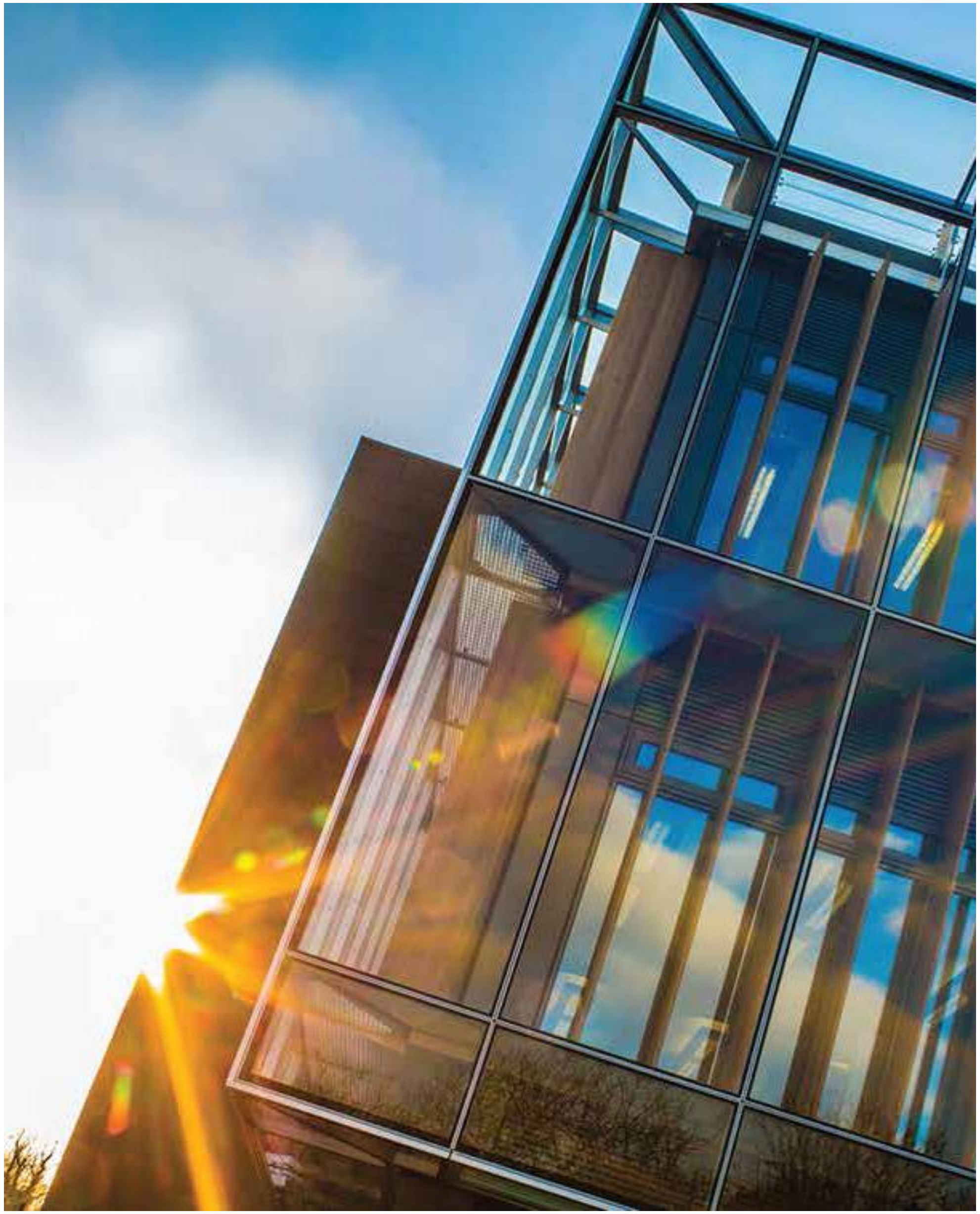
What role could a putative global surface reference network play?

