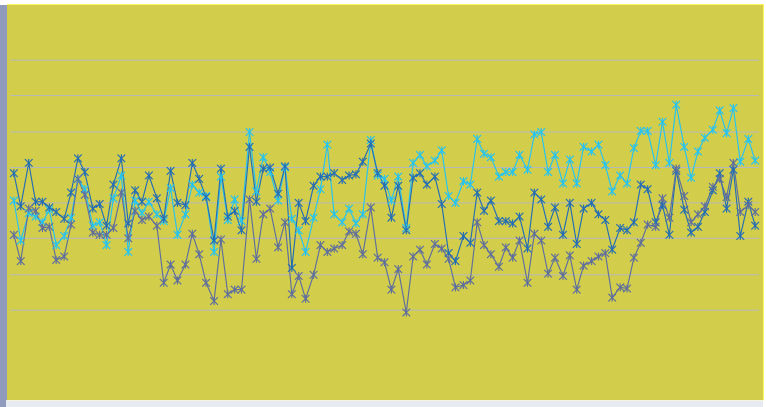

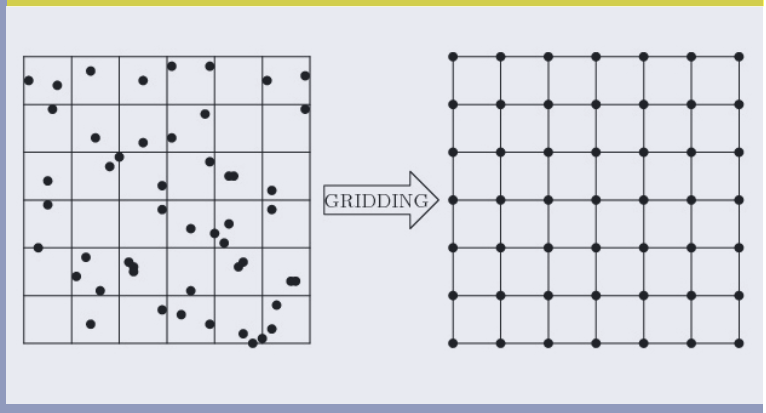

8TH SEMINAR FOR HOMOGENIZATION AND QUALITY CONTROL IN CLIMATOLOGICAL DATABASES AND 3RD CONFERENCE ON SPATIAL INTERPOLATION TECHNIQUES IN CLIMATOLOGY AND METEOROLOGY

BUDAPEST, HUNGARY
12 – 16 May 2014

8TH SEMINAR FOR HOMOGENIZATION AND QUALITY CONTROL IN CLIMATOLOGICAL DATABASES
3RD CONFERENCE ON SPATIAL INTERPOLATION TECHNIQUES IN CLIMATOLOGY AND METEOROLOGY

Organized by the Hungarian Meteorological Service
Supported by WMO

OMSZ

World Meteorological Organization
Weather · Climate · Water

PROGRAMME

Budapest, Hungary
12-16 May 2014

Venue:
The Headquarters of the Hungarian Meteorological Service (1 Kitaibel Pál street, Budapest)

Homogenization sessions: 12 May Monday-14 May Wednesday
Interpolation session: 15 May Thursday
Software session: 16 May Friday
EUMETNET DARE (Data Recovery and Rescue) Team on 13 May Tuesday afternoon

MONDAY, 12 MAY

8:30 – 9:00 Registration

9:00 – 12:00
Opening addresses by
President of OMSZ
Delegate of WMO
Organizers

Introductory Presentations
Hechler, P., Baddour, O.: Elements of sustained data management solutions for climate

10:00 – 10:30 coffee break

Szentimrey, T., Lakatos, M., Bihari, Z.: Mathematical questions of homogenization and quality control

Lindau, R., Venema, V.: On the reliability of using the maximum explained variance as criterion for optimum segmentations in homogenization algorithms

12:00 – 14:00 Lunch break

14:00 – 17:00 Homogenization and quality control of monthly data

Coll, J., Curley, M., Walsh, S., Sweeney, J.: Homogenising Ireland's monthly precipitation records - an application of HOME-R and statistical exploration protocols to the station network

Curley, M., Walsh, S.: Homogenisation of Monthly Maximum and Minimum Air Temperatures in Ireland

Dubuisson, B., Gibelin, A-L., Jourdain, S., Deaux, N., Laval, L.: Reliable long term series for analysing climate change at Météo-France

15:30 – 16:00 coffee break

Domonkos, P.: The ACMANT2 software package

Yosef, Y.: Homogenization of monthly temperature series in Israel - an integrated approach for optimal break-points detection

18:00 – Welcome party
(Hungarian Meteorological Service, 1 Kitaibel Pál street, Budapest)

TUESDAY, 13 MAY

9:00 – 12:30 Homogenization and quality control of monthly data

Willett, K., Venema, V., Williams, C., Aguilar, E., Lopardo, G., Jolliffe, I., Alexander, L., Vincent, L., Lund, R., Menne, M., Thorne, P., Auchmann, R., Warren, R., Bronnimann, S., Thorarinsdottir, T., Easterbrook, S., Gallagher, C.: Homogenisation algorithm skill testing with synthetic global benchmarks for the International Surface Temperature Initiative

Luhunga, P., M., Mutayoba, M., Ng'ongolo, H., K.: Homogeneity of monthly mean air temperature of the United Republic of Tanzania with HOMER

Zahradníček, P., Rasol, D., Cindrić, K., Štěpánek, P.: Homogenization of monthly precipitation time series in Croatia

10:30 – 11:00 coffee break

Lijuan, C., Ping, Z., Zhongwei, Y., Jones, P., Yani, Z., Yu, Y., Guoli, T.: Instrumental Temperature Series in Eastern and Central China Back to the 19th Century

Dunn, R.: Identifying Homogeneous sub-periods in HadISD

Elfadli, K., Brunet, M.: The WMO/MEDARE Initiative: bringing and developing high-quality historical Mediterranean climate datasets into the 21st century

12:30 – 14:00 Lunch break

14:00 – 17:00 EUMETNET DARE (Data Recovery and Rescue) Expert Team meeting (open for everybody)

15:30 – 16:00 coffee break

WEDNESDAY, 14 MAY

9:00 – 12:00 Homogenization and quality control of monthly data

Tayyar, A.: Climate data in Jordan

Djamel, B.: Homogenization of the pluviometric series and the climatic variability in the Northeast region of Algeria

Casabella, N., González-Rouco, J., F., Navarro, J., Hidalgo, A., Lucio-Eceiza, E., E., Conte, J., L., Aguilar, E.: Homogeneity of monthly wind speed time series in the Northeast of the Iberian Peninsula

10:30 – 11:00 coffee break

Guijarro, J., A.: Homogenization of Spanish mean wind speed monthly series

Lucio-Eceiza, E., E., González-Rouco, J., F., Navarro, J., Hidalgo, Á., Jiménez, P., A., García-Bustamante, E., Casabella, N., Conte, J., Beltrami, H.: Quality control of a surface wind observations database for north eastern north America

12:00 – 13:30 Lunch break

13:30 – 16:30 Homogenization and quality control of daily data

Legg, T.: Comparison of daily sunshine duration recorded by Campbell-Stokes and Kipp & Zonen sensors

Venema, V., Aguilar, E., Auchmann, R., Auer, I., Brandsma, T., Chimani, B., Gilabert, A., Mestre, O., Toreti, A., Vertacnik, G., Domonkos, P.: Inhomogeneities in daily data

Acquaotta F., Fratianni, S., Venema, V.: Comparison study of two independent precipitation networks on daily and monthly scale in Piedmont, Italy

15:00 – 15:30 coffee break

Warren, R.: Benchmarking the Performance of Daily Temperature Homogenisation Algorithms

Yuan, F., Tang, G., Wang, X., L., Wan, H., Lijuan, C.: Quality Control and Homogenization of China's 6-hourly Surface Pressure Data

19:00 – Seminar banquet
(Venue: Hungarian Meteorological Service, 1 Kitaibel Pál street, Budapest; 19:00)
(Location of the restaurant: Kaltenberg Étterem, Kinizsi street 30-36, Budapest; 19:30)

THURSDAY, 15 MAY

9:00 – 12:00 Spatial Interpolation, Homogenization and Gridding

Szentimrey, T., Bihari, Z., Lakatos, M.: Mathematical questions of spatial interpolation of climate variables

Bertrand, C.: Creation of a 30 years-long high resolution homogenized solar radiation data set over the Benelux

Journée, M.: Gridding of precipitation and air temperature observations in Belgium

10:30 – 11:00 coffee break

Wypych, A., Ustrnul, Z., Henek, E.: Meteorological hazard maps – methodological approach

Petrović, P., Simić, G., Kordić, I.: Practical Aspects of Raw, Homogenized and Gridded Daily Precipitation Datasets

12:00 – 14:00 Lunch break

14:00 – 17:00 Presentations connected with CARPATCLIM project

Skrynyk, O., Savchenko, V., Radchenko, R., Skrynyk, O.: Homogenization of monthly air temperature and monthly precipitation sum data sets collected in Ukraine

