Sea-ice/Ocean modeling at CNRM-GAME for global climate studies: recent improvements of the sea-ice component

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Abstract

- GELATO dynamic/thermodynamic sea-ice model is embedded in the CNRM-CM5 coupled AOGCM (collaboration CNRM-CERFACS for CMIP5 experiments).
- We developed a forced configuration of GELATO-NEMO3.2/OPA9 using corrected ERAinterim atmospheric forcing.
- Performance of a parametrization of ice surface melt ponds is adressed in both forced and coupled modes.
- **The NEMO-GELATO hindcast is used for process study, as well as initialization of seasonal forecast experiments with the CNRM-CM5 coupled GCM.**

1.Model descriptions and forcing data

Sea-ice component:

GELATO5 (Salas, 2002)

- Coupled to **NEMO3.2/OPA9** ocean dynamics model, in tripolar ORCA1 configuration (L42, ~1°x1° grid).
- EVP rheology,
- Redistribution of ice floes into thickness categories (ice thickness distribution, ITD),
- Enthalpy formulation of sea-ice thermodynamics,
- Interactive prognostic salinity (Vancoppenolle et al., 2009),
- Sea-ice age, treated as a volume tracer.

Forcing data:

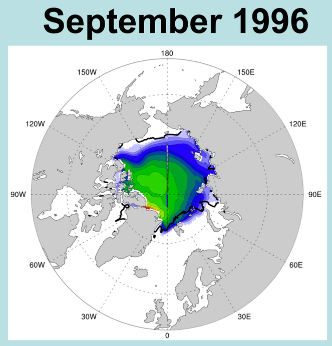
- 2m-T/RH, 10m wind, MSLP (6-hourly), SW/LW incident radiation and daily precipitation from the **ERAinterim reanalysis (ECMWF)**.
- Correction of ERAinterim 2m-T/RH (e.g. Lüpkes et al., 2010), LW/SW in the Arctic and Antarctic (GEWEX).
- CORE bulk formulation of surface fluxes.

2.Hindcast of the Arctic sea-ice cover

Set-up:

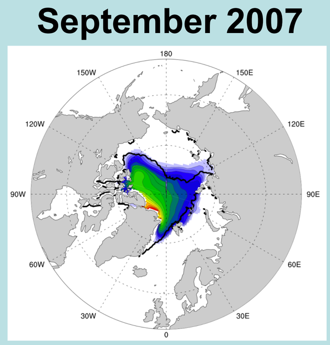
- 8 thickness categories: 0-0.2m, 0.2-0.5m, 0.5-0.9m, 0.9-1.5m, 1.5-2.5m, 2.5-4m, 4-6m, >6m.
- Melting ice albedo: 0.56

