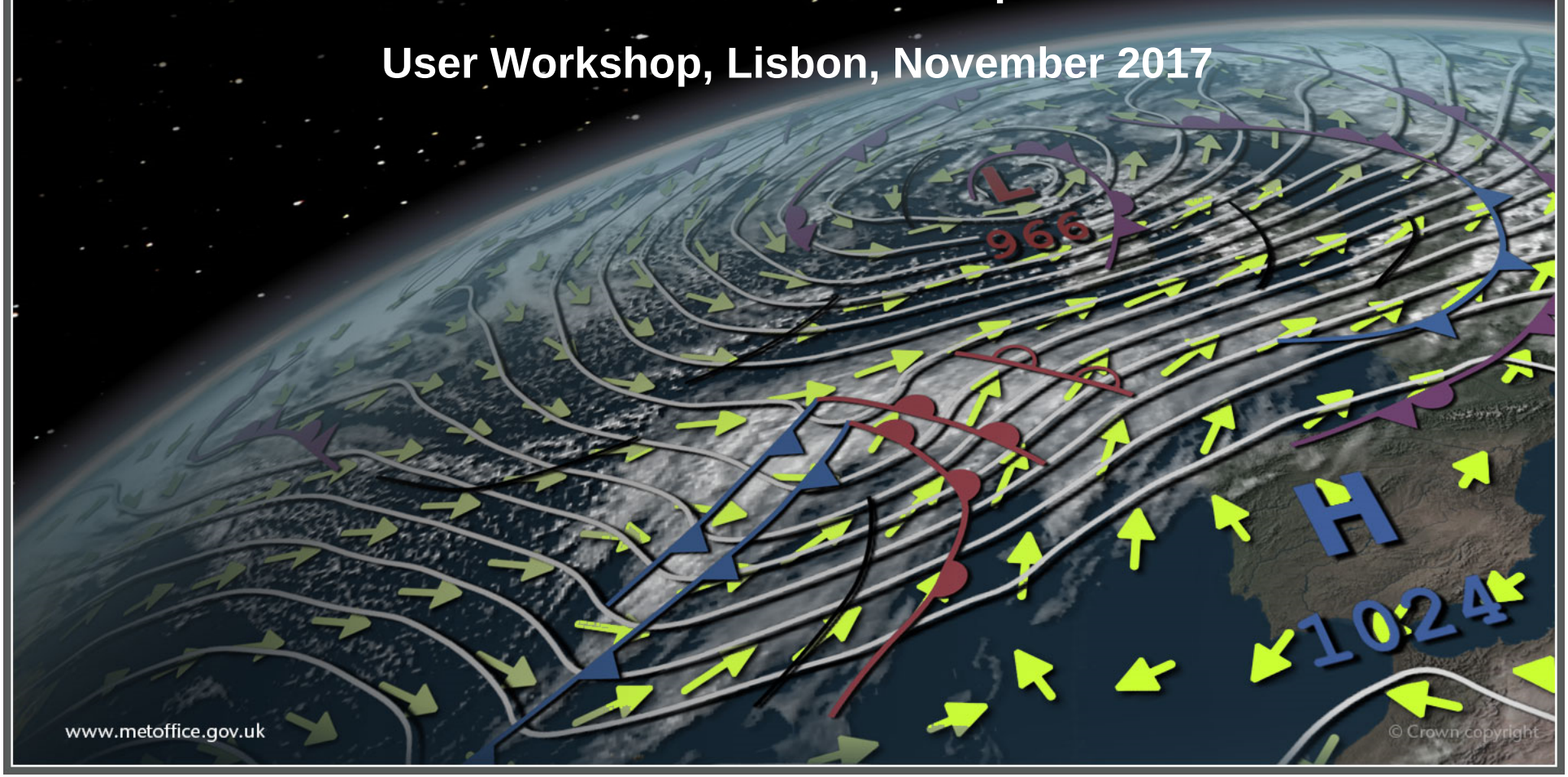
A satellite air temperature record: why, how and what next?

