Wave measurements from drifters

Outcome from JCOMM Technical Workshop on Wave Measurements from Buoys

WMO

IOC/UNESCO

- Deep ocean wave measurements needed to validate
  - Models
  - Satellite observations
- An undrogued drifter is a good wave follower
  - Downwards-looking ADCP
  - GPS
  - ‘First 5’
- Need for careful evaluation of wave drifters
- Proposal for DBCP Pilot Project

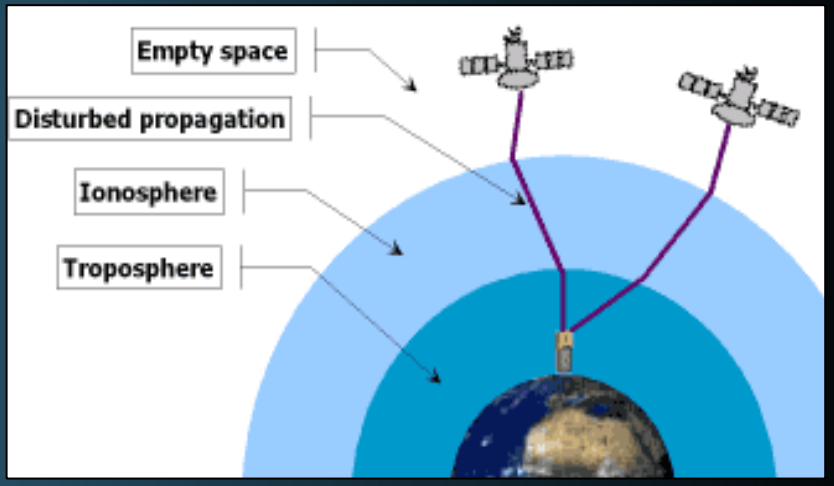
JCOMM Technical Workshop on Wave Measurements from Buoys

GPS basics

- Up to 32 satellites in high orbit (12 h period)
- Almost identical Russian system (GLONASS)
- New European system (GALILEO)
- Navigation by trilateration
  - Range to satellite measured by propagation delay
  - Receiver knows position of satellites

GPS basics – error terms

Sources of User Equivalent Range Errors (UERE)	
Source	**Effect**
Ionospheric effects	± 5 m
Ephemeris errors	± 2.5 m
Satellite clock errors	± 2 m
Multipath distortion	± 1 m
Tropospheric effects	± 0.5 m
Numerical errors	± 1 m

