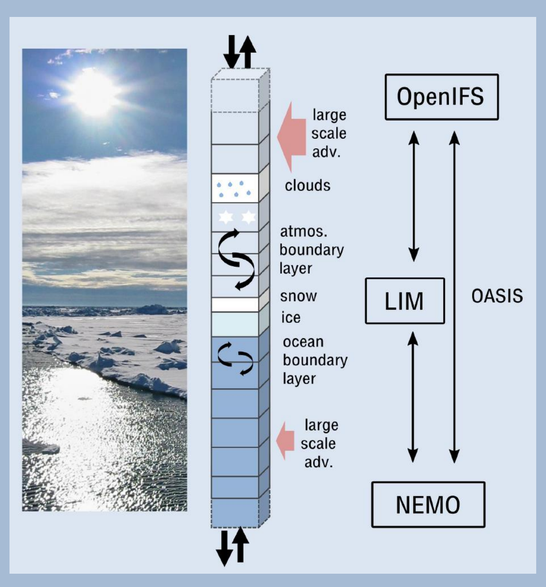
Arctic airmass transformation case explored using an Atmosphere Ocean SCM

Gunilla Svensson (gunilla@misu.su.se) and Kerstin Hartung
Department of Meteorology and Bolin Centre for Climate Research, Stockholm University, Sweden
Swedish e-Science Research Centre

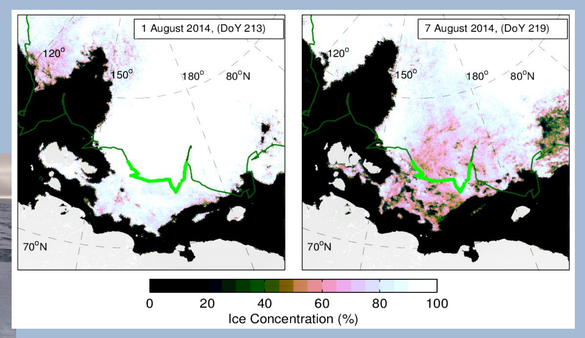
AOSCM



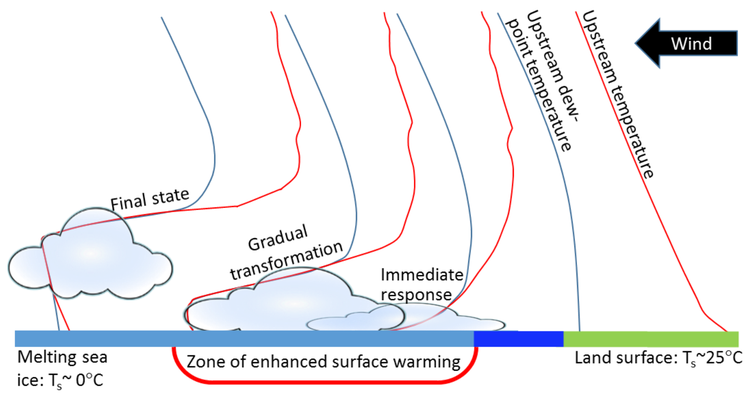
WHY? An Atmosphere Ocean Single Column Model (AOSCM) is developed to be used as a tool for model development and process understanding when the coupling between the atmosphere and the ocean is of great importance. This is particularly the case for the atmosphere over the sea-ice covered Arctic Ocean.

WHAT? The AOSCM is based on the development version of EC-Earth i.e. OpenIFS cycle 40r1, NEMO3.6/LIM3 coupled with OASIS3-MCT. Sensitivity simulations are performed for a case when warm continental air was advected over the sea-ice (Tjernström et al., 2015). The role of the clouds for the surface energy budget has been studied using a LES (Sotiropoulou et al., 2018). Both observations and LES results are here compared with the AOSCM results.

