USACE Quality Controlled, Consistent Measurement Archive

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USACE QCC MEASUREMENT ARCHIVE

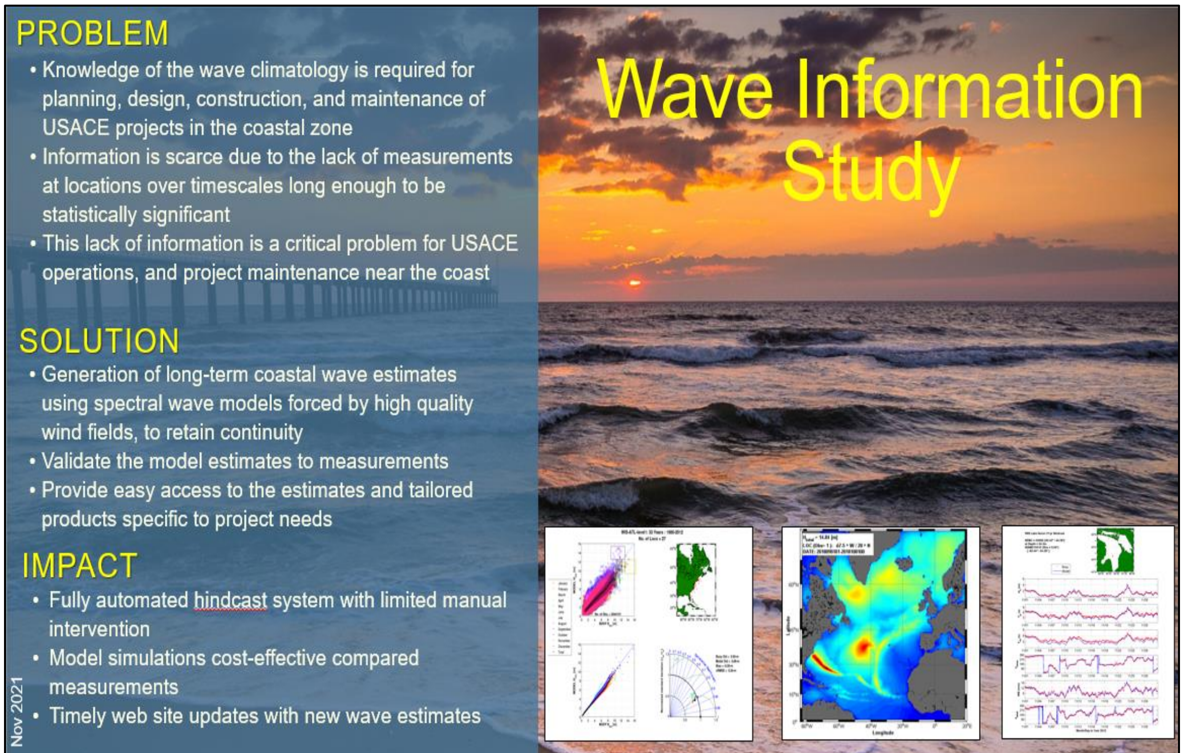
Outline:

1. USACE ERDC CHL Wave Information Study (WIS) – brief overview
2. USACE National Coastal Wave Climate
3. USACE Quality Controlled, Consistent (QCC) Measurement Archive
    1. National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) National Data Buoy Center (NDBC)
    2. Fisheries and Oceans Canada Marine Environmental Data Section (MEDS)

USACE ERDC COASTAL HYDRAULIC LAB (CHL)

Research Oceanographer, Coastal Processes Branch

- PI responsibilities for USACE projects:
  - **National Coastal Wave Climate (NCWC) work unit**
  - **Wave Information Study (WIS) operational and R&D work units**



- The Wave Information Study (WIS): wave climatology needed for planning & design, construction & maintenance of USACE coastal projects – observations too expensive, so WIS fills in the gaps
- WIS provides long-term (~1970) wave estimates along all US coasts, including the Great Lakes, for pre-selected output locations
- Hindcast wave estimates (height, wave period, and direction) and directional spectral estimates
- *USACE ERDC CHL WIS Portal:* https://wisportal.erdc.dren.mil/

NATIONAL COASTAL WAVE CLIMATE (NCWC)

FY20-22 THRUSTS

National Oceanic and Atmospheric Administration's National Data Buoy Center
Center of Excellence in Marine Technology

Question: How accurate are the wave measurement data that are used for USACE WIS validation, wave related R&D and wave model improvements?

National Centers for Environmental Information
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Goal: Clean Data for Assimilation – USACE wave applications and climate trend analyses

Government of Canada

A. Observational data storage errors – develop a clean, quality controlled measurement archive.

- **NOAA NWS National Data Buoy Center (NDBC)**
- **Fisheries and Oceans Canada Marine Environmental Data Section (MEDS)**

Uses: Instrument and Platform evaluations:

- NDBC hull size and wave instrumentation variations

CDIP coastal data information program
Monitoring and Prediction of Waves and Shoreline Change
SIO USACE DBW

Uses: Wave Power Trends:

- Using USACE QCC measurement archive and WIS data to track spatial and temporal variation in wave fields.

