APPLICATIONS OF SMAP TO HIGH OCEAN WINDS

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Current Ocean Surface Wind Measurements

• QuikSCAT (13.4 GHz) and ASCAT (5.3 GHz) scatterometers
  – 25 km resolution
  – Wind vector capabilities for 30 m/s or higher
  – Impacted by rain
• SSMI, AMSR and WindSat radiometers operating at 10, 18, 37 GHz
  – 30-50 km resolution
  – Wind speed sensors for non-raining conditions
  – Wind direction measurements using polarimetry for above 7 m/s wind speed
• Measurement gaps:
  – High winds/rain
  – High resolution
L-Band Dual-Polarized Radar Measurements for Ocean Wind Direction

PALS Data - MBARI M1, 16 August 2000

- PALS L-band radar measurements showed response of ocean wind direction at 8-11 m/s wind speeds
  - Ocean field campaigns conducted in 2000 and 2002

NCAR C-130 aircraft used for PALS Mission

Passive Active L/S-band (PALS) Instrument on the C-130 aircraft
L-band Radar for High Ocean Winds

- L-band JERS1 SAR data showed response to high ocean winds (10-20 m/s).
- Little or no collocations with NSCAT for above 20 m/s wind speeds.

### Graph
- **HH (dB)** vs **Wind Speed (m/s)**
- **0.7 dB per m/s**
- **Shimada et al. IEEE TGRS Mar 2003**

- SMAP L-band radar will provide ocean vector measurements for high winds (10-20 m/s or higher).
  - Essentially unaffected by rain and cloud attenuation
  - High resolution over 70% of the swath
L-band Passive Microwave Observations for High Ocean Winds

- L-band brightness temperatures change by about 6 K from light to 25 m/s wind speed. (Etcheto et al., IEEE TGRS, Oct 2004)
- However, the C-band SFMR on the NOAA P3 have shown radiometer response to hurricane force winds (up to 80 m/s or higher ocean wind speeds).
- If L-band brightness temperatures continue to rise for extreme high winds, SMAP will be invaluable for the sensing of hurricanes.
SMAP Active/Passive Microwave Synergy

- Multiple azimuth looks required for scatterometer vector wind retrievals
- The azimuth diversity degenerates near nadir track and far swath
- Active/passive signals complement each other for wind retrievals, particularly for near nadir track and far swath

\[
\begin{align*}
\sigma_1 & \approx A_0(w) + A_2(w) \cos 2(\phi_w - \phi_1) \\
\sigma_2 & \approx A_0(w) + A_2(w) \cos 2(\phi_w - \phi_2) \\
T_B & \approx T_B(w)
\end{align*}
\]
High Resolution Radar Observations Will Benefit Tracking and Monitoring of Tropical Storms

- State of the art mesoscale model (MM5) employs a few Km grid resolution for hurricanes to improve forecasting accuracy.
- SMAP high resolution radar observations (1-3 km) will have significant potential to provide the critical initial and boundary conditions.

MM5 Simulation of Hurricane Floyd 1999
Courtesy of Shuyi Chen, Joseph Tenerelli, Ralph Foster, and Timothy Liu
PALS: Combined Active and Passive L-band Instrument

- **PALS-II Characteristics**
  - Polarimetric radiometer (1.41 GHz)
    - V, H, +45, and -45 degree polarizations
  - Three-noise-diode design, similar to Aquarius
  - Polarimetric radar (1.26 GHz)
    - VV, HH, VH and HV
    - Parallel V and H receivers
  - Companion nadir-looking IR and video cameras
- **CLASIC campaign on the Twin Otter in summer 2007**
- **High Wind Ocean Salinity Campaign for hurricanes of opportunity on the NASA P-3 in summer 2008**
Examples of PALS/CLASIC 2007 Measurements

- PALS/CLASIC radar and radiometer data, acquired on July 1, 2007 over the Fort Cobb test site in Oklahoma, showed response to various land cover and change of soil moisture.

Precipitation between July 4 and 5 at Lake Fort Cobb.
PALS High Ocean Wind Experiment in Summer 2008

• The Objective: Acquire L-band radiometer and radar data for Aquarius algorithm development
  – High winds (10-30 m/s or higher)
  – Wind direction effects
  – Polarimetric data at 30-45 deg incidence angles
  – Sun glint correction testing
  – RFI detection

• Plan to fly the upgraded PALS (similar to Aquarius) on the NASA P-3 in August-September 2008 to target hurricanes of opportunity
Payload on NASA P-3 for 2008 PALS High Ocean Wind Experiment

- PALS (L-band polarimetric radar/radiometer)
- Ku-band conical scanning radar with VV, HH, VH and HV polarizations for surface winds
- SRA (Scanning radar altimeter for ocean wave topography and spectra): TBC
- Ancillary nadir-looking infrared sensor and video cameras

Parabolic antenna on two-axis gimbals
Summary

• SMAP has strong potential for high ocean wind measurements
  – PALS, JERS1 and WISE01 data have shown the response of L-band radiometer/radar measurements to winds (10-20 m/s)
  – Nearly insensitive to rain and cloud attenuation
• SMAP high resolution radar observations will be beneficial for the tracking and forecasting of tropical storms
• PALS High Ocean Wind experiment in summer 2008 in support of the Aquarius algorithm development will provide data to demonstrate the capability of SMAP for high wind observations.
QuikScat Observation Geometry

- In general, there are multiple wind direction solutions - ambiguities.
- Degenerated look geometries near nadir and far swath

\[
\sigma_{1H} = A_{0H} + A_{1H} \cos(\phi_w - \phi_1) + A_{2H} \cos 2(\phi_w - \phi_1)
\]

\[
\sigma_{2H} = A_{0H} + A_{1H} \cos(\phi_w - \phi) + A_{2H} \cos 2(\phi_w - \phi_2)
\]