ABSTRACT BOOK

9th SEMINAR FOR HOMOGENIZATION AND QUALITY CONTROL IN CLIMATOLOGICAL DATABASES

AND

4th CONFERENCE ON SPATIAL INTERPOLATION TECHNIQUES IN CLIMATOLOGY AND METEOROLOGY

3-7 April 2017

Budapest, Hungary

Organized by the Hungarian Meteorological Service (OMSZ)

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9th Seminar for Homogenization and Quality Control in Climatological Databases and
4th Conference on Spatial Interpolation Techniques in Climatology and Meteorology

Budapest, Hungary 3- 7 April 2017

Edited by

Tamás SZENTIMREY

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PROGRAMME

Budapest, Hungary
03-07 April 2017

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

Homogenization sessions: 03 April Monday-05 April Wednesday
Interpolation session: 05 April Wednesday-06 April Thursday
Software session: 07 April Friday

MONDAY, 03 APRIL

8:30 – 9:00 Registration

9:00 – 12:00

Opening addresses by

President of HMS
Delegate of WMO
Organizers

Introductory Presentations

Hechler, P., Baddour, O.: Underpinning Climate Services

Coffee break

Szentimrey, T.: Introduction on homogenization, quality control, spatial interpolation, gridding

Venema, V., Lindau, R.: Global temperature trend biases and statistical homogenization methods

Lunch break

14:00 – 17:00 Homogenization and quality control

Aguilar, E., Asín, J., Azorín, C., Gilabert, A., Guijarro, J. A., Lopez, J. A., Prohom, M., Rasilla, M., Solé, G.: Evaluation of the Impact over temperature series of the transitions between observation systems (IMPACTRON)

Guijarro, J.A., Cuxart, J., Simó, G., Martínez-Villagrasa, D., López, A., Picos, R., Martí, B., Jiménez, M.A., Gilabert A., Aguilar, E.: Small scale surface heterogeneities and impact on station relocations

Hannak, L.: Analysis of the impacts of the automatization of measurement systems using parallel measurements from German Climate Reference Stations

Coffee break

Domonkos, P.: Time series homogenisation with optimal segmentation and ANOVA correction: past, present and future

Guijarro, J. A., Lopez, J. A., Aguilar, E., Domonkos, P., Venema, V.K.C., Sigró, J., Brunet, M.: Comparison of homogenization packages applied to monthly series of temperature and precipitation: the MULTITEST project

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

TUESDAY, 04 APRIL

9:00 – 12:00 Homogenization and quality control

9:00 – 10:30 New WMO Guidance on homogenisation: Introductory presentation by Victor Venema, followed by an open discussion seeking feedback from seminar participants

Coffee break

Szentimrey, T.: Some theoretical questions and development of MASH for homogenization of standard deviation

Lundstad, E., Stepanek, P., Zahradníček, P.: Long-term homogenised precipitation data sets for Norway

Motrøen Gjelten, H., Lundstad, E., Tveito, O. E.: Homogeneity testing of seasonal precipitation series in Norway

Lunch break

14:00 – 17:00 Homogenization and quality control

Chimani, B., Ganekind, M.: Differences in Climate Evolution Analyses depending on the choice o by homogenization method and time span

Shelton, K., Warren, S., Davis, R., Faulkner, D.: Homogenisation of daily station data in England and Wales

Squintu, A.: Homogenization of ECA&D temperature series

Coffee break

Vint, K., Keevallik, S., Meitern, H.: Inhomogenieties in Estonian air temperature series with CLIMATOL and HOMER

Yosef, Y., Aguilar, E., Alpert, P.: Comparison of different daily adjustment methods for the maximum and minimum temperature in Israel

Mateus, C., Potito, A., Curley, M.: Digitisation and homogenisation of the long term daily (max/min) summer and winter air temperature records in Ireland

WEDNESDAY, 05 APRIL

9:00 – 12:00 Homogenization and quality control

Rustemeier, E., Kapala, A., Meyer-Christoffer, A., Finger, P., Schneider, U., Venema, V., Ziese, M., Simmer, C., Becker, A.: HOMPRA Europe - A gridded precipitation data set from European homogenized time series

Zahradníček, P., Petr, S.: Homogenization of the wind speed time series in Czech Republic

Rasol, D.: Modernisation of Croatian Meteorological Measurements Network

Coffee break

Bertrand, C., Journée, M.: Data QC within the Belgian synoptic and climatological networks: an overview

Michel A, P.: A machine learning perspective towards fully automated quality control in daily weather time series

Delvaux, C.: Quality Control and Homogenization of the Belgian Historical Weather Data

Lunch break

14:00 – 15:20 Homogenization and quality control

Graw, K., Schröder, M., Andersson, A., Kinzel, J., Fennig, K., Hollmann, R.: Stability of satellite based climate data records (CDRs) retrieved by CM SAF

Van Malderen, R., Pottiaux, E., Klos, A., Bock, O., Bogusz, J., Chimani, B., Elias, M., Gruszczynska, M., Guijarro, J. A., Zengin Kazancı, S., Ning, T.: The homogenization of GPS Integrated Water Vapour time series: methodology and benchmarking the algorithms on synthetic datasets

Schröder, M., Lockhoff, M., Shi, L., Graw, K.: The GEWEX water vapor assessment (G-VAP) – results from inter-comparisons and stability analysis

Coffee break

15:40-17:00 Spatial interpolation, gridded datasets

Szentimrey, T.: New developments of interpolation method MISH: modelling of interpolation error RMSE, automated real time Quality Control

Peña-Angulo, D., Celia, S. S., Rodrigues, M., Azucena, J. C., Brunetti, M., González-Hidalgo, J. C.: Comparison of different interpolation methods for the generation of a climatology with maximum and minimum monthly temperatures

19:00 – Seminar banquet

THURSDAY, 06 APRIL

9:00 – 12:00 Spatial Interpolation, gridded datasets

Isotta, F., Begert, M., Frei, C.: Temperature and precipitation grid datasets for climate monitoring based on homogeneous time series in Switzerland

Frei, C., Isotta, F.: Uncertainty in the interpolation of daily precipitation – Insights from an ensemble analysis for the Alps

Lussana, C., Tveito, O. E.: Nordic gridded climate data set, status and plans

Coffee break

Tveito, O. E, Lussana, C.: Ensemble approaches to assess uncertainties in observation gridding

Rehfeldt, K., Kolbe, C., Ziese, M., Rustemeier, E., Krähenmann, S., Becker, A.: Comparison of Three Interpolation Schemes for Six Parameters

Kveton, V: Experiences with snow level estimation for spatial analyse of new snow depth based on precipitation data

Lunch break

14:00 – 17:00 Spatial interpolation, gridded datasets

Mamara, A., Anadranistakis, M., Argiriou. A. A.: Homogenization and gridding of the Greek time series

Petrović, P.: Comparison of Gridded and Observed Temperature and Precipitation Episode Series: A Case Study

Bihari, Z., Szentimrey, T., Kircsi, A.: Some details about the theoretical background of CarpatClim – DanubeClim gridded databases and their practical consequences

Coffee break

Lakatos, M., Szentimrey, T., Izsák, B., Hoffmann, L.: Comparison of E-OBS and CARPATCLIM gridded datasets of minimum temperatures, maximum temperatures and precipitation by Analysis of Variance (ANOVA)

Dobi, I.: Comparison of monthly satellite, modelled and in situ surface radiation data over Hungary

Höpp, S., Rauthe, M., Deutschländer, T., Krähenmann, S., Hänsel S.: Developing a gridded data set of global radiation covering Germany and its neighbouring river catchment areas

FRIDAY, 07 APRIL

9:00 – 12:00 Software Presentations

Domonkos, P.: Software ACMANT3

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

10:30 – 11:00 coffee break

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

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

This session is still open please to inform us in case of intention to present any homogenization or QC or interpolation software!

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Fioravanti, G.: A national dataset of temperature and precipitation daily series for Italy

Guijarro, J. A.: Daily series homogenization and gridding with Climatol v. 3

Kajaba, P., Bochníček, O., Mikulová, K.: Climate Atlas of Slovakia

Josipa K., Lasta, S.: Overview of Parallel Meteorological Measurements in Croatia

Venema, V., Auchmann, R., Aguilar, E., Auer, I., Azorin-Molina, C., Brandsma, T., Brunetti, M., Delitala, A., Dienst, M., Domonkos, P., Erell, E., Gilabert, A., Lin, X., Lindén, J., Lundstad, E., Milewska, E., Nordli, O, Prohom, M., Rennie, J., Petr, S., Trewin, B., Vincent, L., Willett, K., Wolff, M: A global database with parallel measurements to study non-climatic changes

Weissenberger, A., Rasol, D., Andreis, H. L.: Temperature series quality analysis based on the number of corrected values

ABSTRACTS

Evaluation of the Impact over temperature series of the transitions between observation systems (IMPACTRON)

Enric Aguilar[1], **Jesús Asín**[2], **César Azorín**[3], **Alba Gilabert**[1], **José Antonio Guijarro**[4], **José Antonio López-Díaz**[5], **Marc Prohom**[6], **Domingo Rasilla**[7] **and Germán Solé**[8]

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In the framework of the network IMPACTRON (CGL2015-70192-REDT), funded by the Spanish government, a group of Spanish scientists is working on understanding the impact of the transitions in air temperature series.

We define a transition as a change between observing systems involving a large part of an observation network, and having an impact over the derived time series, which is difficult to adjust with relative homogenization approaches. IMPACTRON has identified three transitions affecting the Spanish climate records: (i) the transition from open stands to Stevenson screens (which occurred between the last decade of the XIX century and 1920); (ii) the transition from the city centers to aviation fields or airports, clustered in two periods, 1940s and 1970s; and (ii) the replacement of manual observatories by AWSs, initiated in the late 1980s and still ongoing. The network has been working in documenting those transitions and locating parallel measurements during the last year.

