OPC Mariner's Weather Hazards Workshop

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College Park, MD USA

# Understanding Maritime Freezing Spray, Forecasts, Risks and Hazards

Photo source: NOAA Library Ship Collection


Todd Spindler[1], Joseph Sienkiewicz[2]

1) Lynker at NOAA/NCEP/OPC Ocean Applications Branch
2) NOAA/NCEP/OPC Chief Ocean Applications Branch

*Todd.Spindler@noaa.gov*

# 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**.

Photo source: NOAA Library Ship Collection

**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

# A look under the hood at the icing models

- Several different models are in operational use:

| | | |
|---|---|---|
| **Stallabrass** | 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).

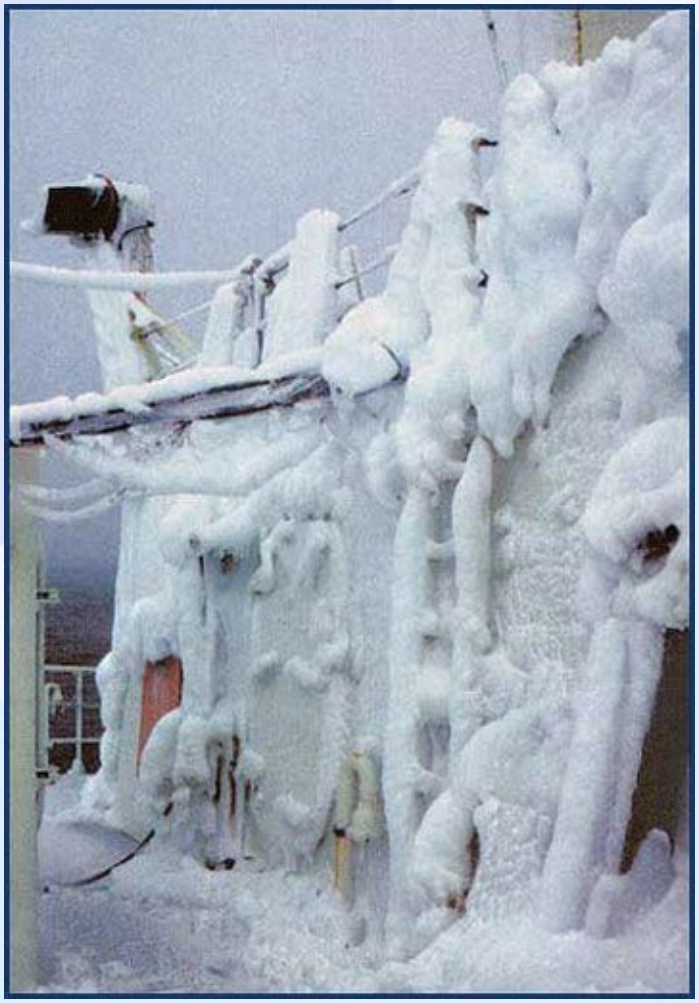


Photo source: NOAA Library Ship Collection

# 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

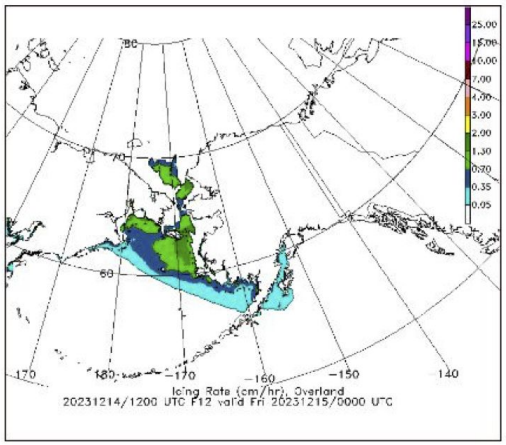
Radiofax

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




Modified Overland (US algorithm in cm/hr)

Stallabrass (Canadian algorithm in cm/hr)

