Wave measurements from drifters
PP-WMD

Report to DBCP-XXVII

JCOMM Technical Workshop on Wave Measurements from Buoys, 2008

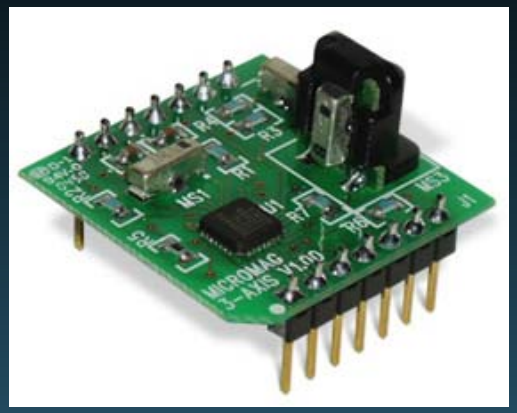
WMO IOC

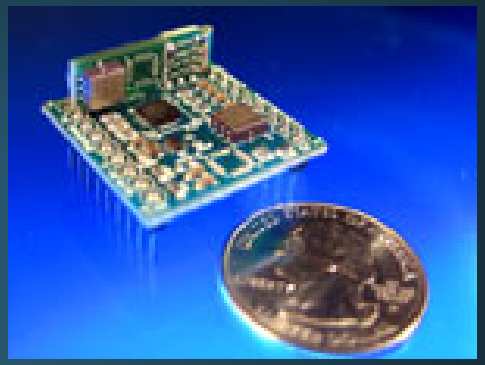
- Deep ocean wave measurements needed for
  - Validation of models
  - Validation of satellite observations
  - Process studies (e.g. for hurricanes and other extreme events)
- An undrogued drifter is a good wave follower and might carry an attitude sensor, e.g. GPS, pitch-roll package
- Presentation of ‘First 5’ as minimum reporting standard
  - Energy spectrum + first four spectral moments
  - See http://www.act-us.info/download/workshop_reports/ACT_WR07-03_Wave_Sensor.pdf
- Need for careful evaluation of wave drifters
- Proposal for DBCP Pilot Projects

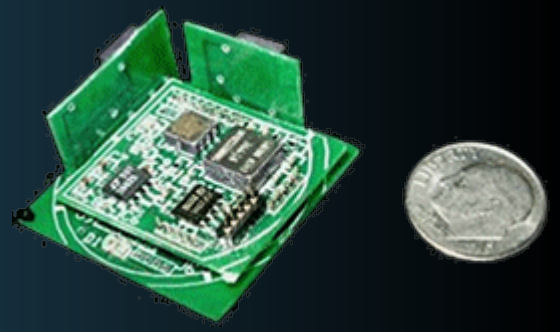
Wave measurements – the ‘Big 3’

- Three time series needed
  - in x, y and z or their derivatives
- No buoy is a perfect wave follower
- Need to compensate for buoy transfer function

Low cost technologies to measure the Big 3







- Not always low cost!
- Energy hungry
  - Sensor itself
  - In situ processing
  - Communications

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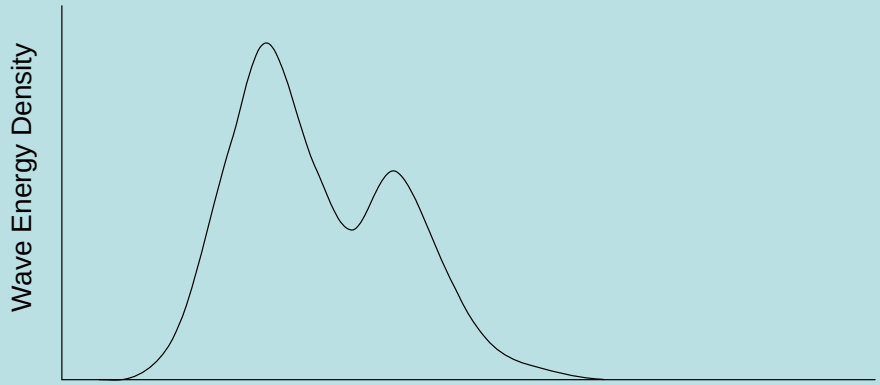
What data do we need to report?

