

Global Climate Change

GC21A MC: 130 Tuesday 0830h
Reconstructions of Nineteenth
Century Climate I (joint with A, B, H,
 OS, V, PP, PA)

Presiding: C Woodhouse, NOAA; H
 Diaz, NOAA/ERL

GC21A-01 0830h INVITED
Nineteenth Century Long-Term
Instrumental Records, Examples
From the Southeastern United States

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Early instrumental records in the United States, defined as those operating before 1892 which is regarded the period prior to the modern climate record, provide a longer perspective of climatic variability at decadal and interannual timescales. Such reconstructions also provide a means of verification for other proxy data. This paper provides a American perspective of historical climatic research, emphasizing the urgent need to properly evaluate data quality and provide necessary corrections to make them compatible with the modern record. Different fixed observation times, different practices of weather instrument exposures, and statistical methods for calibration are the main issues in applying corrections and conducting proper climatic interpretations. I illustrate several examples on methodologies of this historical climatic research, focusing on the following in the Southeastern United States: daily reconstructed temperature time-series centered on Charleston SC and Natchez MS back to the late eighteenth century, and precipitation frequency reconstructions during the antebellum period for the Gulf Coast and coastal Southeast Atlantic states. Results indicate several prominent extremes unprecedented as compared to the modern record, such as the widespread warm winter of 1827-28, and the severe cold winters of 1856 and 1857. The reconstructions also yield important information concerning responses to past ENSO events, the PNA, NAO, and the PDO, particularly when compared with instrumental data from other regions. A high potential also exists for applying the climate reconstructions to assess historical climatic impacts on society in the Southeast, such as to understand climatic linkages to famous case studies of Yellow Fever epidemics and severe drought.

GC21A-02 0850h INVITED
Reconstructing Chesapeake-Area
Nineteenth-Century Climate From
Historical Data

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Research is underway to reconstruct patterns of climate in the southeastern United States based on data collected from historical sources, with the main emphasis on the period 1750-1870. The post-1820 period is particularly well-represented by historical data in dozens of documents ranging from diaries to official weather logs. Such nineteenth-century records from Virginia can be applied to reconstruct aspects of climate for the greater Chesapeake Bay region. Data sets compiled from the vicinity of Charlottesville, Richmond, and Norfolk allow for identification of regional precipitation (rainfall and snowfall) patterns over most of the nineteenth century. A reconstruction of freeze-thaw patterns in the Chesapeake-area derived from the same sources will also be presented. As these data are developed the 1830s are appearing as a decade of extremes, especially marked by years of severe drought and extreme cold.

GC21A-03 0910h
James Madison and a Shift in
Precipitation Seasonality

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An eighteen-year meteorological diary and tree ring data from James Madisons Montpelier plantation provide a consistent reconstruction of early summer and prior fall rainfall for the 18th Century Virginia piedmont. The Madison meteorological diary suggests a seasonal shift in monthly rainfall towards an earlier wet season relative to 20th Century norms. Furthermore, dendroclimatic reconstructions of early summer and prior fall rainfall reflect this shift in the seasonality of summer rainfall. The most pronounced early summer drought during the Madison diary period is presented as a case study. This 1792 drought occurs during one of the strongest El Niño events on record and is highlighted in the correspondence of James Madison.

GC21A-04 0925h INVITED
Spanish historical sources to reconstruct
climate in the Americas during the
XIXth Century