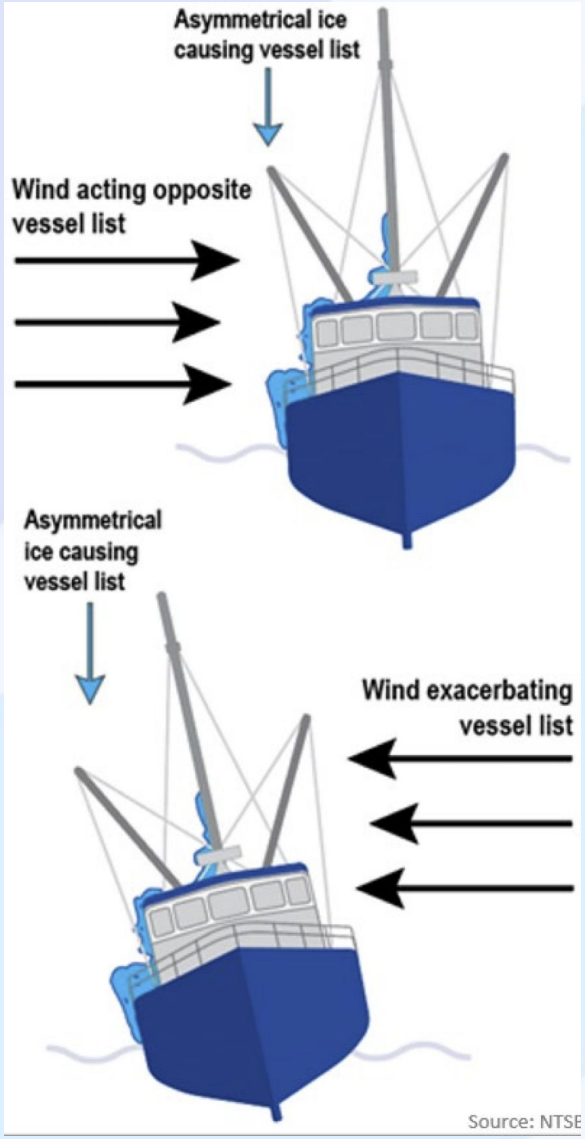
# Risks and Hazards

- 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

