Incidence des incertitudes de mesure sur l'exploitation scientifique

Eric Goberville
Peggy Rimmelin-Maury
Guillaume Charria

Dans les études scientifiques …

Fréquemment considéré ...

résolution des appareils
=
précision des mesures (1 ou 2 écarts-type considérés comme incertitude minimale)

… Incertitude aléatoire donc le grand nombre de mesures permet de réduire l'incertitude …

… d'où une incertitude de la mesure (métrologie) <u>non considérée</u>

for **example,**

Non exhaustif …

nature climate change

REVIEW ARTICLE

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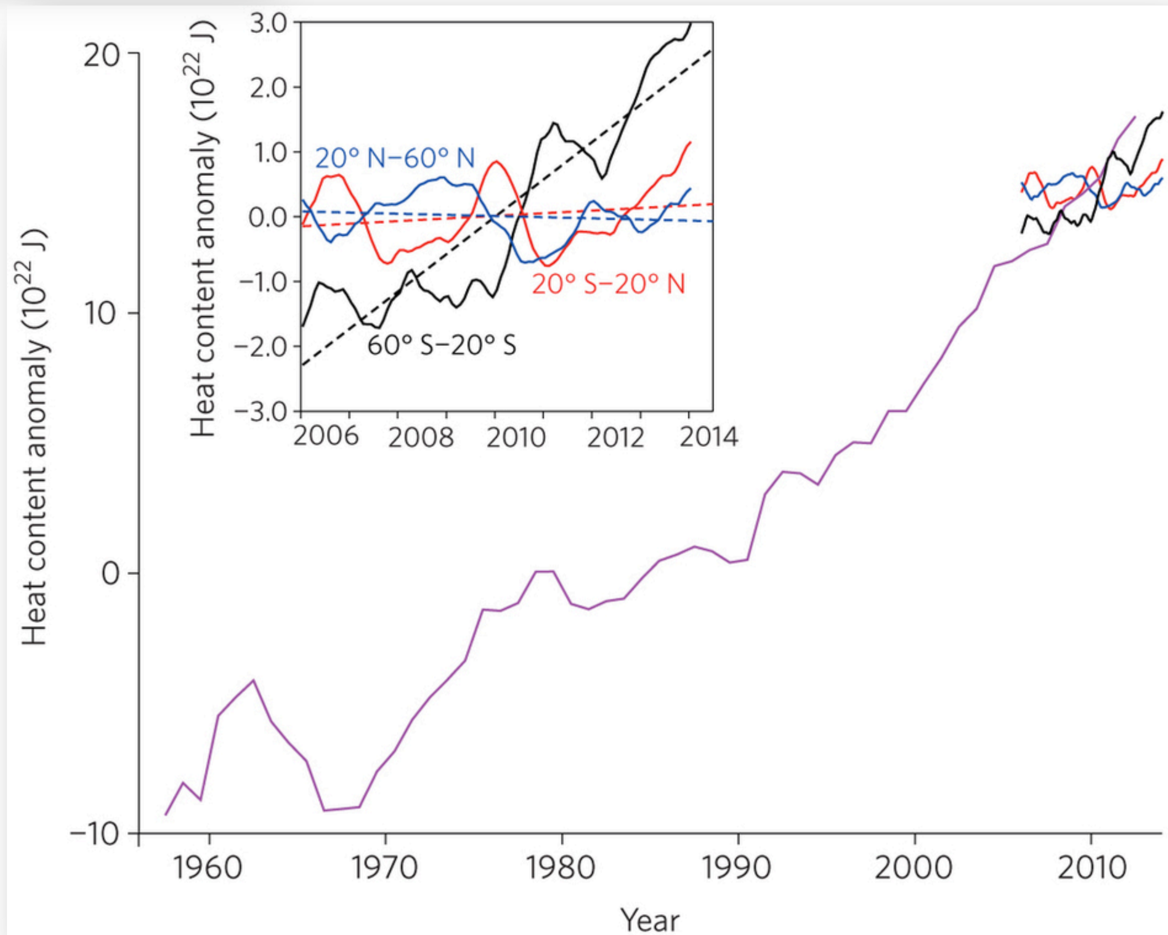
Fifteen years of ocean observations with the global Argo array

Stephen C. Riser[1], Howard J. Freeland[2]*, Dean Roemmich[3], Susan Wijffels[4], Ariel Troisi[5], Mathieu Belbéoch[6], Denis Gilbert[7], Jianping Xu[8], Sylvie Pouliquen[9], Ann Thresher[4], Pierre-Yves Le Traon[10], Guillaume Maze[9], Birgit Klein[11], M. Ravichandran[12], Fiona Grant[13], Pierre-Marie Poulain[14], Toshio Suga[15], Byunghwan Lim[16], Andreas Sterl[17], Philip Sutton[18], Kjell-Arne Mork[19], Pedro Joaquín Vélez-Belchí[20], Isabelle Ansorge[21], Brian King[22], Jon Turton[23], Molly Baringer[24] and Steven R. Jayne[25]

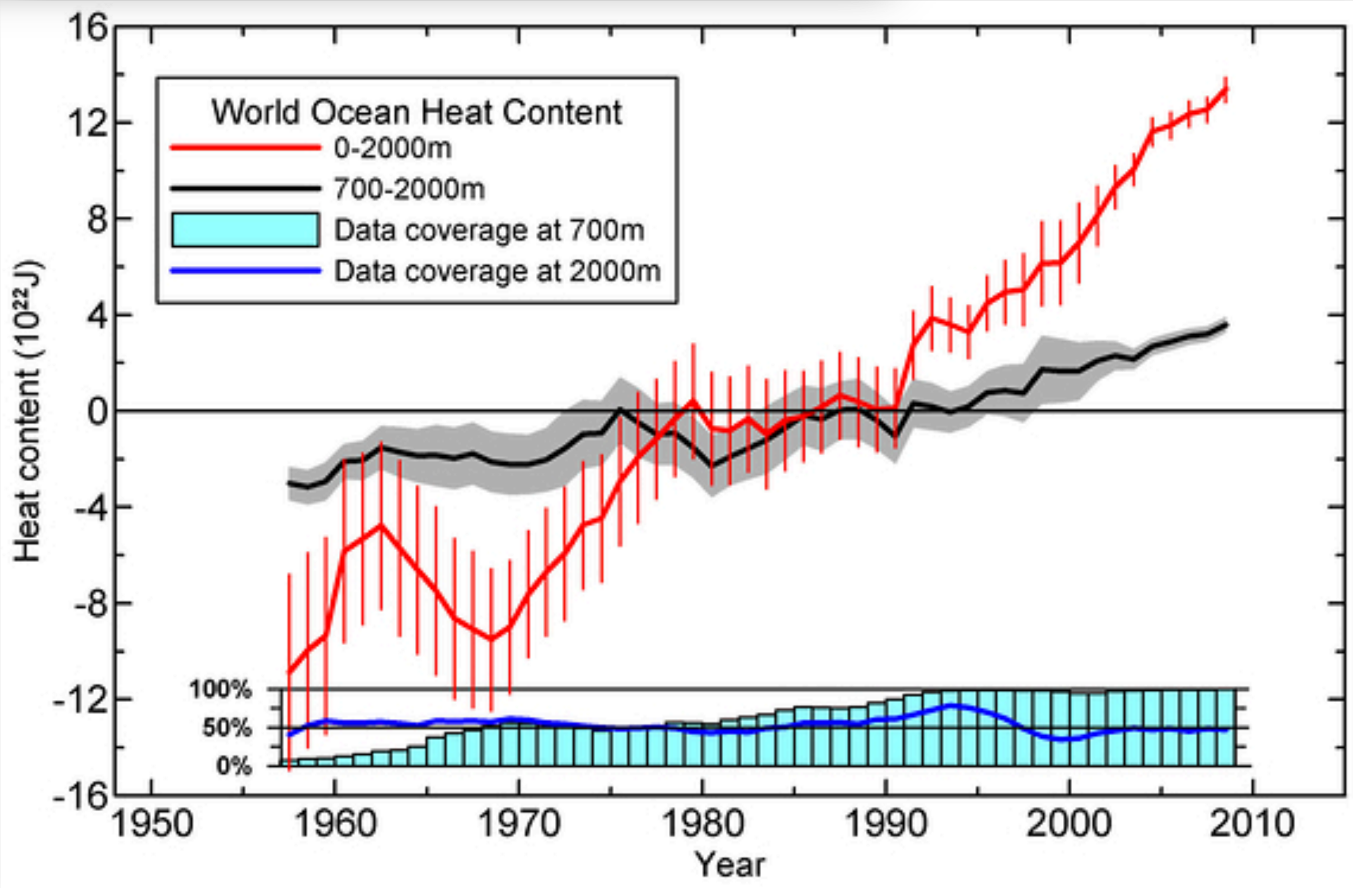


“ The original Argo target called for temperature and salinity accuracies of 0.005 °C and 0.01 salinity units, with a pressure accuracy of 2.5 dbars (equivalent to a depth error of about 2.5 m). Experience has shown that about 80% of the raw profile data transmitted from the floats meet these standards, with little or no correction required. “

