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RCM Compact Polarimetry Applied to Watershed Study

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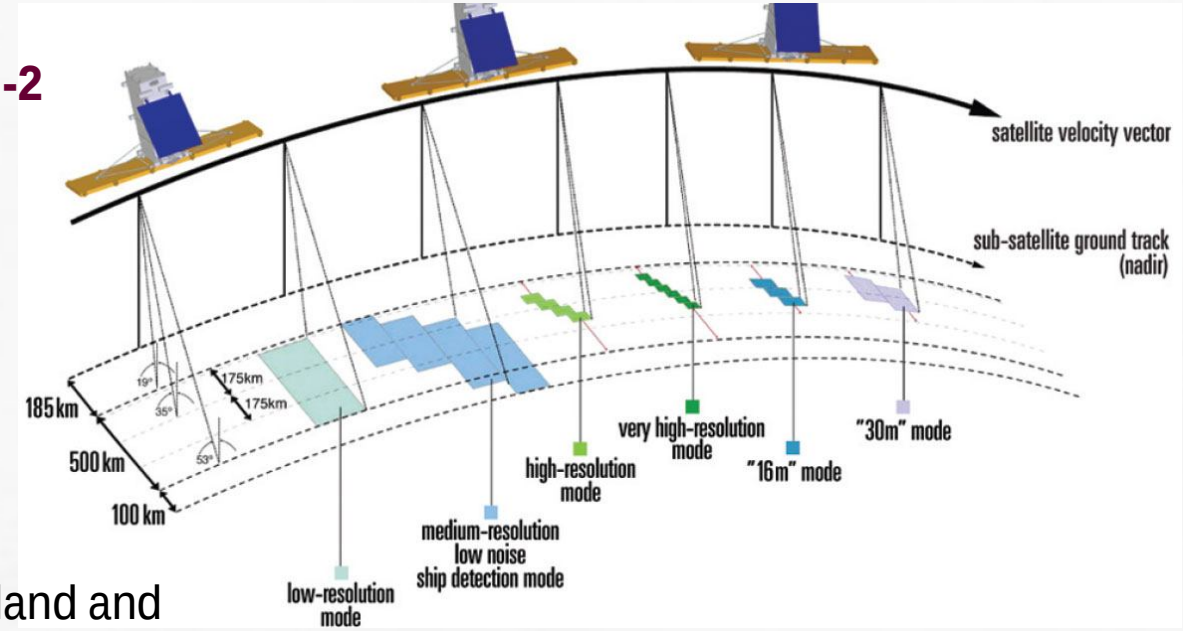
European Space Agency

Outline

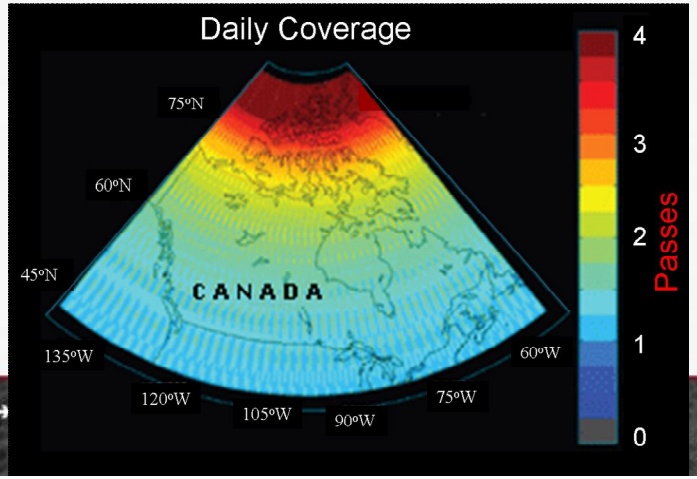
- RCM and ongoing CP projects
- Potential watershed monitoring with RCM
  - Soil moisture
  - Vegetation structure with CP-Insar
- Impact of non-circularity and noise floor

RCM: RADARSAT Constellation Mission

- **In continuity of RADARSAT-1 & -2**
- **Three-satellite SAR mission**
- **10 SAR modes**
  - C-Band
  - Single pol, linear dual-pol, **Compact pol,** exp Quad pol
  - Swath up to 500 km



- **Rapid Revisits & CCD**
  - Daily coverage of Canada's land and oceans
  - Four day InSAR capability



Operational Mission Drivers

- Ecosystem Monitoring
- Disaster Management
- Maritime Surveillance

Project Team & Applications

CCRS

- F. Charbonneau
- B. Brisco
- J. van der Sanden
- R. Touzi
- T. Toutin

Federal Partners

- Canadian Space Agency
- National Defense Canada
- Agriculture Canada
- Environment Canada – Ice Service
- Canadian Forest Service
- Parks Canada Agency
- Royal Military College

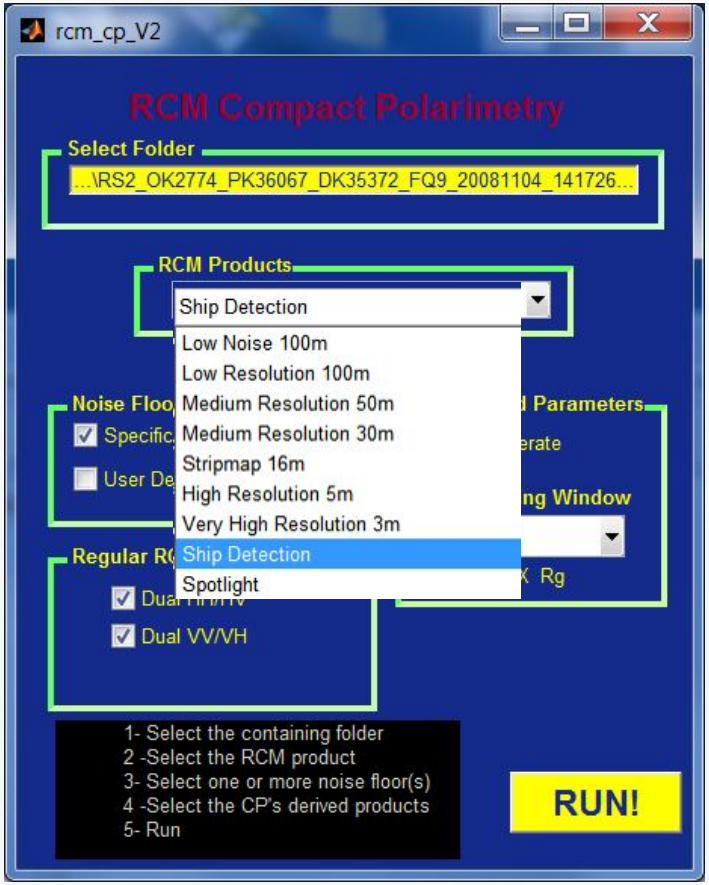
Applications

- CP Simulator
- Calibration
- Surface Modeling
- Agriculture Crops Classification
- GrassLand
- Wetland Classification
- Forestry
- Change detection
- CP-InSAR
- 3D-Radargrammetry
- Lake Ice & River Ice
- Sea Ice Classification
- Wind Speed Retrieval
- Ship/Iceberg Detection
- Oil Slick Detection & Char.

