L-band bi-static scatterometry

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Why?

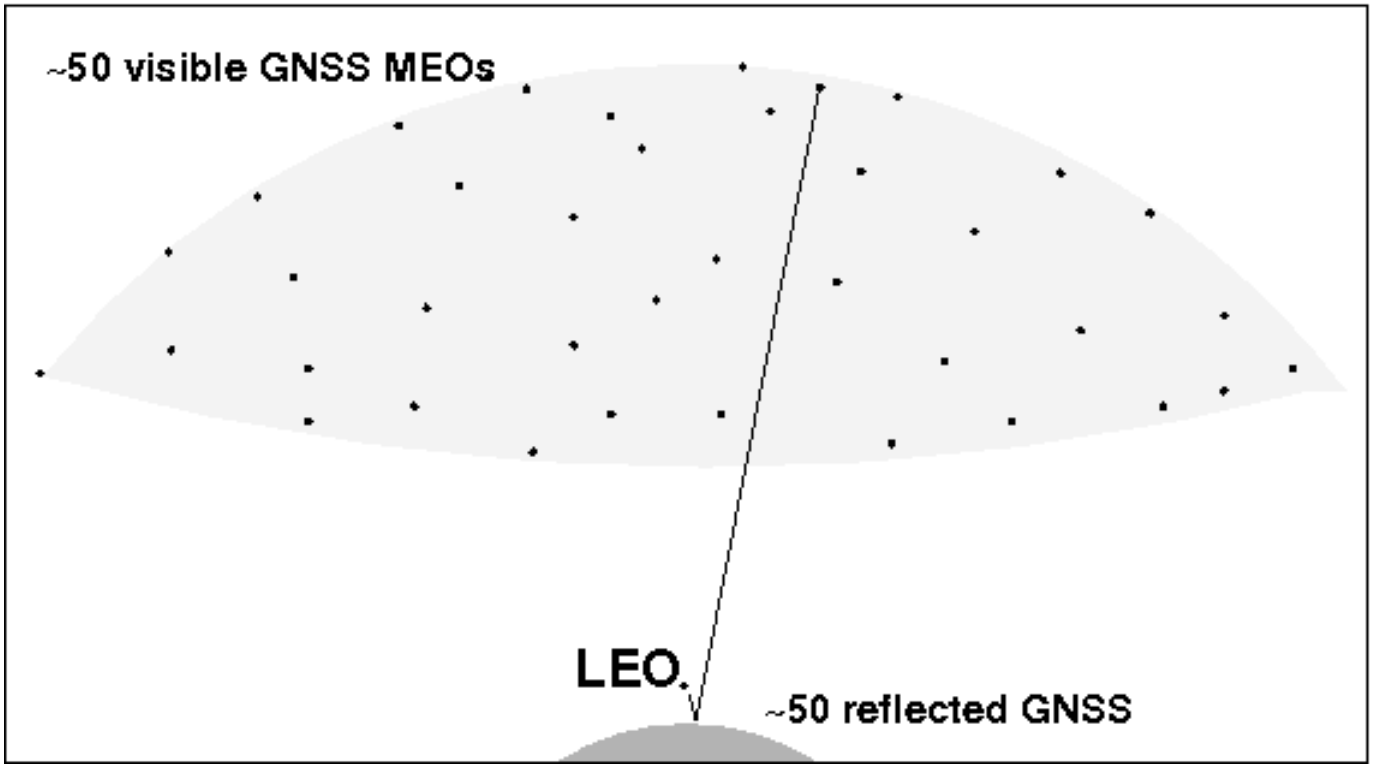
- **NEW OPPORTUNITY:** The Global Navigation Satellite Systems (GNSS) Reflectometry (-R): GPS (32 sat), GLONASS (23 sat), future EU GALILEO (~30, 2 GIOVEs in-orbit), Chinese COMPASS (~30, 2 in-orbit): **~120 MEOs, L-band signals, global coverage**, ~12 hours orbital period.

- **NEW NEEDS:** L-band radiometric missions for Sea Surface Salinity retrievals (SMOS, Aquarius) need roughness corrections, L-band bi-static sigma0.

Contents

- Brief introduction to GNSS-R
- Review on GNSS-R scatterometric results: wind? SHW? ...?
- Discussion on geophysical content of L-band bi-static scatterometry

When all constellations available → ~120 satellites, ~50+ visible simultaneously:



Great potential... FOR WHAT?

Over the Oceans: Wind? SWH? Slopes' statistics? Of which surface structures? Roughness corrections for L-band radiometry? ... other?