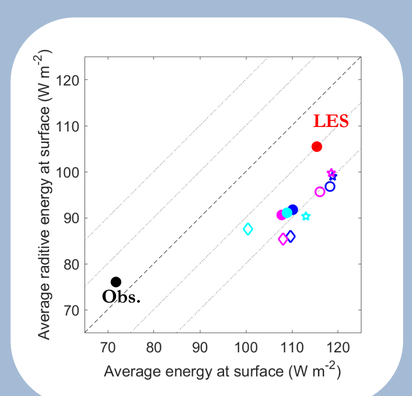
An extreme warm advection episode during ACSE



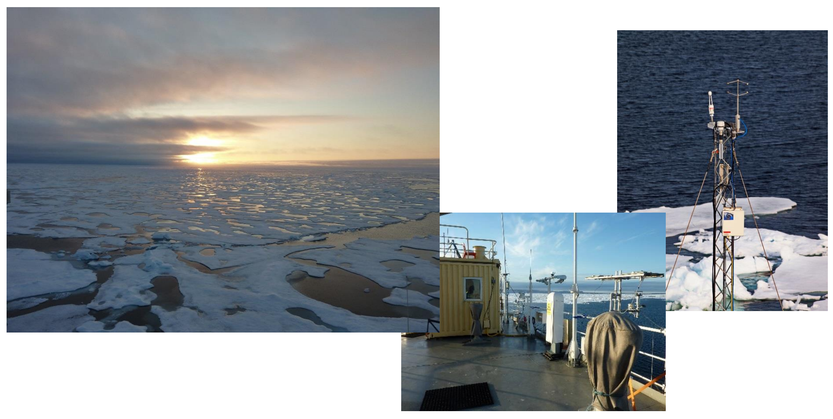
Observations taken onboard the ice-breaker Oden during the Arctic Clouds in Summer Experment, are here used in a case study with the AOSCM. As seen in the satellite figure, substantial melting occurred during these days (Tjernström et al., 2015).



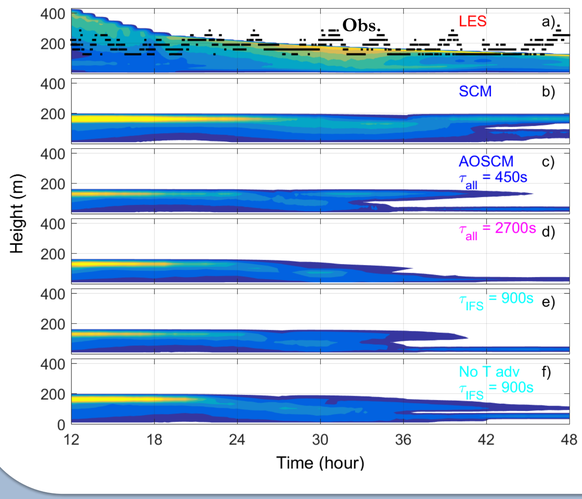
Surface energy budget



Observed surface energy (black) during hour 12 – 48, is less than the LES (red). Both have smaller contributions from the turbulence fluxes than the SCM/AOSCM but with opposite sign.



Cloud liquid water content

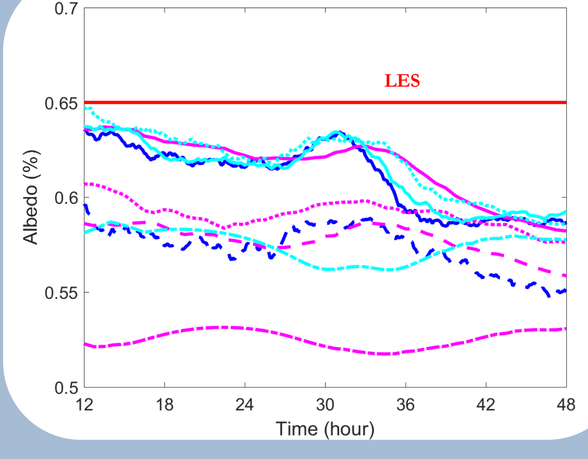


The evolution of the cloud differs between model configuration. Black dots show observed cloud top height.

Preliminary results Sensitivity to timestep, coupling frequency and advection of heat and moisture is examined and compared with LES results and observations for hour 12 to 48 of the simulation.