Land

Maritime

RCM CP Simulator



Inputs: RADARSAT-2 FQ/FQW/SQ/SQW

Noise floor: RCM specs or user defined

Output Products:

- 9 RCM modes
- RCM-CP:
  - ✓ RH, RV, ϕ_{RHRV^*}, RR, RL
  - ✓ Received Stokes vector
  - ✓ CP derived parameters

    m, μ_C , δ, μ_E, SE, α_s, ρ & [Ps,Pd,Pv]
- RCM – Dual
  - ✓ HH/HV et VV/VH
- Compatible with PCI and NEST
  - ✓ Reads orbital info for orthorectification

Watershed Context

- Watershed management involves monitoring “parameters” that have impact on hydrology/hydrogeology
- “Parameters” where SAR is sensitive
  - Soil moisture/roughness
  - Trees (forest)
  - Agriculture crops: cereal (soft crop) and horticulture (hard crop)
  - Change detection (urban dev., wetland & crop type)

Soil Moisture

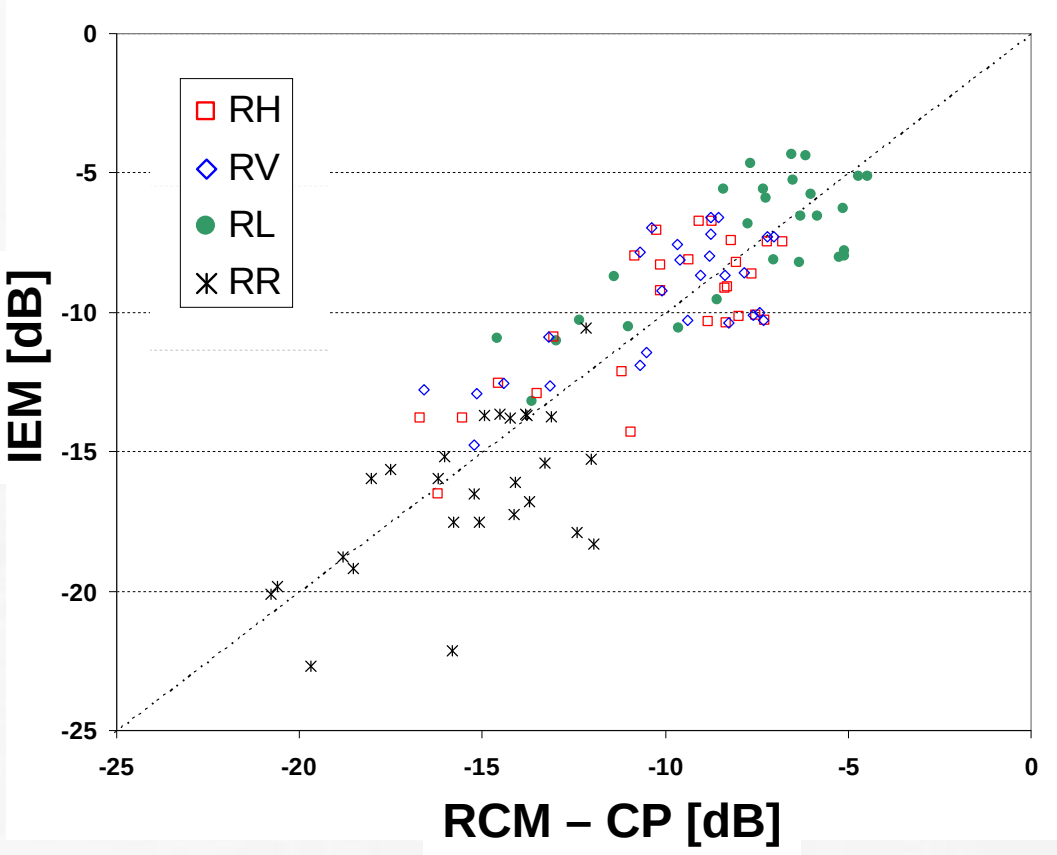
Theoretical modeling

- No reconstruction of HH, VV and HV
- Adapt IEM directly to RH, RV, RL and RR
- Need to
  - Change the Fresnel coefficients
  - Change the field coefficients
  - Better take care of the multi-scattering component

In Situ Measurement

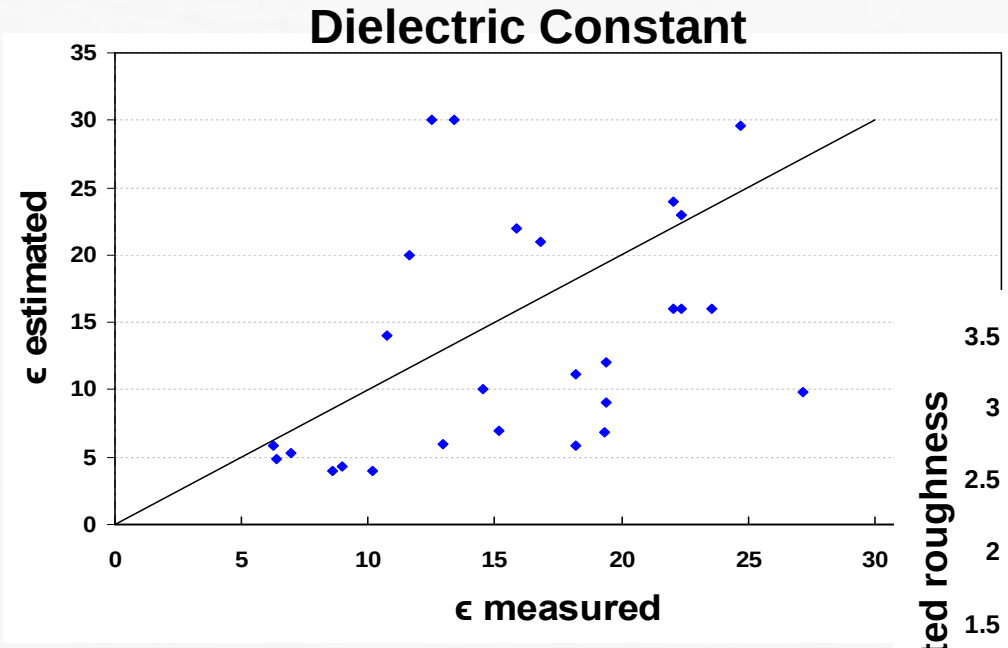
First Approximation – $k_z\sigma_{RMS} < 3$

