Progress in Ocean Surface Vector Winds

Ocean Surafce Winds Task Group (OSW TG)
Part of the IWWg

Objectives – Ocean Surface Winds Task Group – OSW TG

The OSW TG facilitates an open and shared environment to address key points for the general benefit of the meteorological/ocean community, such as:

- Intercalibration of wind products for Climate Data Records and operational users;
- An in-situ wind speed reference for high and extreme winds;
- Methods for the elimination of model OSW biases in NWP data assimilation (local VARBC);
- Improved spatial NWP wind assimilation methods; e.g., high density, errors inflated
- QC optimization for NWP (e.g., avoid moist convection);
- Open high-level wind services and timeliness of the virtual constellation;
- Open data comparisons and open software to share in the community;
- Exploit scatterometer wind stress measurements for improved atmosphere-ocean coupling; use 10-m stress-equivalent winds (de Kloe et al., 2017);
- Development of coastal winds for all scatterometers.

The OSW TG is part of the IWWg and coordinates with CEOS and the IOVWST

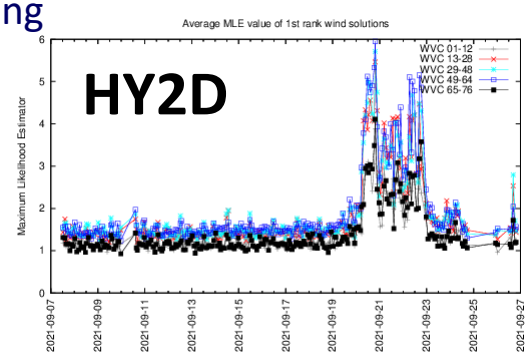
The growing scatterometer constellation

- ASCAT-A, MetOp-A : 2007- 2021 9:30 LST, End-of-service November 2021
- ASCAT-B, MetOp-B : 2012- healthy 9:30 LST
- ASCAT-C, MetOp-C : 2018- healthy 9:30 LST, Excellent for wind changes in convection
- OSCAT-2, ScatSat-1 : 2017- Feb 2021 8:45 LST, Excellent for Ku/C intercalibration
- OSCAT-3, OceanSat3 : Nov 2022 . . . 12:00 LST, in commissioning
- HSCAT-B, HY2B : 2018- healthy 6:00 LST
- HSCAT-C, HY2C : 2020- healthy Not sun-synchronous, regresses
- HSCAT-D, HY2D : 2021- healthy Regresses, development status
- CSCAT, CFOSAT : 2019- demo Stability issues, nadir issues
- WindRad, FY3E : 5/7/'21- healthy 5:30 LST, commissioning

➢ https://scatterometer.knmi.nl/proc_status/

- Vector wind CDRs for ERS (1991-1999), QuikScat (1999-2009), ASCAT (2007-), OSCAT (2014+), needed to monitor re-analyses
- Reanalyses are subject to changing inputs

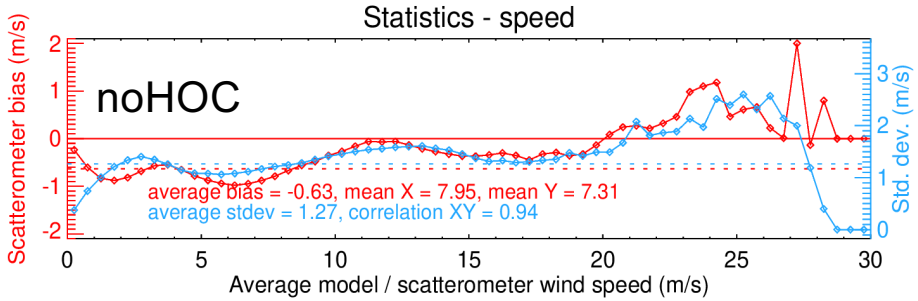
➢ https://scatterometer.knmi.nl/archived_prod/

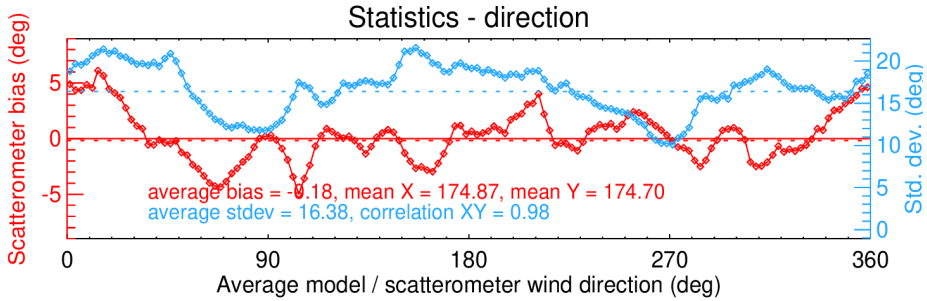


https://scatterometer.knmi.nl/hy2d_25_prod/index.php?cmd=monitoring&period=week&day=0&flag=yes

