THE AVOIDANCE OF HIGH WINDS AND SEAS BY SHIPS TRANSITING THE PACIFIC AND ATLANTIC

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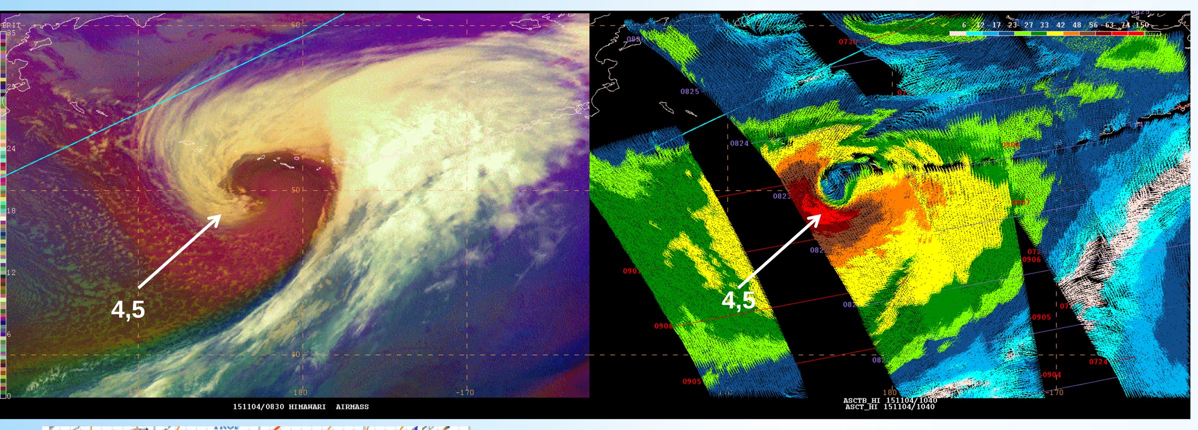
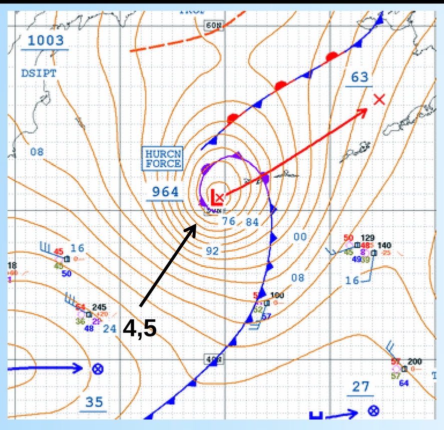
Mid-latitude cyclones



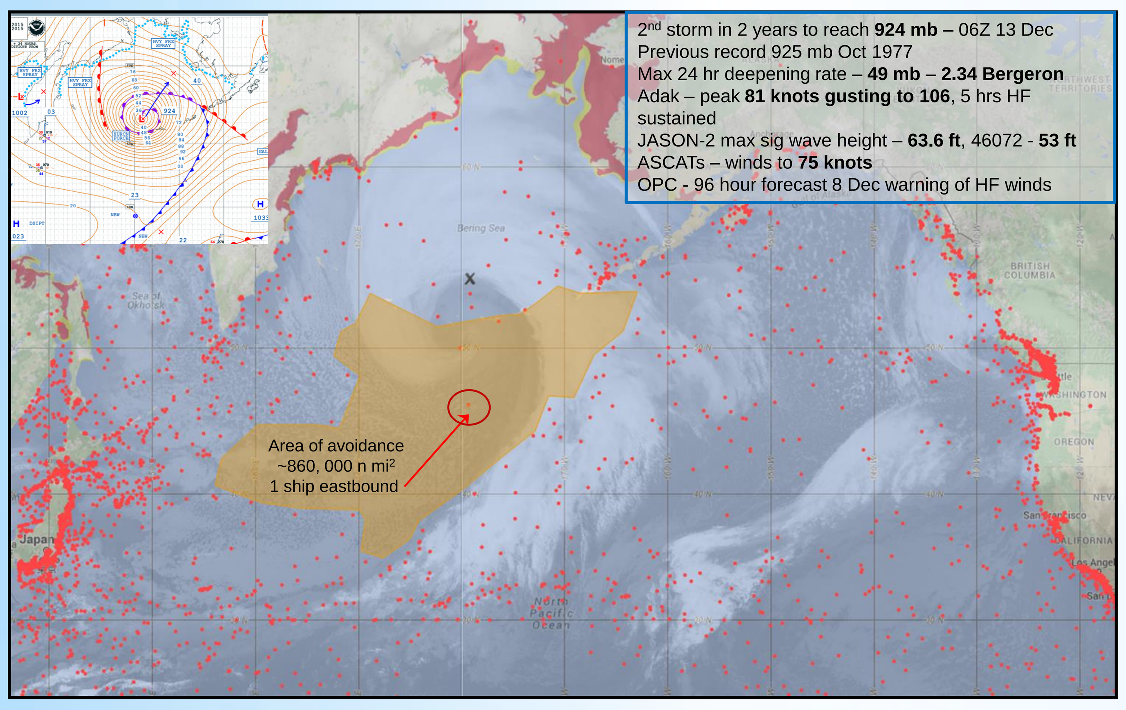


Aleutian extra tropical cyclone 4 Nov 2015, showing RGB Airmass product from the JMA Himawari-8 satellite, ASCAT winds from NOAA NESDIS StAR, and OPC surface analysis and warnings. , Extreme mid-latitude ocean storms follow the below order of evolution and often produce the asymmetric winds field distribution as shown above.