GNSS-R vs. O. Scatterometers

SCATTEROMETERS

- Mono-static
- Back-scattering phenomena
- C-Ku bands:

6-2 cm wavelength

- Frequency-modulation
- Sigma0 measurements

GNSS-R

- Bi-static
- Forward-scattering phenomena
- L band:

~20 cm wavelength

- Phase-modulation
- Waveform deformation (unknown transmitted power)

Review of GNSS-R “scatterometry”

Refs [1,2,3] → 2m/s agreement with wind, from aircraft campaigns, including hurricanes

Ref [4] GNSS-R from space: no wind correlation, but SWH

Ref [5] Weak correlation with wind, little with SWH (ground-based experiment)

Ref [6] GNSS-R from stratosphere, MSS instead of SWH/Wind

Ref [7] Slopes' PDF

and bi-static Sigma-0

Review of GNSS-R "scatterometry"

From [1]

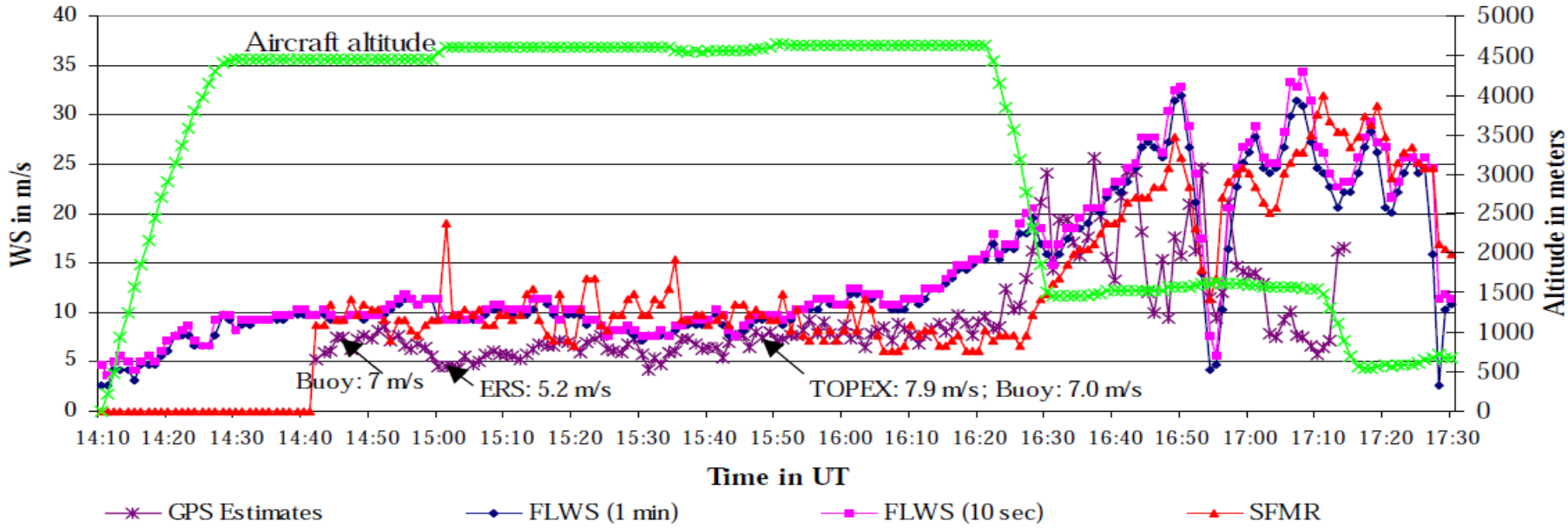
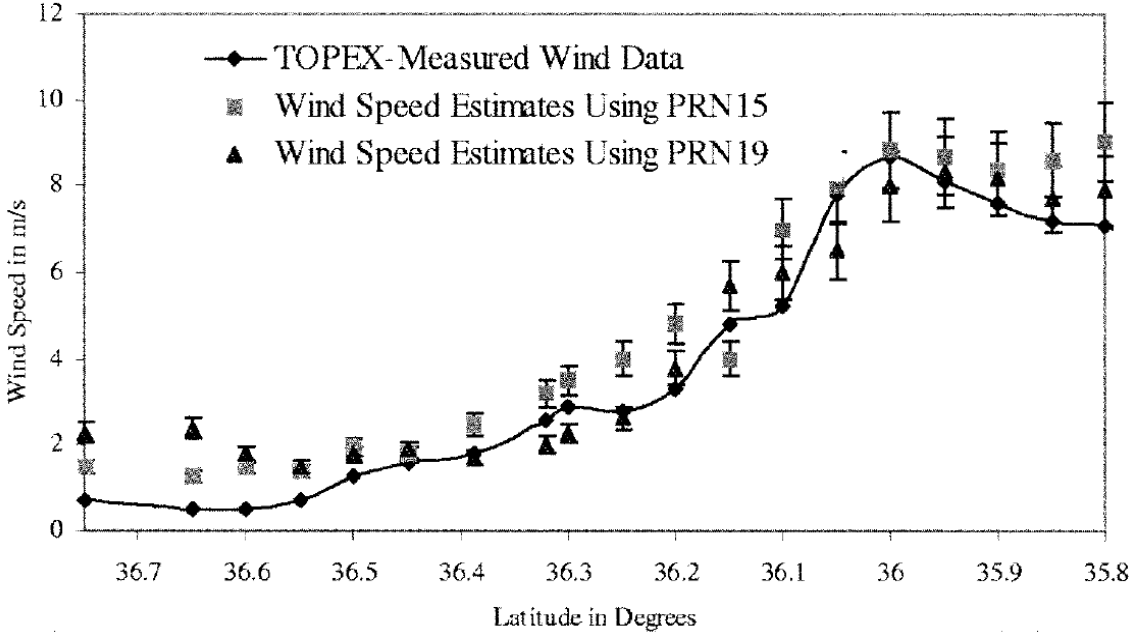