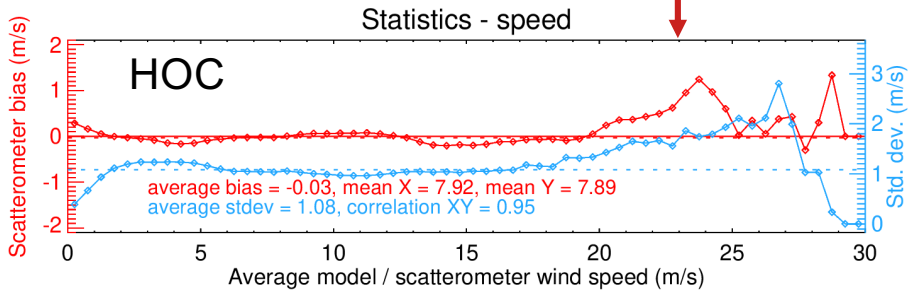
WindRad looks good and stable

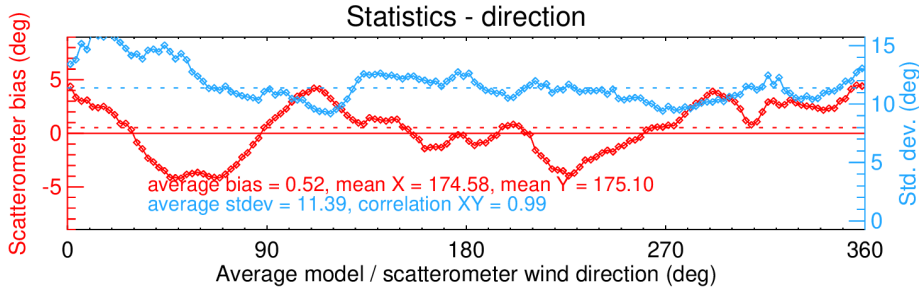
Wind statistics with/without σ^0 Higher-order NWP Ocean Calibration (HOC)





Large bias at high winds is corrected





Li et al., 2023

The EUMETSAT Network of Satellite Application Facilities

OSI SAF Ocean and Sea Ice

OSW TG key issues of relevance to CGMS:

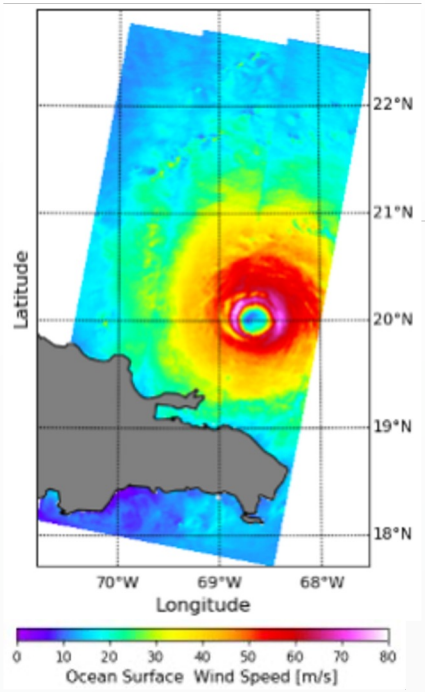
- ESA MAXSS project on wind extremes made good progress providing consistent satellite extreme wind speeds among the different instruments and producer inputs, though uncertainty in in-situ wind speed references is high (Stoffelen et al., 2021);
- WMO International Workshop on Tropical Cyclones (IWTC-10) recommended an operational framework to ensure timely and valuable high-resolution SAR acquisitions of TCs;
- Progress in the commissioning and servicing of scatterometer winds, notably for the NSOAS HY2 series, CMA WindRad, the CFOSAT scatterometer and in preparations for ISRO's Oceansat-3, following OSW TG goals. Today, 7 scatterometers are operated in orbit. Of particular concern remains the uptake of scatterometer winds in NWP systems, due to lack of resources at NWP centers. A correction of geographical OSW model biases in the data assimilation procedure will be needed for an effective use of the virtual constellation of scatterometers that is now available, with potentially large beneficial impact on the NWP forecast quality (~2% per scatterometer?).
- Model biases in OSW, curl and divergence, limit realistic air-sea coupling in models and effective data assimilation

