Some Thoughts on the Surface Mid-Tropospheric Temperature Trend Differences

Based on

Contribution of Stratospheric Cooling to Satellite-Inferred Tropospheric Temperature Trends: Fu, Q., C.M. Johanson, S.G. Warren, and D.J. Seidel, May 6, 2004: *Nature,* 429*,* 55-58

BY

Roger A. Pielke Sr.
Department Atmospheric Science, 1371 Campus Delivery,
Colorado State University, Fort Collins, CO 80523
Phone: 970-491-8293
Fax: 970-491-3314
pielke@atmos.colostate.edu

Thomas N. Chase
Cooperative Institute for Research in Environmental Sciences (CIRES)
and Dept. of Geography, Campus Box 216, University of Colorado, Boulder, CO 80309
tchase@terra.colorado.edu

Ben Herman
Atmospheric Science Department,
University of Arizona, Tucson, AZ 85721
herman@atmo.arizona.edu

May 26, 2004

Fu et al.[1] conclude that their reassessment of Microwave Sounding Unit (MSU) tropospheric temperature trends results in a substantial warming of the troposphere over time from 1979 to 2001, yet the University of Alabama in Huntsville (UAH) results do not indicate as much warming[2]. Using the Fu et al. model with UAH data as inputs, Fu et al. estimate a 1979-2002 trend of 0.11 C/decade (J. Christy, personal communication). This is an important scientific issue, since the global models in the National Assessment Synthesis Team[3] predict a linear-regression warming rate of between +0.24 C to +0.37C per decade at 500 mb over the 1979-2000 time period, which is still higher than even the Fu et al. estimate.

Our research group has specifically investigated the *lower troposphere* temperature trends using the NCEP/NCAR Reanalysis[4,5]. We found that the NCEP/NCAR Reanalysis product does not document as much warming as shown in the global models. The NCEP/NCAR Reanalysis lower tropospheric layer-averaged temperature trend (1000-500 mb) has an average temperature increase between 1979 and 2001 of +0.05 C/decade (and +0.08 C/decade between 1979-2002), although with considerable interannual variability (and which is not statistically different from a zero trend). The Hadley Center, using radiosonde data, has computed a lower tropospheric trend (corresponding to the layer viewed by the UAH lower tropospheric data) for the period 1979-2002 of +0.05 C/decade (their data is described in Parker et al.[6] and Folland et al.[7]), while the UAH lower tropospheric trend for 1979-2002 is +0.07 C/decade (J. Christy 2004, personal communication).

Unfortunately, Fu et al. did not discuss how their data compared to any published trend values from the NCEP/NCAR Reanalysis. Even though our work is with respect to the lower troposphere, if both data sets were accurate it would require that for Fu et al. to be correct, their reported warming must occur almost entirely in the upper troposphere.

As discussed in Pielke and Chase[8], the NCEP/NCAR Reanalysis provides a robust *independent assessment* of the UAH MSU lower tropospheric temperature data, since the Reanalysis is routinely constrained by radiosonde observations. Christy et al.[2] provides documentation of the independence of their data set from the NCEP/NCAR Reanalysis. As further evidence of this independence, Christy and Norris[9] specifically state that the

UAH dataset was fixed, and only afterwards did they contact the National Climate Data Center for Southern Hemisphere radiosonde station data to compare with their values. Radiosonde observations of the lower troposphere associated with their instrumentation also have had only small and fairly random shifts (Parker et al.[6]; Christy and Norris[9]), so that the constraint of the NCEP Reanalysis by radiosondes provides consistency across the time period 1979-present.

The Santer et al.[10] claim, in response to the Pielke and Chase[8] comment, that radiosonde data is used in the UAH products is incorrect. The use of the NCEP/NCAR Reanalysis, therefore, provides a particularly effective *independent* procedure to assess long-term lower tropospheric temperature trends since radiosonde observations are inserted into a global model, which provides a physically-based constraint to the data. Because issues of inhomogeneity of the MSU time series have led to a wide variety of differing trends depending on the processing procedure[2,11,12], the Fu et al. results need to be contrasted with other, independent results.

