Validation of Scatterometer and Radiometer High Winds Using Oil Platform Anemometers - UPDATE

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Background

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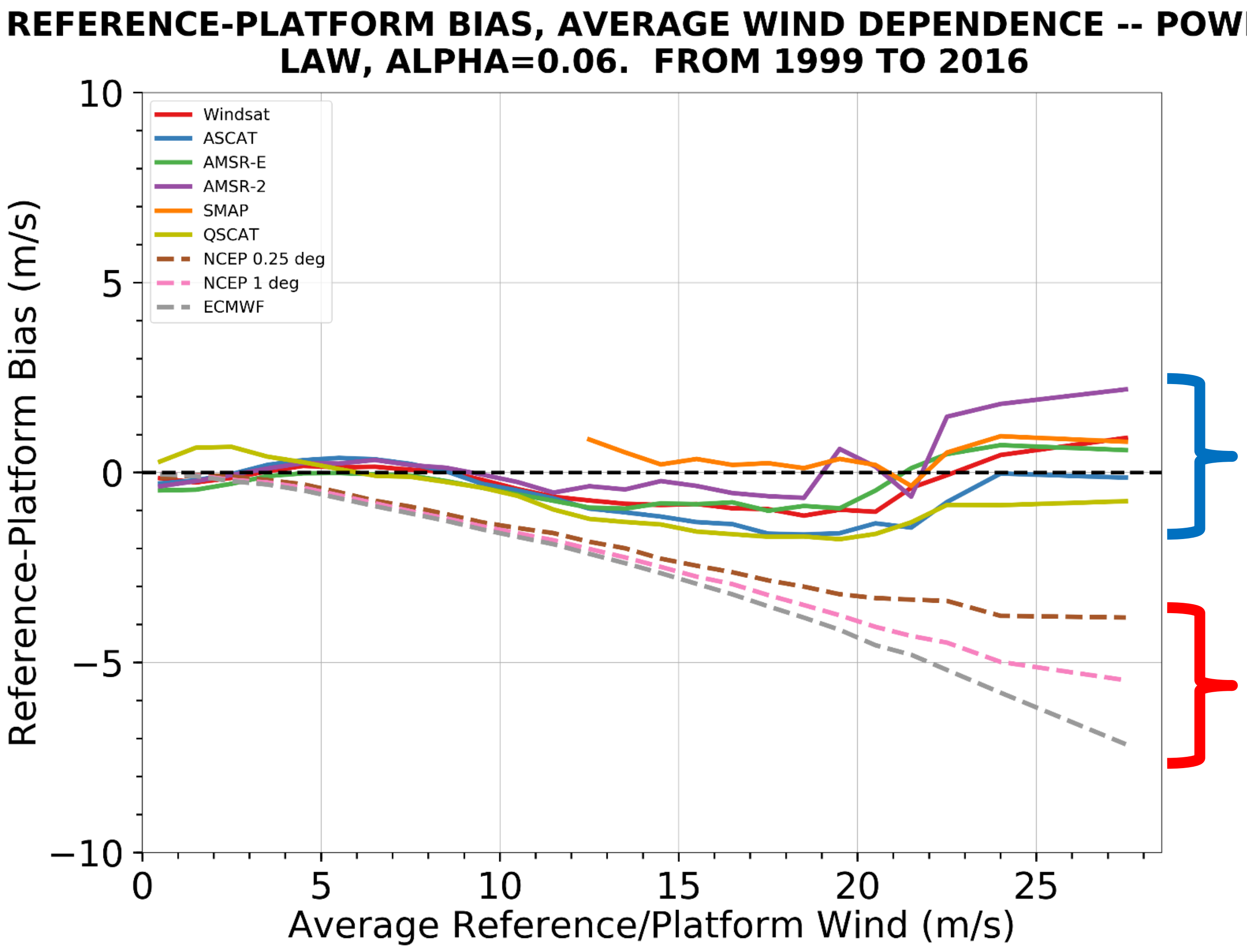
- Satellite winds are consistent with buoys for wind speeds < 15 ms^{-1}, within a 1 ms^{-1} uncertainty.
- Long-standing debate about the validity of buoy winds above 15 ms^{-1}.
  - RSS satellite winds are 10 – 15 % higher than buoys (globally) for these wind speeds.
- Verifying the validity of satellite winds between 15-30 ms^{-1} is extremely important and can help reconcile a major source of inconsistency between various wind datasets.
- Wind measurements from anemometers mounted on oil platforms in the North Sea provide an important in situ validation source for wind speeds between 15-30 ms^{-1}.