OSW TG international venues and outreach:

- Virtual International Ocean Vector Winds Science Team in 2022
- Reference-quality emission and backscatter modelling for the ocean (ISSI)
- Survey Geophysics (2023): Satellite Remote Sensing of Surface Winds, Waves, and Currents: Where are we Now?
- WMO 10th Int. Workshop Tropical Cyclones (IWTC-10)
- SeaSAR 2023

The SAR way to CYMS: from R&D towards an operational service

1km Winds from Sentinel-1 over Irma on 2017/09/07



2016

1st SHOC Campaign: building TC archive, analyzing R&D

SEOM Program

2017

1st high wind processing chain used for S& over the past acquisitions (e.g. Irma, José, Maria major TCs)

2018

Very active global SHOC Campaign

- Massive SAR database of TC obs.
- Consolidated « service chain »

R&D

2019

CYMS preparation

Consolidation

2020

Operational demonstration + extension to European extreme winds in 2021

CYMS

SAR and Scatterometer winds

esa SeaSAR

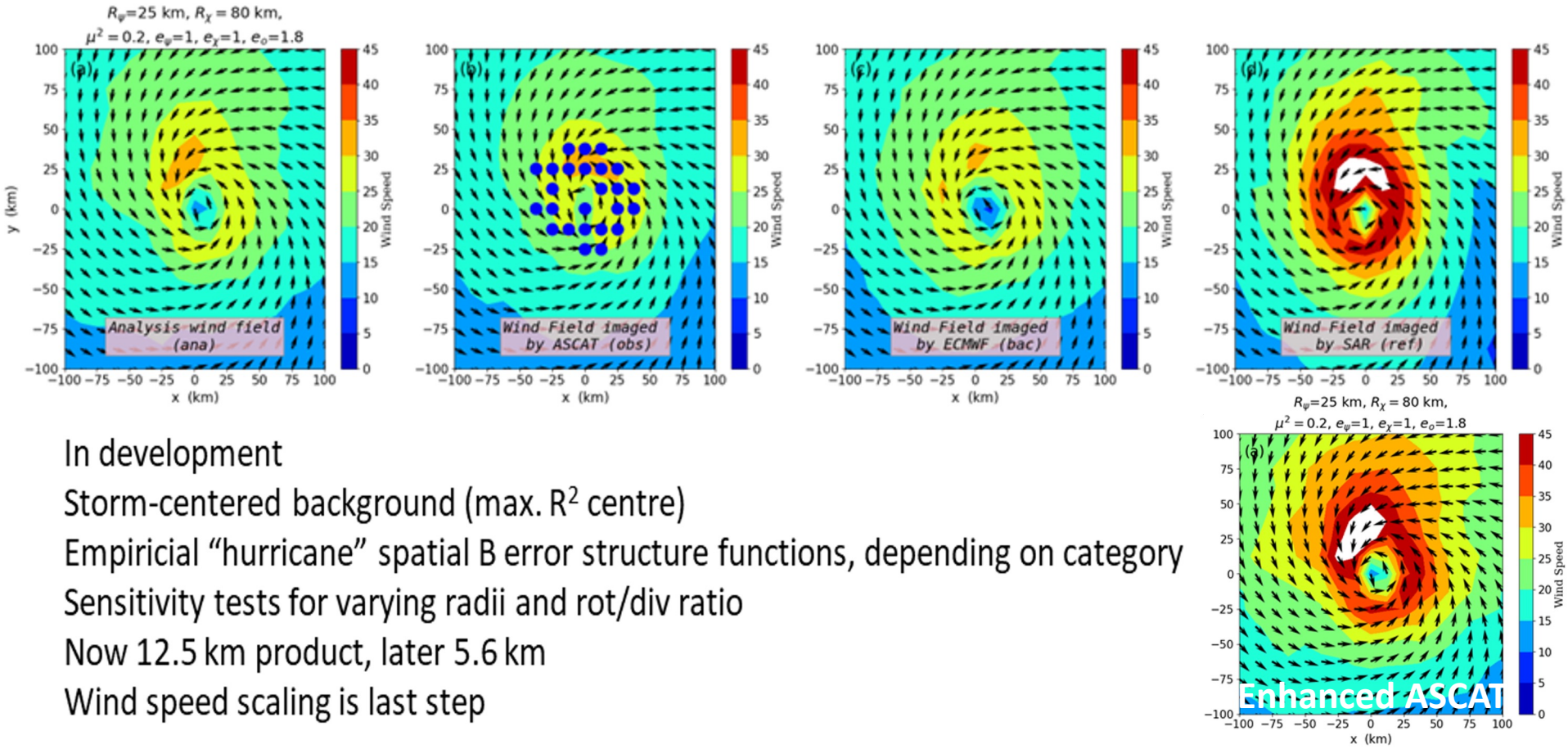
SAR

- Shows details of processes, in particular extremes, coastal and air-sea interaction, useful for scatterometer understanding
- Cannot capture the temporal variability of the atmosphere due to sparse sampling
- Are poorly calibrated with respect to scatterometers and with larger wind errors
- Different producers generate wind products with different characteristics

Scatterometers

- Scatterometers show much more details of mesoscale weather processes than global NWP models do
- The virtual international constellation of Chinese, European and Indian wind scatterometers can capture the temporal variability of the atmosphere on a sub-daily scale
- Scatterometers are generally very stable and well calibrated; NRCS and wind errors are well known and low as compared to in-situ data and model data
- The same empirical GMFs are used for different instruments (also for SAR)
- Very similar retrieval is used for different instruments
- The CGMS Ocean Surface Winds Task Group is tasked to standardize wind products for users

ASCAT resolution enhancement with SAR SAR



In development

Storm-centered background (max. R^2 centre)

Empiricial “hurricane” spatial B error structure functions, depending on category