Peter Thorne



Outline

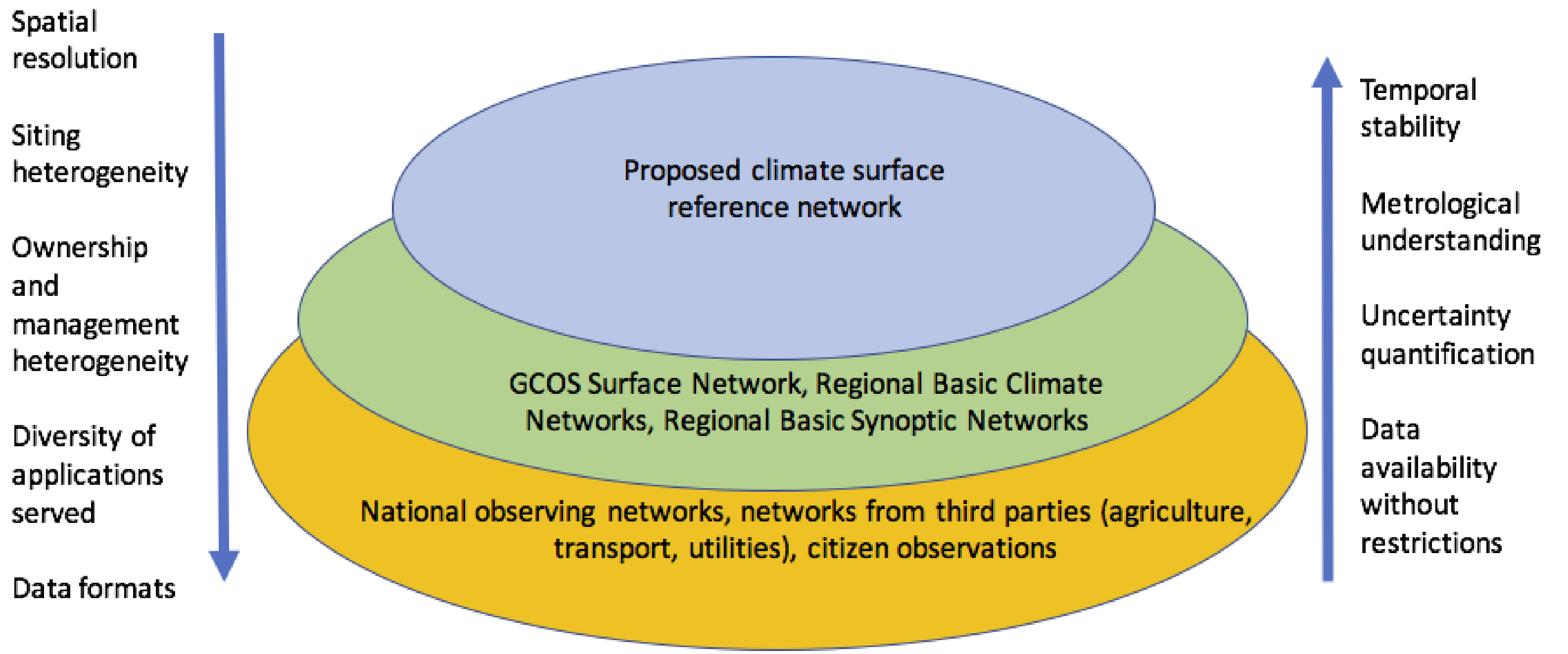
- Why a reference network and why now?
- Network of networks concept
- Underpinning principles for a reference network
- What would a land surface reference network look like?
- How would it be governed and run and how much might it cost?
- What are the foreseen benefits?
- Next steps …

Why a reference network and why now?

- Historical climate records contain irreducible and poorly quantified uncertainties arising from the heterogeneity and imperfect understanding of historical measurement techniques.
- A well maintained reference network would ensure we could say how climate has changed since instigation with high confidence and would help understand other measurements.
- If we are serious about assessing mitigation effectiveness or provision of climate services we need such observations.
- Both GCOS and WMO CCl have invited an ad hoc group to scope …