We agree that the NCEP Reanalysis contains imperfections, but, we examined this issue in Chase et al.[13]. In that study, we completed a detailed global and regional comparison analysis of the UAH lower tropospheric data and the NCEP/NCAR Reanalysis data, which adds to the confidence in the accuracy of the two data sets. We found large statistically significant regional positive and negative temperature trends in both the NCEP/NCAR 1000-500 mb thickness temperature and UAH lower tropospheric data sets that have larger magnitudes than documented biases in the data. A more complete and illuminating comparison for the Fu et al. data, therefore, would include contrasting their results to the regional and global trends obtained from the NCEP/NCAR and ERA-40 Reanalyses (although there is a reported warm bias in recent years in the ERA-40 data set due to the assimilation of the SSM/I satellite data[14]).

The monitoring of tropospheric temperature trends, of course, is an important climate assessment. However, in addition to close scrutiny of this quantity, Fu et al. should also mention that surface temperature trends could be different from tropospheric trends for reasons that the General Circulation Models (GCMs) have not considered. This includes non-spatially representative surface temperature observing sites[15], land-use change effects on surface temperature[(e.g.,16,17, 18,19)], and incomplete representation of surface heat content[20]. Why is there so much confidence in the robustness of the surface temperature trends, yet so much disagreement on the tropospheric trends?

Fu et al. also incompletely characterize other trends in the climate system. They state that there is a reduction of sea ice and snow cover. While Arctic sea ice cover has been decreasing, Antarctic sea ice cover and Northern Hemisphere snow cover have not[21]. The spatial extent of the coldest winter mid-tropospheric minimum temperatures has not become smaller[22]. Ocean heat storage, while warming, is at a rate that is smaller than predicted by most climate change models[23,24]. Such observations, including the observed sudden transitions in the climate system[23], also make linear trend analyses such as presented in Fu et al. of less value.

While it is broadly recognized that humans are altering the climate system in diverse ways[25] the implication from the Fu et al. study is that, except for the issue of the tropospheric temperatures, which they claim to have resolved, the GCMs as decadal climate prediction tools have been validated. This claim, however, assumes that the models are correct, and that observational data that does not confirm model predictions is incorrectly analyzed or interpreted. The focus is on seeking data that agrees with the predictions of the model. Data (such as surface temperature data) that conforms to the GCM predictions is not further scrutinized. Only data, such as the UAH tropospheric trends is questioned, since it does not fit the preconceived assumption concerning the skill of the GCM models. The NCEP/NCAR Reanalysis data, however, which we have analyzed, supports the accuracy of the UAH lower tropospheric data, and raises questions about the robustness of the Fu et al. results.

References

1. Fu, Q., C. M. Johanson, S.G. Warren, and D.J. Seidel 2004: Contribution of stratospheric cooling to satellite-inferred tropospheric temperature trends. *Nature*, **429**, 55 – 58.
2. Christy, J. R., R.W. Spencer, W.B. Norris, W.D. Braswell and D.E. Parker, 2003: Error estimates of Version 5.0 of MSU/AMSU bulk atmospheric temperatures. *J. Atmos. Oceanic Tech.*, **20**., 613-629.
3. National Assessment Synthesis Team, 2001: Climate change impacts on the United States. Cambridge University Press. Cambridge, UK.
4. Chase, T.N., R.A. Pielke Sr., B. Herman, and X. Zeng, 2004: Likelihood of rapidly increasing surface temperatures unaccompanied by strong warming in the free troposphere. *Climate Res*., **25**, 185-190.
5. Kalnay, E., and Coauthors, 1996: The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Amer. Meteor. Soc*., **77**, 437-471.

6. Parker, D.E., M. Gordon, D.P.N. Cullum, D.M.H. Sexton, C.K. Folland and N. Rayner, 1997: A new global gridded radiosonde temperature data base and recent temperature trends. *Geophys. Res. Lett*., **24**, 1499-1502.

7. Folland, C.K., T.R. Karl, J.R. Christy, R.A. Clarke, G.V. Gruza, J. Jouzel, M.E. Mann, J. Oerlemans, M.J. Salinger and S.-W. Wang, 2001: Observed climate variability and change. In: *Climate Change 2001: The Scientific Basis*. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881 pp.