Evolution

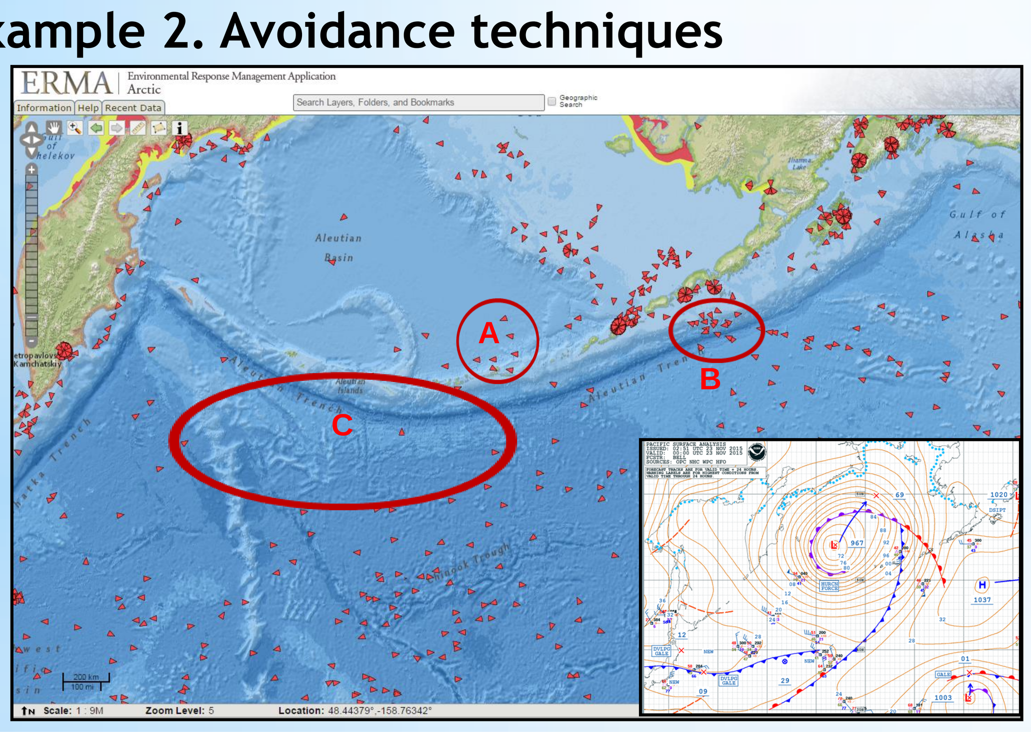
1. Strong frontogenesis develops
2. Bent back front extends SEward
3. Pressure Gradient Force (PGF) maximum develops
4. PGF increases, wraps under cyclone center (south)
5. Hurricane force winds develop within the PGF maximum and cold side of frontogenesis maximum

Example 1. Massive Storm



Example 1. In mid Dec 2015 a massive storm was predicted to explosively intensify and move eastward along the Aleutian chain. The above image shows the IR satellite image with an impressive comma head and ship positions from 0000 UTC 13 Dec 2015. A large area void of ships extends from the central Bering Sea across the northwest Pacific. East and west bound traffic was disrupted to avoid hurricane force winds and huge seas. The lone east bound ship made little headway for a period of time.

