**MS – RAND – CPP – PROG0407**

# HadAT: An update to 2005 and development of the dataset website

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**CV(CR)**

**Contract Deliverable reference number: 03.09.04**

**File: M/DoE/2/9**

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| **Sent to Defra:** | **Signature** | **Linda Livingston** | **Date: 01/04/05** |

**Version Number:** 1.0

**Number of Pages:**

**Security Classification:** Unclassified

# HadAT: An update to 2005 and development of the dataset website

**Holly Coleman, Peter Thorne**

31st March 2005

## Capsule

**Over the past six months we have converted our HadAT radiosonde temperature product to monthly resolution updatable in near real-time. When our HadAT dataset paper is accepted for publication, the monthly updated HadAT will be made available to researchers, via a dedicated website referenced in this report. Updating HadAT through 2005 has not altered our previous conclusion that most of the discrepancy between surface and upper-air temperatures over the satellite period arises in the tropics.**

## Previous work on HadAT

HadAT is the result of three years of Defra-funded work to create an improved climate dataset from the global radiosonde archives to replace HadRT, which had been found to be inadequate as a climate dataset. HadAT uses a near-neighbour "buddy check" approach to identify breakpoints (i.e. step-changes in biases) and adjusts for their effects. The HadAT product was developed for the period 1958-2001. However it was deemed essential that an updated version be made widely available to permit continuous monitoring. It was decided to update solely HadAT2, the product which we believe to be our best estimate of true changes in temperatures aloft. HadAT0 and HadAT1, both of which are based on a subset of HadAT2 stations, will remain frozen seasonal products to 2001. For more details see Thorne et al., 2005, or the website.

## Progress to date and system design

### Creation of monthly HadAT2

Seasonal HadAT2 adjustments derived by Thorne et al. (2005) were applied to the raw monthly anomaly values. Any deletions that had been made were applied to all three monthly values within each deleted season. The 1966-1995 climatologies were recalculated to create our HadAT2 monthly upper-air temperature anomaly product, which was then gridded onto a 10° longitude by 5° latitude grid, as in the original analysis.

### Updating of HadAT2

The method used for the real-time updates is outlined in Figure 1. The dataset was frozen until December 1999 (using the data and adjustments derived by Thorne et al., 2005) and updated solely from January 2000 with new data from CLIMAT TEMP archives held at the Hadley Centre and the Integrated Global Radiosonde Archive (IGRA) (Durre et al., 2005). Quality checks were employed on these new data because pervasive changes to the global radiosonde network have continued to be made subsequent to 2000. It is imperative that we identify and adjust for any resulting systematic biases if HadAT updates are not to contain significant non-climatic signals. We used a similar methodology to that employed in the initial dataset development (Thorne et al., 2005; website audit page). To define potential breakpoints, a running first difference series was calculated from the station minus neighbour difference series using 12 months values either side of each point (stage 3, Figure 1). Critical values were derived as the 95th percentile of the absolute values for each station at each level in the pre-2000 HadAT2 monthly product. Any points after 2000 that were found to exceed the critical value at 3 or more levels for a station in a given month were flagged as being a suspected breakpoint. The procedure is automated until this point, but we strongly believe that automatically adjusting the breakpoints would compromise continuity with the historical methodology employed in Thorne et al., 2005.

We made the decisions whether to adjust each of the potential breakpoints by looking at plots of the difference series for the full period (to provide context) and the update period (Figure 2). We either accepted or rejected the breakpoints identified. If a breakpoint was accepted its timing could be altered based upon our analysis of the data. We also identified a very small number of further breakpoints in some stations based upon our visual analysis. Adjustments were calculated for all confirmed breakpoints using the same method as in Thorne et al., 2005 (see website). A period of up to 3 years (36 months) either side (truncated if there was another breakpoint identified within this period) was used for the monthly data. No breakpoints are identified within the most recent 12 months as a 24-month window is required for their identification.

Adjustments were applied to all the points after and including each breakpoint. Hence HadAT2 has been adjusted to December 1999. Subsequently the neighbour difference series was recalculated and any values equal to or greater than 3.5σ of the pre-2000 series within the new data were deleted (stage 4, Figure 1). There were 955 of these automatic deletions made, representing approximately 0.5% of all post-2000 data points.