A. NDBC OBSERVATIONAL DATA STORAGE SOURCES

NOAA NWS National Data Buoy Center (NDBC)

- Cleanest data - manually QC by NDBC MCC data analysts.
- Individual annual files for stdmet and spectral data – formats differ over the years
- No metadata besides date and time, e.g. no GPS positions or instrumentation metadata
- No secondary (redundant) sensor data
- Contains unidentifiable data from:
  - time periods where the buoys were adrift
  - during service periods (when the buoys were physically on board ships for maintenance)
- No uncorrected spectral data (c_{11}^{m}), which is necessary if the user would like to calculate their own integral wave data

Station 46029 (LLNR 688) - COLUMBIA RIVER BAR - 20NM West of Columbia River Mouth

Owned and maintained by National Data Buoy Center
46.163 N 124.487 W (46°9'48" N 124°29'12" W)

Available historical data for station 46029 include:

- **Quality controlled data for 2022** (*data descriptions*)
  - **Standard meteorological data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Spectral wave density data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Spectral wave (alpha1) direction data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Spectral wave (alpha2) direction data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Spectral wave (r1) direction data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Spectral wave (r2) direction data:** Jan Feb Mar Apr May Jun Jul Aug
  - **Supplemental Measurements data:** Jan Feb Mar Apr May Jun Jul Aug
- **Historical data** (*data descriptions*)
  - **Standard meteorological data:** 1984 1985 1986 1987 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
  - **Continuous winds data:** 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
  - **Spectral wave density data:** 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
  - **Spectral wave (alpha1) direction data:** 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
  - **Spectral wave (alpha2) direction data:** 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
  - **Spectral wave (r1) direction data:** 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
  - **Spectral wave (r2) direction data:** 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021

