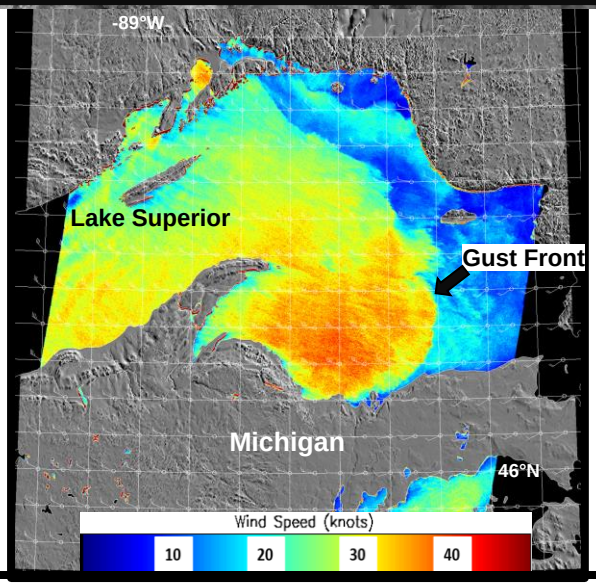
Synthetic Aperture Radar (SAR) Winds

Quick Guide

Why are SAR Winds Important?

Synthetic Aperture Radar (SAR) Winds provide water surface wind speeds over bodies of water and adjacent to coastlines. The SAR backscatter (or Normalized Radar Cross Sections, NRCS) results from surface roughness at the centimeter scale. The increases in backscatter are proportional to the increases in wind speed. NRCS are converted into wind field imagery maps. The wind speeds are color-coded with red colors representing higher wind speeds (i.e. rough water surfaces). Calmer water surfaces with reduced backscatter are displayed in 'cooler' colors: blue and aqua. Similar to buoy wind measurements, SAR Winds are reported at a 10-m height above the surface.



SAR Winds observe a gust front over Lake Superior on 11 November 2024 at 1200Z. In AWIPS, model isotachs will need to be uploaded to complement SAR imagery.

SAR Algorithm

NRCS is a function of wind speed and wind direction. The SAR algorithm incorporates backscattered (active) microwave radar returns from water surfaces and integrates NRCS and numerical model wind direction values to derive wind speed retrievals.

Resolutions, Latency, and Model Input

Spatial: Variable, 20-100 m. SAR Wind imagery displayed at **500 m** via data averaging. NRCS images are averaged to 100 m.
Temporal: < 1 day at high latitudes, 3 days at equator (asc/desc orbits & overlap). For example, over the Great Lakes, expect the data at ~00Z and ~12Z.
Latency: ~1-4 hours due to model availability and data processing.
Model Input: HRRR for the Great Lakes Region, GFS for all other domains.

Wind Speed Accuracy

- For wind speeds less than 30 knots: accuracy < 4 knots.
- Accuracy decreases above 30 kts (~20% error of observed winds by 50 kts).

Impact on Operations

Primary Applications

Wind Impacts: Monitor wind observations that may impact IDSS core partners, such as shipping and fishing industries and coastal communities. Observations can identify areas of high wind and atmospheric boundary layer phenomena (e.g. hurricanes, outflow gusts, gap winds). The product is beneficial in data sparse regions.

Sea or Lake Ice: SAR Wind and NRCS datasets can monitor ice floes over bodies of water.

24/7 All-Weather Data: Data produced for both daytime and nighttime applications. Wind retrievals using SAR data can be performed in clear and cloudy conditions.

Coastlines: High spatial resolution provides wind speed retrievals adjacent to coastlines and in narrow channels/fjords.

Limitations

Wind Speeds Only: The product only provides derived wind speed retrievals. Note, wind estimates are valid if the wind direction model input is accurate, and the backscatter returns are only from wind roughened water surfaces. (Scattering atmospheric phenomena, e.g. hydrometeors, results in invalid wind speeds - see page 2).

