



Motivation and Context

“Can we use in-situ and Scatterometer-derived ocean vector winds as Fiducial Reference Measurements (FRM) for the Calibration and Validation of SAR-derived winds?”

Context: ESA-ITT project **Calibration and Validation for SAR (CANVAS)**

Aims:

- Comprehensive Quality Assessment Framework for SAR
- Guidelines for Uncertainty in Measurement (GUM)
- **FRMs** for L1 measurements and **L2 retrievals**

FRM Definition and Characteristics

Definition: “A suite of independent, fully characterised, and traceable (to a community agreed reference, ideally SI) measurements of a satellite relevant measurand, tailored specifically to address the calibration/validation needs of a class of satellite borne sensor and that follow the guidelines outlined by the GEO/CEOS Quality Assurance framework for Earth Observation (QA4EO) [1]”

Characteristics:

- Traceability (preferably to the International System of Units (SI))
- Independence from satellite-under-test
- Uncertainty Budget
- Documented Protocols
- Accessibility
- Representativeness
- Adequacy of Uncertainty
- Utility

[1] Quality Assurance Framework for Earth Observation. Available online: <https://qa4eo.org/>

What is a Maturity Matrix

- Introduced by the Committee on Earth Observation Satellites (CEOS) [2]
- Provides a visual assessment of a dataset’s state against a set of criteria
- Shows its maturity and the weak points to improve with a color code
- Two parts:
 - Self-assessment
 - Independent Assessment
- **Both parts are provided by the authors of this study**

[2] P. Castracane, N. Fox, and P. Goryl, “The ceos fiducial reference measurements assessment framework.” Poster presented at VH-RODA, 2024.

Adequacy of Uncertainty

Global Climate Observing System (GCOS) requirements for ocean winds [3]

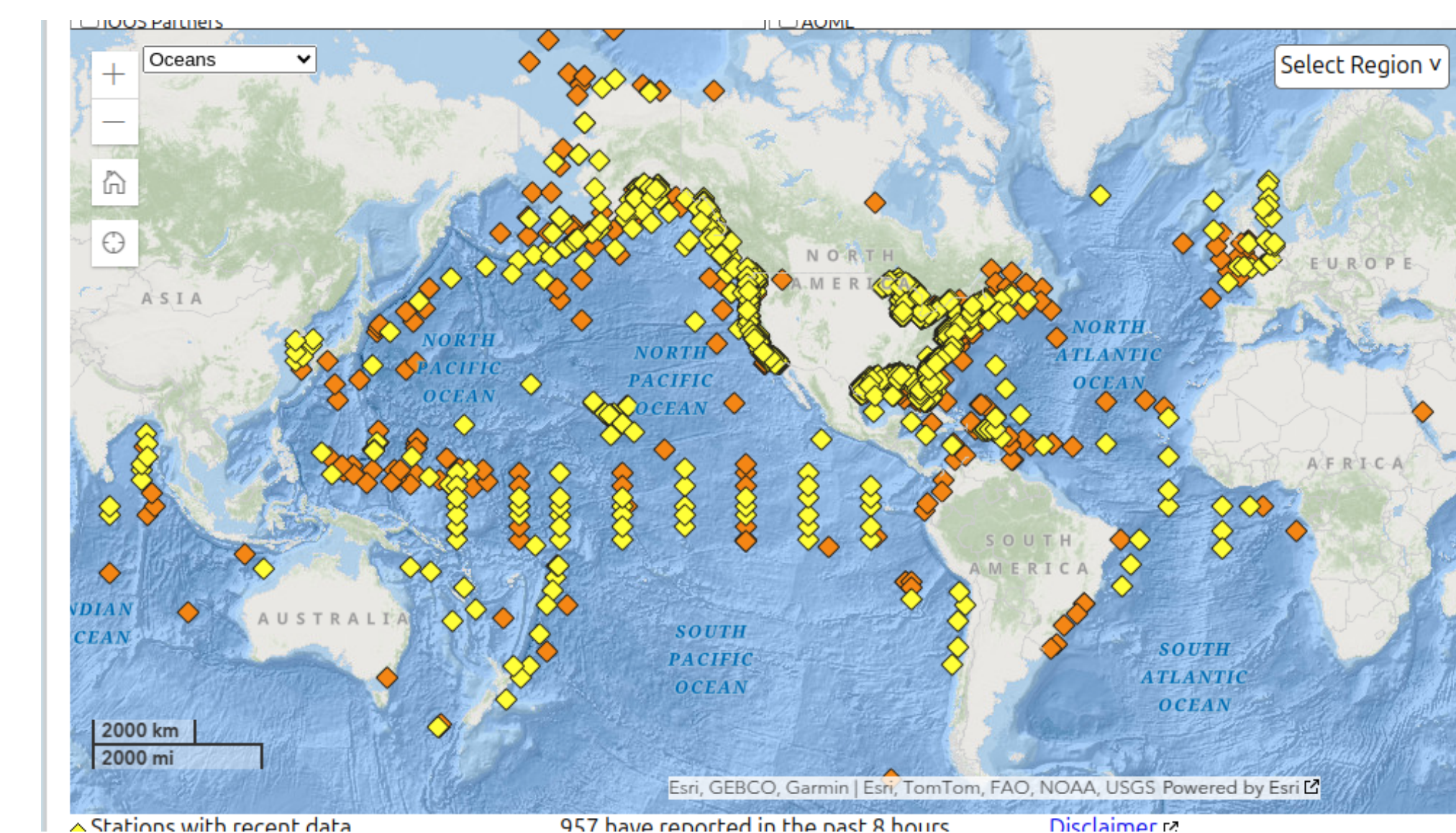
Variable	Horizontal Resolution (km)	Temporal Resolution (h)	Uncertainty (2σ)	Stability per decade
Speed (ms ⁻¹)	10 (100) [500]	<1 (1) [3]	0.1 (0.5) [1]	0.1 (0.25) [0.5]
Direction	10 (100) [500]	<1 (1) [3]	1° (5°) [10°]	1° (2°) [5°]