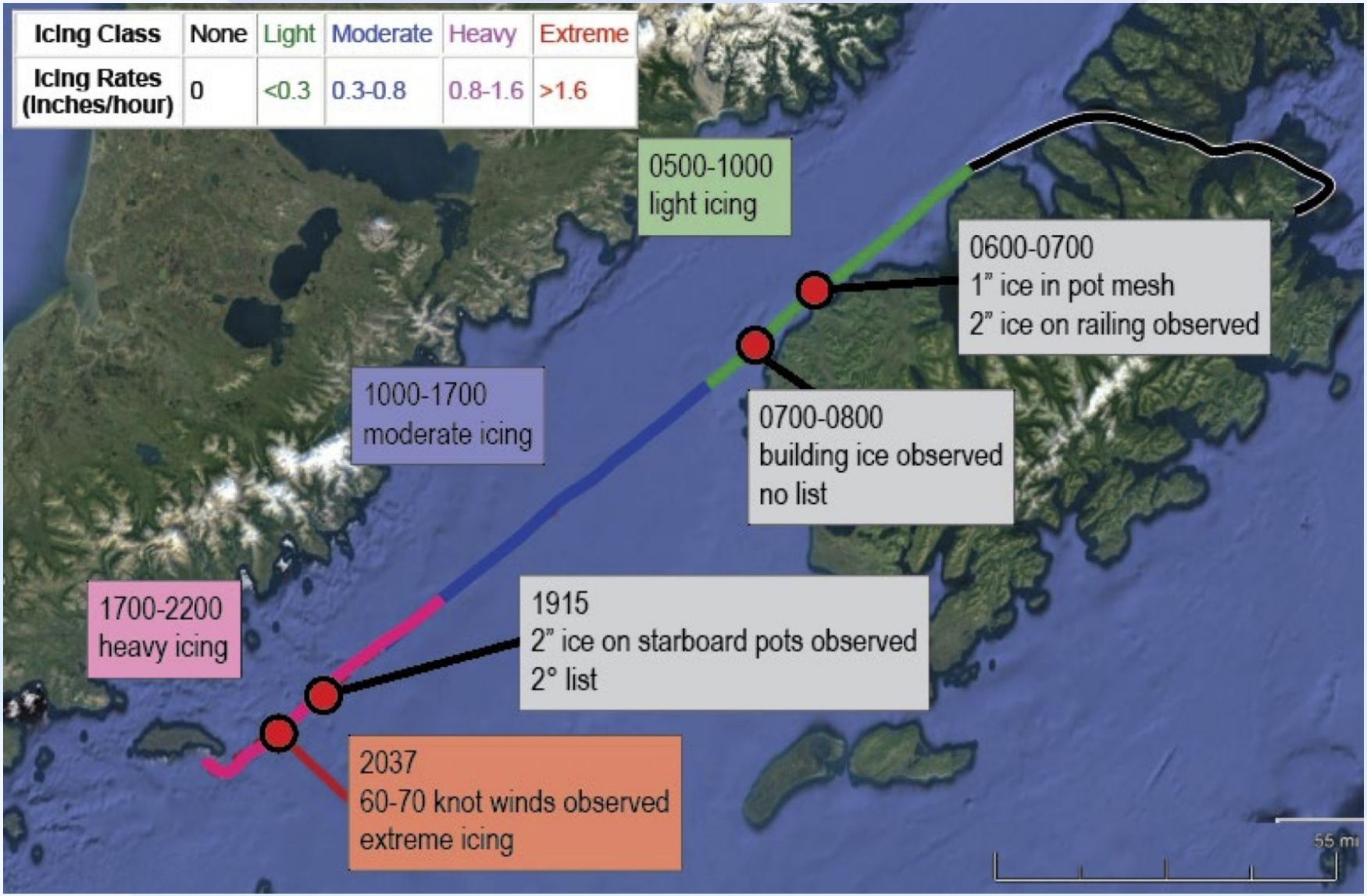
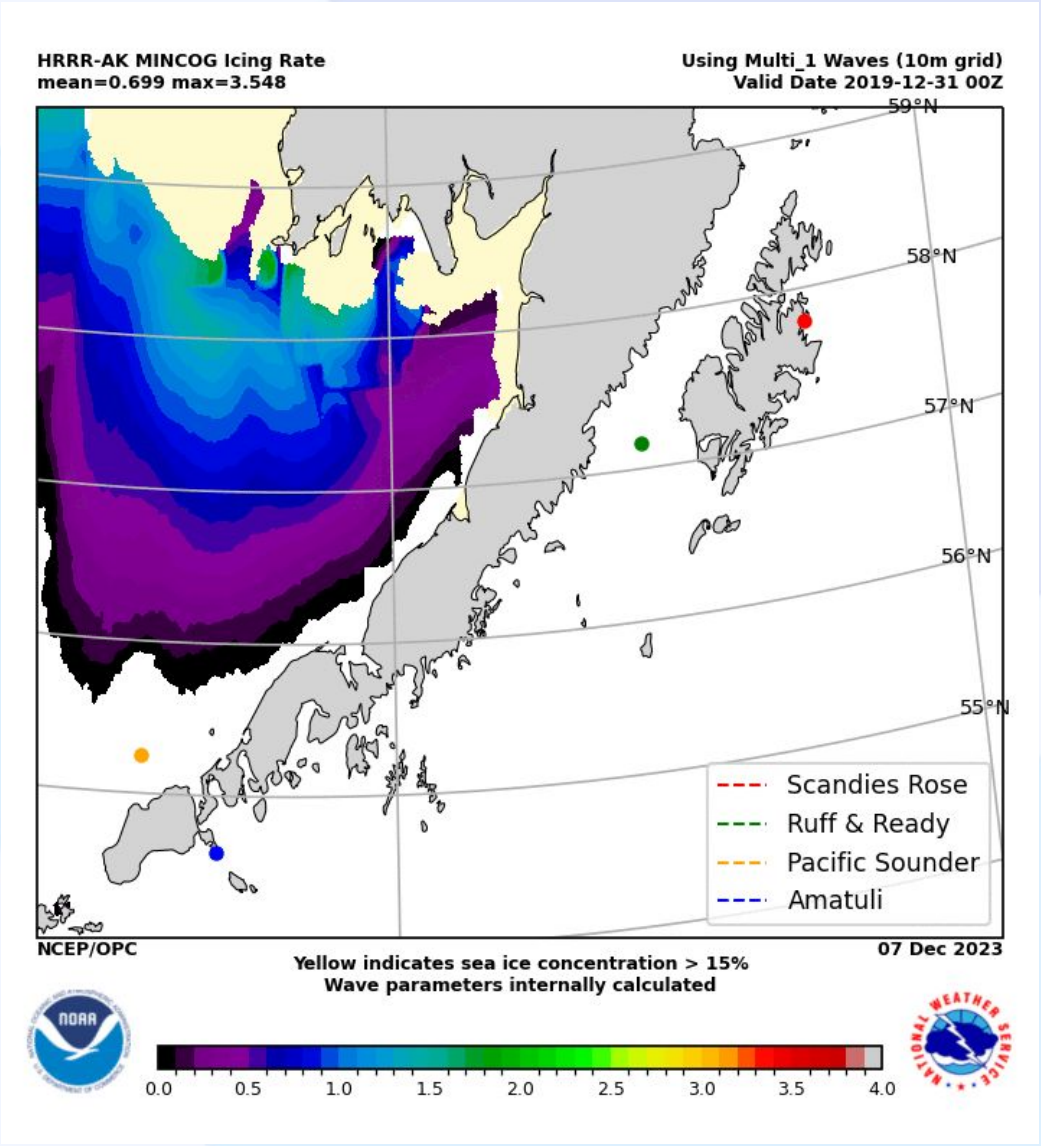