September 1996



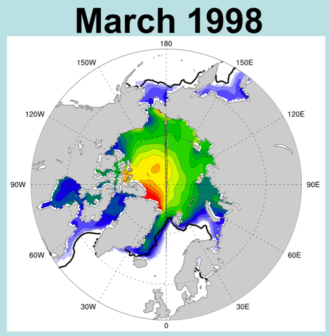
SIE: 7.79 Mkm² *(HadISST: 7.59 Mkm²)*

September 2007



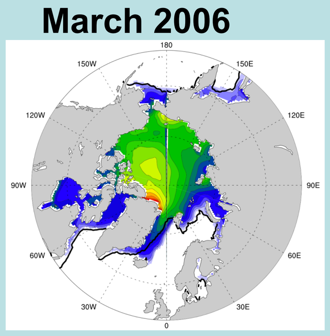
SIE: 5.06 Mkm² *(HadISST: 4.78 Mkm²)*

March 1998



SIE: 16.95 Mkm² *(HadISST: 16.03 Mkm²)*

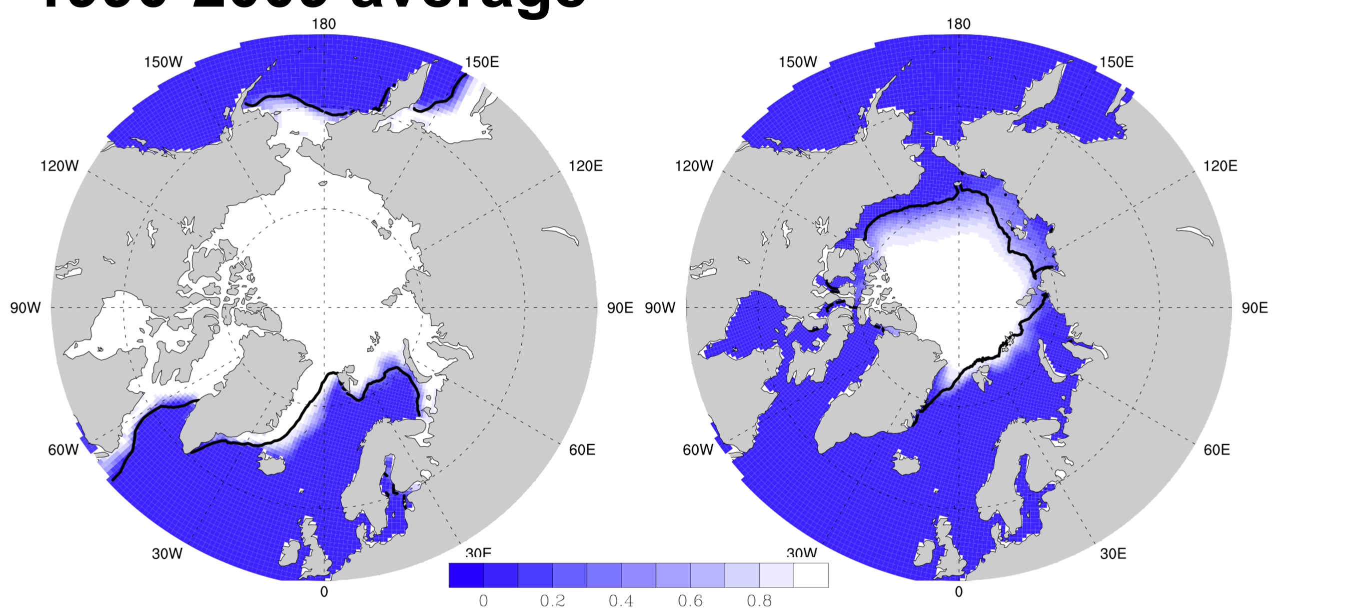
March 2006