8. Pielke Sr., R.A., and T.N. Chase, 2004: Technical Comment: "Contributions of anthropogenic and natural forcing to recent tropopause height changes". Science, 303, 1771b. See also http://blue.atmos.colostate.edu/publications/pdf/R-278b.pdf.

9. Christy, J. R. and W.B. Norris, 2004: What we conclude about global tropospheric temperature trends. *Geophys. Res. Letts.,* **31.** L06211, doi:1029/2003GL019361,2004

10. Santer, B.D., M.F. Wehner, T.M.L. Wigley, and R. Sausen, 2004: Technical Comment: "Response to Comment on "Contributions of anthropogenic and natural forcing to recent tropopause height changes." *Science*, **303**, 1771c.

11. Mears, C.A., M.C. Schabel, and F.J. Wentz, 2003: A reanalysis of the MSU Channel Tropospheric Temperature Record. *J. Climate*, **16**, 3650-3664.

12. Vinnikov, KY, and N.C. Grody, NC, 2003: Global warming trend of mean tropospheric temperature observed by satellites. *Science*, **302**, 269-272.

13. Chase, T.N., R.A. Pielke, J.A. Knaff, T.G.F. Kittel, and J.L. Eastman, 2000: A comparison of regional trends in 1979-1997 depth-averaged tropospheric temperatures. *Int. J. Climatology*, **20**, 503-518.

14. Bengtsson, L., S. Hagemann, and K.I. Hodges, 2004: Can climate trends be calculated from Reanalysis Data? *J. Geophys. Res*. **109**, D11111, doi:10.1029/2004JD004536.

15. Davey, C.A., and R.A. Pielke Sr., 2004: Microclimate exposures of surface-based weather stations - implications for the assessment of long-term temperature trends. *Bull. Amer. Meteor. Soc.*, in press.

16. Bonan, G.B., 1997: Effects of land use on the climate of the United States. *Climatic Change*, **37,** 449-486.

17. Kalnay, E., and M. Cai, 2003: Impact of urbanization and land-use change on climate. *Nature*, **423**, 528-531.

18. Narisma, G.T., and A.J. Pitman, 2003: The impact of 200 years of land cover change on the Australian near-surface climate. *J. Hydrometeor.*, **4**, 424-436.

19. Marshall, C.H. Jr., R.A. Pielke Sr., L.T. Steyaert, and D.A. Willard, 2004: The impact of anthropogenic land cover change on warm season sensible weather and sea-breeze convection over the Florida peninsula. *Mon. Wea. Rev*., **132**, 28-52

20. Pielke, R.A. Sr., C. Davey, and J. Morgan, 2004: Assessing "global warming" with surface heat content. Eos, **85**, No. 21, 210-211.

21. Pielke Sr., R.A., G.E. Liston, W.L. Chapman, and D.A. Robinson, 2004: Actual and insolation-weighted Northern Hemisphere snow cover and sea ice -- 1974-2002. *Climate Dynamics,* in press.

22. Chase, T.N., B. Herman, R.A. Pielke Sr., X. Zeng, and M. Leuthold, 2002: A proposed mechanism for the regulation of minimum midtropospheric temperatures in the Arctic. *J. Geophys. Res*., **107(D14),** 10.10291/2001JD001425.

23. Barnett, T.P., D.W. Pierce, and R. Schnur, 2001: Detection of anthropogenic climate change in the world's oceans. *Science,* **292**, 270-273.

24. Pielk**e** Sr., R.A., 2003: Heat storage within the Earth system. *Bull. Amer. Meteor. Soc*., **84,** 331-335.

25. Rial, J., Pielke Sr., R.A., M. Beniston, M. Claussen, J. Canadell, P. Cox, H. Held, N. de Noblet-Ducoudre, R. Prinn, J. Reynolds, and J.D. Salas, 2004: Nonlinearities, feedbacks and critical thresholds within the Earth's climate system. *Climatic Change*, in press.

26. Cotton, W.R. and R.A. Pielke, 1995: *Human impacts on weather and climate*, Cambridge University Press, New York, 288 pp.