Institution: University of East Anglia

Unit of Assessment: 7 – Earth Systems and Environmental Sciences

Title of case study:

Global Temperature Data Underpins International Climate Negotiations

1. Summary of the impact

Knowledge of the changing global temperature has contributed to an international political agreement being reached about the over-arching objective of climate change mitigation policies. The School's scientists have made a crucial contribution to one of only three datasets that reveal changes to the world's average temperature over the last 150 years. These data have been central to each of the five Assessment Reports of the UN's Intergovernmental Panel on Climate Change (IPCC), upon which successive rounds of international climate change negotiations relied and which led, in 2009, to the adoption of limiting global warming to 2 degrees Celsius as an agreed international policy goal.

2. Underpinning research

The School's pioneering research in the area of climate reconstruction began in the 1970s in the Climatic Research Unit (CRU, a part of the School of Environmental Sciences) under **Lamb** (at UEA from 1972-1997), exploring evidence for climate change during historical time recorded in instrumental, natural and documentary proxy records. More recent work (**Jones** at UEA since 1976, **Wigley** 1975-2010, **Briffa** since 1978 and **Osborn** since 1995) in this area has focussed on the use of high-resolution climate proxies, prominent among them being the analysis and interpretation of tree-ring data.

The School's instrumental temperature series are widely used as a cornerstone in nearly all discussions about climate change, often in the context of reconstructed changes in climate over the last one to two thousand years. Collaboration with the Met Office Hadley Centre (MOHC) has led to the construction of one of only three global (land and marine) temperature datasets in the world (currently named 'HadCRUT4'). It is also the longest established dataset having, for the first time in 1986, combined global land and marine temperature reconstructions. The School produces the land component (CRUTEM4) [1], and MOHC the marine component, which are combined to form the global instrumental temperature dataset HadCRUT4 (1850 to present day) [2]. Despite improvements in data availability in many parts of the world, these new versions closely resemble earlier versions, indicating the robustness of the series. Differences between the newer and older versions are within the ranges of error estimation, the techniques of which were first established in 1997 by School scientists (**Jones, Osborn, Wigley, Briffa**). An update of the highly-cited dataset (CRU TS 2.1) [3] providing spatially-infilled and high-resolution (0.5 by 0.5 degrees latitude/longitude) land grids of temperature, precipitation, vapour pressure and cloud cover has recently been completed (version 3.10). Several other datasets (circulation indices such as the North Atlantic and Southern Oscillations) have been developed through the critical analysis of instrumental records and are routinely updated on the School's CRU website (http://www.cru.uea.ac.uk). As evidenced by citation and download statistics, all the above datasets are very widely used.

The School has been responsible for widely adopted methodological advances in the field of past climate reconstruction [4] and has produced multiple spatially-detailed and regionally-averaged reconstructions of various climate parameters. The School is well known for its reconstruction of mean summer temperature changes, extending over centuries to millennia in different regions of the world. Scientists in the School (**Briffa**, **Jones** and **Osborn**) have produced [5], or contributed to, widely cited and utilised reconstructions of average Northern Hemisphere temperature changes over the last 1,000 years, some based solely on tree-ring data and others based on compendia of multi-proxy sources.

Some scientific applications of these palaeo- and instrumental climate datasets are specifically linked to climate models and their simulations of future climate. It is through comparison of the

instrumental and palaeoclimate datasets with climate model simulations that climate models are improved. More importantly though, the comparisons lead to Detection and Attribution (D&A) studies where temperature changes in the past are explained through the causes of climate change (the sun, greenhouse gases, sulphate aerosols, volcanoes, etc). In 1996, School scientists (**Jones** and **Wigley**) were the first to detect unusual warming in the atmosphere (above the surface) and to attribute this to anthropogenic causes [6].

3. References to the research

[**UEA authors in bold**] {citations from Scopus}

[1] **Jones, P.D., Lister, D.H., Osborn, T.J., Harpham, C., Salmon, M**. and Morice, C.P. (2012) Hemispheric and large-scale land surface air temperature variations: An extensive revision and an update to 2010. *J. Geophys. Res.* 117, D05127, doi:10.1029/2011JD017139 {44}; **Jones, P.D.** and Moberg, A. (2003) Hemispheric and large-scale surface air temperature variations: An extensive revision and an update to 2001. *J. Climate* 16, 206-223, doi: 10.1175/1520-0442(2003)016<0206.HALSSA>2.0.CO;2 {618}.

[2] Morice, C.P., Kennedy, J.J., Rayner, N.A. and **Jones, P.D.** (2012) Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: the HadCRUT4 dataset. *J. Geophys. Res*. 117, D08101, doi:10.1029/2011JD017187 {55}; Brohan, P., Kennedy, J., **Harris, I**., Tett, S.F.B. and **Jones, P.D.** (2006) Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. *J. Geophys. Res*. 111, D12106, doi:10.1029/2005JD006548 {795}.