Birsan, M-V., Dumitrescu, A.: Homogenization and gridding of the Romanian climatic dataset using the MASH and MISH software packages

Szalai, S., Bihari, Z., Lakatos, M., Szentimrey, T.: The CARPATCLIM (Climate of Carpathian Region) project

15:30 – 16:00 coffee break

Lakatos, M., Szentimrey, T., Bihari, Z., Szalai, S.: Homogenization in CARPATCLIM (Climate of Carpathian Region) project

Bihari, Z., Szentimrey, T., Lakatos, M., Szalai, S.: Gridding in CARPATCLIM (Climate of Carpathian Region) project

FRIDAY, 16 MAY

9:00 – 12:00 Software Presentations

Szentimrey, T.: Software MASH (Multiple Analysis of Series for Homogenization)

Stepanek, P.: Software AnClim for tutorial of statistical methods in climatology, including homogenization and ProClimDB for processing of climatological datasets

10:20 – 10:50 coffee break

Domonkos, P.: Software ACMANT2

Szentimrey, T.: Software MISH (Meteorological Interpolation based on Surface Homogenized Data Basis)

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LIST OF POSTERS

Filipiak, J.: Reconstruction of air pressure series in Gdansk, 1739-2010

Legg, T.: Using uncertainty analysis to inform digitisation plans to improve and extend the UK climate series

Péliné Németh, Cs., Szentimrey, T., Bartholy, J., Pongrácz, R., Radics, K.: Homogenization of Hungarian daily wind speed time series using MASH procedure

CANCELLED PRESENTATIONS

Badi, W., Elrhaz, K., Driouech, F.: Homogeneity study for Moroccan precipitation data using two-phase regression method

Kolokythas K. V., Argiriou A. A.: Applying three different methods for the homogenization of a dataset of mean monthly temperature and precipitation time series

Monjo, R., Pórtoles, J., Ribalaygua, J.: Absolute and relative homogeneity test for daily data using KS test

Zhang, H-M., Wuertz, D., Lawrimore, J., Gleason, B., Huang, B., Menne, M., Williams, C.: An Analysis on the Impact of Data Gaps and Gap Fillings on Global Surface Temperature Trends

ABSTRACTS

COMPARISON STUDY OF TWO INDEPENDENT PRECIPITATION NETWORKS ON DAILY AND MONTHLY SCALE IN PIEDMONT, ITALY

Acquaotta[1] F., S. Fratianni[1] and V. Venema[2]
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Long historical climate records typically contain inhomogeneities. Parallel measurements are ideal to study such non-climatic changes. In this study we will analyse the transition from conventional precipitation observations to automatic weather stations. The dataset comes from two independent climate networks in the region of Piedmont, Italy. From this dataset we could identify 20 pairs of stations with up to 15 years of overlap (1986-2003). This is a valuable dataset because it allows us to study an ensemble of independently managed pairs of standard-quality stations.

We have evaluated the effects of the differences between the two Networks on the climate analysis. An accurate statistical analysis to identify if the two series have the same statistical characteristics, same distribution, same mean, median, variance and so on, have been conducted. We have calculated for every month and for every location the precipitation class using the percentiles. We have divided the rain event in four principles class (weak, moderate, heavy and extreme) and, for each one, we have calculated the number of events and the amount of rain and then we have compared the results between the two meteorological stations. For the weak precipitation the major difference is estimated in the number of events and this divergence overestimates or underestimates the dry periods. For the moderate precipitation the major differences are in the amount of precipitation and in the number of events. This class seems influenced by other climatological elements for example the wind and snow and this require an accurate study to estimate the correction factors. For the heavy and extreme precipitation we have not identified great differences between the two series that falsify the behavior of the variables.

Key words: precipitation, parallel measurements, inhomogeneities, extreme events

HOMOGENEITY STUDY FOR MOROCCAN PRECIPITATION DATA USING TWO-PHASE REGRESSION METHOD

Wafae Badi, Khalid Elrhaz, Fatima Driouech
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The aim of this work is to control data quality and test the homogeneity of for precipitation data of 20 Moroccan stations with two-phase regression model with a linear trend for the entire base series (Wang, 2003). The stations used cover all the climatic regions in Morocco according to the regionalization done by El Hamly et al. 1997 and have at least 30 years period. Quality control and inhomogeneity detection are done using dedicated procedures in RClimDex software and RHtestV3 which are developed with R language and are freely available from the ETCCDMI (Expert Team on Climate Change Detection, Monitoring and Indices) website (http://etccdi.pacificclimate.org/software.shtml). RHtestV3 is capable to identify multiple step changes at documented or undocumented change points. As precipitation series are typically non-Gaussian, a log-transformation is used (Wang and Feng 2010). The QC procedure shows no outliers in precipitations series for the whole stations. Change points detected with test of homogeneity, are checked against history station metadata. Homogeneity test exhibits 15 stations data out of 20 are homogenous. Regarding the remaining five stations, three shifts in 3 stations series (Agadir, Fes and Ifrane stations) are located between 2008 and 2009 and are not related to instrumentation change but are easily justified by the climate conditions (very wet season, strong negative NAO, several cyclones southward …). Therefore, these shifts are natural and the whole stations data was kept. Whereas in the two stations (Midelt and Safi), jumps are not documented (and the series after this change point still have more than 30 years. So, only periods after discontinuities were retained (Zhang et al. 2005).

CREATION OF A 30 YEARS-LONG HIGH RESOLUTION HOMOGENIZED SOLAR RADIATION DATA SET OVER THE BENELUX

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To characterize the solar radiation in the Benelux countries, a high resolution (0.03° x 0.03°) gridded data set of monthly mean daily cumulated global horizontal solar radiation has been generated at the Royal meteorological institute of Belgium by combining both in-situ measurements and Meteosat-derived global solar surface irradiance estimations. The data set covers a time period of 30 years (1983 to 2012) including therefore two different generations of Meteosat satellites. Because changes in instrumentation may insert artificial shifts in both measured and satellite-derived time series, the detection and correction of inhomogeneities in the climate series is of paramount importance for avoiding misleading conclusions in solar resources assessment. A two steps procedure was implemented to homogenize the new solar radiation data set. First, ground stations data were homogenized on a monthly time scale basis. Second, the homogenized ground stations time series were used to homogenize the satellites derived data series over the Benelux. Finally, the homogenized in-situ and satellites derived series were merged together.

GRIDDING IN CARPATCLIM (CLIMATE OF CARPATHIAN REGION) PROJECT

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The main aim of CARPATCLIM was the spatial and temporal examination of the climate of the Carpathian Region using harmonized data and standard methodology.

For ensuring the usage of largest possible station density the necessary work phases were implemented on national level with applying same methods and software. The common method for gridding of homogenized daily data series was method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis; Szentimrey and Bihari). Besides the common software, the harmonization of the results across country borders was performed also by near border data exchange.

The main steps of gridding in CARPATCLIM were as follows:

1. Spatial modelling of climate statistical parameters on national level, but using the near border data based on homogenized data series.
   - Determination of some supplementary deterministic model variables, altitude and e.g. other topographic variables (e.g. AURELHY principal components) for the station locations as well as for a half minutes (0.5'x0.5') grid that covers the given area.
   - Modelling of the statistical parameters for the above half minutes grid by use of the derived monthly station data series and the model variables.
   - Cross-border harmonization of the above parameter tables between the neighbouring countries

2. Interpolation of daily data series for a grid (gridding) by MISH on national level, but using the near border data.
   - Interpolation for the 0,1°*0,1° grid by use of the homogenized, controlled, complemented daily station data series and the tables of modelled parameters.

CARPATCLIM homepage: http://www.carpatclim-eu.org/pages/home/

HOMOGENIZATION AND GRIDDING OF THE ROMANIAN CLIMATIC DATASET USING THE MASH AND MISH SOFTWARE PACKAGES

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The development of reliable long-term meteorological data sets is of outmost importance for the assessment of past and future climate. Romania is the largest country in southeastern Europe, having the terrain fairly equally distributed between mountainous (Carpathians), hilly and lowland territories. The elevation varies from sea level to 2544 m.a.s.l., and the climate is continental-temperate with oceanic influences in the central and western parts, continental in the east and Mediterranean in the south. Due to these orographic and climatic particularities, the reliability of the homogenization and interpolation procedures are even of greater importance. This study presents the application of MASH (Multiple Analysis of Series for Homogenization) and MISH (Meteorological Interpolation based on the Surface Homogenized Data Basis) programs – developped at the Hungarian Meteorological Service – on Romanian daily meteorological time series, over the period 1961-2013. The homogenization was applied to all series with less than 25% missing data for the following parameters: precipitation, air temperature (mean, minimum, maximum), soil temperature, air pressure, relative humidity, cloud cover, sunshine hours. The method has also proven to be extremely useful for quality control, with a high detection rate of the (very few) erroneous data records. The interpolation results were verified with independent station data (i.e., the time series from stations that were not involved in the homogenization process were compared to their related grid cells series), as well as with other interpolation techniques.