**Initial Analysis**

The data coverage for January 2005 (Figure 3) is less than that in the early 1990’s (Figure 4), particularly around India; data for which have been blacklisted in IGRA. The coverage has also significantly decreased over Africa, South America and some of the more remote islands. However, some of these will be recovered in planned future work. Data reporting in general decreases towards the ends of the record and particularly in the mid to late 1990’s (Figure 5). One noticeable feature is a spike in March 1992 when there are very few data in HadAT2 as the major data source used has no data in this month. We aim to rectify this in the near future through collaboration with the National Climatic Data Centre where these data originated.

The three major volcanic eruptions, Agung (1963), El Chichón (1982) and Pinatubo (1991), produce obvious warm spikes in the global mean timeseries (Figure 6) at 100hPa. Over the entire period there is an overall cooling in the stratosphere, although this trend is not linear, and cooling increases after the late 1970’s. As noted elsewhere (e.g. Seidel and Lanzante, 2004), a model of ramping down following volcanic events rather than a linear change appears to be an equally compelling description. At 500hPa El Niño Southern Oscillation (ENSO) events can be observed, primarily in 1997/98, as well as the effects of the “regime shift” to a warmer climate in the mid to late 1970’s. Overall there is a net warming in the troposphere, although as in the stratosphere this is not linear.

Over the full period 1958-2005 the troposphere is warming at a similar rate to that at the surface both globally and in the tropics (Figure 7). Tropical tropospheric cooling can be seen in the trends over the satellite era, 1979-2005, despite warming at the surface. However, the tropical cooling is less than that for the original HadAT period(1979-2001). The addition of three globally “warm” years 2002-2004 (at the surface at least) has served to alter the magnitude but not the zonal structure of the trends aloft. The discrepancy between surface and tropospheric trends remains primarily a tropical phenomenon according our state-of-the-art radiosonde and surface based analyses.

## Future Work and time commitments

We will continue to update HadAT2 in near real time on a monthly basis. Each month the previous 12 months of data will be retrieved from the IGRA and CLIMAT TEMP archives (stage 1, Figure 1). The temperatures will be converted to anomalies and any previously calculated adjustments will be applied except those which require re-calculating owing to revised data (stage 2, Figure 1). The new data will be passed through our breakpoint identification and quality control system (stages 3-4, Figure 1), and used to augment the HadAT2 station series before being gridded (stage 5, Figure 1). A series of tests (stage 6, Figure 1) will be applied to check that the various outputs of the system are trustworthy (these are under development as this system is automated over the next few months) and the website will be updated (stage 7, Figure 1). Tests could not be implemented until the system architecture was put in place so require further work.

Our updated station and gridded HadAT2 datasets are on our website at http://www.hadobs.org/hadat/ as well as a full audit trail. Currently access is through http://www.hadobs.org/hadat/private/ with username “hadat” and password “rsonde”. Upon acceptance of the HadAT paper this will be made public for research use. In the meantime we would welcome suggestions as to potential improvements.

We envisage further development, testing and refinement of this system entailing approximately 2 to 3 months person time; and the regular updating to have an annual overhead of order 2-4 person weeks.

## References

Durre, I., R. S. Vose, and D. B. Wuertz , 2005: Overview of the Integrated Global Radiosonde Archive. *Submitted to J. Clim.*

Seidel, D. J., and Lanzante, J. R., 2004: An assessment of three alternatives to linear trends for characterizing global atmospheric temperature changes. JGR 109 Art. No. D14108

Thorne, P. W., Parker, D. E., Tett, S. F. B., Jones, P. D., McCarthy, M., Coleman, H., Brohan, P., and Knight, J. R., 2005:Revisiting radiosonde upper-air temperatures from 1958 to 2002. *Accepted by Journal of Geophysical Research subject to revision*

