

Numerical Ocean and Atmospheric Forecast Models in Search and Rescue: Benefits, Challenges and Possible Improvements in the Future



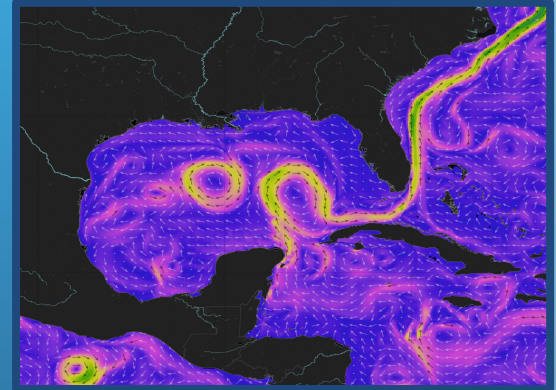
Dr. Cristina Forbes
U.S. Coast Guard
Office of Search and Rescue



Outline

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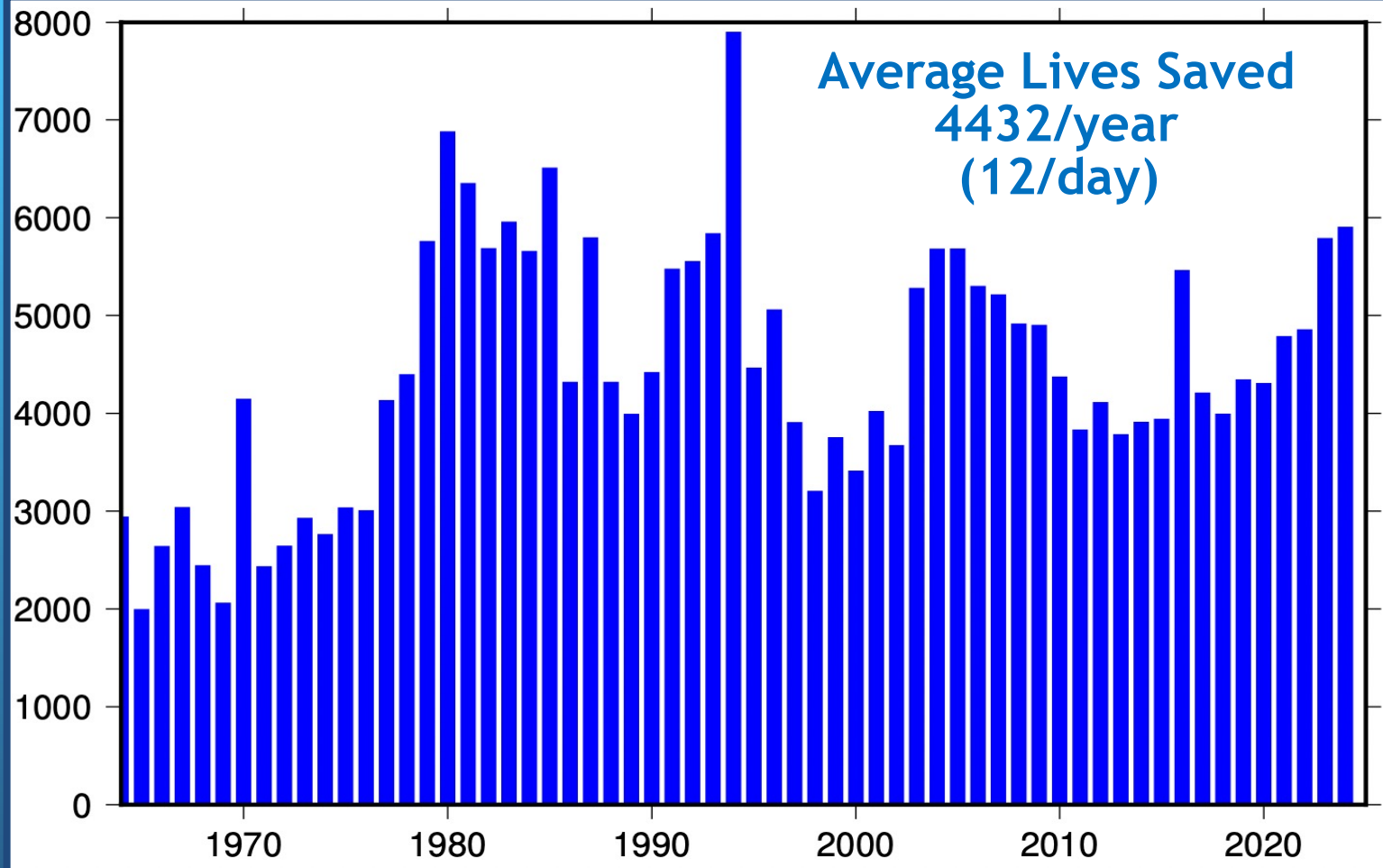
- USCG Search and Rescue Mission & Maritime SAR
- SAROPS Overview
- Environmental data
- SAR Cases Examples
- Summary: SAR challenges, future improvements





USCG Search and Rescue (SAR)

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1964-2024	Total	Avg Yr	Avg Day
Cases	2276445	41389	113
Lives Saved	270405	4432	12



95% within 20 NM from the coast



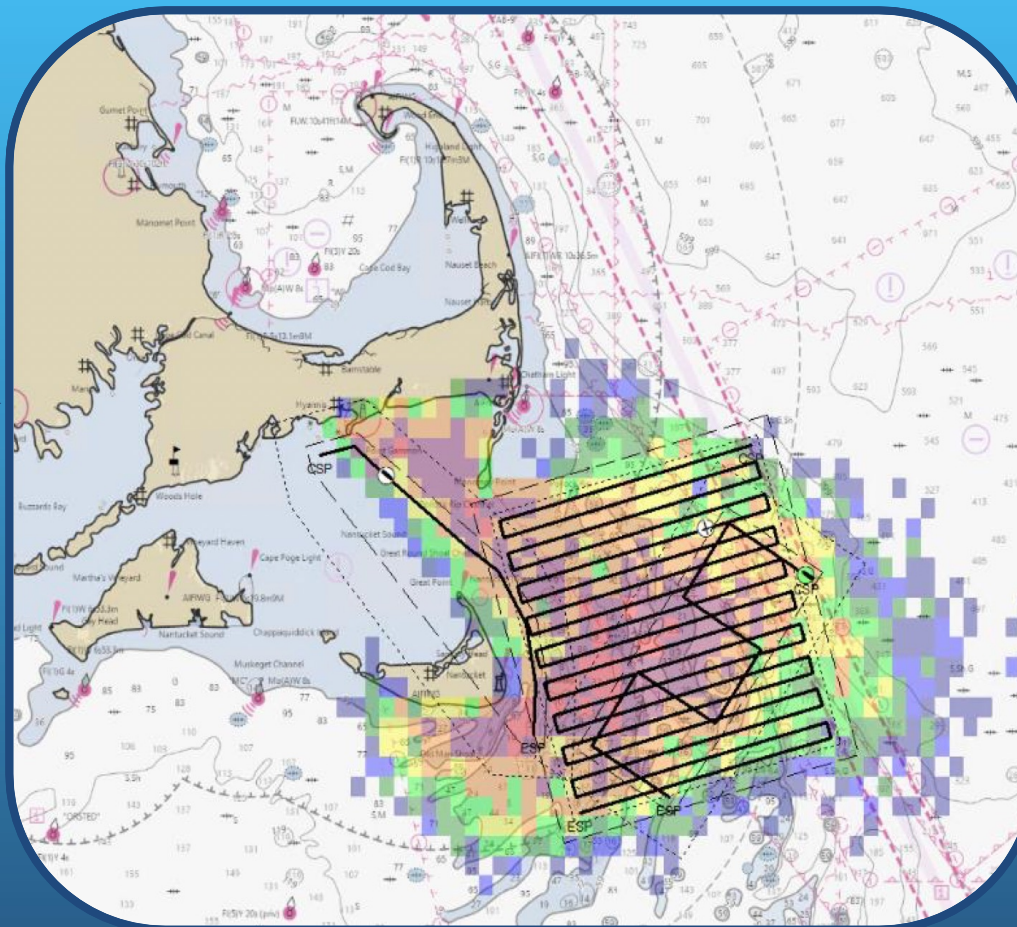
SAROPS Overview

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Distress Incident



Drift Modeling & Planning



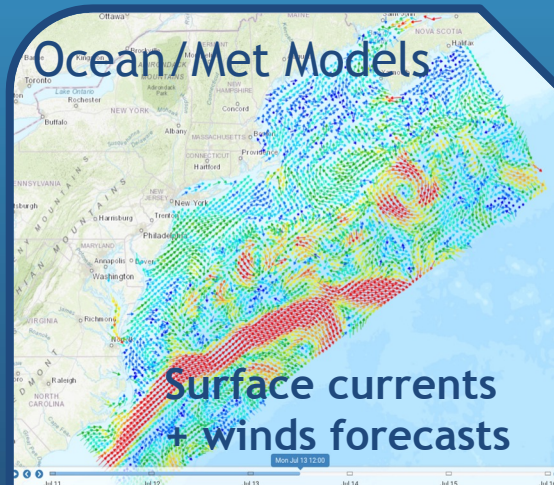
USCG Addendum 2022 - COMDTINST 16130.2G

Search and Rescue



www.sarsat.noaa.gov/rescue-coordination-centers/

Environmental Data Server



Cristina Forbes, USCG-SAR

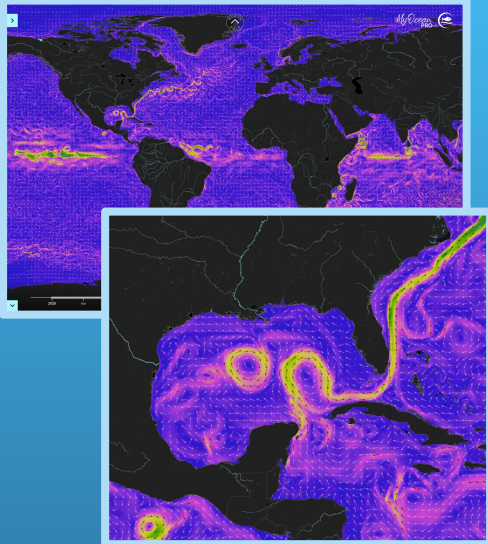
OceanPredict Coastal Ocean & Shelf Seas Meeting COSS-TT, Ifremer, 6/20/2025



