

# Buoy Project

## *Project Presentation*

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April 12, 2018

## Project Background

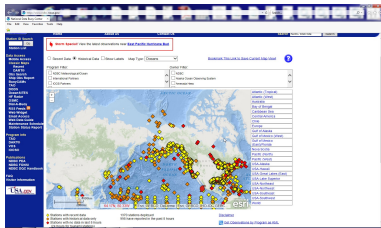
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- The National Data Buoy Center (NDBC) is a part of the National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) of the US government.
- NDBC deploys weather **buoys** which are instruments which **collect weather and ocean data** within the world's oceans.



# Project Background

- The time-series weather data for each buoy are publicly available from the NDBC website ([www.ndbc.noaa.gov](http://www.ndbc.noaa.gov)).



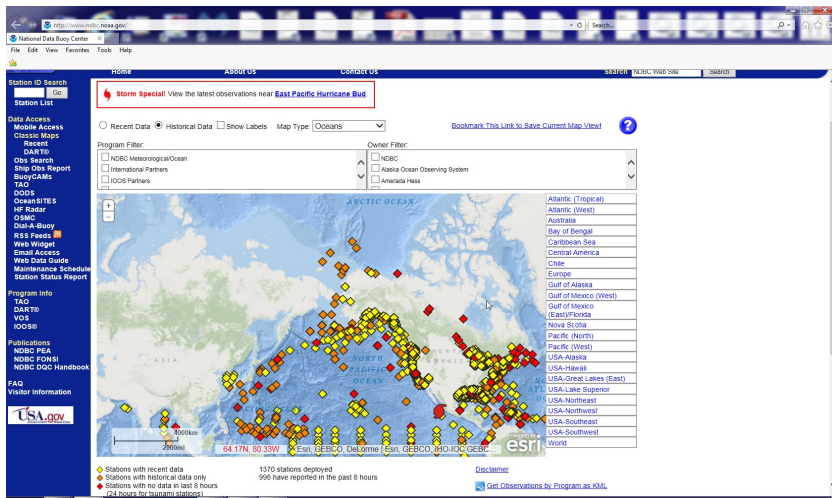
- These data have been used for research (e.g., Chen, Ruf and Cleason, *Journal of Geophysical Research: Oceans*, April 2016) and teaching purposes.

## Part (A) - constructing the dataset

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- Students are asked to locate the data webpage of the Weather Station buoy 46035 at 57.026 N 177.738 W from NDBC.
- Examine the data format for each yearly data file.
- Write an R program to extract and patch the data into two time-series of daily **Air Temperature** and **Sea Temperature** readings recorded at [noon](#).

# Part (A) - constructing the dataset



# Part (A) - constructing the dataset

http://www.ndbc.noaa.gov/ National Data Buoy Center

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HOME ABOUT US CONTACT US SEARCH NDBC WEB SITE

Station ID Search  Go Station List

Data Access Mobile Access Classic Maps Recent DART® Obs Search Ship Obs Report BuoyCAMs TAO DQCS OceanSITES HF Radar OSMC Data-Buoy RSS Feeds Web Widget Email Access Web Data Guide Maintenance Schedule Station Status Report

Program Info TAO DART® VOS IODS® Publications NDBC PEA NDBC FOMSI NDBC DQC Handbook FAQ Visitor Information

USA.gov

**Storm Special!** View the latest observations near **East Pacific Hurricane Bud**

☐ Recent Data ☒ Historical Data ☐ Show Labels Map Type: Oceans [Bookmark This Link to Save Current Map View!](#) ?

Program Filter: ☐ NDBC Meteorological/Ocean ☐ International Partners ☐ IODS Partners

Owner Filter: ☐ NDBC ☐ Alaska Ocean Observing System ☐ Amerasia Hess

Aleutian Basin

Station 46035

NDBC Location: 57.026N 177.738W  
There are no recent (< 8 hours) meteorological data for this station.  
Click [here](#) for other data from this station.

