Joint WMO-IOC Technical Commission
for Oceanography and Marine Meteorology

DBCP-ETWCH Joint Pilot Project on Wave Measurement Evaluation and Testing

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WMO

IOC/UNESCO

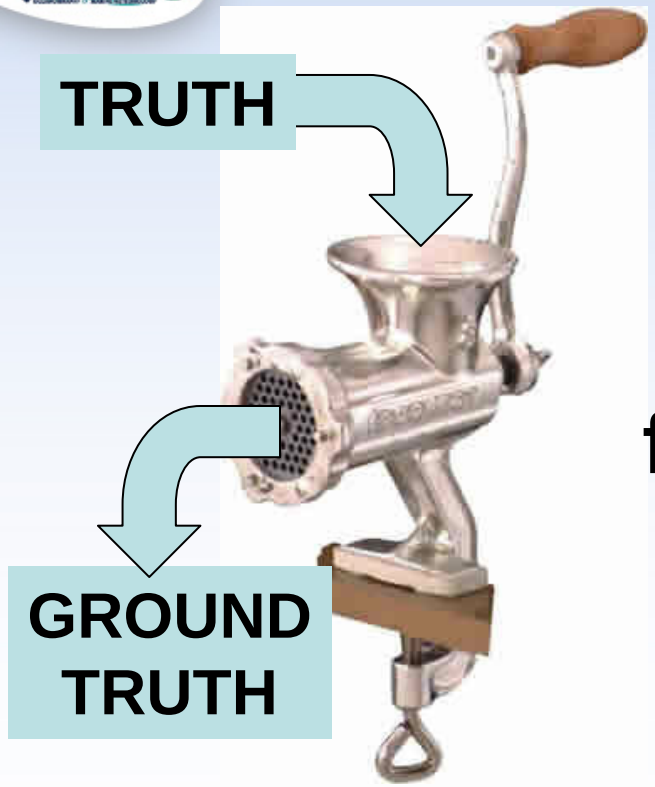
How is your wave measurement?

Courtesy C-C Teng

OceanObs09

“Continuous testing and evaluation of operational and pre-operational measurement systems is an essential component of a global wave observing system, equal in importance to the deployment of new assets”

Swail et al., *Wave Measurements, Needs And Developments For The Next Decade*. OceanObs09 publication.



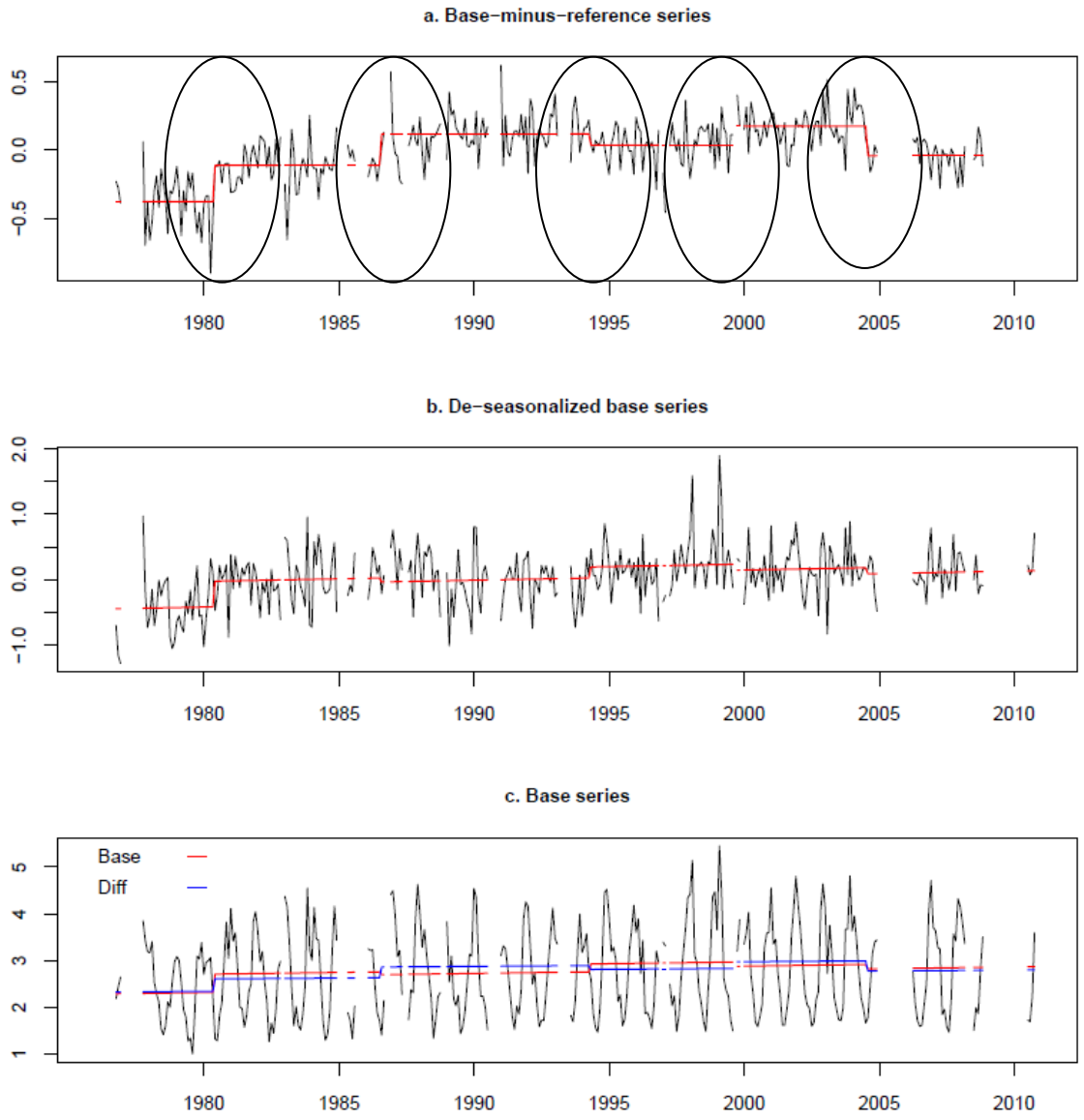
New System for obtaining "ground truth" for wave measurements

