QuikSCAT-derived coastal winds

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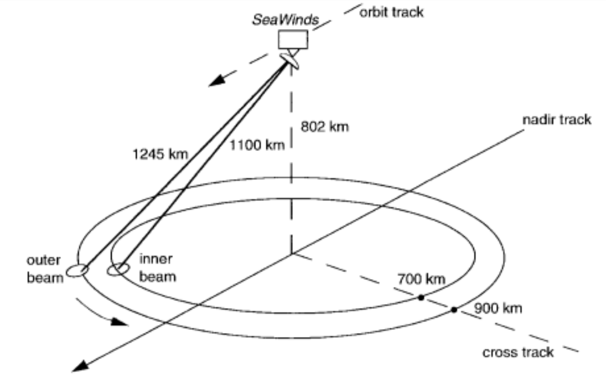
Why coastal winds

- Scientific applications:
  - Weather forecasts (ocean and atmosphere)
  - Coastal dynamics (Diffusion, extreme events such as Acqua Alta, etc.)
  - ...
- Civil applications:
  - Wind farm installation
  - Coastal erosion
  - ...

Scatterometer-derived winds represent the gold standard, but...

Land contamination causing wind biases within ≈25 km

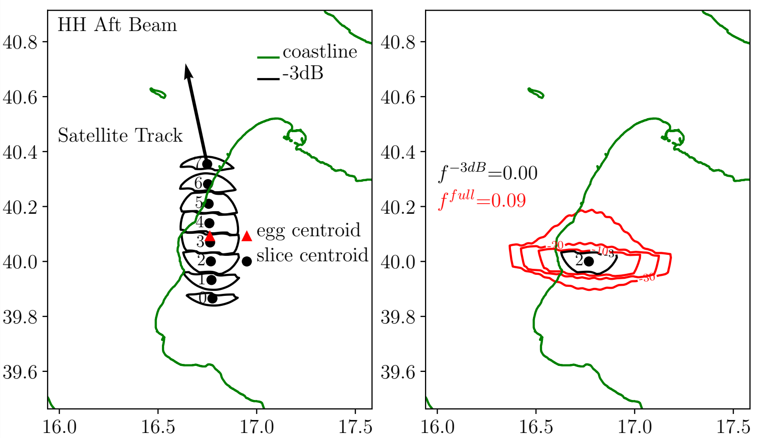
SeaWinds on QuikSCAT and ADEOSII



M. W. Spencer, Chialin Wu and D. G. Long, "Tradeoffs in the design of a spaceborne scanning pencil beam scatterometer: application to SeaWinds," in IEEE Transactions on Geoscience and Remote Sensing, vol. 35, no. 1, pp. 115-126, Jan. 1997, doi: 10.1109/36.551940.

- Ku-band (13.4 GHz)
- Inner beam: H-Pol
- Outer beam: V-Pol
- 4 "views" per each ocean point:
  - H-fore
  - H-aft
  - V-fore
  - V-aft

SeaWinds egg (Inner beam example)



- range filtering
- 8 slices per egg
- slice dimension ≈ 25x8 km^2
- ∀ slice, computation of **Land Contribution Ratio** (f):
  - $f = \frac{\sum_{xy} L_{xy} S_{xy}}{\sum_{xy} S_{xy}}$
  - L_{xy}: land/sea mask
  - S_{xy}: Spatial Response Function (SRF)

Model of land-contaminated σ_0

$$\sigma_0 = (1-f)\ \bar{\sigma}_{0,S} + f\ \bar{\sigma}_{0,L} + \underbrace{[(1-f)\ \epsilon_S(\sigma_{0,S}) + f\ \epsilon_L(\sigma_{0,L})]}_{\epsilon}$$

- $\bar{\sigma}_{0,S}$, $\bar{\sigma}_{0,L}$, ϵ_S and ϵ_L are unknown

State of the art

- $\bar{\sigma}_{0,L}$ estimated from the SeaWinds climatological series [1] or enhanced res.algorithm [2]