[3] The 2022 GCOS ECVs Requirements. Updated in 2025. World Meteorological Organization.

In-situ limitations

- Lack of unique portal for WMO-compliant measurements
- Non-homogeneous file formats and contents
- Non-homogeneous quality control schemes
- Non-homogeneous metadata handling (sometimes missing)

In-situ limitations



Sampling: screenshot from NDBC website

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<history start="2023-03-18" stop="" lat="5.0" lng="-95.0" elev="0" met="y" hull="TAO REFRESH" anom height="4"/>
<history start="2020-06-29" stop="2023-03-17" lat="5.1" lng="-95.0" elev="0" met="y" hull="TAO REFRESH" anom height="4"/>
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<history start="2008-06-11" stop="2009-01-04" lat="4.9" lng="-95.0" elev="0" met="y" hull="ATLAS" anom height="4"/>
<history start="2007-11-18" stop="2008-06-10" lat="4.9" lng="-95.0" elev="0" met="y" hull="ATLAS" anom height="4"/>
```

Presence of “gross errors” in NDBC files. Acquisition history of buoy ID 32303.

Source: <https://www.ndbc.noaa.gov/metadata/stationmetadata.xml>

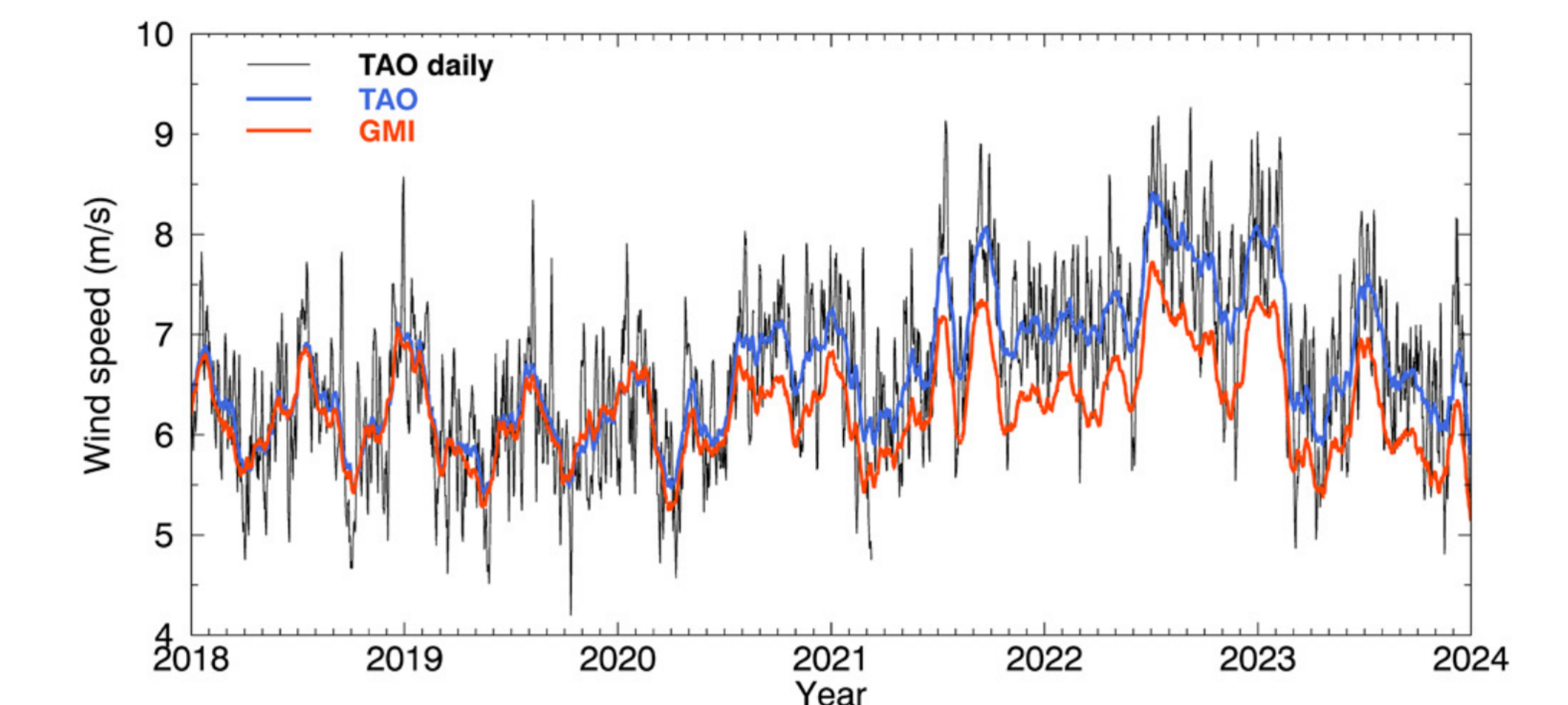


Fig. 2. Averaged time series for the buoy wind speed collocated with GMI rain-free wind speeds within 30 min and 25 km, for the period 2018–23. Here, the buoy winds are converted to a reference height of 10 m, and daily time series for individual buoys are averaged over all the buoys in the TAO array. The black line refers to the daily variability of the buoys, while the colored lines refer to a 30-day running mean, for easier visualization of the difference between GMI (dark orange) and buoy (blue) wind speed time series. In mid-2020, the GMI and buoy average wind speed time series started to diverge, showing a bias of about 0.5–0.8 m s⁻¹. Similar biases were observed even when comparing satellite winds to individual TAO buoys and for different satellites.

[4] L. Ricciardulli, A. Manaster, and R. Lindsley, “Investigation of a calibration change in the ocean surface wind measurements from the tao buoy array,” Bulletin of the American Meteorological Society, vol. 106, no. 2, pp. E242 – E260, 2025.

Maturity Matrices

WMO-compliant in-situ winds

Self-Assessment						Independent Assessor