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The Spanish colonization of the Americas expanded since the beginning of the XVIIth century until the beginning of the XIXth century, when most of the colonies became independent. During this period, a large amount of documentary information was produced, due to the fact that the Spanish Empire was highly centralized and bureaucracy was one of its core elements. Most of these documents are well preserved either in local archives in the Americas or in the Archivo General de Indias in Sevilla, which keeps thousands of bundles relative to any relevant aspect of the ordinary life of the colonies. Different projects are now searching climatic information in this archive with very encouraging results. During the XIXth century Spain kept two colonies in the Americas: Cuba and Puerto Rico, which became independent in 1898. This has allowed that a lot of information survived in Spanish Archives for this period. After a preliminary inspection of different Spanish Archives: Archivo General de Indias, Archivo del Museo Naval and Archivo Historico Nacional (General Archive of Indies, Archive of the Naval Museum and National Historic Archive), it has been possible to identify two main areas of climatic interest: 1) information from ship logbooks connecting Spain with Cuba and Puerto Rico and 2) reports about hurricanes. The information contained in the ship logbooks is very rich and could help to better characterize elements of the large-scale circulation in the Atlantic; the reports on hurricanes can be very detailed and were elaborated by very skilled personnel. The presentation will provide different examples of the potential of these sources and describe different Spanish projects involved in the abstraction of this type of data.

GC21A-05 0945h
Atlantic Hurricane Activity: 1851-1900

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This presentation reports on the second year's work of a three year project to re-analyze the North Atlantic hurricane database (or HURDAT). The original database of six-hourly positions and intensities were put together in the 1960s in support of the Apollo space program to help provide statistical track forecast guidance. In the intervening years, this database - which is now freely and easily accessible on the Internet from the National Hurricane Center's (NHC's) Webpage - has been utilized for a wide variety of uses: climatic change studies, seasonal forecasting, risk assessment for county emergency managers, analysis of potential losses for insurance and business interests, intensity forecasting techniques and verification of official and various model predictions of track and intensity. Unfortunately, HURDAT was not designed with all of these uses in mind when it was first put together and not all of them may be appropriate given its original motivation.

One problem with HURDAT is that there are numerous systematic as well as some random errors in the database which need correction. Additionally, analysis techniques have changed over the years at NHC as our understanding of tropical cyclones has developed, leading to biases in the historical database that have not been addressed. Another difficulty in applying the hurricane database to studies concerned with landfalling events is the lack exact location, time and intensity at hurricane landfall. Finally, recent efforts into uncovering undocumented historical hurricanes in the late 1800s and early 1900s led by Jose Fernandez-Partagas have greatly increased our knowledge of these past events, which are not yet incorporated into the HURDAT database.

Because of all of these issues, a re-analysis of the Atlantic hurricane database is being attempted that will be completed in three years. As part of the re-analyses, three files will be made available:

* The revised Atlantic HURDAT (with six hourly intensities & positions)

** HURDAT meta-file: A text file with detailed information about each suggested change proposed in the revised HURDAT.

*** A "center fix" file: This file is composed of actual observations of tropical cyclone positions and intensity estimates from the following platforms: aircraft, satellite, radar, and synoptic.

All changes made to HURDAT will be approved by a NHC Committee as this database is one that is officially maintained by them.

At the conference, results will be shown including a revised climatology of U.S. hurricane strikes back to 1851.

URL: <http://www.aoml.noaa.gov/hrd/hurdat/index.html>

GC21A-06 1020h INVITED
Climate Reconstruction Using
"Pseudoproxies"

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We test the performance of proxy-based climate reconstruction methods using sets of synthetic proxy climate indicators. The "Pseudoproxies" are constructed through the degradation of instrumental surface temperature data by additive noise with variable statistical properties. Experiments are performed using pseudoproxy networks of varying spatial and seasonal representation and with varying noise attributes. Implications for sampling strategies for improved paleoclimate reconstructions are discussed.

GC21A-07 1040h
Constraints From the Instrumental and
Paleo Data on 19th Century Climate