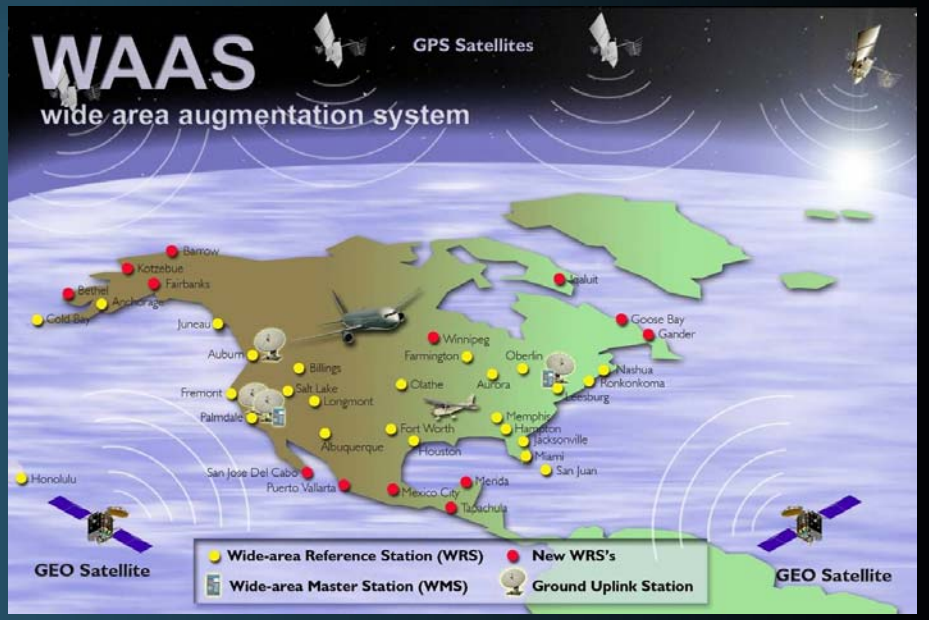


GPS basics – Differential GPS

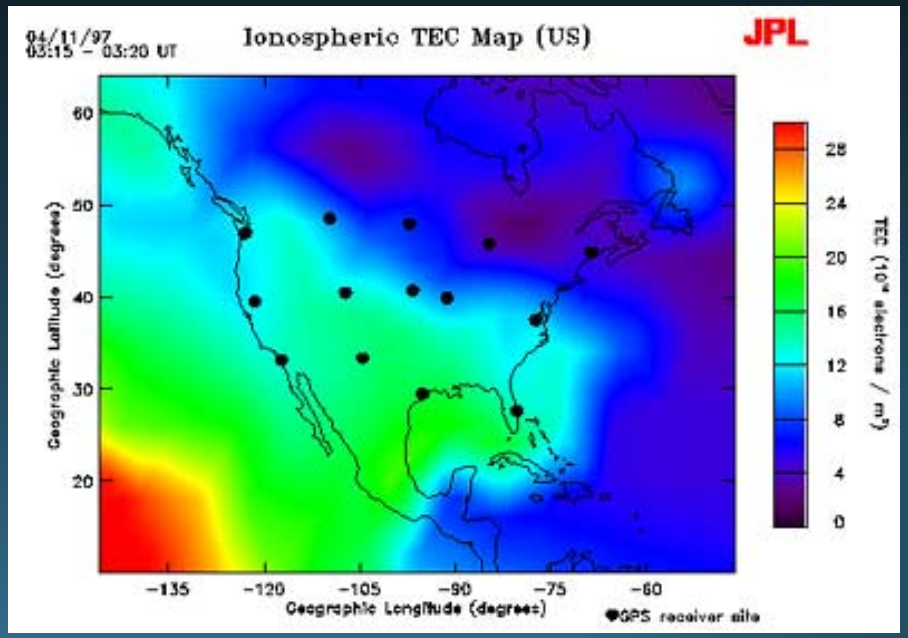
- A means of reducing errors for navigational purposes
- Need base stations in known locations
- Base station estimates range errors for each satellite received
- Broadcasts these errors as corrections for use by mobile
- Accuracies decrease with distance from base station
  - A metre or so at best