HOMOGENEITY OF MONTHLY WIND SPEED TIME SERIES IN THE NORTHEAST OF THE IBERIAN PENINSULA

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Long instrumental climate records are essential for assessing century-scale trends, for the validation of climate models, as well as for the detection and attribution of climate change at global and regional scales. Most observational series of atmospheric variables suffer from inhomogeneities due to changes in instrumentation, station relocations, changes in local environment or the introduction of different observing practices. If such changes are not taken into account, they can have an impact on the assessment of long term variability with implications for the understanding of mechanisms contributing to local and regional multidecadal and centennial variability or, for instance, for model-data comparison in model verification exercises. Several studies have analyzed the homogeneity in temperature and precipitation datasets, while efforts focused on wind speed are scarce. In this work we use a dataset that comprises 738 time series of monthly wind speed recorded in weather stations located in the northeast of the Iberian Peninsula, and 14 buoys in coastal regions of Spain; the longest records spanning from 1938 to 2010. The original time resolution of these data vary from 10 minutes to 6 hours. A quality control (QC) process was previously applied to this dataset and the most important biases were corrected whenever possible. However, the QC has not addressed long term inhomogeneity problems and there could still be a number of unidentified breakpoints that make necessary an homogeneity assessment.

A subgroup of 50 series of monthly wind speed, those with more data in the period 2002-2009 and with more than 20 years of data, have been selected for the application of a semi-automated homogenization algorithm. The algorithm relies upon a pairwise comparison using the Standard Normal Homogeneity Test (SNHT). This method has been selected for this assessment because of its flexibility to work with a high number of series and its good performance in comparison with other methods. The detection and correction of inhomogeneities follows an iterative procedure to resolve multiple undocumented changepoints within a single time series. Depending on the results, the use of the algorithm could be extended to more series. The spatial and temporal occurrence of inhomogeneities will be described, as well as their impact on the analysis of long-term wind speed trends.

HOMOGENISING IRELAND'S MONTHLY PRECIPITATION RECORDS - AN APPLICATION OF HOME-R AND STATISTICAL EXPLORATION PROTOCOLS TO THE STATION NETWORK

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Our instrumental knowledge of climate change prior to the mid-19th century is heavily reliant on a few long meteorological series, mostly from Europe, and even here good instrumental series longer than 150 years are rare. However, climate change studies based only on raw long-term data are potentially flawed due to the many breaks introduced from non-climatic sources, consequently accurate climate data is an essential prerequisite for basing climate related decision making on. Careful quality control (QC) therefore has to be undertaken prior to any data analysis in order to eliminate any erroneous values and to identify the extent of missing values in time series.

Ireland has a good repository of long instrumental series, e.g. daily meteorological data have been recorded at Armagh Observatory since July 1795. Elsewhere there are long records from the late 1800s at Birr, Malin Head and Valentia Observatory e.g. However, for many locations, the quality and extent of the station records are more variable. Therefore preliminary efforts have involved an audit and QC to establish the extent of the station records for the ~1902 monthly precipitation station records in the Met Éireann database, and systematically documenting for each station series the extent of missing monthly values.

The initial sort criteria was to identify all stations with a contiguous monthly record exceeding ~20 years, this identified a subset of 1046 station records requiring further scrutiny. Based on this further QC, two tranches of stations with longer intact contiguous records were identified (n = 88 and n = 114) for the initial homogenisation efforts. A series of statistical and spatial exploration protocols were applied to these station series in order to identify candidate reference networks which were statistically and spatially coherent for the homogenisation phase of the work.

Currently HOME-R is being applied to the first tranche of eighty eight longer station records identified via the QC procedures. The contiguous intact monthly records for this group range from ~40 to 71 years between 1941 and 2012. Results on the reference networks and their associated correlation and geographical distances identified by the HOME-R algorithm are being compared with those derived via the earlier statistical and GIS-based routines. HOME-R is also being used alongside the metadata to homogenise the monthly precipitation records for this initial set of stations. It is anticipated that these routines will be repeated for the next set of one hundred and fourteen records in the near future as experience with the algorithm accrues and the metadata is collated.

HOMOGENISATION OF MONTHLY MAXIMUM AND MINIMUM AIR TEMPERATURES IN IRELAND

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It has been know for some time that homogenised climatological data time series are very important for all climate analysis. However until recently very little work had been done in Ireland to homogenise data series. As the aim of the COST Action HOME was to produce a standard homogenisation method which could be used by all countries, Met Éireann took the decision to wait until after the Action to commence homogenisation of their data series.

In this work HOMER along with available metadata was used to homogenise monthly maximum and minimum monthly air temperatures in Ireland for the period 1941 to 2010. Results from the study will be presented particularly the magnitudes of the breaks, the causes of the breaks, if known and whether or not a break/change has the same affect on maximum and minimum temperature.

Future work will be discussed and the experience of using HOMER software and its pros and cons will also be presented.

HOMOGENIZATION OF THE PLUVIOMETRIC SERIES AND THE CLIMATIC VARIABILITY IN THE NORTHEAST REGION OF ALGERIA

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Because Algeria is situated in the Mediterranean basin, it remains a very vulnerable region in climate change and natural disasters. The scientists consider that rains and thunderstorms as those who characterized the regions of Bab El Oued on Saturday, November 10th, 2001 and which made 1200 deaths and 180 missing persons as well as numerous wounded persons) and Ghardaia (in October 1st, 2008, 40 death) will be more and more frequent and violent and dangerous. The XXIth century will be characterized by an increase of the temperatures, of the order of 4 ° (for Algeria it and foreseen an increase of the order of 1° in 1,5° on the horizon 2020) and a decrease of the rainy seasons.

As many countries of the south shore of the Mediterranean Basin, Algeria, country with essentially semi-arid climate, is confronted with the problem of the development of the sustainable management of its water resources. The rain contributions are modest and irregular, in front of a strong and increasing request with the development of economic activities, the improvement of the living conditions, the increase of the population, and the extension of the urbanization. The problem of water resources becomes more and more worrisome. Of it comes the interest to adopt a strategy of development of the resource and the management of his request to satisfy water requirements and insure the conditions of an optimal use of this resource.

The first step to be exceeded in the studies of phenomena complex as the rain is the available analysis of data. It is important that the series of data are homogeneous, long having a more or less regular functioning and do not have to contain a big number of gaps.

To detect the existence of possible tendencies in series of raifull data, various tests can be used. To consolidate the results of the tests, we used a test not paramétrique, a test of Pettitt, in this particular case, which also presents the peculiarity to localize the moment of the break of the average within the series with a level of meaning which translates the real importance of the detect change.

THE ACMANT2 SOFTWARE PACKAGE

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ACMANT is a multiple break homogenization method that was developed during Action COST ES0601 "Advances in homogenisation methods of climate series (*HOME*)". ACMANT was developed from PRODIGE, keeping several positive features of PRODIGE, but converting it to a fully automatic method with adding new segments to the parent method. The early versions of ACMANT homogenized monthly temperature data only (ACMANT = Applied Caussinus-Mestre Algorithm for homogenizing Networks of Temperature series).

A very early version of ACMANT (ACMANT0) was tested in the blind experiments of HOME, and the residual RMSE was one of the lowest among the participating methods even with that initial version. The development of ACMANT was continued after the blind tests, and the later versions (ACMANT1 and ACMANT2) have significantly higher efficiency than the initial one in the reproduction of climatic trends and in the identification and correction of short-term biases. The full description of ACMANT1 was published in an open electronic journal meanwhile several test experiments were published in conference issues.

In 2013, ACMANT2 software package was constructed. This package has specific computational programs for homogenizing a) daily maximum or daily mean temperatures in mid-to-high latitudes, b) daily minimum temperatures, as well as daily maximum and daily mean temperatures in tropical and monsoonal regions c) precipitation totals. The ACMANT2 software package contains different programs for treating daily or monthly input datasets of any of the mentioned climatic variables. The homogenization is always performed in annual and monthly timescales, but the homogenization results are downscaled to the daily data when the input consists of daily data. All the programs provide automatic homogenization of the chosen climatic variable. The software package and the manual for its use are freely available in web.

ACMANT is a relative homogenization method, its use needs at least 4 time series of a climatic region, preferably with at least 4 spatially comparable values for each month of the period examined. However, individual time series may cover different sections of the period examined, are allowed to contain high ratio of missing data and there is no need of homogeneous reference series.

Although ACMANT is a highly efficient and easy-to-use homogenization method, it is hardly known for climatologists yet. Therefore the goal of this presentation is to make ACMANT2 to be better known, first within the homogenization community, and secondly for the wider climatic community with making other publications. In this presentation the author will

a) present the main characteristics of the computational programs included in ACMANT2 software package and tell the principal rules of the practical application;
b) present the most important characteristics, which facilitate high efficiency for ACMANT2;
c) clarify the relation of ACMANT to HOMER
d) reiterate some experimental evidence of high efficiency of ACMANT;

mention some limitations and possible problems in the use of ACMANT2 software package.

