As part of the PSEMP-sponsored project entitled "Fundamental Environmental Contextual Metrics to Inform Ecosystem Observations", data available for specifying the heat fluxes at the air-sea interface have been collected and analyzed. This document describes the data being considered for use in the real-time dashboard being constructed, and the types of plots that will be included as part of this dashboard. It should be noted that the plots shown here are merely samples and not their final forms; important details need to be worked out in terms of automating the data collection and processing and in graphic design. Nevertheless, they should serve to illustrate the nature of the information that will be provided related to the surface heat fluxes.

Data Sources

The overarching objective of this component of the project is to provide interested parties quantitative information on how the air-sea heat fluxes in the past weeks to months compare with their climatological counterparts during recent years. For this purpose, data sources were sought that both extended far enough back in time, and had good records in terms of continuity/reliability. In addition, the estimates of the surface heat fluxes, including the shortwave and longwave radiative heat fluxes, required combining data from multiple stations. This means that the values that are estimated are more representative rather than exact, which is considered acceptable in the present context in that the primary interest is in present and recent past anomalies based on historical mean values calculated in a like manner. After surveying the various sources of data, and their co-variability, it was decided to provide the surface heat fluxes for what is termed a "Central Sound" location and a "Northern" location. The fluctuations in the fluxes in the two locations track one another, but there are some differences, and having two sites provides continuity in the case of instrument failures or other data drop-outs.

Central Sound – Downward shortwave radiation from Poulsbo.S and Seattle provided by AgWeatherNet, available at https://weather.wsu.edu. Wind, air temperature, and dewpoint temperature data from the West Point C-MAN station (WPOW1), available at https://www.ndbc.noaa.gov/station_page.php?station=wpow1, and sea surface temperature (SST) data from the Tacoma tide gauge station, available https://tidesandcurrents.noaa.gov, and Dockton in Quartermaster Harbor, available at https://green2.kingcounty.gov/marine-buoy/Data.aspx. The daily downward shortwave radiation from the two AgWeatherNet sites are averaged, and while their day-to-day variations are highly correlated ($r \sim 0.9$), the use of two stations should serve to reduce highly local effects. The winds at WPOW1 appear to be representative of those over the waters of Puget Sound, and its air temperatures and dewpoint temperatures also better reflect marine influences better than inland stations. There is also strong coherence between the two sources of SST data but some seasonal effects with the Dockton location tending to feature lower SSTs in winter and higher SSTs in summer. It is assumed it is reasonable to include Dockton data in the characterization of the SST

of central Puget Sound, because a fair proportion of the central Sound is in the form of shallow, coastal waters.
Northern - Downward shortwave radiation from Sequim and Coupeville provided by AgWeatherNet, available at https://weather.wsu.edu. Wind, air temperature, dewpoint temperature and SST data from Buoy 46088, available at https://www.ndbc.noaa.gov/station_page.php?station=46088. Again, the two sources of shortwave radiation data are highly correlated with one another. It turns out that the mean insolation at Coupeville is greater than that at Sequim, even though the latter location is notorious as a relatively dry spot in terms of precipitation.

Methods

All data are converted into daily averages. The measurements of downward shortwave radiation are used to estimate the net longwave radiative fluxes following Reed (2003), which uses the measured insolation versus the insolation under clear skies to gauge the fractional cloud cover, and then values of the cloud cover fraction, SST, air temperature, and surface water vapor pressure (related to dewpoint). Daily values of the sensible and latent heat fluxes were calculated using the "calc.zeng" script in the "Lake Metabolizer" R package; this script computes surface fluxes using the TOGA COARE bulk aerodynamic flux algorithm. Daily values of the net shortwave radiative fluxes (assuming a reflectance of 6%), net longwave fluxes, and the sensible and latent heat fluxes for the Central Sound and Northern locations were computed for the years of 2014 through 2020. Mean values for each Julian day of the year of the downward shortwave radiation and total net heat fluxes were treated with a filter consisting of 15-day running means applied twice. Deviations from this moderately-smoothed climatology for the year of 2021 through 21 March were treated with a 7-day running mean applied once. Sample plots for the Central Sound are included below.

