

A 228-year coral record in the Philippines reveals volcanic cooling in the nineteenth century and globally coherent warming in the late twentieth century

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Abstract

Both proxy and model studies seeking to understand anthropogenic warming have revealed historical variations of sea surface temperature (SST) since the Industrial Revolution. However, because of discrepancies between observations and models for the late nineteenth century, the timing and degree of anthropogenic warming is still unclear. Here we reconstructed a 228-year record of SST and salinity using a coral core collected at Bicol, southern Luzon, Philippines, which is at the northern edge of the western Pacific warm pool. The SST record showed clear volcanic cooling after the eruptions of Tambora and Krakatau in 1815 and 1883, respectively, but the pattern of change differed between them. Although there were discrepancies in SST variations among modeled, observed, and proxy SST data for the late nineteenth to early twentieth century, SST data from the late twentieth century show globally coherent anthropogenic warming, especially after 1975.



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Supporting Information for

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Text S1

Text S1.

Analytical methods, age model and calibrations

For $\delta^{18}\text{O}_{\text{coral}}$ and Sr/Ca analyses, the slabs were microsampled at 0.4-mm intervals following a method developed at Australian National University (Gagan et al., 1994). The analytical procedure and the $\delta^{18}\text{O}_{\text{coral}}$ record for the years 1970–2002 have been published previously (Liu et al., 2013). We report here for the first time continuous $\delta^{18}\text{O}_{\text{coral}}$ and Sr/Ca records from the entire core. The $\delta^{18}\text{O}_{\text{coral}}$ values of samples covering the period from 1890 to 2002 was analyzed using an online system comprising an IsoPrime Isotope-ratio mass spectrometer (GV Instruments Ltd.) coupled to a Multicarb automatic sample treatment system at the Geological Survey of Japan (GSJ), whereas the $\delta^{18}\text{O}_{\text{coral}}$ values of samples predating 1890 were determined by the Center for Advanced Marine Core Research at Kochi University (KCC). All $\delta^{18}\text{O}_{\text{coral}}$ data were normalized to Vienna Pee Dee Belemnite (V-PDB) using the NBS-19 standard ($\delta^{18}\text{O} = +2.2$ Standards and Technology. The International Atomic Energy Agency standard IAEA-603 ($\delta^{18}\text{O} = -2.37 \pm 0.04$) used for some measurements conducted at KCC. The standard deviations of replicate $\delta^{18}\text{O}$ measurements of the standards during the mass spectrometer runs were 0.04KCC, respectively.

Concentrations of Ca and Sr were measured by inductively coupled plasma (ICP) optical emission spectrometry using an IRIS Advantage system (Thermo Electron Co., Ltd) at GSJ and an Agilent 720 system (Agilent Technologies) at Okayama University. We used an analytical method that involves the insertion of a reference solution after every third sample and makes rapid determination of high-precision Sr/Ca ratios feasible (Schrug, 1999). The reference solution was made from JCp-1, a coral material with a known chemical composition provided by GSJ (Okai et al., 2002). Each sample was first weighed ($100 \pm 10 \mu\text{g}$) and then dissolved in 2% HNO_3 . Sr/Ca analyses of samples covering the period after 1883 were conducted at GSJ, and samples predating 1890 were analyzed at Okayama University, respectively, with a 6-year overlap to confirm measurement consistency. The analytical precision of the measurements made at both facilities in terms of the inferred SST was 0.55°C (1σ).

An age model for the period before 1982 was constructed using the Sr/Ca ratios, which reflect SST, with Sr/Ca maxima (indicating relatively cool SSTs) corresponding to growth in January and February, the coolest

months in this region. For the period 1982–2002, the precise timing of the coolest SSTs was determined using IGOSS-nmc SSTs. Other Sr/Ca ratios in this time interval were then converted to the time domain by simple linear interpolation. This age model was confirmed by counting annual density bands on the X-radiographs of the coral core. Age–depth models of the remaining core were developed using the annual density bands and then fine-tuned using the seasonal Sr/Ca cycles. At around 1883, when the Krakatau eruption occurred, geochemical data were disturbed for 1–2 years and the density bands were blurred for about 3 years; thus, the 1982–2002 age model may include an age error of 1–3 years before around 1885. The temporal resolution of the Sr/Ca analyses for the most recent 46 years of the record was approximately monthly, whereas for earlier periods, the resolution was mostly bimonthly. The temporal resolution of the $\delta^{18}\text{O}$ analyses was bimonthly throughout most of the core.

The SST calibration obtained by comparing Sr/Ca minima and maxima to SST maxima and minima, respectively, is (Figure S2a):

$$\text{Sr/Ca} = -0.084\text{SST} + 11.137.$$

Seawater $\delta^{18}\text{O}$ values ($\delta^{18}\text{O}_{\text{sw}}$) were calculated from the paired proxy records as (Cahyarini et al., 2008):

$$\delta^{18}\text{O}_{\text{sw}} = (\delta^{18}\text{O}_{\text{coral}} - \delta^{18}\text{O}_{\text{coral, m}}) - \gamma_1/\beta_1 (\text{Sr/Ca} - \text{Sr/Ca}_m),$$

where $\delta^{18}\text{O}_{\text{coral}}$ is the measured coral $\delta^{18}\text{O}$ value; $\delta^{18}\text{O}_{\text{coral, m}}$ is the mean $\delta^{18}\text{O}_{\text{coral}}$ value; Sr/Ca is the measured coral Sr/Ca ratio and Sr/Ca_m is its mean; and γ_1 and β_1 are the slopes of the linear regressions of $\delta^{18}\text{O}$ (−0.143; Figure S2b) and Sr/Ca (−0.084; Figure S2a), respectively, against IGOSS SSTs. Then the minima (maxima) of $\delta^{18}\text{O}_{\text{sw}}$ and SSS were used to calibrate SSS as (Figure S2c):

$$\delta^{18}\text{O}_{\text{sw}} = 0.790\text{SSS} - 27.103.$$

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Key Points:

- Coral geochemical data from Philippines show clear volcanic cooling only during the nineteenth century.
- A warming trend found in the late twentieth century suggests that the recent warming has been globally synchronous.

Abstract

Both proxy and model studies seeking to understand anthropogenic warming have revealed historical variations of sea surface temperature (SST) since the Industrial Revolution. However, because of discrepancies between observations and models for the late nineteenth century, the timing and degree of anthropogenic warming is still unclear. Here we reconstructed a 228-year record of SST and salinity using a coral core collected at Bicol, southern Luzon, Philippines, which is at the northern edge of the western Pacific warm pool. The SST record showed clear volcanic cooling after the eruptions of Tambora and Krakatau in 1815 and 1883, respectively, but the pattern of change differed between them. Although there were discrepancies in SST variations among modeled, observed, and proxy SST data for the late nineteenth to early twentieth century, SST data from the late twentieth century show globally coherent anthropogenic warming, especially after 1975.

Plain Language Summary

Global warming has been concerned worldwide and model studies play an important role in projecting climate change in the future. To improve accuracy of the model, comparison with observed data is critical. However continuous observed data is inadequate spatially and sometimes there is a discrepancy between the model and observed data. Then proxy data such as coral skeletons is used to understand climate variabilities. In this study, we measured geochemical tracers in a coral skeleton collected from Bicol, southern Luzon, Philippines and reconstructed sea surface temperature (SST) and salinity for more than 200 years. The SST record showed several cooling event due to volcanic eruptions like Tambora and Krakatau in 1815 and 1883, respectively. Although there were discrepancies in SST variations among modeled, observed, and proxy SST data for the late nineteenth to early twentieth century, SST data from the late twentieth century show globally coherent anthropogenic warming, especially after 1975.

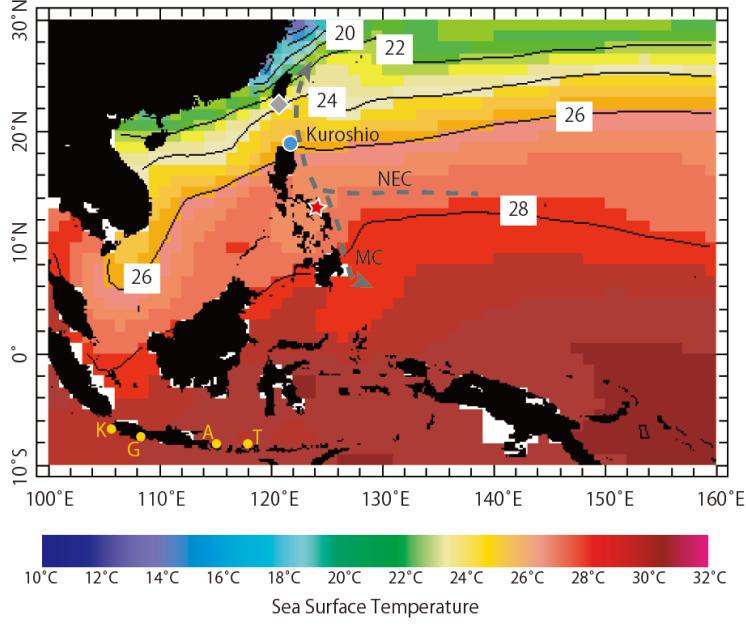
1 Introduction

Historical variations of sea surface temperature (SST) in relation to anthropogenic warming since the Industrial Revolution have been extensively investigated by both proxy and model studies to understand and explain changes in the contemporary climate and to estimate future impacts of climate change (e.g., Neukom et al., 2019; Abram et al., 2020; Hegerl et al., 2011; Ramos et al., 2020; Knutson et al., 2006; Papalexiou et al., 2020). Although recently developed models simulate well the observed long-term warming trend from 1880 to 2014 (Papalexiou et al., 2020), they show pronounced and fairly prolonged cooling during the 1880s. A likely strong contributor to this relatively prolonged cooling behavior is the occurrence of multiple significant volcanic eruptions during this period, such as the 1883 Krakatau eruption, but the discrepancies between models and observations during this period remain unresolved (Knutson et al., 2006). One possible cause may be insufficient observational data, because before 1910, observed data were available from less than 20% of the total ocean area (https://icoads.noaa.gov/index_fig3.html). In contrast, global paleoclimate reconstructions of the past 2,000 years have revealed globally coherent warming only during the twentieth century. Thus, within the past 2,000 years, anthropogenic global warming is not only unparalleled in terms of absolute temperature but also unprecedented in spatial consistency (Neukom et al., 2019). In this regard, paleoclimate records from after 1500 CE show that sustained industrial-era warming of the tropical oceans first occurred during the mid-nineteenth century and was nearly synchronous with Northern Hemisphere continental warming (Abram et al., 2016). However, few proxy data from the subtropical northwestern Pacific, which includes the northern edge of the western Pacific warm pool (WPWP), are available, though this region is of critical importance for determining anthropogenic impacts on the warm pool.