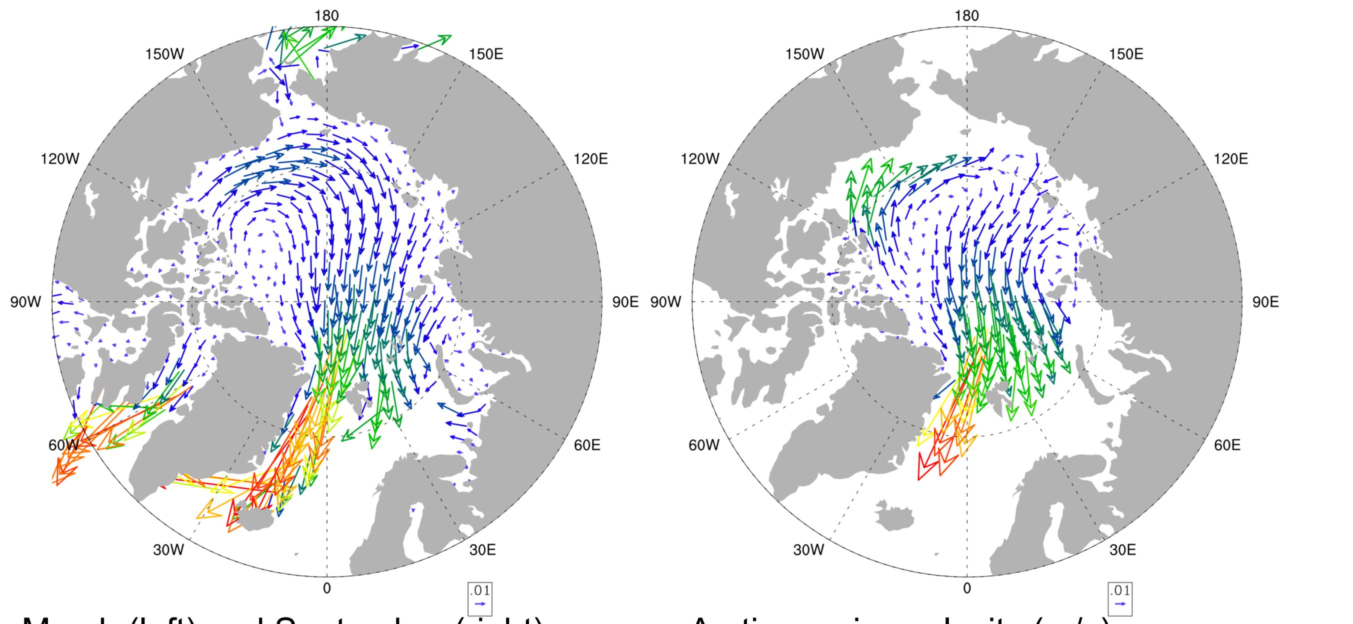
SIE: 16.33 Mkm² *(HadISST: 15.11 Mkm²)*

1990-2009 average

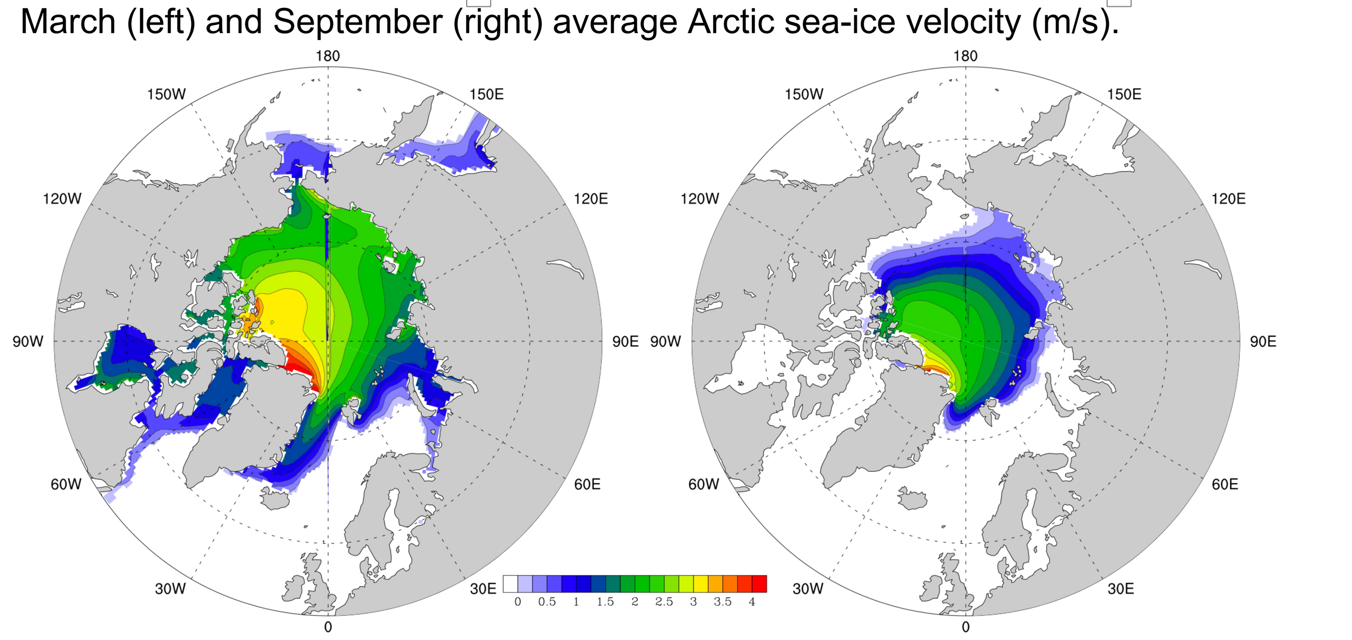
Black line: observation ice edge (HadISST)



March (left) and September (right) average Arctic sea-ice concentration.



March (left) and September (right) average Arctic sea-ice velocity (m/s).