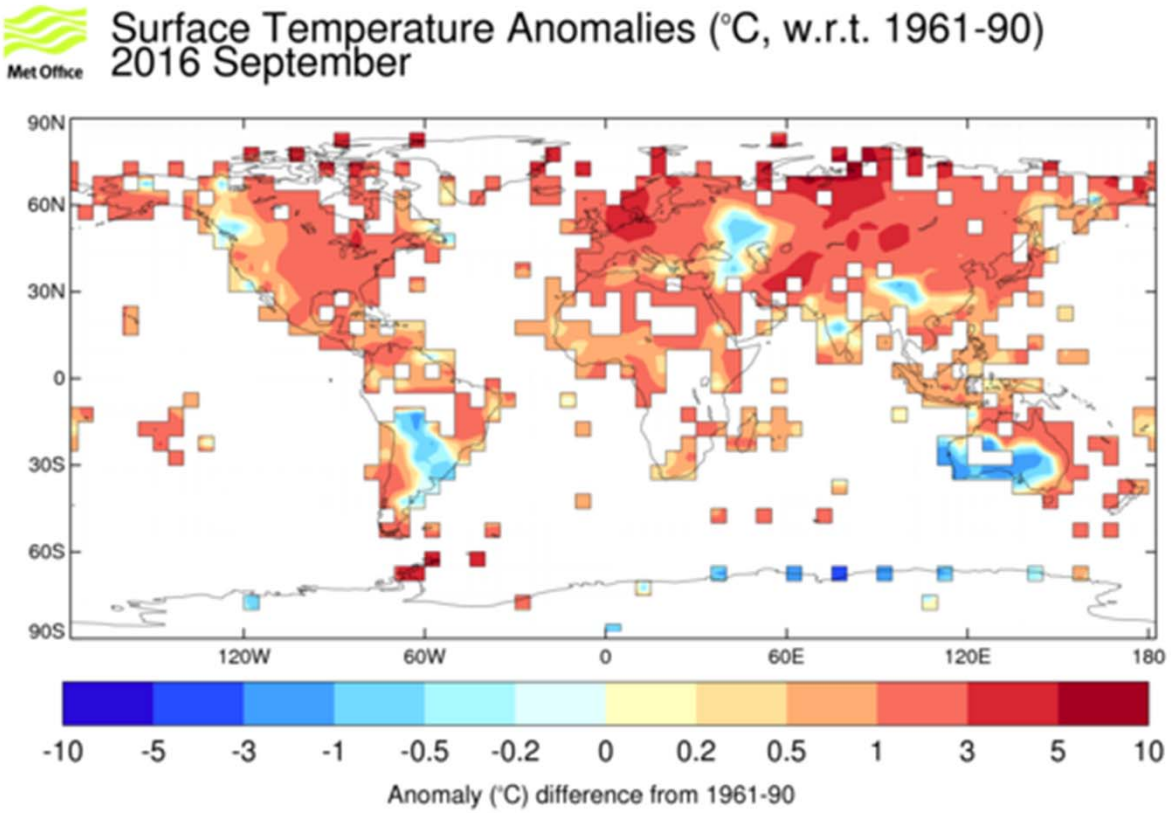
Lizzie Good

Joint EUSTACE and GlobTemperature

User Workshop, Lisbon, November 2017



Why satellite T2m?



CRUTEM4 (http://www.metoffice.gov.uk/hadobs)

- We don't have in situ obs everywhere
  - Regional and global uncertainties
- Satellite data can help infill these gaps
  - We are doing this in EUSTACE
- Or we could use satellite air temp estimates independently?

How can this be done?

