Discovering a decade of coastal winds from Ocean scatterometers

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Planned Data Set

- Global data set of coastal ocean surface winds
  - Extending within 5-10 km of the shoreline worldwide
  - Including QuikSCAT data from 1999-2009
  - Including winds of large land-locked bodies of water (e.g. the Great Lakes)
  - Including OceanSAT-2 data from 2010-2014
  - Including RapidSCAT data for the 2014-2016 mission.

Objectives

- Retrieve *accurate* winds to within 5-10 km of the coast from QuikSCAT data and use those winds to construct a 10-year database of all coastal winds observed by QuikSCAT. Accurate means:
  - RMS errors of the azimuthal and meridional components of the wind are less than 1.5 m/s.
  - Wind speed biases shall be less than 1.0 m/s for true winds over 3 m/s.
  - Data will be validated by comparison to buoys and numerical wind products.
- Similarly retrieve accurate coastal winds from OceanSAT-2 and RapidScat data.

Objectives

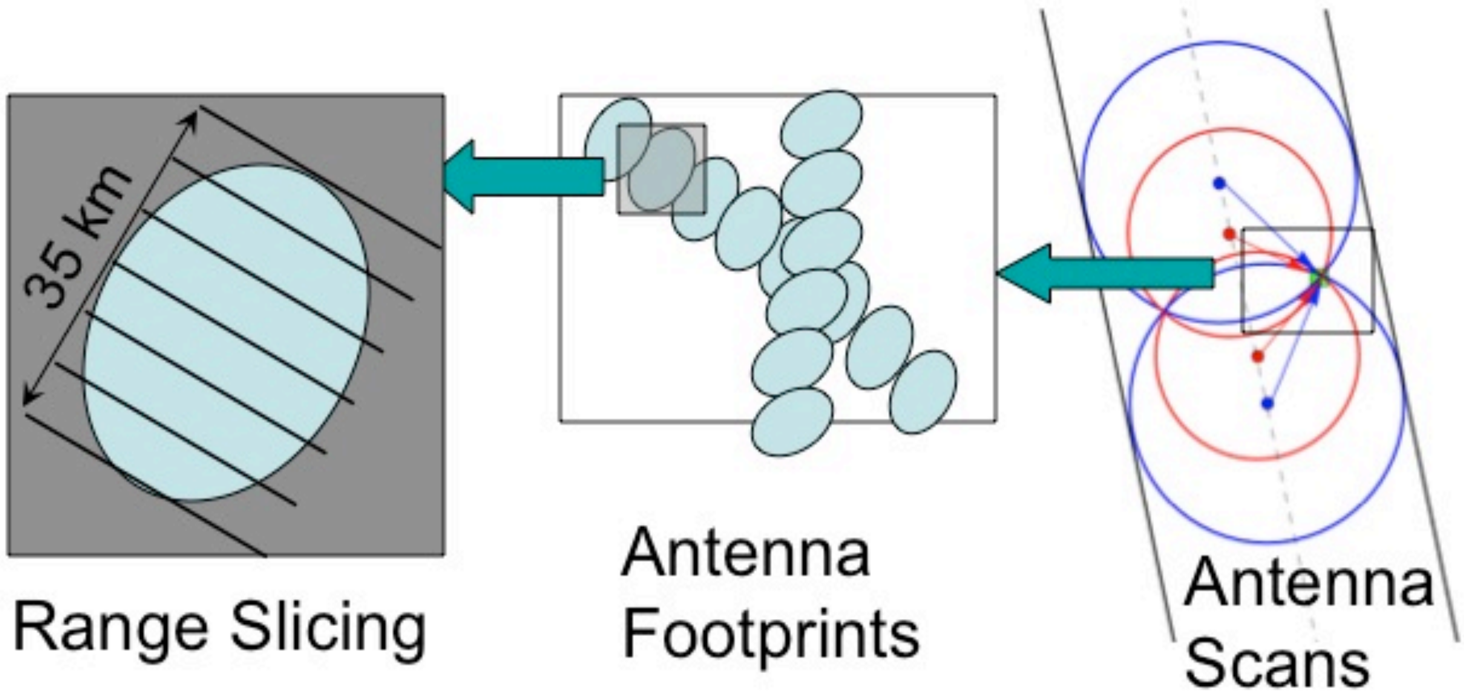
- Publish peer-reviewed papers in an academic journal that describe and validate the data set, and evaluate its scientific utility.
- Utilize the new coastal wind data set to investigate areas of interest in coastal meteorology and oceanography including
  - poorly understood coastal wind patterns such as winter downwelling (poleward winds),
  - amplification of winds between island systems (e.g., the Hawaiian islands and the Channel Islands off the coast of California),
  - production of eddies from coastal jets,
  - the relationship between coastal wind patterns and biological productivity.