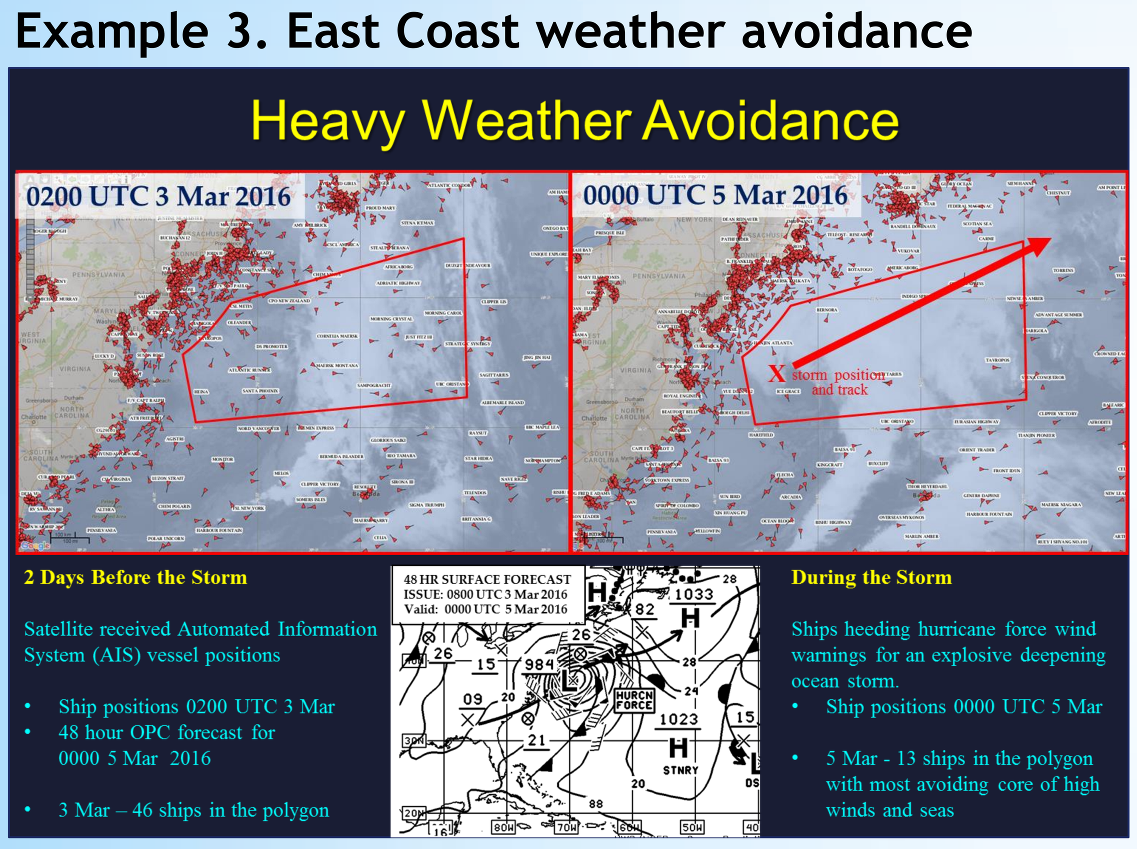
Example 2. Avoidance techniques



Example 2. NOAA Arctic **E**mergency **R**esponse **M**anagement **A**pplication **ERMA** plot showing ship and fishing vessel traffic over the North Pacific on 0000 UTC 23 Nov 2015. Lower right is the OPC surface analysis from 0000 UTC on that date with an intense storm of Hurricane Force centered over the central Bering Sea and moving NE. Three areas of ship avoidance actions can be seen:

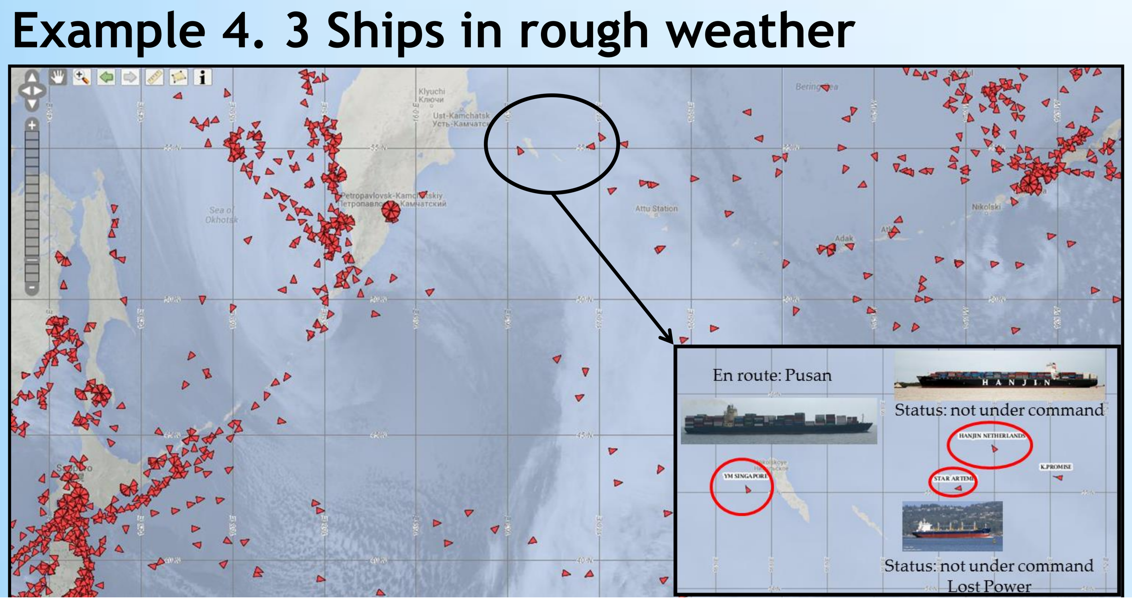
A. - west bound ships are moving slowly at 2-5 knots to avoid damage from heavy seas
B. - vessels are delaying entry through Unimak Pass and entrance to the Bering Sea to avoid severe winds and seas.
C. - A large area void of ships along and south of the western Aleutians is due to vessels taking early actions by routing farther south or delaying transit south of the Aleutians.

Example 3. East Coast weather avoidance



Example 3. Western North Atlantic NOAA Arctic **ERMA** plot showing ship and fishing vessel positions before and during an explosively deepening Hurricane Force storm. Comparisons show an even or consistent traffic density within the red polygon two days before the cyclone developing and (right panel) during the cyclone formation and rapid development. Clearly vessels have altered course and speed to avoid the forecast conditions in particular to the south of the developing cyclone center. This area to the south of the developing cyclone is where hurricane force conditions typically develop.

Example 4. 3 Ships in rough weather



Example 4. Western North Pacific storm from NOAA Arctic **ERMA** showing ship and fishing vessel positions during an explosively deepening Hurricane Force storm. The storm system was moving NNE along the Kurile Islands and approaching the Kamchatka peninsula. Three vessels near the Russian Aleutians were struggling in heavy seas. One (Star Artemis) had lost propulsion, a second (Hanjin Netherlands) listed its status as **Not Under Command** and a third (YM Singapore) had diverted to apparently seek shelter from building seas.