Maynooth University
National University of Ireland Maynooth

Network of networks concept

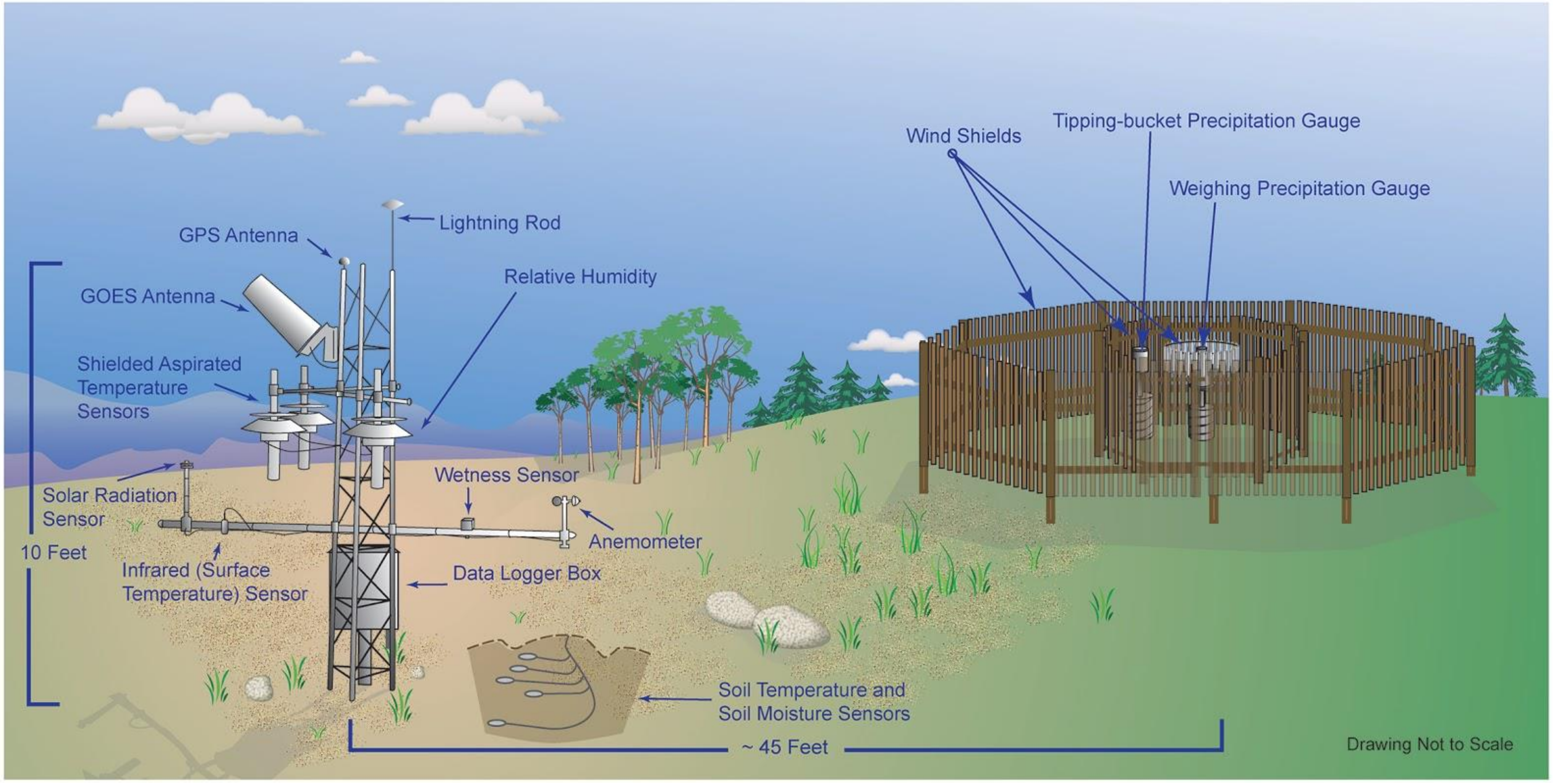


A range of observational capabilities to meet diverse user needs and assure quality can be realised through an explicit network of networks approach.
Thorne et al., 2017, https://doi.org/10.5194/gi-2017-29

Underpinning principles for a reference network

- Traceability
- Comparability
- Representativity
- Long-term operational viability
- Carefully managed change rather than no change
- Full data and metadata retention sufficient to understand and as necessary reprocess observations
- Open data provision

What would a surface reference network look like?