The warm pool of the western tropical Pacific contains some of the warmest seawater globally, with SSTs exceeding 28 °C. Because high SSTs favor deep convection (Roxy, 2014; Zhang, 1993), warm pool variations strongly modulate

the atmospheric circulation (Lindzen & Nigam, 1987; Numaguti, 1995), monsoon rainfall (Cai et al., 2010; Dado & Takahashi, 2017), and tropical cyclone intensity (DeMaria & Kaplan, 1994; Emanuel, 2005). The WPWP, which together with the Indian Ocean warm pool is referred to as the Indo-Pacific warm pool (IPWP), plays a key role in climate and monsoon variability, which not only affects many developing countries throughout Asia and Africa (Zhou et al., 2009; Annamalai et al., 2013; Williams & Funk, 2011) but also influences remote regions and large-scale modes of climate variability (Hoerling & Kumar, 2003; Hoerling et al., 2012; Han et al., 2014). Hayashi et al. (2021) reported that record northwestern Pacific warming occurred in August 2020 under anthropogenic forcing, and expansion of the IPWP due to human-induced global warming has also been reported (Weller et al., 2016; Cravatte et al., 2009; Roxy et al., 2019). To elucidate how anthropogenic forcing has historically affected the warm pool, the long-term variability of SST and sea surface salinity (SSS) in the warm pool must be examined. Recently, Ramos et al. (2019, 2020), who reconstructed long-term SST and SSS records using *Porites* coral from off southern Taiwan and the northeastern tip of Luzon, Philippines, reported that temperature variations seemed to differ between these sites, especially in the early twentieth century. Even including these records, however, few high-resolution coral data for both water temperature and salinity from the northwestern Pacific are available in the PAGES Ocean2k dataset (Abram et al., 2016).

In this study, we conducted Sr/Ca and ^{18}O analyses of a *Porites* coral collected from Bicol, southern Luzon, to reconstruct SST and SSS records over 228 years with a monthly time resolution. These records can be used to investigate the influence of volcanic cooling in the Bicol region because they include years in which large volcanic eruptions occurred, such as Tambora in 1815 and Krakatau in 1883. The WPWP, defined by SSTs of 28.5 °C or more, extends in a band along the equator that reaches 10°N in boreal winter and 30°N in boreal summer (Cravatte et al., 2009). Thus, our sampling site, which is located at the northwestern edge of the persistent warm pool (Figure 1), is positioned suitably for studying the evolution of the warm pool.



2 Materials

and Methods

The Bicol sampling site (13°03 N, 124°01 E) is off southeastern Luzon Island (Figure 1), near where the westward flowing North Equatorial Current (NEC) bifurcates into northward and southward flowing branches. The northward flowing branch is the Kuroshio, which transports a large amount of heat northward, and the southward branch, which has approximately the same volume transport ratio as the Kuroshio, is the Mindanao Current (Nitani, 1972; Toole et al., 1988). At the sea surface, the bifurcation occurs at 13–14°N near a salinity front (Toole et al., 1990; Qu et al., 1998). In the western equatorial Pacific, salinity minima of less than 34.3 due to dilution by precipitation are located at 6–8°N (Donguy & Henin, 1975; Delcroix & Hénin, 1991) and spread into the NEC region (Kimura et al., 1994). The surface water of the NEC, therefore, is composed of both this low-salinity water and high-salinity water (>34.8) due to excess evaporation. A shift of bifurcation latitude may be related to intensity of upwelling (Amedo et al., 2002).

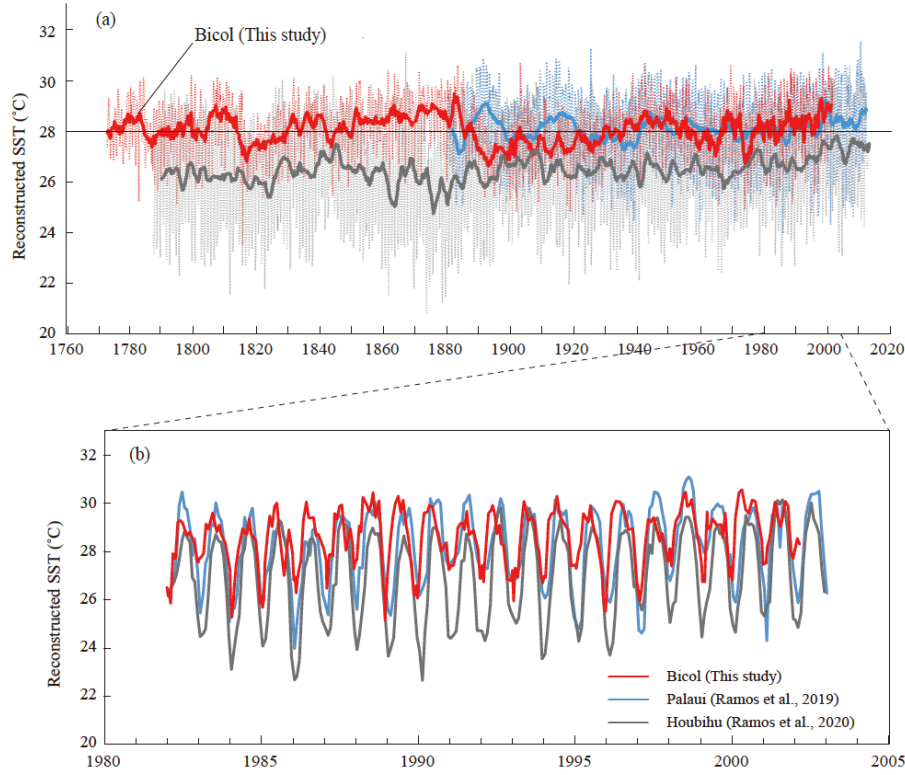
Bicol is also on the northwestern edge of the WPWP (SST > 28 °C), which greatly impacts the global climate through ocean–atmosphere interactions. According to SST records (1° × 1° grid) of the ship- and satellite-derived Integrated Global Ocean Services System Products Bulletin (IGOSS, available from November 1981 to the present), the mean annual SST (12.5°N, 124.5°E) at Bicol was 28.6 °C during 1982–2002. Mean maximum and minimum SSTs were 29.8 °C (mostly in June) and 26.9 °C (in January or February), respectively. SSS also varies seasonally, reaching a maximum (~34.3) in boreal winter and a minimum (around 34) in boreal summer (August to September), based on the

SODA database.

A 2.5-m-long core (SWGM01-01) was collected from a *Porites* sp. colony at 6 m below mean sea level on 16 March 2002. The core was drilled vertically from the top of the colony and then cut into 7-mm-thick slabs in the laboratory. Counting the annual density bands on X-radiographs of these slabs revealed mostly continuous growth and provided an estimated age of around 230 years (Figure S1). Coral ^{18}O and Sr/Ca were analyzed using an online system comprising an IsoPrime Isotope-ratio mass spectrometer (GV Instruments Ltd.) and inductively coupled plasma optical emission spectrometry, respectively. Detailed analytical methods including age model and calibrations to reconstruct SST and SSS are presented in supplementary information.

3. Results and Discussion

3.1., Influences of volcanic eruptions on SST and SSS at Bicol

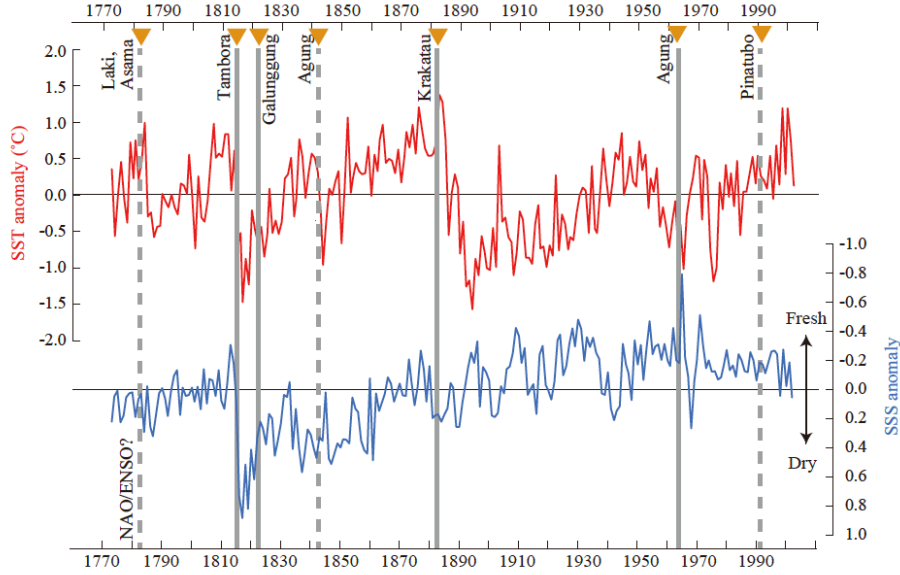


high-resolution time series from Bicol shows that SST varied dynamically during the 228 years of the coral record, with a prominent cooling episode around 1890 (Figure 2a). Other periods of cooling were associated with volcanic eruptions. Among the volcanic eruptions that occurred in Indonesia and the Philippines since the late eighteenth century (Newhall & Self, 1982), we selected four large

The

eruptions, Tambora (1815), Galunggung (1822), Krakatau (1883), and Agung (1963), that satisfied the following three conditions: (1) Volcanic Explosivity Index (VEI) ≥ 5 according to de Maisonneuve and Bergal-Kuvikas (2020); (2) VEI ≥ 4 according to Newhall and Self (1982); and (3) Scaled Amplitude 1 in more than one ice core reference as described in Crowley et al. (1997). According to de Maisonneuve and Bergal-Kuvikas (2020), the eruptions of Agung in 1843 and Pinatubo in 1991 also had VEI ≥ 5 , but, although the reconstructed SST dropped after these eruptions, the magnitude of the SST decrease did not correspond to the VEI (Figure 3).