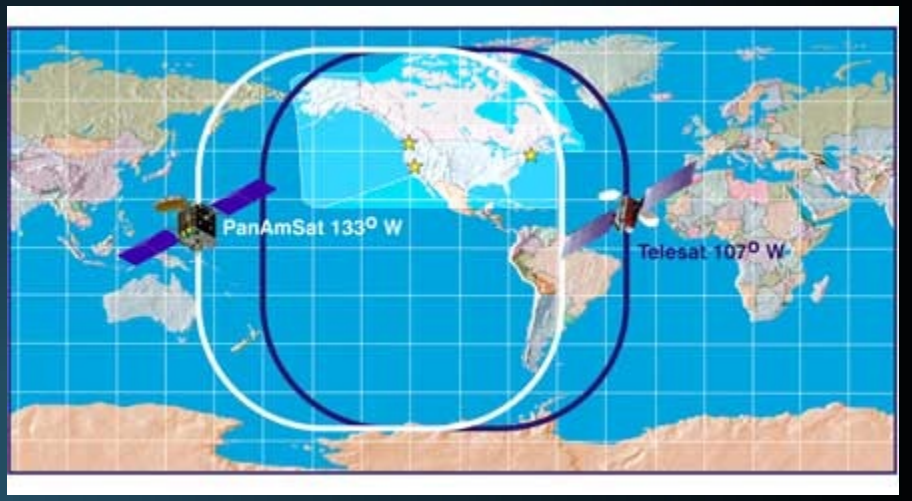
GPS basics - SBAS

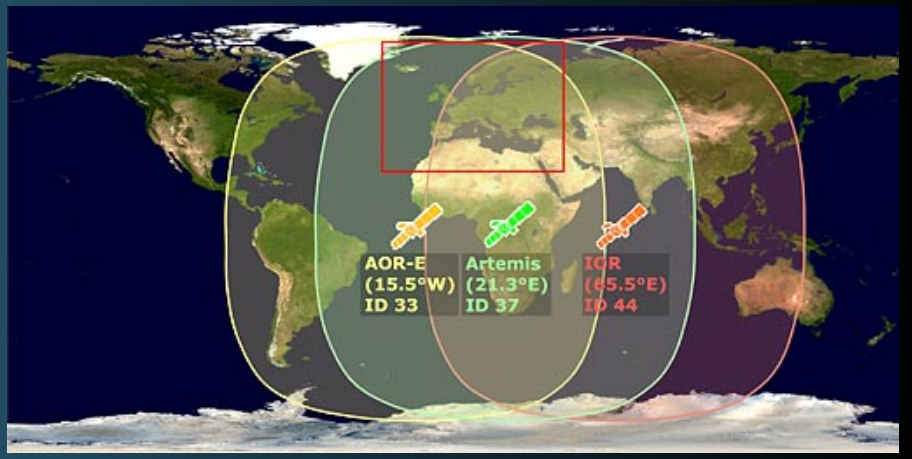
- Satellite Based Augmentation System
  - WAAS, EGNOS, MSAS
- Network of base stations computes correction MAP
  - Total Electron Content (TEC) map
  - Broadcast by geostationary satellites on GPS frequency
  - Regional coverage
  - Height error ~1.3m



GPS basics - SBAS







GPS basics - errors

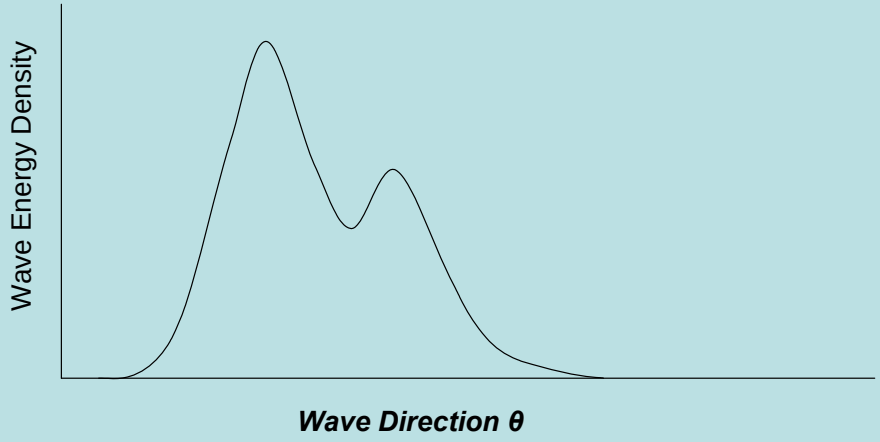
Sources of User Equivalent Range Errors (UERE)		
Source	**Effect**	**Time constant**
Ionospheric effects	± 5 m	10 min
Ephemeris errors	± 2.5 m	1 hour
Satellite clock errors	± 2 m	5 min
Multipath distortion	± 1 m	100 sec
Tropospheric effects	± 0.5 m	10 min
Numerical errors	± 1 m	White noise

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

What data do we need to report?