GEOPHYSICAL RESEARCH LETTERS, VOL. 39, L10603, doi:10.1029/2012GL051106, 2012

World ocean heat content and thermosteric sea level change (0–2000 m), 1955–2010

S. Levitus,[1] J. I. Antonov,[2] T. P. Boyer,[1] O. K. Baranova,[1] H. E. Garcia,[1] R. A. Locarnini,[1] A. V. Mishonov,[1] J. R. Reagan,[1] D. Seidov,[1] E. S. Yarosh,[1] and M. M. Zweng[1]



Erreurs issues d'une simple analyse objective,
pas d'erreur instrumentale prise en compte

Dans les études scientifiques …

Fréquemment considéré ...

résolution des appareils
=
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… Incertitude aléatoire donc le grand nombre de mesures permet de réduire l'incertitude …

… d'où une incertitude de la mesure (métrologie) non considérée

Qu'en est-il des incertitudes systématiques (biais) de chaque dispositif ?

A journey through time …

1σ instrumental resolution: a journey through time

18th Century Min-Max:
±0.25°C

19th Century Land & SST:
±0.25°C

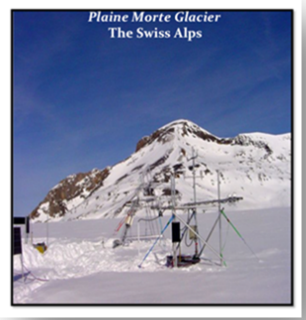
20th Century (Early-Mid)
Land and SST LiG thermometers
Smallest division: 1°C
Resolution limit: **±0.25°C**

20th Century (Mid-Late)
Land and SST LiG thermometers
Smallest division: 0.5°C
Resolution limit: **±0.125°C**

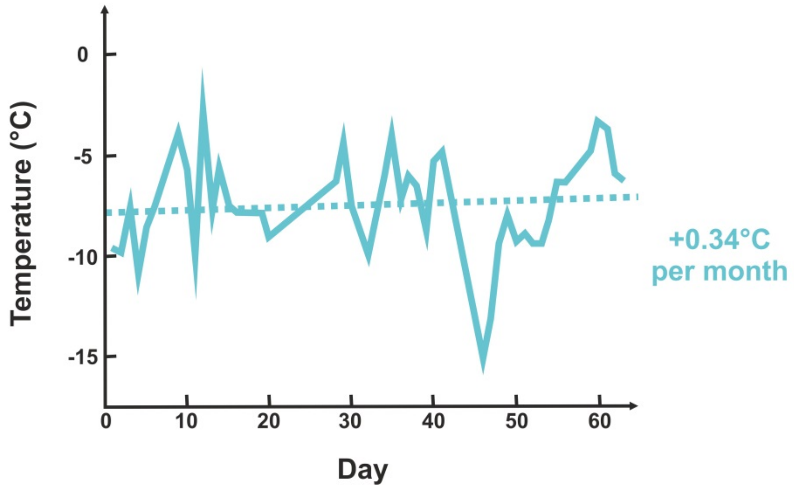
20th Century (Late)
MMTS PRT: **±0.1°C**
Buoy Thermister: **±0.002°C**

Entire 20th Century
Ship Engine Intake Thermometers
Smallest division: 1°C
Resolution limit: **±0.25°C**

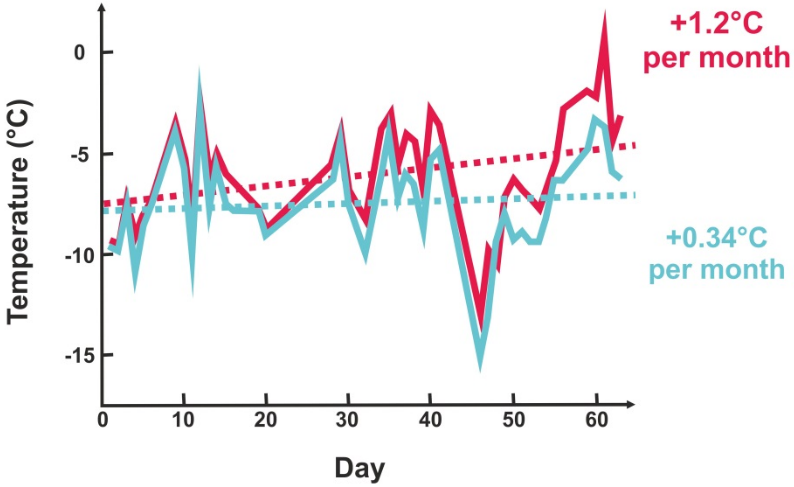
Instrumental error in land surface temperature measurements in the Alpine Plaine Morte Glacier (Switzerland)



Sonic anemometer



RM Young PRT probe



Same environmental conditions but

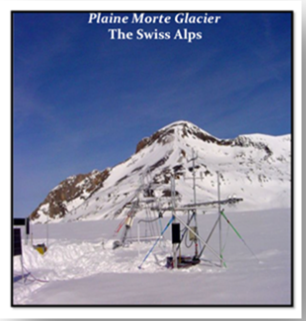
(1) warmer winter air temperatures

(2) trend is more than 3 times greater

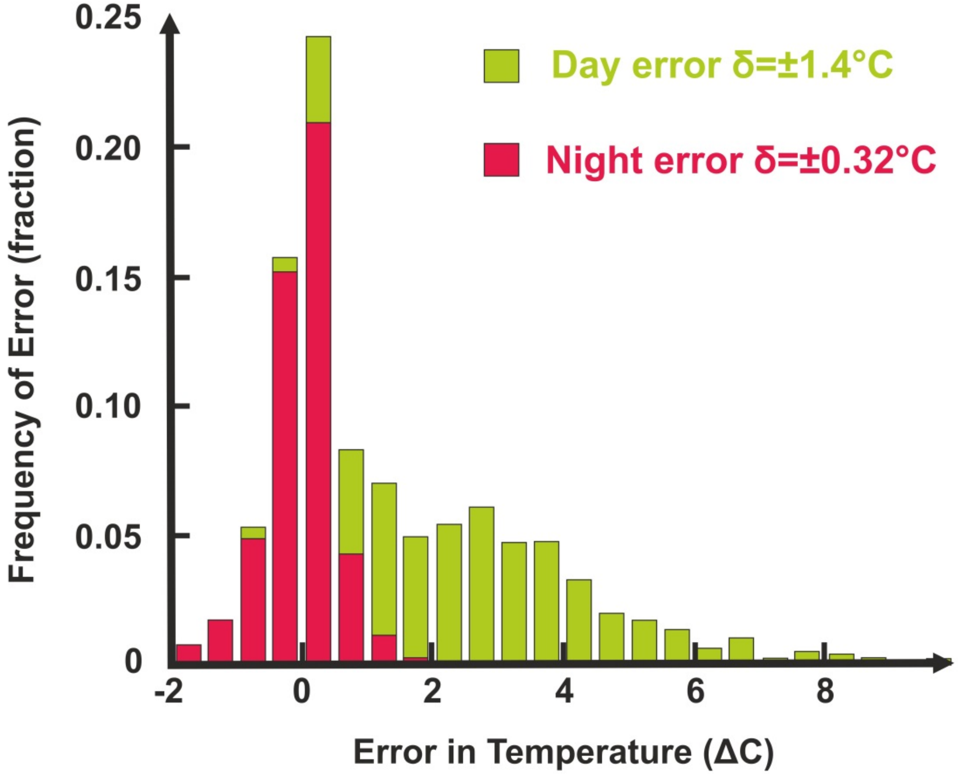
=> spurious warming trend into a global temperature average

https://wattsupwiththat.com

Instrumental error in land surface temperature measurements in the Alpine Plaine Morte Glacier (Switzerland)



