18.14 MONITORING THE HEALTH OF WEATHER AND CLIMATE OBSERVING NETWORKS

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1. INTRODUCTION

The 1997 Conference on the World Climate Research Programme to the Third Conference of the Parties of the United Nations Framework Convention on Climate Change concluded that the ability to monitor the global climate was inadequate and deteriorating. Consequently, the National Research Council (NRC) undertook an assessment of U.S. climate observing capacity. The NRC recommended that a system of network performance measures be developed and monitored on a regular basis to avoid the discovery of observing network problems years after their occurrence (during, for example, a major environmental assessment). The NRC further recommended that an institutional infrastructure be developed to assess the quality of data sets operationally. Such an infrastructure would facilitate the correction of problems as they occur and help avoid long-term negative impacts to the climate record.

To address the NRC recommendations, a project known informally as the Health of the Networks was established at NOAA's National Climatic Data Center. Currently, the performance or "health" of three observing networks is monitored using a variety of performance indicators. Although the list of calculated indicators varies from network to network, special attention is paid to changes in baseline performance and, where possible, to the detection of undocumented changes. Here we provide a brief description of the various performance measures. A simple framework permitting feedback between the monitoring system and network managers also is discussed.

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2. HEALTH OF THE NETWORKS PERFORMANCE MEASURES

The three networks that have been incorporated into the monitoring project thus far include the National Weather Service's Cooperative Observer (Coop) Network, NOAA's Climate Reference Network and the Global Climate Observing System (GCOS) Upper Air Network. Routine monitoring of the relatively straight forward performance measures such as data completeness and some measure of data quality is provided for each network. Data completeness is calculated as total number of observations relative to the expected value while data quality is calculated with respect to the total that passes data review algorithms. Some additional details specific to each network are provided below.

2.1 *NOAA/National Weather Service Cooperative Observer (Coop) Network*

A number of Coop network reports are generated each new data month in order to assist station field managers in addressing network problems in a timely manner. Cooperative data completeness and data quality reports are generated after final processing of the paper observer forms at NCDC. Each report is summarized by National Weather Service (NWS) region, Regional Climate Center (RCC) region, and by state or Weather Forecast Office (WFO) County Warning Area. Only those stations whose observations are less than 80% complete are listed on the NWS and RCC reports. All stations are listed on state reports, but those stations with less than 80% completeness are highlighted in red. Likewise stations whose observations include 8 or more days with apparent errors are listed on the NWS and RCC data quality reports and are flagged in red on the state reports.

A Coop station watch list is generated each data month that includes stations whose monthly data contain an apparent undocumented, and presumably artificial, change point. Although both documented and undocumented changes may be identified and reported, the Coop station watch list is comprised of stations with observation changes detected in the most recent 12 months that do not have a corresponding station history (metadata) record within 6 months of the apparent change date.

Watch list reports are summarized by NWS Region and are intended to provide early warning of possible problems at a station and to ensure that all planned practice changes are recorded in the metadata archives.

To detect undocumented changes, three different test statistics are calculated. A difference series formed between the target location temperature series and its composite reference is evaluated for abrupt changes using the three tests. Identification of a change point occurs when two of the three tests reject the null hypothesis of no change point on or near the same date as described in Menne and Williams, 2004. The approach to change point testing on serial monthly data can be found in Menne and Duchon (2002).

Figure 1 provides an example of a station whose monthly maximum temperature data contain two apparent artificial change points, one in 1998 and the other in 2002. The change in 1998 occurs near the time of multiple observation practice changes and would not cause the station to appear on the watch list. The change in 2002, however, is undocumented and thus would warrant entry on the watch list and some investigation into its cause by personnel at the local NWS Field Office.

2.2 *NOAA's Climate Reference Network*

Network monitoring has been integral to the Climate Reference Network (CRN) since its earliest planning stages. To insure high standards of network performance, redundant observations of temperature and precipitation are part of each station configuration. Daily monitoring therefore includes not only an inventory of data element receipt, but also a comparison between the various redundant measurements at each site for quality assurance purposes. All maintenance activities, routine or otherwise, are logged into the station history archives. Daily CRN check list and element availability reports, among others, are available via the Health of the CRN Network web page: www.ncdc.noaa.gov/oa/hofn/crn/crn-opt.html.

2.3 *GCOS Upper Air Network (GUAN)*

GUAN station data completeness is computed as the percentage of reported observations at each mandatory level relative to the total number of possible sounding days in each data month. The 00 and 12 UTC standard reporting times are summarized separately. Soundings taken within 2 hours of the nominal reporting times are counted. Separate calculations are provided for each of five sounding parameters: geopotential height; temperature; dew point depression; wind speed; and wind direction. In addition, percent completeness is provided relative to those cases when all parameters were available at a given mandatory level as well as for cases where at least one parameter was available.

As a simple measure of data quality, parameter completeness percentages are calculated using both Level 1 (pre-QC) and Level 2 (post-QC) values. Level 1 data is nearly raw having been subject to minimal pre-processing that includes the removal of duplicates. Level 2 data has passed through a series of quality assurance algorithms, which remove suspect values (Durre et al., 2004). Any reduction in completeness between Level 1 and Level 2 data would be a measure of data quality.