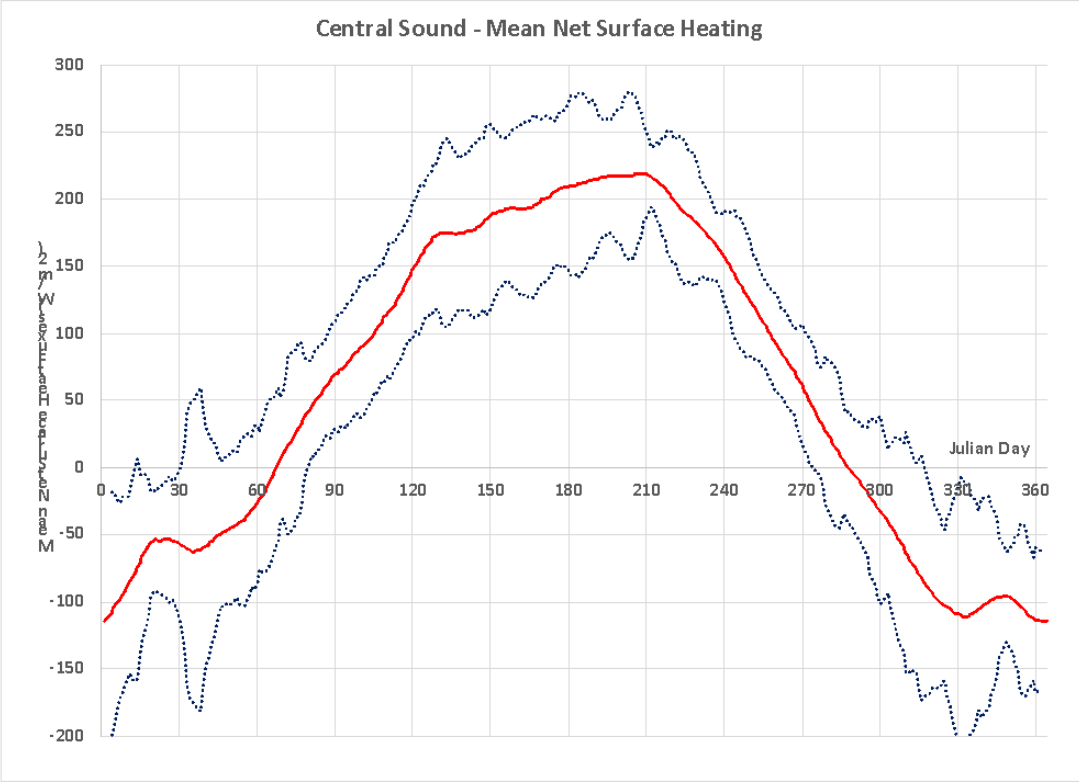

Figure 1 Mean net surface heating rate (W m-2) at the Central Sound location based on observations during 2014 through 2020. The dotted lines indicated the standard deviation in the daily values about the mean.

