Estimation of First-Year Sea Ice Melt Pond Fraction from Compact Polarization SAR

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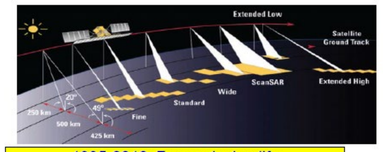
1. Why Estimate Melt Pond Fractions?

1. Covers to 60-90% of sea ice surface [Inoue et al., 2008; Perovich et al. 2011; Polashenski et al. 2012].
2. Surface albedo 4X *smaller* than snow-covered ice
3. Absorbs solar light 4X more efficiently
4. Melt rate under melt ponds up to 3X that of bare ice [Flocco etc, 2012; Kim etc., 2013].
5. Increased absorption of melt ponds accelerates decay of sea ice
6. Intensified warming of ocean delays ice growth in the autumn [Hudson et al., 2013; Schröder et al., 2014; Flocco et al., 2015].

SAR is better than optical sensors - clouds in Arctic summer can be ~80%

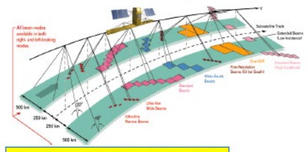
2. How to measure melt ponds?

RADARSAT-1
Only VV polarization



1995-2012; 7-year design life

RADARSAT-2
Quod Polarization; HH, VV, HV, VH



2007-present; 7yr design life

RADARSAT Constellation Mission - RCM

New Compact-Polarization! --- 7yr design life

- How to obtain melt pond retrieval from RCM compact pol (CP) SAR data?
- How to link RADARSAT-2 parameters to RCM parameters in CP?

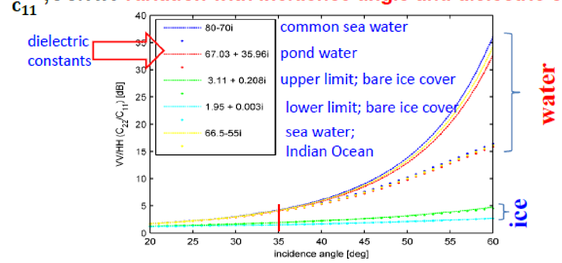
3. Link CP parameters to RADARSAT-2 ratio

Mathematical manipulation + assumption of reciprocity and reflection symmetry…etc. …

$$\frac{C_{22}}{C_{11}} \cong \frac{\sigma^{\circ}_{VV} + \sigma^{\circ}_{HV}}{\sigma^{\circ}_{HH} + \sigma^{\circ}_{HV}}$$

depends on incidence angle +dielectric constant, *not* surface roughness or waves

$\frac{C_{22}}{C_{11}}$, VV/HH variation with incidence angle and dielectric constant

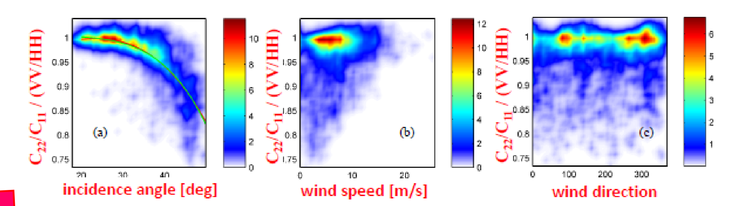


The dashed lines represent VV/HH → RADARSAT-2,
The dotted lines represent C_{22}/C_{11} → RCM
The blue, red and yellow colors represent *different* kinds of water
green and cyan represent *extreme* values of sea ice

4. Empirical approach…

2062 SAR images and collocated NDBC buoys

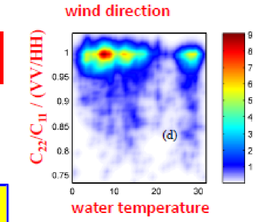
→ link $\frac{C_{22}}{C_{11}}$ from RCM (CP) with VV/HH (RADARSAT-2)