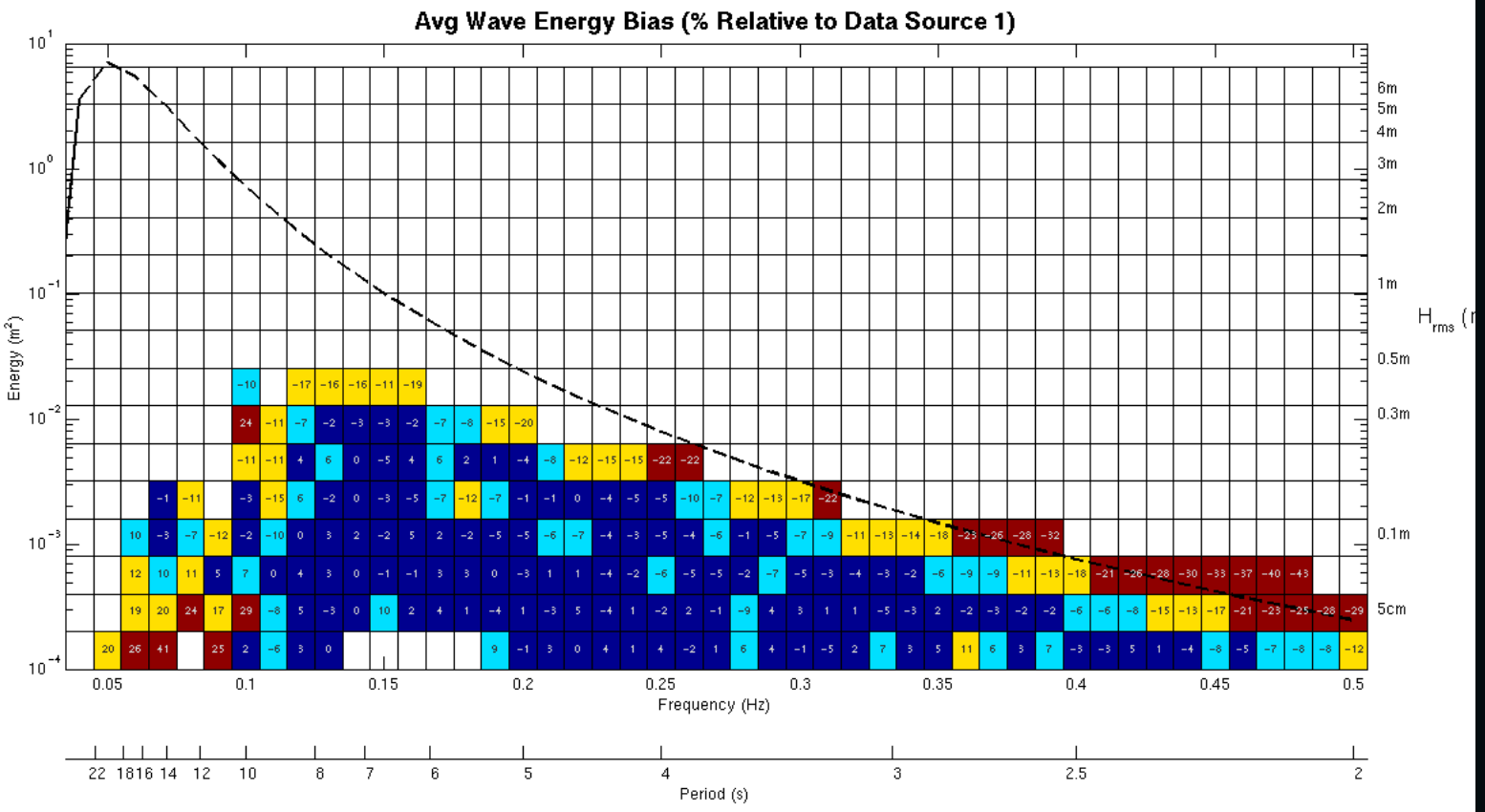
- 'First 5'
  - Power spectrum: coefficients as a function of frequency band (S(f))
  - Directional spectrum: first two pairs of coefficients of spectral moments (a_1, b_1, a_2, b_2)
- Work by O'Reilly (Scripps), Jensen (USACE) and at NDBC
  - Development of IOOS

