Joint WMO-IOC Technical Commission
for Oceanography and Marine Meteorology

Wave Measurement Evaluation and Testing

R. Jensen, V. Swail and B. Lee

Scientific and Technical Workshop of the Data Buoy Cooperation Panel
26 September 2011
Geneva, SWITZERLAND

WMO

IOC/UNESCO

Outline

- Overview of Process
- Co-located results
  - Preliminary results
  - Sensitivity testing
    - Hulls
    - Sensors
  - Atlantic / Pacific
- Preliminary Assessments
- Summary
- Recommendations

Why Do We Need to Test and Evaluate

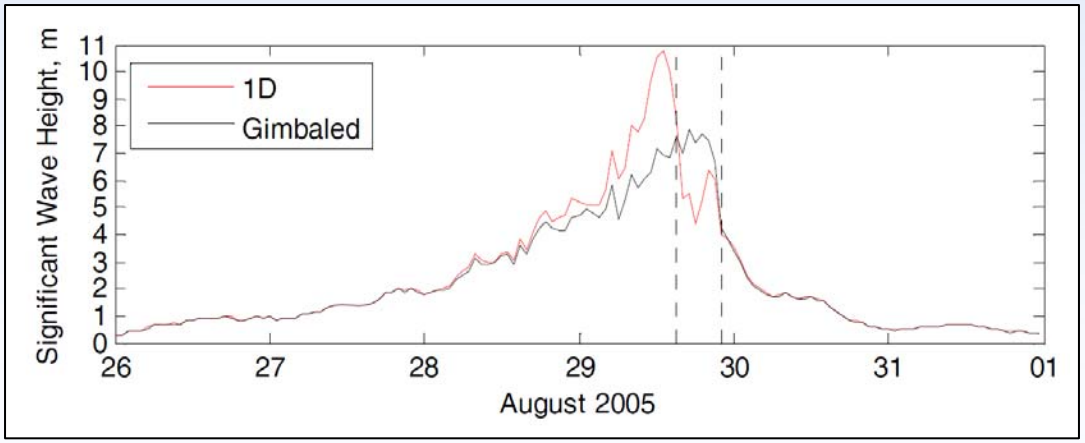
- Waves are difficult to measure
  - Rapid temporal variation
  - Changes in frequency / directional characteristics
  - Spatial variation requires multiple locations
  - Failures: Loss in continuity
    - Natural
    - Human

- Measurements of surface gravity waves are **estimates**
  - From heave-pitch-roll sensors: HIPPY
  - From accelerations (double integrated)
  - From motion sensors (e.g. angular rate)
  - Particle versus slope following

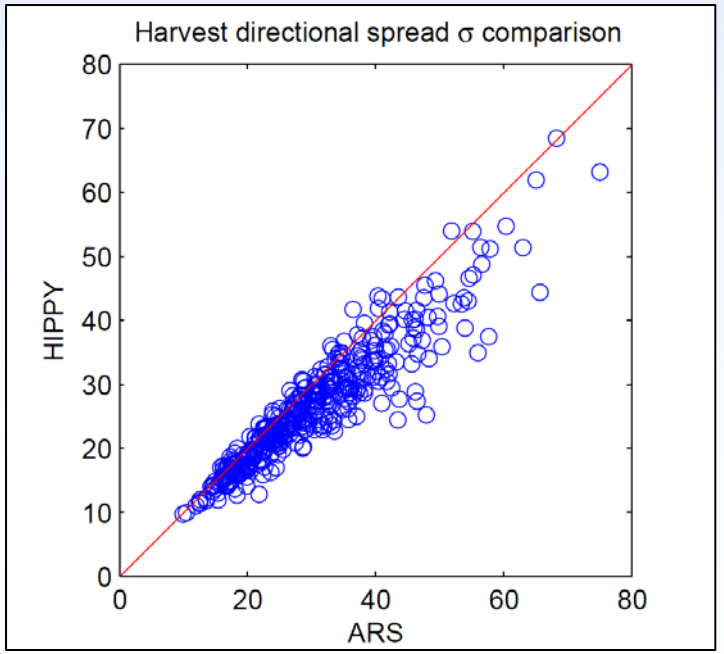
Why Do We Need to Test and Evaluate

- Wave estimates: Based on buoy response
  - Hulls: shape, size, material
  - Super-structure
  - Mooring (including bridle)
  - Sensors
  - Internal analysis package
- Signal to noise:
  - Contamination of wave records
  - Compliance for universal criteria
    - Reduces uncertainty in wave measurements
      - Provides consistency
      - Device to device
      - Underlying processes correctly evaluated