Incorporation of New Models in SAROPS

6

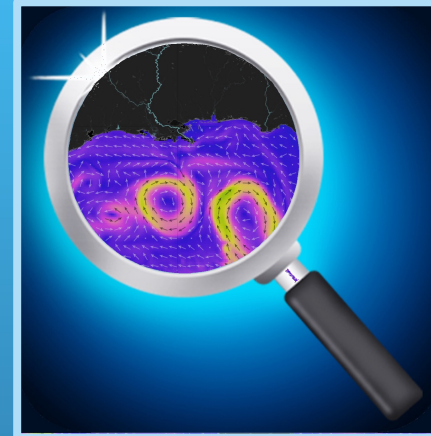
Research & Identification



Processing & Implementation

```
return(j);case 1: return a[w]=a.slice();var d={};c=a.pop();for (v in a.slice())var b=[],e=a.pop();return c.forEach(function(c){a.b+=64,R01G0D1hAQABAIAAAAAAP///yH5BAEAAALAAABAAEAAIAIBKAA title").body(function(a,b,c,d,e){"use strict";function f(a,b)(var c){var d=a[0].scrollbar;return(d instanceof m)||d instanceof n);return a=b(!<div style="width:50px;height:50px;overflow:auto";s.context=a[0],this.scrolling=!1,this.persistent=!1,this.updateHandle"></div></div>".insertAfter(a)).l.call(this,a,c),a.css({}))function o(a,b,c){this.vertical=new m(a,b);this.horizontal=new return this.updateScrollPosition();this.bar.addClass("scrolling"),.prototype.finishScrolling.bind(this),q,this),this),finishScroll l"),this),draggableMode:function(a){var b=this,d=this.drag.binc(a)(a.stopPropagation(),c.off("mousemove",d),b.bar.removeClass("le=this.context.clientHeight/this.context.scrollHeight,this.hanc .context.scrollHeight*100+"%"));this);drag:{value:function(a){t (update:{value:function(){return this.scale=this.context.clien e.css({left:this.context.scrollLeft/this.context.scrollWidth*100 r=n,o.prototype=(startScrolling:function(a){return this.vertical n){return this.vertical.update(),this.horizontal.update(),this .al.bar.addClass("both");this).remove:function(){return this.ver b){return new m(a,b)}function f(a){return z}((n=setTimeout(j,isk s("fa-check"),p=0,!1,clearTimeout(n),n=setTimeout(k,isNaN(a)?t:a oin"),x.show(),Afunction k){return x.hide(),Afunction l(a,b){f
```

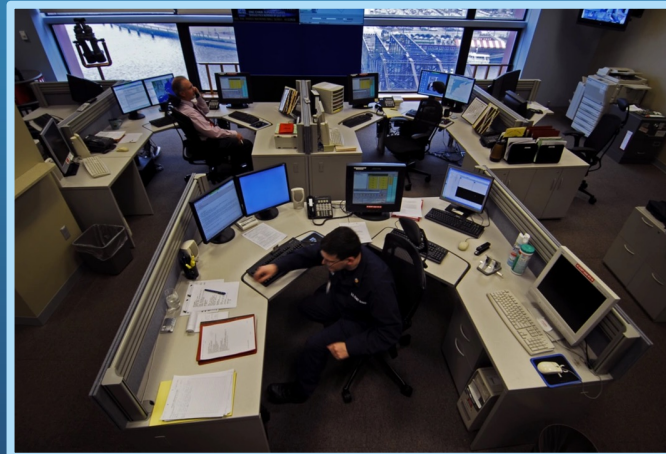
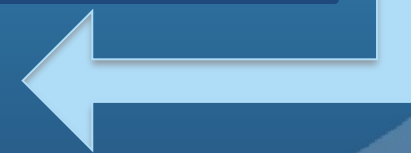
Evaluation & Testing



