



**IICWG and S4D ice model and data  
assimilation workshop  
at DMI  
October 15-17 2008**



# SEARCH for DAMOCLES

- **S4D is SEARCH for DAMOCLES**
  - **SEARCH** (*A Study of Environmental Arctic Change*)
  - **DAMOCLES** is EC IPY Arctic observation and modelling project (*Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies*)



# IICWG & S4D DA Workshop October 15-17, 2008 at DMI

The screenshot shows a Mozilla Firefox browser window with the address bar displaying [http://www.oasys-research.de/iicwg-s4d\\_workshop/goals](http://www.oasys-research.de/iicwg-s4d_workshop/goals). The page content includes the O.A.Sys logo (Ocean Atmosphere Systems) and a navigation menu with items like Home, About Us, Projects, and IICWG/S4D workshop Copenhagen, October 15th to 17th, 2008. The main content area features the title "IICWG/S4D workshop Copenhagen, October 15th to 17th, 2008" and a sub-header "A joint International Ice Charting Working Group (IICWG) and SEARCH for DAMOCLES (S4D) workshop on Assimilation of data into models of the Arctic at the Danish Meteorological Institute (DMI) in Copenhagen." Below this, it states "The Workshop goals" and provides details about the workshop's purpose, location, and themes.

**IICWG/S4D workshop Copenhagen, October 15th to 17th, 2008**

**A joint International Ice Charting Working Group (IICWG) and SEARCH for DAMOCLES (S4D) workshop on Assimilation of data into models of the Arctic at the Danish Meteorological Institute (DMI) in Copenhagen.**

**The Workshop goals**

The International Ice Charting Working Group and S4D (SEARCH for DAMOCLES) are pleased to announce a joint 2008 workshop on Assimilation of data into models of the Arctic.

This is the 2nd announcement and in addition a call for abstracts.

Please send the title of your presentation/poster and a 10-15 line abstract to Leif Toudal Pedersen at DMI (ltp@dm.dk). Please also send the names and affiliation of persons attending the workshop.

The workshop takes place at the Danish Meteorological Institute (DMI) in Copenhagen on October 15-17, 2008.

The goal of the workshop is to exchange ideas and experience between the operational modeling community associated with the International Ice Charting Working Group and the scientific modeling communities associated with SEARCH and DAMOCLES and other scientific projects/organizations.

**The workshop themes are**

- Data for assimilation into models (availability and requirements)
- Model developments and improvements
- Data assimilation (methods and results)

[http://www.oasys-research.de/iicwg-s4d\\_workshop](http://www.oasys-research.de/iicwg-s4d_workshop)



# Workshop goals

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## The workshop themes are

- Model developments** and improvements
- Data assimilation** (methods and results)
- Data** for assimilation into models (availability and requirements)



1. Lars Axell, SMHI, Sweden
2. Lars-Anders Breivik, met.no, Norway
3. Mark Buehner, Environment Canada
4. Tom Carrieres, Environment Canada
5. Alain Caya, Environment Canada
6. Gorm Dybkjær, DMI, Denmark
7. Jean Claude Gascard, LOCEAN-IPSL, France
8. Ian G. Fenty, MIT, USA - ECCO
9. Nick Hughes, met.no, Norway
10. Phil Byongjun Hwang, Scottish Association for Marine Science, UK
11. Frank Kauker, OASys, Germany
12. Thomas Kaminski, FastOpt, Germany
13. Christof Koenig Beatty, Universite Catholique de Louvain, Belgium
14. Thomas Lavergne, met.no, Norway
15. Christian Melsheimer, University of Bremen, Germany
16. An T. Nguyen, JPL, USA - ECCO
17. Leif Toudal Perderson, DMI, Denmark
18. Till A. Rasmussen, DMI, Denmark
19. Mads Hvid Rieberggaard, DMI, Denmark
20. Joao Rodrigues, University of Cambridge, UK
21. Roberto Saldo, DTU, Denmark
22. Jun She, DMI, Denmark
23. Rasmus Tonboe, DMI, Denmark
24. Stiig Wilkenskjeld, DMI, Denmark