Another famous volcanic eruption that affected global or regional climate is the 1783 eruption of Laki, Iceland. Although these previous studies did not include the Laki eruption among large eruptions, its impacts on climatic conditions in the Northern Hemisphere and globally have been widely reported in contemporary sources (Thordarson & Self, 2003). However, D’Arrigo et al. (2011) suggested that the dominant cause of the anomalous 1783/1784 winter was a negative NAO combined with an ENSO warm phase, both of which likely resulted from natural variability unconnected to the Laki eruption. It is difficult to determine whether



Bicol

experiences cooler or warmer conditions during an ENSO warm phase that cannot be explained by absolute cool conditions as in the western equatorial Pacific. Thus, the SST decrease at Bicol that began in 1785 and lasted for a decade cannot be definitively attributed to an ENSO warm phase (Figure 3). It is also difficult to conclude that the cause of this cooling event at Bicol was the Laki eruption alone, because its VEI was not large and associated volcanic cooling was reported mainly in high-latitude regions of the Northern Hemisphere such as Europe and North America. Moreover, Mt. Asama in

Japan erupted at the same time, so the cooling might reflect the combined impact of the two eruptions. Although the cause and mechanism of this late eighteenth century cooling is uncertain, this climate change event probably contributed to the Great Tenmei famine in Japan; this Edo period famine is considered to have begun in 1782 and lasted until 1788.

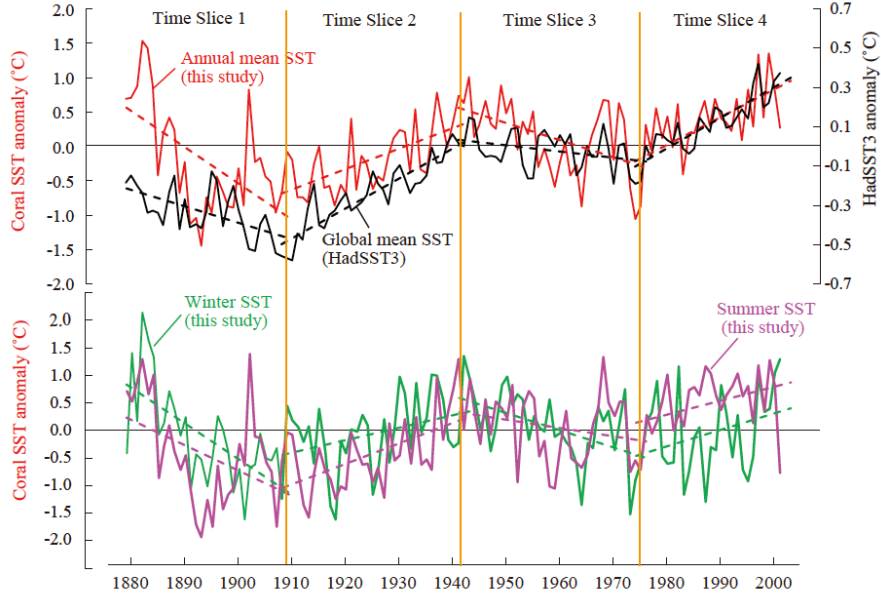
In contrast to the situation after the Laki eruption, the pronounced cooling around Bicol after the Tambora (1815) and Krakatau (1883) eruptions was certainly due to the volcanic eruptions. However, each eruption seemed to affect marine conditions differently. SST cooled relatively sharply by ~ 2.0 °C just after the Tambora eruption, which was associated with a substantial drought (Figure 3), whereas SST cooling by ~ 2.5 °C after the Krakatau eruption began only after a delay of 2–3 years and persisted for a decade with little change in salinity. However, because our age model for the period before 1885 includes an error of 1–3 years (see Section 2), this might be only an apparent time lag; nevertheless, marine conditions were certainly fairly different between these two historically large eruptions. In 1816, the coldest summer in two centuries was observed in both northeastern North America and western Europe and has been widely attributed to the 1815 Tambora eruption (e.g., Luterbacher and Pfister, 2015). In southeast Asia, a hydroclimate reconstruction shows that a strong drought struck regions of India, Indonesia, and southeast Asia that year (Cook et al., 2010). A simulation of the climatic response to the volcanic forcing of the Tambora eruption showed a particularly pronounced surface ocean cooling response in the subtropics (Fasullo et al., 2017). The occurrence of severe drought in southeast Asia and ocean cooling in the subtropics after the Tambora eruption are consistent with our SST and SSS records.

Climate model simulations show that the Krakatau eruption also affected oceanic conditions (Gleckler et al., 2006a). Volcanically induced cooling of the ocean surface penetrated the deep ocean, where it persisted for decades after the event. Multiple models have simulated surface ocean cooling that lasted until around 1900 to 1920, depending on the model, even though the eruption occurred in 1883. This remarkable effect on the oceanic thermal structure, which appears to be longer lasting than previously suspected, is sufficient to offset a large fraction of the ocean warming caused by anthropogenic influences (Gleckler et al., 2006b). Unfortunately, Gleckler et al. (2006a) did not directly compare the climatic impacts of the Tambora and Krakatau eruptions. However, the simulated heat content recovery was much more rapid following eruptions in the late twentieth century, such as the Pinatubo eruption, than it was following the Krakatau eruption, although Pinatubo was comparable to Krakatau in terms of its radiative forcing (Gleckler et al., 2006a). Gleckler et al. (2006a) attributed this difference to the fact that the response to Pinatubo was superimposed on a non-stationary background of a large and increasing anthropogenically forced ocean warming. Alongside the possible impact of prolonged cooling after the Krakatau eruption, coral studies from Ishigaki Island suggest an abrupt shift toward cooler conditions in the earliest part of the twentieth century (Mishima et al., 2010). Mishima et al.

(2010) attributed this cold event to a contemporaneous intensified East Asian winter monsoon (EAWM), which was associated with active heat convection in the tropics and weak westerlies. They suggested that several phenomena in the northwestern subtropical Pacific, including the SST cooling at Ishigaki Island and surface ocean freshening around the Ogasawara Islands, were uniquely coupled during the first few years of the twentieth century (Mishima et al., 2010). Thus, it might be possible to explain the pronounced late nineteenth to early twentieth century cooling at Bicol by the combination of the prolonged impact of the Krakatau eruption and the intensified EAWM. The negligible or only slight ocean surface cooling caused by volcanic eruptions in the late twentieth century, attributed by Gleckler et al. (2006a) to the background of increasing greenhouse-gas forcing, is also consistent with the findings of this study (Figure 3). Overall, reconstructed SSTs at Bicol appear to reflect volcanic cooling events that occurred during the past 228 years, but it is unclear whether the magnitude of cooling (up to ~ 2 °C) at this site is plausible.

3.2., Long-term SST and SSS variations in the northwestern subtropical Pacific

We compared our long-term SST record at Bicol to those reported by Ramos et al. (2019, 2020), who studied corals collected at Houbihu, southern Taiwan, and Palaui, northeastern Luzon (Figure 2a). The seasonality of SST is well reconstructed in the records of the three individual corals: reconstructed SSTs in boreal winter during 1982–2002 were coolest in at Houbihu, and slightly cooler at Palaui than at Bicol (Figure 2b). In contrast, the long-term records from the late nineteenth to early twentieth century showed little consistency among the three corals. In particular, reconstructed SSTs were ~ 2 °C warmer at Palaui than at Bicol for a period of about four decades. The large cooling seen at Bicol after the Krakatau eruption is absent in both the Palaui and Houbihu records, although Ramos et al. (2020) suggested that volcanic activities contributed to the SST variability at Houbihu. Knutson et al. (2006) reported discrepancies between modeled and observed SSTs during the corresponding time period, and the pattern of SST variation differed among the three individual coral records; these results suggest that climate conditions during this period may have been variable, or very sensitive to different forcings, at least in the northwestern Pacific. The SST time series and the SSS variations reconstructed using the Palaui and Houbihu corals have been explained mainly by regional phenomena such as the EAWM and the Pacific Decadal Oscillation (PDO) (Ramos et al., 2019, 2020). In contrast, the decadal trend in the SST record at Bicol from 1880 to 2002 corresponded well to the global mean SST record (HadSST3) for that period.



Statistical

analyses have been used to divide the time series of global surface air temperature anomalies from 1860 to 2014 into stages defined by warming and cooling phases and hiatus periods (Zhu et al., 2018). Following Zhu et al. (2018), Papalexiou et al. (2020) divided the historical time period into four time slices: (1) a cooling phase during 1880–1909; (2) a warming phase during 1909–1942; (3) a hiatus from 1942 to 1975; and (4) a warming phase during 1975–2014. In each time slice, the trend of the SST anomalies at Bicol is similar to that of global mean SST anomalies (Figure 4). In addition, the overall warming of the global SST by 0.59 °C from 1880 to 2002 is similar to that of 0.72 °C for the Bicol SST. Moreover, in Time Slice 4 (1975–2002), even the annual variation is mostly consistent between the observed and reconstructed SST anomalies, which are significantly correlated ($r = 0.74$), although the absolute values of the SST anomalies, and hence the magnitude of warming, differ between them. When we divided the time series of Bicol SST anomalies into winter and summer values, the trend during each time slice was similar (Figure 4), but the absolute values of the SST anomalies differed slightly among time slices; in particular, summer SSTs were warmer than winter SSTs during the most recent warming phase (Time Slice 4). At Palau, Ramos et al. (2019) reported a summertime Sr/Ca-SST increase, but suggested that anthropogenic warming in the wintertime Sr/Ca and SST trends is masked by interannual to multidecadal scale changes driven by the EAWM and the PDO. However, given that Palau is far to the north of the warm pool in winter (Figure 1), it is also possible that the impact of anthropogenic warming might differ between the warm pool and its outer region. Kosaka and Xie (2016), who conducted simulations with a global coupled ocean-atmosphere model in which the tropical Pacific SST was forced to follow the observed temperature evolution, identified the tropical

Pacific as a key determinant of the global mean surface warming rate. The similarity between the global and Bicol SST trends appears to support their hypothesis.

Long-term SSS variations can be decoupled from the SST variations; SSS anomalies show persistent freshening starting around 1820, after the extreme drought following the Tambora eruption (Figure 3). This long-term SSS trend is similar to that reported from Vanuatu in the southwestern Pacific (Gorman et al., 2012). In the northwestern Pacific, the low-salinity front moved northward from 13°N to 17°N during 1970–2000 (Kimura et al., 2001), a finding that suggests that the salinity front can move like the warm pool (Qiu & Lukas, 1996). A shift of the salinity front may thus be responsible for the observed freshening after 1820. In particular, because both warming and freshening trends were found from 1820 to 1880, a northward shift of the warm pool might have been accompanied by northward migration of the salinity front. SSTs at Bicol before 1880 were comparable to those around 2000; most of the time before 1880, SSTs were greater than 28 °C, except during periods of volcanic cooling (Figure 2). These warm SSTs might reflect a northward shift or an expansion of the warm pool, or simply local variations.

Abram et al. (2016), who studied industrial-era warming in both paleoclimate records and model simulations, revealed that the greenhouse forcing causing industrial-era warming commenced around 1830 in the western Pacific and included an enhanced response in the equatorial ocean. This enhanced equatorial response might account for the warming after the Tambora eruption at Bicol, although the warming was largely suspended around 1880, probably as a result of both the Krakatau eruption and an intensified EAWM, which were not considered by Abram et al. (2016).