Atlantic (Tropical)  
Atlantic (West)  
Australia  
Bay of Bengal  
Caribbean Sea  
Central America  
Chile  
Europe  
Gulf of Alaska  
Gulf of Mexico (West)  
Gulf of Mexico (East)/Florida  
Nova Scotia  
Pacific (North)  
Pacific (West)  
USA-Alaska  
USA-Hawaii  
USA-Great Lakes (East)  
USA-Lake Superior  
USA-Northeast  
USA-Northwest  
USA-Southeast  
USA-Southwest  
World

100km 100mi 56.82N 177.24W Esri, GEBCO, DeLorme, NaturalVue | Esri, GEBCO, IHO... esri

1370 stations deployed  
996 have reported in the past 6 hours

Stations with recent data  
Stations with historical data only  
Stations with no data in last 6 hours  
(24 hours for buoy stations)

Disclaimer  
[Get Observations by Program as KML](#)

# Part (A) - constructing the dataset

The screenshot shows the National Data Buoy Center (NOBC) website interface. The browser address bar displays <http://www.ndbc.noaa.gov/>. The page has a blue header with navigation links: HOME, ABOUT US, CONTACT US, and SEARCH. A search bar contains the text "NOBC WIND SENS" and a "SEARCH" button. Below the header, a "Storm Special!" banner highlights "View the latest observations near East Pacific Hurricane Bud".

The left sidebar contains several sections:

- Station ID Search:** Includes a "Go" button and a "Station List" link.
- Data Access:** Includes links for "Mobile Access", "Classic Maps", "Recent", "DART®", "Obs Search", "Ship Obs Report", "BuoyCAMs", "TAO", "DOGS", "OceanSITES", "HF Radar", "OSMC", "Data-Buoy", "RSS Feeds", "Web Widget", "Email Access", "Web Data Guide", "Maintenance Schedule", and "Station Status Report".
- Program Info:** Includes links for "TAO", "DART®", "VOS", and "IOOS®".
- Publications:** Includes links for "NOBC PEA", "NOBC FOMSI", and "NOBC DQC Handbook".
- FAQ:** Includes a link for "Visitor Information".
- USA.gov:** Includes a logo for "U.S. GOVERNMENT".

The main content area features a map of the North Pacific Ocean. A red diamond marker is placed on the map, with a tooltip that reads: "Station 46035 - CENTRAL BERING SEA - 310 NM North of Adak, AK". Above the map, there are filters for "Recent Data" (selected) and "Historical Data", a "Show Labels" checkbox, and a "Map Type" dropdown set to "Oceans". To the right of the map, there is a "Program Filter" and an "Owner Filter" with checkboxes for "NOBC Meteorological/Ocean", "International Partners", "IOOS Partners", "NOBC", "Alaska Ocean Observing System", and "Amerasia Hess".

On the right side of the map, there is a list of regions: Atlantic (Tropical), Atlantic (West), Australia, Bay of Bengal, Caribbean Sea, Central America, Chile, Europe, Gulf of Alaska, Gulf of Mexico (West), Gulf of Mexico (East)/Florida, Nova Scotia, Pacific (North), Pacific (West), USA-Alaska, USA-Hawaii, USA-Great Lakes (East), USA-Lake Superior, USA-Northeast, USA-Northwest, USA-Southeast, USA-Southwest, and World.

At the bottom of the map, there is a scale bar showing 30km and 20mi, and coordinates "57.03N, 177.74W". Below the map, there is a legend indicating: "Stations with recent data" (red diamond), "Stations with historical data only" (orange diamond), and "Stations with no data in last 8 hours (24 hours for buoy stations)" (yellow diamond). It also states: "1370 stations deployed" and "996 have reported in the past 6 hours".

The bottom right corner includes a "Disclaimer" link and a link to "Get Observations by Program as KML". The page is powered by Esri, with logos for Esri, GEBCO, DeLorme, NaturalVue, and IHO.

