HIGHLIGHTS and SCIENTIFIC CHALLENGES of the TC-T

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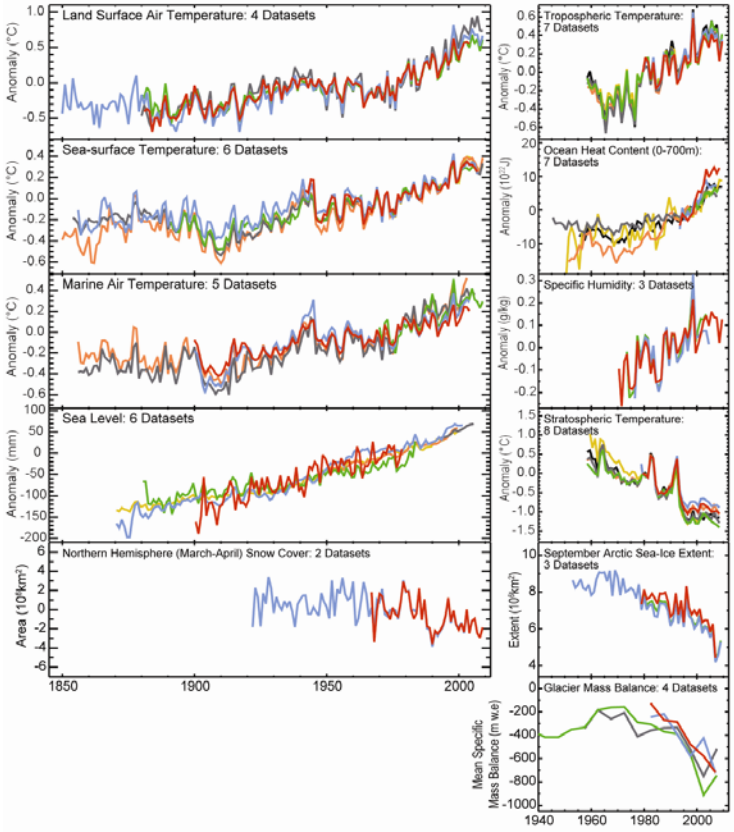
Global warming

"Warming of the climate system is unequivocal from:
- observations of increases in global average air and ocean temperatures,
- uptake of heat by the oceans,
- melting of land ice such as glaciers,
- the associated rise in sea level and
- increased atmospheric surface humidity."

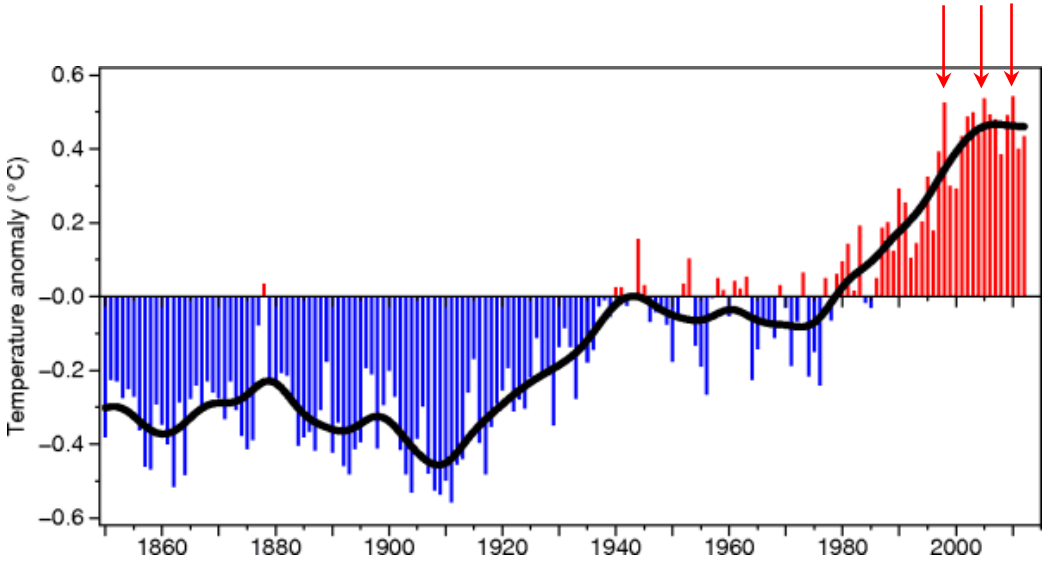
4th Assessment Report of the Intergovernmental Panel on Climate Change, IPCC (2007)