Methodology

- For this study, anemometers underwent rigorous quality control and were compared to satellite and model data.
  - Hourly averaged anemometer wind speeds were collocated with satellite measurements within +/- 1 hour and in the absence of rain.
  - Anemometer winds were reduced to a height of 10m using the power law wind profile with α=0.06.
  - This choice of vertical wind profile is based on work done by Furevik and Haakenstad 2012 and is discussed thoroughly in Manaster et al. 2019* (published in the Journal of Atmospheric and Ocean Technology in May 2019).

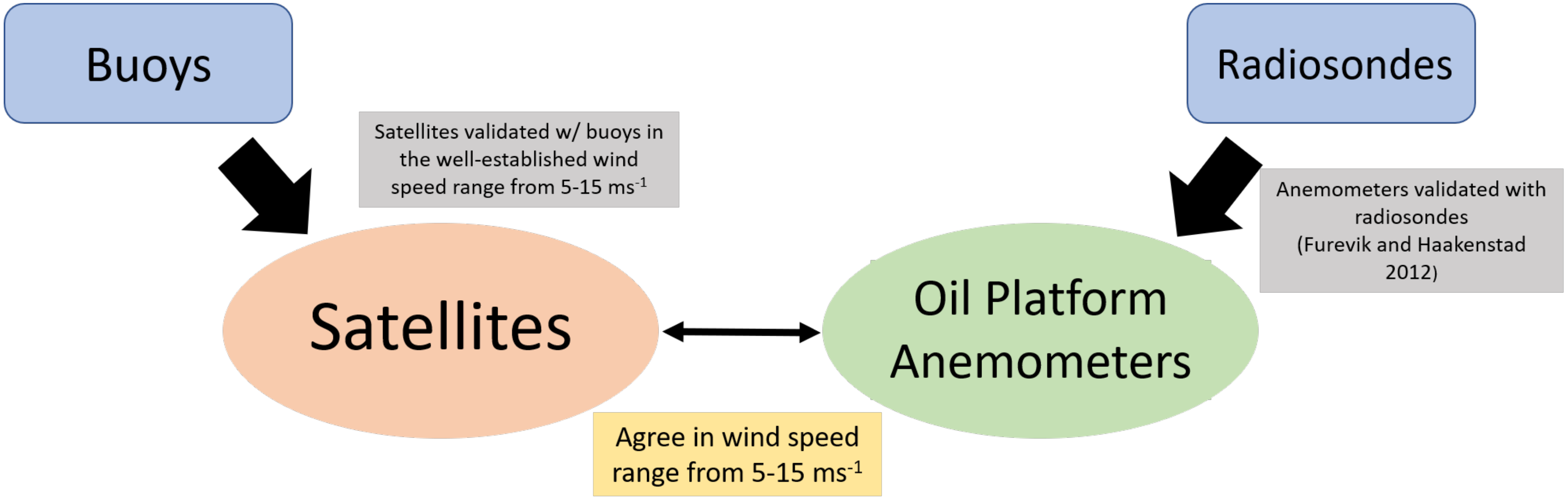
***Manaster, A., Ricciardulli, L. and Meissner, T., 2019. Validation of High Ocean Surface Winds from Satellites Using Oil Platform Anemometers. *Journal of Atmospheric and Oceanic Technology*, 36, 803-818, https://doi.org/10.1175/JTECH-D-18-0116.1.**

Main Conclusions



- Plot shows satellite and model winds minus oil platform anemometer winds in the North and Norwegian Seas for all quality controlled anemometer measurements.
  - Binned vs average wind speed.
  - Model - anemometer differences tend to be LARGER than satellite – anemometer ones.

Why Do We Trust These Satellite Winds at High Wind Speeds?



Furevik, B. R., and H. Haakenstad, 2012: Near-surface marine wind profiles from rawinsonde and NORA10 hindcast. *J. Geophys. Res.*, 117, D23106, https://doi.org/10.1029/2012JD018523.

