

OPC Mariner's Weather Hazards Workshop

16-18 April 2024

College Park, MD USA

Understanding Maritime Freezing Spray, Forecasts, Risks and Hazards



Photo source: NOAA Library Ship Collection

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17 April 2024

OPC Mariner's Weather Hazards Workshop

Overview

- What Is Freezing Spray?
- Forecasting Freezing Spray Conditions
- Risks and Hazards
- F/V Scandies Rose Study
- Summary



What Is Freezing Spray?



Photo source: US Coast Guard

Sea spray icing occurs when the air temperature is below freezing and cold, wave-generated spray **comes in contact with exposed surfaces.**

Moderate to High Wind Speed - Usually above 18 kts or 9 m/s but sometimes lower

Low Air Temperature - Below freezing (-1.7°C or 29°F) (0°C or 32°F in freshwater)

Low Water Temperature - Usually below 7°C or 45°F



Photo source: NOAA Library Ship Collection

A look under the hood at the icing models

- Several different models are in operational use:

Stallabross	1980	Canada, Norway, USA*
Overland	1990	USA, Canada, Norway, Sweden, Japan
MINCOG	2017	Norway

- They share the same issues and problems:
 - Physics of freezing is known.
 - The interaction of ships with waves, wind, and spray is not well understood.
 - Different ships ice differently → difficult to generalize.
 - Ship actions also influence icing rates.

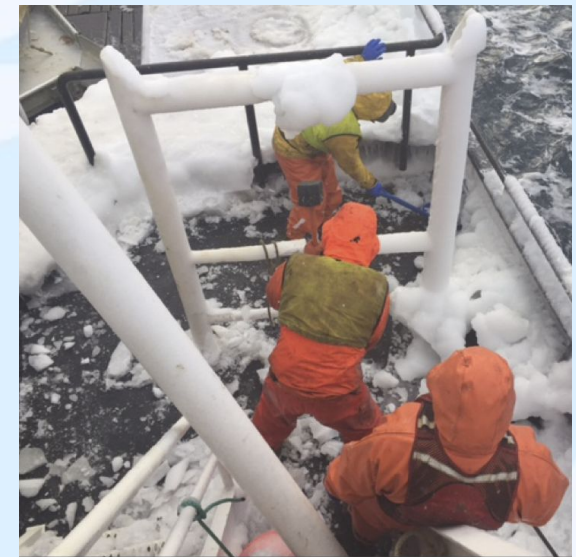


Photo credit: US Coast Guard

Why different models?

- Each method was developed and calibrated using observations from different regions.
 - Stallabrass used 39 reports of icing in the Canadian east coast 1977-1979 from fishing trawlers ranging in size from 34 to 51 meters.
 - Overland used 85 observations of icing in the Alaska area 1979-1983 from ships ranging in size from 25 to 75 meters.
 - MINCOG used 37 icing reports from the Norwegian Coast Guard Nordkapp cutter class in the Barents Sea 1983-1993. The ship class is 105 m (345 ft), 3,200 tons.
- Limited number of observations means virtually no verification



Photo source: NOAA Library Ship Collection

Your Mileage May Vary

- Freezing Spray Forecast is for the **potential** of accumulating ice on a vessel.
- The actual icing rate depends on vessel size, shape, speed, and direction of motion relative to the wind and waves.
- Smaller vessels are more vulnerable.
- Cold vessels accumulate ice faster.
- Beware of asymmetric icing and exposed deck cargo (such as crab pots).



Photo source: NOAA Library Ship Collection

Forecasting Freezing Spray Conditions

NWS Watches and Warnings

- **Freezing Spray Advisory (Coastal only)**

An advisory for an accumulation of freezing spray on a vessel at a rate of less than 2 cm (0.8 in) per hour.

- **Heavy Freezing Spray Watch (Coastal only)**

A watch for an increased risk of a heavy freezing spray event.

- **Heavy Freezing Spray Warning**

A warning for an accumulation of freezing spray at a rate of 2 cm per hour or greater (0.7 cm per hour (0.28 in/hr) or greater in Alaska Region).