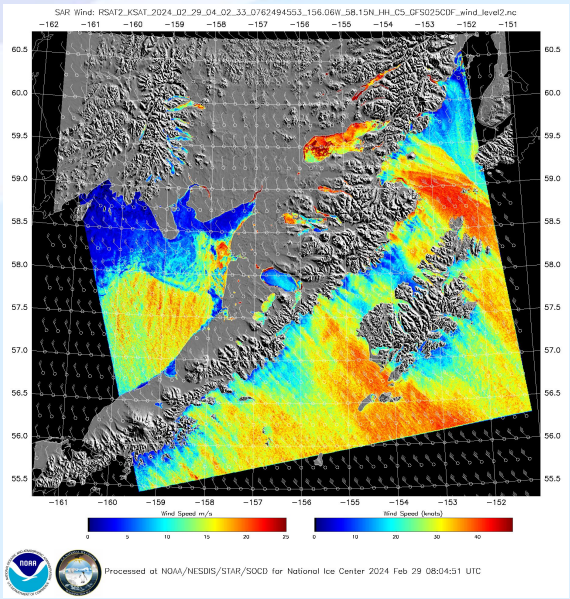

Image source: NTSB Marine Accident Report

# F/V Scandies Rose Study




**Study Goals**

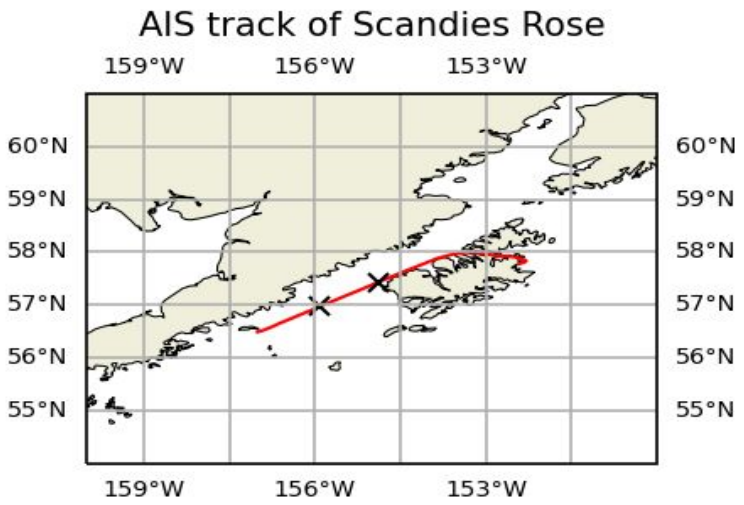
1. See if our highest resolution model (HRRR, 3km grid size) resolves the gap winds and shows the resulting sharp increases in the icing rates.
2. Compute the along-track ice accumulation rates and compare with the NTSB findings.