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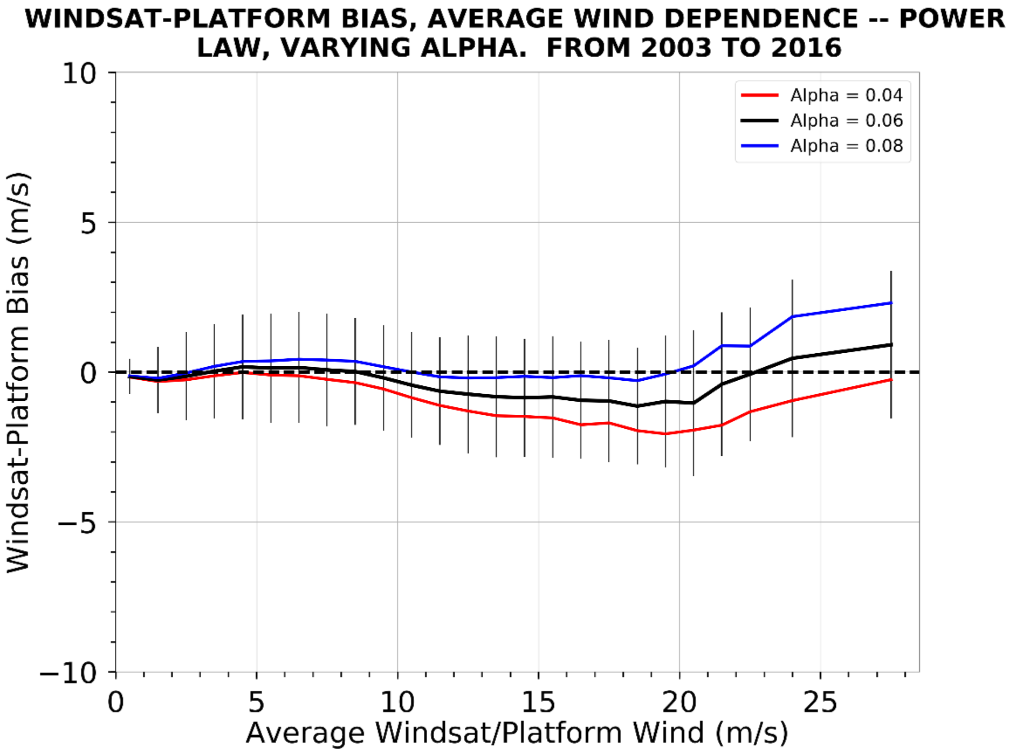
Error Estimates

- Here we address some issues needed to resolve the debate about the validation of satellite winds with anemometers in the range of 15-30 ms^{-1}.
- We analyzed the error budget at moderate and high wind speeds for Windsat – quality controlled anemometer observations.
- Many sources of error were taken into account:
  - **Atmospheric Stability**
  - **Ocean Currents**
  - **Flow Distortion**
  - Errors in anemometer measurements themselves
  - Noise (radiometer/scatterometer)
  - RTM/calibration
  - Spatial/temporal sampling mismatch (Representative error. Wentz 1997*)