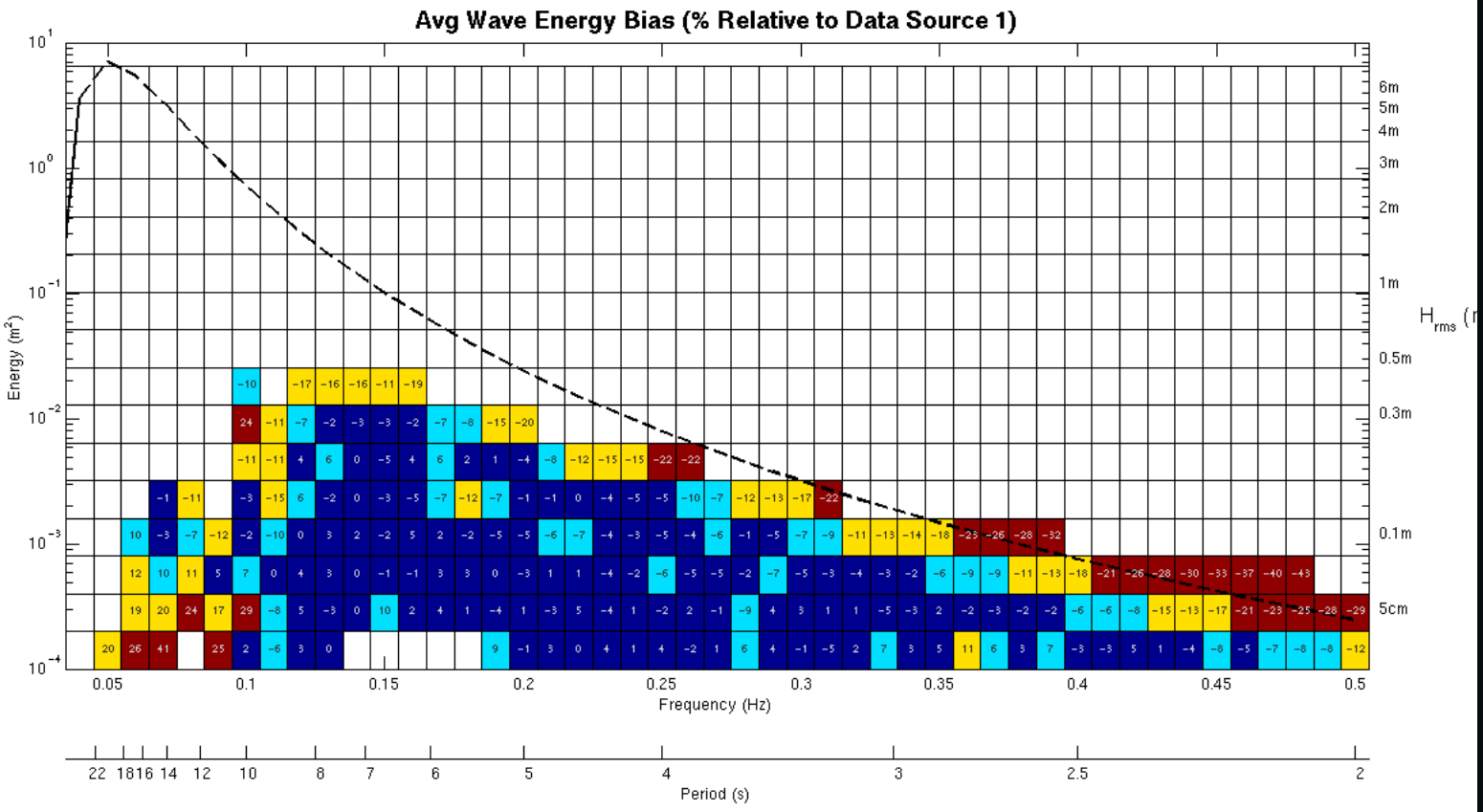
- 'First 5'
  - Power spectrum: coefficients as a function of frequency band (S(f))
  - Directional spectrum: first two pairs of coefficients of spectral moments (a_1, b_1, a_2, b_2)
- Work by O'Reilly (Scripps), Jensen (USACE) and at NDBC
  - Development of IOOS