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



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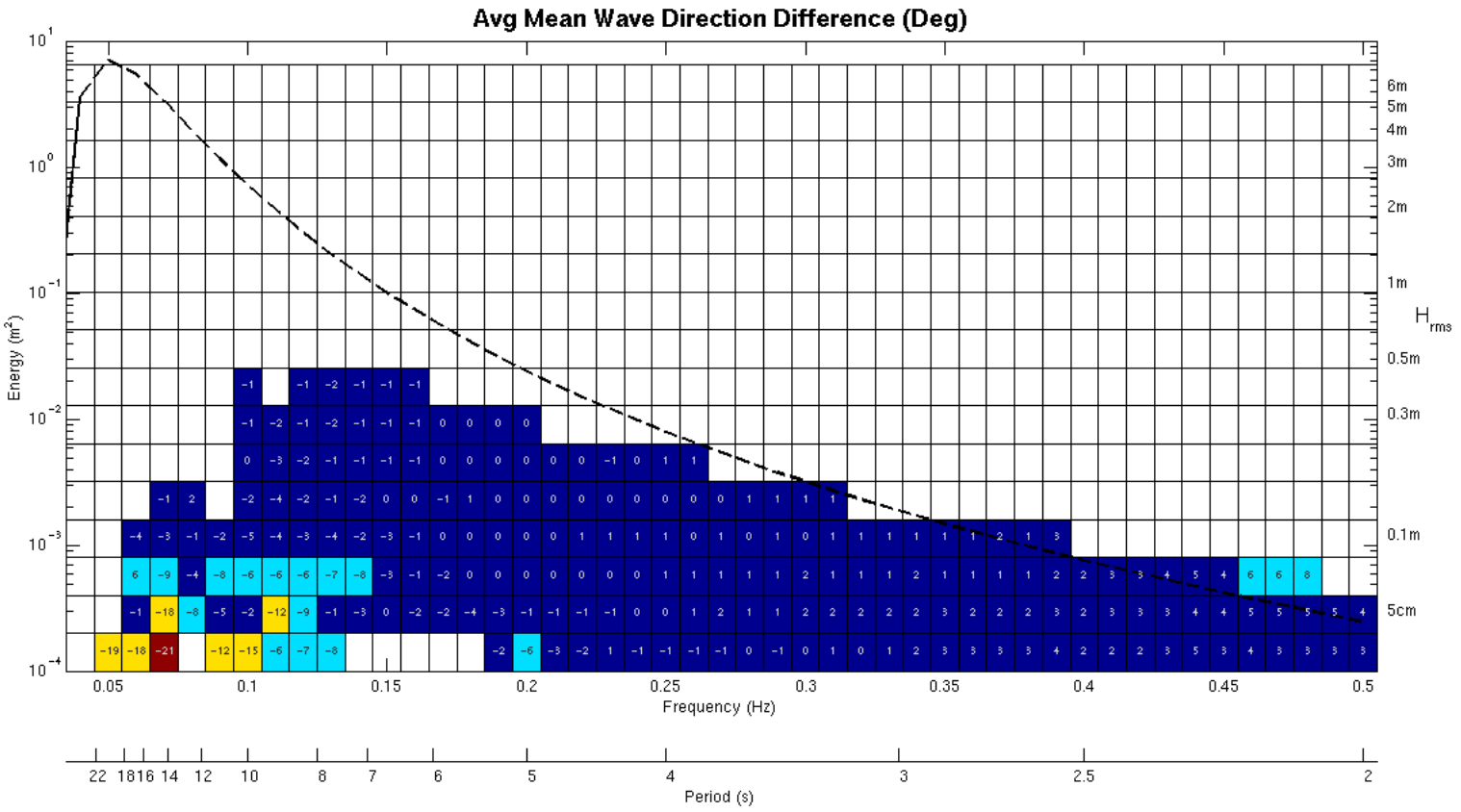