3. REPORTING AND FEEDBACK SYSTEM

A web-based reporting system is provided for each network which allows access to the network monitoring reports. Geographic Information System (GIS) mapping applications also are used to facilitate access to reporting and graphing options and can serve as an entry point to the system. The Interactive Data Language (IDL) and JFreeChart and Java servlets are used to generate summary graphs based upon user input. In addition, station histories are accessible via the map interface or through the various station reports. Oracle® 9i with the spatial component is used to manage the data and ESRI's ArcSDE™ and ArcIMS™ are used for visual display. In the case of the Coop Network, monitoring reports are distributed to NWS regional offices as well as the RCC offices via e-mail.

In Figure 2, a period of record data completeness summary graph is shown for a data element from one of the GUAN stations. The station was selected using the map-based entry point for the Health of the GUAN. The element (500 hPa temperatures for the 00 UTC observations) was selected on the graphing options page that was accessed as a link from the map interface. In this case, the percent complete is calculated with respect to the data that passed the data review evaluations.

4. CONCLUSION

The Health of the Networks monitoring page can be accessed from NCDC's home page (www.ncdc.noaa.gov) by selecting the monitoring link under "Climate Info" or by going directly to www.ncdc.noaa.gov/oa/hofn. At present, user feedback for all network monitoring can be sent to the Health of the Networks e-mail address: NCDC.Network.Performance@noaa.gov. Feedback on the performance summaries is welcome and will be used to improve and streamline the reporting system. A web-based user reporting and tracking system is under development. Additional networks will be included at the rate of roughly two per annum.

5. REFERENCES

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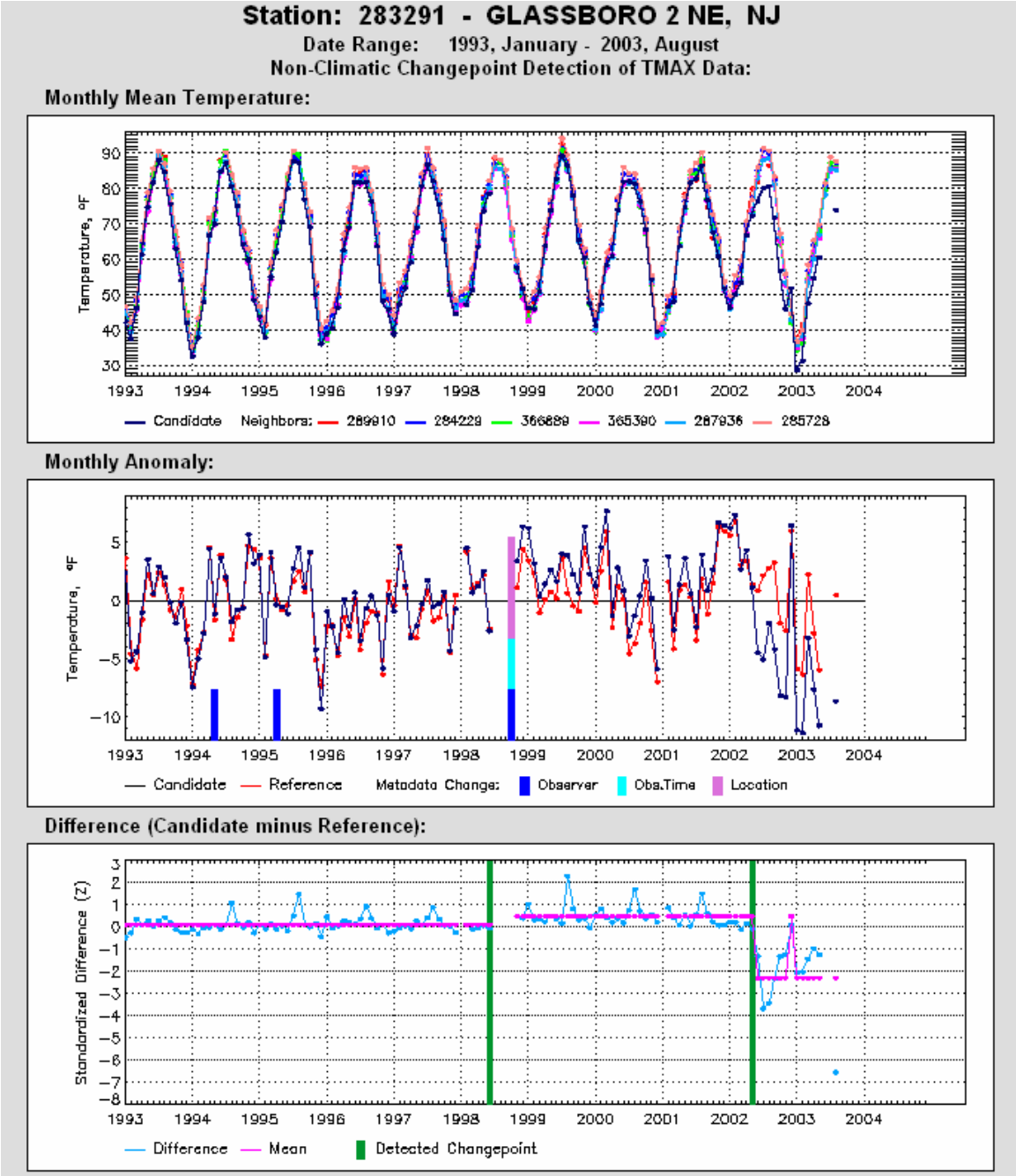