Figure 7. GPS wind speed (WS) estimates along the flight path for Hurricane Michael of October 18, 2000.

From [2]



From [3]

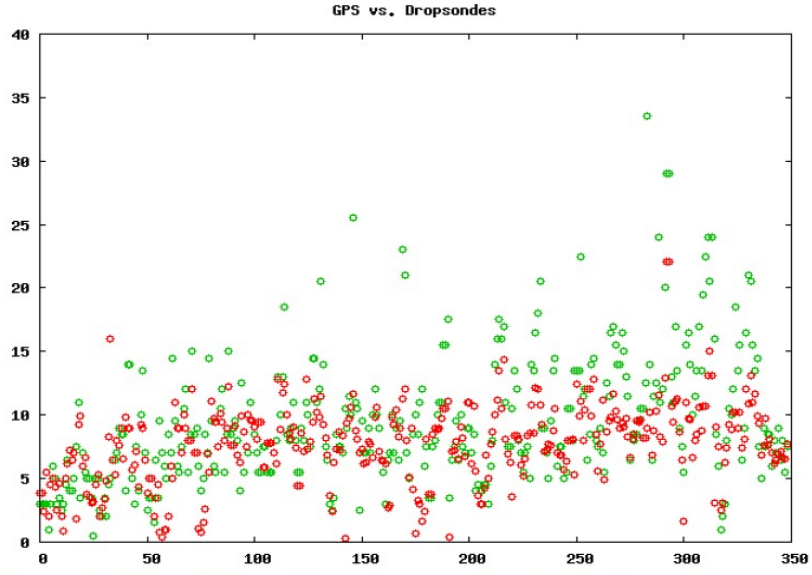


Figure 5-All valid surface dropsonde winds (green) versus GPS valid surface measurements (red) in meters per second. Bulk of data points are from Hurricane Ivan.

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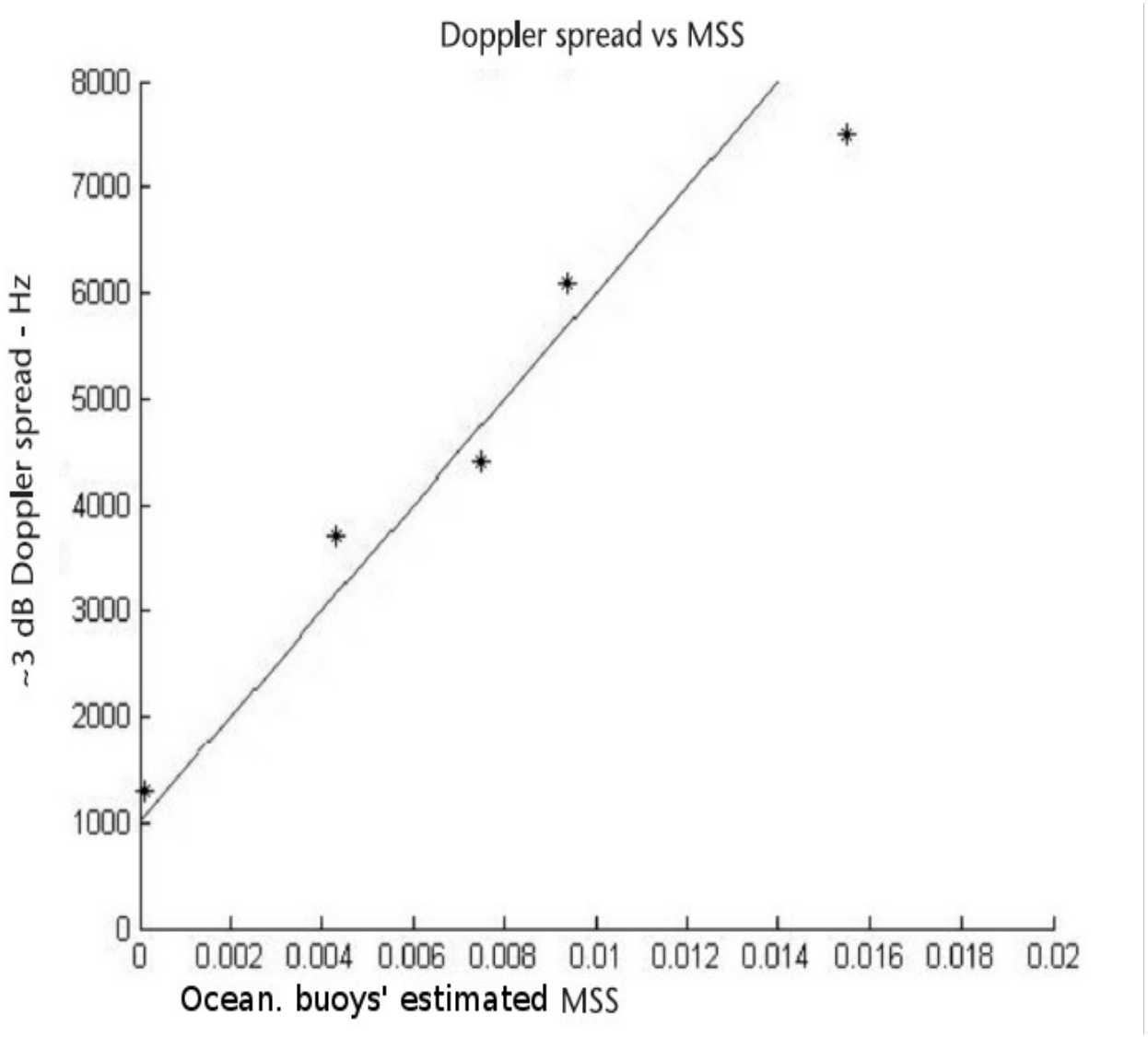
Review of GNSS-R “scatterometry”