Sensitivity tests for varying radii and rot/div ratio

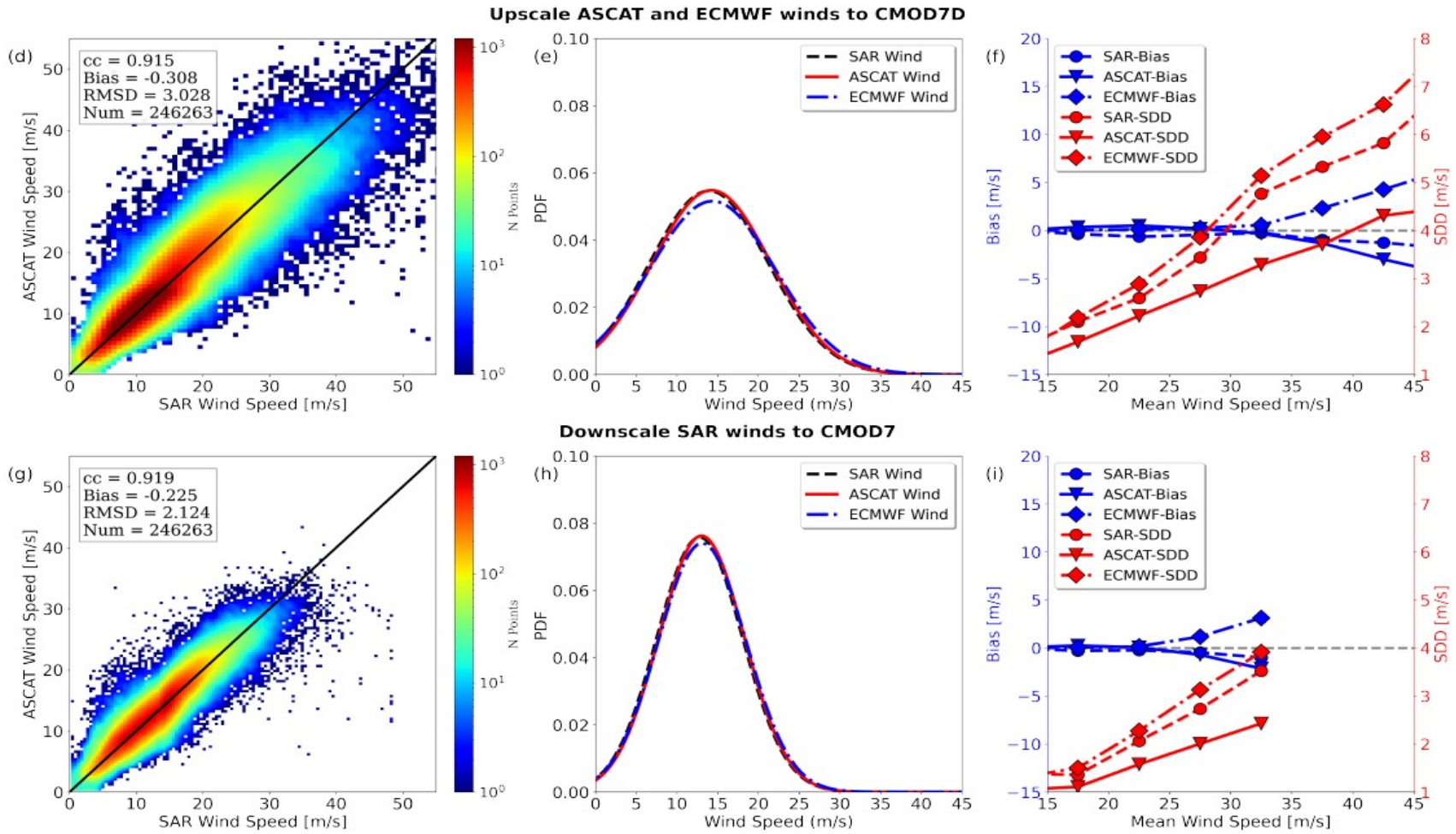
Now 12.5 km product, later 5.6 km

Wind speed scaling is last step