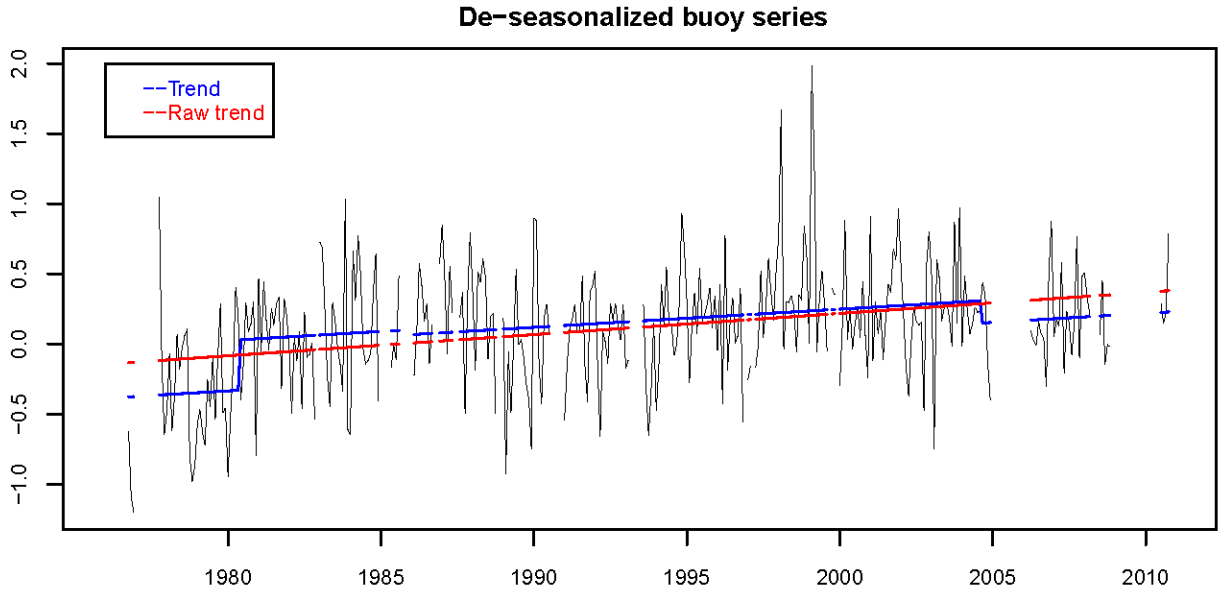
Or

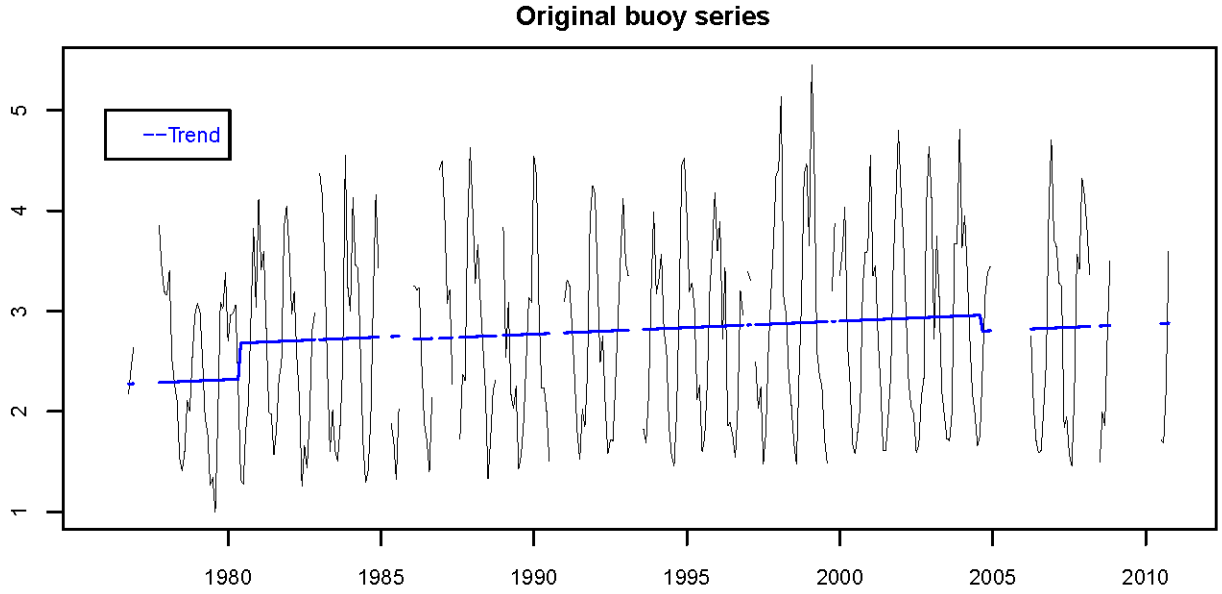
What about an independent group of assessors??

Courtesy Don Resio

46005 - Washington




De−seasonalized buoy series
Trend
Raw trend
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
1980
1985
1990
1995
2000
2005
2010


Original buoy series
Trend
5
4
3
2
1
1980
1985
1990
1995
2000
2005
2010

PP-WET: Objectives

- Develop the basis for an international framework for the continuous testing and evaluation of existing and planned wave buoy measurements
- Coordinate buoy inter-comparison activities.
- Develop technical documentation of differences due to hull, payload, mooring, sampling frequency and period, processing (e.g. frequency bands & cutoff), precision, transmission
- Develop training material to educate users about how to deploy and operate wave sensors appropriately.
- Contribute appropriate material to the JCOMM Standards and Best Practice Guide
- Establish confidence in the user community of the validity of wave measurements from the various moored buoy systems

Status of Intercomparison Activities during the Year

Canada

- Contract continued with to CDIP/SIO to
  - Maintain intercomparison web site
  - Provide intercomparison software to partners
  - Advise on use of intercomparison methodology and web site
  - Advise on intercomparison technical issues
  - Conduct individual intercomparison analyses for participants based on **wave spectra**

- Intercomparison activities – 4 co-deployments
  - **Hecate Strait**: 3D vs DWR, TriAxys vs DWR
  - **Burgeo Bank**: 6N vs DWR; TriAxys vs DWR
  - **Halifax**: 3D vs DWR; TriAxys vs DWR
  - **La Perouse Bank**: 3D vs DWR; TriAxys vs DWR (data being logged onboard)
  - Planning for 6N, TriAxys vs DWR offshore Newfoundland
  - Deployment of SIO wave drifters off Vancouver Island
  - Offer to co-locate SIO GPS sensor in Canadian hull
  - Organize Special Session at 12th Waves Workshop, November 2011
  - See Technical Workshop presentation and following slides for results

Status of Intercomparison Activities during the Year

United States

1. USACE collaborating with NDBC to evaluate dual-sensor single hull deployments with variants of the 3DMG sensor and a HIPPY (see Technical Workshop presentation)
   - 44014 (Virginia Beach) – 3DMG* based on Bender (2009), HIPPY
   - 46029 (Columbia River) - 3DMG*, HIPPY
   - 46042 (Monterey) – buoy farm 3DMG*, HIPPY, DWR
   - 46026 (San Francisco) – Co-Located 3DMG, DWR
2. USACE has provided NDBC funds to continue dual-sensor single hull evaluations with procurement of 2 more HIPPY sensors – 3D buoys on west coast initially then east coast
3. USACE and NDBC have 3-year plan to outfit an existing 6N buoy containing all historical sensor and payload packages, a HIPPY and 3DMG, to be deployed at Monterey
4. USACE and NDBC revising US National Waves Plan, fall 2012. Alliance for Coastal Technologies Report completed
5. USACE has updated and posted on web site WaveEvalTools
6. U of Miami graduate thesis describing WaveEvalTools in detail, and compares ASIS buoy versus NDBC 3D, DWR during Hurricane Ernesto
7. SIO deployed wave drifters at several locations off west coast; investigating co-location of GPS sensor in operational Canadian 3D or 6N hull

Status of Intercomparison Activities during the Year

United Kingdom

- Autonomous Triaxys spectral wave sensors have been deployed on K5, Brittany and Gascogne buoys reporting the ‘first-5’ parameters (as recommended by PP-WET) over a reduced number (32) of frequency bands
  - Spectral wave data is reported every 6 hours from K5 and every 3 hours from Brittany, to GTS in BUFR.
  - These buoys also have a Datawell heave sensor reporting hourly wave data. A comparison of the Triaxys and Datawell wave measurements at K5 is currently being worked up (not First-5).

