SST homogenisation and analysis

What lessons can be learnt for land homogenisation and analysis

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SST and land surface records
Sames and Differents

• Fixed stations vs moving ships
• Standardised equipment vs whatever works
  • Buckets, engine inlet measurements, automated drifters
ICOADS – International Comprehensive Ocean Atmosphere Data Set

International - Large user-base

Comprehensive – Raw observations and lots of metadata

Ocean Atmosphere – Many variables.

Digital plain ascii format

Freely available, public data set
Gathering evidence

Photo courtesy of Philip Brohan

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"Sea temperatures entered in RED are those taken at the circulation intake, and are 20 feet below surface."
Gathering evidence

Observer’s handbooks
Gathering evidence

Scientific papers

Technical reports

Met Office library and archives
Gathering evidence

• Helpful to have all sources in one place
  • Paper archives are less useful than electronic ones.

• Gives historical detail otherwise inaccessible (although hard to trace back to ICOADS)

• Extracting info from diverse sources is challenging

• Hard to systematise the knowledge gained (is it worth it?)
Metadata are heterogeneous too

- Sources are discontinuous
- Some sources biased towards particular information
- Need some way to resolve conflicts between sources
- Need metametadata?

Extra (meta)data does not always equal less uncertainty

Sometimes new metadata contradicts, or has very different characteristics to old metadata
General approach – Minimise assumptions, Multiply estimates

- Generate multiple realisations by varying model parameters through plausible ranges
  - Eg unknown measurement methods, intake biases
  - Try to make few assumptions…
  - …but remember that you have to make some

- Allows for easy tracking of uncertainties through analysis
General approach – Minimise assumptions, Multiply estimates

- Multiple approaches to the problem of homogenisation
  - Variant algorithms
  - Using quasi-independent subsets of data e.g. buckets/intakes/buoys
  - Smith and Reynolds approach
  - Developed corrections on ICOADS 2.0 data and reran for consistency check with ICOADS 2.5
- And, most importantly
  - Seeking independent verification and independent bias estimates
What didn’t work so well

- Difficulty generalising results from old studies, not traceable back to ICOADS
- Difficulty generalising results from small scales to large scales
- Used legacy code and data formats and programming languages that are not freely available: speeds up development but harder to incorporate new metadata. Leads to ad hoc coding, multiple data formats and lack of portability.
- Tried to do a lot in one go - develop bias adjustments, incorporate new ICOADS data, improve QC, put obs in relational data base – things snowball.
  - Is it better to have half an answer now rather than the full answer three years from now?
Reconstruction, Interpolation and all that
A variety of reconstruction techniques

- Wide variety of methods in the literature
  - Reg-EM
  - DINEOF
  - PPCA
  - Bayesian PCA
  - RSOI
  - TEOF
  - OI
  - Plus variations thereof
- And relatively easy to generate more
How do we choose

- Fit for purpose – have different algorithms for different purposes (daily OI vs ERSST)
- Practicality – the algorithm has to run in finite time
- Understanding
- Quality


Understanding

- Need to understand the methods we use
- Intercomparison projects
  - Retrospective intercomparisons are difficult.
  - Hard to keep going without funding – goodwill finite resource also
  - Probably easier to do this from the start
  - Need to define inputs, outputs, tests, benchmarks beforehand.
  - Providing data in common format makes the data more usable and hence more widely used e.g. GHRSSST.

GHRSSST = Group for High Resolution Sea Surface Temperature
Understanding

- Understanding is a process and relies on user feedback
- Tune the methods to the data you have

Image from Rayner et al. 2009 Ocean Obs ’09 community white paper
How to assess reconstruction quality

- Ask an expert – unfashionable but effective
- Scientists know how the observations fit with the real world
- Expert knowledge not easily quantified.
- Can be viewed as ‘subjective’
- Happens in practice anyway even when being ‘objective’
  - Developer pays attention to data
  - Carefully tests results
  - Always on the look out for something that looks ‘funny’
How to assess reconstruction quality

Simple toy models with specified covariance properties

- Pros: easy to understand, answer known a priori, can be as simple or complex as needed
- Cons: doesn’t look like real world
How to assess reconstruction quality

Use model output degraded to look like observational data.

- **Pros**: easy to understand, resembles real world, can test sensitivity to various ‘real world’ problems
- **Cons**: covariances not known *a priori*, limited by available model runs, danger of tuning, danger of overconfidence
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Sometimes the real world does not behave like the equations you write down

This is your problem, not the world’s
Uncertainties uncorrelated between grid boxes
Uncertainties correlated between grid boxes, but assumed uncorrelated.
We learnt the most about our algorithms by testing them till they broke.
Uncertainties are rarely easy to use
Make uncertainties easy to use

- Generate multiple realisations of the data
- Easy to use, easy to understand
- (Potentially) Transparent tracing of uncertainties

Best guess tends to lack variance - doesn’t resemble real world
What worked
• Vary everything that can be varied
• Take multiple approaches to the same problem
• Generate multiple realisations

What didn’t work
• Trying to do everything in one go

Lessons learned
• You can’t always trust Metadata
• Real world is not mathematically convenient
• Helpful to know the limits of your techniques
• Not easy making uncertainties user friendly
Questions and answers