Assessing the EUSTACE estimates of air temperature from satellite and their uncertainties: selection of reference data and validation results

Karen Veal and Darren Ghent, University of Leicester

Yuri Brugnara, University of Bern
John Kennedy, UKMO
Kristina S. Madsen, DMI

Overview/Summary

- Transparent validation using publically available reference data that are independent of the test datasets.

- EUSTACE estimates of air temperature from satellite (SATSTACE) agree well with in situ data

- Land: probably most difficult domain due to heterogeneity of surface and cloud contamination of input LST data.

- Ocean: best of domains for mean difference, larger differences in high gradient regions

- Ice: in situ data available for validation is sparse especially for southern hemisphere sea-ice.

UNIVERSITY OF
LEICESTER

EUSTACE

Strategy and approach

- **Transparent and independent validation** against in situ surface air temperatures (SATs) from land stations, ships, moored buoys and ice buoys.
- Reference data are <u>publically available</u>
- Matchup code and EUSTACE-in situ matchups will be made <u>publically available</u>
- Reference data are <u>independent</u> of data used as input to products
- Approach:
  - Select in situ data for validation by platform
  - Stationary platforms: compare daily temperature statistics
  - Moving platforms: compare EUSTACE daily statistics with observations

- **Product: from-satellite air temperatures (SATSTACE)**
  - Separate fields over land, ocean and ice.
  - Variables: daily Tmin and daily Tmax (Land and Ice); daily Tavg (Ocean and Ice)
- **Product: surface air temperature analysis (FULSTACE)**
  - Single global field
  - Variables: daily Tmean with DTR (Land and Ice); daily Tmean (Ocean)
- EUSTACE grid:
  - Daily statistics for local midnight to midnight, 0.25 x 0.25 degree
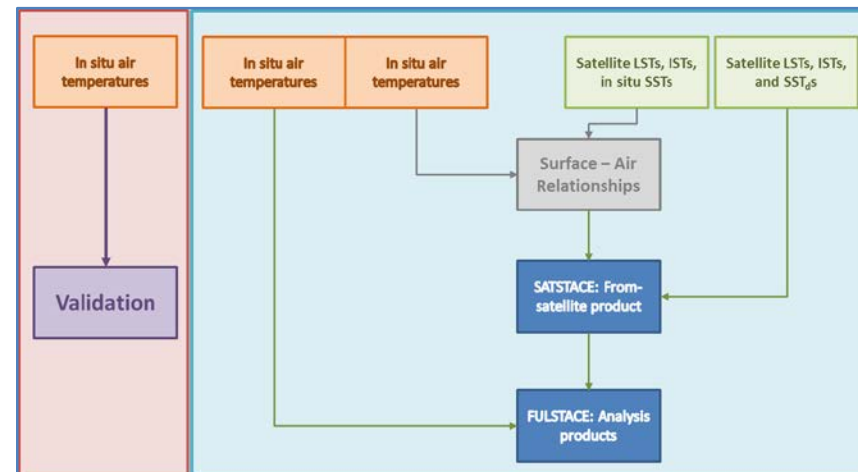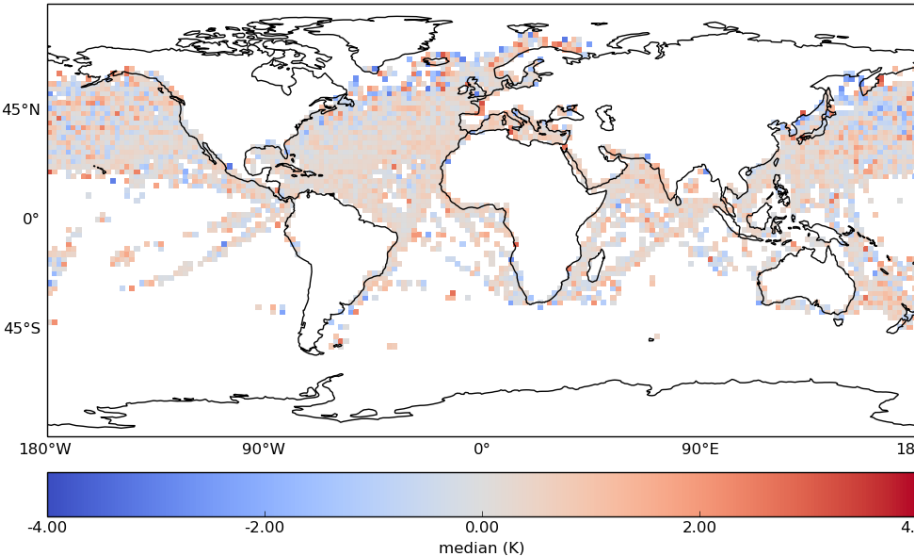
Reference data: ocean