- Plan for later in the year (or early next) to set up an experiment to operate the Datawell MK2 waverider buoy, purchased to facilitate wave measurement comparisons, alongside a regular buoy (with a Triaxys)

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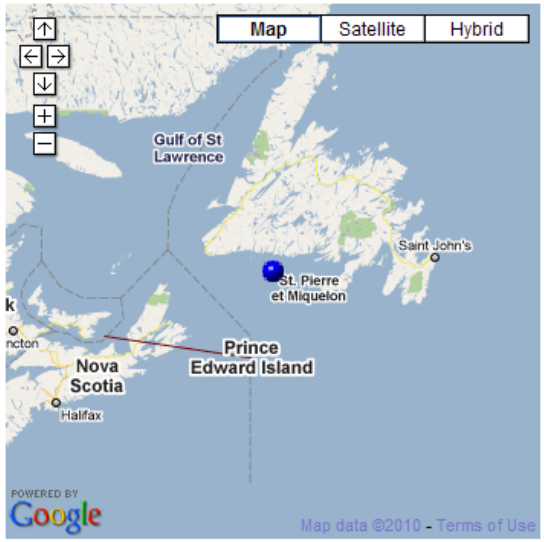
Status of Intercomparison Activities during the Year

- **Norway** – Ekofsik platform wave historical data being assembled for submission to CDIP for analysis – LASAR, waverider, MIROS. Coordination with Conoco regarding deployment of DWR
- **Korea** – multiple co-locations at Ieodo platform. Some issues with submitting data to CDIP for analysis
- **India** – NIOT decided to deploy the buoys (Wavescan and DWR) in very shallow, sheltered waters a few kilometers apart due to the safety of the equipment. The deployment period offered no high sea states, most of them less than 0.5m. Thus the comparison study had very limited value if any
- **OGP** – continue to express interest in providing co-located measurements to CDIP for analysis; expressed interest in follow-on to New York workshop; Ekofisk logistics
- Interest but no definite plans at the moment: ESURFMAR, Australia, China, Japan (especially wave drifters)

- **Other participants are encouraged to join the WET activity by contacting the co-chairs or Secretariat.**

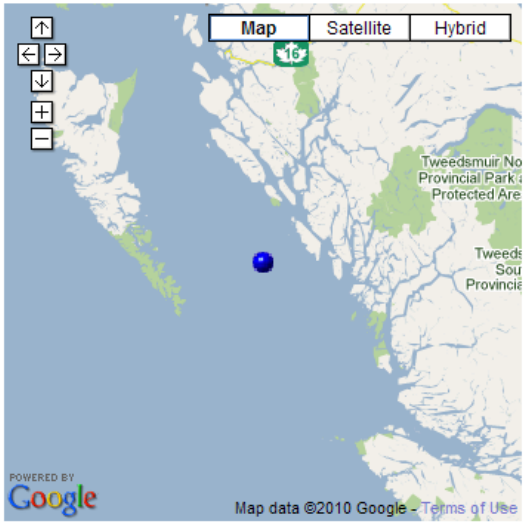
Canadian Co-deployment locations – Phase 1

- Current status: **operational**
- Most recent location: **47 15.91 N 57 20.49 W (47.2652 -57.3415)**
- Instrument description: **Datawell directional buoy**
- Most recent water depth (MLLW): **177 m (581 ft, 97 fm)**
- Measured parameters: **wave energy,wave direction,sea temperature**
- NDBC/WMO identifier: **44235**



170 - Station Map

- Current status: **operational**
- Most recent location: **52 26.20 N 129 47.70 W (52.4367 -129.7950)**
- Instrument description: **Datawell directional buoy**
- Most recent water depth (MLLW): **230 m (755 ft, 126 fm)**
- Measured parameters: **wave energy,wave direction,sea temperature**
- NDBC/WMO identifier: **46138**

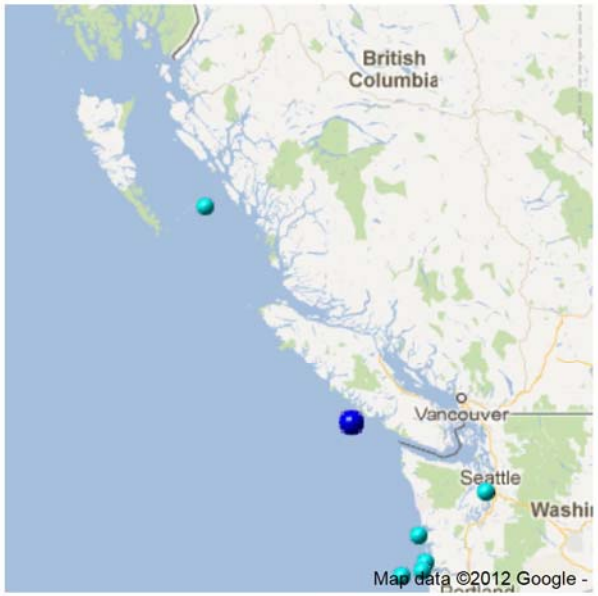


174 - Station Map

DWR co-located with operational 6m NOMAD plus TriAxys sensor at Burgeo Bank
DWR co-located with operational 3m discus plus TriAxys sensor at South Hecate

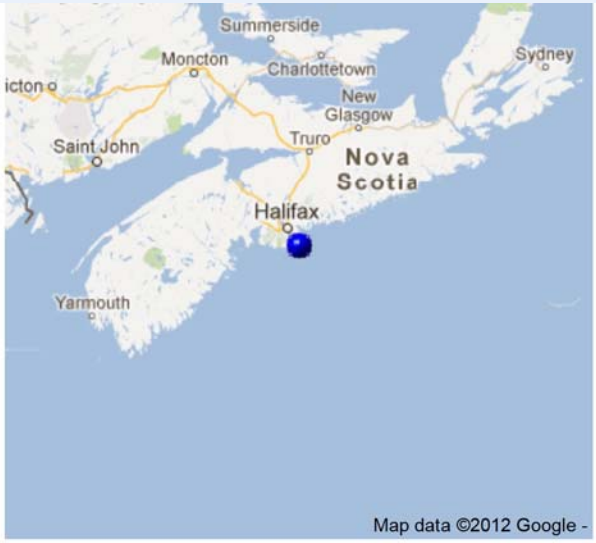
Canadian Co-deployment locations – Phase 2

- Current status: **operational**
- Most recent location: **48 50.61 N 126 0.61 W (48.8436 -126.0102)**
- Instrument description: **Datawell directional buoy**
- Most recent water depth (MLLW): **71 m (233 ft, 39 fm)**
- Measured parameters: **wave energy,wave direction,sea temperature**
- NDBC/WMO identifier: **46139**



195 - Station Map
20nm offshore of Ucluelet Vancouver Island
NOAA Nautical Chart 18007

- Most recent location: **44 30.01 N 63 24.49 W (44.5001 -63.4082)**
- Instrument description: **Datawell directional buoy**
- Most recent water depth (MLLW): **53 m (174 ft, 29 fm)**
- Measured parameters: **wave energy,wave direction,sea temperature**
- NDBC/WMO identifier: **44172**

