

EU SURFACE TEMPERATURE FOR ALL CORNERS OF EARTH (EUSTACE)

Nick Rayner, Met Office Hadley Centre, Science Coordinator EUSTACE project,
and partners

Material provided by Renate Auchmann, Colin Morice, Darren Ghent, Lizzie
Good, John Kennedy, Finn Lindgren and Janette Bessembinder

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*EUSTACE has received funding from the European Union's Horizon 2020 Programme for
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EUSTACE AIMS



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EUSTACE AIMS

EUSTACE will give publicly available daily estimates of surface air temperature since 1850 across the globe for the first time by combining surface and satellite data using novel statistical techniques. To do this, we need to:

- Identify non-climatic discontinuities in daily weather station data, *so users can trust the changes our records show*
- Produce consistent uncertainty estimates for satellite skin temperature retrievals over all surfaces (land, ocean, ice and lakes), *so we know how far to trust the estimates everywhere*
- Understand how surface temperature measured *in situ* and by satellite relates, *to estimate air from skin temperature*
- Estimate values in areas where we have no *in situ* or satellite data, *so users can have daily information here*





CURRENT SOURCES OF SURFACE AIR TEMPERATURE INFORMATION



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CURRENTLY AVAILABLE SURFACE AIR TEMPERATURE DATA

Source	Type	Region / time period	Daily?	Publicly available?	Spatially complete?
ERA-Interim, NCEP/NCAR, JRA-55, 20CR, etc	Dynamic reanalysis, uses model	Global / various	Yes	Yes	Yes
Berkley	Gridded, uses statistics	Land only / from C19th	Yes	Yes	Yes
HadCRUT4, MLOST, GISTEMP, Berkley, etc	Gridded, uses statistics	Global / from C19th (uses SST)	No	Yes	Sometimes
E-OBS, etc	Gridded, uses statistics	Regional land only / from 1950	Yes	Yes	Yes
ISTI, GHCN, ECA&D, etc	Station, obs only	Regional land only / various	Yes	Yes	No
Other data from satellites	Gridded	Global & regional / a few years	Yes	?	Sometimes

EUSTACE SURFACE AIR TEMPERATURE DATA

Source	Type	Region / time period	Daily?	Publicly available?	Spatially complete?
EUSTACE station series	Station, obs only	Global / from C19th	Yes	Yes	No
EUSTACE update to E- OBS	Gridded, uses statistics	Europe / from 1950	Yes	Yes	Yes
EUSTACE air temperature estimates from satellites	Gridded, obs only	Global / last decade or two	Yes	Yes	No
EUSTACE complete air temperature fields	Gridded, uses statistics	Global / from C19th	Yes	Yes	Yes



COMPARISON TO OTHER GLOBAL SURFACE TEMPERATURE PRODUCTS

EUSTACE products will differ from others by:

- Being designed in collaboration with users;
- Using an understanding of the relationship between skin and air temperature to estimate air temperature over the whole globe for a long time period;
- Providing daily, globally-complete estimates of surface air temperature over all surfaces of Earth (land, ocean, ice and lakes) since 1850;
- Clearly indicating where these estimates are reliable, probably using an ensemble;
- Presenting air temperature over the ocean, rather than SST;
- Including fully-homogenised daily station data over Europe;
- Being validated (air temperatures and uncertainties) by comparison to independent data;
- Being documented in a Product User Guide





HOW EUSTACE WILL ACHIEVE ITS AIMS



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IDENTIFYING NON-CLIMATIC DISCONTINUITIES IN DAILY WEATHER STATION MEASUREMENTS



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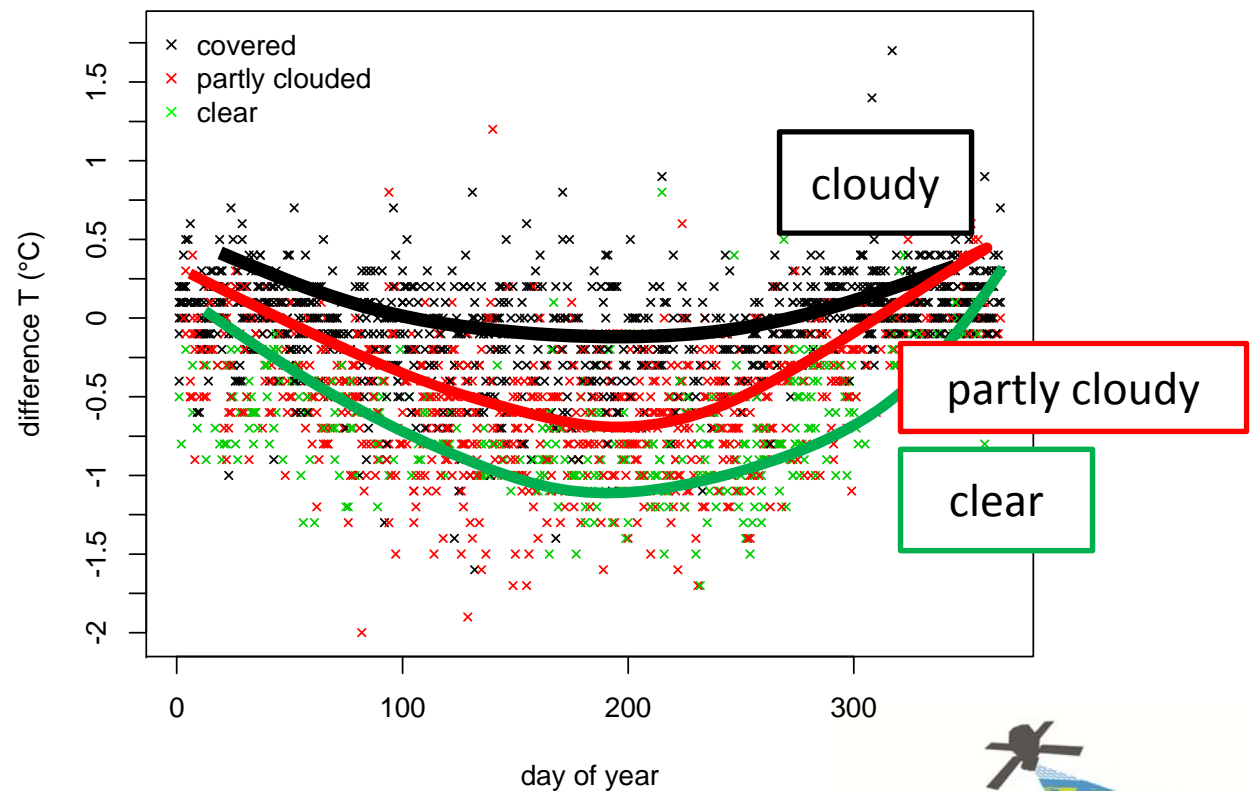


