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Investigations of the Arctic Ocean North of Greenland: The GRASP Initiative

Kurzfassung

Der eisbedeckte Ozean nördlich von Grönland ist eine der am Wenigsten erforschten Regionen der Arktis. Selbst die fundamentalsten Daten über Bathymetrie, Zustand des Eises, Geologie und Geophysik sind dürftig oder fehlen. Zur Zeit liefert die vielbeachtete internationale Forschung neue Resultate aus vielen Teilen des Nördlichen Eismeeres. Das ziemlich unzugängliche Gebiet nördlich von Grönland stellt daher eine Herausforderung für die internationale Wissenschaft dar. Ein neues GRASP (Greenland Arctic Shelf Project) genanntes Programm wird deshalb in die Wege geleitet.

Abstract

The ice-covered Arctic Ocean north of Greenland is one of the least investigated regions of the Arctic. Even the most basic scientific data on bathymetry, ice conditions, geology and geophysics are scarce or absent. Presently, significant international research is providing new results from many parts of the Arctic Ocean. The fairly inaccessible area north of Greenland hence presents a challenge to the international science community. A new program called GRASP (Greenland Arctic Shelf Project) is therefore initiated.

Résumé

L'océan Arctique au nord du Groenland est une des régions les moins explorées de l'Arctique. Même les dates les plus fondamentales concernant la bathymétrie, l'état de la glace, la géologie et la géophysique sont insuffisantes ou non-existantes. Actuellement, d'importantes recherches internationales fournissent des résultats concernant beaucoup de parties de l'océan Arctique. La région assez inaccessible au nord du Groenland est donc un défi pour les explorateurs internationaux. C'est pourquoi un nouveau programme appelé GRASP (Greenland Arctic Shelf Project) est mis en œuvre.

Keywords

Arctic Ocean, North Greenland Shelf

1. Introduction

The Arctic Ocean north of Greenland is one of the least investigated regions of the Polar basin, and many basic questions relating to oceanography, sea-ice, climate, biology, geology and geophysics need to be addressed to understand the structure of the continental shelf, to decipher the geological and climatic history, and to understand the environment, physical properties and living resources of this Arctic Ocean region.

Presently, significant international research is providing new results from many parts of the Arctic Ocean through major international efforts such as the scientific submarine expeditions (SCICEX), major airborne geophysical surveys and the release and compilation of formerly classified oceanographic, hydrographic and climate-related data. Recent data have thus indicated a thinning of the polar sea-ice cover (JOHANNESSEN et al. 1999; ROTHROCK et al.1999; WADHAMS & DAVIS 2000).

A continued future decrease in ice thickness is of importance for global commerce and shipping, and last but not least for possible effects on the fragile Arctic ecological systems. These and other scientific challenges to be investigated in the Arctic Ocean is recently addressed by international scientific community (APPG, 2001).

Activities in the area north of Greenland are still sporadic. To mount a dedicated long-term research effort in this area, the Commission for Scientific Research in Greenland, Copenhagen, initiated an interdisciplinary research initiative called GRASP, the Greenland Arctic Ocean Shelf Project (FORSBERG et al.1999).

The present paper summarises results from a pilot GRASP initiative with airborne and satellite observations of sea ice conditions north of Greenland.

2. Background

The main physiographic and geological features north of Greenland include the Lincoln Sea shelf, Morris Jesup Rise and the Wandel Sea basin, as well as the deeper ocean basins north and north-east of these features (Fig. 1). The Lincoln Sea shelf represents a little known but seismically active sedimentary basin of lower and middle Palaeozoic and Mesozoic-Cenozoic strata (DAWES & PEEL 1981).

Morris Jesup Rise is an aseismic bathymetric feature of probably mixed oceanic and continental origin (DAWES 1990), while the Wandel Sea is characterized by a seismically active and unusually narrow continental shelf margin. Geological information on these pronounced morphological features is sparse, as is the information on hydrography and shelf configuration. Morris Jesup Rise is of special interest as this morphological unit, which extends far into the Arctic Ocean, is an aseismic bathymetric feature of probably mixed oceanic and continental origin (DAWES 1990).