- HadNMat2
  - Hadley Centre Nighttime Marine Air Temperature 2
- SAMOS
  - Shipboard Automated Meteorological and Oceanographic System
  - research ship data
- GTMBA
  - Global Tropical Moored Buoy Array
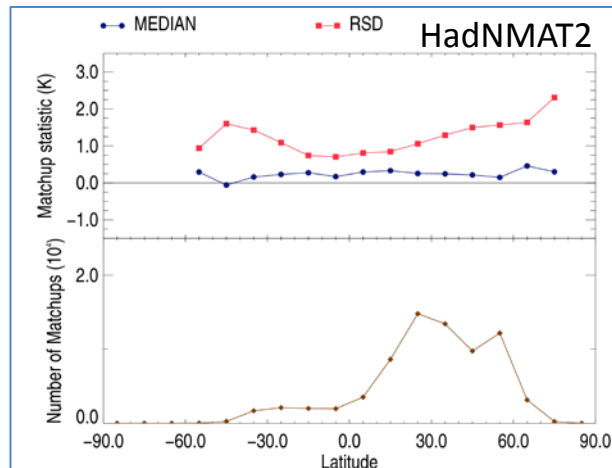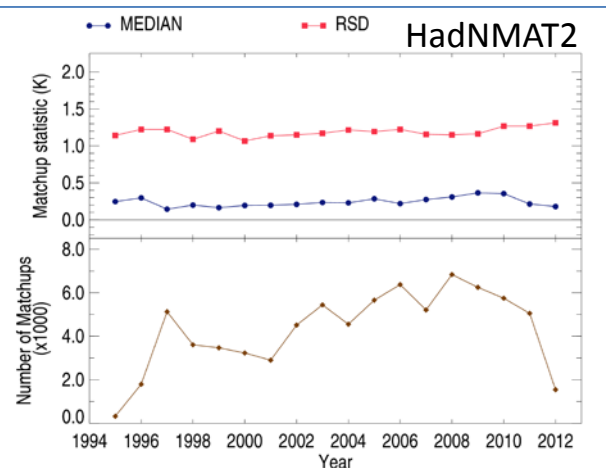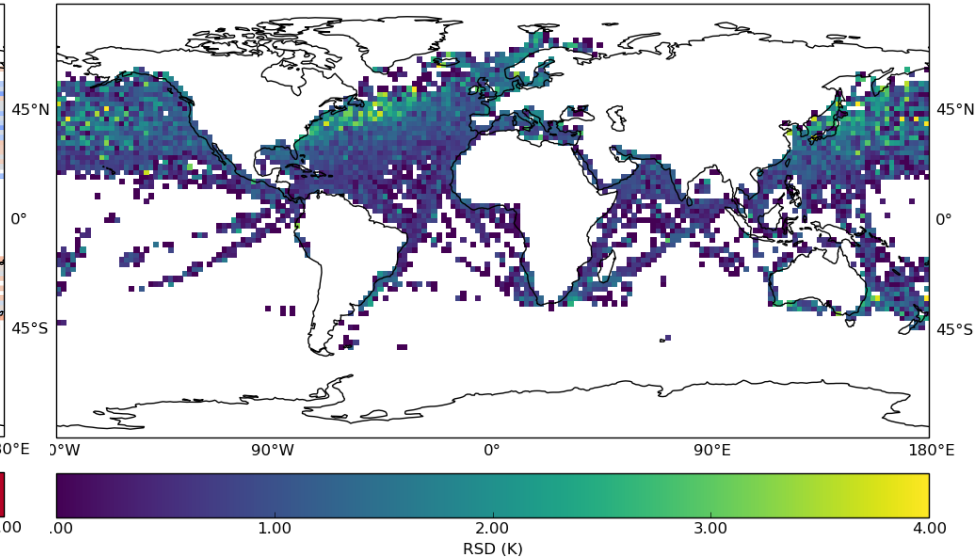 - Calculate daily Tmean on EUSTACE time grid