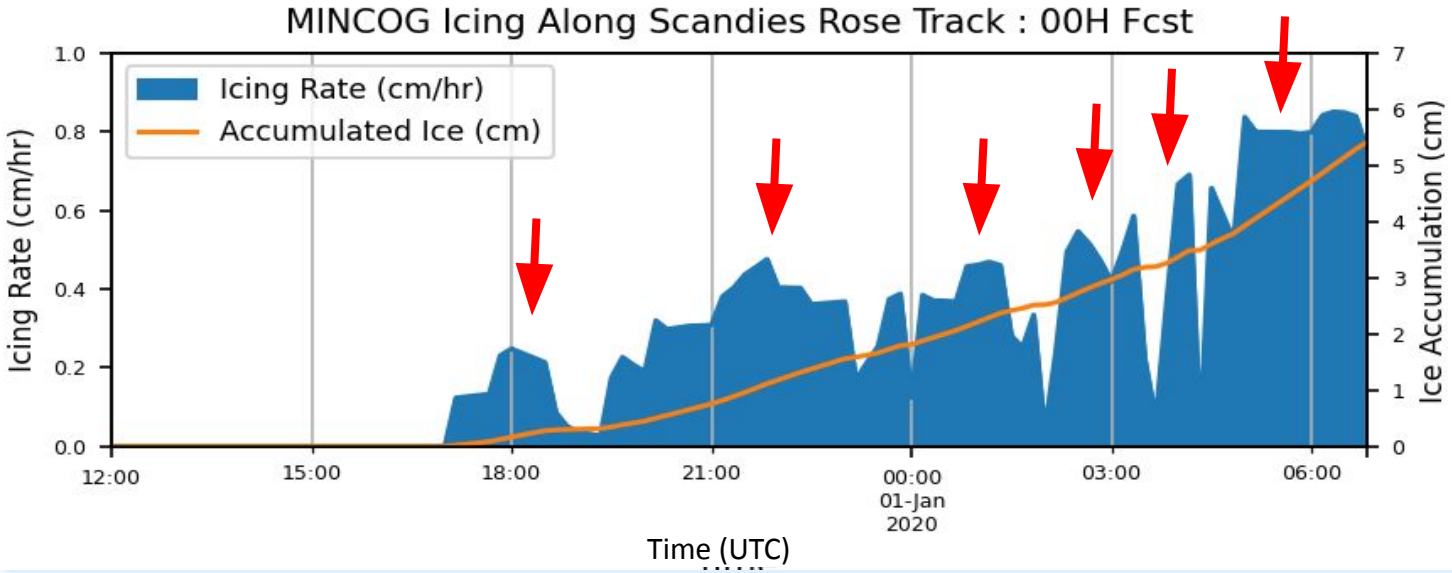

Synthetic Aperture Radar image of the winds near the Aleutian Peninsula Feb 29, 2024.

Image source: NOAA NESDIS

# 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.ntsb.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.ntsb.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?