In this contribution, we present and describe the biases introduced by the selected transitions, based on the set of statistics recommended by the Parallel Observations Scientific Team (POST, ISTI), and discuss the result of the application of different approaches to adjust daily maximum and minimum air temperature series.

Some details about the theoretical background of CarpatClim – DanubeClim gridded databases and their practical consequences

Zita Bihari, Tamás Szentimrey, Andrea Kircsi
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A daily gridded database was established for the Carpathian Region and later for some additional areas in the Danube catchment area (1961-2010, 0.1° spatial resolution, 16 variables). Considering the strict data policy of participating countries, the homogenization – gridding procedures were executed on national level, but applying the same MASH (Multiple Analysis of Series for Homogenization; Szentimrey) and MISH (Meteorological Interpolation based on Surface Homogenized Data Bases; Szentimrey and Bihari) methods and with near border data exchange. Finally the national grids were merged in one common grid.
The essential results of the calculations are the gridded data series but in addition the applied MISH method has other benefits derived from the theoretical structure of the algorithm. MISH consists of two parts: the modelling and the gridding subsystems. The modelling part based on the spatiotemporal data determines the necessary statistical parameters (spatial trend, covariance structure) for the interpolation, gridding procedure, resulting some parameter files. One of the main advantages of MISH is that this modelling process has to be done only once. It means in the practice that an extension of the CarpatClim – DanubeClim data series either in time or for other grid resolution can be realised easily because the statistical parameters are already calculated.

Comparison of different interpolation methods for the generation of a climatology with maximum and minimum monthly temperatures

Dhais Peña-Angulo[1-2], Celia Salinas Solé[1-2], Marcos Rodrigues[1-2], Azucena Jiménez Castalleda[1], Michele Brunetti[3], José Carlos González-Hidalgo[1-2]

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This study presents a new climatology of high spatial resolution for average monthly maximum and minimum temperatures in mainland Spain. This new climatology has been generated using information from archieves of the Spanish State Meteorological Agency (AEMet), after carrying out a quality control and reconstruction process with the original data.

In order to obtain a high spatial resolution grid, different interpolation methods are compared. From this comparison it is observed that the Local Weithing Lineal Regression (LWLR) is the most optimal solution (Brunetti et al. 2014). The LWLR uses a local interpolation considering geographic variables (altitude, orientation, latitude, longitude, slope and distance to the coast), and it estimates temperatures based on a linear regression model. Compared to other tested methods (namely the Regression Kriging and the Regression Kriging with stepwise methods), LWLR provides the best results when applying a crossvalidation procedure both in terms of the obtained spatial variability (with different altitudes) and temporal variability (along all months).

The final results are presented with a monthly high-resolution cartography (~1 Km latitude) of the averages of maximum and minimum temperatures. The results generated are expected to provide a valuable resource to other research fields.

DATA QC WITHIN THE BELGIAN SYNOPTIC AND CLIMATOLOGICAL NETWORKS: AN OVERVIEW

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The presentation will provide an overview of the ground surface networks managed by the Royal Meteorological Institute of Belgium (RMI) and the quality control (QC) processes implemented at the various stages.

No measuring technique is perfect and errors can occur in meteorological observations for a wide variety of reasons, the most common being instrument faults, observer errors, errors in data transmission and clerical error in data processing. A distinction is drawn here between short term issues which affect observations over a finite period (most commonly a single observation, but sometimes persisting over several days or weeks) and longer term influences on a climate record (inhomogeneities) which are not considered here.

From a previously purely manual and time-consuming QC system, the QC procedures are being automated and additional information such as derived from meteorological radars or satellite imageries are progressively integrated in the system. The purpose of this automated data screening is to objectively identify abnormal data values for subsequent review by an experienced data analyst. The review is necessary to determine whether an anomaly results from a problem with instrumentation or whether it accurately reflects unusual meteorological conditions.

Differences in Climate Evolution Analyses depending on the choice o by homogenization method and time span

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HISTALP is a database for longterm homogenized climate data in the Alpine region. It consists of about 200 stations and several parameters. The data are used in numerous scientific publications concerning climate and climate change. The dataset was first published in 2007. Due to improvements of the homogenisation methods and the meanwhile available additional most recent years of data included into the HISTALP-Dataset, a new homogenization run was done. The presentation will provide some basic information on HISTALP, compare the two homogenization methods (HOCLIS and HOMER) and show some analyses of the homogenization results. A first comparison of the two resulting datasets and resulting differences in the climate evolution will be shown.

Quality Control and Homogenization of the Belgian Historical Weather Data

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Thanks to a recent digitization project (data from 1880 to 1950), time series of daily temperature and precipitation data are now available since 1880 for a number of climatological stations in Belgium. Before analysing the climate change, two steps are necessary to have reliable data : the data quality control and the data homogenization.

For the data digitization (1880-1950), classical quality control procedures were not suitable because of the overall low data quality, the low data density, the uncommon errors and the lack of metadata. Specific test procedures have been developed to identify the typical and the most frequent errors of the digitization which can be of a wide variety. When it was possible, the mistakes in data digitization were corrected. This work allowed to create corrected and consistent 'long series' from 1880 to nowadays with a reasonable level of quality. In addition of that project, 'short series' have been created from 1950 to nowadays. For the long and the short series, standard quality control procedures have been applied in order to provide a quality index (validated, suspicious or corrected) to each daily data of precipitation and temperature.

The homogenization of the series is then carried out to remove the non-climatic factors affecting the meteorological records. To do this, the HOMER software is used. The process is ongoing for the temperature data (short series and long series) and will be soon started for precipitation.

Comparison of monthly satellite, modelled and in situ surface radiation data over Hungary

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Knowledge of accurate surface incoming solar radiation is important for both climate studies and solar power applications. Three kind of radiation data sets are available for Hungary: satellite data from EUMETSAT Climate SAF, modelled data from CarpatClim project, and in situ surface observations. The aim of this paper to compare this parallel sets of data and to determine their accuracy.

Satellite retrievals give high resolution data in space and time. The longest radiation data set dedicated for solar application for Europe is the Surface Solar Radiation Data Set - Heliosat (SARAH) developed by EUMETSAT Climate SAF. This includes a satellite-based climatology of the solar Surface Incoming Shortwave radiation (SIS) from 1983 to 2013 with a spatial resolution of 0.05° x 0.05°.

The other source is the outcomes of the CarpatClim Project (http://www.carpatclim-eu.org/) which produced uniformly harmonized and interpolated gridded climate data set for the whole Basin. Carrying out the project was based on the data homogenization method MASH (Multiple Analysis of Series for Homogenization,) and the interpolating method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis). Monthly meteorological data are available in 0.1° spatial resolution from 1961 to 2010. The monthly global radiation characterizing the incoming solar energy is one of the 53 parameters. In absence of long-range surface global radiation data, it was used sunshine duration calculated by Ångström and Prescott methods.

Remote sensed and modelled data sets are validated with set of eight surface measurements (OBS) from the network of Hungarian Meteorological Service. Comparisons were made by pairs of data sets between 2001 and 2010. The Mean Absolute Difference between parallel data set are between 5.5 and 5.5 W/m2, anomaly corrections are above 0.9 in all cases.

Time series homogenisation with optimal segmentation and ANOVA correction: past, present and future

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A bit more than 40 years ago, US statistician Douglas M. Hawkins found out the dynamic programming algorithm for the fast identification of the optimal segmentation among all possible segmentations of a time series. That was an important step towards the feasible and mathematically correct solution of multiple change point problem.
Nowadays two homogenisation methods are based on this technique: one is the COST ES0601 (HOME) recommended interactive method, HOMER, and the other is the fully automatic ACMANT, which also received good critics during HOME and later.
In the presentation we recall the past development of this methodology, analyse the still existing related problems with higher focus on ACMANT, as its creator is the same as the author of the presentation.
In 2016 the third generation of ACMANT software package "ACMANT3" was published. Its improvement relative to earlier versions will be briefly discussed along with some ideas of possible future developments.

A national dataset of temperature and precipitation daily series for Italy

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We report on the development of a new dataset of daily observations of temperature (maximum and minimum) and precipitation for Italy. The purpose is to provide final users a databank of daily series and derived products with consistent format, checked through standardized quality control routines. The data were retrieved from several sources, ranging from the national synoptic network to the regional meteorological, agrometeorological and hydrographic networks. The HIS Central hydrological catalogue is the main source of the historical data series, previously available only in hard copy.
The daily data were quality checked with absolute (basic integrity checks, outlier tests, internal and temporal consistency checks) and relative (spatial) controls. The routines were written in R and implement the quality procedures described by Durre et al. (2010) for the Global Historical Climatology Network (GHCN)-Daily dataset. In order to avoid data degradation, the quality algorithms were carefully tested and the test thresholds properly tuned. As most of the data sources underwent quality controls at the home institutions, a low percentage of erroneous value was detected. Nonetheless, these controls allowed to identify systematic errors (e.g, switch of tmax and tmin series), bad coded missing observations, sequences of repeated values and so on. The spatial controls (regression and corroboration tests) for temperature series were particularly effective in identifying anomalous values not detected by the absolute methods. Because of the its high spatial variability, automated spatial controls were not applied to precipitation series.
The homogeneity of temperature and precipitation series was firstly assessed using the method proposed by Wijngaard et al. (2003), based on four absolute tests: the Standard Normal Homogeneity test, the Buishand Range test, the Pettitt test and the Von Neumann ratio test. This step was useful to identify obvious inhomogeneities, especially in areas with low density of stations. As absolute methods can worsen the series, no adjustment attempt was made.
The homogenization of monthly and daily data is still a work in process. At this purpose we are testing two methods based on the recommendations of the HOME Cost Action (Venema et al., 2012): HOMER (HOMogenization softwarE in R, Mestre et al., 2013) and SPLIDHOM Mestre et al., 2011).
Part of the daily dataset is already available through the national system of climate data SCIA (www.scia.isprambiente.it). As an example of its application, the set of “useful” series identified through the Wijngaard's approach has been used to produce WMO-standard precipitation normals, recently included into the WMO RCC RA VI national products. Finally, the SCIA daily dataset represents a relevant source for the calculation of WMO-CCl indices of temperature and precipitation extremes for Italy.