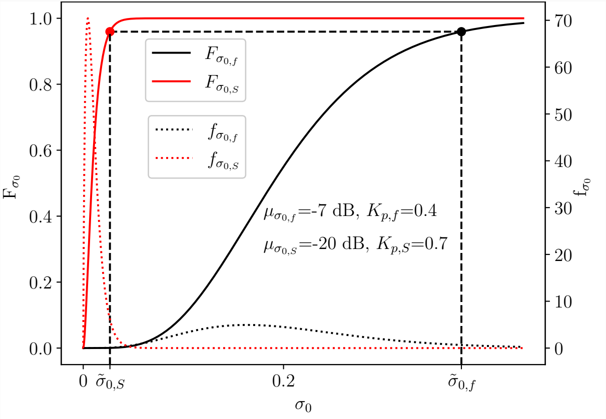
- $\hat{\bar{\sigma}}_{0,S} = \frac{\sigma_0 - f\ \bar{\sigma}_{0,L}}{1-f}$

[1] Fore, A.G.; Stiles, B.W.; Strub, P.T.; West, R.D. QuikSCAT Climatological Data Record: Land Contamination Flagging and Correction. Remote Sens. 2022, 14, 2487. https://doi.org/10.3390/rs14102487
[2] Soisuvarn, S., Jelenak, Z., Chang, P.S., Zhu, Q., Shoup, C.G., 2023. High-resolution coastal winds from the noaa near real-time ascat pro- cessor. IEEE Transactions on Geoscience and Remote Sensing 61, 1–12. doi:10.1109/TGRS.2023.3279764.

f-based σ_0 correction scheme with noise regularization

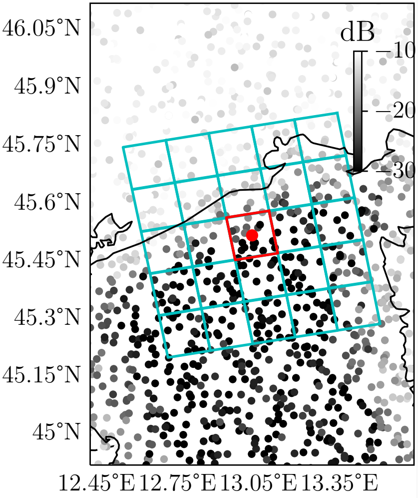
Noise regularization procedure:

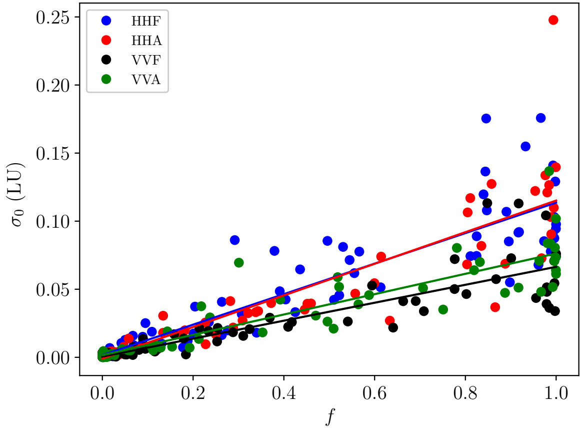
1. $\sigma_0 = \underbrace{\bar{\sigma}_{0,S}}_{b} + \underbrace{\left(\bar{\sigma}_{0,L} - \bar{\sigma}_{0,S}\right)}_{a} f + \epsilon$ [3]
2. $\bar{\sigma}_{0,f} = af + \bar{\sigma}_{0,S}$
3. $\bar{\sigma}_{0,f} \rightarrow \hat{K}_p(\bar{\sigma}_{0,f})$
4. CDF matching:
   $F_{\bar{\sigma}_{0,f},\hat{K}_{p,f}}(\tilde{\sigma}_{0,f}) \equiv F_{\bar{\sigma}_{0,S},\hat{K}_{p,S}}(\tilde{\sigma}_{0,S})$