Sonic anemometer

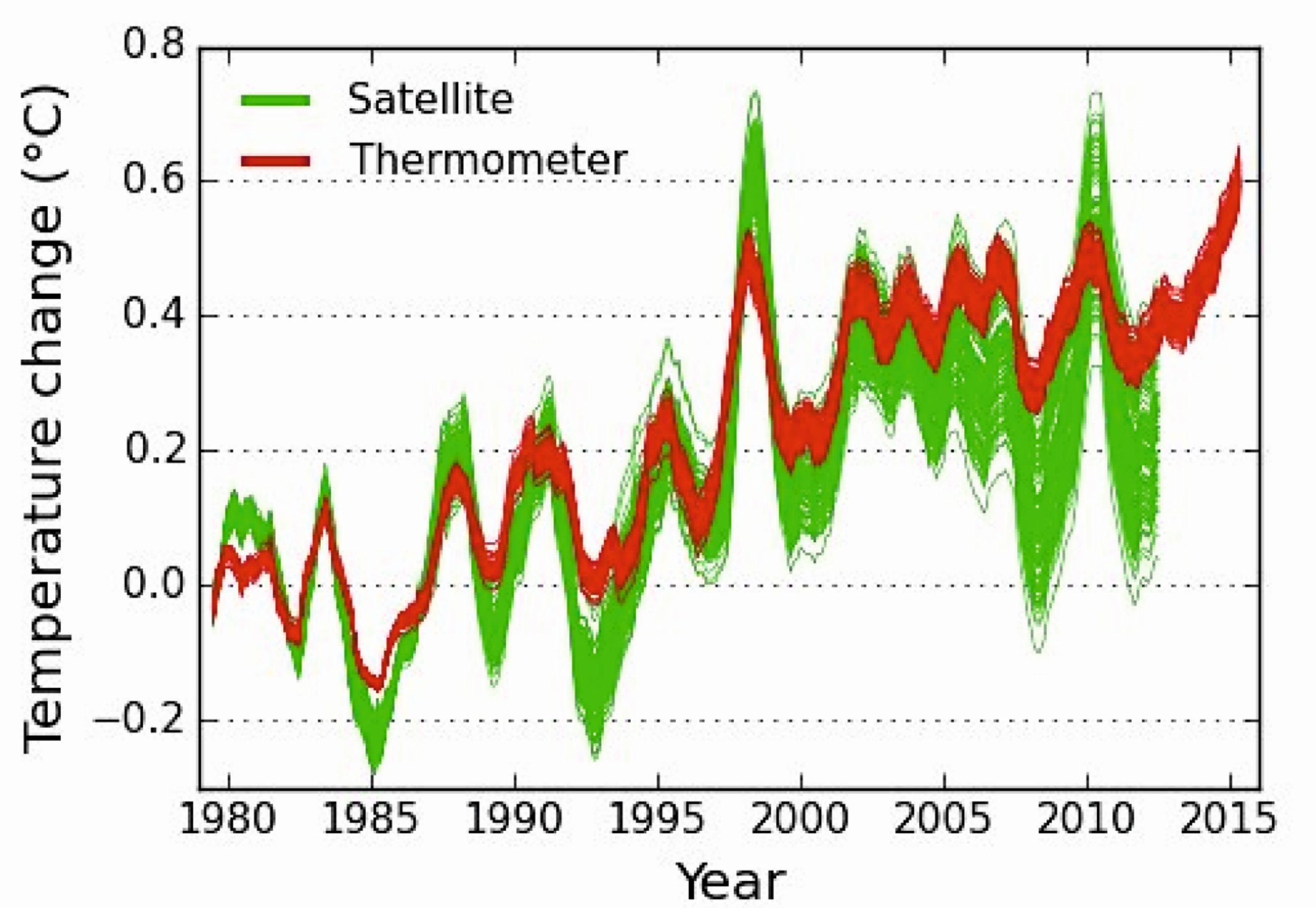


Uncertainty is neither randomly distributed nor constant

Cannot be removed by averaging individual measurements or by taking anomalies

https://wattsupwiththat.com

Satellite data *vs* surface temperature data



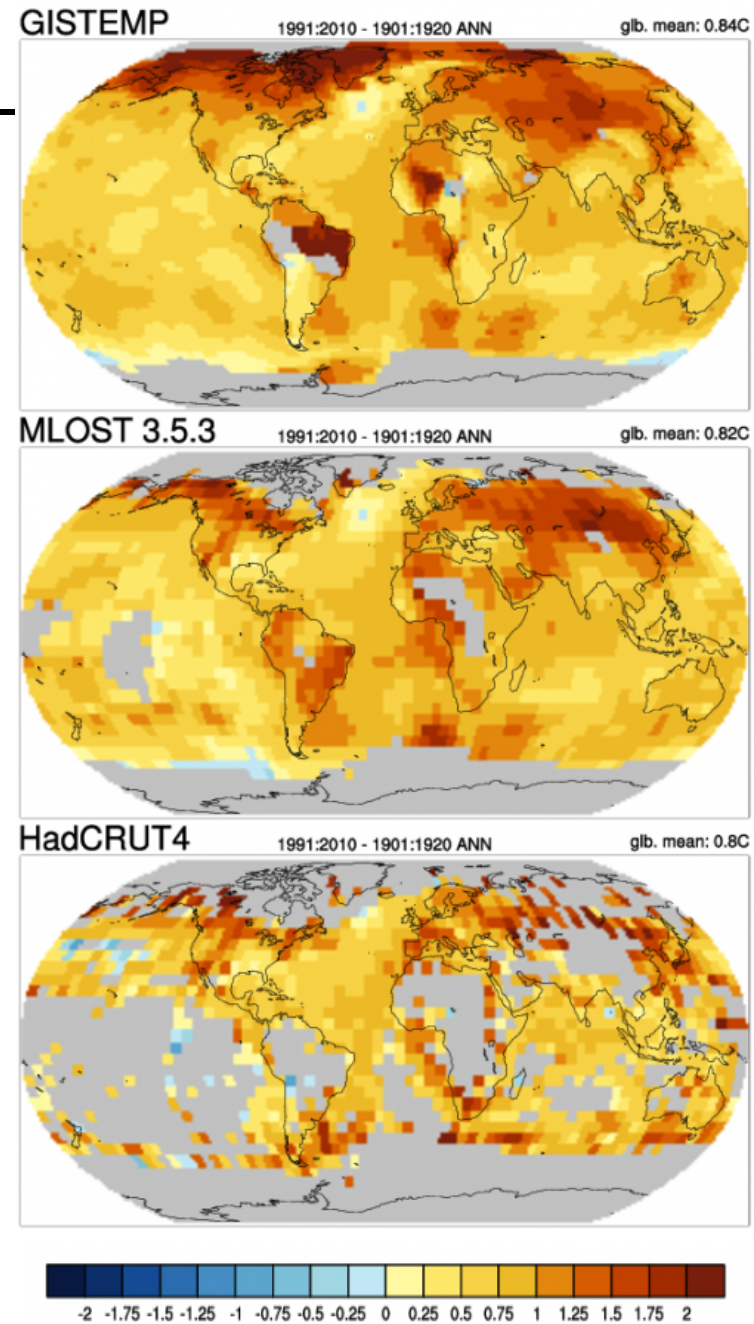
=> The known uncertainties in the satellite trend are five times the uncertainties in the thermometer record trend

Kevin Cowtan

Different Global Temperature Data Sets

Global surface temperature data sets, which combine **historical observations from different sources**, are an essential for monitoring and understanding climate variability and climate change

Their construction is challenging, however due to **difficulties in obtaining data, documenting and accounting for changes in instrumentation and observing practices**



NCAR Climate Data Guide; D. Schneider

Processing raw data to "build" Global Temperature Data Sets

Improvements to NOAA's Historical Merged Land–Ocean Surface Temperature Analysis (1880–2006)

THOMAS M. SMITH

NOAA/NESDIS/STAR/SCSD, and CICS/ESSIC, University of Maryland, College Park, College Park, Maryland

RICHARD W. REYNOLDS, THOMAS C. PETERSON, AND JAY LAWRIMORE

NOAA/National Climatic Data Center, Asheville, North Carolina

Extended Reconstructed Sea Surface Temperature Version 4 (ERSST.v4). Part I: Upgrades and Intercomparisons

BOYIN HUANG,* VIVA F. BANZON,* ERIC FREEMAN,+ JAY LAWRIMORE,* WEI LIU,# THOMAS C. PETERSON,* THOMAS M. SMITH,@ PETER W. THORNE,& SCOTT D. WOODRUFF,** AND HUAI-MIN ZHANG*