# Part (A) - constructing the dataset

http://www.ndbc.noaa.gov/station\_page.php?station=46035

National Data Buoy Center

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

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Search NDBC Web Site Search

Station ID Search  
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Ship Obs Report  
BuoyCAMs  
TAO  
DODS  
OceanSITES  
HF Radar  
OSMC  
Dial-A-Buoy  
RSS Feeds  
Web Widget  
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Web Data Guide  
Maintenance Schedule  
Station Status Report

Program Info  
TAO  
DARTB  
VOS  
IOOS®

Publications  
NDBC PEA  
NDBC FONSI  
NDBC DGC Handbook

FAQ  
Visitor Information

USA.gov

**Storm Special!** View the latest observations near [East Pacific Hurricane Bud](#)

**Station 46035 [LLNR 1198] - CENTRAL BERING SEA - 310 NM North of Adak, AK**

Owned and maintained by National Data Buoy Center  
3-meter foam buoy  
ARES payload  
57.026 N 177.738 W (57°11'33" N 177°44'16" W)

Site elevation: sea level  
Air temp height: 4 m above site elevation  
Anemometer height: 5 m above site elevation  
Barometer elevation: sea level  
Sea temp depth: 1 m below water line  
Water depth: 3656 m  
Watch circle radius: 3678 yards


As of 06:50Z, 05/02/2018, the buoy located at station 46035 has ceased transmitting. Data will be restored during our next service visit to this location.

[Latest NWS Marine Forecast](#)


[Important Notice to Mariners](#)

[Search And Rescue \(SAR\) Data](#)

[Meteorological Observations from Nearby Stations and Ships](#)



Oceans



Esri, GEBCO, D... esri

Large icon indicates selected station.  
○ Stations with recent data  
◆ Stations with no data in last 8 hours (24 hours for tsunami stations)

[Disclaimer](#)

No Recent Reports



# Part (A) - constructing the dataset

The screenshot shows a web browser window displaying the NOAA National Data Buoy Center (NDBC) station page for station 46035. The page title is "NDBC - Station 46035 Rec...". The browser's address bar shows the URL "http://www.ndbc.noaa.gov/station\_page.php?station=46035". The page content is organized into several sections:

- Data for last 5 days:** No data available.
- Data for last 45 days:** These real time data have undergone gross error checking only. Please use with discretion.
  - Real time standard meteorological data and their description
  - Real time spectral wave data and their description
  - Real time raw spectral wave data and their description
  - Real time raw spectral wave (alpha1) data and their description
  - Real time raw spectral wave (alpha2) data and their description
  - Real time raw spectral wave (r1) data and their description
  - Real time raw spectral wave (r2) data and their description
- Quality controlled data for 2018 (data descriptions)**
  - Standard meteorological data: Jan Feb Mar Apr
  - Spectral wave density data: Jan Feb Mar Apr
  - Spectral wave (alpha1) direction data: Jan Feb Mar Apr
  - Spectral wave (alpha2) direction data: Jan Feb Mar Apr
  - Spectral wave (r1) direction data: Jan Feb Mar Apr
  - Spectral wave (r2) direction data: Jan Feb Mar Apr
- Historical data (data descriptions)**
  - Standard meteorological data: 1985 1986 1987 1988 1989 1990 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
  - Continuous winds data: 1989 1990 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
  - Spectral wave density data: 1996 1998 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
  - Spectral wave (alpha1) direction data: 2014 2015 2016 2017
  - Spectral wave (alpha2) direction data: 2014 2015 2016 2017
  - Spectral wave (r1) direction data: 2014 2015 2016 2017
  - Spectral wave (r2) direction data: 2014 2015 2016 2017
  - Supplemental measurements data: 2011 2012 2013 2014 2015 2016 2017
- Search historical meteorological data for observations that meet your threshold conditions**
- Climatic summary table (TXT) and plots of (description of tables and plots)**
  - wind speed
  - air temperature
  - sea temperature
  - air-sea temperature
  - dew point temperature
  - air-dew point temperature
  - sea level pressure
  - peak wind
  - wind gust
  - significant wave height
  - average wave period
  - dominant wave period

Some data files have been compressed with the GNU gzip program.

The [weekly status report](#) and the [weekly maintenance report](#) also provide valuable station information.