UNIVERSITY OF
LEICESTER
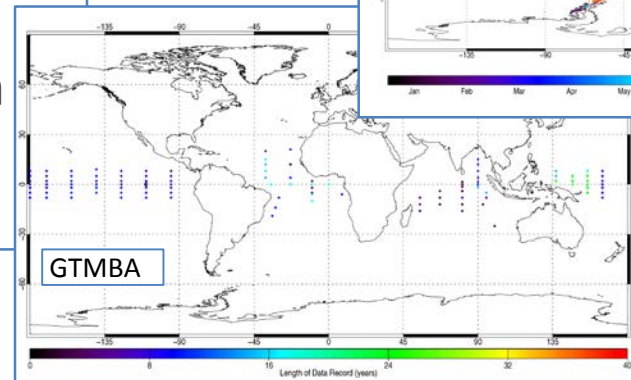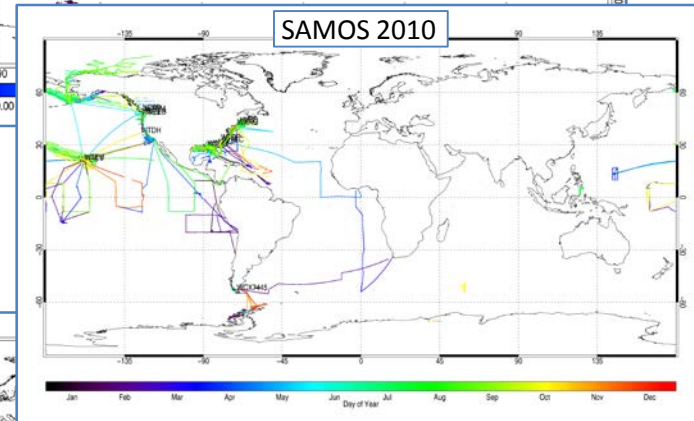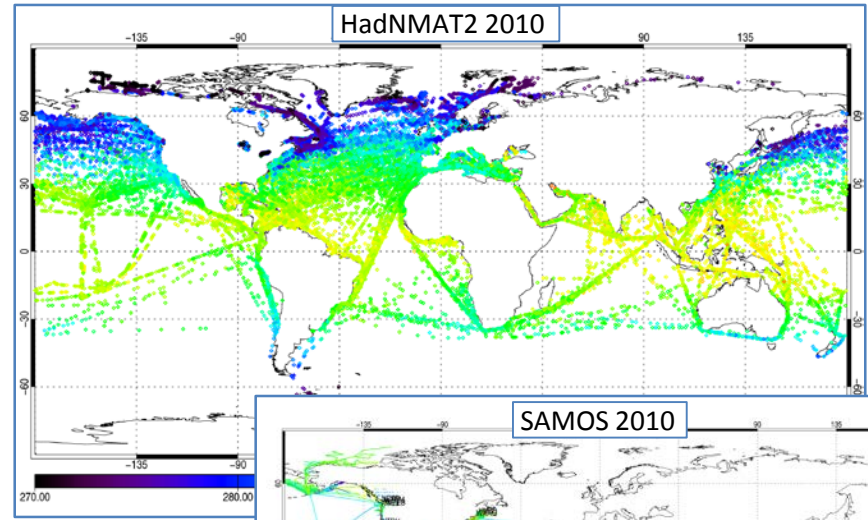
Ocean results

HadNMAT2 — All months — median (K)

HadNMAT2 — All months — RSD (K)

HadNMAT2

HadNMAT2

	Median (K)	RSD (K)
HadNMAT2	0.25	1.19
SAMOS	0.28	1.06
GTMBA	0.22	0.47

EUSTACE

Diagnostics 2: Validation of uncertainty estimates

- Model variance in discrepancy as

  – Variance due to in situ uncertainty + variance due to EUSTACE uncertainty + variance due to matchup process
    - Matchup contribution: e.g. point to grid comparison, difference in measurement height/time

  – $\sigma^2_{discr} = \sigma^2_{in\ situ} + \sigma^2_{EUSTACE} + \sigma^2_{matchup}$