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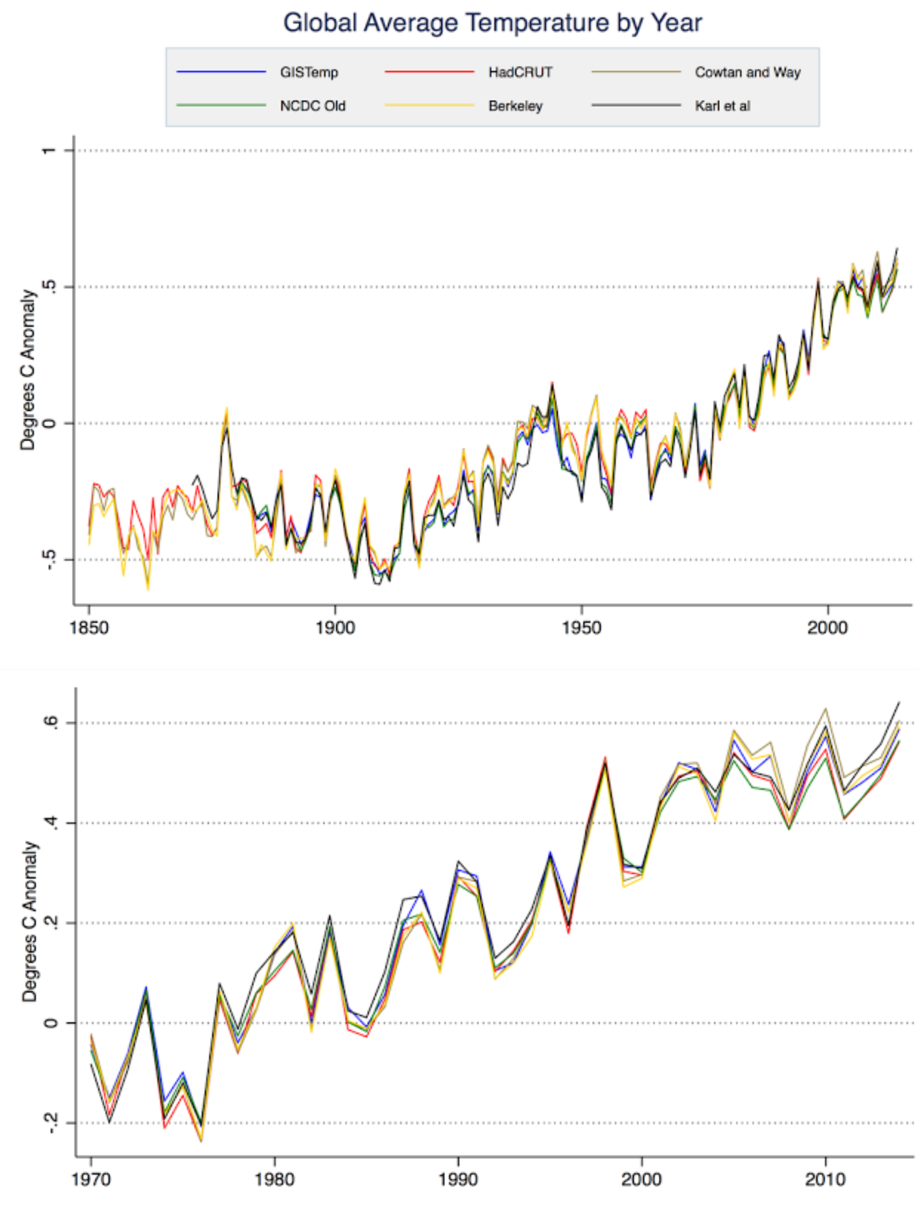
 # National Climatic Data Center, Asheville, and Cooperative Institute for Climate and Satellites, Raleigh, North Carolina
@ NOAA/STAR/SCSB, and CICS/ESSIC, University of Maryland, College Park, Maryland
& Nansen Environmental and Remote Sensing Center, Bergen, Norway
*** National Climatic Data Center, Asheville, North Carolina, and Cooperative Institute for Research in Environmental Sciences, Boulder, Colorado*

Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 data set

Colin P. Morice,[1] John J. Kennedy,[1] Nick A. Rayner,[1] and Phil D. Jones[2,3]

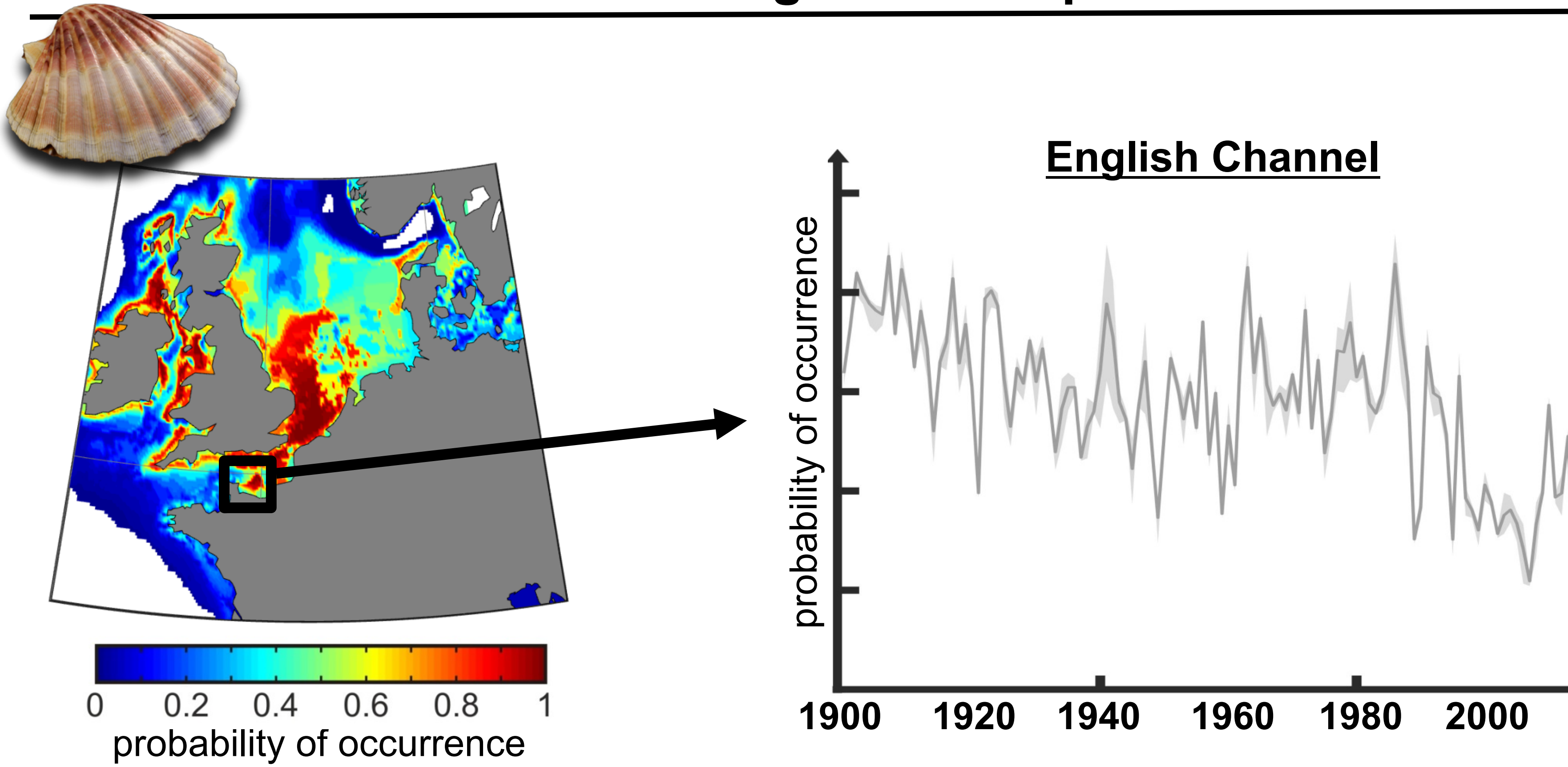
NASA, NOAA, Met Office, Japan Meteorological Agency… process the same raw data with different methodology

but
Consistent temperature estimates



Zeke Hausfather

Influence of these different datasets on ecological niche modeling
ex: the great scallop



=> Main patterns of historical changes in the occurrence of species are equivalent among the different global temperature datasets (NOAA, ICOADS, Cobe)

Goberville et al. (in prep.)