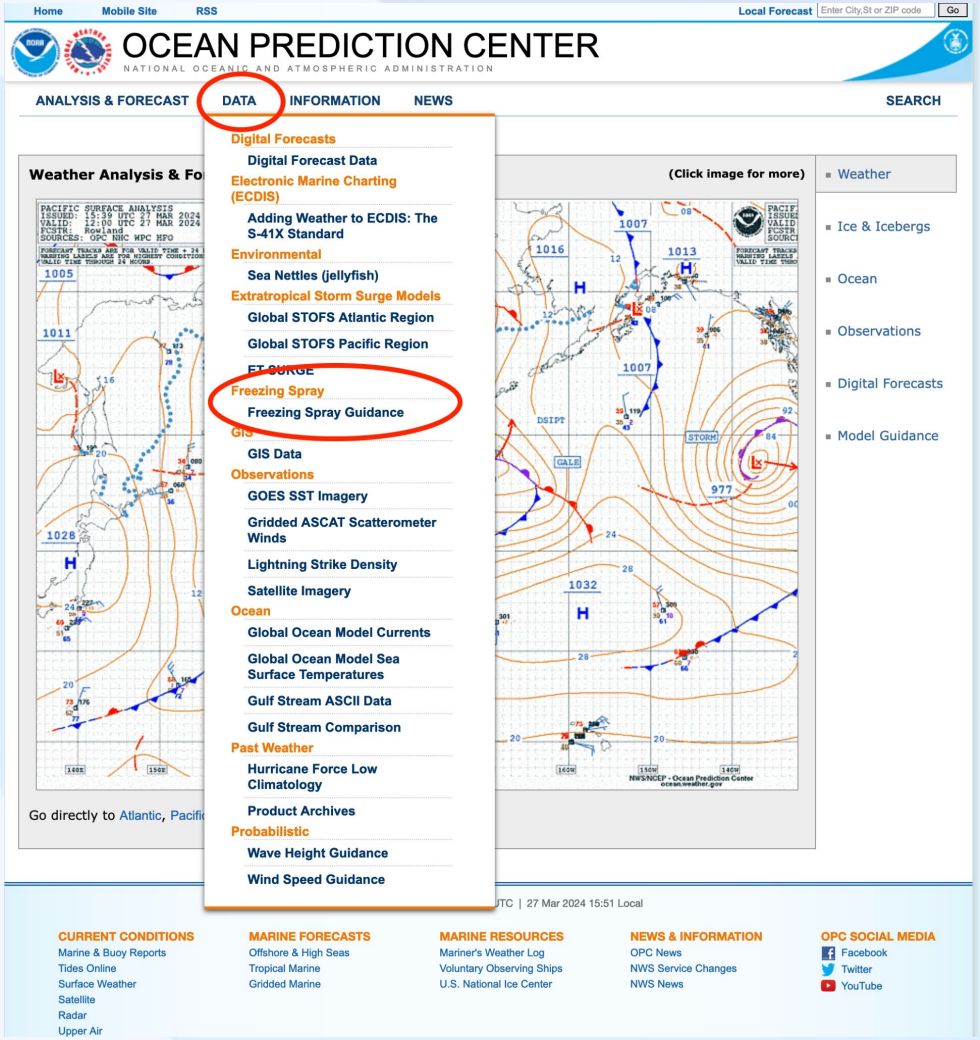
Arctic Testbed & Proving Ground Freezing Spray Project in collaboration with the Skipper Science Partnership https://www.skipperscience.org/

# *Thank You*

Any Questions?

# EXTRAS

# Where to find OPC Freezing Spray Guidance




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)

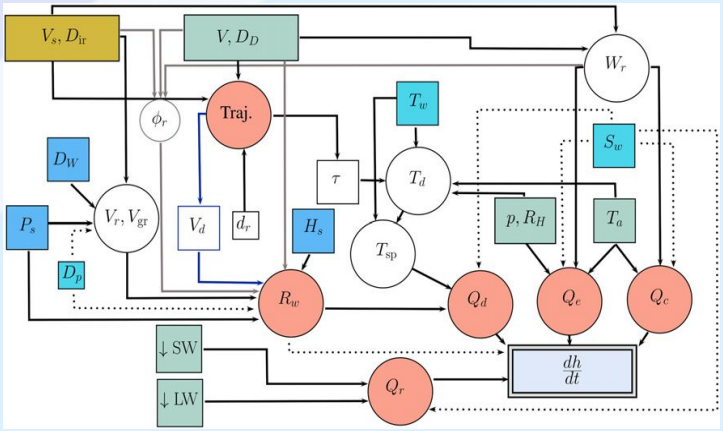
$$\text{Icing Rate} = \underbrace{A(PR) + B(PR)^2 + C(PR)^3}_{\text{polynomial fit}} \quad \text{where} \quad \underbrace{PR = V_a(T_f - T_a)/(1+0.4(T_w - T_f))}_{\text{icing predictor}}$$

- Complex: MINCOG (2017)

Stallabrass (1980) is used by Canada

Overland (1990) is used by US and Norway

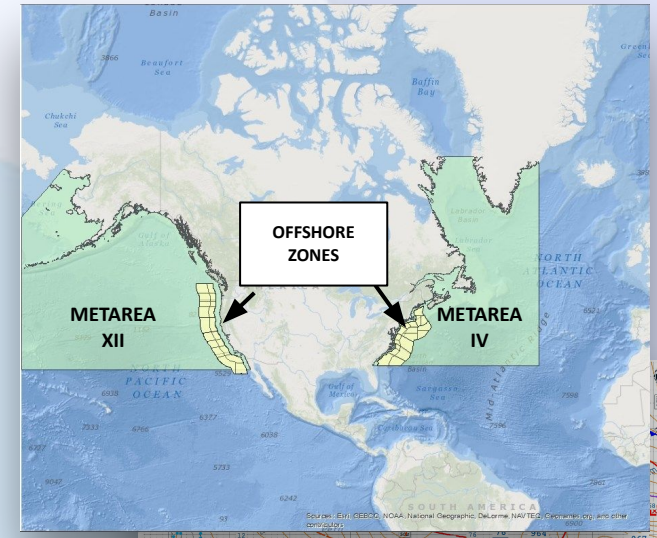
MINCOG (2017) is used by Norwegian Coast Guard