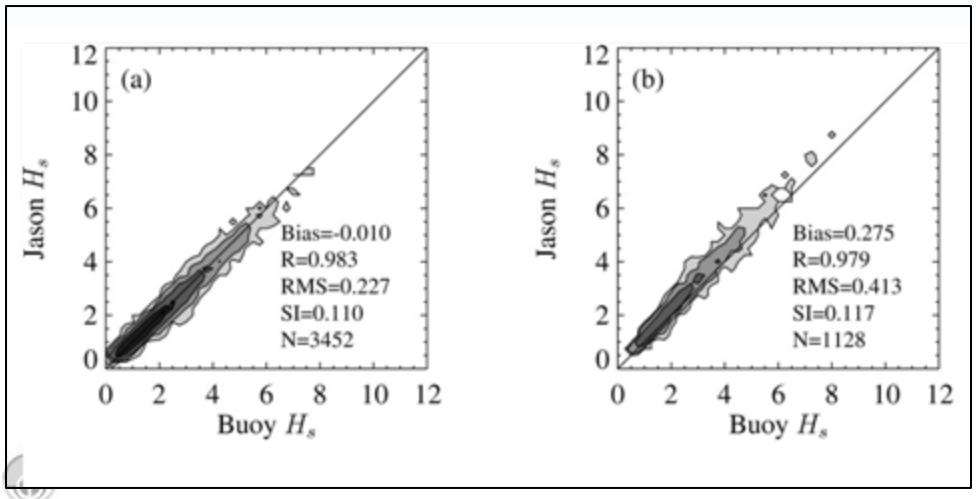
Why Do We Need to Test and Evaluate



Bender et al. (2009)



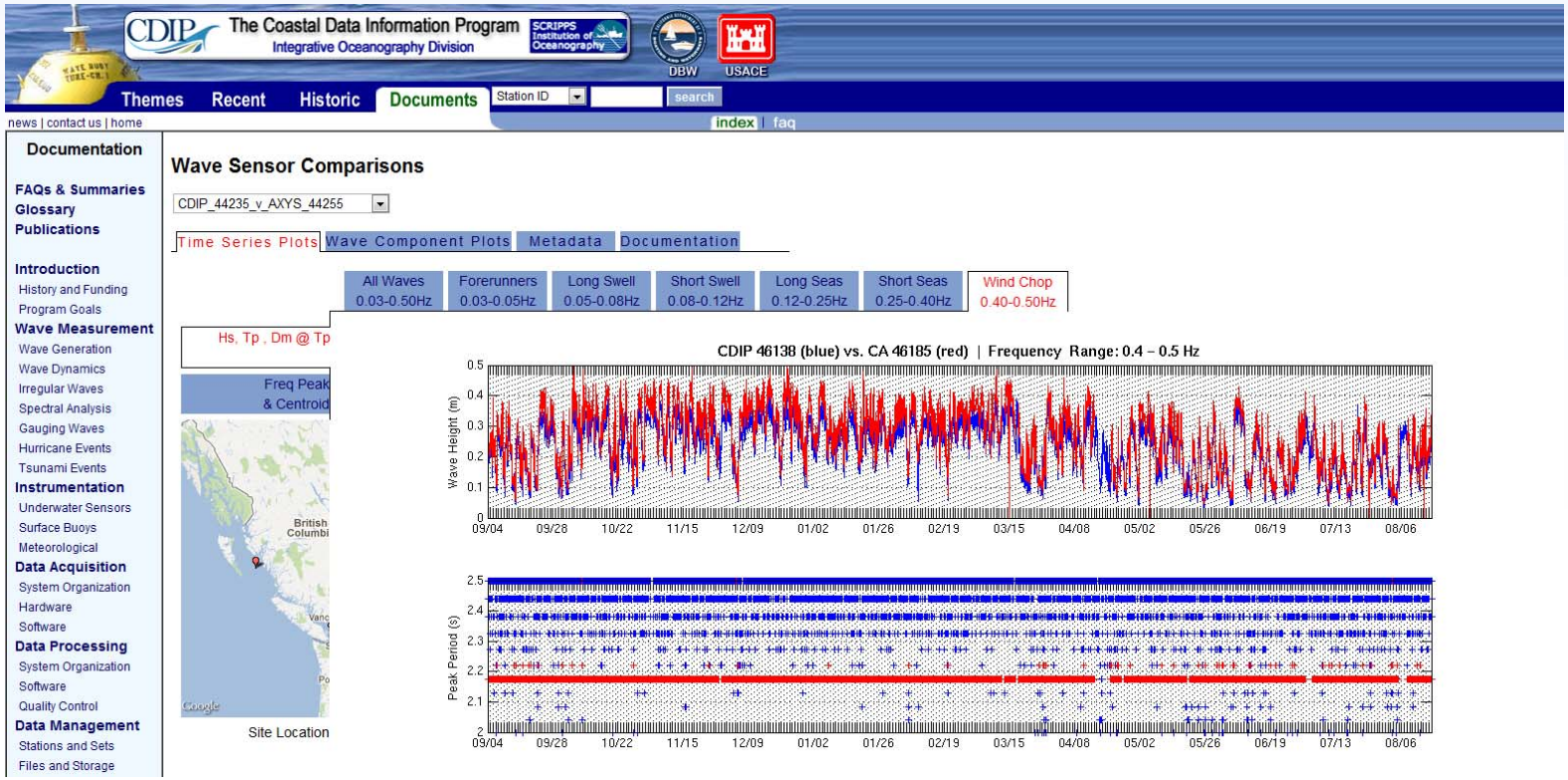
Teng and Bouchard. (2005)