Ni et al., 2023

ASCAT, ECMWF and SAR speed scale

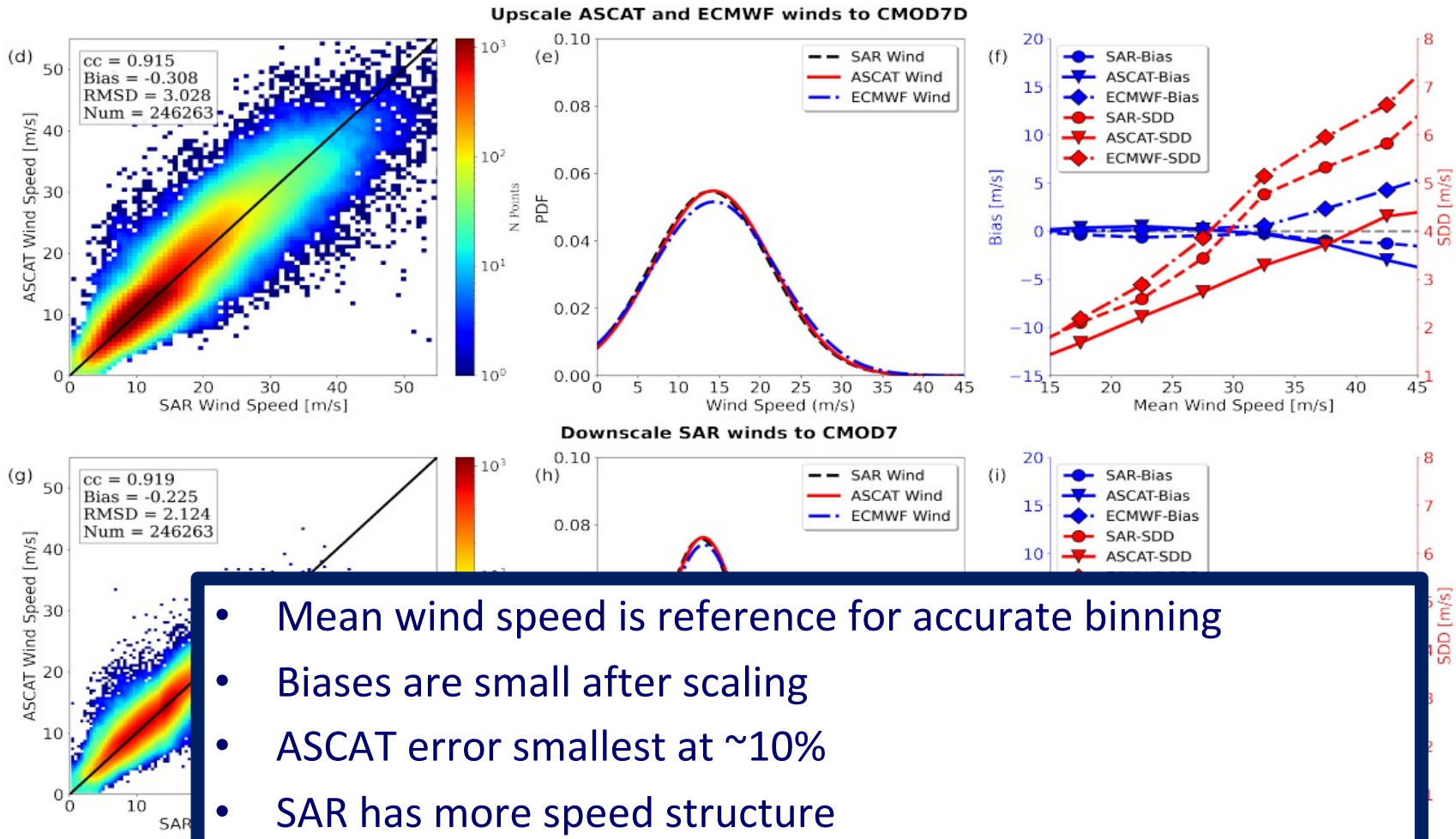
- Triple speed collocation ASCAT, SAR, ECMWF for matching