3.3., Coherent warming trend in the late twentieth century

Although SST behaviors from the late nineteenth to the early twentieth century differed among Bicol, Palaui, and Houbihu, the records of SST anomalies from these three sites were consistent in the late twentieth century, approximately corresponding to Time Slice 4. The warming trend during this period, calculated using high-resolution (biweekly) data, was 0.21 °C per decade at Houbihu and 0.17 °C per decade at Palaui, whereas trends calculated using annual mean data at Bicol, global mean SSTs (HadSST3), and multi-model mean data were 0.40, 0.15, and 0.24 °C per decade, respectively (Papalexiou et al., 2020). At Bicol, excluding the first two years (1975 and 1976, when the mean annual SSTs were very low), the warming trend is 0.25 °C per decade. Although the magnitude of the warming trend differs a little among the sites and the global and modeled mean SSTs, the trends in all records are similar in the late twentieth century, unlike those in the late nineteenth and early twentieth centuries. Neukom et al. (2019) suggested that more than 98% of the globe experienced the warmest temperatures of the past two millennia during the twentieth century. The results of coral studies from the northwestern Pacific show more specifically this coherent anthropogenic warming reported by Neukom et al. (2019) since at least 1975

(Time Slice 4). As Neukom et al. (2019) have suggested, past climates showed extensive spatial variations, reflecting complicated interactions among diverse climatic responses. However, the recent warming has been globally synchronous, showing reduced climatic diversity. The similar warming trends seen at all three coral sites in the northwestern Pacific (Figure 2) support the recent finding that anthropogenic forcing has caused expansion of the IPWP (Weller et al., 2016). The size and intensity of the warm pool in the western Pacific affects both the East Asian monsoon and western Pacific tropical cyclones (Wang et al., 2013; Ueda et al., 2015), and precise long-term SST and SSS records are important for improving our understanding of the evolution of the IPWP.

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Open Research

Our original data of coral Sr/Ca and ^{18}O are presented as a supporting material (Original Data_Inoue et al.pdf). If my article is accepted, I will submit our data in PANGAEA (<https://www.pangaea.de>) that is member of the World Data System.

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Age	Sr/Ca (mmol/mol)	$\delta^{18}\text{O}$ (‰)
2002.20	8.759	-4.724
2002.12	8.738	
2002.00	8.810	-4.766
2001.92	8.782	
2001.83	8.627	-5.274
2001.75	8.608	
2001.67	8.659	-5.014
2001.58	8.698	
2001.50	8.660	-5.011
2001.42	8.609	
2001.33	8.666	-5.111
2001.25	8.737	
2001.17	8.769	-4.843
2001.13	8.826	
2001.08	8.826	
2001.04	8.830	
2001.00	8.747	-5.362
2000.79	8.607	-5.208
2000.68	8.604	
2000.58	8.651	-5.236
2000.47	8.637	
2000.37	8.568	-5.016
2000.26	8.578	
2000.16	8.664	-4.886
2000.11	8.771	
2000.05	8.884	
2000.00	8.838	
1999.97	8.872	-4.901
1999.83	8.649	-5.386
1999.76	8.736	
1999.69	8.690	-5.244
1999.55	8.691	-5.063
1999.41	8.668	-5.175
1999.34	8.703	

1999.28	8.703	-4.860
1999.24	8.644	
1999.21	8.738	
1999.17	8.890	
1999.14	8.878	-4.905
1999.10	8.890	
1999.07	8.836	
1999.00	8.764	-5.131
1998.88	8.684	-5.032
1998.75	8.602	-5.093
1998.72		
1998.69	8.621	
1998.63	8.627	-5.143
1998.59		
1998.56	8.576	
1998.50	8.588	-4.946
1998.44		
1998.38	8.654	-4.777
1998.25	8.676	-4.875
1998.22		
1998.19	8.713	
1998.16		
1998.13	8.835	-4.621
1998.06	8.772	
1998.00	8.819	-4.912
1997.82	8.719	-5.197
1997.73	8.748	
1997.64	8.706	-5.250
1997.55	8.664	
1997.45	8.681	-5.129
1997.36	8.670	
1997.27	8.759	-4.861
1997.18	8.895	
1997.09	8.957	-4.641
1997.00	8.888	
1996.87	8.703	-5.209

1996.73	8.707	
1996.60	8.643	-5.164
1996.47	8.609	
1996.33	8.607	-5.346
1996.20	8.650	
1996.07	8.874	-4.817
1996.00	8.994	
1995.96	8.977	
1995.93	8.942	
1995.89	8.847	-5.021
1995.74	8.751	-5.333
1995.59	8.682	-5.231
1995.52	8.623	
1995.44	8.680	-5.203
1995.30	8.651	-4.942
1995.22	8.757	
1995.15	8.786	-4.747
1995.07	8.844	
1995.04	8.829	
1995.00	8.832	-4.927
1994.91	8.833	
1994.82	8.709	-5.243
1994.64	8.678	-5.142
1994.55	8.659	
1994.45	8.589	-5.305
1994.36	8.651	
1994.27	8.651	-4.990
1994.18	8.675	
1994.09	8.873	-4.724
1994.05	8.870	
1994.00	8.894	
1993.93	8.854	-4.856
1993.87	8.781	
1993.80	8.762	-5.128
1993.73	8.684	
1993.67	8.662	-5.076

1993.53	8.676	-5.123
1993.47	8.641	
1993.40	8.607	-5.057
1993.33	8.671	
1993.27	8.772	-4.720
1993.20	8.874	
1993.13	8.842	-4.600
1993.10	8.842	
1993.07	8.958	
1993.03	8.850	
1993.00	8.887	-4.815
1992.87	8.881	-4.968
1992.73	8.763	
1992.67	8.757	-5.150
1992.60	8.691	-5.140
1992.53	8.722	
1992.47	8.661	-5.191
1992.40	8.622	
1992.33	8.641	-4.806
1992.27	8.651	
1992.20	8.731	-4.846
1992.13	8.848	
1992.10	8.891	
1992.07	8.832	-4.880
1992.03	8.877	
1992.00	8.879	
1991.93	8.779	-5.011
1991.79	8.709	-5.049
1991.64	8.726	-5.265
1991.57	8.643	
1991.50	8.708	-5.231
1991.43	8.684	
1991.36	8.688	-4.884
1991.29	8.701	
1991.21	8.798	-4.739
1991.14	8.831	

1991.11	8.834	
1991.07	8.831	-4.808
1991.04	8.841	
1991.00	8.848	
1990.91	8.753	-5.055
1990.74	8.783	-4.949
1990.57	8.686	-5.046
1990.48	8.629	
1990.39	8.622	-5.177
1990.30	8.646	
1990.22	8.649	-4.784
1990.13	8.723	
1990.04	8.909	-4.534
1990.00	8.947	
1989.96	8.903	
1989.92	8.934	
1989.88	8.937	-4.860
1989.83	8.862	
1989.71	8.738	-5.023
1989.63	8.691	
1989.54	8.603	-5.100
1989.46	8.647	
1989.38	8.589	-5.188
1989.29	8.617	
1989.21	8.663	-5.273
1989.13	8.741	
1989.04	8.865	-4.781
1989.00	8.943	
1988.97	9.025	
1988.94	8.936	
1988.90	8.900	-5.061
1988.77	8.606	-5.401
1988.65	8.665	-5.259
1988.58	8.577	
1988.52	8.618	-5.237
1988.45	8.645	

1988.39	8.623	-5.205
1988.26	8.594	-5.008
1988.19	8.716	
1988.13	8.694	-4.937
1988.06	8.813	
1988.03	8.814	
1988.00	8.823	-5.112
1987.96	8.846	
1987.93	8.761	
1987.86	8.703	-5.098
1987.79	8.738	
1987.71	8.780	-5.074
1987.64	8.694	
1987.57	8.621	-5.156
1987.50	8.627	
1987.43	8.670	-5.071
1987.36	8.651	
1987.29	8.798	-4.677
1987.21	8.793	
1987.18	8.797	
1987.14	8.873	-4.544
1987.11	8.913	
1987.07	8.815	
1987.00	8.775	-5.030
1986.84	8.723	-5.059
1986.76	8.728	
1986.68	8.664	-5.061
1986.52	8.667	-5.081
1986.44	8.609	
1986.36	8.674	-5.053
1986.28	8.816	
1986.20	8.853	-4.483
1986.16	8.883	
1986.12	8.928	
1986.08	8.871	
1986.04	8.885	-5.012

1986.00	8.790	
1985.88	8.707	-5.187
1985.73	8.868	-5.011
1985.58	8.718	-5.156
1985.50	8.614	
1985.42	8.627	-5.131
1985.35	8.697	
1985.27	8.658	-4.968
1985.19	8.731	
1985.12	8.824	-4.760
1985.08	8.952	
1985.04	8.979	
1985.00	8.938	
1984.97	8.966	-4.849
1984.90	8.825	
1984.83	8.747	-5.059
1984.69	8.722	-5.079
1984.62	8.668	
1984.55	8.723	-5.148
1984.48	8.720	
1984.41	8.704	-5.101
1984.28	8.774	-4.758
1984.21	8.831	
1984.14	8.909	-4.591
1984.10	8.974	
1984.07	9.014	
1984.03	8.961	
1984.00	8.850	-5.048
1983.86	8.755	-5.048
1983.72	8.722	-5.160
1983.66	8.692	
1983.59	8.716	-5.139
1983.45	8.648	-4.861
1983.38	8.680	
1983.31	8.705	-4.721
1983.24	8.687	

1983.17	8.789	-4.754
1983.10	8.800	
1983.07	8.805	
1983.03	8.809	-4.913
1983.00	8.821	
1982.96	8.815	
1982.88	8.755	-4.942
1982.73	8.716	-4.956
1982.65	8.727	
1982.58	8.709	-5.103
1982.50	8.684	
1982.42	8.675	-5.148
1982.35	8.680	
1982.27	8.808	-4.820
1982.19	8.790	
1982.12	8.966	-4.674
1982.08	8.931	
1982.04	8.938	
1982.00	8.908	
1981.96	8.843	-5.061
1981.79	8.728	-5.144
1981.71	8.705	
1981.63	8.620	-5.147
1981.46	8.645	-5.237
1981.38	8.590	
1981.29	8.615	-4.874
1981.21	8.768	
1981.13	8.831	-4.640
1981.08	8.798	
1981.04	8.968	
1981.00	8.954	
1980.96	8.878	-4.901
1980.80	8.731	-5.269
1980.64	8.690	-5.272
1980.48	8.696	-5.213
1980.32	8.631	-5.252