## Part (B) - data cleaning

- Students are asked to plot and clean the data.
- Messy data: **outliers, missing values, lost of data** – due to vandalism/stolen of data buoys

### Vandalism of Data Buoys

Chung-Chu Teng, Stephen Cucullu, Shannon McArthur, Craig Kohler, Bill Burnett, Landry Bernard  
NOAA's National Data Buoy Center

#### Data Buoys

Data buoys are floating devices, either drifting or anchored, that are deployed by governmental or recognized scientific organizations or entities for the purpose of electronically collecting and reporting environmental data and information. The U.S. National Data Buoy Center (NDBC), a unit of U.S. National Weather Service's (NWS) Office of Operational Systems (OOS) in the National Oceanic and Atmospheric Administration (NOAA), has three major real-time ocean observing data buoy networks:

- (1) Weather and Ocean Platform

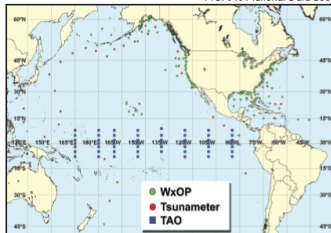
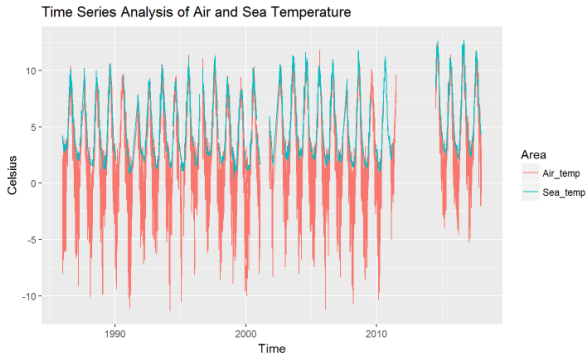


Figure 1 NDBC buoy locations

## Part (B) - data cleaning



- Students have to research and decide on how to clean the data.

## Part (C) - the research question

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- Students are asked to answer the question: Global warming - have the temperatures (both sea and air) increased over the past 30 years?
- Students can use any statistical methods learned in this course.
- All computations have to be carried out in R.
- Each student has to make a presentation and hand-in a final report (professionally written with proper conclusions and justifications).

## My Report - Data Cleaning

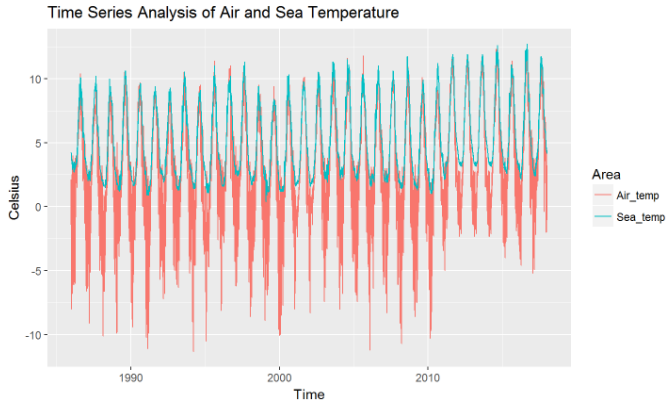
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- There were approximately 30% of data missing or classified as outliers (“999 degree Celsius”).
- I employed the `imputeTS` package to impute and clean the data time series.
- Three options were available in the package. They are: `na.interpolation` (imputation by different interpolation method), `na.kalman` (imputation by structural model and Kalman Smoothing) and `na.seadec` (imputation by seasonally decomposed missing values).
- It was found that the imputed values from Seadec Function would follow the general trends more “naturally” than those from other methods.

# My Report - Data Cleaning

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## Cleaned Data



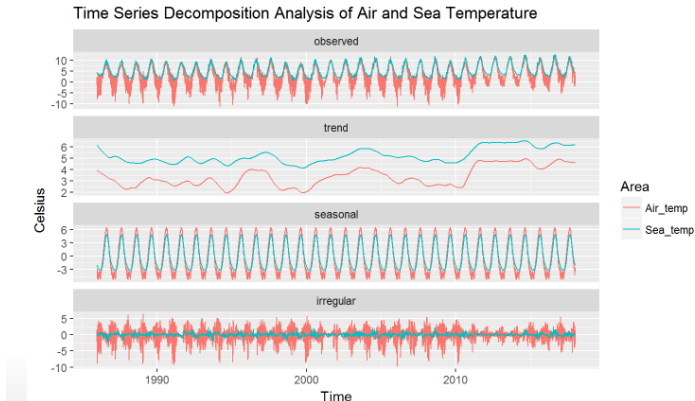
## My Report - Seasonal Decomposition

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- Since the pattern of seasonality is quite stable as reflected in the time series, an additive model is selected for the decompositions.
- The moving average approach is deployed to decompose the trend, seasonality and noise of the air and sea temperatures.
- The `decompose` function is used.

