CANDIFLOS
Characterising and Interpreting FLuxes Over Sea-ice

Principal investigator

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Areas of contribution

Polar atmospheric processes
Modelling and forecasting
Observations
Data archiving

Summary

CANDIFLOS will develop new parameterizations of the turbulent surface fluxes of momentum, heat, and water vapour over sea ice using in situ measurements collected over a total of 18 weeks of cruise time in the Arctic Ocean. The parameterizations will be implemented in the Met Office Unified Model, in both forecast (atmosphere only) and climate (fully coupled, Hadley Centre Global Environment Model version 3, HadGEM3) versions. The impact of the new parameterizations on the surface energy budget and sea ice will be evaluated within HadGEM3.

Description

Interactions between the atmosphere and surface are mediated by turbulent fluxes – chaotic mixing that transports momentum, heat, moisture, and trace gases. Turbulent mixing spans scales from millimetres to 100s
of meters – much smaller than the grid scale of numerical models; such sub-grid-scale processes must be
parameterised in terms of resolved model variables such as mean wind speed, temperature, humidity, etc. The
chaotic nature of turbulent mixing means that exact analytical solutions describing their behaviour are not
available, and we must treat them statistically based on direct measurements.
CANDIFLOS will address long-standing issues with the parameterization of turbulent fluxes over sea ice. The
remote location and harsh conditions of both Arctic and Antarctic sea ice means that very few direct
measurements have ever been made, and models must rely on parameterizations developed at lower latitudes
over other surfaces. The very different conditions that occur over sea ice – a high degree of spatial
heterogeneity, strong temperature contrasts between the ice and open water in leads in the ice, and strongly
stable conditions in winter – mean that the parameterizations developed at lower latitudes are often not
appropriate, and models tend to do a poor job of representing the surface fluxes. The current generation of
models fails to represent the mean changes in sea ice extent over the period of satellite record, and produce
often wildly inaccurate seasonal forecasts of ice extent even a few months in advance.
Although the surface energy budget is dominated by solar and infra red radiation fluxes, the surface turbulent
fluxes have a controlling influence on atmospheric boundary layer structure and the properties of boundary layer
clouds. Clouds are the dominant control on the radiation fluxes; failure to properly represent the turbulent fluxes
thus has a knock-on influence on the surface radiation balance through their impact on cloud. An accurate
representation of turbulent fluxes is thus essential in order for climate models to produce a realistic surface
energy budget.
On shorter timescales, the reduction of Arctic sea ice, and the accompanying increase in commercial activity in
the Arctic (shipping, tourism, petrochemical extraction, etc.) means that there is an urgent need for accurate
operational forecasts of weather, and seasonal forecasts of ice conditions. Delivering these requires much
improved representation of the surface exchange processes that control the atmospheric boundary layer structure
and properties of clouds within it, and contribute to the surface energy budget, and hence ice melt/freeze, and
ice drift.
Significant progress has been made over the last 5 years in developing theoretical models of the physical
processes that control the surface fluxes – including the influence of form drag at ice edges, ridges, melt ponds,
and ice/water temperature contrasts. In-situ measurements are required, however, to determine the appropriate
values of coefficients in these parameterizations, and to evaluate their performance.
CANDIFLOS will utilise a very extensive set of surface flux measurements made during two cruises in the
Arctic Ocean, totalling 18 weeks, to develop state-of-the-art parameterisations for momentum, heat, and water
vapour, tuned to real-world conditions. We will implement the parameterizations within the Met Office Unified
Model, and evaluate the impact on operational, seasonal, and climate scale modelling. Tests will include
validation against independent data sets drawn from other measurement campaigns, including the Met Office
MACSSIMIZE project (spring 2018), the international IGP project in the Iceland Sea (for which Ian Renfrew is
the PI of UK contribution), flux measurement flights over Antarctic sea ice made by the British Antarctic
Survey as part of the ORCHESTRA project, and MOSAiC.

Objectives:
1. To determine the turbulent drag coefficient (and equivalent roughness length) as a function of ice surface
   properties (ice fraction, floe and lead size distributions, freeboard, melt pond fraction) and near-surface
   atmospheric stability.
2. To determine the turbulent transfer coefficients for sensible and latent heat as functions of ice properties and
   atmospheric forcing conditions.
3. To implement new parameterizations of the surface exchange of momentum, heat and moisture over sea ice
   in models.
4. To determine the impact of new surface exchange parameterizations on the modelled surface energy balance,
   atmosphere, ocean, and sea ice on a range of timescales.
5. To test the potential of formulating drag coefficients in terms of satellite derived surface roughness.

All data will be made available through public archives: NERC's atmospheric data archive (a requirement of NERC funding) and the Bolin Centre for Climate Research archive (a requirement of cruise participation). Most data from the 2014 cruise is already available on the NERC archive.

**Timeline**

2018-10-01 - 2021-09-30

**User relevant aspects**

Provision of new parameterizations for operational forecast models.

**Regional emphasis**

Northern hemisphere: Yes

Southern hemisphere: No

**Further specification**

Primary data set is all from within the Arctic Ocean. Additional data from research flights over Antarctic sea ice will be used where possible to validate the parameterizations derived from Arctic observations for Antarctic conditions.

**Key project deliverables**

Extensive data set of in situ flux measurements along with derived turbulent exchange coefficients.
New parameterizations of turbulent exchange over fractional sea ice suitable for implementation in operational and climate models.
New parameterizations formulated in terms of satellite-based radar measurements suitable for use in operational forecast models.
Data management

UK Natural Environment Research Council atmospheric data archive (CEDA)
Core data also archived with the Bolin Centre for Climate Research, Sweden

Is data provided to WMO Global Telecommunication System

No

Real-time provision

N/A