Ocean Surface Wind from Aeolus Sea Surface Returns (SeaFlect)

S. Tjemkes, H. Bonekamp, F. Fell, G. Hesselmans, M. Leidner

Contact: Stephen.tjemkes@verisk.com

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Seaflect: Objective to explore potential to monitor ocean surface winds from Aeolus surface return

Roadmap

- Justification for the study
- Some old results
- Some new results
- Take home message

Big Thanks

To facilitate access to Aeolus data ESA supported the development of the VRE-toolbox

(vre.aeolus.services)

Thanks to ESA, DLR and Daniel Santillan (EOX) for making this available

Summary

- Access to absolute radiometrically calibrated observations are a pre-requisite for the development of new products, which are based on radiometric information of Aeolus observations (like surface reflectance presented here).

- This is currently missing.

If there is an interest to use Aeolus observations beyond the main mission, a demonstration of an absolute calibration appears highly desirable..

Why monitor Sea Surface using Aeolus?

WMO Resolution No: 40:

For safety at sea the increase of current observational capability on ocean surface winds, especially of extreme winds is always needed.

Whitecaps (Korotkevich et al 2021):

Formation of the white caps on the sea-waves crests is a well known physical phenomenon. Its study is important for at least two reasons:

White capping is a powerful mechanism of waves energy dissipation, responsible for transfer of energy and momentum from wind to water.

Determination of the “dissipation function” – the rate of energy and momentum transport from atmosphere to water due to white capping in the wind-driven sea - is the necessary condition for designing of an efficient operational model for wave prediction.

Ocean Color (IOCCG report 5):

UV-a bands would assist in the derivation of surface reflectance from satellite measured radiance, especially for coastal waters.