Update Documentation



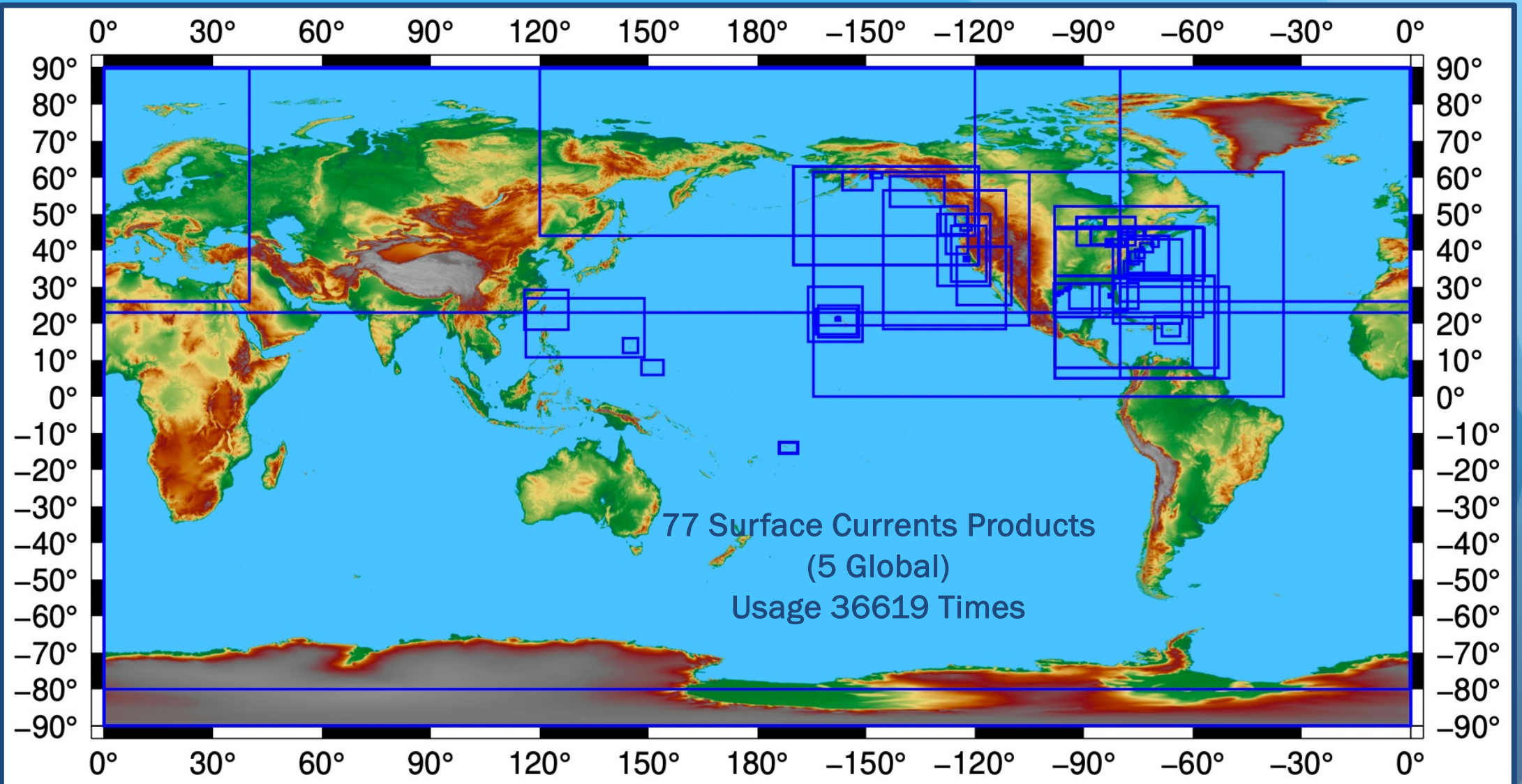
Activation for Operations





Surface Currents Coverage - 2024

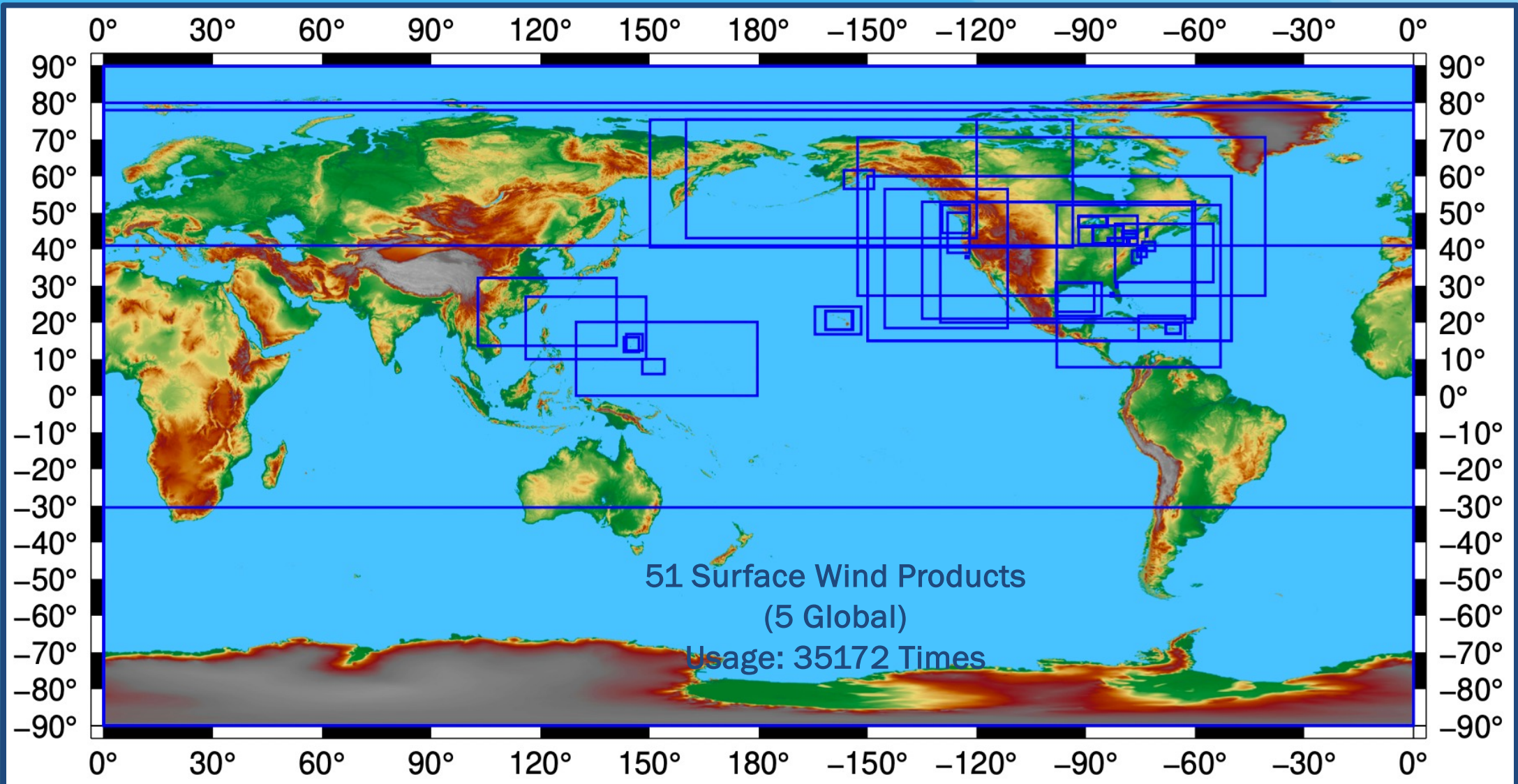
7





Wind Coverage - 2024

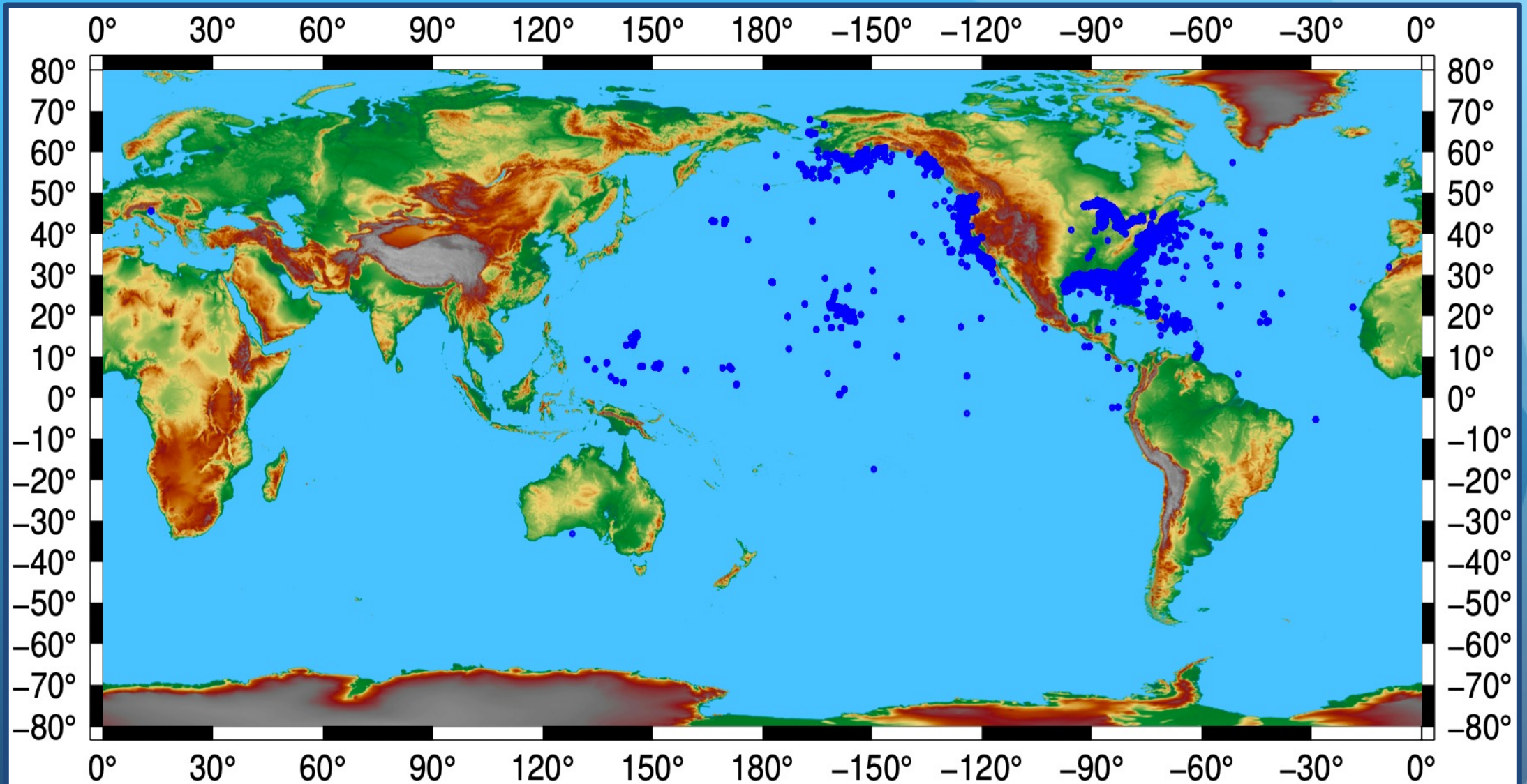
8





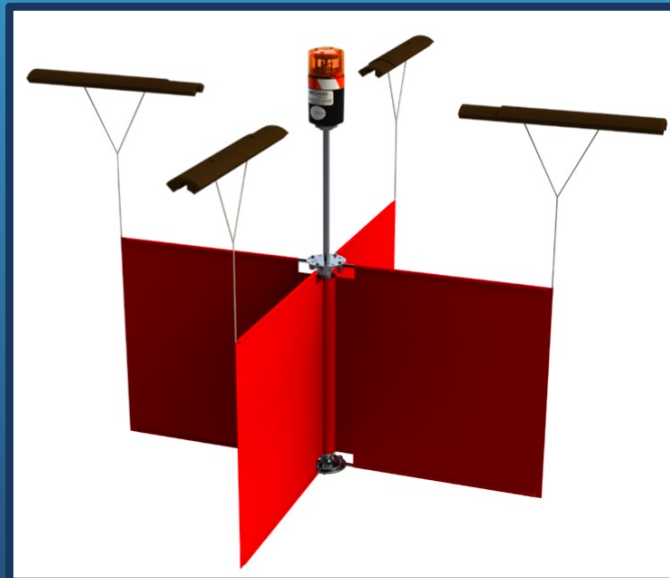
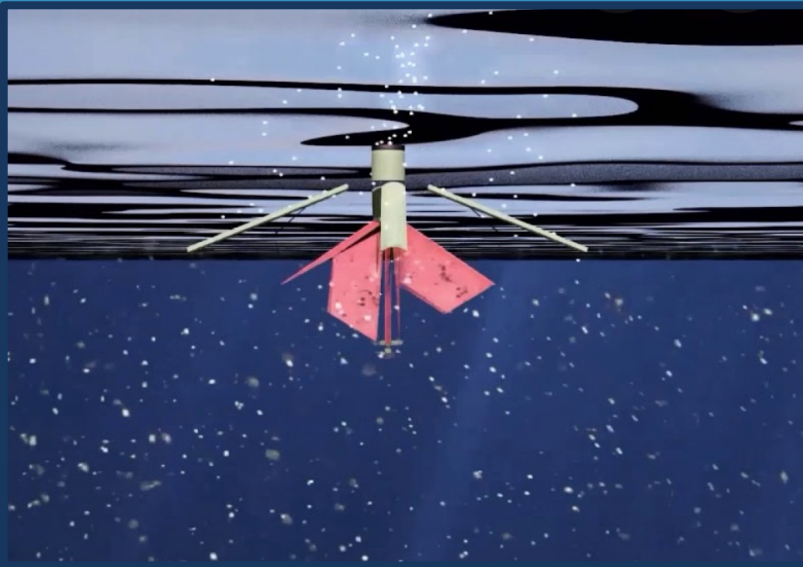
2024 SAROPS Operational Distress Incidents

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Self-Locating Datum Marker Buoy (SLDMB): Surface Currents¹⁰

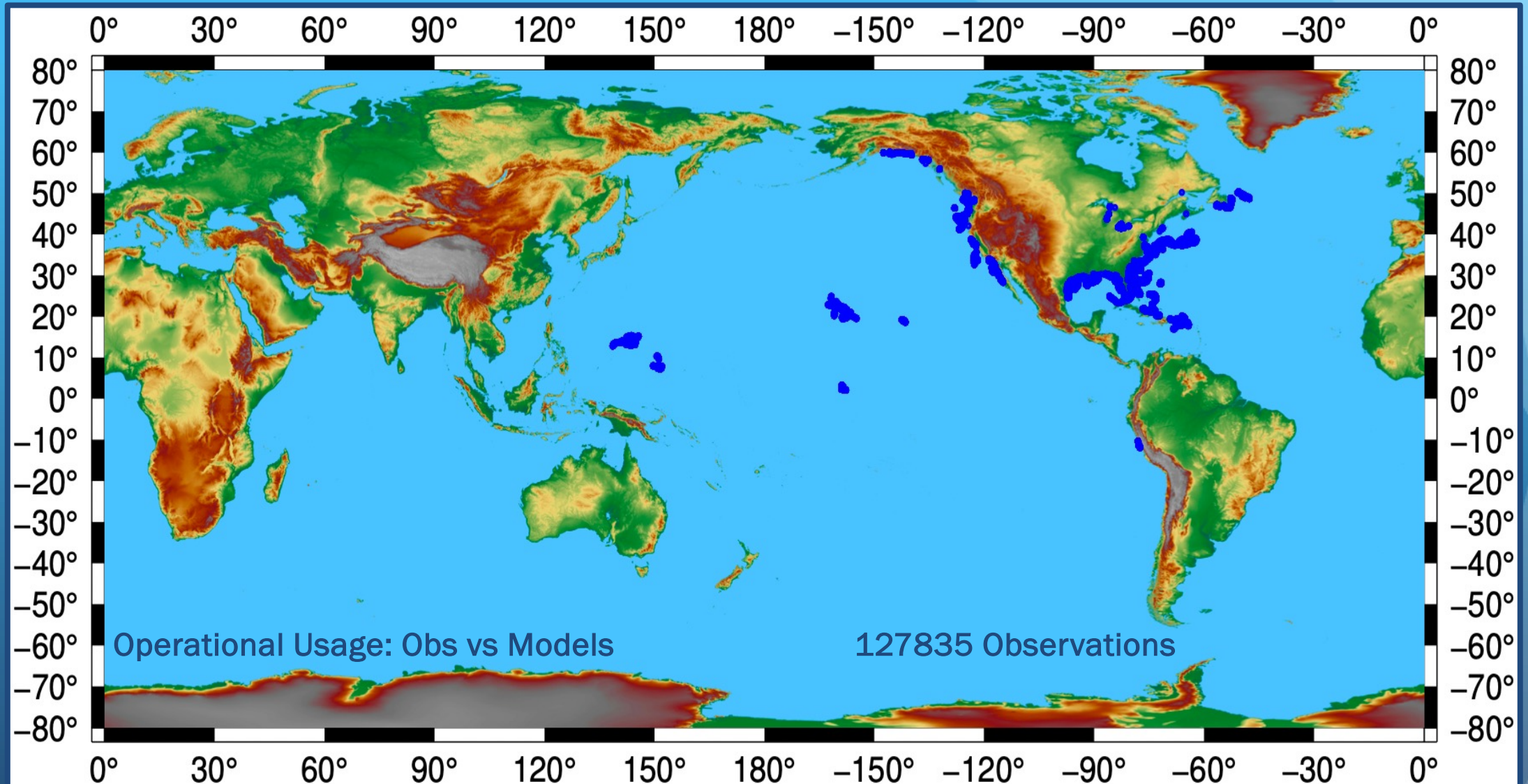


- Drifting buoy design to measure surface currents less than 1 in depth
- Based on the Davis-style drifter design - minimizing effects of wind and waves
- Deployed by aircraft or vessel
- Used by USCG-SAR to choose best matching model