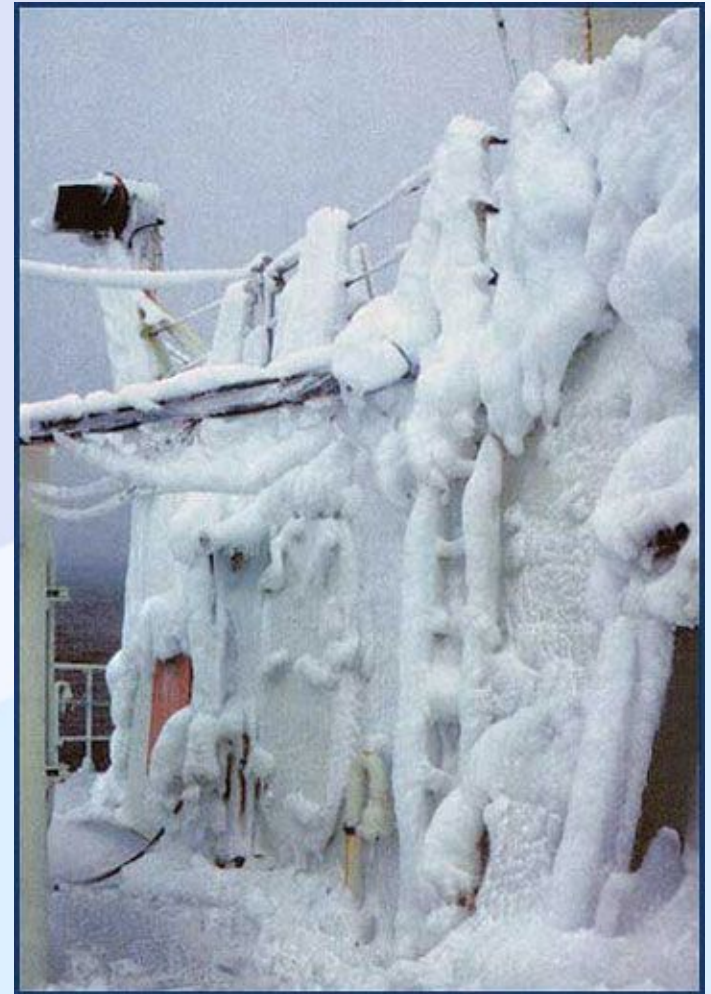


Photo source: NOAA Library Ship Collection

Where Can You Find Freezing Spray Forecasts?

Marine Zone Forecast

...GALE WARNING IN EFFECT THROUGH EARLY FRIDAY MORNING... ...HEAVY FREEZING SPRAY WARNING IN EFFECT THROUGH EARLY FRIDAY

Synopsis: A 1023 mb high over the Arctic Plain will persist through today then weaken in place. A strong 955 mb low over Kamchatka will weaken in place today. A 990 mb low will move to the Yukon Delta by noon Friday with the leading weather front pushing north to St. Lawrence Island and Norton Sound by noon Friday.

Today	E winds 40 kt. Seas 13 ft. Blowing snow. Vsby 1 nm or less. Heavy freezing spray.
Tonight	E winds 40 kt. Seas 15 ft. Blowing snow and freezing fog. Vsby 1 nm or less. Heavy freezing spray.
Fri	E winds 35 kt. Seas 15 ft. Blowing snow. Snow. Vsby 1 nm or less. Heavy freezing spray.
Fri Night	NE winds 30 kt. Seas 12 ft. Heavy freezing spray.
Sat	NE winds 25 kt. Seas 9 ft. Heavy freezing spray.
Sat Night	N winds 20 kt. Seas 9 ft. Heavy freezing spray.
Sun	N winds 20 kt. Seas 9 ft.
Mon	N winds 15 kt. Seas 5 ft.