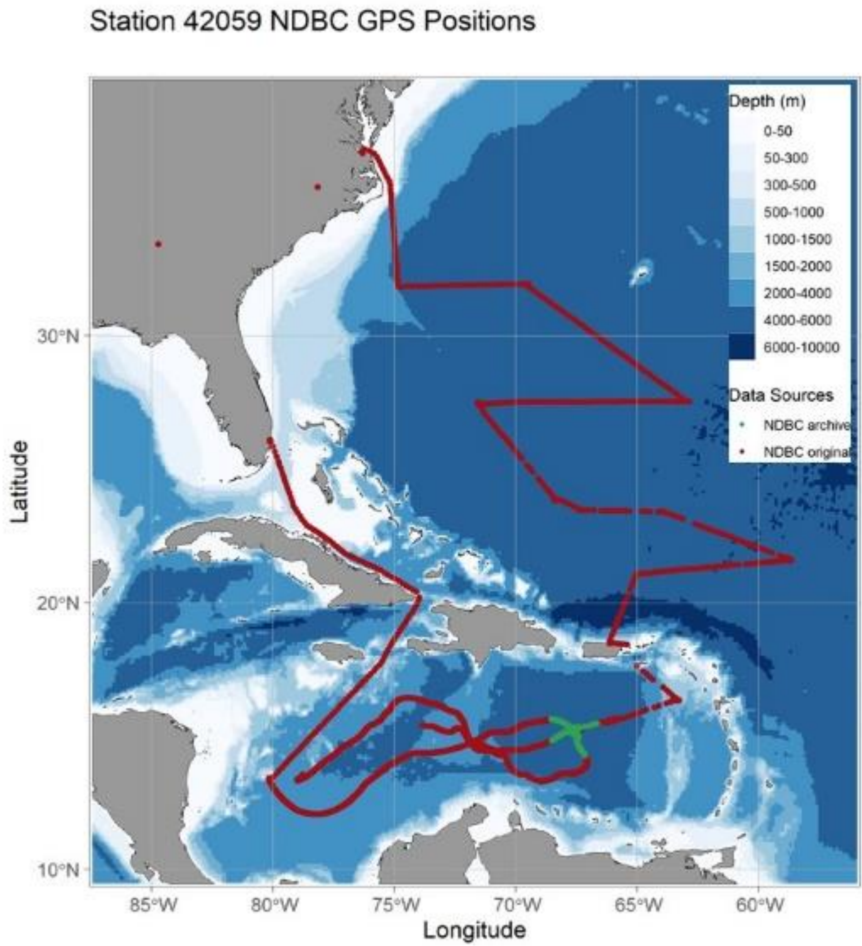
#YY	MM	DD	hh	mm	WDIR	WSPD	GST	WVHT	DPD	APD	MWD	PRES	ATMP	WTMP	DEWP	VIS	TIDE
#yr	mo	dy	hr	mn	degT	m/s	m/s	m	sec	sec	deg	hPa	degC	degC	degC	nmi	ft
2022	01	01	00	00	55	3.8	5.5	99.00	99.00	99.00	999	1018.8	3.8	7.3	-0.9	99.0	99.00
2022	01	01	00	10	67	3.3	5.8	99.00	99.00	99.00	999	1019.0	3.7	7.4	-1.2	99.0	99.00
2022	01	01	00	20	64	2.9	5.1	99.00	99.00	99.00	999	1019.2	3.8	7.3	-0.8	99.0	99.00
2022	01	01	00	30	70	2.8	4.9	99.00	99.00	99.00	999	1019.3	3.8	7.4	-0.8	99.0	99.00
2022	01	01	00	40	58	3.1	5.0	2.64	11.43	7.35	305	1019.5	3.7	7.4	-1.0	99.0	99.00
2022	01	01	00	50	67	3.0	5.1	99.00	99.00	99.00	999	1019.6	3.7	7.5	-0.9	99.0	99.00
2022	01	01	01	00	55	3.2	5.2	99.00	99.00	99.00	999	1019.6	3.7	7.5	-1.2	99.0	99.00
2022	01	01	01	10	50	3.0	5.6	99.00	99.00	99.00	999	1019.7	3.7	7.4	-1.9	99.0	99.00
2022	01	01	01	20	70	3.4	5.4	99.00	99.00	99.00	999	1019.8	3.7	7.5	-2.2	99.0	99.00
2022	01	01	01	30	73	3.6	5.8	99.00	99.00	99.00	999	1019.9	3.7	7.5	-2.5	99.0	99.00
2022	01	01	01	40	70	4.1	6.1	2.61	10.81	7.43	309	1019.9	3.8	7.5	-2.3	99.0	99.00
2022	01	01	01	50	67	4.2	6.6	99.00	99.00	99.00	999	1019.9	3.8	7.5	-2.2	99.0	99.00
2022	01	01	02	00	70	4.3	6.3	99.00	99.00	99.00	999	1020.0	3.8	7.5	-2.5	99.0	99.00
2022	01	01	02	10	69	4.4	6.4	99.00	99.00	99.00	999	1020.2	3.8	7.3	-2.3	99.0	99.00
2022	01	01	02	20	73	4.9	6.8	99.00	99.00	99.00	999	1020.2	3.7	7.3	-1.9	99.0	99.00
2022	01	01	02	30	74	4.7	7.6	99.00	99.00	99.00	999	1020.3	3.7	7.4	-2.1	99.0	99.00
2022	01	01	02	40	76	4.2	7.0	2.82	10.81	7.86	306	1020.4	3.7	7.3	-2.0	99.0	99.00
2022	01	01	02	50	75	4.0	6.5	99.00	99.00	99.00	999	1020.5	3.7	7.4	-1.8	99.0	99.00
2022	01	01	03	00	77	4.8	7.4	99.00	99.00	99.00	999	1020.5	3.6	7.4	-1.6	99.0	99.00
2022	01	01	03	10	75	5.0	7.9	99.00	99.00	99.00	999	1020.6	3.5	7.3	-1.6	99.0	99.00
2022	01	01	03	20	76	5.2	7.6	99.00	99.00	99.00	999	1020.8	3.3	7.4	-1.8	99.0	99.00
2022	01	01	03	30	69	5.0	7.0	99.00	99.00	99.00	999	1020.8	3.3	7.4	-1.8	99.0	99.00
2022	01	01	03	40	74	5.2	7.2	2.31	10.00	7.60	295	1020.9	3.3	7.5	-2.2	99.0	99.00
2022	01	01	03	50	73	5.0	7.3	99.00	99.00	99.00	999	1020.9	3.3	7.3	-2.5	99.0	99.00
2022	01	01	04	00	73	5.1	7.1	99.00	99.00	99.00	999	1021.0	3.2	7.3	-2.3	99.0	99.00
2022	01	01	04	10	79	5.5	7.7	99.00	99.00	99.00	999	1021.0	3.1	7.4	-1.6	99.0	99.00
2022	01	01	04	20	73	5.7	7.9	99.00	99.00	99.00	999	1021.1	3.0	7.5	-1.8	99.0	99.00
2022	01	01	04	30	75	6.5	8.4	99.00	99.00	99.00	999	1021.2	2.9	7.6	-2.0	99.0	99.00
2022	01	01	04	40	77	6.6	8.9	2.53	12.12	7.86	310	1021.2	2.9	7.6	-1.4	99.0	99.00
2022	01	01	04	50	82	6.8	8.6	99.00	99.00	99.00	999	1021.1	2.8	7.6	-1.2	99.0	99.00
2022	01	01	05	00	81	7.1	9.2	99.00	99.00	99.00	999	1021.3	2.8	7.6	-1.3	99.0	99.00
2022	01	01	05	10	81	7.1	10.1	99.00	99.00	99.00	999	1021.3	2.9	7.7	-1.8	99.0	99.00
2022	01	01	05	20	78	7.0	9.7	99.00	99.00	99.00	999	1021.4	2.8	7.7	-1.7	99.0	99.00
2022	01	01	05	30	79	6.8	9.0	99.00	99.00	99.00	999	1021.3	2.8	7.7	-2.2	99.0	99.00
2022	01	01	05	40	86	6.6	9.4	2.36	12.12	7.36	305	1021.3	2.8	7.8	-1.8	99.0	99.00