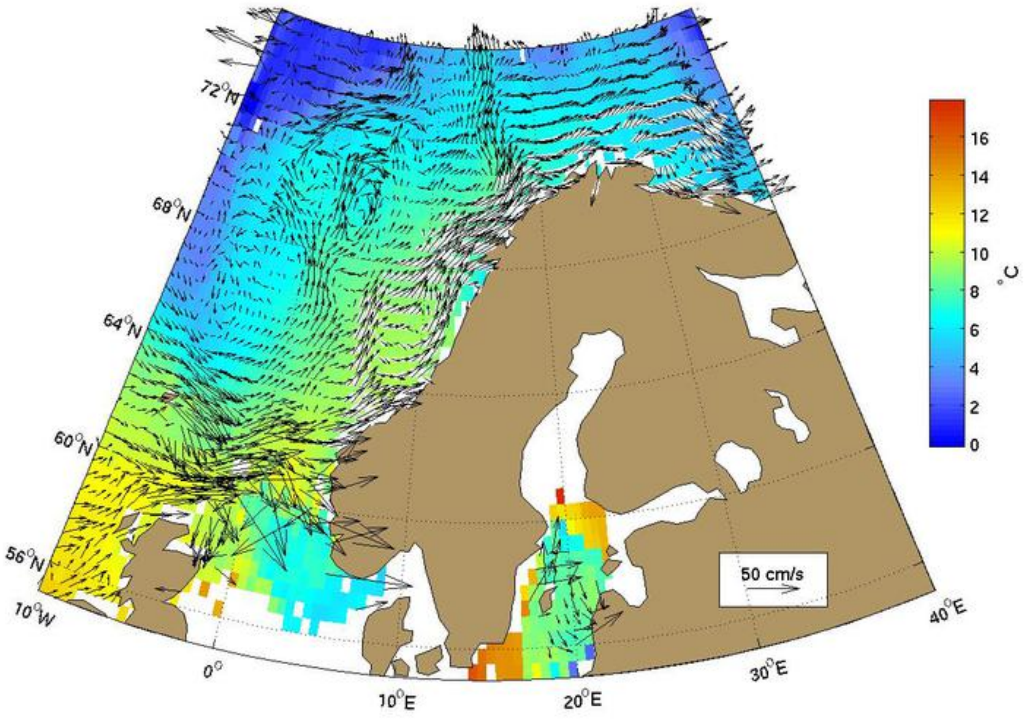
***Wentz, F. J., 1997: A well-calibrated ocean algorithm for special sensor microwave/imager. *J. Geophys. Res.*, 102, 8703–8718, https://doi.org/10.1029/96JC01751.**

Error Budget 1: Vertical Wind Profile

- **Uncertainty in the vertical wind profile due to lack of knowledge of the atmospheric stability at the observation time.**
- We have used power law profile with α=0.06 in order to reference platform winds to 10m.
  - Neutral stability conditions – majority of matchups fall in this category.
  - Explored other profiles and other values of α.
- Range of possible stability conditions leads to error proportional to wind speed.
  - **0.4 ms^{-1}** at W = 10 ms^{-1} and **0.8 ms^{-1}** at W = 22 ms^{-1}