Pencil-Beam Scatterometer Geometry

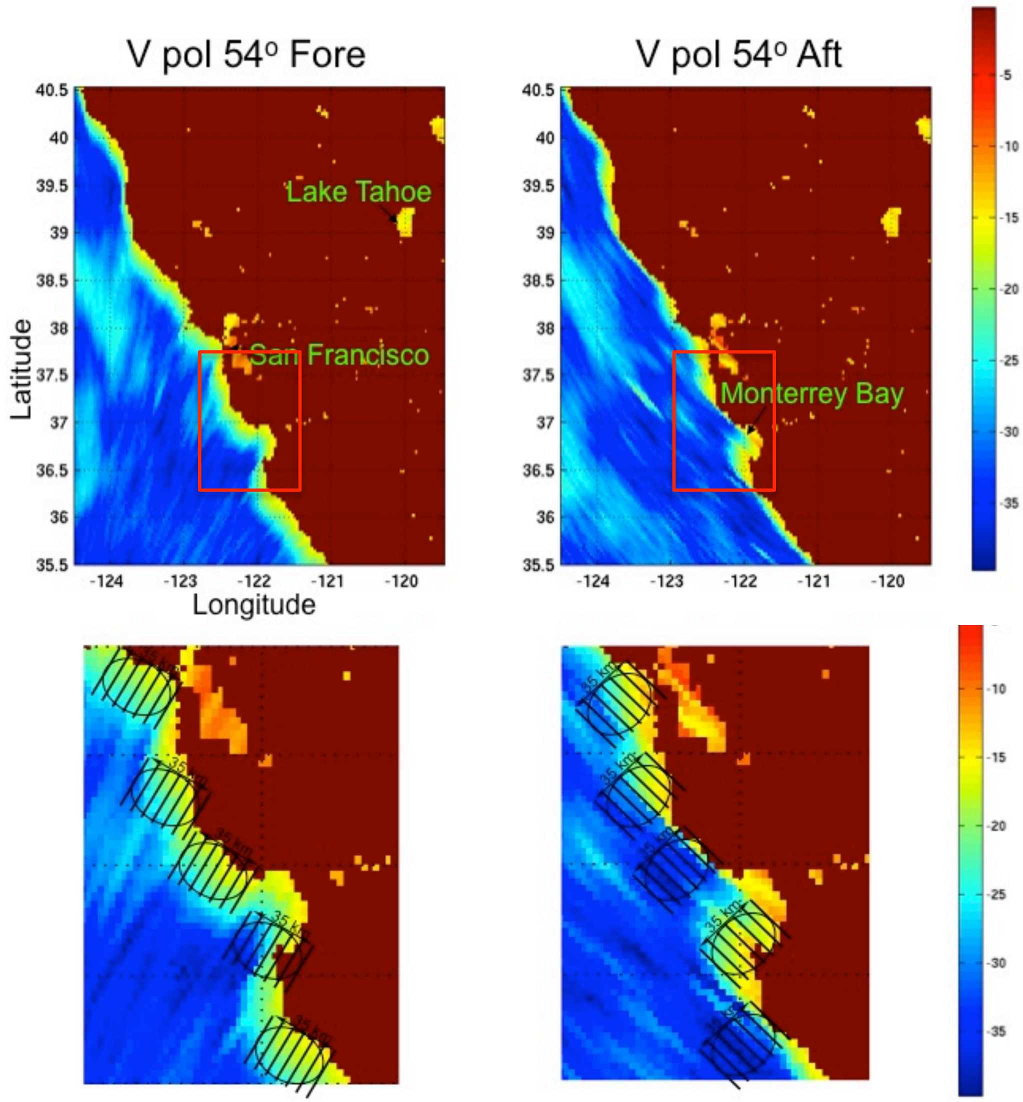
Range slicing improves resolution.

Overlapping footprints provide continuity and beat down noise.

Antenna scans overlap to provide azimuthal diversity.



