Report on the Spring 2005 Nares Strait Field Effort: OPP-0230354 & OPP-0230236

Variability and Forcing of Freshwater Fluxes through Nares Strait and Jones Sound: A Freshwater Emphasis; K. Falkner, M. Torres and R. Samelson (OSU) and A. Münchow and K.-C. Wong (UDel) and Humfrey Melling (IOS, Canada)

Chronicle of Events

The principal objective of the spring 2005 field effort for this project was to retrieve and redeploy 23 moorings that were deployed in Nares St. from the USCGC Healy in August 2003 (Fig. 1). In addition, it was planned to conduct hydrographic sampling in support of the project goals. Since ship-based retrieval operations are challenged by uncertain ice-conditions over a given mooring site, fog, currents and winds in the limited summer season, our preferred strategy was to work from the ice surface in the spring, using aircraft to position personnel and equipment from a nearby field camp. This approach to oceanographic mooring has been used routinely by the Canadian Frozen Sea Research Group (Humfrey Melling) in the Canadian Archipelago and the Beaufort Sea since the mid 1970s, and from time to time by the University of Washington.

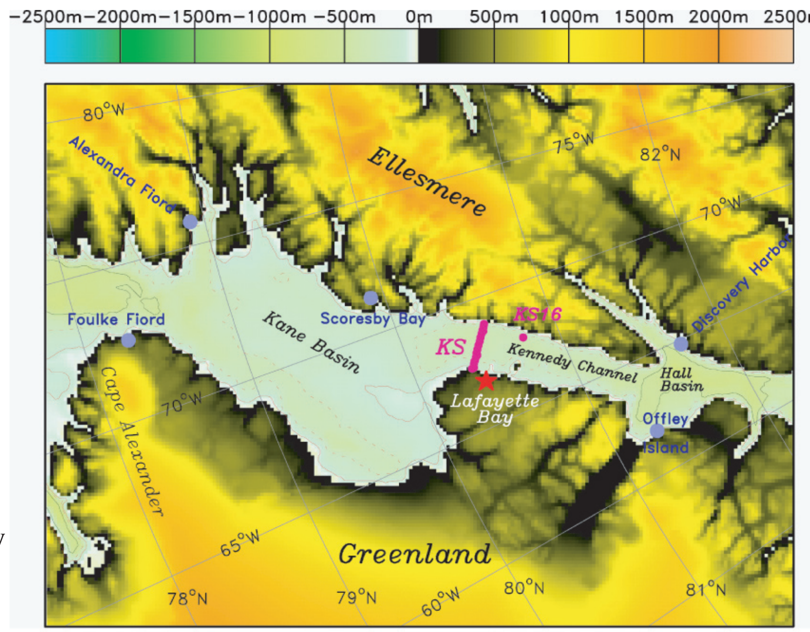
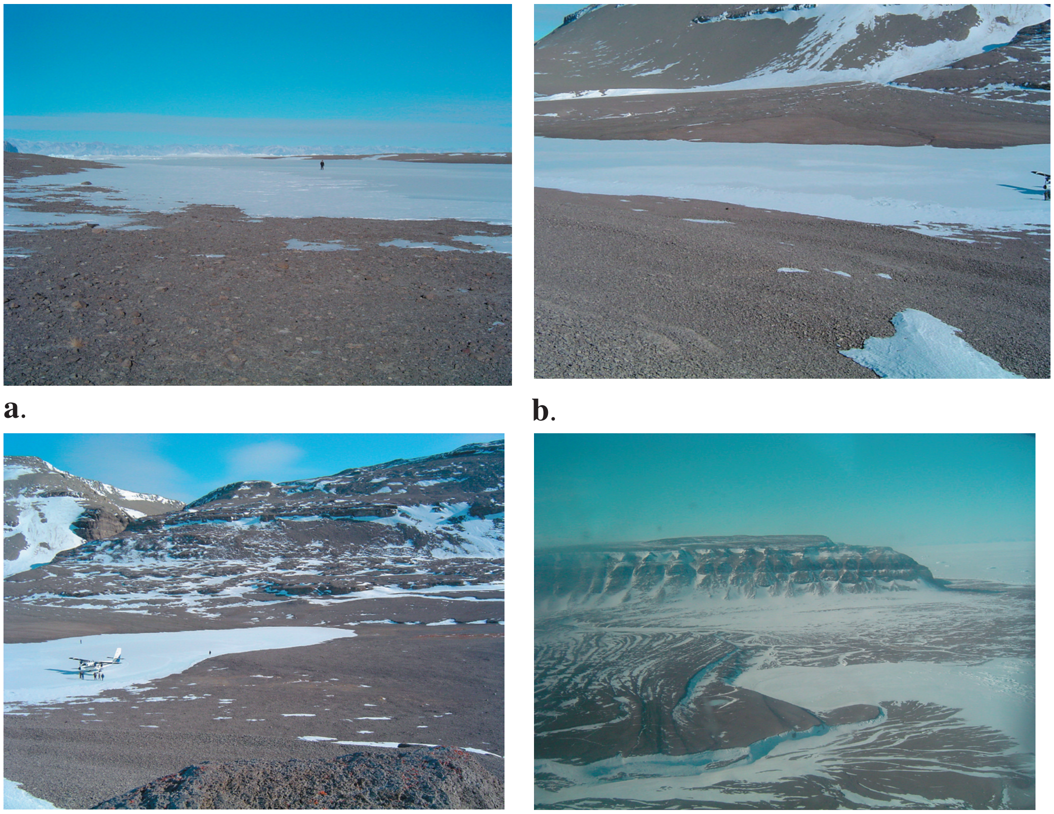


Fig. 1. Mooring locations for Nares St. flux program. Red star marks site of spring 2005 science base camp. Pressure sensing moorings in blue. Main array moorings in pink. to

Planning for the aircraft-based effort took place over a two-year period (2004-05) primarily via conference calls and e-mail. Tom Quinn of VECO Polar Resources was the lead logistics coordinator, in consultation with Andy Heiberg of the University of Washington. Jim Milne of the Defense Research Development Corporation (DRDC), an agency of the Canadian Department of National Defense, was contracted to supply equipment, to set up and to maintain the base camp during April-May 2004. Jim has carried out many such operations in the environs of Alert over the past two decades. He has extensive experience in ice-camp operation for science, and was directly involved in planning efforts.