2024 SLDMB Observation Locations

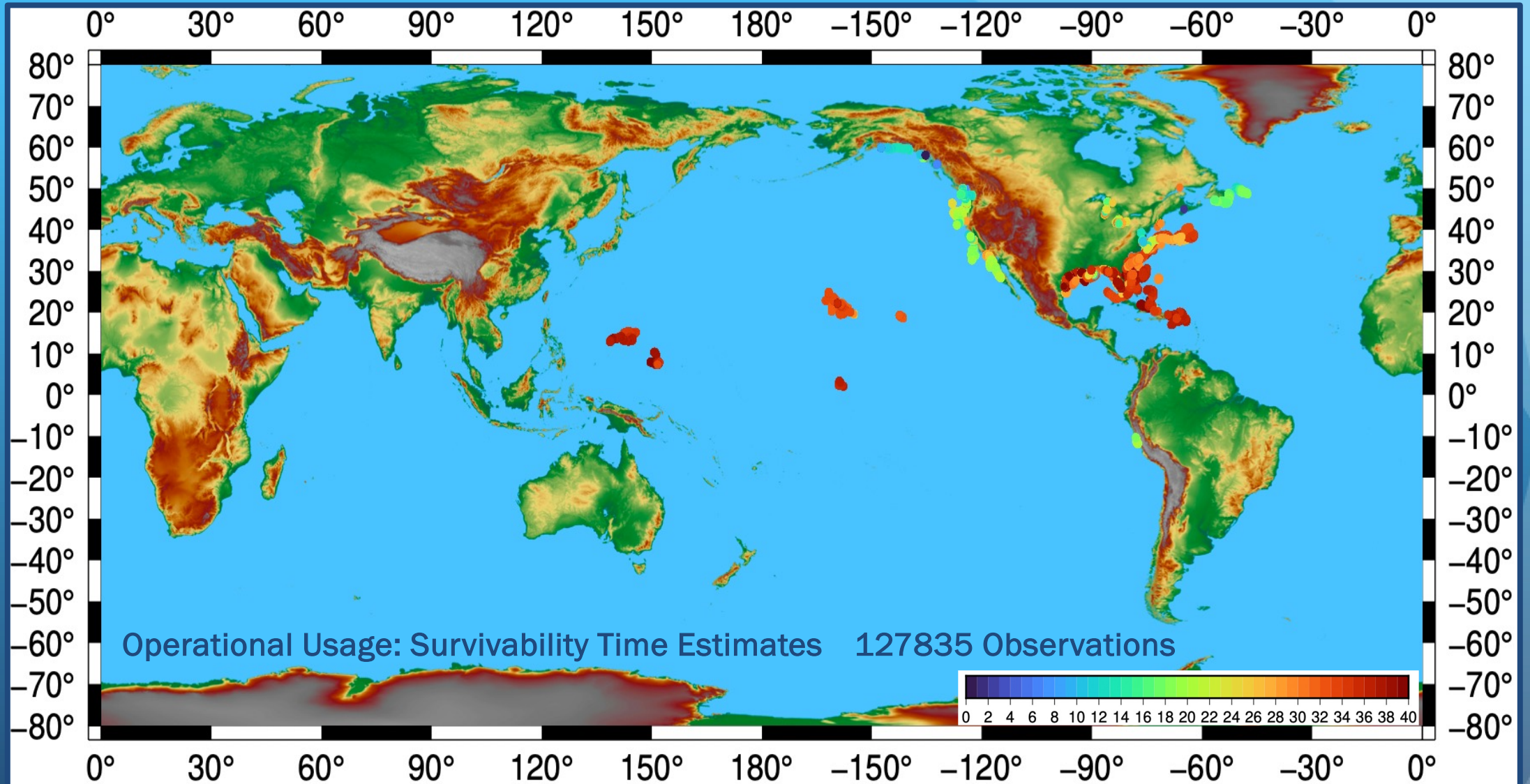
11





2024 SLDMB SST Observations

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USCG-Search and Rescue Requirements for Environmental Data

Parameter	Product	Value
Coverage	Ocean/met variables*	Global and Regional
Forecast output frequency	Ocean/met variables*	6 hrs
Temporal resolution of output	Ocean/met variables*	1 hour
Forecast range	Ocean/met variables*	72 hours
Reliability	Ocean/met variables*	99%
Locations	Ocean/met variables*	Global & regional: open ocean, bays/rivers/lakes, around islands
Height	wind speed/direction	@10 m ★
Layer Depth	surface currents	0-1 m ★
Horizontal resolution	surface currents	10 m in rivers, 50 m-1km in inlets/bays, 1 km in lakes, <=2 km around small islands, <=5 km in open ocean
	winds	<= 2.5 km coasts, 3-12 km vast ocean
Accuracy	currents speed/direction	0.1 m/sec / 10 degrees
	winds speed /direction	1.0 m/sec / 10 degrees
	waves	SWH: 10 cm, period: 1 sec, dir: 10 deg, whitecapping % coverage: 10%
	SST, air temperature	1° C
	rel humidity, precip, visibility	10%

* Ocean and atmospheric variables: wind, surface currents, waves, SST, air temperature , rel humidity, precipitation, visibility

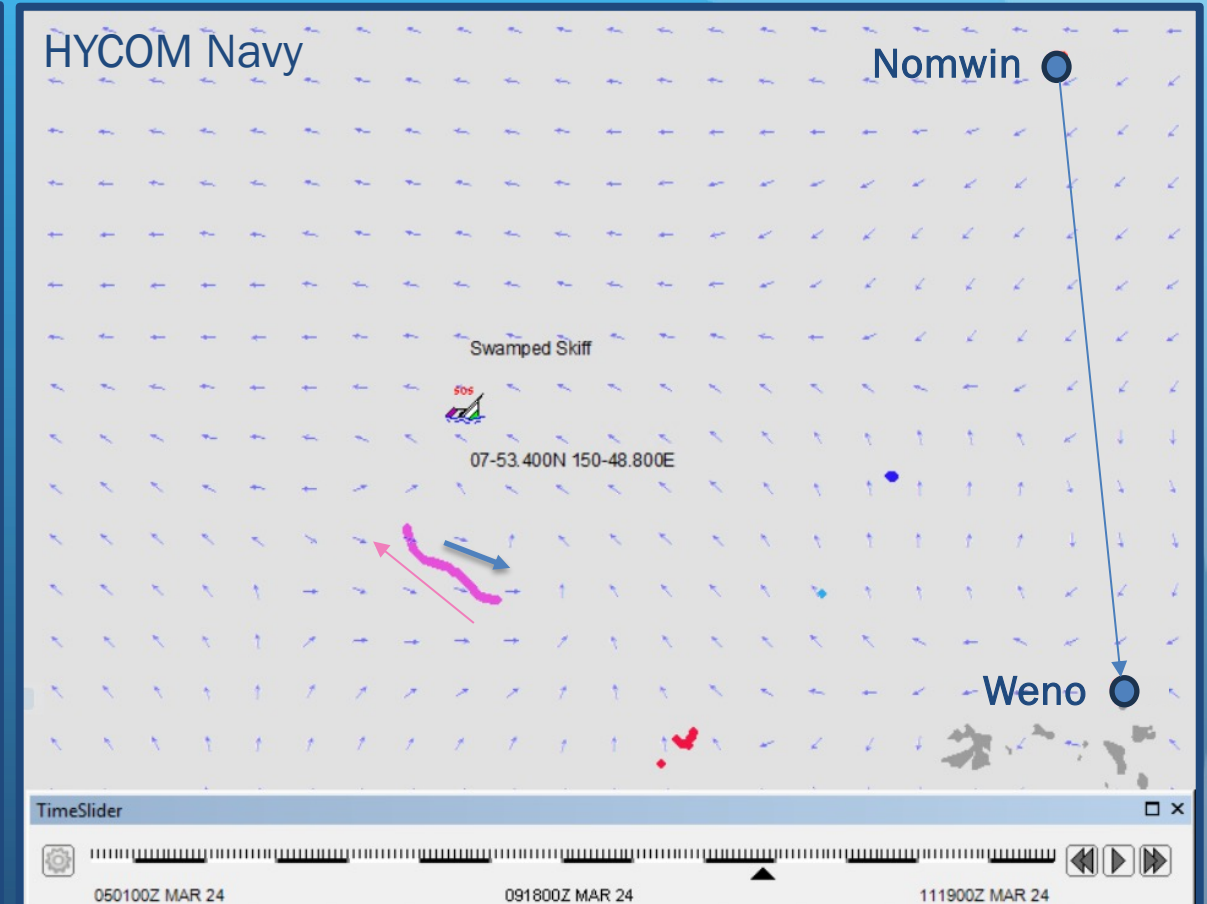
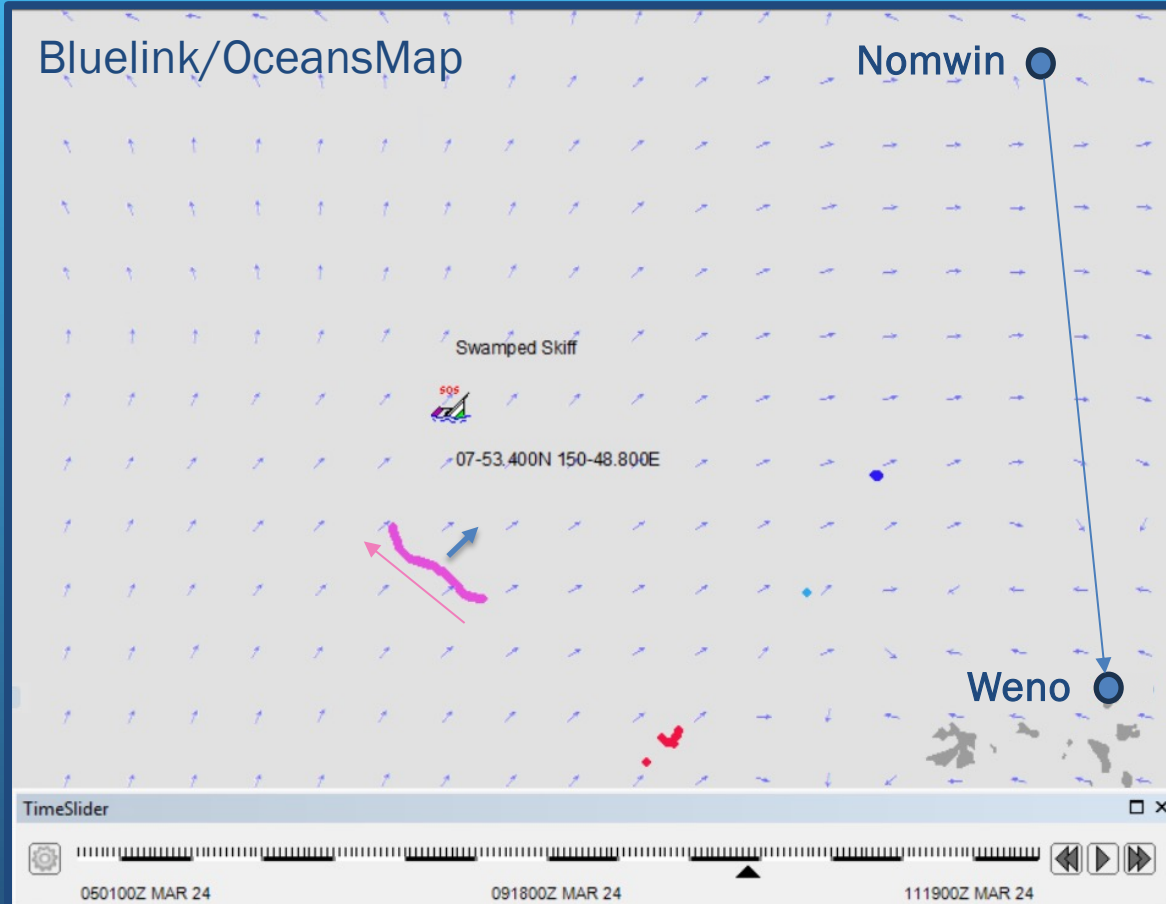
Forbes C, 2022: "CG-SAR Recommendations/Requirements for Environmental Data", U.S. Coast Guard, Search and Rescue, CG-SAR-CF-20220208.