Durrant et al. (2008)

Evaluation Procedure

- Datawell Mark III ***RELATIVE REFERENCE***
- *CDIPtool* selected as the evaluation tool

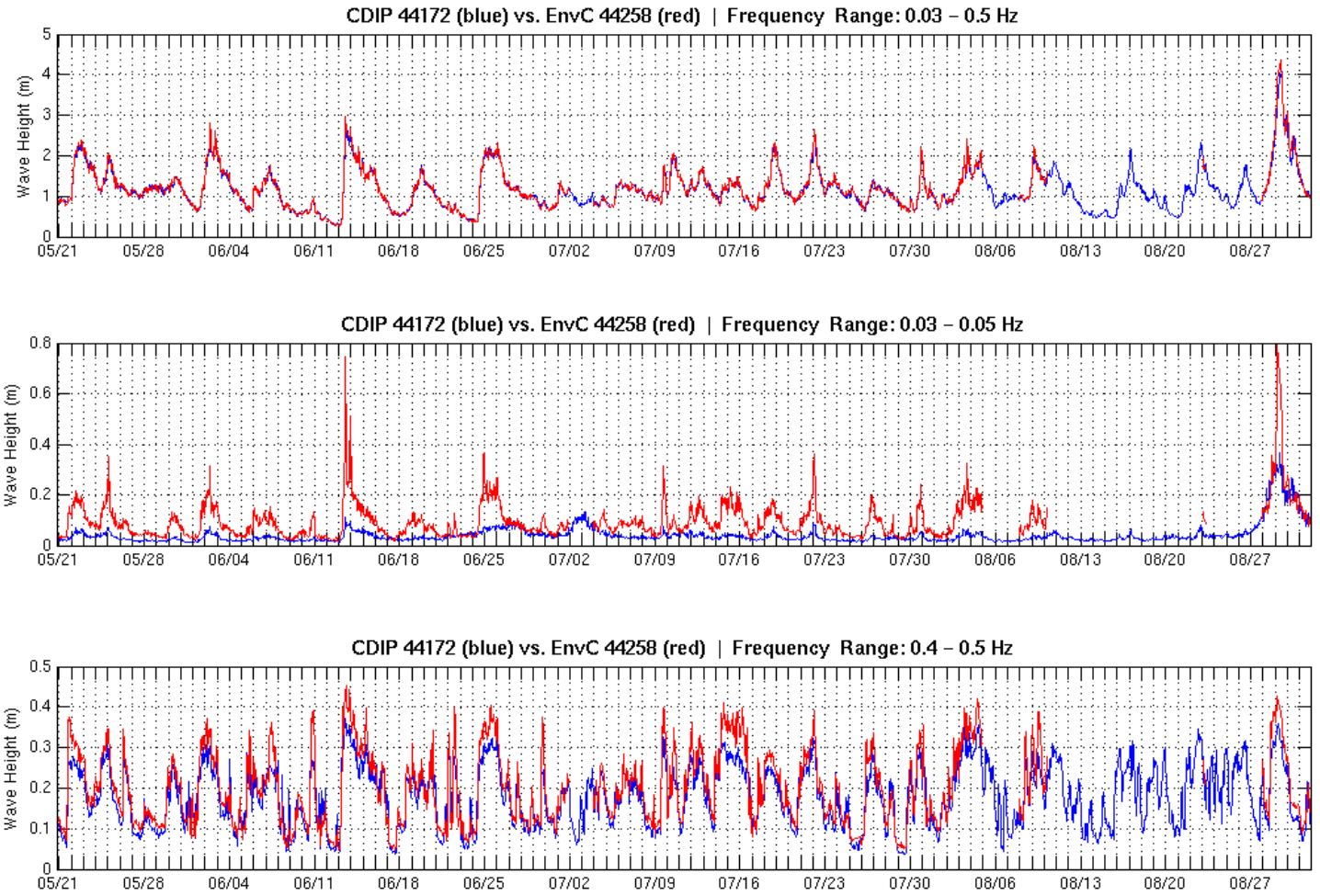


Evaluation Procedure: Co-located

- Series of evaluations
  - Hull, sensor, payload package (3D / 6M)
  - 3D: sensor, payload package (3DM / ARS)
  - 6M: sensor
    - Standard MEDS operational buoy
    - Added the TriAXYS sensor
  - TriAXYS:
    - Standard MEDS 3D operational buoy
    - MEDS 3D Foam