DETECTING DISCONTINUITIES IN DAILY LAND STATION DATA

- signal-to-noise ratio is small
- non-linear effects result in changes to the distribution as well as the mean

Parallel measurements:
Stevenson – Wild screens

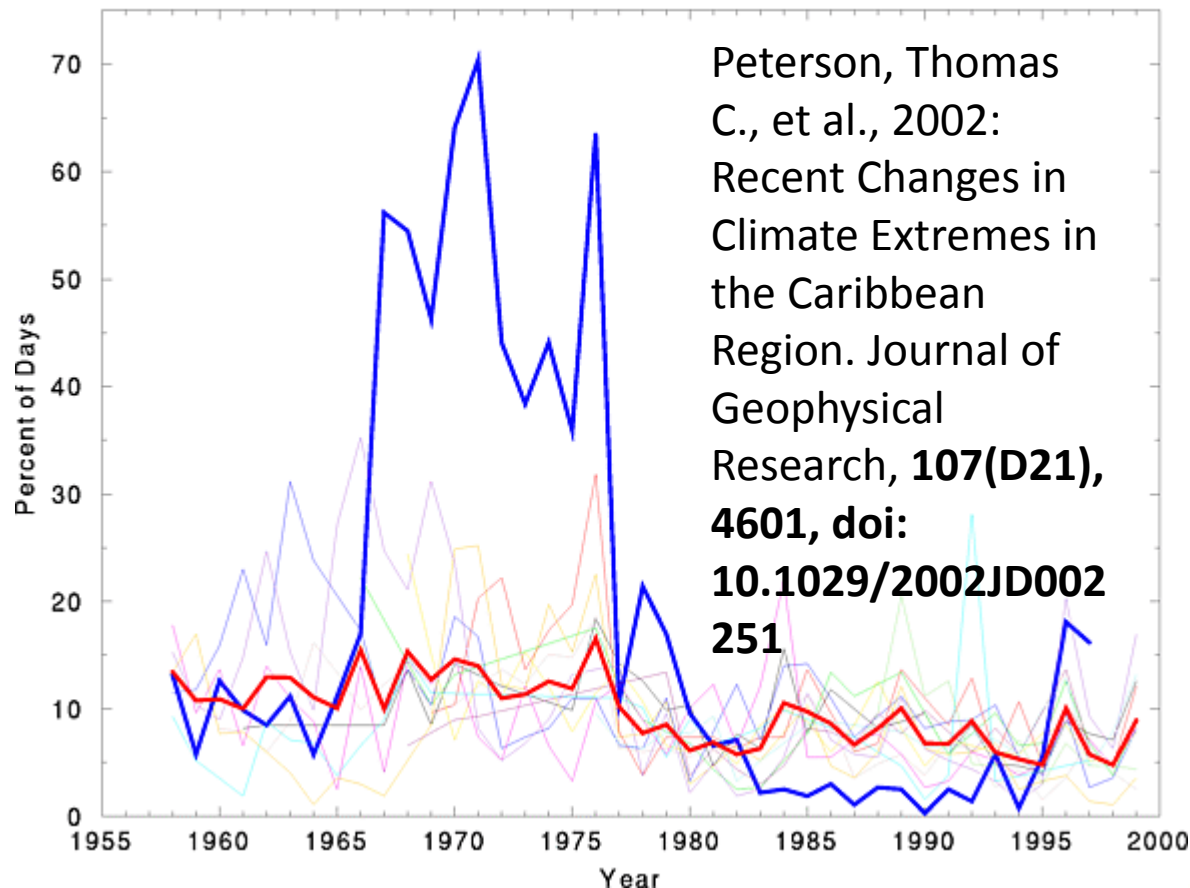
Difference between two
observations of the same
variable at the same place
in different instrument
screens



CONSEQUENCES OF DISCONTINUITIES IN DAILY LAND STATION DATA

Percent of Days that Tmax < 10th Percentile

Based on Percentiles Calculated during Base Period of 1977–1997



Percent of days where daily maximum temperature is greater than the 10th percentile for the period 1977-1997 for 16 stations in the Caribbean Region.