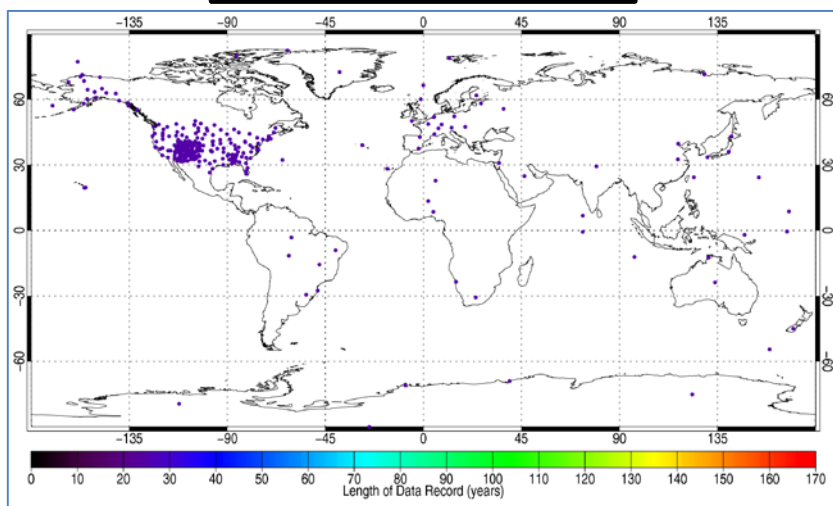67.4% of uncertainty values lie in bins where the matchup discrepancy RSD is within 20% of the model value
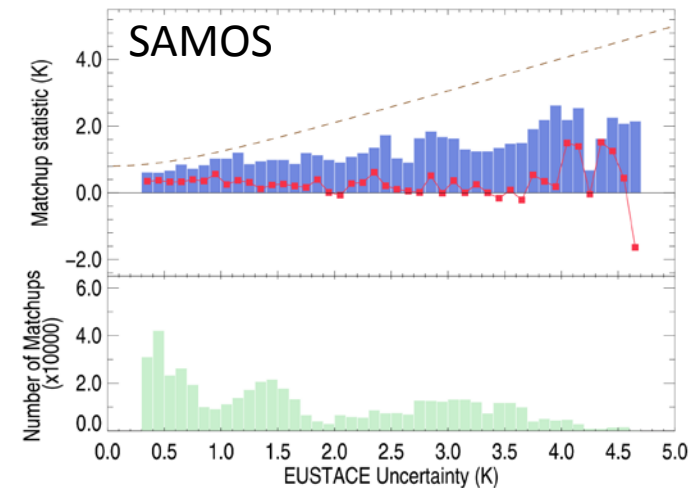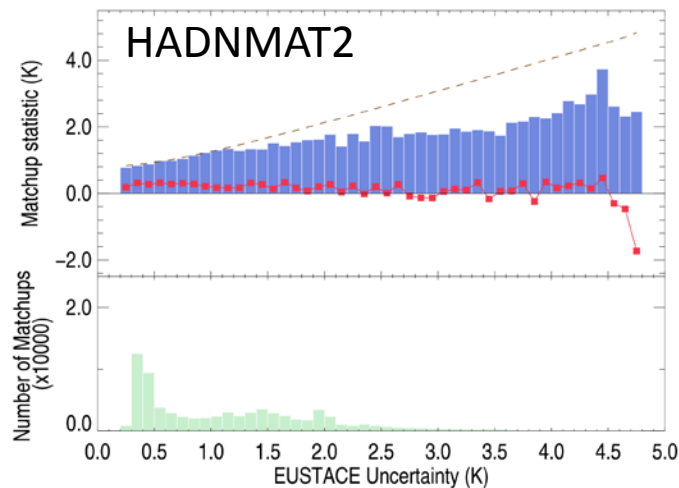
Reference data for validation: land

- EUSTACE matchup database (MDB)
    - ARM, BSRN, USCRN
        - Well maintained
    - Use all observations to estimate daily Tmin, Tmax, Tavg on EUSTACE time grid

- EUSTACE global station dataset (GSD)
    - Wider spatial and temporal coverage than EUSTACE MDB
    - Data are daily Tmin, Tmax (day definition of daily statistic calculation varies)
    - Data from approx. 10 % of stations reserved for validation, select those which best represent the EUSTACE grid box
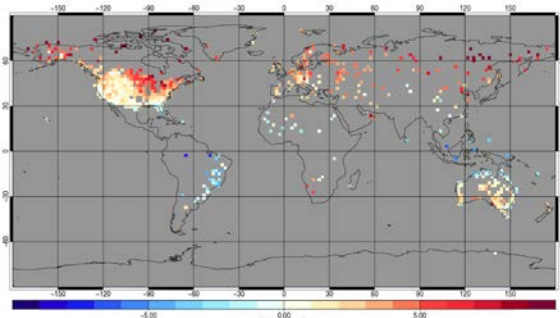
EUSTACE MDB