    - MEDS 6M with TriAXYS
- Data yet to be evaluated
  - 51001: HIPPY, 3DM (3-m) Hawaii - NW
  - 46042: HIPPY, 3DM (3-m) PAC
  - 46029: HIPPY, 3DM (3-m) PAC
  - 44014: HIPPY, 3DM (3-m) ATL

Evaluation Procedure: Co-located

Time Series Analysis for specific differences

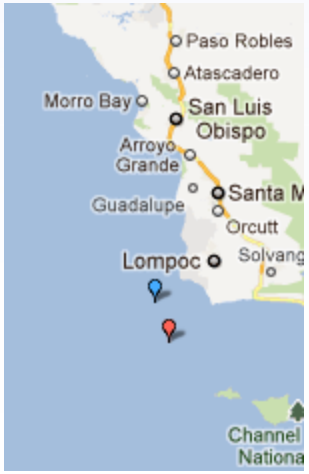


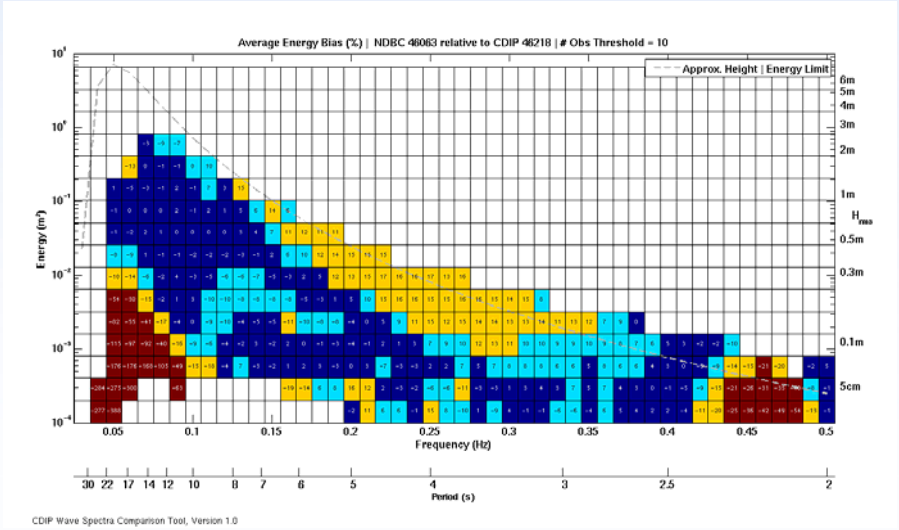
46258: 3D / TriAXYS

Evaluation Procedure: Co-located

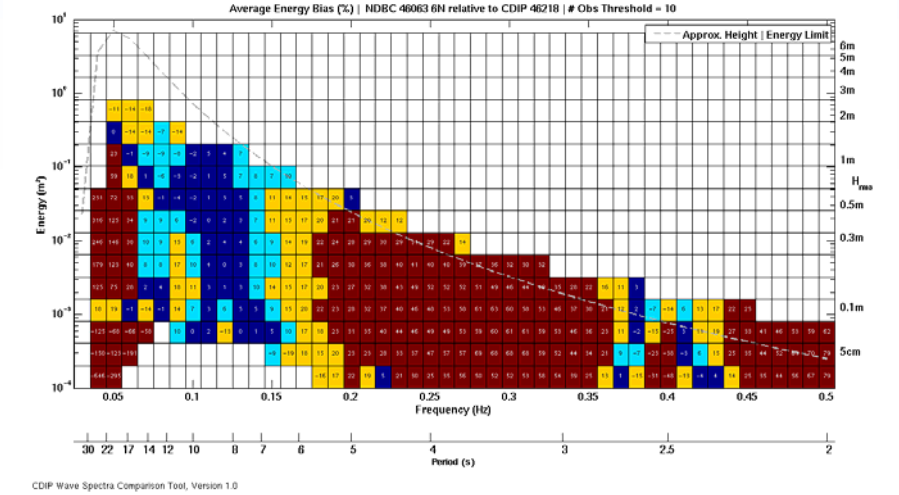
Analysis of Hull / Sensor / Payload Package