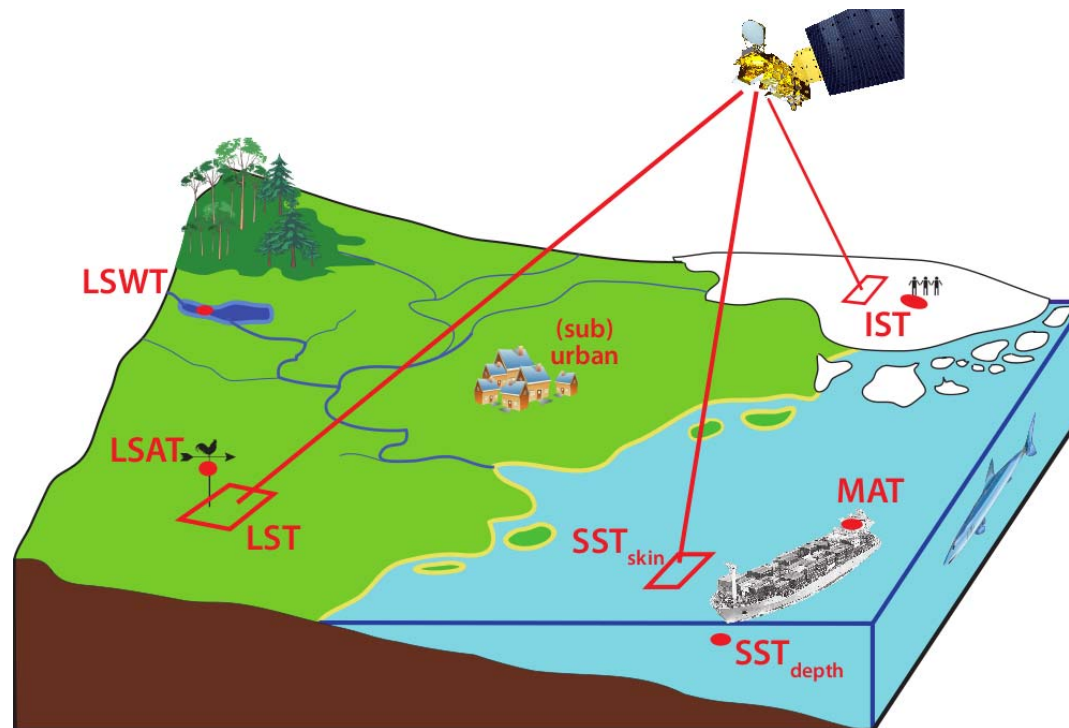
ESTIMATING AIR TEMPERATURE FROM SATELLITE DATA



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UNDERSTAND RELATIONSHIP BETWEEN AIR AND SKIN TEMPERATURE

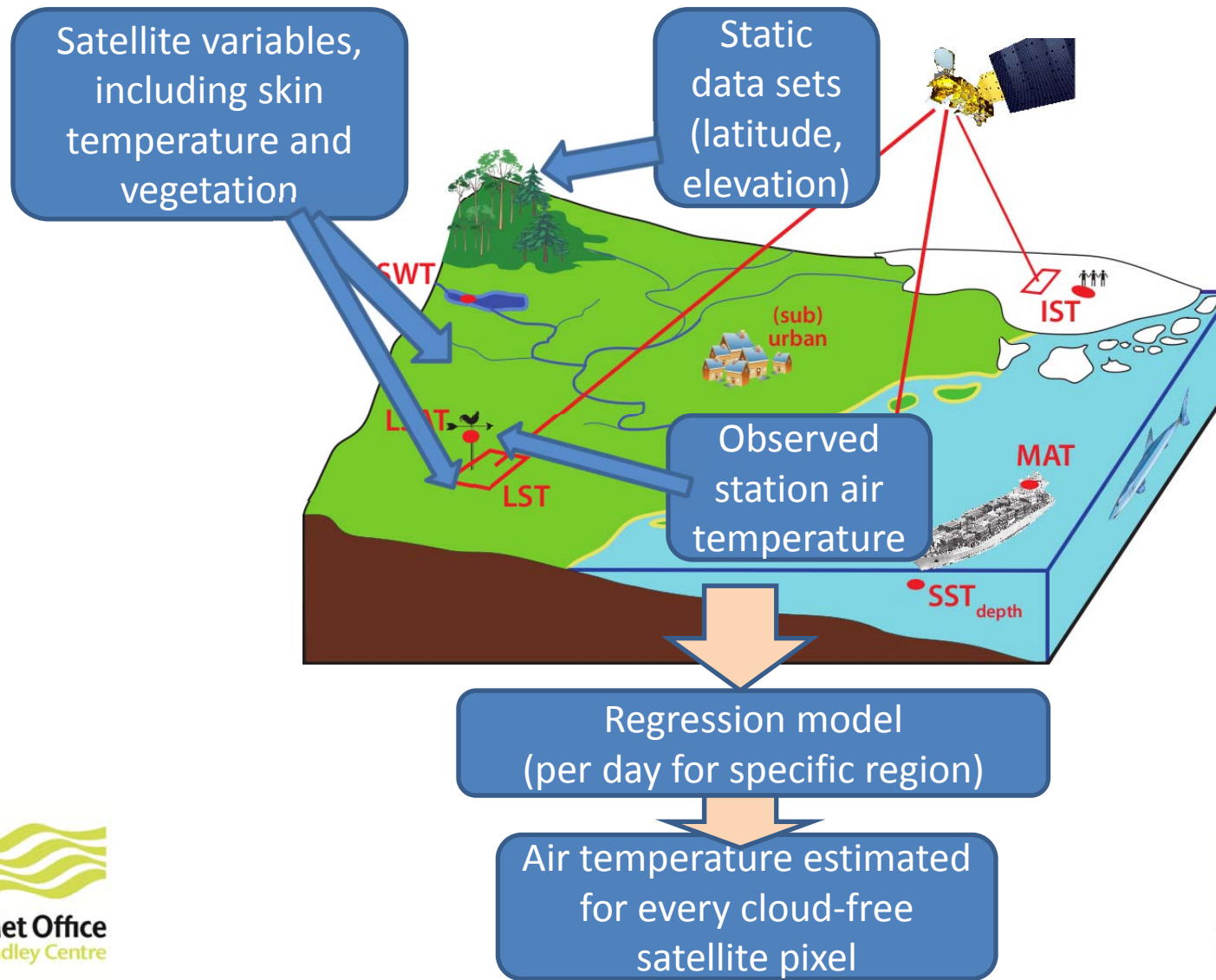


From Merchant et al., 2013 community paper and roadmap:

<http://www.geosci-instrum-method-data-syst.net/2/305/2013/qi-2-305-2013.html>



ESTIMATING AIR TEMPERATURE FROM SKIN TEMPERATURE



ESTIMATING AIR TEMPERATURE FROM SKIN TEMPERATURE

Highest available
resolution in-
filled air
temperature
analysis from
weather station
measurements

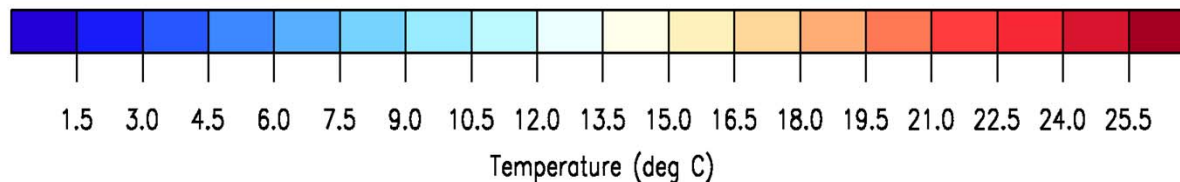
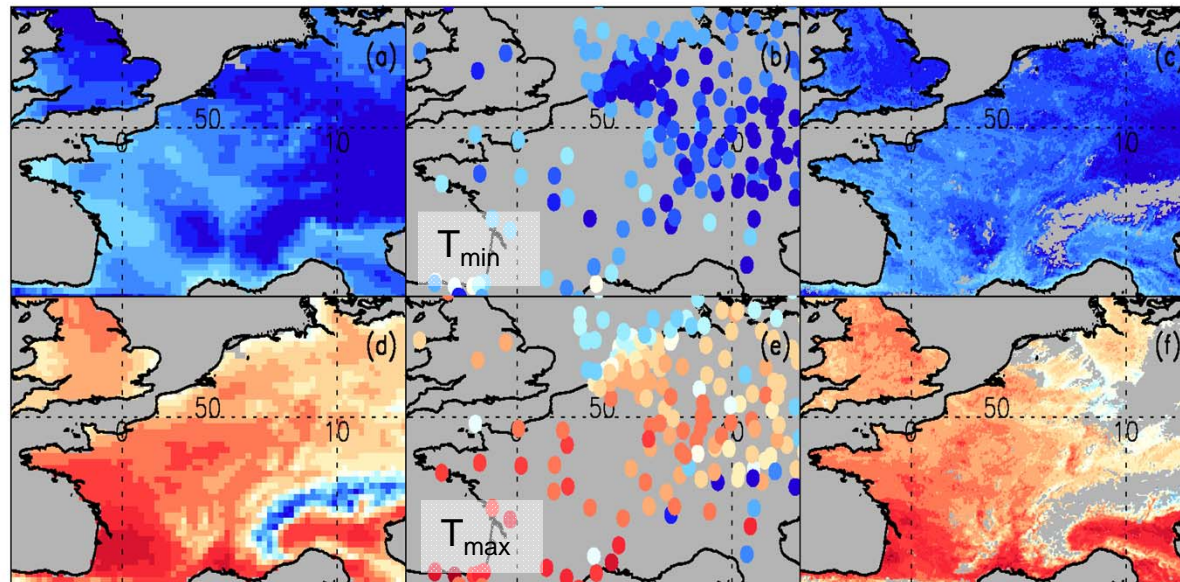
EOBS