- Satellites cannot observed T2m directly. May examples of methods in the literature, particularly over land.
  - Motivation:
    - Better spatial resolution, in situ coverage too sparse/absent.
    - Radiatively-consistent/balanced geophysical parameters
- Approaches:
  - Linear empirical statistical models (most common)
  - Neural networks (e.g. HIRS T2m)
  - Physical retrieval (e.g. AIRS T2m)
  - Physical models (studies, but no current products known)

Satellite T2m prediction in EUSTACE

Empirical statistical model (established approach)

Satellite observations (including skin temp)

In situ Observations

Auxiliary data (e.g. solar zenith)

↓

Statistical Model

↓

0.25° estimates of cloud-free T2m with uncertainties

Physical model (less established)

Satellite 'skin' temp

Atm parameters (e.g. from reanalysis)

Surface properties (estimated from auxiliary data)

↓

Physical equations describing boundary layer

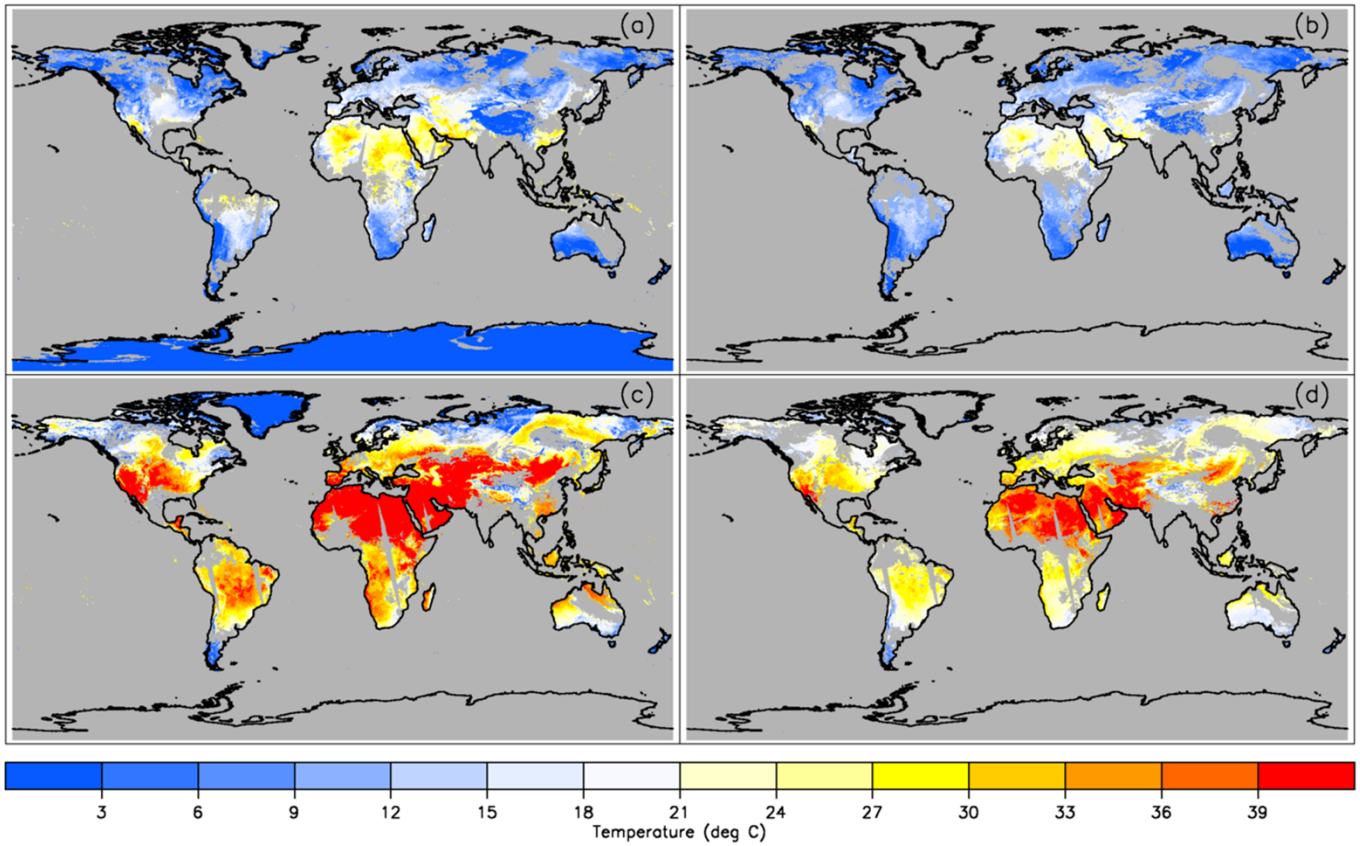
↓

T2m calculated for cloud-free satellite 0.25° grid cell

Example Satellite LST and T2m (1 July 2010)