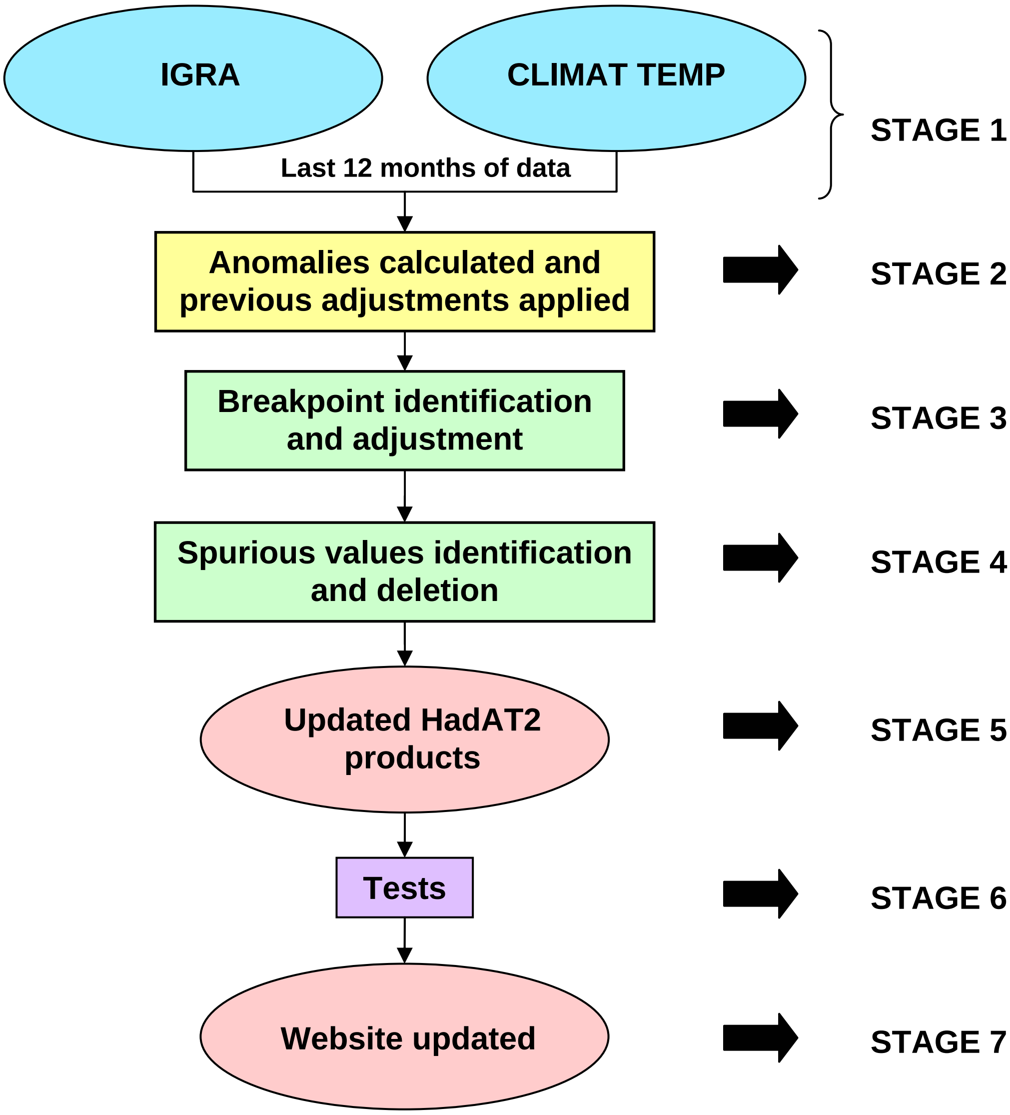



Figure 1: Schematic of the HadAT2 monthly update process

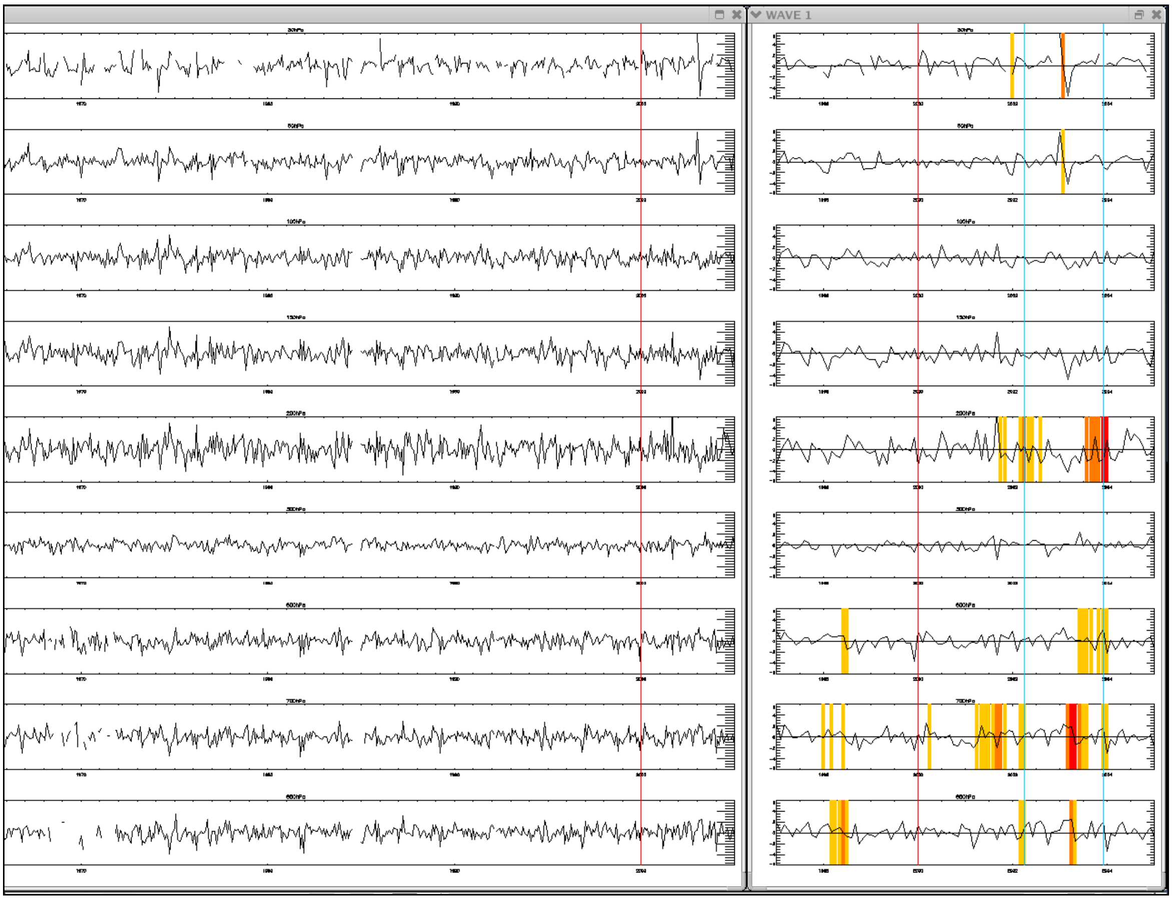
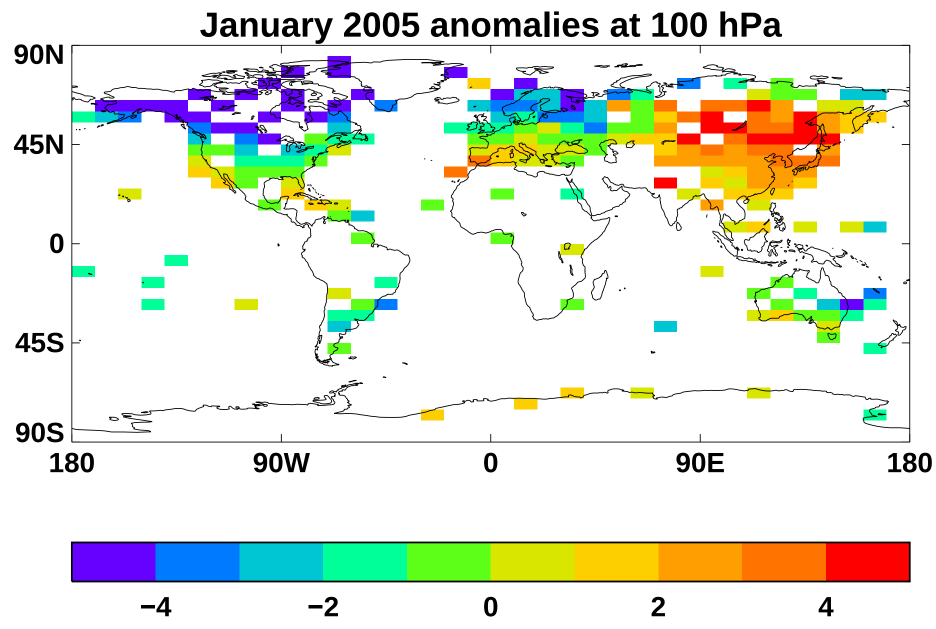



Figure 2: A screen capture of the neighbour difference series plots at each of the 9 pressure levels for station 6181 (Koebenhavn / Jaegersborg, Denmark). These are produced for each station with new data in order to aid the user in making a decision regarding the potential breakpoints within a station series. The left plot covers the full period and the right plot shows the most recent period with the potential breakpoints denoted by the vertical blue lines. The yellow, orange and red bars denote the points at which the first difference series exceeded 1.0 times the critical value, 1.25 times the critical value and 1.5 times the critical value respectively for the given level. The red vertical lines denote Jan 2000 before which our update system makes no adjustments.