The scientific program was to be supported by helicopter from a camp established onshore within close working distance of the main mooring line. The proximity of the base camp permitted optimal use of good weather for operations, and facilitated the ferrying of heavy equipment by sling net to work sites. Reconnaissance to find a suitable location for the base camp was first conducted via helicopter from the Healy in August 2003. Prime candidates were visited again by Twin Otter in early May 2004 to evaluate local conditions during the season of planned actual occupation. At that time, we noted the scarcity of snow cover on level ground on both sides of Kennedy Channel. This circumstance limited the number of locations suitable as landing sites for a ski-equipped Twin Otter. In Lafayette Bay, 6 miles north of the main line of moorings, the smooth frozen surface of a shallow inlet provided an excellent runway for the Twin. Upon landing in 2004, numerous photos were taken under calm sunny skies (Fig. 2). The inlet was located at the junction of two river valleys and was bounded by high relief including headlands to the north and south. Since Crozier Island, immediately offshore, rises to almost 1000 feet, the site was apparently well sheltered. All noted the sparse snow cover, which was taken to signify frequent windy conditions. We judged such episodes of strong wind to be a likely hindrance to our work and a discomfort for personnel, and made allowance in the schedule of work. Unfortunately, we would come to understand that despite our extensive planning efforts, wind would render work out of a shore-based camp with temporary structures in the region impossible.

The project includes a mesocale atmospheric modeling component that is spearheaded by Roger Samelson of OSU. The primary goal of this component was to provide continuous estimates of wind stress in Nares Strait for comparison with the observations of ice motion and ocean properties and currents. The modeling



a. b. c. d.

Fig. 2. Reconnaissance photos from spring 2004. a: Looking from inlet to the west. Ellesmere Island mountains in background with piece of Crozier Island visible on left. b. Looking across inlet to the north. Headlands visible with Franklin Island partly visible to left of headlands. c: Looking at eastern termination of inlet. d. Aerial photo over inlet looking to southern river valley with headlands behind.

approach was chosen because of the technical difficulties and cost of deploying and maintaining meteorological instrumentation in the Strait for the duration of the observing period, and because previous experience with modeling stable layer flow off the west coast of the US suggested it could be successful. In the absence of any current or long-term historical in-situ meteorological measurements, the importance of obtaining ground-truth observations for the model was recognized, and Samelson and Co-PI K. Steffen twice submitted proposals to NSF OPP to deploy an automated weather station near sea level in the Strait. These proposals each received three reviews (E/VG/F, E/VG/G) and were ultimately both declined. Consequently, the accuracy of the model fields was, and largely remains, unknown. The Polar MM5 mesoscale atmospheric model was selected for these studies because of additional physics specifically included for the Arctic environment (see PMG). The model is run once each day in a 36-hour forecast mode using initialization data from the 00 UTC cycle of the global AVN model. Currently, a triply-nested configuration is used, with a fourth inner nest established for use in special cases (Fig. 3). The computational cycle was not optimized for forecast purposes as this had not been the intent of the effort and because the accuracy of the simulations was unknown.

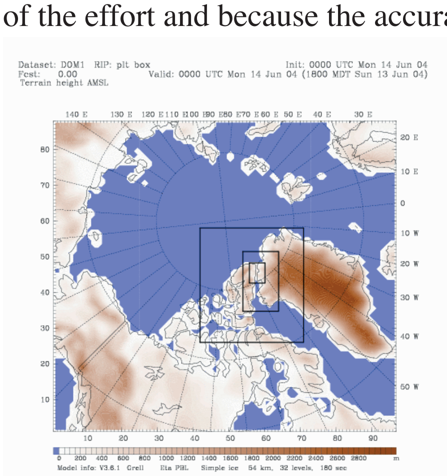


Fig. 3. Meso-scale atmospheric nested model domains.

Model output was plotted and archived daily to construct a continuous hourly estimate of meteorological fields in the Strait. The model climatology was examined in advance of the planned field program, which indicated that spring is a relatively high wind season in the Strait. In the absence of in-situ data, the model results for April-May 2004 were used for guidance in estimating typical and extreme wind-chill conditions, as an input to scheduling our work. The table prepared for this purpose on the basis of the hourly 10-m model winds showed means of 8-9 m/s and extreme events of 16-18 m/s. These appeared to be consistent with the 10-15 m/s low-level jets in the model monthly mean Kennedy Channel cross-sections, and were not interpreted as threatening to the planned field installations and activities.

The project includes a satellite-based study of the ice cover of Nares Strait, spearheaded by Tom Agnew of the Meteorological Service of Canada. Imagery monitored by Humfrey Melling revealed that the ice in the strait ceased moving in early December 2004, at a time of extreme cold, light wind and neap tide. At this time, the ice stalled over the mooring line included giant floes of multi-year ice and tabular bergs in a matrix of first-year ice. Fortunately, the ice south of Hall Basin became unstable at the end of the month, slipping south by about 100 km in 24 hours. The new ice that formed over the mooring line in January was relatively smooth and free of multi-year floes and bergs (Fig. 4). This situation was fortuitous but ideal for the retrieval of sub-sea moorings though the ice.