Example 1: Importance of Observations

Model vs Observations

- 3 fishermen left Nomwin to Weno on March 5 and did not return
- March 9, 2024 @ 1800Z



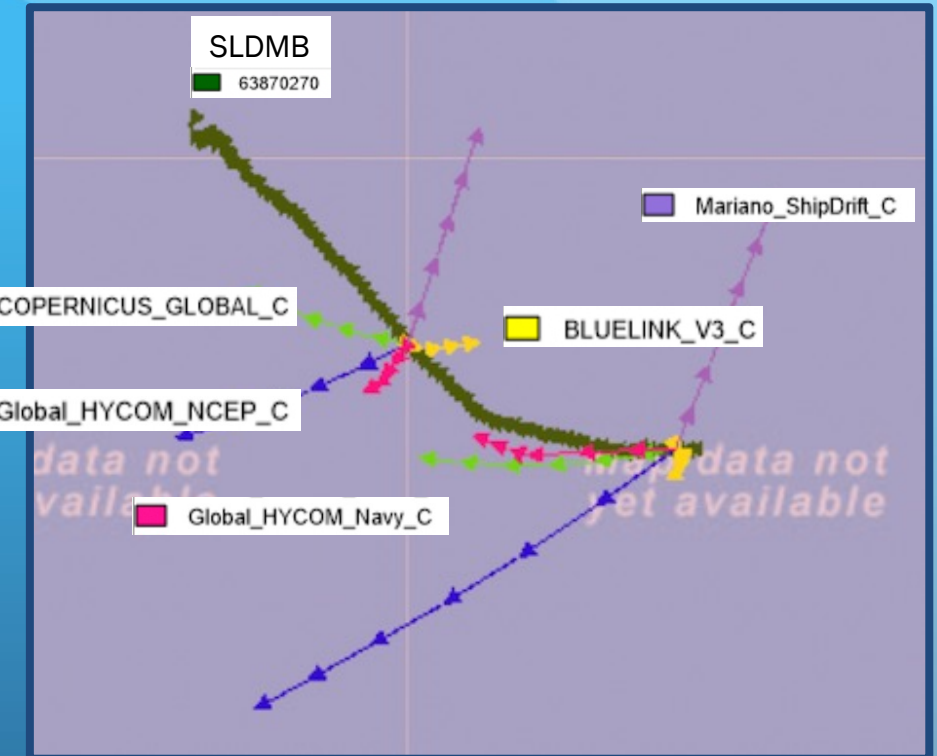
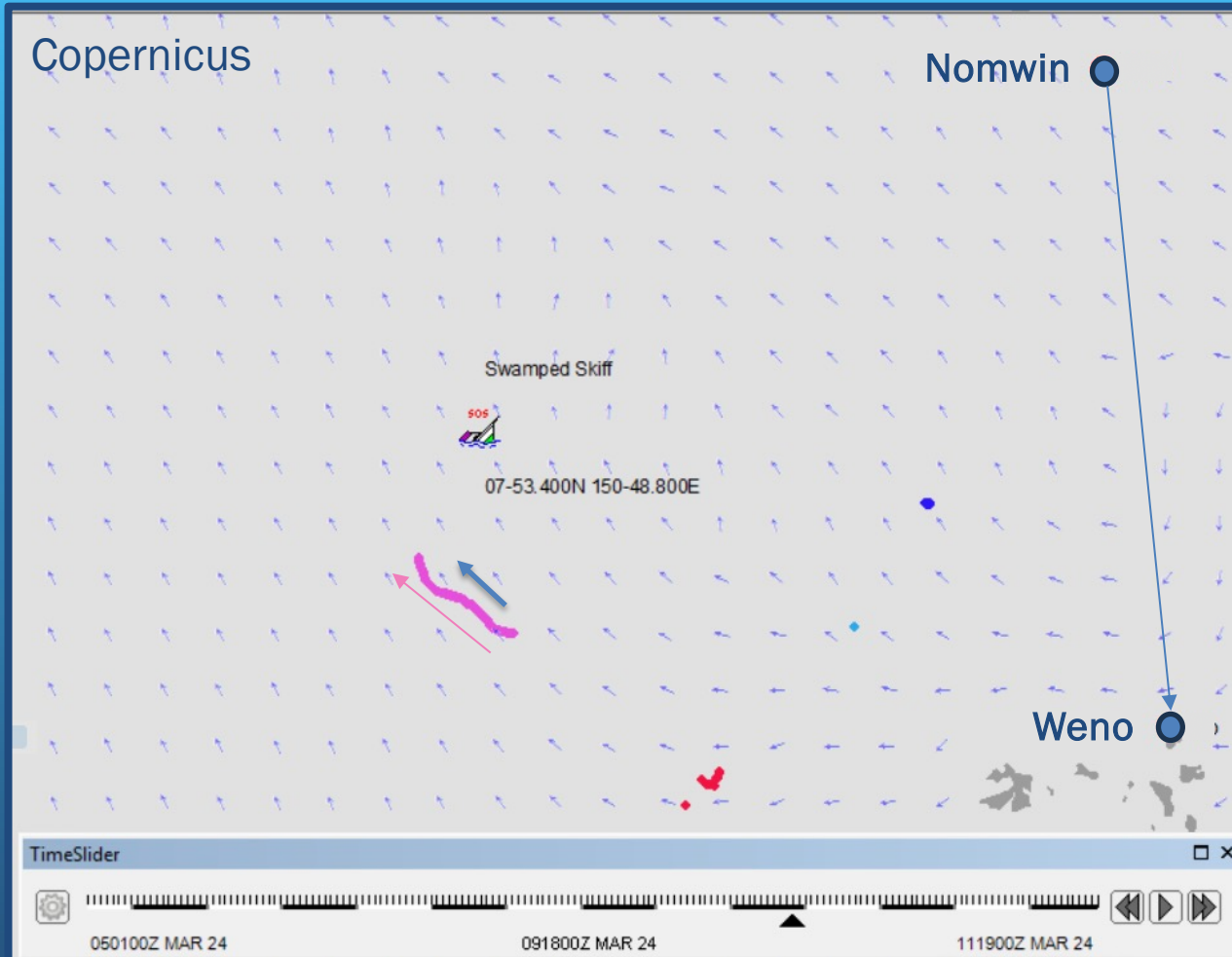


Example 1: Importance of Observations

Model vs Observations

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March 9, 2023 @ 1800Z



Skill Score

$$SS = 1 - \left(\frac{\sum_{i=1}^N d_i}{\sum_{i=1}^N l_{oi}} \right)$$

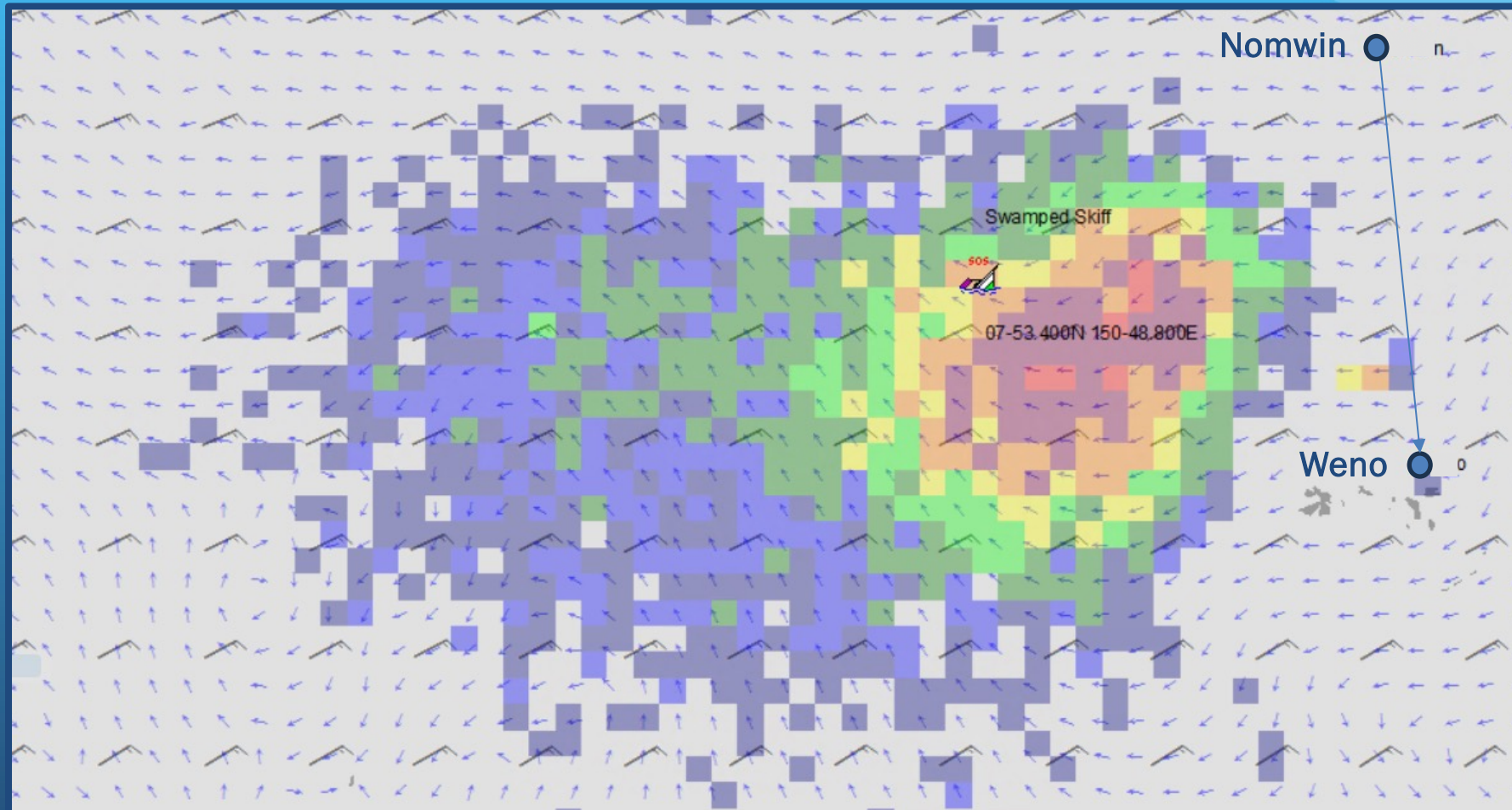
Model	SS
Copernicus	0.56
Hycom_Navy	0.34
Bluelink	NS
Mariano_ShipDrift	NS
Hycom_NCEP	NS