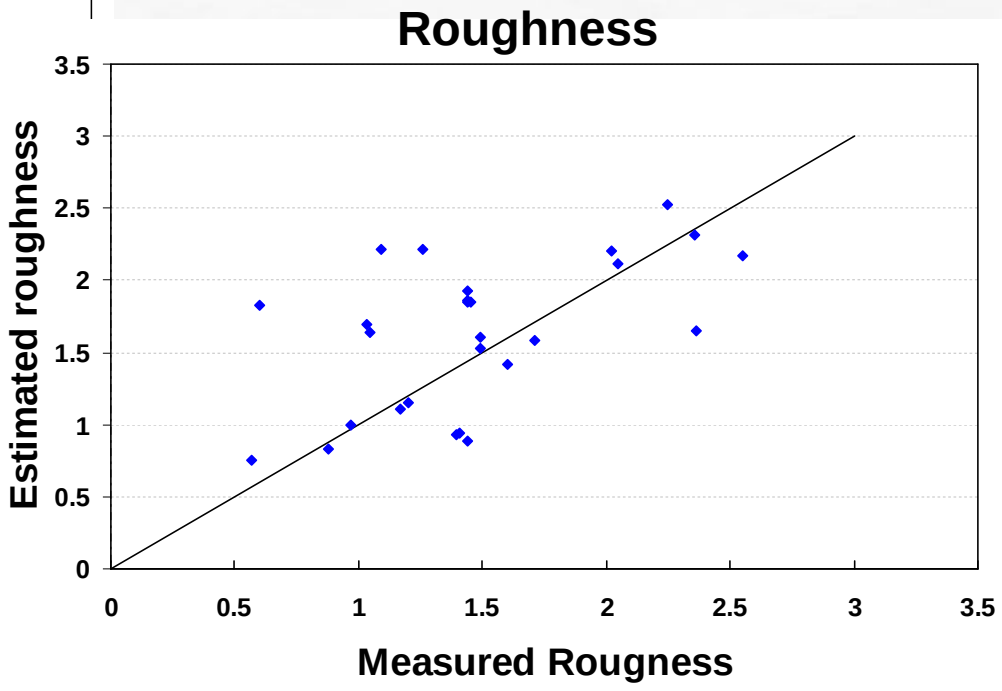
- First trial : Bare soil
- Feeding IEM with in situ



Defining a surface by σ_{rms}, L and a correlation function is always tricky. Since the uncertainty on these parameters is high, we need to be careful with interpretation of results

ε and σ_{rms} estimated from IEM (LUT Approach)





Could have done better with multi-incidence and or multi-date (RCM = daily coverage)

Vegetation Structure

CP-InSAR assessment

C-Band Facts for Vegetation

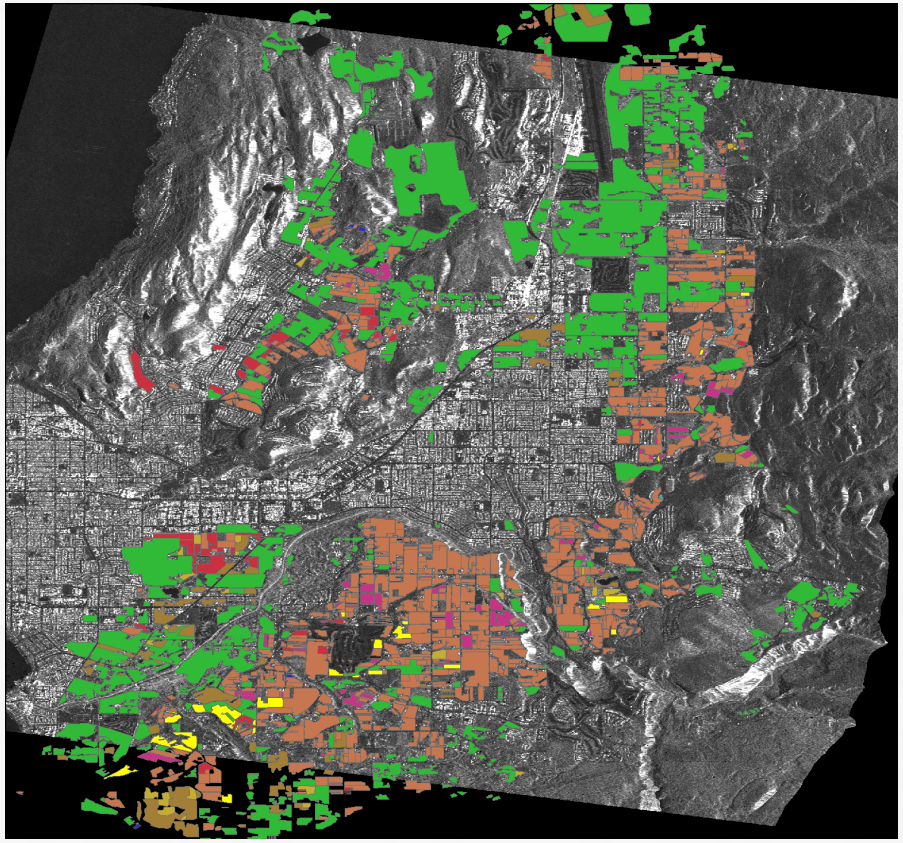
- Short vegetation biomass/density usually well assessed from the volumetric/depolarized component of Dual pol linear, Dual pol CL or full quad
- High biomass == saturation at C-Band
- What about characterization of the tree canopy when leaf off?
  - Single date gives info in some cases (Touzi et al. 2004)
  - Does adding the insar dimension bring new information?

CP InSAR

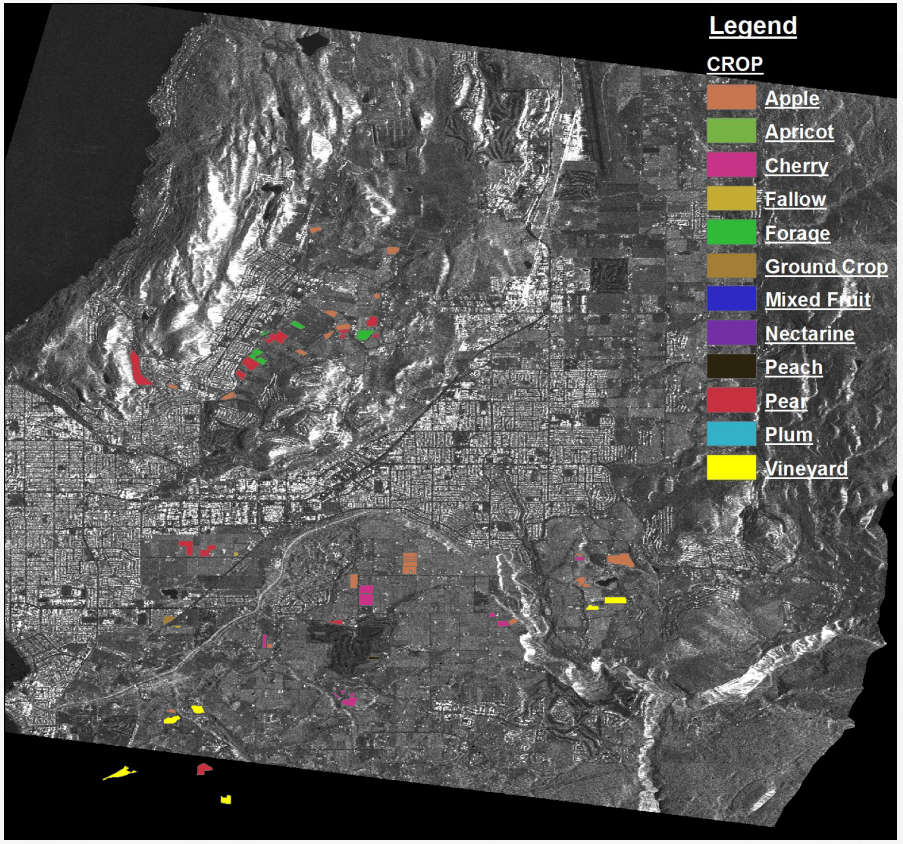
- Limited @ C-band spaceborne
  - Height : not enough sensibility in $\Delta\phi$
  - Not interested doing DEM of the tree scattering center if we don't "see" the ground
  - Current data: RSAT-2
    - 24 days repeat pass = Temporal decorrelation
  - RCM baseline: 200 m orbital tube
- Nevertheless, can we look for structural info?