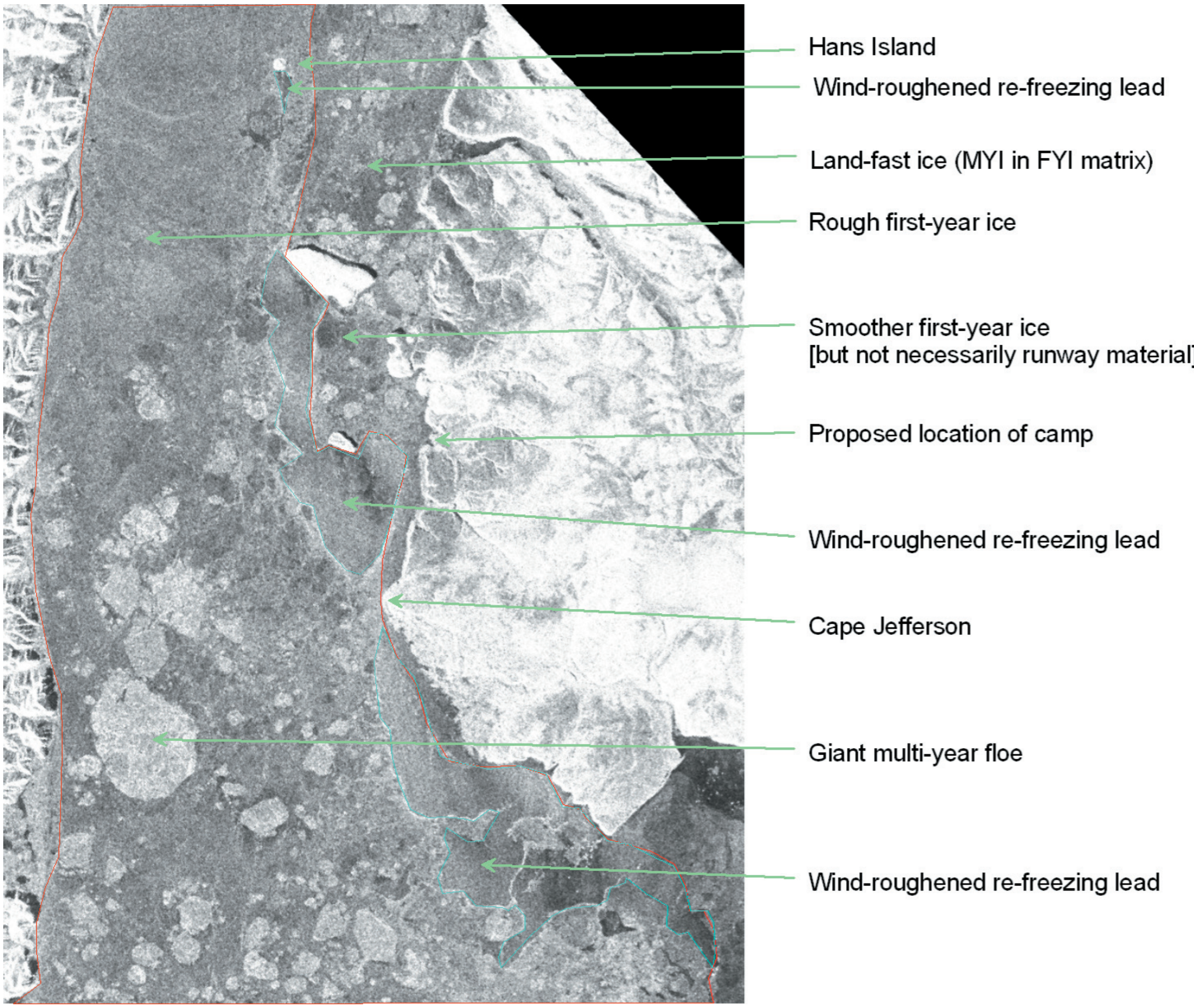


Fig. 4. Southern Kennedy Channel ice imagery, 29-Dec-2004 (annotated).

Camp operations were the responsibility of Jim Milne of DRDC, with assistance from Don Mosher (DRDC) and Dorothy Edwards (sub-contract) as camp cook. Science operations and instrument-performance assessments were the responsibility of Humfrey Melling, with assistance from Andreas Muenchow, Kelly Falkner and Helen Johnson. Specialized technical skills were provided by Ron Lindsay (electronics, instrumentation and ROV), Rob Fuhrmann (hot-water drilling, moorings and ROV) and Scott Rose (moorings), all from IOS and by Dave Huntley (instrumentation and moorings) from UDel. Accommodations were provided for the camp and science contingents, for a helicopter pilot and engineer and for