The Directional Spectrum

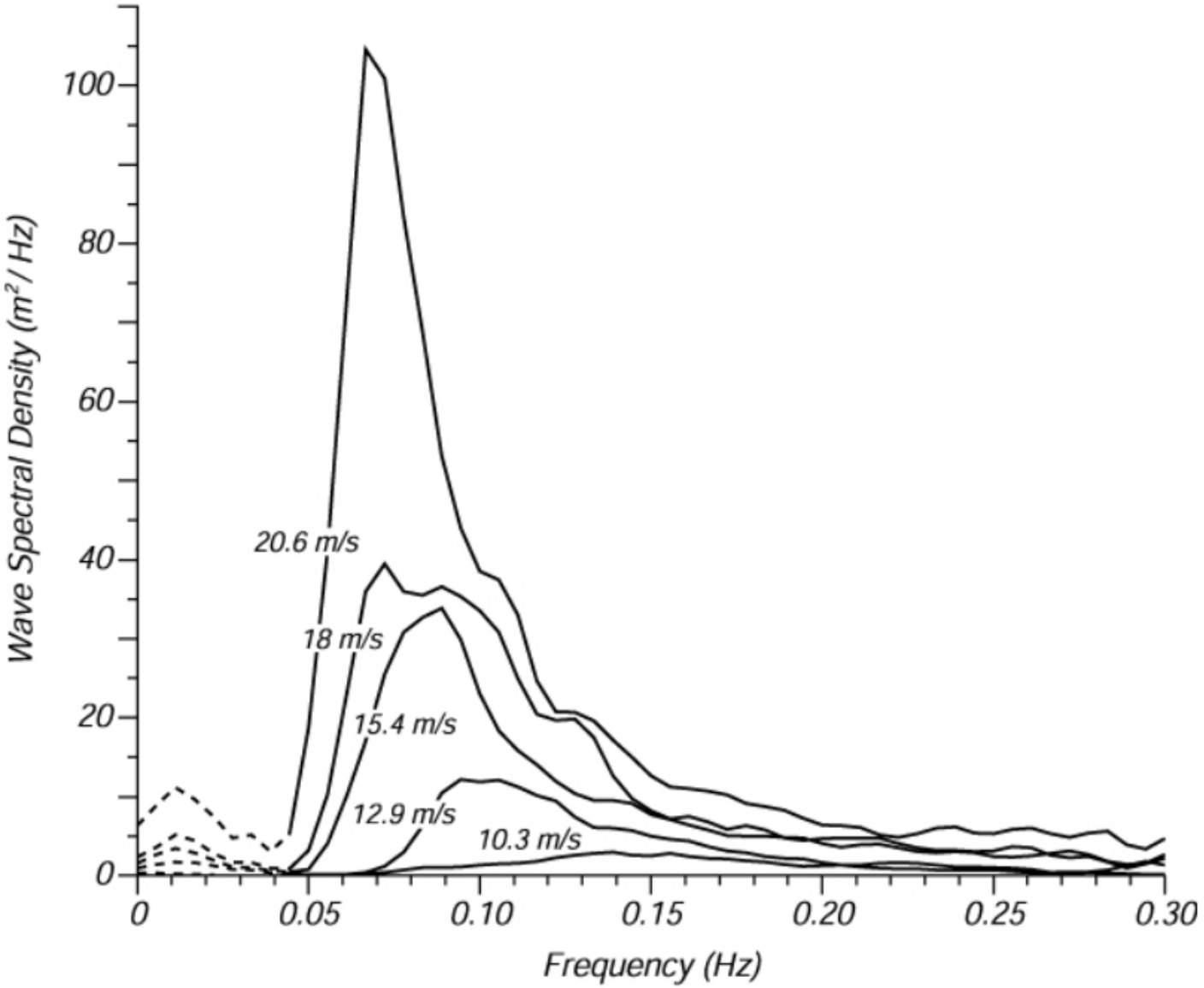


$$S(f,\theta)=S(f)[a1\cdot\cos(\theta)+b1\cdot\sin(\theta)+a2\cdot\cos(2\theta)+b2\cdot\sin(2\theta)+a3\cdot\cos(3\theta)+b3\cdot\sin(3\theta)+a4\cdot\cos(4\theta)+b4\cdot\sin(4\theta)+\ldots\ldots\ldots\ldots\ldots\text{infinity and beyond}]$$

Need for careful intercomparison



Surface Wave Spectra



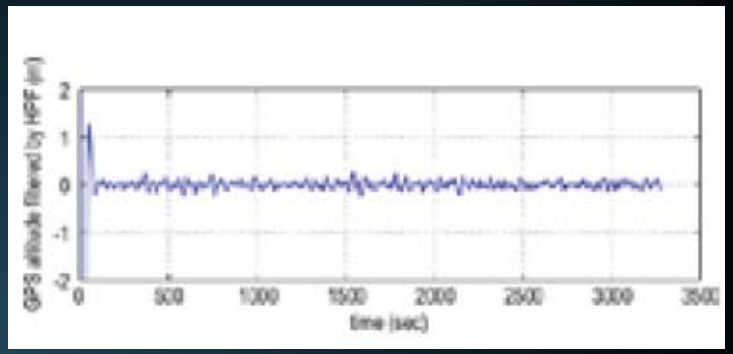
GPS basics - errors

Sources of User Equivalent Range Errors (UERE)		
Source	**Effect**	**Time constant**
Ionospheric effects	± 5 m	10 min