Time series, trend and noise: a case study

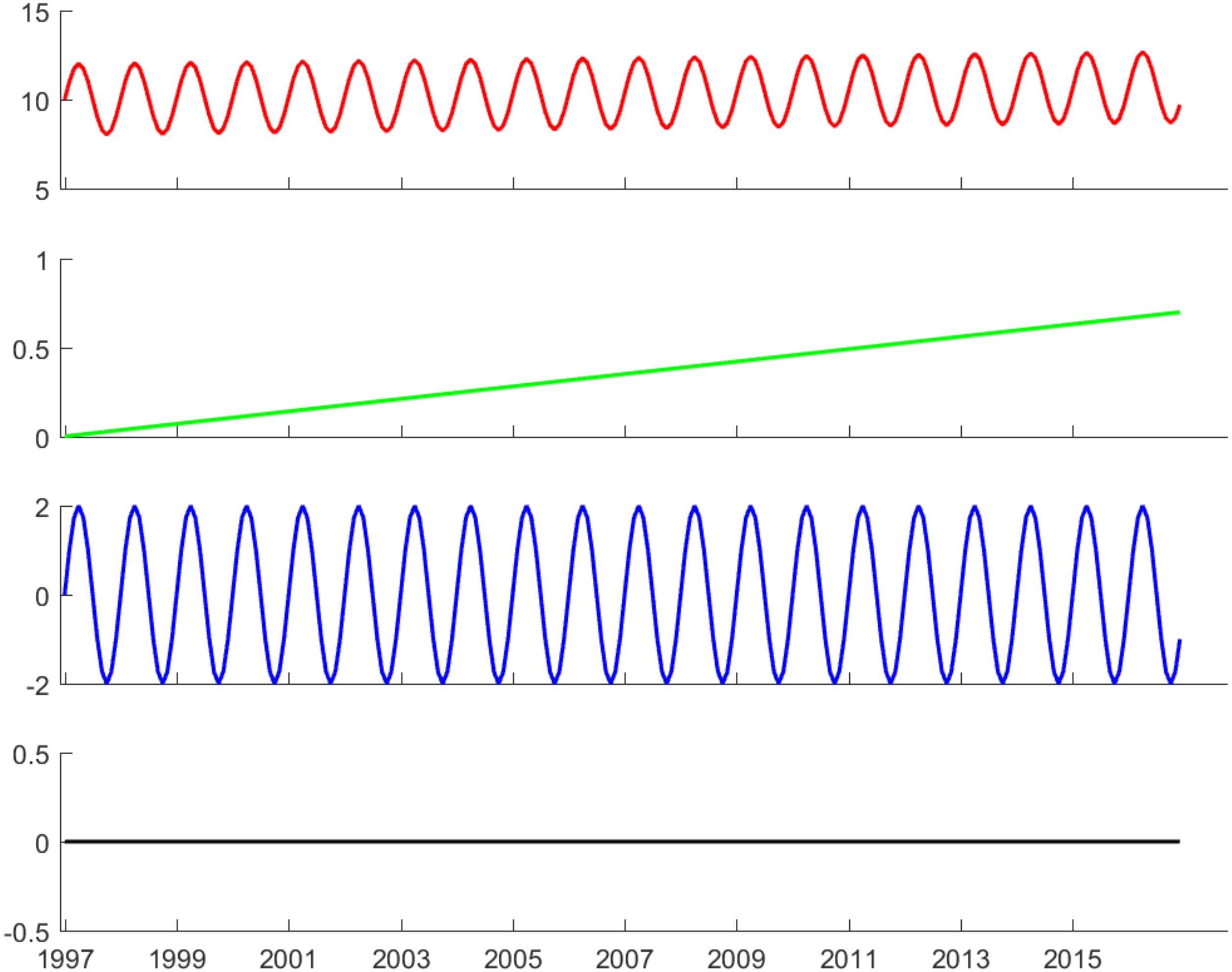
A simple case study of a theoretical time series using classical seasonal decomposition approaches (e.g. decompose package with R)

(1) without uncertainty (no error measurement, no stochasticity)
(2) with error measurement (no stochasticity)
(3) with both error measurement and stochasticity

↓

Consequences on trend estimation?