[3] J. Vogelzang, A. Stoffelen, "ASCAT land correction", SAF/OSI/CDOP3/KNMI/TEC/TN/384

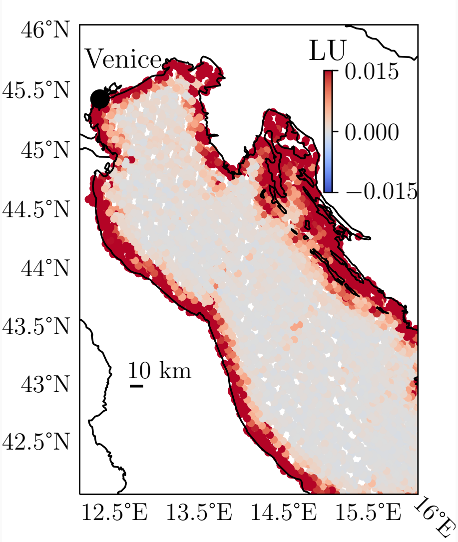
Area test: north Adriatic (Mediterranean basin)

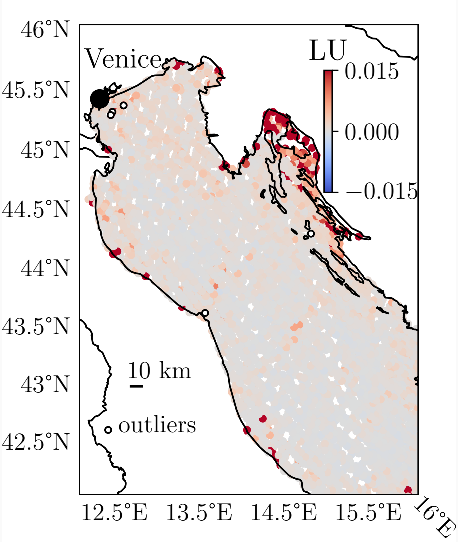




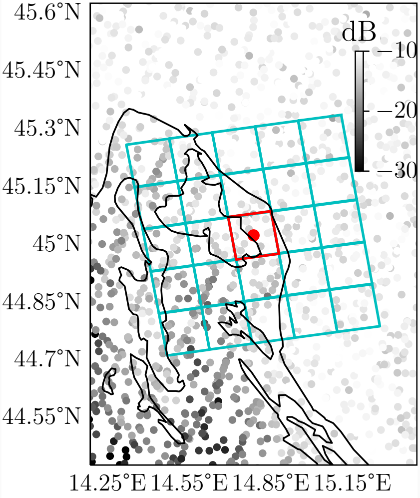
QuikSCAT Full-Resolution file ID 40653

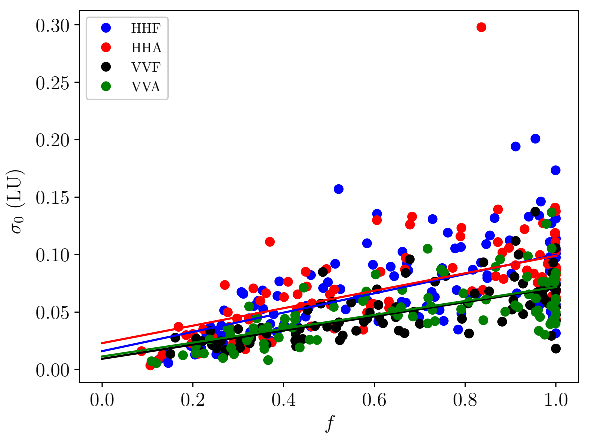
corrected σ_0 with noise regularization





Residual land contamination due to lack of $\sigma_{0,S}$