- Coastal Waters Text Messages and Maps
- Offshore and High Seas Forecasts

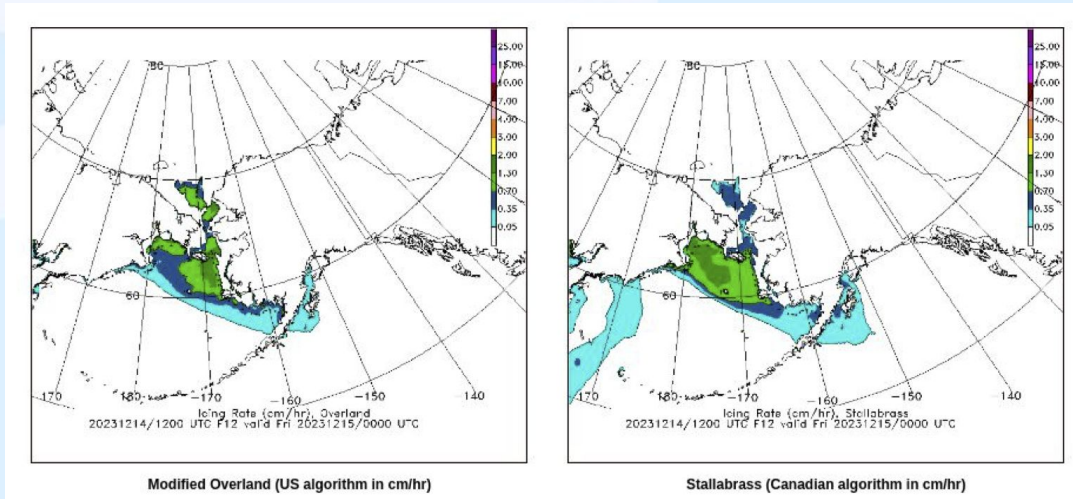
National Weather Service
<https://weather.gov/>

Ocean Prediction Center
<https://ocean.weather.gov>

- NAVTEX
- Radiofax
- SATCOM
- Weather Radio

NWS NCEP Ocean Prediction Center Experimental Freezing Spray Graphics*
 Uses Overland and Stallabrass Methods with ocean and atmospheric model data.
https://ocean.weather.gov/icing_rates

* Experimental, for now



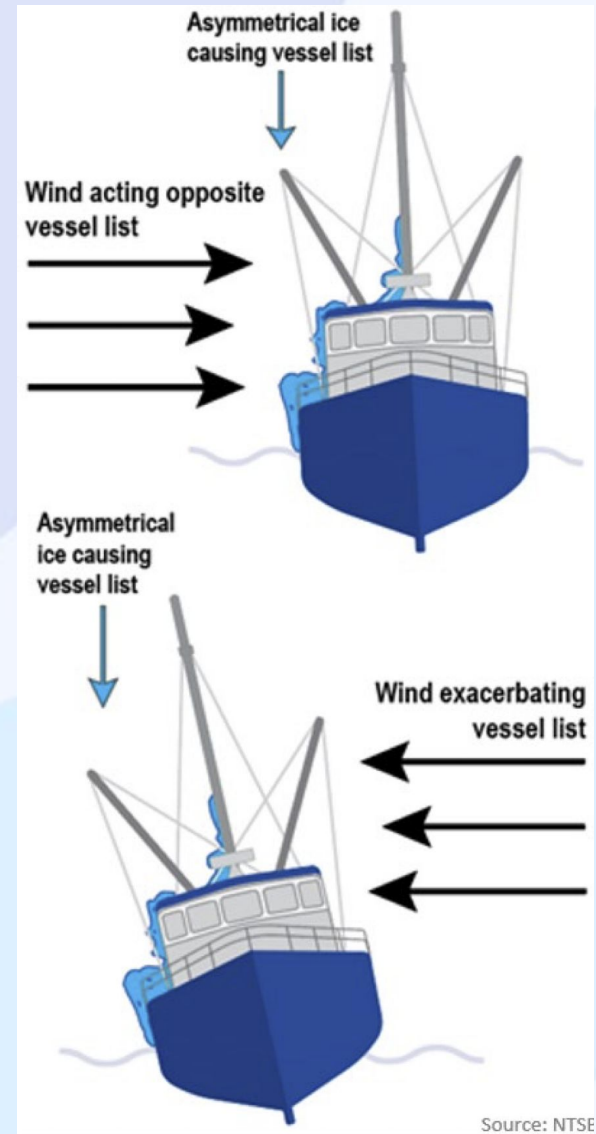
Risks and Hazards

- Impact on vessel stability and maneuverability
- Damage to ship structures and equipment
- Personal safety hazards for crew

Ice accumulation and weight distribution

Engine and equipment failures

Loss of control and capsizing



F/V Scandies Rose Study



Photo source: NTSB Marine Accident Report

- Departed Kodiak, AK 8:35 PM AST on 30 Dec 2019.
- Sailed through the Shelikof Strait toward False Pass en route to the Bering Sea.
- At 9:55 PM AST on 31 Dec USCG received a distress call from the ship, located 2.5 miles south of Sutwik Island.
- At about 10 PM AST on 31 Dec 2019, the ship capsized and sank.
- Of the 7 crew members, 2 were rescued, all others were presumed lost, including the Captain and his son.