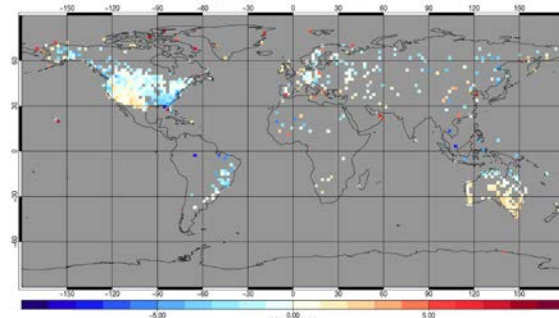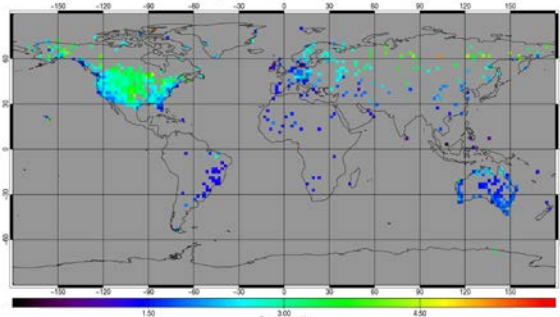EUSTACE GSD selection for validation
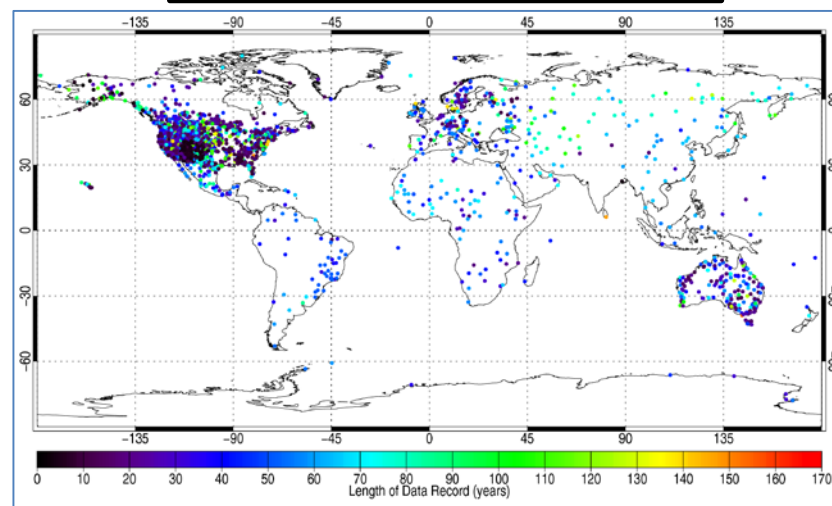
Land results 1: Tmax

Median discrepancy in Tmax Dec-Jan-Feb

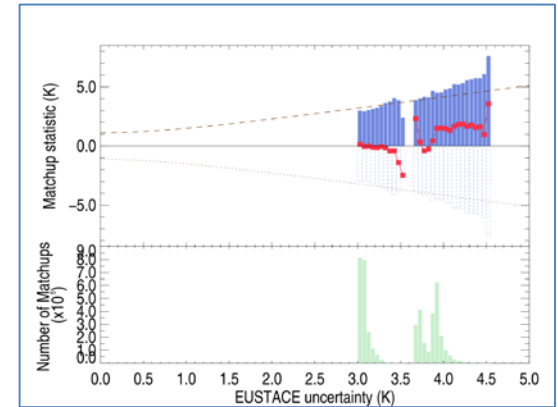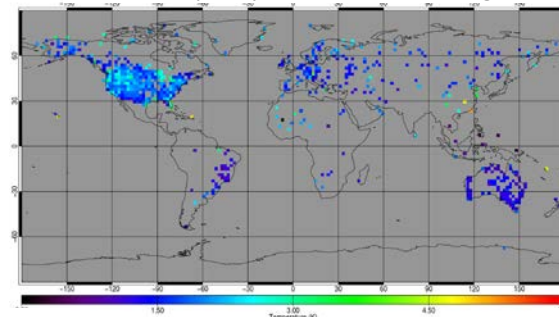Median discrepancy in Tmax Jun-Jul-Aug