1980.16	8.774	-4.800
1980.08	8.956	
1980.00	8.905	-4.636
1979.93	8.842	
1979.86	8.821	-5.100
1979.71	8.691	-5.145
1979.57	8.695	-5.069
1979.43	8.705	-5.220
1979.29	8.660	-4.961
1979.14	8.736	-4.837
1979.07	8.753	
1979.00	8.806	-4.729
1978.92	8.800	
1978.83	8.762	-5.018
1978.67	8.711	-5.093
1978.50	8.679	-5.116
1978.33	8.778	-4.793
1978.25	8.845	
1978.17	8.866	-4.446
1978.08	8.837	
1978.00	8.889	-4.703
1977.82	8.770	-4.931
1977.64	8.669	-4.999
1977.45	8.651	-5.162
1977.27	8.794	-4.780
1977.18	8.770	
1977.09	8.803	-4.752
1977.00	8.907	
1976.92	8.846	-4.890
1976.77	8.802	-4.986
1976.62	8.804	-4.962
1976.46	8.733	-5.125
1976.31	8.903	-4.802
1976.23	8.874	
1976.15	8.933	-4.187
1976.08	8.967	

1976.00	8.919	-4.490
1975.86	8.830	-4.758
1975.71	8.822	-4.939
1975.64	8.720	
1975.57	8.738	-4.952
1975.43	8.870	-4.787
1975.29	8.944	-4.589
1975.21	8.945	
1975.14	8.983	-4.370
1975.07	8.992	
1975.00	8.950	-4.693
1974.83	8.935	-4.902
1974.67	8.761	-5.029
1974.50	8.779	-4.968
1974.33	8.736	-5.065
1974.17	8.739	-4.773
1974.08	8.912	
1974.00	9.044	-4.455
1973.81	8.810	-5.003
1973.76	8.732	-5.226
1973.57	8.632	-5.212
1973.38	8.705	-5.043
1973.19	8.731	-4.662
1973.10	8.855	
1973.00	8.850	-4.704
1972.92	8.756	
1972.85	8.738	-5.173
1972.69	8.631	-5.119
1972.62	8.650	
1972.54	8.764	-5.028
1972.38	8.676	-5.473
1972.23	8.698	-4.946
1972.08	8.843	-5.041
1972.00	8.904	
1971.92	8.874	-5.237
1971.77	8.785	-5.273

1971.62	8.741	-5.256
1971.46	8.653	
1971.31	8.732	
1971.23	8.792	
1971.15	8.919	-4.779
1971.08	8.947	
1971.00	8.833	-5.020
1970.87	8.668	-5.154
1970.73	8.715	-5.214
1970.60	8.653	-5.267
1970.47	8.632	-5.283
1970.33	8.661	-4.942
1970.20	8.771	-4.930
1970.13	8.833	
1970.07	8.888	-4.702
1970.00	8.814	
1969.94	8.807	-5.041
1969.83	8.787	-5.069
1969.72	8.691	-5.089
1969.61	8.564	-5.128
1969.50	8.611	-5.125
1969.39	8.625	-4.892
1969.28	8.665	-4.946
1969.17	8.771	-4.682
1969.11	8.875	
1969.06	8.904	
1969.00	8.793	
1968.92	8.767	-5.111
1968.77	8.723	
1968.62	8.642	-4.261
1968.46	8.652	
1968.31	8.749	-4.569
1968.15	8.829	-4.531
1968.08	8.881	
1968.00	8.844	-4.572
1967.88	8.801	-4.669

1967.75	8.741	-4.841
1967.63	8.682	-4.993
1967.50	8.665	-5.028
1967.38	8.665	-5.145
1967.25	8.748	-4.867
1967.13	8.860	-5.037
1967.06	8.944	
1967.00	8.903	-4.668
1966.90	8.842	-4.907
1966.80	8.738	-4.963
1966.70	8.739	-4.916
1966.60	8.769	-5.086
1966.50	8.773	-5.144
1966.40	8.772	-5.058
1966.30	8.710	-4.867
1966.20	8.829	-4.760
1966.10	8.928	-4.568
1966.00	8.936	-5.037
1965.83	8.795	-5.225
1965.67	8.875	-5.275
1965.50	9.030	-5.146
1965.33	8.868	-5.270
1965.21	8.893	
1965.17	8.730	
1965.00	8.864	
1964.80	8.833	
1964.60	8.807	-5.188
1964.50	8.732	
1964.40	8.723	-5.004
1964.30	8.766	
1964.20	8.836	-4.623
1964.10	8.848	
1964.00	8.968	-4.580
1963.91	8.944	
1963.82	8.832	-4.824
1963.64	8.750	-5.114

1963.45	8.717	-5.174
1963.27	8.743	-4.841
1963.18	8.762	
1963.09	8.932	-4.699
1963.00	8.939	
1962.92	8.893	-5.073
1962.75	8.742	-5.159
1962.58	8.724	-5.337
1962.42	8.685	-5.171
1962.25	8.645	
1962.08	8.885	-4.868
1962.00	8.934	
1961.90	8.892	-4.570
1961.70	8.696	-5.048
1961.50	8.691	-5.236
1961.30	8.773	-5.001
1961.10	8.894	-4.687
1961.00	8.921	
1960.91	8.878	-4.826
1960.73	8.769	-4.963
1960.55	8.811	-5.030
1960.36	8.761	-5.015
1960.18	8.896	-4.491
1960.00	8.926	-4.781
1959.83	8.837	-5.176
1959.67	8.831	-4.950
1959.58	8.855	
1959.50	8.759	-5.136
1959.33	8.795	-5.035
1959.17	8.817	-4.648
1959.08	8.763	
1959.00	8.870	-4.924
1958.90	8.832	
1958.80	8.825	-5.138
1958.60	8.768	-5.009
1958.50	8.742	

1958.40	8.690	-5.201
1958.20	8.789	-4.538
1958.00	8.919	-4.744
1957.78	8.730	-5.004
1957.56	8.714	-5.127
1957.44	8.737	
1957.33	8.833	-5.103
1957.22	8.888	
1957.11	8.912	-4.816
1957.00	8.908	
1956.92	8.877	-5.107
1956.77	8.695	-5.316
1956.62	8.696	-5.282
1956.46	8.663	-5.273
1956.31	8.626	-5.265
1956.15	8.794	-4.685
1956.00	8.896	-4.654
1955.97	8.871	-4.520
1955.87	8.830	-4.905
1955.77	8.792	-4.799
1955.67	8.753	-5.117
1955.56	8.615	-5.156
1955.46	8.705	-5.252
1955.36	8.639	-5.426
1955.26	8.765	-5.237
1955.15	8.679	-5.143
1955.10	8.863	
1955.05	8.878	-4.810
1955.00	8.931	
1954.88	8.790	-5.421
1954.63	8.755	-5.137
1954.38	8.640	-5.311
1954.13	8.752	-5.111
1954.00	8.871	
1953.90	8.862	-4.896
1953.70	8.809	-5.251

1953.60	8.768	
1953.50	8.757	-5.039
1953.40	8.776	
1953.30	8.752	-4.947
1953.20	8.781	
1953.10	8.815	-4.801
1953.00	8.840	
1952.91	8.730	-4.994
1952.73	8.673	-5.257
1952.55	8.731	-5.094
1952.36	8.606	-4.910
1952.18	8.787	-4.626
1952.00	8.879	-4.687
1951.83	8.772	-5.101
1951.67	8.725	-5.492
1951.50	8.743	-5.018
1951.33	8.655	-5.154
1951.17	8.782	-4.877
1951.00	8.836	-4.877
1950.96	8.849	-4.909
1950.80	8.722	-5.120
1950.64	8.647	-5.028
1950.48	8.716	-5.120
1950.32	8.641	-5.281
1950.16	8.646	-4.898
1950.08	8.680	
1950.00	8.848	-4.845
1949.92	8.784	
1949.83	8.808	-5.117
1949.67	8.722	-5.448
1949.50	8.676	-5.237
1949.33	8.631	-5.611
1949.17	8.866	-4.540
1949.00	8.912	-4.545
1948.83	8.694	
1948.67	8.784	-4.777

1948.33	8.681	-5.037
1948.17	8.715	
1948.00	8.948	-4.281
1947.80	8.889	-4.981
1947.60	8.680	-5.141
1947.50	8.628	
1947.40	8.685	-5.029
1947.20	8.726	-4.694
1947.10	8.702	
1947.00	8.846	-4.705
1946.88	8.788	
1946.75	8.743	-4.982
1946.50	8.714	-5.044
1946.25	8.695	-5.094
1946.13	8.742	
1946.00	8.914	-4.705
1945.83	8.863	-5.040
1945.67	8.672	-5.103
1945.50	8.653	-5.317
1945.33	8.718	-4.786
1945.25	8.809	
1945.17	8.874	-4.838
1945.00	8.873	-5.234
1944.95	8.687	-4.983
1944.76	8.649	-5.036
1944.57	8.597	-4.940
1944.38	8.688	-4.746
1944.19	8.790	-4.506
1944.00	8.841	-4.761
1943.92	8.781	
1943.83	8.790	-4.834
1943.67	8.673	-4.868
1943.50	8.678	-5.001
1943.33	8.697	-4.758
1943.17	8.755	-4.516
1943.00	8.805	-4.598

1942.82	8.626	-4.991
1942.64	8.702	-4.893
1942.45	8.567	-4.990
1942.27	8.703	-4.653
1942.09	8.853	-4.399
1942.00	8.936	
1941.91	8.872	-4.458
1941.73	8.746	-4.788
1941.55	8.611	-4.914
1941.36	8.630	-4.815
1941.18	8.791	-4.586
1941.00	8.943	-4.747
1940.83	8.796	-4.996
1940.67	8.644	-5.121
1940.50	8.717	-5.154
1940.33	8.820	-5.015
1940.17	8.852	-4.465
1940.00	8.932	-4.453
1939.83	8.738	-5.037
1939.67	8.701	-4.943
1939.50	8.688	-4.780
1939.33	8.782	-4.486
1939.17	8.792	-4.541
1939.00	8.871	-5.011
1938.83	8.761	-4.980
1938.67	8.594	-5.000
1938.50	8.717	-5.064
1938.33	8.695	-4.931
1938.17	8.760	-4.364
1938.00	8.835	-4.869
1937.77	8.786	
1937.69	8.768	-4.912
1937.38	8.734	-5.041
1937.08	8.761	-5.059
1937.00	8.833	-4.882
1936.67	8.718	-5.158