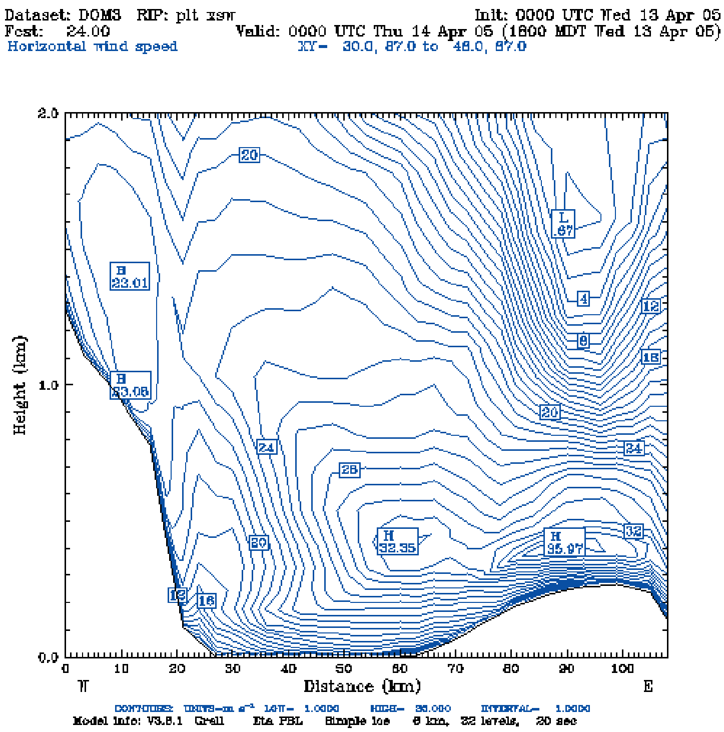
Fig 5. Camp before the wind event: Aerial view (above). On the ground (below).

possible short-term stays by Twin Otter aircrew and media. Although all scientific work was planned around use of the Bell 206-L4 helicopter, a Twin Otter was heavily utilized for setting up the camp (16 round trips to Alert), for bringing in and returning scientific personnel (4 round trips to Resolute), for mid-term rotation of aircrew (2 round trips to Resolute) and for taking down the camp (16 round trips to Alert). The aircraft were sub-contracted at a favorable charter rate through the Canadian Polar Continental Shelf Project (PCSP). The camp was erected during the second week of April and scientists were brought in for occupation on April 12 (Fig. 5).

Fuel requirements for the camp amounted to 216 drums, including helicopter fuel, camp fuel and gasoline for generators and small motors. In addition, there were 18 drums, each weighing 1000 lb, of scrap chain for mooring anchors. This material was rigged by the USAF 62nd MAC, flown to the site on April 12 by two C17A jet transports and dropped onto sea ice 4 miles west of the camp (Fig. 6). There were loads for 65 parachutes. The drops were filmed from the aircraft and, less successfully, from the ground. There was damage to 26 drums, and loss of contents from a smaller number. Two chutes tangled causing free fall of 8 drums, which ruptured dramatically on impact. Other drums were badly deformed on impact, but remained secure (Fig. 7). There was some issue with air traffic control in Iceland. Major Travis Edwards from McCord AFB, officer for the mission and pilot of the lead aircraft, has written up this first experience of the 62nd of an airdrop onto Arctic sea ice from a C17. A copy of this report could be of value to NSF in future operations.

Fig. 6. Fuel drop by C17's: Viewed from camp in process(above). Viewed post-drop (below).

Fig 7. Fuel drum condition: Scattered grouping (above). Distorted by impact (below).



Much of the camp was flattened by extreme winds after the second night of occupation (a narrative of events is appended; Fig 8). Fortunately, the camp was not completely built at this time (3 large Weather Haven tents remained to be erected), scientific equipment remained in shipping cases and the helicopter was not yet on site. Had scientific work already begun, the damage to camp and equipment would have been devastating. It is likely that a helicopter in the open, without a protective enclosure, could have been damaged or destroyed under such conditions.

Fig. 8. April 13, 2005 model predicted winds contoured for southern Kennedy channel.

Fig. 9. Aerial view of the camp after the blow.

The events of April 13 provoked extensive discussion of both logistic and scientific aspects (consultation with Tom Quinn, Mike Krisjensen , Jim Milne, Humfrey Melling, Kelly Falkner, Andreas Muenchow, Roger Samelson). Interest focused on whether this was a freak event, whether it was a characteristic of the particular site chosen (Lafayette Bay) or whether events of this type were characteristic of and frequent throughout the study area. Predicted wind speed at 250-m height from the OSU 6-km model for April 13 equaled the maximum gust speed experienced at ground level (Fig. 9). This suggested that the model might provide advance notice of potentially dangerous events, and an additional model forecast cycle was set up on short notice, with forecasts over 72 hours at 18 and 54-km resolution in addition to the standard 36 hour simulations at 6-km resolution.