Abstract

Commercial ships are required by the International Maritime Organization to transmit information such as name, position, motion, etc. via a device called an **Automated Information System** or **AIS**. The AIS message is designed to enhance situational awareness and reduce the risk of collision between ships by providing a clear identity to communicate passing signals and avoid collision. The AIS is broadcast in the VHF range and can be picked up by low earth orbiting satellites, centrally collected, and distributed. The satellite acquired AIS data has the potential to provide the basis to observe and track vessels across the global ocean. In addition, vessel avoidance behavior in the face of hazardous weather such as high winds and seas can now be observed in real time. This paper will present examples from the NOAA Arctic **Emergency Response Management Application** (**ERMA**) of both successful and less than successful hazardous weather avoidance from the 2015-16 winter season over both the Atlantic and Pacific. The potential to improve warning services will also be discussed and conclusions and thoughts on a path forward to improve weather services will be given.

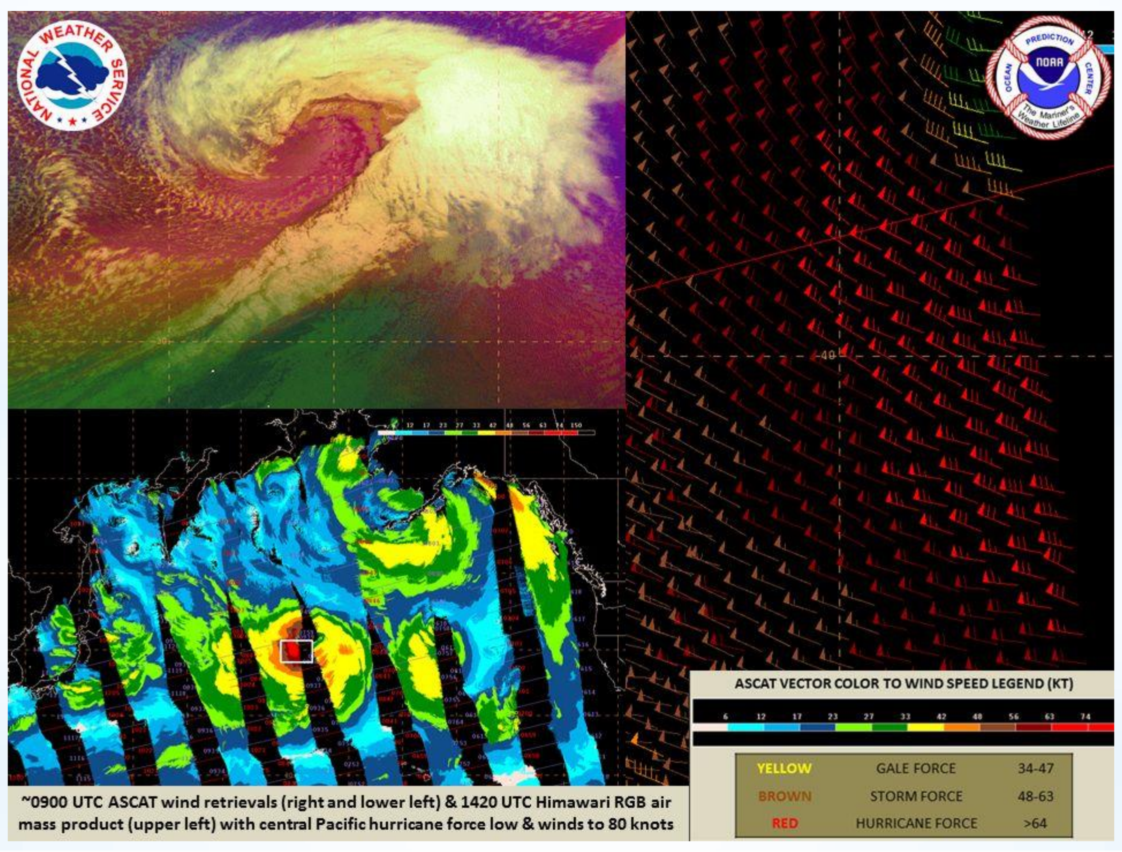
Summary and Conclusions

Satellite received AIS data from vessels operating on the high seas have revealed successful heavy weather avoidance practices. It has also demonstrated when vessels fail to avoid severe conditions.

Below are some findings:

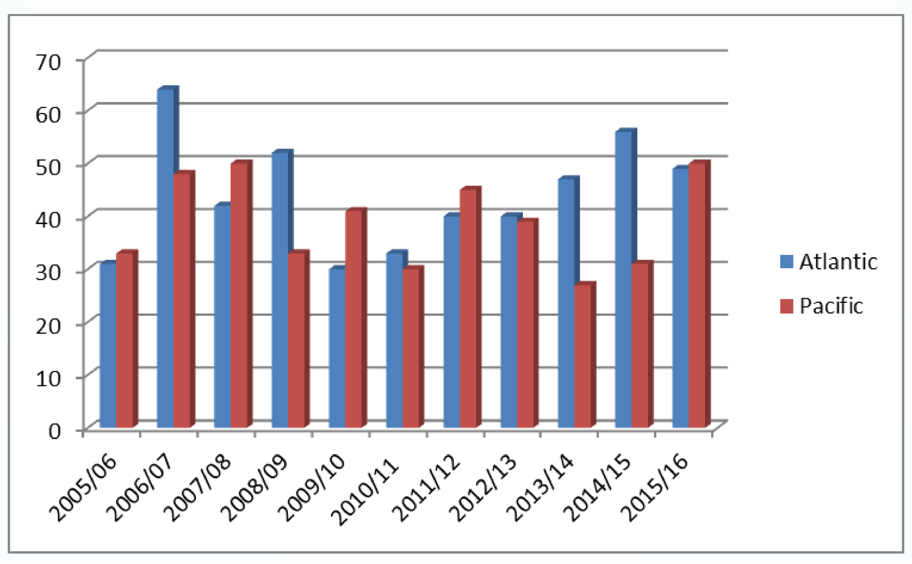
- Weather avoidance is more evident in the North Pacific than western North Atlantic due to the large latitudinal expanse of ocean, routing options and use of the Aleutians as a wind and sea break.
- Vessels attempt to avoid areas of highest winds and seas, however, the specific criteria are not clear (Wind speed , direction, or wave height).
- Hurricane Sandy example(**6**) suggests 50 knots of wind may be one criteria used for avoidance.
- Vessels are making avoidance decisions based on predictions, in some cases 4 or more days in advance.
- Only a very small percentage of ships report weather information.
- Satellite Ocean Surface Vector Winds serve as "sea" truth by providing consistent quality wind speeds, direction, and basis for warning criteria.
- Recommend that Satellite AIS data be integrated into NWS marine forecasters data display systems.
- Avoidance practices are not always successful as shown in Examples 2, 4, 7, and 8.

Ocean vector winds as "sea" truth



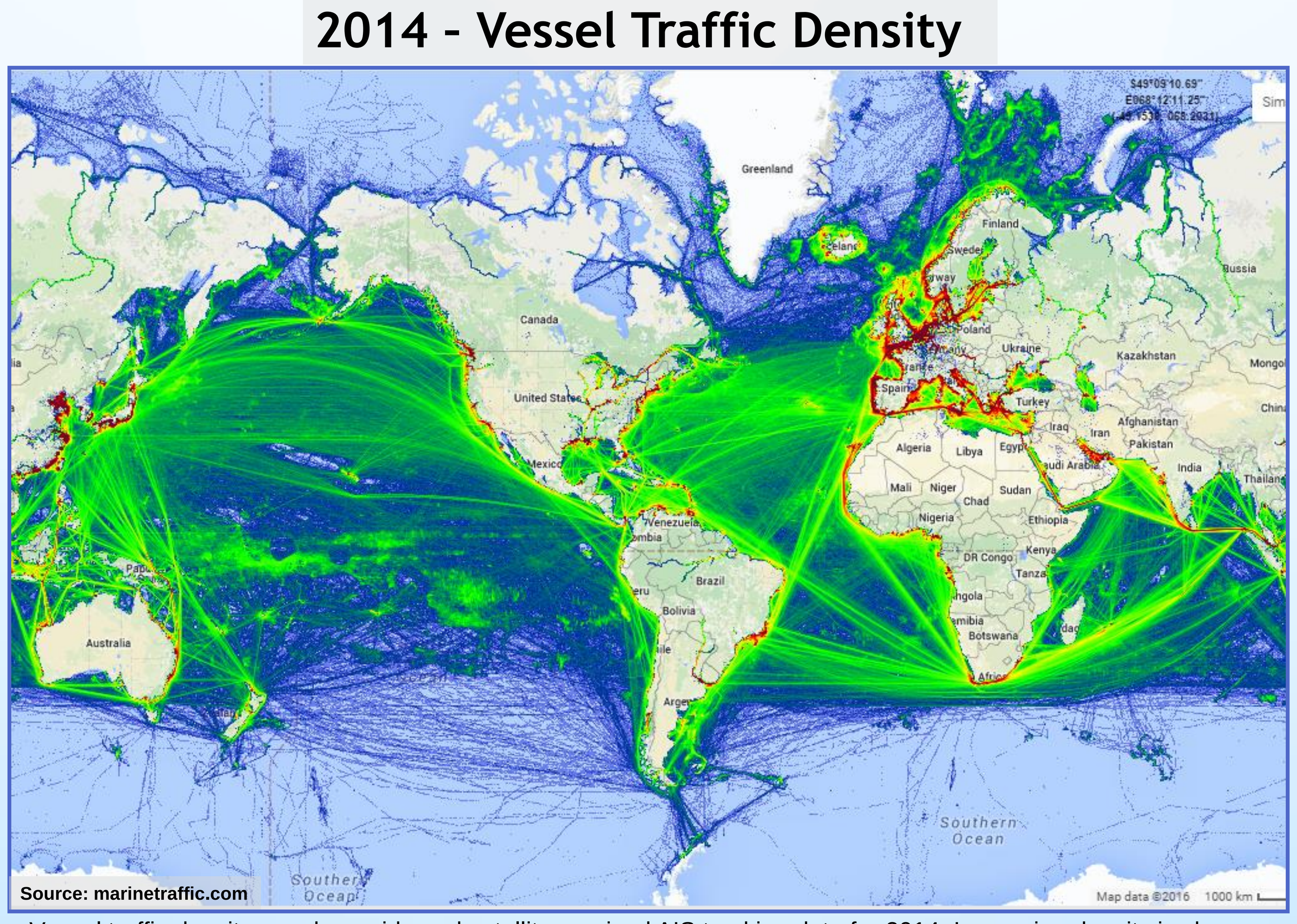
Hurricane Force Storms – Facebook post illustrating the use of satellite imagery RGB Airmass product and ASCAT-A and B scatterometers by NOAA / OPC forecasters to estimate the intensity and warning category for a 2 Jan 2016 central Pacific cyclone. Forecasters have built a familiarity and trust in wind speeds from ASCAT-A and B. Shown here are winds to 75 knots south and southwest of the cyclone center. www.facebook.com/NWSOPC/