Database and Fieldwork: Kelowna, BC

AAFC
Land Use Database



CCRS/AAFC
Fieldwork 2007 & 2011



Why Okanagan Valley for CP-InSAR?

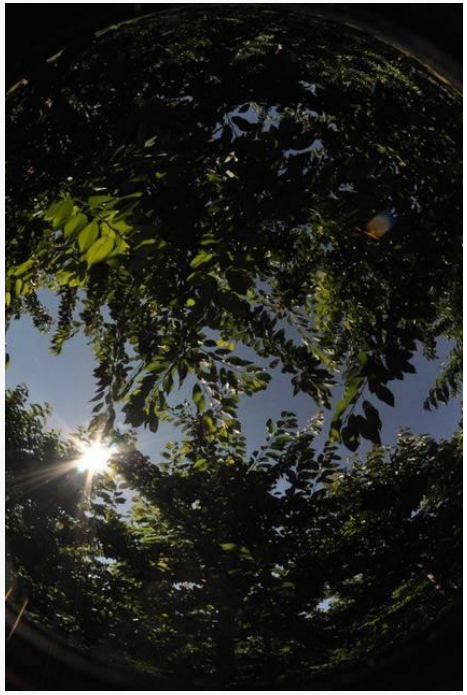
- Coherence at C-Band
  - "Small" trees: prevent saturation
  - Row spacing: Potential to "see" ground
  - Horticulture: Spaced and organized crop
  - Dry environment: Temporal coherence

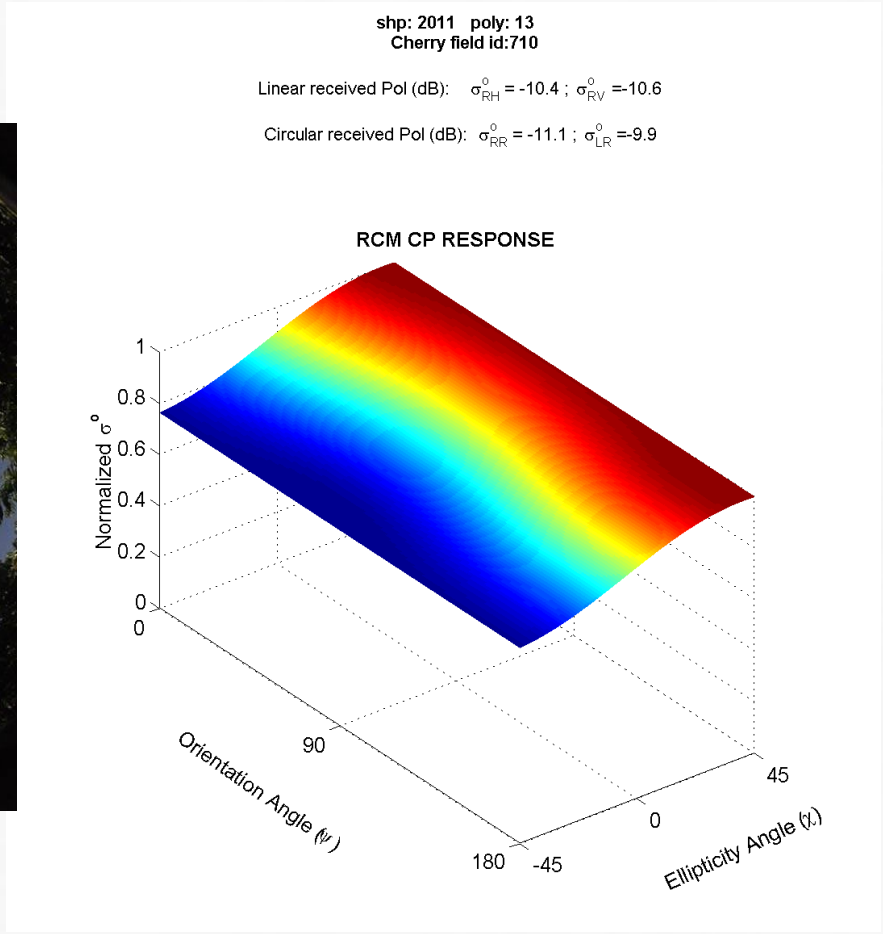
Radarsat-2

- Fine quad
  - Multi-year since 2008 (Mainly late summer/fall season)
  - Multi-Incidence 20º to 45º
- Simulated to RCM-CP

CP Intensity Signature

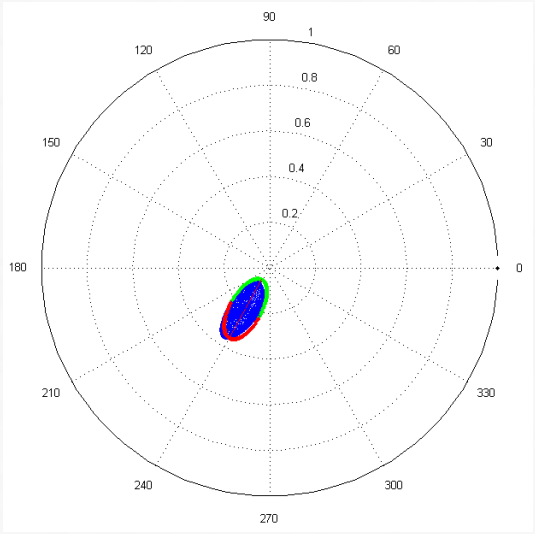
- Dense vegetation is quite boring at C-band





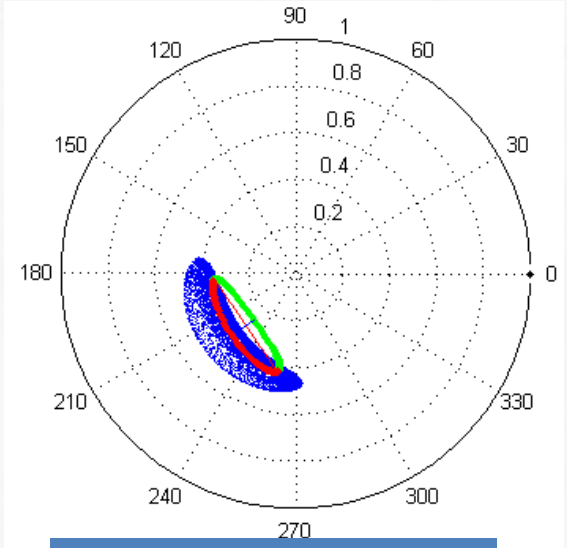
CP-InSAR Coherence Examples

HD Apple (recent)