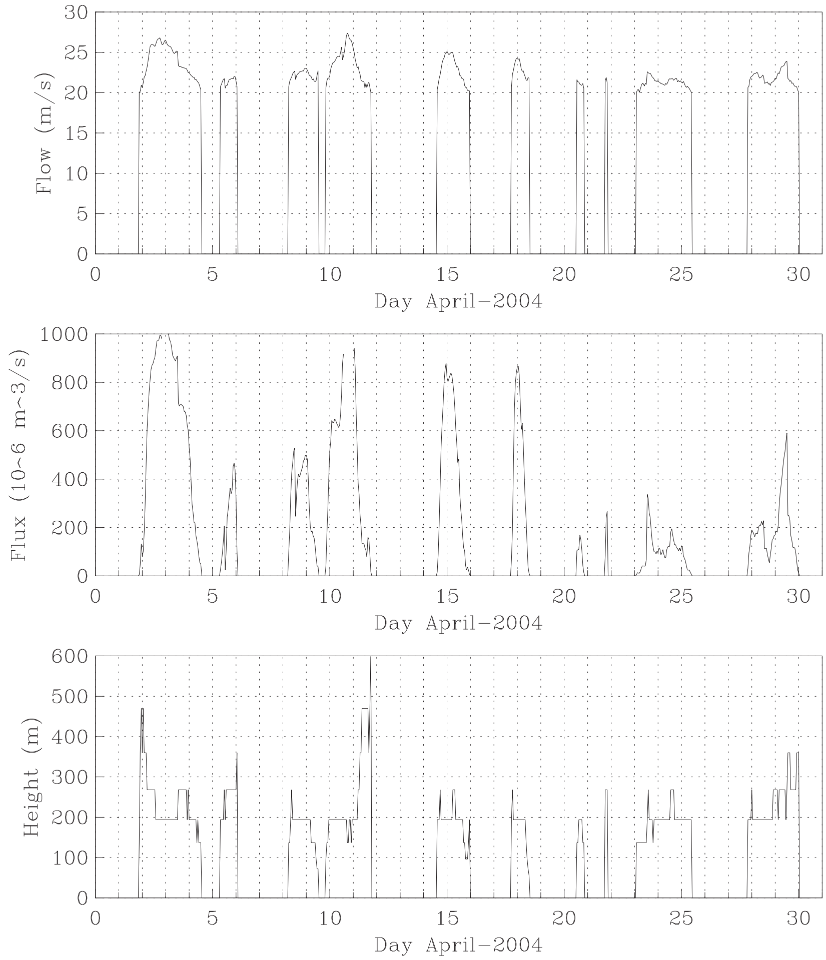


Fig. 10. Sample of wind event plot from the 6-km resolution atmospheric model output. Digitized winds inside the 20 m/s contour within Kennedy Channel below 600-m were integrated to obtain a "flux" as a measure of intensity of low-level winds. The plots show the mean height, flux, and mean speed of the thus identified jet.

The dramatic model-validation point also prompted Muenchow, Melling and Samelson to examine past model output to determine the frequency of occurrence and horizontal extent of strong wind jets above the surface in the upper planetary boundary layer. In April 2004, 10 events were identified of magnitude comparable to that of 13 April 2005, and 4 events in May 2004, half of which lasted 3-4 days (Fig. 10). As previously recognized, the model also indicated a broad domain of strong surface winds, occupying most of Kennedy Channel and extending halfway through Kane Basin (Fig. 11). The group concluded that, in light of the experience at Lafayette Bay, there were no obvious "safe" sites for a camp. This deduction is supported by our observations of minimal snow cover all the way down both sides of Kennedy Channel in April 2004 and 2005. Samelson cautions that other locations such as Scoresby Sound are likely to be subject to similar winds, although model resolution and the paucity of meteorological measurements in the region limits our ability to speak authoritatively on this issue. Discovery Harbor and portions of Kane Basin appear "quiet", but the former is remote from the main mooring line and in a national park (requiring extensive advance permitting) and the latter is the site of calving of the Humboldt glacier; camp sites would have to be at high altitude and would be subject to extensive crevassing. The tough decision was made to abandon camp approach for this season.

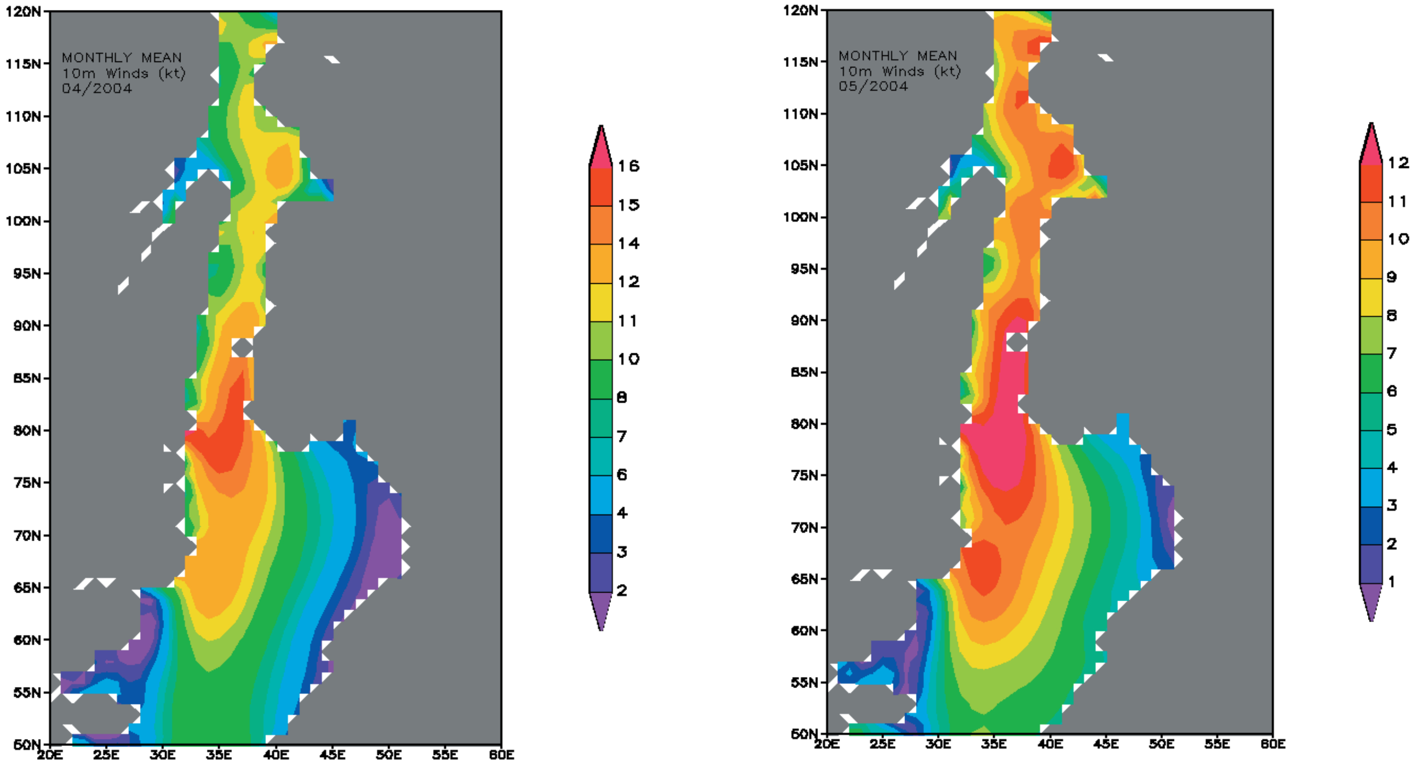


Fig. 11 Model generated surface wind average for April 2004 (left) and May 2004 (right).