3D / ARS / ARES





6M / Inclinometer / DACT

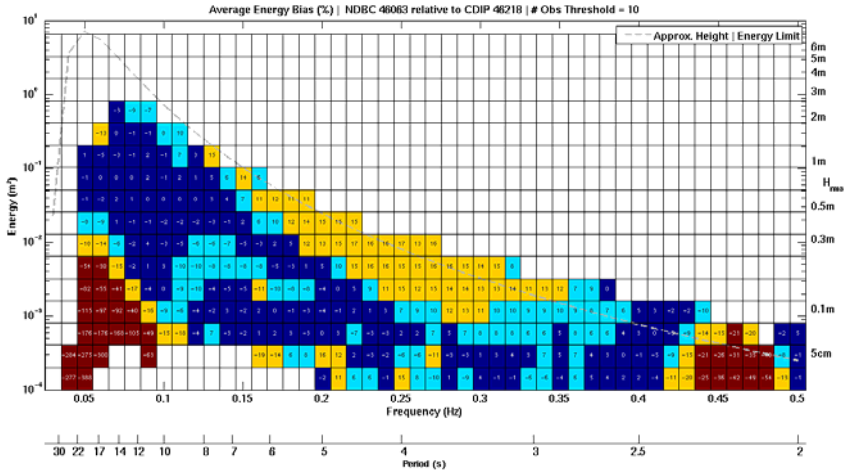


Evaluation Procedure: Co-located

Analysis of Sensor / Payload Package

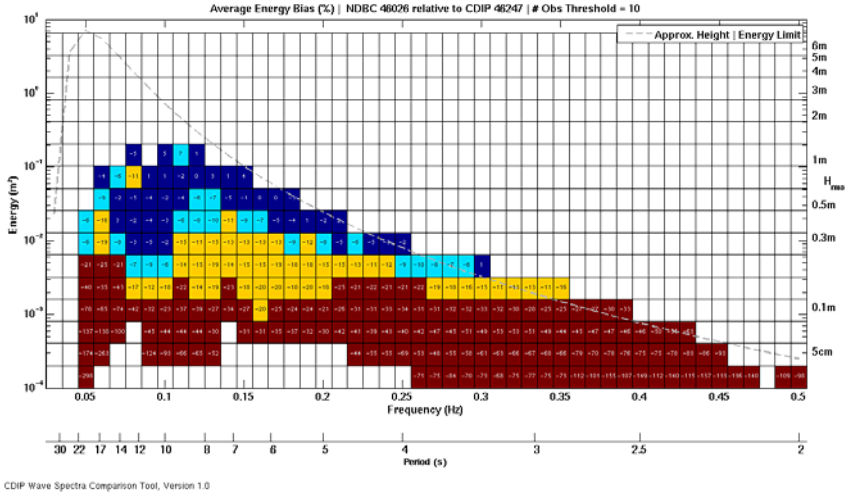
3D / ARS / ARES

46063: Pt. Conception



3D / 3DM / AMPS

46026: San Francisco



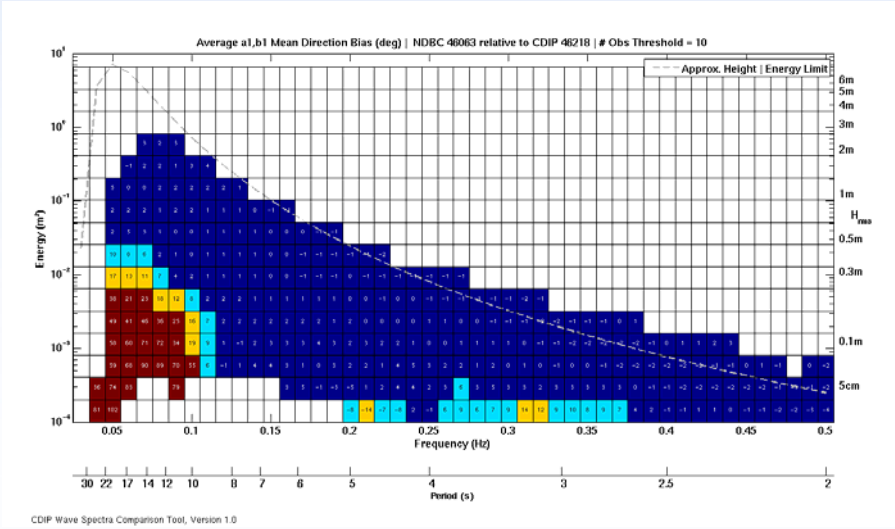
WMO IOC/UNESCO

Evaluation Procedure: Co-located

DIRECTIONAL Analysis of Sensor / Payload Package

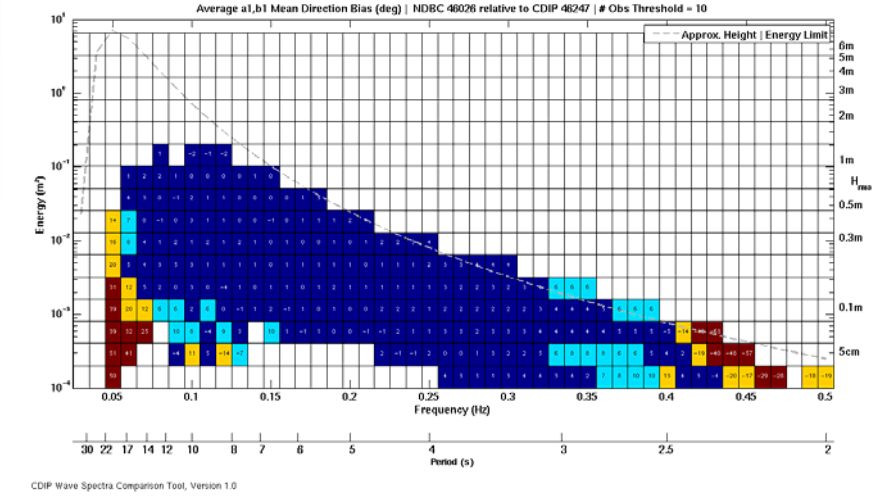
3D / ARS / ARES

46063: Pt. Conception



3D / 3DM / AMPS

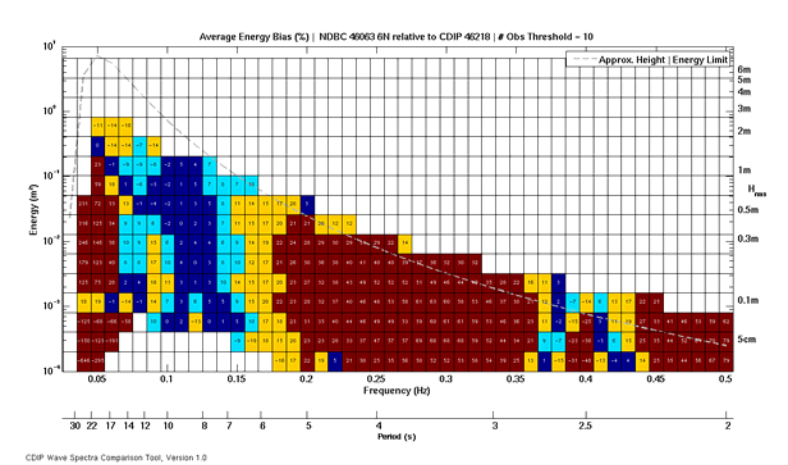