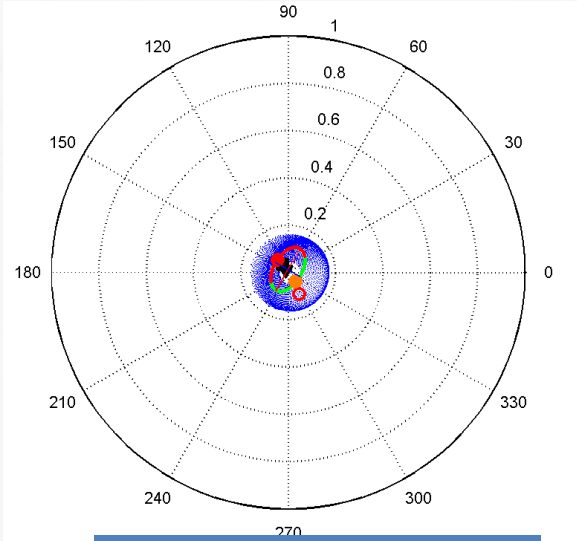
FQ5_Field #20
20111013_20111130

Cherry



FQ5_Field #17
20111013_20111130

Apple

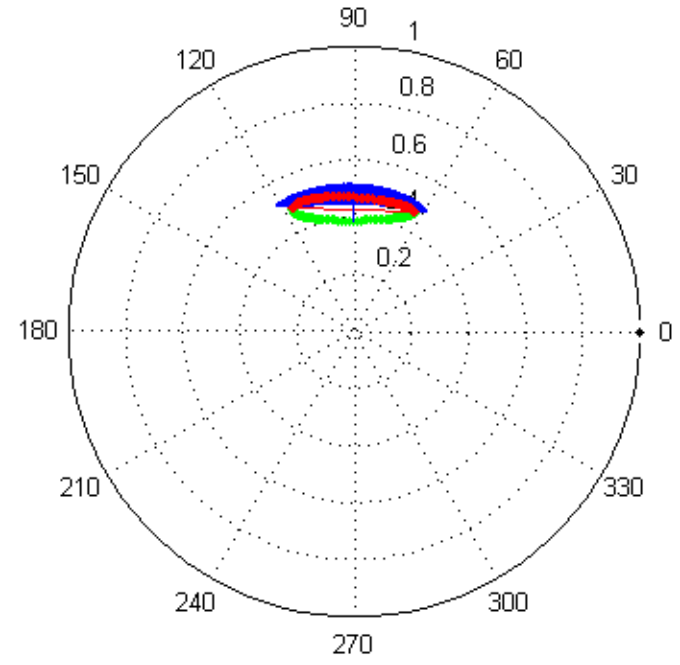


FQ18_Field #9
20121028_20121004

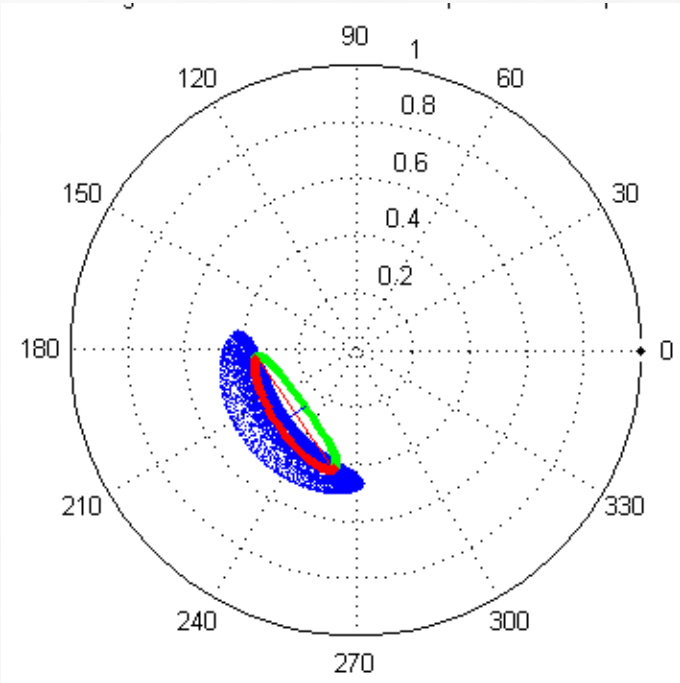
Baseline Effect

Cherry @ 26º

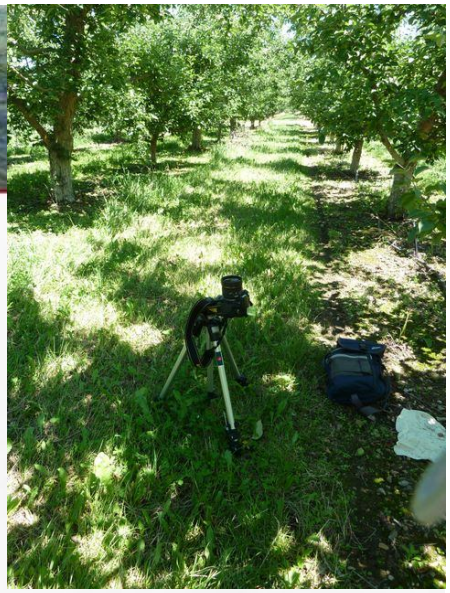