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Release 1c of the Comprehensive Ocean Atmosphere Data Set, which was produced earlier this year, pushes compilations of marine observations from the ship reports back to 1800. The 19th century exhibits dramatic changes in the marine data availability, from on the order of 1000 reports per year in the first two decades to a quarter of million reports per year at the close of the

century. We apply the reduced space objective analysis technique to reconstruct near-global 19th century fields of sea surface temperature, sea level pressure and surface winds with spatial resolution of 4 degrees and monthly or annual temporal resolution. The quality of reconstructions changes significantly with the amount of available data. The reconstructions are validated by the climate variability inferred from land station measurements and by comparison with historical chronologies of prominent climatic events, like El Niño. Instrumental reconstructions are intercompared with the networks of paleoclimatic proxies (coral $\delta^{18}O$ and tree-ring width records). We discuss differences between the trends and dominant covariance patterns derived from the paleo and instrumental data for the 19th vs 20th centuries and attempt to distinguish between data problems and the violation of the assumption of stationarity for means and covariances that is intrinsic for the reconstruction technique. Error estimates derived for the instrumental and paleo data are employed to determine how these data should be combined to produce objectively reconstructed fields.

GC21A-08 1055h

Reconstruction deconstruction: Toward better paleoclimatic estimates

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Paleoclimatic reconstructions suggest significant changes in 19th century oceanographic and atmospheric conditions relative to those of the past century. Are these changes interpretable as climate variability, or do they represent changes in nature of the proxy itself? To address the question we report intercomparisons of proxy data with instrumental data, as well as intercomparisons of proxy reconstructions with each other. Intercomparison of published ENSO indices based on instrumental and proxy data suggests that tree-ring, coral and other high resolution proxy data each have distinct frequency response functions. The spectra of these indices in turn are distinct from spectra of historical observations. Further intercomparisons among proxy indices of ENSO and midlatitude climate variability over the 19th and 20th centuries show that coherencies within biennial, interannual, decadal and secular components vary over time. Interannual and decadal components are generally most coherent, with secular and biennial components least coherent between proxies. The results are an important ingredient in production of objective reconstructions and realistic observational error estimates from blends of instrumental and proxy observations.

GC21A-09 1110h INVITED

Is 20th Century ENSO Activity Unusual? A View From 19th Century Corals and Tree-Rings

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Our view of ENSO from the instrumental record is largely confined to the last half of the 20th century, but records from corals and tree-rings are beginning to provide histories of ENSO and its teleconnections from earlier periods. Here we use corals from the tropical Indo-Pacific and drought-sensitive tree-ring data from the continental U.S. to evaluate ENSO variability in the 19th century. Coral records from the central Pacific, available only since 1840, show clearly that the mid-late 19th century was characterized by decadal, rather than interannual variability. The pattern of decadal variability in tropical Indo-Pacific corals supports the inference that this variance is related to broad-scale ENSO variability, as do drought reconstructions from the southwest U.S. Particularly significant are multi-year (6-8 yr) La Niña events in 1855-1863 and 1879-1888. In the former case, La Niña coincides with extensive and prolonged drought in the U.S. The lack

of a strong drought response in the latter case can be explained by North Pacific changes and reinforces the need for caution in inferring ENSO variability from regions outside the tropical Pacific. Drought-sensitive tree-ring records identify another prolonged La Niña in the early 19th century (1818-1824). Coral records confirm that decadal variability in the Indo-Pacific was stronger in the 19th than in the 20th century. To evaluate the full 19th century ENSO history, we develop new, independent indices of ENSO from ENSO-sensitive tree-ring and coral records. Individual ENSO extreme events are identifiable in these indices. Based on these new indices and on comparisons with existing ENSO reconstructions, a composite index of 19th century ENSO activity is proposed.

GC21A-10 1125h

On the Secular Trend in Snow Accumulation from the Mount Logan Ice Core

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We present an analysis of a 250 year long annually resolved record of snow accumulation from a high altitude site on Mount Logan in the Yukon Territory of Canada. Previous work has shown that the snow accumulation time series exhibits a statistically significant correlation with indices of ENSO activity. In addition, snow accumulation at the site is associated with anomalies in both the tropospheric and land temperatures over Northwestern North America. Over the 250 years of the time series, annual snow accumulation at the site has increased by approximately 15%. Using a variety of statistical tests, we show that this secular trend is highly significant especially during the period from 1800 onwards. We will discuss the implications that this secular trend has on variability in ENSO activity and on trends in surface and tropospheric temperatures since 1800.