Uncertainty in the interpolation of daily precipitation – Insights from an ensemble analysis for the Alps

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With increasing spatial and temporal resolution, gridded climate datasets must be expected to become in a degree erroneous (uncertain) that may be relevant in practical applications. Proficient use of such datasets, therefore, calls for quantitative information about uncertainties. The traditional method for uncertainty estimation, cross-validation, is of limited value. It delivers summary statistics that may, or may not be representative for a concrete use case. Moreover, it is valid strictly at the point scale, whereas the datasets are commonly interpreted at a larger support (e.g. the average over a gridbox).

In this study, we propose a probabilistic spatial analysis of daily precipitation that delivers an ensemble of equally probable realizations, capable of describing uncertainties explicitly on a day-by-day basis, in relation to local rain-gauge density, and as a function of the spatial support (averaging scale). The method was developed within project UERRA (FP7, Uncertainties in Ensembles of Regional ReAnalyses) and is applied, with data from several thousand rain gauges, in the entire Alpine region. Our presentation shall introduce the ensemble technique, illustrate its application, test its reliability, and discuss some findings from our application.

The results point to remarkable variations in the uncertainty of precipitation analyses. It is larger for convective compared to stratiform conditions, not merely as a seasonal pattern, but clearly between individual days. There are cases when the ensemble spread for a 20x20 km^2 area mean precipitation is more than a factor of 5 even for intense precipitation (> 10 mm per day). In other cases, at a similar intensity, the uncertainty is smaller than a factor of 1.5. Generally, the spread of our probabilistic ensemble is found to be considerably larger than that of a "multi-model" ensemble using different deterministic interpolation methods, suggesting that comparison of methods alone bares little information on true uncertainty. One key advantage of a probabilistic analysis is that users can trace uncertainties through their applications. We will illustrate this by deriving uncertainty measures for classical climate indices and at various space scales. Obviously, this offers much more robust observational information for the evaluation of climate models than is available from deterministic datasets.

Homogeneity testing of seasonal precipitation series in Norway

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Long-term high quality time series are crucial in climate analyses. However, long-term series are often inhomogeneous, that is, containing artificial shifts and trends due to changes in instrumentation, observation practices or environment. To account and adjust for such shifts, homogenization procedures have been developed.

At the Norwegian Meteorological Institute a homogeneity analysis of precipitations series of length > 80 years from about 250 stations has started. The series are tested on a seasonal basis using primarily the software MASH, but other softwares such as HOMER will also be used for comparison.

A previous homogeneity analysis of 165 precipitation series was performed in the early 1990s, then using the SNHT-method. There have been many changes in the station network since then. In particular many automatic weather stations have been introduced and replaced old manual stations in the network. There has also been a development in homogenization methods since then. It is therefore important to perform a new analysis.

Stability of satellite based climate data records (CDRs) retrieved by CM SAF

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Reliable and high-quality long term climate data records (CDRs) are of fundamental importance for the analysis of climate variability and change. To enhance the availability of high-quality long term climate data sets the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) provides satellite-derived geophysical parameter data records of currently nearly 30 years suitable for climate monitoring. Parameters based on remote sensing offer global scale and continuous coverage.

To analyze climate variability and change the measured satellite data need to be homogeneous over several decades and should not contain artificial heterogeneities masking natural trends. Abruptly appearing mean value instationarities or sudden variance changes can occur for example due to instrument changes or due to changes in orbit characteristics.

The recent fundamental climate data record (FCDR) provided by CM SAF and available at http://www.cmsaf.eu/EN/Products/DOI/Doi_node.html among other CDRs contains carefully inter-calibrated brightness temperatures (TBs) from the instruments SMMR, SSM/I and SSMIS aboard various satellites of the Defense Meteorological Satellite Program (DMSP). This FCDR facilitates the derivation of essential climate variables (ECVs) eligible for the analysis of climate variability in a homogeneous way.

This presentation will demonstrate the long-term temporal stability of CM SAF CDRs and the method used to derive the decadal stability of monthly mean gridded parameters derived over the global ice free ocean. In addition the spatial differences to independent and partly independent reference data sets will be presented. The results highlight the need for reliable and high quality global reference data.

Comparison of homogenization packages applied to monthly series of temperature and precipitation: the MULTITEST project

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The MULTITEST project, funded by the Spanish Ministry of Economy and Competitiveness, aims at comparing the results of several publicly available homogenization packages for monthly synthetic series of temperature and precipitation. This intercomparison exercise is launched to update the successful COST Action ES0601 (HOME), since many methods have improved their algorithms after the Action's conclusion. However, in order to base the comparisons on a high number of tests, only computer packages that can be run automatically have been tested.

The synthetic databases consists of three master temperature networks of 100 series containing 720 values (equivalent to 60 years of data). They are built with different degrees of cross-correlations between them in order to simulate a range of station densities or climatic spatial variabilities. Also three other similar master networks were developed with precipitation values, this time simulating the characteristics of three different climates: Atlantic temperate, Mediterranean and monsoonal.

From each of these six master series, 100 samples of 10 series each were extracted. After inserting inhomogeneities the homogenization programs were applied to them. Their resulting homogenized series were compared with the original homogeneous series by computing Root Mean Squared Errors and trend biases. The tested computer packages were: ACMANT 3.0, Climatol 3.0, MASH 3.03, RHTestV4, USHCN v52d and HOMER 2.6.

In a first stage, inhomogeneities were applied to the synthetic homogeneous series. We used five different settings with increasing difficulty and realism:

i) big shifts in half of the series;
ii) the same with a strong seasonality;
iii) short term platforms and local trends;
iv) random number of shifts with random size and location in all series; and
v) the same plus seasonality of random amplitude.
The shifts were additive for temperature and multiplicative for precipitation.

A second round was done with increasing number of series in each sample (20, 40 and 80), to check the influence of varying network sizes. More tests will be performed with seasonalities other than sinusoidal, and with simultaneous shifts in a high proportion of series. Finally, tests will be performed on a longer and more realistic benchmark, with varying number of missing data along time, similar to that used in the COST Action ES0601.

Although some of the packages were tested with different settings, not all their capabilities could be tested. These benchmarking experiments are therefore mostly intended to test the performance of the programs in their default configurations and better results may be obtained with a careful tuning of the settings for every problem network. These intercomparisons will be valuable not only for users, but also to the developers of the tested packages, who can see how their algorithms behave under varied climate conditions.

Small scale surface heterogeneities and impact on station relocations

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The department of physics of the University of the Balearic Islands is leading the project ATMOUNT, aiming at studying the influence of topography on atmospheric and surface variables, but these also present some variability on relatively flat terrain due to the heterogeneity of the surface. In order to assess this surface variability, an observing site is maintained at the Campus consisting in a standard automatic weather station (AWS) plus other micro-meteorological instrumentation, and nine secondary sites observing air temperature at 1 and 2 m heigth and at a mean distance of 200 m between them. This observing network is complemented with another AWS operated by the Spanish Meteorological Agency which is located at a similar distance.

Although the simultaneous records of this high density experimental network covers 42 days only days (from June 16 to July 26 of 2016), this period is characterized by a high solar radiation and low to moderate wind, and therefore provide a unique set of data to study the spatial climatic heterogeneity in a Mediterranean site. Absolute daily temperature differences between the sites range between 0.02 and 1.57 °C with an average of 0.53 °C for maximum temperature and from 0.03 to 3.61 °C with an average of 1.35 °C for the minimum.

The differences do not show a dependence on the distances between sites. Dependences on daily temperature range (DTR), mean relative humidity (RH) and daily wind run (WR) have also been checked, with significant results only for the minimum temperatures on DTR and RH.

These differences between sites located at such short distances illustrate the changes expected in summer in the case of small scale relocations, which many times would be thought to have a negligible effect on the temperature series. Therefore, the need to document any changes in the observing conditions and locations of the stations will never be stressed enough.

The impact of transitions between different thermometric screens and between conventional and automatic observations on the temperature series in Spain is the object of study of the research net IMPACTRON, leaded by the University of Tarragona, and the assessment of these small scale variability will serve to quantify the uncertainty in the attribution of the temperature differences caused by those transitions when the parallel measurements have not been taken in exactly the same location.

Daily series homogenization and gridding with Climatol v. 3

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POSTER
The need to homogenize observational series before its use to assess climate variability emerged long time ago. Efforts were initially focused on annual, seasonal and monthly series, and the successful COST Action ES0601 allowed the exchange of ideas between homogenization specialists and the improvement of the their methodologies. But now the stress is put on the homogenization of daily series, since the study of the variability of indexes and extreme values depends on them. The new version 3 of the R Climatol package (Guijarro, 2016) provides functions to facilitate the homogenization of climatological variables at any temporal scale, as long as the data in the series may be considered synchronous (which is doubtful in the case of sub-daily data).

A further improvement incorporated in this version has consisted in enabling the use of the break points detected at the monthly scale to split the daily series into their homogeneous sub-periods, which are then reconstructed by means of a missing data attribution algorithm, thus avoiding the problems previously encountered when trying to interpolate monthly corrections into daily series of variables with a strong bias in their frequency probability distribution. More over, the missing data estimation is based on the Reduced Major Axis (RMA) regression model, which when both the dependent (y) and independent (x) variables are standardized can be expressed as $\hat{y}=x$, and therefore do not experiment the reduction of the dependent variable variance that happens in the Ordinary Least Squares regression $\hat{y}=r{\cdot}x$ when the correlation coefficient (r) is significantly lower than 1. Another important advantage of the RMA regression is that it can be applied even when there are no common observation period between the stations, therefore allowing the use of short nearby series.