From [4], using GNSS reflections captured from a LEO:



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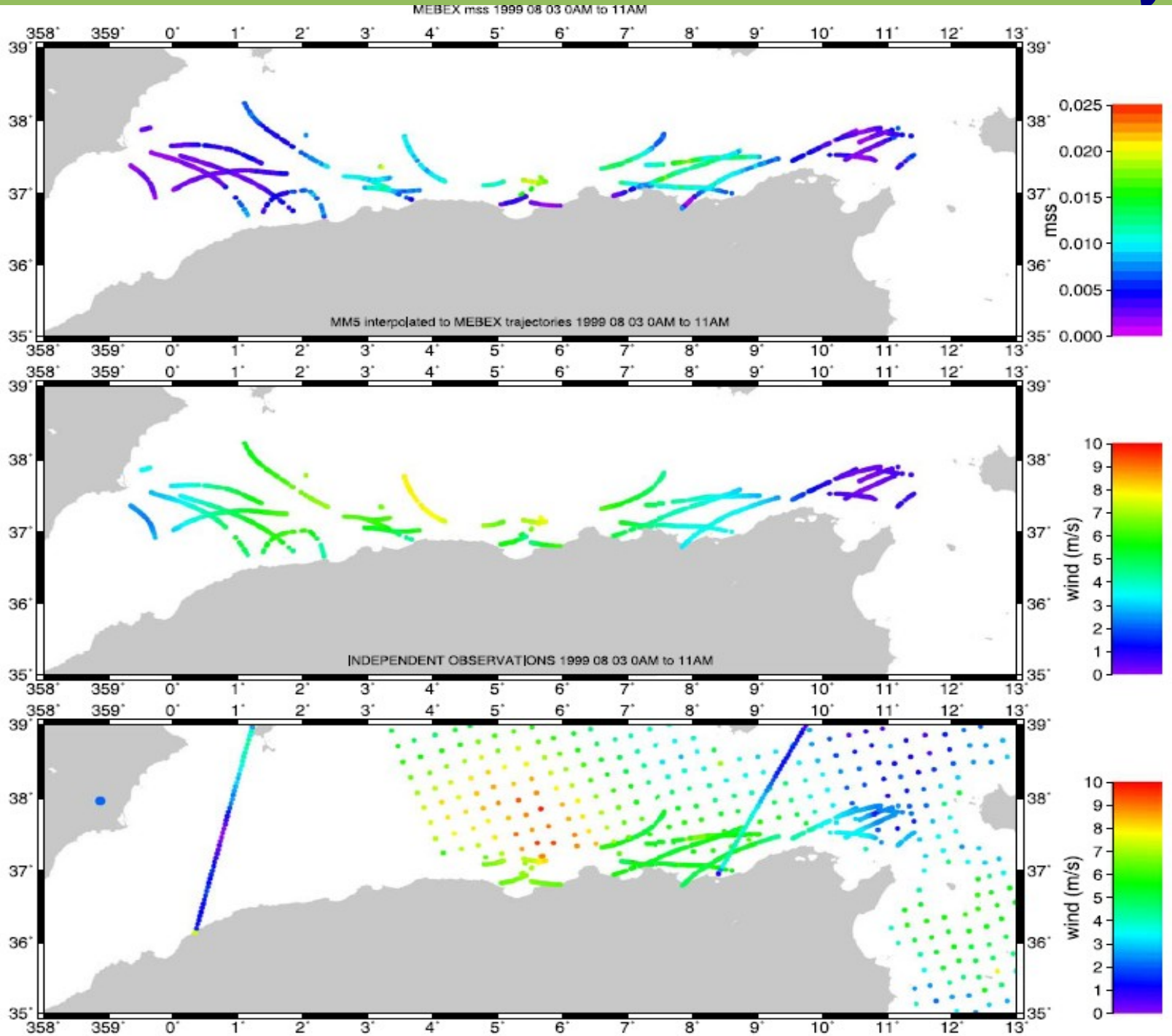
Review of GNSS-R “scatterometry”