Error Budget 2: Ocean Surface Currents

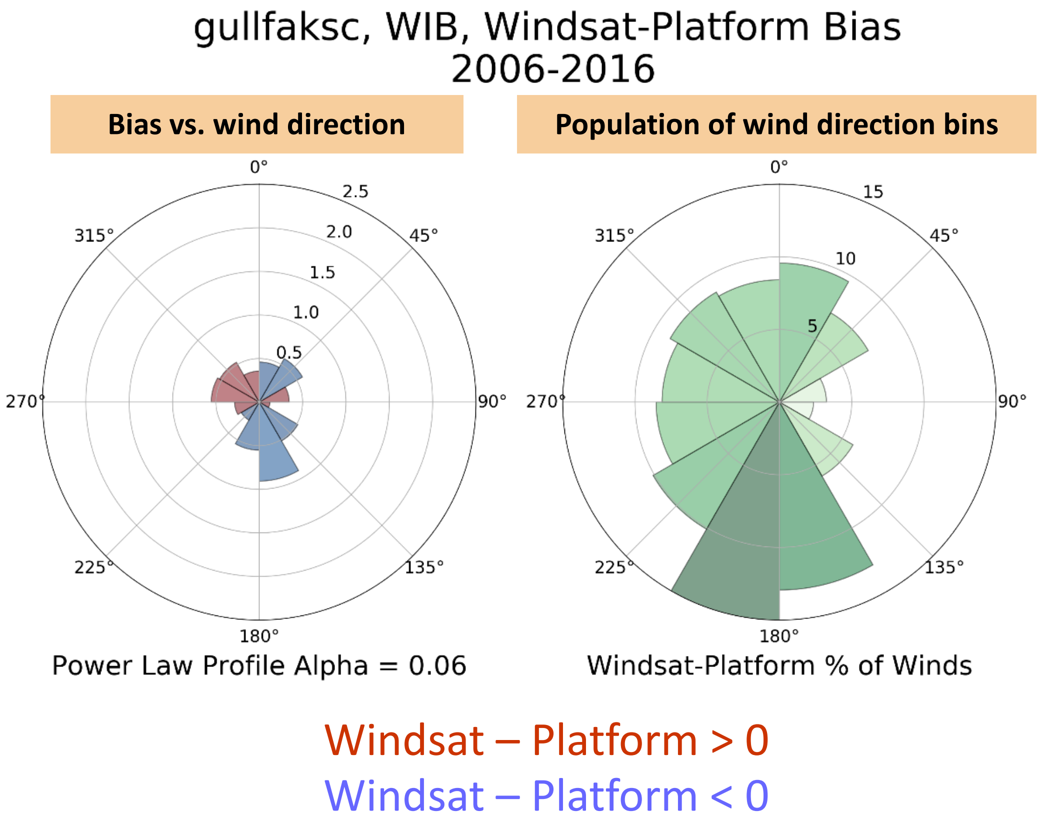


oceancurrents.rsmas.miami.edu/atlantic/norwegian_2.html

- **Neglecting ocean surface currents**
- Satellite data = measure wind speeds w.r.t. moving ocean
- Anemometer data = measure wind speeds w.r.t. Earth
- Currents in North and Norwegian seas mostly < 0.5 ms^{-1}. Rarely higher than 1.0 ms^{-1}.
- Since wind generally does not predominantly come from one direction in this area, we treat ocean currents as a random error source and estimate a value of approximately **0.5 ms^{-1}** for both moderate and high wind speeds.

Error Budget 3: Flow Distortion

- **Possible distortion of the wind field around the oil platform**
- Can depend on height and position of the anemometer mounting on the platform.
- Analysis did not reveal any significant bias of quality controlled anemometer measurements w.r.t. wind direction.
- It is difficult to directly estimate other sources of flow distortion, which might lead to positive/negative biases.
  - We do not expect them to be large at high winds.
  - We estimated their uncertainty contribution as a residual from the error budget starting from observed uncertainty.
- Found the upper bounds of possible flow distortion biases were approximately **0.6 ms^{-1}** for W = 10 ms^{-1} and **1.2 ms^{-1}** for W = 22 ms^{-1}.



	Error source	$W = 10\ \mathrm{m\,s^{-1}}$	$W = 22\ \mathrm{m\,s^{-1}}$
1	Platform anemometer	1.25	>1.25
2	Noise (radiometer/ scatterometer)	0.5	0.5
3	RTM/calibration	0.5	0.5
4	Sampling mismatch	0.9	>1.3
5	Atmospheric stability	0.4	0.8
6	Ocean currents	0.5	0.5
7	Flow distortion	<0.6	<1.2
	Total observed	1.9	2.5

RMS error budget (in ms^{-1}) for the Windsat-platform matcups at two different wind speeds ($W = 10\ ms^{-1}$ and $W = 22\ ms^{-1}$). Table 2 from Manaster et al. 2019.

Paper reference: Manaster, A., Ricciardulli, L., and Meissner, T., 2019. Validation of High Ocean Surface Winds from Satellites Using Oil Platform Anemometers. *Journal of Atmospheric and Oceanic Technology*, 36, 803-818, https://doi.org/10.1175/JTECH-D-18-0116.1.

References

-Furevik, B. R., and H. Haakenstad, 2012: Near-surface marine wind profiles from rawinsonde and NORA10 hindcast. *J. Geophys. Res.,* 117, D23106, https://doi.org/10.1029/2012JD018523.