Hurricane Force Storms 2005-2016



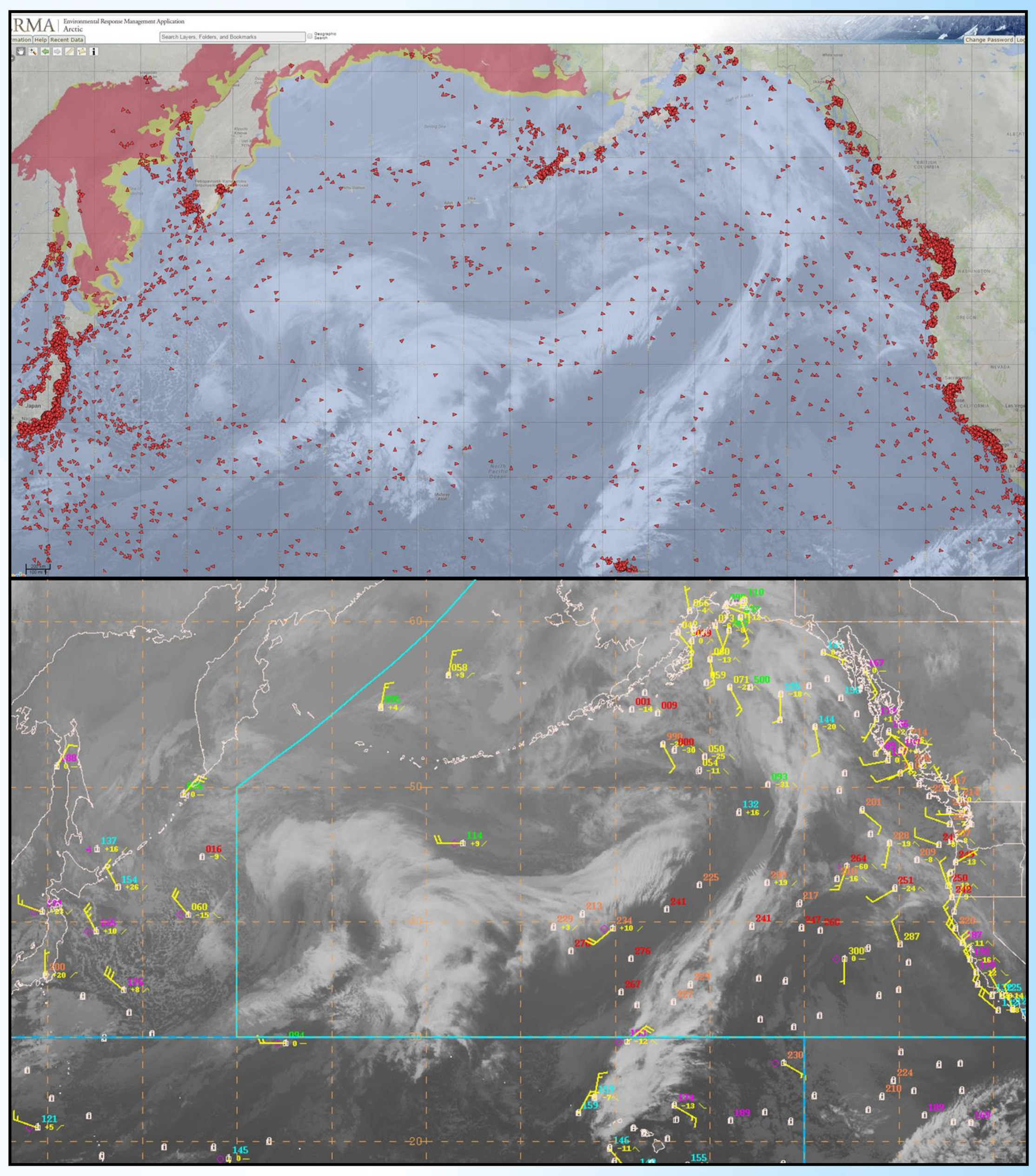
Hurricane Force Storms - Graph showing the number of extra tropical cyclone that reached hurricane force intensity over the North Pacific and North Atlantic oceans 2005-2016. QuikSCAT, ASCAT-A and B, OSCAT and RapidScat have all been used by OPC forecasters to estimate the intensity of each cyclone.