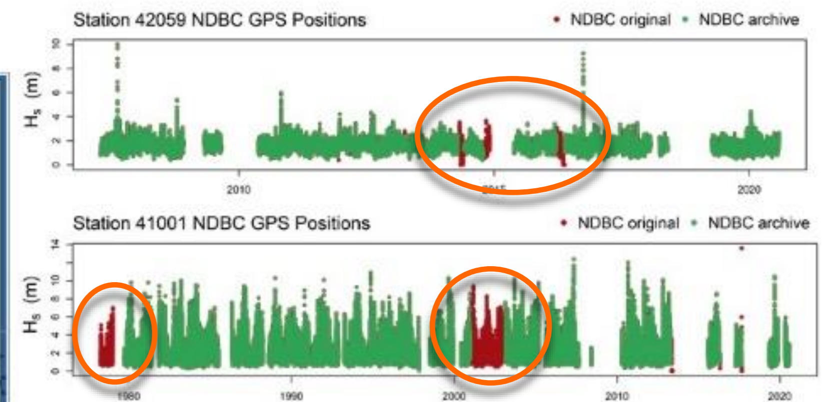
NOAA National Center for Environmental Information (NCEI)

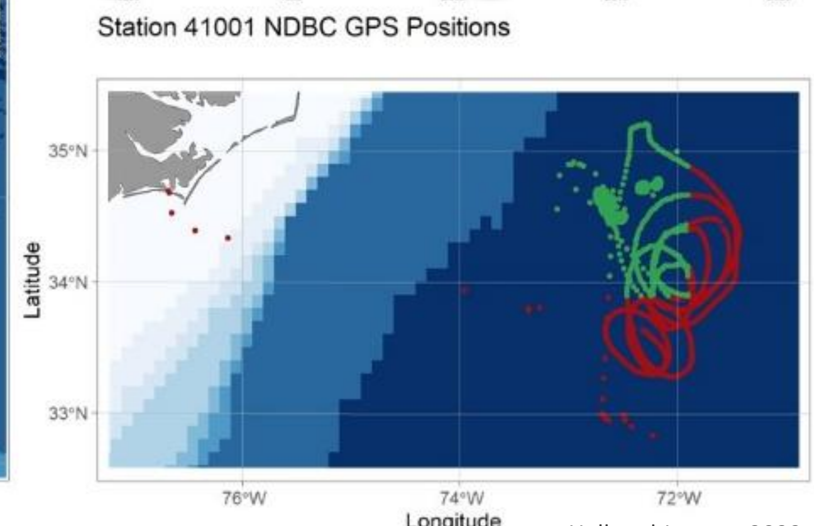
- Official archived for NOAA, i.e. the 'best' NDBC data
- **Data pulled from real-time NDBC data stream - subjected to a very broad, automatic QC protocols**
- Single year_month netCDF file for all data – formats differ over the years
- Includes metadata, e.g. GPS positions and instrumentation metadata
- Instrumentation metadata is inconsistent throughout the years, as well as within each file's payloads
- Includes primary and secondary sensor outputs
- Contains identifiable data from
  - time periods where the buoys were adrift
  - during service periods (when the buoys were physically on board ships for maintenance).
- Includes all spectral wave information, including uncorrected spectral data (c_{11}^{m})

A. NDBC OBSERVATIONAL DATA STORAGE ERRORS

NDBC Stations 42059 and 41001 locations before and after geographical QA/QC







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A. NDBC OBSERVATIONAL DATA STORAGE ERRORS

NDBC Website Data
- Manually QA/QC by NDBC Mission Control data analysts
- No metadata other than date and time, e.g. no GPS positions or instrumentation metadata
- No secondary (redundant) sensor data or indication of sensor switch
- No uncorrected spectral wave data (C_{11m})

NCEI NetCDF Data
- Data pulled from real-time NDBC data stream = Automatic QA/QC protocols (flagged, not removed)
- Includes metadata – however, metadata are inconsistent through time
- Includes primary and secondary sensor outputs, including release flags
- Includes uncorrected spectral wave data (C_{11m})
- netCDF formats change frequently over time

Step 1: Download data

Step 2: Concatenate yearly / monthly data files for each data source

NDBC Buoy Metadata Spreadsheets – station specific metadata
(constructed from the NDBC database and original NDBC service technician log books)

Literature review for buoy and instrument specifications

Step 3: Validate NCEI metadata

Step 4: a) Compare, b) geographically QA/QC, c) attach NCEI verified metadata to NDBC data source

'Best' data set includes…

NDBC station data:
- hull, depth, mooring, payload variables for each date/time record

NDBC meteorological data:
- wind direction, wind speed, wind gust, air pressure at sea level, air temperature, sea surface temperature

NDBC wave data:
- significant wave height, dominant and peak periods, mean wave direction, spectral c_{11}, $alpha_1$ and $alpha_2$, r_1 and r_2

'Best' data set includes…

NCEI metadata:
- **metadata** variables for NDBC meteorological and wave data fields for each date/time record

NCEI wave data:
- spectral c_{11m} and metadata

Step 5: Create 'Best' data set

NetCDF files contain:
- 'Best' data variables with QC flags
- metadata variables with QC flags
- global attributes that mirror NDBC netCDF global attributes were possible
- variable attributes for data and metadata variable fields

NetCDF files are:
- Climate and Forecast (CF) compliant with discoverable standard names and long names
- Missing data fill value = -999.99

Step 6: Create year_month netCDF data files from 'Best' data set for USACE Archive