Another novelty of this version is a function that allows the automatic generation of grids from the homogenized series, which are saved in NetCDF format, also in normalized form. Grids of means and standard deviations are also produced that can be used to unstandardize the daily or monthly grids, but the suggested procedure for this is to generate better rasters of means and standard deviations through geostatistic procedures, introducing the effects of orography and other geographical features that modify the spatial distribution of climatic variables.

Analysis of the impacts of the automatization of measurement systems using parallel measurements from German Climate Reference Stations

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Meteorological parameters were measured systematically since a long time. During this time, measurement systems were changed for example from manual observations to automatic measurements. Changing the measurement system can potentially affect the homogeneity of time series. To study the effects of the automatization of measurements, the German Meteorological Service (Deutscher Wetterdienst) operates parallel measurements at Climate Reference Stations since 2008. Observed meteorological parameters are air temperature, extreme temperatures, soil temperature, air pressure, relative humidity, sunshine duration, and precipitation. This presentation shows first results of the statistical analysis of the differences between the measurement systems and their effects on the homogeneity of time series.

Underpinning Climate Services

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The provision of climate services is among the key priorities of WMO and partners. Building capacities for efficient climate service generation requires basic capabilities in collecting and processing climate related data and information. WMO's Commission for Climatology coordinates and assists in a multitude of activities to underpin climate services including data rescue, Climate Data Management Systems (CDMS), climate data management practice, definition and generation of climate (extremes) indices, homogenisation practices, use of remote sensing data for climate monitoring etc. The talk will provide examples of recent achievements as well as work in progress, such as guidelines, tool developments and project implementation. Keywords of the talk include the International Data Rescue portal I-DARE, WMO CDMS specifications, Climate Services Information System (CSIS), definition of extremes, national climate monitoring products, homogenisation, centennial observing stations etc. Most of the above activities need, generate, support or relate to homogeneous time series and interpolated data fields.

Developing a gridded data set of global radiation covering Germany and its neighbouring river catchment areas

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Due to the increasing impact of climate change and related extreme events an enhanced resilience of transport infrastructure and operating traffic in Germany is required. The adaptation to the increasing impacts of climate change like for instance landslides, wind throw or floods is formalized in the German Strategy for Adaptation to Climate Change (DAS). To counter these negative impacts, the Federal Ministry of Transport and Digital Infrastructure (BMVI) founded a comprehensive national research program on safe and sustainable transport in Germany (www.bmvi-expertennetzwerk.de). Several participating research institutes and agencies operate as a network between science and practice, with the goal of providing effective knowledge transfer and advice for decision makers in government and industry.
One topic of this project is the "Adaptation of the German transport infrastructure towards climate change and extreme events". The examinations are performed by using data of regional climate models (RCM) as well as impact model scenarios to develop suitable adaptation strategies. To adjust biases of RCM data and quantify the impact of climate change a well defined climatological reference is needed. Thus the GermanMeteorological Service provides gridded reference data sets from station data relevant for hydrological applications in high spatial (5 km) and temporal (daily) resolution from 1951 to 2010. For this, the HYRAS data (hydro meteorological gridded data set), developed by the German Meteorological Service within the research program KLIWAS (www.kliwas.de) and already available for precipitation, mean temperature and relative humidity, will be revised and extended by additional parameters like global radiation, minimum and maximum temperature.
The presentation will consist of two parts to demonstrate the current status of the gridded reference data in the project: Part one will show a short outline of the existing HYRAS data set and its gridding methods. Part two will give an overview of the database of global radiation, the method to enhancethe spatial station distribution with sunshine duration data (Ångström relationship) and the basic approach of the gridding method ofglobal radiation.
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Temperature and precipitation grid datasets for climate monitoring based on homogeneous time series in Switzerland

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The lack of long-term climate consistency is a frequent caveat of currently available grid datasets. Changes in the density of station networks over time, together with inhomogeneities in the underlying station series jeopardize their utility for climate monitoring and the analysis of long-term trends.

In this study we present a methodology to derive a monthly grid dataset for Switzerland, dating back as far as 1864, and targeted for applications with a need in long-term consistency. To this end, data is incorporated from a non-varying station network that includes only series that have been carefully examined and corrected for inhomogeneities and extend over the whole time period. The restrictive selection results in a very coarse station density (average spacing 40-80 km). To recover spatial patterns not explicitly resolved by the stations, we combine the measurements with statistical information from a high-resolution temperature/precipitation analysis over a limited recent period and from a much denser station network. For this purpose, RSOI (reduced space optimal interpolation) is adopted, a combination of Principal Component Analysis and Optimum Interpolation.

We demonstrate – for the mountainous region of Switzerland – that the technique can remedy artifacts common to interpolation with variable station densities and that it is capable to reproduce more spatial detail than simple interpolation from the coarse high-quality stations only. We also investigate to what extent spatial variations in long-term temperature trends can actually be reproduced by gridding. This is a critical test for assessing the utility of long-term grid datasets for trend analysis.

Overview of Parallel Meteorological Measurements in Croatia

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POSTER

Meteorological stations network of the Meteorological and Hydrological Service of Croatia (DHMZ) consists of automatic weather stations (AWS) and conventional stations. Most of them are situated at the same location, but as in many other places and countries, some AWS are the only source of surface observations at the sites which are inhospitable or difficult to access. Also, for manned stations, AWS provide data outside the crew's working hours as well as measuring and reporting with higher frequency. This is why it is important to have both conventional and automatic measurements at a location. In Croatia, there is a large number of stations with more than 5 years of parallel measurements of air temperature, relative humidity, wind and precipitation. These parallel measurements will enable us to compare data and eliminate non-climatic factors.

In our stations network, AWS report the objective elements of air and soil temperature, relative humidity, wind (speed and direction), pressure, global and diffuse irradiance, sunshine duration, UVB radiation, precipitation, etc. Data measured at these stations are stored as 10-minute records in internal memory at the location. These records are switched through the GPRS or GSM connections to the pooling computer at the MHSC headquarters, where they are used in real time (raw data) for inputs in local area numerical model (ALADIN), and stored for quality control (to be done at the end of each month). QC consists of logical control (contradiction of coexistence), internal checking (consistency with previous measurements and weather situation at the time), and spatial control.

All of these are mostly subjective methods, i.e. it is left for the individuals to decide whether some data is acceptable or not. Spatial control is often done through comparison with nearby conventional stations, but there isn't any form of systematic comparison.

Some basic comparison of temperature datasets from AWS and conventional stations were done for several locations and the results are shown here.

Keywords: meteorological measurements, automatic weather stations

CLIMATE ATLAS OF SLOVAKIA

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POSTER

The Climatological service of the Slovak Hydrometeorological Institute successfully finished the project “The development of spatial data processing technologies of climate system“. One of the results of this project was also a new Climate Atlas of Slovakia. This Atlas is a comprehensive cartographic work which contains 175 maps of climatological elements and characteristics and over 200 graphs and tables as an additional source of spatial and temporal information. Graphical information is supplemented by texts in Slovak and English.
In the Climate Atlas of Slovakia there are processed characteristics of air temperature, atmospheric precipitation, snow cover, humidity, evaporation, sunshine, cloudiness, global radiation, air pressure, wind, soil temperature and some of dangerous meteorological phenomena. Further characteristics of the upper layers of the atmosphere and selected phenological characteristics in Slovakia supplement the basic climatological parameters.
There are some variables were homogenized by the MASH v3.03 method (T.Szentimrey). This program enables to homogenize monthly as well as daily data series and also to fulfill limited data gaps. The measurements from 75 temperature, 500 precipitation measuring stations and next chosen elements had to be homogenized this software, which required adequate software for an automatic implementation of the needed steps.
The following tree meteorological elements were selected to make presentation for ilustratuion.
The air temperature was homogenized for period 1961-2010 for 75 time series. Next element was relative humidity. The measurements for period 1961-2010 from 62 meteorological stations which met the homogenization criteria. In the analysed period the 1981-2010 the number of 500 precipitation time series with a length of 30 years has been available from the precipitation station network of SHMI, which were homogenized using MASH software.
In this presentation we show these results of Climate Atlas of Slovakia.

Experiences with snow level estimation for spatial analyse of new snow depth based on precipitation data

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Department of General Climatology of the Czech Hydrometeorological Institute issues special winter road maintenance index since 2004. Knowledge of new snow depth is essential for computation of this index. But, new snow depth values are in CHMI's central database available around 10th of the next month for all stations measuring snow data. During actual month snow values are available from limited stations (so called "INTER" stations), only. This can lead to discrepancies between results of preliminary and final spatial analysis of daily snow depths. Department of general climatology of CHMI realizes preliminary spatial analysis of new snow depth based not only on measured snow data but using precipitation totals from automatic weather stations and snow level estimation, too. This presentation shows contemporary stat of these analyses.

Comparison of E-OBS and CARPATCLIM gridded datasets of minimum temperatures, maximum temperatures and precipitation by Analysis of Variance (ANOVA)

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Gridded climate data derived from measurements of meteorological stations are used in climate research, validation of global and regional climate models, in many applications in climate change impacts assessments and derivation of different climate products. Several observational datasets are available to provide background for climate studies and for derivation of climate information for a specific area.

Gridded data sets derived through interpolation of station data. A high-resolution gridded data set of daily climate data over Europe E-OBS is based on the largest available pan-European data set. The E-OBS gridded data set was derived through interpolation of the ECA&D (European Climate Assessment and Data) station data. One of the source of uncertainty of a gridded data is related to the available station data and the other is the interpolation method were used for estimation of the grid values from the underlying station network.