2014 - Vessel Traffic Density



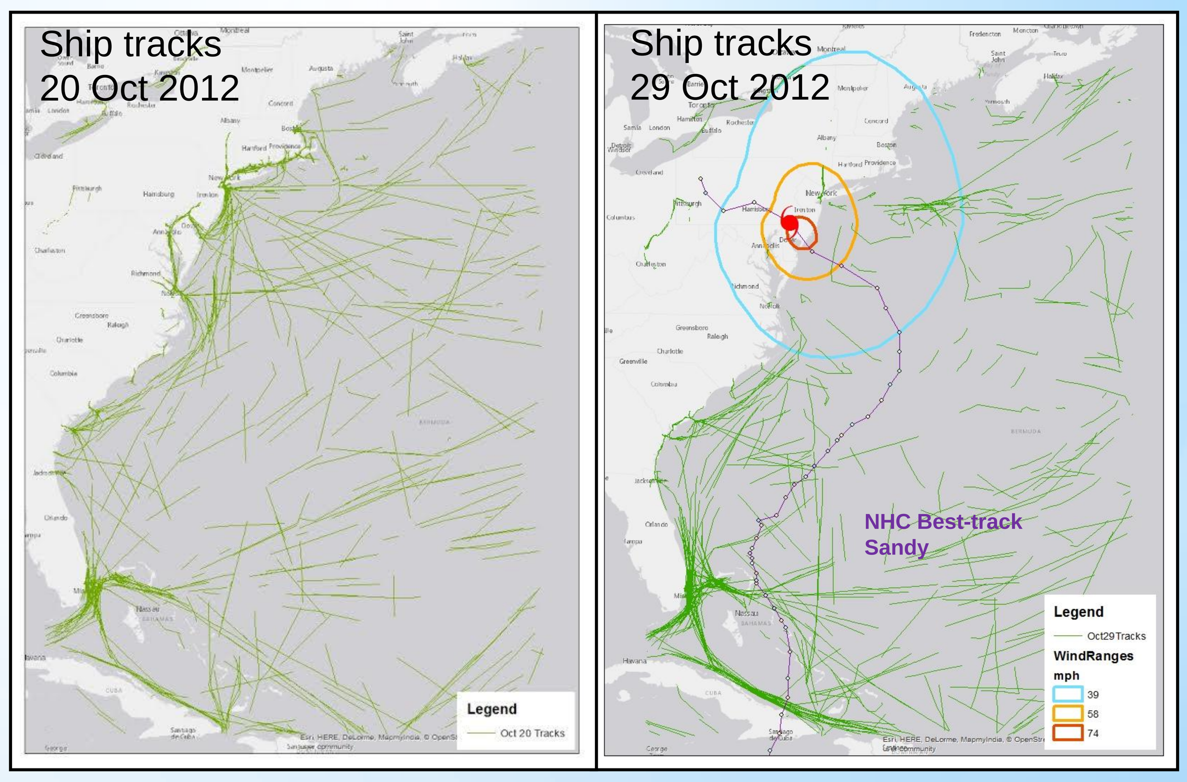
Vessel traffic density per shore side and satellite received AIS tracking data for 2014. Increasing density is shown with warmer colors. Trans-oceanic great circle, parallel, and rhumb line routes are all evident across the globe. Zones of increased fishing activity, restriction zones, oil production and exploration are also discernable across the global ocean. Source: marinetraffic.com

Example 5. Weather observers vs. ships



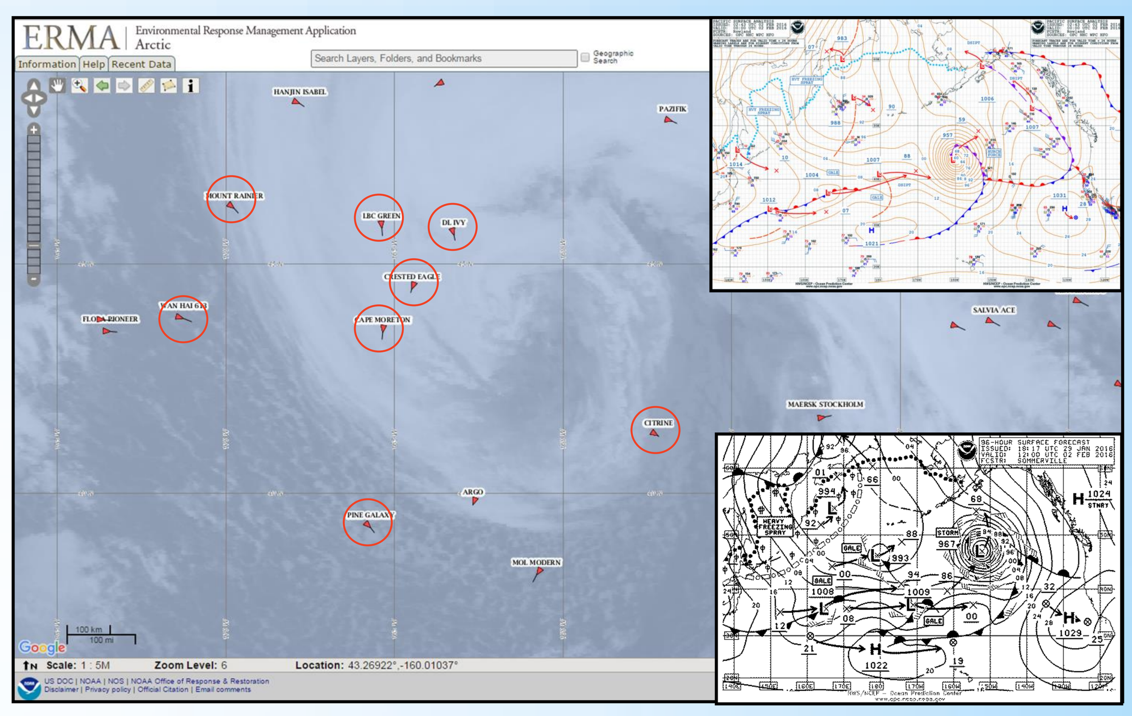
Example 5. North Pacific NOAA Arctic **ERMA** plot showing all ship and fishing vessel positions (top) transmitting AIS messages and (lower) NWS NAWIPS plot showing all meteorological observations from Volunteer Observing Ships, moored buoys, and drifting buoys. Clearly only a small percentage of vessels provide meteorological observations at the synoptic time.