March (left) and September (right) average Arctic sea-ice thickness (m).

Impact of the forcing set

Forcing set	March SIE *(10⁶ km²)*	September SIE *(10⁶ km²)*	May thickness (m)	Sep thickness (m)
DFS4 (ERA40-ISCCP)	17.12	4.21	1.79	0.88
ERAinterim	16.86	6.00	2.16	1.10
ERAinterim corrected	16.94	7.07	2.49	1.87
OBS	15.85[1]	6.89[1]	2.73[2]	-

Comparison between model Arctic sea ice extent (SIE) and thickness averaged over the Central Arctic ocean during the period 1990-2001. SIE observations are based on SSM/I data (1: HadISST, 2: 1993-2001 mean winter thickness in Laxon et al., 2003).

⇨Simulated sea-ice extent and volume are realistic.
⇨Observation-based corrections of atmospheric forcing improve the simulated ice cover.

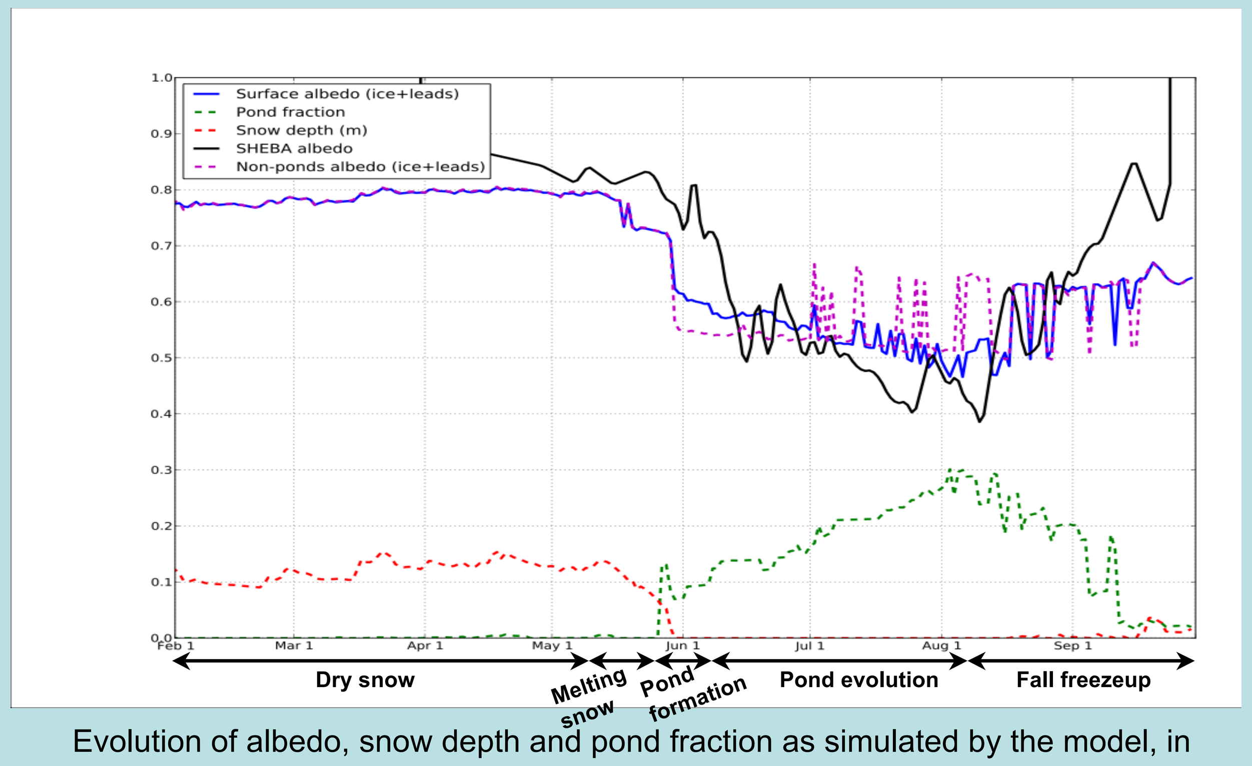
3.Inclusion of melt ponds

Basics of the parametrization:
- Pond growth: top surface meltwater budget (M. Holland, pers. comm.).
- Pond refreezing: formation of pond ice, using surface heat budget.
- Empirical relation pond fraction/pond depth (to be adapted, e.g. using ice age).
- Pond albedo formulation based on Ebert and Curry (1993).