- Temperature is the key indicator quantity
- Assessing climate change depends crucially on correct interpretation of small changes in long-term climate temperature data series
- A rigorous metrological approach is required

Global temperature

- Global average air temperature from 1850 to 2012
- Oldest global time series maintained by the UK Met. Office Hadley Centre
- Weak metrological basis



- **Blue** and **red** rectangles: annual average
- **Black** line : five year average

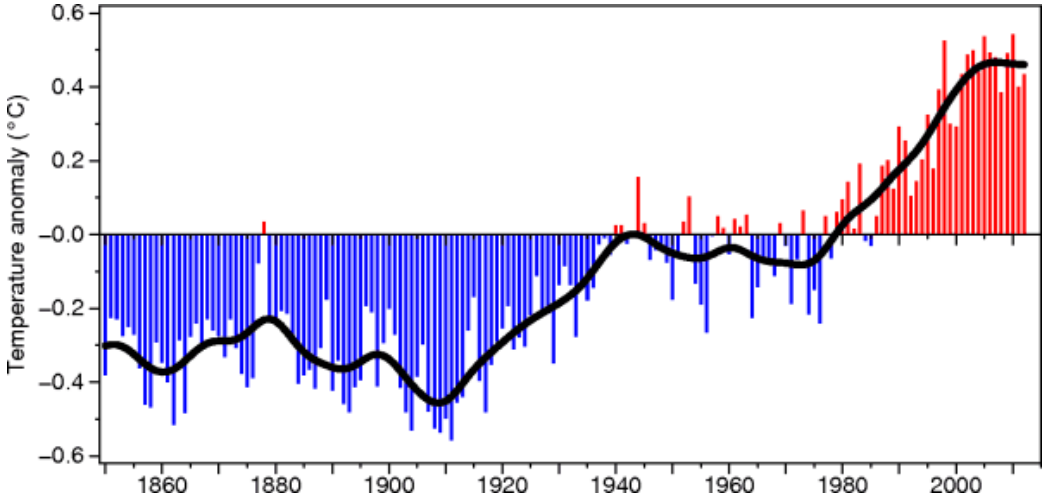
(HadCRUT4: Hadley Centre UK Met. Office, from 1850)

- **Lack of traceability for most, if not all, of the historical and present day records**
- **Lack of complete uncertainty evaluation**

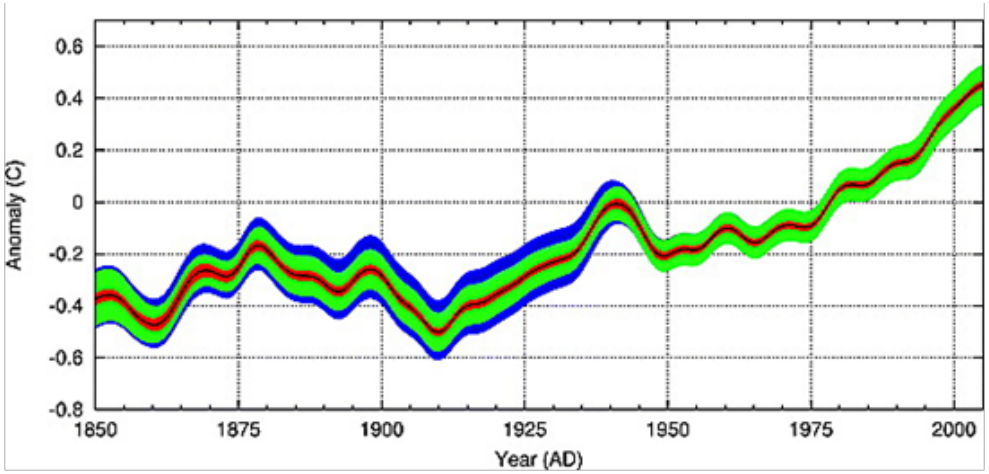
Anomaly 2010: +0.540 ºC
Anomaly 2005: +0.523 ºC
Anomaly 1998: +0.534 ºC