For the area of the Arctic Ocean north of Greenland, the knowledge of bathymetry, ocean-bottom geology, and oceanography is limited, primarily due to the heavy ice conditions, which have prevented any ice breaker operations. Limited airborne geophysical data, inferences from coastal geology, and a couple of shallow profiles in the eastern area are the only sources of information hinting at the sub-sea geological structures. Even the most basic mapping data relating to the bathymetry of the North Greenland continental shelf are insufficient.

Another reason for interest in the Arctic Ocean is the possibility for nations bordering the Arctic Ocean to claim an extension of their territorial limits beyond 200 nautical miles (nm) as a consequence of the UN Laws of the Sea Convention (United Nations 1993). A basic project to collect data on the bathymetry and geological structure of the region north of Greenland is presently under consideration in order to meet the data requirements of the UN Laws of the Sea.

In order to meet the challenge of the scientific and potential political interests in the Arctic Ocean north of Greenland, the GRASP science plan originally suggests acquisition of data on bathymetry, shelf slope, geology, geophysics, oceanography and sea ice from floating ice camps deployed above the 2000–2500 m water-depth contour (FORSBERG et al. 1999; Fig. 1), and supported by helicopter and Twin Otter aircraft. This operation would allow collection of data covering crucial parts of the shelf region from the Wandel Sea in the east to the Lincoln Sea in the west, with special emphasis on Morris Jesup Rise.

3. Observations of Sea Ice

A reconnaissance flight in March 2000 north of Greenland was the first field campaign of the GRASP initiative. The purpose of the flight was to study the sea-ice conditions that may be encountered when the planned ice stations are operated. The observations from the air facilitated interpretation of satellite images acquired by the Canadian satellite Radarsat obtained during the same period (Fig. 4). Two flight lines were undertaken crossing Morris Jesup Rise (Figs. 1, 4).

Data from the radar scenes and aerial observations complement each other. It appears that the sea-ice cover over Morris Jesup Rise was irregular in March 2000. Large areas of multi-year ice were interspersed by leads of 50–75 m widths covered by newly formed ice or even open water. A drift velocity in March 2000 of 2 km/day towards 110° with a direction almost parallel to the North Greenland coast was determined. These preliminary data, together with satellite data from previous years, show that in order for a scientific sea-ice station to pass over the centre of Morris Jesup Rise while collecting data, the station should be deployed at about 85°N 24'W, and would need about two