Publicly available
weather station records

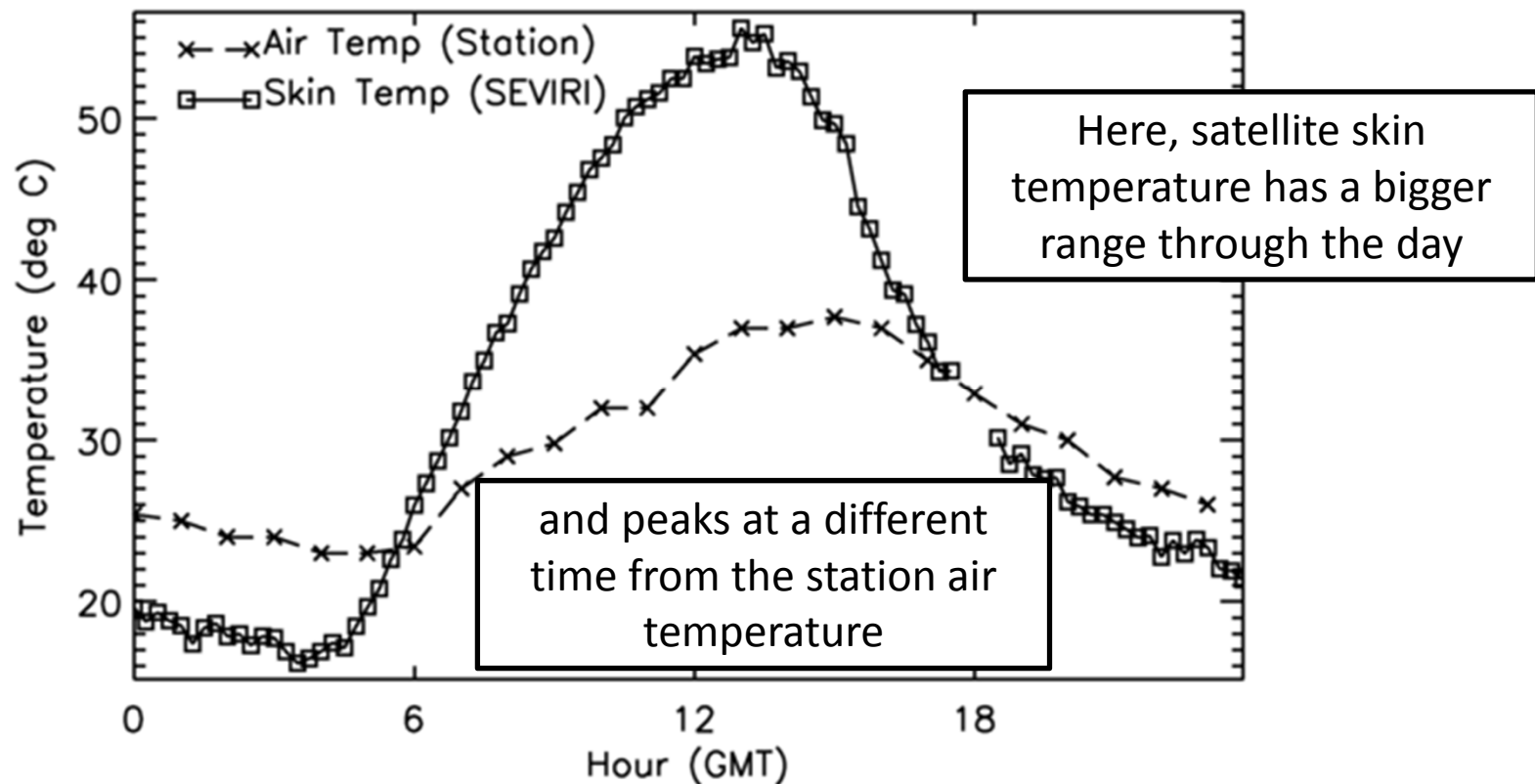
ECA&D

Satellite LSAT

Higher resolution
information on
air temperature
estimated using
surface (skin)
temperature
from satellites



CHALLENGES – DIFFERENCES IN TEMPERATURE EVOLUTION THROUGH THE DAY

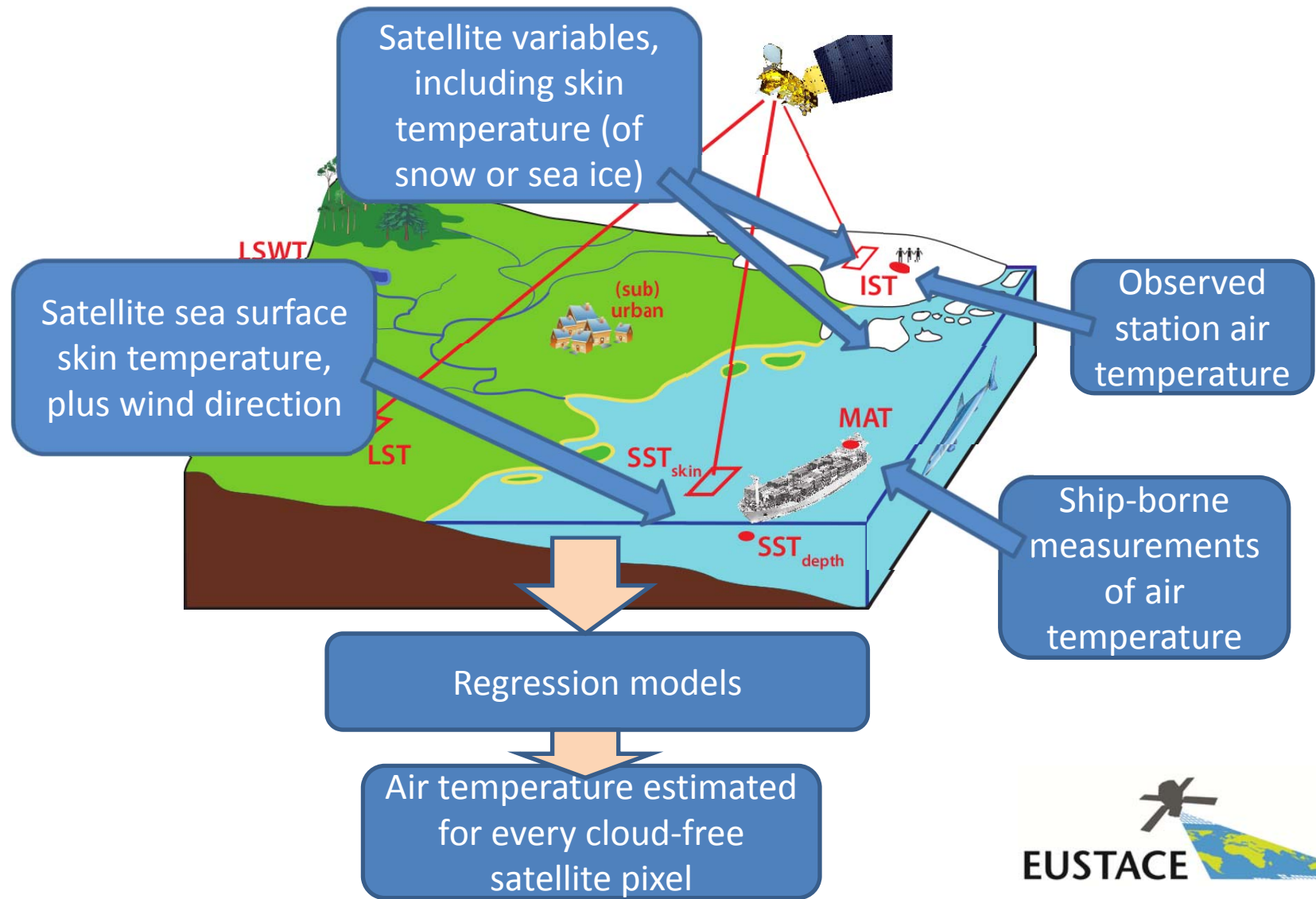


Extreme case of the diurnal cycle on 2 July 2011 of surface skin temperature (from the SEVIRI satellite) and surface air temperature (at a weather station) in Kairouan, Tunisia