-10.0 ... 10.0   -10.0 ... 10.0

MAD discrepancy in Tmax Dec-Jan-Feb

MAD discrepancy in Tmax Jun-Jul-Aug

0.0 ... 10.0   0.0 ... 10.0
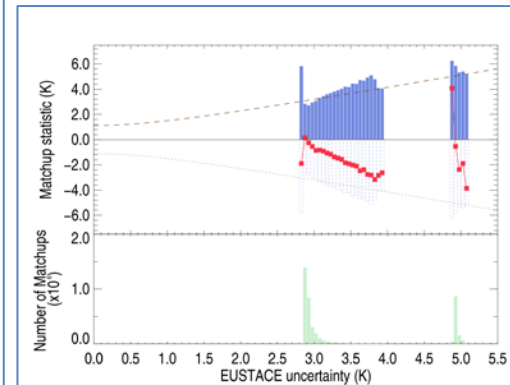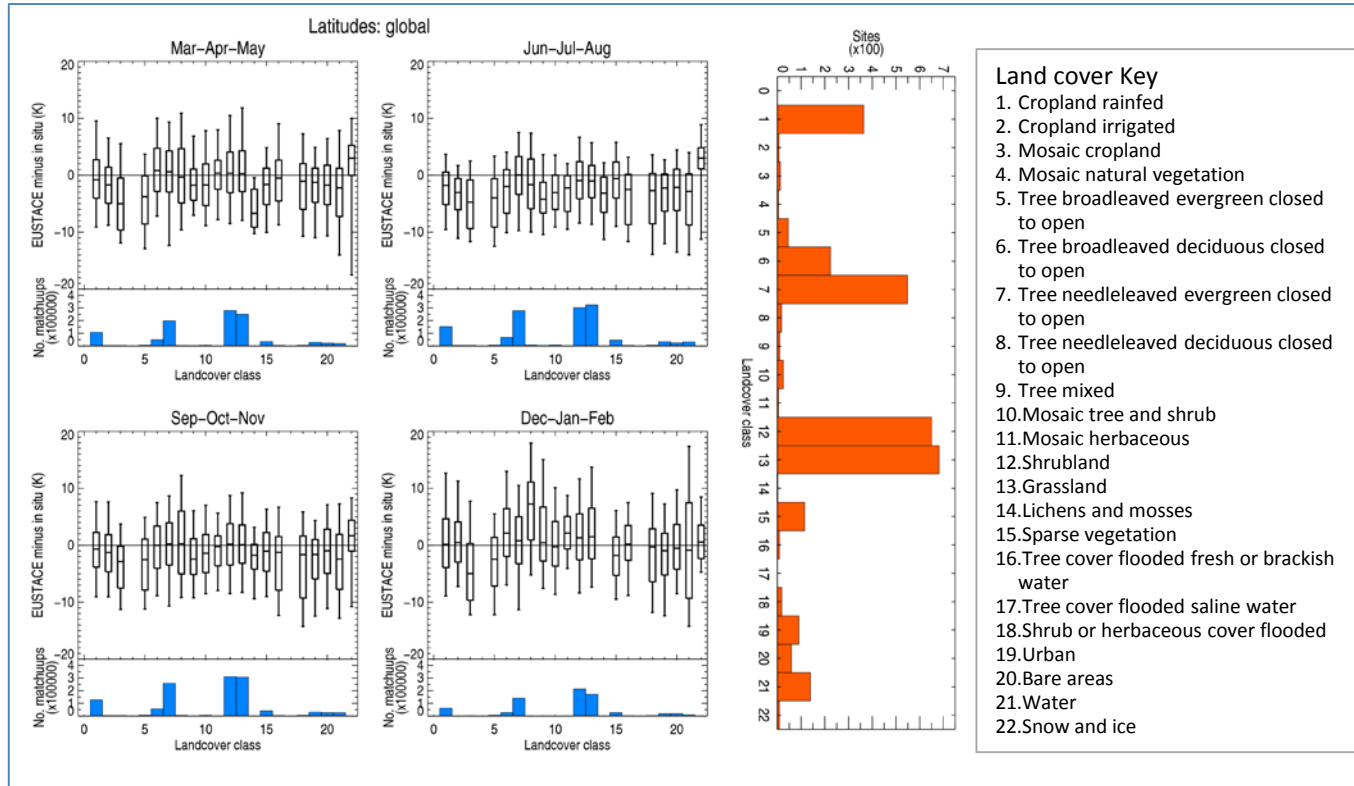

97.9 % of uncertainty values lie in bins where the matchup discrepancy RSD is within 20% of the modelled value

- Median discrepancy 0.48 K, RSD 3.74 K
- Seasonal and regional biases evident with largest positive discrepancy at northern latitudes in summer.

UNIVERSITY OF LEICESTER

EUSTACE

Land Results 2: Tmin

Latitudes: global

Land cover Key
1. Cropland rainfed
2. Cropland irrigated
3. Mosaic cropland
4. Mosaic natural vegetation
5. Tree broadleaved evergreen closed to open
6. Tree broadleaved deciduous closed to open
7. Tree needleleaved evergreen closed to open
8. Tree needleleaved deciduous closed to open
9. Tree mixed
10. Mosaic tree and shrub
11. Mosaic herbaceous
12. Shrubland
13. Grassland
14. Lichens and mosses
15. Sparse vegetation
16. Tree cover flooded fresh or brackish water
17. Tree cover flooded saline water
18. Shrub or herbaceous cover flooded
19. Urban
20. Bare areas
21. Water
22. Snow and ice

98.1 % of uncertainty values lie in bins where the matchup discrepancy RSD is within 20% of modelled value

- Tmin median bias -0.30 K, RSD 3.49 K
- Small variations in median discrepancy with land cover