F/V Scandies Rose Study

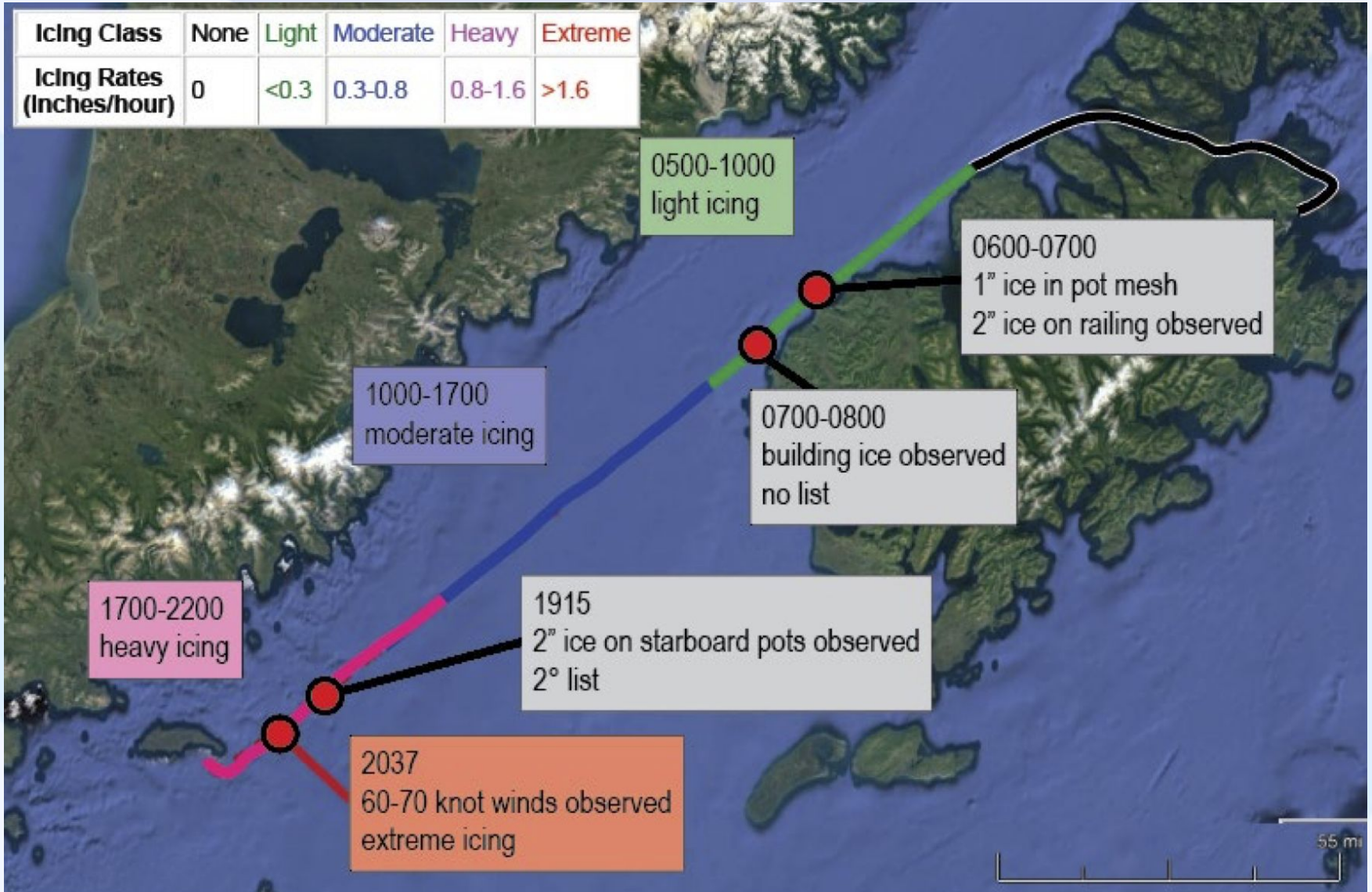


Image source: NTSB Marine Accident Report



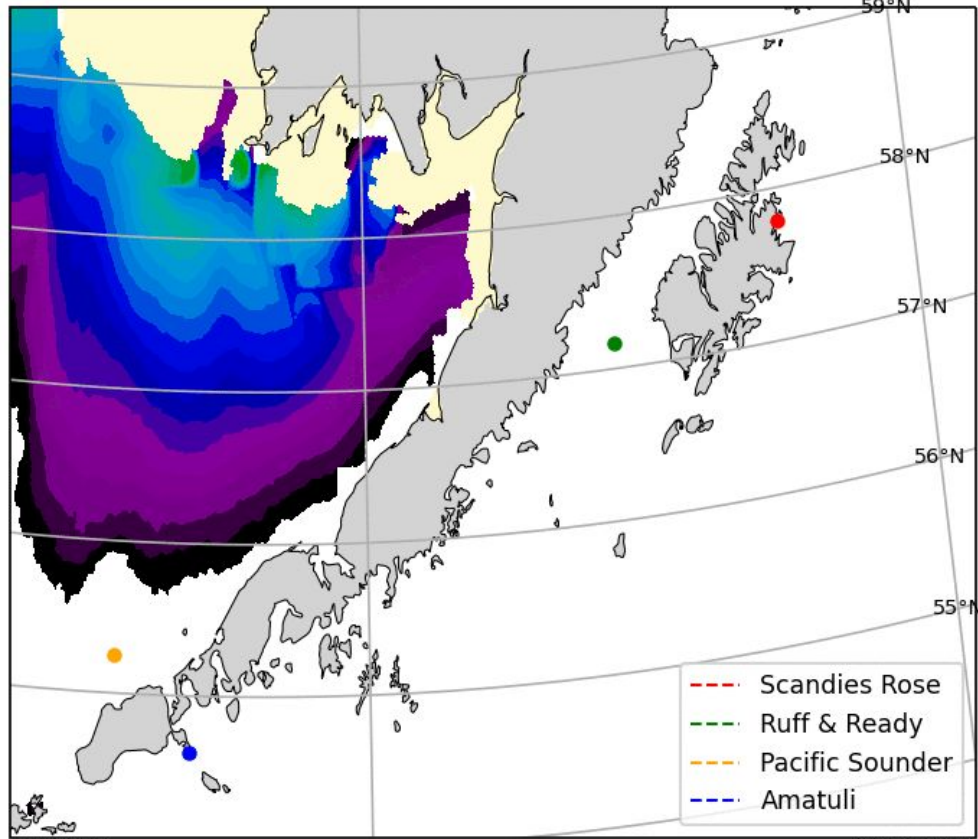
F/V Scandies Rose Study

Study Goals

1. See if our highest resolution model (HRRR, 3km grid size) resolves the gap winds and shows the resulting sharp increases in the icing rates.
2. Compute the along-track ice accumulation rates and compare with the NTSB findings.