Beside the pan European datasets a high resolution climate dataset is available for the Carpathian Region. The CARPATCLIM (2013) dataset consists of a 0.1° spatial resolution homogenized (MASH, Szentimrey), harmonized and gridded (MISH, Szentimrey and Bihari) dataset on daily scale for basic meteorological variables and several climate indicators, 37 in total, on different time scales from 1961 to 2010. The area of CARPATCLIM partly includes the territory of the Czech Republic, Slovakia, Poland, Ukraine, Romania, Serbia, Croatia, Austria and Hungary. 415 climate stations and 904 precipitation stations were homogenized and interpolated to a grid covering the Carpathian Region.

In this paper the statistical properties of the CARPATCLIM and E-OBS gridded datasets are compared for the Carpathian Region on different time scales. In this work the seasonal, annual average maximum temperatures, minimum temperatures and precipitation sums are examined for the overlapping regions of E-OBS and CARPATCLIM in the period of 1961-2010. For the comparison of these datasets we applied the general statistical methodology of Analysis of Variance (ANOVA). This methodology can be used and developed effectively for the characterization of the statistical properties of several spatiotemporal datasets like CARPATCLIM and E-OBS. Station data or gridded datasets with different spatial resolution can be compared by analysing the spatiotemporal means and variances. This methodology also has been built in the modelling part of method MISH in order to evaluate the modelling results.

Nordic gridded climate data set, status and plans

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The Norwegian Meteorological Institute has provided daily gridded observation products since 2004. Within the FP7 UERRA project the analysis domain has been extended to cover the entire Fennoscandia and the new dataset has been named Nordic Gridded Climate Dataset (NGCD). Currently, the two operational gridding systems at MET Norway have been applied to establish NGCD experimental datasets for daily mean temperature and daily precipitation sums covering the period 1981-2010 on a grid having 1x1 Km spacing. The dataset is based on input from ECA&D and the MET Norway climate database (eklima.met.no). The NGCD main objective is to allow evaluation and uncertainty assessment of regional reanalysis output by means of high-resolution conventional climatological dataset in Fennoscandia.

In the future we plan to extend the data sets to cover the period 1971 to present as a part of the planned operational C3S service C3Surf. The plans also include to extend the number of variables, e.g. daily minimum and maximum temperatures.

Furthermore, a Long Term Nordic Gridded Climate Dataser (NGCD_Rec) will be established in the context of C3Surf and in collaboration with MeteoSwiss, which has developed a similar dataset for the Alps. (The rest is taken from C3surf final proposal)

The NGCD_Rec will be a gridded dataset of monthly precipitation for the Fennoscandia with a grid spacing of 5 km and it will extend back into the first half of the 20th century, depending on available long-term high-quality station series in the region. NGCD_Rec is designed for users with a need in long-term time series and high standards in climate consistency. This dataset will be developed in C3Surf with the same methodological approach described in the previous paragraph for HISTALP_Rec.

Long-term homogenised precipitation data sets for Norway

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Homogeneity is important when analysing climatic long-term time series. This is to ensure that the variability in the time series is not affected by changes such as station relocations, instrumentation changes, changes in the surroundings etc.. The objective for this study is to establish methods and to homogenize monthly precipitation data in Norway.

The Norwegian Meteorological institute has developed a number of long-term homogenised climate data sets for Norway. The most prominent of these was for air temperature, which includes 231 stations in Norway with minimum length of 30 years in the years 1861 to 2010 (Andresen, 2011). In the past, this dataset was homogenized by means of AnClim and ProClimDB software. Another data set have been developed for precipitation. The standard normal homogeneity test was applied to 165 Norwegian precipitation series of 75 years or more (Bauer-Hansen & Førland, 1994). Of these series, 50 were found to be homogeneous, while 79 became homogeneous after being adjusted for a single inhomogeneity. In 2012, we have got back to the task of homogenizing precipitation in Norway again. We tested the series with Home.R, but the results obtained were not satisfying. One of the reasons was a lack of monthly adjustment factor. Then, we tried applying MASH. In this homogenization analysis we applied 248 Norwegian Precipitation Series of 80 years or more. In average, this gives a result of over 5 breaks per precipitation station. This was not quite right with the metadata. By the end of 2016, Pavel Zahradníček and Petr Stepanek tested the precipitation series with Home.R again (connected with other ProClimDB software functionality). It gave the results of 307 found breaks and 22 outliers.

In this seminar, we will discuss these data sets, the methods used in the development, and the different homogenization result.

THE HOMOGENIZATION OF GPS INTEGRATED WATER VAPOUR TIME SERIES: METHODOLOGY AND BENCHMARKING THE ALGORITHMS ON SYNTHETIC DATASETS

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Within the COST Action ES1206 “Advanced Global Navigation Satellite Systems tropospheric products for monitoring severe weather events and climate” (GNSS4SWEC), there was a clear interest and need to homogenize a worldwide Integrated Water Vapour (IWV) dataset retrieved with Global Positioning System (GPS), by correcting (artificial) break points due to e.g. instrumental changes. The first activity concentrated on a worldwide GPS dataset covering 100+ stations, with a homogeneous data processing from 1995 to March 2011. As at most of these stations, the ERA-interim reanalysis IWV field output correlates well with the IWV retrieved by GPS, the ERA-interim IWV time series are used as reference and the IWV differences between both sets are considered. The characterization of these IWV differences provided us with typical trend values, seasonal oscillations and noise models, to build a synthetic benchmark IWV dataset of differences. As a matter of fact, three different synthetic datasets have been generated, with different levels of complexity (w/o autoregressive noise, w/o gaps and trends), to assess the impact of these different factors on the performance of homogenization algorithms.

In this presentation, we will show the results of different homogenization algorithms on those 3 different sets of synthetic time series. We present their detection scores and compare the estimated trends (and uncertainties) from their homogenized time series with the true input trends. We analyze the sensitivity of each detection method w.r.t. the complexity of the synthetic datasets. Finally, an outlook of the future activities and a call for participating in our activity will be given.

HOMOGENIZATION AND GRIDDING OF THE GREEK TIME SERIES

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Weather observations are frequently exposed to artificial influences caused by station relocations, changes in the instrumentation, etc. introducing inhomogeneities. Data series of temperature, precipitation and sunshine duration were homogenized on a monthly time scale basis using the HOMER software, a recently developed method for homogenizing monthly and annual climate time series. The data sets cover a climatological normal period of 30 years (1971-2000) and come from the Hellenic National Meteorological Service station network, which is part of the WMO Global Observing System. The temperature data come from 52 meteorological stations and the sunshine duration data from 44 meteorological stations of the HNMS's network. The precipitation data come from 157 meteorological stations, 89 stations belong at the Public Power Corporation S.A. Hellas and 68 stations at the HNMS.

The homogenized derived data series were used to create a high resolution (0.0083333^ox0.0083333^o) gridded data set. The method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis) developed at the Hungarian Meteorological Service was used for the spatial interpolation of homogenized monthly values. The potential to use the elevation and the first 15 AURELHY principal components as temperature predicators was investigated. It was found that in the Mediterranean with an important coastline, the use only of elevation and the AURELHY variables cannot describe temperature. Additional topographical and geographical variables, namely the land to sea percentage and the expected solar irradiance are required. The results revealed that elevation, land to sea percentage and solar irradiance should be used as independent model variables. The work done revealed also that the east-west slopes seem to be associated with mean temperature during all months except between April to July. Also, latitude seems to affect mean temperature as well. Finally, north-south saddles were found to be related to mean temperature only during the winter months. Compared to previous climatologies, the proposed database has the following improvements: data are provided at a higher spatial resolution, temperature data were homogenized, improved geographical and topographical data were used, an interpolation method appropriate for meteorological parameters was applied and the statistical results of the observed versus predicted values were better.

Digitisation and homogenisation of the long term daily (max/min) summer and winter air temperature records in Ireland

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This research is the first to attempt data recovery, digitisation and homogenisation of all available summer and winter long-term instrumental daily maximum and minimum air temperature records since the beginning of meteorological observations in Ireland. The ten long-term records of daily meteorological observations, dating back to the 19th century, are one of the most complete daily time series in Ireland: Botanic Gardens (1848 - 2016), Phoenix Park (1831 - 2016), Armagh Observatory (1844 - 2016), NUI Galway (1861 - 2016), Markree Observatory (1875 - 2016), Birr Observatory (1872 - 2016), Roches Point (1872 - 2016), Valentia Observatory (1872 - 2016), Blacksod Point/Belmullet (1885 - 2016) and Malin Head (1885 - 2016).

It is an important project as most of the daily air temperature records have not been digitised prior to the 1940/50s, and existed in the original observations logs and scattered publications in extremely fragile journals and books stored in various archives across Ireland. The final homogenised series will be used in this PhD project to reconstruct past climate extremes such as heat and cold waves, extreme temperature indices, climate variability and temperature trend analysis.

In this work the maximum and minimum daily air temperature data and available metadata has been recovered and digitised. Gaps in records have been filled using data from other nearby stations. The Irish instrumental records are well-distributed with respect to different geographical influences on local temperatures, such as distance to the Atlantic Ocean, latitude or altitude and orography. In order to determine reference stations for each candidate station, Pearson correlation and first difference correlation coefficients (PETERSON and EASTERLING, 1994) have been calculated. Preliminary work has been carried out to determine the best method to homogenise the data on a daily basis. Due to time constraints and interest in constructing extreme temperature events, only summer and winter seasons have been digitised rather than the full annual series.

The aim of this presentation is to discuss the results of this preliminary study and share experiences of daily homogenisation.