1936.33	8.856	-4.736
1936.00	8.899	-4.869
1935.82	8.861	-5.179
1935.55	8.780	-4.947
1935.45	8.726	
1935.36	8.788	-5.041
1935.18	8.839	-4.779
1935.00	8.921	-4.938
1934.83	8.811	-5.054
1934.67	8.710	-5.155
1934.50	8.734	-5.234
1934.33	8.654	-5.172
1934.17	8.730	-4.912
1934.00	8.845	-4.979
1933.92	8.826	
1933.83	8.821	-5.227
1933.67	8.725	-5.240
1933.50	8.775	-5.045
1933.33	8.759	-5.029
1933.17	8.915	-4.549
1933.00	8.945	-4.951
1932.82	8.739	-5.200
1932.64	8.809	-5.031
1932.45	8.657	-5.094
1932.27	8.747	-4.823
1932.09	8.837	-4.796
1932.00	8.861	
1931.90	8.836	-5.189
1931.70	8.779	-5.316
1931.50	8.712	-4.946
1931.30	8.734	-5.283
1931.20	8.778	
1931.10	8.779	-4.991
1931.00	8.784	
1930.91	8.740	-4.544
1930.73	8.720	-5.606

1930.55	8.724	-5.163
1930.36	8.741	-5.496
1930.18	8.851	-4.946
1930.00	8.915	-5.270
1929.91	8.801	-4.496
1929.82	8.762	-4.951
1929.73	8.664	-4.957
1929.64	8.764	-4.743
1929.55	8.869	-5.174
1929.45	8.812	-5.427
1929.36	8.743	-5.077
1929.27	8.785	-5.244
1929.18	8.804	-5.109
1929.09	8.860	-4.803
1929.00	8.966	-4.903
1928.75	8.813	-5.183
1928.63	8.877	-5.231
1928.50	8.825	-5.209
1928.38	8.776	-5.089
1928.25	8.804	-4.855
1928.00	8.901	-4.662
1927.83	8.789	-4.923
1927.67	8.780	-5.132
1927.50	8.730	-4.997
1927.33	8.734	-4.994
1927.17	8.958	-4.912
1927.00	8.980	-4.807
1926.94	8.807	-4.724
1926.82	8.753	-4.888
1926.71	8.781	-5.058
1926.59	8.884	-4.813
1926.47	8.872	-4.792
1926.41	8.844	
1926.35	8.822	
1926.29	8.752	
1926.24	8.840	

1926.12	8.901	
1926.00	9.014	
1925.85	8.812	-4.621
1925.77	8.801	-4.997
1925.69	8.822	-4.752
1925.54	8.836	-4.862
1925.46	8.761	
1925.38	8.788	
1925.23	8.725	
1925.08	8.864	
1925.00	8.909	
1924.93	8.894	-4.589
1924.80	8.872	-5.126
1924.67	8.810	-5.036
1924.60	8.806	-4.940
1924.53	8.864	-5.178
1924.40	8.736	
1924.27	8.726	
1924.20	8.739	
1924.13	8.744	
1924.00	8.841	
1923.81	8.919	-5.064
1923.62	8.877	-4.806
1923.43	8.803	-4.777
1923.38	8.706	-5.169
1923.19	8.885	-4.865
1923.10	8.846	-4.990
1923.00	8.877	-4.989
1922.86	8.781	-5.061
1922.71	8.795	-4.617
1922.57	8.759	-4.976
1922.43	8.678	-4.859
1922.29	8.693	-5.011
1922.14	8.683	-4.766
1922.00	8.916	-4.857
1921.80	8.841	-4.526

1921.60	8.763	-4.695
1921.40	8.782	-4.658
1921.30	8.905	-4.603
1921.20	8.855	-4.471
1921.00	8.952	-4.789
1920.80	8.869	-4.946
1920.60	8.758	-4.670
1920.40	8.766	-4.603
1920.30	8.843	-4.436
1920.20	8.857	-4.743
1920.00	8.933	-4.769
1919.75	8.806	-4.937
1919.50	8.801	-4.663
1919.38	8.778	-4.581
1919.25	8.852	-4.673
1919.13	8.892	-4.591
1919.00	9.051	-4.612
1918.88	8.855	-5.239
1918.75	8.817	-5.325
1918.50	8.787	-4.969
1918.25	8.747	-4.854
1918.13	8.798	-4.570
1918.00	9.031	-4.622
1917.78	8.854	-5.062
1917.56	8.735	-4.891
1917.33	8.776	-4.891
1917.11	8.894	-4.577
1917.00	8.948	-4.978
1916.88	8.884	-4.579
1916.75	8.729	-4.968
1916.50	8.701	-4.829
1916.25	8.766	-4.417
1916.13	8.818	-4.543
1916.00	8.857	-4.517
1915.91	8.783	-4.853
1915.82	8.789	-4.868

1915.73	8.740	-4.896
1915.55	8.820	-4.925
1915.36	8.747	-4.673
1915.18	8.844	-4.619
1915.00	8.967	-4.561
1914.80	8.828	-4.752
1914.60	8.850	-4.838
1914.40	8.805	-4.674
1914.20	8.901	-4.424
1914.00	8.911	-4.631
1913.80	8.813	-4.646
1913.60	8.810	-4.847
1913.40	8.786	-4.848
1913.20	8.919	-4.478
1913.00	8.935	-4.399
1912.83	8.913	-4.772
1912.67	8.849	-4.920
1912.50	8.739	-4.954
1912.33	8.846	-4.779
1912.17	8.886	-5.053
1912.00	8.885	-4.894
1911.75	8.866	-5.114
1911.50	8.786	-4.976
1911.25	8.681	-4.866
1911.00	8.902	-4.614
1910.86	8.766	-5.065
1910.71	8.678	-5.170
1910.57	8.800	-5.175
1910.43	8.838	-5.106
1910.29	8.812	-4.649
1910.14	8.817	-5.052
1910.00	8.880	-5.165
1909.75	8.813	-5.348
1909.63	8.797	-5.096
1909.50	8.848	-5.130
1909.38	8.721	-5.059

1909.25	8.880	-4.687
1909.00	9.021	-4.774
1908.75	8.819	-4.948
1908.50	8.867	-5.122
1908.25	8.860	-4.592
1908.00	8.944	-4.676
1907.94	8.876	-4.361
1907.71	8.737	-4.895
1907.47	8.804	-4.981
1907.24	8.793	-5.160
1907.00	8.962	-4.733
1906.82	8.827	-4.621
1906.64	8.734	-5.152
1906.45	8.722	-5.082
1906.27	8.816	-5.011
1906.09	8.914	-4.860
1906.00	8.960	-4.210
1905.90	8.886	-4.486
1905.70	8.685	-4.990
1905.50	8.757	-4.867
1905.30	8.738	-4.803
1905.10	8.848	-4.735
1905.00	8.922	-4.503
1904.90	8.835	-4.766
1904.70	8.745	-4.667
1904.50	8.684	-4.951
1904.30	8.701	-5.003
1904.20	8.824	-4.855
1904.10	8.969	-4.745
1904.00	8.919	-4.336
1903.88	8.782	-4.466
1903.63	8.647	-4.871
1903.38	8.658	-4.919
1903.13	8.559	-4.977
1903.00	8.973	-4.595
1902.89	8.960	-4.453

1902.78	8.874	-4.216
1902.67	8.830	-4.200
1902.44	8.756	-4.990
1902.33	8.727	-4.723
1902.28	8.754	-4.775
1902.22	8.956	-4.400
1902.00	9.052	-4.277
1901.88	8.958	-4.381
1901.75	8.851	-3.840
1901.63	8.729	-4.553
1901.50	8.695	-5.043
1901.38	8.715	-4.679
1901.25	8.790	-5.032
1901.13	8.836	-4.648
1901.00	8.975	-4.540
1900.88	8.965	-4.283
1900.75	8.801	-4.380
1900.63	8.764	-4.939
1900.50	8.761	-4.932
1900.38	8.839	-4.916
1900.25	8.823	-4.830
1900.13	8.965	-4.812
1900.00	9.011	-4.477
1899.88	8.948	-4.290
1899.75	8.853	-4.567
1899.63	8.771	-4.812
1899.50	8.842	-5.072
1899.38	8.858	-4.916
1899.25	8.832	-4.873
1899.00	8.947	-4.687
1898.75	8.873	-4.491
1898.63	8.793	-4.848
1898.50	8.806	-4.915
1898.38	8.832	-4.888
1898.25	8.861	-5.010
1898.00	8.916	-4.662

1897.80	8.851	-4.560
1897.70	8.727	-4.822
1897.60	8.787	-4.830
1897.40	8.831	-4.302
1897.20	8.875	-4.658
1897.00	8.895	-4.554
1896.67	8.850	-4.883
1896.50	8.820	-5.073
1896.33	8.863	-5.034
1896.00	8.956	-4.606
1895.75	8.779	-5.003
1895.63	8.787	-4.995
1895.50	8.786	-4.948
1895.25	8.915	-5.079
1895.00	9.001	-4.040
1894.75	8.899	-4.858
1894.50	8.937	-4.836
1894.38	8.835	-4.892
1894.25	8.926	-4.907
1894.00	8.961	-4.360
1893.83	8.944	-4.311
1893.67	8.817	-4.977
1893.50	8.857	-4.898
1893.33	8.847	-4.989
1893.17	8.854	-4.874
1893.00	8.954	-4.225
1892.75	8.903	-4.365
1892.50	8.806	-4.859
1892.38	8.767	-4.909
1892.25	8.857	-4.775
1892.13	8.913	-4.649
1892.00	9.005	-4.181
1891.75	8.798	-4.469
1891.50	8.711	-5.041
1891.25	8.838	-4.703
1891.00	8.897	-4.475

1890.69	8.876	-4.330
1890.62	8.733	-4.811
1890.31	8.859	-4.502
1890.00	8.925	-4.270
1889.80	8.729	-4.622
1889.60	8.753	-4.766
1889.40	8.705	-4.989
1889.20	8.788	-4.413
1889.00	8.885	-4.254
1888.80	8.752	-4.934
1888.60	8.666	-4.994
1888.40	8.743	-5.137
1888.20	8.764	-4.430
1888.00	8.858	-4.738
1887.80	8.698	-5.003
1887.60	8.746	-4.831
1887.40	8.758	-5.109
1887.20	8.779	-4.605
1887.00	8.906	-4.627
1886.80	8.785	-4.884
1886.60	8.746	-4.827
1886.40	8.793	-4.753
1886.20	8.883	-4.419
1886.00	8.924	-4.189
1885.96	8.806	-4.628
1885.92	8.753	-4.833
1885.67	8.664	-4.747
1885.50	8.590	-4.648
1885.33	8.714	-4.786
1885.00	8.780	-4.964
1884.80	8.642	-4.794
1884.60	8.620	-4.918
1884.40	8.660	-4.865
1884.20	8.665	-4.822
1884.00	8.781	-4.634
1883.89	8.735	-4.686