QuikSCAT Land Contamination in NRCS for ~ 5 m/s winds

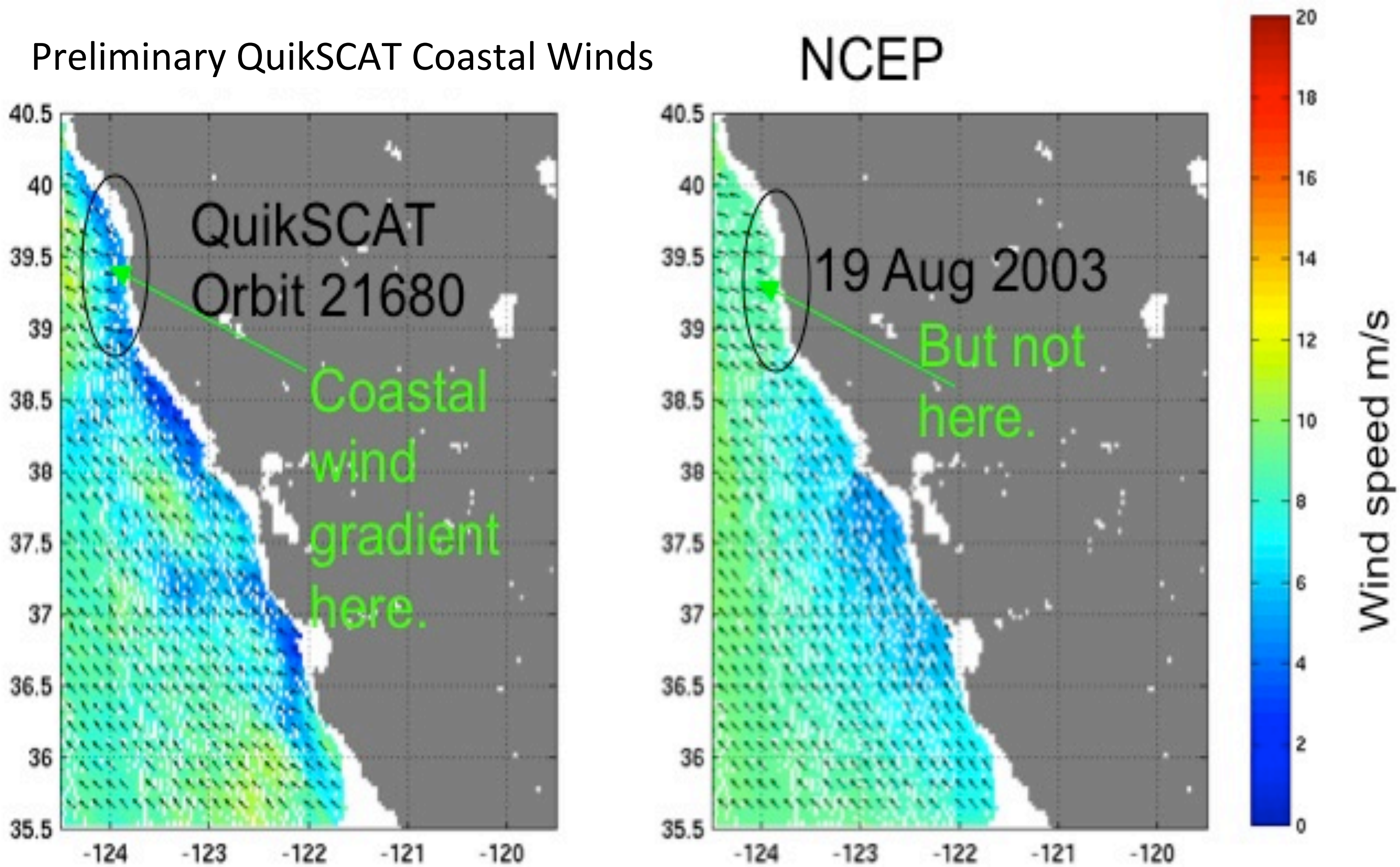


Land contamination results in high NRCS halo around coast.

- In current QuikSCAT L2B product this is handled by throwing out all measurements within ~20-30 km of coast.
- We propose to get within 5-10 km of the coast, by
  - Only excluding measurements that overlap land
  - Correcting measurements with small overlaps using estimated land NRCS values.

Why is this important?

Preliminary QuikSCAT Coastal Winds



Previous Techniques - ELM

- The Empirical Land Mask (ELM) approach (Vanhoff et al, 2013) estimates a different land mask for each antenna beam, and azimuth angle.
  - Presumes land NRCS is less variable than ocean.
  - For each azimuth, beam, latitude, and longitude, a NRCS variability quantity M is computed.
  - When M is above a threshold, land is indicated.
- Advantage: Both slice geometry and land contrast are accounted for by the technique.
- Disadvantage: Only as good as its assumption.
  - Variable land and/or invariant ocean (if any) is incorrectly classified.