## Ice models

- **CICE**
  - Los Alamos Natl. Labs
- **LIM3**
  - Louvain-la-Neuve Ice Model
- **Many ocean models (NEMO, HYCOM, POM, ...)**



## Data assimilation methods

- **3D & 4D variational**
- **Ensemble Kalman Filter**
- **Others/hybrids**
  - **Method of Successive Corrections**
  - **Optimal Interpolation**
  - **nudging**



## Data

- **Ice concentration/Ice charts**
  - OSISAF Reanalysis
  - University of Bremen
  - Met.no
- **Ice drift**
  - OSISAF (met.no)
  - DTU
- **Ice thickness**
  - UCAM
- **Ocean data (Surface and at depth)**
  - DAMOCLES



## **Future**

- **Meeting planned in 2009/10**
  - **Either with Environment Canada or SMHI**
- **S4D is funded until ultimo October 2009**
- **Collaboration between EC/CSA and OSISAF/EUMETSAT**



09:00	Welcome and logistics	Leif Toudal Pedersen
	Goals for the workshop	Leif, Frank, Lars-Anders, Tom
	Introductions	All
09:30	Validation of a regional coupled ocean/sea ice model in the Nares Strait	Till Rasmussen
10:00	Development of operational coupled sea ice and ocean model at DMI	Stiig Wilkenskjeld
10:15	Data assimilation in a regional finite-element Arctic sea-ice model - <b>Cancelled</b>	Ralph Timmermann
10:45	Break	
11:15	Data Assimilation (and more) using the Ensemble Kalman Filter in LIM3	Christof König Beatty
11:45	Assimilation of sea ice observations in a coupled ocean sea ice state estimate of the labrador sea using the adjoint method	I. Fenty
12:15	Lunch	
13:30	Discussion: Is there an optimal ice model for all purposes or classes of models that are more appropriate to ice services or climate modelling. How close are we to having a linearized version of a coupled ice-ocean model?	
14:30	Assimilation of observed and unobserved ocean and sea ice	Lars Axell
15:00	Break	
15:30	Variational assimilation of hydrographic and ice concentration observations into a coupled ocean sea ice model of the Arctic	Thomas Kaminski
16:00	Adjoint analysis of the summer 2007 low in Arctic sea-ice area	Frank Kauker
16:30	Discussion: Strengths and weaknesses of DA techniques and how each can benefit from the other.	
19:30	Workshop Dinner at the Copenhagen Planetarium	



09:00	An overview of some Environment Canada sea ice data assimilation projects	Tom Carrieres
09:30	Sea ice thickness categories and their error covariances for assimilation with a three-dimensional variational data assimilation system	Alain Caya
10:00	Towards the use of high-resolution remote sensing data in a three-dimensional variational analysis system: A collaboration with OSI-SAF	Mark Buehner
10:30	Break	
11:00	Assessment of the ECCO2 regional optimized solution in the Arctic	An T. Nguyen
11:30	The joint NSIDC and EUMETSAT sea ice re-analysis	Rasmus Tonboe
12:00	The DAMOCLES project and beyond - recent advances in oceanographic observations in arctic regions and the legacy of IPY oceanography	Jean-Claude Gascard
12:30	Lunch	
13:30	Discussion: Background error estimation, use of observations, etc. What are main sources of sea-ice background error (i.e. 12-24h forecasts): atmospheric forcing error? ocean forcing error? deficiencies of ice model? uncertain parameters (drag coeff., yield curve)? What fraction of the error can be explained by: ice displacement errors? melt/growth errors?	
14:30	Measurements of Arctic sea ice thickness with upward-looking sonars in 2004 and 2007	Joao Rodrigues
15:00	Break	
15:30	OSI SAF SEA Ice products and their use in ocean-ice-model data assimilation	Lars-Anders Breivik
16:00	The met.no ice chart archive	Nick Hughes
16:30	Discussion: can models and data assimilations systems improve the utility of observations and re-analyses	