From [6] GNSS-R from stratosphere, L-band MSS derived:



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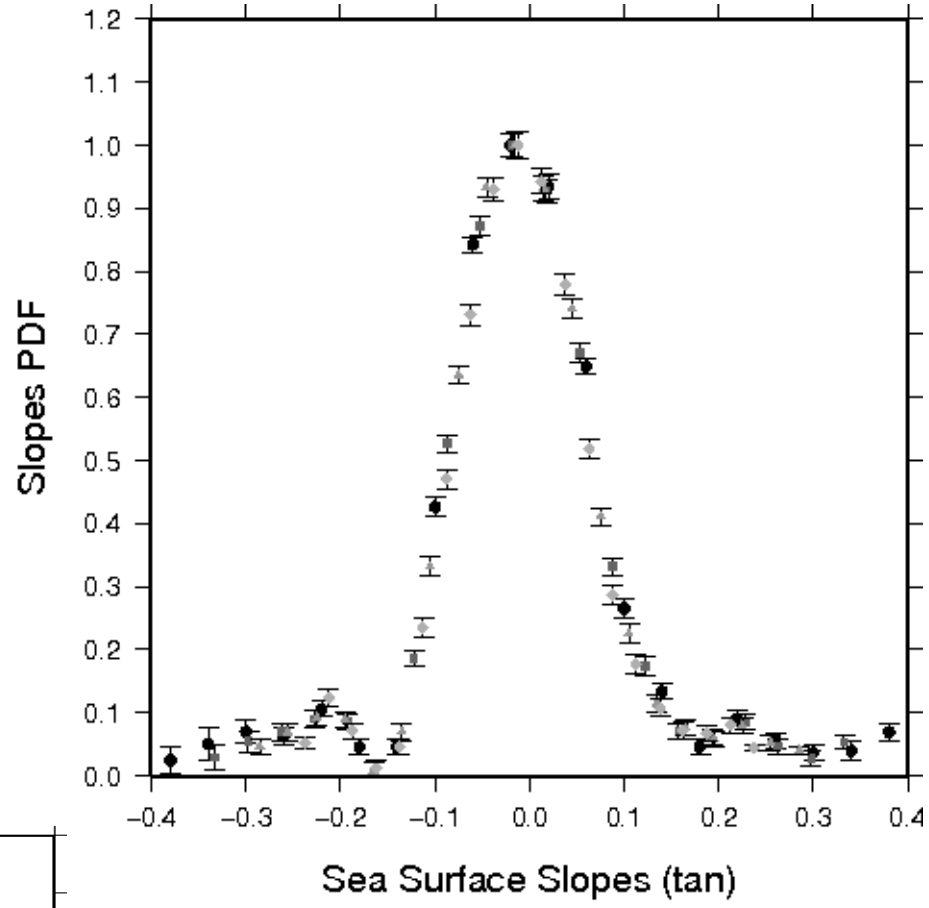
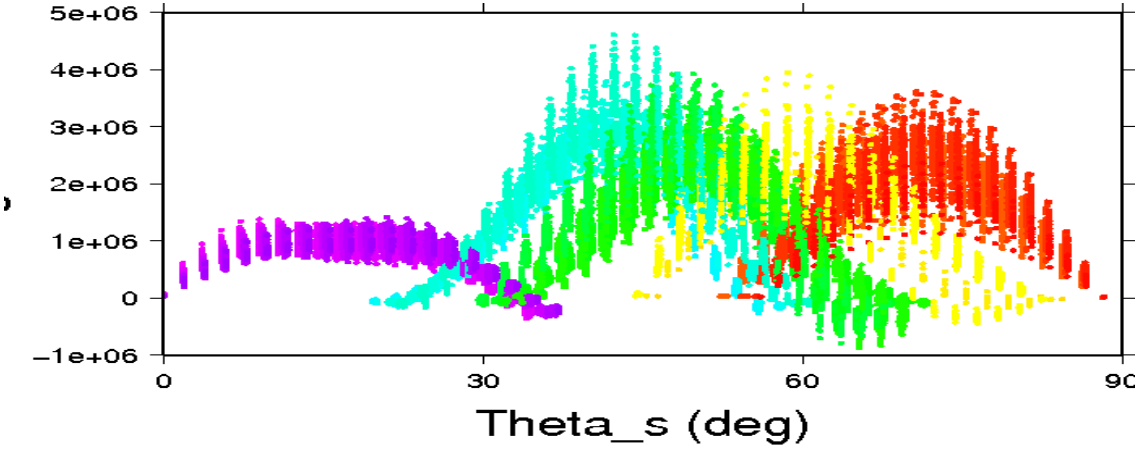
Review of GNSS-R “scatterometry”