HRRR-AK MINCOG Icing Rate
mean=0.699 max=3.548

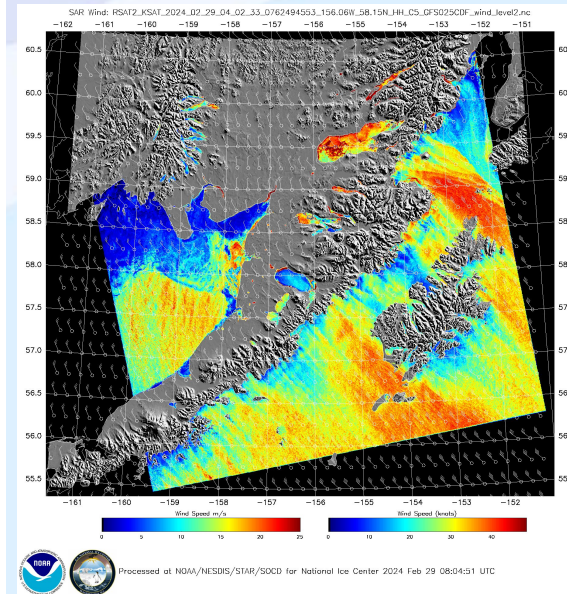
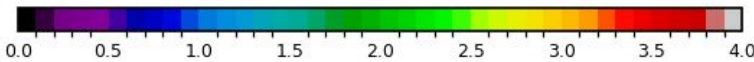
Using Multi_1 Waves (10m grid)
Valid Date 2019-12-31 00Z



NCEP/OPC

Yellow indicates sea ice concentration > 15%
Wave parameters internally calculated

07 Dec 2023



Synthetic Aperture Radar image of the winds near the Aleutian Peninsula Feb 29, 2024.