A simple case study: Additive model xt = Trend + Seasonal + Random



My time series: temperature

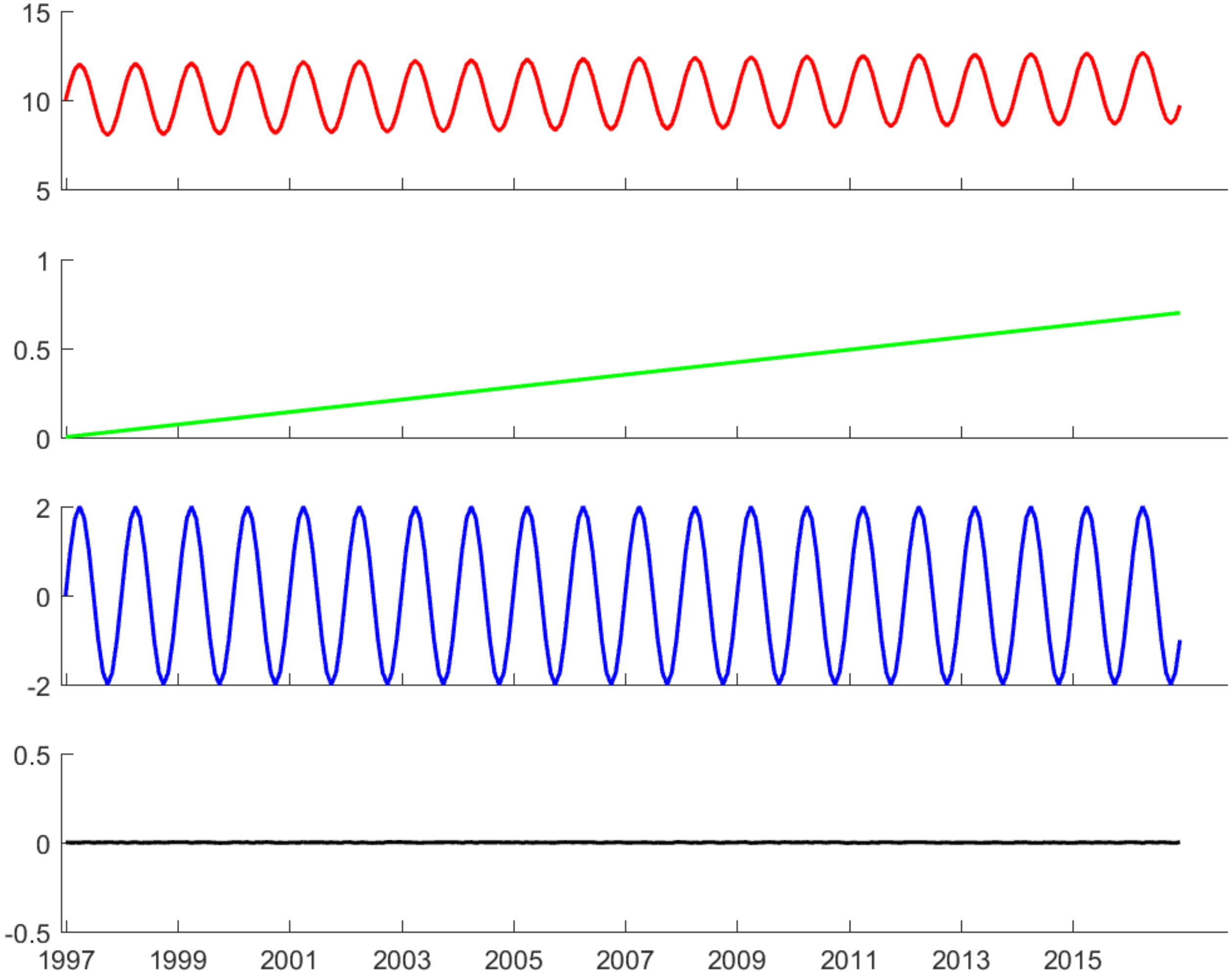
Trend = +0.700°C over the period

Seasonal component

Noise
no error measurement
no stochasticity

A simple case study: I add error measurement: ± 0.0025°C

Expectation: trend = +0.700°C

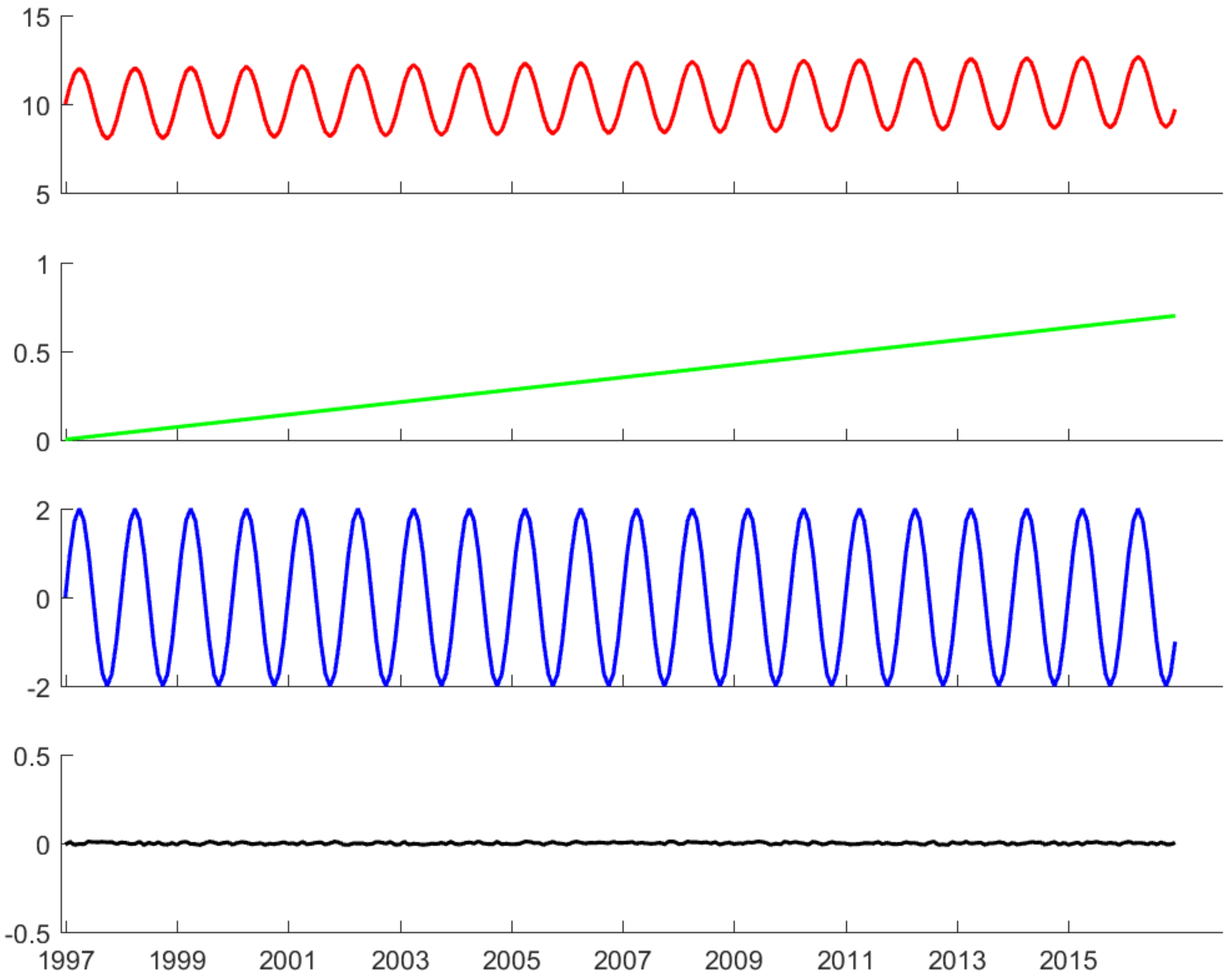


+ error measure = 0.0025°C

Trend = +0.700°C over the period

A simple case study: I add error measurement: ± 0.01°C

Expectation: trend = +0.700°C

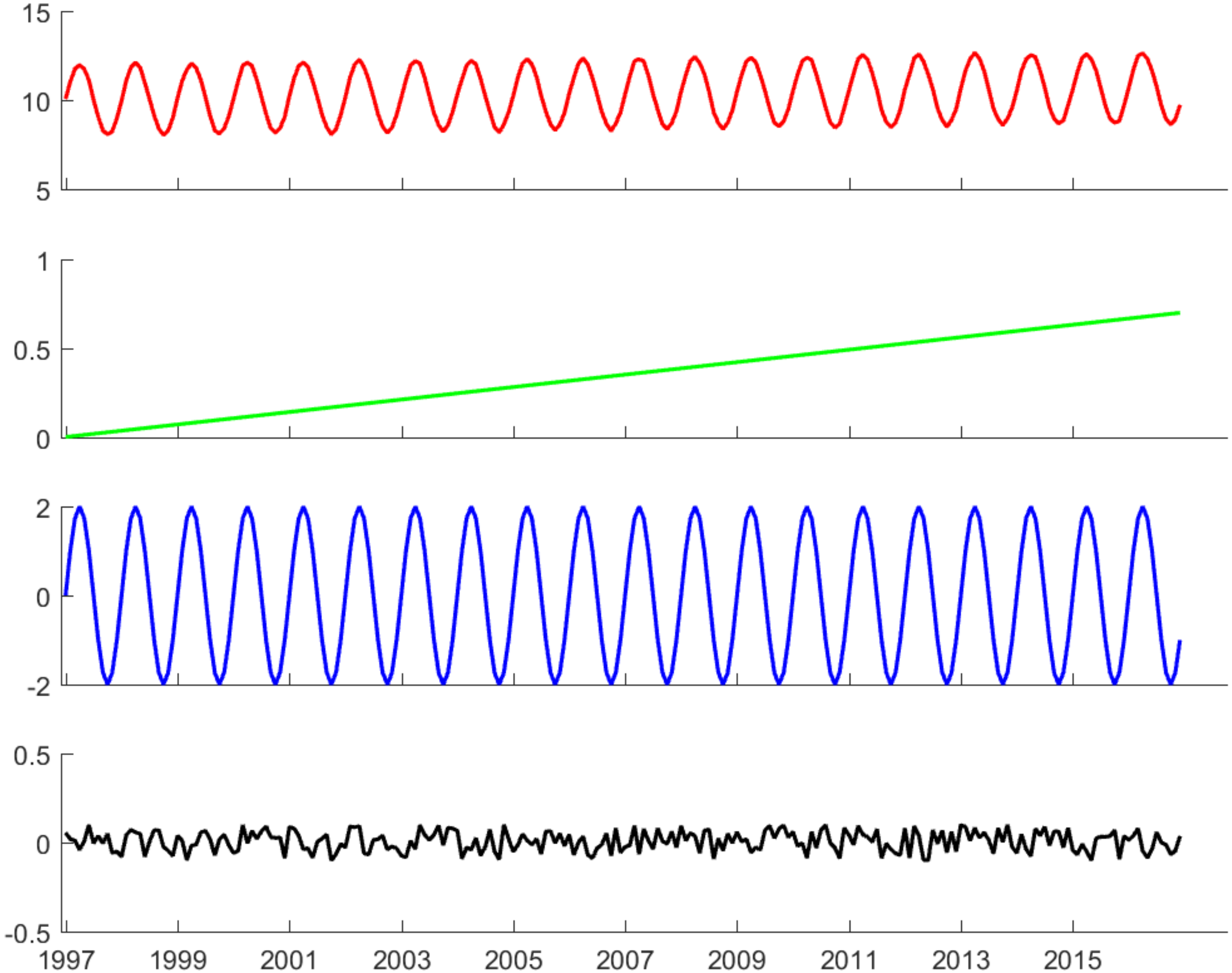