Physical Principle: Surface Range Bin

. ESA Co. 4000133131/20/I-BG

22-Atmospheric Range bins

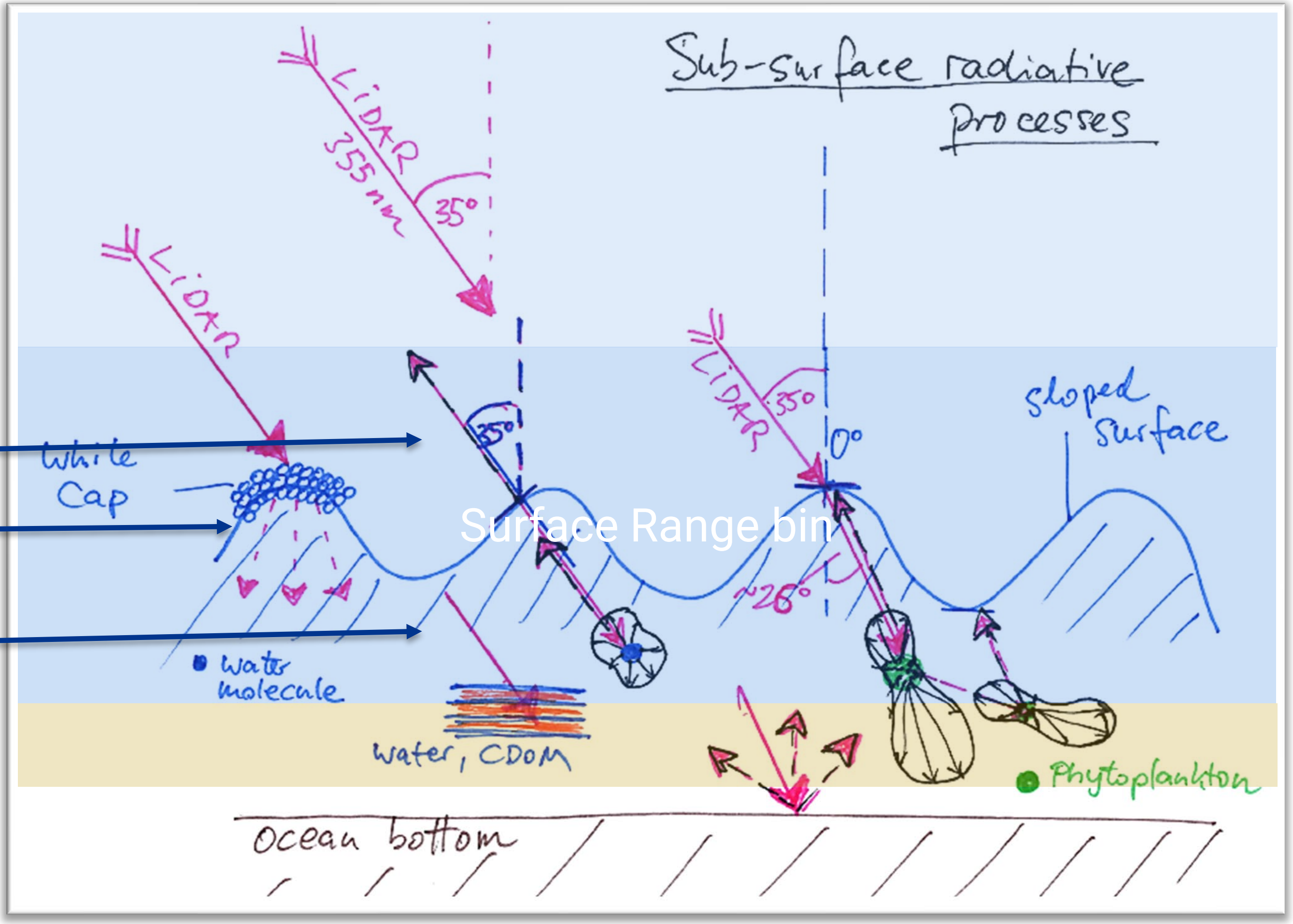
Surface Range bin

Atmospheric sub-layer

Interface

Ocean sub-layer

1Ocean Range bin

