposium? Other meeting?)
- 6 mo. to end of SHEBA



January - July, 2003

Prepare, Submit Synthesis Papers (JGR Special Section? J. Climate Special Section? Other?)
 End of SHEBA Phase 3 (Approximately July, 2003)



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ARCSS Next 5 Years

Diagnose Arctic Climate Variations

- → Correlations among arctic variables
- \rightarrow Correlations with global-scale variations
- → Fingerprinting
- Understand Controlling Factors
 - → Greenhouse gas, Aerosol, Solar Variability
 - Low-latitude SST's
 - → Initial Conditions (e.g. THC, ice (?))
 - → Natural, Unexplained Variability
- Predict Arctic Climate : 10, 50, 100 years
 - \rightarrow A GLOBAL Problem => GCM's
 - → First Stage Prediction Problem: Large Scale
 - → Predictions of First, Second Kind?
 - → Levels of Uncertainty

Linkages within ARCSS

- Large-Scale Climate Problem is Global
- Prediction effort tied model development
- Prioritization in terms of this problem
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The SHEBA Year

- Initial Environment
 - Thin ice
 - →Fresher Upper Ocean
 - Residual Ocean Heat
- Events over time
 - → January ice divergence
 - Oceanic Frontal crossing
 - →Camp Breakup Early Feb
 - March Shear and Ridge
 - →Late May Rain-> Melt Season
 - \rightarrow July Calm, then Storm
 - → Water in Clouds

SHEBA Timeline

- 1993-1994 Pre-planning
- **1995-1996** Phase I
 - → Planning
 - → Analyze existing data
 - Modeling
 - Technology Development
- 1997-1999 Phase II
 - Field Experiment
 - → Initial Data Analysis, Process modeling
- 2000-2002 Phase III
 - → Modeling
 - → Feedback Analysis
 - Linkage to GCM's

Planning and Sponsors

- 1993 Orlando Workshop ('SHEBA' coined)
- **1993 SHEBA Prospectus**
- 1996 SHEBA Science Plan
- **1997 SHEBA Implementation Plan**

Direct Sponsorship of SHEBA Projects

Primary Sponsor - NSF ARCSS Partners - ONR High Latitude Dynamics, JAMSTEC

Collaborating Partners

NASA (FIRE Arctic Cloud Experiment & ECMWF)
DOE (Atmospheric Radiation Measurement)
NASA (Polar: RGPS)
DFO Canada (JOIS, FWI, IOS)
Navy (SCICEX)
USCG
Canadian Coast Guard (Laurentian Region, Arctic Ops)



Ocean-Atmosphere-Ice Feedbacks



Some Key Processes

Processes in the Sea Ice and Upper Ocean:

- Disposition of shortwave radiation in the ice and upper ocean
- Surface albedo and ablation as responses to energy outputs
- → Sea ice-upper ocean coupling
- Arctic Cloud Processes
 - → Formation, maintenance, and dissipation of arctic clouds
 - Arctic cloud microphysics and relationships to atmospheric chemistry
 - Impact of clouds on radiative fluxes

Ice Station Site





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Transport and Logistics



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The CCGS 'Des Groseilliers'



Education and Outreach

- PI Classroom visits, talks
- News Coverage
- Email Q&A, Referrals
- Video
- Educational game on web site
- Field Experiences Impact on careers, community
- New Public Web site

Atmospheric Fluxes (Andreas, et al.)





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So, if you could do it all over again... More Spatial Aggregate Observations (g(h)) More Winter Cloud, Microphysics, CCN's Even better integration with NWP analyses Selected Eulerian time series (ocean, ice) Summer personnel rotations New Satellite Phones