46026: San Francisco



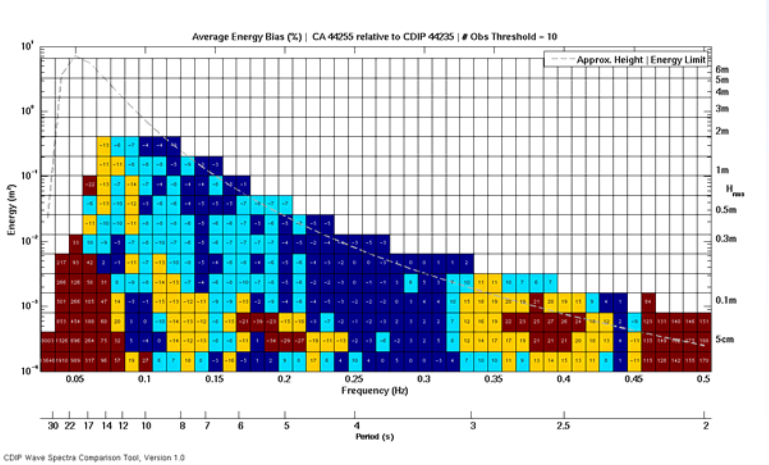
Evaluation Procedure: Co-located

Analysis of: Operational NOMADS

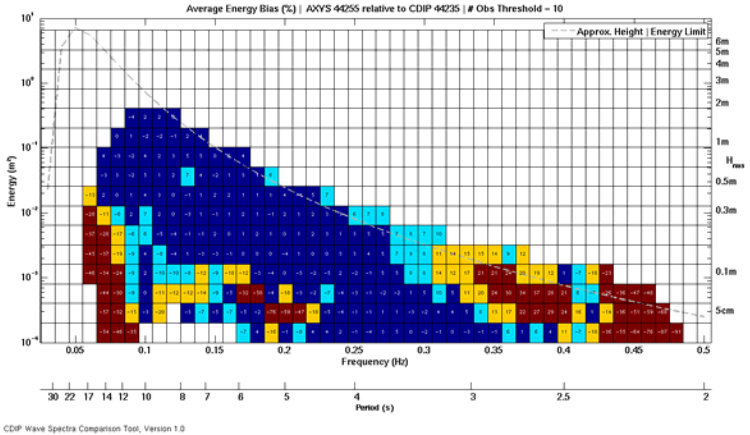
46063 : Inclinometer / DACT



44255: Accelometer / AXYS



44255: TriAXYS* / AXYS

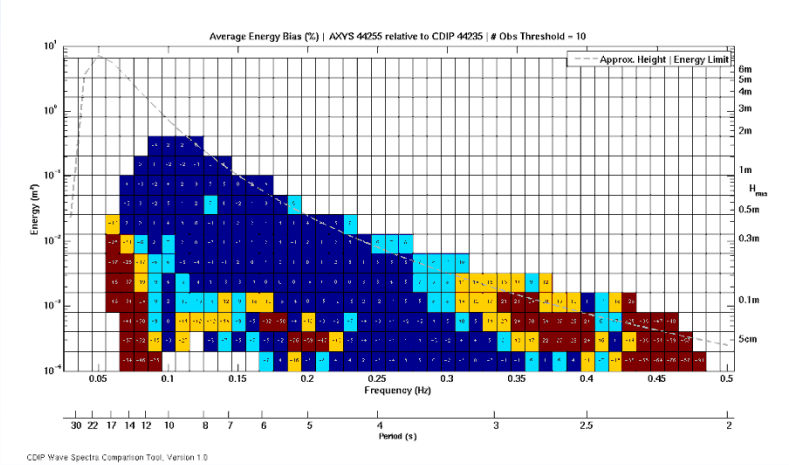


WMO IOC/UNESCO

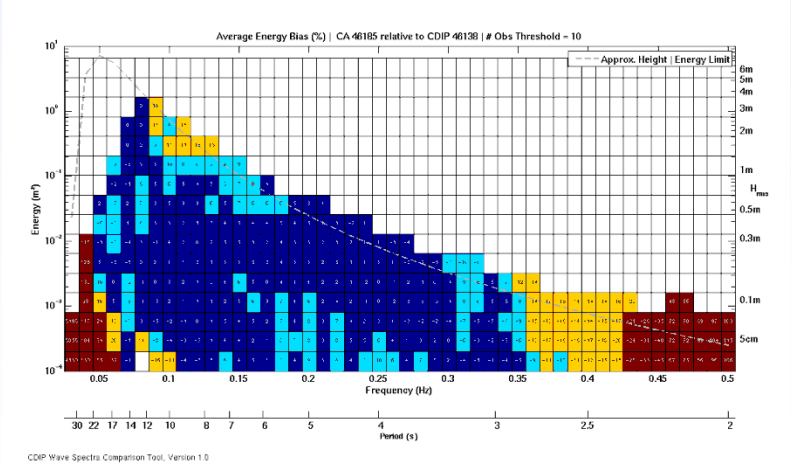
Evaluation Procedure: Co-located

Analysis of: Hull

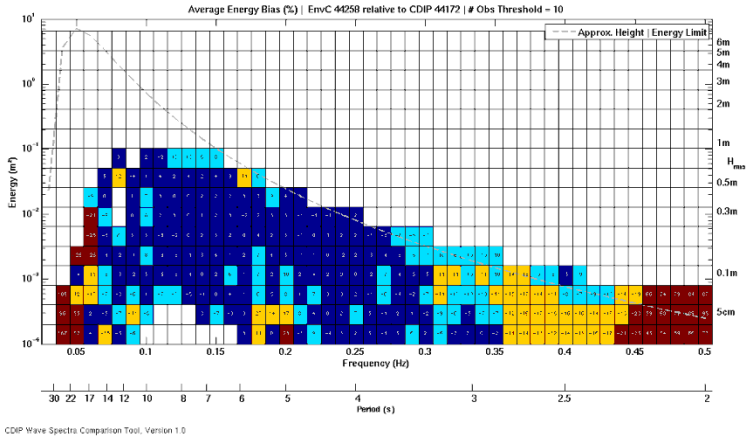
44255: 6M / TriAXYS



46185: 3D / TriAXYS



44258: 3D FOAM / TriAXYS

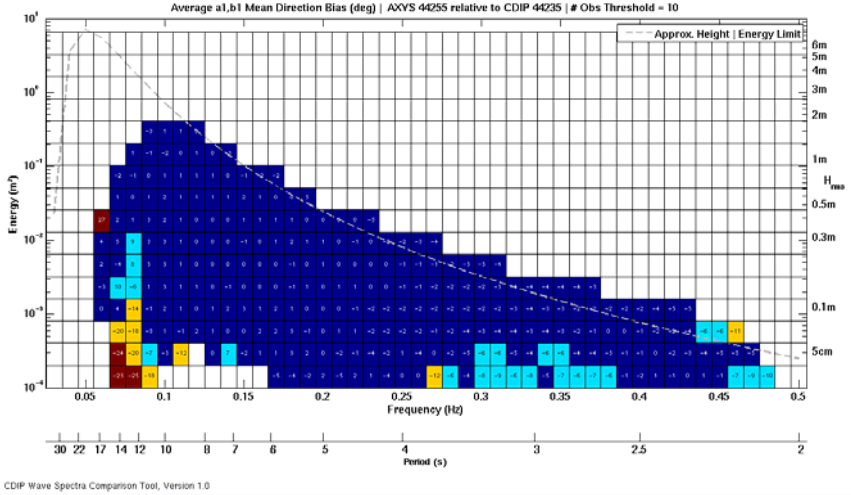