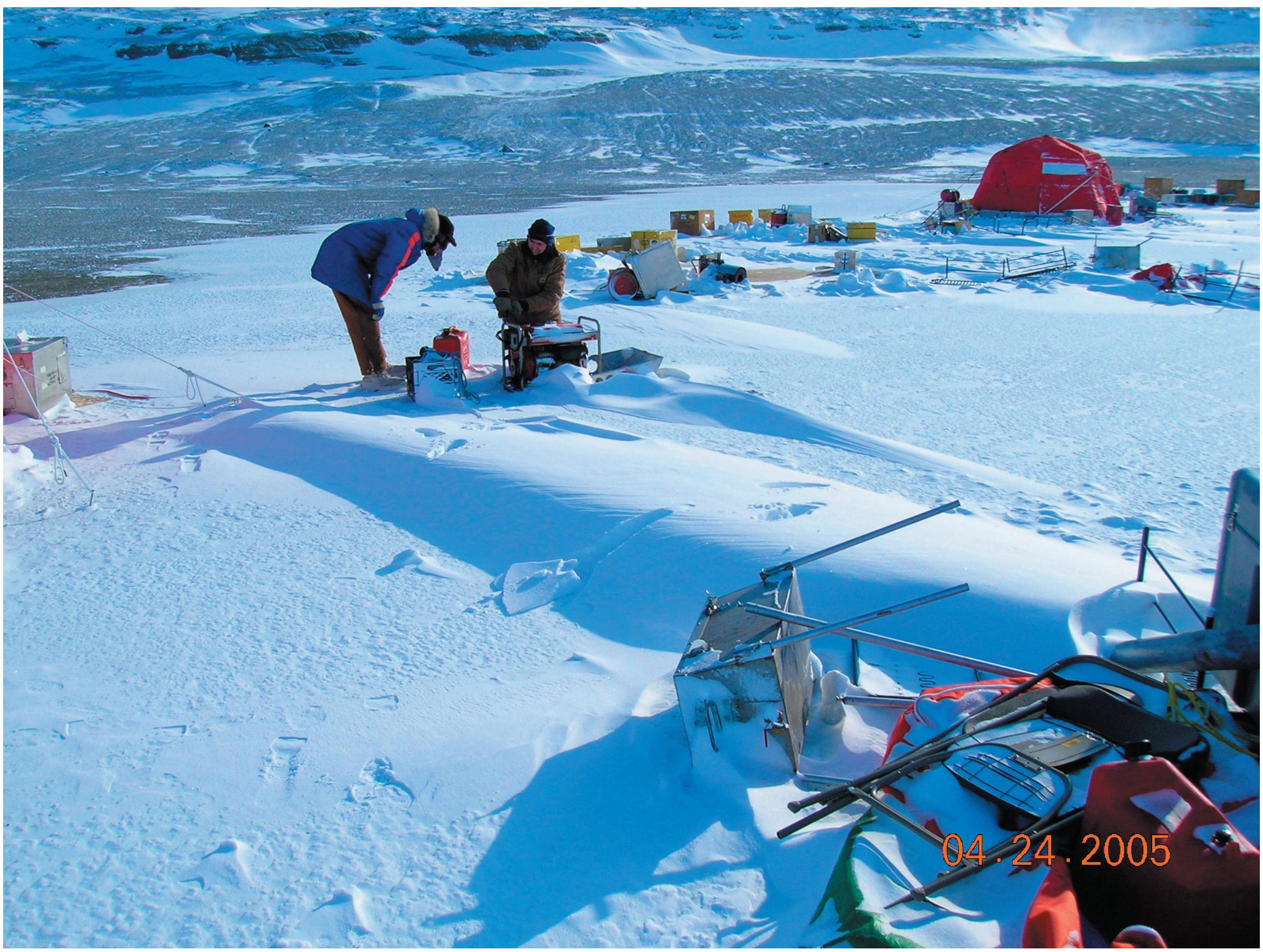
A very fortunate mitigating factor is the 3.5-year operating endurance (determined by installed batteries) for recording instruments and acoustic releases on the moorings. This redundancy was installed on the off-chance that some moorings might be inaccessible in 2005. Although we did not imagine that all might be so, this foresight stands us in good stead.

On abandonment of the primary scientific goals, attention was focused on clean-up of the camp and scientific gear, retrieval of wind-blown items and clean-up of the 50 tons of product at the drop zone. This required the use of a Twin Otter and 206-L4 working in tandem, and very significant manual effort to dig out drums, dismantle cargo loads, dig out parachutes, burn refuse and load aircraft (Fig. 12). The Twin was needed to move equipment to Alert, and the helicopter to consolidate and stage material for loading. The start of this activity was delayed until the April 23 since a Twin Otter was not immediately available. The helicopter was already in the North to support the aborted scientific program. Every six drums of fuel returned to Alert required the consumption of four drums to fuel the Twin otter and two to fuel the helicopter. Clean-up aircraft were fueled at Lafayette Bay. Transported fuel was used in Alert to fuel other aircraft used in the NSF SwitchYard Project. Residual fuel in drums was used for power generation at Alert, and drums were crushed by DND personnel on the base.