RELIABLE LONG TERM SERIES FOR ANALYSING CLIMATE CHANGE AT MÉTÉO-FRANCE

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Climate change analysis requires reliable long term series. The first step to produce such series of climate data is the Data Rescue. It includes searching documents, saving the archives, inventorying the data, selecting useful set of data and metadata, digitising documents and data, and controlling the data. The second step is to homogenize the series, in order to detect and correct the biases due to changes in measurement conditions.

Since 2010, Meteo-France Direction of Climatology has undertaken the homogenization of monthly minimum and maximum temperature and precipitation series over France, associated with a major effort of data rescue. The objective is to get monthly homogenized series covering France, with the highest spatial density and the best quality available, for a period starting in the fifties.

The series are homogenized using HOMER on climatic homogeneous areas. Metéo-France has now a complete set of around 230 monthly homogenized temperature series covering the whole territory. The process is still under way; precipitation series will be available at the end of 2014. In the future, these homogenized series will be regularly updated, the raw series being able to contain inhomogeneities over the recent years.

The first analysis covers the 1959-2009 period, that is the common period for all the available series. The mean trend over this 1959-2009 period is around 0.29°C/decade for minimum temperature and 0.32°C/decade for maximum temperature.

To get information on extremes, daily reference series are required. Meteo-France will now select amongst the monthly homogenized series those which are close enough to apply SPLIDHOM method in good conditions and deliver some daily homogenized temperature.

IDENTIFYING HOMOGENEOUS SUB-PERIODS IN HADISD

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We present the preliminary steps in homogenising HadISD, a sub-daily, station-based dataset covering 1973-2013. Temperature, dewpoint temperature, wind speeds and sea-level pressure are all assessed on a monthly basis using the PHA method of Menne & Williams (2009). Monthly mean values as well as monthly diurnal ranges (for T and Td) and monthly maximum values (wind) are processed using the full network of 6103 stations. Change points are merged if two (from different methods) are within one year of each other. Under the assumption of a Gaussian population of inhomogeneity magnitudes, adjustments as small as around 0.5C, 0.5hpa and 0.5m/s have been successfully detected. No strong biases have been detected in the distributions of adjustment values. We also present an example application of how the information of change point dates and adjustment values can be applied to scientific analyses.

THE WMO/MEDARE INITIATIVE: BRINGING AND DEVELOPING HIGH-QUALITY HISTORICAL MEDITERRANEAN CLIMATE DATASETS INTO THE 21ST CENTURY

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The Greater Mediterranean Region (GMR) has a very long and rich history in monitoring the atmosphere, going back in time several centuries in some countries and at least to the mid-19th century across much of the GMR.

However, despite the efforts undertaken by National Meteorological and Hydrological Services (NMHS), research centres, universities and motivated individuals in Data Rescue (DARE) activities, available and accessible digital climate data are still mostly restricted to the second half of the 20th century for a few countries and since 1970s for most of the GMR. This reality is preventing the region from developing more robust, accurate and reliable assessments of climate variability and change and its adverse impacts on the socio-ecosystems of the Mediterranean Basin, at the same time it is impeding the development of optimum strategies to mitigate and/or adapt the countries to the current and future impacts of climate change.

In addition, the fragmentation and scarcity of long-term and high-quality surface climate records is hampering our ability for better detecting, predicting and adapting the countries to

present and future impacts of climate variability and change as well. This is particularly over this climate change 'hot-spot' region.

The WMO/MEditerranean climate DAta REscue (MEDARE) Initiative was set up to address developimg, accessible and traceable comprehensive long and high-quality instrumental surface climate datasets for the GMR.

The MEDARE Community exercises and implements its functions and actions trough out 4 working groups:

- WG1. Inventorying/assessing/approaching old material sources and holders;
- WG2. DARE techniques and procedures (including digitization);
- WG3. Approaches on best practices for quality controlling and homogenizing specific climate variables;
- WG4. Promotional activities, bringing MEDARE to the wider scientific and other communities.

This structure has allowed the MEDARE Community to undertake many other organizational, implementation and dissemination activities in order to raise awareness on the importance of bringing historical climate datasets into the 21st century, which is paving the way to get achieved the MEDARE's end-goal and objectives.

Among very important objectives of MEDARE initiative are represented in the following:

- To develop comprehensive, long and high-quality surface climate datasets for the GMR with a focus on the relevant Essential Climate Variables (i.e Temperature, precipitation, air and sea , .. etc.) pressure) of the Global Climate Observing System (GCOS) at different scales of time, which are currently required to support the work of the UNFCCC, the IPCC and the WMO/World Climate Program (WCP);
- To seek and mobilise resources and efforts at the national, regional and international scales in support of Data Rescue and Homogenisation (DARE&H) of long and key climate records over the GMR.

MEDARE web-site for linking the MAEDRE Community already implementd, updating and maintaining, while the on-line MAEDRE metadata base infrastructure for the longest and key Mediterranean climate records: about 620 sites documented for mainly TX(max temp)/TN(min temp), RR(rainfall and SLP(sea levei pressure) at daily (sub-daily) scales, puplated to be used by scientists, stakeholders, policy-makers and the general public within the region.

Other efforts of recovering, digitising quality controlling and homogenising for total of 38 daily TX and TN time-series for various locations in the southern and eastern parts of the Mediterranean Basin, where their recent part extends into the first decade of the 21th century, while for some of them data are available since the late part of the 19th century, are being done under the EU-funded EUropean Reanalysis and Observations for Monitoring (EURO4M) project, linked to the World Meteorological Organization (WMO) Mediterranean climate DAta REscue (MEDARE) Initiative.

Finally, build up the Mediterranean climate databases is being the end goal of the MEDARE Initiative.

HOMOGENIZATION OF SPANISH MEAN WIND SPEED MONTHLY SERIES

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Monthly Spanish series of mean wind speed have been compiled for the period 1951-2013, retaining only those with a minimum of 10 years of observations. The first approximation was to use mean wind speeds derived from daily total wind runs. In this way, 233 series were available, although very few of them have data in the first decennial of the study period.

These series were homogenized by means or the R package Climatol twice: a) using a ratio normalization of the data; b) applying a cubic root transformation to the data and standardizing them. The first approach yielded lower RMSE when estimating the series from the neighboring stations, and its homogenization process detected and corrected 71 outliers and 268 breaks.

But the overall correlations were not good enough, and showed a poor spatial coherence. Hence, new series were added from wind speeds computed as an average of observations at 07, 13 and 18 hours UTC (which in old stations often come from different instruments). These data are a good replacement for the wind runs because they have a better time coverage than the wind runs, providing a higher number of available stations at the critical 1951-1960 period, although their values are an 8% higher in average.

The homogenization process of these wind speeds corrected 38 outliers and 360 breaks, yet still presented a noisy correlation structure. Therefore, wind speeds seem to be very prone to inhomogeneities, probably due to its sensitivity to obstacles and surface roughness changes in the surroundings of the observatories. Then a new homogenization was performed adding wind speed series extracted from reanalysis.

Results from this joint homogenization are discussed, analyzing the wind speed long term trends, to end with some conclusions and future work prospects.

ELEMENTS OF SUSTAINED DATA MANAGEMENT SOLUTIONS FOR CLIMATE

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The basic goal of climate data management is to preserve, capture and provide access to climate data and products for use by planners, decision makers and researchers; its overall importance is accepted widely. Current GFCS activities are reinforcing respective needs in order to establish powerful data bases for strengthened climate services at national, regional and global levels.

WMO promotes collaboration among its Members to improve climate data management capacities including data rescue by establishing standards, best practices and guidance as well as by facilitating the implementation of relevant projects and activities at national, regional and global levels.

Many well received implementation and capacity building activities as well as numerous scientific and technical workshops and conferences take place each year in order to improve data management capabilities worldwide. Efficiently sustaining the success of such efforts, however, often remains a considerable challenge, specifically in developing countries. Standardisation, platforms for regular information exchange, and easy access to continuously updated comprehensive guidance material and tools are among the elements to facilitate sustainability. Three examples of related recent WMO initiatives are highlighted hereafter:

INTERNATIONAL DATA RESCUE PORTAL (I-DARE)
An international data rescue portal I-DARE is currently under development within WMO's Commission for Climatology. The I-DARE portal will be a well-structured and attractive single-entry source of information including (i) a global overview of rescued and to be rescued data; (ii) guidance on best practices, software, technology and tools; and (iii) links to existing data rescue sites. Further portal functions comprise arrangements for (i) operating a communication platform for easy information exchange as well as (ii) for portraying DARE success stories with product and service examples in order to stimulate donations as well as help by volunteers ('citizen science').

CLIMATE DATA MANAGEMENT SYSTEMS (CDMS) SPECIFICATIONS
WMO Members benefit from a growing variety of climate data management tools including CDMSs. In response, WMO experts drafted a WMO CDMS specification document, which is currently in print. This document specifies the functionalities that are expected within a CDMS in order to (i) set related standards and best practices as well as (ii) to assist Members in selecting the appropriate CDMS, where required. Once WMO Members and CDMS developers will meet the standard, it is expected that CDMS-related provision of guidance to Members, training, CDMS implementation etc. will become more efficient and sustainable.