Example 6. Hurricane Sandy



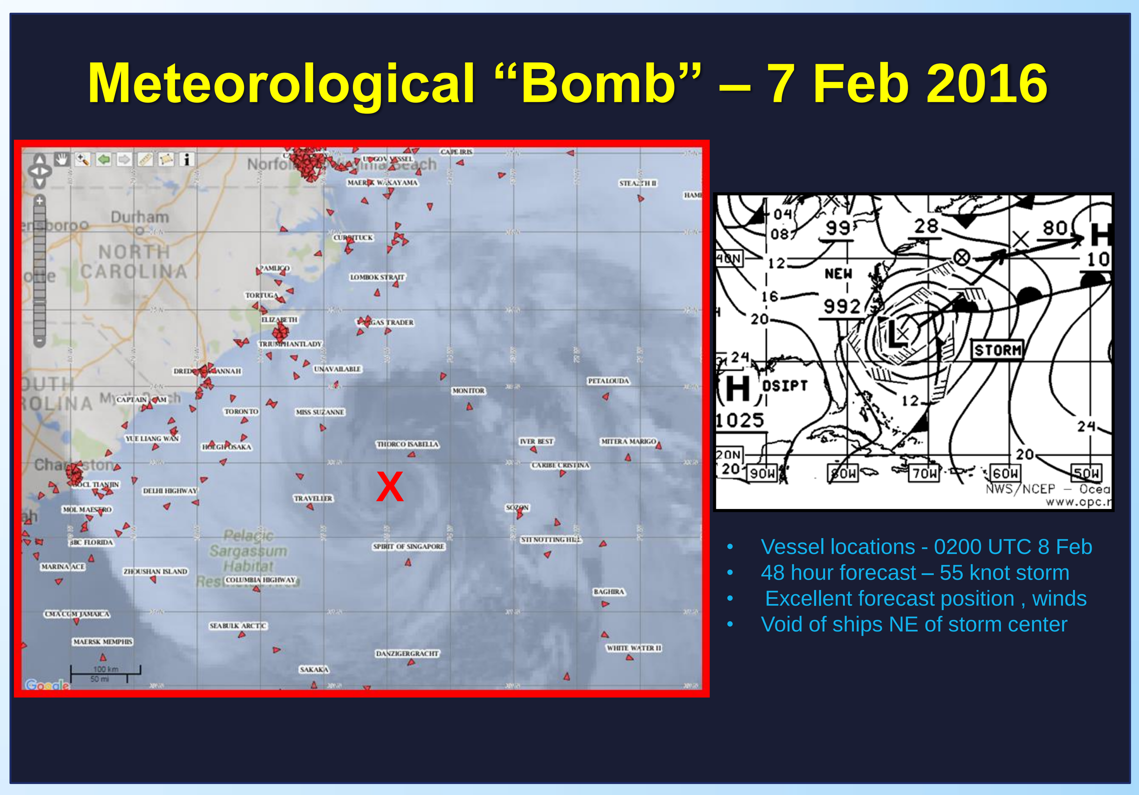
Example 6. Western North Atlantic display of 24 hour ship tracks from satellite - AIS data for 20 Oct (left) and 29 Oct 2012, the day of landfall of Sandy. The NHC best track of Sandy and radii of 39 (cyan), 58 (orange), and 74 (dark orange) mph winds are shown in the right panel. Comparing the two images, clearly vessel traffic in the mid-Atlantic bight has all but ceased with no vessel traffic recorded along the NJ coast, Delaware River, Chesapeake Bay, and southern New England waters. Vessel traffic did increase southeast of New England and from the entrance of the Chesapeake southward on the periphary of Sandy. As an initial estimate it appears that the 58 mph (50 knot) wind speed radius was a potential threshold for avoidance.

Example 7. Ships heading south to head east



Example 7. NOAA **ERMA** plot showing a strengthening central North Pacific cyclone at 2300 UTC 1 Feb 2016. Red circles show east bound ships altering course southward to avoid heavy weather. Surface analysis from 0000 UTC 2 Feb 2016 and 96 hour forecast valid 1200 UTC 2 Feb are shown on the upper and lower right, respectively.

Example 8. Bomb off the southeast U.S. coast



Example 8. A cyclone explosively deepened immediately after formation off the South Carolina coast on the afternoon of 7 Feb 2016. Although the formation and location were well forecast several ships including a cruise ship with over 6,000 people aboard were caught in winds of hurricane force and seas to 35 feet. The **ERMA** plot (above left) shows a large area of avoidance NE of the storm (X), perhaps in anticipation of building seas, and several ships in the vicinity of the storm center and western semicircle. The explosive intensification of this storm should be further studied due to the role of the Gulf Stream as a baroclinic zone and vorticity source, scale interactions, the role of convection, and the explosive increase in wind and sea conditions.