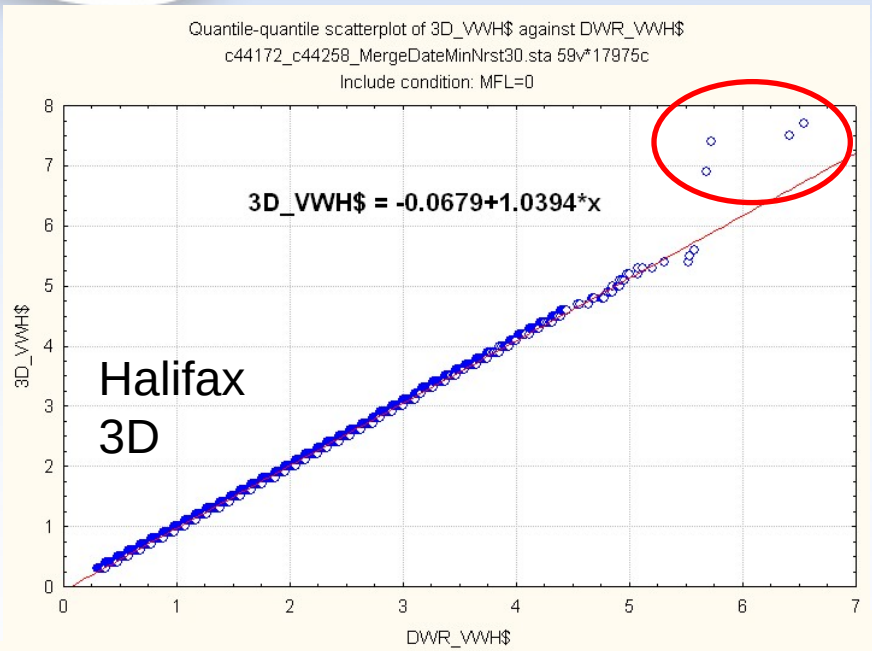


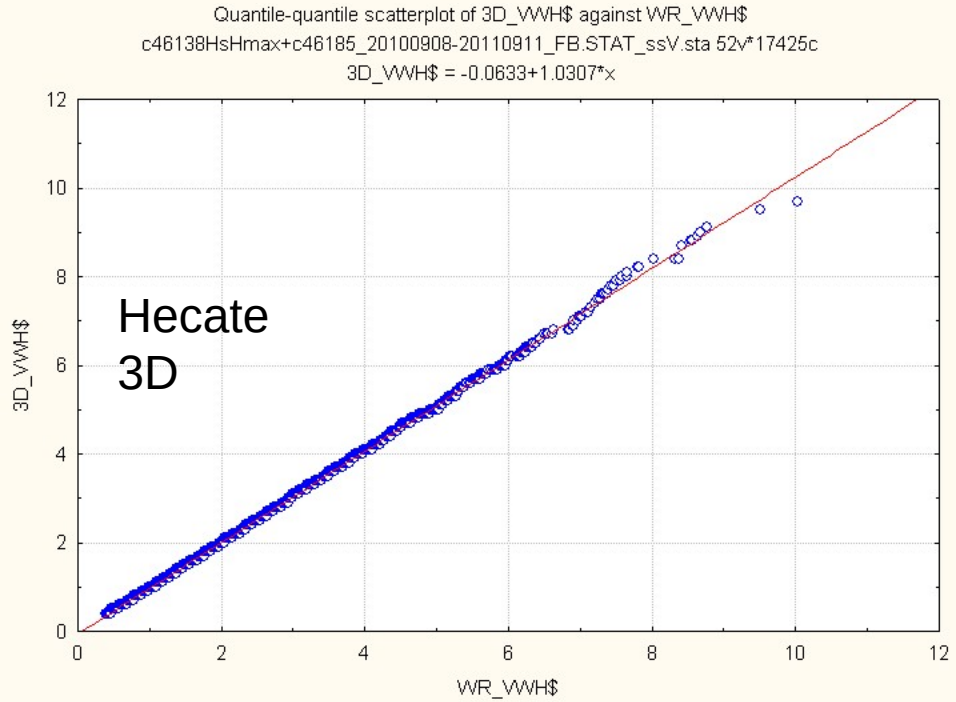
176 - Station Map
5 miles East of Duncan's Cove

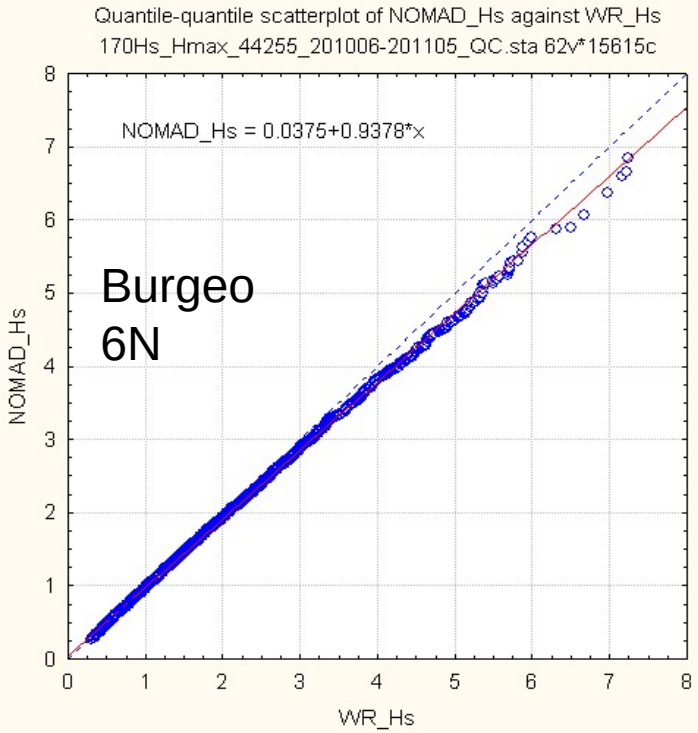
DWR co-located with operational 3m plus TriAxys sensor at Halifax Harbour
DWR co-located with operational 3m plus TriAxys sensor at La Perouse Bank
DWR to be moved to operational 6m NOMAD plus TriAxys offshore East Coast

H_s Comparison

- NOMAD Hs ~ 7% low compared to WR Hs
- 3D Hs ~ 3% > WR Hs (both)
- Treat results with caution! – not First-5.