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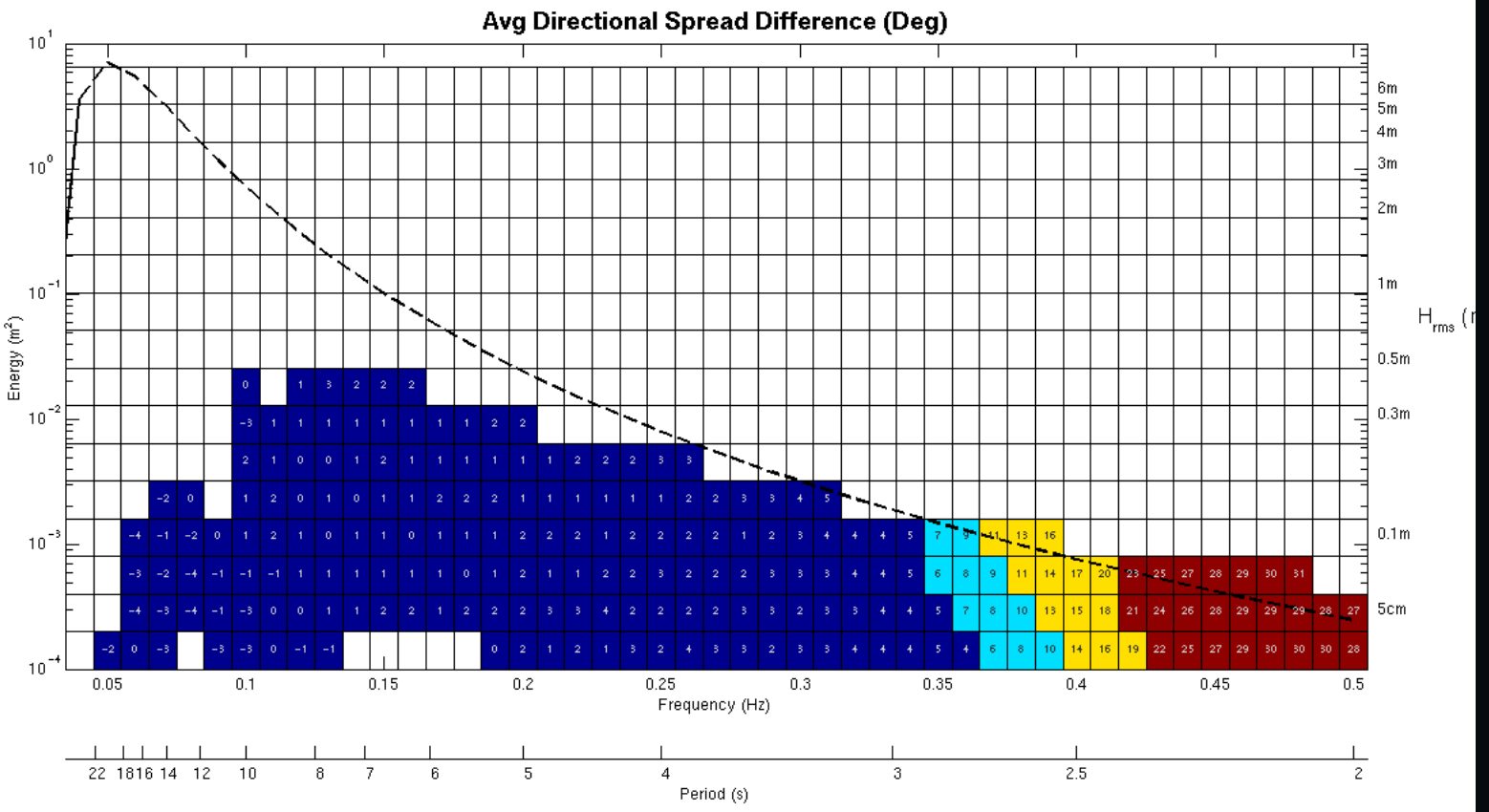
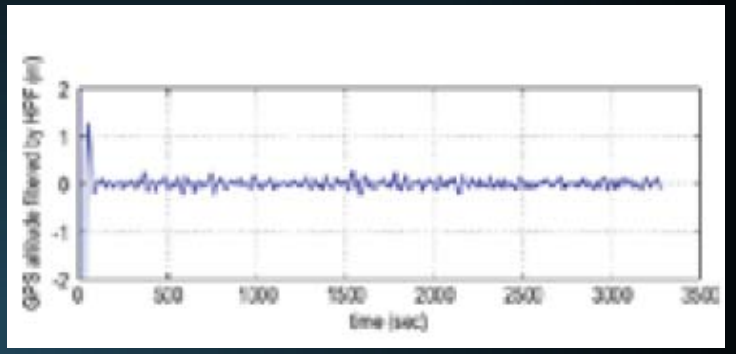
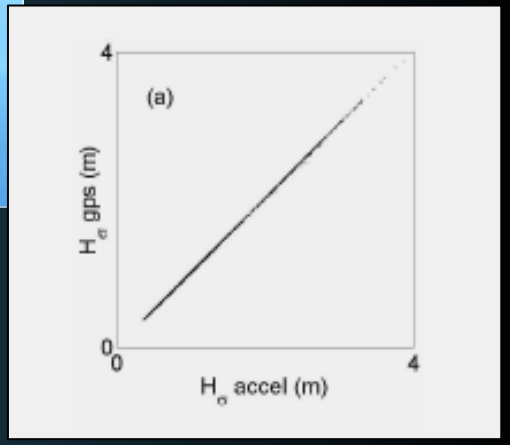