$B_{\perp} = 126m$



$B_{\perp} = 164m$

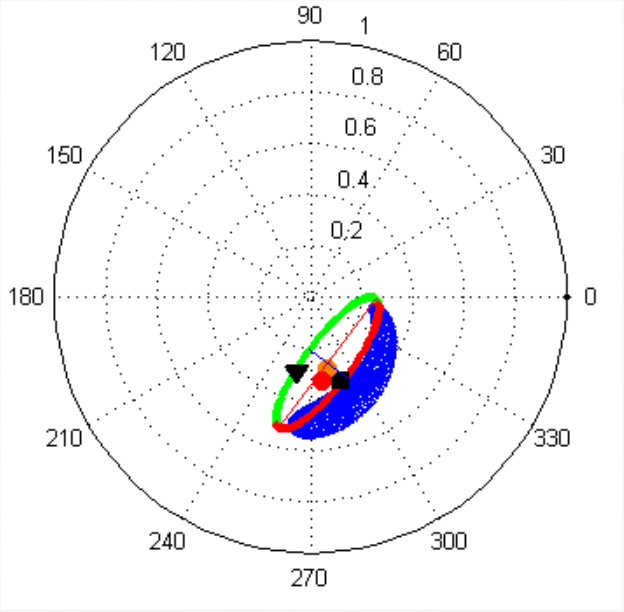


Incident Angle



θ =26°

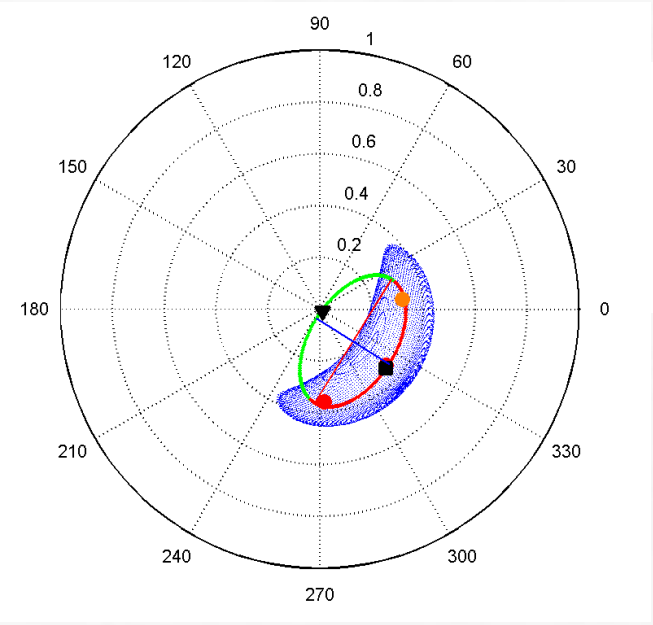
$B_{\perp} = 126m$



20111013_20111106

θ =35°

$B_{\perp} = 122m$

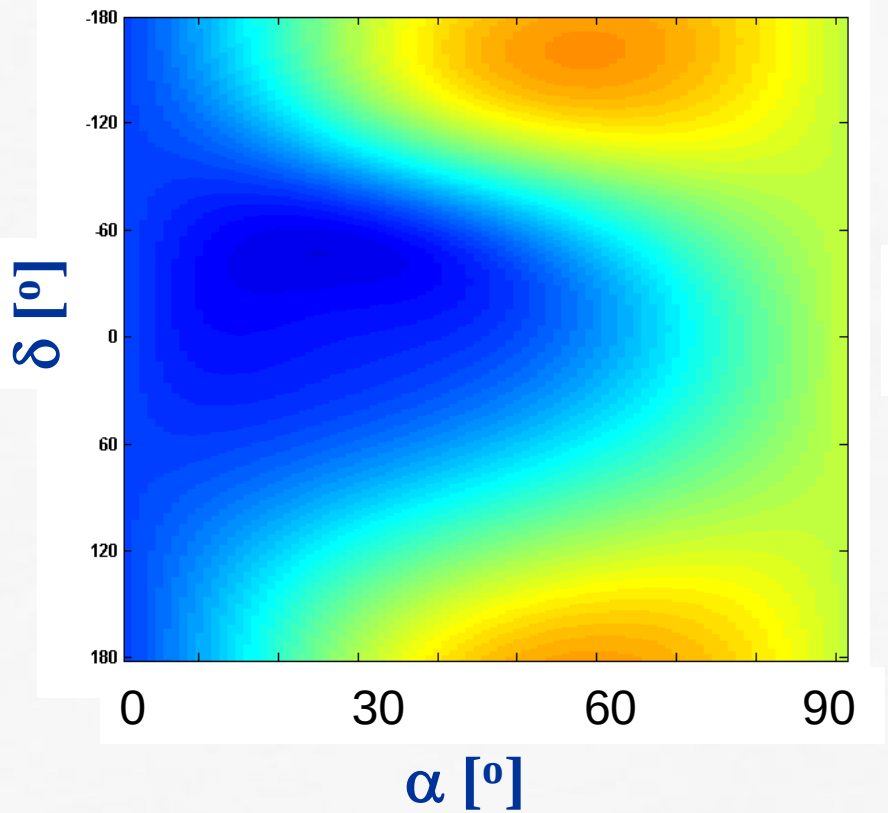


20111120_20111214

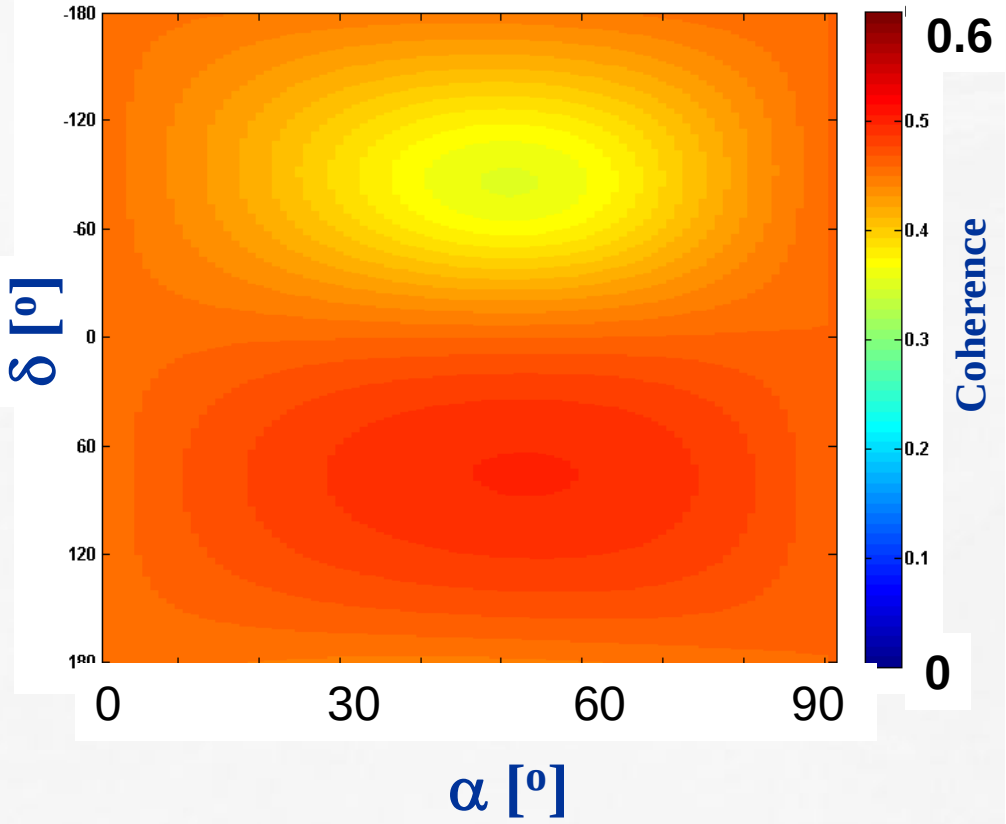
RH
RV