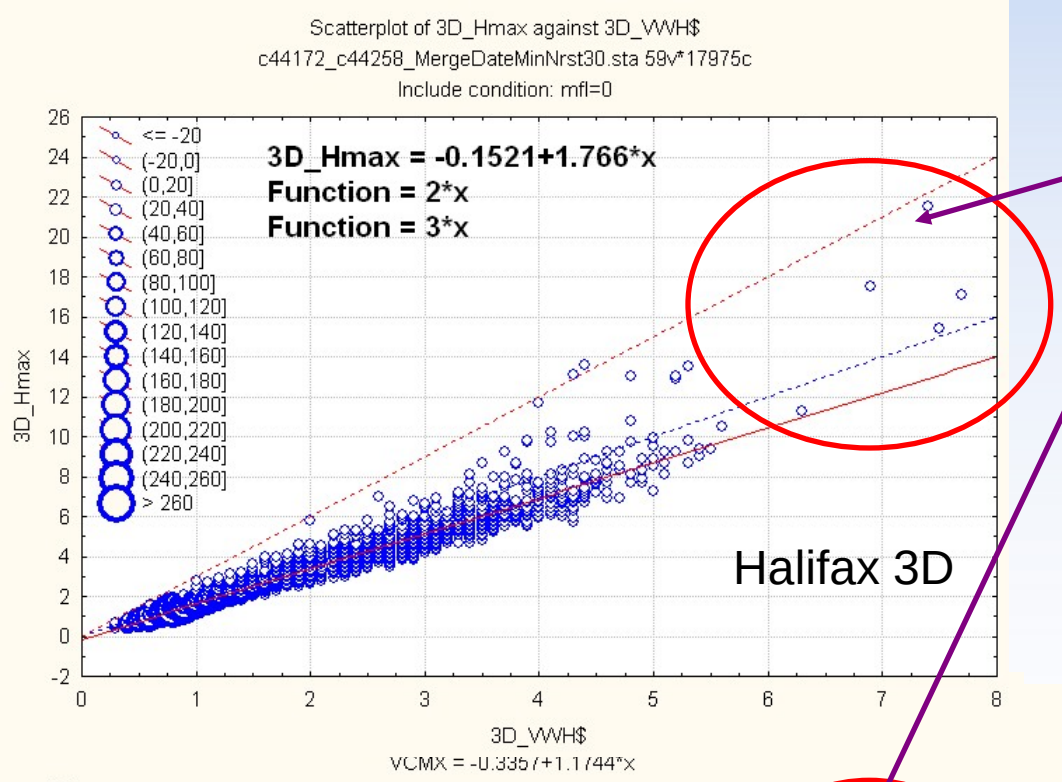




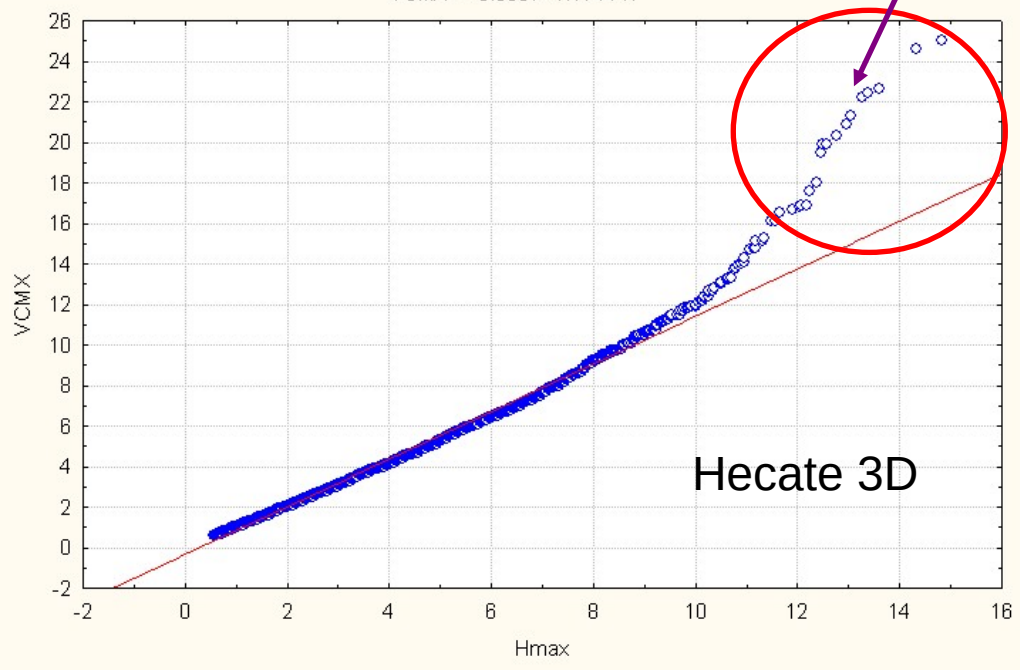


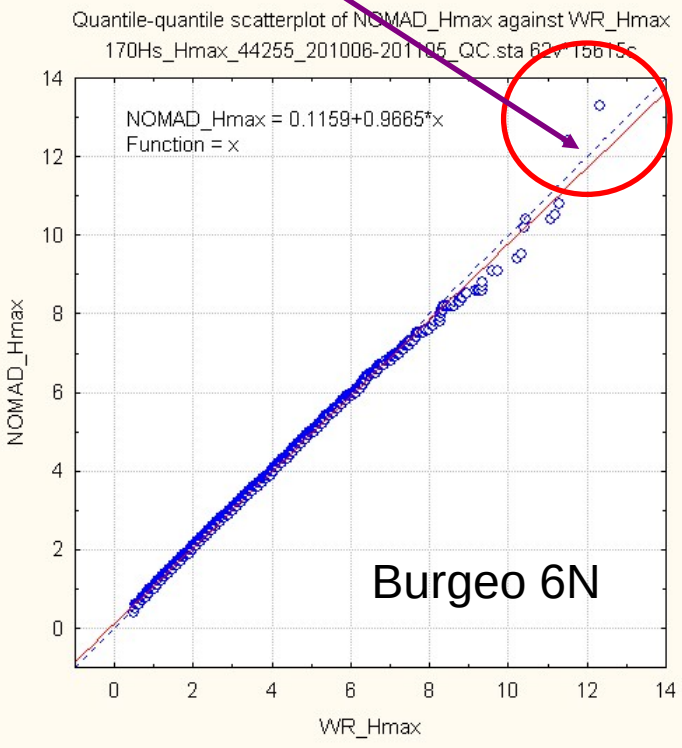
H_{max} Comparison

- Hmax/Hs ratio frequently 2-3 at Halifax 3D
- 3D spuriously high values of Hmax compared to WR



- NOMAD_Hmax = 3% <WR_Hmax
- a few high outliers (NOMAD_Hmax > WR_Hmax)





Ref. No. [UMCES]CBL 12-028
Alliance for Coastal Technologies Indexing No. ACT-12-01

Testing Wave Measurement Systems

WAVES MEASUREMENT SYSTEMS TEST AND EVALUATION PROTOCOLS

IN SUPPORT OF NATIONAL OPERATIONAL WAVE OBSERVATION PLAN

July 2012

Funded by NOAA and the U.S. Integrated Ocean Observing System

Available from:
http://www.act-us.info/

Table of Contents from the ACT report

Wave Measurement Systems Test and Evaluation Protocols

Table of Contents

WMO IOC/UNESCO

Excerpt from the ACT report

As reported by Magnusson (2008) "…(Norwegian Meteorological Institute), Phillips Petroleum Norway, now ConocoPhillips, has recorded waves at or in the vicinity of the Ekofisk complex since 1980. Different sensors have been used, and mounting locations on the complex have changed through time. In the years 1991 to 1993, environmental data were available through modem. Since 1993 data have been transferred in real time through internet. The first winter season (1991-1992), wave data from two height measuring systems (an EMI radar and a Plessey radar) were largely affected by lee effects from the tank structure. Focus was thereafter placed on good quality wave measurements, because forecast skills are highly dependent on measuring feedback. A WAMOS (www.oceanwaves.de) was installed to measure directional wave spectra at 2/4-K, and two new sites were chosen for 2 down looking lasers (Optech lasers), one at flare South, with good exposure to waves from east-west direction, and one at flare North, with relatively good exposure to northerly directions, and also from the east and west sectors. This paper only deals with the wave measurements from the in-situ systems (wave profilers). The two Optech lasers have given relatively good measurements in the period 1995-2005, although with known problems of possible reflection of waves from the tank in northerly situations at the northern flare, and sea spray from the platform legs in the vicinity of both sensors when waves are large, as…" during a storm.

Further Magnusson (2008) goes on to state "Due to decommissioning of the platforms North of the tank, the sensor at flare North was replaced in 2005 with a new system of 4 lasers in an array on the bridge between 2/4-K and 2/4-B (Krogstad et al., these proceedings). The bridge is oriented East-West, with open sector towards North and South. Waves from the westerly sector may be subject to interference with the 2/4-B platform, which is about 80 meters away. The sensor at flare South was replaced with a MIROS down-looking radar altimeter, a Miros Range Finder (MRF)."

9.1 Co-locating Systems

The first and highest priority task of an ACT Test and Evaluation calls for the Datawell Waverider Buoy to be co-located with this array and evaluated against the LASAR.

Although the scientific community is aware of some of the issues with LASAR, the consensus is that a co-location exercise with a directional Waverider is necessary. At present, there is a non-directional Waverider at LASAR. However, ACT will purchase the directional Waverider and be responsible for buoy deployment at the Ekofisk site with Ekofisk oversight. Pre-deployment calibration of the Buoy will be performed by Datawell. This same directional Waverider will be used for all subsequent ACT co-location exercises; thus providing a reference standard for all future testing and evaluation.

For data review and delivery during the reference standard evaluation, the buoy will be capable of both iridium and high frequency (HF) radio communication. HF was considered necessary in case the buoy breaks loose from its mooring. The hand held GPS tracking unit, essential in recovery, communicates via HF. Iridium communication has proven to be very reliable offshore and out of range of the HF radio communication.

2012-07-25

In Situ Wave Measurements: Sensor Comparison and Data Analysis

Clarence O. Collins III
University of Miami, Tripphysicist@gmail.com

From Table of Contents from the Collins thesis

From Collins thesis: WET File Format for intercomparison

first 5 Fourier coefficients using equations from section 4.2.3. The coefficients are then compiled into the proper file input for the WET program.