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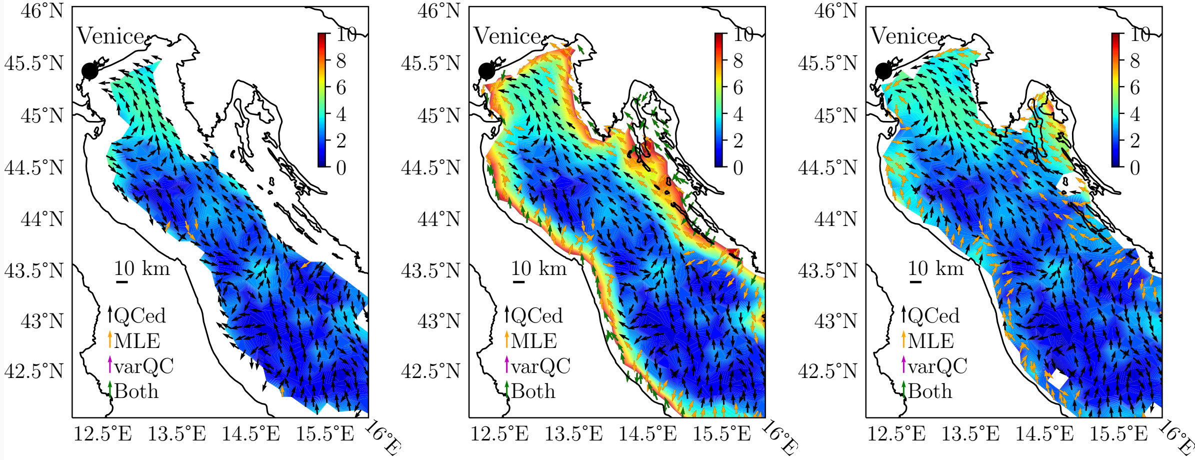
Retrieval experiments

Name	f^{th}	Noise regularization	Orbit IDs
CTRL	0.02	NO	40651-40664
NC	0.5	NO	40651-40664
NR	0.5	YES	40651-40664

CTRL represents the state-of-the-art at OSI-SAF

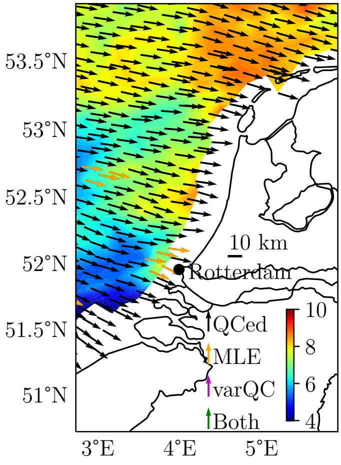
- Two area tests: **North Adriatic** (Mediterranean) and **Netherlands**
- Day: 10^{th} April 2007
- WVC grid: 12.5 km