[3] **Mitchell, T.D**. and **Jones, P.D**. (2005) An improved method of constructing a database of monthly climate observations and associated high-resolution grids. *Int. J. Climatol*. 25, 693-712, doi:10.1002/joc.1181 {1492}; **Harris, I.**, **Jones, P.D.**, **Osborn, T.J.** and **Lister, D.H.** (2013) Updated high-resolution monthly grids of monthly climatic observations: the CRU TS 3.10 dataset. *Int. J. Climatol.* 33, doi:10.1002/joc.3711 {19}.

[4] **Briffa, K.R., Osborn, T.J**., Schweingruber, F.H., **Harris, I.C., Jones, P.D**., Shiyatov, S.G. and Vaganov, E.A. (2001) Low-frequency temperature variations from a northern tree-ring density network. *J. Geophys. Res*. 106, 2929 2941, doi: 10.1029/2000JD900617 {316}

[5] **Jones, P.D., Osborn, T.J. and Briffa, K.R.** (2001) The evolution of climate over the last millennium. *Science*, 292, 662 667, doi: 10.1126/science.1059126 {283}

[6] Santer, B.D., Taylor, K.E., **Wigley, T.M.L.**, Johns, T.C., **Jones, P.D.**, Karoly, D.J., Mitchell, J.F.B., Oort, A.H., Penner, J.E., Ramaswamy, V, Schwarzkopf, M.D., Stouffer, R.J. and Tett, S., 1996: A search for human influences on the thermal structure of the atmosphere. *Nature* 382, 39-46, doi:10.1038/382039a0 {278}

4. Details of the impact

During the period 2008-2013 the world's governments have adopted an agreed climate change mitigation policy goal of limiting global warming to no more than 2 degrees Celsius above the pre-industrial average temperature. This was first agreed at the 15th Conference of the Parties to the UN Framework Convention on Climate Change (COP15) in Copenhagen in December 2009 [7] and was confirmed at COP18 in Doha in December 2012 [8]. (This goal had originally been adopted by the EU in 1996 and re-confirmed in 2007, and was also adopted by the G8 Summit in July 2009). In agreeing this goal it was necessary to note that the global-mean warming observed thus far had been 0.8°C – thus setting the level of policy ambition necessary to limit further warming to no more than 1.2°C. This '2 degree' policy goal is now guiding national (e.g. UK – see [9]), European [10] and international efforts to negotiate and implement a range of policy measures which will be effective and sustainable.

In reaching this global agreement at COP15, after 15 years of international negotiations, the world's governments relied upon (see [7], [8]) the four successive assessment reports of the UN's IPCC, published in 1990, 1996, 2001 and 2007 (and the Fifth Assessment Report agreed in September 2013). The global temperature datasets produced by the School were and continue to

be central to these IPCC Reports; in particular, the HadCRUT3 dataset was used for the 2007 Report which guided the COP15 negotiations [11]. The importance of these data for the international negotiations is shown by the fact that the UN World Meteorological Organisation (WMO) brought forward its press release for the annual update of these data to November/December, to coincide with the UNFCCC talks being held at that time of year (e.g. WMO Press Release for the COP18 Doha meeting [12]). This demonstrates that these data are vital for informing decision-makers each year about the current state of world climate. The work of the School – jointly with the Met Office Hadley Centre - in making it possible to quantify and monitor the world's average surface temperature has therefore *directly contributed* to this internationally-agreed climate policy goal. Without these IPCC reports being able to draw upon the School's work, very specifically upon successive versions of the global temperature dataset, the importance of addressing the dangers of anthropogenic climate change would be much less well recognised and acknowledged by politicians and policy-makers around the world. The impact of this work extends well beyond the IPCC and the UNFCCC. The first diagram in many reports on climate change policy and adaptation is the HadCRUT4 global temperature series (most recently by the European Environment Agency [13]), and the update each year is headline news in many media outlets. Indeed it is one of the most famous diagrams in science.

The importance and significant impact of this work on national and international climate policy and public engagement was vividly demonstrated, but in a very different way, in November and December 2009. Professional email correspondence between scientists in the School and colleagues around the world was obtained illegally and made publicly available via the internet. The subsequent controversy became known as '*Climategate'* and revolved around a number of issues, but most critically whether the School's temperature data (including reconstructed temperature data over the last millennium) had been improperly manipulated. The importance of this question, and hence the impact of the School's work in this area, demanded a series of subsequent independent inquiries: by the House of Commons Select Committee on Science & Technology; the Muir-Russell Independent Climate Change Email Review; and the Oxburgh Scientific Assessment Panel. All of these Inquiries unambiguously affirmed the quality and reliability of the School's work – [e.g. 14].