Ephemeris errors	± 2.5 m	1 hour
Satellite clock errors	± 2 m	5 min
Multipath distortion	± 1 m	100 sec
Tropospheric effects	± 0.5 m	10 min
Numerical errors	± 1 m	White noise

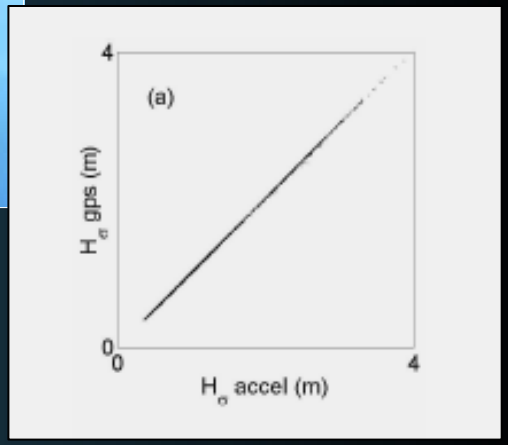
Power spectrum of most errors lies well below ocean wave power spectrum

Practical systems

- JMA/JAXA protoype wave buoy
  - GPS World, May 2005
  - HP filter to separate out wave signal
  - Claimed accuracy of a few cm
  - US Patent 6847326



- Datawell wave buoy DWR-G
  - Sea Technology, Dec 2003
  - Probably similar technique