CLIMATE DATA MANAGEMENT FRAMEWORK (CDMF)
WMO prepares for an initiative to launch a CDMF in order to meet future GFCS climate data requirements. The following deliverables should constitute the substance of the global CDMF: (i) Updated or new technical regulations and guidance material for climate data management, its elements and operational practices, (ii) Identification of an extended range of

climate data types needed to support GFCS on an operational basis, (iii) Development and promulgation of a commonly agreed set of standards and consistent practices for certain key data management elements including for data, metadata and related archiving facilities and information services, (iv) Harmonisation of terminology for data management and its elements, and (v) Improved procedures for quality control, quality assurance, related information services at NMHSs and any other climate data holding institutions.

Eventually, discussions are encouraged to stimulate similar activities to further sustain existing initiatives in the domains of homogenization and spatial interpolation. Relevant requirements can be addressed to the proposed CCl Task Team on Homogenization, expected to be established by the 16th Session of CCl (CCl-16) in early July 2014.

GRIDDING OF PRECIPITATION AND AIR TEMPERATURE OBSERVATIONS IN BELGIUM

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The Royal Meteorological Institute of Belgium (RMI) has recently updated the precipitation and air temperature climate maps of Belgium in order to account for the reference period 1981-2010. These climate maps include information on the annual, seasonal and monthly normal values as well as on the mean number of precipitation days, heavy precipitation days, summer days, tropical days, frost days and winter days per year. These maps mainly rely on the observations of the daily precipitation quantities and daily extreme temperatures from the network of the climatological stations maintained by voluntary observers.

Several issues were investigated in this study. First, a tradeoff had to be found between the number of stations used in the mapping process and the level of data completeness of the corresponding time series. Second, the benefit of exploiting covariate data was investigated. A typical covariate for both precipitation and temperature is the orography. Another covariate for precipitation quantities results from measurements of the precipitation quantities made with an ancillary networks of pluviometers. In particular, the South part of Belgium, which exhibits a quite complex orography with respect to the rest of the country, is covered by an additional network of about 90 automatic sensors that became operational in 2005. The 2005-2012 mean precipitation quantities at these stations enabled to improve the mapping of the precipitation normals for the period 1981-2010. Then, the possibility to consider observations uncertainties within the interpolation process was investigated. Finally, the annual cycle of the mean precipitation quantities was analyzed by principal component analysis (PCA).

APPLYING THREE DIFFERENT METHODS FOR THE HOMOGENIZATION OF A DATASET OF MEAN MONTHLY TEMPERATURE AND PRECIPITATION TIME SERIES

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Time series of climatic data is the basis in research on climate behavior and climate change; such a time series is considered to be homogeneous when any changes in it are due only to changes in climate and not to other, extraneous reasons. Many climatic parameters are affected by a number of non-climatic factors which may introduce discontinuities - non-homogeneities - in their time series making them inadequate for climatic studies as their use may lead to misinterpretations of climate over either a small or a wider area. Several methods have been developed in order to detect and correct these non-homogeneities, since the time series used for climatic studies have to be not only as complete but also as homogeneous as possible. Two of the most essential climatic parameters are considered to be temperature and precipitation since they affect and determine the climate of a whole region. . In this study the homogeneity of a subset of temperature and precipitation time series from meteorological stations of western Greece, belonging to the Hellenic National Meteorological Service network, is examined using three different homogenization methods, MASH, Climatol and HOMER. Aim of this process is to compare the results of these three methods including the indentified breakpoints, outliers, correction terms and changes in trends before – after homogenization as well. The differences between homogenized temperature and precipitation data are also discussed.

HOMOGENIZATION IN CARPATCLIM (CLIMATE OF CARPATHIAN REGION) PROJECT

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The focus of the presentation is the homogenization activity in the CARPATCLIM (2010-2013) project. The main aim of CARPATCLIM was the spatial and temporal examination of the climate of the Carpathian Region using harmonized data and standard methodology. The consortium led by the Hungarian Meteorological Service (OMSZ) together with 10 partner organizations from 9 countries in the region was supported by the JRC to create a daily harmonized gridded dataset during the period between 1961 and 2010. The target area of the project partly includes the territory of Czech Republic, Slovakia, Poland, Ukraine, Romania, Serbia, Croatia, Austria and Hungary. 415 climate stations and 904 precipitation stations were used in the project to achieve the objectives. The final outcome of the CARPATCLIM is a ~10 × 10 km resolution homogenized and gridded dataset on daily scale for 13 basic meteorological variables and several climate indicators, 37 in total, on different time scales from 1961 to 2010.

For ensuring the usage of largest possible station density the necessary work phases were implemented on national level with applying same methods and software. The common used methods and software in the project was the method MASH (Multiple Analysis of Series for Homogenization; Szentimrey) for homogenization, quality control, completion of the observed daily data series; and the method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis; Szentimrey and Bihari) for gridding of homogenized daily data series. Besides the common software, the harmonization of the results across country borders was performed also by near border data exchange.

The high quality of times series got through the MASH procedure are guaranteed by the excellent monthly benchmark results from the COST "HOME" Action and the promising outcomes of the daily tests.

The main steps of homogenization in CARPATCLIM were as follows.

1. Near border data exchange before homogenization.
2. Homogenization, quality control, completion of the daily data series on national level by using near border data series.
3. Near border data exchange after homogenization.

MASH is an automatically working software. The test results of the homogenization and quality control (e.g., detected errors, degree of inhomogenity of the series system, number of break points, estimated corrections, and certain verification results) are documented in automatically generated tables during the homogenization process.

CARPATCLIM homepage: http://www.carpatclim-eu.org/pages/home/

COMPARISON OF DAILY SUNSHINE DURATION RECORDED BY CAMPBELL-STOKES AND KIPP & ZONEN SENSORS

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This presentation compares readings of daily sunshine durations from Campbell-Stokes (CS) and Kipp & Zonen (KZ) instruments, and provides equations to be used to derive CS equivalent readings from KZ data. Given the increased use of KZ recorders, owing to automation of observations, we have a need to convert readings from these to estimates of CS equivalents in order to maintain homogeneity of UK sunshine records. The tendency is for K&Z recorders to observe fewer sunshine hours than C-S instruments, because the latter have a tendency towards 'over-burn' of the daily card during times of intermittent sunshine. Corrections are larger on days with just a few hours of sunshine than on days which are totally overcast or sunny. This study builds on earlier work with monthly sunshine totals, and shows that due to the character of the over-burn tendency the adjustment of sunshine totals on a daily basis leads to greater homogeneity.

USING UNCERTAINTY ANALYSIS TO INFORM DIGITISATION PLANS TO IMPROVE AND EXTEND THE UK CLIMATE SERIES

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POSTER

At present, the historical national and regional UK gridded analyses of observations at the Met Office extend as far back as 1910 for monthly temperature (maximum, mean and minimum) and rainfall, 1929 for monthly sunshine, and mostly 1961 for a range of daily variables. Work has been done (Legg 2014, in prep) to determine how many stations we require in our network in order to be able to calculate with sufficient accuracy areal-average monthly statistics of climate parameters for the UK. We wish to extend our series further back in time, since at present there are earlier observations which exist in the digital archive, and many more in the Met Office paper archive. We are planning to digitise more of this data, and gridded analysis and exploration of uncertainty can be used to inform the most cost-effective strategies for prioritising digitisation

INSTRUMENTAL TEMPERATURE SERIES IN EASTERN AND CENTRAL CHINA BACK TO THE 19TH CENTURY

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Climate change researchers have paid much attention to the inter-decadal variability and long-term trends of surface air temperature (SAT). Both long-term and homogeneous instrumental SAT data series are essential for studying the characteristics of global and regional climate change. Over past decades, the establishment of long-time SAT series has attracted extensive attention worldwide and great progress has been achieved.

In this study, we bring together different source datasets and use quality control, interpolation, and homogeneity methods to construct a set of homogenized monthly mean surface air temperature (SAT) series for eighteen stations in eastern and central China from late 19th century. Missing values are statistically interpolated and cross validation method is used to assess the accuracy of the interpolation approaches. Results show that the errors of interpolation are small and the interpolated values are statistically acceptable. Multiple homogeneity methods and all available metadata are used to assess the consistency of the time series and then to develop adjustments when necessary. Thirty-three homogeneity breakpoints are detected in the eighteen stations and the time series are adjusted to the latest segment of the data series. The adjusted annual mean SAT generally shows a range of trends of 1.0° to 4.2°C/100 years in northeastern and southeastern China and a range of trends of -0.3° to 1.0°C/100 years in central China near 30°N. Compared to the adjusted time series, the unadjusted time series underestimate the warming trend during the past 100 years. The regional and annual mean SAT over eastern and central China agrees well with estimates from a much denser station network over this region of China since 1951 and shows a warming trend of 1.52°C/100 years during 1909-2010.