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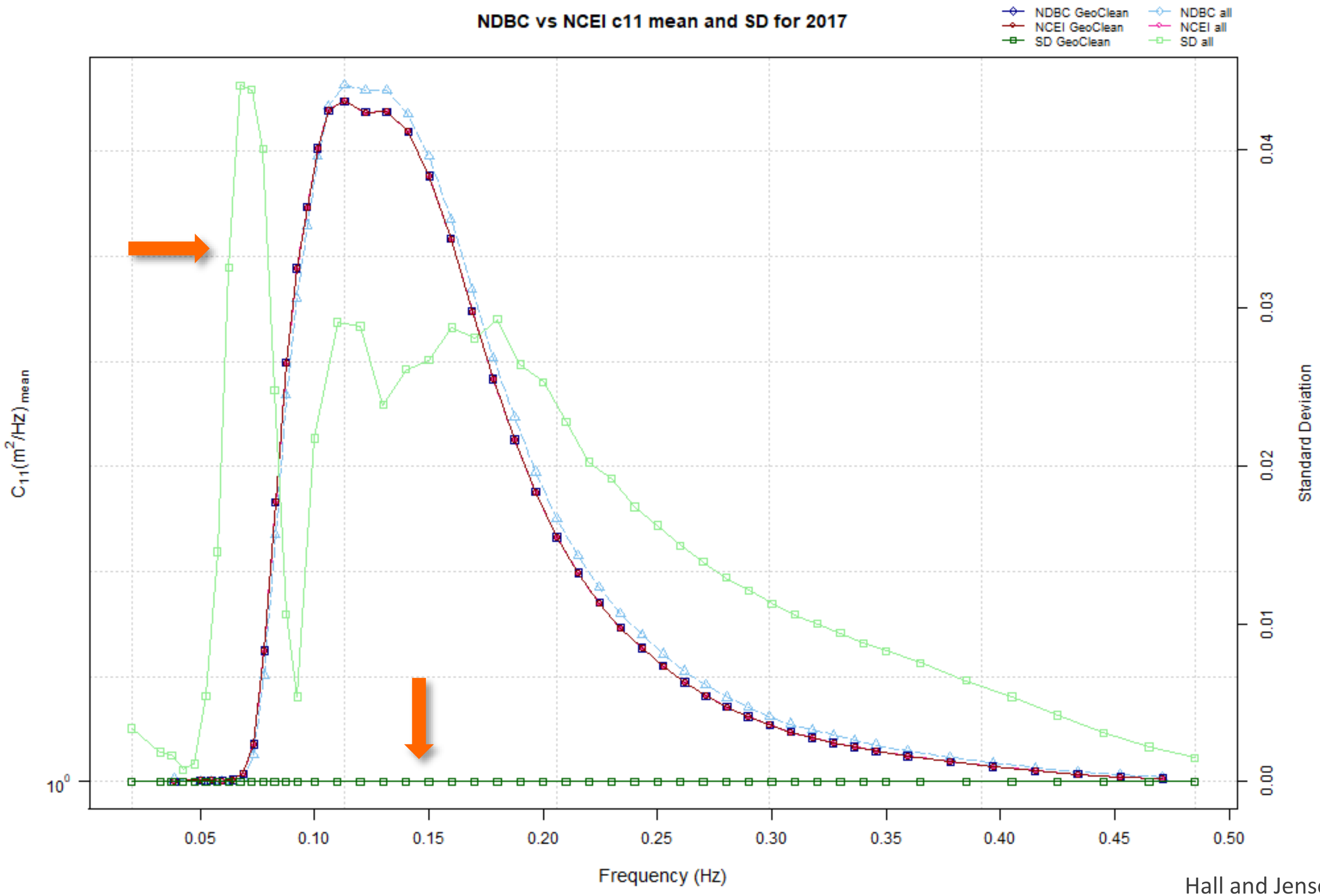
A. NDBC OBSERVATIONAL DATA STORAGE ERRORS

NDBC station 41008 geographically QA/QC spectral wave energy (C_{11})



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A. NDBC OBSERVATIONAL DATA STORAGE ERRORS

Both re-published in the UNESCO / IOC Ocean Best Practices (OBP) Repository:
Repository of community practices in Ocean Research, Applications and Data/Information Management
https://repository.oceanbestpractices.org/

Hall, C. & R.E. Jensen. 2022. USACE Coastal and Hydraulics Laboratory Quality Controlled, Consistent Measurement Archive. *Scientific Data* 9:248.
https://doi.org/10.1038/s41597-022-01344-z
OBP Repo: https://repository.oceanbestpractices.org/handle/11329/2063

Hall, C. & R.E. Jensen. 2021. Utilizing Data from the NOAA National Data Buoy Center. ERDC/CHL CHETN-I-100. Vicksburg, MS: U.S. Army Engineer Research and Development Center.
http://dx.doi.org/10.21079/11681/40059
OBP Repo:
http://dx.doi.org/10.25607/OBP-1087

US Army Corps of Engineers

Utilizing Data from the NOAA National Data Buoy Center

By Candice Hall and Robert E. Jensen

PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) guides users through the quality control (QC) and processing steps that are necessary when using archived U.S. National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) wave and meteorological data. This CHETN summarizes methodologies to geographically clean and QC NDBC measurement data for use by the U.S. Army Corps of Engineers (USACE) user community.