From [7], discrete slopes' PDF, non-Gaussian features can be captured:



GNSS-R inverted bi-static sigma-0:



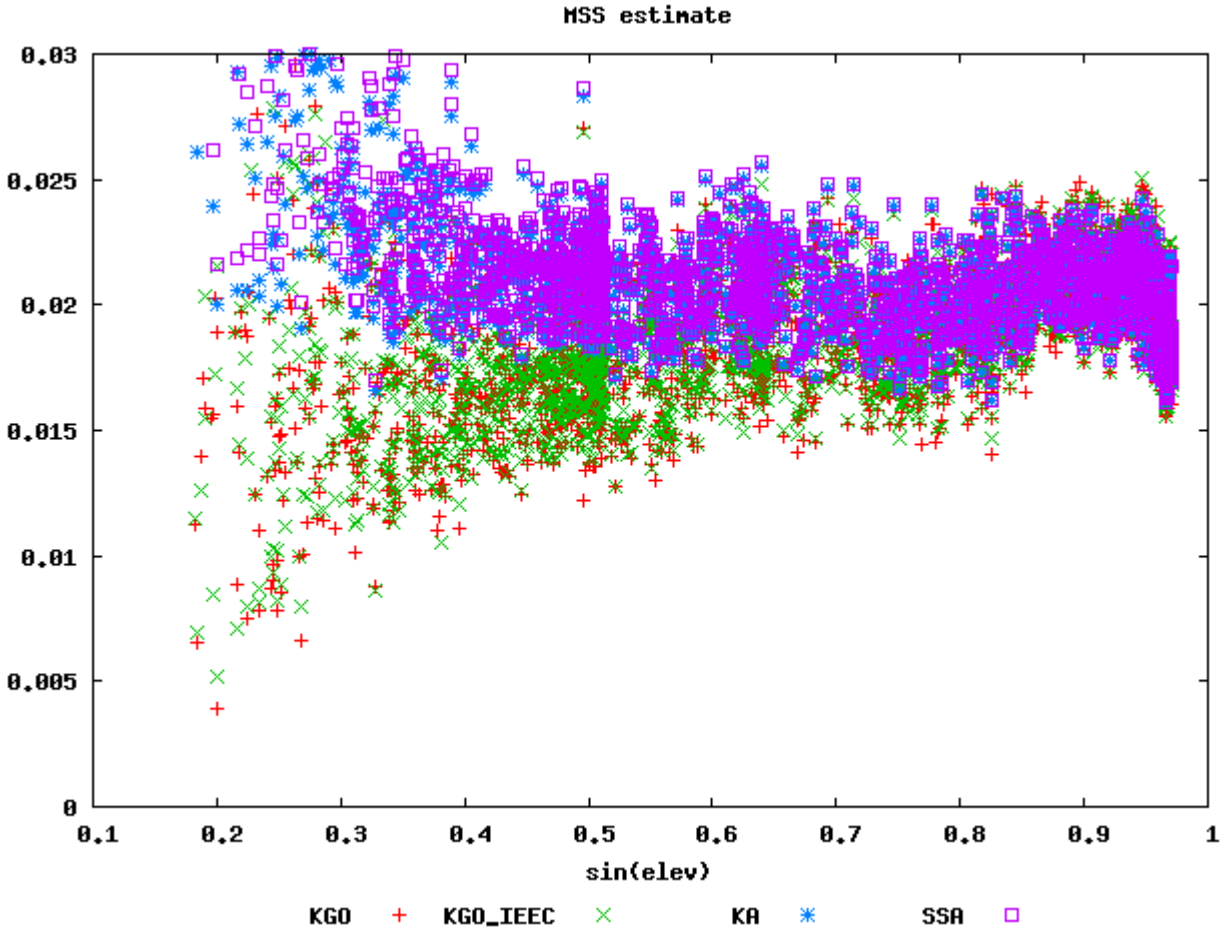
Discussion

SCATTERING PHENOMENA:

It has been assumed that K-GO scattering model reproduces sufficiently well L-band GNSS-R