OTHER CHALLENGES - ESTIMATION OF TMAX/TMIN AND IMPACT OF CLOUD

- Calculate daily Tmin/Tmax over land from the satellite data and use this to estimate Tmean.
- EUSTACE Tmin/Tmax product from the satellite data for the recent past. This will not be all-sky because we cannot retrieve skin temperature when it is cloudy using infra-red sensors.
- Even when geostationary satellite data are used, full diurnal cycle will not be observed because of cloud in most locations. May fit a diurnal model to estimate Tmean.
- Exploring the detailed impact of cloud on the air/skin temperature relationship and the likely relative accuracy of our estimates of Tmax, Tmin and Tmean.

ESTIMATING AIR TEMPERATURE FROM SKIN TEMPERATURE – OTHER SURFACES



ESTIMATE VALUES IN AREAS WHERE WE HAVE NO *IN SITU* OR SATELLITE DATA ON A PARTICULAR DAY



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STATISTICAL ANALYSIS METHODS

Global temperature data sets have either been based on simple aggregation of data in grid boxes or on statistical techniques developed in geosciences in the 1980s and 1990s.

The state-of-the-art in the spatial statistics research community is far ahead of the methods generally used in the Earth sciences.

Two approaches will be investigated in EUSTACE:

1. An “advanced standard” method based upon the more advanced methods currently used in surface temperature data set construction.
2. State-of-the-art novel spatial statistics.

DEVELOPMENT OF STATE-OF-THE-ART ANALYSIS METHODS

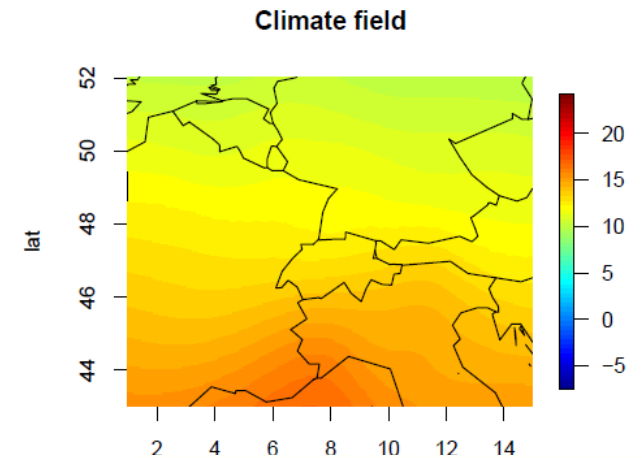
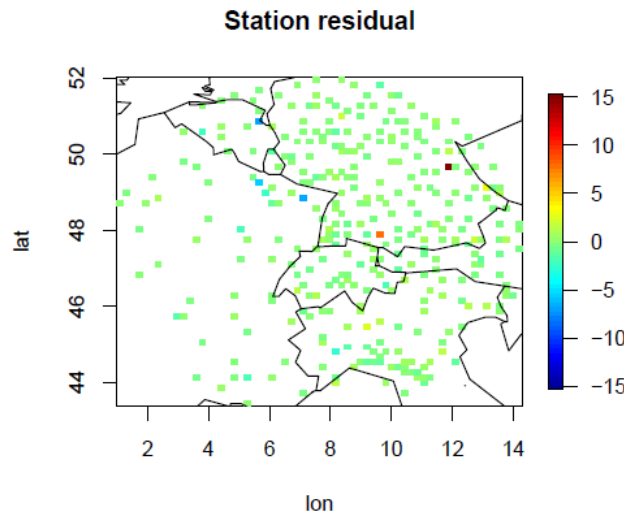
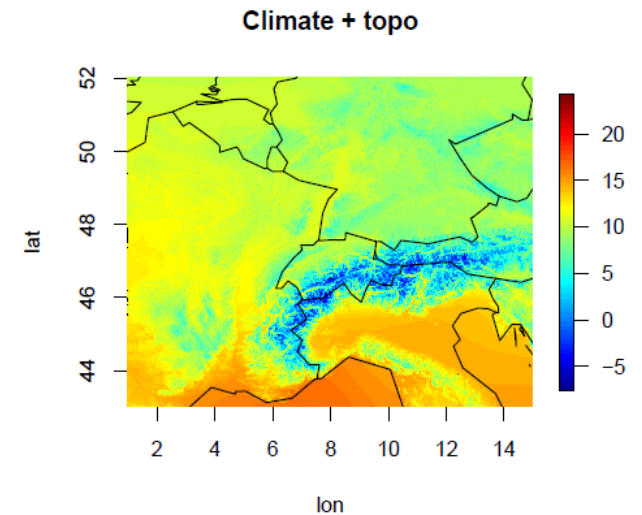
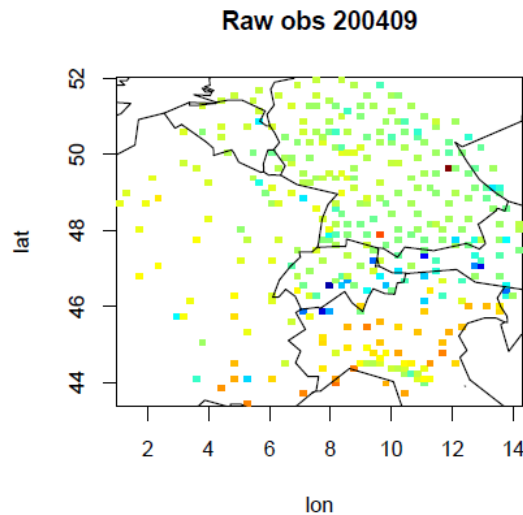
Build a statistical model of surface air temperature, where the different sources of air temperature observations and estimates are used in a hierarchical fashion, using the uncertainty quantified in the air temperature estimation stage as a basis to weight each data source.