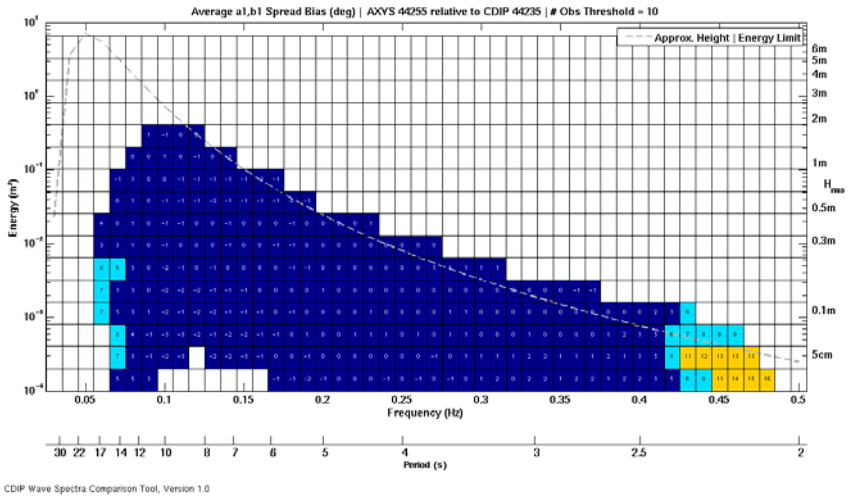
WMO IOC/UNESCO

Evaluation Procedure: Co-located

Analysis of: Directional Estimates from NOMAD

6M / Tri-AXYS/ AXYS





WMO IOC/UNESCO

Evaluation Preliminary Conclusions

- Larger systematic differences are a result from
  - Sensor type
  - Analysis package
  - Hulls, super-structure, mooring
- Some biases found could be corrected
  - Appears to be analysis:
    - Transformation from acceleration to displacement
- NDBC's NOMAD requires further evaluation
  - Co-location definition violated
- NDBC's 3DM motion sensor appears to contain biases
  - Multi-sensor evaluation underway
- NOMAD's capability to estimate directions

Recommendations

- Continue to test and evaluate
- New PC version now available *CDIPtool*
- NDBC 6M NOMAD evaluated to Directional Waverider (co-location)
- Evaluation of Buoy Farm Data Sets Monterey, CA
- Evaluation of multi-sensor packages (NDBC)
- Meta data for historical wave measurement platforms
  - **Sensor**, payload, analysis packages
- Bench Test analysis packages (IEEE, time series, etc)
- Real-time data transmission of time series

Questions