However, estimates degrades as incidence angle drops:

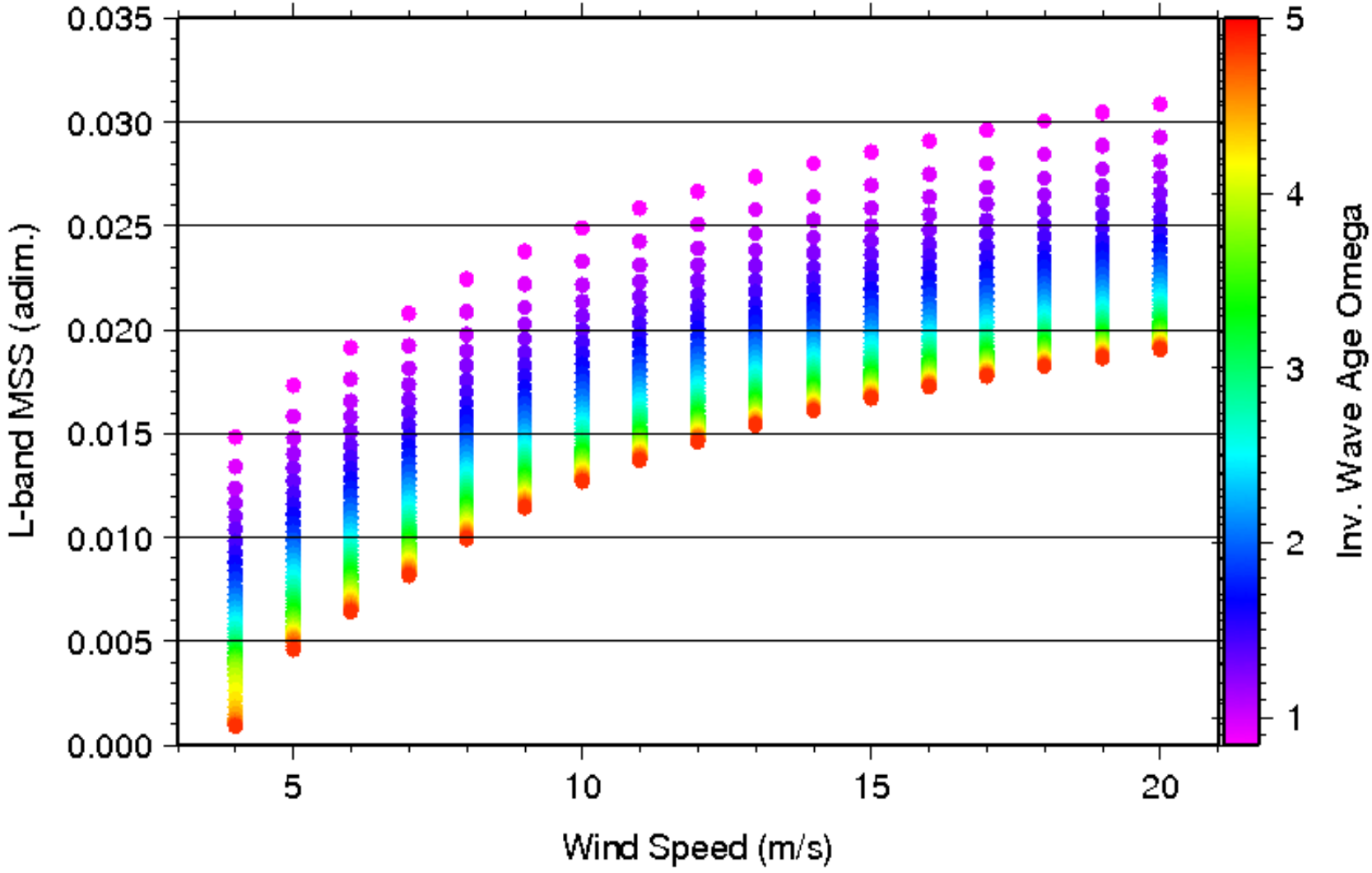
Flight experiment, CoSMOS 2006:



Discussion

Stage of sea development:

L-band MSS highly dependent on inverse wave age:



Elfouhaily's spectra, with k0/3 filter:

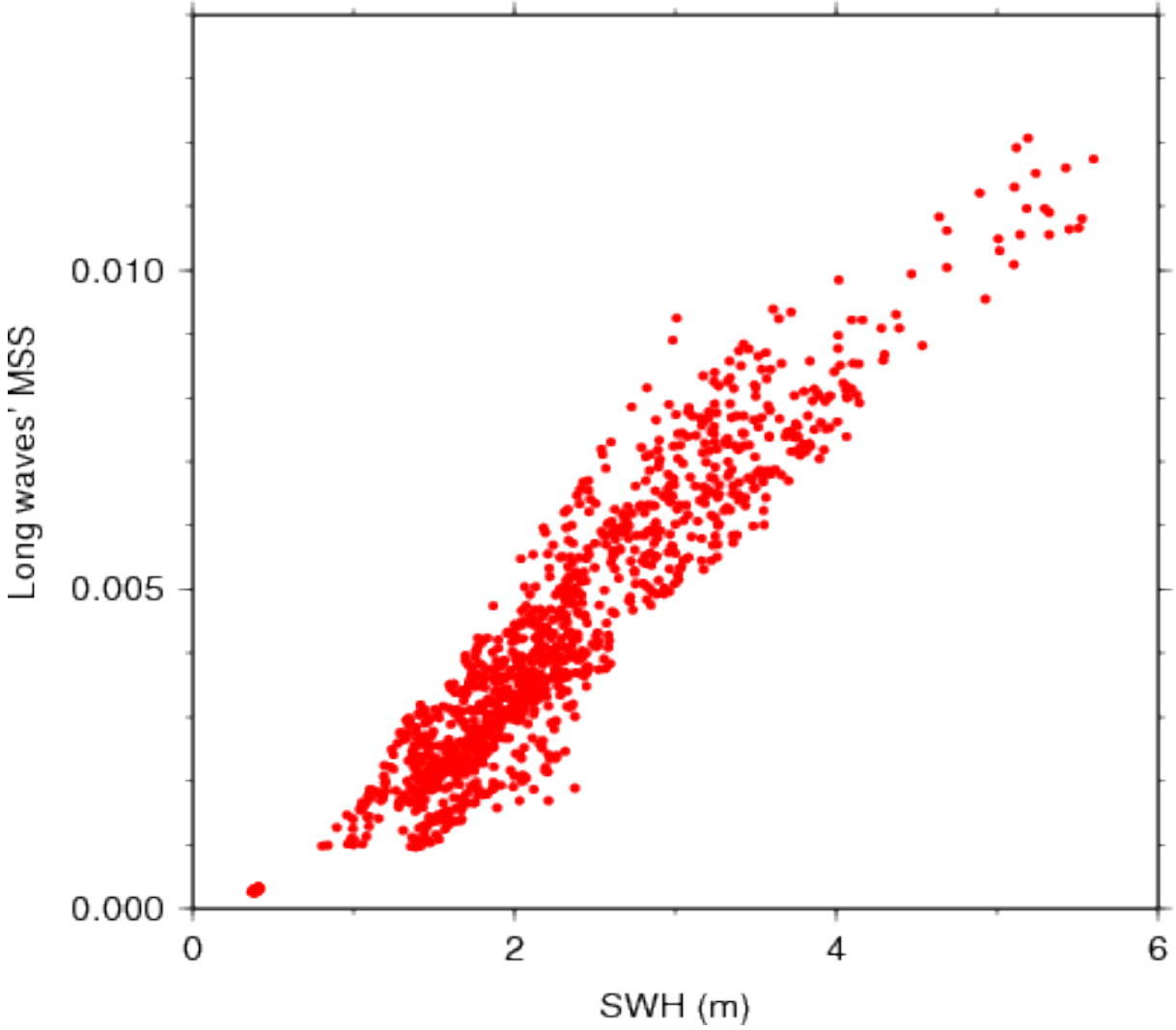
Discussion

Swell:

The contribution of long waves to the MSS is relatively small. But it must be accounted for:

MSS from MIROS wave radar measured long waves' spectra

(North Sea, 20 days April 2006)



Summary

GNSS constellations will soon provide capability for **~50+ simultaneous reflections** in a wide diversity of geometries, global coverage

GNSS, **L-band (~20 cm wavelength)** → sensitive to intermediate ocean wavelengths, between wind-induced ripple and long waves. What is this useful for?

→ To correct **roughness effects in L-band radiometric** SSS measurements (not covered in this talk, but Thursday 8:45AM)

→ Shown to contain contributions from a combination of wind, wave age, and swell phenomena

→ **"L-band roughness"** as an Ocean product to help completing the sea surface characterization?

A new perspective onto the sea surface.

GNSS-R data server

GNSS-R data server (40+ flights, 7+ month ground-based campaigns):

http://www.ice.csic.es/research/gold_rtr_mining/

freely available for research activities

References

[1] Komjathy et al., ION 2001 National Technical Meeting, Long Beach, CA, January 22-24

[2] Garrison et al., IEEE-TGRS Vol 40, NO. 1, JANUARY 2002

[3] Katzberg et al., 2005

[4] S. Gleason, PhD thesis, University of Surrey, UK, 2006

[5] J.F. Marchán, PhD thesis, Universitat Politècnica de Catalunya, Spain, 2009

[6] Cardellach et al., Remote Sensing of Environment, 88, 2003

[7] Cardellach and Rius, Remote Sensing of Environment, 112, 2008