Diamond et al., 2013, https://doi.org/10.1175/BAMS-D-12-00170.1

Maynooth University
National University of Ireland Maynooth

Potential GCOS Essential Climate Variables which could be observed, and which are likely metrologically ready to observe from an *early stage*

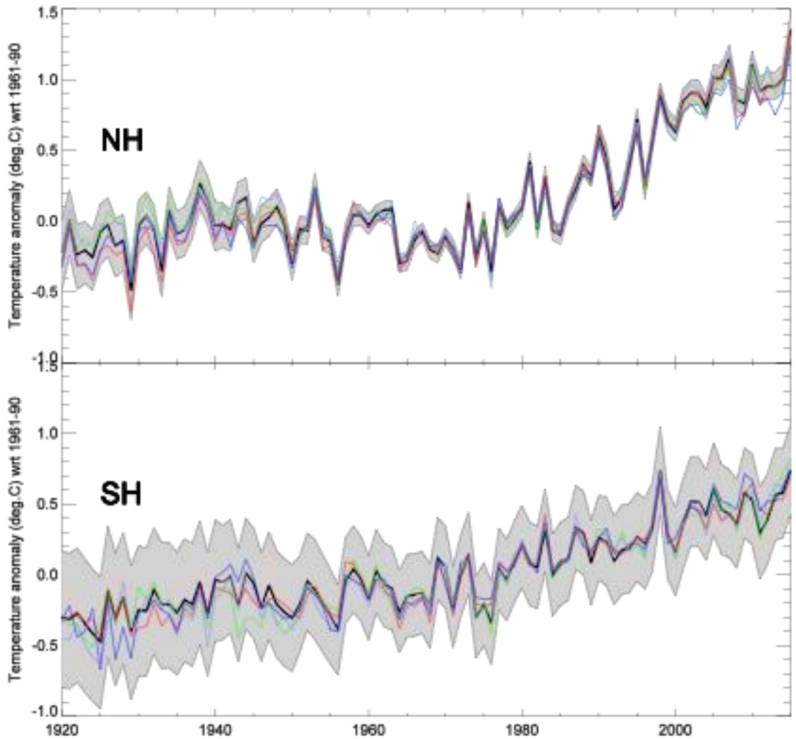
Only variables relevant to the site should be considered (e.g. snow cover likely not relevant in Sahara desert!)

Network should "start small, but start" so may start with very highest priority variables and grow over time

Domain	**Selected GCOS Essential Climate Variables of relevance**
Atmospheric	*Air temperature* *Wind speed and direction* *Water vapour* *Pressure* *Precipitation* *Surface radiation budget*
Composition	*Carbon Dioxide* *Methane* Other long-lived greenhouse gases Ozone (and precursors) Aerosols (and precursors)
Terrestrial	River discharge *Snow cover* Permafrost Albedo Land cover (including vegetation type) Fraction of absorbed photosynthetically active radiation (FAPAR) Leaf area index (LAI) Above-ground biomass Soil carbon Fire disturbance *Soil moisture* *Land surface temperature*