INTRODUCTION: The USACE acknowledges that "Estimates of wave conditions are needed in almost all coastal engineering studies" (USACE 2002, II-1-1). The expense to monitor waves along all U.S. coasts can become cost prohibitive; however, the importance of wave measurements is real. The USACE has adopted a paradigm of strategically positioning wave measurement sites to maximize their effectiveness and filling in the gaps with model estimates. To satisfy this requirement, in the 1970s, the USACE developed the Wave Information Studies (WIS) that computes long-term (over 4 decades), hourly wave estimates along all U.S. coastlines, including the Great Lakes and U.S. island territories (USACE 2020).

The WIS wave estimates require in situ buoy wave data for validation and calibration similar to that of Ortiz-Royero and Mercado-Irizarry (2008); Reguero et al. (2012); Rusu and Guedes Soares (2012); Van Nieuwkoop et al. (2013); Stopa and Cheung (2014); Stopa and Mouche (2016). One source of WIS validation data is the NDBC network of meteorological and wave measurement buoys.

NDBC has deployed buoys with wave measurement capabilities around the U.S. coastline and the Great Lakes since the 1970s. Long-term time series data from a single buoy site have experienced multiple instrumentation modifications and data archival upgrades with advances in technology. Between 1970 and 2020, NDBC has deployed at least eight directional wave measurement systems for operational or experimental use (e.g., Steele et al. 1985; NDBC 1996; NDBC 2003; Teng et al. 2007; Crout et al. 2008; Teng et al. 2009; Riley et al. 2011; Hall et al. 2018a; Riley et al. 2019).

While NDBC has worked hard to minimize the effects of the modifications on its data (e.g., Teng and Timpe 1995; Teng et al. 2007; Riley and Bouchard 2015; Hall et al. 2018a), different versions of these data are archived in multiple online locations, each with their own set of storage protocols. If these data are used without prior knowledge of these archival idiosyncrasies, use of the measured data in wave-related research activities may be compromised. This CHETN summarizes the steps required to achieve the best available time-series datasets for all buoy data collected by NDBC since the 1970s.

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DATA DESCRIPTOR

USACE Coastal and Hydraulics Laboratory Quality Controlled, Consistent Measurement Archive

Candice Hall[1,2] ✉ & Robert E. Jensen[1]

The US Army Corps of Engineers (USACE) utilizes the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) buoy measurements for validation of their wave models and within coastal applications. However, NDBC data are accessible via multiple archives; each with their own source-specific storage, metadata, and quality control protocols, which result in inconsistencies in the accessible data. Therefore, USACE has developed an independent, quality controlled, consistent (QCC) Measurement Archive that captures the best available NDBC observations with verified metadata. This work details the methodology behind this USACE QCC Measurement Archive; showcasing improvements in data quality via geographical location and wave parameter examples. Note that this methodology only removes known erroneous data, it does not verify data quality from an alternate source. This self-describing, USACE QCC Measurement Archive therefore provides a database of consistently stored, geographically QA/QC'd NDBC data and metadata.

Background & Summary

One of the U.S. Army Corps of Engineers (USACE) missions is to oversee operations and maintenance activities in the coastal waters of the U.S. These activities include sediment transport, hardened structures, harbor navigability, climate resilience and coastal protection, all of which require knowledge and assessment of the wave climate. For practical assessments, USACE wave related technologies require accurate and homogeneous wave measurements from *in situ* observational platforms.

To that end, USACE sponsored an investigation into uncertainty errors in the wave measurement systems that are used for evaluating products such as their Wave Information Study (WIS), a wave hindcast effort that serves as the basis for resolving the U.S. wave climate. Of particular interest are measurement errors that may compromise wave model evaluations. These errors may be indistinguishable from wind forcing or wave model deficiencies, and may transfer into other USACE wave and coastal applications.

One source of validation data is the National Oceanic and Atmospheric Administration (NOAA) National Data Buoy Center (NDBC) *in situ* buoy meteorological and wave measurements. As of 2022, NDBC publishes their data via two different streams: real time and historical. The real time data feed undergoes broad, automated QA/QC protocols[1] to meet emergency management and forecasting agency latency commitments that require swift publication to the Global Telecommunications System (GTS). These 'Real Time Data' files are also published within individual stations pages on the NDBC website as tabular files that are continually updated and cover the last forty-five days (e.g. https://www.ndbc.noaa.gov/station_realtime.php?station=41009).

Once latency commitments are met, NDBC manually QA/QC's[1] these data and stores them within station specific 'Historical Data' text files on their website on a monthly basis (e.g. https://www.ndbc.noaa.gov/station_history.php?station=41009). As per NOAA requirements, NDBC archives their data on a monthly basis in the official NOAA archives, which are found at the National Center for Environmental Information (NCEI; https://www.ncei.noaa.gov/access/marine-environmental-buoy-database/). NDBC collates their website data annually and copy these data, in a Unidata's Network Common Data Form (netCDF) format, for storage on the NDBC Distributed Oceanographic Data Systems framework (DODS; https://dods.ndbc.noaa.gov/thredds/catalog/data/catalog.html). Essentially, the NDBC website and the DODS may be considered as a single source of NDBC historical data that are stored in different formats.