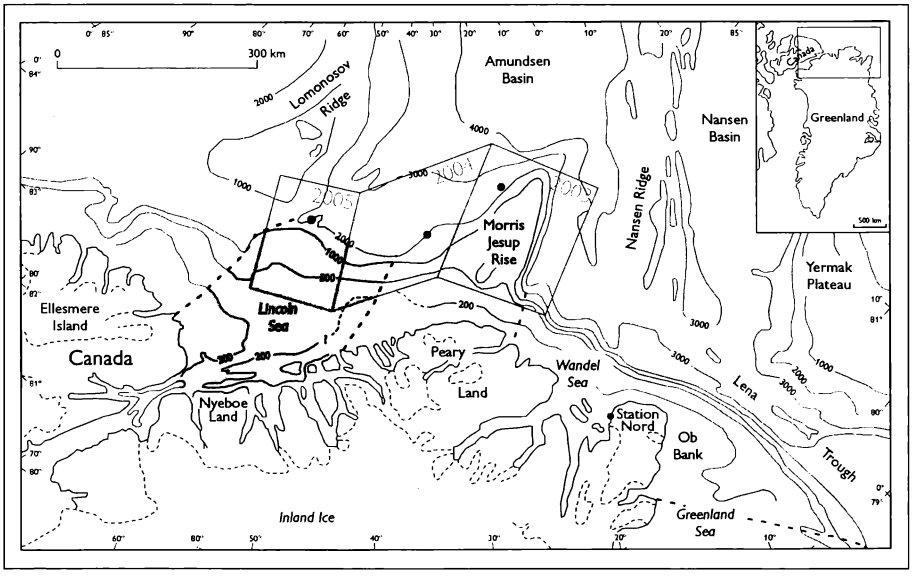

Fig. 1: North Greenland continental margin with main physiographic regions (Lincoln Sea, Morris Jesup Rise, Wandel Sea) shown in blue tones. Modified from DAWES (1990). Location of the ice-drift camps proposed by GRASP for 2003, 2004 and 2005 are shown by black dots in the framed areas. The camps might be replaced by or combined with icebreaker operations. Bathymetric contours are in metres.

months to drift across the Morris Jesup Rise. In April 2001 a new GRASP field campaign was undertaken north of Greenland to provide comparative data which data are presently being processed. The data included airborn laser scanning allimetry and video recording of the Polarbasin north of Greenland as well as tests with through-ice ecco sounders and in-situ ice properties.