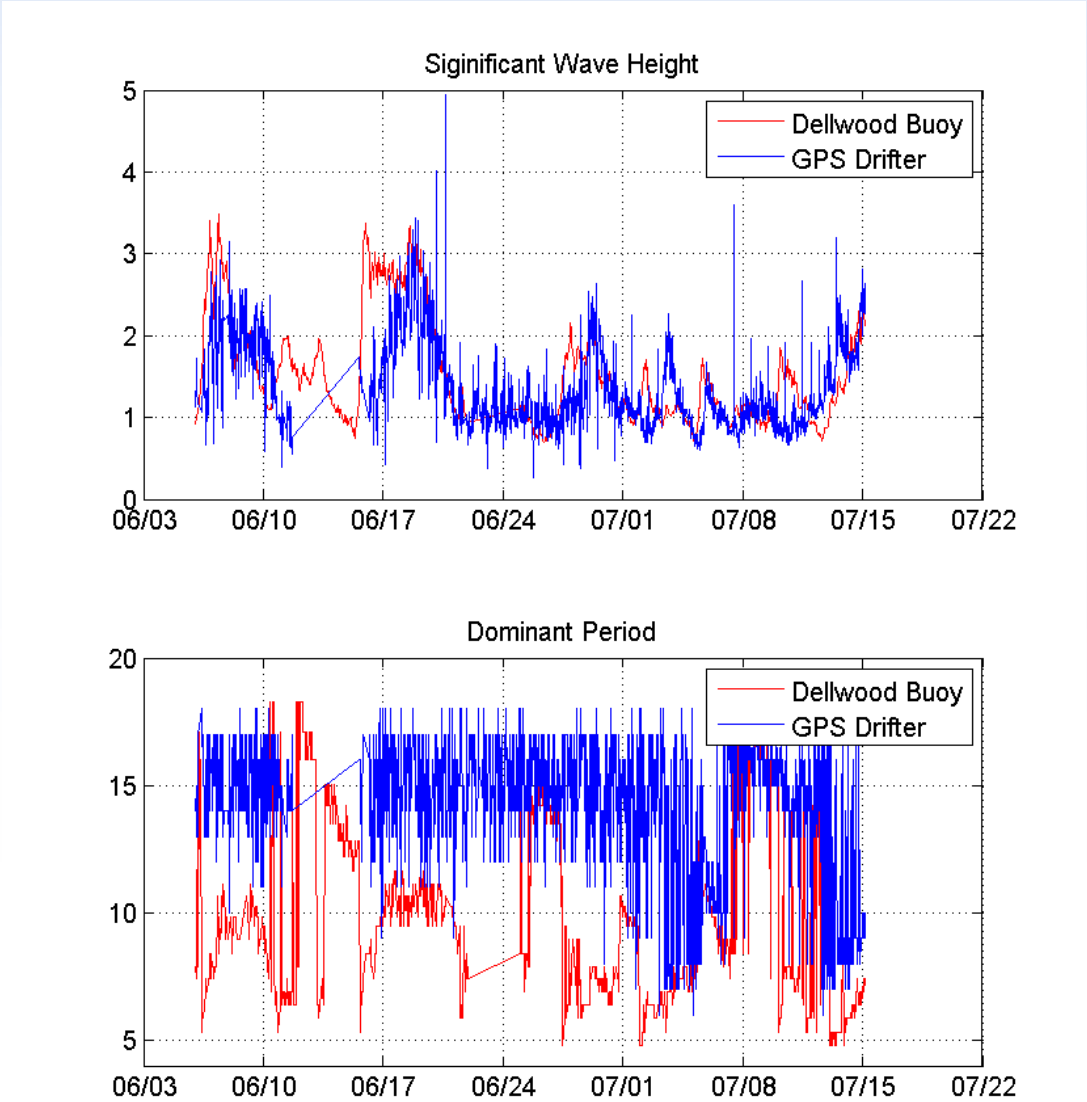
6.5 WET File Format

The WET program uses a specially formatted file called a .vsp file. It is structured in the following way:

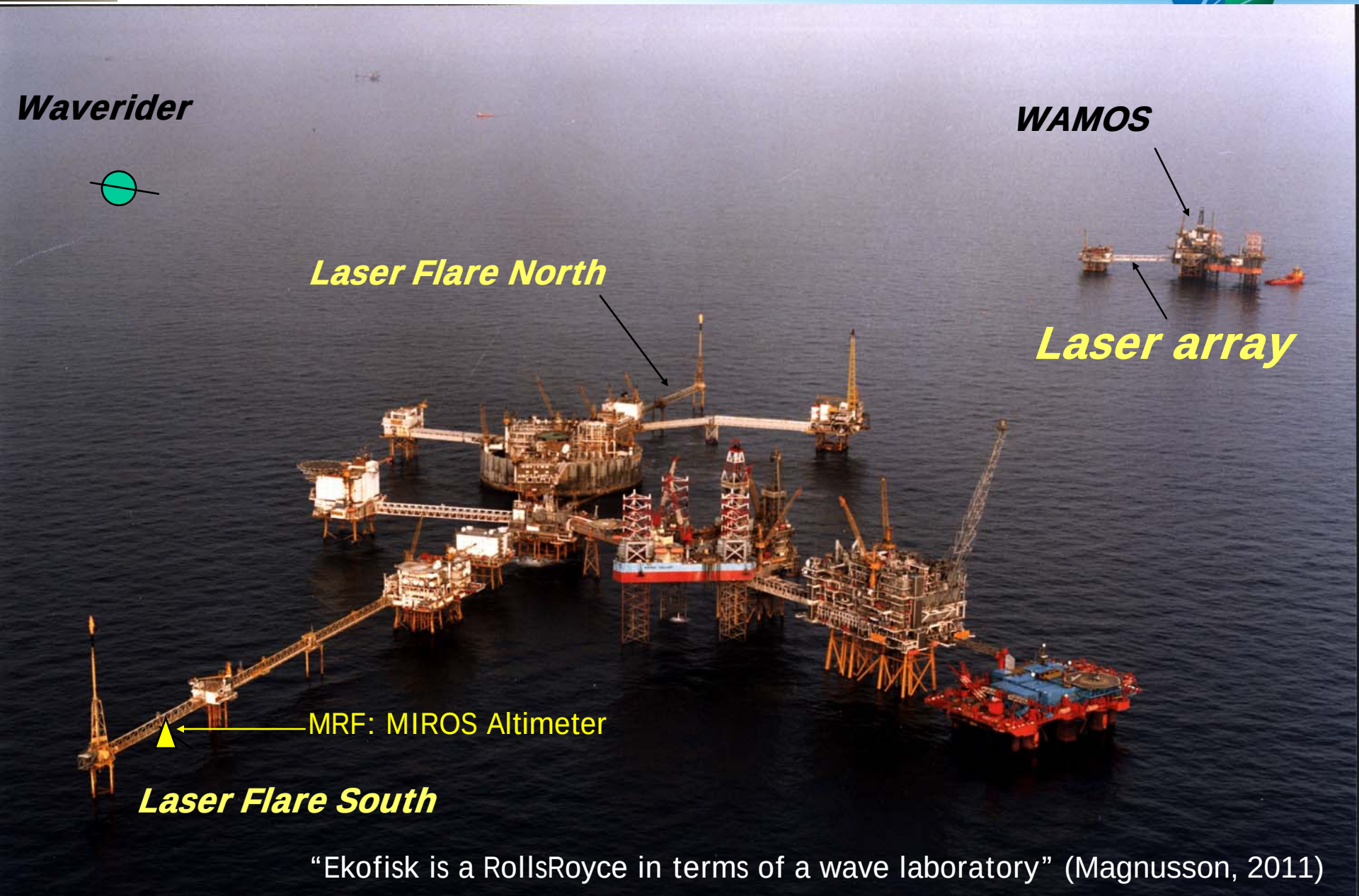
line 1: Year Month Day Hour Minute TR_UTC n
line 2: f_1 bandwidth(f_1) $A_0(f_1)$ $A_1(f_1)$ $B_1(f_1)$ $A_2(f_1)$ $B_2(f_1)$ cr(f_1)
line 3: f_2 bandwidth(f_2) $A_0(f_2)$ $A_1(f_2)$ $B_1(f_2)$ $A_2(f_2)$ $B_2(f_2)$ cr(f_2)
.
.
.
line n+1: f_n bandwidth(f_n) $A_0(f_n)$ $A_1(f_n)$ $B_1(f_n)$ $A_2(f_n)$ $B_2(f_n)$ cr(f_n)
line n+2: Year Month Day Hour Minute TR_UTC n
.
.
.

