SAMSI / IMAGe Summer Program: The International Surface Temperature Initiative

NCAR, Boulder, Colorado July 8th-16th 2014

Lead Organizers: Doug Nychka (IMAGe), Richard Smith (SAMSI), Peter Thorne (ISTI)

Scientific Organizing Committee: Enric Aguilar, Robert Lund, Jessica Matthews, Matt Menne, Blair Trewin, Venema, Kate Willett, Claude Williams

Summer Program synopsis and essential information / resources

The summer program aims to explore new and innovative techniques to the homogenization (adjustment for non-climatic artefacts) and analysis of global and regional land surface air temperature records, including Uncertainty Quantification and the construction of spatially complete estimates. It brings together experts in statistics, applied math and climate science to work collaboratively on this problem. Given the inter-disciplinary nature of the work and that it will largely be developmental / investigative work any question is reasonable. Although people are welcome to report the workshop outcomes externally via blogs, twitter or other social media please do not attribute names without permission to such reporting.

Most of the time will be spent in small groups working on practical applications and case studies. Their intended modus operandi and a brief outline of intended work from each session's chairs are given in the appendix. The organizers intend to be flexible in the structuring of the work and receptive to suggestions from participants as the program progresses. Please find an organizer to provide any such suggestions.

In terms of logistics to get from the millennium hotel to the site and back a number of participants have been supported to have hire cars for the duration, which provide a degree of flexibility in travel arrangements. To get from the hotel to the meeting location takes about 15 minutes. Participants requiring transport from the hotel should convene in the lobby 15 minutes prior to the start of each day to be driven to the venue.

The meeting report draft will be developed during the workshop. Attendees are encouraged to provide edits to this googledrive hosted document at http://tinyurl.com/samsi-image-isti

Background materials, code, papers etc. (a finite selection) can be found at http://www.surfacetemperatures.org/samsi_image_summer_program
If you wish materials to be hosted here please send the details to Peter @ peter.thorne@nersc.no

Agenda

Tuesday July 8th

8.30 – 9.00 Registration

Session 1 Welcome and introductory remarks
Session chair: Kate Willett

9.00 – 9.20 Welcome to Boulder and IMAGe program, local logistics and orientation – Doug Nychka

9.20 – 10.00 Introductory statements from all participants (optional single slide – must be uploaded to projector PC before 9am or can be sent in advance to Venema @ vvenema@uni-bonn.de). Limited to 1 minute each.

- Name
- Institution
- Background expertise
- Personal aims for the workshop

10.00 – 10.30 Coffee

10.30 – 10.50 Welcome from SAMSI, SAMSI program objectives for this workshop and the broader SAMSI environmental statistics program landscape – Richard Smith
10.50 – 11.10 The International Surface Temperature Initiative framework in a nutshell – Peter Thorne

Session 2 Problem-set orientation and state of the art

In this session speakers should aim to leave 5-10 minutes for discussion at the end of the talk.

Session 2a. Data, some typical real-world breakpoint characteristics, and benchmarks available for use
Session Chair: Richard Smith

11.10 – 11.40 The ISTI databank – its construction, its formats, its metadata and its data characteristics – Peter Thorne on behalf of Jared Rennie
11.40 – 12.10 The ISTI benchmarks – their construction and characteristics – Kate Willett

12.10 – 13.30 Lunch

13.30 – 14.00 Statistical properties of breaks and some case studies of the types of problems that current techniques have identified in the 'raw data' – Lucie Vincent

Session 2b. State of the art summaries

Session Chair: Peter Thorne

Statistical approaches to breakpoint detection

14.00 – 14.30 Methods for a single breakpoint – Jaxk Reeves

14.30 -15.00 Changepoint methods for data with trends– Colin Gallagher

15.00 – 15.30 Multiple changepoint methods – Robert Lund

15.30-16.00 Coffee

Climate science homogeneity assessments

16.00 – 16.45 Current homogenization approaches applied in climate science – their strengths and weaknesses – Enric Aguilar / Venema

16.45 – 17.30 NCDC's pairwise homogenization algorithm applied to the databank, and its application to benchmarks over the US domain – Matt Menne

17.30 Close

17.30 – 19.30 Poster session and icebreaker

Wednesday July 9th

Session 2. Cont.