Ni et al., 2022 : SAR and ASCAT Tropical Cyclone Wind Speed Reconciliation (MAXSS)

ASCAT, ECMWF and SAR speed scale

- Triple speed collocation ASCAT, SAR, ECMWF for matching

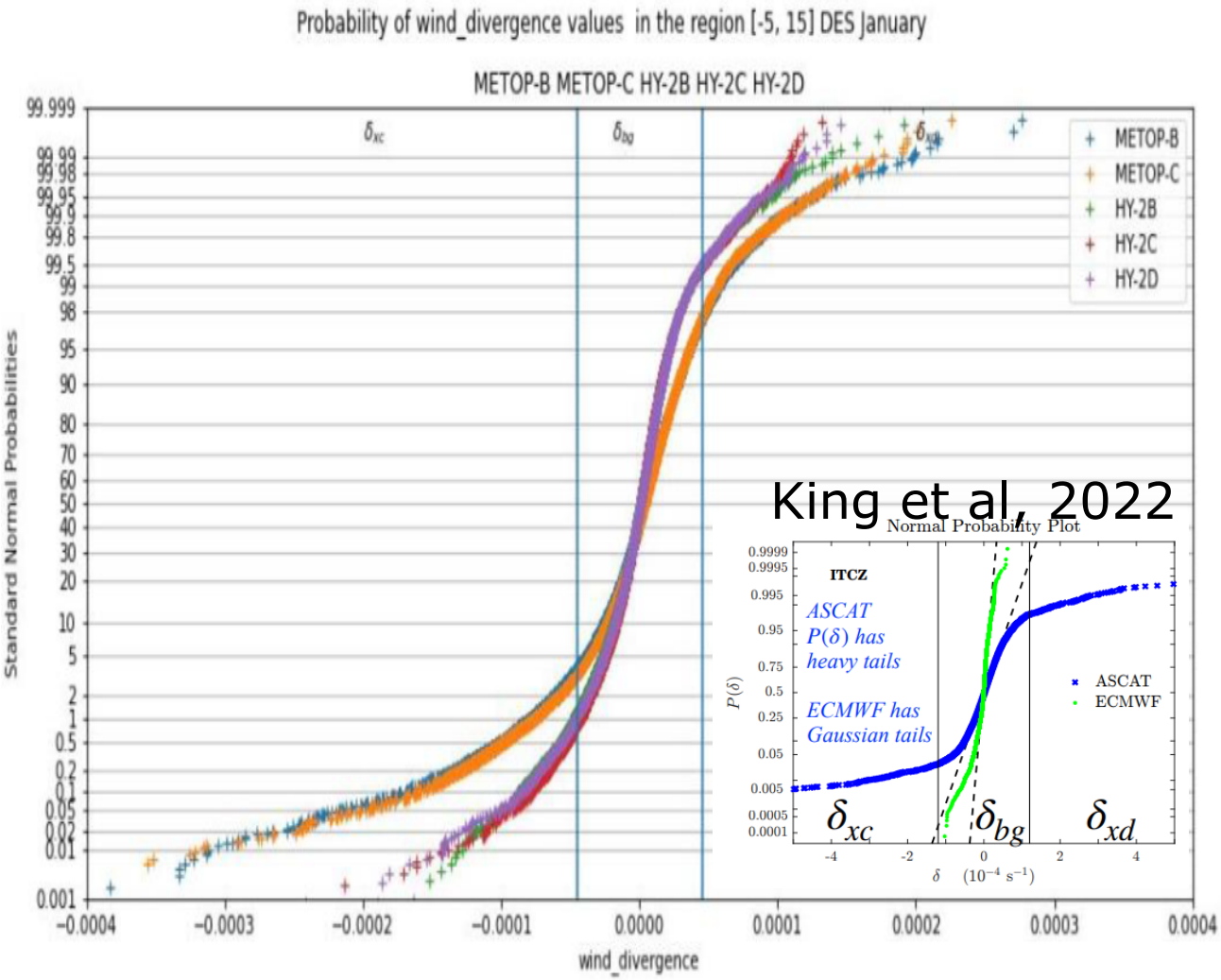


- Mean wind speed is reference for accurate binning
- Biases are small after scaling
- ASCAT error smallest at ~10%
- SAR has more speed structure
- ECMWF is smooth

