Chapter 6

Conclusion

6.1 Summary

Three main topics have been studied and discussed in this thesis: the use of the NRCS combined with PRDF measurements from dual polarized SAR stripmap data in a sea surface wind retrieval scheme, the NRCS and Doppler models based on the generalized curvature ocean surface scattering model.

Using dual polarized X-band data, we have explored the potential use of the PRDF in sea surface wind retrieval. Such a task requires two separate GMFs for the NRCS and Doppler centroid estimations, respectively. The GCM-NRCS and GCM-Dop GMFs have been selected in this study, where wind fields are inferred from a series of dual polarized X-band TerraSAR-X images obtained along the Norwegian coast. These wind field estimations are compared with in proximity \textit{in situ} measurements for validation purposes. We find that mean estimated wind speeds from each selected TerraSAR-X scenes agree well with their respective collocated \textit{in situ} measurements. We also note the use of the PRDF helps decrease the number of wind ambiguities down to two. Furthermore, the PRDF helps decrease geometric $D_c$ contribution and possible instrumental Doppler errors.

The backscatter model based on the electromagnetic surface scattering model, first introduced in [Engen et al., 2006], is also revisited. A sea surface spectrum undressing procedure is now being included in the model, as well as a more realistic description of the sea surface. The latter is made possible by including asymmetrical surface waves into the model, which we refer to as a skewness related phase component. Such an approach helps improve the GCM-NRCS GMF performance compared to CMOD5.n GMF, where an up/down-wind asymmetry is now present for all tested wind and radar conditions.

This skewness related phase component is also included in the GCM-Dop, first introduced in [Pedersen et al., 2004], for winds up to 10 m/s. For winds greater than 10 m/s, a wave breaking component is included instead. The performance of this Doppler model is measured against the semi-empirical CDOP GMF for various wind and radar
conditions. The model has been found to perform well compared to CDOP, by providing a more realistic Doppler centroid model. Just as with the backscatter model, the GCM-Dop now exhibits up/down-wind asymmetry when either the skewness phase related coefficient or the wave breaking component is included in the model. In certain wind and radar conditions however (e.g. between 7 and 10 m/s wind speed with incidence angle less than 32 degrees), the GCM-Dop overestimates the $D_c$ especially in the up-wind condition. This may indicate that the current version of the skewness phase related coefficient needs further work.

### 6.2 Future works

While the potential use of the PRDF in SAR sea surface wind retrieval measurements is explored in this thesis, we make the claim that this metric helps reduce significantly possible surface current $D_c$ contribution. Follow-up work could include dedicated SAR data acquisitions over coastal areas exhibiting both surface current and wind field; combined with *in situ* measurements, validation work would either confirm or deny this claim. Furthermore, the PRDF performance in SAR sea surface wind retrieval measurements could be analyzed for different radar operating frequency other than X-band.

At this point, the improved versions of the backscatter and Doppler models have only been tested against semi-empirical GMFs such as CMOD5.n and CDOP, respectively. The next step should include actual sea surface wind retrievals using these two models combined with actual NRCS and $D_c$ measurements from a SAR instrument such as TerraSAR-X, RadarSAT-2, or Sentinel-1. These retrieved measurements could then be compared to *in situ* measurements.

Finally, both backscatter and Doppler models do not have to be tied to the electromagnetic scattering model from [Engen et al., 2006]. It would be interesting to re-derive these models using a different electromagnetic model and measure their respective performance.
Bibliography


About the author — Faazi Said was born in France but grew up in the beautiful islands of French Polynesia. He first received both his Bachelor and Master of Science in Electrical Engineering from Brigham Young University in Provo, Utah in 2007 and 2009, respectively. He has spent a total of four years working fulltime towards the Ph.D degree, two of them spent in Tromsø, Norway, and the last two years as a guest scientist at Ifremer-Brest, France. He is now living with his family in the United States of America where he works as a support scientist for the Ocean Surface Winds Team (OSWT) of the Center for Satellite Application and Research, at the National Oceanic and Atmospheric Administration (NOAA) in College Park, Maryland.