Aspects of interpretation / usage

8.30 – 8.50 Principals of uncertainty quantification of relevance to this workshop – Richard Smith

8.50 – 9.15 HadCRUT4 – a practical example of providing uncertainty quantification to surface temperature estimation – Colin Morice

9.15 – 10.00 Statistical Inference for Spatial Observations – Doug Nychka

10.00 – 10.15 Outline of plans for remainder of workshop – how it will work – Peter Thorne / Richard Smith / Doug Nychka

10.15 – 10.45 Coffee

Session 3 Formulation of potential approaches and forming of initial practical breakout groups.
Session Chair: Jared Rennie

This session will lead to the formation of what is proposed to be 5 initial breakout groups to consider the problem from distinct perspectives. In addition to the breakout groups Peter Thorne, Kate Willett, Jared Rennie and Doug Nychka will be 'floating'

participants spending time with each group to provide help and advice on the databank, the benchmarks, and other generic aspects. Further details on how the breakouts are intended to work are given in the appendix along with a brief paragraph from each set of chairs. Breakouts have co-chairs.

10.45 Developing innovations to and assessing sensitivities in NCDC's PHA algorithm – Matt Menne and Claude Williams

11.05 Further developing an algorithm based upon work by NIST – Antonio Possolo and Bo Li

11.25 Developing new and novel techniques and modifying techniques not yet applied globally – Enric Aguilar, Robert Lund and Venema

11.45 Aspects of spatial statistics including imputation of missing values – Richard Smith / Colin Morice

12.05 -13.30 lunch

13.30 – 14.00 Independent Confirmation of Global Warming without the use of station temperatures, Jeff Whitaker

14.00 -14.30 Form breakout groups

14.30 – 15.30 Practical work session in breakouts

15.30 – 16.00 Coffee

16.00 – 17.00 Continue work in breakouts

17.00 -17.30 Brief reports to plenary on initial status and issues and suggestions

Thursday July 10th

8.30 – 10.00 Practical work session in breakout groups

10.00 – 10.30 Coffee

10.30 – 11.00 Some trials and tribulations of homogenization in Africa and S. America – Enric Aguilar

11.00 – 12.00 Continued practical work in breakout groups

12.00 – 13.30 Lunch

13.30 – 1400 Title TBD, Finn Lindgren

14.00 – 15.30 Brief reports back to plenary and plenary based discussions (Chair: Doug Nychka)

15.30 – 16.00 Coffee

16.00 – 17.30 Continued practical work in breakouts

17.30 Close

Friday July 11th

8.30 – 10.00 Practical work session in breakout groups

10.00 – 10.30 Coffee

10.30 – 11.00 The LatticeKrig R package and method - Dorit Hammerling

11.00 – 12.00 Continued practical work in breakout groups

12.00 – 13.30 Lunch

13.30 – 14.00 The homogeneity and homogenization of daily temperature data – Venema

14.00 – 15.30 Brief reports back to plenary and plenary based discussions (Chair: Matt Menne)

15.30 – 16.00 Coffee

16.00 – 17.30 Continued practical work in breakouts

19.30 Workshop dinner – TBD, At own cost
We shall finalize this in situ in the first couple of days.

Saturday July 12th

8.30 – 10.00 Practical work session in breakout groups

10.00 – 10.30 Coffee

10.30 – 12.00 Continued practical work in breakout groups

12.00 – 13.30 Lunch

13.30 – 15.30 Brief reports back to plenary and plenary based discussions (Chair: Enric Aguilar)

15.30 Break

Sunday July 13th
Mid-workshop break day.

Two activities to be offered – a bike ride and a hike. Details will be forthcoming early in the week and a sign up sheet available. Participation in these organized activities is entirely optional.

Monday July 14th
8.30 – 10.00 Practical work session in breakout groups

10.00 – 10.30 Coffee

10.30 – 11.00 Changepoint and trend assessment in daily snowfall data – Jon Woody

11.00 – 12.00 Continued practical work in breakout groups

12.00 – 13.30 Lunch

13.30 – 15.30 Brief reports back to plenary and plenary based discussions (Chair: Kate Willett)

15.30 – 16.00 Coffee

16.00 – 17.30 Continued practical work in breakouts

Tuesday July 15th
8.30 – 10.00 Practical work session in breakout groups

10.00 – 10.30 Coffee

10.30 – 11.00 Model Identification in Past Climate Reconstruction – Bo Li

11.00 – 12.00 Continued practical work in breakout groups

12.00 – 13.30 Lunch

13.30 – 15.30 Brief reports back to plenary and plenary based discussions (Chair: Peter Thorne)

15.30 – 16.00 Coffee

16.00 – 17.30 Continued practical work in breakouts

Wednesday July 16th

Closing Session
Session Chair: Doug Nychka

08.30 – 11.30
Closing reports and presentations from Breakout chairs (20-30 mins each)
Chairs to report on:

- Method

- Initial findings and issues discovered
- Future plans of the group (if any)

[Coffee 10.00 – 10.30]

11.30 – 12.00 Plenary discussion

12.00 – 13.00 Wrap up and next steps – Peter Thorne, Richard Smith and Doug Nychka
- Summer program report to SAMSI
- Possible paper(s) arising
- Possible future work avenues arising
- ISTI timetable for initial full benchmarking process (Kate Willett)

13.00 Workshop close

13.00 -14.00 Lunch

Appendix:

Breakout groups

1. Intended modus operandi

Breakout group activities are intended to be a mix of discursive and practical hands on activities. Breakout leads have been designated in advance to provide some methodological foci desired to be covered and these will be advertised on the morning of the second day.

Breakout groups are given autonomy to organize the specifics of their scheduling and working as they see fit. Breakout groups will be facilitated by the floating workshop participants. Furthermore, the organizers shall provide some guidance on expectations on a daily basis.

Groups should report to plenary at least daily. Groups are expected to take time to prepare the summary to maximize its usefulness. The individual who is reporting to plenary should be rotated amongst the group members so that we benefit from hearing from the totality of individual perspectives.

The organizers expect to be flexible in how the breakout phase is undertaken and may consider e.g. reconstituting the groups if deemed necessary by participants. Participants are strongly encouraged to provide feedback and suggestions during the workshop.

2. Breakout descriptors

There are a total of 5 proposed breakouts as per the agenda. These are presented here in the order they will be presented on the second morning.

Breakout #1: Developing innovations to and assessing sensitivities in NCDC's PHA algorithm

FACILITATORS: Matt Menne and Claude Williams

PURPOSE: NCDC personnel have developed two different approaches to pairwise "homogenization". The first, known as the Pairwise Homogenization Algorithm (PHA; Menne and Williams, 2009), has been run operationally to homogenize U.S. (since 2007) and global monthly land surface temperatures (since 2011). The second, known as the Bayes Factor Algorithm (BFA; Zhang et al., 2012), has been evaluated on U.S. data, but application to global data is in the earliest stages.

The pairwise approach to homogenization essentially consists of three stages:

1) Changepoint detection (in difference series formed between each series as a target and nearby correlated series)
2) Changepoint attribution (assigning a changepoint to the series that caused the

break in the set of difference series); and,
3) Changepoint correction (computing the size of the break in the target series).

The PHA addresses each step sequentially whereas the BFA combines the first two steps through a Bayes Factor Model selection procedure. Below is a list of potential areas for improvement to these components. The specifics will depend on the interests and expertise of the breakout group members and the bullets are not necessarily in priority order. Alternative options may also be proposed by other breakout group members.

Changepoint detection and attribution:

i. For the PHA, consider alternative breakpoint detection routines to the current use of SNHT with the semi-hierarchical splitting algorithm (e.g., dynamic programming methods). As part of this, some exploration into the appropriateness/necessity of including a trend parameter in breakpoint detection would also be valuable.

ii. For the PHA, consideration could be given to the potential use of dynamic programming for the joint detection of all breaks in the target-neighbor series group thereby combining stages (1) and (2) above and/or using some form of joint detection with multiple parameters for each station series (e.g., maximum, minimum, average temperature plus diurnal temperature range).

iii. For the PHA, explore the use of iteration in detection/correction to improve algorithm efficiency.

iv. For the BFA, further development could be devoted to optimal use of metadata priors in breakpoint detection.

v. Some onsite comparison of results from the PHA and BFA as applied to the ISTI databank might also be valuable.

Changepoint correction:

i. For both the PHA and BFA, enhance the breakpoint adjustment factor calculation through alternative means such as a network-wide unified correction model (ANOVA) approach or spatial interpolation method.

Breakout #2: NIST Proposal for Homogenization of Surface Temperature Records

FACILITATORS: Antonio Possolo (National Institute of Standards and Technology, NIST) and Bo Li (Univ. of Illinois at Urbana-Champaign)

PURPOSE: Review and evaluate the procedures that have been proposed by Adam Pintar et al. (2013, AIP Conf. Proc. 1552) to detect change-points and to correct time series of surface temperature measurements that may have been affected by factors

unrelated to the climate, for example changes in instrumentation, relocation of weather stations, urban encroachment, physical interference, etc.