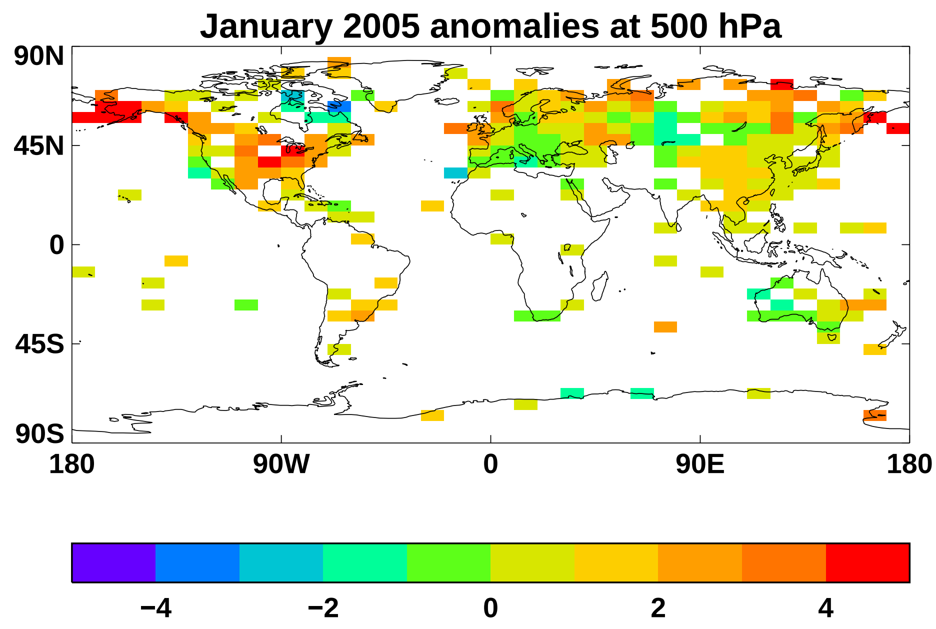




Figure 3: Plots of HadAT2 gridded monthly temperature anomalies (K) for January 2005 at 100hPa and 500hPa.