Previous Techniques - LCR

- The Land Contamination Ratio (LCR) approach (Owen and Long, 2009) computes the spatial response of each measurement (slice)
  - A slice is land contaminated if the portion of its integrated spatial response over land exceeds a threshold.
- Advantage: More precise use of geometry than ELM, no empirical assumption
- Disadvantage: Does not account for variations in radar brightness over land.

Proposed Technique

- LCRES, similar to LCR except Expected Sigma-0 (ES) over land is included in the integration.

LCRES = $\hat{\sigma}_{0land} = \iint R(x,y)L(x,y)E(\sigma_0|x,y,b,\alpha)dxdy$ (1)

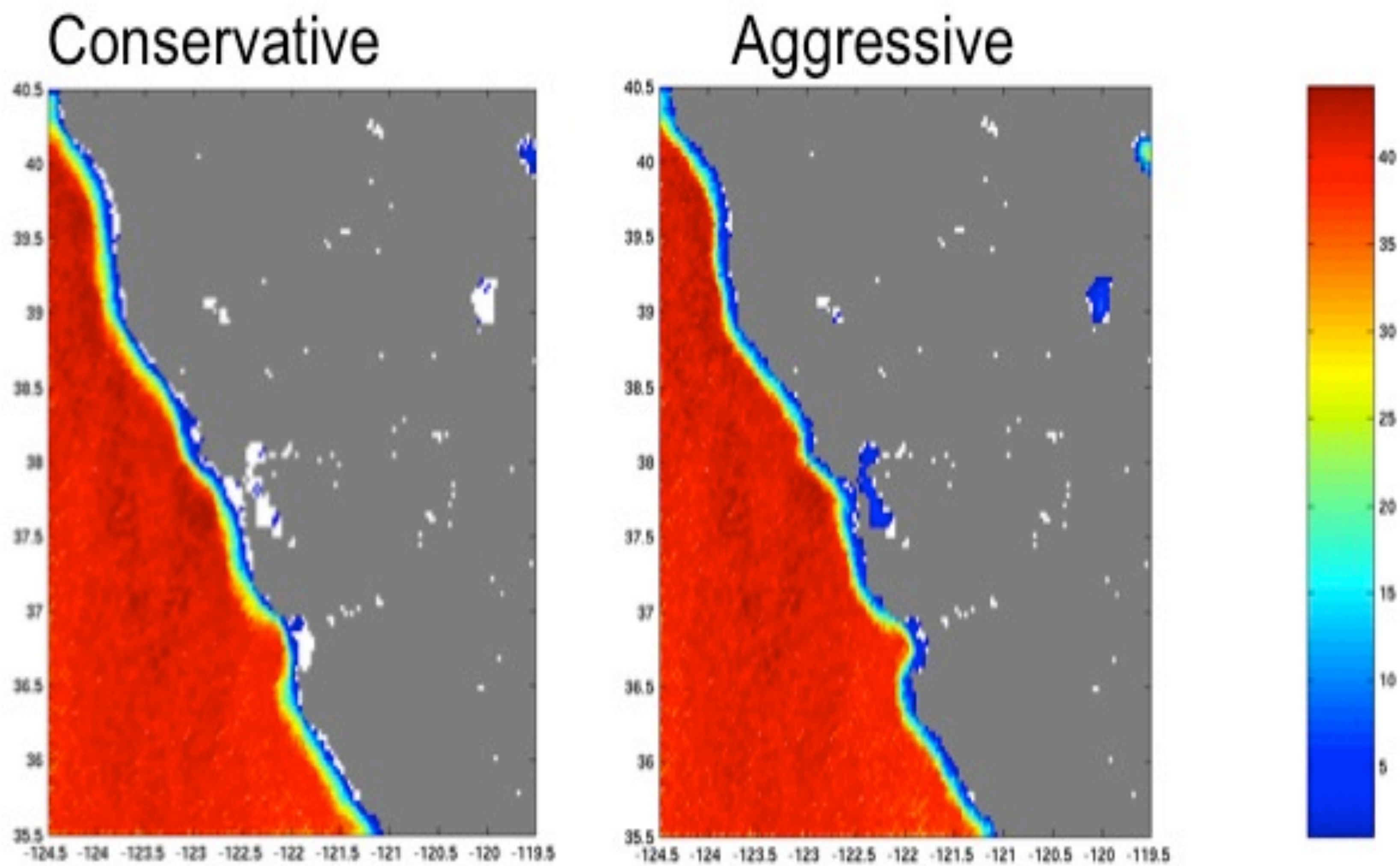
$$f_{land} = \frac{\iint R(x,y)L(x,y)dx\,dy}{\iint R(x,y)dx\,dy} \quad (2)$$