Processed at NOAA/NESDIS/STAR/SOCD for National Ice Center 2024 Feb 29 08:04:51 UTC

Image source: NOAA NESDIS

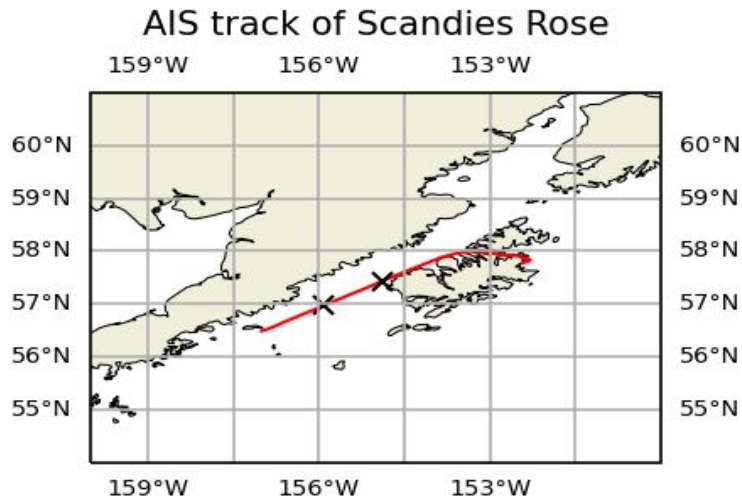


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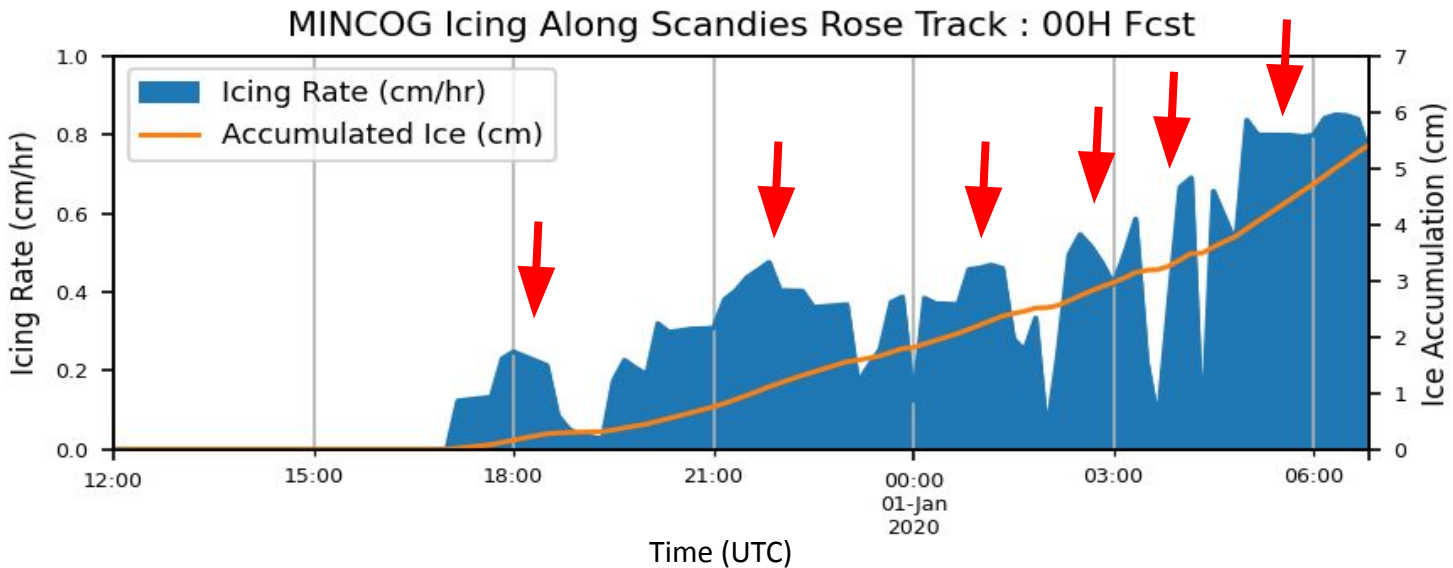
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F/V Scandies Rose Study



5.5 cm = 2.2 inch total ice accumulation, suggests that the final peak is still less than what was experienced.



