QuikSCAT-derived coastal winds

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6\(^{th}\) October 2023

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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 $\approx 25$ km
SeaWinds on QuikSCAT and ADEOSII

- 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 $\approx 25 \times 8 \text{ km}^2$
- $\forall$ 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)

![Diagram showing HH Aft Beam, Satellite Track, egg centroid, slice centroid, coastline, and -3dB contours.]

IOVWST 2023, Nanjing, 30th Nov
Model of land-contaminated $\sigma_0$

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

- $\bar{\sigma}_{0,S}$, $\bar{\sigma}_{0,L}$, $\epsilon_S$ and $\epsilon_L$ are unknown

State of the art

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

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


Noise regularization procedure:

1. $\sigma_0 = \bar{\sigma}_{0,S} + \left( \bar{\sigma}_{0,L} - \bar{\sigma}_{0,S} \right) f + \epsilon$ [3]

2. $\bar{\sigma}_{0,f} = a f + \bar{\sigma}_{0,S}$

3. $\bar{\sigma}_{0,f} \rightarrow \hat{K}_p(\bar{\sigma}_{0,f})$

4. CDF matching:
   \[ F_{\bar{\sigma}_{0,f},\hat{K}_p,f}(\bar{\sigma}_{0,f}) \equiv F_{\bar{\sigma}_{0,S},\hat{K}_p,S}(\bar{\sigma}_{0,S}) \]

Area test: north Adriatic (Mediterranean basin)

QuikSCAT Full-Resolution file ID 40653
corrected $\sigma_0$ with noise regularization

10 km

Venice

12.5°E 13.5°E 14.5°E 15.5°E 16°E
42.5°N
43°N
43.5°N
44°N
44.5°N
45°N
45.5°N
46°N

−0.015
0.000
0.015

LU

outliers
Residual land contamination due to lack of $\sigma_{0,5}$
Retrieval experiments

<table>
<thead>
<tr>
<th>Name</th>
<th>$f^{th}$</th>
<th>Noise regularization</th>
<th>Orbit IDs</th>
</tr>
</thead>
<tbody>
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<td>0.02</td>
<td>NO</td>
<td>40651-40664</td>
</tr>
<tr>
<td>NC</td>
<td>0.5</td>
<td>NO</td>
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</tr>
<tr>
<td>NR</td>
<td>0.5</td>
<td>YES</td>
<td>40651-40664</td>
</tr>
</tbody>
</table>

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
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°

- Wind speed:
  - \( U = C \cdot \text{SarMod}2^{-1}(\sigma_0, \theta) \) (Lu et al. 2018)

ASAR-derived winds

\[ \sigma_{0,\text{ASAR}} \]

\[ \mathbf{\vec{u}}_{0.9}^{\text{ASAR}} \]
Comparison between QuikScat and Envisat derived winds

\[ \mathbf{u}_{\text{ASAR}} \] vs \[ \mathbf{u}_{\text{QS}} \]

Black markers: rainy WVCs
Preliminary Conclusions & Future Work

Preliminary conclusions

- $\sigma_0$ correction with noise regularization is effective
- Wind retrievals are good, also in internal seas
- Coastal sampling gain: +400% within 5 km and $\approx$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)
Acknowledgements

- Project financed by OSI-SAF
  EUMETSAT: OSI_VSA_20_01, OSI_VSA_20_03, OSI_VSA_21_03, OSI_VSA_22_02

- Special thanks to
  - Prof. Dave Long (BYU)
  - Dr. Bryan Stiles and Dr. Roy Scott Dumbar (JPL)
Back-up slides