LST Night

LST Day



Tmin

Tmax

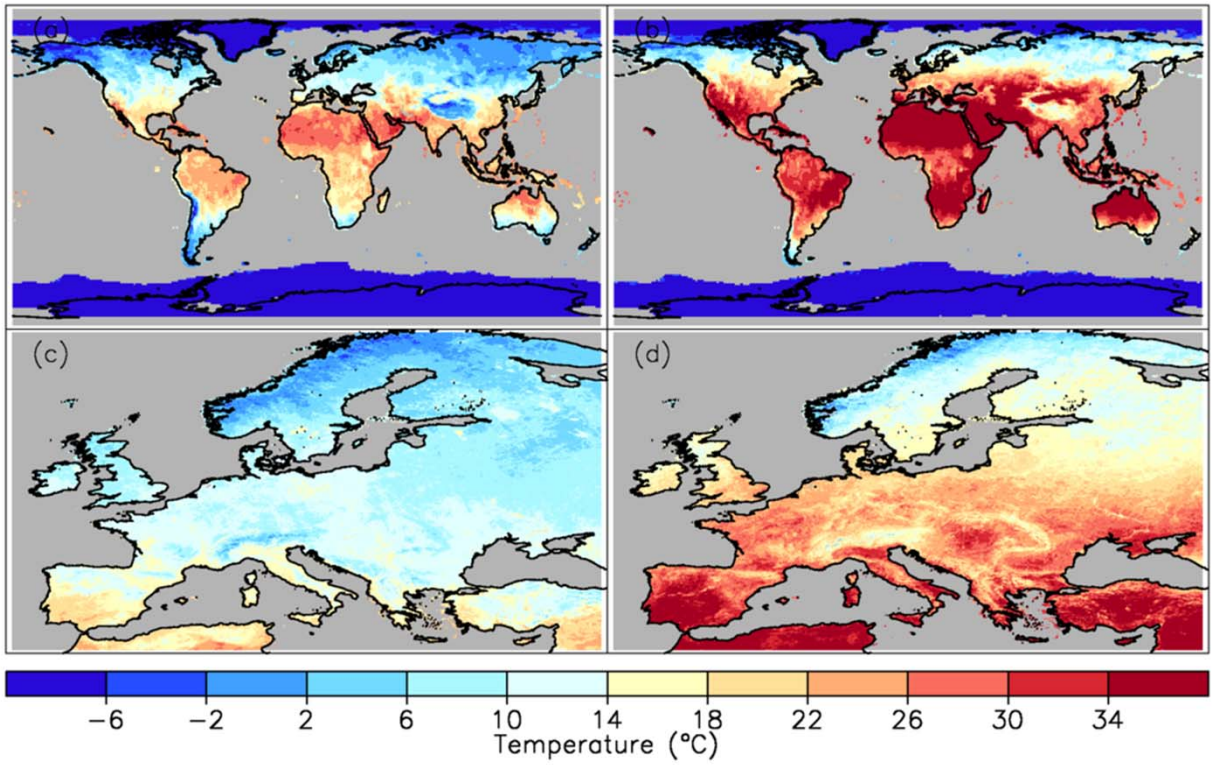
- Satellite T2m estimates provided with uncertainty components with differing correlation properties
- Blended with in situ => statistical analysis

What next?

- **Global** ST now available from several sensors
- **Multi-decadal** records -> Climate Data Records (CDR) being generated
- **Moderate/high** spatial resolution, e.g. 1-5 km (IR).
- 2-96 observations per day per sensor.