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A. MEDS OBSERVATIONAL DATA STORAGE

Fisheries and Oceans Canada Marine Environmental Data Section (MEDS)

- Wave data: https://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/waves-vagues/data-donnees/index-eng.asp
- Single files for historical bulk wave parameters (.csv) and metadata (.csv)
- Single year to date (y2d) files (.fb)
- Annual spectral data files (.fb)

Configuration	All CSV Data	Year to Date of Spectral Data	Annual Files of Spectral Data	File Size (KB)
meta_c45149.csv				27
	C45149_CSV.ZIP			2,128
		C45149_Y2D.zip		182
			C45149_2000.ZIP	545.9
			C45149_2001.ZIP	770.7
			C45149_2002.ZIP	1,149.6
			C45149_2003.ZIP	1,514.5
			C45149_2004.ZIP	1,390.2
			C45149_2005.ZIP	1,562.6
			C45149_2006.ZIP	1,351.5
			C45149_2007.ZIP	976.4
			C45149_2008.zip	375.1
			C45149_2009.zip	1,349.1
			C45149_2010.zip	1,575.8
			C45149_2011.ZIP	957.3
			C45149_2012.ZIP	1,147.1
			C45149_2013.ZIP	1,421.5
			C45149_2014.zip	1,449.3
			C45149_2015.zip	1,576.5
			C45149_2016.ZIP	1,243.0
			c45149_2017.zip	1,347.5
			C45149_2018.ZIP	926.2
			C45149_2019.ZIP	1,016.6
			C45149_2020.zip	1,106.1
			C45149_2021.zip	1,211.2

Actions:

- Data extracted from various formats for consistency
- Available metadata sourced and merged with concatenated files
- Data were QC'd as per MEDS QC codes
- Exported as year_month netCDF files

```
AE               S Lake Huron              C45149
   43.5330   81.9670    58.0 2000 5 6 1123    34.1    0.100E+01    1  13   3   2  41
 0.20500E+03WDIR 0.13000E+01WSPD 0.20000E+01GSPD 0.00000E+00WDIR 0.00000E+00WSPD
 0.00000E+00GSPD 0.99910E+03ATMS 0.18400E+02DRYT 0.18300E+02SSTP 0.42097E+02LTG$
 0.83113E+02LNG$ 0.66081E-01LCF$ 0.20000E+01LRP$
  0.02VCAR  0.00VWH$  0.00VCMX 14.22VTPK  2.20VTP$
  0.3906E-02  0.3906E-02  0.1606E-01  0.7813E-02  0.3906E-02  0.1451E-01
  0.1172E-01  0.3906E-02  0.1211E-01  0.1563E-01  0.3906E-02  0.8540E-02
  0.1953E-01  0.3906E-02  0.5027E-02  0.2344E-01  0.3906E-02  0.2499E-02
  0.2734E-01  0.3906E-02  0.1187E-02  0.3125E-01  0.3906E-02  0.3512E-03
  0.3516E-01  0.3906E-02  0.1491E-03  0.3906E-01  0.3906E-02  0.2003E-04
  0.4297E-01  0.3906E-02  0.4460E-04  0.4688E-01  0.3906E-02  0.9603E-04
  0.5078E-01  0.3906E-02  0.2590E-03  0.5469E-01  0.3906E-02  0.3145E-04
  0.5859E-01  0.3906E-02  0.3641E-04  0.6250E-01  0.3906E-02  0.2242E-04
  0.6641E-01  0.3906E-02  0.2778E-04  0.7031E-01  0.3906E-02  0.6117E-04
  0.7422E-01  0.3906E-02  0.4361E-04  0.7813E-01  0.3906E-02  0.2003E-04
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  0.8984E-01  0.3906E-02  0.1830E-04  0.9375E-01  0.3906E-02  0.3481E-04
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  0.1348E+00  0.7813E-02  0.2596E-04  0.1445E+00  0.1172E-01  0.4719E-04
  0.1563E+00  0.1172E-01  0.3600E-04  0.1699E+00  0.1563E-01  0.3327E-04
  0.1875E+00  0.1953E-01  0.4361E-04  0.2090E+00  0.2344E-01  0.5283E-04
  0.2344E+00  0.2734E-01  0.5050E-04  0.2676E+00  0.3906E-01  0.3940E-04
  0.3086E+00  0.4297E-01  0.3216E-04  0.3652E+00  0.7031E-01  0.4882E-04
  0.4512E+00  0.1016E+00  0.5342E-04
AE               S Lake Huron              C45149
   43.5330   81.9670    58.0 2000 5 8  923    34.1    0.100E+01    1  13   3   2  41
 0.21000E+03WDIR 0.22000E+01WSPD 0.36000E+01GSPD 0.00000E+00WDIR 0.00000E+00WSPD
 0.00000E+00GSPD 0.98910E+03ATMS 0.16900E+02DRYT 0.18500E+02SSTP 0.42097E+02LTG$
 0.83113E+02LNG$ 0.66081E-01LCF$ 0.20000E+01LRP$
  0.02VCAR  0.00VWH$  0.00VCMX  2.22VTPK  2.20VTP$
  0.3906E-02  0.3906E-02  0.1662E-01  0.7813E-02  0.3906E-02  0.1607E-01
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  0.1953E-01  0.3906E-02  0.5203E-02  0.2344E-01  0.3906E-02  0.2586E-02
  0.2734E-01  0.3906E-02  0.9374E-03  0.3125E-01  0.3906E-02  0.3285E-03
  0.3516E-01  0.3906E-02  0.1064E-03  0.3906E-01  0.3906E-02  0.2780E-04
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  0.9766E-01  0.3906E-02  0.3685E-04  0.1016E+00  0.3906E-02  0.3147E-04
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  0.1348E+00  0.7813E-02  0.2657E-04  0.1445E+00  0.1172E-01  0.4267E-04
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```

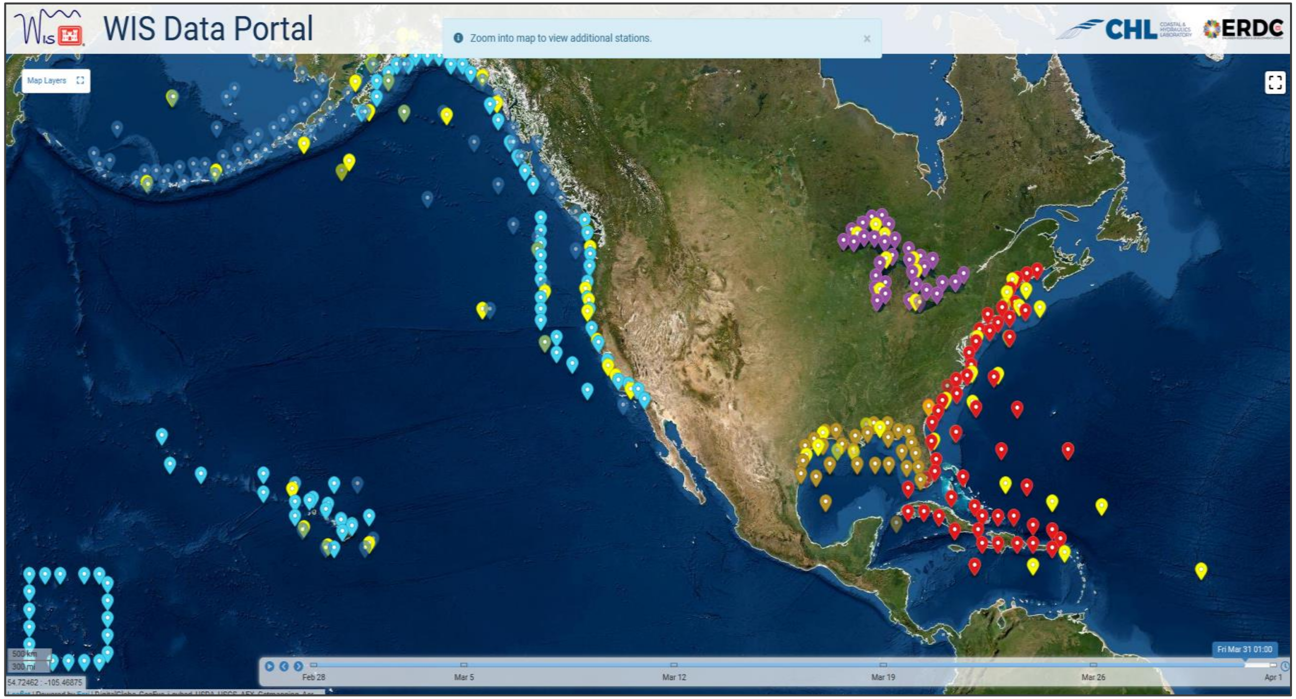
USACE QCC MEASUREMENT ARCHIVE SOURCES

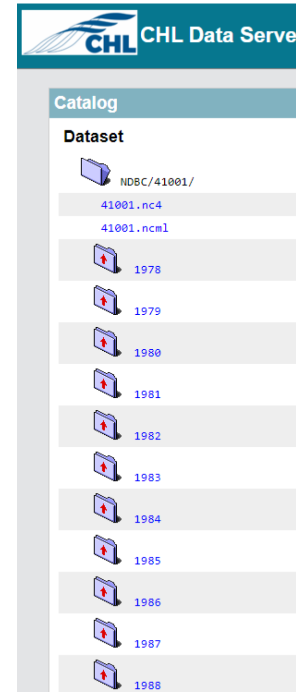
1. USACE ERDC CHL WIS Portal:

https://wisportal.erdc.dren.mil/

2. USACE ERDC CHL Data Server (Thredds): NDBC & MEDS

https://chlthredds.erdc.dren.mil/thredds/catalog/buoys/catalog.html





3. 1970 – 2021 Static NDBC Archive in the ERDC Knowledge Core:

Hall, C. & R.E. Jensen. 2022. USACE QCC NDBC Measurement Archive. ERDC Knowledge Core, Engineer Research and Development Center, Coastal and Hydraulics Laboratory. http://dx.doi.org/10.21079/11681/43121

QUESTIONS?

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