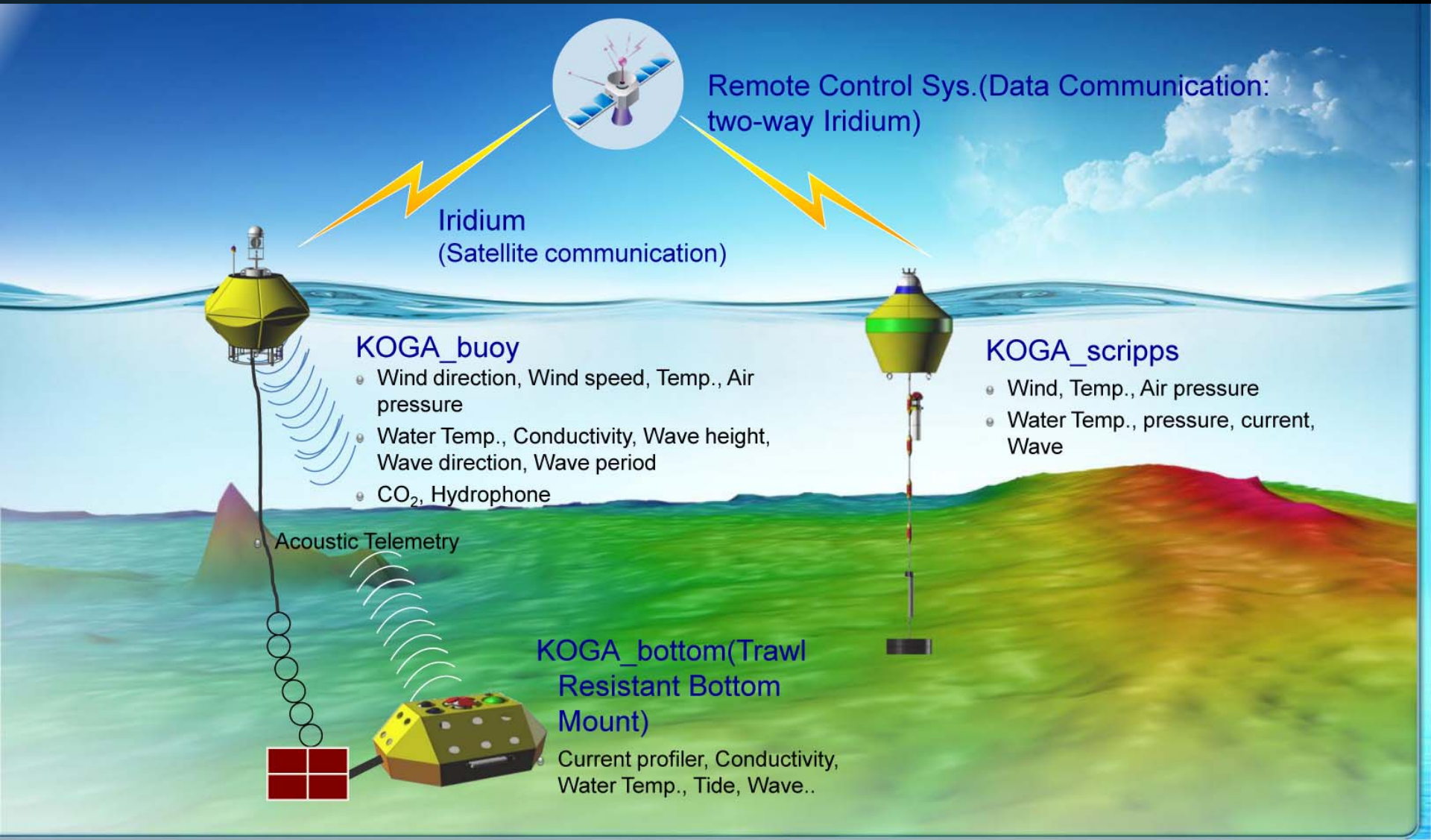
Practical systems

Continental Control Design, Inc.