1883.78	8.633	-4.836
1883.67	8.566	-4.990
1883.56	8.653	-4.960
1883.00	8.739	-4.823
1882.98	8.803	-4.686
1882.91	8.735	-4.660
1882.84	8.646	-4.928
1882.77	8.636	-4.903
1882.70	8.657	-5.045
1882.63	8.655	
1882.56	8.615	
1882.49	8.601	
1882.42	8.652	-4.740
1882.35	8.732	
1882.28	8.741	
1882.21	8.822	
1882.14	8.747	-4.655
1882.07	8.852	
1882.00	8.903	
1881.81	8.801	-4.827
1881.62	8.715	
1881.43	8.680	
1881.38	8.631	-4.911
1881.19	8.777	-4.632
1881.00	8.796	-4.401
1880.80	8.771	-4.975
1880.60	8.651	-5.111
1880.40	8.684	-5.175
1880.20	8.616	-4.989
1880.00	8.952	-4.760
1879.80	8.717	-5.117
1879.60	8.696	-5.011
1879.40	8.650	-4.963
1879.20	8.754	-4.635
1879.00	8.861	-4.318
1878.86	8.774	-4.931

1878.71	8.673	-5.193
1878.57	8.690	
1878.43	8.631	-5.079
1878.29	8.607	-4.994
1878.14	8.842	-4.868
1878.00	8.870	-4.845
1877.83	8.702	-5.184
1877.67	8.649	-5.135
1877.50	8.670	-5.245
1877.33	8.649	-5.238
1877.17	8.770	-4.886
1877.00	8.789	-5.131
1876.80	8.645	-5.245
1876.60	8.633	-5.130
1876.40	8.635	-5.053
1876.20	8.668	-4.867
1876.00	8.819	-4.626
1875.83	8.732	-4.807
1875.67	8.697	-4.995
1875.50	8.669	-4.894
1875.33	8.639	-4.984
1875.17	8.822	-4.455
1875.00	8.841	-4.610
1874.80	8.793	-4.915
1874.60	8.668	-5.080
1874.40	8.663	-5.101
1874.20	8.634	-5.098
1874.00	8.744	-4.680
1873.83	8.723	-5.183
1873.67	8.686	-5.257
1873.50	8.717	-5.168
1873.33	8.697	-5.408
1873.17	8.711	-4.585
1873.00	8.820	-4.713
1872.86	8.736	-5.021
1872.71	8.635	-4.877

1872.57	8.668	-5.133
1872.43	8.664	-5.027
1872.29	8.648	-4.769
1872.14	8.683	-4.714
1872.00	8.918	-4.678
1871.83	8.724	-4.775
1871.67	8.694	-4.913
1871.50	8.641	-4.964
1871.33	8.588	-4.933
1871.17	8.818	-4.749
1871.00	8.956	-4.706
1870.83	8.776	-4.925
1870.67	8.731	-4.826
1870.50	8.716	-5.046
1870.33	8.731	-4.840
1870.17	8.755	-4.726
1870.00	8.887	-4.761
1869.80	8.748	-5.093
1869.60	8.686	-5.040
1869.40	8.693	-4.928
1869.20	8.653	-4.779
1869.00	8.863	-4.524
1868.86	8.841	-4.370
1868.71	8.751	-4.956
1868.57	8.706	-4.894
1868.43	8.727	-4.920
1868.29	8.649	-5.012
1868.14	8.723	-4.698
1868.00	8.888	-4.572
1867.83	8.747	-4.983
1867.67	8.654	-5.097
1867.50	8.622	-4.940
1867.33	8.657	-4.934
1867.17	8.806	-4.580
1867.00	8.957	-4.838
1866.83	8.726	-5.058

1866.67	8.646	-5.006
1866.50	8.643	-5.121
1866.33	8.677	-4.915
1866.17	8.853	-4.672
1866.00	8.885	-4.833
1865.98	8.783	-4.601
1865.88	8.730	-4.607
1865.78	8.673	-4.776
1865.68	8.697	-5.015
1865.59	8.709	-5.061
1865.49	8.699	-5.011
1865.39	8.727	-4.938
1865.29	8.709	-5.128
1865.20	8.757	-4.937
1865.10	8.802	-4.764
1865.00	8.894	-4.342
1864.86	8.740	-4.607
1864.71	8.627	-4.956
1864.57	8.612	-5.125
1864.43	8.680	-4.864
1864.29	8.675	-4.813
1864.14	8.747	-4.927
1864.00	8.813	-4.800
1863.89	8.746	-4.654
1863.78	8.717	-4.617
1863.67	8.691	-4.669
1863.56	8.596	-4.871
1863.44	8.740	-4.828
1863.33	8.737	-4.891
1863.22	8.666	-4.995
1863.11	8.685	-5.139
1863.00	8.881	-4.425
1862.80	8.712	-4.790
1862.60	8.683	-4.859
1862.40	8.694	-4.925
1862.20	8.723	-4.925

1862.00	8.955	-4.610
1861.95	8.798	-4.499
1861.76	8.771	-4.198
1861.57	8.585	-4.705
1861.38	8.680	-4.757
1861.19	8.682	-4.635
1861.00	8.887	-4.164
1860.83	8.758	-4.179
1860.67	8.689	-4.564
1860.50	8.742	-4.669
1860.33	8.781	-5.447
1860.17	8.829	-4.987
1860.00	8.892	-5.280
1859.83	8.726	-4.461
1859.67	8.674	-4.680
1859.50	8.662	-4.629
1859.33	8.698	-4.545
1859.17	8.773	-4.592
1859.00	8.815	-4.359
1858.69	8.796	-4.247
1858.38	8.641	-4.729
1858.08	8.716	-4.781
1858.00	8.870	-4.287
1857.86	8.782	-4.365
1857.71	8.738	-4.325
1857.57	8.680	-4.645
1857.43	8.694	-4.655
1857.29	8.761	-4.696
1857.14	8.778	-4.804
1857.00	8.861	-4.438
1856.83	8.842	-4.511
1856.67	8.664	-4.593
1856.50	8.699	-4.766
1856.33	8.748	-4.939
1856.17	8.751	-4.899
1856.00	8.811	-4.638

1855.80	8.785	-4.509
1855.60	8.636	-4.915
1855.40	8.670	-4.917
1855.20	8.701	-4.865
1855.00	8.924	-4.569
1854.75	8.737	-4.657
1854.50	8.749	-4.969
1854.25	8.734	-4.983
1854.00	8.827	-4.530
1853.75	8.799	-4.411
1853.50	8.680	-4.820
1853.25	8.734	-4.817
1853.00	8.898	-3.993
1852.95	8.691	-4.635
1852.76	8.615	-4.806
1852.57	8.629	-4.773
1852.38	8.619	-4.737
1852.19	8.722	-4.692
1852.00	8.872	-4.419
1851.80	8.752	-4.438
1851.60	8.627	-4.765
1851.40	8.681	-4.686
1851.20	8.737	-4.437
1851.10	8.897	-4.706
1851.00	8.934	-4.221
1850.83	8.883	-3.964
1850.67	8.738	-4.530
1850.50	8.830	-4.700
1850.33	8.800	-4.631
1850.17	8.873	-4.443
1850.00	8.890	-4.046
1849.83	8.770	-4.289
1849.67	8.637	-4.730
1849.50	8.665	-4.887
1849.33	8.695	-4.949
1849.17	8.784	-4.554

1849.00	8.967	-3.907
1848.75	8.788	-4.248
1848.50	8.672	-4.673
1848.25	8.747	-4.521
1848.00	8.854	-4.456
1847.80	8.815	-4.271
1847.60	8.734	-4.244
1847.40	8.688	-4.463
1847.20	8.815	-4.679
1847.00	8.849	-4.301
1846.75	8.737	-4.299
1846.50	8.667	-4.488
1846.25	8.740	-4.664
1846.00	8.949	-4.288
1845.75	8.828	-4.559
1845.50	8.718	-4.928
1845.25	8.807	-4.824
1845.00	8.896	-4.597
1844.75	8.810	-4.170
1844.50	8.733	-4.715
1844.25	8.899	-4.696
1844.00	9.000	-3.947
1843.93	8.864	-4.284
1843.86	8.802	-4.638
1843.71	8.714	-4.547
1843.57	8.754	-4.678
1843.43	8.779	-4.696
1843.29	8.810	-4.637
1843.14	8.842	-4.336
1843.00	8.868	-4.161
1842.75	8.771	-4.519
1842.50	8.747	-4.630
1842.25	8.665	-4.510
1842.00	8.833	-4.226
1841.86	8.780	-4.237
1841.71	8.738	-4.128

1841.57	8.708	-4.655
1841.43	8.631	-4.874
1841.29	8.673	-4.868
1841.14	8.787	-4.745
1841.00	8.848	-4.337
1840.80	8.742	-4.369
1840.60	8.693	-4.704
1840.40	8.666	-4.932
1840.20	8.761	-4.700
1840.00	8.803	-4.460
1839.75	8.736	-4.282
1839.50	8.715	-4.759
1839.25	8.704	-4.899
1839.00	8.868	-4.544
1838.87	8.827	-4.424
1838.75	8.661	
1838.62	8.770	
1838.50	8.899	
1838.37	8.682	-4.551
1838.25	8.780	
1838.12	8.800	
1838.00	8.848	
1837.88	8.749	-4.604
1837.85	8.689	-4.326
1837.73	8.707	
1837.61	8.753	-4.775
1837.48	8.728	
1837.36	8.764	-3.971
1837.24	8.695	
1837.12	8.698	
1837.00	8.844	
1836.80	8.733	-4.291
1836.60	8.635	-4.683
1836.40	8.712	-4.648
1836.20	8.695	-4.699
1836.00	8.807	-4.649

1835.86	8.751	-4.324
1835.71	8.653	-4.813
1835.57	8.746	-4.856
1835.43	8.778	-4.857
1835.29	8.792	-5.021
1835.14	8.844	-4.600
1835.00	8.939	-4.301
1834.75	8.787	-4.385
1834.50	8.775	
1834.25	8.779	-4.552
1834.00	8.881	
1833.84	8.752	-4.544
1833.68	8.775	
1833.52	8.713	
1833.48	8.668	-5.036
1833.32	8.637	
1833.16	8.771	-4.975
1833.00	8.850	-4.925
1832.75	8.715	-4.880
1832.50	8.680	-4.935
1832.25	8.709	-5.071
1832.00	8.921	-4.309
1831.75	8.608	-4.757
1831.50	8.687	-4.881
1831.25	8.823	-5.151
1831.00	8.925	-4.413
1830.75	8.837	-4.359
1830.50	8.692	-4.756
1830.25	8.762	-4.673
1830.00	8.952	-4.455
1829.78	8.853	-4.768
1829.56	8.751	-4.766
1829.33	8.771	-4.408
1829.11	8.872	-4.126
1829.00	8.882	-4.129
1828.83	8.752	-4.459