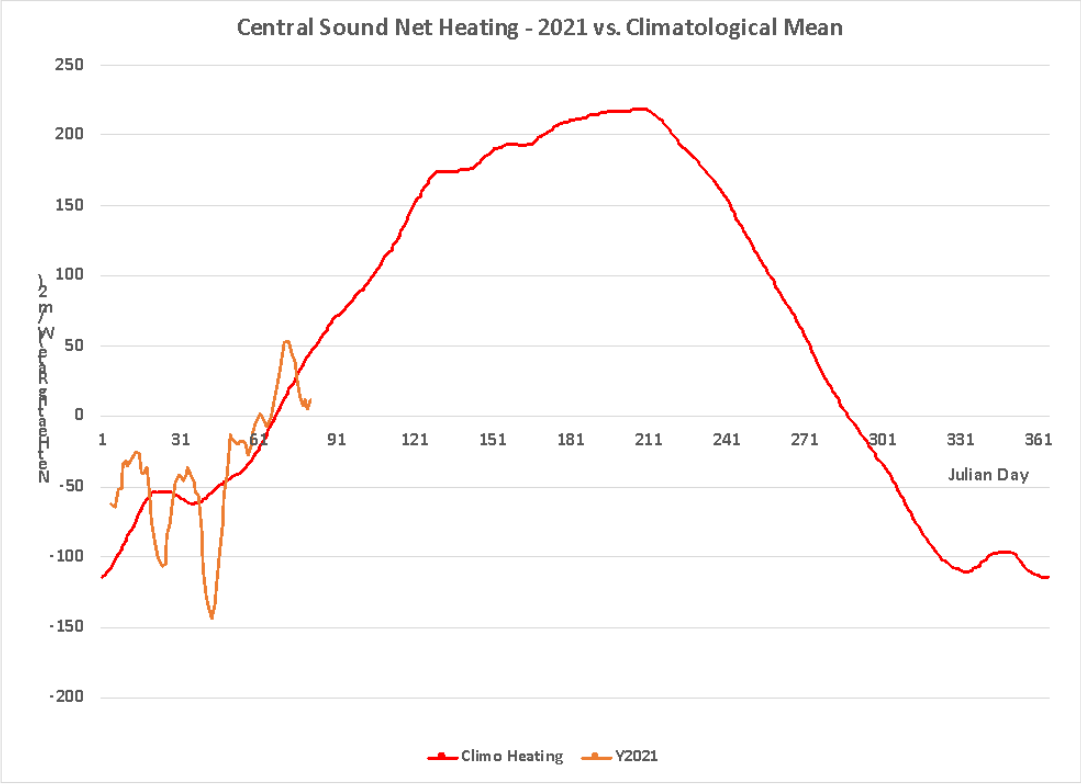

Figure 2 Mean net surface heating rate (red; W m-2) at the Central Sound location based on observations during 2014 through 2020. The orange trace indicates daily values from 1 January through 25 March 2021, with a seven-day running mean.