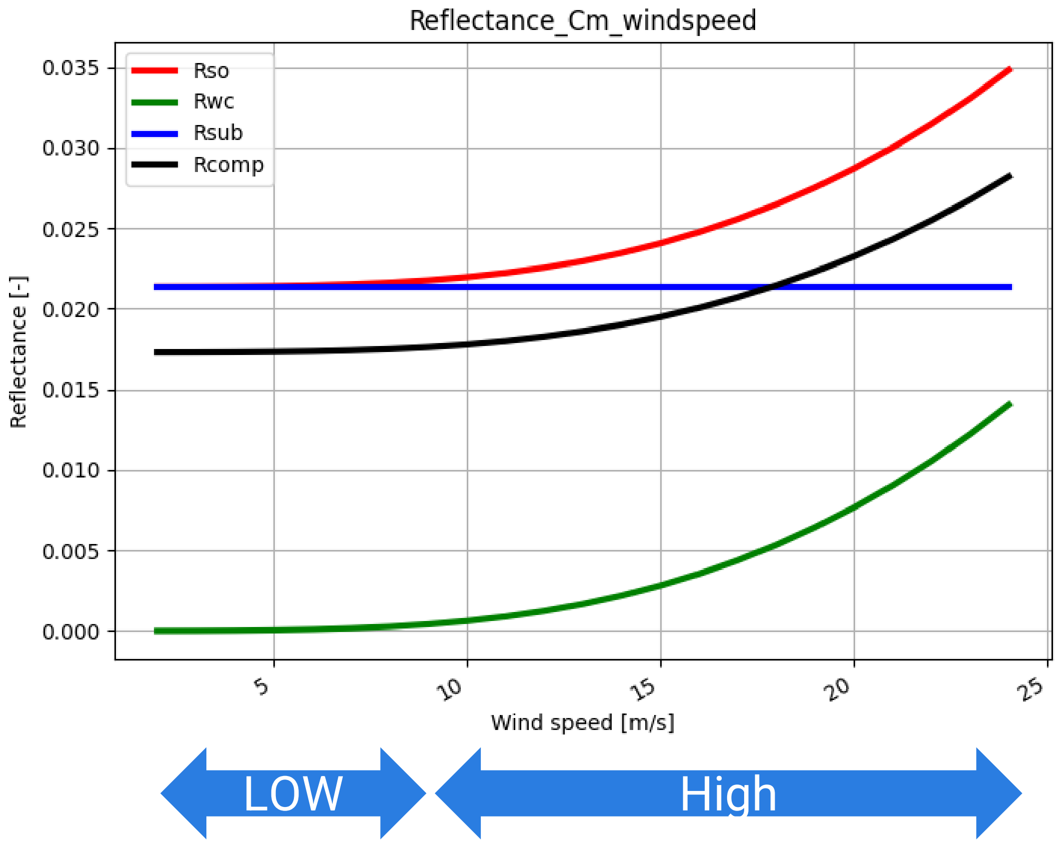


Physical Principle

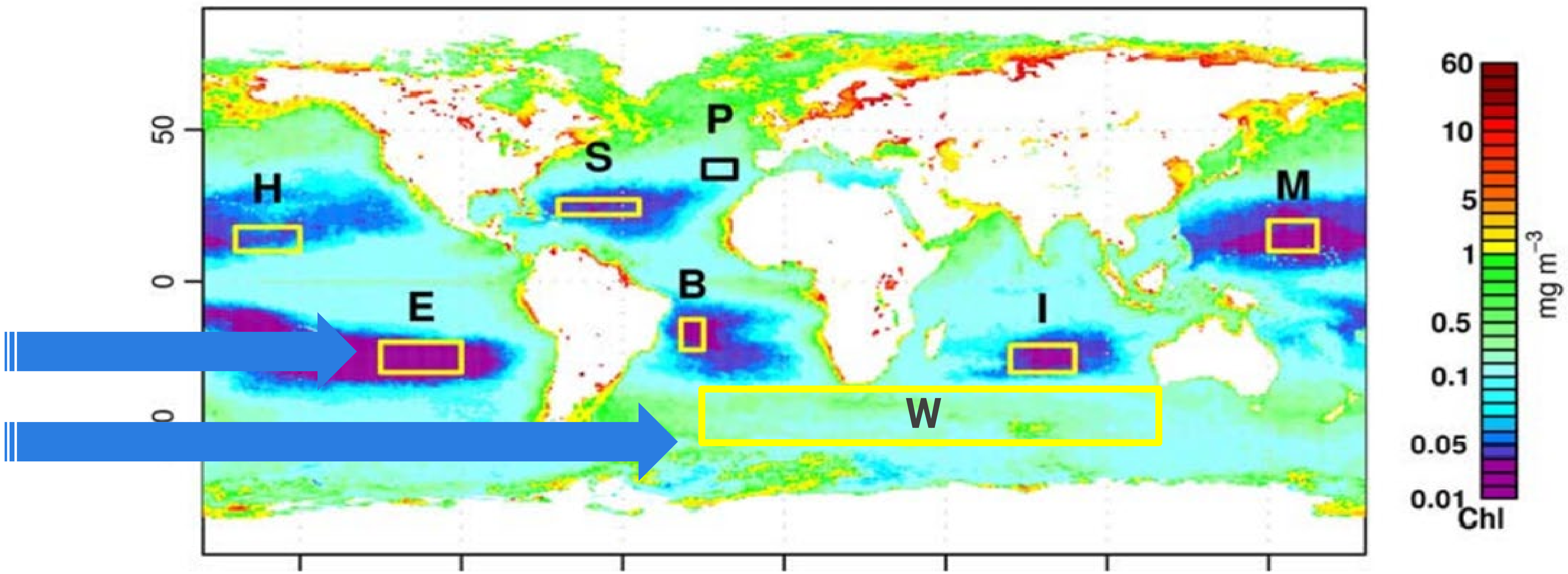
Increasing windspeed, results in increasing white cap fraction, which in turn will result in increased return signal.