Summary

- Freezing Spray forms when the following conditions exist:
 - Moderate to High Wind Speed
 - Air Temperature below freezing
 - Low Water Temperature
- Ice accumulation rates are influenced by the ship
- Ice accumulation can be a severe threat to ship stability and crew safety
- Use available weather forecasts to stay informed of freezing spray conditions



Resources

Ice Accumulation: Addressing the risks of ice from freezing spray on vessel stability

<https://www.nts.gov/Advocacy/safety-alerts/Documents/SA-074.pdf>

The Dangers of Ice Accumulation

<https://www.dco.uscg.mil/Portals/9/DCO%20Documents/5p/CG-5PC/CG-CVC/CVC3/notice/flyers/25E-Icing.pdf>

Capsizing and Sinking of Commercial Fishing Vessel Scandies Rose

<https://www.nts.gov/investigations/Pages/DCA20FM009.aspx>

Free COMET[®] courses

- Freezing Spray Science

https://www.meted.ucar.edu/education_training/lesson/10253

- Freezing Spray Communications

https://www.meted.ucar.edu/education_training/lessons/10254

Want to Help Us Improve?

Arctic Testbed & Proving Ground Freezing Spray Project in collaboration with the Skipper Science Partnership <https://www.skipperscience.org/>



Thank You

Any Questions?



EXTRAS



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Where to find OPC Freezing Spray Guidance

The screenshot shows the Ocean Prediction Center (OPC) website interface. At the top, there are navigation links for Home, Mobile Site, RSS, Local Forecast, and a search bar. The main navigation menu includes Analysis & Forecast, DATA (circled in red), INFORMATION, NEWS, and SEARCH. A dropdown menu is open under DATA, listing various data products. 'Freezing Spray' is circled in red within this menu. Other items in the menu include Digital Forecasts, Electronic Marine Charting (ECDIS), Environmental (Sea Nettles, Storm Surge Models), GIS Data, Observations (GOES SST, ASCAT, Lightning, Satellite), Ocean (Global Ocean Model), Past Weather (Hurricane Force Low, Product Archives), and Probabilistic (Wave Height, Wind Speed). The background of the website shows a weather map of the North Atlantic with pressure systems and fronts.

https://ocean.weather.gov/icing_rates
or go to ocean.weather.gov and select DATA and Freezing Spray Guidance

OPC Freezing Spray Guidance page currently shows as “Experimental”. That will be changed in the near future.



Calculating Freezing Spray Rates

- Relatively (ahem) simple: Overland (1990)

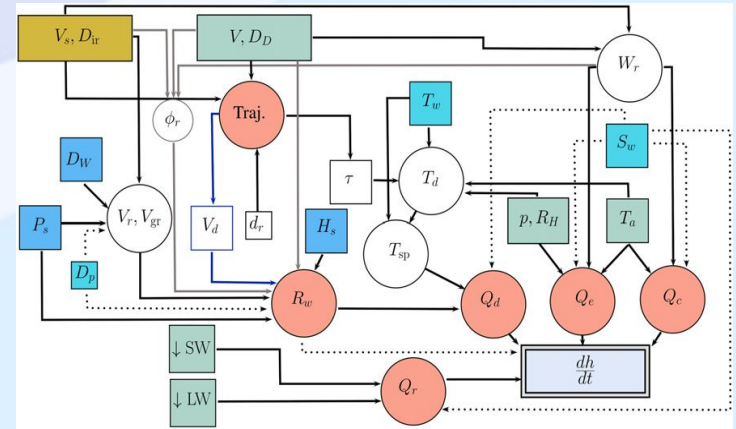
$$\text{Icing Rate} = \underbrace{A(\text{PR}) + B(\text{PR})^2 + C(\text{PR})^3}_{\text{polynomial fit}} \quad \text{where} \quad \underbrace{\text{PR} = V_a(T_f - T_a) / (1 + 0.4(T_w - T_f))}_{\text{icing predictor}}$$

- Complex: MINCOG (2017)