$$\hat{\sigma}_{0ocean} = \frac{\sigma_0 - \hat{\sigma}_{0land}}{1 - f_{land}} \quad (3)$$

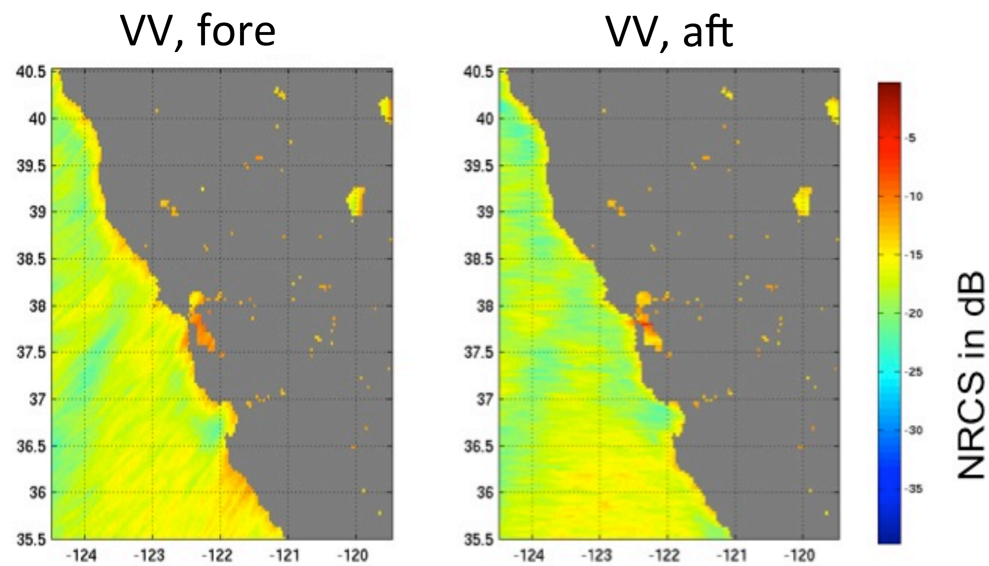
Proposed Technique

- Conservative approach:
  - Throw out measurements where LCRES exceeds a threshold (0.0005 = -33 dB, for preliminary results)
- Aggressive approach:
  - Throw out measurements where LCRES exceeds a higher threshold (0.005 = -23 dB, for preliminary results)
  - Correct Remaining measurements using equation(3)
- NRCS variability (as used by ELM) and as computed by (Jaruwatanadilok et al, 2013) is used to refine land map L, spatial responses R, and thresholds.