NWP Wind Directions: Low resolution model wind direction values may not be representative over fine spatial scale phenomena and could result in significant wind speed errors at those locations.

Ice or High Wind? Backscattering from microwave radar returns can exhibit differences between sea ice and open water. During winter, areas of sea (or lake) ice will produce erroneous high wind speeds.

Water Surface Only: Wind retrievals are only possible over open water and not over land.

Contributors: CIRA, CIMSS, NOAA NWS and NOAA STAR. [2025 Update]

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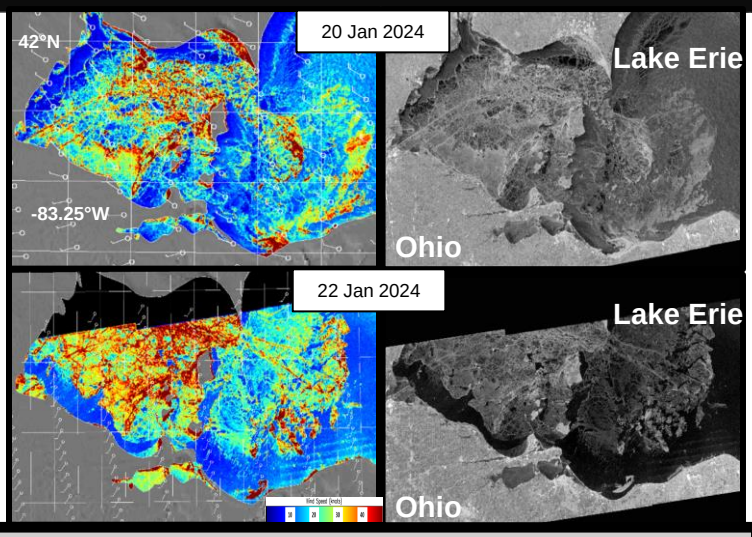
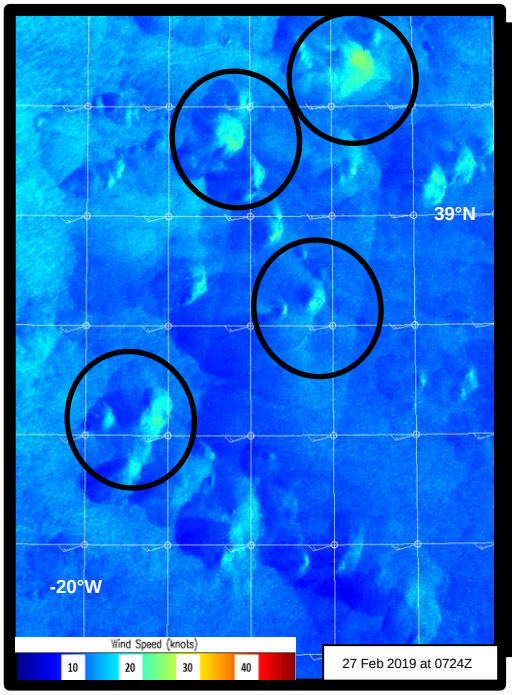
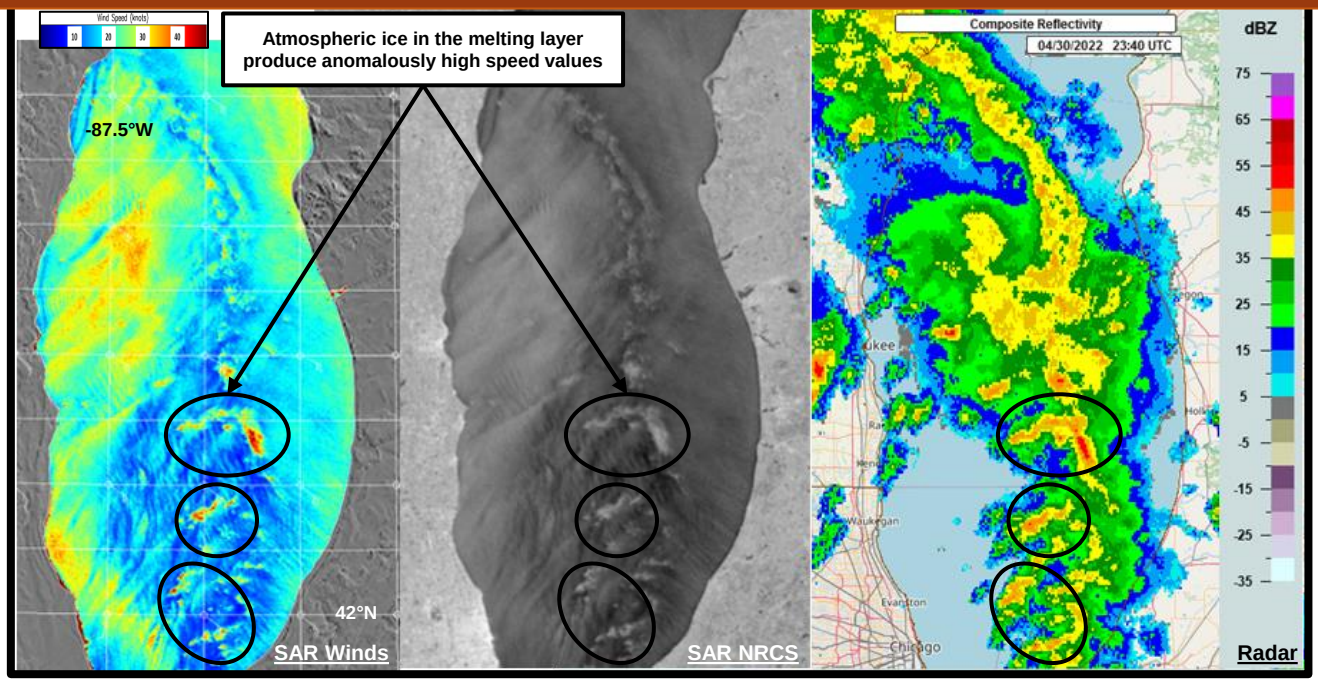