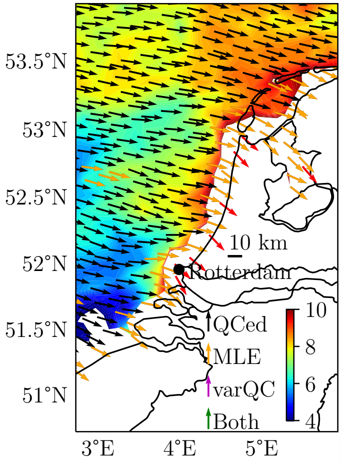
Retrieved winds: North Adriatic

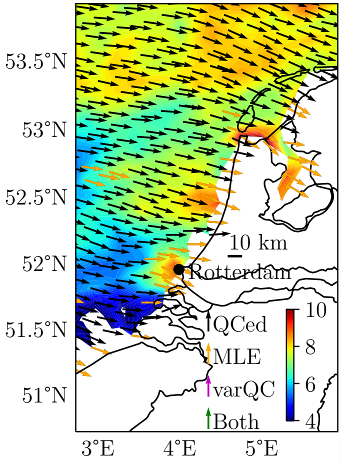


CTRL NC NR

Retrieved winds: Netherlands

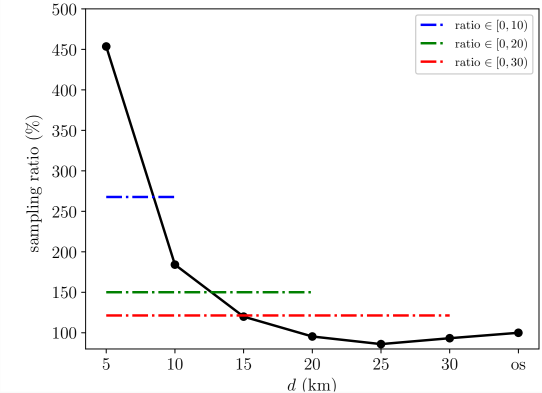




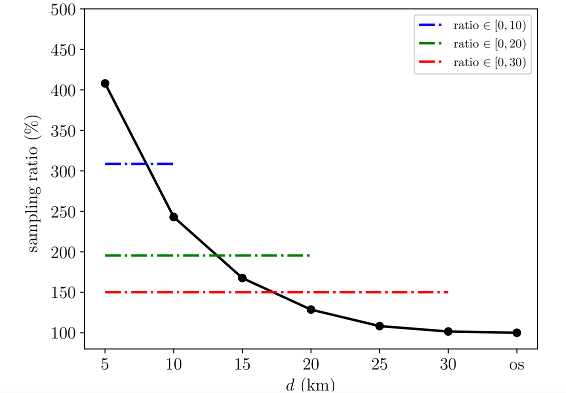


CTRL **NC** **NR**

Sampling rate improvement



w.r.t. CTRL

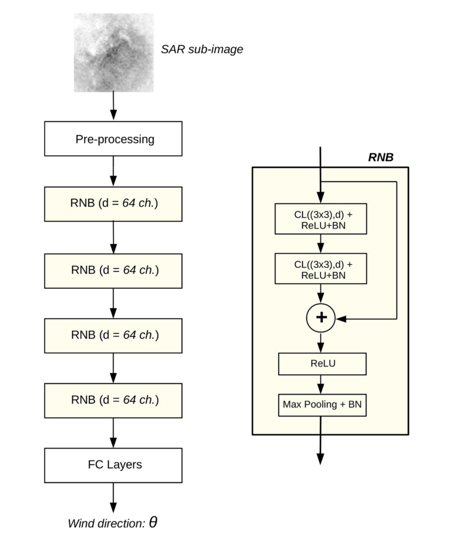


w.r.t. NC

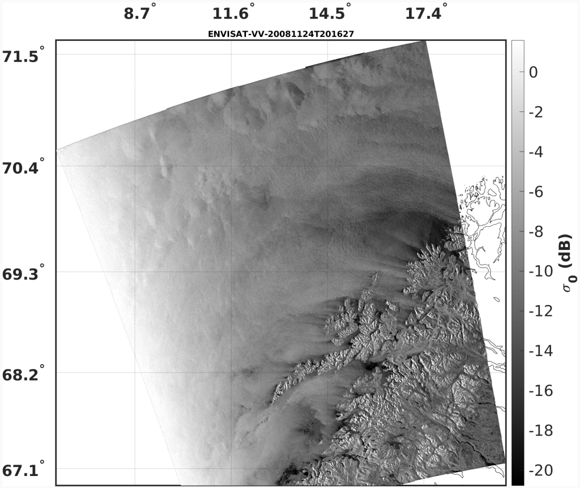
Envisat ASAR-derived winds

- Wind direction:
  - Method: Deep Learning with Convolutional Neural Network (CCN) with Residual Neural Network structure (**ResNet**)
  - Configuration: 4 layers, 64 channels
  - Training dataset of **816,000** pairs:
    - 25 Sentinel 1 GRDW IW images
    - ECMWF FC 0.125^o
- Wind speed:
  - U=C_SarMod2$^{-1}(\sigma_0, \theta)$ (Lu et al. 2018)