Practical systems

- 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

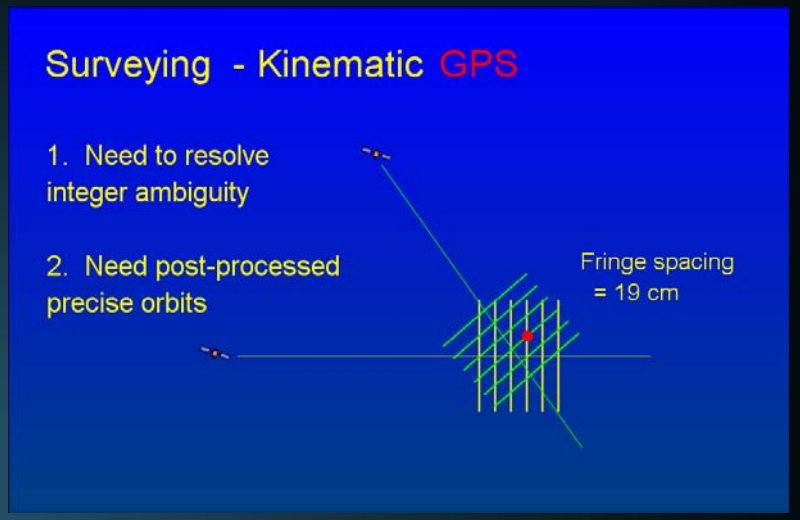


- Datawell wave buoy DWR-G
  - Sea Technology, Dec 2003
  - Probably similar technique



Future directions?

- Carrier phase techniques
  - Low-cost CP-capable receivers are available
  - Can use transmissions other than GPS
- DBCP Pilot project for low-cost technologies
  - Submit proposal to DBC24
  - Can we recover useful wave data from the 30-40cm dia buoys that make up our 1200+ drifter fleet?



JCOMM/DBCP/ETWS Pilot

- 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