Return signal from surface range bin (Rso):

- Backscatter from atmosphere (sub-layer, not shown)
- Backscatter from surface (Interface, Rsurf)
  - Combination of white caps (Rwc) + offset from specular reflection
- Offset from ocean (sub-layer, Rsub)

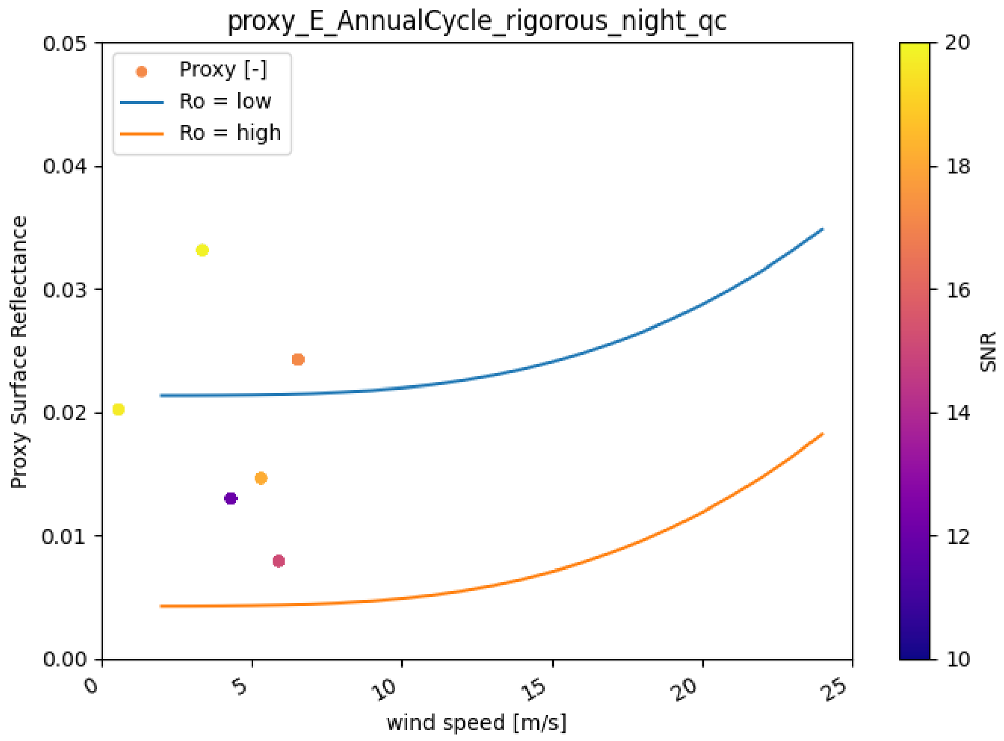


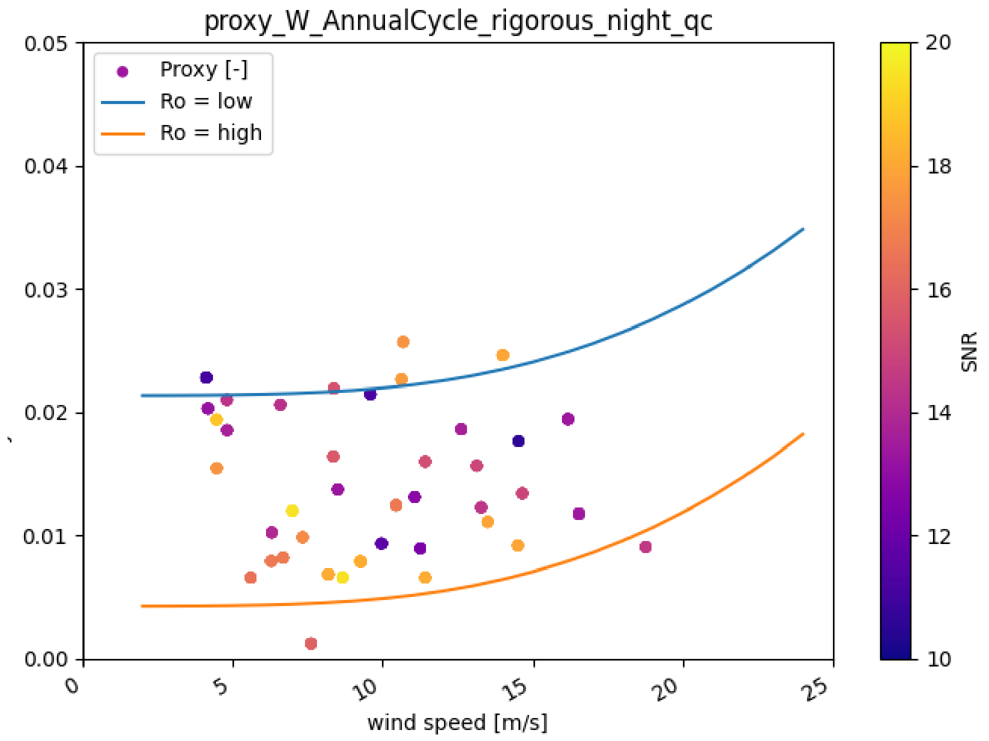
Experiments



Chlorophyll concentration [Chl] (mg m−3), annual composite (year 2006) of SeaWiFS data for the global ocean. The rectangle E (for Easter Island) is located in the South Pacific Gyre. Source: Morel et al. [2010].

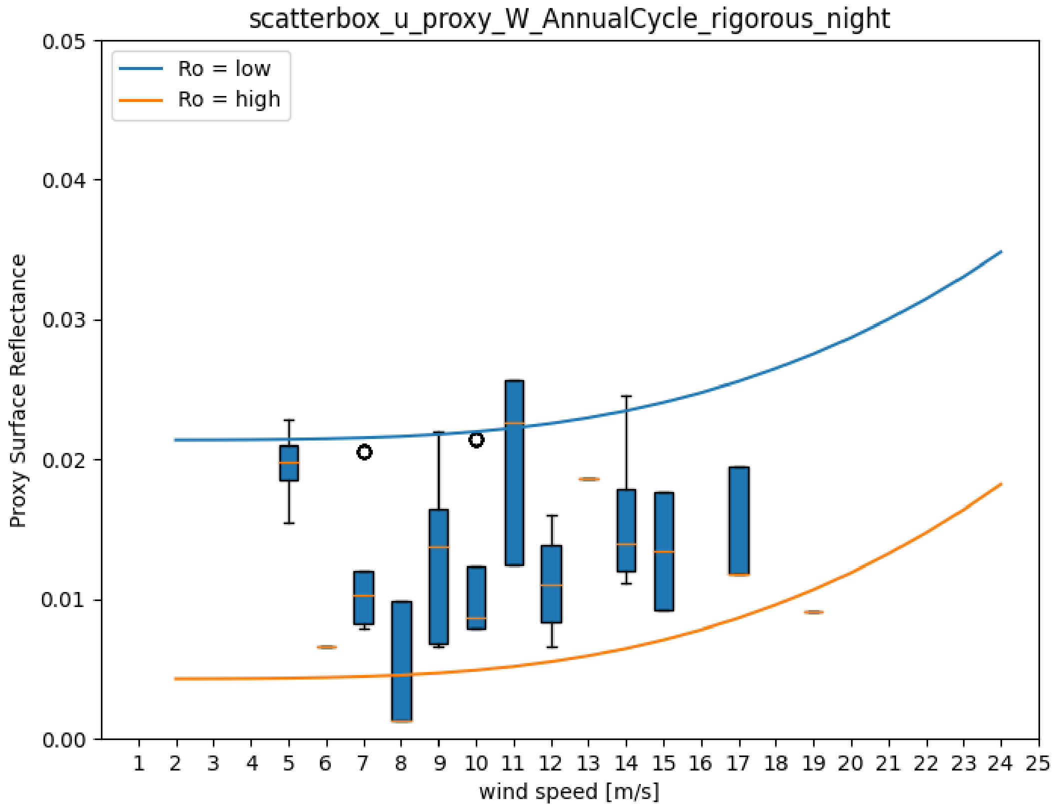
Example region E (left) W(right)





Despite radiometric stable target, relatively large scatter in proxy reflectance in low wind regime.

After binning region W



Result of Phase I: for all filtered observations over period of interest for all oligotrophic regions

Low windspeed regime (< 7-8 m/s)

- Dependency of proxy reflectivity on sub-surface radiative properties is expected, which could explain part of the scatter as the sub-surface for region W is not stable.
- But scatter is too large to determine an offset, could be “Atmospheric Noise”: clouds-aerosol in an 87 km strip can be expected

High windspeed regime (> 9-10 m/s):

- A very strict QC is needed to see a signal in region W which is not in contradiction to the simple theoretical model.