Key words: instrumental temperature series, China, in recent 100 years

Publication

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ON THE RELIABILITY OF USING THE MAXIMUM EXPLAINED VARIANCE AS CRITERION FOR OPTIMUM SEGMENTATIONS IN HOMOGENIZATION ALGORITHMS

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Relocations of climate stations and changes in observation techniques cause artificial breaks in climate records that hamper the study of true climatic changes. Homogenization algorithms are searching for abrupt changes in the difference time series between two neighboring stations to detect such breaks. In multiple breakpoint methods, the optimal segmentation is searched using the maximum explained variance as criterion.

We test this commonly applied detection method by artificial data that contain inhomogeneities with normally distributed amplitudes at random positions and that is additionally superimposed by random scatter. In case of artificial data the true signal is known and the skill of any segmentation can be easily assessed by the mean square difference. In real cases, multiple breakpoint methods rely on the maximum explained variance as criterion. We show that these two metrics, true skill and maximum explained variance are only weakly correlated for signal-to-noise ratios (SNRs) of ½. That can be understood by considering the growth of the explained variance with growing break number separately for the break and noise part. Both obey similar mathematical formulae, but on different scales.

We find that random segmentations explain already about half of the break variance; for the noise fraction, optimum segmentations are superior by to random segmentations by a factor of five. Therefore, maximum variance is often attained where break positions are optimized according to the noise, especially when the SNR is smaller than 1. As consequence, break detection based on maximum explained variance becomes inaccurate and alternative formulations need to be investigated. For higher SNRs, such as assumed in the HOME benchmark, this problem is less severe.

QUALITY CONTROL OF A SURFACE WIND OBSERVATIONS DATABASE FOR NORTH EASTERN NORTH AMERICA

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This work summarizes the Quality Control (QC) process applied to an observational database of surface wind module and direction in North Eastern North America. The data set consists of 523 stations compiled from three different sources: 343 land sites from Environment Canada (EC; 1940-2009) located in the provinces of Atlantic Canada and Quebec; 40 buoys distributed over the East Coast and the Canadian Great Lakes provided by Fisheries and Oceans Canada (FOC; 1988-2008); and 140 land sites over both Eastern Canada and North Eastern USA provided by the National Center of Atmospheric Research (NCAR; 1975-2010). The combined time-span of the records lasts close to 70 years with varying time resolutions of hourly, 3 hourly and 6 hourly data, and uneven measurement units, time references and heights. The QC process is structured into 5 phases that sequentially detect specific problems in data quality. The sequence of the QC is described below:

1. The first phase deals with the unification of measurement units and recording times.
2. The second phase detects data sequences that might be erroneously duplicated within the same series or between different stations.
3. The third phase unifies the criteria to consistently define calm and true North values along the dataset, identifies unrealistic observations within each time series and detects stations with unrealistic mean and/or standard deviations in the database.
4. The fourth phase targets the detection of abnormal behaviors in low and high variability on wind time series. The low variability checks detect unrealistic constant chains of data values and in the case of low wind speeds, apply an spatial comparison. Regarding high variability, a combination of a blip test and a spatial comparison identifies unrealistic jumps that can involve either lone values or longer data sequences.
5. The fifth phase deals with the detection of long term biases. In the case of the wind speed, this is focused on long data sequences in daily averages that present unrealistic values in either mean, variance or the coefficient of variation. This step targets larger sequences than the typical QC processes are designed to detect, but shorter than those targeted by homogenization analyses. The detected erroneous time intervals are deleted. A process to correct biases in wind direction is developed, based on the automatic comparison of wind roses. The vane shifts are corrected taking the most recent orientation as a reference. This angle correction method can be, in a way, also regarded as a homogenization process. In addition to the description of the methodology, a discussion on the spatiotemporal distribution and possible causes for errors is provided. The overall impact of the QC process in the statistics of the observational time series is also presented.

HOMOGENEITY OF MONTHLY MEAN AIR TEMPERATURE OF THE UNITED REPUBLIC OF TANZANIA WITH HOMER

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For the first time, monthly mean air temperatures of the United Republic of Tanzania (URT) are homogenized by using HOMER software package. Monthly mean minimum (TN) and maximum (TX) air temperature from1974 to 2012 were used in the analysis. These datasets were obtained from Tanzania Meteorological Agency (TMA). The analysis reveals larger number of artificial break points in TX (12 breaks) than TN (5 breaks) time series. The homogenization process was assessed by comparing results obtained with Correlation analysis and Principal Component analysis (PCA) of homogenized and non-homogenized datasets. Mann-Kendal non-parametric test was used to estimate the existence, magnitude and statistical significant of potential trends in the homogenized and non-homogenized time series. Correlation analysis reveals strong correlation in homogenized TX than TN in relation to non-homogenized time series. Results from PCA suggest that the explained variances of the principal components are higher in homogenized TX than TN in relation to non-homogenized time series. Mann-Kendal non-parametric test reveals that the number of statistical significant trend increases with homogenized TX (96%) than TN (67%).

Keywords: Homogenization; HOMER software package; ANOVA; Air temperature

ABSOLUTE AND RELATIVE HOMOGENEITY TEST FOR DAILY DATA USING KS TEST

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For most climate studies, quality control of data is required to detect possible problems from the time-series. Daily data are especially used in the analysis of extreme events and to characterize the variability of weather (e. g. cold/heat waves and dry/wet spells). However, there are difficulties in detecting inhomogeneities present at a daily scale. Usually, the daily data are aggregated at a monthly scale and then it is applied a homogeneity test (like the SNHT by Alexandersson).

In this work we present a method for detecting inhomogeneities at a daily scale by using the non-parametric test of Kolmogorov-Smirnov (KS). The method can be used both absolutely and relatively, that is, by comparing (or not) with a reference time-series. In any case, the technique consists of two steps: First, potential candidates of inhomogeneity are detected by analyzing the KS p-value from the comparison of two consecutive populations (absolute test) or two populations corresponding to the same days of two different time-series (relative test). The candidate jumps are chosen from a p-value equal or less than the one obtained from an artificially introduced inhomogeneity. Second, we analyze the similarity of the data sets that are cut by the candidates. In this way we distinguish between isolated odd populations (possible outliers) and inhomogeneous time segments.

Some advantages of this method are that it does not only detect the changes in the mean but it is also capable of detecting changes in the daily deviation and even other changes in the form of the probability distribution. In addition, the test can be used in an absolute way, which is useful for areas with limited data and a low correlation between stations.

PRACTICAL ASPECTS OF RAW, HOMOGENIZED AND GRIDDED DAILY PRECIPITATION DATASETS

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Climate assessments that are based on daily data series deal with three types of data: raw (observed), homogenized and gridded datasets. Although every type of data has its own advantages, results of such climate assessments depend upon the choice of type of data. In order to examine to what extent this choice might affect the results, a comparison of data processing products from daily precipitation series has been made between the raw, homogenized and gridded datasets. In its various stages, project CARPATCLIM has dealt with the three types of data. Therefore, a selection of data from Serbia is used for this survey. Two types of data processing products from daily precipitation data were examined: climate indicies and extreme daily precipitation.

Indicies used in this survey are related to precipitation and they are WMO recommended. A set of 11 indicies is processed. These indicies are calculated from daily precipitation data basis and, as a result, annual index values are returned. The comparison analysis of these indicies showed that there are certain differences between raw and homogenized data as well as grid point data that showed more significant differences. These differences come from various factors.

Extreme daily precipitation was calculated from selected raw and homogenized series as well as series from the grid point nearest to the measurement location. The output results returned significant differences between the three types of data. Causes of these differences are not only mathematical.

This survey shows the good and poor sides of homogenization and gridding daily precipitation datasets. The given results show that choice of dataset should depend upon the purpose of future surveys that engage daily precipitation data.

HOMOGENIZATION OF HUNGARIAN DAILY WIND SPEED TIME SERIES USING MASH PROCEDURE

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POSTER

Wind speed is especially affected by the local environment, so long term wind observations involve inhomogeneities due to change of measuring methods, sensors, surroundings of stations or moving into a new location. Therefore homogenization is necessary in order to make reliable analysis of datasets.

To avoid misinterpretations of wind climate parameters' trends, daily wind datasets were homogenized using MASH (Multiple Analysis of Series for Homogenization) procedure at 19 Hungarian synoptic stations in the period from 1975 to 2012. Different wind related climate indices were defined and calculated from original and homogenized daily wind speed data series.

This study discusses the validation of the homogenization process, presents the results of the quality control and compares different climate indices

HOMOGENIZATION OF MONTHLY AIR TEMPERATURE AND MONTHLY PRECIPITATION SUM DATA SETS COLLECTED IN UKRAINE

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Our study is devoted to homogenization of climate data series collected in Ukraine. We have considered two data sets. First set is monthly mean air temperature data and second one is monthly sums of precipitation. In both cases data were collected at 174 Ukrainian climatological stations which are uniformly distributed on Ukrainian territory. The mean distance between stations is approximately 50 km. Period of interest is from 1961 till 2010. Original time series did not have a lot of missing data. Their total number at every time series was less than 1 %.