# My Report - Seasonal Decomposition

## Seasonal Decomposition

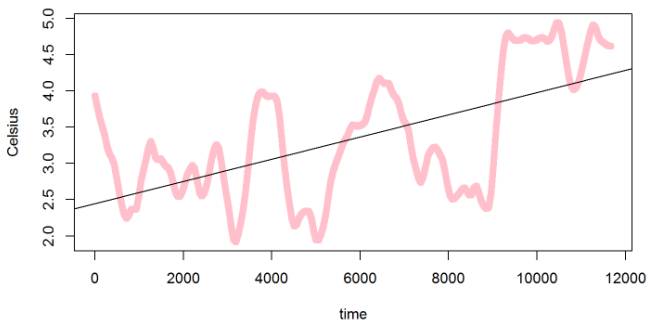




# My Report - Linear Trend

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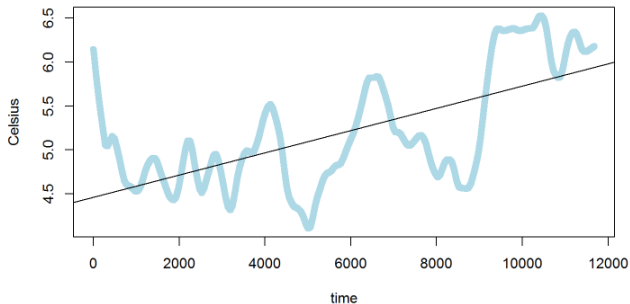
Trend: Air temperature



# My Report - Linear Trend

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Trend: Sea temperature



## My Report - Conclusion

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- We fitted linear regressions to the trends and find that the slopes are positive and they are statistically significant.
- We conclude that [Global warming](#) did exist as the temperatures (both sea and air) increased over the past 30 years.
- The R codes used in the project have been stored and submitted in a separate file.

# My Report - Final Remark

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## Robustness Check

To check whether sampling affected our evaluation of temperature change, let's conduct simple robustness check when temperature = 0:00, 6:00, 18:00 and compare with 12:00.

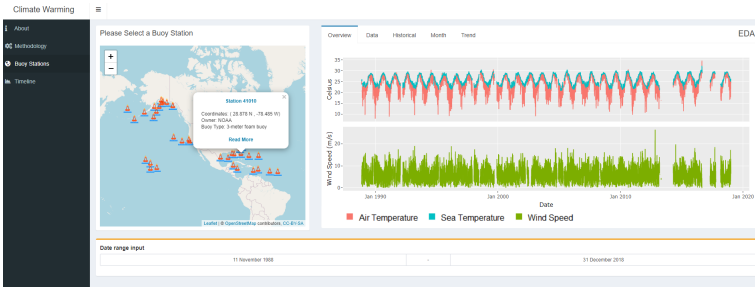
```
##          tau      sl S      D      varS
## Air.Time_0 0.3382657 0 23083382 68240392 177205149696
## Air.Time_6 0.3505084 0 23918828 68240392 177205149696
## Air.Time_12 0.3590287 0 24500260 68240392 177205149696
## Air.Time_18 0.3716339 0 25360442 68240392 177205149696
```

```
##          tau      sl S      D      varS
## Sea.Time_0 0.3823255 0 26090036 68240384 177205149696
## Sea.Time_6 0.3794484 0 25893702 68240384 177205149696
## Sea.Time_12 0.3917121 0 26730586 68240384 177205149696
## Sea.Time_18 0.393612 0 26860232 68240384 177205149696
```

- Similar results and conclusions have been obtained as compared to the **noon** time data.

# My Report - Shiny Dashboard

- Project can be also extended to explore different buoy with shiny dashboard



- [kclt.shinyapps.io/climate\\_warming](https://kclt.shinyapps.io/climate_warming)