Global temperature

- **Red** and **blue** rectangles: annual average
- **Black** line: 5 years average



- **Black** line: best estimate value
- **Red** band: station uncertainty
- **Green** band: limited coverage added
- **Blue** band: urbanization, changes in design and siting of thermometer added



World Meteorological Organization (WMO)

- Data recorded by satellites, radiosondes, buoys and land-based weather stations around the world

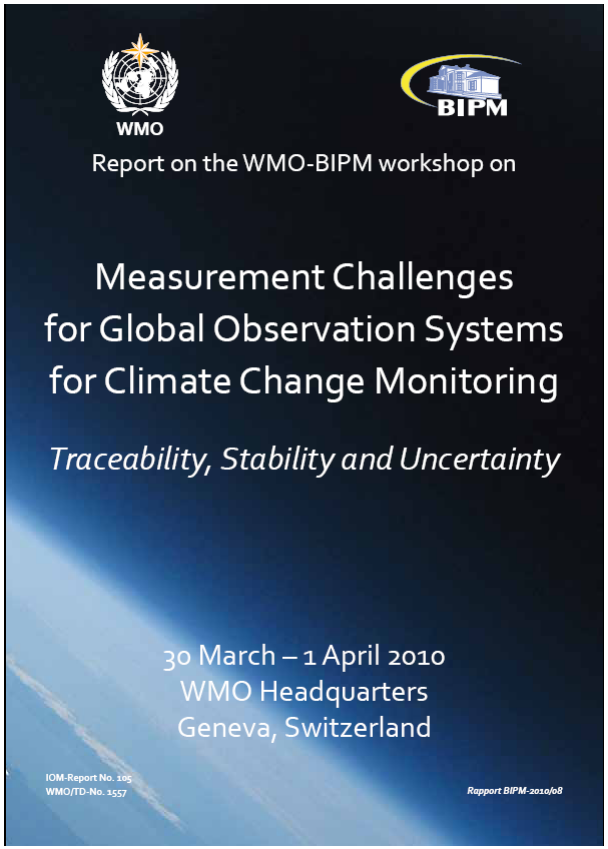
- Data processed by different observation systems

- WMO: UN agency, authoritative voice on the state of the earth's atmosphere, the oceans and the climate

- WMO recently recognized the need to base the global observing system of the earth's climate on:
  - SI traceable measurement standards with
    - well-characterized uncertainty analysis
    - well-monitored and well-maintained stability

- WMO signed the MRA on April 1st 2010

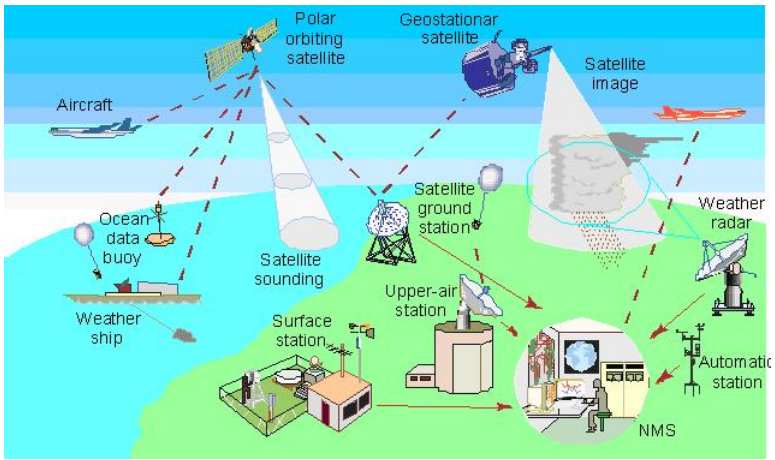
- WMO Integrated Global Observing System to be based on robust metrological traceability