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A machine learning perspective towards fully automated quality control in daily weather time series

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Quality control (QC) in weather time series is of fundamental importance since it increases data reliability and paves the way for more robust and accurate analyses. This process is usually performed by humans with certain degree of expertise and can be very time consuming. One of the main challenges of making it completely automatic is that errors present in the signals are difficult to distinguish from natural variations, in particular at daily data resolution level. Machine learning techniques have been extremely successful in finding complex patterns to solve a wide range of problems, especially where historical data or context plays an important role. Examples can be seen in stocks markets forecasting, Chess or Go adversarial games, multi-target tracking in surveillance systems, with outstanding results that exceed human capabilities. In this work, we present a machine learning perspective to the QC problem in daily weather time series. Our approach relies in historical raw and corrected data of a station and its neighboring peers, to train a machine learning model by "showing it" errors and corrections; once the training is complete, it is then used to predict corrections in newly/unseen raw data. This approach allows both detecting errors and correcting them with predicted values, which is a step towards fully automated QC systems. Preliminary experiments performed with min/max daily temperature records from Belgian climatological stations show encouraging results.

Comparison of Gridded and Observed Temperature and Precipitation Episode Series: A Case Study

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As a continuation of the CARPATCLIM project, the DanubeClim project extends gridded meteorological datasets towards south, covering the whole territory of Serbia. Additionally covered region features presence of short episode series in areas with sparse station network with long series. Due to their length, episode series are no suitable for use in the DanubeClim project.

With an idea of enhancing gridded datasets with additional input from more locations, an effort to include episode series into the present station network has been made. A comparison of temperature and precipitation series for the nearest grid point and the exact location of the episode series is performed on different temporal scales.

The results of the comparison reveal possibilities and limitations for including episode series into a long-term gridded series, especially taking temporal scales into account.

Modernisation of Croatian Meteorological Measurements Network

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Demands for the real-time weather data are growing in all fields of meteorology but especially in modelling, forecasting and alerting tasks. The Meteorological and Hydrological Service of Croatia (DHMZ) is about to start the project of Modernisation of Croatian Meteorological Measurements Network (METMONIC) funded by the European Regional Development Fund. The modernisation consists of automation of most surface stations, introduction of new upper-air measurements with a wind profiler and microwave radiometer at one location and a lidar at another location. The remote measurements are going to be improved with modernisation of existing weather radars and three new radars are going to be placed along the Adriatic coast. Oceanographic measurements will also be modernised with installation of four marine data buoys.

Modernisation of measurements will hugely increase the flow of data coming to the headquarters of DHMZ on daily basis, so the databases for storing and working with all the data should be improved. New sensors and measurements of meteorological elements that had never been measured before will require new methods of data management and quality control. Great challenges will appear in a few years as the new data should be merged with the old data series, but hopefully we will have enough metadata and parallel measurements for producing the climate data series of the highest quality.

Comparison of Three Interpolation Schemes for Six Parameters

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The European Commission has funded the Copernicus Emergency Management Service (EMS), which up to now includes the European Flood Awareness System (EFAS) and the European Forest Fire Information System (EFFIS). Within this framework, the Meteorological Data Collection Center (Copernicus MDCC) collects and processes data from European data providers and supplies regularly gridded and station related analyses as resulting input data for the EMS's EFAS and EFFIS. To identify the optimum interpolation scheme for the currently six EMS relevant parameters (precipitation total, maximum temperature, minimum temperature, mean vapor pressure, daily mean wind speed, daily total radiation) a comparison of three different interpolation methods using European station observation data on a daily basis covering May 2014 has been conducted. This month featured high precipitation amounts in some areas of Europe, especially in the Balkan states and Italy. Such periods of high precipitation amounts across topographically structured terrain are a challenge for interpolation schemes to represent the entire variability actually taking place, thus most suitable for the comparison. We compared Inverse Distance Weighting (IDW) (Ntegeka et al., 2013), SPHEREMAP (Willmott et al., 1985) and Ordinary Kriging (Krige, 1966). Furthermore, the uncertainty information of the gridded product is provided. A leave-one-out cross validation was utilized to assess the quality of the interpolation schemes and different error metrics were calculated, as they focus on different aspects of uncertainties. For this calculation we used the mean error (ME), the mean absolute error (MAE) and the mean square error (MSE) to compare the results of each method per parameter. The error metrics shows small differences between the three schemes and depends on the respective parameter. Yamamoto's approach was used to determine the uncertainty of the gridded fields in order to find the best interpolation scheme (Yamamoto, 2000). This analysis revealed that IDW is the best performing scheme regarding the computational effort. However, SPHEREMAP is more robust against spatially inhmogeneous density of input data. Furthermore the grids generated by SPHEREMAP are more reliable and the overall uncertainty is lower than in the other tested interpolation schemes comparing all parameters. Therefore our recommendation for operational services is this interpolation technique. Yamamoto's approach performs better than the leave-one-out cross validation to assess the uncertainty of gridded fields, as it is used for the generation of near-real-time grids and is applicable also to other gridded data sets.

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HOMPRA Europe - A gridded precipitation data set from European homogenized time series

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For the understanding and analysis of long-term trends in precipitation, a robust data base is essential. Changes in the measuring conditions, but also errors made during the data recording, can lead to breaks and outliers in the data.

The new product of the Global Precipitation Climatology Center - HOMPRA Europe (HOMogenized PRecipitation Analysis of European in situ data) is a BIAS-corrected monthly rainfall data set with 1° spatial resolution. The data set consists of 5373 carefully selected precipitation time series held by the GPCC, which have been quality controlled and homogenized. The time series cover the period 1951-2005 with less than 10% of missing values.

Due to the high number of series, an automatic algorithm had to be developed that can cope with the different rainfall distributions in Europe and months without precipitation. The algorithm basically consists of three parts:

*Selection of overlapping station networks in the same precipitation regime, based on partial rank correlation and Ward's method of minimal variance. Since the underlying time series should be as homogeneous as possible, the station selection is carried out by deterministic first derivation in order to reduce artificial influences.

* The natural variability and trends were temporally removed by means of highly correlated neighboring time series to detect artificial break-points in the annual totals. This ensures that only artificial changes can be detected. The method is based on the algorithm of Caussinus and Mestre (2004).

* In the last step, the detected breaks are corrected monthly by means of a multiple linear regression (Mestre, 2003).

Since the homogenization algorithm is automated, its validation is essential. The performance of the method was tested using artificial data sets. In addition, a sensitivity study was applied by varying the reference stations. If available in digitized form, the station history was also used to search for systematic errors in the jump detection.

Finally, the actual HOMPRA Europe product is produced by interpolation of the homogenized series onto a 1° grid using one of the interpolation schemes operationally at GPCC (Becker et al., 2013 and Schamm et al., 2014).

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The GEWEX water vapor assessment (G-VAP) – results from inter-comparisons and stability analysis

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A large variety of water vapour data records is available to date. Without proper background information and understanding of the limitations of available data records, these data may be incorrectly utilised or misinterpreted. The overall goal of assessments of climate data records (CDRs) is to conduct objective and independent evaluations and inter-comparisons in order to point out strengths, differences and limitations and, if possible, to provide reasons for them. The need for such assessments is part of the GCOS guidelines for the generation of data products. The GEWEX Data and Assessments Panel (GDAP) has initiated the GEWEX water vapor assessment (G-VAP) which has the major purpose to quantify the current state of the art in water vapour products (upper tropospheric humidity, specific humidity and temperature profiles as well as total column water vapour) being constructed for climate applications. In order to support GDAP and the general climate analysis community G-VAP intends to answer, among others, the following questions:

a) How large are the differences in observed temporal changes in long-term satellite data records of water vapour on global and regional scales?

b) Are the differences in observed temporal changes within uncertainty limits?

c) What is the degree of homogeneity (break points) of each long-term satellite data record?

A general overview of G-VAP will be given. The focus of the presentation will be on observed inconsistencies among the long-term satellite data records as observed by inter-comparisons, comparisons to in-situ observations and the stability analysis. On basis of consistently applied tools major differences in state-of-art CDRs have been identified, documented and to a large extend explained. The results and the answers for TCWV are summarized as follows: On global ice-free ocean scale the trend estimates among long-term data records were generally found to be significantly different. Maxima in standard deviation among the data records are found over, e.g., tropical rain forests. These and other noticeable regions coincide with maxima in mean absolute differences among trend estimates. These distinct features can be explained with break points which manifest on regional scale and which typically do not appear in stability analysis relative to ground-based observations. Results from profile inter-comparisons will also be shown and exhibit, among others, that the observed break points are not only a function of region but also of parameter.

Homogenisation of daily station data in England and Wales

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The Environment Agency (EA) in England is developing a gridded dataset of historical potential evapotranspiration (PET) across England and Wales for the period 1961 onwards, based on observed climate data. The dataset will be used to validate and calibrate existing surface exchange schemes that provide inputs to operational hydrological models.
The calculation of PET, using the Penman-Monteith equation, requires temperature, humidity, radiation and wind speed information. Spatial and temporal discontinuities have been identified in PET calculated using standard methodologies within the UK. For example, inhomogeneities have been identified in the wind speed observations currently used within these calculations.
The first step in deriving the gridded PET dataset is the generation of homogeneous time series of relevant meteorological data for each available station across England and Wales. To ensure robustness and reproducibility of the final homogenised dataset, the fully-automatic homogenisation package MASH is used. The use of an automatic homogenisation package reduces the subjectivity in the homogenisation process and reduces the possibility for the introduction of errors due to inexperienced data homogenisers. MASH also allows daily data, both additive and cumulative, to be homogenised using a single consistent process.
The following meteorological station data are homogenised: 0900 UTC 2m air temperature, 0900 UTC 2m dewpoint temperature, 24-hour maximum 2m air temperature, 24-hour minimum 2m air temperature, 24-hour average 10m wind speed, and 24-hour sunshine duration. Complete calendar year data are available for the period 1961 to 2013. For each variable, network coverage varies greatly throughout this period, with a mixture of record lengths across the network for each variable. Due to the frequent presence of missing data, and the existence of numerous sites with short records, the networks selected for homogenisation are limited to stations with record lengths of at least 15 years (or 20 years for some variables). This yields network sizes of 300-400 stations for each of the temperature variables, 250 for sunshine and 150 for wind speed.
Results from the homogenisation of completed variables will be presented using the verification scores determined within the MASH process, along with some of the challenges faced and lessons learned during the experience.
Questions will also be posed regarding how best to proceed with integrating future updates of meteorological data into the homogenised time series, and how to handle the homogenisation of shorter record sites.