+ error measure = 0.01°C

Trend = +0.705°C over the period

A simple case study: I add error measurement: ± 0.1°C

Expectation: trend = +0.700°C

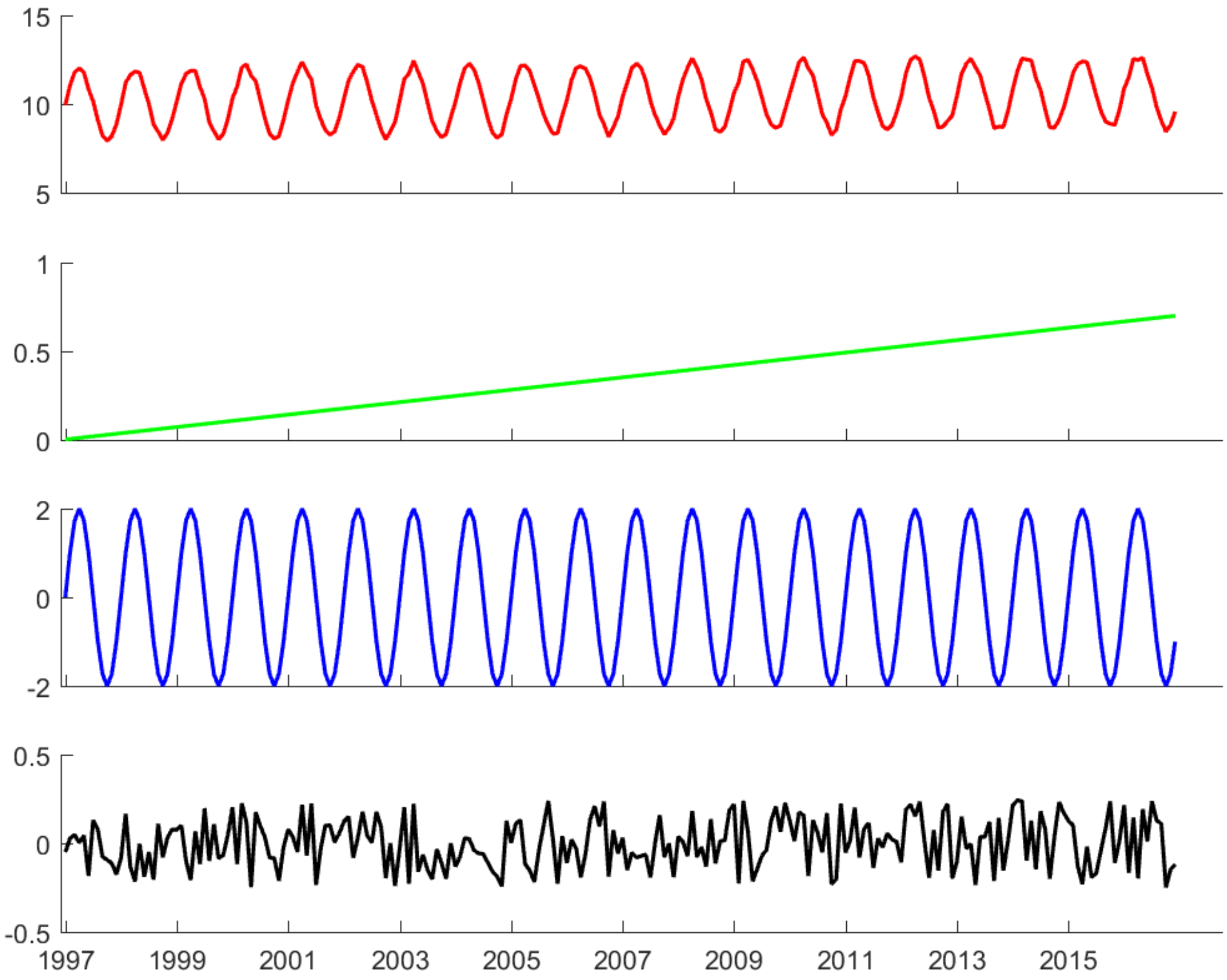


+ error measure = 0.1°C

Trend = +0.696°C over the period

A simple case study: I add error measurement: ± 0.25°C

Expectation: trend = +0.700°C

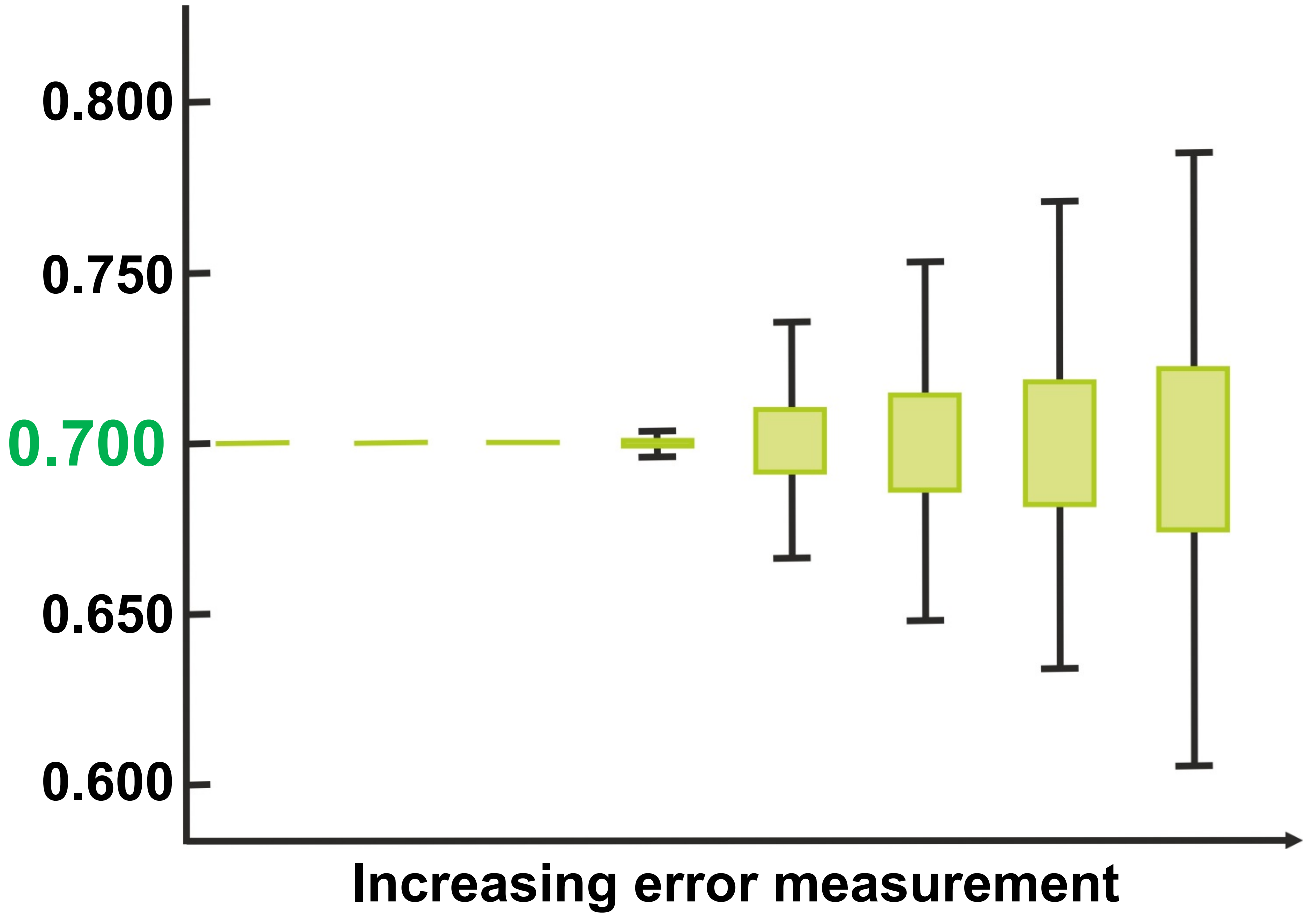


+ error measure = 0.25°C

Trend = +0.763°C over the period

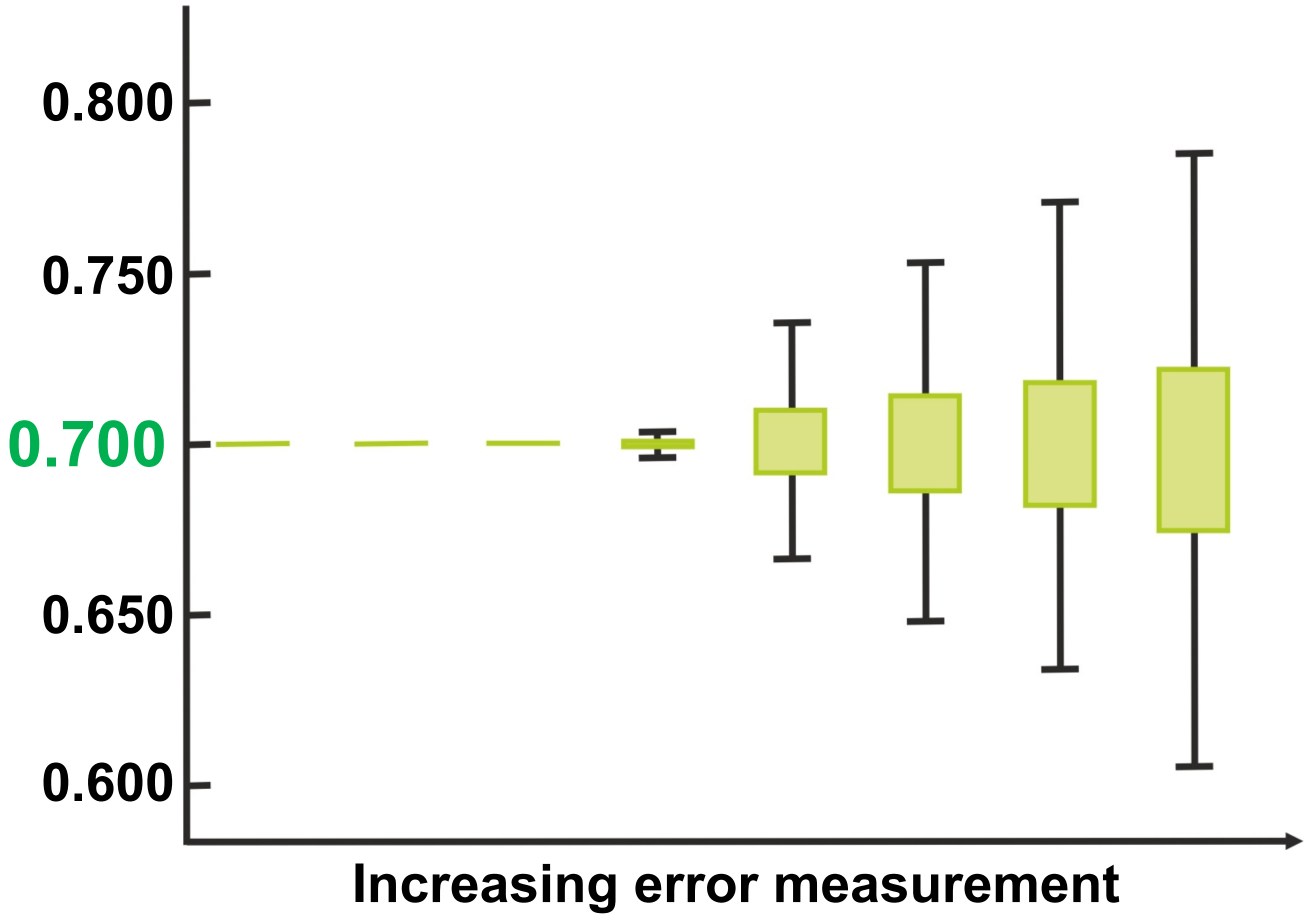
A simple case study: adding only error measurement