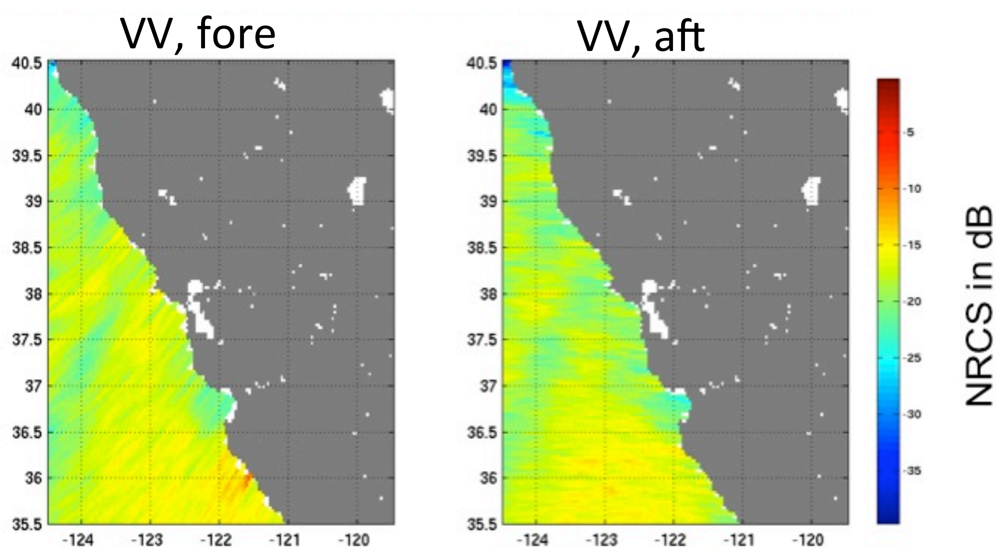
Preliminary Results-Coverage Frequency



Preliminary Results-NRCS

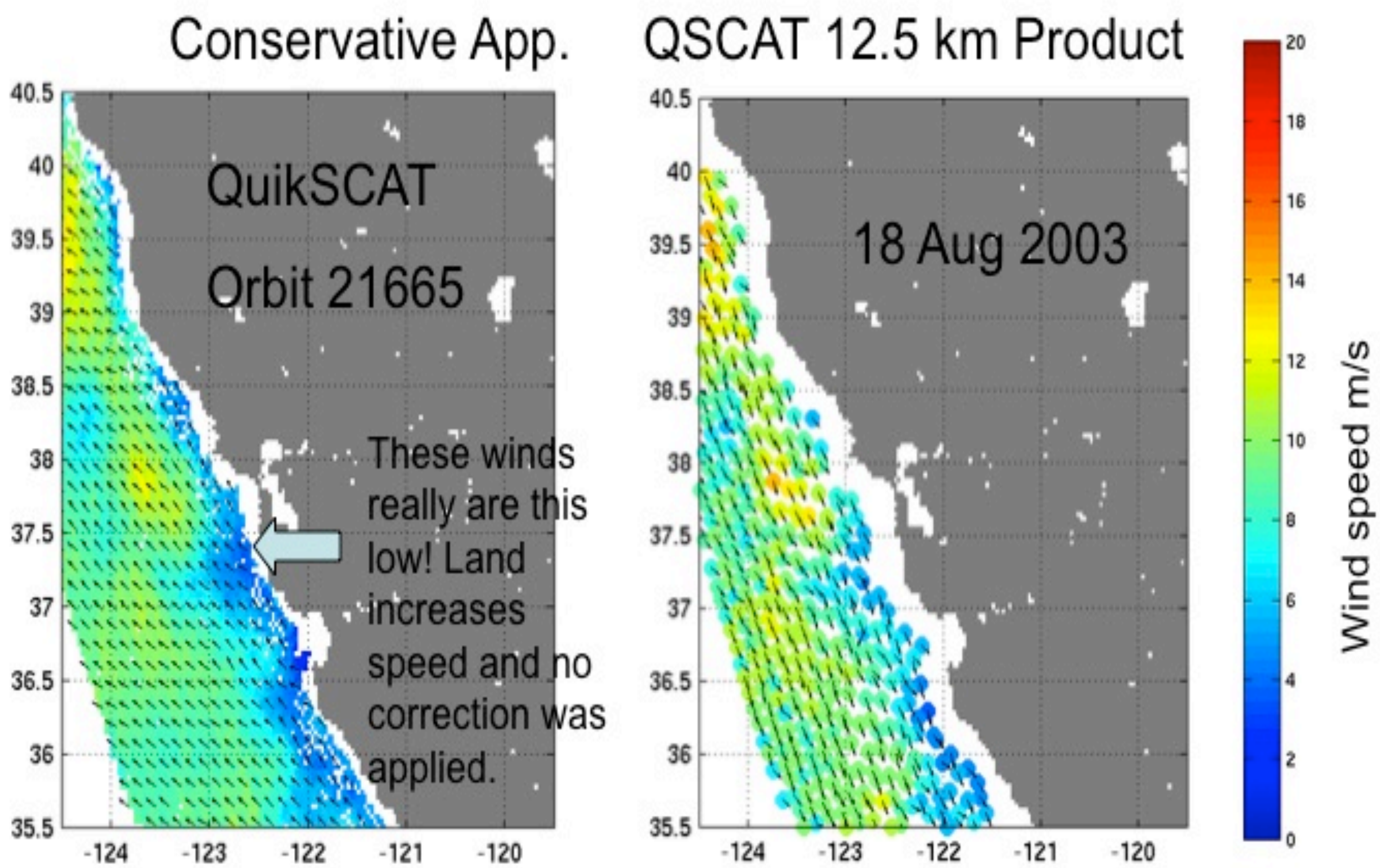


Land Contamination of NRCS in ~15 m/s wind scene.