Reference data: ice

- Some additional quality control at DMI
- Land-ice stations on Greenland
  - GCNET - Greenland Climate Network
  - PROMICE - Programme for Monitoring of the Greenland Ice Sheet
- Stations on Antarctica land and ice-shelves
  - AMRC - Antarctic Meteorological Research Center stations
  - National Climatic Data Center (NCDC)
- Sea-ice buoys and campaigns
  - ACSYS - Arctic Climate System Study
  - DAMOCLES - Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies
  - CRREL - Cold Regions Research and Engineering Laboratory
  - ECMWF - European Centre for Medium range Weather Forecasting (ECMWF),
  - FRAMZY - Fram Strait Experiment
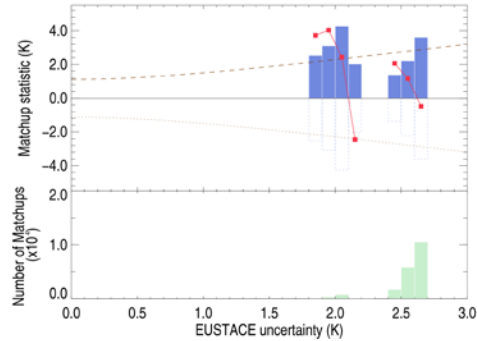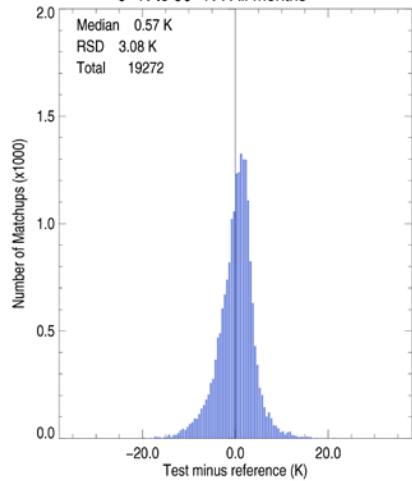 - Polarstern cruises
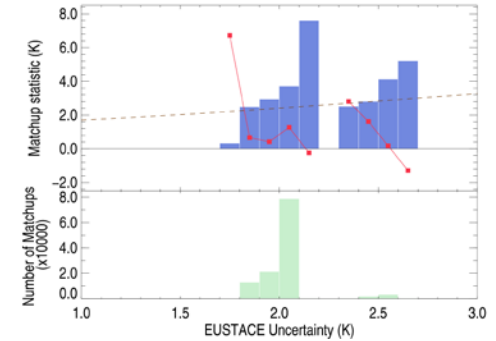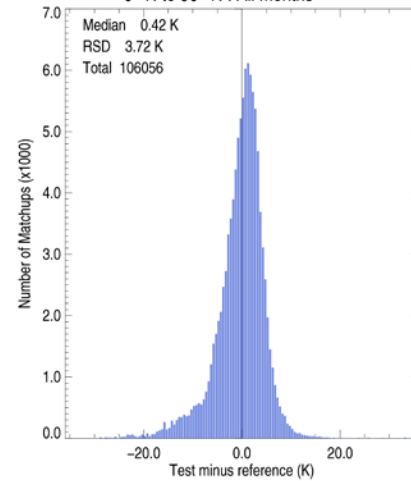
Ice Stations
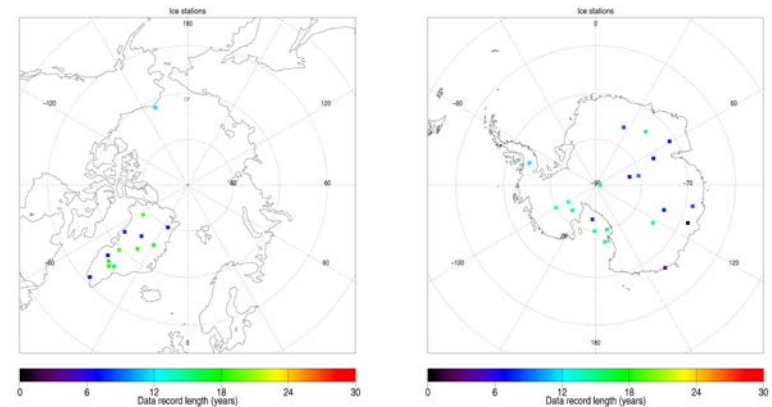
Sea-ice buoy data
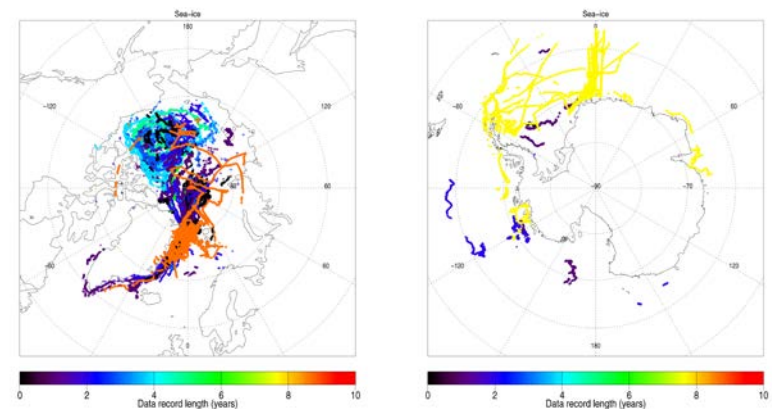
UNIVERSITY OF LEICESTER