GlobTemperature CDR (ATSR): September 2003

LST Night *LST Day*

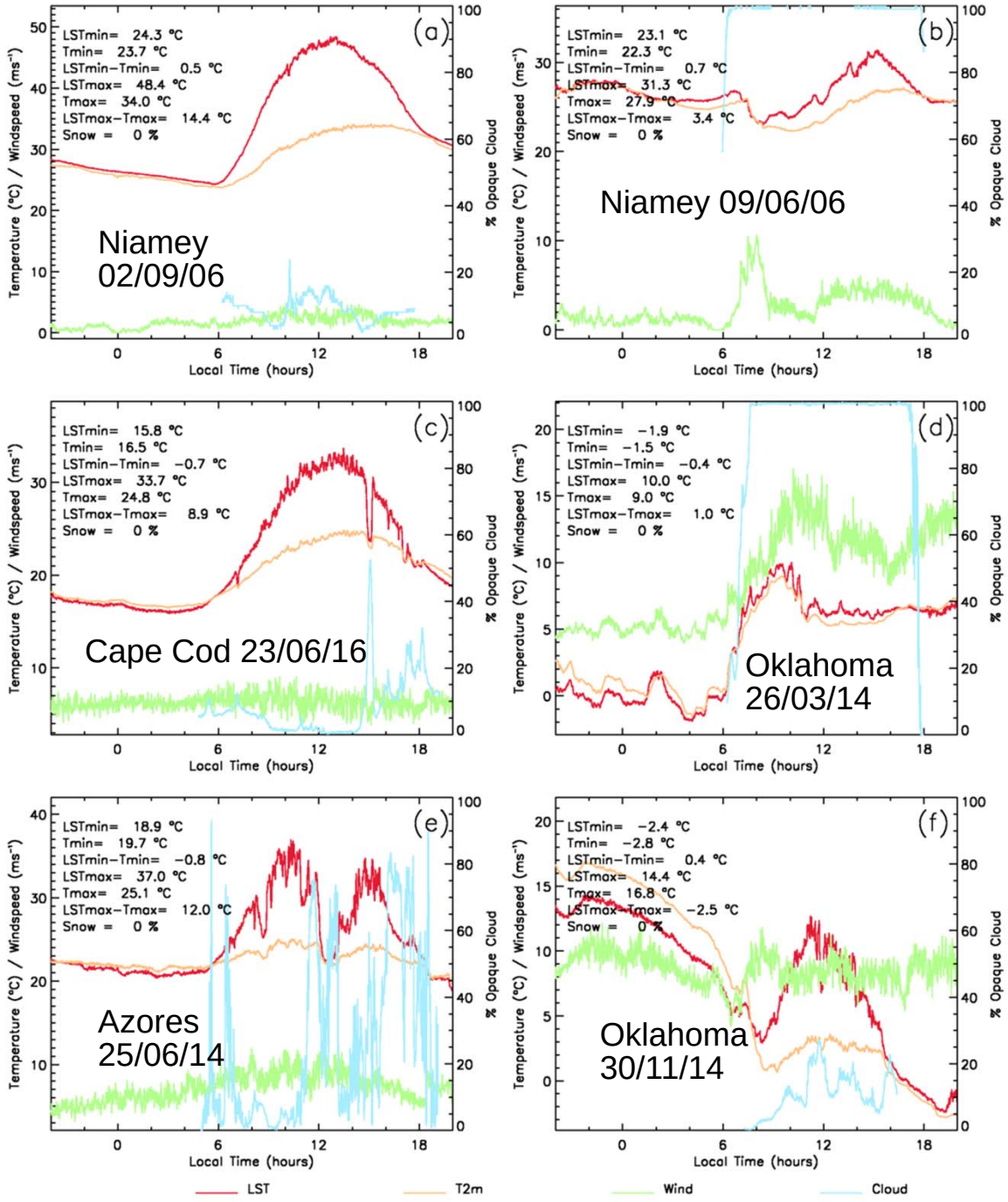


Challenges

- Need (good!) satellite ST CDR/FCDR
- More in situ data (to train empirical models – little evidence to suggest other methods perform better)
  - E.g. Africa, southern oceans, all ice surfaces, high elevation
- Need CDRs for auxiliary data (e.g. vegetation)
- Coverage: users don't want cloud gaps. Microwave?
  - Blended IR/MW => T2m estimates everywhere
- Skin vs T2m relationships complex – better models could be developed
  - What can be done under cloud?