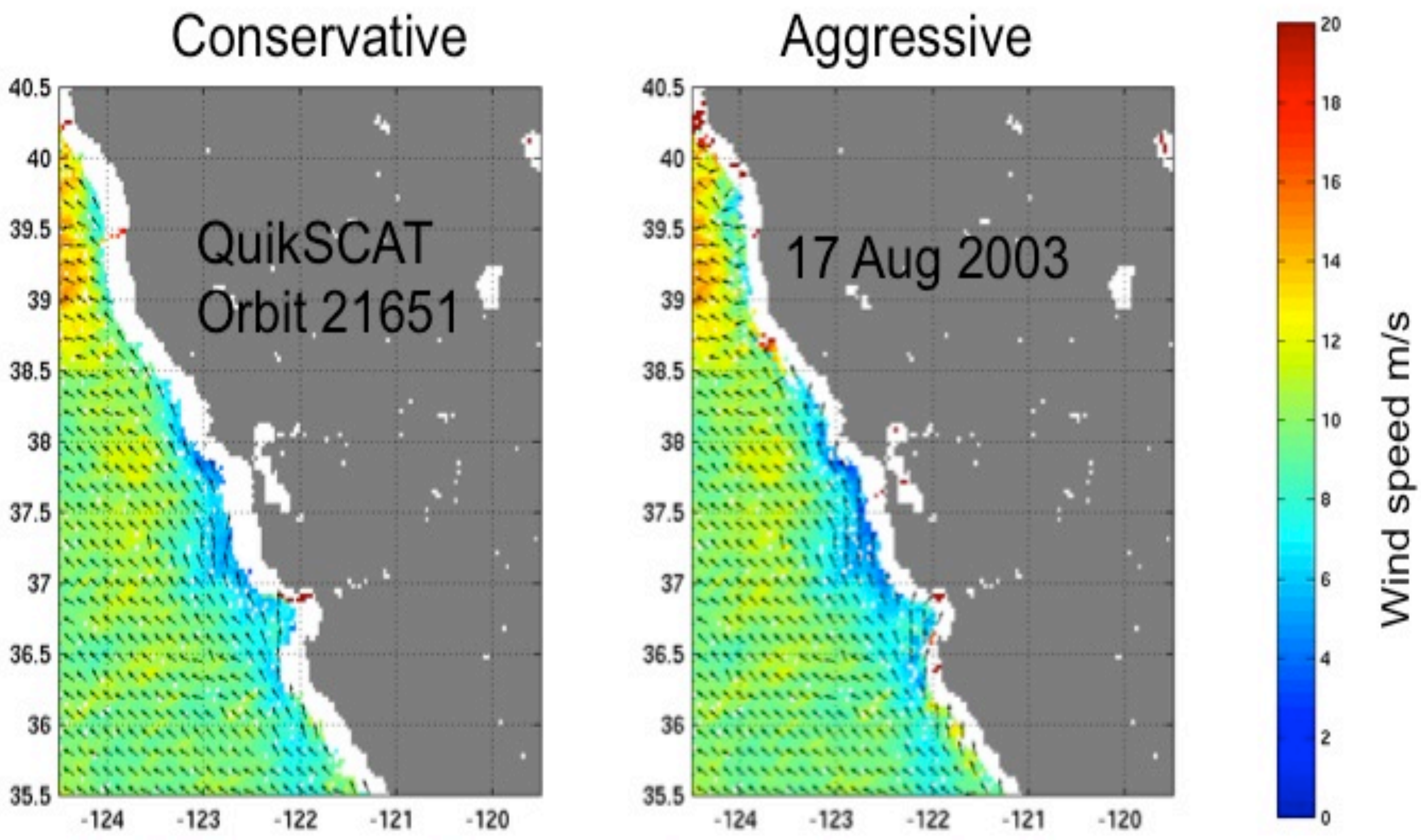


Same as above with NRCS that overlap land removed. (Conservative Approach)