Where $A_0(f_i)$ is the wave energy density (m^2/Hz) at frequency (f_i), $A_1(f_i)$, $B_1(f_i)$, $A_2(f_i)$, $B_2(f_i)$ are the normalized directional Fourier coefficients at frequency (f_i). cr(f) is a check ratio which is not currently used so it is always set to 0. TR_UTC is the time difference between UTC and the local time on the wave record. Since all data is recorded in UTC this is also 0. n is total number of frequency bands.

Comparison of drifter mounted GPS wave sensor with MSC East Dellwood weather buoy



Wave instrumentation on Ekofisk, central North Sea (56.5 N 3.2 E)

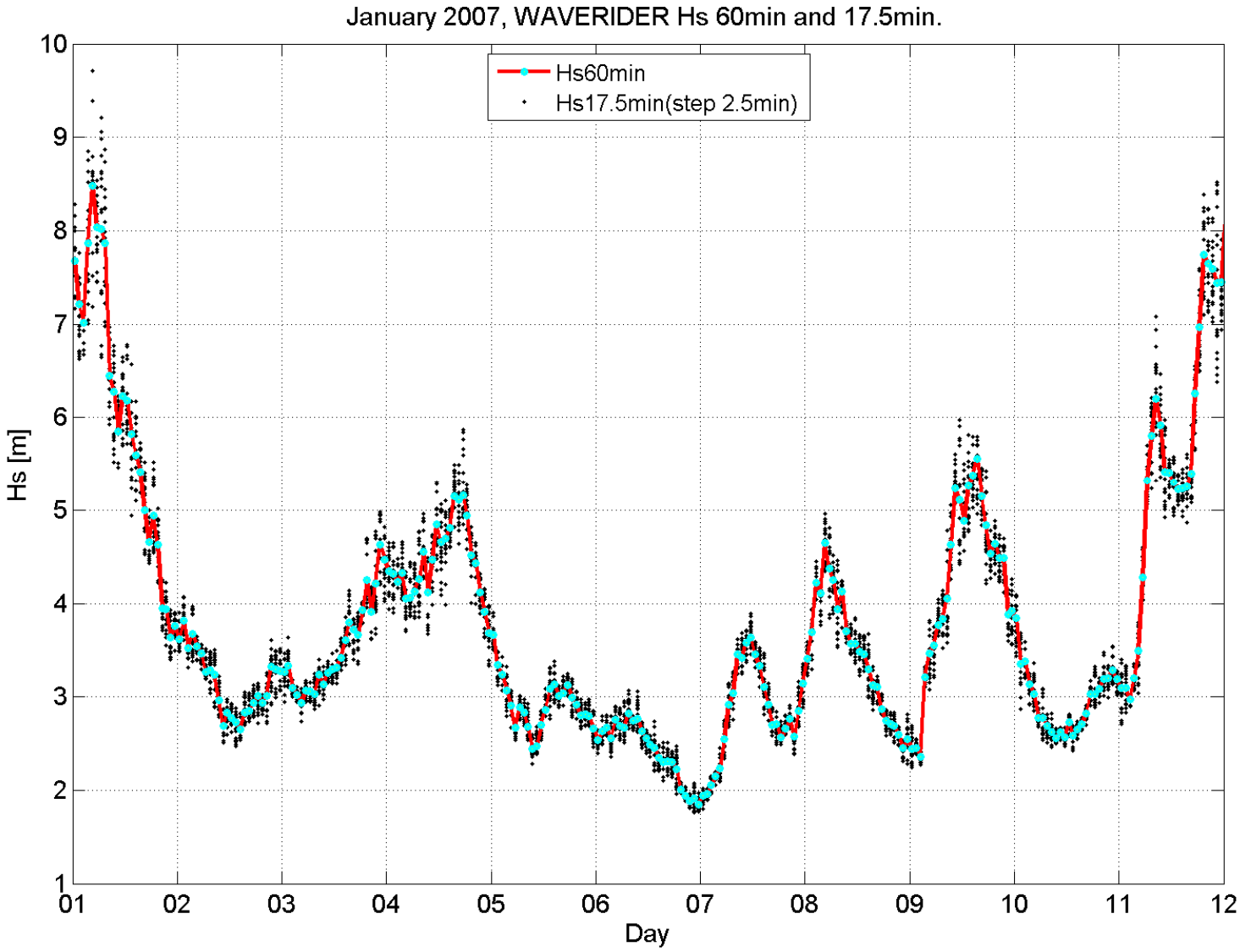


"Ekofisk is a RollsRoyce in terms of a wave laboratory" (Magnusson, 2011)

Wave height: White, green or blue water?