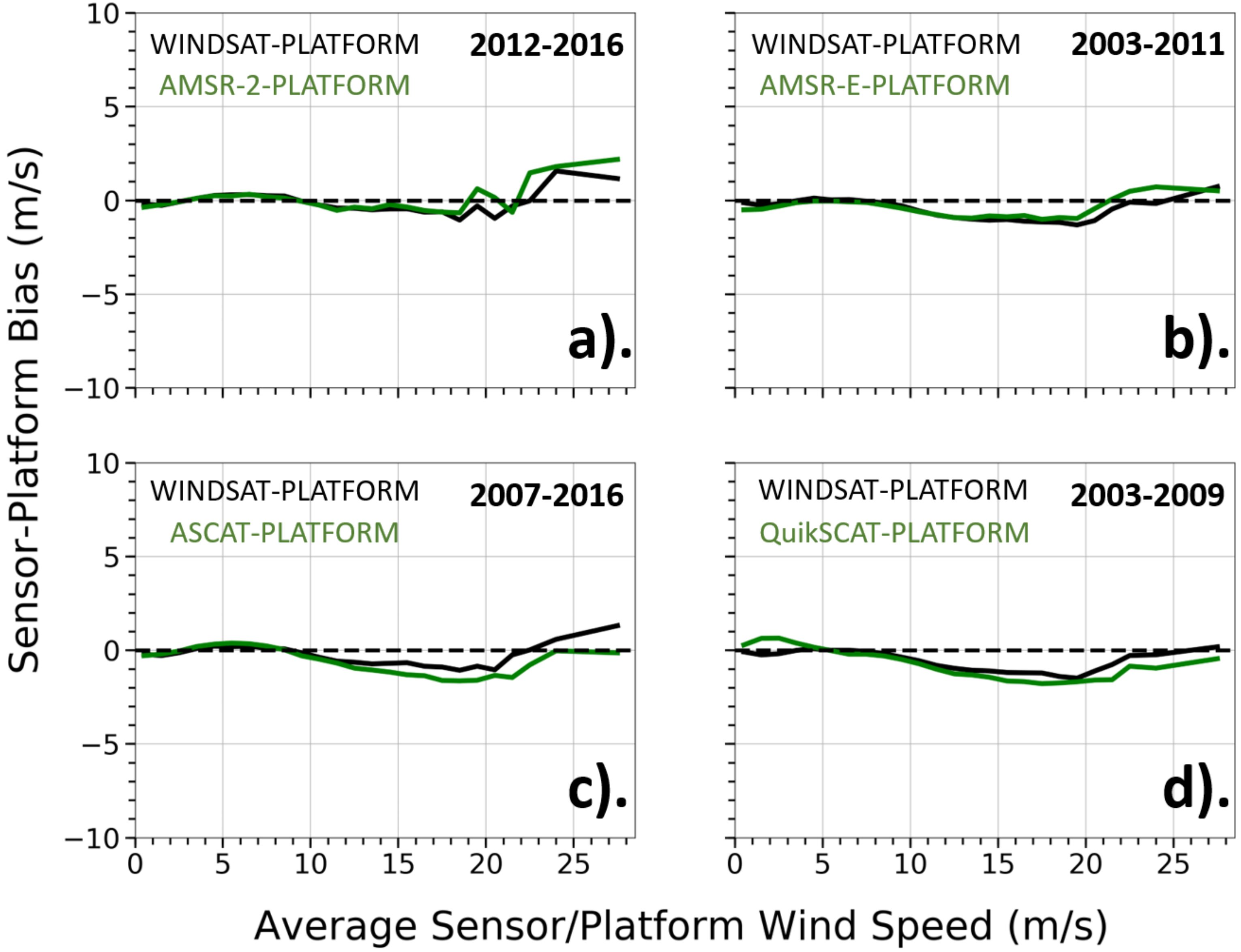
-Kettle, A. J., 2015: A diagram of wind speed versus air-sea temperature difference to understand the marine atmospheric boundary layer. *Energy Procedia*, 76, 138–147, https://doi.org/10.1016/j.egypro.2015.07.879.

-Manaster, A., Ricciardulli, L. and Meissner, T., 2019. Validation of High Ocean Surface Winds from Satellites Using Oil Platform Anemometers. *Journal of Atmospheric and Oceanic Technology*, 36, 803-818, https://doi.org/10.1175/JTECH-D-18-0116.1.

-Pineau-Guillou, L., F. Ardhuin, M. N. Bouin, J. L. Redelsperger, B. Chapron, J. R. Bidlot, and Y. Quilfen, 2018: Strong winds in a coupled wave–atmosphere model during a North Atlantic storm event: Evaluation against observations. *Quart. J. Roy.Meteor. Soc.,* 144, 317–332, https://doi.org/10.1002/qj.3205.

-Wentz, F. J., 1997: A well-calibrated ocean algorithm for special sensor microwave/imager. *J. Geophys. Res.,* 102, 8703–8718, https://doi.org/10.1029/96JC01751.