LST vs T2m

Important influence:
- Wind speed
- Cloud
- Vegetation
- Snow
- Land cover
- Geographical location
- Elevation

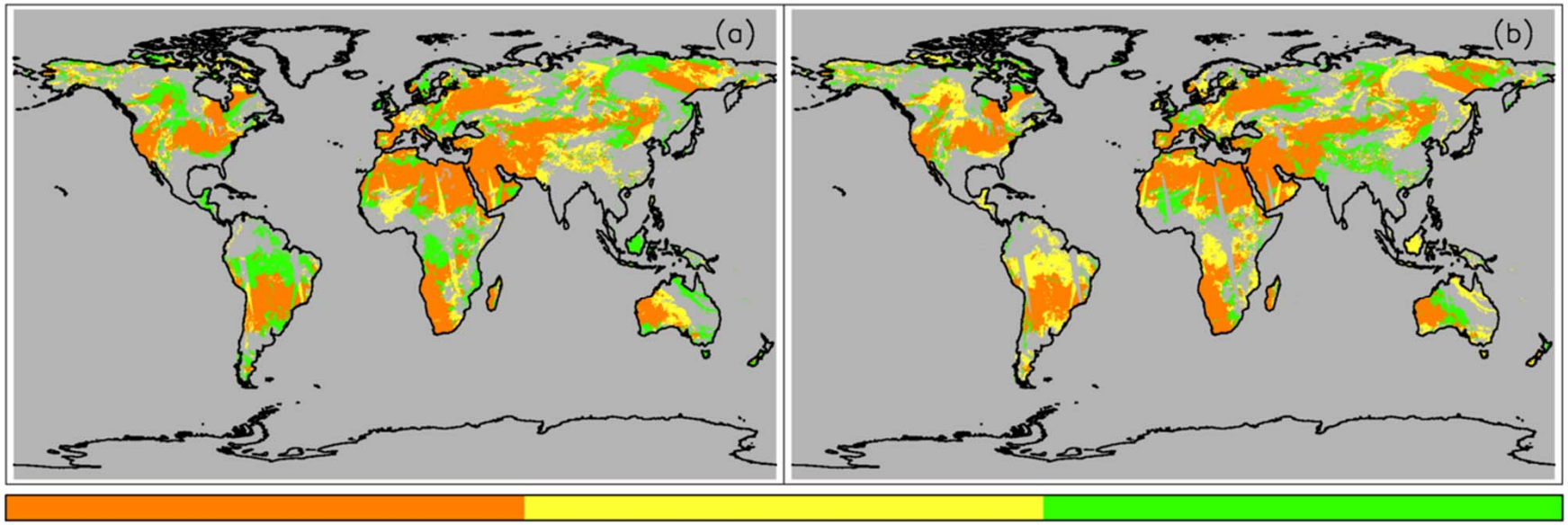


- Good, E. J. (2016), An in situ-based analysis of the relationship between land surface “skin” and screen-level air temperatures, J. Geophys. Res. Atmos., 121, 8801–8819, doi:10.1002/2016JD025318.