EUSTACE

Ice results
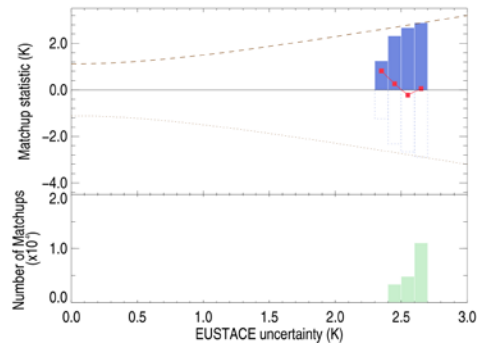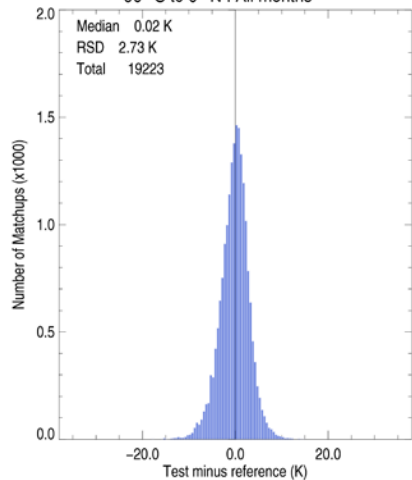
Arctic Land

Arctic Sea
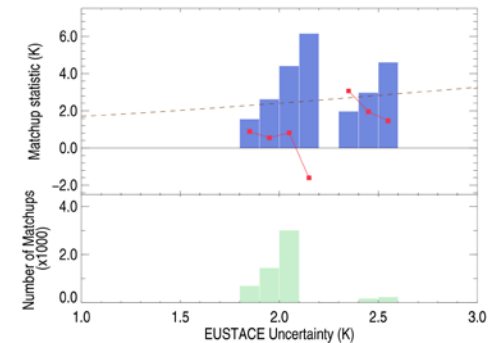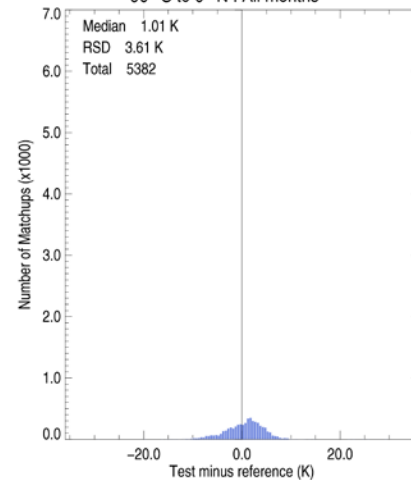
Antarctic Land

Antarctic Sea

Summary

- Transparent validation using publically available reference data that are independent of the test datasets.

- EUSTACE estimates of air temperature from satellite (SATSTACE) agree well with in situ data

- Land: probably most difficult domain due to heterogeneity of surface and cloud contamination of input LST data. Regional and seasonal biases are evident. Global mean Tmin median bias to in situ is -0.30 K (RSD 3.49 K); Tmax +0.49 K (3.74 K). Uncertainty estimates characterize differences with in situ data well.

- Ocean: domain closest to in situ: Tavg median bias +0.25 K (1.19 K). Larger differences in high ST gradient regions. Uncertainty estimates characterize differences with in situ data well.

- Ice: in situ data available for validation is sparse especially for southern hemisphere sea-ice. Median biases are between 0.0 K and 1.1 K with RSDs of 2.73 K to 3.72 K depending on region and land/sea. Uncertainty estimates are generally good although slightly underestimated in places.

- Further assessment of EUSTACE products will be made by intercomparison with AIRS (Atmospheric InfraRed Sounder) data, other air temperature analyses, and reanalyses.

UNIVERSITY OF
LEICESTER

EUSTACE

QUESTIONS