Breakout #3: Developing new and novel techniques and adapting existing techniques to a global scale

FACILITATORS: Enric Aguilar (Center for Climate Change, C3 Universitat Rovira i Virgili), Robert Lund (Clemson), and Venema (Uni Bonn)

PURPOSE: This breakout group will tackle two different, but related tasks. The first one will be to conduct an effort to adapt methods/software currently designed for small to medium size regional networks to the automatic processing of large global datasets, particularly our benchmarks.

The questions to be addressed to complete this task are a preliminary discussion of the methods/software to work with. Their strengths and weaknesses will be contrasted focusing on their capability to cope with the problems of modern homogenization. A non-comprehensive list of problems would include:
1. dealing with serial autocorrelation;
2. the detection of multiple breakpoints;
3. the presence of missing values or low density/ low correlation networks;
4. the approach selected to apply the relative homogenization principle (pairwise comparison, reference series computation) or
5. the handling of artificial trends.

To apply these methods, an approach to the regionalization of the globe will be needed to identify climatologically coherent areas. Both these problems need the domain knowledge of the climatologists and methods from the statistical community.

The second task of this breakout group, the development of new techniques, will follow similar steps. With a previous discussion facilitated by the chairs on suitable novel approaches, the group will decide which of those it is willing to develop and how to regionalize networks and combine their results, generate references or comparisons to meet the relative homogenization principle for, detection and adjustment.

Important fundamental problems that such new methods should solve are 1) the multiple breakpoint problem and 2) the fact that also the reference time series contain inhomogeneities. The HOME benchmark showed that the methods that tackled these two problems are the most accurate ones. However, both problems are not yet solved optimally. The next big step is expected to be the joint homogenization of all series simultaneously, rather than station by station. A big challenge outside the scope of this meeting is the homogenization of the distribution of daily data although the use of daily data in detection (not favored now by most homogenizers) could be explored if time permits.

For both tasks, a small set of validation measures should be agreed in advance.

Breakout #4: Breakout group on geospatial statistical methods for homogenization / imputation of missing data

FACILITATORS: Richard Smith (SAMSI, UNC) and Colin Morice (Met Office, UK)

PURPOSE: From the point of view of creating climate data sets, the most important first steps are:

1) Existing homogenisation algorithms commonly use reference series derived from nearby meteorological stations (often the mean of N neighbouring station series) but generally do no take uncertainty in these series into account. Mitigation of spurious adjustments in remote stations may be possible by accounting for uncertainty in spatial interpolation used to construct reference series.

2) Imputation of missing values to permit use of short records/those without data in a climatological reference period. Existing algorithms for constructing climate datasets require station data to be available in a reference period (normally 30 years), otherwise data of a station is typically discarded.

3) Computationally feasible application to global data sets (the ISTI databank currently consists of around 32,000 station temperature series).

4) Homogenization algorithms that are robust to differences in long-term temperature changes in different regions (e.g. algorithms that don't attempt to remove known features such as rapid warming in high northern latitudes).

Here are some initial thoughts on how the above points could be tackled by the breakout group. It seems that we potentially have quite a bit of time to work on this over the length of the workshop, although we can't do all of it. Here's the list ranging from A) should do this to G) ambitious blue sky thinking.

A) Local reconstructions (Gaussian process/kriging) for constructing the reference series required by existing homogenisation algorithms.

B) Alternative methods of spatial data analysis: Cressie's fixed rank kriging approach, lattice kriging methods (Nychka, Hammerling), methods based on stochastic PDEs (Lindgren), the INLA approach.

C) Development of homogenization algorithms similar to existing reference series approaches but use uncertainty information from A.

D) Imputation of missing values in climatological reference period and/or estimation of series mean and possibly higher order statistics based on data for neighboring stations.

E) Use of geospatial methods that allow for differences in variability in different regions - non-stationary covariance models.

F) "Large scale reconstructions" for sparse data regions in the past. Existing observational climate datasets use methods related to principal component analysis to infer temperatures in poorly observed regions from available observations elsewhere. Are such approaches useful for homogenization or do they lead to spurious break point detection/adjustments?

G) Spatio-temporal modelling. Many issues here: computation cost, appropriate modelling of temporal relationships, non-uniform long term changes spatially/non-stationary statistics. Temporal and well as spatial modelling may be necessary to deal with the issues relating to homogenisation of remote stations.

H) Breaking away from reference series methods - use in Bayesian hierarchical models, model marginal likelihood, minimum description length approaches? Explore connections with the breakout group on new / novel breakpoint and adjustment techniques, which is looking at the development of new algorithms including Bayesian approaches.