Homogenization of ECA&D temperature series

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Homogenization of temperature series is a fundamental step in climatological analysis. This is of great importance due to artificial signals introduced by changing features of the stations throughout the years. Relocation, replacement of the instrument or changes in the surroundings introduce step-like or more complicated signals that can deeply affect the quality of indices and trend calculations. Such errors may lead to erroneous estimates of climate change. For these reasons, the change points need to be recognized and corrected, which requires identifying their timing and amplitude. Metadata can be present to help in this process, but most of the times statistical methods are required to identify these breaks, because metadata is often absent. A large set of break detection methods have been developed and published in recent years. These have been compared and combined to find the most efficient procedure for the identification of change points in the temperature series. Once the breaks have been found, the series need to be corrected by calculating the amplitude of the change points. This can be done looking at changes in the (yearly or monthly) means or in the higher orders (such as percentile values) of the temperature distribution. Analysis shows that The latter method better approaches the chosen benchmark (manually homogenized) series in terms of indices and trends. This method has been applied to the European ECA&D dataset. The homogenized series have then been blended with data from nearby station, in order to produce longer series. After this step a new homogenization procedure has been performed to avoid step-like changes due to the blending "joints". Finally, in order to provide an homogenized data-set with the highest quality, a second iteration of break detection, adjustment calculation and blending has been performed using the outcomes of the first iteration as input and as references (longer, higher quality and thus better results). The new homogenized data-set has then been compared with the original one, looking at changes in extremes, trends and climate indices.

Introduction on homogenization, quality control, spatial interpolation, gridding

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Theoretically there is a strong connection between these topics since the homogenization of climate data series and the data quality control procedures need spatial statistics and interpolation techniques for spatial comparison of data. On the other hand the spatial interpolation procedures (e.g. gridding) require homogeneous, high quality data series to obtain good results.

The main topics of homogenization and quality control are the following:

- Theoretical, mathematical questions. There is not any exact mathematical theory of the homogenization.
- Methods for homogenization and quality control (QC) of monthly data series, missing data completion.
- Spatial comparison of series, inhomogeneity detection, correction of series.
- Methods for homogenization and quality control (QC) of daily data series, missing data completion, examination of parallel measurements.
- Relation of monthly and daily homogenization, mathematical formulation of homogenization for climate data series generally.
- Usage of metadata.
- Manual versus automatic methods.
- Theoretical evaluation and benchmark for methods, validation statistics.
- Applications of different homogenization and quality control methods, experiences with different meteorological variables.

The main topics of spatial interpolation are the following:

- Theoretical, mathematical questions.
- Temporal scales: from synoptic situations to climatological mean values.
- Interpolation formulas and loss functions depending on the spatial probability distribution of climate variables.
- Estimation and modelling of statistical parameters (e.g.: spatial trend, covariance or variogram) for interpolation formulas using spatiotemporal sample and auxiliary model variables (topography).
- Characterization, modelling of interpolation error.
- Use of auxiliary co-variables, background information (e.g.: dynamical model results, satellite, radar data) for spatial interpolation, relation with data assimilation, reanalysis.
- Applications of different interpolation methods for the meteorological and climatological fields, experiences with different meteorological variables.
- Gridded databases.
- Real time data quality control (QC) procedures based on spatial comparison, interpolation.

Some theoretical questions and development of MASH for homogenization of standard deviation

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There are several methods and software for homogenization of climate data series but there is not any exact mathematical theory of the homogenization. Therefore we have to formulate some questions of homogenization in accordance with the mathematical conventions. The basic question is 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. Another problem is the relation of monthly and daily data series homogenization.
The theme of homogenization can be divided into two subgroups, such as monthly and daily data series homogenization. These subjects are in strong connection with each other of course, for example the monthly results can be used for the homogenization of daily data. In the practice the monthly series are homogenized in the mean only, while there exist some trials to homogenize the daily series also in higher order moments. These procedures are based on a popular assumption that is the correction of mean is sufficient for monthly series, and the correction of higher order moments is necessary only in the case of daily data series. In general, it is tacitly assumed that the averaging is capable to filter out the inhomogeneity in the higher order moments. However, this assumption is false, since it can be proved if there is a common inhomogeneity in the standard deviation of daily data then we have the same inhomogeneity in monthly data. Therefore we develop a mathematical procedure for the homogenization of mean and standard deviation together. Building of this procedure in our software MASH (Multiple Analysis of Series for Homogenization; Szentimrey) is ongoing and it is based on the examination of monthly series and the monthly results are applied for the homogenization of daily series. We remark if the data are normally distributed then the homogenization of mean and standard deviation is sufficient since in case of normal distribution if the first two moments are homogenous then the higher order moments are also homogeneous.

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/

New developments of interpolation method MISH: modelling of interpolation error RMSE, automated real time Quality Control

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The main difference between MISH and the geostatistical interpolation methods can be found in the amount of information used for modelling the necessary statistical parameters. In general at the geostatistical methods built in GIS the sample for modelling is only the predictors, which is a single realization in time. At MISH method we use the spatiotemporal data for modelling since the long data series form a sample in time and space as well. The long data series is such a specialty of the meteorology that makes possible to model efficiently the statistical parameters in question.
The new developments of the new version MISHv2.01 are connected with modelling of climate statistical parameters and the interpolation error moreover a real time data quality procedure has been also built in the system.
At MISH method modelling of the climate statistical parameters is a cornerstone and the interpolation system is based on this one. The earlier modelling system was elaborated for the monthly and daily expected values and the spatial correlations. These are the basic statistical parameters of the interpolation procedures. At the new version the monthly and daily standard deviations and the daily temporal correlations also can be modelled. Consequently the modelling subsystem of MISH is completed for all the first two spatiotemporal moments. If the joint spatiotemporal probability distribution of the given variable is normal then the above spatiotemporal moments determined uniquely this distribution that is the mathematical model of the climate.
The next development is modelling of the interpolation error RMSE (Root Mean Square Error) in order to characterize quantitatively the uncertainties of the interpolation. This procedure is based on the earlier representativity modelling and the present standard deviation and temporal autocorrelation modelling together.
The last novelty of the new MISH version is an automated real time Quality Control (QC) procedure for observed daily and monthly data. According to the test scheme, the observed values are compared to certain interpolated values using modelled optimal parameters and the modelled interpolation error. During the procedure multiple spatial comparison is tested similarly to the QC procedure built in our MASH (Multiple Analysis of Series for Homogenization; Szentimrey) method. The main difference between the MASH and MISH QC procedures is, while at MASH it is developed for time series and the statistical parameters are estimated from the series in classic statistical way, at MISH it is a real time test and modelled statistical parameters are used.

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_2017/software

Ensemble approaches to assess uncertainties in observation gridding

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Gridded representations of climate observations have become important for a large number of applications. The Norwegian Meteorological Institute has provided daily gridded observation data sets with a 1x1 km spatial resolution since 2004. Since last year we also provide hourly data. Currently we are running two gridding models; (i) the original model applying residual kriging for temperature where the external trend parameterization is based on climatology and triangulation with an elevation dependence for precipitation, and (ii) Bayesian optimum interpolation where the the background fields are defined by a smoothed regional analysis of the observed field. The data sets are updated in real-time.

Both these models are deterministic by nature and provide only one realisation of the estimations. The uncertainty is addressed by cross-validation at the observation points. To better assess the uncertainty ensemble methods in observation gridding have become an interesting approach.

There are several ways to set up ensemble estimation systems for observation gridding. The two principal challenges in such analysis are the representativity of observation network and descriptions of vertical and horizontal gradients in complex terrain. We have investigated the gradients and the station representativity in a residual kriging interpolation for temperature applying a locally weighted regression approach to create ensemble members. The analysis is done on a daily scale, and reveal large temporal and spatial variations in the influence of the predictors in the spatial trend field. We will present the results of this preliminary study and discuss different approaches for ensemble gridding.

Global temperature trend biases and statistical homogenization methods

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The global land temperature trend may be biased due to remaining inhomogeneities. Well-homogenized national datasets on average clearly show more warming than global collections (GHCN, CRUTEM, GISTEMP, etc.) when averaged over the region of common coverage. We will present the temperature trend differences for several dozen national temperature series.

This finding makes research into statistical homogenization more pressing. We have estimates for the uncertainties due to remaining inhomogeneities from numerical validation studies. We urgently need analytic work on the uncertainties in a certain dataset or station that is based on the inhomogeneities found and the network characteristics.

There are several possible causes of cooling biases, which have not been studied much. Siting could have improved. Increases in irrigation could lead to a spurious cooling trend. Early thermometer screen have a warm bias compared to Stevenson screens. Currently we are in a transition to Automatic Weather Stations. The net global effect of this transition is not clear at this moment.

The latter two transitions are difficult to homogenize using relative statistical homogenization because the entire network is affected. In the Global Historical Climate Network (GHCNv3), homogenization does not change the global mean temperature much in these periods.