‘Multi-model’ approach can improve coverage

Tmin

Tmax



LSTngt + LSTday

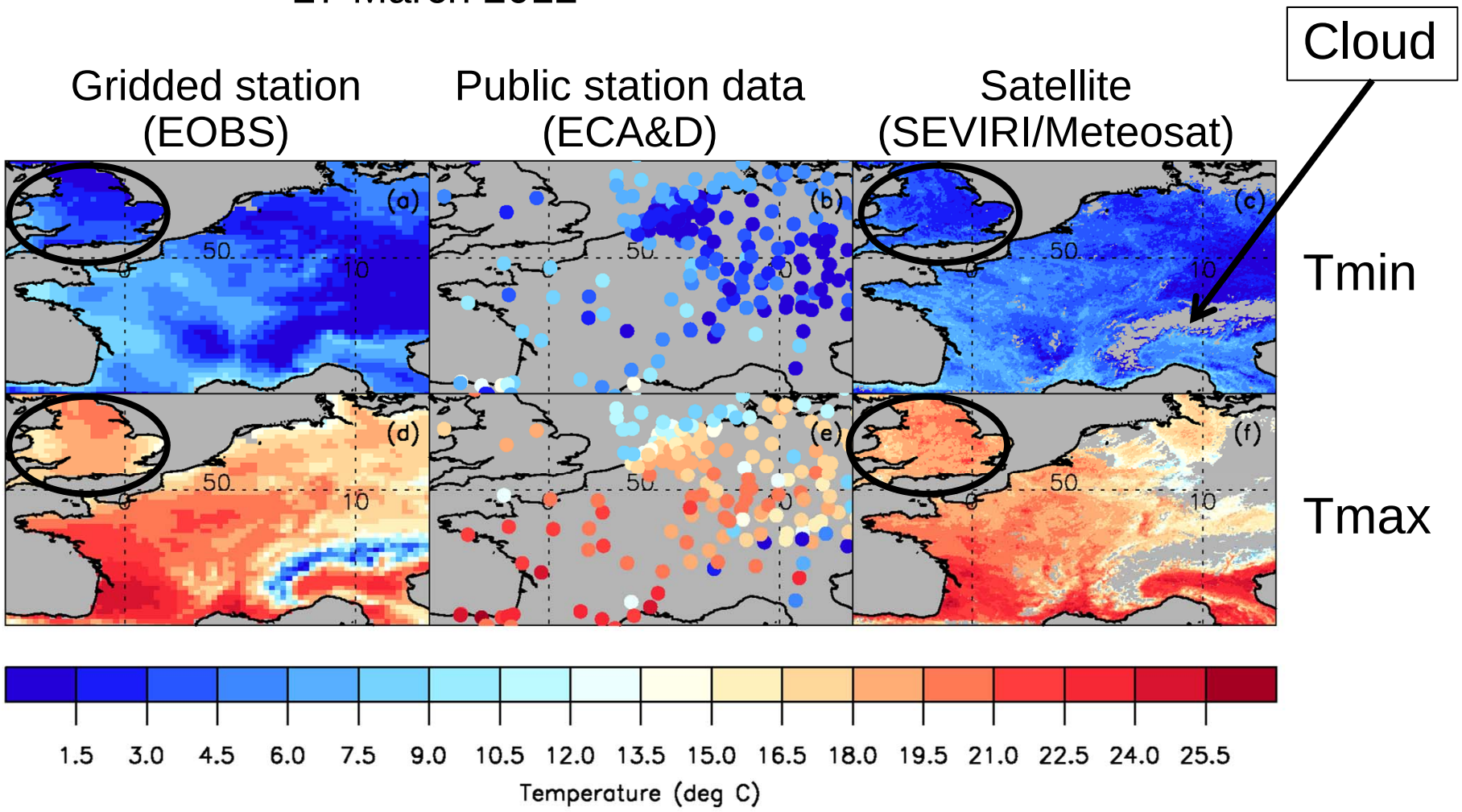
Tmin: LSTngt
Tmax: LSTday

Tmin: LSTday
Tmax: LSTngt

- Predicting T2m using multiple overpassess/sensors

Estimating T2m from satellites

27 March 2012



Good, E. (2015), 'Daily minimum and maximum surface air temperatures from geostationary satellite data', doi: 10.1002/2014JD022438.

A very detailed view….