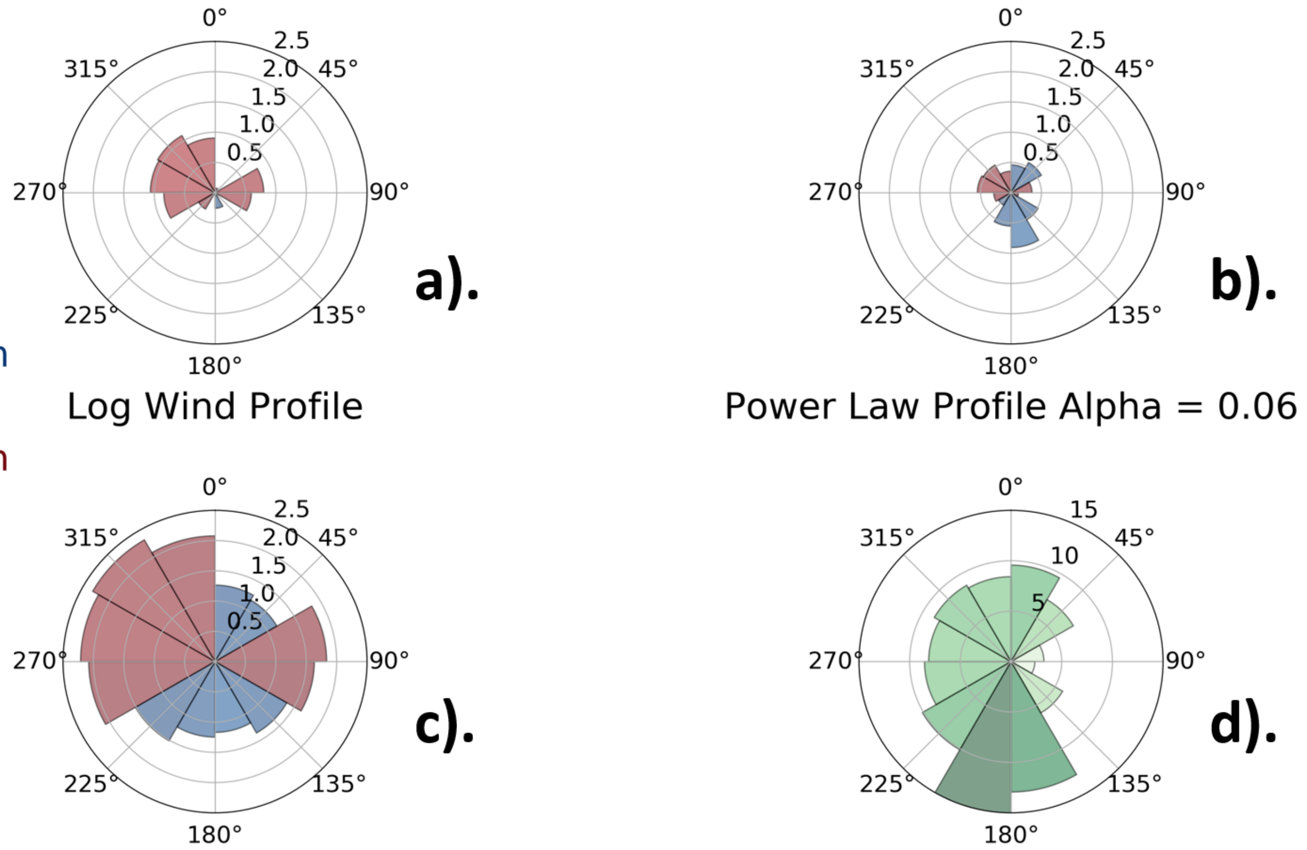
BACKUP SLIDES


WINDSAT-PLATFORM
AMSR-2-PLATFORM
2012-2016
a).
WINDSAT-PLATFORM
AMSR-E-PLATFORM
2003-2011
b).
WINDSAT-PLATFORM
ASCAT-PLATFORM
2007-2016
c).
WINDSAT-PLATFORM
QuikSCAT-PLATFORM
2003-2009
d).
Sensor-Platform Bias (m/s)
Average Sensor/Platform Wind Speed (m/s)
10
5
0
−5
−10
0
5
10
15
20
25

gullfaksc, WIB, Windsat-Platform Bias 2006-2016

Windsat < Platform
(negative bias)

Windsat > Platform
(positive bias)



Log Wind Profile

Power Law Profile Alpha = 0.06

Power Law Profile Alpha = 0.13

Windsat-Platform % of Winds