09:00	Arctic Wide Ice Motion Estimation from Operational Satellite Imagery : improving the time span and accuracy of low resolution products	Thomas Lavergne
09:30	High resolution Arctic Sea Ice drift	Leif Toudal Pedersen
10:00	Satellite remote sensing of Arctic surface parameters at University of Bremen	Christian Melsheimer
10:30	Break	
11:00	Discussion: Intro by Thomas Lavergne - Satellite derived ice drift is NOT velocity. Operational sources of sea ice drift and thickness, error estimation and representativeness	Thomas Lavergne
12:00	Planning: collaborations, future meetings, etc.	
12:30	Lunch, main meeting ends	
13:30	IICWG IPY Project coordination	



# Models

## Discussion:

**Is there an optimal ice model for all purposes or classes of models that are more appropriate to ice services or climate modelling. How close are we to having a linearized version of a coupled ice-ocean model?**



# Data assimilation techniques

## Discussion:

**Strengths and weaknesses of DA techniques and how each can benefit from the other.**



# Discussion: Data Assimilation Techniques

- Variational (3D/4D-Var) vs. Ensemble Kalman filter for operational forecasting
- In Numerical Weather Prediction applications, both give relatively similar quality results for roughly similar computational cost
- Differences:
  - 3D-Var requires TLM/AD of observation operators (EnKF does not)
  - 4D-Var also requires TLM/AD of forecast model (EnKF does not)
  - 3D/4D-Var requires estimate of  $P^f$  (B) matrix
  - EnKF requires estimate of model/forcing uncertainties
  - EnKF requires assumptions to make ensemble covariances useable (localization)
  - Strong non-linearities treated differently:
    - 4D-Var searches for maximum likelihood estimate of nonlinear problem with normally distributed observation and background errors (problems with multiple minima)
    - EnKF only extracts covariances (neglect higher order moments) from nonlinearly evolved pdf in low-rank subspace



# Discussion: Data Assimilation Techniques

- **Similarities:**
  - Both require observation operators and observation uncertainty estimates
  - Both generally assume normally distributed errors
  - Both propagate state error covariances in time:
    - 4D-Var implicitly with TLM/AD of forecast model
    - EnKF explicitly only in space spanned by ensemble members
  - Both can be implemented as a fixed-lag smoother in operational context – not clear which treats time dimension better



# Discussion: Data Assimilation Techniques

- **Issues specific to sea-ice data assimilation**
  - **Nonlinearity due to e.g.:**
    - Melt/freeze onset
    - Internal ice forces
    - Advection of discrete ice floes
  - **Non-Gaussian (and probably biased) errors due to bounded variables**
  - **How to make best use of drift observations**
  - **How to adjust unobserved variables, e.g. thickness, underlying ocean state**
- **Have intercomparisons been done between 3D/4D-Var and EnKF? Should one be done? In what context, a simple ice-only model?**



# Error estimation – ice models

## Discussion:

### Background error estimation, use of observations, etc.

- What are main sources of sea-ice background error (i.e. 12-24h forecasts):
  - atmospheric forcing error?
  - ocean forcing error?
- **Deficiencies of ice model?**
  - uncertain parameters (drag coeff., yield curve)?
- **What fraction of the error can be explained by:**
  - ice displacement errors?
  - melt/growth errors?



## Modelling background errors: Questions

- What are main sources of sea-ice background error (i.e. 12-24h forecasts):
  - atmospheric forcing error?
  - ocean forcing error?
  - deficiencies of ice model?
  - uncertain parameters (drag coeff., yield curve)?
- What fraction of the error can be explained by:
  - ice displacement errors?
  - melt/growth errors?
- Extension to 4D-Var:
  - requires a linearized model for evolving the correction fields to obs times ( $\leq 12h$ )
  - does not have to be (maybe shouldn't be) linearization of full ice-ocean model, what should be included?



## Improved analyses

### Discussion:

**Can models and data assimilations systems improve the utility of observations and re-analyses**



## Proper use of data

### Discussion:

**Satellite derived ice drift is NOT velocity.  
Operational sources of sea ice drift and  
thickness, error estimation and  
representativeness**



**Thank you  
for your  
attention!**