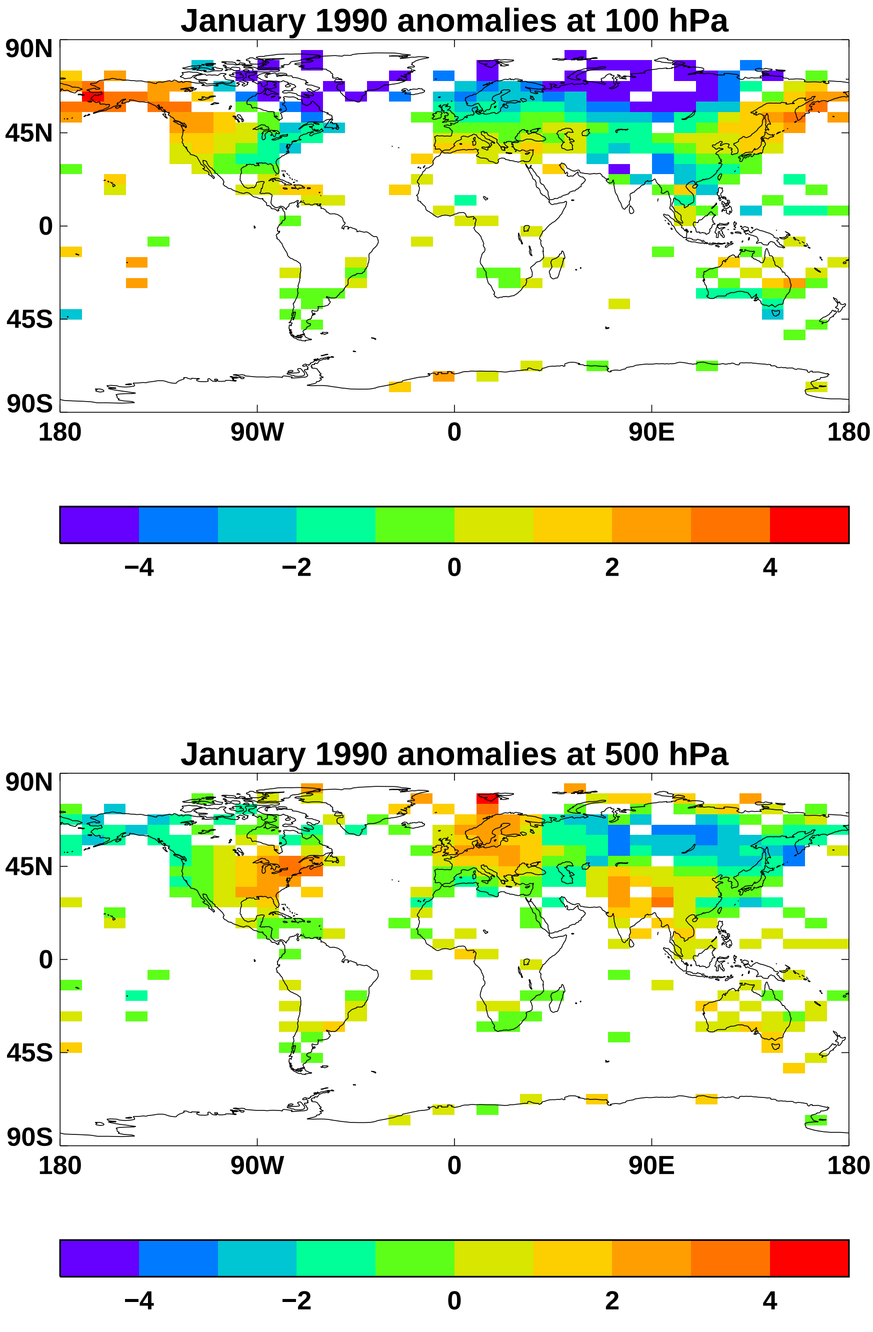



Figure 4: As Figure 3 but for January 1990

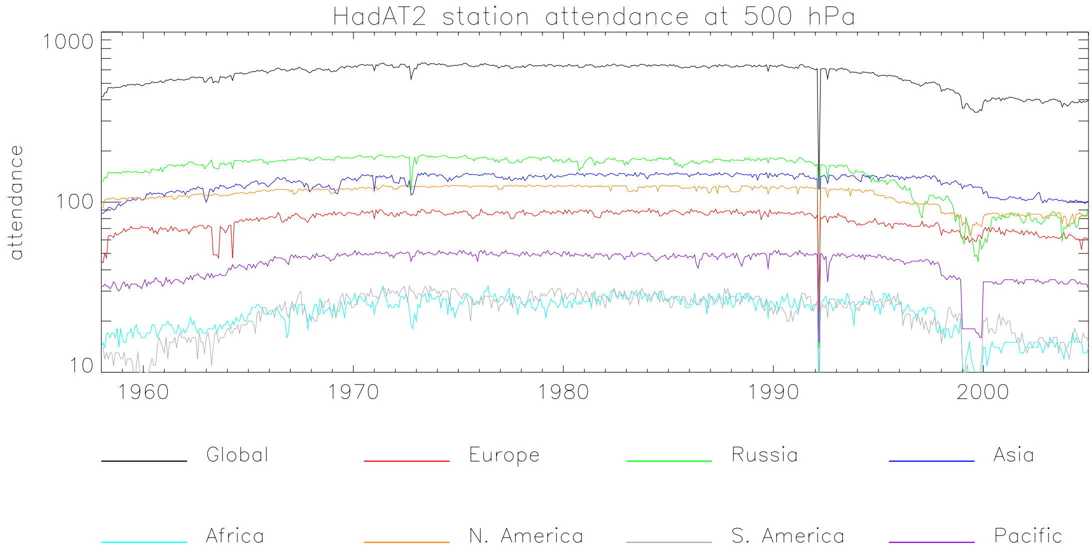



Figure 5: Plot of HadAT2 global and regional station attendance at 500hPa. Note the logarithmic y-axis.