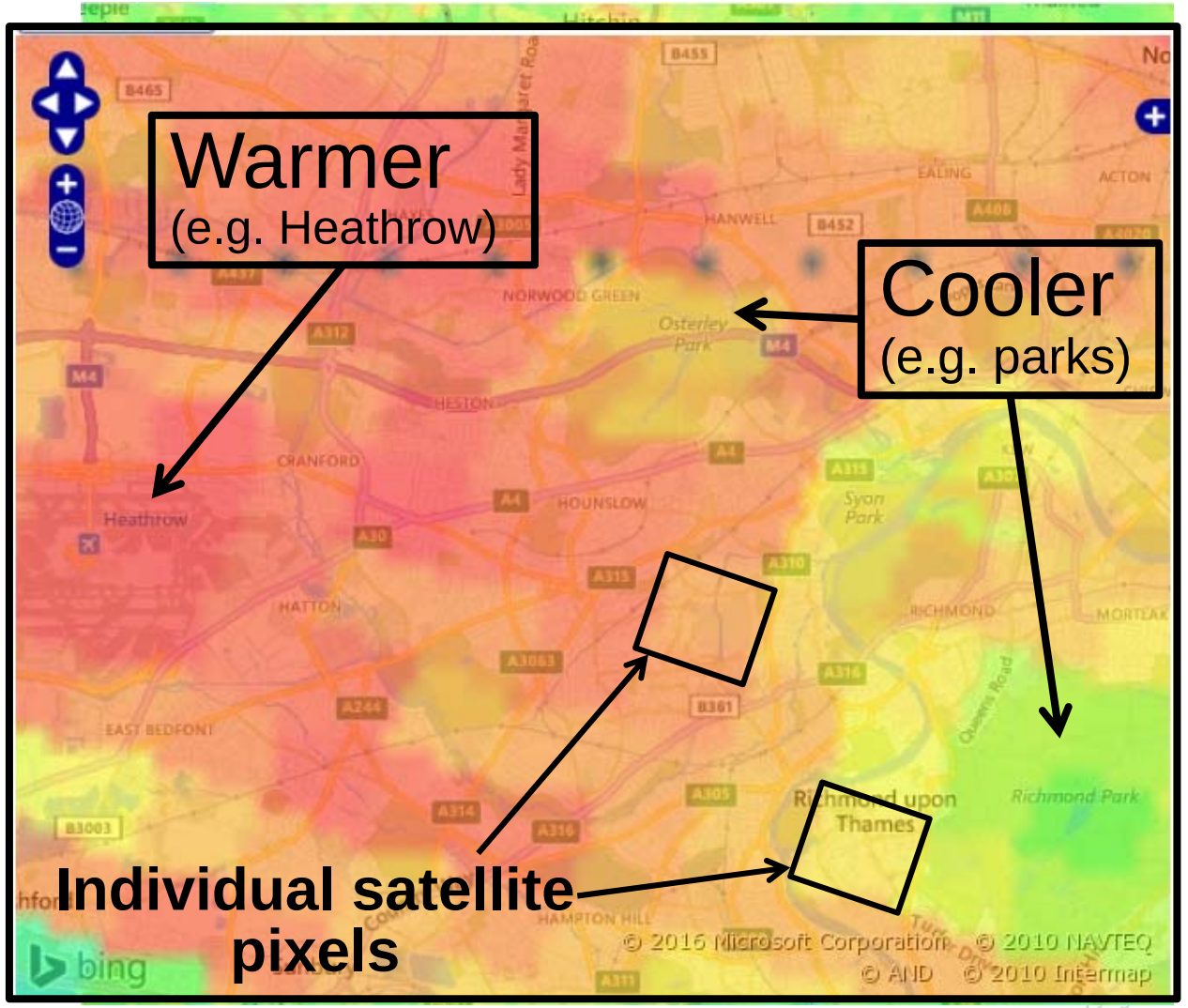
18 July 2006
@ 11.30 GMT

1 km spatial resolution

Real-time data (e.g. hours to <1 day lag) could provide rapid-response information.

Satellites to correct station inhomogeneities?

Source data: MODIS/Terra, courtesy of NASA



Summary

- Satellite T2m estimates can provide new information
  - Higher spatial resolution and better coverage than in situ
  - Combine with station T2m, or use independently. Correct station inhomogeneities?
- Need stable, homogeneous satellite data sets (including auxiliary data) for climate
- Empirical models seem to work well, but should continue research on methods
  - wind, cloud, MW, multi-sensor, sub-daily…
  - Need more in situ data for training / evaluation

Met Office

Questions and Answers