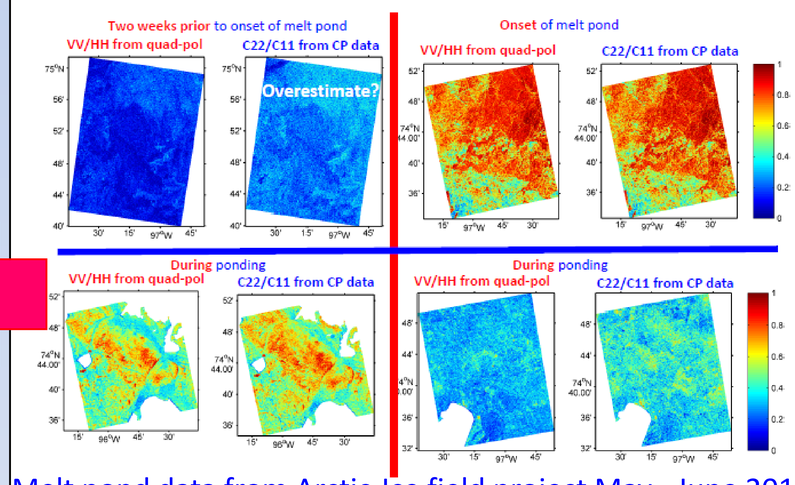
$$\frac{C_{22}}{C_{11}} \Big/ \frac{VV}{HH} = CPQP = P_1\theta^3 + P_2\theta^2 + P_3\theta + P_4$$

P_1	P_2	P_3	P_4
-3.697e-6	0.000114	0.0007335	0.9666

$$f_p = 0.1525 \cdot 10 \cdot \log_{10}\left(\frac{C_{22}}{C_{11}}/CPQP\right) + 0.1564$$

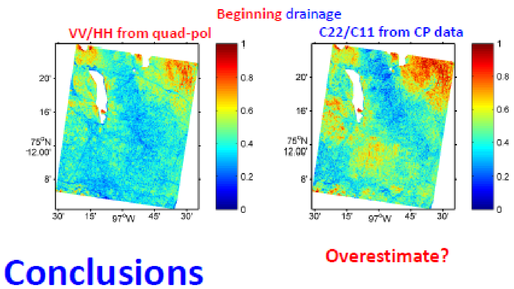


5. Area results … melt pond fractions



Melt pond data from Arctic-Ice field project May - June 2012

6. Results…

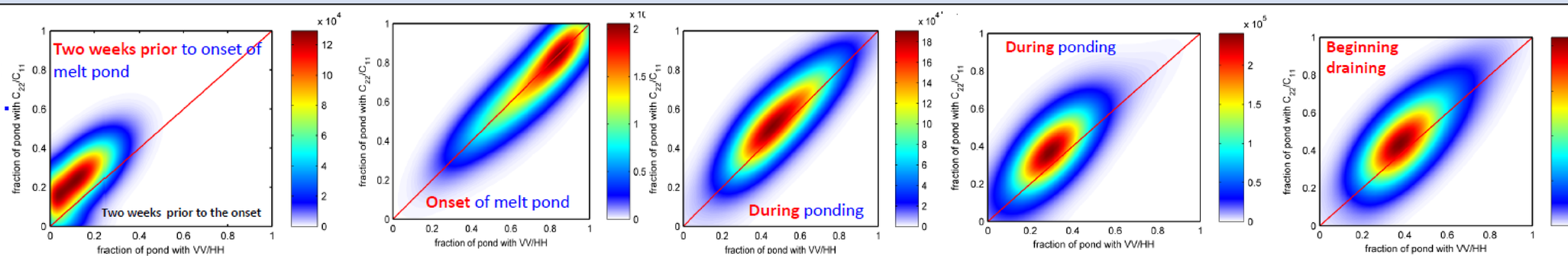


Conclusions

1. Completed results for 5 stages of melt ponding for the models for VV/HH from RADARSAT-2 quad-pol and C_{22}/C_{11} from simulated CP RCM
2. Suggest we can use RCM C_{22}/C_{11} to estimate melt pond fractions for FYI.

Li, H., Perrie, W., Li, Q., & Hou, Y., 2018 : Estimation of melt pond fractions on first year sea ice using compact polarization SAR. Journal of Geophysical Research: Oceans, 122, 8145–8166. https://doi.org/10.1002/ 2017JC013248

Appendix: analysis… scatter plots



Melt pond fractions from VV/HH (x – axis) and simulated CP SAR data from CPQP (y – axis)
Colorbar is number of pixels.