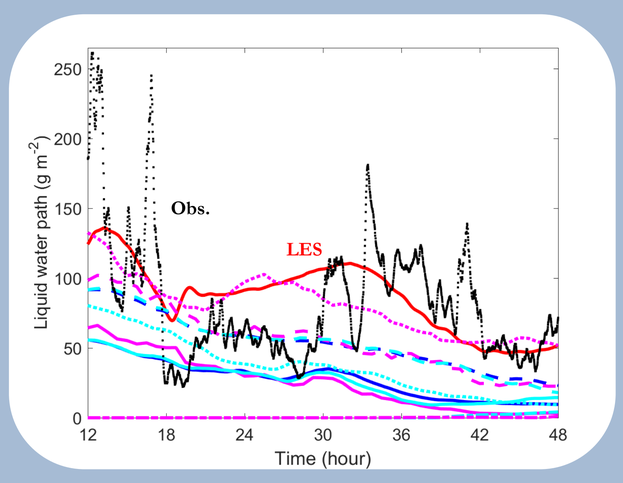
The cloud liquid water, lifetime and height of the cloud is sensitive to the changes. The cloud is not sensitive to the initial albedo, which is different in the coupled and uncoupled simulations. The change in albedo over the simulation is substantial. The advection of moisture is needed to maintain the cloud both in LES and SCM/AOSCM.

Albedo



The albedo, calculated from the radiative fluxes, is changing with time (only the LES is constant, no observations are available) as the temperature, ice conditions and clouds are changing.

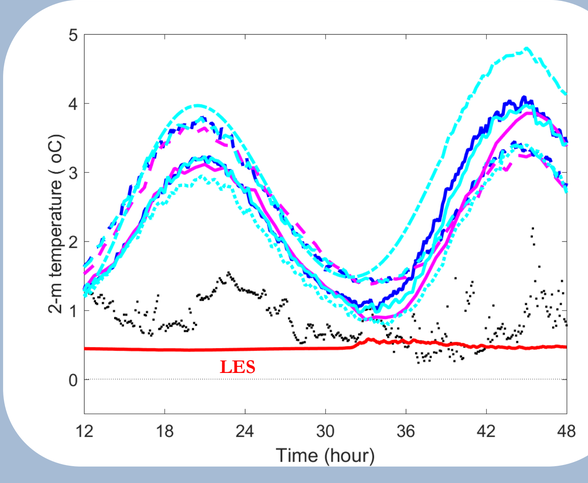
Liquid water path



The observations (black) show large temporal varability. The LES has more cloud liquid water than the SCM that has more than the AOSCM. An almost constant difference between the SCM and the AOSCM is detected.

Experiment	τ_{OIFS} (s)	τ_{NEMO} (s)	$\tau_{Coupling}$ (s)	Symbol
SCM	450	-	-	
AOSCM	450	450	450	
SCM	2700	-	-	
No temp advection	2700	-	-	
No humidity advection	2700	-	-	
AOSCM	2700	2700	2700	
AOSCM	900	2700	2700	
No temp advection	900	2700	2700	
No humidity advection	900	2700	2700	

Temperature at 2m



The observations (black dots) are taken at about 25 m above surface. The diurnal variation in 2-m temperature in the model comes from the skin temperature that is allowed to change even though the ice is melting.

References

Hartung, K. et al., 2018: An EC-Earth coupled atmosphere-ocean single-column model (AOSCM) for studying marine and polar processes. Manuscript.
Tjernström M. et al., 2015: Warm-air advection, air mass transformation and fog causes rapid ice melt, *Geophys. Res. Lett.*, **42:** 5594–5602
Sotiropoulou et al., 2018: Warm-air advection and air-mass transformation over melting sea ice in the summer Arctic. Submitted to QJRMS.

Acknowledgements

Michael Tjernström for photos and the whole ACSE team for observations. Georgia Sotiropoulou for LES results. Hamish Struthers at NSC, LiU and SNIC for computational resources. The AOSCM support from Glenn Carver et al., at ECMWF.