GRUAN: the first metrologically-based observing network

- WMO: World Meteorological Organization
  - Oversee all observing systems

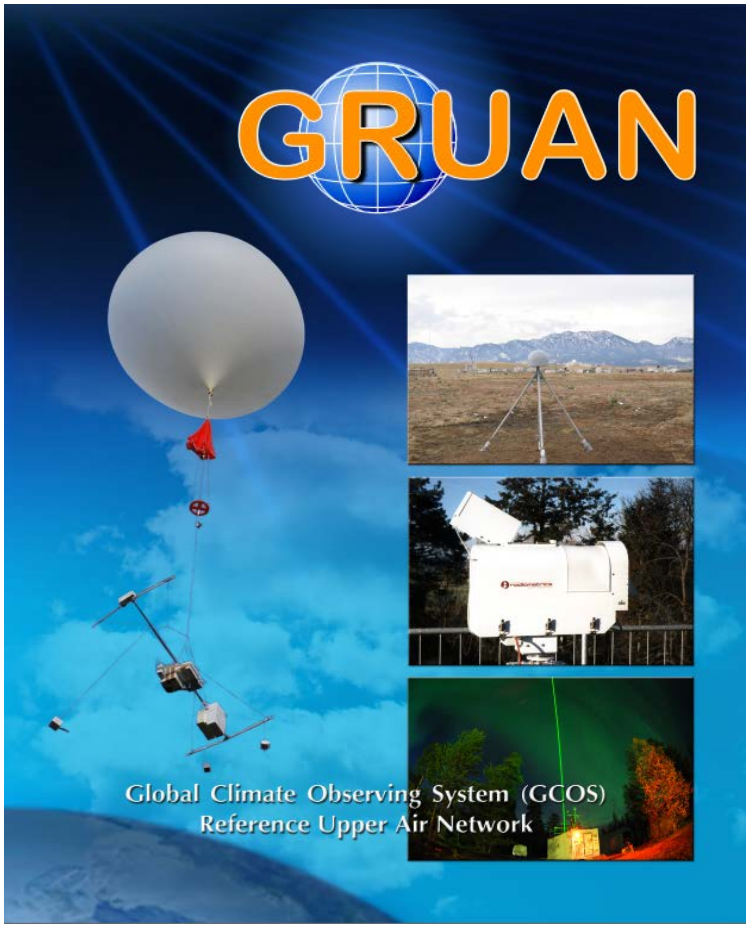
- GCOS: Global Climate Observing System
  - Built on existing observing systems:
    - GOS: Global Observing System
    - GAW: Global Atmospheric Watch
    - GOOS: Global Ocean Observing System
    - GTOS: Global Terrestrial Observing System



- GRUAN: GCOS Reference Network for Upper Air Climate Observations (2015)
  - First metrologically-based observing network

GRUAN Goals

- Maintain observations for several decades
- Focus on complete estimates of measurement uncertainty
- Ensure traceability of measurements to SI units or internationally accepted standards
- Ensure long-term stability by managing instrumental changes
- Measure a large suite of co-related climate variables with deliberate measurement redundancy



ENV07: MeteoMet

➢ Meteorology + Metrology = Metrologically-based Global Observing System

➢ ENV07: MeteoMet

- **Goal: Traceability of surface and upper air measurements of *P, T, H, V* in the atmosphere**
- *Coordinator: Andrea Merlone, INRiM*

METEOMET
Metrology for Meteorology

MeteoMet and GRUAN

➢ MeteoMet is playing a unique and key role in GRUAN implementation

• Procedures: support GRUAN in adopting the appropriate metrological tools (VIM, GUM) and a robust uncertainty definition and evaluation

→ Revision of GRUAN manual and guide

• Devices:

→ ACQUAVIT2: intercomparison of GRUAN humidity sensors supplied by world leading manufacturers

→ Development of calibration chambers for the calibration of radiosondes sensors (-52 ºC to +40 ºC)

→ Development of calibration chambers for ground-based atmospheric measurement stations

Global Warming?