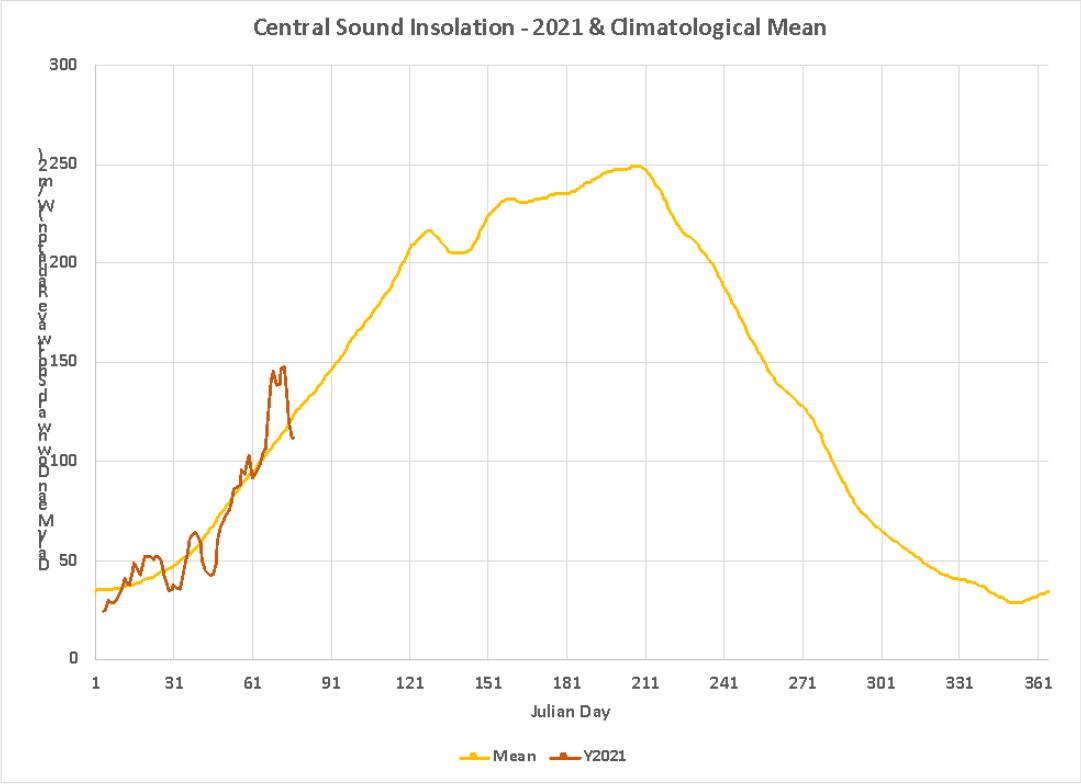

Figure 3 Mean downward shortwave radiative heat fluxes (yellow; W m-2) at the Central Sound location based on observations during 2014 through 2020. The brown trace indicates daily values from 1 January through 25 March 2021, with a seven-day running mean.

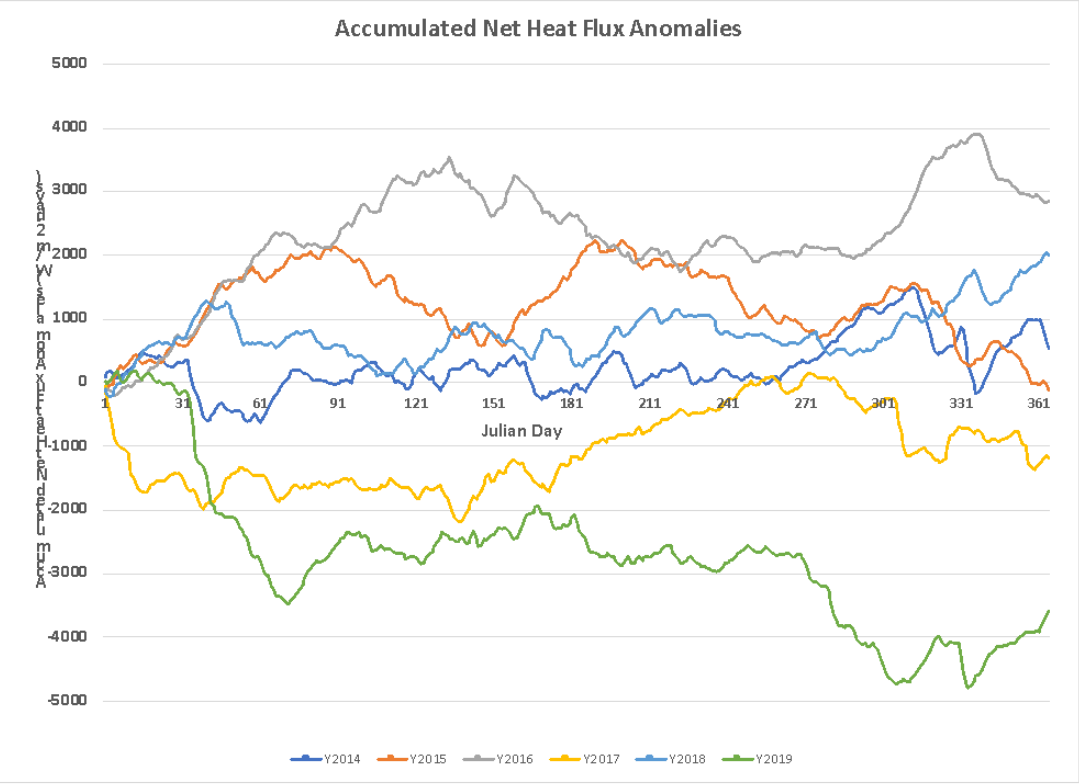

Figure 4 Accumulated net heat flux anomalies (W m^{-2} day) at the Central Sound location for the years of 2014 through 2019.