RR
RL

Coherence Signatures: w1= w2

Cherry

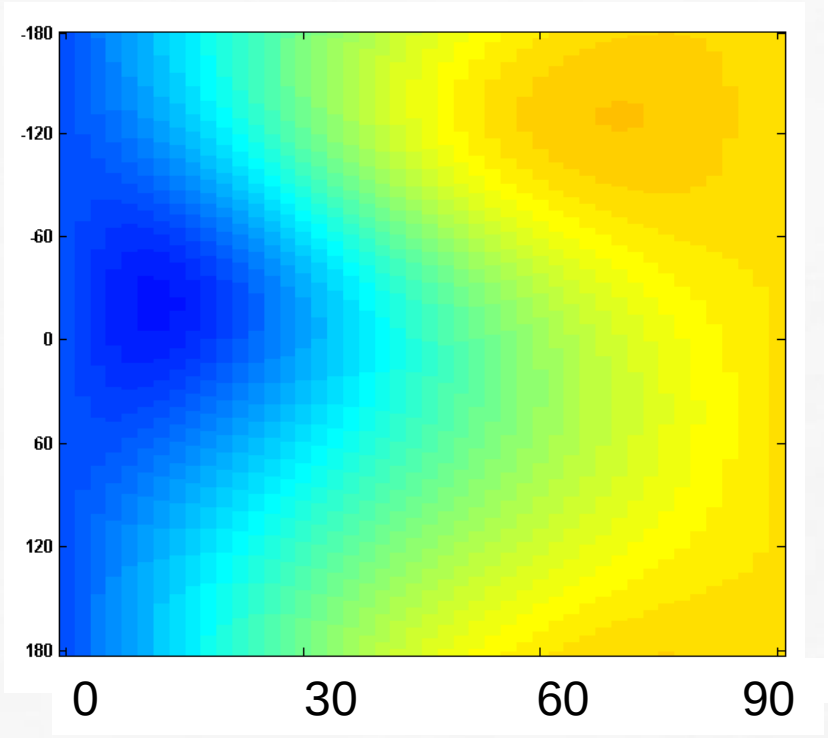


Old Apple



Coherence Signatures: w1 ≠ w2

Cherry



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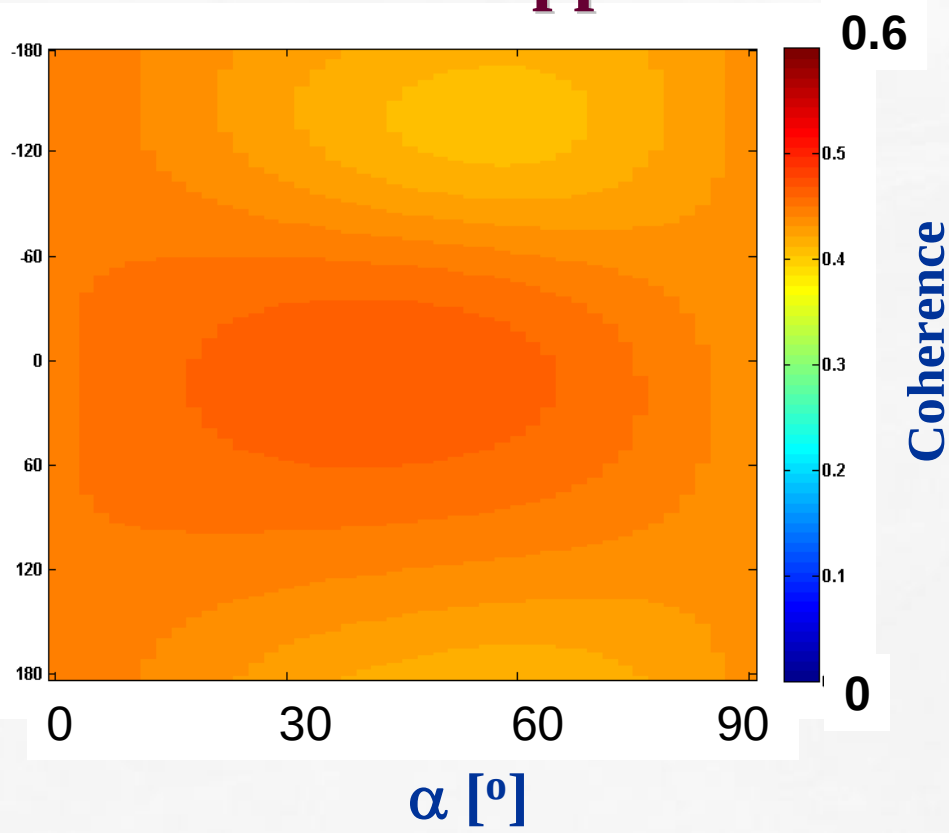
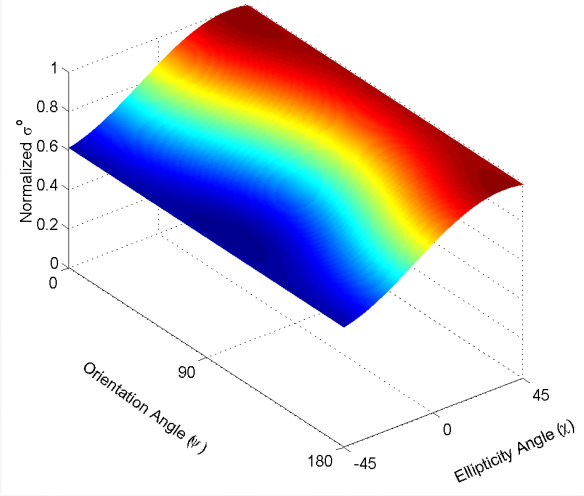
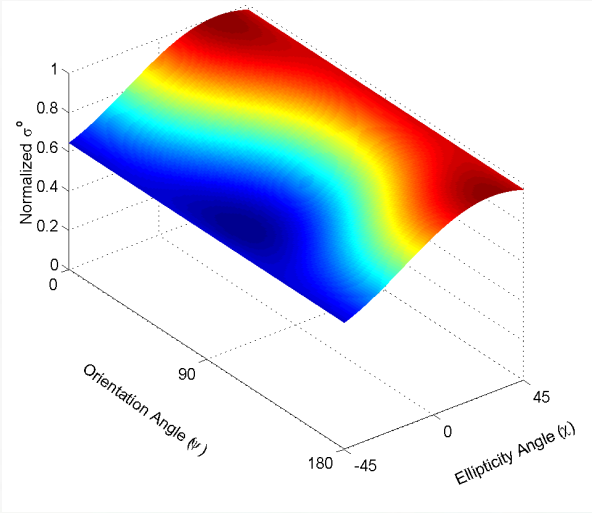