Maynooth University
National University of Ireland Maynooth

To assess annual mean LSAT need 170 or so well-spaced sites

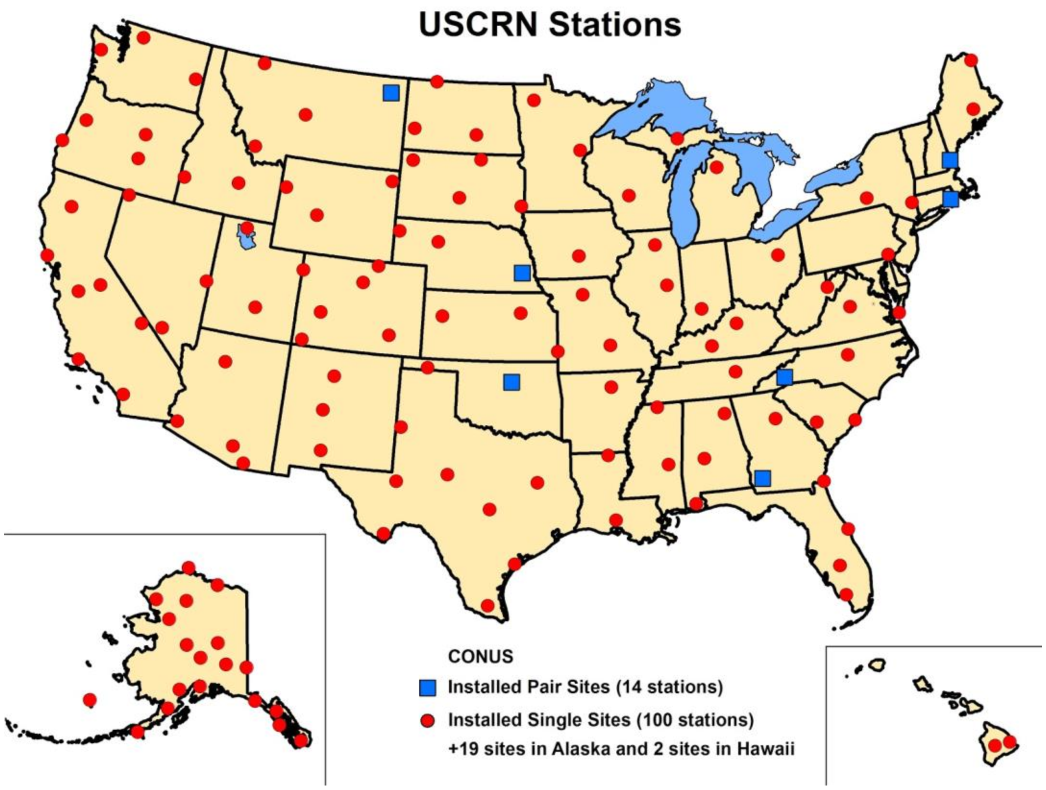


Taking several independent samples of 170 well-spaced long-term station records from CRUTEM4 (coloured lines) and comparing to full sample (solid black) and quantified uncertainties (after Morice et al., 2012) in grey shade.

➡ 170 well-spaced sites would adequaely resolve annual variations in global LSAT

But would need greater density for lower correlated variables!

To resolve CONUS temperature and precipitation …



Greater station density required because the scales of precipitation are smaller.

Sufficient to resolve the CONUS precipitation series but still not sufficient for regional

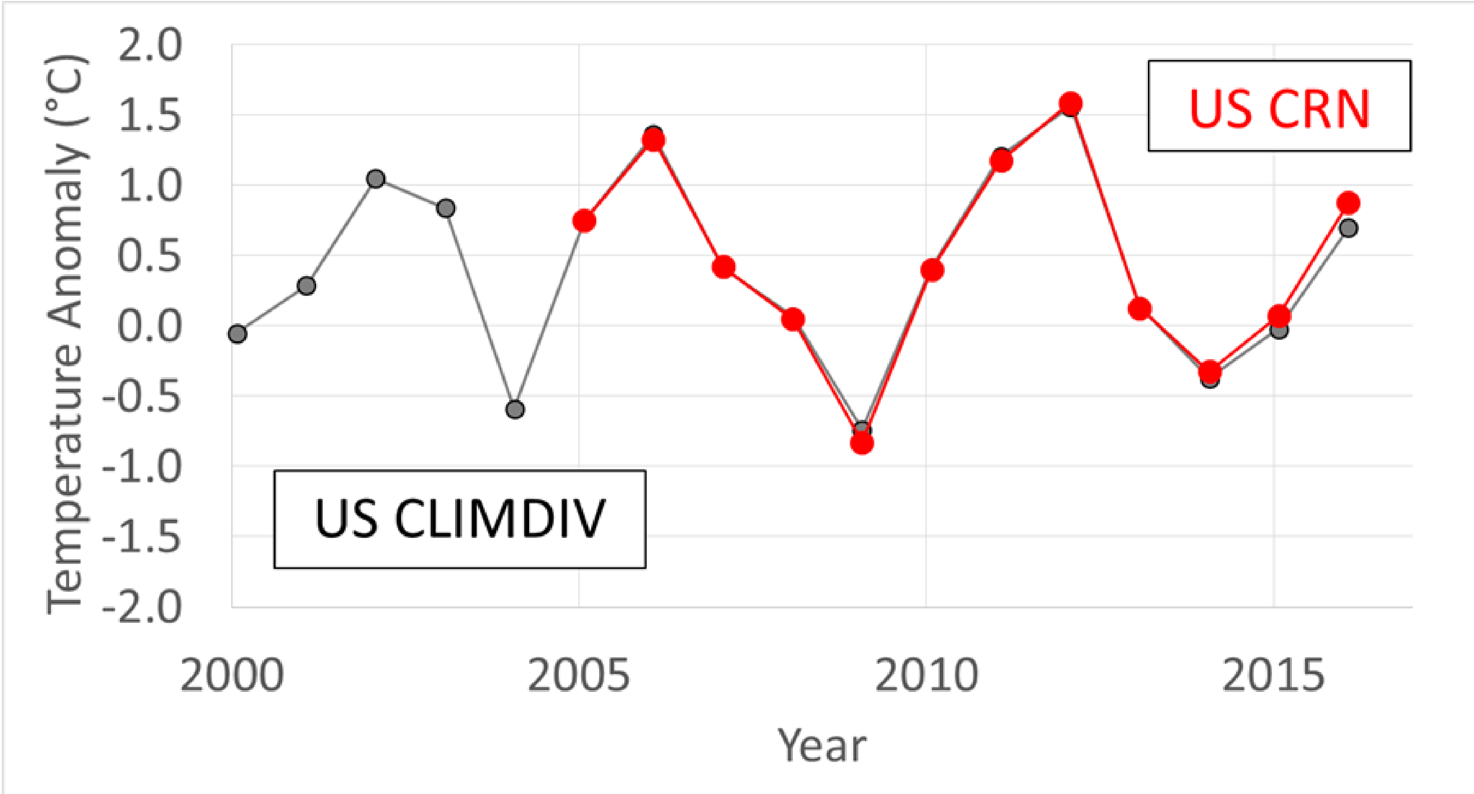
Network density inescapably intertwined with what it is required to do (variables, timescale, spatial fidelity)