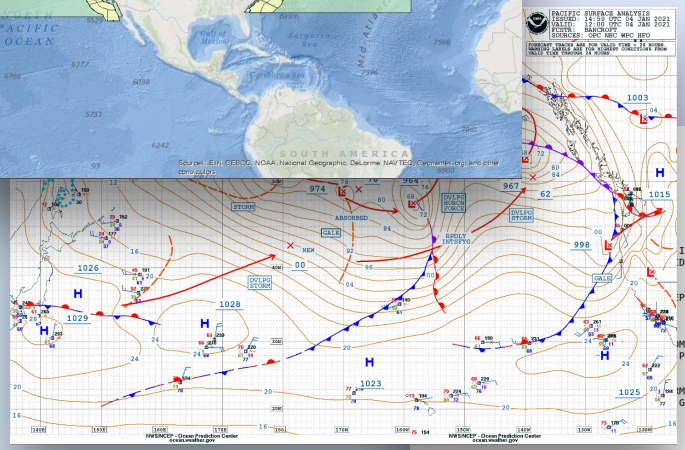

MINCOG model flow chart

These methods work for fresh water, too.

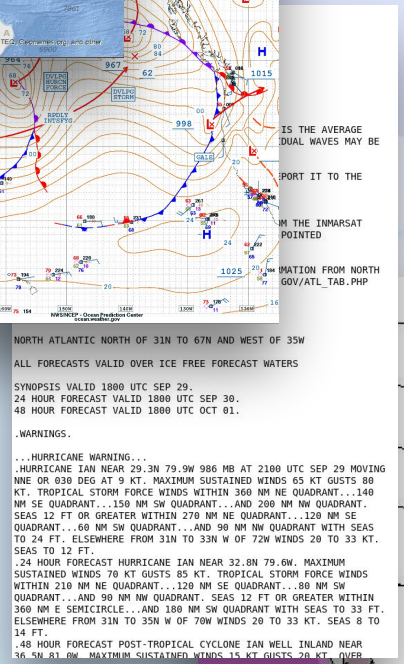
# NOAA's Ocean Prediction Center




**Areas of Responsibility**

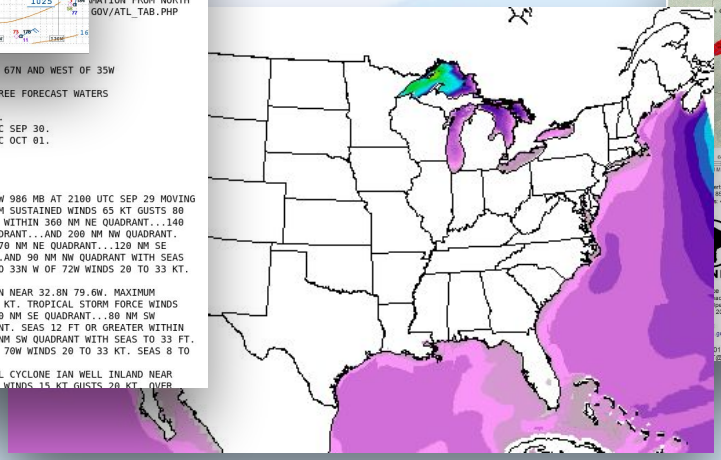


**Atlantic and Pacific Graphical Products**

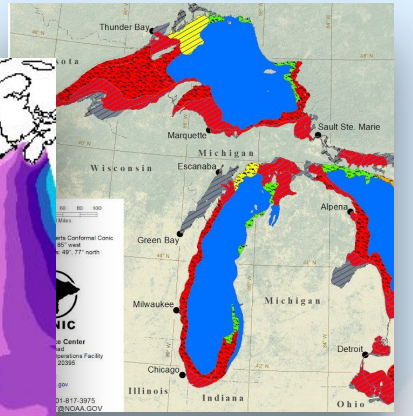



**Text Products**

**Gridded Products**



**NWS Sea Ice Products**




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.

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