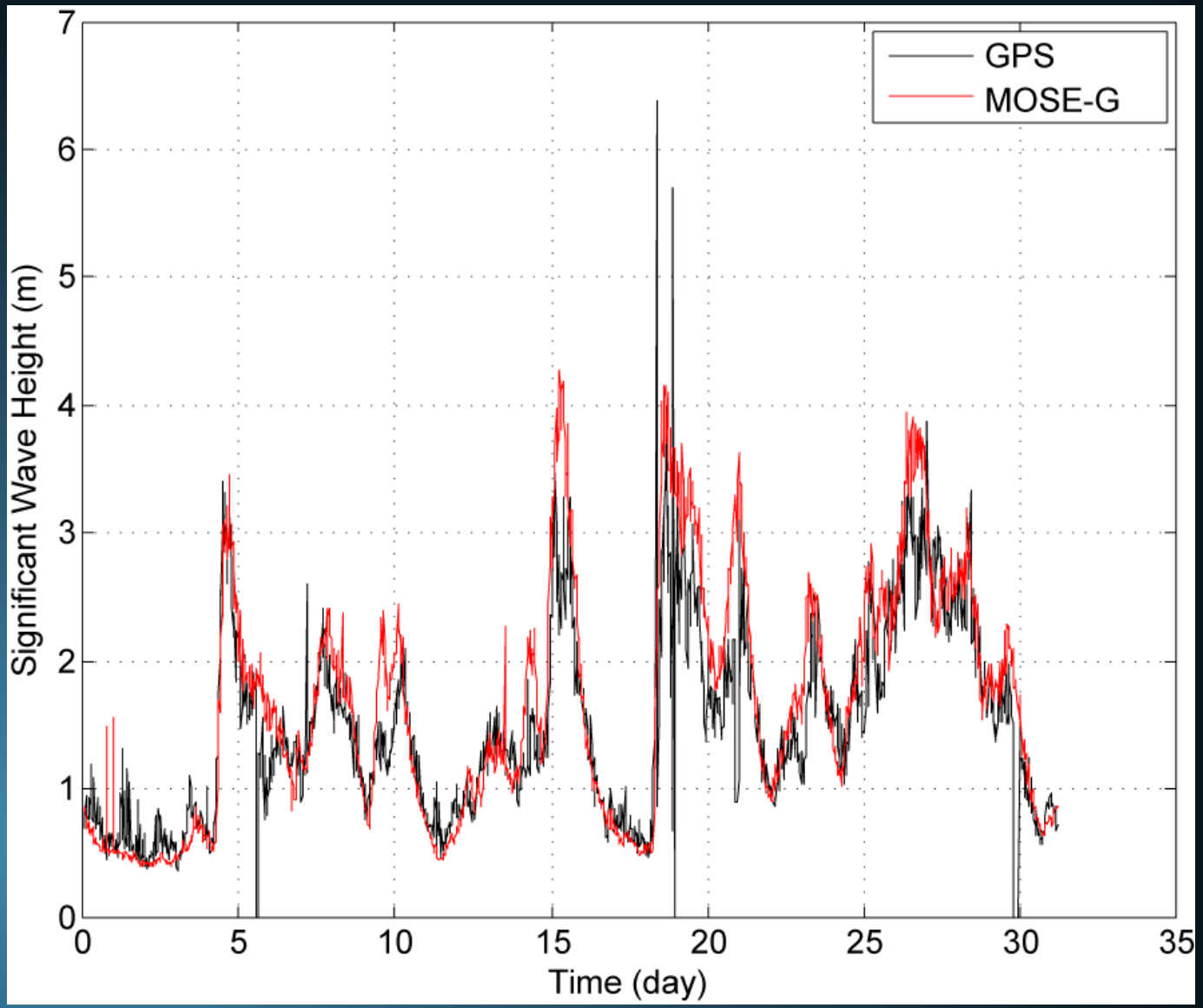
- Cell Phone GPS receiver 3D orbital velocities
- Microcontroller does the spectral analysis
- Iridium SBD modem ships data globally
- Hull is polycarbonate ice cream ball

Courtesy Peter Niiler *et al*

KOGA buoy (5 m) – Datawell MOSE-G
KOGA Scripps (0.75 m) - GPS



Significant wave height (4×σ)



PP-WMD

- Objectives
  - Evaluate feasibility of wave measurement from drifters
  - Explore in particular use of GPS as the cost-effective means of yielding 2-dimensional wave spectra
  - Prove the technology by measurements and intercomparison with existing trusted wave measurement technologies
  - Deploy up to 50 wave measurement drifters within the framework of the pilot project
  - Establish confidence in user community in the validity of wave measurements from drifters
- Approved by DBCP XXIV
  - Up to 3 years
  - Up to $30k ‘seedcorn’ funding

Steering Committee Membership

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Suggestions

- Request Panel to continue with PP-WMD
- Revise PP membership
- Move operational focus to Scripps
- Test GPS sensors on PP-WET platforms
- Investigate ways of characterising sensor inside SVP