GC21A-11 1140h

Sea ice in the Baltic and Barents Seas in Relation to Large-Scale Atmospheric Circulation Patterns and Oceanic Productivity

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The past record of sea ice conditions in the Baltic and Barents Seas has been studied extensively using historical records, and extends back to 1715 and 1864 respectively. We have collected and chemically analysed an ice core from Lomonosovfonna, Svalbard, that also spans this period at close to annual resolution. Using singular spectrum analysis we have been able to identify several periodicities in the sea ice extent series that are also seen in the indices of large scale atmospheric circulation patterns such as the North Atlantic Oscillation. We are able to track the changes in amplitude of the various periodicities over time. Methansulfonic acid (MSA) is a tracer of marine biological productivity, which depends to a large degree on the sea ice cover. The ice core data shows that a significant change in MSA occurred in 1920, with the earlier period having higher concentrations than the later period. There is also a change in the phase of the MSA variations relative to those in sea ice extent around Svalbard. The 1920's marked the maximum extent of glaciers in Svalbard, and the largest rise in Svalbard air temperature occurred in 1917, there was also a dramatic reduction in ice coverage in the sea to the west of Svalbard. In the

Baltic record we also see a change in character of the ice coverage, that also corresponds to a change in the North Atlantic Oscillation index. The re-organization of sea ice cover in the Barents Sea is closely associated with a change in the position of the Icelandic low pressure cell which affects the winter storm tracks across the Atlantic, leading to a change in the Baltic Sea ice conditions.

GC22A MC: Hall D Tuesday 1330h

Reconstructions of Nineteenth Century Climate II (joint with A, B, H, OS, V, PP, PA)

Presiding: C Woodhouse, NOAA; H Diaz, NOAA/ERL

GC22A-0270 1330h POSTER

A Probability Model for Analyzing Regime Shifts Over Time

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Graphical and numerical techniques exist to represent the duration, magnitude, and intensity of climatic events. We have now developed statistical decision and limit methodologies for quantifying time series fluctuations and regime shifts. Here we analyze a reconstructed annual index of the Pacific Decadal Oscillation (PDO) by fitting parametric models to represent the duration and magnitude of climatic episodes. Duration is defined as the number of consecutive years PDO is above or below its overall median, and magnitude is the sum of PDO index values for any given duration. Our parametric model admits a natural interpretation and can be easily applied to many time series data sets. Assuming that a regime shift can occur every year, independently of prior years, with some small probability, we naturally obtain a class of standard waiting time distributions (waiting times for the regime shift). Because magnitude can be expressed as a random sum of N random variables (where N is the duration of the episode), its probability distribution can be approximated by a limiting distribution for random sums. We explicitly describe these distributions, and estimate their parameters from the PDO data obtaining a reasonably good fit. Given these statistical models for duration and magnitude of climatic episodes, we can now compute climatological probabilities, such as the likelihood of magnitude exceeding any given value. These models also enable us to quantify the statistical significance of any climatic episode, and help us decide whether two episodes are significantly different from one another.

GC22A-0271 1330h POSTER

Recent warming in northwestern Ontario, Canada, inferred from borehole temperature profiles

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We have inverted temperature depth profiles measured in drillholes to infer the recent changes in ground surface temperature for northwestern Ontario. A total of 45 temperature profiles are available for the region north and northwest of Lake Superior. Most of these temperature profiles are 600m or deeper. Some of these profiles have been eliminated because of known non climatic perturbations (lakes, topography, clear signs of ground water circulation). The remaining profiles were inverted individually; all the profiles from the same site were inverted jointly, and finally all the profiles with the same depth range were inverted simultaneously. The inversions consistently show a recent (1-2K) warming of the ground surface. This trend is similar to that inferred from the interpretation of some 10 temperature-depth profiles from northern Manitoba and Saskatchewan. However, there is no indication that a cold episode preceding the warming of the past 200 years, such as inferred in Manitoba and Saskatchewan, also occurred in northwestern Ontario.