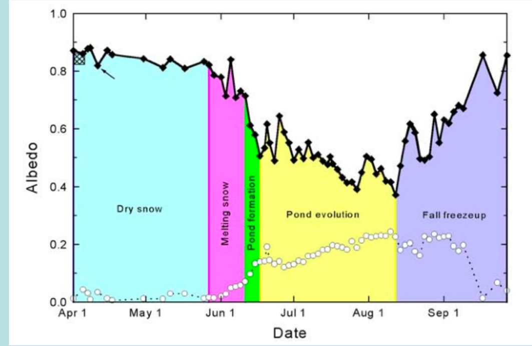
⇨ No update of water fluxes, or ice addition to the ITD.
⇨ Suitable for inclusion in a fully coupled AOGCM.

Forced mode

Hindcast of the SHEBA period (September 1997-September 1998)



Evolution of albedo, snow depth and pond fraction as simulated by the model, in forced configuration, during the 1998 winter-spring-summer at SHEBA locations (no pond albedo: melting ice albedo is specified; SHEBA albedo: see Perovich et al., 2002).

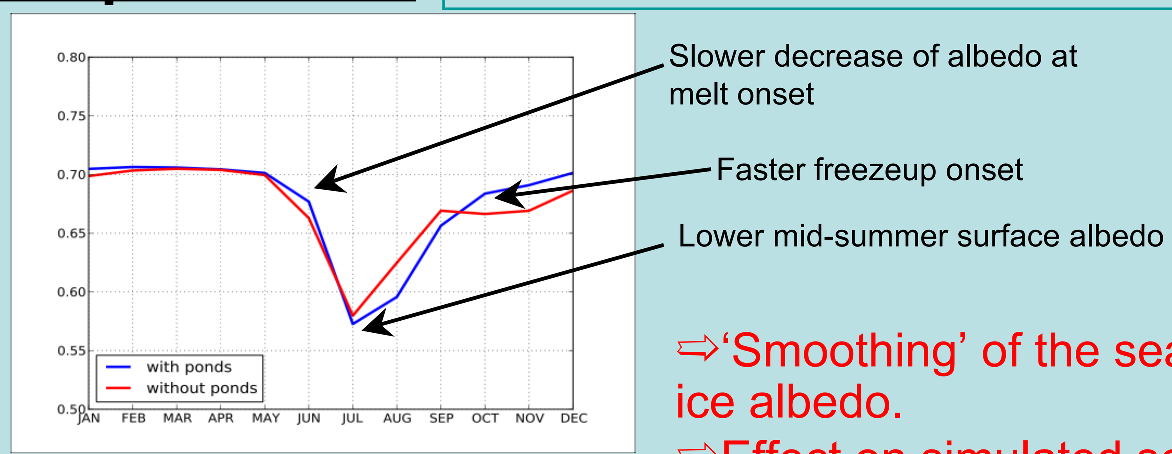


Time series of albedo along the SHEBA albedo line. (*Source: Perovich et al., 2002*)

⇨Timing of each phase of albedo evolution is realistic.

Coupled mode

10-year simulation under preindustrial GHG forcing



10-year mean annual cycle of sea-ice albedo averaged over Central Arctic.

CNRM-CM5 coupled GCM:
- Ocean-ice: **NEMO-GELATO**
- Atmosphere: **ARPEGE-Climat**
- Land surface: **SURFEX**
- Coupling: **OASIS**

⇨'Smoothing' of the seasonal variations of sea-ice albedo.
⇨Effect on simulated sea-ice volume (increase).
⇨Feedback to be further investigated…

4.Perspectives

- Parametrization of snow densification (not shown).
- Interactive melt ponds.
- Optimization of sea-ice dynamics (collab. McGill University…).
- Improving atmospheric forcing sets in the polar regions.
- Ensemble seasonal forecasts of the Arctic sea-ice with CNRM-CM5.

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