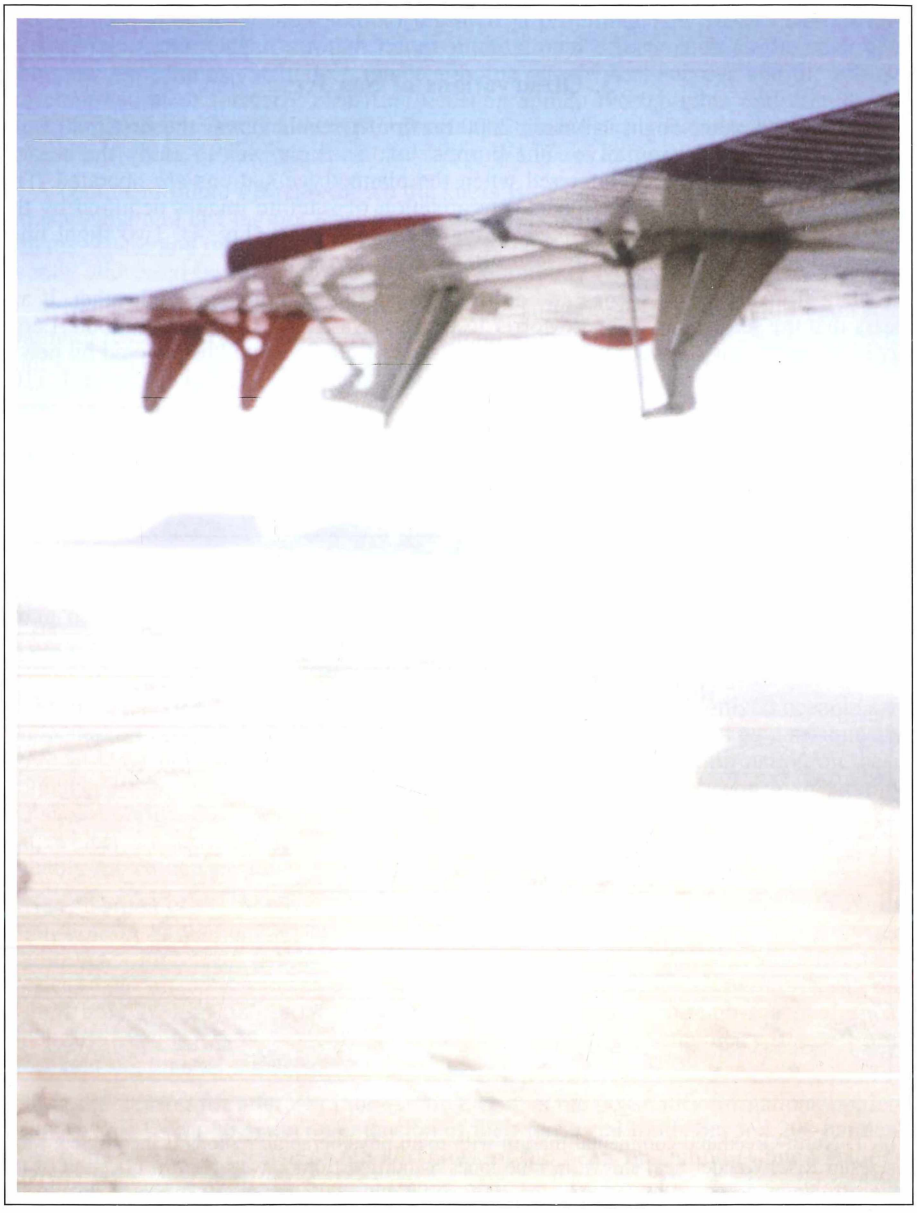

Fig. 2: Sea ice in the Polar Basin north of Greenland

Fig. 3: Twin Otter airplane before a GRASP-flight over the Polar Ocean

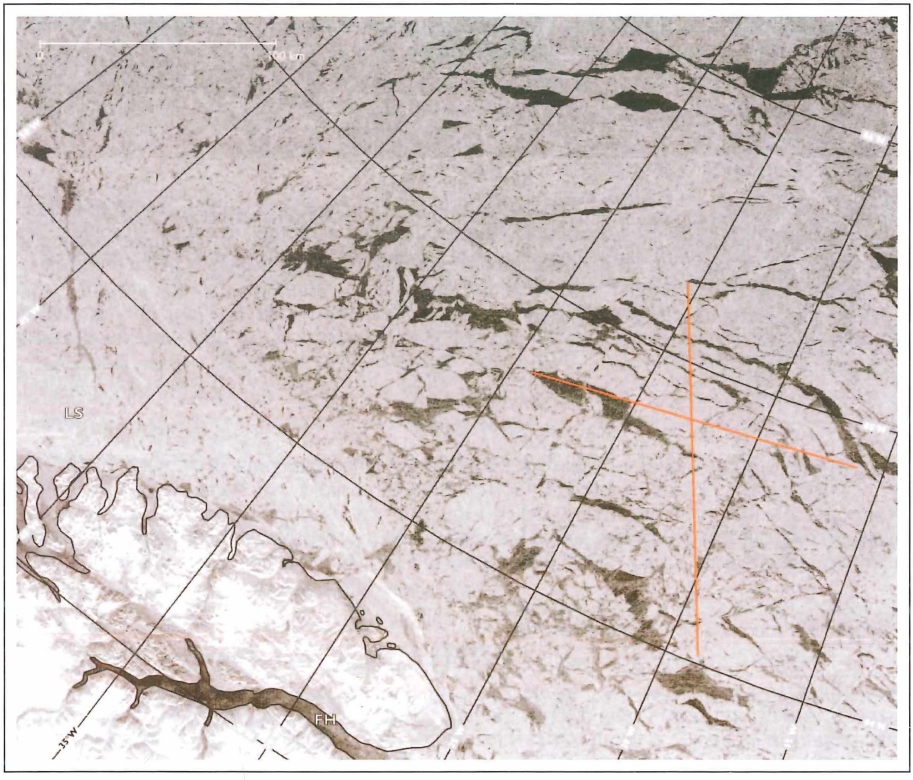

Fig. 4: Radarsat scene acquired on 6 March 2000 showing an area of the sea-ice covered Arctic Ocean measuring 500 x 500 km. Northernmost Greenland (Peary Land) with Frederick E. Hyde Fjord (FH) marked. An E-W-trending feature in the sea-ice along latitude 84°N indicates the boundary between the faster moving ice of the main central Arctic Ocean gyre and the stationary or slow moving sea ice of the Lincoln Sea region (LS). The flight lines from March 2000 are indicated in red over Morris Jesup Rise.

4. Acknowledgement

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