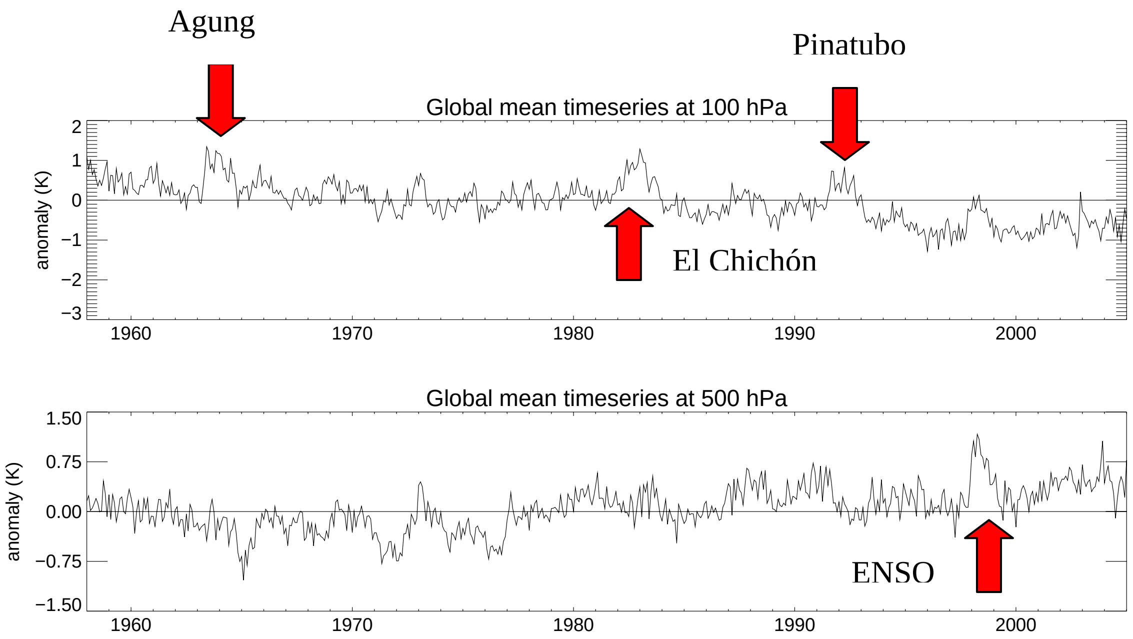



Figure 6: The global mean timeseries of HadAT2 temperature anomalies (K) relative to a 1966-95 climatology at 100hPa and 500hPa.

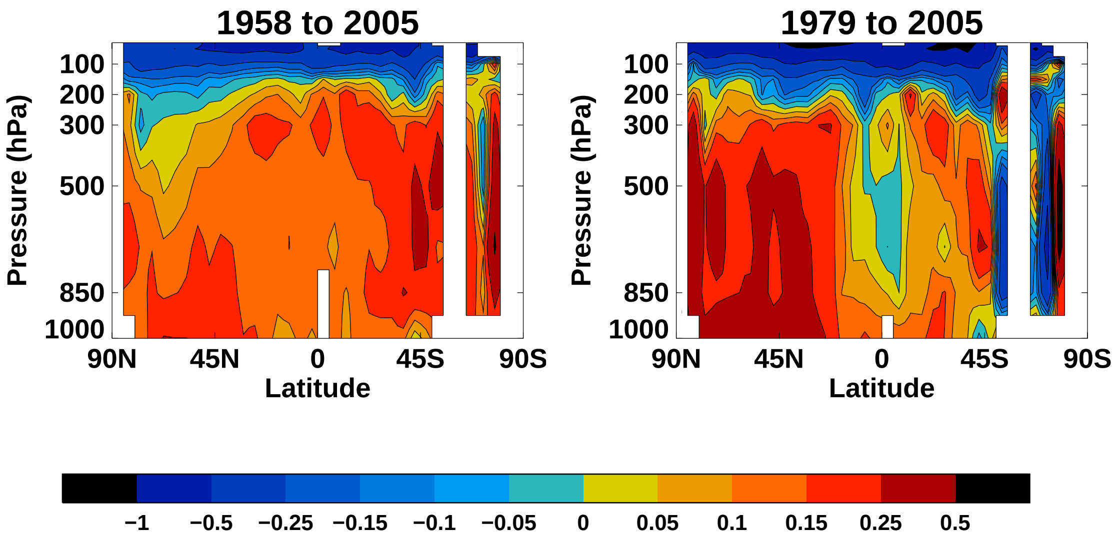



Figure 7: Linear trends in zonal mean temperature (K/decade) in HadAT2 for 1958-2005 and 1979-2005. 1000hPa data are from HadCRUT2v subsampled to the time-varying HadAT2 500hPa availability