Started a Phase II: Explore the measurements

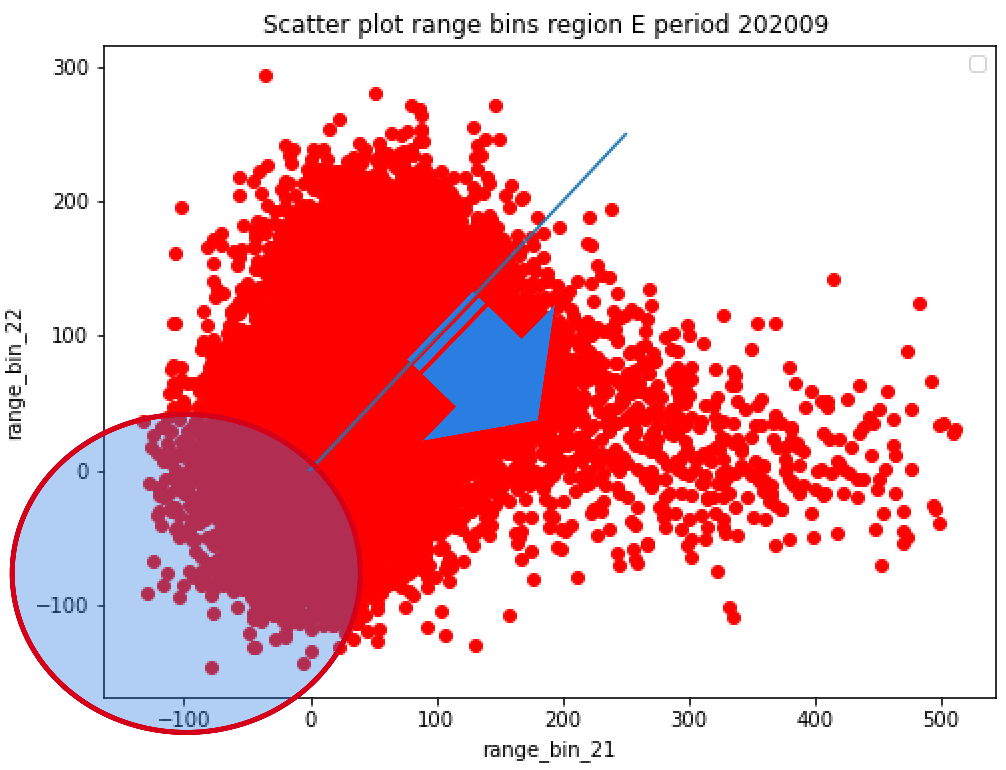
The observations (at 87 km) are an accumulation of measurements at 3 km.
Explore the measurements to improve the yield.

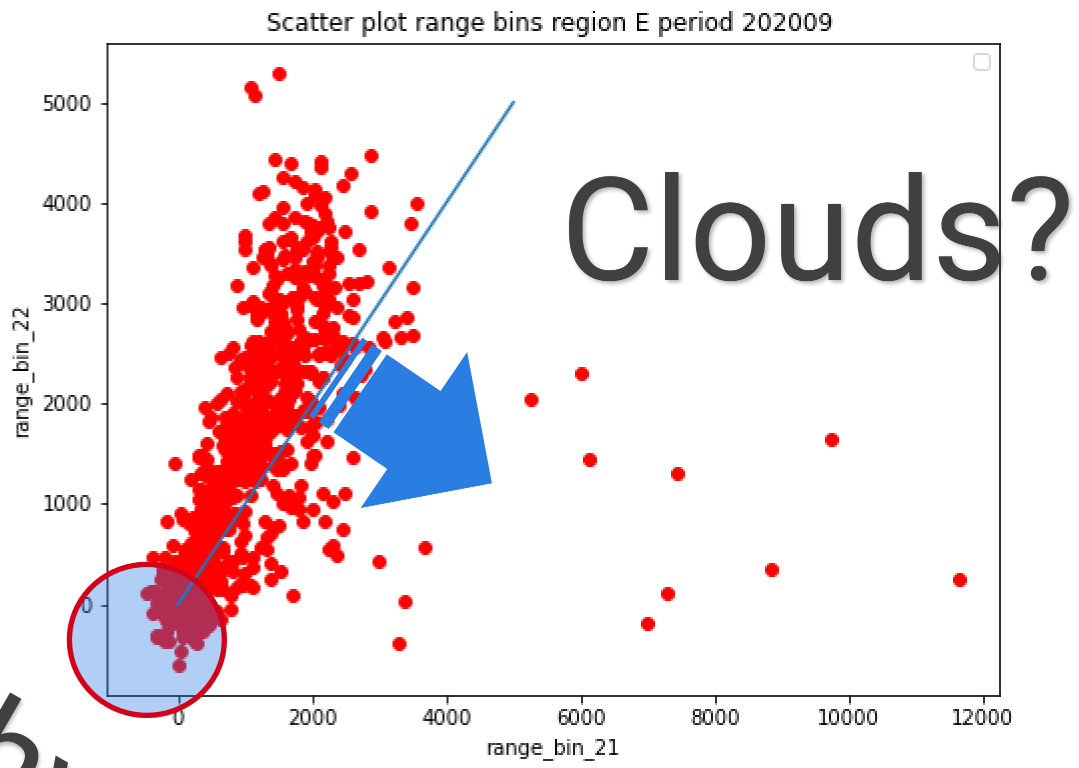
With the risk that we replace atmospheric noise (clouds) by measurement noise

Unfortunately: the use of measurements brought

more questions,
noise,
reduced the yield
increased the entropy (with us)