Ni et al., (MAXSS)

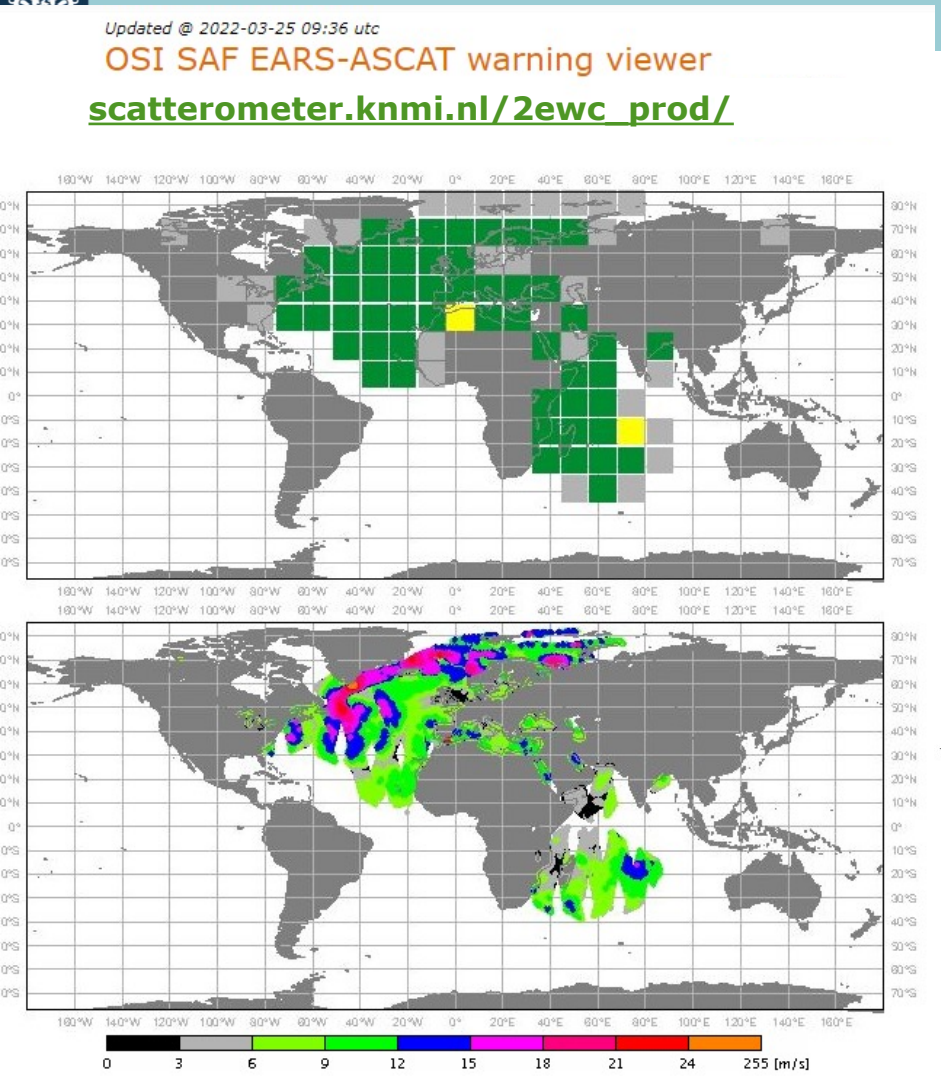
L3/L4 product uncertainty analysis

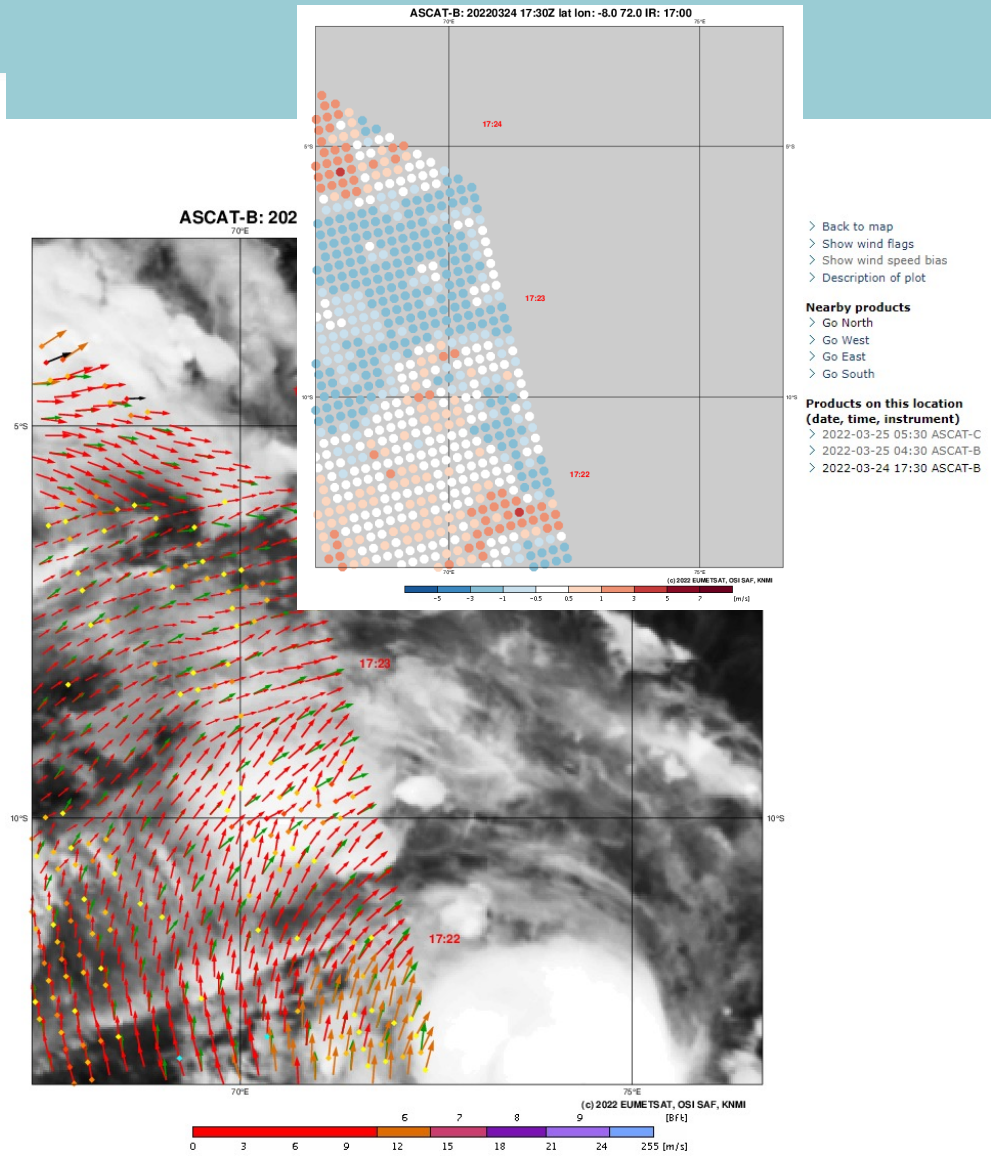
- King et al., 2022 show association of extreme ASCAT convergence and divergence to heavy rain
- ECMWF div. is close to Gaussian (straight line)
- Pencil-beam winds (HY) also show extremes, but particularly less extreme (small-scale) convergence
- How to deal with this in Copernicus L4 user products?



Miguel Fernández et al., in preparation

KNMI cyclone visualization and EARS Early Warning





✓ Warns fast in case of climatologically large deviation between ECMWF and ASCAT

To be considered by CGMS:

- For improved satellite wind speed calibration, collaboration on WMO level with in-situ experts and with dropsonde providers is recommended in order to better comprehend in-situ measurement data and their accuracy in extreme conditions, which is of large societal relevance;
- Encouragement and support from satellite agencies would accelerate the effective use of the OSW that they produce in NWP with potentially large effect on forecast quality of the extending virtual scatterometer constellation;
- To define an official international operational framework to ensure timely and valuable high-resolution SAR acquisitions of Tropical Cyclones.

Plenary OSW:

Wind extremes calibration

- To what in-situ winds would you tune your model (drag)?
- Any need for a consolidated physical in-situ reference?

Encouragement and support for the effective use of the constellation

- Are you ready to exploit the constellation?
- How do you correct large geographical model biases?
- What is needed for ocean coupling and earth system dynamics?
- What support would be needed (manpower, data, open tools, advice)?

Operational framework high-resolution SAR acquisitions of Tropical Cyclones

- Need for coastal winds (wind farming, civil protection, ocean forcing . . .)

Any other OSW needs, observations, . . .

OSW priorities?