The regions in space and time that only have sparse data will be linked to regions that have more data, by the statistical model.

By building the model as a combination of random processes on different temporal and spatial scales, the spatio-temporal interpolation estimates only those aspects of the temperature process about which the data are informative, and gives reasonable uncertainty estimates about other aspects which we do not have enough data to reconstruct.

CREATE COMPLETE FIELDS

- Estimation is methodologically challenging on the resolution intended
- Need state-of-the-art computationally efficient spatial statistics and numerical methods
- Proof-of-concept spatio-temporal statistical model developed in the ISTI/SAMSI/IMAGe workshop July 2014





VALIDATION



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HOW WILL WE KNOW IF EUSTACE PRODUCTS ARE ANY GOOD?

We will:

- Adhere to standardised validation protocols for each surface type, with the aim to fit the profile of Quality Assurance for Essential Climate Variables Data (QA4ECV)
- Extend existing principles from SST and LST to match up collocated surface air temperature against *in situ* measurements across all surfaces:
 - Withhold sufficient fully-SI-traceable measurements for the highest quality validation, ensuring full independence from project output datasets
 - Validate the uncertainty information to increase confidence in the quality of the data products
- Inter-compare on common spatial and temporal grids the output surface temperature datasets with other surface air temperature datasets and reanalysis data



**University of
Leicester**

Courtesy Darren Ghent, Univ Leicester



USER ENGAGEMENT WITH EUSTACE

EUSTACE products will be made for wide range of users: researchers, policy makers, health, agriculture, etc.

User engagement needed **from the start** to assure usability/salience

Activities in which users can be engaged and/or informed:

- User workshops (first was splinter session at EGU (April 2015), then virtually via WebEx (May 2015)): users' requirements
- As trail blazers
- Dissemination on the progress and products through web site
- Guidance on use of products

EUSTACE will have been successful when the products are used. **If you are interested, please contact janette.bessembinder@knmi.nl**



EUSTACE PRODUCTS



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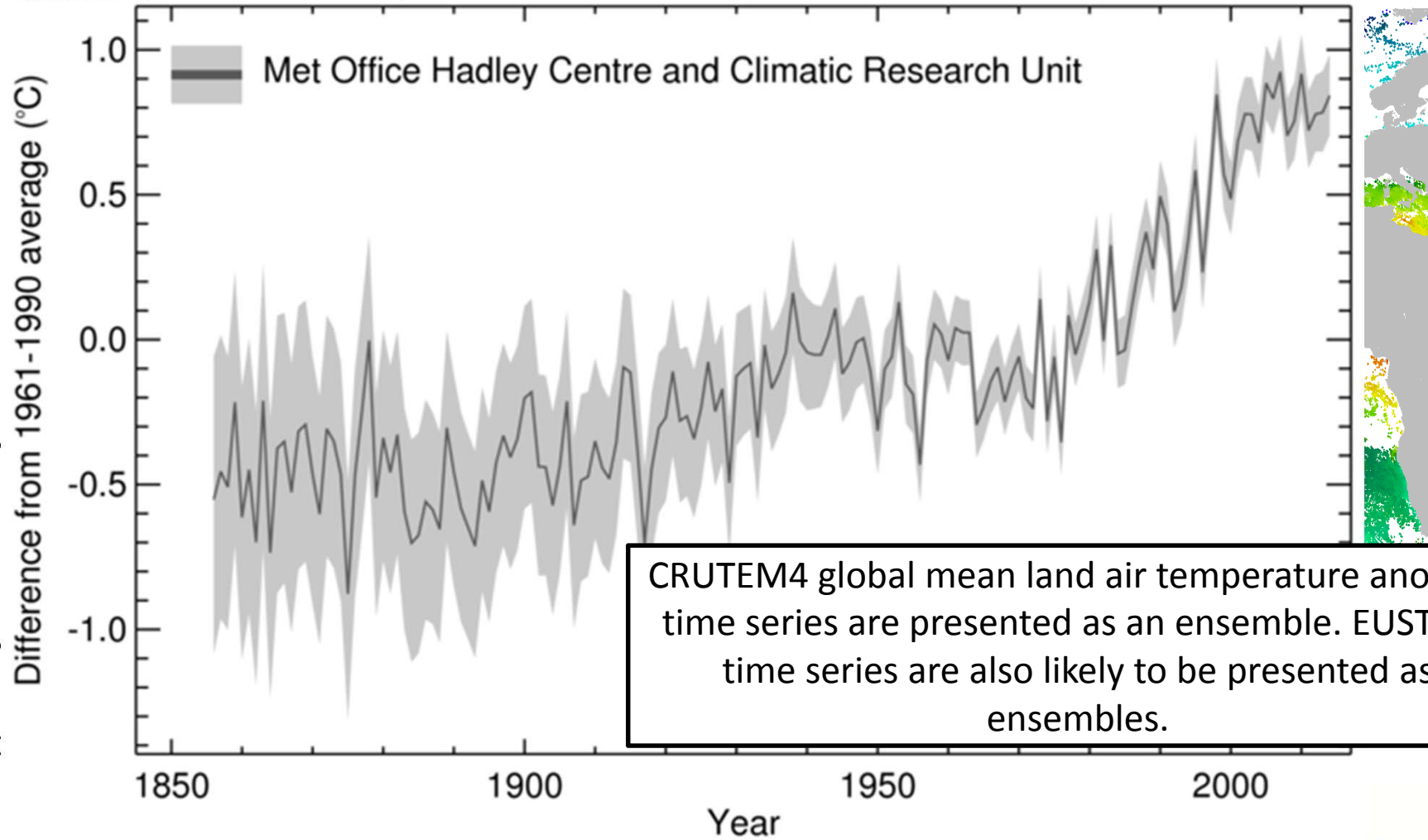
EUSTACE PRODUCTS