CP signature vs CP insar signature

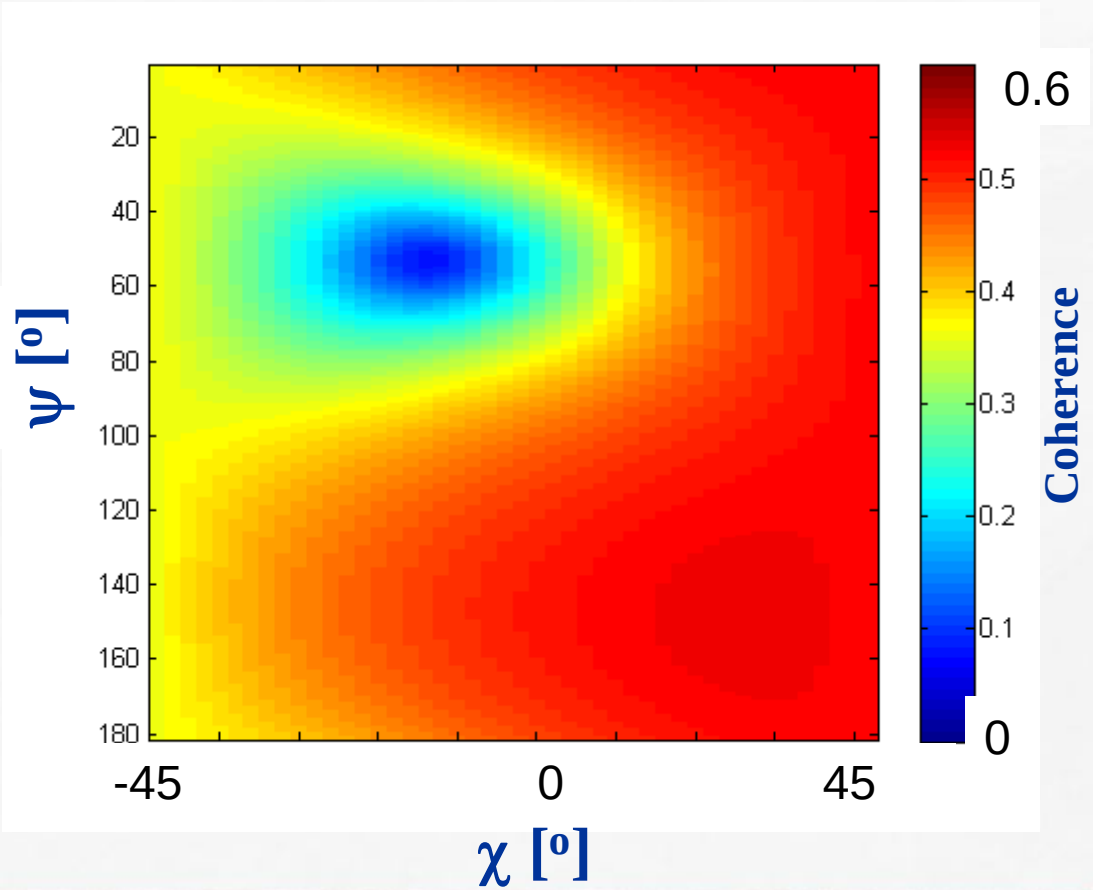
Master



Slave

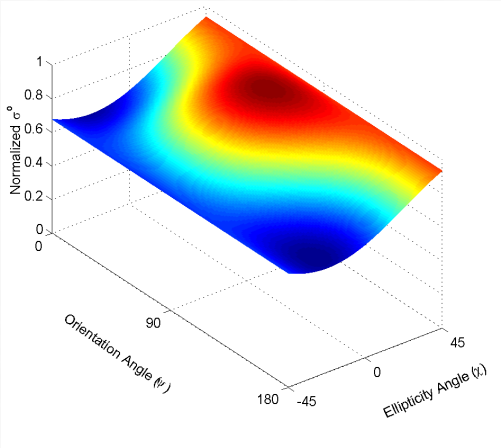


Old Apple

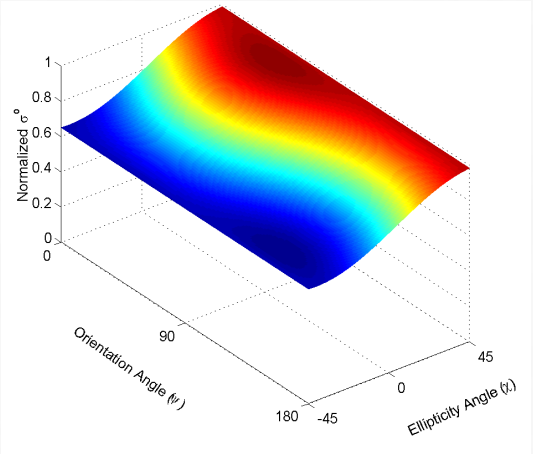


Intensity vs coherence

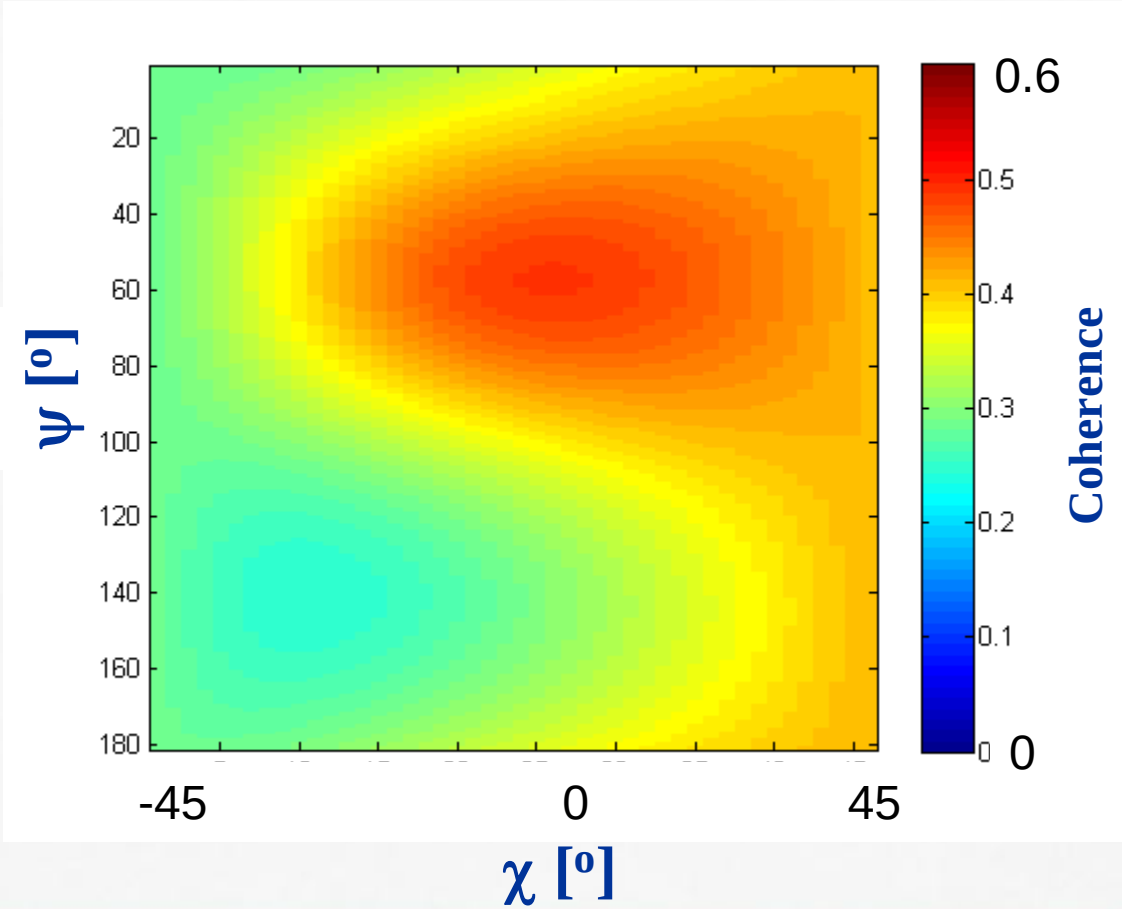
Master



Slave



HD Apple



Conclusion

CP potential for watershed

- Soil moisture estimation from CP will be possible. RL has a higher return on bare soil and is less affected by the non-circularity.
- Agriculture crop classification (presented at IGARSS'12).
- Change detection as good as linear dual pol configuration.
- CP Insar (from R2 data) is limited but 4 days repeat pass should bring some potential for structure characterization.

Acknowledgement

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