Figure 1. Example of interactive Health of the Coop Network web page display showing: top panel--monthly mean maximum temperatures from the target (candidate) station and from six nearby stations; middle panel--monthly temperature anomalies for the candidate and a composite reference series formed using the temperature series from neighboring stations; and, bottom panel--the standardized difference between the candidate series and the composite reference. Change points are indicated by the green bars in the lower panel and point to the last date of the former level. Station history changes are indicated in the middle panel by the vertical bars.

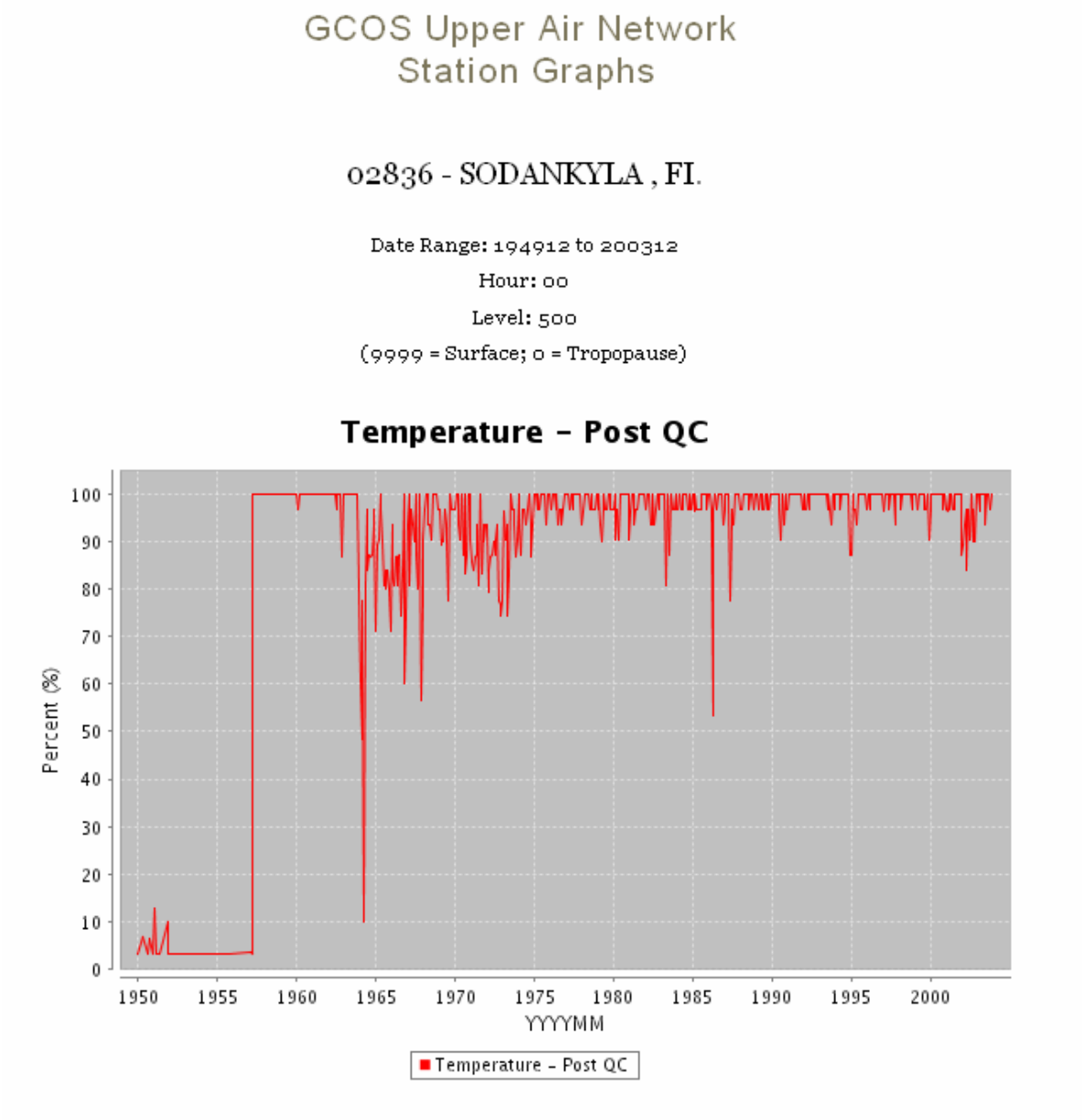

Figure 2. Example of a data completeness graph for a GUAN station – Temperature completeness after Quality Control for the 500 hPa level for the period of record ending 200312.