Example 1: Importance of Observations

SAROPS Drift Modeling: Probability Map

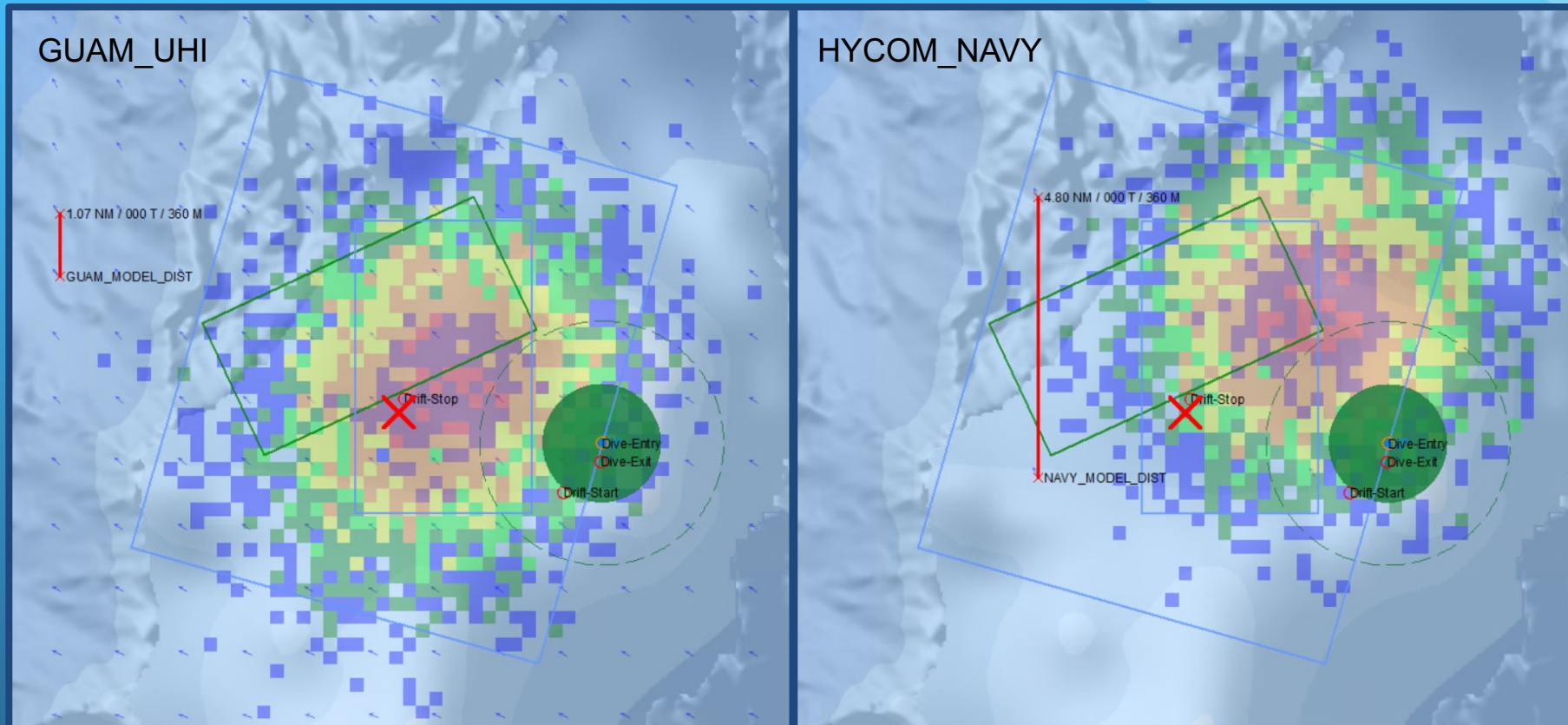
- Boat found capsized, one fisherman deceased and two missing





Example 2: Importance of Resolution

Missing Divers in Santa Rosa Reef , 30 NM from Guam - 28 OCT 2023



Model Resolution = 1 NM = 1.98 km

Model Resolution = 4.8 NM = 8.89 km

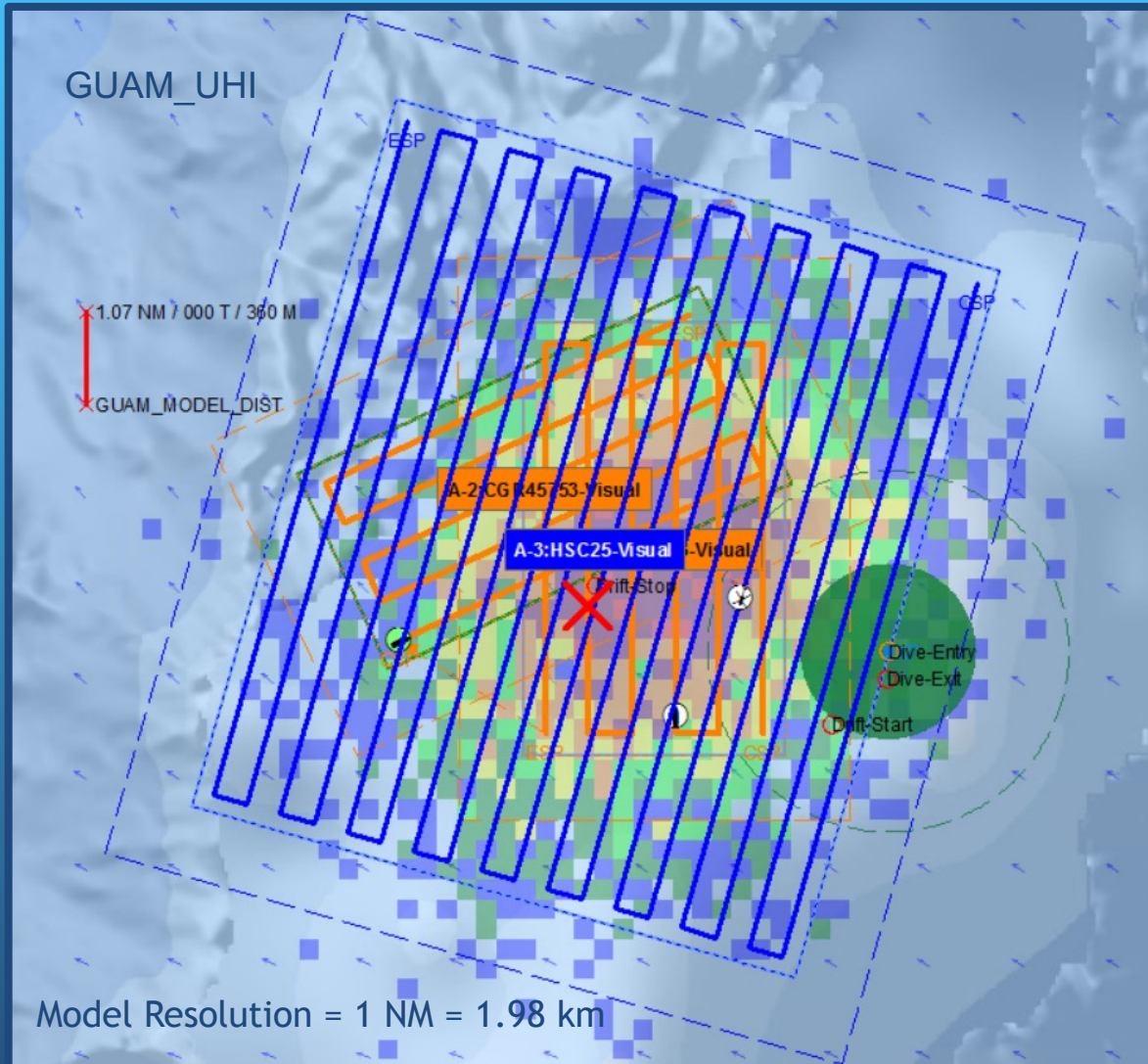
Divers Found @ X = 3.15 NM , Bearing: 296 T
from start of drift

Distance of highest probability center
between models 2.7 NM = 5 km



Example 2: Importance of Resolution

Missing Divers in Santa Rosa Reef , 30 NM from Guam - 28 OCT 2023



A U.S. Navy MH-60 Knighthawk from Helicopter Sea Combat Squadron 25 rescues three divers off the coast of Agat, Guam, Oct. 28, 2023. (U.S. Coast Guard)

https://www.stripes.com/theaters/asia_pacific/2023-10-31/guam-rescue-missing-divers-11900402.html