Homogenization of climate data series was performed by means of the MASH software. We used a quasi automatic algorithm for MASH which was tested, proved and used in CARPATCLIM project.

Inhomogeneity of original air temperature time series was very high. For example, average test statistics (TS) for yearly time series was equal to 301.33 what exceed a critical value (equals to 20.86) more than 14 times. TS for certain time series reached very high values (maximal TS was 32029.89). After homogenization we obtained the average TS 23.79 what seems to be acceptable.

The homogenization procedure allowed us to decrease significantly inhomogeneities in monthly time series as well. This can be concluded from the verification tables calculated before and after homogenization (the Verisum files).

Time series of monthly precipitation sums were much more qualitative. The average TS for yearly time series was equal to 22.29 what was less than a critical value. But, TS for several time series were still very high. This means that homogenization was necessary. After homogenization we obtained good results for both yearly and monthly time series.

Thus, the homogenized time series (the homogenized data sets) can serve as a good base for further studies of current state of regional climate in Ukraine.

In both cases (temperature and precipitation) homogenization was performed without any metadata. In order to assess the efficiency of the homogenization software in break points detection we collected metadata (possible break points) from historical description of Ukrainian climatological stations. Comparison of break points detected by MASH with metadata has shown that approximately 20 % of detected break points can be explained by metadata.

THE CARPATCLIM (CLIMATE OF CARPATHIAN REGION) PROJECT

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There is a growing requirement for good quality, long-term climate data time series. The different national data policies do not make possible to use comparable, high resolution climate data in the international projects. The CARPATCLIM project solves this problem in the Greater Carpathian Region by the support of the European Parliament under the supervisorship of JRC. The differences in the national data policies was overbridged by the creation of gridded database, and that was the reason, that the most possible data were used with the minimum of bilateral data exchange.

Large problem is the differences in the national measuring networks, data management methods. Therefore, not only common management methods were used, but even the same software was applied avoiding the deviations in the coding of the algorithms. For getting the necessary station density, data rescue activities were supported in the frame of the project. The commonly used homogenisation and data management software was the MASH, and the gridding software was the MISH. The temporal resolution is one day, and the spatial resolution is 0,1°*0,1°. 18 meteorological variables were calculated (12 from it from the original measurements, the others calculated from them), and all together more than 50 variables and indices (mostly in connection with drought).

The gridded database is freely available from the project's homepage. The homepage contains not only the data, but all the information (metadata, index calculation, management procedures, etc.) can be find there making the project repeatable.

MATHEMATICAL QUESTIONS OF HOMOGENIZATION AND QUALITY CONTROL

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There are several methods and software for the homogenization of climate data series but there is not any exact mathematical theory of the homogenization. At the examinations mainly the physical experiences are considered while the mathematical formulation of the problems is neglected in general. Moreover occasionally there are some mathematical statements at the description of the methods in the papers – e. g. capability to correct the higher order moments – but without any proof and this way is contrary to the mathematical conventions of course. As we see the basic problem of the homogenization is the unreasonable dominance of the practical procedures over the theory and it is the main obstacle of the progress. Therefore we try to formulate some questions of homogenization in accordance with the mathematical conventions. The planned topics to be discussed are as follows.

- The mathematical definition of the inhomogeneity and the aim of homogenization. It is necessary to clarify that the homogenization of climate data series is a distribution problem instead of a regression one.
- Relation of monthly and daily data series homogenization.
- Mathematical overview on the methodology of spatial comparison of series, inhomogeneity detection, correction of series.
- Relation of theoretical evaluation and benchmark for methods, validation statistics.

Software MASH (Multiple Analysis of Series for Homogenization; Szentimrey) can be downloaded from the webpage:
http://www.met.hu/en/omsz/rendezvenyek/homogenization_and_interpolation/software/

MATHEMATICAL QUESTIONS OF SPATIAL INTERPOLATION OF CLIMATE VARIABLES

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We focus on the basic mathematical and theoretical questions of spatial interpolation of meteorological elements. Nowadays in meteorology the most often applied procedures for spatial interpolation are the geostatistical interpolation methods built also in GIS software. The mathematical basis of these methods is the geostatistics that is an exact but special part of the mathematical statistics. However special meteorological spatial interpolation methods for climate variables also can be developed on the basis of the mathematical statistical theory. The main difference between the geostatistical and meteorological interpolation methods can be found in the amount of information used for modeling the necessary statistical parameters. In geostatistics the usable information or the sample for modeling is only the predictors, which are a single realization in time. While in meteorology we have spatiotemporal data, namely the long data series which form a sample in time and space as well. The long data series is such a speciality of the meteorology that makes possible to model efficiently the statistical parameters in question. The planned topics to be discussed are as follows.

- Temporal scales, from daily values to climatological mean values.
- Interpolation formulas and loss functions depending on the spatial probability distribution of climate variables.
- Estimation and modeling of statistical parameters (e.g.: spatial trend, covariance or variogram) for interpolation formulas using spatiotemporal sample and supplementary model variables (topography). Use of supplementary co-variables, background information (e.g.: dynamical model results, satellite, radar data) for spatial interpolation.
- Creation of gridded climatological databases.

Software MISH (Meteorological Interpolation based on Surface Homogenized Data Basis; Szentimrey and Bihari) can be downloaded from the webpage:
http://www.met.hu/en/omsz/rendezvenyek/homogenization_and_interpolation/software/

CLIMATE DATA IN JORDAN

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Jordan started climate data measuring since 1921, those data included wide range of data; temperature, pressure, wind, cloud, precipitation, solar radiation…etc.

The weather stations in Jordan distrusted in all the main areas of Jordan, the number of such stations have been changing through time, the number of stations range from 54 stations to 28 stations right now, including automatic weather station, agriculture, synoptic and climate stations.

The main challenging of climate data collecting and analyzing is the great range of climate properties between the different regions of Jordan due to the great changes of topography in Jordan, in 2013 the highest annual rainfall was (682.9 mm) in Salt station while the lowest annual rainfall was (21.4 mm) in Azraq station, and the highest maximum temperature was (44.8°C) in Rwaished station in the Eastern desert of Jordan while the lowest minimum temperature was (-16°C) in Shoubak station in the Southern heights of Jordan. Such sharp seasonal variations is combined with; Mediterranean, arid and semi-arid climate types dominate Jordan.

These data are processed manually and then computerized by using Oracle 9i. Data base was developed in JMD. containing all the observed data.

Archiving and digitizing the documents and charts related to such data is ongoing future project in the JMD.

INHOMOGENEITIES IN DAILY DATA

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Daily datasets have become a focus of climate research because they are essential for studying the variability and extremes in weather and climate. However, long observational climate records are usually affected by changes due to nonclimatic factors, resulting in inhomogeneities in the time series. Looking at the known physical causes of these inhomogeneities, one may expect that the tails of the distribution are especially affected. Although the number of national and regional homogenized daily temperature datasets is increasing, inhomogeneities affecting the tails of the distribution are often not or insufficiently taken into account.

In this literature review we investigate the physical causes of inhomogeneities and how they affect the distribution with respect to its mean and its tails. We review what is known about changes in the distribution from existing historical parallel measurements. We discuss effects of the state-of-the-art homogenization methods on the temperature distribution. Finally, we provide an overview of the quality of available daily datasets that are often used for studies on changes in extremes and additionally describe well-homogenized regional datasets.

As expected, this review provides evidence that the tails of the distribution are generally more affected by non-climatic changes than the means. This is a problem because the question to which extent daily homogenization methods can reduce those effects is insufficiently studied and most available methods are focused on temperature only. More specifically, it is advised to study whether the current deterministic correction methods should be succeeded by stochastic methods. Concerning the large scale available daily datasets, many of them are not homogenized (with respect to the distribution), whereas the number of national and regional homogenized datasets is strongly growing.

Given the strong interest in studying changes in weather variability and extremes and the existence of often large inhomogeneities in the raw data, the homogenization of daily data and the development of better methods should have a high research priority. This research would be much facilitated by a global reference database with parallel measurements. The climate community, and especially those involved in homogenization, bias correction and the evaluation of uncertainties, should take an active role to foster the compilation of such a reference database. We have started an initiative collecting parallel datasets. Its aims will be explained and its progress will be presented.

BENCHMARKING THE PERFORMANCE OF DAILY TEMPERATURE HOMOGENISATION ALGORITHMS

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Having reliable temperature records at all temporal scales is important, but different challenges come with different time scales. Daily data are more noisy and variable than monthly or annual data and they also incorporate a lot of data points even over a relatively short time period. This means that methods for assessing the performance of homogenisation algorithms that can be used on monthly data may need to be re-thought for daily data. Extremes in temperature data in particular are important for people at the societal scale, but are often lost if the data are aggregated over larger time periods.

Here I present my current work to create synthetic daily temperature series for regions of North America that look like the real world, but where the truth about errors and variability is known a priori. We need these synthetic data to be able to inform our analysis of homogenisation algorithm performance and enable the improvement of these algorithms, which will in turn improve the climate data we rely on for so many of our climate studies.