Nature of FRM	FRM Instrumentation	Operations/ Sampling single instrument	Data	Metrology	Completeness, coverage and distribution	
Descriptor	Instrument Documentation	Automation level	Data completeness	Uncertainty characterization	Validation capacity	Guidelines adherence
Location / availability of FRM	Evidence of traceable collocation	Measurand sampling/ representativeness	Availability and usability	Traceability documentation	Geographical coverage	Utilization feedback
Range of instruments	Maintenance plan	ATBDs on processing / software	Data format	Comparison/ calibration of FRM	Centralized data, processing, quality assessment and adherence to community standards	Metrology verification
Complementary observations	Operator expertise	Guidelines on transformations to satellite pixel	Ancillary data	Adequacy for intended class of instrument/ measurand	Timeliness	Independent verification
FRM CLASSIFICATION						B

Legend

Grade
Not assessed
Not assessable
Basic
Good
Excellent
Ideal

Scatterometer-derived winds

Self-Assessment						Independent Assessor
Nature of FRM	FRM Instrumentation	Operations/ Sampling single instrument	Data	Metrology	Completeness, coverage and distribution	
Descriptor	Instrument Documentation	Automation level	Data completeness	Uncertainty characterization	Validation capacity	Guidelines adherence
Location / availability of FRM	Evidence of traceable collocation	Measurand sampling/ representativeness	Availability and usability	Traceability documentation	Geographical coverage	Utilization feedback
Range of instruments	Maintenance plan	ATBDs on processing / software	Data format	Comparison/ calibration of FRM	Centralized data, processing, quality assessment and adherence to community standards	Metrology verification
Complementary observations	Operator expertise	Guidelines on transformations to satellite pixel	Ancillary data	Adequacy for intended class of instrument/ measurand	Timeliness	Independent verification
FRM CLASSIFICATION						B

Preliminary Conclusions

- In-situ measurements not far from FRM standard
- So do scatterometer-derived winds
- For in-situ, we recommend:
 - standardize file formats and contents
 - provide raw data
 - set-up of a unique portal for WMO-compliant buoy measurements
- For scatterometers, we recommend the construction of a Climate Data Record