Stallabrass (1980) is used by Canada

Overland (1990) is used by US and Norway

MINCOG (2017) is used by Norwegian Coast Guard

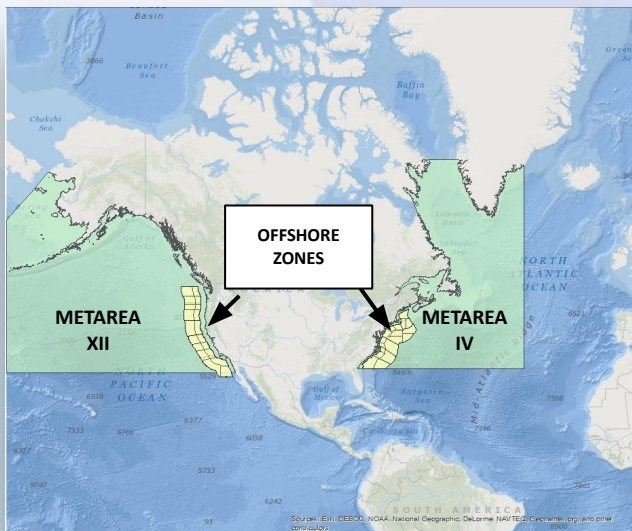


MINCOG model flow chart

These methods work for fresh water, too.

NOAA's Ocean Prediction Center

Areas of Responsibility

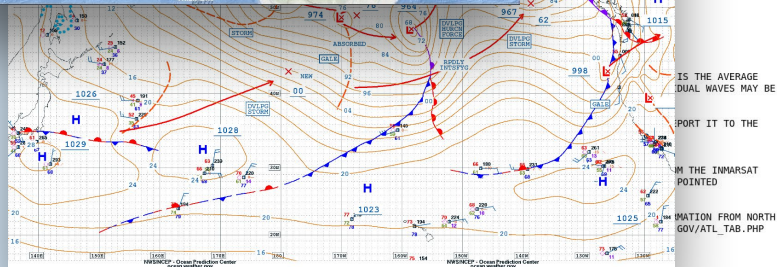


OPC originates and issues marine warnings and forecasts, continually monitors and analyzes maritime data, and provides guidance of marine atmospheric variables for purposes of protection of life and property, safety at sea, and enhancement of economic opportunity.

Atlantic and Pacific Graphical Products

These products fulfill U.S. responsibilities with the World Meteorological Organization and Safety of Life at Sea Convention (SOLAS).

Text Products



NORTH ATLANTIC NORTH OF 31N TO 67N AND WEST OF 35W
 ALL FORECASTS VALID OVER ICE FREE FORECAST WATERS
 SYNOPSIS VALID 1800 UTC SEP 29.
 24 HOUR FORECAST VALID 1800 UTC SEP 30.
 48 HOUR FORECAST VALID 1800 UTC OCT 01.
 WARNINGS.
 ... HURRICANE WARNING ...
 ... HURRICANE IAN NEAR 29.3N 79.9W 986 MB AT 2100 UTC SEP 29 MOVING NINE OR 630 DEG AT 9 KT. MAXIMUM SUSTAINED WINDS 65 KT GUSTS 80 KT. TROPICAL STORM FORCE WINDS WITHIN 360 NM NE QUADRANT...140 NM SE QUADRANT...150 NM SW QUADRANT...AND 200 NM NW QUADRANT... SEAS 12 FT OR GREATER WITHIN 270 NM NE QUADRANT...120 NM SE QUADRANT...60 NM SW QUADRANT...AND 90 NM NW QUADRANT WITH SEAS TO 24 FT. ELSEWHERE FROM 31N TO 33N W OF 72W WINDS 20 TO 33 KT. SEAS TO 12 FT.
 ... 24 HOUR FORECAST HURRICANE IAN NEAR 32.8N 79.6W. MAXIMUM SUSTAINED WINDS 70 KT GUSTS 85 KT. TROPICAL STORM FORCE WINDS WITHIN 210 NM NE QUADRANT...120 NM SE QUADRANT...80 NM SW QUADRANT...AND 90 NM NW QUADRANT... SEAS 12 FT OR GREATER WITHIN 360 NM E SEMICIRCLE...AND 180 NM SW QUADRANT WITH SEAS TO 33 FT. ELSEWHERE FROM 31N TO 35N W OF 70W WINDS 20 TO 33 KT. SEAS 8 TO 14 FT.
 ... 48 HOUR FORECAST POST-TROPICAL CYCLONE IAN WELL INLAND NEAR 36.5N 81.6W...MAXIMUM SUSTAINED WINDS 15 KT GUSTS 20 KT... OVER

NWS Sea Ice Products

Gridded Products