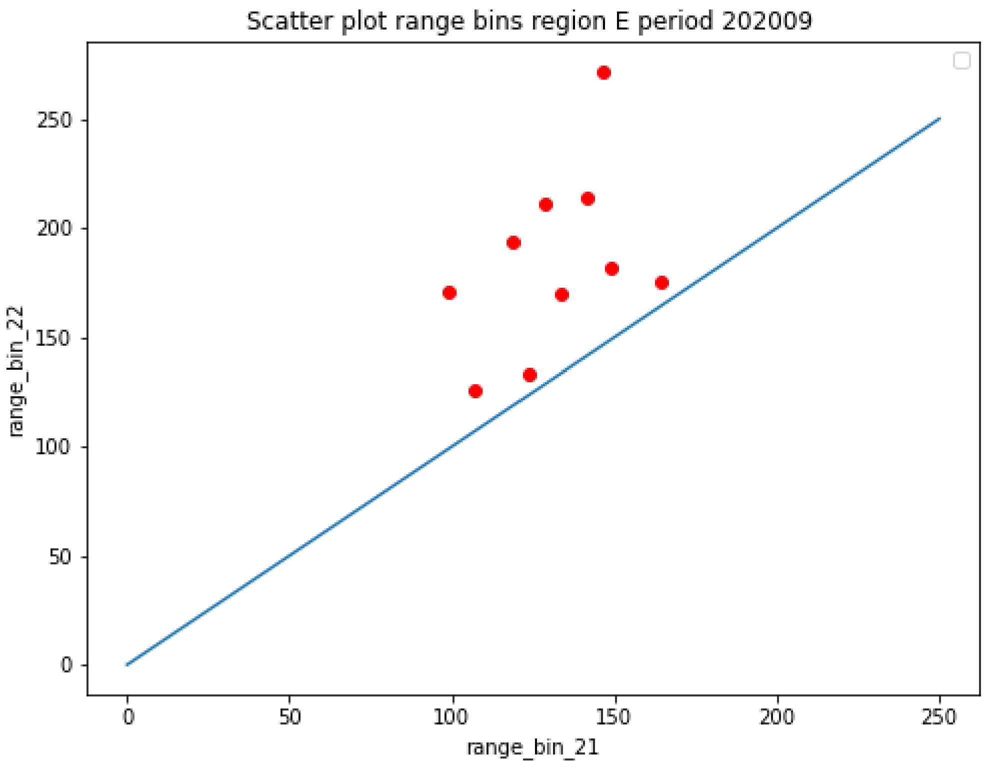
ACCD Counts for range bin 21 – range bin 22 (surface): unfiltered