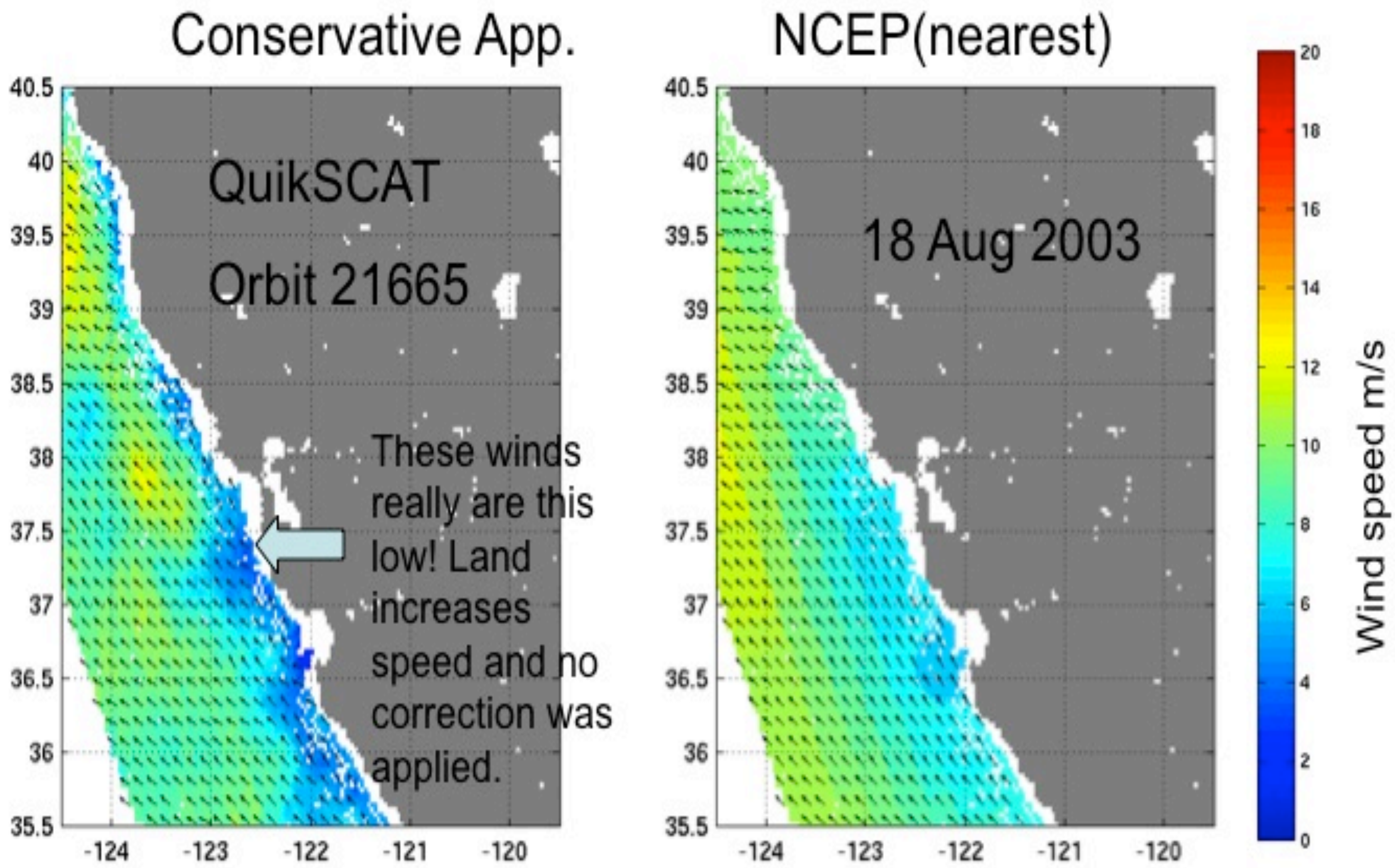
Preliminary Results-Wind



Preliminary Results-Wind



Preliminary Results-Wind



References

- Owen, M.P.; Long, D.G., "Land-Contamination Compensation for QuikSCAT Near-Coastal Wind Retrieval," *Geoscience and Remote Sensing, IEEE Transactions on* , vol. 47, no.3, pp.839,850, March 2009.
- Vanhoff, B., Freilich, M., and Strub, T., "QuikSCAT Level 3 Near-Coast Wind and Stress Fields with Enhanced Coastal Coverage (OSU): US West Coast Region: Guide Document," 6 June 2013, obtained on from http://podaac.jpl.nasa.gov on Sept 25, 2013.
- Jaruwatanadilok, S.; Stiles, B.W., "Trends and Variation in Ku-Band Backscatter of Natural Targets on Land Observed in QuikSCAT Data," *Geoscience and Remote Sensing, IEEE Transactions on* , vol.PP, no.99, pp.1,8, doi: 10.1109/TGRS. 2013.2281722