Before and after image comparisons of SAR Winds (left) and NRCS (right) that show lake ice floes initially located along the south shore of Lake Erie (20 Jan) that moved northward two days later (22 Jan). Sea ice produces high backscattered returns which are falsely translated into high wind values, however the imagery appearance of sea ice edges and sea ice areal extent are conspicuous. Colors over ice should not be interpreted as valid wind speeds.



SAR Winds (left) observes cold pools in the form of 'mounds' (or 'craters'). Features are produced from localized downward accelerating winds associated with each pool (black ellipses). Wind direction input is westerly, however wind speed values near or around the cells may be prone to error, due to differences between model wind input and actual wind directions.

SAR Winds and Hydrometeors: SAR Winds, NRCS, and corresponding radar observe a line of storms that passed through Lake Michigan on 30 April 2022 at ~23:40Z. Hydrometeors embedded within the convection can produce false high wind values since the scattering is not from the water surface.



Resources - **SAR Winds Data Online:** Near-Real-Time (Great Lakes), Archive (Global) and data from NOAA OSPO. **Documents:** SAR Wind User Guide (Full-Res), SAR Marine User's Manual, and SAR Winds ATBD. **ESA Sentinel Online:** Sentinel-1 Mission. **NOAA CoastWatch:** SAR Winds. **CIMSS Satellite Blogs:** Ice Floes, Bore Features, Lake-Effect Cloud Bands and Great Lakes Ice Examples. **FDTD Satellite Applications Webinar:** SAR Winds - Convective Applications over Lake Superior. **Hyperlinks not available when viewing material in AIR Tool.**

Note: SAR imagery in AWIPS will not have isotachs plotted, users will need to upload the model surface winds in complement to the imagery. Additionally, users can display the SAR wind speed imagery and the corresponding ice mask in AWIPS.