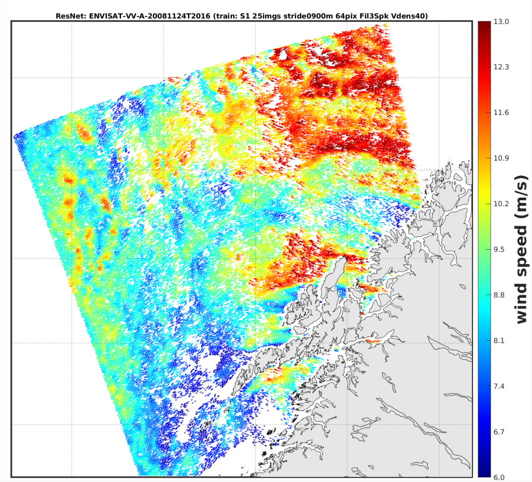
Zanchetta and Zecchetto, "Wind direction retrieval from Sentinel-1 SAR images using ResNet", Remote Sensing of Environment, 253, 2021 (https://doi.org/10.1016/j.rse.2020.112178)



ASAR-derived winds

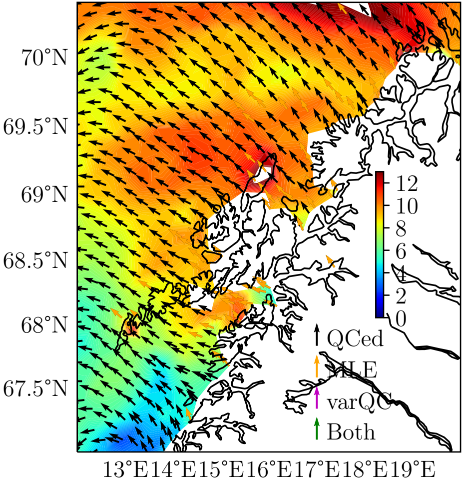


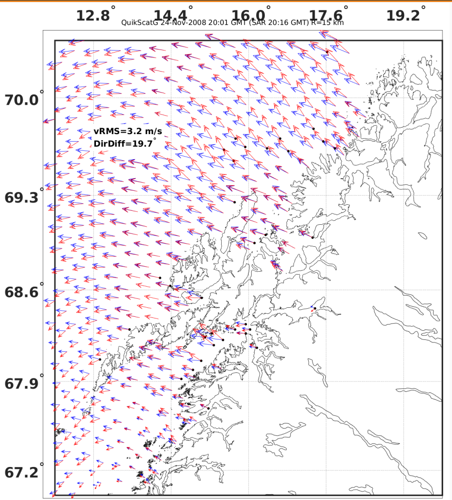
$\sigma_{0,ASAR}$



$\vec{\mathbf{u}}^{0.9}_{ASAR}$

Comparison between QuikScat and Envisat derived winds





$\vec{\mathbf{u}}^{12.5}_{ASAR}$ vs $\vec{\mathbf{u}}^{12.5}_{QS}$

Black markers: rainy WVCs

Preliminary Conclusions & Future Work

Preliminary conclusions

- σ_0 correction with noise regularization is effective
- Wind retrievals are good, also in internal seas
- Coastal sampling gain: +400% within 5 km and ≈300% within 10 km
- Encouraging agreement with SAR-derived winds

Future work

- MLE threshold tuning
- Assessment of any residual contamination
- Validate winds (how? Against buoys, models, SAR-derived winds?)
- Improve ResNet-derived winds and consistency with QS winds
- Export Noise-Reg to other pencil-beam scats (OceanSat, HY-2)

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Back-up slides