Previous validation studies of statistical homogenizations unfortunately have some caveats. The main problem is that the used artificial datasets had a relatively large and too optimistic signal to noise ratio (SNR). Our recent work on multiple breakpoint detection methods shows that real-world SNRs may be as small as about 0.5. For these realistic cases, statistically significant breaks are identified, but the corresponding segmentation is about as good as a random segmentation.

The joint correction method using a decomposition approach (ANOVA) can remove the bias when all breaks (predictors) are known. Any error in the predictors will, however, lead to a systematic undercorrection of any large-scale trend bias.

New WMO Guidance on homogenisation

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The Task Team on Homogenisation (TT-HOM) is writing the next WMO guidance on homogenization, which is mainly aimed at helping National Meteorological and Hydrological Services (NMHSs) to produce better quality datasets to study climate, climate variability and climate change.

There are two fundamental types of homogenization: 1) homogenization of the means and 2) homogenization of the distribution that also adjusts the variability around the mean. The former is typically used to homogenize annual and monthly data, while the latter is mostly used for daily data. The focus of this guidance will be on the homogenisation of the means; this type is understood best and most commonly applied in operational practise. This guidance will explain the limitations of only homogenizing the means, but the adjustment of the distribution is difficult and not sufficiently well understood at this time and considered to be beyond the scope of this guidance. The guidance is furthermore limited to the homogenization of instrumental land station data.

The homogenization guidance of TT-HOM will have three parts.

1. A traditional report with the basic information on the homogenization of monthly data, including its mathematical basis, a discussion on the available methods and how to apply them and needs for further research. This part is structured in a way that can offer advice for individuals / institutions starting with homogenisation, as well as for more advanced practitioners and developers. See below for details.
2. A Frequently Asked Questions (FAQ) on the internet. This way we can stay up to date. The answers will be shorter and more informal and link to relevant information sources for details, including our report.
3. A list with the publically available software packages, their capabilities, strengths and weaknesses. This list of software packages will be kept up to date on the internet, it is currently at: http://www.meteobal.com/climatol/tt-hom/

Part I of the traditional report is aimed at getting new people started with homogenization. It discusses the prerequisites, focussing on why they are important for homogenization: data rescue of the observations themselves and of information on the history of the measurements, as well as quality control and network selection. It lists most reasons for inhomogeneities to illustrate the kind of problems a homogenizer may encounter and explains the various approaches to homogenization and how to select the data for homogenisation. It provides guidance for the selection of adequate homogenisation software packages for the task at hand.

Part II of this report discusses more advanced background topics and is intended for advanced users and developers of homogenisation methods. It gives a short historical overview of homogenization methods. It has a chapter with a mathematical description of the homogenization problems, which aims to support designers of homogenization algorithms. It gives guidance on interacting with operational departments on questions of the station network management. The overview provided by the guidance also makes clear what we do not know well enough yet. Thus in the last chapter ideas for future homogenization research are given.

A global database with parallel measurements to study non-climatic changes

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In this work we introduce the rationale behind the ongoing compilation of a parallel measurements database, in the framework of the International Surface Temperatures Initiative (ISTI) and with the support of the World Meteorological Organization. We intend this database to become instrumental for a better understanding of inhomogeneities affecting the evaluation of long-term changes in daily climate data.

Long instrumental climate records are usually affected by non-climatic changes, due to, e.g., (i) station relocations, (ii) instrument height changes, (iii) instrumentation changes, (iv) observing environment changes, (v) different sampling intervals or data collection procedures, among others. These so-called inhomogeneities distort the climate signal and can hamper the assessment of long-term trends and variability of climate. Thus to study climatic changes we need to accurately distinguish non-climatic and climatic signals.

The most direct way to study the influence of non-climatic changes on the distribution and to understand the reasons for these biases is the analysis of parallel measurements representing the old and new situation (in terms of e.g. instruments, location, different radiation shields, etc.). According to the limited number of available studies and our understanding of the causes of inhomogeneity, we expect that they will have a strong impact on the tails of the distribution of air temperatures and most likely of other climate elements. Our abilities to statistically homogenize daily data will be increased by systematically studying different causes of inhomogeneity replicated through parallel measurements.

Current studies of non-climatic changes using parallel data are limited to local and regional case studies. However, the effect of specific transitions depends on the local climate and the most interesting climatic questions are about the systematic large-scale biases produced by transitions that occurred in many regions. Important potentially biasing transitions are the adoption of Stevenson screens, relocations (to airports) efforts to reduce undercatchment of precipitation or the move to automatic weather stations. Thus a large global parallel dataset is highly desirable as it allows for the study of systematic biases in the global record.

We are interested in data from all climate variables at all time scales; from annual to sub-daily. High-resolution data is important for understanding the physical causes for the differences between the parallel measurements. For the same reason, we are also interested in other climate variables measured at the same station. For example, in case of parallel air temperature measurements, the influencing factors are expected to be global radiation, wind, humidity and cloud cover; in case of parallel precipitation measurements, wind and wet-bulb temperature are potentially important.

Metadata that describe the parallel measurements is as important as the data itself and will be collected as well. For example, the types of the instruments, their siting, height, maintenance, etc.

Because they are widely used to study moderate extremes, we will compute the indices of the Expert Team on Climate Change Detection and Indices (ETCCDI). In case the daily data cannot be shared, we would appreciate contributions containing these indices from parallel measurements.

For more information: http://tinyurl.com/ISTI-Parallel

Inhomogenieties in Estonian air temperature series with CLIMATOL and HOMER

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This study presents results of the application of the two tools: HOMER software and “Climatol” package to the air temperature series in Estonia. HOMER (HOMogenization softwarE in R) is a software designed for homogenisation of essential climate variables at monthly scale. “Climatol” is a contributed R package holding functions for climatological series homogenisation and it is coded to produce also climatological summaries and grids from homogenised results. “Climatol” is able to deal with monthly and daily data. However, also HOMER “basic checks” already contain adaptations from “Climatol”, in a present study “Climatol” package is applied also separately, to get more detailed results.
The datasets of monthly mean air temperature as well as monthly absolute maxima and minima for HOMER and daily mean, daily absolute maxima and minima for “Climatol” were obtained from Estonian Environment Agency (ESTEA). Data from 22 locations over Estonia were used, 8 locations having data from 1925 to 2016 and 14 location having data for the period 1961-2016.
The focus on the homogeneity of Estonian air temperatures with three purposes using HOMER software: 1) to run fast quality control - detecting outliers and checking outlier validity; 2) homogeneity testing with HOMER software – to determine which change points are significant and to give a review on significant breakpoints (also using information from metadata); 3) to detect and correct eventual inhomogeneities in the dataset.
The focus on the homogeneity of Estonian air temperatures with three purposes using “Climatol”: 1) to find binary splits on whole series with SNHT (also using explanations from metadata); 2) to calculate anomalies after missing data recalculation; 3) apply corrections and adjust series.
The results of both tools to Estonian temperature series are explained and presented here.

TEMPERATURE SERIES QUALITY ANALYSIS BASED ON THE NUMBER OF CORRECTED VALUES

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POSTER

At MHSC a relational database was introduced in 2008. Until that year all original climate data exist in paper form only, while to the data in electronic form corrections were applied without keeping an untouched electronic copy of the original. Since 2008, the original data are saved separately, while corrections are only applied to a copy of the dataset, thus making a comparison of the two datasets possible.

Using the 2008-2015 dataset, the aim was to find the percentage of data that were corrected in each series, and use it to analyse the quality of the series. The results can be used in practice to evaluate the quality of an observer's work, taken into account in climate analyses of the series or explain inhomogeneities in certain periods.

The analysed parameters are: air temperature (from the three main daily observations), daily maximum and minimum temperature and wet-bulb temperature, usually being the most corrected or deleted parameter. The percentage of corrected data in each series is determined, and from it the quality of the series itself is assessed.

Comparison of different daily adjustment methods for the maximum and minimum temperature in Israel

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Break-point detection is mainly done through monthly means although there are few methods that can detect breaks on daily resolution (CLIMATOL, ACMANT). The daily adjustment can be done usually after this stage by some approaches such as interpolating the monthly values to the dailies or by fitting the distribution of sub homogeneous period to the other sub homogeneous period. Based on these approaches, several methods were developed in order to deal with daily adjustments. Each method generates the daily correction factors differently which affects the higher order distribution moments and as a consequence may even change the general means and trends.
In our study, the break-point detection is based on monthly resolution applying jointly relative homogenization methods (HOMER, ACMANT, CLIMATOL), accompanied by metadata gathered from the comprehensive Israel Meteorological Service archive.
Among the several daily adjustments techniques, we have choose to apply HOM, SPLIDHOM, VINCENT, CLIMATOL methods to the database. Our integrated model defined the monthly breaks and just then, we applied the different techniques.
By comparing these common methods, we will stress their influence both on the shape of the distributions and on some extreme indices trends recommended by the Expert Team on Climate Change Detection and Indices (ETCCDI) for few Israeli case study stations.

Homogenization of the wind speed time series in Czech Republic

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Wind speed is one of the most problematic meteorological elements in a sense of its reliability. Problems were caused mainly by change of a way of measurements – the automation of the meteorological network. This changes of instruments – switching from observations in Beaufort scale to measurements by means of automated cup anemometers and later ultrasonic instrument – together with need of frequent calibration of automated cup anemometers (easy to fail), are a few examples of problems that have to be faced. Together with the fact that wind speed has weak spatial relationship and thus problem finding proper reference series, makes the homogenization (and data quality control) quite difficult. Even though the time series of average wind speeds were successfully homogenized and daily values are shows to be homogeneous by various statistical tests (e.g. in Štěpánek et al 2013), it did not eliminate the problem with significant inhomogeneities in the number of days above a certain threshold. For example, we observe significant decrease in the number of days with a maximum wind gust above 20 m/s after 1997 when the automation of the meteorological stations began in the Czech Republic.
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