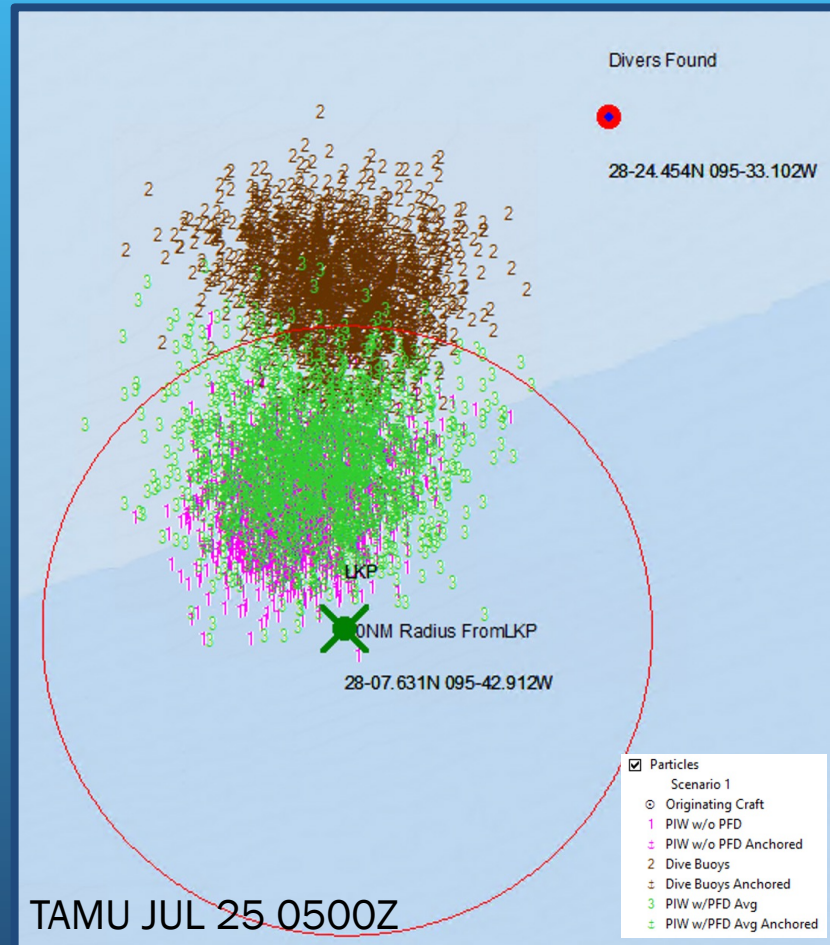
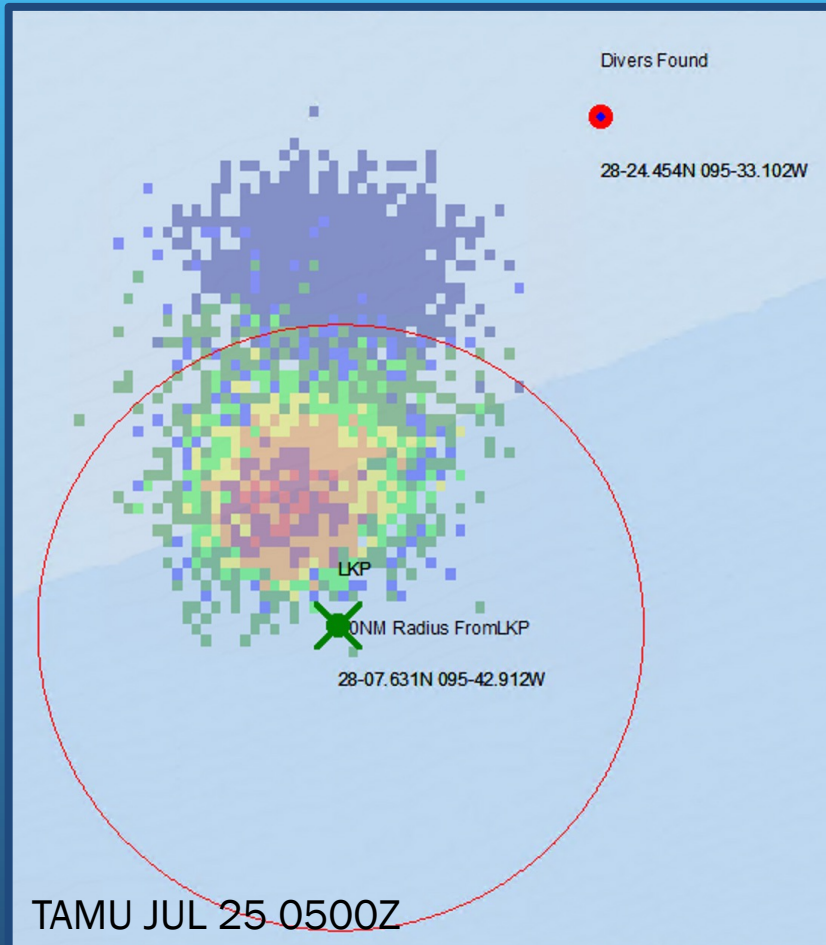
Divers Found @ X = 3.15 NM/Bearing: 296 T



Example 3: Drift Modeling

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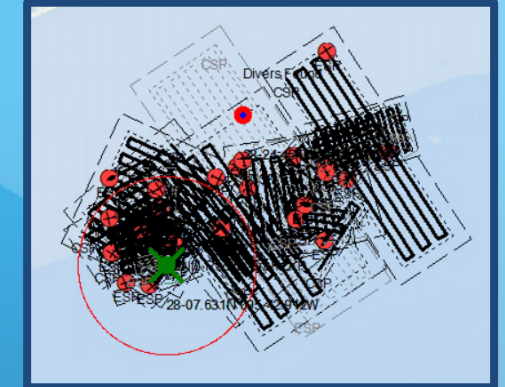
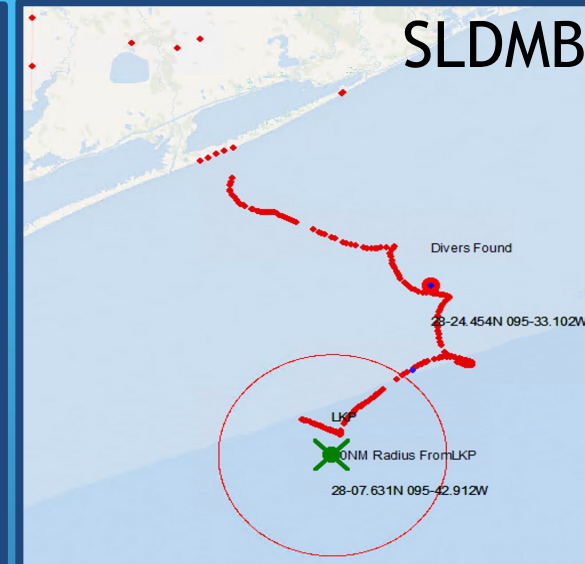
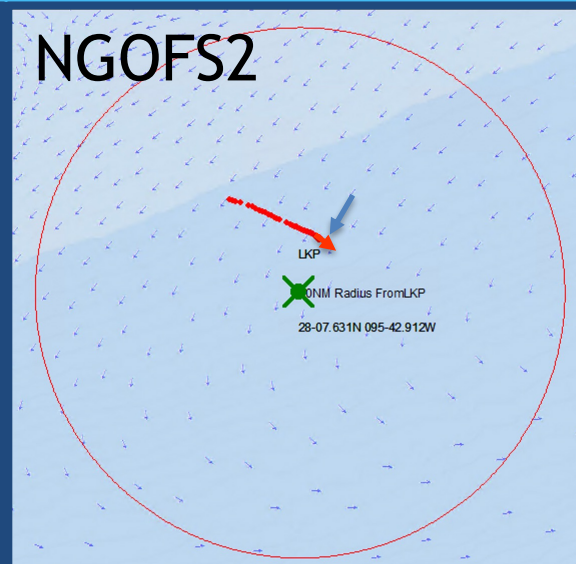
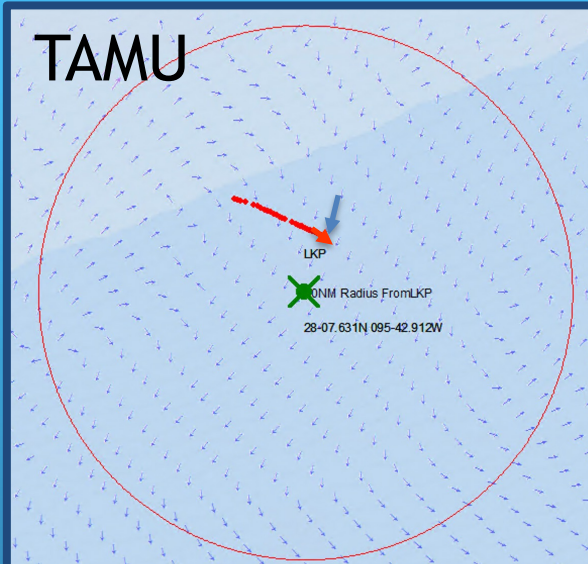
- Case of 2 missing divers offshore Port O'Connor, Texas, USA on July 24, 2024.
- They had resurfaced when a squall hit with strong winds and low visibility.
- Once the squall lifted, the 2 divers were nowhere in sight.



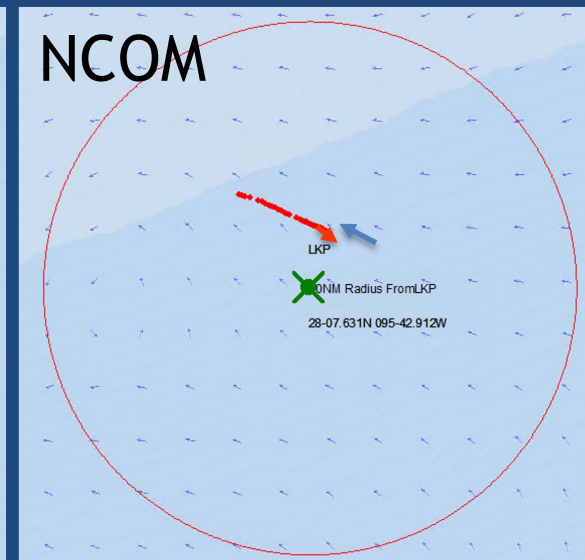
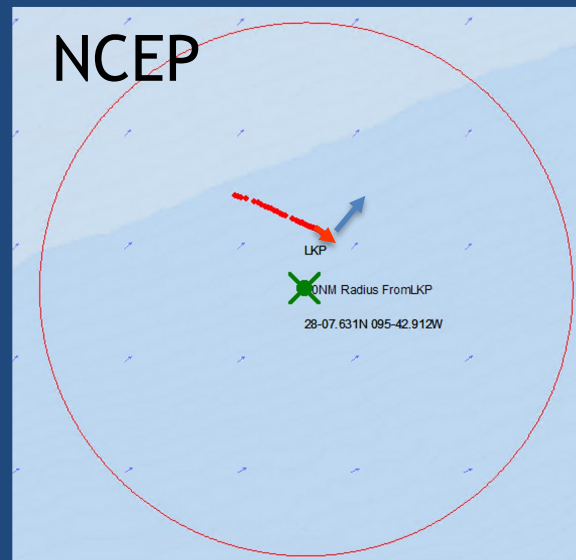
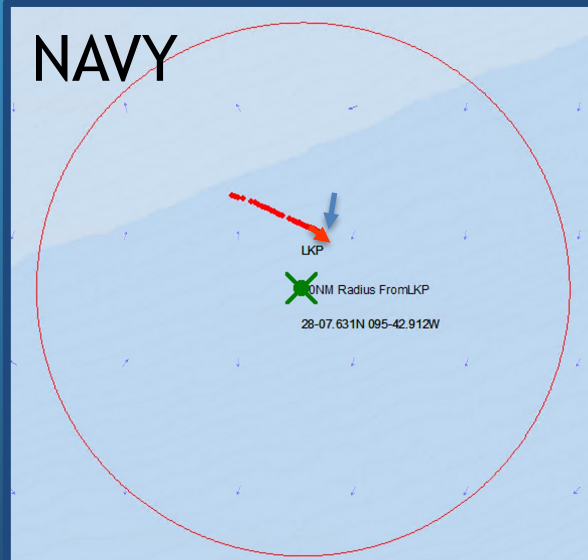