The School's unique work on global temperature data has also had impact on public awareness, political negotiations and policy development on climate change through its widespread use in Detection and Attribution (D&A) of climate change due to human activities. The scientific community's efforts to reconstruct up to 2,000 years of past Northern Hemisphere temperatures, in which the School has played a key role, helps address a range of policy-relevant questions. Instrumental warming during the 20th century is 'clear and unequivocal' [11] and study of these longer periods helps determine the unusualness of this warming in much longer time sequences.

The School's datasets (HadCRUT4 and its precursor global temperatures, Northern Hemisphere temperature proxies, and instrumental precipitation data) have been used in almost all studies that have considered the D&A problem. The Special Report on Extremes (SREX) of the IPCC extended D&A to also consider the extremes of the climate as manifest in temperature, precipitation and storm datasets [15] and again relied upon the School's datasets. The School's datasets are widely used by many less-developed governments around the world. Access is through the World Bank [16], who have taken our 'national' products for all UN countries and recognized territories (developed in Ref [3] above) and extended the work to additionally include all major river basins of the world.

5. Sources to corroborate the impact

[7] UNFCCC (2009) *The Copenhagen Accord* Decision Chapter 15; paragraph 2 states:
"*We agree that deep cuts in global emissions are required according to science, and as documented by the IPCC Fourth Assessment Report with a view to reduce global emissions so as to hold the increase in global temperature below 2 degrees Celsius, and take action to meet this objective consistent with science and on the basis of equity*"

[8] UNFCCC (2012) *Ad hoc working group on long-term cooperative action under the Convention*
"*Decides that Parties will urgently work towards deep reduction of global GHG emissions required to reach the below 2 degree goal and global peaking [as soon as possible][by*

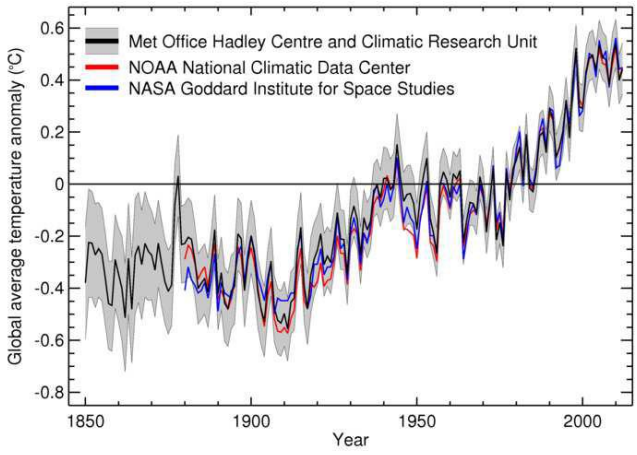
2015], consistent with science, such as IPCC AR4"

[9] HM Government (2013) *Supporting international action on climate change*
This document quotes the rise in global temperature to date (0.8°C) based on the HadCRUT4 dataset) and the policy goal of limiting this warming to 2°C:
"*The industrial revolution led to an increase in greenhouse gas emissions caused by human activity. The Earth's surface has consequently warmed by about 0.8°C since around 1900, with much of this warming occurring in the past 50 years."*

[10] European Commission (2008) What is the EU doing about climate change?

[11] IPCC (2007) *Climate change 2007: the physical science basis*
"*Gridded data sets combining land-surface air temperature and SST anomalies have been developed and maintained by three groups: CRU with the UKMO Hadley Centre in the UK (HadCRUT3 …*"
See also Table 3.3 for further evidence.

[12] WMO (2012) Press Release No.966: Record Arctic sea-ice melt, multiple extremes and high temperatures
This press release contains the figure below:



[13] European Environment Agency (2012) *Climate change, impacts and vulnerability in Europe 2012*
See: pages 57-59

[14] Report of the International Scientific Assessment Panel set up under Lord Oxburgh to examine the research of the Climatic Research Unit. See: p 4:
"*We believe that CRU did a public service of great value by carrying out much time-consuming meticulous work on temperature records at a time when it was unfashionable and attracted the interest of a rather small section of the scientific community. CRU has been among the leaders in international efforts in determining the overall uncertainty in the derived temperature records and where work is best focussed to improve them*."

[15] IPCC (2012) Managing the risks of extreme events and disasters to advance climate change adaptation A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change
See: Chapter 3, pp 109-230, e.g. see p127; P.D Jones is cited 16 times in this Chapter

[16] World Bank *Climate change knowledge portal: for development practitioners and policy-makers* http://sdwebx.worldbank.org/climateportal/index.cfm
The Climatic Research Unit at the University of East Anglia is acknowledged as the source of the climate data:
http://sdwebx.worldbank.org/climateportal/index.cfm?page=why_climate_change