Fig. 12. Aftermath of the wind:
a. Humfrey Melling gathering scattered equipment.
b. Don Mosher and Scott Rose defueling generator for the return flight.
c. Humfrey Melling, Kelly Falkner, Scott Rose and Rob Furhmann digging out parachutes and fuel drums.
d. Co-pilot George McBain, Humfrey Melling, Kelly Falkner, Scott Rose and Ron Lindsay loading the twin with parachutes and fuel.
e. Helicopter pilot Collin LaVallé and Scott Rose digging out parachutes and drums.
f. Ron Lindsay using ATV to retrieve blown debris at campsite.

a.

b.



c.

d.

e.

f.

All science gear was recovered and returned to Alert. All parachutes excepting nine that were damaged were dug out, packed on a Herc pallet and returned to Scotia Airbase with the 109th. Unused food (4325 lbs) was packed on a pallet and off-loaded to VECO at Kangerluusuaq. Another pallet of food could not be transported by the 109th on May 5 because of load limitations. Due to concern for quality in warming weather, this food was donated to DND for use at Alert. Mooring anchors weighing 20,000 lb were shifted by sling to bare rock just south of the Lafayette camp, awaiting future use by this project, or removal by ship at the next available opportunity.

We initially had hope that some truncated version of the science plan might be completed following clean-up. However, weather limited clean-up activity to less than 1 day out of 2 – fog at Alert from the flaw lead, strong winds in the Strait, fog in the Strait with either north wind from the flaw lead, or south wind from the North Water. However, by the time that clean-up was completed on May 12, there was strong pressure to return the Twin Otter. We retreated to a very modest objective – visit the main line of moorings and interrogate each release to assess the present status of the array. This operation could be accomplished by the helicopter alone, and information on missing moorings could be a guide in planning alternate logistics for the project. We flew on two consecutive days, only to be turned back by strong head winds and poor visibility about 70 miles short of our destination. With progressively deteriorating weather, characteristic of the season, we abandoned even this modest objective.

Possible New Logistics for the Nares Strait Moorings (to be developed)

1. Adjust next effort to accomplish only the recovery of moorings with no redeployments.

2. Since moorings carrying pressure recorders are most readily recovered through the ice, use aircraft to recover them in the spring of 2006. A Twin Otter with onboard sled and skidoo would provide a practical combination more versatile and available than a helicopter.

3. Revert to ship-based operation for main mooring lines (Larsen or Louis) in August 2006, when ice conditions are statistically most favorable. To optimize chances of recovery, have the ship in service throughout the optimal working window (July 20-Sep 5) (Fig. 13). It must be acknowledged that ice conditions are likely to be a significant impediment to operations. Lengthy waits may be required for heavy multi-year floes to clear from sites through action of wind and current. Supplementary activities (e.g. hydrographic sampling) might be effectively carried out at such times. It is possible that light ice conditions could permit an expedient achievement of the mooring operations also allowing supplementary activities.

Fig. 13. Ice distribution climatology for locations in Nares Strait.