1828.67	8.686	-4.524
1828.50	8.718	-4.702
1828.33	8.815	-4.482
1828.25	8.831	-4.259
1828.17	8.921	-4.102
1828.00	8.943	-4.176
1827.86	8.766	-4.295
1827.57	8.715	-5.029
1827.29	8.742	-4.874
1827.14	8.943	
1827.00	8.956	-4.256
1826.75	8.696	-4.707
1826.50	8.740	-4.886
1826.25	8.793	-4.794
1826.00	8.862	-4.324
1825.75	8.737	-4.577
1825.50	8.741	-4.614
1825.25	8.865	-4.277
1825.00	8.960	-4.216
1824.75	8.799	-4.638
1824.50	8.796	-4.565
1824.25	8.870	-4.558
1824.00	8.939	-4.099
1823.80	8.731	-4.594
1823.60	8.741	-4.643
1823.40	8.760	-4.763
1823.20	8.893	-4.700
1823.00	8.958	-4.100
1822.80	8.816	-4.099
1822.60	8.765	-4.493
1822.40	8.763	-4.627
1822.20	8.834	-4.781
1822.00	9.003	-4.204
1821.87	8.885	-3.965
1821.75	8.790	-4.067
1821.50	8.756	-4.601

1821.25	8.780	-4.101
1821.00	8.892	-4.462
1820.75	8.780	-4.355
1820.50	8.728	-4.610
1820.25	8.773	-4.668
1820.00	8.913	-4.128
1819.75	8.841	-4.051
1819.50	8.823	-4.408
1819.25	8.897	
1819.00	8.971	-4.007
1818.67	8.831	-4.314
1818.33	8.790	-4.481
1818.00	8.941	-3.992
1817.75	8.788	-4.031
1817.50	8.950	-4.100
1817.25	8.888	-3.662
1817.00	8.988	-3.753
1816.90	8.831	-4.094
1816.80	8.839	
1816.70	8.830	
1816.60	8.871	
1816.50	8.809	-4.289
1816.40	8.825	
1816.30	8.774	
1816.20	8.746	
1816.10	8.774	-4.139
1816.00	8.939	
1815.86	8.884	
1815.72	8.901	
1815.59	9.163	
1815.55	8.663	-4.906
1815.41	8.717	
1815.28	8.652	-5.099
1815.14	8.772	
1815.00	8.962	-4.353
1814.80	8.716	-5.056

1814.60	8.664	-5.080
1814.40	8.676	-5.207
1814.20	8.784	-5.055
1814.00	8.809	-4.733
1813.80	8.721	-4.988
1813.60	8.700	-5.028
1813.40	8.727	-5.210
1813.20	8.802	-5.336
1813.00	8.929	-4.671
1812.75	8.729	-4.771
1812.50	8.657	-5.096
1812.25	8.692	-4.888
1812.00	8.761	-5.091
1811.80	8.736	-4.561
1811.60	8.694	-4.609
1811.40	8.655	-4.952
1811.20	8.634	-5.075
1811.00	8.835	-4.857
1810.80	8.813	-4.335
1810.60	8.620	-5.098
1810.40	8.630	-5.004
1810.20	8.706	-5.081
1810.00	8.911	-4.552
1809.80	8.699	-4.699
1809.60	8.673	-5.167
1809.40	8.662	-5.046
1809.20	8.728	-5.187
1809.00	8.900	-4.816
1808.97	8.843	-4.503
1808.83	8.664	-4.839
1808.69	8.683	-4.980
1808.55	8.622	-4.866
1808.41	8.649	-4.991
1808.28	8.782	-4.928
1808.14	8.822	-4.941
1808.00	8.834	-4.631

1807.83	8.686	-4.685
1807.67	8.605	-5.128
1807.50	8.712	-4.960
1807.33	8.645	-5.105
1807.17	8.715	-5.104
1807.00	8.831	-4.928
1806.75	8.664	-4.970
1806.50	8.621	-5.071
1806.25	8.736	-4.966
1806.00	8.945	-4.678
1805.67	8.791	-4.585
1805.50	8.734	-4.867
1805.33	8.749	-4.684
1805.17	8.722	-4.780
1805.00	8.941	-4.617
1804.80	8.882	-4.357
1804.60	8.734	-4.826
1804.40	8.752	-5.138
1804.20	8.766	-5.198
1804.00	8.924	-4.746
1803.86	8.876	-4.436
1803.71	8.821	-4.506
1803.57	8.717	-4.869
1803.43	8.722	-4.856
1803.29	8.739	-4.814
1803.14	8.791	-4.690
1803.00	8.975	-4.340
1802.80	8.798	-4.536
1802.60	8.648	-4.807
1802.40	8.681	-5.069
1802.20	8.770	-4.936
1802.00	8.895	-4.893
1801.80	8.836	-4.183
1801.60	8.745	-4.575
1801.40	8.770	-4.896
1801.20	8.885	-4.965

1801.00	8.974	-4.501
1800.97	8.813	-4.762
1800.83	8.760	-4.495
1800.69	8.626	-4.932
1800.55	8.801	-4.905
1800.41	8.760	-4.974
1800.28	8.740	-4.987
1800.14	8.875	-4.684
1800.00	8.875	-4.704
1799.89	8.730	-4.643
1799.78	8.689	-4.953
1799.67	8.685	-4.940
1799.56	8.626	-4.956
1799.44	8.598	-4.998
1799.33	8.672	-4.949
1799.22	8.738	-4.964
1799.11	8.925	-4.823
1799.00	8.940	-4.409
1798.94	8.801	-4.536
1798.71	8.694	-4.931
1798.47	8.716	-5.096
1798.24	8.718	-5.068
1798.00	8.969	-4.176
1797.75	8.697	-4.862
1797.50	8.719	-4.870
1797.25	8.775	-4.986
1797.00	8.886	-4.584
1796.80	8.787	-4.452
1796.60	8.699	-4.660
1796.40	8.700	-4.840
1796.20	8.722	-4.880
1796.00	8.928	-4.565
1795.80	8.781	-4.563
1795.60	8.671	-4.839
1795.40	8.724	-5.151
1795.20	8.811	-5.285

1795.00	9.027	-4.465
1794.80	8.852	-4.641
1794.60	8.711	-4.942
1794.40	8.732	-4.892
1794.20	8.756	-5.146
1794.00	8.920	-4.612
1793.80	8.804	-4.606
1793.60	8.695	-4.911
1793.40	8.749	-4.821
1793.20	8.795	-4.978
1793.00	8.858	-4.597
1792.69	8.783	-4.425
1792.38	8.698	-4.799
1792.08	8.731	-4.867
1792.00	8.966	-4.422
1791.80	8.849	-4.400
1791.60	8.737	-4.804
1791.40	8.716	-4.794
1791.20	8.732	-4.995
1791.00	8.903	-4.667
1790.83	8.832	-4.630
1790.67	8.769	-4.684
1790.50	8.683	-5.075
1790.33	8.722	-4.746
1790.17	8.732	-4.948
1790.00	8.935	-4.747
1789.83	8.928	-4.294
1789.67	8.767	-4.567
1789.50	8.733	-4.884
1789.33	8.683	-4.943
1789.17	8.803	-4.793
1789.00	8.982	-4.807
1788.80	8.859	-4.358
1788.60	8.713	-4.668
1788.40	8.764	-4.881
1788.20	8.788	-4.799

1788.00	8.961	-4.275
1787.83	8.854	-4.258
1787.67	8.709	-4.560
1787.50	8.758	
1787.33	8.916	-4.694
1787.17	8.842	-4.323
1787.00	8.894	-4.343
1786.83	8.781	-4.542
1786.67	8.758	-4.678
1786.50	8.752	-4.741
1786.33	8.816	-4.654
1786.17	8.837	-4.493
1786.00	8.854	-4.247
1785.83	8.788	-4.470
1785.67	8.759	-4.771
1785.50	8.764	-4.800
1785.33	8.745	-4.793
1785.17	8.869	-4.670
1785.00	8.906	-5.131
1784.80	8.738	-4.423
1784.60	8.617	-4.900
1784.40	8.605	-4.963
1784.20	8.708	-5.044
1784.00	8.818	-4.217
1783.80	8.755	-4.510
1783.60	8.679	-4.912
1783.40	8.619	-4.949
1783.20	8.645	-4.891
1783.00	9.016	-4.924
1782.86	8.827	-4.768
1782.71	8.778	-4.410
1782.57	8.713	-4.762
1782.43	8.684	-4.891
1782.29	8.704	-4.951
1782.14	8.736	-5.014
1782.00	8.898	-4.631

1781.80	8.772	-4.509
1781.60	8.667	
1781.40	8.655	-4.958
1781.20	8.657	-4.965
1781.00	8.836	-4.501
1780.83	8.810	-4.571
1780.67	8.696	-4.924
1780.50	8.726	-4.871
1780.33	8.639	-5.084
1780.17	8.818	-4.783
1780.00	8.880	-4.655
1779.75	8.686	-4.877
1779.50	8.656	-4.855
1779.25	8.682	-5.017
1779.00	8.853	-4.776
1778.80	8.838	-4.510
1778.60	8.745	-4.817
1778.40	8.753	-4.754
1778.20	8.827	-4.963
1778.00	8.894	-4.447
1777.75	8.837	-4.431
1777.50	8.710	-4.806
1777.25	8.754	-4.699
1777.00	8.837	-4.654
1776.80	8.775	-4.334
1776.60	8.692	-4.602
1776.40	8.645	-4.838
1776.20	8.734	-4.986
1776.00	8.868	-4.658
1775.80	8.839	-4.301
1775.60	8.716	-4.892
1775.40	8.704	-4.854
1775.20	8.762	-5.076
1775.00	8.881	-4.827
1774.80	8.821	-4.650
1774.60	8.795	-4.927

1774.40	8.819	-4.584
1774.20	8.825	-4.712
1774.00	8.876	-4.511
1773.83	8.786	-4.376
1773.67	8.736	-4.691
1773.50	8.712	-4.605
1773.33	8.676	-5.020
1773.17	8.754	-4.801
1773.00	8.837	-4.556