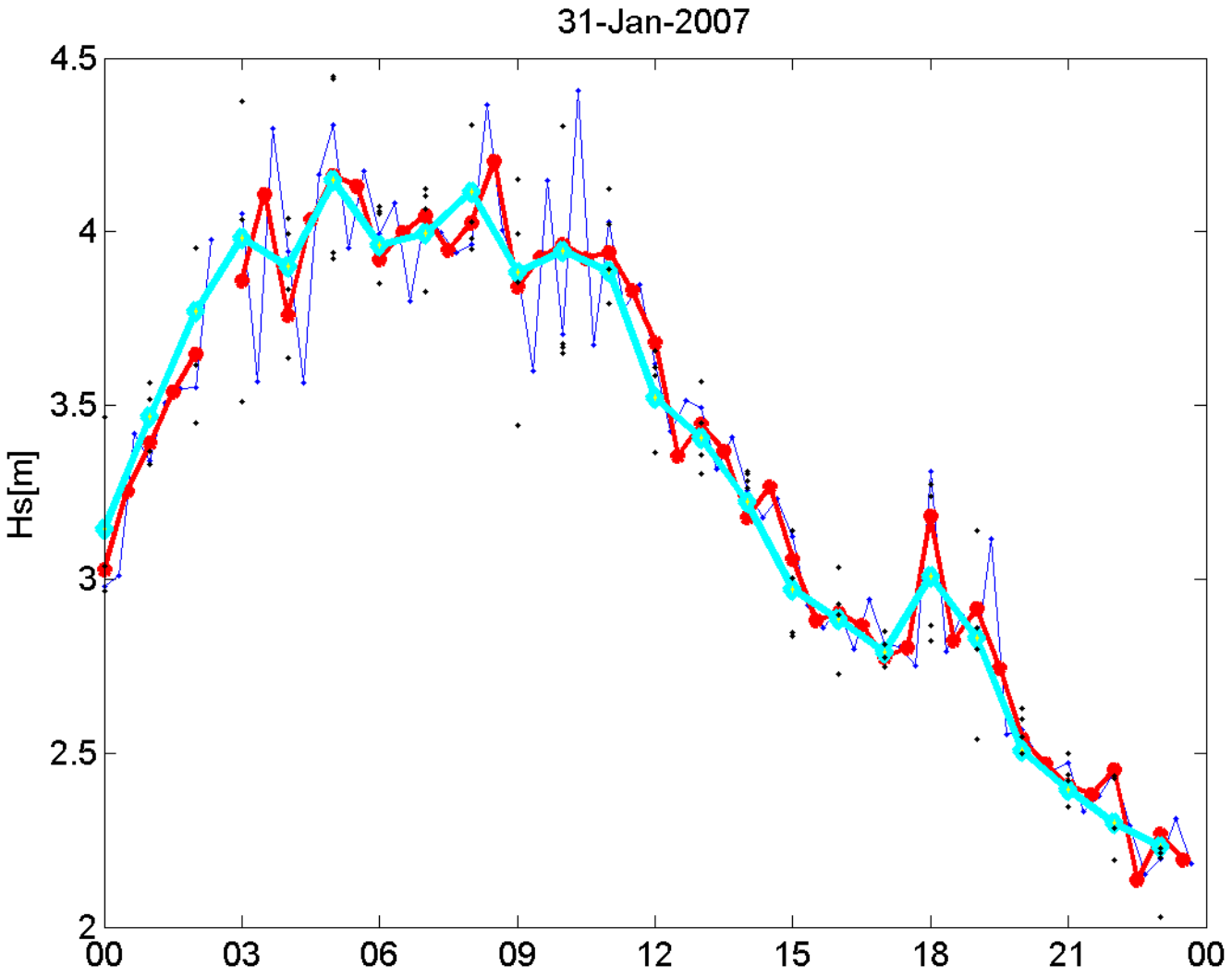
Courtesy A.K. Magnusson

Sampling Variability of Wave Measurement



Courtesy A.K. Magnusson

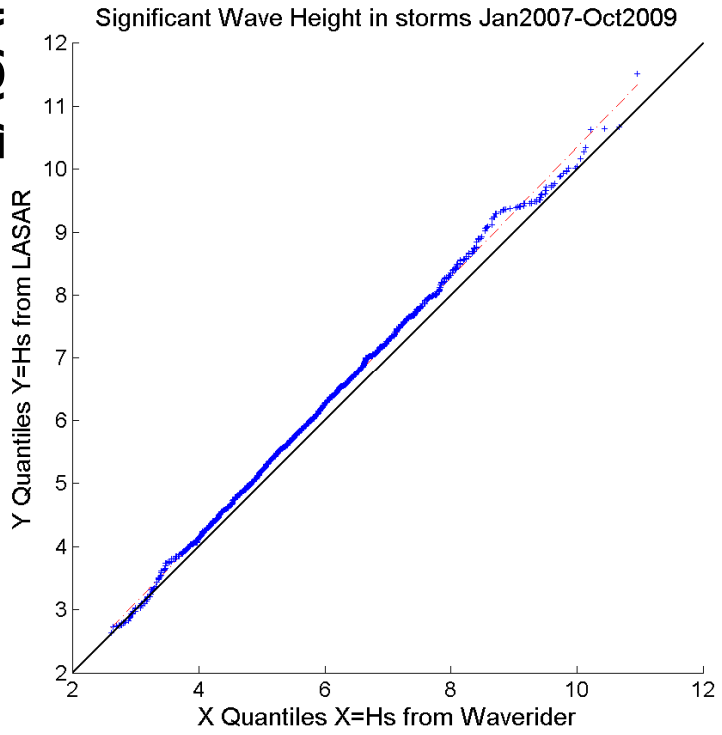
Sampling Variability of Wave Measurement



Courtesy A.K. Magnusson

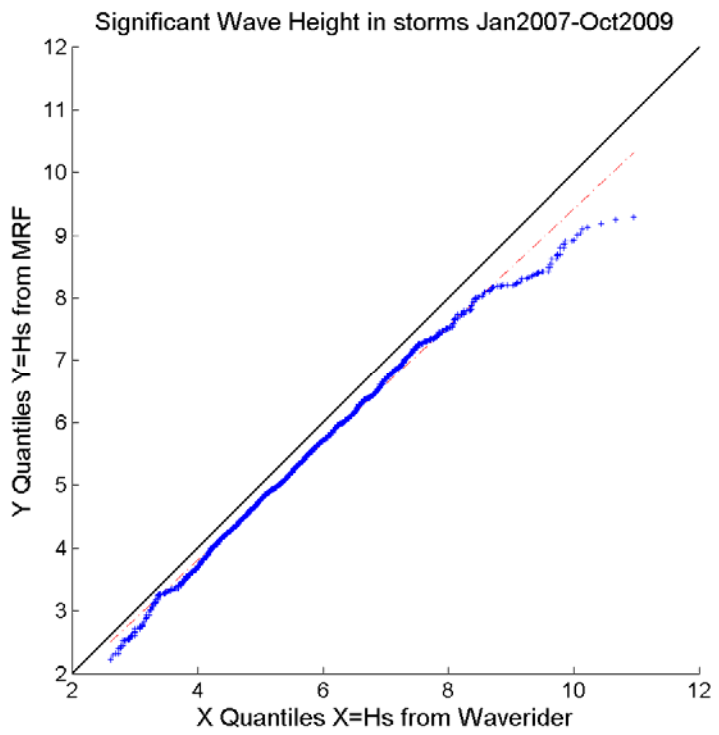
Comparison of Hs in 20 storms jan2007-oct2009 qq-plot

LASAR



Waverider

MRF



Waverider

Source: “What is True Sea State?” Magnusson, 11th Waves Workshop

Immediate Priorities for PP-WET

- Compare an existing NDBC 6N buoy containing all historical sensor and payload packages, a HIPPY and 3DMG
- Evaluate additional wave drifters, including dual-sensor comparison of GPS sensor in 3D or 6N hull
- Operate the Datawell MK2 waverider buoy alongside a regular UK buoy (e.g. K-5)
- Co-locate DWR with the LASAR array at Ekofisk – requires a buoy!!
- Continue Canadian co-locations including another 6N
- More directional spectral intercomparisons

Recommendations to DBCP-28 for PP-WET

- Encourage additional agencies/countries to carry out intercomparisons
- Encourage RMIC RA-IV (and other RMICs with wave component) to play a key role in the Pilot Project
- Review membership – action co-Chairs, Secretariat
- Plan follow up technical workshop on results to date – action co-Chairs , Secretariat
- Develop guidelines on the best practices for measurement of reliable, high-quality spectral wave measurements, including directional spectra – action co-Chairs – patience!
- Continue the Pilot Project for another year, with no additional funding support

PP-WET Steering Team membership

- Val Swail, Co-Chair (ETWCH, EC)
- Bob Jensen, Co-Chair (USACE)
- David Meldrum (DBCP, SAMS)
- Jean Bidlot (ECMWF)
- Kwang-Chang Lim (KHOA)
- Bill Burnett (NOAA/NDBC)
- Julie Thomas (UCSD)
- Hans Graber (U. Miami)
- Diana Greenslade (BoM)
- Venkatesan (India)
- Luca Centurioni (UCSD)
- Chris Marshall (EC)
- Bill O'Reilly (UCSD)
- Jon Turton (Met Office)
- Christian Meinig (NOAA/PMEL)
- Anne Karin Magnusson (met.no)
- Kevin Ewans (Shell)
- George Forristall (ForOcean)
- Colin Grant (OGP Metocean)
- DBCP Technical Coordinator

- Secretariat support will be provided by WMO and IOC.

- Boram Lee (WMO)
- Etienne Charpentier (WMO)

PROPOSED PP-WET WORKPLAN
OCTOBER 2012 TO SEPTEMBER 2013

- Coordinate intercomparisons of wave measurements from different platforms, on an opportunistic basis;
- Publish intercomparison results and updated status reports on Pilot Project web site;
- Develop a plan for a continuous testing and evaluation program;
- Promote widely the pilot project goals and objectives, and results, to encourage enhanced participation and additional partners, including investigation of an alternative testing site on an ocean platform, and greater involvement of Regional Marine Instrumentation Centres (RMIC);
- Contribute to training material to educate users about how to deploy and operate wave sensors appropriately;
- Contribute, as appropriate, to the JCOMM Standards and Best Practice Guides, including a recommended approach to making reliable, high-quality spectral wave measurements, including directional spectra;
- Decide whether to continue the pilot project for a further year and investigate follow-on mechanisms;
- Present results to DBCP-29 and other scientific fora.


Thank you.