Product	Description	Date
Station series and E-OBS update	Global data set of daily weather station air temperature measurements (Tmax and Tmin) with non-climatic breaks identified – Station time series and gridded for Europe	Dec 2016
Satellite skin temperature retrievals	Daily satellite skin temperature estimates for all surfaces of Earth with consistent uncertainty estimates – Gridded or along satellite's track (TBD)	Oct 2015
Skin/air temperature relationships	Understanding of the relationship between surface skin and surface air temperature over all surfaces of Earth and in different seasons – A report	Dec 2016
Air temperature estimates from satellites	Daily estimates of surface air temperature from skin temperature retrievals - Gridded or along satellite's track (TBD)	Jun 2017
Globally complete air temperature fields	Globally-complete daily fields of surface air temperature over all corners of Earth since 1850 – Gridded (0.25° lat/lon) perhaps an ensemble. (Tmax and Tmin over land, Tmean elsewhere.)	May 2018
Derived products	For example, global means and climatologies	May 2018

WHAT EUSTACE PRODUCTS MIGHT LOOK LIKE



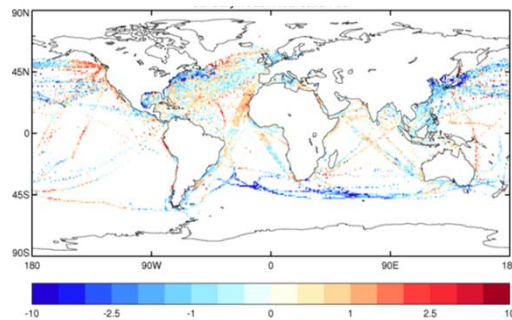
Global average air temperature anomaly over land
(1856 - 2014)



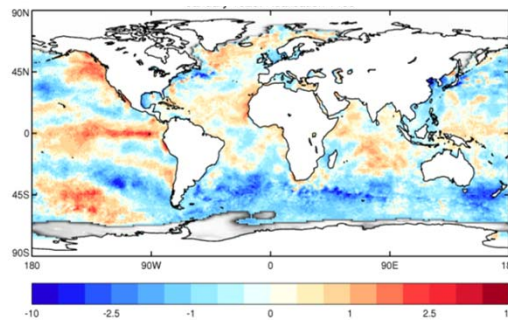
ENSEMBLES TO CONVEY UNCERTAINTIES?

Produce multiple versions of the same temperature field which are all consistent with the sparse historical *in situ* measurements

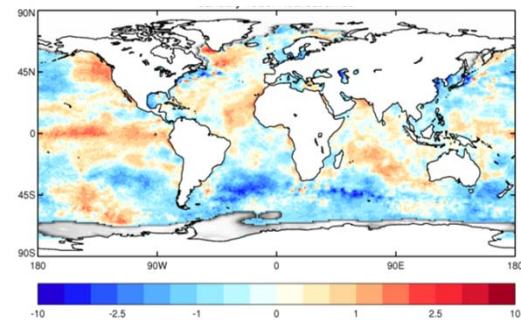
Observations



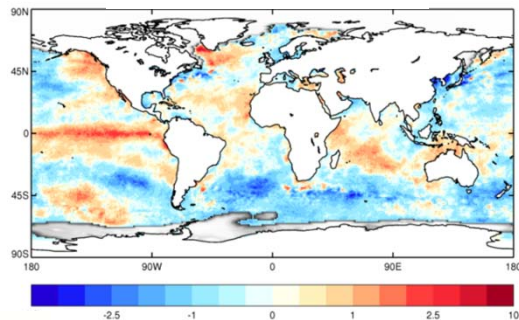
Member 1466



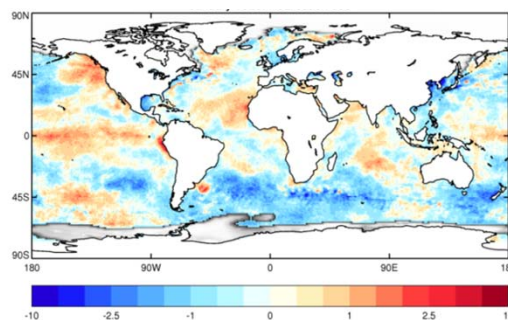
Member 69



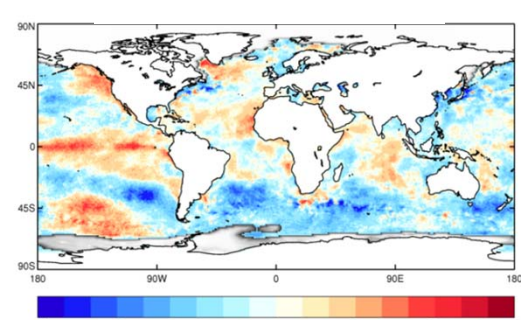
Member 137



Member 396



Member 1059



-10 -2.5 -1 0 1 2.5 10

SUMMARY

EUSTACE will give publicly available daily estimates of surface air temperature since 1850 across the globe for the first time by combining surface and satellite data using novel statistical techniques. To do this, we need to:

- Identify non-climatic discontinuities in daily weather station data, *so users can trust the changes our records show*
- Understand how surface temperature measured *in situ* and by satellite relates, *to estimate air from skin temperature*
- Estimate values in areas where we have no *in situ* or satellite data, *so users can have daily information here*
- Validate our estimates using independent data





MANY THANKS FOR LISTENING

TIME FOR QUESTIONS



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