By performing the procedure iteratively (i.e. 999 simulations) with different error values, we detect that the noise induced by error measurement might also have consequences on trend quantification

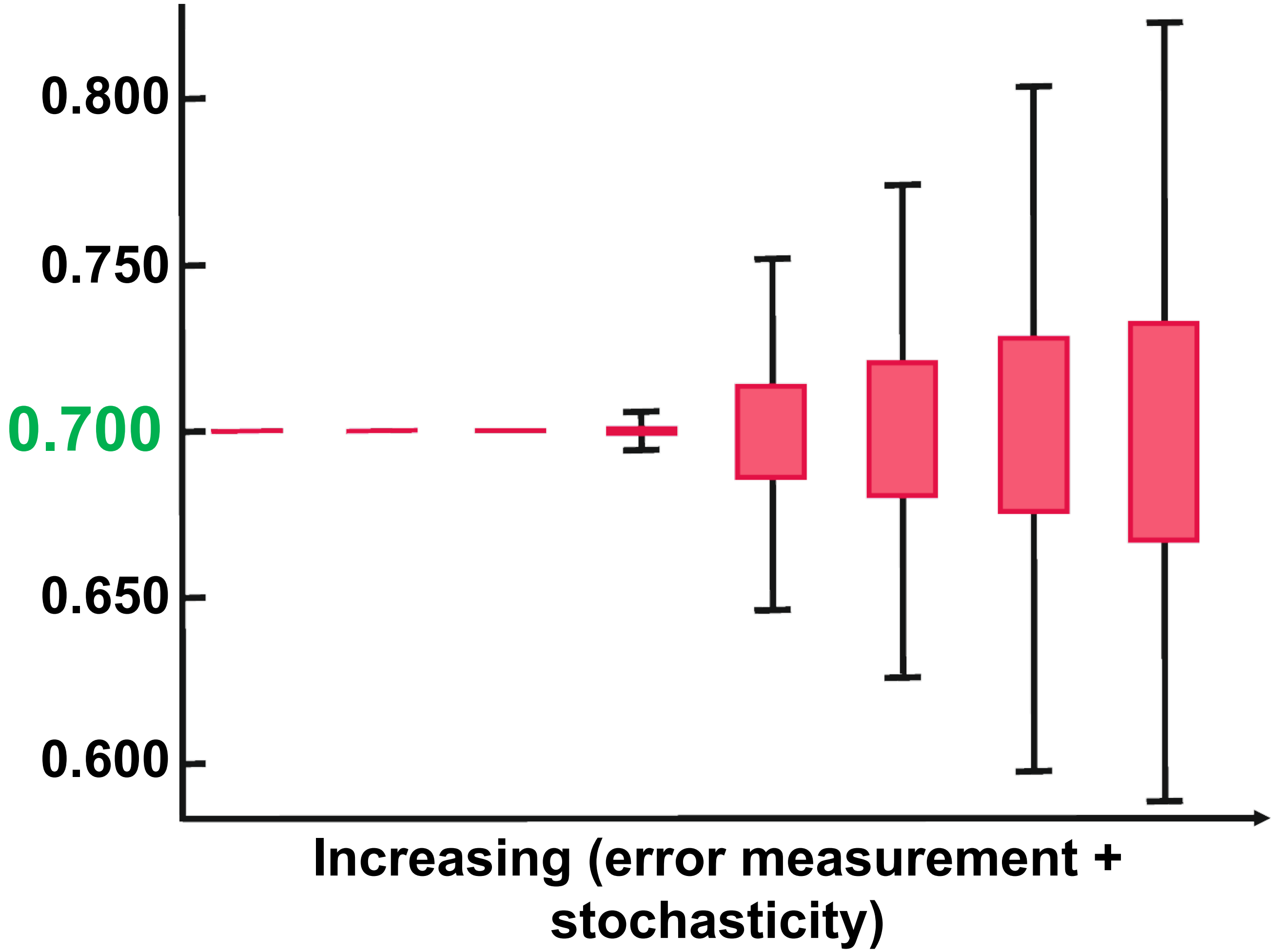


=> Although the random noise is supposed to be removed!

And now, with a part of environmental stochasticity…



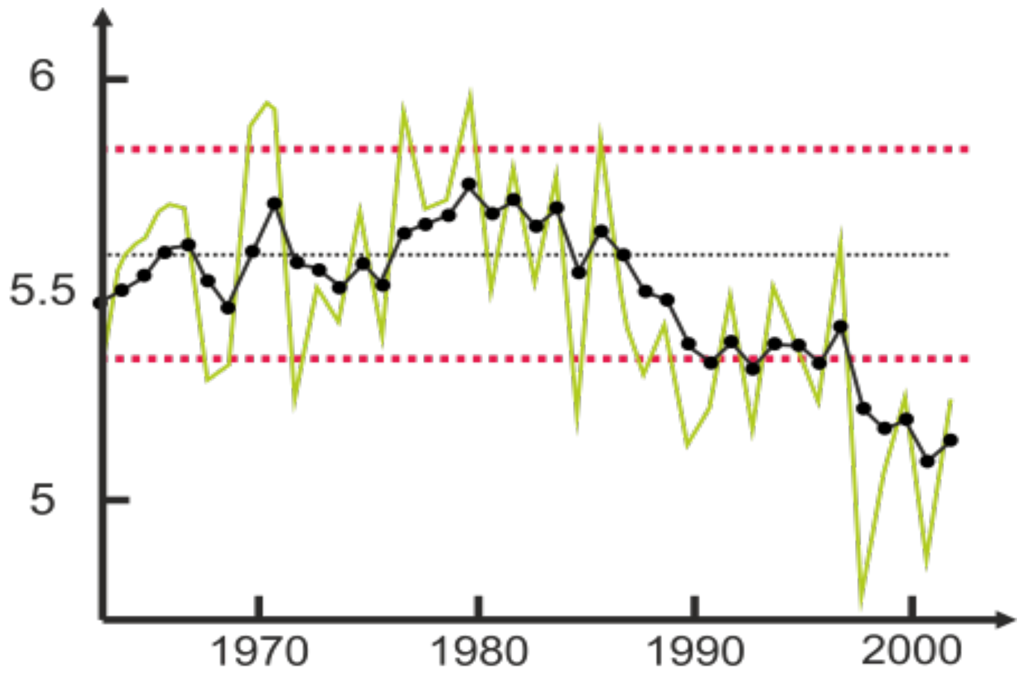
And now, with a part of environmental stochasticity…



=> It is essential to be cautious when a trend is quantified… Although they are able to remove noise, decomposition approaches do not guarantee a precise estimation of the trend

Considering the range of uncertainty to « better » detect changes

Control charts procedures:
Shewhart-style charts, EWMA chart, Cusum chart…



Depending on the method, algorithms are more or less sensitive to small and large changes in the state of a system

But several methods can also be combined

=> Only if the range of uncertainty is known and constant over time

Goberville et al. (in prep.)

Conclusions & perspectives

Considération des incertitudes dans exploration scientifique:

Variable et sujet à discussion

(car incertitudes encore mal cernées notamment sur la composante systématique)

Importance d'une concertation analyse scientifique et métrologie

Conclusions & perspectives

Considération des incertitudes dans exploration scientifique:

Variable et sujet à discussion

(car incertitudes encore mal cernées notamment sur la composante systématique)

Importance d'une concertation analyse scientifique et métrologie

De possibles recommandations:

- Avoir une approche **« en pleine conscience » des incertitudes**
- Améliorer les **meta-données** incluant des informations sur les incertitudes
- Proposer des **méthodes d'intercomparaison**
- Explorer les observations en relation avec les experts en **métrologie**


THANK
YOU!