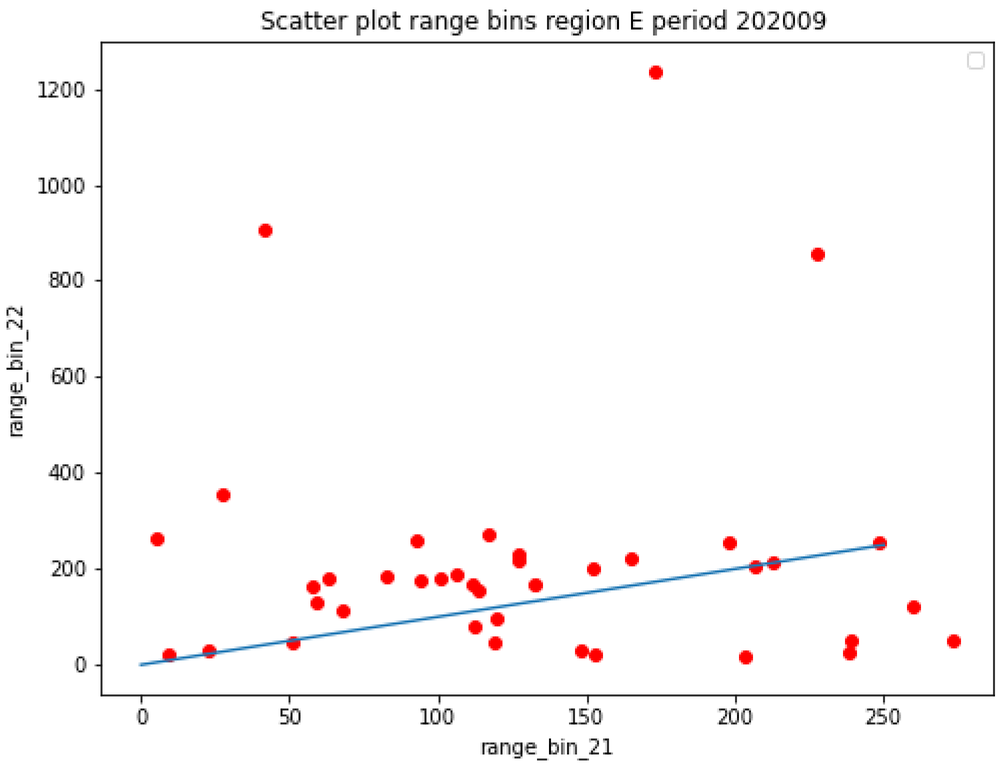




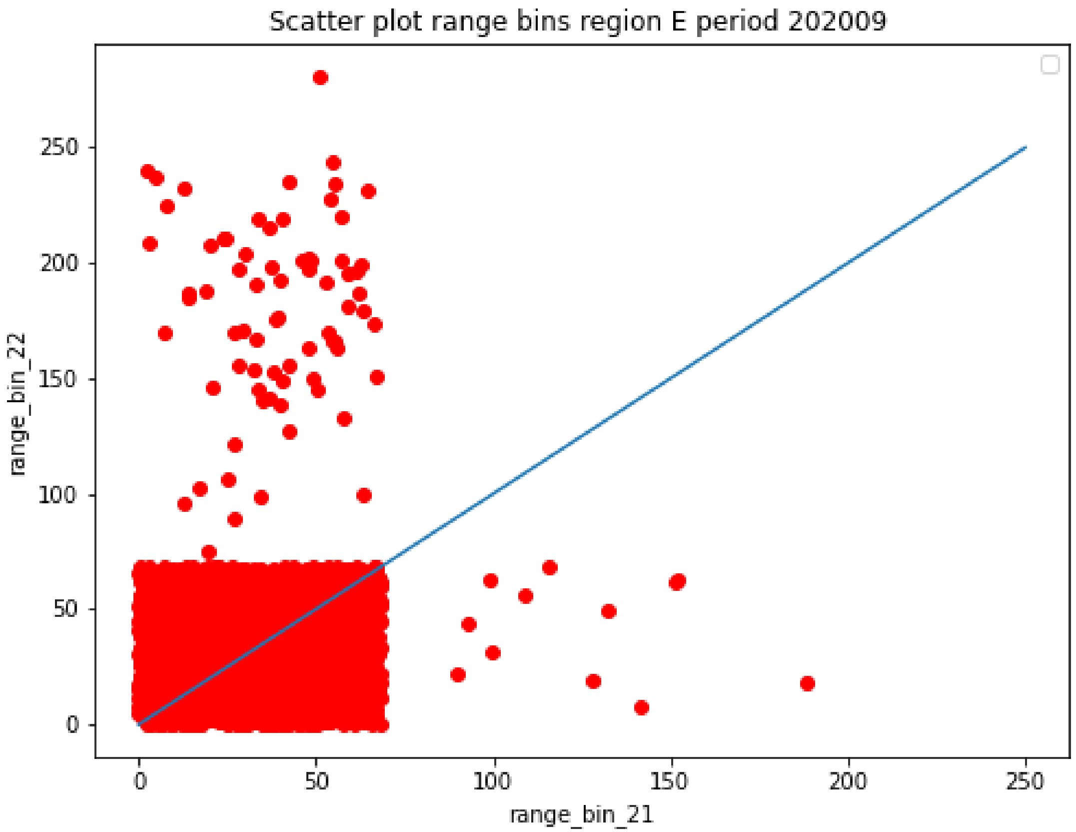
Unphysical?

ACCD Counts for range bin 21 – range bin 22 (surface): Filtered (0<SNR<20; 0 < SCAT < 1.9)





Reminder filtering is everything (incomplete filtering on SCAT)