Example 3 : Models vs. Obs

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- 30 active/planned searches during the 40 hrs in inclement weather
- Search planning software optimizes search pattern taking into account previous searches



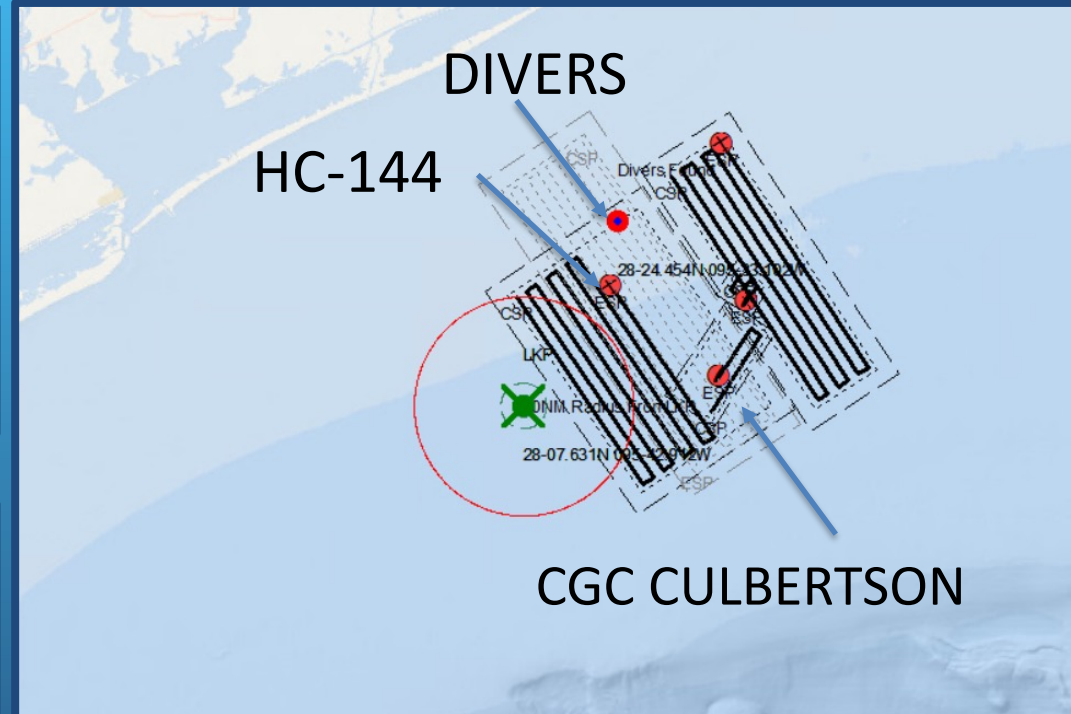
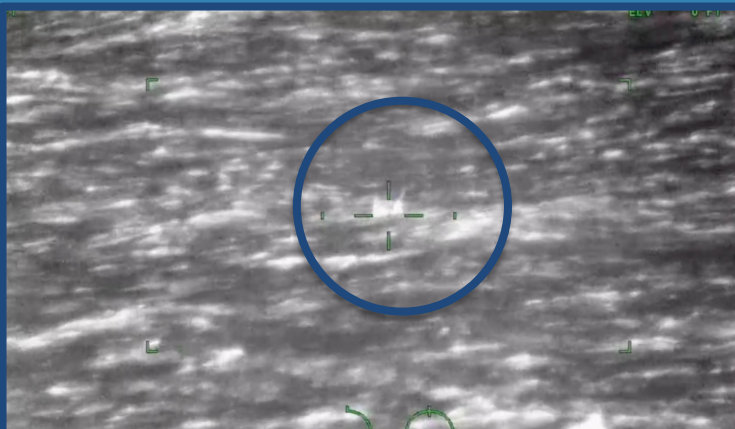
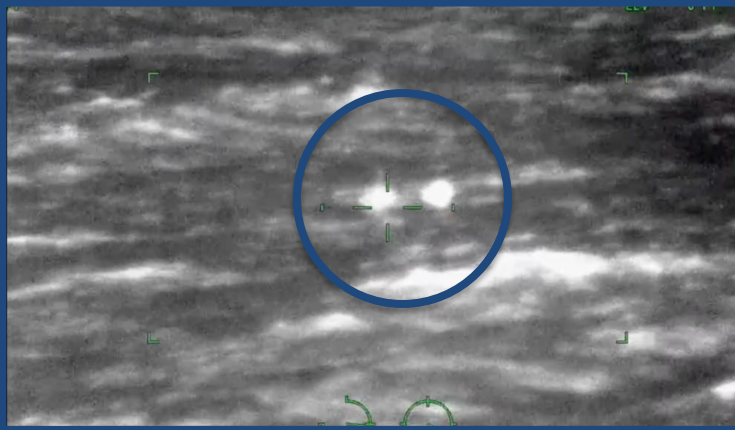
Model	July24-25	SS
Copernicus		0.17
Hycom_Navy		0.30
Bluelink		NS
NGOFS2		0.16
Hycom_NCEP		0.05
NCOM		NS
TAMU		NS
ARMS-RELO		0.55



Example 3: Search Planning

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- HC-144 detected flashlight and observed 2 PIWs
- Video: <https://www.news.uscg.mil/Press-Releases/Article/3851358/coast-guard-rescues-missing-divers-near-matagorda-texas/>

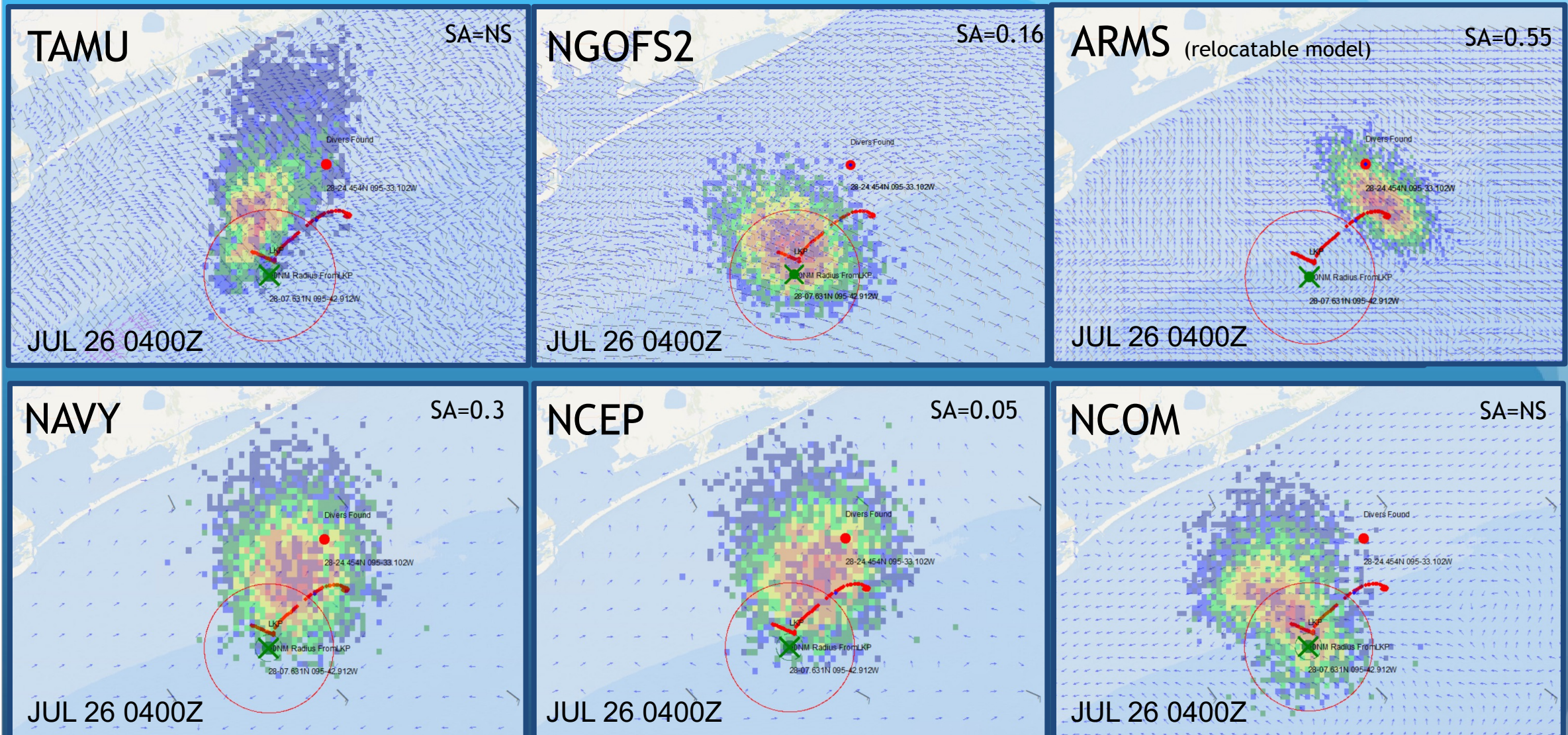


- CGC CULBERTSON diverted to location, rescued the 2 PIWS





Example 3: Probability Maps



Summary and Questions?

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★ SAR Challenges:

- Uncertainties in time/location of distress incident, search object(s)
- Accurate environmental data: essential for SAR
- Adequate horizontal and vertical resolution in models
- Specs for SAR: wind speeds @ 10m and surface currents @ 1m depth

★ Future Improvements that can benefit SAR:

- Expansion of observational networks (i.e. buoys)
- Higher Resolution Models (i.e. remote islands)
- Relocatable Models (i.e. deployable, easy to configure, fast)
- Artificial Intelligence/Machine Learning Models (e.g. AIFS).

★ CG-SAR continuously collaborates w/international & national government agencies, academia & industry to improve data and tools for successful SAR missions. Collaborative efforts are vital to saving lives at sea!

★ Feedback/Questions: Maria.C.Forbes@uscg.mil, CristinaForbes11@gmail.com

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Cristina Forbes, USCG-SAR

OceanPredict Coastal Ocean & Shelf Seas Meeting COSS-TT, Ifremer, 6/20/2025