HOMOGENISATION ALGORITHM SKILL TESTING WITH SYNTHETIC GLOBAL BENCHMARKS FOR THE INTERNATIONAL SURFACE TEMPERATURE INITIATIVE

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Our surface temperature data are good enough to give us confidence that the world has warmed since 1880. However, they are not perfect - we cannot be precise in the amount of warming for the globe and especially for small regions or specific locations. Inhomogeneity (non-climate changes to the station record) is a major problem. While progress in detection of, and adjustment for inhomogeneities is continually advancing, monitoring effectiveness on large networks and gauging respective improvements in climate data quality is non-trivial. There is currently no internationally recognised means of robustly assessing the effectiveness of homogenisation methods on real data - and thus, the inhomogeneity uncertainty in those data.

Here I present the work of the International Surface Temperature Initiative (ISTI; www.surfacetemperatures.org) Benchmarking working group. The aim is to quantify homogenisation algorithm skill on the global scale against realistic benchmarks. This involves the creation of synthetic worlds of surface temperature data, deliberate contamination of these with known errors and then assessment of the ability of homogenisation algorithms to detect and remove these errors. The ultimate aim is threefold: quantifying uncertainties in surface temperature data; enabling more meaningful product intercomparison; and improving homogenisation methods. There are five components work:

1. Create 30000 synthetic benchmark stations that look and feel like the real global temperature network, but do not contain any inhomogeneities - analog-clean-worlds.
2. Design a set of error models which mimic the main types of inhomogeneities found in practice, and combined them with the analog-clean-worlds to give analog-error-worlds.
3. Engage with dataset creators to run their homogenisation algorithms blind on the analog-error- world stations as they have done with the real data.
4. Design an assessment framework to gauge the degree to which analog-error-worlds are returned to the original analog-clean-worlds by homogenisation and the detection/adjustment skill of the homogenisation algorithms.
5. Present an assessment to the dataset creators of their method skill and estimated uncertainty remaining in the data due to inhomogeneity.

METEOROLOGICAL HAZARD MAPS – METHODOLOGICAL APPROACH

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The aim of the study is to present spatial differentiation of extreme weather phenomena which occurred in previous decades and to indicate the regions for which the phenomena are predicted. The maps – one of the components of IT system for country protection against extreme hazards (ISOK) created by the consortium of Polish institutions, including the Institute of Meteorology and Water Management – National Research Institute – present meteorological phenomena such as: temperature extremes, heavy and floods leading rainfalls, strong winds, intensive snowfalls, fogs, glaze, rime and thunderstorms with hail.

To identify areas especially exposed to feasible meteorological threats and to create maps, climatological analyses were performed (for the periods: 1951/1966-2010). The climatological maps were created using three different approaches.

For temperature, heavy rainfall and particular characteristic of snowfall extreme cases were defined with a decadal resolution. The climatological maps of daily values occurring with the probability of 1, 5 and 10% were created using the methods most popular in climatology: ordinary kriging, residual kriging, and in some cases other methods, called combined.

For the characteristics of wind speed as well as the other snowfall and snow cover along with fog-, glaze-, hailstorm-, and rime due to sparse spatial network risk maps were depicted in the form of signature, with monthly and seasonal resolution.

Because of the lack of the data detailed analyses of the coexistence of specific weather conditions and atmospheric processes contributing to the occurrence of weather phenomena such as hailstorm, fog, rime and glaze were also conducted. As the reference, data from aerological soundings, aviation weather reports, and standard data was used; spatial differentiation was achieved with the use of the data from RegCM model. For fog phenomenon weather conditions were also related to the environmental ones which are favorable for its occurrence, i.e. topography and land cover, thanks to which spatial differentiation shows also mesoscale phenomena likely to develop or be intensified due to favorable local conditions.

By representing spatial differentiation of the elements and phenomena extremes estimated with the probability of their occurrences in Poland climatological maps serve as a background information for the warning maps.

Warning maps will be generated in ISOK system (in automatic mode) relying on formulated algorithms describing occurrence of meteorological hazards. The algorithms will facilitate generation of maps forecasting probability of occurrence of defined hazards (temperature extremes, heavy rainfalls, strong winds, snowfalls) or occurrence of conditions supporting appearance of a given phenomenon (thunderstorms with hail, fogs, rime, glaze).

HOMOGENIZATION OF MONTHLY TEMPERATURE SERIES IN ISRAEL - AN INTEGRATED APPROACH FOR OPTIMAL BREAK-POINTS DETECTION

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In 2013 the Israel Meteorological Service (IMS) started to use homogenization methods systematically. After examining several common homogenizations methods recommended by ACTION COST-ES0601 and WMO we developed a procedure for optimal break-points detection of monthly temperature data. The procedure and the results from its application to five candidate stations in Israel (Jerusalem, Elat, Zefat Har Kenaan, Beit Jimal and Negba) for the period 1950-2012, are introduced. The input data was the time series of maximum and minimum monthly temperatures.

In our first experiments, we found out that the absolute homogeneity tests gave insufficient results for Israel. Therefore, we decided to rely on the relative methods using the reference stations.

Our integrated approach for optimal break-points detection was based on a number of advanced homogenization methods: ACMANT, HOMER2.6, RHtestV3 and AnClim. The reference series were built from more than 30 stations, using cluster analysis aiming to find the best fitting stations. The important factor in making decisions, in the break-point detection, was the exclusive reliable metadata found in the IMS archive, though sometimes the final location of the break-point was not among the registered events in the station recorded history. After summarizing all the results and establishing the break-points set, we carried out the adjustment step of homogenization either manually or with ACMANT or HOMER2.6.

Finally, the homogenization procedure as a whole improved the data of each station, sometimes considerably, with a rather wide annual range of correction factors that varied between -1.23ºC and +1.09ºC.

QUALITY CONTROL AND HOMOGENIZATION OF CHINA'S 6-HOURLY SURFACE PRESSURE DATA

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Aiming to produce a homogeneous high-quality 6-hourly surface pressure database, this study applied a comprehensive quality control (QC) system and a data homogenization procedure to correct both random and systematic errors in 6-hourly surface pressure data from 194 sites in China for the period 1951-2012. Relocation and/or joining of stations were found to be the main causes for discontinuities (systematic errors) in the surface pressure database (including both station pressure and sea level pressure). Both physical and statistical approaches are used to detect and correct errors, along with available metadata. The hydrostatic model is used to identify and correct for errors caused by the use of incorrect station elevation values in the reduction of barometer readings to station or sea level pressure values, or by changes in station elevation due to relocation and/or joining of two or more station records. A statistical approach based on the penalized maximum F test was also used when a physical-based correction is not possible due to lack of related data or metadata (e.g. an elevation change was documented, but the old station elevation was not). However, all discontinuities that were adjusted in this study have metadata support (i.e., documented change points). As a result, pressure data for 74 of the 194 sites were adjusted for station elevation changes using the hydrostatic model, and pressure data for additional 31 sites were homogenized using a quantile-matching adjustment method. The effect of the artificial discontinuities on pressure trends was also assessed by comparing the trends of the raw and homogenized pressure data.

HOMOGENIZATION OF MONTHLY PRECIPITATION TIME SERIES IN CROATIA

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Various types of studies require a sufficiently long series of data processed identically over the entire area. For climate analysis, it is necessary that analysed time series are homogeneous, which means that their variations are caused only by variations in weather and climate. Unfortunately, most of the climatological series are inhomogeneous and contain outliers that may significantly affect the analysis results. The 137 stations with precipitation measurement belonging to the meteorological station network governed by the Meteorological and Hydrological Service of Croatia were selected for the present analysis. Most of the data series cover a period from the late 1940s or early 1950s through the year 2010. For quality control and homogenization, an approach based on the software ProClimDB/Anclim was applied. In this study, we describe the results from the quality control and homogenization process for monthly precipitation sums as well as the spatial relationship of precipitation in the Croatian region. The precipitation network in Croatia is fairly homogeneous as only 23% of the 137 analysed stations are found to be inhomogeneous.

AN ANALYSIS ON THE IMPACT OF DATA GAPS AND GAP FILLINGS ON GLOBAL SURFACE TEMPERATURE TRENDS

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The apparent slowdown/pause in the global surface warming over the last decade has highlighted the importance in the lacking of observational data in the Arctic and other regions, as the Arctic has indicated enhanced warming over other large regions. Internationally there are several global surface temperature datasets that are generated using various techniques on gap filling and data binning/averaging, as well as different processes for data preparation. In this presentation we study the data gaps that exist in the selected datasets and analyze their impact on the global and regional temperature trends over various time periods. Among these datasets are the US NOAA's merged land-ocean surface temperature (MLOST, recently renamed as NOAA-TEMP), the US NASA Goddard Institute for Space Studies Surface Temperature Analysis (GISTEMP), the UK Met Office's Hadley Center and University of East Anglia's Climate Research Unit analysis – HadCRUT4, and most recently the analysis of Cowtan and Way (2014). Our findings will be presented at this conference