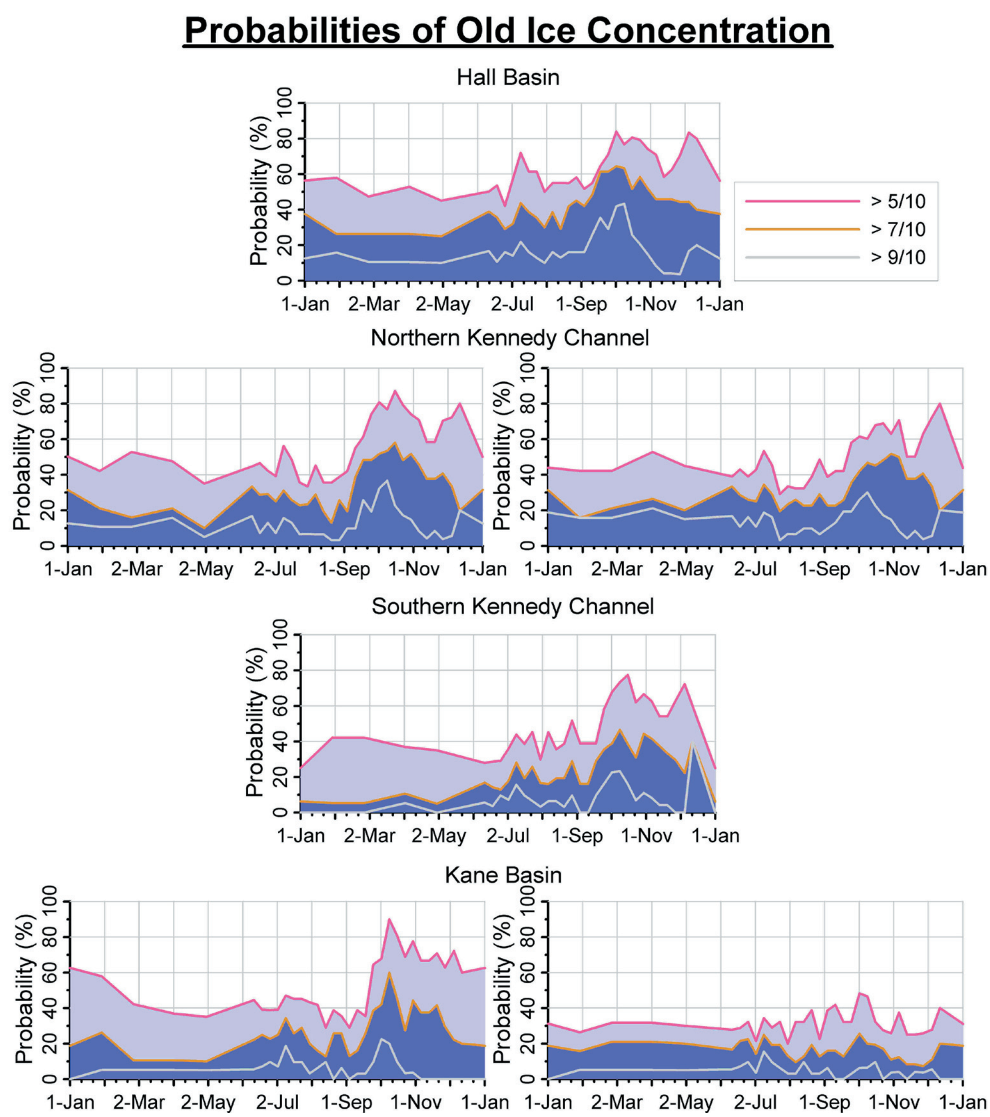


Fig. 14. Second wind event that appeared worse than the first.
Before (above) and after (below).

Narrative of Event

The eight residents of the Lafayette camp tucked in at about mid-night on April 12. There was a light overcast and conditions were calm. There are 24 hours of daylight at this latitude in mid April. Residents were wakened at about 4:00 a.m. on April 13 by brief intense bursts of wind interspersed with long (15 minutes) intervals of calm. Over time the bursts became longer and the intervals shorter. By mid-morning the average speed of wind had reached 20 kt, with extreme gustiness. Conditions were too windy to set up the large tents that were to become our kitchen and workshop spaces.

Winds increased though the day. In late afternoon, the Weather Haven storage tent (12'x20') came down in winds gusts exceeding 50 kt. One octagonal tent (Arctic Oven) followed soon after. Many camp items streamed downwind (Fig. 12). Things like airborne plywood were a significant danger; one person was nearly hit by a flying sheet, and another was bruised in the shin by a flying object. Personnel mustered in one of the remaining four Arctic Ovens to hold it down. As winds strengthened, two more were blown away.

During the evening the strength of winds and gusts increased, with the latter over 60 kt at one time of measurement. The vacant tent was secured from within to heavy duffle bags and extra guy lines were added. There was little opportunity for sleep.

These extreme winds were not associated with "weather" excepting a little thin cloud and snow. The air pressure was steady. A passing storm was not the cause. Instead, the event appears to have been a manifestation of intense airflow through Kennedy Channel in response to decreasing pressure in Baffin Bay. This is a peculiarity of local conditions, associated with the high elevation of Greenland and Ellesmere Island and the atmospheric "Arctic inversion". This general flow pattern appears from the model simulations to be characteristic during much of the fall, winter, and spring seasons. However, its implications for extreme and hazardous wind were not apparent from the evaluations of the model surface-wind climatology, the interpretation of which was also limited by the general uncertainty regarding the accuracy of the simulations .

By mid morning of April 14, the wind had decreased to 35-40 kt and was much less gusty. However, the speed and direction (across the runway) precluded access by aircraft from Alert. The need for holding down the tent decreased progressively. The Twin Otter (Paul Rask) arrived in late afternoon, flying down the runway at about a 45° angle. People and personal gear were loaded and evacuated to Alert. Jim and Don remained at Alert. Melling, Lindsay, Fuhrmann, Rose, Huntley and Edwards continued (non-stop) to Resolute.

The primary cause of this incident was wind of extreme strength and gustiness. At the climax of the event, the average wind exceeded 45-50 kt and gusts were off the top of the scale at 60 kt. Winds of this strength have never been encountered by DRDC personnel who have worked in the vicinity of Alert (150 miles to the north of Lafayette Bay) for more than 30 years. We are the first ever to establish a winter camp in Kennedy Channel. Although Nares Strait has a reputation for strong winds, these have generally been regarded as an inconvenience to operations and a discomfort to personnel, rather than a serious threat to the safety of personnel and aircraft.

The camp was established using Arctic Oven octagonal tents, based on a design developed by DREP for their work in the High Arctic. Our cooking, storage and working shelters were to be tents of the “Quonset” design, made by Weather Haven of Vancouver and used worldwide. Tents of this design have been used in the High Arctic and Antarctic for many years. The tents were erected on floors built from OSB laid over foam insulation laid onto the level frozen surface of a small inlet at the coast. The tents were tied down to 15 or 25-cm steel spikes set into the ice. All tents had flaps at least 30-cm wide, on which we piled snow “mined” from a drift on the other side of the inlet. Unfortunately, the wind came up so soon after the snow was placed that it had not the opportunity to set up hard. Because the cover of snow on both the ice and the land was very thin, it was not possible to further stabilize the tents by digging them down to the substrate.

The large Weather Haven tent succumbed on failure of the guy lines at points of attachment both to the tent and to the ice. Initially, attachments to this large tent ripped from the skin because of wind force on the end wall of the structure. Subsequently, sidewall attachments to the ice failed when the steel spikes of about 5/16” diameter were bent over by the force on the guy lines. The supporting structure of metal poles buckled and many welds failed. The guy lines of the Arctic Ovens gave way at the ice. Guy line stability was undermined when the tent base progressively shifting downwind across the ice. This shifting would not have occurred had it been possible to dig in the tent.

The two remaining tents, very securely guyed, remained standing until April 29. They buckled under the guys under the influence of winds at this time, which appear to have been even stronger than those experienced two weeks earlier (Fig. 14). Our decision to abandon the camp approach was confirmed to be the wise although extraordinarily disappointing one.