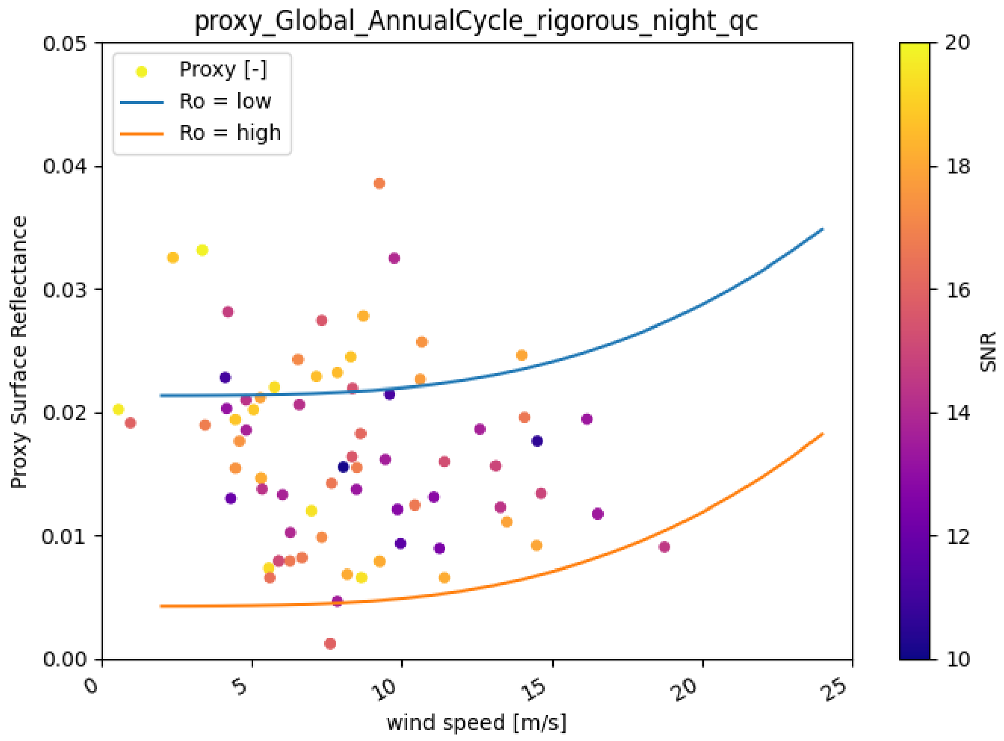


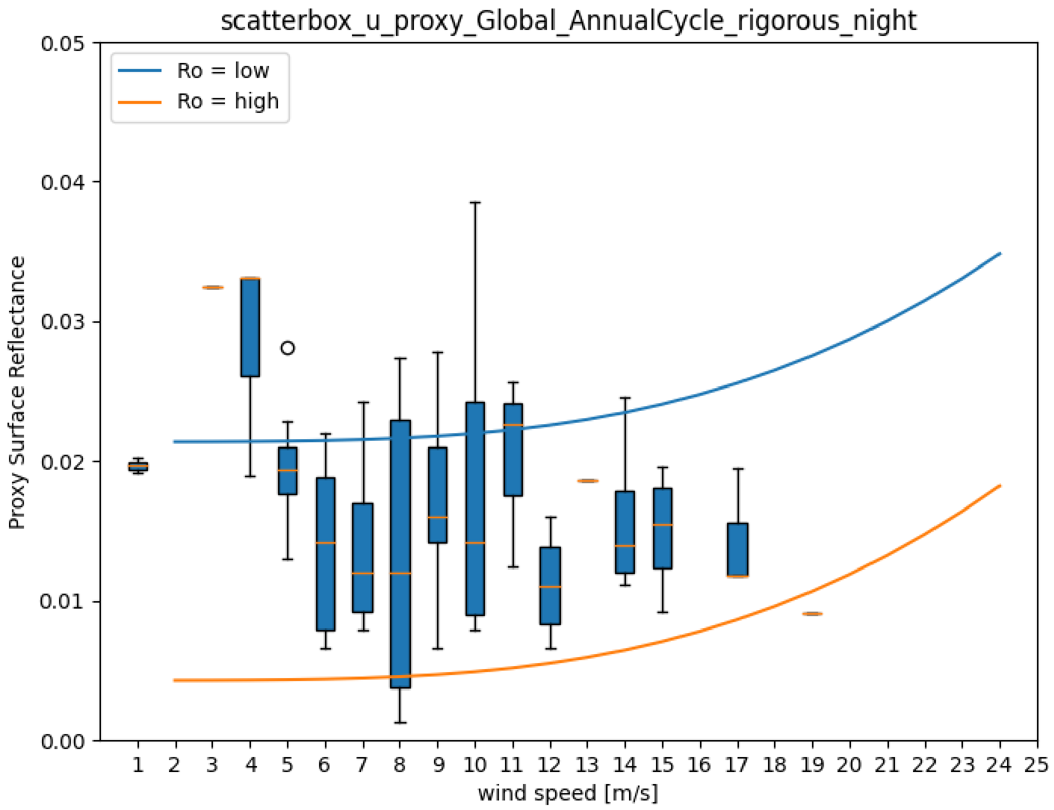
Initial analysis of measurements

- **There are many unphysical measurements. They do not show up in the observations as the observations is just a linear adding of ALL measurements. Negative measurement values are balanced by the positive measurement values.**

- **Missing absolute radiometric calibration prevents the accumulation of the measurements or observations from different sites to improve statistics.**

Observations all oligotrophic regions





The above plots were generated with a strict QC: snr, scat, rms and solar altitude values to filter observations

Discussion

The analysis of the Mie ACCD counts for the monitoring of sea surface state is (well) beyond Aeolus main mission objectives.

A number of elements could contribute to the weak signal found:

Large footprint:

The observational data has a footprint of 87 km. Unlikely that all measurements are cloud free. An initial analysis of the measurements at 3 km resolution, has been performed, which resulted in a loss of yield.

Definition of surface range bin / thickness of range bins

There is an uncertainty in the altitude of interfaces, it is essential to know where the surface interface is to "estimate" the atmospheric contribution in the surface range bin return signal.

Atmospheric Correction:

Ad-hoc correction of atmospheric contribution, need to improve this using AUX-MET (density in stead of geometrical thickness, ongoing: (VRE provides collocated AUX-MET!)).

Critical: No radiometric calibration:

L1B product is uncalibrated, not clear if the Aeolus product contains information to perform a calibration. Radiometric noise of the measurements (at 3 km) is not known.

Critical: analysis of on-ground processing:

The observations are processed on ground to support main mission. A large number of negative return signals are found, also for the top most atmospheric range bin.

Summary and Conclusions (preliminary)

Performed an initial analysis of the Mie useful signal (ACCD counts) for selected regions and atmospheric conditions to understand possible relation between windspeed and return signal

This is pre-requisite for the generation of new Aeolus products:.

- **a surface reflectance product**
- **a surface wind or white cap product**

Initial results for selected regions indicate

- **relatively large scatter for low wind speed regime**
- **a weak signal of increased surface reflectance with increasing windspeed**

Analysis is difficult because

- **noise in the return signal (from atmosphere and from instrument)**
- **missing radiometric calibration**
- **Large number of unphysical measurements**

Summary and Conclusions (preliminary)

If there is an interest to use Aeolus observations beyond the main mission, a demonstration of an absolute calibration appears highly desirable.

Thank you for your attention

contact:stephen.tjemkes@verisk.com