How would it be governed and run and how much might it cost?

- Closest governance corollary is the GCOS Reference Upper-Air Network which is similarly global
  - Oversight body e.g. a Working Group
  - One or more 'Lead Centres' managing day-to-day operations
- USCRN costs have typically been 50-100K US$ per site to set up and run for a decade
- Exact costs f(rationale, design, exact solution), but will be lower than e.g. a typical single satellite mission

What are the foreseen benefits?

- Long-term high quality series at selected points
- Characterisation of nearby sites
- Process studies
- Sites for instrument R&D and verification including satellites that sense the surface
- Confirming efficacy of homogenisation techniques applied to historical measurements



Grey is the homoenised US record, red is US Climate Reference Network. Raw record (not shown) is biased relative to USCRN.

Satellite validation (most recent relevant citations of USCRN paper)

Brian Wardlow et al. 2017. Advancements in Satellite Remote Sensing for Drought Monitoring. Drought and Water Crises, 225-258.

Ashok Mishra et al. 2017. Drought monitoring with soil moisture active passive (SMAP) measurements. Journal of Hydrology 552, 620-632.

H. Lievens et al. 2017. Joint Sentinel-1 and SMAP data assimilation to improve soil moisture estimates. Geophysical Research Letters 44:12, 6145-6153.

Satya Prakash et al. 2017. Potential of satellite-based land emissivity estimates for the detection of high-latitude freeze and thaw states. Geophysical Research Letters 39.

Ming Pan et al. 2016. Soil Moisture Estimation Using Active and Passive Remote Sensing Techniques. Hydrologic Remote Sensing, 37-56.

Next steps

- The outline given here will shortly be submitted to a journal.
- The GCOS Atmospheric Observations Panel for Climate have instigated a task team to develop the idea further and scope interest amongst NMSs, industry and scientists
- The group will meet 1-3 November at Maynooth University
- Chair is Howard Diamond (NOAA)

What is needed to proceed...?

- Buy-in from WMO members – are sufficient countries willing to contribute?
- Buy-in from users (*cough* ESA support / involvement would be incredibly valuable *cough*)
- Development of protocols
- Design of network – what sites, where, observing how?
- One or more organisations agreeing to take on a coordination role

We should care about this now because the impacted generation of scientists, politicians, civil servants and citizens will be - collectively - our children and grandchildren, and it is - to the best of our ability - our obligation to pass on to them the possibility to make decisions with the best possible data. Having left a legacy of a changing climate, it is the very least that successive generations can expect in order to enable them to more precisely determine how the climate has changed.